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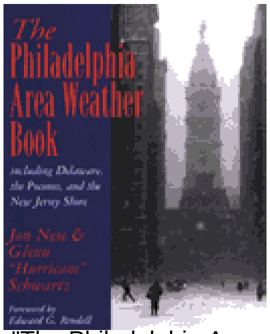


"The Philadelphia Area Weather Book" is available in the Sci-Store!

FRANKLIN'S FORECAST

El Nino "Some are weatherwise, some are otherwise." Benj. Franklin

The Franklin Institute's Five Day Forecast

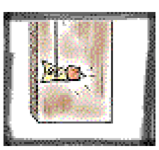
In 1735, "Poor Richard," aka Ben Franklin, wrote:

"Some are weatherwise, some are otherwise."

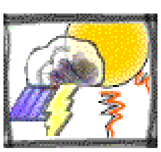
In 1743, Ben observed that northeast storms begin in the southwest. On horseback, he chased a whirlwind almost a mile to find out why. "Poor Richard" printed some of the first recorded weather forecasts. Clearly, Ben Franklin had weatherwisdom.

With "Franklin's Forecast," you can build your own weather station, learn about today's sophisticated weather technologies, and check the weather right now. **Don't be otherwise. Be weatherwise!**

El Nino If Ben had been in the tropical Pacific Ocean, he might have noticed El Niño too. Find out about the **Hot Air over Hot Water**.

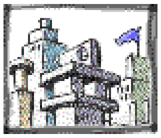


You can **make your own weather station**. Simple devices like the barometer and wind direction indicator are all you need to get started as a weather forecaster for your own neighborhood.

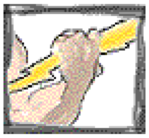


Wherever you are, whatever the time, you can check the **weather right now**. Use "Franklin's" shortlist of the best webweather sources to check the forecast for your own hometown or favorite destination.

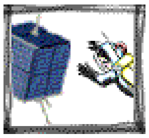
Meteorologists are weatherwatchers. You can be a weatherwatcher, too. Just keep your eyes open for **weather events**.



RADAR revolutionized the field of meteorology. Learn how to read **RADAR** images and you'll make a better forecast.



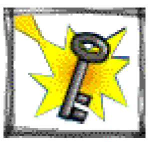
Lightning strikes are awesome displays of nature's power. They also offer clues for tracking storms.



The real weatherwatchers are in outer space. In orbit above planet Earth, **weather satellites** provide pictures of atmospheric activity.

Weather Activities
Career Connections

Weather Hotlist
Curriculum Connections



If you are in the Philadelphia area, these charts of **historical weather data** and this list of **Philadelphia Area Weather Connections** may interest you. **NBC-10's Earthwatch Weather Workshops**, with our chief meteorologist and the NBC-10 Earthwatch Weather Team, may also be of interest.
Get information about **conserving water and drought situations**.

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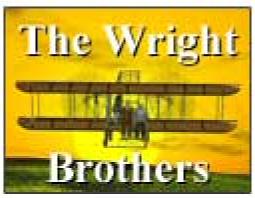
Learn The Franklin Institute Online

FOR TEACHERS



ONLINE EDUCATION

SPECIAL EVENT

The Human Brain - Research and Rewards Archived Webcast

SEARCH

SPECIAL EVENT

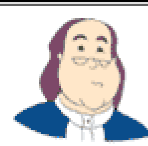
FOR TEACHERS

Community Science Action Guides

ONLINE EXHIBIT

The Heart

ONLINE EXHIBIT



Benjamin Franklin

PECO.

EDUCATORS

Keystone Science Network

VISIT GUIDE FOR TEACHERS

School Field Trip Planner

Educational Programs are available during your Visit to the Museum.

A Teacher's Guide to Institute Exhibits and Films and Exhibit Correlations to National/State Standards (PA, NJ, DE) are accessible online.

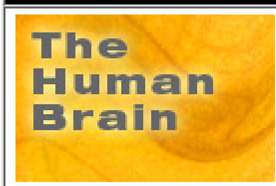
Traveling Science Shows bring science demonstrations to your location.

The **2003 Flight Forecast** online program challenged K-12 students to predict the weather conditions for flight at the Centennial of Flight celebration at the Wright Brothers National Memorial in Kitty Hawk, North Carolina on December 17, 2003. **The results are in. Check out the most accurate forecasts!**

ONLINE EDUCATIONAL PARTNERSHIPS

Signature Programs of the Center for Innovation in Science Learning

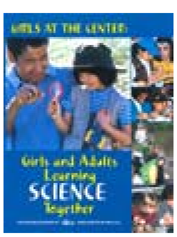
ONLINE LEARNING RESOURCES



The Human Brain
New Presentation!
Delve into the depths of the human brain. Learn about nourishing, protecting, exercising, and resting your body's most important organ.

INTERACTIVE

Effective Detective
Be a detective!
You have 25 chances to discover the secret rule governing a natural phenomenon.

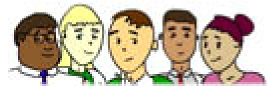


Girls at the Center: Girls and Adults Learning Science Together is a timely guidebook of tested programs and ready-to-use materials that invite girls and adult partners to become enthusiastic science learners. Girls at the Center is the result of a four-year collaboration of The Franklin Institute Science Museum and the Girl Scouts of the U.S.A. and was field-tested with multi-cultural audiences in 42 sites nationwide. This book will have particular value for youth leaders and groups, parents, homeschoolers, parent-teacher organizations, museum educators, and community-based organizations.

ONLINE LEARNING RESOURCES

Online Math Collection
"Exhibit Math" enhances your visit to three Franklin Institute exhibits. "Melting Pot Math" offers a collection of math problems inspired by cultures around the world. Use the problems to make connections between social studies and math class. Try the "Open Ended Math Problems" and "Seasonal Math Problems" too.

Welcome to My World!
Careers in Science and Technology
What career should you pursue if you're interested in science and technology? Find out! Follow along with some professionals as they spend a day at work.



ONLINE LEARNING RESOURCES

The Spotlights
Each one of The Spotlights incorporates outside Web resources into a conceptual package that can be used in a science classroom or at home on your own. From soccer to spiders, fruit to forest flames, and chemistry to the calendar, open your mind to a variety of fascinating topics.

Educational Hotlists
Sort through organized lists or go directly to your topic of interest. The Hotlists are Internet resources that science educators and enthusiasts may find useful. All websites have been screened for educational appropriateness, and will save you time in locating quality resources.

COLLECTION

The Wright Brothers Aeronautical Engineering Collection
The Franklin Institute Science Museum has the largest collection of artifacts from the Wright brothers' workshop. Efforts are underway to provide online access to the entire collection.

ONLINE LEARNING RESOURCES

Pieces of Science
"Pieces of Science" is an online gallery of sixteen educational resources related to a collection of historical science objects. Online Museum Educators in the United States and United Kingdom created the pieces, which have been mapped against the U.S. National Science Education Standards.

ONLINE STUDY UNITS

Living Things
This unit of study will stimulate critical thinking for both teacher and student. Hands-on science with inquiry-based facilitation provides motivation for learning about individuals, families, neighborhoods, and the entire circle of life of living things. Birth, growth, reproduction, and death are natural parts of our natural world.

Wind: Our Fierce Friend
This unit of study investigates wind as a friend and as a foe. Our relationship with the wind is often uncertain; learn more about our fierce friend by exploring the science of wind energy.

ONLINE LEARNING RESOURCES

El Nino: Hot Air Over Hot Water
What is El Nino? Where do scientists look for it? Background information, activities, and online resources are available for discovering what all the hot air is about.

Franklin's Forecast
Be your own neighborhood weather forecaster with Franklin's Forecast, an online exhibit about weather forecasting. Build your own weather station, learn about today's sophisticated weather technologies, and check the weather right now. Don't be otherwise. Be weatherwise!

EARTHFORCE
Volcanoes erupt, the crust quakes, and rivers rage. EARTHFORCE is everywhere. For scientists, the word force is defined as a push or pull that causes a change in motion. Explore the pushing and pulling in the core, crust, or water of the Earth that causes motion like eruptions, quakes, or floods.

ONLINE LEARNING RESOURCES

Undersea and Oversee
The oceans challenge us to understand and protect them. One school, located in the School District of Philadelphia, Pennsylvania, accepted the challenge to oversee the ocean. The Douglass School students visited the Atlantic Ocean and investigated its ecosystem. Follow along on their real ocean journey or take your own online ocean journey.

An Inquirer's Guide to the Universe
What do we already know about planets and the universe? What don't we know? Read about space science fact and fiction, write a story about an imaginary planet, or read what someone else wrote about an imaginary universe. Also includes inquiry tips for teachers. It's out of this world!

ONLINE LEARNING RESOURCES

Science Learning Network
The Science Learning Network (SLN), which originated as a three year project funded by the National Science Foundation and Unisys Corporation, demonstrated an online community of educators, students, schools, science museums, and other institutions practicing a new model for inquiry science education.

ONLINE LEARNING RESOURCES

Minutes from ME
For quick classroom activities, browse through some of Margaret Ennis' work. A part-time teacher and volunteer at The Franklin Institute, Margaret knows how to make online learning fun.

Musing with Mac
Words that connect. John D. MacArthur offers links to the past that illuminate our future.

THINGS TO DO

Find out what's new to do at The Franklin Institute.

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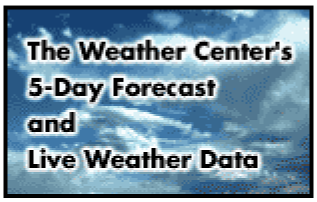
COLLECTION

WEATHER CENTER



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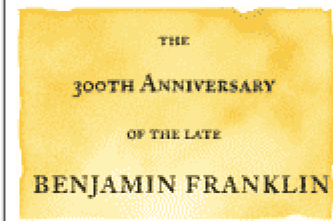
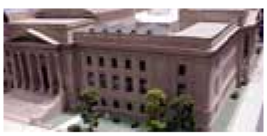
BENJAMIN FRANKLIN



AWARDS PROGRAM

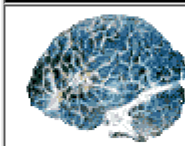
EXHIBIT HALLS



COLLECTION

INQUIRY ATTIC

DAILY SCIENCE



Brain Drops

LIVE IMAGES

LEGACY

Institute History and Mission	Journal of The Franklin Institute	Benjamin Franklin National Memorial

ONLINE LEARNING RESOURCES

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Pieces of Science

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EXPLORATIONS

The Franklin Institute Lecture Series - 2004 Explorations

OTHER COLLECTIONS	
Journey In Time	Time Keepers

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- GO Buy tickets online.
- GO Book a Traveling Science Show.

SPECIAL EVENTS

Bug Invasion
May 14-16, 2004

Badge Day
May 22, 2004

TITANIC
THE ARTIFACT EXHIBITION

SEARCH GO

FOR TEACHERS

School Field Trip Planner

FELS PLANETARIUM

BECOME A MEMBER

MUSEUM STORE

Sci-Store

EXHIBIT HALLS

THE FRANKLIN AIR SHOW

IMAX FILMS

VISITOR INFORMATION

Admission Prices	Museum Hours	Membership Information
Travel Directions	Group Reservations	Tour du Jour
Exhibit Halls	Daily Demonstrations	Shopping and Dining

VISIT GUIDES

Basic Visit Guide	Visit Guide for Members	Visit Guide for Teachers
Visit Guide for Groups	Visit Guide for Travelers	Special Needs Visit Guide

QUICK LINKS

Field Trip Planner | Teacher Guides	Tuttleman IMAX Theater	Fels Planetarium	Events Calendar
Save $10 on Membership!	Online Sci-Store	SkyBike	Sales and Catering

PAID EDUCATIONAL PROGRAMS

Explorations Lecture Series	Camp-In	Homeschool Series

Traveling Science Shows	Discovery Camp	
Spring Break Camp	Birthday Parties	Weekend Workshops

NEWS

The Franklin Institute Press Box

Please note that Bioscience/The Heart is CLOSED for renovation through October, 2004.

ONLINE EXHIBIT

Submit your memories of the Heart!

Help The Franklin Institute Celebrate the 50th Anniversary of the Heart by submitting your own memory of the museum's famous organ. You can also read other remembrances.

THINGS TO DO	MAILING LIST
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Unisys at the World Business Forum. May 10-11, 2004, Radio City Music Hall, New York City
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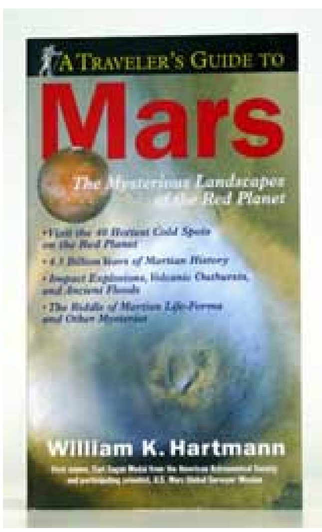

A Traveler's Guide to Mars
William K. Hartman

(From The Franklin Institute's popular guest author appearances, we offer this special personally autographed book. For a limited time, we are also offering free freight on all autographed books. Hurry, selection is limited. A $5.00 handling fee is applied to all autographed books.)

This extraordinary Baedeker is accessible, up-to-date, and extensively illustrated with photographs from Mariner 9, Pathfinder, the Hubble Space Telescope, and ongoing Mars Global surveyor spacecraft. William Hartman provides an awesome visual itinerary that includes: Olympus Mons, the largest volcano in the solar system, three times higher than Mount Everest; Tharisi Planitia, the "high plains" of Mars, rising 29,000 feet and wide enough to cover Europe; and Valles Marineris, an equatorial canyon so vast that America's Grand Canyon would appear a mere tributary.

SKU: 020557 (Paper)
Price: $18.95 +fee
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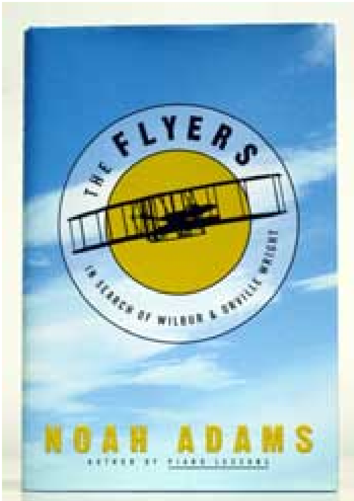
Order A Traveler's Guide to Mars!



The Flyers: In Search of Wilbur and Orville Wright
Noah Adams

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The Flyers brings an unprecedented spirit of immediacy to one of history's most dramatic stories. Noah Adams takes readers along as he travels the route of Wilbur Wright's first trip to North Carolina's then desolate Outer Banks. In Ohio, Adams explores Huffman Pairie, the Wright's flying field (and the country's first airport) at the edge of Dayton. In France, he finds the dirt horseracing track where the Wright Flyer circled high above and smashed world records. He visits the parade grounds of Fort Myer, Virginia, where Orville made test flights for the U.S. Army, and Governor's Island in New York Harbor, Wilbur's takeoff point for a daring 20-mile round trip up the Hudson River. Through scores of letters, diaries, oral accounts, and other material, Adams explores the talent and intensity of the Wright family, including the deeply complex and sometimes tragic bond between Orville and his younger sister Katherine.

SKU: 020633 (Hardbound)
Price: $22.00 +fee
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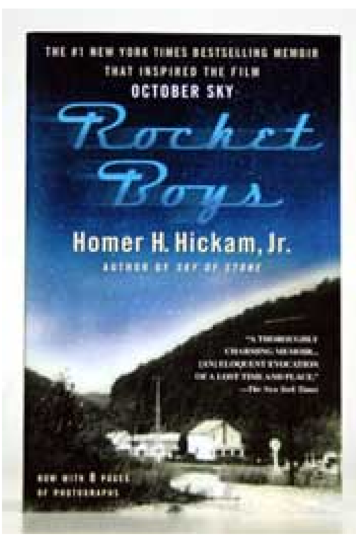
Order The Flyers: In Search of Wilbur and Orville Wright!



The Rocket Boys
Homer Hickam, Jr.

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The #1 New York Times best-selling memoir that inspired the film "October Sky," *Rocket Boys* is a uniquely American memoir—a powerful, luminous story of coming-of-age at the dawn of the 1960s, of a mother's love and a father's fears, of a group of young men who dreamed of launching rockets into outer space and made those dreams come true. With the grace of a natural storyteller, Hickam—an engineer for NASA—paints a warm, vivid portrait of the harsh West Virginia mining town of his youth, evoking a time of innocence and promise. Exquisitely written and marvelously entertaining.

SKU: 020950 (Paper)
Price: $13.95 +fee
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Order The Rocket Boys!

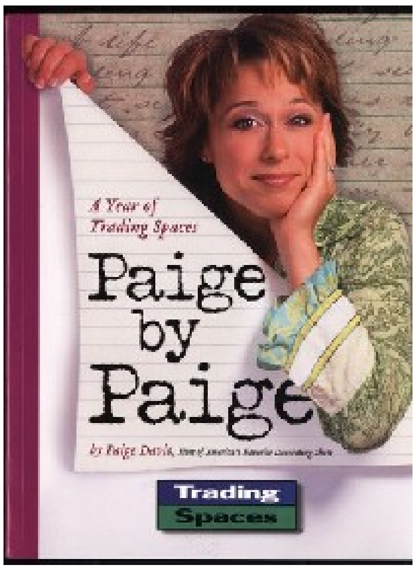
October Sky DVD
Homer Hickam, Jr.

(From The Franklin Institute's popular guest author appearances, we offer this special personally autographed DVD. For a limited time, we are also offering free freight on all autographed books. Hurry, selection is limited. A $5.00 handling fee is applied to all autographed books.)

From Universal Studios comes the DVD of their marvelous movie "October Sky," based on Homer Hickam's book *Rocket Boys.* A wonderful gift for aspiring young scientists or the whole family. Wide Screen Format. Autographed DVD by Homer Hickam Jr.

SKU: 021688 (DVD)
Price: $15.00 +fee
(Member Price: $13.50 +fee)

Order October Sky DVD!



Paige by Paige
Paige Davis

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Paige Davis, host of The Learning Channel's *Trading Spaces*, offers fans a peek into what happens when the camera isn't rolling, during the taping of the show's third season. Interactions on screen are even more interesting after readers learn what life is like on the road with the zany cast and crew. Includes photos taken by Paige. The Franklin Institute was home base to the crew last summer.

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Price: $19.95 +fee
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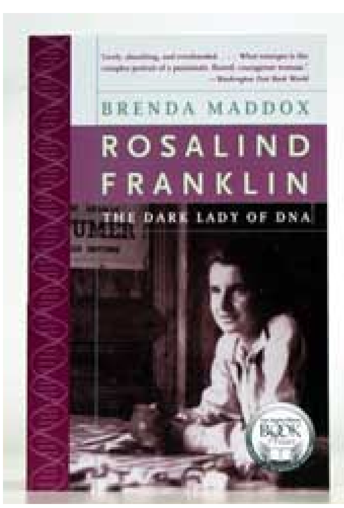
Order Paige by Paige!



Rosalind Franklin: The Dark Lady of DNA
Brenda Maddox

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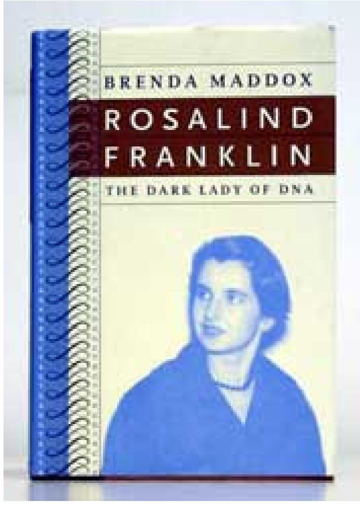
In 1962, Maurice Wilkins, Francis Crick, and James Watson received the Nobel Prize, but it was Rosalind Franklin's data and photographs of DNA that led to their discovery. Brenda Maddox tells a powerful story of a remarkably single-minded, forthright, and tempestuous young woman who, at the age of 15, decided she was going to be a scientist, but who was airbrushed out of the greatest scientific discovery of the 20th century.



SKU: 021353 (Hardbound)
Price: $29.95 +fee
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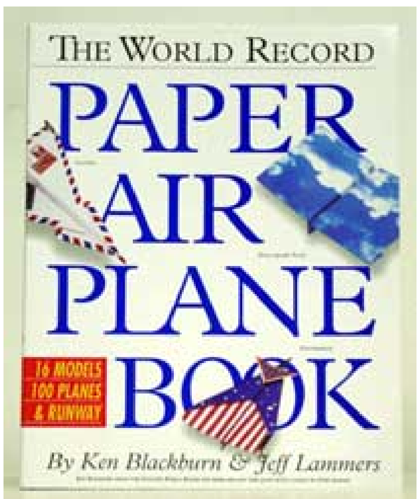
SKU: 021570 (Paper)
Price: $15.95 +fee
(Member Price: $14.36 +fee)

Order Dark Lady of DNA!



The World Record Paper Airplane Book
Ken Blackburn

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Combining the fun of making a piece of paper fly with the science of aeronautical engineering, here is an all-you-need (and then some) book for beginners and experienced flyers alike. Written with soaring enthusiasm by the world's record-holder for keeping a paper airplane aloft. Book contains 16 different designs, from the basic dart to a bi-plane, an autogyro, tear out runway, flight log. It's everything you need to top the 18.80-second record of Blackburn.

SKU: 014139 (Paper)
Price: $14.95 +fee
(Member Price: $13.46 +fee)

Order World Record Paper Airplane Book!

Aviation Legends Paper Airplane Book
Ken Blackburn

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Fly a piece of history. Presenting the greatest hits of powered aviation—here are easy to make, accurate, and air worthy replicas of 12 historically important planes.

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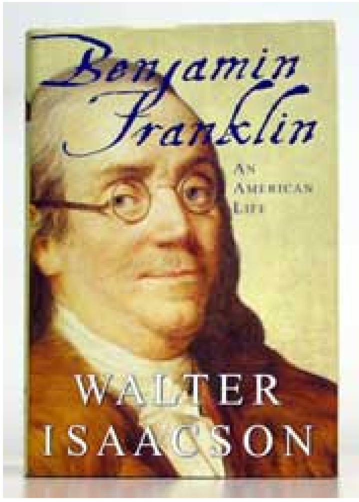
Price: $15.95 +fee
(Member Price: $14.36 +fee)

Order Aviation Legends Paper Airplane Book!

Benjamin Franklin, an American Life
Walter Isaacson



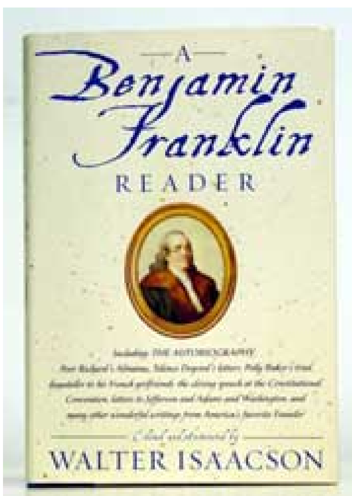
(Future Author Events **-** *Personalized autographed books may be ordered prior to the following event. Books ordered in advance will be shipped at no charge. All book orders must be received, by the Institute, at least* ***2 weeks in advance of the event date****. A $5.00 handling fee is applied to all autographed books.)*

Veteran newsman and author Walter Isaacson paints a colorful and intimate narrative, providing a full sweep of Franklin's amazing life, from his days as a runaway printer to his triumphs as a statesman, scientist, and Founding Father. He chronicles Franklin's tumultuous relationship with his illegitimate son and grandson, his practical marriage, and his flirtations with the ladies. He also shows how Franklin helped to create the American character and why he has a particular resonance in the 21st century.
Event: March 4, 2004

SKU: 020614 (Hardbound)
Price: $30.00 +fee
(Member Price: $27.00 +fee)

Order Benjamin Franklin, an American Life!

A Benjamin Franklin Reader
Walter Isaacson



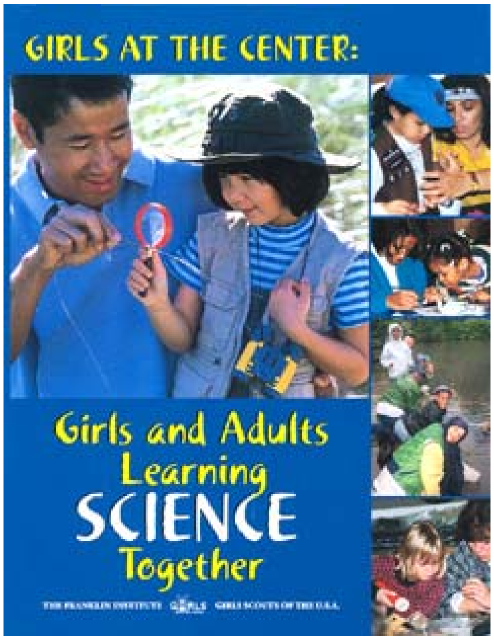
(Future Author Events - Personalized autographed books may be ordered prior to the following event. Books ordered in advance will be shipped at no charge. All book orders must be received, by the Institute, at least ***2 weeks in advance of the event date****. A $5.00 handling fee is applied to all autographed books.)*

From the author of the best seller *Benjamin Franklin, an American Life* comes this fine collection of Franklin's writings. Selected and annotated by Isaacson, this collection of Franklin's writings shows why he was the best selling author of his day and remains America's favorite founder of wit. **Event: March 4, 2004**

SKU: 021491 (Hardbound)
Price: $21.95 +fee
(Member Price: $19.76 +fee)

Order A Benjamin Franklin Reader!

Girls at the Center: Girls and Adults Learning Science Together
by Dale McCreedy and Tobi Zemsky
Girls at the Center: Girls and Adults Learning Science Together is a timely guidebook of tested programs and ready-to-use materials that invite girls and adult partners to become enthusiastic science learners. Girls at the Center is the result of a four-year collaboration of The Franklin Institute Science Museum and the Girl Scouts of the U.S.A. and was field-tested with multi-cultural audiences in



42 sites nationwide. This book will have particular value for youth leaders, parents, homeschoolers, parent-teacher organizations, museum educators, faith-based youth groups, and community-based organizations.

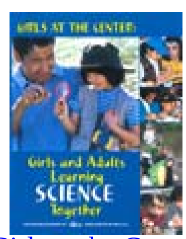
Special features of Girls at the Center:

- Activity resources in English and Spanish.
- Six basic science themes: structures, habitats, communication, energy, the science of sports, and water.
- Workshops presented in two formats: one for ages 5-10 and the other for ages 11-14.
- Ready-to-use at-home science activity packets.
- Science events for the whole family.

About the Authors:
Dale McCreedy is Director of Gender and Family Learning Programs at The Franklin Institute Science Museum in Philadelphia. With major funding from the National Science Foundation, she has directed national gender equity programs of the Institute, in collaboration with Girl Scouts of the U.S.A., since 1988. Ms. McCreedy is the 2002 winner of the Maria Mitchell Award for Women in Science.

Tobi Zemsky is a seasoned elementary school teacher, who has designed science learning programs for The Franklin Institute and the Wagner Free Institute of Science in Philadelphia.

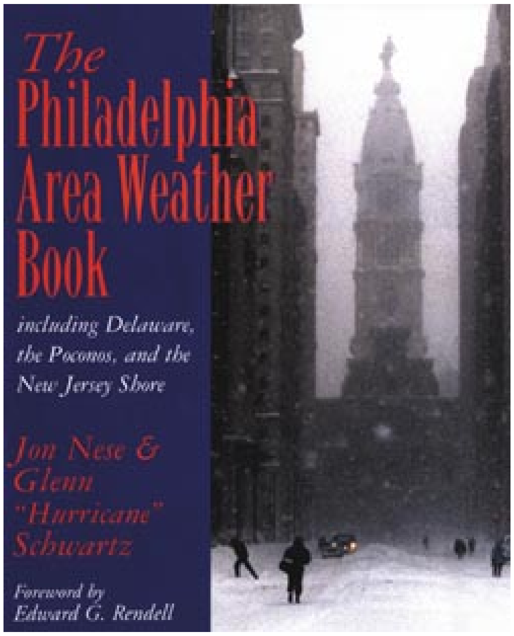
SKU: 019453
Price: $23.95
(Member Price: $21.56)



Order Girls at the Center Book!

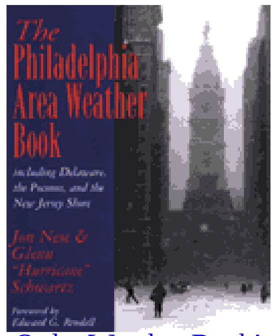
The Philadelphia Area Weather Book
Two respected meteorologists, Dr. Jon Nese and Glenn "Hurricane" Schwartz, Meteorologist at NBC-10 in Philadelphia, teamed up to write *The Philadelphia Area Weather Book*, a history of the region's weather and its importance in American weather history.

Nese and Schwartz offer a lively account of the weather forecaster's daily role and a series of fun facts, such as the hottest summer, the snowiest winter, and the strongest tornado. *The Philadelphia Area Weather Book* provides explanations of

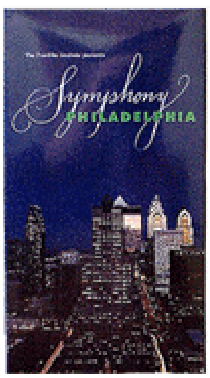


forecasting significant storms and statistics, and averages for every day of the year are presented to the reader. The book, focusing on weather from the Poconos and Philadelphia to southern New Jersey and the Shore to Delaware, contains 150 illustrations. *The Philadelphia Area Weather Book* is an invaluable reference source for weather enthusiasts and the interested general public.

SKU: 018758
Price: $27.65
(Member Price: $25.19)



Order Weather Book!



Symphony Philadelphia

Symphony Philadelphia will take you on a whirlwind tour of the City of Brotherly Love like you've never seen before. The sounds of the Philadelphia Orchestra accompany you on this eight-minute exploration of one of America's greatest cities.

This unique film is an introduction to the four story, domed Tuttleman IMAX® Theater experience. The journey begins with a warp-speed taxi ride through the streets of Philadelphia. Along the way, you'll witness the hustle and bustle of 30th Street Station, experience the artistic brilliance of Philadanco, and journey through time to the birth of our nation at Independence Hall and the Liberty Bell. The tour comes to a close in the Benjamin Franklin National Memorial at The Franklin Institute.

Preview a sample of "Symphony Philadelphia." (2.0M)

SKU: 069941
Price: $7.99
(Member Price: $5.99)

Order Symphony Philadelphia!

The Franklin Institute Presents:
Philadelphia Anthem
The Franklin Institute Science Museum presents ***Philadelphia Anthem***, A Celebration of A Great American City.
It's a peaceful morning on a quaint Center City street. But in an instant, you're soaring above the trees and flying over the City of Brotherly Love. For eight minutes, you'll experience the vibrancy and beauty of one of America's great cities in the award-winning ***Philadelphia Anthem***.

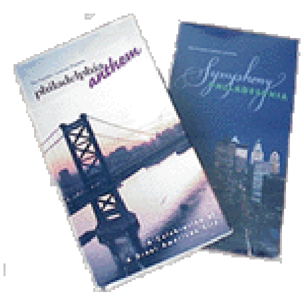
This signature film introduces the eye-popping IMAX experience on the four-story wraparound screen of the Tuttleman IMAX Theater. The film's breathtaking vistas and pulsating soundtrack have made it a classic, must-see "experience."

March with a Mummers String Band, rejoice with a gospel choir, and see an entire Philadelphia Flyers hockey game compressed into 10 seconds. From a row along Eakins' Schuylkill River, to a flight over the city's majestic gateway—the Benjamin Franklin Bridge—to the Amish countryside and the battlefields of Valley Forge, ***Anthem*** is a heart-warming—even heart-pounding—valentine to Philadelphia.

Preview a sample of "Philadelphia Anthem." (2.2M)

SKU: 069940
Price: $7.99
(Member Price: $5.99)

Order Philadelphia Anthem!



Video 2-Pack
Experience twice as much Philadelphia with this Video 2-Pack of ***Symphony Philadelphia*** and ***Philadelphia Anthem***.

Scroll up for detailed descriptions and samples of each video.

SKU: 069942
Price: $15.99
(Member Price: $11.99)

Order Video 2-Pack!

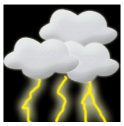
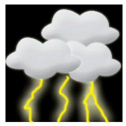
To purchase merchandise from the Museum Store, fill out this ORDER FORM.
Call 215.448.1134 with ordering or merchandise questions.
Let us know that you found these products on our website!

Back to Online Sci-Store

Weather @ The Franklin Institute

Historical Data | The Philadelphia Area Weather Book

Quick Outlook

Mon. Evening	Tue.	Tue. Evening	Wed.	Thu.	Fri.	Sat.
						
LOW: 67°F	HIGH: 88°F	LOW: 63°F	HIGH: 82°F	HIGH: 86°F	HIGH: 87°F	HIGH: 81°F

Full Forecast

The Franklin Institute Forecast
As of 3:30 PM, Monday, May 10, 2004

TONIGHT:
An evening shower or thunderstorm possible, then partly cloudy with patchy fog, Low 67.

TOMORROW:
Partly cloudy & very warm with the chance for an afternoon shower or thunderstorm, High 88.

TOMORROW NIGHT:
A few evening showers or thunderstorms, otherwise partly cloudy, Low 63.

WEDNESDAY:
Sunny mixing with a few clouds, High 82.

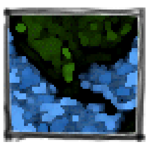
THURSDAY:
Partly sunny with a chance of afternoon storms, High 86.

FRIDAY:
Mostly sunny, warm & a bit humid, High 87.

SATURDAY:
Partly sunny with the chance of afternoon showers and thunderstorms, High 81.

Hot Air over Hot Water

In the 1500s, fishermen who lived in South America began to wonder about a current of unusually warm water that came to their shore every few years near Christmastime. Since the fishermen believed in the birth of the Christ child at Christmas, and since they spoke Spanish, they named the hot water El Niño, which means "the infant" in Spanish.



Where do scientists look for El Niño? The hot water usually comes first to the coasts of Peru and Ecuador in South America.

But if we've known about El Niño for four hundred years, why is everyone talking so much about the hot water this year?

The 1997-1998 El Niño may or may not be stronger than ever before. Scientists are still deciding. One thing that is definitely different about this El Niño is the technology that scientists are using to study it.

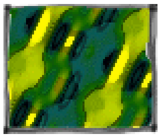
Scientists and governments from around the world—United States, France, Japan, Korea and Taiwan—are sharing knowledge and funding for The **Tropical Atmosphere Ocean (TAO) Array**.

But why all the fuss anyway about some hot water in the tropical Pacific Ocean? Well, it's not just the hot water. It's also the hot air.

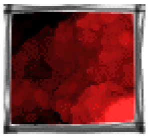
Try this: take two cups that are the same. They can be ceramic, plastic, styrofoam, whatever, as long as they're the same. Fill one with cool water. Fill the other with hot water. (Not boiling, just good and hot.) Place them on a table. Hold each of your hands over one cup and feel the difference in the air above the water. (Don't actually touch the water. Just feel the air.) The hot water warms the air above it. The cool water doesn't.

Now, imagine you fill your bathtub with hot water. Think about how warm and steamy the air in the bathroom gets. Now, imagine millions and millions of bathtubs-ful of hot water. All of that moist, hot air has to go somewhere. Scientists know that hot air rises and carries the moisture with it. Once the moisture gets into the air and starts to cool, rainclouds start to form.

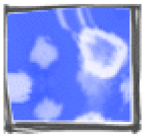
Now try this: hold a small mirror over the cup of hot water for a few minutes. The moisture in the air should collect on the mirror, and, as it cools, form tiny droplets. Imagine the bathroom mirror after you fill the bathtub with hot water. The "water" on the mirror is caused by the water vapor in the air gathering and cooling. Now imagine the air over the hot water of the tropical Pacific Ocean. Huge rainclouds start to form and flooding results in South American countries along the coast.



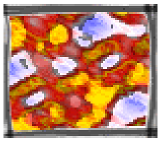
It's not quite that simple, but the **science of El Niño** does start with those basic ideas about hot air over hot water.



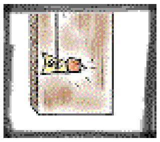
Today's news about **hot air** over hot water is available online. Keep track of the latest news reports. **Send your own local news reports about the effects of El Niño where you live**.



Today's hot air over **hot water** is available online. Keep track of the latest science reports.



More **general background information** about El Niño is available.



Make Your Own Weather Station

Meteorologists study the weather by recording and analyzing data. You can become an amateur meteorologist by building your own weather station and keeping a record of your measurements. After a while, you'll notice the weather patterns that allow meteorologists to forecast the weather.

Since weather happens outside, you'll need to construct your weather station inside of a **weatherproof box**. Find a sturdy plastic or wooden box that can be placed on its side. Before you take the box outside, attach a **thermometer** to the bottom of the box. Once you turn the box on its side, the thermometer will be in the back of the box, protected from direct weather conditions.

Take your box outside and find a safe, sturdy location on the north side of the building where it's shadiest. Position the box securely beside the building, perhaps on a brick foundation.

Keep Your Own Weather Journal

Every meteorologist needs to keep a good weather journal. Remember, good observations make good forecasts.

Make Your Own Barometer

Since barometers are very sensitive to minor changes in weather conditions, you'll want to keep the barometer indoors to get more accurate readings.

Make Your Own Hygrometer

Place your hygrometer outdoors, inside your weatherproof weather station box. The hygrometer will measure the amount of moisture in the air, or humidity.

Make Your Own Rain Gauge

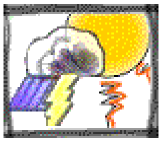
Your rain gauge needs to be kept outdoors, but not inside the weatherproof box. If it's possible, though, you may want to keep them near each other to make it easier to record your data.

Make Your Own Weather Vane

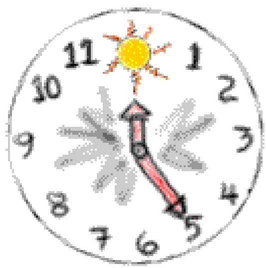
A weather vane is also know as a wind direction indicator. The vane points in the direction from which the wind blows.

Make Your Own Compass

To record your weather data, you'll need a compass. You can make your own using only a stick, a few stones, and the sun.



Weather Right Now



How's the weather **right now**? Several sources of weather information offer forecasts and weather reports for most of the globe. Using these resources, you can practice your forecasting skills.

First, begin by checking The Franklin Institute's Five Day Forecast for Philadelphia.

- The Franklin Institute Forecast

These websites offer current weather information for regions around the world. These are the best source for weather information "right now."

- Unisys Weather
- Philadelphia Area Weather Connections
- WeatherPost
- CNN Weather
- WeatherNet
- USA Today Weather
- Earth Watch: Weather on Demand
- Live Weather Images
- Weather Information for 1,295 US Cities

Use these weather images to practice making your own forecasts.

- CNN Weather Maps
- WeatherNet Weather Maps
- Washington Post Weather Images
- Real Time Weather Data

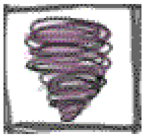
When the weather gets tough, these websites really get going. Weather warnings and advisories are posted here for all regions.

- Current National Weather Warning Areas
- FEMA Tropical Storm Watch
- Hurricane '01

- Huracan.Net
- National Hurricane Center
- Interactive Weather Information Network

Fly through a weathermap or look through a WeatherCam to see real weather, right now.

- WeatherNet WeatherCams
- WeatherFlight

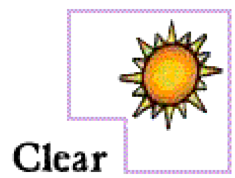


Eventual Weather

Basically, meteorologists use technology to look for these kinds of weather. There are, of course, some variations, but if you can use RADAR, satellite images, and lightning detectors to recognize these weather phenomena, you should succeed as a forecaster.

Use satellite images and RADAR reflectivity and velocity images to watch for **hurricanes**. If you see a spiral formation, a calm area at the center of the spiral, and a band of severe thunderstorms, expect a hurricane.

When RADAR shows no precipitation and satellite images show no clouds, don't worry. You can forecast a **clear day**, everyone's favorite forecast.

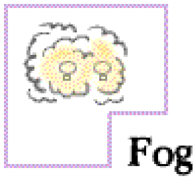


RADAR reflectivity images are ideal for tracking **showers**. You'll see the location and use the color codes to read the intensity of the precipitation.

Your biggest challenge will be to forecast where a **tornado** may form. RADAR velocity images can help pinpoint which thunderstorms are most likely to spawn a tornado. The destruction is the best evidence.

Like liquid precipitation, use RADAR reflectivity images to identify the location and intensity of **snow showers**. Keep an eye on the temperature, too.

Rain reflects RADAR quite nicely, making **rain** just about the easiest kind of precipitation to track. RADAR reflectivity images pinpoint the location of rain quite well.

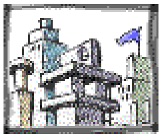


Follow the **fog** recipe for predicting the appearance of ground-based clouds. Conditions need to be right: the air temperature must fall to the dewpoint and the ground must be moist.

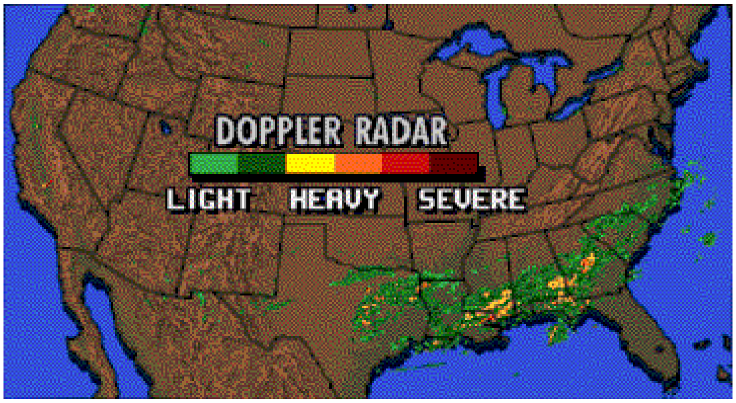
RADAR reflectivity and velocity images track the location and severity of **thunderstorms** which form when there are substantial air temperature differences between layers of the atmosphere.

Recognize a **cold front** by the line of clouds and precipitation that often accompany it. RADAR and satellite images can show the location and intensity of a cold front.

On RADAR images, **severe thunderstorms** can resemble common thunderstorms. Pay close attention to the color key which will show the severity of the storm.



RADAR - o l o g y

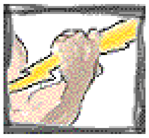


Meteorology today relies on RADAR as an important tool for analyzing and forecasting weather events. Since the development of RADAR systems, weather has become less mysterious. Oral and early written history tell of legends associated with weather. Angry gods were to blame for sudden violent weather events. Today, RADAR allows us to foresee violent weather. Imagine how powerful a RADAR-equipped meteorologist would have been in ancient times. Early meteorologists were thought to be magicians, at least when their forecast came true.

To understand just how useful RADAR is for meteorologists, explore **RADAR History**, **RADAR Science**, and **RADAR Detection**.

More about RADAR (929k)

BACK



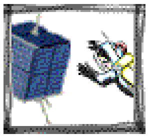
Bright Light Fright

LIGHTNING

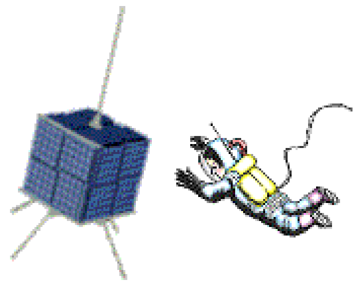
One of the most powerful forces in nature, lightning was once magical, mysterious, and misunderstood. Historically, myth and legend accounted for lightning with stories of angry gods and heroes. Today, meteorologists uses lightning as a tool for analyzing and forecasting the intensity and movement of thunderstorms. While lightning is still a little mysterious, meteorologists now understand it and know how to prepare for it. Of course, every once in a while lightning does still put on a magic show.

To understand a little of lightning's magic, take a look at **Lightning History**, **Lightning Science**, and **Lightning Detection**.

BACK



Like The Moon



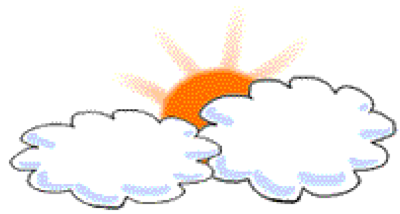
It was on October 4, 1957, that the first man-made object ever achieved orbit around Earth in outer space. The Russian satellite Sputnik was designed to measure and transmit information about the density of the upper atmosphere as it circled the Earth. Before then, all atmospheric information that meteorologists had was based on "looking up" instead of "looking down." Since Sputnik, the science of satellites has advanced significantly. Specialized satellites now orbit the Earth for telecommunications, global broadcasting, oceanic observations, scientific research, and military purposes, as well as for atmospheric observation. It's amazing to consider the rapid progress and evolution of satellite technology.

Meteorological satellites themselves have changed considerably since Sputnik. Weather observation and forecasting has become much more reliable today, thanks to the sophisticated satellites currently orbiting Earth. Find out more about them by exploring **Satellite History**, **Satellite Science**, and **Satellite Images**.

MORE
About Sputnik

BACK

Weather Activities



Making snowballs and catching raindrops aren't the only way to get your hands on the weather. Try some of these activity plans for doing hands-on weather science investigations.

All of these online activities offer interesting ideas for learning more about weather science.

- Try Your Own Weather Forecasting
- Classroom Activities
- WebQuest-Weather Watchers
- Build a Classroom Tornado
- Build a Tornado Exhibit
- Build a Lightning Exhibit
- Severe Weather Information Kit
- Students & Teachers Exchanging Data, Information & Ideas
- K-12 Activities and Projects in Weather and Climate

Try these online activities, too.

- Weather Folklore
- Severe Weather - Hurricanes
- Musical Meteorology

BACK

Career Connections

If you've enjoyed "Franklin's Forecast," perhaps you have what it takes to pursue a career in meteorology. These websites offer some tips and answer some questions.

- Careers in Meteorology
- Ask Jack
- Meteorology and Your Career

BACK

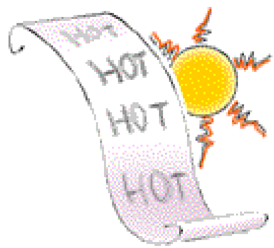
Enjoy The Franklin Institute Online

SEARCH GO

Made possible by UNISYS

webteam@www.fi.edu

Weather Resources



These background information resources can enhance your exploration of weather science and help you become an amateur meteorologist.

- Weather or Not?
- Hurricane and Natural Disaster Brochures
- The Weather Calculator
- Weather Glossary
- US Interactive Climate Pages
- The Cloud Boutique
- Online Meteorology Guide
- Weather Instructional Materials
- Weather Wizards
- The Weather Ahead from The Old Farmer's Almanac
- Mt. Washington, NH: Wildest Weather in The US
- How The Weather Works
- World Weather Watch
- Weather Here and There
- NOAA Online Photo Collection

Severe weather must be taken seriously. These websites can help.

- Storm Prediction Center
- Everything You Want To Know About Tornadoes
- Guide to Hurricane Information
- Guide to Tornado Information
- Guide to Thunderstorm Information
- NOAA Severe Storms Spotters Guide
- Turn, Turn, Turn: Scientists Unravel the Twisted Ways of Tornadoes
- NOAA Hurricane and Tornado Brochure

- Hail
- Wind
- Tornadoes
- Lightning

Meteorologists study El Niño and La Niña to help them understand weather trends.

- Hot Air over Hot Water
- La Niña
- El Niño
- The Year of El Niño
- El Niño and The Southern Oscillation
- El Niño: Special Report
- El Niño - Resources from NOAA
- El Niño Information
- El Niño Resources
- Children of the Tropics: El Niño and La Niña
- El Niño Educational Module
- NOAA La Niña Information

Can we learn from the past? Can historical weather patterns help us prepare for the future?

- Past Hurricanes & Other Tropical Cyclone Information
- The Great Hurricane of 1938
- Hurricane History Timeline
- Historical Weather Database

Curriculum Connections

For science educators, these connections to the National Science Education Standards should help plan for using "Franklin's Forecast" in the classroom.

"Franklin's Forecast" aligns quite nicely with two of the NSES Sample Classroom Scenarios. In particular, Make your own Weather Station perfectly meets many of the goals of the scenarios.

- Weather
- Weather Instruments

For **grades 1 through 4**, there are several instances where "Franklin's Forecast" can support NSES goals.

- Science as Inquiry - Content Standard A
- Earth and Space Science - Content Standard D
- Science and Technology - Content Standard E

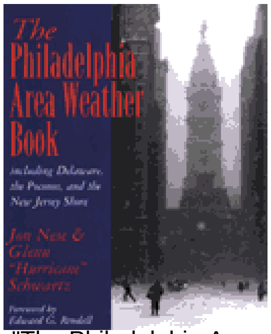
In **grades 5 through 8**, many of the same weather-related themes continue.

- Science as Inquiry - Content Standard A
- Earth and Space Science - Content Standard D
- Science and Technology - Content Standard E

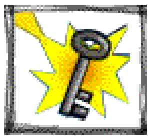
Even in **grades 9 through 12**, some aspects of the NSES guidelines can be addressed using "Franklin's Forecast."

- Science as Inquiry - Content Standard A
- Science in Personal and Social Perspectives - Content Standard F

BACK



"The Philadelphia Area Weather Book" is available in the Sci-Store!



Philadelphia Weather Data

What was the weather like in Philadelphia? These tables of historical weather data offer a look back in weathertime.

The weather data on this page were recorded at The Franklin Institute, which has been an observing site for the National Weather Service since 1993. **We also have available the official weather data for Philadelphia, which goes all the way back to 1872.**

All temperatures are recorded in degrees Fahrenheit. "Max" equals the high temperature, while "min" equals the low temperature. "Liquid" refers to rain plus melted snow and is measured in inches. "Snow" and "depth" refer to snowfall and measured snow depth in inches. "T" stands for "trace," which means that precipitation did occur but was too little to be measured. To a meteorologist, "trace" means less than one-hundreth of an inch for liquid precipitation, and less than one-tenth of an inch for snow.

2004

[January | February | March | April]

2003

[January | February | March | April | May | June | July]
[August | September | October | November | December]

2002

[January | February | March | April | May | June | July]
[August | September | October | November | December]

2001

[January | February | March | April | May | June | July]
[August | September | October | November | December]

2000

[January | February | March | April | May | June | July]
[August | September | October | November | December]

1999

[January | February | March | April | May | June | July]
[August | September | October | November | December]

1998

[January | February | March | April | May | June | July]
[August | September | October | November | December]

1997

[January | February | March | April | May | June | July]
[August | September | October | November | December]

1996

[January | February | March | April | May | June | July]
[August | September | October | November | December]

1995

[January | February | March | April | May | June | July]
[August | September | October | November | December]

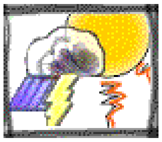
1994

[January | February | March | April | May | June | July]
[August | September | October | November | December]

1993

[August | September | October | November | December]

For more Philadelphia area weather data, try the National Weather Service in Mount Holly, New Jersey, the Pennsylvania State Climatologist, the New Jersey State Climatologist, or the Delaware State Climatologist.



Philadelphia Area Weather Connections

[Current Observations | Satellite/Radar | Forecasts | Historical data | Other Stuff]

Current Observations

- Most recent observations
- Last 24 hours of observations at: Allentown, Atlantic City, Dover, Newark, Wilmington, Lancaster, Harrisburg, Willow Grove, Philadelphia, Northeast Philadelphia, Reading, Trenton
- Severe Weather Information: Special weather statements, Watches and Warnings, Latest watch boxes, Text data
- Pennsylvania weather summary from National Weather Service
- Tri-state maps: Temperature, dew point, wind, visibility, weather
- Regional maps: Pressure, Temperature, Winds, Dew point
- Pollution/pollen counts: Philadelphia Pollen, Camden Air Quality
- Other Philadelphia area weather sites: National Weather Service, Stormfax

Satellite Imagery

- Latest Visible: Tri-state, Northeast, USA, USA (with loop & zoom), North America
- Latest Infrared: USA, USA (with loop & zoom), North America, Colorized North America
- Latest Water Vapor: Northeast, USA, USA (with loop & zoom)
- Other Loops: Tri-state close-up (visible), USA (infrared), Atlantic Ocean (infrared), Pacific Ocean (infrared),

Radar Imagery

- Local Radars : Philadelphia, Dover, New York City, Binghamton, State College, Pittsburgh, Washington, DC, Others
- Regional Radars: New England (loop), Mid Atlantic (loop)
- National Radar Composite: USA (loop)

Forecasts

- The Franklin Institute 5-day forecast for the local area
- National Weather Service forecasts : NWS Zone Forecasts, Eastern PA/NJ/DE/MD, PA/NJ/DE/NY/MD
- Offshore Marine Forecasts : NJ and DE, East coast tides

- Forecast maps (USA) :
  Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday
- Forecast highs/lows (USA):
  Today: Highs, Lows; Tomorrow: Highs, Lows; 2 Day: Highs, Lows; 3 Day: Highs, Lows; 4 Day: Highs, Lows; 5 Day: Highs, Lows; 6 Day: Highs, Lows;
- Computer-generated forecasts for: Allentown, Atlantic City, Dover, Wilmington, Philadelphia, How to Decode these forecasts
- Long-range temperature and precipitation forecasts for Allentown, Atlantic City, Wilmington, Philadelphia
- Other forecasts: PA/NJ Agricultural, Ultraviolet Index

Historical Weather & Climate Data

- Sun/Moon rise/set information for Philadelphia
- Daily Climatological Summary for Allentown, Atlantic City, Philadelphia, Wilmington
- Temperature, dewpoint, pressure graphs for Philadelphia for the last: 48 hours, 10 days, 1 month, 2 months
- Hourly observations for Philadelphia over the last 2 months or so
- Daily high/low/precipitation data for many Pennsylvania cities
- Summary of previous month's climate at Allentown, Philadelphia
- Daily weather data from The Franklin Institute since 1993
- Daily weather data from Philadelphia Int'l Airport since 1997
- Philadelphia area weather data from 1872 to 2001

Other Stuff

- Current month's Celestial Almanac, Generalized Sun/Moon Rise/set Information
- Additional National Weather Service Information for Pennsylvania, New Jersey, Delaware
- Water temperatures (maps): Global; (text): East coast ; Buoys: Delaware Bay, VA Beach
- Pennsylvania County map or Color topographic map
- Explanation of Meteorology acronyms, Severe weather terms

NBC-10's Earthwatch® Weather Workshops at The Franklin Institute

The Franklin Institute, in partnership with **NBC-10**, presents the **NBC-10 Earthwatch® Weather Workshop** program. Franklin Institute meteorologists and the **NBC-10 Earthwatch®** meteorological team collaborate and co-present these workshops.

Students love learning about the science of storms in these lively presentations. Shows relate to the prevalent weather topics of the season, with meteorologists using the latest technologies to probe hurricanes in the fall, winter storms in the winter, and tornadoes and thunderstorms in the spring.

NBC-10's Earthwatch® Weather Workshops are held in Musser Theater. Each show lasts about 30-40 minutes.

The 2002-2003 school year program runs from October 1, 2002 through June 12, 2003.

Grades 1-3: Tuesday at 11AM, Wednesday at 10AM
Grades 4-7: Tuesday and Thursday at noon, Wednesday at 11AM

During the school year, School Group Presentations are available **by reservation only**.

Informational brochures are distributed during the workshops. To make a reservation, call 215.448.1201. For more information, call 215.448.1246. Cost is $45 per group of 30 or less (each additional student is $1.50). Chaperones are free.

Watch **NBC-10** on the evenings of these **NBC-10 Earthwatch® Weather Workshops** for video footage recorded at The Franklin Institute. **NBC-10** also airs Weather Windows which are drawings made by young visitors to show weather and its changing forces.

The Franklin Institute is pleased to recognize **NBC-10's** participation in programming for the **NBC-10 Earthwatch® Weather Workshops** as well as their media sponsorship of the Museum's Weather Center.

"The Philadelphia Area Weather Book" is available in the Sci-Store!

