Operational Predictions of Atmospheric Dispersion at National Oceanic and Atmospheric Administration (NOAA)

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National Weather Service

18th Annual George Mason University Conference on
Atmospheric Transport and Dispersion Modeling, Fairfax, VA June 25, 2014

NOAA operational predictions of atmospheric dispersion

Routine predictions:

1. Smoke predictions nationwide
2. Dust predictions over contiguous 48 states (CONUS)

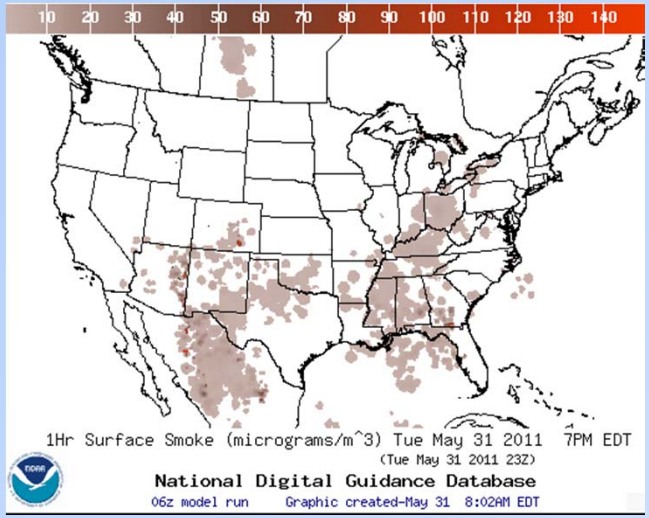
http://airquality.weather.gov/

Incident support:

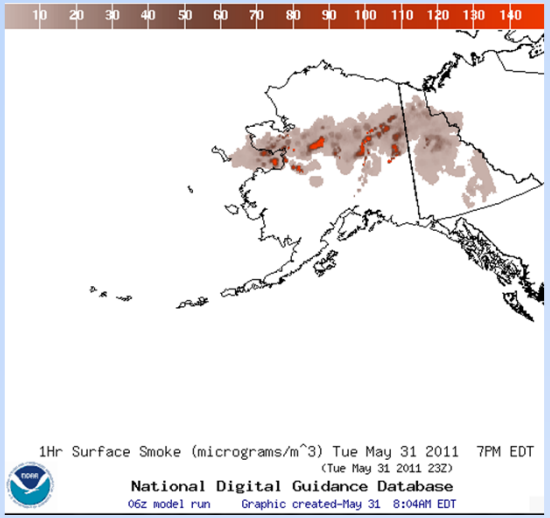
3. Volcanic ash
4. Radiologic contamination
5. Chemical releases

Smoke predictions

Operational predictions at http://airquality.weather.gov



Surface Smoke



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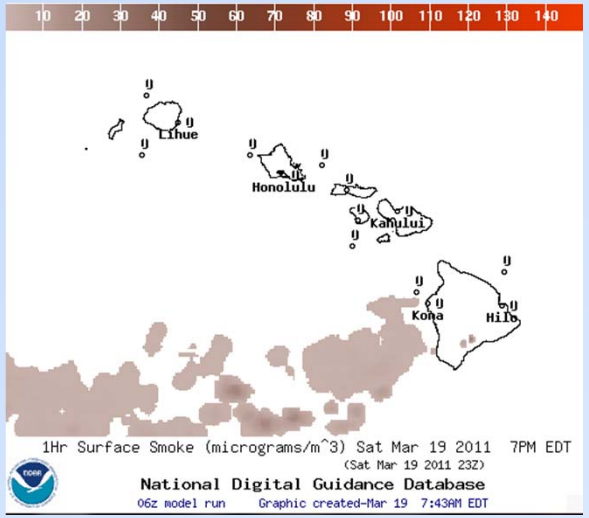
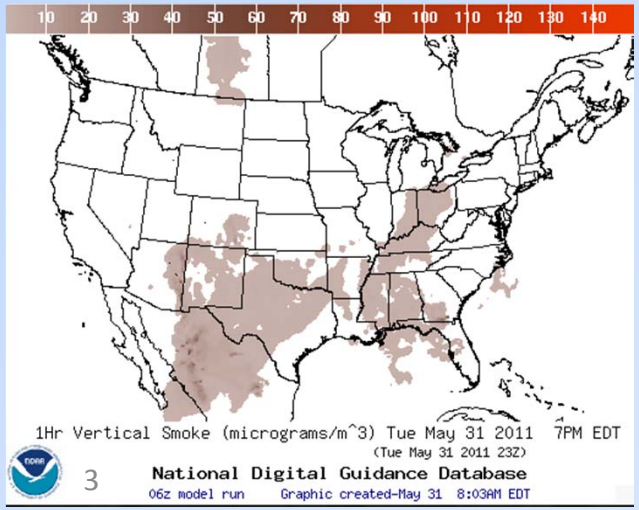
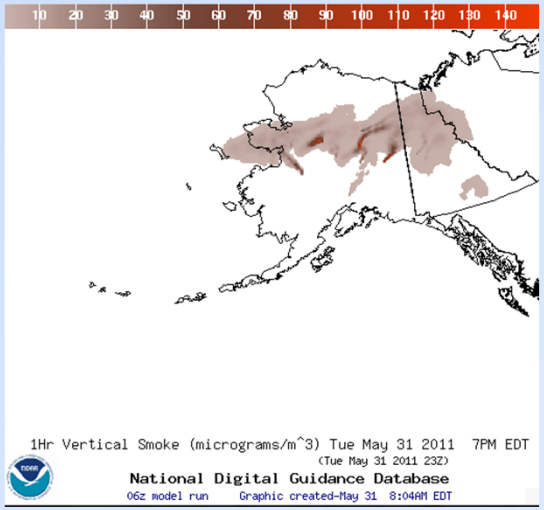


Surface Smoke

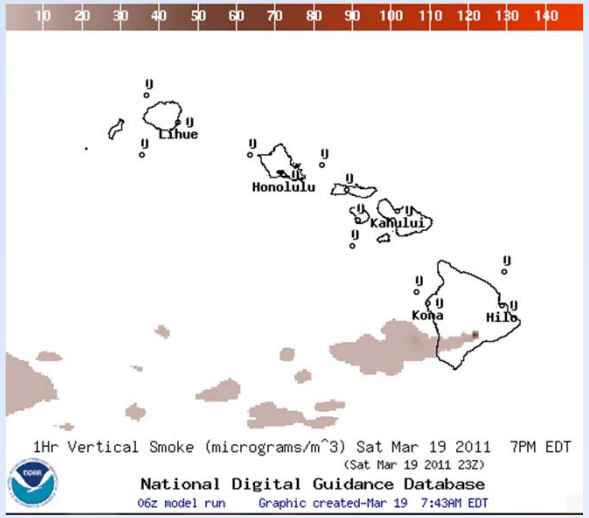
Vertical Smoke



Vertical Smoke



Vertical Smoke



Smoke Forecast Tool

Major Components

NWP Model

NAM/NMMB

NOAA/NWS

Weather Observations

NOAA

USFS

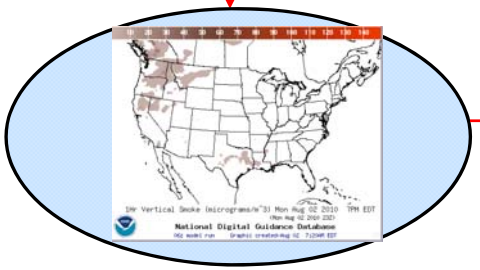
NESDIS HMS Fire Locations

HYSPLIT Module:

