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City of Toronto Airshed Modelling

Ontario Section Annual Conference
6 October 2010

Golder Associates

Outline

- Background
- Purpose of Study
- Accomplishments
  - List of PAC's
  - Emissions
  - Meteorology
  - Neighborhood assessments
- Results to-date

Background

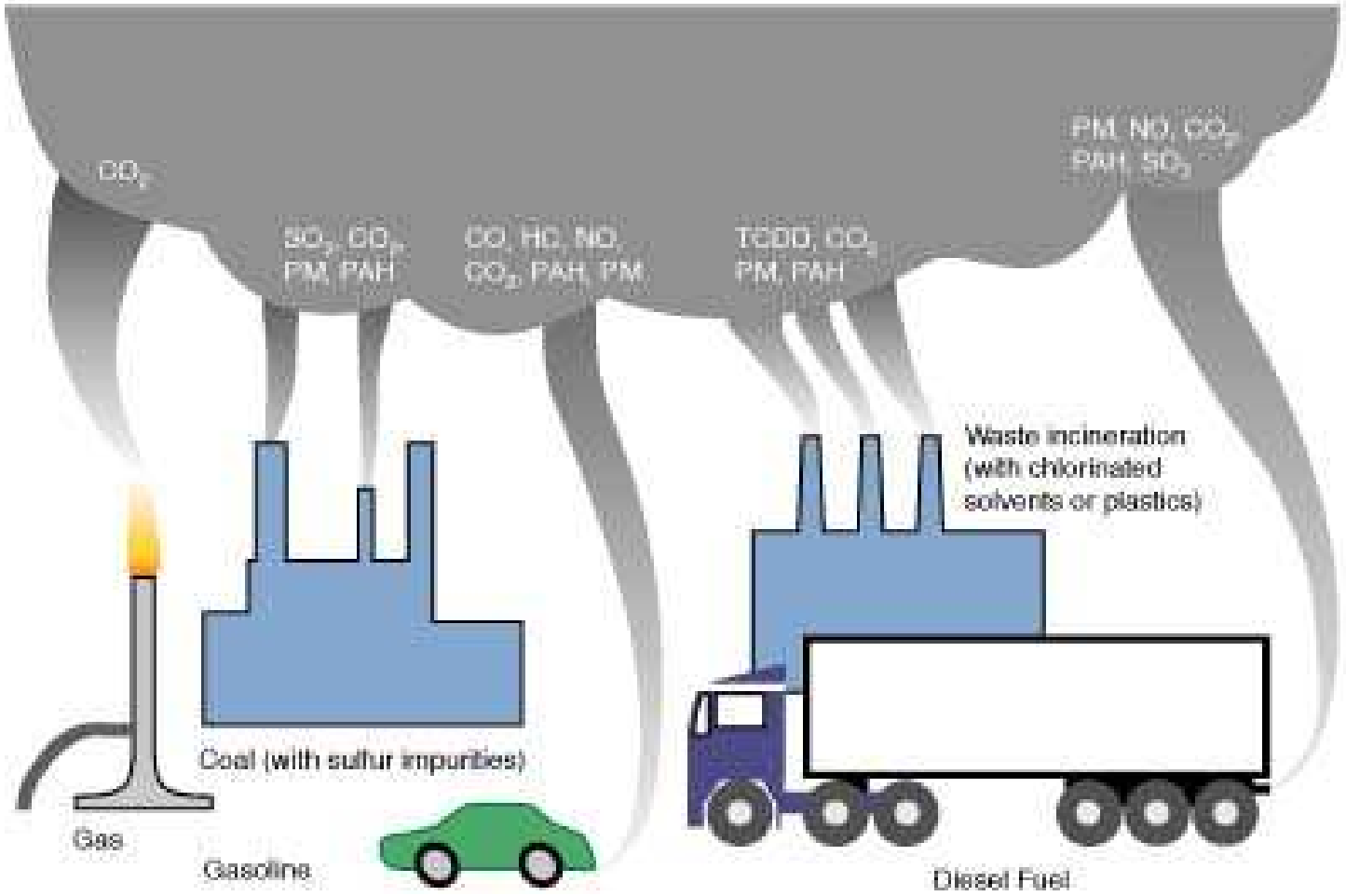
- Toronto is Canada's largest city
  - Population of about 2.6 million people
  - 44 wards
  - 140 Neighbourhoods
- Maximum north-south distance of 21 kilometres & a maximum east-west distance of 43 km.
- MOH identified air quality as a growing concern that community residents are exposed to
- Recommended that a " study of cumulative air quality impacts … be completed"

Integrated Air Quality

- Air quality is made up of many different substances, from many different locations and source types.
  - Many small local sources
  - Large sources far, far away.

- We do not know which are the dominate sources or how they impact the airshed!

Contributions to an Airshed



Study Objective

- What are the origin of the emissions that contribute to Toronto's air quality?
- What is the cumulative concentration of local and transboundary sources?
- What is he health impact of these emissions?

