# Current and Potential Satellite Data Applications for the Air Resources Laboratory Air Quality, Dispersion, and Deposition Programs


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with contributions from Tianfeng Chai, Alice Crawford, Pius Lee, Ariel Stein, Daniel Tong, …and many others


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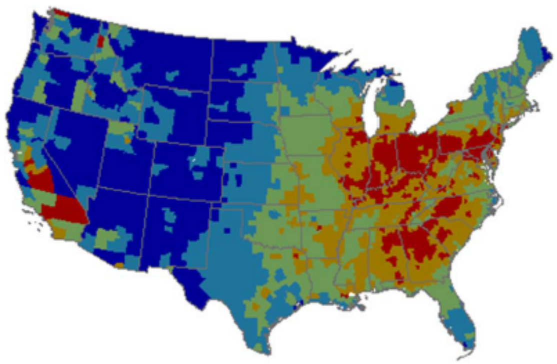
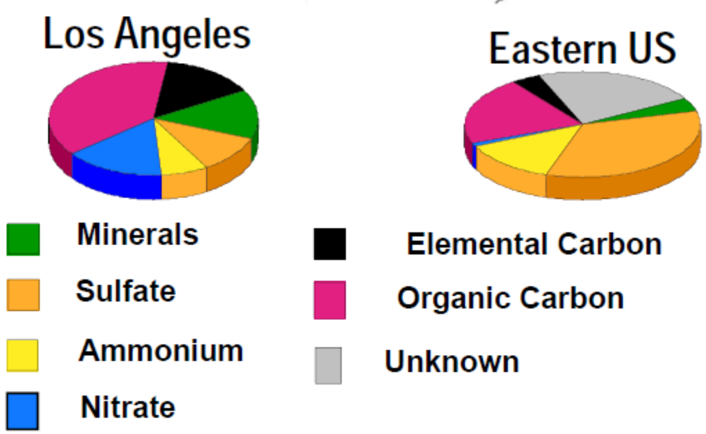
Slide "borrowed" from Dan Costa "New Directions in Air Quality Research at the US EPA"

# *Public Health Burden of $PM_{2.5}$*

## (Fann et al., 2011)

Percentage of $PM_{2.5}$ related deaths due to 2005 air quality levels by county






| Summary of National $PM_{2.5}$ impacts due to 2005 air quality | |
|---|---|
| Excess mortalities (adults)[A] | 130 to 320,000 |
| Percentage of all deaths due to $PM_{2.5}$[B] | 5.4% |
| ***Impacts among Children*** | |
| ER visits for asthma (<18 yr) | 110,000 |
| Acute bronchitis (age 8-12) | 200,000 |
| Exacerbation of asthma (age 6-18) | 2,500,000 |

[A] Range reflects use of alternate PM mortality estimates
[B] Population-weighted value using Krewski et al. (2009) PM mortality estimates

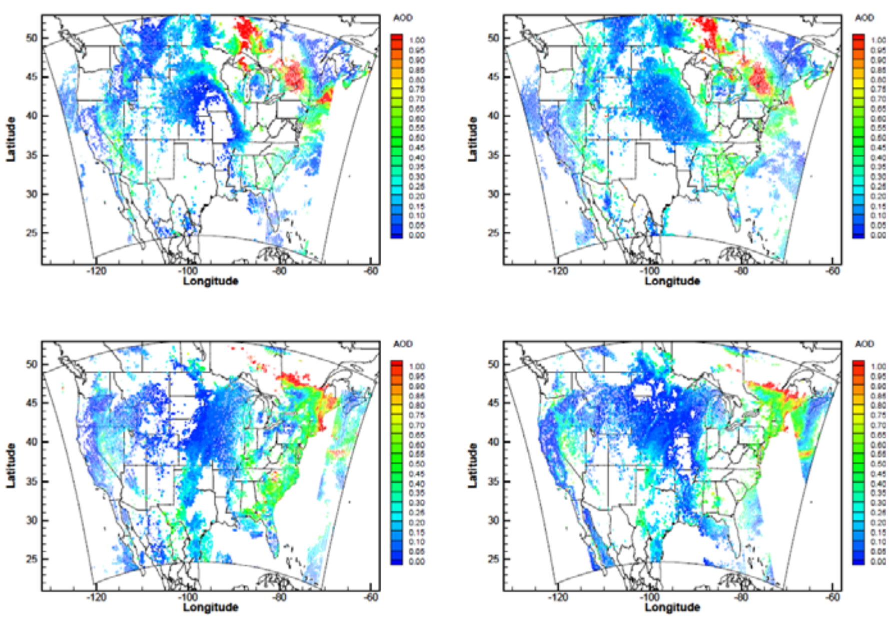
# NAQFC $PM_{2.5}$ Forecasts with AOD assimilation

| Cases | 12Z | 17Z | 18Z | 20Z | 00Z* | 06Z* |
|---|---|---|---|---|---|---|
| C0 | - | - | - | - | - | - |
| C1 | - | Terra total AOD | - | Aqua total AOD | - | - |
| C2 | $PM_{2.5}$ | - | $PM_{2.5}$ | - | $PM_{2.5}$ | $PM_{2.5}$ |
| C3 | $PM_{2.5}$ | Terra total AOD | $PM_{2.5}$ | Aqua total AOD | $PM_{2.5}$ | $PM_{2.5}$ |

