HYSPLIT

Hybrid Single Particle Lagrangian Integrated Trajectory Model

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Air Resources Laboratory

ARL Laboratory Review
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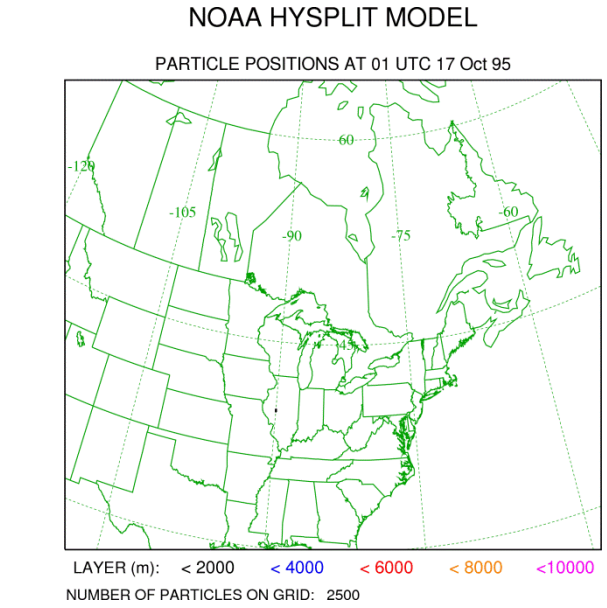
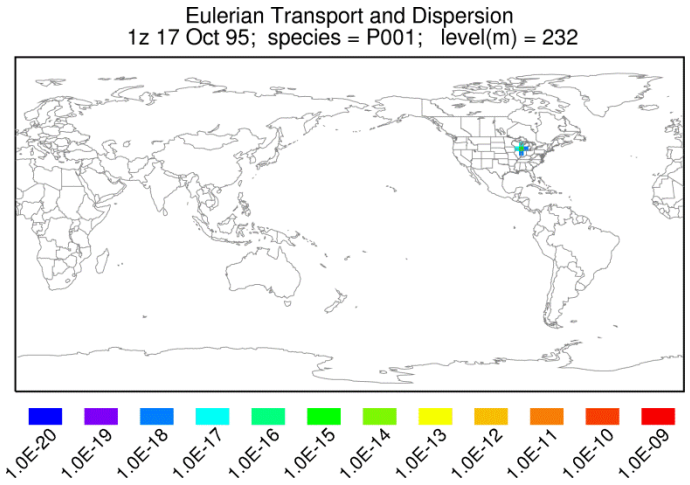
Goals
Research and Applications

- **Emergency Response**
  - Radiological releases
  - Improvised nuclear devices
  - Chemical releases
  - Volcanic eruptions (Barbara Stunder)
- **Air Quality**
  - Kilauea plume prediction
  - Fire smoke and Wind-blown dust (Ariel Stein)
  - Global pollutant transport
  - Source-receptor analysis (Mark Cohen)
- **Model Evaluation**
  - Data Archive of Tracer Experiments and Meteorology
  - Meteorological data assimilation
- **Decision Support**
  - Dispersion model training
  - Real-time Environmental Applications and Display sYstem

HYSPLIT Description and History





- **Numerical Approach**
  - Follows particle motion
  - Off-line (easy to re-run)
  - Requires meteorological fields
  - Particle or puff solutions
  - UNIX, PC, Mac, Web
- **History**
  - 1980's used only soundings
  - 1990's switched to model fields
  - 2000's incorporate 3D turbulence
- **Future Directions**
  - In-line and multi-cpu
  - 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) 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

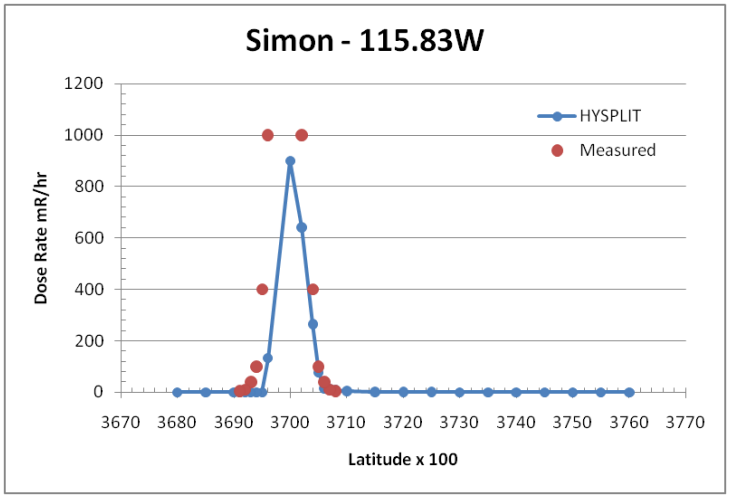
Radiological Releases

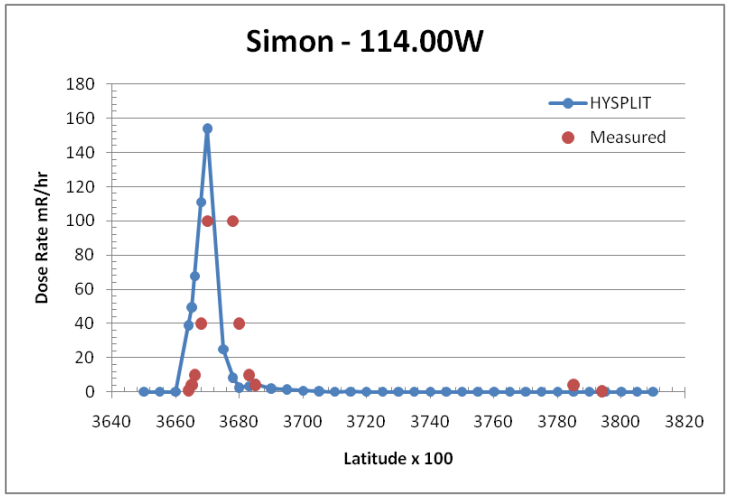
RSMC TIME OF MODEL RUN (YYYYMMDDCC_HHMM)	MODEL PARAMETERS	JOINT STATEMENT	VIEW PRODUCTS	TRAJECTORIES	TIME PERIOD 1 +24 HRS	TIME PERIOD 2 +48 HRS	TIME PERIOD 3 +72 HRS
Washington 2011011306_1334 All Products	Cover (Postscript)	Region III/IV	Check All Uncheck All	Trajectories (traj.txt)	Exposure Deposition	Exposure Deposition	Exposure Deposition
Montréal 2011011300_1424 All Products	Cover (Postscript)	Region III/IV	Check All Uncheck All	Trajectories (traj.txt)	Exposure Deposition	Exposure Deposition	Exposure Deposition
Melbourne 2011011300_2351 All Products	Cover (Postscript)	Region V	Check All Uncheck All	Trajectories (traj.txt)	Exposure Deposition	Exposure Deposition	Exposure Deposition
Exeter All Products	Cover (Postscript)	Region I/VI	Check All Uncheck All	Trajectories (traj.txt)	Exposure Deposition	Exposure Deposition	Exposure Deposition
Toulouse 2010112610_5602 All Products	Cover (Postscript)	Region I/VI	Check All Uncheck All	Trajectories (traj.txt)	Exposure Deposition	Exposure Deposition	Exposure Deposition
Beijing 2010111800_1150 All Products	Cover (Postscript)	Region II	Check All Uncheck All	Trajectories (traj.txt)	Exposure Deposition	Exposure Deposition	Exposure Deposition
Tokyo no incident All Products	Cover (Postscript)	Region II	Check All Uncheck All	Trajectories (traj.txt)	Exposure Deposition	Exposure Deposition	Exposure 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**
  - New product for NOAA's HSPO and NWS WFOs
  - Linked to research and operational NOAA forecast models