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Philadelphia PA 19103
215 448 1200

webteam@www.fi.edu

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Drought Information | Saving Water Indoors | Saving Water Outdoors

Drought Information

- New Jersey drought information
- Pennsylvania drought information
- Delaware drought information
- Maryland drought information
- NOAA's Drought Information Center
- United States Drought Monitor
- Monitor streamflows nationwide
- Drought index: Palmer Drought Severity Index

Saving Water Indoors

- Never put water down the drain when there may be another use for it such as watering a plant or garden, or cleaning.
- Check that your home is leak-free. Read your water meter before and after a two-hour period during which you are certain that no water is being used. If the meter does not read exactly the same, there is a leak.
- Repair dripping faucets by replacing washers. If your faucet is dripping at the rate of one drop per second, you can waste 2,700 gallons per year.
- Check for toilet tank leaks by adding food coloring to the tank. If the toilet is leaking, color will appear in the bowl within 30 minutes (flush as soon as test is done, since food coloring may stain tank). If the handle frequently sticks in the flush position, letting water run constantly, replace or adjust it. And avoid flushing the toilet unnecessarily. Dispose of tissues, insects and other such waste in the trash rather than the toilet.
- Take shorter showers. Replace your showerhead with a low-flow version.
- Use the minimum amount of water needed for a bath by closing the drain first and filling the tub only one-third full. Stopper the tub before turning the water on. The initial burst of cold water can be warmed by adding hot water later.
- Don't let water run while shaving or washing your face. Brush your teeth while waiting for water to get hot; then wash or shave after filling the basin.
- Retrofit all wasteful household faucets by installing aerators with flow restrictors.
- Operate dishwashers and clothes washers only when they are fully loaded, or properly set the water level for the size of load you are using.
- When washing dishes by hand, fill one sink or basin with soapy water. Quickly rinse under a slow-moving stream from the faucet.
- Store drinking water in the refrigerator rather than letting the tap run every time you want a cool glass of water.
- Do not use running water to thaw meat or other frozen foods. Defrost food overnight in the refrigerator or by using the defrost setting on your microwave.
- Kitchen sink disposals require lots of water to operate properly. Start a compost pile as an

alternate method of disposing food waste instead of using a garbage disposal.

- Insulate your water pipes. You'll get hot water faster plus avoid wasting water while it heats up.
- Never install a water-to-air heat pump or air-conditioning system. Air-to-air models are just as efficient and do not waste water.
- Install water-softening systems only when necessary. Save water and salt by running the minimum amount of regenerations necessary to maintain water softness. Turn softeners off while on vacation.
- Check your pump. If you have a well at your home, listen to see if the pump kicks on and off while the water is not in use. If it does, you have a leak.
- When adjusting water temperatures, instead of turning water flow up, try turning it down. If the water is too hot or cold, turn the offender down rather than increasing water flow to balance the temperatures.

Saving Water Outdoors

- Don't overwater your lawn. As a general rule, lawns only need watering every 5 to 7 days in summer and every 10 to 14 days in winter. A hearty rain eliminates the need for watering for as long as two weeks. And water lawns during the early morning hours when temperatures and wind speed are the lowest. This reduces losses from evaporation.
- Don't water your street, driveway, or sidewalk. Position your sprinklers so that your water lands on the lawn and shrubs...not the paved areas.
- Install sprinklers that are the most water-efficient for each use. Micro and drip irrigation and soaker hoses are examples of water-efficient methods of irrigation.
- Regularly check sprinkler systems and timing devices to be sure they are operating properly. It is now the law that "anyone who purchases and installs an automatic lawn sprinkler system must install a rain sensor device or switch which will override the irrigation cycle of the sprinkler system when adequate rainfall has occurred." To retrofit your existing system, contact an irrigation professional for more information.
- Raise the lawn mower blade to at least three inches. A lawn cut higher encourages grass roots to grow deeper, shades the root system and holds soil moisture better than a closely clipped lawn.
- Avoid overfertilizing your lawn. The application of fertilizers increases the need for water. Apply fertilizers that contain slow-release, water-insoluble forms of nitrogen.
- Mulch to retain moisture in the soil. Mulching also helps to control weeds that compete with plants for water.
- Plant native and/or drought-tolerant grasses, ground covers, shrubs and trees. Once established, they do not need to be watered as frequently and they usually will survive a dry period without any watering. Group plants together based on similar water needs.
- Do not hose down your driveway or sidewalk. Use a broom to clean leaves and other debris from these areas. Using a hose to clean a driveway can waste hundreds of gallons of water.
- Outfit your hose with a shut-off nozzle that can be adjusted down to fine spray so that water flows only as needed. When finished, turn it off at the faucet instead of at the nozzle to avoid leaks.
- Use hose washers between spigots and water hoses to eliminate leaks.
- Do not leave sprinklers or hoses unattended. Your garden hoses can pour out 600 gallons or more in only a few hours, so don't leave the sprinkler running all day. Use a kitchen timer to remind yourself to turn it off.
- Check all hoses, connectors and spigots regularly.
- Consider using a commercial car wash that recycles water. If you wash your own car, park on the grass to do so.
- Avoid the installation of ornamental water features (such as fountains) unless the water is recycled.
- If you have a swimming pool, consider a new water-saving pool filter. A single backflushing

with a traditional filter uses from 180 to 250 gallons or more of water.

Sources: South Florida Water Management District and Water - Use it Wisely

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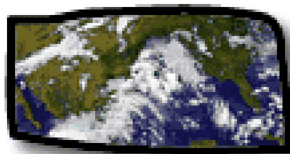
5 Day Weather Forecast

To Franklin's Forecast

SCIENCE LEARNING NETWORK

www.sln.org

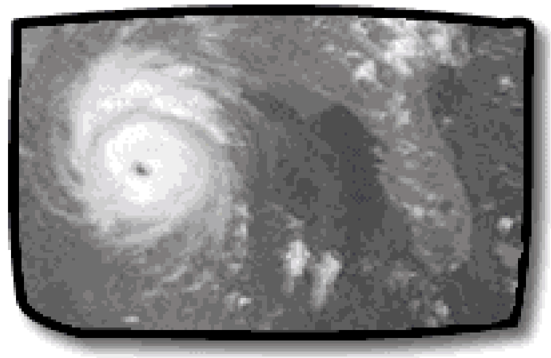


Check out news and links

FLASH! Browse this month's "Ten Cool Sites."

Visit our museums

EXPLORE! Visit our international network of museums for the best inquiry resources on the web.



Explore our resources

INQUIRY! See the winner of "The Unisys Prize" for 2003.

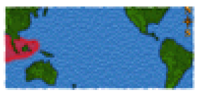
Find out about our network

Funding Provided by Unisys and The National Science Foundation

El Niño

El Niño's Coasts

For hundreds of years, scientists have known where to look for the unusually warm water that signals the arrival of El Niño. The western coast of South America, particularly the coasts of Peru and Equador, are El Niño's favorite beaches. Every few years, warmer than usual water splashes onto the beaches, bringing with it the hot air that feeds rainstorms.



This animation of El Niño (408k) illustrates the movement of the warm water after the trade winds weaken.

When El Niño is not visiting, the warm surface water along the coast of South America is normally blown away, westward toward Asia, by the trade winds. It's a long way to go, but the warm water arrives and gathers near Indonesia, actually causing the Pacific Ocean to be deeper there. Every few years, however, the trade winds stop blowing strongly, allowing the excess warm water near Indonesia to drift back toward South America, evening out the Ocean's depth.

Why do the trade winds stop blowing strongly? Scientists are not sure. The latest scientific instruments that are recording the 1997-1998 El Niño data may suggest some answers.

The extra warm water near South America creates extra warm air, causing extra rain. Meanwhile, on the Indonesian side, the decrease in warm water means a decrease in warm air, which means less rain. Serious drought conditions often result in that region of the world.

So scientists know where to look for the hot water, but we're still not entirely sure where to look for the effects of El Niño. Flooding in Peru and Ecuador is surely the result of El Niño. Drought in Indonesia is another result. But how about mild winters in Canada? Or excess rain in California? As scientists learn more about El Niño, it looks more as if El Niño's effects are everywhere.

The following resources offer excellent explorations of the global impact of El Niño.

El Niño: Online Meteorology Guide

> This module from the University of Illinois offers a thorough explanation of the location of El Niño.

The Wrath of El Niño

> From PBS...an exploration of the global consequences of El Niño.

El Niño and California Precipitation

Preparation for El Niño

> These two resources relate specifically to the effects of El Niño in California.

BACK

El Niño

The TAO Array

In December of 1994, the Tropical Atmosphere Ocean (TAO) Array was completed. The TAO Array is a series of about seventy buoys carefully placed in the tropical Pacific Ocean. Each buoy has special equipment that records information about the water and the air above the water. All of the buoys work together, forming an array, to give scientists a big picture of climate conditions in the area. The buoys send their data to scientists everyday by way of weather satellites that orbit Earth. Since 1994, scientists have been able to watch the water and the air for signs of El Niño. Once they notice that the water is getting warmer, they can keep track of the other changes and help to make predictions about the effects of El Niño better than they ever have before.

It took many years of research and work to build the TAO Array, and each buoy in the Array only works for about a year. Of course, that's pretty good for a computer that gets left outside in the heat and rain! So scientists have to service the buoys constantly, cruising around the ocean from one buoy to another. But, so far, all of the work has definitely been worth it. We know more about the 1997 El Niño than any before. Plus, when the tropical water cools, and El Niño ends, scientists can study the ocean and the atmosphere and learn other things too. The TAO Array is not just for studying El Niño.

The TAO Array took over ten years to complete with countries around the world working together. The United States, France, Japan, Korea, and Taiwan have all contributed to the Array. Why? Because El Niño effects weather worldwide. For some, El Niño brings heavy rain and flooding. For others, extremely dry weather means not enough food and people starving.

The more scientists can learn about El Niño, the better prepared all human beings can be.

These resources offer the best information about the TAO Array and the technology that scientists use to monitor El Niño.

Tour of the TAO Project

> From NOAA's Pacific Marine Environmental Laboratory, the tour is a friendly introduction.

The Tropical Atmosphere Ocean Array

> This is the complete collection of information about the TAO Array.

BACK

El Niño

Hot Science

When a pool of water gets hot, the surface begins to evaporate quickly, adding moisture and heat to the air above it. The hot air rises, and carries the moisture with it. This process is known as convection. Once the moist, hot air rises and begins to cool, the process of precipitation begins. This cycle is perfectly normal and happens over warm ocean water all of the time.

So why is El Niño a problem? The difference is the location of the hot water. Normally, the hot water gathers in the western tropical Pacific Ocean where the ecosystem has adapted to the heavy rains that result. During El Niño, the hot water gathers in the eastern tropical Pacific Ocean where the climate, geography, and people are not prepared for the unusual weather events.

As scientists learn more about El Niño, people around the world can better prepare for the unusual weather events. While it is unlikely that El Niño will ever be harmless, in future years the hot air over hot water may become less dangerous.

Scientists who study El Niño need to understand many different areas of science including oceanography, climatology, and meteorology. These excellent resources explore some of the science, although none of them are easy for young kids to read alone. They are fairly simple for adults and older kids to understand, however.

El Niño Rules

> From "The Why Files," this resource explains the basic science of El Niño as well as the history and effects.

The Child Returns

> This module explains the situation, the spheres, remote sensing, and what El Niño is.

Children of the Tropics: El Niño and La Niña

> Written by scientists, this basic overview of the science of El Niño is relatively easy to understand.

El Niño and the Southern Oscillation: A Reversal of Fortune

> A thorough exploration of the science of El Niño, written for a general audience.

Oceans and Climate

Ocean Currents

> Explore how ocean currents impact climate.

Ocean Currents: We All Go with the Flow

> Currents influence climate and living conditions for plants and animals, even on land.

Ocean Currents: Floating Shoes

> Sixty thousand Nike shoes spilled from a storm-tossed cargo ship. Their journey to land is a fascinating adventure, retraced here.

Tracking Ocean Currents: Tritium and Turbidity

> Learn how scientists track ocean currents.

Activity: Find the Gulf Stream

Use global ocean drifter buoy data to chart the Gulf Stream.

BACK

El Niño

Today's Hot Air

Thanks to El Niño, science is the top story in many daily news reports, and the online news services are no exception. These websites offer the latest news about El Niño as well as archives of older news stories.

- Yahoo
- Current News
- USA Today
- Environmental News Network Special Report
- Newspaper & Magazine Articles Online
- Scientific Articles

Contribute to the collection of "El Niño News."

You can help keep track of all of the hot air over hot water. Pay attention to your local news reports, and read your local newspapers every day. If you see any local effects of El Niño, record them here. They'll be added to the collection at the bottom of this page.

BACK

Warmer than Average Temperatures , By Karen , Philadelphia, Pennsylvania, USA

Washing a Car On January 4th? , By Linda , Easton, Pa.

Early '98 expected to be wet. El Nino phenomenon to bring cooler weather. , By 7th Grade - St. Amant Middle School , St. Amant, Louisiana

No snow in Austria , By Michael , Scheiblingkirchen

Ice Storm '98 , By Jennifer Lynn , Montreal, Quebec, Canada

Lots of Change , By DXL & EKF , Olympia, WA

MUCH Warmer in Iowa , By Alex & Bradly , Oelwein

Mild January For Northeast Georgia , By Danny Ware , Cleveland, Georgia 30528

Driving your horse in the winter?? , By Bethany Collins , Athens Michigan

Yearly Rainfall in One Month , By Stephen Rice , San Jose, Calif

Dangerous Storms , By Kurt Olson , Oberlin, Ks

Snow in Monterrey N.L. MEXICO , By Daniel Campos , Monterrey N.L. MEXICO

Guayama , By EDUARDO , GUAYAMA P.R. 00784

NO RAIN FOR TEMP. 90 F , By EDUARDO , GUAYAMA

HOT TEMPERATURE - 90 F , By EDUARDO , GUAYAMA PR 00784

HOT WEATHER OVER SOUTH COAST TEMP. 90 F , By EDUARDO , GUAYAMA PUERTO RICO 00784

Record amount of rain , By Robert Brandstrom , San Diego, California

El Niño

Today's Hot Water

Another reason that El Niño was in the news so much is that the 1997-1998 event was being tracked on the World Wide Web, where people all around the world could access the latest information. Data from the TAO Array, which scientists use to check the temperature of the hot water and hot air every day, is available for anyone to use.

These resources provide information on the 1997-1998 El Niño event.

- El Niño Hits Hard
- El Niño Wreaks Havoc
- Update: Status of the Current El Niño
- The 1997/98 El Niño: Impacts and Outlook
- El Niño Returns

BACK

El Niño

Hot Stuff

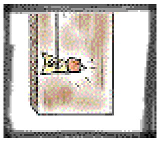
These resources offer general information for learning about El Niño.

- Tracking El Niño
- NOAA's El Niño Site
- Glossary
- Resources: Bibliographies
- FAQ
- Movies
- Animations of the Current El Niño Event
- Questions and Answers with a Research Scientist
- La Niña

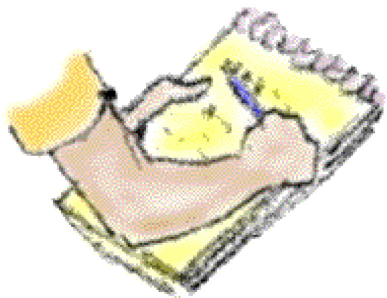
These educational classroom activities suggest some useful activities for learning about El Niño.

- A GLOBE Activity - El Niño vs. Non-El Niño Years
- NASA's Observatorium Teacher's Guides
- Webquest: El Niño or El No-no

BACK



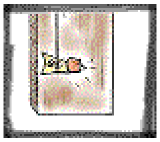
Keep Your Own Weather Journal



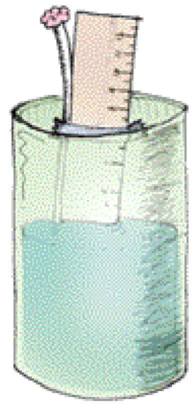
At least once each day, you should record the measurements from each of your weather instruments in your weather station. Keep an orderly chart, like the one pictured, so that you'll be able to notice patterns in your weather data.

Date	12/20	12/21	
Time	11:16	1:04	
Temperature	44	46	
Barometric Pressure	30.26	30.32	
Humidity	High	High	
Precipitation Type	None	Rain	
Precipitation Amount	Ø	1/4 in.	
Wind Direction	W	NW	

BACK



Make Your Own Barometer



You'll need these materials:

- a glass or beaker with straight sides
- a ruler (12 inch)
- tape
- one foot of clear plastic tubing
- a stick of chewing gum
- water

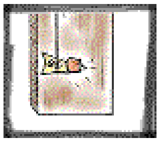
Begin by standing the ruler in the glass and holding it against the side. Tape the ruler to the inside of the glass. Make sure that the numbers on the ruler are visible.

Stand the plastic tube against the ruler in the glass. Make sure that the tube is not touching the bottom of the glass by positioning the tube up a half inch on the ruler. Secure the tube by taping it to the ruler.

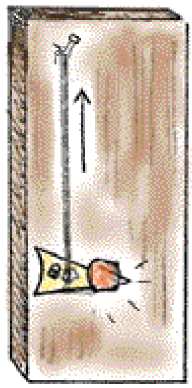
Chew the stick of gum so that it is soft. While you're chewing, fill the glass about half way with water. Use the plastic tube like a straw and draw some water half way up the tube. Use your tongue to trap the water in the tube. Quickly move the gum onto the top of the tube to seal it.

Make a mark on the ruler to record where the water level is in the tube. Each time you notice a change in the water level, make another mark. You'll notice, over time, that the water level rises and falls. Pay attention to the change in weather as the water level changes.

The water in the tube rises and falls because of air pressure exerted on the water in the glass. As the air presses down (increased atmospheric pressure) on the water in the glass, more water is pushed into the tube, causing the water level to rise. When the air pressure decreases on the water in the glass, some of the water will move down out of the tube, causing the water level to fall. The change in barometric pressure will help you to forecast the weather. Decreasing air pressure often indicates the approach of a low pressure area, which often brings clouds and precipitation. Increasing air pressure often means that a high pressure area is approaching, bringing with it clearing or fair weather.

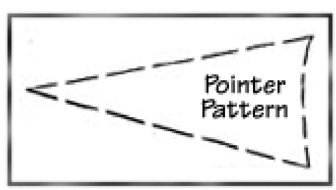


Make Your Own Hygrometer

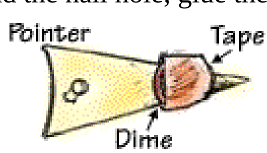


You'll need these materials:

- a scrap piece of wood or flat styrofoam (about 9 inches long and 4 inches wide)
- a flat piece of plastic (about 3 inches long and 3 inches wide) thin enough that you can cut
- 2 small nails
- 3 long strands of human hair (about 8 inches long)
- a dime
- glue
- tape
- hammer
- scissors (strong enough to cut plastic)



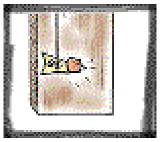
First, cut the piece of plastic into a triangular shape (refer to pictures). Then, tape the dime onto the plastic, near the point. Poke one of the nails through the plastic pointer, near the base of the triangle. Wiggle the nail until the pointer moves freely and loosely around the nail. On the plastic pointer, between the dime and the nail hole, glue the hair strands to the plastic.



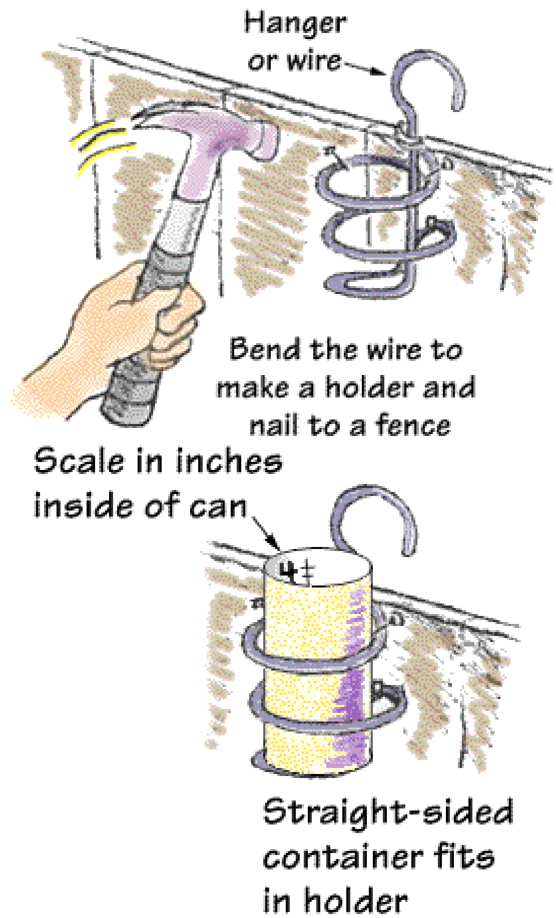
Position the pointer on the wood or styrofoam base about three quarters of the way down the side. (Refer to picture.) Attach the nail to the base. The pointer must be able to turn easily around the nail. Attach the other nail to the base about one inch from the top of the base, in line with the pointer. Pull the hair strands straight and tight so that the pointer points parallel to the ground. That is, make sure the point of the pointer is perpendicular to the hair. The hair should hang perfectly vertical and the pointer should point perfectly horizontal. Glue the ends of the hair to the nail. If the hair is too long, trim the ends.

The human hair cells will indicate the level of moisture in the air by expanding and contracting. When their air is moist, the hair will expand and lengthen, making the pointer point down. When the air is dry, the hair will contract and shorten, making the pointer point up. When you make your hygrometer observations each day, you should make a mark to indicate where the pointer points. Over time, you'll be able to see the humidity patterns that will help you forecast the weather.

BACK



Make Your Own Rain Gauge

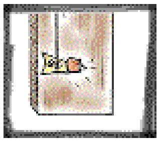


You'll need these materials:

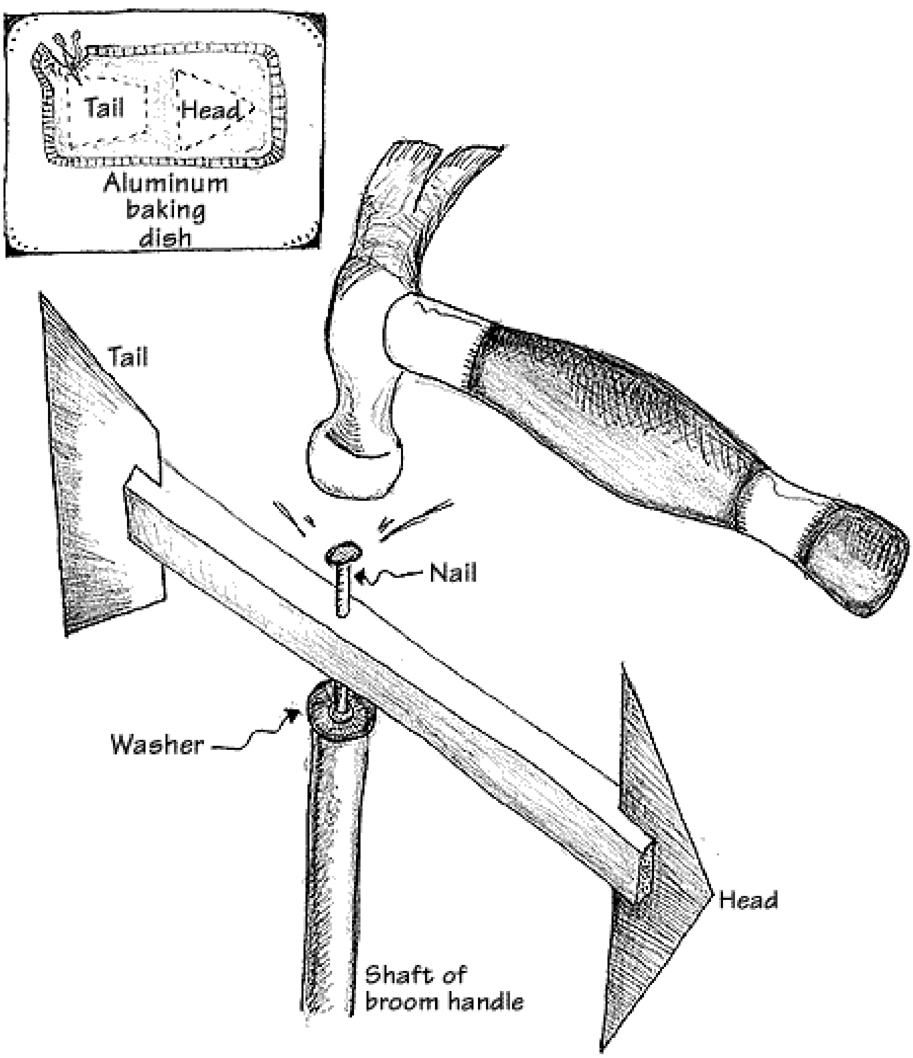
- a glass beaker (or any straight-sided glass that can be marked with a measuring scale)
- a coat hanger or wire (bent to make a holding rack -- see picture)
- hammer and nails (to secure the rack)

Basically, any measuring glass left outside can serve as a rain gauge. However, since most rain showers are usually quite windy, you'll want to fasten your rain gauge somewhere so that it doesn't blow over. Locate a good place for your gauge. There should be nothing overhead, like trees, electric wires, or the edge of a roof. These obstructions can direct rainwater into or away from your gauge, creating a false reading. The edge of a fence, away from the building, is often a good place for your gauge.

Once you have found the spot, attach the holding rack (refer to picture). Then, slip your measuring glass into position. Wait for rain, then record your measurement, and empty the glass.



Make Your Own Weather Vane



You'll need these materials:

- a long wooden dowel (about the size of a broom stick)
- an aluminum pie plate
- a 12 inch long piece of wood (A sturdy ruler would work)
- nails
- a metal washer
- hammer
- glue
- small saw (or serrated knife)
- wire (for mounting)
- scissors (strong enough to cut aluminum)

Begin with the 12 inch piece of wood. Use the small saw (or serrated knife) to cut a vertical slit at each end of the stick. The slit should be about one half inch deep. At the midpoint (exactly halfway) of the top of the stick, hammer one nail all the way through the stick. Then turn the wood around the nail several times until the stick turns easily around the nail.

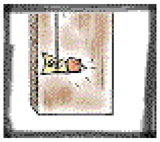
Refer to the pattern picture and cut the head and tail from the aluminum plate. Glue the head into the slot at one end of the wooden stick. Glue the tail into the other end. Allow time for the glue to dry before you take the vane outside.

Attach the weather vane to the long wooden dowel by placing the metal washer on the end of the dowel and then hammering the nail through the wooden stick and into the wooden dowel. (Refer to the picture.) Make sure that the vane moves freely and easily around the nail.

Now you are ready to mount your weather vane outside. If you mounted your rain gauge on a fence, you may want to mount your weather vane near it. Position the wooden dowel beside the fence and secure it with wire. Try to get the vane as high above the fence as you can while still keeping the dowel steady and secure.

The head of the pointer will always point to the direction from which the wind is blowing. For example, if the head points to the NorthEast, then the wind is blowing from the NorthEast. It's as simple as that. (A common mistake is to think that the wind is blowing toward the NorthEast.) Record your wind direction readings in your weather journal.

BACK



Make Your Own Compass

In order to know which way the wind is blowing, you'll need a compass. You might like to make your own.

You'll need these materials:

- A flat area where the sun shines directly (no shade)
- A straight stick or dowel, about 18 inches long
- Four heavy rocks (about the size of golf balls)
- A few smaller stones for marking

Locate a flat sunny space near your weather station. Begin by digging a hole about six inches deep. Bury the base of the stick. The stick should now be standing up to a height of twelve inches.

The first thing you'll need to do is locate "North." Before school in the morning, place a small marking stone at the end of the shadow cast by the stick. After school, later in the afternoon, the shadow should be about the same length as it was in the morning, but in a different direction. Place a marking stone at the end of the afternoon shadow. Position your right foot on the morning stone and your left foot on the afternoon stone. Your body now faces south. Another way to think of this is that the two shadows meet at the stick to form an "arrow" pointing south.

Once you have located "south," place one of the four heavy stones on the ground, about twelve inches in front of the stick. Position a second stone in the "north" position by tracing a straight line opposite away from south. Position "east" and "west" carefully opposite from each other. Be sure that they are equally distant from "north" and "south." You can use your compass to find wind direction and other weather data.

BACK

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FRANKLIN'S FORECAST

El Nino "Some are weatherwise, some are otherwise." Benj Franklin

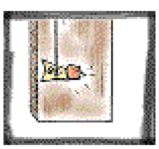
The Franklin Institute's **Five Day Forecast**

In 1735, "Poor Richard," aka Ben Franklin, wrote:
"Some are weatherwise, some are otherwise."

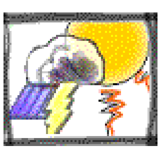
In 1743, Ben observed that northeast storms begin in the southwest. On horseback, he chased a whirlwind almost a mile to find out why. "Poor Richard" printed some of the first recorded weather forecasts. Clearly, Ben Franklin had weatherwisdom.

With "Franklin's Forecast," you can build your own weather station, learn about today's sophisticated weather technologies, and check the weather right now. **Don't be otherwise. Be weatherwise!**

El Nino If Ben had been in the tropical Pacific Ocean, he might have noticed El Niño too. Find out about the **Hot Air over Hot Water**.

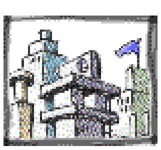


You can **make your own weather station**. Simple devices like the barometer and wind direction indicator are all you need to get started as a weather forecaster for your own neighborhood.

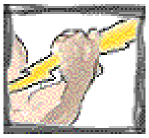


Wherever you are, whatever the time, you can check the **weather right now**. Use "Franklin's" shortlist of the best webweather sources to check the forecast for your own hometown or favorite destination.

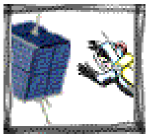
Meteorologists are weatherwatchers. You can be a weatherwatcher, too. Just keep your eyes open for **weather events**.



RADAR revolutionized the field of meteorology. Learn how to read **RADAR** images and you'll make a better forecast.

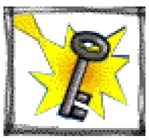


Lightning strikes are awesome displays of nature's power. They also offer clues for tracking storms.



The real weatherwatchers are in outer space. In orbit above planet Earth, **weather satellites** provide pictures of atmospheric activity.

Weather Activities
Career Connections
Weather Hotlist
Curriculum Connections



If you are in the Philadelphia area, these charts of **historical weather data**, may interest you. **NBC-10's Earthwatch Weather Workshops**, with our chief meteorologist and the NBC-10 Earthwatch Weather Team, may also be of interest.
Get information about the **current drought situation**.

[Unisys Home Page](#)
[Unisys Transportation](#)
[Weather Solutions](#)

Unisys Weather

Home
Information
Contents

Analyses

Satellite Images
Surface Data
Upper Air Data
Radar Data

Forecasts

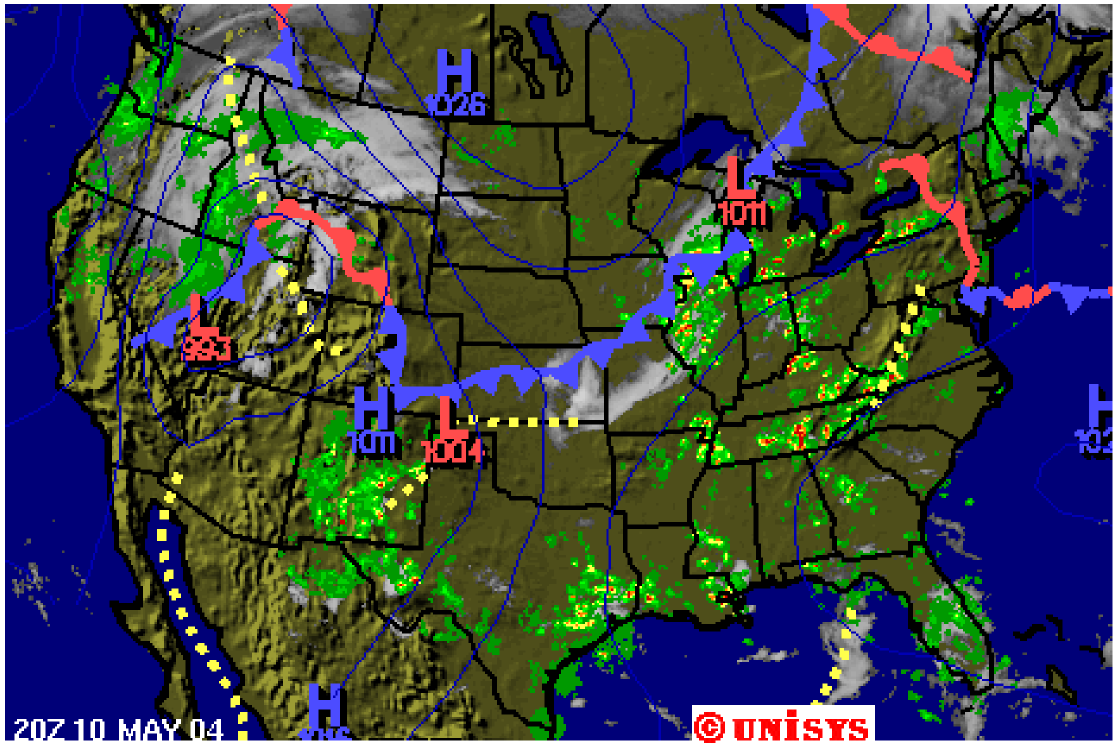
Model Statistics
NGM Model
Eta Model
AVN Model
MRF Model
RUC Model
ECMWF Model

Miscellaneous

Hurricane Data
Archive of Images
USGS Maps

Enter a zip code or city name to get forecast:

GO SETUP



Current satellite image and surface map (Click on map for forecast) [loop]

Visible Satellite Image	Enh IR Satellite Image	Satellite Surface Map
US Radar Summary	Eta Model Forecast	MRF 10 day Forecast

NEWS

Summus and Unisys Partner to Create Weather Services for Mobility

FAQ
First Time User
Site Survey
Guest Book

The intent of this weather site is to provide a complete source of graphical weather information. This is intended to satisfy the needs of the weather professional but can be a tool for the casual user as well. The graphics and data are displayed as a meteorologist would expect to see. For the novice user, there are detailed explanation pages to guide them through the various plots, charts and images. The data on this site are provided from the National Weather Service via the NOAAPORT satellite data service. All the images are generated using the Weather Processor (WXP) analysis package which is available from Unisys.

- For questions and information on this server, NOAAPORT and WXP, contact Dan Vietor at *devo@ks.unisys.com*
- For sales information on Unisys weather solutions, contact Robert Benedict at *robert.benedict@unisys.com*
- *Last modified June 30, 2003*

Weather

U.S. FORECAST LOCATOR (Enter Zip or City, St.) go

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WEATHER

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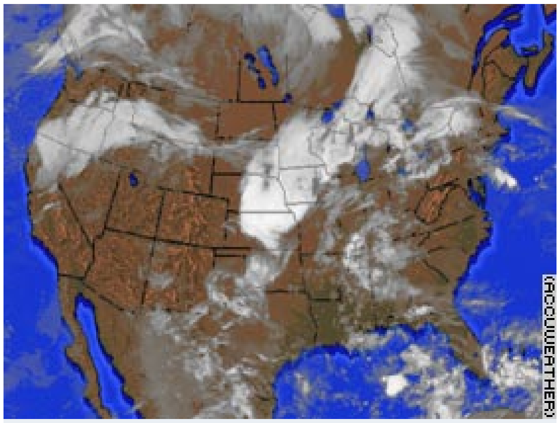


Rain in most of the country

Overcast skies promised rain in much of the country early Monday, except for in the Southwest and portions of the East.

FULL STORY

- Storms spin tornadoes, hail into Minnesota
- Mother, toddler die in flooding

PERSONALIZE YOUR WEATHER

Get your hometown weather on the home page! Enter city name or U.S. ZIP code:

[GO]

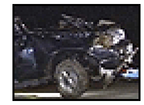
ZIP goes to nearest of 10,000 cities.

Or **select location from a list**

VIDEO

MORE VIDEO

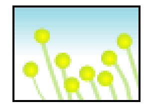
7 dead in Maine car crash



PLAY VIDEO

ALLERGY REPORT

Conditions across the United States



FIND WEATHER AROUND THE WORLD

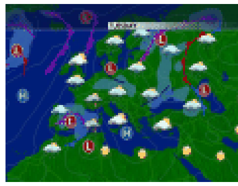
- UNITED STATES
- CANADA
- EUROPE
- AFRICA
- ASIA
- AUSTRALIA
- C.AMERICA/CARIBB.
- MIDDLE EAST
- SOUTH AMERICA

Enter city name or U.S.
Zip Code: [GO]

Or **select location from a list**

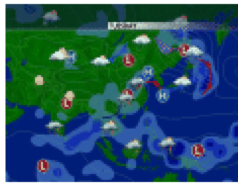
WEATHER MAPS

North America
Forecast
Temperature
Satellite | Radar

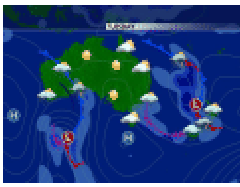


Europe
Forecast
Temperature
Satellite

Africa
Forecast
Temperature
Satellite



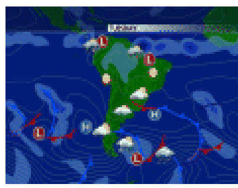
Asia
Forecast
Temperature
Satellite



Australia
Forecast
Temperature
Satellite

Central America/ Caribbean
Forecast
Satellite

Middle East
Forecast
Temperature
Satellite



South America
Forecast
Temperature
Satellite

YOUR WEATHER E-MAIL ALERTS

- Hurricanes
- Forecasts (Weather)
- Tornado
- National Weather Service

Activate or Create your own

Manage alerts | What is this?

TORNADOES

- Gallery: Testing tornado myths
- Quiz: Twister trivia
- Gallery: Facts and safety tips
- Special Report

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- Allergy Report
- Beach Report
- Ski Report
- Disaster Relief
- NOAA Weather Radio

UM Weather

Connecting You To The World Of Weather

Welcome to **UM Weather**, the Internet's premier source of weather information. Providing access to thousands of forecasts, images, and the Net's largest collection of weather links, UM Weather is the most comprehensive and up-to-date source of weather data on the Web. Thanks for stopping by! UM Weather is a non-profit service sponsored by The Weather Underground at the University of Michigan at Ann Arbor.

FastForecast...Enter a city, state, country, zip code, or station code for the current National Weather Service forecast: [ ] Get It Reset

Examples: "NY", "Albany", "11234", "ALB", or "France"

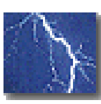
Keep track of the latest forecasts & warnings, radar, maps, computer model forecasts, and special weather advisories/warnings here on UM Weather -- your source for comprehensive weather information!

WeatherSites

The list that made us famous. Nearly three hundred WWW, gopher, telnet, and FTP weather sites -- the most comprehensive weather index on the Internet.

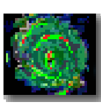
USA Weather

City-by-city forecasts, conditions, warnings, and weather graphics for each of the fifty states.



Canada Weather

Regional forecasts, advisories, conditions, and reports for each of the Canadian Provinces and Territories.

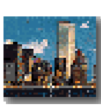


Radar and Satellite

Point-and-click access to the Internet's best Nexrad and color satellite imagery.

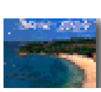
Ski Weather

Snow conditions and mountain-specific weather reports directly from the National Weather Service.



Travel Cities Weather

Nexrad radar, color satellite photos, climate information, forecasts, and conditions for thirty popular destinations nationwide.



Tropical Weather

The Net's most comprhensive collection of tropical storm-related links, including National Hurricane Center reports and incredible graphics.

WeatherCams

Live and daily pictures of weather conditions at over 700 locations around North America.

WeatherMaps

The Net's best surface and upper air analyses, including temperature maps, regional weather plots, and jet stream maps.

Weather Software

The Internet's only weather software archive, providing access to over two dozen of the best weather applications for Macs and PCs.

UM Weather pages have been visited over **689209100** times. Last modified: October 6, 2002.

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Weather

USA TODAY Weather

Flooding makes Mother's Day deadly for mother and daughter in Pa.

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Find a forecast Enter a city name or ZIP Code Go

powered by Google GO

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- Radar
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- Precipitation
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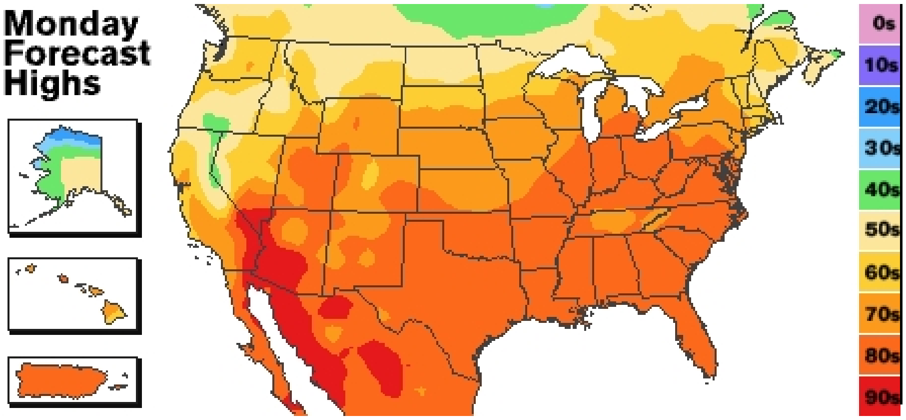

05/10/2004 - Updated 03:27 PM ET

Rip currents: a silent killer of swimmers

Study seeks ways to predict these currents - the leading cause of ocean drownings.

Story

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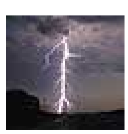


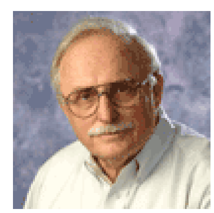
Learn about its science and safety.

Resources

Weather basics

Our guide to atmospheric science.

Weather questions answered



Ask Jack

Answers to latest questions

What should a student do to prepare for a career in weather?

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Homes flooded in eastern Alaska

Water up to two feet high also closes roads.

Rare tornado kills 2 in China

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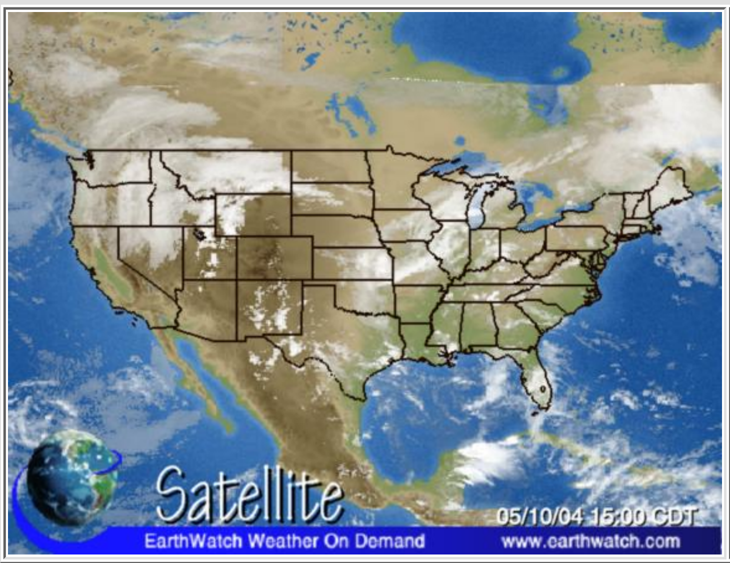

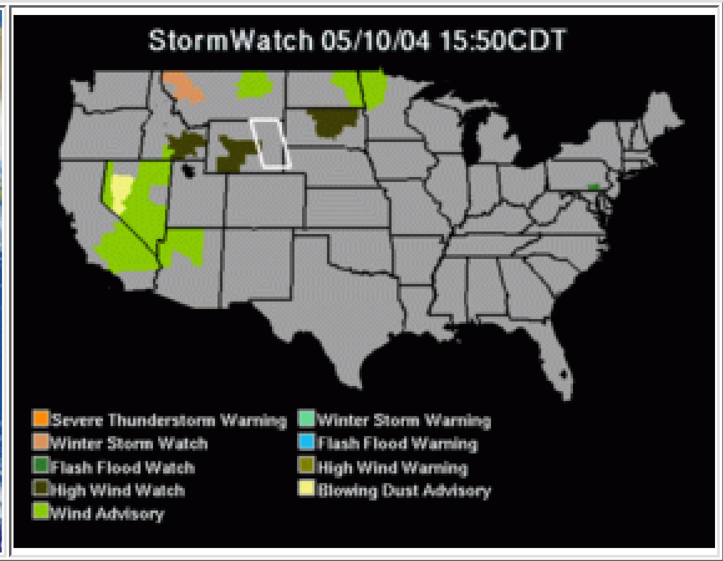

Click on either image to see more or choose a selection from the menu above.

ATLANTIC & PACIFIC SATELLITE IMAGES *(INCLUDING TROPICS)*

Our web site has been designed to bring you more information with EarthWatch® Weather on Demand and to make that information easier to find. The button bar on the top of each page will help you navigate our web site

We encourage links to our pages and provide free icons for those links.

EarthWatch Awards and Recognition

StormWatch data provided by Meteorlogix

Welcome to Live Weather Images! Today is Monday, May 10.

Quick Weather Links: | 24-hr forecast | Surface Analysis | Max Temps Expected | U.S. or Atlantic infrared | Europe infrared |

weatherimages.org LIVE WEATHER IMAGES (LWXI) Since 1996

A new site design is in the works... it might be a little "buggy" for a couple months while the upgrade slowly progresses.

MAIN MENU

- Weather Images
- Weather Cams
- Interactive Page
- Discussion Board
- Other Stuff
- Books & More HOT
- About LWXI

Welcome!

This is a one-stop weather site. From here, you can get radar and satellite imagery, other weather maps, and cool weather cam views! To start exploring, *move your mouse over the menu to the left*. This site is currently being redesigned, so you may experience some bugs. These will be worked out in due time. Thanks for cruising by! Please surf around and enjoy your visit:-)

Mission Statement:
To provide free, to the general public, a concise and user-friendly weather web site that conveniently pulls together the most valuable and frequently accessed weather data on the Internet.

LWXI News

The online stores are now open!

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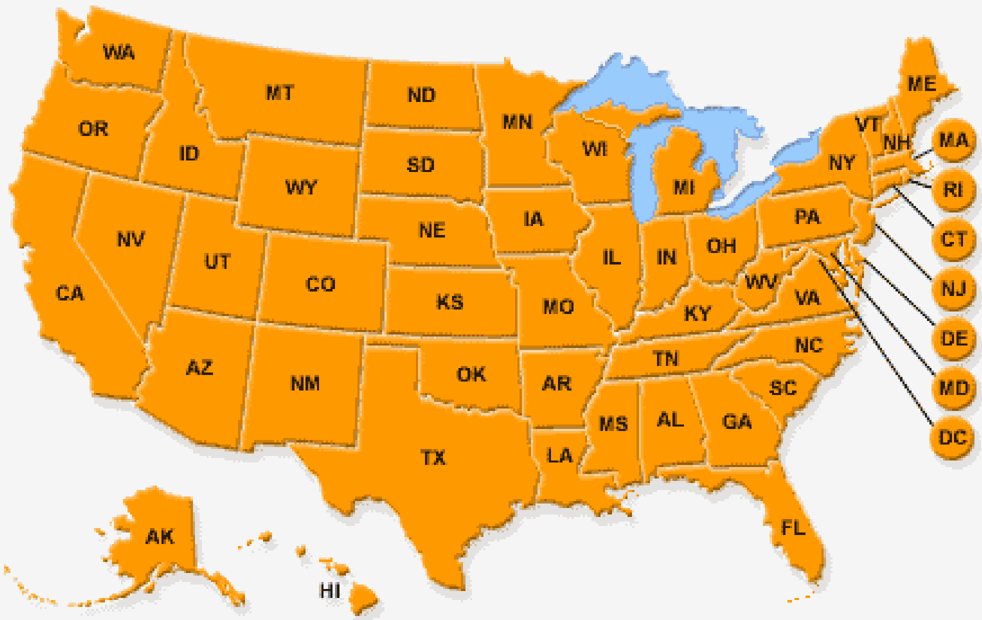
WxUSA Weather Hub

Click on a state to get weather information for cities in that state



Go To A State For Weather Information

Alabama Go

[International](#) [Hurricane](#) [Ski Reports](#) [News](#) [Sports](#) [Travel](#)

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UM Weather WeatherMaps

Welcome to UM Weather's Weather Maps page. This page provides easy accesss to over two dozen surface, upper air, temperature, and computer model maps from around North America.

Main | Forecasts | Maps | Models | Radar-Sat | Skiing | Software | Travel | Tropical | Wx Cams | Wx Sites

National Surface Maps

Surface Map from Ohio State
Surface Map from TWC
New England Surface Map
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Northern Hemisphere 850mb
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Precipitable Water Contour
1000-500mb Thickness Contour
500mb Height Contour
300mb Wind Speed
Raw/Graphical Sounding Data

UM Weather

WEATHER IMAGES

DC Area Weather Images

National Weather Images

International Weather Images

Weather Images

DC Area Weather Images

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Satellite Pictures in Motion
- Northeast

Precipitation Radar
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- D.C. Metro Radar

Precipitation Radar in Motion
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UV/Air Quality Maps
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- Air Quality Index (AQI)

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- Air Quality Index (AQI)

- Current Wind Chill
- Current Heat Index
- Severe Weather Watches
- Today's Highs
- Tonight's Lows
- Today's Forecast
- Tomorrow's Forecast

- U.V. United States
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- New Zealand
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- Pacific Ocean - Southeast
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Satellite Pictures in Motion

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- Today - Europe
- Today - U.K.
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- Tomorrow - Europe
- Tomorrow - U.K.

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Questions? Comments? Suggestions? E-mail weather@weatherpost.com.

IWIN National Warnings Area

Warning Catagories

Tornado	Hurricane	Severe Thunderstorm
Flash Flood		Flood
Non Precipitation		Coastal Flood
Winter Storm	Show All	Special Marine

Back to IWIN Main Level

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HURRICANE

Hurricane Home

TRACKING THE STORM
- Maps and data
- Online tracking map
- Printable tracking map
- E-mail updates

STORM SURVIVAL
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- During the storm
- After the storm
- Food & supply list
- Choosing shutters

LEARN MORE
- Hurricane science
- Science news
- 500 years of history
- Hurricane names

CHANNELS

SOUTH FLORIDA NEWS
Broward County
Palm Beach County
Miami-Dade County
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Nation/World
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Contests

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Jobs
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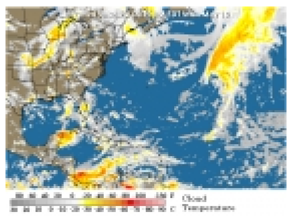
May 10, 2004

HURRICANE HEADQUARTERS

2004 hurricane season begins June 1



- Official NHC outlook
- Tropical data

Maps:
- Atlantic
- Gulf of Mexico
- Caribbean

Expert: U.S. can expect 'hellacious' damage from major hurricanes

The U.S. coastline can expect "hellacious" damage from major hurricanes in the near future, said noted hurricane prognosticator Bill Gray on Friday, renewing his warning that the Atlantic basin has entered an era of intense hurricane activity.

Hurricane expert William Gray

Current conditions in South Florida

Expert predicts 14 named storms in Atlantic this year

FORT COLLINS, Colo. -- The Atlantic will probably see 14 named storms this year, eight of them hurricanes and three of them intense hurricanes, a storm researcher said Friday.

Whirling storm kills two and destroys hundreds of homes in Brazil -- but was it a hurricane?

A whirling storm battered the coast of southern Brazil on Sunday, killing two people, injuring at least 39 others and destroying hundreds of homes, civil defense officials said Sunday.

Hurricane season capped nine-year stretch of busy storm activity

MIAMI -- The 2003 Atlantic hurricane season capped a nine-year stretch of above-average storm activity in the region that will go down as the busiest period on record, government forecasters said in a report Monday.

Masters of disasters: Red Cross volunteers step in to save day

Florida's forgotten storm: The Hurricane of 1928

10 lessons for a category 5 hurricane

Finding shelter for your family

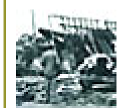
ACTIVE STORMS

There are no active storms at this time.

E-MAIL UPDATES

Stay alert. **Sign up to get hurricane updates** delivered by e-mail.

1928 HURRICANE



Read about the night 2,000 died and see historic film. Also: special report profiles South Florida's seven most devastating hurricanes.

WORTH A LOOK

It's been a decade since **Hurricane Andrew hit South Florida**. Look back with eyewitness accounts, "then and now" photos and original articles from 1992.

2004 STORM NAMES

Alex, Bonnie, Charley, Danielle, Earl, Frances, Gaston, Hermine, Ivan, Jeanne, Karl, Lisa, Matthew, Nicole, Otto, Paula, Richard, Shary, Tomas, Virginie, Walter

COLUMNISTS

Michael Mayo
News Columnist

Howard Goodman
Palm Beach columnist

Vanessa Bauza
News Columnist

Buddy Nevins
Political Columnist

Anthony Man
Political columnist

Ken Kaye
Aviation Columnist

Michael Turnbell
TRANSPORTATION COLUMNIST

Make plans now to protect your family

Shutters are first line of defense

Main | News | 2004 Season | Maps | Reconnaissance | Information | Past Storm History |

Sister Sites
HuracanNet en Español
Puerto Rico Weather
Puerto Rico SKYWARN

2004 Season
Dr. Gray Forecast

Tropical Outlook:
Atlantic, East Pacific

Tropical Discussions:
Atlantic, East Pacific

Maps
Doppler Radar
Precipitation, Alt
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Satellite Image
Caribbean, Loop
Water Vapor
Visible
Infrared

Tracking Chart
Eastern Pacific (pdf)
Full Atlantic (pdf)
Western Atlantic (pdf)

Audio
NOAA Radio San Juan
What is NOAA Radio?

Reconnaissance
Flight Schedule, Alt
Detailed Vortex
Recco Observation

Information
National Weather Service (NWS)
Hurricanes
StormReady
Floods

More Information

The Atlantic hurricane season runs from June 1 through November 30.

Alex | Bonnie | Charley | Danielle | Earl | Frances | Gaston | Hermine | Ivan | Jeanne | Karl | Lisa | Matthew | Nicole | Otto | Paula | Richard | Shary | Tomas | Virginie | Walter

Atlantic	
Tropical Weather Outlook 11/30/2003 at 10:14 PM	Tropical Weather Outlook - Image Courtesy of NHC
Tropical Weather Discussion 05/10/2004 at 01:51 PM	Monthly Tropical Weather Summary 12/18/2003 at 03:01 PM
Eastern Pacific	
Tropical Weather Outlook 11/30/2003 at 11:33 PM	Tropical Weather Outlook - Image Courtesy of NHC
Tropical Weather Discussion 05/10/2004 at 11:30 AM	Monthly Tropical Weather Summary 12/01/2003 at 10:45 AM
Other Products	
Tropical Model Comparison 05/10/2004 at 02:06 PM	
High Seas Forecasts	
Atlantic 05/10/2004 at 11:41 AM	Northeast Pacific 05/10/2004 at 11:31 AM

Tropical Cyclone FAQ
The Saffir-Simpson Scale
Glossary

Storm Names
North Atlantic
Eastern Pacific
Central Pacific
Western Pacific
Other Regions

Labelled with ICRA

Southeast Pacific
05/10/2004 at 12:28 PM

If you would like information on:

- El Niño, click here
- The water level of the Lake Guajataca and Carraizo, click here
- El Optical density (the dust of the Sahara desert), click here
- Dr. Gray forecast, click here
- National Hurricane Center Forecast products, click here
- Puerto Rico's weather conditions and discussion, click here
- Heat Index, click here.
- Air Quality Index (San Juan, PR), click here.

If you have a comments, questions or suggestion about the website please Contact Us

In a moment your browser will be redirected to the
About the NHC page http://www.nhc.noaa.gov/aboutnhc.shtml.

If nothing happens, please use the link above.

The National Hurricane Center
Max Mayfield, Director
Ed Rappaport, Deputy Director

The National Hurricane Center (NHC) maintains a continuous watch on tropical cyclones over the Atlantic, Caribbean, Gulf of Mexico, and the Eastern Pacific from 15 May through November 30. The Center prepares and distributes hurricane watches and warnings for the general public, and also prepares and distributes marine and military advisories for other users. During the "off-season" NHC provides training for U.S. emergency managers and representatives from many other countries that are affected by tropical cyclones. NHC also conducts applied research to evaluate and improve hurricane forecasting techniques, and is involved in public awareness programs.

NHC also contains the Chief, Aerial Reconnaissance Coordination, All Hurricanes (CARCAH) unit. It is a small three person unit, an Operating Location of the 53rd Weather Reconnaissance Squadron (Hurricane Hunters) out of Keesler Air Force Base near Biloxi, Mississippi. CARCAH's mission is to coordinate all aerial reconnaissance requirements at NHC (Atlantic requirements) and at the Central Pacific Hurricane Center (Central Pacific requirements), then task the flying units to meet these requirements.

Data from the reconnaissance aircraft (normally a WC-130) is fed directly to CARCAH via satellite down link. It is quality controlled then provided directly to the hurricane specialist for use in the forecast and warning process. It is also entered into the world weather networks.

During the winter season, CARCAH also coordinates the aerial reconnaissance requirements in support of the National Winter Storms Operations Plan, which provides for flights off the U.S. east coast and over the Gulf of Mexico when severe winter storms are expected. The data is again received at CARCAH and quality controlled before it is submitted to the National Centers for Environmental Prediction. It is then included in their suite of computer weather prediction models.

