Upwind Downwind Conference

Hamilton Airshed Modelling System

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Acknowledgements

Thank you for the support and involvement of:

- Hamilton Industrial Environmental Association
- City of Hamilton
- Environment Hamilton
- Ministry of the Environmental and Climate Change

Why Airshed Modelling?

Why are we doing this?

- Need to understand what is impacting air quality and where it is coming from
- Help with policy decisions
- Concerns over what should be prioritized

Is anyone else doing this?

- Regional air quality modelling performed by government agencies and research institutions
- Municipalities are starting to take control of their air quality
  - Halton
  - Peel Region
  - City of Toronto

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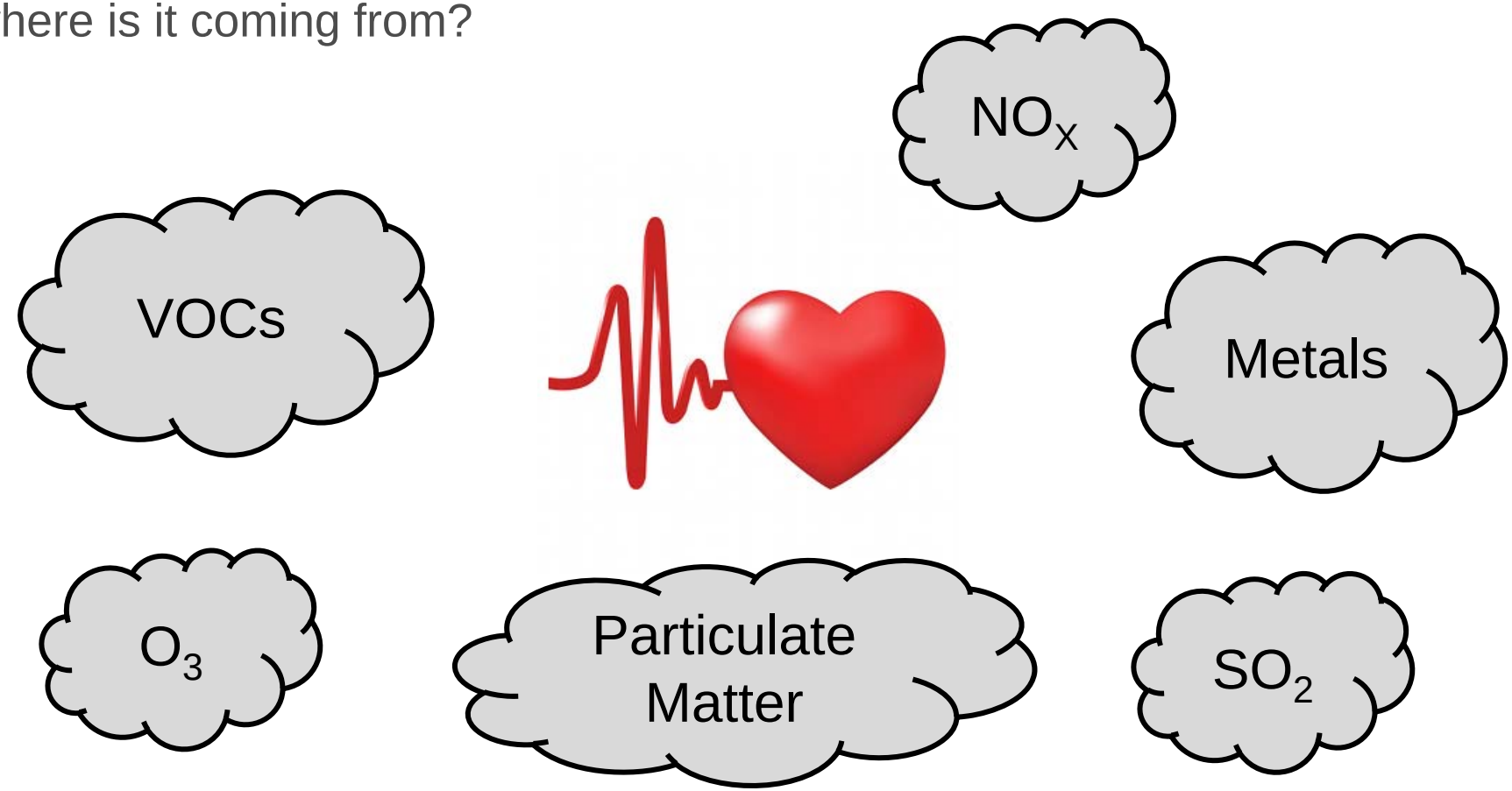
BAQS-MET Study (2007)

- Border Air Quality and Meteorology Study (BAQS-Met) in Southwestern Ontario in 2007
- Focus on the Windsor-Sarnia region
- Purpose
  - Understand how lake-driven meteorology impacts air quality in the region
  - Improve models used for forecasting and policy scenarios
- Regional air quality transported into the region is typically poor
- Local emissions can be enhanced by the presence of the Great Lakes
  - Pollutants trapped within smaller volume than would normally occur
  - Localized peaks in O_3 and $PM_{2.5}$
- **Even if poor air quality is transported into the region, local controls are still important**

Health Impacts in Hamilton

What's impacting the health and well-being of Hamilton residents and where is it coming from?



Project Objectives

Challenge:

- Unraveling the Hamilton Airshed
  - nature and level of contribution of various local and regional background sources to air quality;
  - geographical distribution of ambient air concentrations
  - hourly, daily and seasonal changes to consider

Solution:

- Develop, implement and execute an Airshed Modelling System for the City of Hamilton
  - Process emissions from sources into ambient air concentrations
  - Include local, regional and transboundary influences
- Verify modelling results with observations from local ambient monitoring
- Assess short-term and long-term exposure levels

Unraveling the Hamilton Airshed

Need to consider both large and small scale influences on the airshed

Source: https://asiancan.wordpress.com/hamilton/mm-hamilton-entrance/

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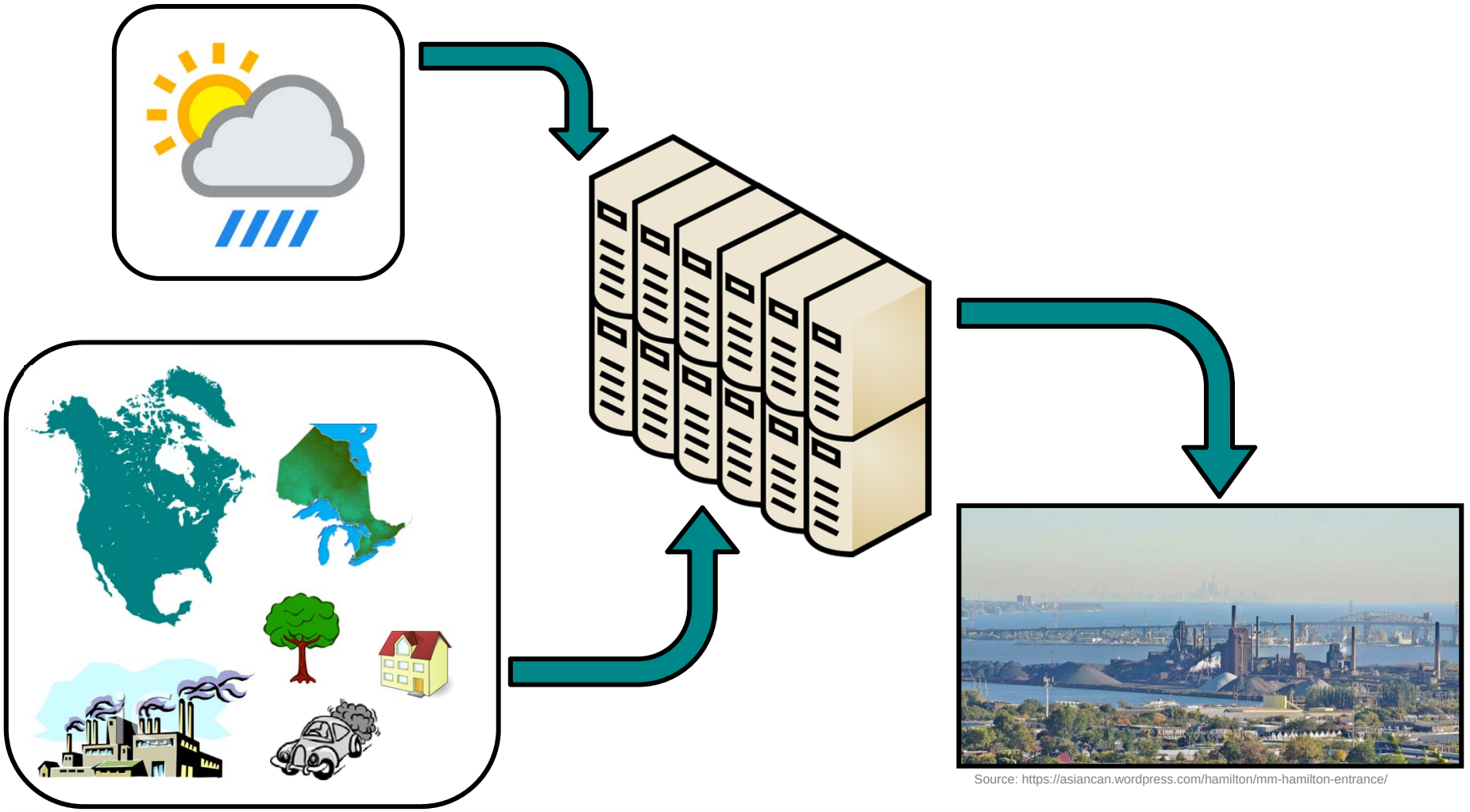
Solution: Multi-Tiered Airshed Modelling System



