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Talking Points for VISITview Lesson

Fog Detection and Analysis With Satellite Data

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1. Title

2. Fog has a major impact on air safety and efficiency, and may also affect surface transportation. Satellite detection is an important tool to help mitigate these effects.

3. Topic outline of presentation.

4. Differences in the radiative properties of fog and stratus in the 3.9 and 11 micron GOES channels result in temperature contrasts that allow their detection at night.

5. Temperature transect along the line A-B from southwest Kansas to central Oklahoma. Fog and stratus (near point B) appear significantly cooler at 3.9 microns than at 11 microns. In the area of cirrus clouds (Point A) the opposite is true. In cloud-free regions, there is little difference in the two channels. In addition to the 11-3.9 micron fog product, the 3.9 micron channel alone can also show the fog clearly because of the large thermal gradient at the cloud edge.

6. In this example, the 11 micron IR is better than the 3.9 channel over land, but the opposite is true over water. The two-band difference provides the best overall depiction, regardless of conditions.

7. Some subjective rules are listed here to help identify likely areas where the lowest ceilings and visibilities can be found in the 11-3.9 micron images.

8. The 11-3.9 micron image shows that fog has formed overnight in the valleys of New Mexico and southeast Arizona, while higher based stratocumulus and altostratus (based on colder top temperatures in the 11 micron IR image at right) can be seen over southwest Kansas, southern Colorado, and southeast Utah.

9. Light east-southeast flow, high dew points, and cloud-free conditions over the Ohio Valley, lower Great Lakes, and northern Midwest create an ideal situation for fog formation on the night of 19 July 2001.

10. Animation of the 11-3.9 micron fog product on 19 July 2001 (hourly from 0115 UTC to 1115 UTC) shows fog formation over Wisconsin, southwest Minnesota, and the Ohio Valley.

11. An animation of the 11-3.9 micron fog product on 2 August 2001 (hourly from 0300 UTC to 1200 UTC) shows how coastal California stratus develops in the inland valleys, possibly aided by two vortices just offshore that can act to deepen the marine layer.

12. Color enhancement can aid interpretation of derived image products, although caution is required due to the assignment of fixed thresholds that may not be representative in some situations. Avoid subtle red-green combinations that may be difficult to distinguish for those who are color-blind.

13. A NWS Western Region web site has information on how to modify or enhance satellite images on AWIPS. More information is also available from a NESDIS web page.

14A-14B. In this two panel comparison of the AWIPS CONUS sector 11-3.9 micron image, color enhancement allows easier identification of the low cloud areas (shown in yellow), and cirrus (black to light blue).

15. A special color enhancement, originally derived with the help of PIREPs from 1989-92, can be used to estimate the depth of fog and stratus cloud layers.

16. Information on the fog depth enhancement (such as this color graph) is found at the web site shown.

17. This is an example of how the fog depth enhancement can be applied, for a case on 15 March 2000 in the Southern Plains. Thicker patches of stratus and fog (red and yellow areas) persisted for more than five hours.

18. Verification of GOES fog depth technique using recent PIREPs (1997-2001) shows some correlation. Outliers are probably due to multi-layered cloud situations.

19. Limitations of the fog detection capability of GOES are listed. Some relate to satellite instrument characteristics, others to cloud and surface properties.

20. This shows how the resolution of the fog imagery improved with the GOES-8 Imager versus the GOES-7 sounder in 1994.

21. A comparison of IR fog detection capability for 4 km resolution GOES versus 1 km AVHRR data from the NOAA polar orbiting satellites.

22. Marine stratocumulus has a smaller 3.9 - 11 micron brightness temperature difference (BTD) at night, due to the larger droplet sizes present, compared with ship condensation trails which have very small droplets. This requires a smaller IR threshold than the 2 degree K value normally used. Coarse sandy soils (shown in the desert areas) have the same signal as fog in the two channel product.

23. An example showing how the 2 degree K threshold used in the fog product can result in underestimation of fog in the Puget Sound area.

24. An experimental product has been developed to highlight areas where low ceilings (<1000 ft) are likely. The images are available at the web site shown. A simple test at each pixel location determines if the GOES IR cloud top temperature is within 4 degrees K of the surface

(METAR) temperature, provided low clouds are indicated in the two channel product. If so, it is identified as a location where IFR ceilings are likely.

25. This example shows the experimental Low Cloud Base product (right) compared with a simple two band fog product (left). Most areas of IFR ceilings in the Coastal Plain are identified by the LCB image. Thin cirrus over South Carolina results in mis-classified low clouds.

