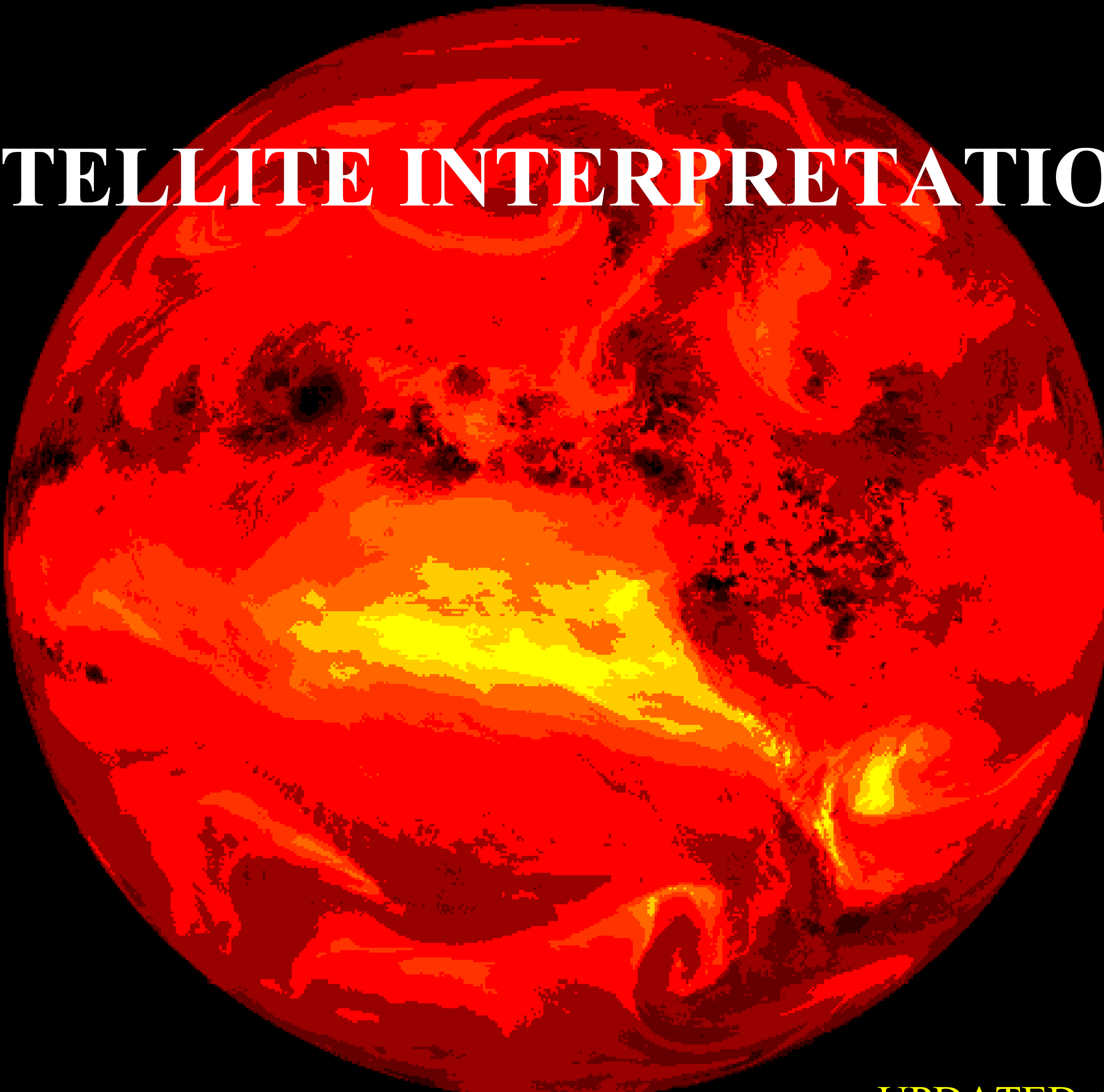
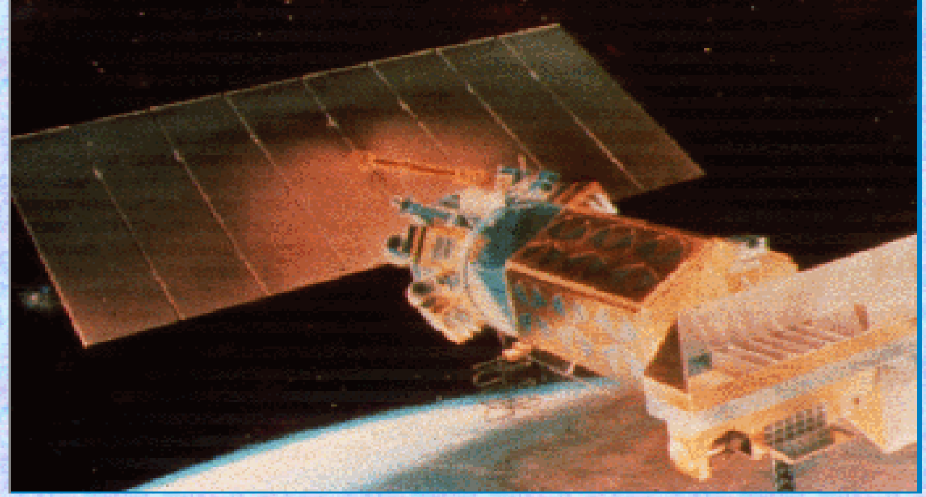
SATELLITE INTERPRETATION



UPDATED: 28 Feb 2000



VIEWING CONSIDERATIONS

RESOLUTION: THE SMALLEST INDIVIDUAL ELEMENT THAT A SATELITE SENSOR CAN DETECT

ATTENUATION: THIS PROCESS REDUCES THE AMOUNT OF ENERGY REACHING THE SATELLITE SENSOR SO CLOUD TOPS APPEAR HIGHER AND COLDER THAN THEY ACTUALLY ARE. DEPENDS UPON THE VIEWING ANGLE OF THE SATELLITE.

CONTAMINATION: THIS OCCURS WHEN ENERGY REACHES THE SATELLITE SENSOR FROM TWO OR MORE SOURCES. THE TYPICAL SITUATION FOR CONTAMINATION TO OCCUR INVOLVES A HIGH CLOUD WHICH IS NOT THICK ENOUGH TO COMPLETELY BLOCK OUT RADIATION FROM ANOTHER SOURCE.

FORESHORTENING: A LOSS OF RESOLUTION CAUSED BY AN OBLIQUE VIEWING ANGLE RESULTING IN DISTORTION NEAR THE EDGE OF THE EARTH'S SURFACE ON ANY TYPE OF SATELLITE IMAGERY. THE RESULT IS AN OVERESTIMATION OF CLOUD COVERAGE.

OTHER FACTORS: GRIDDING ERRORS, SUN ANGLE, LATITUDE, SUN GLINT

FOG AND STRATUS

CAN BE EASILY SEEN ON VISUAL IMAGERY BECAUSE OF THE SHARP CONTRAST BETWEEN THE FOG/STRATUS AND THE TERRAIN.

VISUAL IMAGERY: APPEARS WHITE TO LIGHT GREY, IN A UNIFORM SHEET.

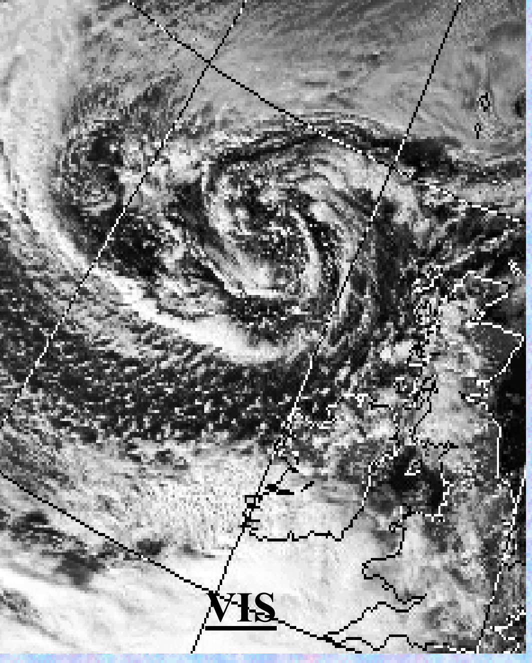
INFRARED IMAGERY: DARK GRAY SHADES APPEAR WITH LITTLE OR NO CONTRAST BETWEEN THE CLOUDS AND LAND SINCE THEY ARE ABOUT THE SAME TEMPERATURE.

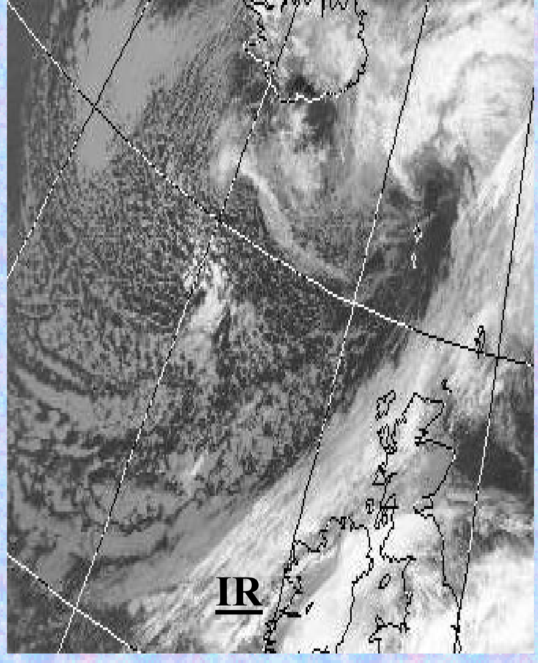
OCCASIONALLY, FOG AND STRATUS FORMING UNDERNEATH A RADIATION INVERSION IN THE EARLY MORNING HOURS WILL APPEAR DARKER THAN THE SURROUNDING CLOUD-FREE REGION.