Source: https://asiancan.wordpress.com/hamilton/mm-hamilton-entrance/

Project Approach: Capturing Hamilton

Source: https://asiancan.wordpress.com/hamilton/mm-hamilton-entrance/

Success requires the following:

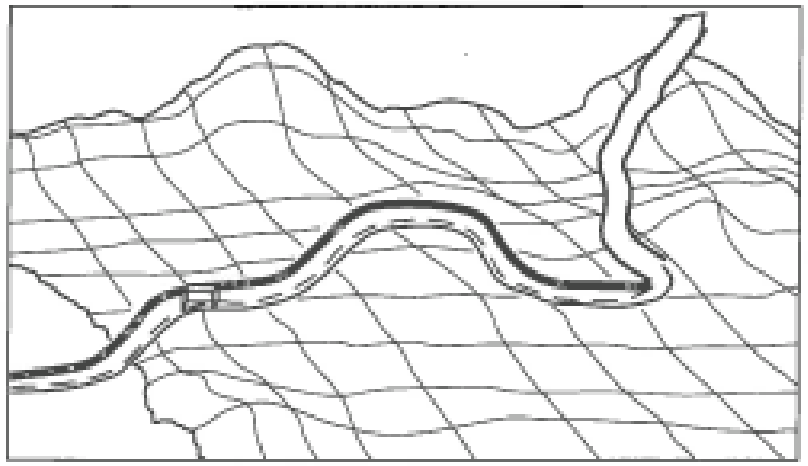
- ✓ Understanding of the region of interest and its influences
- ✓ A Big Computer
- ✓ Knowing what you are doing!

- Capture influences on a global, regional and local scale
  - Meteorology
  - Air Quality
- Capture the unique geography
- Capture variation of regional and local emission sources with time
  - Industrial
  - Commercial
  - Residential
  - Transportation (rail, airways, marine and roads)
  - Agricultural/biogenics

Which Air Quality Model?

CALPUFF: Lagrangian Dispersion Model

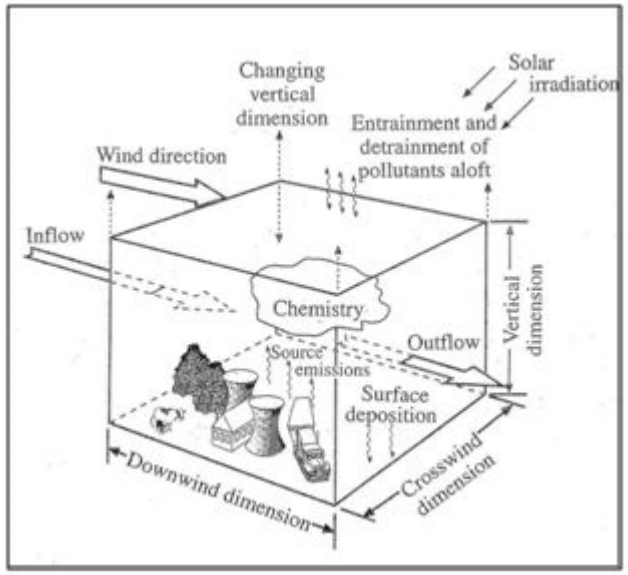
- Air parcel advected through atmosphere undergoes chemical transformation



Source: Seinfeld and Pandis (1998). Atmospheric Chemistry and Physics: From Air Pollution to Climate Change