Emergency Response
Improvised Nuclear Devices





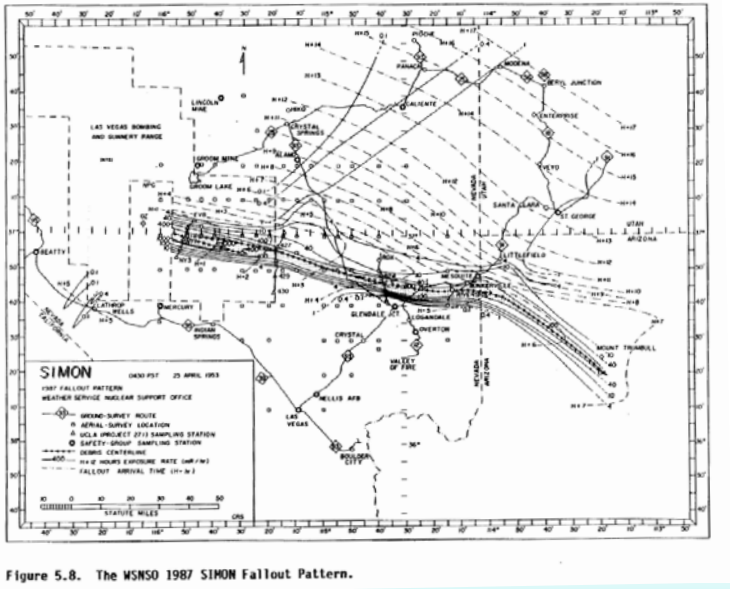
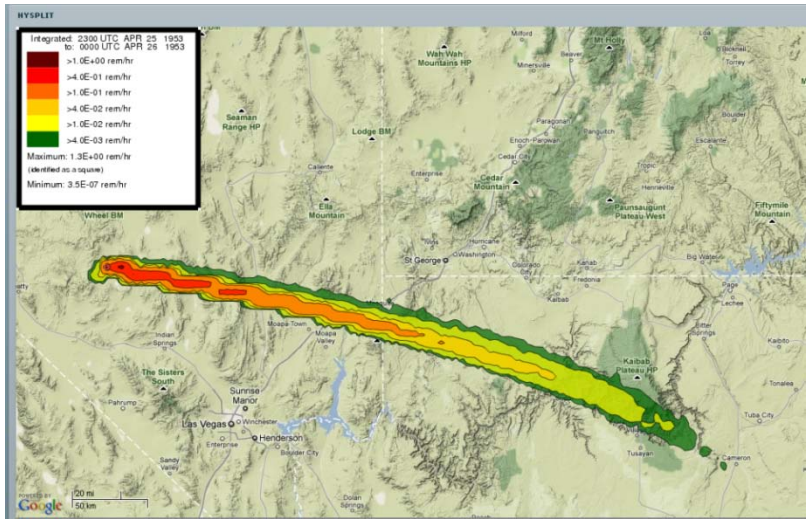
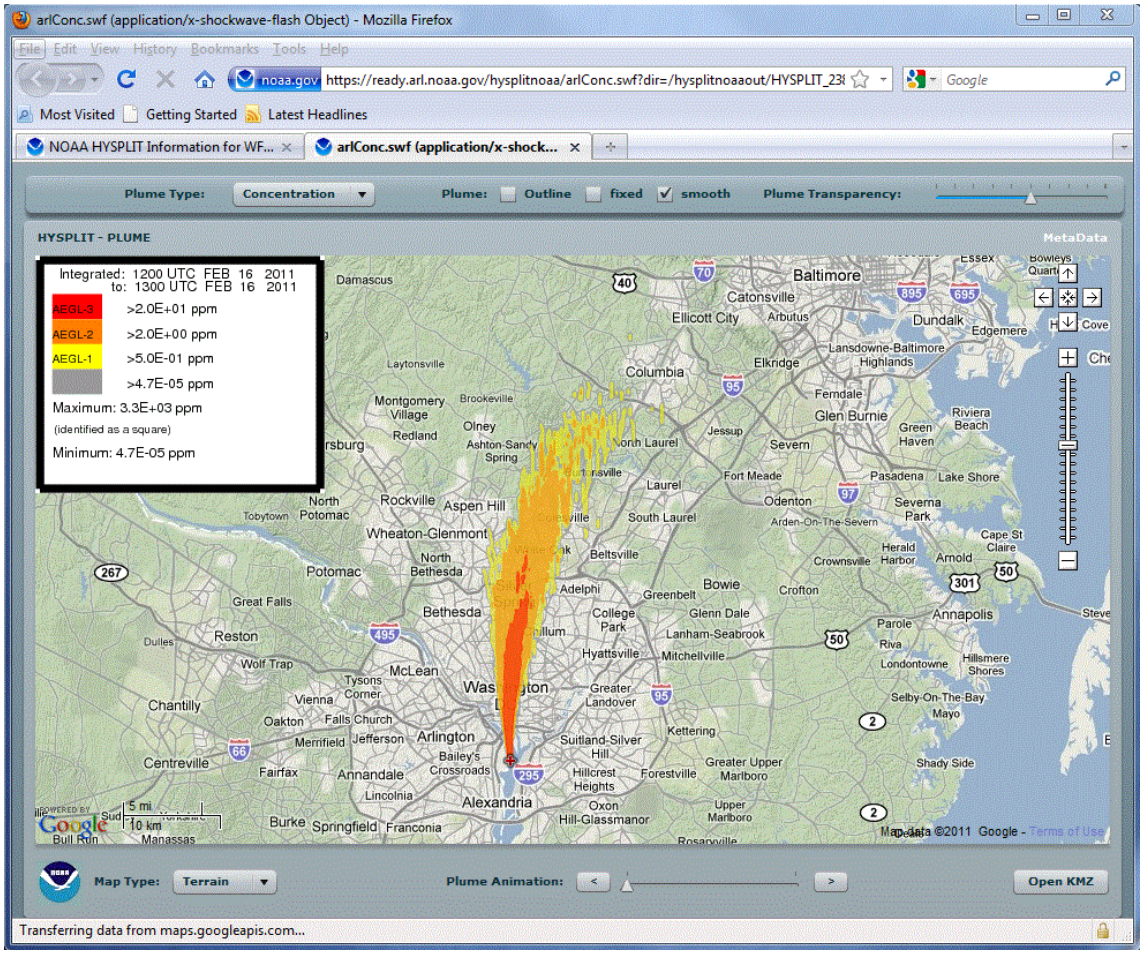


Figure 5.8. The WSNSO 1987 SIMON Fallout Pattern.



