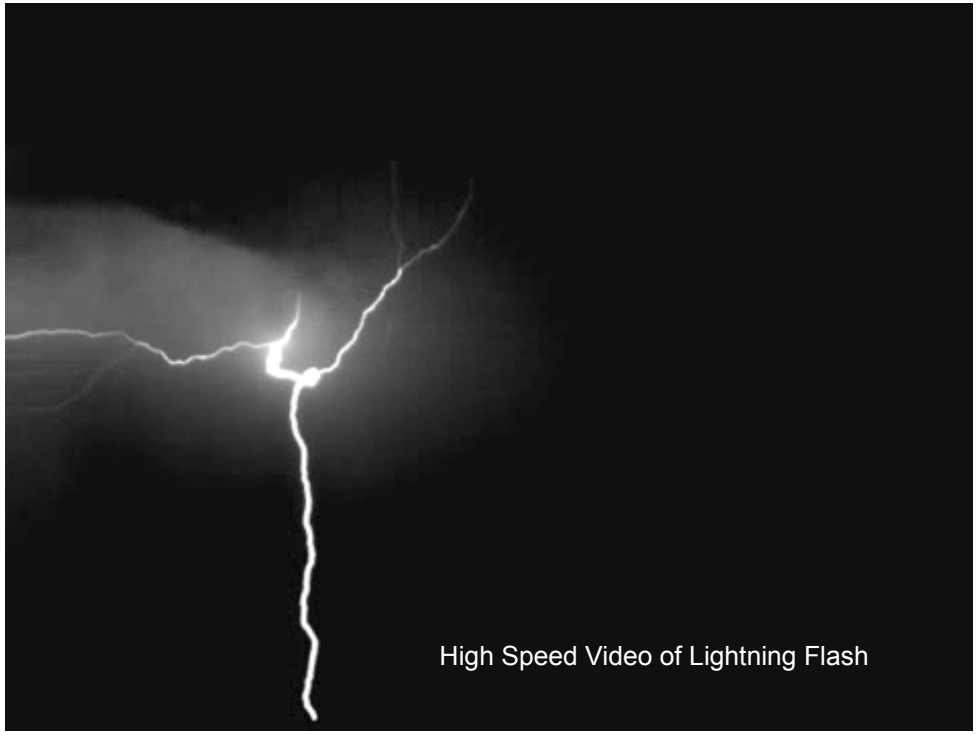
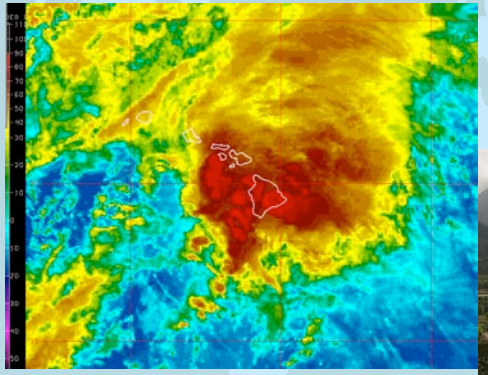


1

MET200 Lecture 23 Hawaii Weather Hazards and Air Mass Thunderstorms

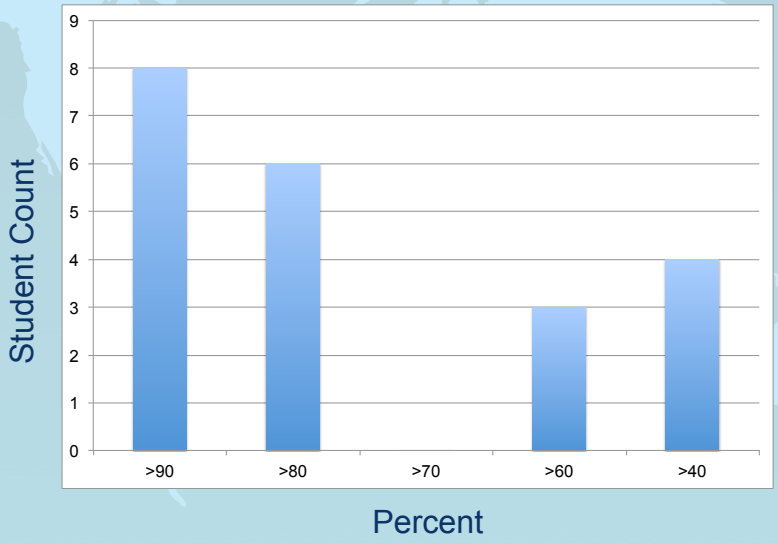


Hilo Flood November 2000

Hanalei Flood November 2009

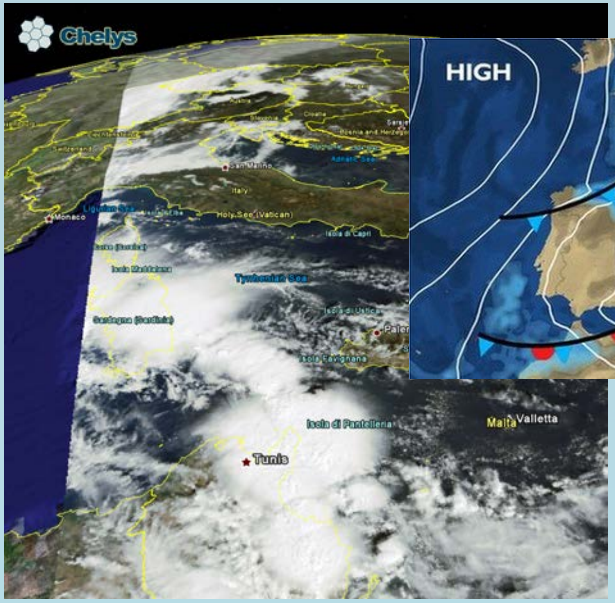
2

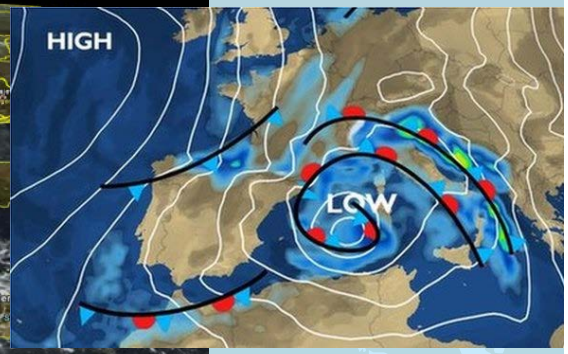
Quiz 3 Scores



3

Sardinia Floods





- >17 inches of rain in 24 hours, 18 fatalities.