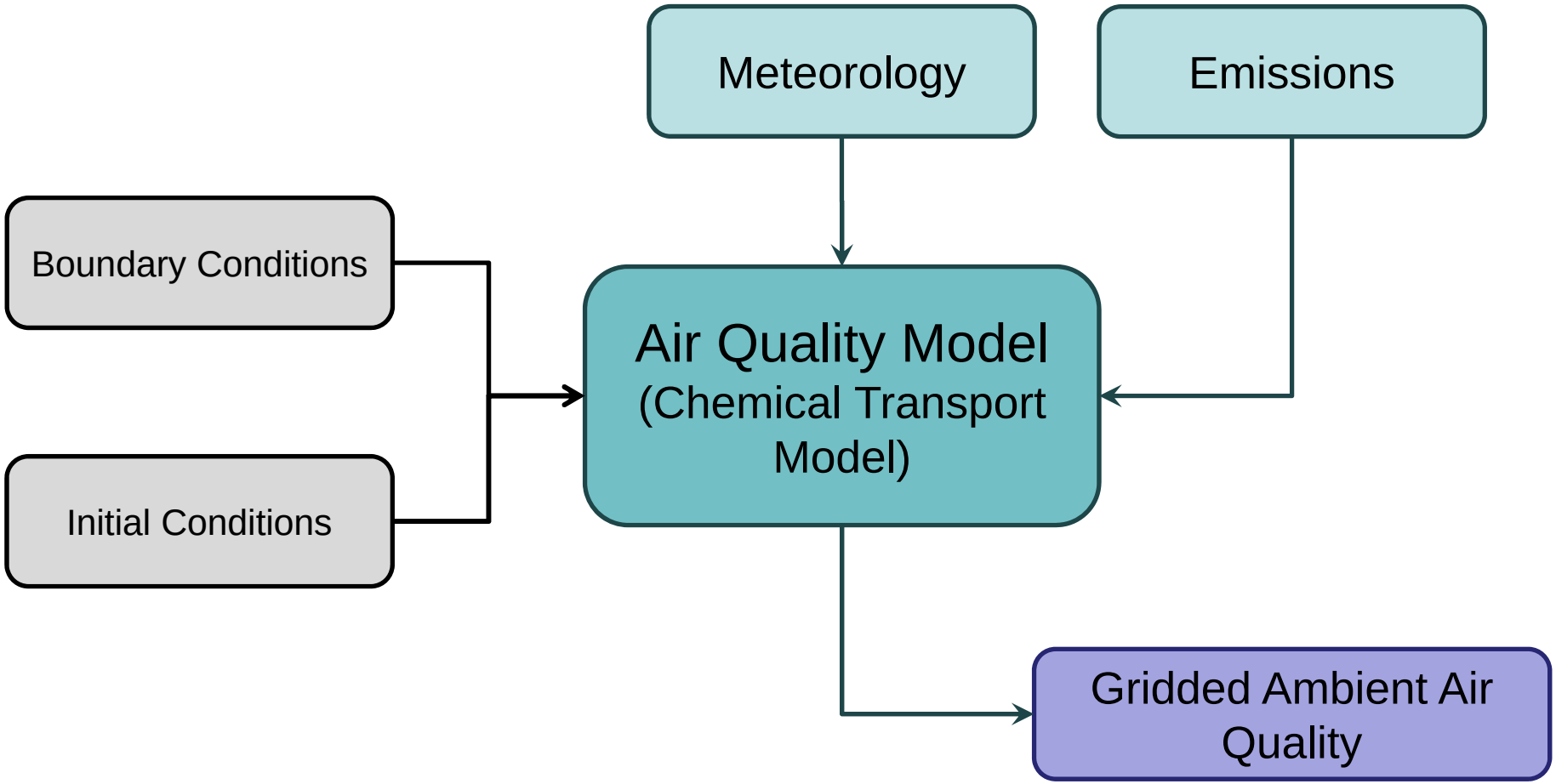
CMAQ: Eulerian Chemical Transport Model

- Array of fixed air parcels undergo chemical transformation



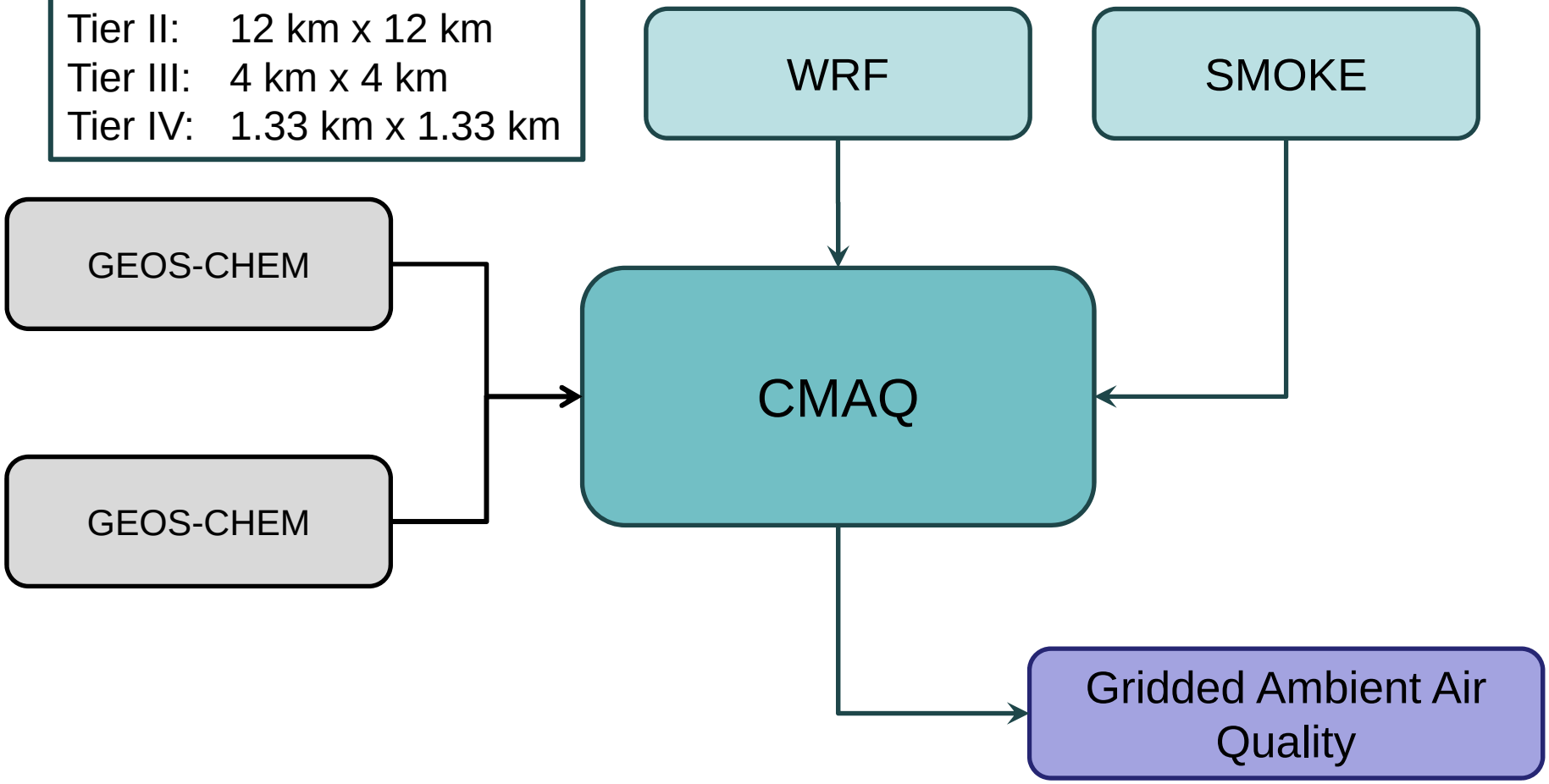
Source: http://www.romair.eu/aria/data/principle.jpg

Air Quality Modelling System

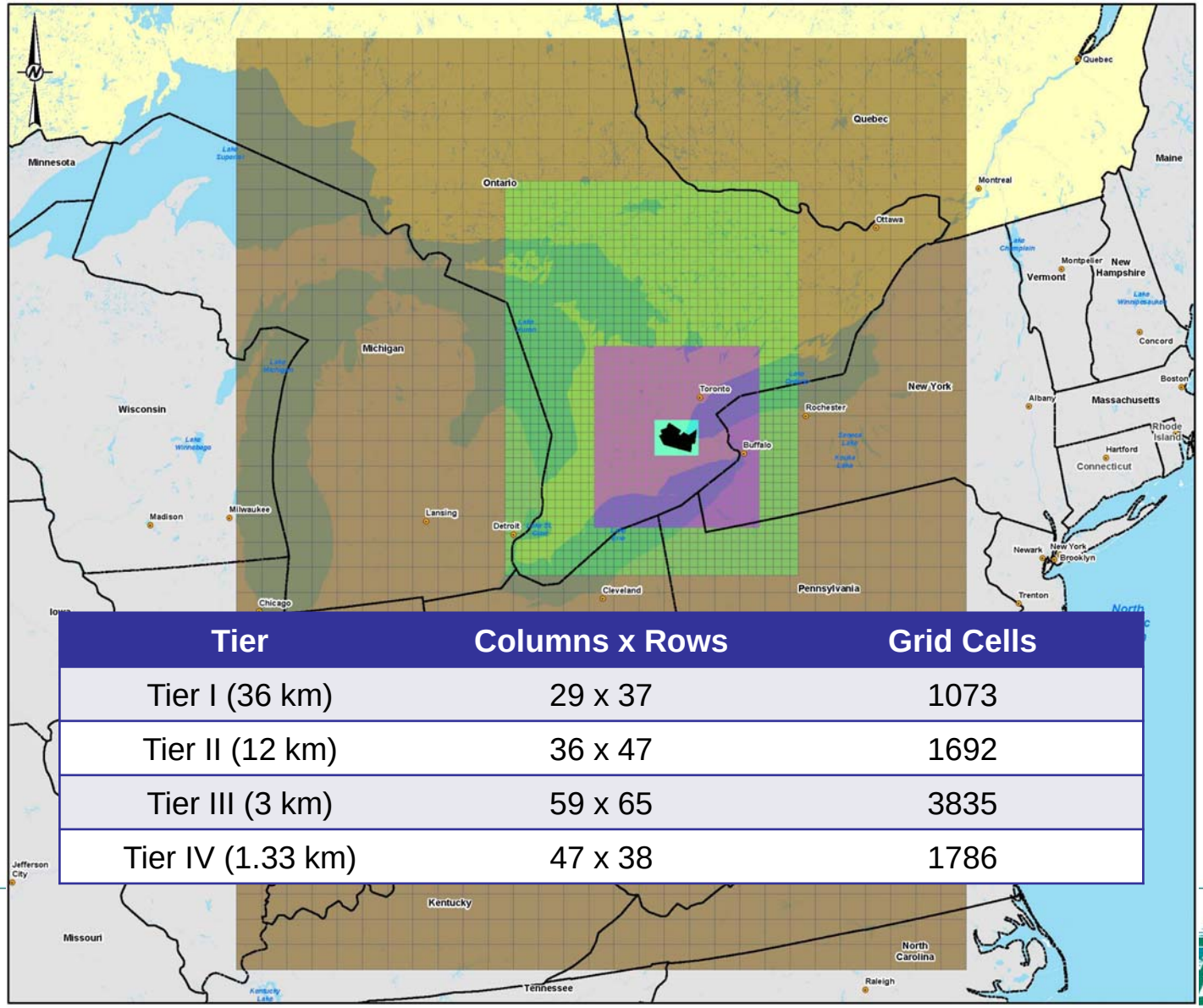


Air Quality Modelling System

Tier I:	36 km x 36 km
Tier II:	12 km x 12 km
Tier III:	4 km x 4 km
Tier IV:	1.33 km x 1.33 km



Grid Density: Tier I, II, III & IV



Tier	Columns x Rows	Grid Cells
Tier I (36 km)	29 x 37	1073
Tier II (12 km)	36 x 47	1692
Tier III (3 km)	59 x 65	3835
Tier IV (1.33 km)	47 x 38	1786

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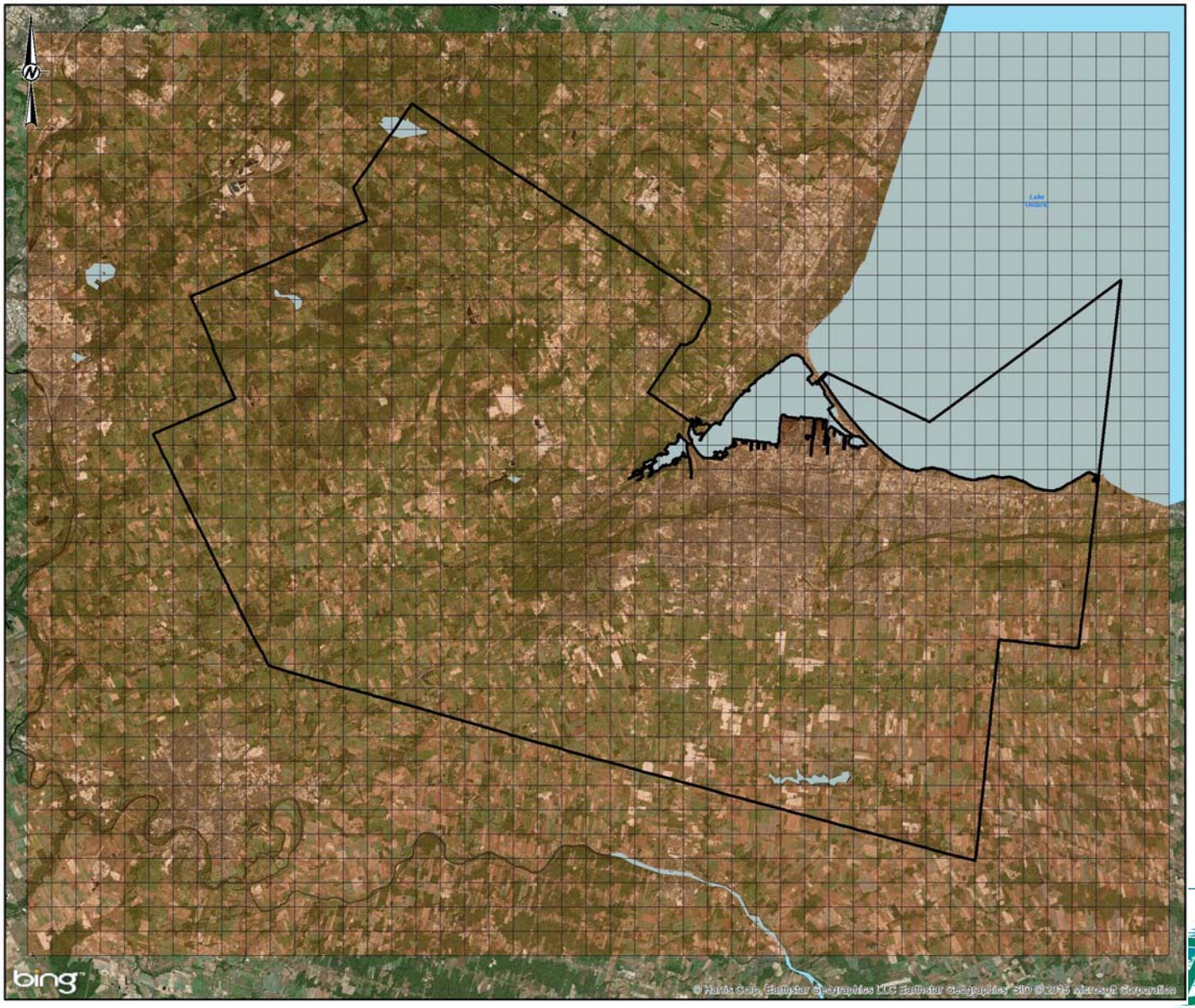
Grid Density: Tier IV



