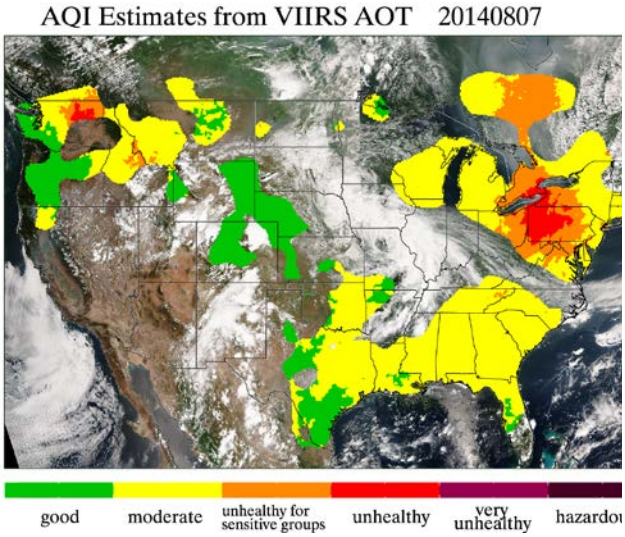
A Quick Guide to Air Quality Applications of JPSS VIIRS Aerosol Products

Why Are Aerosol Products Important?

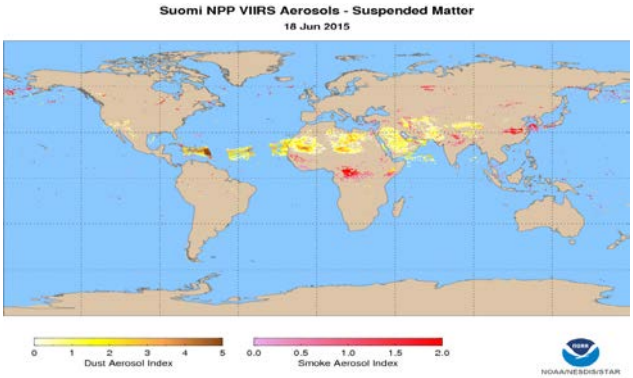
Natural and anthropogenic aerosols (suspended particulate matter) affect local and global temperature, biogeochemical processes, and air quality. Sources of aerosols include urban/industrial pollution and natural environmental disasters such as volcanic eruption, dust outbreaks, and biomass burning associated with agricultural land clearing and forest fires. As a climate forcing component of the atmosphere, aerosols change the amount and distribution of radiation that is available for heating by reflecting and absorbing radiation and by changing cloud formation and radiative properties of clouds. These lead to changes in atmospheric circulation and the hydrological cycle. Aerosols are also detrimental to human health and environment. High concentrations of aerosols, when inhaled, lead to upper respiratory diseases including asthma. They decrease visibility and lead to unsafe conditions for transportation. The Environmental Protection Agency (EPA) estimates that 106 million plus people in the United States live in areas of poor air quality, which adds about $143 billion dollars per year in hospital expenditure.

Aerosol loading of the atmosphere is measured, as **Aerosol Optical Thickness (AOT)**, at an increasing number of surface stations. However, the sampling of the stations is still far from a global representation over land, and very sparse over ocean. For true global coverage, satellite-based measurements are essential. For nearly two decades, NASA's space-borne Earth Observation System (EOS) sensors such as the MODerate Resolution Imaging Spectrometer (MODIS) have been observing the Earth, providing aerosol data products that complement ground observations of air quality. As the EOS era draws to its end the SNPP/JPSS (Suomi National Polar-orbiting Partnership/Joint Polar Satellite System), as one of the successor program, will provide the needed continuity. The **Visible Infrared Imaging Radiometer Suite (VIIRS)** aboard SNPP and JPSS has been designed as a continuation mission for the MODIS sensor.

Currently, MODIS and Geostationary Operational Environmental Satellite (GOES) AOT products are used to derive Air Quality Index (AQI), which is distributed to end users via internet (http://www.star.nesdis.noaa.gov/smcd/spb/aq/). AOT has been shown to be a good proxy to surface aerosol concentrations when aerosols are well mixed in the lower atmosphere. VIIRS will provide continuity for this application. The VIIRS **Suspended Matter (SM)** product, currently not derived for MODIS, provides information on the type of the aerosol such as **dust, volcanic ash, haze, and smoke** associated with observed AOT values. This information is qualitative (binary yes/no) for all aerosols except for smoke which is provided as a quantitative measure in the units of $\mu g/m^3$. The identification of aerosol type is useful to



AQI derived from VIIRS AOT for August 7, 2014. Gaps in coverage are due to clouds and bright surfaces.

