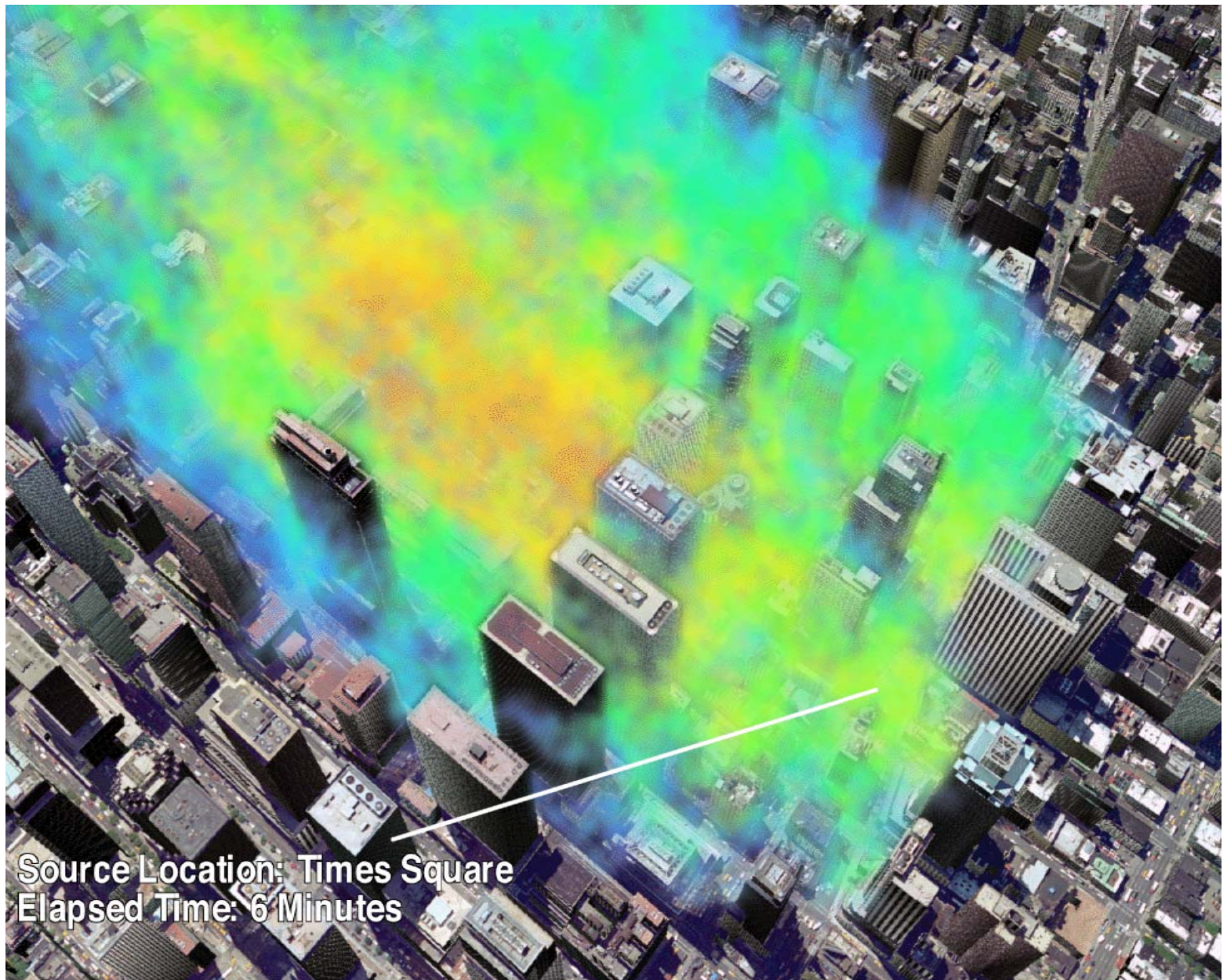# Atmospheric Transport and Dispersion Modeling in Coastal Urban Environments

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Monterey, CA

Source Location: Times Square
Elapsed Time: 6 Minutes

Atmospheric Transport and Dispersion Modeling in Coastal Urban Environments

- An evolving synergism between a mesoscale numerical weather prediction (NWP) model and an emergency response model.

- Naval Research Laboratory (NRL) COAMPS[®1] mesoscale NWP model
  - ➢ COAMPS is a nonhydrostatic mesoscale model with multiple nests
  - ➢ full suite of physical parameterization schemes
  - ➢ multi-level urban canopy parameterization.
  - ➢ 5 nests with horizontal resolutions of 27-9-3-1-0.333 km.