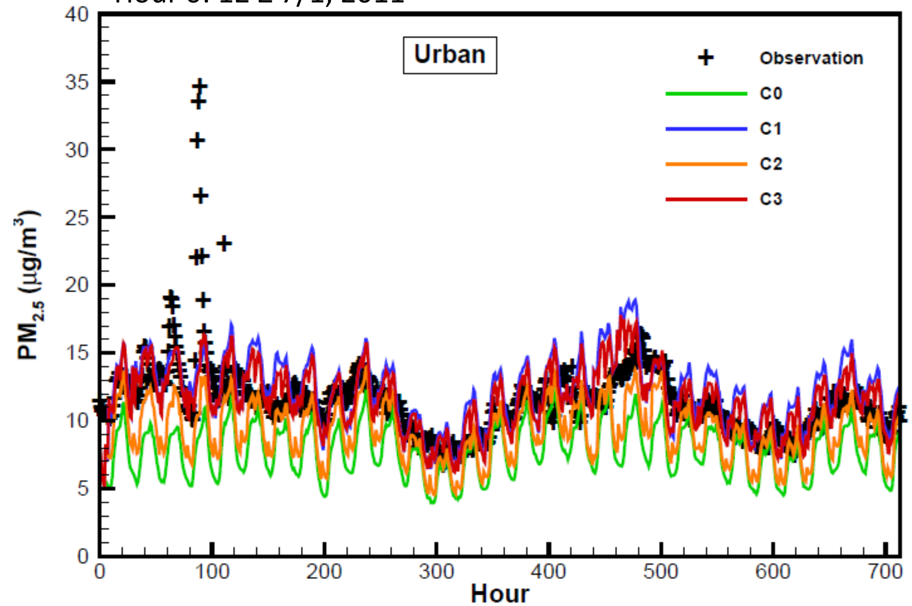
Terra Aqua

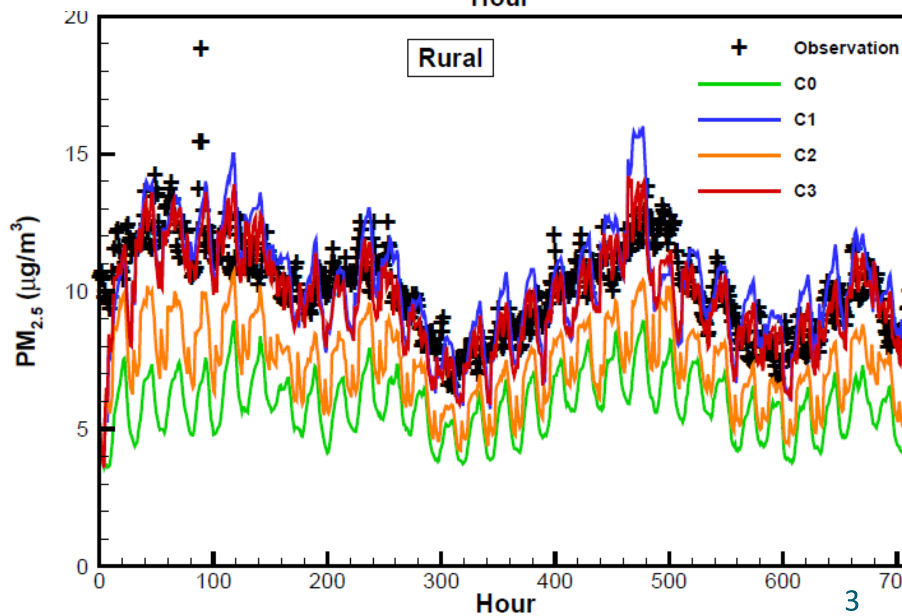
7/19, 2011

7/20, 2011




Hour 0: 12 Z 7/1, 2011



# Ozone Mapping and Profiler Suite (OMPS)

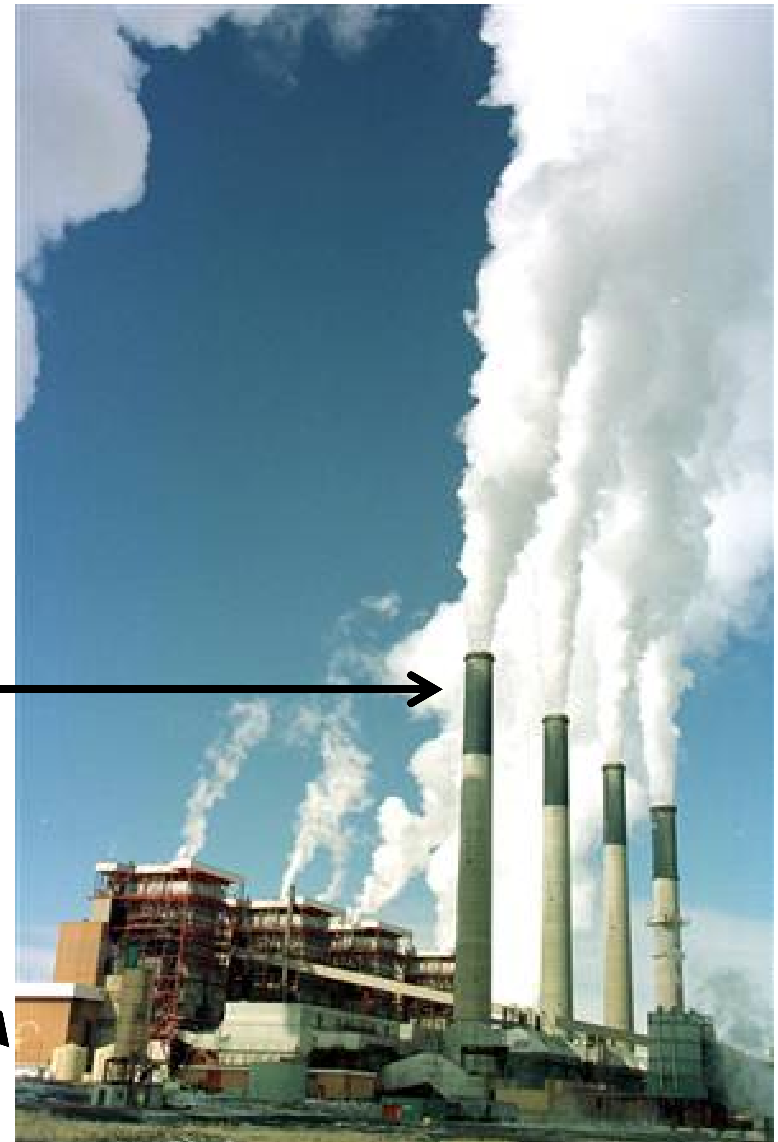