4

Sardinia Floods

Last Lecture: Weather Modeling

Steps in Numerical Weather Prediction

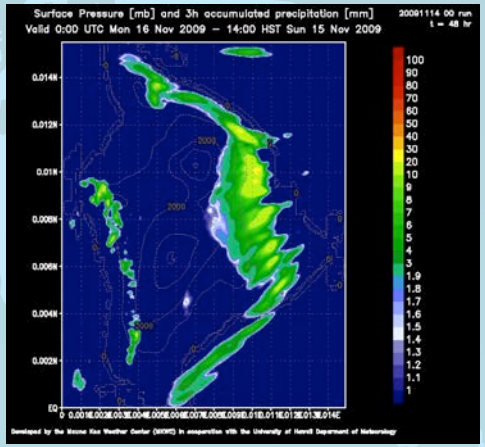
1. Input all available observations.
2. Interpolate data to points on an evenly spaced grid.
3. Apply laws of physics, including parameterization of surface and cloud processes too small for the model to directly include - integrate equations forward in time.
4. Output resulting forecast as contoured maps for interpretation.

Challenges in modeling hazardous weather in Hawaii

1. Lack of observations - we are surrounded by ocean.
2. The resolution (or grid spacing) of the model is not fine enough to fully capture the physics of convective clouds and the impact of mountains on the flow.

Modeling of Heavy Rain Forecasts

- Global models
  - Guidance up to 16 days
  - Identify weather patterns and ingredients favorable for heavy rains
  - Precipitation forecast is poor, but can be useful in qualitative sense
- Regional models
  - Guidance up to 3 days
  - Provides better details on spatial distribution
  - Rainfall forecasts are better than global models, but still relatively poor and used mainly in qualitative sense.



NWS Flash Flood Advisories

- Flood Potential Outlook (36 hr in advance)
  - Event is possible within 36 hr
- Flood Watch (36 hr in advance)
  - Event is likely within 36 hr
- Flash Flood Warning (updated every 3 hr)
  - Threat to life and property is imminent or occurring

Weather Hazards in Hawaii

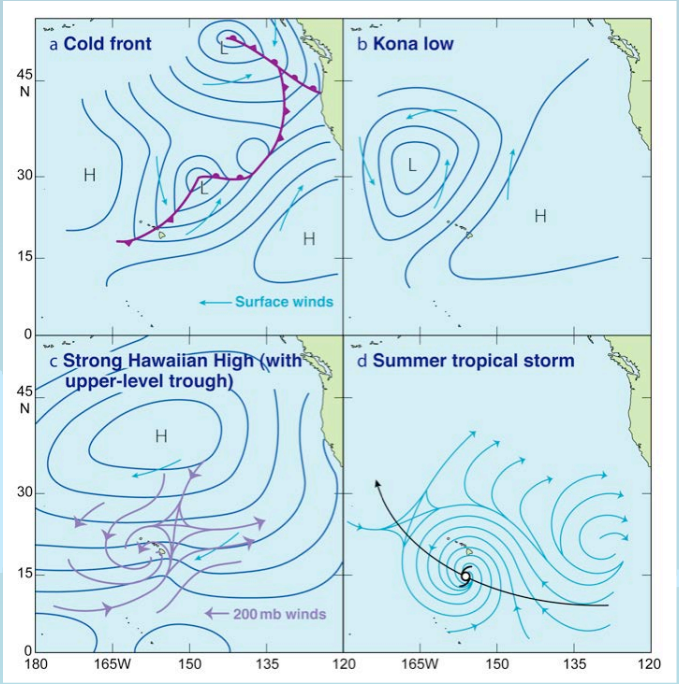
- Heavy Rains and Flash Flooding
- High Winds
- Large Ocean Swell and Surf
- Storm Surge
- Blizzards at High Altitude (Mauna Kea, Mauna Loa and Haleakala)
- Severe Thunderstorms
  - Water spouts, Lightning, Flooding, High Winds, Tornados (rare).

"Bad" Weather Patterns in Hawaii

There are four large-scale weather patterns that produce hazardous weather in Hawaii.

1. Midlatitude Cyclones
   Cold frontal passage, shear lines
2. Kona Lows
3. Strong Surface High Pressure
4. Tropical Cyclones

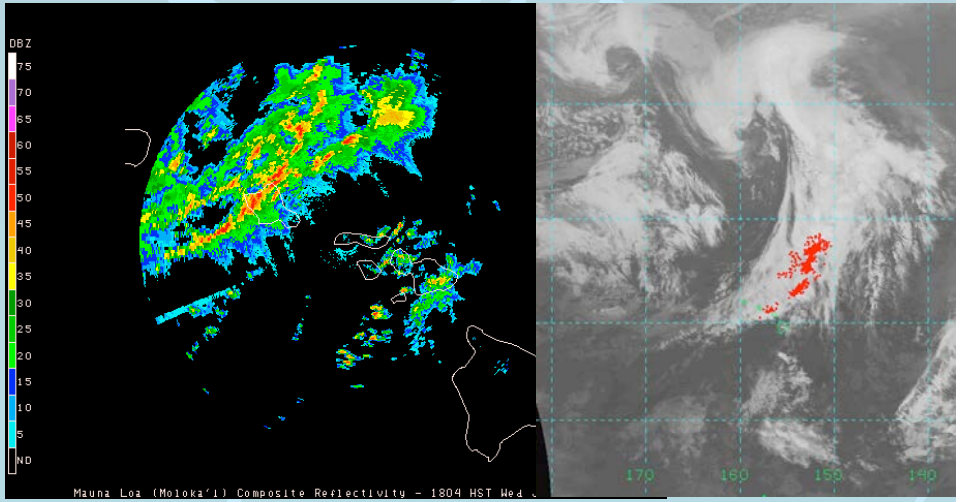
Weather Patterns in Hawaii



Weather Hazards in Hawaii

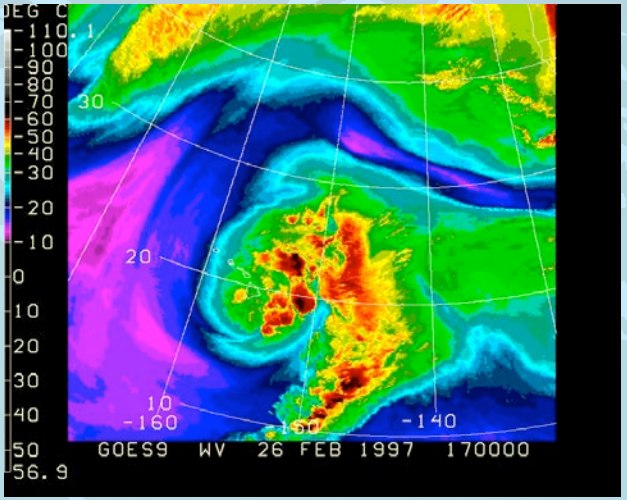
1. Midlatitude cyclones - cold fronts
   - flooding
   - high winds
   - waves and swell
2. Kona lows
   - flooding
   - high winds
   - waves and swell
3. Extra strong Hawaiian highs
   - high trade winds
   - waves and swell
4. Tropical cyclones
   - winds
   - waves and swell
   - storm surge
   - flooding