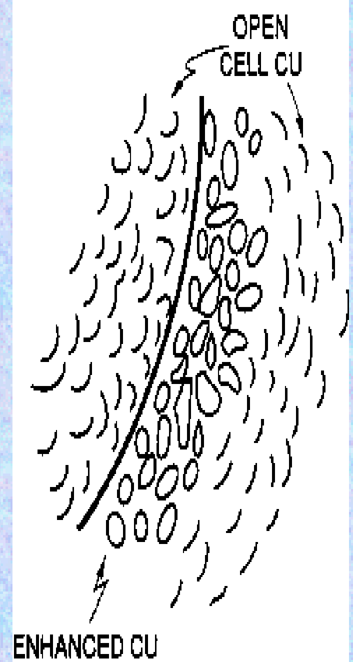
VALLEY FOG

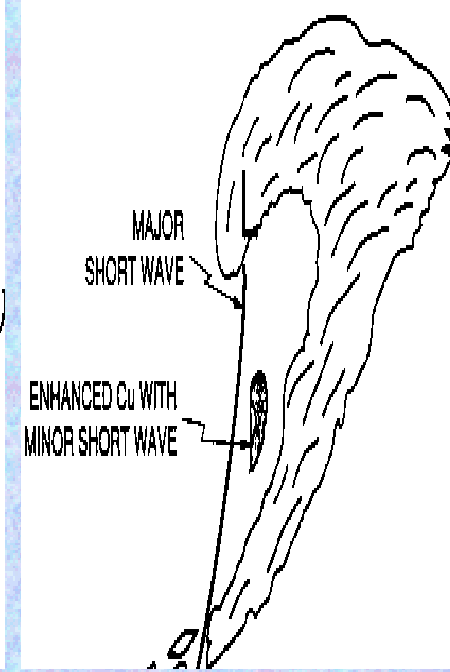
Cold air tends to drain into low-lying areas at night under light wind conditions. This makes these areas most prone for fog formation, especially during the colder months.

In this situation, rain-cooled air became trapped in the central valleys of California. A high pressure system dominated the area from the onset of the fog on December 12th, preventing any significant mixing of the air mass. Fog persisted for over two weeks.









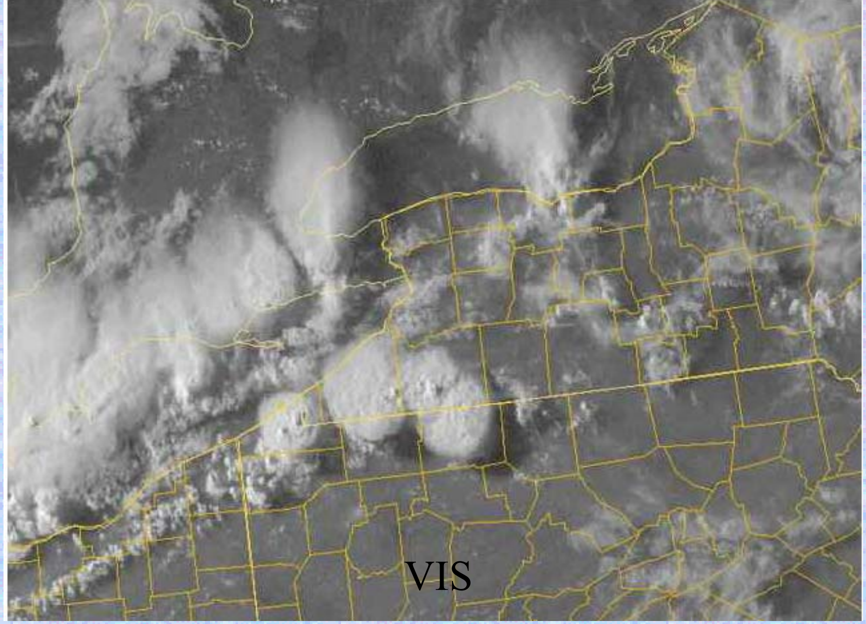
STRATOCUMULUS: VIS: APPEARS LIGHT GRAY TO WHITE WITH A TEXTURED LOOK. HAS CONTINUOUS CLOUD SHEETS COMPOSED OF PARALLEL ROLLS OR CELLULAR ELEMENTS

. IR: APPEARS DARK GRAY. THE CELLULAR OR TEXTURED APPEARANCE MAY NOT BE OBSERVED DUE TO THE SENSOR RESOLUTION.

CUMULUS: VIS: APPEARS AS A SMALL WHITE CLOUD USUALLY SEEN AS A FIELD OF UNORGANIZED "POPCORN" CUMULUS.

IR: INDIVIDUAL CLOUD ELEMENTS USUALLY ARE NOT DESCERNIBLE DUE TO THE RESOLUTION. ONLY LARGE CONCENTRATED AREAS OF CUMULUS ARE DISCERNIBLE AND THEY APPEAR AS A DARK GREY SINCE THE CLOUD TEMP IS AVERAGED WITH THE WARMER TEMP OF THE UNDERLYING SURFACE AROUND THE CLOUDS.

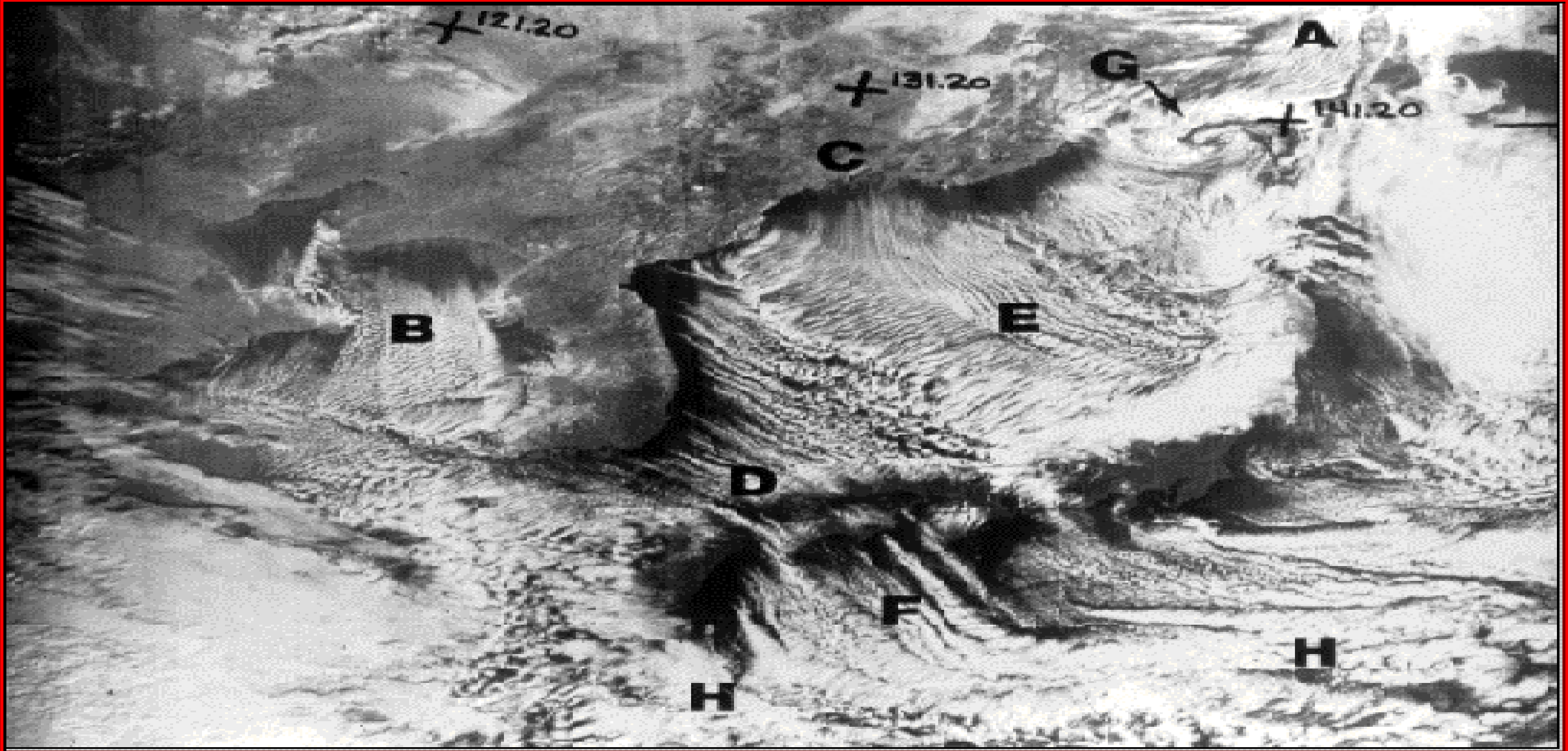
TOWERING CUMULUS: VIS: CLOUDS ARE CIRCULAR WHICH APPEAR LIGHT TO BRIGHT WHITE. IR: APPEAR LIGHT GRAY AND ARE LIGHTER THAN CUMULUS



CUMULONIMBUS: VIS: APPEAR BRIGHT WITH A ROUND OR ELONGATED ANVIL PLUME. THEY HAVE A SHARP UPSTREAM CLOUD EDGE AND A THIN, DIFFUSE ANVIL WHICH SPREADS OUT DOWNSTREAM. INDIVIDUAL UPDRAFT CELLS KNOWN AS OVERSHOOTING TOPS ARE OFTEN VISIBLE AS A BULGE ABOVE THE OTHERWISE, SMOOTH ANVIL TOP. THIS NORMALLY INDICATES SEVERE WEATHER BELOW THE OVERSHOOTING TOPS.

IR: APPEAR BRIGHT WHITE. A TIGHT GRAY SHADE IS OFTEN PRESENT ON THE UPSTREAM EDGE OF THE ANVIL CIRRUS AND LOOSENS RAPIDLY DOWNSTREAM. THIS TIGHT GRADIENT INDICATES STRONG UPDRAFTS RESISTING THE UPPER LEVEL FLOW.

