

thermosphere—the atmospheric zone located above the mesopause (the atmospheric transition zone located between the mesosphere and the thermosphere at an altitude of 50 to 53 miles) beginning at an altitude of 53 miles and characterized by a great rise in temperature with increasing altitude.

thunderstorm—created when a lower layer of warm air rises into a layer of cold air, resulting in a powerful updraft of warm, moist air and a violent downdraft of rain and hail.

tidal wave—a large wave caused by strong winds, but not actually related to the tides; the nontechnical term for a tsunami.

tornado—a violently whirling column of air that extends downward from a cumulonimbus cloud; from the Spanish word *tronada*, meaning "thunderstorm."

troposphere—the atmospheric zone below the tropopause (the atmospheric transition zone located between the troposphere and the stratosphere, six to 12 miles above the Earth); at increasing altitudes, the troposphere is characterized by water vapor, vertical winds and decreasing temperatures.

typhoon—another name for a hurricane

water vapor—water in the form of a gas; steam.

One family's ordeal

On May 3, 1999, one of the most violent tornadoes ever known to hit Oklahoma struck. The Carlin family—parents Scott and Susan and their two young children—of Oklahoma City was huddled in its tornado shelter, hoping that the tornado would pass quickly:

Scott: The walls started vibrating really heavily. You could actually feel the tornado coming.

Susan: You could hear it breaking up everything and all the debris flying around . . . glass breaking. We went to the right corner of the shelter and hugged each other. The next thing we know, the cellar door starts tapping, and then boom, it is gone.

Scott: I looked through where the door was, and you could see straight up inside the tornado. I could see debris flying around.

Susan: Afterwards, we walked out of this cellar, and everything was gone . . . everything we've had for 10 years of being married was trashed.

Things to think about

*Although monsoons occur in northern Australia and parts of West Africa, they are weaker and don't reach as far inland as those in India. Why?

*Something tall can expect a lot of lightning. How many times each year do you think the Empire State Building (whose lightning conductors take the electricity safely down the building to the ground) gets hit, on average? 17? 23? 34? more?

*A lot of tornado damage could be prevented if houses could be built to withstand the things that tornadoes hurl at them. Engineers used a compressed-air cannon to shoot wood planks, at 100 miles per hour, into walls made of wood, brick, concrete block and reinforced steel. Only the reinforced steel could deflect the planks. Why?

Internet Resources

<http://www.earthweek.com>

A weekly update on weather activities around the globe; includes kids' and educators' pages.

<http://www.wind.ttu.edu>

Maintained by the Institute for Disaster Research at Texas Tech, this site is chock-full of information about wind and wind-related phenomena—for kids, adults and teachers.

<http://www.usatoday.com/weather>

News information about a variety of climates and weather situations.

<http://hurricanes.noaa.gov/>

A comprehensive site dedicated to the massive weather systems.

<http://geography.about.com/library/weekly/aa102599.htm?terms=monsoons>

All about the monsoons of India and Asia.

<http://www.nssl.noaa.gov/edu/tlg/>

General information and interesting facts on lightning.

<http://www.azstarnet.com/~anubis/sabintro.htm>

Agirl who was actually struck by lightning tells her story and goes into detail about lightning safety.

<http://thunder.nsstc.nasa.gov/primer/>

Adetailed site with a well-rounded look at lightning.

http://science.nasa.gov/newhome/headlines/essd11jun99_1.htm

Lightning info from NASA's International Conference on Atmospheric Electricity

Other Resources

For students:

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For adults:

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Share the Secrets of the Atmosphere. Readers Digest Association Inc., 1995.

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the Science of Climate. Delacorte Press, 1999.

Verkaik, Jerrine, and Arjen Verkaik. *Under the Whirlwind: Everything You*

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EXTREME WEATHER

Although "you can't do anything about the weather," as the old saying goes, people are fascinated with it. Extreme climates, such as the frigid, desolate plains of Antarctica, attract adventurers who pit their stamina against the unrelentingly harsh environment. Armchair weather-watchers are curious about the oddities: the hottest place on Earth, the driest, the rainiest. Episodes of violent weather—tornadoes, hurricanes, blizzards, turbulent thunderstorms—remind us that much in the natural world is still outside of human control. This series explores many types of extreme weather, from inhospitable locations such as the completely arid Atacama Desert in northern Chile to killer storms that can destroy a town in minutes. It also discusses how meteorologists use increasingly sophisticated technology to track approaching storms and issue life-saving warnings before "nature takes its course."