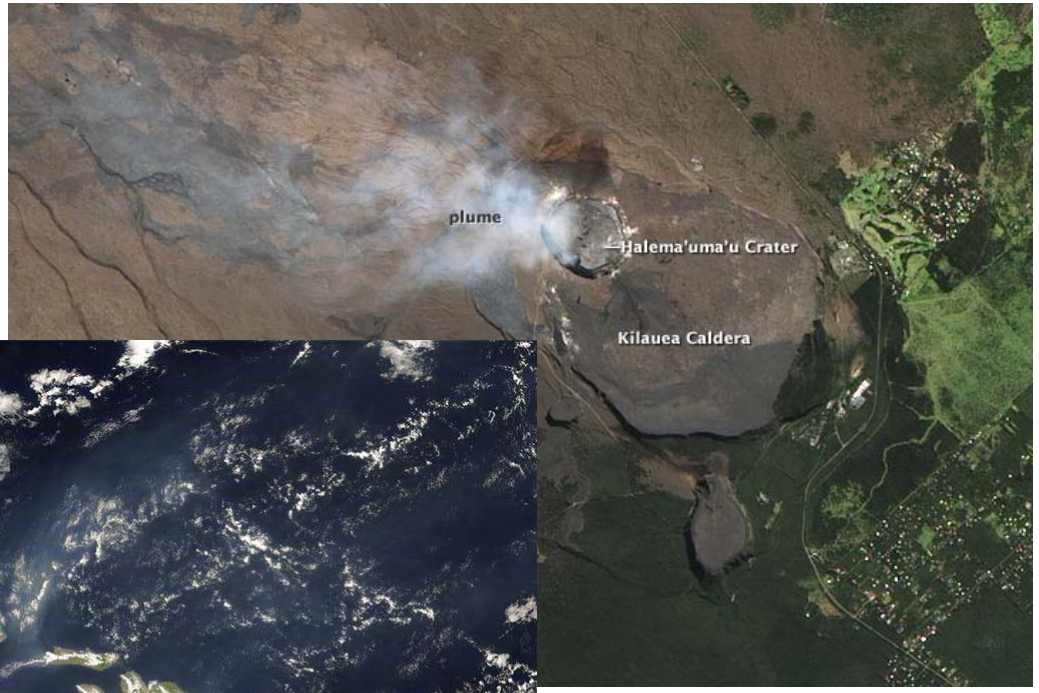
Emergency Response

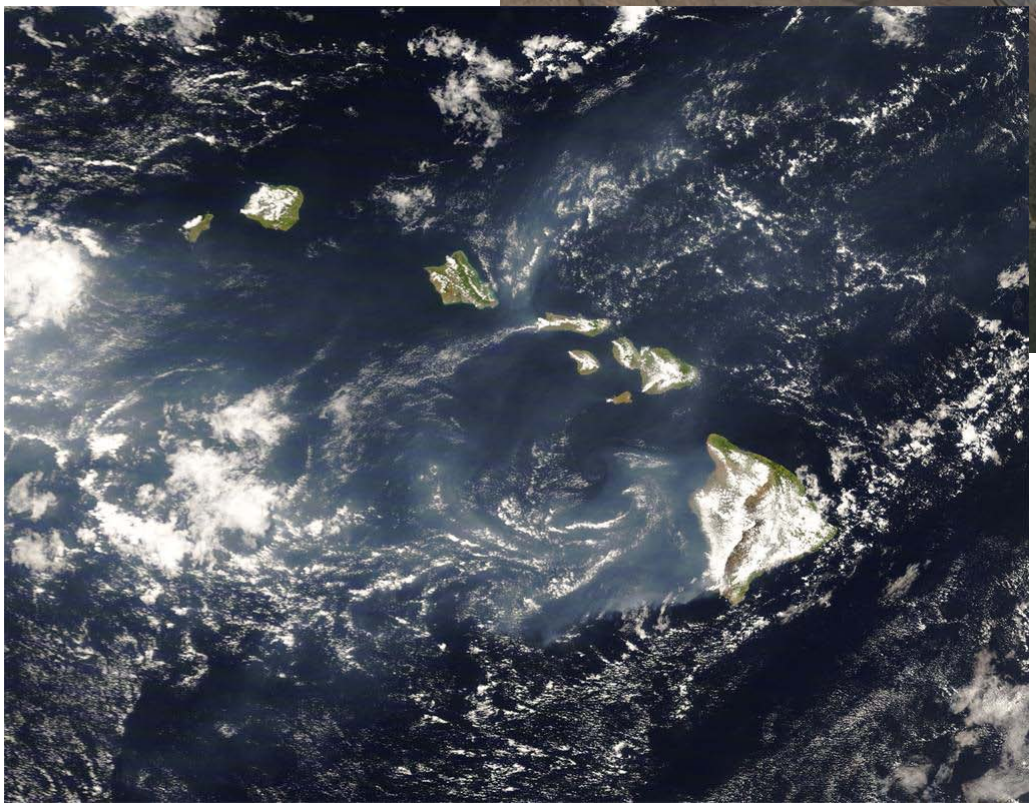
Chemical Releases



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

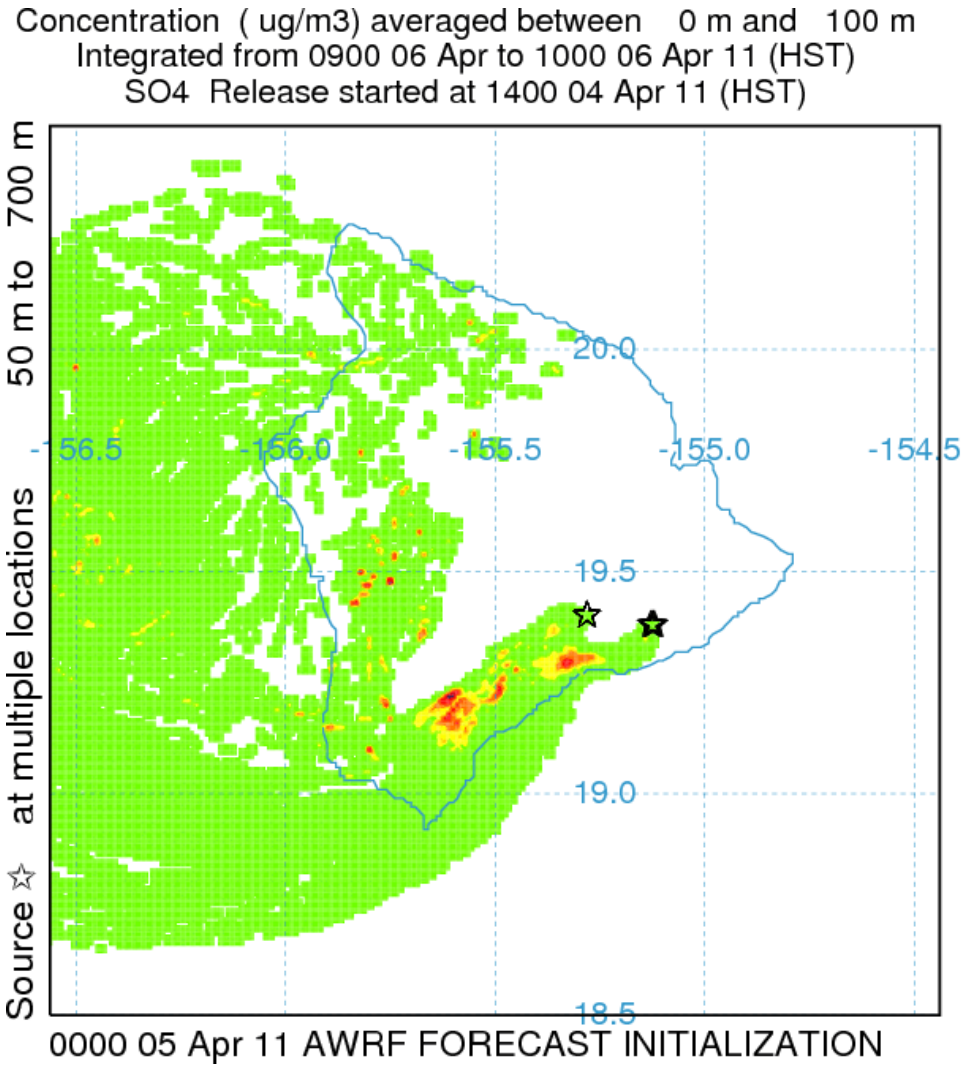
Air Quality





Air Quality

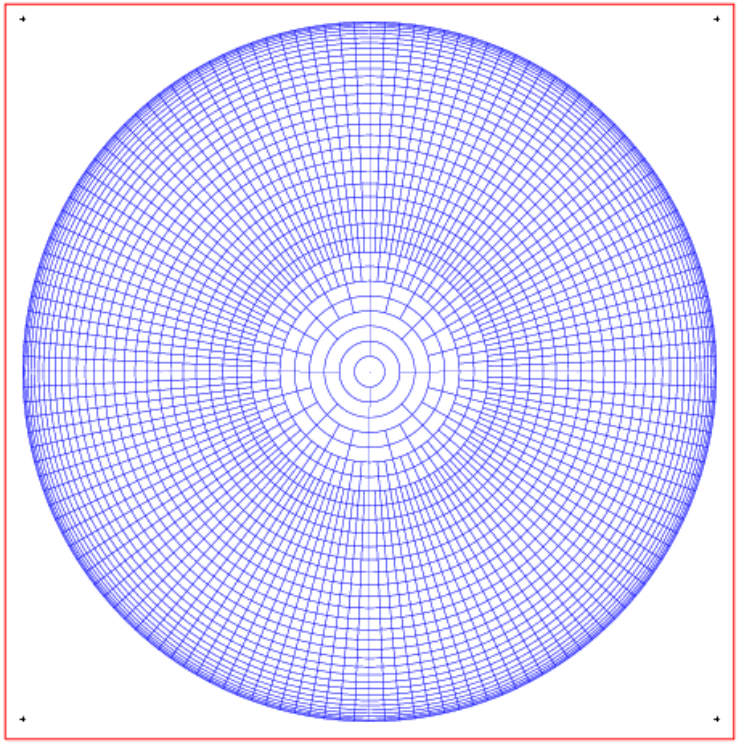
Pu'u'O'o and Halema'uma'u Plume Prediction



- **Approaches**
  - Model linked with locally (UH) run 1-km resolution WRF
  - Real-time emissions monitoring
  - Measurement data for verification
  - Results available on-line
- **Future Directions**
  - Conversion of SO_2 to SO_4 in unique vent environment

