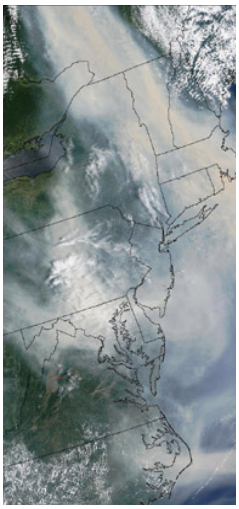
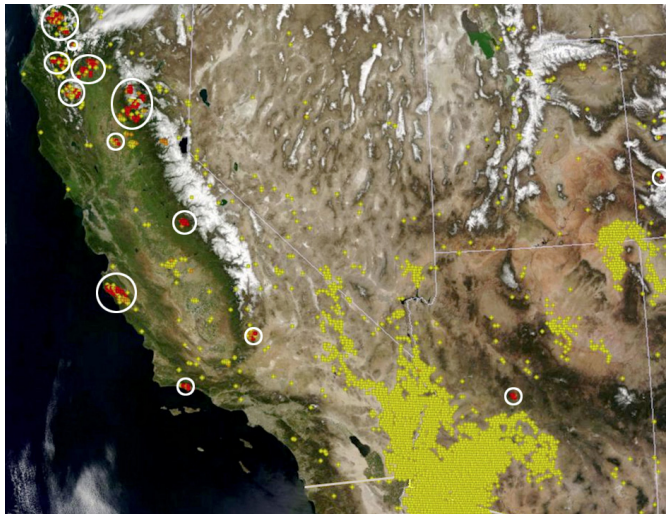
GOES-R Aerosols/Air Quality/Atmospheric Chemistry



What is GOES-R?
The Geostationary Operational Environmental Satellite - R Series (GOES-R) is the next generation of National Oceanic and Atmospheric Administration (NOAA) geostationary Earth-observing systems. Superior spacecraft and instrument technology will support expanded detection of environmental phenomena, resulting in more timely and accurate forecasts and warnings. The Advanced Baseline Imager (ABI), a sixteen channel imager with two visible channels, four near-infrared channels and ten infrared channels, will provide three times more spectral information, four times the spatial resolution and more than five times faster coverage than the current system. Other advancements over current GOES capabilities include total lightning detection (in-cloud and cloud-to-ground flashes) and mapping from the Geostationary Lightning Mapper (GLM) and increased dynamic range, resolution and sensitivity in monitoring solar X-ray flux with the Solar Ultraviolet Imager (SUVI). The first satellite in the GOES-R series is scheduled for launch in 2016.

Why are aerosol products important?
Aerosols (suspended particulate matter) are a key component of urban/industrial photochemical smog that leads to deteriorated air quality. They are also the primary pollutant in natural environmental disasters such as volcanic eruptions, dust outbreaks, biomass burning associated with agricultural land clearing and forest fires. Aerosols are detrimental to human health and the 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 more than 106 million people in the United States live in areas of poor air quality, costing about $143 billion dollars per year in hospital expenditures. Aerosols are also a major climate-forcing component. They affect the radiative balance of the Earth, cooling or warming the atmosphere (depending on aerosol composition).

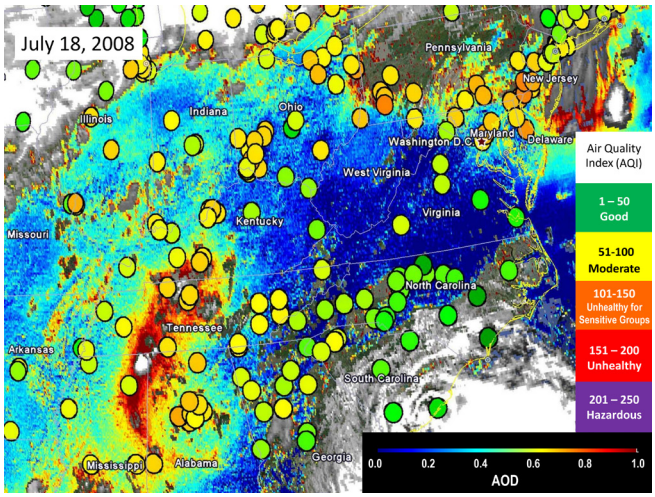


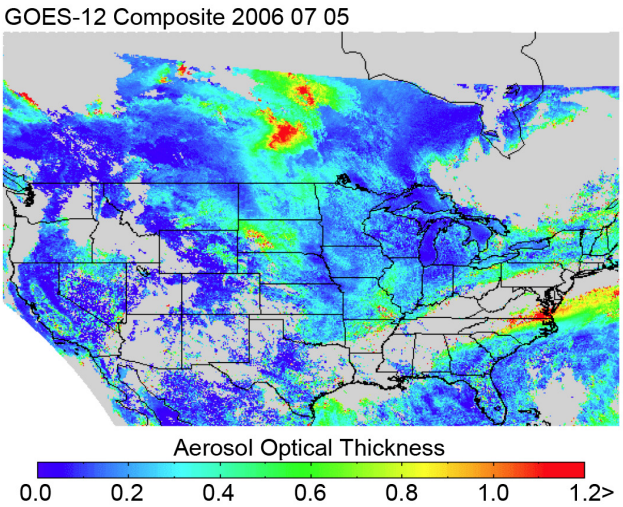
D. Neil, S. Kondragunta, K. Pickering, A. Prados, R. Pinder, G. Osterman, and J. Szykman, Environmental Manager, 2009

