



An overview of HYSPLIT's science and applications development

Dr. Ariel Stein
NOAA's Air Resources Laboratory

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Tianfeng Chai, and Alice Crawford**

3rd Annual CICS-MD Science Meeting
November 12-13, 2014
College Park, MD

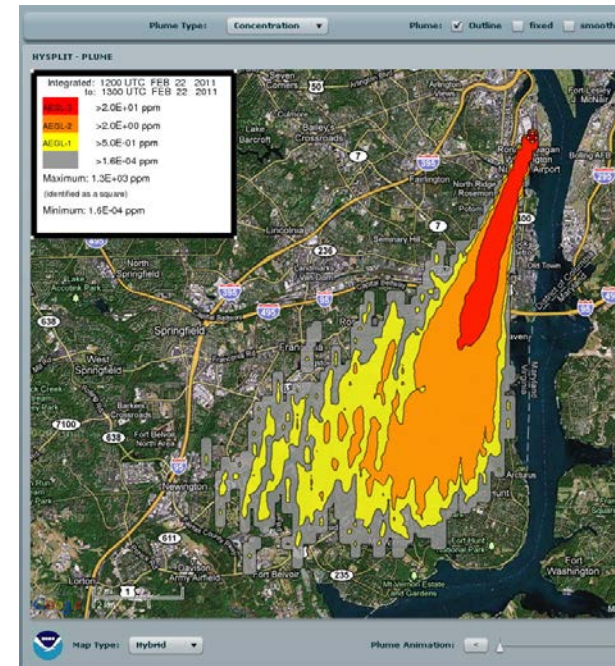
Atmospheric Dispersion and Boundary Layer

- Goals

- Improve dispersion predictions and understanding of those predictions through dispersion research, models, and tools
- Improve measurement and prediction of the boundary layer and the underlying land-surface

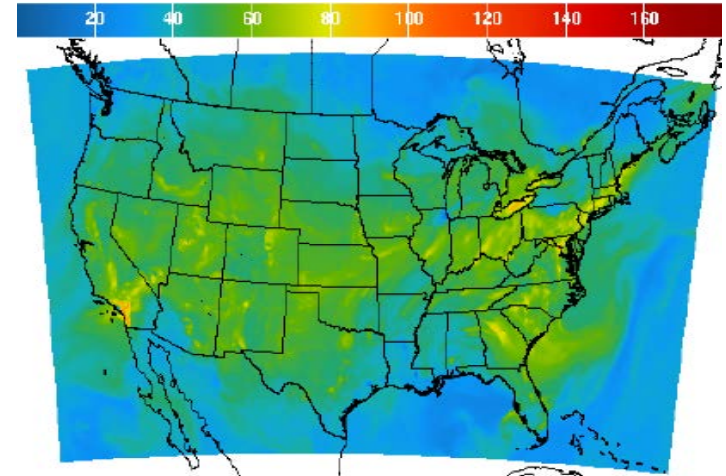
- Major Activities

- Boundary-layer characterization and prediction
- Dispersion modeling
- Decision support tools
- Model evaluation
- Renewable energy
- Support for DOE, NASA, DOD, DHS, WMO



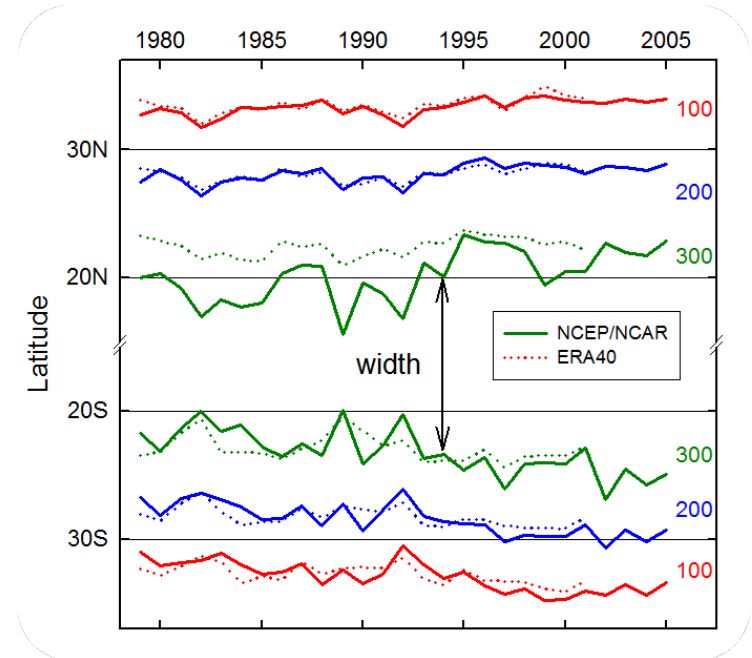
Air Quality

- Goals
 - Improve NOAA's operational air quality predictions
 - Improve understanding of ecosystem-relevant air pollution, including mercury and nutrients
- Major Activities
 - Air quality forecast system R&D
 - Monitoring and process studies
 - Assessment of mercury and nutrient fluxes to/from ecosystems

