NARAC Update

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NARAC-IMAAC Program

Lawrence Livermore National Laboratory

Presented at SCAPA

Las Vegas, NV

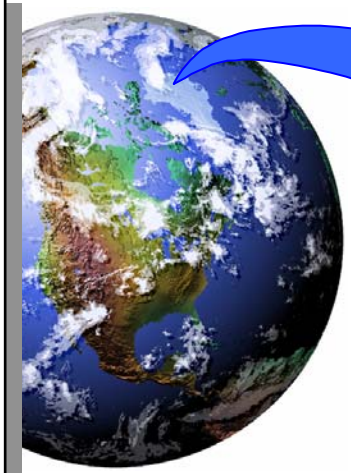
May 4, 2006

This work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

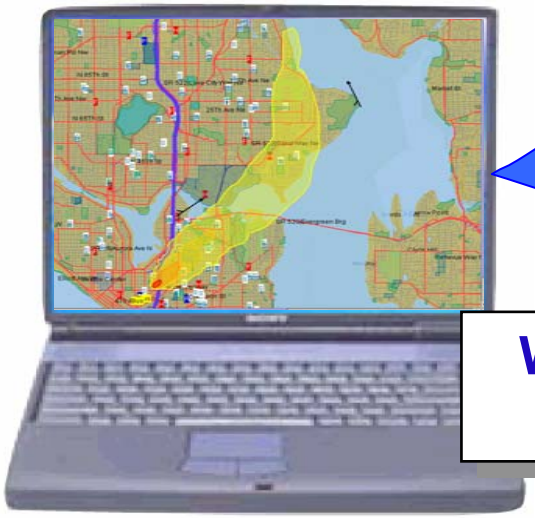
NARAC provides reach-back emergency response service

We access world-wide weather data and geographical information:

- **Observed & forecast weather data**
- **Terrain & land surface**
- **Maps**
- **Population**

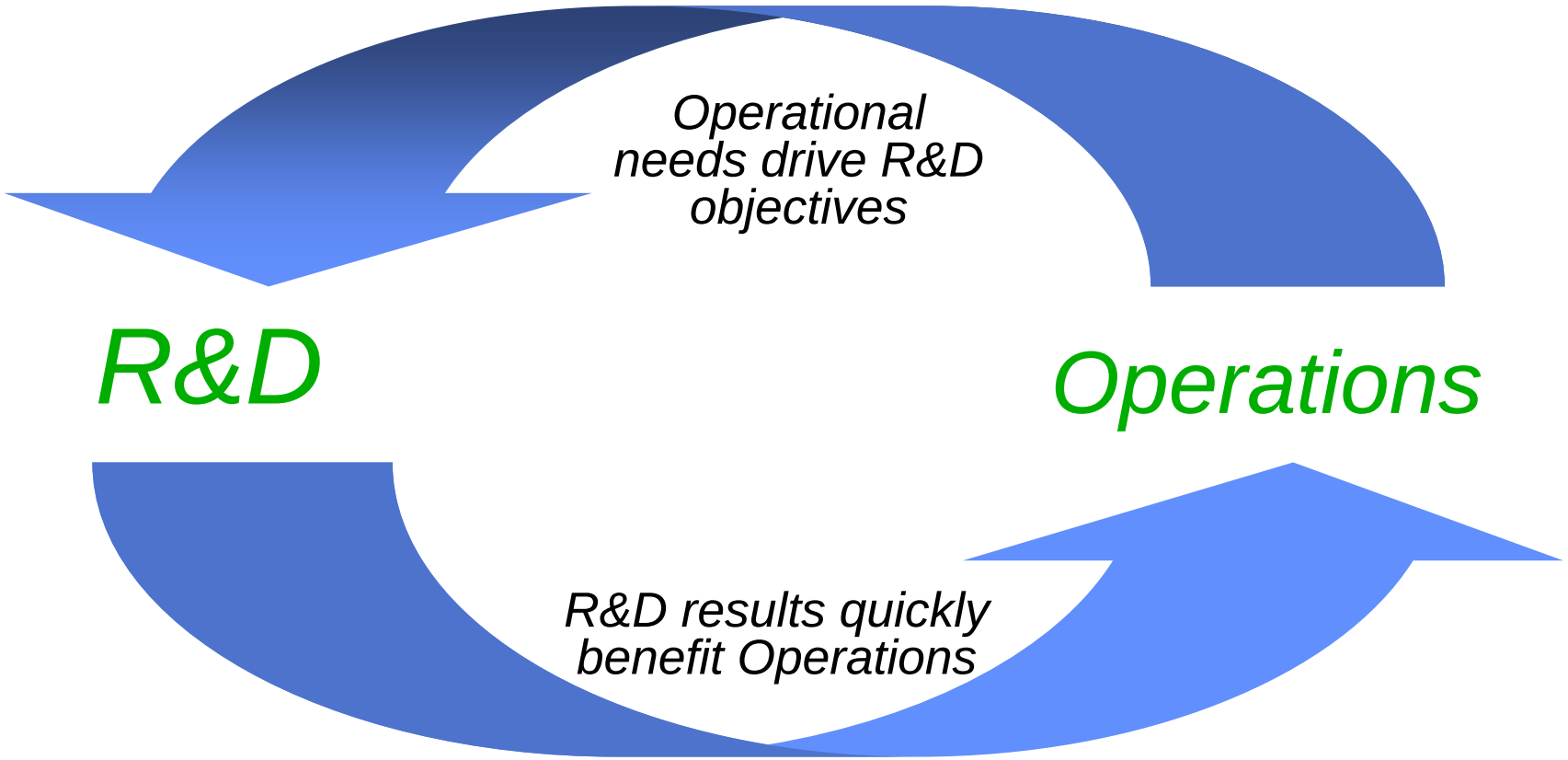


National Center at LLNL with 24x7 scientific support



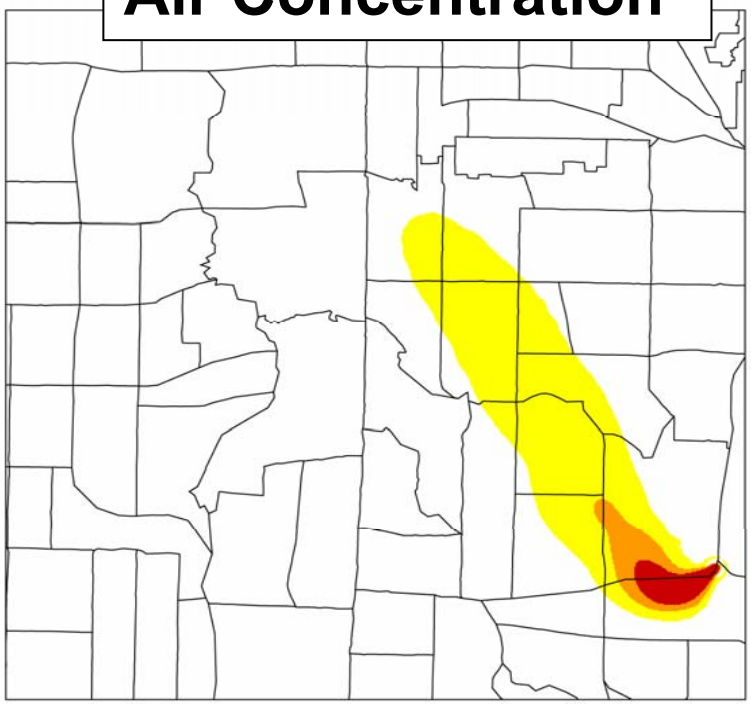
We deliver plume model predictions in minutes *via secure Web pages*