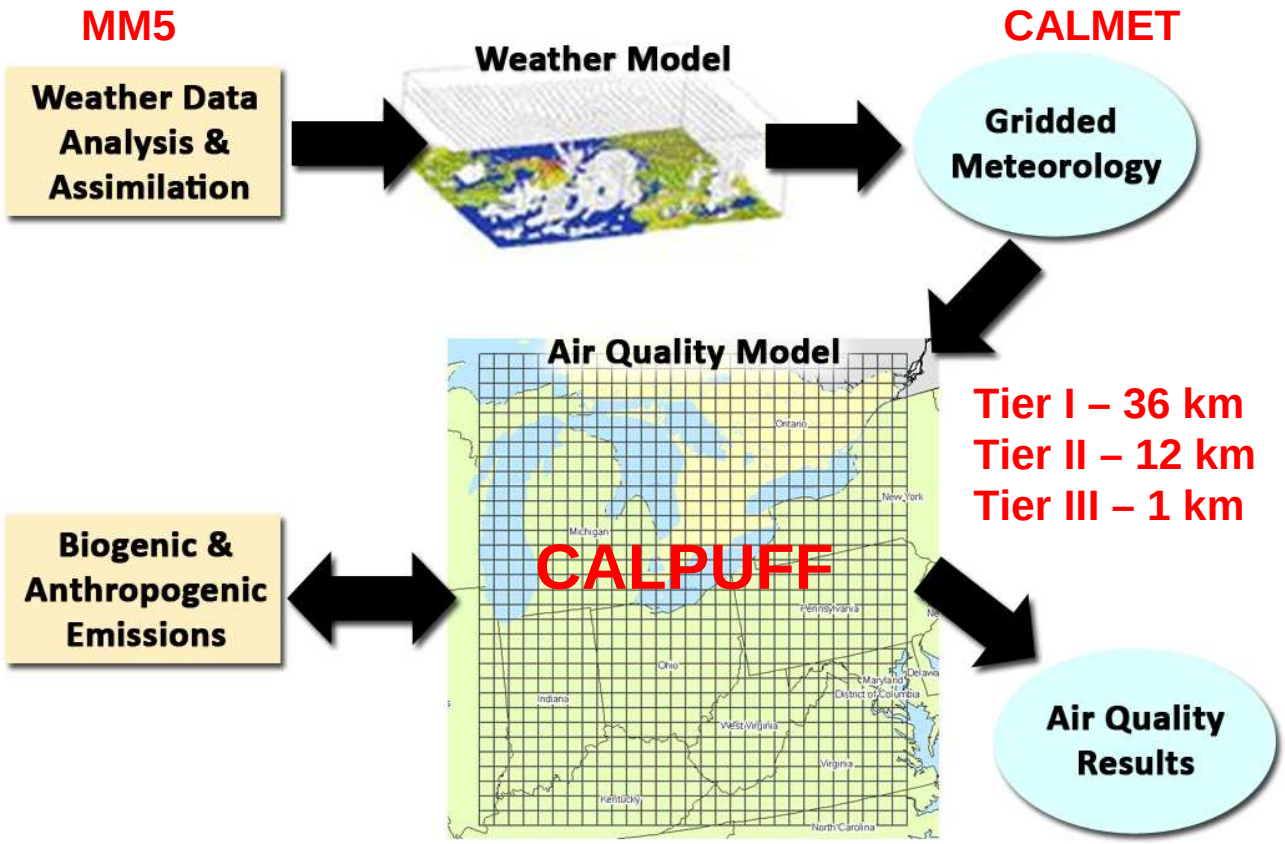
Decisions

- Selection of contaminants of known or suspected concern that influence the airshed.
- Selection of an appropriate air quality modelling system
- Determination of the size and extent of the surrounding domain which contributes to the airshed of interest.

List of Priority Air Contaminants

1. Acetaldehyde
2. Acrolein
3. Benzene
4. 1,3-Butadiene
5. Cadmium
6. Carbon tetrachloride
7. Chloroform
8. Chloromethane
9. Chromium
10. 1,4-Dichlorobenzene
11. 1,2-Dichloroethane
12. Dichloromethane
13. Ethylene dibromide
14. Formaldehyde
15. Lead
16. Manganese
17. Mercury
18. Nickel compounds
19. Nitrogen Oxides
20. PAHs (as B[a]Ps)
21. $PM_{2.5}$
22. Tetrachloroethylene
23. Toluene
24. Trichloroethylene
25. Vinyl Chloride
26. Carbon Monoxide (CO)
27. PM_{10}
28. Sulfur Dioxide
29. VOC (anthropogenic/Biogenic)
30. Ozone

Toronto Airshed Modelling System



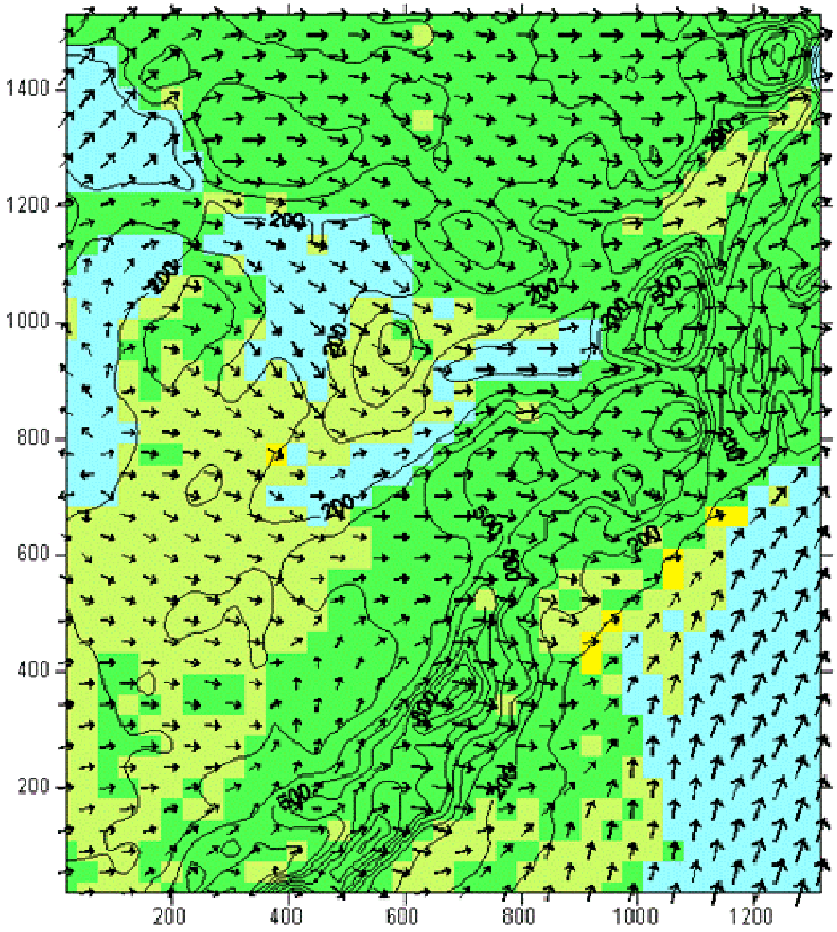
Approach

- Three Tiered System
  - Tier 1 – 36 km Grid - United States Emissions
  - Tier 2 – 12 km Grid - Ontario Emissions
  - Tier 3 – 1 km Grid - City of Toronto Emissions Only
- Evaluate the impact of each grouping on a community of interest independently
- Effectively determining the cumulative contribution of all sources on a community

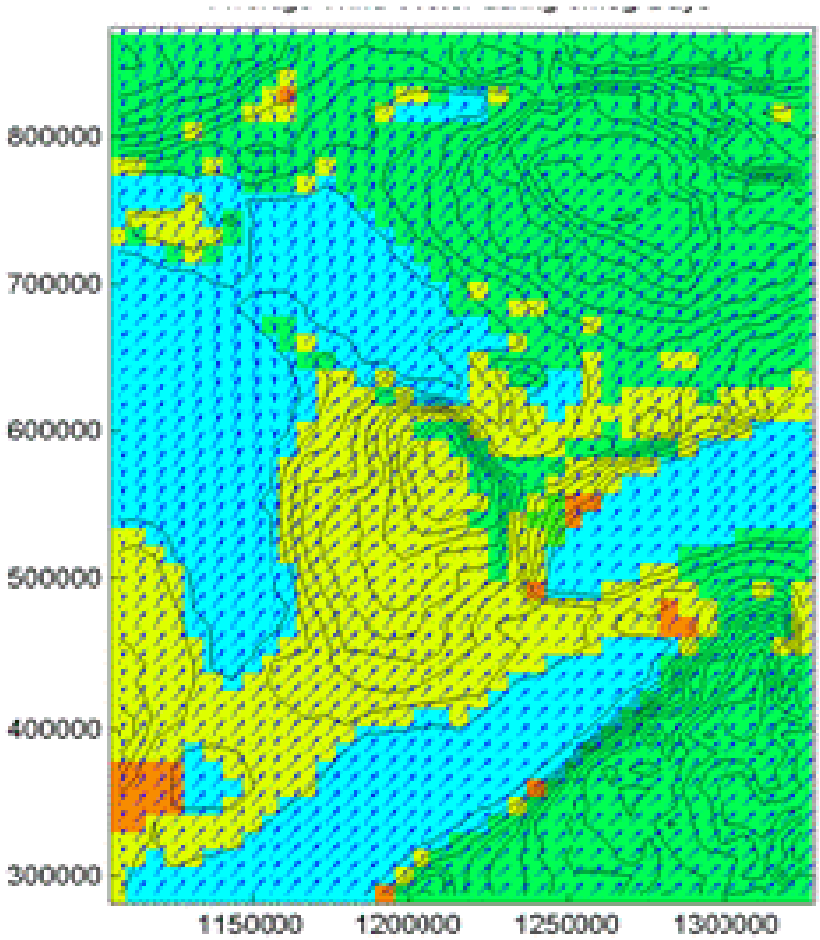
Gridded Meteorological Data

- The Toronto met data was prepared using MM5 and then downscaled using CALMET
- MM5 was execute on three nested domain
  - 108 km ,36 km and 12 km
- Runs for nest number 2 and 3 uses warm starts
  - i.e., both nest starts 24hrs after the mother domain
  - FDDA/analysis nudging was used only for mother domain
- **TIER I - CALMET for 36 km Resolution**
  - Initialized using 36km MM5 data
- **TIER II/III – CALMET for 12 km/1 km Resolution**
  - Initialized using 12km MM5 data