Air Quality

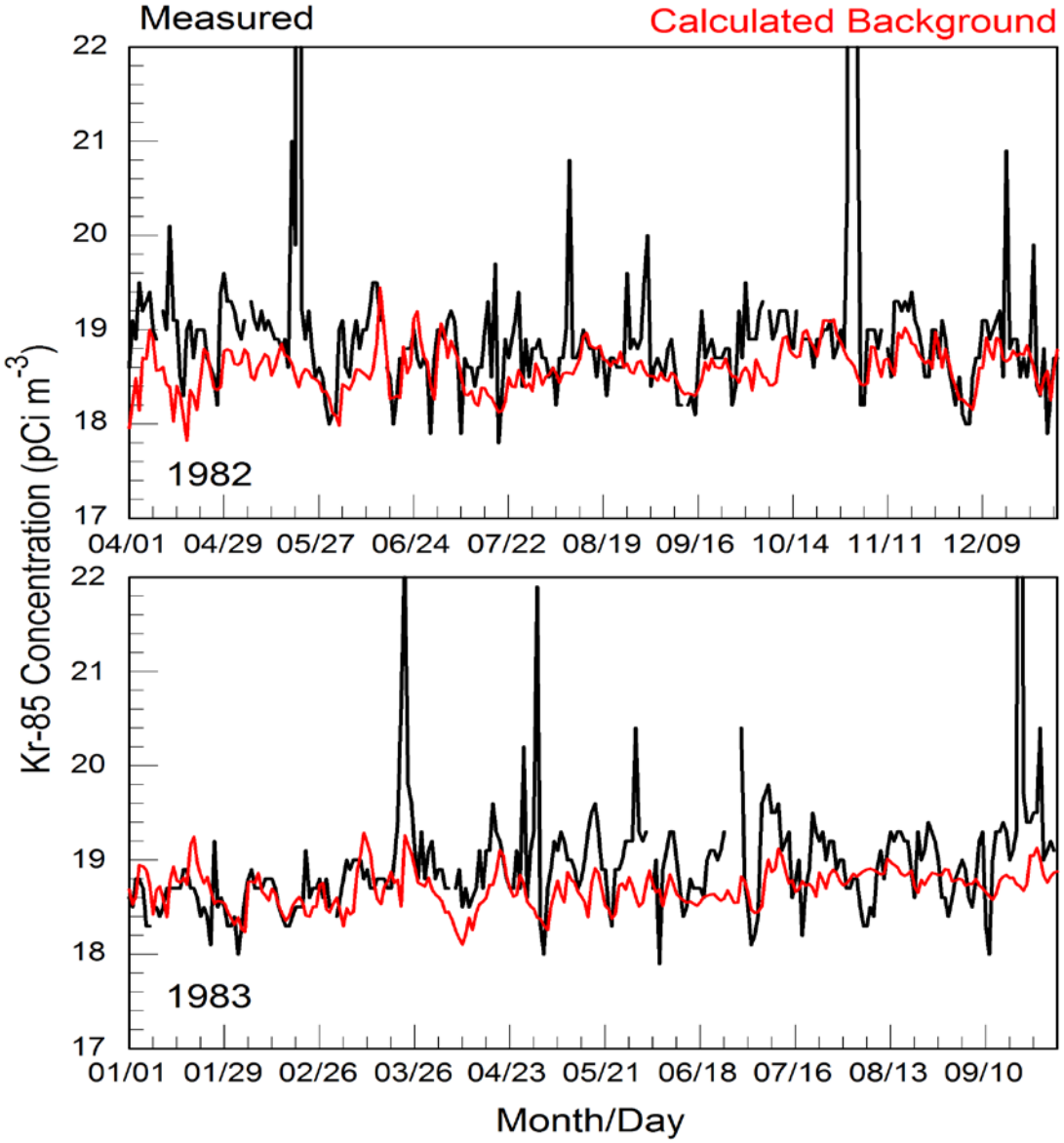
Global Pollutant Transport



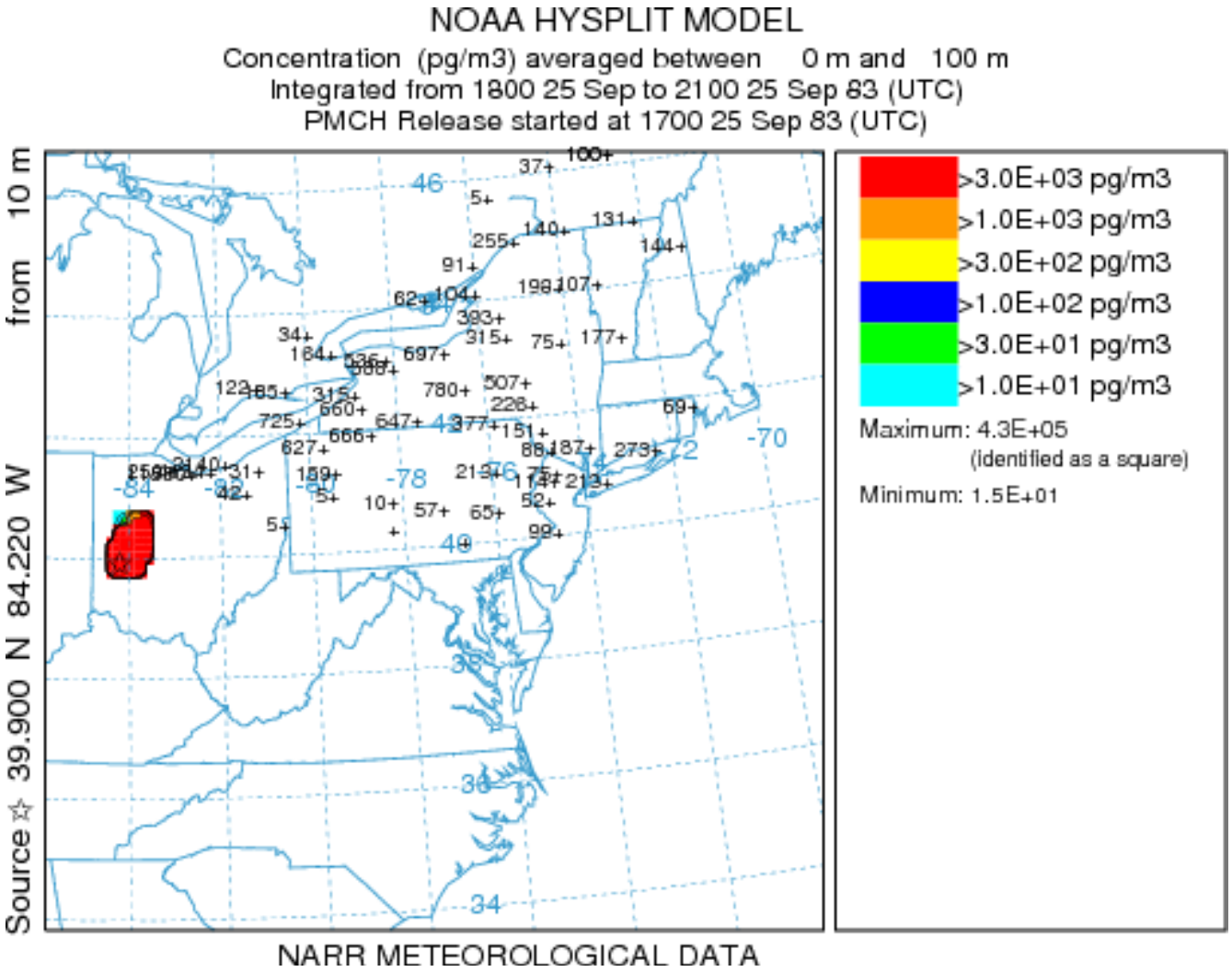
- **History**
  - Many of the old Kr-85 experiments affected by varying background concentrations
  - Lagrangian models not suitable for global predictions
- **Approaches**
  - Stand-alone Eulerian global CTM model to predict background
- **Accomplishments**
  - Fast for single species (2.5 deg 20 min/yr)
  - CTM now included as a HYSPLIT subroutine
  - Hg background for source-receptor analysis
- **Future Directions**
  - Parallelization needed for multiple species
  - Nested grids may be required

