



INL HYSPLIT

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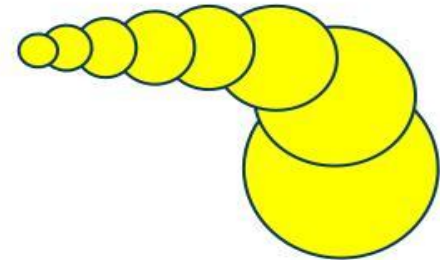


Outline

- MDIFF Modeling System
- Rationale for NOAA HYSPLIT model adoption
- Requirements for new INL HYSPLIT System
- Drivers for NOAA's HYSPLIT effort
- Current modeling applications of HYSPLIT
- HYSPLIT model evaluation
- HYSPLIT training, popularity, relevancy
- Adaptation of HYSPLIT for use at the INL

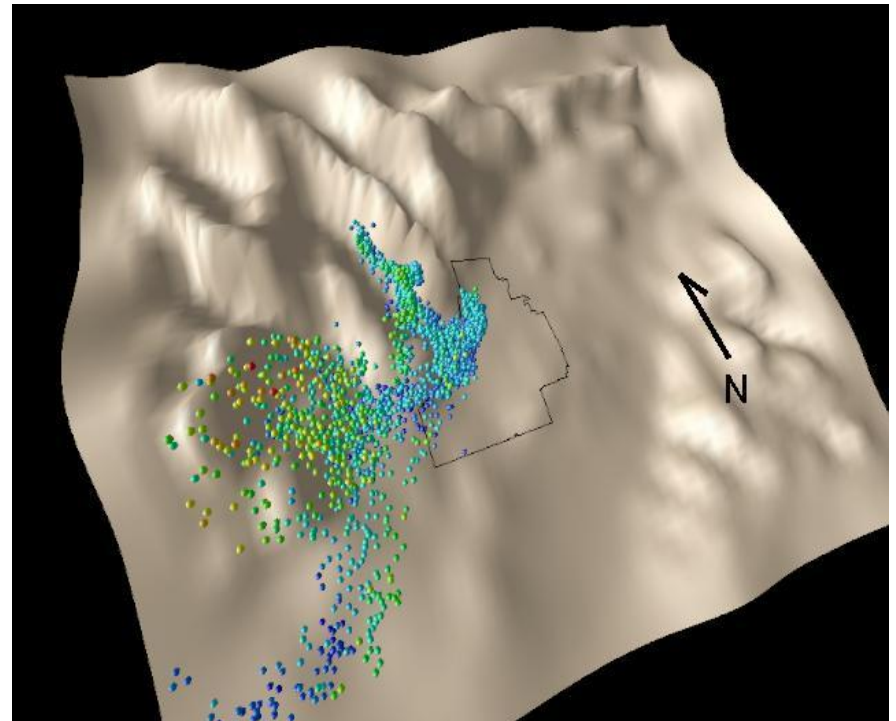
Older MDIFF Model

- Largely unchanged since 1990's
 - DOS/Windows 3.1 based
- Puff model
- 2-d wind field
- Totally “in-house” modeling system
 - No effective outside support
 - Resources insufficient to continue in isolation
- Lacks important features (deposition, dose computations, forecast capability)

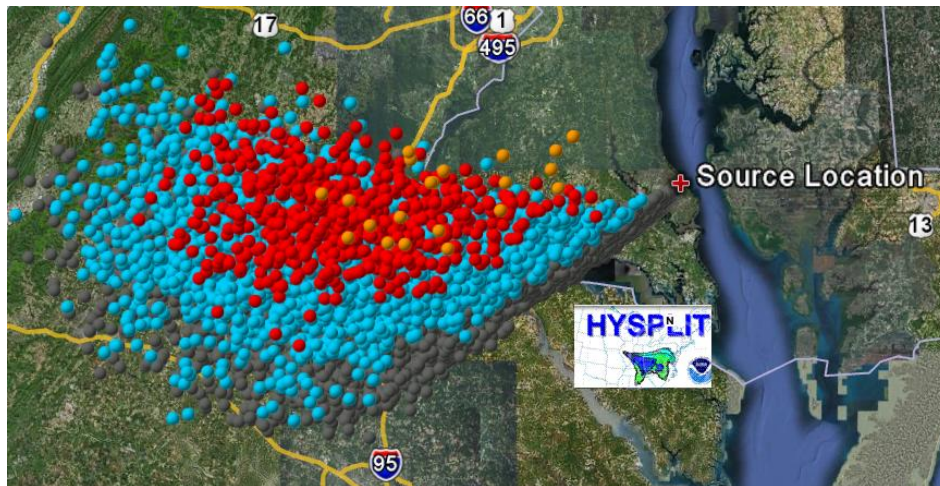


NOAA HYSPLIT Model

- HYSPLIT = HYbrid, Single-Particle Lagrangian Integrated Trajectory
- Developed in the 1980's
 - Continuously being updated
- Widely used within and outside NOAA
 - Emergency response
 - Radiological plumes
 - Chemical plumes
 - Volcanic ash
 - Air quality
 - Wildfire smoke
 - Dust
 - Dioxin
 - Mercury
- Uses NOAA forecast models
 - 3-d wind field
- Includes deposition, decay, doses, multiple radionuclides
- Leverages limited local resources



HYSPLIT Description & Future Directions



- Additional Features
 - Follows particle motion
 - Off-line (easy to re-run)
 - Requires meteorological fields
 - Particle or puff solutions
 - UNIX, PC, Mac, Web
- Future Directions
 - In-line and multi-cpu
 - Shared memory optimization