Wind Vectors – Summer vs SMOG



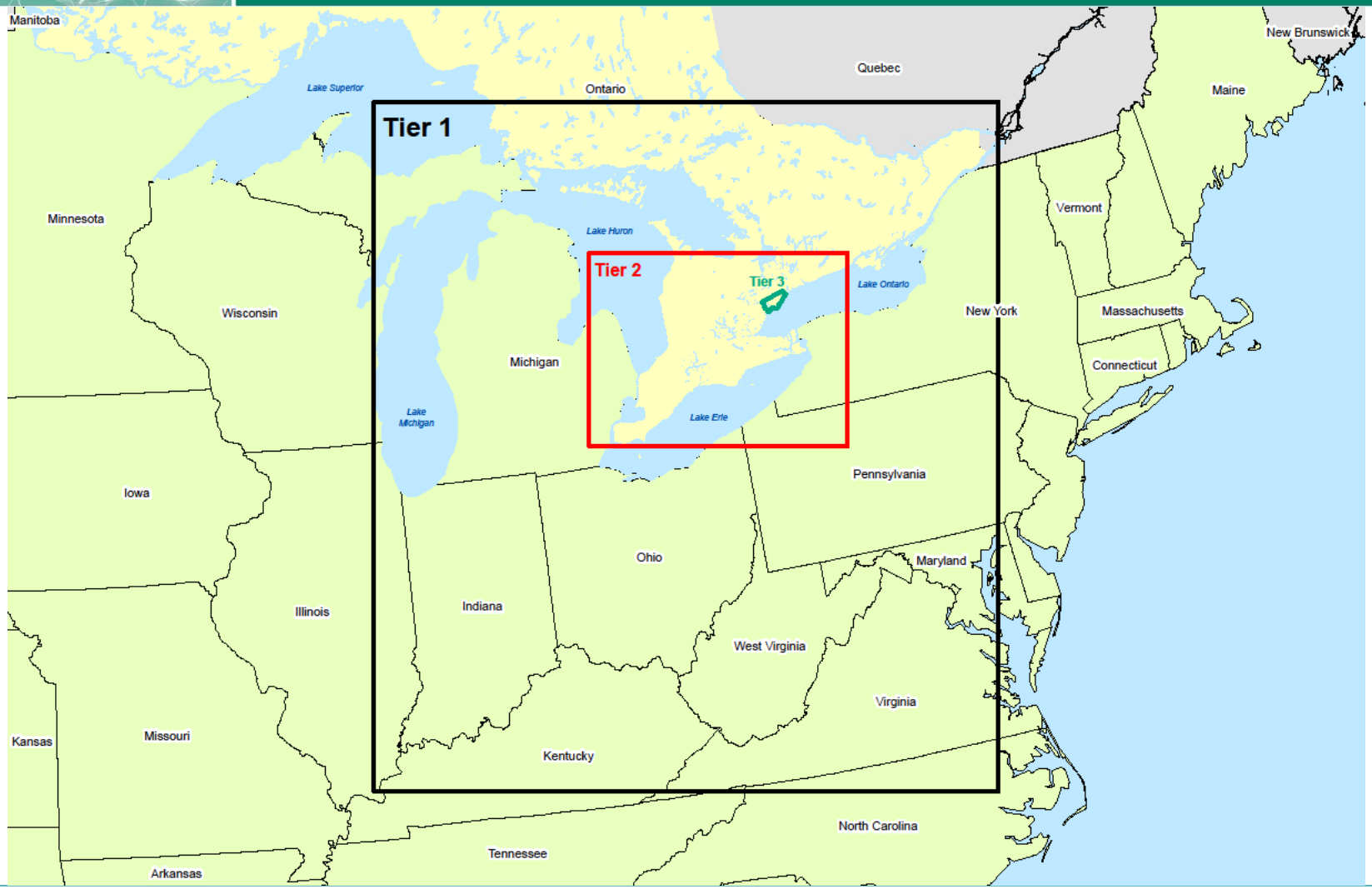
June - August 2006 - Average Value



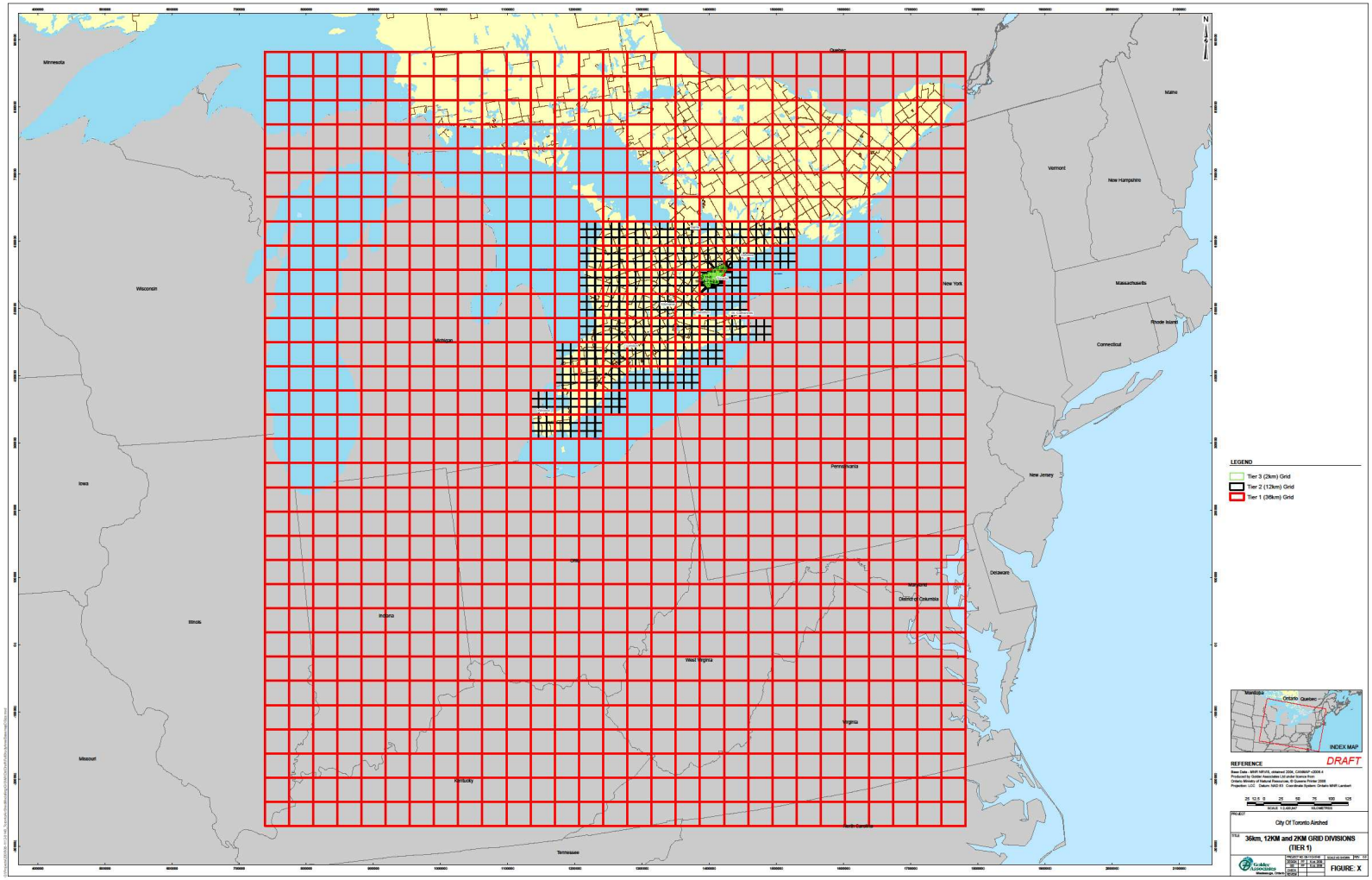
Emission Data

- **TIER I –**
  - SMOKE provided the temporal and spatial emission
  - Used 2002 QA/QC Emission Inventory
  - Processed with AirTool to generate CALPUFF ready hourly files
    - Industrial
    - Commercial and Residential
    - Mobile
    - Nonroad
- **TIER II/III –**
  - AirTool emission processor to create CALPUFF ready files
    - Based on 2006 emission/activity data
    - Industrial Points (NPRI)
    - Commercial and Residential (commercial and residential natural gas usage, autobody shops, dry cleaners, commercial solvents, other residential heating sources)
    - Mobile (on-road vehicles)
    - Non-road (airport, marine, rail, lawn mowers, agricultural vehicles)
    - Biogenic and Agricultural

