

Project Report:

NASA and NAAPS Products for Air Quality Decisions

PI: D. Westphal, Naval Research Lab.

Sub-Project:

Exceptional Event Decision Support System (EE DSS)

Co-PI, R. Husar, Washington University

Presented at

NASA Applied Sciences Program, Health and Air Quality

St. Paul, MN, September 24-26, 2013

Report Outline

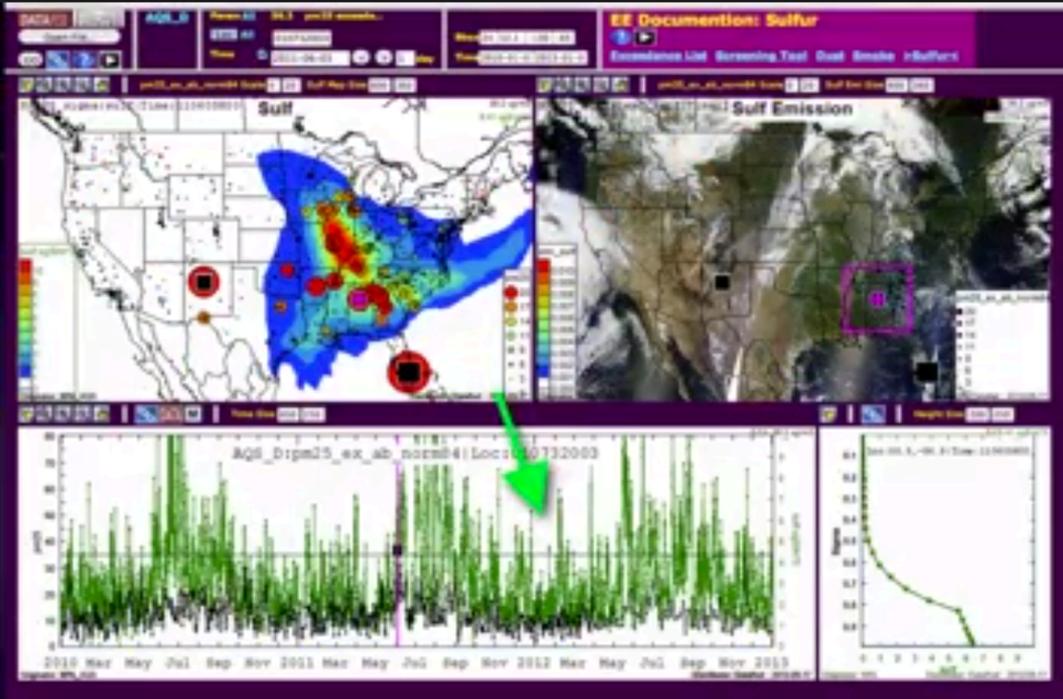
- Exceptional Event Decision Support System (EE DSS)
- Interaction with end users: States, Federal & Reg. EPA
- Recent application example: Hawaii Volcano
- Project Accomplishments, Plans: ARLs & Sustainability

EE DSS YouTube Channel

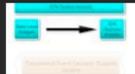
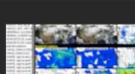
YouTube Rudolf Hus

Exceptional Event Decision Support System (EE DSS) by DataFedScreencasts

3/5



The screenshot displays the EE DSS software interface. It features a top navigation bar with tabs for 'EE Documentation: Sulfur', 'Exceedance List', 'Screening Tool', 'Sulf Smoke', and 'Sulfurt'. The main area is divided into four panels: a map of the United States with a color-coded sulfur concentration overlay, a satellite-style map of the same region with a purple box highlighting a specific area, a time-series plot of sulfur concentration from 2010 to 2012, and a smaller plot showing a concentration profile. A green arrow points to a specific data point in the time-series plot.

- 1  **EE DSS Intro**
by DataFedScreencasts
- 2  **EE Screening Tool**
by DataFedScreencasts
- ▶  **EE Causality Document Tools**
by DataFedScreencasts
- 4  **EE Exceedance List**
by DataFedScreencasts
- 5  **EE Data Console**
by DataFedScreencasts

1:43 / 2:10

Channels of Interaction with EE DSS Users

Webinars, Individual interactions

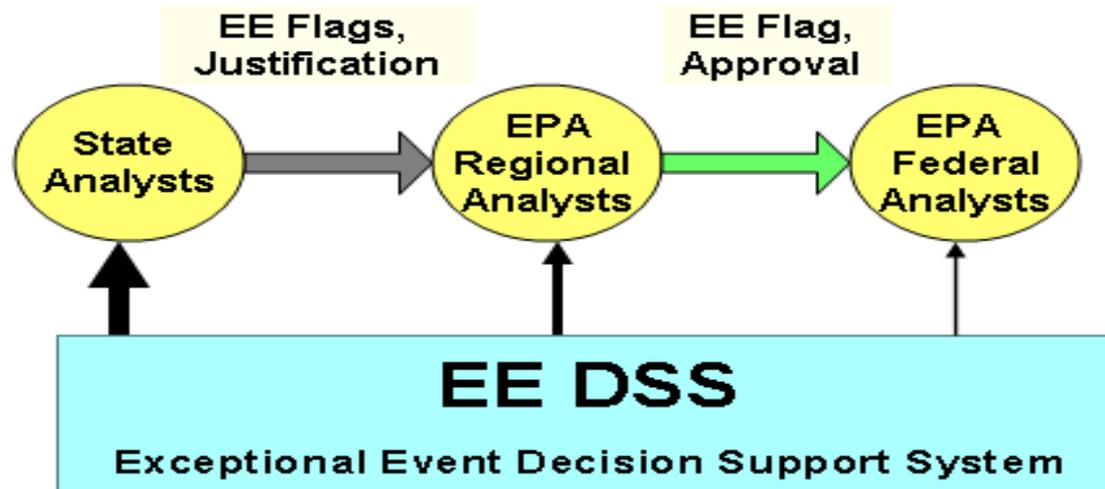
Community wikis – sharing documents, collaborating

Video Channel – Introductions, tools instructions

Personal Communication

Webinars with the EE DSS Users in 2013:

Apr 30, May 29, Jul 25, Sep. 19



Typical Webex Meeting Agenda

- **Introduction** (1-2 min): Beth Palma, EPA, OAQPS
- **Webex, participation** (5 min): Erin Robinson, ESIP Moderator
- **EE DSS description** (30 min): Rudy Husar, Washington University
- **Use Cases of EE DSS**(20 min): E. Robinson,; Participants; R. Husar

Application-Task-Centric

Workspaces Example:

EventSpaces

Google Search | Bookmarks | PageRank | AutoLink | AutoFill | Send to

article | discussion | edit | history | move | watch

Exceptional Air Pollution Event Analysis Community Workspace

Exceptional Event (EE):

An air quality exceedance that would not have occurred *but for* the presence of a natural/nonrecurring event.

This is a community workspace for illustrative analyses of smoke, dust and other unusual events. Contributions are welcome of observations, models, tools, methods, analyses and discussions. *Ideas on wiki contents and layout will be most appreciated!!*

What's New

- 2007-11-10: Space-Time Trend of PM Compliance
- 2007-11-09: Required Evidence for Flagging EEs
- 2007-11-08: Analysed Exceptional Events
- 2007-10-22: Southern California Wildfires
- 2007-10-11: EE Wiki Up, Telecon| EEs by Region | EE Analyses

EE Context

Regulatory

EE Rule | Talking Points | EPA Docs | 1998 EPA Guide

Issues

Regulatory | Scientific | Technical | Other..

People

People interested in Exceptional Event Analyses

Air Pollution Events

Illustrative EE Analyses

Smoke | Dust | July 4th

Candidate Events by EPA Region

Region 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10

EE-Related Resources

Tools and Methods

Datasets

Reports, Papers

Websites

Catalog - Find Dataset

071022SoCalSmoke

Description: Drought and Santa Ana winds created "perfect fire" conditions in S. California

- There is a wealth of information on the event dispersed over the Web
- This wiki is for capturing info resources on the smoke and its air quality impacts
- Users are encouraged to contribute and to **use the resources to analyze and learn**

Type: NA | Pollution | Location: Southern California | Dates: October 22, 2007 - November 1, 2007 | Lat: 30.38 | Lon: -110.110

Interested in the California Smoke Event? Please join us in harvesting web resources!

Please use the tag [071022SoCalSmoke](#) in [Del.icio.us](#), [Flickr](#), [Blogs](#), [YouTube](#) to identify Web resources. Ideas, comments, questions? Contact [rhusar@ma.wustl.edu](#) or [stefan@wustl.edu](#)

Science-Oriented Websites

Aerosol and Smoke Forecasts

DatasetTitle	ProviderAbbr	DataType	SampleMethod	
AIRNOW	Surface Monitoring Data for PM2.5 and Ozone	EPA	POINT	Point
EMC Model	EMC_Model	NOAA	SegImage	Model
GOCART G_OL	Global Chemical Transport Model	NASA	GRID	Model
NAAPS GLOBAL	NRL Global Aerosol Model	NRL	Image	Model
NAAPS NoAm	NRL Global Aerosol Model	NRL	Image	Model

Web pages to smoke forecasts, tagged as 071022SoCalSmoke Forecast:

USFS BlueSky/CMAQ California Predictions | Experimental smoke prediction page from USFS/STVDR/NASA/NOAA, 26 October 2007, by rafscallon

IDEA - Infusing satellite Data into Environmental Applications | 26 October 2007, by rhusar

Aerosol and Smoke, NearRealTime

DatasetTitle	ProviderAbbr	DataType	SampleMethod	
AIRNOW	Surface Monitoring Data for PM2.5 and Ozone	EPA	POINT	Point
CALIPSO	CALIPSO Lidar Browse Images	NASA	Image	RemoteSens
GASP	Global Aerosol Source Prediction	NOAA	SegImage	Model
MODIS	MODIS Aerosol Optical Depth	NOAA	Image	RemoteSens
GOCART G_OL	Global Chemical Transport Model	NASA	GRID	Model
MOPITT Day	Dataset Title	NCAR	Image	RemoteSens
NOAA HMS WFS	Dataset Title	NOAA	POINT	RemoteSens
OMI AI G	OMI Absorbing Aerosol Index	NASA	GRID	RemoteSens
OnEarth JPL	OnEarth Daily Aqua Terra Global Composite Images	NASA	SegImage	RemoteSens
SURF MET	Global Surface Meteorology Monitoring Network	PSWC	POINT	Point
SURF MET WIND	Global Surface Meteorology Monitoring Network	PSWC	POINT	Point

Interagency real time smoke monitoring | 29 October 2007, by srl_dsc

Fire Hazard Mapping System - Satellite Services Division | 24 October 2007, by rhusar

Specific Exceptional Event

YouTube Videos

List of selected videos from YouTube.

