



MET 4994 Remote Sensing: Radar and Satellite Meteorology
MET 5994 Remote Sensing in Meteorology

**Lecture 21: Satellite Imagery Interpretation:
Identifying Clouds**

Basic Cloud Types

- **High clouds (Family A)** — composed of small ice crystals: Cirrus (Ci), Cirrostratus (Cs), Cirrocumulus (Cc), and Anvil Cirrus
- **Middle clouds (Family B)** – composed of supercooled water droplets and graupel: Altocumulus (Ac), Altostratus (As)
- **Low clouds (Family C)** – composed of water droplets: Stratocumulus (Sc), Stratus (St)
- **Low to middle with some vertical extent (Family D1)** – Cumulus (Cu), Nimbostratus (Ns)
- **Low to middle with considerable vertical extent (Family D2)** – Towering Cumulus (TCu) , Cumulonimbus (Cb)

FIU CLOUD ATLAS 2006

Names link to cloud type descriptions. Pictures link to photo galleries.

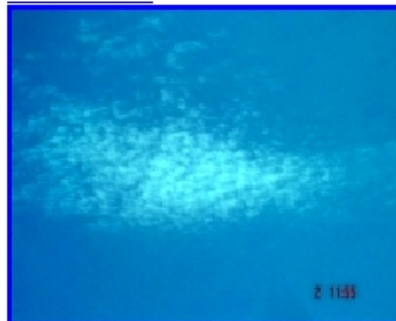
High Clouds

Cloud base:
Tropics, 6-18 km
Mid Lat, 5-13 km
Polar, 3-8 km

[Cirrostratus](#)



[Cirrocumulus](#)



[Cirrus](#)



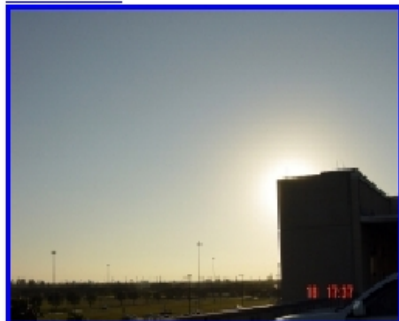
Clouds of Vertical Development
[Cumulonimbus](#)



Middle Clouds

Cloud base:
Tropics, 2-8 km
Mid Lat, 2-7 km
Polar, 2-4 km

[Altostratus](#)



[Alto cumulus](#)



[Stratus](#)



[Stratocumulus](#)



[Nimbostratus](#)



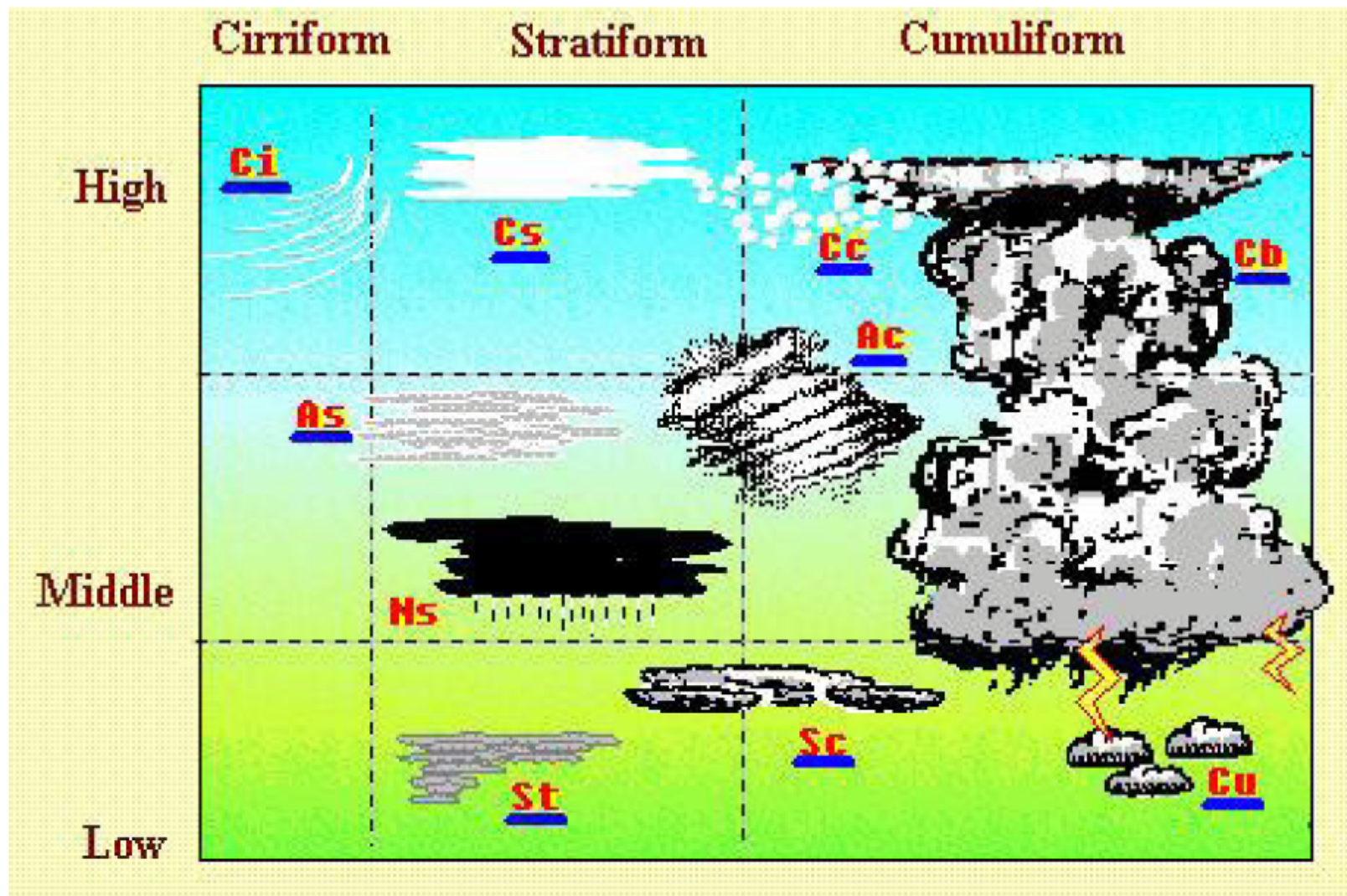
[Cumulus](#)



Low Clouds

Cloud base below
2 km in all
latitudes

Clouds on MetSat Imagery



High Clouds (Bases 5-13 km)

- **Cirrus (Ci):** thin hooks, strands, and filaments or dense tufts and sproutings.

i) Visible imagery:

- (1) Brightness normally a darker or translucent appearance, often obscuring definitions of lower features. A light gray compared to thicker clouds.
- (2) Texture fibrous with banding perpendicular to winds.

ii) IR imagery:

- (1) Brightness usually dense patches are very bright but thin cirrus is subject to considerable contamination and appears much warmer (darker gray) than the actual temperature.
- (2) Texture subject to variation due to contamination.

High Clouds (2)

- **Cirrostratus (Cs):** High/thin to dense continuous veil of stable ice crystals covering an extensive area. Commonly found on equatorial side of jet streaks.
 - Visible imagery:** generally appears white, thick, smooth, and organized when associated with cyclones. Casts shadows on surfaces below.
 - IR imagery:** appears as uniformly cold (white), often the coldest, cloud layer (except when cumulonimbus clouds are present) with small variations in gray shades. Thin cirrostratus has considerable contamination problems.

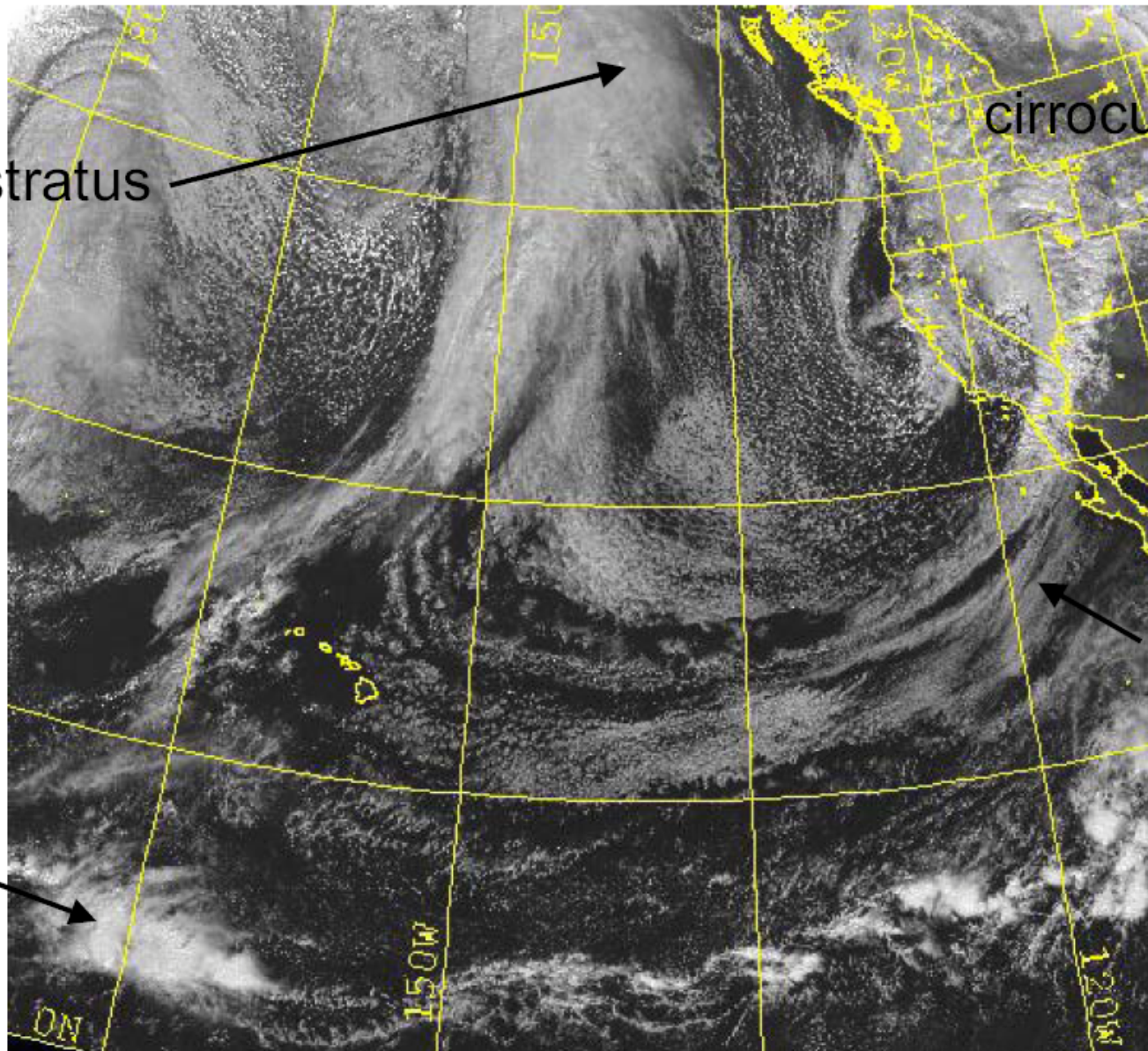
High Clouds (3)

- **Anvil Cirrus** (detached from cumulonimbus clouds) dense remains of thunderstorms, usually irregularly shaped, aligned parallel to the upper level winds. Vary in shape and especially in size from 5 to 500 km. Tends to become thin and dissipate rapidly.
 - Visible imagery** bright white but diffuse. Thick anvils may cast shadows on lower surfaces whereas thin anvils are often translucent to lower features.
 - IR imagery** bright white patches, usually coldest (whitest) cloud, except when active thunderstorms are present.

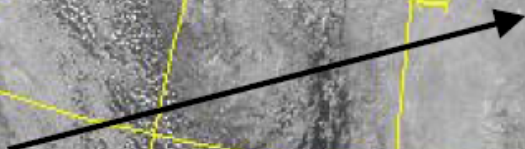
High Clouds (4)

- **Cirrocumulus (Cc)** : cumuliform ice crystal clouds formed by upward vertical motions in the upper troposphere. May precede rapidly developing cyclone.
 - Visible imagery** thin patches of clouds, gray to white, usually in advance of a cyclone. Individual elements often below the resolution of geostationary sensors.
 - IR imagery** similar to cirrostratus, white to gray clouds subject to contamination.

High Clouds



cirrostratus



cirrocumulus ???

cirrus bands

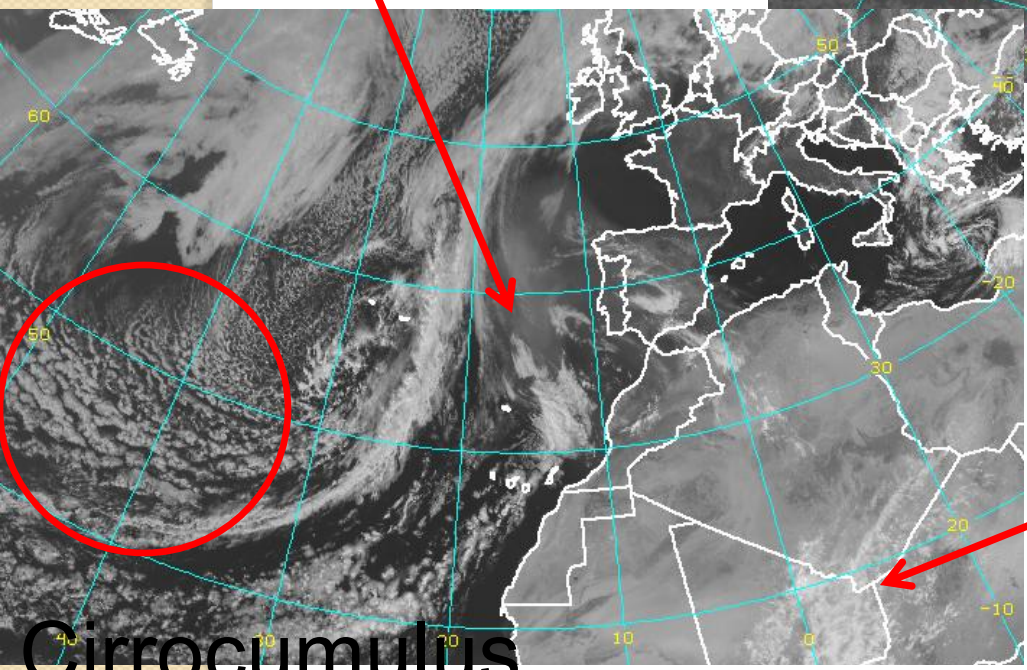
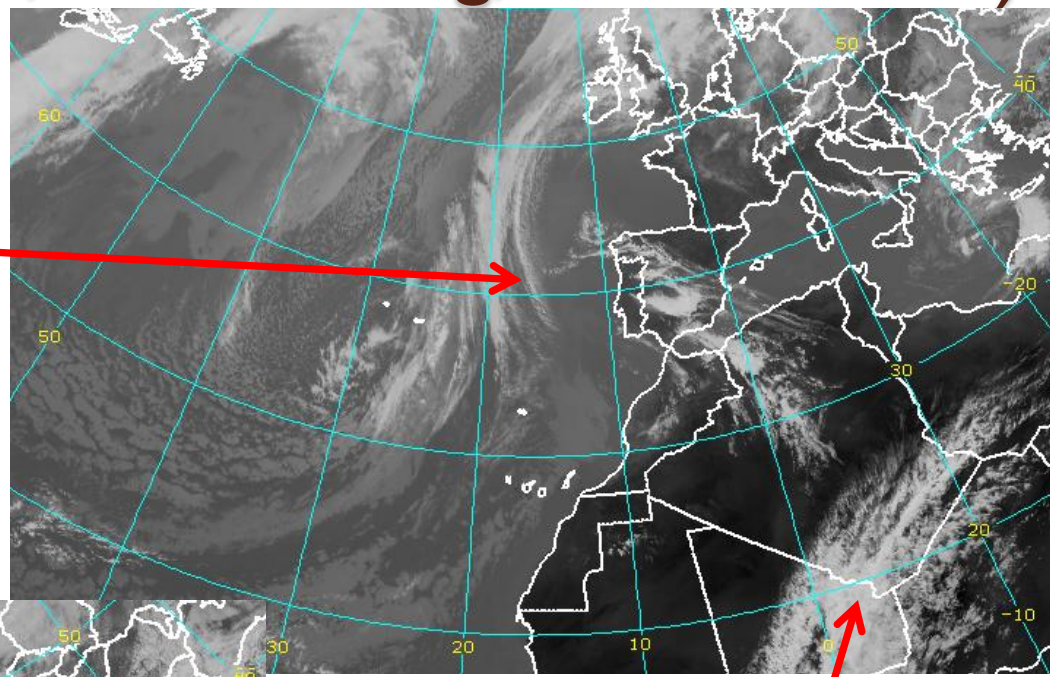


anvil cirrus



Guess? (12:00UTC, this morning, METEOSAT-9)

