Micro SWIFT/SPRAY (MSS)

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Agenda

- **Micro SWIFT/SPRAY Overview**
- **Joint Urban 2003 Simulations**
  - IOP2 and IOP8
- **MSS Integration in HPAC**
- **Summary**

Problem Statement

- One of JSTO's 'Early Warning' Thrusts:
  - ***"CBRN Hazard Prediction in Complex Urban Terrain with Near-real Time Accuracy"***

- M&S challenges for urban simulations include:
  - Extensive structural databases and interfaces
  - Complex flow patterns
  - High resolution modeling requirements

Micro SWIFT/SPRAY Solution

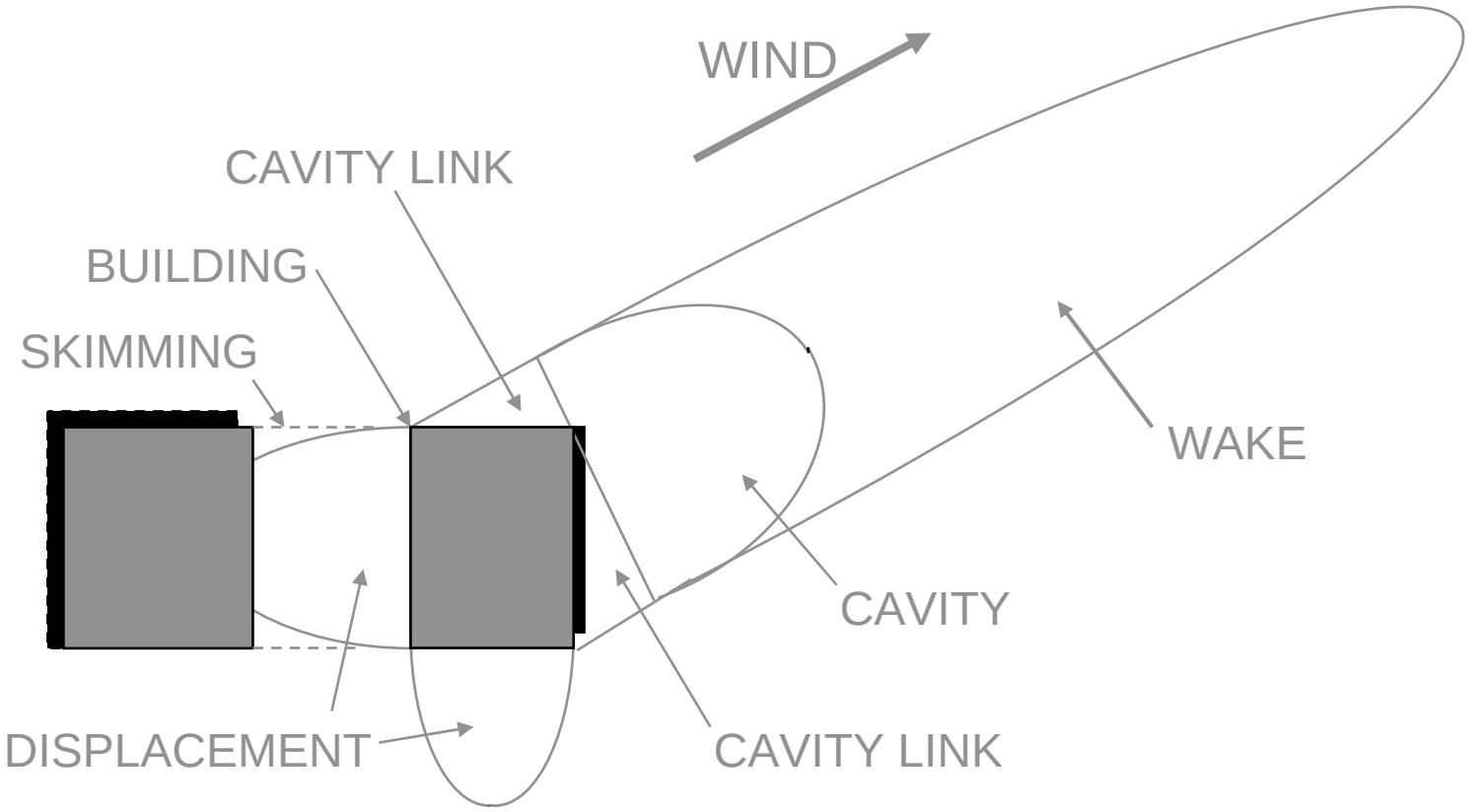
- The wind field solver, MicroSWIFT, is an adaptation of SWIFT, a mature, well validated mass consistency model
- MicroSWIFT is designed to handle urban topography, length scales, and flow features.
- Particle transport is modeled using a Monte-Carlo Lagrangian technique, MicroSPRAY.

Micro SWIFT /SPRAY Elements

- **Exact representation of buildings**
- **Initial estimate of 3D mean flow from SWIFT, driven by available meteorological data**
- **Analytical corrections for flow about obstacles**
- **Entire flow field is iteratively updated to satisfy mass consistency**
- **Dispersion simulated using a Monte-Carlo Lagrangian technique**

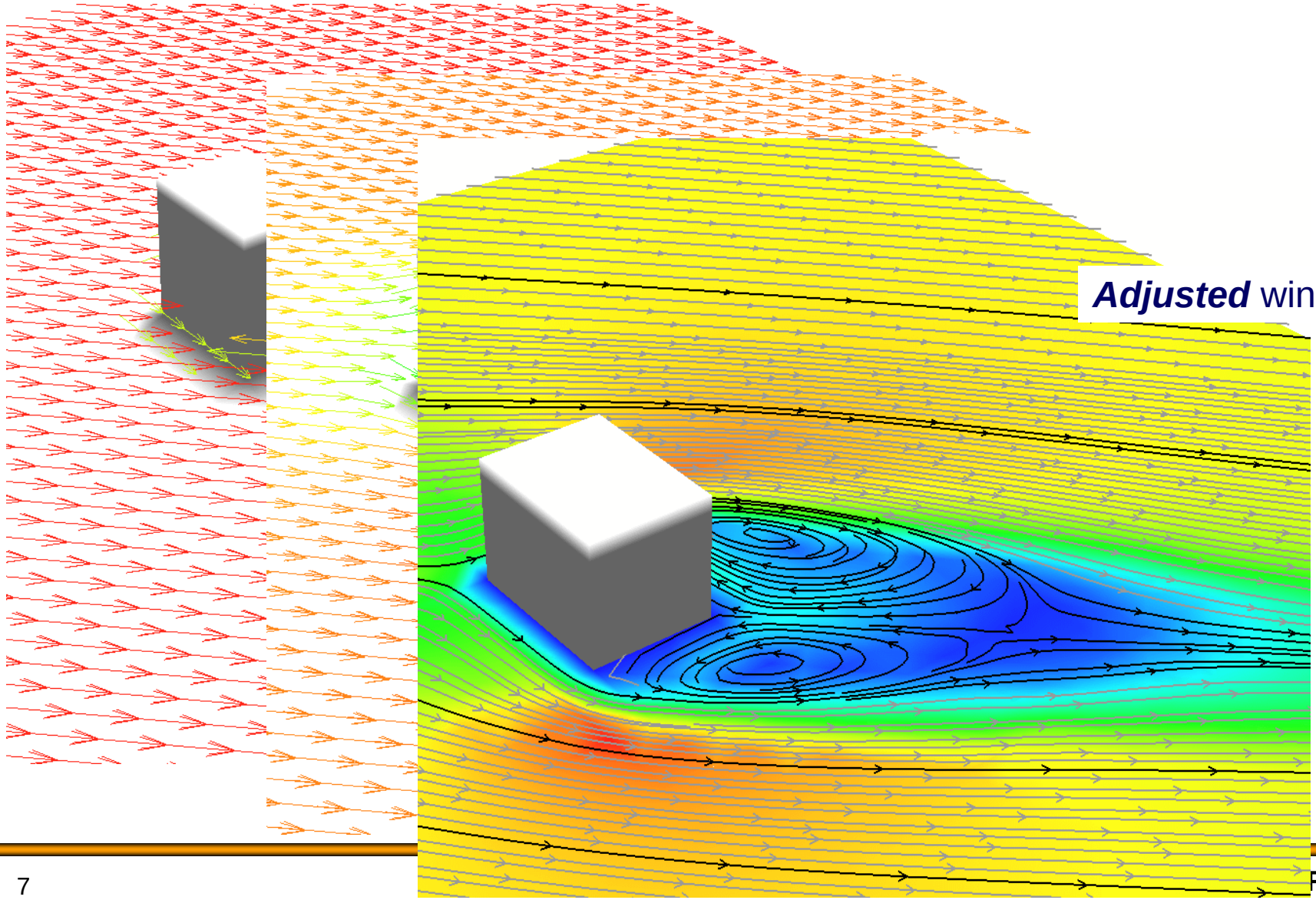
Urban SWIFT Wind Field Construction

Typical Objects - Building and Flow Zones:



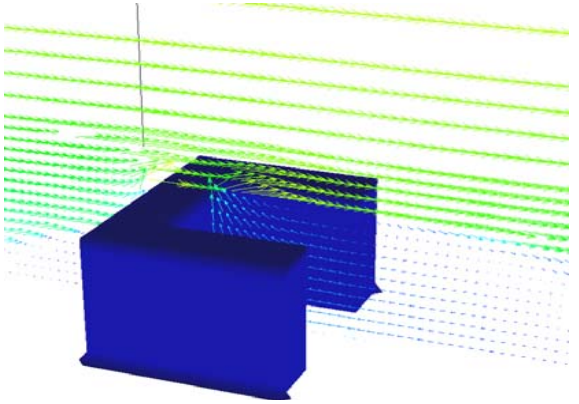
Micro SWIFT Steps

Interpolated wind field

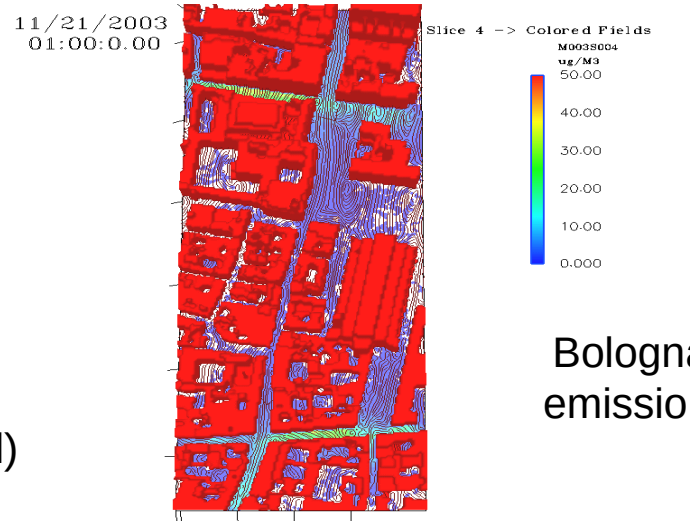


Adjusted wind field

Primary MSS Validation Cases



U-shaped Building (Kastner-Klein, et al)



Bologna traffic emissions study

- **U-Shaped Building (Wind tunnel data)**
- **L-Shaped Building (Wind tunnel data)**
- **Salt Lake City "Joint Urban 2000" (Field Experiment)**
- **Oklahoma City "Joint Urban 2003" (Field Experiment)**
- **Bologna, Italy (Field Experiment)**

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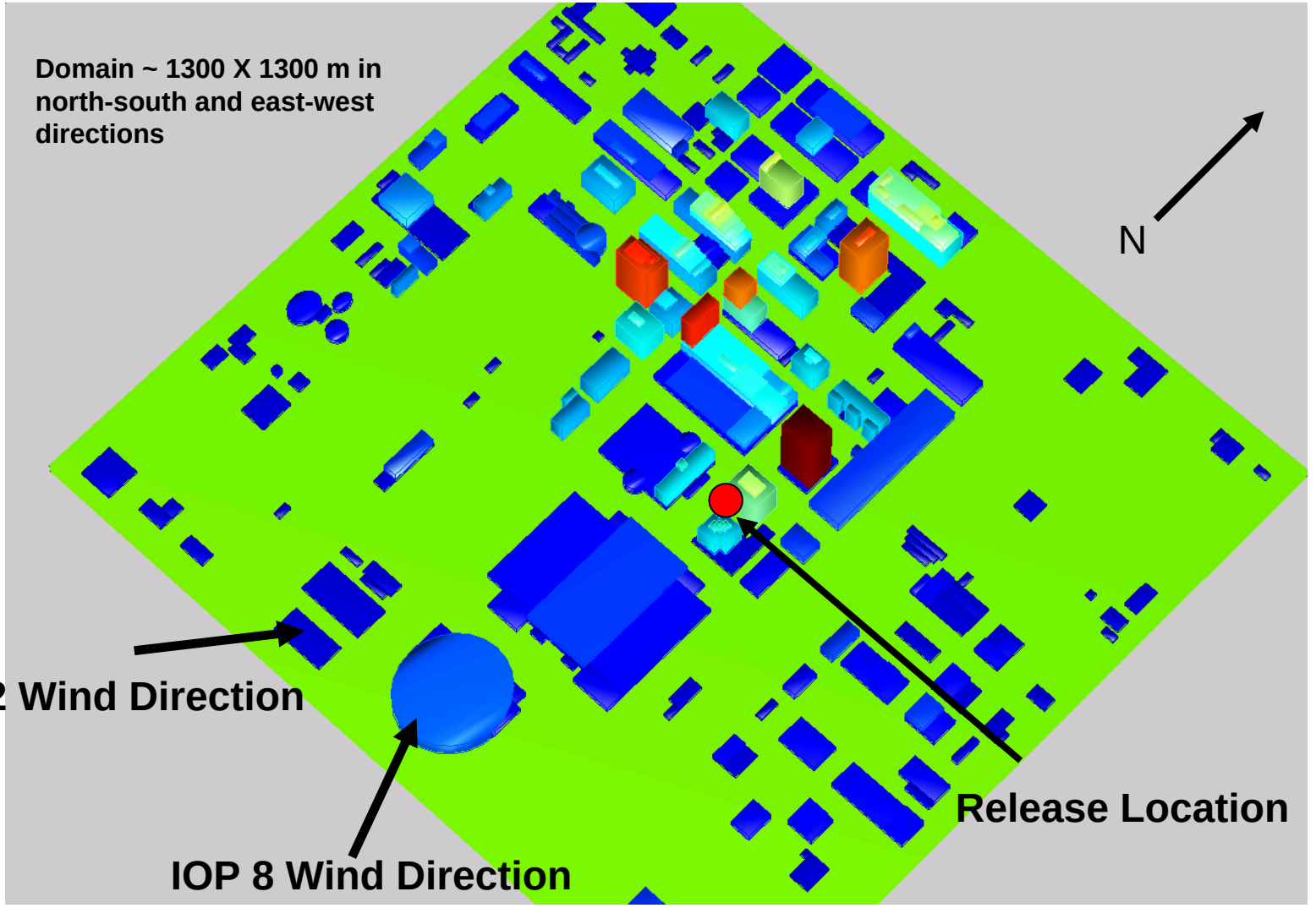
  - IOP2 and IOP8
- **MSS Integration in HPAC**
- **Summary**

JU 2003 Simulations

- **The JU2003 Field Data provides a unique database for the evaluation of urban dispersion models.**

- **Selected IOPs are the basis for an intercomparison of diagnostic urban wind field models**
  - See paper by John Hannan et al.

Urban Model Domain for JU2003



JU2003 IOP Comparison

- **IOP2*** (2 July 2003)
  - Westin release (Daytime)
  - SW winds
  - 3 CRs (5 g/s)

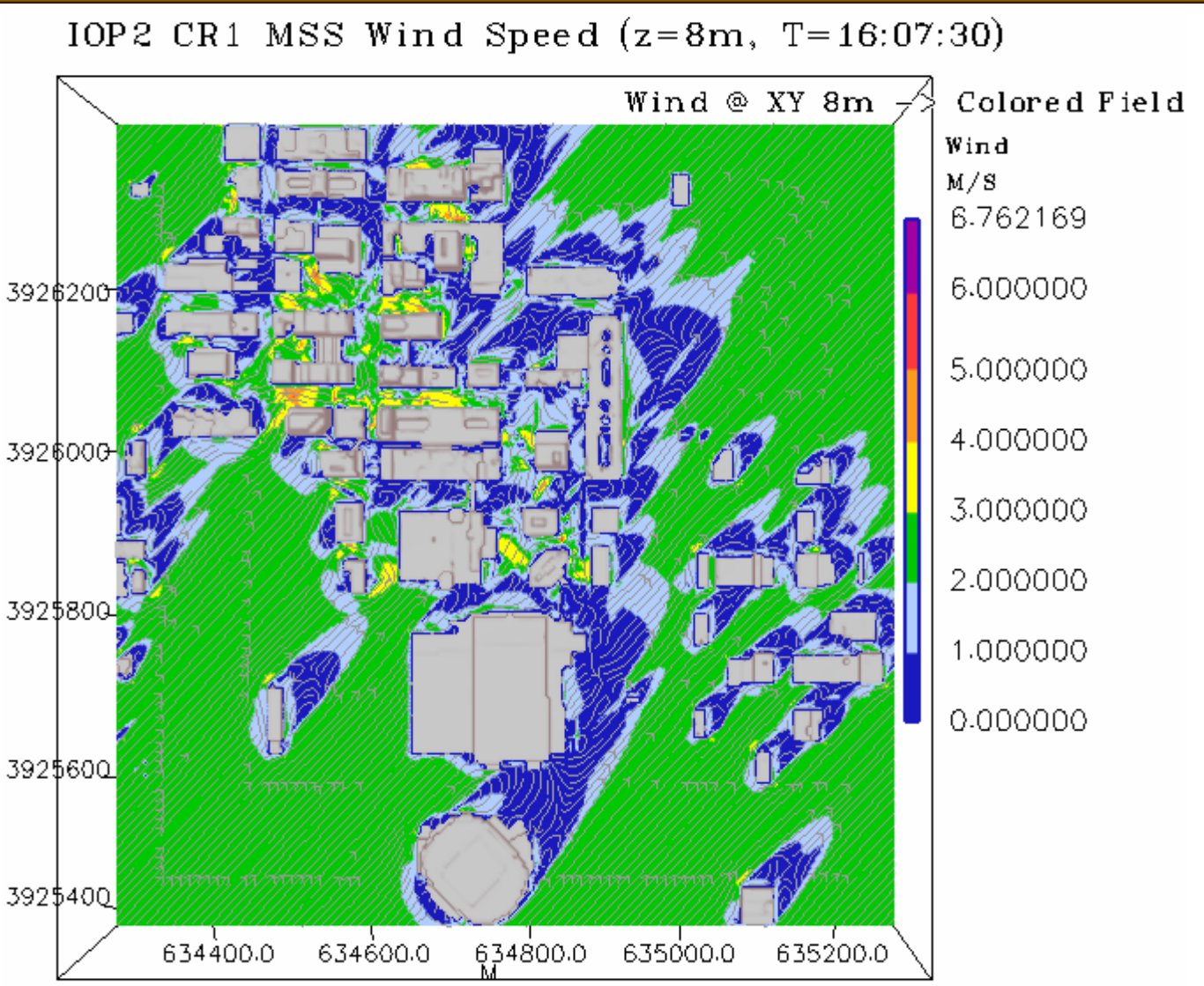
- **IOP8*** (18 July 2003)
  - Westin release (Night)
  - Southerly winds
  - 3 CRs (3 g/s)

