Operational Dispersion Predictions at NOAA and Development of Aerosol Capabilities for the Next Generation Global Prediction System (NGGPS)

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NOAA operational predictions of atmospheric dispersion

Routine predictions:

- Smoke predictions nationwide http://airquality.weather.gov/
- Dust predictions over contiguous 48 states (CONUS) http://airquality.weather.gov/
- CTBTO on-demand backtracking capability

Incident support:

- Volcanic ash
- Radiological contamination
- Chemical releases

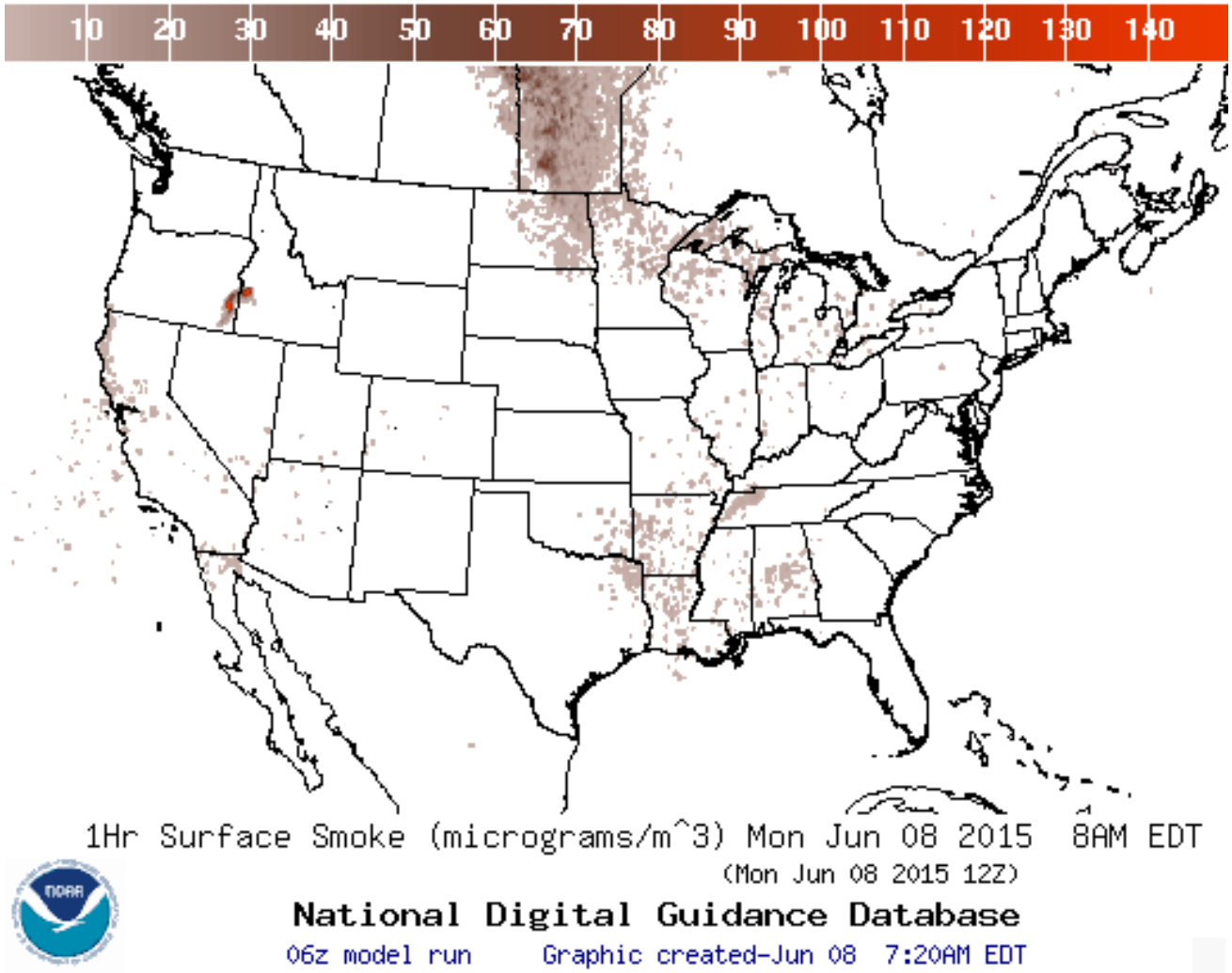
All the above dispersion applications rely on HYSPLIT model.

Development of fine particulate matter predictions:

- Wildfire smoke sources and dust sources are now included in CMAQ model

Smoke Predictions

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



- Smoke predictions for CONUS (continental US), Alaska and Hawaii
- NESDIS provides wildfire locations
- Emissions estimates from USFS Bluesky system (Testing updated version)
- HYSPLIT model for transport, dispersion and deposition (Rolph et. al., W&F, 2009)
- Recent updates include increased plume rise, decreased wet deposition, changes in daily emissions cycling
- Developed satellite product for verification (Kondragunta et.al. AMS 2008)

