Recent Progress in NAQFC Emission Forecasting

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Challenges in NAQFC Emission Forecasting

- **Time lag is a major obstacle for NAQFC emission forecasting.**

  Forecasters want: *emission of tomorrow;*

  Data availability: *emission data 4+ years old*.
  (three years labor, one year QA, post-processing and release).

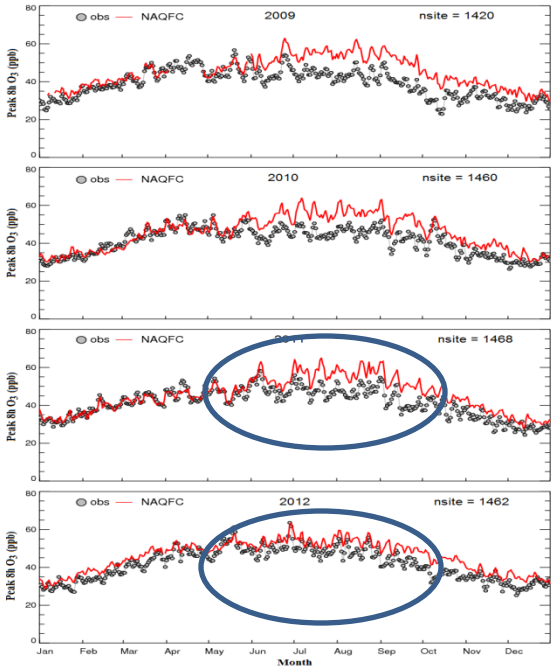
How to overcome this problem?

- **NAQFC Practices:**

  Option 1, no update (2007-2011) - Dear price paid;

  Option 2, use EPA emission projection (2012-2015).

  Option 3, emission data assimilation (2016-?).



(Tong et al., Atmos. Environ. 2015)

Impact of the Great Recession on US Air Quality

- **Starting – Ending time:** December 2007 – October 2009;

- **Cause:** Bursting of the housing bubble in 2007, followed by a subprime mortgage crisis in 2008;

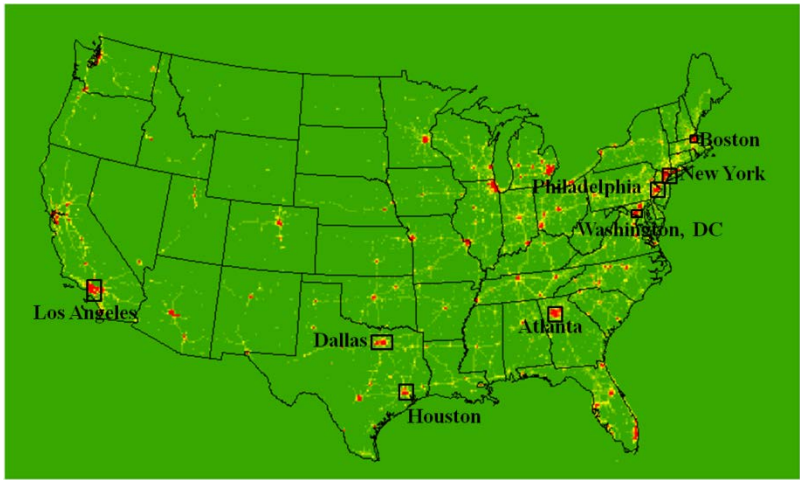
- **Impacts:**
  - Unemployment rate: 4.7% in Nov 2007 → 10.1% in Oct 2009.
  - Income level: dropped to 1996 level after inflation adjustment;
  - Poverty rate: 12% → 16% (50 millions);
  - GDP: contract by 5.1%;

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

Question: What does it mean to Air Quality (and Emissions)?

Methodology

- **Emission Indicator – Urban NOx in Summer**
  - **Short lifetime → proximity to emission sources**
  - **Urban NO2 dominated by local sources;**
  - **High emission density → low noise/signal ratio;**
- **NOx Data sources**
  - **Satellite remote sensing (OMI-Aura NO2).**
  - **Ground monitoring (EPA AQS NOx);**
  - **Emission data (NOAA National Air Quality Forecast Capability operational emissions);**
- **Deriving the trend:** (Y2–Y1)/Y1×100%
- **Selection of urban areas**



