TEMPESTES I CICLONS

Cicle "Ciència i Societat" 2006-2007

Universitat de les Illes Balears

Romu Romero (Grup de Meteorologia – Dept. de Física)

OVERVIEW

1) Thunderstorms

2) Tropical cyclones

3) Extratropical cyclones

4) Numerical weather prediction

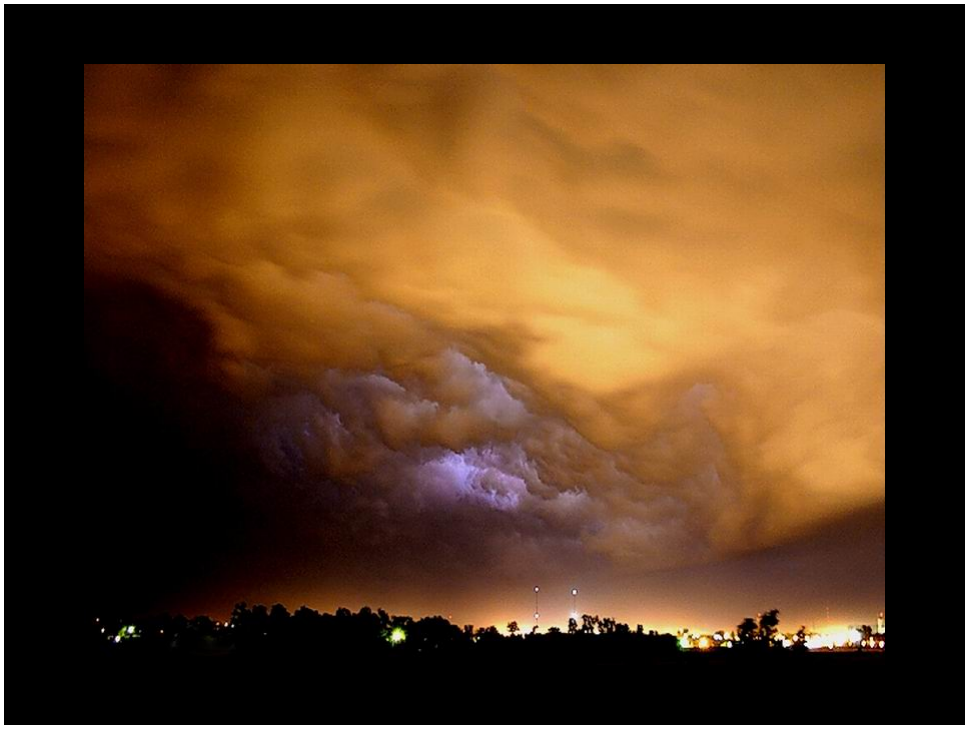
Thunderstorms

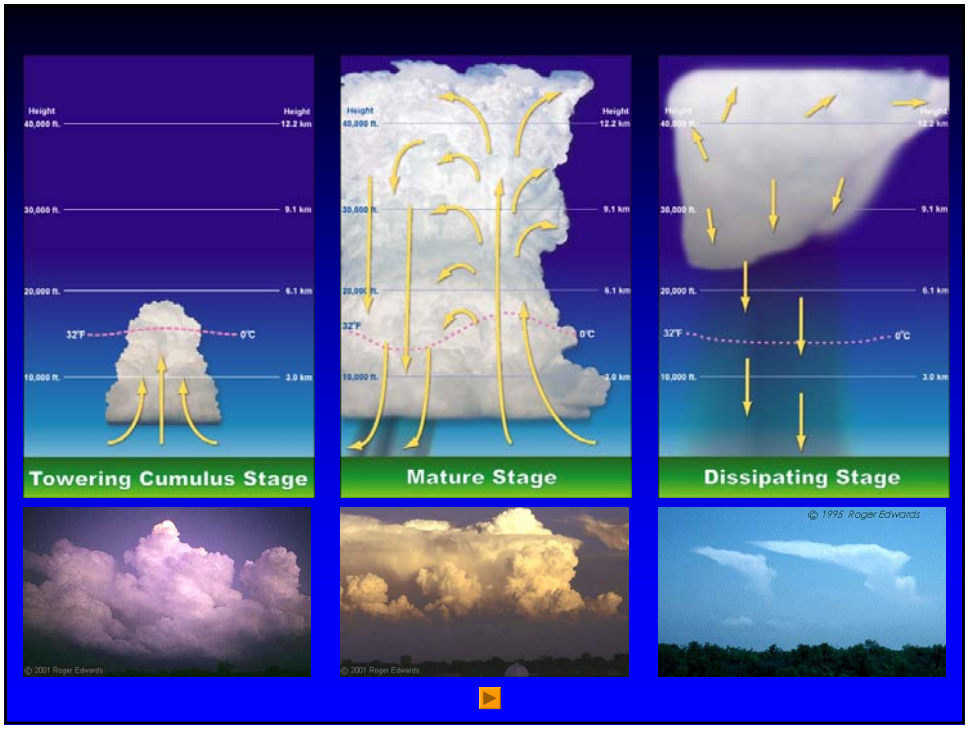
Definition

A local storm

- Produced by a cumulonimbus cloud
- Always accompanied by lightning and thunder
- Often accompanied by gusty winds, heavy rain, and occasionally by hail
- Sometimes violent at the surface

Category	Wind Speed	Precipitation
Ordinary	< 35 knots (40 mph)	Variable
Approaching Severe	> 35 knots (40 mph)	Hail > 1/2 inch
Severe	> 50 knots (58 mph)	Hail > 3/4 inch





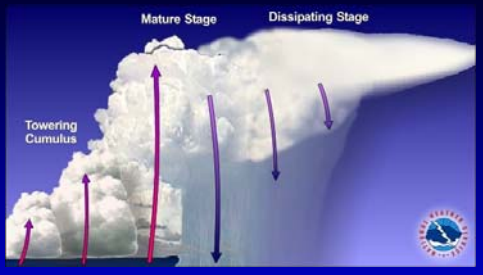
Types

- **Single Cell** - Short-lived storms (20 to 30 minutes) that cover a limited area (a few square miles). These storms are relatively uncommon.
- **Multicell** - The most common type, multicell thunderstorms are an organized cluster of two or more single cell storms. Air flowing out of one storm fuels other storms, causing new storms to develop on the right or rear storm flank every 5 to 15 minutes.
- **Supercell** - Supercells are relatively uncommon but produce the most severe weather, last the longest (1 to 6 hours), and travel 200 miles or more. These storms can cause winds of more than 78 mph, giant hail (e.g., 2 inches), and significant tornado activity. Supercells produce updrafts of 56 to 112 mph that coexist with sustained downdrafts. Together, the updrafts and downdrafts act to extend the storm's duration.
- **Squall Lines** - A line or band of active thunderstorms, a squall line may extend over 250 to 500 miles, may be from 10 to 20 miles wide, and consist of many laterally aligned cells that do not interfere with one another. The cells may be any combination of types (ordinary to severe, single cell to supercell). Squall lines may form along cold fronts, but often form as much as 100 miles ahead of an advancing cold front in the warm sector of an extratropical storm. They often trail a large, flat cloud layer that brings significant rain after the storms pass.

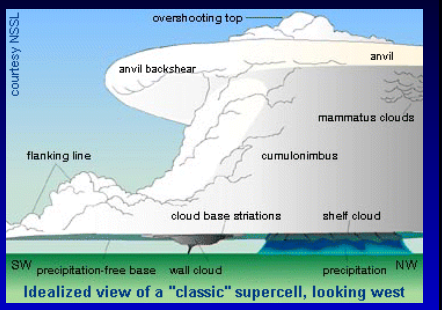
Associated Hazards

- Lightning
- Hail
- Damaging winds
- Heavy rain causing flash flooding
- Tornadoes
- Lightning-caused fire