Smoke Verification using Satellite Data

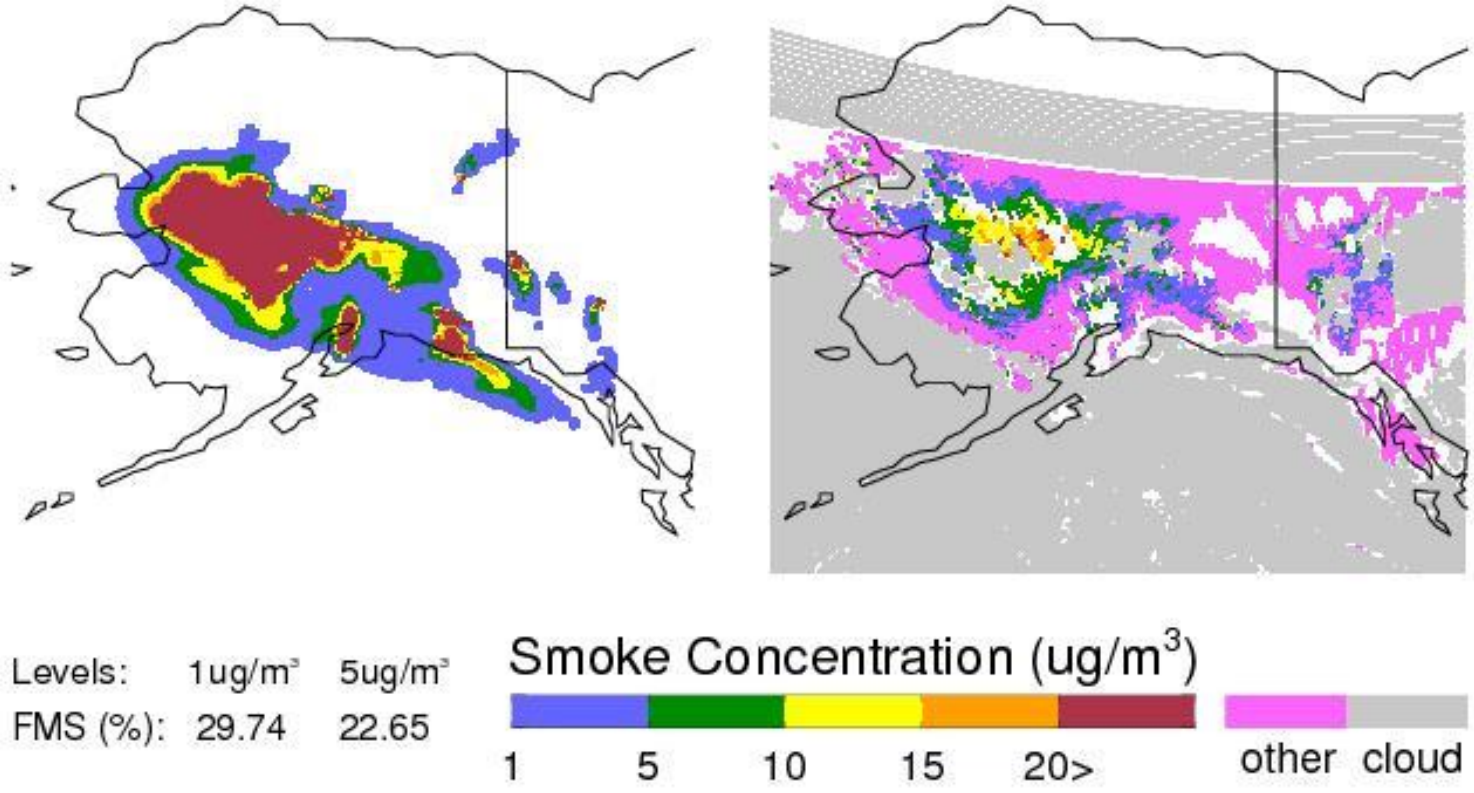
July 13, 2009 example

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

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

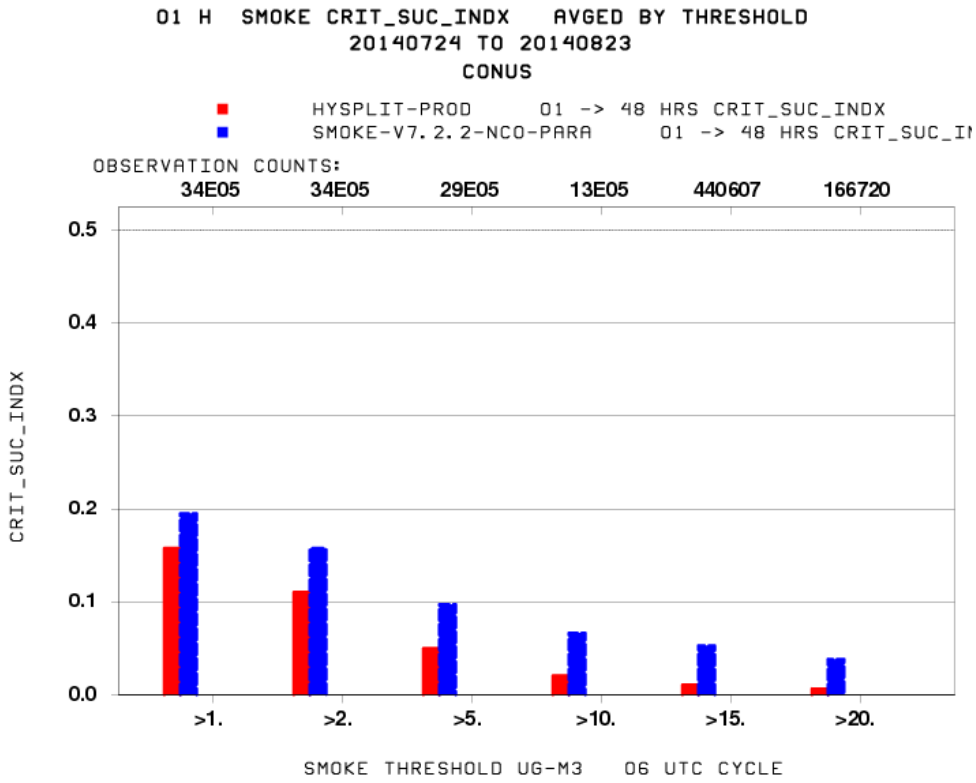
GOES smoke product: Confirms areal extent of peak concentrations

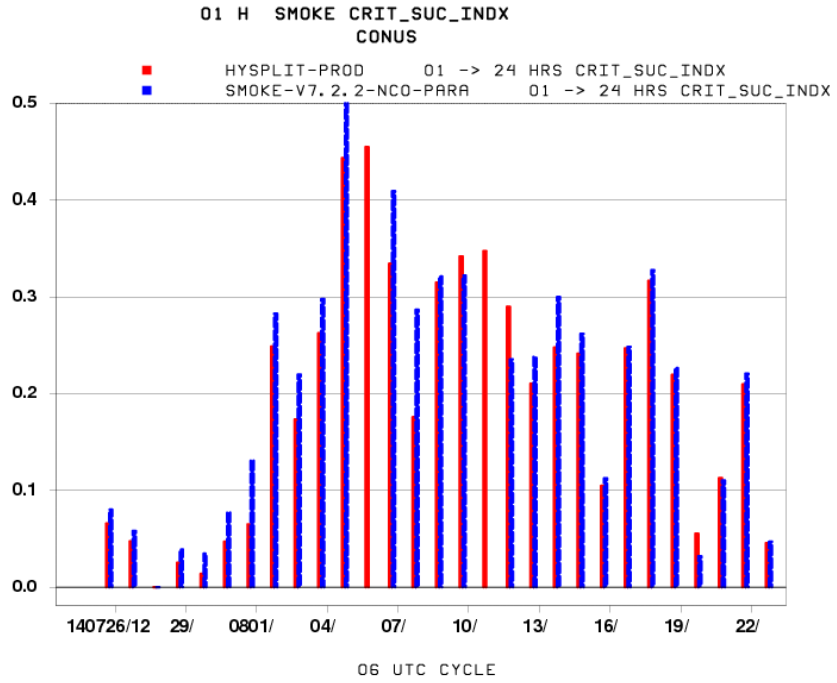
FMS = 30%, for column-averaged smoke > 1 ug/m^3