Radar Loop of Passing Cold Front



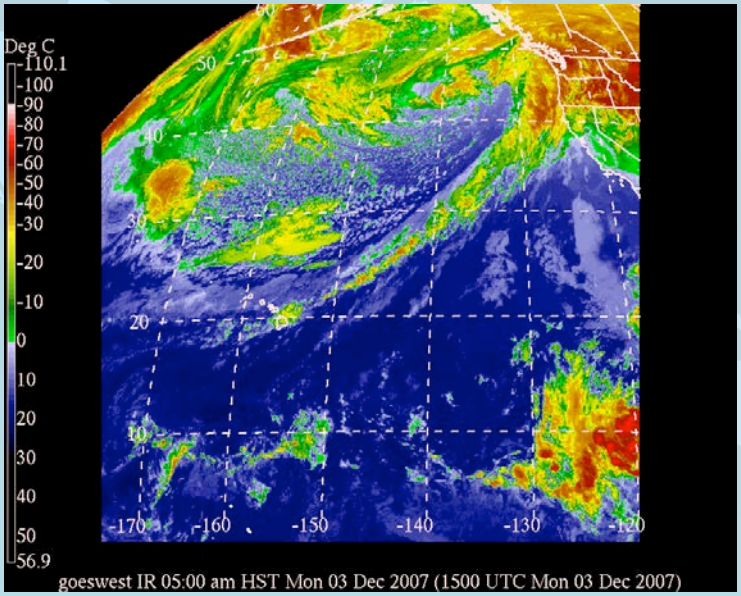
Wednesday 1/12/11. Flooding closes roads, schools on Maui. Landfill waste washes up between Ko Olina and Kahe Power Plant. High winds down power lines.

Kona Low



Kona lows form south of 30˚N latitude and are cut off from the polar jet stream.

Kona Low



12/07 Kona Low

- Pali Highway shut down in Honolulu-bound direction
- More than 45,000 without power across Oahu
- Toppled poles blocking Farrington Highway
- Wind-damaged roof reported on home in Kahaluu
- Storm results in multiple school closures
- 61 mph wind at Schofield Barracks
- High surf
- Heavy rains and flooding

Kona Low



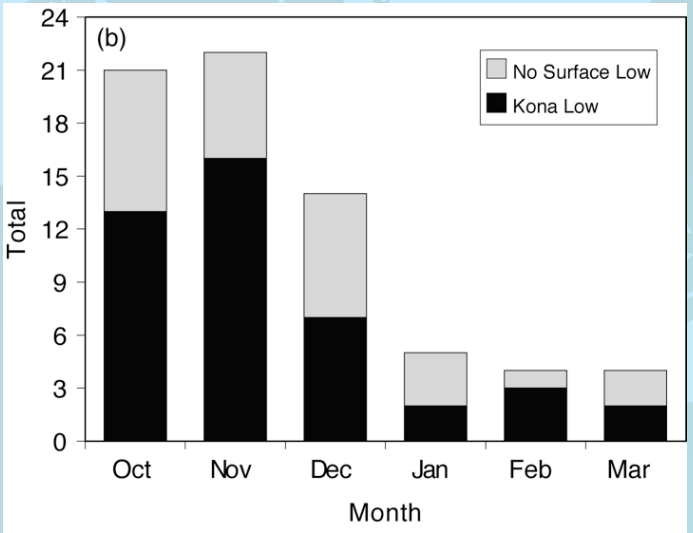

Kona Low




Kona Low




Monthly Distribution of Kona Lows



Kona Low

- Kona lows all have an upper-level low aloft.
- The upper-level low is cold and it is cut off from the polar jet stream.
- New convection forms near and east of upper level low center.

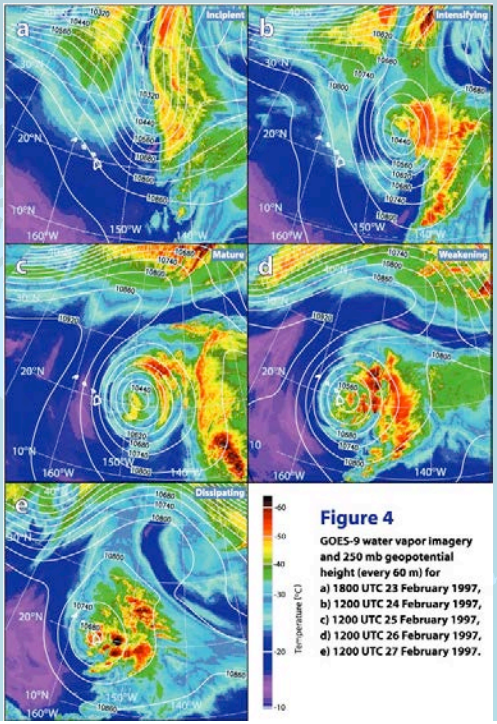


Figure 4
GOES-9 water vapor imagery and 250 mb geopotential height (every 60 m) for a) 1800 UTC 23 February 1997, b) 1200 UTC 24 February 1997, c) 1200 UTC 25 February 1997, d) 1200 UTC 26 February 1997, e) 1200 UTC 27 February 1997.

Kona Low

- The surface low moves southward as it deepens.
- The surface low moves westward as it dissipates.
- Thunderstorms form on the east side of the surface low.
- The strongest winds are on the north side and in rainbands.

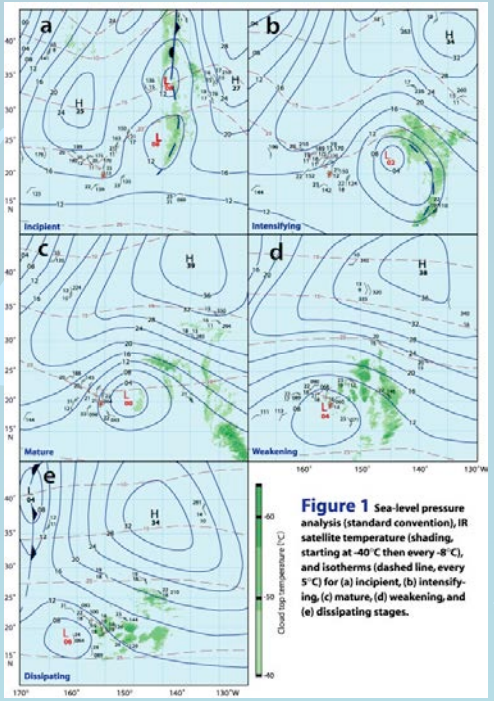
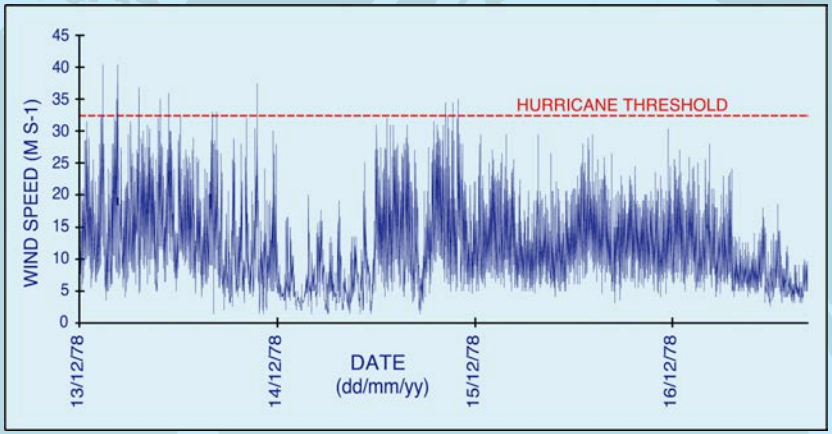


Figure 1 Sea-level pressure analysis (standard convention), IR satellite temperature (shading, starting at -40°C then every -8°C), and isotherms (dashed line, every 5°C) for (a) incipient, (b) intensifying, (c) mature, (d) weakening, and (e) dissipating stages.

