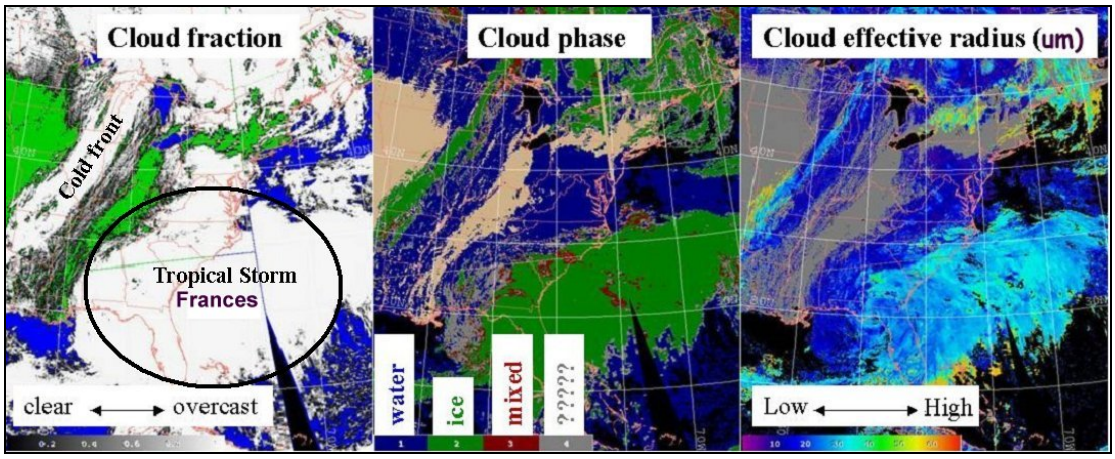
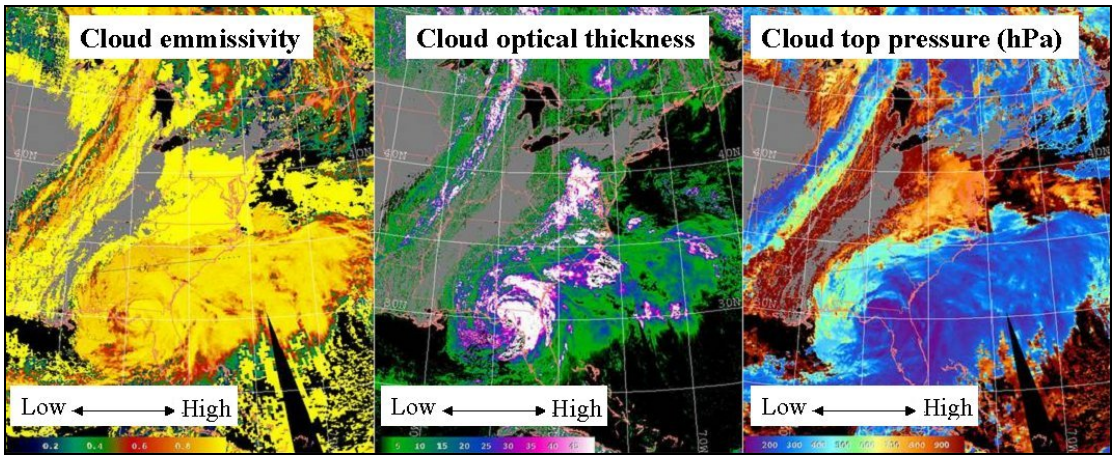
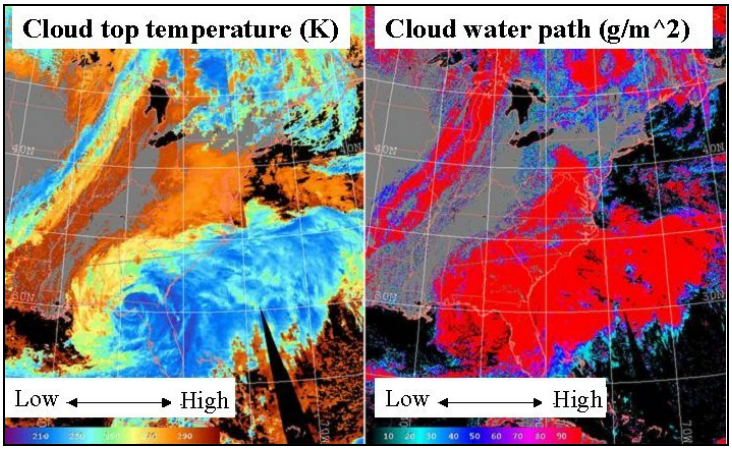
NexSat

Satellite Product Tutorials:

Cloud Properties







Above:

The products above display the cloud properties of Tropical Storm Frances (formerly Hurricane Frances), as it moved across the Florida peninsula during the morning hours on 9/06/2004. A cold front across the Midwest is also evident. The legends within each product above are labeled in intensity. These products are developed and supplied to the Naval Research Laboratory's NexSat web site from the MODIS Science Team at NASA-Goddard Space Flight Center.

Why We're Interested…

Clouds play a major role in the radiation balance of the earth. Much of the current research effort is geared in this area; the ability to better identify cloud cover and cloud properties will greatly aid researchers in assessing global warming or cooling. Other areas that greatly benefit from better sensing of cloud properties include weather prediction models, weather forecast analyses, hurricane prediction, military and aircraft operations, and many others.