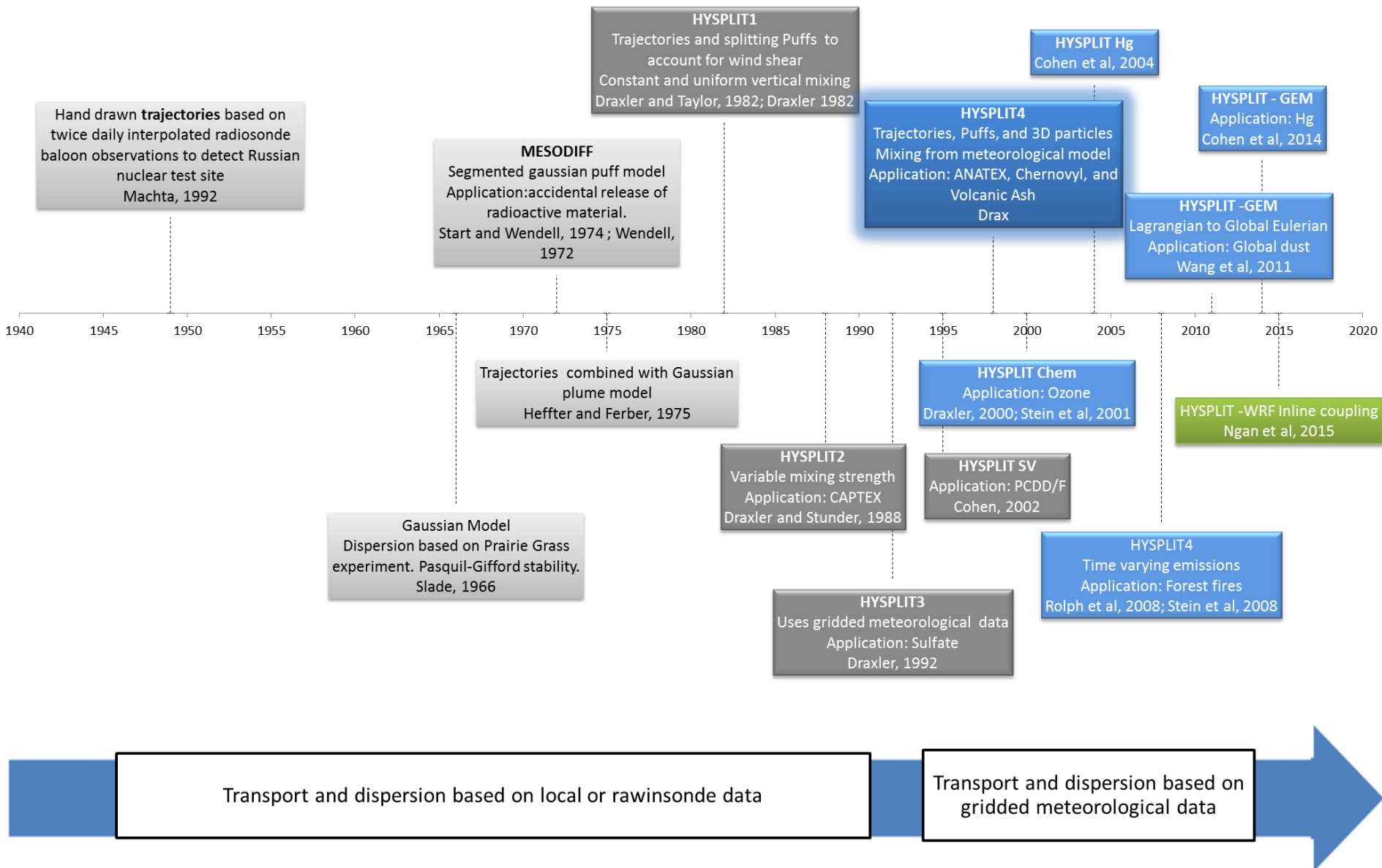


Climate

- Goals
 - Improve the understanding and prediction of climate variability and change
- Major Activities
 - Reference observations
 - Atmosphere-land surface interactions
 - Climate variability and change analysis
 - Assessment of regional climate impacts



History of the HYSPLIT model





HYSPLIT

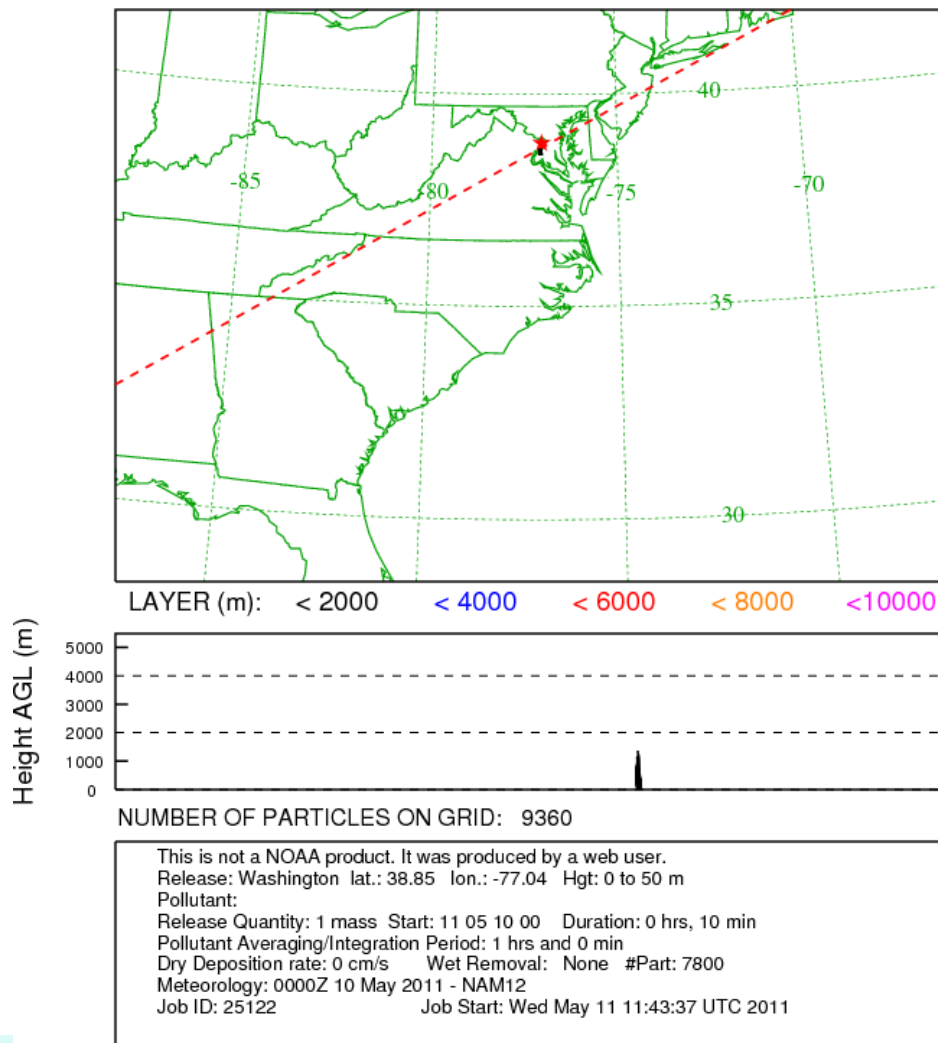
Research to Applications

- **Emergency Response**
 - Radiological releases
 - Improvised nuclear devices
 - Chemical releases
 - Volcanic eruptions
- **Model Evaluation**
 - Data Archive of Tracer Experiments and Meteorology
- **Decision Support**
 - Dispersion model training
 - Real-time Environmental Applications and Display sYstem
- **Air Quality**
 - Fire smoke
 - Global pollutant transport
 - Wind-blown dust



HYSPLIT Description and History

NOAA HYSPLIT MODEL
PARTICLE CROSS-SECTIONS
PARTICLE POSITIONS AT 01 UTC 10 May 11



- **Numerical Approach**
 - Follows particle motion
 - Off-line
 - Requires meteorological fields
 - Particle or puff solutions
 - UNIX, PC, Mac, Web
- **History**
 - 1970's used charts and dividers
 - 1980's used only soundings
 - 1990's switched to model fields
 - 2000's incorporate 3D turbulence
- **More than 3000 registered users worldwide**
- **Future Directions**
 - In-line and multi-cpu
 - Evaluate TKE partition
 - Shared memory optimization