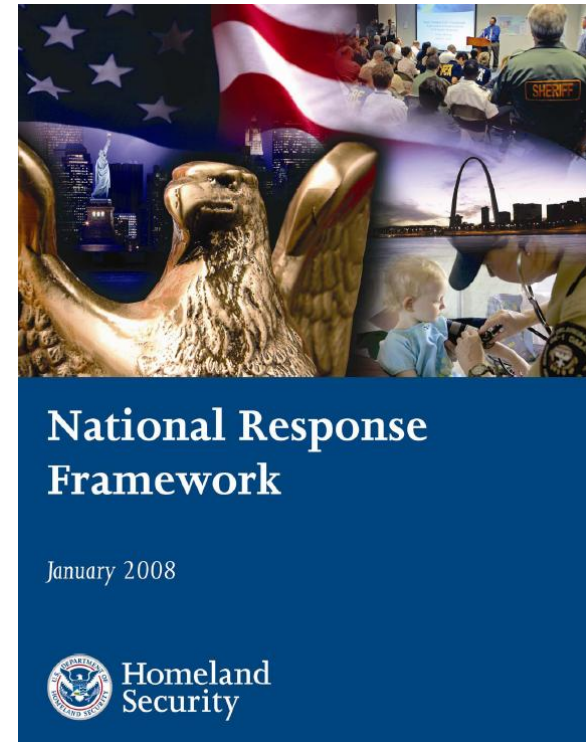
Requirements for New INL System

- Retain popular features from MDIFF system
 - Client/server configuration
 - Pre-configured INL release scenarios
 - User authentication (computer security)
 - Fast execution
- Browser-based client software
- High-quality background map with terrain, cities, etc.
- Easy manipulation of output plots
- Either analyses (“nowcasts”) or forecasts
- Multiple radionuclides with dose computations
- Meaningful contours for emergency managers
- Use existing NOAA modeling capability as much as possible



NOAA HYSPLIT Model National Drivers

- The National Response Framework (NRF)
 - Approved by the President
 - Emergency Support Functions in 6 areas:
 - Firefighting (smoke plume forecasting)
 - Public Health and Medical Services
 - Search and Rescue
 - Oil and Hazardous Materials Response (includes participation in the Interagency Modeling and Atmospheric Assessment Center–IMAAC)
 - Energy
 - Public Safety and Security





Emergency Response

Radiological Releases

- **History**

- Chernobyl accident (IAEA)
- WMO Regional Specialized Meteorological Center (RSMC)
- Support NMS in WMO Regions III and IV (Central & South America)

- **Accomplishments**

- HYSPLIT installed in Australia (BoM) and China (CMA)
- Model based source-attribution applied at CTBTO








- **Approaches**

- Web exchange of graphics and model fields
- Communicating uncertainty through multiple dispersion products



Emergency Response

Radiological Releases

RSMC TIME OF MODEL RUN (YYYYMMDDCC_HHMM)	MODEL PARAMETERS	JOINT STATEMENT	VIEW PRODUCTS	TRAJECTORIES	TIME PERIOD 1 +24 HRS	TIME PERIOD 2 +48 HRS	TIME PERIOD 3 +72 HRS
 Washington 2011011306_1334 All Products	Cover (Postscript)	Region III/IV	<input type="button" value="Check All"/> <input type="button" value="Uncheck All"/>	<input type="checkbox"/> Trajectories (traj.txt)	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition
 Montréal 2011011300_1424 All Products	Cover (Postscript)	Region III/IV	<input type="button" value="Check All"/> <input type="button" value="Uncheck All"/>	<input type="checkbox"/> Trajectories (traj.txt)	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition
 Melbourne 2011011300_2351 All Products	Cover (Postscript)	Region V	<input type="button" value="Check All"/> <input type="button" value="Uncheck All"/>	<input type="checkbox"/> Trajectories (traj.txt)	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition
 Exeter All Products	Cover (Postscript)	Region I/VI	<input type="button" value="Check All"/> <input type="button" value="Uncheck All"/>	<input type="checkbox"/> Trajectories (traj.txt)	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition
 Toulouse 2010112610_5602 All Products	Cover (Postscript)	Region I/VI	<input type="button" value="Check All"/> <input type="button" value="Uncheck All"/>	<input type="checkbox"/> Trajectories (traj.txt)	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition
 Beijing 2010111800_1150 All Products	Cover (Postscript)	Region II	<input type="button" value="Check All"/> <input type="button" value="Uncheck All"/>	<input type="checkbox"/> Trajectories (traj.txt)	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition
 Tokyo no incident All Products	Cover (Postscript)	Region II	<input type="button" value="Check All"/> <input type="button" value="Uncheck All"/>	<input type="checkbox"/> Trajectories (traj.txt)	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition	<input type="checkbox"/> Exposure <input type="checkbox"/> Deposition

Emergency Response

Improvised Nuclear Devices

- **History**
 - ARL participated in early atmospheric testing
- **Approaches**
 - 212 species considered
 - Partitioned between gas and 60 particle size bins
 - Time-decayed dose post-processing
- **Accomplishments**
 - Product for NWS Weather Forecast Offices
 - Linked to research and operational NOAA forecast models



