Air Quality Products from GOES-R Advanced Baseline Imager (ABI) and Hyperspectral Environmental Suite (HES)

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Abstract

The Advanced Baseline Imager (ABI) and the Hyperspectral Environmental Suite (HES) instruments on the next generation Geostationary Environmental Operational Satellite (GOES)-R will provide unprecedented information on air quality. GOES-R will measure five of the seven criteria pollutants identified by the Environmental Protection Agency. Plans are currently underway to develop various air quality products (aerosol optical depth, particle size, aerosol type, carbon monoxide, methane, sulfur dioxide, ozone, fires, trace gas and aerosol emissions) over the Americas at temporal resolution ranging from five to 60 minutes for the imager and the sounder respectively. These products are expected to become operational after the launch of GOES-R in 2013. We will describe the ongoing algorithm and product development work and discuss potential applications of these products.

GOES-R Aerosols/Air Quality/Atmospheric Chemistry Application Team

Chair:
Kondragunta, Shobha – *NOAA/NESDIS/STAR*
Members:
Alexie, Lyapustin – *University of Maryland, Baltimore County*
Ackerman, Steven – *University of Wisconsin, Madison*
Hoff, Raymond – *University of Maryland, Baltimore County*
Laszlo, Istvan – *NOAA/NESDIS/STAR*
Li, Zhanqing – *University of Maryland, College Park*
Pierce, Brad – *NASA Langley Research Center*
Schmidt, Chris – *University of Wisconsin, Madison*
Szykman, James – *Environmental Protection Agency*

Sensor	Bands	Product	Applications
ABI	0.47µm, 0.86µm, 2.1µm	Aerosol optical depth, type (dust vs non dust), particle size (effective radius), and fraction of fine mode vs coarse mode	EPA – PM2.5 monitoring NWS – PM2.5 forecasting NIEHS – Health impacts CDC – Health impacts
ABI	9.6µm	Total column ozone	FAA – Clear-air turbulence NWS – Ozone forecasting
ABI	3.9µm, 11µm	Fire location, size, intensity and carbon consumption Aerosol and trace gas emissions	EPA – Assessments NWS – Forecasting
ABI	11µm, 12µm	Dust detection	EPA – Monitoring
HES	800 – 1000 cm^{-1}	Dust loading and height Volcanic ash detection, amount and height Smoke plume height	VAAC – Advisories EPA – Monitoring NWS – Forecasting
HES	1650 – 2250 cm^{-1}	Carbon monoxide Methane	EPA – Assessments NWS – Forecasting NOAA – Climate
HES	950 – 1050 cm^{-1}	Ozone profile	NWS – Forecasting
HES	600 – 800 cm^{-1}	Ash cloud height Smoke plume height	VAAC – Advisories NWS - Forecasting
HES	1100 – 1200 cm^{-1}	Sulfur dioxide	VAAC – Advisories

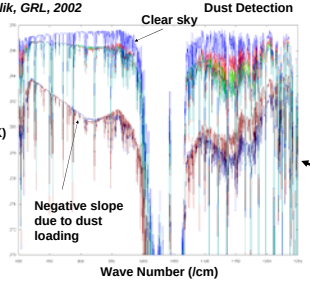
Air Quality Application Team Tasks

Develop algorithms for the following products:
- Aerosol Optical Depth (AOD), particle size, aerosol height from ABI
- Aerosol/SO_2/volcanic ash detection from HES
- GOES-R data application tool, IDEA (Infusing satellite Data into Environmental Applications)
- Trace gas and aerosol emissions from ABI
- Total ozone algorithm from ABI
- Smoke/dust plume height from HES
- Develop assimilation procedures to assimilate aerosol products into air quality models

Interactions with other Application Teams

- Soundings team for trace gases (CO, CH_4, O_3 profile)
- Land team for fire location, size, and intensity
- Winds team for aerosol wind retrieval
- Clouds team for implementing cloud-screening algorithms into aerosol algorithms

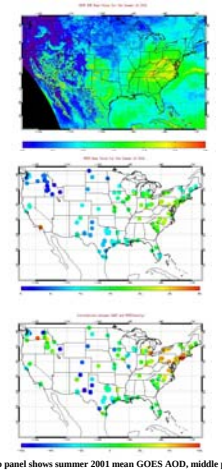
Sokolik, GRL, 2002



EPA – Environmental Protection Agency
NWS – National Weather Service
NIEHS – National Institute for Environmental Health Sciences
CDC – Center for Disease Control
FAA – Federal Aviation Administration
VAAC – Volcanic Ash Advisory Centers