OMPS detects large plumes

## $NO_2$, $SO_2$, & HCHO data

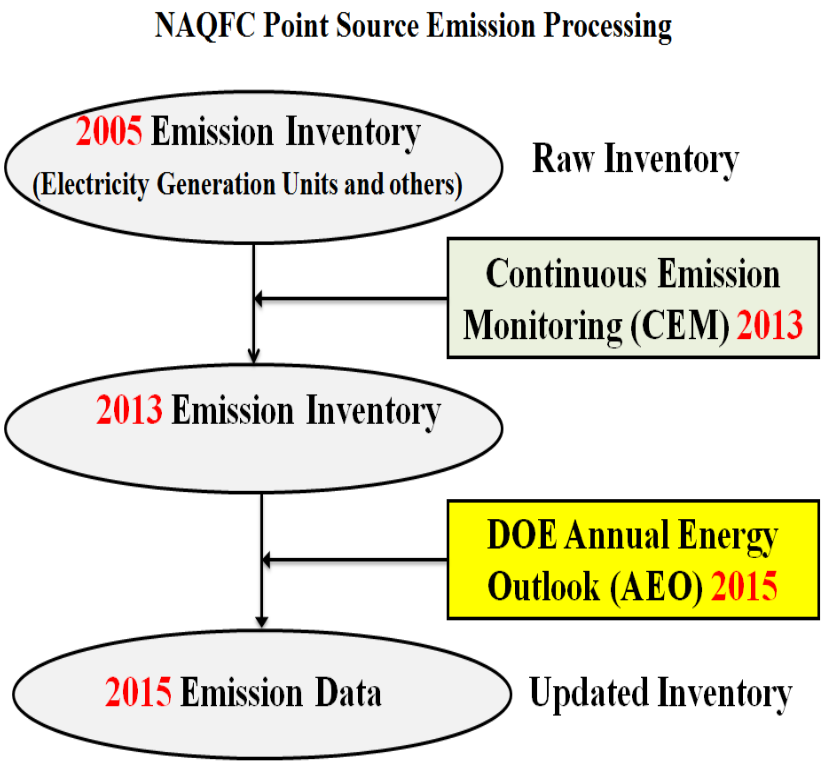
***OMPS detects pollution in the lower levels of the column***

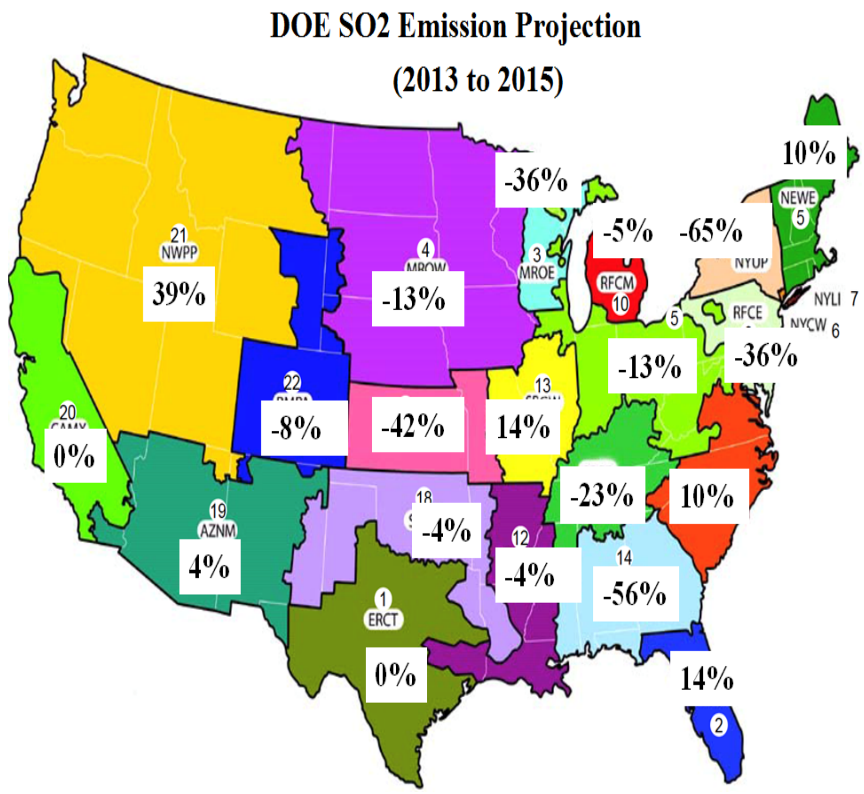
**CEMS (Continuous Emission Monitoring System)**

