Homeland Security Research at the EOHSI Center for Exposure and Risk Modeling (CERM)

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Exposure Measurement and Assessment Division
Environmental and Occupational Health Sciences Institute (EOHSI)
a joint project of UMDNJ – R. W. Johnson Medical School and Rutgers University
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Overview of Homeland Security Research at CERM

Aims:

- to develop, evaluate and refine computational tools for characterizing population exposures and doses associated with chemical and biological agents released during emergency events

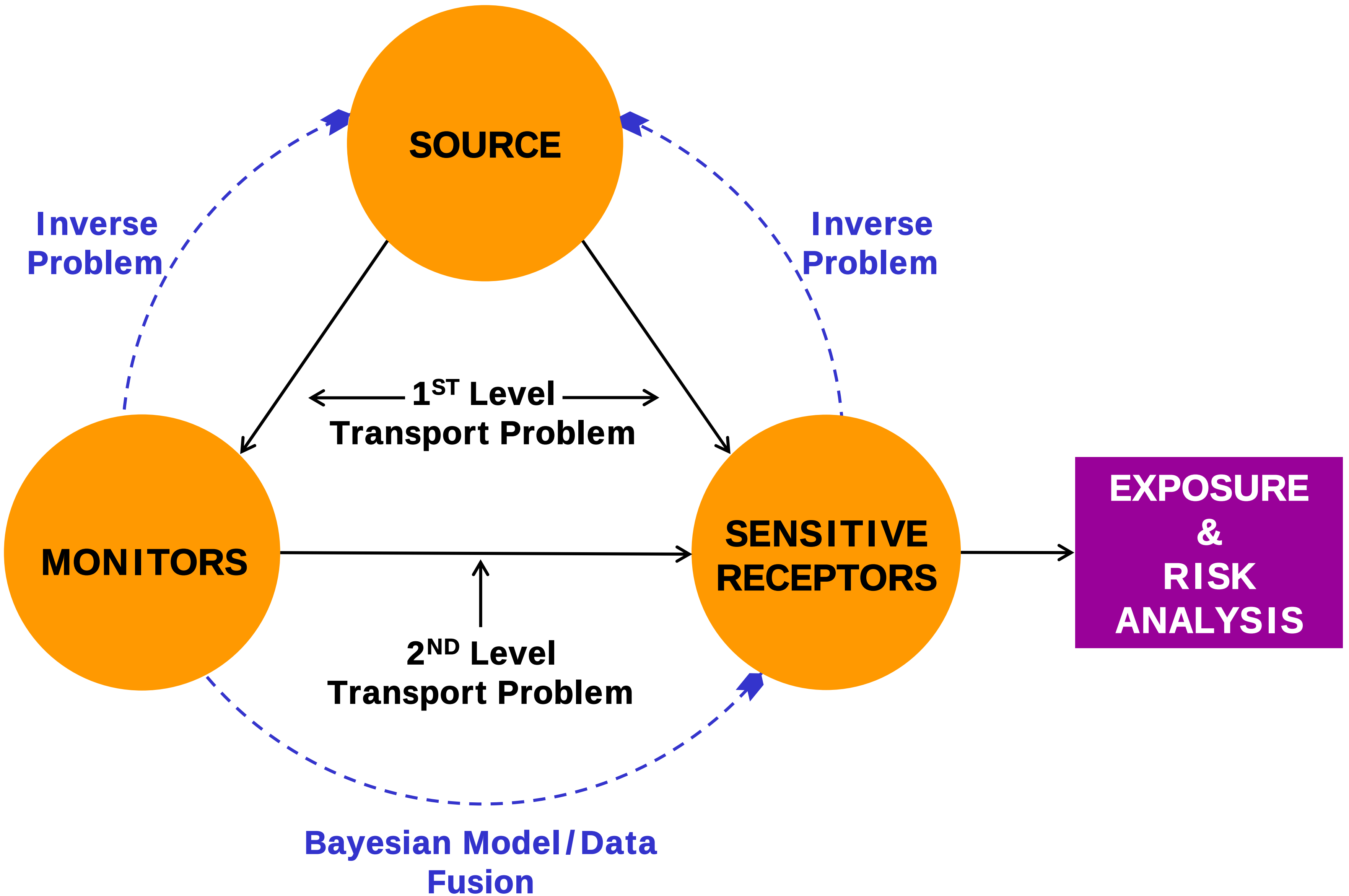
Computational tools:

- predictive environmental and biological models for contaminant release, transport, and fate
  - *multiple spatial scales (e.g. regional, urban, local, neighborhood, microenvironmental, personal, organ/tissue)*
  - *multiple temporal scales (e.g. from seconds to weeks)*
- integrated exposure information systems for dynamic linking of models with comprehensive databases and Geographic Information Systems characterizing
  - *environments/microenvironments (via e.g. meteorology, hydrogeology, land use and cover, building properties, etc.)*
  - *populations (via demographic attributes, activity patterns, etc.).*

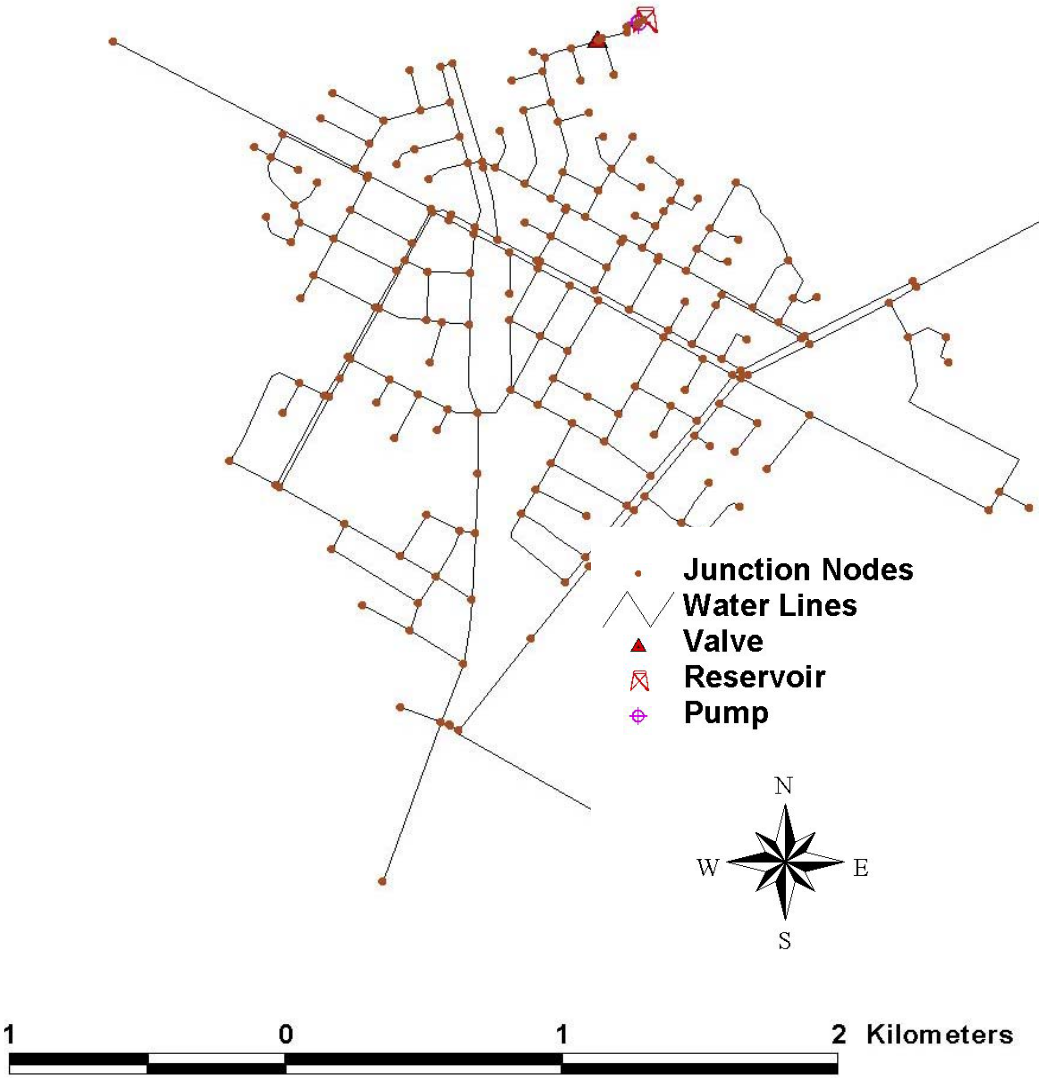
Examples of Currently On-Going Homeland Security Related Projects at CERM Include:

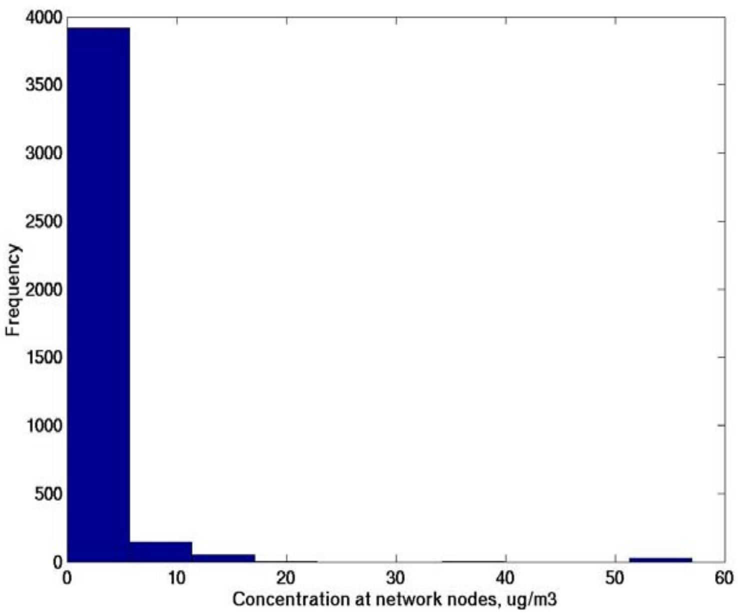
- Evaluation of existing environmental fate/transport models for their applicability and limitations in emergency situations; refinement of models
- Modeling studies of emergency events (such as fires) at or near nuclear and hazardous waste facilities
- Development of prototype source-to-dose modeling systems for characterizing multipathway exposures to chemical and biological warfare agents
- Reconstruction of population exposures to the contaminants released from the fires and collapse of the World Trade Center on 9/11/2001
  - *to provide analyses of lessons learned and to support a variety of health impact studies*
- Development and application of computationally efficient "model/data fusion" techniques for real-time
  - *inverse problem solution (source characterization)*
  - *Bayesian real-time model "calibration"*
  - *uncertainty characterization and reduction*
- Analysis and optimization of spatiotemporal contaminant monitoring network designs.
- Development of protocols for hospital personnel response to emergency events involving chemical warfare agents