WATER VAPOR: APPEAR AS A BRIGHT WHITE AREA IN A REGION OF DARKER SHADES. CUMULONIMBUS ANVILS ARE NORMALLY THE BRIGHTEST FEATURES ON A WATER VAPOR IMAGE. OFTEN THERE IS A DARKENING UPWIND OF A SEVERE THUNDERSTORM . TIS INDICATION OF STRONG SUBSIDENCE IMPLIES STRONG VERTICAL MOTION NEARBY.

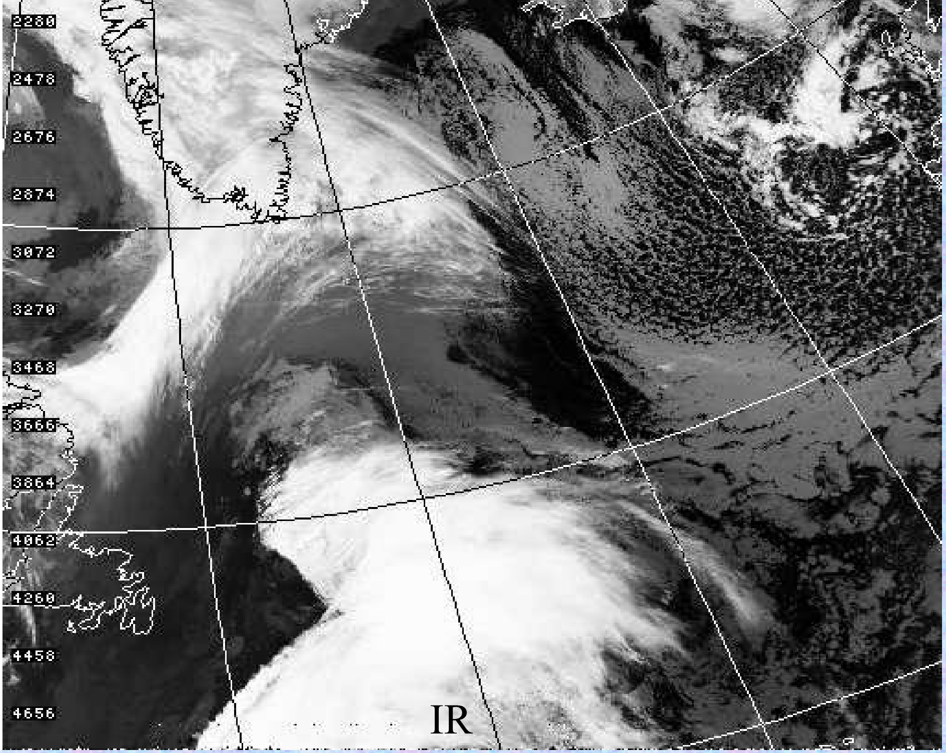


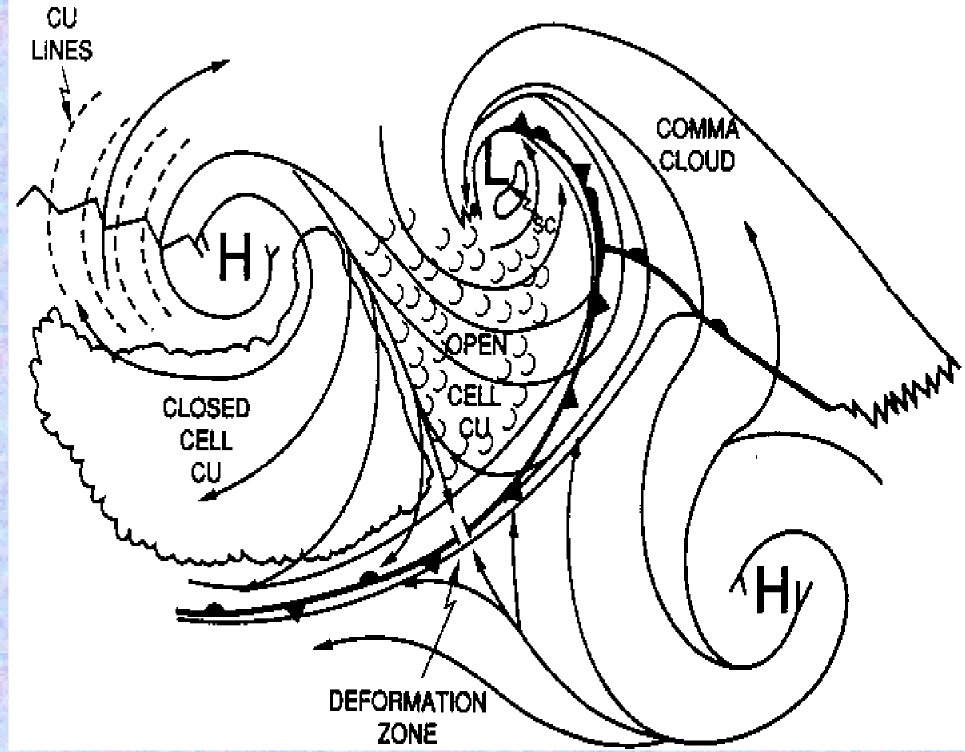
CLOUD STREETS

Frequently during winter months, outbursts of very cold air move from East Asia across Japan. These show up clearly on satellite images over the waters off the east Asian coasts. In this image, cloud streets indicating north winds are seen at (A), (B) and (C). Streets indicating northwest winds occur at (D), (E), and (F). Most of these directional changes are due to the blocking effect of mountains, which divert the cold, stable air around them. However, a small "polar low" can be seen at (G). Farther offshore near (H), the clouds become larger and flatter, indicating a change to stratocumulus. These stratocumulus cloud lines are not usually parallel to the low level winds.

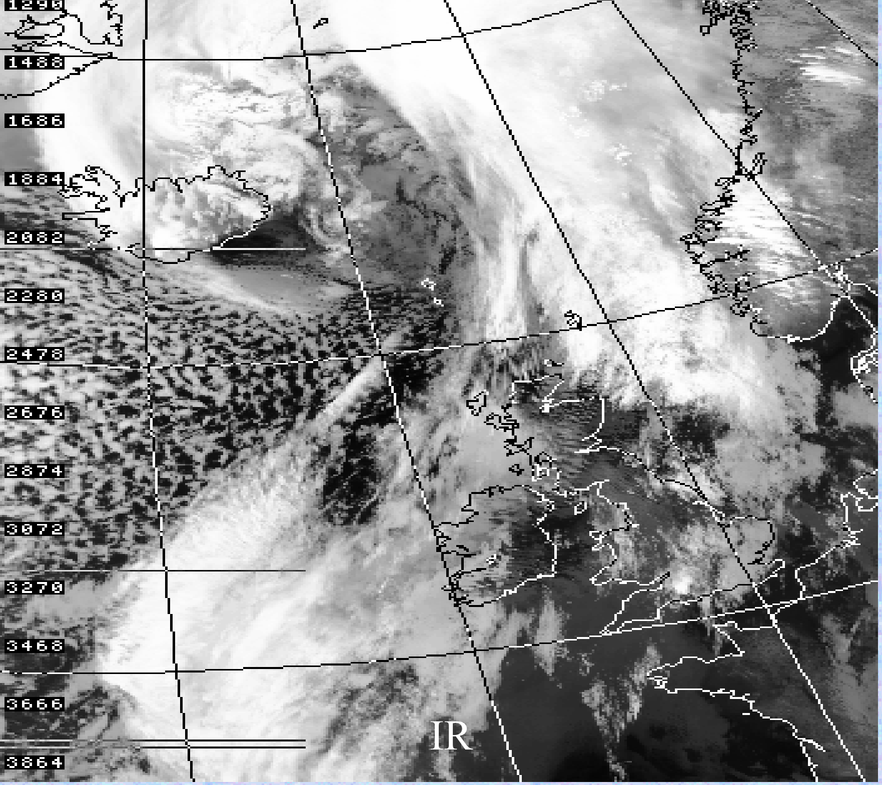
CLOUD STREETS

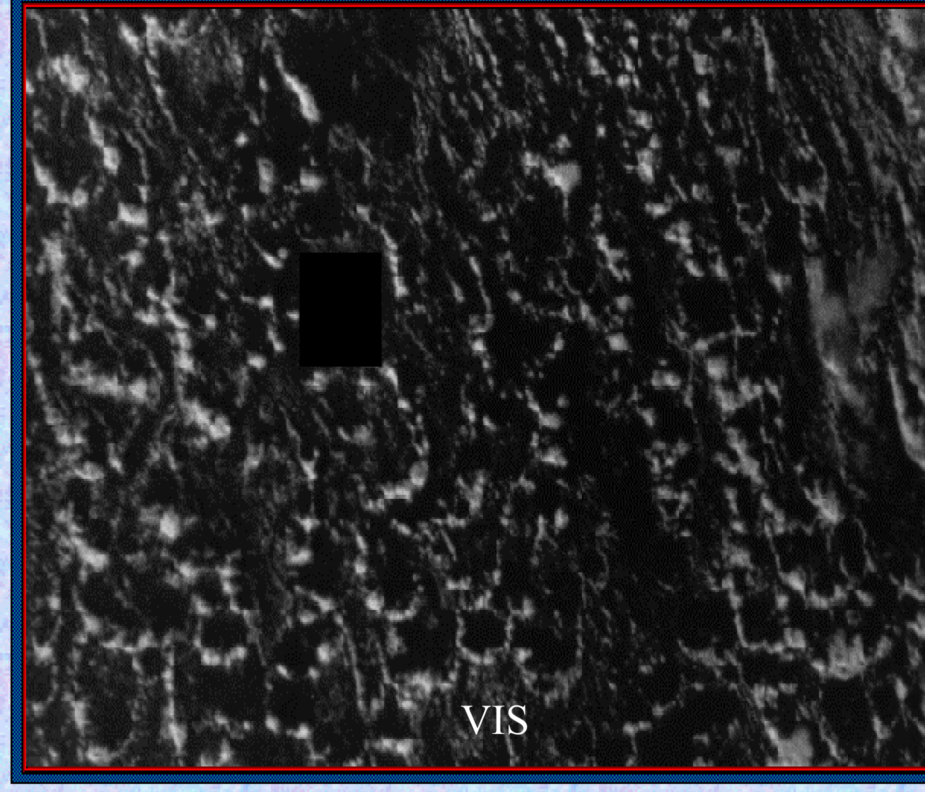
In the fall and winter, these conditions frequently occur in the wake of cold frontal passages off colder continents. In this image, many cloud streets are present in the Gulf of Mexico and off the southeastern U.S. coast. Notice that in both areas the cloud streets begin as very narrow lines, gradually getting wider and then changing direction, as at (A). The lines are nearly parallel to the vertical wind shear within the cloud layer. The young cumulus clouds are excellent indicators of wind direction near the coast where they are narrow and where the shear is due to surface friction. They are not good wind direction indicators offshore where they broaden out and become stratocumulus. Here the vertical shear is often different from the surface winds. To the rear of the front at (B) the cloud lines are parallel to the front, not to the low level wind.