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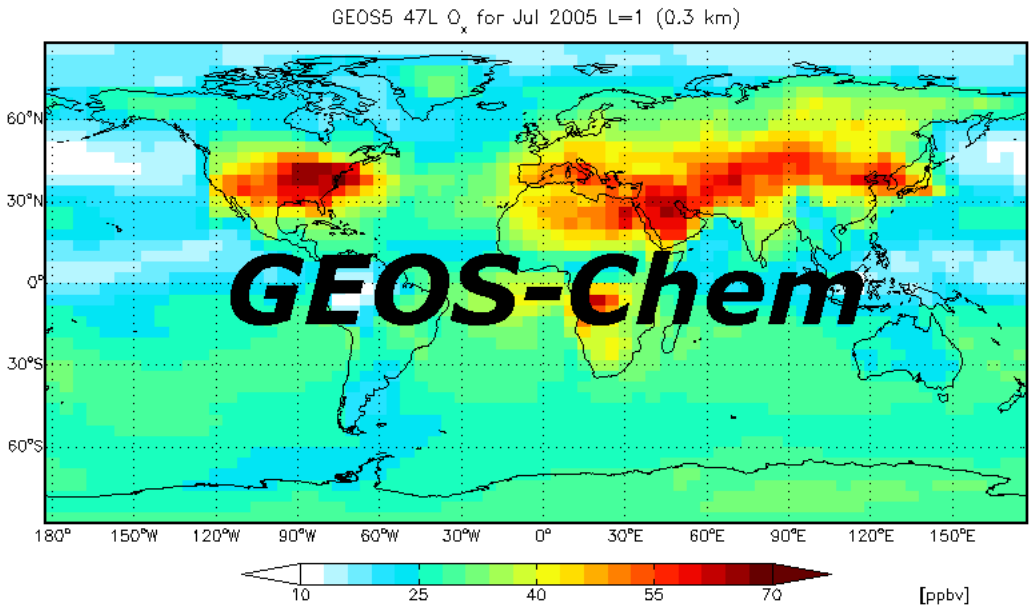
Boundary Conditions / Initial Conditions

GEOS-Chem focuses on chemical species with longer lifetimes that can be transported around the globe

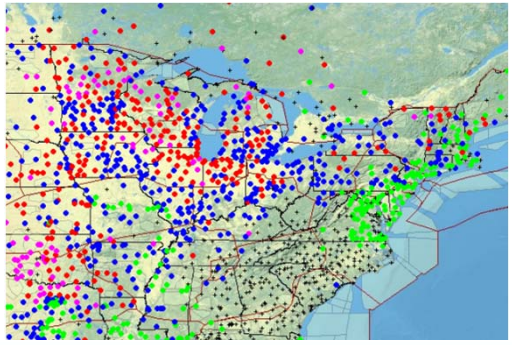


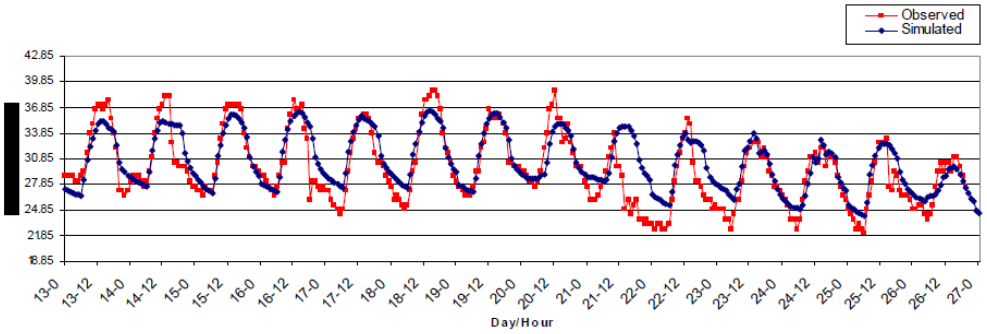
Influence locally will be driven by local sources, not boundary or initial conditions

Image source: http://acmg.seas.harvard.edu/geos/doc/man/

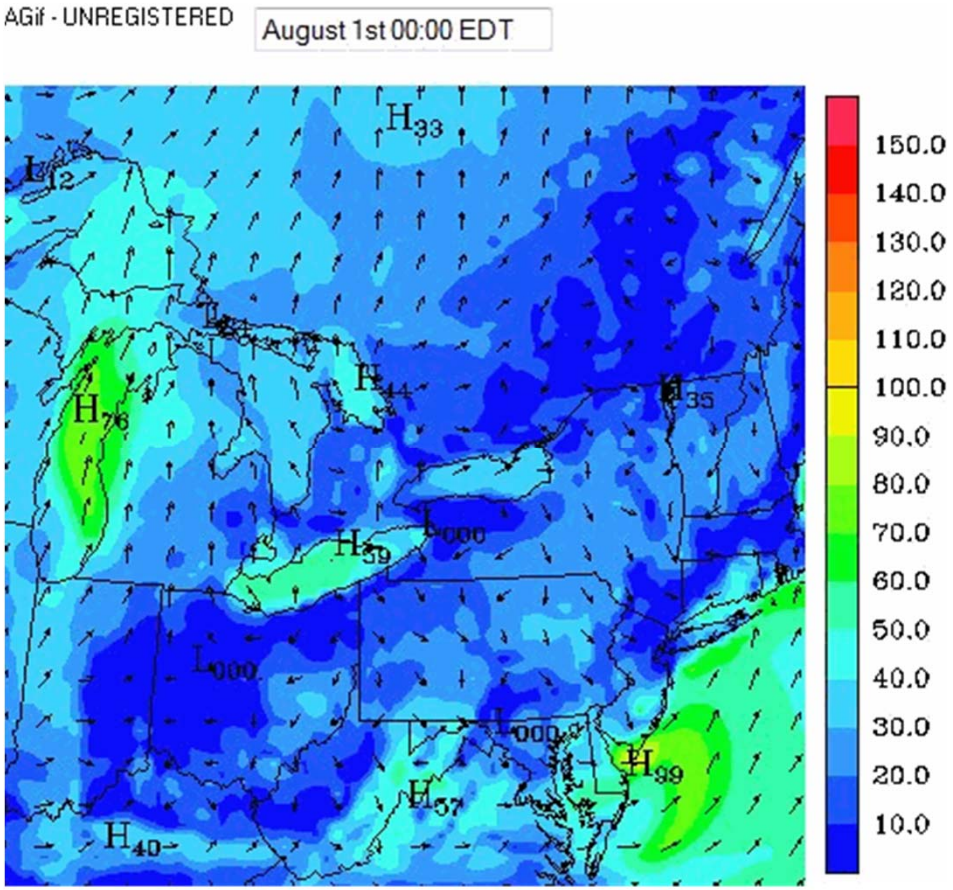
Meteorological Modelling

- Weather Research and Forecasting-Advanced Research WRF (WRF-ARW) Model v.3.6.1
- Nested 36-12-4-1.33 km domains
- Modelling 2012 to produce hourly predictions for each day of the year
- North American Regional Reanalysis initialization data set
- Grid and observational nudging
  - NCEP ADP Global Upper Air Observational Weather Data
  - NCEP ADP Global Surface Observational Weather Data
- Model performance evaluation (MPE) will be conducted to determine adequacy of model predictions