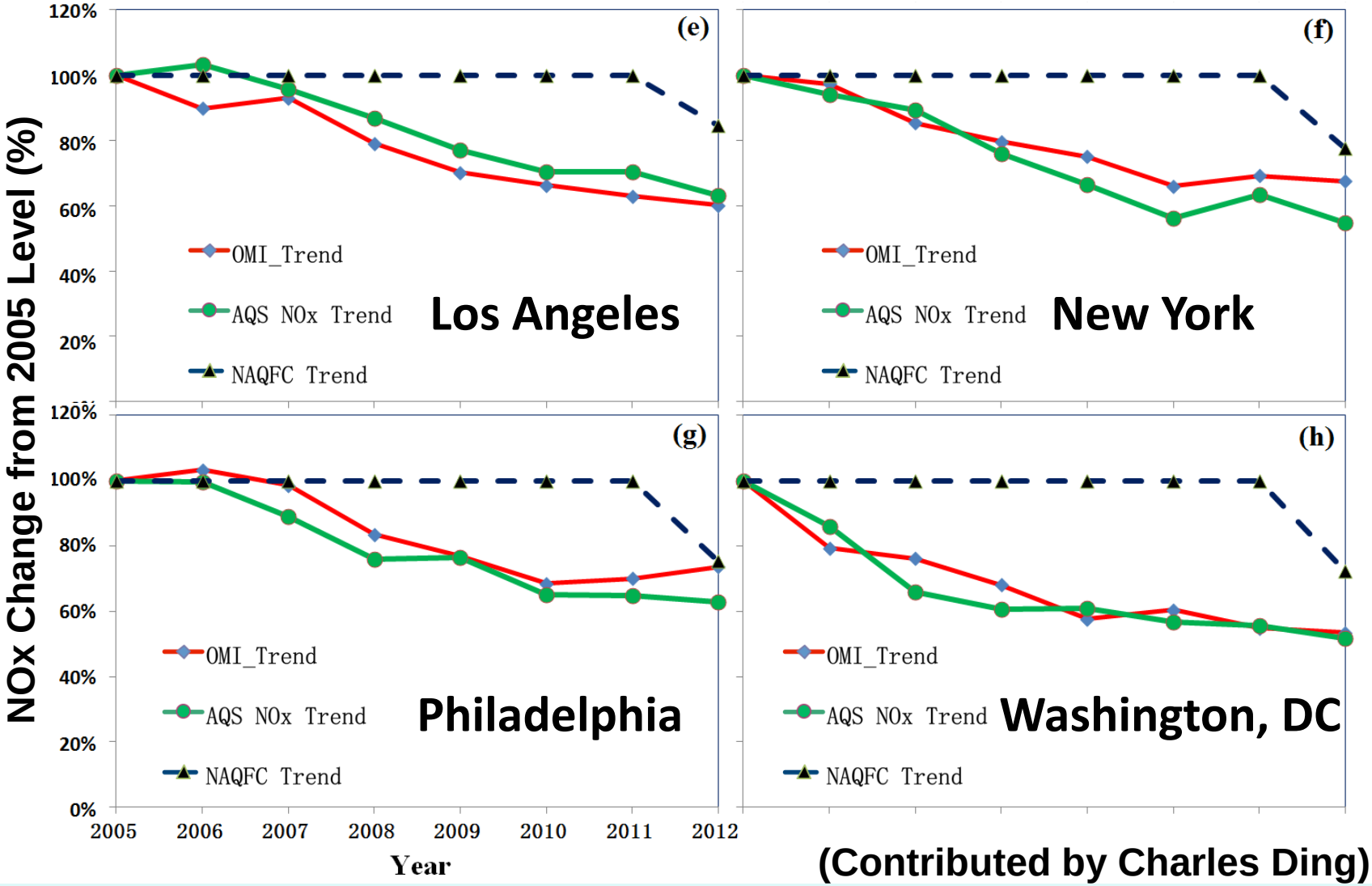
NOx Changes
Prior to, during and after the Recession

Stage	Sources	Atlanta	Boston	Dallas	Houston	Los Angeles	New York	Philadel-phia	Washing-ton, DC	Mean
Before	OMI SP	-11.7	-9.4	-7.5	-5.7	-3.3	-7.5	-0.6	-12.3	-7.3
	AQS	-9.9	-2.1	-5.2	0.7	-2.0	-5.5	-5.5	-18.7	-6.0
During	OMI SP	-5.5	-7.5	-8.9	-7.9	-13.1	-6.2	-11.7	-13.0	-9.2
	AQS	-17.5	-7.0	-13.0	-14.0	-10.3	-13.6	-7.0	-3.7	-10.8
After	OMI SP	-6.0	-3.3	-2.1	0.4	-5.0	-3.2	-1.2	-2.3	-2.8
	AQS	1.4	-6.1	0.1	0.2	-6.4	-5.4	-6.1	-5.3	-3.4

- **Distinct regional difference;**
- **Average NOx changes are consistent for OMI and AQS data;**
- **-6%/yr - -7%/yr prior to Recession;**
- **-9%/yr - -11%/yr during Recession;**
- **-3%/yr after Recession (Recovery?).**

(Tong et al., 2015)

Inter-Comparison of OMI, AQS and NAQFC



(Contributed by Charles Ding)

Feasibility Study: Emission Data Assimilation

(Project funded by OAR USWRP program, PM: J. Cortinas)

Can satellite data be used to rapidly refresh NOx emission?