Emergency Response

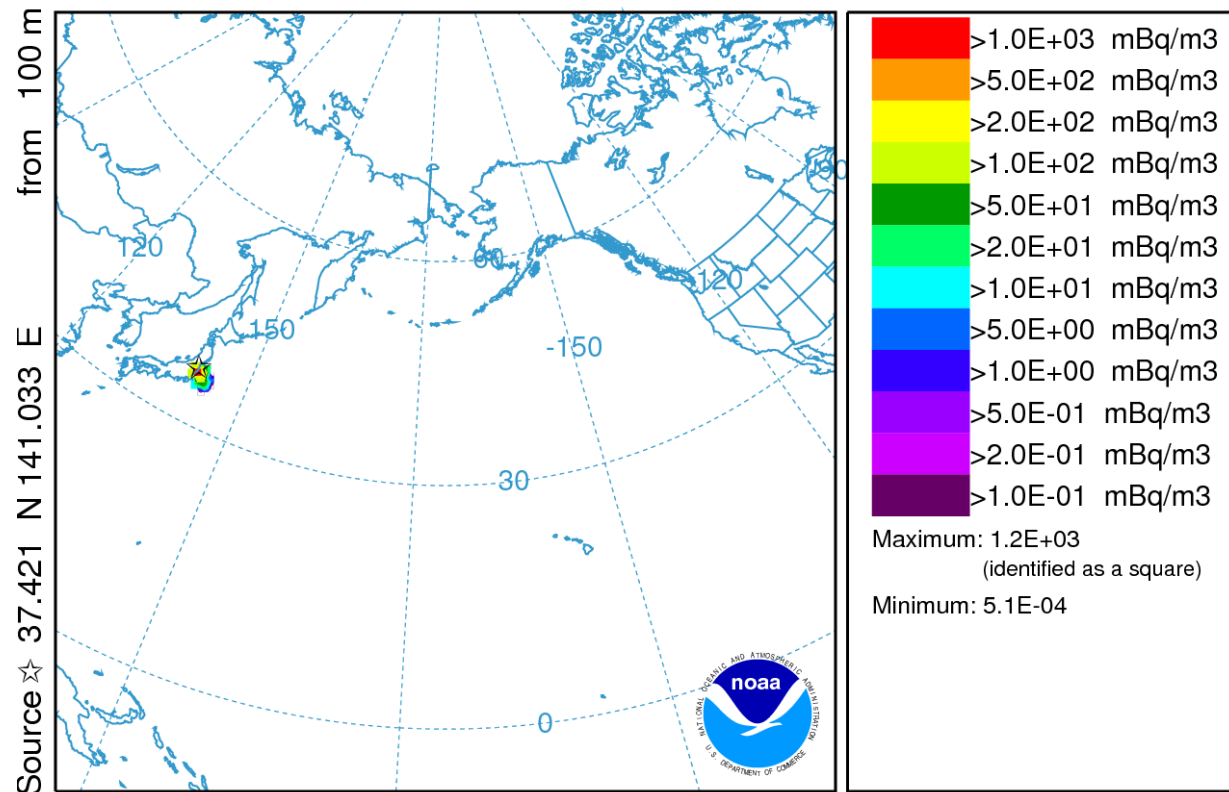
Radiological Releases

- **History**
 - Chernobyl accident (IAEA)
 - WMO Regional Specialized Meteorological Center (RSMC)
 - Support NMS in WMO Regions III and IV (Americas)
- **Accomplishments**
 - HYSPLIT installed in Australia (BoM), China (CMA) and Argentina (SMN)
 - Model based source-attribution applied at CTBTO
- **Approaches**
 - Web exchange of graphics and model fields
 - Communicating uncertainty through multiple dispersion products

Fukushima Simulations

NOAA HYSPLIT MODEL

Concentration (mBq/m³) averaged between 0 m and 500 m
 Integrated from 1800 11 Mar to 0000 12 Mar 11 (UTC)
 Cpar Release started at 1800 11 Mar 11 (UTC)



GHDA METEOROLOGICAL DATA

- Cs-137 air concentrations
- 5000 particles per hour
- 0.5 degree NOAA GDAS meteorological data

Emergency Response Improvised Nuclear Devices

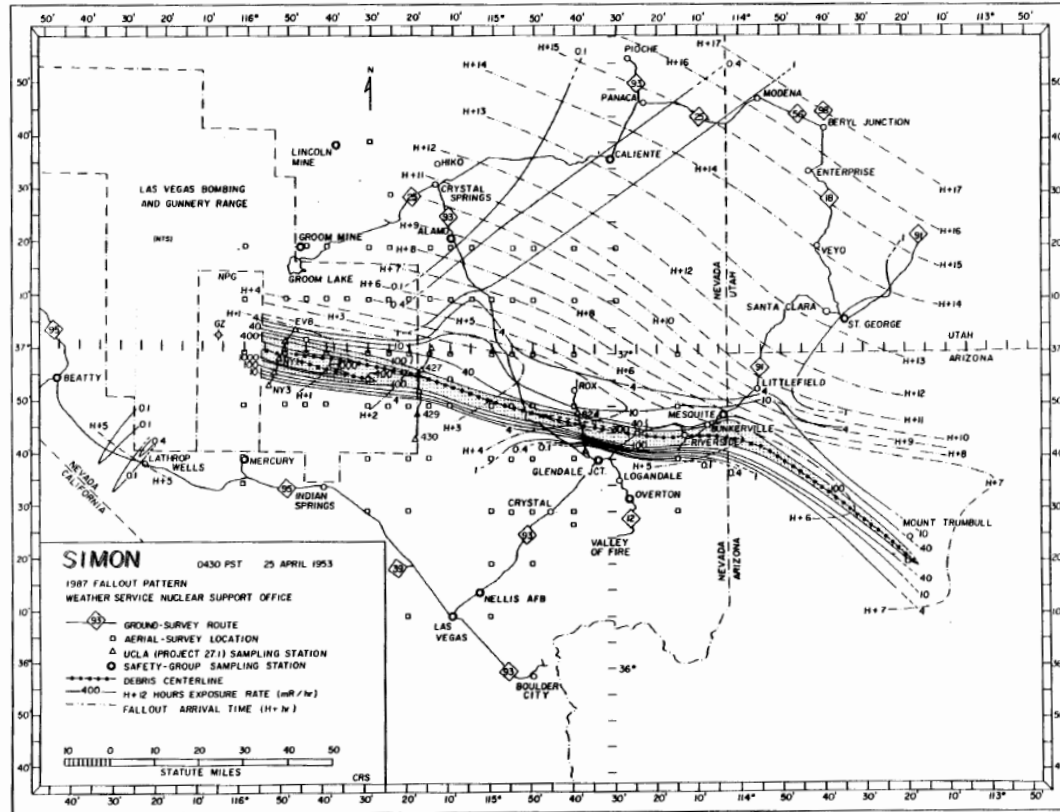


Figure 5.8. The WNSO 1987 SIMON Fallout Pattern.

History

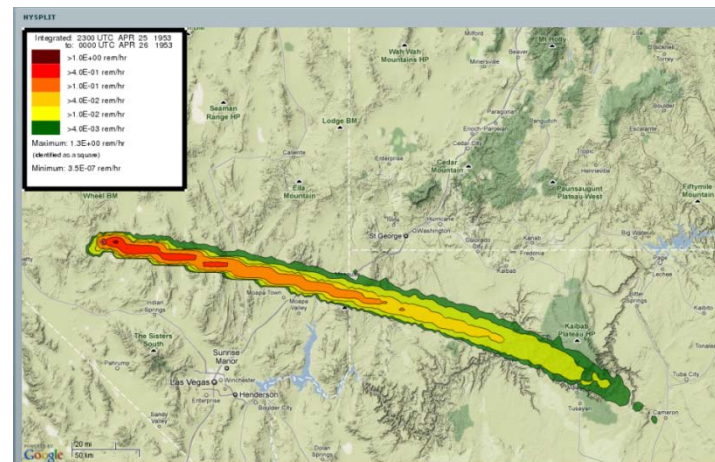
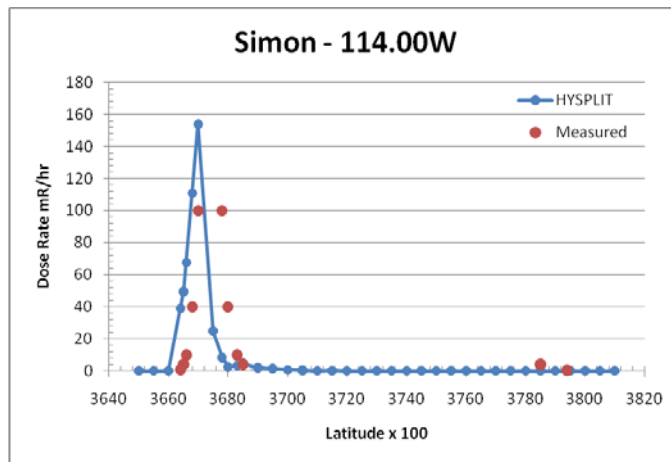
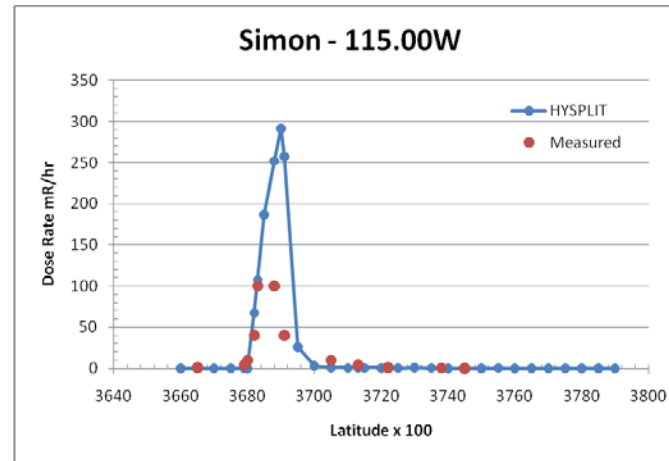
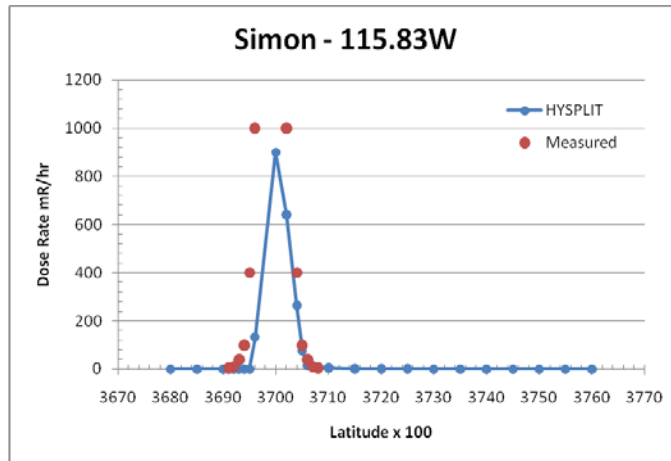
- ARL participated in early atmospheric testing