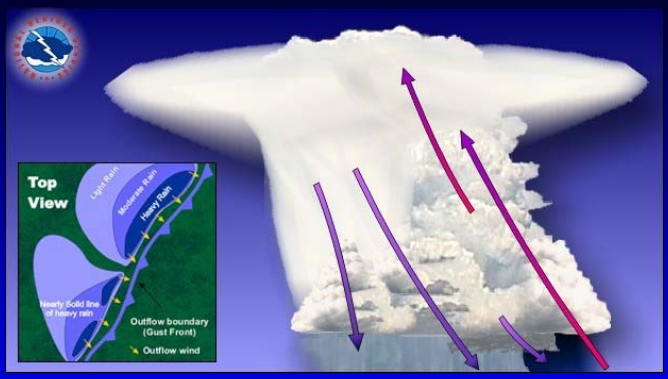
Multicell

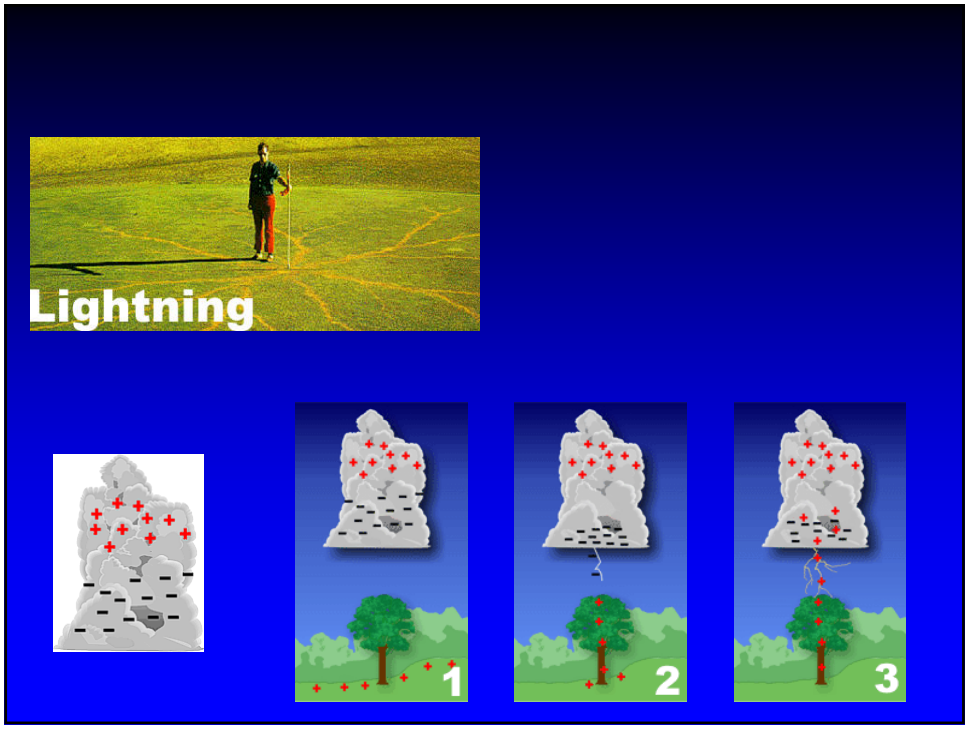


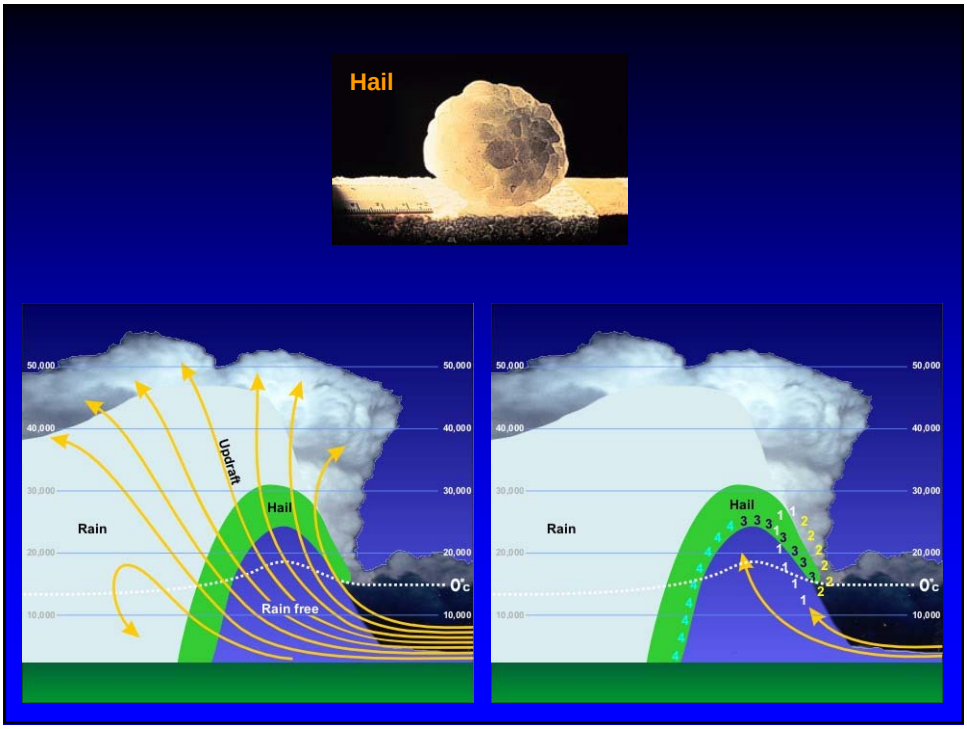
Supercell



Squall Line



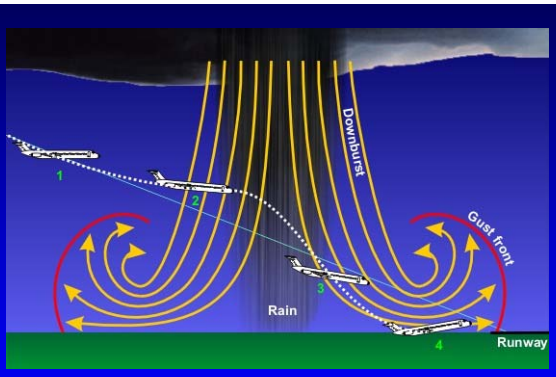

Lightning
1
2
3


Hail
50,000
40,000
30,000
20,000
10,000
Updraft
Hail
Rain
Rain free
0°c
Hail
Rain
0°c

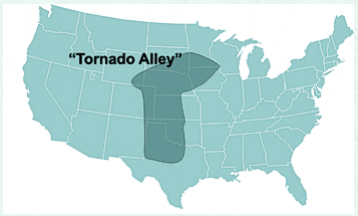

An example: The severe hail storm in Alcañiz (16th August 2003)

Damaging winds

Damaging wind from thunderstorms is much more common than damage from tornados. In fact, many confuse damage produced by "straight-line" winds and often erroneously attribute it to tornados. Wind speeds can reach up to 100 mph (161 km/h) with a damage path extending from hundreds of miles.