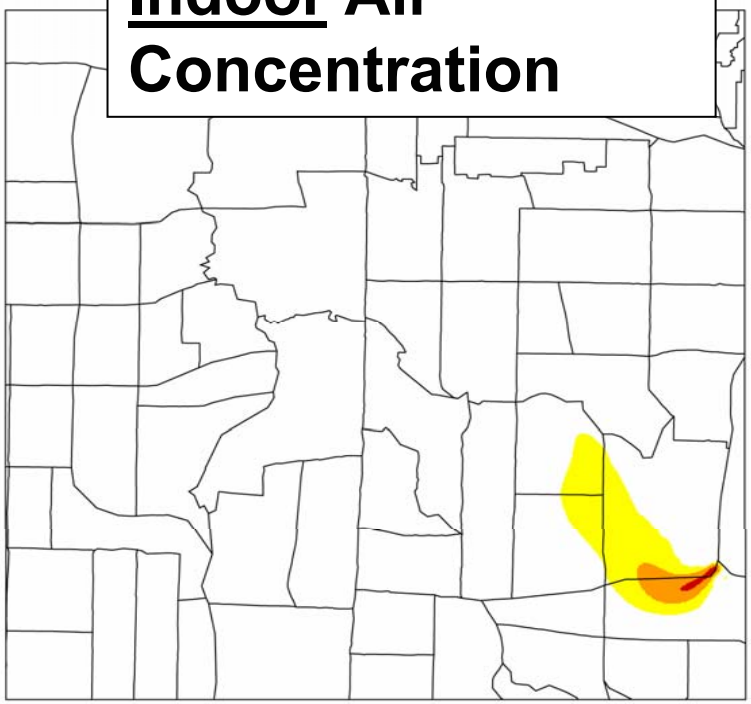
LLNL Combines Research & Development (R&D) and Operations



R&D is a collaborative effort with many national and international organizations

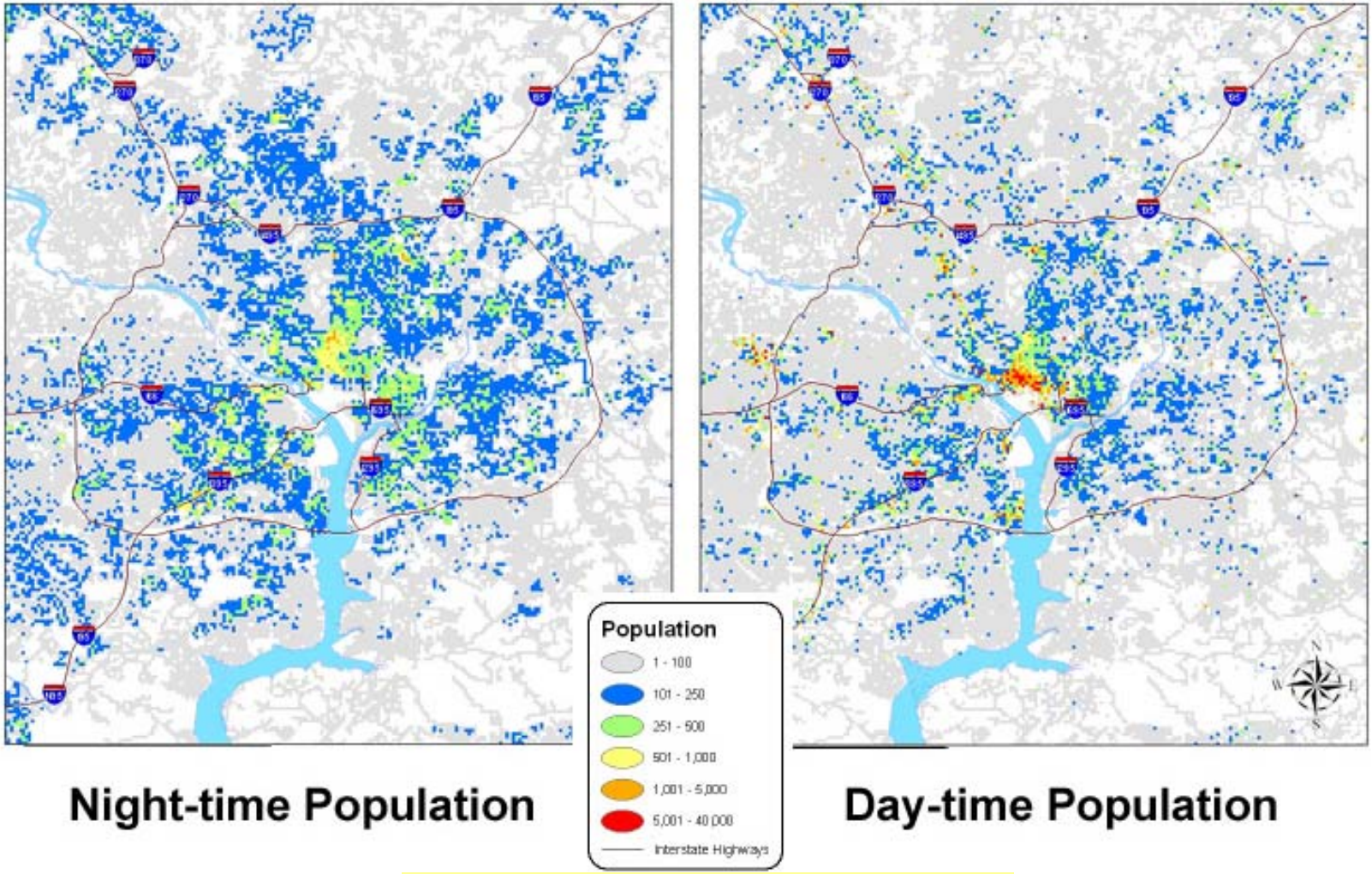
NARAC is Integrating LBNL Research on Outdoor-Indoor Infiltration Models





Building leakiness data from several states is used with Census data on residences to infer statistical relationships and derive a U.S.-wide geospatial database