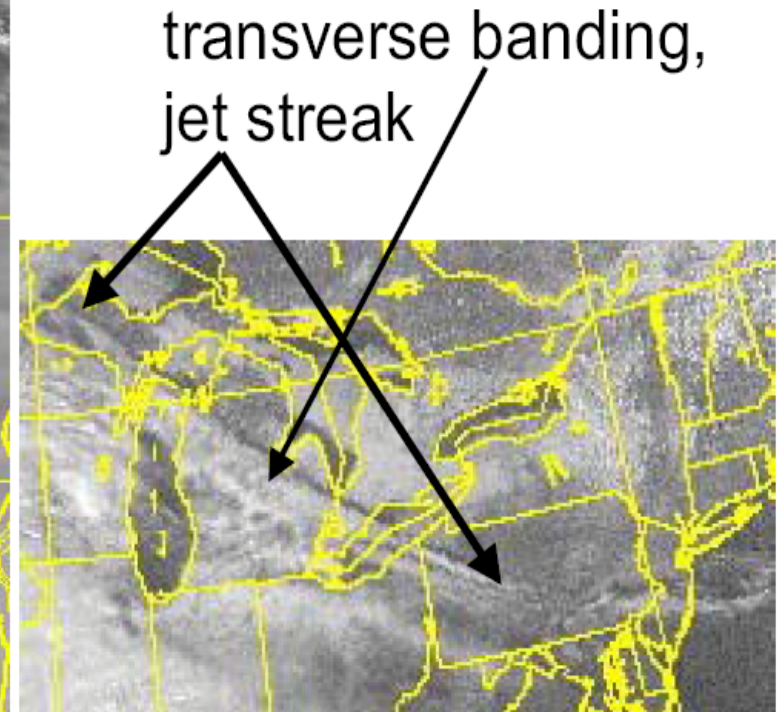
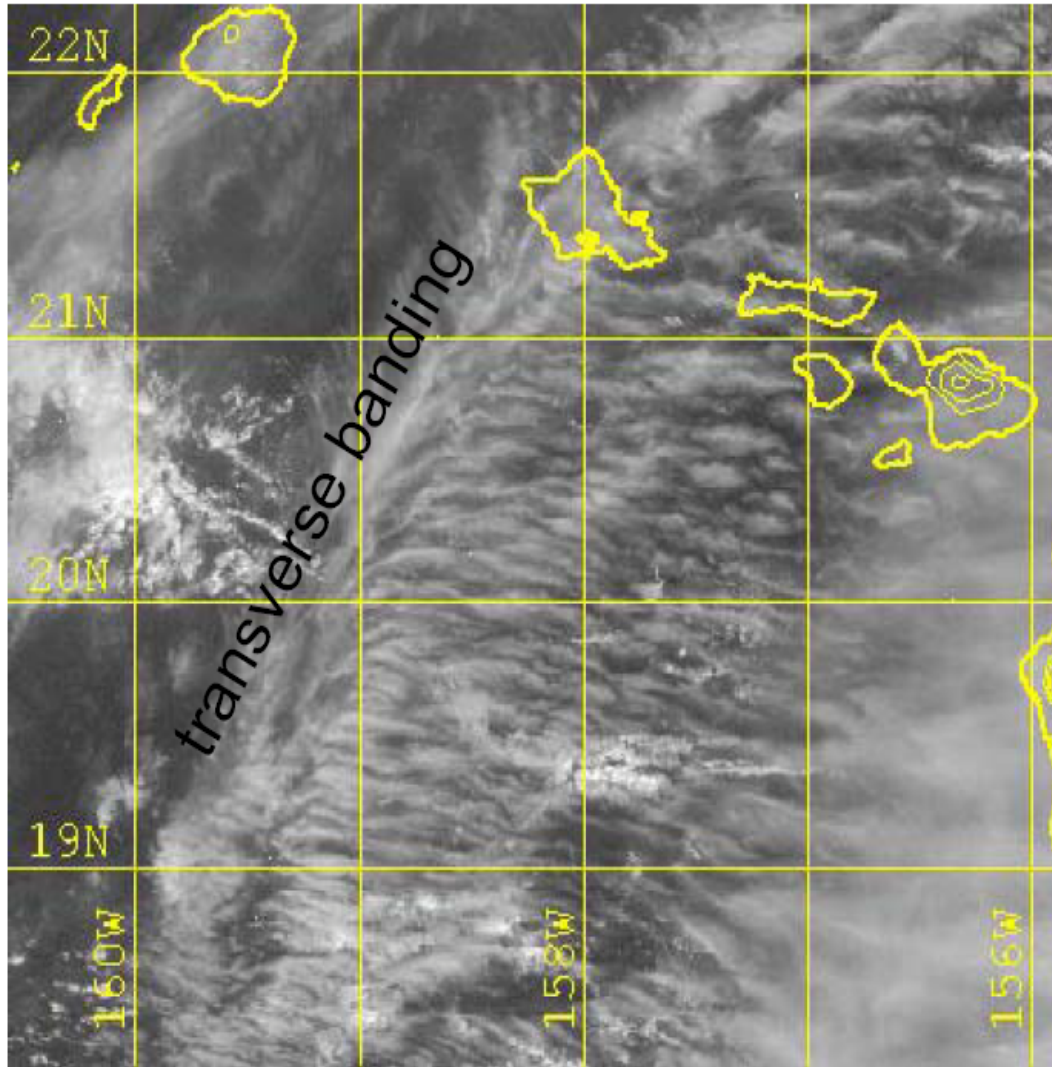
Cirrus



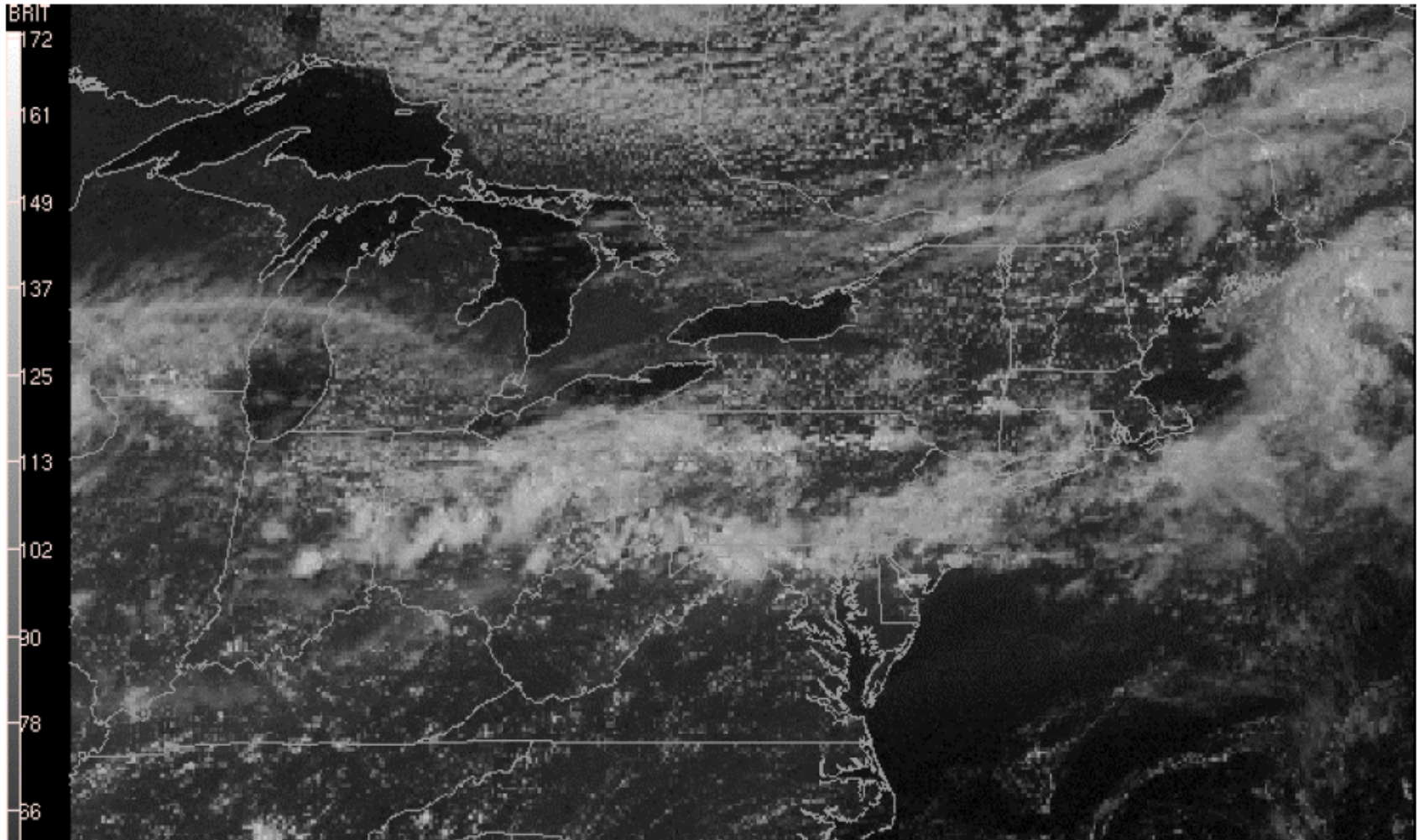
Cirrostratus

Cirrocumulus

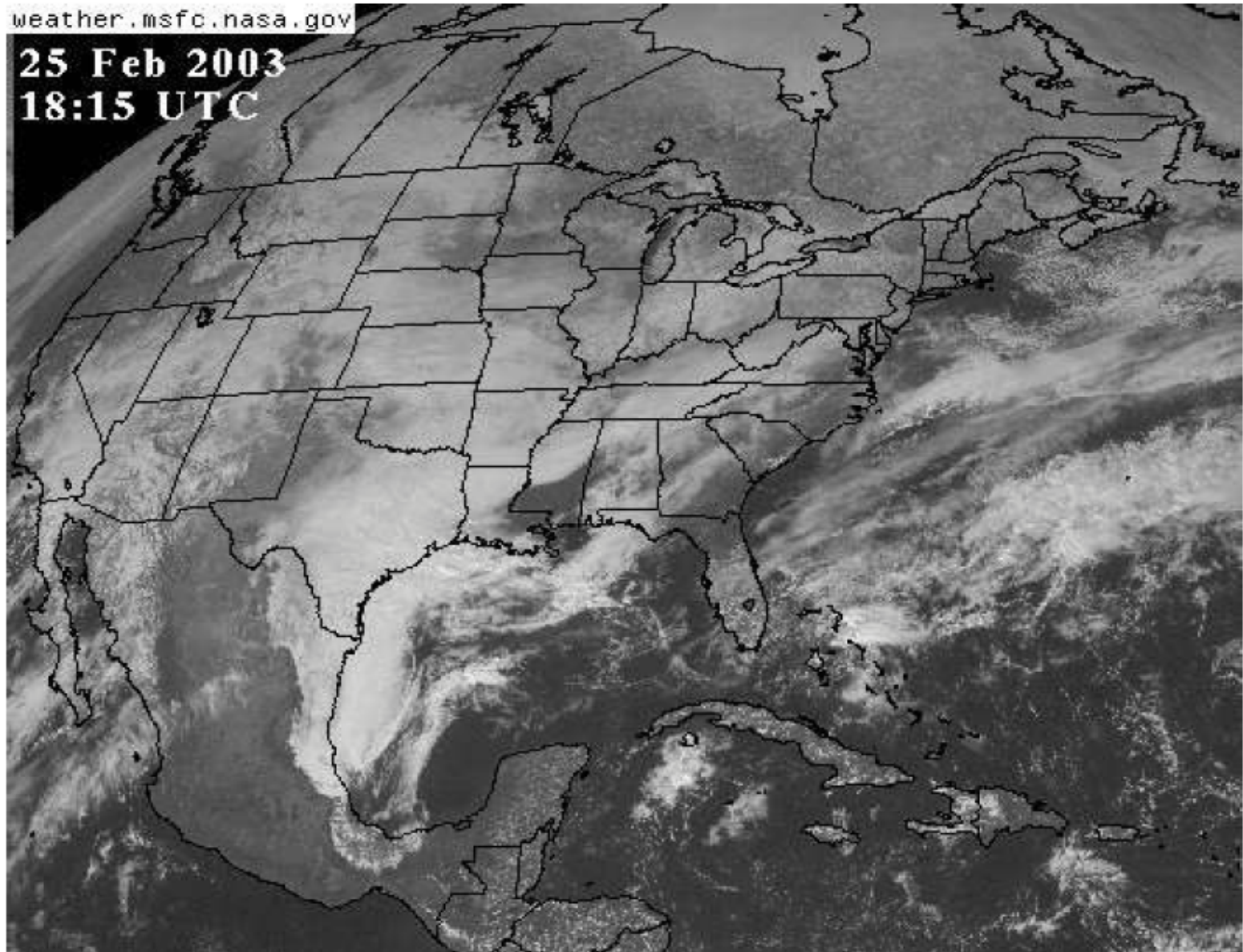
Jets and Cirrus Clouds



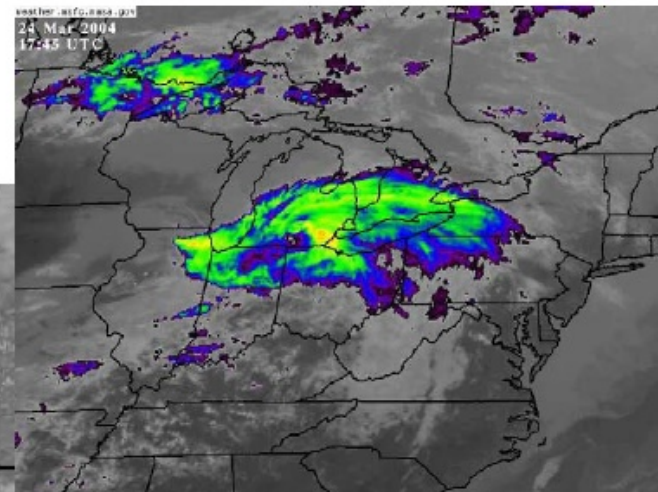
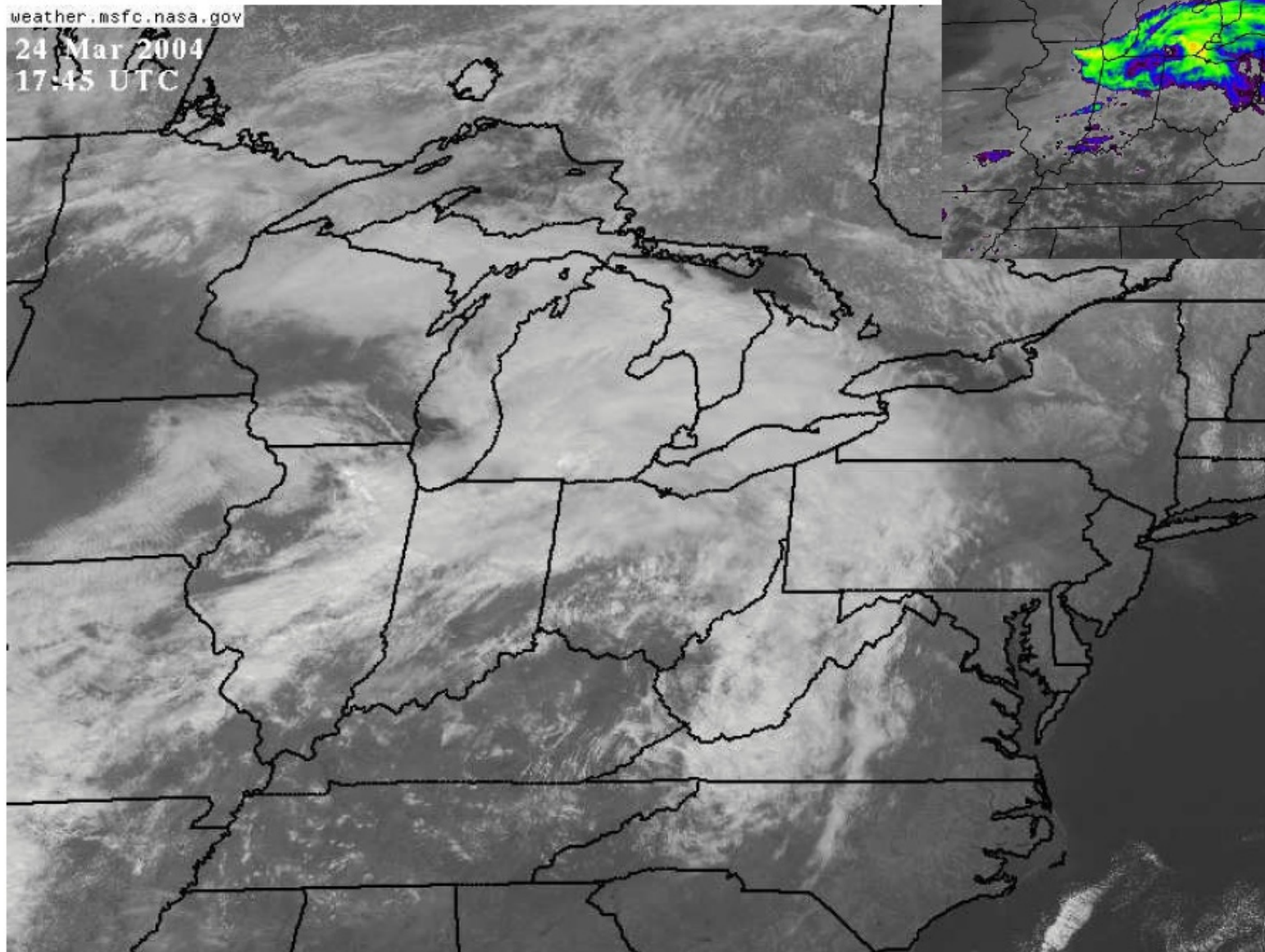
Find the Jet