Manuscript about smoke verification product is in preparation

Canada/ Mexico Emission impact July –August, 2014 CONUS CSI verification

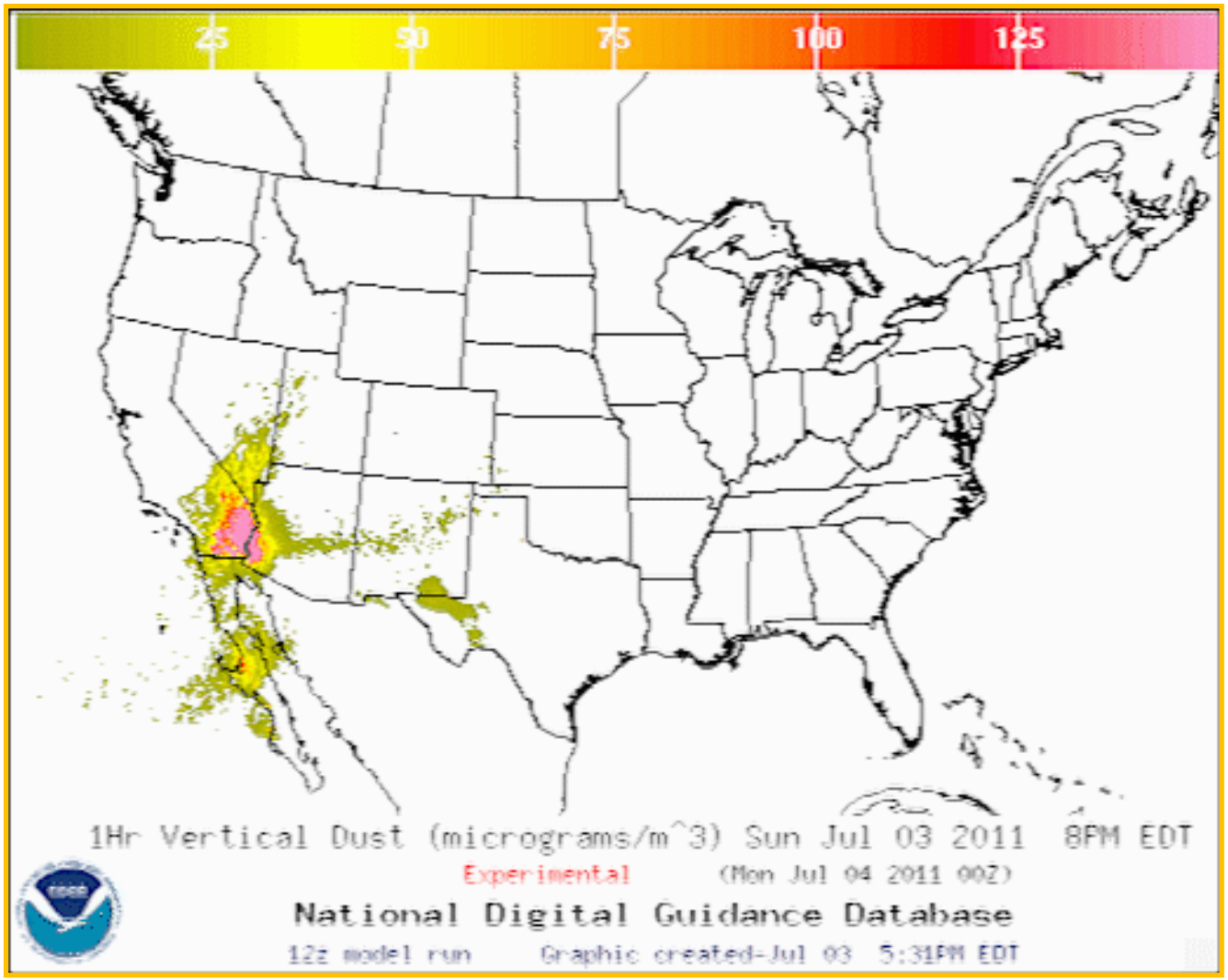




Improved performance (higher CSI for all thresholds) of the updated smoke predictions with new Canadian and Mexican emissions

CONUS Dust Predictions

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

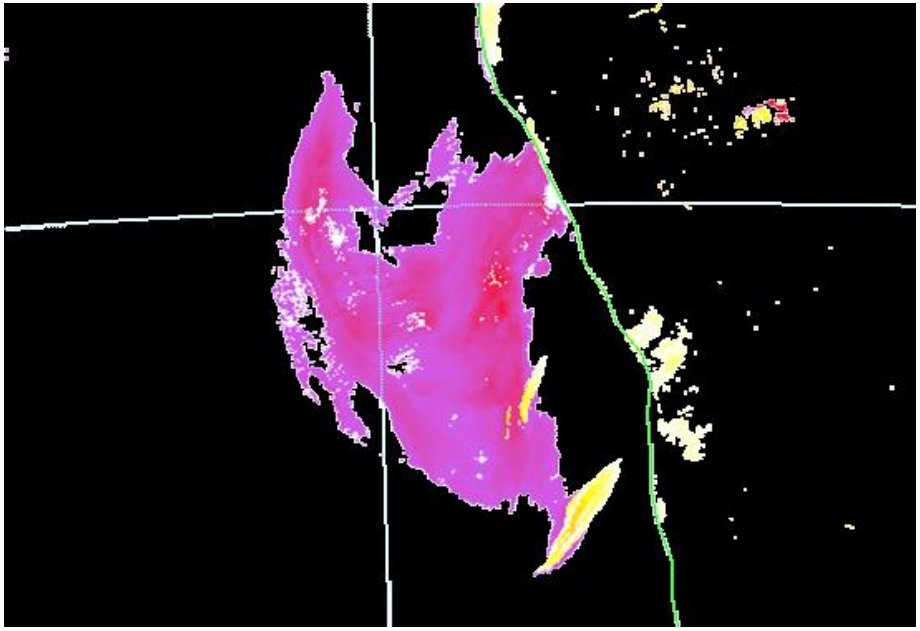


- Standalone prediction of airborne dust from dust storms:
- Wind-driven dust emitted where surface winds exceed thresholds over source regions
- Source regions with emission potential estimated from MODIS deep blue climatology for 2003-2006 (Ginoux et al. JGR 2010)
- Emissions modulated by real-time soil moisture.
- HYSPLIT model for transport, dispersion and deposition (Draxler et al., JGR, 2010)
- Wet deposition updates in July 2013
- Developed satellite product for verification (Ciren et.al., JGR 2014)

VIIRS Dust and Smoke Detection for Air Quality Forecast Applications

$$DAI = -100*[\log_{10}(R_{412nm}/R_{445nm})-\log_{10}(R'_{412nm}/R'_{445nm})]$$
$$NDAI = -10*[\log_{10}(R_{412nm}/R_{2.25um})]$$

Dust Aerosol Index and
Non Dust (smoke) Aerosol Index
in preoperational real time testing
at NOAA/NESDIS/STAR

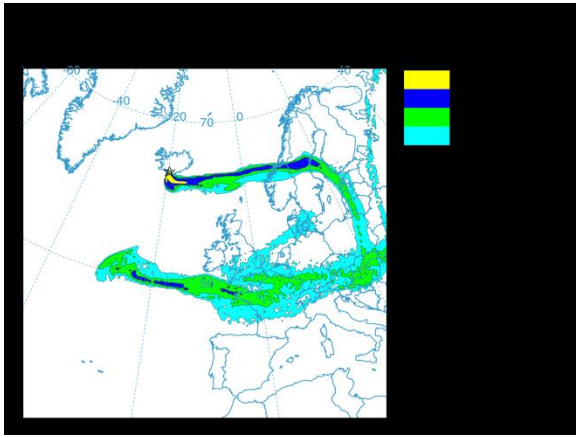


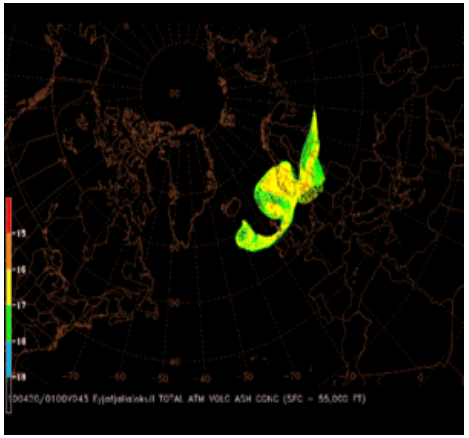
Dust Aerosol Index Smoke Aerosol Index

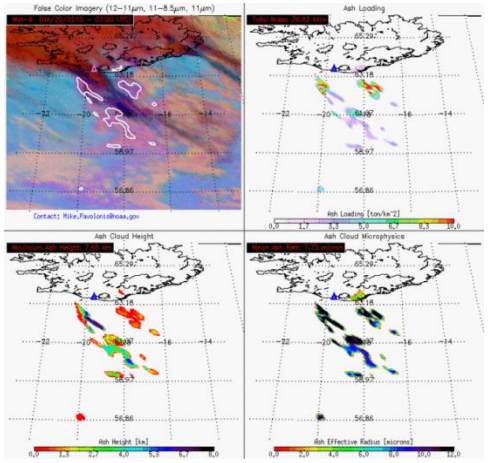
NOAA's Volcanic Ash Assets

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. Heffter, 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.

