National Atmospheric Release Advisory Center / Interagency Modeling and Atmospheric Assessment Center Overview

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National Atmospheric Advisory Center
NARAC

IMAAC
Interagency Modeling and Atmospheric Assessment Center

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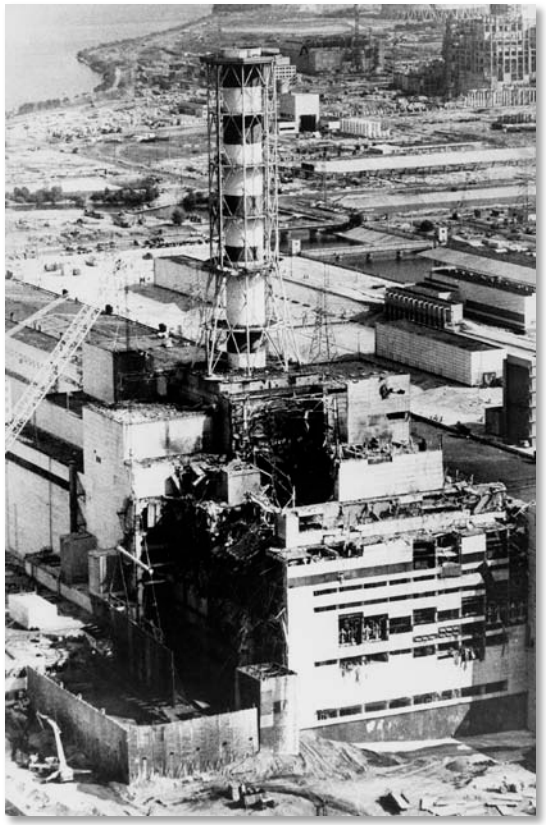
NARAC/IMAAC Provides Critical Information to Protect the Public and the Environment

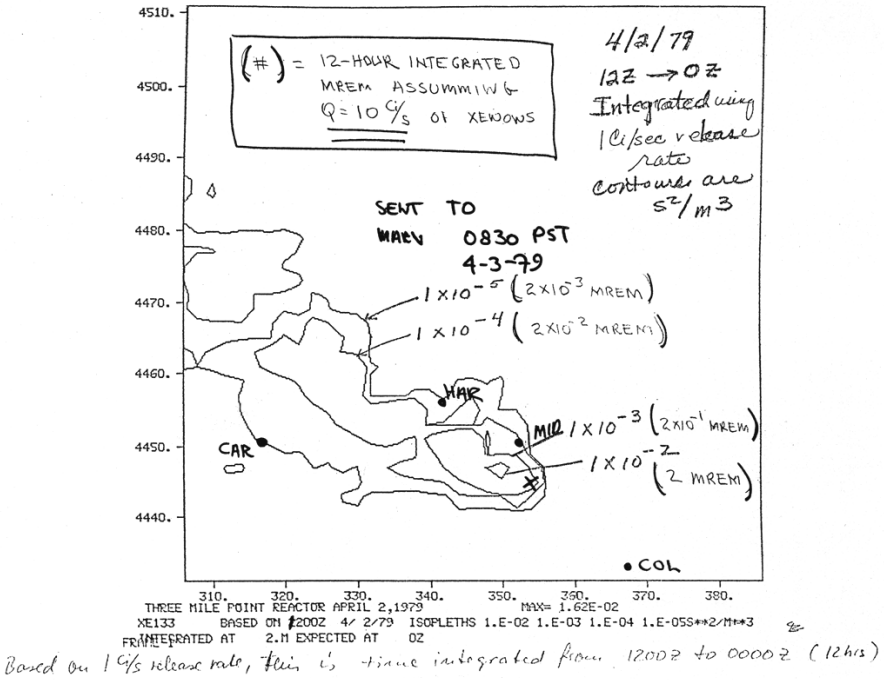


Hazardous airborne releases are a rapid and effective means to impact large populations. NARAC/IMAAC has capabilities to respond to toxic industrial chemical spills, nuclear-power plant accidents, fires, chemical/biological agents, radiological/nuclear devices (RDDs, INDs), and some natural airborne hazards.

NARAC's First Emergency Response was for Three Mile Island (Dept. of Energy / Nuclear Regulatory Commission)

Original DOE Operations Center at LLNL

Three Mile Island Nuclear Power Plant and DOE Aerial Measurement Survey



NARAC prediction of downwind dose from a potential release from the Three Mile Island nuclear power plant

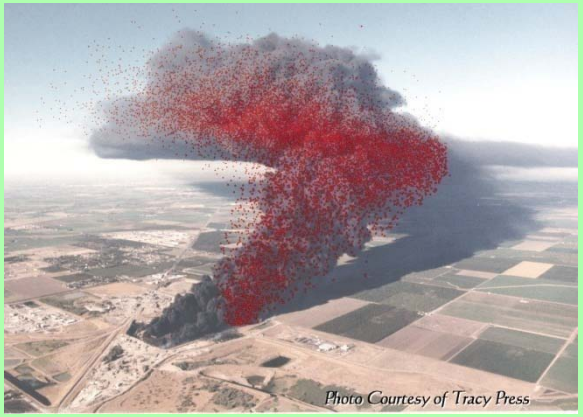
NARAC/IMAAC Provides Operational Services, Tools, and Expertise for Preparedness, Response, & Recovery

Event Information

- Weather data
- Nuclear, radiological, chemical, and biological source information
- Terrain, land use, and population databases
- Measurement data and observations

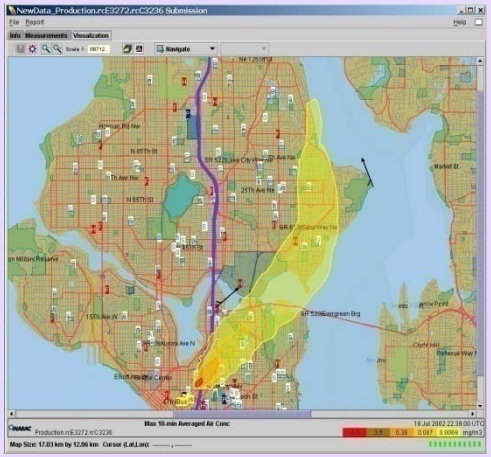
Operational Services and Expertise

- Suite of stand-alone to advanced WMD modeling tools (multi-scale models)
- 24/7/365 expert scientific staff (< 5 min. reach-back)
- Detailed analysis, expert interpretation, quality assurance, and training
- Event reconstruction



Actionable Information

- Hazard areas and affected populations
- Health effect, public protective action, and worker protection levels based on federal guidelines
- Casualty, fatality, and damage estimates
- Planning and consequence assessments



Center Has a 30-Year Record of Timely and Accurate Multi-Hazard Atmospheric Release Assessments

1973 DOE R&D Program

1979 ARAC Operational Center established

Generation-2 system (nuclear/radiological)

Naval Nuclear Propulsion Program

DOE site support for toxic industrial chemicals

DOE CBNP program

1996 DOE NARAC facility dedicated

Generation-3 system (CBRN)

2002-2005 LINC

2004 IMAAC established

2007 IXP Web

2008 CMweb

1980

1985

1990

1995

2000

2005

2010

1979 Three Mile Island reactor leak

1980 Titan Missile explosion AK

1980 China atmospheric nuclear tests

1983 Russian Cosmos satellite re-entry

1986 Chernobyl reactor accident

1988 Henderson NV rocket fuel plant explosion

1991 Mt. Pinatubo eruption, Philippines

1991 Kuwaiti oil field fires

1993 TOMSK-7 waste-tank explosion, USSR

1993 Richmond, CA oleum tank car release

1997 Cassini satellite launch

1998 Tracy tire dump fire

1999 Tokaimura criticality accident

2001 Post-September 11 threat scenarios

2003 Staten Island oil barge fire

2003-2004 New Years Orange Alert

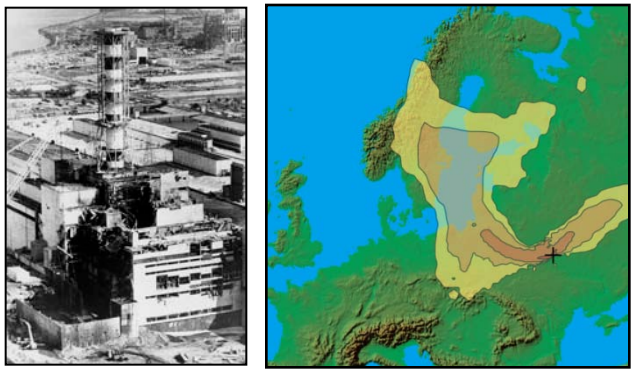
2004 Conyers, GA chemical fire

2006 NASA Pluto New Horizons launch

2007 TOPOFF4

2009 Inaugural events

2010 NLE 2010



Chernobyl reactor building after explosion (Ukraine, 1986) and LLNL plume prediction

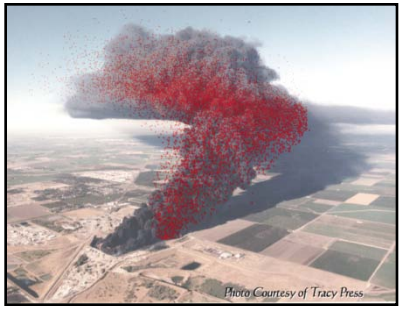
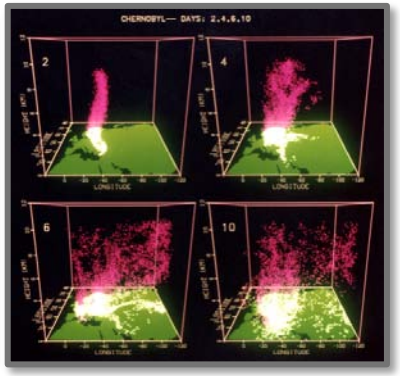


Photo of smoke from tire dump fire (Tracy, California,1998) with plume prediction in red

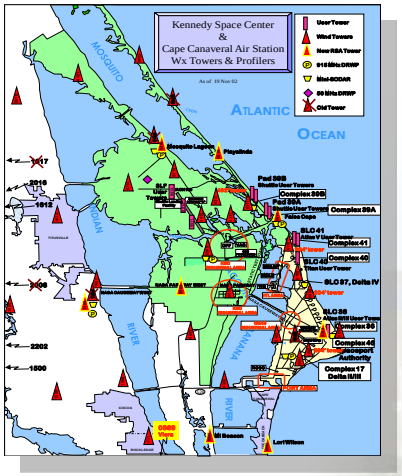
NARAC 30th Anniversary Timeline (April 2009)

NARAC Successfully Supports A Wide Range of DOE, DHS, DoD, NASA, and Other Missions

- DOE/NNSA Emergency Operations
  - Office of Emergency Response
  - Office of Emergency Management (DOE site support)
  - National Technical Nuclear Forensics program
  - Office of International Emergency Management and Cooperation
- DOE / DoD Naval Nuclear Propulsion Program
- NASA spacecraft launch support (coordinated via the DOE Office of Radioisotope Power Systems)



NARAC briefing (left) and predictions of the spread of Chernobyl radioactivity over Europe and Asia (right)



NARAC provides the Senior Science Advisor and support for NASA spacecraft launches

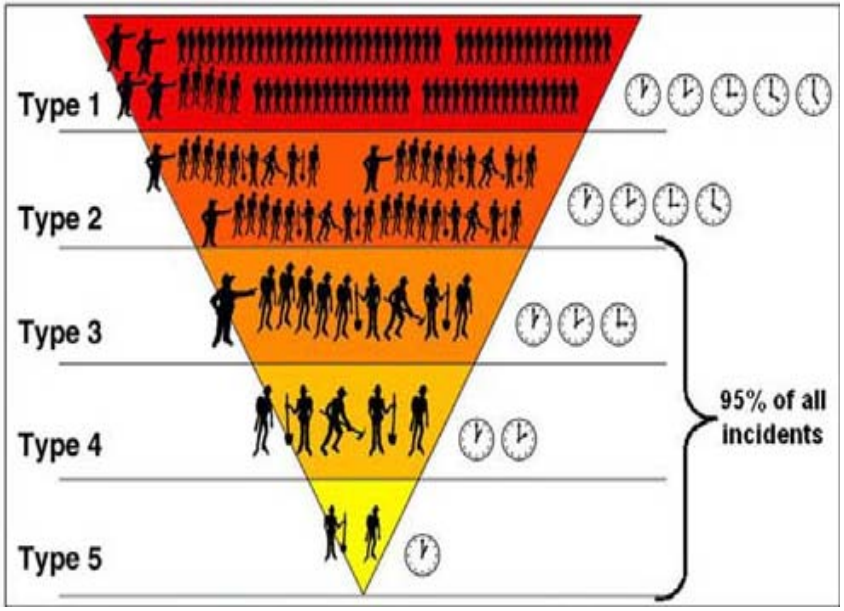
IMAAC Coordinates Federal Dispersion Modeling Under the National Response Framework

- IMAAC created by the Homeland Security Council in 2004
  - Led by DHS, which provides the IMAAC Director
  - Partnership between eight federal agencies
  - 2010 MOU recognizes NARAC as the "operations hub of the IMAAC" (five-year renewal)
- National deployment plan
  - Federal operations centers
  - Federal agency regional assets (e.g., EPA OSCs, NOAA SSCs)
  - Special events
  - National Exercise Program

The IMAAC "provides a single point for the coordination and dissemination of Federal dispersion modeling and hazard prediction products that represent the Federal position" during actual or potential incidents - *National Response Framework, 2009*

IMAAC is Available to Respond to Major Atmospheric Release Emergencies

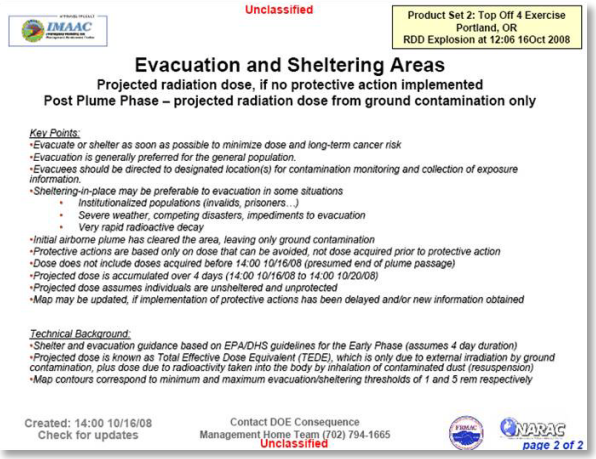
- *Any* local, state, tribal, or federal agency may activate IMAAC for a major atmospheric release emergency
- Guidance for activation is based on Incident Command System / National Incident Management System (ICS/NIMS) Incident Types
  - IMAAC should be activated for Type 1-2 incidents (extended, large-scale releases)
  - IMAAC may be activated for Type 3 incidents, even if they do not require Federal coordination and for Type 4 incidents with the potential for becoming Type 3 incidents



FEMA EMI ICS200_IG Visual 6.22
http://training.fema.gov/emiweb/is/IS200b/IG/06_IGICS200b_Sept2010.pdf

IMAAC should always be activated for a real-world threat or possible release involving a Weapon of Mass Destruction (WMD)

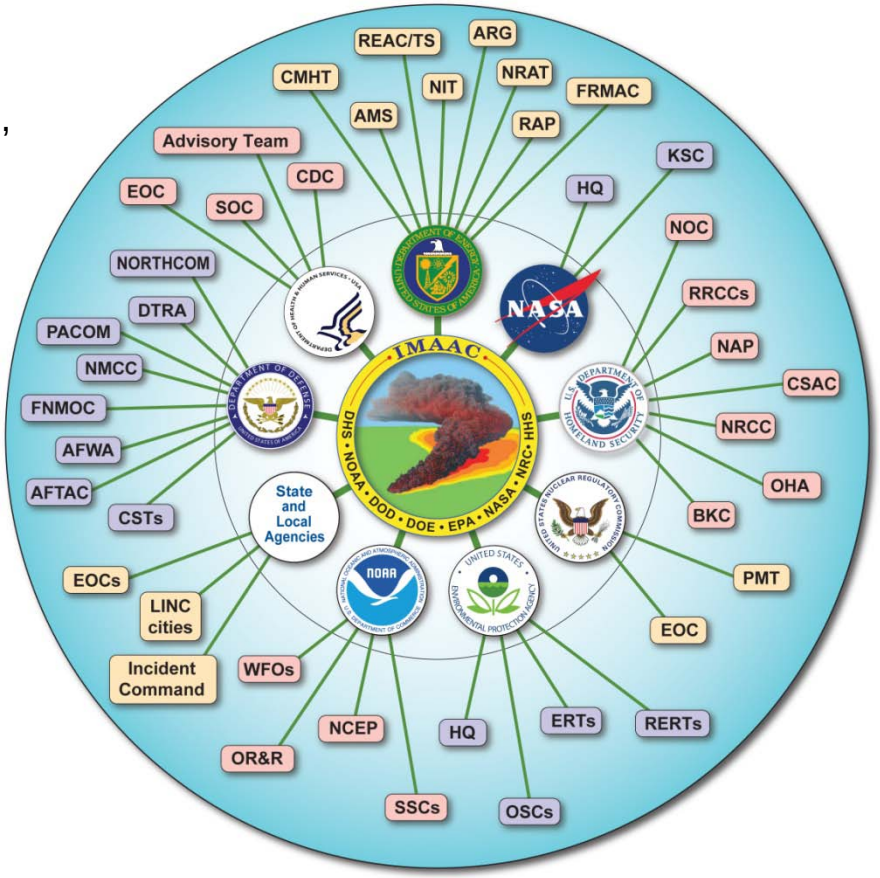
NARAC/IMAAC Products Guide Response Decisions on Evacuation, Sheltering, Relocation and Worker Protection



NARAC/IMAAC supports over 300 collaborating local, state, and federal agencies, 2,500 on-line users, and 10,000 requests/year, including approximately 100 exercises and 20 real-world events annually requiring staff support.

NARAC/IMAAC Provides Integrated Emergency Response in Collaboration with Over 300 Agencies

- DHS national and regional operations centers (NOC Watch, FEMA Response Watch Center, NRCC/RRCCs, and IMATs)
- DOE national operations center and nuclear incident response teams (ARG, AMS, CM, JTOT, RAP, REAC)
- Interagency radiological response centers and teams (e.g., Federal Radiological Monitoring and Assessment Center, Advisory Team for Environment, Food and Health)
- DOD national operations centers and teams
- EPA operations centers and regional response teams
- HHS Secretary's Operations Center and CDC Director's Emergency Operations Center
- NASA launch facilities and mission operations
- NOAA national centers and teams (NCEP, NOAA Response and Restoration Division)
- NRC national and regional operations centers and teams
- Naval Nuclear Propulsion Program
- State operations centers and response teams
- Civil Support Teams (National Guard Bureau)
- Local Integration of NARAC with Cities (LINC) pilot cities and regional partners

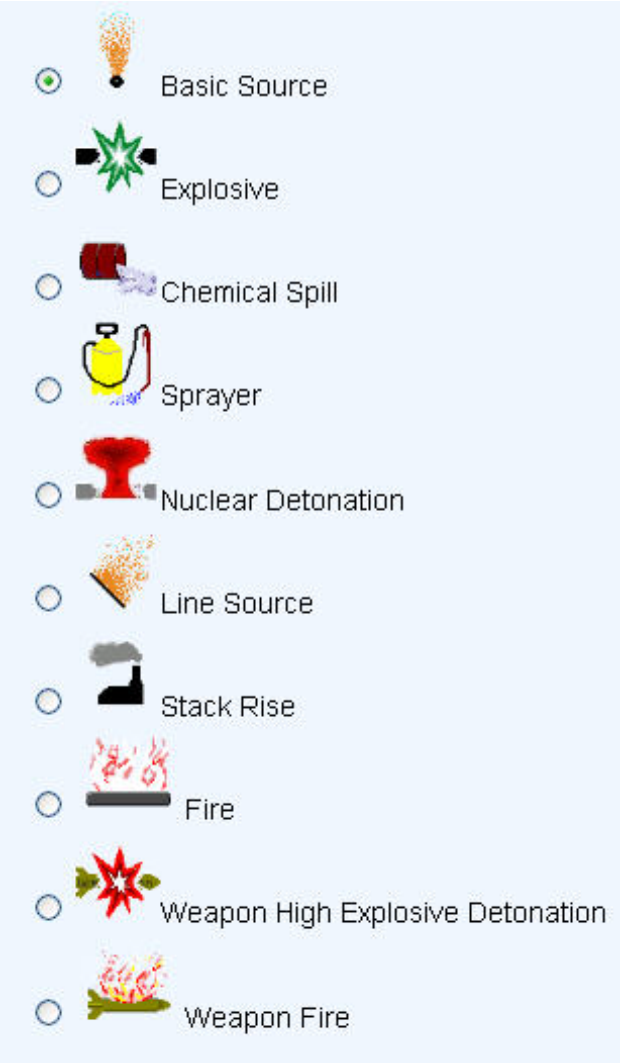


NARAC/IMAAC Provides Actionable Information to Inform Emergency Response Decisions

- Guide safe approach routes
- Site incident command posts or resources
- Deploy field monitoring teams (sampling plan guidance)
- Assist in evacuation, sheltering-in-place, and relocation decisions
- Inform need for personal protective equipment (PPE)
- Estimate potential impacts on, and contamination of, critical infrastructure
- Estimate potential number of casualties requiring hospital or medical treatment
- Determine areas where agricultural crops may be contaminated (human food and animal feed)

Key Information is Needed to Drive NARAC/IMAAC Plume Modeling Analyses

- Provide as much information as possible when requesting NARAC/IMAAC assistance
- Essential information (initial product):
  - Location of release (e.g., latitude/longitude, street address)
  - Time of release
- Other key information (effects products):
  - Type of material (e.g., biological agent, bio-toxin, toxic industrial chemical, chemical agent, radiological isotopes)
  - Type of release (e.g., spill, fire, explosion)
  - Amount released or at risk (e.g., 90 ton rail car, 1000 Curies, 2 lbs)
  - Observations related to the initial plume (e.g., height of plume, size of crater)
- Do *not* delay. Contact NARAC/IMAAC even with partial information.