  [1]COAMPS is a registered trademark of the Naval Research Laboratory

COAMPS Boston Domain: Nests 3, 4, and 5
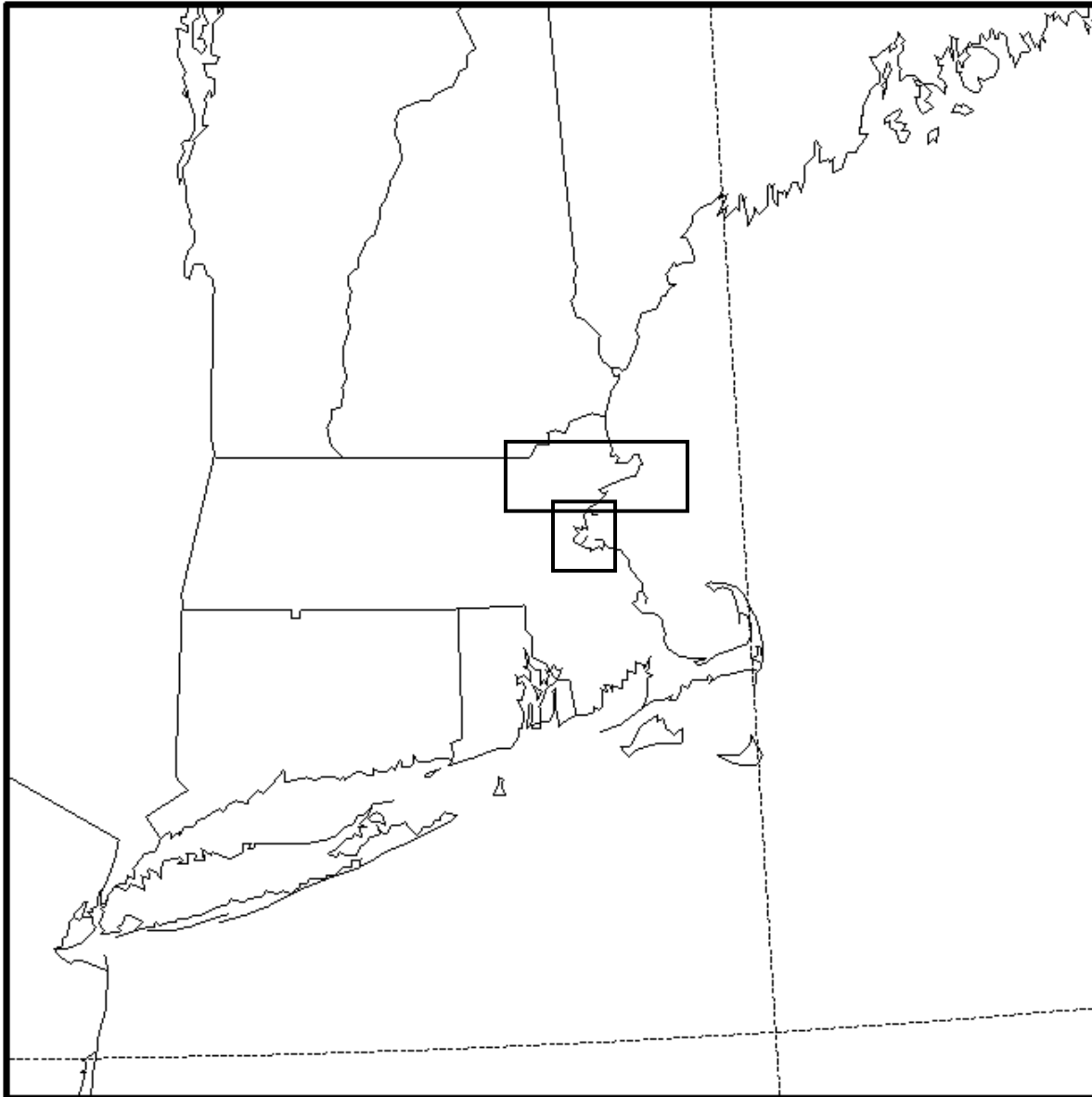
Nest 3: 181 x 181 (3 km)

Nest 4: 91 x 91 (1 km)

Nest 5: 91 x 91 (0.333 km)

Atmospheric Transport and Dispersion Modeling in Coastal Urban Environments

- CT-Analyst[1] emergency response model, also developed at NRL.
  - CT-Analyst designed to provide first responders information on plume characteristics and hazard envelopes in the event of an accidental or intentional release of hazardous material into the atmosphere
  - Typically CT-Analyst employs wind fields which do not change from one location to another and have prescribed vertical variation. COAMPS can provide realistic three-dimensional meteorological fields to CT-Analyst, thereby improving the reliability of plume nowcasts.
- Linked COAMPS/CT-Analyst system used in support of the presidential inauguration in January 2009 and for DHS-sponsored Golden Phoenix Experiment in Los Angeles, CA (2010), as well as a DHS-sponsored field experiment in Boston, MA and another experiment in Hamburg, FRG (2011)

[1]CT-Analyst is a registered trademarks of the Naval Research Laboratory

Development of an air-ocean-CT coupled system

Three components, which have been extensively validated, are linked together:

COAMPS-OS: Operational mesoscale prediction system for over 10 years
Fully 2-way coupled air-ocean-wave model; State-of-the-art physics and data assimilation