Approaches

- Dose based upon fission yields
- 212 species considered
- Partitioned between gas and 60 particle size bins
- Activity distribution with height based upon yield
- Time-decayed dose post-processing

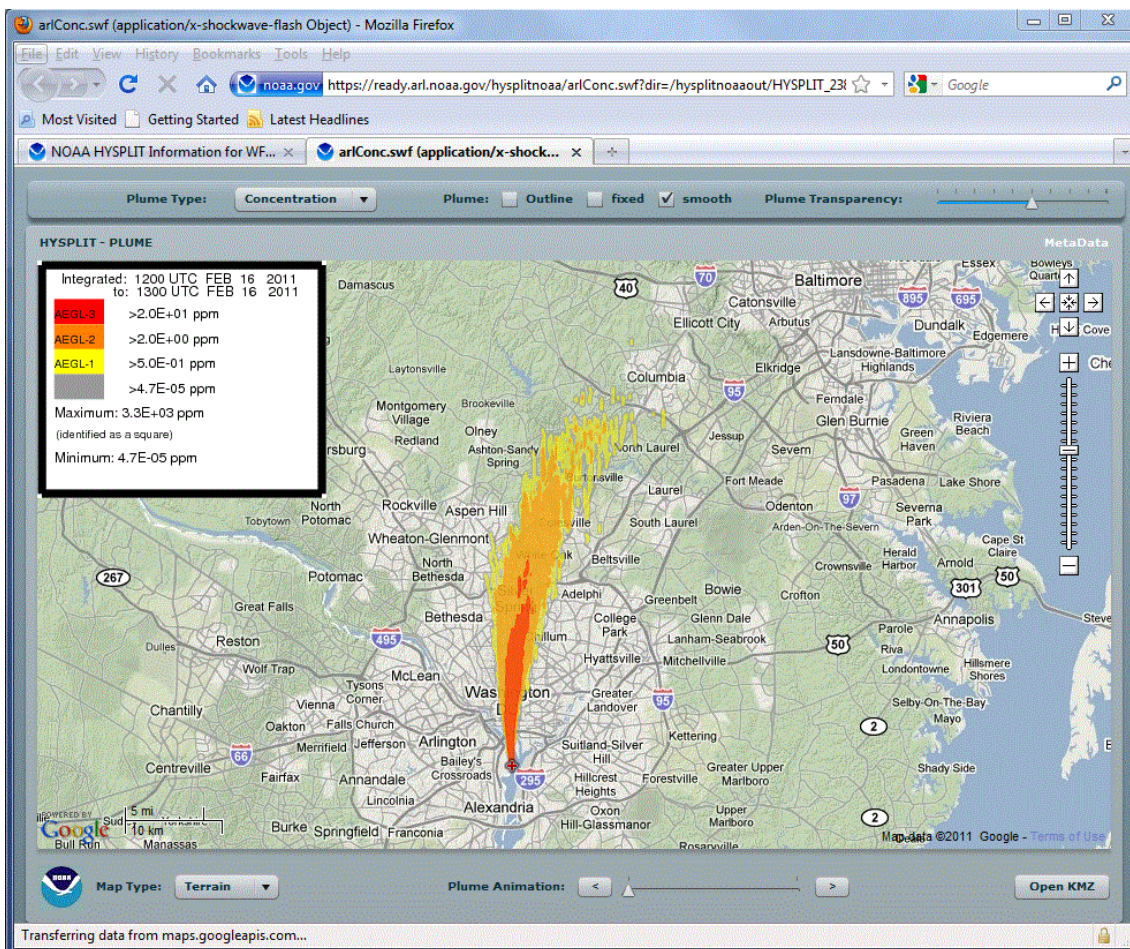
Emergency Response

Improvised Nuclear Devices



Emergency Response

Chemical Releases



History

- Post 9/11 HLS application for WFOs run at NCEP
- Initial web interface for NWS WFO

Approaches

- Link to Computer-Aided Management of Emergency Operations (CAMEO) chemicals data
- Collaboration with OR&R to include Areal Locations of Hazardous Atmospheres (ALOHA) source model

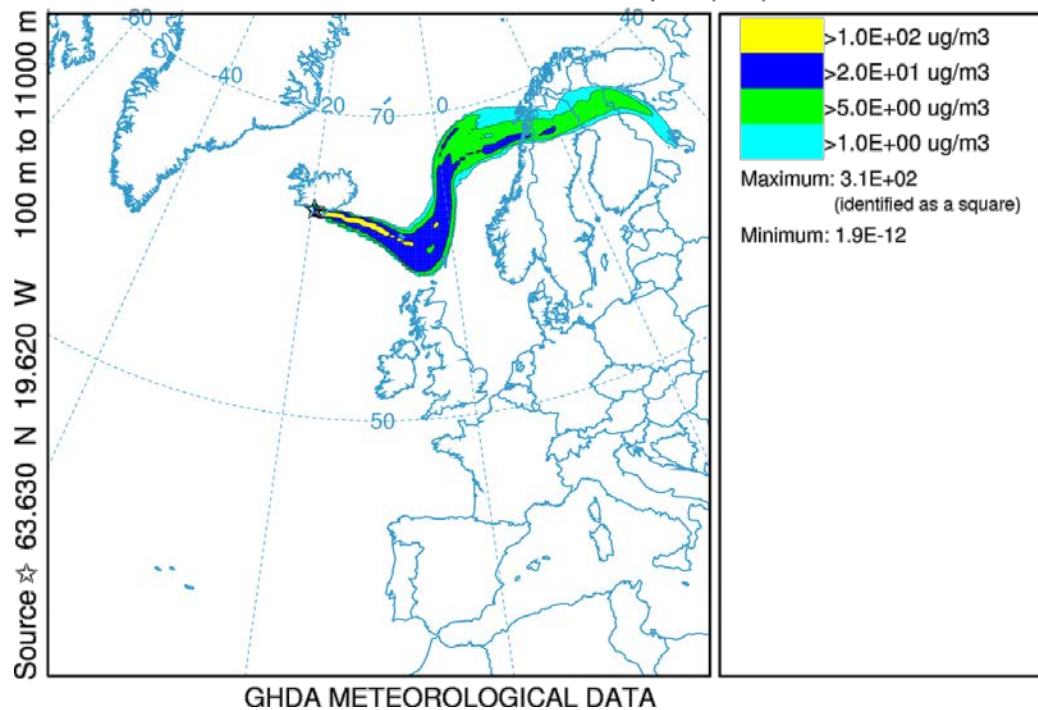
Accomplishments

- Incorporating chemical plume modeling capability at WFO

Emergency Response

Volcanic Eruptions

NOAA HYSPLIT MODEL
Concentration (ug/m³) averaged between 0 m and 10000 m
Integrated from 0000 15 Apr to 0100 15 Apr 10 (UTC)
SUM Release started at 0000 15 Apr 10 (UTC)



History

- Mt. St. Helens – forecast trajectories to the USGS
- Mt. Redoubt – KLM encounter

Approaches

- Source term uncertainty (mass, particle size, height)
- New requirement for quantitative air concentration

Accomplishments

- Primary customer is the Washington Volcanic Ash Advisory Center (NCEP and NESDIS)
- HYSPLIT installed in Australia, Argentina, and AFWA



POSTER: Producing Quantitative Forecasts of Volcanic Ash using the HYSPLIT Transport and Dispersion Model.