Approach: Replace EPA projection factors by observation-based factors

Use both satellite and ground observations;

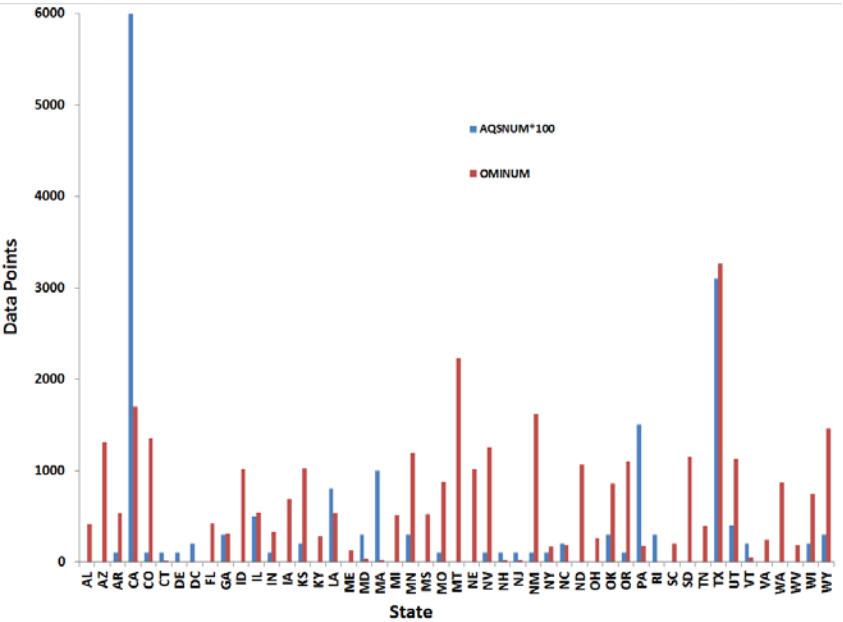
Optimal data fusion algorithm.

$$AF = \frac{\Delta S \times f_S + \Delta G \times f_G}{N_S \times f_S + N_G \times f_G}$$

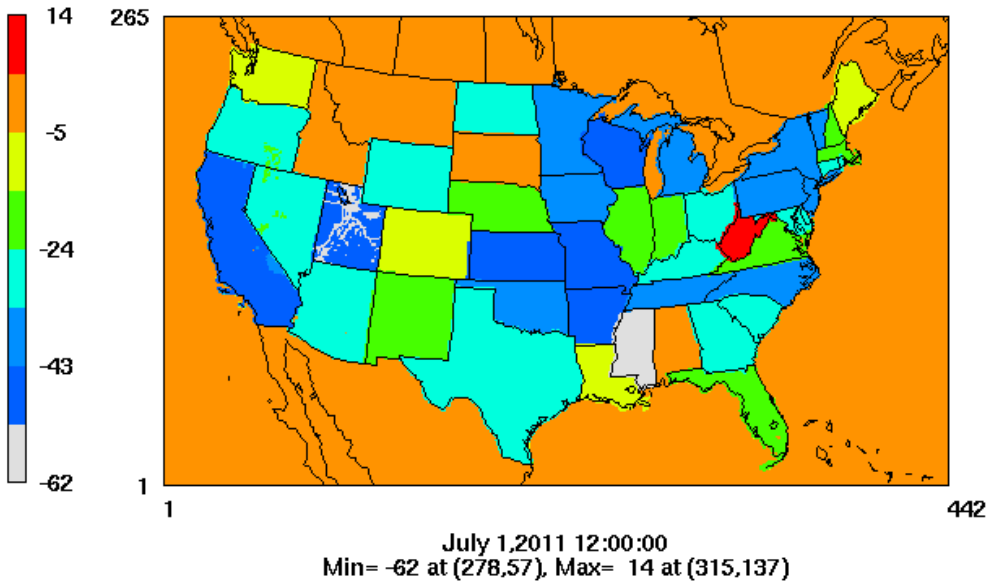
ΔS and N_S - changing rate and data number of satellite data;
ΔG and N_G -- rate and number of ground data;
f_S and f_G -- weighting factors for satellite and ground data;

Why both satellite and ground observations?

Comparison of OMI and AQS (x100) Samples



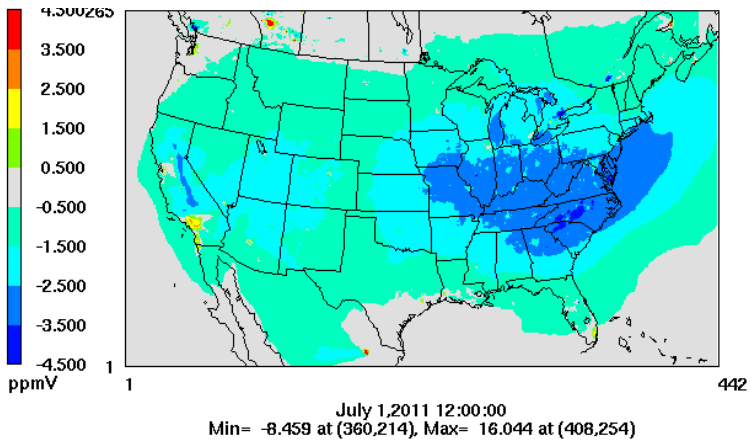
State-level Projection Factors from OMI and AQS