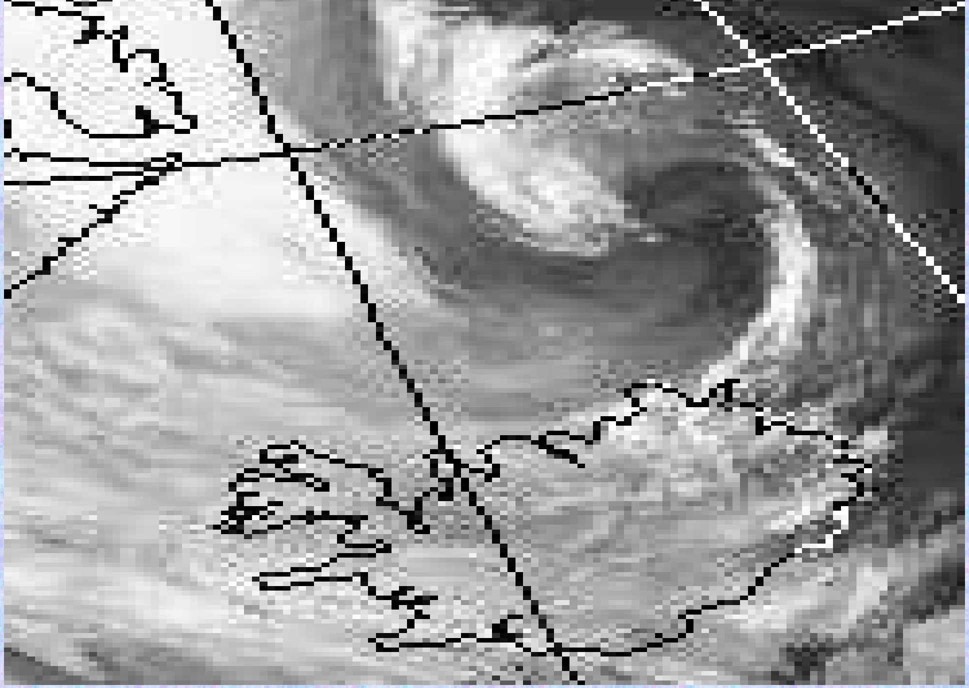


<u>Closed-cell SC</u> is cellular, closely packed SC that forms mostly over ocean areas. The individual elements vary in size from 5 to 50km.. They're typically found in large sheets associated with the anticyclonic flow of the subtropical high or with high pressure systems behind cold fronts. Clouds typically are located in the southern half of the high.Closed-cell SC is formed due to low-level instability or convective mixing with a subsidence inversion capping the mixing. The instability or mixing is due to either surface heating, radiative cloud-top cooling, or weak cold-air advection over a warmer water surface. **<u>VIS imagery</u>**: closed-cell SC appears as gray shades ranging from white in the center to medium gray to white on the edges. They will have a large quilt-like pattern with a slight separation between the elements. **<u>IR imagery:</u>** closed-sell SC will usually appear similar to ST with a very uniform, medium gray to dark gray shade due to resolution problems.





Open-cell cumulus - These are CU clouds that usually form over water behind mid-latitude cyclones and are caused by strong cold air advection over warmer water. They are associated with cyclonic or straight line flow. There is a sharp transition between cellular clouds, showing a separation between stable (closed-cell SC) and unstable (open-sell CU) air. Their vertical development is typically capped by a weak inversion above the cloud layer. The elements vary in size from 5 to 50 km. **VIS imagery**: Open-cell CU appears as open and closed ringlets of CU with clear centers like chicken wire. In strong low-level winds, these ringlets will become distorted and line up. Individual elements may be difficult to detect due to the sensors resolution. **IR imagery**: open-cell CU appears medium to dark gray due to contamination and resolution problems. Parts of the open-cell CU field may appear as a uniformly darker gray shade than the rest of the field. Although open-cell CU is higher than closed-cell SC, open-cell CU will look lower due to contamination and sensor resolution.

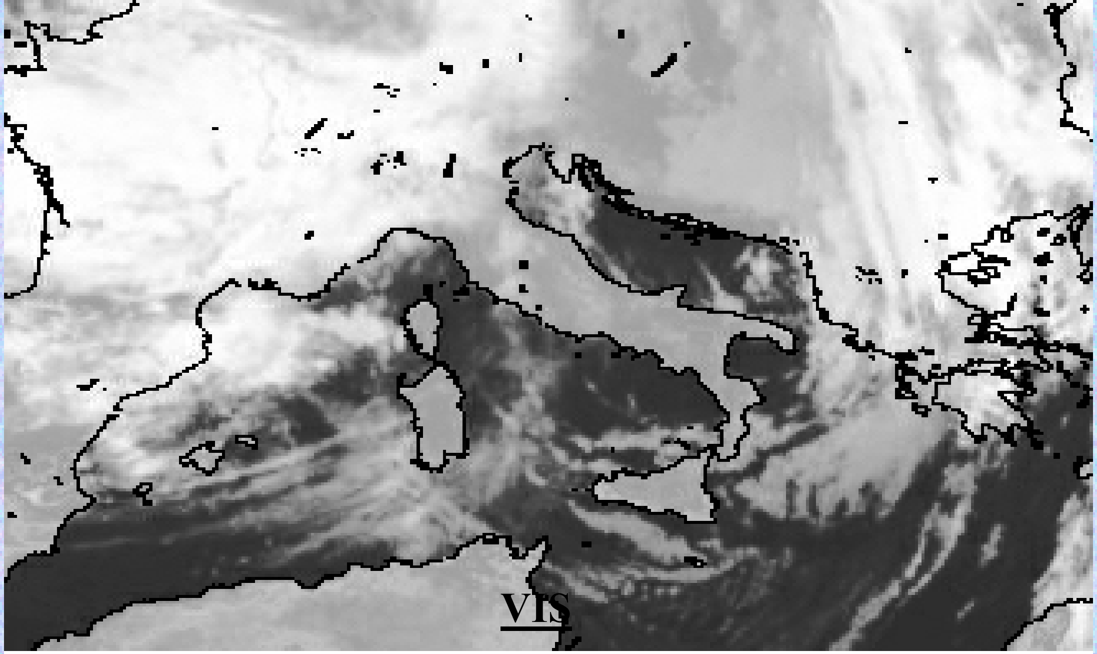


Actiniform Clouds - These are skeletal remains of closed-cell SC, which are easily confused with open-cell Cu. Actiniform clouds are found in or along the western side of the closed-cell SC. On VIS imagery, actiniform clouds are light gray, due to contamination, with a fish bone or chicken wire appearance. Actiniform clouds are medium gray to dark gray, showing up slightly warmer than open-cell CU on IR imagery. Individual elements are not identifiable. If too much contamination is present, the area will show up as a dark spot or hole in the clouds.

Rope Clouds - This is a very narrow line of CU/TCU usually found over water and occasionally over very moist coastal land areas. Rope clouds range from several hundred miles in length to several thousand. They are very representative of the surface cold front over water. The rope cloud has the same appearance as CU/TCU in the VIS and IR imagery.

TRANSVERSE BANDS (VIS, 1931Z, 21 DEC 87)

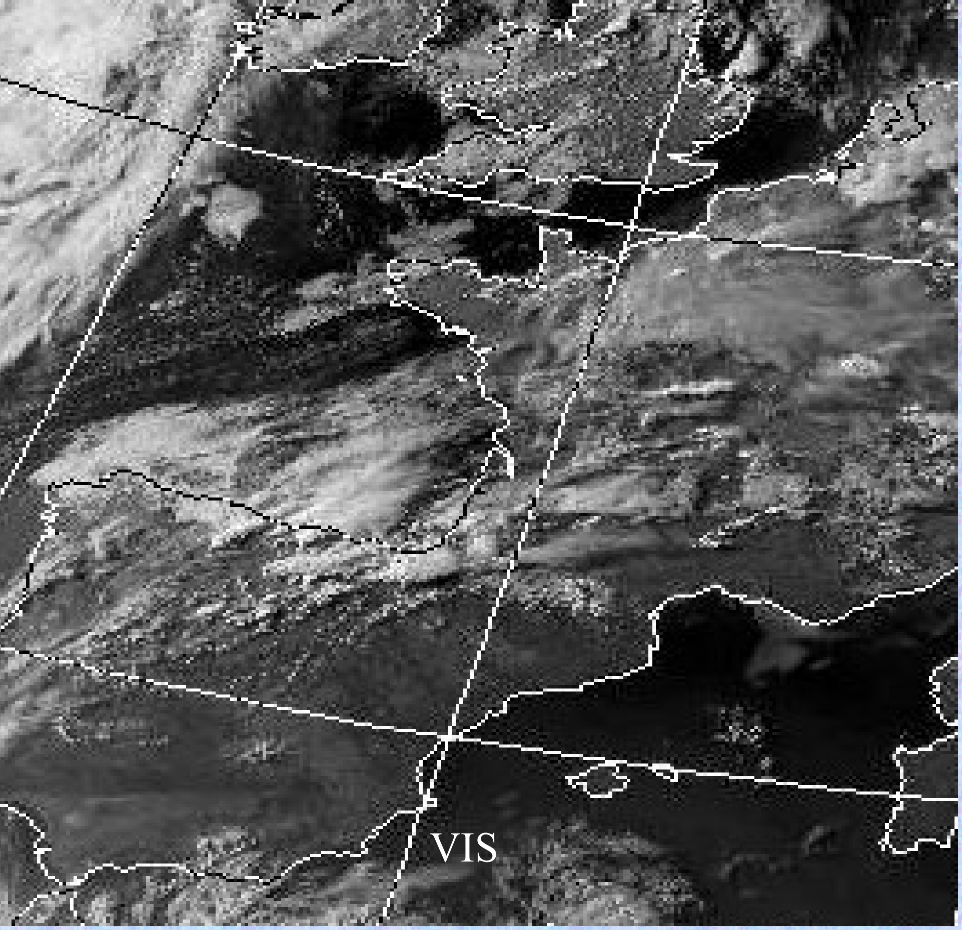
Transverse bands are wave-like features found in high altitude clouds. They are most often found in the cirrus on the equatorward side of the subtropical jet stream, as seen in the middle of this visible image (arrows).