Hurricane Force Trade Winds

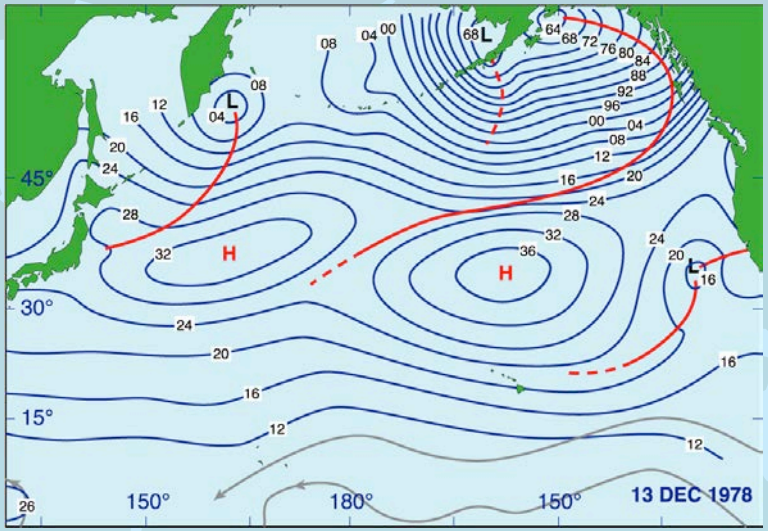
Research Vessel Holo Holo sank in the Alenuihaha Channel under high wind conditions, December 1978.

Hurricane Force Trade Winds



Hurricane force trade winds recorded by anemometer in Waikaloa, Hawaii, December 1978.

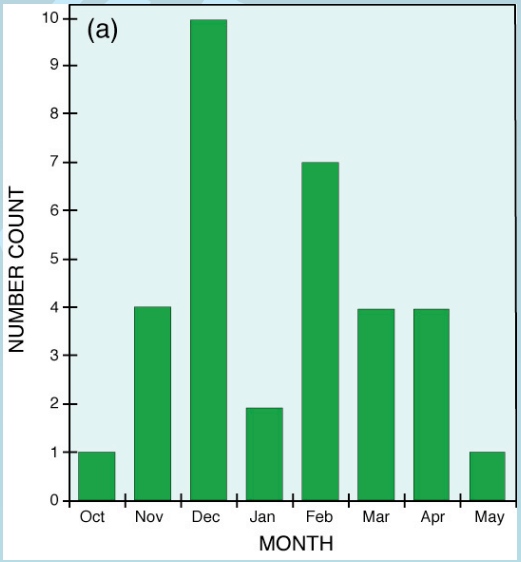
Strong Hawaiian High



Sea-level pressure analysis for 13 December 1978.

Monthly Histogram of Trade-wind Events

Histogram showing monthly distribution of 33 strong trade wind events impacting Hawaii



Air Mass Thunderstorms and Lightning

Air Mass Thunderstorms

- Environment
- Life Cycle
- Climatology
- Lightning

Stability in the Atmosphere

Essentially, warm (cold) air relative to its surroundings will rise (sink). To determine the atmosphere's stability for vertical motions we need to know and compare the temperature of rising/sinking air parcels with the temperature in the surrounding environment.

Stability in the Atmosphere

How do we diagnose stability in the atmosphere? What assumptions are implicit to our analysis of soundings for stability?

Air Mass Thunderstorms

Environment: Air Mass thunderstorms are triggered by lifting.

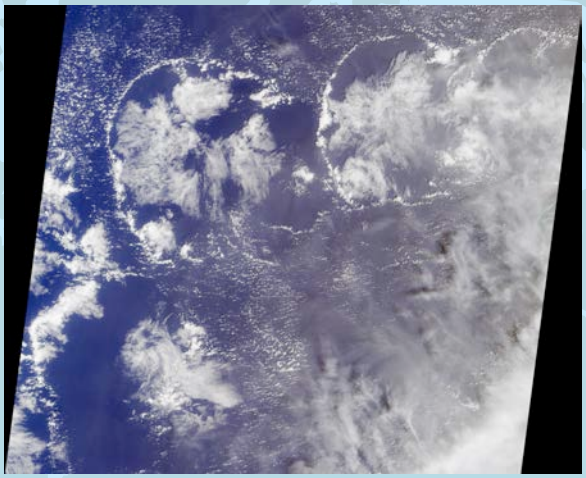
Lifting is provided by

- Sea-breeze circulations
- Land-breeze circulations
- Mountain-valley circulations
- Solar heating
- Outflows from earlier thunderstorms

Florida Lightning

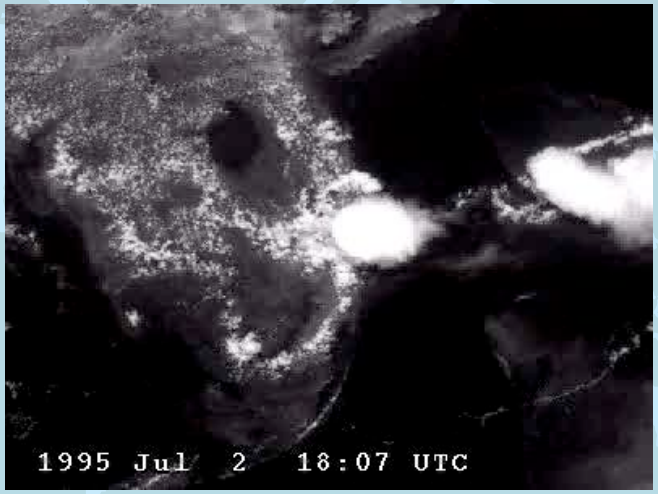
Thunderstorms are initiated over the ocean at night by a land breeze front.

Gust Front – Outflow Boundary



Cold-air downdrafts enhanced by evaporative cooling, rain or hail spread horizontally when they reach the surface causing a gust front.