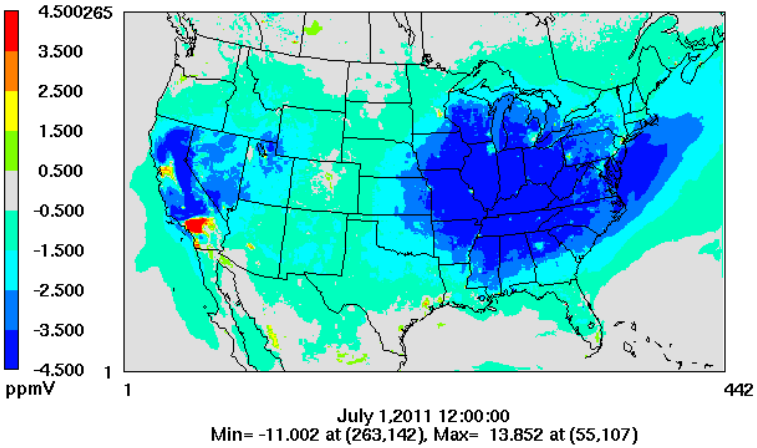
OMI Preprocessing: 1) Quality filter; 2) Set a cut-off value; 3) Calculate lower and higher 25% percentiles

Performance Evaluation of NAQFC O_3 Forecasting

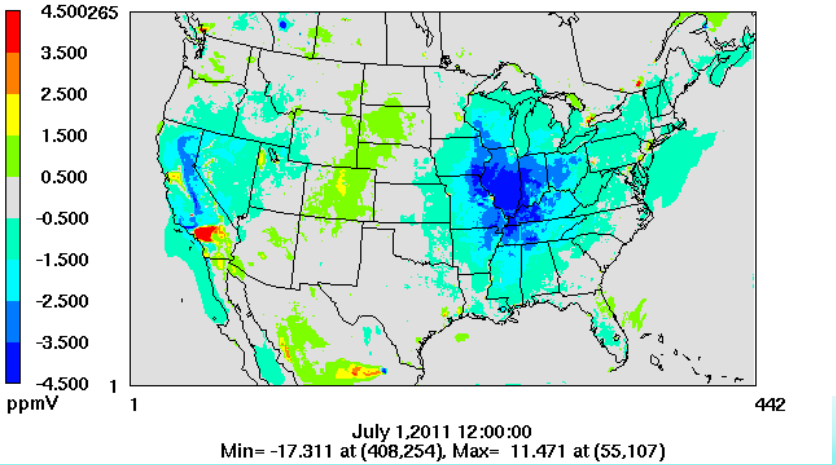