26. The graph at lower left shows the classic vertical temperature profile in fog and low stratus conditions. The sounding at Alpena, Michigan indicates that a higher cloud layer was present above the fog, leading to underdetection of low ceilings in the LCB image (IR minus surface temperature was > 4 K).

27. Regional verification of the LCB product shows that it performs best in the central and western U. S., and worst along the East Coast.

28. Visible and shortwave IR imagery (1.6 and 3.9 microns) are useful in the detection and monitoring of fog during the daylight hours. A "reflectance product" can provide similar results by removing much of the thermal component from the 3.9 micron band.

29. Fog over snow cover can be very difficult to detect during daytime with visible imagery. In this example, the 3.9 micron image highlights the stratus and fog due to strong reflectance of sunlight at this wavelength, leading to warm brightness temperatures relative to the land.

30A-30B. The 1.6 micron near-IR channel (from NOAA AVHRR or NASA MODIS) also provides good discrimination of fog from snow, due to stronger solar reflectance by the fog.

31A-31B. The 3.9 IR micron channel is shown to be just as effective as the 1.6 micron channel, based on this MODIS comparison.

32. By using multi-color compositing techniques, information from three spectral channels can be merged into one image. In this example, the fog appears yellow, since the strongest signal comes from the visible (red) and 1.6 micron (green) color guns. Similar color composites from the NOAA AVHRR during daytime can be obtained at the Web address shown.

33. A fog bank usually dissipates from the outer edges inward. When winds are a factor, the upstream portion of a fog bank tends to dissipate fastest. Thick fog, overlying thick cloud layers, and cool or moist surfaces tend to retard fog clearing.

34. On 14 June 2001 at 1045 UTC, the GOES-8 visible image shows extensive sea fog over coastal shelf waters, extending inland into the Middle Atlantic states. The remnants of Tropical Storm Allison are located over eastern North Carolina.

35. Animation of GOES-8 visible imagery on 14 June 2001 (from 1015 UTC to 1845 UTC) shows little or no clearing offshore where the coastal shelf waters are cool, and slow clearing in the foothills of the Appalachian Mountains (eastern Pennsylvania and northern New Jersey) due to uplsope flow.

36. Animation of GOES-8 visible imagery on 19 July 2001 (from 1215 to 1645 UTC) shows rapid clearing of fog over Wisconsin, despite some cirrus spreading over the area from the west. The outside-inward clearing trend is clearly evident in northern Wisconsin.

37. Animation of GOES-10 visible imagery (hourly from 1500 to 2100 UTC) shows marine stratus dissipating rapidly in inland valleys of California, except where it is being replenished by strong onshore flow, such as in the San Francisco and Monterey Bays. Note the Catalina eddy in the Los Angeles bight, which accelerates clearing to its northwest, but retards clearing to its east

38. Forecasting the time of clearing requires knowledge of fog depth, obtained from aircraft pilot reports, or satellite techniques. Techniques using satellite brightness differences, and cloud parameters versus location and time of year have also been developed.

39. Data from a 1938 study shows fog depth versus clearing time at three locations in the United States, appended with more recent data from the San Francisco Bay area. There is good agreement in the results (the later clearing time required for the SFO stratus is to be expected).

40. A PC program by Bob Jackson, CWSU Auburn, Washington, provides forecast time-of-clearing by entering some basic information about location, ceiling height, and fog top.

41. Some other satellite-derived products are available to assist in the anticipation of nighttime fog formation.

42. Sea surface temperatures, combined with surface dew points and wind information can be used to predict the likelihood of fog development. SST on 19 July 2001 was near or below the dew points (high 60's to low 70's F) along the west shore of Lake Michigan north of Chicago where dense advection fog developed during the night.

43. GOES moisture products (Total Precipitable Water and 11-12 um IR) can help assess areas where fog is more (or less) likely. In this example over the Midwest on 29 August 2002, fog and stratus formed mainly to the west of a pronounced dry zone shown in the satellite products over Michigan and Illinois.

44. A surface wetness index, available at the indicated web site, is derived from two Special Sensor Microwave Imager (SSM/I) polarized channels at 85 GHz and 19 GHz. On 19 July 2001, the SWI indicates wet conditions over Minnesota, northwest Iowa, and eastern South Dakota where radiation fog developed during the night.

45. The Cloud Top Height product produced from GOES Sounder data now has improved height values for low level stratus.

46. Near-term improvements to GOES are limited to the capability to operate the Imager through the Spring and Fall eclipse periods by GOES-N. An Advance Baseline Imager will provide higher resolution and more frequent imaging by ~2013.

47. This is an example of what 2 km resolution on the ABI will provide for fog detection applications.

48. Summary of satellite data applications in fog detection and short range forecasting.

49. Internet resources for obtaining products and more information.

50. Acknowledgments