Emergency Response Improvised Nuclear Devices

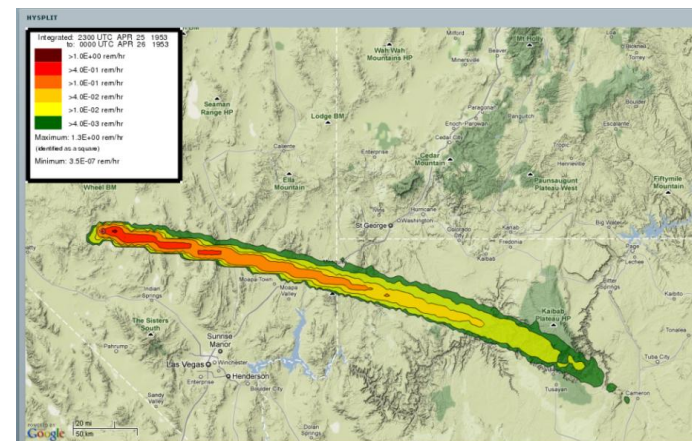
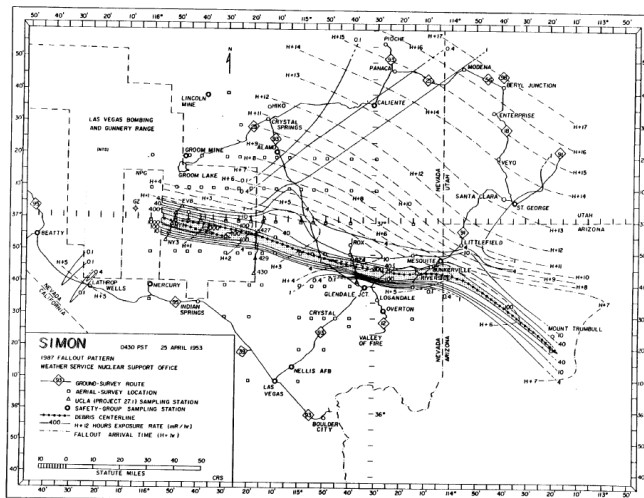
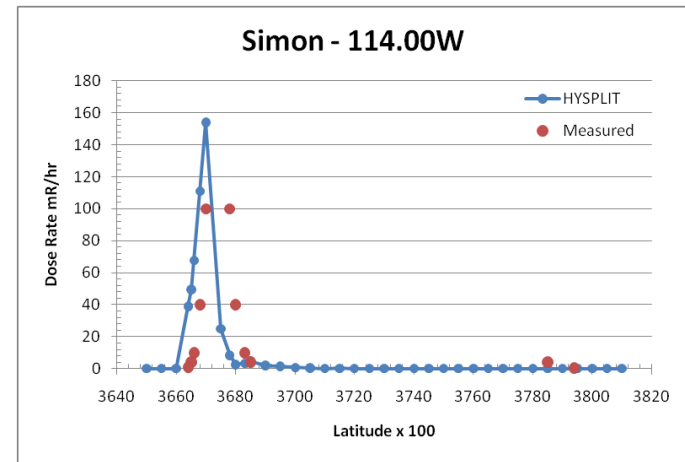
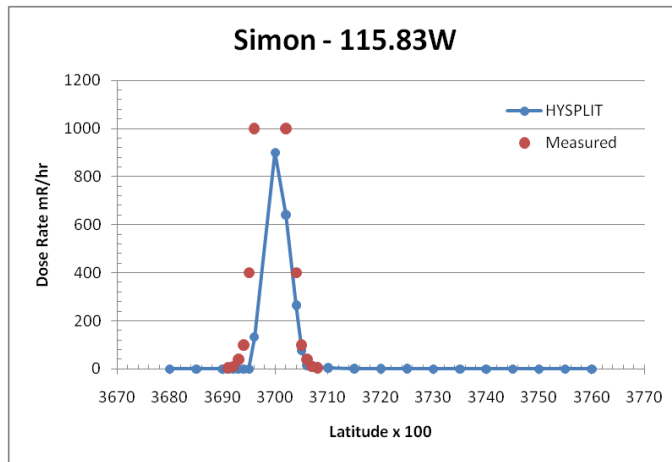
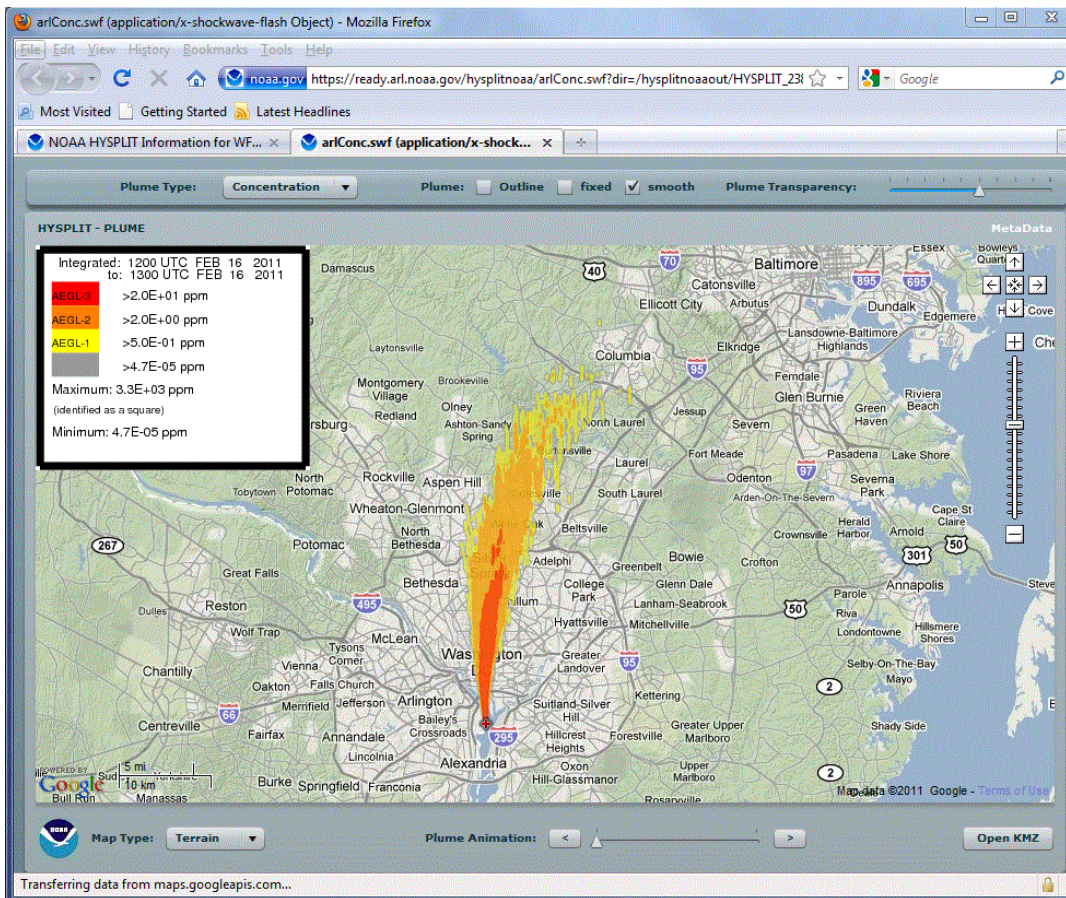


Figure 5.8. The WSN50 1987 SIMON Fallout Pattern.

