Challenges in Air Quality Services

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- Forecasting and Early Warning;
- Public Health;
- Land management;
- Agricultural and food security;
- State Implementation Plan (SIP);
Forecasting and Early Warning

(Stakeholders: Ivanka Stajner and Pius Lee, NOAA)

- NOAA National Air Quality Forecast Capability (NAQFC) generates four real-time products: Ozone, PM$_{2.5}$, Fire/Smoke, and Dust.

**O$_3$ Forecasting**

**PM$_{2.5}$ Forecasting**

[Map of O$_3$ forecasting]

[Map of PM$_{2.5}$ forecasting]

http://airquality.weather.gov/

A major gateway to disseminate satellite observations and model prediction of air quality products to the public.
Emission Modeling

Air Quality Forecast

Meteorology Forecast

Emission Forecast

Real World Emissions

Model-ready Emission

Emission Inventories
Need of rapidly updated Emissions

- Time lag is a major obstacle for AQF.

  Forecasters want: *emissions for tomorrow*;
  Data availability: *emission data 4+ years old*.

  How to overcome this problem?

- Common Practices:

  Option 1, no update;
  Option 2, use emission projection;
  Option 3, update with satellite observations.
NOAA NAQFC Ozone Forecast

2009: NEI Only
(NEI: National Emission Inventory)

2012: NEI with Projection
(Tong et al., 2015)
The 2008 Global Economic Recession

- **Cause:** Housing bubble in 2007 followed by a subprime mortgage crisis in 2008;

- **Impacts:**
  - Unemployment rate: 10.1% in 2009.
  - Poverty rate: 16%;
  - GDP: contract by 5.1%;

- **Worst economic recession since the Great Depression**

**Question:** Was the change reflected in NAQFC emissions?
NO$_x$ Trends from OMI, AQS and NAQFC

Comparison to 2005 values

Atlanta

Philadelphia

OMI = Ozone Monitoring Instrument on NASA’s Aura Satellite
AQS = Air Quality System

Philadelphia

Atlanta
NO\textsubscript{x} Trends during the Great Recession

- Consistent trends from OMI and AQS;
- Faster NO\textsubscript{x} reduction during the Recession and slower after that.
“Recession” Emissions

Use fused satellite (OMI) and ground (AQS) data to obtain realistic emission changes.

Fusing AQS & OMI

\[ AF = \frac{\Delta S \times N_s \times f_s + \Delta G \times N_g \times f_g}{N_s \times f_s + N_g \times f_g} \]

State-level Changing Factors

Comparison of OMI and AQS (x100) Samples

(Source: Tong et al., 2016) (2005 to 2011)
O₃ Changes with/without Recession (2005 – 2011)

Without Recession

Recession

(Tong et al., 2016)
Oil and Gas Emissions

*(Stakeholder: Ivanka Stajner, NOAA/NWS)*

**Shale Gas Production**

- Rapid increase in shale gas production (NO\textsubscript{x} and VOCs);
- Shift of fuel use in power plants;

**Challenges:**

Unknown impact on emissions and air quality.
Dust Storms and Valley Fever

- Rapid increase in Valley fever infection (CDC, 2013);

- Increased Ca\(^{2+}\) deposition in rainfall (Brahney et al., 2013);

- Increased dust deposition in snowfall (Clow et al., 2016);

- Earlier onset of spring dust season (Hand et al., 2016);

Challenges:
1. Need consistent and robust long-term dust trends;
2. Understand health impacts of increased dust activity.
State Implementation Plan (SIP) Modeling

- Modeling datasets (emission, meteorology, initial concentration, lateral boundary conditions, etc.);

- Natural event identification (wildfire, dust storms, stratospheric intrusion);

- Trans-boundary transport;

- Air quality of emission sectors;

- End of Season Emission Surge;
# Summary

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<tr>
<th>Challenges</th>
<th>Outstanding Issues</th>
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<tr>
<td>1. Emission and air quality forecasting</td>
<td>Emission time lag; fire (time lag, intensity, injection height; gas species); dust; oil and gas; NH₃;</td>
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<td>2. Major Socio-economic Events (Recession, Fracking)</td>
<td>Timely capture of emission changes; credible assessment of their impact on air quality (and human health);</td>
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<td>3. SIP Modeling</td>
<td>Benchmark dataset; Reliable base case; boundary conditions; natural events (fire, etc).</td>
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<td>4. Agriculture</td>
<td>Wind erosion over rangeland; Ozone over cropland; Seasonal outlook/forecasting;</td>
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<td>5. Exposure</td>
<td>Long-term nose-level data records; PM2.5 chemical composition; real-time information for emergency response;</td>
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