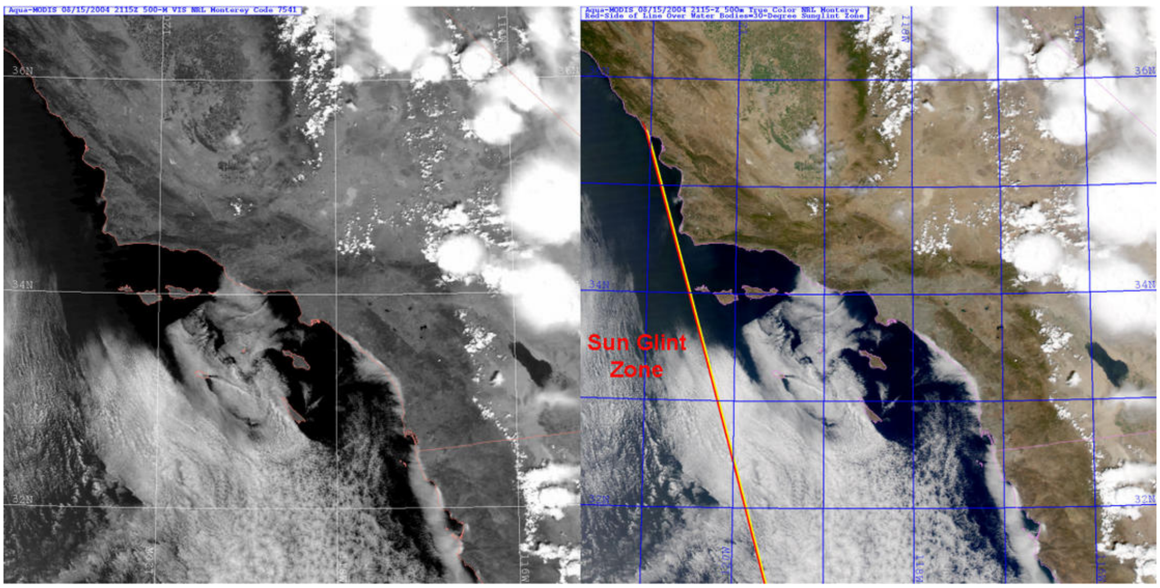
Satellite Product Tutorials:

True Color Imagery



Above: By simulating the response of human vision, true (a.k.a. "natural") color imagery provides a visually intuitive depiction of the satellite-observed scene. In this example, while visible channel imagery (left) over Southern California provides a good depiction of the marine stratocumulus clouds offshore and the inland thunderstorms, true color (right) provides additional detail of blue Pacific waters, green farmland in the San Joaquin Valley (at upper left), and the gray concrete metropolis of Los Angeles (center). The Sun Glint zone (discussed below) delineates areas over water where reflected sunlight brightens the scene. The true color imagery examples on NexSat are derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) instruments flying aboard the Terra and Aqua satellites as part of the NASA Earth Observing System (EOS) project.

Why We're Interested…

To experts and non-experts alike, making sense of conventional visible-channel satellite imagery (usually displayed as black-and-white pictures) is often a considerable challenge. This is especially true for areas where a large variety of surface types exist. Since our eyes are only sensitive to a handful of shades of gray in a black-and-white image, much of the information is missed. On the other hand, depicting this same scene in the context of a color photograph allows us, through familiarity, to more easily associate colors directly with known constituents (like green forests, brown land, gray-concrete urban zones, tan deserts, and blue oceans). As we are always seeking to simplify our ability to relate to satellite measurements, true color imagery is a highly desired capability.