Emergency Response

Chemical Releases

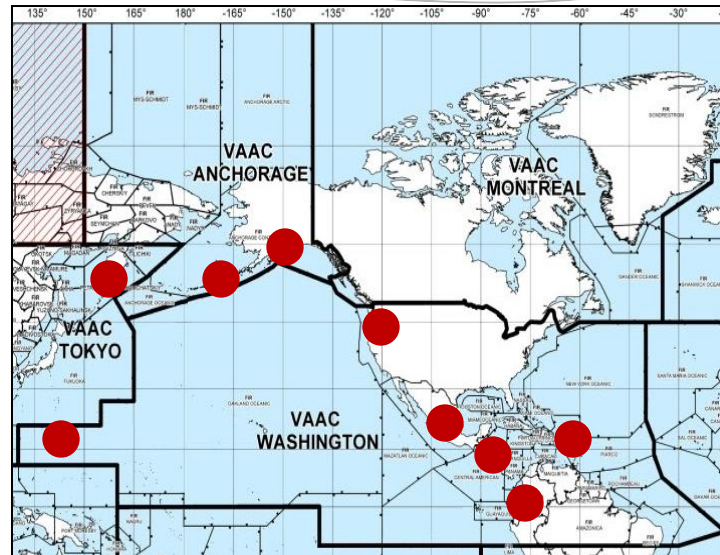
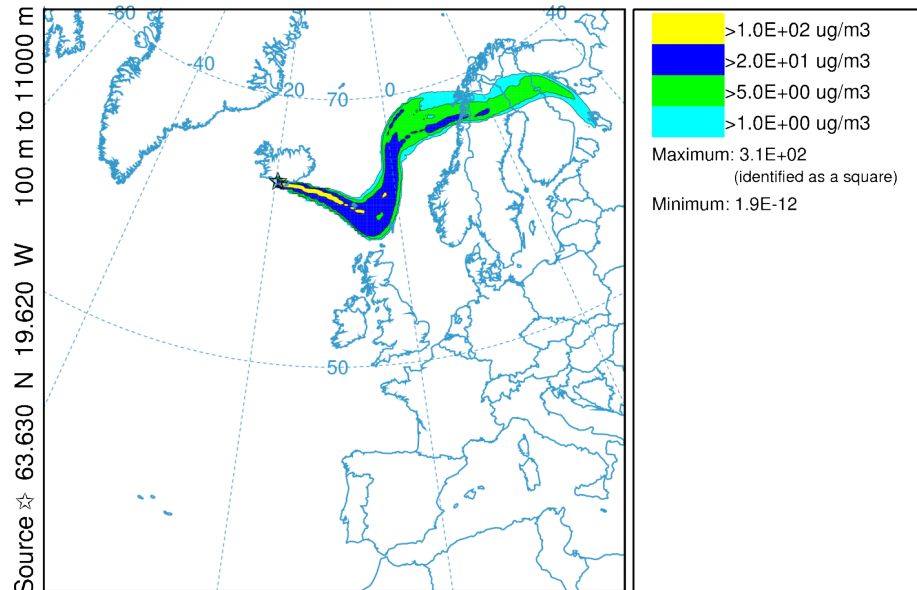


- History
 - Simple web interface for NWS WFO plume dispersion capability
- Approaches
 - Collaboration with OR&R to include ALOHA source model
 - Link to CAMEO chemicals data
- Accomplishments
 - Incorporating chemical plume modeling capability at WFO

Volcanic Ash Forecasts For Aviation

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)

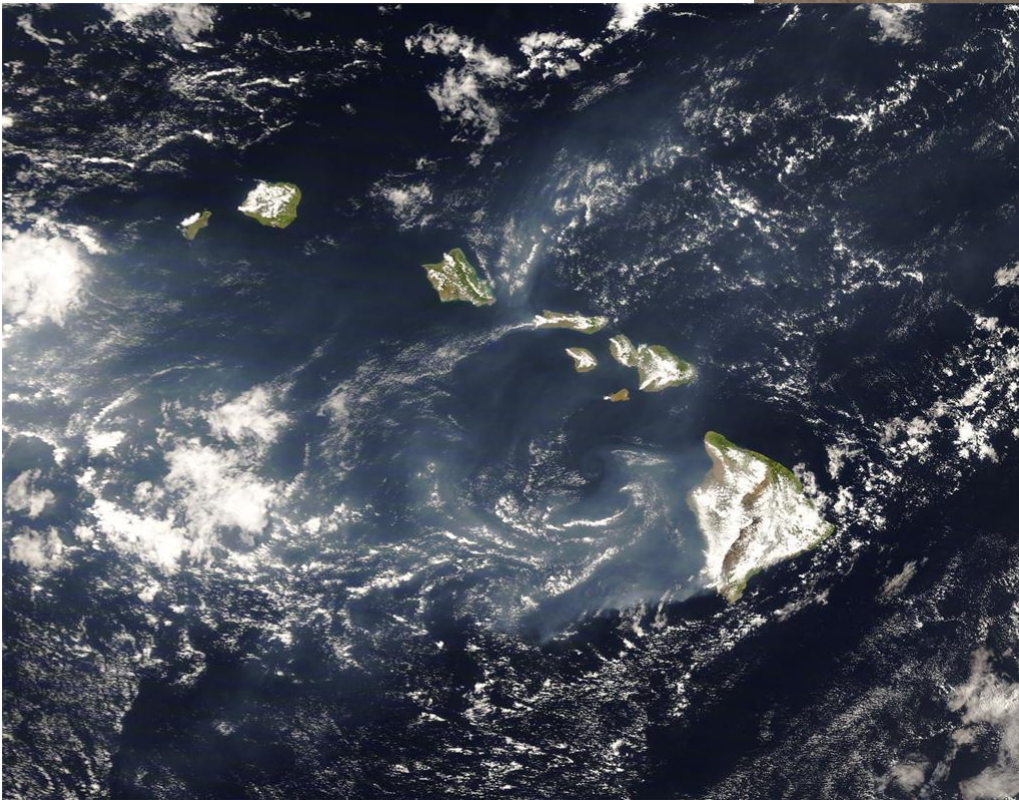
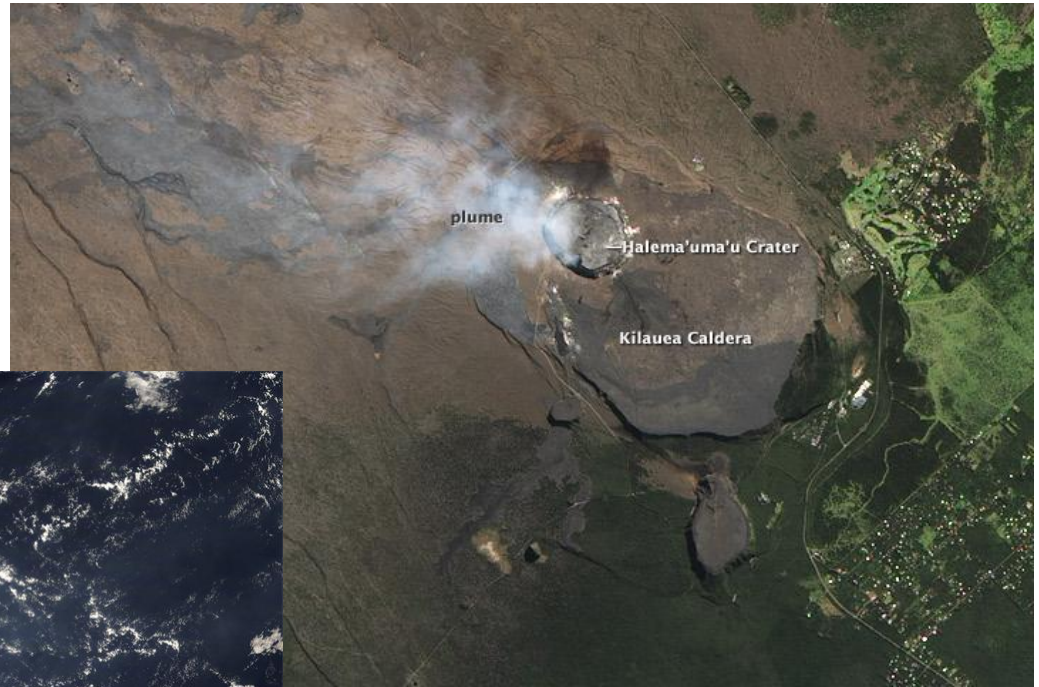