Example Meteorological Modelling



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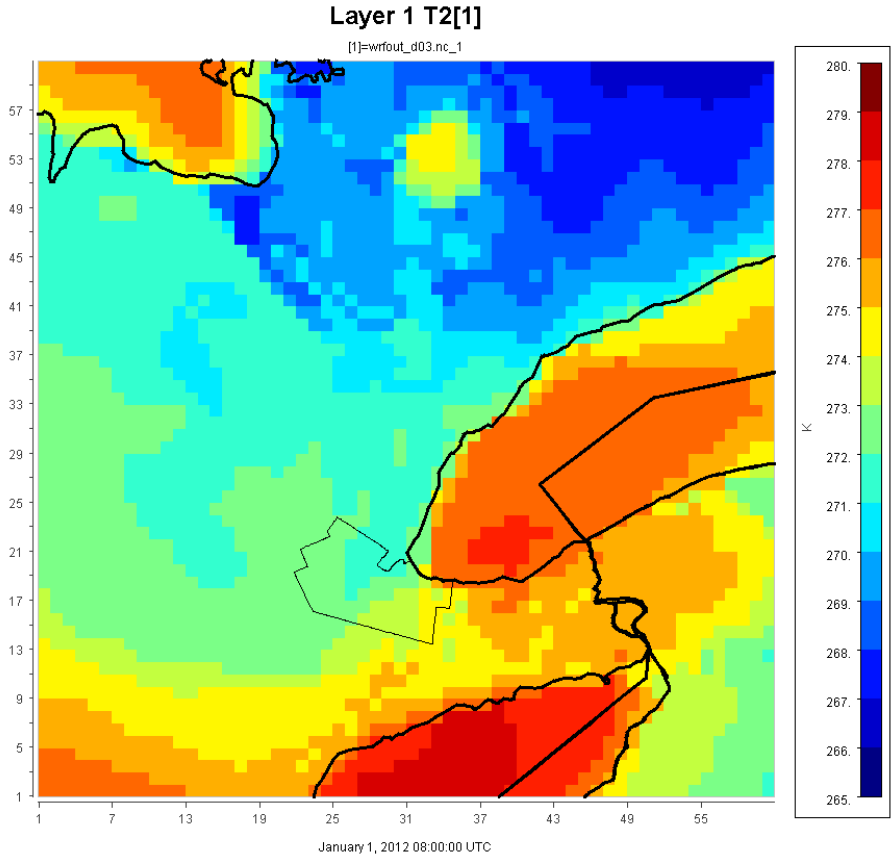
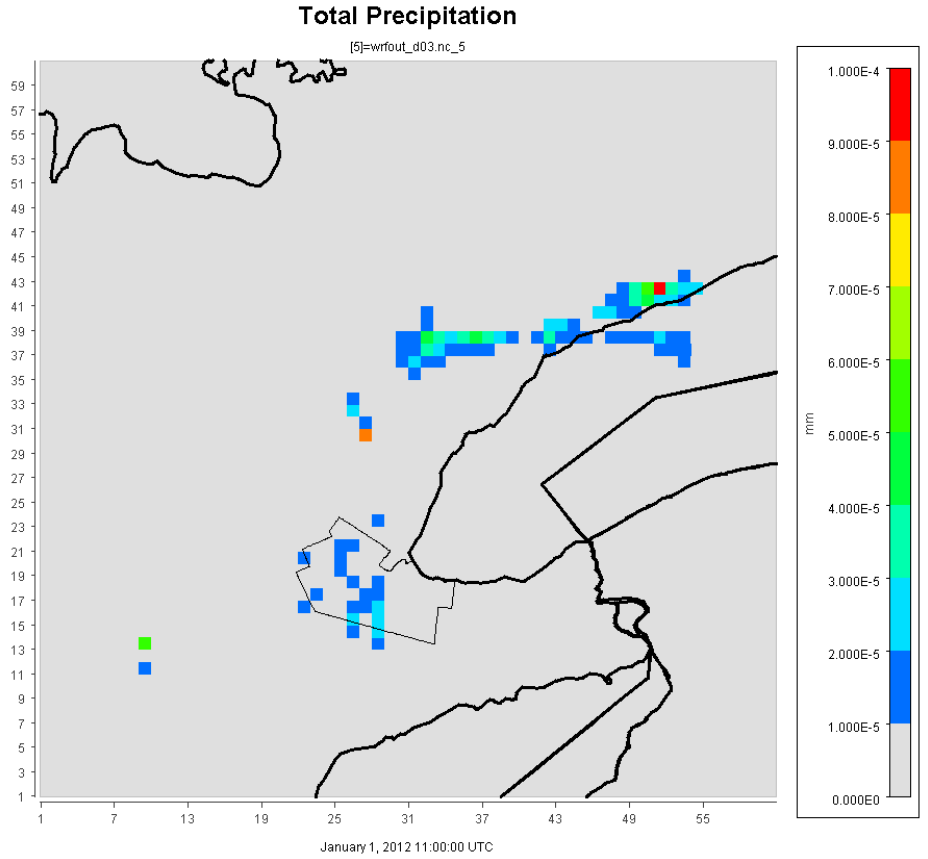
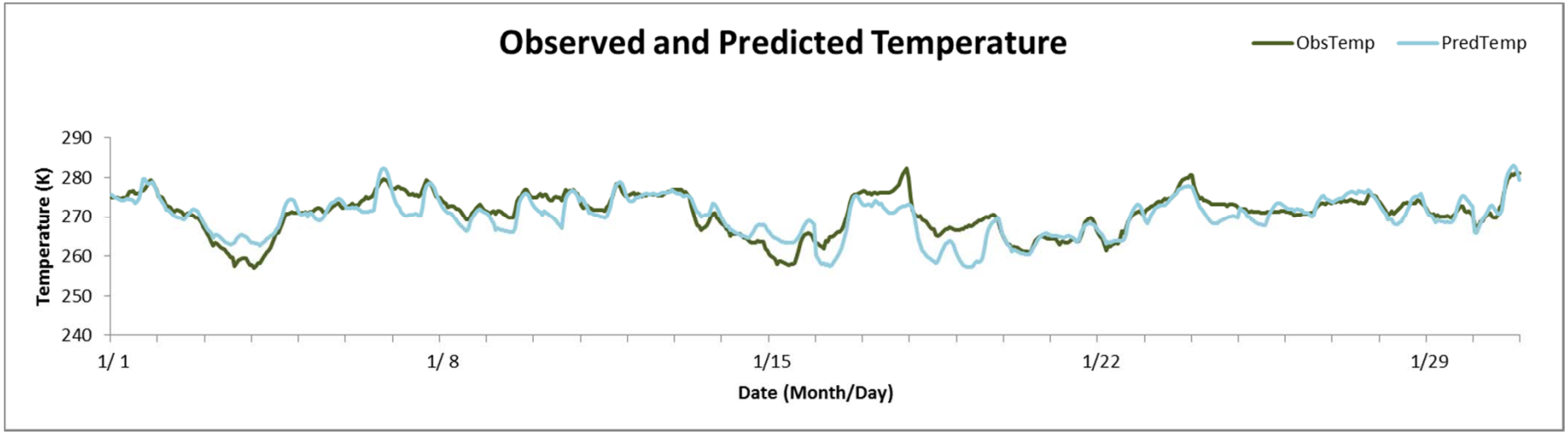
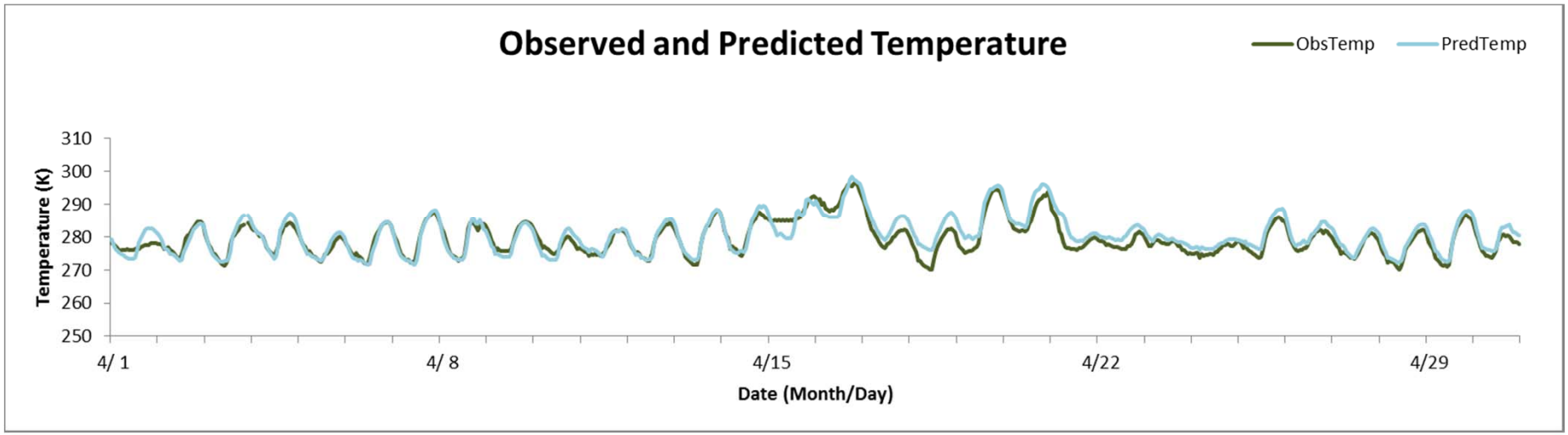




