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Canada

Atmospheric Mercury Monitoring in Canada

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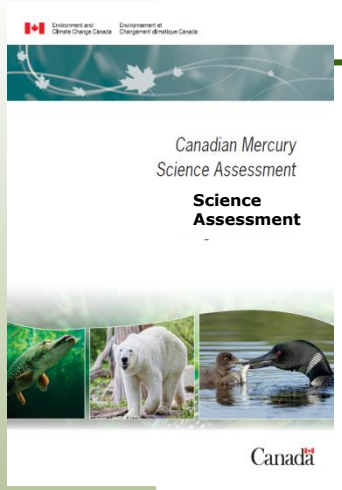
Mercury is an important issue in Canada

- Certain Canadian populations are at higher risk of exposure
- MeHg levels can be high enough (>0.3 μg g^{-1}) to pose a risk to the reproductive health of fish and fish-eating wildlife
- ~ 90% of annual provincial/ territorial fish consumption advisories are from high Hg levels
- Hg levels exceed the Canadian limit for commercial sale of fish at many sites across Canada
- 95% of anthropogenic Hg deposited in Canada comes from external source regions
- Canada is a net recipient of mercury

Canadian Mercury Science Assessment



Synthesis of mercury research results collected within Canada

- Understand the status of mercury in the Canadian environment and the impact on ecosystems and the Canadian population

- Quantify current and past levels of Hg in the environment
- Determine knowledge gaps of transport routes from points of emission to exposure to ecosystems
- Identify key indicators of stress and exposure
- Develop the capacity to predict changes in indicators

- **Develop a baseline status for mercury levels in Canada**

Highlights of scientific findings

- ✓ Mercury remains a risk to Canadian ecosystems and human health
- ✓ In humans, the average exposure of Canadians to mercury is low
- ✓ Levels of Hg in the air in Canada are mostly decreasing
- ✓ Trends in the levels of Hg in biota vary
- ✓ Significant global-scale reductions in mercury emissions are predicted to be required to reduce mercury levels in fish below those currently observed across Canada.

Policy questions

? In light of our current understanding of mercury in the Canadian environment, where, and to what extent, do we need to continue atmospheric and effects monitoring?

? Where, and on what, should we focus future research efforts for mercury

Policy Answers

- ✓ Atmospheric deposition is the main pathway for the introduction of mercury to watersheds, and thus air levels need to be understood to follow the pathways through the environmental compartments
- ✓ Wet deposition of mercury is a good indicator of changes in the mercury load from the atmosphere to the environment
- ✓ More monitoring and research is required to entirely understand atmospheric transformation and deposition of mercury
- ✓ Atmospheric monitoring is undertaken to address several different goals including: (1) to measure the input levels of mercury to ecosystems; (2) to measure ambient levels resulting from domestic and regional emission sources; and (3) to assess transboundary transport of mercury into Canada.

Air Monitoring Networks in Canada over time

Initiated cohesive monitoring in 1997

- Canadian Atmospheric Mercury Measurement Network (CAMNet)
- Canadian Air and Precipitation Monitoring Network (CAPMoN)
- Northern Contaminants Program (NCP)
- Environment Canada – Clean Air Regulatory Agenda (CARA)
- Environment and Climate Change Canada (CCAP)

  - ✓ Atmospheric total gaseous Hg (TGM) / gaseous elemental Hg (GEM)
  - ✓ Wet deposition (total and methyl Hg)
  - ✓ Atmospheric speciation
    - Gaseous elemental Hg (GEM)
    - Reactive Gaseous Hg (RGM)
    - Particulate Hg (PHg)
  - ✓ Passive sampling research to initiate monitoring

Canada

Air Monitoring in Canada over time

Air monitoring

1. **CAMNet**
(1996-2007) 9-13 sites

2. **CAPMoN**
(2007-present) 4 sites

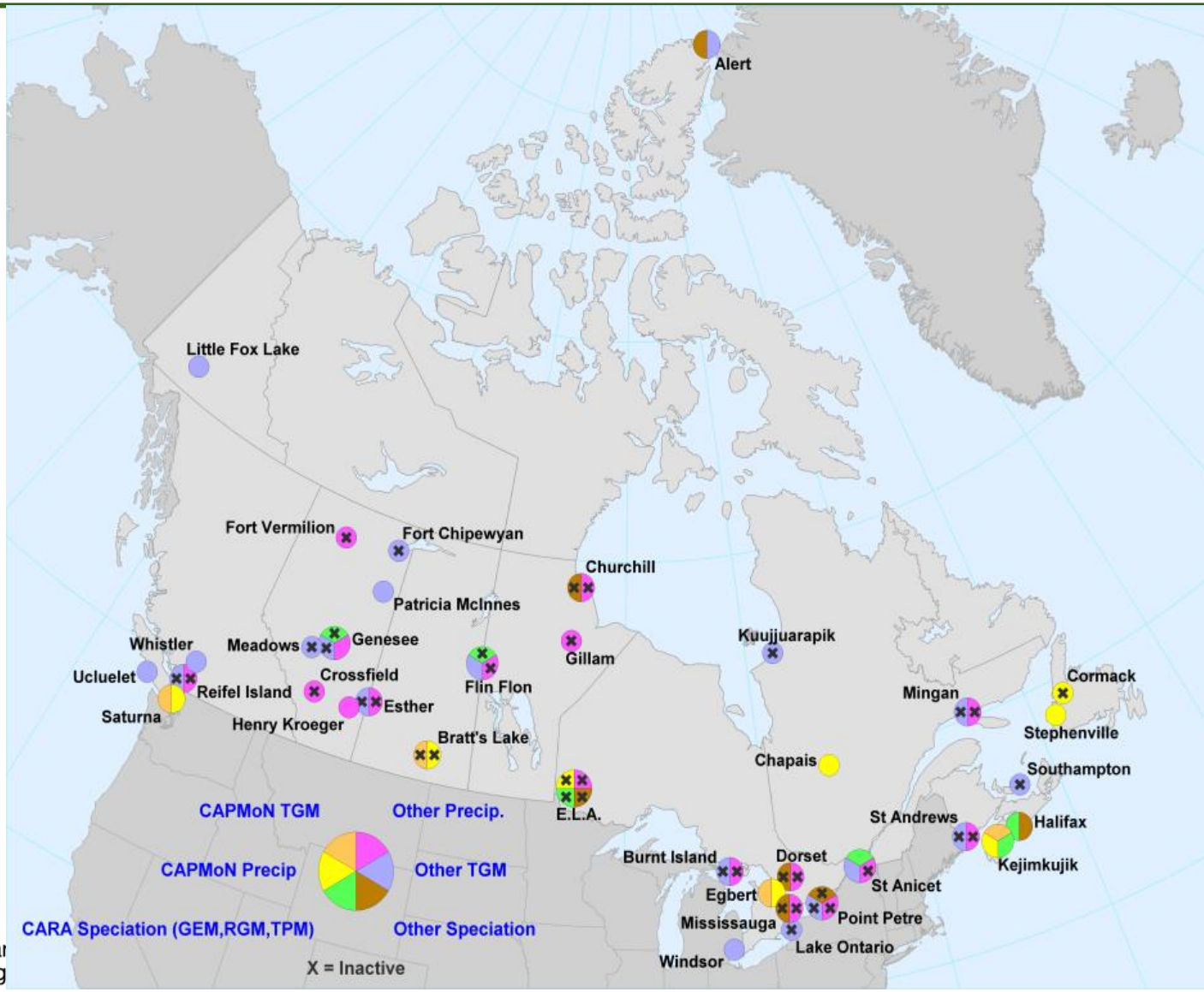
3. **Wet deposition**
(1996-now) 5-6 sites
CAMNet/CAPMoN

4. **NCP** (1995-now)

5. **CARA** (2005-2015)

