Air Quality Forecasting
Applications of GOES-16 ABI Data

Amy K. Huff
Department of Meteorology and Atmospheric Science
Pennsylvania State University
AC-VC-14
May 4, 2018
Air Quality Forecasting in the U.S.

- **State, local, and tribal government agencies** issue air quality forecasts to protect the public from the adverse health effects of **criteria pollutants**
  - NOAA (NWS) does not issue air quality forecasts, but does provide support (numerical air quality model guidance)

- Forecasts typically issued by mid-afternoon (~3 PM), valid for the **next day**
  - Allows for lead time to communicate with public, local governments, businesses, schools
  - Available on state and local websites and AirNow national website (http://www.airnow.gov/)

- Communicated using the color-coded **Air Quality Index (AQI)**
Air Quality Alerts

• $O_3$, $PM_{2.5}$, $PM_{10}$ are the most commonly forecasted pollutants in the U.S.
• **Air Quality Alert (AQA)** issued to public on days when forecast for pollutant exceeds **National Ambient Air Quality Standard (NAAQS)**
• In practice, this translates to a **Code Orange, Red, Purple, or Maroon** forecast on the AQI scale
• Public warned to take action to limit their exposure to pollutants
• AQA forecasts are the **most important** ones to get correct!!
Wildfire Emissions Plumes and Blowing Dust

• Emissions plumes from large wildfires contain:
  – Primary PM$_{2.5}$ and PM$_{10}$ (smoke aerosols)
  – Nitrogen oxides ($\text{NO}_x$) and volatile organic compounds (VOCs): precursors for secondary formation of O$_3$ and PM$_{2.5}$

• Wildfire emissions plumes can be lofted above the boundary layer and remain relatively intact while traveling long distances, often 100s of km
  – If the wildfire plume mixes to the surface downwind, it can substantially increase local O$_3$ and PM$_{2.5}$
  – Wildfires are becoming larger, more intense, and more frequent

• Blowing dust affects PM$_{10}$ and PM$_{2.5}$ air quality (dust aerosols)
  – Primarily in arid regions, like the Southwestern U.S. (local sources)
  – Transported Saharan dust periodically affects the Atlantic and Gulf coasts
Forecasting the Impacts of Wildfires and Blowing Dust

- Our typical air quality forecasting methods are not much help with wildfire plumes and blowing dust
  - They are uncommon events, so climatology doesn’t work
  - Persistence will always miss the onset day of a fire- or dust-influenced event, but it can help with subsequent days (if it’s a multi-day event)
  - Numerical air quality models tend to under-predict because they don’t account for wildfire emissions or dust transported from outside of the CONUS

NAQFC under-predicts O₃ on days influenced by fires
Fort McMurray Fire Smoke Plume, May 7, 2016

NAQFC (left) under-predicted PM$_{2.5}$ in Midwest associated with smoke from Ft McMurray fire
Satellite Aerosol Products

• Air quality forecasters turn to aerosol satellite products to help track wildfire emissions plumes and blowing dust
  – Aerosol optical depth (AOD): quantitative measure of aerosols
  – Smoke/dust mask: qualitative measure of aerosols
  – Dust color imagery (dust RGB): locations, movement of blowing dust
  – GeoColor/true color (RGB): locations, movement of smoke and dust

• Historically, satellite aerosol data had limited usefulness for operations
  – Polar-orbiting satellites: low temporal resolution
    • Observations not available in time for early-afternoon forecasting deadlines
  – Previous generation GOES: low spectral resolution
    • No high-accuracy, multi-channel aerosol products
Example: VIIRS Data

- This is the extent of the VIIRS RGB and AOD available by my forecast deadline (~2 pm)
- Shobha did all she could to increase the latency, but observations are available too late in the afternoon
- VIIRS data are more useful for post-analysis
Advanced Baseline Imager on GOES-R Satellites

- **Advanced Baseline Imager (ABI)** on GOES-16 (GOES-East) and GOES-17 (soon to be GOES-West) is revolutionizing the forecasting of air quality associated with fires and dust
- ABI has **16 spectral bands** vs. 5 on previous GOES imager
  - New products!
  - Higher accuracy and spatial resolution!
- **Faster scan rate** compared to previous GOES imager
  - More frequent observations!
  - Routine CONUS and full disk views!
- **Only 20 min latency!**
ABI GeoColor: Dust Storm in Southwest U.S., April 12, 2018

1800-2350 UTC
ABI Dust RGB: Dust Storm in Southwest U.S., April 12, 2018

1800-2350 UTC
Most of the event occurred after the VIIRS observation!
So forecasters couldn’t use polar-orbiting satellite data to detect and track blowing dust associated with this event!
ABI Smoke Mask: Local Fires in Florida, March 23, 2018

Smoke mask is β-maturity
Not for scientific use

1600-2000 UTC
VIIRS RGB and Smoke Mask

- VIIRS captured the smoke event, but it is only a snapshot
- Doesn’t show the evolution or growth of the plume like the ABI can!
- And VIIRS was not available in time to inform the forecast!
New NOAA AerosolWatch Website
Access to Near Real-Time ABI and VIIRS Aerosol Imagery for Operational Users

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

Zoom in/out
Open archive; Time Stamp
Animation controls
Select ABI and VIIRS Products
Select animation, save image
Overlay observed PM$_{2.5}$, state/national labels

CONUS or Full Disk view
Plans for 2018

- 2018 ozone season in the Mid-Atlantic is underway; runs May 1 Sept 30
- Pilot study to use ABI **AOD, smoke mask, and GeoColor** to track transport of plumes from wildfires
  - Fires cause many of the highest magnitude and most widespread (geographically) O₃ events in the Mid-Atlantic
  - But AOD and smoke/dust mask currently **β-maturity**
  - Waiting for provisional maturity products, anticipated soon (June 2018)
  - Fully validated products expected Fall 2018
- GOES-17 currently in its check-out orbit at 89.5 °W
  - Will become GOES-West later this year (~200 days after launch)
  - Lots of fires in Western U.S., Canada!
Acknowledgements

• Support for air quality forecasts:
  – Pennsylvania Department of Environmental Protection
  – Delaware Department of Natural Resources and Environmental Control

• Support for NOAA aerosol products and AerosolWatch:
  – Shobha Kondragunta, Hai Zhang, and the NOAA aerosol Cal/Val team
  – NOAA JPSS and GOES-R programs
    • Air Quality Proving Ground
    • Fire and Smoke Initiative