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Ambient Atmospheric Measurements of Speciated Mercury and Total Gaseous Mercury in the Canadian Oil Sands Region

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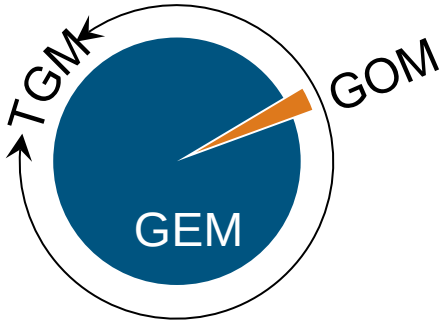
Purpose

To better understand factors influencing atmospheric mercury concentrations, including sources and transportation/transformation processes in the Canadian oil sands region.

Background

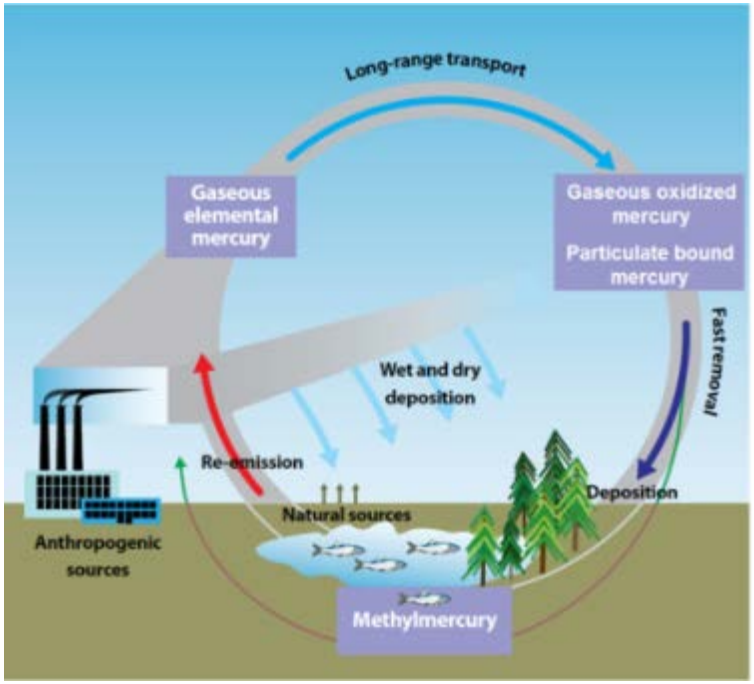


Total **G**aseous **M**ercury (**TGM**):

- TGM data is useful for understanding transport processes.