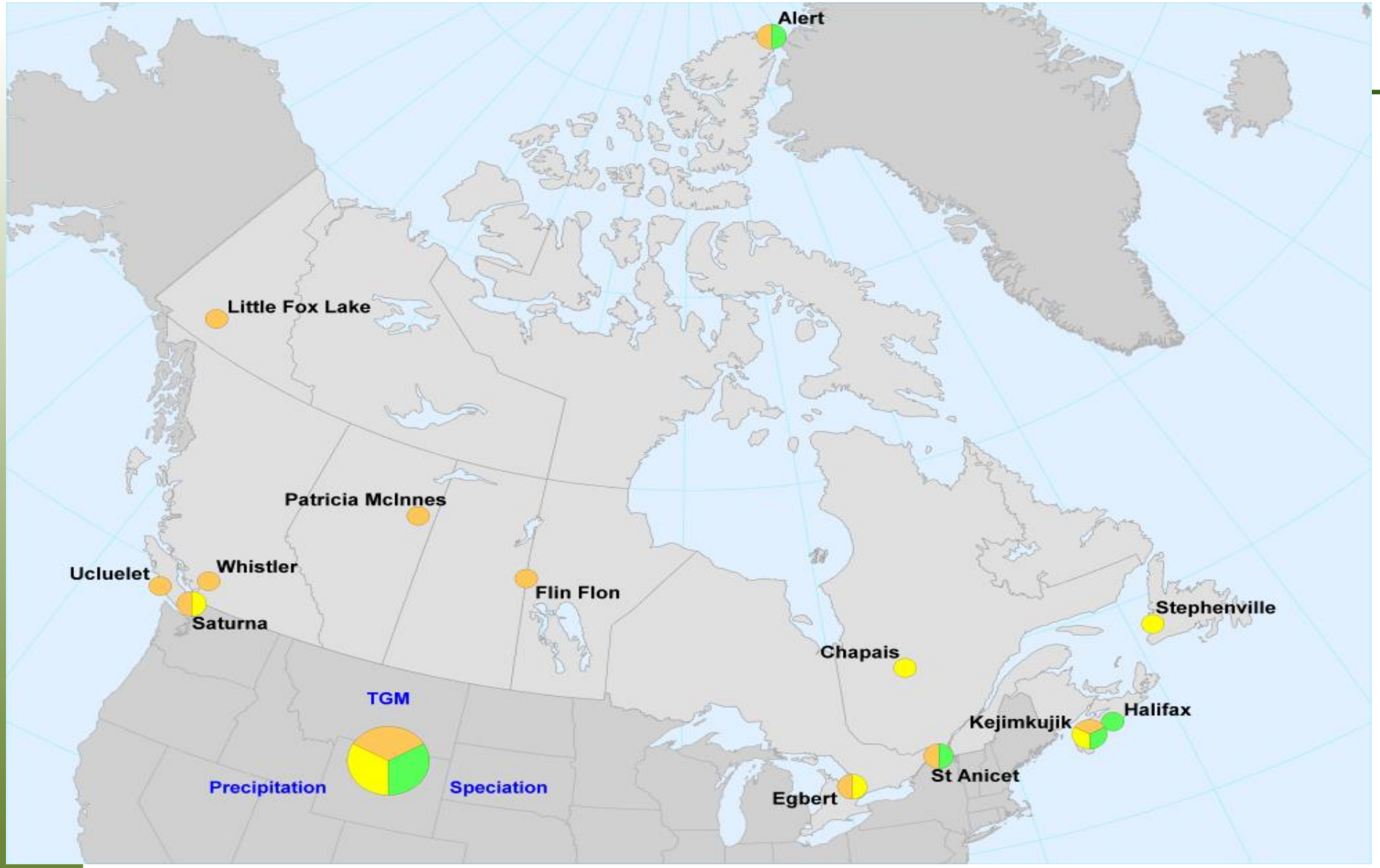
6. **IPY** (2008-2010)

7. **CCAP** (2015 - …)



Environment and Climate Change

Air Monitoring today in Canada



TGM - total gaseous Hg; Speciation – air gas and particles; Precipitation - total and methyl Hg

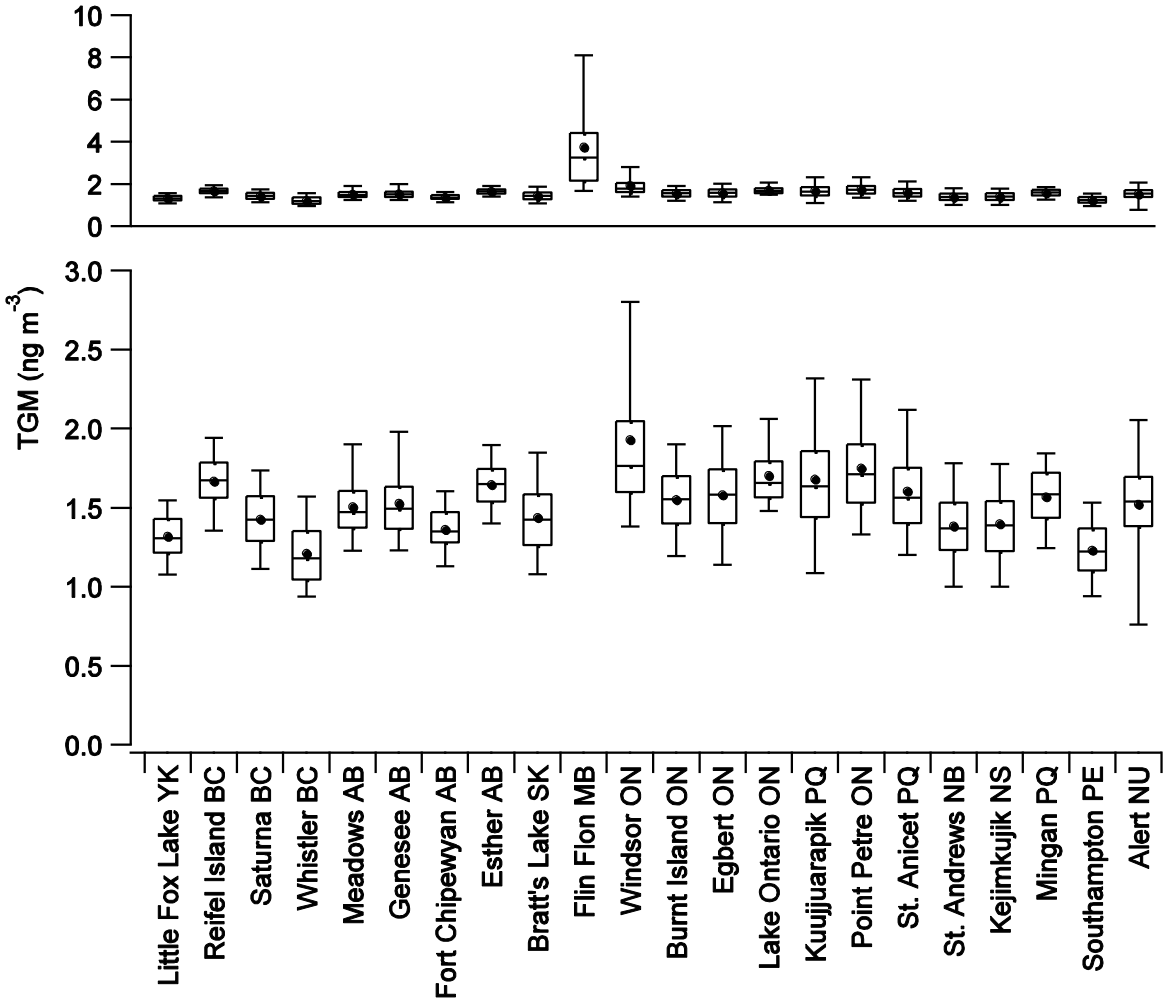
Canadian research products

- Monitoring
  - Assess spatial and temporal air concentration levels (Cole *et al*., 2014)
  - Determine trends with time (Cole *et al*., 2014)
  - Provide data for modeling
- Processes
  - Select specific environments of concern
  - Investigate transport, transformation and deposition
  - Provide information to research community (esp. modelers)
- Modelling
  - Assess concentration levels across all of Canada
  - Produce deposition maps across all of Canada
  - Assess source regions of Hg coming into Canada

TGM concentration in Canada (over all years)