Meteorology: Tier IV Temperature





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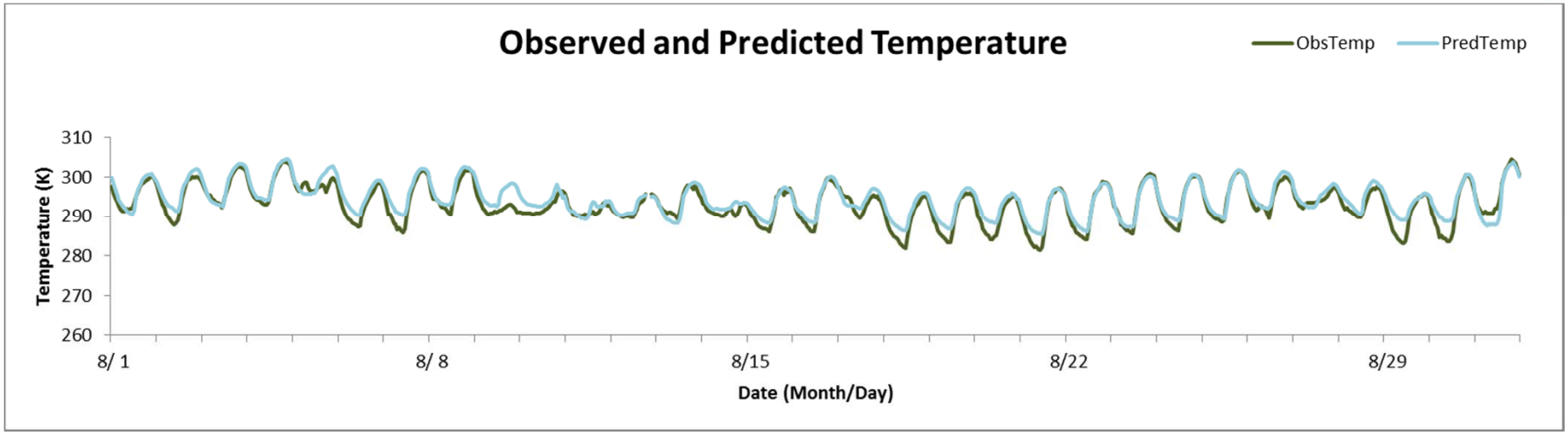
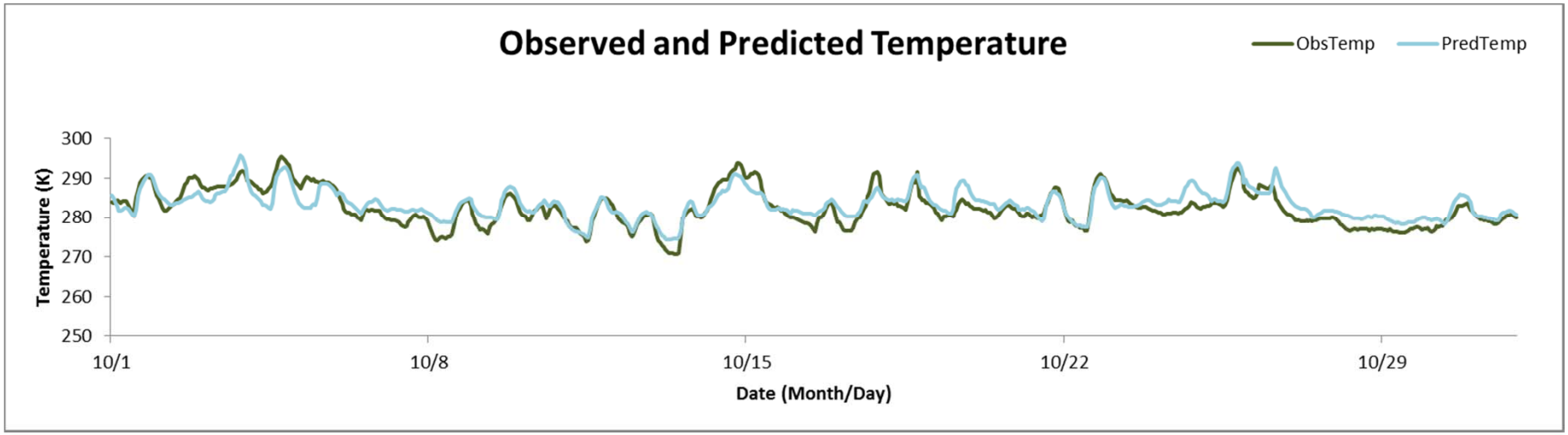
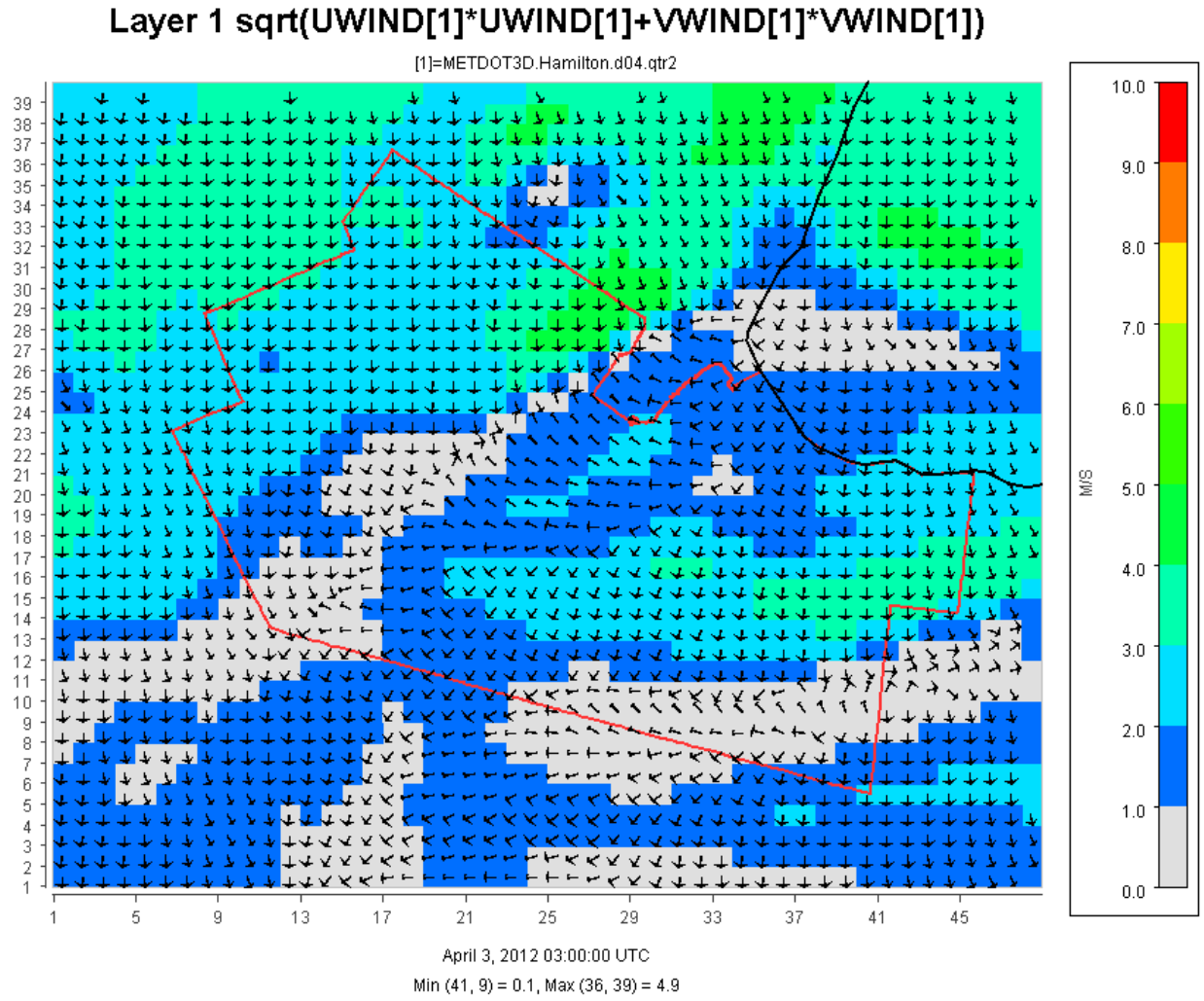