**The AQS (Air Quality System) surface sites detect near-surface concentrations**

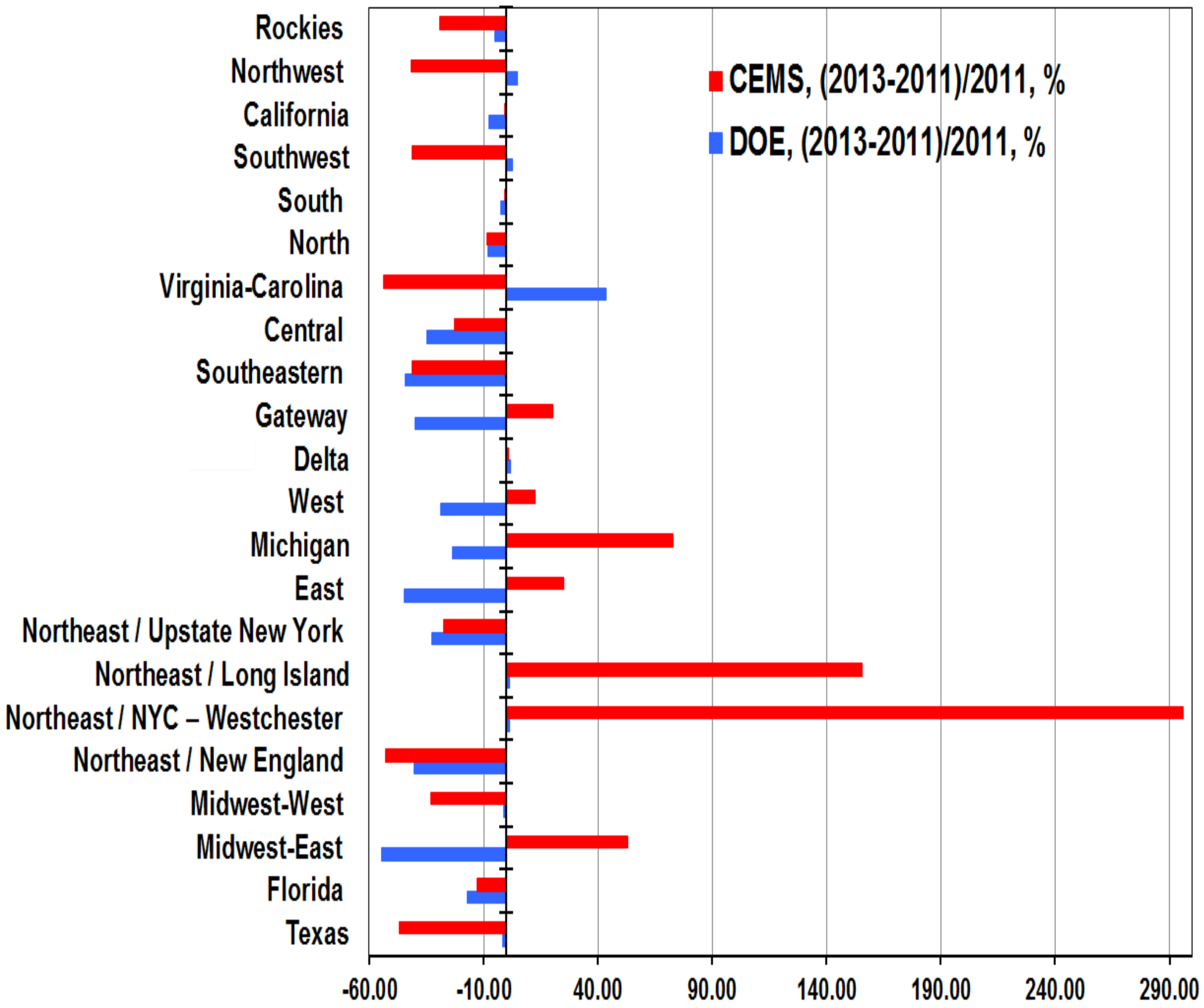


# SO2 Emissions from Large Power Plants

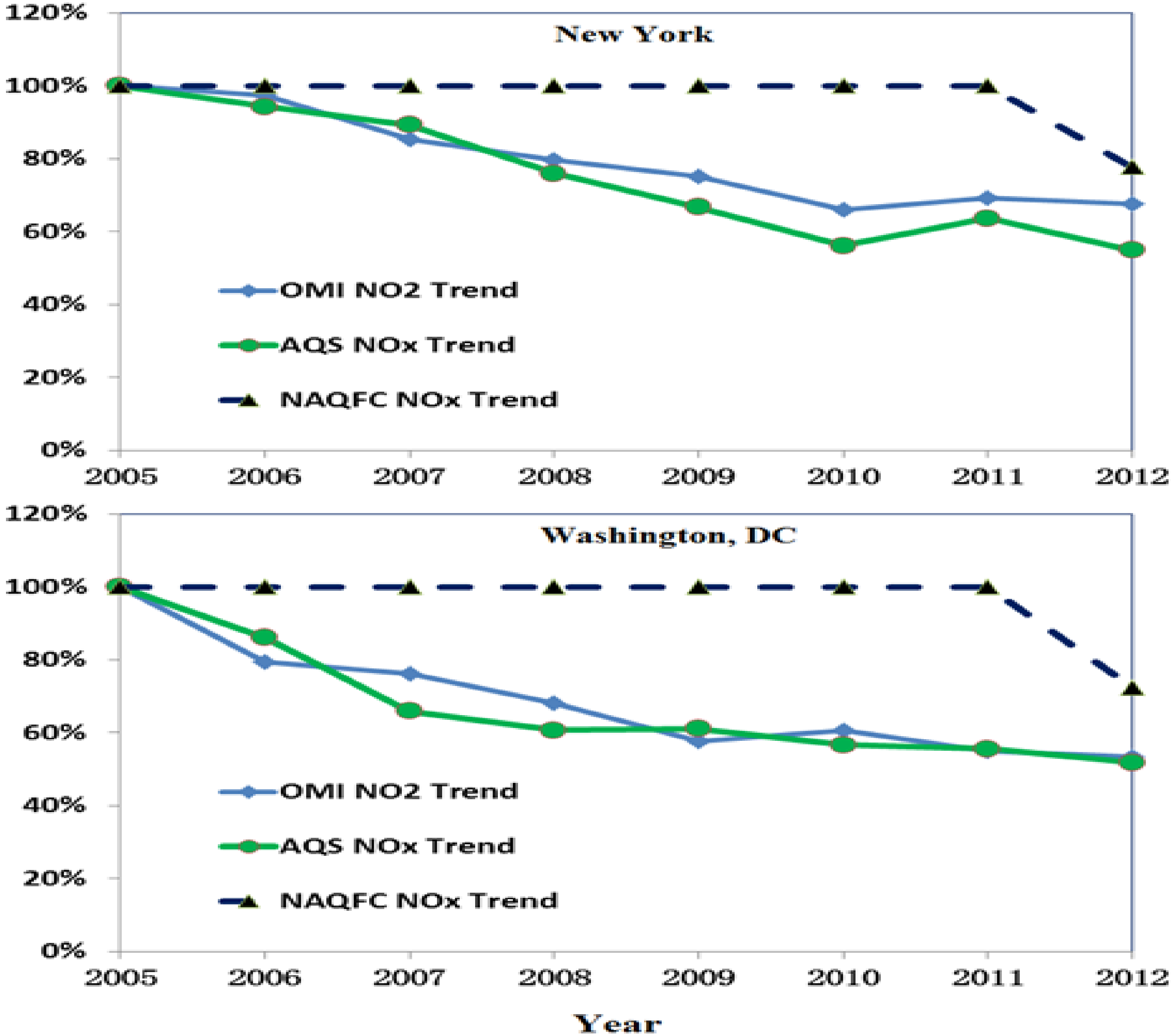


# Comparison of DOE Projections with Measurements

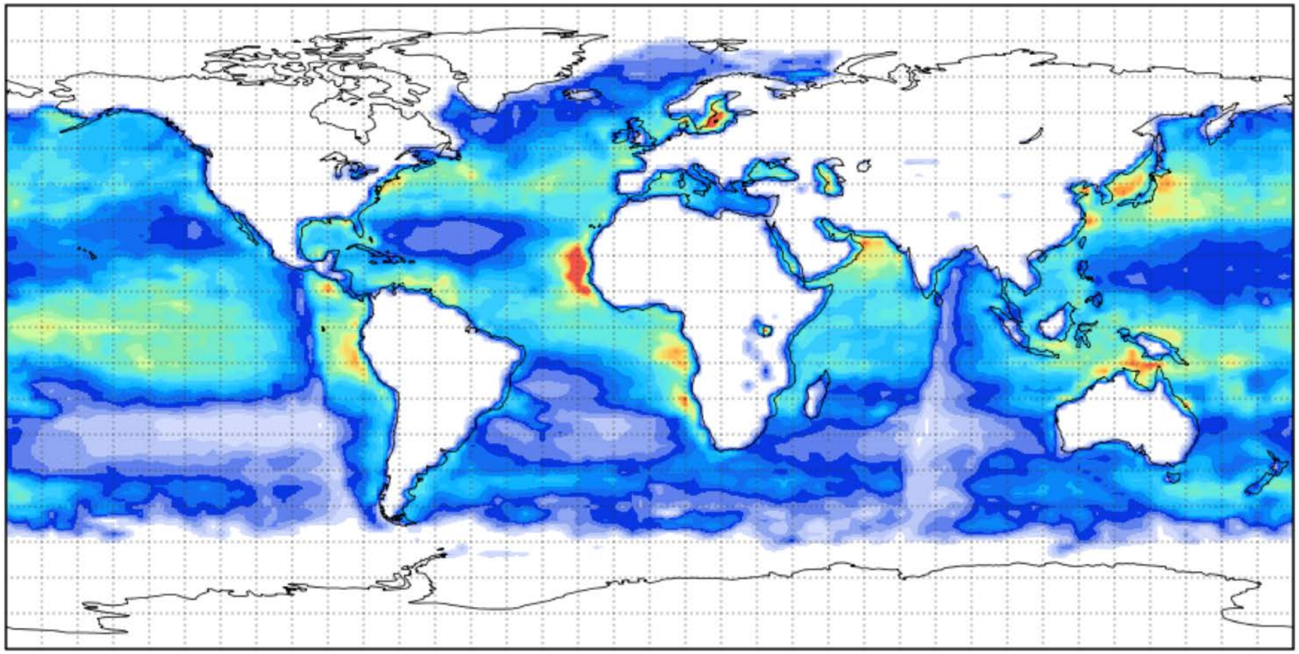


# Another Application: OMPS NO2

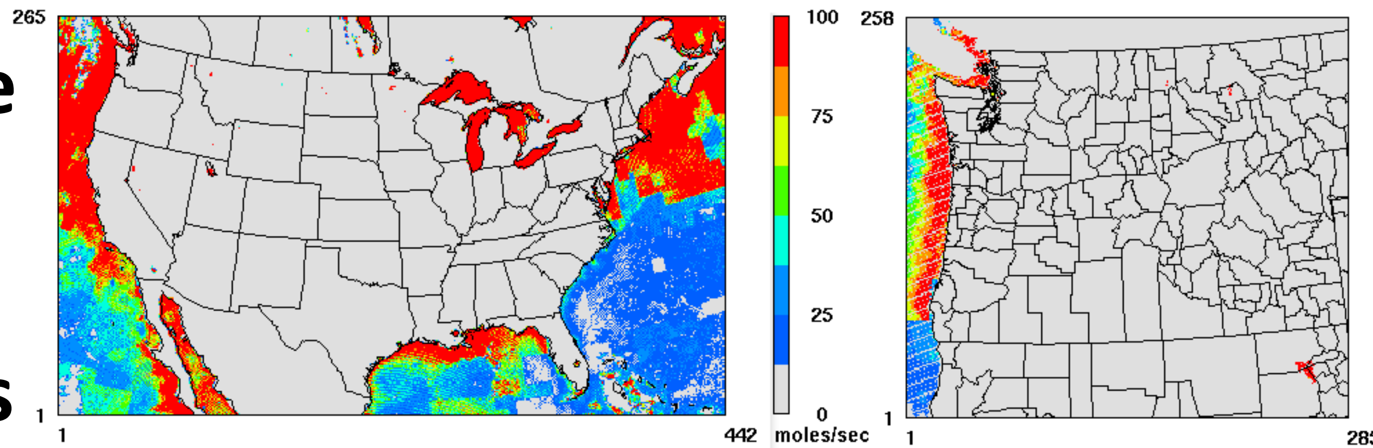