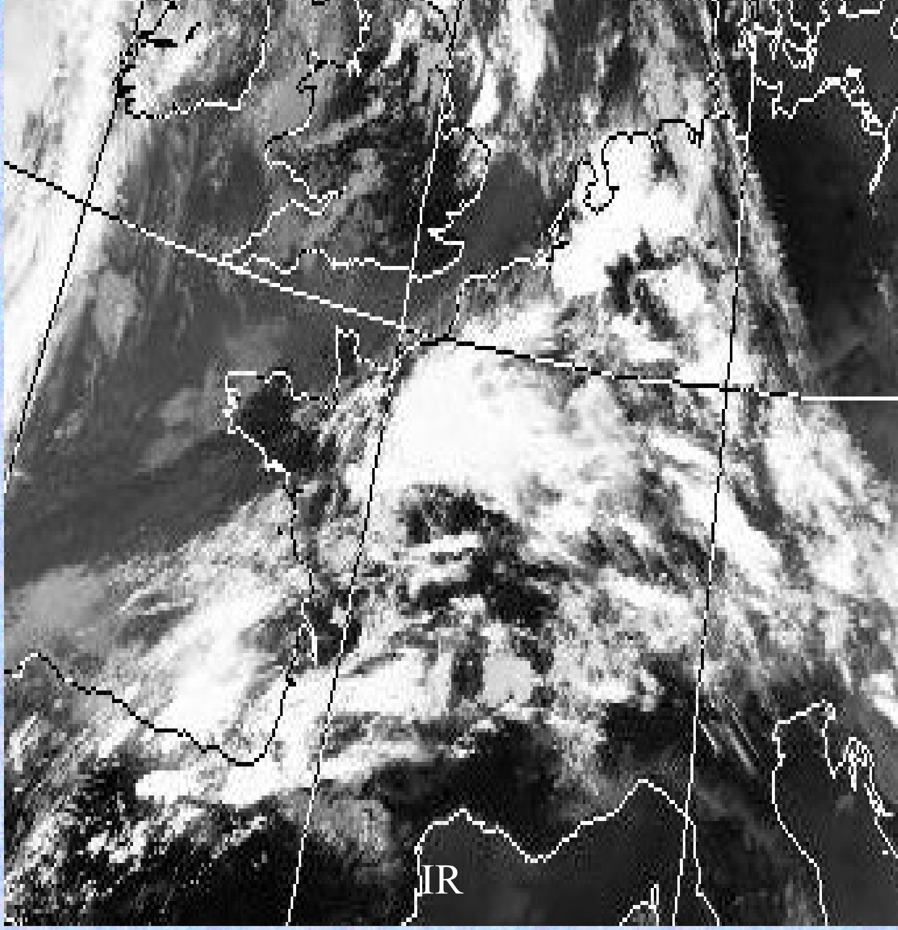


Cirrus streaks

These are small isolated patches of CI generally occurring away from other clouds. They develop in areas where there is insufficient moisture for an entire CI shield to form. On **VIS imagery** thin wisps of CI are very susceptible to contamination. The gray shades will range from medium gray to white.

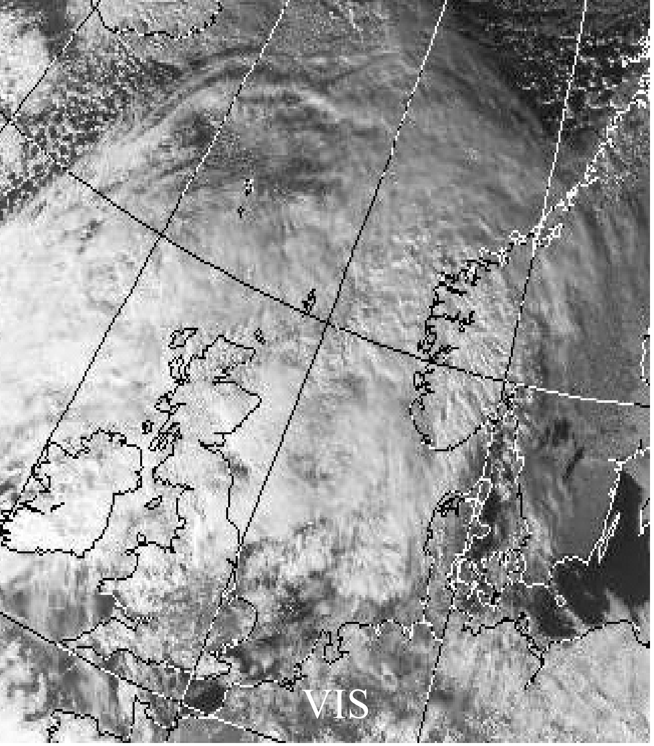
IR imagery: They will appear as a medium gray to white shade. Again, the imagery is very susceptible to contamination. On enhanced IR imagery, gray shade contouring is limited due to contamination problems.

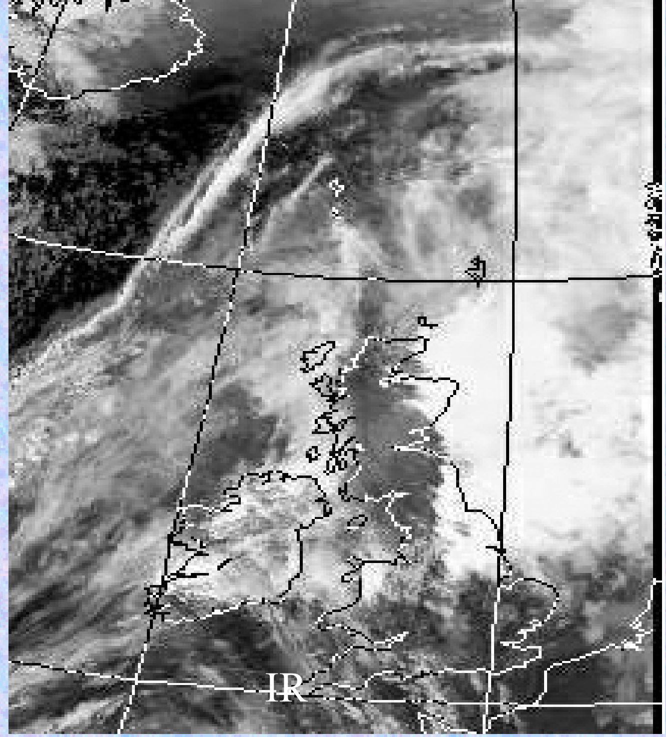


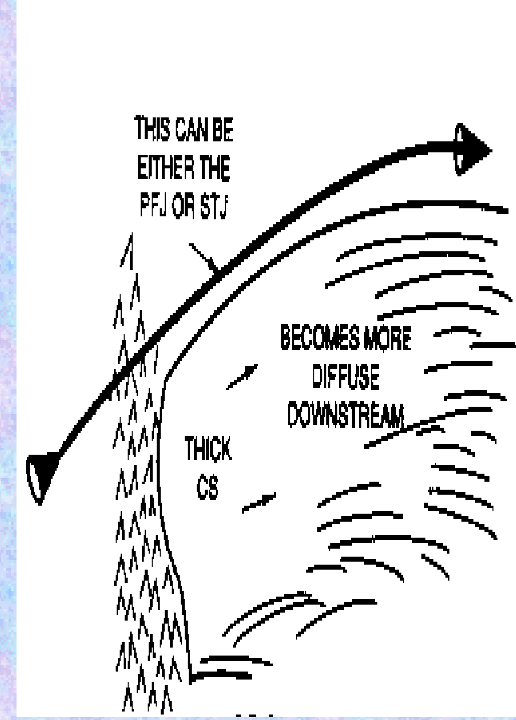


Anvil Cirrus VIS- Anvil cirrus or thunderstorm blow off has a sharp upwind edge with a fuzzy, diffuse downstream edge. The blow off from numerous thunderstorms combines to form an extensive CS canopy. Anvil cirrus appears on **VIS imagery** as bright white on the upstream edge gradual darkening on the downstream side as it thins and becomes translucent. Unless overshooting tops are present, anvil cirrus is very smooth.