NOAA HYSPLIT forecast with source term constructed from satellite retrievals.

Kasatochi, Aleutian Islands, August 2008

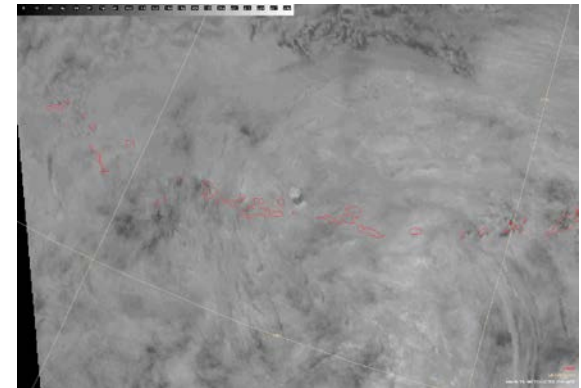
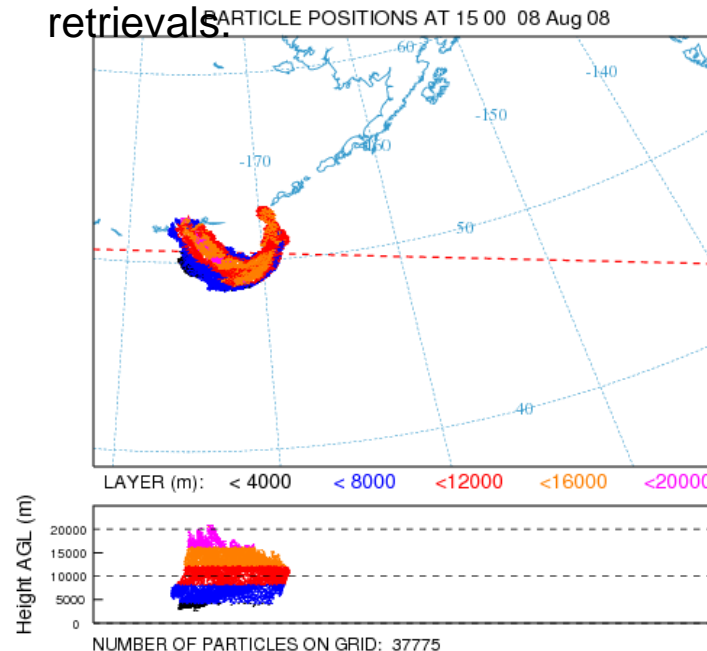


PHOTO: GOES visible satellite images 2230 to 2340 UTC on 08/07/2008.
Dave Schneider. Alaska Volcano Observatory / USGS.

***Alice M. Crawford (a,b), Barbara J.B. Stunder (b),
Steven. R. Albersheim , Michael. J. Pavolonis (d)***

(a) Cooperative Institute for Climate and Satellites, University of Maryland, College Park, MD, 20740

(b) NOAA Air Resources Laboratory, College Park, MD 20740

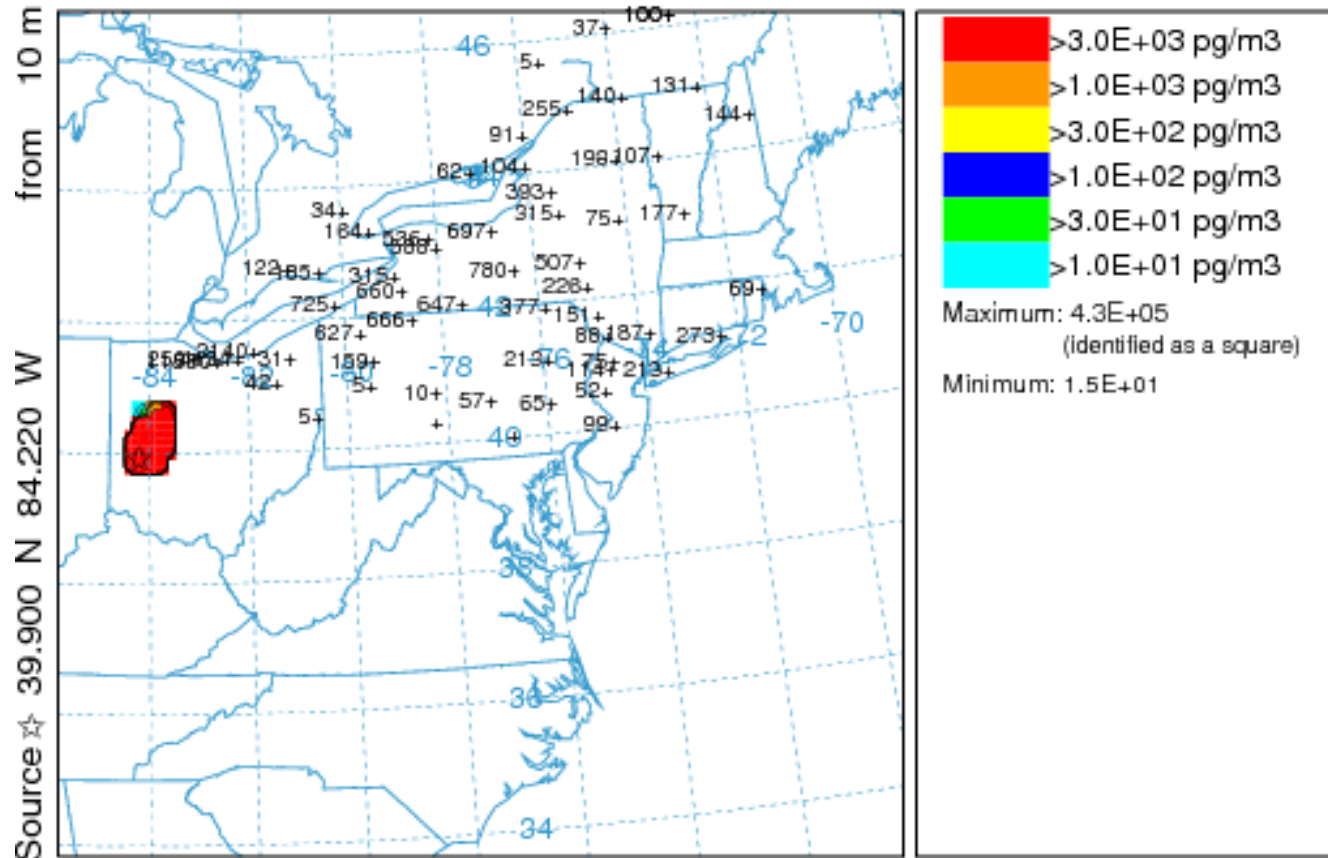
(c) Federal Aviation Administration, Aviation Weather Division, Washington, DC 20591

(d) NOAA Center for Satellite Applications and Research, Madison, WI, 53706

Model Evaluation

NOAA HYSPLIT MODEL

Concentration (pg/m³) averaged between 0 m and 100 m
 Integrated from 1800 25 Sep to 2100 25 Sep 83 (UTC)
 PMCH Release started at 1700 25 Sep 83 (UTC)



NARR METEOROLOGICAL DATA



Model Evaluation

Data Archive of Tracer Experiments and Meteorology

Information Summary

DATEM - Data Archive of Tracer Experiments and Meteorology

[Information on the DATEM project](#)

Click on the experiment name for experiment details.