# VIIRS Marine Isoprene Emission

**Global Isoprene (April 2014)**

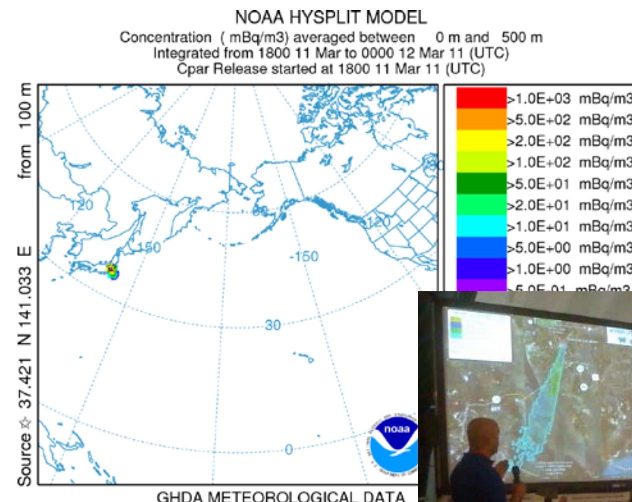


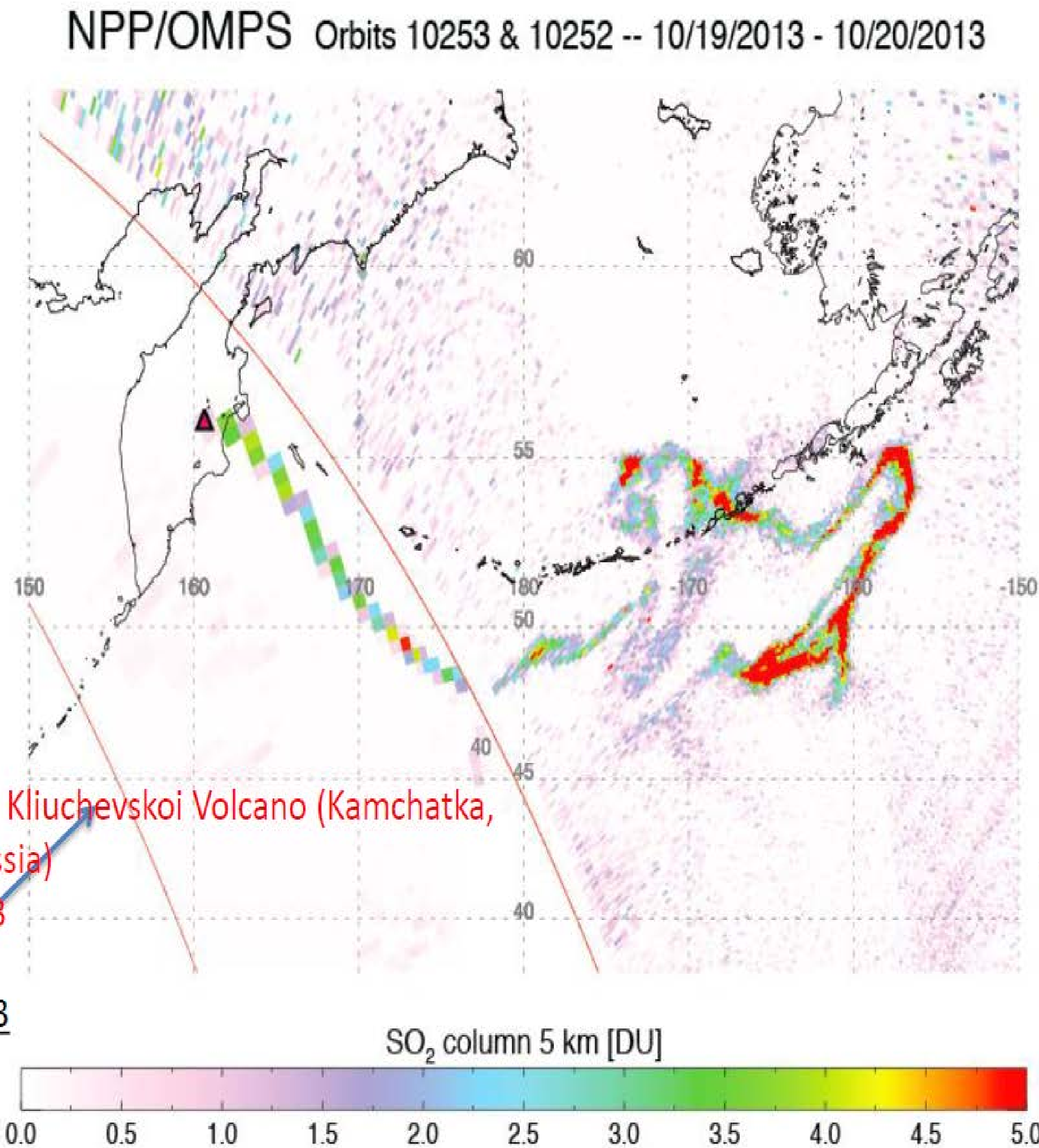
**Isoprene into model domains**



# Atmospheric Transport and Dispersion

## Dispersion Modeling System




Eruption of Kliuchevskoi Volcano (Kamchatka, Eastern Russia)
10/19/2013

Orbit: 10253