Tornadoes



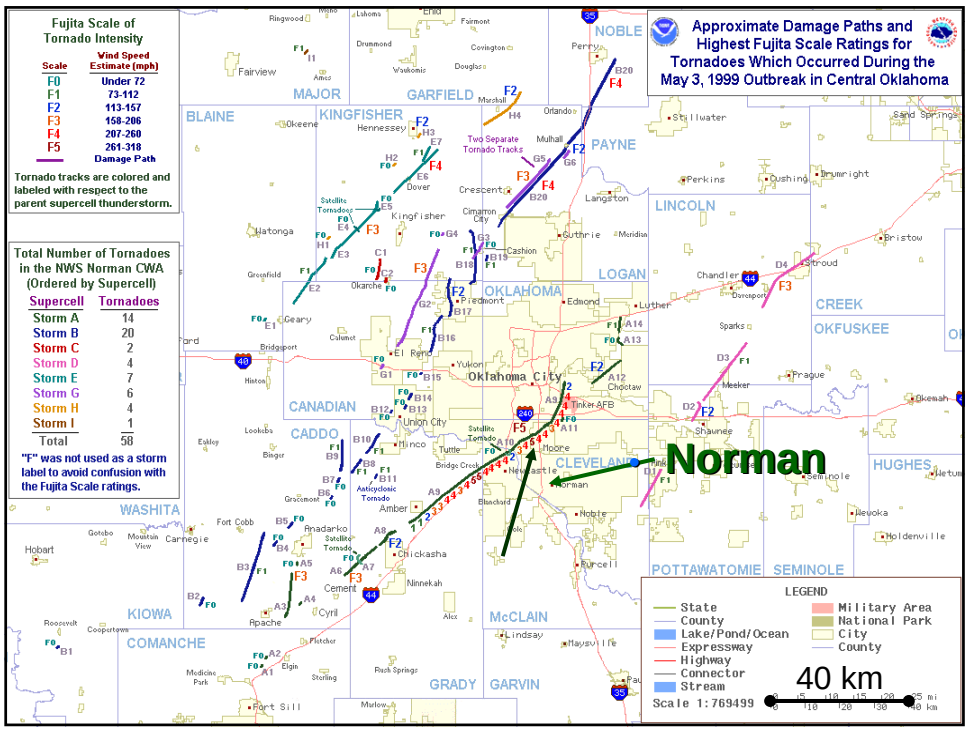
Definition

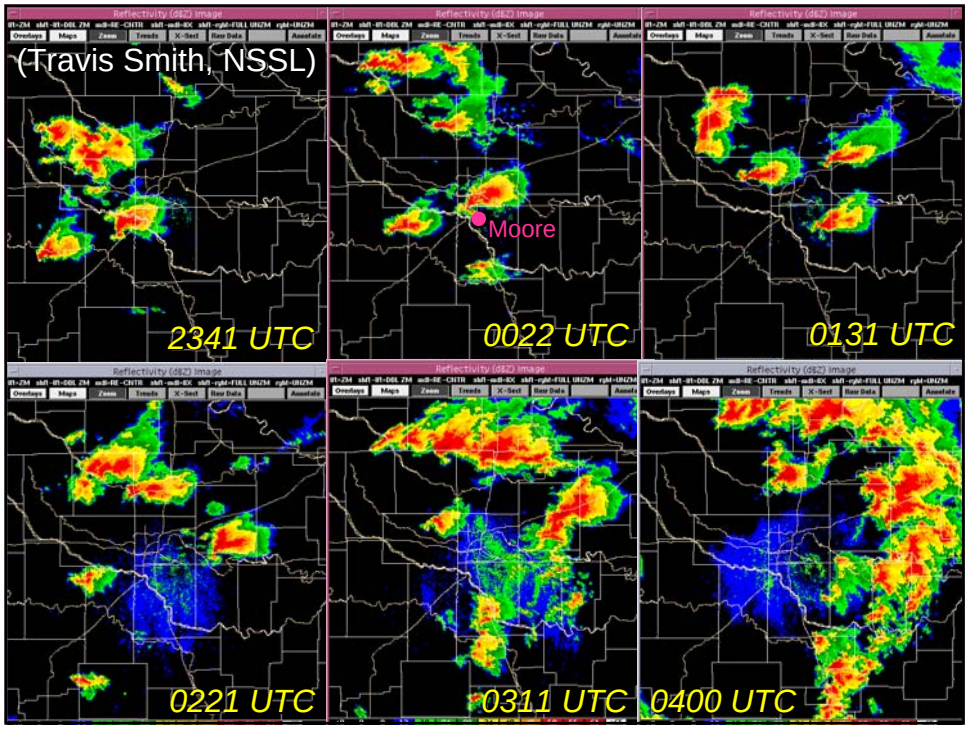
Tornadoes are the most violent storms on earth, with estimated wind speeds as high as 300 miles per hour or more. A tornado is a violently rotating column of air that extends from the base of a thunderstorm and comes in contact with the ground. The spinning motion of a tornado is almost always counterclockwise.

Thunderstorms develop in warm, moist air in advance of eastward-moving cold fronts. These thunderstorms often produce large hail, strong winds, and tornadoes. Tornadoes in the winter and early spring are often associated with strong, frontal systems that form in the Central States and move east. Occasionally, large outbreaks of tornadoes occur with this type of weather pattern. Several states may be affected by numerous severe thunderstorms and tornadoes.

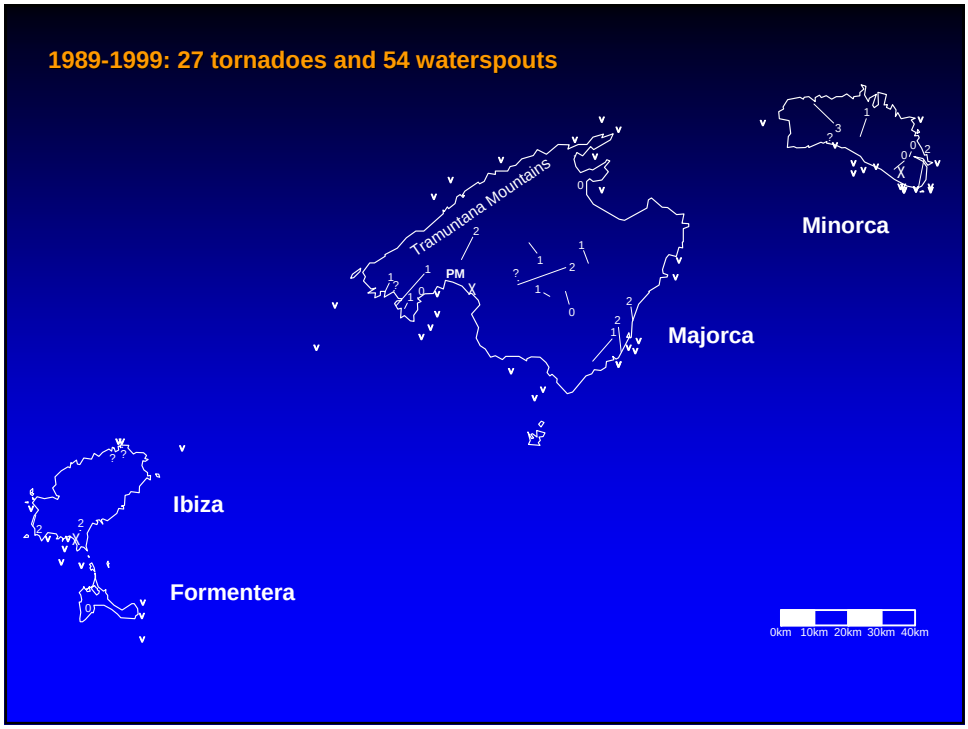
During the spring in the Central Plains, thunderstorms frequently develop along a "dryline," which separates very warm, moist air to the east from hot, dry air to the west. Tornado-producing thunderstorms may form as the dryline moves east during the afternoon hours.

Along the front range of the Rocky Mountains, in the Texas panhandle, and in the southern High Plains, thunderstorms frequently form as air near the ground flows "upslope" toward higher terrain. If other favorable conditions exist, these thunderstorms can produce tornadoes.


Fujita Scale of Tornado Intensity
Scale
Wind Speed Estimate (mph)
F0 Under 72
F1 73-112
F2 113-157
F3 158-206
F4 207-260
F5 261-318
Damage Path
Tornado tracks are colored and labeled with respect to the parent supercell thunderstorm.
Total Number of Tornadoes in the NWS Norman CWA (Ordered by Supercell)
Supercell Tornadoes
Storm A 14
Storm B 20
Storm C 2
Storm D 4
Storm E 7
Storm G 6
Storm H 4
Storm I 1
Total 58
"F" was not used as a storm label to avoid confusion with the Fujita Scale ratings.
Approximate Damage Paths and Highest Fujita Scale Ratings for Tornadoes Which Occurred During the May 3, 1999 Outbreak in Central Oklahoma
Norman
NOBLE
MAJOR
GARFIELD
BLAINE
KINGFISHER
PAYNE
LINCOLN
LOGAN
OKLAHOMA
CREEK
OKFUSKEE
CANADIAN
CADDO
CLEVELAND
HUGHES
WASHITA
POTTAWATOMIE
SEMINOLE
KIOWA
McCLAIN
COMANCHE
GRADY
GARVIN
Oklahoma City
Two Separate Tornado Tracks
Satellite Tornadoes
Anticyclonic Tornado
LEGEND
State
County
Lake/Pond/Ocean
Expressway
Highway
Connector
Stream
Military Area
National Park
City
County
Scale 1:769499
40 km


(Travis Smith, NSSL)
Moore
2341 UTC
0022 UTC
0131 UTC
0221 UTC
0311 UTC
0400 UTC


(Jarboe)
(Schultz)
(Jarboe)
(Lindley)
(Schultz)
(Lindley)
(Peppler)
(Carey)
(Zaras)


1989-1999: 27 tornadoes and 54 waterspouts
Tramuntana Mountains
PM
Majorca
Minorca
Ibiza
Formentera
0km 10km 20km 30km 40km

Tornadoes occasionally accompany tropical storms and hurricanes that move over land. Tornadoes are most common to the right and ahead of the path of the storm center as it comes onshore.

A **funnel cloud** is a similar column of air that is not in contact with the ground. A **water spout** is a tornado that is over water. When either a funnel cloud or a water spout comes in contact with the ground, it becomes, by definition, a tornado.