▶ [Cross APpalachian Tracer EXperiment \(CAPTEX\)](#)

Release: Dayton, OH: Sep. 18, 25, Oct. 02, 14 1983 & Sudury, ONT: Oct. 26, 29 1983

▶ [Atlantic Coast Unique Regional Atmospheric Tracer Experiment \(ACURATE\)](#)

Release: Savannah River Plant, SC: Spr. 1982, Sum. 1982, Fal. 1982, Win. 1982/3, Spr. 1983,

▶ [Across North America Tracer EXperiment \(ANATEX\)](#)

Release: Glasgow, MT and St. Cloud, MN: Jan. through Mar. 1987

▶ [OKlahoma Tracer EXperiment \(OKTEX\)](#)

Release: Norman, OK: Jul. 08 1980

▶ [MEtropolitan Tracer EXperiment \(METREX\)](#)

Release: metropolitan Washington, DC: Jan. through Dec. 1984

▶ [European Tracer EXperiment \(ETEX\)](#)

Release: Rennes, France: Oct. 23 1994

● Approach

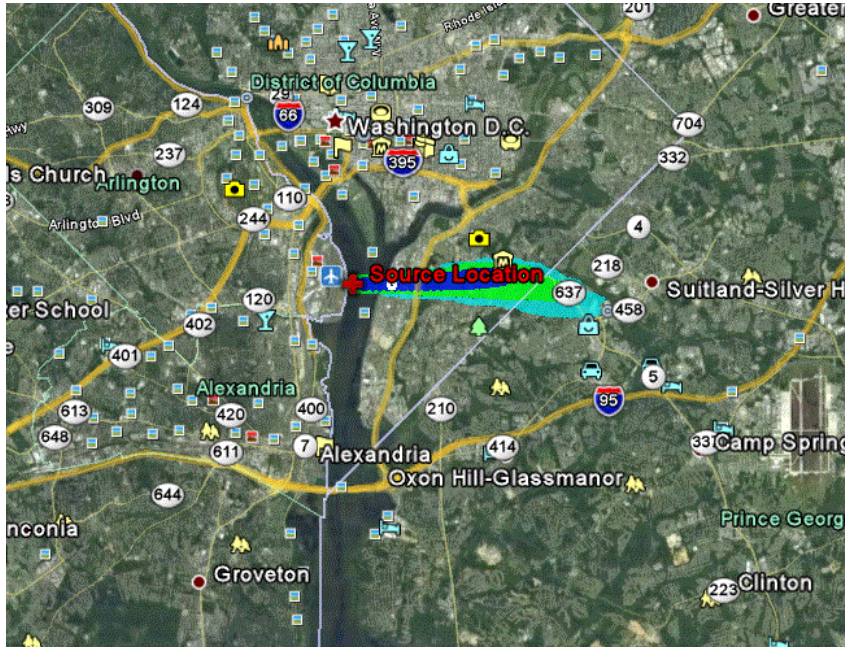
- Creation of the North American Regional Reanalysis (NARR)
- Common statistical evaluation protocols

● Accomplishments

- Web access to run HYSPLIT for each experiment
- Standardized model change testing in conjunction with version control

Decision Support

Real-time Environmental Applications and Display sYstem

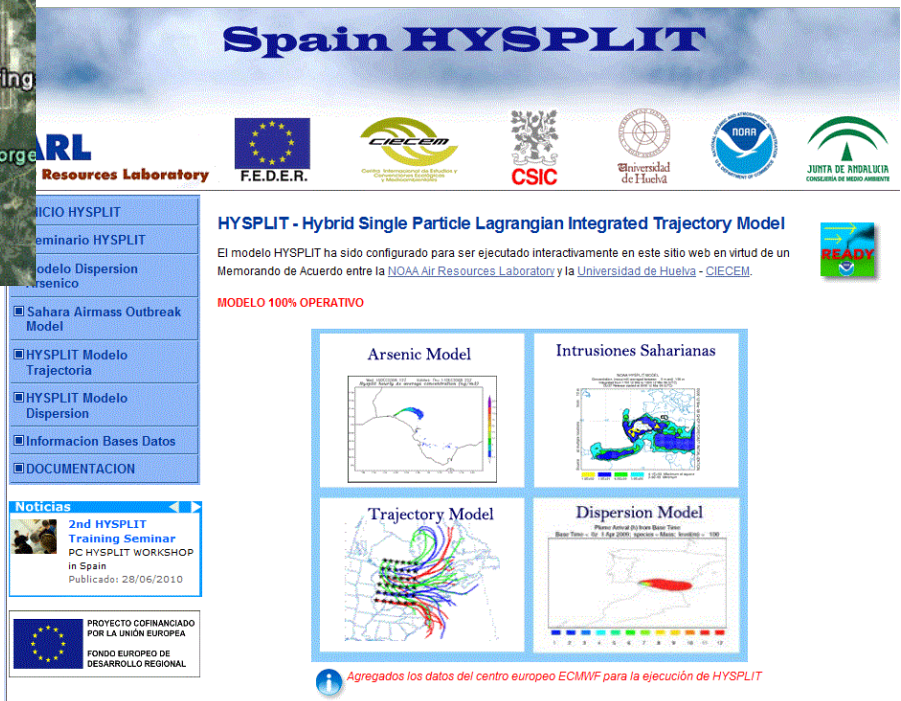


Accomplishments

- 45,000 unregistered user runs on average per month
- Mirror and backup capabilities (only one in Spain)

Future Directions

- Couple with GSD's High Resolution Rapid Refresh at ESRL



Spain HYSPLIT

Resources Laboratory

Logos: F.E.D.E.R., CIECEM, CSIC, Universidad de Huelva, NOAA, JUNTA DE ANDALUCÍA

HYSPLIT - Hybrid Single Particle Lagrangian Integrated Trajectory Model

El modelo HYSPLIT ha sido configurado para ser ejecutado interactivamente en este sitio web en virtud de un Memorando de Acuerdo entre la NOAA Air Resources Laboratory y la Universidad de Huelva - CIECEM.

MODELO 100% OPERATIVO

Navigation Menu:

- Inicio HYSPLIT
- Seminario HYSPLIT
- Modelo Dispersion Arsenico
- Sahara Airmass Outbreak Model
- HYSPLIT Modelo Traectoria
- HYSPLIT Modelo Dispersion
- Informacion Bases Datos
- DOCUMENTACION

Noticias

2nd HYSPLIT Training Seminar
PC HYSPLIT WORKSHOP in Spain
Publicado: 28/06/2010

PROYECTO COFINANCIADO POR LA UNIÓN EUROPEA
FONDO EUROPEO DE DESARROLLO REGIONAL

Model Results:

- Arsenic Model
- Intrusiones Saharianas
- Trajectory Model
- Dispersion Model

Agregados los datos del centro europeo ECMWF para la ejecución de HYSPLIT



Air Quality

Fire Smoke

HYSPLIT Smoke Analysis using Scalable Vector Graphic

[SVG Help](#)