Blogs

Posts that contain California Fire per day for the last 30 d

POWERED BY Technorati

Google Blog Search: California Fire Smoke

Near Real time Data Console

Web Harvesting for 'California Smoke'

Google Searches

- Google News Search: California Fire Smoke
- Google Image Search: California Fire Smoke
- Google Web Search: California Fire Smoke

Flickr Images

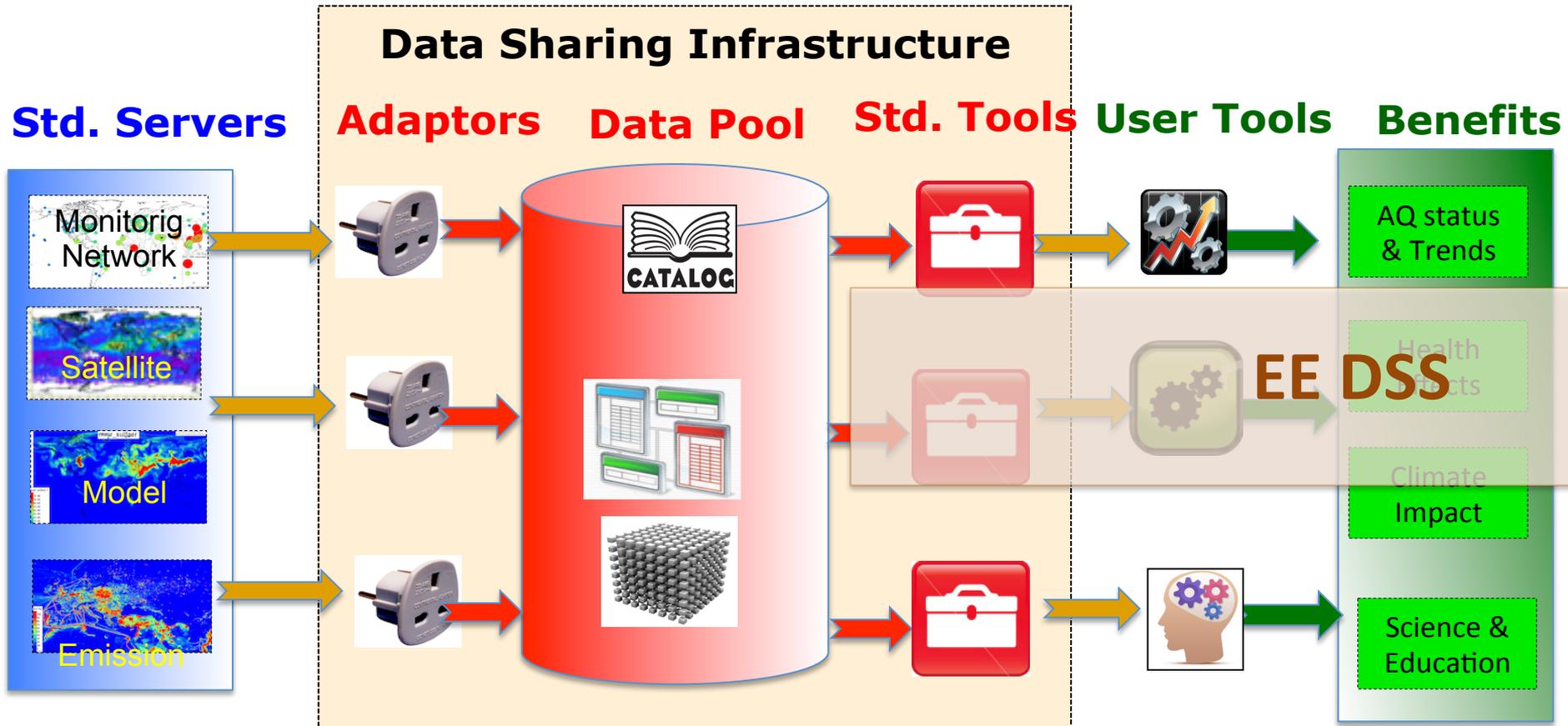
- Flickr Images: California Smoke, after Oct 21, 2007

The image collection below is a subset of smoke pictures extracted from the above particular interest to smoke pattern, transport and color.

Flickr Favorites Slide Show

Harvest Resources

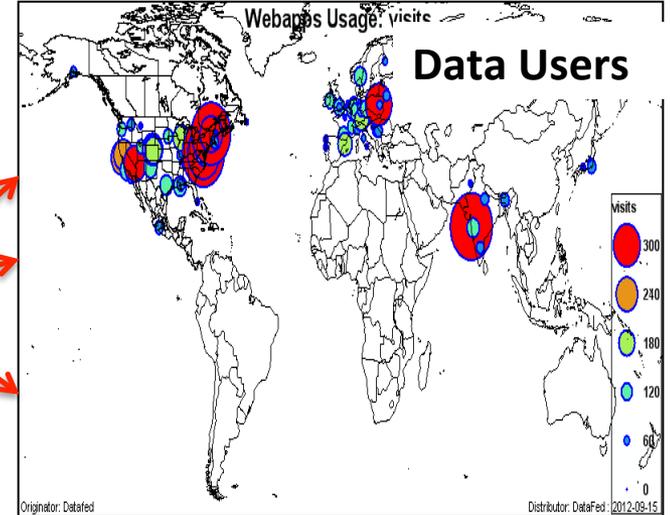
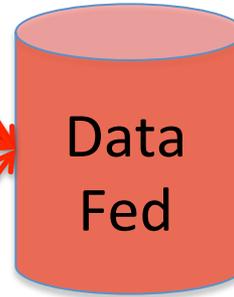
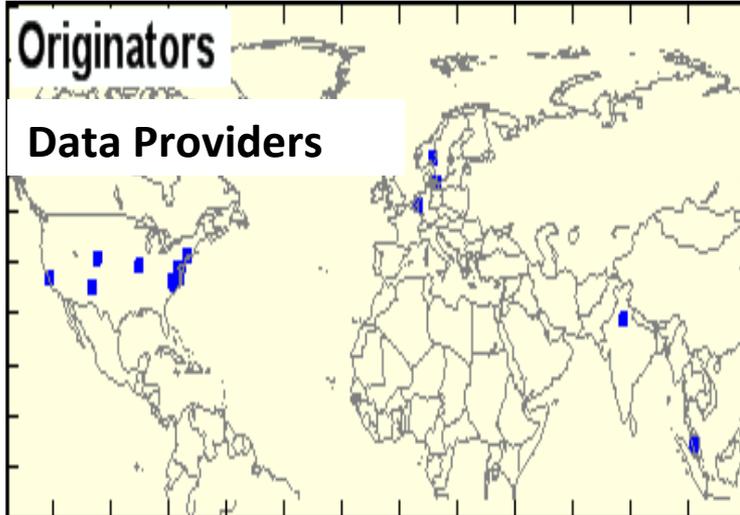
EE DSS Built on Federated Data System. DataFed:



DataFed is an implementation of the GEOSS data sharing paradigm
DataFed also includes client applications for data browsing, exploration and analysis
These flexible tools can be used on any dataset form anywhere on the Web.

DataFed Usage Pattern

Based on Google Analytics Data/Tool Access Count (not clicks)



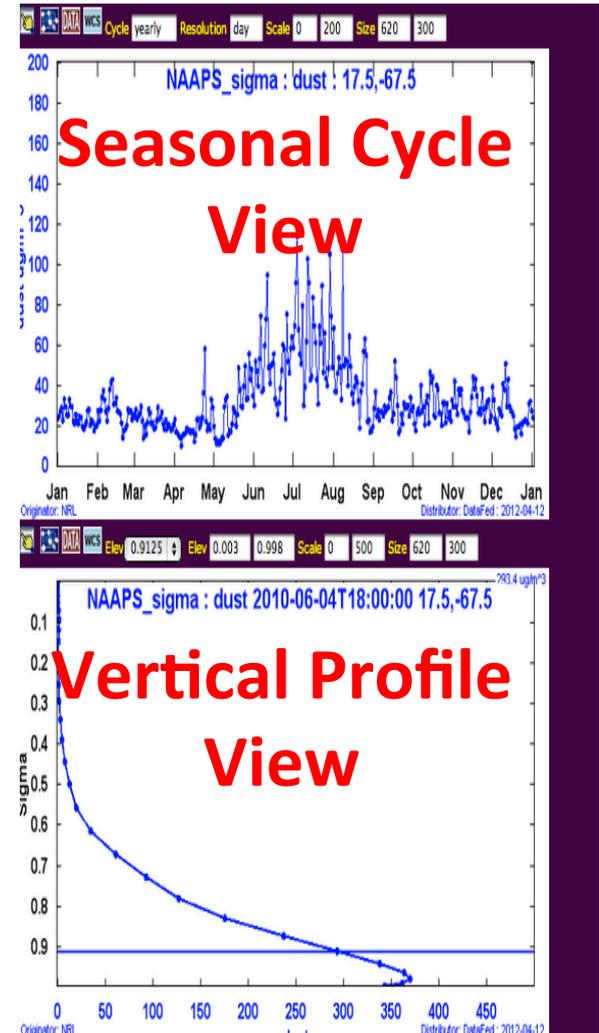
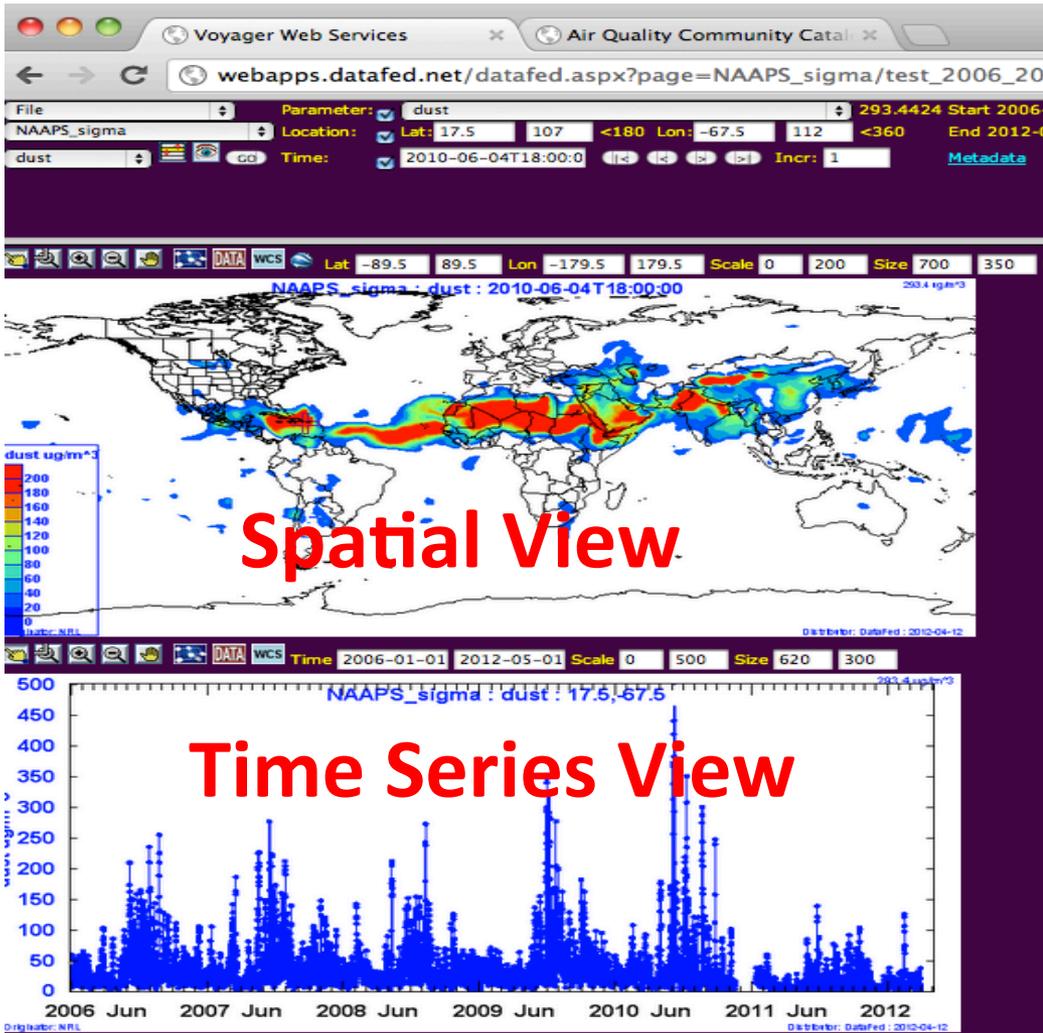
Data Types:

Surface Obs: AirNOW, AQS, AirBase
Satellites: MODIS, OMI
Emissions: NAAPS, EDGAR
Models: NAAPS, MACC, CMAQ

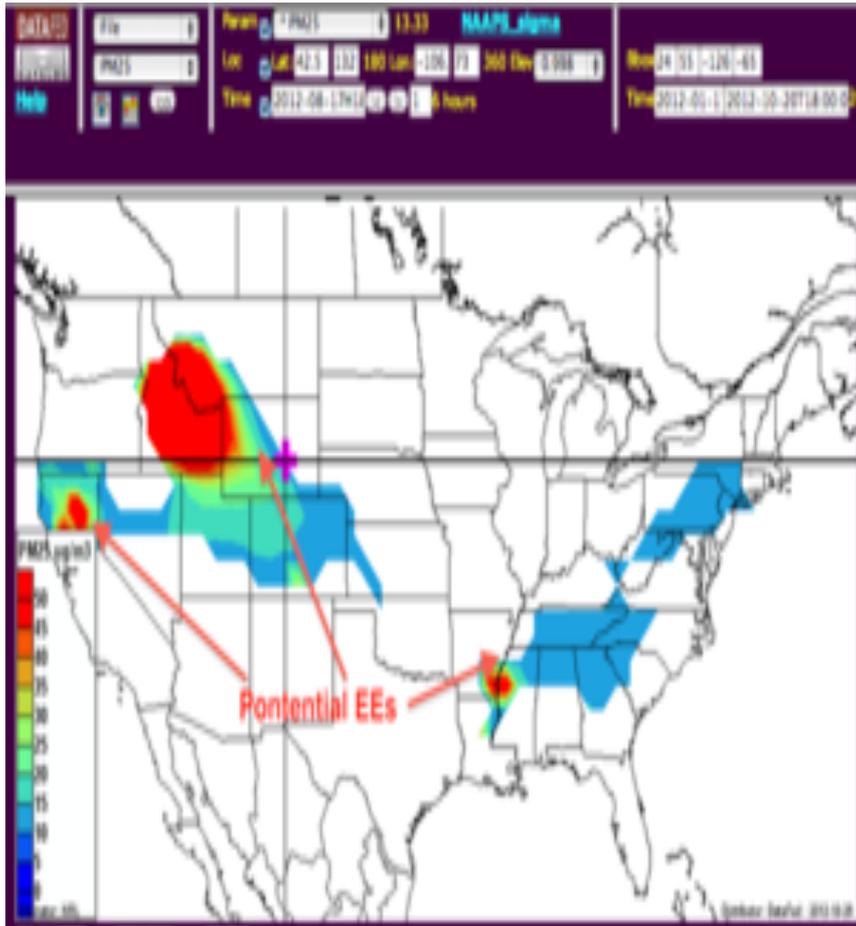
Applications:

Forecasting: NE US
AQ Managm.: ESs – EUS,
Atm. Science: IIT Bombay
Inform Public: ?? Web users

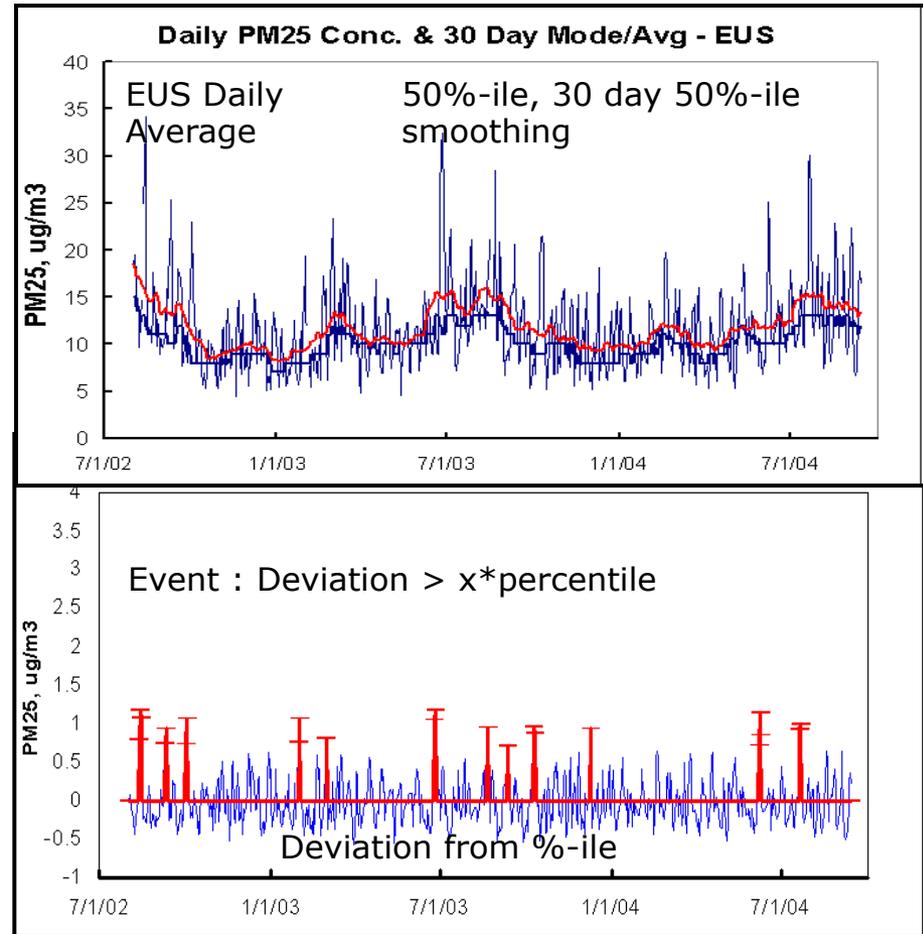
Datafed Browser and Programming Environment



Automatic Event Screening & Detection Tool

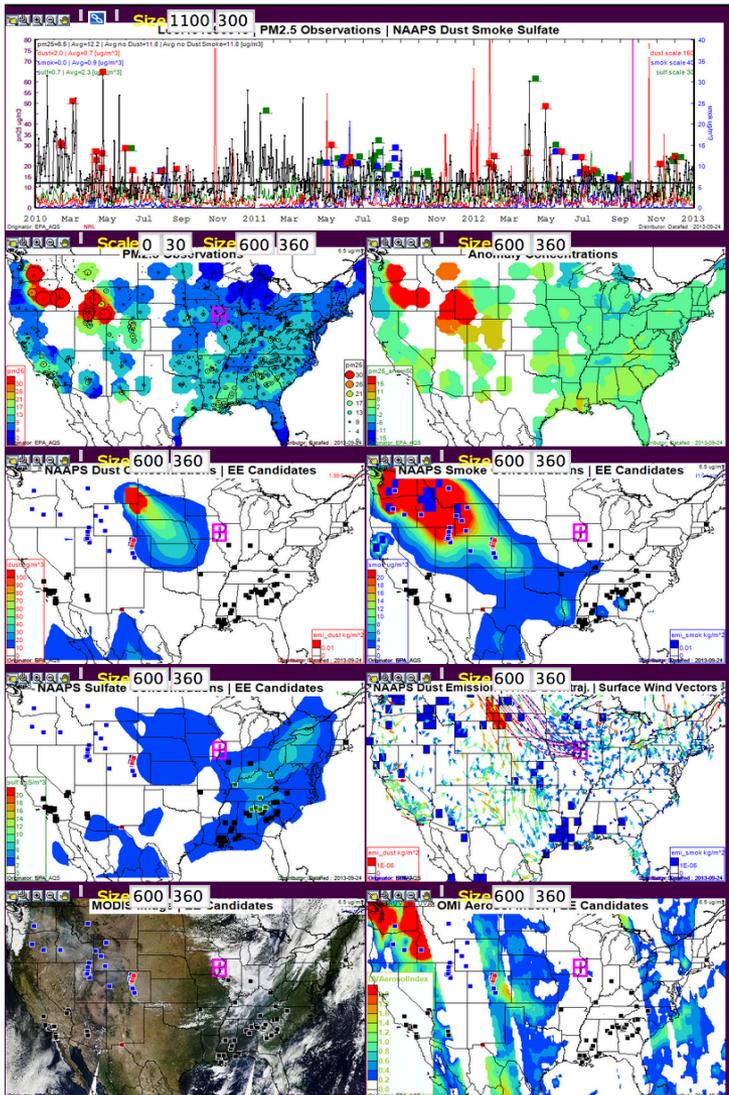


Spatial event screening: e.g. smoke surface conc. > 10 ug/m³



Temporal event screening: e.g. smoke surface conc. > x percentile of 'normal' values.

NAAPS has a key role in EE DSS: Attribution of exceedances to smoke or dust



Relevant NAAPS Qualities

1. Assimilates satellite aerosol optical thickness and fire pixels
2. Provides 4D aerosol structure for dust, smoke, sulfate, sea salt
3. Open access to 10 years of global simulations (via DataFed)



NAAPS Model

Navy Aerosol Analysis and Prediction System

Purpose: Forecast of global concentrations for EO propagation, scene and radiance correction, with focus on lower tropospheric phenomena

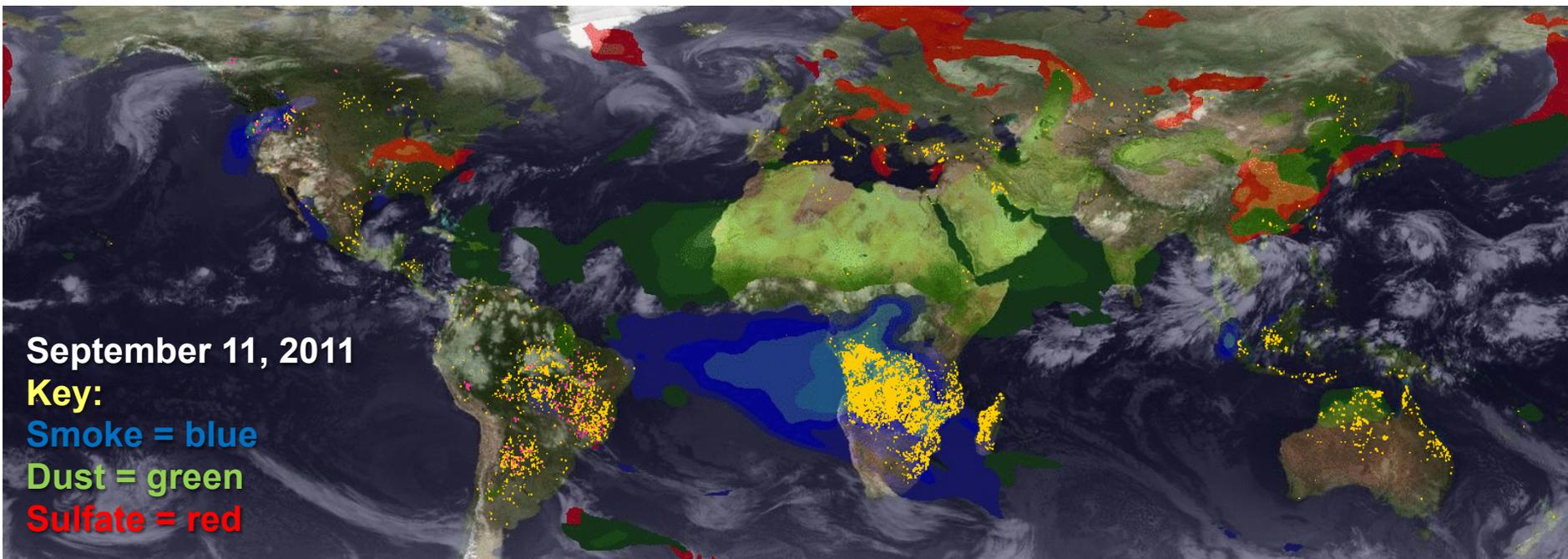
Method: Solve the advection-diffusion equation at each grid point for each species m :

$$\partial C_{\downarrow m} / \partial t = V \cdot \nabla C_{\downarrow m} + \partial \tau_2 C_{\downarrow m} / \partial z \uparrow_2 + S_{\downarrow m} - R_{\downarrow m}$$