How This Product is Created…

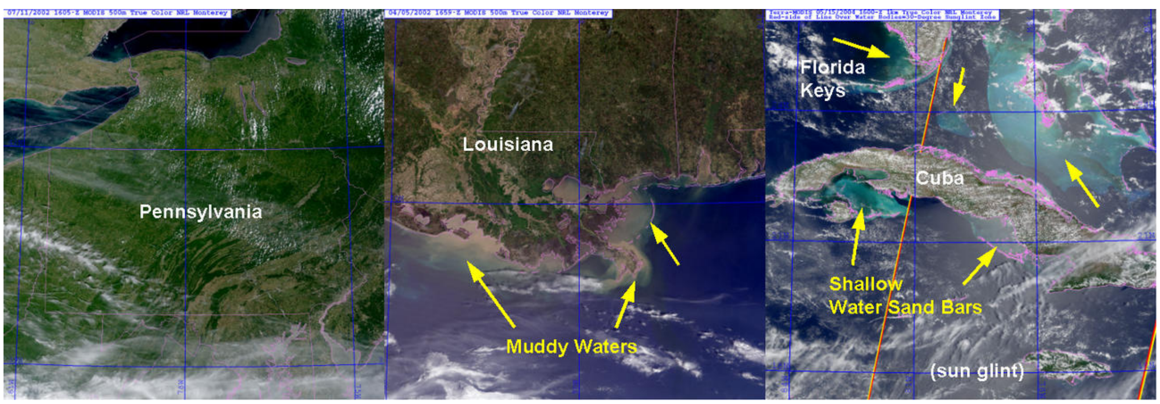
- As a little background, the human retina contains two different kinds of light-capturing cells (called photoreceptors) enabling vision at low and high light levels: the "rod" cells and "cone" cells. The rod cells offer high sensitivity to low light, but not to color (these cells are responsible for our night vision). The cone cells respond to high levels of light in three main regions (called "bands") of the visible light spectrum …red, green, and blue.

- If we shine white light (sunlight, for example) through a prism, we see all the colors of the rainbow projected onto the ground, revealing the true nature of white light as a blend of all these color components. If we placed a measuring device (detector) in the blue part of this projection, it will proceed to measure the "blue component" of the white light. Likewise, we could place detectors in the red and green portions to measure those respective components. A detector on a satellite can "filter" sunlight reflected off clouds and the Earth's surface to measure only a small component over the desired band.

- By using satellite measurements from bands having responses similar to those of the human retina's cone cells, we can proceed to re-create a picture of the scene. The molecules comprising the Earth's atmosphere (mostly Nitrogen and Oxygen) preferentially scatter the blue light (and this is why our sky appears blue), so we apply some behind-the-scenes corrections to account for this and allow us to see a "clean view" to the clouds and surface. We write computer software to do this correction, and then scale the strength of each corrected-band contribution between 0 and 255 (called "byte-scaling"). The last step is to combine this information into a single red/green/blue (RGB) image displayable on computer terminals.

How to Interpret…

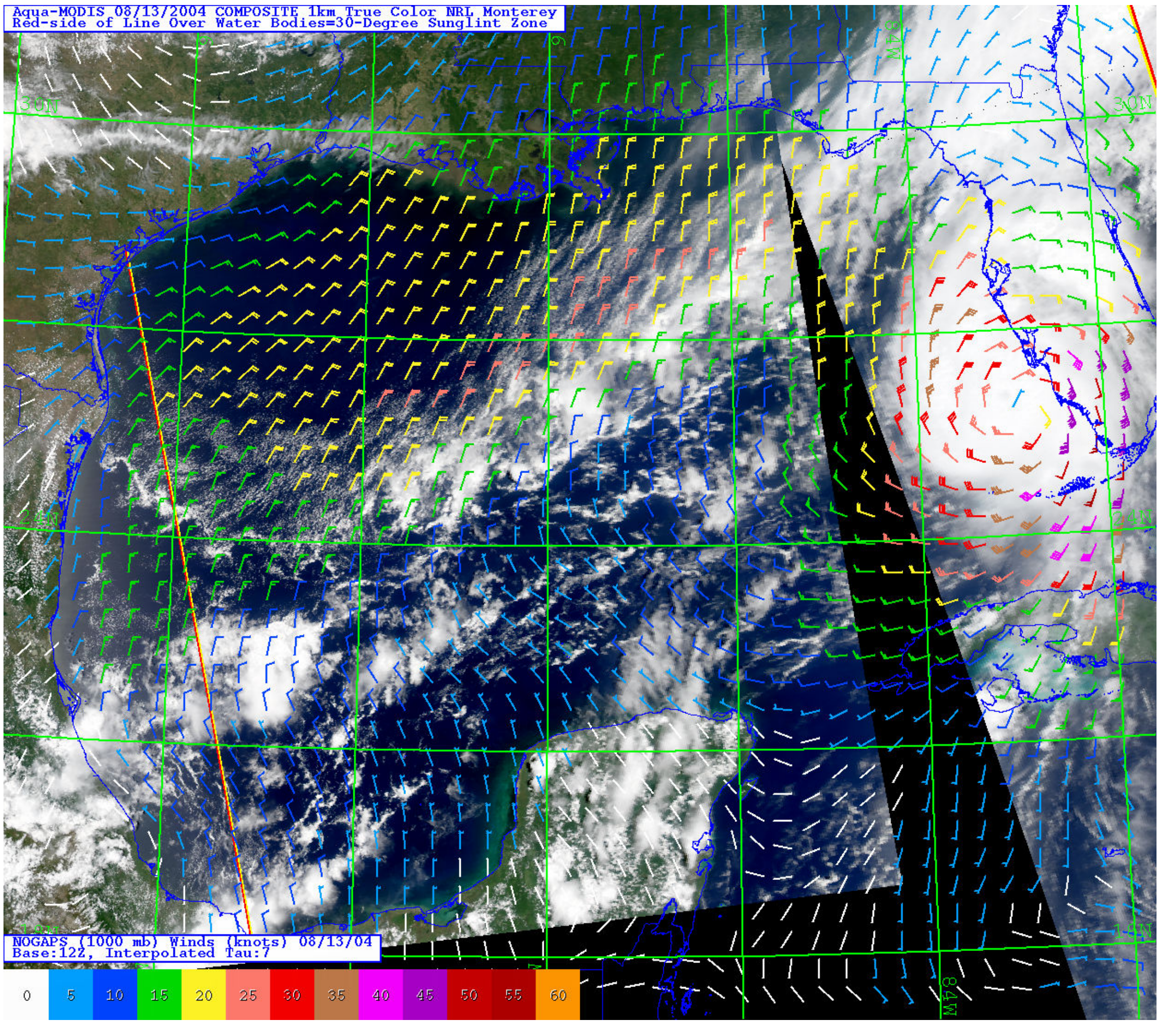
True color imagery requires the least amount of explanation from the standpoint of color content, but retains the challenges of interpreting various cloud structures, snow cover, and complex topography. To reasonable approximation, these images bear similarity to what an astronaut on the Space Shuttle or International Space Station might observe from roughly 500 miles above the surface. The examples below demonstrate how true color depicts lush green deciduous forests over Pennsylvania, the tan sediment-laden waters of the Mississippi River delta, and turquoise shallow-water sand bars in the Caribbean.