NOAA/OAR

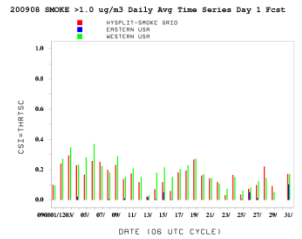
USFS's BlueSky Emissions Inventory:

USFS



Verification:

NESDIS/GASP Smoke

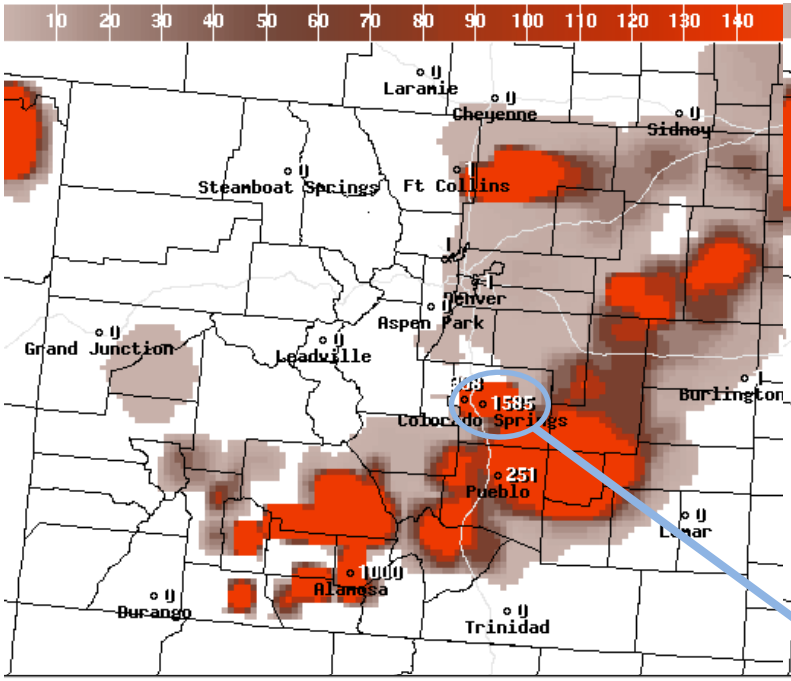


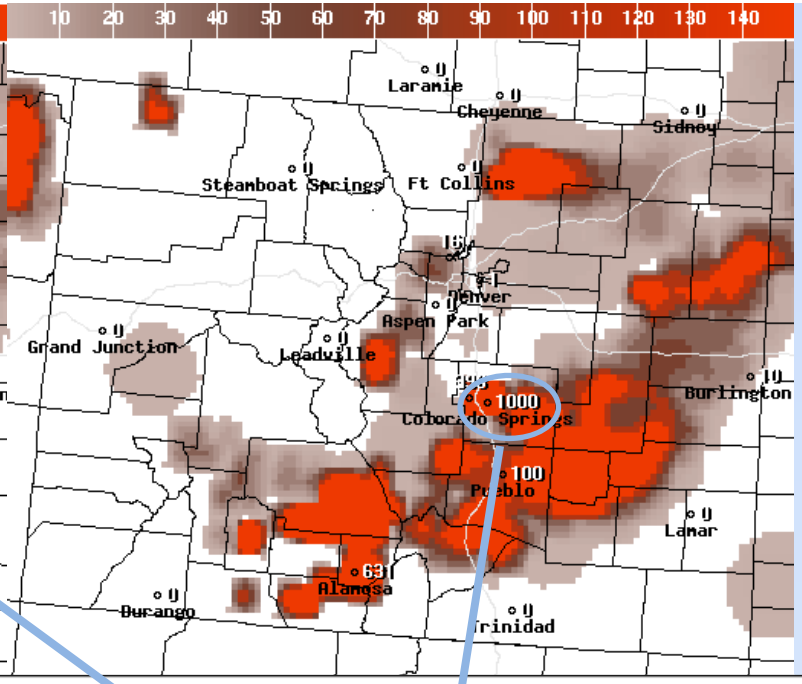
http://airquality.weather.gov/

Waldo Canyon Fire, CO

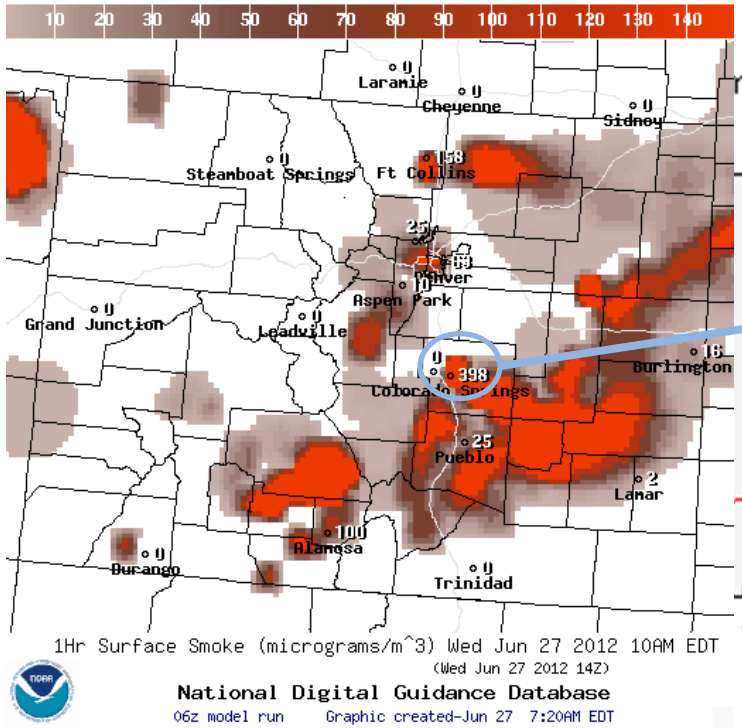
- Began on June 23, 2012 west of Colorado Springs
- Close to 19,000 acres burned
- Smoke plume reached heights of 20,000 feet
- More than 32,000 people evacuated
- Many homes burned
- Fire 100% contained as of July 17