Advection and turbulent mixing: Controlled by dynamical model NOGAPS

Sources and sinks: Dependent on dynamics and **remote sensing**

Initial State: Based on previous forecast and **remote sensing**





NASA Data for NAAPS Initialization

Forecasting is an initial value problem:

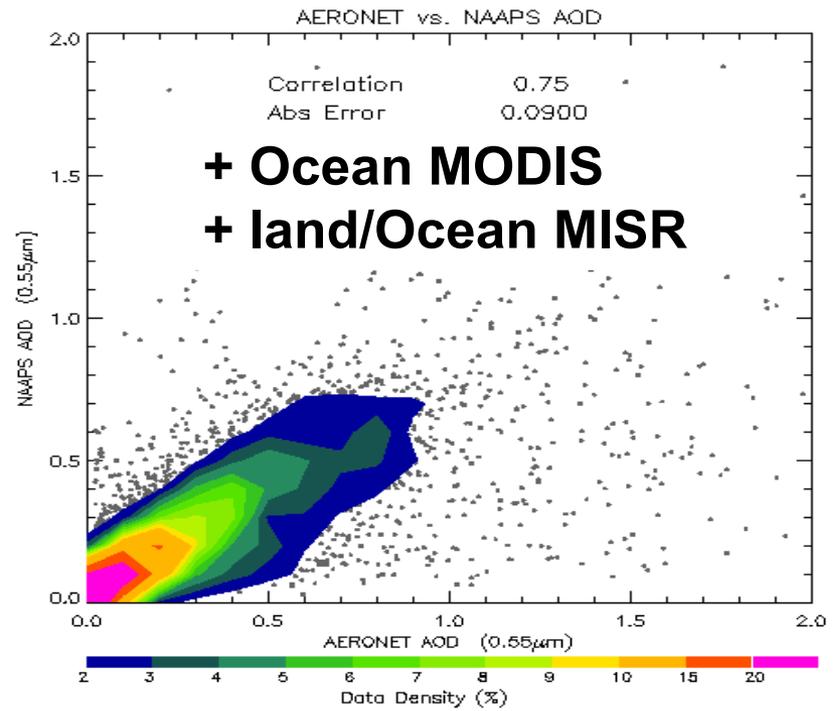
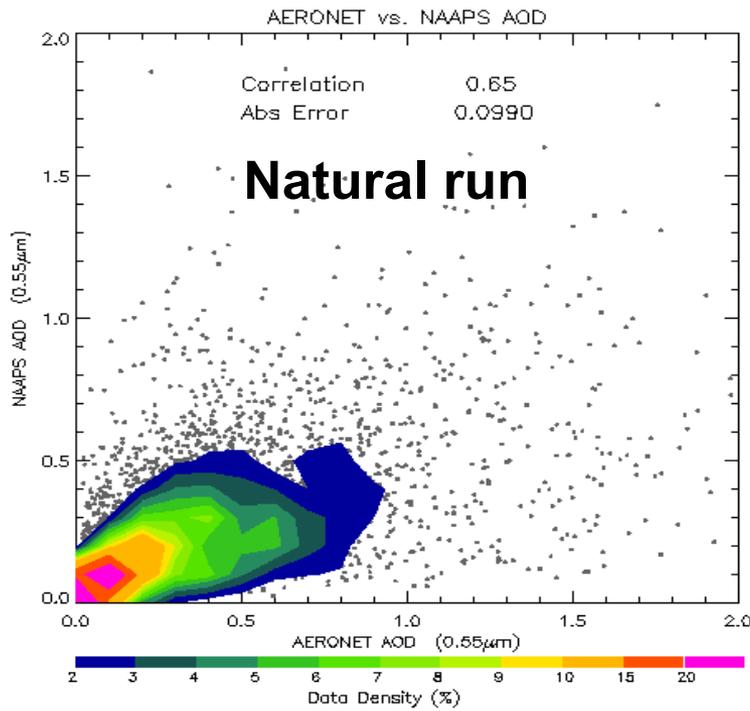
Requires the 3-D distribution of aerosol concentration at the start of the forecast:

Assimilation of previous forecast + information from **remote sensing** of aerosols

Current capabilities:

Aerosol Optical Depth (AOD; 2-D) (MODIS and MISR)

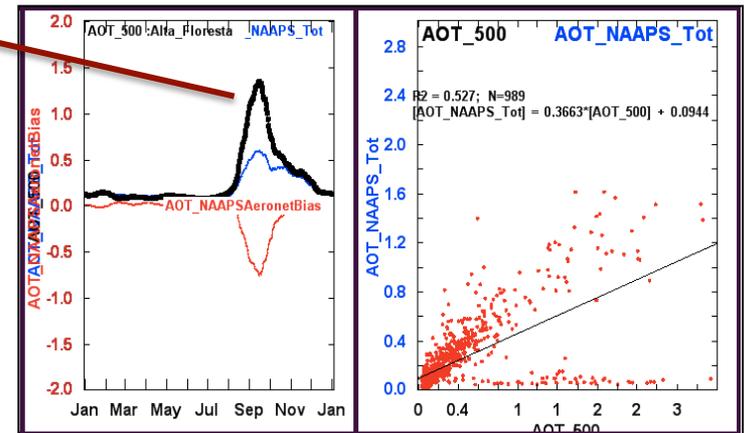
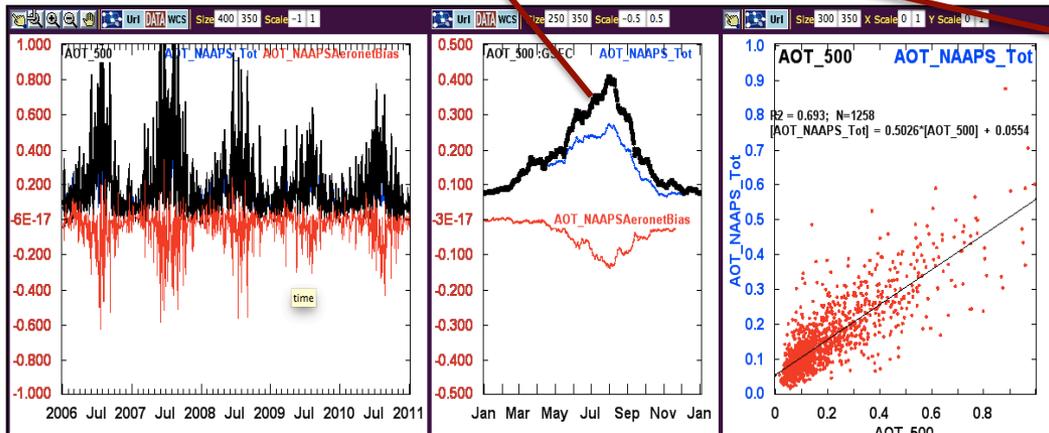
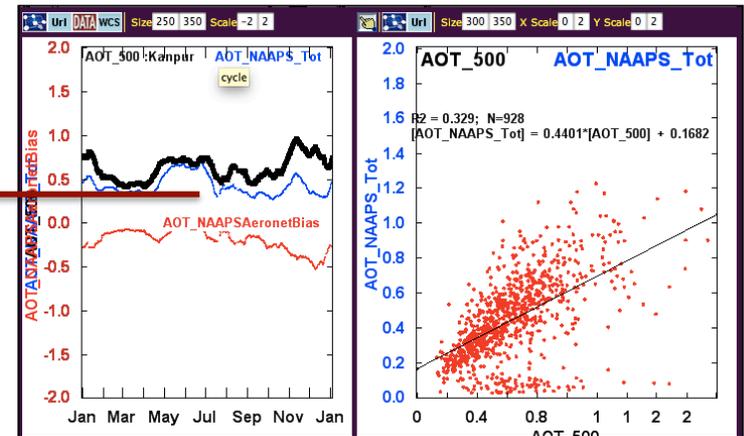
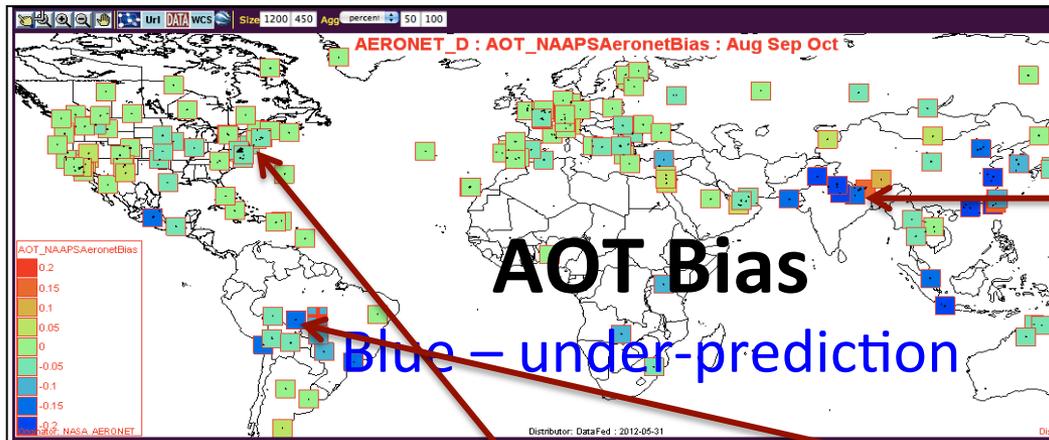
Extinction (3-D) (CALIPSO)



Multi-sensor assimilation is critical to aerosol assimilation.