INTRODUCTION PART I

The weather—it's there every day. Sun, wind and rain are basic to life. But sometimes the weather is more than just "there"—it becomes violent. Monsoon winds, for example, bring the world's heaviest rain. During a wet monsoon, mountain rivers burst their banks and the lowlands are swamped with floodwater. Flash floods can cause a great deal of destruction, occurring when a lot of rain over a large area gets funneled into a small area, resulting in a powerful current that sweeps away buildings, cars and people. Lightning is another powerful force—the most powerful on Earth. Learn why lightning must neutralize itself by hitting a tall object or the ground. Visit one Swiss mountain village where a flash flood brought 10,000 tons of mud and rocks; rescue helicopters had to pluck people off rooftops and out of trees. And huddle in a storm shelter with one terrified Oklahoma City family as a deadly tornado sweeps through their town. And because there is nothing we can do about weather like this but try to predict it and prepare for it, learn how storm trackers are using the latest technology to save lives.

EXTREME WEATHER

INTRODUCTION: PART I

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Monsoons

Monsoon winds bring the world's heaviest rain. While there are monsoons in Africa and all over southern Asia, the monsoons in India are the most intense.

A monsoon begins with an extreme absence of rain. Summer approaches, and India bakes in the sun. Everything south of the Himalayas is dust dry, sweltering under a rising plume of heat.

As the air rises, it is replaced by the wet monsoon winds from the sea, which bring in moisture-laden clouds from the ocean and over the coastal mountains. These clouds settle in the low pressure left by the rising heat, and then the rains begin. This movement of moisture is carried eventually to the slopes of the Himalayas, where they stop until they're all rained out. Unlike other extremes of weather, the monsoons are predictable.

Although life isn't easy during the season of the world's hardest rain, it does make the crops grow. The catastrophe is the occasional year when the monsoons don't come.

Flash Floods

Heavy rain plus high mountains can mean trouble anywhere in the world. In the Swiss Alps, heavily populated valleys dot the steep sides of the mountains, and at the bottom lie natural bowls, such as the picture-postcard village of Brig (Brigue). In 1993, an enormous rain cloud, sailing low, got trapped against the mountains that tower above Brig and dumped its full load of water.

A flash flood is the result of a lot of rain over a large area being funneled into a small area, and what makes a flash flood so destructive is its suddenness. One moment, Brig was normal, if rainy, and the next, a giant river was crashing through it at a rate of 10 feet a second. That much water moving that fast is very, very strong—almost impossible to resist.

Every parked car on or near the main street was wrecked, some 800 cars in all. Every house and business at ground-floor level was gutted. More than one hundred people had to be quickly evacuated from one restaurant into the hotel upstairs. Rescue helicopters plucked people off rooftops and out of trees. They did a good job, and as a result, in the end, only two people were killed. Along with the water, which poured off the mountainsides for 12 hours, came 10,000 tons of mud and rocks, which had to be cleaned up. Cleaning up took months and cost half a billion dollars.

To try to predict flash floods, scientists have flown into clouds for a closer look, using airplanes packed with sensors to analyze everything going on around them. They also drop weather-sensitive capsules, called radiosondes, to analyze the air all the way down.

Lightning

Lightning is five times hotter than the sun. It makes the very air explode, which we hear as thunder. During lightning, the air is full of electrically charged ions, and the lightning passes from one ion to another as if along a wire, giving each bolt a different shape. At first the bolts may go from cloud to cloud, but as the electricity gets stronger, it must neutralize itself to the ground. The lightning bolt goes for the nearest object, which is usually the highest.

Sometimes in open country, people can be among the tallest objects around. In the U.S. every year, about 100 people are struck, and it doesn't even have to be raining. If you are struck, chances are the lightning will leave you shocked and burned, but still alive. That's because the electricity usually just passes over your skin. If the strike is big, it does kill, by getting into the body and stopping the heart.

A quarter of all people killed by lightning were standing under a tree at the time. Trees are lightning magnets, and when one is struck, the electricity fizzes off it in all directions. The best place to head is a car, with the windows up, because metal conducts lightning away from anything inside and into the ground.

Timeline

1752 — Benjamin Franklin flies a kite during a Pennsylvania thunderstorm to show that lightning is electrical. As lightning flashes, sparks jump from a key fastened to the bottom of a damp kite string. Franklin's hand is insulated by a silk ribbon attached to the string.

1861 — During monsoon season, Cherrapunjee, India, the "wettest town on Earth," sets the world record for six months: 73 feet, eight inches of water falls from April to September.

March 18, 1925 — The most violent tornado on record sweeps across Missouri, Indiana and Illinois, killing 689 people and injuring 2,000; 11,000 are left homeless.