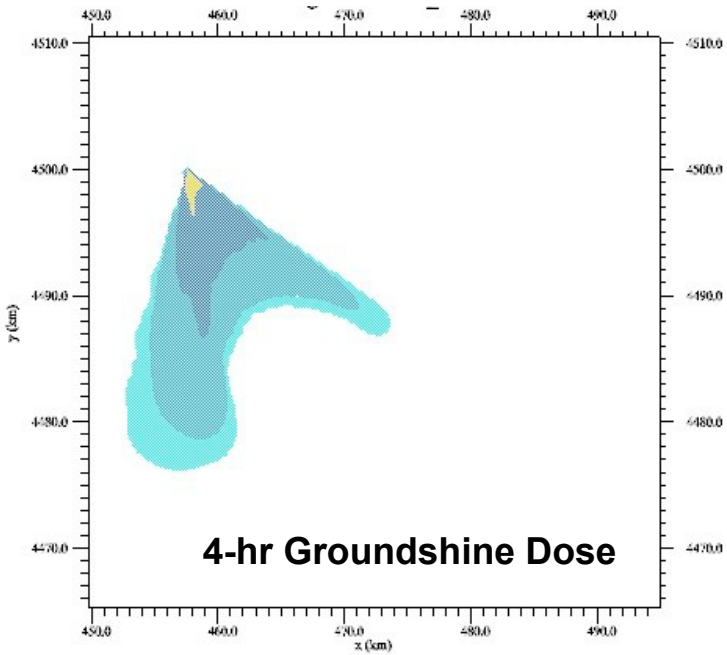
NARAC uses new LANL Database of Time-varying Population Density to Estimate Affected Population



Example for Washington, DC

NARAC is Collaborating on Developing an Advanced Nuclear Fallout Model

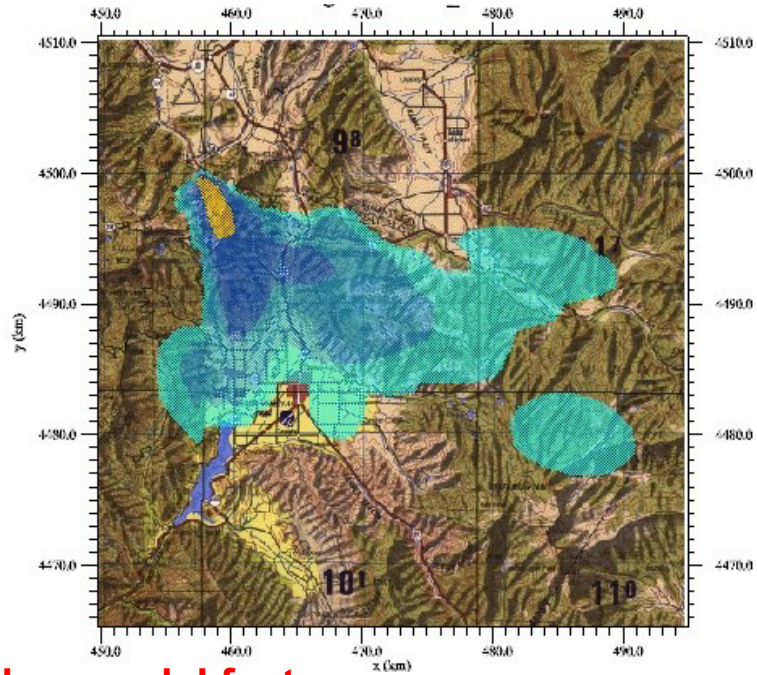
Existing Operational Model (KDFOC)



Existing model features:

- 1-D (vertical) wind variation
- Large fallout particles
- Gross activity
- Groundshine
- Buried, surface or air burst

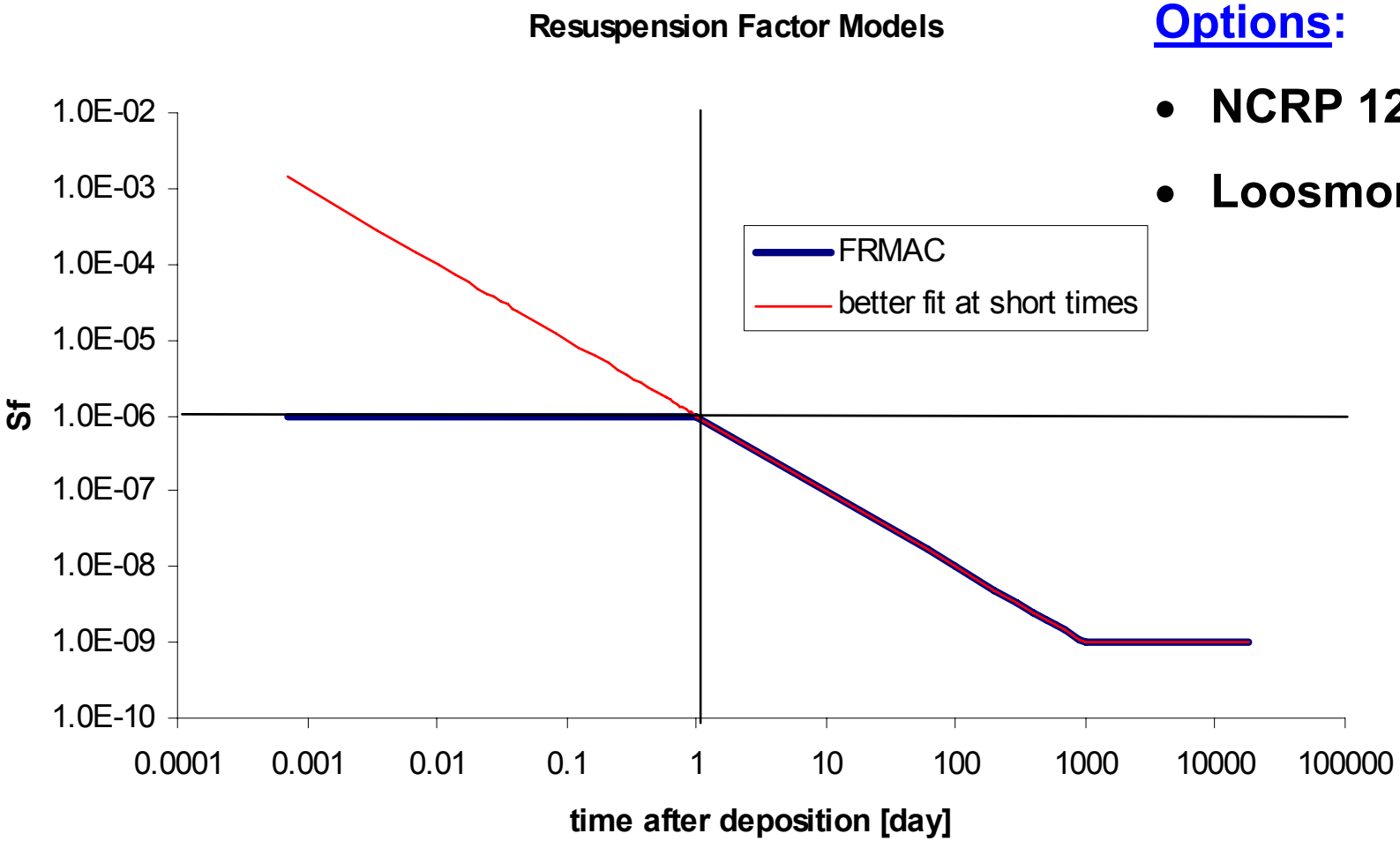
New Model (LODI-FOC)



New model features:

- 4-D wind variation & terrain effects
- Large and respirable particles
- Gross activity & specific nuclides
- Groundshine, cloudshine & inhalation doses
- Rainout
- Long-range transport
- Buried, surface or air burst; Multi-bursts