MODEL-Data BIAS Evaluation Tool (EPA Supported)

NAAPS evaluation for total Aerosol Optical Depth (AOD)
AERONET: Surface-based, well calibrated, global, multi-year

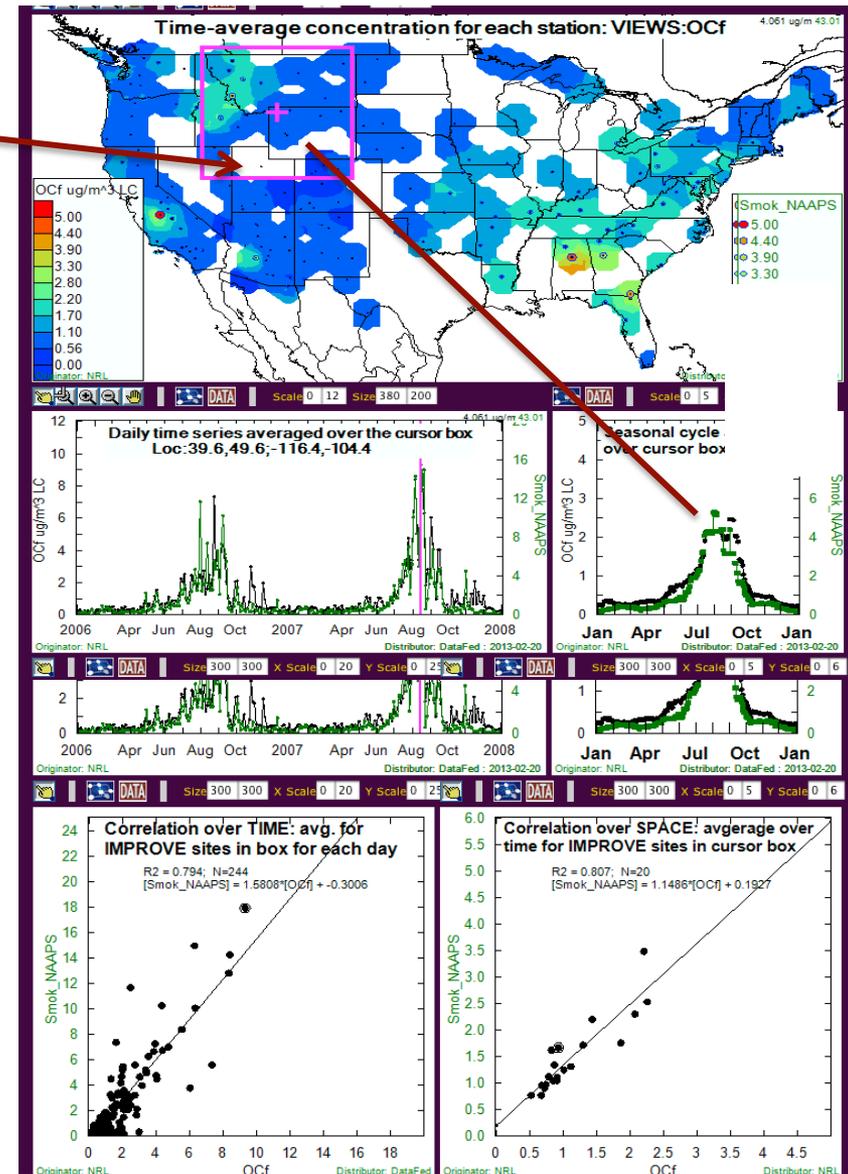


NAAPS evaluation for surface smoke concentration

Surface-based Total Organic Carbon Comparison measurements

Data from VIEWS data system
Companion NAAPS sub-project

- **Time series** of measured IMPROVE OCf and NAAPS smoke over the cursor box shows close co-variation
Seasonal cycle of OCf and NAAPS averaged over the cursor box and multiple years is very similar.
- **Temporal correlation** shows that NAAPS properly simulates the temporal smoke variation over NW
- **Spatial correlation** indicates that NAAPS reproduces the spatial distribution of smoke
- **Spatial and temporal correlation in the purple box is excellent: small bias**
- **At other regions of the US, OCf has biogenic and urban-industrial sources**



EE DSS Support Request from EPA Region 9

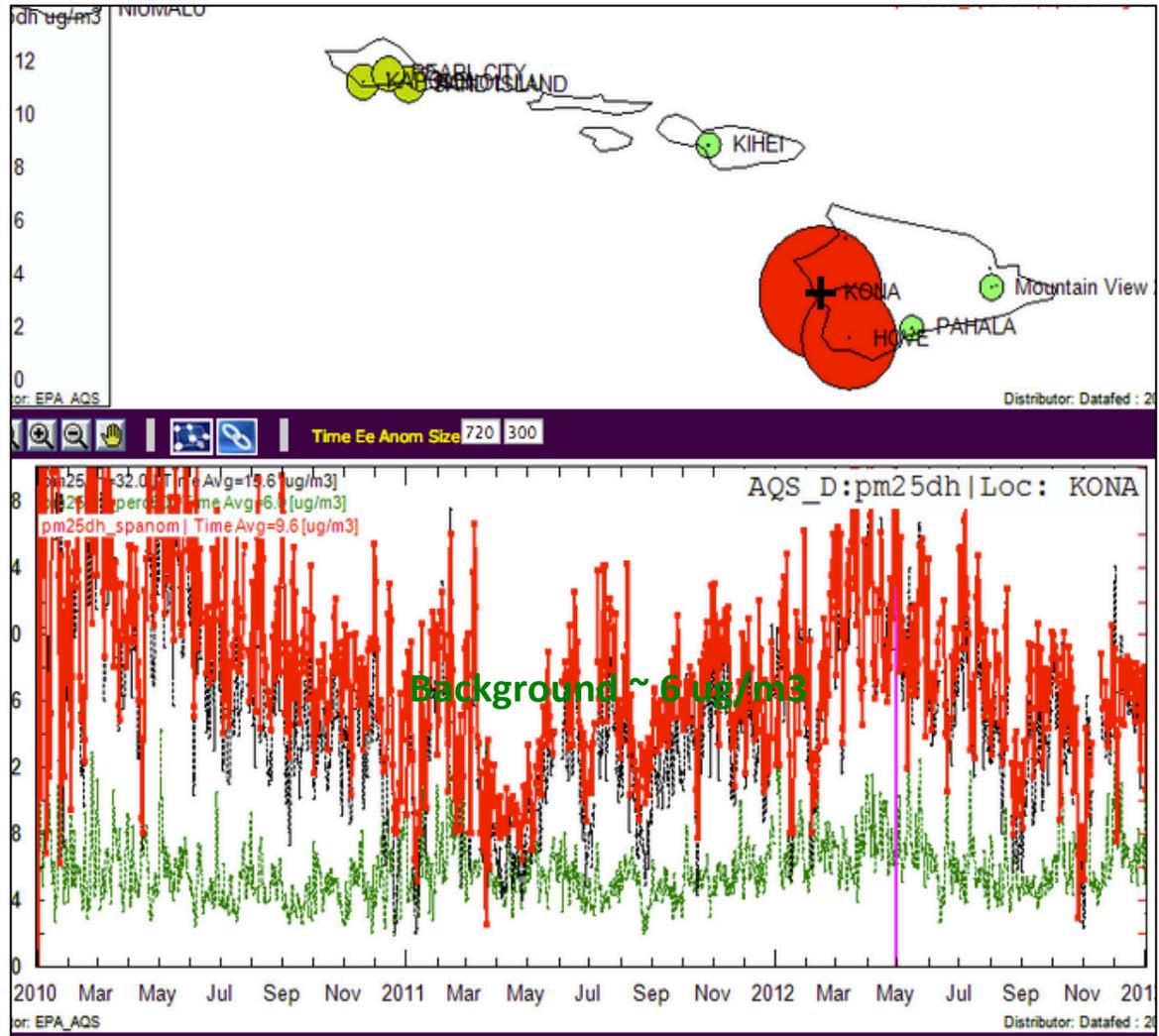
Volcanic EEs in Hawaii

- EE Detection
 - Which monitors are candidate violators of PM2.5 NAAQS?
 - What days have values above the PM2.5 NAAQS?
- EE Documentation
 - What are the other sources of PM2.5 near the monitor(s)
 - Do they impact the monitors on exceedance days?
 - Can one illustrate the effect of other sources vs. the volcano?
 - What are the conditions when volcano impacts on EE monitors?
 - What is the volcanic source/emission strength?
 - What are the met. conditions/pathways of volcanic?
 - Are these consistent for most events?
 - Are the tools and methods adequate to document the above?
 - What surface & satellite obs. and modeling tools are available?
 - Can those be combined/integrated for robust EE documentation?

Distinguishing volcano vs background PM2.5 sources

Spatial anomaly: Excess over the fluctuating background PM2.5 concentration

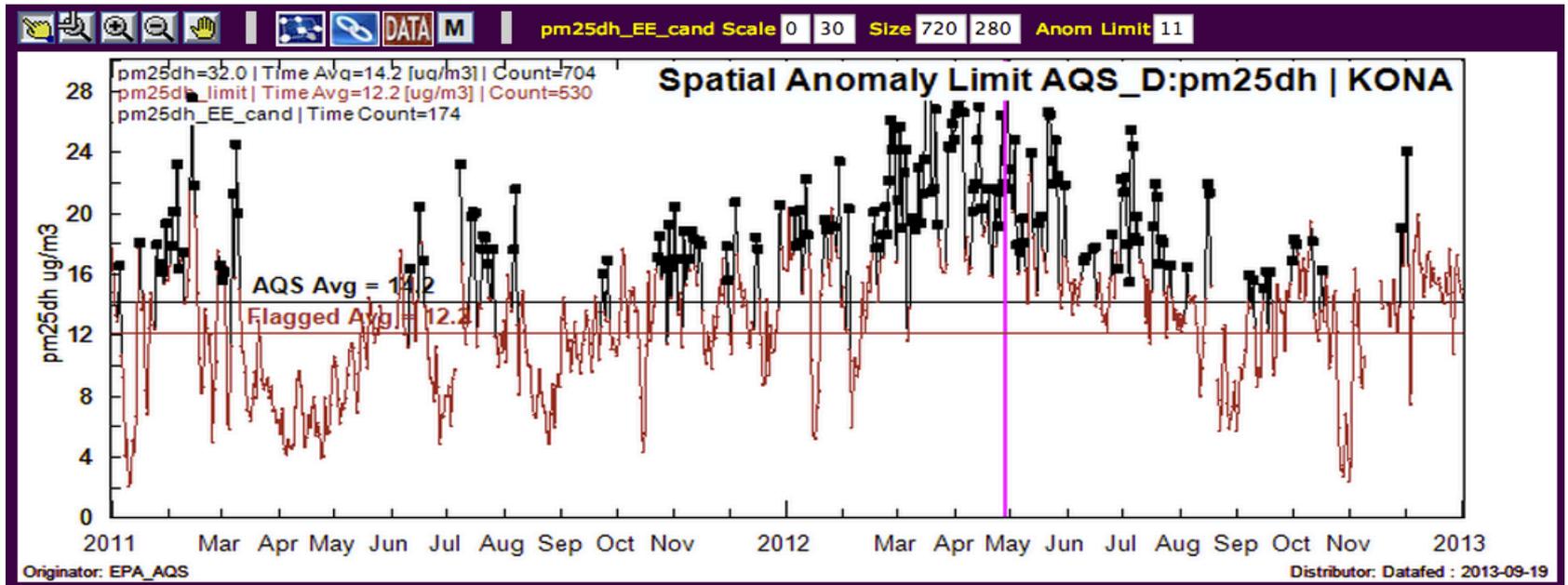
Red line is the spatial anomaly:
Excess PM2.5 at KONA over the
spatially uniform but time-varying
background



Spatial analysis could help
distinguishing background and
volcanic PM2.5

What days have values above the PM2.5 NAAQS?