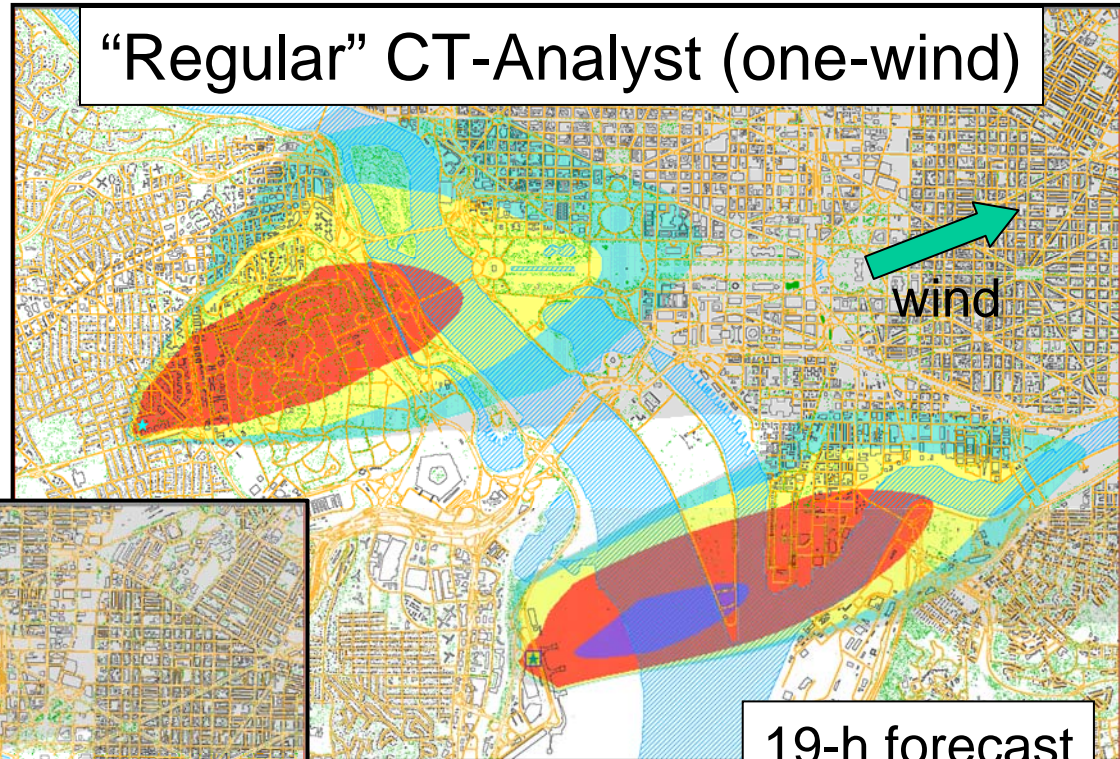FAST3D-CT: 3-D CFD model
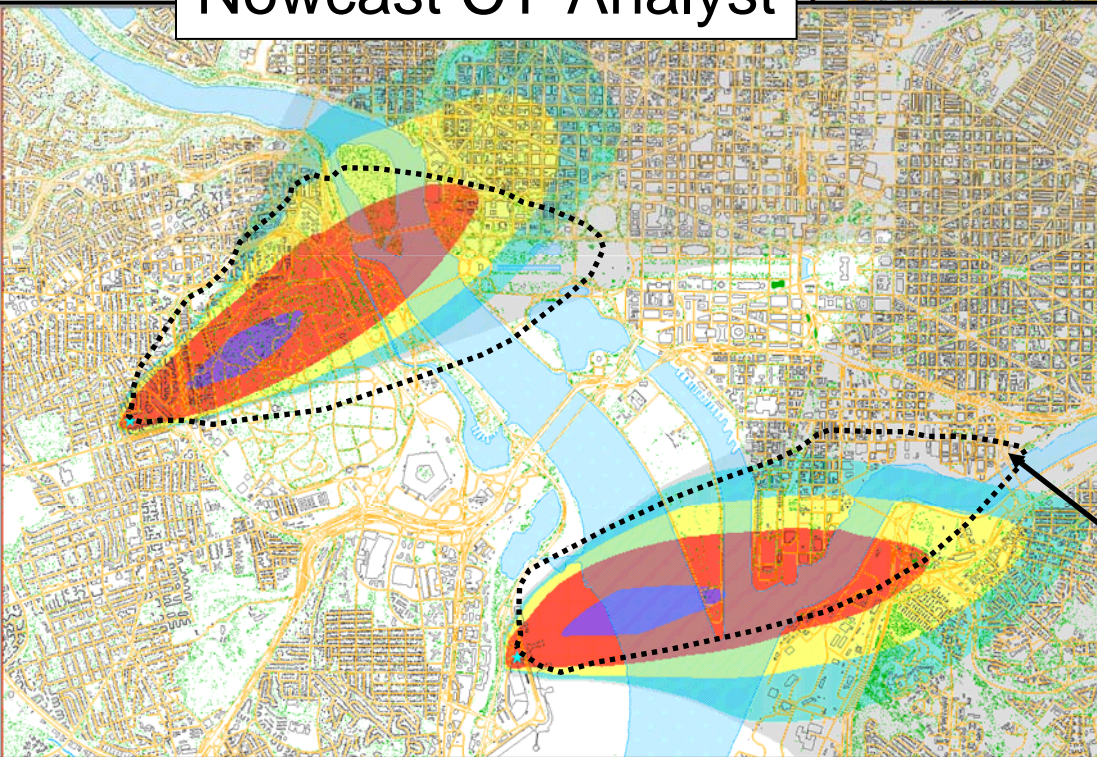

Vortex Shedding from the Washington Monument
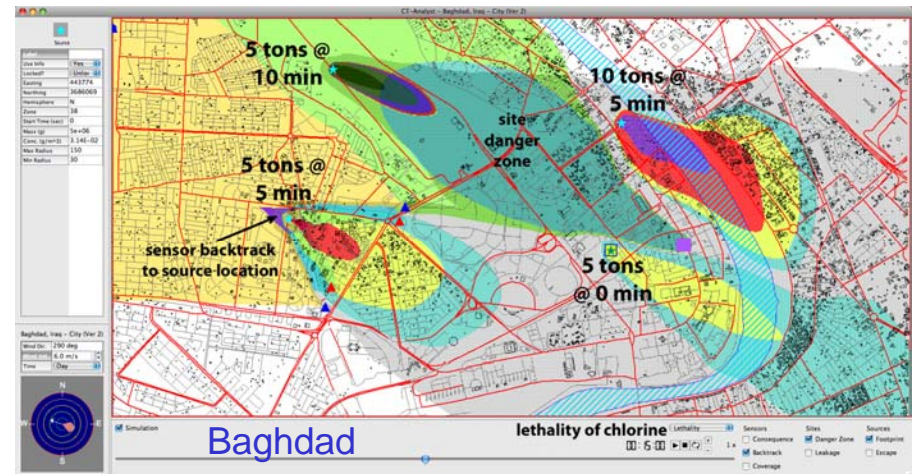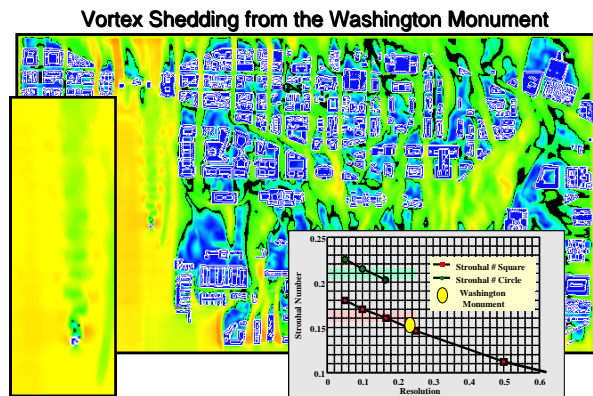
Baghdad