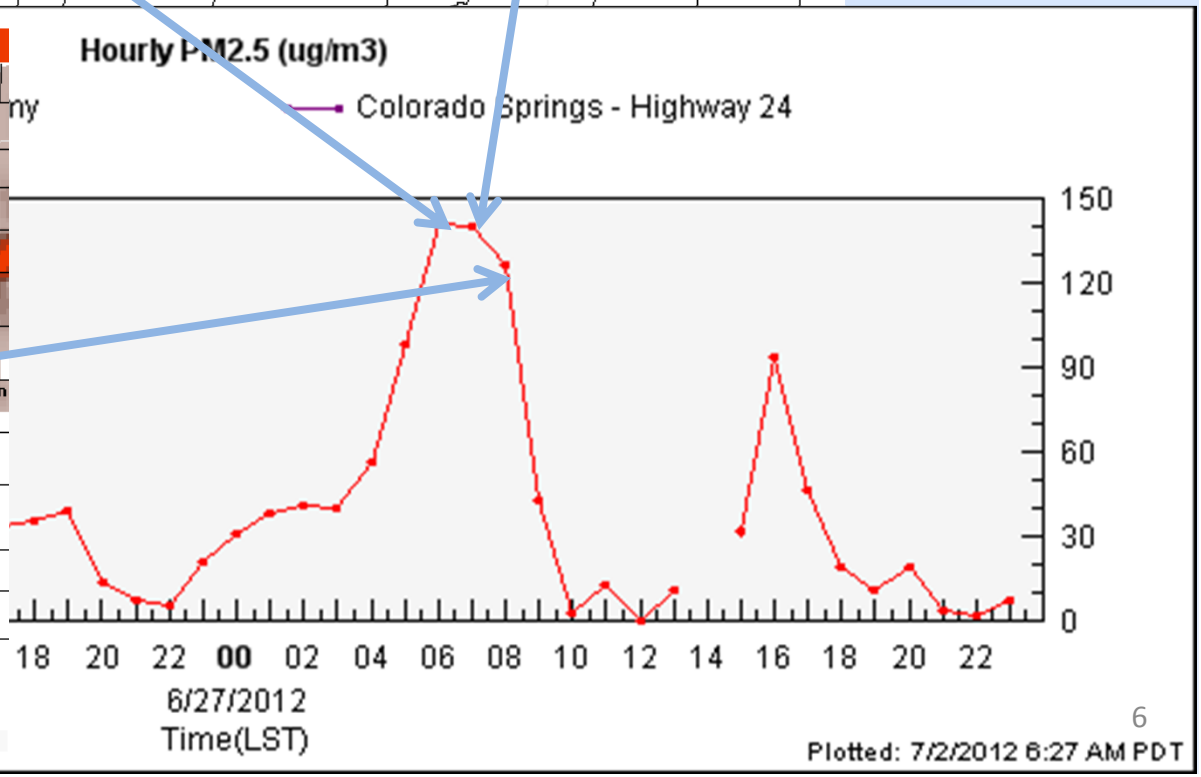
Waldo Canyon fire on June 26 in Colorado Springs





NOAA's smoke predictions correctly predicted observed downward trend in PM2.5 due to Waldo Canyon fire, but concentrations were overestimated





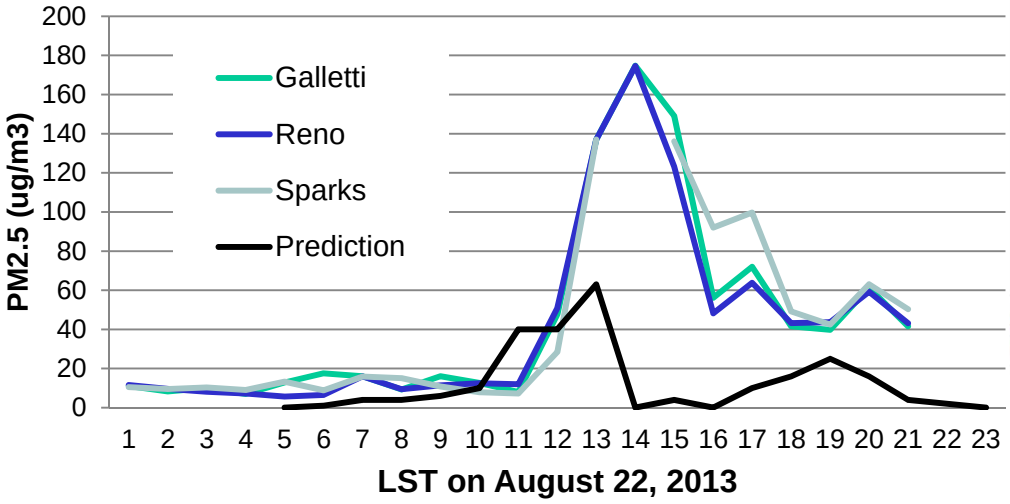
Rim Fire in California

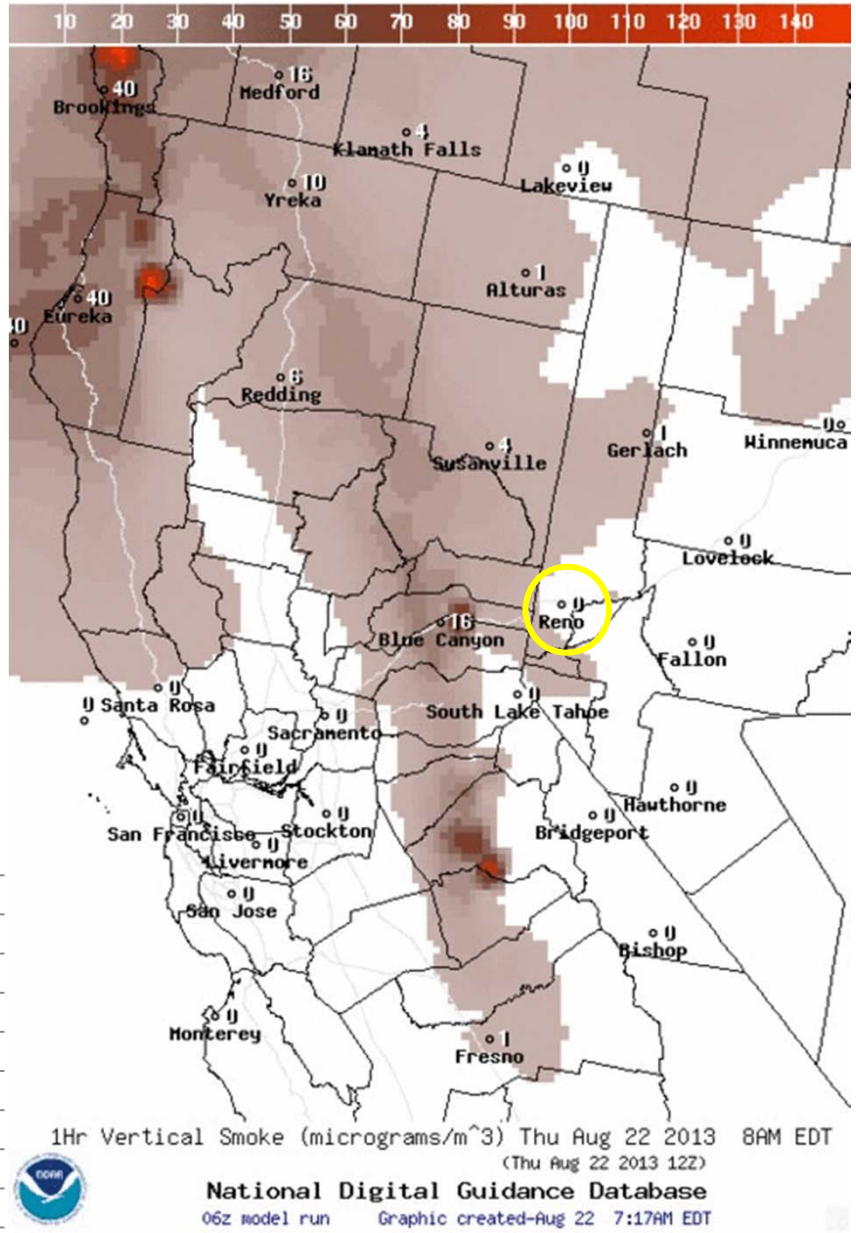
The largest wildfire ever recorded in Yosemite National Park. Fire started on August 17, 2013.