● = historically active volcano



Air Quality

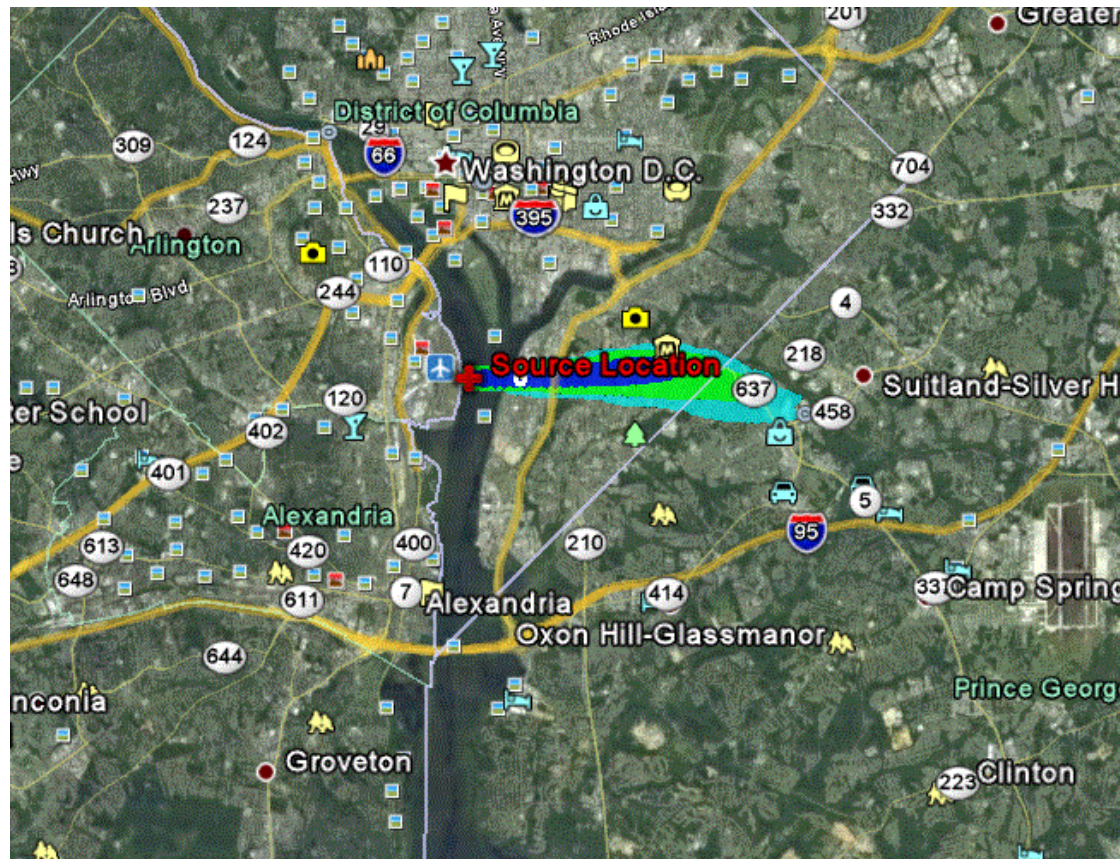
Pu'u'O'o and Halema'uma'u Plume Prediction



- Approaches
 - Model linked with locally (UH) run 1-km resolution WRF
 - Real-time emissions monitoring
 - Results available on-line