How This Product is Created…

The MODIS Cloud Products displayed above ingests infrared and visible satellite data from both the Terra and Aqua satellites at a 1 X 1 km pixel resolution. NRL receives the products via MODIS at approximately 1.5 hours after the data is collected. The individual processing techniques can be found at http://modis-atmos.gsfc.nasa.gov/MOD06_L2.

How to Interpret…

There are 8 cloud property products developed by the MODIS Science Team that NRL displays (see above). The following is a brief general description.

I. Description of individual cloud properties

1. Cloud fraction: This product provides the user with a clear assessment of the amount of cloud cover over the region of interest. Cloud amounts range from clear (green for land and blue for water) to varying amounts of cloud ranging from almost clear (dark gray) to completely cloudy or overcast (bright white). As displayed above, bright white regions are within the heart of Hurricane Frances and the cold front central axis, whereas varying

shades of gray exist within the boundaries of these weather systems.

2. Cloud phase: This product is color coded and depicts whether the top of the cloud is detected as either water, ice, water and ice mixed, or unknown. As shown above, coldest regions of the hurricane and the central axis of the cold front are in the ice phase, whereas the warmer regions of these systems are in the water phase. A few pockets of red within the hurricane are in the mixed phase. Finally, some unknown cloud phase exist within the western portion of the hurricane, west of Florida.
3. Cloud effective radius: Although the mathematics behind this product is complex, the resulting value provides what amounts to a representative cloud droplet radius in microns. This product greatly aids researchers in calculating other atmospheric products.
4. Cloud emmissivity: This product describes the cloud's ability to absorb and radiate energy. Lower values indicate that either the cloud is not emitting energy back to space (absorbing the energy) or that the cloud particles do not contain much density. In addition, ice emits less radiation than water droplets.
5. Cloud optical thickness: Optical thickness is a measure of transparency, i.e., allowing light to pass through. One way of visualizing optical thickness is to think of an object within fog. An object that is immediately in front of you has an optical thickness of zero, since you can see the object clearly. As the object moves away from you, the object becomes fuzzier, and the optical thickness increases toward one. Clouds which contain a higher density of droplets (tops of thunderstorms, hurricanes, cold fronts) contain higher optical thickness and will be harder to see through.
6. Cloud top pressure: This product depicts the tops of clouds in atmospheric pressure units: hecto-Pascal (10^2 Pascals). (more familiarly, 1 hPa = 1 millibar). Pilots often like to use cloud top pressure to determine relative heights within the atmosphere they are flying into.
7. Cloud top temperature: This product depicts the tops of clouds in degrees Kelvin. To convert to degrees Celsius, subtract the value by 273.15 degrees.

8. Cloud water path: Liquid water path [weight in grams of water droplets in a square meter air column (gm/m^2)] is a measure of the total amount of liquid water present in an air column. In the figure above, the red regions within the hurricane and cold front indicate the densest regions of cloud water droplets.

II. Relationships between the various cloud properties

This section provides a brief description in relating one product to another.

- Cloud fraction vs Cloud phase: Although one can determine only that clouds exist within the cloud fraction product, one can clearly distinguish the water from ice clouds within the cloud phase product, especially along the cold front axis.
- Cloud phase vs Cloud emissivity: From the cloud phase product, we view the regions of water cloud (blue) vs ice cloud (green). Corresponding clouds within the cloud emissivity product indicate that the water cloud regions within the cold front and hurricane have slightly higher (bright yellow) emissivity values than ice clouds (orange-yellow). This is due to differences in optical properties between ice crystals and liquid water drops.
- Cloud phase vs Cloud optical thickness: Although the clouds associated with both the leading edge of the Midwestern cold front and the northeastern quadrant of the hurricane are extensive in coverage, the cloud optical depth product indicates that these regions are rather thin or transparent.
- Cloud top temperature vs cloud phase: The cloud tops colder than freezing are shown within the blue and yellow shaded regions within the cloud top temperature product. Compared to the cloud phase product, one can find small regions where water clouds exist below freezing, indicating super-cooled liquid water (some of these areas are denoted as "mixed phase" and are shaded in red on the cloud phase product). Pilots try to avoid these regions due to the hazardous aircraft icing conditions associated with these clouds.

Looking Toward the NPOESS Era…

Cloud properties are of vital importance for future research. With its high resolution and daily coverage of cloud products over the earth, the MODIS

satellites provide legacy for the NPOESS/VIIRS sensor and a paradigm shift toward improved cloud characterization in this forthcoming operational era.

Did You Know…?

In an instantaneous sense, clouds actually contribute to global cooling, thus counteracting the global warming associated with increasing CO_2 in the atmosphere. Incoming solar radiation is reflected back into space rather than reaching the earth. In contrast, clouds also prevent outgoing radiation from the earth, but the net effect is weighted toward less solar radiation, thus global cooling. As man-made pollutants increase with time, the additional aerosols serve as condensation nuclei for smaller droplets and more reflective clouds. The sticking point is that while clouds contribute to climate, they are also a function *of* climate—forming and dissipating in accordance to the environmental state. Through complicated and poorly understood feedbacks, clouds interact on many levels with all the elements of the earth-atmosphere system, so currently we can't say with any degree of confidence that global warming will be offset by clouds. Only after observing an extensive time series of cloud properties can we hope to answer these questions.

Want to Learn More?

http://cloudsat.atmos.colostate.edu/
http://modis-atmos.gsfc.nasa.gov/products.html

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