NOx (oxides of nitrogen that are precursors to photochemical smog) emissions derived from GOES observations for July 2008 forest fires in California. Nearly 1.3 million acres of forest land burned in June and July 2008, releasing several tons of NOx into the atmosphere. On certain days in July 2008, NOx emissions in northern California were as high as 325 tons, quite substantial compared to anthropogenic emissions which are generally below 10 tons for regions where fires occurred. Emissions less than 40 tons are shown in yellow and emissions greater than 40 tons in red.

The **Aerosol Optical Depth (AOD)** product is a quantitative measure of the atmospheric aerosol loading in a vertical column from the top of the atmosphere to Earth's surface. It is an effective proxy for surface aerosol concentrations when aerosols are well mixed and uniformly distributed in the lower atmosphere. By measuring **AOD** from the GOES-R ABI, one can obtain information on surface aerosol concentrations to be used in air quality monitoring and forecasting applications. The **Aerosol Detection** product is qualitative; it indicates the presence of aerosol (dust and/or smoke) in a given pixel and can be used to quickly identify the location of dust and smoke plumes.

How will GOES-R detect aerosol hazards?
Aerosols are suspended particles in the atmosphere that scatter and absorb sunlight. When present in high concentrations, they are easily visible in satellite imagery. For routine detection and quantitative retrieval of aerosol amounts, the challenge is to separate the aerosols from clouds and bright surfaces. The ABI does this by using measurements at different channels from the visible to thermal infrared. The 2.1 μm channel is transparent to most





*Above left: High values of **AOD** observed by GOES on July 18, 2008 across the eastern US correlate well with EPA surface monitors (circles) showing moderate to unsafe Air Quality Index. Above right: A daily composite of atmospheric aerosol loading (in unit-less quantity of optical depth) observed from GOES-12 for July 5, 2007. Widespread smoke aerosols from wildfires in Canada were transported to the U.S. GOES visible band (0.62 µm – 0.72 µm) observations were used to derive the **Aerosol Optical Depth/Thickness**. Daily composite was created using 30-minute imagery to cover for the data gaps due to clouds.*

aerosols and is used to obtain surface contribution to the satellite observed radiances over dark vegetated surfaces. A suite of infrared channels is used to detect clouds. Once a surface is characterized and cloudy pixels are identified, aerosols are retrieved through ABI measured radiances in the visible bands using pre-computed look-up tables. Qualitative information on the presence of aerosols can also be obtained using brightness temperature difference between 11 μm and 12 μm and other spectral and spatial variability tests, especially for dust and smoke aerosols. The ABI fire detection scheme uses the near-infrared (3.9 μm) radiances to look for thermal signatures of fire referenced to the 11.2 μm thermal window, which accounts for the background surface. Fires and aerosol and trace gas emissions from the fires are currently derived from GOES imager measurements and the same algorithms have been adapted for the ABI. Emissions (aerosol and trace gas flux values) are estimated using linear regression models based on 3.9 μm band fire radiative power (measure of radiative heat output) and emissions.

Research and Development Partners for Aerosol Products
- Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin
- NOAA National Environmental Satellite, Data, and Information Service, Center for Satellite Applications and Research (NESDIS/STAR)
- I. M. System Group, Inc. at Camp Springs, MD
- Earth Resources Technology, Inc.
- University of Maryland, Baltimore County
- Battelle Memorial Institute

On the Web http://alg.umbc.edu/aqpg/

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What are the benefits?

GOES-R aerosol products will be more accurate than current GOES products (GOES-R ABI accuracy is ~10% compared to current GOES AOD at ~20%). Additionally, the availability of these products at a 5-minute interval will be beneficial to the user as the products can be tailored to 15-minute or 30-minute composites to fill the data gaps associated with clouds. The use of near real-time fire and smoke aerosol emissions in operational numerical air quality prediction models will greatly enhance the accuracy of forecast guidance. The combination of numerical forecast guidance and near real-time satellite aerosol imagery will benefit field forecasters in their air quality warnings and alerts. Accumulation of satellite data over a long time period and extending the current GOES record is also useful for air quality assessment work done by the EPA.

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