CT-Analyst: Emergency response system for transport and dispersion of windborne contaminants. Exercised for several cities: Los Angeles, Washington DC, Chicago, New York City, Houston, Detroit, Oklahoma City, Baghdad

What's missing: Nowcast CT-Analyst
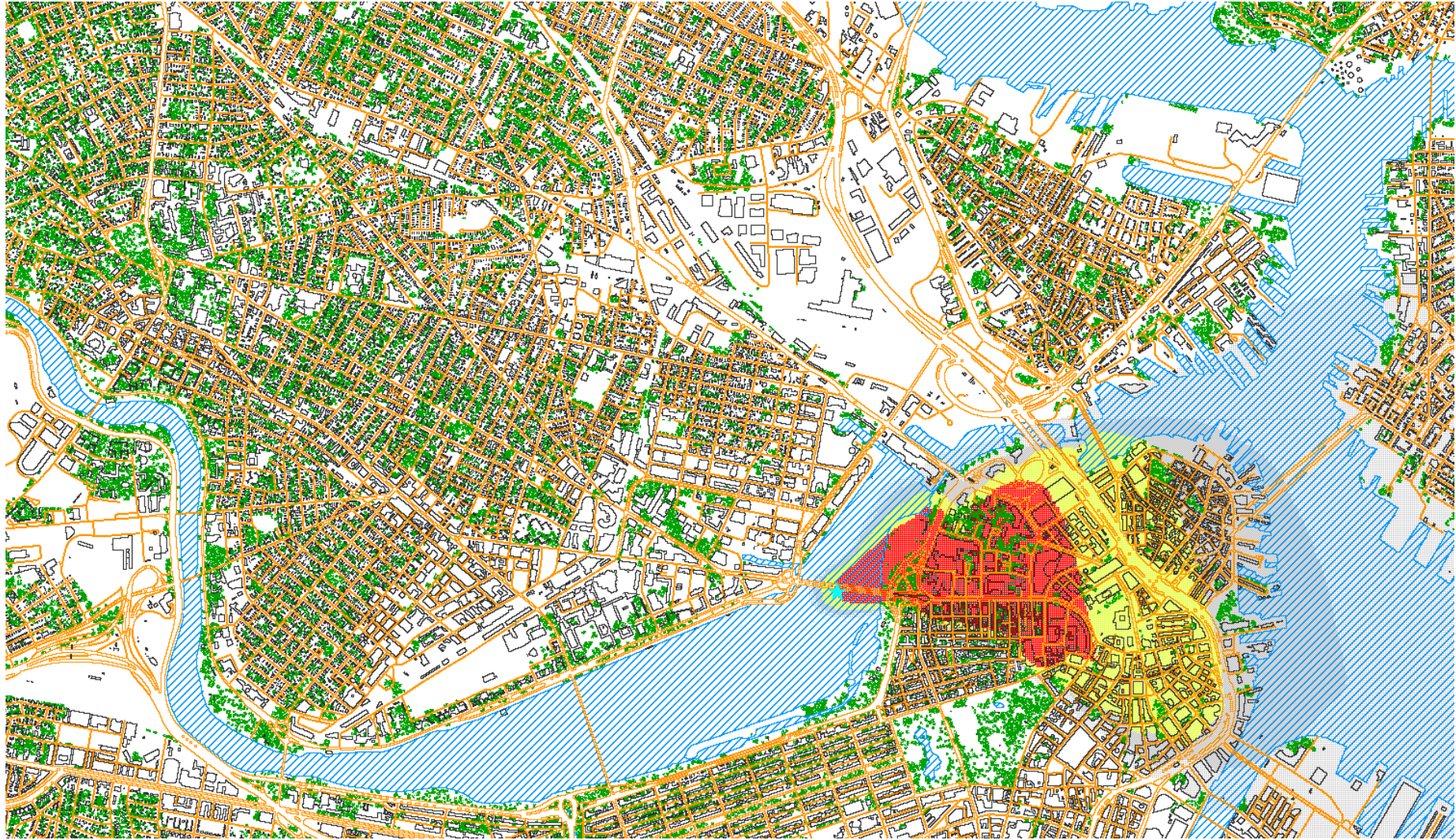

"Regular" CT-Analyst (one-wind)

wind

Nowcast CT-Analyst

19-h forecast

Nowcast results in a concentration footprint that is distinctly different.