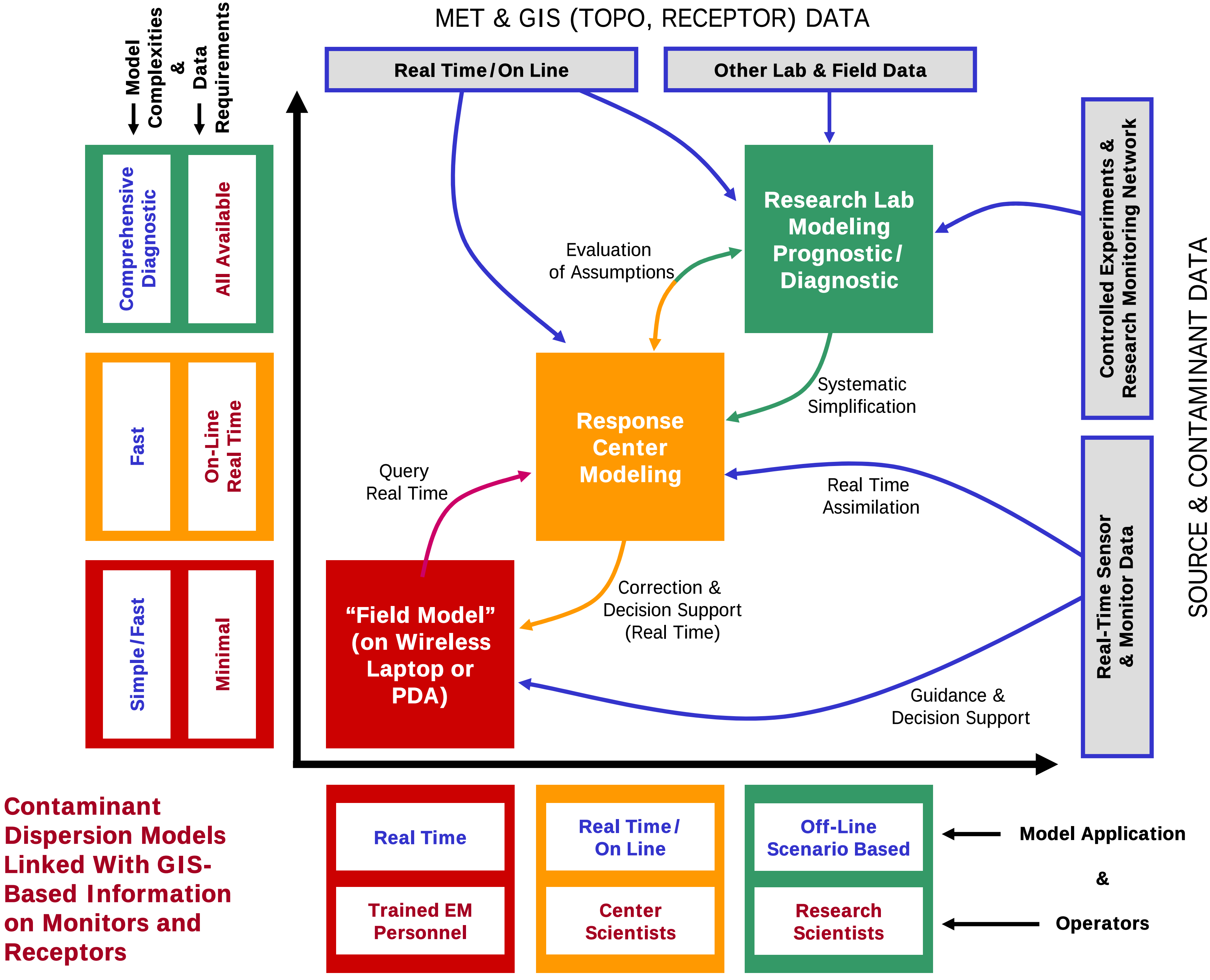
Modeling for Emergency Response: A Framework for Model/Data Fusion with Application to Both Forward and Inverse Problems



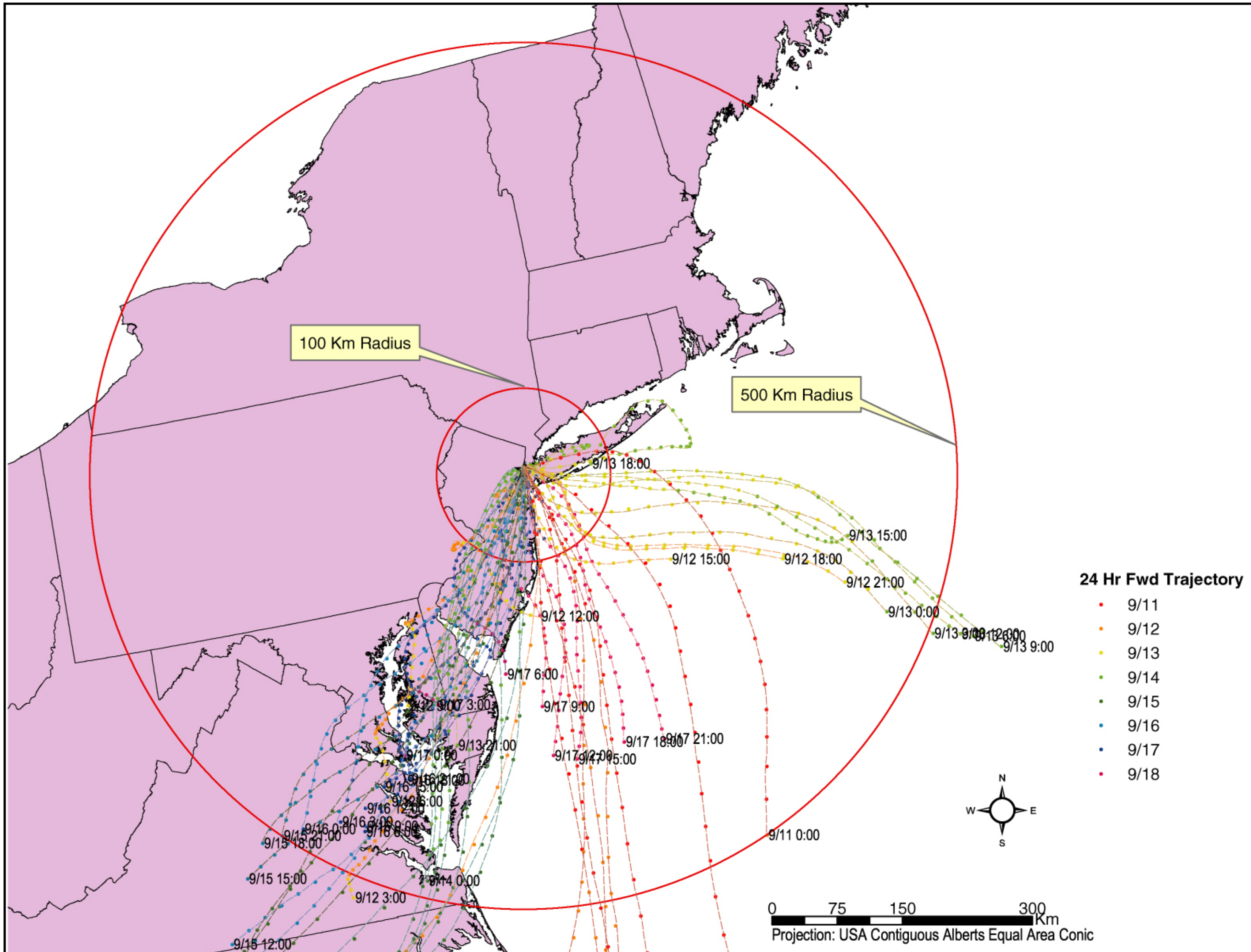
Interlude: Example EPANET Application for Distribution of a Toxicant in Municipal Water Network Involving Two Suppliers





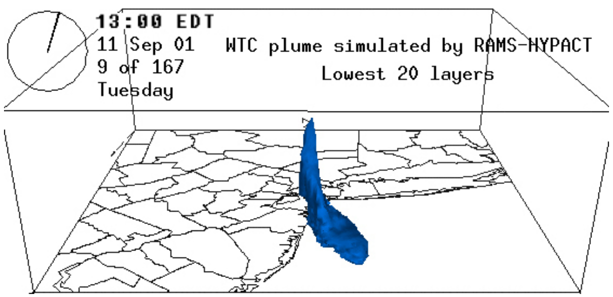

MET & GIS (TOPO, RECEPTOR) DATA
Real Time / On Line
Other Lab & Field Data
Model Complexities & Data Requirements
Comprehensive Diagnostic
All Available
Fast
On-Line Real Time
Simple / Fast
Minimal
Research Lab Modeling Prognostic / Diagnostic
Evaluation of Assumptions
Systematic Simplification
Response Center Modeling
Query Real Time
Real Time Assimilation
"Field Model" (on Wireless Laptop or PDA)
Correction & Decision Support (Real Time)
Guidance & Decision Support
Controlled Experiments & Research Monitoring Network
Real-Time Sensor & Monitor Data
SOURCE & CONTAMINANT DATA
Real Time
Trained EM Personnel
Real Time / On Line
Center Scientists
Off-Line Scenario Based
Research Scientists
Model Application
&
Operators
Contaminant Dispersion Models Linked With GIS-Based Information on Monitors and Receptors

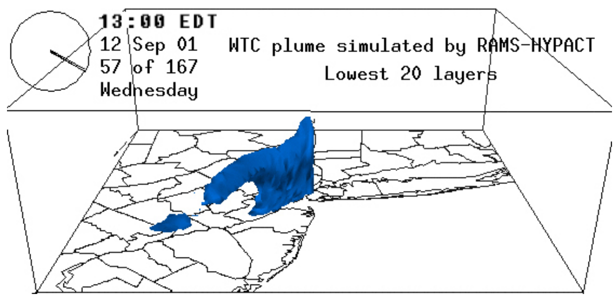
Example Ia – Regional Scale: Trajectory Analysis for Screening Regional Scale Characterization Using the NOAA HYSPLIT Model (Potential for Long Range Transport of the WTC Plume)