- Total gaseous mercury
- 23 sites
- Different time periods
- Inset Flin Flon*

*metals smelter

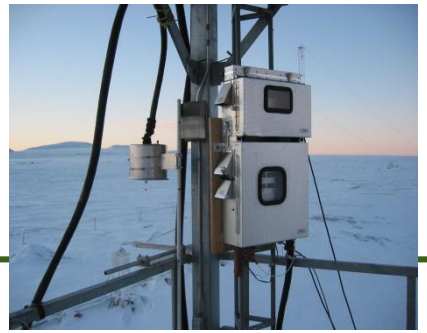


Temporal trends for TGM

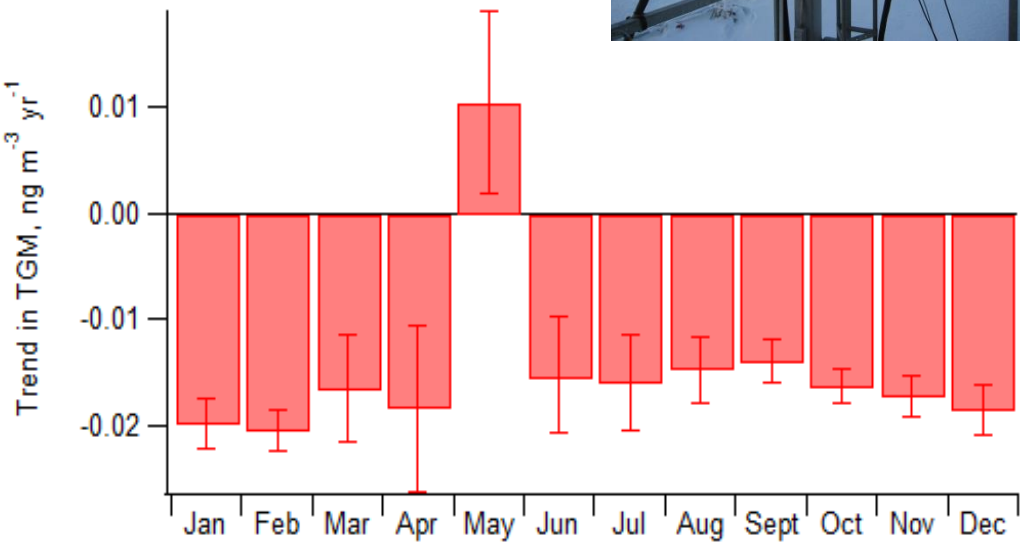
Site	Time period	TGM trend, pg m^{-3} yr^{-1}	TGM trend, % yr^{-1}
Reifel Island	1999-2004	-55 *(-70 to -40)*	-3.3 *(-4.2 to -2.4)*
Genesee	2004-2010	-6 *(-21 to +1)^{ns}*	-0.4 *(-1.4 to +0.1)^{ns}*
Bratt's Lake	2001-2010	-37 *(-48 to -23)*	-2.5 *(-3.4 to -1.6)*
Burnt Island	1998-2007	-15 *(-22 to -7)*	-1.0 *(-1.4 to -0.4)*
Egbert	1996-2010	-20 *(-27 to -16)*	-1.3 *(-1.7 to -1.0)*
Kuujjuarapik	1999-2009	-40 *(-55 to -23)*	-2.4 *(-3.4 to -1.4)*
Point Petre	1996-2007	-29 *(-38 to -20)*	-1.7 *(-2.2 to -1.2)*
St. Anicet	1995-2009	-24 *(-29 to -19)*	-1.5 *(-1.8 to -1.2)*
St. Andrews	1996-2007	-30 *(-42 to -20)*	-2.2 *(-3.1 to -1.5)*
Kejimkujik	1996-2010	-14 *(-20 to -6)*	-1.0 *(-1.4 to -0.5)*
Alert	1995-2009	-11 *(-15 to -6)*	-0.7 *(-1.0 to -0.4)*

- **Overall levels declined 10-26%** *(-0.9% to -3.3% yr^{-1} - over varying years)*
- **Greater decreases closer to emission sources**
- **Arctic shows different patterns**
- **Canadian Emissions decreased 85% since 1990**

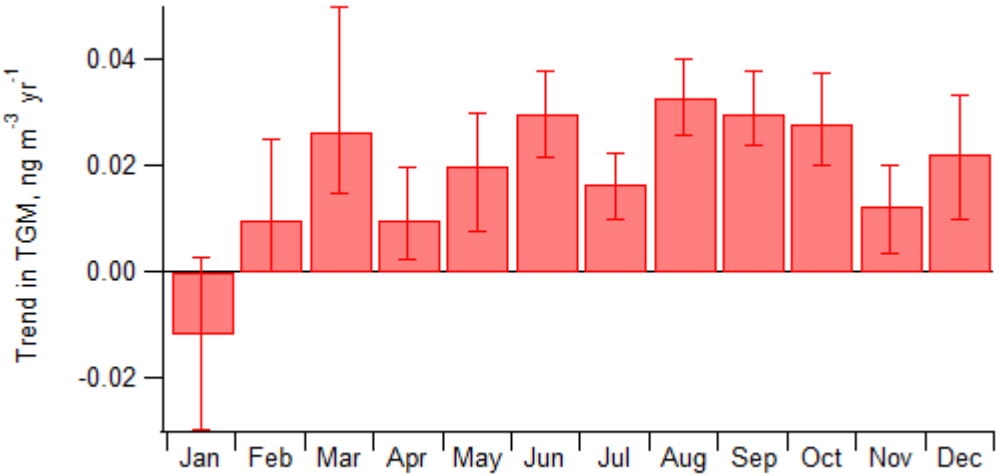
Arctic TGM trends differ from temperate regions



High eastern Arctic (Alert)
overall annual trend
(1995-2013)
-0.987% per year



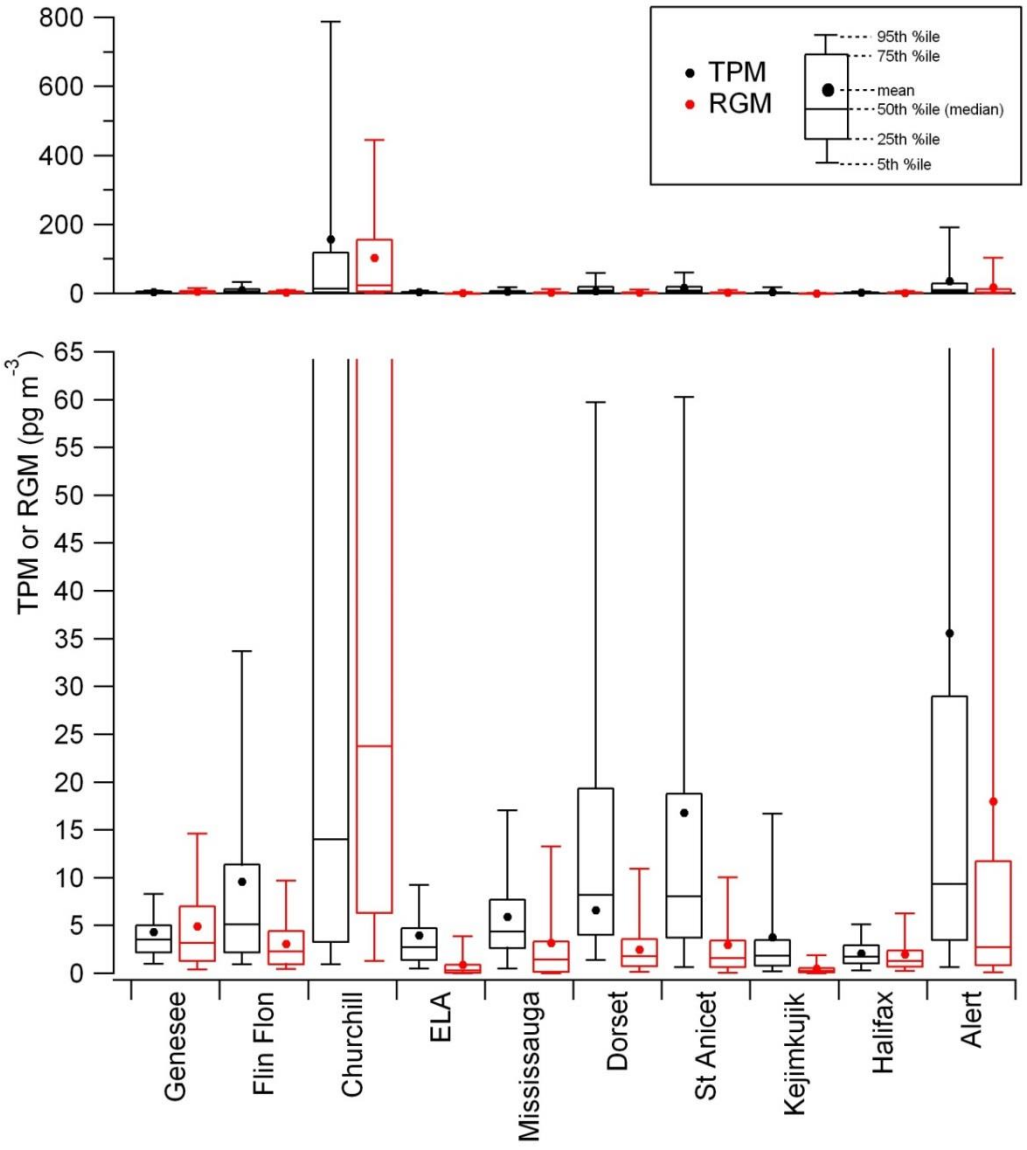
Western Arctic (Little Fox Lake)
overall annual trend
(2007-2014)
+ 1.40 % per year