**IOP used for comparison of Rockle-based models*

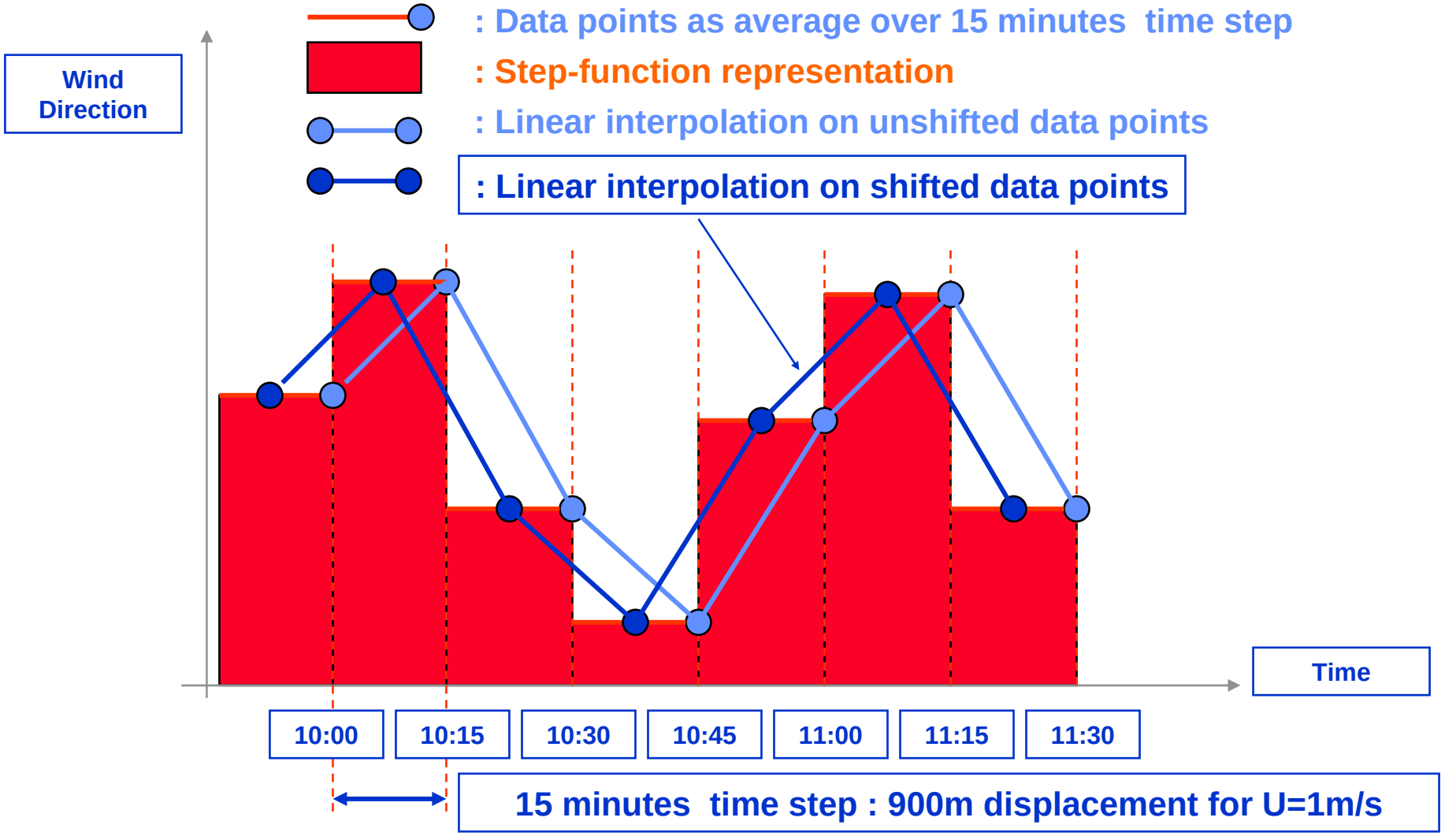
MSS Predictions for JU2003 IOP2

- OKC JU2003 IOP2 Test Conditions
  - Date: July 2, 2003
  - Release location: Westin
  - Continuous releases/times examined:
    - *CR1/1000-1030CST*
    - *CR2/1200-1230CST*
    - *CR3/1400-1430CST*
  - Met data input to MSS: PNNL Sodar
  - MSS computation domain (see slide)
    - *domain size: ~1km square*
    - *horizontal resolution: 4m X 4m*

MSS Wind Speed at h = 8 m



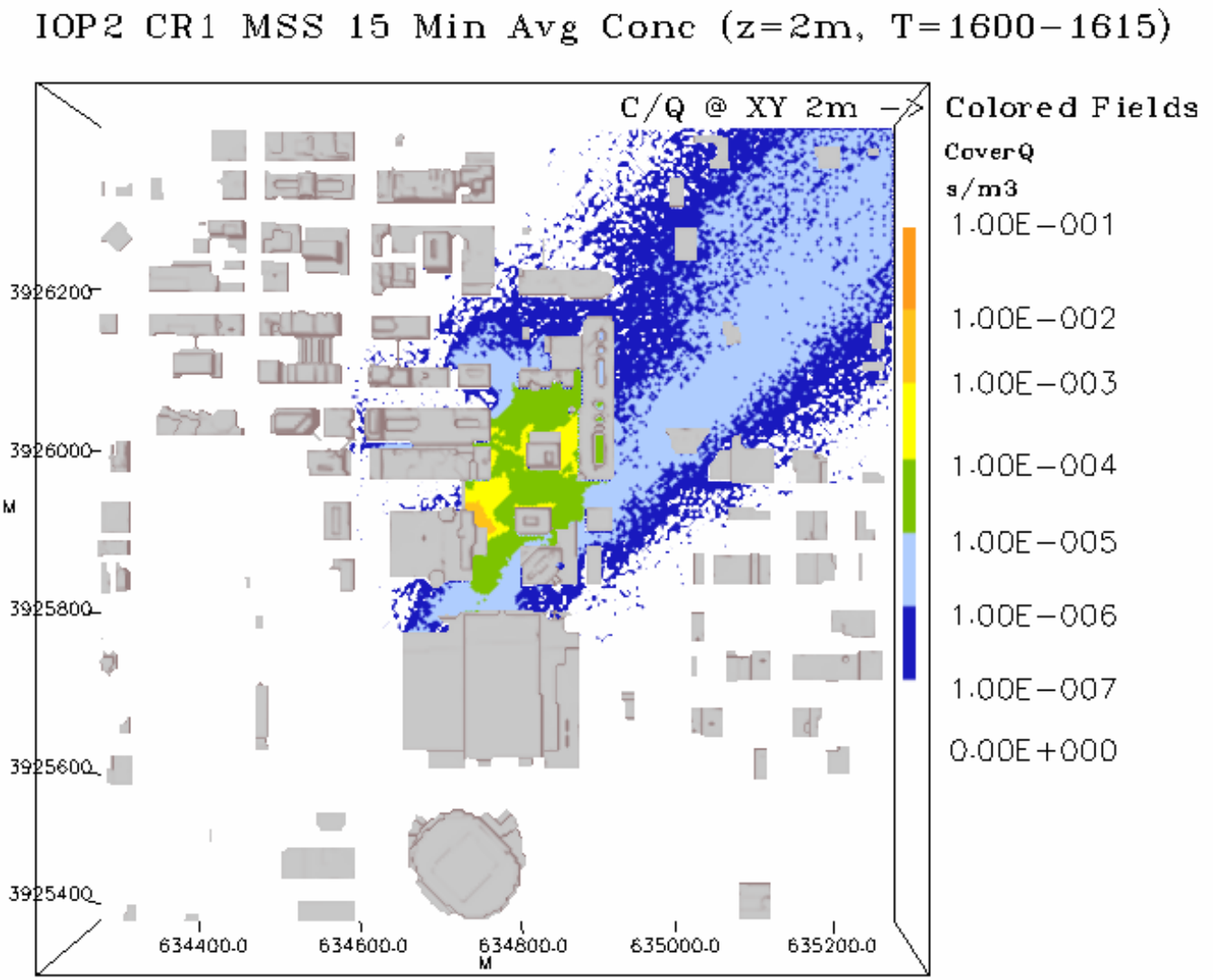
Need for high-resolution in time in the MET input for MSS