Additional Information Can be Valuable During an NARAC/IMAAC Response

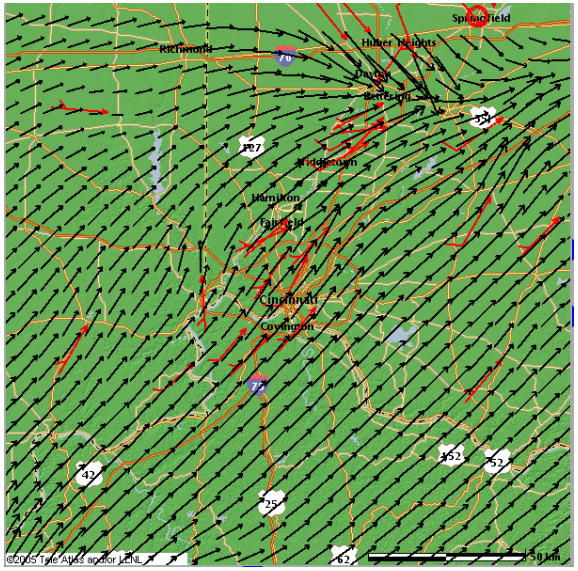
- Local meteorological observations

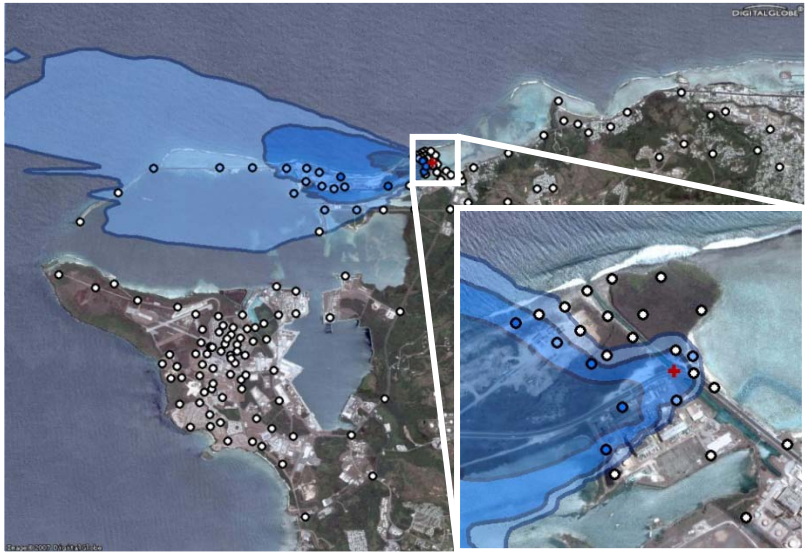
- Field measurement data
  - Type of measurement or instrument
  - Location
  - Time of measurement
  - Measures value, units, threshold, sensitivity

- List of agencies involved in response for NARAC/IMAAC product distribution

NARAC/IMAAC Provides Auxiliary Analyses For Situational Awareness

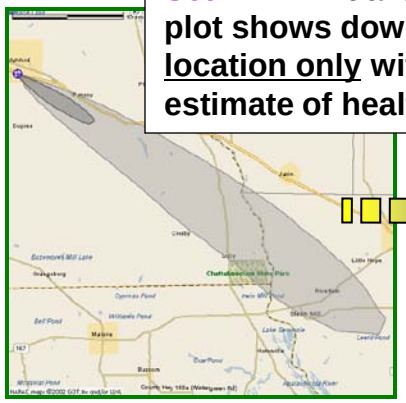
- Wind observations and fields
- Numerical weather prediction forecasts
- Field measurement data
- Deposition (standard in radiological cases)
- Time series or plume animations





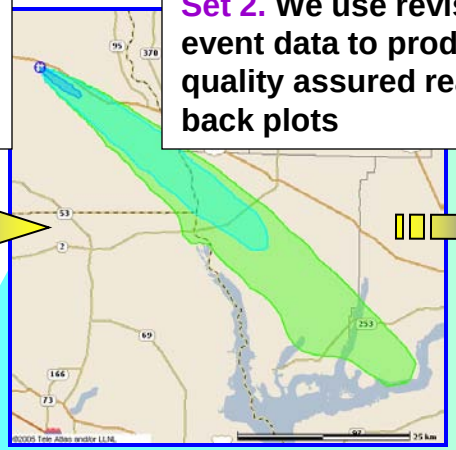
Standard Operational Procedures Couple Modeling and Monitoring in a Cyclical Process

Set 1. An initial automated plot shows downwind <u>location only</u> with no estimate of health effects



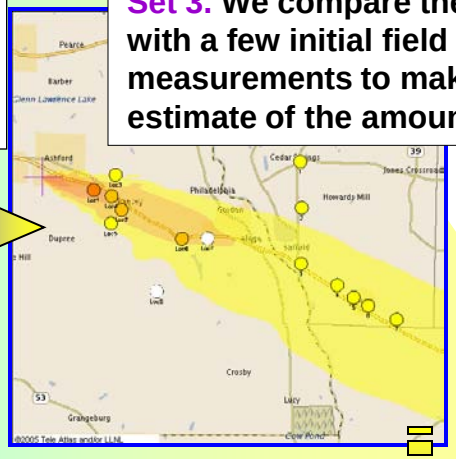
Automated Web-Initiated or via Emergency Call; Only know release time and location

Set 2. We use revised event data to produce quality assured reach-back plots



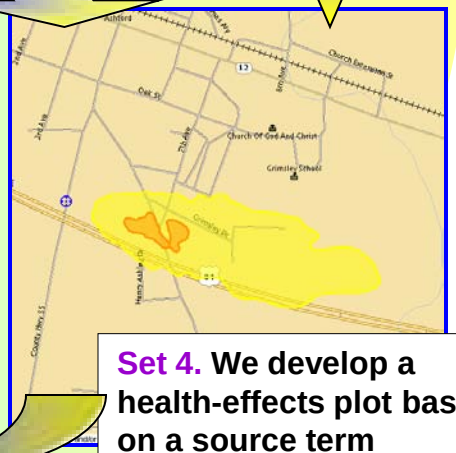
Example revised data: Updated source location, detailed weather

Set 3. We compare the model with a few initial field measurements to make an initial estimate of the amount released



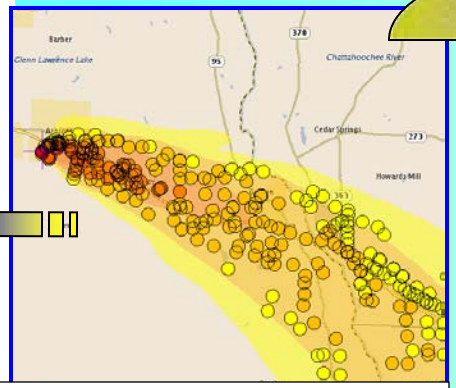
Source scaled to initial set of measurements

Set 4. We develop a health-effects plot based on a source term estimated from field measurements

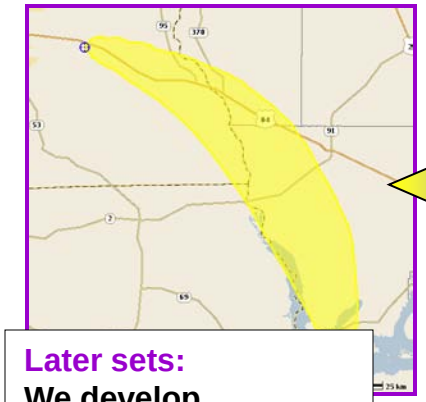


Cycle of new products based on updated sets of measure-ments

Set 5. We use more extensive sets of field measurements to improve the accuracy of the source term calculation



Later sets:
We develop Relocation and Food-Ingestion plots



NARAC/IMAAC Products

National Atmospheric Advisory Center
NARAC

IMAAC
Interagency Modeling and
Atmospheric Assessment Center

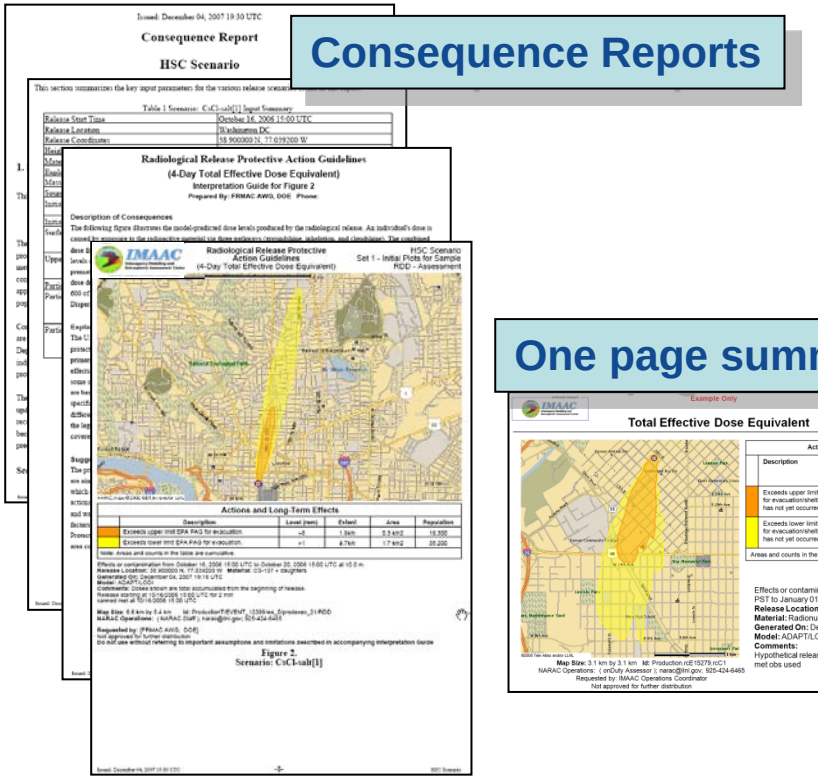
NARAC/IMAAC Products Inform Decisions on Evacuation, Sheltering, Relocation, Worker Protection, and Sampling Plans

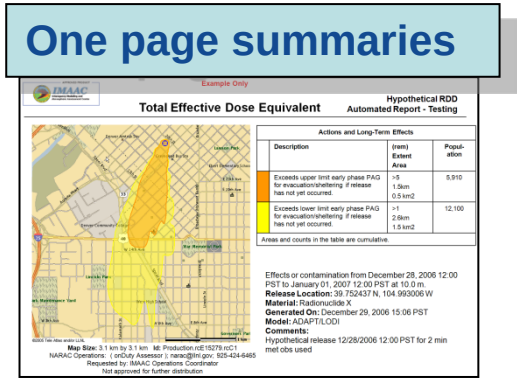
- Standard plot sets
  - Plume hazard areas
  - Affected population numbers
  - Expected health effects
  - Protective action guide levels
  - Geographical information
- Multi-page consequence reports
  - Expanded descriptions
  - Input data and assumptions
  - Interpretation guides
- Briefing Products for decision makers

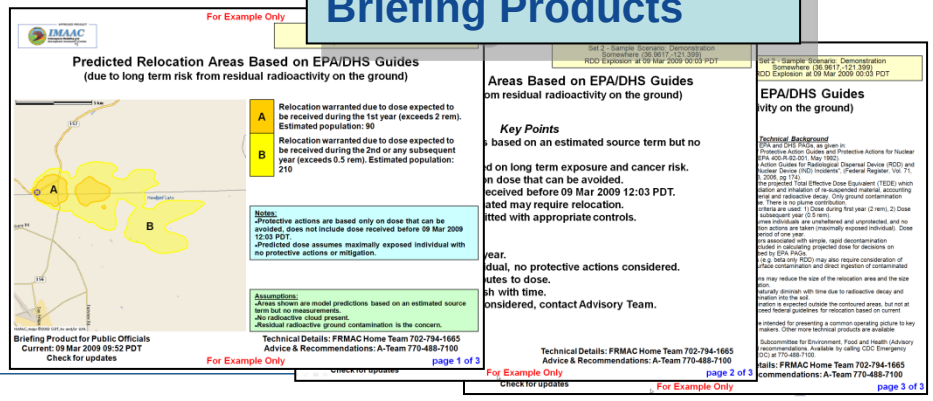
Available on IMAAC/NARAC/CM Web

PDF, PowerPoint, HTML/XML, JPG/PNG graphics,

ESRI Shape and Google Earth KMZ GIS files with plume areas

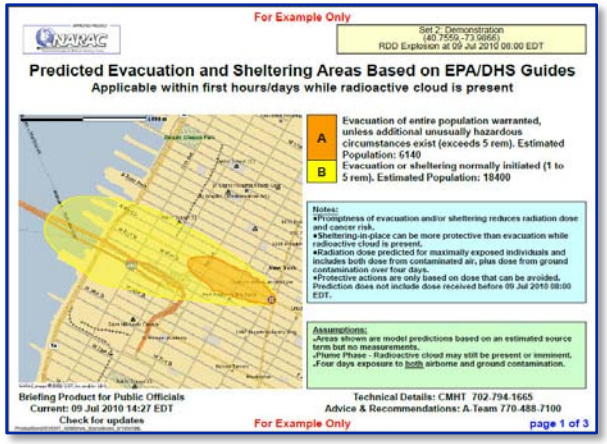






Briefing Products Were Tailored to Convey Key Information to Senior Officials and Federal, State, and Local Decision Makers

- Homeland Security Council tasking to develop products to communicate key information about the impacts of hazardous releases and possible actions in non-technical terms to decision makers
  - DOE-funded RDD/IND briefing products completed in collaboration with RSL
  - DHS-funded Chem/Bio briefing products designed, not yet implemented


For Example Only

Set 2: Demonstration
(40.7559, -73.9866)
RDD Explosion at 09 Jul 2010 08:00 EDT

Predicted Evacuation and Sheltering Areas Based on EPA/DHS Guides

Applicable within first hours/days while radioactive cloud is present

A — Evacuation of entire population warranted, unless additional unusually hazardous circumstances exist (exceeds 5 rem). Estimated Population: 6140

B — Evacuation or sheltering normally initiated (1 to 5 rem). Estimated Population: 18400

Notes:
- Promptness of evacuation and/or sheltering reduces radiation dose and cancer risk.
- Sheltering-in-place can be more protective than evacuation while radioactive cloud is present.
- Radiation dose predicted for maximally exposed individuals and includes both dose from contaminated air, plus dose from ground contamination over four days.
- Protective actions are only based on dose that can be avoided. Prediction does not include dose received before 09 Jul 2010 08:00 EDT.

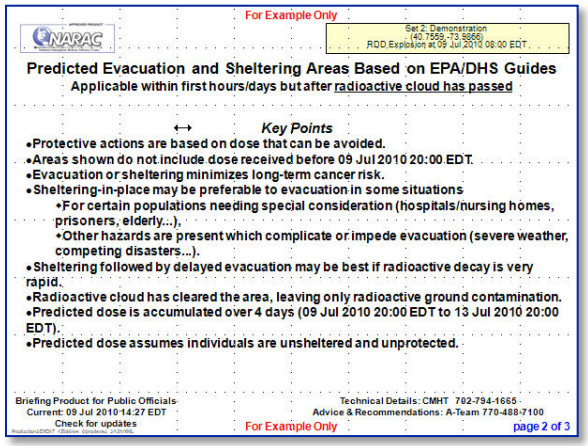
Assumptions:
- Areas shown are model predictions based on an estimated source term but no measurements.
- Plume Phase - Radioactive cloud may still be present or imminent.
- Four days exposure to both airborne and ground contamination.

Briefing Product for Public Officials
Current: 09 Jul 2010 14:27 EDT
Check for updates

Technical Details: CMHT 702-794-1665
Advice & Recommendations: A-Team 770-488-7100

For Example Only — page 1 of 3

Slide 1. Plot:
Map with legend, notes on key briefing points, and assumptions


For Example Only

Set 2: Demonstration
(40.7559, -73.9866)
RDD Explosion at 09 Jul 2010 08:00 EDT

Predicted Evacuation and Sheltering Areas Based on EPA/DHS Guides

Applicable within first hours/days but after radioactive cloud has passed

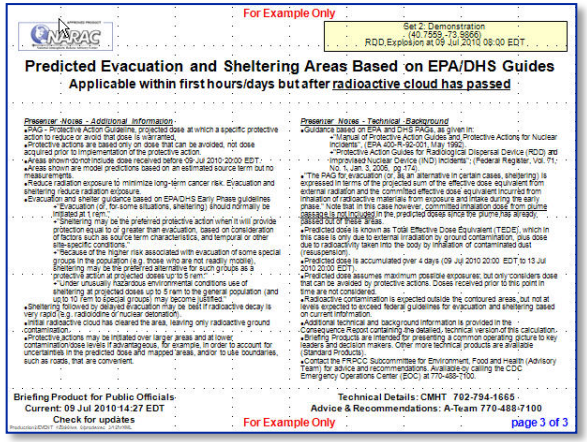
↔ *Key Points*
- Protective actions are based on dose that can be avoided.
- Areas shown do not include dose received before 09 Jul 2010 20:00 EDT.
- Evacuation or sheltering minimizes long-term cancer risk.
- Sheltering-in-place may be preferable to evacuation in some situations
  - For certain populations needing special consideration (hospitals/nursing homes, prisoners, elderly...),
  - Other hazards are present which complicate or impede evacuation (severe weather, competing disasters...).
- Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid.
- Radioactive cloud has cleared the area, leaving only radioactive ground contamination.
- Predicted dose is accumulated over 4 days (09 Jul 2010 20:00 EDT to 13 Jul 2010 20:00 EDT).
- Predicted dose assumes individuals are unsheltered and unprotected.

Briefing Product for Public Officials
Current: 09 Jul 2010 14:27 EDT
Check for updates

Technical Details: CMHT 702-794-1665
Advice & Recommendations: A-Team 770-488-7100

For Example Only — page 2 of 3

Slide 2. Key Points:
Expanded list of key information concerning the product and/or relevant actions for consideration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Set 2: Demonstration
(40.7559, -73.9866)
RDD Explosion at 09 Jul 2010 08:00 EDT

Predicted Evacuation and Sheltering Areas Based on EPA/DHS Guides

Applicable within first hours/days but after radioactive cloud has passed

Presenter Notes - Additional Information
- PAG - Protective Action Guidelines, projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- Protective actions are based only on dose that can be avoided, not dose acquired prior to implementation of the protective action.
- Areas shown do not include dose received before 09 Jul 2010 20:00 EDT.
- Areas shown are model predictions based on an estimated source term but no measurements.
- Reduce radiation exposure to minimize long-term cancer risk. Evacuation and sheltering reduce radiation exposure.
- Evacuation and shelter guidance based on EPA/DHS Early Phase guidelines
  - Evacuation (of, for some situations, sheltering) should normally be initiated at 1 rem.
  - Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation, based on consideration of factors such as source term characteristics, and temporal or other site-specific conditions.
  - Because of the higher risk associated with evacuation of some special groups in the population (e.g. those who are not readily mobile), Sheltering may be the preferred alternative for such groups as a protective action at projected doses up to 5 rem.
  - Under unusually hazardous environmental conditions use of sheltering at projected doses up to 5 rem to the general population (and up to 10 rem to special groups) may become justified.
- Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid (e.g. radioiodine of nuclear detonation).
- Initial radioactive cloud has cleared the area, leaving only radioactive ground contamination.
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous, for example, in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient.

Presenter Notes - Technical Background
- Guidance based on EPA and DHS PAGs, as given in:
  - "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - "Protective Action Guides for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents"; (Federal Register, Vol. 71; No. 1, Jan. 3, 2006, pp.174).
- "The PAG for evacuation (or, as an alternative in certain cases, sheltering) is expressed in terms of the projected sum of the effective dose equivalent from external irradiation and the committed effective dose equivalent incurred from inhalation of radioactive materials from exposure and intake during the early phase." Note that in this case however, committed inhalation dose from plume passage is not included in the predicted doses since the plume has already passed out of these areas.
- Predicted dose is known as Total Effective Dose Equivalent (TEDE), which in this case is only due to external irradiation by ground contamination, plus dose due to radioactivity taken into the body by inhalation of contaminated dust (resuspension).
- Predicted dose is accumulated over 4 days (09 Jul 2010 20:00 EDT to 13 Jul 2010 20:00 EDT).
- Predicted dose assumes maximum possible exposures; but only considers dose that can be avoided by protective actions. Doses received prior to this point in time are not considered.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal guidelines for evacuation and sheltering based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products).
- Contact the FRRCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available-by calling the CDC Emergency Operations Center (EOC) at 770-488-7100.

Briefing Product for Public Officials
Current: 09 Jul 2010 14:27 EDT
Check for updates

Technical Details: CMHT 702-794-1665
Advice & Recommendations: A-Team 770-488-7100

For Example Only — page 3 of 3

Slide 3. Presenter Notes:
Additional information and technical background (for use by the presenter, not intended to be shown)

NARAC/IMAAC Provides Standard Plots Derived From Interagency Input and Consensus

- Plot standards are developed with user input and agency consensus
  - Standard plot format and color schemes
  - Standard plot types and contour values
  - Consequence reports documenting model inputs and assumptions and providing interpretational guidance
  - Maps showing areas reaching health effect levels, and protective action guides from DHS/EPA, if available
- Default plots produced automatically when a model request is made
  - Web users may directly initiate a modeling request
  - NARAC-IMAAC Operations can produce and share results with designated users
- NARAC-IMAAC Operations provides reach-back support to:
  - Develop additional event-specific plots
  - Refine predictions based on field data and event information
  - Provide subject matter expertise on plots and analyses

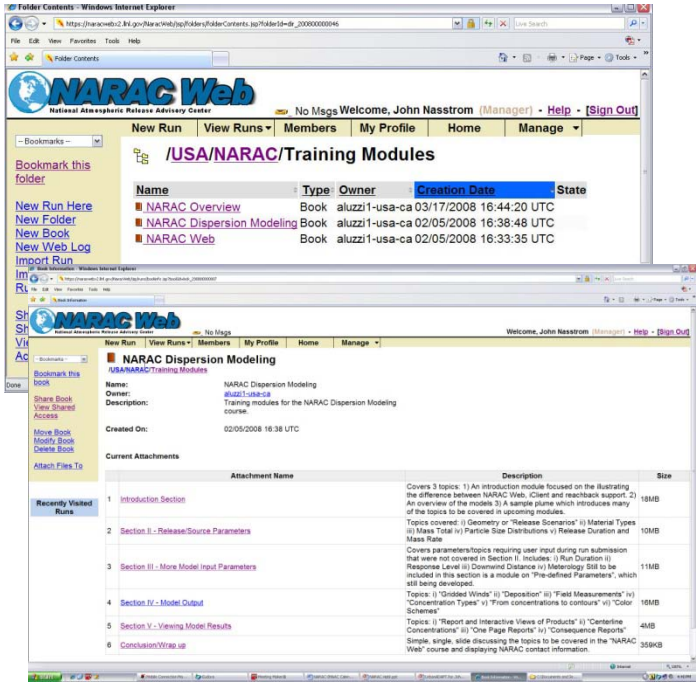
Standard Product Contour Level and Color Scheme are Used for Ease of Interpretation

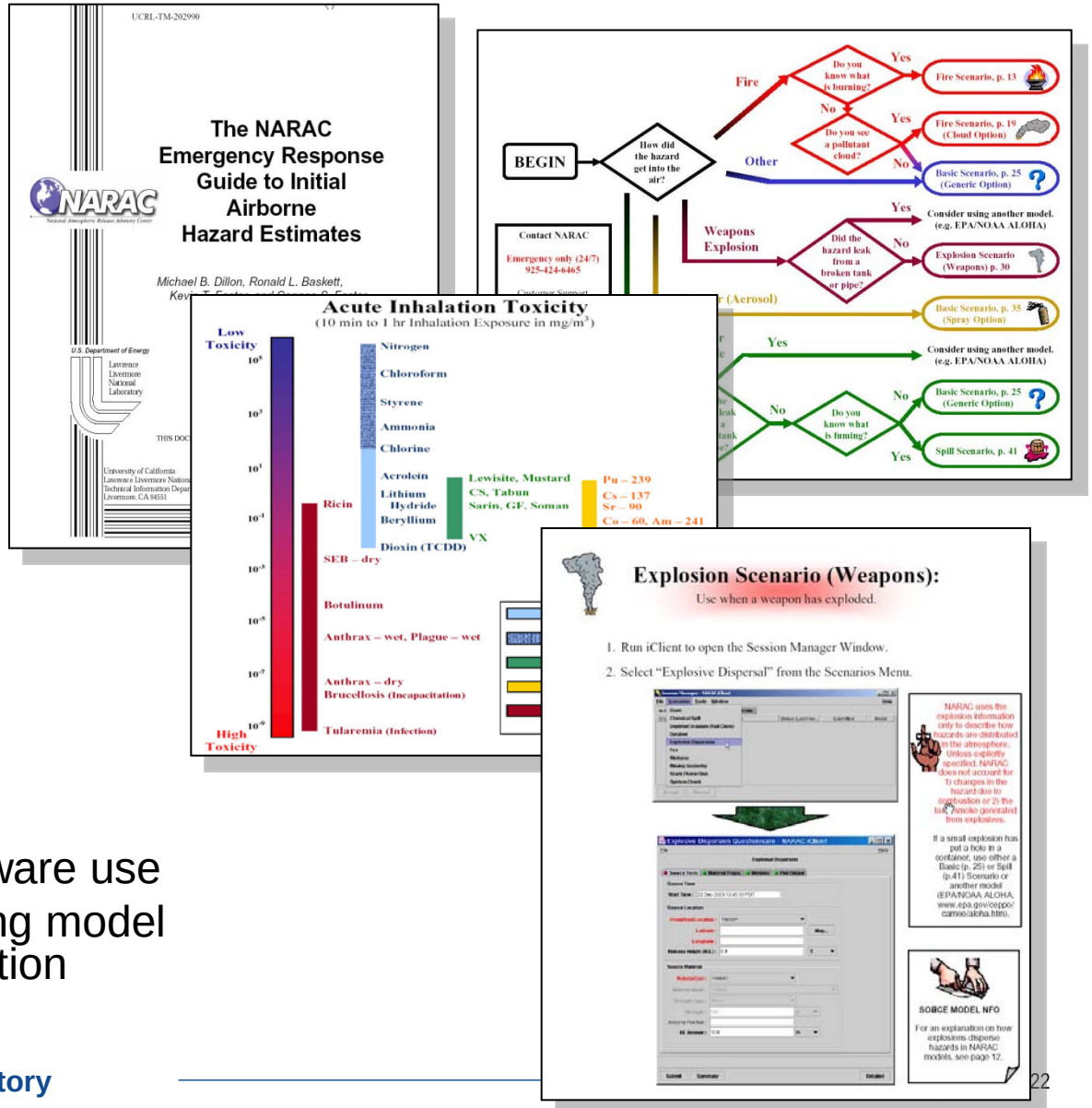
Model Contour Levels	Have levels been reached?	Contour Colors	Description Wording
Acute/Chronic exposure/dose or protective action guideline levels exist in the NARAC database (release amount assumed to be known)	Yes		Consistent with EPA, NRC, FDA or other guidance.
	No		May be below health effect or PAG levels. Possibly contaminated area. Confirm with monitoring surveys.
Customer specified levels	Yes		Customer specified levels.
	No		Below customer specified levels.
No levels exist in NARAC database (or no release amount known)			No guidelines specified. Possibly contaminated area.