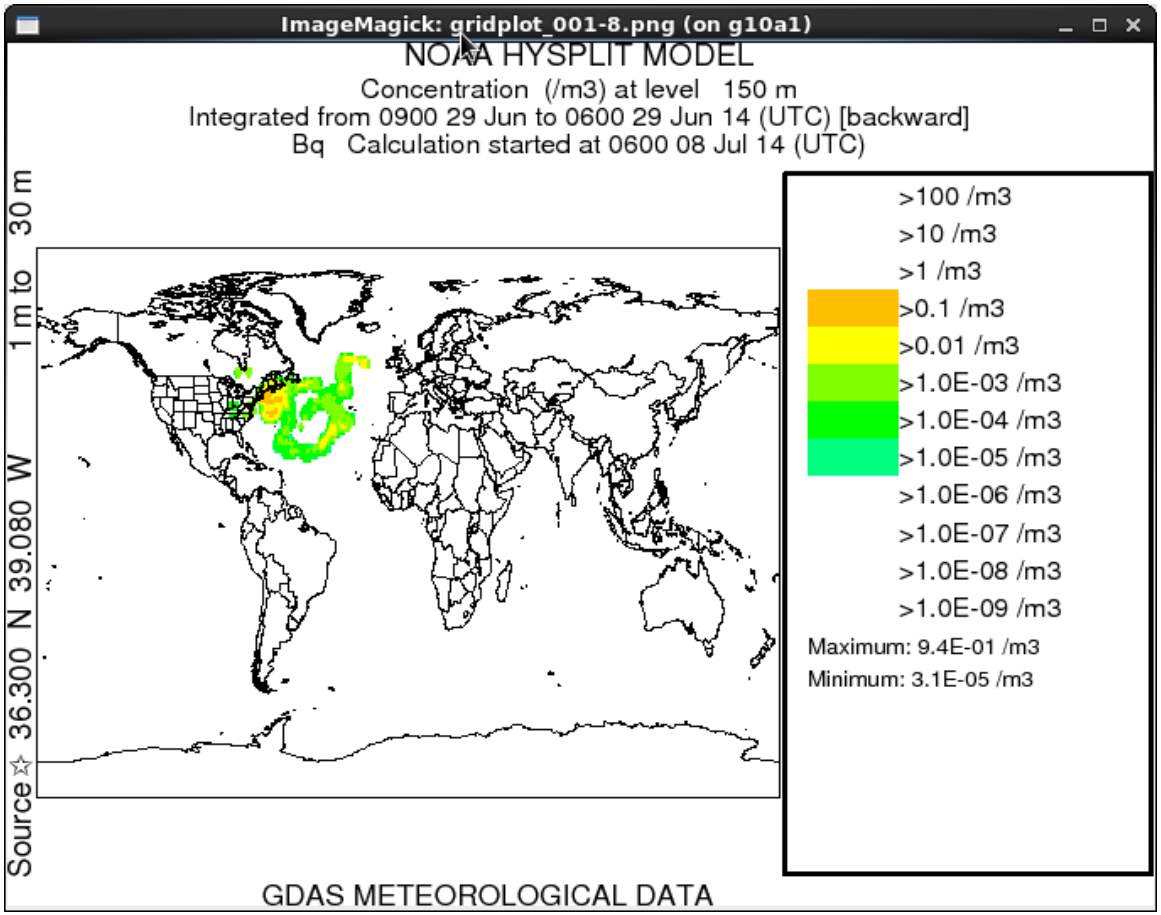
UNSCEAR 2013 Report Vol 1: Sources, Effects and Risks of Ionizing Radiation, Scientific Annex A.

CTBTO Backtracking

On-demand backtracking capability is operationally implemented by NOAA to provide potential source locations to the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) per MOU with the Department of State.

- Operational CTBTO response system was implemented in September 2014 at NCEP.
- The system relies on NOAA's dispersion model code (HYSPLIT) with backtracking capability and essential source attribution codes and scripts with integrated testing, verification and documentation.
- The prototype system provides responses to CTBTO requests.

Visualization: Dispersion Plot



Testing of PM2.5 Predictions

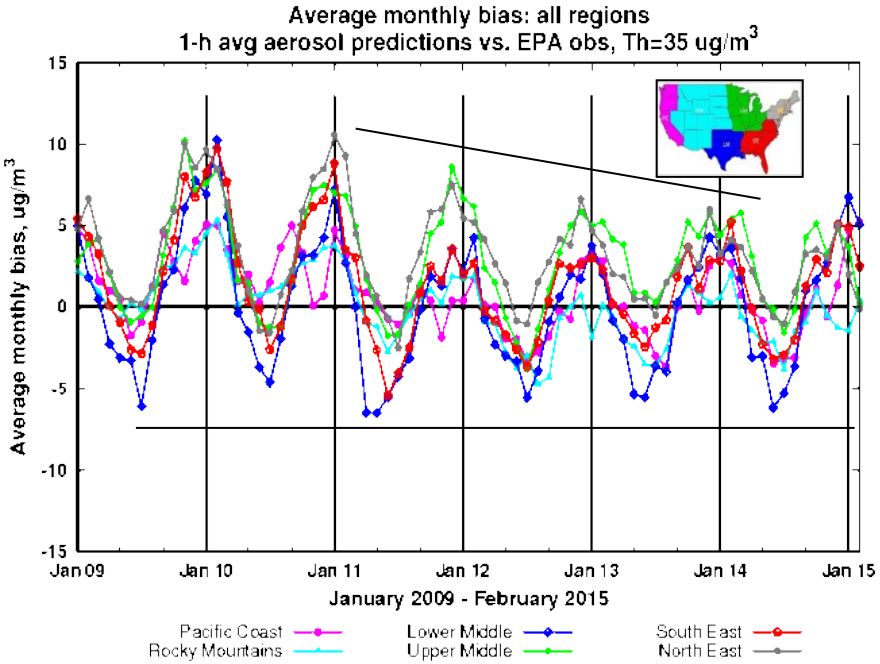
AQ Forecaster Focus group access only, real-time as resources permit