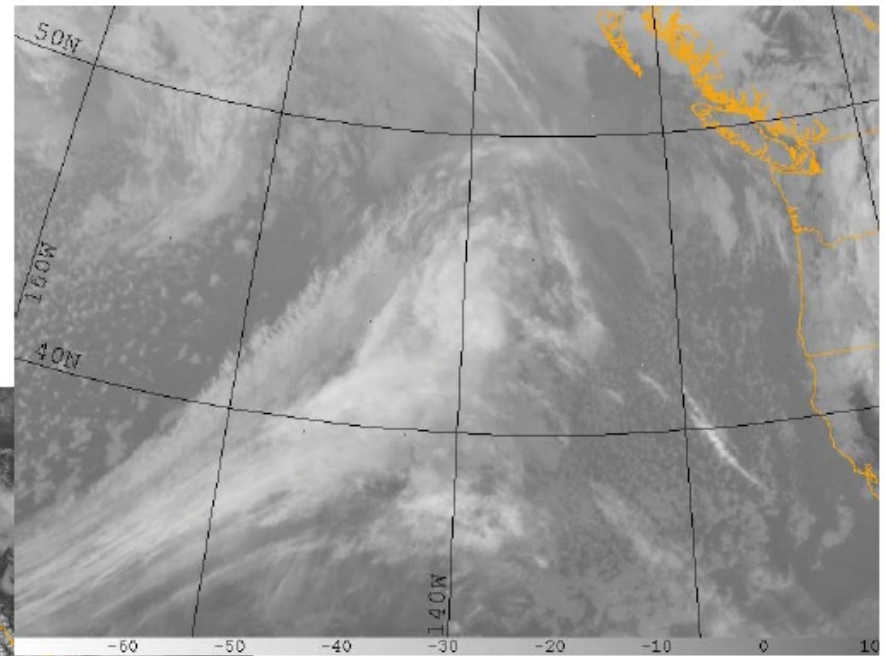
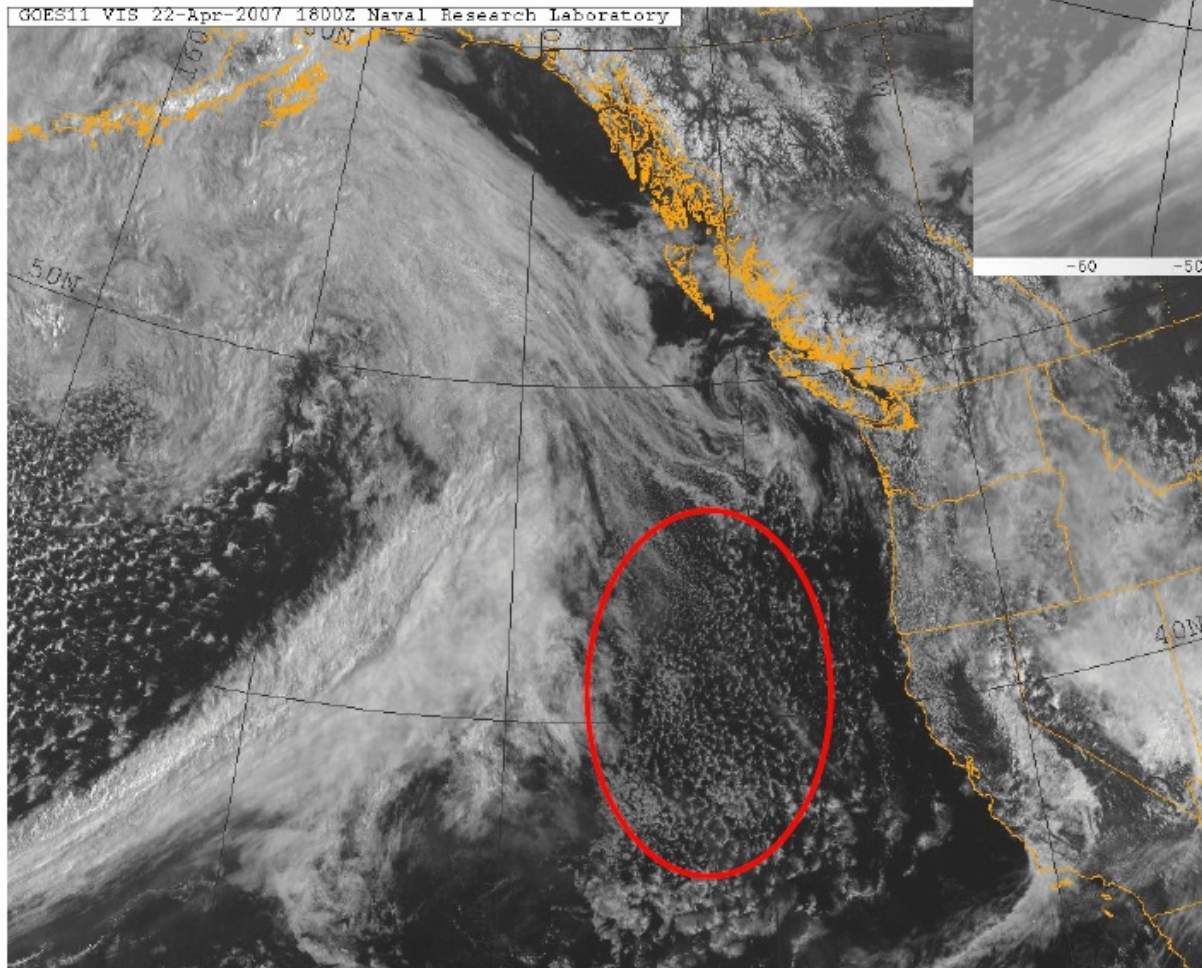
Find the Jet



Cirrostratus



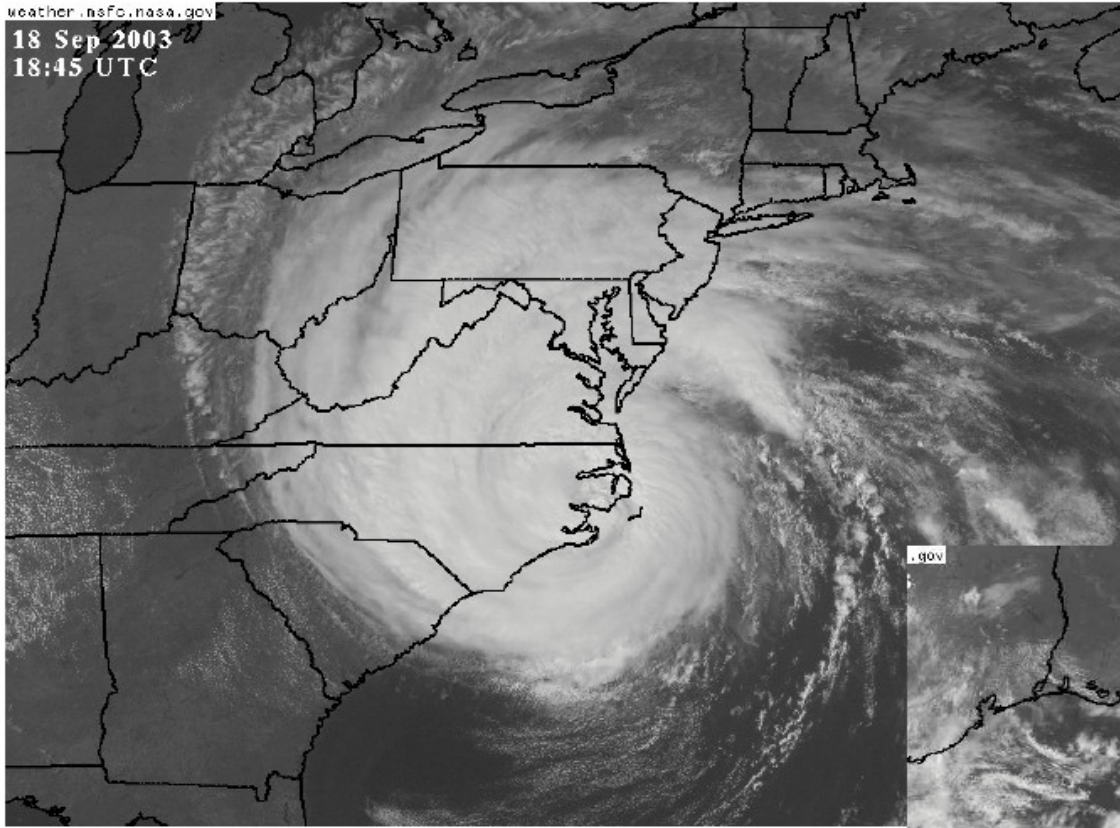
Cirrocumulus



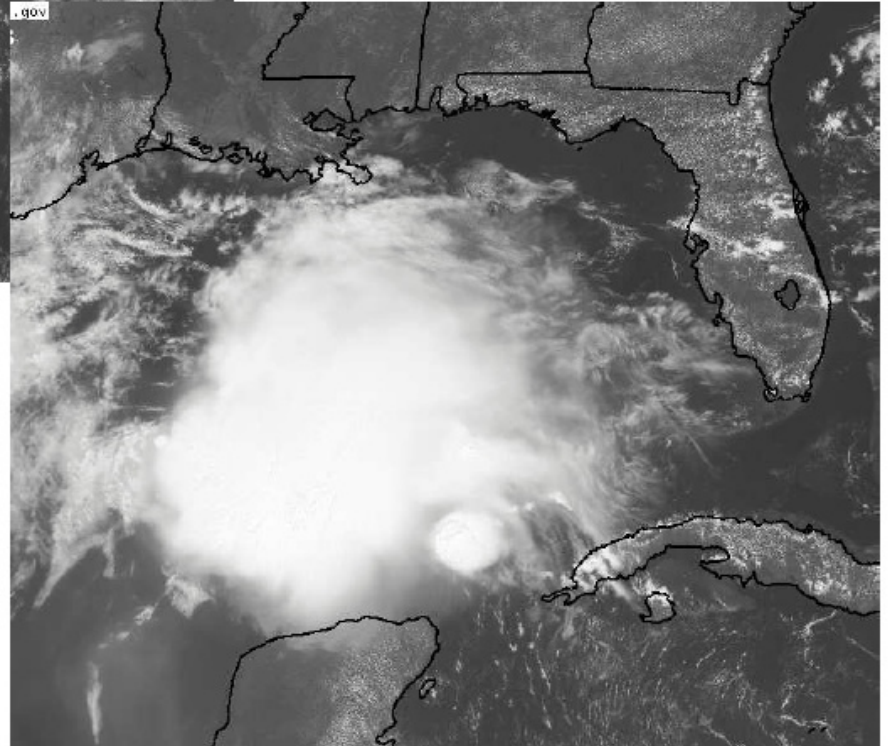
The oval indicates where cirrocumulus *may* be found.

It can be difficult to distinguish between low and high clouds here due to contamination of thin high clouds on IR and attenuation due to thick low clouds on Vis.

18 Sep 2003
18:45 UTC



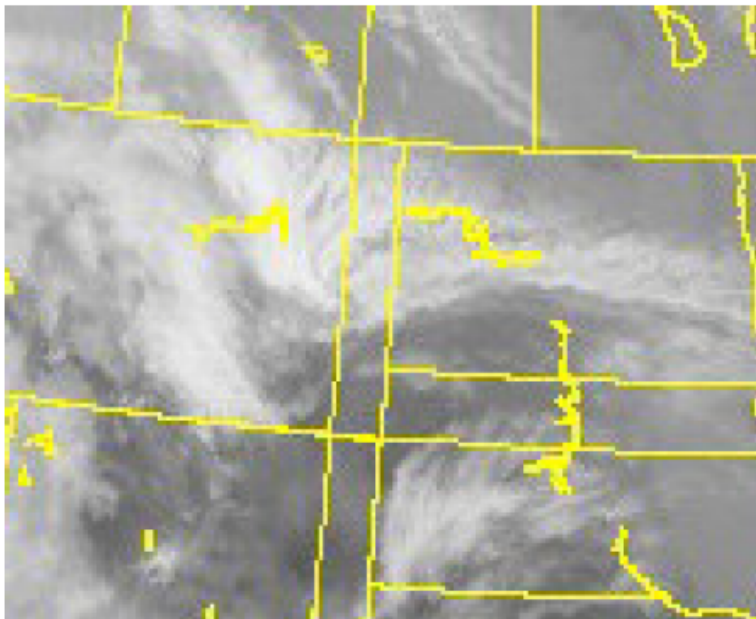
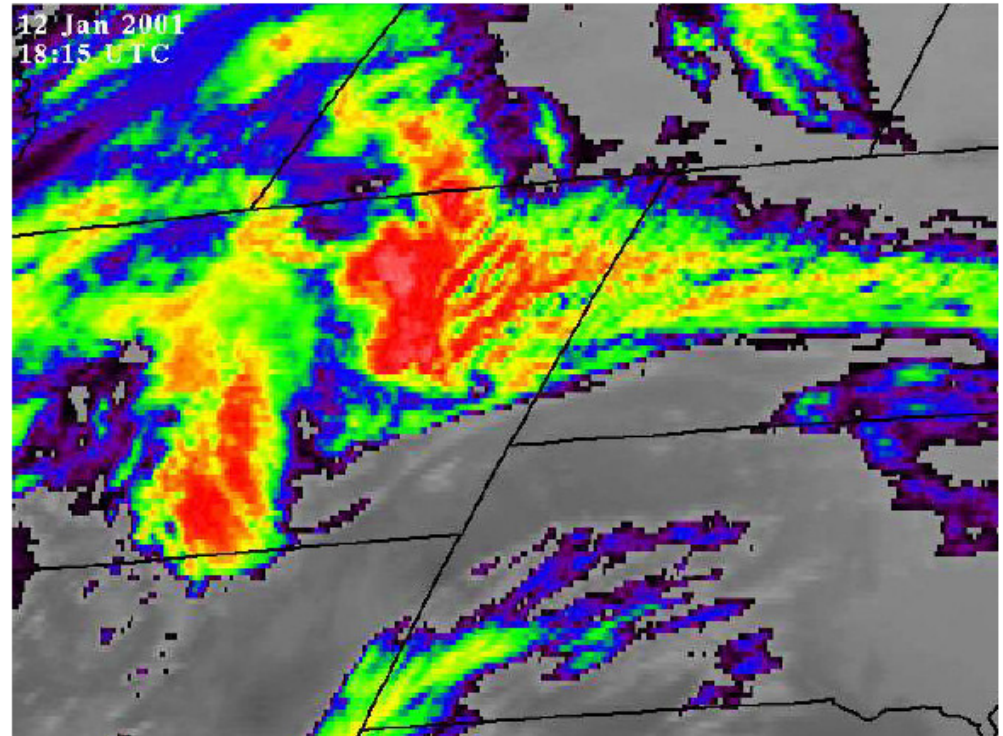
Anvil Cirrus