Effect of Using EPA Projection



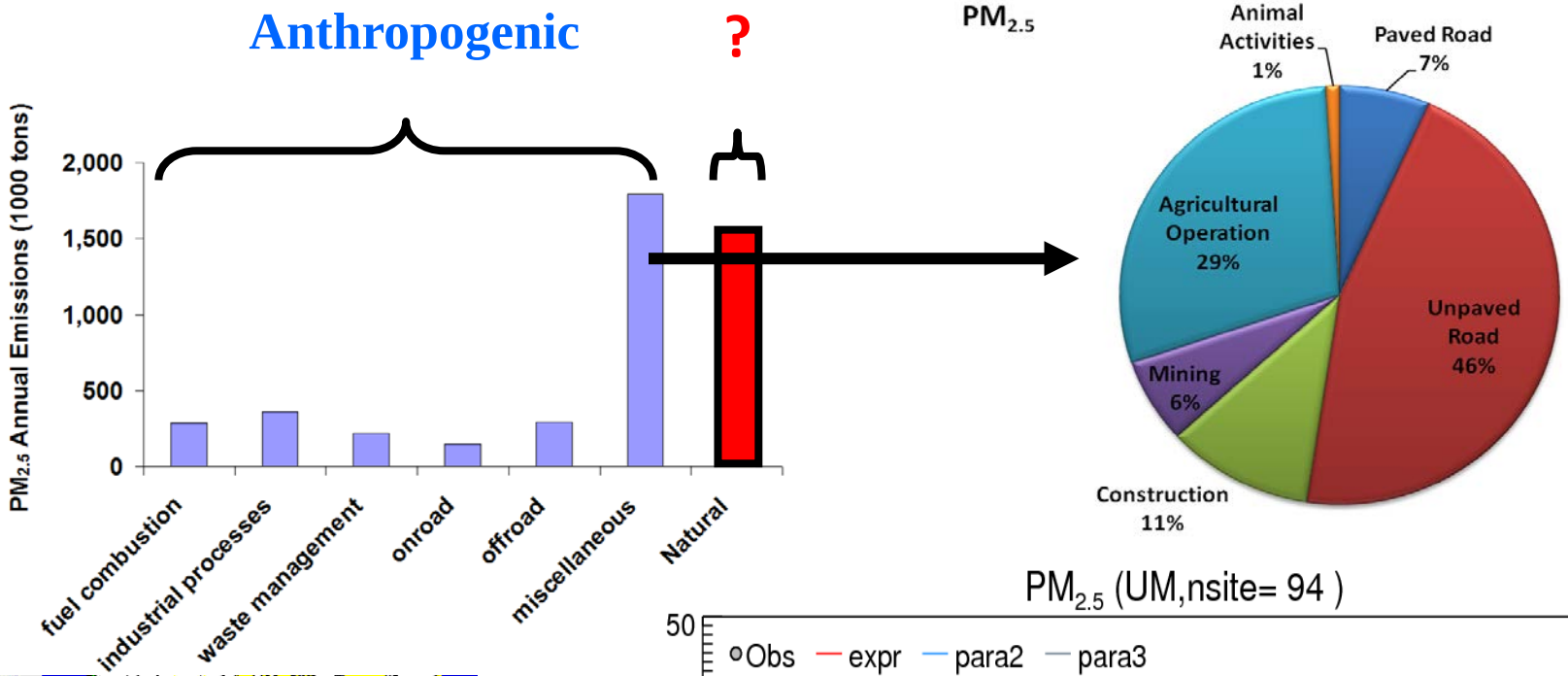
Effect of Using New Factors

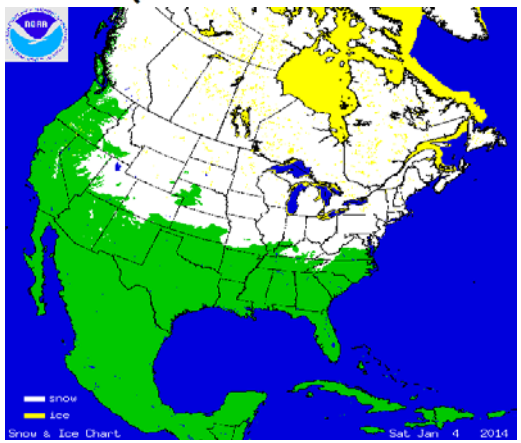


Difference

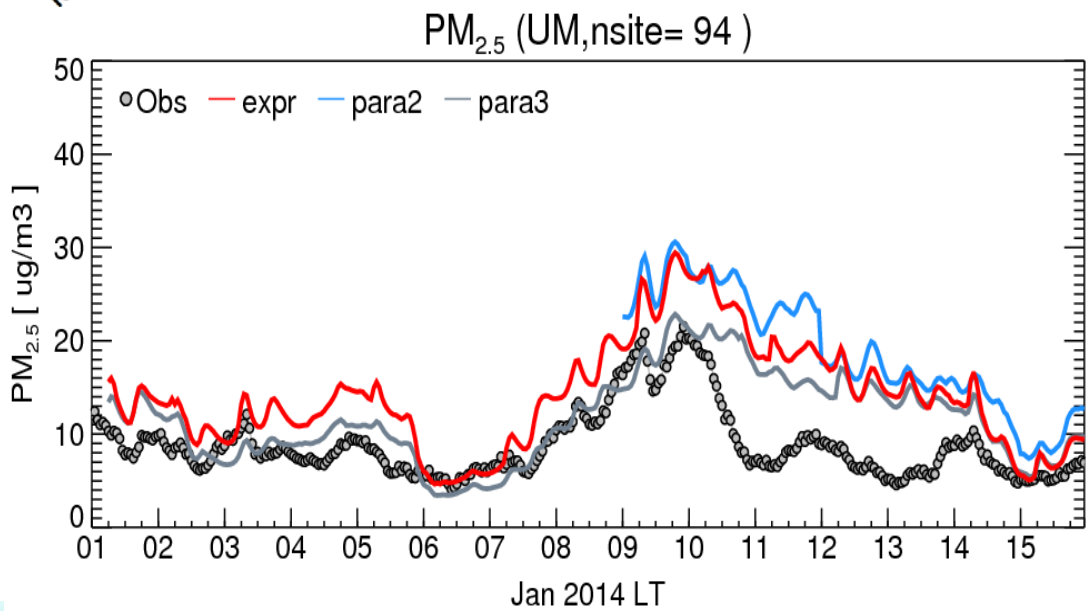


Snow/ice effect on fugitive emissions





(Credit: NOAA NIC)