Meteorology: Tier IV Wind Convergence



Emissions: Compounds of Concern

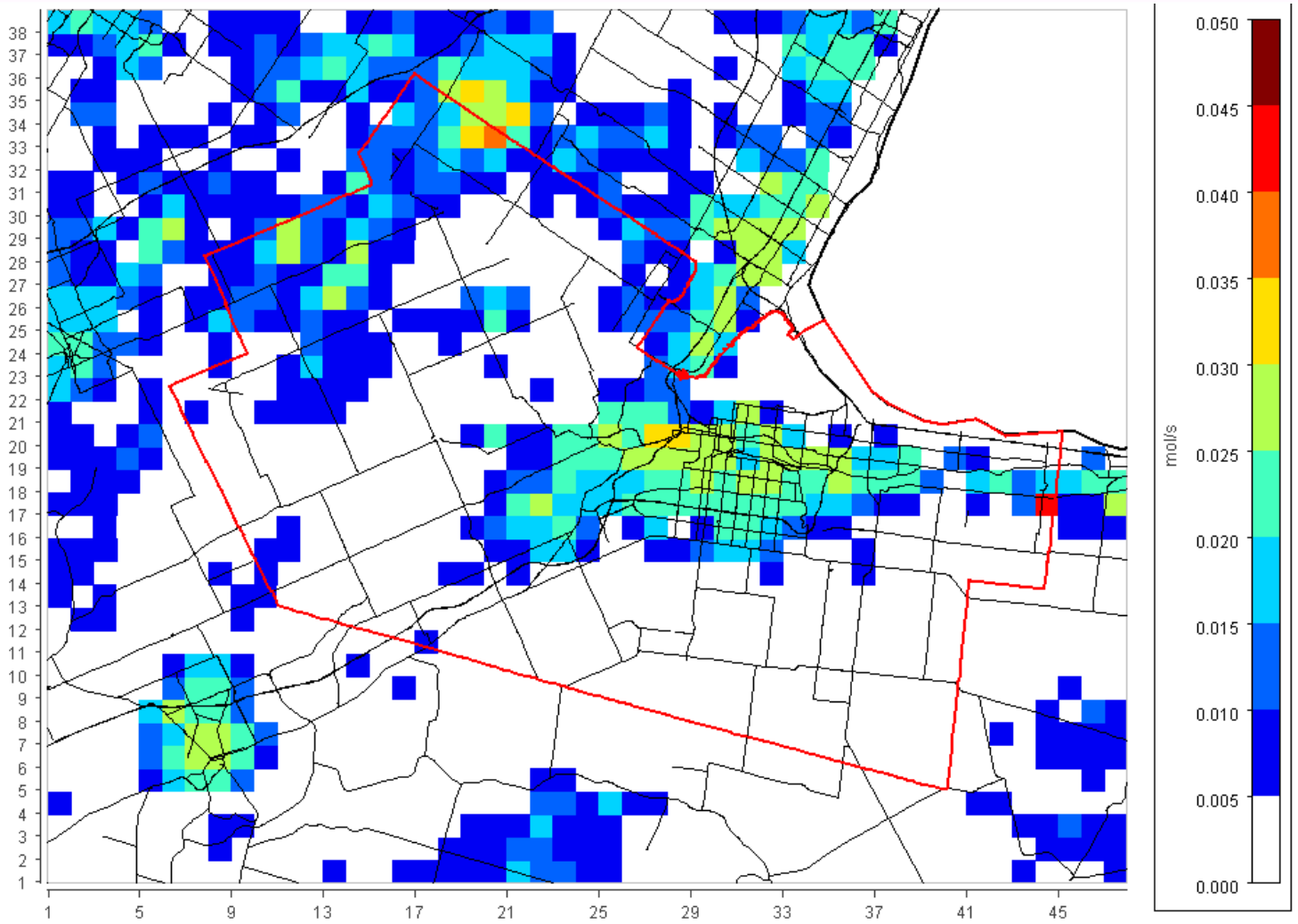
- Which ambient air concentrations have the greatest impact on the health and well-being of Hamilton residents?
  - Look at current emission sources in the area
  - Consult with HIEA, Hamilton Health and Stakeholders

Selected Compounds of Concern		
Nitrogen Oxides (NO_2 and NO)	Chromium (VI)	Ammonia
Sulphur Dioxide	Lead	Benzene
Ozone	Manganese	Formaldehyde
Particulate Matter (TSP, PM_{10}, $PM_{2.5}$)	Mercury (gaseous)	Benzo[a]pyrene
Cadmium	Mercury (non-gaseous)	VOCs (Anthropogenic/Biogenic)
Chromium (III)	Nickel	

Data sets for Emissions

- Environment Canada
  - NPRI – Annual Emissions by Industrial Facility including stack parameters for large point sources
  - NPI – Annual emissions by province for non-road mobiles (e.g. airports, rail, marine)
- Great Lakes Commission (GLC)
  - Centralized Air repository On-Line (CAROL) – Emission Inventory data by county
- Municipality Property Assessment Corporation (MPAC)–
  - Property codes and land use classifications
- Transport Canada and GO Trains
  - Transportation schedules
- StatsCan
  - Provincial statistics on population and energy use
- Union Gas
  - Natural gas purchasing data by postal code
- USEPA
  - Webfire Database – temporal profiles and emission factors by SCC codes

Tier IV Biogenic Isoprene Emissions



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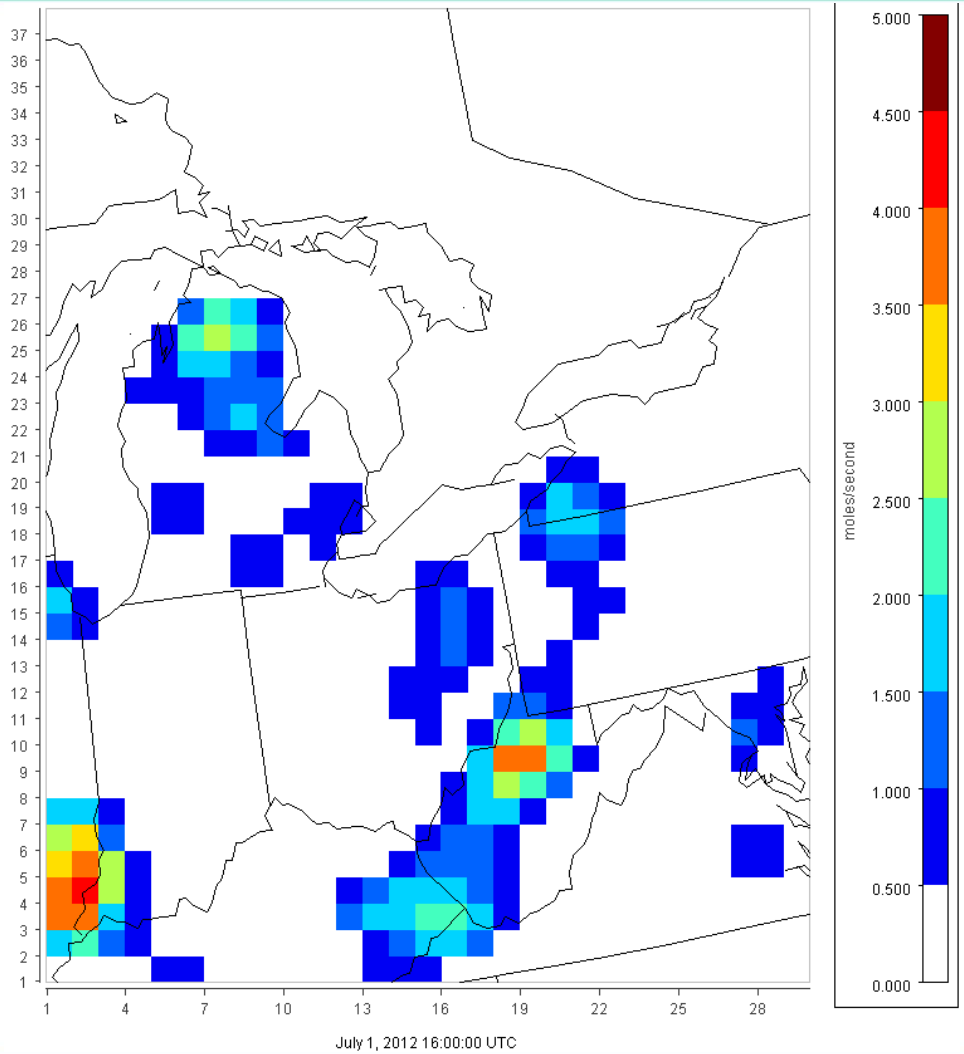
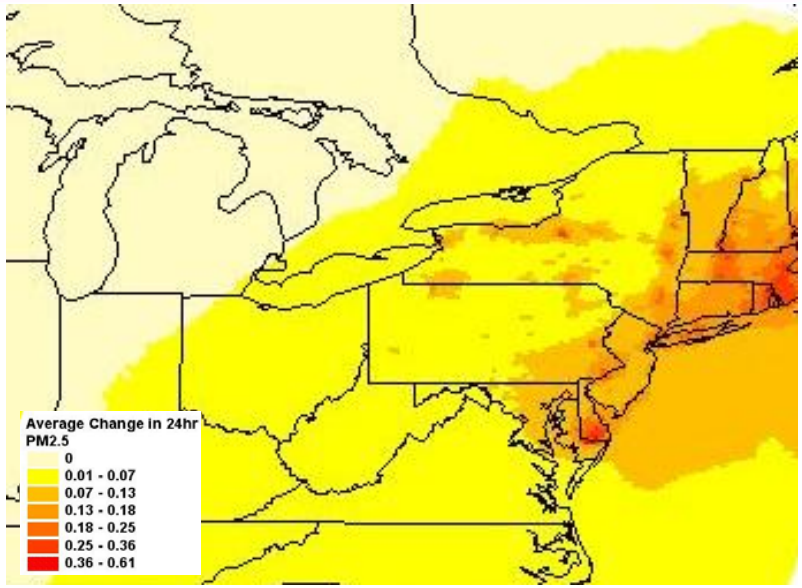
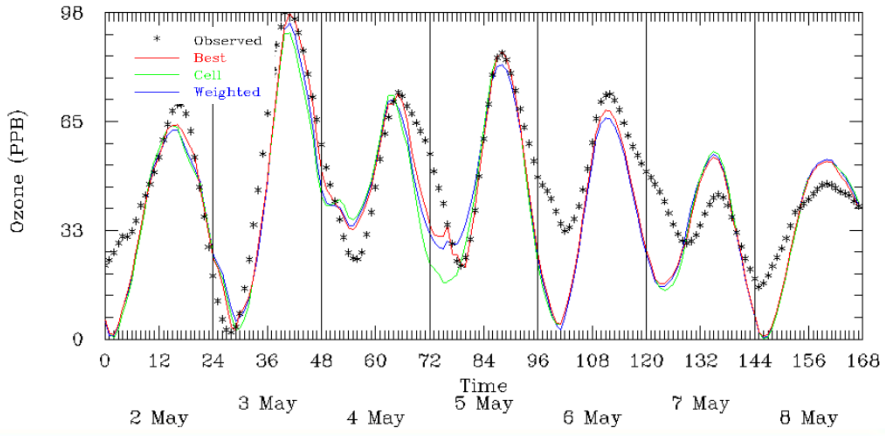
Tier I US Industrial Paraffin (PAR) Emissions