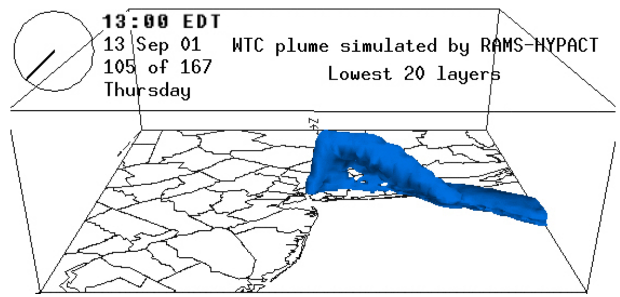


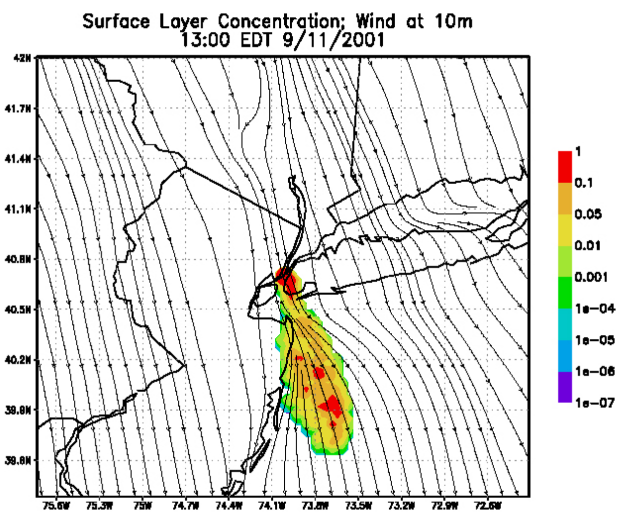
Example Ib - Mesoscale: Instantaneous Views of the WTC Plume, Simulated Using the RAMS/ HYPACT Prognostic System

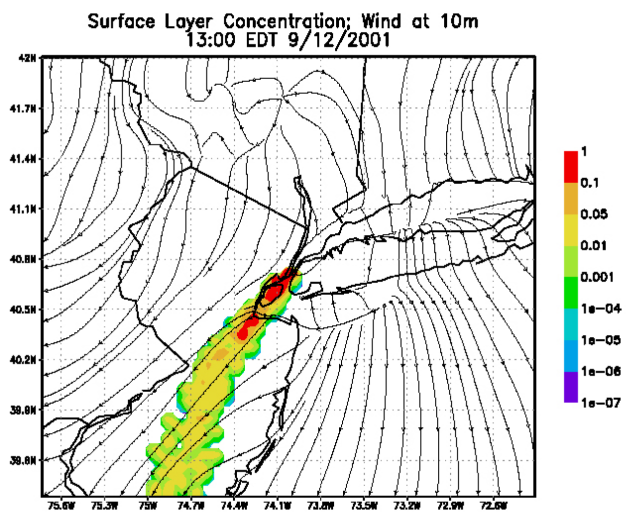
Top: 3-d Plume View; Bottom: Surface Layer Wind Fields and Concentration Gradients (Concentration Fields are Normalized with Respect to Maximum of Each Instance)

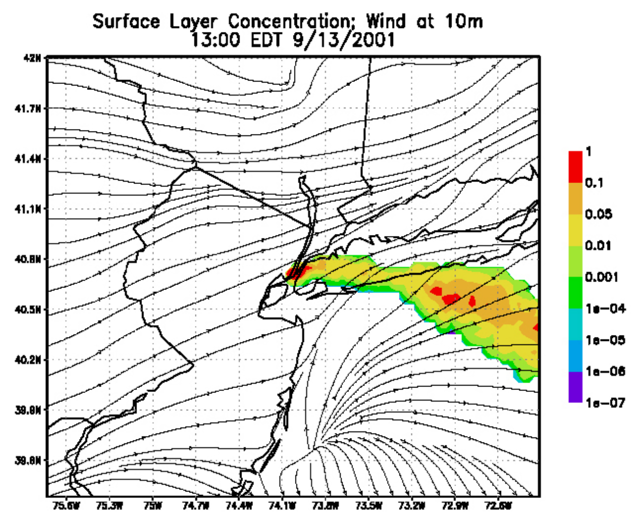




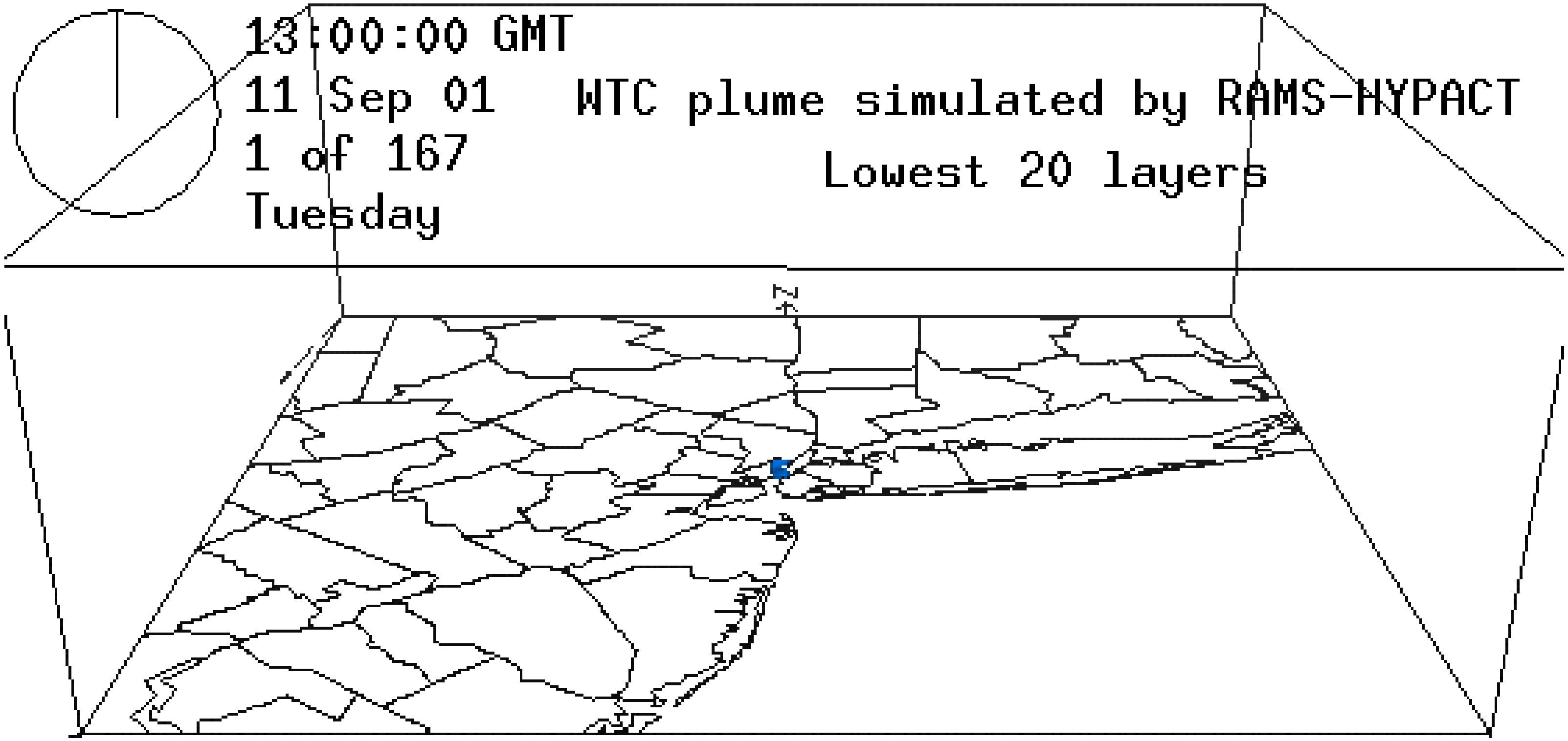




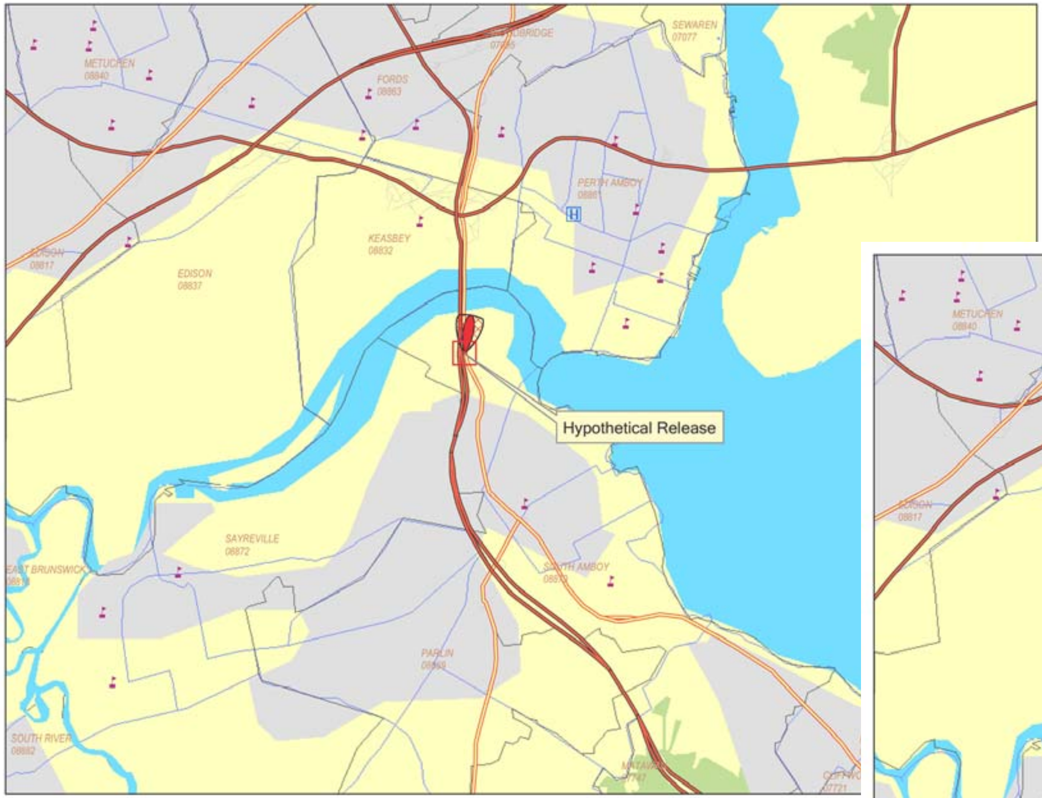




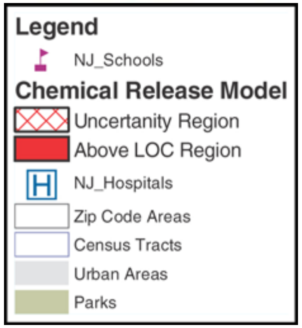
WTC Plume Dispersion Modeling Employing the Mesoscale Prognostic RAMS/HYPACT Platform