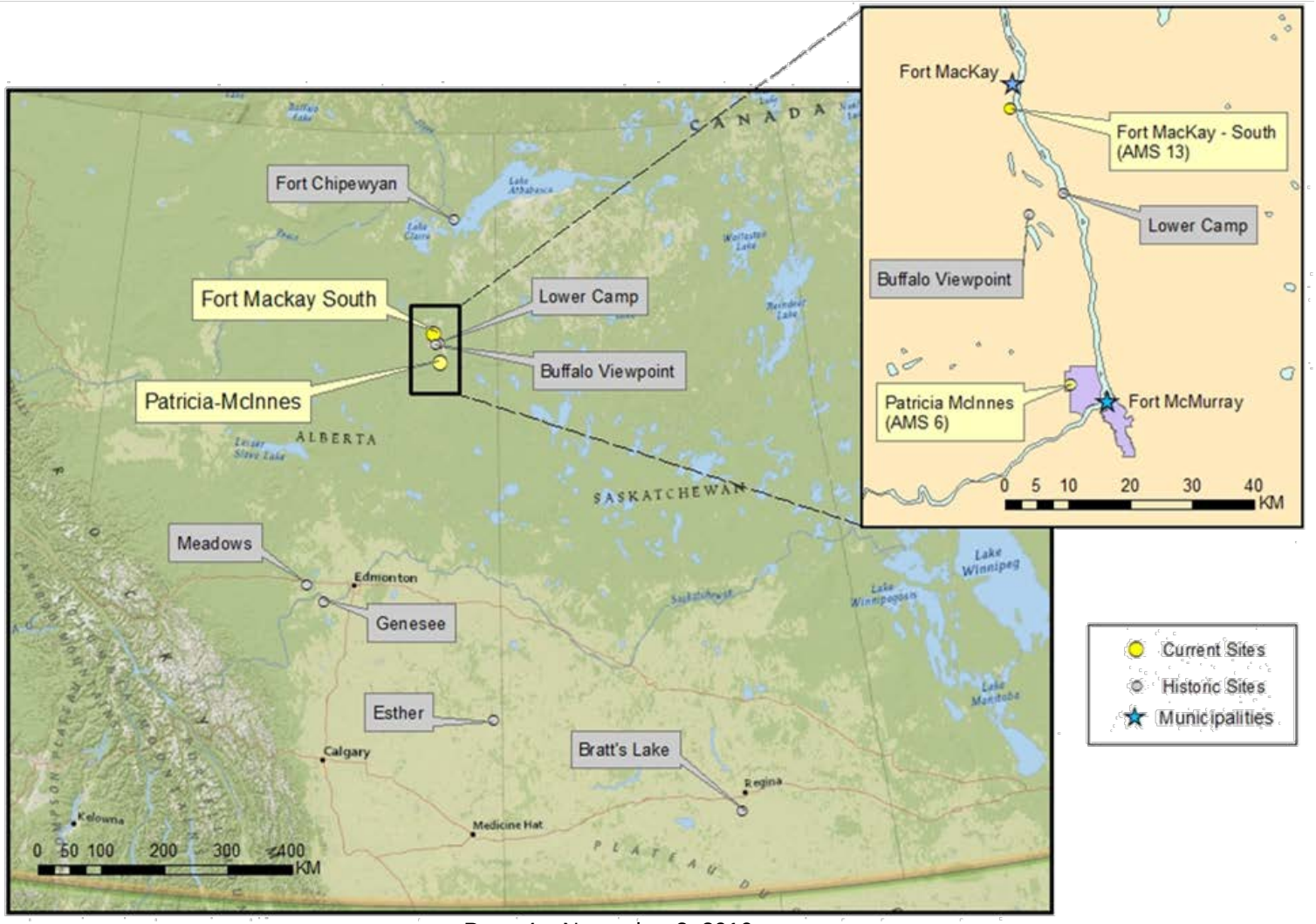
Speciated Mercury:

- **G**aseous **E**lemental **M**ercury (**GEM**)
- **G**aseous **O**xidized **M**ercury (**GOM**)
- **P**articulate **B**ound **M**ercury (**PBM**)
- Speciated mercury data improves understanding of deposition and transformation processes.



Adapted from UNEP, Technical Background Report for the Global Mercury Assessment, 2008.

Monitoring Map



Methods

TGM:

Tekran 2537 mercury analyzers.

Mercury analyzer near Fort McKay, AB

Monitoring station in Fort McMurray (Photo: WBEA)