The visible column is composed of water droplets formed by condensation in the funnel. The fast-moving winds (either flowing into the tornado or in the main tornadic circulation) cause most of the damage. The vortex (or multiple vortices) sucks in air from near the ground, along with dirt and debris. The dirt and debris block light, giving the tornado a dark color.

Tornadoes are defined in terms of the Fujita Scale, which ranks tornadoes on the basis of wind speed and damage potential. The Fujita Scale is shown in the following table.

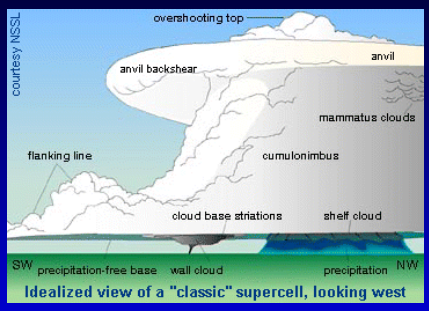
Category	Wind Speed	Effects
F0	40-72 mph	**Light damage**: Some damage to chimneys; branches break from trees; shallow rooted trees pushed over; sign boards damaged
F1	73-112 mph	**Moderate damage**: Roof surfaces peeled off; mobile homes pushed from foundations or overturned; cars pushed off roads
F2	113-157 mph	**Considerable damage**: Roofs torn off frame houses; mobile homes demolished; large trees snapped or uprooted
F3	158-206 mph	**Severe damage**: Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted
F4	207-260 mph	**Devastating damage**: Well-constructed houses leveled; structures with weak foundations blown off some distance
F5	261-318 mph	**Incredible damage**: Strong frame houses lifted off foundations and carried considerable distance to disintegrate

F-scale	Class	Wind speed		Description
		mph	km/h	
F0	weak	40-72	64-116	gale
F1	weak	73-112	117-180	moderate
F2	strong	113-157	182-253	Significant
F3	strong	158-206	254-332	severe
F4	violent	207-260	333-419	devastating
F5	violent	261-318	420-512	incredible

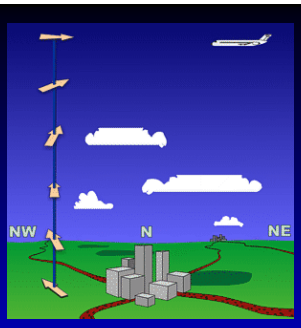
12/10/2004

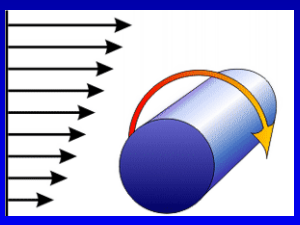
7/9/2005

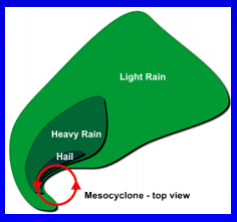
Supercell Mesocyclone

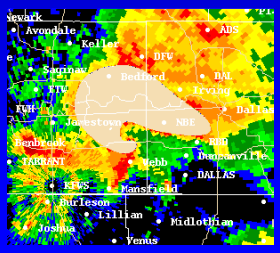


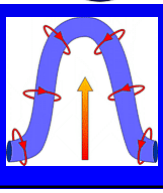
Idealized view of a "classic" supercell, looking west



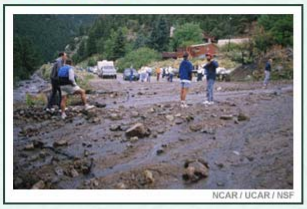








Flash Floods



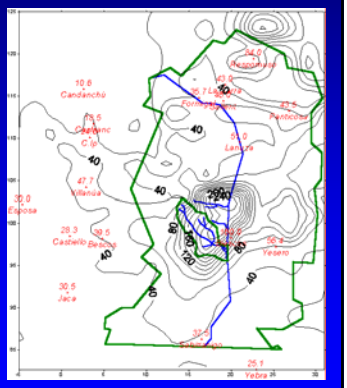
Definition

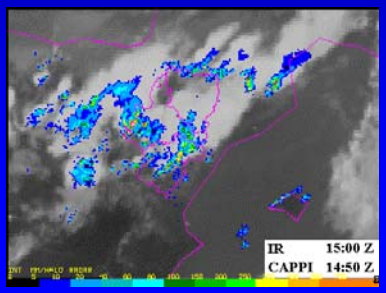
A flash flood occurs suddenly, within a short time (from minutes to less than 6 hours) after a causative event. Flash floods are the number one weather-related killer in the U.S. Nearly half of all flash-flood fatalities are auto related.

Causative events include heavy rains from slow moving thunderstorms, dam or levee failure, or the sudden release of water from the breakup of an ice jam. Intense, short-duration rainfall on impervious areas, such as urban areas or certain soils, also causes flash floods.

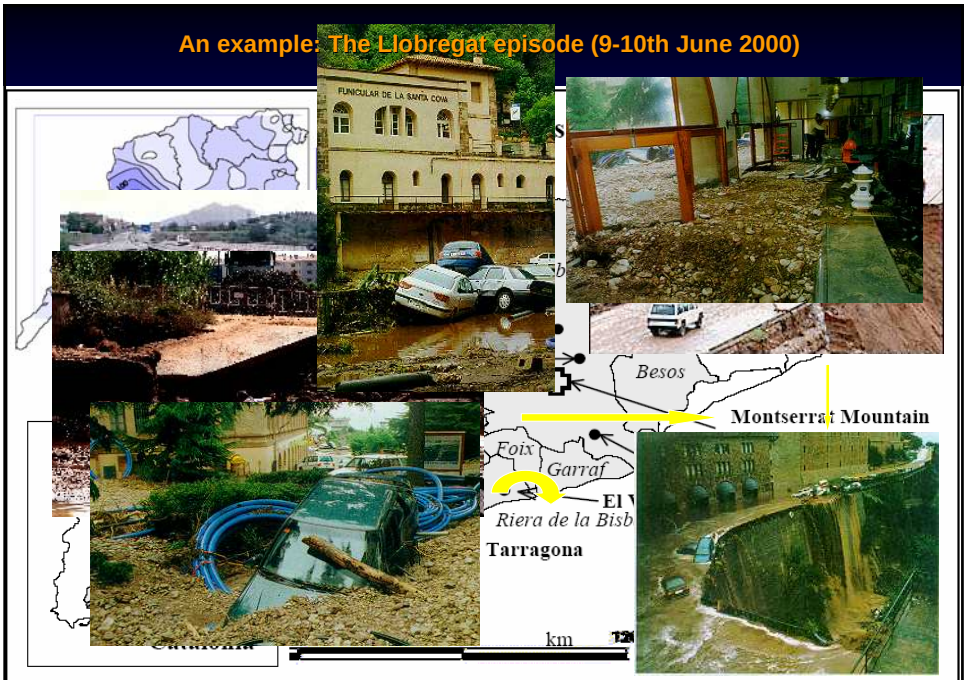
Flash floods are most prevalent on small streams, generally draining areas ranging in size from a few square miles to several hundred square miles. The most dangerous flash floods are usually associated with steep mountain streams, canyons, and desert washes where they can manifest themselves as a wall of water traveling downstream.

An example: The Biescas event (7th August 1996)





An example: The Llobregat episode (9-10th June 2000)



Characteristics

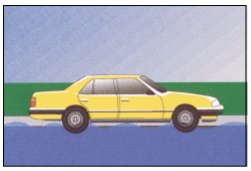
Rainfall intensity and duration affect the potential for flash floods. Other non-meteorological factors that could affect an area's ability to absorb water include the topography, soil conditions, and ground cover.

Topography is important, especially when there are steep slopes. Gravity rapidly moves the water to the lowest point(s), reducing the time the runoff is susceptible to being absorbed by the ground, as well as funneling water from larger areas into the lowest region.

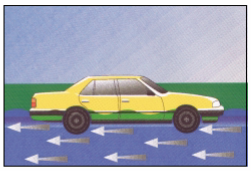
Some soils can absorb runoff more effectively (i.e., sand is better than clay) and reduce runoff. Soils covered with vegetation tend to retard runoff, and mitigate rapid accumulation of water at low points. Wet soils have limited capability to absorb runoff, so rainfall is more effective in causing flooding when soils are moist. Frozen soils also do not allow for absorption of runoff. Finally, some soils, such as clay, that have been "baked" by long periods of hot, dry conditions, often have little capability to absorb runoff.

