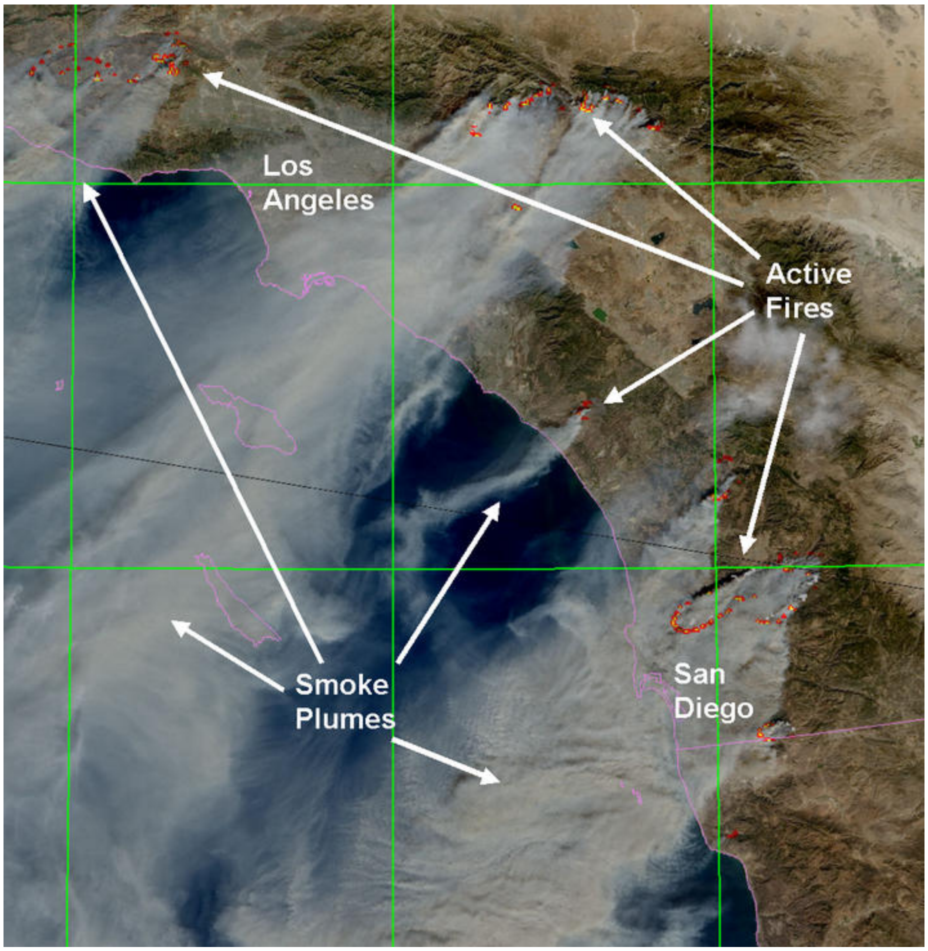
Satellite Product Tutorials:

Detecting Fires



Above: In October 2003, wildfires fueled by years of drought and strong Santa Ana winds ravaged Southern California. The firestorm as observed by MODIS from 500 miles overhead is shown in the above image. Here, active fires highlighted in red and yellow (hottest). The military used similar products during the early stages of Operation Iraqi Freedom to monitor the oil fields of southern Iraq (during the 1991 Gulf War they were set ablaze and caused severe visibility hazards for pilots).

Why We're Interested…

Annually, fire kills nearly 3,700 people (including 100 firefights in the line of duty), injures over 20,000, and is responsible for property losses exceeding $10 billion. Deaths related to fires are higher in the United States than any other industrialized country world. Our ability to minimize the destructive impact of fires is directly related to how early we can identify and respond to them. This is particularly true for fast-spreading wildland fires that spark up in the poorly monitored back country and can race toward populated areas. We are also interested in fires from the perspective of the Earth's radiation balance, and by extension, the climate. Smoke injected into the atmosphere from global fires is thought to play an important yet poorly understood role here. For both applications, satellites provide the wide-area coverage to assist in this monitoring.

How This Product is Created…

Our eyes are sensitive to light waves from the visible part of the spectrum (roughly, waves having lengths between 0.4 and 0.7 microns). Instruments flown aboard weather satellites can be designed to "see" other wavelengths of light besides visible (which represents a very narrow part of the full spectrum of light), including those corresponding to heat emissions. The 4.0 micron channel offers exceedingly high sensitivity to heat sources (even when the heat source does not entirely fill the scene being viewed by the instrument). For this reason, 4.0 micron is well-suited for the detection of fires and hot-spots on the earth's surface.

A single satellite image is actually composed of many individual "picture elements" (or "pixels"), each representing a small area of the overall scene. The size of a single pixel is related to the area viewed by the sensor at a given point in time (called the instantaneous geometric field of view—IGFOV, or "pixel footprint"), the rate at which that IGFOV sweeps across the scene (related to the "scan rate" of the system), and the time allowed for that sensor to collect the information (called the integration time). Consideration for all this parameters allows us to in specify the "spatial resolution" characterizing a given sensor. For example, an area 100 miles on a side that is viewed by a satellite having 1-mile spatial resolution will be represented by a 100 by 100 pixel image.

Since 4.0 micron measurements are so much more sensitive to heat than channels at longer wavelengths in the infrared, we look for significant departures in measured temperatures between 4.0 micron and 11.0 micron. At the same time, we look for spatial structure of these differences to help identify discrete "hot spots" in the scene. To reduce the effect of clouds and especially cloud edges, we enforce additional limits on the amount of variability of the 11.0 micron measured temperature. Pixels identified as containing fire or hot-spot are identified, and an additional flag is set for those having significant temperature differences (greater than 20 degrees Celsius) between 4.0 and 11.0 micron measurements—these latter pixels are considered "significant" sources. The fire detection product itself is a simple mask (that is, a digital dataset with values of "1" for detected fire and "0" for no fire analyzed each pixel of the scene). We color code this mask and overlay it upon true color imagery to create the fire product. At night, the mask is overlaid upon infrared imagery.

How to Interpret…

In the imagery, heat-detected pixels are set to red, and the significant source pixels are set to yellow. The algorithm does not differentiate between fires and hot-spots (for example, smoldering wood cannot be distinguished from an active grass fire). The NWP wind version of these products overlays surface wind data matched to the satellite observation time as a way of verifying and predicting the near-term smoke plume motion.

Note: Due to contamination by sunlight in the 4.0 micron "fire detection band" during the daytime hours, the algorithm must be more conservative in what it classifies as a hot-spot during daytime passes. As a result, the product will sometimes miss smaller fires during the day that the nighttime algorithm (no sunlight and thus more aggressive thresholds) would have detected.

Looking Toward the NPOESS Era…

NPOESS-VIIRS will provide both detection methods mentioned above on the same platform and at higher spatial resolution than contemporary platform. The nighttime visible channel on VIIRS will provide an alternative method of detection via sub-pixel scale light emissions from active fires—adding a level of discrimination not directly available to the 4.0 micron heat-signature technique.

Did You Know…?

Lightning from summertime thunderstorms is one of the main natural causes for wildland fires, including the massive Yellowstone fire of 1988.

Want to Learn More?

The MODIS Rapid Response Team produces near real-time hi-resolution products, including fire detection.
Visit the U.S. Fire Administration website
The University of Wisconsin-Madison operates the Automated Biomass Burning Algorithm (ABBA) resource.

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