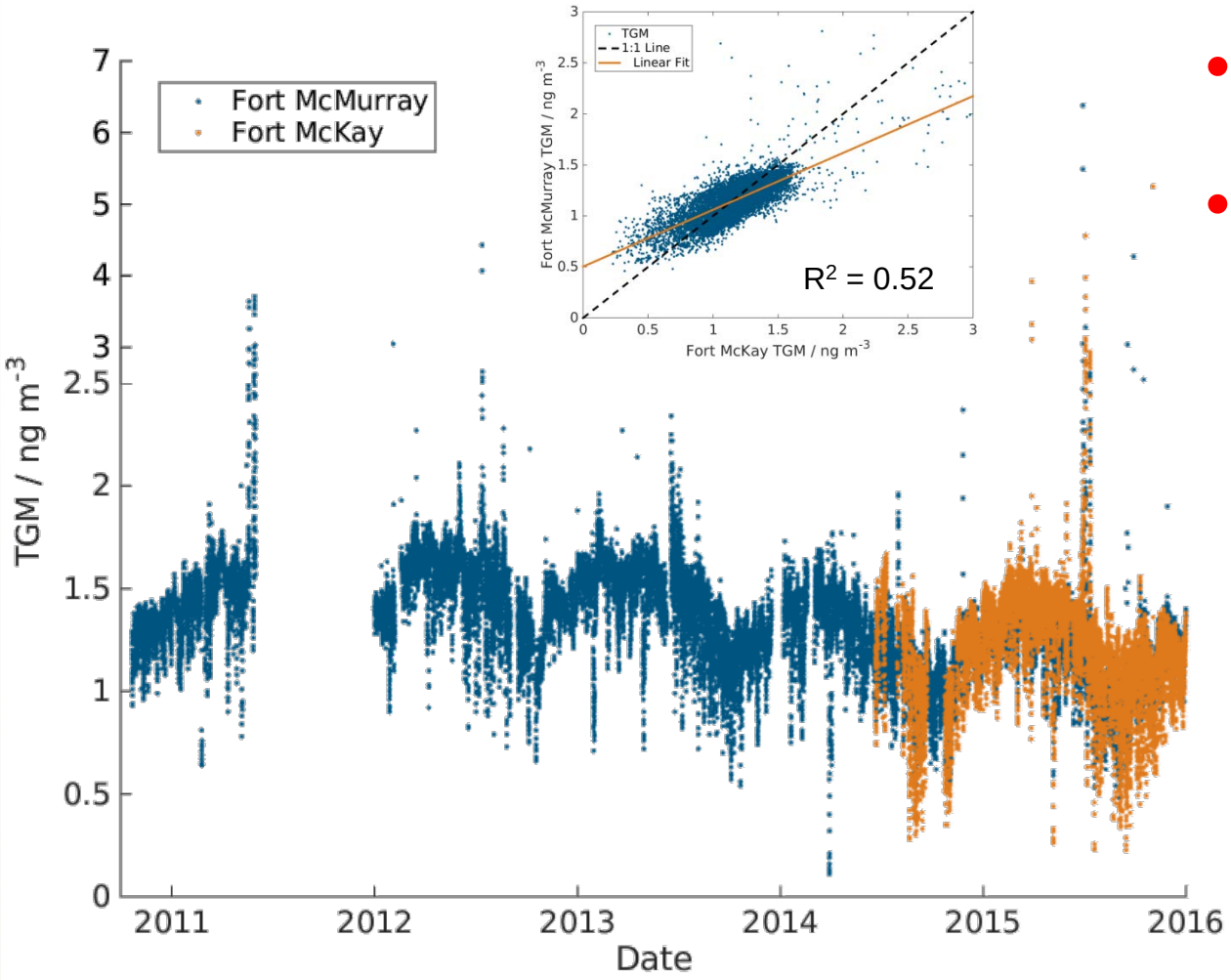
Speciated Hg:

Tekran 2537/1130/1135 mercury speciation samplers ($PM_{2.5}$ and PM_{10} inlets).

Speciated Hg instrumentation near Fort McKay

Standard operating procedures taken from Canadian Atmospheric Mercury measurement Network (CAMNet).