The most severe flash floods can roll boulders, tear out trees, destroy buildings and bridges, and scour out new channels. However, less serious flash flooding is still capable of taking lives. As little as a foot of moving water is enough to sweep a car into deeper flood waters. Also, children playing in flood waters, especially near culverts and drainage pipes, can be swept away. Other hazards associated with flash floods include:

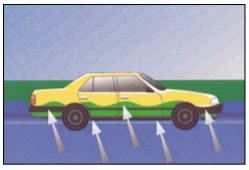
- **Sudden release of huge walls of water** - Floating debris or ice can collect at an obstruction and restrict the flow of water. Pressure builds up behind the jam, and when the pressure bursts through, a huge wall of water of up to 30 feet is released, causing tremendous destruction.
- **Debris flows** - Debris caught in the water flow acts as battering rams, causing additional destruction.
- **Mud slides** - Flash floods can also trigger mud slides in areas with clay soils, saturated soils, or little ground cover.



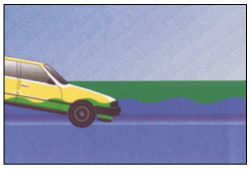
Water weighs 62.4 lbs. per cubic foot and typically flows downstream at 6 to 12 miles an hour.



When a vehicle stalls in the water, the water's momentum is transferred to the car. For each foot the water rises, 500 lbs. of lateral force are applied to the car.

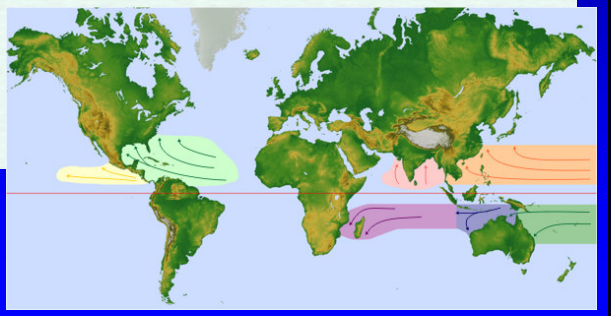


But the biggest factor is buoyancy. For each foot the water rises up the side of the car, the car displaces 1,500 lbs. of water. In effect, the car weighs 1,500 lbs. less for each foot the water rises.



Two feet of water will carry away most automobiles.

Tropical Cyclones



Definition

Tropical cyclones are coastal storms that form over the ocean, within the tropics. These storms cover a smaller area than extratropical coastal cyclones; the storm center is warmer than the surrounding air, and the strongest winds are about 10,000 feet above the ground.

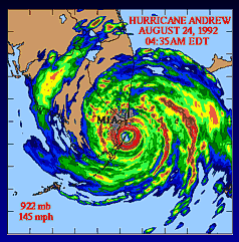
Tropical Cyclones:

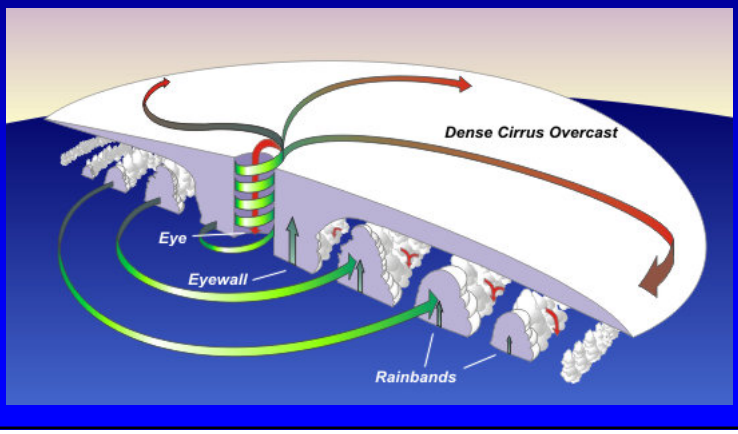
- Form over a tropical ocean
- Cover a smaller area (200-500 miles across)
- Have a storm center warmer than the surrounding air
- Have the strongest winds at about 10,000 feet

Tropical cyclones are categorized by wind speed as shown in the next table.

Category	Wind Speed
Tropical Depression	Maximum sustained winds near the surface less than 39 mph
Tropical Storm	Winds of 39-73 mph
Hurricane	Winds of 74 mph or more

In the Northern Hemisphere intense tropical cyclones are called hurricanes, a term that echoes colonial Spanish and Caribbean Indian words for evil spirits and big winds. (NOTE: A hurricane is called a typhoon if formed in the Western Pacific and a cyclone if formed in the Indian Ocean.) The storms are products of the tropical ocean and atmosphere, powered by the easterly trades and temperate westerlies and their fierce energy. Around the core, winds blow with lethal velocity, the ocean develops inundating surge, and as they move ashore, tornadoes may descend from the advancing thunderclouds.



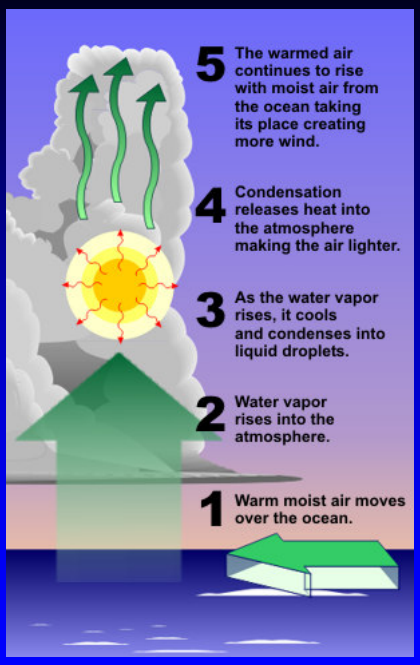


The letters Q, U, X, Y, and Z are not included because of the scarcity of names beginning with those letters. If over 21 named tropical cyclones occur in a year, the Greek alphabet will be used following the "W" name. In addition, after major land-falling storms having major economic impact, the names are retired.

2006	2007	2008	2009	2010	2011*
Alberto	Andrea	Arthur	Ana	Alex	Arlene
Beryl	Barry	Bertha	Bill	Bonnie	Bret
Chris	Chantal	Cristobal	Claudette	Colin	Cindy
Debby	Dean	Dolly	Danny	Danielle	Dennis
Ernesto	Erin	Edouard	Erika	Earl	Emily
Florence	Felix	Fay	Fred	Fiona	Franklin
Gordon	Gabrielle	Gustav	Grace	Gaston	Gert
Helene	Humberto	Hanna	Henri	Hermine	Harvey
Isaac	Iris	Isidore	Ida	Igor	Irene
Joyce	Jerry	Josephine	Joaquin	Julia	Jose
Kirk	Karen	Kyle	Kate	Karl	Katrina
Leslie	Lorenzo	Lili	Larry	Lisa	Lee
Michael	Michelle	Marco	Mindy	Matthew	Maria
Nadine	Noel	Nana	Nicholas	Nicole	Nate
Oscar	Olga	Omar	Odette	Otto	Ophelia
Patty	Pablo	Paloma	Peter	Paula	Philippe
Rafael	Rebekah	Rene	Rose	Richard	Rita
Sandy	Sebastien	Sally	Sam	Shary	Stan
Tony	Tanya	Teddy	Teresa	Tomas	Tammy
Valerie	Van	Vicky	Victor	Virginie	Vince
William	Wendy	Wilfred	Wanda	Walter	Wilma

Greek Alphabet: Alpha, Beta, Gamma, Delta, Epsilon, Zeta, Eta, Theta, Iota, Kappa, Lambda, Mu, Nu, Xi, Omicron, Pi, Rho, Sigma, Tau, Upsilon, Phi, Chi, Psi, Omega

*This is also the names of storms for the 2005 hurricane season. Some of the names in this list may be retired when the Regional Association IV - Hurricane Committee, of the World Meteorological Organization, meets later this spring.



Cat.	Speed	Damage
1	**74-95 mph** 64-82 kts 119-153 km/hr	No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Some damage to poorly constructed signs.
2	**96-110 mph** 83-95 kts 154-177 km/hr	Some roofing material, door, and window damage of buildings. Considerable damage to shrubbery and trees with some trees blown down. Considerable damage to mobile homes, poorly constructed signs, and piers.
3	**111-130 mph** 96-113 kts 178-209 km/hr	Some structural damage to small residences and utility buildings with a minor amount of curtainwall failures. Damage to shrubbery and trees with foliage blown off trees and large tress blown down. Mobile homes and poorly constructed signs are destroyed.
4	**131-155 mph** 114-135 kts 210-249 km/hr	More extensive curtainwall failures with some complete roof structure failures on small residences. Shrubs, trees, and all signs are blown down. Complete destruction of mobile homes. Extensive damage to doors and windows.
5	Greater than **155 mph** 135 kts 249 km/hr	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. All shrubs, trees, and signs blown down. Complete destruction of mobile homes. Severe and extensive window and door damage.

