USING ICE AND SEDIMENT CORES TO QUANTIFY CLIMATE-WARMING INDUCED INPUTS OF REMOBILIZED MERCURY TO LAKE HAZEN (NUNAVUT)

Danielle Lemire[1], Igor Lehnherr[1] (igor.lehnherr@utoronto.ca), Alison Criscitiello[2], Jessica Serbu[3], Jane Kirk[4], Amila De Silva[4], Cora Young[3]

[1]Department of Geography, Geomatics and Environment, University of Toronto Mississauga, ON
[2]Canadian Ice Core Lab, University of Alberta, Edmonton
[3]Department of Biological Sciences, University of Alberta, Edmonton, AB
[4]Environment and Climate Change Canada, Burlington, ON
[5]Department of Chemistry, York University, Toronto, ON

1. Introduction

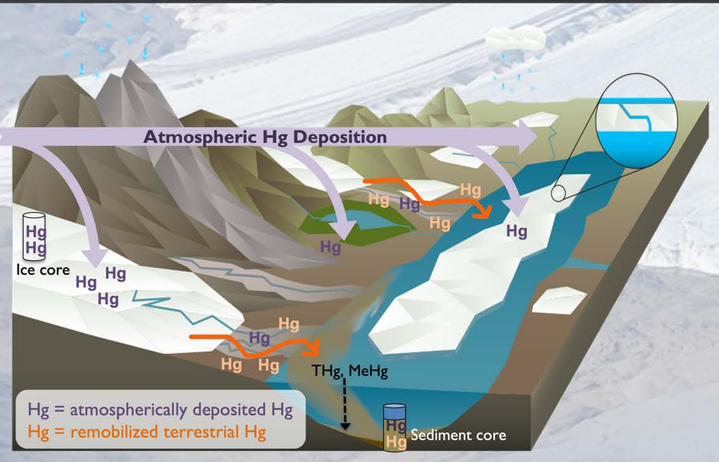

Figure 1. Hg deposition and remobilization in a glaciated watershed. Ice cores record the accumulation of atmospherically-deposited Hg, whereas sediment cores incorporate Hg inputs from both atmospheric and catchment/terrestrial sources (soil, sediment, permafrost, etc.).

- Anthropogenic mercury (Hg) emissions are stabilizing and/or declining (e.g., due to the Minamata Convention on Mercury)[1]
- BUT climate change may delay recovery from Hg pollution by remobilizing terrestrial Hg into aquatic ecosystems via increased glacial runoff and permafrost thaw slumping
- Temporal records of Hg (from sediment and ice cores) help us understand how Hg contamination of Arctic ecosystems has changed over time in response to changes in emissions and climate.

2. Objectives

1. Quantify atmospheric Hg deposition and accumulation over the past ~100 years in the Mt. Oxford ice core record
2. Quantify Hg in rivers discharging into Lake Hazen to determine the role of sources (glacial vs. non-glacial rivers) and discharge (high vs. low flow years) in remobilizing and transporting Hg.
3. Compare Hg accumulation in the sediment and ice core records to determine if temporal trends in Hg inputs into the lake are driven primarily by changes in atmospheric Hg deposition or by the climate-change induced remobilization of Hg from the catchment.

3. Study Site

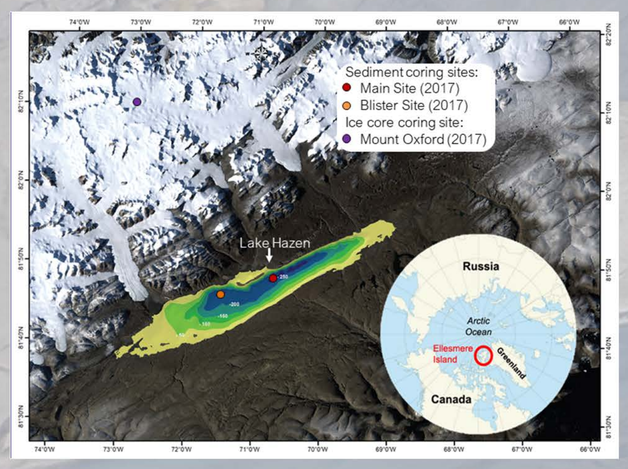

Figure 2. Map of the Lake Hazen region in Quttinirpaaq National Park, Ellesmere Island, Nunavut, showing location of ice and sediment coring sites.