Above zero – increasing trend
Below zero – decreasing trend

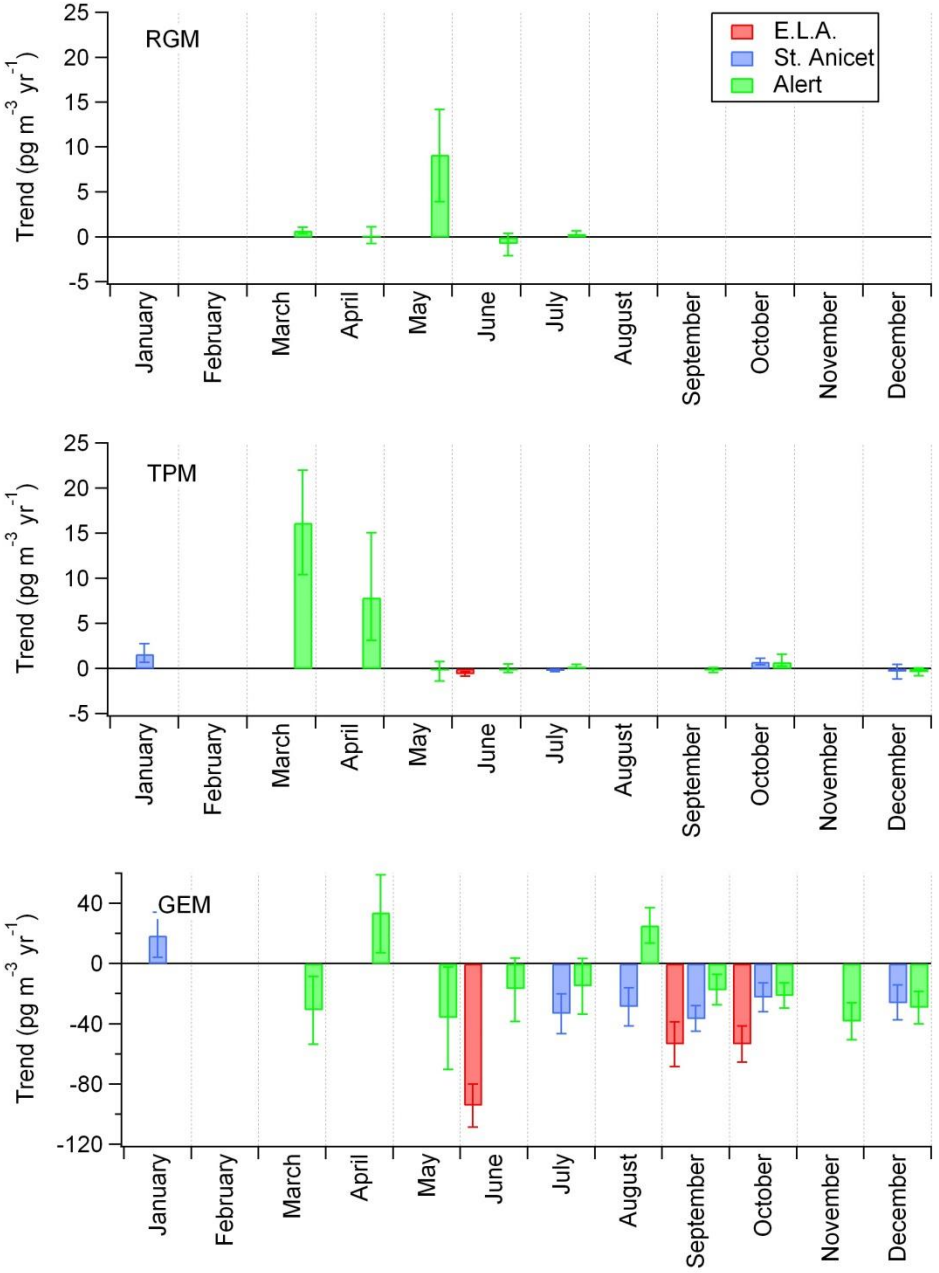
Speciation Concentration in Canada Particulate (TPM), Reactive Gaseous Hg (RGM)

- **Hg^0 converts to Hg^{2+}**
- **Reactive gaseous mercury (RGM)**
- **Total particulate mercury (TPM)**
- **11 sites**
- **Inset includes Churchill***
- * over a very short time during spring



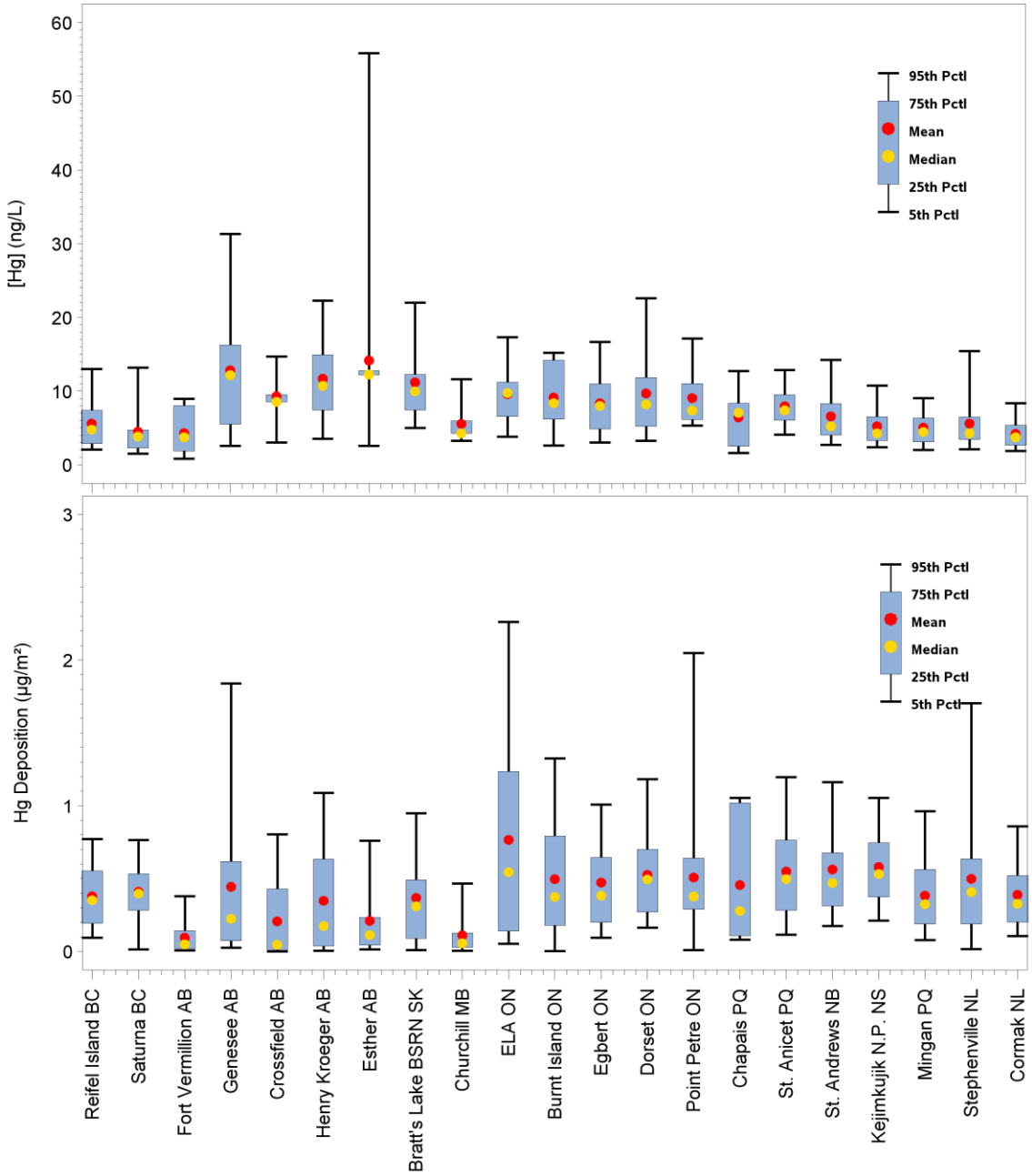
Trends of Hg speciation

- **Overall trends not reported**
- **Very small trends**
- **Monthly trends**
  - **RGM Alert May +6.8 % increase**
  - **Other no trend for RGM**
  - **TPM ELA and St A, some months -3 to +12%**
  - **TPM Alert April +7%**
  - **GEM decreasing**
- **Speciation starting to increase at some locations**



Mercury concentration and deposition in precipitation

- **Total Hg concentrations**
- **Total Hg deposition**
- **Part of US MDN**
- **22 sites**
- **Flin Flon (smelter)**
  - **Conc:158 ng L^{-1}**
  - **Dep: 6.05 ug m^2**
- **Higher levels close to local emission sources**



Hg concentration trends in precipitation

Site	Time period	[Hg] trend, [a] ng L^{-1} yr^{-1}	[Hg] trend, % yr^{-1}
Egbert	2000–2010	-0.18 (-0.31 to -0.05)	**-2.1** (-3.7 to -0.6)
St.Anicet	1998–2007	-0.22 (-0.41 to -0.05)	**-2.8** (-5.2 to -0.6)
St.Andrews	1996–2003	-0.25 (-0.43 to -0.02)	**-3.7** (-6.5 to -0.3)
Kejimkujik	1996–2010	-0.12 (-0.17 to -0.06)	**-2.2** (-3.3 to -1.2)
Mingan	1998–2007	-0.13 (-0.23 to +0.01) (NS)	**-2.5** (-4.6 to +0.2) **(NS)**
Cormak	2000–2010	-0.07 (-0.15 to +0.01) (NS)	**-1.7** (-3.5 to +0.3) **(NS)**