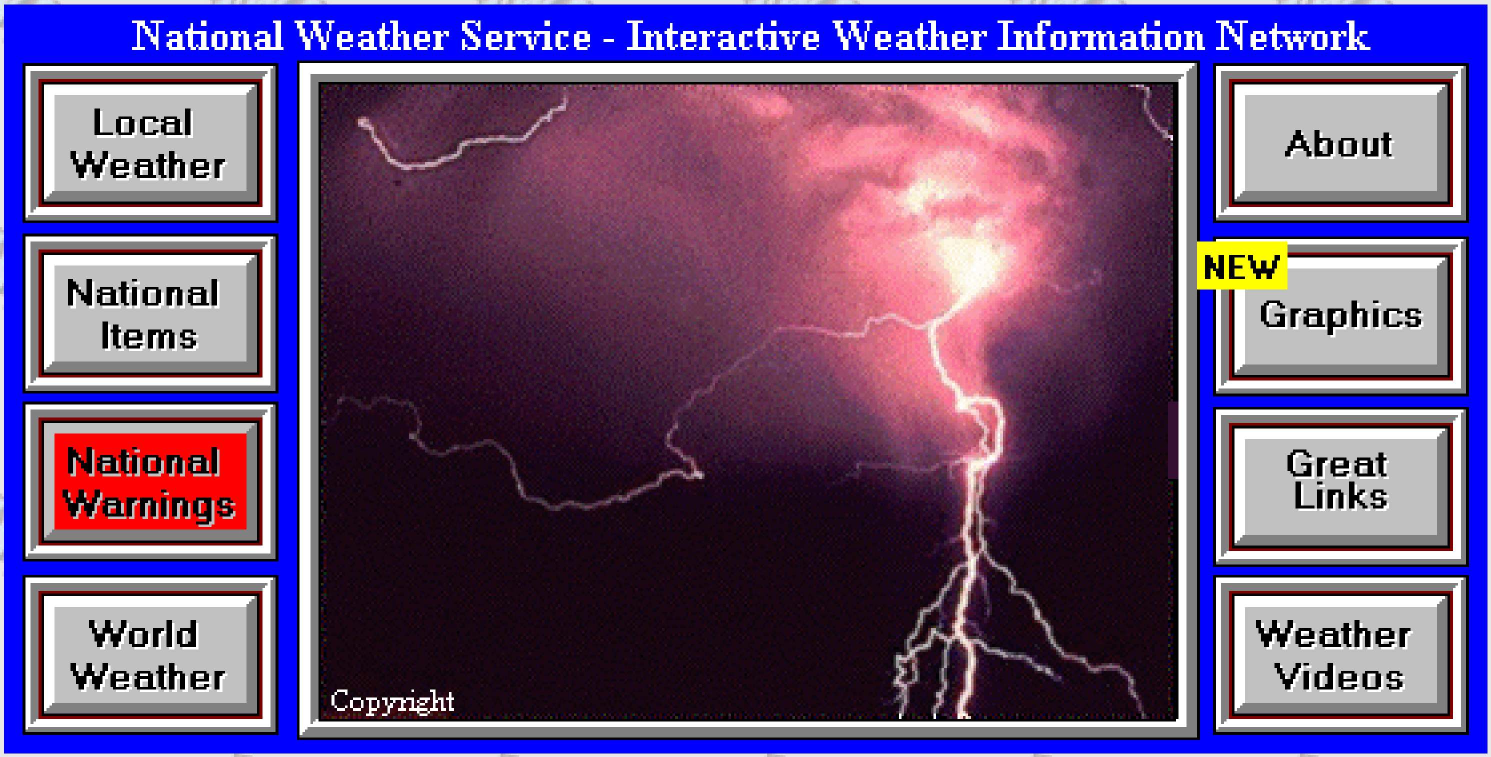
Take a graphical look at what's involved in a Hurricane Forecast. (60K GIF)

National Hurricane Center
Tropical Prediction Center
11691 SW 17th Street
Miami, Florida, 33165-2149 USA
Todd.Spindler@noaa.gov

Page last modified: Thursday, 13-Feb-2003 14:47:42 CST

NEW ANIMATION-->[**Try out the new ANIMATED IWIN - (High Speed Users)**]

Active Warnings: Flash Flood, Flood, Non Precipitation, Severe Thunderstorm, Winter Storm



This page will "REFRESH" itself every 60 seconds to keep you up to date

Click HERE to make this your HOMEPAGE!

Active Warnings:

Flash Flood

- Kentucky
- Louisiana
- Ohio
- Pennsylvania
- Puerto Rico

Flood

- Kansas
- Michigan
- Puerto Rico

Non Precipitation

- Arizona
- California
- Connecticut
- Idaho
- Massachusetts
- Minnesota
- Montana
- North Dakota
- New Hampshire
- Nevada
- Rhode Island
- South Dakota
- Utah
- Wyoming

Severe Thunderstorm

- Arkansas
- Kentucky
- Maryland
- Missouri
- Ohio
- Pennsylvania
- Tennessee
- Virginia

Winter Storm

- Idaho
- Montana
- Oregon

Updated Mon May 10 16:54:06 2004

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For comments or problems please contact:W-IWIN.Webmaster@noaa.gov

UM Weather WeatherCams

UM Weather's newly-expanded **WeatherCams** page provides access to over 800 weather cameras across North America, the largest list on the web! Click on the links below and travel to your favorite city or resort. If you find a cam that we haven't listed, drop us a line and we'll add it to the list!

Alaska
Anchorage - Touch 'N Go
Fairbanks - Dash Deli
Fairbanks - Frontier Flying
Fairbanks - NDO
Fairbanks - PolarNet
Gakona - U.S. Navy
Juneau
Valdez - National Wx Svc

Alabama
Auburn - WSFA
Birmingham - WVTM
Huntsville - WAAY
Huntsville - WHNT
Mobile - WKRG
Montgomery - WSFA

Alberta
Banff - Sulphur Mtn
Banff - Tower 19
Calgary - alberta.com
Calgary - CICT
Edmonton - alberta.com
Edmonton - V-Wave
Lake Louise - albert.com
Sunshine Village - alberta.com

Arizona
Phoenix - ADOT/FMS
Tempe - Tempe In Touch
Tucson - UA Tucson

Arkansas
Little Rock - KARK
Little Rock - KATV

Michigan
Alma - Liberty Access
Ann Arbor - IAS
Boyne Falls - Hemlock Cam
Boyne Mountain - RSN
Eagle Harbor - CableAmerica
Houghton - MTU
Howell - ISMI
Idlewild Lake - Cyber-Biz
St. Joseph - WNDU

Minnesota
Buffalo - School District 877
Duluth - ComputerPro
Duluth - St. Mary's Medical Center
Duluth, Lake Superior - Minnesota Power
Minneapolis - WCCO

Mississippi
Corinth - CrossRoads
Water Valley

Missouri
Kansas City - KCTV
Kansas City - Middle West
Lake of the Ozarks State Park
Lake of the Ozarks 2
St. Louis - ArchCam - Sears

Montana
Big Mountain - RSN
Big Sky - RSN
Bozeman - Bozeman Daily Chronicle
Bridger Bowl - RSN
Glaciers - RSN
Helena - NOAA

British Columbia
[Blackcomb Ski Area - RSN]
[Panorama Ski Area - RSN]
[New Westminster - eduConnection]
[Vancouver - BC Yellow Pgs]
[Vancouver - Multiactive]
[Vancouver - Telemark Systems]
[Whistler/Blackcomb - RSN]
[Whistler - Multiactive]

California
[Alameda - City Of Night]
[Albion - Heidsite]
[Auburn - RWCS]
[Bear Mtn - RSN]
[Berkeley - UCBerkeley]
[Cardiff - Surflink]
[Catalina Island - Catalina Is. Inn]
[Central California - Crazy Joe's]
[Donner Summit - IWN]
[Emerald Hills - Basic Telepresence]
[Fremont - Lam Research]
[Fullerton - Pacific Audio & Alarm]
[Fullerton Santa Fe Depot]
[Hayward]
[Hermosa Beach - Good Stuff Restaurant]
[Hermosa Beach - Hermosa Wave]
[Hollywood - RFX]
[La Jolla]
[La Jolla - UCSD]
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[Lake Tahoe - RSN]
[Lake Tahoe - Virtual Lk Tahoe]
[Los Angeles - Electric LA]
[Los Angeles - JC Sportscards]
[Los Angeles - UCLA BruinCam]
[Los Angeles - USC TommyCam]
[Mammoth Mtn - RSN]
[Mono Lake - Mono Lake Cmte]
[Mount Shasta - Siskiyou County]
[Mount Wilson - UCLA]
[Nevada City - American Business Register]
[New Mtn High - RSN]
[Oakland - KTVU]

[Kalispell - Dave & Marla]
[Kalispell - NOAA]
[Whitefish - Black Star Beer]

Nebraska
[Lincoln - Bryan Memorial Hospital]
[Lincoln - Information Analytics]

Nevada
[Incline Village - IWN]
[Lake Tahoe - Adventure West]
[Lake Tahoe - Harvey's Tahoe]
[Las Vegas - KLAS]
[Las Vegas - Polo Towers]
[Reno - IWN]

Newfoundland
[St.John's -- OZ FM]

New Hampshire
[Attitash - RSN]
[Cranmore - RSN]
[Great Glen - RSN]
[Loon Mtn - RSN]
[Madison - Hedgehog Hill Group]
[Manchester - WMUR]
[Mt Washington - Observatory]
[Mt Washington - RSN]
[Plymouth - PSC]
[Waterville Valley - RSN]

New Jersey
[Alloway - Access Systems]
[Point Pleasant - Exit 98]
[Red Bank - ePresence]
[Somewhere in the state - AT&T]
[Vernon Valley - RSN]

New Mexico
[Albuquerque - Global 66]
[Angelfire - RSN]
[Carlsbad - Brad & Misty]
[Portales - ENMU & KENW]
[Ski Apache - RSN]
[Taos Ski Valley - RSN]

New York

Oakland-Alameda County Coliseum
Palm Springs
Palmdale
Pasadena - BeeHive Technologies
Pine Mountain Club - Frazier Mountain Internet
Quincy - Walltech
Redwood City - TEA
Sacramento - KXTV
San Clemente
San Diego - CONNECTnet
San Diego - Topin
San Diego - Vigra
San Diego Bay - LiveNet
San Francisco
San Francisco
San Francisco - Bank of America
San Francisco - Bay Bridge Approach
San Francisco - ComputersAmerica
San Francisco - Exploratorium
San Francisco - KGO
San Francisco - KPIX
San Francisco - KPIX traffic cams
San Francisco - KRON
San Francisco - Michael E. Mortimer
San Francisco - Reardon
San Francisco - Sybase
San Francisco - WaxMuseum
San Francisco & Bay Area - KTVU
San Jose - IBM
San Jose - KNTV
San Marcos - CSU
Santa Cruz - InterAct
Santa Cruz - Slug Video
Santa Cruz - ZCO.Net
Santa Monica Bay - Westland Network
Sausalito - Bike Rental
Sierra at Tahoe - RSN
Snow Summit - RSN
Squaw Valley, USA - RSN
Summit - InterAct
Tehachapi RailCam
Truckee - MagnifEye
Vallejo - Words & Graphics

Albany - WRGB
Eastchester - Cornell's Hardware
Hawthorne - PRIDE
Hunter Mtn - RSN
Lindenhurst
New York City - Apuzzo Video
New York City - Engineering Information
New York City - Kinya
New York City - Manhattan Transfer
New York City - Mike Martino
New York City - Realtech
New York City - WTCA
New York City - Brooklyn - PrattCam
New York City - Brooklyn Bridge - Romdog
New York City - Bryant Park - OTEC
New York City - Manhattan - ACRWeb
New York City - Manhattan - MTE
New York City - Rockefeller Center
New York City - Statue of Liberty - Shareholder
New York City - Times Square
New York City - Times Square - Earthcam
Olean - Micro Training Center
Rochester - WHEC
Syracuse - OCC
Syracuse - Syracuse Online
Westhampton Beach - First Hampton Realty
Windham - Ski Windham

North Carolina

Asheville - Digipic
Asheville - Wilcox Travel
Beaufort - Bill Stocks
Cape Hatteras - RSN
Charlotte - WBTV
Charlotte - WSOC
Greenville - ECU
Raliegh - Triangle Wx

North Dakota

Bismarck - KFYR
Fargo - KXJB
Grand Forks - RWIC/UND
Theodore Roosevelt NP - NOAA

Nova Scotia

Venice - Westland Network
Yosemite Cam - Virtual Yosemite
Yosemite National Park
Yuba City

Colorado
Arapahoe Basin - RSN
Aspen - Aspen Internet
Aspen - RSN
Aspen - SnowRide
Beaver Creek - Vail Resorts
Blackhawk - Dan Hays
Boulder - Echoflight
Boulder - GWHA
Boulder - Reputable Systems
Breckenridge - BreckNet
Breckenridge - RSN
Breckenridge - Vail Resorts
Colorado Springs/Pueblo - KOAA
Colorado Springs - Cheyenne Mountain Zoo
Colorado Springs - Pikes Peak - Softronics
Colorado Springs - USAFA
Conifer - Conifer High School
Copper Mountain - RSN
Crested Butte - RSN
Denver - KUSA
Denver - KCNC
Eldora - DCN
Evergreen - Corey
Fort Collins - Andy Casiello
Keystone Mtn - RSN
Nederland - RM Digital Peeks
Old Englewood - WhiteStar
Pine Junction - Wayne Harrison
Pueblo - Mmighty
Pueblo - USC
Shaffers Crossing - Den's Barber Shop
Steamboat Springs - Steamboat Online
Tiny Town
Vail - RSN
Vail - VailNet
Winter Park - RSN

Connecticut
Torrington - Linda's yard

Halifax - Dalhousie U
Halifax - Raland Kinley
Halifax - Thunder New Media

Ohio
Cincinnati - WCPO
Cleveland - Book Stacks Unlimited
Cleveland - Browns
Cleveland - Cuyahoga River
Cleveland - NASA Lewis Research Center
Columbus - OSU
Columbus - WBNS
Dayton - Wright St Univ
Toledo - Medical College of Ohio
Waynesville - Wayne Twp. Fire Dept.

Oklahoma
Oklahoma City - KOCO
Oklahoma City - KWTV
Tulsa - KJRH

Ontario
Collingwood - Blue Mtn Resorts
London - Sammy's Souvlaki
Niagara Falls - Sheraton
Ottawa - Ottawa Citizen
Toronto - Ministry of Transportation

Oregon
Beaverton - KATU
Corvallis - Oregon State Univ.
Eugene - Univ. of Oregon
La Grande - EOU
Mount Bachelor - RSN
Mount Hood/Timberline - KGW
Portland - KGW
Oregon Highways - DOT
Portland - KOIN
Portland - Rose Quarter
Portland - MediaForte
Portland - Traffic Management
Portland - Waterlily Cam
Salem - KGW

Pennsylvania
Champion - 7 Springs

Delaware
Bethany Beach - Mc Mahon
Newark - Univ. of Delaware
Rehoboth Beach - DelMarVa OnLine
Rehoboth Beach - NetWatch
Rehoboth Beach - PorchCam
Wilmington - NetWatch

Florida
Boca Raton - Royal Colonial Apts
Clearwater Beach - Internet Advertising
Coconut Grove - WTMI
Fort Lauderdale - Bootlegger
Fort Lauderdale - Elboroom
Fort Lauderdale & more - SoFLA
Fort Myers - WBBH
Gainesville - UF
Indian River Cam - Florida Saltwater Fishing
Jacksonville - AT & T
Key Largo - Coral Technologies
Melbourne Beach - Buddha
Melbourne Beach - InternetU
Miami & South Beach - Erdman Video
NASA
Orlando - Disney
Orlando - Marcus Sharpe
Palm Beach - GOPBI
Panama City - Chateau Motel
Pembroke Pines - Sedona Systems
St.Petersburg - WTVT
Tallahassee - FSU
Tampa - WFLA
Tampa - WTVT
Tampa Bay - St. Petersburg Times

Georgia
Atlanta - 66 traffic cams
Atlanta - Emory U
Atlanta - WAGA
Atlanta - WSB
Augusta - Georgia Golf Hall of Fame
Augusta - WRDW
Buckhead - Information Architecture
Macon - WMAZ

Gettysburg
Milford - SBC
Philadelphia - ATL
Philadelphia - NetWatch
Pittsburgh - Andrew's Window
Pittsburgh - Parkway West - OnTV
Pittsburgh - CMU Network Development
Pittsburgh - WTAE
State College - CASI
State College - Penn State Univ.
Whitetail Ski Area - RSN

Prince Edward Island
Borden-Carleton - PEI Gov.

Quebec
Montreal - Convention & Vistors Bureau
Tremblant Ski Area - RSN

Rhode Island
Narragansett Bay - Hydroactive
Pojac Point - Atlantic Consulting
Providence - Providence Journal
Providence - TeleCAM

South Carolina
Columbia - WIS-TV
Spartanburg - TelePlex

Tennessee
Bristol - Corporate Image
Cookeville
Gallatin - VSCC
Gatlinburg - Smoky Mountain Mall
Knoxville - W. E. Conner
Martin - UTM
Memphis - Flameout
Memphis - WREG
Memphis Midtown - WMC
Memphis Riverside - WMC
Nashville - Midtown Printing
Nashville - WTVF

Texas
Amarillo - KVII
Austin
Austin - ITM

Savannah - WTOC - Daily
Tallulah Falls - WINOA

Hawaii
Hawaiian Eye - Planet Hawaii
Honolulu - HVCB
Honolulu - Traffic Cams
Kanaha
Kihei, Maui - Maui Cheetah
Lahaina, Maui - Bogus Brothers
Maalaea, Maui
Maui - Inmaui.com
Maui - Windcam - Bob's Windsurf
Maui - Iao Valley - SOL
Mauna Loa Observatory
Oahu - Manoa Valley - SOL
Oahu - Sunset Beach - SOL
Poipu, Kauai - Stay Kauai

Idaho
Alder Flats - WolfCam
Orofino - J. Boswell
Wardner

Illinois
Champaign-Urbana - AOSG at NCSA
Chicago - Perceptual Robotics
Chicago - WGN
Chicago Lakefront - The Habitat Co.
Evanston - Perceptual Robotics
Kankakee - Olivet U
Lena - Le-Win HS
Moline - Quad-Cities RiverCam
Quincy - WGEM
Rock Island - Quad-Cities LeveeCam

Indiana
Edinburgh - AJCC
Evansville - WEHT
Fort Wayne - WANE
Hebron - NetNITCO
Indianapolis - Indianapolis-Marion County
Indianapolis - IUPUI
Indianapolis - WRTV
Indianapolis - WXIN
Jasper - The Computer Center

Austin - KTBC
Austin - University of Texas
College Station - Highway 30 - A & M
College Station - KBTX
College Station - A & M
College Station - University Dr. - A & M
Dallas - Glenn's Digital Den
Dallas - WFAA
Euless - Mark Marshall
Houston - BallParkCam
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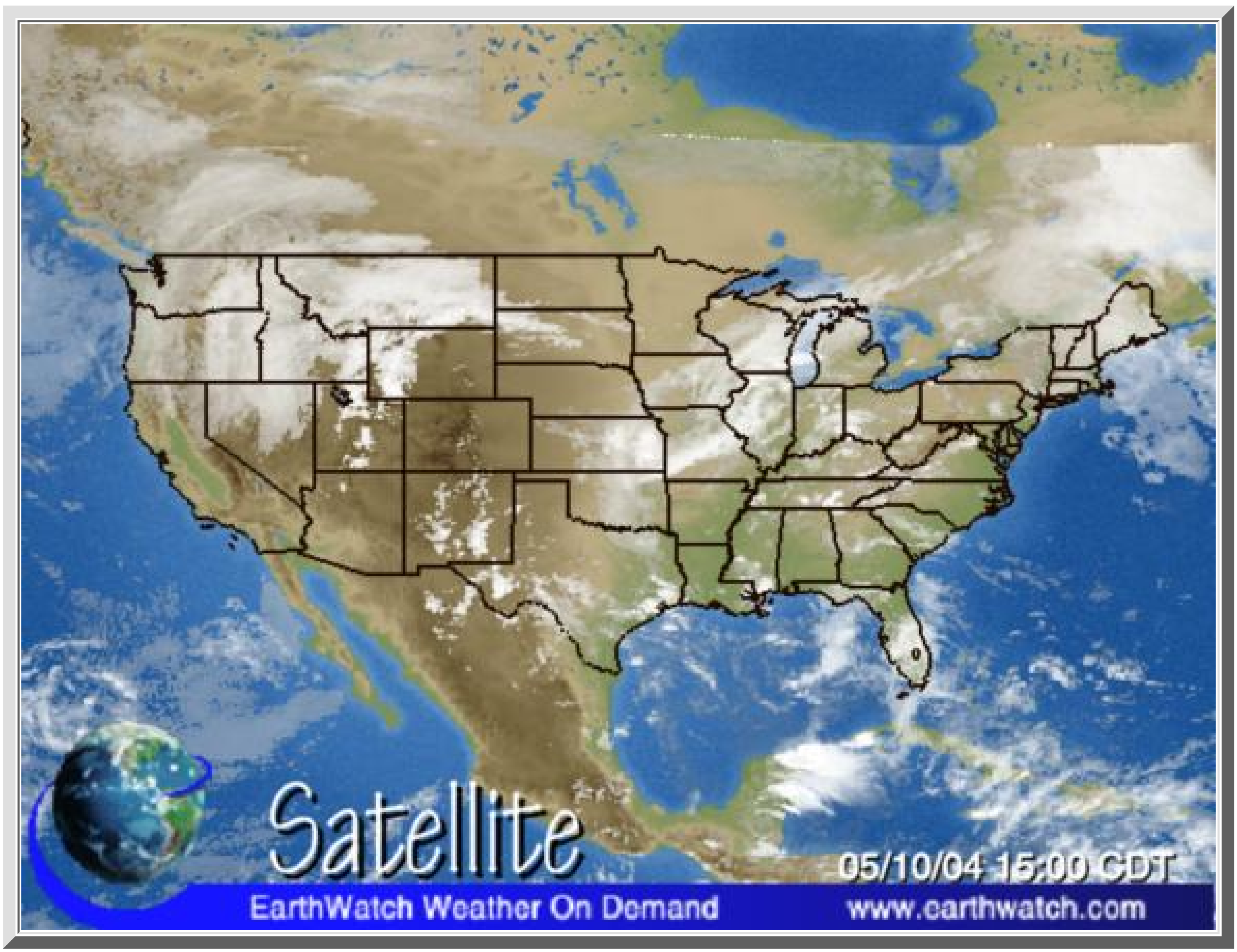
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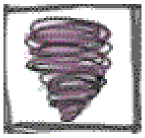
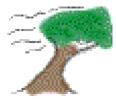


Hot, Humid, Hurricanes



Hurricanes are huge storms of moist air that form over the warm tropical oceans. They feature heavy rain and fierce winds of speeds of 75 miles per hour or higher. Hurricanes can also bring severe thunderstorms and tornadoes along for fun. Summer and early autumn is considered hurricane season because hurricanes feed on hot, humid air. Hurricanes develop and grow over warm ocean waters and need the warmth and moisture of the water to survive. When a hurricane hits coastal land, it hits hard with heavy rain, thunderstorms, flooding, and wild winds. Over land, the hurricane is fighting to stay alive, a fierce struggle it is destined to lose. Without the warm ocean water beneath, the hurricane will die.

MORE

More about Hurricanes

Meteorologists track hurricanes using satellite images and, when the hurricane is close to land, RADAR reflectivity and velocity images. A RADAR image of a hurricane shows the typical spiral formation, bands of severe thunderstorms, and the calm, central eye of the storm.

Hurricanes on The Horizon (1541k)

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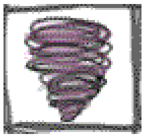
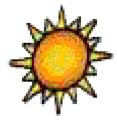


Speaking Clearly



Sometimes, a meteorologist looks at RADAR and satellite images and finds them clear. That's everyone's favorite forecast! When the air is free of any precipitation, there are no objects to reflect the RADAR, so the images are clear.

Remember that the term "weather" refers to the atmospheric conditions around us at any given time. Therefore, a clear day is weather too. Most meteorologists would call clear days the very best kind of weather!

On a Clear Day... (1223k)

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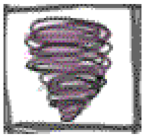


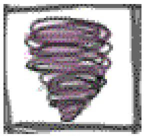
Shower Power

Showers are small local periods of rain or snow that last a short time. They are usually of light to moderate intensity and are likely to start and stop suddenly. You can predict your own showers by noticing the rapid change in the appearance of the sky as a shower approaches. Often, the intensity of a shower varies with quick changes between light and moderate precipitation.

Showers are easy to track using RADAR images. A reflectivity image indicates the location and intensity of a shower. Showers often stretch over a wide area, but the precipitation itself falls in localized patches as the showers move.

Take a Shower (1262k)

BACK



Tornado? Tornadon't!

Tornadoes are extremely violent local storms that form when a whirling vortex of air develops inside of a severe thunderstorm and lowers to the ground. You'll recognize a tornado by its distinctive funnel cloud shape. A rapidly spinning vortex of air, extending to the ground, a tornado produces the fastest wind on Earth—in extreme cases, greater than 250 miles per hour. Tornadoes can appear any time of year, but are most common during the spring and summer months.

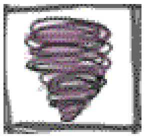
MORE

More about Tornadoes

Because tornadoes form and strike so quickly, RADAR images don't really help to forecast tornadoes far in advance. However, the velocity mode of Doppler RADAR usually gives ten to fifteen minute warnings for those in the path of a developing tornado. The best evidence of a tornado is often the devastation and destruction on the ground. The wicked winds of strong tornadoes will destroy anything in their path. The resulting destruction is the storm's signature.

Tornado! (1192k)

BACK



Snow Shows

Snow is a particularly pretty form of precipitation. Snow crystals, basically frozen water molecules, are six-sided ice crystals that form when the air temperature is below the freezing point for water: 32 degrees Fahrenheit, or zero degrees Celsius. A snowflake is a bundle of several snow crystals. A snowstorm can also include periods of sleet or freezing rain if the air temperature varies. Snowstorm intensity can range from flurries to blizzards.

As with rain showers, snow showers can be tracked and forecasted using RADAR images, although snowflakes don't reflect RADAR waves quite as well as raindrops. Reflectivity images show the location of a snowstorm and its intensity.

Showing Snowing (1503k)

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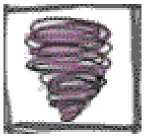
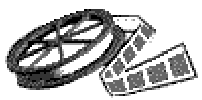


Plain Rain

Rain is liquid precipitation. When water droplets in clouds become too heavy to stay aloft, they fall out of the cloud, towards the ground. As the most common form of precipitation, rain can vary dramatically in intensity. Many weather events involve rain. Hurricanes, thunderstorms, and delicate drizzle show the variety of storms and forms that rain can take.

Since rain reflects RADAR quite well, rain is among the easiest types of precipitation to track and forecast with RADAR. Meteorologists may not always get the intensity forecasts quite right, but pinpointing the location of rain showers has become routine for forecasters.



Rain (1175k)

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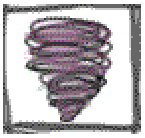
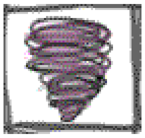
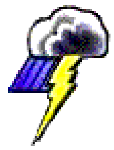


Foggy Bottom

Fog is a cloud based on the ground, rather than in the atmosphere. Fog forms when there is a lot of moisture near the ground, or when the air near the ground cools to the dew point. The temperature to which air must be cooled in order for the water vapor in the air to condense into liquid water is known as the dew point. If air near the ground cools to this temperature, water vapor from the air will become visible as dew on the ground or fog in the air.



Thunderful

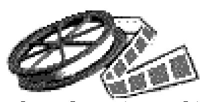


Thunderstorms form when there are great air temperature differences between layers of the atmosphere. Most common during the spring and summer months, thunderstorms form when warm, moist air near the ground rises to great heights. The rising air cools and, eventually, the moisture in the air (water vapor) condenses, forming a towering raincloud. You'll recognize a thunderstorm by the sound of its thunder, the rain showers, wind, lightning, and, sometimes, hail.

MORE

More about Thunderstorms

RADAR images show the location and severity of thunderstorms. Meteorologists can track and forecast the movement of a thunderstorm.



Thunder! (1365k)

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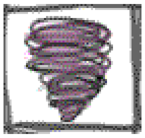


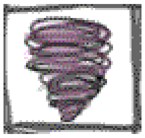
Good Old Cold

A cold front occurs where a large mass of cold air meets a mass of warmer air, and the cold air advances on the warmer air. Remember that warm air rises. So, when the two air masses meet, the heavier cold air pushes up the lighter warm air. The disruption in the atmosphere causes clouds, rain, gusty winds, and, sometimes, thunderstorms followed by cooler temperatures.

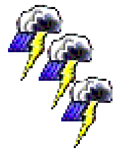
If a cold front approaches on a hot day, it can cause an abrupt change in the weather like a thunderstorm. Later, however, after the cold front passes, the cooler air is a welcome relief.

As with any storm, satellite and RADAR images provide tracking information for meteorologists to locate and measure cold front activity.

Cold Front (611k)



Severious



Severe thunderstorms feature heavy rain, intense lightning, strong gusty winds, hail, and, sometimes, tornadoes. Among the most violent of all weather events, severe thunderstorms strike fiercely and quickly. Severe thunderstorms are especially dangerous because they can produce tornadoes.

MORE

More about Severe Thunderstorms

On a RADAR reflectivity image, meteorologists detect severe thunderstorms using the intensity color key. The shape and size of a severe thunderstorm may look the same as a less dangerous storm, but the intensity colors immediately indicate the severity.

Severe Weather (1531k)

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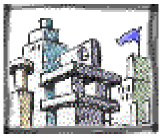
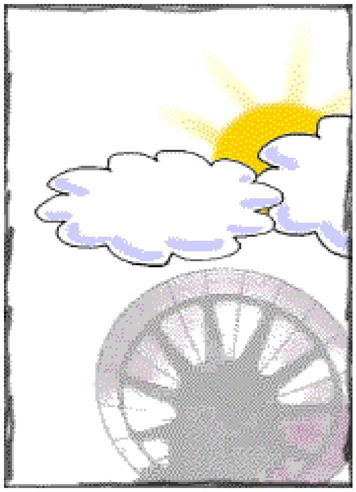
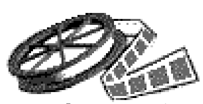


RADAR Days



Before RADAR could be born, scientists first needed to understand the principles of radio waves. In 1887, a physicist named Heinrich Hertz began experimenting with radio waves in his laboratory in Germany. He found that radio waves could be transmitted through different materials. Some materials reflected the radio waves. He developed a system to measure the speed of the waves. The data he collected, and the information he uncovered, encouraged further scientific investigation of radio.

Hertz's experiments were the foundation for the development of radio communication, and, later, RADAR.



Heinrich Hertz (112k)

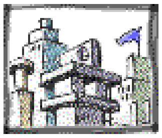
Thirty years later, scientists around the world were researching the practical use of radio waves to detect and locate objects. Throughout the 1920s and 1930s, great effort was put into developing a system by which you could transmit and receive radio waves, providing useful information.

By the 1940s, and the outbreak of World War II, the first useful RADAR systems were in place. Germany, France, Great Britain, and the United States all used RADAR to navigate their ships, guide their airplanes, and detect enemy craft before they attacked.

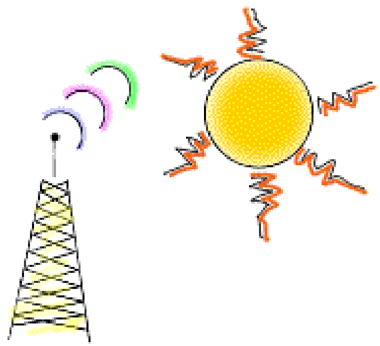
In the midst of war, the most significant peacetime application of RADAR was discovered. During the war, RADAR operators continually found precipitation, like rain and snow, appearing in their RADAR fields. Scientists had not known that RADAR would be sensitive enough to detect precipitation. Only during the war did the use of RADAR to study weather become obvious.

Today, RADAR is an essential tool for analyzing and predicting the weather.

The History of RADAR (725k)



Listen To The Air



If you're in a room with a window, go open the window. Then come back. If you're not in a room with a window, just wait quietly.

Finished? Good. You just let all of the radio waves into the room.

Radio waves are constantly traveling through the air in your community. They're invisible, like light waves. Together, radio and light waves are part of the spectrum of electromagnetic energy. The radio waves are the longest in the spectrum, making them easiest to generate and transmit over long distances. This physical property makes radio waves an ideal means of communication.

Do you have a radio? You know, an old-fashioned AM/FM radio? Inside your radio is a "receiver" which receives and translates the communication signals carried on the radio waves that are traveling through the air in your community. Each "radio station" in your community transmits radio waves at their own unique "frequency." That way, you can tune in and receive their radio waves instantly. Or, what seems instant to our ears. Radio waves travel at the "speed of light," 186,282 miles per second. So, when your team's star hitter swings the bat and sends the baseball soaring out of the stadium, the radio announcer's excited cry reaches your radio just a tiny little fragment of a second later.

The air in your community and in your room is an ideal "transmitter" of the radio waves. The air allows the radio waves to travel comfortably through. Many materials, however, do not allow the radio waves to travel through; rather they "reflect" the radio waves, causing them to bounce back. The metal of an airplane's wing, the rock of a mountain, and the water in a storm cloud are all reflective materials. When radio waves hit them, the waves bounce back.

These properties of materials and of radio waves made **RADAR** possible.

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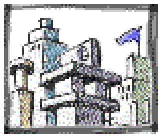
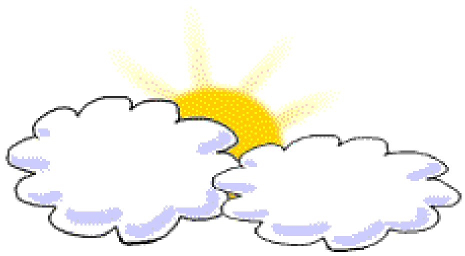
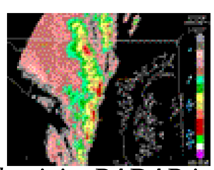


Detective RADAR



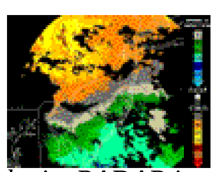
Doppler RADAR can detect the location and intensity of storms (reflectivity), the speed and direction of wind (velocity), and the total accumulation of rainfall (storm total). RADAR systems generate a different image for each.

A reflectivity image shows the location where rain, snow, or other precipitation is falling and how intensely. Meteorologists read a corresponding color key to interpret the reflectivity image. Different colors indicate different intensities of the precipitation.



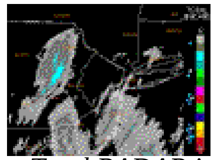
Reflectivity RADAR image

Velocity images reveal the speed and direction of winds. Again, meteorologists use a color key to interpret the velocity image. The color keys are not standard, but on some images warm colors, like red and orange, indicate that winds are blowing away from the RADAR site. Cool colors, like green and blue, indicate that winds are blowing towards the RADAR site. Then, the color key is used to determine the speed of the winds.



Velocity RADAR image

A storm total image shows how much total precipitation has fallen. The corresponding color key allows meteorologists to see quickly the accumulation of rain, snow, or other precipitation.



Storm Total RADAR image

Meteorologists learn how to read RADAR images in order to understand and forecast the many kinds of weather which can be detected with RADAR. RADAR also **detects other objects** in the atmosphere, though, so reading RADAR images takes practice.

MORE

Try Your Own Weather Forecasting

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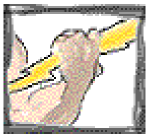


Current Electricity History

Can you remember the first time you ever saw a lightning bolt in a dark, stormy sky? The awesome power of a lightning strike is etched into your memory. Without scientific understanding, lightning is frightening.

Early cultures relied on myth and magic to explain lightning and to ease their fears.The ancient Greeks, for example, believed that the king of all the gods, Zeus, threw lightning down from the heavens to show his anger at the people below. Lightning was his weapon.

As the study of weather science progressed, people stopped thinking of lightning as a punishment from the gods. It wasn't until the 1700s, though, that science really began to understand lightning.

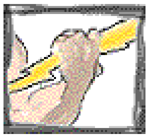
Benjamin Franklin was one of the first lightning scientists. In 1752, he performed his legendary kite experiment. During a thunderstorm, he tied a metal key to the end of a kite string and set his kite flying in the storm's winds. When sparks jumped from the electrified key, he knew that electrical current had travelled from the electrified air above down the kite string to his key. He had suspected that lightning was actually a natural form of electricity. With the experiment, he was able to conclude that lightning was an electrical current.

In the years that followed, scientists learned more and more about lightning. Although there is no completely safe way to avoid a lightning strike, scientists tested theories to provide some protection.

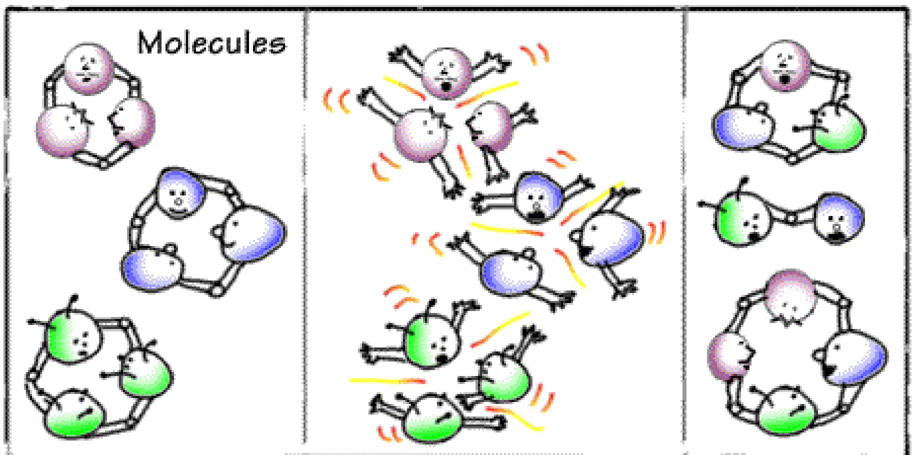
In the 1970s, meteorologists and other scientists developed lightning detection networks. Today, they can track lightning strikes all over the country using the National Lightning Detection Network which uses magnetic sensors and computers to detect when and where lightning strikes the ground. Lightning data is instantly provided to meteorologists for analysis.

Lightning is still frightening because of its ferocious power. Lightning is classified as plasma, the fourth state of matter. So, stay out of its way.

MORE
Sprites and Elves: Lightning's Strange Cousins



Electric Discharge



Opposites attract. That's lightning.

Lightning really is as simple as that. In and around a thunderstorm cloud there are areas of positively charged energy and areas of negatively charged energy. When the oppositely charged areas are near each other, an electrical discharge of energy travels between them. That's lightning.

The cloud areas get their charges as water and ice particles move and interact. Smaller, positively charged particles rise to the top of the cloud, and larger, negatively charged particles gather near the bottom. As soon as the buildup of charge is great enough, the oppositely charged particles attract and discharge their energy as a bolt of lightning.

Watch out below, though, because the excess energy near the bottom of the cloud causes lightning strikes on the ground below. When the electrical charge at the bottom of the thundercloud is strong enough, channels of charged air, called leaders, reach down toward the ground in search of positively charged air. The leaders attract other charged channels, called streamers, up from the ground. When a leader and a streamer meet, the powerful electrical current flows between them, causing the familiar flash of lightning.

Have you ever seen lightning flash from the top of a thunderstorm? Have you ever seen lightning strike horizontally across the sky? Although less common, these are two of the **variety of lightning bolts** you might see.

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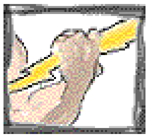


Look For Lightning

Each year, on average, lightning kills about eighty-five Americans and injures many more. Lightning also destroys homes, sparks massive forest fires, and ruins electrical and communications systems, causing millions of dollars worth of damage. Detecting and tracking lightning help save property, and, most importantly, human lives.

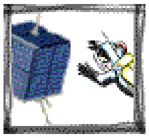
Since the 1970s, meteorologists have used the National Lightning Detection Network to locate and track thunderstorms. Lightning detection images show where lightning has struck the ground, allowing meteorologists to determine where the most severe storm activity is.

Throughout the United States, a system of magnetic sensors and computers form the National Lightning Detection Network. When lightning strikes the ground, the sensors detect the massive electrical discharge. Data from the nearest sensors is combined to locate the exact strike location. Via computer networks, the strikes are recorded on national maps for meteorologists to track thunderstorms.

Thunderstorms and lightning occur most commonly in moist warm climates. On average, in the United States, Central Florida sees the most lightning and the Pacific Northwest sees the least. Central Florida's hot and humid air offers prime conditions for thunderstorm formation, and, therefore, lightning.

On lightning detection images, negative and positive lightning strikes appear differently. Negative cloud-to-ground lightning strikes appear on the images as green stars. Positive strikes appear as pink triangles.

BACK



On The Outside, Looking In

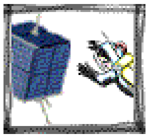
In 1947, an unmanned American rocket carried a camera into outer space and recorded pictures of Earth from space. The pictures showed how the atmosphere appeared from above. Cloud formations were clearly visible. The pictures gave scientists proof that weather observations could be made from space on a regular basis.

In 1960, the first weather satellite was launched into orbit around planet Earth. Called **TIROS**, for **T**elevision **I**nfra**R**ed **O**bservational **S**atellite, it carried a video camera to make regular observations of the atmosphere below. For the first time, meteorologists were able to compare their localized ground-based weather observations with broader pictures of the weather system. Weather forecasting took a dramatic leap forward. After the initial successes, nine more TIROS satellites were put into orbit during the 1960s.

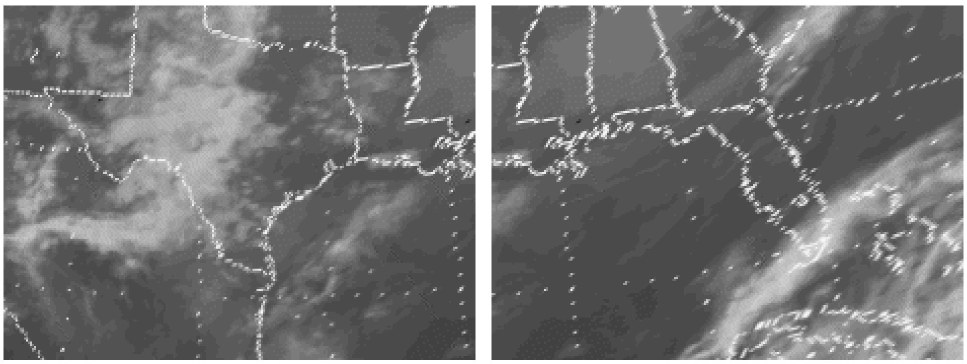
In 1966, the United States placed its first weather satellite in high, geostationary orbit. Called **ATS**, for **A**pplications **T**echnology **S**atellite, the satellite travelled at the same speed the Earth rotates, appearing to remain stationary with respect to the Earth below. From this geostationary orbit location 22,300 miles above the equator, ATS took the first pictures showing a whole hemisphere of the Earth at once. With ATS images, meteorologists saw how clouds moved and storms formed over wide regions.

The development of satellite weather technology had an enormous impact on the field of meteorology. The "big pictures" came into focus, and weather forecasting became more accurate.

BACK



Simple Satellite Science



Weather satellites take "pictures" of the atmosphere below, but not photographs. Sensors on the satellite measure energy waves that radiate and reflect from the Earth's atmosphere below. The energy waves include light waves, infrared waves, and microwaves. The sensors' energy wave data is then sent by radio to powerful computers on Earth. The energy wave patterns are translated by the computers and a corresponding image is generated for meteorologists to interpret. Variations in the energy wave patterns will indicate atmospheric conditions such as cloudiness, temperature, and moisture levels.

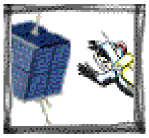
Not all satellites are the same. Some satellites, called geostationary satellites, circle the Earth at a very high orbit so that their speed matches the Earth's rotation. In relation to the Earth below, they appear to remain stationary. From their high point, geostationary satellites provide images of an entire hemisphere at once. Geostationary images allow meteorologists to track the development of large storms, like hurricanes and severe thunderstorms, over wide areas of the atmosphere.

Today, severe weather is observed all around the world using the geostationary satellites that are currently flying high in orbit. The United States has two: "**GOES-East**" and "**GOES-West**." The European Space Agency placed "**Meteostat**" in orbit. Japan has "Himawari," and India has "Insat." Together, these five geostationary satellites form the **G**lobal **A**tmospheric **R**esearch **P**rogram (GARP). Originally proposed by the United Nations, the GARP improved worldwide weather watching.

There are other satellites that make several orbits around Earth per day, passing over both the North and South poles on each orbit. These non-geostationary satellites, called polar-orbiting satellites, are in a low-orbit of only 530 miles above Earth. Every twenty-four hours they pass over the entire Earth's atmosphere as the planet rotates beneath them.

Polar-orbiting satellites were designed to monitor the entire atmosphere, recording precise measurements of the energy that Earth radiates and reflects into space. This data is interpreted by computers to make detailed models and images of atmospheric temperature, moisture level, and ozone layer integrity, as well as clouds.

BACK



Picture Show

Satellites provide several types of images for meteorologists to interpret. To determine cloud cover during the day, meteorologists use **visible images**. Visible images are the most like photographs because they show the sunlight that is reflected from the Earth. On visible images, cloud cover reflects the most sunlight, appearing white against the darker areas of land and ocean.

Meteorologists use **infrared images** to determine the temperature in the atmosphere. This information can then be used to infer cloud cover. Infrared energy radiates from objects on Earth below in relation to the temperature of the objects. The warmer an object, the more infrared radiation it emits. Clouds are usually cooler since they're high in the sky, so they emit less infrared energy than the ground. Satellite sensors measure the amount of infrared energy emitted by the clouds and ground below, and computers interpret the data, generating infrared images for meteorologists to use.

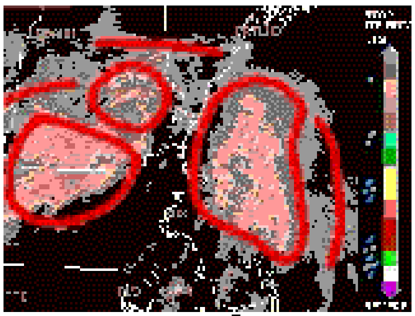
To track the movement of moisture in the atmosphere, meteorologists use **water vapor images** which show the patterns of moisture and dryness. Satellite sensors measure the amount of energy that water vapor molecules emit. Those energy readings reveal patterns of moisture and dryness high in the atmosphere which meteorologists can interpret to track the movement of clouds, precipitation, and even non-cloudy air.

BACK

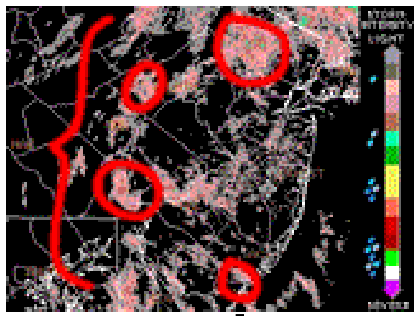
What's The Forecast?

Over time, and with practice, meteorologists learn to interpret RADAR images. Take a look at these reflectivity images for a typical few days and see if you can forecast the weather event that the image reveals. Then, check to see if your forecast was right.

Note: These are only example forecasts for illustration. They are not meant to represent any realtime weather forecasts.



Monday



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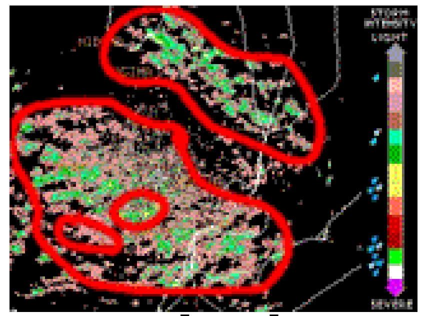

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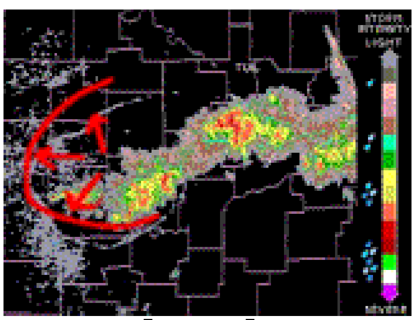
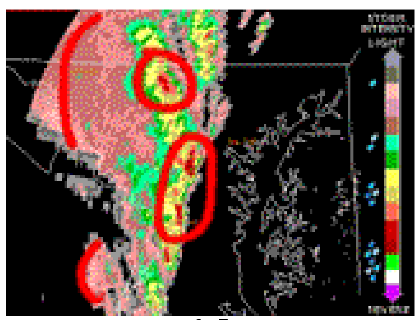
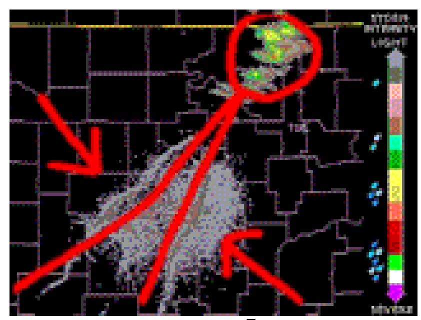


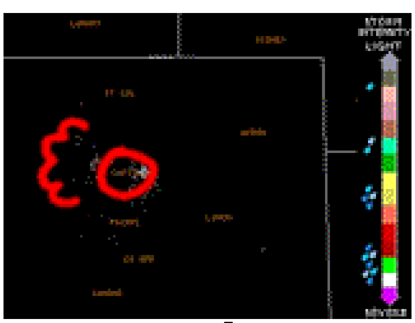
Thursday



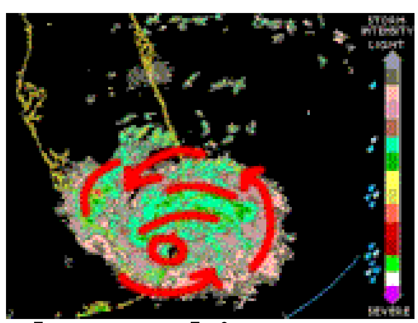
Friday



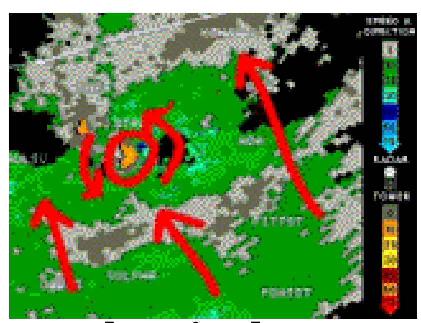
Saturday



Sunday



The Penultimate Day



The Final Day

BACK

WW2010™
University of Illinois

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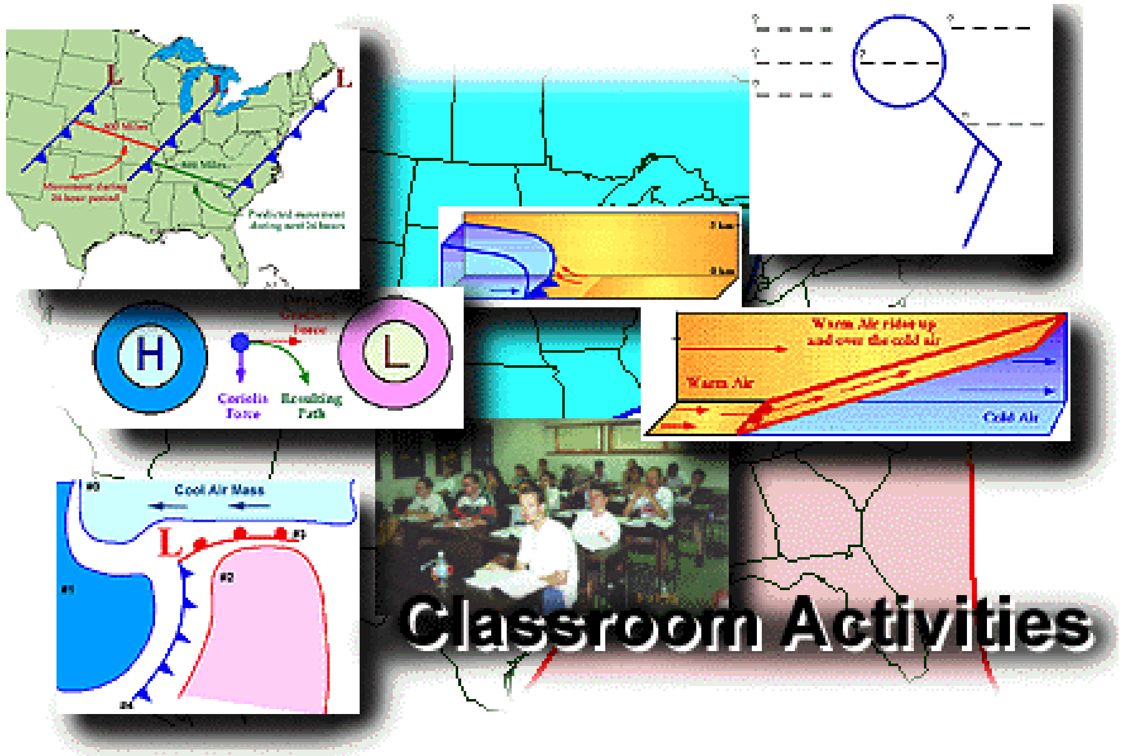

Graphic by: Steven E. Hall

The following classroom activities introduce a variety of fundamental topics in meteorology. All necessary data and instructional resources are accessible from each activity. In addition, each activity is accompanied by a corresponding teacher guide (or answer key). Up to 90 minutes of classroom time may be needed to complete each activity.

Activities

Last Update: 07/12/97

Pressure

Atmospheric pressure, high and low pressure centers, and the pressure gradient force.

Air Masses

Characteristics of air masses that commonly influence weather in the U.S. and how to identify them on weather maps.

Precipitation Along Fronts

The development of precipitation along warm fronts and cold fronts.

Midlatitude Cyclones

Anatomy of midlatitude cyclones and how to identify them on weather maps.

Coordinated Universal Time (UTC)

Converting back and forth between local time and UTC.

Surface Observation Symbols

Interpreting meteorological data from observation symbols displayed on weather maps.

Current Weather Symbols

Interpreting common weather symbols found on weather maps.

Forecasting Temperatures
Influences of cloud cover, wind, snow cover and advection on forecasting temperatures.

Forecasting Precipitation
Useful indicators for predicting the development of precipitation.

The navigation menu (left) for this module is called "Classroom Activities" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Trusting the Forecast

Terms for using data resources. CD-ROM available.
Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

pressure

Tiny Tornado hits LCCC

Laramie County Community College, 1400 E. College Dr., Cheyenne, Wyoming, 82007

A Tiny Tornado

Students in Dr. Kevin Kilty's meteorology class spent a morning building and studying a model tornado.
It is a simple matter to build a model tornado.

All one needs is a

- vacuum cleaner or wet/dry vac
- box fan
- and a block of dry ice.

The box fan on a low setting is positioned at the end of a lab bench about 20 feet from the block of dry ice. It blows air across the bench top which generates shear in the air flow. One might think of the shear as a sheet of vortex threads lying across the bench top and flow down it with the general flow of air.

Meanwhile the vacuum cleaner has its suction end positioned about 6 inches above the block of dry ice. When one of the vortex threads is sucked into the vacuum cleaner, it becomes stretched in length.

By a well known theorem of vortex motion, this causes it to intensify; and causes one end of the intensified thread to attach to the block of dry ice. Now we have a little tornado on the bench top. The tornadoes are short lived. They last only a few seconds.

A video of one such tornado(5 MB) and an article from LCCC's Wingspan are available to download.

The little tornado is violent enough to pick up pieces of frost from the dry ice and throw them about the lab bench."It is really fun to see such a tiny thing become so furious," says Dr. Kilty.

A more detailed and mathematical description of tornado formation and rotation is available.

Henry R. Derr, Instructor, Chemistry/Mathematics
Math, Ag, Science and Health Division
Laramie County Community College
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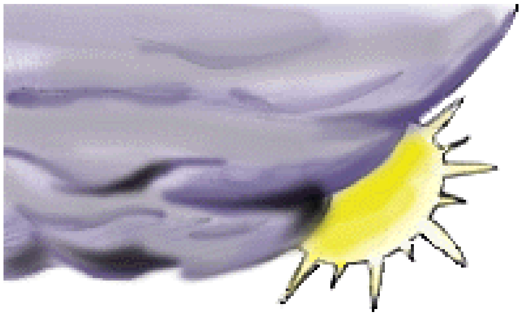
Cheyenne, Wyoming 82007-3299
307-778-1129
hderr@Lccc.cc.wy.us

URL: http://www.science.Lcc.whecn.edu/Physics/Stewart/Tornado.html

- Other Experiments(Cloud Chamber, Laser,...)
- LCCC Engineering Program of Study

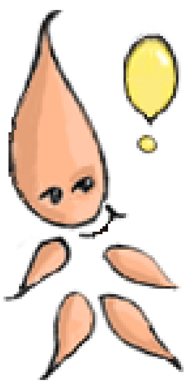


Web Weather for Kids - Experiment!

Make a Tornado!!

Home | Thunderclouds | Lightning | Hearing thunder | Tornadoes

"Tornadoes are born out of large (supercell) thunderstorms that often grow to over 40,000 feet. A column of warm humid air will begin to rise very quickly. Find out what else is needed to make a tornado."



