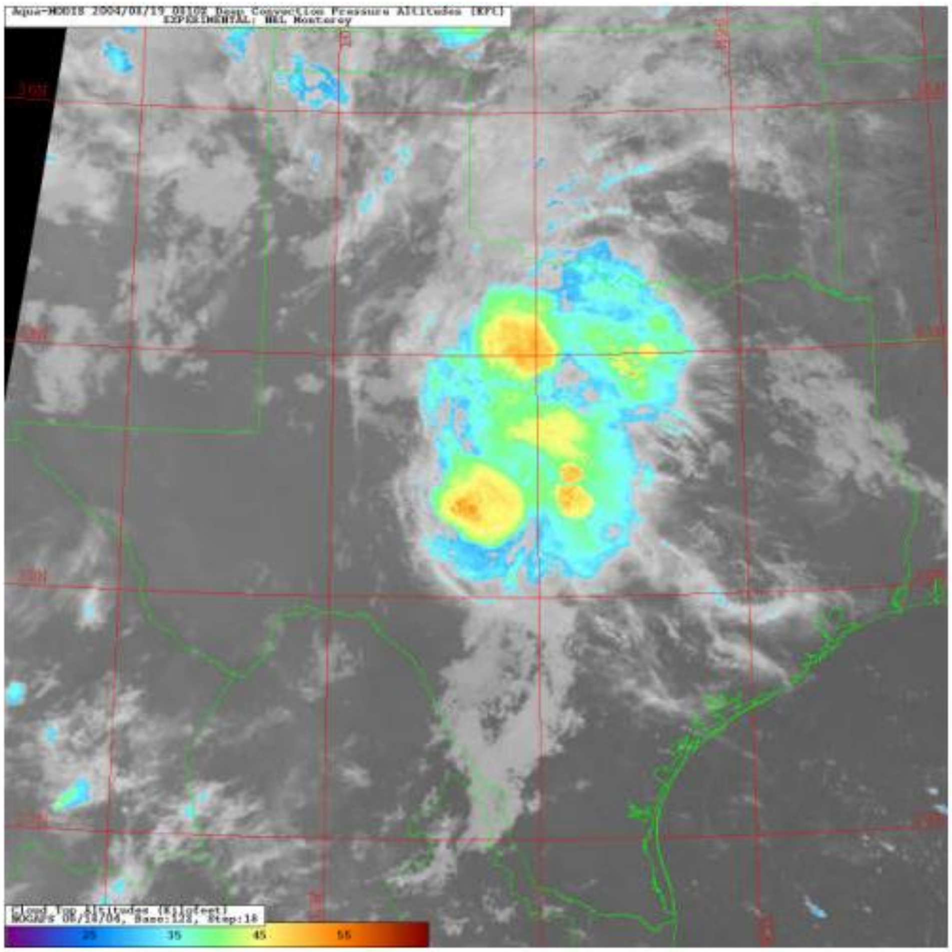
Satellite Product Tutorials:

Convective Cloud Heights



Above: A massive cluster of thunderstorms (colored region) has broken out over Central Texas in the late evening hours. The MODIS convective cloud top product can identify individual cells within the cluster (yellow and orange) by virtue of its 1 km spatial resolution infrared channel data. By comparing the color shades to the color bar at the bottom of the image, you can estimate the convective tops in thousands of feet. Some of the highest tops are well over 16 km (50,000 feet)!

Why We're Interested…

The aviation community depends on knowledge of convective cloud tops to help aircraft avoid hazardous flying conditions. Satellite images have long been used for this purpose but only in a qualitative way. The convective cloud product gives quantitative information about the vertical extent of mature storms. Of course, some radars can give similar information, but the satellite technique we describe here has been used in regions outside the range of surface-based radars, including large expanses of tropical oceans. Also, most operational weather service radars operate at frequencies insensitive to cloud particles (sensing instead the rain drops), and so the "echo tops" reported by these systems seldom represent the true vertical extent of the turbulent cloud structure.