Transport of smoke towards Reno, NV on 8/22/2013 was confirmed by GOES-14 satellite imagery.

NWS office in Reno included smoke and haze in their forecast.

Observed PM2.5 concentrations peaked around 2 pm LST, predicted concentrations at the surface peaked at 1 pm, and the highest predicted concentration was lower than observed.





http://airquality.weather.gov

Prediction model was updated on July 26, 2013

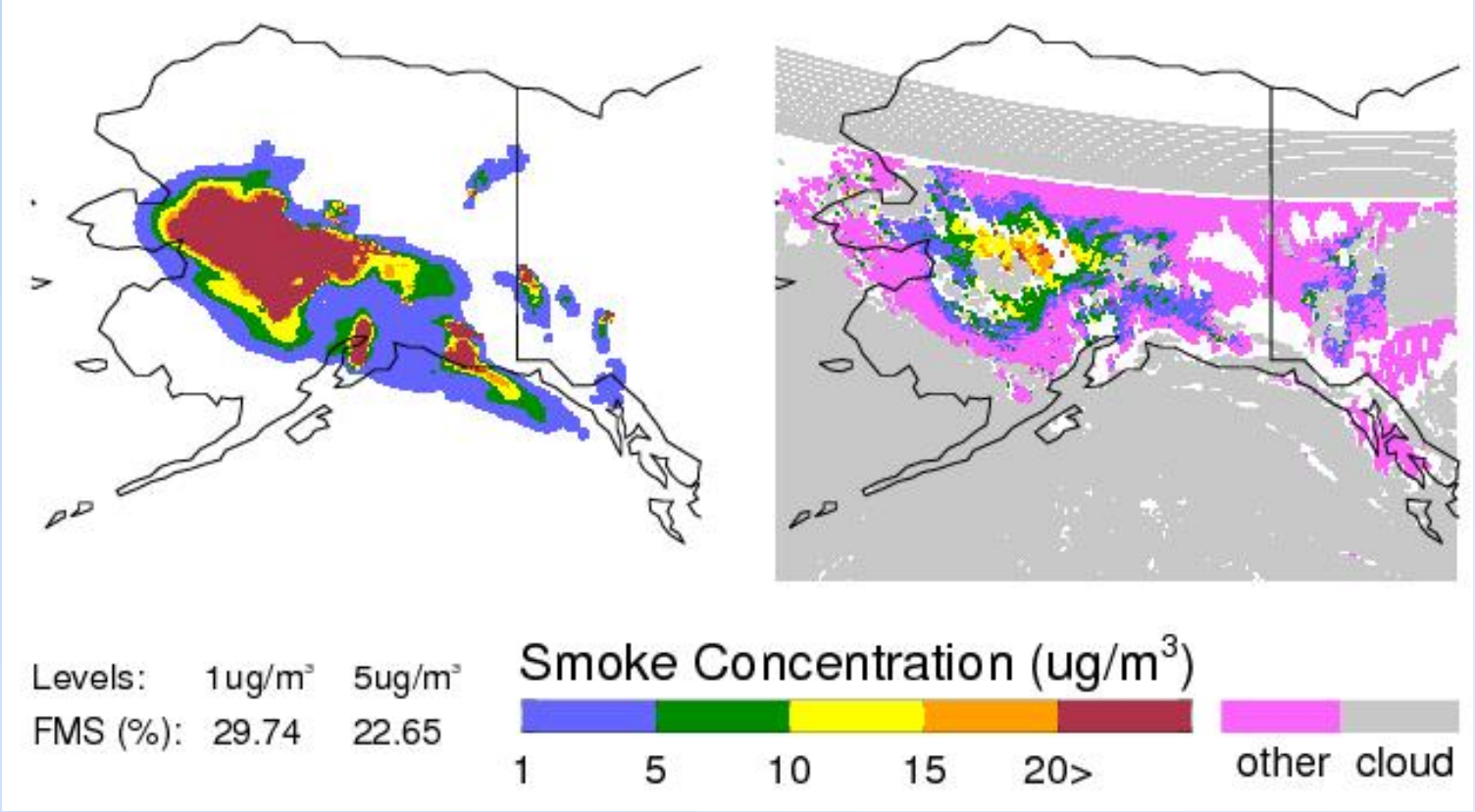
Smoke Verification Example

7/13/09, 17-18Z, Prediction:

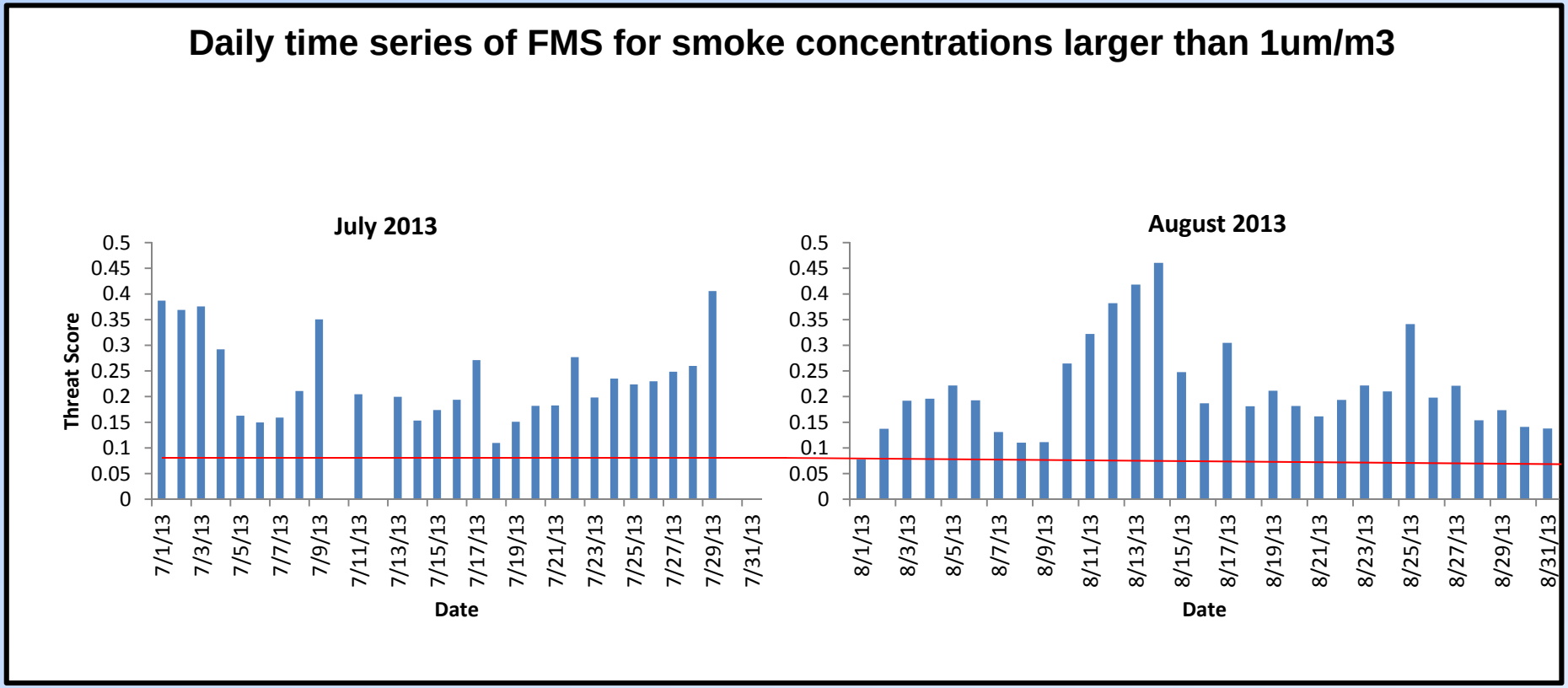
7/13/09, 17-18Z, Observation:

GOES smoke product: Confirms areal extent of peak concentrations

FMS = 30%, for column-averaged smoke > 1 ug/m^3



Verification of smoke predictions for CONUS



- **Figure of merit in space (FMS), which is a fraction of overlap between predicted and observed smoke plumes, threshold is 0.08 marked by red line**
- **NESDIS GOES Aerosol/Smoke Product is used for verification**
- **Since July 26, 2013, the model includes the following updates: increased plume rise, decreased deposition, changes in daily emissions cycling**

Dust Forecast Tool for CONUS

Major Components

NWP Model

NMMB

NOAA / NWS

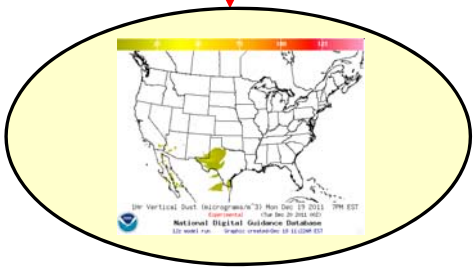
Weather Observations

NWP Post-processors for AQ Modules

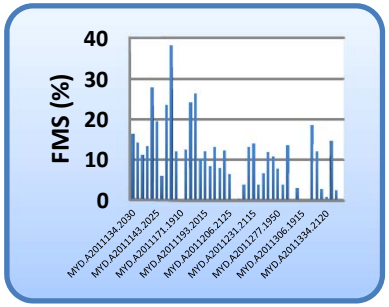
HYSPLIT Module:

NOAA / OAR

NOAA / GFDL
Map of possible dust sources

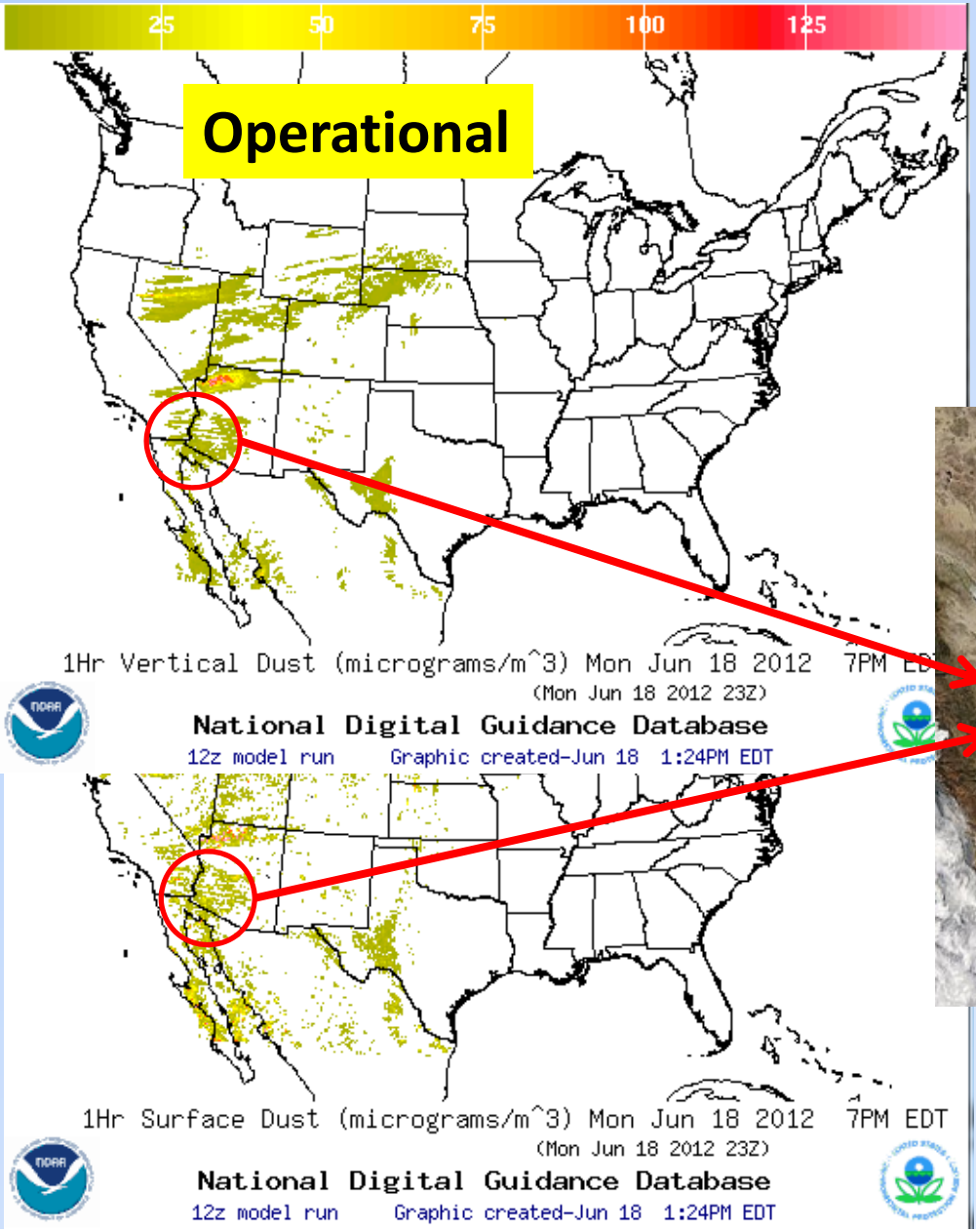


Verification:
NESDIS Dust

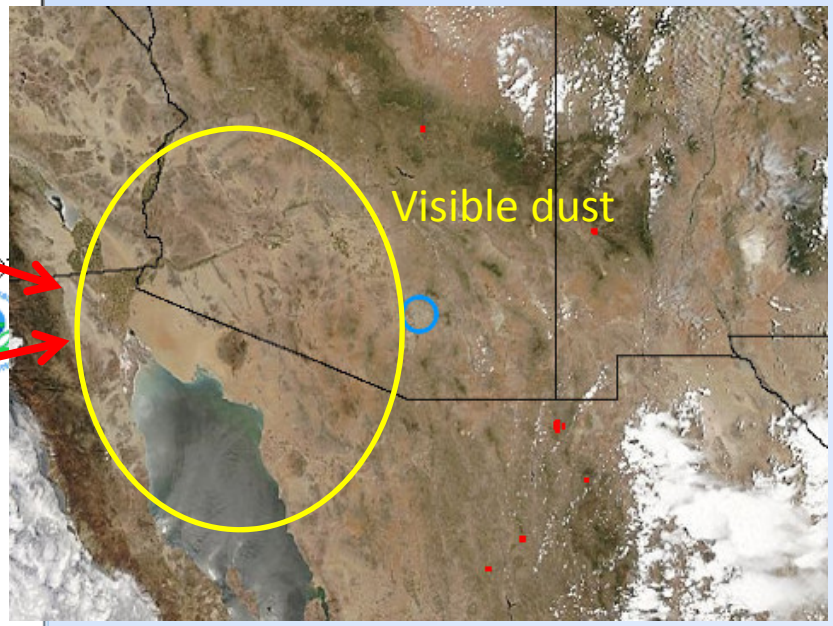


http://airquality.weather.gov/

Dust prediction over CONUS



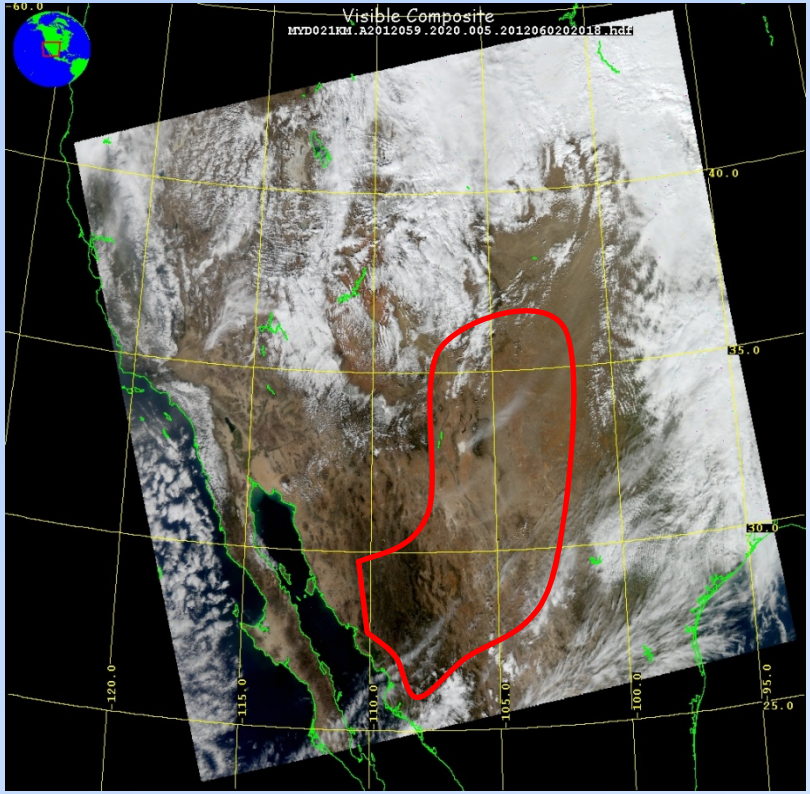
- Wind-driven dust emitted where surface winds exceed thresholds over source regions. Emissions modulated by real-time soil moisture information
- Source regions with emission potential estimated from monthly MODIS deep blue climatology (2003-2006)
- HYSPLIT model for transport, dispersion and deposition. Time step increased in 2012 to reduce time necessary to produce predictions.