Top: Hurricane Isabel

Right: Gulf of Mexico
mesoscale convective system

Using IR Enhancements

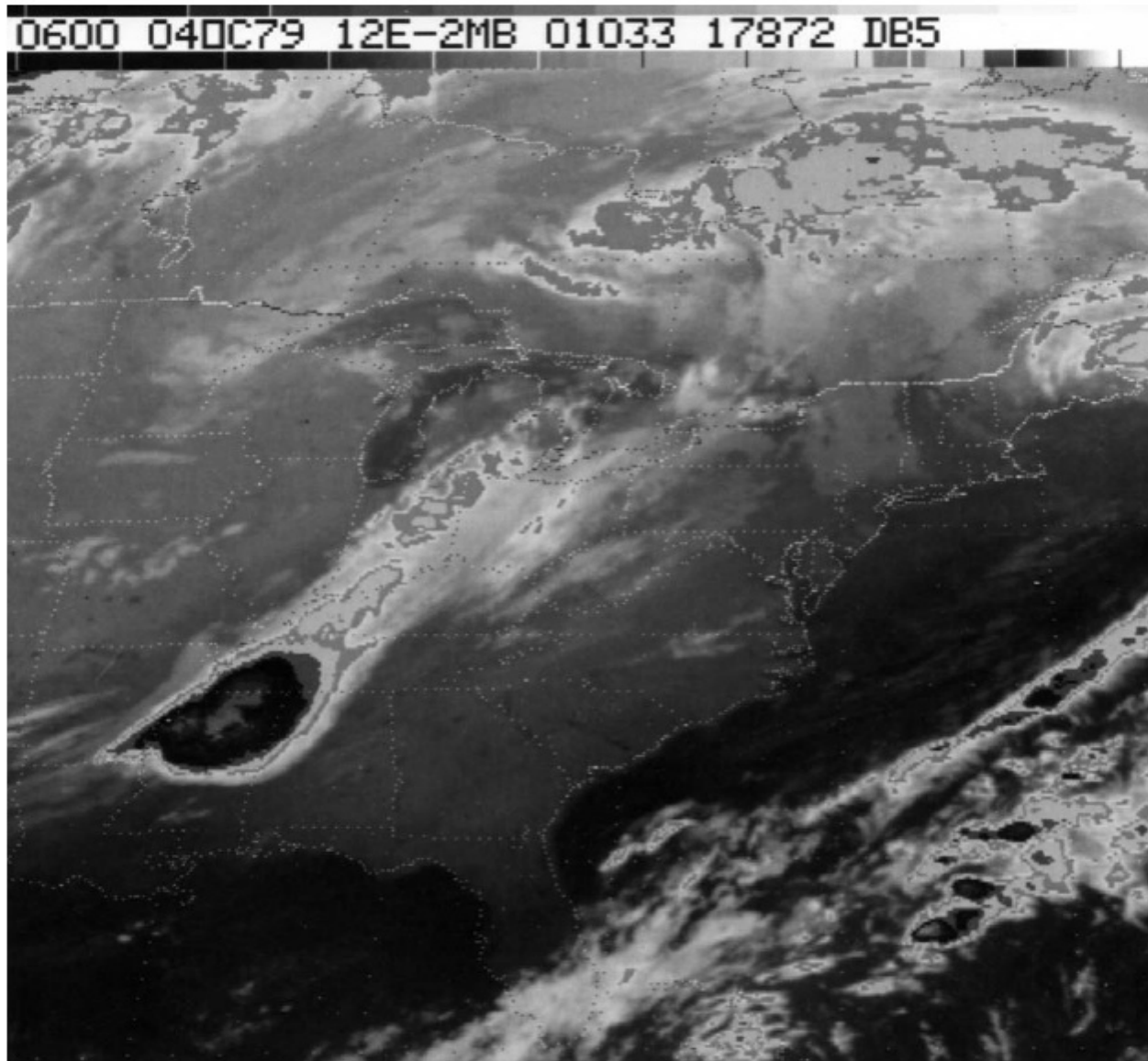


Cloud free,
very warm
surface
temperatures

Weak,
warm cloud
tops, low
altitude

Intense,
cold cloud
tops, high
altitude

Old Style B&W Enhancement



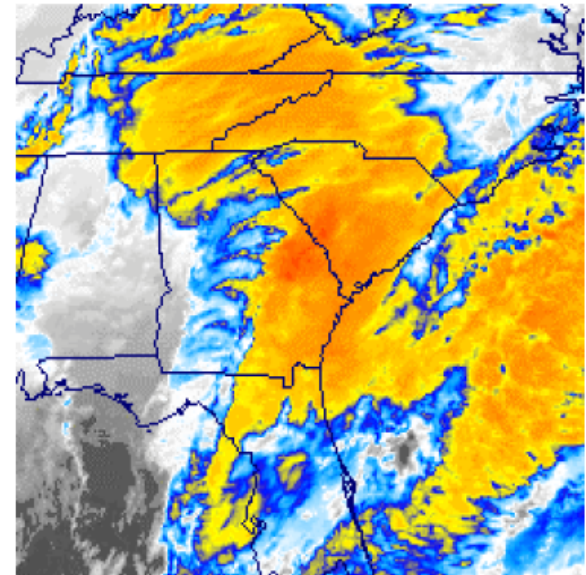
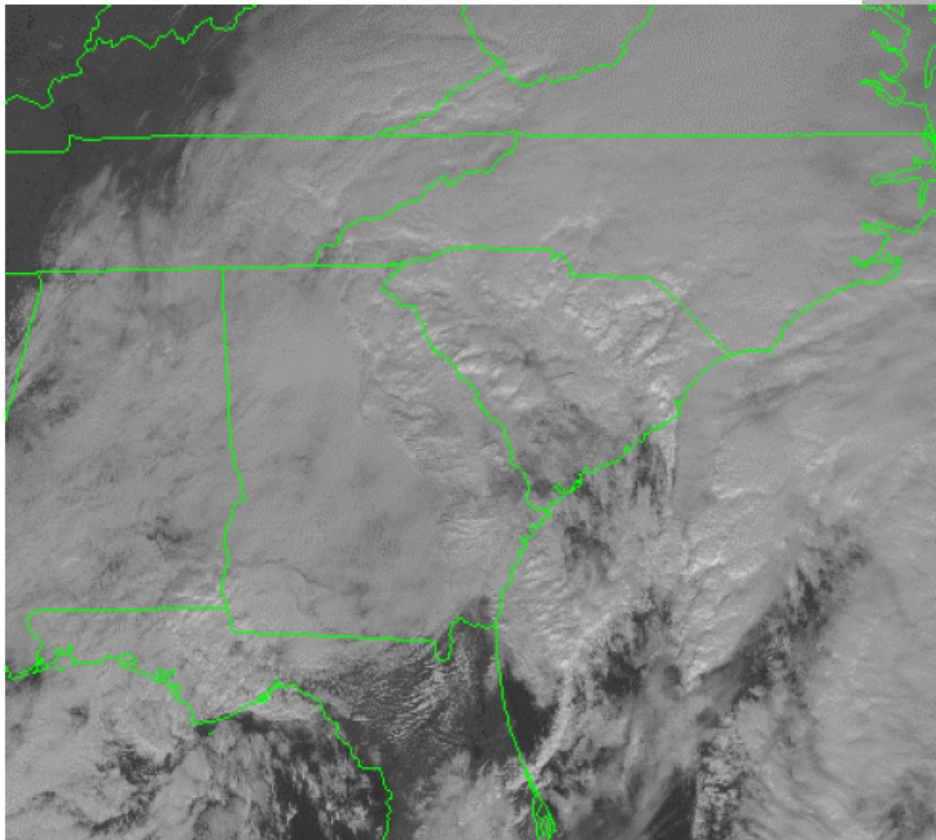
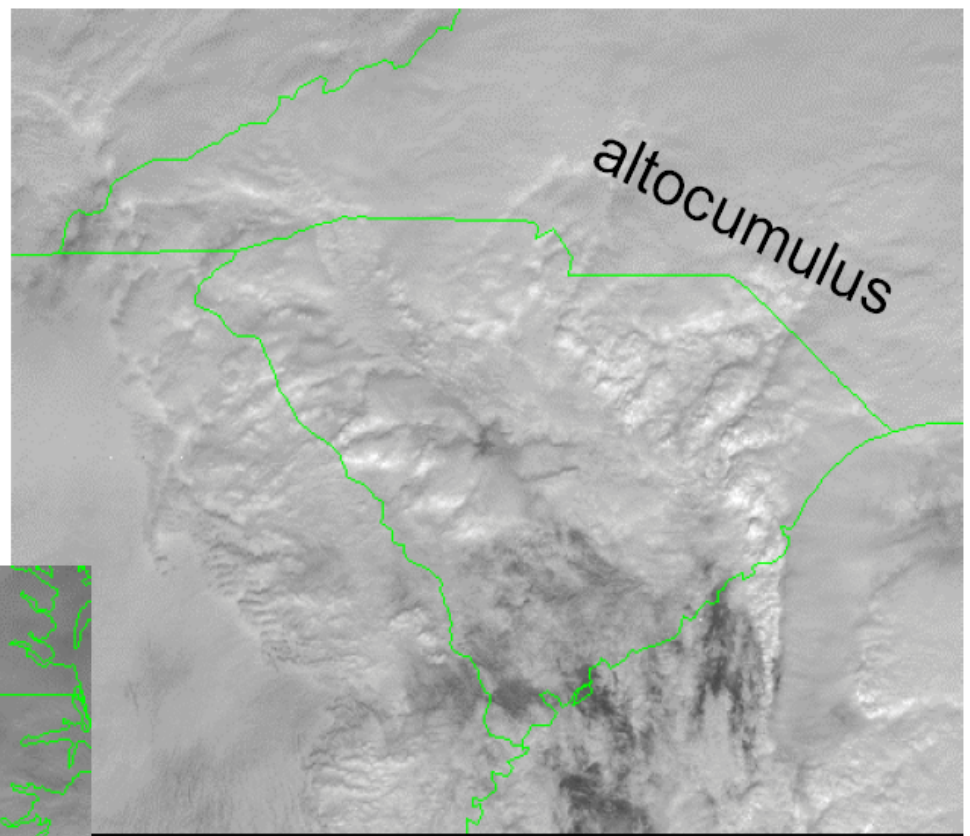
Middle Clouds (Bases 2-7 km)

- **Alto cumulus (Ac)** indicates vertical motion and moisture in the mid-troposphere. Usually accompanies large, organized synoptic scale cyclones, minor upper tropospheric waves, and tropical waves. For well-developed systems, sometimes masked by extensive cirrus.
 - Visible imagery** Bright white, textured, or lumpy, and very difficult to distinguish from stratocumulus.
 - IR imagery** Colder (lighter gray) than stratocumulus but warmer (darker gray) than high clouds. Must be compared to other clouds in the area.

Middle Clouds (2)

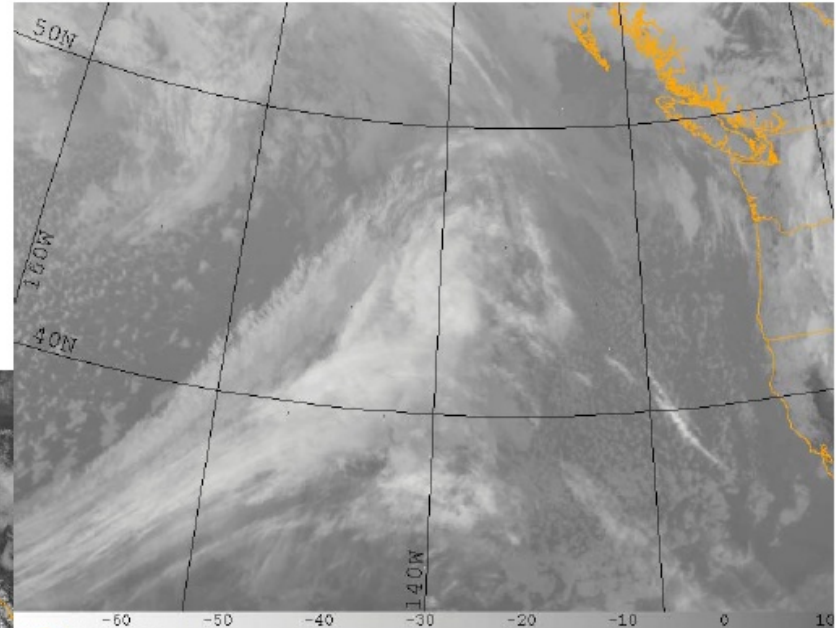
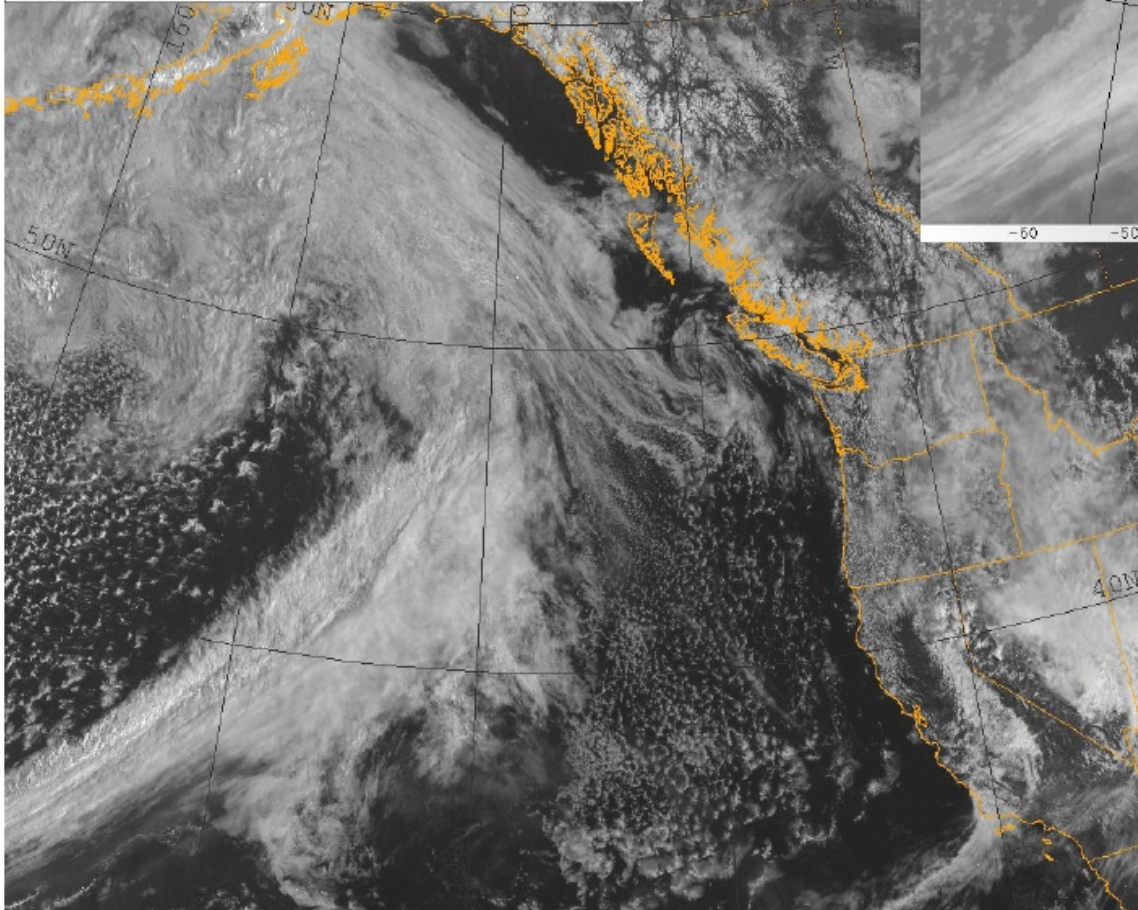
- **Altostratus (As)/Nimbostratus (Ns):** stratiform cloud in mid levels. Normally found in extensive sheets with cyclones.
 - Visible imagery** Bright white, extensive sheet. May be difficult to distinguish from low or high stratiform clouds. Often textured, unlike cirrostratus, but uniform. May cast shadows, unlike stratus.
 - IR imagery** nearly uniform gray shade indicating the middle temperature ranges. Usually distinguishable by comparison with other cloud layers, warmer (grayer) than cirrus, colder (brighter) than stratus.