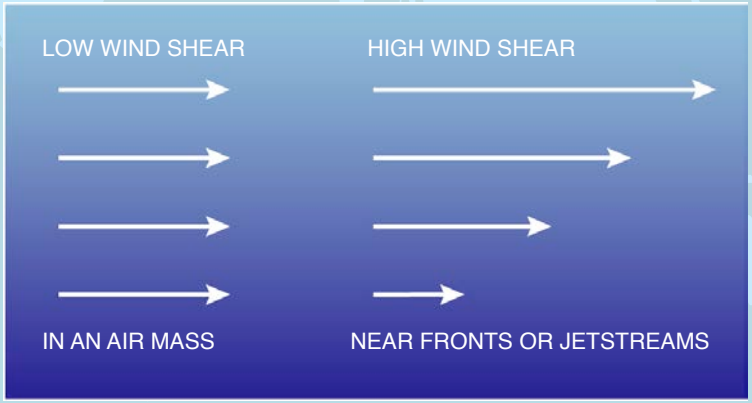
Sea Breeze



Converging Gulf of Mexico and Atlantic sea breezes produce uplift and thunderstorm development in Florida.

Air Mass Thunderstorms

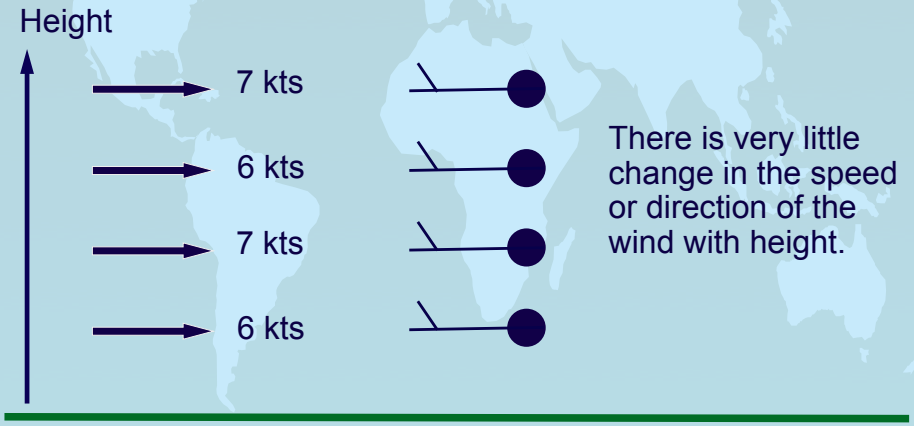
Environment: Air Mass thunderstorms form in regions of relatively light winds and light wind shear. Thus they form away from fronts and jet streams.



Air Mass Thunder Storm Severe Thunderstorm

Wind Shear

Example of little or no vertical wind shear:



There is very little change in the speed or direction of the wind with height.

Air Mass Thunderstorms

Short-lived, isolated thunderstorms that are not severe are often called air-mass thunderstorms.

There are three stages describing the life cycle of an air-mass thunderstorm.

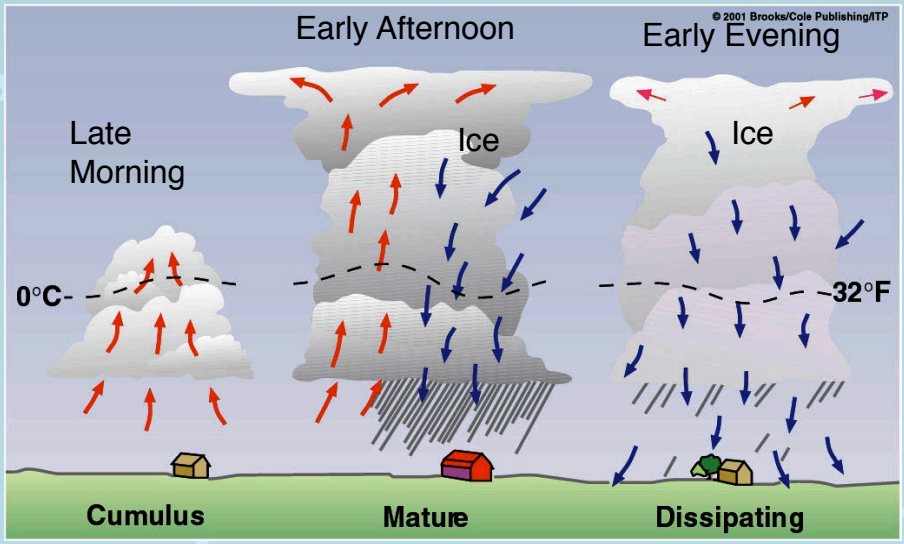
cumulus

mature

dissipating

Three Stages in Life Cycle of Air Mass Thunderstorm over the Colorado Rocky Mountains

Air Mass Thunderstorms



Three stages in the life cycle of an air-mass thunderstorm.

Cumulus Stage

- Growing cumulus cloud dominated by updraft - transporting warm, moist air upward
- No precip is reaching the surface at this stage, though it begins to form in the cloud
- Air parcel temperatures in the cloud are warmer than the surrounding air.

Cumulus Stage

Note the rain-free cloud base

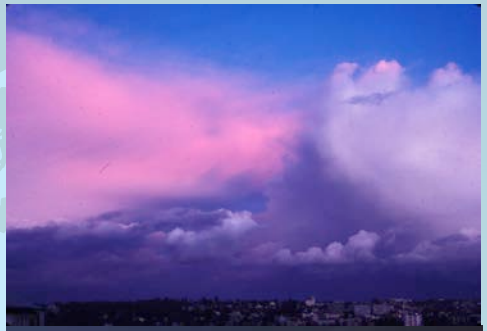
Mature Stage

- Storm is most intense, cloud tops can reach tropopause - with overshooting tops, seen in satellite imagery.
- Ice and water are both present in the cloud.
- lightning and thunder may be present
- Storm is characterized by warm updraft and cold, downdraft, with precipitation reaching the surface
- Downdraft can produce strong, gusty winds at surface

Mature Stage

Dissipating Stage

- Storm is dominated by the downdrafts.
- Precipitation intensity at the ground weakens.
- End up with a cold pool of air at the ground, warm air is now aloft.
- Hence, the storm has stabilized the environment



Lightning

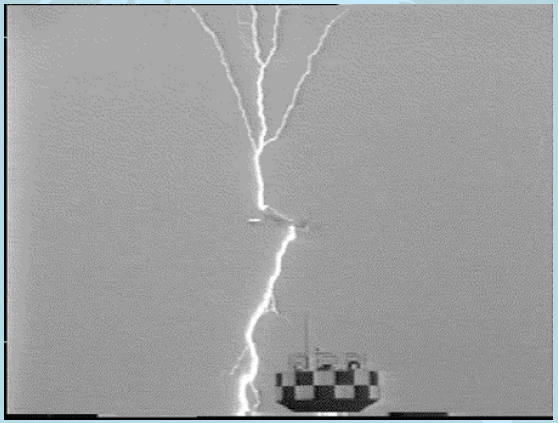
Lightning

Lightning

Cause of wild fires and house fires.