Air Quality

Global Pollutant Transport



Model Evaluation



Model Evaluation

Data Archive of Tracer Experiments and Meteorology

Information Summary

DATEM - Data Archive of Tracer Experiments and Meteorology

Information on the DATEM project

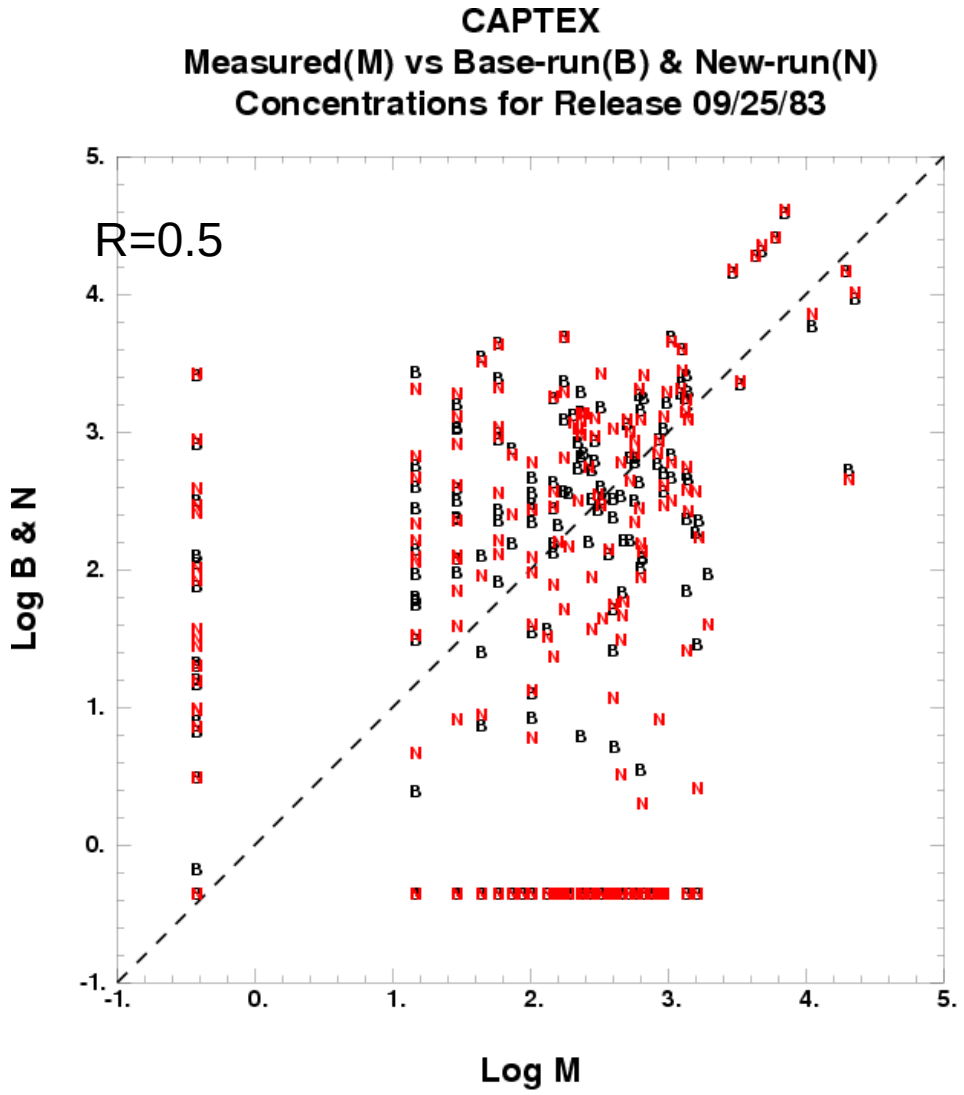
Click on the experiment name for experiment details.

- 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 NARR … data better than observations!
  - Common statistical evaluation protocols
- **Accomplishments**
  - Web access to run HYSPLIT for each experiment
  - Standardized model change testing in conjunction with version control

Model Evaluation

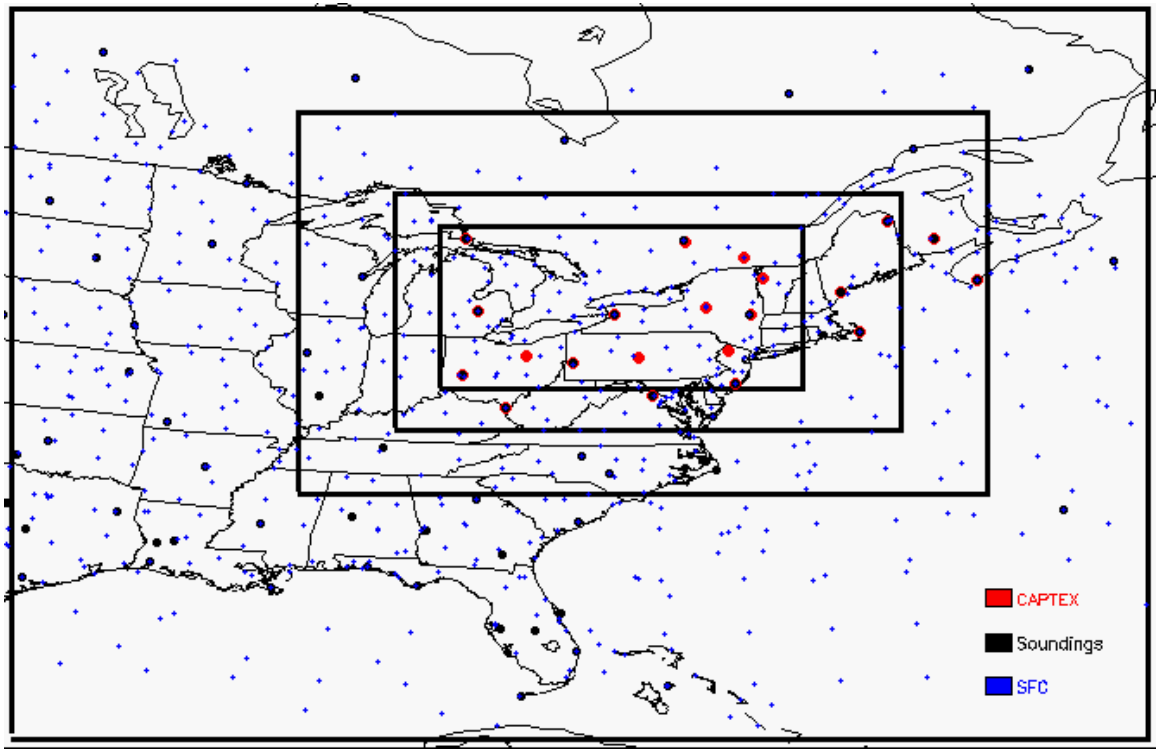
Data Archive of Tracer Experiments and Meteorology



- **Future Directions**
  - More user training on model parameters
  - Include more dispersion experiments
  - Add new meteorological data files …