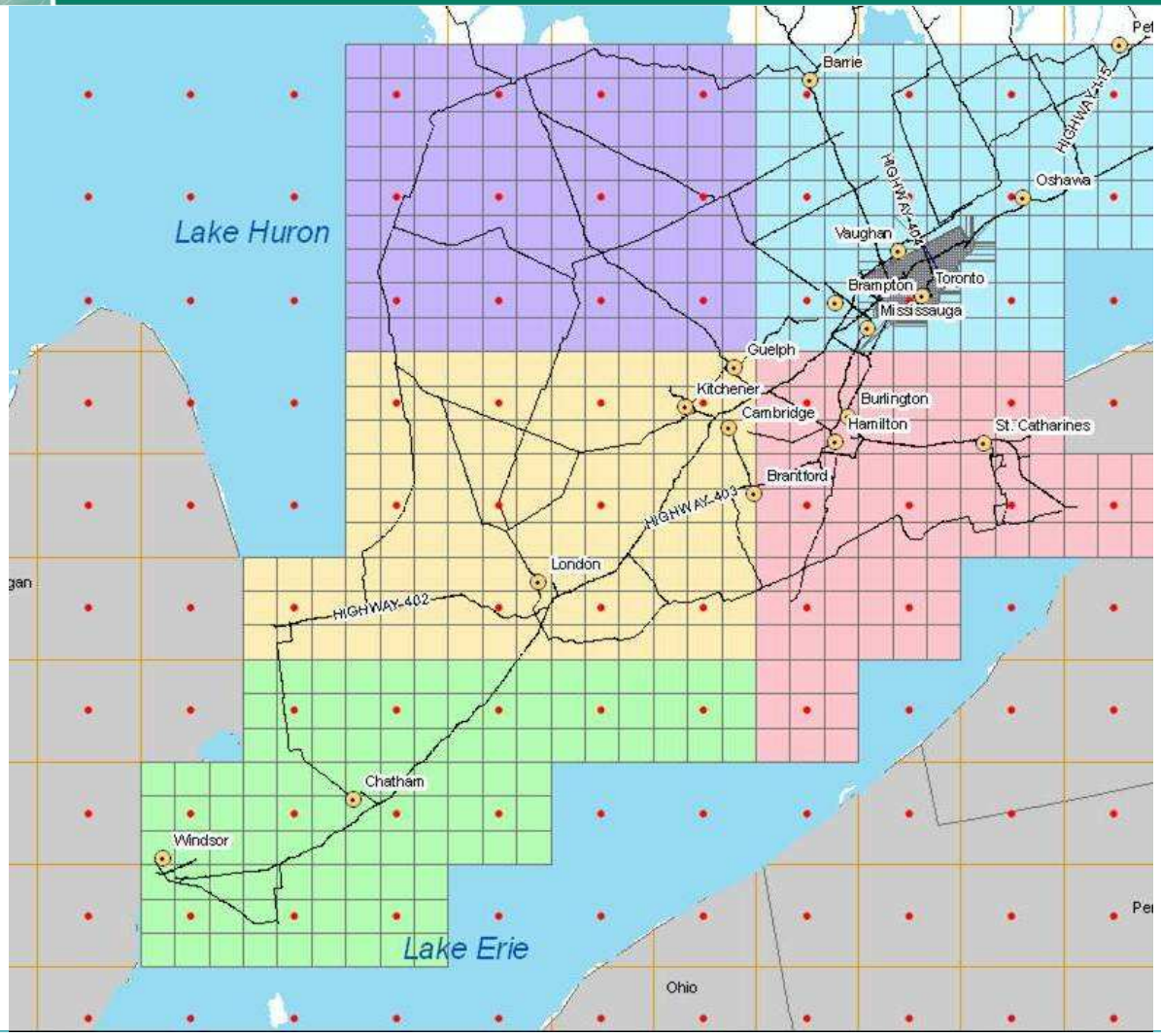
Three Tier Domains



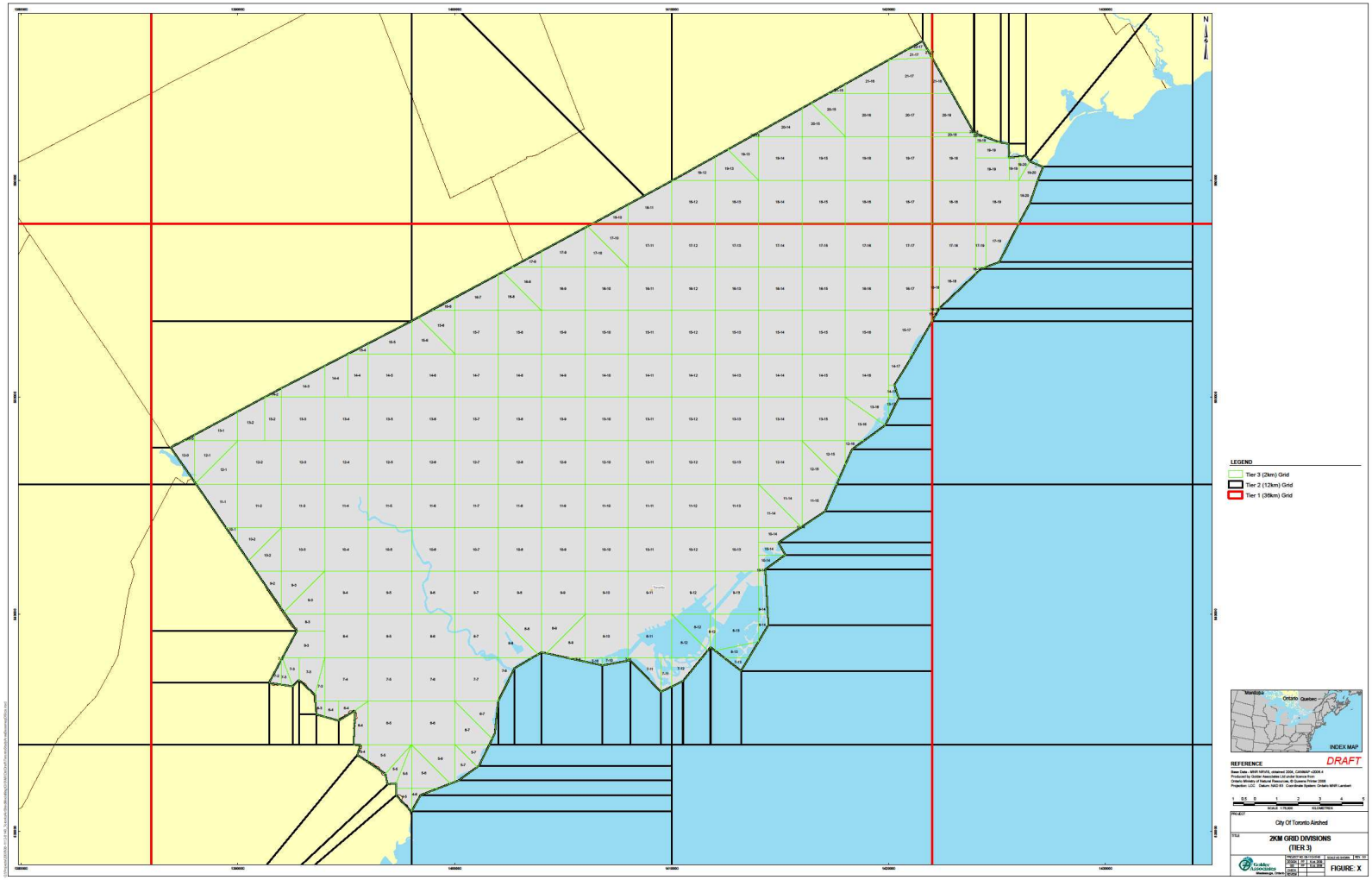
Tier 1 – US Domain



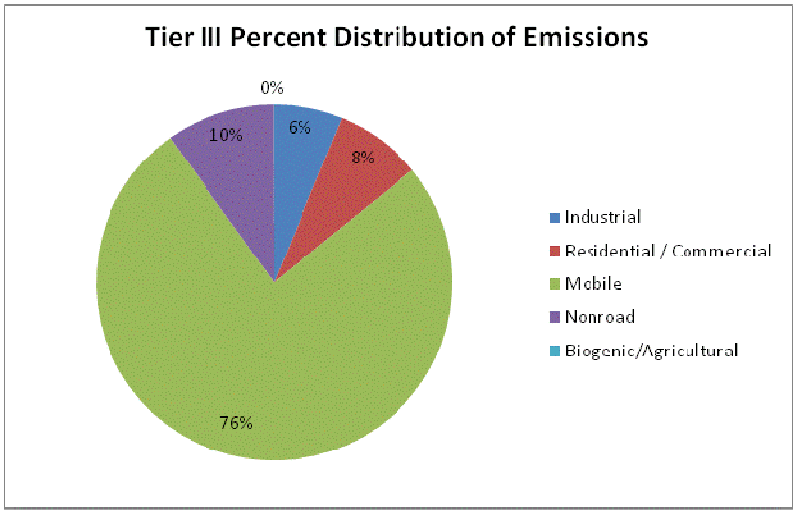
Tier II – Ontario Domain