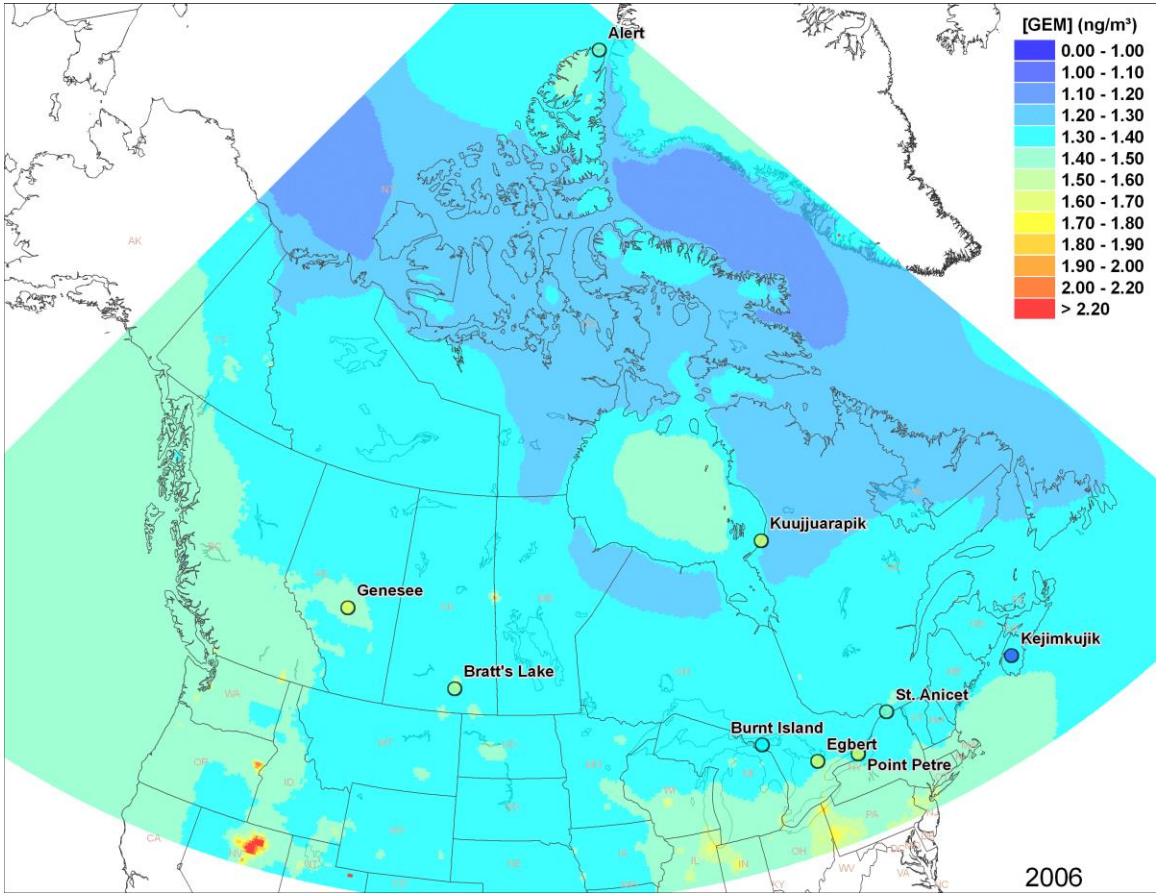
Volume weighted monthly means
95% confidence limits in parentheses
Data for sites > 5 years
NS not statistically significant from zero

Trends also differ over time periods

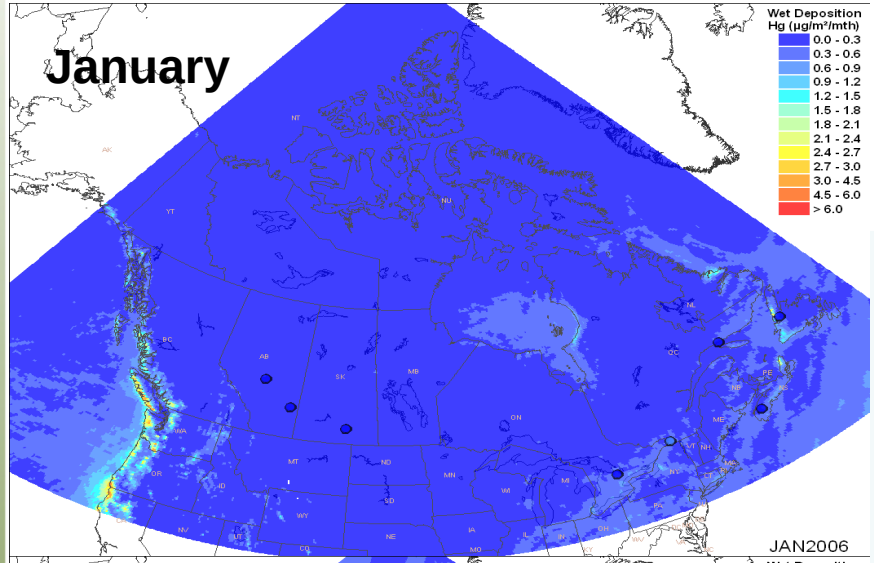
Model results

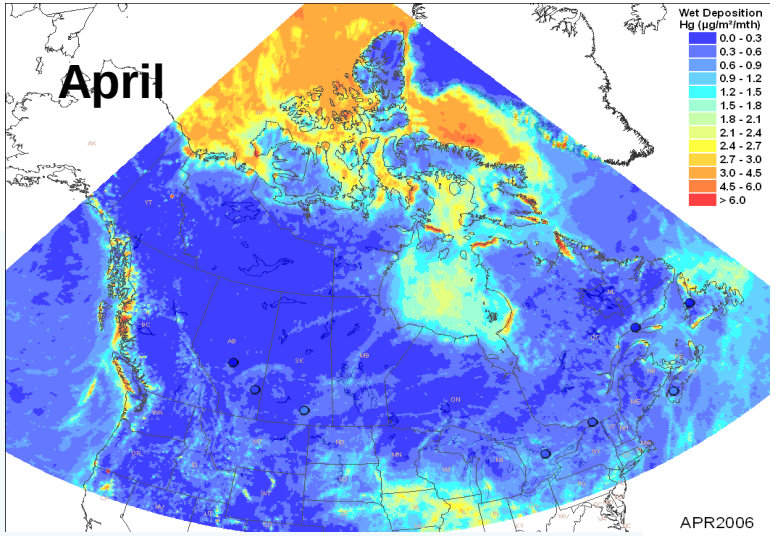
Global/Regional Atmospheric Heavy Metals Model

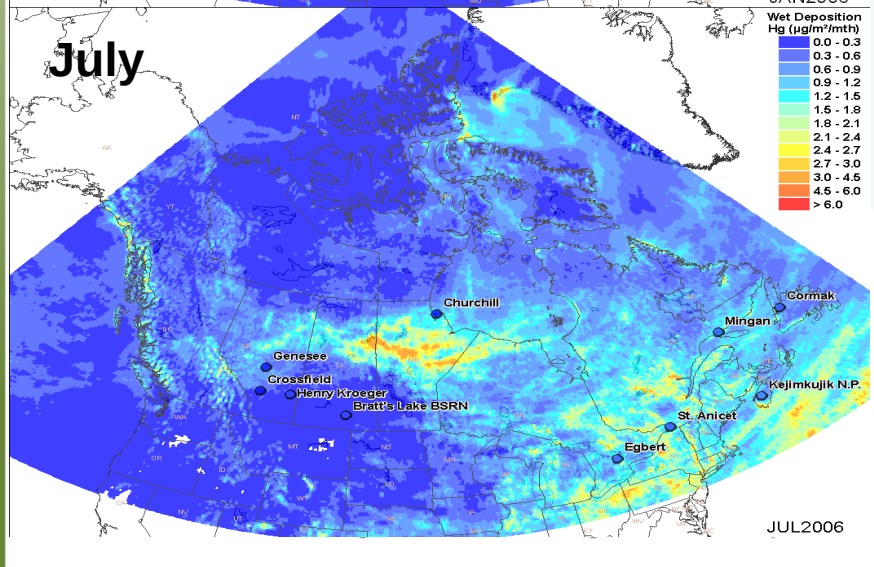
Modelled annual means of GEM and TGM measurements at Canadian sites active throughout 2006