Teacher Tips

Glossary:

Funnel cloud:
A rotating column of air extending from a cloud but not reaching the ground.
<return>

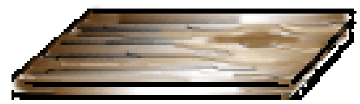
Vortex:
Whirling motion or mass.
<return>

Make a tornado!
Twister in a jar!

Activity #1: Make a tornado

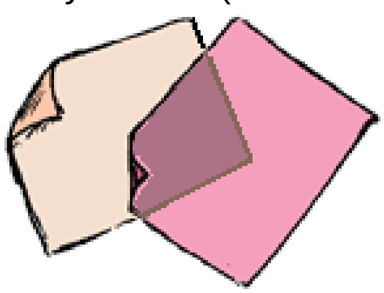
Stuff you need

Piece of wood, 10 x 12 inches

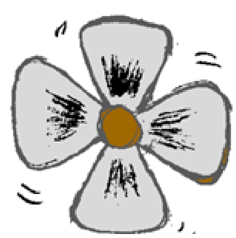


Glue gun

Vinyl sheets (.010" thickness) 9 x 10 inches (2 of them)



Small hand-held fan



Deli dish or cup

Clear plastic plant saucer (7" across). Cut out a hole, 2"

Wind shear:
Any sudden change in wind speed or direction.
<return>

across, in the middle of it

Water

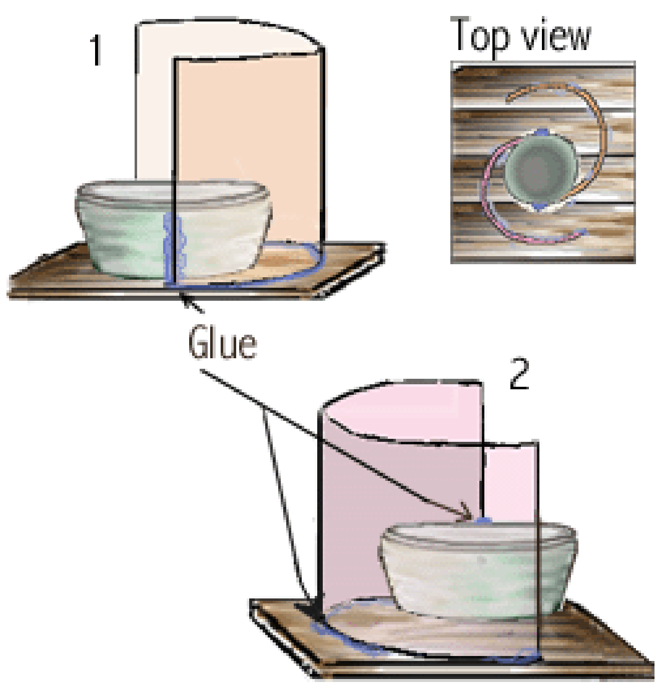
Dry ice

Make it happen

1. Glue the cup in the center of the piece of wood.

2. Glue one of the vinyl sheets onto one side of the cup. Then glue the rest of the sheet in a half circle around but not touching the cup.

3. Glue the second sheet to the opposite side of the cup. Glue the rest of the sheet in a half circle. The two sheets must overlap, but not touch.



4. Pour about half a cup of water in the cup.

5. Using gloves, place a few small pieces of dry ice in the cup.

6. Quickly place the saucer upside down on the top of the two pieces of vinyl.

7. Turn on the fan and place it in the hole facing up to draw the air up.

8. Watch the tornado spin!

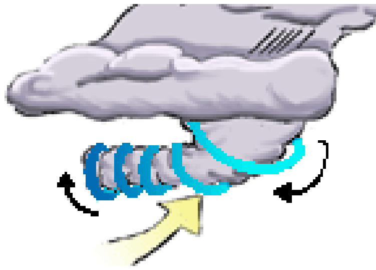
Here are some students who did it too. (Requires an mpeg player like Microsoft ActiveMovie) Did you make the same mistake they did?

Think about it

We've discussed updrafts, but how would the column of air begin to rotate without a huge fan placed on top of the thunderhead?

What's happenin'?

This is not completely understood by scientists, but one way the rotation appears to happen is when winds at two different altitudes blow at two different speeds creating wind shear. For example, a wind at 1000 feet above the surface might blow at 5mph and a wind at 5000 feet might blow at 25mph. This causes a horizontal rotating column.



If this column gets caught in a supercell updraft, the updraft tightens the spin and it speeds up, much like a skater's spin speeds up when the skater pulls in their arms. A funnel cloud is created.

The rain and hail in the thunderstorm cause the funnel to touch down creating a tornado.

Activity #2: Twister in a jar

Stuff you need

8 oz. jar with lid

Water

Vinegar

Clear liquid dish soap

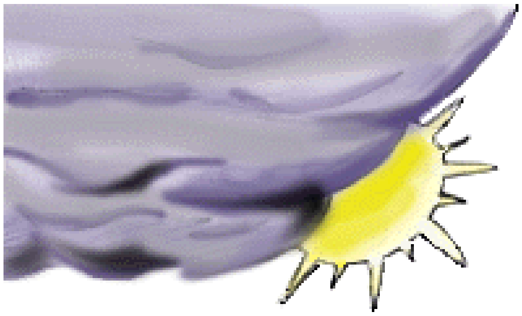
Glitter

Make it happen

1. Fill the jar 3/4 full of water.
2. Put in one teaspoon of vinegar and one teaspoon of dish soap.
3. Sprinkle in a small amount of glitter.
4. Close the lid and twist the jar to see a tornado like a vortex form.

Look here for more information:

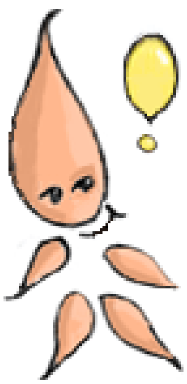
USA Today Weather Page - A Close-up View of Tornadoes



Web Weather for Kids - Experiment!

Make Lightning!!

"Lightening is caused by static electricity in thunderclouds that have built due to convection of warm and cool air masses."



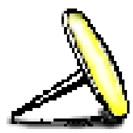
Teacher Tips

Glossary:

Stuff you need

Styrofoam plate

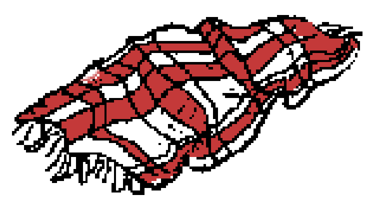
Thumbtack



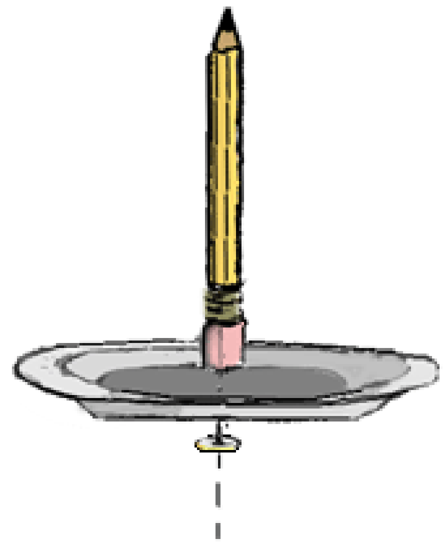
Pencil with new eraser

Aluminum pie pan

Small piece of wool fabric



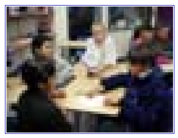
Make it happen



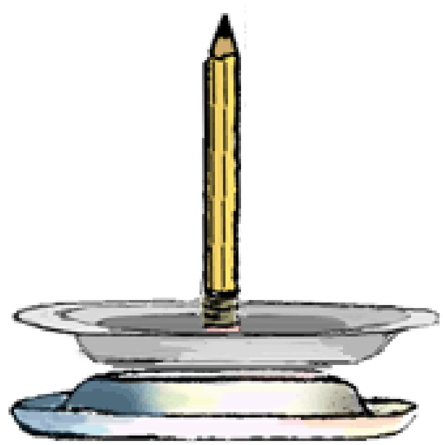
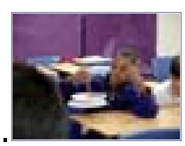
1. Push the thumbtack through the center of the aluminum pie pan from the bottom.

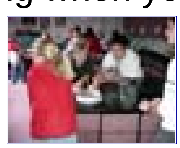
2. Push the eraser end of the pencil into the thumbtack. (The pencil becomes a handle to lift the pan.)

3. Put the styrofoam plate upside-down on a table. Rub the underside of the plate with the wool for one minute. Rub hard and fast like these kids are doing...

  (click on a picture to enlarge it.)

4. Pick up the pie pan using the pencil "handle" and place it on top of the upside-down plate,

 ... like this...  (click on the picture to enlarge it.)

5. Touch the pie pan with your finger. If you don't feel anything when you touched the pan, try rubbing the plate again.  (click on the picture to enlarge it.)

Try turning the lights out before touching the pan. Do you see anything when you touch the pan?


Watch this video clip (you'll need a player that plays mpeg video, like Microsoft ActionMovie) and listen to the excitement after the lights are turned out! The camera doesn't pick up the spark, but the kids sure do!

For extra excitement, get a neon tube (Neon Gas Spectrum Tube, catalog item #60910, available for about $20 from Edmund Scientific, among other places). Hold the neon tube with one hand keeping a finger over one of the ends. Touch the other end to the pie plate.

(Just for fun, check this out. . . )

Think about it

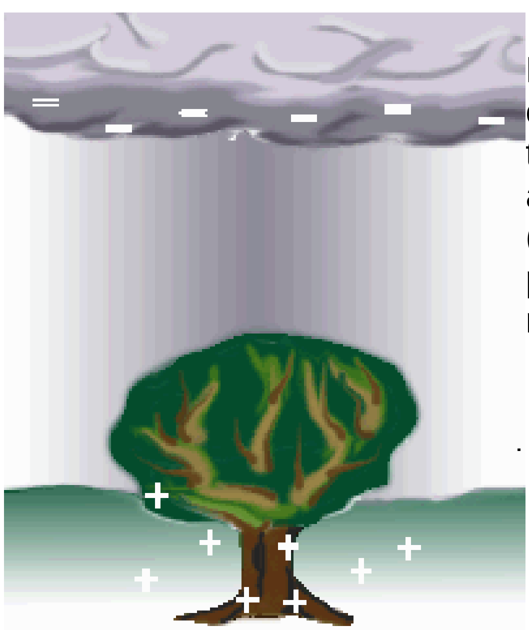
What happened when you touched the metal pie pan?

What caused that?

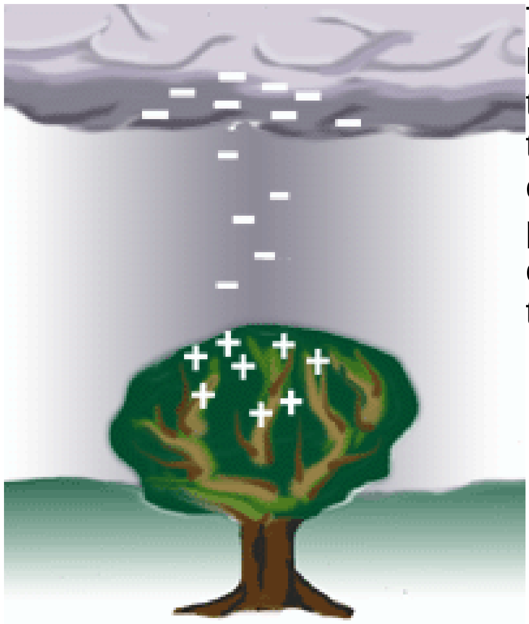
How do you think this experiment relates to the formation of lightning?

Listen to one student's explanation. (Requires an mpeg player like Microsoft's ActiveMovie.)
Does this make sense to you? Why or why not?

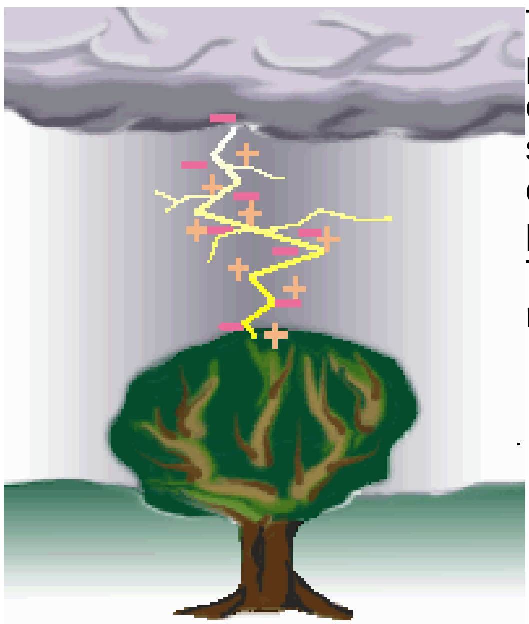
What's happenin'?



It's all about static electricity! Lightning happens when the negative charges (electrons) in the bottom of the cloud (and your finger) are attracted to the positive charges (protons) in the ground (and the pie pan). The resulting spark is like a mini bolt of lightning.



The accumulation of electric charges has to be great enough to overcome the insulating properties of air. When this happens, a stream of negative charges pours down towards a high point where positive charges have clustered due to the pull of the thunderhead.



The connection is made and the protons rush up to meet the electrons. It is at that point that we see lightning and hear thunder. A bolt of lightning heats the air along its path causing it to expand rapidly. Thunder is the sound caused by rapidly expanding air.

Look here for more information:

[USA Today Weather Page - Anatomy of a Lightning Stroke]

[National Lightning Safety Institute]

[Lightning Safety for Outdoor Sports Events]

K-12 Education

Because climate, pollution, and the environment are part of the everyday awareness of young people, the atmospheric sciences offer an unusual opportunity to teach science in engaging, relevant ways. UCAR's K-12 education programs target both students and educators.

PROGRAMS AT UCAR

About the Sun
A basic guide to all things solar, produced by the NCAR High Altitude Observatory

Climate & Global Change Geoscience Education Workshop
The goal of the workshop is to provide standards-relevant science content, training on easy to implement inquiry-based classroom activities, and a broad overview of the geosciences in the context of climate and global change to educator-leaders who are teaching sciences at the middle and high school levels.

Colorado Computational Science Fair
High-school competition sponsored by NCAR and Colorado State University

EXPLORE the Atmospheric Sciences
Newsletter of informal science education of UCAR and NCAR

Global Weather Services in 2025
A vision of future weather services

Greenie Environmental Stewardship Awards
Awards recognize special Earth Day projects in the areas of recycling, composting, environmental education, energy, conservation, sustainability, and air and water quality

Hurricane Strike!
A multimedia learning package created by COMET®, Hurricane Strike! is aimed primarily at middle school students. It integrates disaster safety and preparedness with science instruction, providing an engaging interactive learning environment. It also dovetails with science and safety content in the American Red Cross Masters of Disaster curriculum. If you have a T1/DSL line (or equivalent), you can access Hurricane Strike! directly from the web. If you have a slower connection, you should download the module to your hard drive and run it locally.

LEARN: Atmospheric Science Explorers
Enhancement program for science teachers

Learning about Science Easily and Readily Series (LASERS)
Lectures and brochures on atmospheric research topics
Children of the Tropics: El Nino and La Nina
Constant as the Sun? A Look at Solar Variability

Modeling in the Geosciences Workshop NEW!
Environmental concerns are becoming increasingly pressing and complex, requiring citizens to have much better understanding of Earth systems and processes, and the methods scientists use to unravel this complexity to develop an understanding of the underlying systems. Models are an important tool used by scientists to study and better understand complex systems. To increase teacher understanding of models and their utility in Earth System Science studies, NASA s Earth System Enterprise is sponsoring the Modeling in the Geosciences Workshop (MGW) for middle and high school teachers that will explore Earth System Modeling concepts that are relevant for classroom use.

Roberts Forum
Illustrated talks on current research regarding the atmospheric and related sciences

Science Now
Newsletter for science teachers published by UCAR and SIRS, Inc., an educational publisher

Skymath

Mathematics curriculum using real-time weather data

Unidata
Sites Using Unidata Systems for K-12 and General Education Outreach

Web Weather for Kids
Hands-on activities for teaching atmospheric sciences

Windows to the Universe
A fun and different Web site about the Earth and Space sciences

PROGRAMS AT UCAR MEMBER AND AFFILIATE INSTITUTIONS

University of Arizona
K-12 Geoscience Education

University of California, Irvine
UCI Science Education Programs Office

University of Colorado, Boulder

Florida State University
Direct Readout Services for the K-12 Community - Florida EXPLORES!

Harvard University
Technical Educational Resource Center Global Laboratory

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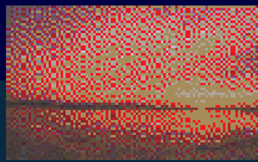

Weather Folklore

Welcome To Weather World's Huge Collection Of Weather Folklore And Weather Wits!

Weather World welcomes you to its Weather Folklore page. Here, you will find over 200 weather folklore sayings to help you forecast with a funny touch. Also, you will find WeatherWits, yes, WeatherWits. These are simply weather jokes with an attitude. Each month there will be five new WeatherWits on this page. If you can come up with a good WeatherWit, send it to Weather World at the e-mail prompt at the bottom of this page. Your name and e-mail address will be included directly under your WeatherWit! If your Weather Wit is really funny, it will be included in the Funniest WeatherWit section. The WeatherWits that you'll see below are provided by Norm Dvoskin, a weather anchor for News 12, Long Island. He is from Melville, NY and has written a book called Weather Wit. If you would like info on ordering a copy of his book, then e-mail Weather World for more information. Direct your message to Clayton Stiver.

General Weather Folklors

-
- **Horses run fast before a violent storm or before windy conditions.**
- **Pigs gather leaves and straw before a storm.**
- **Flowers close up before a storm.**
- **If the bull leads the cows to pasture, expect rain; if the cows precede the bull, the weather will be uncertain.**
- **Expect rain and maybe severe weather when dogs eat grass. (This almost always happens before we have a major oubreak of tornadoes)**
- **Wolves always howl more before a storm.**
- **When the rooster goes crowing to bed, he will rise with a watery head.**
- **Ants are busy, gnats bite, crickets sing louder then usual spiders come down from their webs, and flies gather in houses just before rain and possible severe storms.**
- **Evening red and morning gray Are sure signs of a fine day.**
- **Evening gray and morning red, put on your hat or you'll wet your head.**
- **When small clouds join and thickne, expect rain.**
- **Dandelion blossoms close before a storm.**

- **If autumn leaves are slow to fall, prepare for a cold winter..**
- **When the leaves of trees turn over, it foretells windy conditions and possible severe weather**
- **Redbirds or Blubirds chatter when it's going to rain**
- **Birds on a telephone wire indicate the coming of rain.**
- **Before a storm, cows will lie down and refuse to go out to pasture.**
- **When spiders weave their webs by Noon, fine weather is coming soon.**
  If wasps build their nests high, the winter will be long and harsh.
- **When it is evening you say, "It will be fair, for the sky is red." And in the morning, "It will be stormy today, for the sky is red and threatening."**
  Matthew 16:2
- **It will be a cold, snowy winter if:**
- **-Squirrels accumulate huge stores of nuts.**
- **-Beavers build heavier lodges than usual.**
- **-Hair on bears and horses is thick early in season.**
- **-the breastbone of a fresh-Cooked turkey is dark purple.**
- **A severe summer denotes a windy autumn;**
- **A windy winter a rainy spring;**
- **A rainy spring a severe summer;**
- **A severe summer a windy autumn;**
- **A month that comes in good, goes out bad.**
- **A warm christmas,**
- **A Cold Easter.**
- **The sky turns green in a storm when there is hail.**
- **A veering wind will clear the sky,**
- **A backing wind says storms are nigh.**
- **When you look out your window and see your Dogs jumping around and ducking Its a sign that its hailing.**
- **When dogs in your house start looking paranoid scitso frenique expect very heavy sleet for 5 hours.**

Tips for seeing what the Humidity and temperature is.

-
- *** To find out what the humidity is.**
  Get a ruler, hold it up in the air, lined up with a Jet contraill, Make sure that it's at the Start or at the End of the contrail.
  After you have done so. move the messuring stick up the contrail.
  In other words mesure the Contrail, By 12"
  For Example: 12" + 12" + 12" + 12" = 48" So that would be 12" 4 times, times 10

**So 4x10 = 40 and so on.
If the conrail is 58" long than that would be 12" + 12" + 12" + 12" + 6" = 53"
That would be calculated as 4.5 like 10 = 45 = 45% RH**

- **Put a pine cone outside where you can observe
it from time to time. How does it change when the humidity increases?
It closes up in moist weather to protect the seeds..**
- **Using A cricket is a great thermometer!!
In the evening when crickets are in the cool grass, count the number of chirps they make in 14 seconds that will be the temperature in their location (the temperature may be different where you are standing)..**
- **Warm summer means a cold winter, a dry spring means ample summer rainfall;
a windy autumn is followed by a mild winter.**
- **The first frost in autumn will be exactly six months after the first thunderstorm of the spring.**
- **Using Woolly Bears to predict the winter season...
Folklore says that if the brown stripe is wider than the black stripes, the winter will be long and
harsh.**

Tips for your lawn..

-
- **Here Is a little tip for when your thinking about Watering your garden this summer!!!
It will save you time and Money!!
It is more ifficient to water your lawn in the evening than in the afternoon
On a warm day, up to 50% of the water is lost to evaporation when the sun is shining overhead!!
also, sometimes when you water while the sun is over head, it will kill your flowers.
But the bad thing about watering your garden in the evening is, when the sun is not out the water
cant evaporate as fast, thus the water remains on the grass overnight and it mildews and kills your
grass.**

Tips for forecasting.

-
- **Get a rock from somewhere, and place it somewhere like in your yard or something!
Thats all you have to do, and your ready for forecasting!!!!!
If you dont want to use a rock, you can use a horse, works just as well!!!**
- **If it's dry ------Weather's Clear**
- **If it's wet -----It's Raining**
- **If its white ---It's Snowing**

- **If it's gone ---Tornado**

Short RangeWeather Folklors

-
- **If the goose honks high, fair weather;**
- **If the goose honks low, foul weather.**
- **The low flight of rooks indicates rain.**
- **Birds flying low, Expect rain and a blow**
- **If the lark flies high, Expect fair weather.**
- **When swallows fleet soar high and sport in the air, He told us that the welkin would be clear.**
- **Wild geese fly high in pleasant weather And fly low in bad weather.**
- **Everything is lovely when the goose honks high.**
- **If the rooster crows on going to bed, you may rise with a watery head.**
- **If the raven crows, expect rain.**
- **When geese cackle, it will rain.**
- **When ducks quack loudly, it's a sign of rain.**
- **The hooting of the owl brings rain.**
- **If the sparrow makes a lot of noise, rain will follow.**
- **When parrots whistle, expect rain.**
- **Fish bite best before a rain.**
- **When fish break water and bite eagerly, expect rain.**
- **When porpoises sport and play, there will be a storm.**
- **Trout jump high When a rain is nigh.**
- **The crab his briny home forsakes, And srives on land to a roam.**
- **Bubbles over calm beds of water means rain is coming.**
- **Marshes give off an eerie light before a rain.**
- **Wells give murky water before a storm.**
- **Look for foam on the river before a rain.**
- **When bubbles are rising on the surface of coffee and they hold together, good weather is coming; If the bubbles break up, weather you don't need is coming.**
- **Underground miners can smell rain coming.**
- **When ditches and ponds Offend the nose, Look for rain And stormy blows.**
- **When boiling water more rapidly vanishes, expect rain.**
- **If pavements appear rusty, rain will follow.**
- **When the glass falls low, Prepare for a blow; When the glass is high, Let your kites fly.**

- **In the winter, a heavy snow is predicted if the barometer falls and the temperature rises.**
- **When the wind backls, and the weather galss falls, Then be on your guard against rain and squalls.**
- **If cirrus clouds form in weather with a falling barometer, it is almost sure to rain.**
- **A summer thunderstorm that does not depress the barometer will be very local and of little consequence.**
- **Spings start to flow just before a rain.**
- **Sap from the maple tree flows faster before a rain shower.**
- **Water rising in springs and wells indicates rain.**
- **Many springs that have gone dry will have a good flow of water before rain.**
- **Wells gurgle and yield muddy water before a storm.**
- **Soot falls down before a rain.**
- **If burning coals stick to the bottom of a pot, it is the sign of a tempest.**
- **Fires burning paler than ushual and murmuring within are significant of storms.**
- **Burning wood pops more before rain and snow.**
- **The katydid's song gives the following temperatures:**

- **Kay-tee--did it-----------78F**

- **Kay-tee--didn't----------74F**

- **Kay-tee--did--------------70F**

- **Kate-Didn't----------------66F**

- **Kate-tee--------------------62F**

- **Kate--------------------------58F**

- **Cockroaches are more active before a storm.**
- **Locusts sing when the air is hot and dry.**
- **Ants are very busy, gnats bite; Crickets are lively, spiders leave their nest; And flies gather in houses before a rain.**
- **Open crocus, warm weather; Closed crocus, cold weather.**
- **Tulips open their blossoms when the temperature rises, they close again when the temperature falls.**
- **The daisy shuts it's eye before rain.**
- **If the marigold should open at six or seven in the morning and not close until four in the**

afternoon, we may reckon on settled weather.

- **When pipes smell stronger, it's going to rain.**
- **If the perfume of flowers is unusually preceptible, Expect rain.**
- **Flowers smell best just before a rain.**
- **When ditches and ponds offend the nose, Look for rain and stormy blows.**
- **If a dog pulls his feet up high while walking,**
  A change in the weather is coming.
- **Cats scratch a post before wind, Wash their faces before a rain, And sit with backs to the fire before snow.**
- **Cats with their tails up and hair aparently electrified indicate appproaching wind.**
- **When spirders webs in air do fly, The spell will soon be very dry.**
- **If garden spiders forsake their webs, it indicates rain.**
- **If spiders are many aand spinning their websm The spell will soon be very dry.**
- **Spiders enlarge abd repair their webs before bad weather.**
- **A reddish sun has water in his eye; before long you won't be dry.**
- **When the sun sets bright and clear, An easterly wind you need not fear.**
- **Clouds on the setting sun's brow indicate rain.**
- **Evening red and morning gray; A good sign for a fair day.**
- **When the sun sets unhappily with a red veiled face; Then will the morning be angry with wind and storm.**
- **A red evening and a gray morning sets the pilgrim walking.**
- **And evening red, and a morning gray, sets the traveler on his way;**
  but an evening gray and a morning red, put on your hat, you'll wet your head.
- **If the sun in red should set, the next day surely will be wet; if the sun should set in gray, the next will be a fair day.**
- **An evening gray, and a morning red, makes the shepherd hang his head.**
  When walls are wet, expect some rain.
- **If metal lates and dishes sweat, it is a sign of rain.**
- **Quarries of stone and slate indicate rain by moist exhaltation from the stone.**
- **When stones sweat, rain you'll get.**
- **Pale moon rains,**
- **Red moon blows;**
- **White moon neiter rains or blows.**
- **The moon her face be red, of water she speaks.**
- **If the moon rises clear, expect fair weather.**
- **When the moon rises red and appears large, with clouds, expect rain in twelve hours.**
- **When the moon is darkest near the horizon, expect rain.**
- **If salt is sticky, and gains in weight; it will rain before too late.**
- **When cheese salt is soft, expect rain.**
- **Tobacco gets moist before a rain.**

- **Oily floors quite slippery get before the rain makeseverything wet.**
- **If there is dew on the grass in the morning, fair weather.**
- **When dew is on the grass, rain will never come to pass.**
- **Mist rising from the pond, fair weather tomorrow.**
- **Clear moon, frost soon.**
- **When mountain moss is soft and limpid, expect rain.**
- **When corn fodder stands all dry and crisp, go on your outing, there's no great risk.**
- **Doors and drawers stick before a rain.**
- **When ropes are tight it's going to rain;**

  When weather's fair, they're slack again.
- **Knots get tighter before a rain.**

  Ropes shorten before a rain.
- **When locks turn damp in the scalp house, it will surely rain.**
- **Guitar strings shorten before a rain.**
- **Dandelion blossoms close before a rain.**
- **When the milkweed closes its pod, expect rain.**
- **The ppitcher plant opens wider before a rain.**
- **Chickweeds close their leaves before a rain.**
- **Closed is the pinkeyed pimpernel before rain.**
- **When corn fodder is crisp, fair weather; When corn fodder is limp, rain is coming.**
- **If smoke falls to the ground, it is likely to rain.**
- **Campfires are more smky before a rain.**
- **The factory smoke stack is more of a nuisance before a rain.**
- **Frogs crpal before a rain; But in the sun are quiet again.**
- **If toads apear in large numbers, expect rain.**
- **If frogs make a noise at the time of cold rain, warm dry weather will follow.**
- **If many earthworms appear, rain will follow.**
- **If you see toadstools in the morning, expect rain by evening.**
- **When frots jump across the road, they are looking for rain.**
- **Dead branches falling calm weather indicates rain.**
- **If cumulus clouds are smaller at sunset than at noon, expect fair weather.**
- **When cumulus clouds become heaped in leeward during a strong wind at sunset, thunder may be expected during the night.**
- **If wooly fleeces spread the heavenly way, be sure no rain distrubs the summer day.**
- **When clouds sink below the hills, foul weather; When clouds rise above the hills, fair weather.**
- **After back clouds, fair weather.**
- **If cloudy and it soon decreases, certain fair weather.**
- **A round-topped cloud and flattened base, carries rainfall in its face.**
- **When moutains and cliffs in the clouds appear, some sudden and violent showers apppear.**

- **Long foretold, long last Short notice, soon passed.**
- **Enough blue sky in the Northwest to make a pair of dutchman's breeches is a sign of approaching fair weather.**
- **When clouds are upon the hills, they'll come down by the mills.**
- **When lookout mountain has its cap on, it will rain in six hours.**
- **Clouds upon the hills, if rising, do not bring rain, if falling, rain follows.**
- **If clouds rise in heaps of white, soon will the country of the corn priests be pierced with arrows of rain.**
- **Cumulus clouds in a clear blue sky, it will likely rain.**
- **Sunshiney shower last half an hour.**
- **Clouds small and round like a dapply-gray, with north wind, fair for a day.**
- **The higher the clouds, the fairer the weather.**
- **When smoke rises but not too high, clouds won't grow and you'll kee dry.**
- **Mackerel skies and mares' tails**

  Make tall ships carry low sails.

WeatherWits

- **Barbecue Season - When you love the grate outdoors.**
- **Favorable Launch Weather - A good orbitunity.**
- **International Date Line - One of those 1-900 numbers.**
- **Morning Showers - Drench toast.**
- **Weather Forecaster - A person to whom one and one is two ... probably.**

This Month's Funniest WeatherWit

- **My favorite TV weatherman just got married. He said, he was happy today but would be taking things four days at a time.**

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teacher pages **Exploring the Environment** modules & activities

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Musical Meteorology

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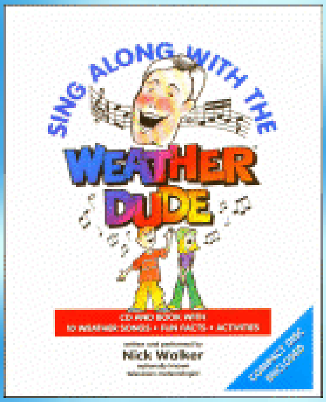

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- Lyrics to "That's the Way Winds Blow" (Audio)
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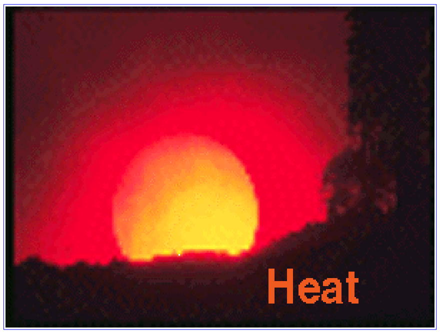

Hazards Support Activities

National Oceanic and Atmospheric Administration

NOAA Technical Memorandum NWS SR-145

A COMPREHENSIVE GLOSSARY OF WEATHER TERMS FOR STORM SPOTTERS

Michael Branick
NOAA/WFO Norman

Contents

Introduction to the First Edition

This glossary contains weather-related terms that may be either heard or used by severe local storm spotters or spotter groups. Its purposes are 1) to achieve some level of standardization in the definitions of the terms that are used, and 2) provide a reference from which the meanings of any terms, especially the lesser-used ones, can be found. The idea is to allow smooth and effective communication between storm spotters and forecasters, and vice versa. This is an important necessity within the severe weather warning program. Despite advances in warning and forecasting techniques (e.g., Doppler radar), the human eye will always be a vital part of any effective warning system. *Storm spotters are, and always will be, an indispensable part of the severe local storm warning program.*

A complete list of terms probably is impossible to arrive at, but this list is as comprehensive as possible. Certainly it is not necessary for every spotter to know the meaning of *every* term contained herein. In this sense, the glossary serves as a reference. In fact, many of the terms may never be heard at all; they are included here just in case, someday, they are. (By the way, inclusion of a term in this glossary does *not* give license to use it freely in radio or phone communication. Use of technical terms should be kept to a minimum.) But there are some terms for which the meanings are both important and specific. The important ones are preceded by asterisks; all spotters should be familiar with the definitions of these terms before taking an active role in any spotter group.

I have written the definitions in what hopefully passes as "layman's terms." They are written to be easily understood by the storm spotter, regardless of his or her meteorological background. At times I have sacrificed technical purity for simplicity, and the result may prompt a few moans from the technical purists. So be it; this glossary wasn't written for them. Many of the terms are so closely interrelated, though, that it becomes necessary to "cross-reference;" that is, to use one or more terms in the definition of another. In this glossary, all terms that are hyperlinked within a definition are terms that are defined themselves elsewhere.

The glossary is a culmination of an effort which began in the spring of 1991. Many individuals with considerable experience in severe storm research and storm spotting (or chasing) contributed to the glossary. Because of the many comments offered by these individuals, there was disagreement on the descriptions of some terms. Those terms that were identified as such as being somewhat more controversial are handled in the text by inclusion of a second paragraph in the description, which discusses any cautions or controversy regarding the use of the term.

One last word: Storm spotting is vital, but also can be very dangerous. *No one should attempt storm spotting without first obtaining the proper training!* This glossary in itself is not to be considered sufficient training material to qualify oneself as a spotter. Further training, usually provided by the National Weather Service, must be obtained through local agencies (usually Emergency Management) before one can be certified as a storm spotter. There is also something to be said for the so-called storm chasers, who chase storms mainly for the thrill of it (and as such are *not* spotters). Chasers of all levels of background and experience will no doubt find this glossary useful or at least interesting. But while I commend their enthusiasm, I must emphasize that the glossary does *not* condone storm chasing as a leisure activity - especially for the unprepared. Proper training and foreknowledge of the dangers are required of everyone who meets face to face with severe thunderstorms - regardless of the reason for the encounter.

Michael L. Branick
National Weather Service, Experimental Forecast Facility
Norman, Oklahoma
June 1992

Introduction to the Second Edition

Based on feedback since its introduction, the "Spotter Glossary" (as this glossary has come to be known) has achieved considerable popularity among spotters - at least in the southern Plains region of "Tornado Alley." In this region, spotters actively seek as much information as possible when assessing severe weather potential on a given day. The information available often includes products which contain technical terms which are more esoteric to operational meteorology, and less familiar to those who do not pursue meteorology as a living. Examples include forecast discussions issued by local National Weather Service offices, and convective outlooks and discussions issued by the Storm Prediction Center (SPC, formerly known as SELS/NSSFC).

The question arises as to just how far one should go into the technical realm of operational meteorology when compiling a glossary like this for storm spotters. The dilemma is thus: The spotters' thirst for knowledge is admirable, but how much of the technical jargon *really* needs to be understood by spotters in the field?

I certainly do not want to turn the glossary into a meteorological textbook for spotters (or anyone else). That is not its purpose. Spotters have a vital role in the warning program, as do forecasters. And while interaction between them is an absolute necessity, one must be careful not to allow the two functions to overlap so much that we end up with spotters routinely generating their own forecasts and disregarding those made by the forecasters. That is not the spotter's function; spotting is.

On the other hand, I applaud the spotters who demonstrate a genuine interest in understanding the atmosphere that they are trained to observe. If they are interested in understanding what the forecaster is talking about when he/she refers to, say, "isentropic lift" or a "right-rear quad of an upper jet max", then they should have a place to find at least a general description of the unfamiliar terms. This is preferable to saying, "you don't need to know that." And those who are "turned off" by the technical jargon need not look into it further.

I have attempted to "strike a happy medium" by adding a number of meteorological terms and phrases to this edition, accompanied by general definitions. New terms to this addition, many of which were added at the suggestion of spotters, are listed below. They at least should help the spotter to understand a little more about why a particular feature is important to severe weather forecasting. Those who wish to pursue a particular issue beyond what is covered in this glossary are directed to the local library or the nearest university meteorology department.

Note that a similar dilemma arose in the first edition, regarding the inclusion of "slang" terms that are used most often by storm chasers. Again I distinguish between chasers and spotters - the former tending to observe storms for their own gratification, the latter tending to do so more for the needs of the community. The "slang" dilemma continues, but as with the first edition I have gone ahead and included many slang terms that I consider appropriate for spotter use. That means that terms like "Caprock delight" (which may be anything *but* a delight to residents in the path of one) will not be found herein, but that slang terms that are more-or-less universally accepted, such as "bear's cage" or "anvil crawlers," probably will appear.

Finally, modernization of the National Weather Service requires a few updates. NMC now is NCEP; SELS now is SPC. The Eta and RUC models are now here. And NEXRAD is no longer the NEXt-generation weather RADar, but is here now. The latest changes have been incorporated accordingly into the glossary.

Mike Branick
September 1996

List of words added in the second edition

Glossary

Quick Alpha Access:
A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

-A-

AC - Convective outlook issued by the SPC. Abbreviation for **A**nticipated **C**onvection; the term originates from the header coding [ACUS1] of the transmitted product. See SWODY1, SWODY2.

ACCAS (usually pronounced ACK-kis) - **A**lto**C**umulus **CAS**tellanus; mid-level clouds (bases generally 8 to 15 thousand feet), of which at least a fraction of their upper parts show cumulus-type development. These clouds often are taller than they are wide, giving them a turret-shaped appearance. ACCAS clouds are a sign of instability aloft, and may precede the rapid development of thunderstorms.

Accessory Cloud - A cloud which is dependent on a larger cloud system for development and continuance. Roll clouds, shelf clouds, and wall clouds are examples of accessory clouds.

Advection - Transport of an atmospheric property by the wind. See cold advection, moisture advection, warm advection.

Air-mass Thunderstorm - Generally, a thunderstorm not associated with a front or other type of synoptic-scale forcing mechanism. Air mass thunderstorms typically are associated with warm, humid air in the summer months; they develop during the afternoon in response to insolation, and dissipate rather quickly after sunset. They generally are less likely to be severe than other types of thunderstorms, but they still are capable of producing downbursts, brief heavy rain, and (in extreme cases) hail over 3/4 inch in diameter. See popcorn convection.

Since all thunderstorms are associated with some type of forcing mechanism, synoptic-scale or otherwise, the existence of true air-mass thunderstorms is debatable. Therefore the term is somewhat controversial and should be used with discretion.

Algorithm - A computer program (or set of programs) which is designed to systematically solve a certain kind of problem. WSR-88D radars (NEXRAD) employ algorithms to analyze radar data and automatically determine storm motion, probability of hail, VIL, accumulated rainfall, and several other parameters.

Anticyclonic Rotation - Rotation in the opposite sense as the Earth's rotation, i.e., clockwise in the Northern Hemisphere as would be seen from above. The opposite of cyclonic rotation.

Anvil - The flat, spreading top of a Cb (cumulonimbus), often shaped like an anvil. Thunderstorm anvils may spread hundreds of miles downwind from the thunderstorm itself, and sometimes may spread upwind (see back-sheared anvil).

Anvil Crawler - [Slang], a lightning discharge occurring within the anvil of a thunderstorm, characterized by one or more channels that appear to crawl along the underside of the anvil. They typically appear during the weakening or dissipating stage of the parent thunderstorm, or during an active MCS.

Anvil Dome - A large overshooting top or penetrating top.

Anvil Rollover - [Slang], a circular or semicircular lip of clouds along the underside of the upwind part of a back-sheared anvil, indicating rapid expansion of the anvil. See cumuliform anvil, knuckles, mushroom.

Anvil Zits - [Slang], frequent (often continuous or nearly continuous), localized lightning discharges occurring from within a thunderstorm anvil.

AP - Anomalous Propagation. Radar term for false (non-precipitation) echoes resulting from nonstandard propagation of the radar beam under certain atmospheric conditions.

Approaching (severe levels) - A thunderstorm which contains winds of 35 to 49 knots (40 to 57 mph), or hail 1/2 inch or larger but less than 3/4 inch in diameter. See severe thunderstorm.

Arcus - A low, horizontal cloud formation associated with the leading edge of thunderstorm outflow (i.e., the gust front). Roll clouds and shelf clouds both are types of arcus clouds.

AVN - AViatioN model; one of the operational forecast models run at NCEP. The AVN is run four times daily, at 0000, 0600, 1200, and 1800 GMT. As of fall 1996, forecast output was available operationally out to 120 hours only from the 0000 and 1200 runs. At 0600 and 1800, the model is run only out to 72 hours.

-B-

Back-building Thunderstorm - A thunderstorm in which new development takes place on the upwind side (usually the west or southwest side), such that the storm seems to remain stationary or propagate in a backward direction.

Backing Winds - Winds which shift in a counterclockwise direction with time at a given location (e.g. from southerly to southeasterly), or change direction in a counterclockwise sense with height (e.g. westerly at the surface but becoming more southerly aloft). The opposite of veering winds.

In storm spotting, a backing wind usually refers to the turning of a south or southwest surface wind with time to a more east or southeasterly direction. Backing of the surface wind can increase the potential for tornado development by increasing the directional shear at low levels.

Back-sheared Anvil - [Slang], a thunderstorm anvil which spreads upwind, against the flow aloft. A back-sheared anvil often implies a very strong updraft and a high severe weather potential. (See Fig. 7, supercell.)

Barber Pole - [Slang], a thunderstorm updraft with a visual appearance including cloud striations that are curved in a manner similar to the stripes of a barber pole. The structure typically is most pronounced on the leading edge of the updraft, while drier air from the rear flank downdraft often erodes the clouds on the trailing side of the updraft.

Baroclinic Zone - A region in which a temperature gradient exists on a constant pressure surface. Baroclinic zones are favored areas for strengthening and weakening systems; barotropic systems, on the other hand, do not exhibit significant changes in intensity. Also, wind shear is characteristic of a baroclinic zone.

Barotropic System - A weather system in which temperature and pressure surfaces are coincident, i.e., temperature is uniform (no temperature gradient) on a constant pressure surface. Barotropic systems are characterized by a lack of wind shear, and thus are generally unfavorable areas for severe thunderstorm development. See baroclinic zone.

Usually, in operational meteorology, references to barotropic systems refer to *equivalent* barotropic systems - systems in which temperature gradients exist, but are parallel to height gradients on a constant pressure surface. In such systems, height contours and isotherms are parallel everywhere, and winds do not change direction with height.

As a rule, a true equivalent barotropic system can never be achieved in the real atmosphere. While some systems (such as closed lows or cutoff lows) may reach a state that is close to equivalent barotropic, the term barotropic system usually is used in a relative sense to describe systems that are really only close to being equivalent barotropic, i.e., isotherms and height contours are nearly parallel everywhere and directional wind shear is weak.

Bear's Cage - [Slang], a region of storm-scale rotation, in a thunderstorm, which is wrapped in heavy precipitation. This area often coincides with a radar hook echo and/or mesocyclone, especially one associated with an HP storm.

The term reflects the danger involved in observing such an area visually, which must be done at close range in low visibility.

Beaver('s) Tail - [Slang], a particular type of inflow band with a relatively broad, flat appearance suggestive of a beaver's tail. It is attached to a supercell's general updraft and is oriented roughly parallel to the pseudo-warm front, i.e., usually east to west or southeast to northwest. As with any inflow band, cloud elements move toward the updraft, i.e., toward the west or northwest. Its size and shape change as the strength of the inflow changes. See also inflow stinger.

Spotters should note the distinction between a beaver tail and a tail cloud. A "true" tail cloud typically is attached to the wall cloud and has a cloud base at about the same level as the wall cloud itself. A beaver tail, on the other hand, is not attached to the wall cloud and has a cloud base at about the same height as the updraft base (which by definition is higher than the wall cloud). Unlike the beaver tail, the tail cloud forms from air that is flowing from the storm's main precipitation cascade region (or outflow region). Thus, it can be oriented at a large angle to the pseudo-warm front.

Blue Watch (or Blue Box) - [Slang], a severe thunderstorm watch.

Boundary Layer - In general, a layer of air adjacent to a bounding surface. Specifically, the term most often refers to the *planetary boundary layer*, which is the layer within which the effects of friction are significant. For the earth, this layer is considered to be roughly the lowest one or two kilometers of the atmosphere. It is within this layer that temperatures are most strongly affected by daytime insolation and nighttime radiational cooling, and winds are affected by friction with the earth's surface. The effects of friction die out gradually with height, so the "top" of this layer cannot be defined exactly.

There is a thin layer immediately above the earth's surface known as the *surface boundary layer* (or simply the surface layer). This layer is only a part of the planetary boundary layer, and represents the layer within which friction effects are more or less constant throughout (as opposed to decreasing with height, as they do above it). The surface boundary layer is roughly 10 meters thick, but again the exact depth is indeterminate. Like friction, the effects of insolation and radiational cooling are strongest within this layer.

Bow Echo - A radar echo which is linear but bent outward in a bow shape (Fig. 1). Damaging straight-line winds often occur near the "crest" or center of a bow echo. Areas of circulation also can develop at either end of a bow echo, which sometimes can lead to tornado formation - especially in the left (usually northern) end, where the circulation exhibits cyclonic rotation.

Box (or Watch Box) - [Slang], a severe thunderstorm or tornado watch. See blue box, red box.

BRN - See Bulk Richardson Number.

Bubble High - A mesoscale area of high pressure, typically associated with cooler air from the rainy downdraft area of a thunderstorm or a complex of thunderstorms. A gust front or outflow boundary separates a bubble high from the surrounding air.

Bulk Richardson Number (or BRN) - A non-dimensional number relating vertical stability and vertical shear (generally, stability divided by shear). High values indicate unstable and/or weakly-sheared environments; low values indicate weak instability and/or strong vertical shear. Generally, values in the range of around 50 to 100 suggest environmental conditions favorable for supercell development.

Bust - [Slang], an inaccurate forecast or an unsuccessful storm chase; usually a situation in which thunderstorms or severe weather are expected, but do not occur.

BWER - **B**ounded **W**eak **E**cho **R**egion. (Also known as a vault.) Radar signature within a thunderstorm characterized by a local minimum in radar reflectivity at low levels which extends upward into, and is surrounded by, higher reflectivities aloft (Fig. 2). This feature is associated with a strong updraft and is almost always found in the inflow region of a thunderstorm. It cannot be seen visually. See WER.

- Glossary (A-B)
- Glossary (C-H)
- Glossary (I-R)
- Glossary (S-Z)

National Weather Service
Norman, Oklahoma
1200 Westheimer Drive
Room 101
Norman, OK 73069

NWS Norman Webmaster

Updated on July 13, 2003

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You are at: CDC Home ► US Climate ► State map

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For the latest information regarding our web and data services, please see the status page.

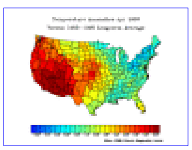
United States Interactive Climate Pages

Point and click climate information for individual cities in the US

Obtain the climatologies of temperature, precipitation and other variables for cities throughout the United States and its possessions.

- Fast lane (detailed maps): suitable for high speed connection
- Slow lane: suitable for modems and high traffic times
- Even Slower lane (text access): when even the slow lane is a little too slow

Climate Maps for the United States

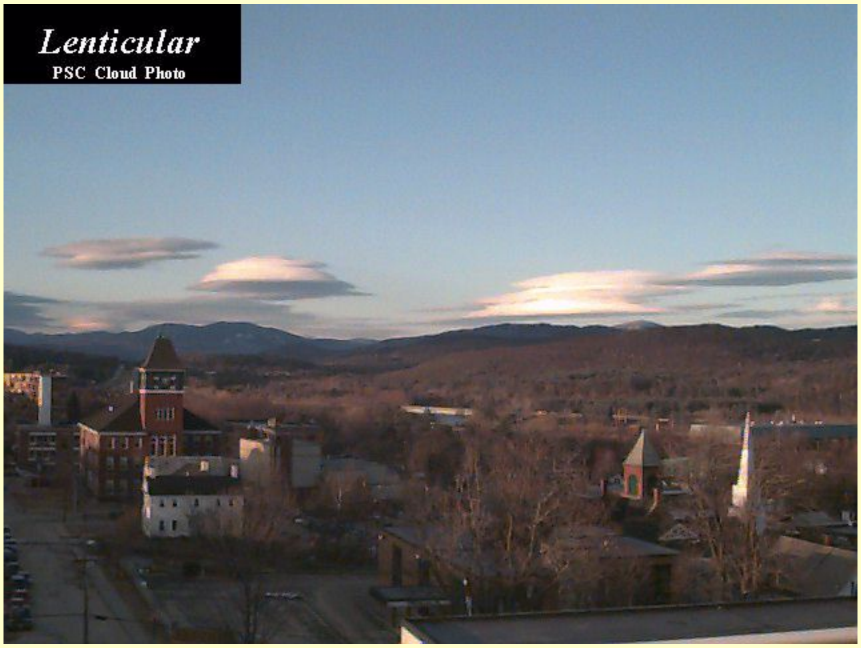


Create maps of monthly US temperature and precipitation products from 1895 to the present.

Other Useful Pages:

- Where to find climate data. If it's not here, where to get past data, climatologies etc.
- Glossary of terms, data, and project construction details
- List of related climate and educational websites
- Suggestions for use of these pages by teachers (under construction-send me some!)

NOAA-CIRES Climate Diagnostics Center
Document maintained by Cathy Smith (cathy.smith@noaa.gov)
Updated: Mar 4, 2003 10:49:02 MST
http://www.cdc.noaa.gov/USclimate/index.html



Lenticular Clouds over Plymouth, NH

Plymouth State University Meteorology Program Cloud Boutique

The Plymouth State Meteorology Program has developed this server to provide explanations of and access to detailed pictures of some basic cloud forms. The cloud images are relatively large (640x480) in order to show detailed structure and features. All of these pictures were taken in the local area around Plymouth, New Hampshire and most from the weather observation deck on the roof of the Boyd Science Center on the Plymouth State campus. Clouds can move and change shape quickly as indicated in this 30 minute time-lapse mpeg video loop. The purpose of this "boutique" is to provide a general cloud reference and is not intended to provide an all-inclusive list. Images will be added to or changed as opportunities permit.

Cloud Classification

Clouds are generally classified based on characteristics, such as, altitude, appearance, or origin. Altitude distinctions apply to those clouds that fit in various layers of the atmosphere as follows:

- high clouds - have bases above 18,000 feet
- middle clouds - have bases between 7,000 and 18,000 feet
- low clouds - have bases below 7,000 feet
- fog - cloud in contact with the ground
- multi-level clouds... vertically thick spanning multiple layers
- orographic clouds - distinct clouds that form via interaction between wind and mountainous terrain features

In appearance, clouds may be thick or thin, have well defined edges or be very diffuse, appear hairlike, cellular, towering, or in sheets, and be associated with fair weather or precipitation. Most clouds owe their existence to upward vertical motion of air, hence they are often associated with weather producing phenomena, such as fronts, troughs, and low pressure systems. However, topography can also help move air upwards and produce clouds.

Cloud Descriptions and Pictures

This section provides verbal descriptions and pictures of clouds that have been observed in this area. Because of their size, these images have been stored in JPG format. To view a picture, click on the appropriate cloud name or other highlighted text.

High Clouds are primarily composed of ice crystals and include the following:

- Cirrus are high altitude wispy clouds. They are usually quite thin and often have a hairlike or filament type of appearance. The curled up ends as depicted in this picture are very common features.
- Cirrocumulus are high clouds that have a distinct patchy and/or wavelike appearance, such as, in our patchwork cirrocumulus photo, composed of many individual cloud elements, or in our wavy cirrocumulus photo with its banded linear structure. These features are common to all types of cumuloform clouds.
- Cirrostratus are high clouds that usually blanket the sky in ill-defined sheets. These clouds are usually optically thin and the sun and moon can usually shine some light through. Like other stratiform clouds, one usually can't detect distinct cells or sharp features. This picture shows the sun shining through a gray, diffuse cirrostratus overcast.

Middle clouds have many similarities to the cumuloform and stratiform high clouds. Since they are closer to a groundbased observer, the cumuloform elements in particular appear larger than their high cloud counterparts. They can contain ice crystals and/or water droplets and may occasionally be associated with some light precipitation.

- Altocumulus have distinct cloud elements and are either in a patchy, scattered distribution or can appear in linear bands. The altocumulus in this photo by Jay Shafer consists of a number of individual cloud elements. Jay also took this beautiful sunset photo of altocumulus clouds.
- Altostratus have a more uniform and diffuse coverage where it is difficult to detect individual elements or features. In this picture, a few altocumulus clouds in the foreground precede a more uniform deck (see arrow) of altostratus.

Low clouds are most often composed of water droplets, but can have ice crystals in colder climates. Some of these clouds can develop into the multi-level clouds and can go through various phases, such as, a morning stratus deck turning into late morning stratocumulus, then early afternoon cumulus, and vertical development into cumulonimbus which can produce heavy rain and possible lightning and thunder.

- Cumulus are usually puffy and often have very distinct edges and usually a noticeable vertical development. They often have a poporn-like appearance. Cells can be rather isolated or they can be grouped together in clusters as shown in this photo. The main cumulus cloud pictured in this view was nearly overhead, so the vertical extent is hidden from view. However, since the sun is on the other side of the cloud, its thickness is evident from the negligible amount of light passing through its center.
- Stratocumulus can be widely scattered (as depicted in this photo, but are usually concentrated closer together in clusters or layers and have very little vertical development. This photo of a stratocumulus layer from above was taken by Jay Shafer, a Plymouth State meteorology graduate, from Mt. Washington. Jay also went down to a lower elevation and took another photo providing a closeup, side view of a stratocumulus cloud in this deck. These relatively flat clouds usually lack the sharp edges and "popcorn" appearance of most normal cumulus clouds.
- Stratus are usually the lowest of the low clouds. Stratus often appear as an overcast deck (as shown), but can be scattered. The individual cloud elements have very ill-defined edges compared to most low cumuloform clouds (e.g. cumulus and stratocumulus).
- Fog can be considered as a low stratus cloud in contact with the ground. When the fog lifts, it usually becomes true stratus. This photo shows fog over the Pemigewasset River basin with clear skies elsewhere.

Multi-layer clouds are the heavy precipitation producers. The depth of these clouds give precipitation hydrometeors a better environment to develop and grow.

- Nimbostratus are often included in many texts as low clouds, but here they are considered multi-layer clouds because their vertical extent often goes well into the middle cloud region and these clouds often have even taller cumulonimbus clouds embedded within them. The clouds are very dark, usually overcast, and are associated with large areas of continuous precipitation. If it's a gray and rainy day as shown in this photo, the sky most will most likely be filled with nimbostratus clouds.
- Cumulonimbus, as shown in this photo (with cumulus in the foreground), are the clouds that can produce lightning, thunder, heavy rains, hail, strong winds, and tornadoes. They are the tallest of all clouds that can span all cloud layers and extend above 60,000 feet. They usually have large anvil-shaped tops (as shown) which form because of the stronger winds at those higher levels of the atmosphere. This first "cb" picture was taken by Plymouth State student Bill Schmitz from an airplane outside of the New York City area--note the three smaller turrets developing. Another picture shows a view from the ground of a cumulonimbus with a base at around 3,000 feet and vertical development upward to around 30,000 feet - small compared to most thunderstorms which are associated with really severe weather. Sometimes, strong cumulonimbus clouds can have appendages protruding from the base of the cloud, which are called "mammatus" clouds because they resemble the mammary glands of mammals. They indicate that the atmosphere is quite unstable and can also be an indicator of impending severe weather. The picture of mammatus clouds, shown here, was taken by Mark Gibbas, a Plymouth State meteorology alumnus, at Acadia National Park.

Orographic clouds, as the name implies, are produced by the flow of air interacting with mountainous terrain.