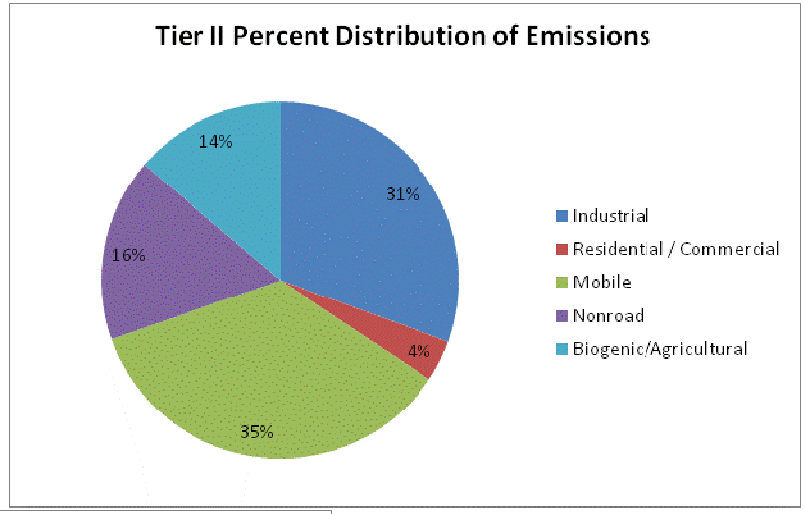


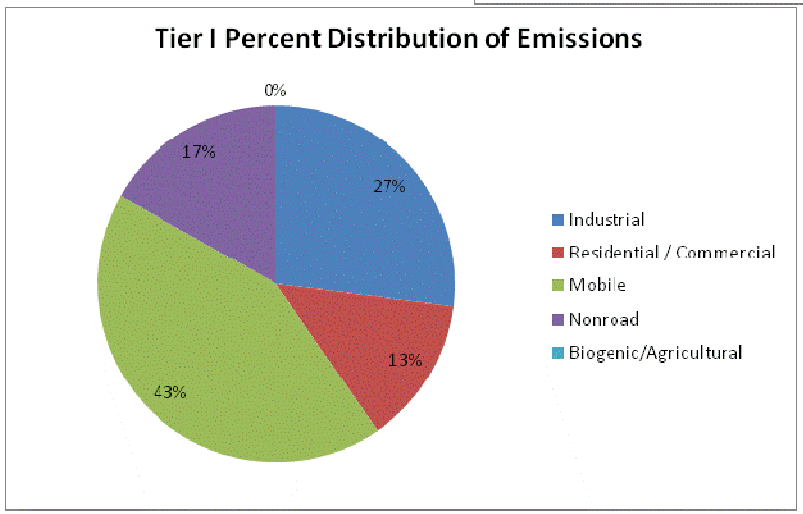
Tier III – Toronto Domain

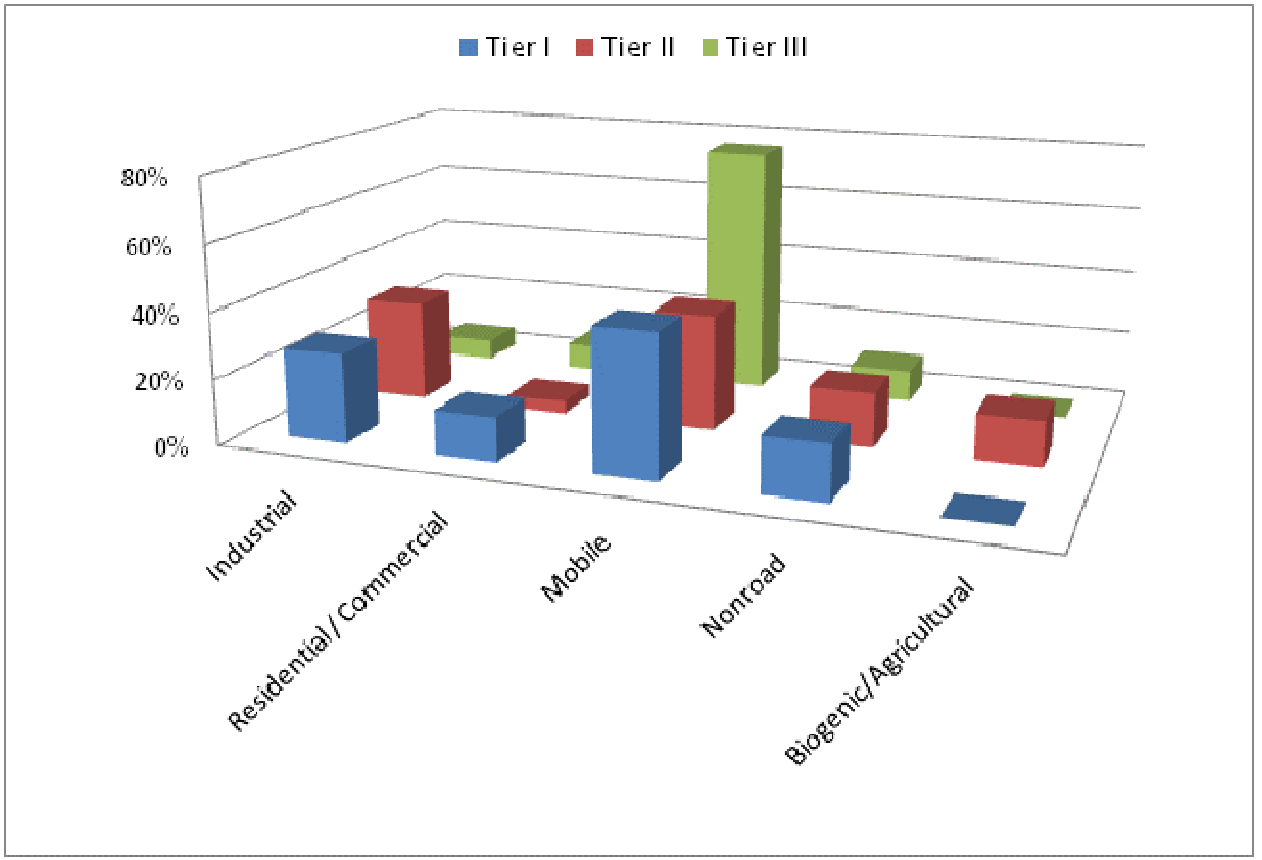


Distribution of Emission Sources