A Standard Default Plot Set if Provided For Each Type of Release

Release Type	Default Plot Type
Unknown source material	Hourly average air concentration Deposition if particulate is used
Industrial chemical	"Peak" average air concentration
Chemical agent	"Peak" average air concentration
Biological agent	Time-integrated air concentration
Explosive	Health effects from blast overpressure
Radiological	Dose, dose rate, deposition
Nuclear	Prompt effects, dose, dose rate

NARAC/IMAAC Provides Extensive User Documentation Including User Guides and Web-Based Training



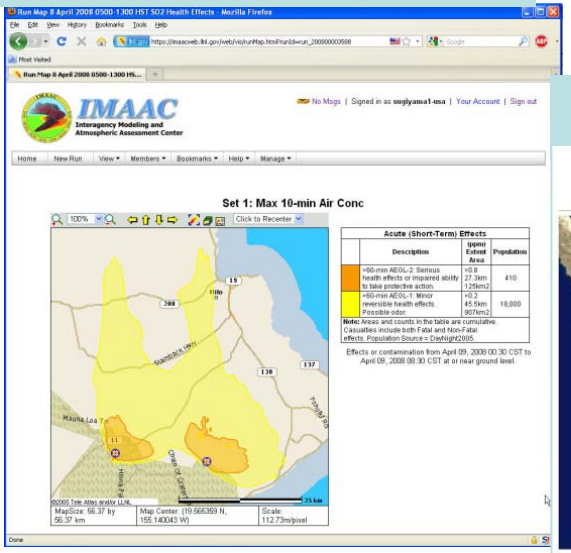


- Technical manuals
- Web-based training
- Step-by-step guide to software use
- Guide books for determining model inputs from known information

NARAC/IMAAC Web Sites Allow User Communities to Request Model Runs and Share Information

- *NARAC Web* serves as the foundation for multiple user community portals
- *IMAAC Web* supports the DHS interagency community
- *CMweb* serves as the unified DOE NA-42 Web site for distribution of consequence management data and model products (NARAC and FRMAC)
- *IXP* Web supports the IAEA and signatory agencies under DOE NA-46 auspices

https://cmweb.llnl.gov



https://imaac.llnl.gov

https://ixp.llnl.gov

Examples of IMAAC Real-World Event Support

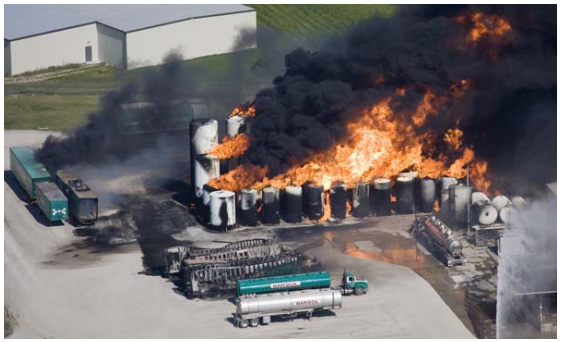
National Atmospheric Advisory Center
NARAC

IMAAC
Interagency Modeling and Atmospheric Assessment Center

IMAAC Has Provided Support for Numerous Real-World Emergencies

May 25-26,2004 chemical warehouse fire in Conyers, GA

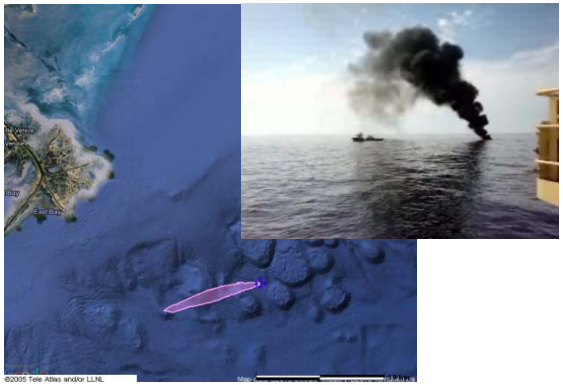
July 28, 2005 solvent plant industrial fire in Ft. Worth, TX



July 17, 2007 Barton solvents fire in Valley Center, KS

Jan 16, 2007 train derailment fire in Sheperdsville, KY

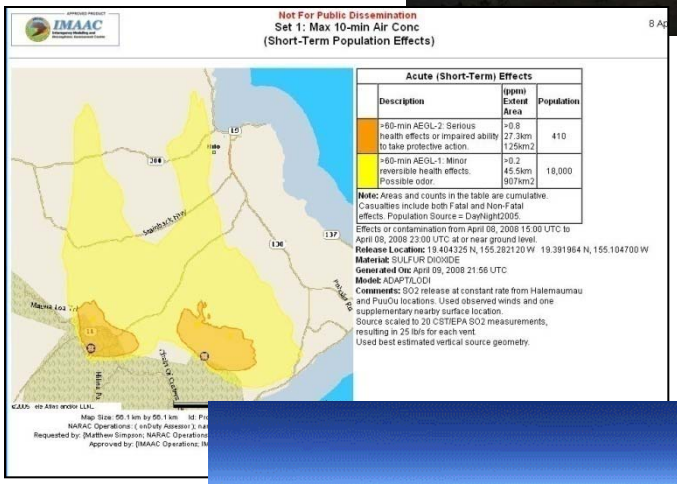
April 7-10, 2008 Kilauea, Hawaii sulfur dioxide releases



May-June, 2010 Deepwater Horizon in-situ burns, Gulf of Mexico

IMAAC Responded to an Interagency Request for the Kilauea, Hawaii, Volcanic Eruption (April 7-11, 2008)

- EPA On-Scene Coordinator requested IMAAC activation due to potential health impacts from SO_2 (sulfur dioxide) releases from two volcanic vents, Hawaii
- Initial calculation based on USGS estimate of release amount and wind forecast from the Honolulu Weather Forecast Office
- Coordinated with DHS, EPA, DTRA, NOAA, Civil Support Teams (CST), National Park Service, USGS and State/County of Hawaii
- Performed additional analyses based on local observations and high-resolution weather forecasts
- Conducted initial measurement-model analysis based on CST field data
- Provided 24-hr high-resolution forecasts of winds and plumes
- Required utilization of both standard operational tools and new simulation capabilities



Not For Public Dissemination

Set 1: Max 10-min Air Conc
(Short-Term Population Effects)

Acute (Short-Term) Effects

	Description	(ppm) Extent Area	Population
	>60-min AEGL-2: Serious health effects or impaired ability to take protective action.	>0.8 27.3km 125km2	410
	>60-min AEGL-1: Minor reversible health effects. Possible odor.	>0.2 45.5km 907km2	18,000

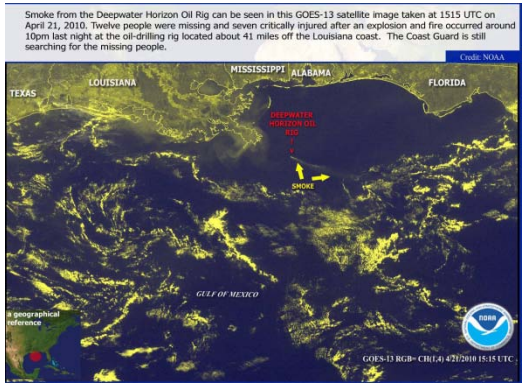
Note: Areas and counts in the table are cumulative. Casualties include both Fatal and Non-Fatal effects. Population Source = DayNight2005.

Effects or contamination from April 08, 2008 15:00 UTC to April 08, 2008 23:00 UTC at or near ground level.
Release Location: 19.404325 N, 155.282120 W 19.391984 N, 155.104700 W
Material: SULFUR DIOXIDE
Generated On: April 09, 2008 21:56 UTC
Model: ADAPT/LODI
Comments: SO2 release at constant rate from Halemaumau and PuuOu locations. Used observed winds and one supplementary nearby surface location.
Source scaled to 20 CSTIEPA SO2 measurements, resulting in 25 lb/s for each vent.
Used best estimated vertical source geometry.

NARAC/IMAAC Recently Provided Analysis and Predictions for Gulf of Mexico Oil Fires and Iceland Volcano Eruption

- Eyjafjallajökull volcano eruption, Iceland (IXP)
  - April 17-19. Demonstration calculation of local ash air concentration and deposition
  - Forecasts provided to Iceland Civil Defense and Met Offices

- Deepwater Horizon, Gulf of Mexico (IMAAC)
  - April 22. Platform oil fire
  - April 27-May 18. Oil spill burns
  - Products shared with NOAA, EPA, DHS



Satellite picture of smoke plume from oil platform fire 2010 April 21

Examples of NARAC/IMAAC Real-World Event Support

Queen City Barrel Warehouse Fire
Cincinnati, OH

National Atmospheric Advisory Center
NARAC

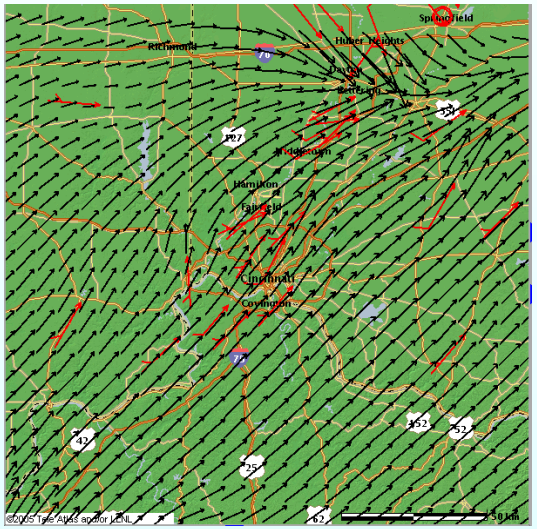
IMAAC
Interagency Modeling and Atmospheric Assessment Center

IMAAC Responded to the Queen City Barrel Chemical Warehouse Fire in Support of the City of Cincinnati

- 7:25pm EDT. Massive fire begins at chemical storage facility (50000 drums)
- Cincinnati Fire, Health, and Environmental Departments immediately concerned about potential health effects from unknown chemicals in the smoke
- 7:45pm EDT. Cincinnati activates and requests LLNL assistance
- 7:54 pm EDT. IMAAC distributes initial predictions via Web
- 8:00pm EDT. Cincinnati uses initial predictions to guide approach routes, air sampling, and shelter-in-place recommendations

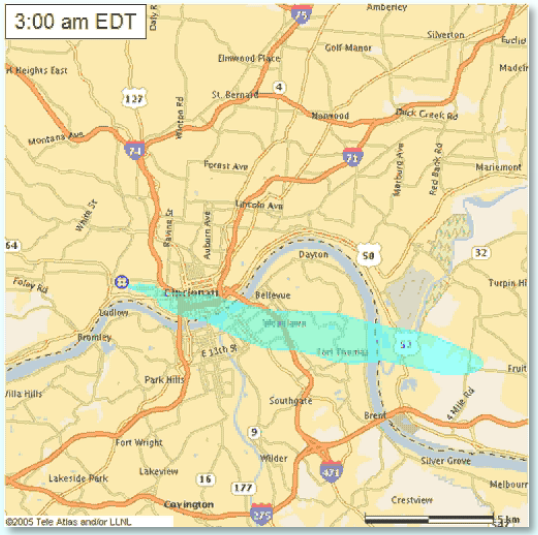
Queen City Barrel chemical warehouse fire
Evening Local News
August 19, 2004

IMAAC Worked with Cincinnati Responders to Develop Accurate Impact Predictions



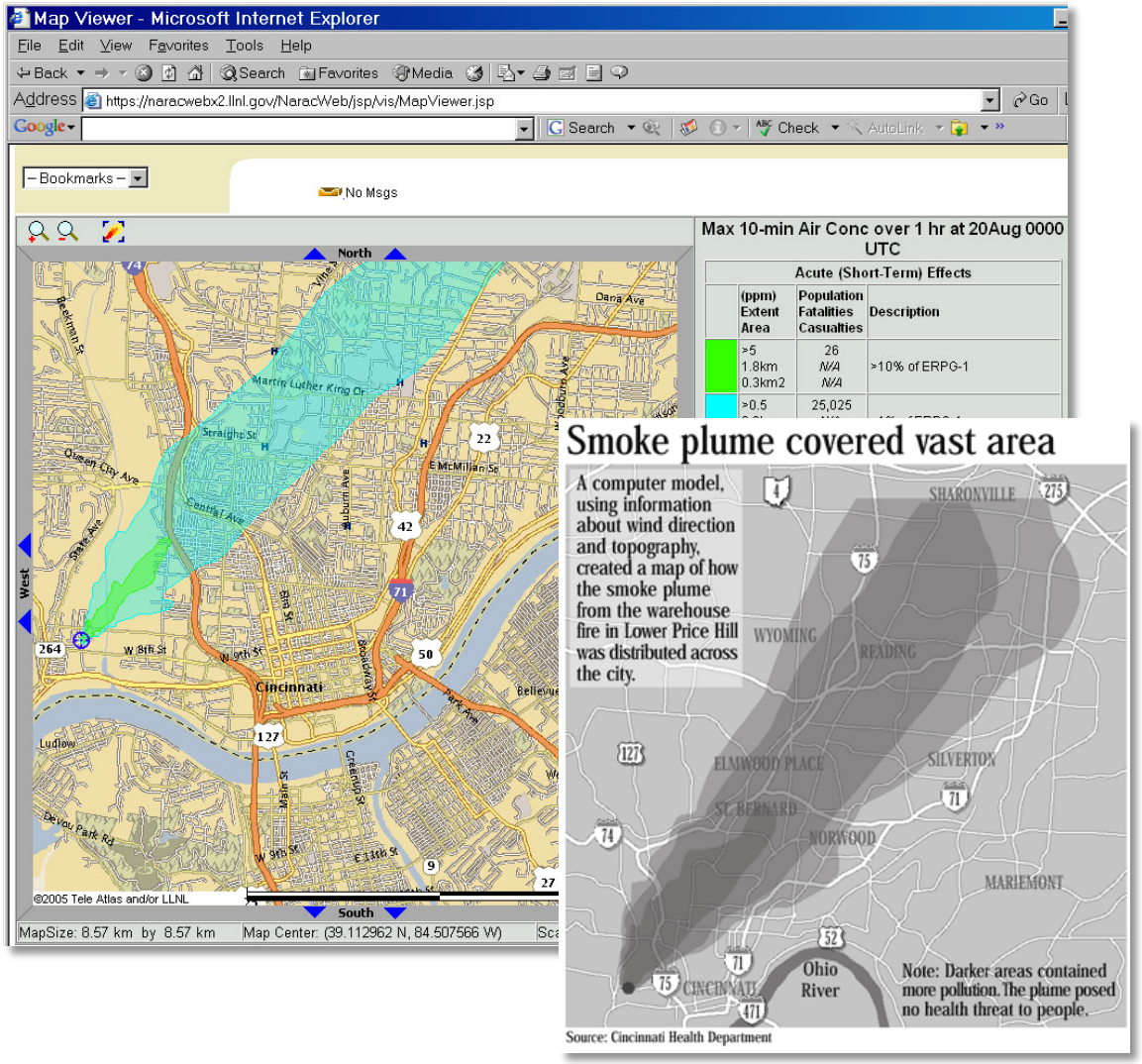
Surface observations (red arrows) and model wind pattern (black vectors) at time near the beginning of the fire

Winds shifts due to passage of a front, caused plume to change direction (initial northeast heading veering later to the southeast)



- Analysis of local and regional weather observations
- Selection of NOAA National Weather Service ETA model as the best forecast data
- Changing weather conditions communicated to Cincinnati, Ohio, and EPA incident command and responders

IMAAC Worked with Cincinnati Responders to Develop Accurate Impact Predictions



8:00pm – 12:00am

- Analysis of chemical inventory to estimate emission rate
- Maps of acute health impacts
- Updated plume maps based on air sampling, photographs, eye witness accounts

9:00am (next day)

- Cincinnati releases plots based on IMAAC analyses and briefs plots on TV

Examples of NARAC/IMAAC Exercise Support

TOPOFF4 Exercise - 2007 October 15-19

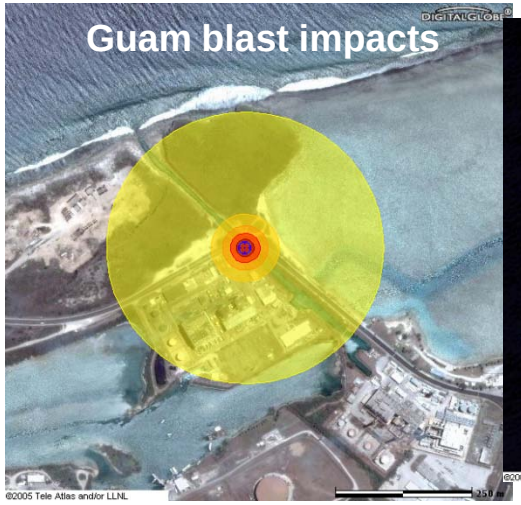
Empire 09 - 2009 June 2-5

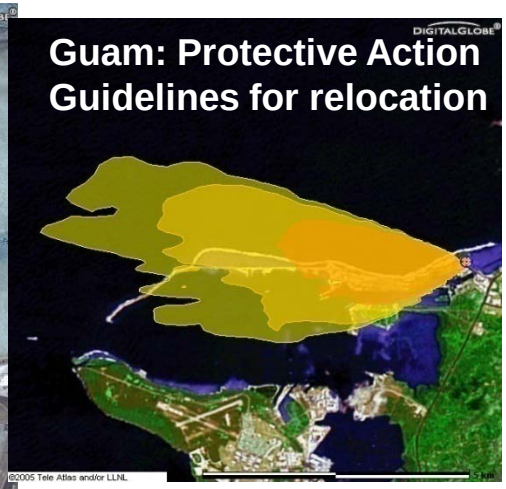
National Atmospheric Advisory Center
NARAC

IMAAC
Interagency Modeling and Atmospheric Assessment Center

IMAAC/NARAC Successfully Supported the Congressionally-Mandated Top Officials 4 (TOPOFF4) Counterterrorism Exercise

- Largest exercise to date involving over 15000 participants
- Tested response to three radiological dispersal device attacks (Guam, Oregon, Arizona)
- LLNL staff served as exercise planners and controllers
- IMAAC/NARAC provided 24x7 support 2007 October 15-19
  - Worked collaboratively with operations centers, field teams, and technical experts
  - Predicted blast and radiation impacts
  - Correctly estimated source and explosive quantity from limited initial field data
  - Distributed plots to a wide range of federal, state, and local agencies



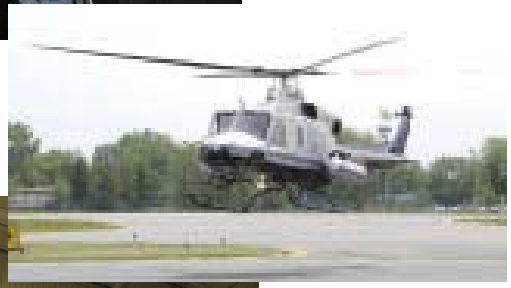


NARAC Supported the DOE-Led Empire 09 Full Scale Exercise (June 2-5, 2009)

- DOE-led Tier II National Level Exercise
- 550 participants from 30 federal, New York State and local agencies in Albany NY
- NARAC planner / controller / observer deployed to Albany NY
- Excellent performance from NARAC staff, who generated eight major sets fo analyses/ predictions in a timely manner
- Successful first exercise application of new LLNL CMweb portal to distribute all NA-42 consequence management products
- First use of new RDD Briefing Products (developed pursuant to a Homeland Security Council tasker)
- New NA-42 TI-developed software used to streamline electronic processing of eFRMAC field data and speed up NARAC response time
- Generation of special products to address scientific issues arising from overlapping cesium and americium RDD plumes

NARAC Operations LLNL

Aerial Measurement System helicopter



FRMAC Operations, Albany NY

Examples of IMAAC Special Event Support

2009 Presidential Inauguration

National Atmospheric Advisory Center
NARAC

IMAAC
Interagency Modeling and Atmospheric Assessment Center

IMAAC Supported the Pre-Inaugural and Inauguration National Security Special Events (January 17-21, 2009)

- IMAAC engaged in three months of pre-event coordination in preparation for the Inauguration
- LLNL deployed an IMAAC liaison to the US Secret Service-led Multi-Agency Communications Center (MACC)
- IMAAC established excellent working relationships with federal, state, and local agencies
- IMAAC Operations at LLNL stood up for extended hours and participated in plume modeling exercises
- DHS IMAAC Director expressed his appreciation and thanked IMAAC Operations for its outstanding support
- DHS Secretary Chertoff thanked the MACC for the highest level of preparedness for any NSSE on his watch

Inauguration of President Obama January 20, 2009

DHS Secretary Chertoff thanks MACC participants

Ron Baskett (LLNL) at IMAAC Desk in MAAC (right) with DOE Senior Energy Official (left) and NOAA liaison (center)

NARAC/IMAAC Modeling System

National Atmospheric Advisory Center
NARAC

IMAAC
Interagency Modeling and
Atmospheric Assessment Center

Component-based NARAC/IMAAC Computer Systems at LLNL Support In-house and External Users

LLNL Computer Systems

Central System: Automated model set-up and execution software

- Weather Data & Forecasts
- Geographic/Terrain Data
- CBRN Material Property Data
- Dose/Risk Factor Data
- Measurement Data
- Source models
- 3-D Meteorological, Dispersion and Fallout Models
- Prompt Effects Models
- Data-driven modeling tools
- Mapping and product generation software
- Population, casualty and fatality estimation