- The Lake Hazen watershed is extensively glaciated and climate-warming is increasing the rate of glacier melt, river discharge and sediment transport.[2]

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References:
1. Streets, D. et al., 2019, *Atmos. Environ.*, 201: 417
2. Lehnherr, I. et al. 2018. *Nat. Commun.*, 9: 1290

4. Ice core record of atmospheric Hg accumulation (1920-2016)

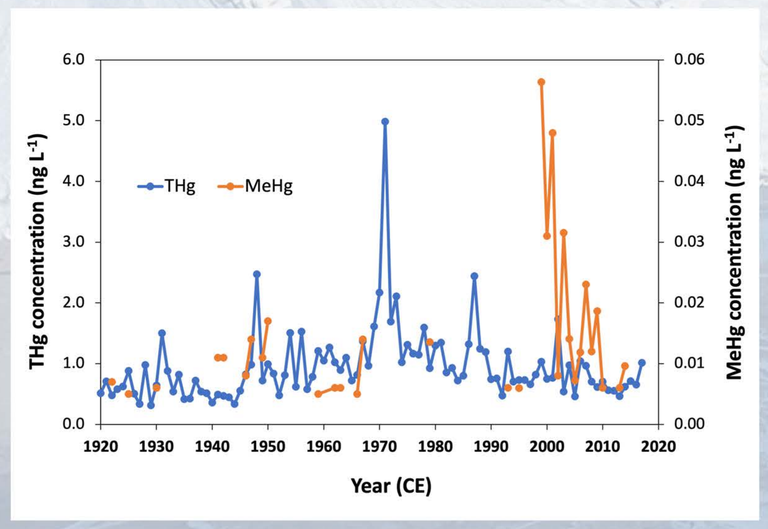

Figure 3. Concentrations of total Hg (THg) and methylmercury (MeHg) in the Mt. Oxford ice core (1920-2016).

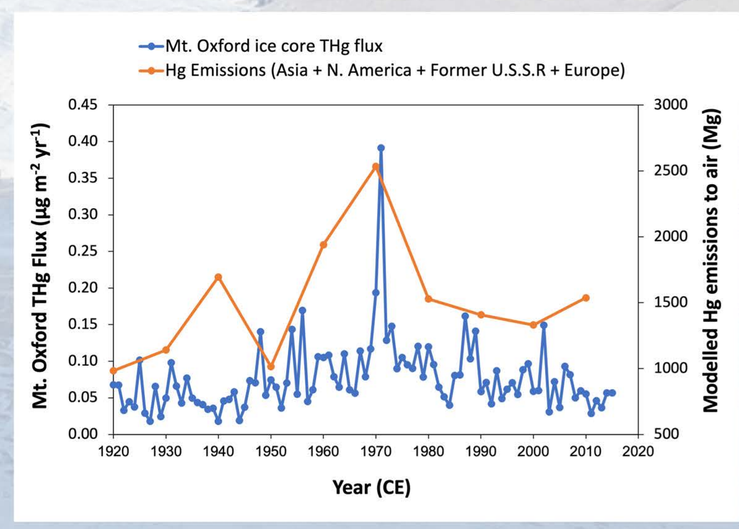

Figure 4. THg accumulation flux in the Mt. Oxford ice core record compared with modelled decadal anthropogenic Hg emissions to air. Plotted emission values represent the total from the four most likely source regions: Asia, N. America, former USSR and Europe (calculated with data from Streets et al., 2019)[1].

- THg concentrations and fluxes exhibit short-term variability and a distinct peak in the early 1970s, but no long-term increase during the past 100 years. No correlations were found between Hg and either particulate-matter or black carbon, and only weak correlations with other metals (e.g., Pb, Cu).
- Ice core THg fluxes show some coherence with modelled estimates of anthropogenic Hg emissions to air from the four most likely source regions (Asia, N. America, former USSR and Europe); e.g., both show a distinct peak in the early 1970s.
- MeHg concentrations were below detection in 57% of samples, but elevated during the period of 1999-2009. These represent some of the first MeHg measurements made in ice cores, however, the drivers behind these trends have not been elucidated.