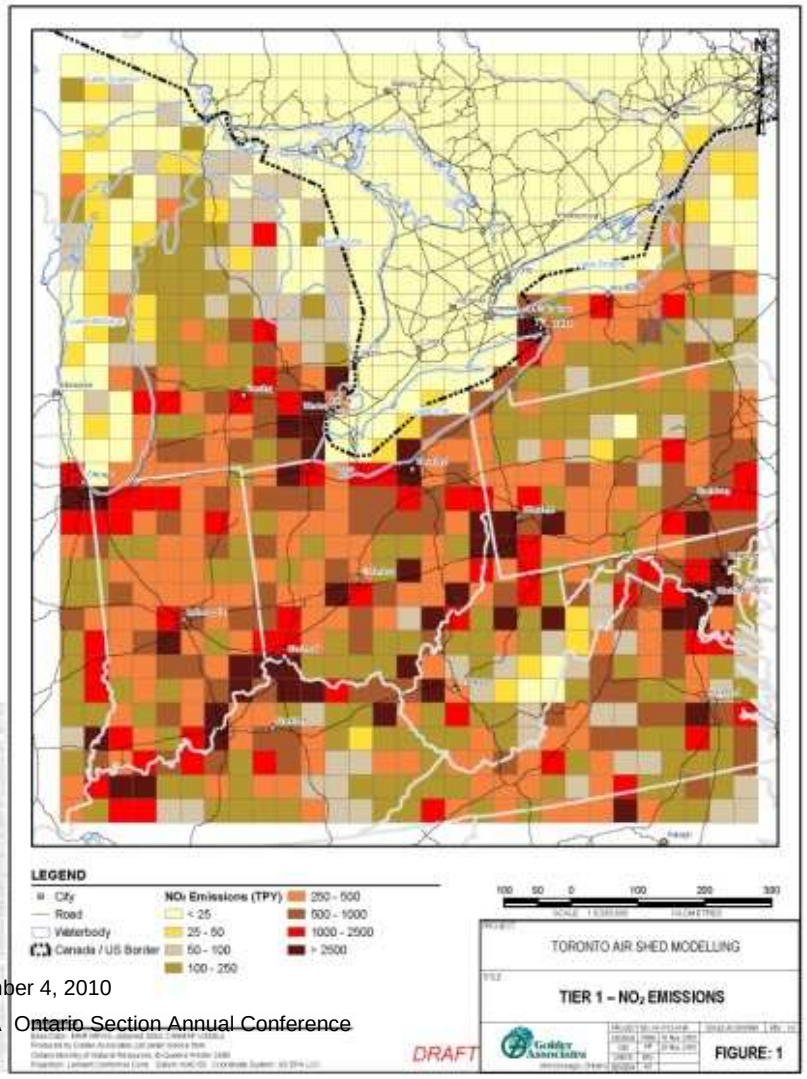




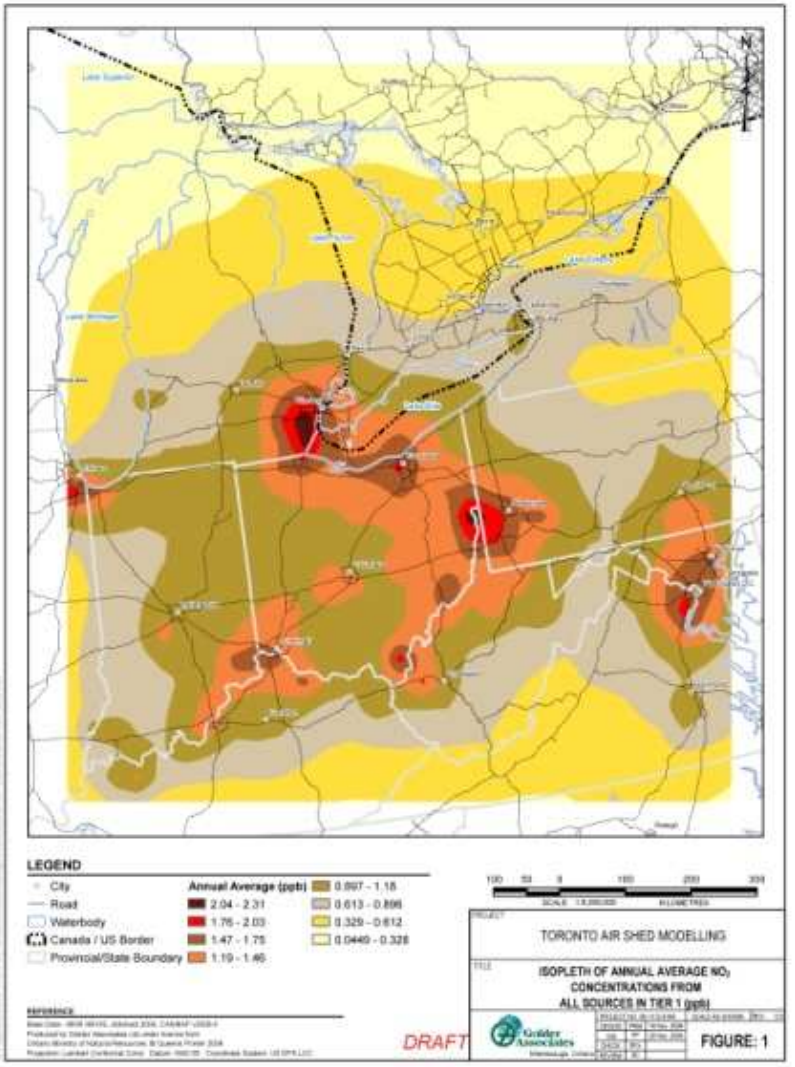

Tier I
Tier II
Tier III
80%
60%
40%
20%
0%
Industrial
Residential/Commercial
Mobile
Nonroad
Biogenic/Agricultural