HYSPLIT SMOKE - ANALYSIS

Click the boxes to turn on/off parameter

☒ Fires

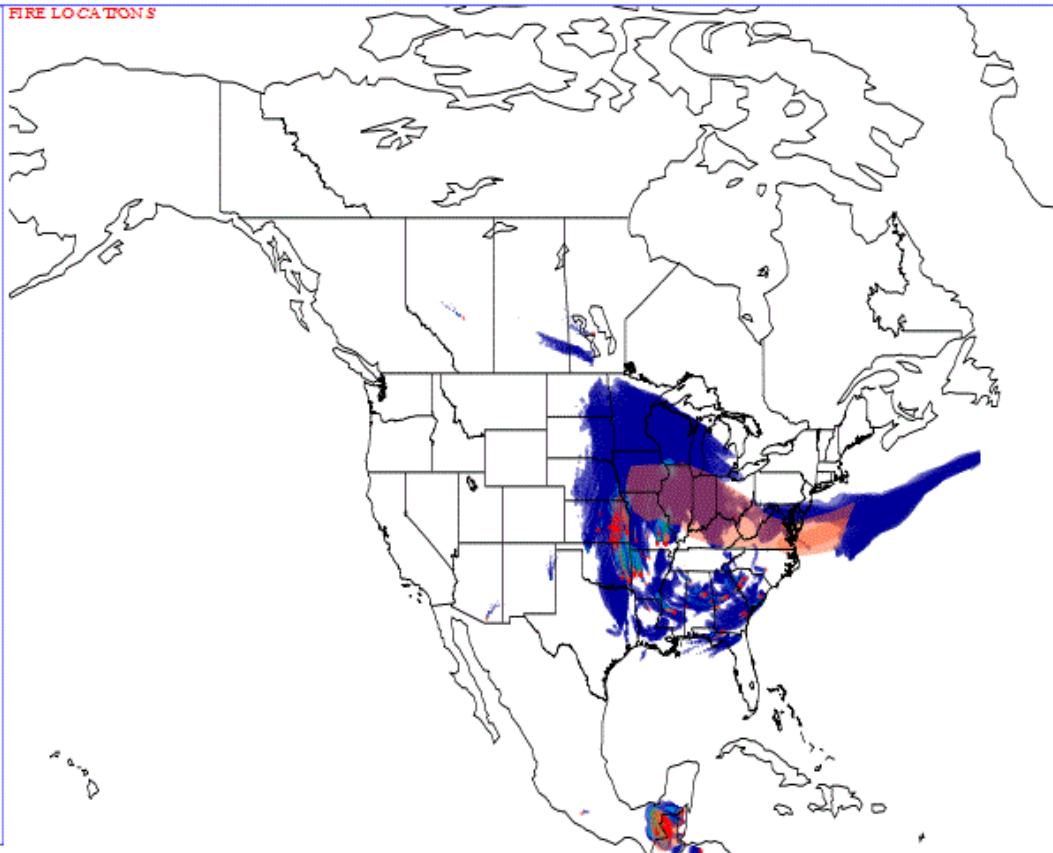
☒ Map

HMS Analyzed Smoke

All On ☒
All Off ☐

1215-1815Z	<input checked="" type="radio"/>	2015-2145Z	<input checked="" type="radio"/>
1215-2315Z	<input checked="" type="radio"/>	2015-2215Z	<input checked="" type="radio"/>
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1245-1445Z	<input checked="" type="radio"/>	2045-2245Z	<input checked="" type="radio"/>
1300-1500Z	<input checked="" type="radio"/>	2115-2315Z	<input checked="" type="radio"/>
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1415-1545Z	<input checked="" type="radio"/>	2245-0045Z	<input checked="" type="radio"/>
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1430-1630Z	<input checked="" type="radio"/>		
1500-1600Z	<input checked="" type="radio"/>		
1515-1715Z	<input checked="" type="radio"/>		
1515-2015Z	<input checked="" type="radio"/>		
1545-1745Z	<input checked="" type="radio"/>		
1545-2115Z	<input checked="" type="radio"/>		
1600-1700Z	<input checked="" type="radio"/>		
1615-1715Z	<input checked="" type="radio"/>		
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1645-2045Z	<input checked="" type="radio"/>		
1745-1945Z	<input checked="" type="radio"/>		
1815-1915Z	<input checked="" type="radio"/>		
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1845-1945Z	<input checked="" type="radio"/>		
1915-2015Z	<input checked="" type="radio"/>		
1945-2045Z	<input checked="" type="radio"/>		
1945-2115Z	<input checked="" type="radio"/>		
2015-2115Z	<input checked="" type="radio"/>		

FIRE LOCATIONS



HYSPLIT Smoke

(1 hr avg.)

All On ☒
All Off ☐

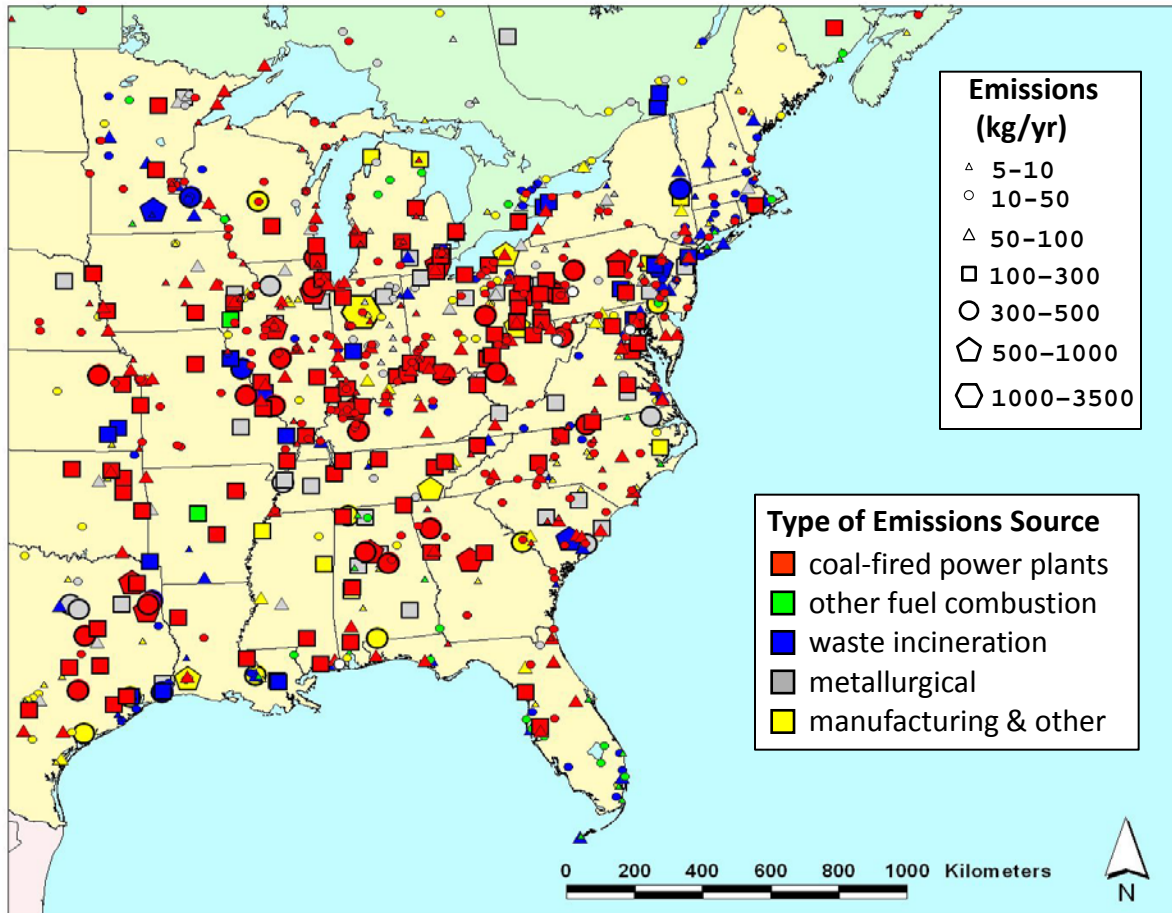
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10Z	<input checked="" type="radio"/>	22Z	<input checked="" type="radio"/>
11Z	<input checked="" type="radio"/>	23Z	<input checked="" type="radio"/>
12Z	<input checked="" type="radio"/>	00Z	<input checked="" type="radio"/>
13Z	<input checked="" type="radio"/>	01Z	<input checked="" type="radio"/>
14Z	<input checked="" type="radio"/>	02Z	<input checked="" type="radio"/>
15Z	<input checked="" type="radio"/>	03Z	<input checked="" type="radio"/>
16Z	<input checked="" type="radio"/>	04Z	<input checked="" type="radio"/>
17Z	<input checked="" type="radio"/>	05Z	<input checked="" type="radio"/>
18Z	<input checked="" type="radio"/>	06Z	<input checked="" type="radio"/>