5. Hg inputs and accumulation in Lake Hazen

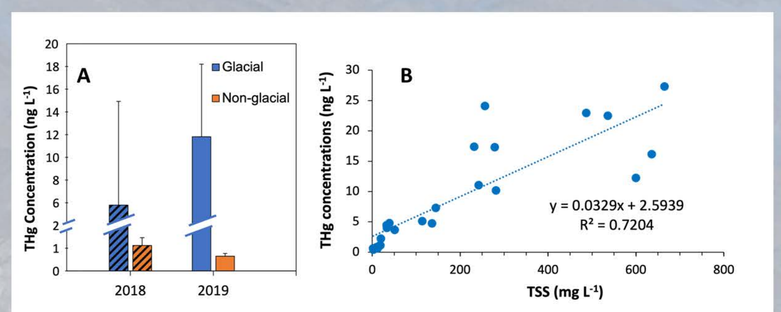

Figure 5. (a) Unfiltered THg concentrations in glacial and non-glacial rivers discharging into Lake Hazen during low (2018) and high (2019) flow years. (b) Relationship between unfiltered THg and total suspended solids (TSS) in glacial rivers.

- Unfiltered THg concentrations are higher in glacial rivers (vs. non-glacial) and during high flow years. Unfiltered THg concentrations in glacial rivers are correlated to concentrations of total suspended solids (Fig. 5).
- THg accumulation in Lake Hazen sediment increased dramatically beginning in the mid 1990s, peaking between 2007-2012 when glacier runoff was similarly elevated (Fig. 6).
- Hg accumulation in Lake Hazen sediment exhibit a clear decoupling from atmospheric Hg sources and is driven by the remobilization of terrestrial Hg from the catchment to the lake (Fig. 7).
- Remobilization of terrestrial Hg from the catchment is driven by increased glacier melt (and permafrost thaw) which causes increased erosion along river channels and thus greater delivery of particulate-bound Hg to the lake.

Take-Home: Climate change is likely to slow the recovery of glacierized Arctic watersheds from Hg contamination, countering the anticipated benefit from recent international efforts to reduce Hg emissions

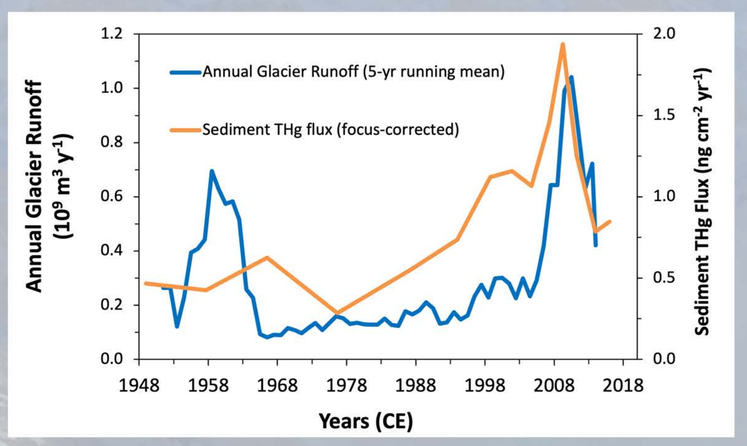

Figure 6. Hg fluxes in Lake Hazen sediment and modelled annual glacier runoff (5-year mean) in the Lake Hazen watershed.

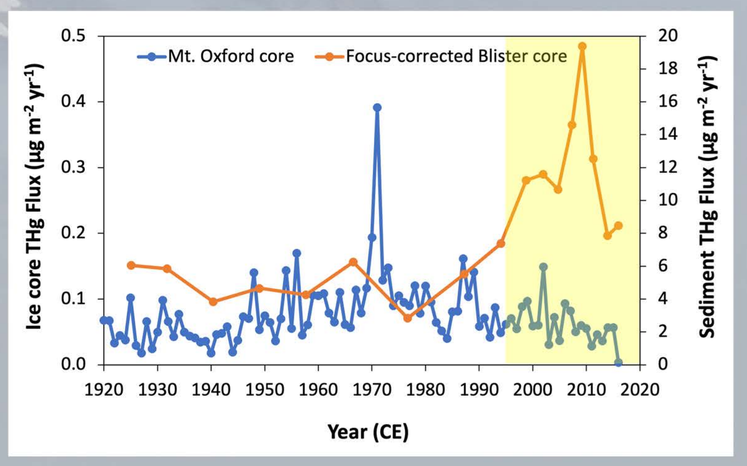

Figure 7. Hg accumulation in the Mt. Oxford ice core and the Lake Hazen sediment core, showing a decoupling of trends beginning in the mid 1990s.