Model Evaluation

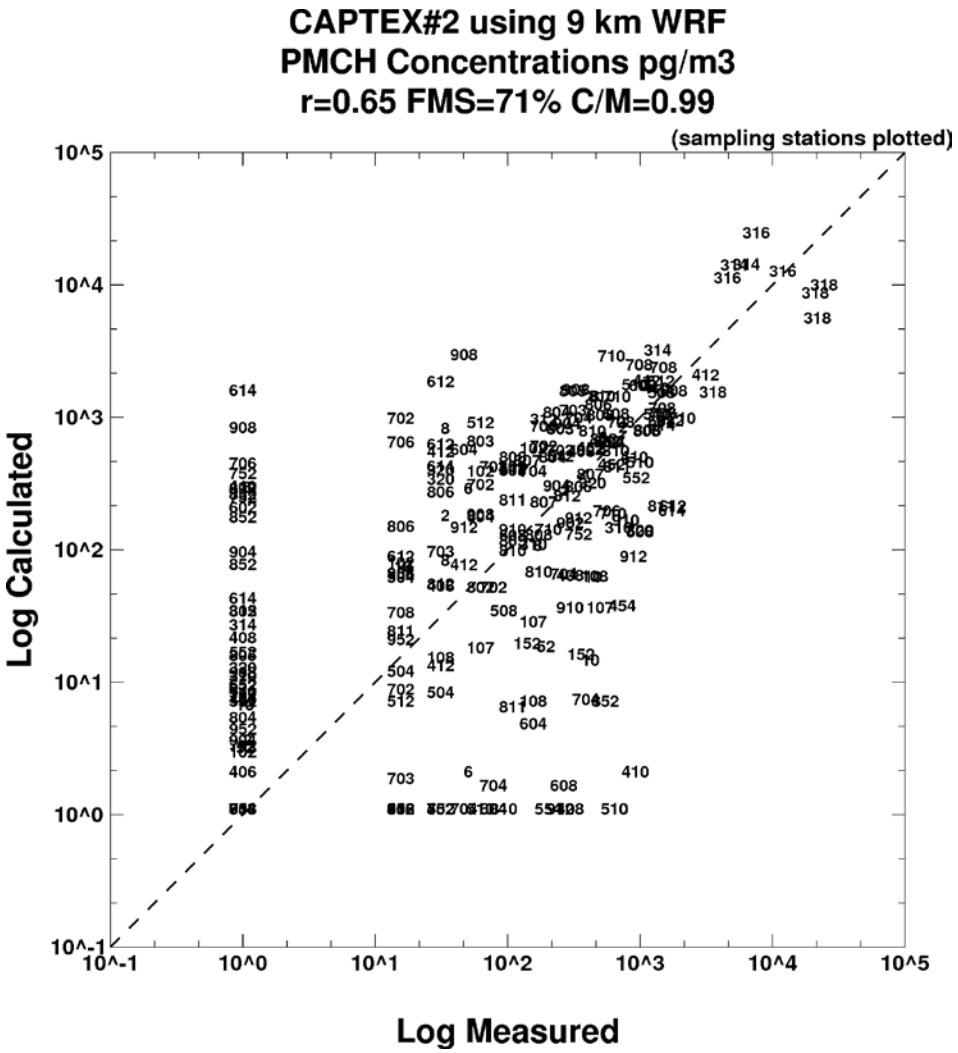
Meteorological Data Assimilation



- **Approaches**
  - Testing WRF-ARW with historical tracer measurements
  - Manage data volume (1 km domain = 1.6 Gb / time)

Model Evaluation

Meteorological Data Assimilation

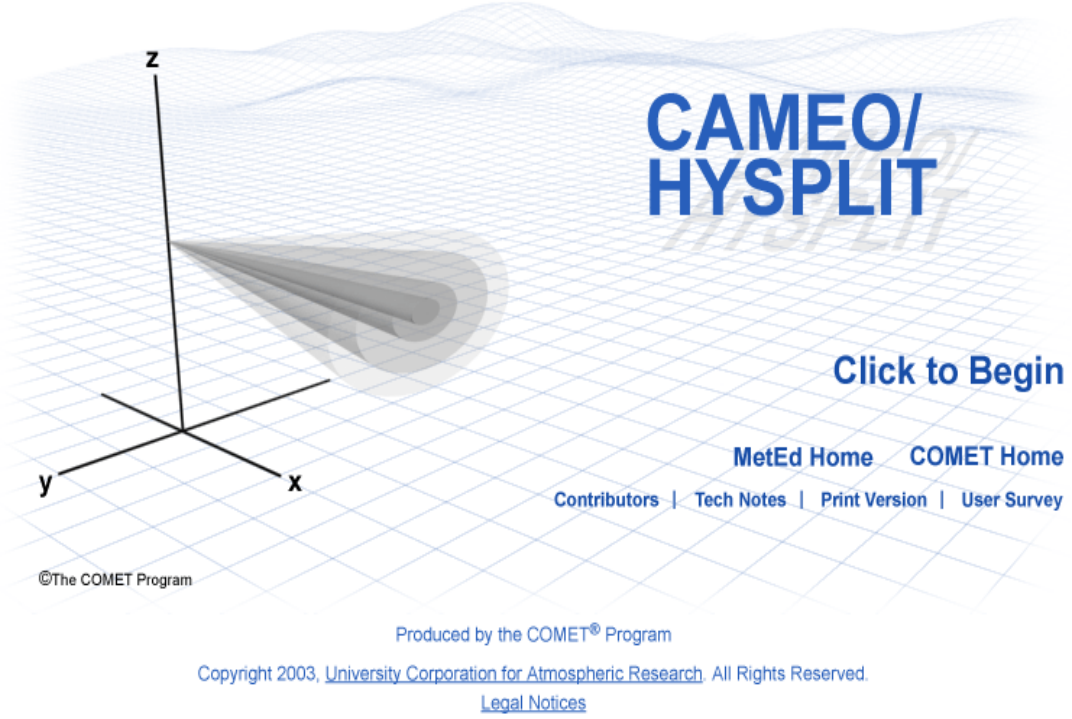


- **Future Directions**
  - Evaluate …
    - time frequency versus grid size
    - Instantaneous versus time averaged fields
    - In-line model versus off-line model
    - Optimize model's data I/O for large files