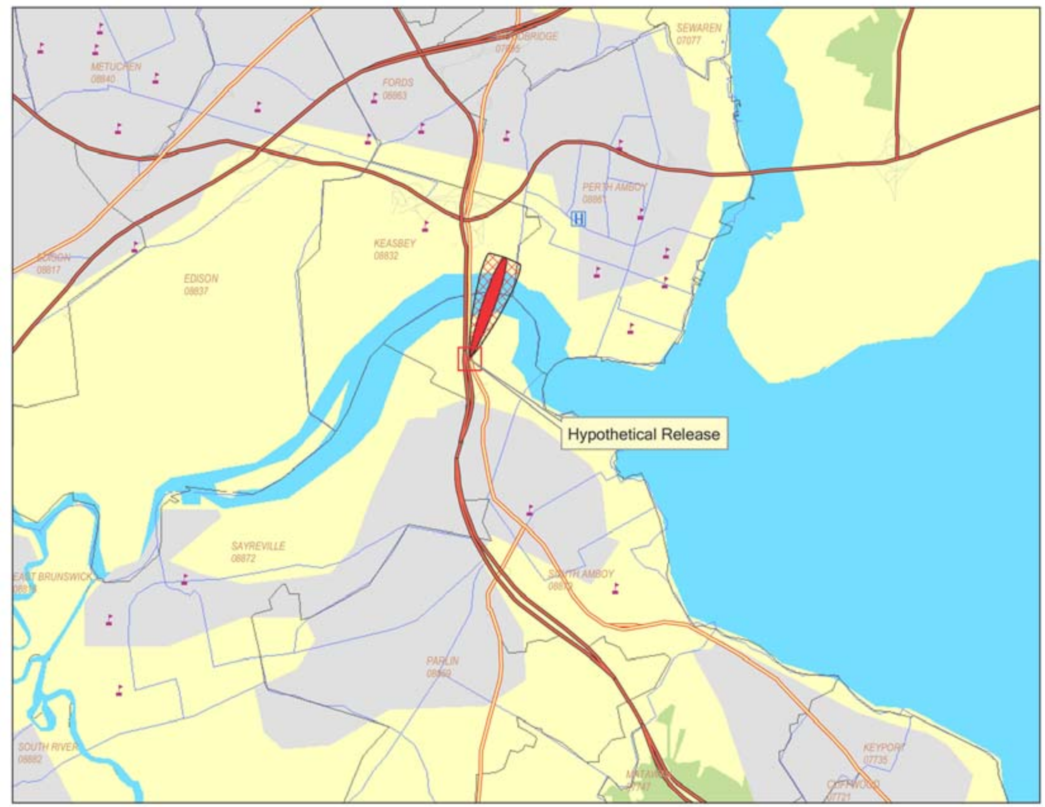


Understanding Limitations and Refining Models for Environmental Releases - Example II: Calculations of Hypothetical Release in NJ using the ALOHA Model



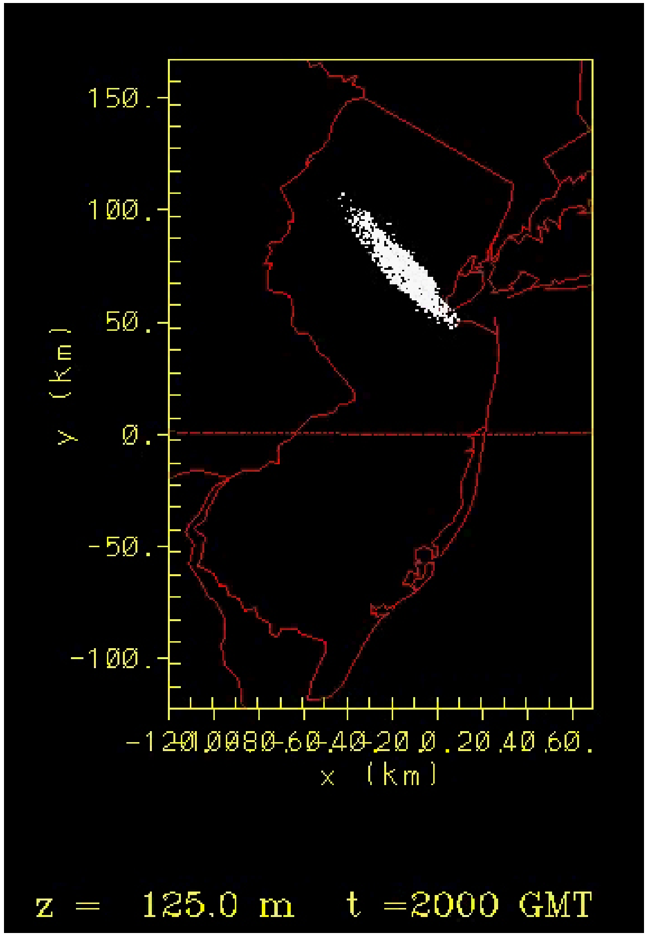
July 12, 1995, 2:00 pm

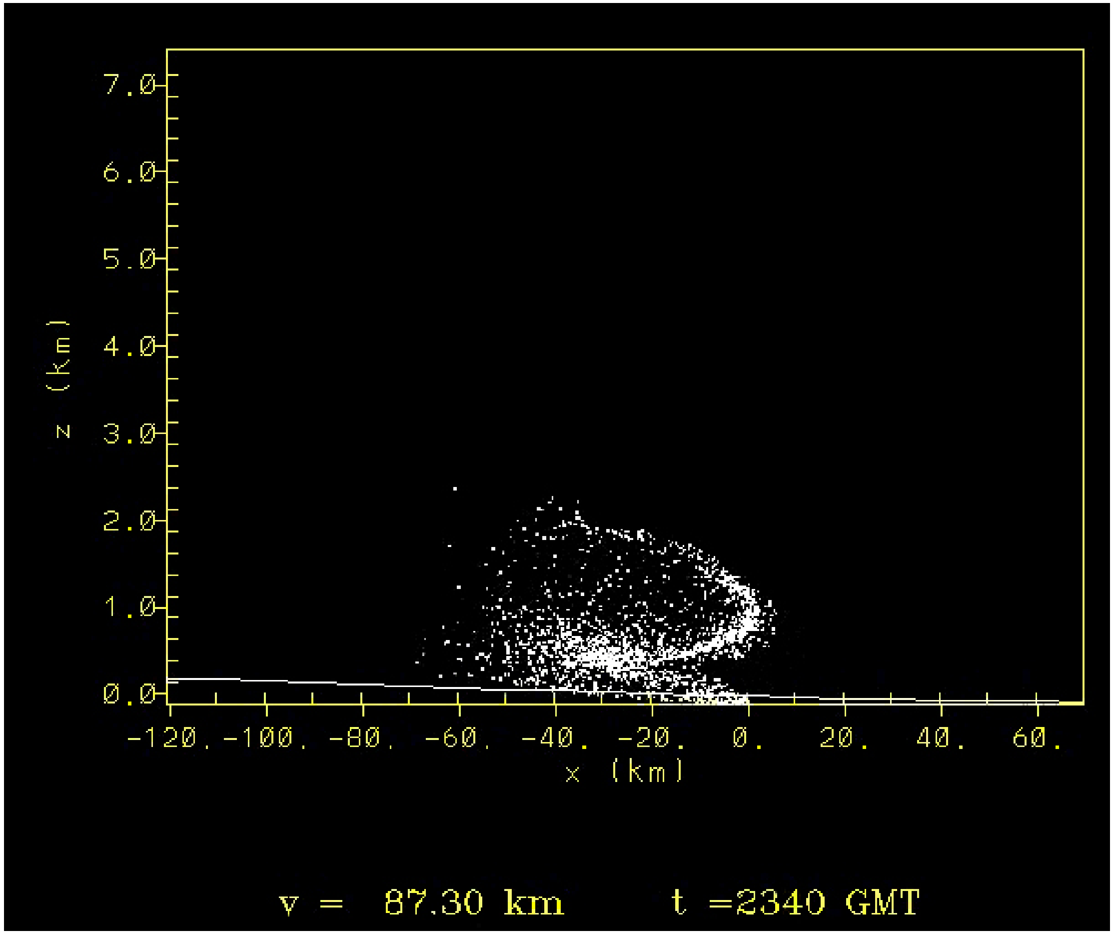




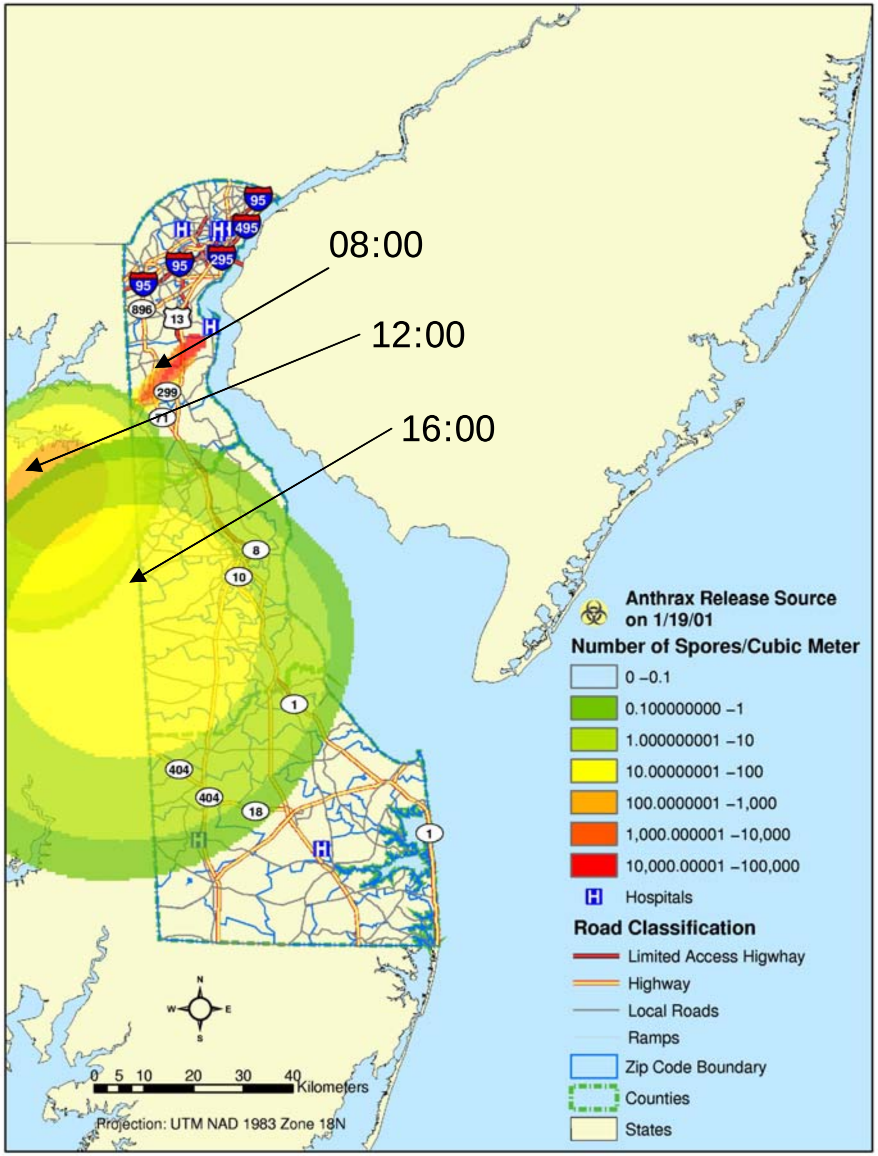
July 12, 1995, 7:00 pm

Simulation of the Same Case Study With a Comprehensive System that Accounts for Sea Breezes (RAMS-HYPACT) Produces a Very Different Picture of the Dispersing Plume