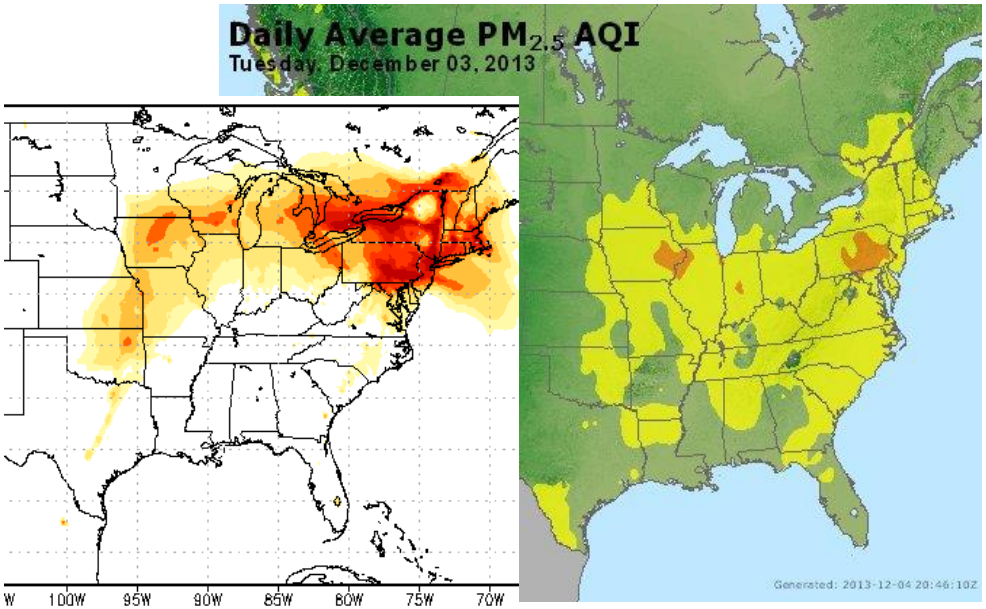
Aerosols over CONUS

From NEI sources only before summer 2014

- CMAQ:
  CB05 gases, AERO-4 aerosols
- Sea salt emissions

- Show seasonal bias-- winter, overprediction; summer, underprediction





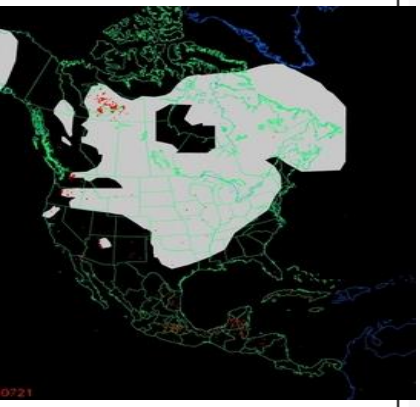
NAQFC PM2.5 test predictions

Forecast challenges

- *Improving sources for **wildfire smoke and dust** – in testing since summer 2014*
- *Chemical mechanisms eg. SOA*
- *Meteorology eg. PBL height*
- *Chemical boundary conditions/trans-boundary inputs*

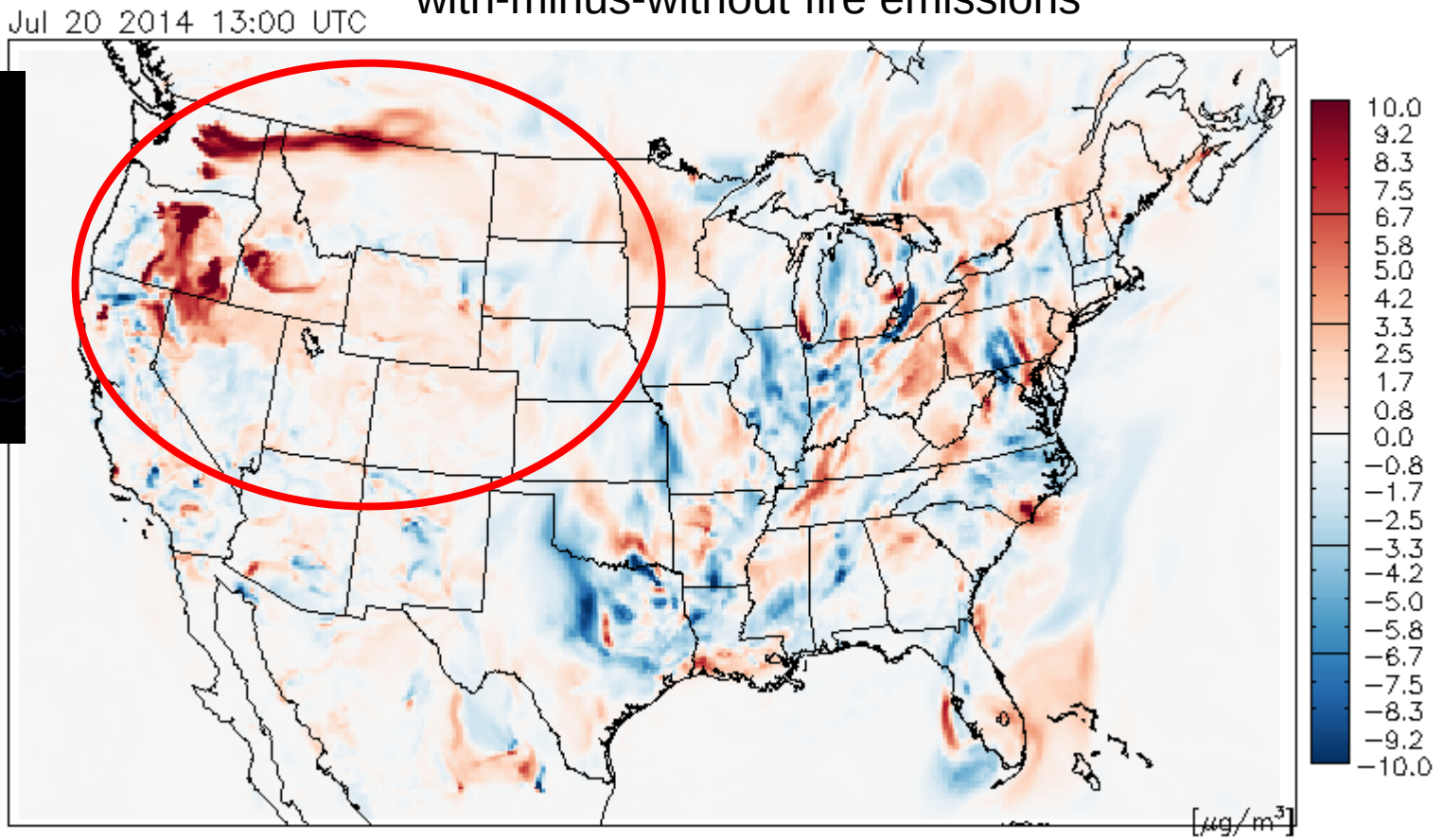
Impact of forest fires in testing of PM2.5 predictions