NARAC Resuspension Upgrades



Options:

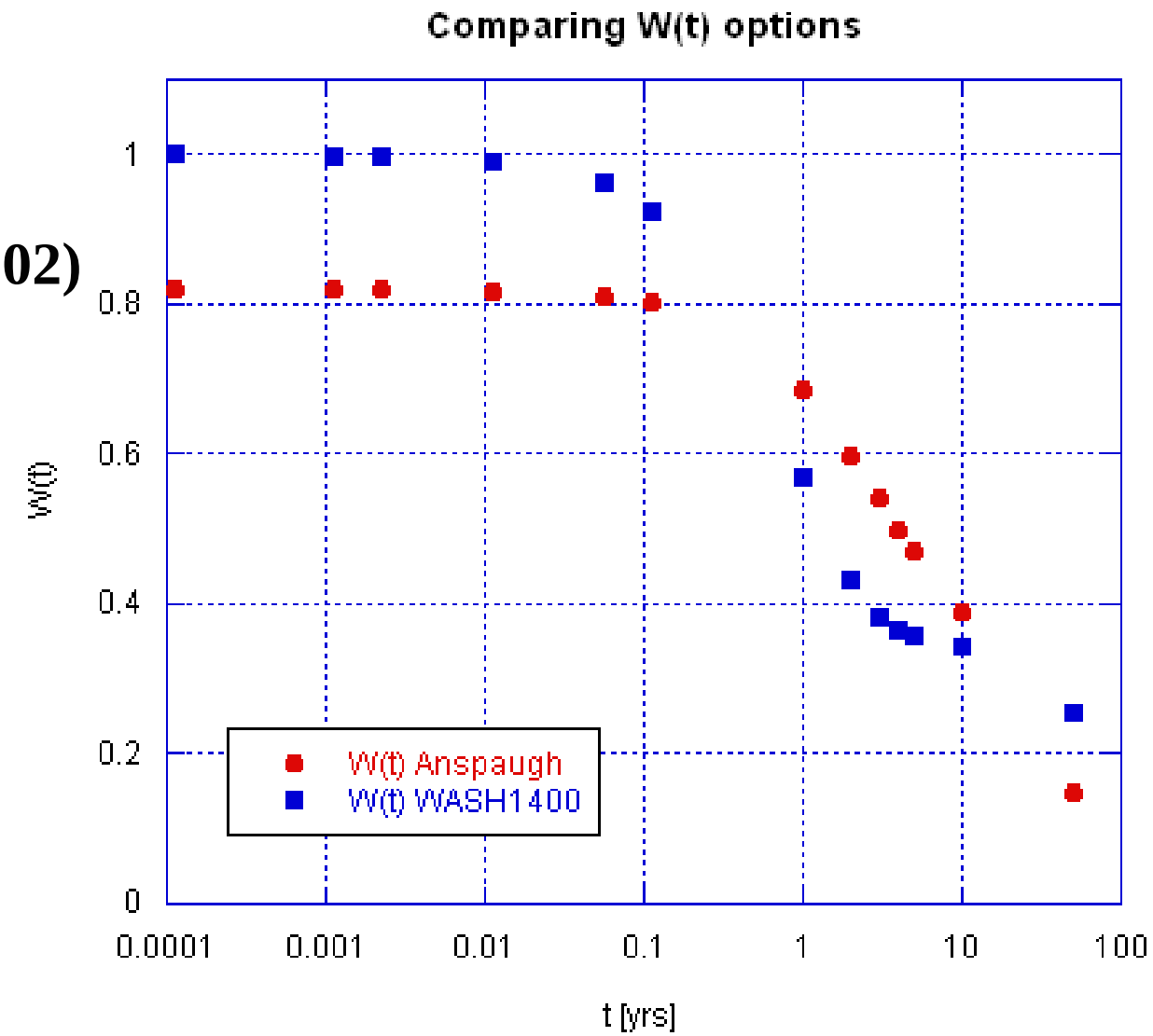
- **NCRP 129 (FRMAC)**
- **Loosmore (2003)**

Loosmore, G.A., *Evaluation and Development of Models for Resuspension of Aerosols at Short Times After Deposition.* Atmospheric Environment, 2003. **37:** 639-647

NARAC Weathering Factor Upgrades

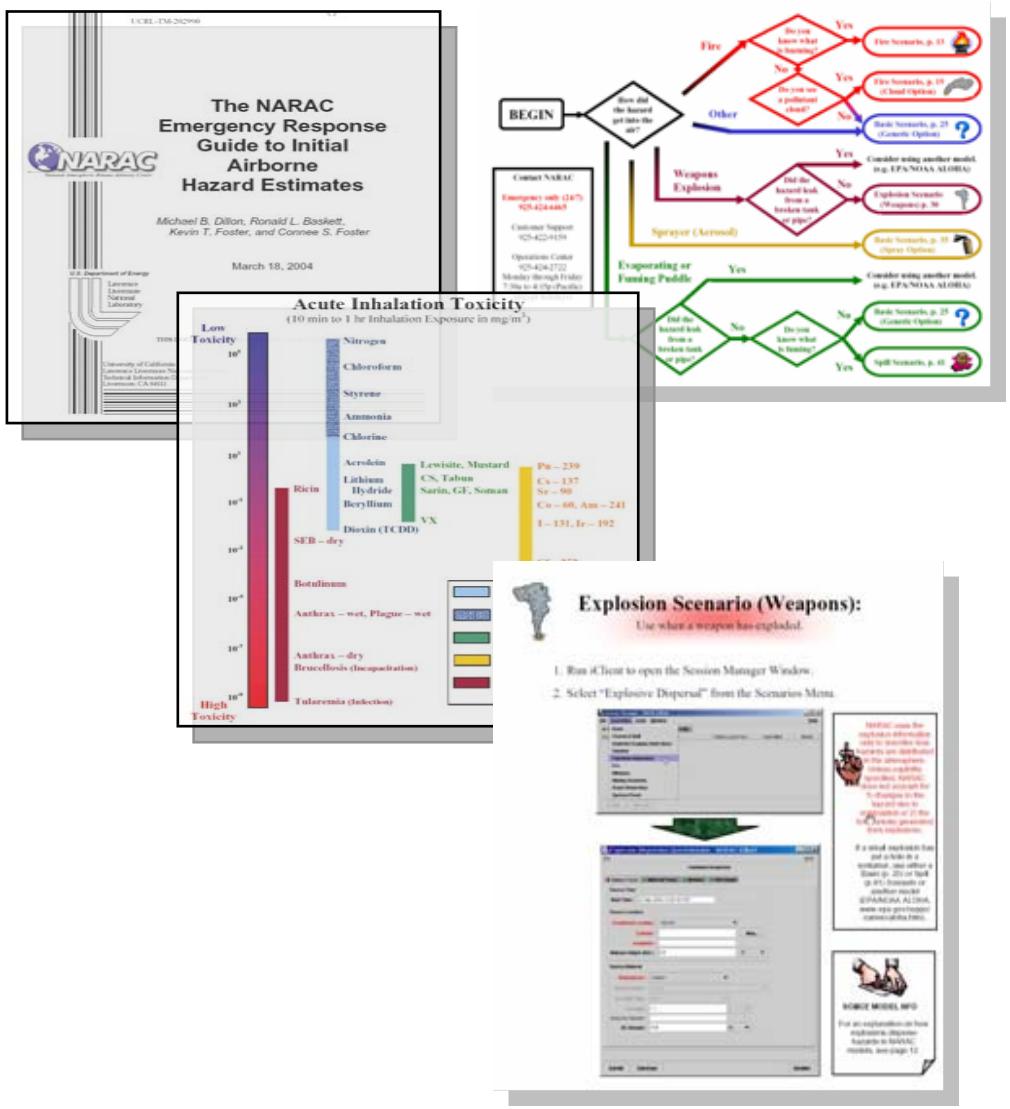
Options:

- **WASH 1400**
- **Anspaugh (2002)**



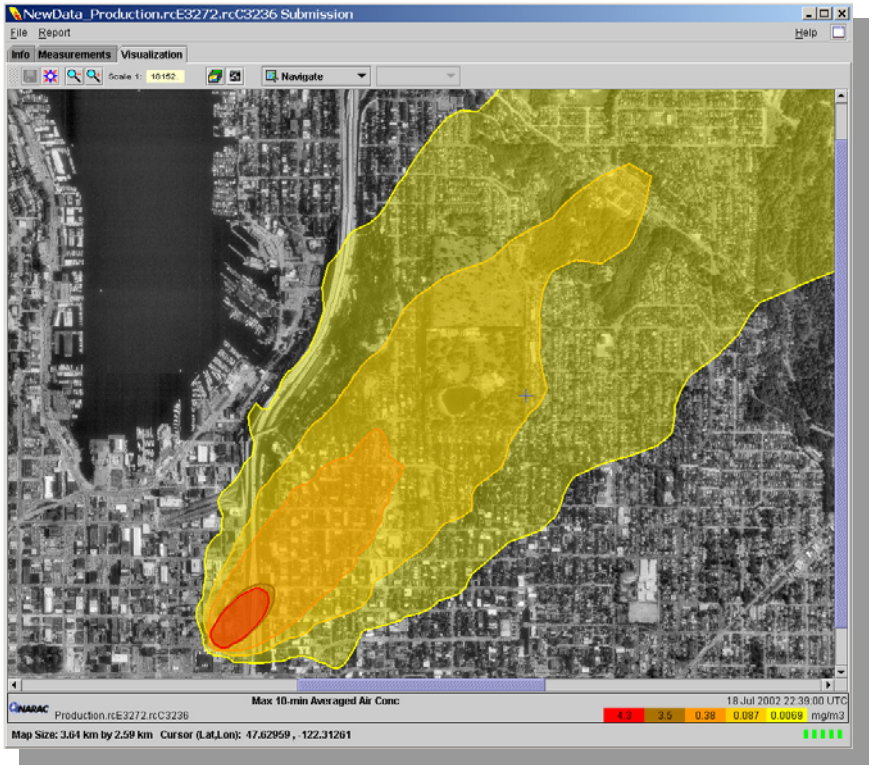
New NARAC Guidebooks and Training Materials

- Developed guidebooks for determining model inputs
- Explains model defaults and assumptions
- Step-by-step guide to NARAC iClient options
- Joint guidance material on how to use NARAC and CAMEO/ALOHA systems during an incident – in progress



Integration of NARAC and EPA/NOAA CAMEO/ALOHA Chemical Hazard Databases and Plume Modeling Tools

- Completed standardization of hazard levels and color for both ALOHA v5.3 and NARAC plume modeling results
  - Red: life threatening effects (AEGL3, ERPG3 or TEEL3)
  - Orange: serious long-lasting effects (AEGL2, ERPG2 or TEEL2)
  - Yellow: notable discomfort (AEGL1, ERPG1 or TEEL1)
- Designing software interface between CAMEO/ALOHA and NARAC iClient
- Standardized on chemical material property databases (DIPPR)



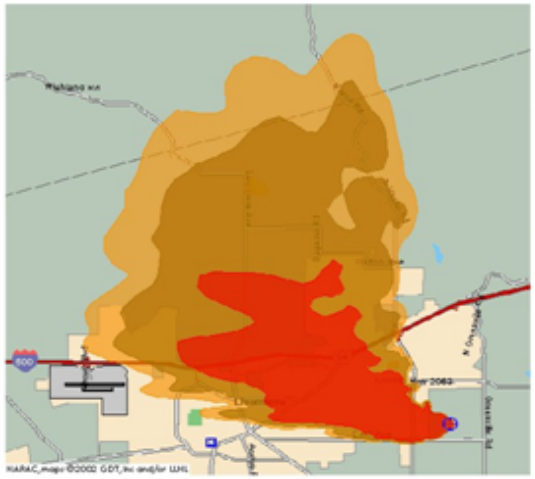
AEGL: EPA Acute Emergency Guideline Level
ERPG: American Industrial Hygiene Association (AIHA) Emergency Response Planning Guideline
TEEL: DOE Subcommittee on Consequence Assessment & Protective Actions (SCAPA) Temporary Emergency Exposure Limits

Expanded NARAC-Sandia Model Products and Reports

- Multi-page format
- Input data and assumptions
- Expanded descriptions of products and interpretation guide
- Definition of terms
- Approvals
- Date/time issued
- Input data and assumptions:
  - Source term
  - Field measurements
  - Weather data (observations/forecast)
- Future: Description of type/quality of data
  - Known, estimated or unknown source term
  - Model projection
  - Model prediction calibrated with measurement data

SET 1: Long–Term Population Effects and Mitigating Actions
(4–day TEDE; Chronic Effects with Early Phase PAGs)

Sample Exercise Plot
Initial Run – Testing



Map Size: 14.3 km by 14.3 km
Id: Development/EVENT_5324/wrs_0/prodexec_4/all
Narac Operations: Staff; email: narac@llnl.gov; phone: (925) 422–7627
Requested By: NARAC Operations

Effects or contamination from 19 Sep 2003 16:00 UTC to 19 Sep 2003 17:00 UTC at or near ground level.

Long–Term Effects and Actions

Level	(Rem) Area (km2) Extent (km)	Pop. exposed All Illnesses Fatal Illnesses	Description
	>25 19.2 n/a	19,791 1,539 698	Increased cancer risk. Evac. Req. Respiratory protection/sheltering req.
	>5.0 56.6 n/a	27,423 1,438 747	Evac. recommended. Shelter in place if no evacuation.
	>1.0 79.6 n/a	30,966 1,448 752	Consider evacuation. Shelter in place if no evacuation.

Note: Areas and counts in the table are cumulative.
Acute (short–term) effects are not included in these figures.