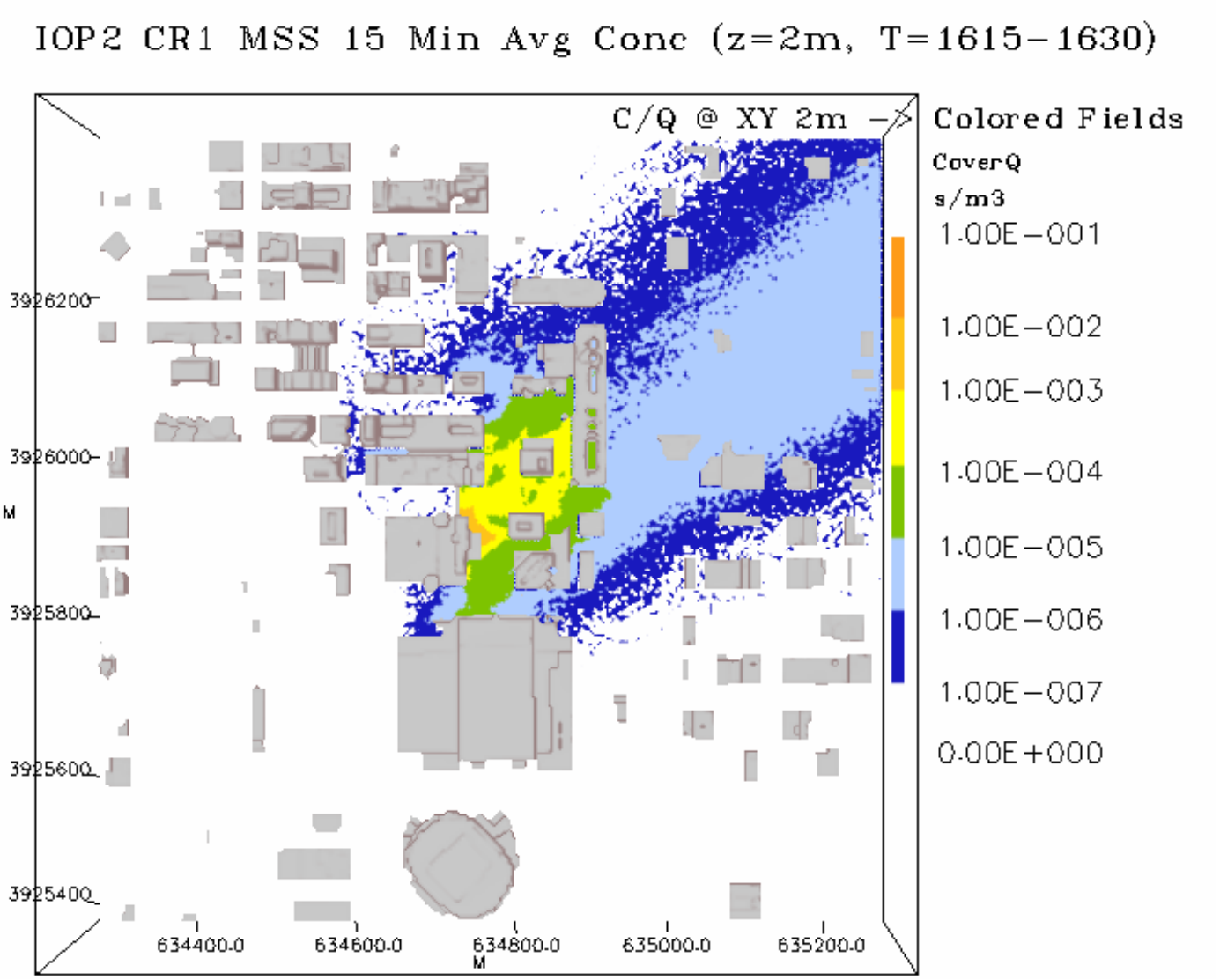
Issues regarding the averaging periods and HPAC/MSS inputs

- Long term averages for wind inputs:
  - Can lead to unrealistic results, especially when the winds are variable over the 15 minute averaging period.
  - Particularly important for microscale modeling.
  - SWIFT and MSWIFT within HPAC interpolate between solutions at instantaneous times. Preferred approach is to assign wind average to mid-point of averaging interval and interpolate between interval mid-points.
  - Realism is improved with shorter averaging periods.
  - MSS computational efficiency allows, and microscale in some cases requires, real time calculations for averaging periods of 15 minutes or less.