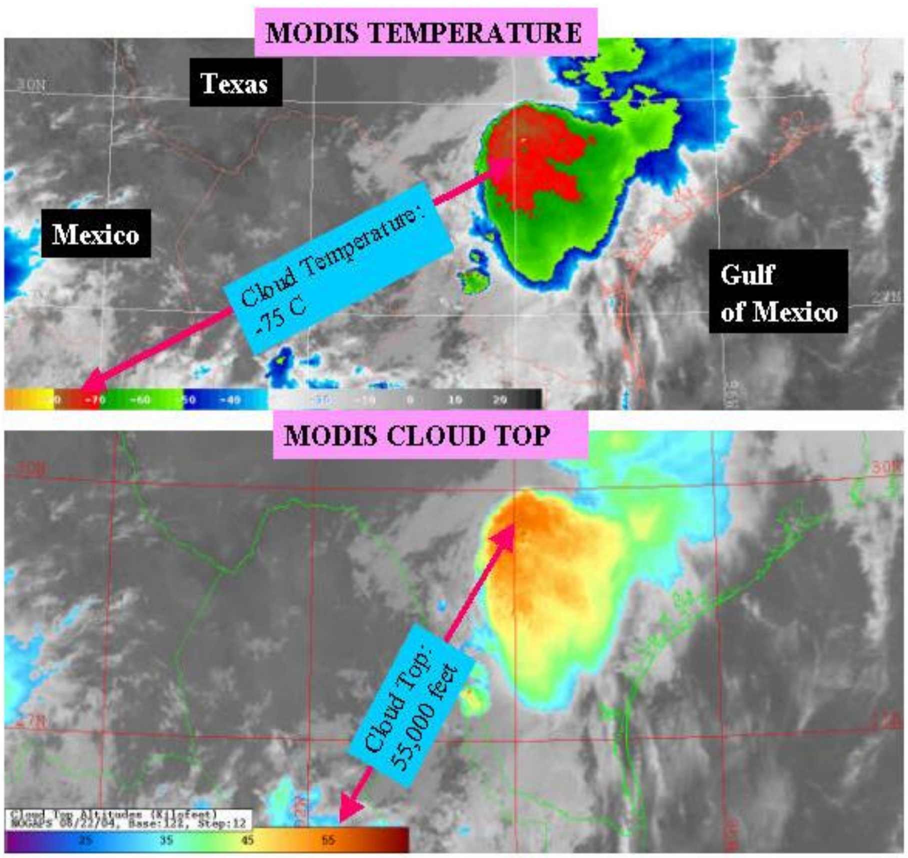
How This Product is Created…

First, deep convection (defined as a storm whose top has reached the upper troposphere) is isolated using a brightness temperature difference between 6.7-μm (a water vapor absorption channel) and 11.0-μm (an infrared-window channel) imagery. Low level clouds produce temperatures lower than their actual cloud top temperatures in the 6.7 μm channel due to emission contributions from cooler water vapor present in the atmospheric column above them, while upper level clouds (being above most of this vapor) produce temperatures close to their actual cloud top temperatures. Since the atmosphere is transparent to the 11.0 μm window channel, cloud top temperatures are representative of actual cloud top temperature for all thick clouds, regardless of their level in the atmosphere,

Differences between the 11.0 and 6.7 μm channel brightness temperatures result in large values for low level or semi-transparent (optically thin) clouds, and small values for thick, upper level clouds. The latter are what we are interested in focusing on for the deep convection product, so we use the 11.0-6.7 μm difference to capture this subset of the clouds in the scene. The infrared temperature of each picture element (or pixel) in this subset cloud field is compared to a vertical temperature profile provided by the Navy Operational Global Atmospheric Prediction System (NOGAPS) numerical model valid for the same time and place. The height in the atmosphere where the satellite and NOGAPS temperatures match is the estimated cloud top.

How to Interpret…

Below, the top image shows a colorized MODIS infrared image. Greens and red colors denote the coldest tops characteristic of deep convective clouds. The arrows show how someone can determine the temperature of the cloud top by matching the particular color of a feature with the color bar. This is an easy procedure possible using most infrared images on the internet, but not very useful to weather forecasters since they need to know the height of the cloud top, not its temperature. The bottom cloud top image is based on the same data. Here, color can now be used to depict the actual height. In this case the orange color corresponds to a height of about 55,000 feet.



As designed, the product does not determine the heights of low clouds: if no color appears (gray-scale infrared imagery only) no estimate is possible. For thin clouds around the edges of thunderstorms, underestimation of height may occur. We can adjust these heights to correspond to the readings produced by aircraft altimeters, which assume a "standard" (or averaged) atmospheric profile in the calibration of height as a function of pressure.

Looking Toward the NPOESS Era…

The NPOESS Visible/Infrared Imaging Radiometer Suite (VIIRS) will feature higher spatial resolution (roughly a factor of 2) for the channels used for convective cloud top. Therefore the product will be more detailed and accurate. More importantly, since NPOESS products will be available in about a half hour from overpass time anywhere in the world, the operational value of the VIIRS cloud top product will be multiplied.

Did You Know…?

There are nearly 1,800 thunderstorms are in progress over the surface of the earth at one time! More deaths from lightning occur on the East Coast. Lightning is responsible for more fires in the West because the lightning season coincides with the dry season.

Want to Learn More?

Jones, D., 2004a: The Future of Earth—Sensing from Space, The Next Generation Satellite Series: A Look at NPOESS and Its Benefits. *Earth Observation Magazine*, 13, 1, 4-10.

Jones, D., C. Nelson, and M. Bonadonna, 2004c: NPOESS: 21st Century Space-Based Military Support, *Earth Observation Magazine*, 13 4, 24-3

Author*: NRL Monterey, (webmaster@nrlmry.navy.mil)*

Last Modified: 1/6/2006