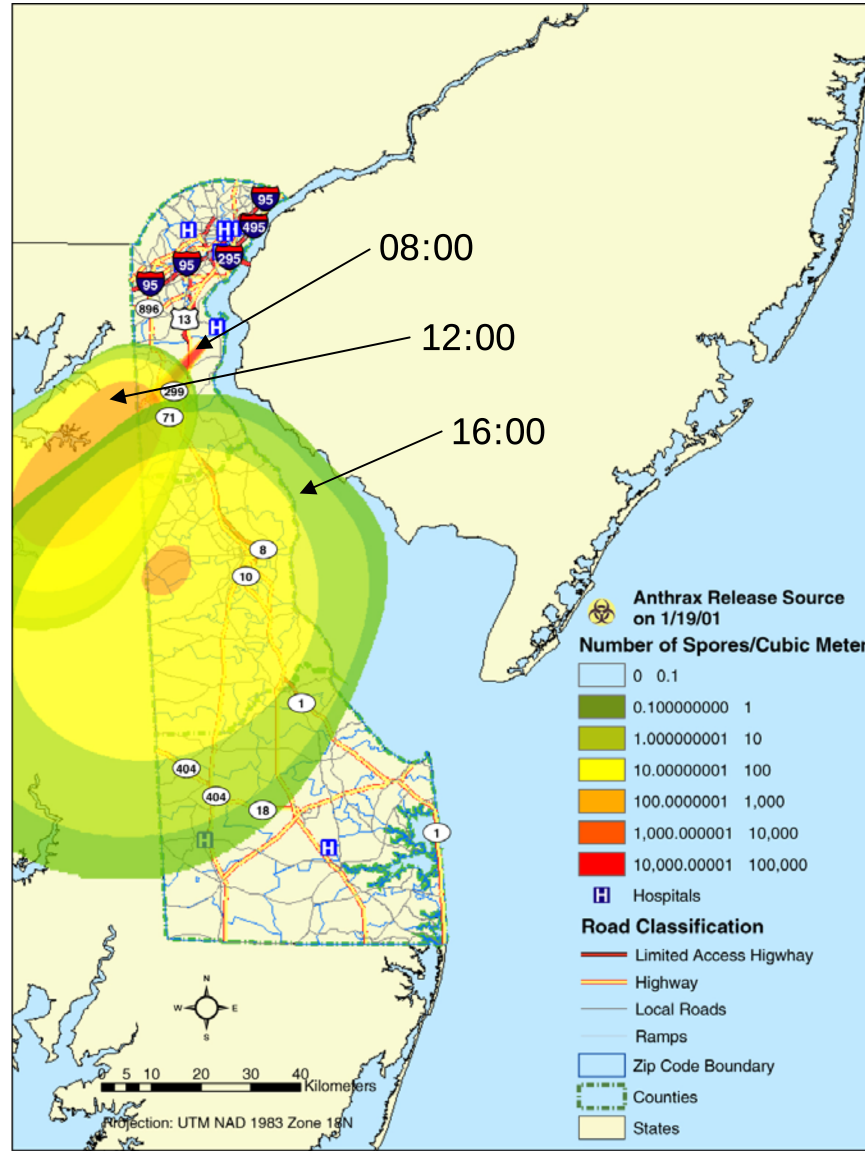




Example II: Hypothetical Anthrax Release Simulation Results from CALPUFF – Model Setup Critically Affects Predictions

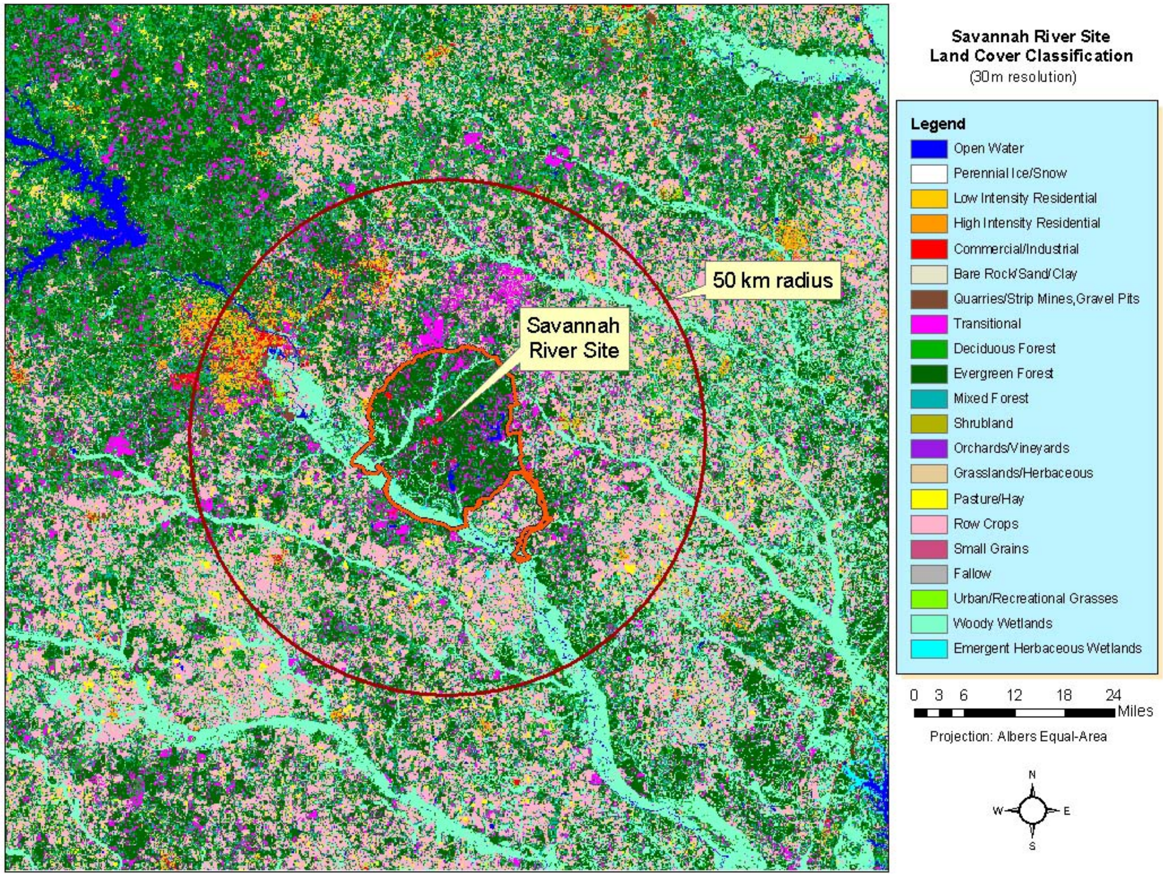


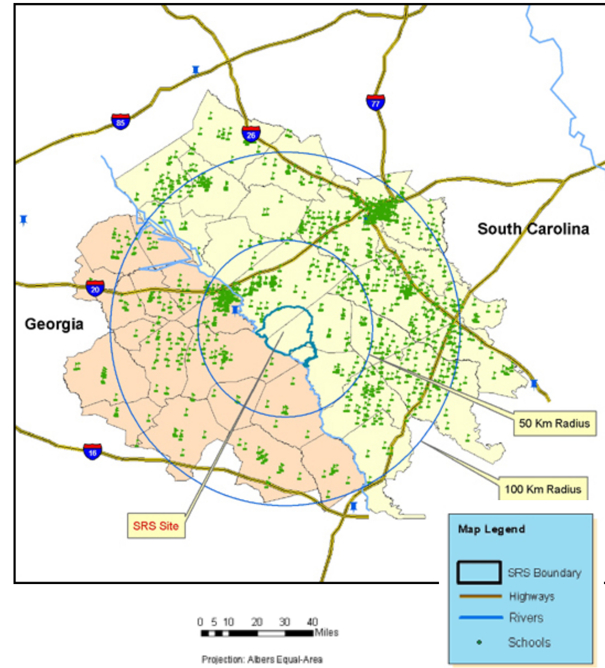
Instantaneous release modeled with CALPUFF at 1km resolution (08:00, 12:00 & 16:00)

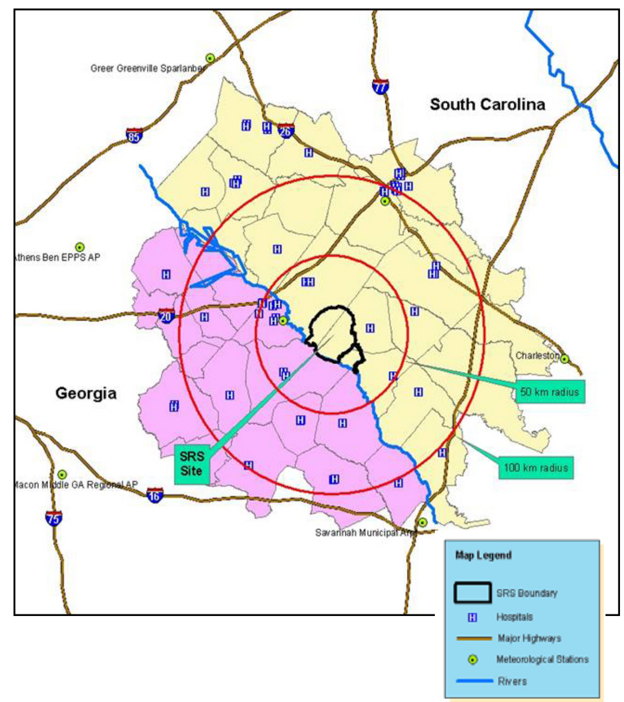


Instantaneous release modeled with CALPUFF at 250m resolution (08:00, 12:00 & 16:00)