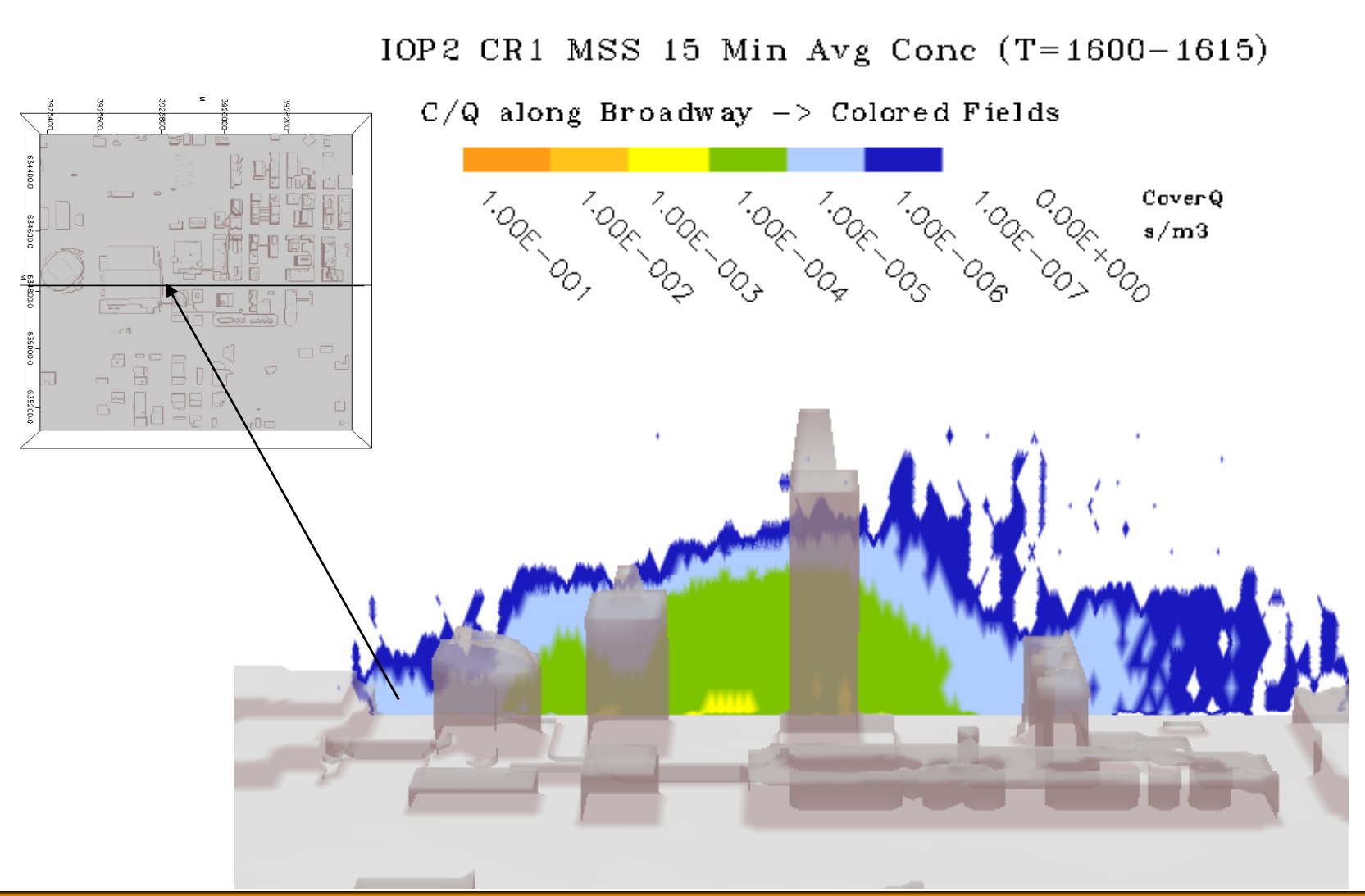
IOP2 Concentration Contours



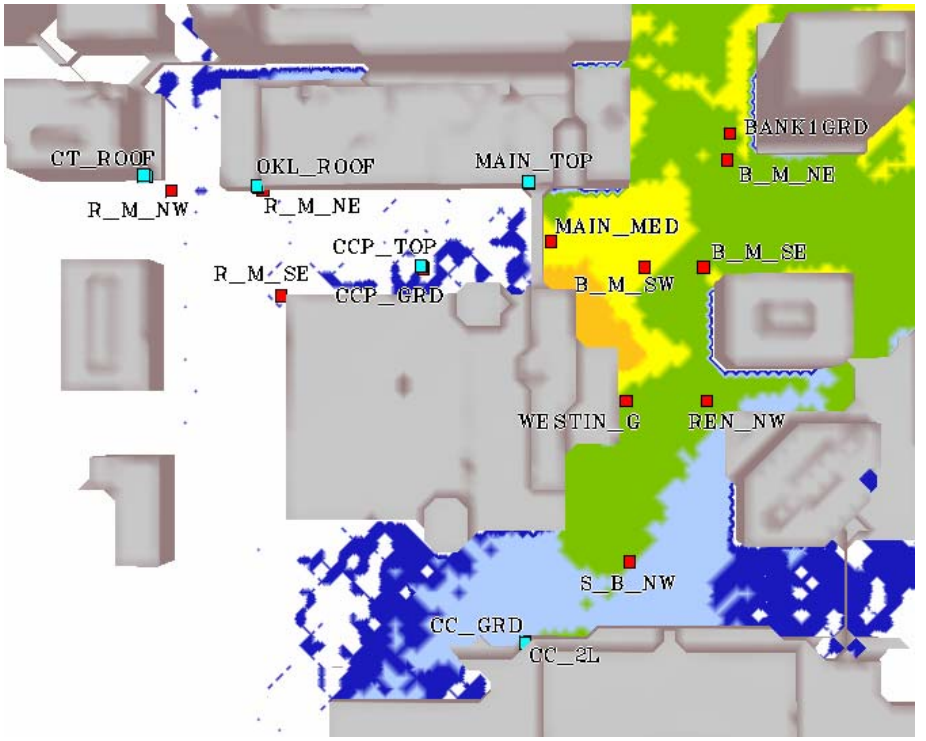
IOP2 Concentration Contours

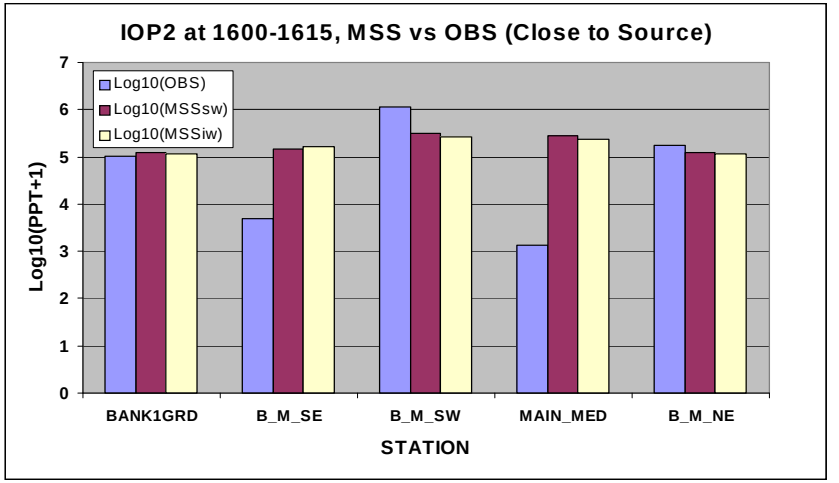


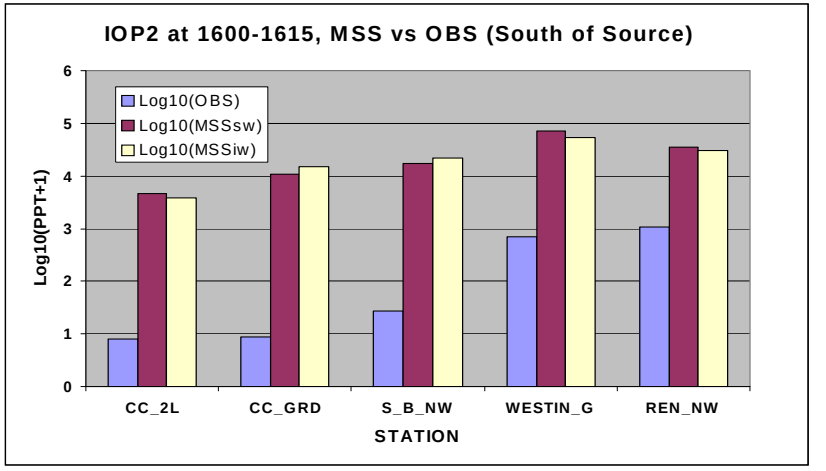
Vertical Concentration Profiles



Comparison of Concentration Predictions with Sampler Data







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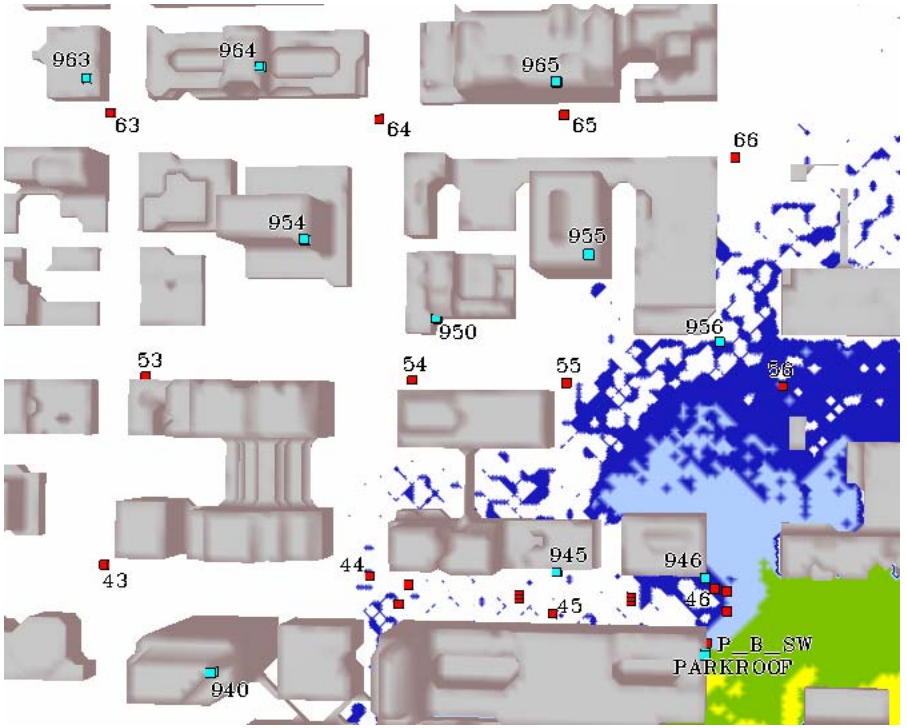
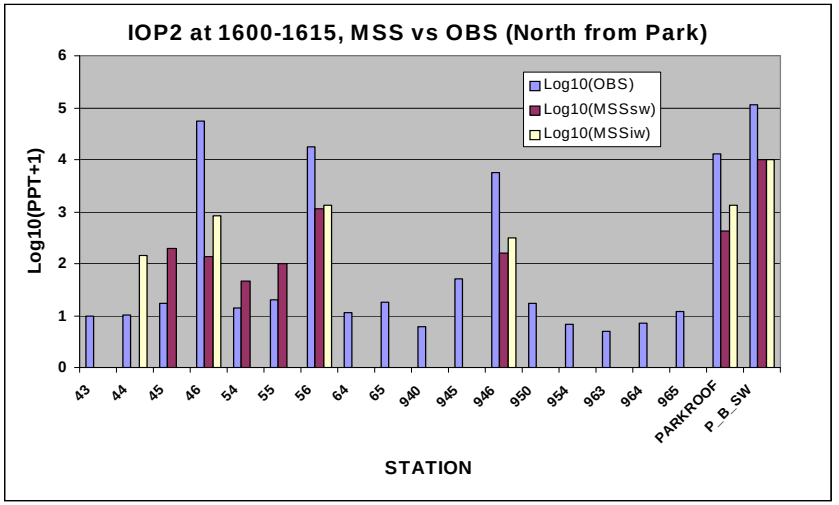
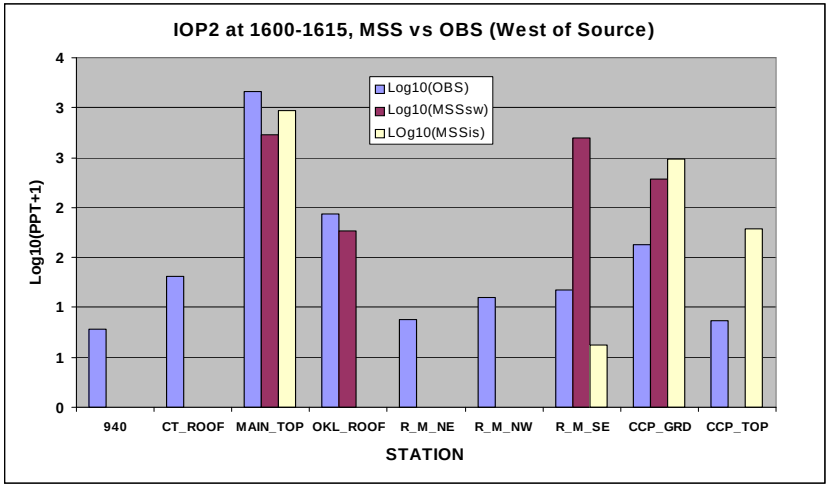