For Kona (2011-12), determined by the [Hawaii EE DSS Screening Tool](#)

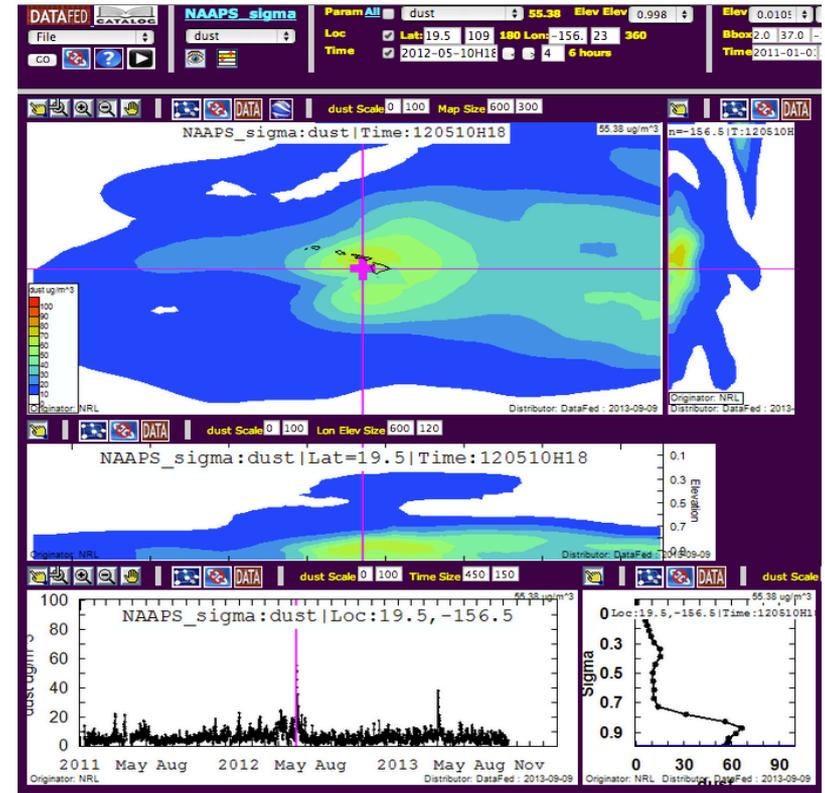
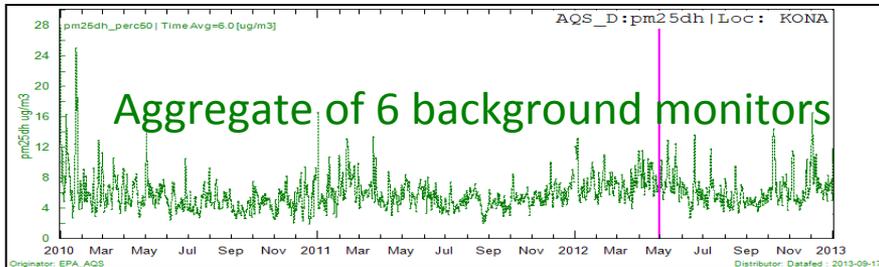
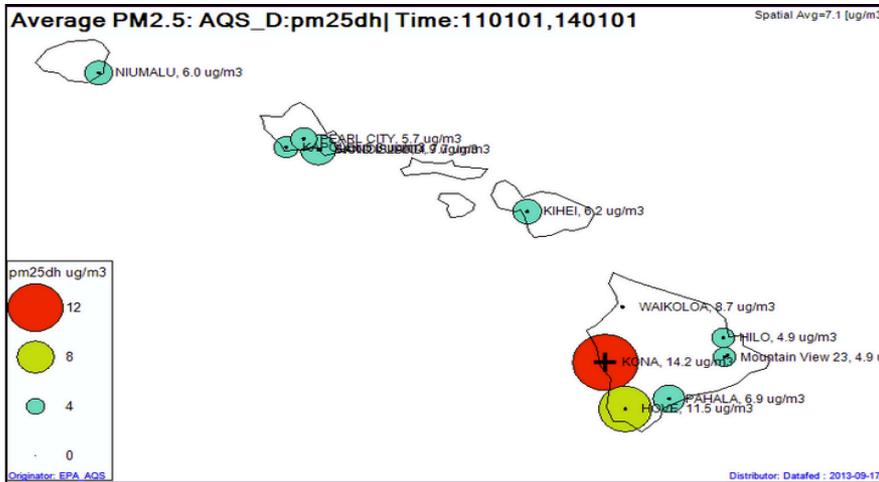


There are other strategies for flag-day selection from the pool of 477 that is above 12 ug/m3. Another approach is based on spatial anomaly, i.e. deviation from the neighboring sites. Using that criteria would require flagging 174 days, compared to 168 days.

Given the many (over ~250) days to be flagged, choosing a good flag sampling and flag documentation strategy is a key task for the collaborating workgroup.

Other sources of PM2.5 impacting the EE monitor(s)

Background PM2.5 – oceanic aerosol

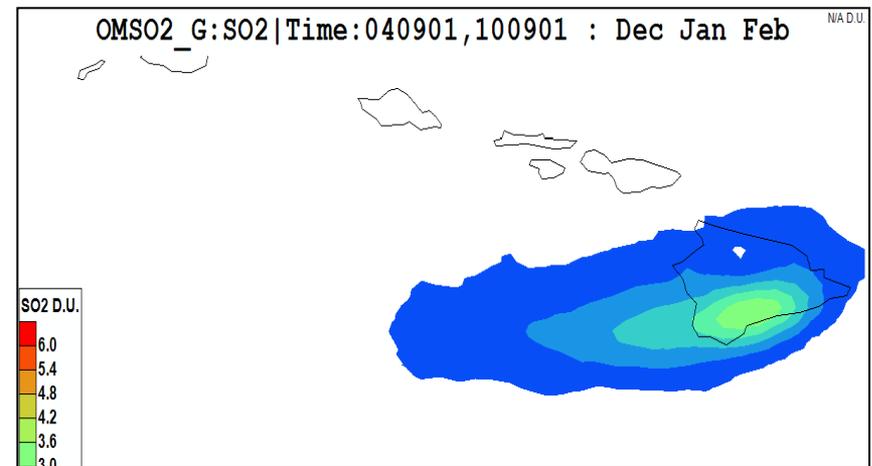
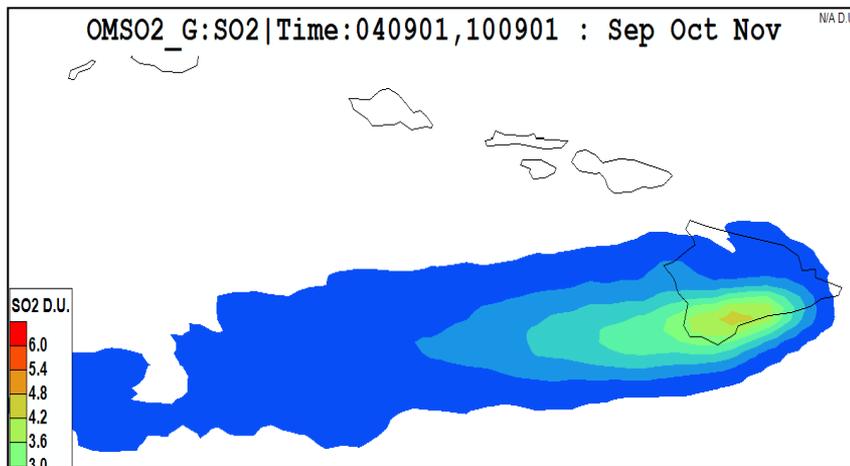
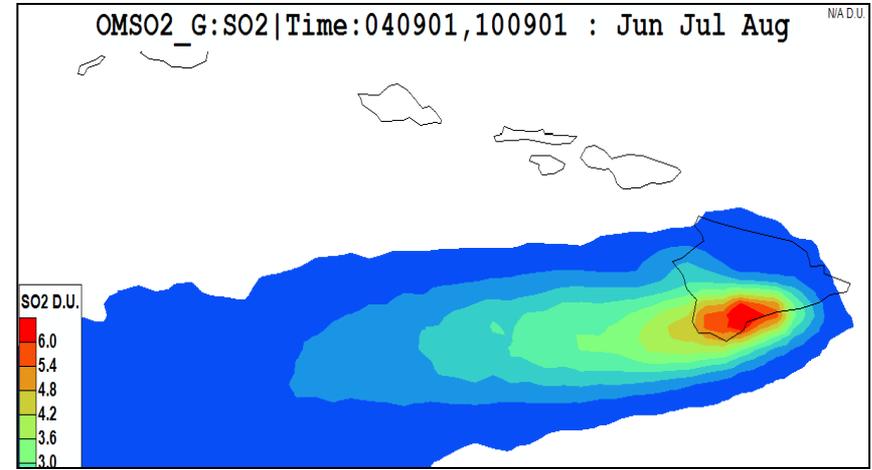
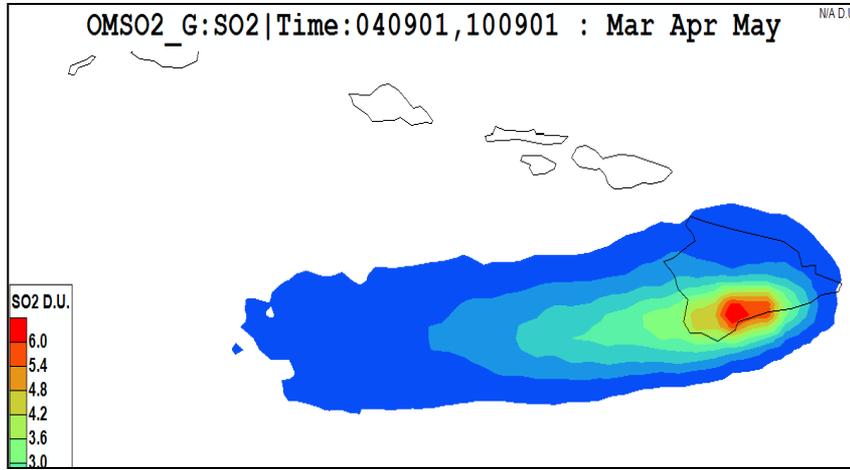


The Hawaii background PM2.5 is quite uniform at ~ 6 ug/m3
But spikes up to 12 ug/m3 can occur near-simultaneously at all monitors.

A possible source of background spikes is Asian dust reaching HI – suggested by the NRL NAAPS model
These should be considered as ‘other sources’.