Middle Clouds



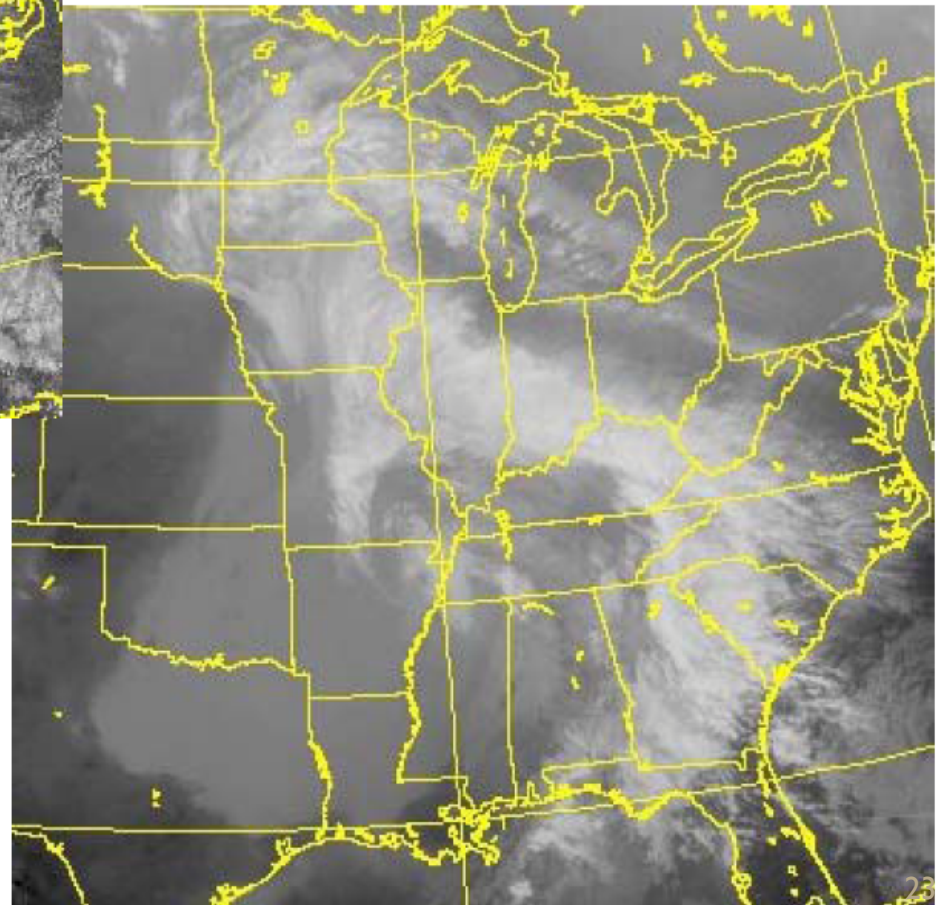
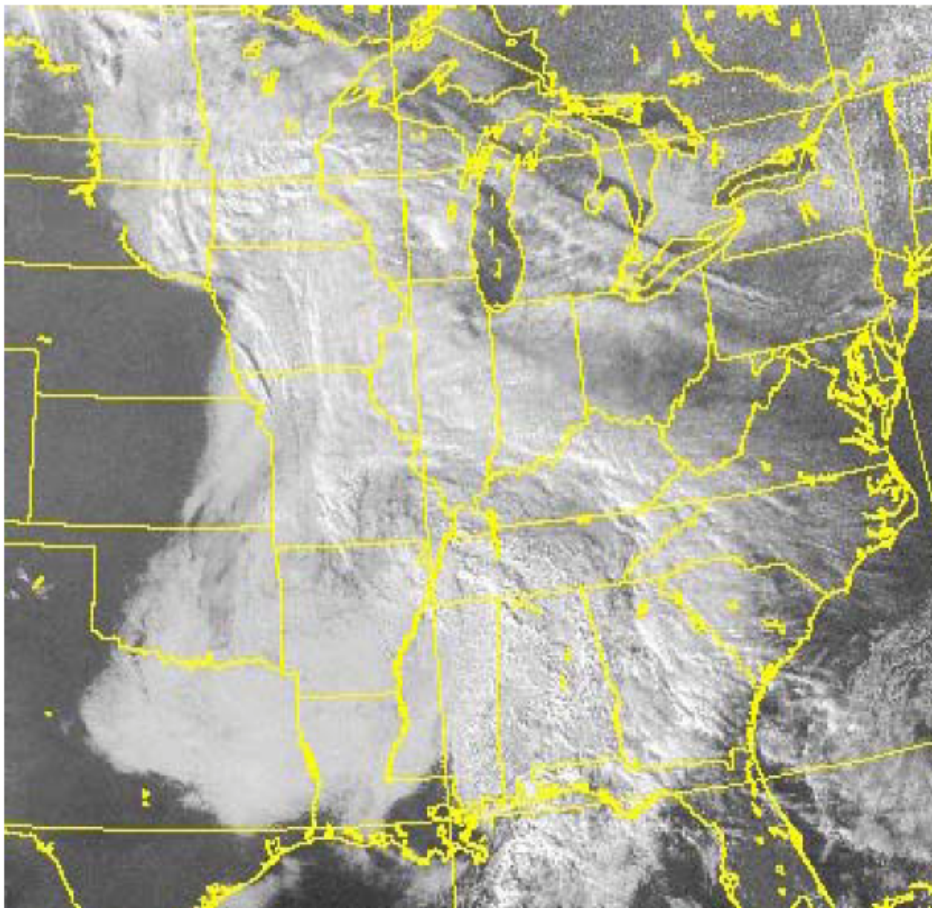
Find the Middle Clouds

GOES11 VIS 22-Apr-2007 1800Z Naval Research Laboratory



Use the configuration of the storm and the combination of texture (vis) and temperature (IR) to find the most likely place for middle clouds.

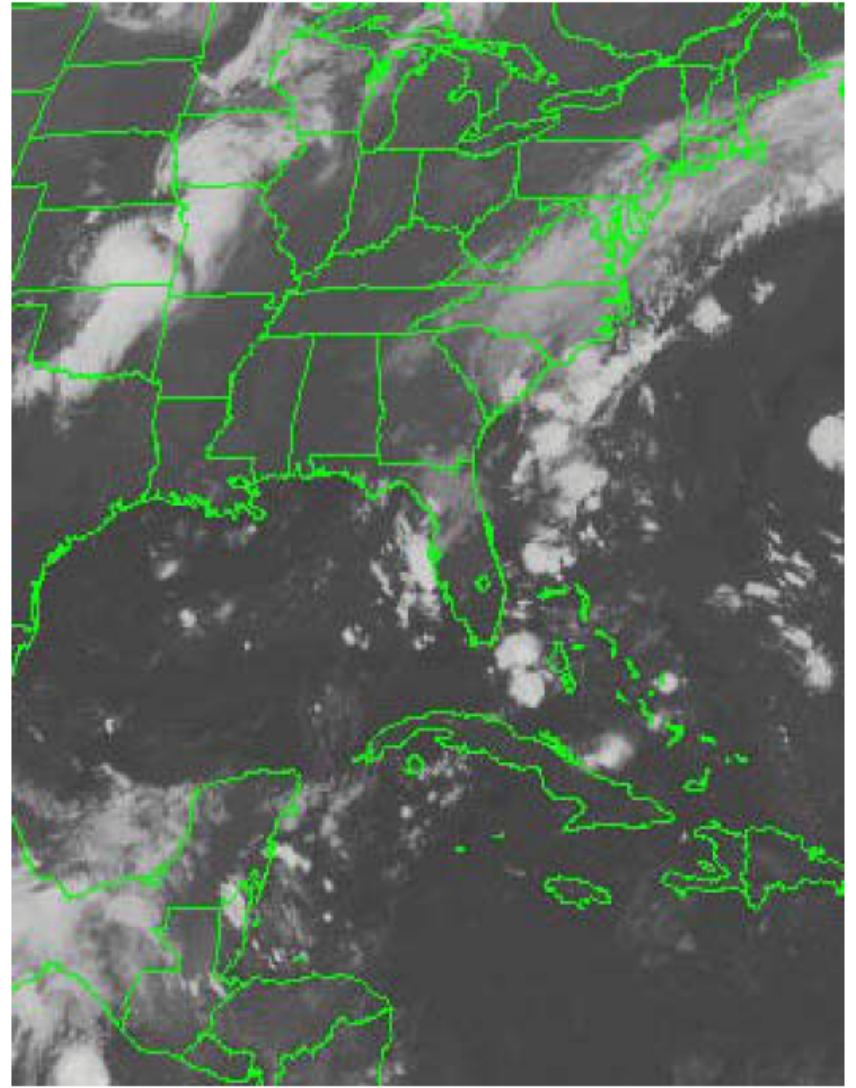
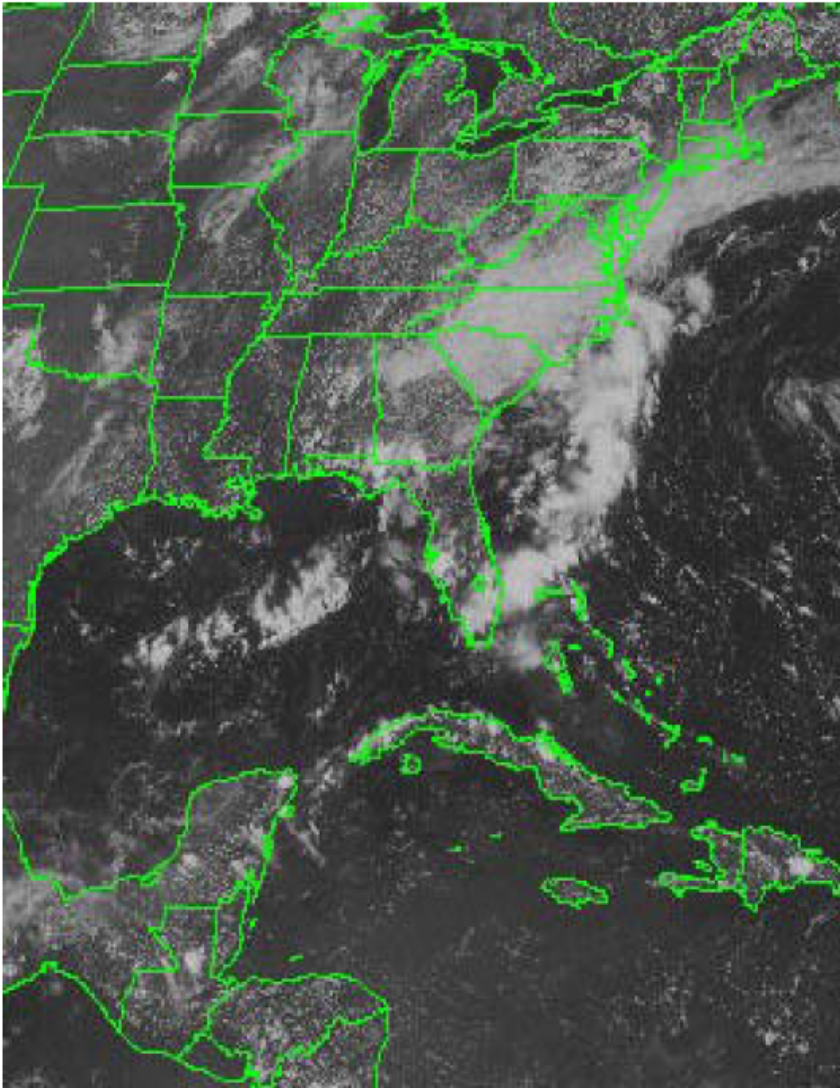
More Middle Clouds



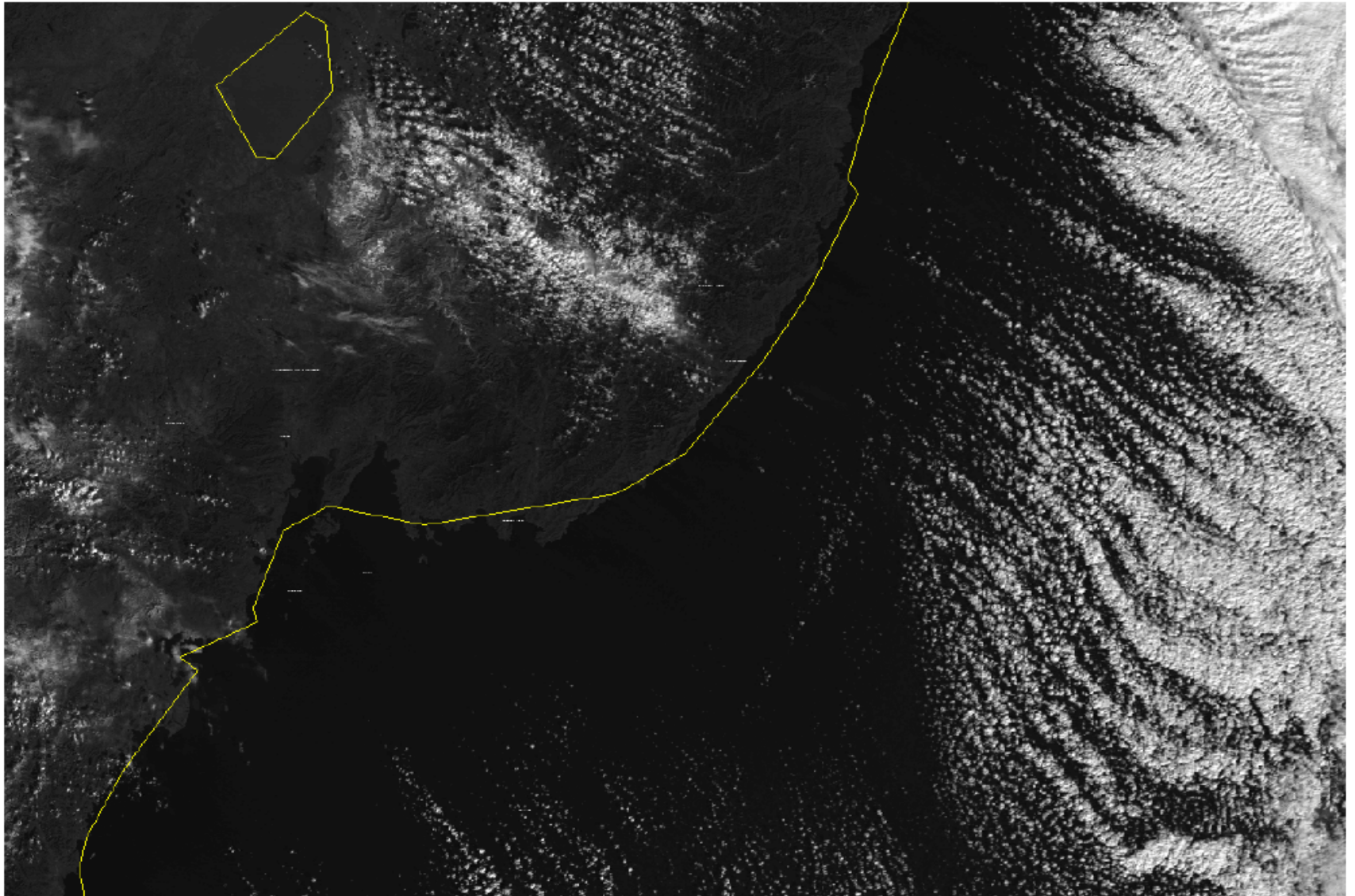
Low Clouds (Bases below 2 km)

- **Cumulus (Cu):** similar to detached cauliflower-like clouds with sharp outlines. Often, a region of unorganized cumulus (“popcorn”) forms over landmasses during fair weather. Cumulus clusters whose edges are clearly visible are referred to as “open cell” cumuli.
 - Visible imagery** scattered individual elements are often below the resolution of geostationary sensors and appear as gray areas due to contamination. Large individual elements and groups of broken cumulus appear as bright white blobs of clouds.
 - IR imagery** only large areas show due to contamination, appearing as dark gray blobs.

Low Clouds: Cumulus



Cumulus Cloud Streets



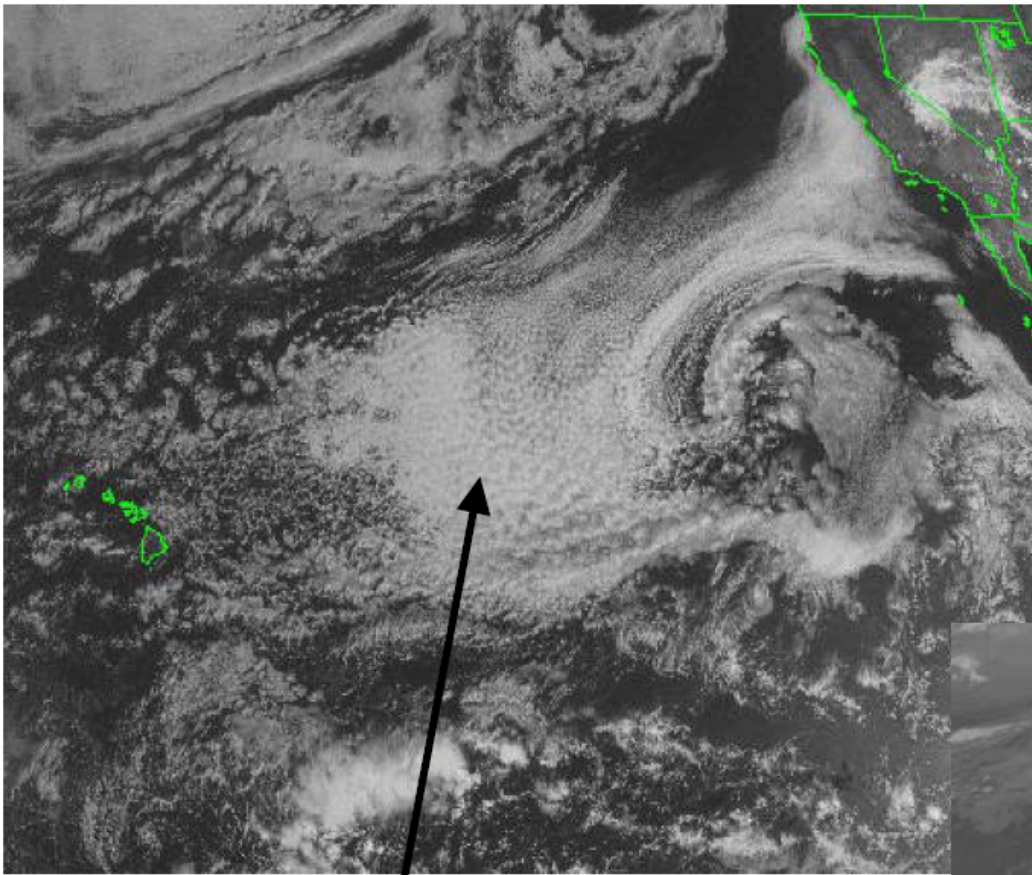
Low Clouds (2)

- **Stratocumulus (Sc)** formed by the spreading of cumulus or convective development of stratus.