Source Location: 37.6841N, 121.707W
Material:
Comments ... arting at 09/19/2003 16:00:00 UTC for 1 hr

LIST OF PRODUCTS:

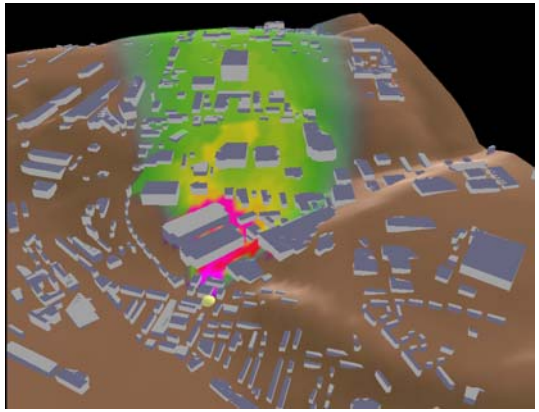
- Set 1: Short–Term Population Effects (1–day TEDE; Acute Effects)
  These effects result from the projected combined dose caused by radiation from the material deposited onto the surface, radiation from the material as it is carried in the air, and radiation from the material that has been inhaled and retained by the body. Uses a probit analysis based on published EPA relationships between compariatively high radiation doses received over short time periods and resulting percentages of the exposed population experiencing near–term fatalities or non–fatal deleterious health effects. Presents percentages of the population that will experience these effects and includes population counts of the total number exposed, number of fatalities, and combined number of fatal and non–fatal casualties.
- Set 1: Long–Term Population Effects and Mitigating Actions (4–day TEDE; Chronic Effects with Early Phase PAGs)
  Identifies areas that exceed EPA–developed dose limits at which specific protective or mitigating actions should be considered. These Protective Action Guide (PAG) limits are based on an assessment of the risk of developing cancer in exposed individuals over their lifetime or producing genetic disorders in subsequent generations. These risks result from the projected combined dose caused by radiation from the material deposited onto the surface, radiation from the material as it is carried in the air, and radiation from the material that has been inhaled and retained by the body. Presents population counts of the total number exposed, number of expected subsequent fatal cancers, and combined number of expected subsequent fatal and non–fatal cancers.

METEOROLOGY:

Canned metdata observations were used for this calculation
Precipitation is included in this calculation
PGT stability class D was used in this calculation
Profile:

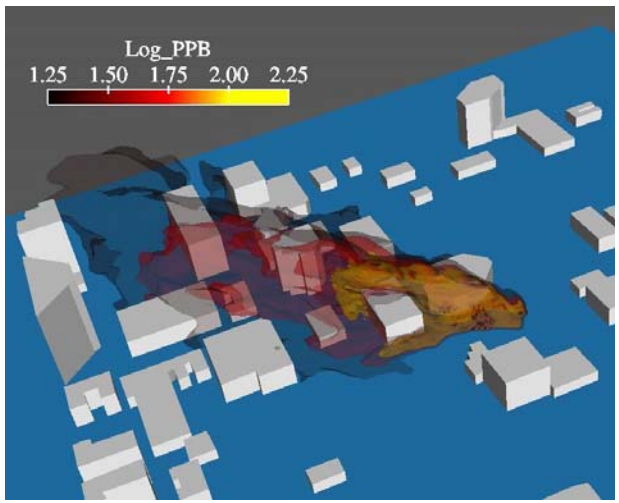
Building-scale Flow and Dispersion Models

- **Fast-running empirical UDM urban model (developed by UK DSTL)**



UDM Model

- **High-resolution building-scale computational fluid dynamics model (FEM)**

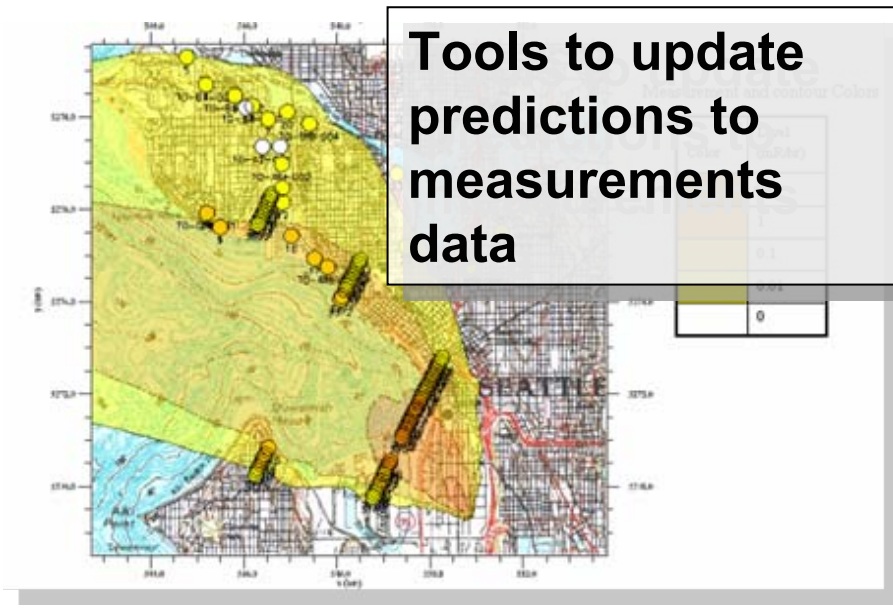


FEM Model

Automating Processing of AMS and ERDS Data for Updating Model Predictions - LLNL, RSL and SNL collaboration

- Extensible Markup Language (XML) file for storing and Web-based sharing of measurement data — self-describing text format defines measurement data, instrument, units, time, location, etc.
- Measurement data maps and visualization
- Measurement data filtering, grouping and outlier elimination
- Measurement-to-calculation ratio comparison, statistical analysis, and determination of improved source term for plume model