Airplane Cabins are Insulated

Lightning



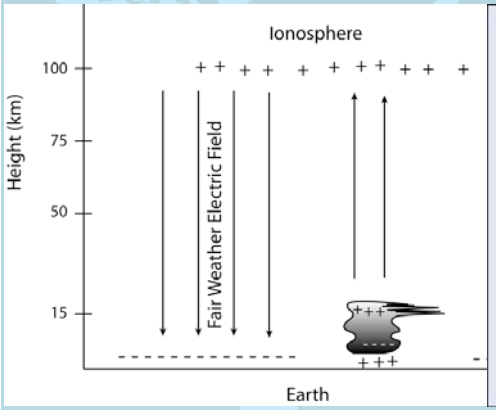
Avoid High Places

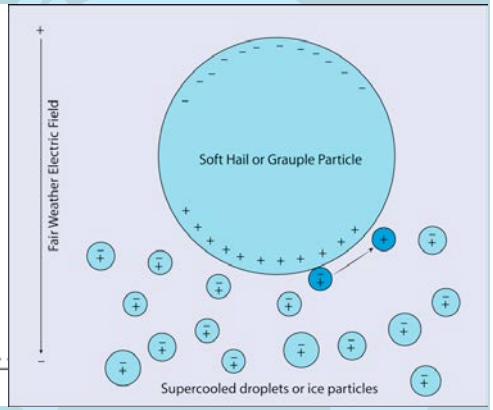
Avoid high & exposed places during thunderstorms

Lightning

Lightning is associated with bursts of rainfall.

Lightning

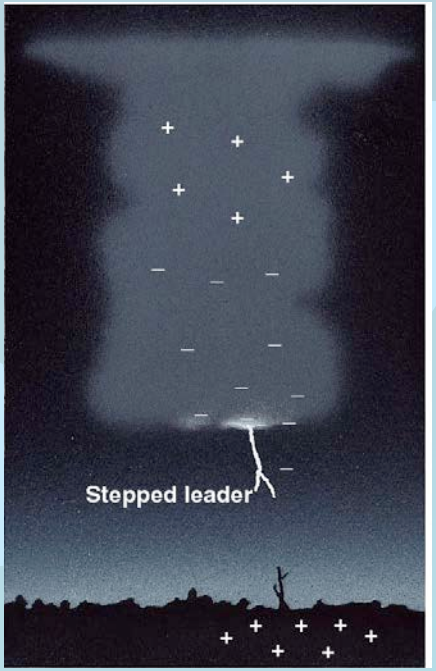




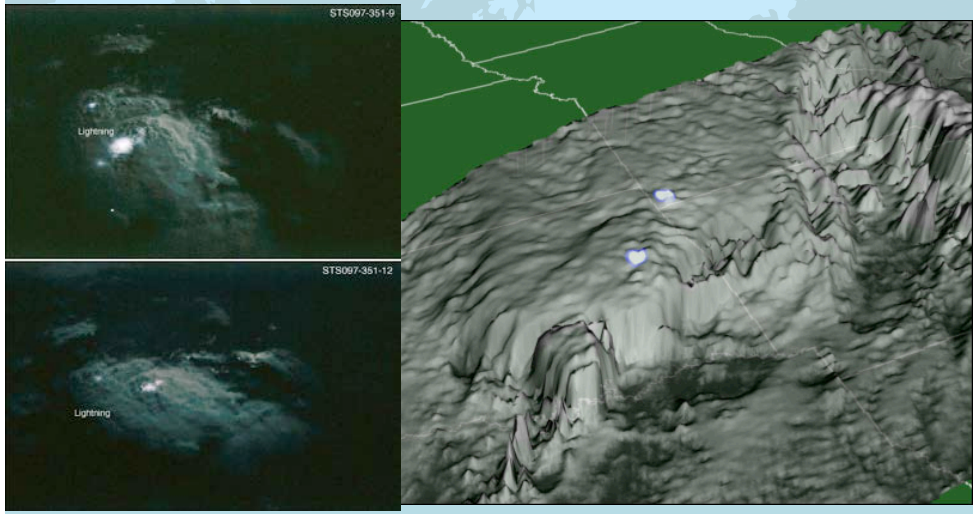
Charges are separated in the thunderstorm cloud by up and down drafts and precipitation processes in the presence of the fair-weather electric field.

Lightning

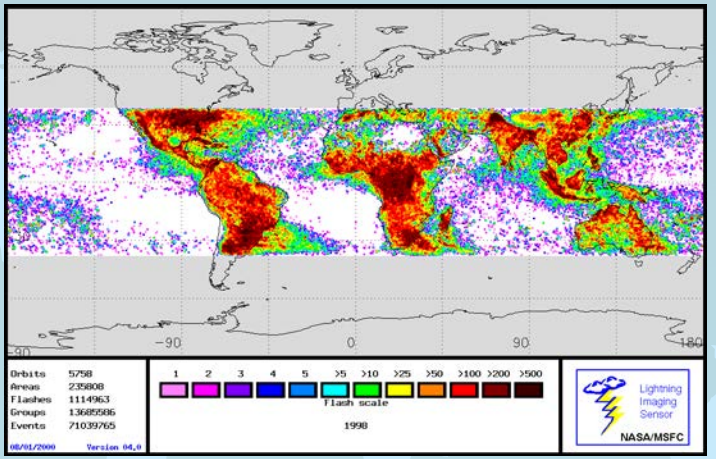
Charges are separated in the thunderstorm cloud by up and down drafts and precipitation processes in the presence of the fair-weather electric field.



Measuring Lightning from Space



Lightning from Space

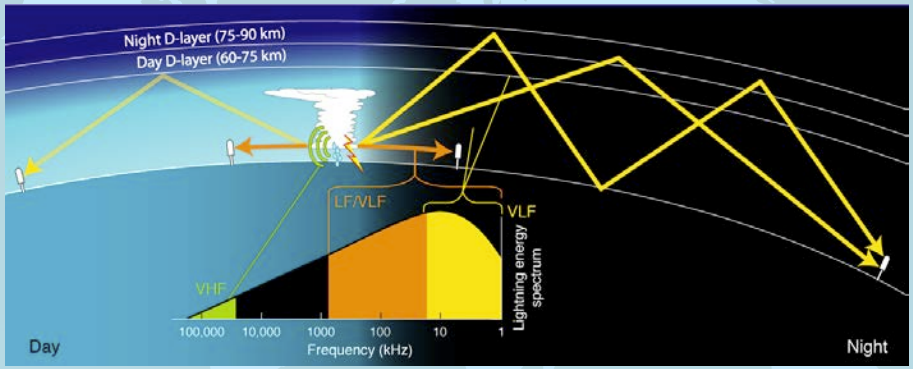


At any given moment there are more than 44,000 thunderstorms raging around the globe. The combined affect of all the lightning strikes is to bring negative charge to the ground, and positive charge to the ionosphere, resulting a charge differential and a fair-weather electric field.