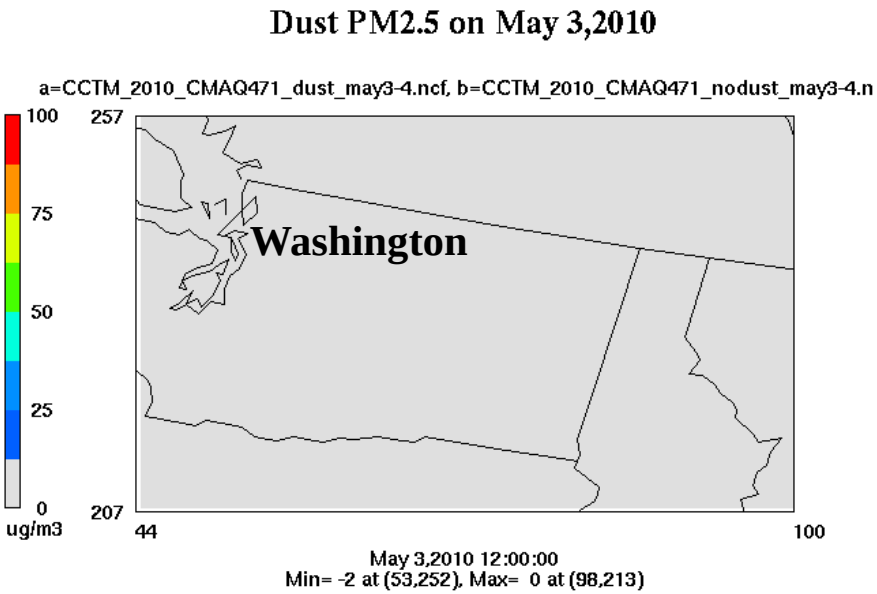


Windblown Dust Emission

- **Modified Owen's Equation (*Tong et al., in preparation*):**

$$F = \sum_{i=1}^{M}\sum_{j=1}^{N} K \times A \times \frac{\rho}{g} \times S_i \times SEP \times u_* \times (u_*^2 - u_{*ti,j}^2)$$

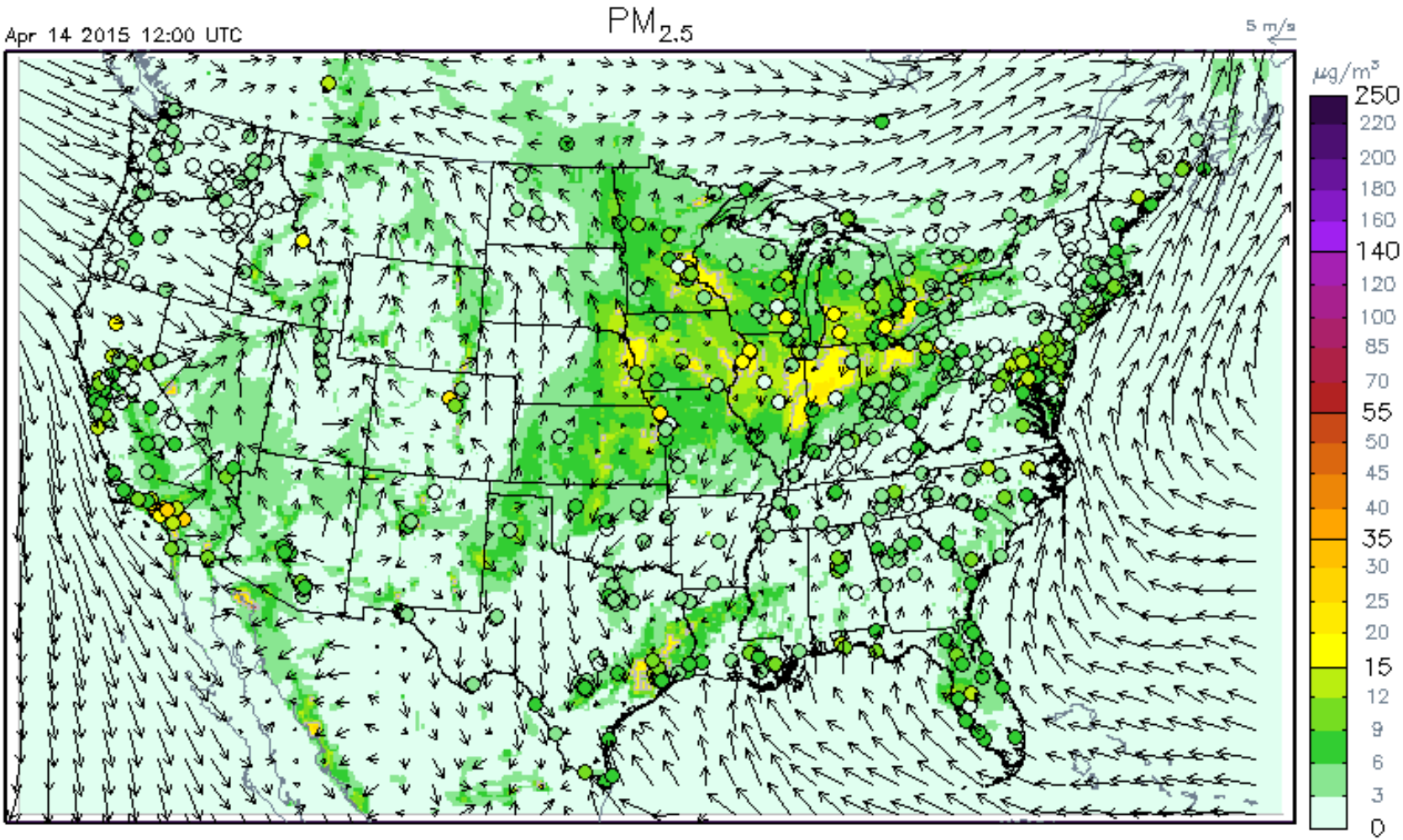
- **Threshold Friction Velocities (*Gillette et al.1980, 1982*)**
- **Effect of nonerodiable elements (*Marticorena et al, 1995*):**
- **Effects of soil moisture (*Fecan et al, 1999*):**



12:30 p.m, May 3,2010

--http://earthobservatory.nasa.gov/NaturalHazards

NAQFC Dust Storm Forecasting (April 14, 2015)