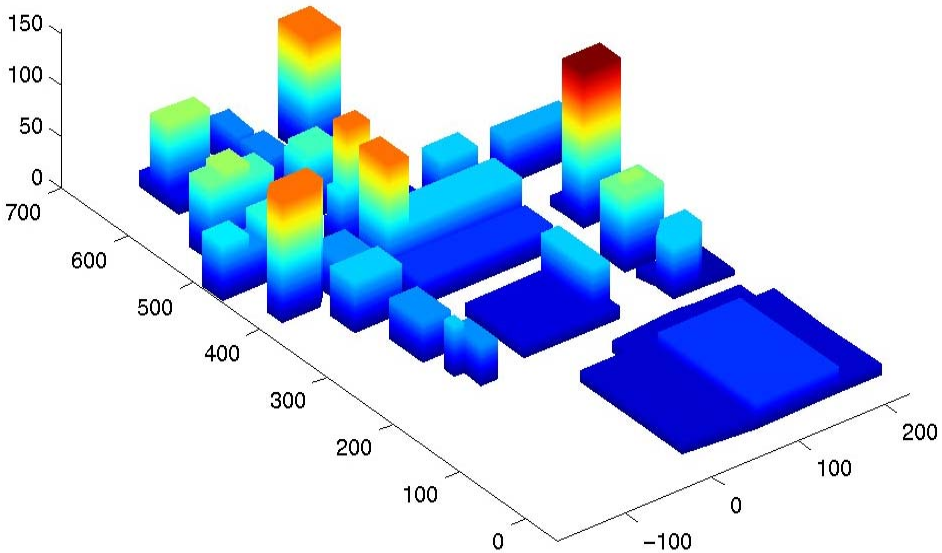
XML Measurement Data File

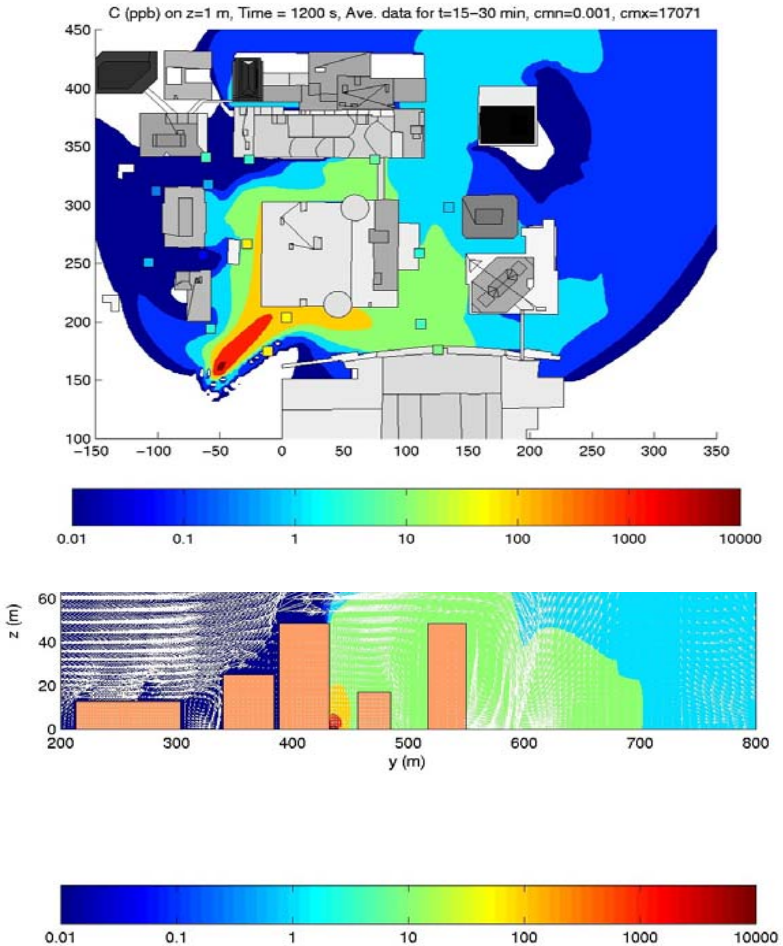


Tools to update predictions to measurements data

NARAC is using Joint Urban 2003 (JU2003) Oklahoma City Field Study Data to Evaluate Urban Models

Computational Fluid Dynamics (CFD) Model Explicitly resolves buildings in the source area



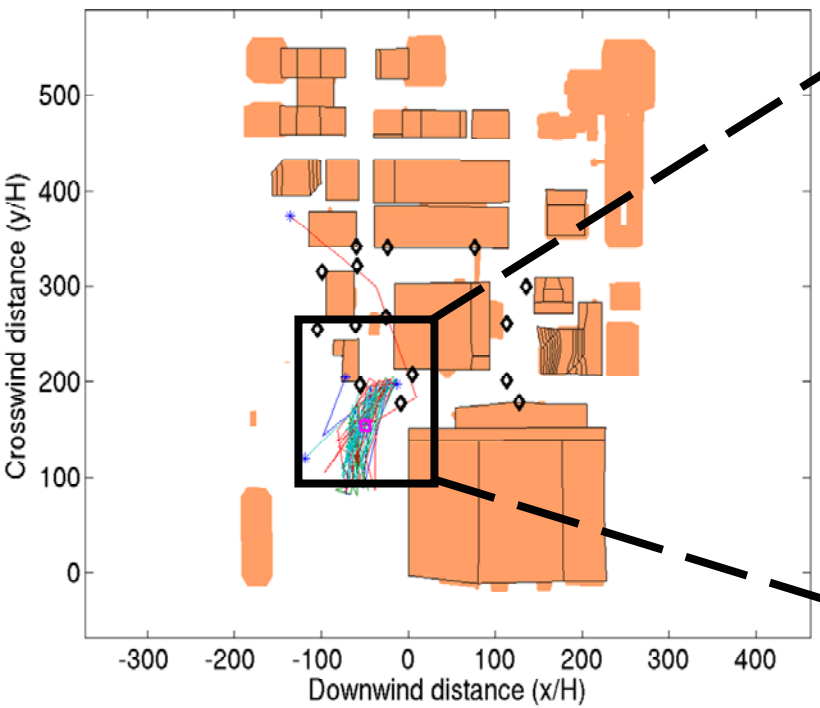


LLNL is Developing a Rigorous Method for Inverse Modeling and Event Reconstruction

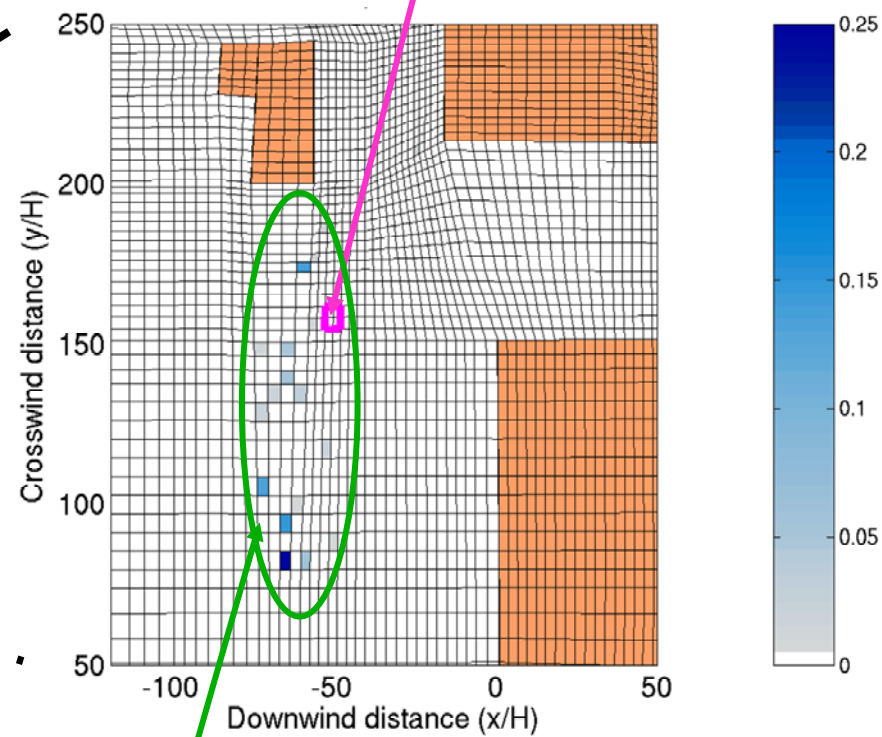
- **Goal:**
  - To automate the utilization of sensor field measurements to estimate source terms and optimize predictions
- **Approach:**
  - Couple sensor data and simulation via Bayesian inference, stochastic sampling, and optimization methods
  - Backwards analyses to determine probabilistic distribution of unknown source characteristics
  - Optimal and probabilistic forward plume model predictions