Remote Access Computer System

User interfaces and Analysis Tools for LLNL scientists

Internet/Intranet

External User Tools

***IMAAC/CM/NARAC Web* tools**

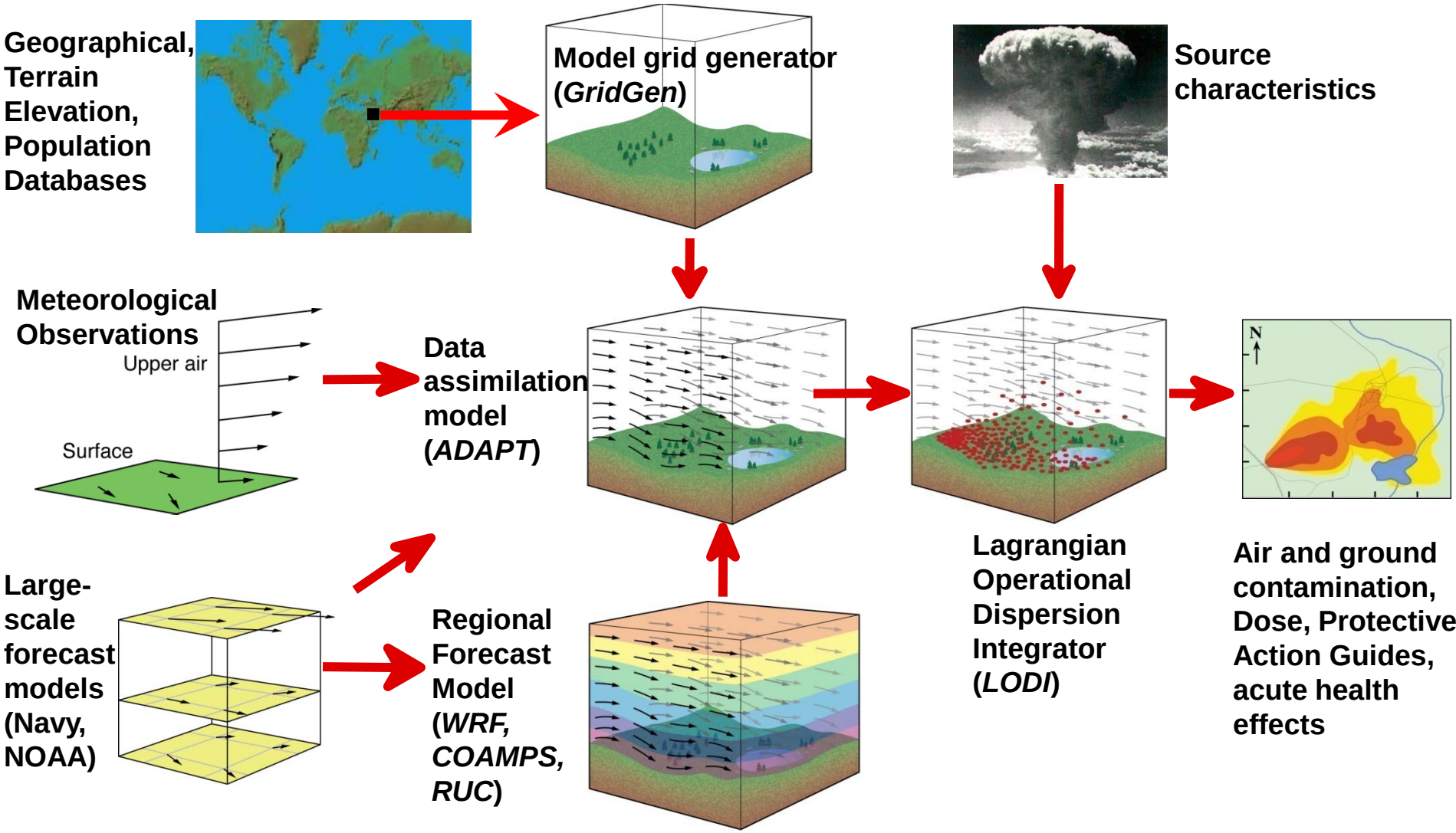
NARAC iClient

HotSpot

Standalone models and mapping

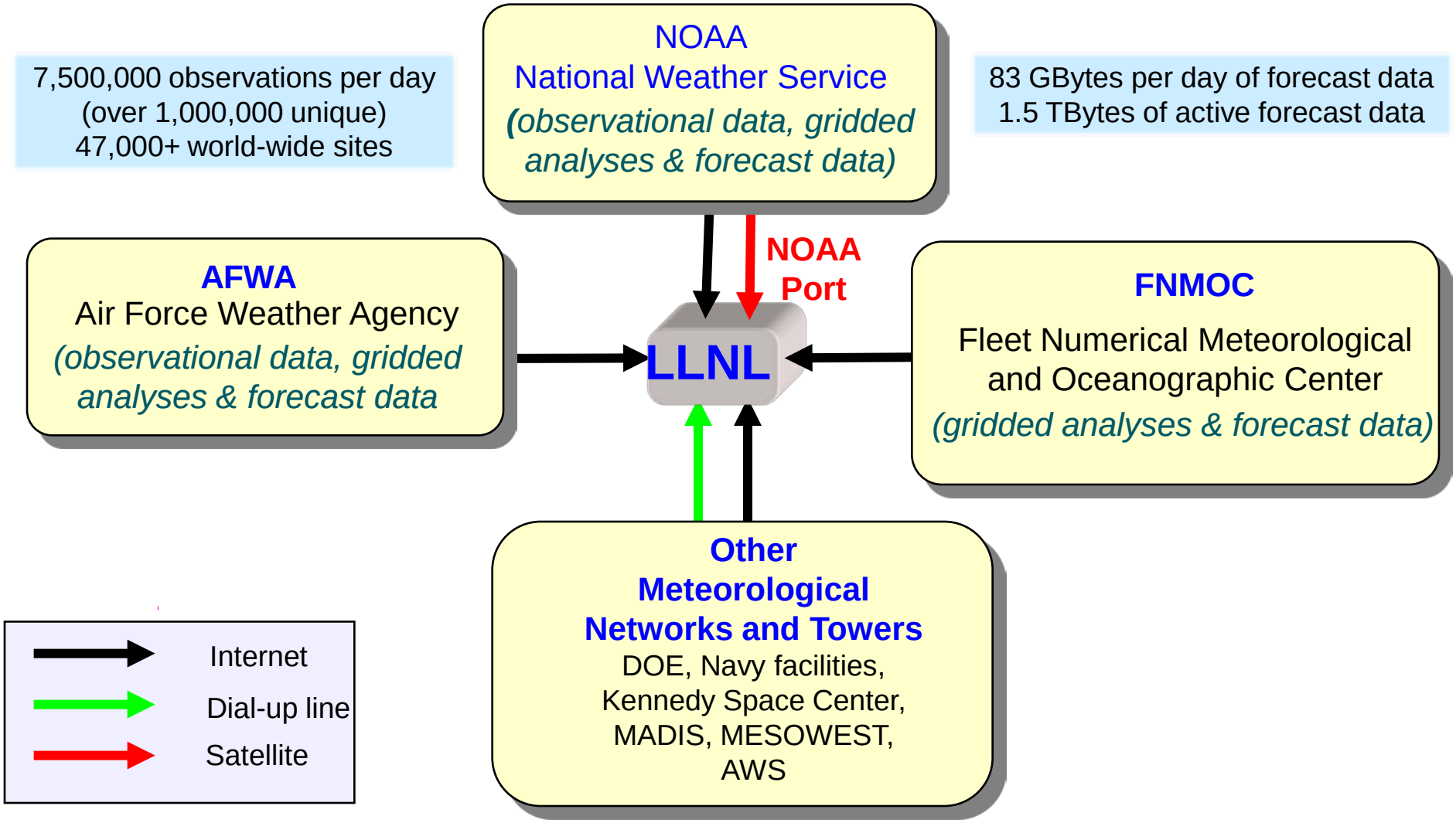
- Over 400 software applications
- 50 databases
- 3 million lines of computer code
- 28 servers
- 8 data storage systems

NARAC/IMAAC Central Modeling System Provides Automated 3-D Worldwide Plume Model Predictions

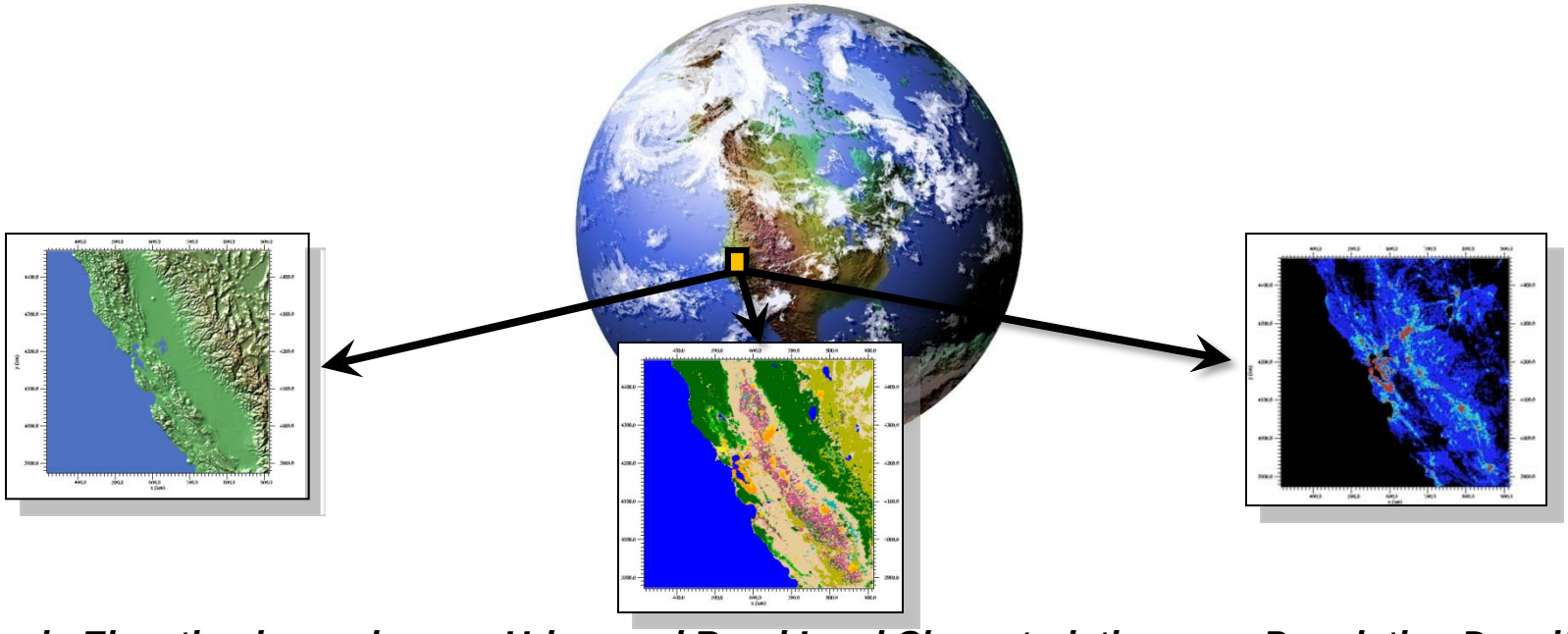


Automated initial products are available in 5 to 10 minutes. Quality-assured refined products based on field data are available in 10 – 60 minutes, depending on the quantity and quality of the data.

Multiple Weather Services and Networks Provide Automated Meteorological Data to LLNL



World-Wide Geospatial Databases Provide Input Data to Model Calculations and Assessment Products



Terrain Elevation is used in 3-D meteorological flow and dispersion models

Global coverage
- NGDC 10km
- USGS 1km
- NIMA DTED (1km, 100m, and 30m)

U.S. coverage
- USGS DEM 30m

Urban and Rural Land Characteristics are used to model their effects on wind and turbulence

Global coverage
- ORNL 1km GLCC

U.S. coverage
- USGS 200m LULC
- USGS 30m NLCD
- NGA 133-city 3-D building data
- LBNL US building infiltration database

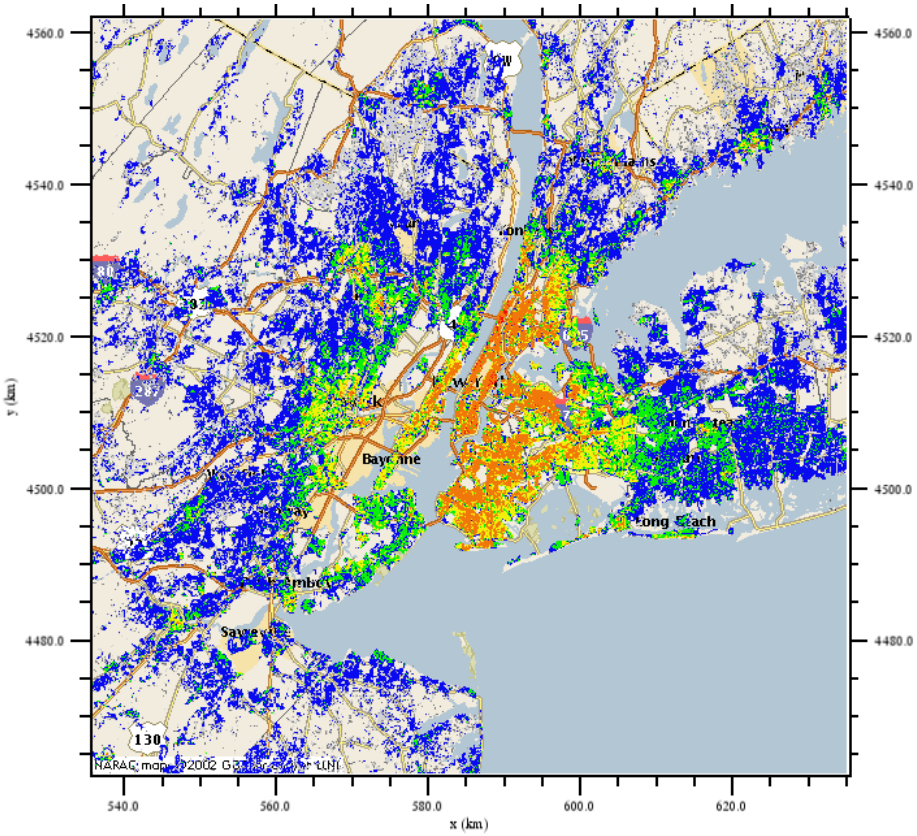
Population Density is used to estimate affected population and casualties

Global coverage
- ORNL 1km LandScan

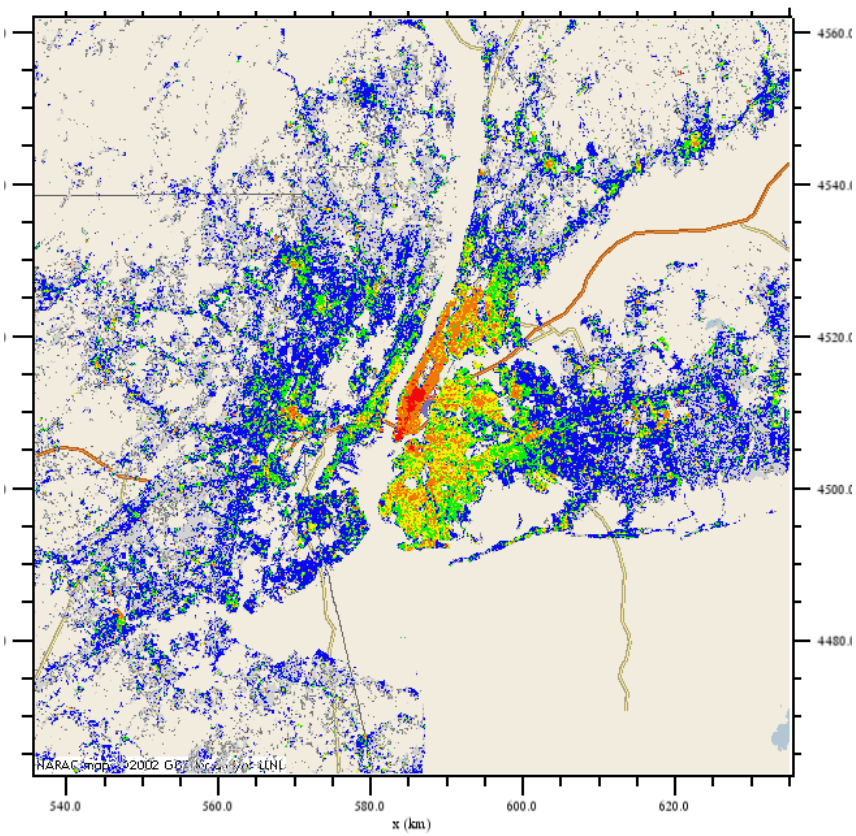
U.S. coverage
- Census Bureau
- LANL day and night
- ORNL LandScanUSA day and night

High-Resolution Day-Night Population Databases are Used in Model Calculations

Nighttime Population Density
New York City Area

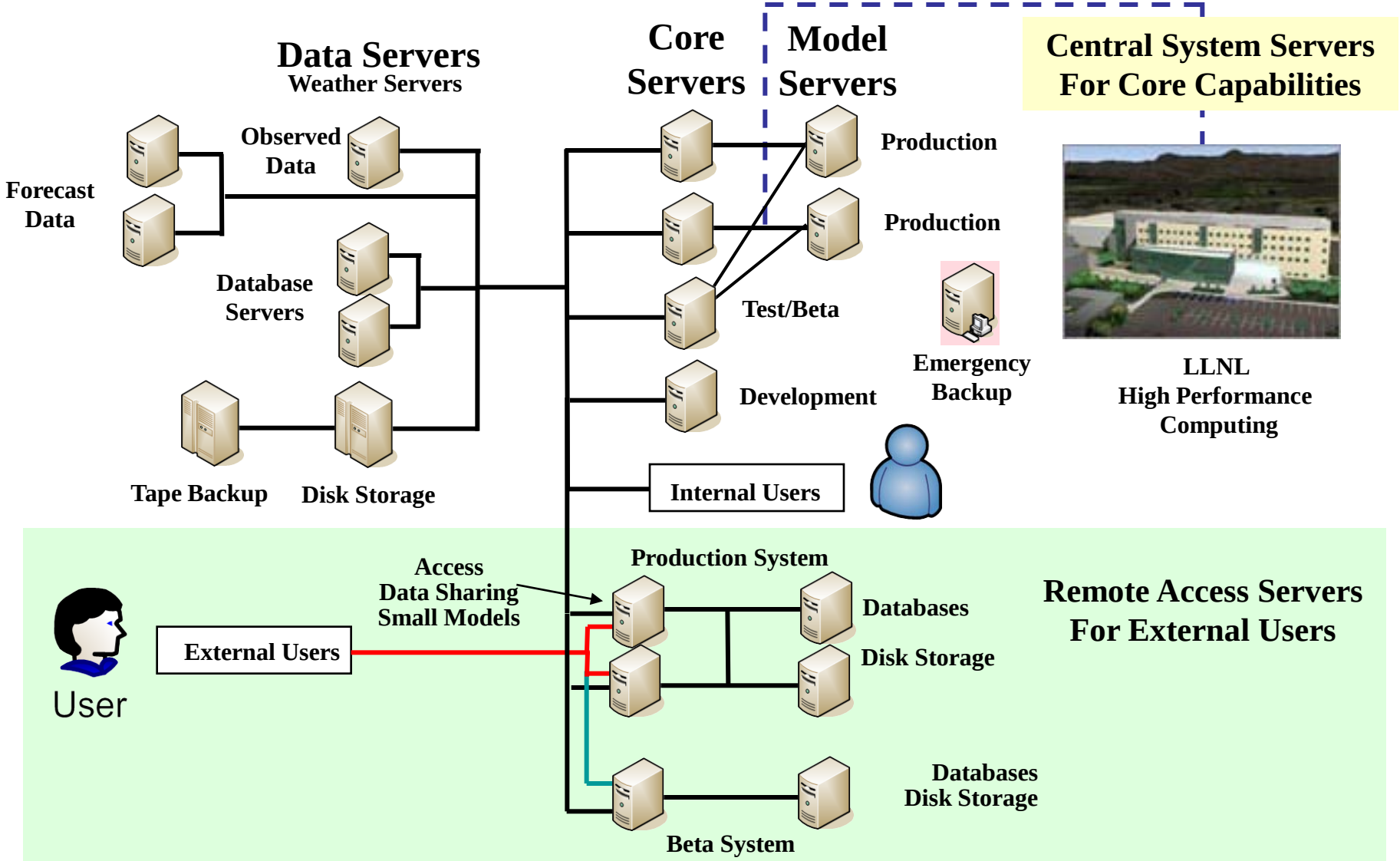


Daytime Population Density
New York City Area



Oak Ridge National Laboratory LandScanUSA day-night population data obtained from HSIP GOLD dataset

Modular, Redundant, Fault-Tolerant Servers Ensure 24/7 Reliability of Computer Systems

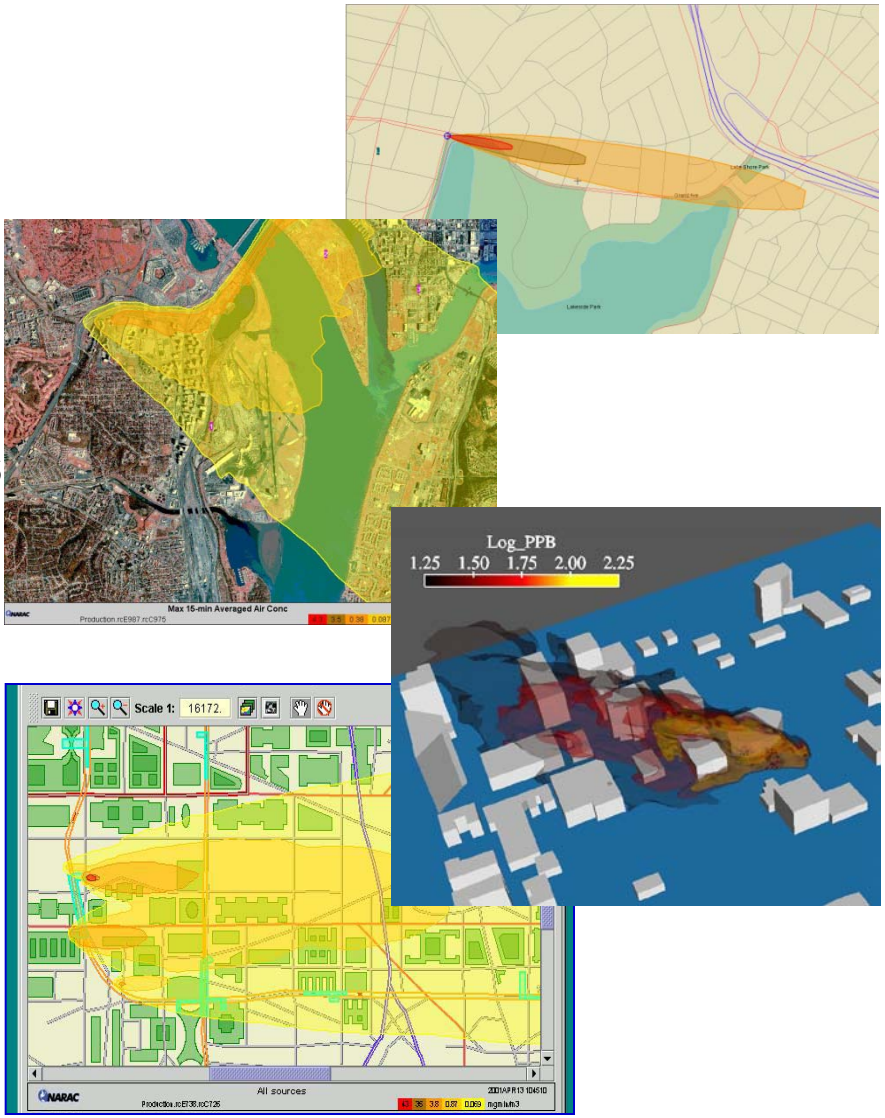


Multiple Source Term Models are Used in NARAC/IMAAC Plume Model Predictions

- Explosive dispersal devices: airborne fractions, particle-size distribution (SNL Source Term Calculator)
- Nuclear detonation (LLNL KDFOC3, LWAC)
- CBRN material properties (DIPPR, ORNL, DoD)
- Chemical and biological weapon sources/sprayers (SNL Source Term and Dose Response Assessment Tool)
- Classified weapons data (DoD, DOE)
- Toxic industrial chemicals (leaks, spills, tanks) (NOAA/EPA)
- Explosive prompt blast effects prediction (SNL *BLAST* model)
- Buoyant & momentum plume rise from fires or stack emission (LLNL *LODI* model)
- Nuclear power plant release characteristics (NRC *RASCAL* model)