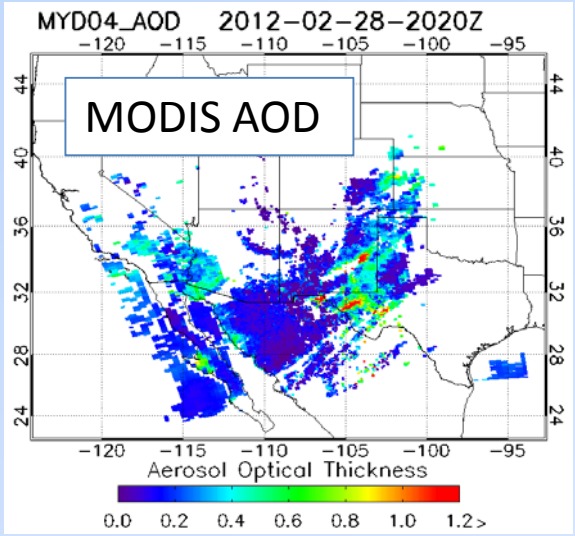


AQUA MODIS image on June 18, 2012

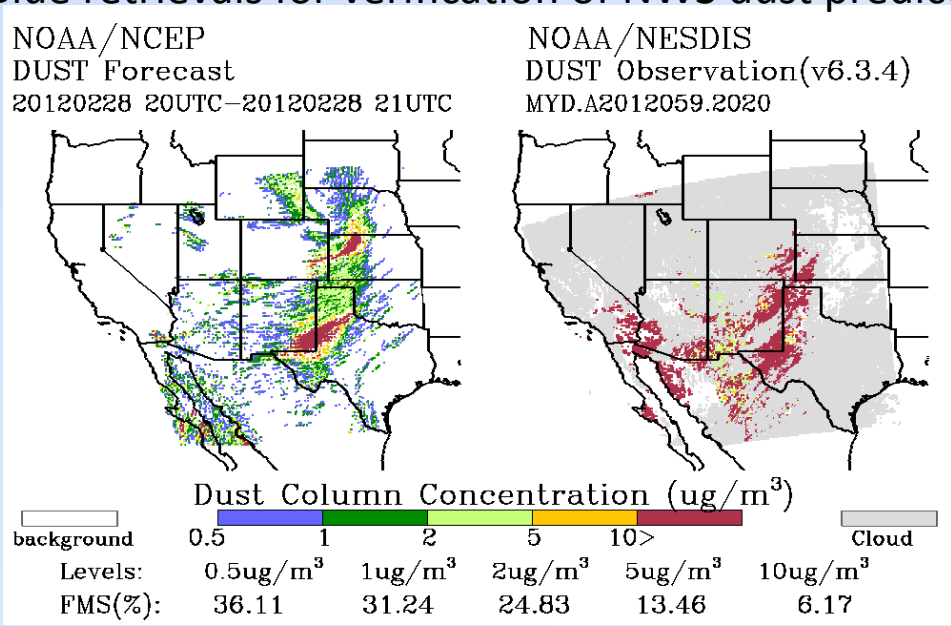
Draxler, R. R., P. Ginoux, and A. F. Stein (2010), An empirically derived emission algorithm for wind-blown dust, J. Geophys. Res., 115, D16212, doi:10.1029/2009JD013167.

Dust Event and Verification on 02/28/2012





NESDIS developed dust retrieval using MODIS Deep Blue retrievals for verification of NWS dust predictions



- Large dust storm occurred in Central Plains resulting in large swath of blowing dust
- Generated from eastern New Mexico, Western Texas, Texas Panhandle, southeast Colorado, Oklahoma Panhandle, and Western Kansas

Ciren P. & Kondragunta S. (2014), Dust Aerosol Index (DAI) Algorithm for MODIS, Journal of Geophysical Research: Atmospheres, DOI: 10.1002/2013JD020855.

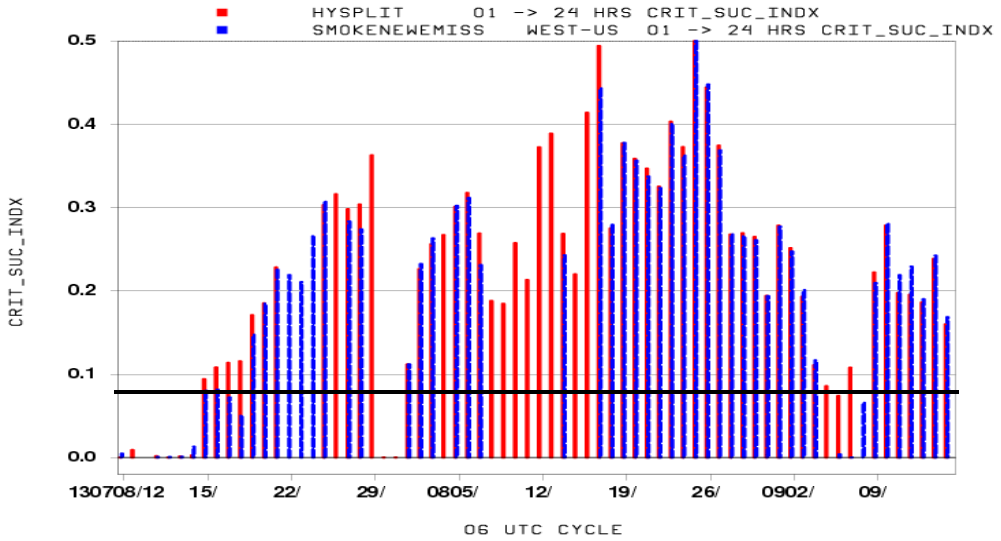
Testing of dispersion prediction updates

- Testing and evaluation of smoke predictions with automated detection of Mexican and Canadian fires
- Evaluation of smoke dispersion predictions using 4 km meteorological fields
- Evaluation of potential smoke prediction improvements from the updated USFS BlueSky system

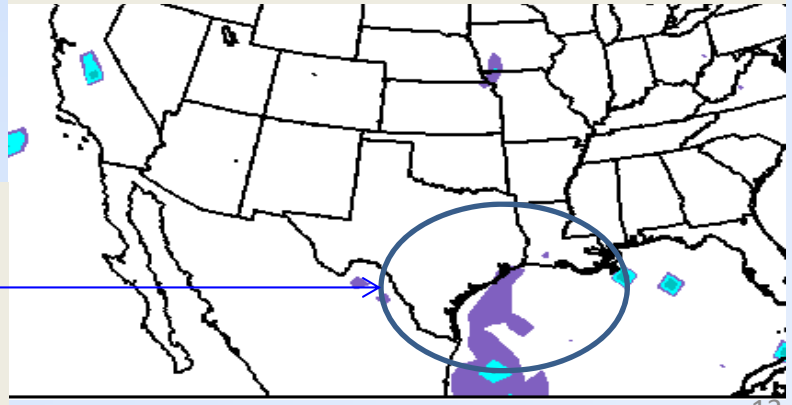
Updated HYSPLIT version in testing includes:

- Improved volcanic ash simulations by better treatment of the lowest model layer
- Faster dispersion calculations using pre-calculated random numbers

Canada/ Mexico Emission impact
July 8 – Sept. 15, 2013 CONUS CSI verification



Experimental HYSPLIT Smoke Surface Forecast
April 14, 2014

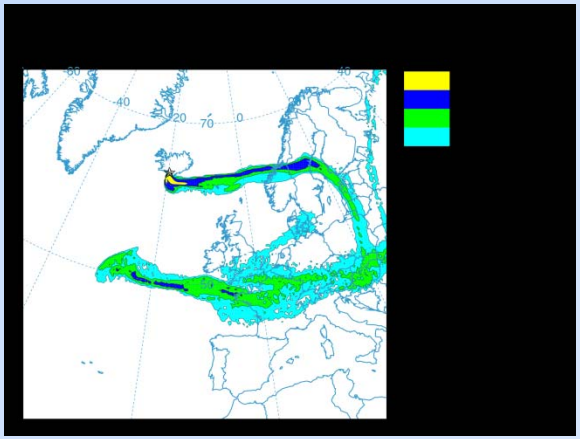


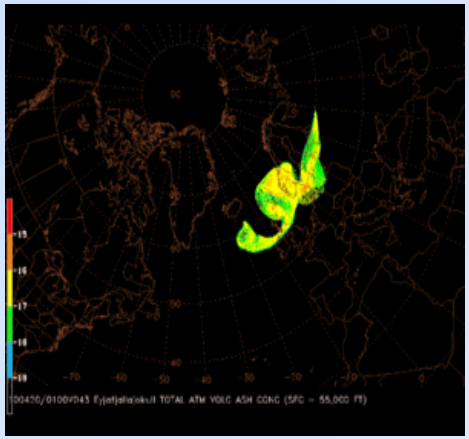
This plume is due to fire detections in Mexico, included in test predictions, but not in operational predictions.
Real-time testing results from
http://www.emc.ncep.noaa.gov/mmb/aq/hysplit/web/html/