Hydrometeorological hazards associated with hurricanes include the following:

- **Coastal Flooding** caused by storm surge
- **Windstorms** due to extremely strong winds
- **Riverine flooding** caused by heavy rains
- **Tornadoes**

These hazards are described below. For more information refer to the fact sheet for each hazard.

Historically, the worst damage from hurricanes comes from coastal flooding caused by storm surge. A storm surge is an abnormal rise in water level caused by wind and low-pressure forces; the lower the pressure of the storm, the greater the height of the storm surge. High winds and low pressure can build a wall of water out in the ocean about 10 feet high. The highest surges in the U.S. have reached 20 feet. When the surge reaches land, the wall of water can cause extensive coastal flooding.

Hurricane-force winds also can cause extensive damage and death. The strongest winds in a hurricane occur from 10 to 30 miles from the center of the eye, in a region called the **eyewall**. Winds that extend outward from the eyewall in the front right quadrant are the most devastating. Precursor winds will affect land well before the most damaging winds of the eye.

When a hurricane reaches land, it begins to weaken as it loses its warm-water energy source and encounters greater surface friction over land. This weakening process is gradual, so even though wind speeds may be reduced by 50 percent within 12 hours, hurricane-force winds can penetrate far inland in that timeframe. Additionally, tropical storm-force winds can extend far beyond the storm center and, although weaker, can cause significant damage.

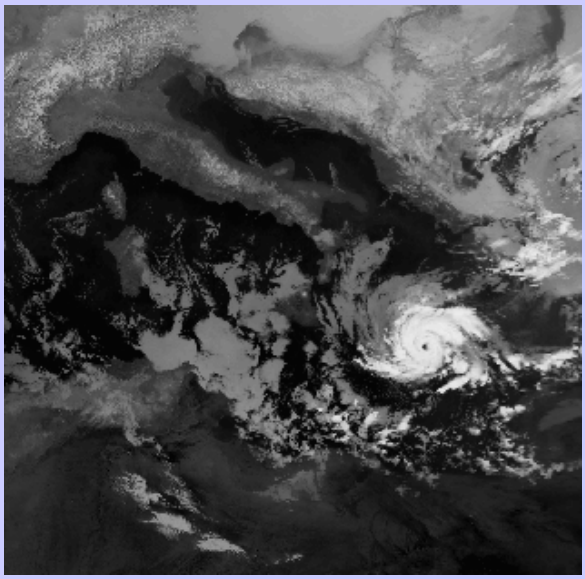
Coastal and inland jurisdictions affected by hurricane winds should anticipate:

- Widespread damage to homes (especially mobile homes) and businesses
- Extensive tree damage along roadways, which may inhibit or block access
- Extensive damage to electric and telephone lines, especially if large trees are uprooted
- Damaged and/or destroyed signs and traffic-control devices
- Damaged radio and television towers

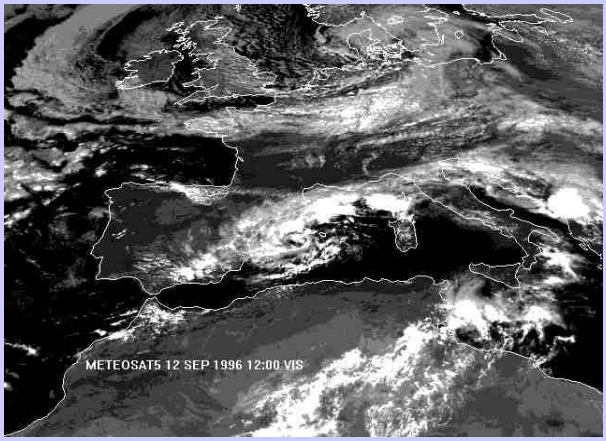
Widespread torrential rains of 6 to 12 inches are not uncommon in hurricanes and can produce deadly and destructive floods. Riverine flooding is a major threat to areas well inland.

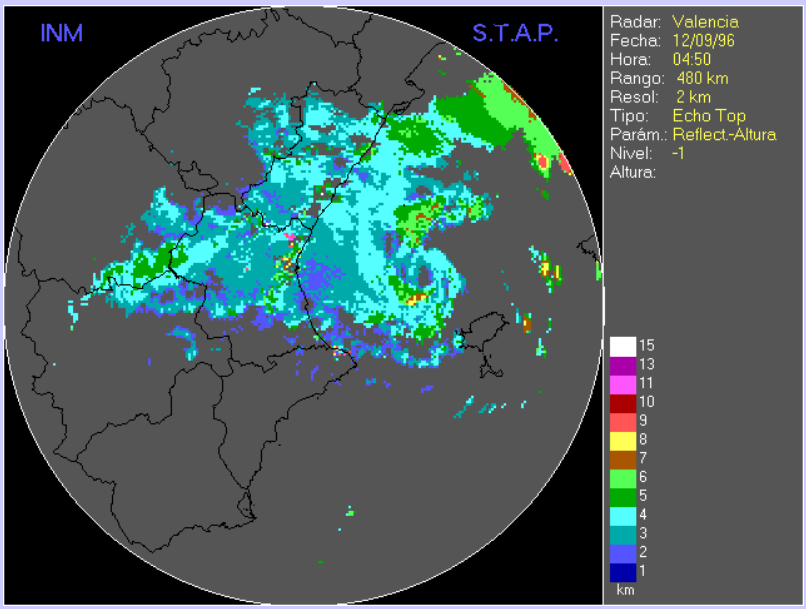
Hurricanes may also spawn tornadoes, which add to the hurricane's destructive power. These tornadoes most often occur in the thunderstorms embedded in rain bands out from the right front quadrant of the hurricane, although they can also occur near the eyewall.