Earth-Based Lightning Detection

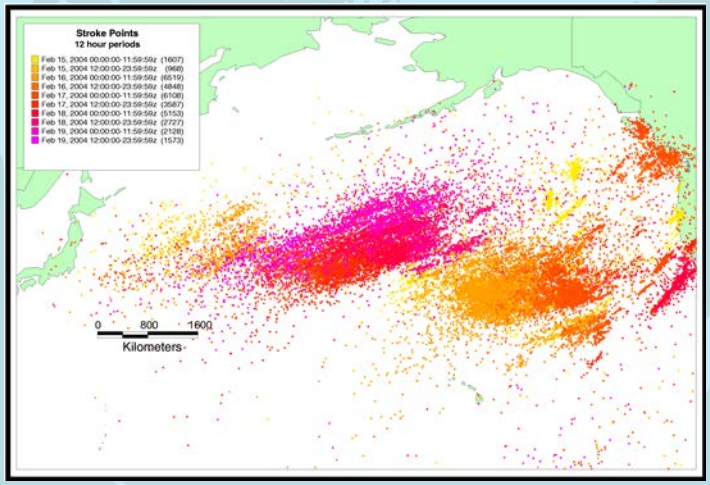
Earth-based lightning detectors observe radio noise created by lightning, which travels long distances in the wave guide between the ocean and ionosphere.

Earth-Based Lightning Detection

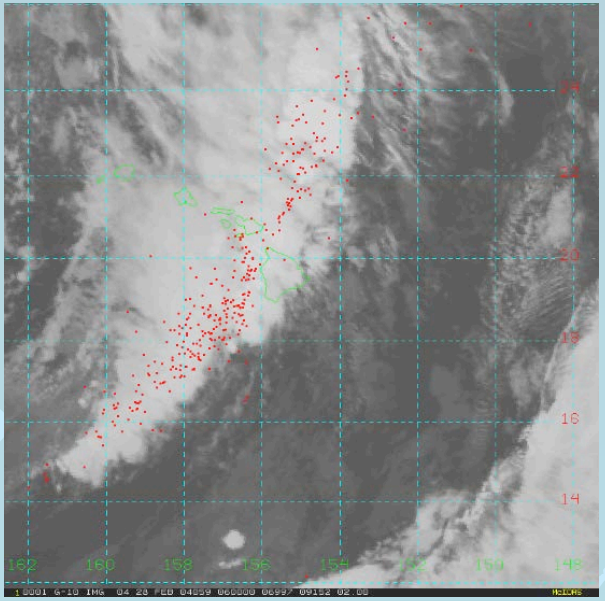


Earth-based lightning detectors observe radio noise created by lightning, which travels long distances in the wave guide between the ocean and ionosphere.

5 Days of Pacific Lightning Activity

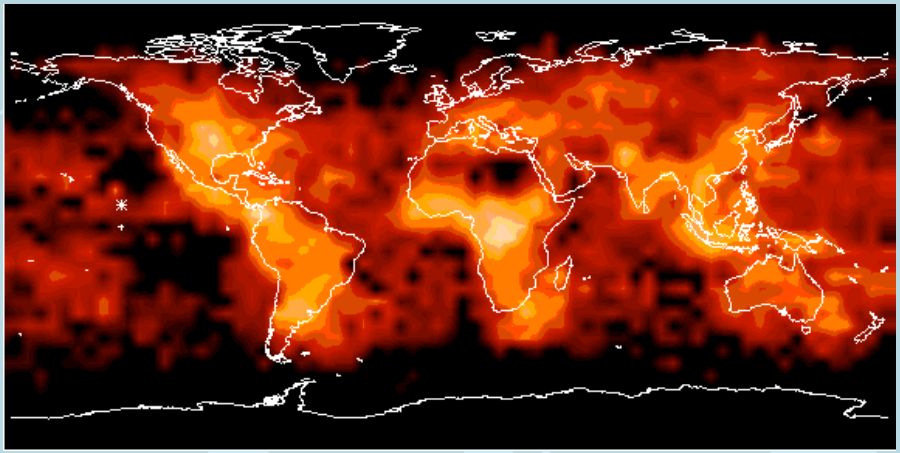


Hawaiian Squall Line



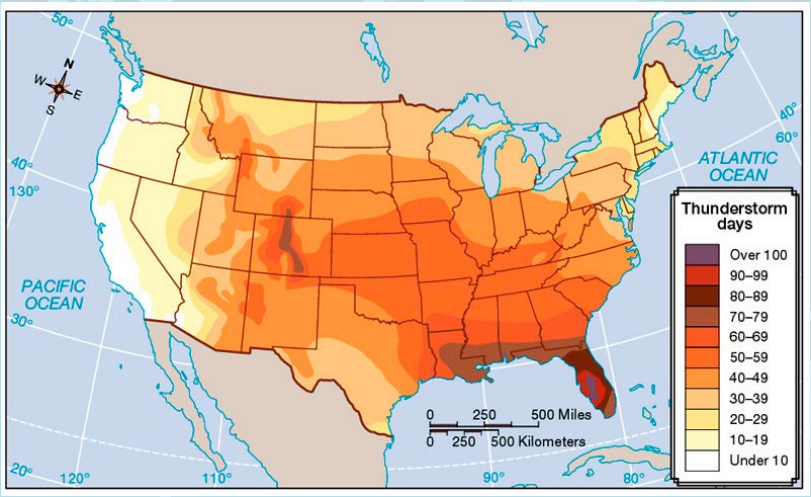
28 February 2004

Earth-Based Lightning



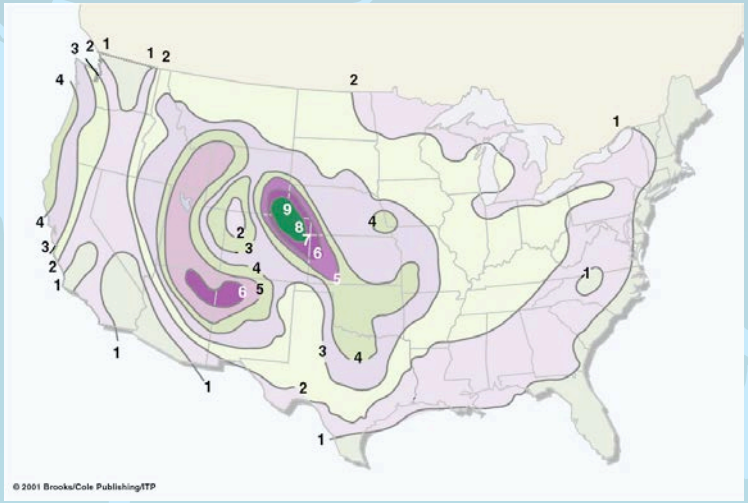
At any given moment there are more than 44,000 thunderstorms raging around the globe. The combined affect of all the lightning strikes is to bring negative charge to the ground, and positive charge to the ionosphere, resulting a charge differential and a fair-weather electric field.