Decision Support

Real-time Environmental Applications and Display sYstem

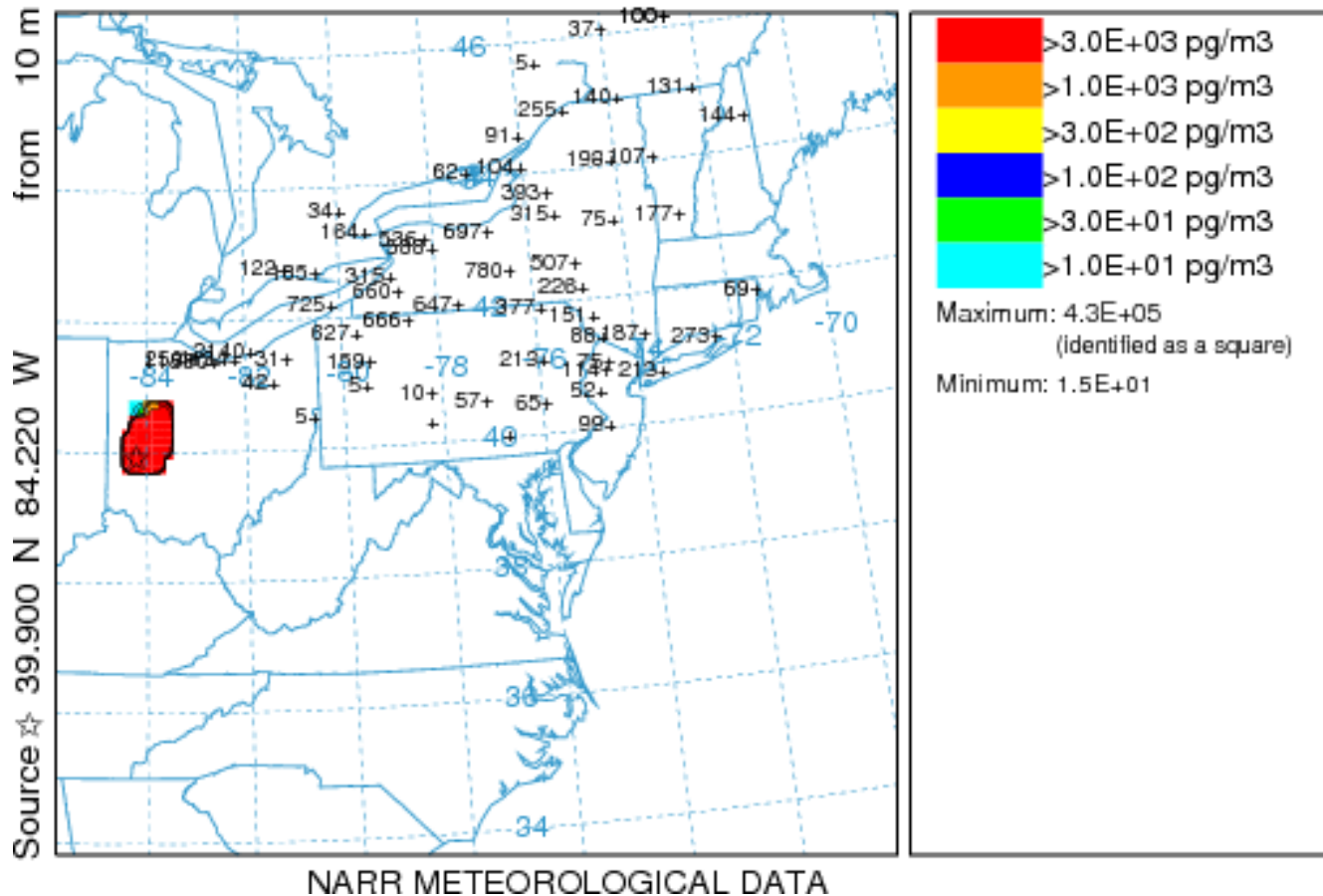


- **Approaches**
 - WEB based interface
 - Perl for input and Postscript (PS) output
 - Utilities to convert PS to SVG, ESRI-SHP, KMZ
- **Accomplishments**
 - New interface using FLASH and output to Google Maps
- **Future Directions**
 - Couple with NOAA's High Resolution Rapid Refresh forecast model for reverse 911 notifications

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)





Model Evaluation

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 & Sudbury, 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 \(METREX\)](#)

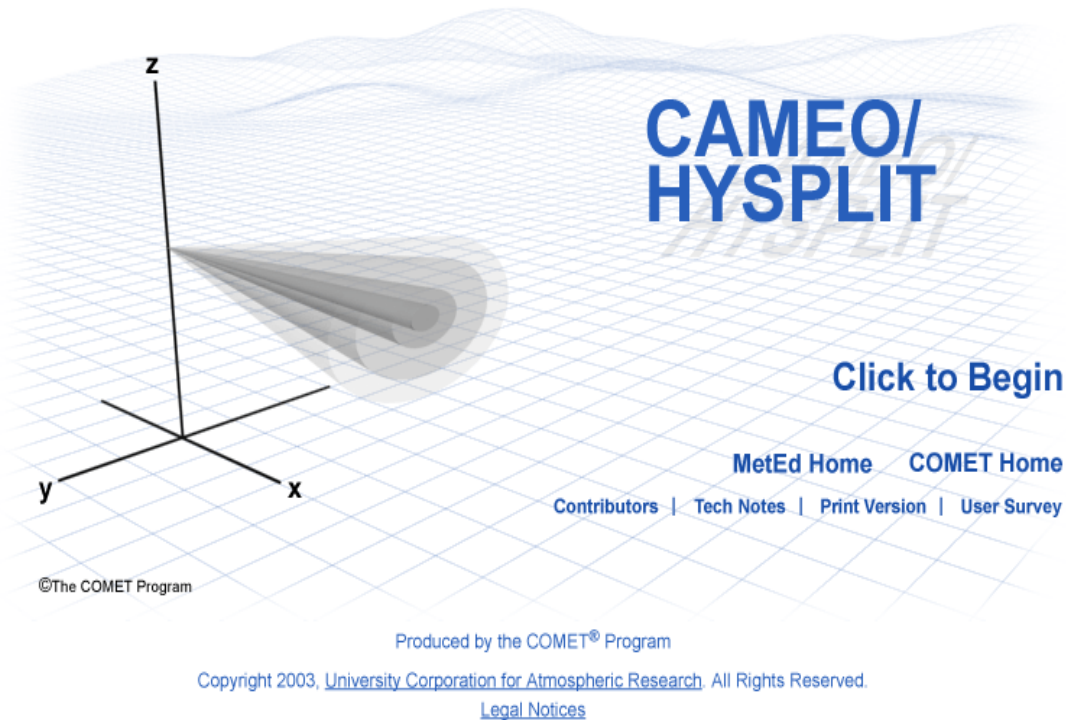
Release: metropolitan Washington, DC: Jan. through Dec. 1984

▶ [EUropean Tracer Experiment \(ETEX\)](#)