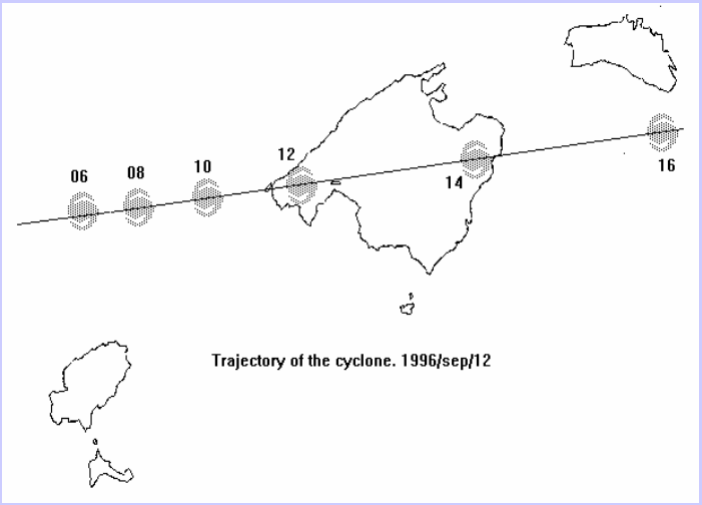
Medicane of 15-17 January 1995



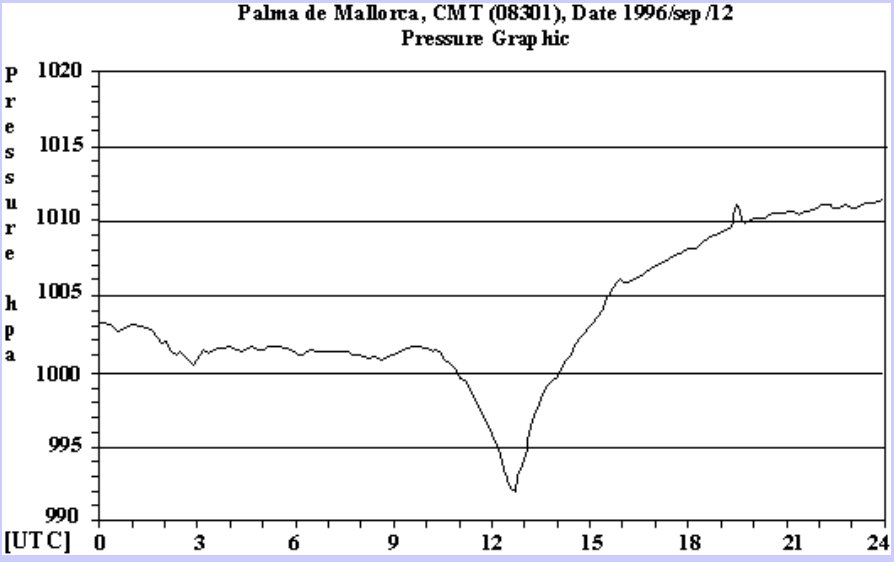
Medicane of 12 September, 1996



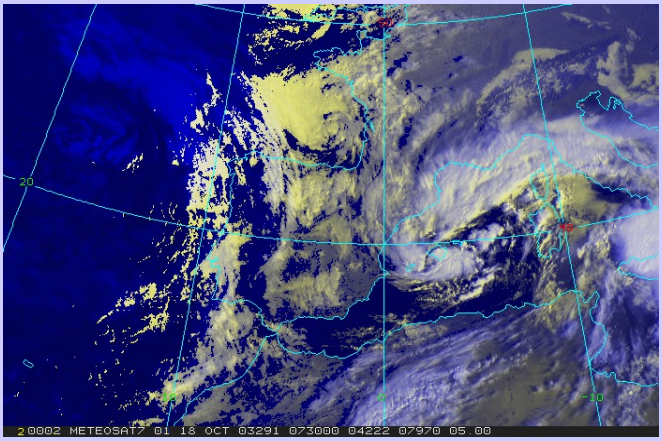


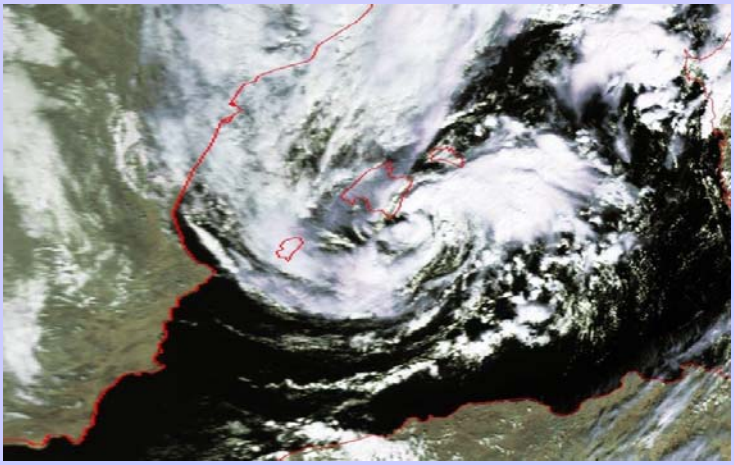


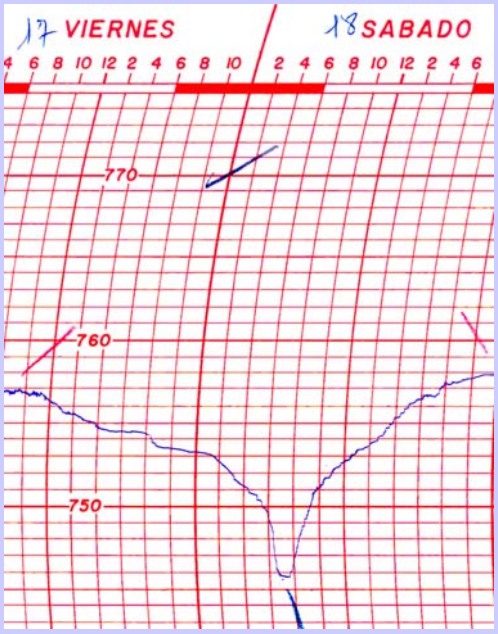
Trajectory of the cyclone. 1996/sep/12

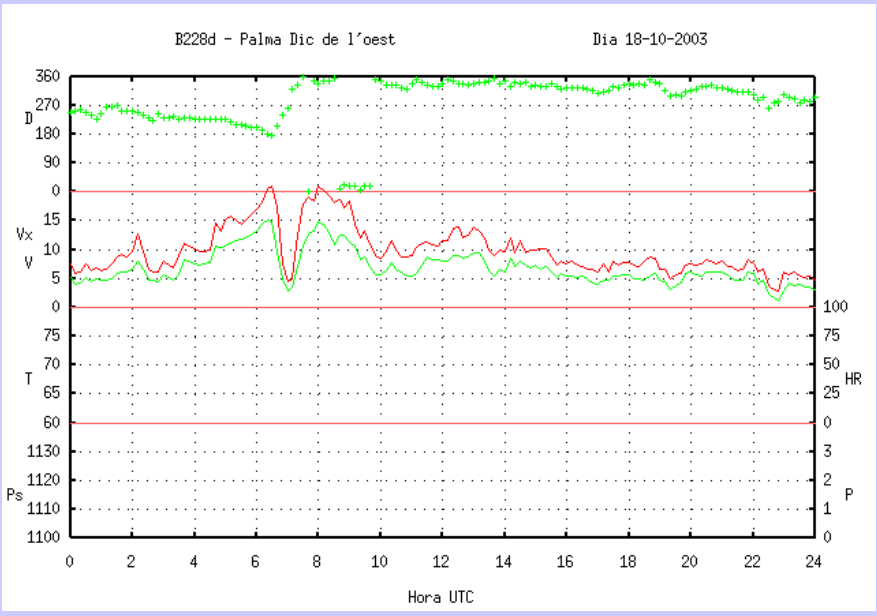


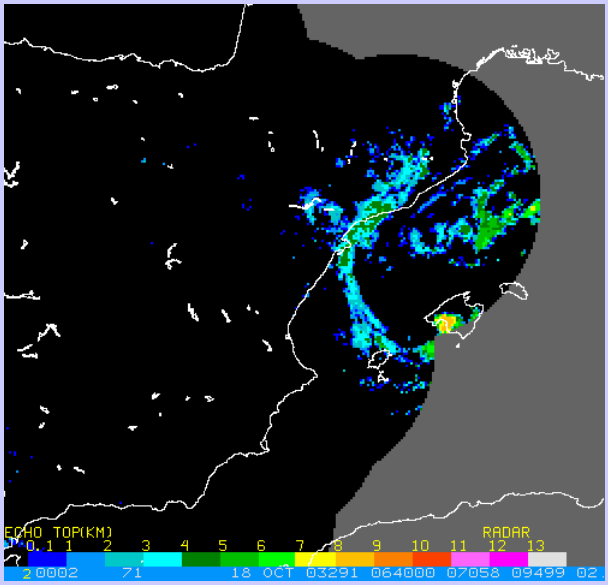
Medicane of 18 October, 2003



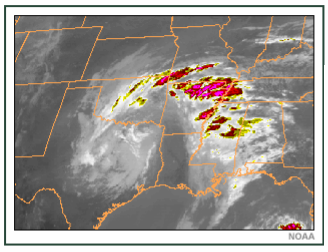



17 VIERNES
18 SABADO
4 6 8 10 12 2 4 6 8 10 2 4 6 8 10 12 2 4 6
770
760
750


B228d - Palma Dic de l'oest
Dia 18-10-2003
D
Vx
V
T
Ps
HR
P
Hora UTC



Extratropical Cyclones



Definition

Most of the storms that affect U.S. weather are extratropical. These are deep, low-pressure storms that form outside the tropics off the Pacific coast, in the Gulf of Mexico, over the Atlantic Ocean, or in the Great Lakes.