OMI Satellite Columnar SO2

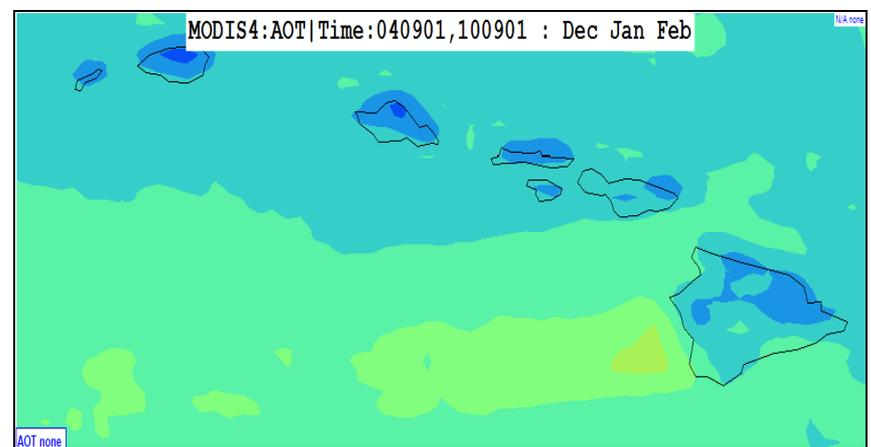
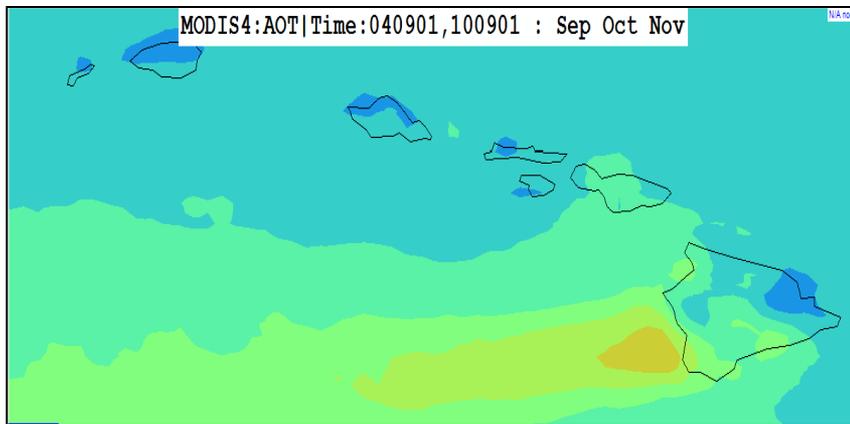
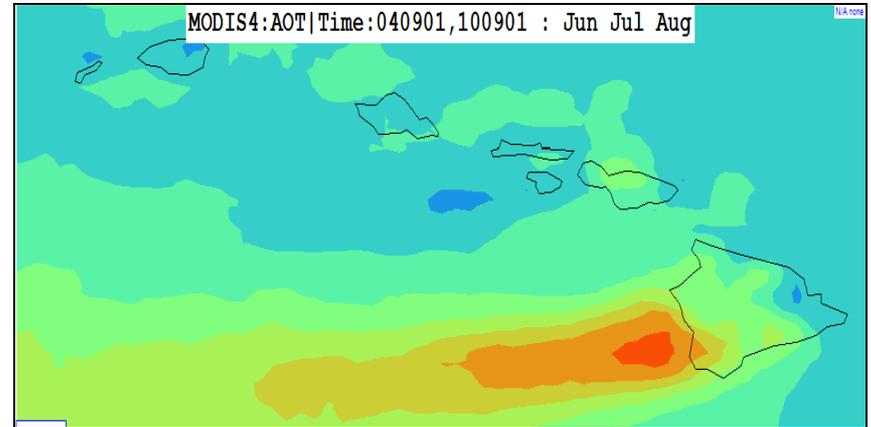
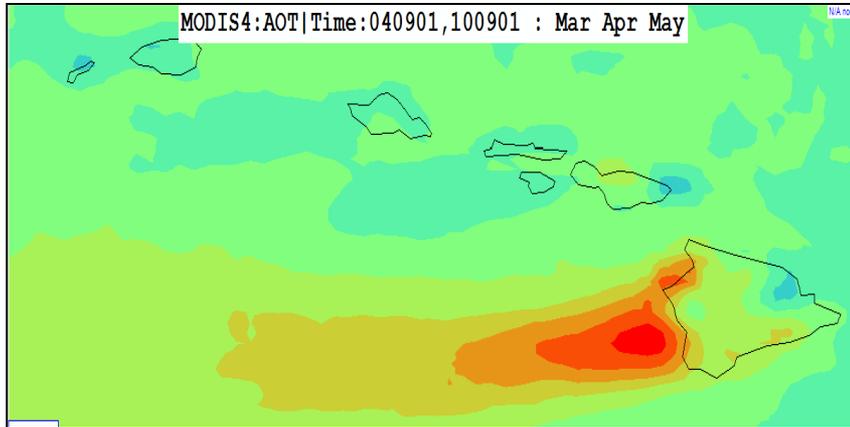
Seasonal averages, 2004-2010



The SO2 concentration is highest at the volcano – in the vicinity of the EE sources
The transport is mostly toward the West with the trade winds

MODIS satellite measurements of volcano aerosol (sulfate)

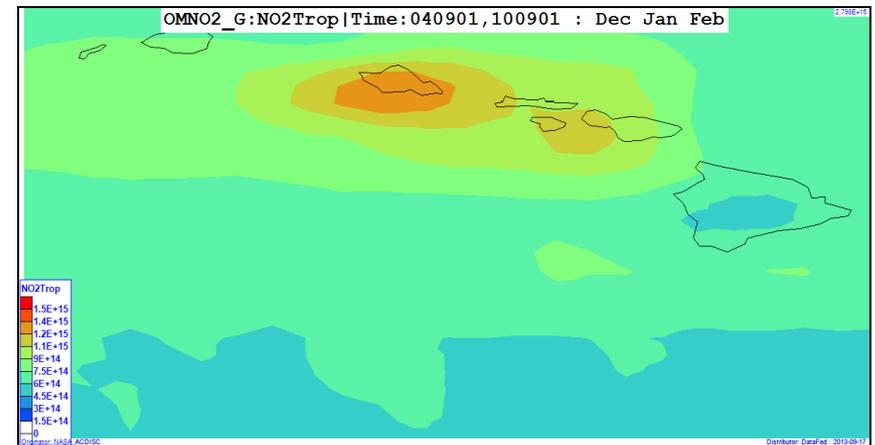
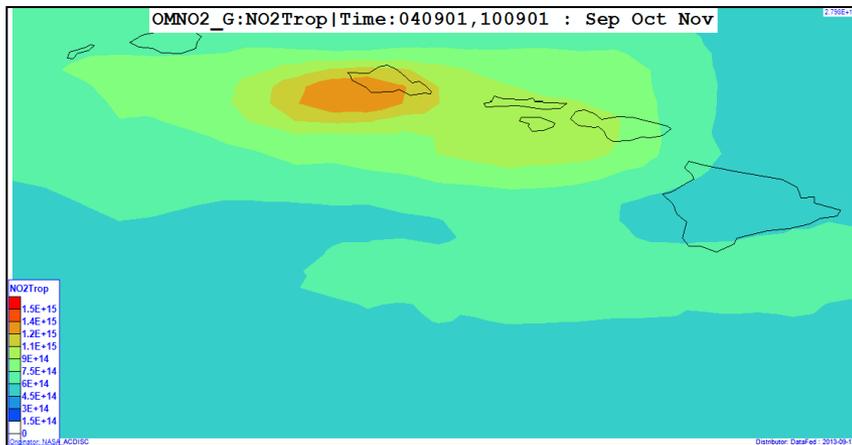
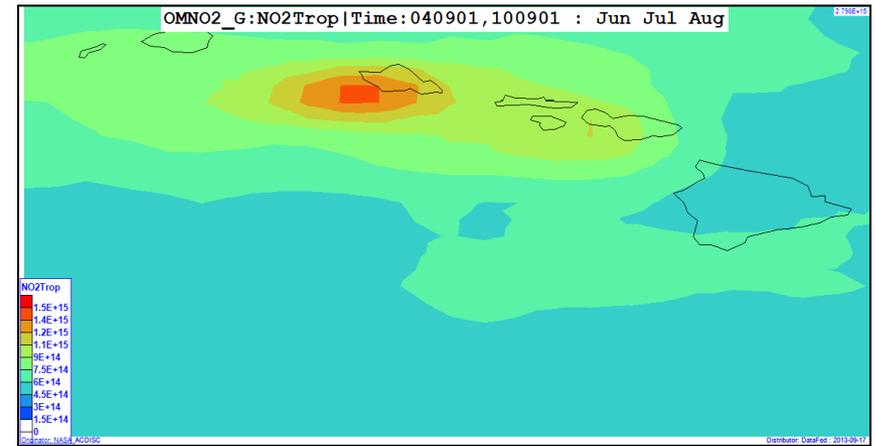
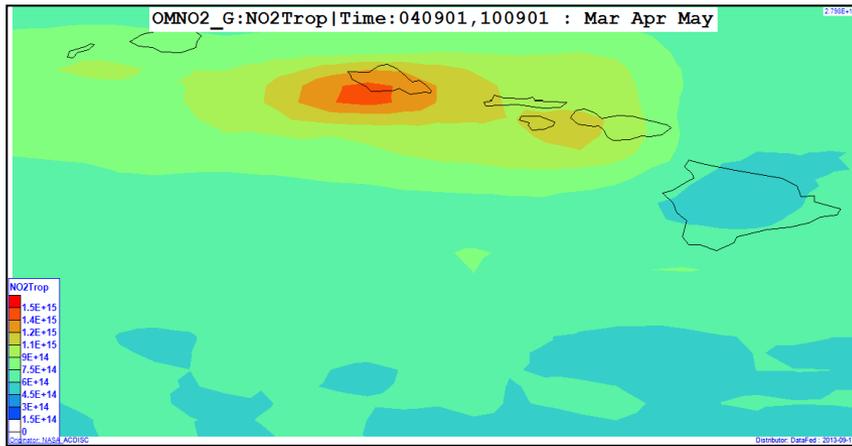
Seasonal averages of AOD, 2004-2010



High AOD downwind of Hawaii, the volcano source. No evidence for other major sources
Seasonally the volcano aerosol plume is more in the Spring and Summer
Plume transport is with the trade winds

OMI satellite measurements of columnar NO₂

Seasonal averages, 2004-2010

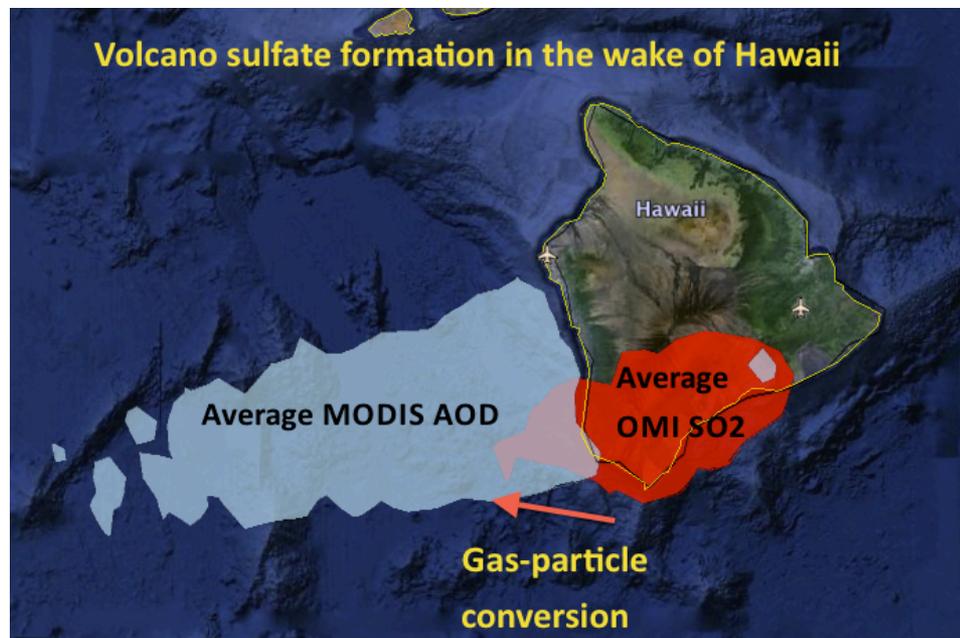
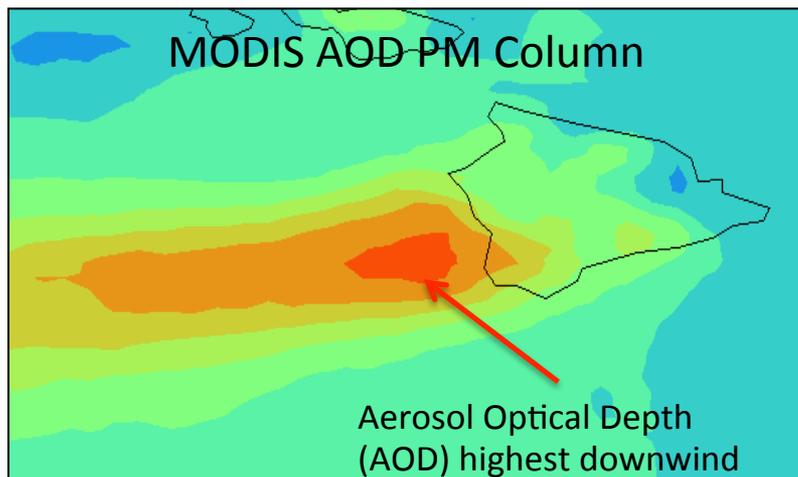
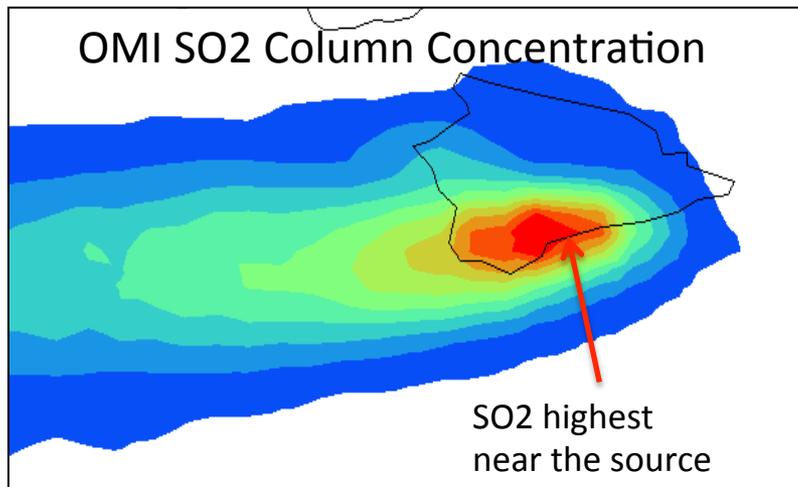


Indicates the high anthropogenic emissions in Oahu. No NO₂ signal over Hawaii

Why is the PM2.5 impact so far away from the SO2 source?