NOx/NO_2 – TIER I

Annual Emissions (T/a)

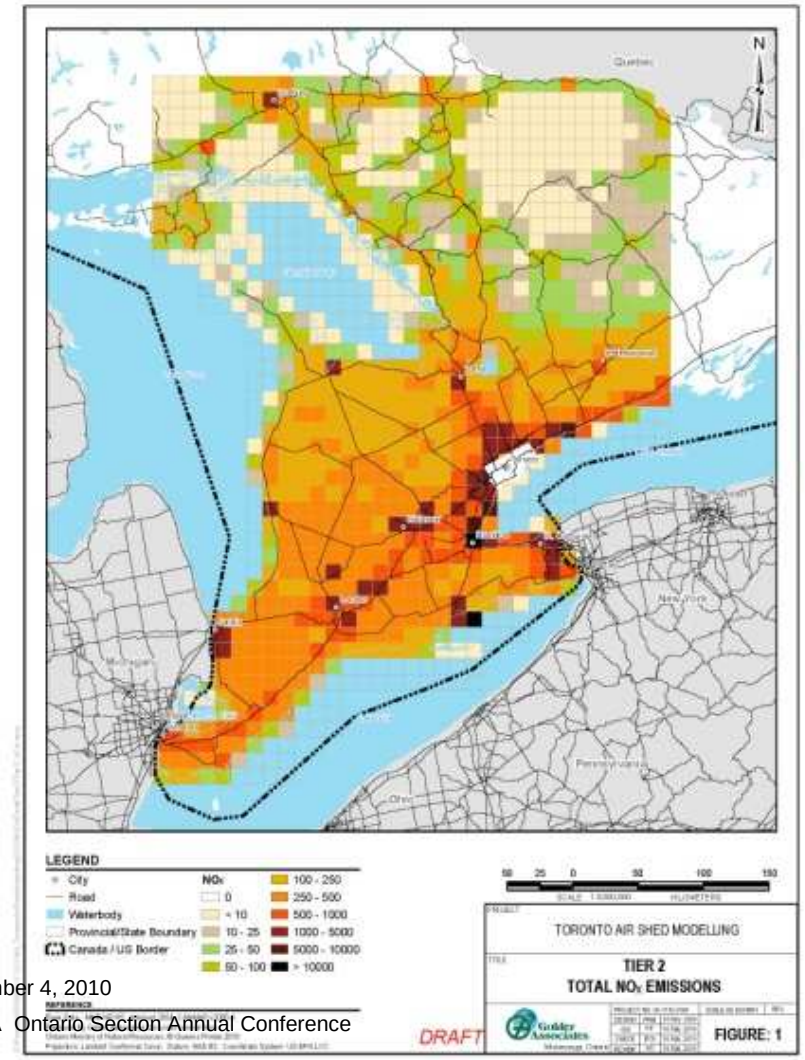


Annual Concentrations (ppb)

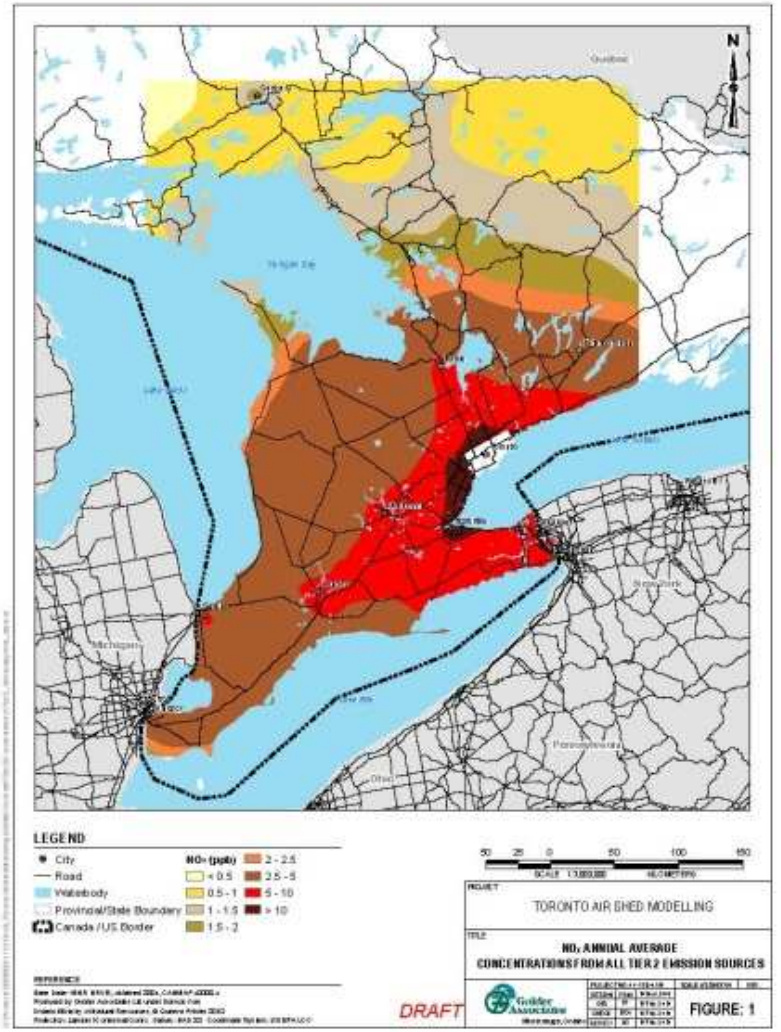


NOx/NO_2 – TIER II

Annual Emissions (T/a)