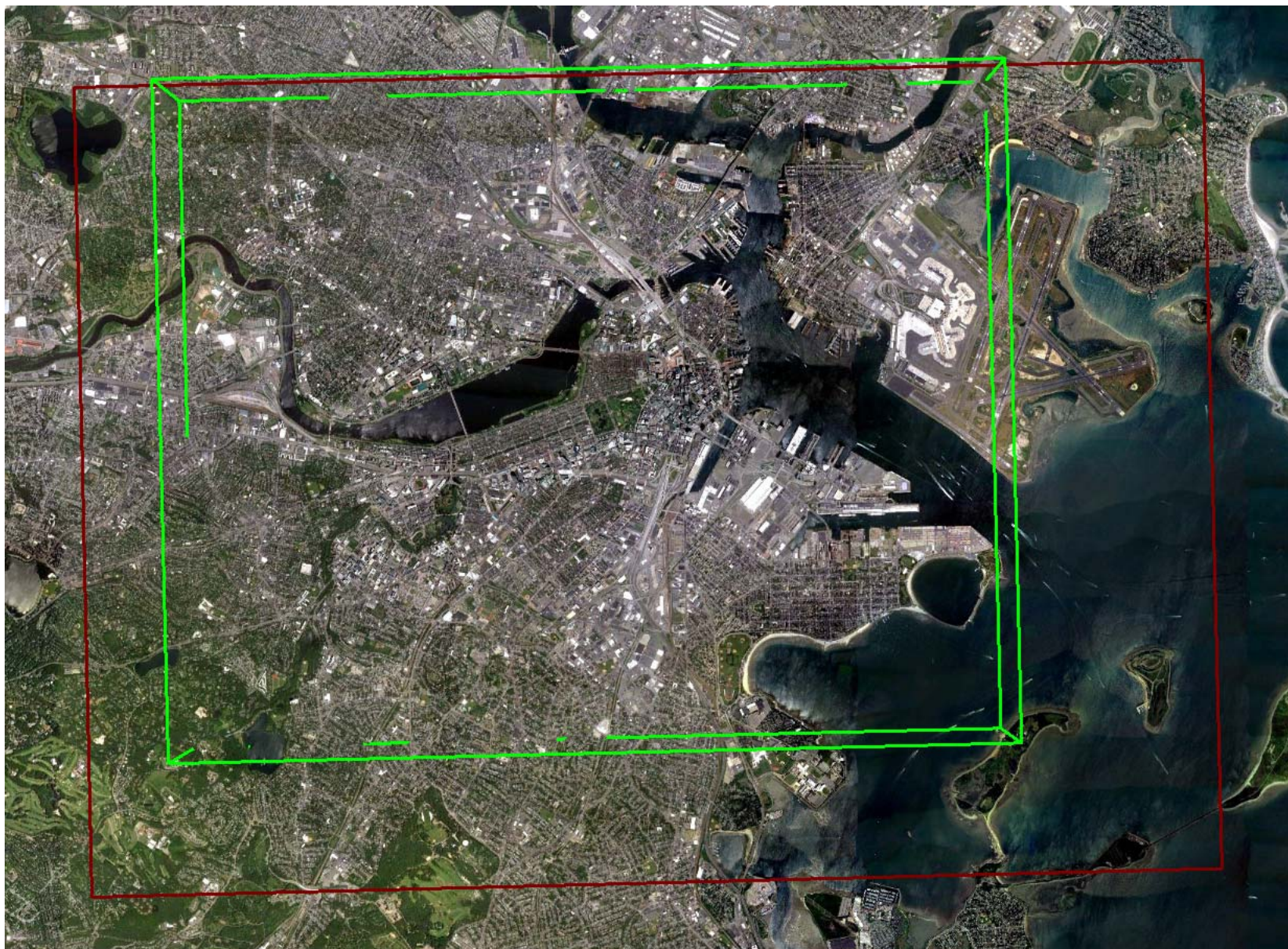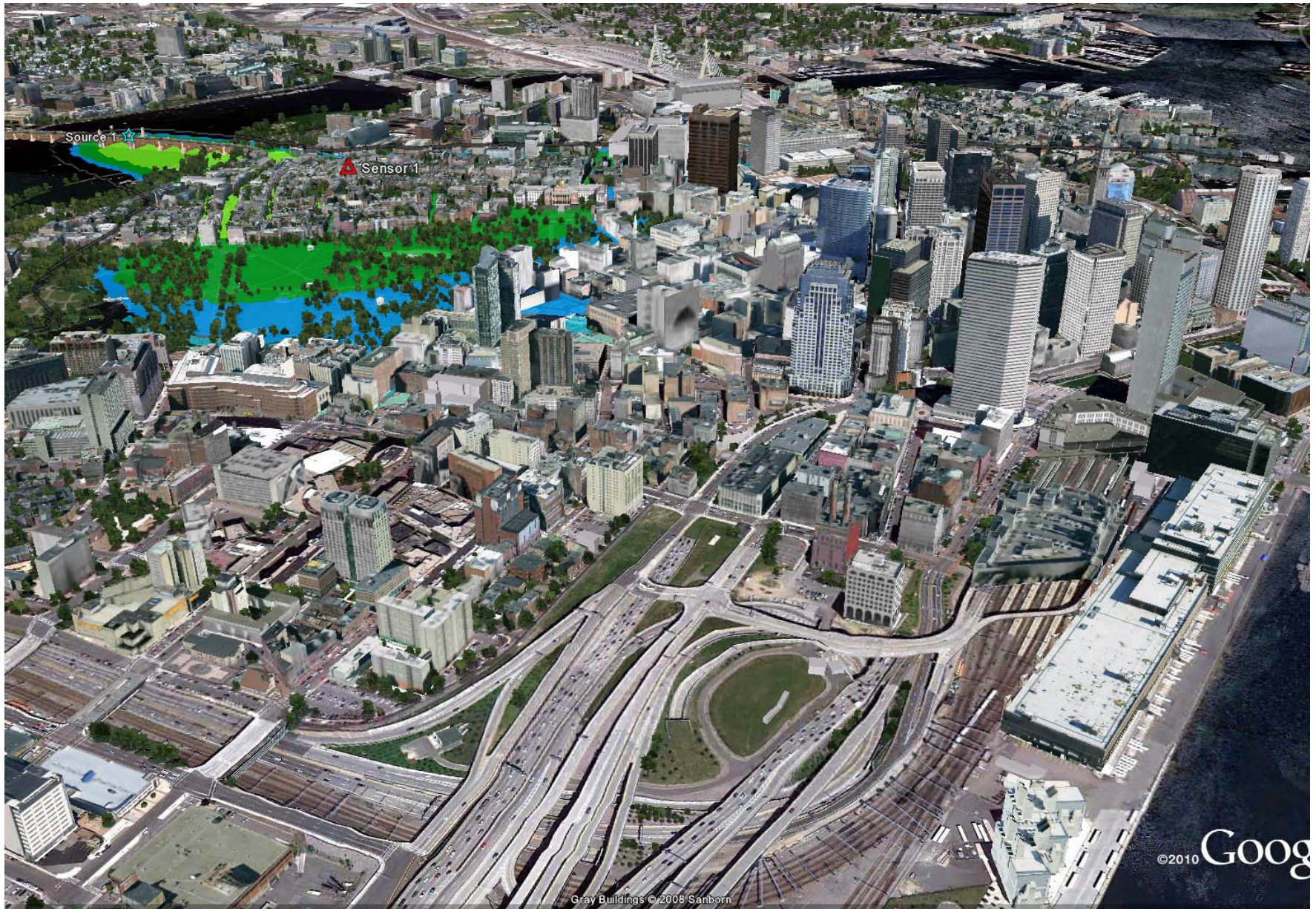(Dashed line is Regular CT-Analyst "yellow" concentration)