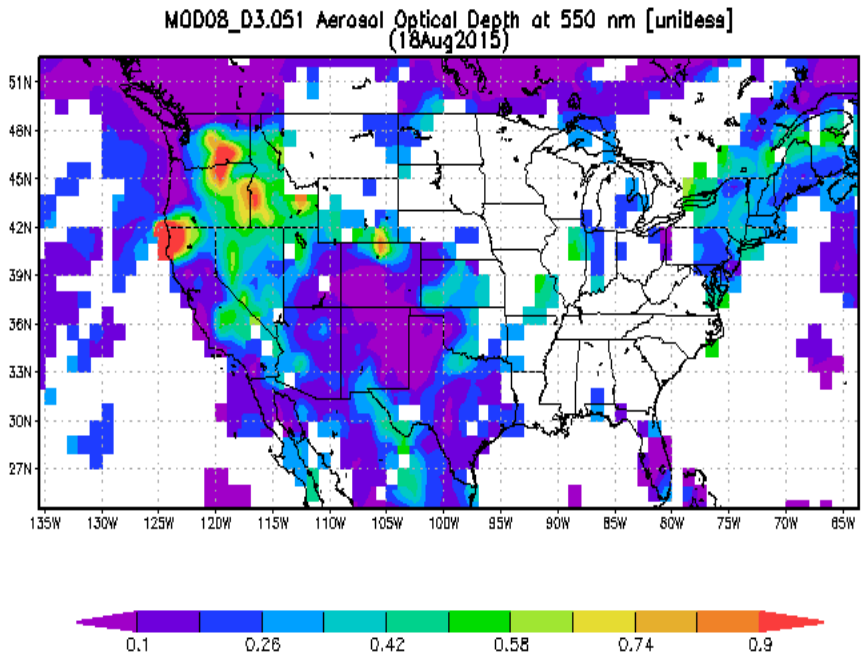


(More dust works by M. Huang)

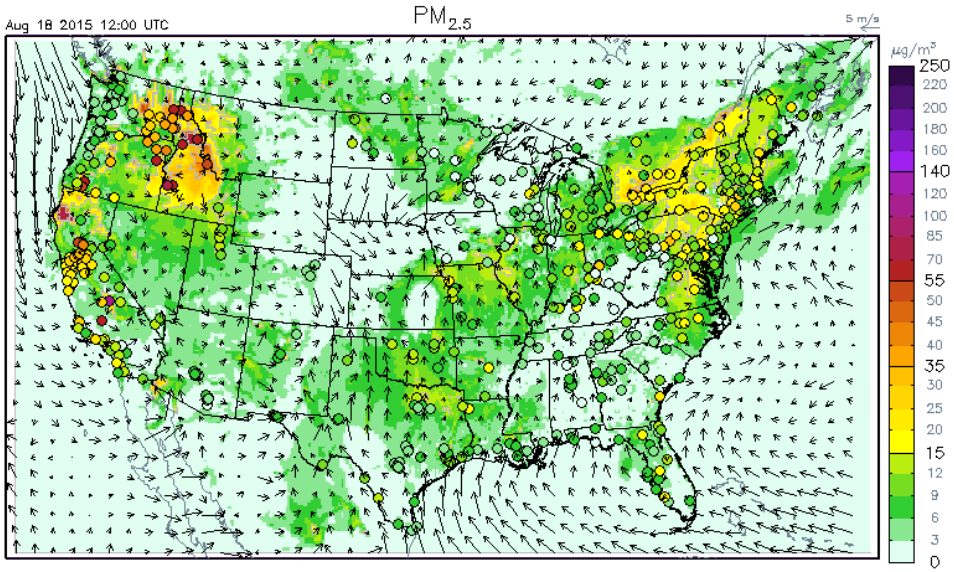
Dynamic Fire Emission

- Fire detection: NOAA Hazard Mapping System (HMS);
- Emission estimation: BlueSky Smoke Emission (H. Huang poster)
- ARL modifications for optimal performance with NAQFC (L. Pan)