NARAC/IMAAC Utilizes a Suite of In-House and Collaborating Agency Atmospheric and Plume Models

- LLNL regional modeling suite (ADAPT/ LODI) and fallout model (KDFOC)
- Weather forecast models (NOAA, Air Force and Navy global and regional models)
- Radiological plume models (DOE HOTSPOT)
- Hazmat / toxic industrial chemical models (e.g., NOAA/EPA ALOHA / CAMEO, EPICode)
- Nuclear power plant (NRC's RASCAL)
- Prompt/blast effects models (SNL's BLAST and NUKE)
- Urban building-scale models (FEM3MP, UDM)
- NOAA HYSPLIT
- DoD Joint Effects Model / HPAC
- Subway (ANL), indoor (LBNL/NIST)



NARAC/IMAAC
Automated Reach-back Modeling Capabilities

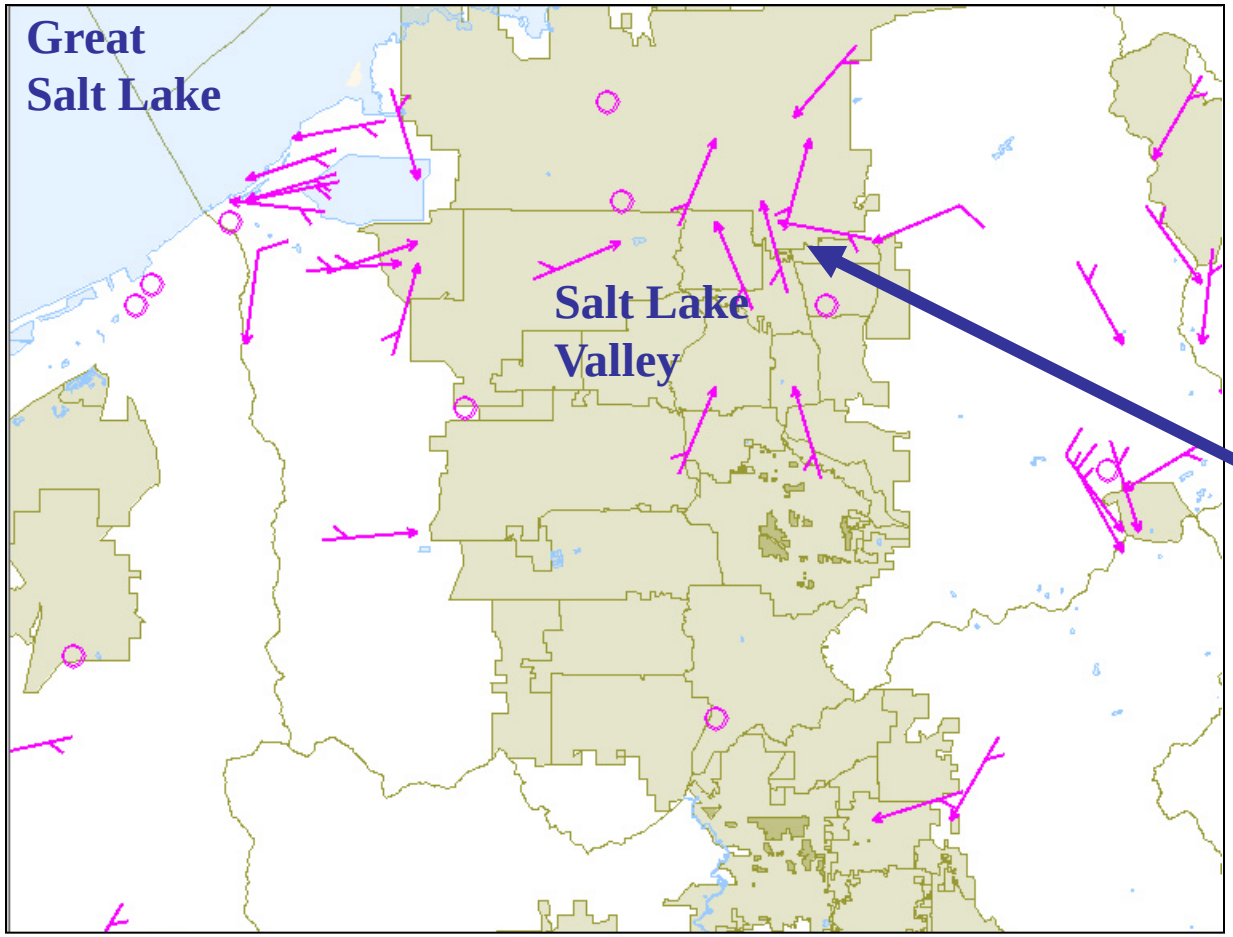
Hypothetical Salt Lake City RDD

National Atmospheric Advisory Center
NARAC

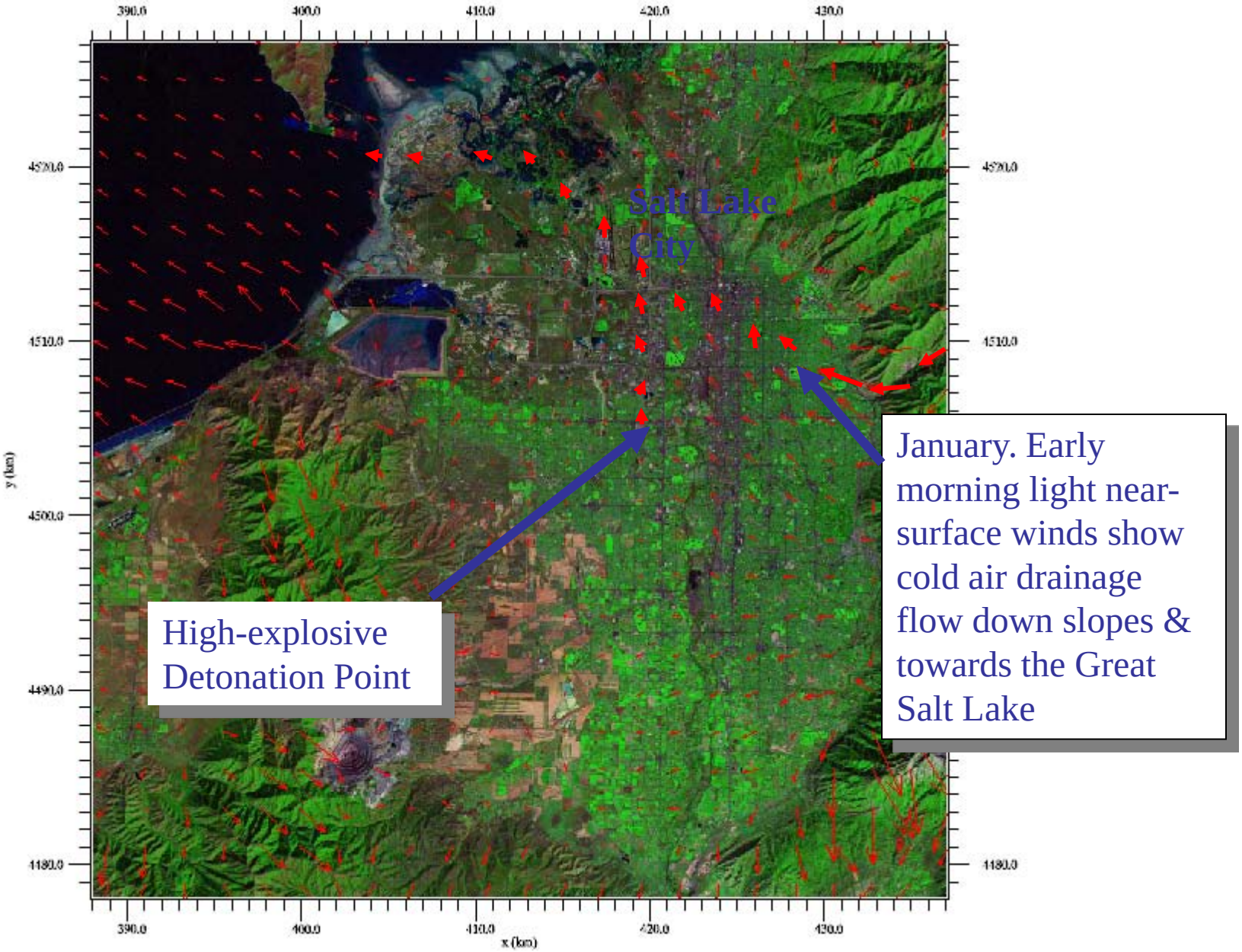
IMAAC
Interagency Modeling and
Atmospheric Assessment Center

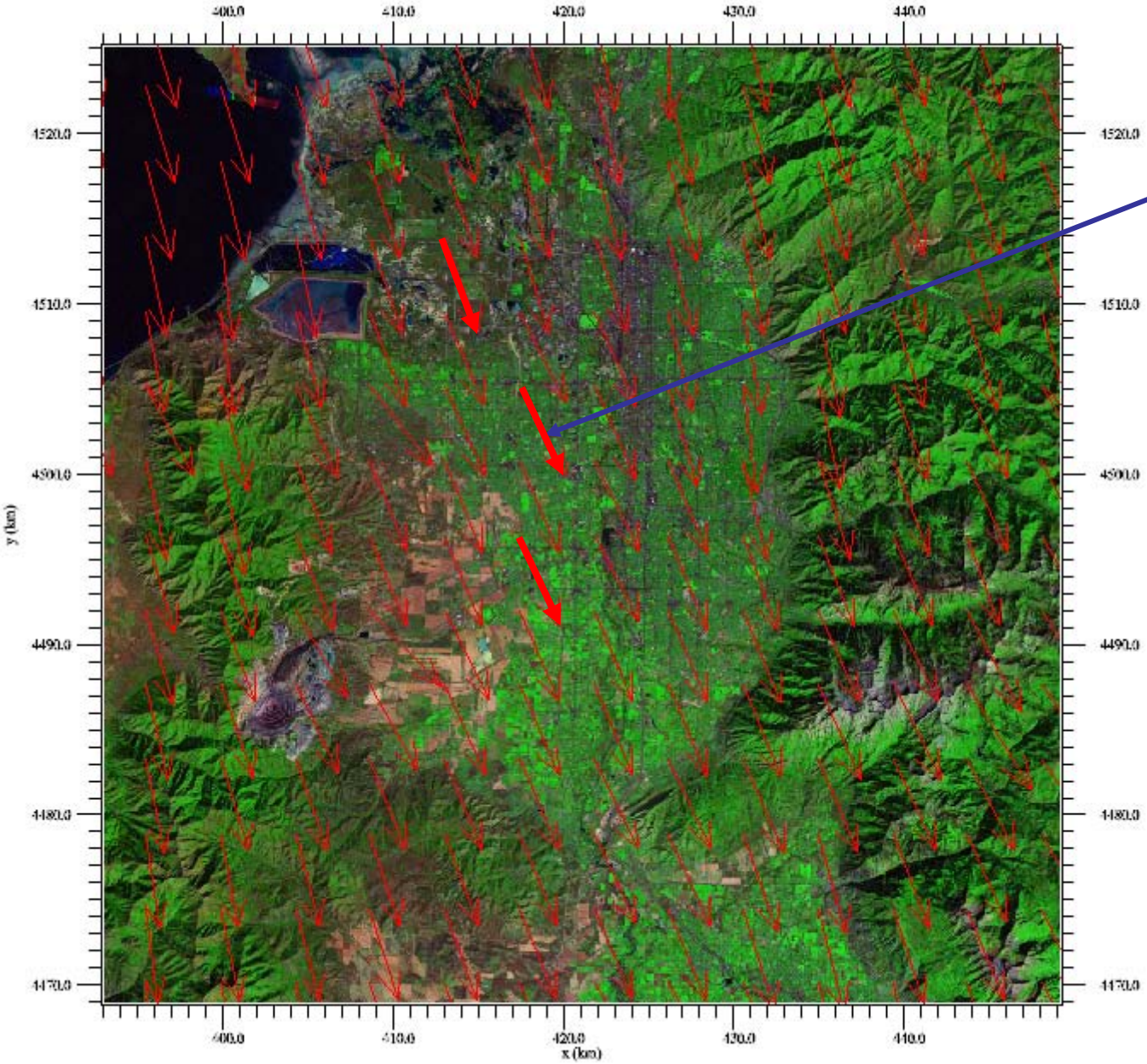
Winter Case Study: Hypothetical RDD in Salt Lake City

Mesonet Surface Wind Observations

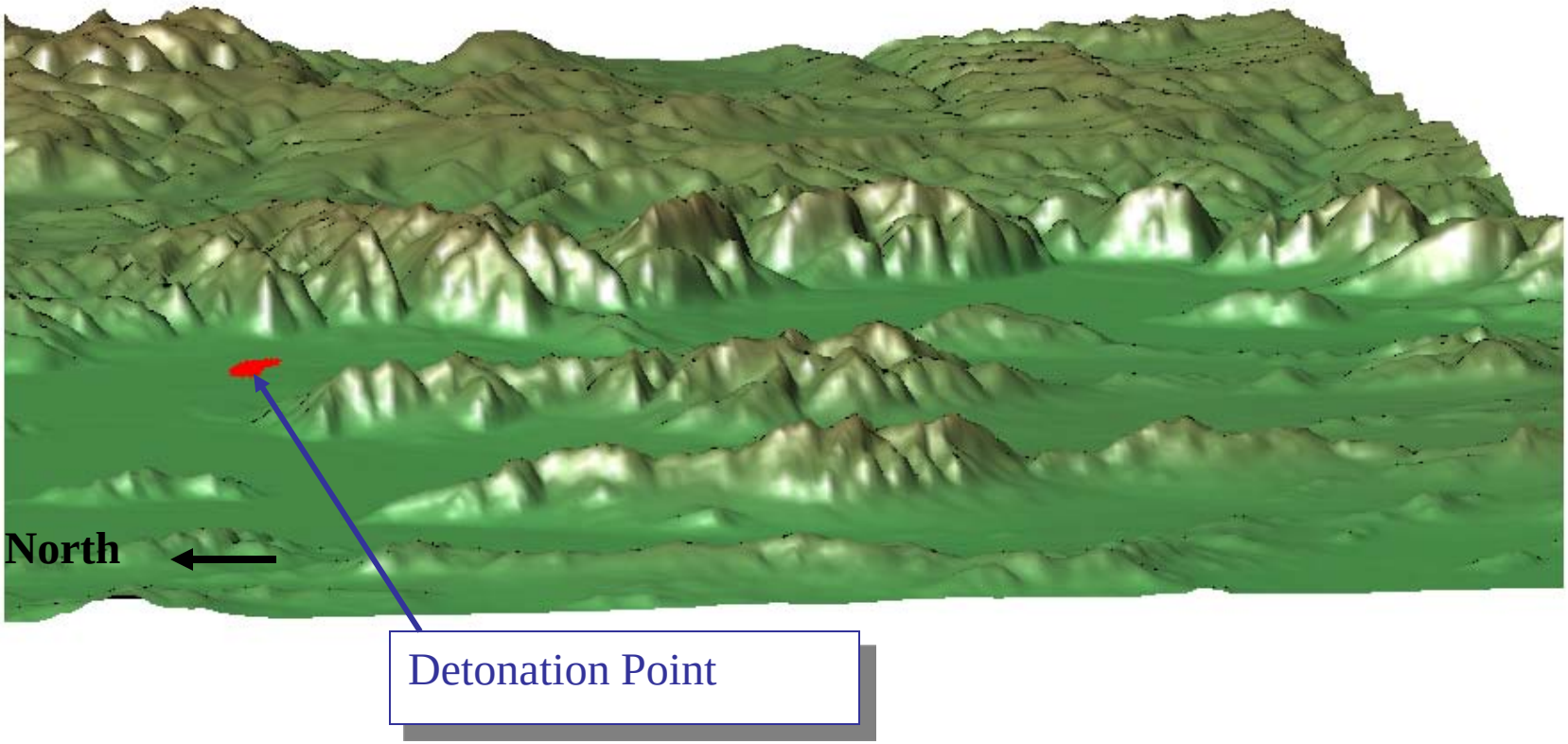


January. Early morning light near-surface winds show cold air drainage flow down slopes & towards the Great Salt Lake

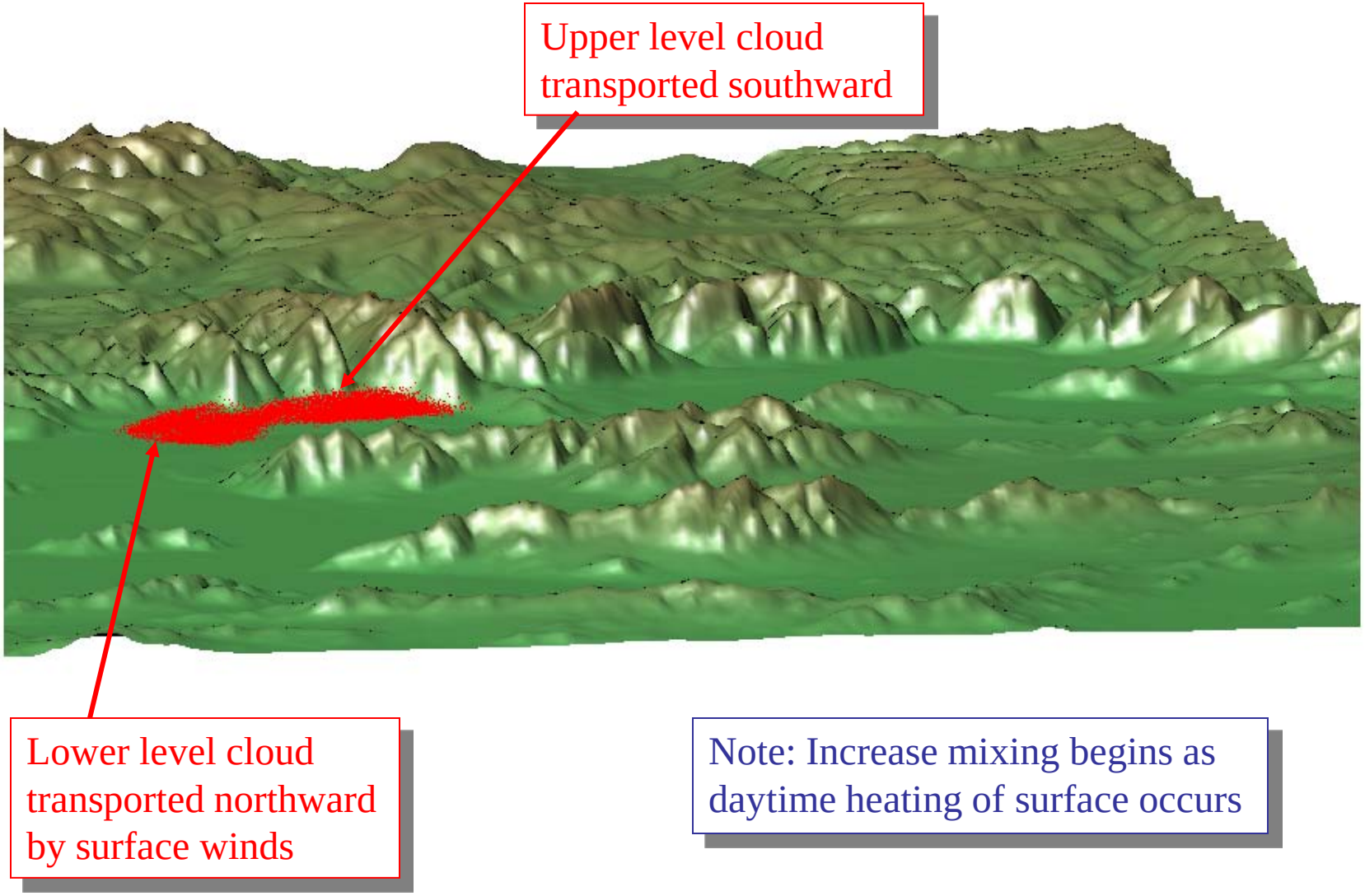

390.0
400.0
410.0
420.0
430.0
4520.0
4510.0
4500.0
4490.0
4480.0
y (km)
x (km)
Salt Lake City
High-explosive Detonation Point
January. Early morning light near-surface winds show cold air drainage flow down slopes & towards the Great Salt Lake

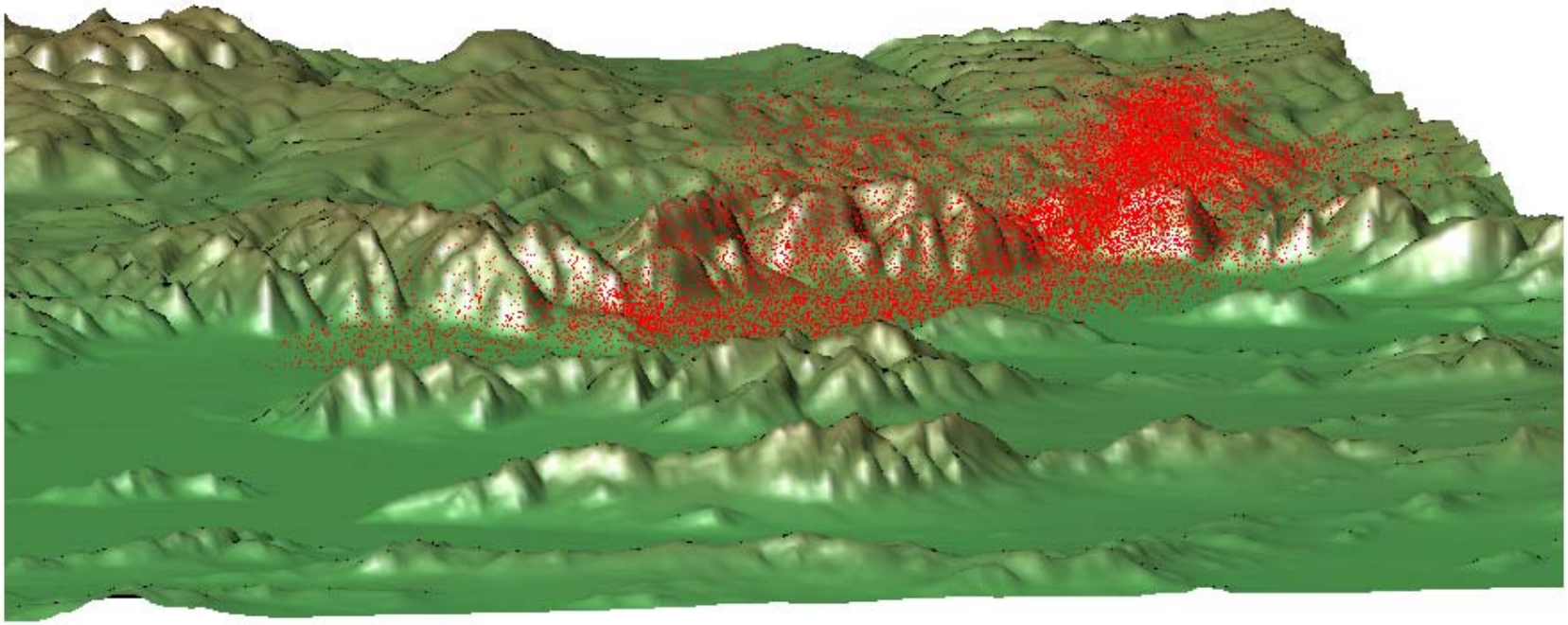


Stronger Upper-level winds from the north

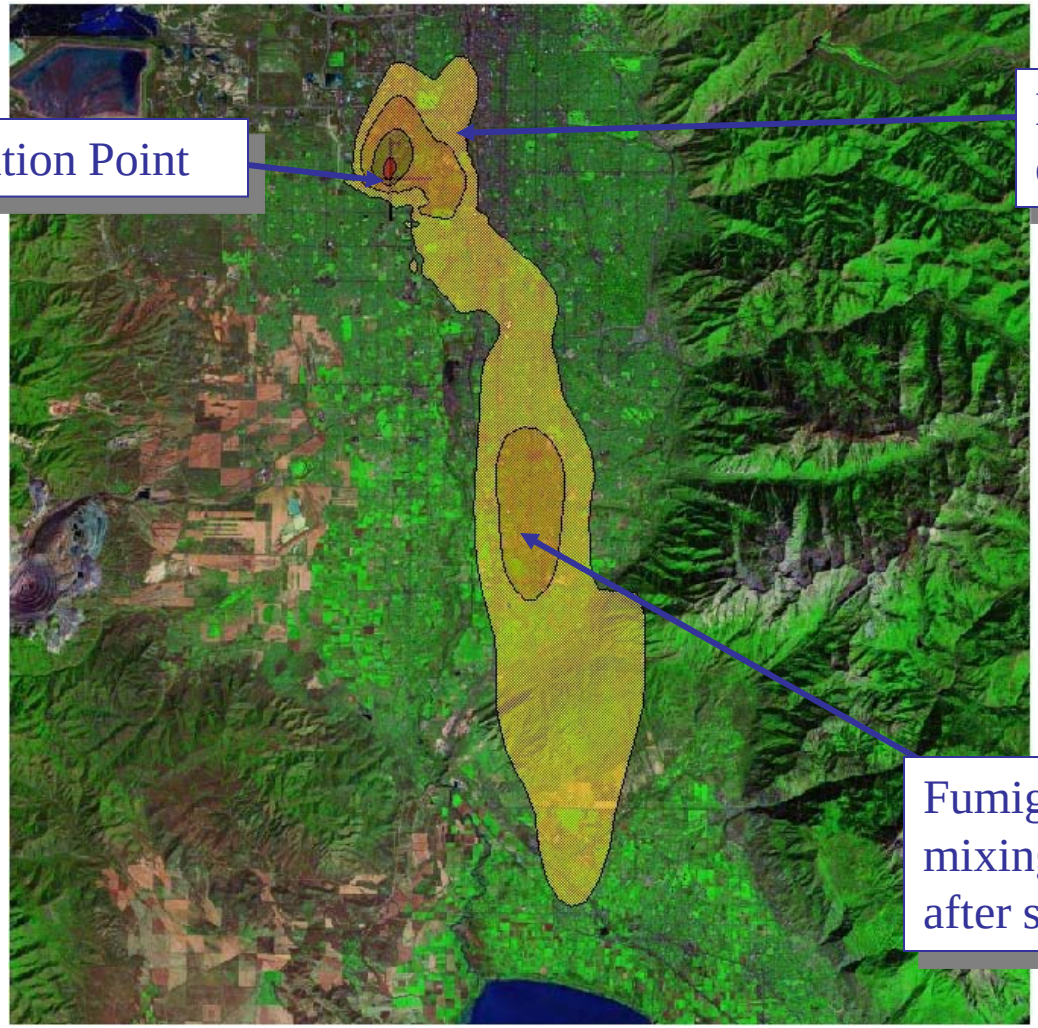


Red particles show LLNL NARAC ADAPT/LODI dispersion simulation using SNL ERAD explosive source characteristics (particle size distribution and spatial distribution of mass from surface to several hundred meters above ground) — Simulation begins at 05:00 MST (ends at 11:00 MST)