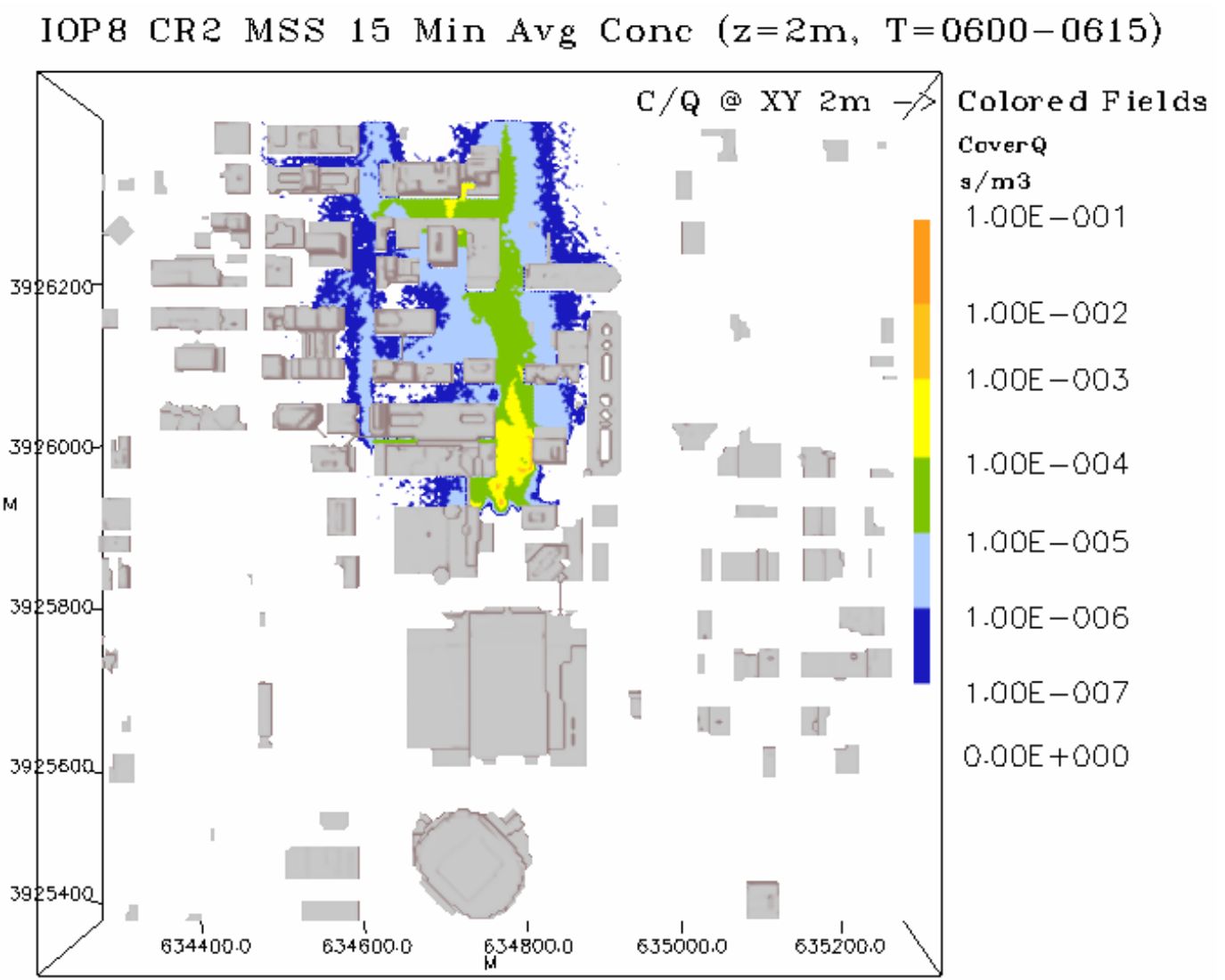




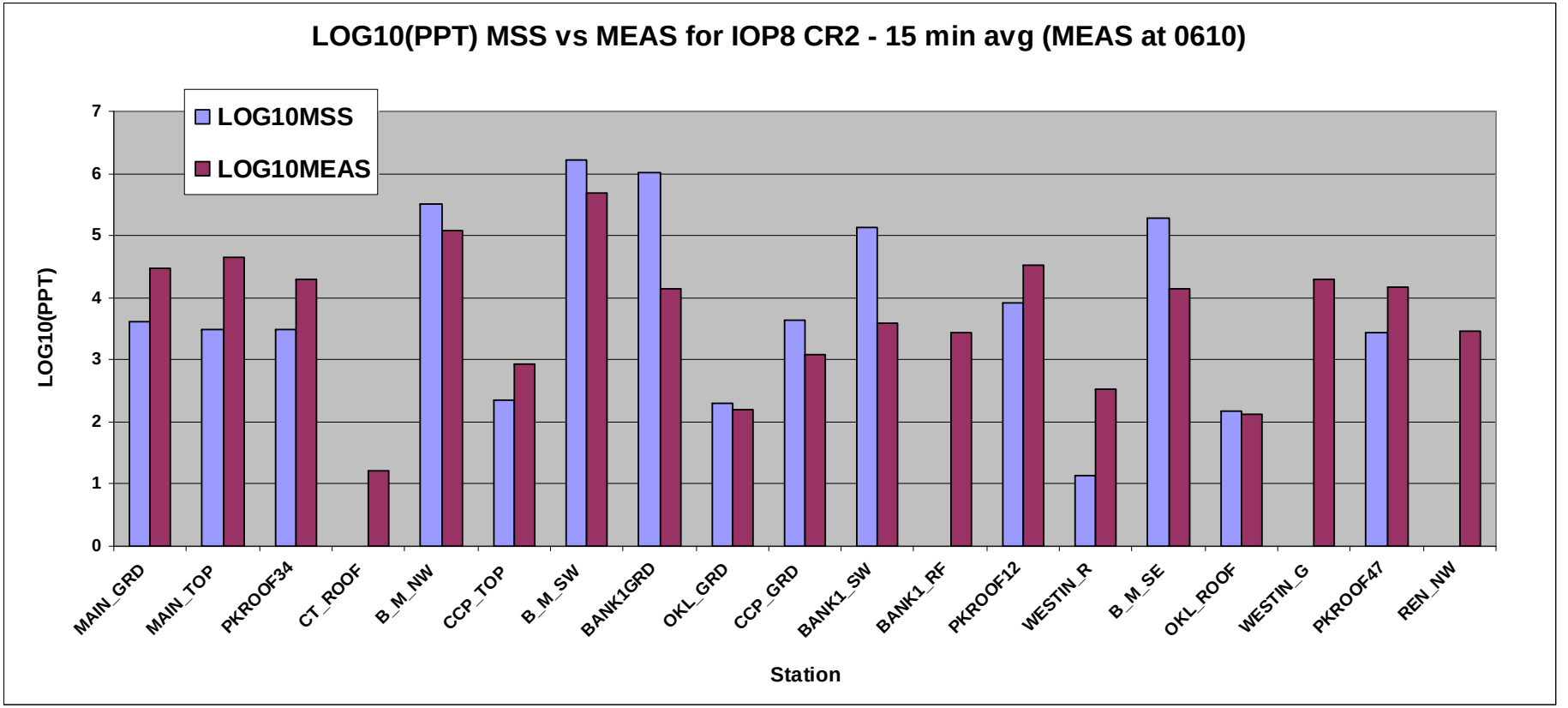
MSS Simulations for JU2003 IOP8

- OKC JU2003 IOP8 Test Conditions
  - Date: July 18, 2003
  - Release location: Westin
  - Met data input to MSS: PNNL Sodar
  - MSS computation domain (see slide)
    - *domain size: 1km square*
    - *horizontal resolution: 4m X 4m*