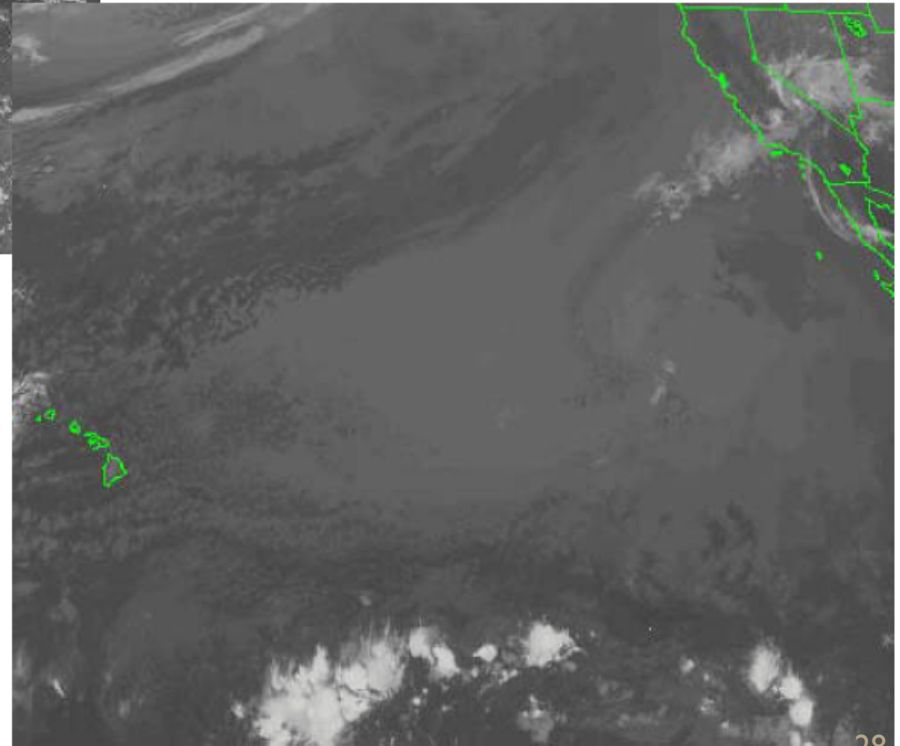
i) Visible imagery light gray to white, appearing in cloud lines or sheets composed of parallel rolls. Textures are noticeable.

ii) IR imagery Dark gray, often difficult to distinguish from the surface due to contamination. Cellular or textured nature often not observed.

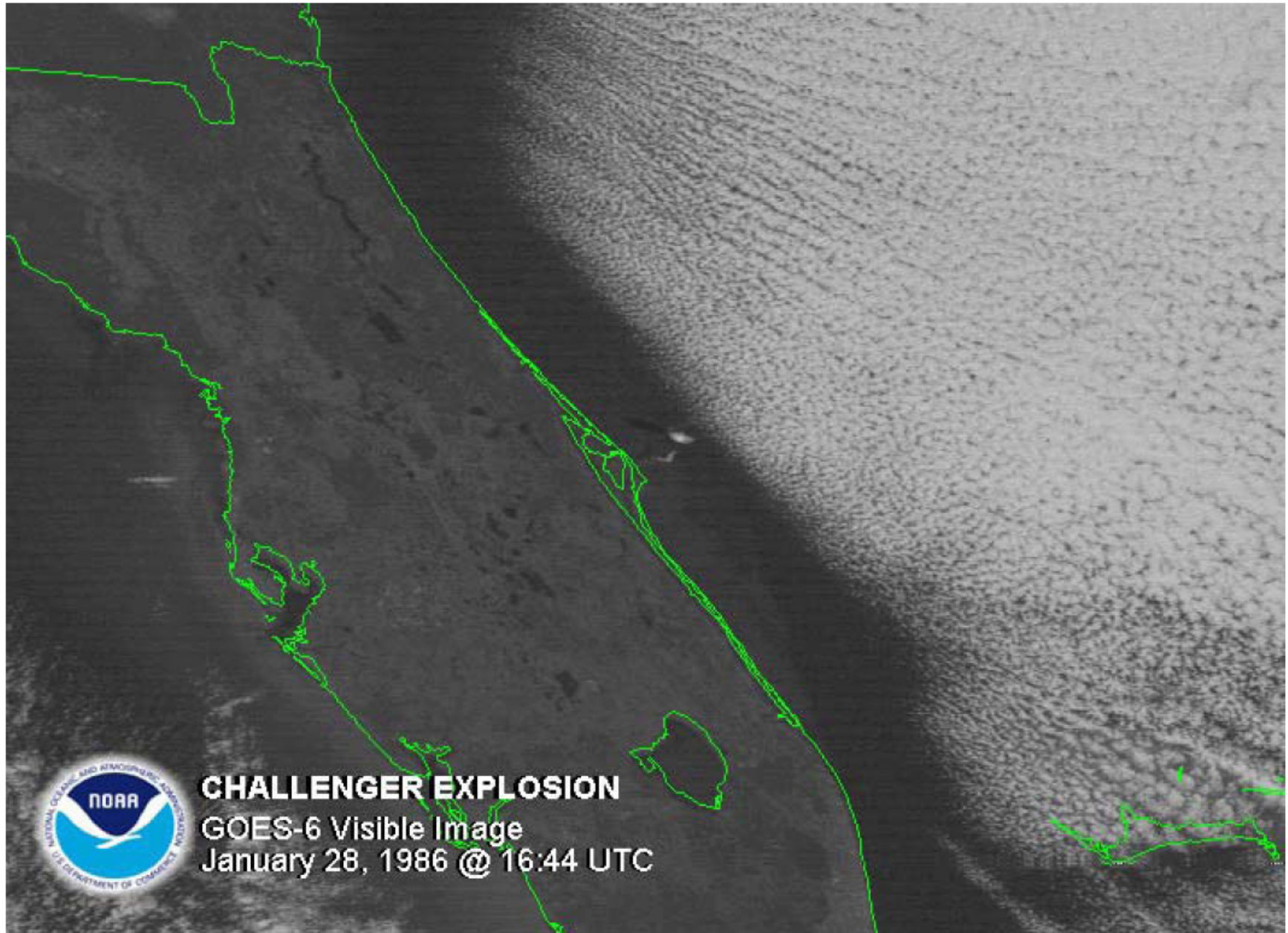
Low Clouds: Stratocumulus



SC Cloud Sheet



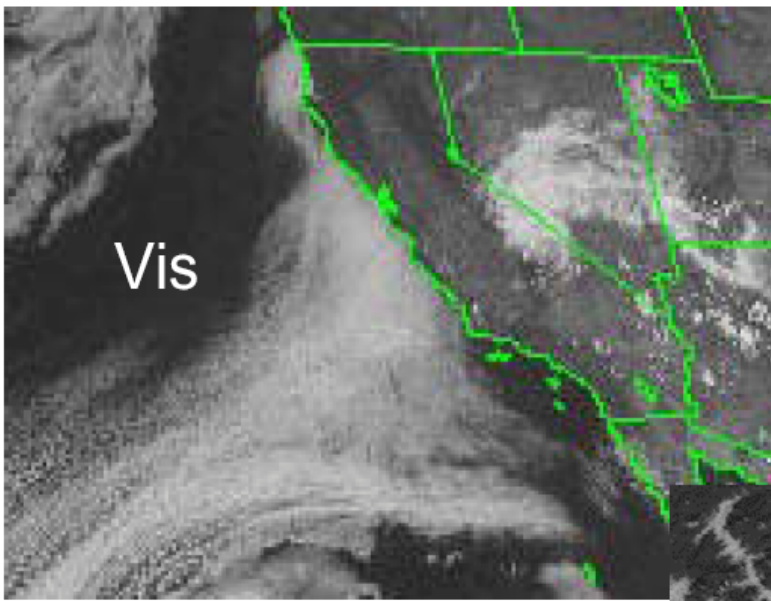
Low Clouds: Stratocumulus



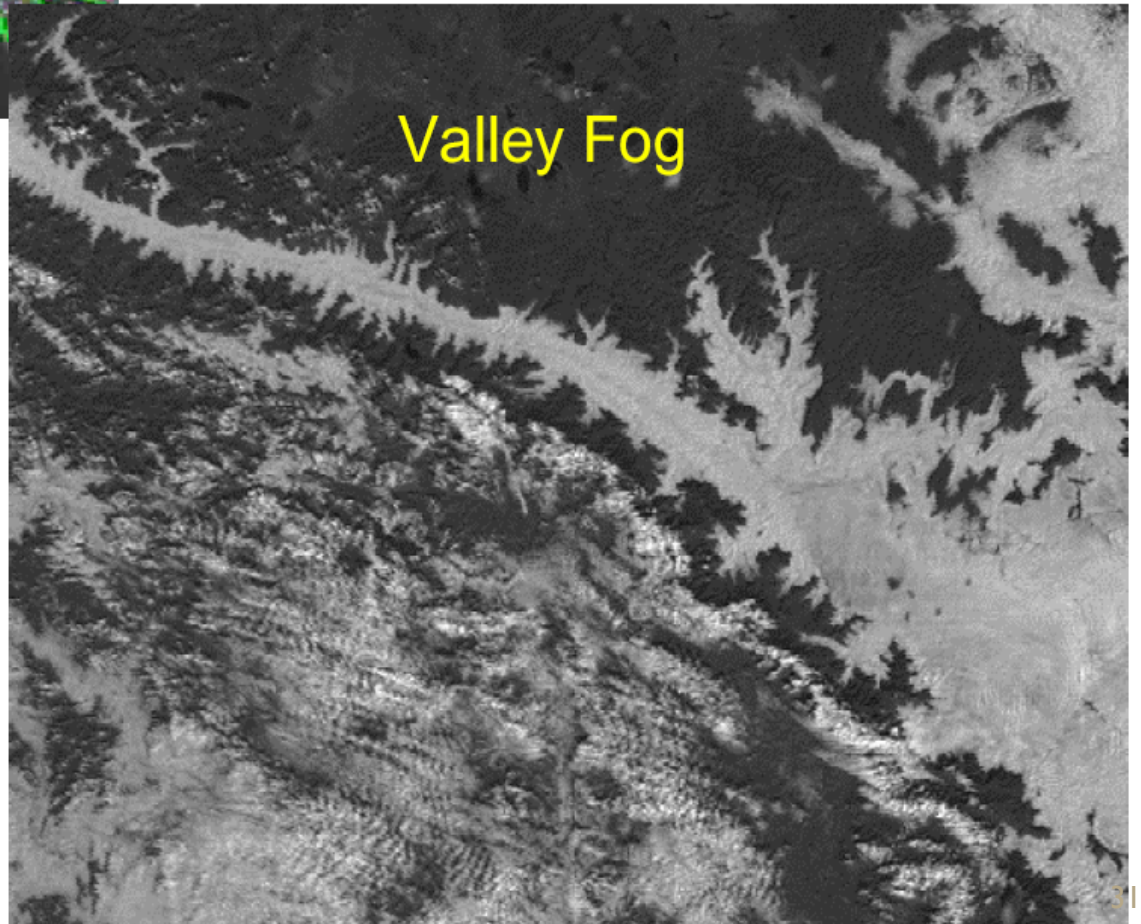
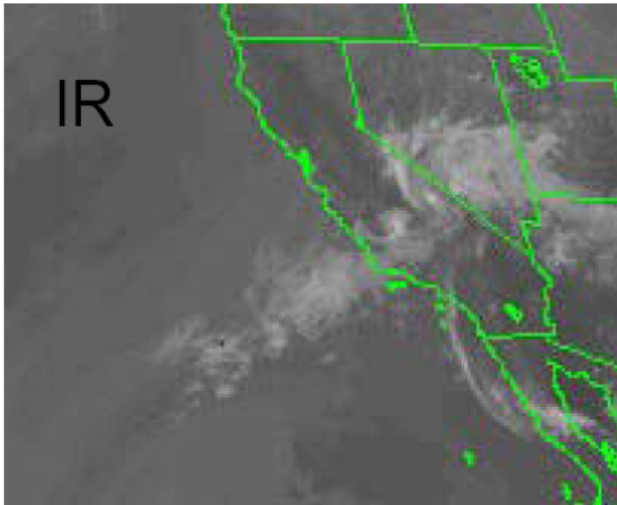
Low Clouds (3)

- **Stratus and Fog** caused by various means. Large areas of stratus are found over cold ocean currents, as warm subsiding air underneath anticyclones meets the cold water below.
 - Visible imagery** white to gray, uniform, smooth sheet, except when terrain features penetrate above the stratus tops. Coastal and valley stratus often outlines the surrounding terrain.
 - IR imagery** nearly invisible due to lack of contrast between the surface and cloud top temperatures. Occasionally, stratus forming beneath a radiation inversion will appear warmer (darker) than the surface, and is called “black” stratus.

Low Clouds: Stratus/Fog



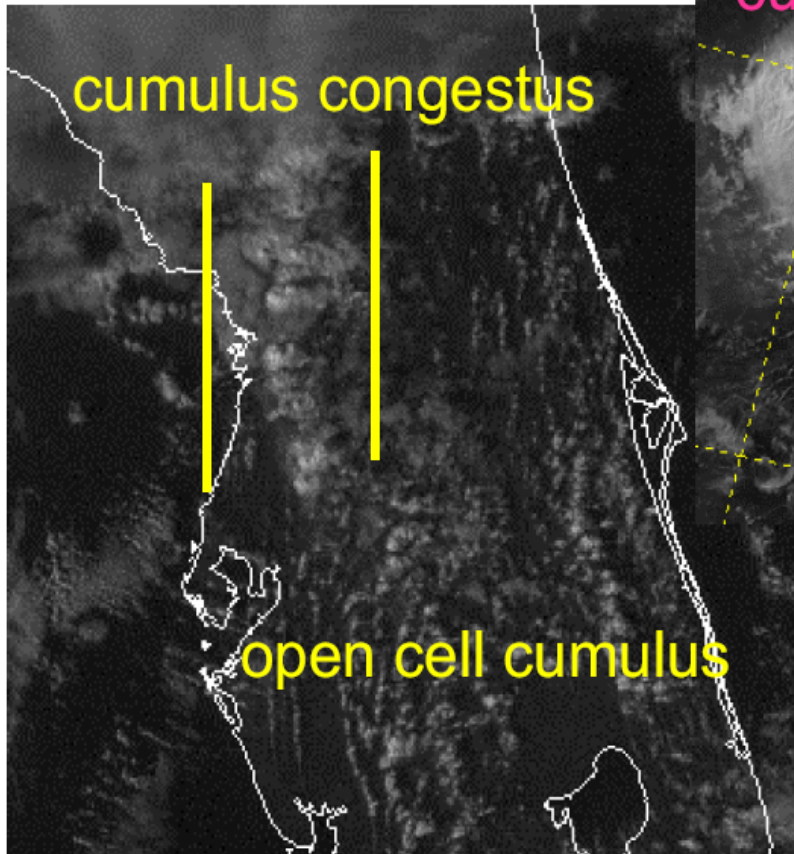
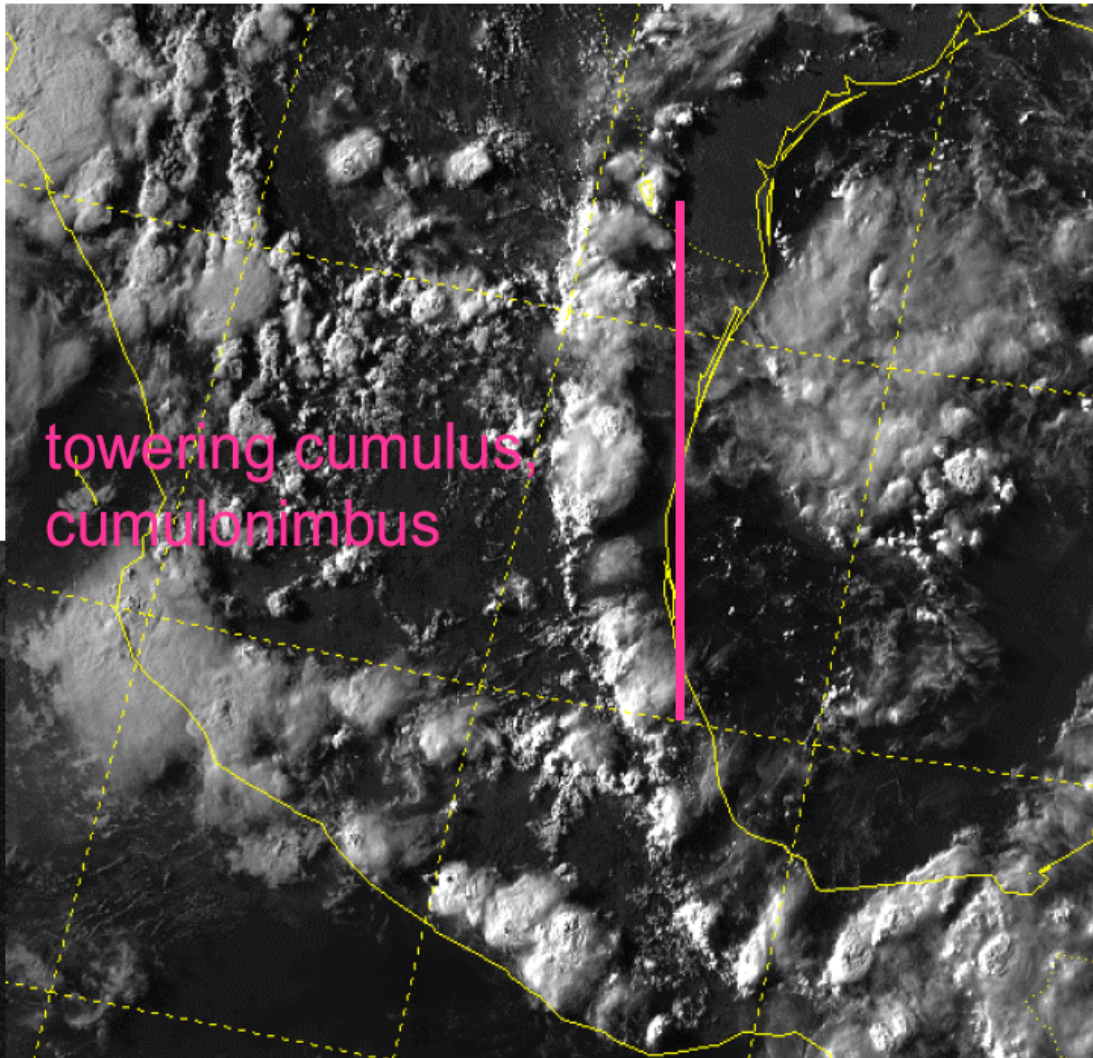
CA Coastal Stratus



Miscellaneous Cloud Forms

- **Open Cell Cumulus** cumulus clusters whose edges are clearly visible.
- **Enhanced Cumulus** area of cumulus congestus, towering cumulus, or cumulonimbus clouds. Associated with fronts, PVA, or orography, and appear as very bright dots in a field of otherwise uniform open cell cumulus.