Upper level cloud transported southward
Lower level cloud transported northward by surface winds
Note: Increase mixing begins as daytime heating of surface occurs



Winter Case Study: Hypothetical RDD Ground-level Time-integrated Dose

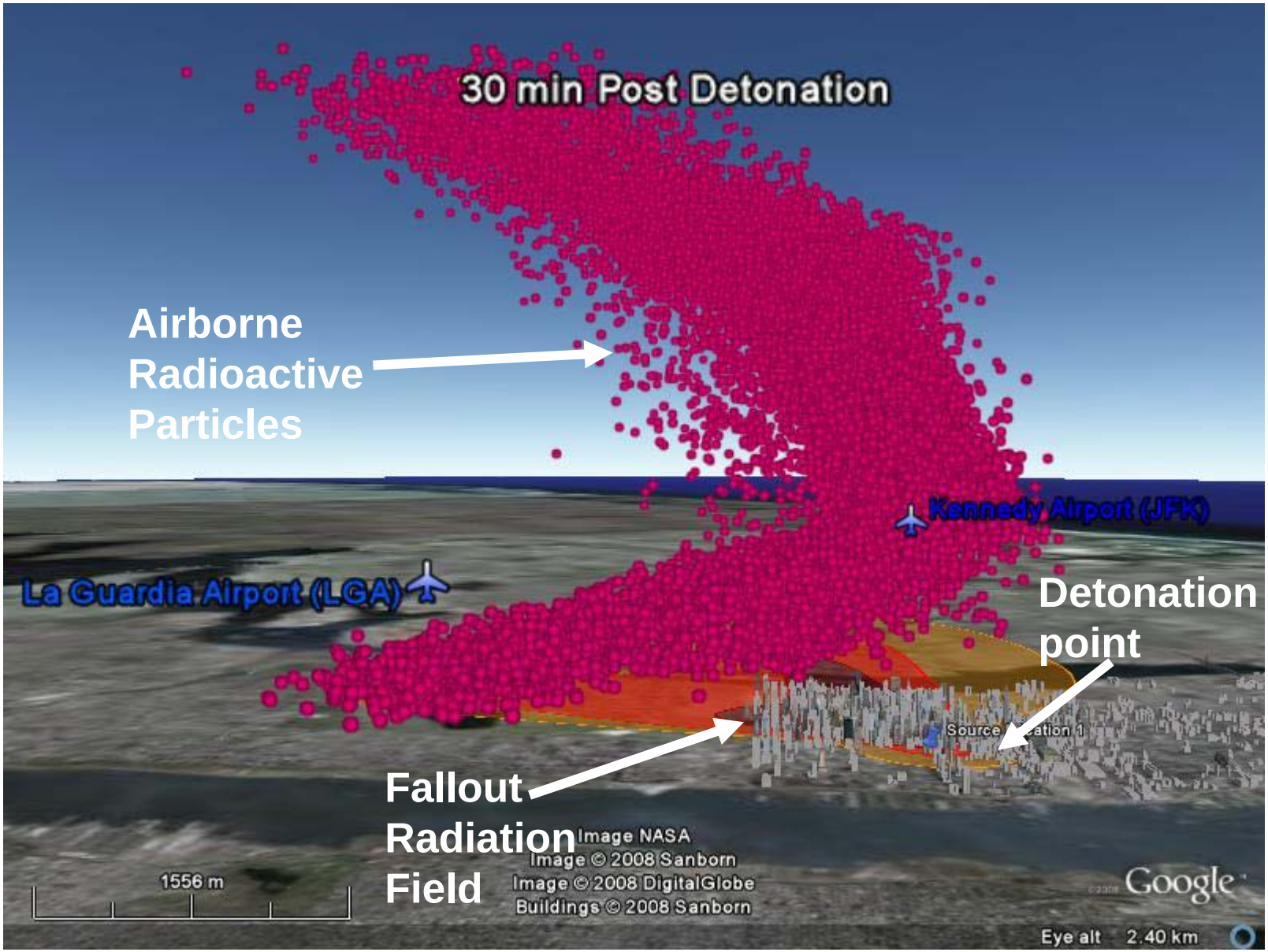


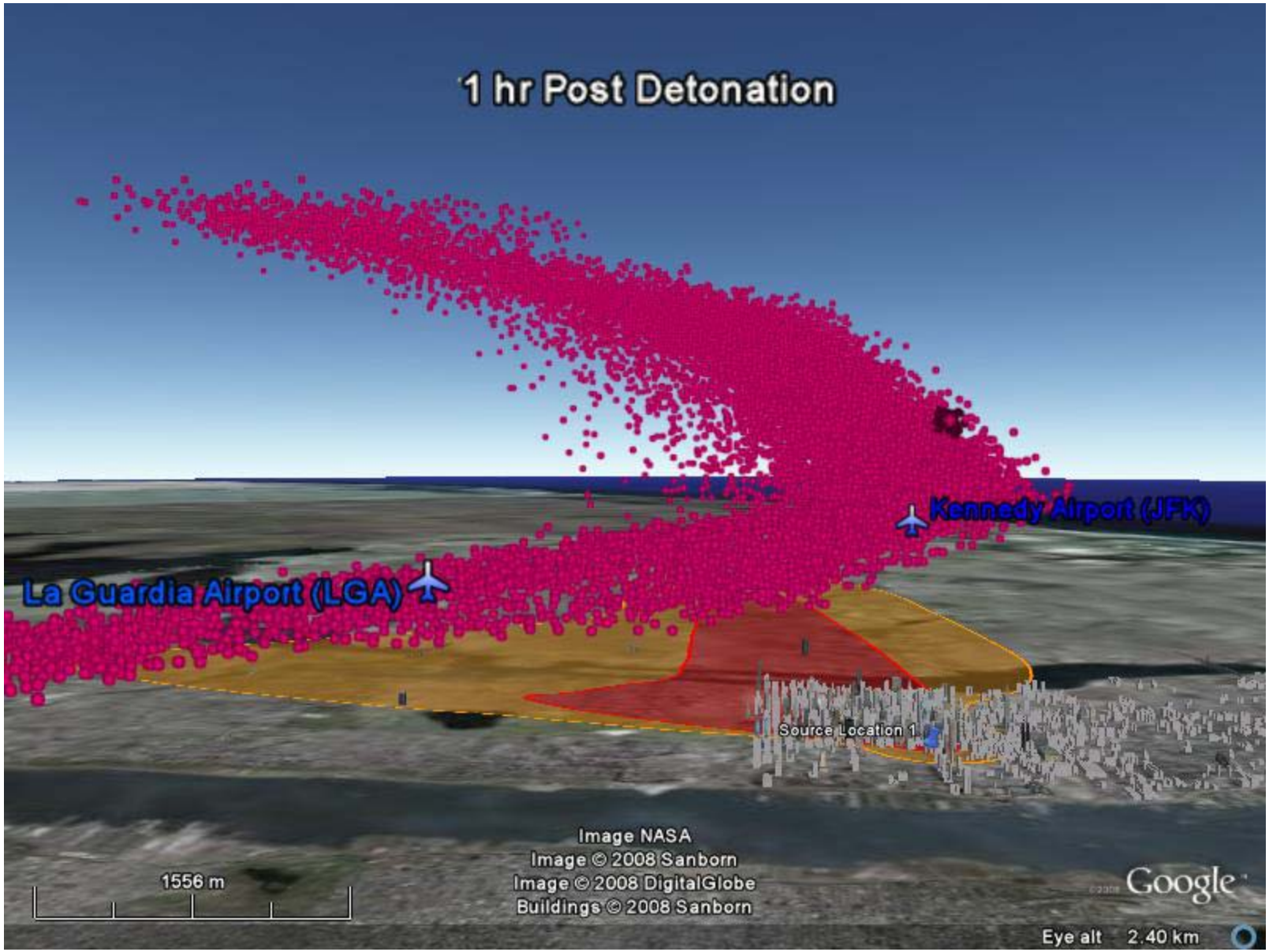
Animation of NARAC/IMAAC Model Simulation of Airborne Nuclear Debris Cloud and Fallout Contamination Footprint

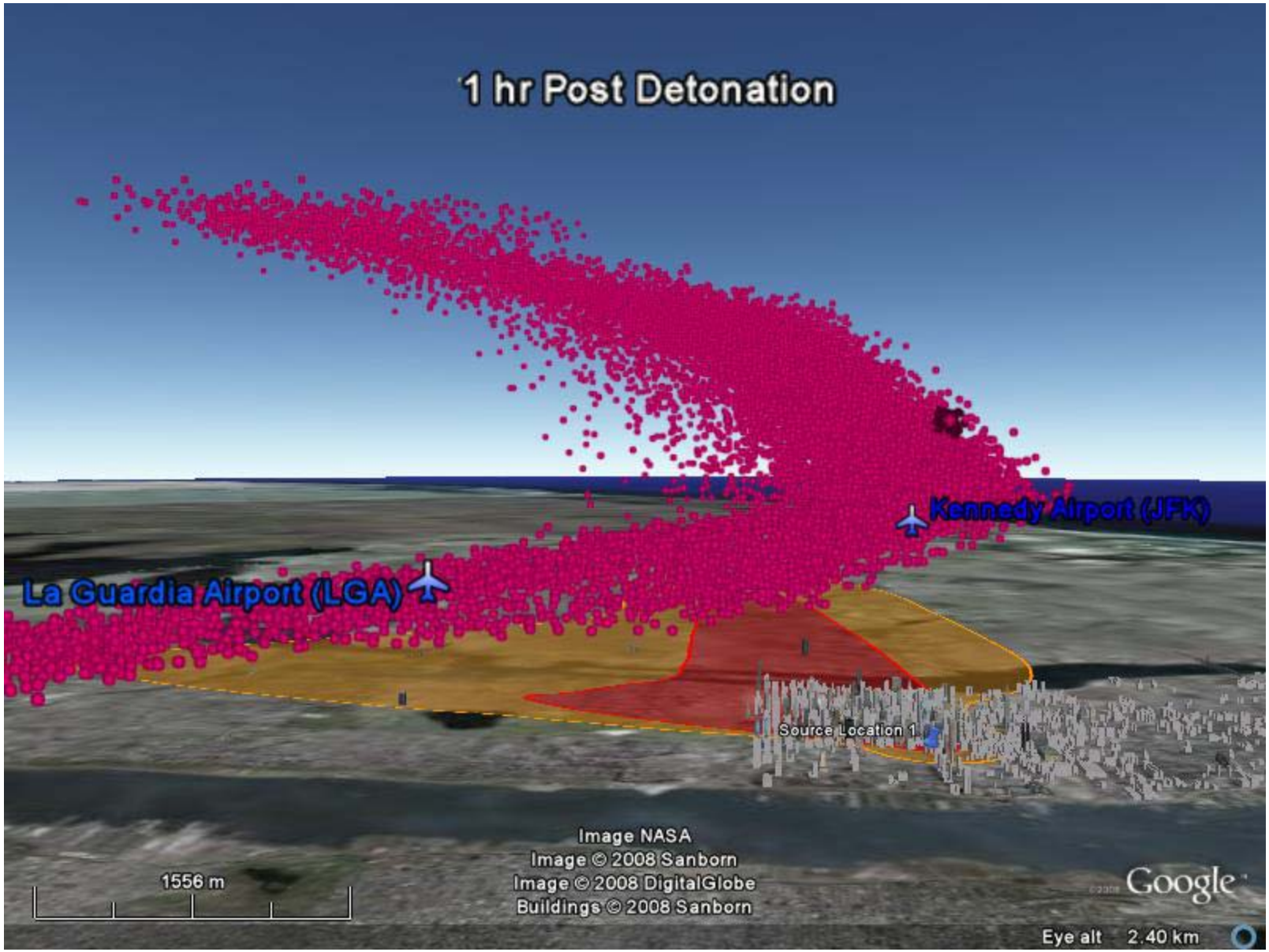
IND Response Strategy
Planning Guidance

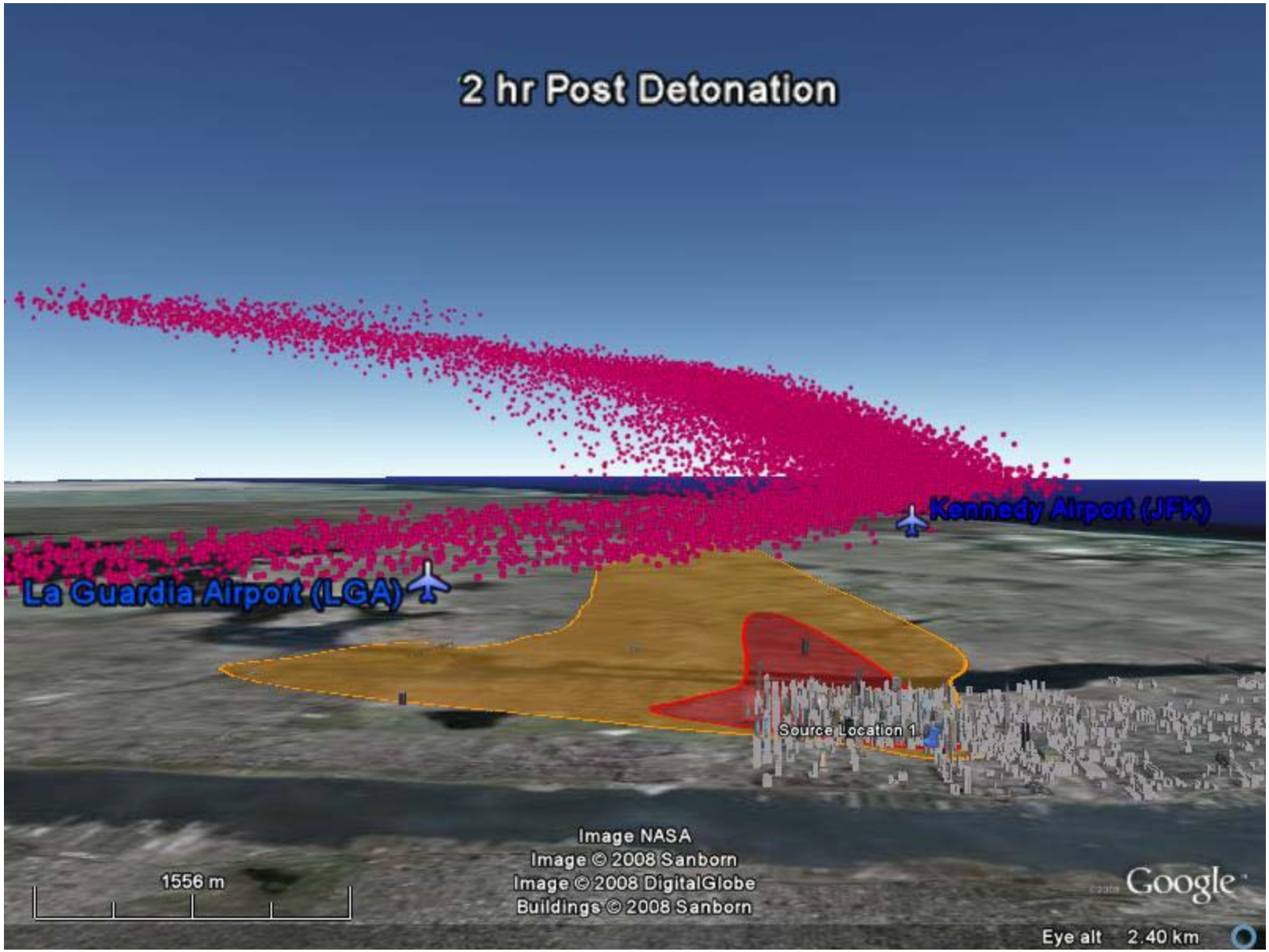
National Atmospheric Advisory Center
NARAC

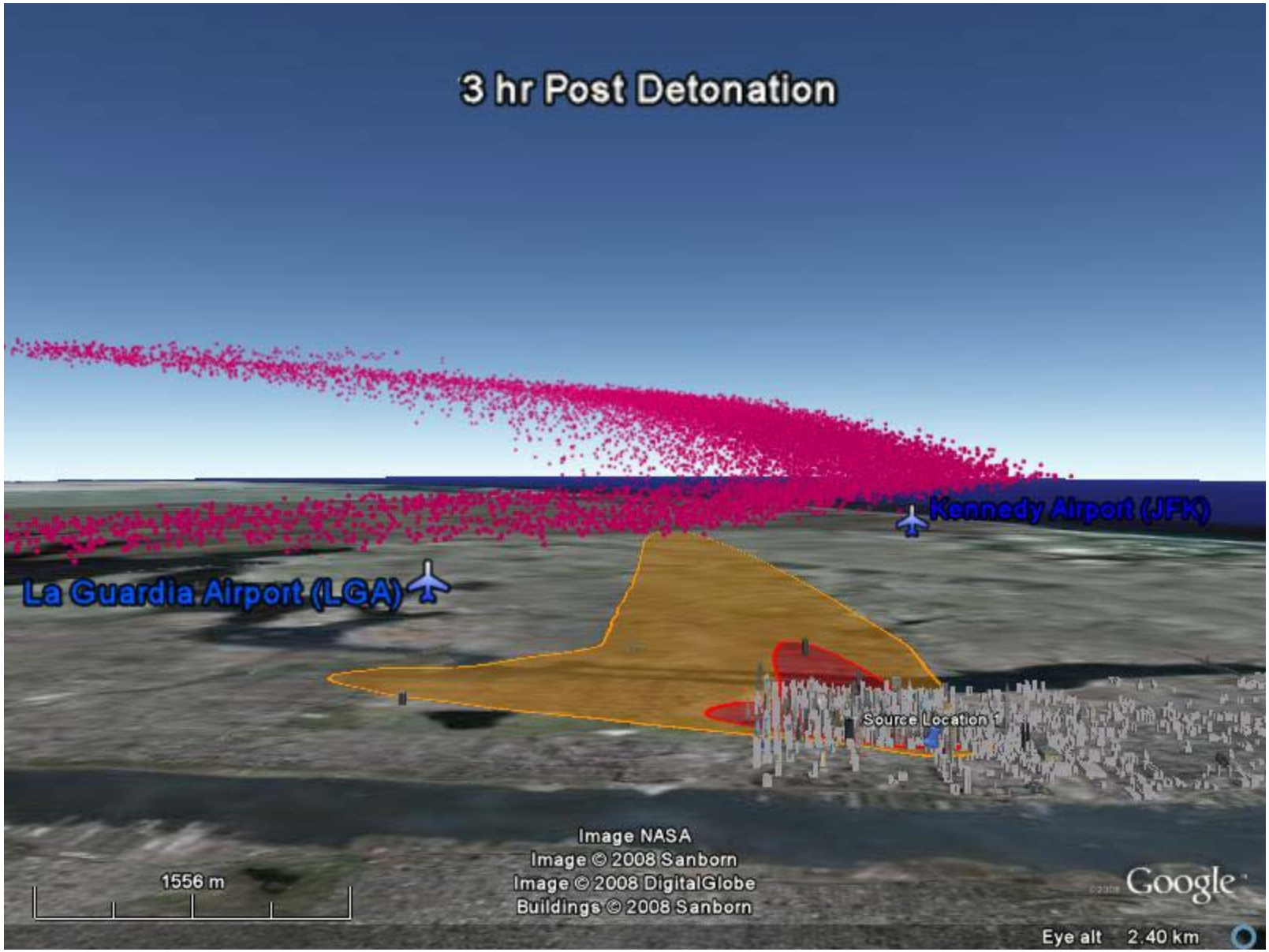
IMAAC
Interagency Modeling and Atmospheric Assessment Center