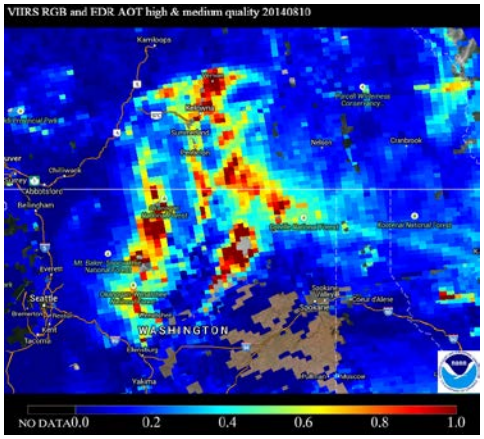


SNPP VIIRS SM image shows trans-Atlantic transport of Saharan dust (gold) reaching the US. The impact of long-range transport of dust on US air quality is one of the phenomena that can be monitored by VIIRS. Smoke from biomass burning is shown in red color.

objectively classify pollution events and attribute deteriorated air quality to anthropogenic vs. natural causes. The knowledge of aerosol type is also useful for long-term trend analysis to diagnose if a regional trend in AOT coincides with a trend in emissions of different types of aerosols.

How Will VIIRS Detect These Hazards?

Aerosols are suspended particles in the atmosphere that scatter and absorb sunlight. When present in high concentrations, they are easily visible in the satellite imagery. For routine detection and quantitative retrieval of the amount of aerosols, the challenge is to separate the aerosols from clouds and bright surfaces. For aerosol products (AOT and SM) from VIIRS, this is done by using the measurements at different channels from the visible to thermal infrared. The 2.25 µm channel is transparent to most aerosols and is used to characterize the surface as dark or bright. Additionally, some surface features (e.g., soil, snow/ice etc.) are identified by a combination of tests using visible and thermal channels. A suite of different visible and infrared channels are used to detect clouds. Once surface is characterized and cloudy pixels are identified, AOT is retrieved using VIIRS measured radiances in the visible bands using pre-computed look-up tables.



SNPP VIIRS AOT derived for smoke aerosols from Washington State Carlton Complex fires that burned 256,000 acres. Image for August 10, 2014.

Qualitative information on the presence of volcanic ash is obtained using brightness temperature difference between 11 µm and 12 µm and other spectral and spatial variability tests.

How Do These Products Work?

The air quality community is using aerosol products from GOES and MODIS in various applications and expects product continuity from VIIRS to feed those applications. The MODIS dust detection product is used to verify the National Weather Service (NWS) operational dust forecasts, and the AOT products from GOES and MODIS are used by the Environmental Protection Agency (EPA) in air quality assessment and the enforcement of its Exceptional Events Rule. The urban/industrial aerosol pollution, which is of utmost importance to the EPA from air quality standards compliance, tends to be well mixed in the planetary boundary layer and is often well-correlated to the satellite-derived AOT. VIIRS will extend the use of satellite-derived AOT product for monitoring air quality into the next two decades. The AOT and SM observations, when combined with a simple transport model, allow forecasters to determine the influence of upwind aerosol loadings on local air quality.

What are the Advantages of SNPP VIIRS?

The main advantages of SNPP VIIRS over its predecessor sensor, MODIS, are its **high spatial resolution (~750 m at nadir), wide swath (~3000 km) that provides full global coverage (i.e., no orbital gaps near the equator), and minimal degradation in resolution at the edge of the scan**. These features allow the monitoring of smoke plumes from smaller fires and short duration dust storms.

What Are the Benefits?

The use of the near real time VIIRS aerosol products in operational numerical aerosol prediction models can enhance the accuracy of forecast guidance. The combination of numerical forecast guidance and near real time satellite aerosol imagery will benefit the field forecasters in formulating their air quality/visibility warnings and alerts.

Research and Development Partners for Aerosol Products

- NOAA/NESDIS Center for Satellite Applications and Research
- I. M. System Group, Inc.
- Pennsylvania State University

On the Web

https://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea/

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