Release: Rennes, France: Oct. 23 1994

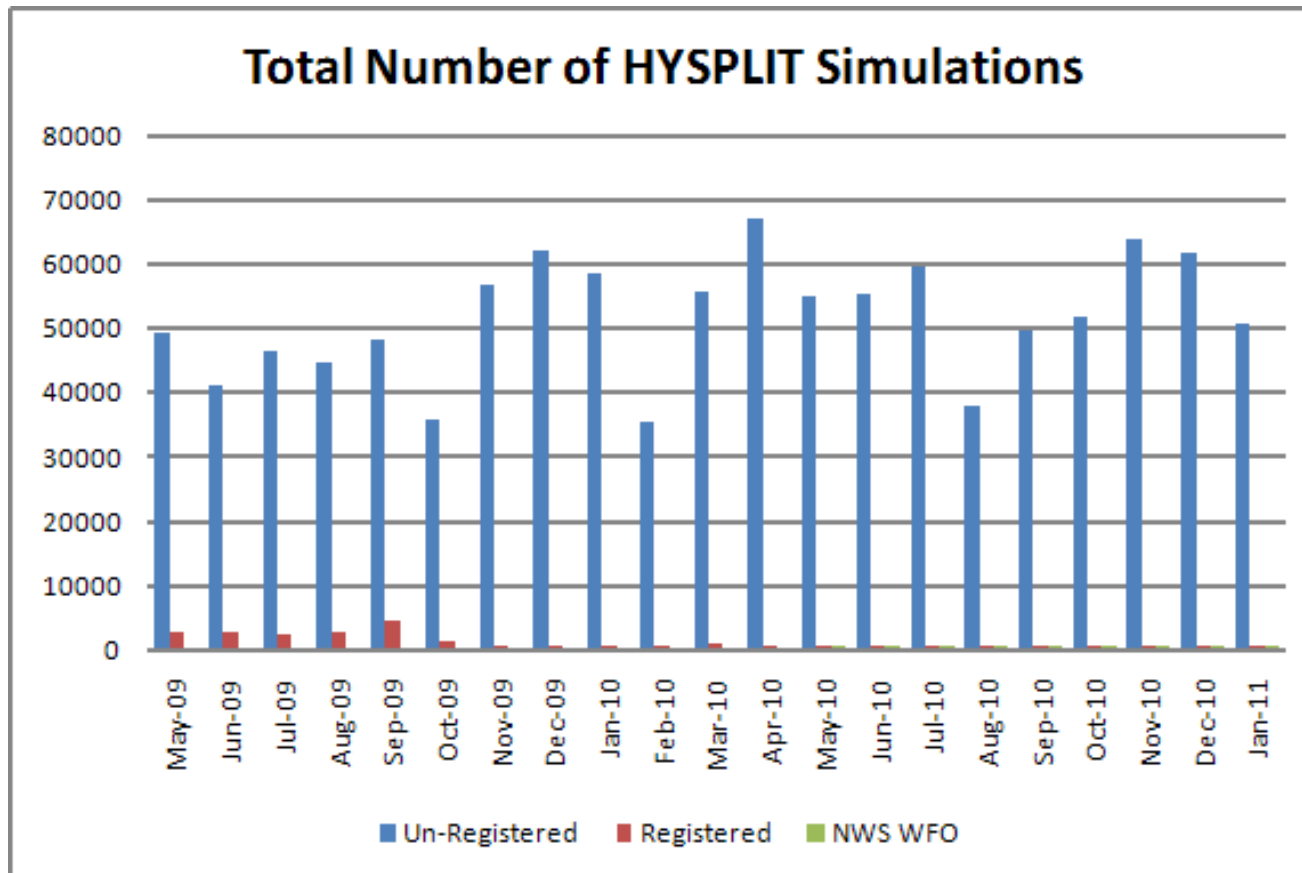
- Approach
 - Uses the North American Regional Reanalysis
 - Common statistical evaluation protocols
- Accomplishments
 - Web access to run HYSPLIT for each experiment
 - Standardized model change testing in conjunction with version control

HYSPLIT Model Training



- **Approaches**
 - Annual 3-day training workshops (14 since 2004)
 - Interact with stakeholders
- **Accomplishments**
 - Collaboration with COMET to satisfy WFO training requirement

HYSPLIT Popularity



- 50,000 web simulations per month
- PC downloads: 4743

HYSPLIT Model Relevancy

- Deep Water Horizon
- Iceland Volcano
- Japanese Fukushima Dai-ichi nuclear reactors