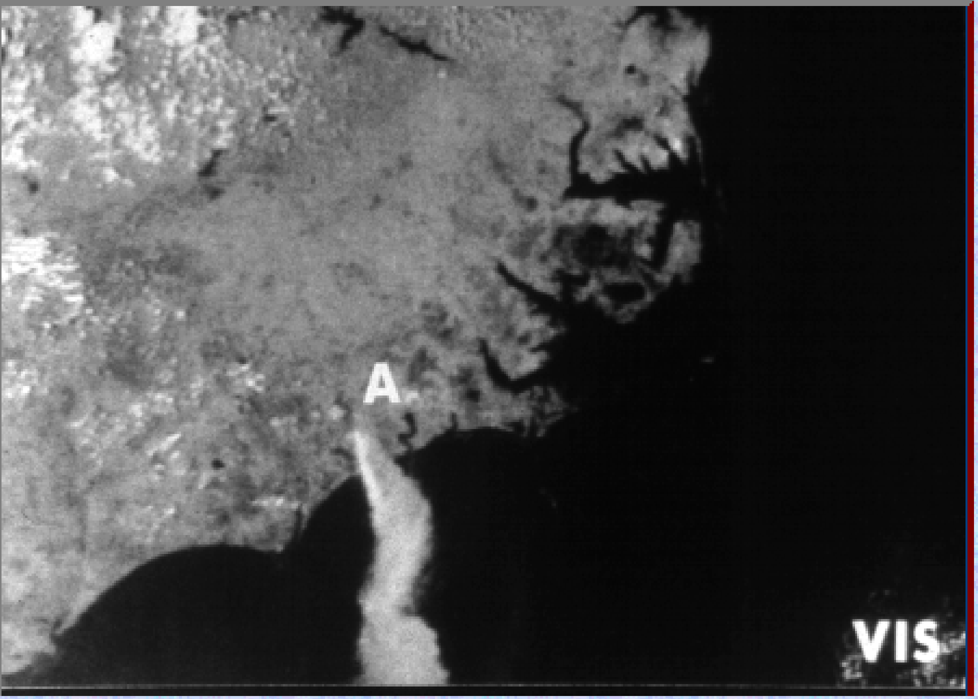
Anvil Cirrus IR - On IR and WV imagery, they appear as bright white patches. On enhanced IR imagery, you'll have a contouring of the cloud tops helping you define the height.





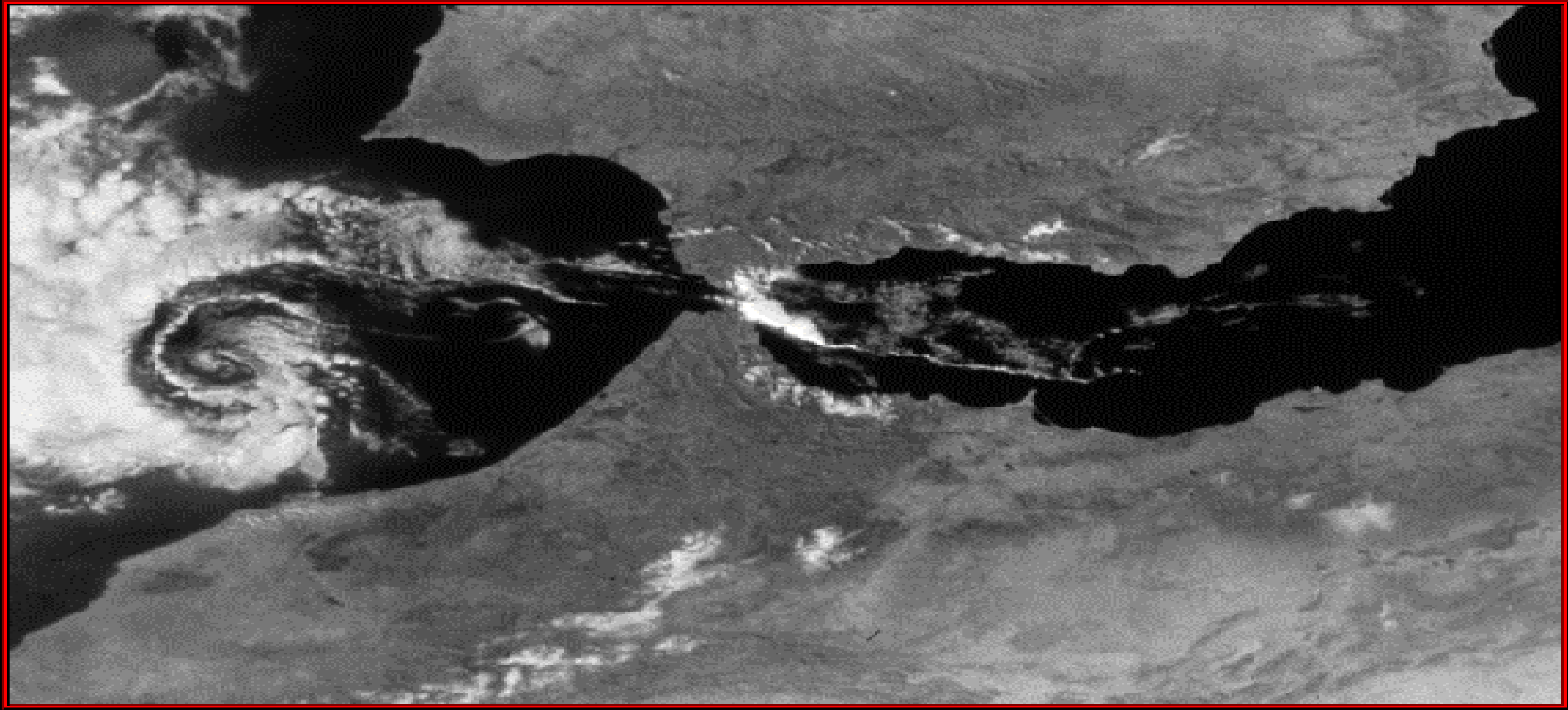


<u>Leeside Cirrus</u> - Lee-of-the-mountain cirrus, or leeside cirrus, is a multi-layered CI cloud shield on the lee of a mountain chain. A sharp, stationary upwind cloud edge, along the ridge line, shows the presence of standing mountain waves. They tend to form late at night and dissipate in the afternoon. There is an inversion or isothermal layer above the mountain tops. The cloud tops range from 25,000-35,000 ft with bases from 10,000 - 15,000 ft. Their occurrence appears highly dependent on the presence of a high-level moisture source in a strong wind zone. It's typically located with and just south of the PFJ but does not have to be near the jet stream. **<u>WV imagery</u>** helps identify areas of moist air where leeside cirrus may occur while other imagery will show the area as cloud free. Leeside cirrus will affect the temperatures by blocking out incoming solar radiation. Leeside cirrus appears bright white with a sharp edge along the ridge line on **<u>VIS imagery</u>**. It can appear as thick CS, becoming more diffuse downstream. Contamination is a problem on the downstream edge. On IR imagery, leeside cirrus is a bright white gray shade.. **<u>Enhanced IR imagery</u>** will show contouring of the cloud tops.



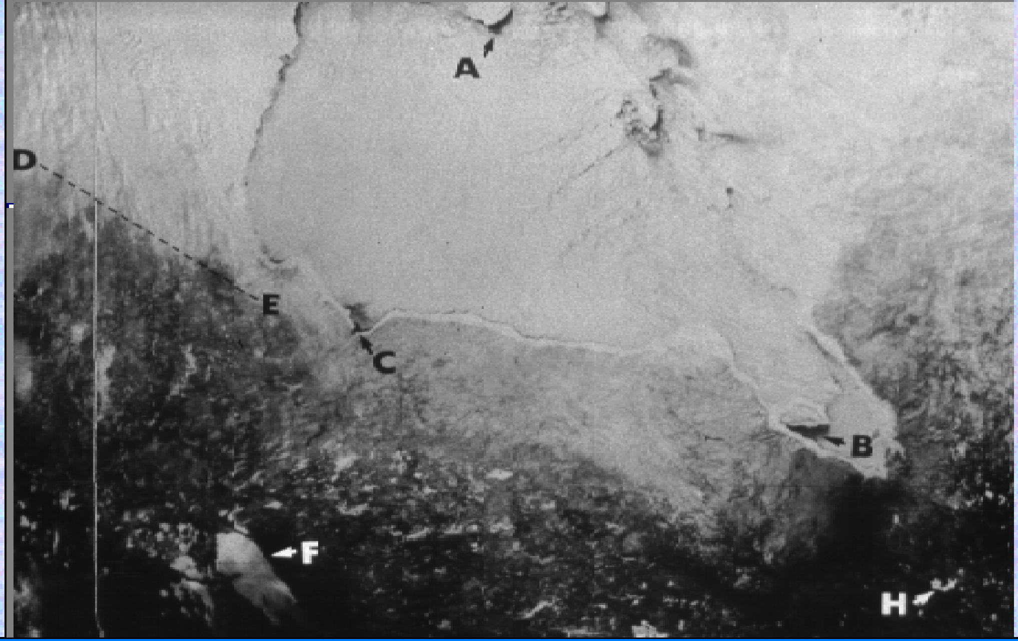
Carolina Fire

Dust, smoke, haze and fog are also often detected in satellite imagery. When skies are clear, smoke from large fires can be clearly seen. In the upper visible top image, smoke from a forest fire near the North Carolina Coast is seen at (A). The smoke pattern from a single fire area starts as a narrow bright band and expands sideways as it blows downwind. On a less windy day than this, the smoke may rise vertically. Strong upward air motions from fires may help produce a cloud, sometimes a thunderstorm. Notice that the infrared image shows the smoke is colder (whiter) than the offshore waters.