IOP8 Concentration Contours

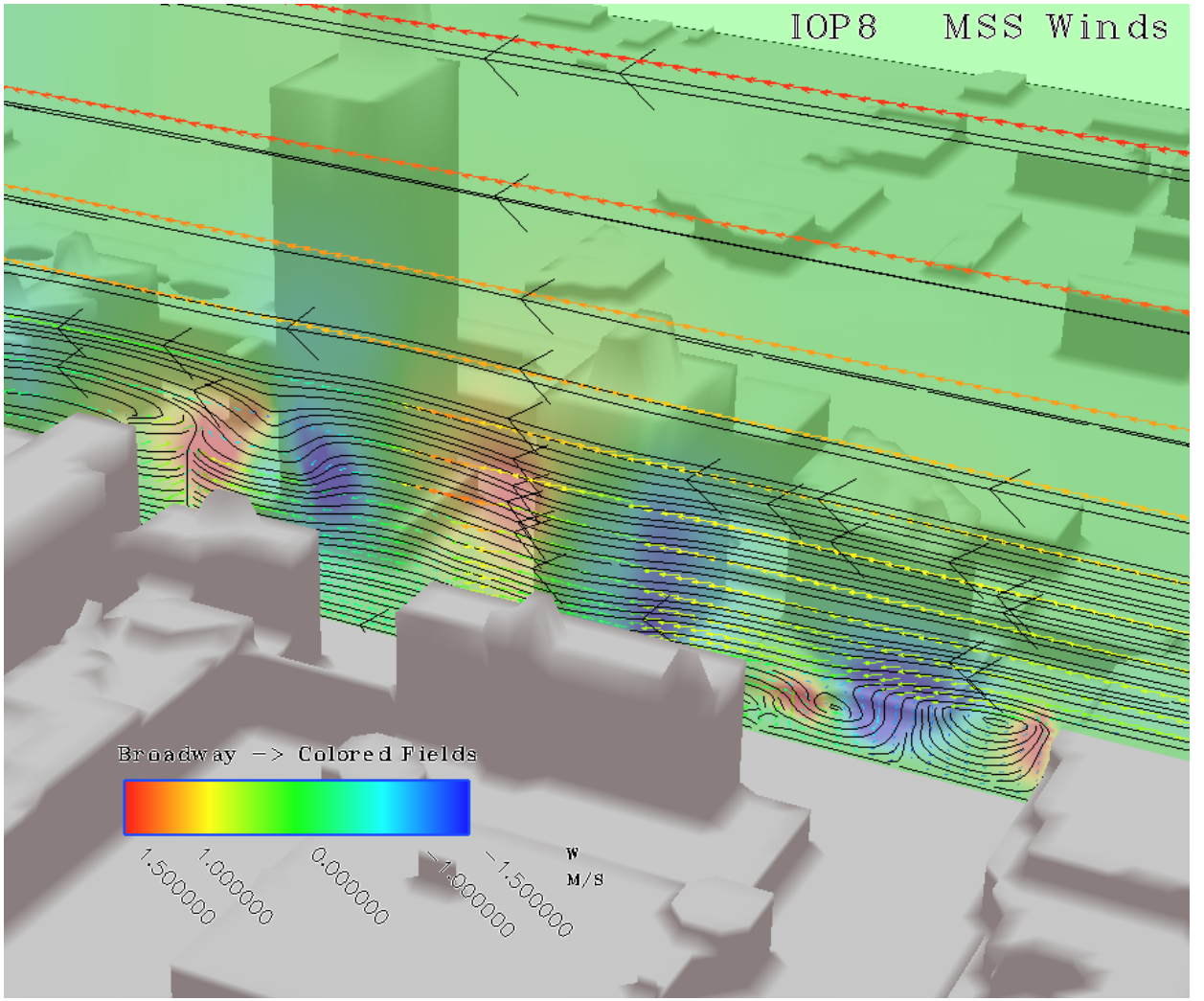


Comparisons with Selected Tracer Instruments

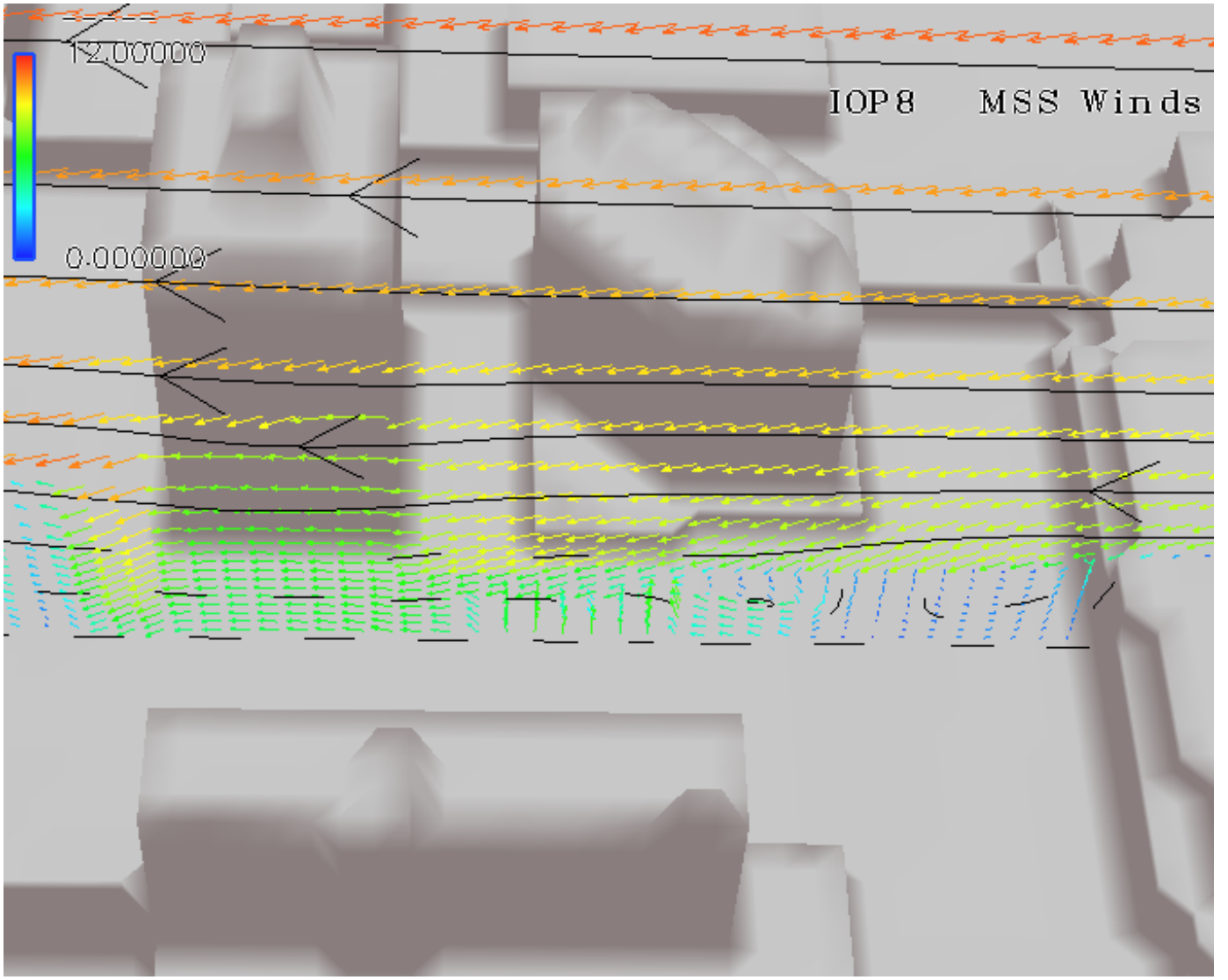


- **Data indicates upstream advection (e.g. at Westin_G and Ren_NW) that MSS does not predict.**
- **Sensitive to relative position of reattachment and release points.**

Velocity Vectors along Broadway for IOP8



Velocity Vectors along Broadway



Agenda

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- **Summary**

MSS – HPAC Interface
MSS Input Provided by HPAC

- **Domain – 640 m^2 to 1 km^2 @ 3, 4, or 5 m resolution, centered on the release location**
- **Meteorology – profiles extracted from the larger domain SWIFT mass consistent wind field, which can be based on:**
  - Observations – surface and/or upper air
  - Gridded output of NWP models (in MEDOC format)
  - Historical data (AFCCC climatology)
  - Fixed winds
- **Terrain/land use – interpolation of the HPAC DTED level 0 (1 km) and LandScan databases**
- **Urban structures – triangulation of Shapefiles obtained from GEDIS (Geographic and Environmental Database Information System)**
- **Release – type, location, amount, duration, material properties**

MSS – HPAC Interface
MSS Output Provided to HPAC

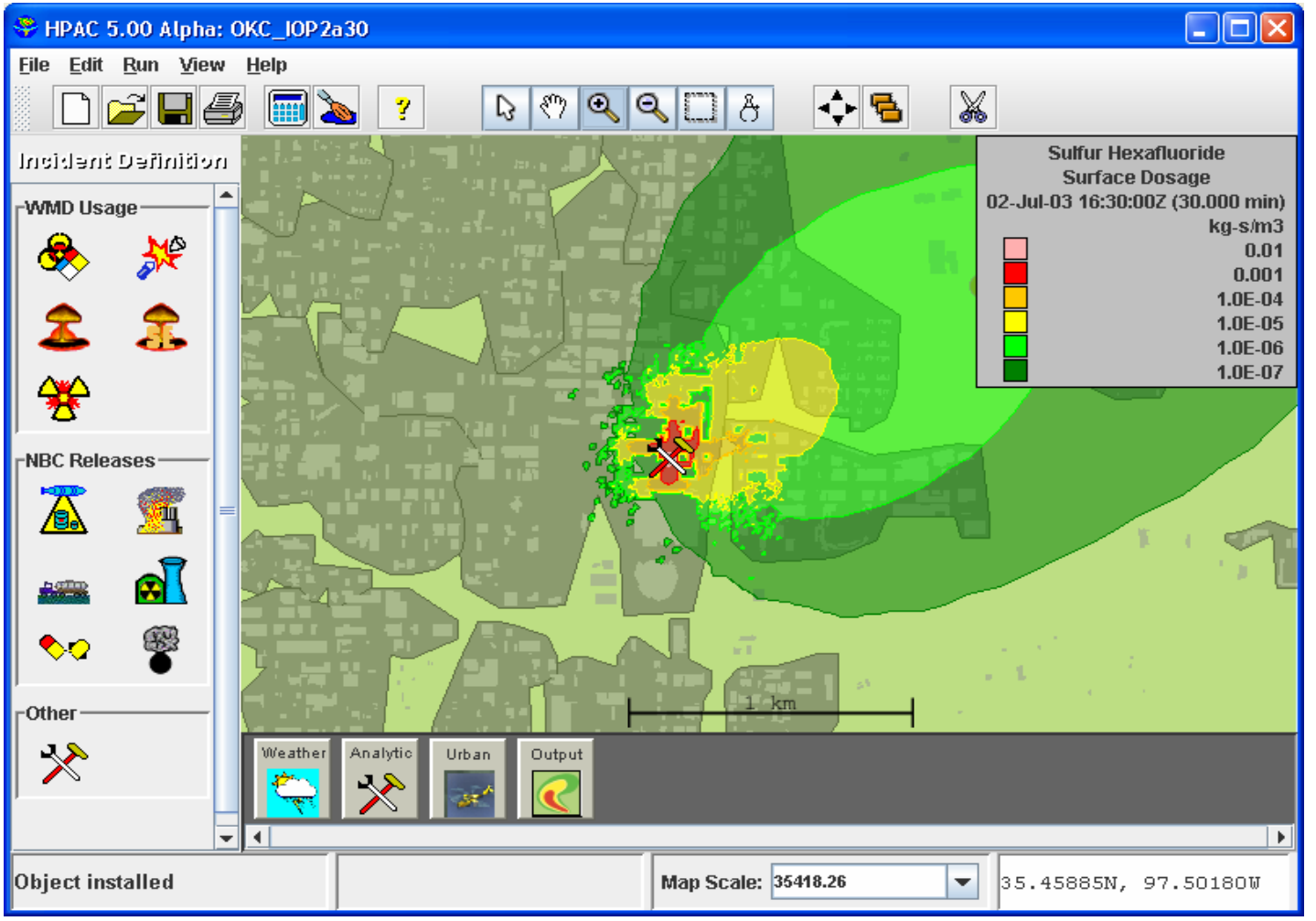
- **Puffs – created by aggregating particles as they leave the MSS domain, at specified synchronization times**