- Cap clouds form when air containing water vapor is uplifted on the windward slide of the slope and reaches saturation producing liquid water cloud droplets and a cloud which can "cap" the summit. The spectacular picture was provided by Michael Nahmias and shows the cap cloud shrouded summit of Mt. Ranier.
- Lenticular clouds are lens-shaped clouds that can result from strong wind flow over rugged terrain. At the time of this photo, the winds were blowing around 30-40 mph from right to left, forming several lenticular clouds. Sometimes they stack up like pancakes in multiple layers as are several depicted in this first photo. The strong flow produces a distinct up and down wavelike pattern on the lee side of the mountain or large hill and the lenticular clouds tend to form at the peaks of these waves. They sometimes are very round and the edges are so well defined that they resemble flying saucers. This close up sequence shows a large lenticular cloud at various stages of illumination as the sun moved lower on the horizon and lit the cloud from below. Another lenticular cloud can be seen in the background of the last frame of the sequence. These photos were taken on January 25, 1999 in Plymouth, NH, by James D. Rufo, a Plymouth State meteorology graduate. Mrs. Lorraine Brown of Bristol NH captured this same cloud formation from about 20-25 miles further away in these pictures. Lenticular clouds are often placed into the middle cloud category since they are most common at those altitudes. Plymouth State meteorology graduate, Jay Shafer, has also provided some stunning additional lenticular pictures taken around the White Mountain region of New Hampshire.

Another "specialty" cloud is one that can develop due to Kelvin-Helmholtz (K-H) instability waves and subharmonic resonance with other waves in the atmosphere. This can result in an intertwined or spiral cloud pattern as shown in this picture, which was also taken by James D. Rufo. H-H instability is the result of strong wind shear. K-H clouds that form in early stages can resemble well-organized waves that appear to be breaking like ocean waves.

Another type of cloud can be formed from the vapor contained in the exhaust of a jet engine of an airplane when they are flying at high enough altitudes where cold temperatures cause the vapor to turn into ice crystals like cirrus clouds. These clouds are called "contrails" (short for "condensation trails") and look like lines in the sky. The photo shows two contrails. The one on the lower right was formed by a jet that flew a few minutes ahead of the jet which formed the contrail in the center. The newer contrail is narrower and hasn't had the chance to diffuse like the older one.

Return to Plymouth State Weather Center

Another useful cloud information resource is the U of Illinois Cloud Catalog.

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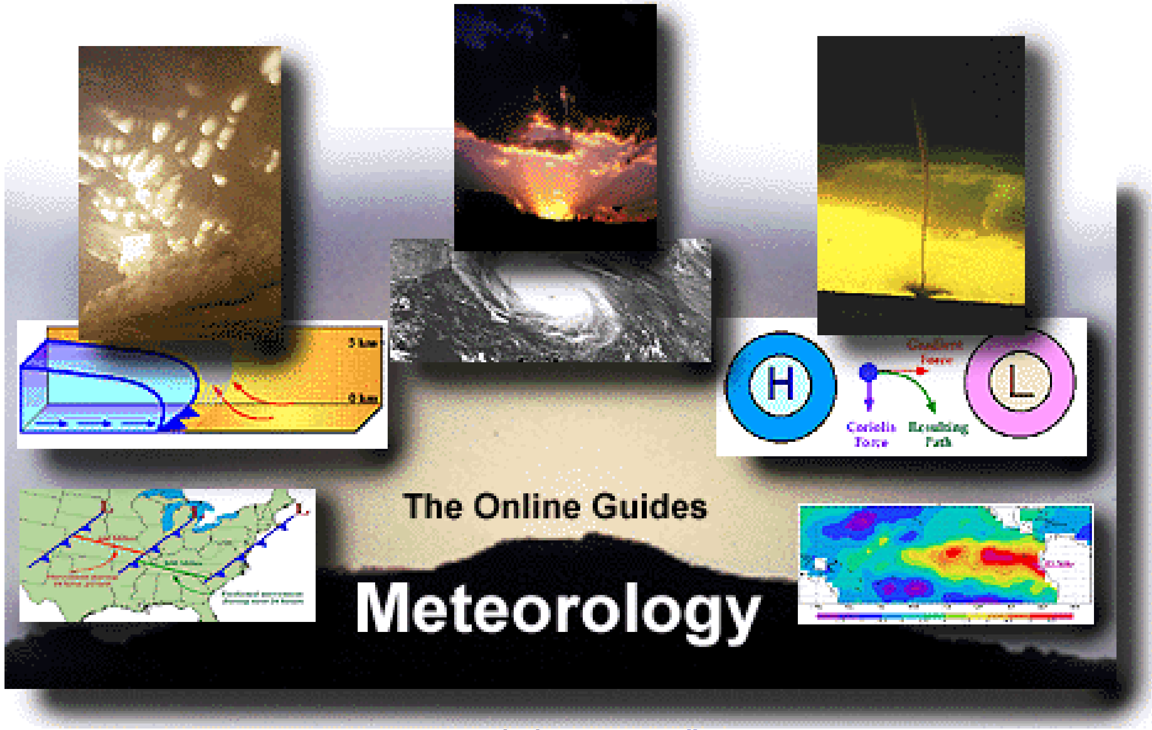
*For more information or comments, contact **Jim Koermer** at koermer@mail.plymouth.edu.*



Graphic by: Steven E. Hall

The Online Meteorology Guide is a collection of web-based instructional modules that use multimedia technology and the dynamic capabilities of the web. These resources incorporate text, colorful diagrams, animations, computer simulations, audio and video to introduce fundamental concepts in the atmospheric sciences. Selected pages link to (or will soon link to) relevant classroom activities and current weather products to reinforce topics discussed in the modules and allow the user to apply what has been learned to real-time weather data. Available modules include:

Modules

Last Update: 09/02/99

Light and Optics
The interaction between light and atmospheric particles and the colorful optical effects that result.

Clouds and Precipitation
Cloud classifications and the processes by which clouds and precipitation develop.

Forces and Winds
Forces that influence the flow of air and how they interact to produce wind.

Air Masses and Fronts
The most common types of air masses and fronts, plus a look at the different types of advection.

Weather Forecasting
General forecasting methods, important surface features, plus forecasting tips for different scenarios.

Severe Storms

The online version of NOAA's Severe Storm Spotters Guide. Investigates the different types of thunderstorms, their associated components, plus an in depth look at tornadoes.

Hurricanes
The anatomy of hurricanes, how they develop and why they are so dangerous.

El Niño
Why El Niño develops and the global impact it has on weather patterns and economics.

Hydrologic Cycle
The circulation and conservation of the earth's water.

The target audience for the Online Meteorology Guide is high school and undergraduate level students. However, these resources have been used by instructors throughout K-12, undergraduate and graduate level education. Contents of the Online Meteorology Guide were developed by graduate students and faculty through our efforts in the Collaborative Visualization Project (CoVis), which was funded by the National Science Foundation. These resources have been reviewed by faculty and scientists at the University of Illinois and the Illinois State Water Survey. Many of these resources were tested in a classroom environment and have been modified based upon teacher and student feedback.

The navigation menu (left) for this module is called "Meteorology" and the available modules are listed as menu items, beginning with this introduction. Click on the menu item of interest to go to that particular module. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Online Guides

Air Masses, Fronts

Instructional Materials in Weather & Climate

Below are the CLN "Theme Pages" which focus on specific topics within Weather and Climate. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Air Quality Theme Page
- Clouds Theme Page
- El NiñoTheme Page
- Blizzards & SnowTheme Page
- Floods Theme Page
- Global Warming/Climate Change Theme Page
- Hurricanes Theme Page
- LightningTheme Page
- Ozone Depletion Theme Page
- TornadoesTheme Page
- Water Quality Theme Page

General Weather and Climate Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Weather and Climate. Please read our disclaimer.

- AskERIC Lesson Plans - Science: Earth Science

  There are a number of lessons on weather within this general earth science collection.

- Bizarre Stuff You Can Make In Your Kitchen

  This site is an ever growing warehouse of the kinds of projects some of the more demented of us tried as young people, collecting in one place many of the classic, simple science projects that have become part of the collective lore of amateur science. It is a sort of warped semi-scientific cookbook of tricks, gimmicks, and pointless experimentation, concoctions, and devices, using, for the most part, things found around the house. These are the classics. Strange goo, radios made from rusty razor blades, crystal gardens... amateur mad scientist stuff. If you happen to learn something in the process, consider yourself a better person for it.

- Earth and Space Science

  About 10 brief lesson plans in weather for elementary level students from CanTeach.

- Especially Elementary

  Three lessons on weather for elementary students.

- Forecasting

  This instructional unit is part of the "Science With OAR" web site developed by the University of South Alabama. It consists of explanatory sections on weather forecasting, student activity assignments, and links to other sites where students can collect the data to answer the questions.

- Gathering Weather Information

  A six day teaching unit in which students gather weather data from the internet and use them to predict weather patterns.

- How the Weatherworks: Activities, Experiments and Investigations

  Four activities that can be used to study the sky and clouds.

- National Geographic.com

  Use the keyword search engine on this home page of the National Geographic.com web site to retrieve weather/climate resources from their database (keyword = "climate" will produce more hits, but try keyword = "weather" as well). Caution: not all of the lesson plans may be what you're looking for and you'll get more than just lesson plans with the keyword search.

- [The] Sky's the Limit

  Each month, IBM provides a new set of Internet activities focused around a specific theme for a targeted range of grade levels. This link is to a unit in which grade 5-9 students use the Internet to research clouds, rainbows, and other weather related phenomena found in the sky.

- Understanding World Climates

  A two week teaching unit for grade 5 students who start by learning the basic reference points and grids used on the earth and end with a beginning knowledge of world climates. Student activities include mapping reference points and climate zones, constructing climographs, solving climograph locations' mysteries, constructing rainfall isolines, and writing and illustrating mini notebooks of the controls of climate.

- Weather

  This page within Houghton Mifflin's Education Place Web Site has four extension activities for primary students: Tracking Local Weather, Measuring Rainfall, Wind Direction, and Wind Observation.

- [The] Weather Dude

  A weather page especially for kids, parents and teachers from Seattle's KSTW-TV. There are links to explanations of weather terminology, links to teacher/parent resource materials on weather and other sciences, and links to resource materials where kids can learn more about weather and other sciences.

- WeatherEye

- Weather/Meteoroloy

  The Nebraska Earth Science Education Network (NESEN) has collected about 30 lesson plans , organized by age groups, in meteorology from NESEN teachers.

- Weather: The Final Front

  Here's a meta-list of links to pages of weather activities/lessons designed for K-12 students and teachers by a Northern Ontario Consortium. Their categories of weather lessons include: air, atmosphere, climate, interpreting the weather, precipitation, water cycle, and weather in general.

- Weather Here and There

  A six lesson integrated weather unit incorporating Internet interaction and collaborative problem solving for students in Grades 4-6 (Math, Science, Geography, and Language arts).

- Weather or Not: Here I Come

  The New Jersey Networking Infrastructure in Education Project provides this lesson plan in which students collect data for weather and marine reports.

- [The] Weather Unit

  This interdisciplinary Weather Unit, intended for students in Grades 2-4, has lessons and activities that can be implemented in various subjects (math, science, reading & writing, social studies, geography, art, music, drama, physical education).

Top of Page

Note : The sites listed above all have lesson plans/activities for the Weather teacher. For other resources in this subject area (e.g., instructional materials in General Science, Life Science, or Physical Science), or for curricular content and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

THE SCIENCE ARCADE

The Science Arcade is a festival for the mind. Step through a portal to a new imagination station. Each station includes games, activities, and creative projects for exploring the world of science.

mission: space

Games and activities involve girls in space exploration. Tour the International Space Station. Construct models of space shuttles and rockets and create a space station. Visit Mission Control and observe an actual launch. Play Aero-Stars and learn about the accomplishments of the many women who have participated in space exploration. Junior Girl Scouts will complete the Aerospace badge.

GO

weather wizards

Play games, design posters and postcards. Try to change the weather. Find out about different types of clouds and learn how to be safe in different weather conditions. Junior Girl Scouts will complete the Weather Watch badge.

new! meteorology careers jeopardy

Would you like to be a meteorologist? Take a virtual tour of a real TV weather station and learn about the cool technology Broadcast Meteorologists use. Investigate six of the many exciting meteorology careers and decide if one is right for you. Click here to play meteorology careers jeopardy now!

GO

| Home |

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| Privacy Statement | Plugged-In to the Web Links |

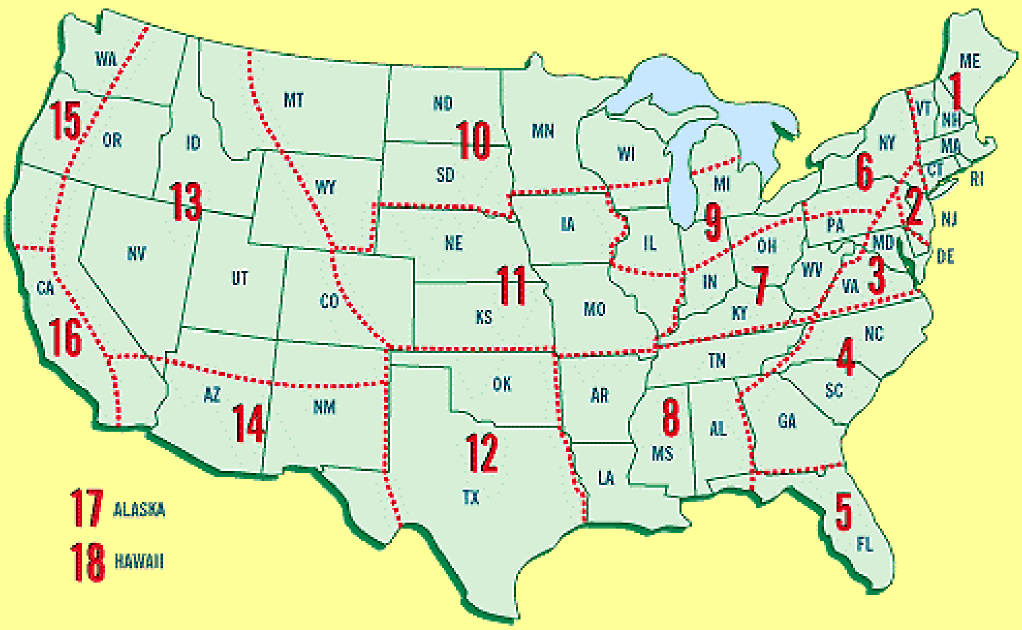
The OLD FARMER'S ALMANAC

Long-Range Weather Forecasts

THE 2004 OLD FARMER'S ALMANAC contains long-range weather forecasts from November 2003, through October 2004. As a courtesy to our Web site visitors we provide the detailed forecasts for this month and next here on Almanac.com. An exception is that we provide the forecast for the entire period for Alaska and Hawaii.

To obtain the complete 12-month forecasts, please purchase a copy of the Almanac at your local retailer: grocery store, drug store, mass merchandiser (eg. K-Mart or Wal-Mart), or bookstore. Or order single copies on-line or subscribe for the next three years and save!

For the long-range weather forecast through next month, click on the map or number of the region you want to view. Or select from **seven Canadian regions**. You may also view the **5-day weather forecast** for Boston or a city of your choice.



U.S. Regions: 1 ~ 2 ~ 3 ~ 4 ~ 5 ~ 6 ~ 7 ~ 8 ~ 9
10 ~ 11 ~ 12 ~ 13 ~ 14 ~ 15 ~ 16 ~ 17 ~ 18

How *The Old Farmer's Almanac* Weather Forecasts Are Made
Our weather forecasts are determined by the use of a secret formula (devised in 1792 by the founder of this Almanac, Robert B. Thomas), enhanced by the most modern scientific calculations based on solar activity, particularly sunspot cycles. We also analyze weather records for particular locales. We believe nothing in the universe occurs haphazardly; there is a cause-and-effect pattern to all phenomena, including weather. It follows, therefore, that we believe weather is predictable.

Modesty requires, however, that we add this caveat: It is obvious that neither we nor anyone else has as yet gained sufficient insight into the mysteries of the universe to predict weather long-range with anything resembling total accuracy.

Yankee Publishing Inc., P.O. Box 520, Dublin, NH 03444, Phone 603-563-8111

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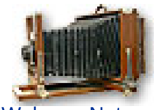

Webcam Network

MOUNT WASHINGTON OBSERVATORY

The Mount Washington Observatory is a non-profit and educational institution whose purpose is to maintain a permanently staffed observatory atop Mount Washington and to use this unique station and other facilities to conduct programs of environmental observation and technical research, and to develop educational programs to advance public knowledge of the unique meteorology, natural sub-arctic environment, and human history of the Mount Washington region.

Conditions as of Monday 11:49 a.m. est

Outside Air Temperature	Windspeed	15 Minute Gust	Wind Direction	Wind Chill
40.4°F	22 MPH	31 MPH	224° (SW)	31°F

Observer's Comments:

** The Mount Washington State Park Sherman Adams Building is now CLOSED until mid-May. No public shelter or services of any kind are available on the summit. Plan accordingly! The Mount Washington Auto Road and Mount Washington Cog Railway are also CLOSED for the winter season. Hikers wishing to ascend Mount Washington must always be fit, experienced, well-clothed and equipped. Be sure to check the weather conditions and weather forecast before your trip. Remember, too, to check the U.S. Forest Service Avalanche Bulletin whenever there is snow on the ground - avalanche fatalities on Mount Washington have occurred as early as November. For further information see our section on Winter Visits to Mount Washington. **

05:22 AM Mon May 10, 2004 EDT
In airline lingo, there are times called "shoulder periods". If there are such things here on the Summit, then this week is in one. Transitions are in the air everywhere. Spring is doing its best to establish more moderate weather, but

Winter is reluctant to give up its reign. If you have visited this site recently, you have read the departing intern's reflective comments. Yet, at the same time interviews for their replacements are taking place. The Observatory facility also is undergoing significant changes. A new coat of paint presents a cleaner, neater environment for the crew and the visiting general public. Perhaps more important is the removal of a large quantity of unused electric wire that has accumulated over the last 24 years. It seems that we're getting ready for the fiber optic era. In the midst of these changes, the old reliable things remain: the green flashes at sunrise and sunset, the halos around the sun and moon, and the sun dogs. One of the joys of membership in the Observatory is the ability to volunteer on the Summit and to experience its environment and phenomena. This is a very special place, and I suggest that you experience it yourself.

Jim Good - Summit Volunteer

Past Comments

Latest News & Events

Calendar of Events

seek the peak

Seek the Peak is a great way to get out and experience the White Mountains and help the Mount Washington Observatory along the way. July 23-24, 2004.

Observing Our Weather and Open House
A program of art and science for adults and children with nationally recognized artist Tomie dePaola and The Weather Notebook's Bryan Yeaton. Saturday, May 22nd at the NEW Mount Washington Center.

Annual Meeting 2004
Join the Mount Washington Observatory for a day of celebration at the New Mount Washington Center Saturday, June 12.

Mount Washington EduTrips
EduTrips are winter educational overnight trips to the summit of Mount Washington. The EduTrips include a stay at the Observatory and informative sessions on the mountain environment. For info on the 2003-2004 season, click here.

New Online Shop

Photo Gallery
Photos from the summit and beyond

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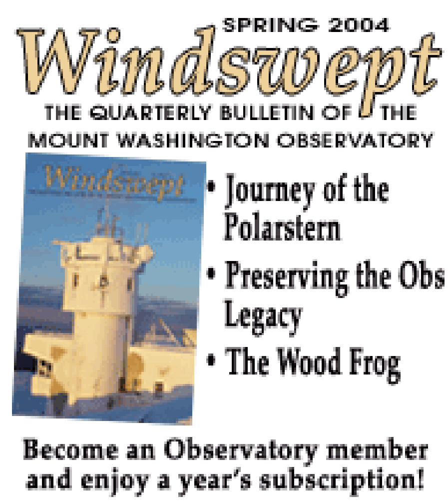
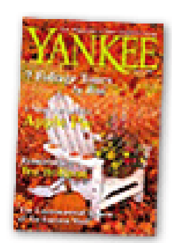
Volunteering, Internships, Positions.



Obs Teams up with Yankee



The Observatory and Yankee Magazine have teamed up to present this great offer. Subscribe to Yankee for only $20 and with each paid subscription the Observatory will receive an $8 donation!

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Weather

10/27/2003 - Updated 01:44 PM ET

Guide to the science of the atmosphere

Below are links to graphics and text that examine various weather phenomena, including the basics of things such as winds, what goes on in thunderstorms, tornadoes or hurricanes, or how dust from the Sahara Desert sometimes crosses the Atlantic Ocean.

This page is organized by general topic, similar to the chapters in another widely used weather resource, *The USA TODAY Weather Book.*

Learn how the sun drives our weather

- The sun's heat powers weather
- Earth's tilt creates seasons
- Air masses and their sources
- Day, night are not equal on the equinox
- Frequently asked questions about the seasons
- Weather on a cubical earth: what would it be like?
- Space weather storms earth
- Understanding space weather

The what and why of wind

- Understanding air pressure
- Barometers measure air pressure
- How pressure differences create wind
- Coriolis – how earth curves winds
- Inside look at high and low pressure systems
- Understanding air density
- The seabreeze, how it forms
- Jet streams – world's fastest winds
- The jet stream changes with the seasons
- Jet streaks stir up storms
- Air motion defines surface pressure systems
- Wind shear basics
- Understanding winds, jet streams
- Understanding turbulence
- Calculating the wind
- Mountain weather: topography has major effect

Storms and fronts

- Anatomy of a low pressure area
- Understanding extratropical storms
- How extratropical and tropical storms differ

When water changes forms: from clouds, fog to rain, snow

Floods and droughts

Snow, cold and ice

Lightning, thunderstorms and tornadoes

Lightning

Thunderstorms

Tornadoes

- What is a tornado?
- Some tornadoes have more than one vortex
- The ingredients needed for tornadoes
- Fujita Scale: rating tornadoes by the damage they do
- Climatology: When, where they strike most
- Tornado alley
- Waterspouts and other small vortexes
- What watches and warnings mean
- Understanding tornadoes

Hurricanes

- Sorting out the storms: tropical vs. extratropical
- What a hurricane is
- Hurricanes form and grow in stages
- Video: how a hurricane develops
- Glossary: understanding tropical cyclone terms
- Ingredients hurricanes need
- Where hurricanes, similar storms form around the world
- Intertropical Convergence Zone (ITCZ) breeds storms
- When and where hurricanes hit
- Bermuda High helps steer hurricanes in summer
- Storm surge adds to a hurricane's danger
- Slow-moving hurricanes can kill themselves (upwelling)
- Winds shear can tear apart a hurricane
- Ranking hurricanes – the Saffir-Simpson scale
- Hurricane hunters fly into storms
- Pacific hurricanes rarely hit the USA
- Why, how hurricanes are named
- Hurricane home page

The sky

- Why the sky is blue
- Mammatus clouds, their true meaning
- Raindrops bend sunlight into rainbows
- Self-destruct sunshine
- Sorting out clouds
- Sky watching photo album
- Resources: Sky color, phenomena
- Temperature differences bend sound waves

Predicting weather

- Measuring the weather
- Weather satellites
- Understanding weather radar
- Understanding forecasting
- Weather technology resources

The global climate, **weather in our future**

- Getting a handle on climate
- The 'greenhouse effect' makes Earth inhabitable
- How the 'greenhouse effect' works
- How global warming occurs
- Understanding the science of climate change
- Climate change resources
- All about ozone
- Sahara dust clouds Caribbean sky each year
- Understanding El Niño, La Niña
- How an El Niño begins
- How El Niño affects weather
- Global weather patterns index
- Resources: Winds carry dust around the world

Extreme weather

- Learning what 'normal weather' is
- Daily USA temperature extremes
- USA's hottest, coldest temperatures, by state
- Resources: Weather records
- Guide to apparent temperature
- The new (2001) wind chill index

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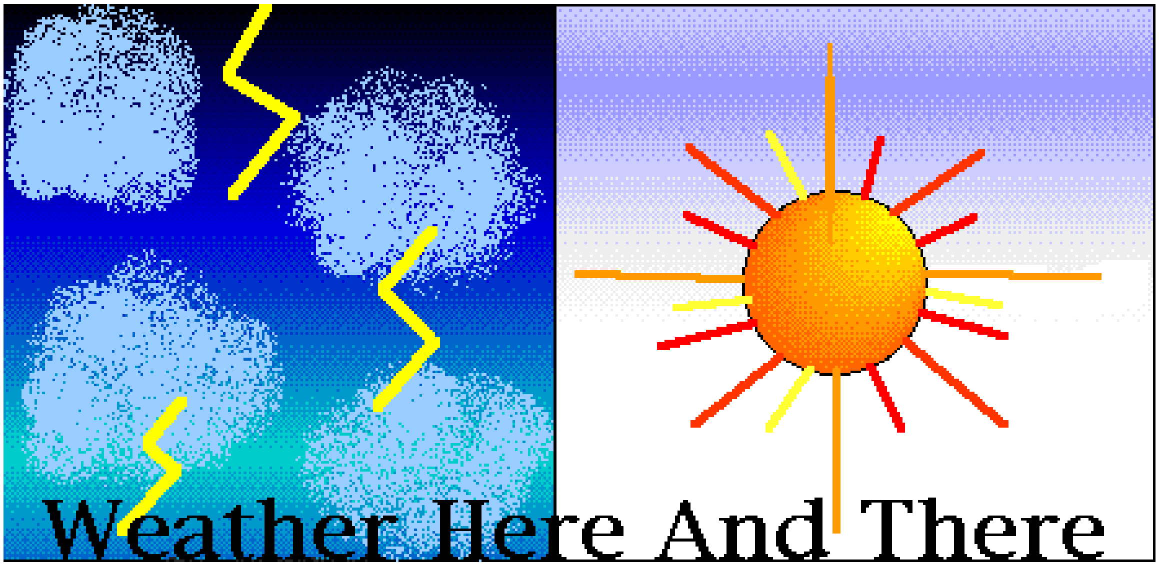

BASIC OVERVIEW OF UNIT

WEATHER HERE AND THERE is an integrated weather unit which incorporates interaction with the Internet and hands-on collaborative, problem solving activites for students in grades four through six. This unit is divided into six lessons. The lessons integrate math, science, geography, and language arts in the process of teaching and learning about weather phenomena. Students will become involved in collaborative problem solving using e-mail as well as through joining projects offered via the Internet. *The Global Education Project* will help students see the relevance of science by interacting with scientists and other students across the world, as they collaborate in the study of weather in their environment.

The first three lessons focus on learning basic meteorological concepts about weather elements, how to take measurements using appropriate weather instruments, and recognizing basic weather trends and patterns.

The last three lessons focus on studying weather maps and applying the knowledge and experience about weather to associate weather trends and patterns in the process of making accurate forecasts. The unit culminates with a weather broadcast of a twenty-four hour forecast presented by students and focusing on a network of weather stations in the United States created by the students.

Unit Directory

We'd sure appreciate Your Comments on this web site!

There were quite a few people who contributed to this web site. Please take a moment to read the Credits.

Last updated July 1995.

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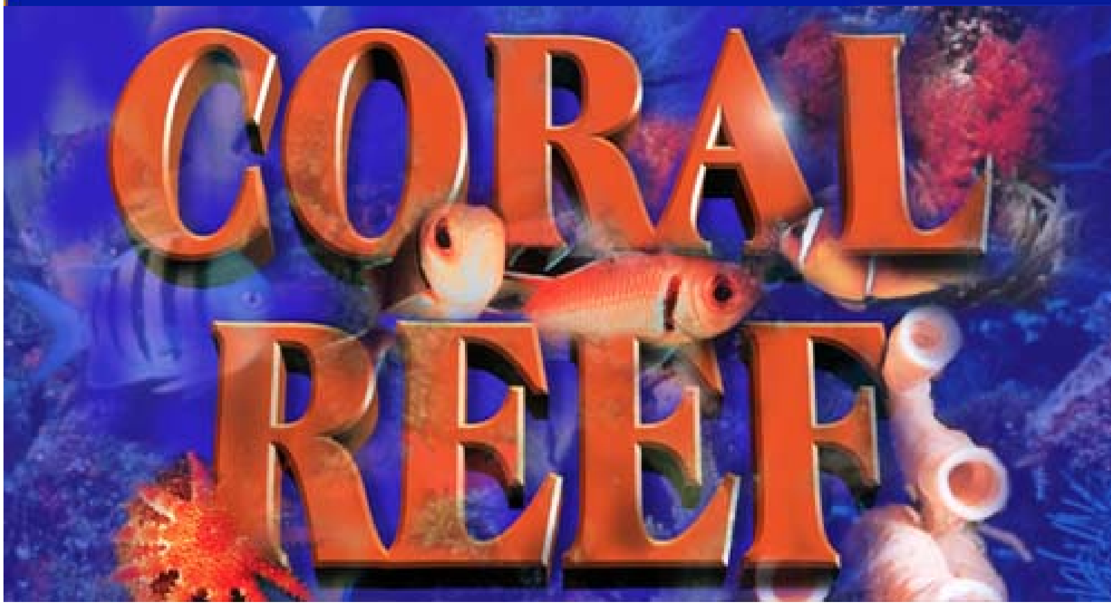

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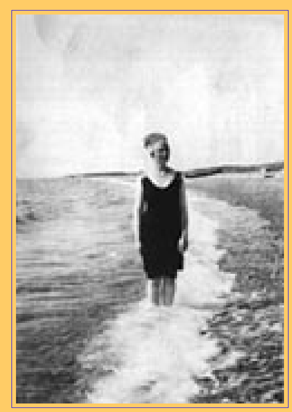

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- Other NOAA Photo Sites
- NOAA Home Page
- NOAA History

The NOAA Photo collection would not exist but for the generous individuals who are willing to share their remarkable images and observations with America and the rest of the world; meet the men and women who have made the NOAA Photo Library possible.

- NOAA Central Library

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www.nws.noaa.gov

National Weather Service

Storm Prediction Center

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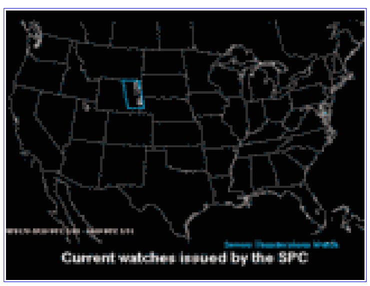
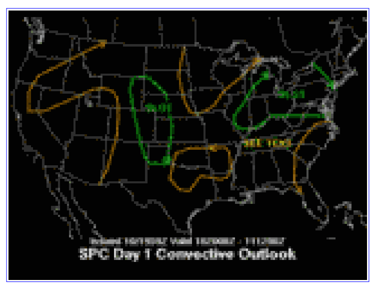
Top News of the Day...

- Please use spc.feedback@noaa.gov to send us your feedbacks/questions.
- New enhancement to the SPC watch status products begin April 20, 2004.
- May 4, 2003 tornado outbreak links.
- **NOAA Issues Draft Policy to Foster "Fair Weather" Partnerships**
  The National Oceanic and Atmospheric Administration (NOAA) is requesting public comment on a newly drafted policy governing NOAA's NationalWeather Service interactions and cooperation with the greater consortium of public, private and academic weather and climate institutions. Details...

  Updated: May 10, 2004



Current Watches



Day 1 Outlook

Today's storm reports

Today's Reports

Shamrock, TX Tornado from May 16, 1977

Weather Topics:
Watches, Mesoscale Discussions, Outlooks, Fire Weather, All Products, Contact Us

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Talk Today

07/20/00- Updated 01:44 PM ET

Everything you want to know about tornadoes

You sent in the questions and National Weather Service meteorologists and National Oceanic and Atmospheric Administration scientists doing cutting edge tornado research provided the answers. USA TODAY Online presents the answers below with more to come. Check here during the rest of May for the latest answers. If your answer isn't here, take a look on USA TODAY's "Frequently asked questions about tornadoes" page.

Experts answer your tornado questions

Answers below are about: "Hearing" tornadoes, safety at amusement parks, Twister reality, lightning in funnels, environmental damage, plasma vortex, tornado shelters, tornado myths, tornadoes in the past, vortex pressure, cold-air funnels, tuning in tornadoes, tornado wind damage, tornadoes in cold weather, direction tornadoes spin, Tornado Vortex Signatures, why tornadoes are round, twister power and mobile home safety.

Q: I am a tornado chaser and have to answer endless questions from my students. Recently, I thought I caught a news story about a guy who was able to predict a tornado by using a bunch of garden hoses all connected at a central spot. Evidently, he could hear sound changes, much as varying levels of water in a thin-necked bottle will produce different sounds if you blow across the top of it. From what I could gather from this story, this guy laid out a whole load of hoses, in varying lengths, sort of in the shape of a bike wheel. The air rushing by the outer end of the hose would produce sounds that would be identifiable if a tornado was certain. My question is obvious: Heard anything about this? If so, Where can I find more information. If not, thank you for your time.

Environmental Technology Laboratory

Answered by: Alfred Bedard, Jr., aerospace engineer, NOAA Environmental Technology Laboratory, Boulder, Colo.

A: The system detects very low frequency sound waves well below the range of human hearing (near 1 Hertz) and uses an array of 4 sensors located on an area about the size of a football field. Because the sounds are weak we need to remove wind noise and hence the use of lengths of porous irrigation garden hose at each of the 4 sensors. Sound appears over the area covered by the "octopus" of hose essentially simultaneously while wind eddies do not and are averaged out. We have detected sounds using this system at ranges greater than 1,000 miles. Low frequency sounds travel in a detectable form for long distances. (more below)

Q: About a month ago on ABC news Dr. Al Bedard from NOAA demonstrated a devise for detecting tornadoes. The devise consisted of an array of common garden hoses connected to a central sensor. It was able to give 30 minutes warning of a approaching tornado. I have tried to contact Dr. Bedard several times with no response. I am trying to find out what he is using for a sensor. Is it a pressure sensor, a low frequency microphone, a variable oscillator controlled by the pressure. What??? Thanks for your help.

Answered by: Alfred Bedard, Jr., aerospace engineer, NOAA Environmental Technology Laboratory, Boulder, Colo.

A: Our goal is to detect sounds at low frequencies near 1 Hertz in the presence of wind noise. The pressure amplitudes are quite small (about 1 microbar or the equivalent in pressure altitude of about 1 centimeter). Conventional microphones do not respond at such low frequencies and conventional microbarographs do not have enough sensitivity. We use a differential pressure sensor with a high pass pneumatic filter to get the sensitivity we need, but the filter insures that we do not let lower frequency, large amplitude pressure changes exceed the dynamic range of the sensor and yet respond to the frequencies we are interested in.

- Finding the geophysical sources of infrasound

Q: Where is the safest place to go if a tornado hits near or in an amusement park? I was recently at Great America when the warning sirens sounded. I was petrified because there didn't seem to be any "safe" place to go. While most people made a mad dash for their cars, I ushered my family into the nearest bathroom. The only thing is, the bathroom happened to be VERY near a very large roller coaster. I felt trapped!! We didn't want to get in our car and be jammed into the parking lot with the other thousands of people trying to get out, yet I felt unsafe in the bathroom. It also didn't help that there was no open field in sight, nor did any of the employees give us any advice except to lay flat on the ground. Please tell me what would have been the safest thing to do.

First answer by: Charles A. Doswell III, research meteorologist, NOAA National Severe Storms Laboratory, Norman, Okla.

A: This is a very difficult problem and one that scares many of us in the research community. Tornadoes harm people primarily through flying debris, usually generated from the destruction of structures. In situations like amusement parks, sporting events, or any other large gathering of people, the problems are:

- an abundance of materials available to become airborne debris;
- considering normal lead times for tornado warnings (no more than 20 minutes, and typically less than that), it is virtually impossible to evacuate such gatherings in time; and
- a lack of any sturdy shelters.

I can imagine the panic-stricken crowd trampling one another in the attempt to get in their vehicles and drive away. This is a bad strategy, since it almost certainly will create a hopeless traffic jam and people would be caught in their vehicles, notorious death traps in a tornado. The only alternative is to require storm shelters at any such gathering place, at least in regions where tornadoes are possible, capable of holding a capacity crowd. The cost of building such shelters almost certainly would be viewed as prohibitive.

The chances of someone experiencing this are very low, of course. People are much more likely to be struck by lightning or to have a motor vehicle accident going to or coming from the event. Although the probability of a disaster in this sort of situation is so low it probably does not make economic sense to build shelters at every conceivable gathering place, nevertheless it eventually will happen.

Lisa had some reason to be frightened, because if a tornado actually strikes a crowded amusement park or some sporting event (a violent tornado in Omaha narrowly missed a busy horse racing track; another tornado near Memphis just missed a crowed dog racing track), a major disaster is possible. She was also quite right to be concerned about getting caught in the parking lot, so the bathroom probably was as good a choice as any among the limited available options. People should seek the sturdiest place of shelter they can find that can reduce the threat from flying debris. Engineered structures (like the roller coaster or a modern office building) are unlikely to fail in a tornado.

(Editor's note: Questions about tornado safety are difficult because scientists don't always agree about what's best. Here is another opinion.)

Office of Meteorology *Second answer by: William Alexander, meteorologist, NOAA Office of Meteorology, Silver Spring, Md.*

The safest thing in such a situation mirrors what to do if confronted with an approaching tornado in a traffic jam. Avoiding the cars was the smartest thing to do. However, to seek shelter in the bathroom may not have been, unless it's part of a reinforced permanent building. Aside from such a permanent structure, the best place to seek shelter is in the lowest spot of terrain possible--a ditch or ravine, perhaps under a bridge. The reason is, most serious injuries and fatalities from tornadoes are the result of missiles--things thrown at high speed. Those objects fly horizontally, so placing yourself below the rest of the ground level will allow most debris to pass over you.

(While the experts can't always give a firm answer to questions about what to do when a tornado threatens, they will agree that your best bet is to avoid

threats whenever you can. First, keeping track of the weather and being aware of potentially severe weather is something folks who live in places where severe storms often hit, such as the central USA, should already be doing. Outbreaks of severe storms, which usually are when the most violent and deadly tornadoes will form, are more often than not forecast well in advance, sometimes several days in advance. The forecasters can't pinpoint exactly where a tornado might strike two days ahead of time, but they often can see the necessary ingredients for big storms coming together. Second, play it safe. Perhaps a call to the amusement park before visiting would help you to decide if it's a safe venture when severe storms are possible. If a significant tornado outbreak is forecast, don't go to the amusement in that area unless someone there can tell you they have a designated tornado shelter large enough to hold the park's visitors.)

Q: The people in the movie *Twister* made little balls to go up in a tornado. Have people tried to do that or is that some make-believe thing?

Q: I was wondering if the device used in the movie *Twister* is actually possible or practical. You know, the "Dorothy" thingamajig with hundreds of sensors swirling around inside the tornado. If it is possible or practical, has it ever been done? I'm sure when the movie came out months ago you got lots of questions about it, but perhaps you could answer it again?

Answered by: Joe Golden, NOAA senior scientist, National Oceanic and Atmospheric Administration, Silver Spring, Md.

A: The "DOROTHY" device in the movie *Twister* was derived from a real-life invention by Dr. Al Bedard of NOAA's Environmental Technology in the late l970s. Dr. Bedard's idea was copied by the movie's producers, but did not have the small spherical sensors and transmitters packed inside; indeed, it was called the "TOtable Tornado Observatory" or TOTO, after Dorothy's pet dog in the film, "The Wizard of Oz."

TOTO weighed about 350 pounds and had rugged weather sensors sticking up on the outside to measure wind, pressure and temperature, with batteries and recording equipment inside the metal cylinder. It was carried out on tornado chases by scientists at National Severe Storms Laboratory in Norman, Oklahoma, and Professor Howard Bluestein, University of Oklahoma, during the l980s, but they found it very difficult to deploy TOTO in the direct path of a tornado, unlike the frequent tornado intercepts depicted in *Twister*! Scientists thought at first that the feasibility of replicating the "DOROTHY" technology depicted in the movie was remote; however, in recent months, interactions with technical people in the Defense Department suggest that highly-advanced technologies developed during in the early 1980s may indeed allow the fabrication of a tornado-probing device such as "DOROTHY", but there may be better platforms available in Department of Defense to launch probes into a tornado SAFELY than placing a "DOROTHY" device directly in a tornado's path at close range on the ground.

Q: Does lighting really appear inside the eye of a tornado? I saw the movie *Twister* and never expected it to appear there. If so, what causes it to?

Answered by: Ron Holle, research meteorologist, NOAA National Severe Storms Laboratory, Norman, Okla.

A: If lightning ever occurs inside a tornado, it is extremely rare. There is no conclusive evidence that it has done so. Both lightning and tornadoes are caused by strong convection - cumulonimbus clouds - with strong updrafts in deep clouds. Lightning needs an updraft that reaches high enough for some water droplets to freeze and form ice, which occurs above about 15,000 feet in warm seasons and locations. Similarly, tornadoes need strong updrafts and other wind conditions in the convection. But the likelihood of them occurring simultaneously in time and space is extremely small.

Q: Is there any pollution that is made by a tornado? If not, what environmental impacts can tornadoes have? Can they damage the environment?

Answered by: John Snow, dean of the College of Geosciences at the University of Oklahoma, Norman, Okla.

A: One can look at damage to the environment in many ways. Certainly, tornadoes can cause great destruction along their paths, but this damage is usually confined to a small area, typically a few hundred meters wide; the strong winds surrounding the tornado core (the funnel cloud) may do noticeable damage out to a kilometer or two (0.6 to 1.2 miles) to either side of the damage track. However, this is in fact a natural phenomena, dramatic and violent, but completely natural.

I think where we get into "environmental problems" is when a tornado strikes a facility that contains potentially hazardous or toxic materials. There is a lot of this sort of stuff around; it ranges from farm chemicals to trash in the local landfill to medical waste awaiting disposal to radioactive materials in storage. Not only can this material be spread around the immediate site where the tornado strikes, a small (but important) fraction can be carried aloft into the thunderstorm and then transported along ways down stream. I have data suggesting that such material might go several hundreds of kilometers (hundreds of miles) before returning to Earth's surface.

I should note that there is also some evidence linking tornadoes with the spread of diseases, such as histoplasmosis, which is due to a fungus found in the soil. The exact cause and effect is not clear, but it is likely due to the lofting and later fallout of small quantities of soil.

I have also heard of a biology researcher investigating the possibility that this long range transport process could be responsible for the spread of certain types of small animals and plants across portions of the U.S.

- Scientists are learning more about tornadoes by studying where they take debris

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Q: A college friend of mine said he read somewhere that some past studies indicated that a tornado vortex could be treated as a plasma. Does a charge distribution (electron/ion) exist in a tornado vortex?

Answered by: Vlad Mazur, research meteorologist, NOAA National Severe Storms Laboratory, Norman, Okla.

A: Plasma is a fully ionized gas consisting of free electrons and positively charged ions which makes plasma electrically conductive. Ionization can be produced by heating to a high temperature, by an electrical discharge, or by light impact. A tornado vortex is a vortex of air. There are no processes involved in the tornado formation that can ionize the air in the vortex thus transferring it into plasma.

Q: Would you know of any companies in North America that manufacture underground tornado shelters (not made of concrete or brick)? I'm just not having any luck on the Web finding something like this. Can you help?

Answered by: Tim Marshall, editor, STORMTRACK MAGAZINE, storm chaser, Dallas, Texas

A: To my knowledge there is no underground tornado shelter manufacturer on-line. Most of the tornado shelters I have seen are steel tanks that are set in the ground. There are a lot of mom and pop shelter places in tornado alley, but I haven't seen one produced on a mass scale - like on an assembly line.

Q: Do you know of any research on topographic features impacting tornado development or direction of travel? I live in the southeast and there appear to be recognizable "tornado alleys" in our area in which several tornadoes have followed the same path over a period of several seasons.

Answered by: Harold Brooks, research meteorologist, NOAA National Severe Storms Laboratory, Norman, Okla.

A: There have some studies that have looked at this question, but little conclusive evidence can be drawn. In general, tornadoes are rare enough events that it takes a very long time to create a large sample. Other factors, such as population density, often are involved with topography to make it difficult to separate effects in the observations. There appear to be areas that are tornado minima, such as the Ozark Mountains, but it is hard to draw definite conclusions. It is likely that topography could change the direction of the inflow into a thunderstorm, for instance, which could affect the storm's behavior. Recently, Patrick King of Environment Canada has shown evidence that lake breezes off of the Great Lakes appear to influence tornado distributions in

Ontario, primarily by influencing where storms form.

Many towns in the central United States that have not been struck by a tornado for many years have a story about some topographic feature, usually a river, or a hill, that "protects" the town from tornadoes. One of the most memorable of these "legends" was that Burnetts Mound protected Topeka, Kansas. On June 8, 1966, a violent tornado passed directly over Burnetts Mound, killing 16 people and causing $100 million in damage in Topeka.

Q: I'm looking for data on the 1990 Plainfield, Ill., tornado maps of its destruction, injuries, damage reports. A general area on were the tornado touched down would be helpful. Thanks for your help. I've been looking for awhile but not much break down on certain tornadoes.

Answered by: Bob Maddox, NOAA Cooperative Institute for Mesoscale Meteorological Studies, Norman, Okla.

A: The National Oceanic and Atmospheric Administration sometimes surveys significant storm events and for very unusual or severe events conducts a natural disaster survey. For Plainfield a Natural Disaster Survey, essentially an assessment of the event and National Weather Service forecast and warning procedures, was done. A very detailed damage survey of the tornado was done by Professor Ted Fujita of the University of Chicago. All of the pertinent details requested in this question are provided by Fujita in: "Plainfield Tornado of August 28, 1990," which is the first chapter in the American Geophysical Union Monograph 79.

Q: What would the sea-level adjusted pressure in an F-5 tornado be? I realize that any meteorological instruments struck directly by such a storm would be most unlikely to survive. Do computer models give a meaningful answer? Is the lowest pressure in a F-5 tornado likely to be lower than any recorded reading in a hurricane?

Answered by: Joe Golden, NOAA senior scientist, National Oceanic and Atmospheric Administration, Silver Spring, Md.

A: A very good question. There are very few surviving pressure records following a tornado's passage, because most conventional instruments, including anemometers are destroyed. Eyewitnesses watching aneroid barometers **during** a tornado's passage directly overhead, have reported pressure drops of as much as five inches of mercury (normal atmospheric pressure is around 30 inches). However, such readings are taken under great stress and are therefore unreliable. Theoretical estimates based on assumed vortex flow models for an F5 tornado yield estimates around 100 millibars, or one-tenth drop from normal atmospheric pressure. During the recent NSSL VORTEX l994-95 experiment, heavy instrument packages called TURTLES were dropped in front of a large tornado, and one of them was passed over by the tornado core, and recorded a pressure drop. An important question is whether or not the pressure sensor makes it into the core of the tornado, and not just the edge.

Q: What exactly is a cold-air funnel? Are they dangerous?

Answered by: Harold Brooks, research meteorologist, NOAA National Severe Storms Laboratory, Norman, Okla.

A: There has been little systematic study of "cold-air funnels." They are associated with cold pools of air aloft, typically with clear skies in the wake of cold fronts. The instability of the atmosphere may be sufficient to support deep convective clouds (towering cumulus) if there is enough moisture in the lowest part of the atmosphere. Often such situations occur with large values of vertical vorticity (a measure of the tendency of the atmosphere to rotate) in the 10-30,000 feet altitude layer of the atmosphere. While the mechanism of formation of cold air funnels is unclear, it is possible that it is simply due to the stretching of the vorticity by the air going up as part of the deep convection. Just as when an ice skater starts to rotate faster as he or she pulls in his or her arms, the stretching of vorticity intensifies the rotation in the storm.

Cold air funnels rarely touch down, but can, in the right circumstances, cause minor damage to vulnerable structures.

Q: When I was a young person, I recall a rumor that the close proximity of a tornado could be "seen" by tuning your television (black and white in those days) to channel 13, darkening the screen, then turning to channel 2 to see if the screen was dark or bright (or something like this). Is there any method to use a television for such a purpose?

Answered by: John Snow, dean of the College of Geosciences at the University of Oklahoma, Norman, Okla.

A: You are referring to what was (or is called) the "Weller Method" of tornado detection (named after its proponent). This was a popular technique a decade or so ago, when people still had individual TV antenna's. The idea was to use the TV set as a lightning detector (a detector of the radio waves emitted by a lightning flash), and under some conditions it would work. The idea was that tornadic thunderstorms were very active lightning producers. However, the method had (has) several shortcomings. Not all tornadic storms produce large amounts of lightning. TV's are not all equally sensitive, and in fact some are made to filter out lightning signals. If you are connected to cable, it won't work. The bottom line is that the method provide completely unreliable in actual field tests. Did it work sometimes? Yes, but most of the time it did not -- it either indicated a tornadic storm when none occurred, or it did not indicate the presence of such a storm when in fact one was nearby. In meteorological terms, its success score was too low and its false alarm rate too high to be of use.

Q: I was in the April 19, 1996 Decatur, Ill. tornado. I have some questions about some of my observations. The house had the roof and rear wall removed, but the ceiling drywall and attic insulation came down and remained with the house, the roof trusses were not seen again at least not by me. An interior door and frame were pushed out of the wall and taken down the hall and beds that were made had the blankets and sheets removed. Many small items were not moved. Could differential air pressure explain some of these observations?

Answered by: Tim Marshall, editor, STORMTRACK MAGAZINE, storm chaser, Dallas, Texas

A: Actually wind pressure is what causes the damage to a house - not air pressure. The reasons why walls and roofs go, but the coffee maker on the kitchen table remains is that large objects have more force placed on them than small objects. If roofs and walls are not tied down properly, they can easily become airborne. Proper attachments - like straps and clips are needed to resist the uplift loads created on a house by the wind.

Q: I was watching the news recently and heard something about cold-weather tornadoes. Is there such a thing and what exactly causes one?

Answered by: Harold Brooks, research meteorologist, NOAA National Severe Storms Laboratory, Norman, Okla.

A: Tornadoes typically occur in situations where the surface air is warm and moist, but not completely saturated. The warm, moist air rises, leading to the development of the parent thunderstorm. If the surface air is too cold or dry, it won't rise. Storms can form in those environments, but they require that the rising air starts from somewhere above the ground.

Current conceptual models of the processes leading to tornadoes have focused on the role of the cooling of air associated with the evaporation of precipitation in downdrafts of thunderstorms. Again, if the environmental air is cold, it is difficult to evaporate water in it. An important, unknown question is how deep a layer of cold air would be required to retard the process of evaporation enough to prevent the development of low-level rotation.

Significant tornadoes have been observed with temperatures near freezing (for example, the Altus, Okla., tornado of 22 February 1975), but they are rare and almost certainly involve processes going on above the surface layer leading to surface rotation.

Q: Why do tornadoes go counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere? Why does it sometimes reverse?

Q: Do tornadoes spin in opposite directions in the Southern Hemisphere than in the Northern Hemisphere?

Answered by: Joe Golden, NOAA senior scientist, National Oceanic and Atmospheric Administration, Silver Spring, Md.

A: All of the available observations suggest that the vast majority of Northern Hemisphere tornadoes do indeed rotate counter-clockwise, while those in the Southern Hemisphere tend to rotate in the clockwise direction (both are cyclonic). This is due in large measure to the statistical influence of the earth's rotation, the Coriolis Force, has on the larger scale flow regime that spawns tornadic thunderstorms; they tend to form within larger-scale cyclonic flows, i.e. large low-pressure areas with frontal zones. However, there is growing scientific evidence from videos of tornadoes and their close- cousins, waterspouts, and aerial damage surveys of tornado damage that a few percent (up to 10 percent) of Northern Hemisphere tornadoes rotate clockwise, or anticyclonically, and may be very destructive.

Q: What is a Tornado Vortex Signature and how does it appear on a Doppler radar screen?

Answered by: Greg Stumpf, research meteorologist, NOAA National Severe Storms Laboratory, Norman, Okla.

A: Tornadic Vortex Signature (or TVS for short) is the signature of a tornado, or tornado-like vortex as seen in radial velocity fields of the Doppler radar. Radial velocity is defined as the wind speed either directly away from the radar beam or directly toward the radar beam (Doppler radar cannot measure winds that blow "perpendicular", or directly across the radar beam). The TVS usually shows up a very small area (about 1/2 to 1 mile in diameter) of strong radial velocities, where half of the velocities are toward the radar, and the other half are away from the radar. When different colors are used to depict velocities blowing away from the radar versus toward the radar, the TVS will show up as adjacent areas of contrasting colors on the radar screen. The National Oceanic and Atmospheric Administration's National Severe Storms Laboratory has developed "algorithms" (or computer programs) that can automatically detect TVSs using Doppler radial velocity data, leading to an increase in the time between the Tornado Warning, and the actual tornado occurrence on the ground. More about Doppler radar is in USA TODAY's Weather technology index.

Q: Why are tornadoes round?

Answered by: Bob Davies-Jones, research meteorologist, NOAA National Severe Storms Laboratory, Norman, Okla.

A: Air revolves around a tornado in a circular orbit because it is being sucked in towards the low pressure or partial vacuum at the center and, at the same time, being centrifuged out of the tornado. These opposing forces are the same on all sides of the tornado. Hence, tornadoes have to be round by symmetry. Satellites orbit around the earth for a similar reason, except the inward force in this case is gravity.

Q: How much power does the strongest tornado have? And, I know *Twister* is not true but can a tornado be a mile wide?

Answered by: Joe Schaefer, director, NOAA/NWS Storm Prediction Center, Norman, Okla.

A: The total energy in a tornado is relatively low. A typical tornado contains 10,000 kilowatt-hours, while a hurricane contains 10,000,000,000 kilowatt-hours. (For comparison, a Hydrogen Bomb also contains 10,000,000,000 kilo-watt hours.) However, because a tornado is so much smaller than a hurricane, the energy density (energy per unit volume) of a tornado is about 6 times greater for a tornado than for a hurricane. In terms of energy density, a tornado is the strongest of nature's storms.

In a study of 34 years of tornado tracks (over 22,800) storms, it was found that the median tornado had a path length of 0.3 miles, and a width of 0.1 mile. But tracks 31 miles or longer were reported with 17 tornadoes, and 60 tornadoes had tracks that were at lease one mile wide!

Q: I have a new manufactured home, some people call it a mobile home, but is not a mobile home. It is on a permanent foundation, anchored in several locations that go though the walls, roof and through the other side. They're constructed the same as a track home (site built). What safety concern should I have? The same as a regular home or mobile home owner in reference to tornadoes? The home was built with special features which include an emergency pressure relief valve.

Answered by: Tim Marshall, editor, STORMTRACK MAGAZINE, storm chaser, Dallas, Texas

A: Usually, houses already have an opening or many openings, such as broken windows, or even more serious damage, thus, I don't believe a pressure release valve will be of any benefit. Inflow winds that roar at ground level into the base of the tornado can cause damage way before the tornado even hits your house.

This answer is similar to the one above about "differential pressure" doing damage in a home, with the addition that as a tornado approaches you must go through the radius of maximum winds (rmw) to get in the center where the lower pressure is.

- Ask Jack, other answers to frequently asked tornado questions
- Storm Prediction Center's detailed tornado FAQ
- Where in the USA tornadoes strike most
- Gateway to the world of tornado research
- Index to understanding tornadoes

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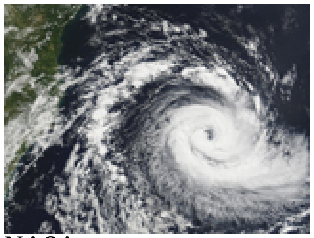
04/28/2004 - Updated 06:51 PM ET

A look at the 2003 season - Hurricane science and safety

Storm Report



NASA

Rare hurricane hits Brazil

March storm was first known South Atlantic hurricane.

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Special hurricane graphics package

- Graphic explaining how hurricanes are born and grow
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- Graphic illustrating hurricane categories
- Gallery of Hurricane Isabel photos
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Click here for the package

Looking ahead to the 2004 season

- 2004 should be a busy season
- Profile of William Gray

The 2003 hurricane season

- List of 2004 Atlantic, eastern Pacific names

The 2003 hurricane season

- 2003 Atlantic, eastern Pacific storm index
- Isabel: The year's worst hurricane
- Fabian battered Bermuda

Graphics help you understand hurricanes

- The evolution of a hurricane
- What makes a storm a hurricane
- Hurricanes can quickly become monsters
- Slow-moving hurricanes often die
- How hurricanes create storm surge
- Wind rolls create strongest gusts on land
- How wind shear weakens hurricanes

Living with hurricanes

- Hurricane safety guide
- Preparing your home for a hurricane
- How to keep a hurricane from ruining your vacation
- When and where hurricanes hit
- Categories communicate danger

Learning about hurricanes

- Hurricane scale communicates danger

- [Why, how people fly into hurricanes]
- [How and why storms are named]
- [Hurricane, tropical cyclone glossary]
- [Resources: Hurricane, tropical cyclone history]
- [Understanding hurricane science, technology]
- [History of Category 5 hurricanes]

Tropical cyclones around the world

Hurricanes and typhoons are both the kind of storm known as a tropical cyclone.

- How tropical cyclones differ from other storms
- When, where tropical cyclones hit
- Eastern Pacific hurricanes
- Hurricanes rarely hit Hawaii
- The world's tropical cyclone forecasting centers

Photo galleries

- Hurricane Isabel in 2003
- A wide-ranging look at hurricanes
- Isidore's romp in 2002
- Flight into Isidore
- NASA: Current, historical hurricane images

Tracking charts you can download and use

- Atlantic, Gulf of Mexico, Caribbean maps: jpg or pdf
- Eastern & Central Pacific map: pdf only

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03/30/2004 - Updated 07:24 AM ET

Tornadoes are Earth's most violent storms

Tornadoes are the most violent storms on Earth. Winds spiraling into them usually exceed 100 mph and can reach speeds of 300 mph.