Difference between two PM2.5 predictions: with-minus-without fire emissions

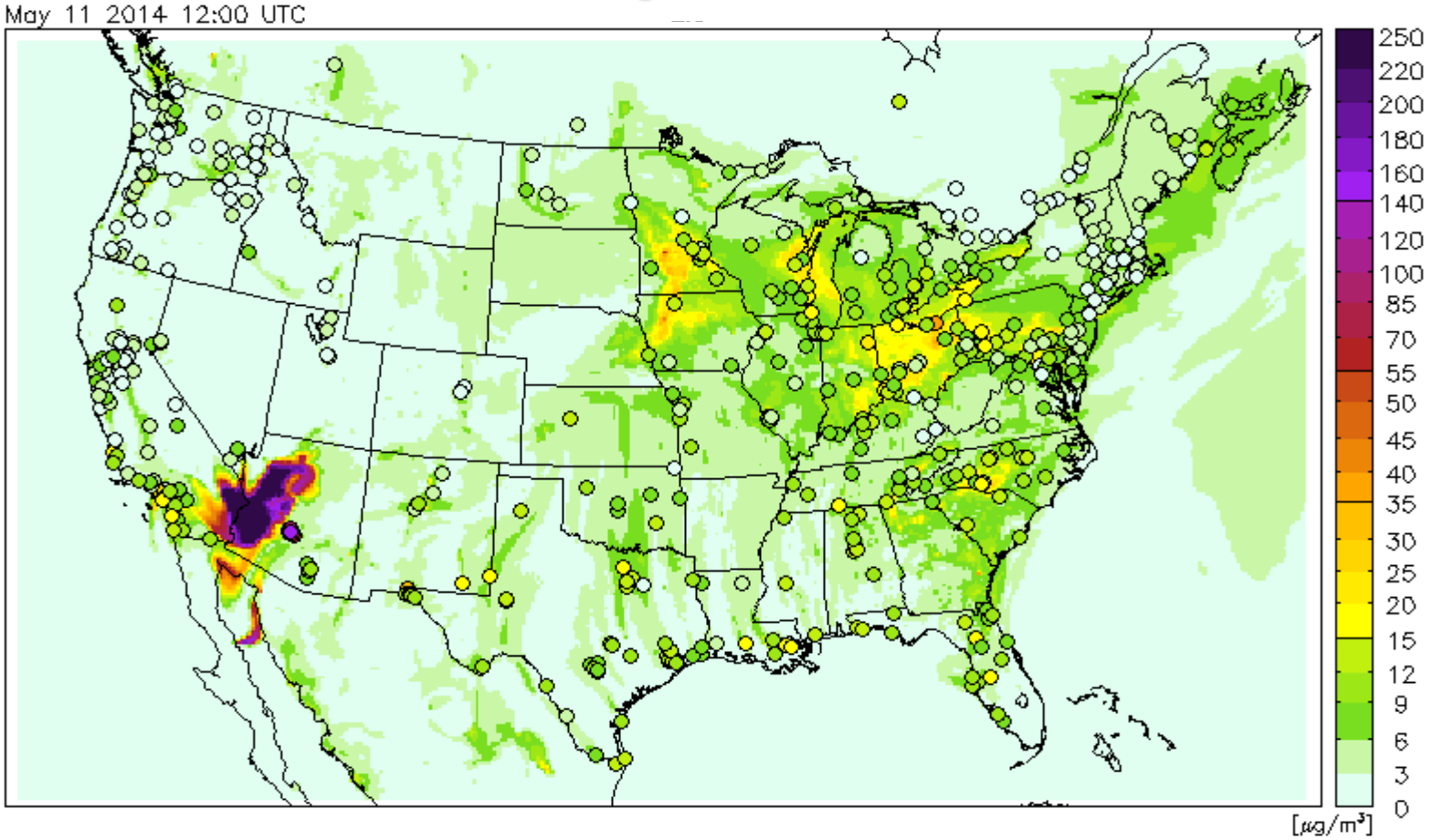


NOAA NESDIS Hazard Mapping System Fire and Smoke Analysis

Detection of wildfire locations from satellite imagery



Blowing Dust Event in testing of PM2.5 predictions



Independent NOAA/NESDIS analysis narrative based on satellite imagery:

BLOWING DUST

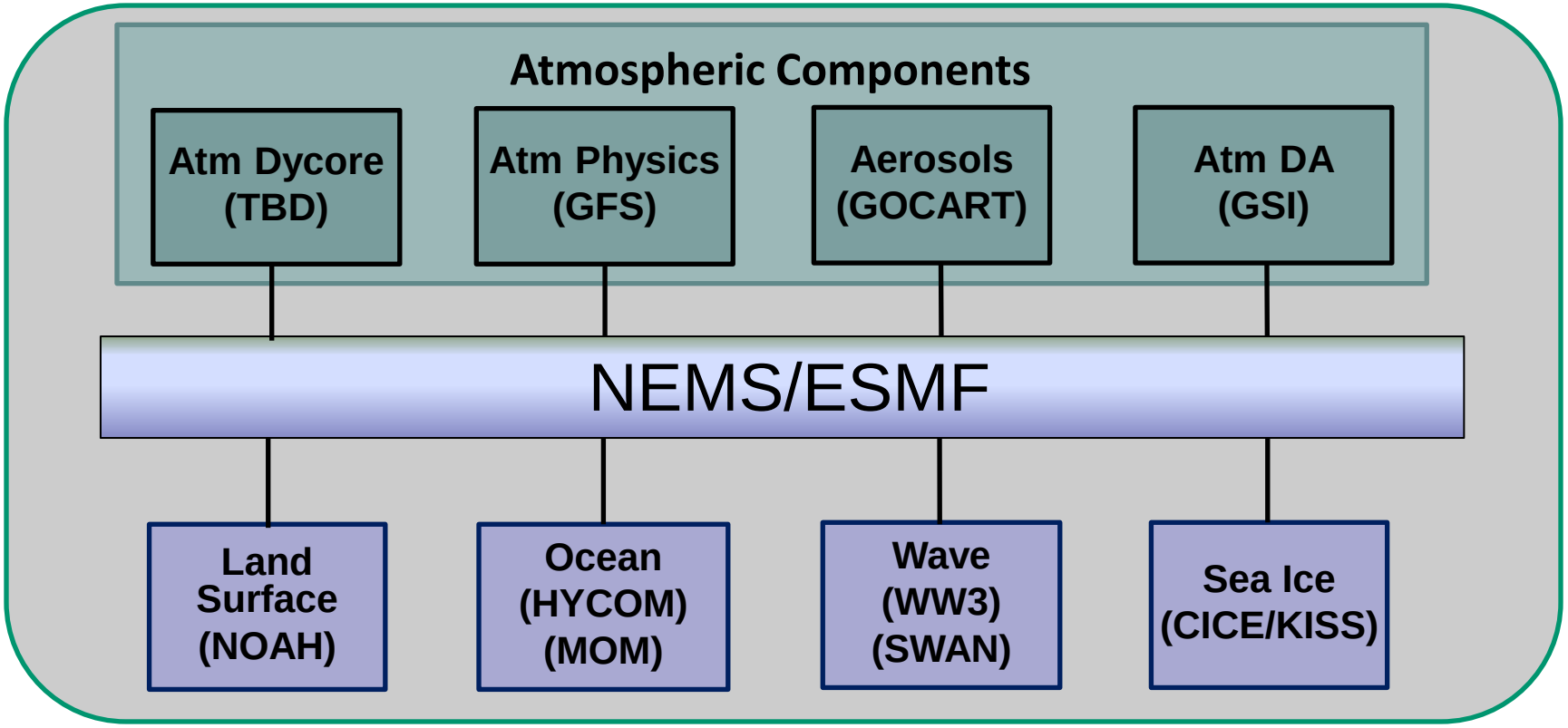
California/Arizona: An area of moderately dense blowing dust was visible sweeping across northern Baja California/Arizona into western New Mexico behind a strong cold frontal boundary. This remnant dust originated from multiple areas in southern California last evening.

Next Generation Global Prediction System (NGGPS)

- Design, develop, and implement the NGGPS in 2019 to
  - Extend forecast to 30 days
  - Incorporate atmosphere, ocean, ice, land surface, waves, and aerosol model components
  - Fully couple the system using NEMS/ESMF
- Fully utilize evolving high performance computing (HPC) capabilities
- 5-year community effort
  - Contribute to NGGPS development
  - Model components available as community code

NGGPS website: http://www.nws.noaa.gov/ost/nggps

NGGPS Prediction Model Components



- NGGPS implementation plan development includes an aerosol team
- Development of dust/aerosol capabilities is underway by universities and federal labs

NGGPS Dust/Aerosol Development in Progress

- *Paul Ginoux (NOAA GFDL)*
  - Implementation and Testing of Regional and Global Dust Forecasting
- *Sarah Lu (SUNY Albany)*
  - Investigation of Aerosol Effects on Weather Forecast using NCEP Global Forecast System – radiative effects
  - Improving Cloud Microphysics and Their Interactions with Aerosols in the NCEP Global Models
- *Georg Grell (NOAA/ESRL/GSD)*
  - Using Advanced Photochemical and Aerosol Modules to Verify the Applicability of GOCART Aerosol Modules within Global Weather Prediction Models
- *Zhanqing Li (Univ. of MD)*
  - Evaluating the Impact of Cloud-Aerosol-Precipitation Interaction (CAPI) Schemes on Rainfall Forecast in the NGGPS

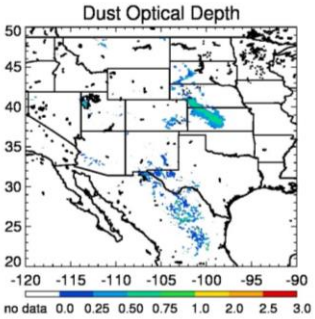
Implementation and testing of regional and global dust forecasting