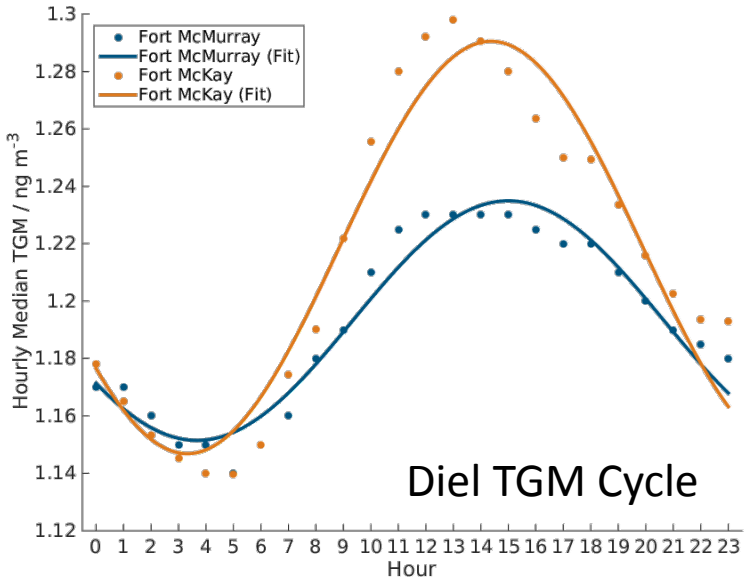
TGM – Fort McKay vs. Fort McMurray

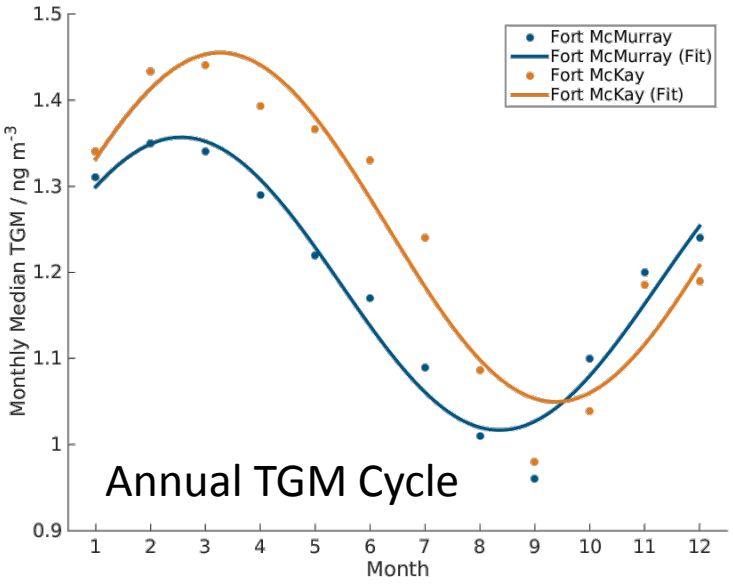


- Sites are correlated with $R^2 = 0.52$
- Skewed regression between sites for concurrent measurements

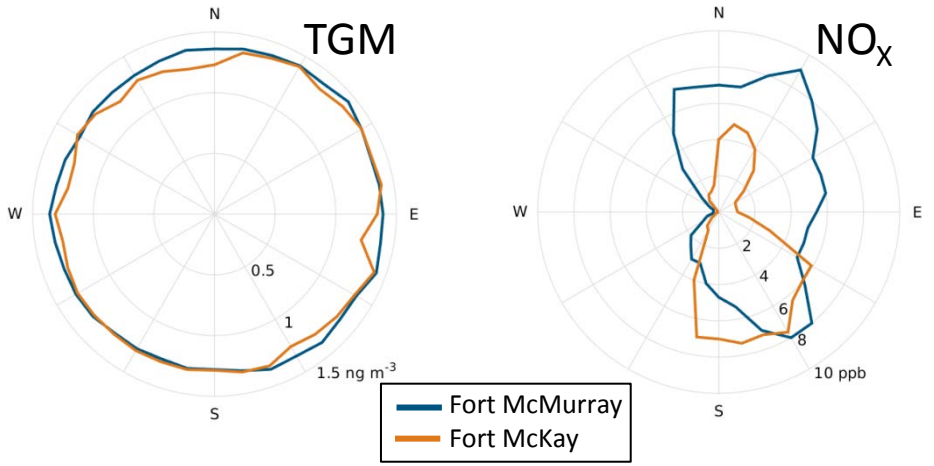
	Median (ng m^{-3})	Std. Dev. (ng m^{-3})
Fort McMurray	1.33	0.24
Fort McKay	1.22	0.27
Fort McMurray (Concurrent)	1.20	0.21