In the USA, an average of 1,000 tornadoes spin up beneath thunderstorms each year, and these typically kill about 60 people.

Tornadoes and the threat of tornadoes are a key part of the USA's spring weather because spring brings favorable tornado conditions. But tornadoes can occur any time of the year, during the day and at night.

NOAA

Tornado touches down in Dimmitt, Texas, on June 2, 1995. The photo was taken by tornado research scientists.

The National Weather Service defines a tornado as "a violently rotating column of air in contact with the ground and pendant from a thunderstorm." In other words, a thunderstorm is the first step in the creation of a tornado. Then, if other conditions are right, the thunderstorm might spin out one or more tornadoes.

Three key conditions required for thunderstorms to form are:

• Moisture in the lower to mid levels of the atmosphere.

• Unstable air. That is, air that will continue rising once it begins rising from near the ground.

• A lifting force. Something is needed to cause the air to begin rising. The most common lifting force is heating of air near the ground. As the air warms it becomes lighter and begins rising. Advancing masses of cool air, which force warm air upward, also trigger thunderstorms.

When all the conditions are present, humid air will rise high into the sky and cool and condense into towering clouds, forming thunderstorms. This air rising into a thunderstorm is called an updraft. Tornadoes form in within a thunderstorm's updraft.

The strongest tornadoes are often near the edge of the updraft, not far from where air is descending in a downdraft caused by the thunderstorms with falling rain or hail. This is why a burst of heavy rain or hail sometimes announces a tornado's arrival.

Tornadoes are commonly associated with the nation's heartland – in a 10-state area stretching from Texas to Nebraska that also includes Colorado, Iowa, Illinois, Indiana, Missouri and Arkansas, known as Tornado Alley.

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Today's Top Weather Stories

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" Three dead after boat capsizes in New England - 8:15 AM
" Heat wave takes toll on strawberry fields - 8:07 AM

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But, they are not limited to this region. Tornadoes have occurred in all 50 U.S. states and are, in fact, more common in Florida than they are in Oklahoma.

Florida tornadoes are generally weak — for tornadoes — with winds around 100 mph.

Tornadoes that have hit Oklahoma, on the other hand, are some of the most violent on record. A tornado that struck Oklahoma City and its southern suburbs in 1999 had winds of nearly 320 just above the ground.

Tornadoes are ranked by the damage they do using the six-tiered Fujita Scale. F0 and F1 tornadoes on the scale are considered "weak" and cause minimal to moderate damage with winds from 40-112 mph. F2 and F3 tornadoes are considered strong, packing winds of 113-206 mph that can cause major to severe damage. Violent tornadoes are those classified F4 and F5 with winds exceeding 206 mph. Damage is extreme to catastrophic.

(**Related:** Fujita Scale ranks tornadoes by damage)

Most weak tornadoes last 10 minutes or less, traveling short distances. Violent tornadoes have been known to last for hours and a few have traveled more than 100 miles.

Tornado graphics and photo gallery

- Anatomy of a tornadic thunderstorm
- A close-up look at a tornado
- Gallery of tornado photos

Tornado safety

- Your guide to tornado safety
- Tornadoes don't give much warning
- Overpasses are tornado death traps
- A home shelter can save your life

Watch out for tornadoes

- Where twisters strike the most
- When tornadoes are most likely
- Major cities are not immune from tornadoes

Further tornado research

- Resources: Tornado history
- Resources: Tornado science and research
- Resources: Tornado chasing

Weather

10/27/2003 - Updated 03:14 PM ET

Resources: Thunderstorms

Thunderstorms are one of the most common and most noticeable weather products of our atmosphere. They form worldwide, spit out deadly lightning, band together to form hurricanes, and can spin up the world's fastest winds inside tornadoes. The links below take you to information about the nature, structure and detailed studies of thunderstorms.

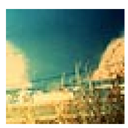
Harald Edens/NWS
A thunderstorm near Goodland, Kan., sparks cloud-to-ground lightning.

Read more

Weather to watch

- Severe weather watches, warnings
- What watches and warnings mean
- Thunderstorm safety

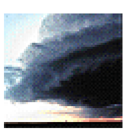
Learn all about severe weather



- Understanding thunderstorms
- Understanding lightning
- Understanding tornadoes
- Understanding floods, droughts
- Understanding hurricanes
- Understanding winter weather

Scroll down this page for links to more information, beginning with types of thunderstorms and including thunderstorm dangers, history and science. Some of the links below are to Web sites that are not part of USATODAY.com, but which have authoritative information. A separate browser window will open for each outside page you wish to view.

Types of thunderstorms

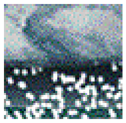


- What is a thunderstorm
- Multicells: How thunderstorms grow into clusters
- What makes a thunderstorm severe
- What's needed for powerful thunderstorms
- Supercell thunderstorms are kings
- Supercells have unique characteristics
- Squall lines generate damaging winds
- 'Bow echo': strong winds aloft create signature shape
- Derechos are long lines of windy thunderstorms
- Mesoscale convective complex (MCC)
- How a mesoscale convective complex forms
- 'Dry' thunderstorms spark lightning, start fires

Lightning and thunder

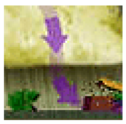
- Lightning makes them thunderstorms
- Anatomy of a lightning stroke
- Lightning flashes in different forms
- How lightning creates thunder
- Resources: Lightning science and safety

Thunderstorm precipitation



- How thunderstorms create hail
- Why some thunderstorms unleash downpours
- How thunderstorm 'trains' trigger flash floods
- Monsoon rain eases Southwest's summer heat

Thunderstorm winds



- Tornado: Nature's most violent wind
- 'Gust front' often triggers new thunderstorms
- Downbursts drag strong winds to the ground
- What causes a downburst, and its kin, the 'microburst'
- Microbursts: A handbook for visual identification
- The Semi-official Microburst Handbook homepage
- Collapsing thunderstorms can send out a 'heat burst'

Thunderstorms and air travel

- Thunderstorms: A pilot's worst nightmare
- 'Microbursts' can cause plane crashes

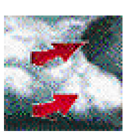
Predicting severe thunderstorms

- Storm Prediction Center issues 1-, 2-, & 3-day outlooks
- How the atmosphere becomes unstable, stable
- Air's stability determines cloud types
- Lifted index measures instability, storm potential
- Convective caps air severe storm formation
- How a convective cap forms
- Plains dryline helps trigger severe thunderstorms

Thunderstorm climatology

- Global map showing days with thunderstorms, June - August
- The Thunderstorm Project – 1946-49: Where it all began
- SPC: Historical hail information
- SPC: Historical wind and wind damage information
- Australian Severe Weather Web site
- Tornado and Storm Research Organisation (TORRO)

Thunderstorm research



- What makes them tick? (STEPS project)
- Supergraphic: Examining thunderstorms inside and out
- National Severe Storms Laboratory

Questions and answers about thunderstorms

- Answers to Ask Jack questions about thunderstorms

On the Web

- Skywarn
- Storm spotter guide
- Advanced storm spotter guide, text only, or pdf version – requires Adobe Acrobat Reader
- Storm spotter glossary of terms

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- types of t-storms
- tstorm components
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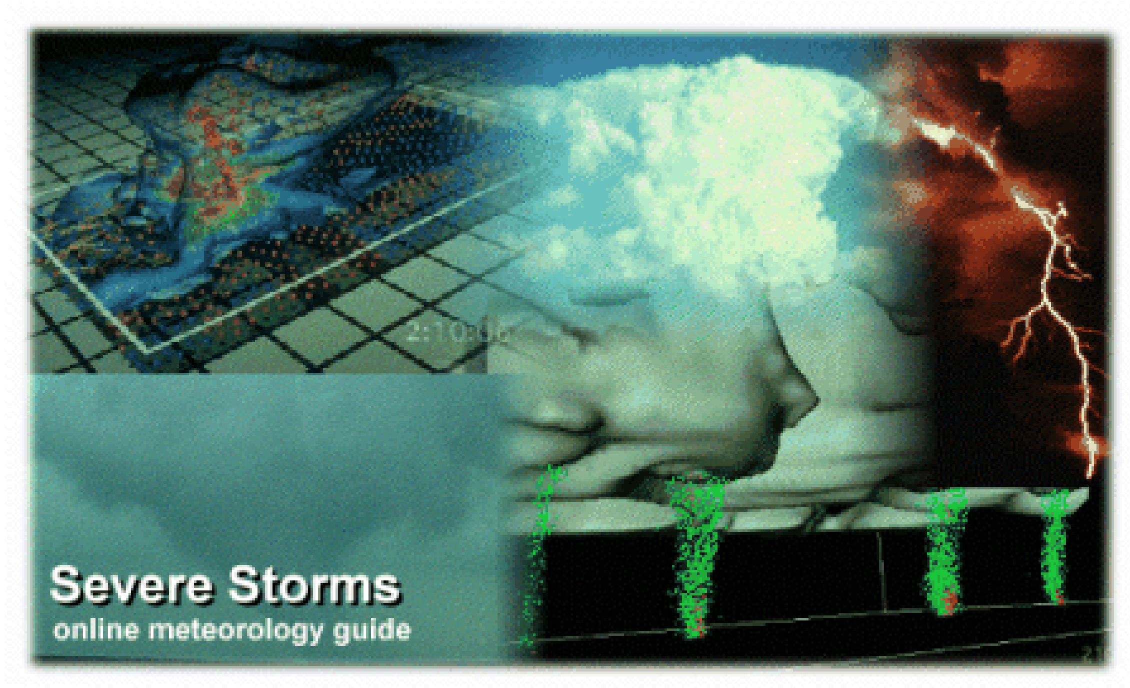


Graphic developed by: Dan Bramer

The Severe Storms Module is a combination of two elements. The first is the NOAA Severe Storms Spotters Guide. The second is a section recently added to discuss the efforts and results of modeling severe storms. The Severe Storms Spotters Guide contains supplemental instructional resources and a program designed to familiarize meteorologists and advanced severe storm spotters with the basic "building blocks" of convective storm structure. The focus of the training series is the development of a thunderstorm "spectrum" and a discussion of the physical characteristics and severe weather potential of the various storm types in the spectrum.

Sections

Last Update:05/15/99

Dangers of Thunderstorms
Includes: lightning, floods, hail, winds and tornadoes.

Types of Thunderstorms
Single cells, multicell clusters, multicell lines (squall lines) and supercells.

Components of Thunderstorms
Updrafts and downdrafts, outflow phenomena, wall clouds and the effects of wind shear on thunderstorm development.

Tornadoes
Tornadoes, cyclic storms and low-level flow fields associated with tornadic thunderstorms.

Modeling
Supercells, squall lines, and other phenomena recreated inside computers for the benefit of forecasting and understanding.

Acknowledgments
Those who contributed to the development of this module.

The critical role of atmospheric dynamics and thermodynamics in determination of storm type is stressed. We will take a close look at the storms themselves; from the small, summer storms capable of producing dangerous "microbursts" to the large "supercell" storms which spawn destructive tornadoes.

The navigation menu (left) for this module is called "Severe Storms" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

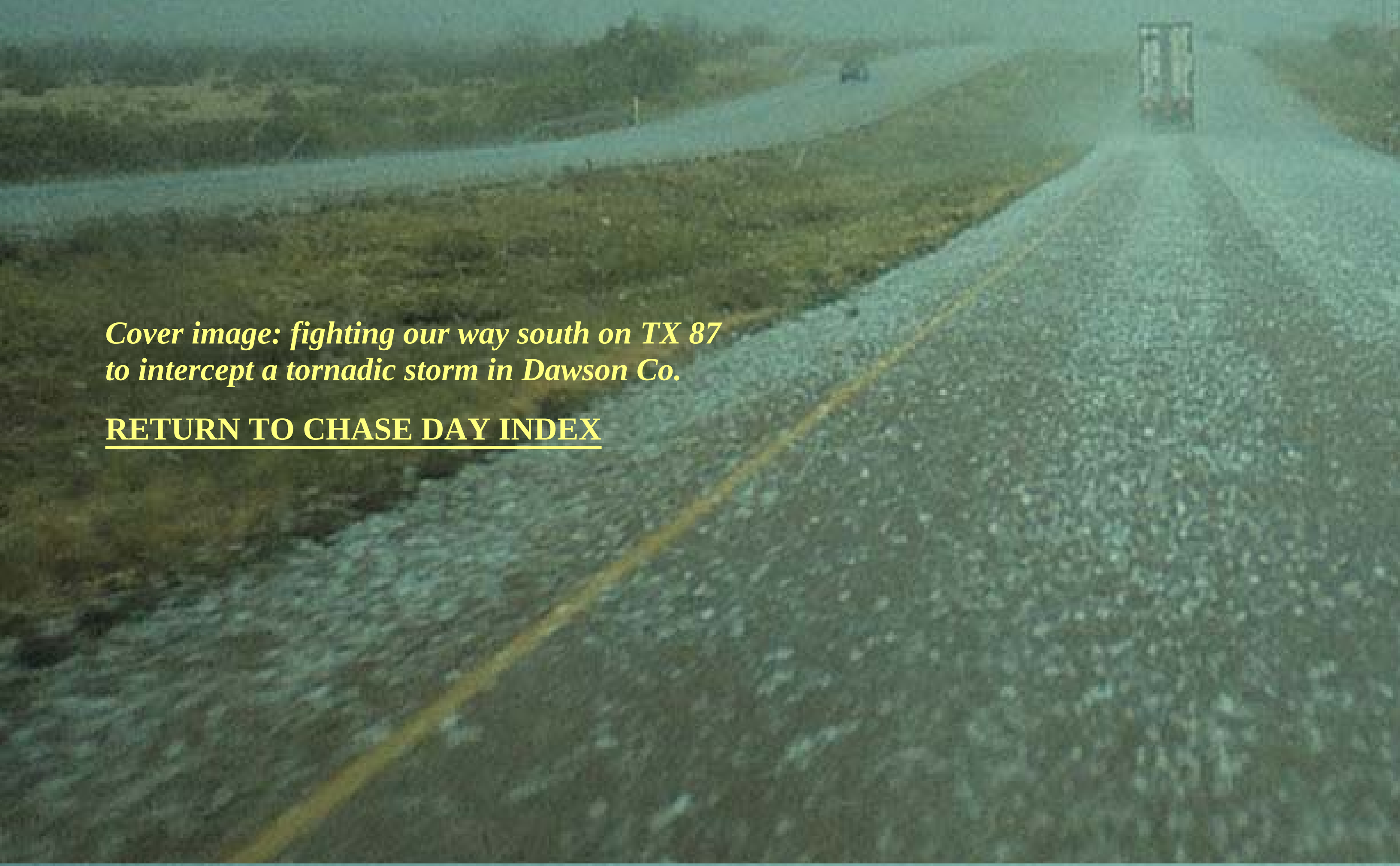
Upper Air Features

Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at the University of Illinois at Urbana-Champaign.

Dangers of T-storms

HAIL STORMS

Gene Moore - Chase Day



Cover image: fighting our way south on TX 87
to intercept a tornadic storm in Dawson Co.

RETURN TO CHASE DAY INDEX

Wind storms, Gust Fronts & Outflow

Gene Moore - Chase Day

Gust Front Storms With Rotation - Tricky Business

This severe storm in northeast Colorado was producing a gust front and rotating at the same time. Note the cyclonic banding above the outflow on the left side of the image (west) where the storm is approaching. An old cell to the east is providing and outflow boundary for the storm to ride along. It never produced a tornado, but storms that have both these features of rotation, and strong straight line winds can cause considerable property damage.

Atmospheric conditions did support a tornado out of another storm about 40 mile south of this cell an hour later. The image was taken near Akron, Colorado.

Gust Front Appearance in a Rotating Supercell

The storm pictured here on first glance would appear to be a gust front storm but looks are deceiving. Not the small tree on the east side of the small town (or just left of center). It's leaning over to the west as strong winds feed into the storm. The shelf appearance does not guarantee the storm is a gust front producer or in an outflow stage. In this particular case the storm produced a confirmed tornado with F-2 damage about an hour and a half after this picture was taken. After dark, I watch with a group of chasers as an elephant trunk tornado formed about a mile west of our position, but we were unable to capture it in the lightning.

Severe Colorado Hail and Wind Storm that is not Rotating

A Colorado storm is pictured here that moved northeast into far southwestern Nebraska. It looks somewhat similar to the previous storm, but is not rotating and blasted us with strong straight winds and hail. If you see a storm like this watch the motion on the top of the shelf cloud. Is it pushing out, or rotating back into the storm? This one was pushing out. Also, watch in wind direction under the leading edge to see if the storm has inflow like the two pictured above or winds are gusting our and away from the storm.

Squall Line with a Stacked Shelf Cloud

Vehicles rush to beat the storms approaching from the north. This is an example of a typical squall line with strong straight line winds, heavy rain and hail. The leading edge of the clouds brings a cold wind shift coming out of the storm. The cold air works like a shovel scooping up moisture and forming new convection and storms on the leading edge of the outflow.

Severe Colorado Hail and Wind Storm

This storm produced high winds on the leading edge of the gust front and then battered homes with large hail. The clouds on this outflow boundary were horizontally turning over as it rushed out to the east. The temperature dropped dramatically, which is usually the case during summer thunderstorms on the high plains.

Strong Straight Line Winds and a Dangerous Gustnado

This storm produced straight line wind over 80 MPH. and caused considerable property damage in rural sections of north central Oklahoma. This was part of a line of storms producing widespread high wind over a large of northern Oklahoma. The cloud base was quite high, about 7,000 feet above ground level, and the large cloud of dust is over 3,000 feet high and a quarter mile wide at the bottom. It was rotating violently, and produced an audible roar that could be heard for about 2 miles. This (straight line) wind driven "spin up" lasted for over 10 minutes while I drove toward it and another 5 minutes after I got in front of it. It was in the earlier days of my chasing and I had no idea how powerful such a vortex could be. The circulation propagated along at the speed of the outflow, but was rotating faster than the surrounding winds. When I heard the loud roar and saw trees and shrubs flying apart I made a hasty retreat. Circulations such as this must be rare and this is the only one I have witnessed. As a tornado, I estimate it would be only rated at F-1 which is weak, but certainly a storm that demands respect. More commonly gustnadoes are smaller and short lived. On days when conditions are correct multiple gustnados may occur. These gustnados did have a circulation at cloud base.

Monster Gust Front

A cranked up gust front roaring across the countryside. This is known as an arcus-gust front. Note the arc shape to the outflow and the dust being carried into the air. These storm can move at 60 plus MPH. and usually deliver more dirt that rain since the precipitation area is narrow and it moves by fast. Tornadoes get the headlines, but these storms can create wide spread damage.

Return To Chase Day Index Page

Tornadoes - Many Are Different From What Dorothy Saw

A Look at Different Shapes & Sizes of Tornadoes

The Wedge Tornado

Typical "wedge tornado" is straight on the sides not funnel shaped and has a wide damage path. It's usually as wide, or wider than it is tall. These monsters are not necessarily stronger than funnels or other shaped tornadoes, but they do cover much more ground. This particular tornado was hanging out the west side of a supercell thunderstorm in the Texas Panhandle. The vehicle in the foreground is an NSSL chase vehicle doing its job long before books and movies told about chasing storms. In those days there was little glory just long days and tiring drives home while Oklahoma City DJ's played requested songs for the returning chasers. Occasionally, there was big reward like on this day.

Shortly after this photo was taken this tornado tore through a small Texas town. Residents saw it coming and were under ground, or in a safe shelter. This was the first in a series of tornadoes to

strike the Texas Panhandle and western Oklahoma that day.

Another Wedge Tornado With A Different Appearance

This tornado lacks the typical funnel or classic tornadic appearance. Huge funnels like this one that are a mile wide are unrecognizable at close range as a tornado, but tend to appear as a boiling wall of fog approaching from out of no where since they favor a position close to the rain wall. Generally the rain stops and the tornado makes a rapid appearance. These storms are the ones that are generally blamed for "striking without warning" since some people try to observe the tornado before taking shelter. Funnels of this character are more common in the southeastern quarter of the nation.

The width of this particular beast varies depending on whose damage survey one believes. Original damage surveys measured over a mile wide at some places, but newer versions put it at less than half that size. When it crossed the interstate at I-40; the appearance from one mile away filled one half the drivers side window all the windshield and part of their passenger window. Now the amazing part; two men on motorcycles were lying in the depression between lanes as it passed over. They saw it coming and dumped their bikes to lie flat (very flat) in a depression. It worked, both were unhurt. Odds are they will remember that day for a long time.

A Classic Tornado, But It's White

When I first sent pictures off to New York City to be review for sale I got a call complaining that tornadoes weren't white, how could they sell this? It's all in the angle of the sun. The tornado seen here is "front lit" by sunlight so it's white. Most tornadoes are photographed as they move in from the west with the sunlight filtering in behind them. Those tornadoes are generally black to dark grey. Regardless of the color the damage is the same. We were following a tornado a couple miles to our north-northwest and this surprise funnel spun out of the clouds right in front of us. It was only down on the ground for about 30 seconds then quickly lifted. No damage resulted.

Sometimes The Funnel Does Damage And The Condensation Funnel Is Not On The Ground.

This contorted tube type tornado did tree damage in the forested area to our north. The funnel appears to not be on the ground, but it was for quite a while. As part of a TV crew in 1980, we photographed this tornado from 2 miles south. There was no lightning or rain where we were doing our taping, a perfect setup, we thought. Lightning came down from the anvil of the storm and struck the powers lines

traveled down the pole and across the barb wire fence. Four of us found ourselves on the ground after a bright arc came out of my hand and struck my friend Steve who was standing behind me. All of us survived, but we were sore for a couple of days. The video was shown on a TV station in Oklahoma City. After the news a technician recorded another story over the tape. The record of the lightning strike was lost forever except in our minds, where it remains very clear to this day.

Discontinuous Funnel in the Rain

This tornado was northeast of Bennett, Colorado in the late 1980's. The funnel made an sudden appearance from out of the rain then extended a weak circulation to the ground. It was hard to tell if the funnel looped back into the rain or it had a break in the condensation. Funnels such as this are hard to see and an example of what may lurk in the rain during a day when the potential for tornadic storms is present.

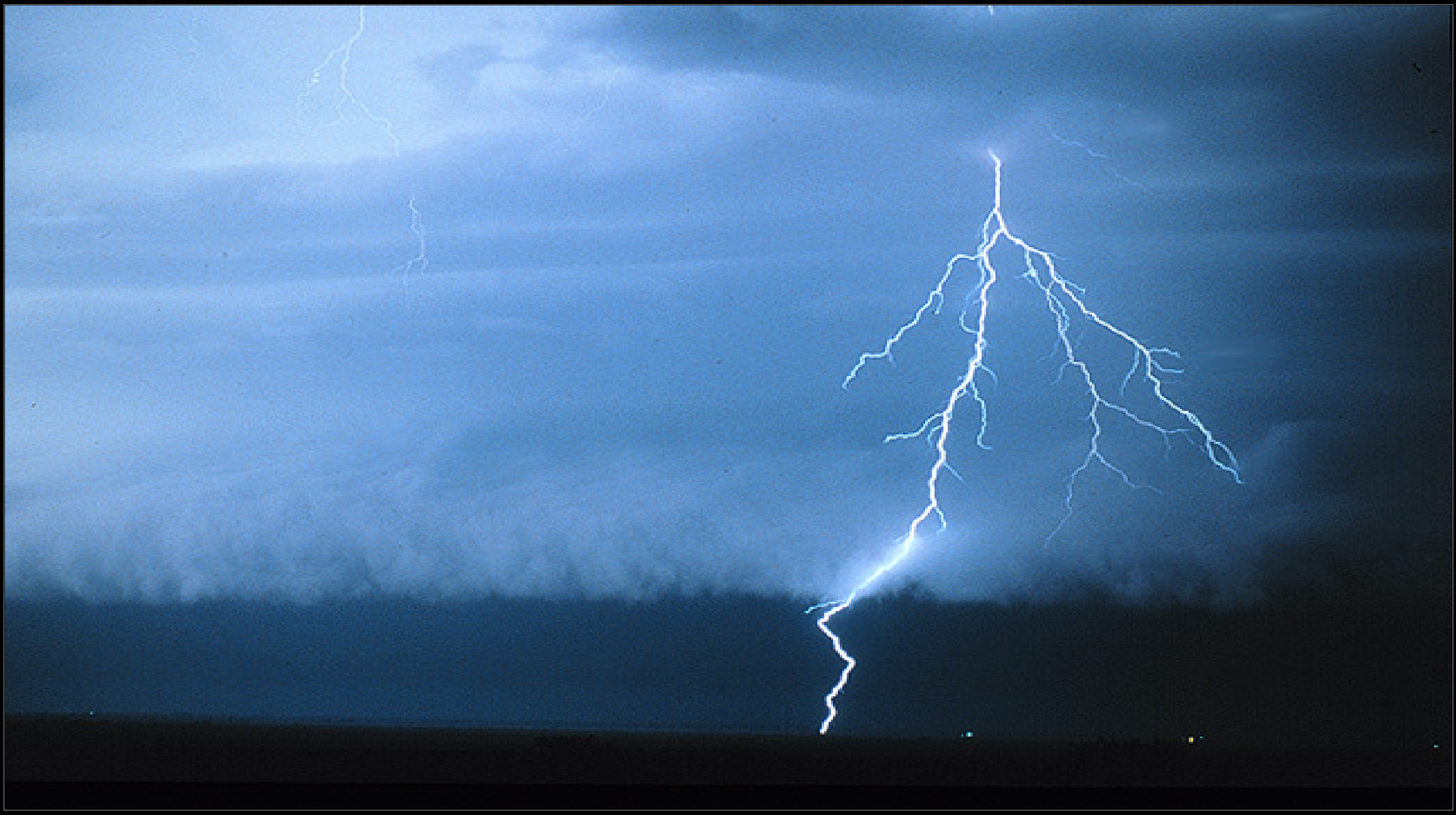
This particular tornado did not do any damage that we know about. The northeast sections of Adams County, Colorado is mainly open farm land with sparsely scattered homes.

GO TO TORNADOES PART 2

Back to Chase Day Index Page

Lightning and Storms

Chase Day © copyright Gene Moore



Lightning on a Gust Front

Can high wind bend a channel of lightning? It appears to be happening in this images taken in western Oklahoma. Strong winds form a gust front into a shelf cloud along the leading edge of the storm. Storms with this configuration are usually fast movers with strong straight line winds. This cell was moving east at 60 MPH. The blue color is from the film, but I liked it so I left it.

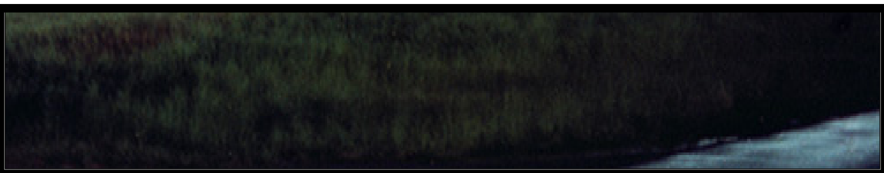
Want to learn more about the lightning and understand what's going on in these storms? Kids can learn more about lightning by visiting sources such as the National Geographic Page on lightning . Lightning extending from thunderstorms into space is a new area of study and may be observed in special situations involving very clear dark skies.

Cloud to Ground Strikes

Cloud to ground lightning looks the best when it's out of the rain. Two types of lightning are in the first image. Lightning under the cloud base that on the edge of the rain and lightning coming out of the anvil striking outside the edge of the storm. Both are clear of the rain area and show good branching.

Using Lightning To Illuminate the Tornado

Lightning is common in a tornadic thunderstorm, but often after the tornado is on the ground the lightning diminishes. This was a lucky shot, well not total luck, I was there. It's really hard to do this, as I have tried for years. On numerous occasions I have had a tornado in the lightning and something goes wrong to keep me from getting it. One time I had two tornadoes going on simultaneously in the lightning east of Wichita, Kansas. I broke out of



the storm too close to them and they just roared by as I was trying to get set up. For this shot I was on a little hand tripod setting on the car hood, which is fast to set up, and it wasn't raining so I could stand outside.

Lightning Over The City

The secret to good lightning shots over the city is to get a great vantage point and stay dry (and out of the lightning) as the storms move in. In this image a severe thunderstorm rains lightning down on Oklahoma City. The lightning is on the leading edge of the gust front where new storms are forming. That keeps it out of the rain so the branching shows up on the film.

Shooting lightning over the city is the easiest place if you want to take pictures like these. Setting up the camera from a second story window or a balcony of an apartment is a good start. I use a window clamp tripod in a car for safety. Since a group of us storm chasers got hit (not hurt) we have been really careful. If you want to learn more about lightning I could tell you how I do it, but someone else that takes great lightning had already done it. So visit Chuck Doswell's site for lightning tips before you try this, and your results will be better.

Combining a Red Sunset and the Lightning

A very red sunset combine with an isolated severe storm over Ardmore, Oklahoma produced this unusual shot. No colored filters or Photoshop tricks here, just a great sunset. Oh, and the way to check if weather and astronomy pictures are authentic, look at the white lights, are they white, or red? This photo was taken from the scenic overlook in the Arbuckle Mountains.

Daylight Lightning Hits A New Mexico Mountain Side

It's common knowledge that lightning hits the highest spots, right? By watching lightning long enough in the mountains one will discover it hits where it pleases. It frequently bypasses the mountain tops to strike in the valleys or hillsides. If you're out in a lightning storm it's best to get under cover and away from big trees, but just because your on lower ground is no guarantee of protection.

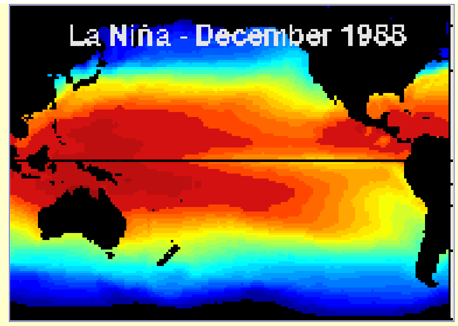
Lightning Backlights A Mesocyclone

Lightning is generally very active during the formation stages of a mesocyclone. In this image I was able to take advantage of the situation by capturing a rapidly rotating wall cloud, with a tail cloud streaming in from the east.

Go to Lightning Part 2

U.S.Department of Commerce / NOAA / PMEL / TAO / **El Niño theme Page**

What is La Niña?



La Niña is characterized by unusually cold ocean temperatures in the Equatorial Pacific, compared to El Niño, which is characterized by unusually warm ocean temperatures in the Equatorial Pacific.

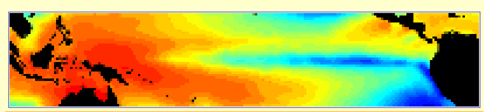
Read more on	
Some recent El Niño and La Niña events	Impact on global climate
See La Niña and El Niño animations	The origin of the name, La Niña
Where to find more information	Selected references and publications

Current conditions		
El Niño and La Niña in the entire Pacific ocean	Pacific ocean temperatures recorded last night	Current conditions from NOAA's La Niña page

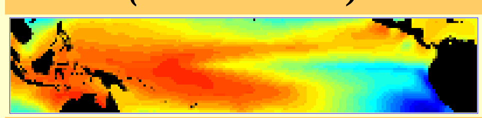
See also	
Everything you wanted to know about El Niño	3D animations of La Niña and El Niño

Shown below is the Reynolds sea surface temperature in the equatorial Pacific from Indonesia on the left to central America on the right (20N - 20S, 100E - 60W).

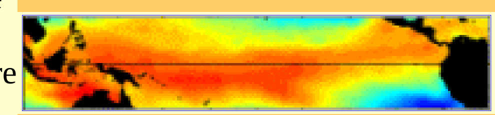
Normal Equatorial Pacific Ocean surface temperatures (December 1993) are shown in the middle panel, including cool water, called the 'cold tongue', in the Eastern Pacific (in blue, on the right of the plot) and warm water in the Western Pacific (in red, on the left). Strong La Niña conditions during December 1998 are shown in the top panel. The Eastern Pacific is cooler than usual, and the cool water extends farther westward than is usual (see the blue color extending further to the left). Strong El Niño conditions, in December 1997, are shown on the bottom panel, with warm water (red) extending all along the equator. El Niño and La Niña are opposite phases of the El Niño-Southern Oscillation (ENSO) cycle, with La Niña sometimes referred to as the cold phase of ENSO and El Niño as the warm phase of ENSO.



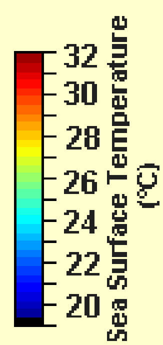
La Niña (cold) Conditions (December 1998)



Normal Conditions December 1993



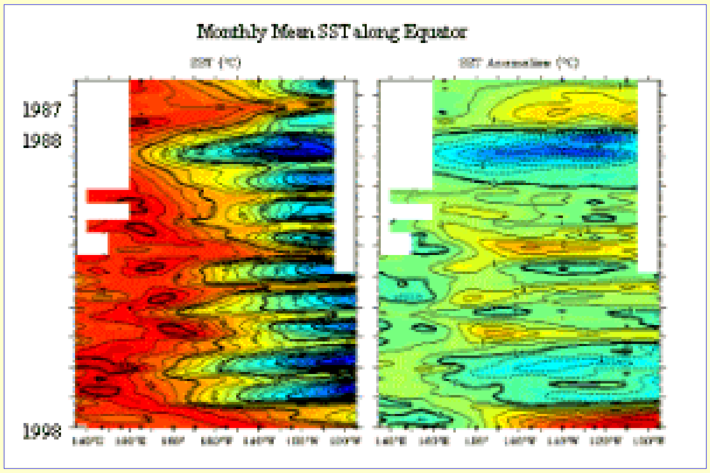
El Niño (warm) Conditions December 1997



Recent La Niña and El Niño events

Different La Niña and El Niño events vary in strength

In the left hand panel, you see the sea surface temperature at the Equator in the Pacific Ocean (Indonesia is towards the left, South America is towards the right). Time is increasing downwards from 1986 at the top of the plot, to the present, at the bottom of the plot. The first thing to note is the blue "scallops" on the right of the plot, in the eastern Pacific. These indicate the cool water typically observed in the Eastern Pacific (called the "cold tongue"). Cold tongue temperatures vary seasonally, being warmest in the northern hemisphere springtime and coolest in the northern hemisphere fall. The red color on the left is the warm pool of water typically observed in the western Pacific Ocean. El Niño is an exaggeration of the usual seasonal cycle.



Mean and anomalies of sea surface temperature from 1986 to present, showing El Niño events 1986-1987, 1991-1992, 1993, 1994 and 1997 and La Niña events in 1985 and 1995.

During the El Niño in 1986-1987, you can see the warm water (red) penetrating eastward in the Spring of 1987. There is another El Niño in 1991-1992, and you can see the warm water penetrating towards the east in the northern hemisphere spring of 1992. The 1997-1998 El Niño (at the bottom) is unusually strong.

El Niño and La Niña years are easier to see in the anomalies on the right hand panel. The anomalies show how much the sea surface temperature is different from the usual value for each month. Water temperatures significantly warmer than the norm are shown in red, and water temperatures cooler than the norm are shown in blue. In the right-hand plot of sea surface temperature anomalies, it is very easy to see El Niños, with water warmer than usual (red) in the eastern Pacific, during in 1986-1987, 1991-1992, 1993, 1994 and 1997-1998. It is unusual for El Niños to occur in such rapid succession, as was the case during 1990-1994.

Notice the very cool water (blue), in the Eastern Pacific, in 1988-1989, and the somewhat less cool water in 1995. These are La Niña events, which occur after some (but not all) El Niños. Typically, El Niño occurs more frequently than La Niña. A list of El Niño and La Niña years is provided by the National Center for Environmental Prediction (NCEP).

El Niño and La Niña events vary in strength. For example, the La Niña in 1987 was a stronger than the La Niña in 1995, and the 1997-1998 El Niño is unusually strong.

La Niña impact on the global climate

In the U.S., winter temperatures are warmer than normal in the Southeast, and cooler than normal in the Northwest.

Global climate La Niña impacts tend to be opposite those of El Niño impacts. In the tropics, ocean temperature variations in La Niña tend to be opposite those of El Niño.

At higher latitudes, El Niño and La Niña are among a number of factors that influence climate. However, the impacts of El Niño and La Niña at these latitudes are most clearly seen in wintertime. In the continental US, during El Niño years, temperatures in the winter are warmer than normal in the North Central States, and cooler than normal in the Southeast and the Southwest. During a La Niña year, winter temperatures are warmer than normal in the Southeast and cooler than normal in the Northwest. See **U.S. La Niña** impacts from the National Weather Service. Also see this graphically in plots of temperature and rainfall anomalies in El Niño and La Niña years from Florida State University. An anomaly is the value observed during El Niño or La Niña subtracted from the value in a normal year.

La Niña and El Niño animations

Where are animations of La Niña and El Niño events?

If you have an MPEG animation viewer, and sufficient memory, you can view an animation which shows the changes in monthly sea surface temperature in the tropical Pacific Ocean. A Java animation is also available. Notice the weak La Niña peaking in December 1995, and the strong El Niño building in 1997. The animation is about 1 Megabyte in size. As you view this animation, you will see a weak La Niña peaking in December 1995. The bottom panel in the animation, labeled anomalies, shows how much the sea surface temperature for each month is different from the long term average for that month. The green color in the anomalies plot indicates that the temperature of the water is slightly cooler than is normal for that month. A strong El Niño is shown by the warm water spreading from the western Pacific to the eastern Pacific during 1997. The red color in the anomalies plot indicates that the temperature of the water is much warmer than is normal for that month.

The origin of the names, La Niña and El Niño

La Niña is sometimes referred to as El Viejo

El Niño was originally recognized by fisherman off the coast of South America as the appearance of unusually warm water in the Pacific ocean, occurring near the beginning of the year. El Niño means The Little Boy or Christ child in Spanish. This name was used for the tendency of the phenomenon to arrive around Christmas. **La Niña** means The Little Girl. La Niña is sometimes called El Viejo, anti-El Niño, or simply "a cold event" or "a cold episode". There has been a confusing range of uses for the terms El Niño, La Niña and ENSO by both the scientific community and the general public, which is clarified in this web page on definitions of the terms ENSO, Southern Oscillation Index, El Niño and La Niña. Also interesting is the Web page Where did the name El Niño come from? An excellent glossary of El Niño terminology has been provided by UCAR.

More information on La Niña and El Niño

- Today's El Niño Information - *Updated daily!*
- Latest real-time TAO data
- Children of the Tropics: El Niño and La Niña.
- Frequently Asked Questions
- Predictions and Forecasts
- Present conditions in the tropical Pacific *measured by NOAA's TAO network of moored buoys*
- El Niño Theme Page: *Centralized access to widely distributed information*
- **Sites in Spanish and Portuguese language**
- Discussion of global precipitation differences in El Niño and La Niña years
- El Niño terminology
- Check out information on the La Niña Summit that took place in July 1998

Selected references and publications

- Philander, S.G.H., 1990: El Niño, La Niña and the Southern Oscillation. Academic Press, San Diego, CA, 289 pp.
- Hayes, S.P., L.J. Mangum, J. Picaut, A. Sumi, and K. Takeuchi, 1991: TOGA-TAO: A moored array for real-time measurements in the tropical Pacific Ocean. Bull. Am. Meteorol. Soc., 72, 339-347. *(abstract available)*
- McPhaden, M.J., 1993: TOGA-TAO and the 1991-93 El Niño-Southern Oscillation Event.

Oceanography, 6, 36-44. ***(entire paper available)***

- Lee, Martin E., and Chelton, Dudley, Oceanic Kelvin/Rossby Wave Influence on North American West Coast Precipitation, NOAA Technical Memorandum (NWS WR-253)
- El Niño references: TAO refereed journal articles and other TAO papers.
- NOAA Reports to the Nation - El Niño and Climate Prediction

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Credits and Acknowledgements | TAO Diagrams

Part of the El Niño theme page, provided by the TAO project
oar.pmel.taogroup@noaa.gov

teacher pages Exploring the Environment modules & activities

El Niño: The Child Returns

El Niño. Regional or global consequences?

[Situation] [Remote Sensing] [The Spheres] [What Is an El Niño?]

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- Measuring El Niño
- El Niño impacts
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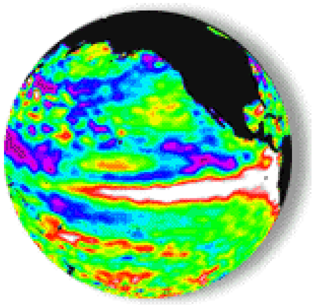

Kelvin wave information, collected by the joint U.S./French TOPEX/Poseidon satellite in April 1997, shows the evolution of warm water in the equatorial Pacific Ocean. Kelvin waves are often precursors to El Niño events. This is the beginning of our most recent El Niño.

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If you are not immediately directed to the El Niño Theme Page

Click here for the high Bandwidth (lots of graphics) version
Click here for the low Bandwidth (less graphics) version

The text content of both these pages are similar.

Experiencing problems with this page? eugene.burger@noaa.gov

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USGS News and Information on El Niño

Floods || Landslides || Coastal Hazards || Climate || News Releases || Other Information

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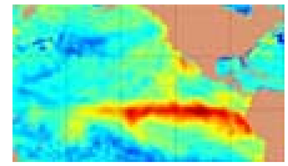


What is El Niño?

- What is El Niño? (30-Nov-1999)

Floods

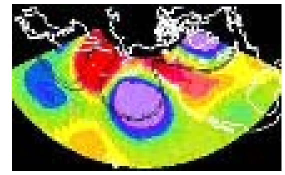
- El Niño Sea-Level Rise Wreaks Havoc in California's San Francisco Bay Region (31-Jan-2000)
- 1998 California Floods (11-Mar-1998)
- The Spring Runoff Pulse from the Sierra Nevada (14-Jan-1998)
- Effects of El Niño on Streamflow, Lake Level, and Landslide Potential (16-Dec-1997)
- Climate and Floods in the Southwestern U.S. (10-Jul-1997)
- Real-time flows on rivers and streams
- More USGS information on Floods

Landslides

- Recent landslide events--News and Information (updates regularly)
- Landslide publications and reports (14-Oct-2003)
- USGS Circular 1244 (26-Sep-2003)
  "National Landslide Hazards Mitigation Strategy -- A Framework for Loss Reduction"
- USGS Landslide Hazards web site
- More USGS information on Landslides
- Information on Landslides during the 1997-98 El Niño:
  - Map Showing Locations of Damaging Landslides in Alameda County, California, Resulting From 1997-98 El Niño Rainstorms (10-Jan-2000)
  - El Niño and 1998 California Landslides (20-Mar-1998)
  - Geologic mapping and El Niño: Landslide and debris-flow susceptibility maps, including southern California, Mojave Desert, and San Francisco Bay Area (02-Feb-1998)
  - Landslide Recognition and Safety Guidelines (29-Jan-1998)
  - USGS Producing Landslide Hazard Maps for Emergency Services in San Francisco Bay Area (16-Dec-1997)
  - Potential San Francisco Bay Landslides During El Niño (16-Dec-1997)
  - El Niño and the National Landslide Hazard Outlook for 1997-1998 (16-Dec-1997)
  - Effects of El Niño on Streamflow, Lake Level, and Landslide Potential (16-Dec-1997)

Coastal hazards

- El Niño Sea-Level Rise Wreaks Havoc (31-Jan-2000)
  in California's San Francisco Bay Region
- Coastal Erosion Along the U.S. West Coast During 1997-98 El Niño (12-August-99)
- Coastal Erosion From El Niño Winter Storms (31-Aug-1998)
  with before and after air photos from Southern Washington, Northern Oregon, Central California, and Southern California
- 1982-1983 El Niño Coastal Erosion, San Mateo County, California (6-May-1998)
- 1997-98 El Niño Coastal Monitoring Program (31-Mar-1998)
  with before and after photos of Santa Cruz County, California beach erosion.
- Hydroclimatology of San Francisco Bay Freshwater Inflows and Salinity, with weather and salinity movies (14-Jan-1998)
- El Niño Effects on Sea-Level Near San Francisco Bay (16-Dec-1997)
- Coastal Impacts of an El Niño Season (3-Nov-1997)
- More USGS information on Coastal hazards



Climate

- Long-term climate variation in the Mojave Desert (15-Jan-1998)
- The Spring Runoff Pulse from the Sierra Nevada (14-Jan-1998)
- El Niño Effects on Sea-Level Near San Francisco Bay (16-Dec-1997)
- Effects of El Niño on Streamflow, Lake Level, and Landslide Potential (revised 16-Dec-1997)
- Climate and Floods in the Southwestern U.S. (10-Jul-1997)

News Releases

-

Other information

- What is El Niño?
- Origin, Incidence, and Implications of Amazon Fires (30-Mar-1998)
- Other sources of El Niño information

URL: http://walrus.wr.usgs.gov/elnino/
Maintained by: Laura Zink Torresan
Last modified: 15 October 2003 (lzt)
For more information, please contact the El Niño Web Team

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COAPS Library Subject Guides to the Internet

El Niño & La Niña Resources on the Internet

- **El Niño Cartoons** - Almost 40 cartoons in the collection.
- Search the El Niño publications database.
- El Niño: Facts, Figures, Images and Predictions. This paper, published in College & Research Libraries News, is available online by following the link above.
  Print version: Mariner, Vincent A., 1998: College & Research Libraries News, v59, no.9, p. 663-667.

- Comprehensive Bibliography On The El Niño Phenomena. Scout Report SELECTION
- El Niño Mediagraphy compiles resources such as film, videotape, atlases, CD-Roms and other media depicting El Niño.
- The North American Climate Patterns Associated With The El Niño-Southern Oscillation.
  This is the online companion to the print version released as COAPS Project Report Series 97-1 in March 1997.
- Impacts of ENSO on U.S. Tornadic Activity.
- El Niño Stickers! Exploring the lighter side of El Niño.
- An exciting new CD-Rom about El Niño is now available.

El Niño refers to a massive warming off the coastal waters of Peru and Ecuador and the Southern Oscillation to the related atmospheric component of this phenomenon, often abbreviated as ENSO. The ocean warming covers a band from 10 degrees N to 10 degrees S and extends more than 90 degrees of longitude. Typically, the warming starts late in the boreal spring or summer and builds to a peak at the end of the year, with the event usually over by the following summer. It is a quasi-periodic phenomenon with global consequences in the form of flooding, droughts, and other phenomena. (TAMU, Glossary of Oceanography and the Related Geosciences with References)

This index defines ENSO years based on sea surface temperature anomalies.

Please visit the ENSO Index According to JMA SSTA page for more information.

Cold Phase	Neutral Phase	Warm Phase
1945	1944	1951
1946	1950	1957
1947	1952	1963
1948	1953	1965
1949	1958	1969
1954	1959	1972
1955	1960	1976
1956	1961	1982
1964	1962	1986
1967	1966	1987
1970	1968	1991
1971	1974	
1973	1977	
1975	1978	
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	1993	
	1994	
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	1996	

El Niño/Southern Oscillation Categorized Years
(Based on the JMA - SST Anomaly Index).

Scout Report SELECTION

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Date of last update: Tuesday Dec 22, '98

El Niño

Children of the Tropics: El Niño and La Niña

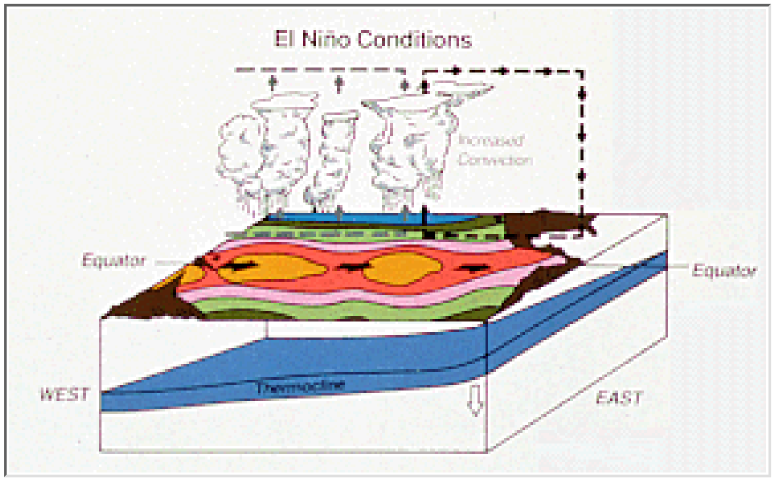
Bob Henson[1]

Kevin E. Trenberth[2]

February 1998 • updated October 2001

[1] University Corporation for Atmospheric Research (UCAR) Communications

[2] National Center for Atmospheric Research (NCAR) Climate and Global Dynamics Division, Climate Analysis Section (NCAR is sponsored by the National Science Foundation)



Thumbnail sketch of ocean - atmosphere coupling during El Niño. The details of this interaction are described in this article, its accompanying figures, and animations portraying the evolution of sea surface temperatures during the El Niños of 1982-83 and 1997-98. Links to other El Niño related sites are also provided.

For many years, coastal residents of Peru had noticed a strange feature of the eastern Pacific Ocean waters that border their home. This region of tropical yet relatively cool water is host to one of the world's most productive fisheries and a large bird population. In the first months of each year, a warm southward current usually modified the cool waters. But every few years, this warming started early (in December), was far stronger, and lasted as long as a year or two. Torrential rains fell on the arid land; as one early observer put it, "the desert becomes a garden." Warm waters flowing south brought water snakes, bananas, and coconuts from equatorial rain forests. However, the same current shut off the deeper, cooler waters that are crucial to sustaining the region's marine life.

This is El Niño, "the Christ child," so named because of its frequent late December appearance. Once thought to affect only a narrow strip of water off Peru, it is now recognized as a large-scale oceanic warming that affects most of the tropical Pacific. The meteorological effects related to El Niño and its counterpart, La Niña (a cooling of the eastern tropical Pacific), extend throughout the Pacific Rim to eastern Africa and beyond.

El Niño is normally accompanied by a change in atmospheric circulation called the Southern Oscillation. Together, the ENSO (El Niño-Southern Oscillation) phenomenon is one of the main sources of interannual variability in weather and climate around the world. Since recognizing some

25 years ago that the oceanic and atmospheric parts of ENSO are strongly linked, scientists have moved steadily toward a deeper understanding of ENSO. Climate forecasters have taken the first steps toward predicting the onset of El Niño and La Niña events months in advance. Still, much remains to be learned about these children of the tropics.

The Basics of ENSO

Among the many global phenomena connected to the El Niño-Southern Oscillation (ENSO) are Asian monsoons. The migration of the monsoon each year has been linked to the tropical Pacific rainfall patterns that are part of ENSO. The image highlights late monsoon season thunderstorms near Jamalpur, northern Bangladesh, 90.5°E, 25.0°N, 31 August 1985. From bottom right to top left one is looking southwest across Bangladesh to the Bay of Bengal and the northeastern coast of India. Evident in much of the photo is the silt laden Brahmaputra River and its branches in floodstage, flowing towards the Bay of Bengal. Jamalpur lies southwest of the Khasi Hills which form much of the state of Meghalaya in northeastern India. Geographical atlases typically show precipitation in the Khasi Hills to fall in the range of 3000-5000 mm (120-195 inches) annually, depending on elevation. However, in many localities of the Khasi Hills, annual rainfall amounts far exceed the upper limit of this range, noteworthy being Cherrapunji [elevation 1312 m (4306 ft)] on the Shillong plateau where the monsoon and strong orographic effects conspire to produce 11,420 mm (450 inches) of rain annually. Up to 9700 mm (382 inches) of this precipitation falls during the monsoon from late May to mid September, with monthly amounts in June and July often exceeding 2500 mm (98 inches). NASA image STS51F-31-069.

It was the atmospheric part of ENSO-the Southern Oscillation, or SO-that first attracted the attention of scientists. Sir Gilbert Walker documented and named the SO in the 1930s. Other persistent patterns of high and low pressure had been previously noted in the North Pacific and North Atlantic; thus, the "southern" in SO.

The clearest sign of the SO is the inverse relationship between surface air pressure at two sites: Darwin, Australia, and the South Pacific island of Tahiti. As seen in Figure 1, high pressure at one site is almost always concurrent with low pressure at the other, and vice versa. The pattern reverses every few years. It represents a standing wave or "see-saw", a mass of air oscillating back and forth across the International Date Line in the tropics and subtropics.

This two-dimensional picture was extended vertically by renowned meteorologist Jacob Bjerknes in

1969. He noted that trade winds across the tropical Pacific flow from east to west. To complete the loop, he theorized, air must rise above the western Pacific, flow back east at high altitudes, then descend over the eastern Pacific. Bjerknes called this the Walker circulation (in honor of Sir Gilbert); he also was the first to recognize that it was intimately connected to the oceanic changes of El Niño and La Niña.

The persistent easterly trade winds are a key ingredient in the ENSO process. They have two major effects:

- Pushing water toward the western Pacific. The sea level in the Philippines is normally about 60 centimeters (23 inches) higher than the sea level on the southern coast of Panama.
- Allowing the westward-flowing water to remain near the surface and gradually heat. This gives the water's destination-the western Pacific-the warmest ocean surface on Earth. Usually above 28°C (82°F), parts of this pool are sometimes as warm as 31.5°C (89°F).

As warm surface water collects in the western Pacific, it tends to push down the thermocline, the boundary separating well-mixed surface waters from deeper, colder waters. The thermocline is usually about 40 meters (130 feet) deep in the eastern Pacific but varies from 100 to 200 meters (330-660 feet) deep in the west. Figure 2 depicts a sequence of longitude-depth cross-sections of mean temperature in the equatorial Pacific Ocean for the months of December 1996, and April, August, and December of 1997. This period corresponds to the onset and intensification of the 1997-98 El Niño event. Clearly evident in Figure 2 is the normal pooling of very warm water and the depression of the thermocline in the western Pacific in December of 1996, and the eastward march of warmer than normal temperatures (positive temperature anomalies) from this region during the 1997-98 El Niño event. Notice the extensive cap of exceptionally warm surface waters in the eastern Pacific in December of 1997, the tell-tale signal of the arrival of El Niño in the Pacific coastal waters of equatorial South America. One can well imagine that the presence of this abnormally warm water profoundly influences and interferes with the normal upwelling of cold deep water and the delivery of life-sustaining nutrients to the base of the marine food chain.

An animation of sea surface temperature (SST) anomalies from March of 1992 through December of 1997 also illustrates the early stages of the 1997-98 El Niño in the Pacific Ocean, and completes the three-dimensional picture of the eastward migration of the equatorial warm pool during this event. (1997-98 El Niño SST animation, 1.7MBytes, MPEG format, courtesy of Tim Scheitlin, NCAR Scientific Computing Division Visualization Lab.)

The persistent oceanic heat surrounding Indonesia and other western-Pacific islands leads to frequent thunderstorms and some of the heaviest rainfall on Earth. The rainfall is abetted by the upward motion produced by the Walker circulation. The distribution of SSTs drives the enhanced rainfall, Walker circulation, and associated trade winds, which in turn are responsible for the ocean currents and the distribution of SSTs. The atmosphere drives the ocean and the ocean drives the atmosphere in a truly coupled mode of behavior. An example of this coupling can be found in Figure 3, which shows higher than normal rainfall centered on the equator and International Date Line during the strong El Niño of December-January-February of 1982-83. The enhanced rainfall is attributable to the presence of anomalously warm SSTs during El Niño, and in this example accounts for upwards of 4-6 mm per day (about 0.2 inch per day) more precipitation than what is typical. [A 1982-83 El Niño SST animation (1.2MBytes, MPEG format, courtesy of Tim Scheitlin, NCAR Scientific Computing Division Visualization Lab) is provided which portrays the state of

Pacific Ocean SST anomalies from October of 1981 to August of 1985.] Figure 4 summarizes the salient features of the atmosphere-ocean interaction and coupling during normal and El Niño conditions.

Anatomy of El Niño

The sea-level pressure at Darwin can be used as an index of the SO and, by extension, as a guide to the major ENSO events of the past. Figure 5 shows the Darwin pressure anomalies (deviations above or below normal) of the past century, smoothed to eliminate short-term effects. Positive anomalies of Dawrin sea-level pressure correspond to El Niño events, negative anomalies to La Niña. Note that

- El Niño and La Niña events tend to alternate about every three to seven years. However, the time from one event to the next can vary from one to ten years.
- The strength of the events, as judged by the pressure anomaly, varies greatly from case to case. The strongest El Niños in this record occurred in 1982-83 and 1997-98 (The effects of 1982-1983 included torrential storms throughout the southwest United States and Australia's worst drought this century. Figure 6 shows other, related world impacts from this event.)
- Sometimes El Niño and La Niña events are separated not by their counterparts, but by rather normal conditions.

Figure 5 and other evidence like it reveals that ENSO is a quasi-periodic yet highly variable phenomenon. Sometimes the warm waters generated by an El Niño flow all the way across the Pacific. The 1997-98 event increased surface water temperatures near Peru by 5°C (9°F). In the much weaker event of 1986-87, the warm water extended eastward only as far the mid-Pacific (near 170°W) and raised the temperatures there a modest 1°C (1.8°F) or so. In still other cases, warm anomalies first appear offshore of Peru and then progress westward to meet the preexisting warm pool.