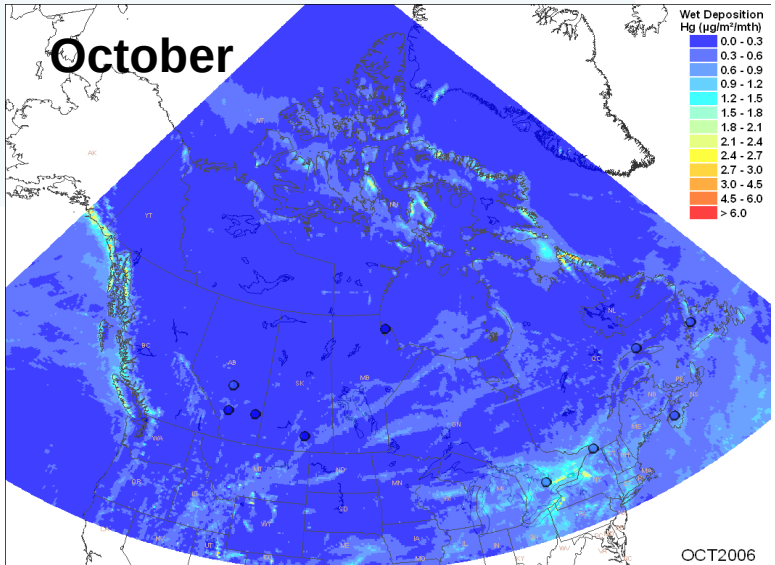


Wet deposition concentrations as modelled and measured (dots) in 2006



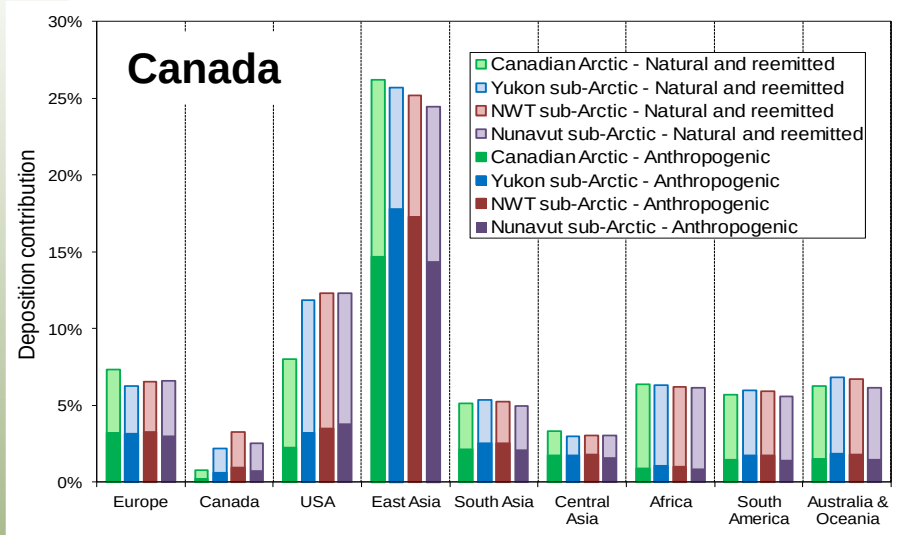


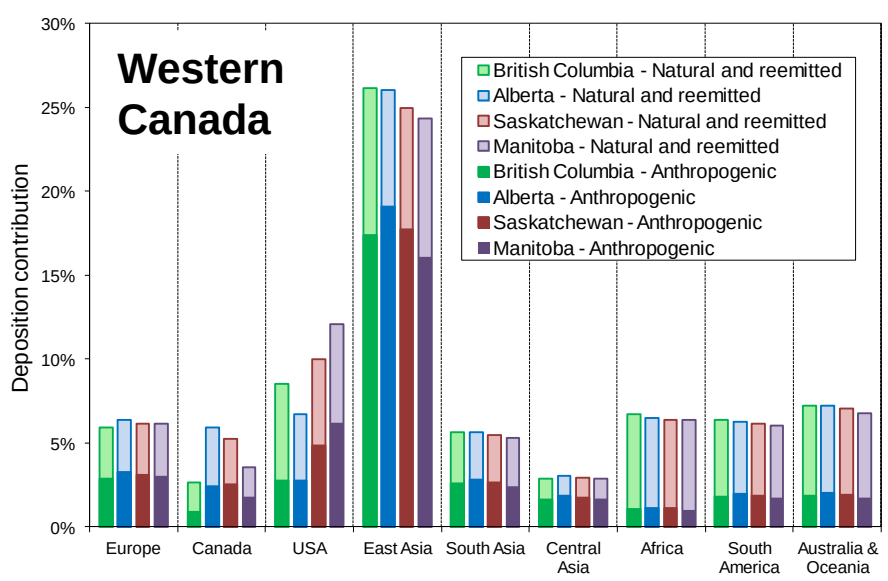




Hg deposition regional contribution

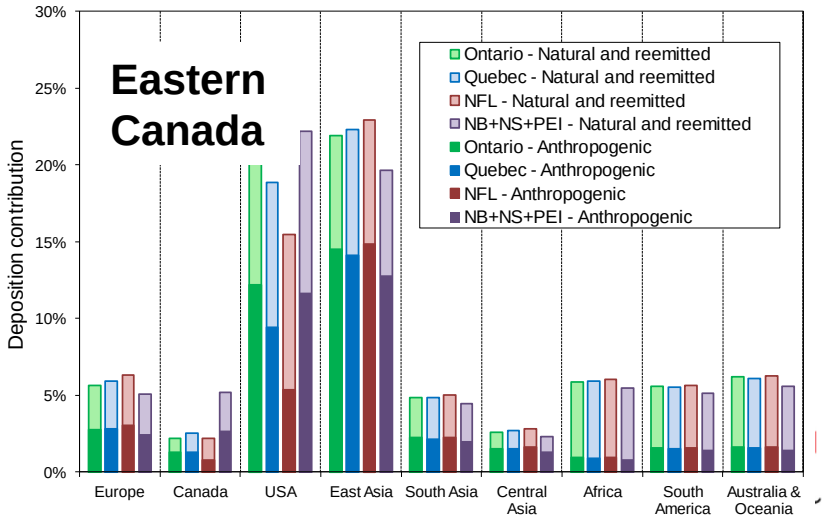
Global/Regional Atmospheric Heavy Metals Model for 2005





Relative contributions from individual source regions to net mercury deposition

Over 95% of anthropogenic Hg deposited in Canada comes from sources outside of Canada



Information courtesy of Ashu Dastoor, Environment Canada
from the Canadian Mercury Science Assessment - Chapter 4

Where should we monitor Hg in Canada?

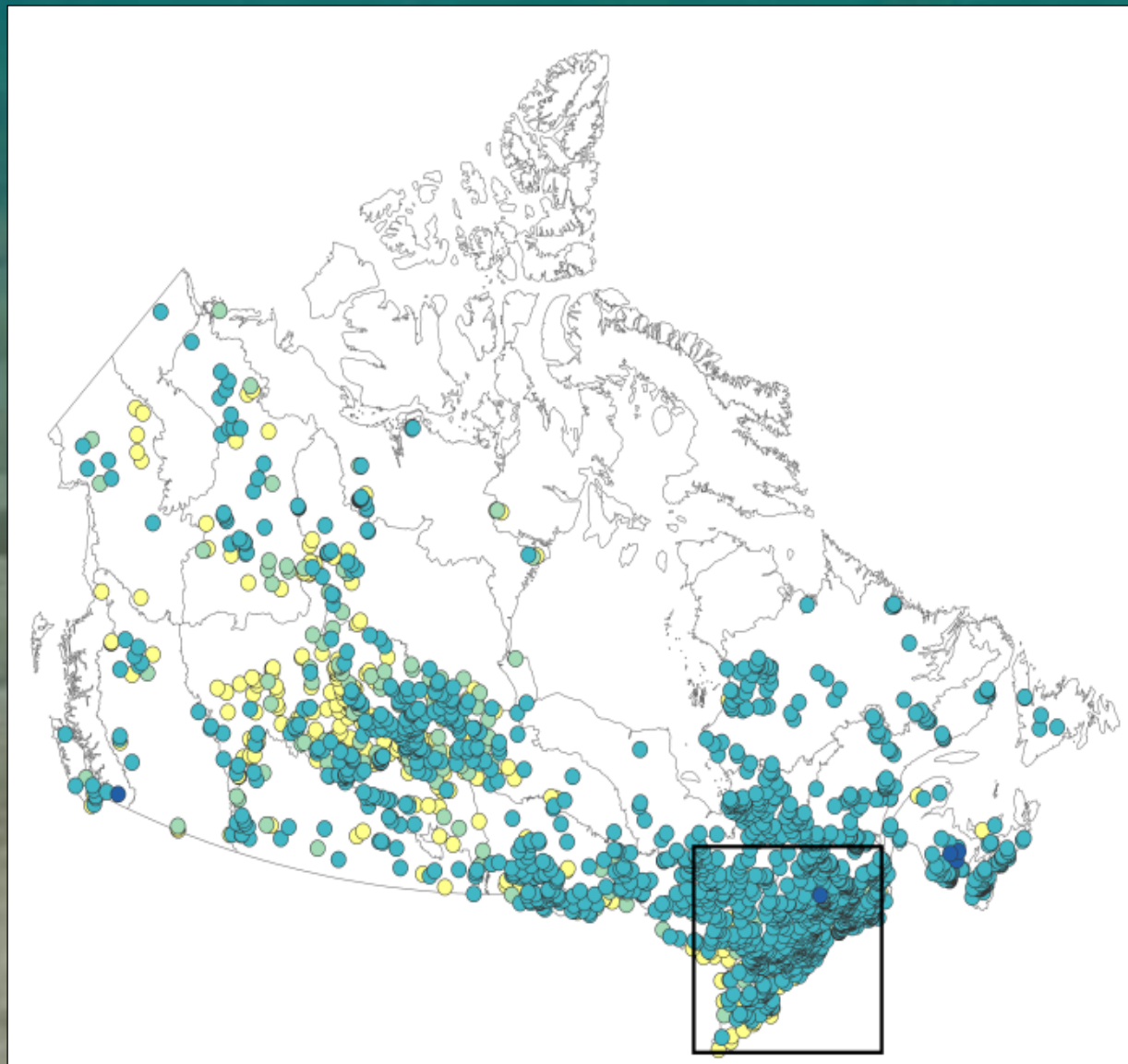
Atmospheric monitoring is undertaken to address several different goals:

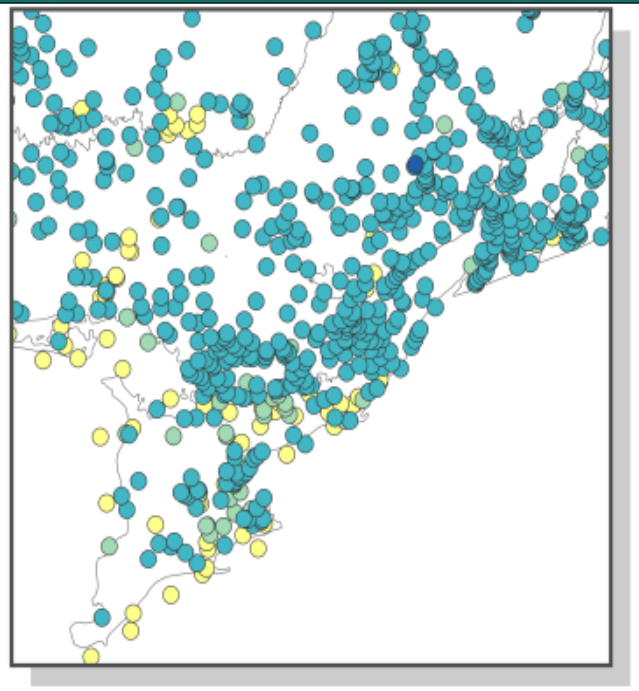
1. Input levels of mercury to ecosystems