TGM – Fort McKay vs. Fort McMurray

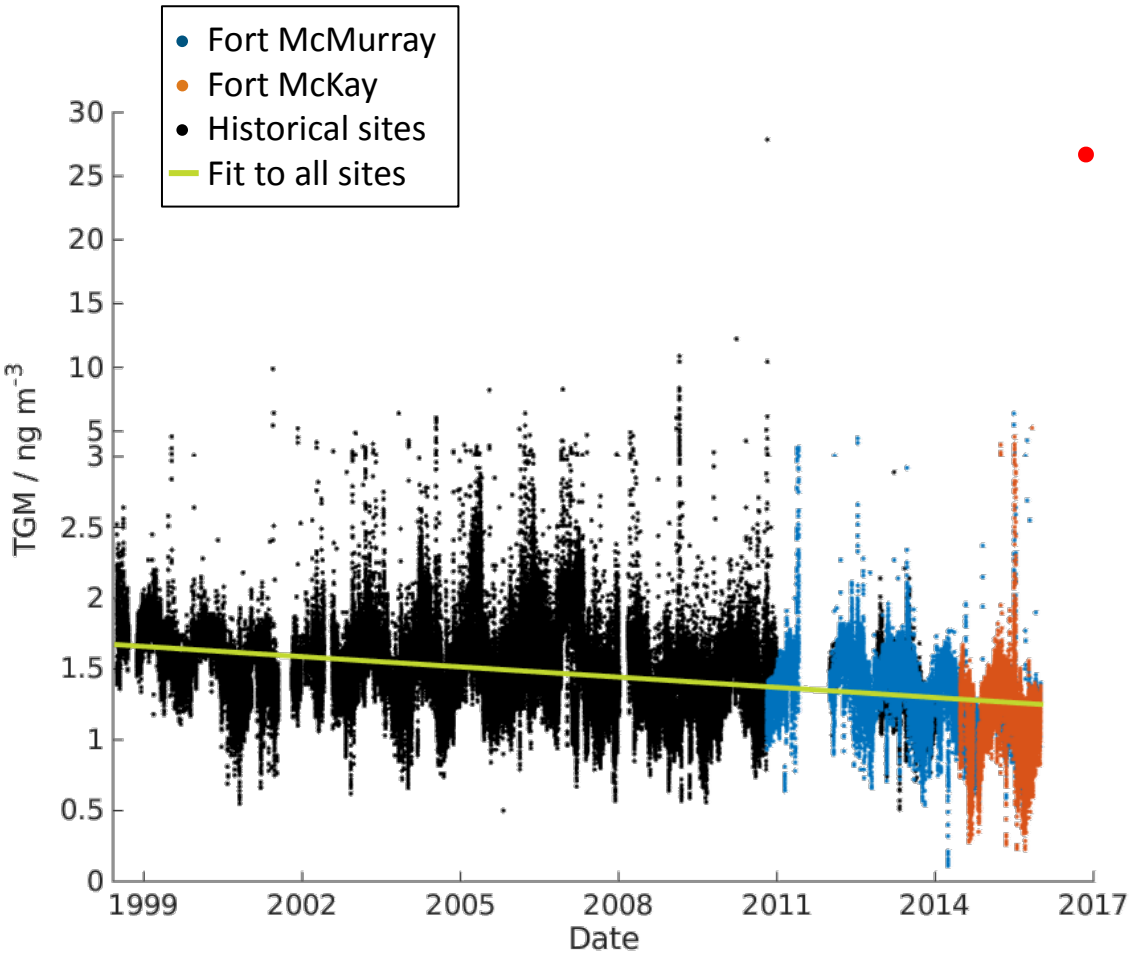




- Similar diel/annual cycles at each site:
  Max: Mid-Afternoon/Late Winter
  Min: Dawn/Early Fall
- TGM does not exhibit directionality, unlike other pollutants in the region.



TGM – Broader Comparison

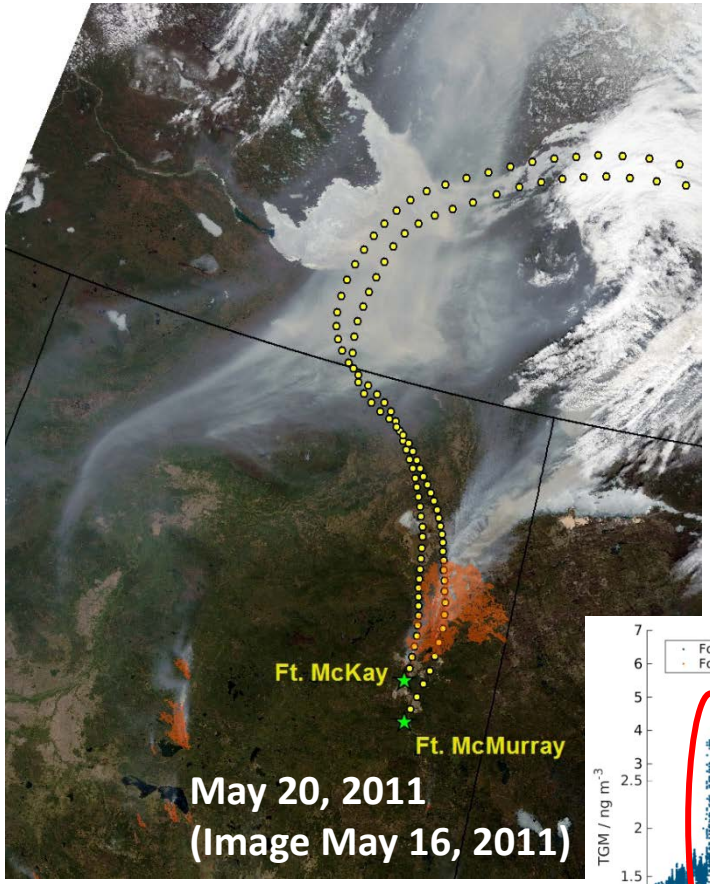


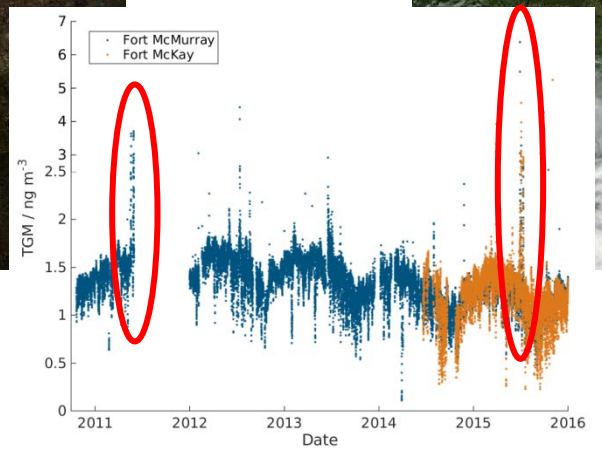
- Western Canadian Hg emissions dropped 60% (4% yr^{-1}) from 2000 to 2015.[1]
- Long-term trends are statistically significant ($p<0.05$) for the combined data set, Fort McMurray, and literature[2] comparison:

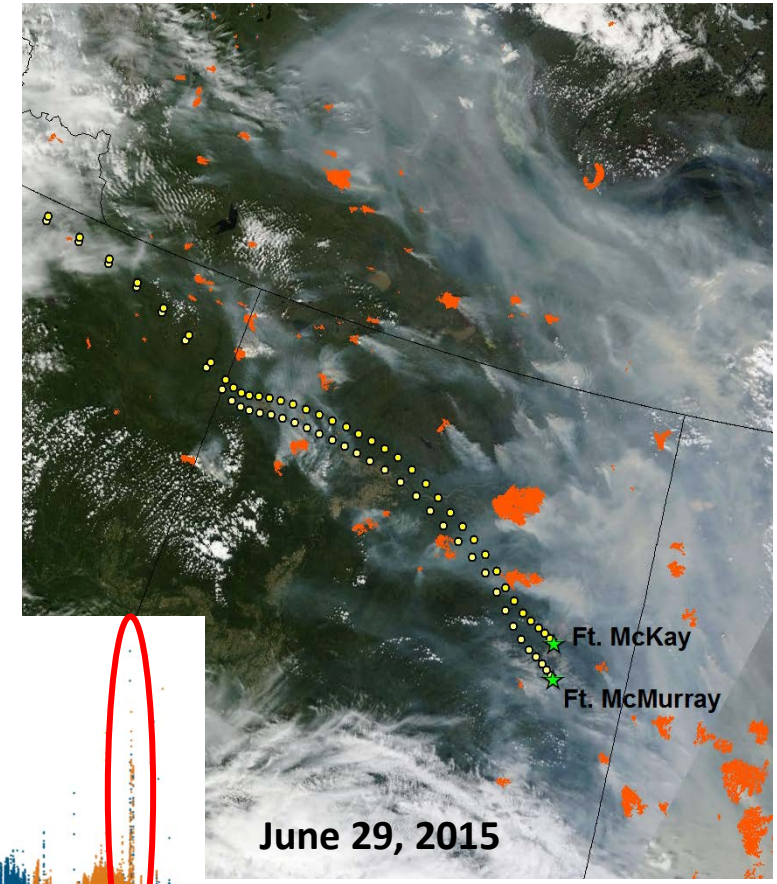
Station(s)	Long-term trend (Seasonal MK)
Fort McMurray (2010 – 2015)	-5.5 % yr^{-1}
All sites (1998 – 2015)	-1.5 % yr^{-1}
Western North America[2] (1997 – 2007)	-1.5 % yr^{-1}

[1] NPRI, Environment Canada (2016)
[2] Weiss-Penzias, et al., STOTEN (2016)