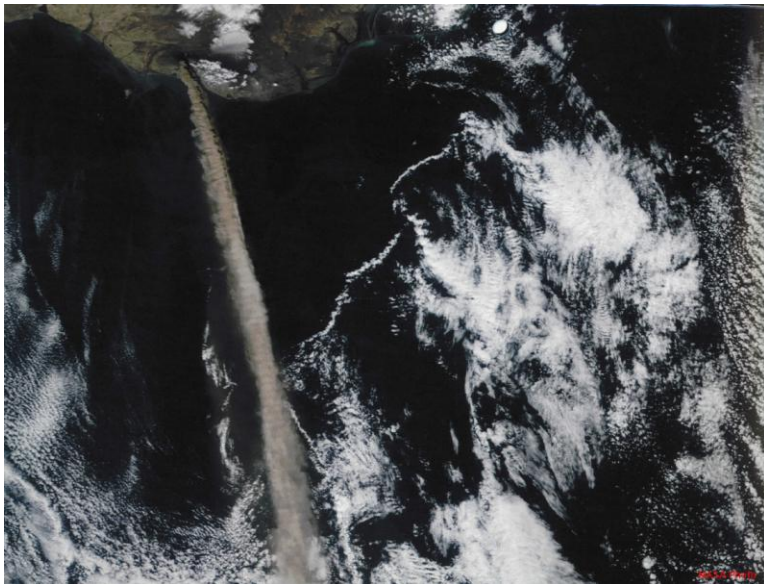


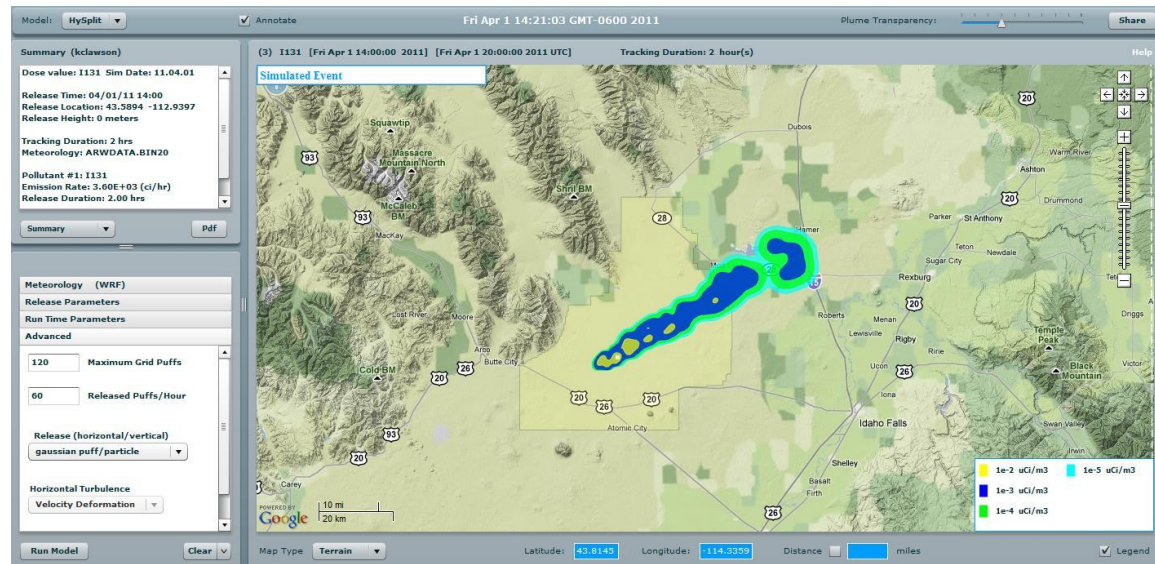
Photo taken June 22, 2010. Photo courtesy Dr. Oscar Garcia / Florida State University.



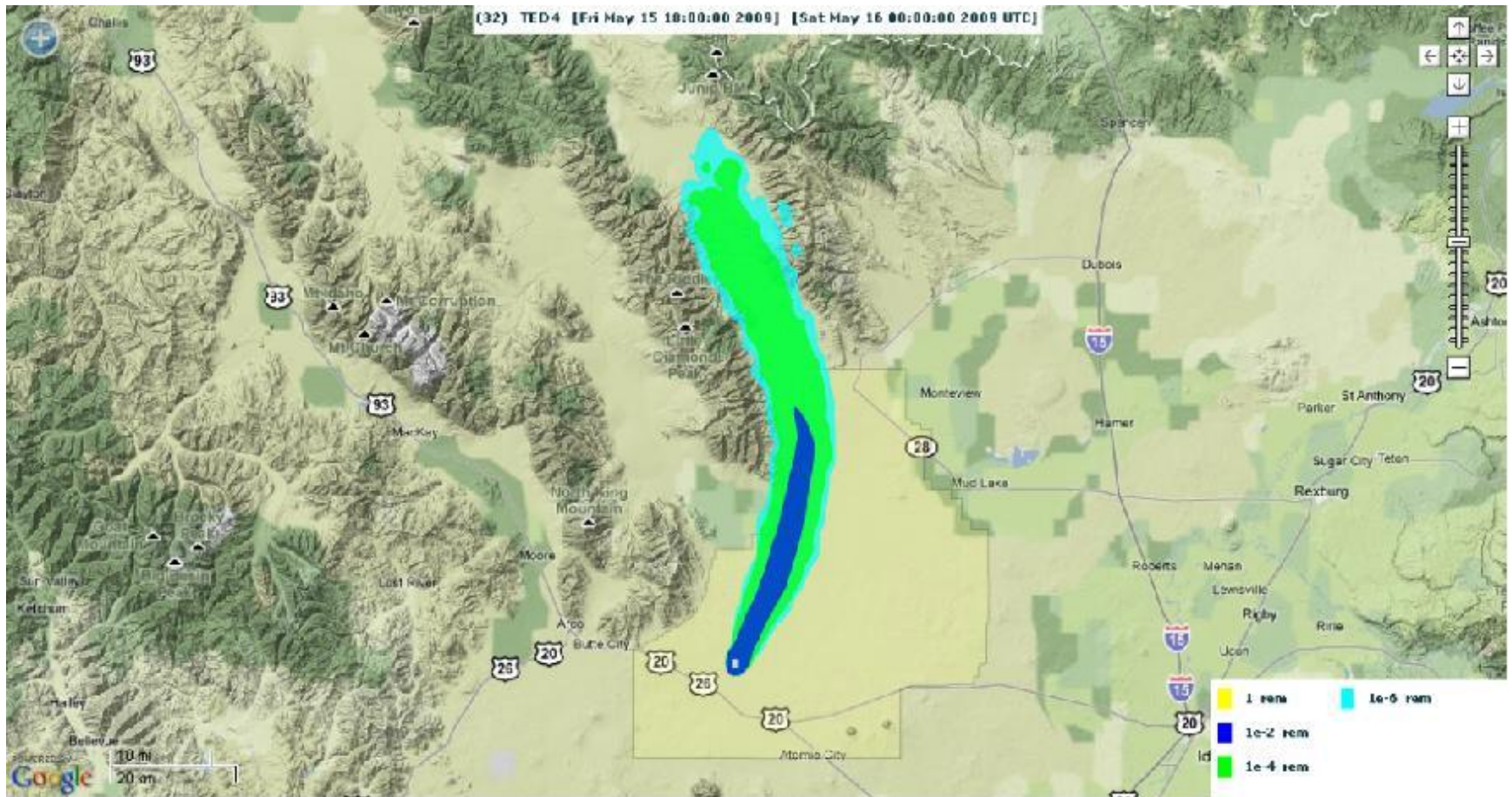
REUTERS

Initial HYSPLIT Shortcomings for INL Use

- Inability to use NOAA/INL Mesonet observations
 - Developed wind-field pre-processor program to interpolate Mesonet observations
- Radiological dose algorithm not complete
 - Improved algorithm
- Default interface not suitable for INL application
 - Developed browser-based interface
 - Based on Flash technology
- Default output products more for research applications
 - New output based on Google Maps
 - Fully interactive



Example Plume





Future Work

- Additional INL-specific features
 - Radiological release from arbitrary location (e.g., transportation event)
- Improve execution speed
 - Graphics Processing Units (GPUs)
 - Multi-core processing
- Improve mesonet pre-processor with improved diagnostic model
- Scenario management program
- Integration with other NOAA dispersion codes
 - ALOHA