NOAA NGGPS project

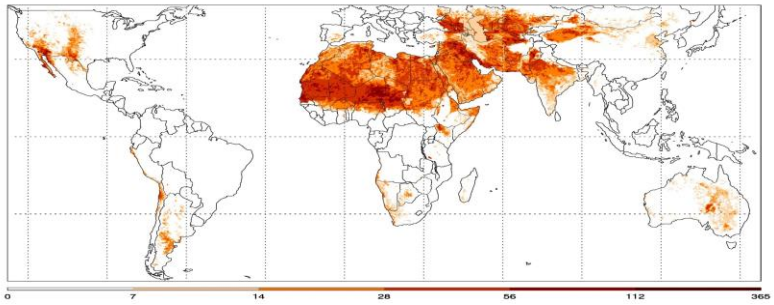
PI: Paul Ginoux (NOAA GFDL)

1. Dust Sources Inventory

Dust detection using MODIS satellite at 0.1° resolution (~10 km) daily for 12 years (2003-2014). Dust source = location of the most frequent dust events (Ginoux et al., Rev. Geophys., 2012). Unique global high resolution dust sources inventory.

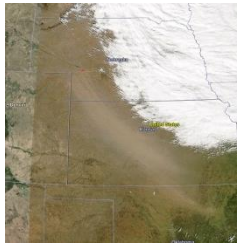


One granule of satellite pixels at a time from regional to global, daily and for 12 years of newly released MODIS data →

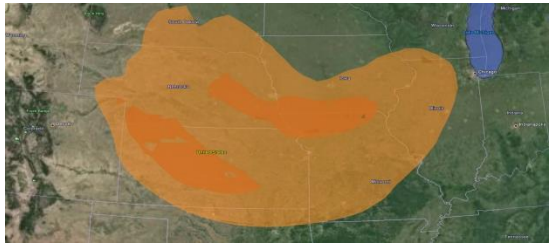


2. Dust Simulation/forecasting

Dust simulation with NMMB for one year (2012), global and CONUS (high resolution)

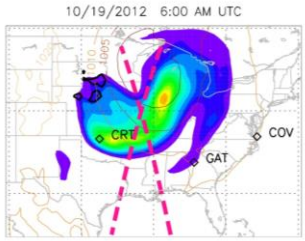


Dust events are frequent in the High Plains, creating deadly accident, shutting Interstate Highways, such as in October 2012. →

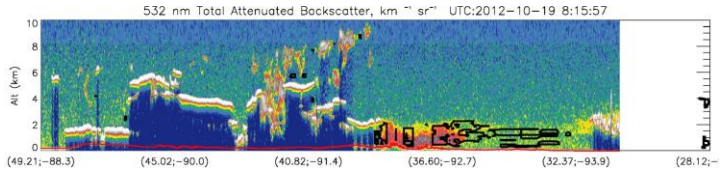


3. Model Evaluation

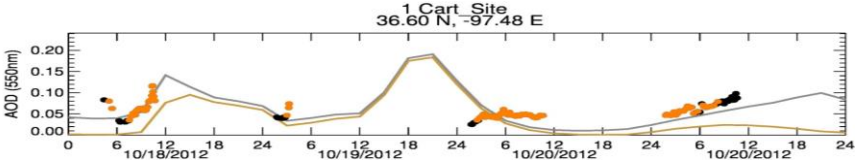
Evaluation and skill scores using ground-based and satellite data

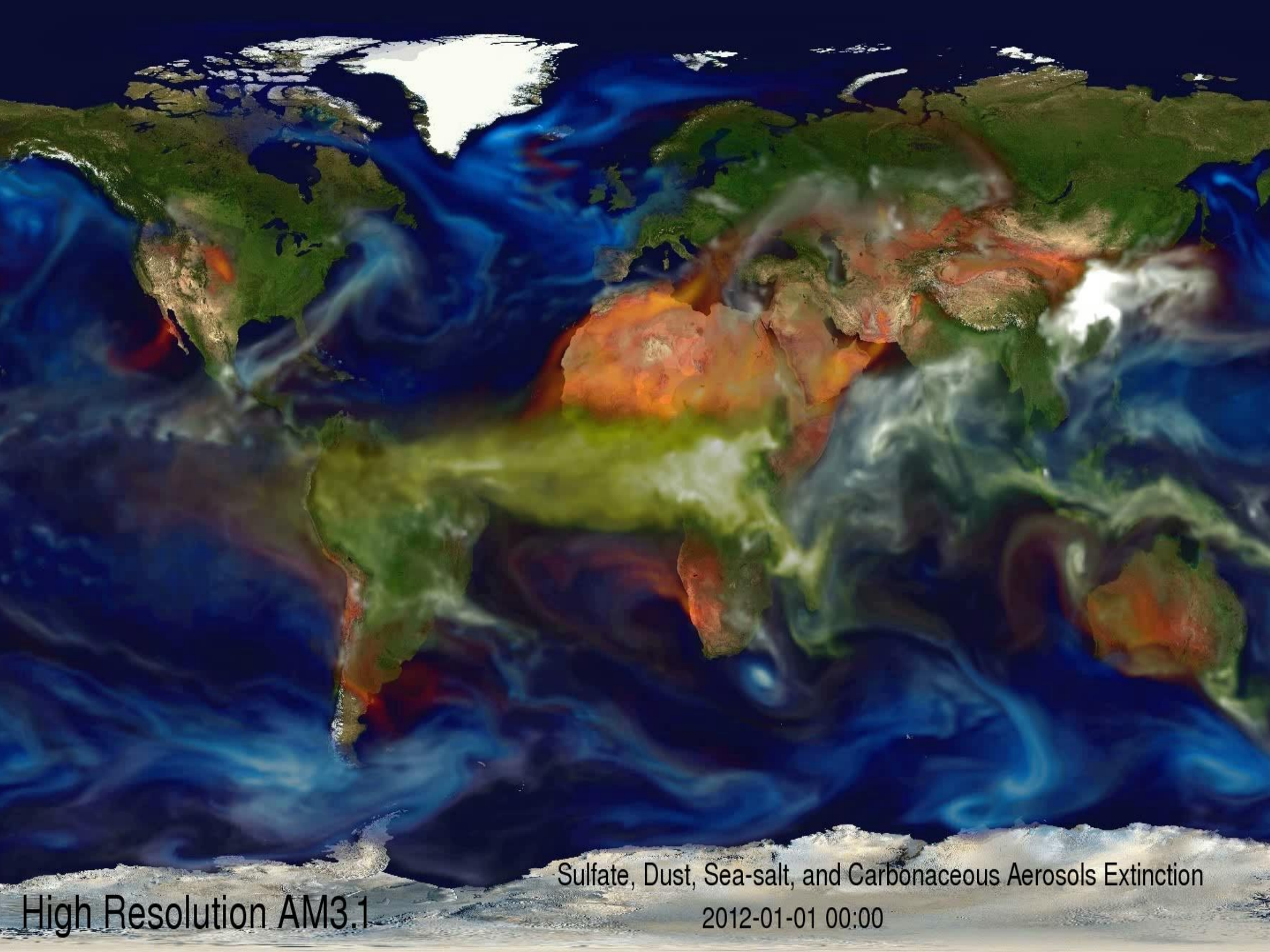


CALIPSO lidar



AERONET sunphotometer

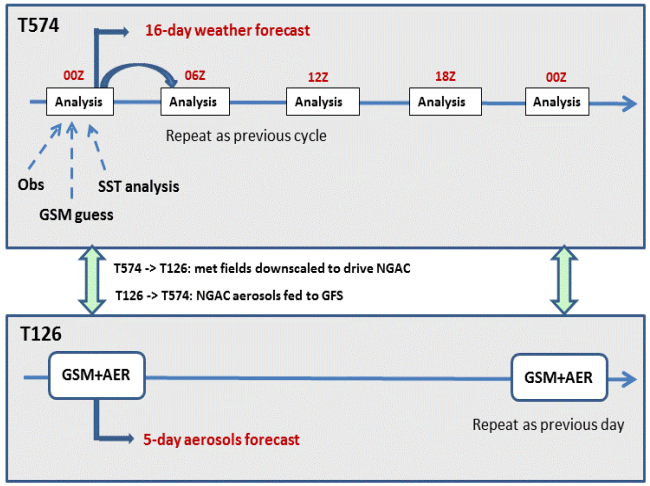



Sulfate, Dust, Sea-salt, and Carbonaceous Aerosols Extinction
2012-01-01 00:00
High Resolution AM3.1