*Low-res*

Orbit: 10252
*Hi-res*

# Volcanic Ash Forecasting for Aviation

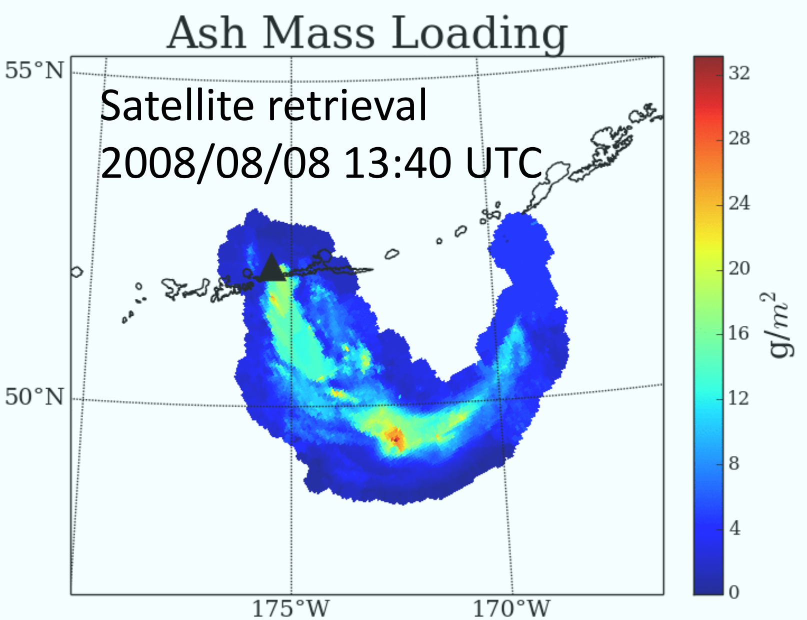
CURRENT: Ash source term subject to large uncertainties (estimate of mass of ash can be off by orders of magnitude). Satellite observations ⟹ Human ⟹ Model

Satellite based Volcanic Ash Retrieval Algorithm from NOAA/CIMSS

http://volcano.ssec.wisc.edu/.