April 3, 1974 — A super outbreak of tornadoes rips through 13 states from Alabama to Ontario, Canada: 148 tornadoes in 21 hours; 315 people are killed and 6,000 injured.

1975 and 1978 — India grows bumper crops in the summers as a result of heavy monsoon rains.

July 13, 1977 — Lightning hits a power transformer 50 miles north of New York City; the resulting short circuit shuts down the city for 20 hours. On a hot summer's night, 10 million people are without light or air conditioning. Streets are jammed as traffic lights go out, the subway system is closed down, trains are trapped between stations and people are stuck in skyscraper elevators. Shops are ransacked, and over 700 looters are caught; looters also start some 600 fires.

March 1991 — More than 15,000 lightning strikes result from a single, six-hour storm over Illinois, Iowa, Missouri and Wisconsin.

1993 — In Brig, Switzerland, a huge raincloud gets trapped by the surrounding mountains, causing a flash flood; water crashes through the town at a rate of 10 feet per second for 12 hours, killing two people, destroying 800 cars and bringing 10,000 tons of mud and rocks.

mid-1990s — In Venezuela, violent rainstorms set off mudslides, which bury villages and cause 50,000 deaths.

May 3, 1999 — One of the most destructive tornadoes in U.S. history sweeps through Oklahoma City, Oklahoma, killing 41 people, destroying 8,000 buildings and causing a billion dollars worth of damage.

Tornadoes

Tornadoes, which are spawned by thunderstorms, spiral slowly across the landscape, packing wind speeds of up to 300 miles an hour. There are about 1,000 tornadoes in the U.S. each year, and on average, 80 people a year die in them.

A third of all American tornadoes are born in Texas, Oklahoma and Kansas. Close to Earth, moist breezes off the Gulf of Mexico sweep toward Canada, and very high up, the jet stream barrels down from Northwest Canada. Sandwiched between is a layer of dry, warm air from the Southwestern deserts. The sun heats the ground and evaporates the water from the Gulf breeze, creating thunderclouds. These rise until they hit a ceiling, known as a lid, which keeps the thunderclouds from rising further. But sometimes the clouds build up so much that they burst through the lid right into the path of the icy jet stream. This is what puts the twist in the twister—at the bottom, the clouds are blowing one way, and at the top, the other.

From the ground you see what's known as a supercell, with a fast-spinning center called a wall cloud. The spinning lowers the air pressure, sending the supercell's twisting center up from the ground until it touches the wall cloud and becomes a tornado. Objects can be lifted into the vortex, or turned into missiles. After a strong tornado, buildings may look as if they were hit by bombs.

Vocabulary

blitzkrieg — a sudden, overwhelming attack (the term comes from warfare, where it means a sudden, swift, large-scale offensive intended to win a quick victory).

blizzard — snow blown in a wind at more than 35 miles an hour.

cyclone — another name for a hurricane.

cumulonimbus cloud — a giant thundercloud. This type of dense cloud, which develops vertically through all cloud levels; consists of water droplets, ice crystals and sometimes hail, and is associated with thunder, lightning and heavy showers.

hurricane — a windstorm with a violent, whirling movement and waterlogged air; also called a cyclone or a typhoon.

ion — an electrically charged atom or group of atoms.

jet stream — a high-altitude current of air that circles the globe. As the Earth spins, the air masses break up into separate, swirling bands of weather. The boundary between the two northernmost bands is marked by the jet stream.

mesosphere — the atmospheric zone located above the stratopause (the atmospheric transition zone located between the stratosphere and the mesosphere at an altitude of 31 to 34 miles) at an altitude of 34 to 50 miles; at increasing altitudes, it is characterized by decreasing temperatures.

monsoon — in India, the season from April to October during which a wind from the Indian Ocean and South Asia blows from the southwest, bringing heavy rains.

negative charge — having an excess of electrons. (see "positive charge.")

neutralize — to make electrically neutral; that is, with neither a positive or a negative charge.

positive charge — having a deficiency of electrons. (see "negative charge.")

storm surge — during a hurricane, when huge areas of the ocean get lifted up between 20 and 40 feet, inundating the whole area.

stratosphere — the atmospheric zone located above the tropopause (the atmospheric transition zone located between the troposphere and the stratosphere, six to 12 miles above the Earth); 12 to 31 miles above the Earth, the stratosphere is characterized by increasing temperatures at increasing altitudes.

supercell — created when a large thunderstorm begins to rotate because outside winds are intense; tornadoes are born from supercells.