Investigation of Aerosol Effects on Weather Forecast using NCEP Global Forecast System

PI: Sarah Lu, University at Albany, State University of New York (SUNYA)

Project goal: Explore the optimal configurations for the GFS to represent aerosol processes. Year 1 plans include:



An enhanced dual resolution system, allowing aerosol information from low resolution NGAC to be fed into high resolution GFS.

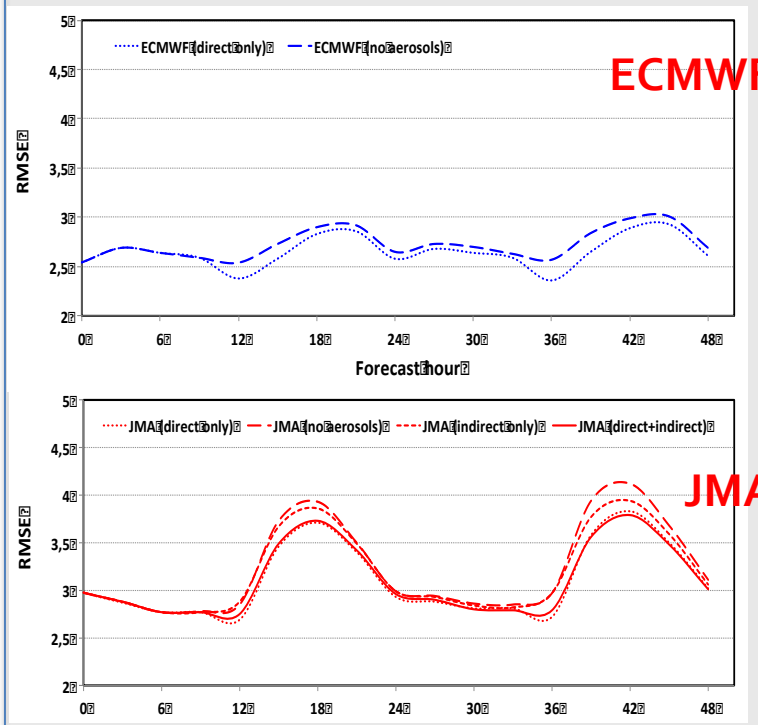
- Upgrade the infrastructure in the dual resolution system, allowing NGAC aerosol fields fed into GFS
- The radiation package in GSM will be modified so aerosol optical properties can be determined from GOCART aerosol species taken from external NGAC output files (the loose coupling option) or internally from 3-dimensional tracer arrays (the tight coupling option)
- The GSI/CRTM code will be modified so aerosol radiative effects can be determined from aerosol fields from external low-resolution NGAC files (the loose coupling option) or from prognostic aerosol fields in GSM guess files (the tight coupling option)
- GFS parallel scripts will be modified to enable two-way coupling (the loose coupling option)
- Evaluate NCEP RTG_SST analysis system with the aerosol option incorporated.
- RTG_SST analysis with and without considering aerosol attenuation will be generated, and the impact of aerosols on SST analysis will be assessed using in situ observations

Using advanced photochemical and aerosol modules to verify the applicability of GOCART aerosol modules within global weather prediction models

Georg A. Grell (NOAA/ESRL/GSD) and Stuart A. McKeen (NOAA/ESRL/CSD)

- Use gas-phase and aerosol chemistry packages with different levels of sophistication in state-of-the-art global modeling systems
- Determine the degree of complexity necessary to estimate the impact of aerosols on numerical weather prediction skill
- Deliverables will include chemistry and aerosol packages for inclusion in any NGGPS modeling system as well as scientific publications

- For NGGPS this will accelerate development and implementation of weather prediction model components (aerosol models), and improve coupling between the component model systems
- The evaluated chemistry and aerosol packages can be included in any of the NGGPS modeling systems



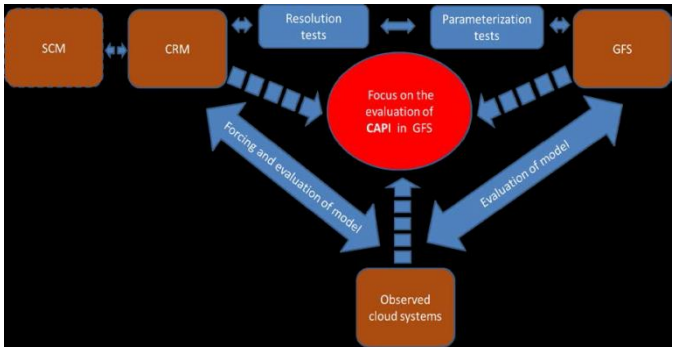
Improvement when including aerosols for near surface temperature predictions as shown by a Working Group for Numerical Experimentation and a model intercomparison case over Brazil. Examples from 2 operational center models include radiation interaction (direct effect) and microphysics interaction (indirect effect). “No aeroso” runs were done with climatologies

Evaluating the Impact of Cloud-Aerosol-Precipitation Interaction (CAPI) Schemes on Rainfall Forecast in the NGGPS

Principal Investigator: Zhanqing Li - ESSIC, University of Maryland
Co-Principal Investigator: Seoung-Soo Lee - ESSIC, University of Maryland
Co-Investigators: Yu-Tai Hou, Jun Wang, Shrinivas Moorthi - NOAA/NCEP/EMC
Sarah Lu - SUNY Albany

Approach to evaluate schemes:

- Evaluating the performance of the new physical schemes associated with accounting for the aerosol effects that affect rainfall forecasts and cloud simulations through in-depth comparisons with extensive global satellite and ground-based products And observation-based findings



An integrated approach to evaluate the GFS model regarding CAPI by using CRM, SCM, and observations.

- Understanding the causes of discrepancies in simulating clouds and their interactions with aerosol between current and new schemes, and between model simulations and observations by virtue of a high-resolution cloud-resolving model (CRM)

Improving the physical parameterizations of cloud-aerosol interactions allows for efficient, accurate and more complete representations of physical processes and their interactions across scales

Summary

Operational predictions of atmospheric dispersion

- NOAA provides smoke predictions nationwide, dust predictions for CONUS, and an on demand back-tracking capability for CTBTO
- NOAA provides incident support for volcanic ash, radiological contamination and chemical release dispersion
- HYSPLIT model

Development of fine particulate matter predictions for the US

- Wildfire smoke sources and dust sources are included in CMAQ model
- Linkage with global dust/aerosol predictions

Next generation global prediction system (NGGPS)

- Improved aerosol modeling and coupling with atmospheric radiation and microphysics