Climatology of Lightning over US



Thunderstorm days per year.

Climatology of All Hail Storms

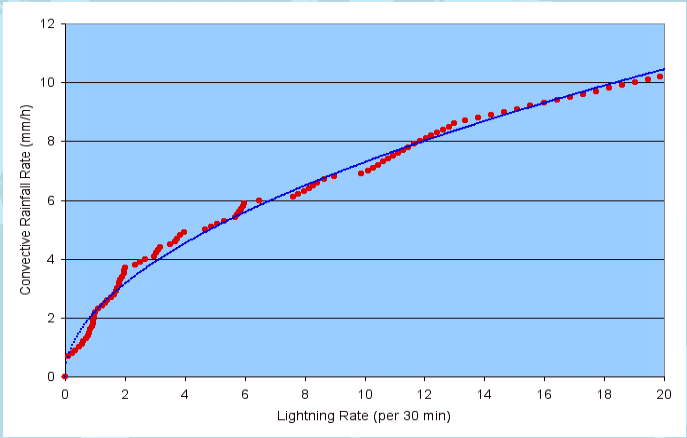


Number of days during which hail is observed each year.

Lightning

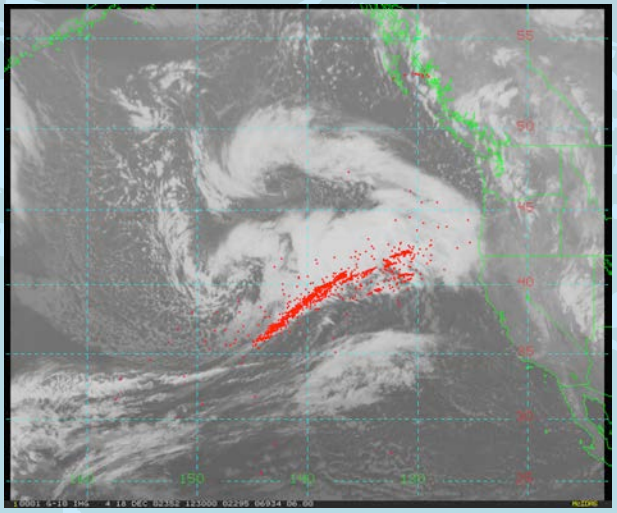
Lightning is associated with bursts of rainfall.

Lightning - Convective Rainfall Relationship



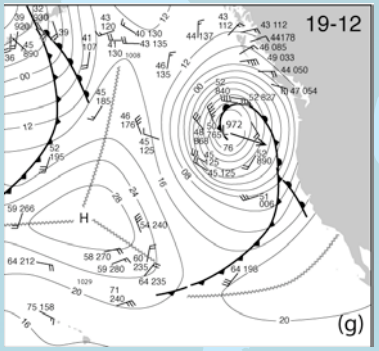
There is a relationship between lightning strikes and rainfall. Thus, the observed rate of lightning flashes seen by satellite can be input in weather prediction models as rainfall.

Midlatitude Cyclone

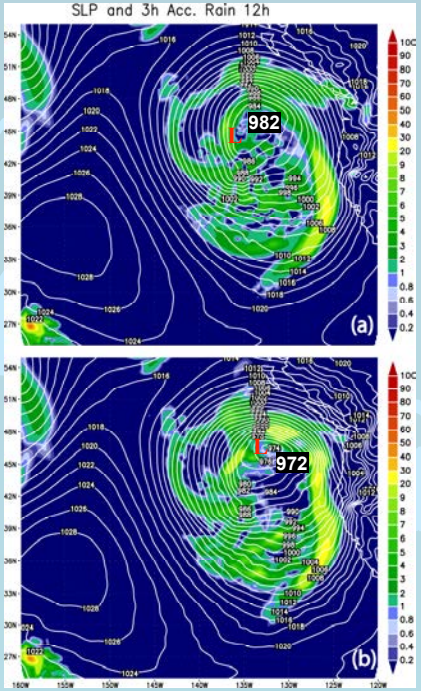


North-East Pacific Low 19 December 2002

Storm Simulations Improve When Lightning is Included



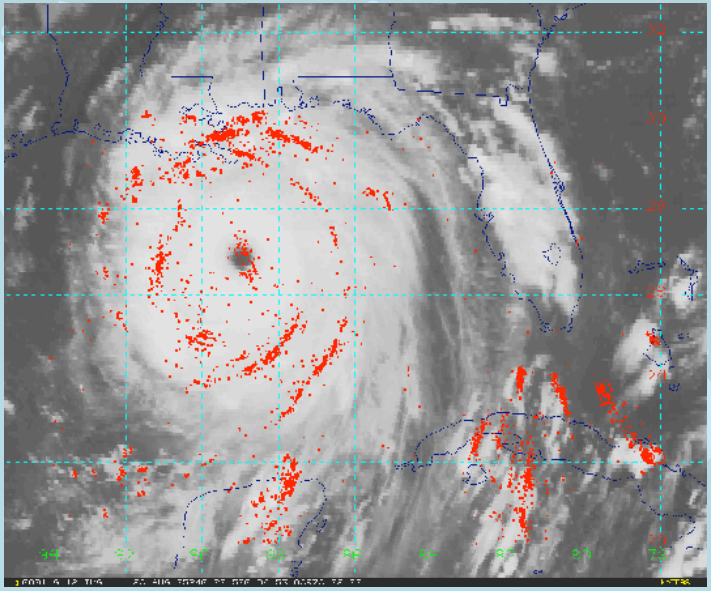
Surface analysis
Valid 1200 UTC
19 December 2002



Without lightning

With lightning

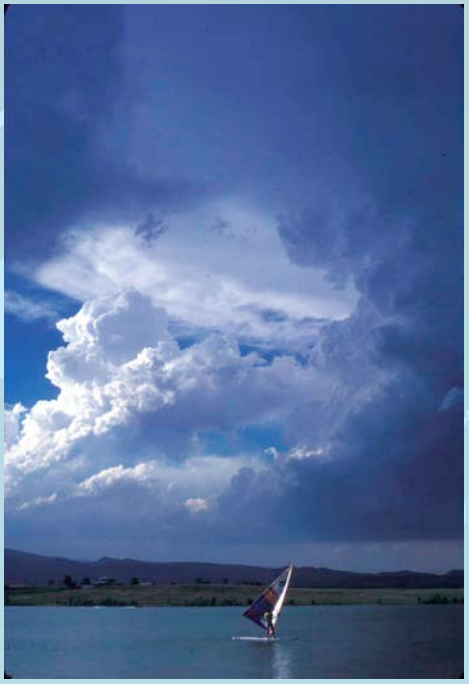
Lightning Strikes in Katrina



Questions?

- Next time severe thunderstorms and tornados.....

What stage is this storm in?



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