2. Ambient levels resulting from domestic and regional emission sources

3. Transboundary transport of mercury into Canada

Ecosystem impacts: Fish eating fish





Risks

Impaired behaviour

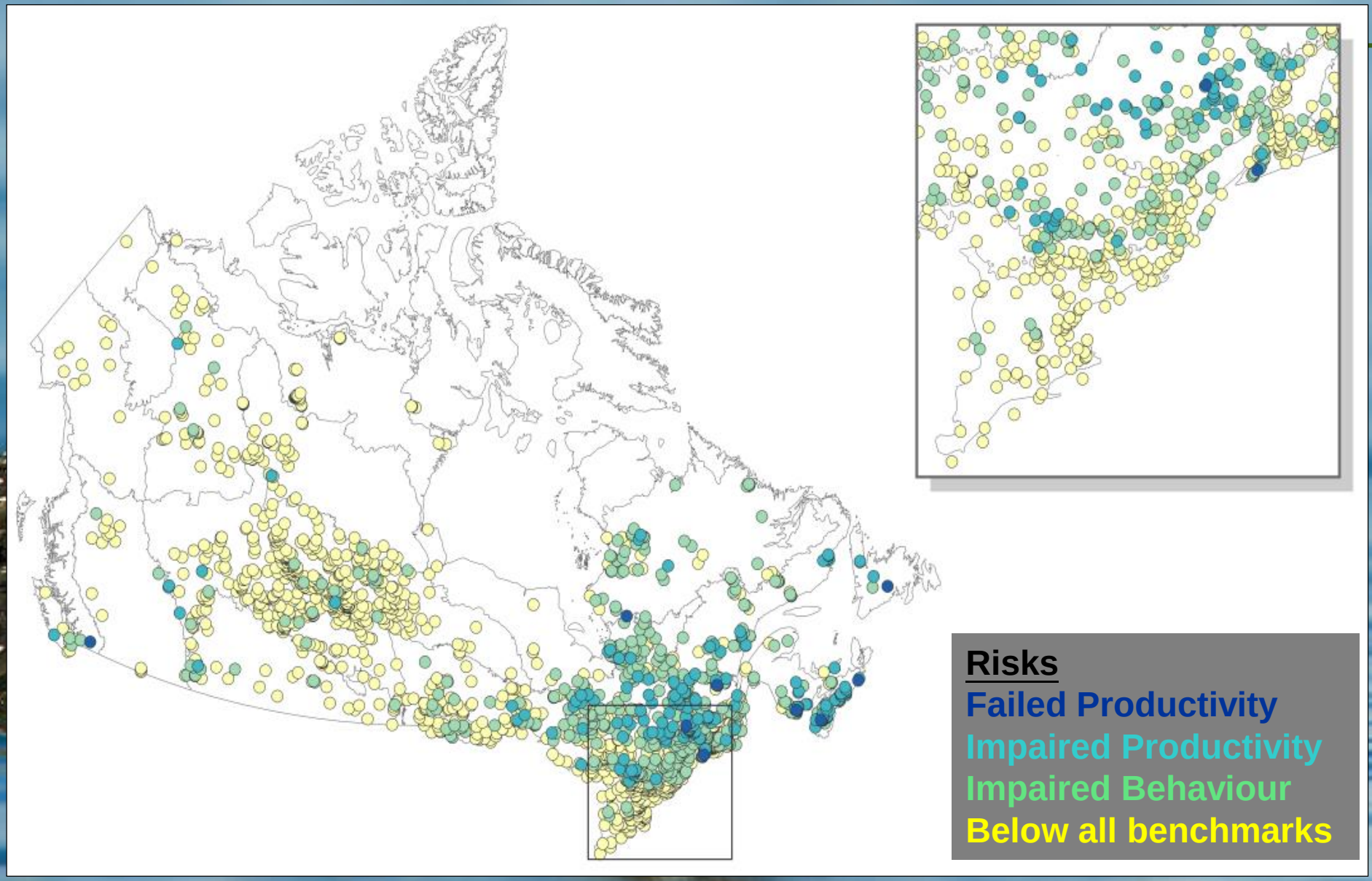
Health impairment

Impaired reproduction

Below all benchmarks

Mercury is a risk to Iconic Canadian bird

The Common Loon

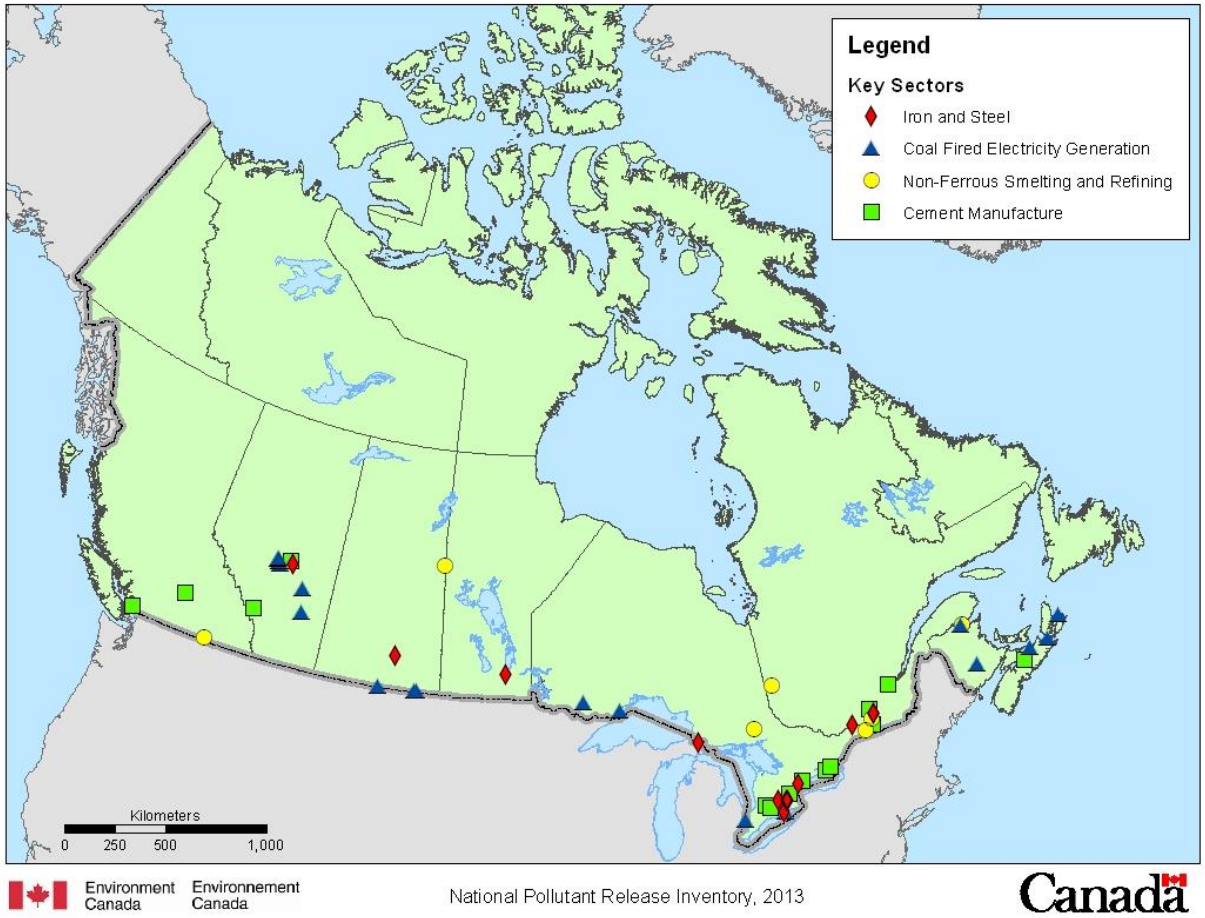


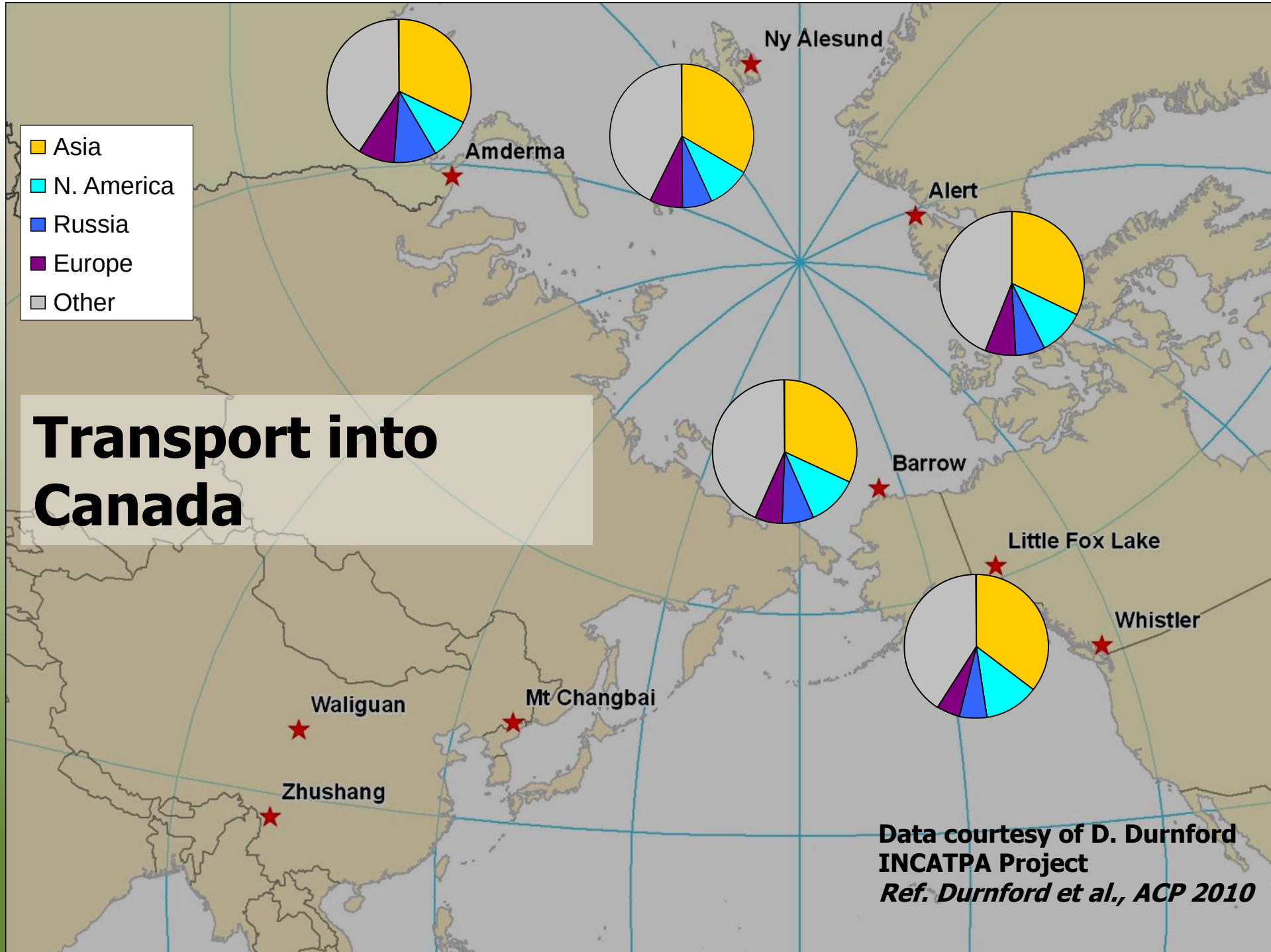
Canadian Anthropogenic Emissions

- Canadian emitters from the four most important industrial sectors
- Contribute > half of Canada's emissions.

Sectors

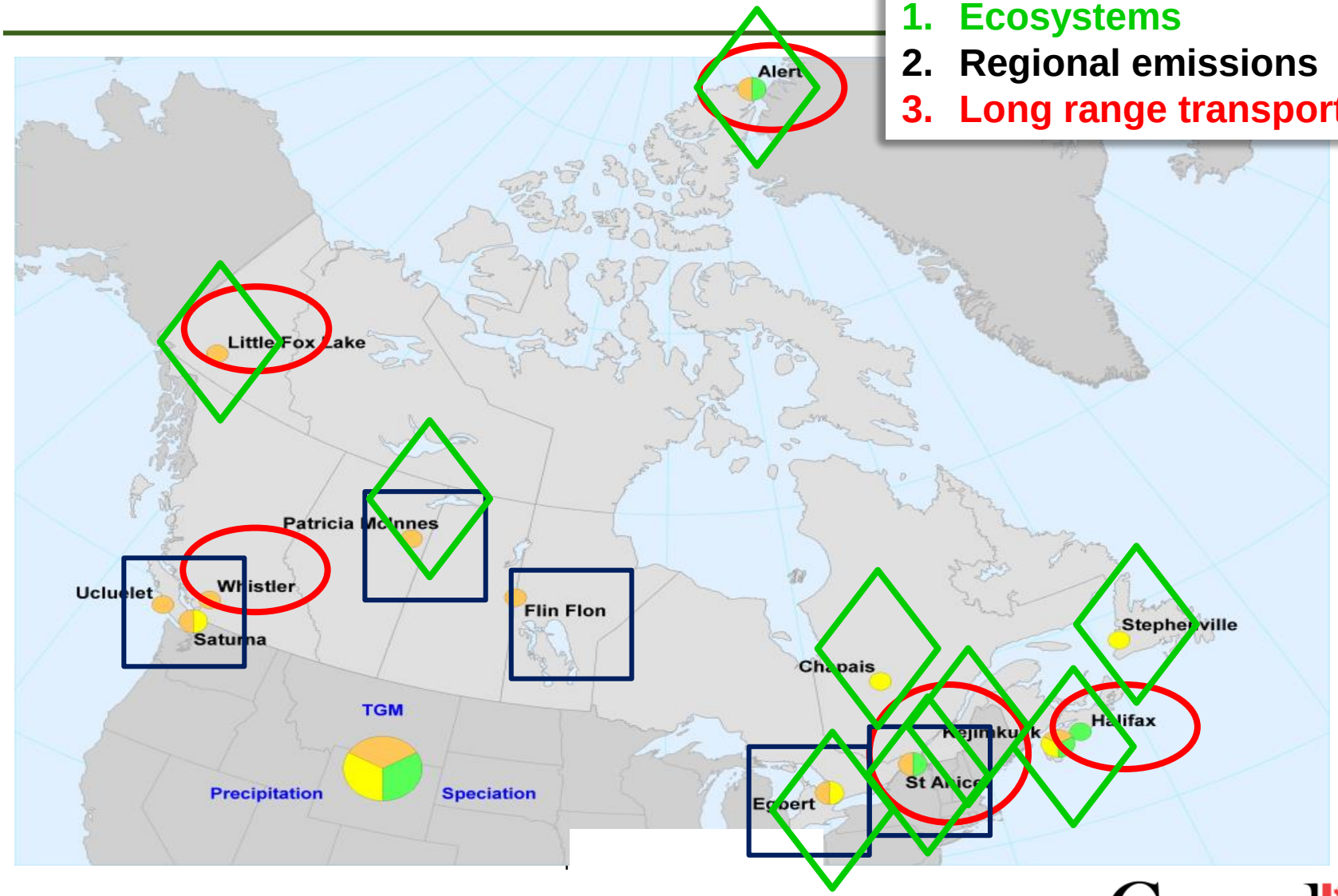
- Iron and steel production
- Coal-fired power plants
- Non-ferrous metals processing
- Cement production and processing




Asia
N. America
Russia
Europe
Other
Transport into Canada
Ny Ålesund
Amderma
Alert
Barrow
Little Fox Lake
Whistler
Waliguan
Mt Changbai
Zhushang
Data courtesy of D. Durnford
INCATPA Project
Ref. Durnford et al., ACP 2010

Air Monitoring today in Canada

1. Ecosystems
2. Regional emissions
3. Long range transport



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Thank you!