Decision Support

Decision Support

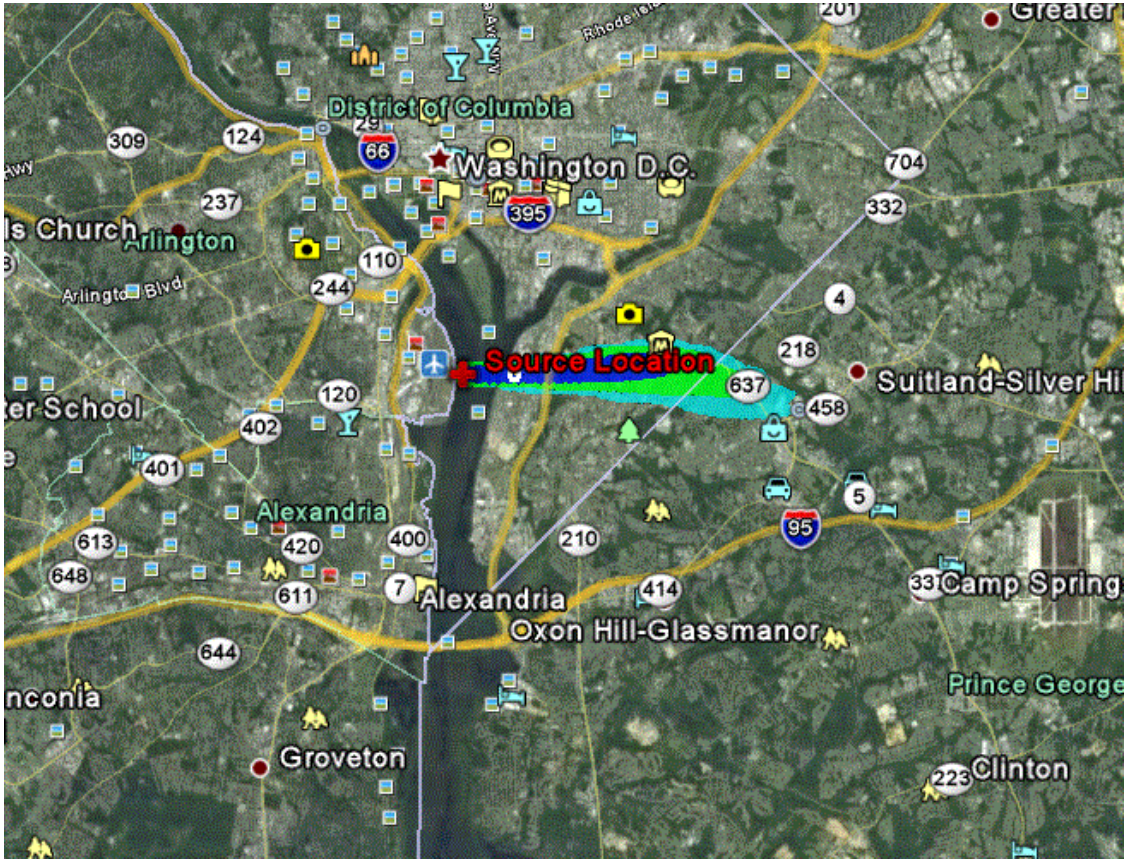
Dispersion Model Training



- **Approaches**
  - Annual 3-day PC training workshop (14 since 2004)
  - Interact with stakeholders
- **Accomplishments**
  - New collaboration with COMET to satisfy WFO training requirement
- **Future Directions**
  - Need to develop a model front-end black-box

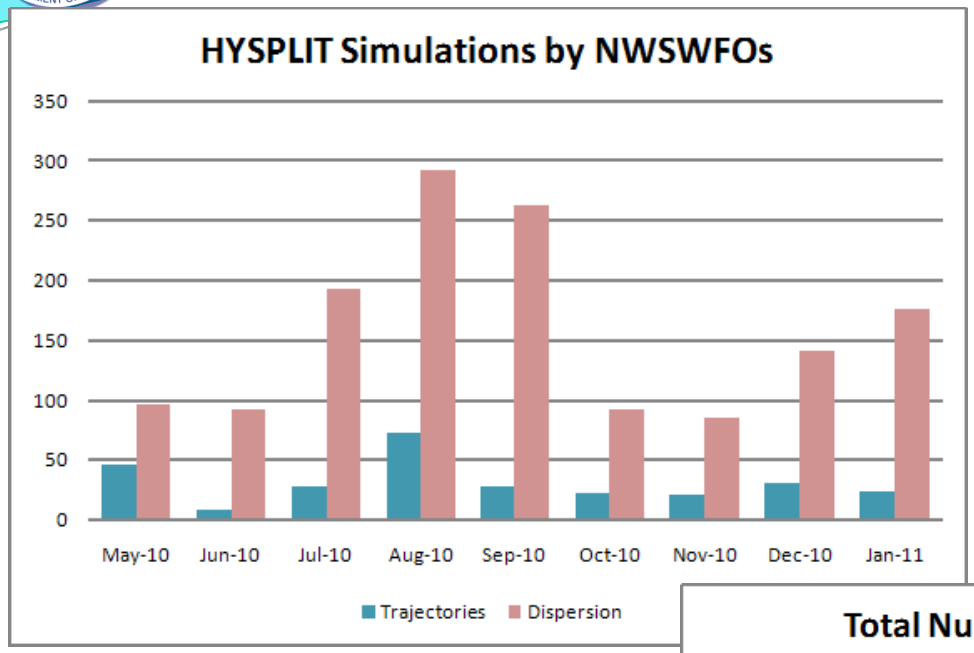
Decision Support

Real-time Environmental Applications and Display sYstem

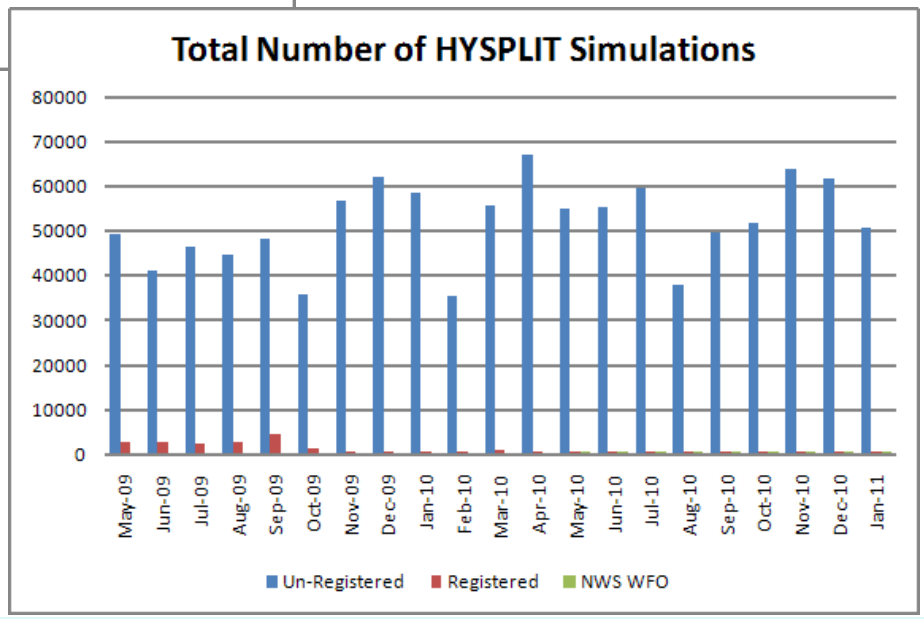


- **Approaches**
  - WEB based interface
  - Perl for input and Postscript (PS) output
  - Utilities to convert PS to SVG, ESRI-SHP, KMZ
- **Accomplishments**
  - New interface using FLASH and output to Google Maps
- **Future Directions**
  - Couple with GSD's High Resolution Rapid Refresh at ESRL

Indicators of Success



- **Emergency Response**
  - 150 web simulations per month
- **Air Quality**
  - 50,000 web simulations per month
  - PC downloads: 4743
- **Decision Support**
  - Workshops ~ 140 persons
  - Invitational ~ 100 persons
  - International ~ 100 persons



Collaborators / Partners

- Australian Bureau of Meteorology: HYSPLIT, GUI, SVG
- Chinese Academy of Meteorological Sciences: MeteoInfo
- National Cancer Institute: nuclear testing dose
- Office of Response and Restoration: ALOHA/CAMEO
- ESRL Global Systems Division: GTAS
- ESRL Global Monitoring Division: STILT integration
- US Forest Service: Bluesky, VSMOKE
- University of Huelva: arsenic, dust, READY web
- University of Hawaii: Kilauea SO2/SO4 plumes

Possible Future Directions

- Emergency Response
  - Establishment of a Plume Prediction Center
  - Web backup and redundancy
  - Closer coupling of dispersion and meteorology models

- Decision Support
  - Dispersion model integration into AWIPS-II
  - Dispersion model linked with local predictions