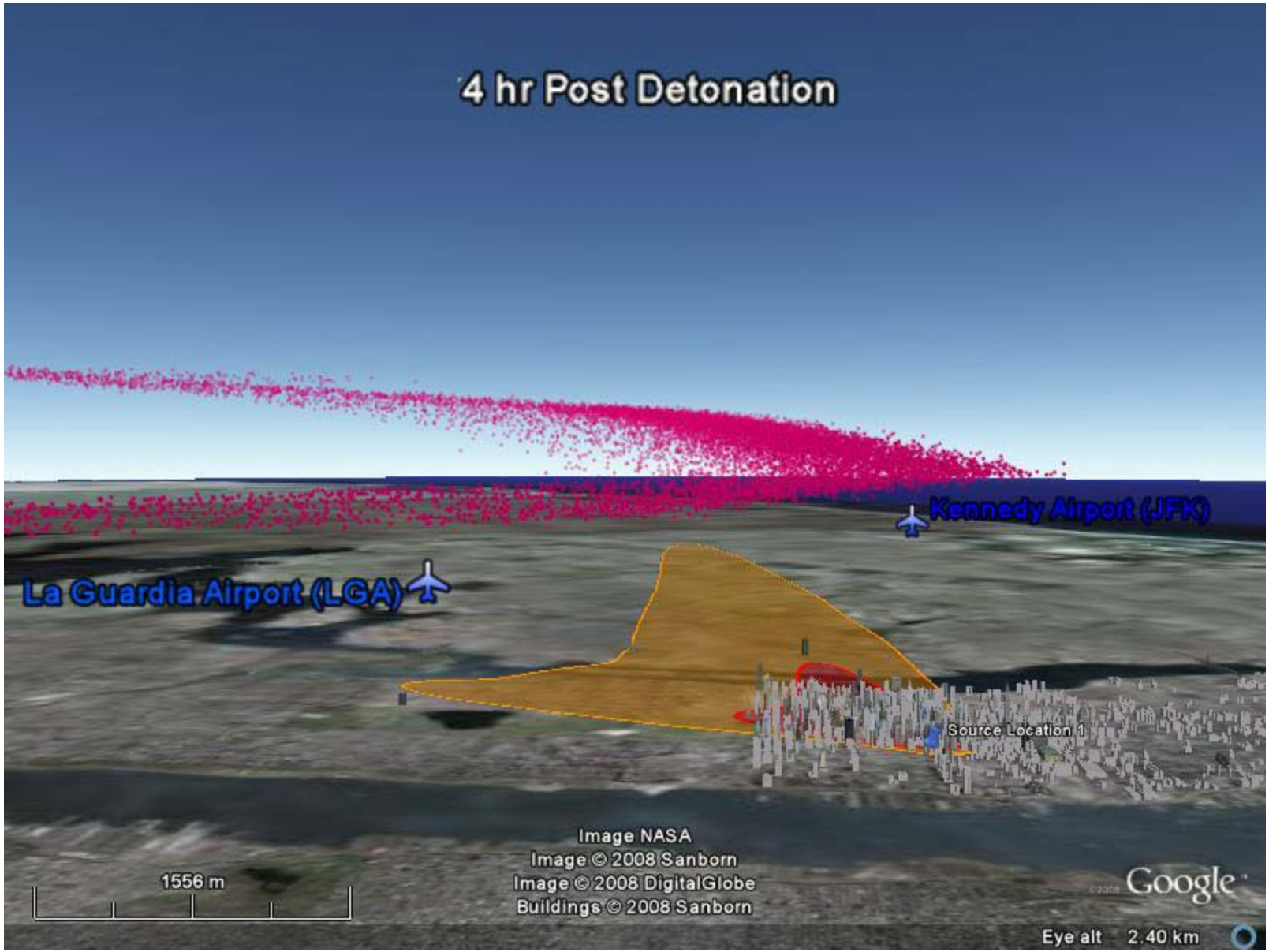

30 min Post Detonation
Airborne Radioactive Particles
Kennedy Airport (JFK)
La Guardia Airport (LGA)
Detonation point
Fallout Radiation Field
Image NASA
Image © 2008 Sanborn
Image © 2008 DigitalGlobe
Buildings © 2008 Sanborn
1556 m
Google
Eye alt 2.40 km

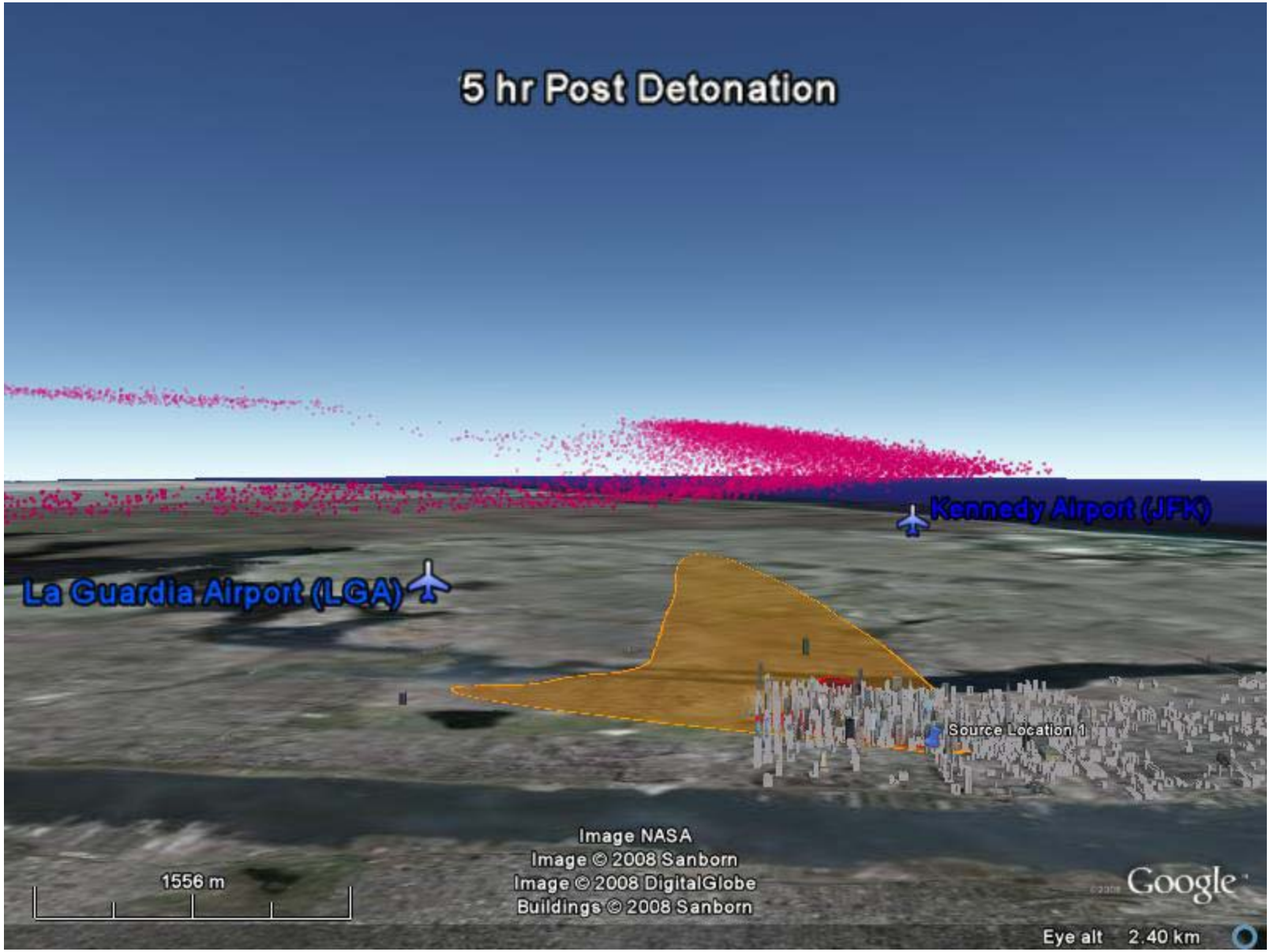

1 hr Post Detonation
Kennedy Airport (JFK)
La Guardia Airport (LGA)
Source Location 1
Image NASA
Image © 2008 Sanborn
Image © 2008 DigitalGlobe
Buildings © 2008 Sanborn
1556 m
Google
Eye alt 2.40 km


1 hr Post Detonation
Kennedy Airport (JFK)
La Guardia Airport (LGA)
Source Location 1
Image NASA
Image © 2008 Sanborn
Image © 2008 DigitalGlobe
Buildings © 2008 Sanborn
1556 m
Google
Eye alt 2.40 km


2 hr Post Detonation
Kennedy Airport (JFK)
La Guardia Airport (LGA)
Source Location 1
Image NASA
Image © 2008 Sanborn
Image © 2008 DigitalGlobe
Buildings © 2008 Sanborn
1556 m
Google
Eye alt 2.40 km


3 hr Post Detonation
Kennedy Airport (JFK)
La Guardia Airport (LGA)
Source Location 1
Image NASA
Image © 2008 Sanborn
Image © 2008 DigitalGlobe
Buildings © 2008 Sanborn
1556 m
Google
Eye alt 2.40 km


4 hr Post Detonation
Kennedy Airport (JFK)
La Guardia Airport (LGA)
Source Location 1
Image NASA
Image © 2008 Sanborn
Image © 2008 DigitalGlobe
Buildings © 2008 Sanborn
1556 m
Google
Eye alt 2.40 km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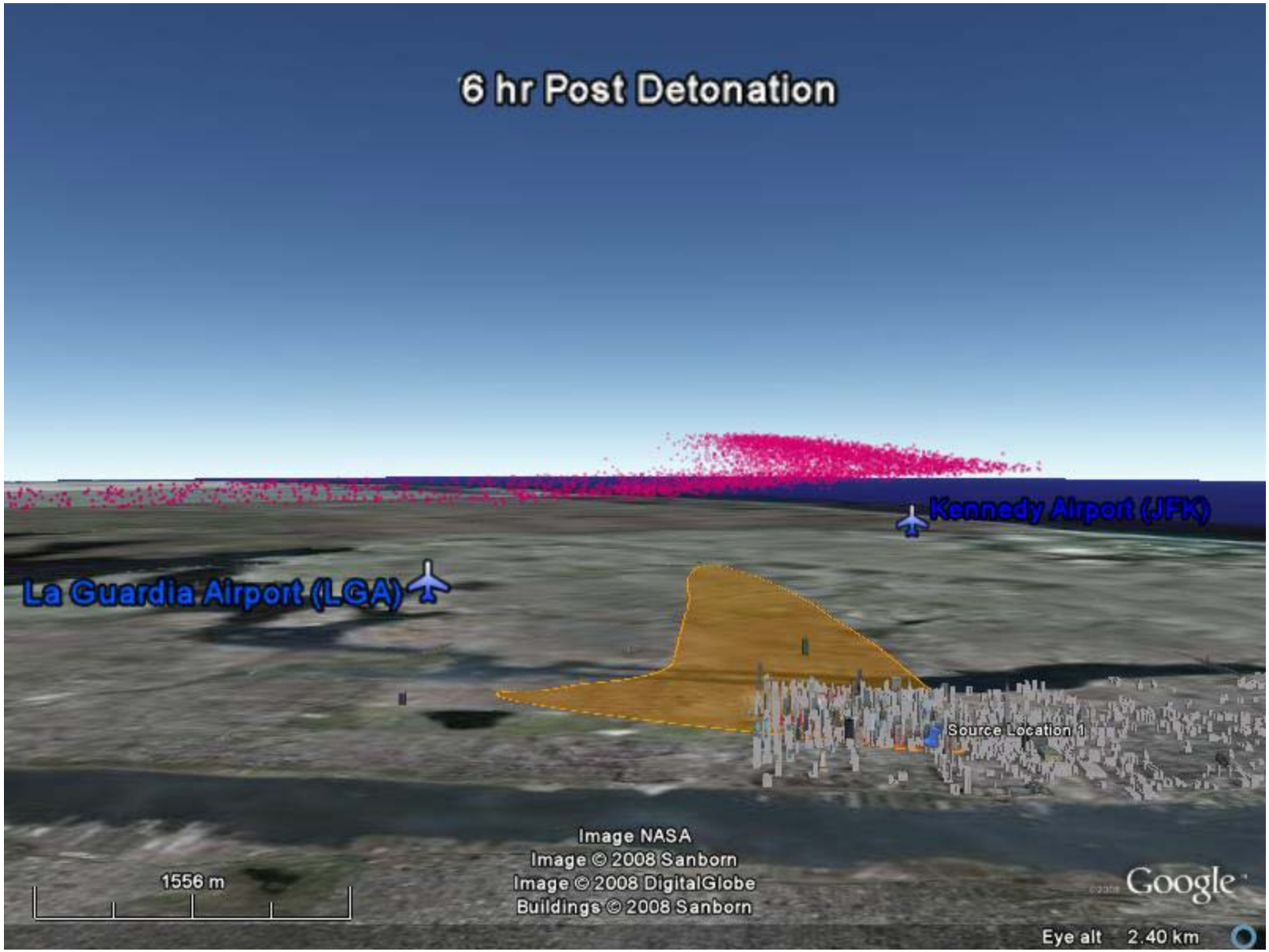
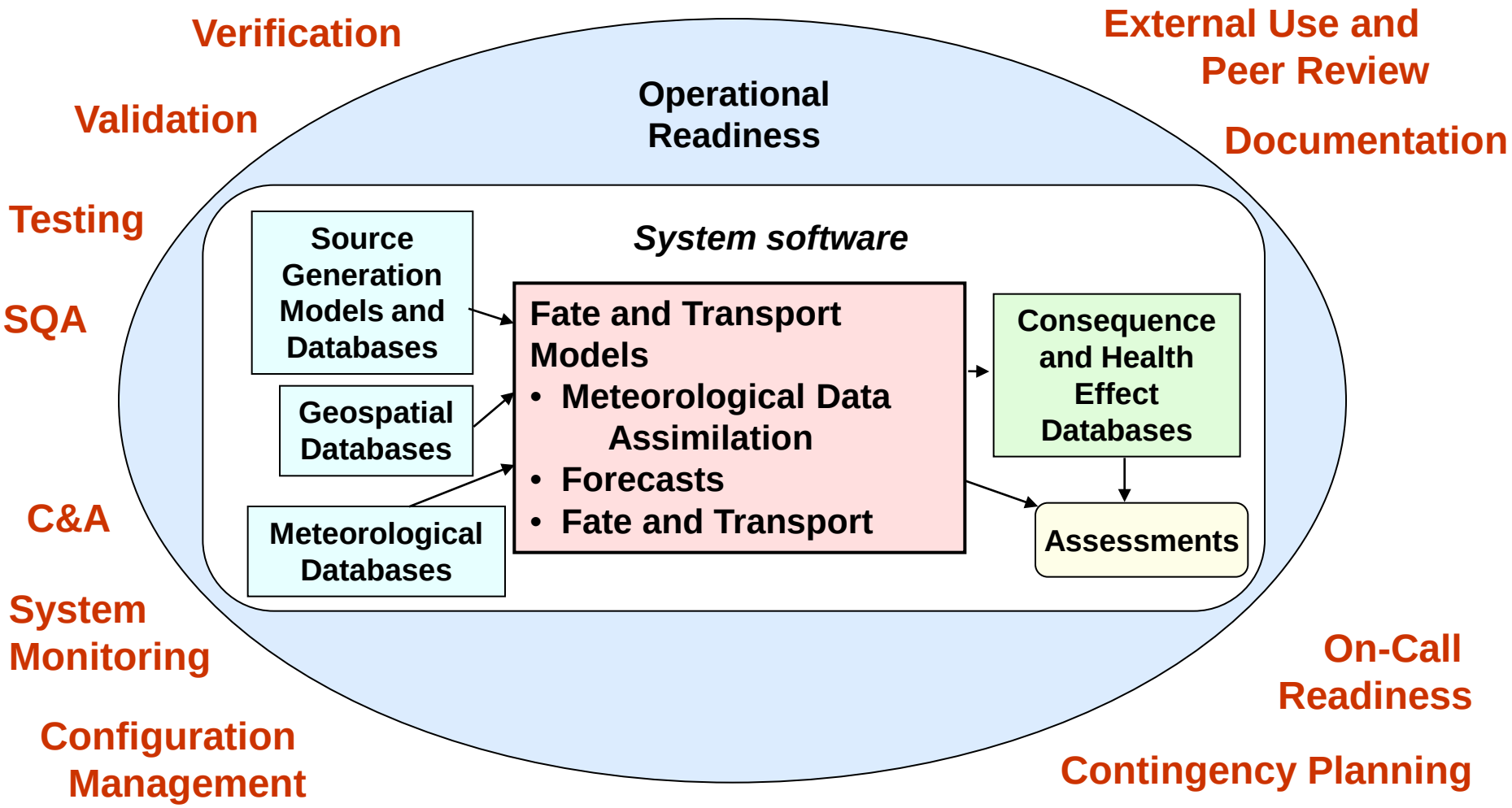
Kennedy Airport (JFK)
La Guardia Airport (LGA)
Source Location 1
Image NASA
Image © 2008 Sanborn
Image © 2008 DigitalGlobe
Buildings © 2008 Sanborn
1556 m
Google
Eye alt 2.40 km

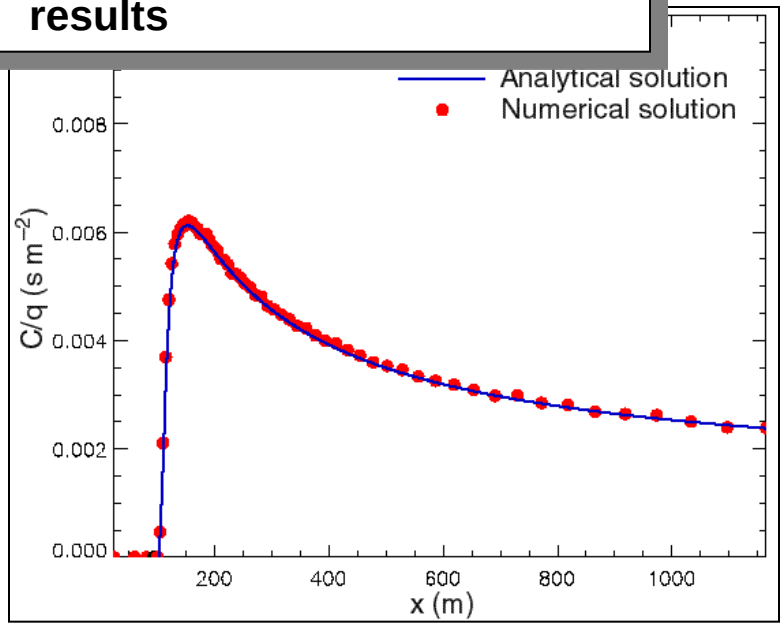

6 hr Post Detonation
Kennedy Airport (JFK)
La Guardia Airport (LGA)
Source Location 1
Image NASA
Image © 2008 Sanborn
Image © 2008 DigitalGlobe
Buildings © 2008 Sanborn
1556 m
Google
Eye alt 2.40 km

A Comprehensive Approach to Quality Assurance and Operational Readiness Ensures Reliability and Accuracy



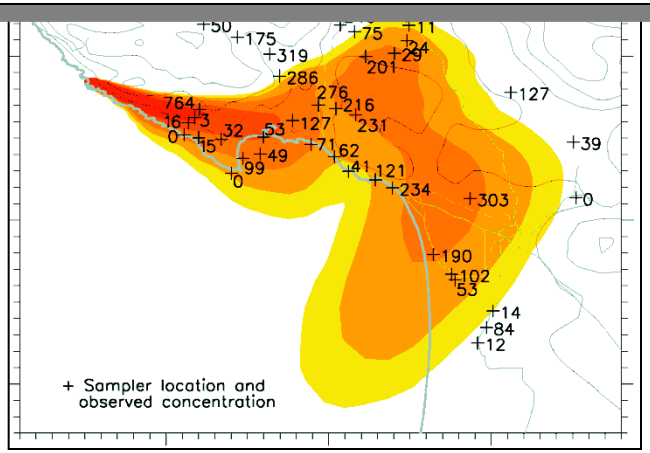
NARAC/IMAAC Models and Capabilities are Extensively Tested and Evaluated

- **Analytic solutions test models versus known, exact results**



- **Field experiments test models in real-world cases**

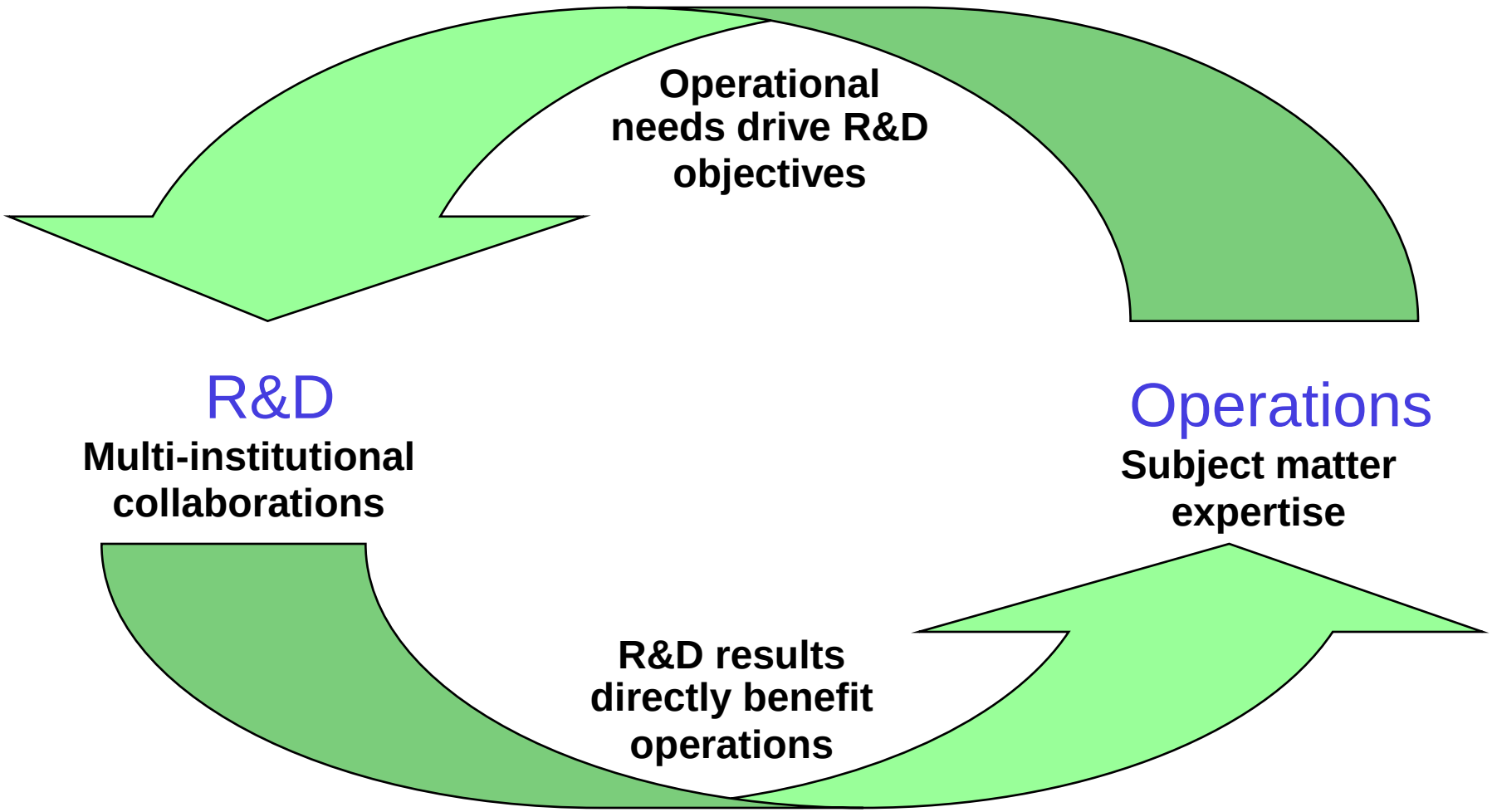
Examples: Roller Coaster, Project Prairie Grass, Savannah River Musicale Atmospheric Tracer Studies, Diablo Canyon Tracer Study, ETEX, Urban 2000, Joint Urban 2003, UDP



- **Operational testing** evaluates the usability, efficiency, consistency and robustness of models for operational conditions

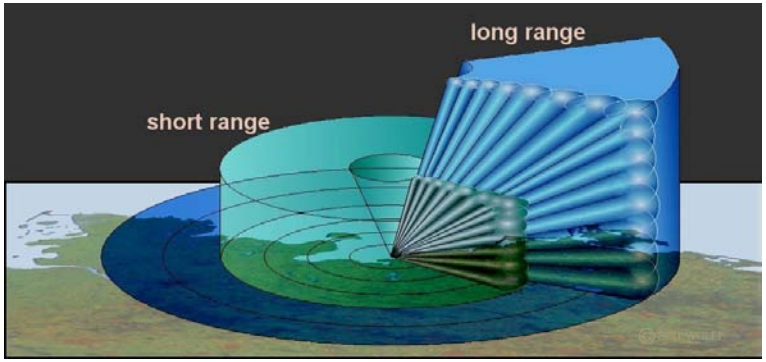
Examples: Chernobyl, Kuwait oil fires, tire fires, industrial accidents, Algeciras Spain Cesium release, Tokaimura criticality accident, Cerro Grande (Los Alamos) fire