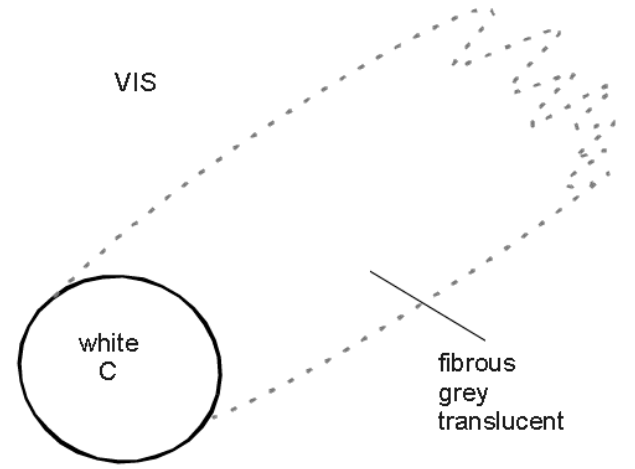
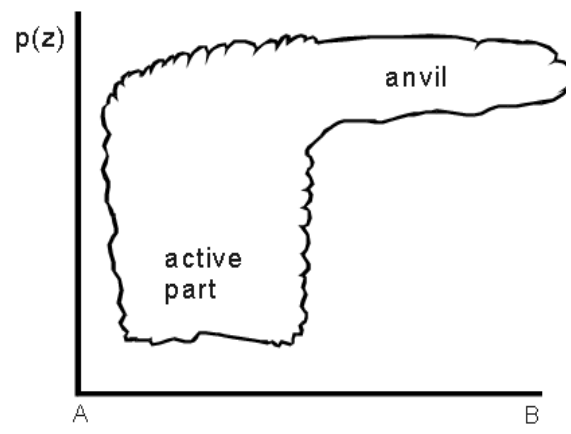
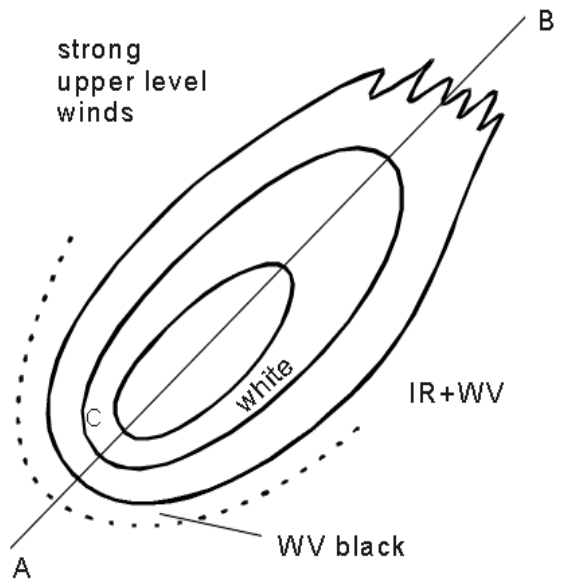
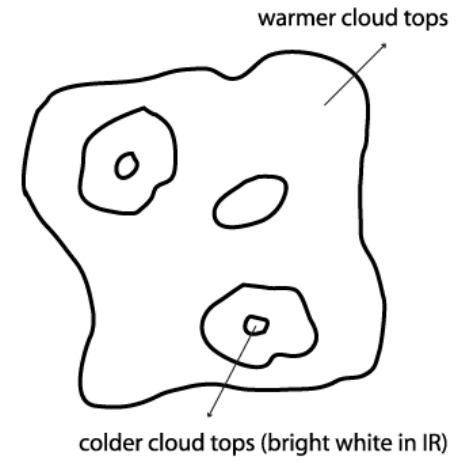
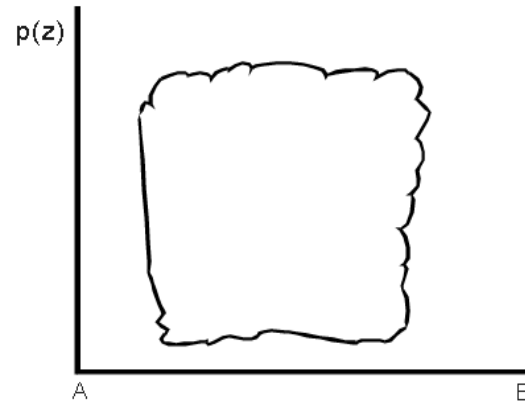
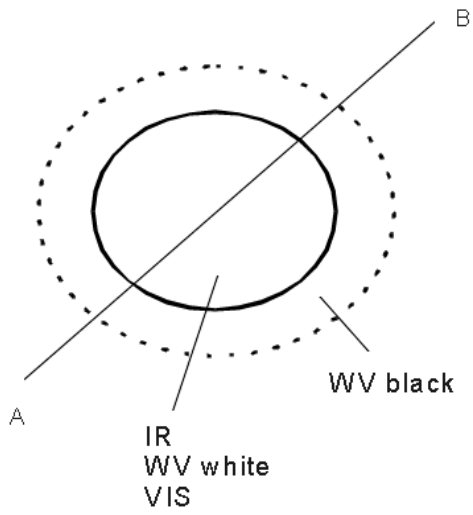
Enhanced Cumulus



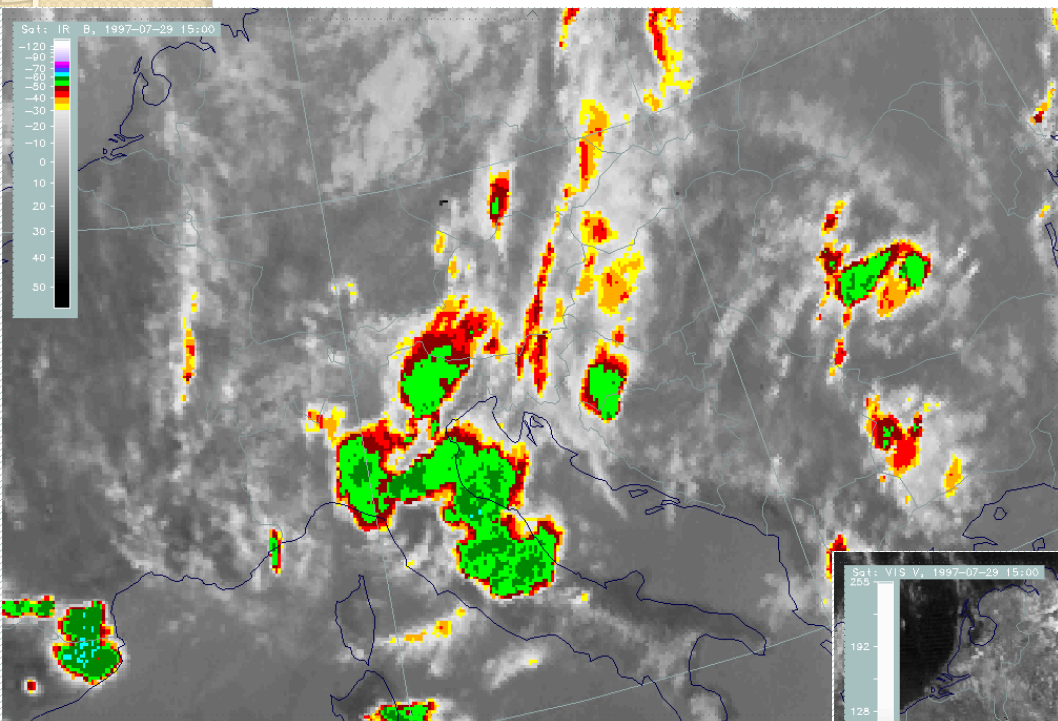
Squall Line: a propagating line of enhanced cumulus.

Mesoscale Convective System (MCS)

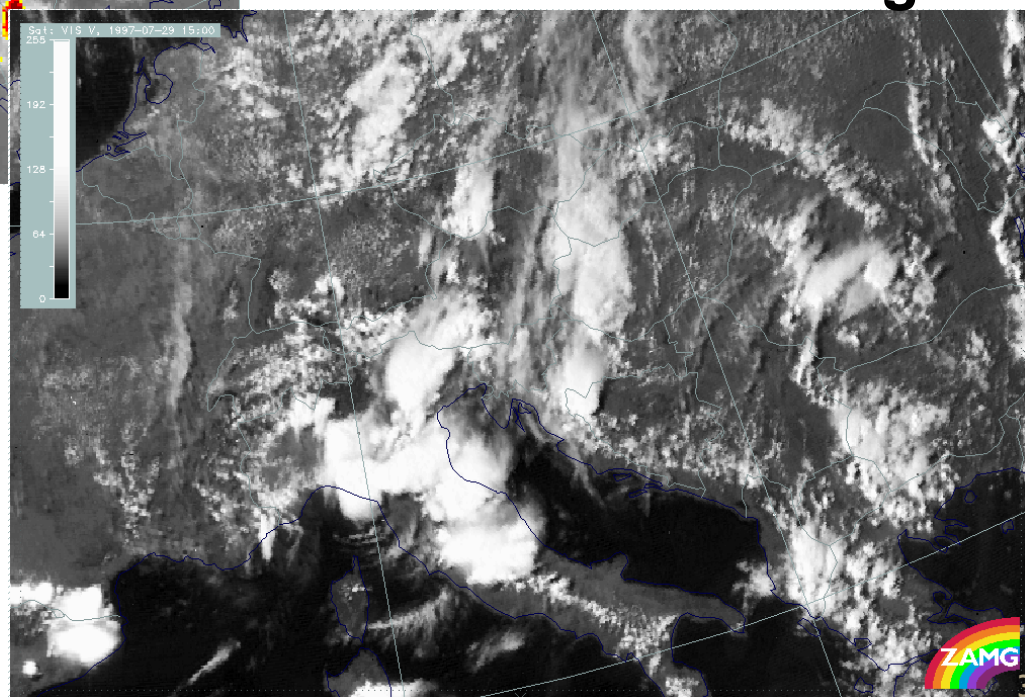
- In the satellite images an MCS looks like a mesoscale cloud cluster, which has a **circular or oval shape** depending on upper level wind strength.
- In IR, WV and VIS images MCS are characterized by high pixel values (white) in the active part, indicating cloudiness which extends through the whole troposphere.
- The upstream edges of the cloud cluster are generally very sharp. In situations with high upper level winds, the high cloud is transported downstream leading to an extended white cloud shield in the IR but a fibrous grey texture in the VIS image. The brightest grey shades can be found in the active part upstream.
- In the case of MCSs consisting of several independent sub-storms, the cloud patches have more irregular appearance and distribution of cloud top height. In such cases VIS images show a lumpy appearance.



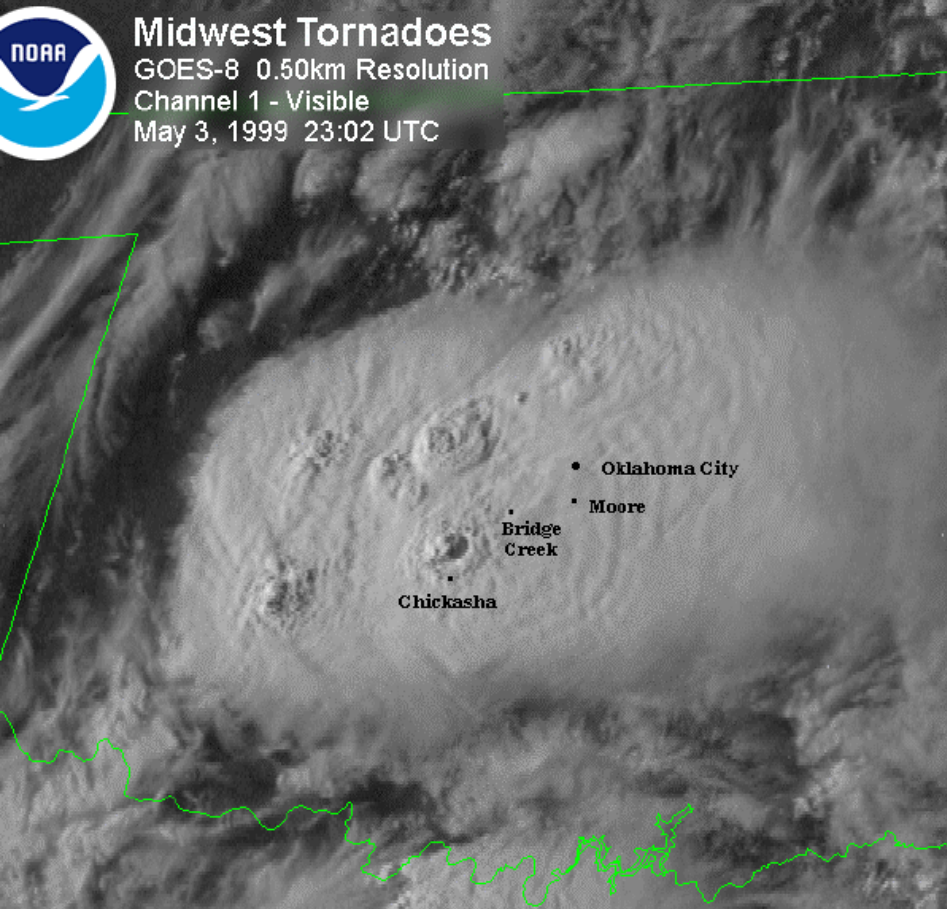
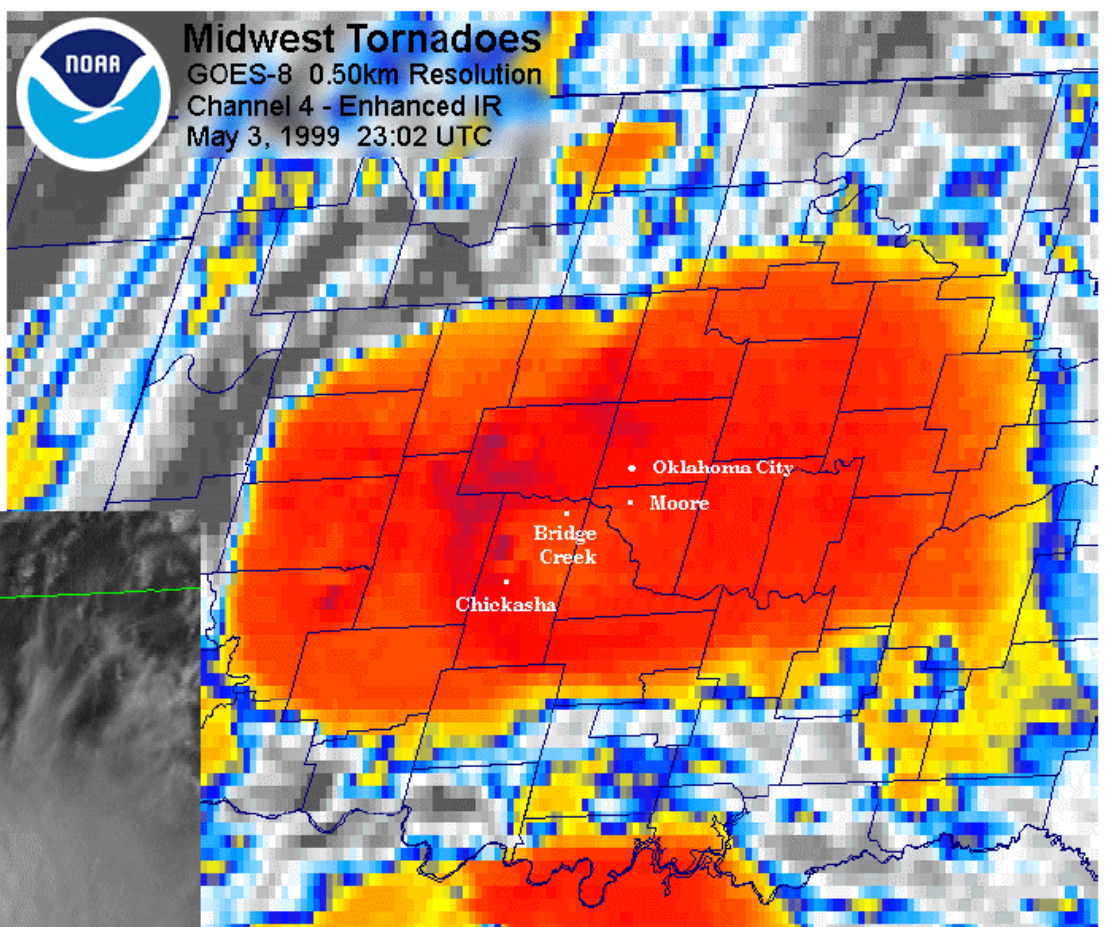
29 July 1997/15.00 UTC - Meteosat IR enhanced image