**Quantitative Information**

- Mass loading
- Top height
- Effective radius



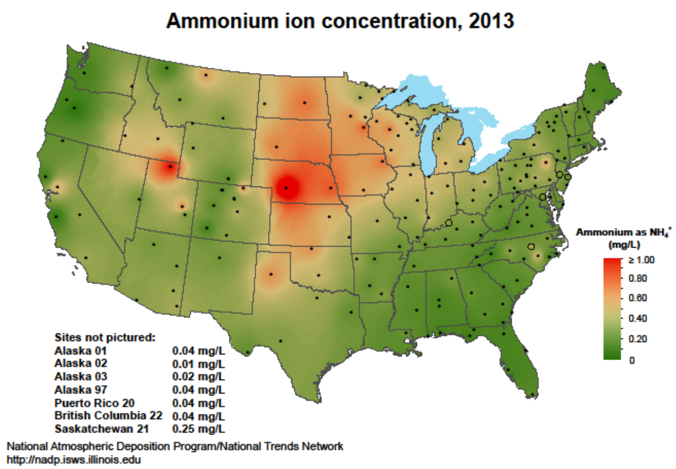

2008 Eruption of Kasatochi, Aleutian Islands.

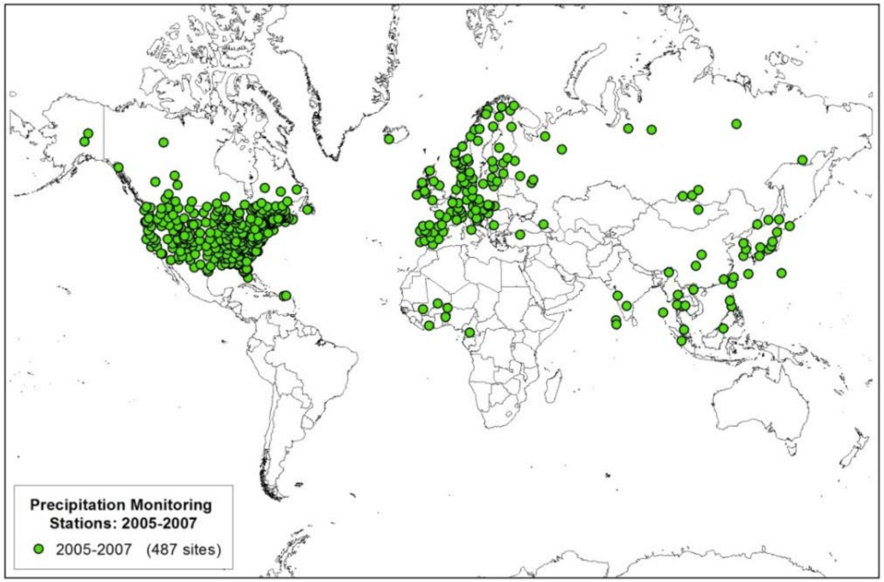
Ash retrievals were provided by Michael Pavolonis and are available at ftp://ftp.ssec.wisc.edu/pub/geocat/noaa_ash_retv/kasatochi

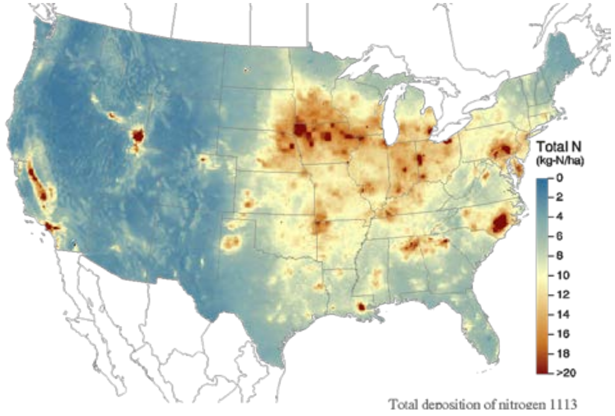
PROPOSED:
Satellite retrieval ⟹ Model

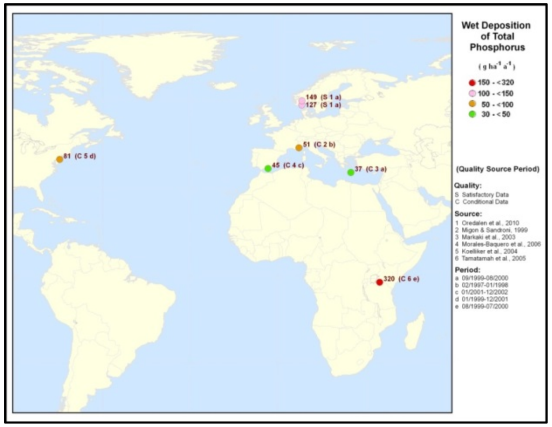
- Improve Source term (3 different approaches):
  - Amount of mass determined by matching HYSPLIT output with measured mass loading.
  - Source constructed from measurement of mass loading, top height and effective radius. Ash initiated at observed position rather than at the volcano vent.
  - Inversion algorithm utilizes satellite measurements to determine likely emission profile at the vent (ash mass as a function of time and height).
- Evaluation of model output using satellite measurements.
  - Evaluation statistics used to direct model development efforts.
  - Provide information to VAAC on model performance as an eruption is unfolding.