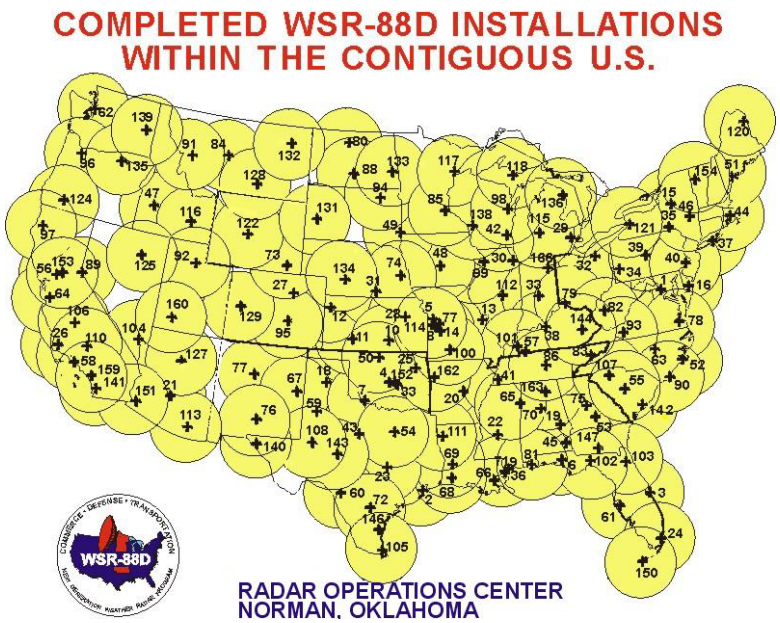
LLNL's State-of-the-Science System Benefits from a Tight Coupling of R&D and Operations



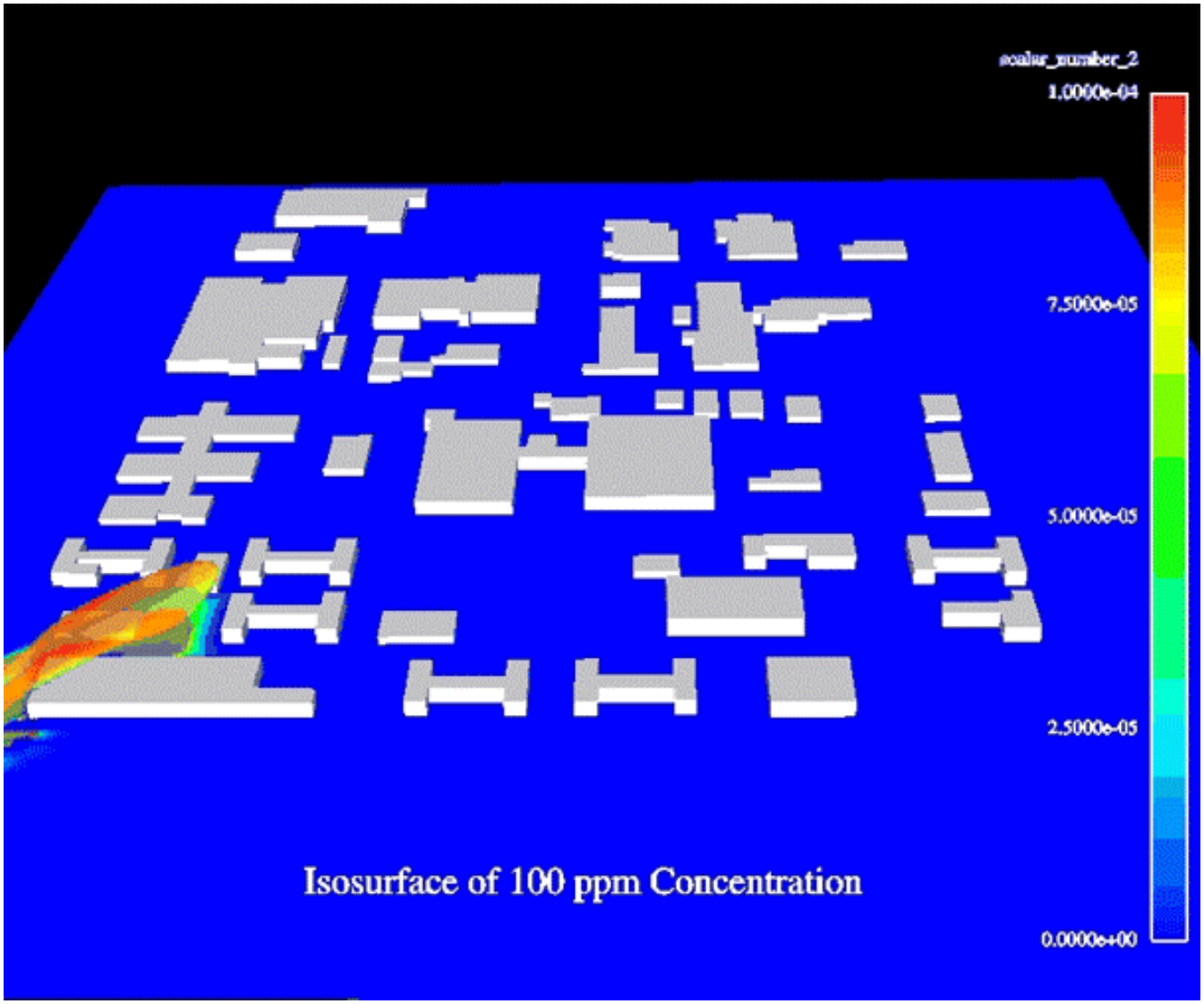
DHS S&T Project Evaluated the Impact of NEXRAD Radar Derived Winds for Dispersion Applications

- Radar potentially provides higher resolution upper air data by measuring the altitude, range, speed of moving objects
- Use PNNL developed-algorithm used to convert raw data to gridded profiles
- Quantify availability of NEXRAD data
- Quantify NEXRAD data availability
- Conduct statistical analysis of impact of NEXRAD-derived into diagnostic
- Evaluate impact of NEXRAD-data assimilation into weather prediction models





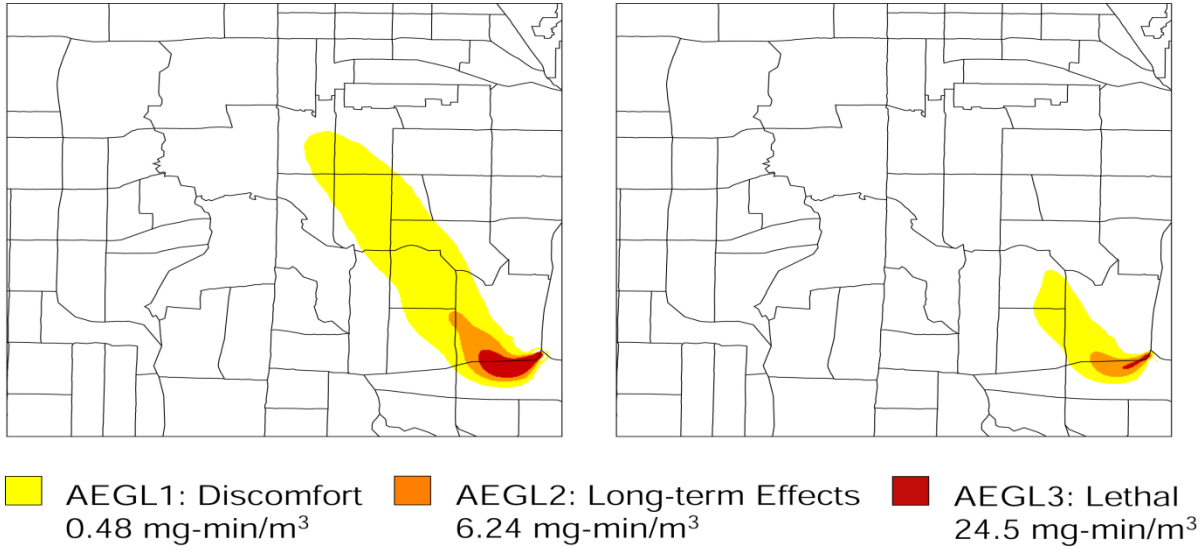
Urban Models are Providing New Capabilities for Protecting Health and Safety

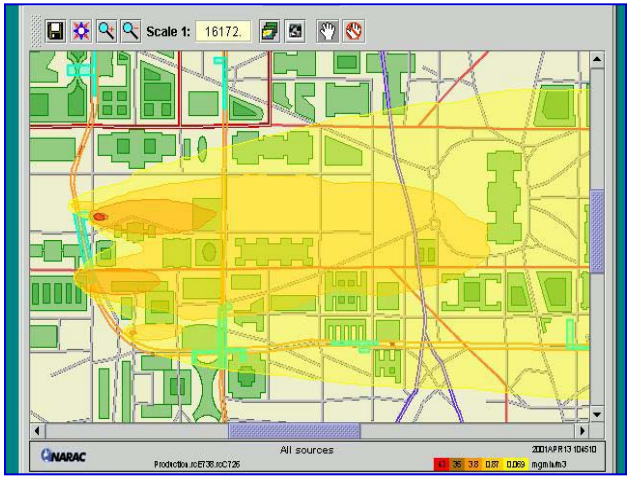


LLNL Calculated Indoor Exposures Based on Coupled Outdoor and Subway/Indoor Models (with ANL and LBNL)

Outdoor Plume Air Concentration

Corresponding Indoor Air Concentration

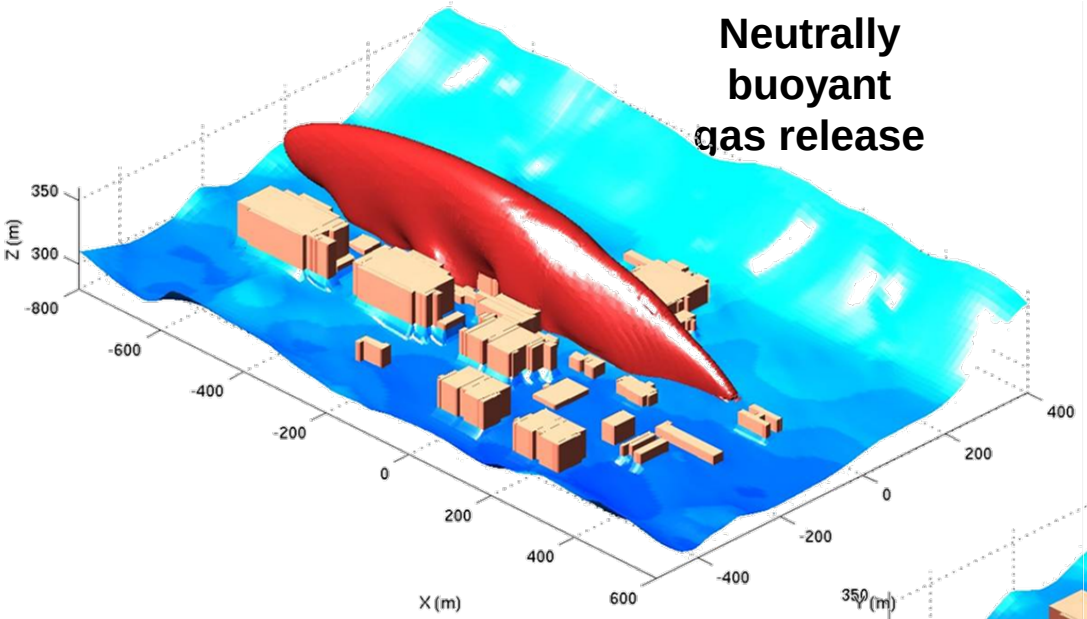




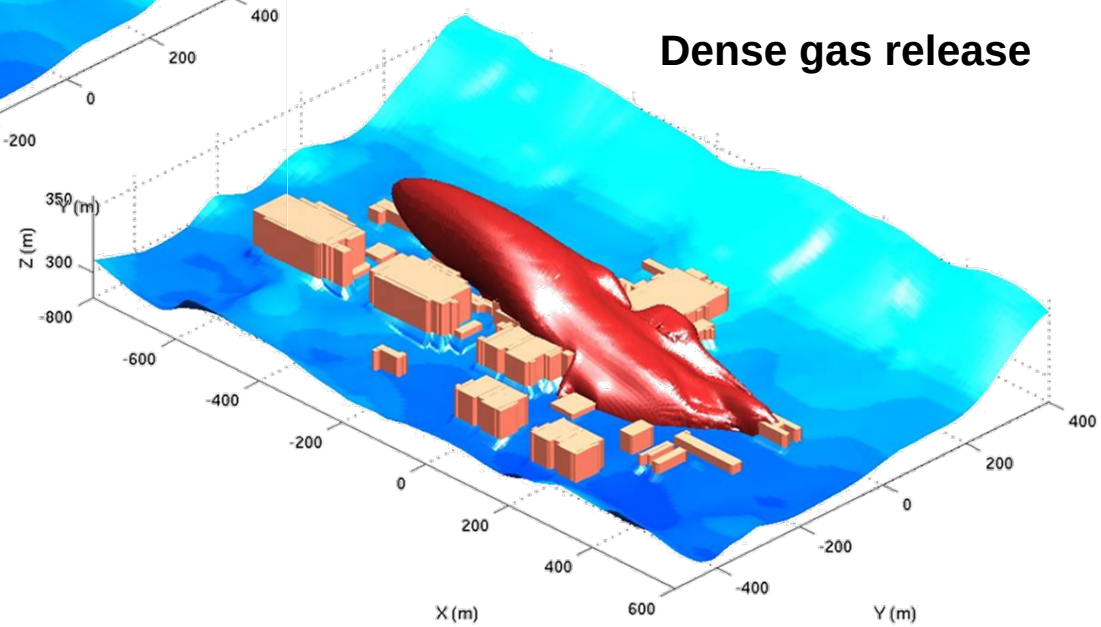
Building leakiness data and Census data on residences used to develop statistical relationships and derive a U.S.-wide geospatial leakiness database to infer indoor exposures from outdoor plumes (LBNL collaboration)

Prototype capability estimates outdoor impacts from a subway release (coupled ANL-LLNL model)

Dense Gas Physics Coupled to CFD Models Provides Realistic Predictions for Toxic Industrial Chemicals in Urban Areas



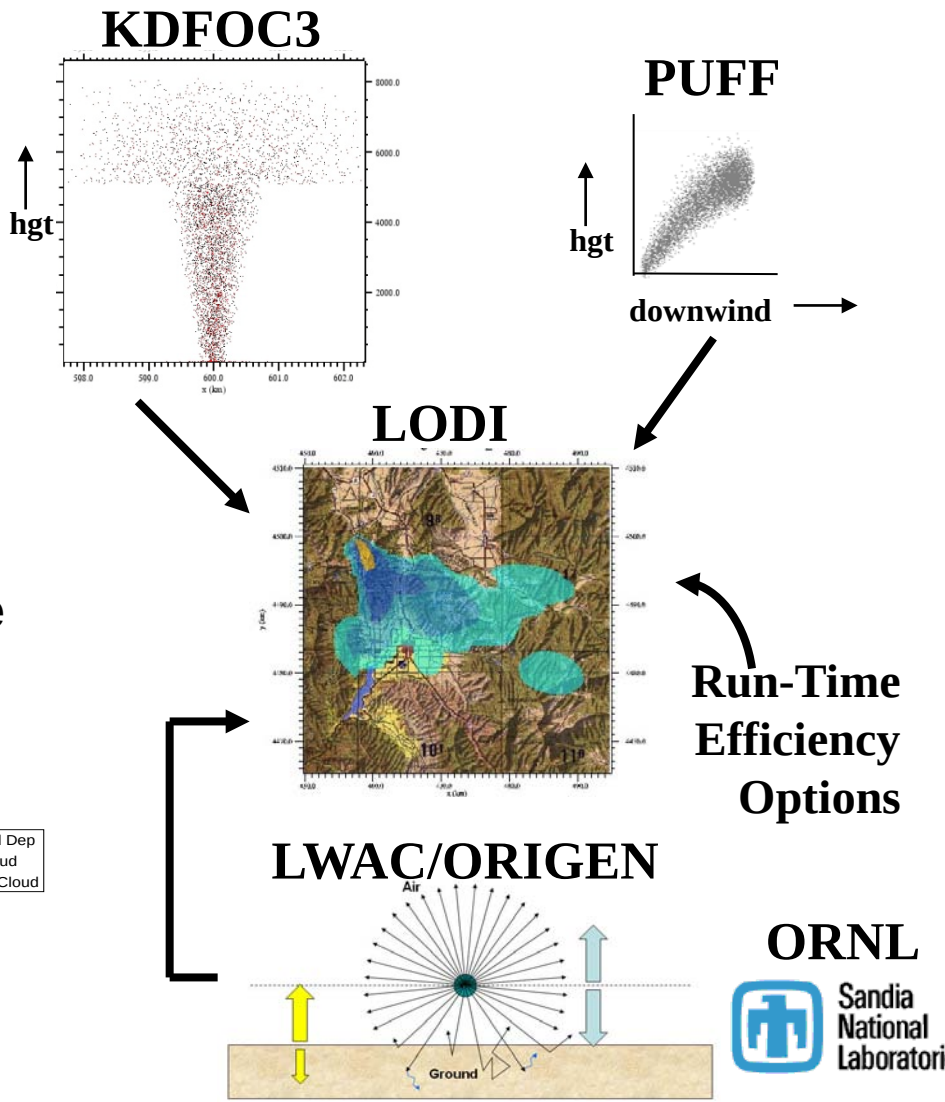
Isosurfaces of 200 mg/m^3 10 minutes after release



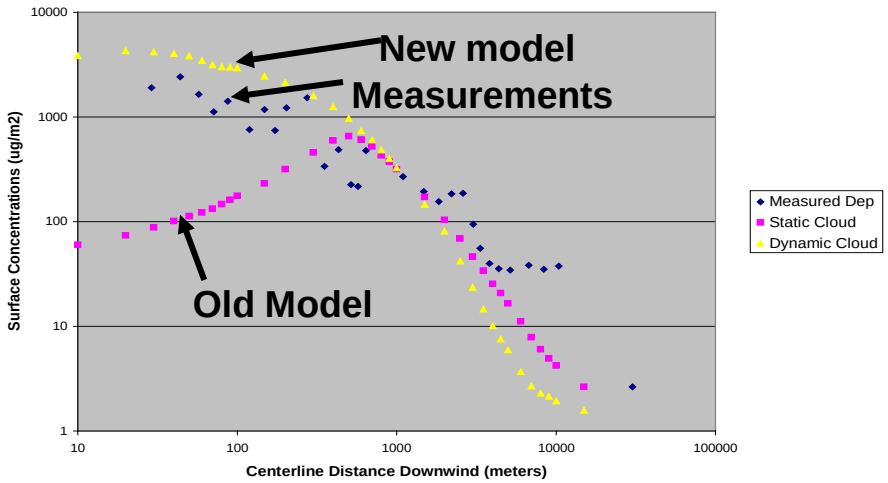
Buildings increase vertical mixing. Gas density suppresses vertical mixing, while increasing lateral spreading near the source and upwind dispersion.

New LLNL-SNL Explosive Dispersal Model Improves Predictions of Ground-level Contamination

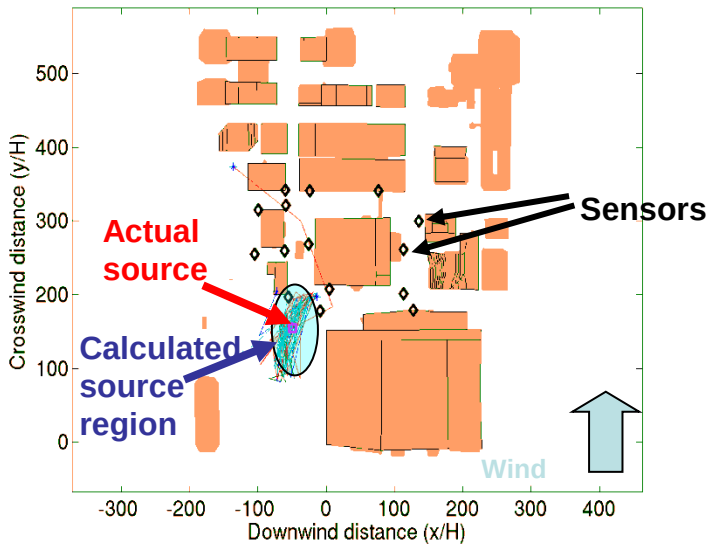
- KDFOC3 nuclear detonation source description extended and used in LODI particle dispersion model
- Neutron-activation products from LWAC code
- Fission product inventory from ORNL ORIGEN code
- Sandia PUFF dynamic high-explosive cloud rise model

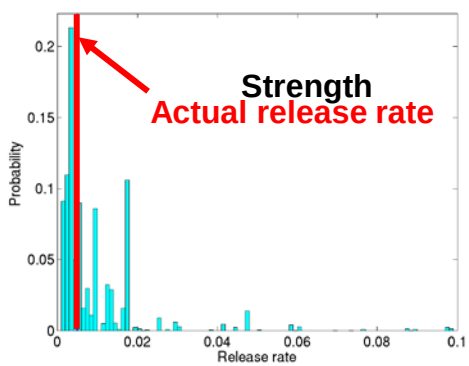


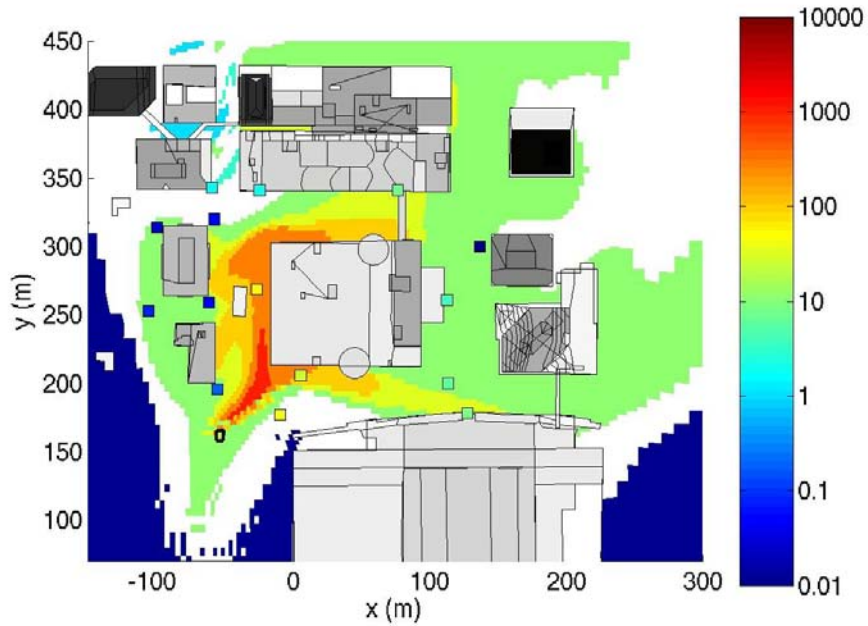
Deposition versus Downwind Distance



Event Reconstruction Produces Composite Plume with Uncertainty Estimate Based on Field Data







90% confidence plume

Event reconstruction based on Bayesian inference and stochastic sampling estimates source location to within a half block and release rate (left figures) for the JU2003 Oklahoma City release. The 90% confidence level composite plume contours are compared to field data (colored squares) in the figure at right.

Additional Information

National Atmospheric Release Advisory Center
NARAC

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Email: narac@llnl.gov

IMAAC
Interagency Modeling and Atmospheric Assessment Center

Web: imaacweb.llnl.gov
Email: imaac@llnl.gov