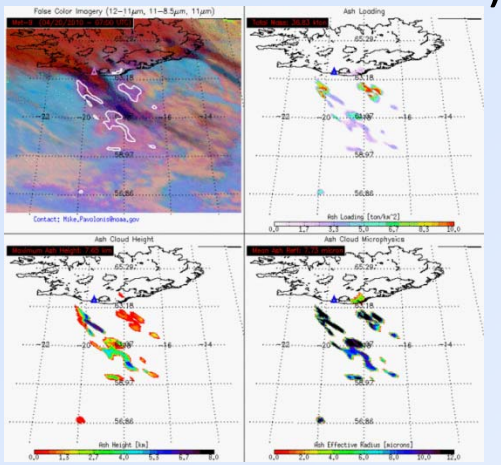
NOAA's Volcanic Ash Assets

Response to the Eruptions of Eyjafjallajokull *Volcano*

- NESDIS (Satellite imagery resources – top and horizontal extent of cloud)
- Washington and Anchorage VAACs (detection/tracking, forecasting)
- NWS/OAR (HYSPLIT) - *Stunder, B.J.B., J.L. Heffter, R.R. Draxler (2007), Airborne Volcanic Ash Forecast Area Reliability, Weather and Forecasting, 22:1132-1139, DOI: 10.1175/WAF1042.1*
- Meteorological Watch Offices (Aviation Warnings for Volcanic Ash – SIGMETs)
  - NWS/NCEP Aviation Weather Center
  - NWS Weather Forecast Office Honolulu
  - NWS Alaska Aviation Weather Unit
- Center Weather Service Unit (1 per FAA Air Route Traffic Control Center)







Dispersion of radioactive material

- NOAA is the home for the U.S. Regional Specialized Meteorological Center under WMO that supports International Atomic Energy Agency (IAEA)

- For the Fukushima Daiichi's nuclear power plant incident:
  - IAEA requested NOAA transport simulations, which were shared with IAEA member countries.
  - NOAA worked with DOE to inform the federal community about the transport of radiation. NOAA also responded to requests for support from multiple agencies.
  - NOAA atmospheric modeling group provided estimates of deposition into the ocean for NOAA's ocean radiation simulations.
  - HYSPLIT runs were used for these simulations (NOAA/ARL, NOAA/NCEP).
  - NOAA developed an approach for quickly updating predictions or evaluating multiple emissions scenarios. *Draxler & Rolph (2012) J. Geophys. Res., 117, D05107, doi:10.1029/2011JD017205.*

- UNSCEAR 2013 Report:
  - NOAA provided calculations of air concentration and deposition that were used by other experts to estimate radiation doses.
  - The NOAA dispersion model, HYSPLIT, and meteorological data from NCEP were extensively used in the Committee's evaluation.
  - Additional radiation dose for majority of people in Japan and for people in neighboring countries is less than typical yearly amount of natural background radiation.

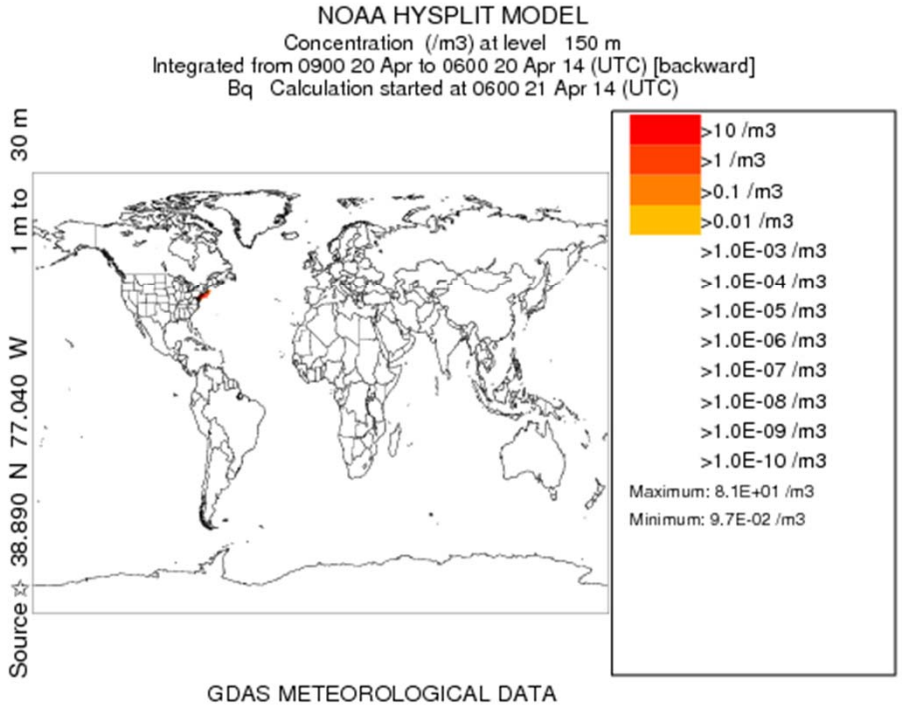
  UNSCEAR 2013 Report Vol 1: Sources, Effects and Risks of Ionizing Radiation, Scientific Annex A.

CTBTO Backtracking

NOAA is working on implementation of an operational on-demand backtracking capability to provide potential source locations to the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) per MOU with the Department of State.

- Relies on NOAA's dispersion model code (HYSPLIT) with backtracking capability and essential source attribution codes and scripts with integrated testing, verification and documentation.
- Source attribution software tested with CTBTO data collected after the Fukushima accident.
- A prototype system is providing responses to CTBTO requests.
- Operational CTBTO response system implementation is planned for September 2014; system testing and integration is in progress at NCEP.

Hypothetical test example



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Incident support:

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4. Radiologic contamination
5. Chemical releases

Recent updates:

- Modified smoke plume rise, updated deposition parameters, and transitioned all predictions to a new operational computing system
- Testing CTBTO on-demand backtracking capability; planning operational implementation
- Testing updates to emissions and use of higher resolution meteorology