Extratropical cyclones:

- Form outside the tropics
- Cover a large area (700-1000 miles across), often larger than tropical cyclones
- Have a storm center that is colder than the surrounding air
- Have their strongest winds in the upper atmosphere

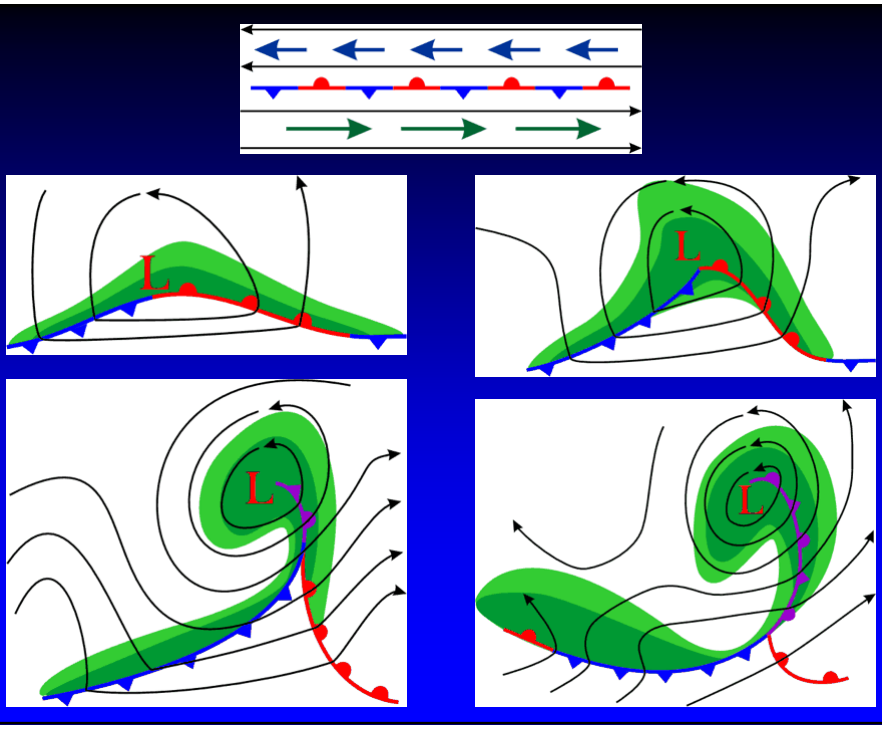
Characteristics

Under ideal wind and temperature conditions, a coastal low-pressure system deepens rapidly. Because these storms form over water, which has a smoother surface than land, wind speeds pick up rapidly. Less weather data is available from the ocean areas, so detection may lag behind storm development. Extratropical cyclones tend to deepen quickly near the shore, which shortens the time available for communities to respond.

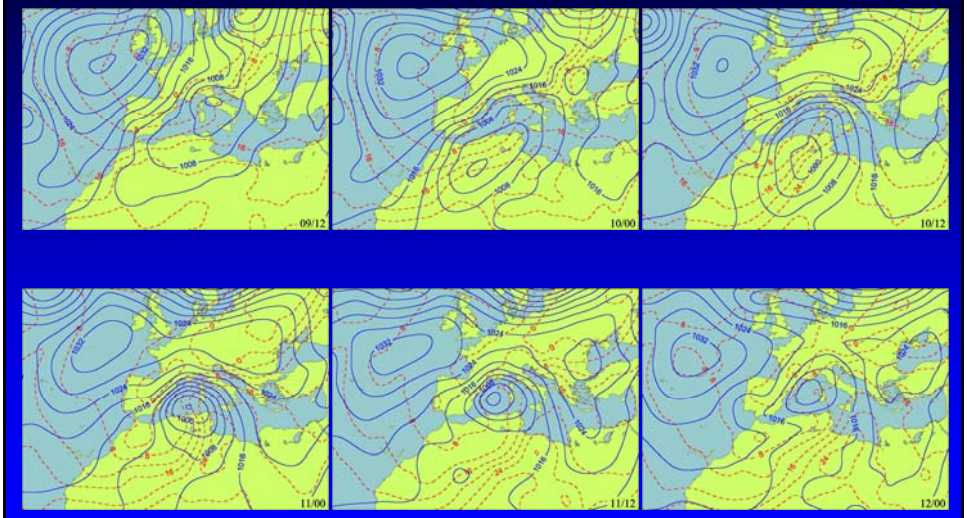
Hazards from extratropical cyclones include:

- Swells, storm surges, and huge waves that pound the coastline
- Very high winds generated by strong pressure gradients
- Coastal flooding
- Heavy rains, flooding, and flash flooding
- Heavy snow
- Mud slides
- Downbursts
- Tornadoes

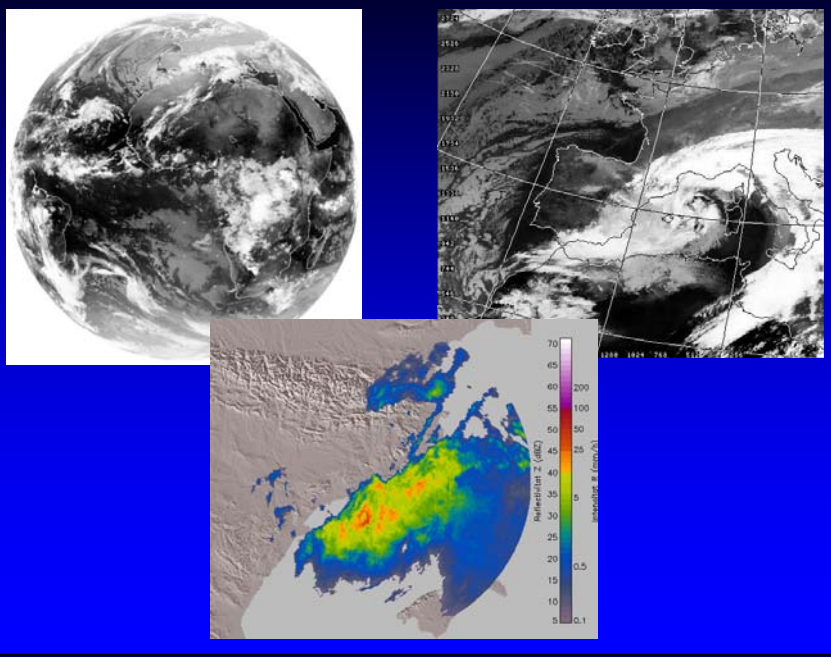
Refer to the fact sheets on coastal floods, winter storms, and tornadoes for more information on these hazards.



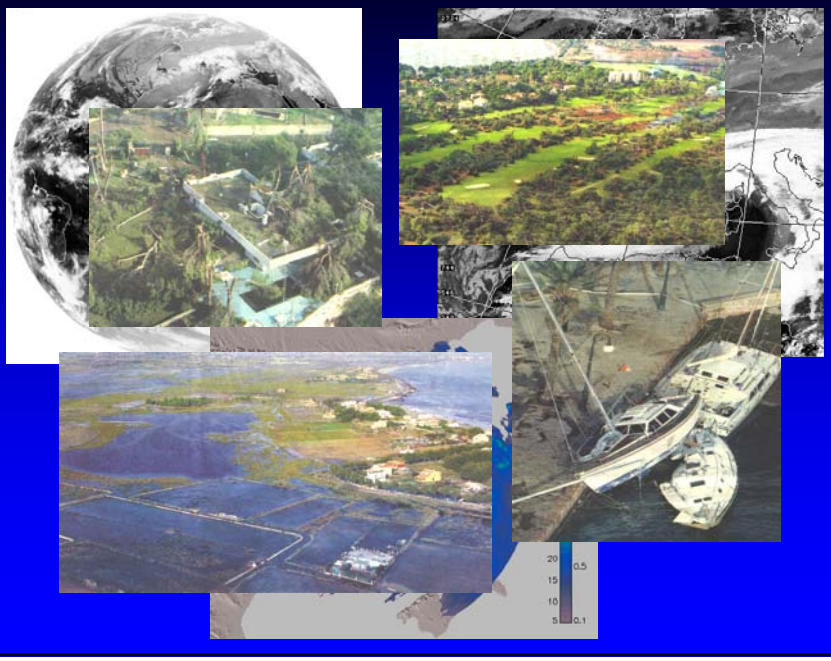
An example: The November 2001 superstorm



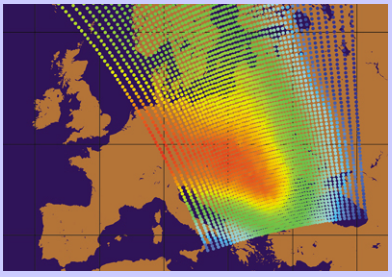
An example: The November 2001 superstorm

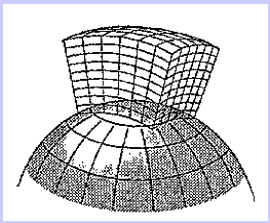


An example: The November 2001 superstorm



Numerical Weather Prediction





Example 1.- Numerical simulation of the November 2001 superstorm

http://mm5forecasts.uib.es/superstorm

Example 2.- Local meteorological predictions for the Balearic Islands

http://mm5forecasts.uib.es/OCLIBlocal


GRÀCIES PER
LA VOSTRA ATENCIÓ !!!