CT-Analyst Depiction of Plume Interacting with the Urban Landscape of Boston

CT-Analyst Domain for Boston

CT-Analyst Depiction of a plume interacting with the Urban Landscape of Boston

Wind Dir. 296°
Wind Vel. 8.86 m/s
Wind Height 100.00 m

000 sec

Density (g/m³)

>0
0.001
0.002
0.005
0.01
0.02
0.05
0.1
0.5
1
5

Another Plume over Boston

Source 1

Gray Buildings © 2008 Sanborn
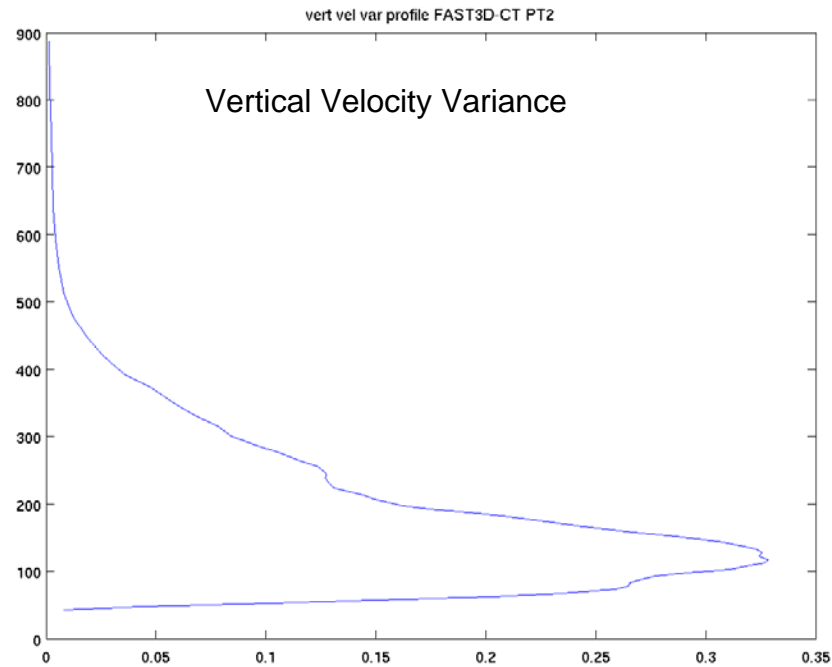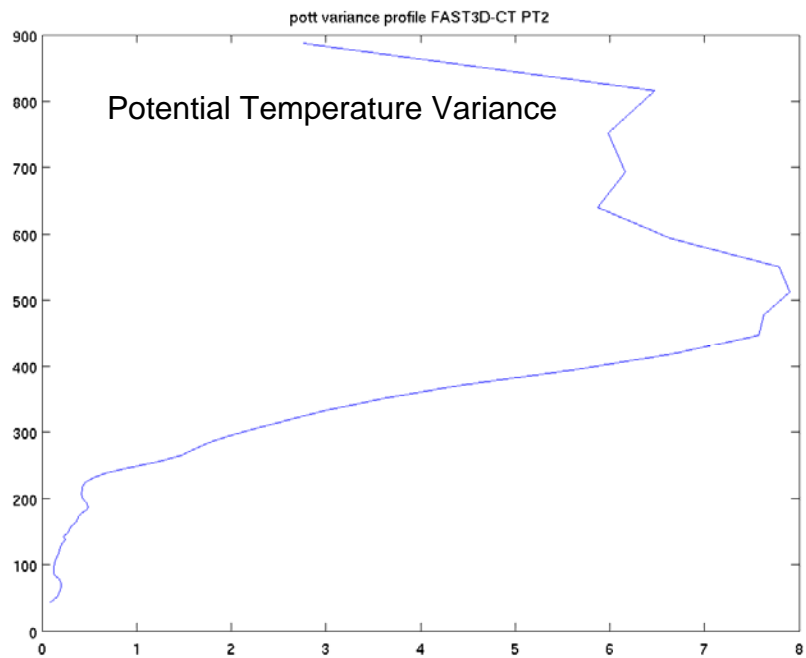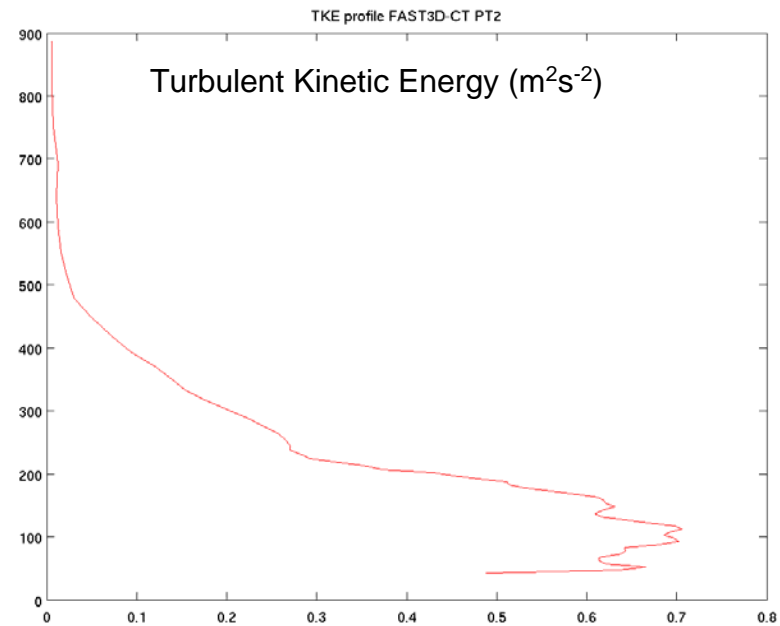
©2010 Google