Bjerknes was unable to determine why the SO reverses or why the ENSO changes from warm to cold conditions (El Niño to La Niña). This is still a subject of intense research. Although the atmosphere and ocean act in harmony after an ENSO event begins, some intriguing questions remain. What sets the system off? Is there really a self-sustained cycle in the atmosphere-ocean system? What is the role of other influences?

Recent work using computer models of ENSO hints that the storage of heat throughout the tropical ocean is a key element. Apparently, as rainfall and cloud cover are reduced during La Niña, the increased solar input heats up the ocean, especially in the deep western-Pacific warm pool. During El Niño, heat is transported from the tropics to higher latitudes by ocean currents, and additional heat goes to the atmosphere, mainly through evaporation. Global temperature averages can reflect this heat input, rising by as much as 0.3°C (0.5°F) in the months after a strong ENSO event. Thus, the tropical Pacific Ocean loses heat during El Niño and gains it during La Niña.

Could it be the length of time needed to "recharge" the ocean with heat that determines when ENSO events start and stop? Some model results point in this direction. However, conditions outside the tropics also seem to be important. Atmospheric changes over the South Pacific Ocean often precede

SO changes by one to three seasons. Some studies have related the onset of El Niño to anomalous snowfall over Asia and to the southeast Asian monsoon. Ocean wave disturbances that travel across the tropical and subtropical Pacific may also play a role as they reflect off ocean-basin boundaries. Madden-Julian Oscillations, which occur in the atmosphere with periods of 40-50 days typically, contribute to westerly (from the west) wind bursts in the western tropical Pacific and may also play an important role. Even random weather "noise" may initiate events in the coupled system that start an El Niño or La Niña. Perhaps there are multiple ways that an ENSO event can be triggered. Even so, the system's inclination toward an ENSO event can be predicted with increasing success.

Predicting ENSO and its Effects

Even before we know when or how a particular El Niño or La Niña is going to evolve, we can say something about the regional and global effects it is likely to have. This is due to teleconnections: physical relationships that result from the dynamics of atmospheric and oceanic waves. The impact of teleconnections on weather patterns can be illustrated with statistics. Just as high pressure at Darwin tends to occur with low pressure at Tahiti, the presence of El Niño has been correlated with a number of wide-ranging atmospheric events. Figure 7 shows locations that have a consistent increase or decrease in precipitation during El Niño events, with the most common months of that occurrence indicated. Some of the best-established effects are enhanced rainfall over the central Pacific, Peru, Ecuador, and the southern United States and drought in INdonesia, Australia, southern Africa, and northeastern Brazil.

In other locations, the impact of El Niño can have two or more different "flavors." For instance, California can experience very wet conditions (such as in 1940-41, 1982-83, and 1991-92) or drought (1986-87 and 1987-88), depending on how far east the ENSO-related rainfall extends in the tropical Pacific. Predicting which flavor will dominate for a given event is difficult, because very small changes in SSTs can become magnified to produce large differences in rainfall patterns outside the tropics. Precipitation in California is clearly connected to ENSO, but it may vary greatly from one El Niño to the next.

In another approach to prediction, some researchers are using computer models to attempt to reproduce the physics of the ocean and atmosphere as they evolve during ENSO events. This became possible in the 1980s as computer power became sufficient to include ocean-atmosphere interactions in the large-scale climate models used to study such topics as greenhouse warming. Such models have been able to reproduce many of the oceanic and atmospheric effects of ENSO in the tropical Pacific, especially those that occur at the start of an El Niño event.

In 1986, a milestone was reached when the El Niño beginning late that year was successfully predicted months in advance by a computer model at Lamont-Doherty Earth Observatory of Columbia University. Using a state-of-the-art General Circulation Model (GCM) in 1992, NCAR was the first to demonstrate the evolution of ENSO-like behavior in a hypothetical atmosphere containing twice the carbon dioxide of the present (a state likely to be reached by the year 2060). The model indicates that the rainfall anomalies connected to El Niño and La Niña may become stronger in a global-warming scenario.

Forecast Frontiers

In the past, an inadequate understanding of the relevant physical processes and a lack of observational data covering vast areas of tropical oceans have been amongst the principal obstacles for scientists engaged in ENSO prediction. Significant improvement of the observational data base was brought about by the Tropical Ocean Atmosphere (TAO) array of 70 instrument buoys moored throughout the equatorial Pacific Ocean. Completed in 1994, and renamed the TAO/TRITON array in 2000 in recognition of the Japanese contribution of Triangle Trans-Ocean Buoy Network (TRITON) buoys in the western Pacific, the array gathers surface meteorological and oceanographic data and records ocean temperature to a depth of about 500 meters (1650 feet). Data collected by the TAO array (as displayed in Figure 2) played a central role in the early detection of the onset of the 1997-98 El Nio, marking a significant improvement over the detection of the 1982-83 event.

A vast array of ships, aircraft, and buoys collected oceanographic and atmospheric data throughout the western tropical Pacific as part of the Tropical Ocean and Global Atmosphere Program's Coupled Ocean - Atmosphere Response Experiment (TOGA-COARE) from November 1992 through February 1993. Shown is one of the 70 TAO instrument buoys being deployed as part of TOGA. (NOAA image.)

What are the remaining obstacles to predicting El Niño and La Niña? One is to better understand their cyclic yet variable beginnings and endings. The factors leading to the end of an El Niño event are not yet entirely clear, as evidenced by the failure of computer models to predict the end of the El Niño that began late in 1990. The Lamont-Doherty model called for the event to end in 1992. In late 1993, however, it was still in progress and actually intensifying, making it the longest-running El Niño in half a century. This El Niño finally ended in 1995. More recently, several of the major computer models correctly forecast the onset of the 1997-98 El Niño months in advance, although none of the models anticipated its intensity, and one model persisted in forecasting no El Niño even after the 1997-98 event had developed. The use of subsurface ocean data from the TAO array was a major factor in the successful forecast.

To further complicate matters, the baseline against which El Niño and La Niña events are measured may itself be changing. Indications are that the average temperature of the tropical Pacific has risen slightly in the past decade or so. If so, a new benchmark for measuring the onset and conclusion of ENSO events may have to be set.

These lines of research and data acquisition, and in particular the forecast of the 1997-98 El Niño well in advance, has captured the public's eye as never before. In fact publicity surrounding El Niño has become so prevalent in the United States that many events of tenuous relation are nevertheless being attributed to El Niño. While many predictions and impacts of the forecasts are being realized, some (such as failure of the Australian wheat crop) are not. Continued verification of the forecasts and post analyses of this event will bring future benefits. It is clear that accurate information on El Niño's impact, and forecasts of its future evolution, will be of great benefit in planning for drought, flood, and temperature extremes and in mitigating the resultant loss of life and property. If we cannot hope to control the effects of ENSO, there is real hope that we can understand and forecast its life cycle.

Related Sites

The following are links to sites that offer web-based El Niño information. The URLs listed here are subject to change and beyond the control of the authors.

- NOAA's El Niño Theme Page
- Lamont-Doherty Earth Observatory Climate Group's ENSO Monitor
- El Niño Hot Spots

Much of the original information in this report was drawn from "General Characteristics of El Niño-Southern Oscillation,"by Kevin Trenberth, in Teleconnections Linking Worldwide Climate Anomalies, *edited by Michael Glantz, Richard Katz, and Neville Nicholls (Cambridge University Press, 1991).*

Last revised: Wed May 17 11:28:21 MDT 2000

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severe storms
weather forecasting

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introduction
definition
'97-'98 event
upwelling
non el nino years
el nino events
sea surface temps
impacts on weather
economic impacts
prediction

User Interface
graphics text

Graphic by: Yiqi Shao

Periodically, the flourishing fish populations commonly found off the west coast of Peru South America are replaced by the sight of dead fish littering the water and beaches. Unusual weather conditions occur around the globe as jet streams, storm tracks and monsoons are shifted. Such disarray is caused by a warm current of water that appears every three to seven years in the eastern Pacific Ocean called El Niño. This module introduces El Niño, conditions are responsible for its occurrence, plus the impact it has on the rest of the world. The El Niño instructional module has been organized into the following sections:

Sections

Last Update: 04/28/98

Definition
Introduces El Niño, when El Niño events have been recorded and how it compares to La Niña.

'97-'98 Event
Provides a brief insight into the most recent El Niño event.

Upwelling
Introduces upwelling, the thermocline and how they impact local sea life populations.

Non-El Niño Years
Typical oceanic and atmospheric conditions that exist in the tropical Pacific when no El Niño is present..

El Niño Events
Conditions that lead to an El Niño event and how El Niño

influences upwelling processes, tropical rainfall and local fish populations.

Sea Surface Temperatures
El Niño visualized through sea surface temperature anomaly plots.

Impacts on Weather
The influence of El Niño on weather conditions worldwide.

Economic Impacts
Reduction in local fish populations, which in turn affect local industry and market prices worldwide.

Detection and Prediction
Methods and resources used by NOAA for detecting and predicting the presence of El Niño.

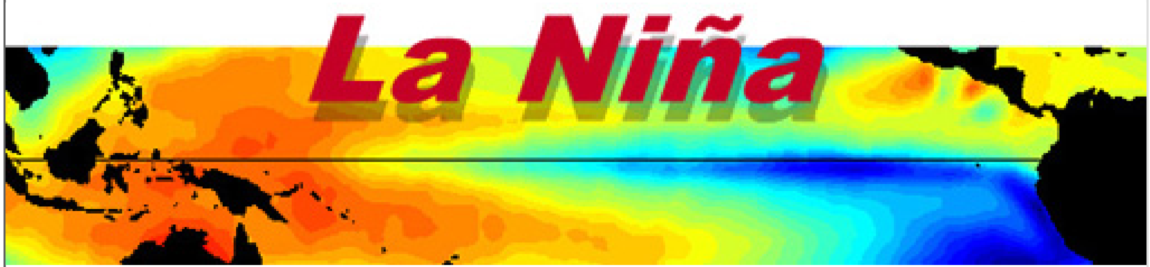
Acknowledgments
Those who contributed to the development of this module.

The navigation menu (left) for this module is called "El Nino" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Precipitation

definition

National
Oceanic and Atmospheric
Administration



La Niña Information

What is La Niña?
La Niña is characterized by unusually cold ocean temperatures in the eastern equatorial Pacific, as compared to El Niño, which is characterized by unusually warm ocean temperatures in the Equatorial Pacific. **Click here** for a whole list of frequently asked questions.

Previous Cold Phases
La Niñas occurred in 1904, 1908, 1910, 1916, 1924, 1928, 1938, 1950, 1955, 1964, 1970, 1973, 1975, 1988, 1995

Temperature and Precipitation Impacts During La Niña
Seasonal mean temperatures and precipitation maps for the United States during strong La Niña are available from NOAA's National Climate Prediction Center.
Current Monthly/Seasonal Forecast

Typical La Niña Impacts
La Niña tends to bring nearly opposite effects of El Niño to the United States — wetter than normal conditions across the Pacific Northwest and dryer and warmer than normal conditions across much of the southern tier. The impacts of El Niño and La Niña at these latitudes are most clearly seen in wintertime. In the continental U.S., during El Niño years, temperatures in the winter are warmer than normal in the North Central States, and cooler than normal in the Southeast and the Southwest. During a La Niña year, winter temperatures are warmer than normal in the Southeast and cooler than normal in the Northwest.

What does La Niña mean?
La Niña means "The Little Girl." La Niña is sometimes called El Viejo (Old Man), anti-El Niño, or simply "a cold event" or "a cold episode".

ENSO/La Niña Forecast
The National Centers for Environmental Prediction's **(NCEP)** **Climate Prediction Center** forecasts (ENSO Advisory, June 9, 1998) indicate strengthening cold episode conditions in the tropical Pacific during the remainder of 1998. Other statistical and coupled model forecasts indicate a similar evolution. The predictions during May indicate that a cold episode will likely develop during the next six months and continue through the northern 1998-99 winter.

For more information contact **John Leslie** at (301) 713-0622.

Following is a list of NOAA Internet sites with additional La Niña information:

WHAT YOU'LL FIND	NOAA ORGANIZATION
The Official La Niña Home Page	**Environmental Services Data Information Management**
Seasonal Mean Temperatures and Precipitation for the United States during Strong La Niñas	**Climate Prediction Center**
List of warm and cold episode years	**Climate Prediction Center**
What is La Niña?	**Pacific Marine Environmental Lab**

La Niña/Cold Phase (graphic)	Climate Prediction Center
Sea Surface Temperature Charts (updated regularly)	National Environmental Satellite, Data and Information Service

In a moment your browser will be redirected to the
NHC/TPC Archive of Past Hurricane Seasons page http://www.nhc.noaa.gov/pastall.shtml.

If nothing happens, please use the link above.

NHC/TPC Archive of Past Hurricane Seasons

Hurricane Season Tropical Cyclone Reports

The National Hurricane Center's Tropical Cyclone Reports (formerly called Preliminary Reports) contain comprehensive information on each storm, including synoptic history, meteorological statistics, casualties and damages, and the post-analysis best track (six-hourly positions and intensities).

Atlantic, Caribbean, and the Gulf of Mexico

1958-1994 **1995** **1996** **1997** **1998** **1999** **2000** **2001** **2002** **2003** **2004**

Note: 1958-1994 are scanned images of the printed reports

Eastern Pacific (out to 140°W)

1988-1994 **1995** **1996** **1997** **1998** **1999** **2000** **2001** **2002** **2003** **2004**

Note: 1988-1994 are scanned images of the printed reports

Hurricane Season Tropical Cyclone Product Archives

The National Hurricane Center's Tropical Cyclone Product Archive is the complete set of tropical cyclone text advisories and graphic images released by the NHC during the hurricane season.

The tropical cyclone graphics archives are accessed through the **Graphics Archive** link at the top of the individual storm archive pages (graphics from the mid-2000 season and later are available).

1998 **1999** **2000** **2001** **2002** **2003** **2004**

Hurricane Season Tropical Cyclone Monthly Summary Archives

At the end of each month during the hurricane season the NHC releases a brief summary of the tropical cyclone activity during the month. These summaries are viewed as interim to the Tropical Cyclone Reports, which are much more comprehensive. The

Breakpoints

Hurricane History
TPC Archives
Climatology
Deadliest
1492-1996 (Atlan)
1900-2000 (USA)
Most Expensive
Most Intense
US Strikes by Decade
US Strikes by State

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Visitor Information
NHC Library
Joint Hurricane Testbed
WX4NHC Amateur Radio Station
TPC Anonymous FTP Server

Contact Us
Webmaster

November summary reviews the tropical cyclone activity over the course of the entire season.

1999 2000 2001 2002 2003 2004

Hurricane Season Forecast Verification Reports

The National Hurricane Center issues every six hours a 72-hour track and intensity forecast for all tropical cyclones in the north Atlantic and east Pacific basins. Forecasts are verified by comparison with a best-track post analysis of all available track and intensity data.

1995 1996 1997 1998 1999 2000 2001 2002 2003

Some Infamous Atlantic Storms:

- **Hurricane Gordon (1994)**
- **Hurricane Andrew (1992)**
- **Hurricane Hugo (1989)**
- **Hurricane Gilbert (1988)**

Information on Hurricane History in the Atlantic

**THE DEADLIEST, COSTLIEST, AND MOST INTENSE
UNITED STATES HURRICANES FROM 1900 TO 2000
(AND OTHER FREQUENTLY REQUESTED HURRICANE FACTS)**
by
Jerry D. Jarrell(retired), Max Mayfield, and Edward N. Rappaport
NOAA/NWS/ Tropical Prediction Center
Miami, Florida

Christopher W. Landsea
NOAA/AOML/Hurricane Research Division
Miami, Florida

THE DEADLIEST ATLANTIC TROPICAL CYCLONES, 1492-1996
by Edward N. Rappaport and Jose Fernandez-Partagas
28 May 1995
NOAA Technical Memorandum NWS NHC 47
updated 22 April 1997 by Jack Beven

**Deadliest, Costliest, and Most Intense
U.S. Hurricanes of the 20th century**

- **Deadliest (through 1996)**
- **Costliest**
- **Most Intense**
- **U.S. Strikes by Decade (through 1996)**
- **U.S. Strikes by State (through 1996)**

Monthly Weather Review Atlantic Annual Summaries 1881-2000

Monthly Weather Summaries of the hurricane seasons for the years 1881 - 2000 are available from the NHC Library. The Monthly Weather Summaries were published by the U.S. Weather Service between 1881-1973. Since 1974 the Monthly Weather Summaries have been published by the American Meteorological Society

.

Hurricane Season Climatology

Average Cumulative Profile Throughout the Hurricane Season

This article describes the progress of a typical hurricane season in terms of the total number of tropical systems and hurricanes produced throughout the year in the Atlantic and East Pacific basins.

Past Tracks of Atlantic Tropical Cyclones

These are images of Atlantic Tropical Storm and Hurricane tracks. For more information please see the book "Tropical Cyclones of the North Atlantic Ocean 1871-1992", published by the Department of Commerce and the National Oceanographic and Atmospheric Administration.

Track Maps for 1851-1910, courtesy of the AOML/HRD Reanalysis Project

Note: Images for 1921-present are GIFs of about 190K size or larger.

1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003

Central North Pacific Hurricane History (1800s - 2001)

(Compiled by the Central Pacific Hurricane Center, Honolulu).

Hurricane Best Track Files (HURDAT)

The data format of these track files is explained here.

Atlantic Tracks File 1851-2003 (1.02MB)

The Atlantic Tracks File is an ASCII (text) file containing the 6-hourly (0000, 0600, 1200, 1800 UTC) center locations (latitude and longitude in tenths of degrees) and intensities (maximum 1-minute surface wind speeds in knots and minimum central pressures in millibars) for all Tropical Storms and Hurricanes from 1851 through 2003. More information on this file is found in NOAA Technical Memorandum NWS NHC 22 "A Tropical Cyclone Data Tape for the North Atlantic Basin, 1886-1983: Contents, Limitations, and Uses" by Brian R. Jarvinen, Charles J. Neumann, and Mary A. S. Davis.

For detailed information regarding the re-analysis of the Atlantic hurricane database - currently 1851-1910 have been completed - go here.

Eastern North Pacific Tracks File 1949-2003 (553K)

(Also available from Colorado St. University.)

The East Pacific Tracks File is an ASCII (text) file containing the 6-hourly (0000, 0600, 1200, 1800 UTC) center locations (latitude and longitude in tenths of degrees) and intensities (maximum 1-minute surface wind speeds in knots and minimum central pressures in millibars) for all Tropical Storms and Hurricanes from 1949 through 2003. More information on this file is found in NOAA Technical Memorandum NWS NHC 25: A Tropical Cyclone Data Tape for the Eastern and Central North Pacific Basins, 1949-1983: Contents, Limitations, and Uses - Mary A. S. Davis, Gail M. Brown, and Preston Leftwich - September, 1984.

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Tropical Prediction Center
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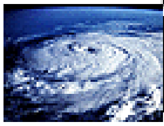
Miami, Florida, 33165-2149 USA
Todd.Spindler@noaa.gov
Page last modified: Monday, 26-Apr-2004 12:31:27 CDT



The Long Island Express

The Great Hurricane of 1938

September 21, 1938.

Facts of the 1938 Hurricane (Francis, 1998)

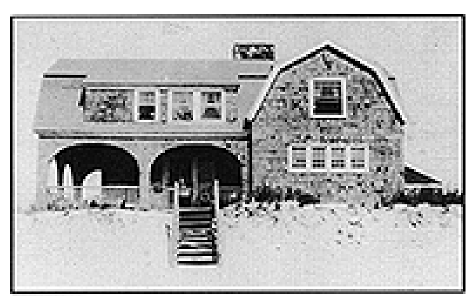
- Peak Steady Winds - 121 mph
- Peak Gust - 186 mph at Blue Hill Observatory, MA.
- Lowest Pressure - 27.94 in (946.2 mb) at Bellport, NY
- Peak Storm Surge - 17 ft. above normal high tide (RI)
- Peak Wave Heights - 50 ft. at Gloucester, MA
- Deaths - 700 (600 in New England)
- Homeless - 63,000
- Homes, Buildings Destroyed - 8,900
- Boats Lost - 3,300
- Trees Destroyed - 2 Billion (approx.)
- Cost - $6.2 million (1938), $15 billion (1998 adjusted)

That morning a *New York Times* editorial entitled "Hurricane" concluded, *"Every year an average of three such whirlwinds sweep the tropical North Atlantic between June and November. In 1933, there was an all-time record of twenty. If New York and the rest of the world have been so well informed about the cyclone, it is because of an admirable organized meteorological service"* (Allen, 1976).

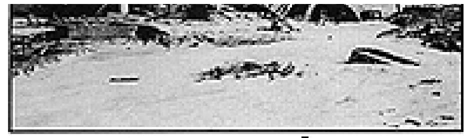
Except for Charlie Pierce, a junior forecaster in the U.S. Weather Bureau who predicted the storm but was overruled by the chief forecaster, the Weather Bureau experts and the general public never saw it coming. Later that day, the greatest weather disaster ever to hit Long Island and New England struck in the form of a category 3 hurricane. Long Island, New York and New England were changed forever by the ***Long Island Express***.

The immediate affect of this powerful hurricane was to decimate many Long Island communities in terms of human and economic losses, however, the long term effects linger today. The '38 Hurricane created the Shinnecock Inlet and widened Moriches Inlet which, to this day, are changing the landscape of the south shore due to their influence on the natural littoral sand transport. History has shown that these powerful storms are rare but do in fact occur with long-term frequency. Case studies have shown that the next time a storm like the Long Island Express roars through, it might be the greatest disaster in U.S. history.

Please visit the links below for a comprehensive review of this storm. To best view this site, you should have your video resolution set to at least 800x600 pixel depth and at least 16-bit color (Hi Color). Visit this helpful page for more information on how to change your video settings.



Quogue - Before



Quogue - After

IV. Human Interest Stories

- Personal Letters
- Beavers Save the Day

V. Geological Impact

- Shinnecock Inlet Creation
- Affect On Shaping Coastal Long Island

VI. Hurricane/Storm Climatology of Long Island

- Historical Frequency
- Historic Events
- National Frequency & Future Deaths

VII. What Does The Future Hold For Long Island?

- Top 15 Storms Today
- Doomsday Predictions

VIII. References Cited

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Historical Weather Database

Temperature and precipitation data for 2,000 cities worldwide is available in our historical database. Each city page includes some or all of the following climate summaries:

- Avg. Temp.
- Avg. High Temp.
- Avg. Low Temp.
- Record High Temp.
- Record Low Temp.
- Avg. Temp.
- Avg. High Temp.
- Avg. Low Temp.
- Highest Recorded Temp.
- Lowest Recorded Temp.
- Normal Monthly Preciptation
- Avg. Snowfall
- Avg. Wind Speed
- Avg. Days of Preciptation
- Avg. Morning Rel. Humidity
- Avg. Afternoon Rel. Humidity
- Percent of Days With Sunshine
- Mean No. of Clear Days
- Mean No. of Partly Cloudy Days
- Mean No. of Cloudy Days
- Mean No. of Days Below 32ºF

City, State or Country:

U.S. Metric

Find it!

Information in this area was provided by the National Weather Service -- San Francisco, the International Station Meteorological Climate Summary, the Global Historical Climatology Network, and the National Climatic Data Center.

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National Weather
Marine Weather
FEMA

Air Quality Theme Page

CLN Theme Pages

Below are the CLN "Theme Pages" that support the study of Air Quality. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) that will help teachers provide instruction in this theme.

- Global Warming/Climate Change
- Ozone Depletion

Air Quality Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Air Quality. Please read our disclaimer.

- Acid Rain

  In this interdisciplinary Web research project, junior high students use the Web to research information in the field of a chosen specialist, compile and analyse the data, meet with each other, and then write a report on their findings. The basic questions that they address are: What is acid rain? How does it affect the environment (and us)? Where does it come from?How can it be prevented or minimized? They may choose to be a specialist in chemistry, economics, history, environment, health, or politics/government. Each specialist is given a set of Web links to begin the research.

- Acid Rain Program

  A comprehensive site from the U.S. Environmental Protection Agency with information about acid rain. The following list of links to their site are particularly relevant to students.

  - Acid Rain: A Student's Sourcebook (A unit on acid rain that has background information, descriptions of the causes and effects of acid rain, solutions about what can be done, and experiments with activities.)
  - Effects of Acid Rain This page provide more information on how acid rain effects our environment.

- Air Junk

  Here's an activity for children to make airborne junk collectors and collect air samples. Some background information is also provided.

- Air Pollution

A site established for European schools and designed for younger students, it explores the following seven areas of concern for air pollution: Acid Rain, Domestic Smoke, Smog, The Greenhouse Effect, Particulates, Radionuclides, and Ozone Layer Depletion. Included with each page is a link to a glossary for words used while discussing air pollution.

- Air Quality

Greater Vancouver Regional District publishes a large collection of information concerning the air quality for Fraser Valley and Vancouver area. The links are identified as particularly important air quality concerns and their principles can be applied to areas in the world.

- Air Quality Lesson Plans and Data

The Texas Natural Resource Conservation Commission provides a number of lessons and activities for educators who wish to teach K-12 students about air quality. Lesson plans are provided on such topics as acid rain, air pressure, ozone, plants, oxygen, and pollution control.

- Air Quality Research Branch (Clean Air)

As part of Environment Canada, the menu on this page will link you to air quality information as it is impacted by the following air pollution concerns: acidifying emissions, persistent organic pollutants (POPs), hazardous air pollutants, smog, stratospheric ozone depletion, and climate change. In addition, there is a link with a focus on the Arctic because scientist are finding that the Arctic is the ultimate resting place for many air pollutants.

- Automobiles and Light Trucks

The U.S. Environmental Protection Agency publishes information about the impact of automobiles and air quality that includes carbon monoxide, ozone, emissions and tips on how you can help to reduce air pollution with your car.

- Health and Air Quality - Let's Talk About Air

Educational materials on air quality, indoor air quality, and pollution.

- Educational Resources for Students and Teachers

Lesson plans, activities, and fact sheets on air quality from the Louisiana Department of Environmental Quality.

- Environmental Priority - Clean Air

A page by Environment Canada that explains what causes air pollution, why we should be concerned and what is being done to protect our air.

- It's Your Health

The depletion of our ozone layer has a serious impact on future generations from the dangers of being exposed to the sun's ultraviolet rays (UV rays). The information on this page describes how UV rays can cause sunburn, premature skin aging, cataracts and skin cancer, and even weaken the immune system.

- Indoor Air Quality (IAQ)

Studies have indicated that indoor air pollution can have significant effects on human health.

This site investigates a number of the factors causing us to experiences greater exposure to indoor air pollution than in past decades. Many of these factors have to do with construction techniques and materials used in modern buildings. This site presents information on three environments that affect us: l arge buildings, homes and residences, and schools.

- [The] Kyoto Protocol: Challenges and Opportunities

Documents in this site explain the historic agreement from December 1997 Kyoto Protocol that commits the developed countries to reduce their greenhouse gas emissions to acceptable levels. It identifies a number of issues raised by different countries and the reduction conditions Canada agreed to.

- Microbiological Contamination of Residential Indoor Air

Here's information about how humid or damp conditions in the home promote the growth of bacteria, mold and dust mites. Also you'll find how these organisms can contribute to poor indoor air quality and how they can cause health problems.

- Project A.I.R.E.

A.I.R.E. (Air Information Resources for Educators) was designed as a source of resources for K-12 teachers on air pollution issues. It includes warm-up exercises, lessons, and additional reading information - all saved in PDF format.

- Smile Program Biology Index

Teachers participating in the SMILE (Science and Mathematics Initiative for Learning Enhancement) summer session programs each create a single concept lesson plan. This database has a few lessons on air quality in their section on Environmental Studies and Ecology. Caution: Since there is a wide number of authors who have contributed to the database, the detail and quality of the lesson plans will vary.

- Smog and Your Health

You can read about how smog has become the term given to the chemical "soup" that is often visible as a brownish yellow haze over urban areas. Formed from motor vehicle and industrial pollution, smog is potentially hazardous to human health by seriously affecting the respiratory system.

- Urban Smog

Environment Canada publishes information about what smog is, how to know you are in it, the effect on your health, and what can be done about it. The following link is designed with the younger student in mind.

  - Smog: Let's Clear the Air (A page with similar information as the site, but written for students.)

- Unified Air Toxics Website: Basic Facts

The basic facts on this page include: What are Toxic Air Pollutants? What are the Effects of Toxic Air Pollutants? Which Pollutants are Considered Toxic? and How are Toxic Pollutants Released into the Atmosphere? In addition, there are links to further information on health risks associated with air pollution.

- [What's Riding the Wind in Your Community?]

  Yet another resource from the US Environmental Protection Agency. This is a one week teaching unit for students in Grades 5-8 in which they collect air samples and analyze them.

- [Workplace Air Quality]

  Information defining what "Indoor Air Pollution" is and the effects on our health from many of the pollutants that could be in the air. Some of the pollutants listed (along with their effects) include: tobacco smoke, formaldehyde, volatile organic compounds, microorganisms, asbestos, carbon monoxide and more. In addition, there is a checklist to test your environment and what you can do improve your indoor air quality.

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Note: The sites listed above will serve as a source of curricular content in the study of Air Quality. For other resources in Social Studies (Environment) (e.g., curricular content in Biomes, Endangered Species, or Hazardous Waste Disposal), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Clouds Theme Page

This "Theme Page" has links to two types of resources related to the study of clouds. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme. Please read our disclaimer.

- ## All About Clouds

  USA Today has a series of hyper-linked articles on clouds. Topics covered include: types of clouds, interrelationships between stability and clouds, and how clouds influence weather.

- ## AskERIC Lesson Plans: Meteorology

  The above link is to AskEric's Meteorology page where you'll find plenty of lessons about the weather if you wish to browse/search their site yourself. Or, use the links below to go directly to some lesson plans specifically about on clouds.

  - Cloud Types A lesson plan for Grade 5 students. Students will be able to identigy and describe four different cloud types (cirrus, stratus, cumulonimbus, and cumulus).
  - Clouds A multidisciplinary lesson for grdes 4-6 that not only teaches them about clouds but can encourage abstract thinking, writing and painting.
  - Weather Forecasting Grade 6-8 students learn abaout basic cloud formations in this unit on forecasting weather.

- ## [The] Cloud Case

  WeatherEye, a public service of KGAN presents this interactive lesson for grades 5 to 8 students (teacher's guide).

- ## Cloud Formation

  A lab experiment through which students can determine how clouds are formed.

- ## Cloud Gallery

  This site provides different photographs of clouds that students may download, use, and/or adapt as they wish.

- ## Clouds and Precipitation

  From the University of Illinois: "The purpose of this module is to introduce a number of cloud classifications, different types of precipitation, and the mechanisms responsible for producing them."

- ## Clouds: One Key to Foretelling the Weather

  This tutorial from Environment Canada gives brief explanations on how various types of clouds are formed as well as pictures of sixteen types.

- How the Weatherworks: Activities, Experiments and Investigations

  Activities that can be used to study the shape and color of clouds.

- PSC Meteorology Program Cloud Boutique

  A general cloud reference source with detailed pictures.

- [A] Review of Theoretical and Observational Studies in Cloud and Precipitation Physics: 1991-1994

  The content at this site is presented at a somewhat advanced level but it should be appropriate for high school students. Topics include: various types of clouds; electrification of clouds; clouds as components in the global climate system ; possible influence of cloud condensation on climate; acid rain and cloud chemistry, and more.

- Tips for Painting Clouds

  Just what a teacher needs for a multi-disciplinary unit on clouds.

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Note: The sites listed above will serve as a source of curricular content in Clouds. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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El Niño Theme Page

This "Theme Page" has links to two types of information related to the study of El Niño. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme. Please read our disclaimer.

- El Niño

  An instructional module from the University of Illinois which introduces El Niño, describes the conditions responsible for its occurrence, and outlines the impact it has on the rest of the world (e.g., weather, economy). Also provided are data on non-El Niño years, sea-surface temperature plots, detection and prediction information.

- El Nino: Canadian Effects

  Learn about the effect of El Nina on all of Canada or specific Canadian regions.

- [The] El Niño

  The Institute of Ocean Sciences (IOS) of Fisheries and Oceans Canada provides this British Columbia resource. Included is information on: An Historical Sketch; What is the effect of El Niño on B.C. coastal waters? Brief notes on the biological impacts; How does El Niño work? How does this affect higher latitudes? El Niño forecasting - how are we doing? The Current Situation.

- El Niño and La Nina

  "USA Today" sponsors this site which provides not only general background information articles but also links to current news stories about El Niño's impact around the world.

- El Nino or El No-no

  In this Web Quest, students learn more about El Nino and La Nina Cycles by collecting and analyzing data and sharing their findings in a speculation paper.

- El Niño Loss Reduction Center

  The US Federal Emergency Management Agency provides wide ranging information on the potential disruptive effects of El Niño.

- El Niño Versus Non-El Niño Years

  A lesson plan for students in grades 9-12 in which they compare and contrast El Niño data. Note: the actual data are not provided as part of this lesson plan but they should be available from other sites on this web page.

- El Niño:Understanding and Predicting via Our Current Technology

  An on-line course for students in grades 9-12. In addition to basic information about El Niño, there are links to research information and other El Niño sites, access to earth science data, and connections to Earth scientists and Earth science teachers.

- El Niño/Southern Oscillation (ENSO) Information

  The National Oceanic and Atmospheric Administration (NOAA) provides: What happens during an "El Niño"? A 3-D animation of the tropical Pacific ocean during a simulated ENSO cycle; What are the effects of ENSO on climate? What is the current state of El Niño? Some differences between recent El Niño events; What is the state of the current climate? What are the forecasts for El Niño? Resources for teachers.

- Exploring the Environment: El Nino

  This module is part of "Exploring the Environment"[a] (ETE) from NASA's Classroom of the Future[a]. In ETE, high school students are faced with a real life problem and their goal is to use problem solving skills and internet based data (e.g., remotely sensed satellite images) to propose and defend a solution. A Teacher's Guide is available. This link is to the ETE home page since it gives the easiest access to necessary introductory and teacher information. To access the El Nino module, click on "Modules and Activities" and then "El Nino".

- National Oceanic and Atmospheric Administration (NOAA)

  This US government site has answers to frequently asked questions, information on impacts of El Niño, forecasts, and access to related data.

- Science with Noaa Research: El Nino

  An instructional module from the University of Illinois which introduces El Niño, describes the conditions responsible for its occurrence, and outlines the impact it has on the rest of the world (e.g., weather, economy). Also provided are data on non-El Niño years, sea-surface temperature plots, detection and prediction information.

- Tracking El Nino

  This Nova Online Web Site explores different aspects of El Nino including an Anatomy of El Nino, Chasing El Nino and and El Nino's Reach. You can also read a correspondent's dispatches on El Nino for a PBS/Online Adventure.

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Note: The sites listed above will serve as a source of information about El Niño. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Blizzards and Snow Theme Page

CLN Theme Pages

Below are the CLN "Theme Pages" that supplement the study of blizzards and snow. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans), which will help teachers provide instruction in this theme.

- Antarctic Theme Page
- Arctic Theme Page
- Glaciers Theme Page
- **Natural Disasters**
  - Avalanches Theme Page
  - Earthquakes Theme Page
  - Floods Theme Page
  - Hurricanes Theme Page
  - Tornadoes Theme Page
  - Tsunamis Theme Page
  - Volcanoes Theme Page

General Blizzard and Snow Resources

Here are a number of links to other Internet resources that contain information and/or other links related to blizzards and snow. Please read our disclaimer.

- Blizzard Attack

  In this interactive lesson, grade 7-12 students make a fictitious journey between two cities during adverse weather conditions, and learn some of the basic skills needed to stay safe during winter storms. A teacher's guide is available.

- Building an Igloo

  Even if you're not interested in actually building an igloo, this site will explain how its construction can keep people warm in severe weather conditions.

- Don't Be Too Flaky

  An activity in which students measure the density of water, ice, and snow.

- ## Ice and Snow

  Dragonfly Magazine has four articles about snow where kids can learn about the Antarctica and making an igloo, learn why ice floats and is slippery, read interesting facts about snow, or make a virtual flake.

- ## In Praise of Snow

  This lengthy article in the Atlantic Monthly is an intellectual study of snow - for high school students only.

- ## All About Snow

  If you want to know why snow is white, or why forecasting snow can be so difficult, this is the site for you. Learn the difference between a blizzard and a squall, or find out what graupel is in theGlossary page. Check the snow Gallery for some historic photos of blizzards and snow from the National Weather Service.

- ## Mad Scientist Network

  Use this search engine to find all the Mad Scientist Network files on "snow", and you'll find over 150 questions about snow that students have asked and had answered. The answers tend to be brief, but the sheer quantity of information available in the files is worthwhile.

- ## **Minnetonka Elementary Science Center**

  - Snow/Water/Ice A lesson plan in which K-1 students learn to identify two properties of snow.
  - Snowman Unit Grade 2-3 lesson plan in which students make a snowman, write a descriptive paragraph about making it, and then perform a variety of mathematical measurements on it.
  - So Much Snow Grade 4-5 students explore how much water results from the melting of two litres of snow.

- ## **National Snow and Ice Data Center**

  - [The] Blizzards of 1996 The site explains what a blizzard is, why they're dangerous, and why there was so much snow in the 1996 blizzards.
  - Have Snow Shovel, Will Travel A web document giving historical descriptions of snow/blizzards in the U.S. - including how the settlers coped, a history of snow removal efforts, famous snowstorms, snowiest cities in the US, and blizzard safety.
  - Questions and Answers about Snow
  - Snow Fact Sheet
  - Snow Glossary

- ## Precipitation: Online Meteorology Guide

  An explanation of the varying atmospheric conditions that produce hail, freezing rain, sleet, and snow.

- ## Snow

Students can learn about the basics of snow, snow art, and how to build a snow castle.

- ## Snow Activities

  There are lots of elementary teaching resources offered by this home schooling family. Included are suggestions for snow-based activities within science, art, literature, and food.

- ## Snowbound

  The Grade 7 Natural Disasters Project provides a brief description of blizzards along with a wind chill chart.

- ## Snow Flake Designs

  - Ben & Jerry's Happy Holiday Paper Snowflakes Instructions for making three paper snow flake designs.
  - How to Make Paper Snowflakes General instructions for making paper snow flakes with different designs.
  - Snowflake Detailed instructions.
  - Snowflake Designer Design your own snowflake using this interactive Shockwave plug-in.
  - Snowflakes Instructions for making five paper snow flake designs.

- ## Snow Flake Imagery

  - Electron Microscopy Unit Snow Images of snow crystals made from a low temperature scanning electron microscope.

- ## Snow School

  Spring Brook Manufacturing, a snowshoe company, offers a collection of lesson plans/units on snow. Be sure to see their selection of lesson plans and ideas for teaching PE in the snow (e.g., Pass the Snowball, Human Sled Pull, Orienteering, Raid the Snow Fort). For outdoor education information on how plants and animals live in snowy conditions, check out the link to the Glacier National Park Environmental Education Guide. There are also a couple of experiments with snow - some of which are their own and some from other sites that are already on this Theme Page.

- ## Snowtastic Snow

  Here's a Web Quest Junior contestant with lots of information about snow. Elementary students can read about the ice age (history), learn about hypothermia (PE&Health), learn more about the science of snow, play games, or engage in a couple of activities.

- ## TrackStar

  TrackStar is an online interface that allows instructors to create lessons for students by sequencing existing instructional content in various Websites within a lesson. Students explore one topic at a particular location within one Website, then move on to the next topic at another Website. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the Websites beyond the designated instructional content are also possible.

This link is to their search page from where a keyword search on "snow" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding Websites, sequencing the tours) will vary widely within the TrackStar collection.

- Winter

  Suggestions for some primary level winter activities that include literature sources, bulletin board ideas, science activities, and crafts.

- Winter Storms

  A unit on winter storms, complete with interactive components: weather maker, and winter storm timeline.

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Note: The sites listed above will serve as a source of curricular content in Blizzards and Snow. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu, which will give you access to educational resources in all of our subjects.

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Floods Theme Page

Below are the CLN "Theme Pages" which supplement the study of floods. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- **Natural Disasters**
  - Avalanches Theme Page
  - Blizzards Theme Page
  - Earthquakes Theme Page
  - Hurricanes Theme Page
  - Tornadoes Theme Page
  - Tsunamis Theme Page
  - Volcanoes Theme Page
- Water Quality Theme Page

General Floods Resources

Here are a number of links to other Internet resources which contain information and/or other links related to floods. Please read our disclaimer.

- Flood Hazard Management

  The BC Ministry of Water, Land and Air Protection provides various information about flooding in BC including: flood hazard management, floodplain mapping, emergency response (e.g., sandbag dike construction), picture images.
- Dartmouth Flood Observatory

  Dartmouth College in the US uses remote sensing technology as a tool for early detection, mapping, measurement, and analysis of world-wide extreme flood events. In addition to downloadable satellite images, there is a register of international large river flooding for the last several years in their site.
- FEMA for Kids

  The U.S. Federal Emergency Management Agency has developed this site so that young students can learn about various disasters, what to do during and before them, and what causes them. The site also includes activities (games, quizzes, challenges), a library of resources (e.g., pictures), and resources for parents and teachers.
- Flash Flood

Here's an interactive lesson for students in grades 3-10 about flash floods and other types of floods. Topics include identifying different types of floods, preparing for a flood, flood watches and warnings. A teacher's guide is included as are a student assignment and quiz.

- Flood!

  This web site is a companion to a Nova program on the flooding of the upper Mississippi flood plain in 1993. Students can read how people dealt with the deluge and learn the benefits of a flood. A teacher's guide is available.

- Floods: How Can Water be Powerful Enought to Move a House?

  Newton's Apple, a public television production, provides student activities so that they can better understand floods and their control.

- Floods: What To Do Before and After

  Advice from the Canadian Mortgage and Housing Corporation on the precautions one can take before a flood and what one can do afterwards to repair damages.

- Flood Stories From Around the World

  Story legends about floods organized by region of the world.

- Just Doing My Job

  In this site, grade 6-10 students can learn how satellite images were used to help flood evacuations during a 1993 US flood. In addition to the story, the site contains student activities and a teacher's guide. There is also a link to another NASA site in which students engage in activities to learn more about remote sensing technology.

- Manitoba Flood Information

  This is the Government of Manitoba's Flood web site. In addition to announcements about current potential flooding, it has information about the flood of 97 as well. Included are facts and figures of the flood, photographs, personal health and safety guidelines, guidelines for what to do when returning to flooded out residences, and advice on avoiding scams.

- Red River Diary

  The virtual diary of a free lance writer and photographer who chronicled the Red River flood of 1997 (North Dakota and Manitoba) while it was happening. Read their observations and view their pictures as they provided web coverage of the flood.

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Note: The sites listed above will serve as a source of curricular content in Floods. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu, which will give you access to educational resources in all of our subjects.

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Global Warming/Climate Change Theme Page

Below are the CLN "Theme Pages" which support the study of Global Warming/Climate Change. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Air Quality
- Ozone Depletion

Global Warming/Climate Change Resources

This "Theme Page" has links to two types of resources related to the study of global warming / climate change. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme. Please read our disclaimer.

- Encyclopedia of the Atmospheric Environment

  Published online in 2000, the "Encyclopedia of the Atmospheric Environment" is a clever two-level encyclopedia about climate, global warming, weather, and related topics for grades 9 to 12 students.

- Environmental Change Education/Outreach Program

  The Nebraska Earth Science Education Network (NESEN) has collected over a dozen lesson plans in climate change from NESEN teachers participating in two workshops. Look in the 1997 and 1998 workshop sections for the lesson plans.

- Explorer: Global Warming

  A downloadable lesson plan complete with overhead masters (in pdf format) for students in grades 3-9. "This lesson plan covers the major greenhouse gases, human activities that contribute to the change of the Earth's atmosphere, and why there is a concern about climate changes. Also addressed are strategies for dealing with potential global warming and the major contributors to global warming. The possible effect of a global warming on forests, agriculture, health, wildlife, and the oceans are addressed."

- **[The] Franklin Institute Science Museum**
  - Bringing the Greehouse Effect Down to Earth In this lab activity, high school students compare the amount of Carbon Dioxide in four different sources of gases.

- [The] Greenhouse Effect in a Jar An elementary/junior high experiment that will serve as an introduction to the greenhouse effect. Skills include observing and recording data, use of a control, drawing conclusions from results, and use of a model.

Global Change

This teaching unit from the United States Geological Survey is intended for students in grades 4-6 although some activities can be used with older or younger students. The unit consists of an introduction and many activities. Each activity has background material, an experiment, suggestions for further reading and extensions.

Global Climate Change

Environment Canada provides answers to the questions: "What is climate change?" "What is Canada doing?" "How will climate change affect you?" and "What can you do?" There are other useful resources within or linked to this site - we've provided direct links below.

- Government of Canada: Global Climate Change This site has been designed specifically to inform Canadians about climate change, how it affects our environment, and what the Canadian government is doing about it. In addition to these sections, be sure to check out the Resource Room as well as the Activity Room.
- [A] Primer on Climate Change Indepth information on the issue of climate change, its impacts, and measures we can explore to reduce greenhouse gas emissions.

Global Climate Change Student Guide

The online textbook "Global Climate Change Student Guide" is an authoritative Web resource for upper-grade and college Environmental Science students.

Global Warming: Focus on the Future

There are four sections to this site. In "It is happening" students can get the historical perspective on global warming as well as information on what the issue is. There are also articles describing impacts, discussions of solutions, and games/puzzles for students.

Global Warming Unit

This teaching unit from LETSNet (Learning Exchange for Teachers and Students through the Internet) consists of five lessons designed for middle school and high school students.

Greenhouse Warming: Fact, Hypothesis, or Myth?

A look at the validity of the Greenhouse Warming Theory.

National Environmental Indicator Series - Climate Change

Environmental indicators are selected key statistics, which represent or summarize a significant aspect of the state of the environment, natural resource sustainability, and related human activities. This site provides information about the climate change issues such as: Carbon dioxide intensity, Global atmospheric concentration of green house and more.

National Forum on Climate Change: Proceedings

These proceedings are the records of a series of meetings which brought together a citizens' panel of 25 respected Canadians in a National Forum on Climate Change in 1998. The panel heard a full range of expert opinion and examined all aspects to the topic objectively. The information is arranged in a series of meeting minutes and, as such, access to the reports is somewhat cumbersome.

- ## NASA fact sheets

  NASA Fact Sheets are produced in an effort to educate the general public on the major issues and natural phenomena that scientists will be studying using data provided by the Earth Observing System. These files are in PDF format.

- ## Sierra Club of Canada: Climate Change

  This site provides a view on climate change from the perspective of a Canadian environmental protection group. In addition to basic information on global warming, there are research reports, data summaries, and announcements.

- ## Skepticism Net: Global Warming

  A meta-list of links to resources on the web which dispute or question the claims of global warming.

- ## Still Waiting for Greenhouse

  The introduction to this web site describes itself thusly: "This website demonstrates what many climate scientists know to be exaggerated claims and political propaganda about`Global Warming', based on unscientific (mostly computer model) evidence. The observed evidence indicates that little or no global warming is happening and little should be expected. "

- ## TrackStar

  TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

  This link is to their search page from where a keyword search on "global and warming" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

- ## **United Nations Framework Convention on Climate Change**

  - Beginner's Guide to the Convention A description of environmental problems that the world is facing and what we are doing about it through the Convention.
  - Climate Change Information Kit Thirty fact sheets (also in downloadable format) which cover: Understanding of the Climate System; Facing the Consequences; The Climate Change Convention; Limiting Greenhouse Gas Emissions; and Facts and

Figures.

- [The] Convention and the Kyoto Protocol Full text of the protocol along with information on the status of its implementation.
- Country Information Snapshots of action taken by a large number of countries to meet their domestic and international climate change commitments.

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Note: The sites listed above will serve as a source of curricular content in Global Warming/Climate Change. For other resources in Social Studies -Environment (e.g., curricular content, lesson plans, and theme pages), click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

Hurricanes Theme Page

Below are the CLN "Theme Pages" which supplement the study of hurricanes. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- **Natural Disasters**
  - Avalanches Theme Page
  - Blizzards Theme Page
  - Earthquakes Theme Page
  - Floods Theme Page
  - Tornadoes Theme Page
  - Tsunamis Theme Page
  - Volcanoes Theme Page

General Hurricanes Resources

Here are a number of links to other Internet resources which contain information and/or other links related to hurricanes. Please read our disclaimer.

- ## 1901-1996 U.S. Landfalling Hurricanes

  A collection of GIF maps that display the locations where and when hurricanes hit the US coastline bordering with the Atlantic Ocean and Gulf of Mexico . Each map is organized by decade and each hurricane is colour coded according to its degree of severity.

- ## Canadian Hurricane Centre

  Environment Canada, Atlantic Region, monitors all hurricane activity along the Atlantic Seaboard. If hurricane activity appears to threaten Eastern Canada, the Centre will inform the region's residents of potentially damaging weather conditions and provide tracking information and services.

- ## Counting on the Havoc of Hurricanes

  In this lesson plan, grade 6-12 students use a NY Times article as a starting point to "define and classify all the different ways in which numbers are used in forecasting and coping with the effects of a hurricane. They then conduct research to compare and contrast these numbers as they apply to Hurricane Floyd and other recent hurricanes. Finally, they graph their findings."

- ## Create an Art Object Depicting a Hurricane

  A practical art lesson plan for any elementary classroom. It can be used with younger students to encourage them to draw representations of hurricanes. This lesson can be easily expanded for older student to include some hurricane research.

- Exploring the Environment: Severe Weather: Hurricanes

This module is part of "Exploring the Environment"[a] (ETE) from NASA's Classroom of the Future[a]. In ETE, high school students are faced with a real life problem and their goal is to use problem solving skills and internet-based data (e.g., remotely sensed satellite images) to propose and defend a solution. A Teacher's Guide is available. This link is to the ETE home page since it gives the easiest access to necessary introductory and teacher information. To access the hurricanes module, click on "Modules and Activities" and then "Hurricanes". The challenge students will have is to use the history of Hurricane Andrew (1992) to track, analyze and predict the course of a new hurricane that may threaten North America this school year.

- Handle a Hurricane

In this StormSmart lesson from WICS NewsChannel 20, high school students assume the role of a mayor of a city threatened by an approaching hurricane and needing to make a decision whether to evacuate the city. They read news reports about the storm, memos from staff advising the mayor on whether or not to evacuate, and basic information about hurricanes before announcing their decision.

- [The] Heat is On! Creating Weather Emergency Guides in the Science Classroom

In this lesson plan, grade 6-12 students research severe weather conditions common to their geographic location and create weather emergency guides for extreme weather conditions such as tornadoes, floods, blizzards, thunderstorms and hurricanes. They use a New York Times article as a starting point for their explorations.

- Hurricane!

Use this link to download the .pdf file for a primary level, 10 lesson unit on hurricanes. Students learn report writing skills while studying the weather of the Caribbean islands, hurricanes, and hurricane preparation.

- Hurricane Centre

Current news from a Florida media outlet. In addition, they have information on hurricane tracking, names, and terms. There are extensive sections providing advice to residents on how to prepare for hurricanes. For example, there are hints on: checking your roof, how to find a safe place to hide, building plywood shutters, getting a survival kit organized, what to do with your pet, and much more. A collection of maps is available in different formats for downloading, printing and use on-line to help you track storm and hurricane activities. Also, check out "Hurricanes in History" for brief historical summaries of hurricane events off the US Atlantic coastline, starting with Columbus in 1495.

- Hurricane Disaster Service

The American Red Cross provides extensive information about hurricane preparation and how to stay safe during a hurricane. Information includes on-line resources and downloadable PDF documents.

- Hurricane: Storm Science

  Designed for elementary students, the materials in this site include explanations, diagrams/images, stories, activities, and downloadable materials. Contents cover the following topics: What is a hurricane like? How do hurricanes work? What happens when a storm comes? What paths do hurricanes take? Has anyone else been in a disaster?

- Hurricanes

  Supported by the University of Illinois, this site describes several introductory hurricanes characteristics and issues including: What hurricanes are; How they get their names; What affects their development; and, How to rate their destruction with the Saffir-Simpson Scale. Advanced hurricane information is available after accessing these introductory pages.

- Hurricanes

  This instructional unit is part of the "Science With OAR" web site developed by the University of South Alabama. It consists of explanatory sections on hurricanes, student activity assignments, and links to other external hurricane sites where students can collect the data to answer the questions.

- Hurricanes

  The U.S. Federal Emergency Management Agency sponsors this "FEMA for Kids" site on hurricanes. Students can read information specially developed for them on classification, historical events, naming conventions, origins, disaster scales, and hurricane hunters. The site includes a number of student activities as well.

- Hurricanes Spark a Storm of Classroom Activity

  Education World provides activities and Internet connections to engage students of all ages in a study of hurricanes.

- Hurricane Trailhead

  This is the starting point for a virtual field trip on hurricanes from Tramline. Experts in the subject have selected a number of web sites on hurricanes and arranged them in a sequence to tell a story for students to follow. Students can move from one web stop in the field trip to the next with ample opportunity to explore within the individual web site as they wish. However, since their web browser page has been split into an inner part (showing that stop in the field trip) and an outer part (giving navigational tools to go through the entire field trip), they can always return to their "tram" and go to the next stop. To be effective, teachers would have to ensure that student browsing through the field trip sites was purposeful. Teacher guides can be printed.

- Hurricane Watch

  Internet-based activities related to hurricanes for students across the subjects and across the grades from Education World.

- Images/Movies of Hurricanes and Special Events

  More than 500 satellite photos of hurricanes, tropical storms and typhoons starting from

1968. These photos, collected by National Climatic Data Center, are categorized by year. The collection includes the following types: colour, radar, infrared and MPEG movies.

- National Hurricane Center - Tropical Prediction Center

  The Tropical Prediction Center is located in Miami, Florida and works cooperatively with the National Weather Service to track and monitor hurricane and storm activity off the US Atlantic coast. A comprehensive site for information regarding current and past hurricane activity.

- Tracking A Hurricane

  A lesson plan designed for students in grade 9-12 who are familiar with trigonometric conversion formulas from rectangular to polar and back again.

- TrackStar

  TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

  This link is to their search page from where a keyword search on "hurricanes" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

- Weather Eye

  We were successful in finding a site of weather instructional materials for teachers. The following links will take you directly to lessons for the grade range listed.

  - Cadet Section 20 weather related lessons for grade 2-8. One of the lessons is for hurricanes, the others could be modified to include hurricane activity.
  - Expert Section Six extensive lessons suitable for Grade 6-12. Most the lessons are designed for role play situations. For example, in the lesson "Handle a Hurricane", students take the role as "Mayor" and must make decisions regarding the town's safety as the hurricane approaches.

- [The] Wrath of Hurricane Mitch

  In this lesson plan, grade 6-12 students "investigate how hurricanes and other natural disasters can devastate the elements of the infrastructure of a country, as well as the lives of its people. Students then work in committees, each focused on one element of a country's infrastructure, to analyze the existing infrastructure problems in Honduras caused by Hurricane Mitch, devise possible solutions for these problems, and assess how each aspect of a country's infrastructure is interdependent to the others. Students also determine how lesser developed countries and developed countries differ in times of catastrophe." They use a New York Times article as a starting point for their explorations.

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Note: The sites listed above will serve as a source of curricular content in Hurricanes. For other resources in Weather (e.g., curricular content), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

Lightning Theme Page

Below are the CLN "Theme Pages" which support the study of electricity-related concepts such as Lightning. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Electricity (Concepts) Theme Page
- Electronics (Circuitry) Theme Page
- Magnetism Theme Page

General Lightning Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Lightning. Please read our disclaimer.

- Bright Light Fright

  View this section of the Franklin Institute (what would be more appropriate?) for information on the history and science of lightning. They also have a piece on lightning detection.

- Design a Lightening Calculator

  In this activity, students will learn how to predict lightening distances and discover why light travels faster than sound.

- Fire Weather

  The Alberta Ministry of Environmental Protection collects data on lightning strikes within the province and makes them available from this site both cumulatively and daily. They also describe their lightning detection system.

- Frequently Asked Questions about Lightning

  From Kerry Anderson of the Canadian Forest Service in Edmonton

- Human Voltage: What Happens When People and Lightning Converge?

  A readable news article from NASA that describes the incidence and impact of lightning strikes on the human body.

- Kids' Lightning Information and Safety

  Developed by a lightning strike victim, this site offers kids' information on lightning and lightning safety. Sabrina writes, "it really hurts when you are struck by lightning and I want to help other kids to learn more about lightning safety. I want to share what I have learned with you. I think that the more you know, the safer you can be."

- Lightning

  This instructional unit is part of the "Science With OAR" web site developed by the University of South Alabama. It consists of explanatory sections on lightning, student activity assignments, and links to other external lightning sites where students can collect the data to answer the questions.

- Lightning and Atmospheric Electricity Research at the GHCC

  Don't let the name scare you away from this NASA site. For a sound introduction to lightning (history, basics, safety, etc.) check out their "Lightning Primer." Then, to learn more about how NASA's space program is involved, read their section on Space Research and Observations.