Aqua MODIS AOD



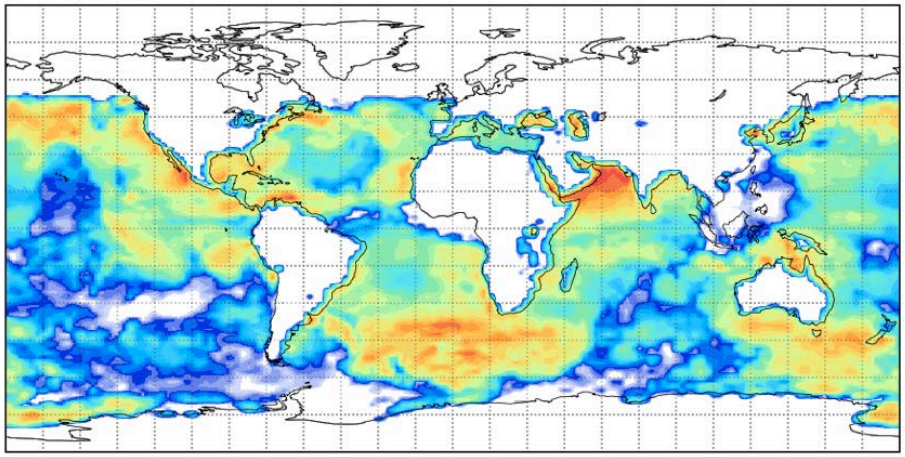
NAQFC $PM_{2.5}$ Forecasting



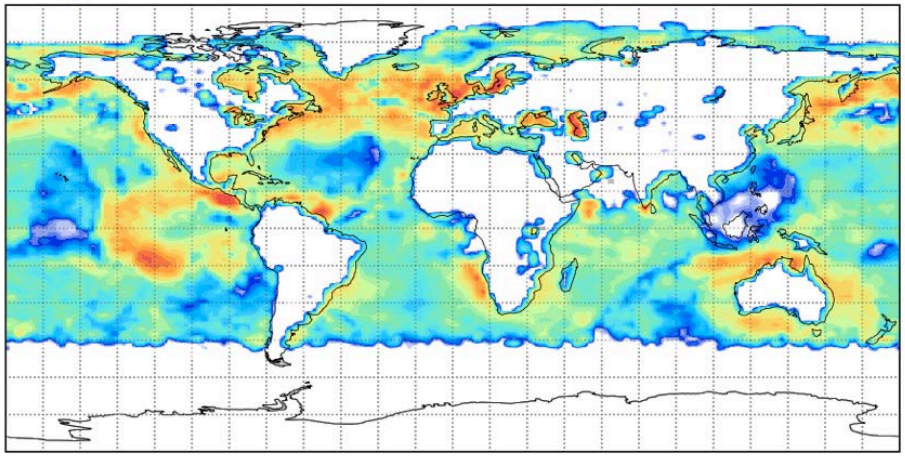
Marine Isoprene Emission Product

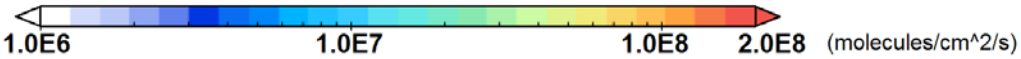
2013

January



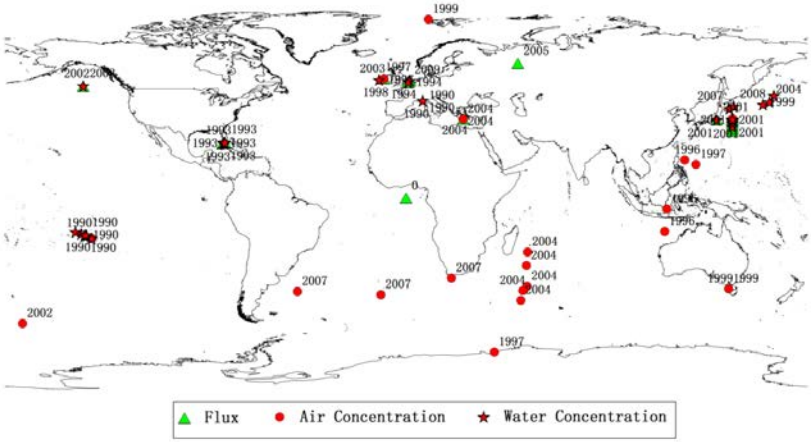
July

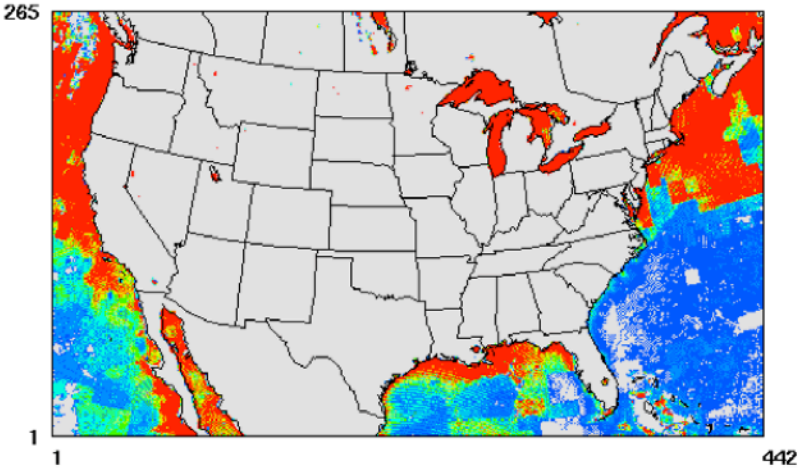




(NOAA JPSS Project)

Marine Isoprene Observations





Isoprene in NAQFC domain

(M. Wang: Ocean color and isoprene)

Emission Forecasting: Challenges and Possible Solutions

Emission Challenges	Existing or Proposed Solutions
1. Huge number of emission sources	NEIs and SMOKE-like Emission Processing
2. Gap between NEIs and forecast years	Emission forecasting capability
3. Weather effects on emissions	Inline emission modeling;
4. Major Socio-economic Events (Recession, Fracking, Disasters);	Emission data assimilation capability
5. Missing natural Sources (Fire, Dust, Volcano, Lightning, Marine, etc)	Process-based emission models