TGM – Impact from Wildfires



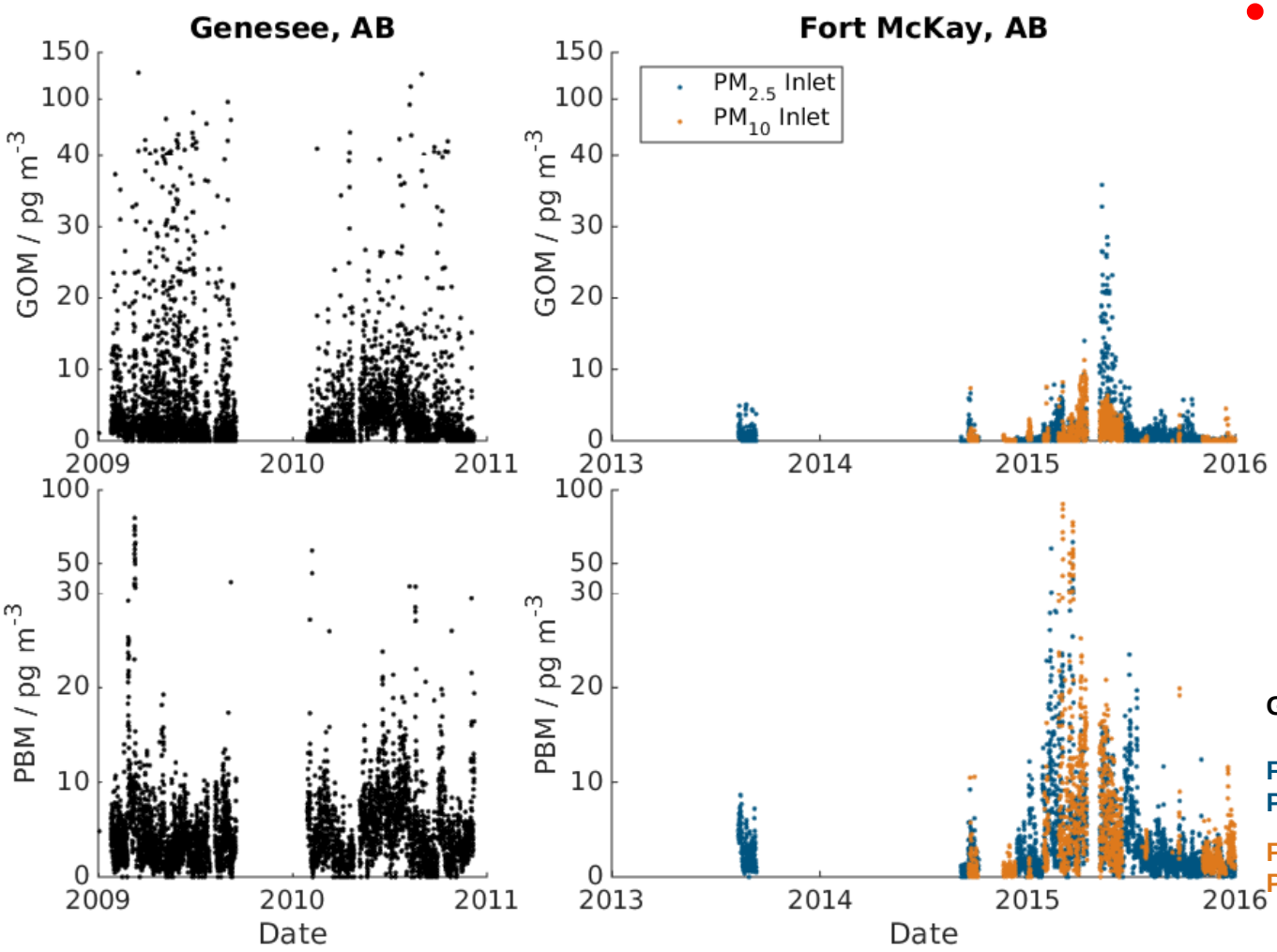




- Highest TGM values can typically be associated with wildfire events.

(Imagery from NASA: Terra/MODIS.)