Zoom of Plume Margin
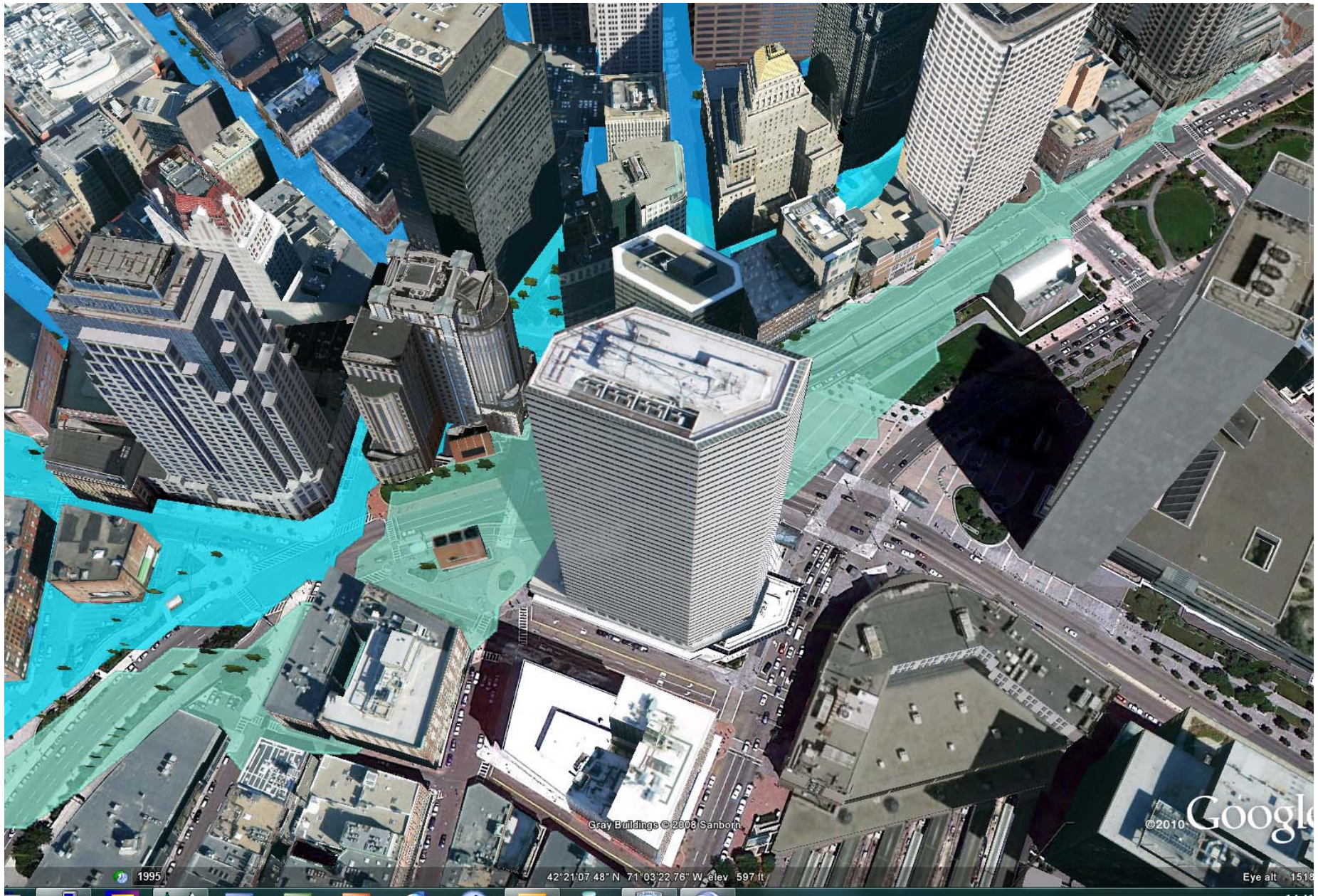
One Financial Center

FAST-3D Results for Boston

- FAST-3D is a CFD model used in conjunction with CT-Analyst

- FAST-3D is run multiple times for each city with different wind speeds/directions

- FAST-3D provides the turbulent interaction with the urban landscape

- CT-Analyst incorporates results from FAST-3D

- Thus, CT-Analyst provides nearly instantaneous plume morphology while still incorporating a fully turbulent wind field

FAST3D Profile Location

pott profile FAST3D-CT PT2

Potential Temperature (K)