SO2-Sulfate conversion takes time and distance

Satellite measurements of SO2 and AOD
Average 2004-2010, June, Jul August

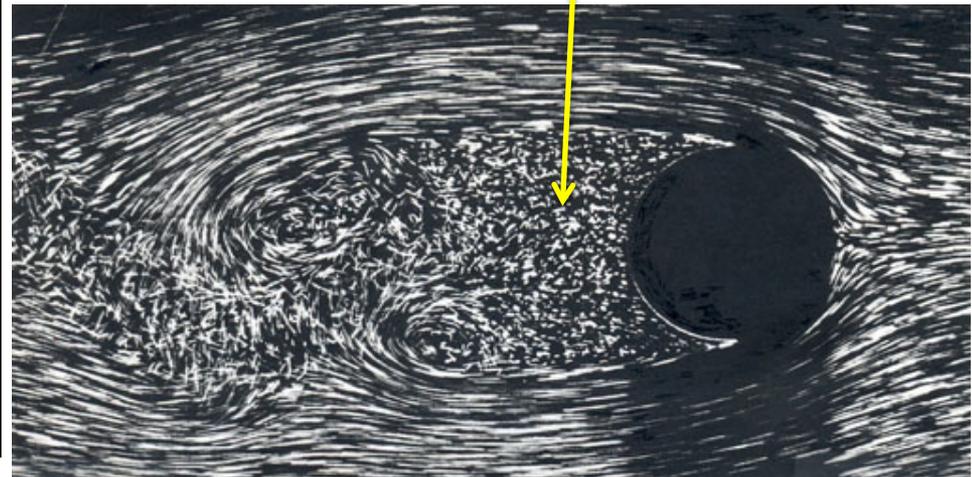
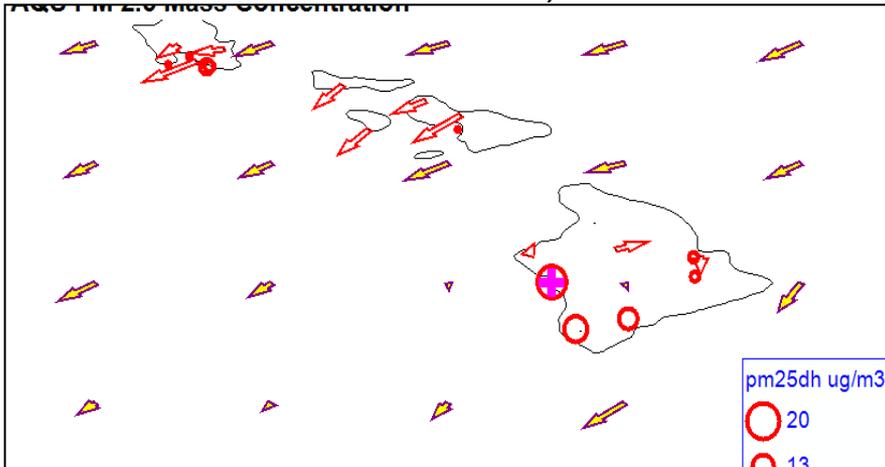


Possibly accelerated
in fog/clouds -> VOG

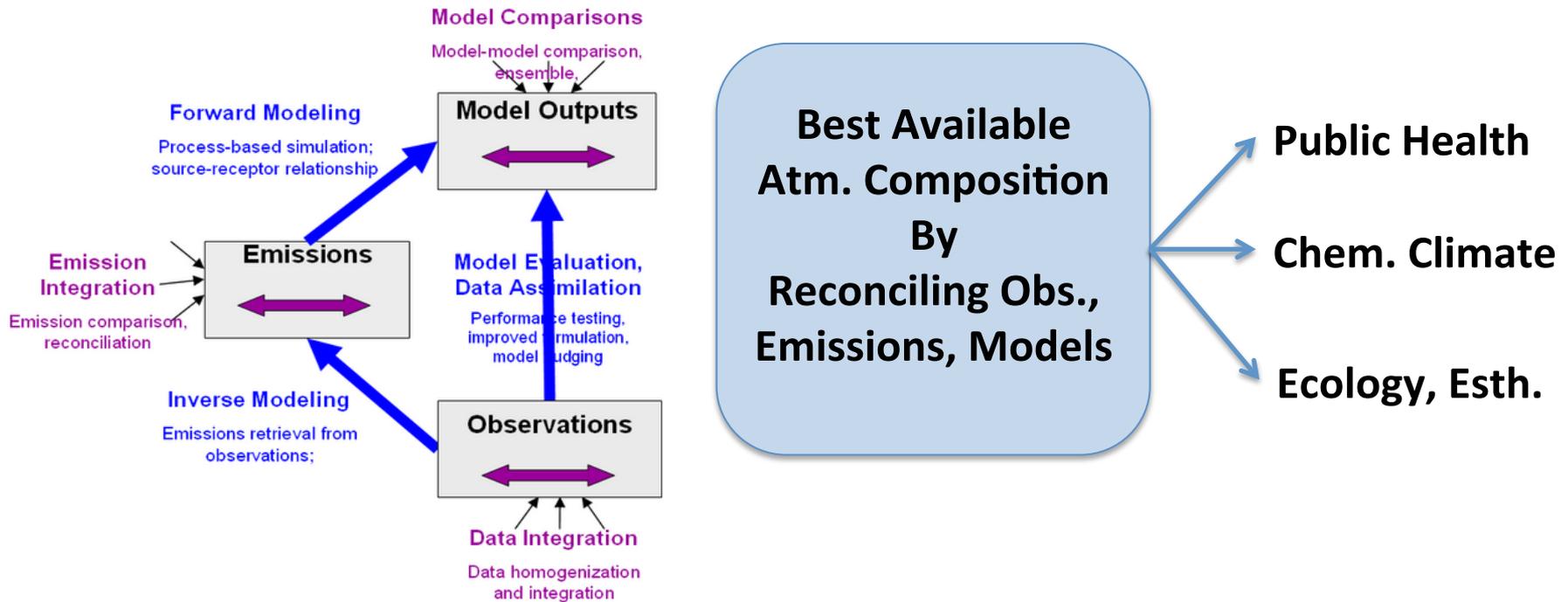
Aspects of volcanic emission transport: Conceptual



Surface Winds: Measurements, NOGAPS model



Technical Challenge: Closing Satellite-Surface PM Gap



By iterative refinement of of Emissions, Observations and Models

The NAAPS Model is an effective approach to close the Emission-Observation-Model loop.

Accomplishments and Contributions of Project

Project Contribution to EPA & States:

Pre-DSS EE analysis:

State-by-State; ad hoc, slow, non-uniform

From Local, ad hoc, to national EE detection, analysis, documentation

Final EE analysis:

Uniform national EE detection screening Tools for EE analysis, flag documentation

EE DSS Tools are applicable for NAAQS compliance –‘Designation’

Project Contributions to NASA

Initial Readiness Level 6:

Satellite and model data in silos, inaccessible, unused

From demonstrated functionality to proven functionality of EE DSS

Final Readiness Level 8:

DSS Functionality Proven; NASA satellite and NAAPS products in use for smoke & dust event flagging

Actual ARL is ~ 8.5. Proven operational application. Sustainability uncertain

Project: NASA and NAAPS Products for AQ Management

Application Readiness Levels (ARLs)

Actual Proposed

- **ARL 6 Demonstration in Relevant Environment (Potential Demonstrated)**
 - Prototype application system beta-tested in a simulated operational environment
 - Projected improvements decision-making demonstrated in simulated OP environment
- **ARL 7 App. Prototype in Partner's Decision-Making (Functionality Demod)**
 - Prototype application system integrated into end-user's operational environment
 - Prototype application functionality tested & demonstrated in decision-making activity
- **ARL 8 Application Completed & Qualified (Functionality Proven)**
 - Finalized app. tested, proven operational, operate as expected in user's environment
 - Application qualified and approved by user for use in decision-making activity
 - User documentation and training completed

End ARL is ~ 8.5 - Operational application is proven. Sustainability uncertain

- **ARL 9 Application Completed & Qualified (Functionality Proven)**
 - Sustained use of application system in decision-making context

AQ Management Schedule

Deadlines for

Exceptional Event Flagging and Documentation

to be used in initial

Designations for PM_{2.5} NAAQS

QS Date	Data for Year	Flagging Deadline	Detailed Document Deadline
/Annual NAAQS (g/m ³), Dec. 2012	2011, 2012	July 1, 2013	December 12, 2013
	2013	July 1, 2014 ^a	August 1, 2014

Near-term Plans For EE DSS

- Follow EPA schedule to apply the EE DSS
- Complete Final Project Report to NASA, Feb 2014.
- Continue seeking means to sustain the EE DSS infrastructure



Many Thanks:

- Contact: Rudy Husar, rhusar@wustl.edu

Many thanks to:

- Kari Hoijarvi, Washington University
- Anshu Tirumali, Washington University
- Rich Poirot, State of Vermont
- Doug Westphal, Naval Research Lab
- Neil Frank, EPA
- Ali Omar, NASA Applied Sciences

Links

- PM2.5 [EE Screen PM25](#)
 - Bakersfield, CA - Winter peaked, Exceedances over the normal variation, 84 percentile
 - Also summer peaks
 - [Salt Lake City July 4](#)
 - Ditto , July 4th
- PM2.5 Smoke
 - [West Washington - Smoke](#)
 - Click Smoke Dust
- PM10 [EE Screen PM10](#)
 - Click Dust Smoke
- Ozone [EE Screen Ozone](#)
 - Sequence 2012-06-26, Click Arkansas
 - 2012-06-27, 28, 29, 30, 7-01 Click Charlotte
- [2011 Ozone Kansas smoke](#)
 - Click Back trajectory
- [Kansas Smoke Ozone](#)
 - Back trajectory
- [Kansas Smoke KMZ](#)

http://wiki.esipfed.org/index.php/2013-04-30_EE_DSS_Webinar_Demo