- Lightening in a Jar

  Students create lightening in a clear plastic jar with a light bulb.

- [The] Lightning Page

  A very comprehensive site that contains basic explanatory information as well as photo and sound files. A lengthy index lists such sections as survivors, FAQs, myths, strike maps, safety and more. Note this site is actively sponsored by Christian Internet Services (CIS).

- Lightning Photography

  Over 150 photographs by Michael Bath.

- Lightning Photography

  Over 75 photographs of lightning strikes by Dave 'stormguy' Crowley. He also offers photography and safety tips.

- Personal Lightning Safety

  The Lightning Safety Institute offers advice on personal protection in outdoor recreational events, parks, swimming pools, boats, and in general. They also have other useful information.

- Severe Storms: Online Meteorology Guide

  Dangers, types and components of thunderstorms.

- Sparks and Lightning

  An article explaining sparks, lighting and conductive plasma.

- [The] Strike

  This site has pictures of what the owner advertises as the "closest 12 stroke lightning strike ever caught on video" as well as background information on the event. Included are also other pictures from professional stormchasers and links to related sites.

- **Strike One**

  This link is to an archive of over 25 lightning strike pictures taken by Michael Fewings whose goal is to combine artistry with lightning. See also his "current" photographs from this page and his tips on how to "avoid" being struck.

- **Thunderstorms**

  The U.S. Federal Emergency Management Agency sponsors this "FEMA for Kids" site on thunderstorms/lightning. Children can read information specially developed for them on terminology, what lightning is, what if someone is hit by lightning, facts and fiction, photos, things to know, and what one might feel in a disaster.

- **TrackStar**

  TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

  This link is to their search page from where a keyword search on "lightning or thunder or storm" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

- **Weather Eye: Lightning**

  Student tutorials, experiments with static electricity, an interactive safety section, and a quiz for grades 5-9.

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Note: The sites listed above will serve as a source of information about Lightning. For other resources in Sciences (e.g., curricular content in Earth, Life or Physical sciences, etc), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

Ozone Depletion Theme Page

Below are the CLN "Theme Pages" which support the study of Ozone Depletion. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Air Quality
- Global Warming/Climate Change
- Reduce, Reuse, Recycle Theme Page

Ozone Depletion Resources

This "Theme Page" has links to resources related to the study of the Ozone Depletion. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme. Please read our disclaimer.

- Air Quality Lesson Plans and Data

  The Texas Natural Resource Conservation Commission provides a number of lessons and activities for educators who wish to teach K-12 students about air quality. Lesson plans are provided on such topics as acid rain, air pressure, ozone, plants & oxygen and pollution control.

- [The] Earth Times

  An on-line magazine, Earth Times offers current and past news stories with a focus on the environmental issues, sustainable development concerns, population and current affairs. The Earth Times is the only independent international nonpartisan newspaper focusing on environment and economic development, and such interrelated concerns of the international system as human rights, population, trade, and women's and children's rights. Its mission is primarily to inform and educate audiences about the pressing issues of interdependence in which the environment plays a central role. Present and back issues are available for browsing or searching.

- Exploring the Environment: UV Menace

  This module is part of "Exploring the Environment" (ETE) from NASA's Classroom of the Future. In ETE, high school students are faced with a real life problem and their goal is to use problem solving skills and internet based data (e.g., remotely sensed satellite images) to propose and defend a solution. A Teacher's Guide is available. This link is to the ETE home page since it gives the easiest access to necessary introductory and teacher information. To access the ozone module, click on "Modules and Activities" and then "UV Menace."

- [Fact Sheet: Health and Environmental Effects of Ground-Level Ozone]

  Ground-Level ozone is the primary ingredient of smog. This page explains in an easy to read format the following topics:

  - Why are We Concerned about Ground-Level Ozone?
  - Who is Most at Risk from Exposure to Ground-Level Ozone?
  - How does Ground-Level Ozone Harm the Environment?
  - What Improvement Would Result from EPA's New Standards?
  - Background: What is Ground-level Ozone?

- [(The) Greenhouse Effect]

  Written for Elementary and Middle school students, to learn about the "The Greenhouse Effect" and "The Ozone Layer".

- [Ground-Level Ozone]

  Created for the State of Texas, this page describes the two types of ozone, how it is formed and some of the problems related to each type.

- [Ozone]

  Nasa's Observatorium presents an article on ozone for students in grades 9-12 which presents the effects of ozone depletion on the Earth, discusses the formation and destruction of ozone, and summarizes the history and the politics of the Montreal Protocol. There's also a teacher's guide with suggested student activities, but you'll have to read through the article to find it.

- [The Science of Ozone Depletion]

  Be sure to check out Effects of Ozone Depletion, Ozone Depletion and Environmental Effects, UV-B Radiation: How to protect yourself.

- [[The] Ozone Hole Tour]

  From the University of Cambridge's Centre for Atmospheric Science, this tour begins with an introduction including a history of the issue and proceeds to a description of recent discoveries in the Antartic. The third part of the tour examines the science beyond the issue - what are the ingredients that make ozone loss occur? The final segment summarizes current research.

- [Stratospheric Ozone]

  From this comprehensive Environment Canada site, you can learn about ozone depletion, health and environmental impacts, the Canadian Ozone Layer Protection Programs, Canadian data, and international efforts. There's also a special Kid Zone which has these resources especially designed for young students.

  - [Healthy Living with Sunshine]
  - [Ozone Guarding Our Earth]
  - [[The] Ozone Layer: What's Going On Up There?]

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Note: The sites listed above will serve as a source of curricular content in Ozone Depletion. For other resources in Social Studies - Environment (e.g., curricular content), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

Tornadoes Theme Page

Below are the CLN "Theme Pages" which supplement the study of tornadoes. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- **Natural Disasters**
  - Avalanches Theme Page
  - Blizzards Theme Page
  - Earthquakes Theme Page
  - Floods Theme Page
  - Hurricanes Theme Page
  - Tsunamis Theme Page
  - Volcanoes Theme Page

General Tornadoes Resources

Here are a number of links to other Internet resources which contain information and/or other links related to tornadoes. Please read our disclaimer.

- (A) Comprehensive Glossary of Weather Terms for Storm Spotters

  This glossary contains weather-related terms that may be either heard or used by severe local storm spotters or spotter groups.

- EarthWatch Weather On Demand

  A graphic intensive site showing satellite and radar weather pictures for North America. At this page, you can choose detailed, current weather images of Canada. The StormWatch button at the top of the page is for the US only.

- [The] Fujita Scale

  "The Fujita Scale (also known as the Fujita-Pearson Scale) is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure." The page also has many links to tornado resources.

- [The] Heat is On! Creating Weather Emergency Guides in the Science Classroom

  In this lesson plan, grade 6-12 students research severe weather conditions common to their geographic location and create weather emergency guides for extreme weather conditions such as tornadoes, floods, blizzards, thunderstorms and hurricanes. They use a New York

Times article as a starting point for their explorations.

- Kansas Tornado Chasers

  The purpose of this site is to educate the public, spotters, and chasers of the subject of tornadoes. The site includes tornado history, photos, videos, forecasts, nowcasts, preparation, and much more. Check out their kidspage and safety links.

- Severe Weather Related Sites

  A meta-list of sites related to severe weather.

- Tornadoes

  Part of Scientific American's site, this page has descriptive information about Supercells, Tornado Chasing, Signature of a Vortex, Spinning Up, and Touchdown.

- Tornadoes

  This instructional unit is part of the "Science With OAR" web site developed by the University of South Alabama. It consists of explanatory sections on tornadoes, student activity assignments, and links to other external tornado sites where students can collect the data to answer the questions.

- Tornadoes: Going Around in Circles

  Sponsored by the National Institute for Science Education, this site provides answers the following questions: What are tornadoes?; Where does a twister get all that energy?; How to protect yourself when a tornado is close?; and How does a twister affect the natural landscape? Get the answers to these questions, then take the "twisted test".

- Tornado in a Bottle

  A lesson plan for grades 3-5 that lets them create a vortex in a bottle.

- Tornado Information Index

  A meta-list of sites from USA Today. It has links to resources on tornado safety, tornado science, tornado research, tornado chasing and more....

- (The) Tornado Project On-line

  A page of resources from a small group who collects, compiles and makes tornado information available. This site specializes in tornado myth, tornado oddities, personal experiences, tornado chasing, tornado safety, and tornadoes from the past.

- Tornado Trailhead

  This is the starting point for a virtual field trip on tornadoes from Tramline. Experts in the subject have selected a number of web sites on tornadoes and arranged them in a sequence to tell a story for students to follow. Students can move from one web stop in the field trip to the next with ample opportunity to explore within the individual web site as they wish. However, since their web browser page has been split into an inner part (showing that stop in the field trip) and an outer part (giving navigational tools to go through the entire field trip), they can always return to their "tram" and go to the next stop. To be effective, teachers would have to ensure that student browsing through the field trip sites was purposeful.

Teacher guides can be printed.

- [The] TORRO Tornado Intensity Scale

  This Scale is used to categorize windspeeds in tornadoes. From the following list, learn about the criteria used to rate the tornado's windspeed: viewing the damage caused, engineering analysis of the damage caused, Doppler radar, photogrammetric analysis, and direct measurement.

- TrackStar

  TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

  This link is to their search page from where a keyword search on "tornadoes" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

- Vortex

  Grades 4-10 lesson plan using 2 - 2 litre bottles to create a tornado in a bottle.

- Vortex: Unraveling the Secrets

  The story of an expanding tornado and its resulting consequences are set in a story plot similar to a mystery novel. The authors begin the mystery with a description of some of the events and facts. Then they lead the reader through information that helps them understand and possibly solve why the tornado occurred. There are two versions available, Java enhanced (slow downloading) and low band width.

- (The) Weather Unit

  A weather unit complete with many primary class lesson plans integrated into all subjects areas.

- What is a Tornado?

  A detailed essay describing various characteristics of tornadoes with accompanying photos. Part of its purpose is to dispell misconceptions about tornadoes.

Note: The sites listed above will serve as a source of curricular content in Tornadoes. For other resources in Weather (e.g., curricular content), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

Water Quality Theme Page

Here are a number of links to Internet sites which contain information and/or other links related to the specific theme of water quality. Please read our disclaimer.

[The] Daybook

From this searchable database of lessons plans, we gathered together the following intermediate grade lesson plans into one location for your convenience:

- Water Unit: Adhesion: Part 1 of 6 Introduces students to the property of adhesion.
- Water Unit: Physical Properties: Part 2 of 6 Introduces students to the physical properties of water by having them guide water droplets around a race course outlined on a piece of wax paper.
- Water Unit: Surface Tension: Part 3 of 6 This unit introduces students to the physical properties of surface tension on water by floating a needle on it.
- Water Unit: Surface Tension: Part 4 of 6 Students demonstrate surface-tension by dropping pennies into a full glass of water and watching as the water begins to form above the glass.
- Water Unit: Cohesion: Part 5 of 6 This lesson introduces students to the property of cohesion - the way water likes to stick together. Students are asked to visualize and draw water droplets.
- Water Unit: The Uses of Water: Part 6 of 6 This final activity involves the students in categorizing the uses of water. They are asked to collect and chart data about the different uses of water in their home.

Eliminating Microorganisms from Water

An activity, designed by the Chlorine Chemistry Council (CCC), in which students create water samples with microorganisms, examine the sample, and then remove the organisms.

Fundamentals of Physical Geography

Although this online textbook from Michael Pidwirny, Okanagan University College, is intended for postsecondary students studying introductory physical geography, much of it may be applicable for high school students as well. Contents include over two hundred pages of information, more than three hundred 2-D and animated graphics, an interactive glossary of terms, a study guide, links to other Internet resources, and a search engine. See the Table of Contents to directly access the Hydrology section.

Educating Young People About Water

The following three links allow you to download PDF files that describe and explain a comprehensive community based water education program.

- A Guide to Program Planning and Evaluation This first section "walks program planners through the steps in setting up and evaluating a youth water education program- bringing together the key components that can lead to an effective, sustainable program."

- A Guide to Unique Programming Strategies The second part "tells the story of 37 program coordinators from around the country. Discover how they integrate community water education issues and youth development needs into unique program designs."
- A Guide to Goals and Resources This section "provides the program coordinator with 100 water education curricula summaries, environmental education topics and goals, and multimedia resources."

Environment Canada's Freshwater Web Site

Here's a comprehensive Canadian site designed with educators and students in mind. Most content has been written for grade 6-12 students with learning materials available for grade K-12 teachers. From the home page, be sure to check out: The Management of Water (covers topics like water modeling, water pollution, water quality, water use...); The Nature of Water (covers information on ecosystems, ground water, properties of water...); Teacher's Corner (free learning aids ad teaching materials); Water and Culture (articles on water and Canadian identity).

Environmental Priority-Clean Water

A page by Environment Canada that explains what causes water pollution, why we should be concerned, and what is being done to protect our water.

Exploring the Environment: Water Quality

This module is part of "Exploring the Environment"ª (ETE) from NASA's Classroom of the Futureª. In ETE, high school students are faced with a real life problem and their goal is to use problem solving skills and internet-based data (e.g., remotely sensed satellite images) to propose and defend a solution. A Teacher's Guide is available. This link is to the ETE home page since it gives the easiest access to necessary introductory and teacher information. To access the water quality module, click on "Modules and Activities" and then "Water Quality".

Floods Theme Page

This CLN theme page provide curricular and instructional resources on the associated topic of floods.

Groundwater in British Columbia

The Ministry of Lands, Parks and Housing of British Columbia maintains a meta-list of links to information and resources relating to groundwater in the Province.

Groundwater Remediation Project

Supported by the National Water Research Institute, this site has information on Canadian groundwater resources including PDF reports on various issues, links to other groundwater sites, and groundwater education.

Hydrologic Cycle

Nasa's Observatorium presents an article explaining the five processes which make up the hydrologic cycle (condensation, precipitation, infiltration, runoff, and evapotranspiration). A quiz and a word search activity are provided as well.

- [The] Incredible Journey

  A lesson plan for upper elementary students that uses the roll of a die to simulate the movement of water within the water cycle.

- Lifewater Canada

  Extensive information is available regarding a vast array of water pump construction, water collection, water storage, water quality testing and treatment, and effective sanitation. The focus of the information, assembled by a Christian Organization, is to aid Third World countries in improving and developing healthy water sources.

- Liquid Assets

  This unit has four lessons on the water cycle, water use, measuring water quality, and water pollution for intermediate/junior high students. Lessons include suggested learning activities that teachers can incorporate with their own ideas.

- Oil, Water, and Chocolate Mousse

  The purpose of this Environment Canada site is to provide information about the impact of oil spills. Some topics include: When Oil Spills, Prevention is the Best Cure, Always Be Prepared, What Can I Do To Help? and more.

- Project Wet: Lesson Plans

  The Project WET Curriculum and Activity Guide is an interdisciplinary water education program developed for teachers of kindergarten through grade 12. It contains a range of water education concepts and multidisciplinary activities.

- Properties of Water

  A lesson plan for K-8 biology teachers on the properties of water. The language level of the content will probably be too high for students to use directly.

- Smile Program Biology Index

  Teachers participating in the SMILE (Science and Mathematics Initiative for Learning Enhancement) summer session programs each create a single concept lesson plan. This database has a few lessons on water quality in their section on Environmental Studies and Ecology. Caution: Since there is a wide number of authors who have contributed to the database, the detail and quality of the lesson plans will vary.

- TrackStar

  TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

This link is to their search page from where a keyword search on "water" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

U.S. Environmental Protection Agency: Curriculum: Water

This page contains links to a variety of curriculum resources on water for students as well as links to student activities.

Utahlink - Teacher Resource Book

Over 30 science lesson plans from Utah State that are designed for elementary aged students. You can browse through their set of science resources above, or we've made direct links to four below which focus on water and how it interacts in our environment.

- Activity # 1 - Ground Water Students create a model for the percolation of water through the soil and observe the filtering process achieved as water enters a sample of ground water. Students are challenged to create a more effective system.
- Activity # 2 - Water Sheds and Basins A mountain of soil is observed as water is sprinkled and then poured down the valley.
- Activity # 3 - Water Cycle Terrarium Students make a terrarium out of two-liter pop bottles and observe the water cycle in action.
- It's Raining in the School An introduction to the concept of the water cycle containing demonstrations on condensation, precipitation and accumulation.

Wastewater System

Greater Vancouver Regional District site provides a range of information describing a number of wastewater issues that apply to many cities and towns. The following three links identify common wastewater issues and answers:

Water

Over 10 lesson plans/suggested activities for studying water that span grades K-12.

Water - Facts and Tips

Health Canada published this page of general information on drinking water and some general tips on water conservation.

Water Myths and Realities

This page provides answers to many questions concerning water quality, water sources, and impacts on your health.

Water Quality Resources

About 8 lesson plans, activities, and fact sheets on water quality from the Louisiana Department of Environmental Quality. You'll need to scroll down the page to find the links.

Water Science for Schools

The U.S. Geological Survey offers a wide range of water science information about water and its uses, its special characteristics and its availability on earth. Included with this information are activities, questions and answers, pictures, maps, data tables and links to further resources.

Wastershed Game

Students simulate the role of a manager of a watershed, making decisions in response to issues and then seeing the consequences of those decisions.

Water, Water Everywhere

A research project designed for elementary students. Students will gather precipitation levels from two sides of the Cascade Mountains, enter information into spreadsheets, create graphs of the data and discuss the implications of their results.

Water, Water Everywhere, Nor Any Drop to Drink

In this lesson plan, grade 6-12 students "investigate the importance of water historically and in their daily lives and examine the nature of water as a limited resource. Students work in groups to research technological systems that have aimed to use water in the most productive ways, evaluate those systems, and create "How It Works" posters of those systems that incorporate their research." They use a New York Times article as a starting point for their explorations.

Water What-ifs

This site has a number of lesson plans related to exploring the characteristics of water. Although the site is designed for Delaware and North Carolina teachers, the information and lessons are comprehensive and transferable. Lessons are suitable for both middle and high school students, encourage inquiry and collaboration into the investigation of water quality, and explore the following content areas: pH, temperature, dissolved oxygen, nitrates/phosphates, and macroinvertebrate surveys.

Top of Page

Note: The sites listed above will serve as a source of curricular content in the Water Quality. For other resources in Social Studies - Environment (e.g., curricular content in Biomes, Endangered Species, or Hazardous Waste Disposal), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

CLN Disclaimer

The CLN is an educational portal linking to hundreds of websites on the World Wide Web. Although the sites linked to the CLN have been reviewed and selected by K-12 educators and is intended as an educational resource site for teachers, students and parents, the presence of a link on the CLN does not represent an endorsement of the site by Open School BC. The sites that are listed within CLN are individually responsible for the content and accuracy of the information found in their site.

CanTeach has a new home! The file you are looking for has moved.
Please update your bookmarks.

Your browser will redirect you in a few moments,
or click here to go there now.

**CanTeach has a new home! The file you are looking for has moved.
Please update your bookmarks.**

**Your browser will redirect you in a few moments,
or click here to go there now.**

Earth and Space Science

- Constellations (K-3)
- Graphing Contellations (3+)
- Alternative Snowflakes (K-2)
- Cloud Watching (3+)
- The Sound of Rain (K+)
- Weather Around the World (5+)
- Making a Rainstick (2+)
- Measuring Rain With a Rain Catcher (6+)
- Acid Rain & Plants (Any)
- Where Does the Wind Come From (2+)
- A Variety of Ways to Make a Windsock
- Air Takes Space #1 (2+)
- Air Takes Space #2 (2+)
- Air Takes Space #3 (1-3)
- Rock Collecting (2-4)
- Making Fossils (K-3) (K+)
- Metamorphic Rock: Melting Rocks (K-3)
- Earthquakes(4+)

Gathering Weather Information

Life Skills:

- Complex Thinking

Time Frame:
6 class periods that run 45 minutes each.

Group Size:
Individual

Summary:
Students use weather data and information found on the Internet to predict weather patterns.

Primary Core Objective:
Science - Earth Systems 3600- Objective 2:
Relate energy sources and transformation to the effects on Earth systems.

. Describe the difference between climate and weather, and how technology is used to monitor changes in each.
b. Describe the effect of solar energy on the determination of climate and weather (e.g., El Nino, solar intensity).
c. Explain how uneven heating at the equator and polar regions creates atmospheric and oceanic convection currents that move heat energy around Earth.
d. Describe the Coriolis effect and its role in global wind and ocean current patterns.
e. Relate how weather patterns are the result of interactions among ocean currents, air currents, and topography.

Materials:

- video clip or picture showing a local weather disaster
- Internet access or daily weather maps
- daily forecast and/or NOAA Weather Radio
- thermometers
- wind gauge
- cloud charts
- barometer

Background For Teachers:
This lesson plan has some great Internet links but it will not teach you how to interpret weather data. If you are unfamiliar with weather patterns, cloud charts, etc... then you will need to do some personal study.

You may also want to register your class in the Weather Project. Students can enter their collected weather data and chart the results online.

Intended Learning Outcomes:

- Make observations, measurements, and predictions.
- Use reference sources to gain information.

- Identify variables and describe relationships between them.
- Collect and record data.
- Analyze data and draw warranted inferences.
- Understand science concepts and principles.

Instructional Procedures:
Day 1

Introduce the lesson by asking students question such as:

What is the weather forecast for today?
What is the weather forecast for tomorrow? Next week?
Why is it important to know what the weather will be like?

2. Show clip on weather disaster. Talk about instances where knowing the weather beforehand has been helpful in the students' lives.

3. Use Internet maps or daily weather maps to teach students how to do general predictions. Hand out 'Today's Weather' sheet (see link below). Have students use instruments to get local conditions.

Days 2-5

Take 10-20 minutes out of class and have students look at weather maps and make their own predictions. Have them go out and take current conditions. Come in and listen to local NOAA weather radio.

Day 6

Have students do Day 6 on their own at home. (They will have to guess at actual temperatures and wind speed.)

Conclusion

Once students have collected weather data for six days, instruct them to graph, analyze, and interpret their data. Instruct them to look for trends and draw inferences.

Web Sites

- Surface Weather Conditions
  Wind directions, iso bars, temperatures.
- Current US General Weather Conditions
  Typical weather map as found in newspapers.
- SLC National Weather Service
  Will give you access to lots of weather information.
- National Radar Summary
  Precipitation information.
- KSL Weather Page
  Today's weather and other resources from KSL TV.
- U OF U School of Meterology
  Weather camera and other Utah weather related

links.

- How to Build a Weather Station
  A set of plans for building an inexpensive weather station.

Extensions:
Challenge students to collect weather data on their own for a month. Encourage them to note patterns and explain weather trends. Provide several years worth of data to your students and ask them to generalize local weather patterns.

Research how new technologies have changed scientists' understanding of atmospheric systems. Describe how technological advances in meteorology have improved the quality of life.

Assessment Plan:
Give students weather data that is valid but with which they are unfamiliar. Ask them to graph, interpret, and analyze the data. Instruct them to use the data to predict upcoming weather.

Author:
ROB WAGNER

Created Date :
Jan 29 1997 16:43 PM

How the Weatherworks

Activities, Experiments and Investigations

Welcome to our ***Activities, Experiments and Investigations*** index page. These are a sampling of some of our favorite "things" to do in studying about the weather. The listing is far from complete, but it should give you a good idea about how we use weather as a bridge to multi-disciplinary education.

Many of these activities, experiments and investigations are from our published materials (this link takes you to our web store). You are free to use the activities in your classroom. Should you wish to use any of these in any other way, please contact How The WeatherworksTM...for permission. THANKS!

Finally, this page has been coded to appear in either Arial or Helvetica font for easier reading. If you do not have either of these fonts installed on your system, the Netscape or Internet Explorer default font should operate. If you encounter any problems reading this page, please contact How The WeatherworksTM...

- **NEPHELOCOCCYGIA**
  This activity involves looking for shapes in the clouds. There's also a great interactive language arts activity.
- **SKY WINDOWS**
  What color is the sky or the clouds? Check it out using this "unique" weather instrument. You'll never look at the clouds in the same way again.
- **NOAA WEATHER SATELLITES**
  The National Oceanic and Atmospheric Administration (NOAA), the parent agency of the National Weather Service, launched a new geostationary

weather satellite April 24, 1997 and another May 3, 2000. Weather satellites are a great way to study clouds and cloud patterns from above. HOW THE WEATHERWORKS will be publishing a set of four weather satellite posters in the Fall of 2003.

- **More activities to be posted in the future -- Please come back and check out the latest additions.**

This page was last updated on May 31, 2003.

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REDIRECTING

The National Geographic education site has moved! You are being automatically redirected. Please update your bookmarks to reflect our new Web address (URL).

If you do not see the education site within a few seconds, [click here.](#)

NEW: Find Maps, Facts, and Photos

GO!

Search One-Stop Research for our most popular subjects (such as tigers or Egypt) and get results organized by type: pictures, articles, video, maps, and more.

Search for Educational Materials

SUBJECT

RESOURCE TYPE

GRADE GO!

Search by keyword:

GO!

Or, search our publications index for articles in *National Geographic*, *NG Kids*, and more.

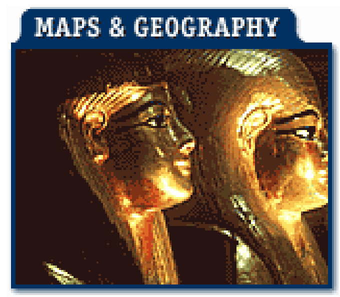
How can we help you teach?

Educator Favorites:

— GeoSpy
— Education Foundation
— Xpeditions
— National Geographic Bee
— Printable Maps
— GeoBee Quiz Game
— Local Geography Alliances
— Calendar of Events

We've been nominated for Webby Awards! Register to vote for the People's Voice Webby Award today.

Pyramids of Ancient Egypt
Explore the pyramids of ancient Egypt with a time line, facts, diagrams, and more!



Egypt Country Profile
Get the facts on Egypt with this quick profile of the country's flag, maps, and history.

Online Adventure
Game: Daily Life in Ancient Egypt
Test your knowledge of Egypt with this wacky brainteaser.

Maps and Geography
Egypt: Easy-Print Map
Show students the geography of Egypt with this printer-friendly map—available with and without place-names.

Teacher Community
Apply for Marine Sanctuary Field Studies
This summer join a select group of teacher-student pairs chosen to explore the Channel Islands in California or Gray's Reef in Georgia. Get eligibility requirements, program overviews, and applications.

Lesson Plan
Ancient Worlds Workshop: Egypt
This lesson teaches students about the geography of daily life in ancient Egypt.

Teacher Store
Ancient Egypt Posters
Travel back in time to the land of the pharaohs with this poster set.

— Grants for Educators
— MapMachine
— News Story of the Day
— Photo of the Day
— Television Programming
— Geography Action
— Homework Help
— Bookmark Factory
— Encyclopedia
— Editorial Style Manual (PDF)

Extension Sites:
— Windows on Literacy
— Reading Expeditions
— GeoKits

Our Magazines:
— *National Geographic*
— *NG Kids* (formerly *World*)
— *Traveler*
— *Adventure*
— *NG Explorer* (Classroom)

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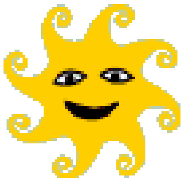
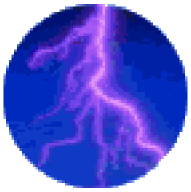
Cadet

Section

For Grades

2 to 8





Expert

Section

For Grades

6 to 12

Teachers'

Lounge

Lesson

Plans

& Resources

Parents'

Center

Fun With Your Children!

Register! KGAN Current Weather

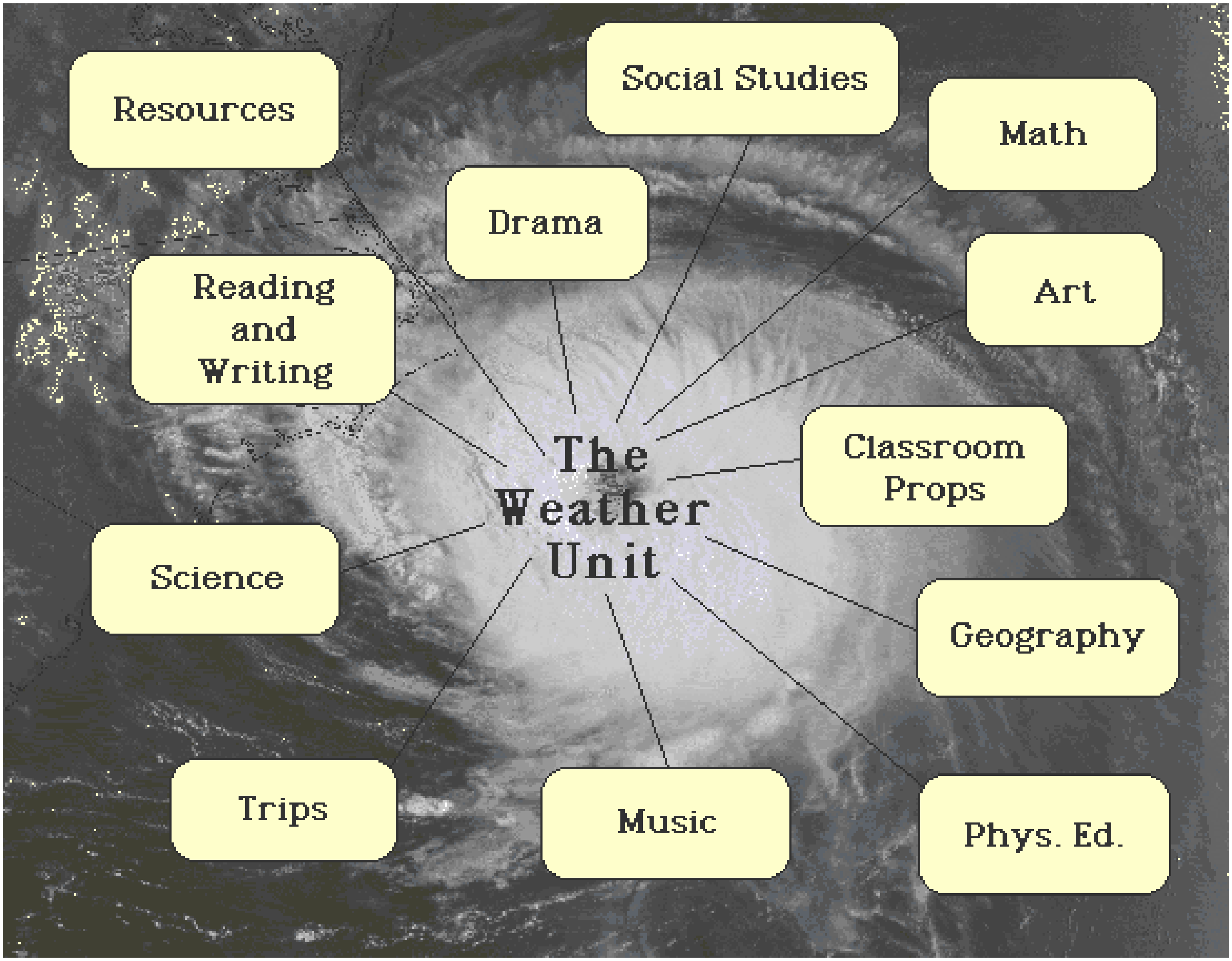
WeatherEye is a public service of KGAN and is sponsored by Central Iowa Power Cooperative (CIPCO). Click on Louie the Lightning Bug for electrical safety information and the Electric Universe.

More lessons like these available at The Curriculum Archive

Teachers! ... click here for an interesting book review project for your students this year!

... click here for global warming resource for your students

The Weather Unit



Welcome to the Weather Unit! Click on a subject heading to view current lessons.

- Math
- Science
- Reading & Writing
- Social Studies

- Geography
- Art
- Music
- Drama
- Physical Education
- Field Trips
- Classroom Props
- Resources
- Other
- More lessons

Looking for a specific lesson? ... try this search engine

Post Comments about the Unit

Read Comments about the Unit

Return to Collaborative Lesson Archive

Teachers! Please visit our new project - The Collaborative Lesson Archive and give us your feedback.

-

Subject Areas

Find what you are looking for by subject. If you don't see your subject here, try a search.

- Aboriginal Studies
- Business Education
- Career Studies
- Current Events
- English/Language Arts
- English as a Second Language
- Environmental Studies
- Fine Arts
- Health, Nutrition, and Personal Planning
- Information Technology
- Mathematics
- Media Literacy
- Multiculturalism
- Physical Education
- Reference Materials
- Science
- Social Studies
- Technology Education

Unspecific Subject Areas

For Kids Only **(.... but for Primary Teachers too!)**	Games, activities, downloadable software, songs, postcards, places to publish...... all for kids. Since these resources address many basic skills, primary teachers will find this part of CLN useful as well.

General Education Resources	Some WWW resources do not fit nicely into the specific subject areas listed above. In this section, you'll find our collection of education directories or "meta-lists" as well as our collection of general lesson plan sites.

Educational Resources in Science

Curricular Resources
(Information/explanations for students and teachers wishing to learn more about Science)

Earth Science	General Science	Life Science	Physical Science
• Astronomy (CR) • Geology (CR) • Paleontology (CR) • Weather/ Climate (CR)	• General Science (CR)	• Life Science (CR)	• Chemistry • Physics

Instructional Materials
(Lesson plans and teaching tips/ideas for Science teachers)

Earth Science	General Science	Life Science	Physical Science
• Astronomy (IM) • Geology (IM) • Paleontology (IM) • Weather /Climate (IM)	• General Science (IM)	• Life Science (IM)	• Chemistry (IM) • Physics (IM)

Theme Pages
(Curricular resources as well as Instructional Materials on specific Scientific topics)

Air Quality

Asteroids, Comets, and Meteors

Biomes

- Antarctic Theme Page
- Arctic Theme Page
- Drylands/Deserts
- Temperate Forests
- Tropical Rainforests
- Wetlands

Bubbles

Clouds

Dinosaurs

Electricity (Concepts)

Electronics (Circuitry)
El Niño
Famous Canadians
[Simple] Flying Machines
Gardening
Genetics/Biotechnology
Gerbils-Hamsters
Glaciers
Global Warming
Hot Air Balloons
[The] Human Body's Senses • Hearing • Sight • Smell • Taste • Touch
[The] Human Body's Systems • Brain/Nervous System • Circulatory System • Digestive System • Muscular System • Respiratory System • Skeletal System
Inventors and Inventions
Kites
Lightning
Magnetism

Natural Disasters

- Avalanches
- Blizzards
- Earthquakes
- Floods
- Hurricanes
- Tornadoes
- Tsunamis
- Volcanoes

Oceanography

Ozone Depletion

Paper Airplanes

Periodic Tables

Pictures

Rocks, Minerals and Mining

Science Fair

Soaps and Soap Making

Sound

Water Quality

Whales

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Cold, snow
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Beach weather
Ski conditions
Resources
Weather briefs
Highs and lows
Tools
Talk Today
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Alerts

Travel ›
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Weather

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01/09/2004 - Updated 02:52 PM ET

Understanding Clouds and fog

Clouds are usually the most obvious feature of the sky. They both reflect weather patterns and play a role in what the weather does. The links below take you to a great deal of information about clouds.

Locations of clouds

- Low-level clouds: (generally found below 6,500 feet, or 2,000 meters) Low-level clouds are usually composed of liquid water droplets, but they can have snow and ice crystals in cold weather
- Mid-level clouds: (generally found between 6,500 and 23,000 feet, or 2,000 and 7,000 meters) Most mid-level clouds are composed of liquid water droplets during summer and a liquid droplet-ice crystal mix during winter. Mid-level cloud names are preceded by an "alto" prefix.
- High-level clouds: (generally found above 20,000 feet, or 6,000 meters) High-level clouds are composed of ice crystals and tend to be very thin and wispy. High-level cloud names are preceded by a "cirro" index

Today's Top Weather Stories

" Two killed in Pennsylvania flooding - 12:21 PM
" Study seeks rip current predictions - 8:14 AM
" High water floods homes in Alaska - 7:56 AM
" Three dead after boat capsizes in New England - 8:15 AM
" Heat wave takes toll on strawberry fields - 8:07 AM

Add USATODAY.com headlines to your Web site

Names represent different kinds of clouds

- Stratus clouds are a uniform gray and usually cover most of the sky.
- Cirrus clouds are thin and high in the sky.
- Cumulus clouds are lumpy and can stretch high into the sky.
- Thunderstorms are cumulus clouds, sometimes called "thunderheads."
- Mammatus clouds have pouches that hang down.

More about different types of clouds

- Australian Severe Weather: Photos of clouds
- Plymouth State College: Cloud Boutique.
- NASA: On-line cloud chart with many photos

People and clouds

- Conspiracy theories find menace in contrails.
- Understanding cloud seeding.

Different kinds of fog, where fog forms

- Fog, how to forecast when it's possible
- Advection fog forms when humid air flows over cold ground or water.
- Radiation fog forms on generally clear, cool nights.
- Steam fog forms over water, often in the fall.
- Overnight rain can enhance fog that forms in the morning.
- **Precipitation fog** forms when rain or snow falls.. As precipitation falls into drier air below the cloud, the liquid drops or ice crystals evaporate or sublimate directly into water vapor. The water vapor increases the moisture content of the air while cooling the air. This often saturates the air below the cloud and allows fog to form.
- **Upslope fog** is very common along large hills and mountains. It forms when winds blow up the side of a hill or mountain, which cools the air.
- **Valley fog** forms in mountain valleys during winter and can be more than 1,500 feet thick. Often, the winter sun is not strong enough to evaporate the fog during the day. When the air cools again the following night, the fog often becomes thicker, which makes it even harder for the sun to burn it off the following day. These fogs can last for several days until strong winds blow the moist air out of the valley. The tendency for cool, dense air to pool at the bottom of valleys also enhances valley fog.
- Pop-up map: Yearly average days with fog in the USA

AP

A ferry motors through steam fog as it passes House Island in Casco Bay on its way to Portland, Maine, where the temperature dropped to minus-8 on Jan. 9, 2004.

Clouds and the atmosphere, the water cycle

- Why cloudy nights tend to be warmer.
- Understanding water in the atmosphere.
- Dust can stifle rain formation in clouds.
- Weatherwise: How much clouds weigh
- How the Weatherworks: Sky Awareness Week.
- U. of Ill.: Clouds and precipitation
- USGS: Clouds are part of the water cycle.

Questions and answers about clouds

- Help on identifying an unusual cloud
- Answers archive: Clouds, fog, rain, snow, drizzle

Clouds and climate change

- NASA: Clouds and climate change.
- NOAA: Clouds and climate.

Learn more about the sky and space

Learn about the sky, space

- Resources: Astronomy and space
- Resources: Sky colors and phenomena
- Resources: Clouds
- Resources: Auroras
- Resources: The sun and space weather
- Sun and moon, rise and set times, time zones

Photo gallery, graphics

- Sky watching photo gallery
- Understanding the moon's phases
- Earth's tilt creates the seasons

El Niño RULES!

PRESENT	A record El Niño?
PAST	History -- the old fisherman knew. Causes. Sun heats ocean. Ocean warms air. Effects. How big? Really big.
FUTURE	El Niño = destiny? Not always. Be prepared. And what about global warming?

POSTED 20 OCT 1997

The Why? files

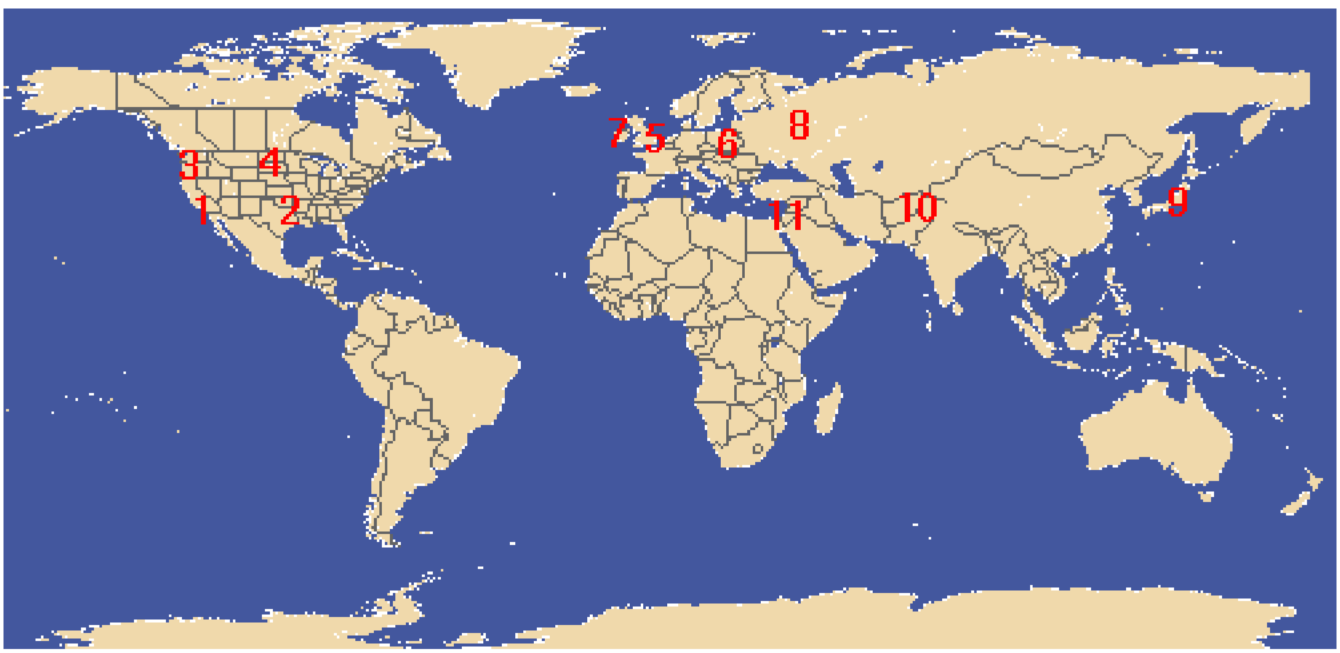
MORE

There are 1 2 3 4 5 6 7 8 documents.
Bibliography | Credits | Search

Forecast: moderate coastal climates, variable temperatures inland

Ocean water and currents affect climate §. Because it takes far more energy to change the temperature of water than land or air, water warms up and cools off much more slowly than either. As a result, inland climates are subject to more extreme temperature ranges than coastal climates, which are insulated by nearby water.

Over half the heat that reaches the earth from the sun is absorbed by the ocean's surface layer, so surface currents move lots of heat. Currents that originate near the equator are warm; currents that flow from the poles are cold.

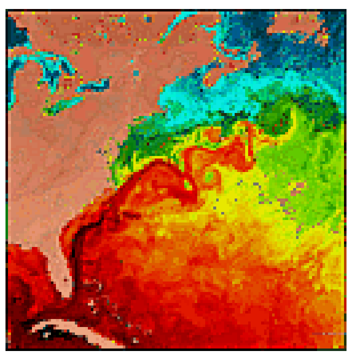


Highs and lows, coastal vs. inland §

City	(low) Jan	(high) July	(*N) latitude
1) Los Angeles	64*F 18*C	81*F 27*C	34.0
2) Little Rock	50*F 10*C	90*F 32*C	34.5

3) Seattle	4*F	72*F	47.5
	7*C	22*C	
4) Bismarck	18*F	82*F	47.0
	-8*C	28*C	
5) London	45*F	73*F	51.5
	7*C	23*C	
6) Warsaw	32*F	75*F	52.5
	7*C	24*F	
7) Belfast	43*F	64*F	54.0
	6*C	18*C	
8) Moscow	16*F	73*F	56.0
	-9*C	23*C	
9) Tokyo	46*F	82*F	35.0
	8*C	28*C	
10) Kabul	36*F	88*F	35.0
	2*C	31*C	
11) Beirut	63*F	90*F	34.0
	17*C	32*C	

Why is snow rare in London but common in Boston? When the warm Gulf Stream moves Caribbean heat to the North Atlantic, the water cools and releases a tremendous amount of heat into the atmosphere. Winds blowing west to east carry this moist warmth toward Europe §.

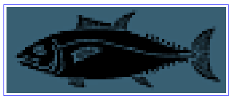
The Gulf Stream as drawn by Benjamin Franklin (left) and a satellite-derived sea surface temperature map of the Gulf Stream (right)

London (latitude 51.5 degrees North)
average annual precipitation - 23.8 inches (60.4 cm) record snowfall - 8 inches (20 cm) during one day, March 1947

Boston (latitude 42.3 degrees North)
average annual precipitation - 43.8 inches (111 cm) record snowfall - 23.6 inches (60 cm) during one day, February 1978

More Information

- The NOAA Weather Page
- Current Weather, Climate and Forecast Maps
- Interactive U.S. Weather Map - from Purdue University

 **Ocean Planet Exhibition Floorplan**

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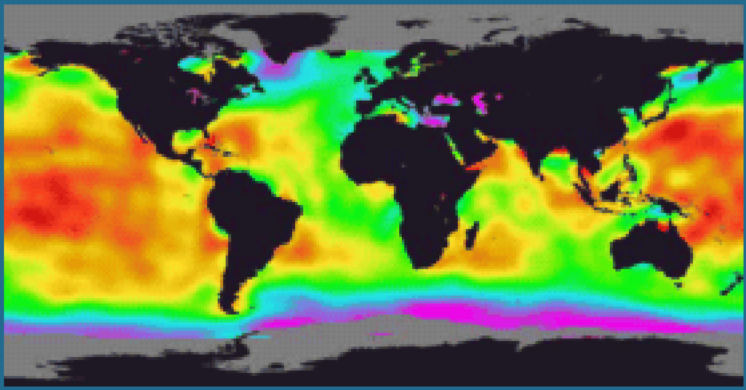
Ocean Currents

We all go with the flow.



Ocean waters are constantly on the move. How they move influences climate and living conditions for plants and animals, even on land.

Currents flow in complex patterns affected by wind, the water's salinity and heat content, bottom topography, and the earth's rotation.

Dynamic Ocean Topography (952 kbyte mpeg)

Animation of two years of satellite-derived Dynamic Ocean Topography data from the Topex/Poseidon Mission

Upwelling brings cold, nutrient-rich water from the depths up to the surface. Earth's rotation and strong seasonal winds push surface water away from some western coasts, so water rises on the western edges of continents to replace it. Marine life thrives in these nutrient-rich waters §.

Deep water forms when sea water entering polar regions cools or freezes, becoming saltier and denser. Colder or saltier water tends to sink §.

A global "conveyor belt" set in motion when deep water forms in the North Atlantic, sinks, moves south, and circulates around Antarctica, and then moves northward to the Indian, Pacific, and Atlantic basins. It can take a thousand years for water from the North Atlantic to find its way into the North Pacific §.

Warm surface currents invariably flow from the tropics to the higher latitudes, driven mainly by atmospheric winds, as well as the earth's rotation.

Western boundary currents are good examples of warm surface currents: they are warm and fast, and they move from tropical to temperate latitudes §.

Cold surface currents come from polar and temperate latitudes, and they tend to flow towards the equator. Like the warm surface currents, they are driven mainly by atmospheric forces §. Gyres form when the major ocean currents connect. Water flows in a circular pattern--clockwise in the Northern Hemisphere, and counterclockwise in the Southern Hemisphere §.

The Gulf Stream surface current is a western boundary current, one of the strongest--warm, deep, fast, and relatively salty. It separates open-ocean water from coastal water.

U.S. WOCE (World Ocean Circulation Experiment) This animation depicts the variation of ocean temperature in the North Atlantic over a period of 1 year.

The California current is an eastern boundary current. It's broad, slow, cool, and shallow. Eastern boundary currents are often associated with upwelling.

The Somali current, off Africa's eastern coast, is unusual because it reverses direction twice a year. From May to September it runs north; from November to March it runs south. As it flows northward, upwelling supports productive marine life, but productivity falls when the current begins to move southward.

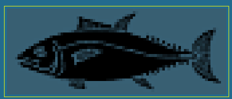
Upwelling stirs the soup and serves up a stew of nutrients that have settled into deep water.
(illustration coming soon)

The ocean is layered: warmer on top, cold at the bottom. Organisms move from one layer to another, and plant and animal remains containing nutrients "rain" down, but the layers stay fairly separate in all but a few places.

Coastal upwelling occurs against the western sides of continents in the Atlantic, Indian, and Pacific. There, colder water rises to replace warm surface water blown out to sea by strong offshore winds. Upwelling supports about half of the world's fisheries, although these cool waters account for only 10 percent of the surface area of the global ocean §.

More Information:

- Smithsonian's Art to Zoo Lesson Plans including one on Ocean Currents



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Staying on Top

These shoes just did it

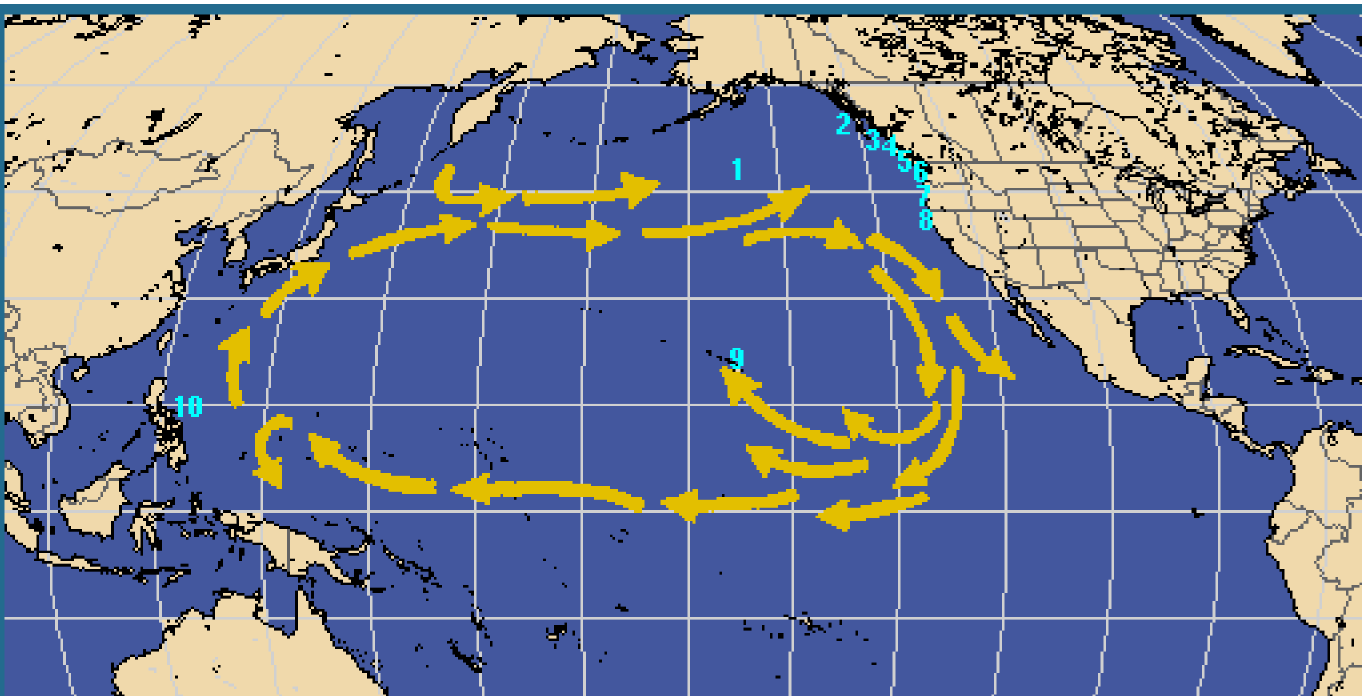
Surface currents in the oceans move in large slow circles called gyres. That explains the story of 60,000 Nike shoes spilled from a storm-tossed cargo ship in the northeastern Pacific in May 1990 §.

The shoes washed ashore one at a time but were wearable after a scrub-down to remove barnacles, algae, and tar.

Beachcombers held swap meets to find matched pairs.

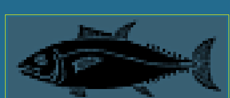
Shoes courtesy of Steve McLeod and Donovan Johnson

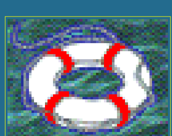
Six months to a year later, beachcombers from British Columbia to Oregon began to find shoes. Oceanographers constructed a computer model that predicted the shoes' route. In 1993, shoes were found in Hawaii. If the shoes complete the gyre's circuit, they will turn up in Japan and the Philippines, and in 1996 or 1997 again wash up on North American shores §.



The North Pacific gyre has been dropping off shoes around the Pacific since 1990.

1	shoe spill, May 27, 1990
2	250 recovered, March 26, 1991
3	200 recovered, May 18, 1991
4	100 recovered, January-February 1991
5	200 recovered, November-December 1990
6	200 recovered, February-March 1991
7	150 recovered, April 4, 1991
8	200 recovered, May 9-10, 1991
9	several recovered, January-March 1993
10	predicted, January-July 1994

 **Ocean Planet Exhibition Floorplan**



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Tracking Ocean Currents

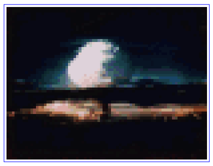


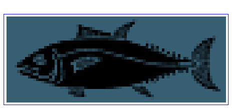
photo © National Atomic Museum

Radioactive tritium became a perfect marker for tracking ocean water §. Scientists sampling North Atlantic water found that tritium released into the atmosphere before the 1962 nuclear test ban treaty, mixed downward by 1973. By 1980, the same tritium had moved into deep areas off Florida. The water had taken about 20 years to travel 3000 miles (4800 km) through the sea at an average speed of less than half a mile a day, about half the speed of a snail §.

Turbidity currents sweep sediment from shallow water to deep

Not all currents are predictable. Turbidity currents are submarine avalanches. Sediments settle and accumulate in shallow areas like the edges of the continental shelf and slope. Often triggered by an earthquake, they can spill down the continental slope into deep water. Fast turbidity currents carrying suspended sediments may spread over wide areas §.

Transatlantic telegraph cables snapped from north to south over thirteen hours in 1929, when an earthquake off New England sent sediments slumping and sliding. Scientists calculated that the resulting turbidity current traveled 25-35 miles per hour (40-55 kph), and covered an area slightly larger than Maine and Connecticut §.



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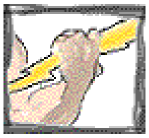
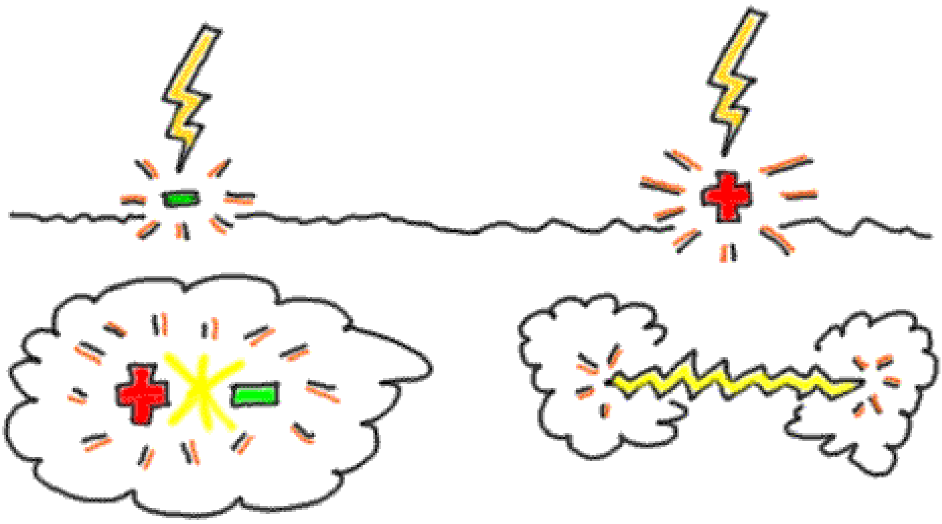


Three Strikes



Cloud-to-ground lightning bolts are the most familiar and the most dangerous. Most cloud-to-ground lightning strikes come from the negatively charged bottom of the cloud to the positively charged ground below. Often, cloud-to-ground lightning bolts strike the highest object, like the top of a building or the highest limb on a tree. The lightning strikes can cause fire and property damage. If a human being is the highest object in the lightning bolt's path, the strike can cause severe injury or death. Although cloud-to-ground lightning is the most dangerous, it is also the most understood because it leaves so much evidence behind.

Most cloud-to-ground lightning strikes bring negative energy down to the ground, but some strikes deliver positive charge to the ground. Positive strikes are less common and emerge from the higher regions of the thundercloud. Some meteorologists believe that positive lightning strikes indicate storms that are more likely to spin out tornadoes.

Not all lightning bolts strike the ground. Many lightning discharges occur within and between thunderclouds. The most common type of lightning, called intracloud lightning, strikes between positive and negative areas in the same cloud. The bolt is not usually visible, but rather appears like a broad flash in the sky. A less common lightning strike occurs between oppositely charged areas of separate clouds. Known as intercloud lightning, the strike passes through clear air and provides a stunning bolt of light. Intercloud lightning poses a particular hazard to airplanes in flight because it passes through the clear air between clouds.

BACK