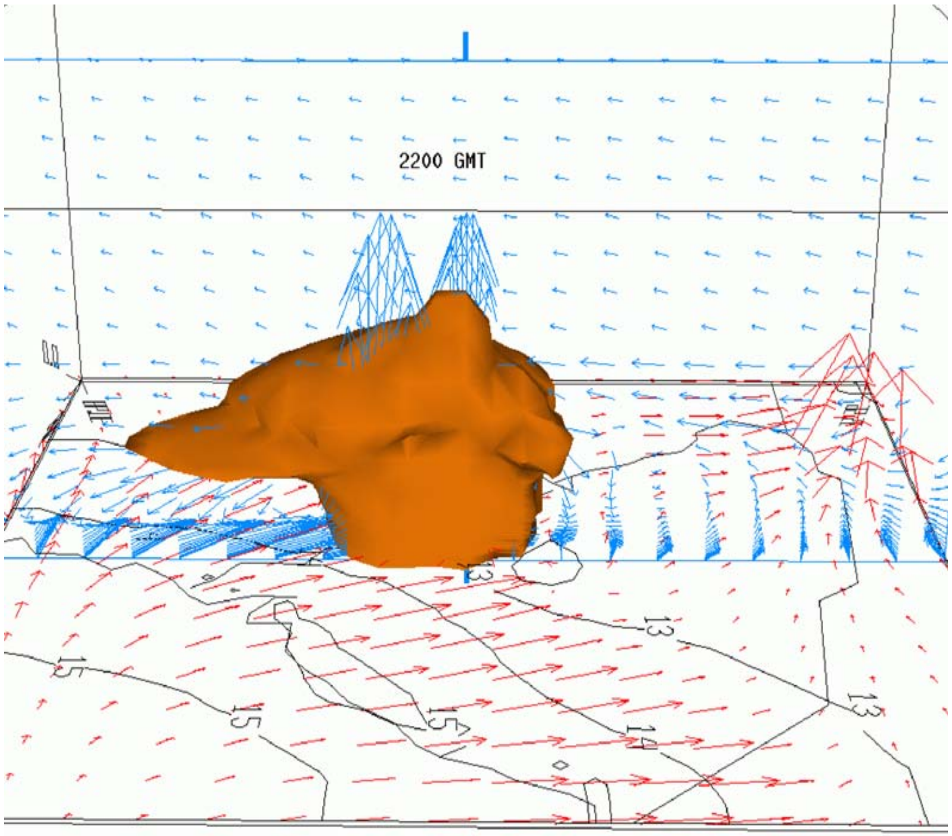
Example III: EIS for the Savannah River Site Incorporates a Variety of Spatial/Temporal Databases



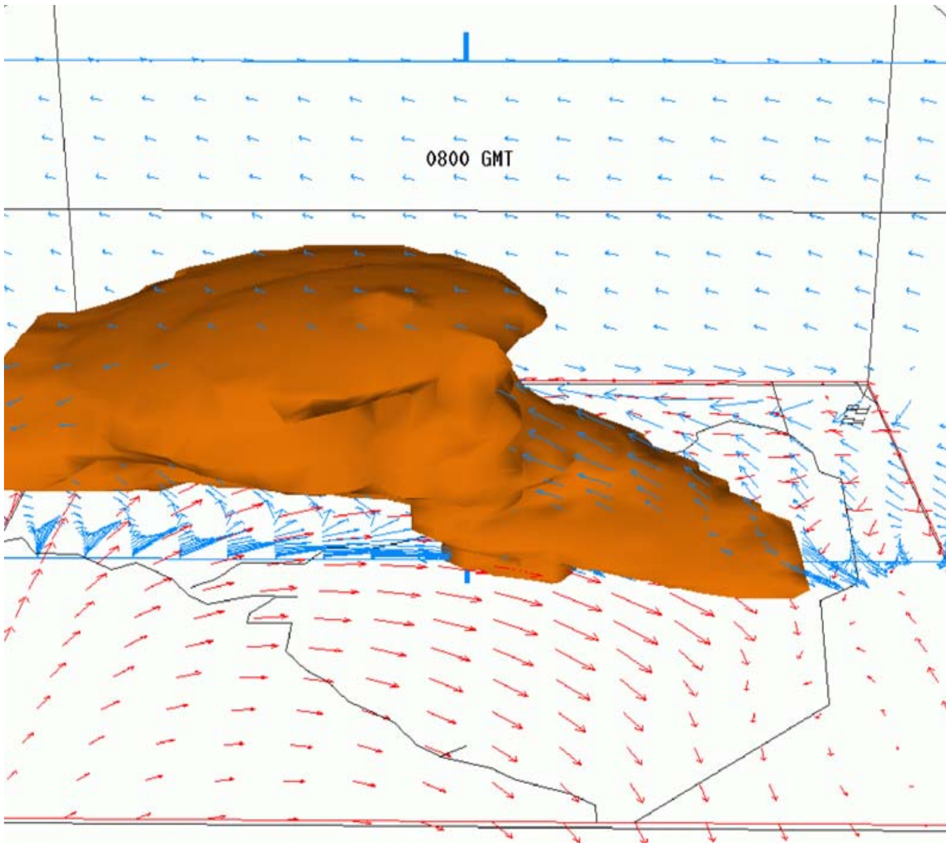




3-D Views of Smoke Plume from Controlled Forest Fire in the Vicinity of SRS (Superimposed to the ABL Wind Field)

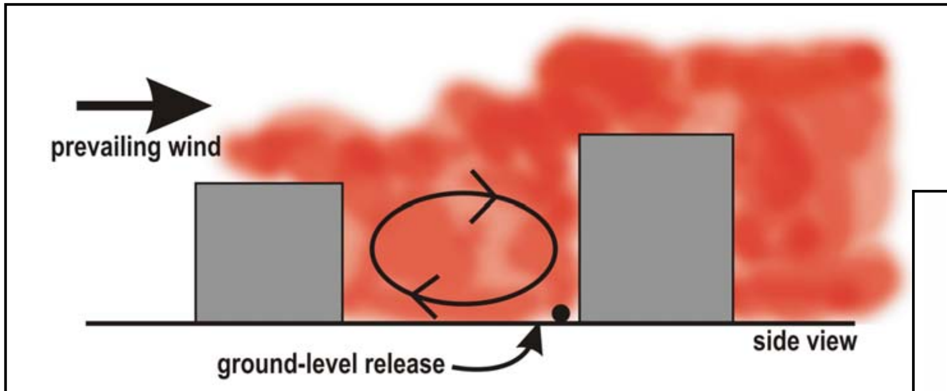


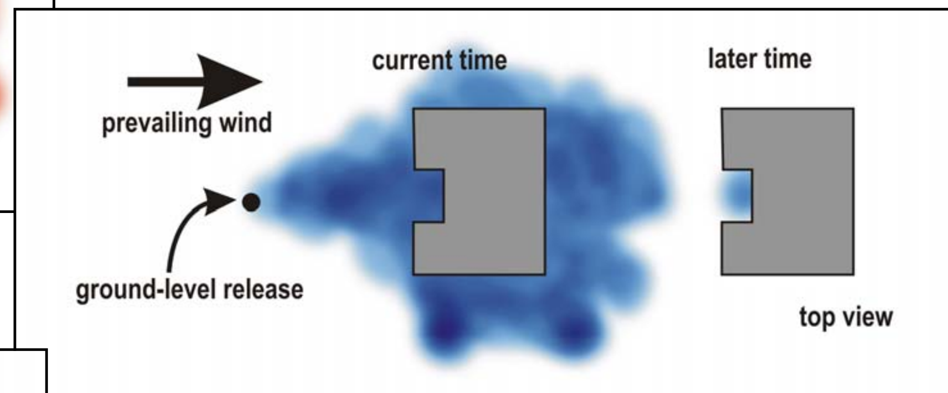
the smoke plume at 2200 GMT (5:00 PM local time)

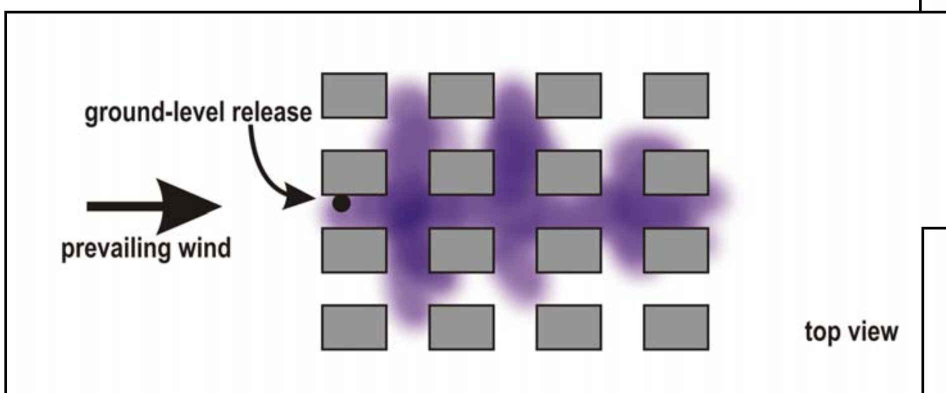


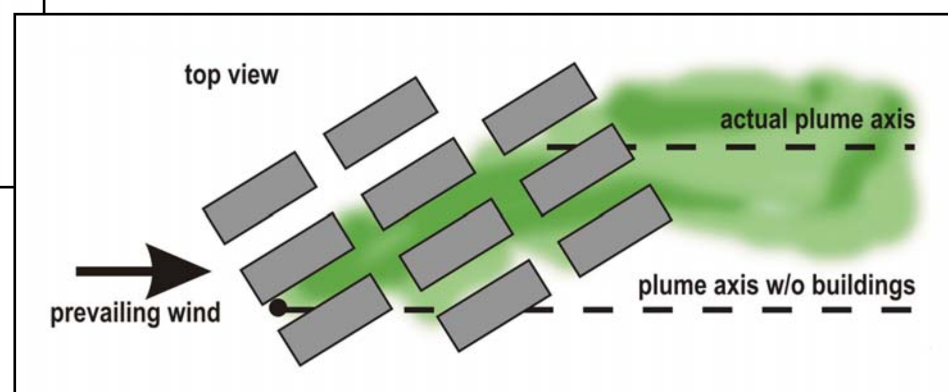
the smoke plume at 0800 GMT (3:00 AM local time, next day)