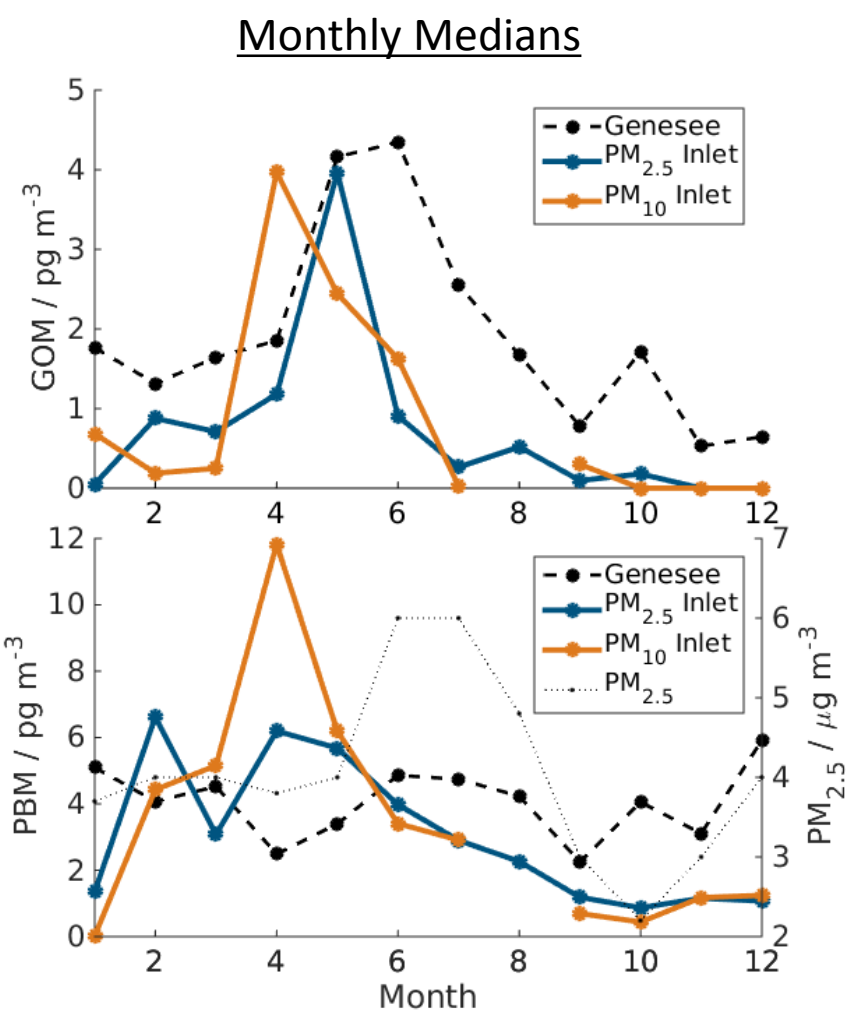
Speciated Hg



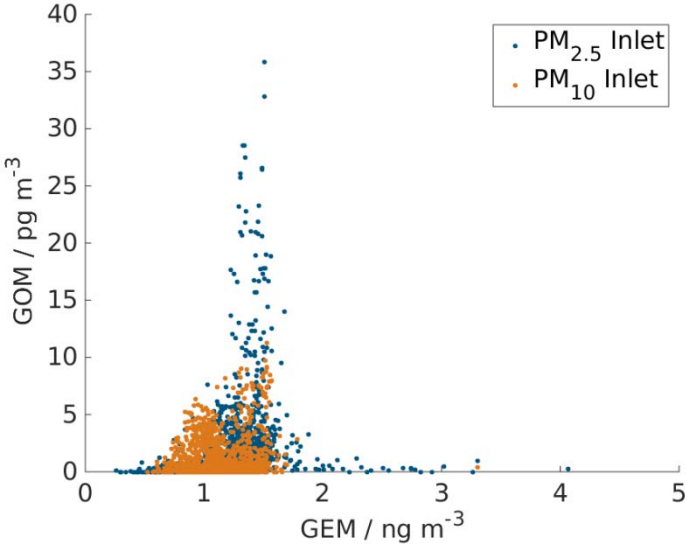
- Hg Speciation comparison between oil sands region (Fort McKay, AB) vs. coal-fired power plants region (Genesee, AB)

	Median (Std Dev.) (pg m^{-3}) GOM	PBM
Genesee	1.89 (8.31)	3.82 (4.90)
Fort McKay $PM_{2.5}$ Inlet	0.30 (2.75)	1.99 (4.65)
Fort McKay PM_{10} Inlet	0.20 (1.73)	2.52 (8.48)

Speciated Hg



- Seasonal cycle of Fort McKay GOM similar to Genesee GOM observations near a coal-fired power plant.
- Some discrepancies in maxima likely related to short period of record.
- Max PBM earlier than max $PM_{2.5}$.
- No clear conversion between GEM ↔ GOM.



Conclusions & Future Direction

- TGM measurements at both sites in the oil sands region are well-correlated; it is not yet clear why data at both sites are skewed from 1:1.
- There is an annual and daily cycle in oil sands TGM data, with no directionality.
- Statistically significant long-term decreasing trend for Fort McMurray (and all Alberta/Saskatchewan sites combined) TGM measurements; but trend over all sites is not as negative as Western Canadian mercury emissions.
- Highest TGM concentrations can be attributed to wildfire events.
- In general, values of GOM and PBM are lower in the oil sands region than in an area impacted by coal-fired power plants.
- PBM in the oil sands shows a monthly averaged peak in the spring, coinciding with the spring maximum in TGM; by comparison an area impacted by coal-fired power plants shows more consistent PBM monthly averages for the duration of the year, suggesting year-round oil sands operations are not an important source of PBM.
- There is no major distinction between speciated Hg monitoring using $PM_{2.5}$ vs PM_{10} inlets at Fort McKay.
- There is no clear conversion between GOM and GEM in the oil sands region.
- Future work will include mercury in wet deposition sampling to further study deposition effects and links to mercury in terrestrial/aquatic ecosystems.

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Questions?