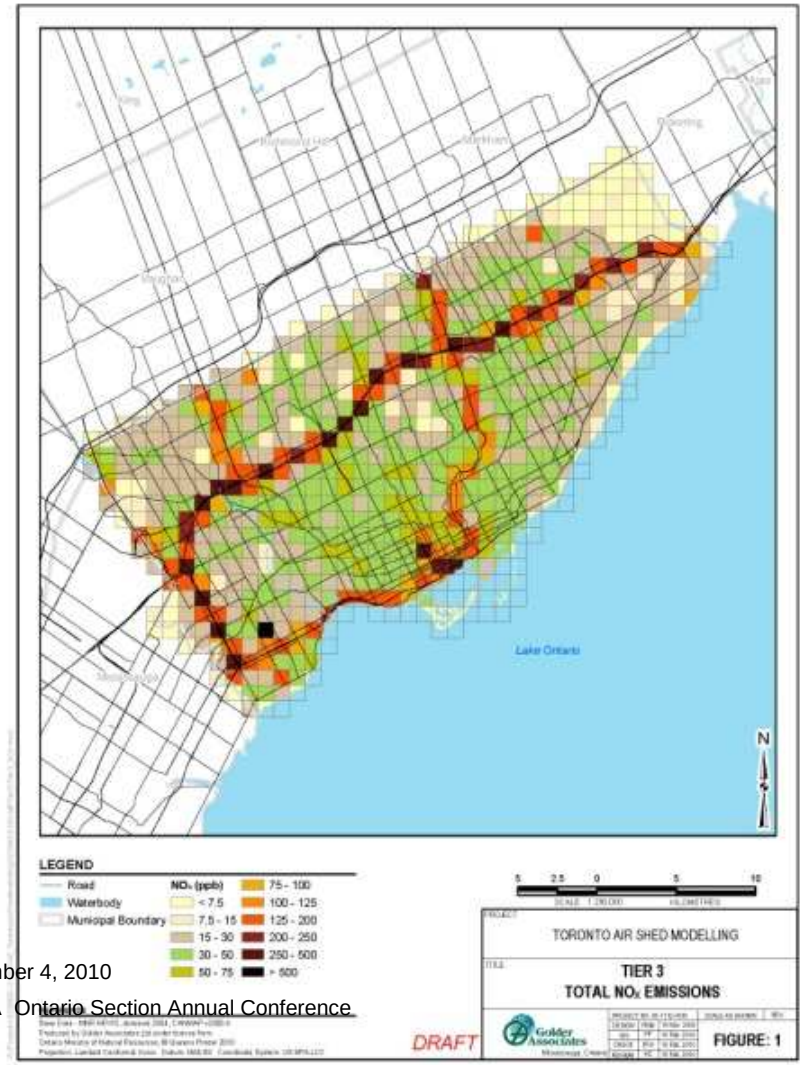


Annual Concentrations (ppb)

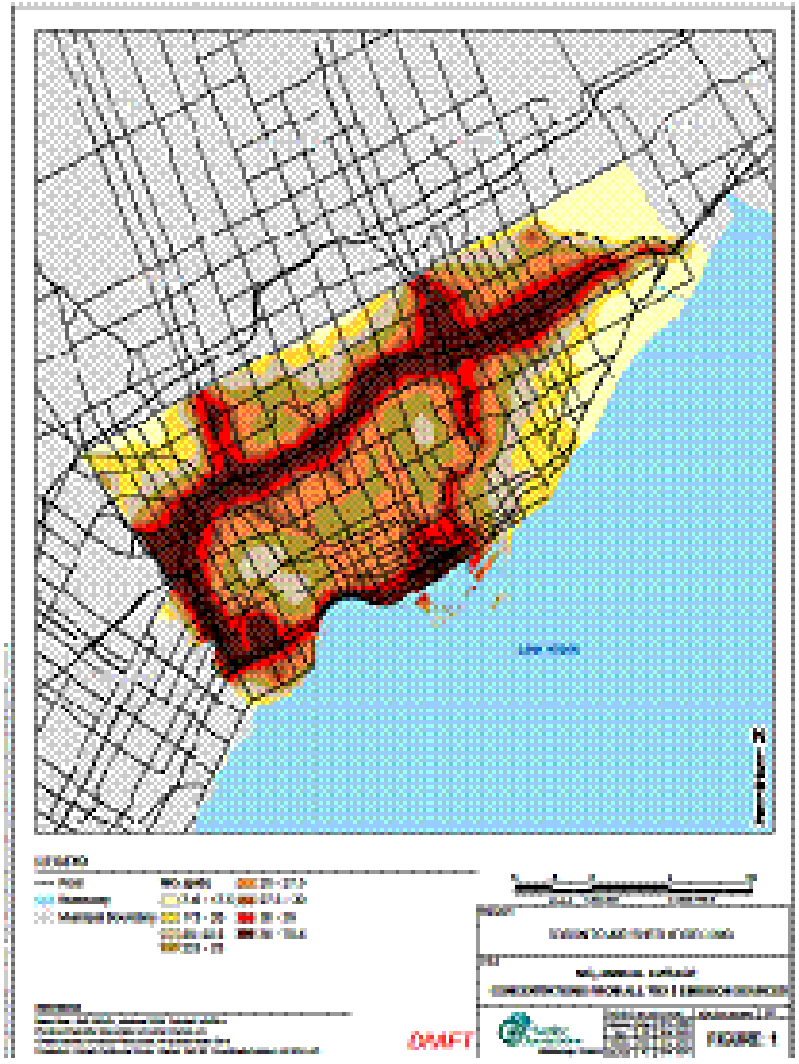


NOx/NO2 – TIER III

Annual Emissions (T/a)



Annual Concentrations (ppb)



How Good Are The Results?

		Modelled				Monitored	
		Tier III	Tier II	Tier I	Cumulative	MOE Monitor	NAPS Monitor (3)
Sampling Cell or Location	**Units**	**20_22**	**19_22**	**22_18**		**Toronto Downtown (31103) Bay /Wellesley**	**Toronto Downtown (060427) 223 College St**
Nitrogen Oxides	ppb	34.0	9.5	8.6	52.1	26.1	—
Carbon Monoxide	ppb	178.5	42.9	45.7	267.1	325.5	—
Sulphur Dioxide	ppb	0.5	1.3	4.8	6.6	1.9	—
$PM_{2.5}$	$\mu g/m^3$	4.0	1.4	2.0	7.4	7.3	10 ± 8
PM_{10}	$\mu g/m^3$	11.6	3.4	4.6	19.6	—	15 ± 11
1,3-Butadiene	ppb	0.029	0.010	0.007	0.046	—	0.04 ± 0.04
Benzene	ppb	0.17	0.05	0.06	0.28	—	0.30 ± 0.15
Toluene	ppb	1.12	0.20	0.27	1.59	—	1.12 ± 0.91
Lead	$\mu g/m^3$	0.000	0.001	0.001	0.002	—	0.002 ± 0.002
Dichloromethane	ppb	0.045	0.009	0.008	0.062	—	0.19 ± 0.11
Tetrachloroethylene	ppb	0.039	0.009	0.004	0.051	—	0.042 ± 0.028

Next Steps

- Toronto Health evaluating the health impact
- Cumulative dosage of combining the air contaminants based on carcinogenic and non-carcinogenic
- Analyzing source contribution of vehicle, industrial, commercial

Summary & Conclusions

- Daily and Annual integrated concentrations for 29 species have been realized
- Emissions distribution in domain
  - US Domain –90%
  - Ontario –9%
  - Toronto –1%
- Concentration contribution to Toronto
  - US - 38%
  - Ontario -24%
  - Toronto -38%
  - but highly dependent on species
- Cumulative evaluation for multiple contaminants demonstrates there is no silver bullet …
- Local sources tend to dominant most important species

Acknowledgements

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  - Biljana Cosic, Swandoyo Hartono, Inna, Yankova and Paul Pengelly
- City of Toronto Environment Office
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  - Stephanie Gower

THANK YOU!