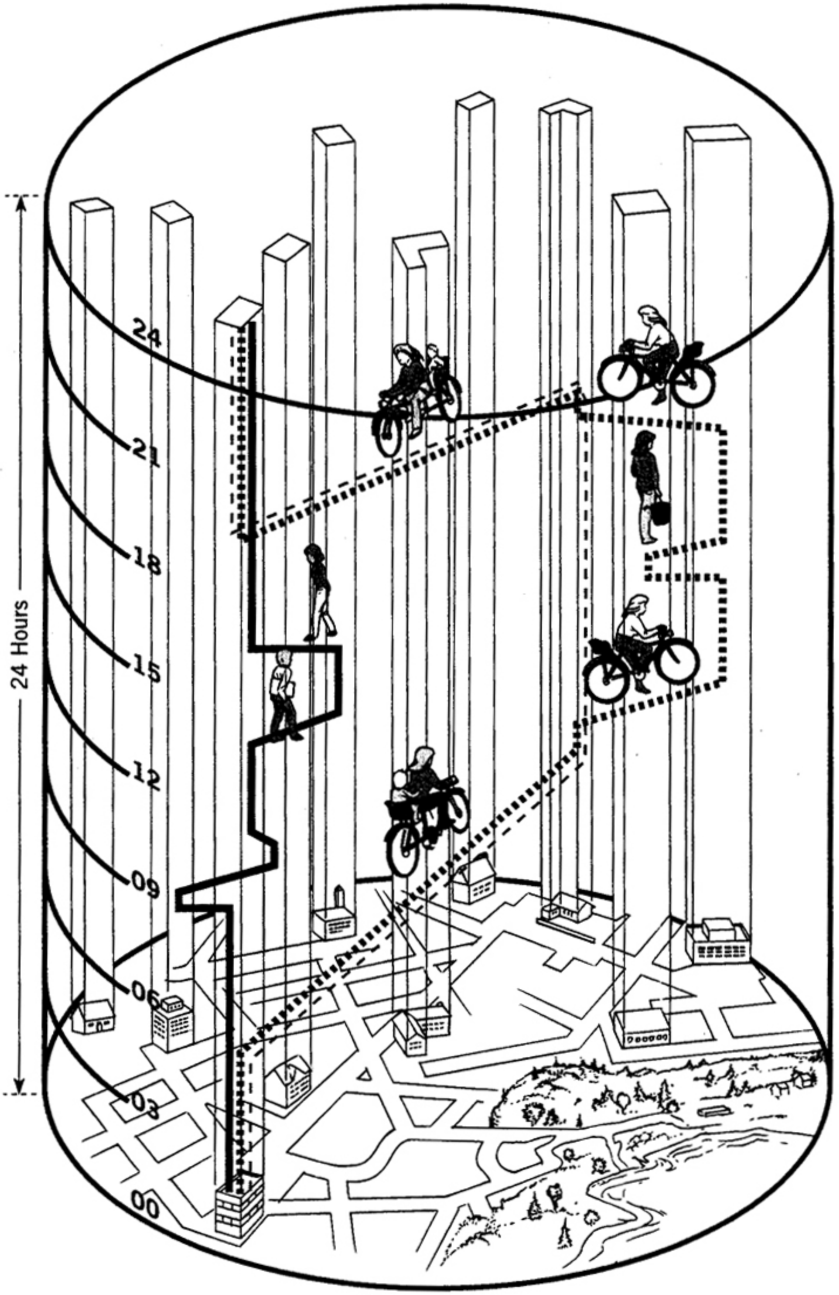
Caveat: Neighborhood Scale Effects Can Modify Significantly Estimates from Atmospheric Transport Models or from Monitor Interpolations (Barriers, Channeling, Local Flows, Trapping): Need for Both CFD & Simplified Models







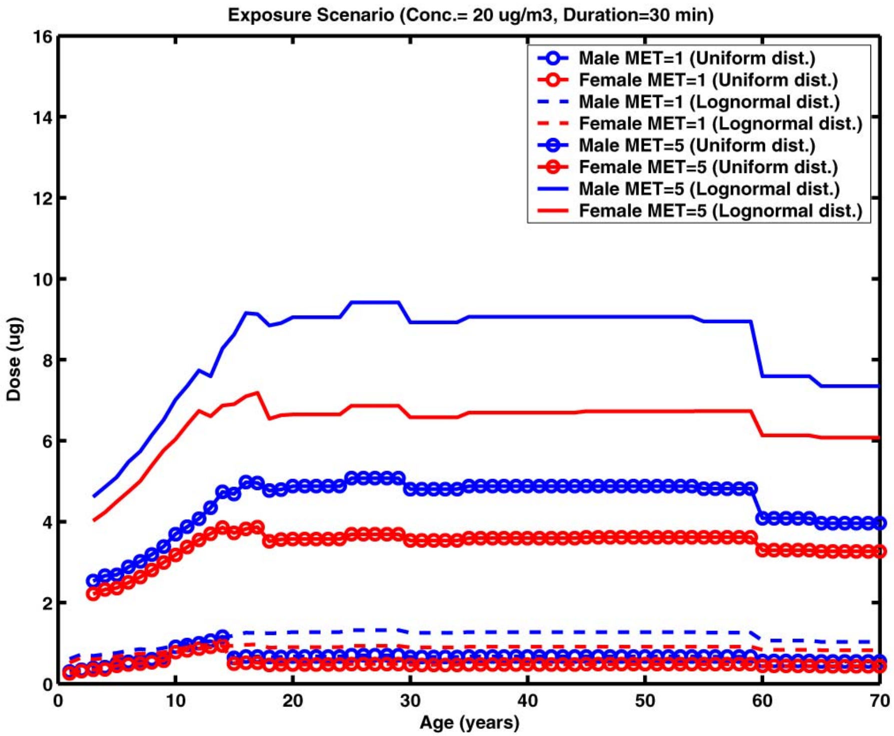




People/Time/Space: Adapted from Parkes & Thrift (1980)

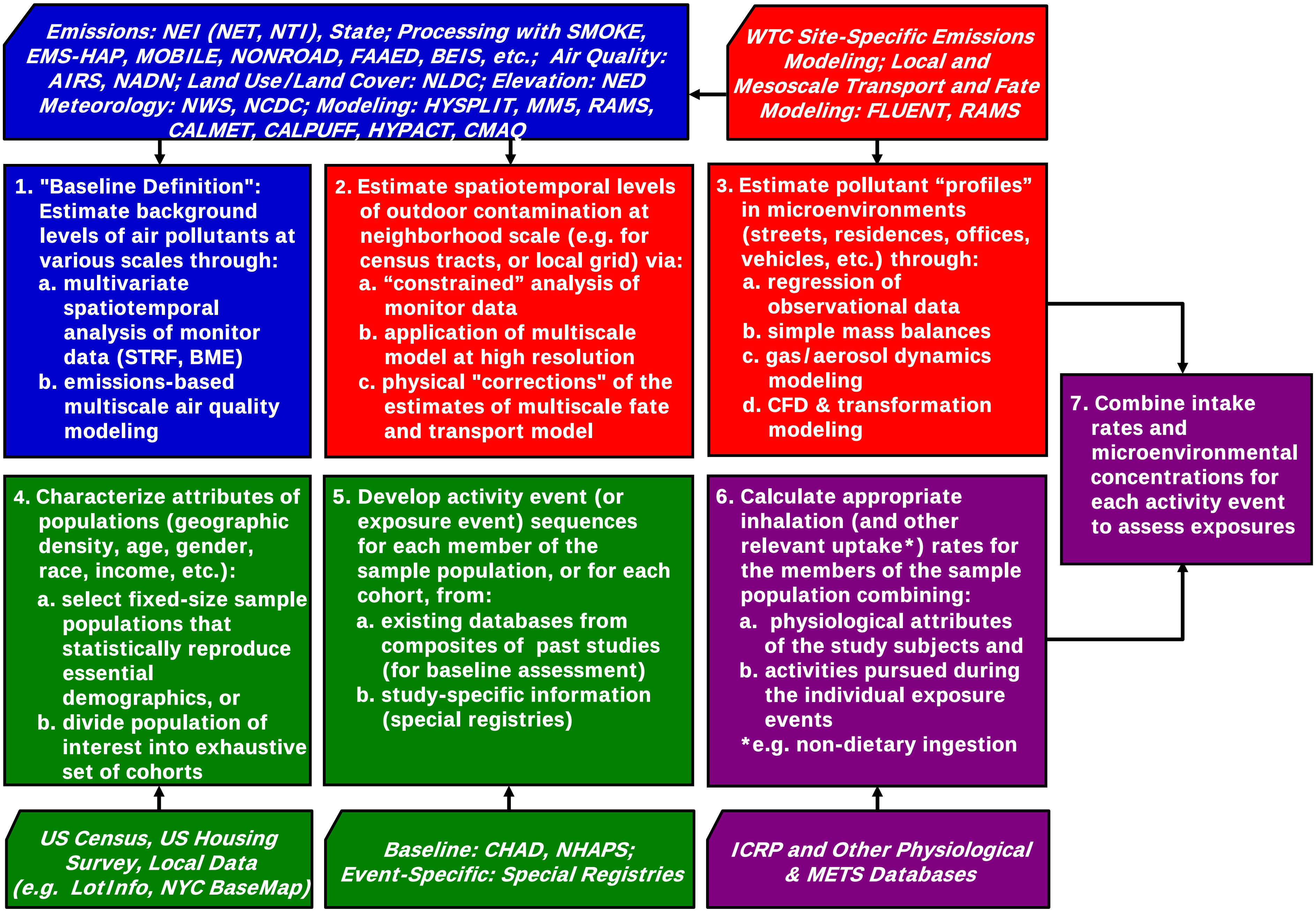
Fact: **In addition to time and geographic location, factors such as: dynamic microenvironmental attributes, demographic and physiological characteristics, activity patterns, etc. differentiate significantly the exposures and doses of individuals (and of selected subpopulations) that result from an environmental (emergency) event**

Challenge: All relevant information must be integrated in a consistent/unifying framework (Spatiotemporal Exposure Information System)