TKE profile FAST3D-CT PT2

Turbulent Kinetic Energy (m^{2}s^{-2})

pott variance profile FAST3D-CT PT2

Potential Temperature Variance

vert vel var profile FAST3D-CT PT2

Vertical Velocity Variance
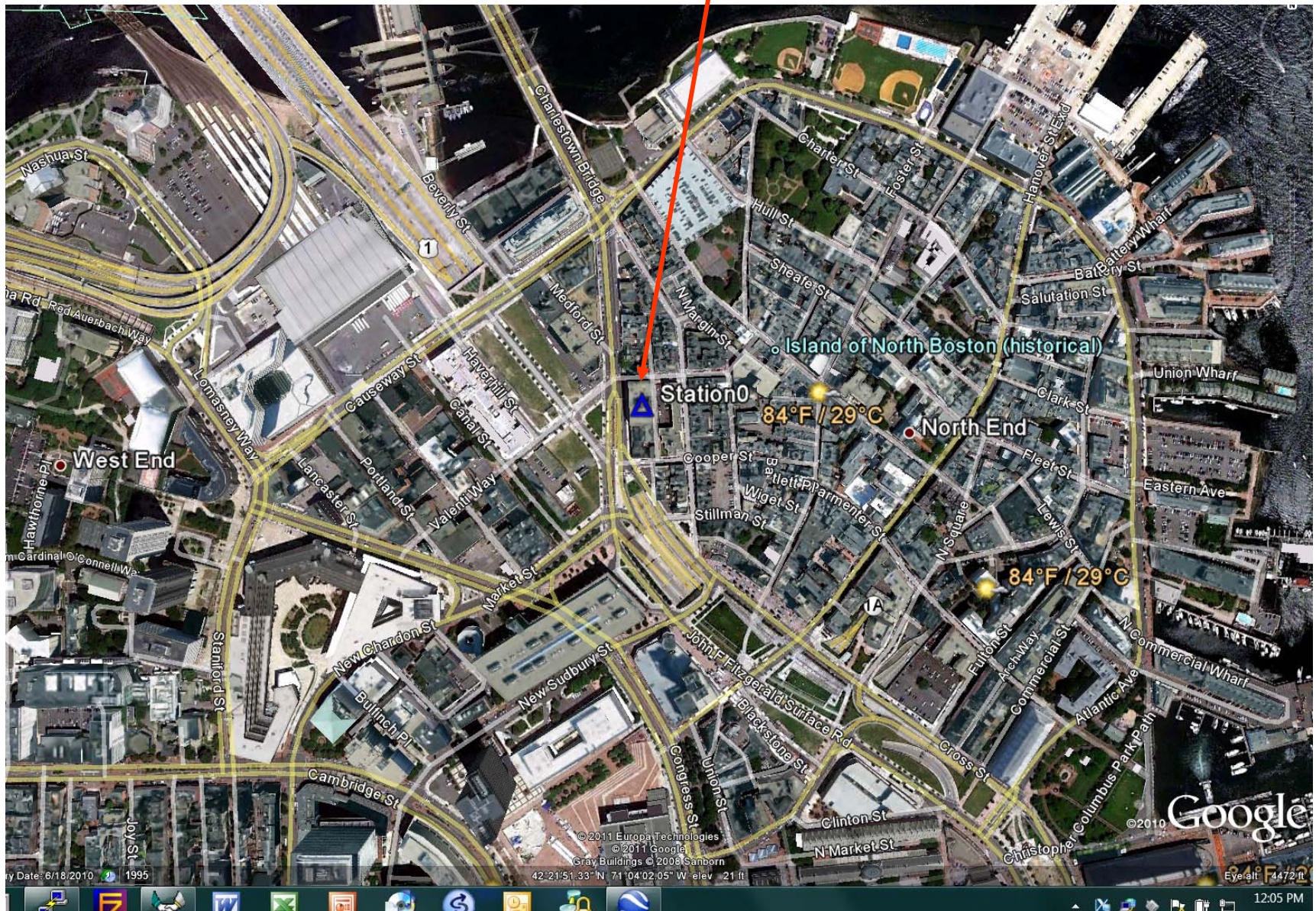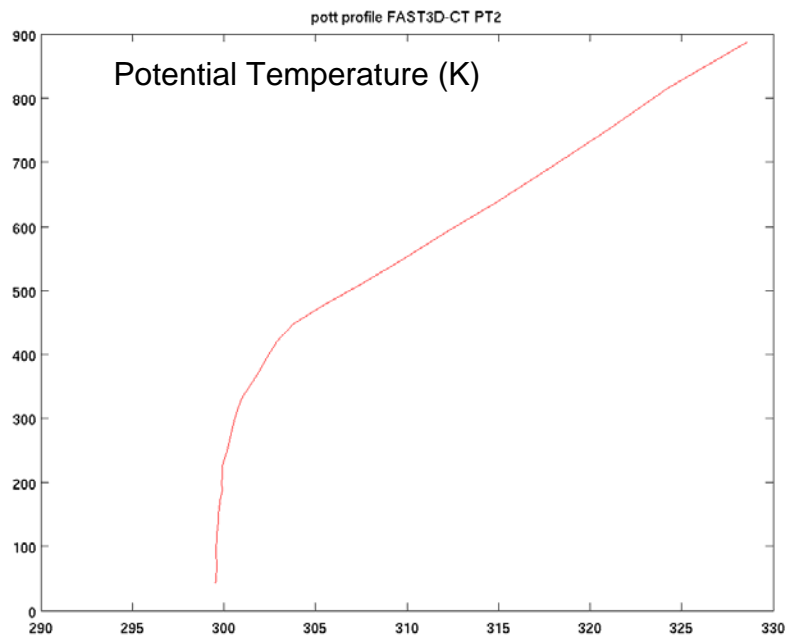
Conclusions

- Short-range transport/dispersion of toxic plumes in urban areas are primarily controlled by urban aerodynamics with turbulence. Meteorology is also important but at longer/larger scales.

- The crucial operational issue is to retain time-dependent CFD accuracy while computing with sufficient speed for *real-time emergency assessment*.

- COAMPS can provide "nowcasts" of the wind field, turbulence, and BL depth

- CT-Analyst can quickly provide first responders with information on plume characteristics as well as approximate source location & source strength

- CT-Analyst provides nearly instantaneous plume morphology while still incorporating a fully turbulent wind field

Conclusions

- Combining COAMPS with FAST3D-CT and CT-Analyst allows for realistic wind variability to impact plume diagnostics

- The combined system will still provide an immediate response – no additional time latency for realistic wind field