Contour Levels

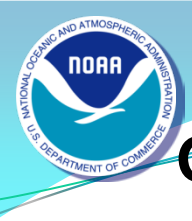
<input checked="" type="radio"/>	1 ug/m3
<input checked="" type="radio"/>	5 ug/m3
<input checked="" type="radio"/>	20 ug/m3
<input checked="" type="radio"/>	100 ug/m3

Air Quality

Source-Receptor Analysis for Dioxin and Mercury



- **Approaches**
 - Lagrangian focus to optimize source-receptor capability
 - Specialized receptor accounting algorithms
 - Emission based analyses
- **Accomplishments**
 - Extension to global domain to compute background values



Meteorological Modeling Using WRF-ARW Model for Grand Bay Intensive Studies of Atmospheric Mercury

Fong (Fantine) Ngan^{1,2}, Mark Cohen¹, Winston Luke¹, Xinrong Ren^{1,2} and Roland Draxler¹

¹ NOAA/ARL, College Park, MD, ² UMD/CICS, College Park, MD

Two sets of sensitivity tests were conducted using WRF-ARW model for the Grand Bay intensive periods, to examine influences on model performance and regional flow predictions:

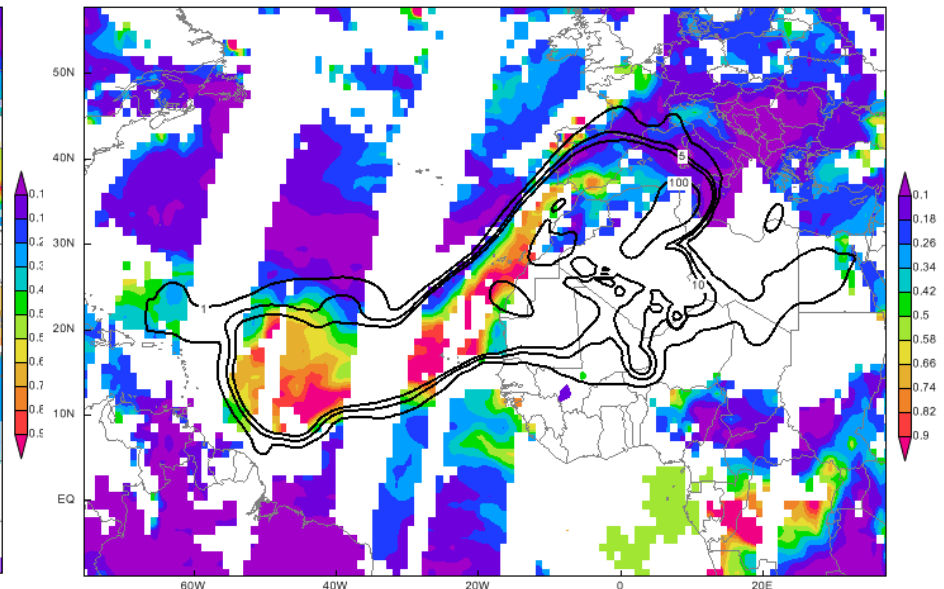
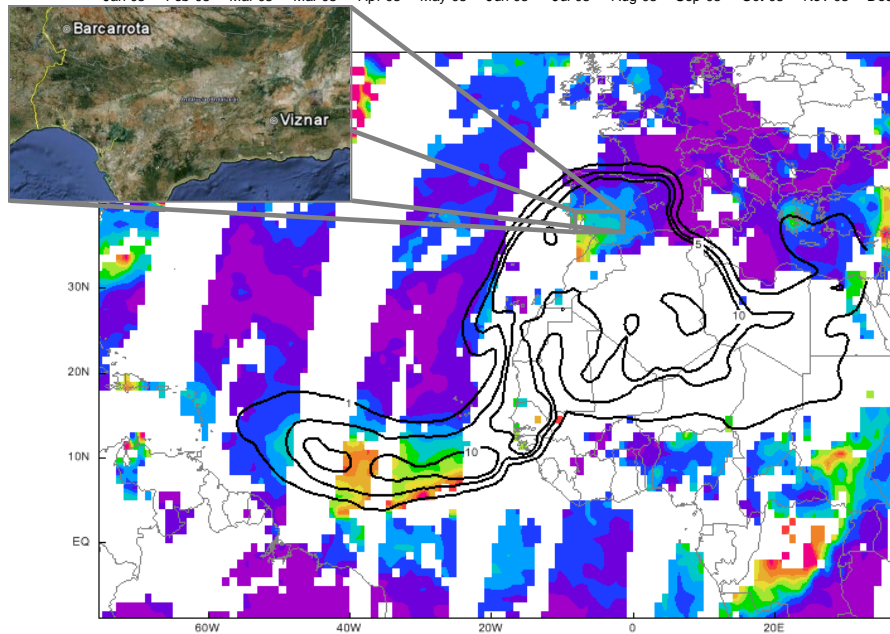
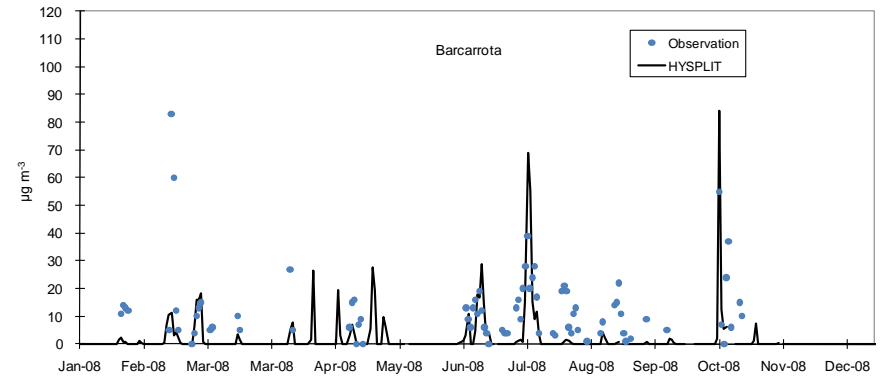
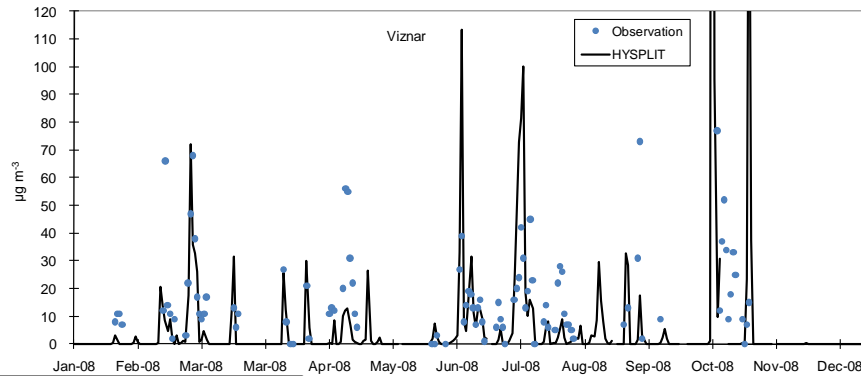
1) Use of different reanalysis data for WRF

The inner most domain inherited differing features of reanalysis data that resulted in generating different regional flow patterns. Larger differences were observed in the WRF results in the summer campaign than the spring period.

2) Use of different nudging configurations

The grid nudging, together with observational nudging, had a positive effect in wind prediction. But nudging of temperature and moisture led to overestimates of precipitation that would have potentially large impacts on mercury modeling through effects on wet deposition.

Dust from North Africa



Part of a Memorandum of Agreement with the University of Huelva, Spain