Air Quality Modelling

- Model compounds of concern (e.g., $PM_{2.5}$, O_3, SO_2, NO_2, CO, VOCs, NH_3)
- Two-way nested modelling
- Sensitivity modelling
  - Source group sensitivities (commercial, residential, industrial, biogenic-agricultural, non-road, on-road)
  - With and without local emissions
- Post–processing:
  - Model performance evaluation using MOE and local ambient air monitoring
  - Analyze 24-hr & annual data
  - Focus on trends as well as absolute values
  - Provide breakdown on contribution of various source groups to concentrations





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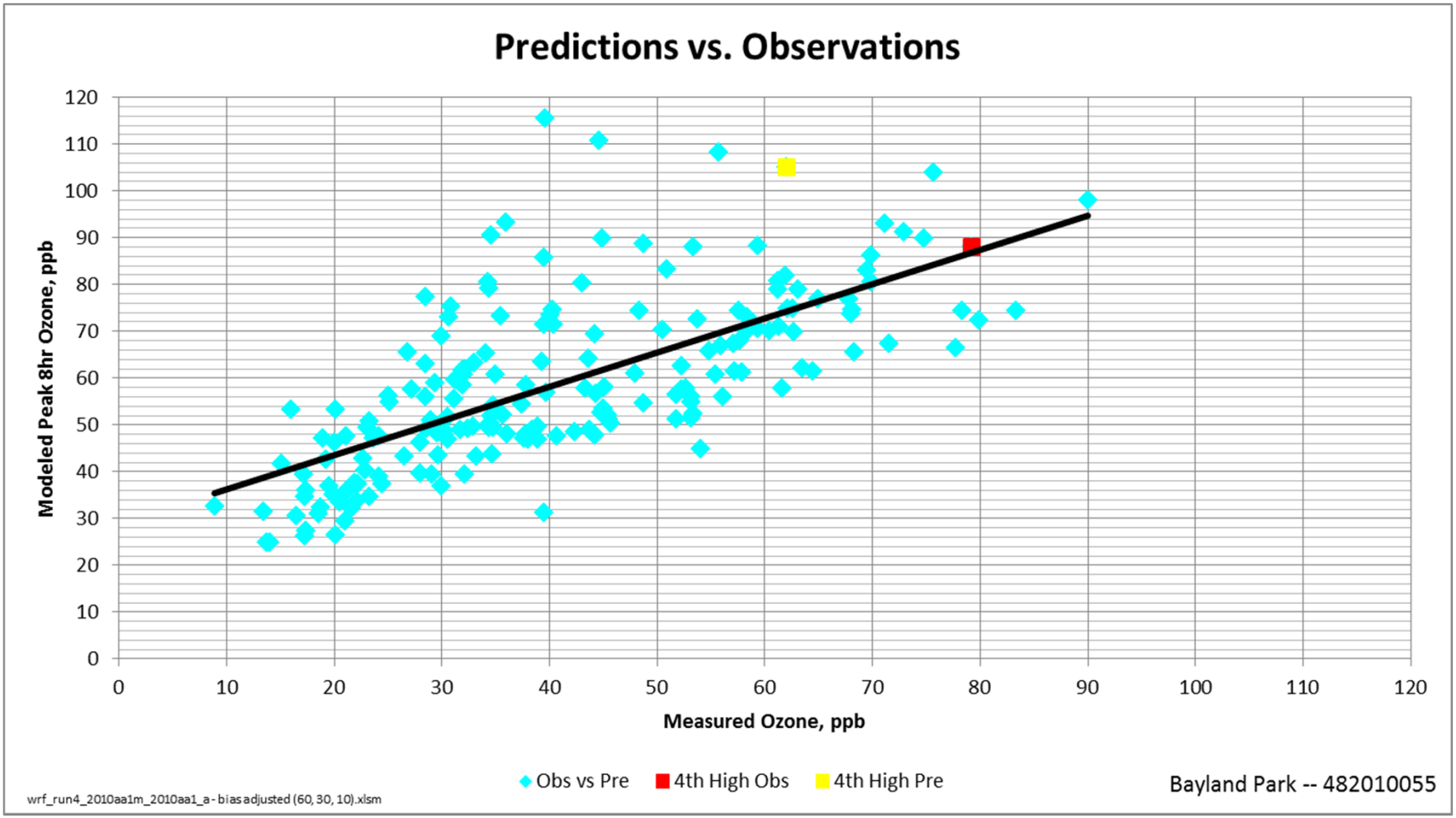
Example Results – Ozone



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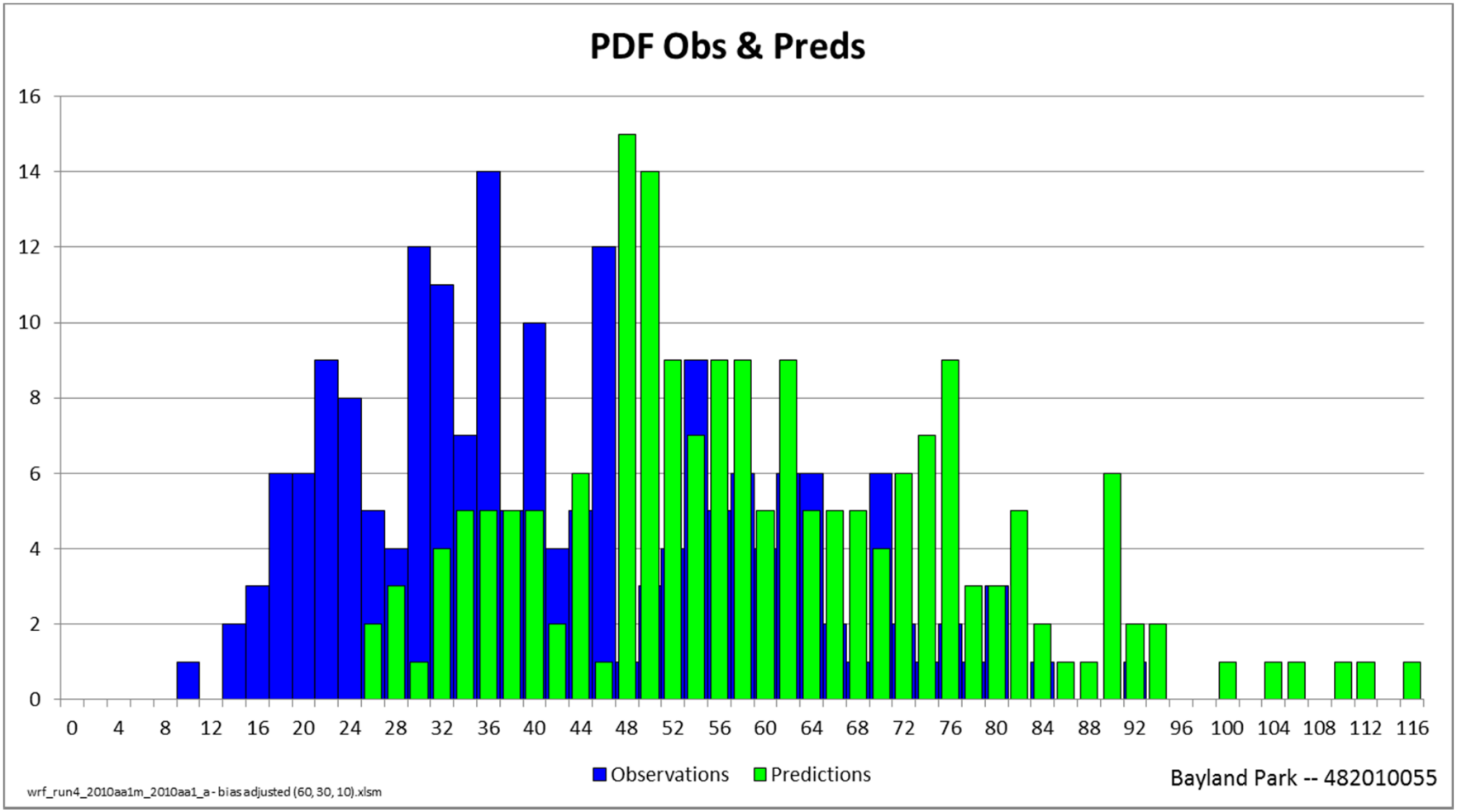

Questions?

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