Drawn on the true color images are yellow/red lines encircling regions over the water where sunlight reflection may occur. These "sun glint" zones reside on the red-side of the line, and usually appear as a general brightening of the water areas. The behavior is tied strongly to local wind speeds. Higher winds roughen the waters and broaden the glint zone area. Locally calm winds and smooth waters can either remove the glint effect entirely (forming dark patches on the water surrounded by brighter regions where the winds are not as calm) or create an "extreme" bright glint feature if the sun/satellite geometry is such that the sun is mirror-reflected directly to the satellite.

Overlaying surface winds from a numerical weather prediction model is another way to add information to the imagery. In the example below, a short-term forecast from NRL's Coupled Ocean/Atmosphere Mesoscale

Prediction System ([COAMPS™](#)) is shown upon a Aqua-MODIS true color composite (swaths from two adjacent orbits stitched together) of Hurricane Charlie as he makes landfall in Florida. Black areas correspond to regions missed in between the two Aqua orbits.



Looking Toward the NPOESS Era…

MODIS is a predecessor to the Visible/Infrared Imaging Spectrometer ([VIIRS](#)) to fly on [NPOESS](#). VIIRS will contain several channels similar to MODIS, including those capable of rendering true color imagery at 370 m spatial resolution (resolving the scene down to about 120 yards). True color is available from the instruments aboard current operational satellite constellation (the Polar Operational Environmental Satellites ([POES](#)) system). The POES Advanced Very High Resolution Radiometer ([AVHRR](#)) can approximate true color through a combination of visible, near and thermal infrared channels, but the technique fails to capture the full breadth and quality of information available to sensors having all three (red, green, and blue) bands, and sometimes can introduce misleading features (like yellow low clouds and blue high clouds—hardly "true" color!).

Did You Know…?

Since the cone cells of our eyes are only sensitive to red, green, and blue bands of visible light, our brain has to do a lot of the work in order for us to visualize the full color spectrum (the proof of this is that we can take three relatively narrow detector bands in the red/green/blue and form true color image to begin with). Combinations of these bands are synthesized by our brain and interpreted as the appropriate color. For example, we cannot actually "see" yellow light (form by combining red + green). "Color blindness" is usually a misnomer in the sense that these individuals usually see in color, but due to a problem with the red or green cone cells have varying degrees of difficulty in differentiating these colors. Blue cone cell deficiency is extremely rare.

Want to Learn More?

COMET® Program NPOESS Education and Training Series:

- Dust enhancement tutorial (contains a discussion of false/true color techniques)
- NPOESS Program Overview

The MODIS Rapid Response Team produces near real-time high-resolution true color products.

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