29 July 1997/15.00 UTC - Meteosat VIS image

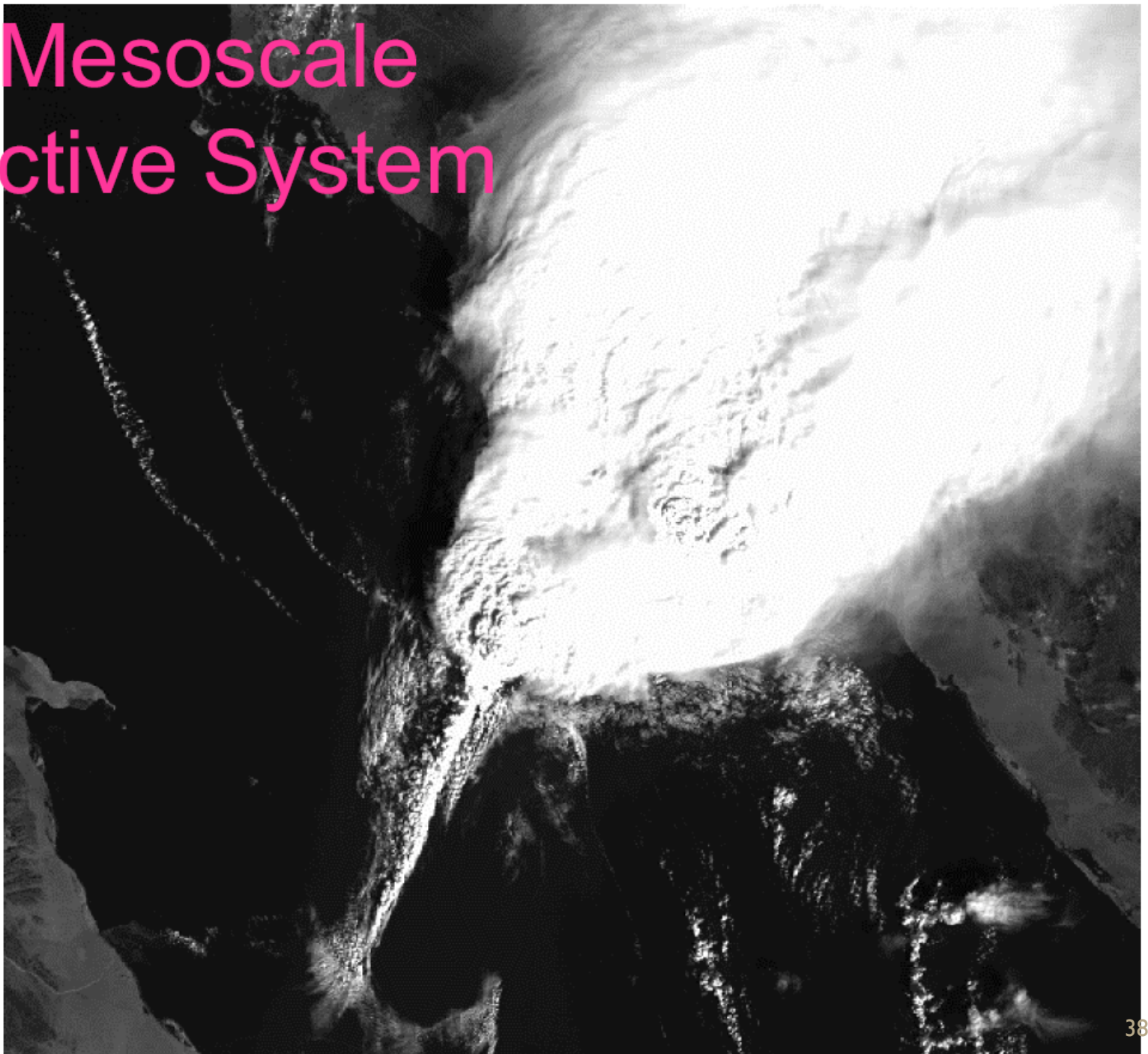


MCS: IR vs. Visible



The Mesoscale Convective System

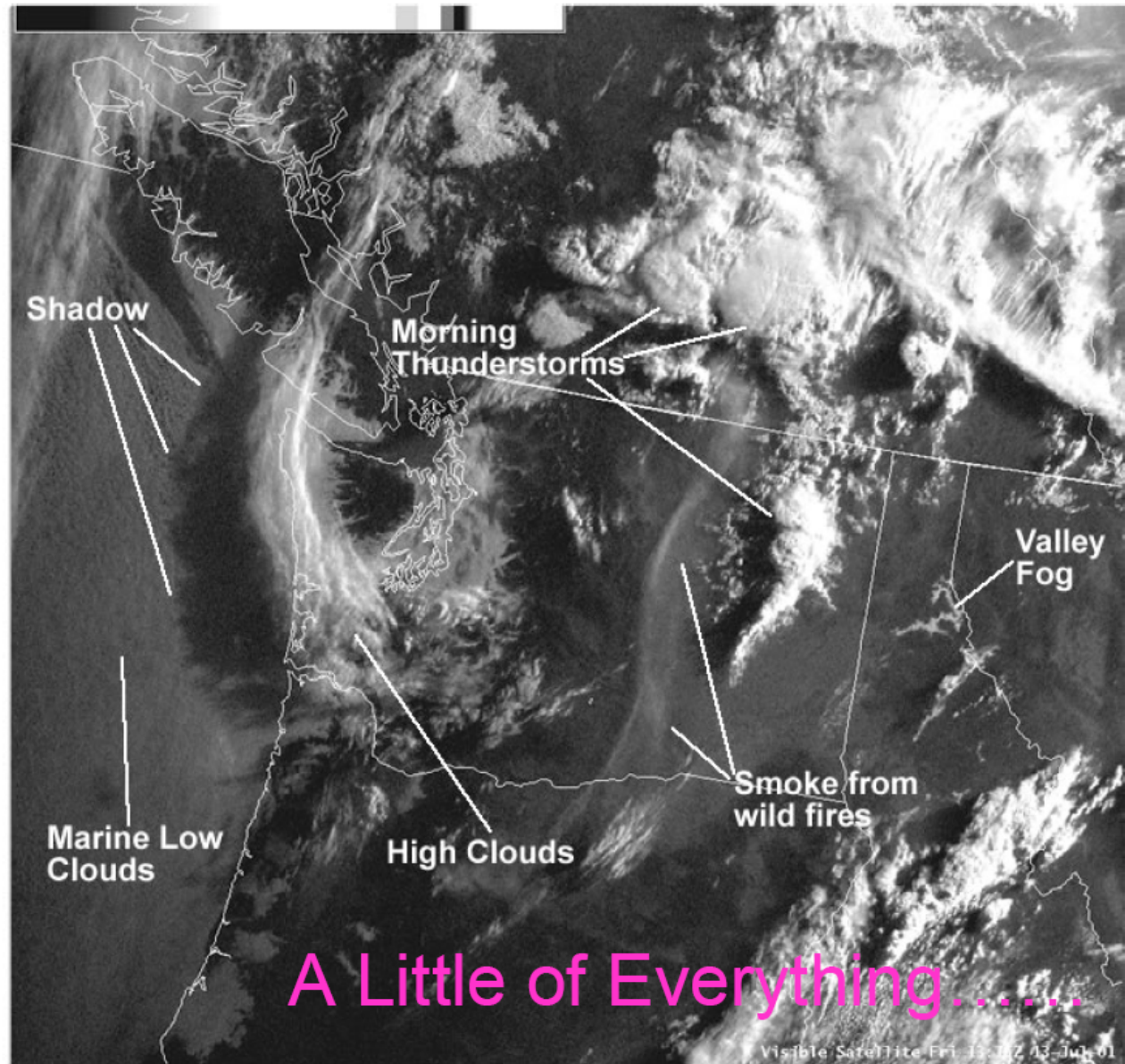
(or MCS)



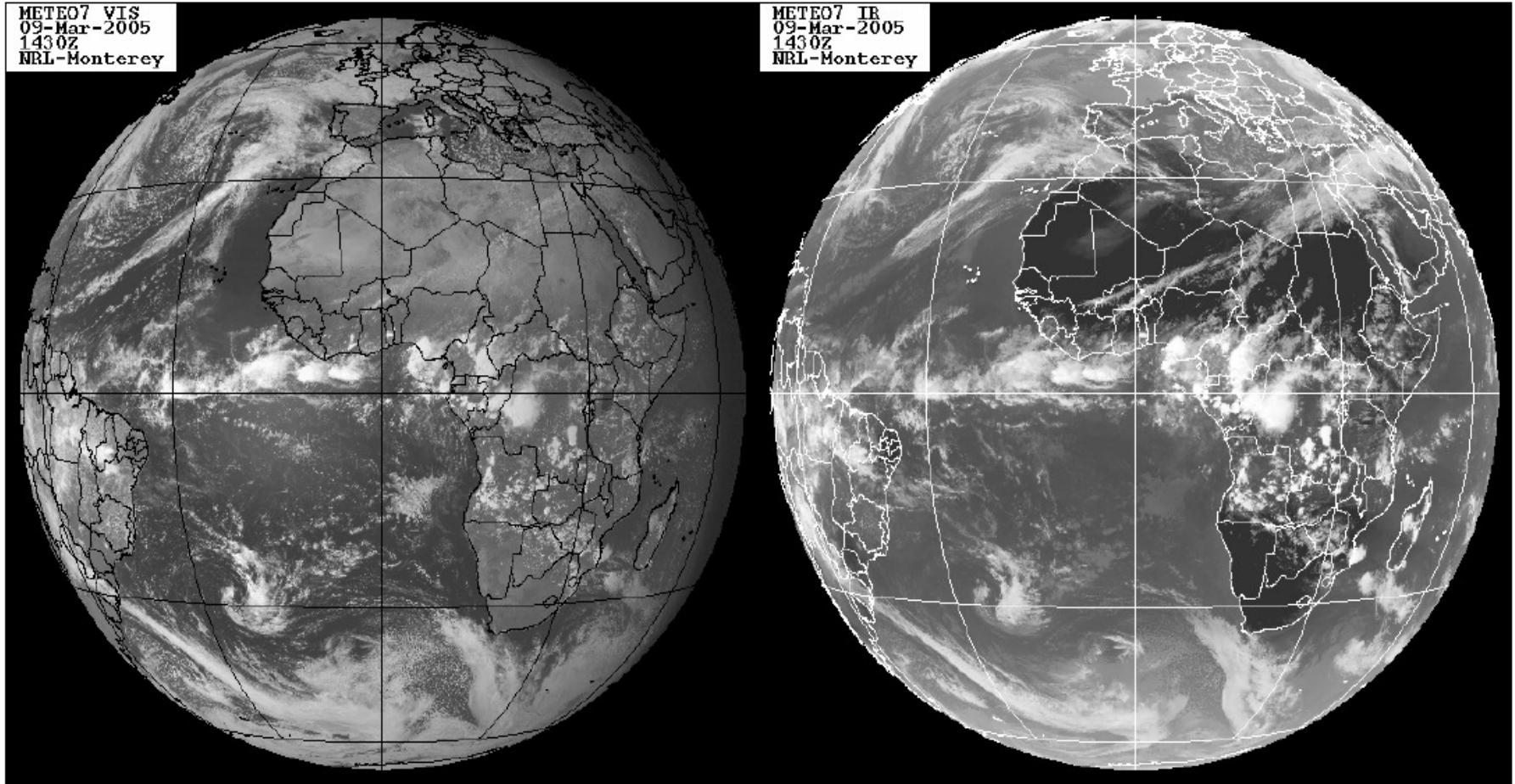


Half-hour IR image loop showing the development of MCSs:
<http://rammb.cira.colostate.edu/wmovl/VR/Tutorials/SatManueumetsat/SATMANU/CMs/Cb/loop1.htm>

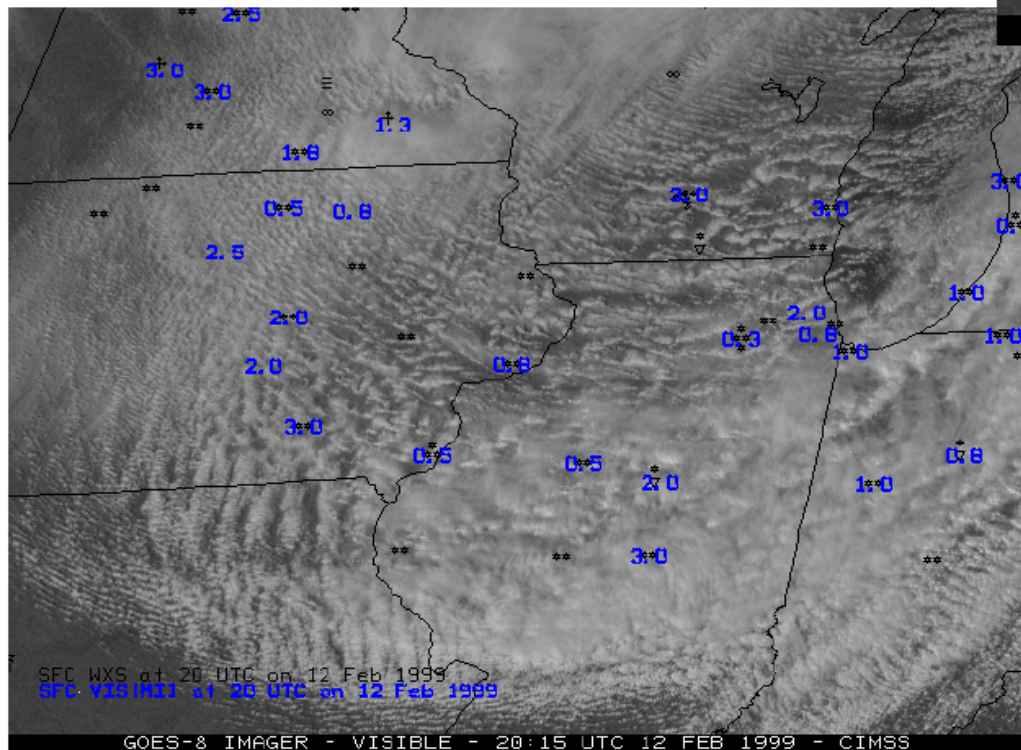
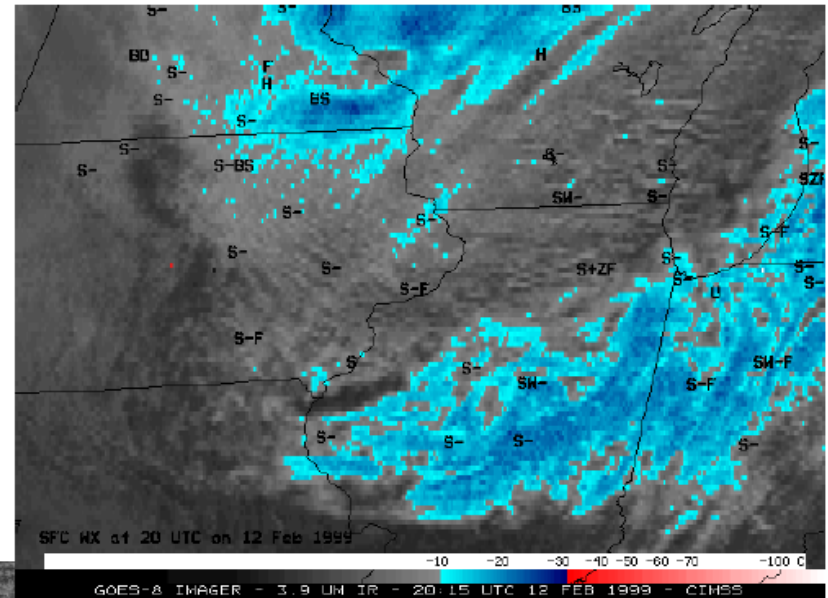
More Cloud Examples



The ITCZ and Convection



Convective Snow Squalls



GOES-8 3.9 μm shortwave IR imagery (**above**) revealed that the cloud tops over the region on 2/12/99 were a mixture of supercooled water droplets (dark gray enhancement, due to reflection of solar near-IR) and ice crystals (warmer than -10°C , light gray enhancement; -10°C and colder, blue enhancement; due to emission of terrestrial near-IR).