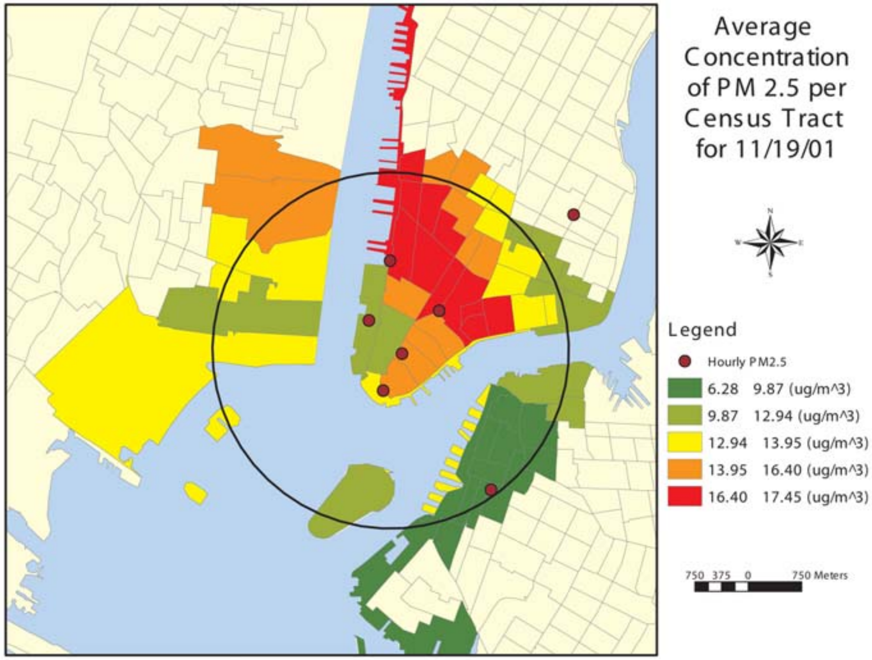


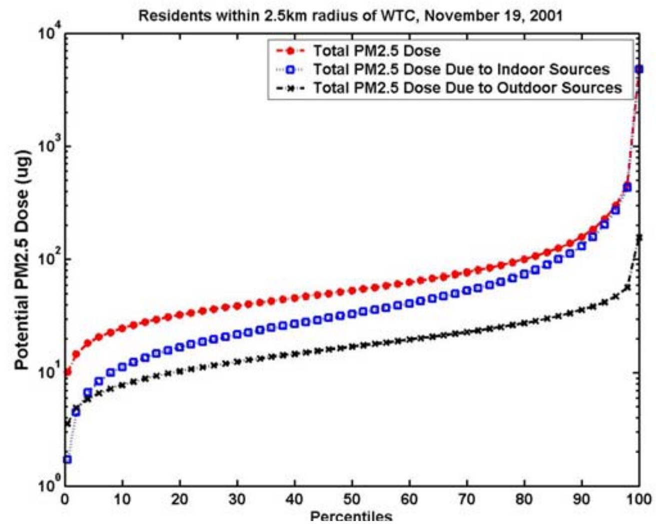
Example: Dependence of inhaled fine PM dose on gender, age, and activity (MET= Metabolic Equivalent of Tasks)

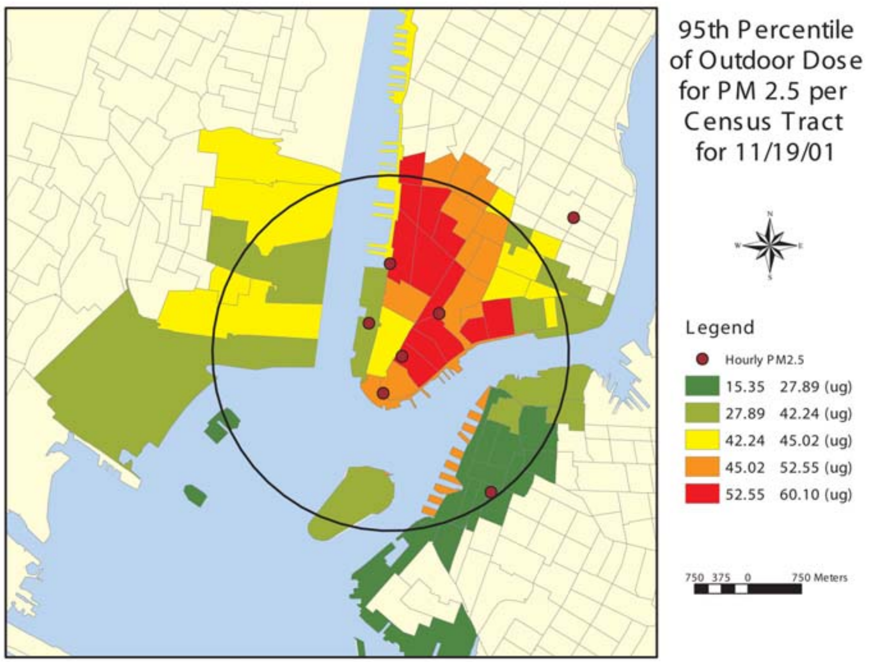
Integrated Framework for Reconstructing Exposures to the WTC Plume

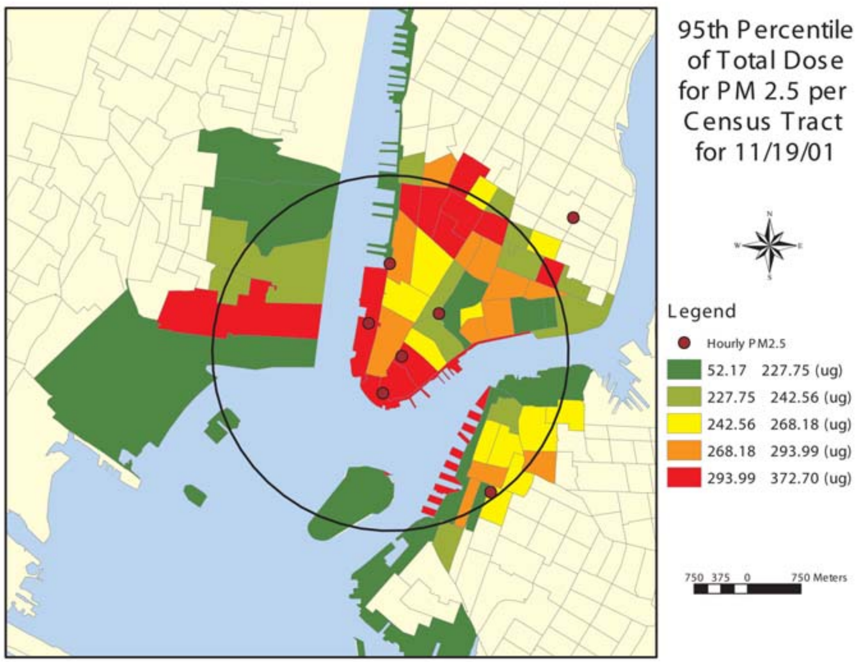


MENTOR/SHEDS baseline simulation, for 11/19/2001, of inhaled doses of PM2.5 due to outdoor and indoor sources for the population in census tracts within 2.5km of WTC

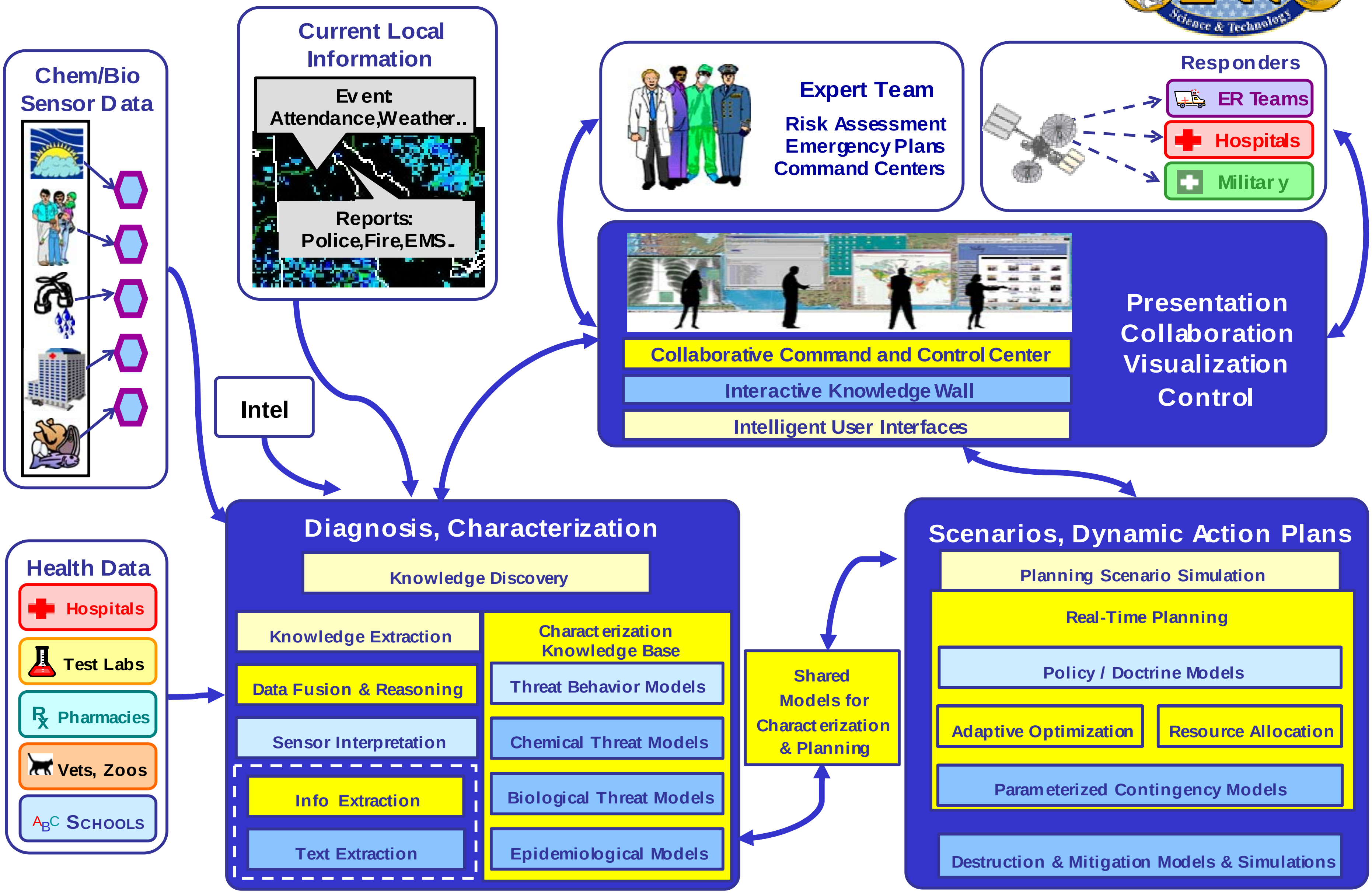








Integrated Biological & Chemical Warfare Defense (IBCWD): A Collaborative Project Led by Quantum Leap Innovations



CCL Research on Environmental Contaminant Release, Transport / Fate, and Exposure / Dose for Emergency Events

Funded By:

- US EPA
  - *Center for Exposure and Risk Modeling (CERM) at EOHSI*
- US DOE
  - *Consortium for Risk Evaluation with Stakeholder Participation (CRESP)*
- NIEHS
  - *Environmental Health Center at EOHSI*
- US Office of Naval Research
  - *Quantum Leap*
- NJ DEP
- Department of Veterans Affairs (VA)