- **Plot quantities inside the MSS domain**
  - Surface dosage
  - Surface concentration
  - Concentration slices
  - Vertically integrated concentration

- **3D wind and turbulence fields at specified times**
- **3D concentration and surface dosage fields at specified times**
- **Concentration values at specified locations (samplers) at specified times**

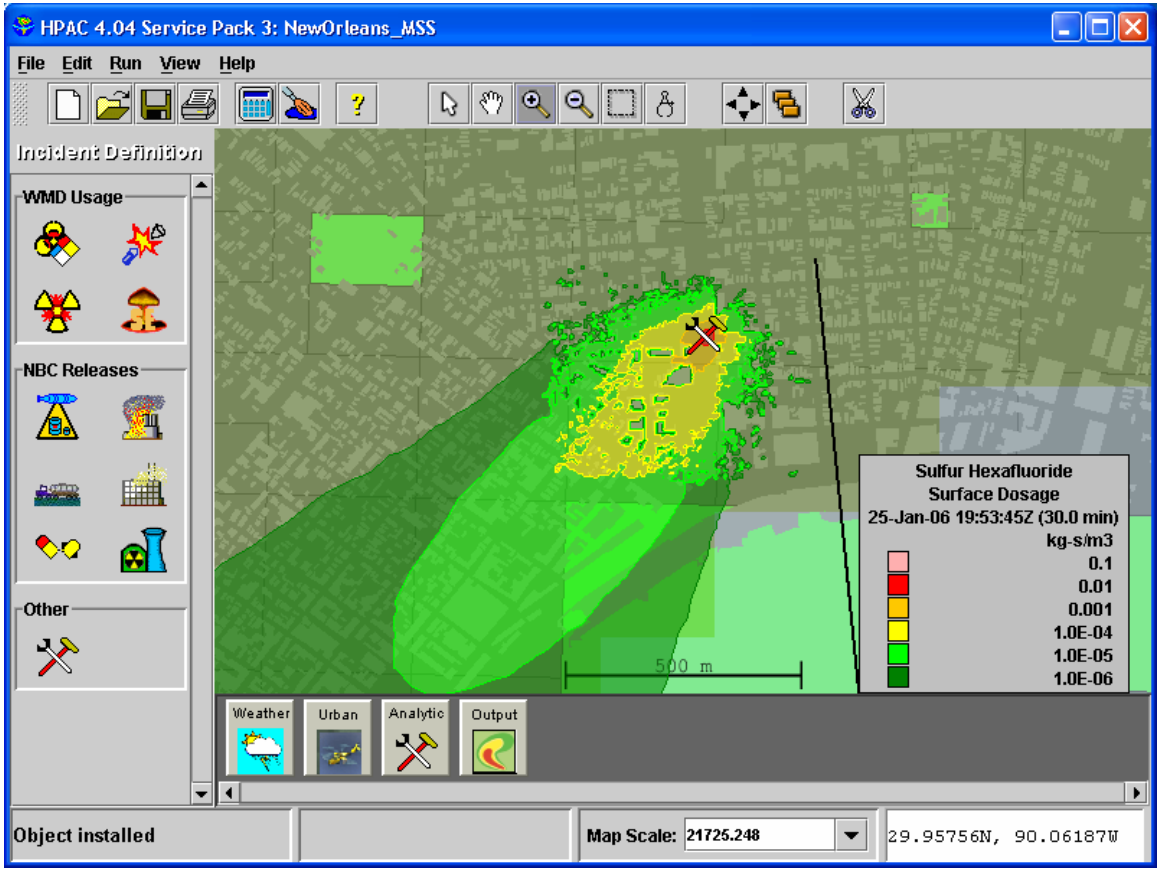
HPAC 5.00- Oklahoma City

Met: PNNL profile; Domain: 1 km @ 4 m

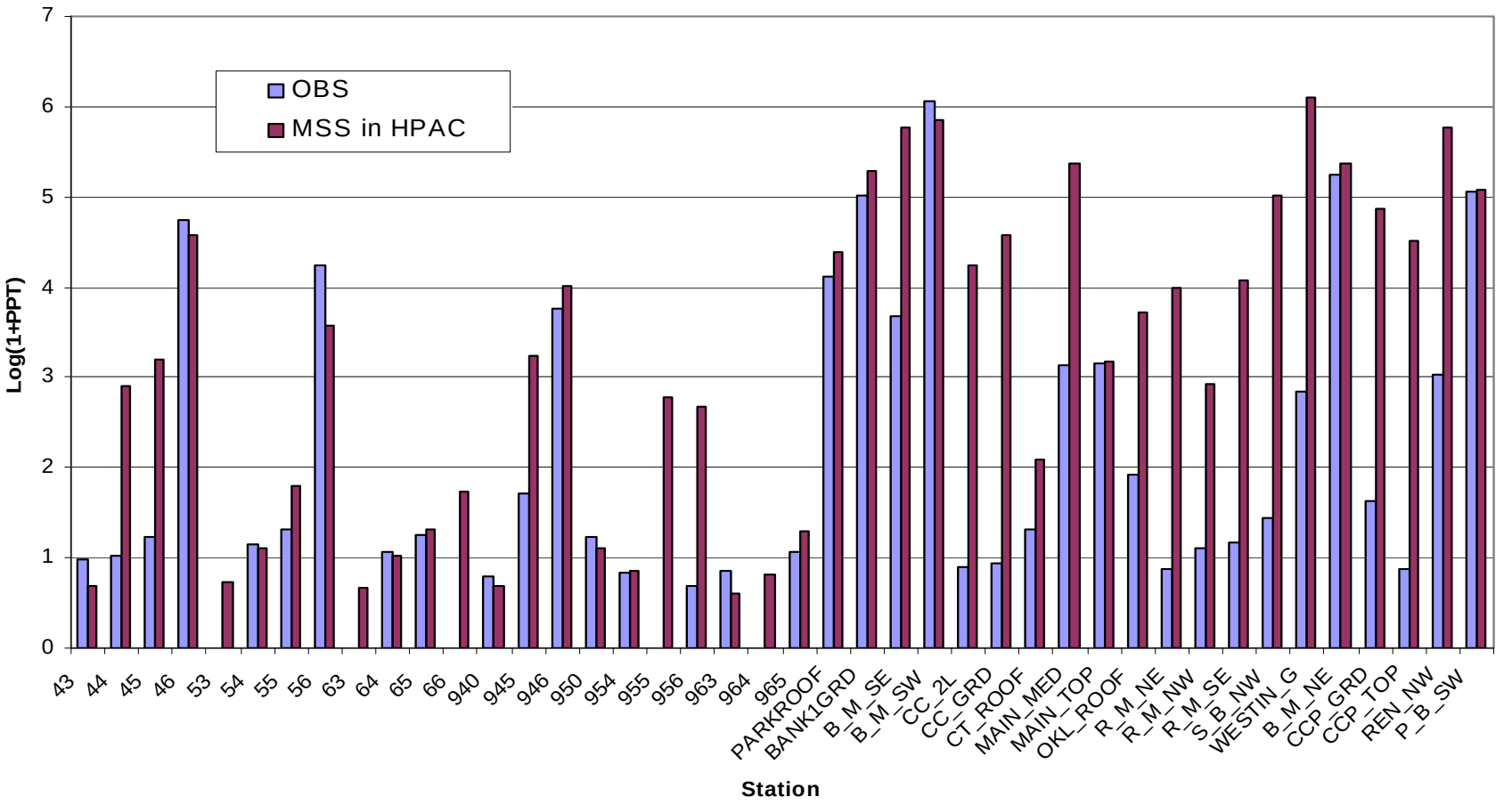


MSS: New Orleans

Met: fixed winds (MSWIFT at 0 min); Domain: .8 km @ 5 m; Runtime: 5 min.



MSS/HPAC Predictions



MSS applications in France

CEA-DAM **is the military division of the French Atomic Energy Commission.**

(Commissariat à l'Energie Atomique – Direction des Applications Militaires)

- **Acquired MSS for Urban Emergency Response (Paris, other major cities).**
- **Develops a centralized operational system.**
- **Decided to fund the parallelization of the MSS code.**

MSS applications in PARIS

- *Release in the City Center : Châtelet – Les Halles*

- *Courtesy of CEA-DAM*

Dr. Patrick ARMAND

MSS applications in PARIS

- *Release in the City Center : Place de la Concorde*

- *Courtesy of CEA-DAM Dr. Patrick ARMAND*

Summary

- **Micro SWIFT/SPRAY (MSS) is operational in HPAC 5.0**
- **Current focus on validation**
  - JU 2003 and international studies
- **Comparisons with JU 2003 data indicate some successes, and some areas requiring more attention**
  - Correct modeling of advection (recirculation, channeling, vertical transport, etc.) in urban terrain may be more important than turbulent diffusion.
  - Results are highly dependent on MET input.
  - Collaboration between Röckle-based modelers is proceeding and demonstrating benefits.