# Wet and Dry Atmospheric Deposition



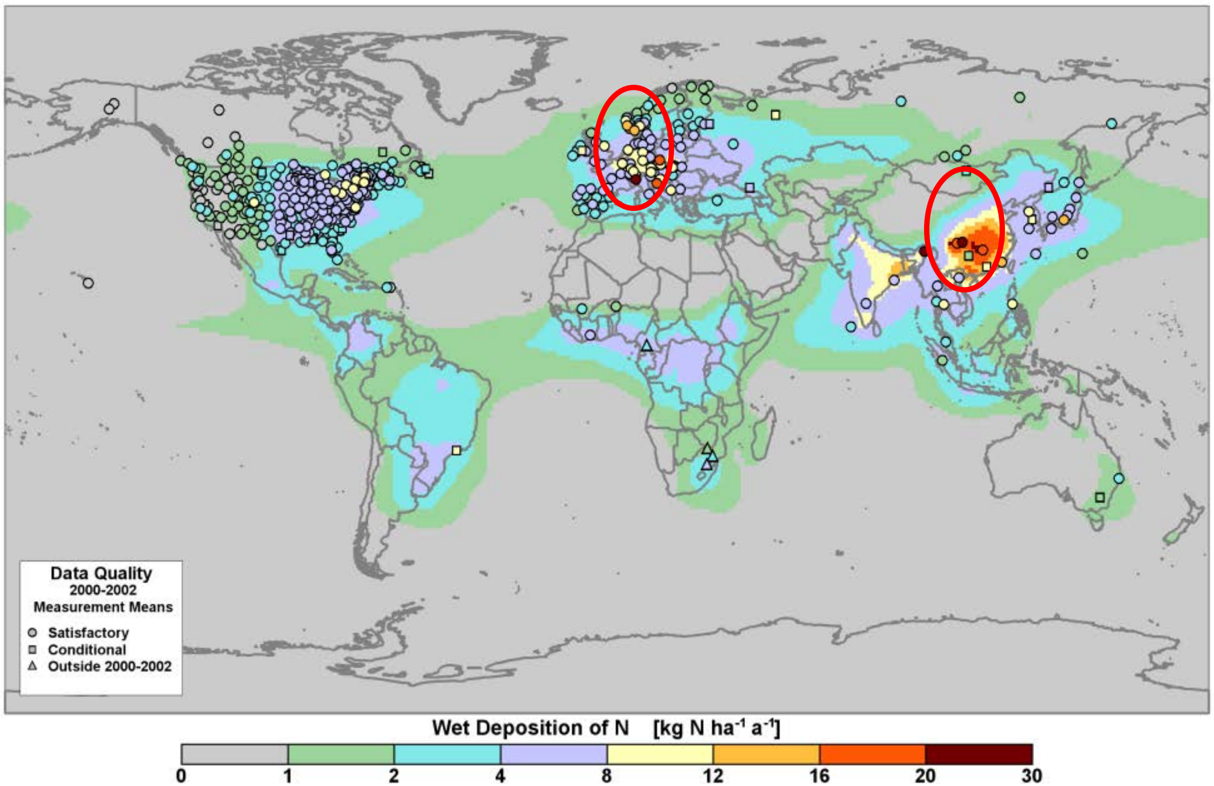



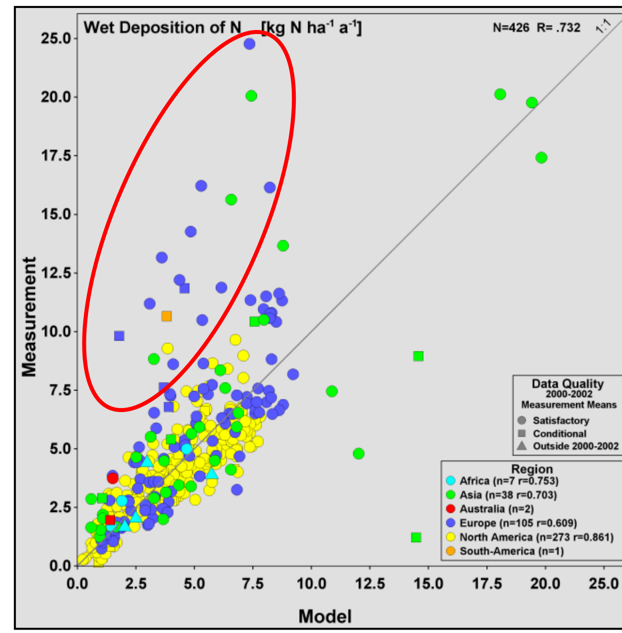

Deposition of Major Ions Nationally and Globally

# *Nitrogen*

## Wet deposition of Oxidized + Reduced Nitrogen




### Model versus Measurement Results




- High deposition in eastern North America, Europe and Asia
- Reasonable model-measurement comparability except in Europe and parts of Asia

Slide courtesy of R. Vet

AGU PUBLICATIONS

Global Biogeochemical Cycles

RESEARCH ARTICLE

10.1002/2014GB004805

**Key Points:**
- $NO_2$ and $SO_2$ dry deposition is derived from space-based measurements
- Global and regional budgets of dry deposition are determined
- $NO_2$ and $SO_2$ deposition in urban areas is examined

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# Global dry deposition of nitrogen dioxide and sulfur dioxide inferred from space-based measurements

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**Abstract** A method is developed to estimate global $NO_2$ and $SO_2$ dry deposition fluxes at high spatial resolution (0.1° × 0.1°) using satellite measurements from the Ozone Monitoring Instrument (OMI) on the Aura satellite, in combination with simulations from the Goddard Earth Observing System chemical transport model (GEOS-Chem). These global maps for 2005–2007 provide a data set for use in examining global and regional budgets of deposition. In order to properly assess $SO_2$ on a global scale, a method is developed to account for the geospatial character of background offsets in retrieved satellite columns. Globally, annual dry deposition to land estimated from OMI as $NO_2$ contributes 1.5 ± 0.5 Tg of nitrogen and as $SO_2$ contributes 13.7 ± 4.0 Tg of sulfur. Differences between OMI-inferred $NO_2$ dry deposition fluxes and those of other models and observations vary from excellent agreement to an order of magnitude difference, with OMI typically on the low end of estimates. $SO_2$ dry deposition fluxes compare well with in situ Clear Air Status and Trends Network-inferred flux over North America (slope = 0.98, $r$ = 0.71). The most significant $NO_2$ dry deposition flux to land per area occurs in the Pearl River Delta, China, at 13.9 kg N $ha^{-1}$ $yr^{-1}$, while $SO_2$ dry deposition has a global maximum rate of 72.0 kg S $ha^{-1}$ $yr^{-1}$ to the east of Jinan in China's Shandong province. Dry deposition fluxes are explored in several urban areas, where $NO_2$ contributes on average 9–36% and as much as 85% of total $NO_y$ dry deposition.