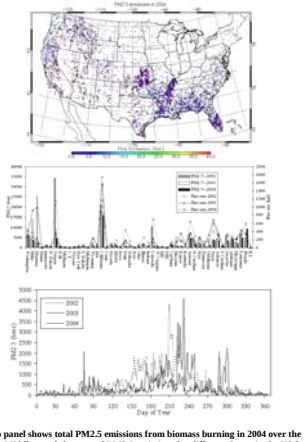
Current Air Quality Applications of Satellite Data

Pollution Monitoring



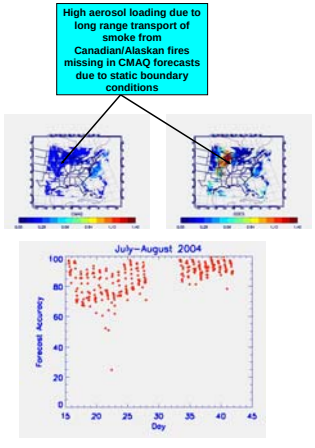
Top panel shows summer 2001 mean GOES AOD, middle panel shows summer 2001 mean surface PM2.5 concentrations, and the bottom panel shows correlation coefficient between AOD and surface PM2.5 derived using 2001 data. Note that aerosol loading both in the column (as observed by GOES) and at the surface (as observed by the EPA PM2.5 network) is higher in the eastern and south central US. Correlation coefficients, similarly, are high in the eastern US. Similar findings were reported by Engel-Cox et al., 2004. Studies are underway to understand the geographical differences in correlation between satellite and surface observations

Emissions Monitoring



Top panel shows total PM2.5 emissions from biomass burning in 2004 over the US. Middle panel shows total PM2.5 emissions for different States in the US for different years. Bottom panel shows seasonal variations in PM2.5 emissions for different years. Note that forest fire emissions are larger in southeast, south central, and northwest US with Oregon and California leading the other states. Seasonally, PM2.5 emissions are highest in the summer for all years investigated. *Information on fire location and size for this product came from NOAA/NESDIS WildFire_Automated Biomass Burning Algorithm (WF_ABBA), courtesy of C. Schmidt, University of Wisconsin-Madison*

Air Quality Modeling/Forecasting



NOAA/NESDIS is supporting the NWS air quality forecasting efforts by providing satellite data for forecast verification. A case study was conducted on NWS research/developmental PM2.5 forecasts issued for the 2004 INTEX/NEAQS field campaign. This time period was dominated by long-range transport of smoke from forest fires in Canada/Alaska. The NWS model (Eta-CMAQ system) did not include the long range transport in its simulations and hence missed large aerosol loadings observed by GOES Imager (top panel). Bottom panel shows time series of forecast accuracy determined for an event/non-event (event identified as AOD > 0.65) from July 15 – August 10, 2004 by comparing GOES AODs with CMAQ AODs. Forecast accuracy was in general between 60% and ~100%.

GOES-R Capabilities

- Enhanced aerosol products at five minute refresh rate enabling now-casting capabilities for PM2.5
  - Current GOES imager aerosol product is of limited use especially over bright surfaces and when thick dust/smoke plumes are involved. Center of thick plumes is masked out due to the algorithm's inability to differentiate between thick aerosol plume and low cloud
  - Hyperspectral coverage in the long-wave window region on the HES will provide information on atmospheric dust loading/composition/height. Current GOES sounder does not have that capability
- Air quality now-casting tools
  - Current GOES aerosol products at 30-minute interval have already proven to be valuable in guiding aircrafts/ships deployment to chase pollution. *GOES-R aerosol products have the potential to take this to a new level, now-casting*
  - Total ozone at five minute refresh rate will be able to provide FAA with clear-air turbulence warnings
- Trace gas retrievals at hourly refresh rate
  - First ever from a geostationary platform. Extremely useful for monitoring emissions from industrial and biomass burning sources. Current capabilities, at daily time scales, very useful but not adequate for updating models. NWS requires at least four cloud-free observations per day and GOES-R will be able to meet that requirement