Air Quality Products from GOES-R Advanced Baseline Imager (ABI)

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Abstract

The Advanced Baseline Imager (ABI) instrument on the next generation Geostationary Environmental Operational Satellite (GOES)-R will provide unprecedented information on air quality. GOES-R will measure several of 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, sulfur dioxide, ozone, fires, trace gas and aerosol emissions) over the Americas at temporal resolution of five minutes for the imager. These products are expected to become operational after the launch of GOES-R in 2014. We will describe the ongoing algorithm and product development work and discuss potential applications of these products.

GOES-R Air Quality 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 (UMBC)*
Laszlo, Istvan – *NOAA/NESDIS/STAR*
Li, Zhanqing – *University of Maryland, College Park (UMCP)*
Pierce, Brad – *NASA Langley Research Center*
Schmidt, Chris – *University of Wisconsin, Madison*
Szykman, James – *Environmental Protection Agency*

Sensor	Bands	Product	Applications
ABI	Visible and Near Infrared	• Aerosol optical depth • Aerosol type (dust *vs* non dust) • Aerosol particle size (effective radius) • Aerosol fraction of fine mode vs coarse mode	EPA – PM2.5 monitoring NWS – PM2.5 forecasting NIEHS – Health impacts CDC – Health impacts
ABI	Infrared	• Total column ozone	FAA – Clear-air turbulence NWS – Ozone forecasting
ABI	Infrared	• Fire location • Fire size • Fire intensity • Aerosol and trace gas emissions	EPA – Assessments NWS – Forecasting
ABI	Infrared	• Dust detection • Smoke detection • Volcanic ash detection • SO2 detection and optical depth	EPA – Monitoring VAAC - Advisories
ABI	Infrared	• Ash cloud height • Smoke plume height	VAAC – Advisories NWS - Forecasting

Air Quality Application Team Tasks

Develop algorithms for the following products:
- Aerosol Optical Depth (AOD) and aerosol particle size (P.I.: Istvan Laszlo, NOAA/NESDIS)
- Aerosol height from ABI (P.I.: Allen Chu, UMBC)
- Aerosol/SO_2/volcanic ash detection from ABI (P.I.: Steve Ackerman, UW-Madison)
- GOES-R data application tool, IDEA (Infusing satellite Data into Environmental Applications) (P.I.: Ray Hoff, UMBC)
- Trace gas and aerosol emissions from ABI (P.I.: Shobha Kondragunta, NOAA/NESDIS)
- Total ozone algorithm from ABI (P.I.: Christopher Schmidt, UW-Madison)
- Smoke/dust plume height from ABI (P.I.: Steve Ackerman, UW-Madison)
- Develop assimilation procedures to assimilate aerosol products into air quality models (P.I.: Shobha Kondragunta, NOAA/NESDIS)

Interactions with other Application Teams

- Land team for fire location, size, and intensity
- Winds team for aerosol wind retrieval
- Clouds team for implementing cloud-screening algorithms into aerosol algorithms
- Proxy data team to develop proxy data sets

Current Ongoing Activities

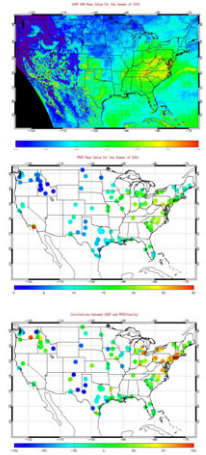
❑ Preparation of proxy datasets using MODIS, SEVIRI, and mesoscale model simulations is underway. ABI like synthetic radiances are being generated to facilitate algorithm development work by various principal investigators

❑ Preparation of algorithm design reviews has been completed. Most algorithms depend on heritage algorithms such as MODIS, VIIRS, and current GOES

❑ Proposed revisions to GOES-R Mission Requirement Document have been completed and submitted to GOES-R Program Office

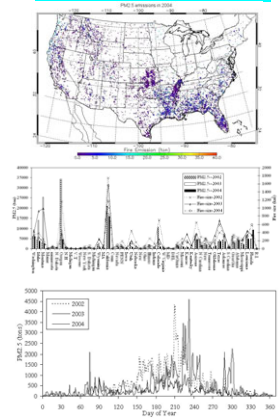
Air Quality Applications of Current GOES Imager Data

Pollution Monitoring



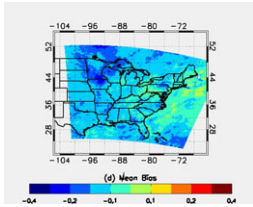
Top panel shows summer 2001 mean GOES AOD, middle panel shows summer 2001 mean surface PM2.5 concentrations, and the bottom panel shows correlation coefficient between AOD and surface PM2.5 derived using 2001 data. Note that aerosol loading both in the column (as observed by GOES) and at the surface (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. Figure above shows mean bias between observed and forecast AOD for July 15 – August 15, 2004.

GOES-R ABI Capabilities

- Enhanced aerosol products at five minute refresh rate enabling now-casting capabilities for PM2.5
  - Onboard calibration
  - Multi-channel retrieval
  - Ability to differentiate between smoke and dust
- 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
- Enhanced fire products for aerosol and trace gas emissions estimates
  - Ability to differentiate between small fires and large fires
  - Improved spatial and temporal coverage
- Pseudo-true color imagery for forecasters

Infusing satellite-Data into Environmental Applications (IDEA)

- **A joint NASA-NOAA-EPA initiative. Currently running in pre-operational mode on NESDIS computers. Will become operational at NESDIS in 2007**
- **Provides forecast guidance for surface air quality (PM2.5)**
  - Dust storms
  - Smoke from forest fires
  - Urban/industrial haze
- **Trajectories are initialized at locations with aerosol optical depth > 0.4 at 50, 100, 150, and 200mb and run using 12Z NOAA/NCEP NAM forecast data providing 48 hr forecast**
- **System requirements**
  - Direct broadcast receiving station for satellite data
  - Trajectory model
  - Regional meteorological forecast model output
  - Algorithms to derive aerosol optical depth or related parameters
  - Surface PM2.5 measurements from EPA
- **System flexibility**
  - Easily adaptable to other regions of the globe
  - Easy to modify to input other satellite data. IDEA is being modified to use current GOES aerosol data and GOES-R ABI proxy data in preparation for GOES-R launch