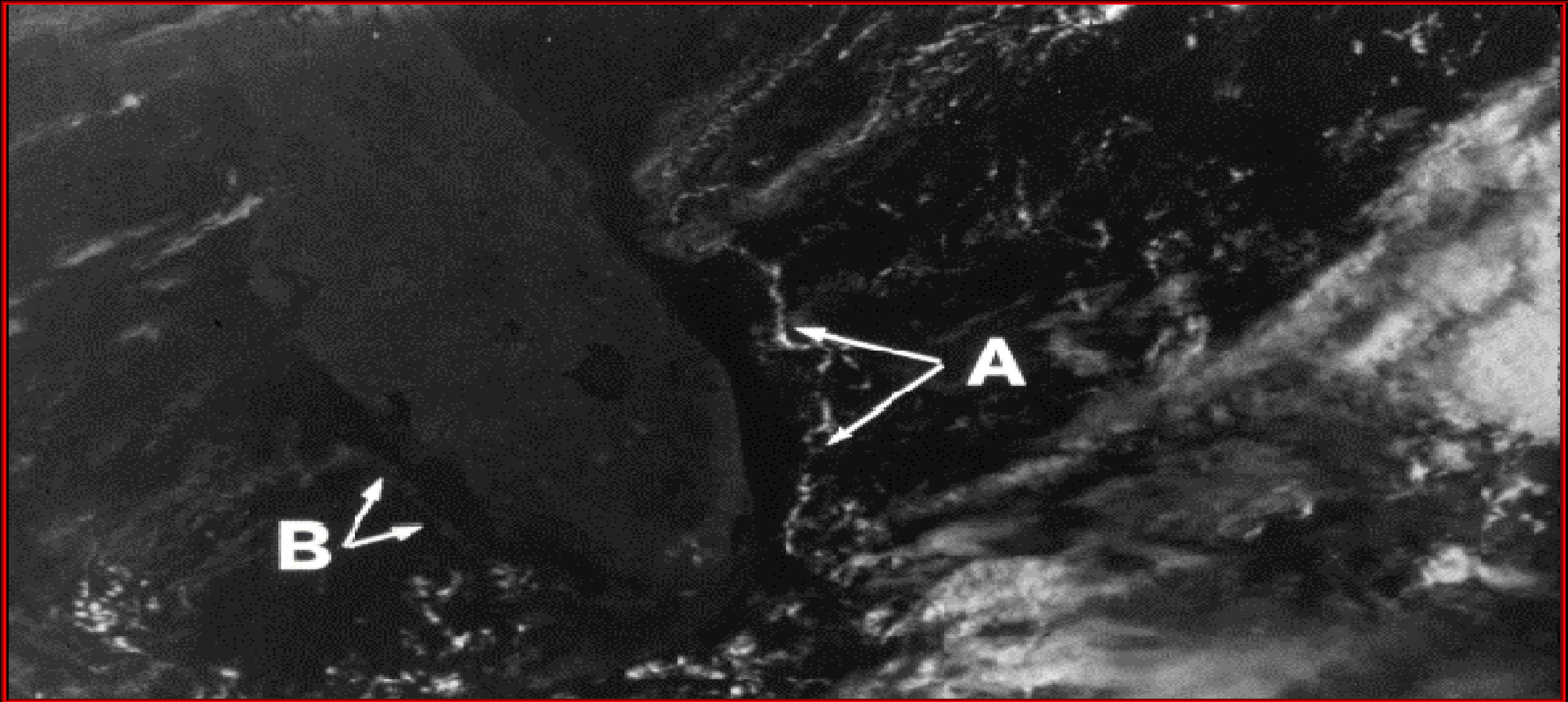
GAP WINDS

Strong winds are often channeled through gaps in mountain ranges. You may be able to detect their presence by cloud patterns or shapes, water temperature distributions, reflections of sunlight off water surfaces, or blowing spray. On many days each year, strong easterly winds blow through the Strait of Gibralter, at the western end of the Mediterranean Sea. When an inversion lies below the level of the mountain tops bordering the Strait, strong, low level winds called the Levante may develop. A long, low-level cloud line may be evident in the upstream convergence zone. This line often lasts as long as the strong winds continue. Downstream, cyclonic eddies are frequently observed. Although these sometimes look like strong cyclones or polar lows, the winds in them are usually quite weak.



Ice Over Hudson Bay

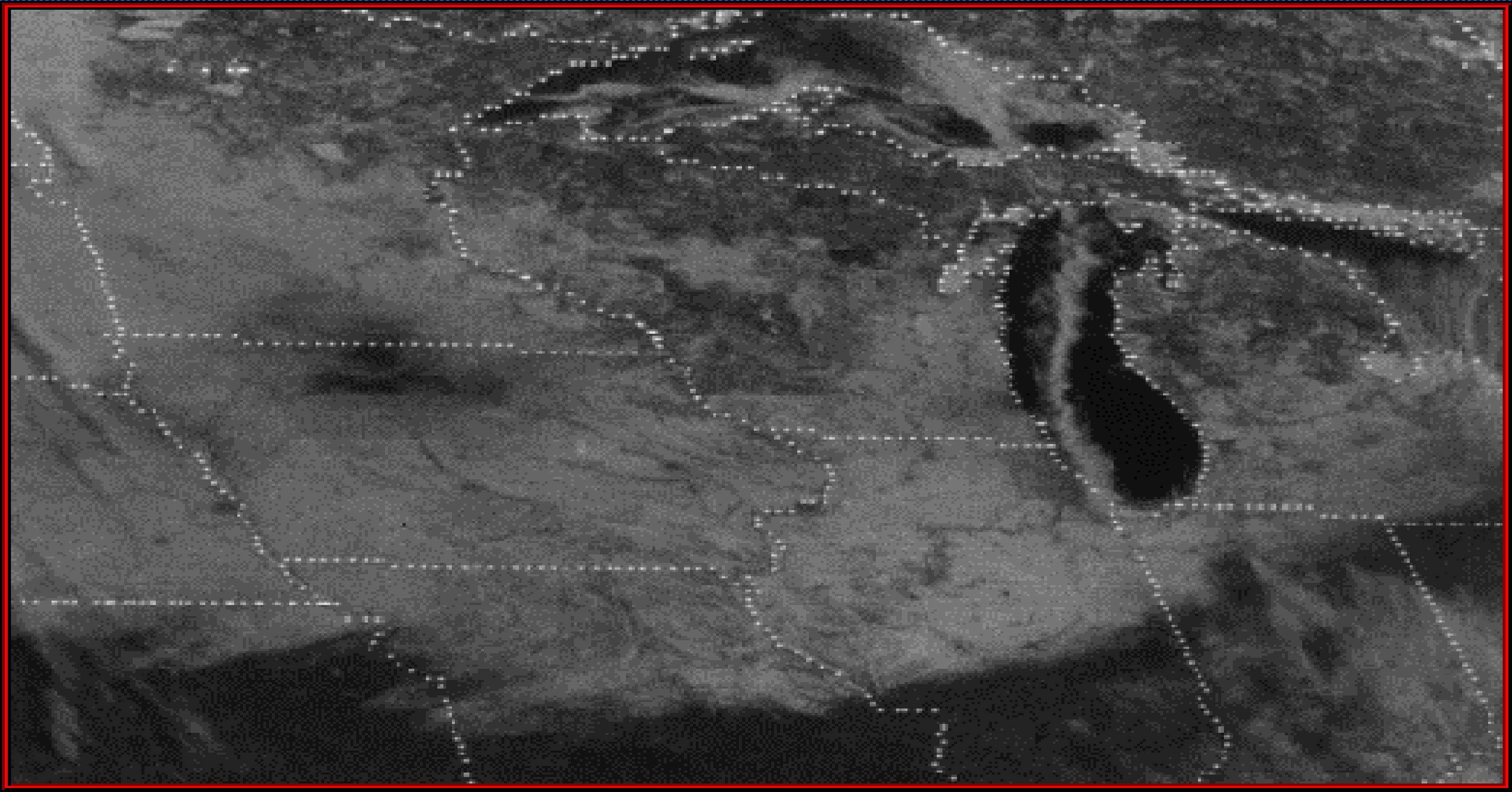
Hudson and James Bays, located between 50° North and 65° North latitude, freeze each Winter and remain frozen most of the Spring. Due to limited atmospheric moisture in the area, very little snow falls, and all the surrounding lakes are frozen. The bright area along the southern shore between (B) and (C) is "fast ice", ice frozen or fastened to shore all winter. Floating ice, which moves with the wind and tide can be seen away from the shore. The dark areas in this image at (A, B, and C) are ice free areas, due to the tide and wind moving the ice offshore. North of line (D-E) lies the tundra, where treeless snow covered land is white. South of (D-E), the tree covered land is dark; only frozen and snow covered lakes, such as at (F, G, and H) are white.



LAND BREEZE

At night, convection over land usually ceases as the land cools. If the air over the land is dry, cooling is often quite rapid. When the air over the land becomes cooler than the surrounding waters, the cool air flows seaward in what is called a land breeze. A line of cumulus is sometimes located at its leading edge.

In this image of Florida, taken early in the day (0800 LST), skies are clear over the land and a line of convective clouds can be seen off the southeast coast (A). A weaker line is seen off the southwest coast (B). In each case the winds are blowing offshore perpendicular to the coast.