Event Reconstruction is Performed Via Bayesian Inferencing and Stochastic Sampling

Markov chain sampling



Actual source location

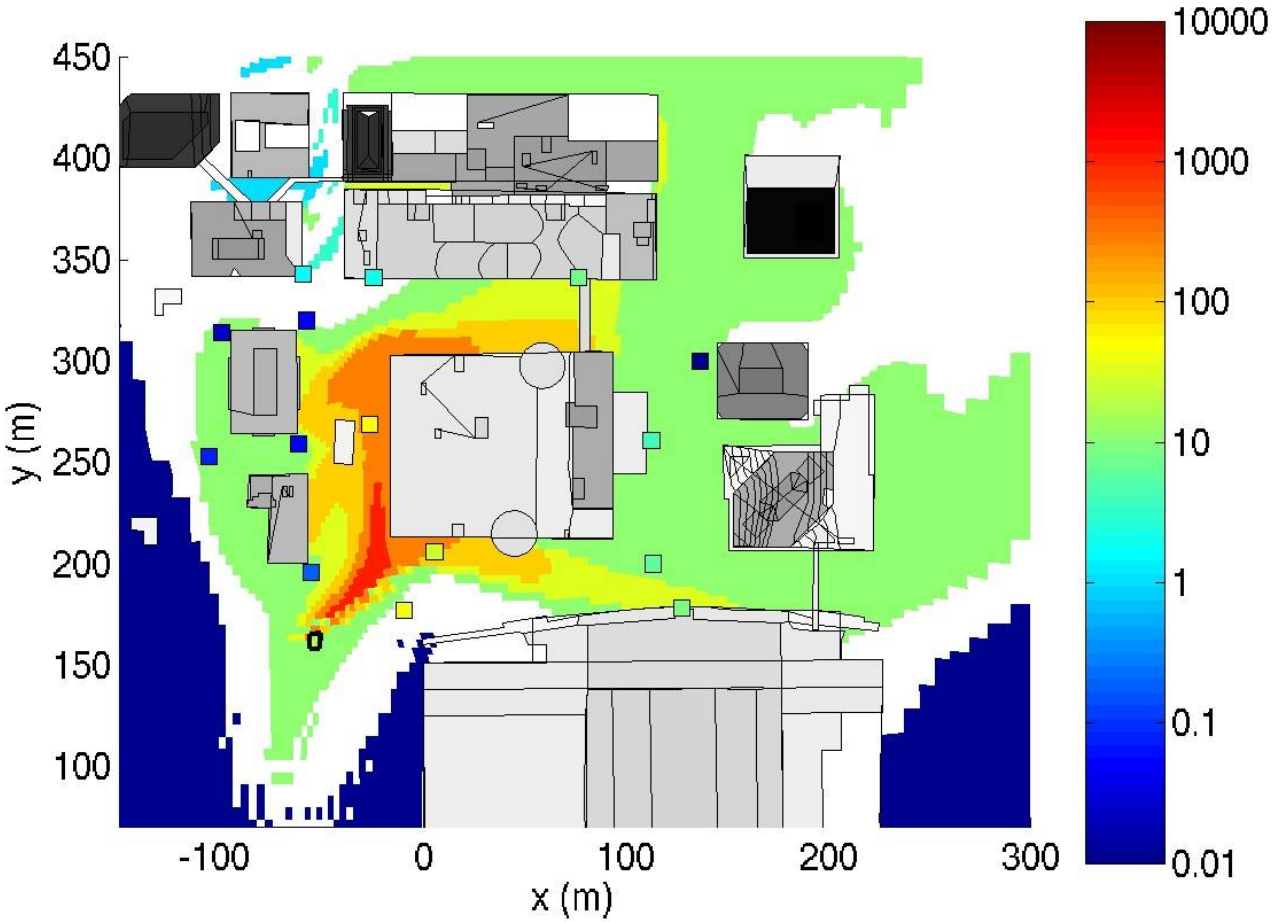


Inflow wind

Sensors (◊)

Source location determined to <½ block area

Event Reconstruction Composite Plume Provides Confidence Levels (Uncertainty Estimates)



- Contours show 90% confidence limits for given air concentration level
- Dark blue region envelopes composite plume (< 0.01 ppb)
- White indicates areas where 90% confidence limit cannot be determined (depends on chosen threshold of 0.01 ppb)

Some Key NARAC Developments

1. New database of time-varying population density to estimate affected population *with LANL*
2. Next-generation nuclear fallout model with *Sandia National Labs*
3. Expanded Sandia/NARAC automated consequence reports
4. New resuspension and weathering factors with *FRMAC Assessment WG*
5. Building effects in dispersion models with *UK DSTL*
6. Data-driven modeling to automatically optimize plume predictions with measurement
7. Exterior to interior building air exchange with *Lawrence Berkeley National Laboratory*
8. Interfaces to GIS software with *RSL*, *ESRI* and *LLNL/E&E GIS* group
9. Rainout and washout using high-resolution NOAA weather RADAR precipitation data
10. Improve resuspension models for ground-deposited contamination

LLNL NARAC-IMAAC Works Closely with Many Organizations to Provide Integrated Emergency Response Support

- **DOE National, Regional Operations Centers and Response Teams** — Headquarters and regional EOCs, RAP, ARG, RAP, NRAT, JTOT, CM/FRMAC, AMS, Triage, REAC
- **DHS National and Regional Operations Centers and Response Teams** — HSOC, FEMA NRCC and RRCCs, TSOC, WMDO-IM, and USCG, US Secret Service
- **Federal, Interagency Response Centers and Teams** — IMAAC (includes DHS, DOD, DOE, EPA, NASA, NRC), FRMAC (with DOE and EPA), Federal Advisory Team for Environment, Food and Health (includes EPA, USDA and HHS)
- **Nuclear Sites** — DOE sites, Naval Reactor sites, and DoD Sites
- **DOE NA-23 Office of International Emergency Management and Cooperation**
- **DOD National Operations Center and Teams** — USNORTHCOM, DTRA, National Guard
- **NRC National and Regional Operations Centers and Response Teams**
- **EPA Operations Centers and Regional Response Teams** — On-Scene Coordinators
- **NOAA National Centers and Teams** — Hazardous Material Response Division, National Centers for Environmental Prediction (NCEP), regional Weather Forecast Offices, Incident Meteorologists
- **National Laboratories —** Sandia, Remote Sensing Laboratory, Lawrence Berkeley, Argonne, Oak Ridge, Los Alamos, Pacific Northwest
- **LLNL centers of chemical, biological and nuclear expertise** — Biological Defense Knowledge Center, NSTTAR, NAP, Forensic Science Center
- **NASA** — Kennedy Space Center
- **Local and State Operations Centers and Teams** — State EOCs and agencies, DHS/LINC demonstration cities

LLNL supports over 300 collaborating local, state, and federal agencies and emergency operations centers, with over 1700 on-line users