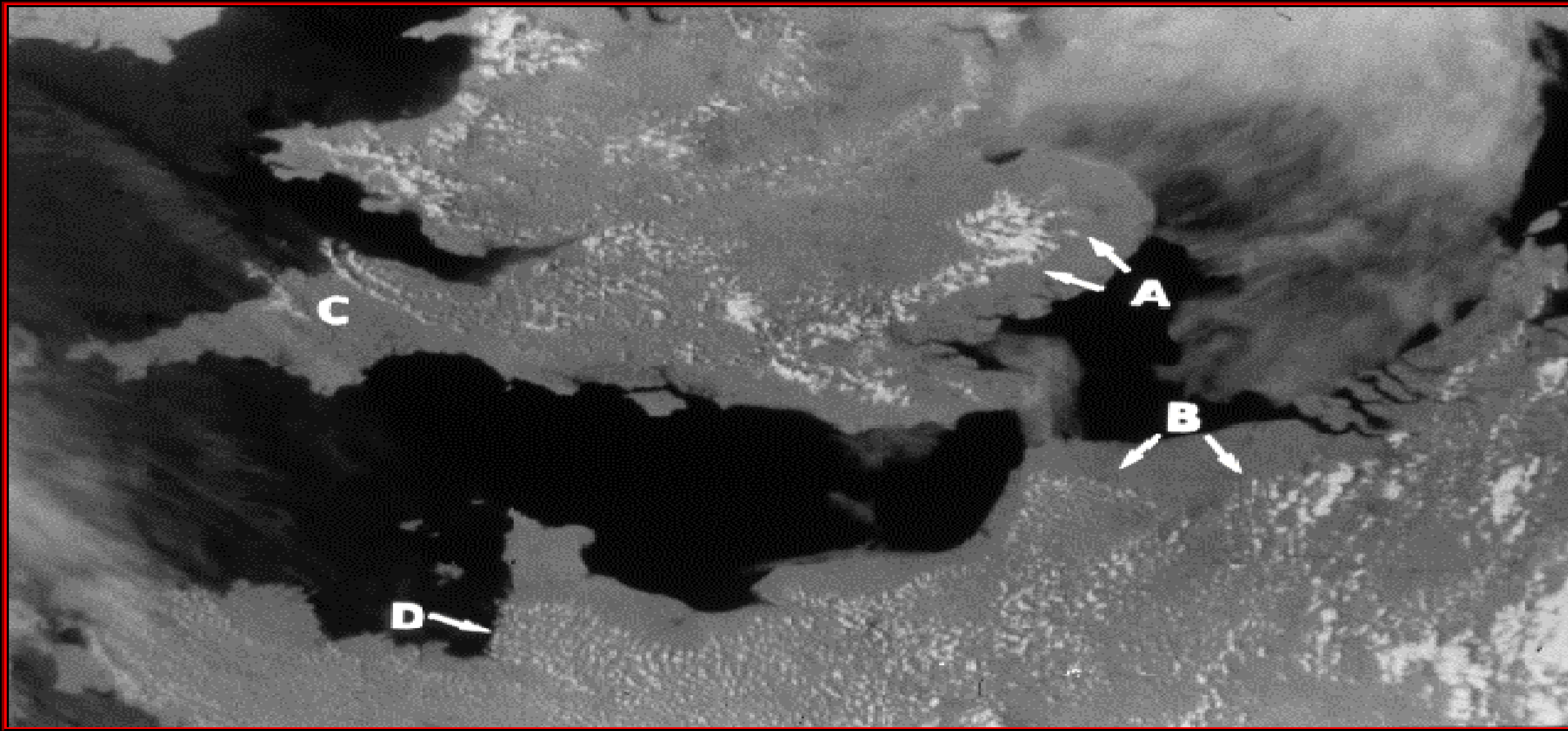


CONVERGING LAND BREEZE

Land breezes from the cold, snow-covered east and west shores of Lake Michigan are converging over the warmer lake to form a continuous line of cumulus clouds. The general wind flow is from the north. Heavy snow fell near Chicago on this day.

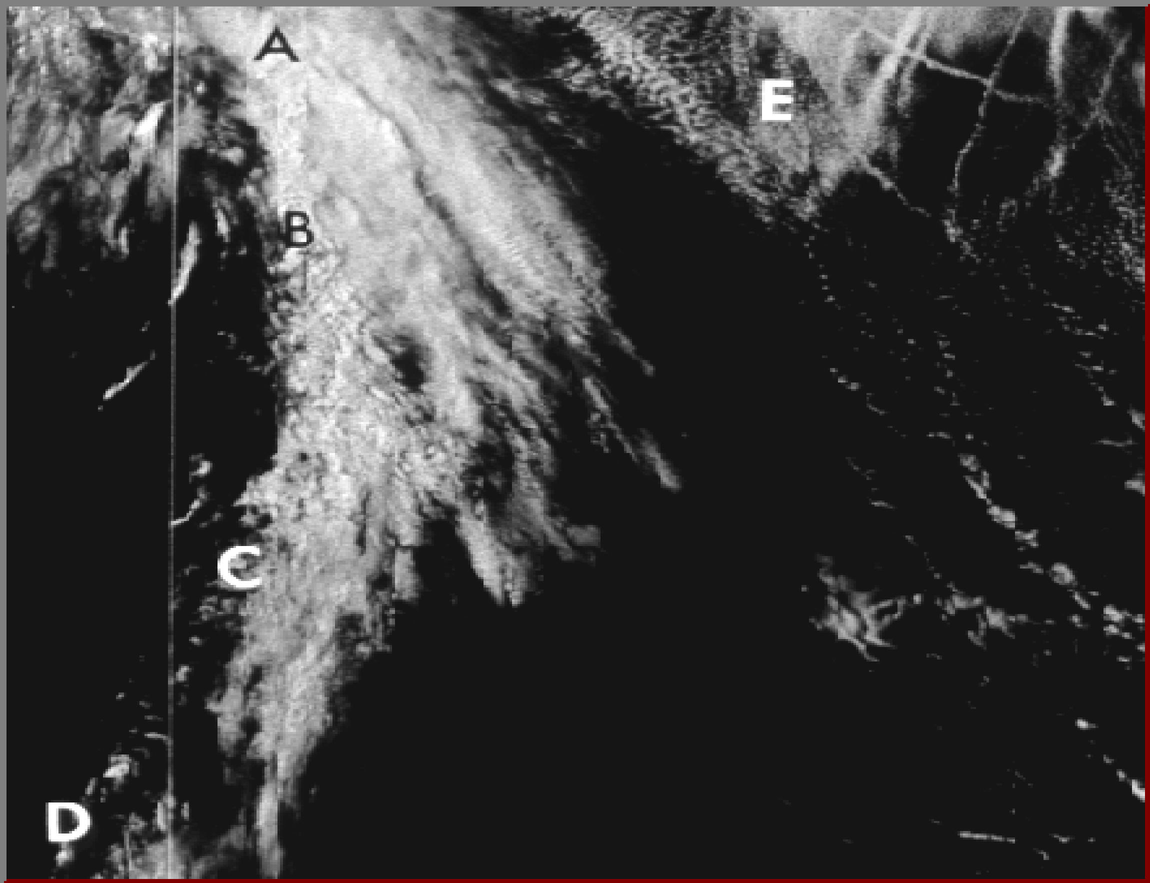
SEA BREEZE

The prevailing winds in September over northeastern South America are from the east and southeast. The sea breeze during the day tends to modify the prevailing midday flow near the coast, creating east to northeast winds. In this image we see thunderstorms in a line along the sea breeze front (A-B), in coastal Guyana.



SEA BREEZE

Fair weather cumulus cloud patterns are often excellent indicators of surface and low level wind direction. Their location on days with sea breezes or other onshore flow gives excellent clues for determining local wind directions. A sea breeze results from differential solar heating, where land is warmed more than an adjacent ocean, thus creating an onshore wind flow. Clear coastlines with an inland line of cumulus will likely have a sea breeze blowing onshore. In this image, eastern England (A) and northern Europe (B) have onshore sea breezes in the clear zones. Over western England (C), where the cumulus pattern extends to the coast, no sea breeze is moving inland; therefore, winds must be off shore. Similarly, at the west coast of Normandy on the Gulf of St. Malo (D), the cumulus clouds extend to the coast, indicating winds with an offshore (easterly) component.



Ship Trails

The imagery presented so far has been designed to help you recognize some of the surface and near surface water features. Now we will examine the clouds and cloud patterns which accompany different atmospheric circulation patterns. The band of clouds (A - B - C - D) is typical of a weak cold front in subtropical ocean areas. At the northern end of the cloud band (A), cirrus covers the more convective and brighter lower clouds. The stratocumulus east of the front at (E) is caused by convection under a stable layer (inversion). The criss-cross lines of enhanced clouds form because smoke from ships increases the number of condensation nuclei and add moisture to the air. These are similar to aircraft condensation trails.

FINAL THOUGHTS

CONCEPTS OF INTERPRETING WEATHER SATELLITE IMAGERY

LOOK AT THE SYNOPTIC SITUATION: WHEN INTERPRETING SPECIFIC FEATURES, ENSURE YOU LOOK AT THE WHOLE IMAGE TO DETERMINE WHAT THE FEATURE IS AND HOW IT FITS INTO THE SYNOPTIC SITUATION. DON'T GET TUNNEL VISION AND JUST LOOK AT ONE FEATURE.

USE AVAILABLE IMAGERY: USE THE DIFFERENT IMAGERY TOGETHER WHENEVER POSSIBIBLE TO TAKE ADVANTAGE OF EACH ONES UNIQUE PROPERTIES. THE VISUAL WILL DEFINE SMALL-SCALE FEATURES SUCH AS TERRAIN, CLOUD SHADOWS, TEXTURE, SMALL LOW CLOUDS, ETC. THE INFARED IMAGERY MAKES RELATIVE CLOUD HEIGHT ANALYSIS POSSIBLE, AND THUS, SPECIFIC CLOUD TYPES.

CONTINUITY: ANOTHER EXCELLENT WAY TO FOLLOW CLOUD FEATURES AND SHOULD BE USED AT ALL TIMES. AT NIGHT WHEN NO VISUAL IMAGERY IS AVAILABE, LOOK AT THE LAST VISUAL AND INFARED IMAGERY OF THE DAY. THEN FOLLOW THE FEATURES ON THE INFRARED THROUGH THE NIGHT KEEPING IN MIND WHAT THEY WOULD LIKE ON THE VISUAL.

TERRAIN: ALWAYS USE AN ATLAS OR LOCAL TERRAIN MAP WHEN INTERPRETING THE IMAGERY. THIS ENSURES THAT YOU DON'T MISTAKE TERRAIN FEATURES FOR CLOUDS. FOR EXAMPLE, LOW LYING FOG/STRATUS VERSUS SNOW COVERED TERRAIN.

RESOURCES

BASIC SATELLITE IMAGERY INTERPRETATION

WEATHER TRAINING FLIGHT SATELLITE ANALYSIS

THE WORLD WIDE INTERNET

THANKYOU!