Co-Located Ice and Sediment Core Records Reveal Climate-Warming Induced Acceleration of Hg Inputs to Lake Hazen, Nunavut (Canada)

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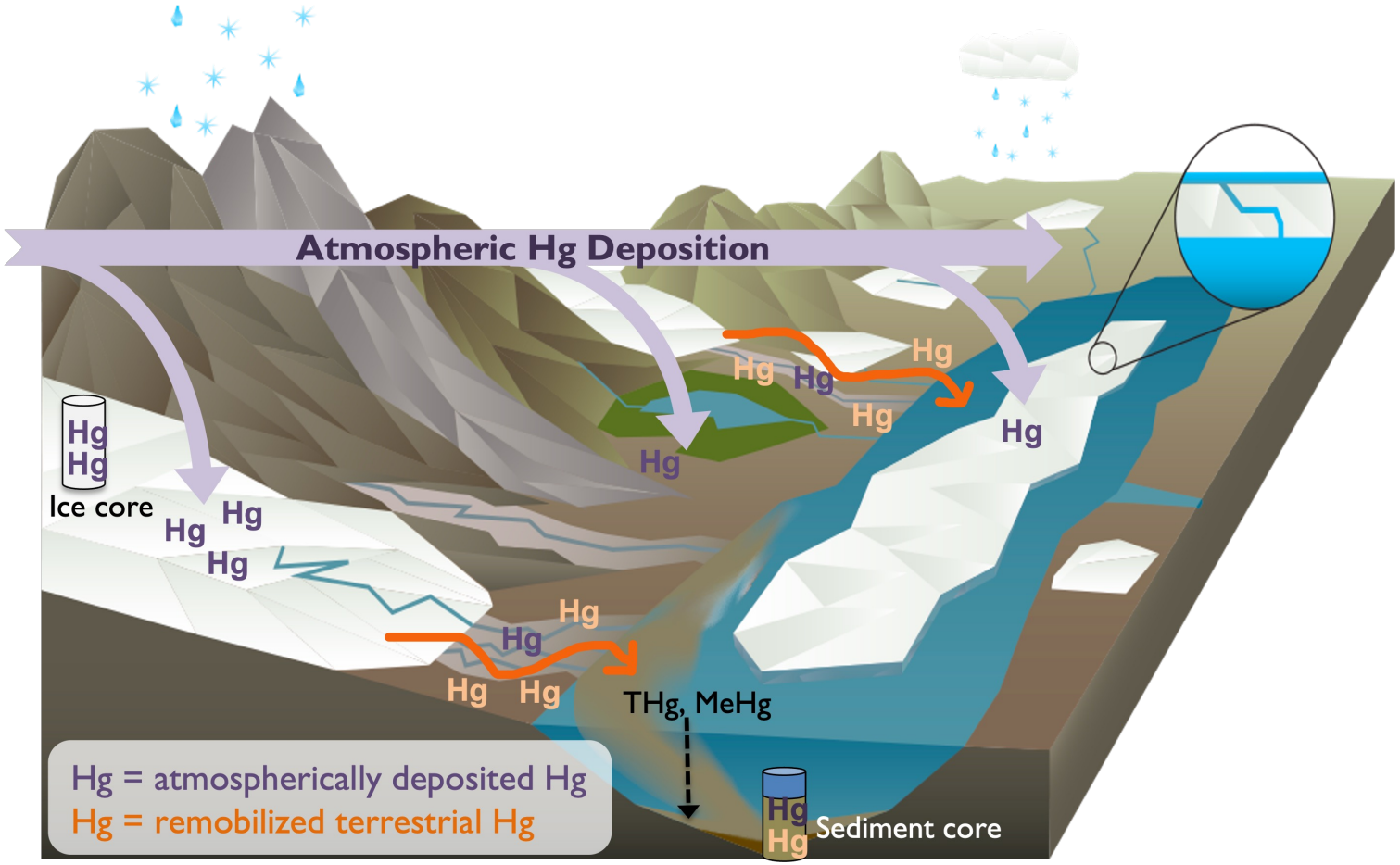
How is Hg contamination of Arctic ecosystems responding to changes in climate and Hg emissions?

- Many potential impacts of climate change, net effect not always clear
- Anthropogenic Hg emissions have plateaued → recovery?
- Co-located temporal records of Hg accumulation archived in lake sediment & glacier ice can provide some answers

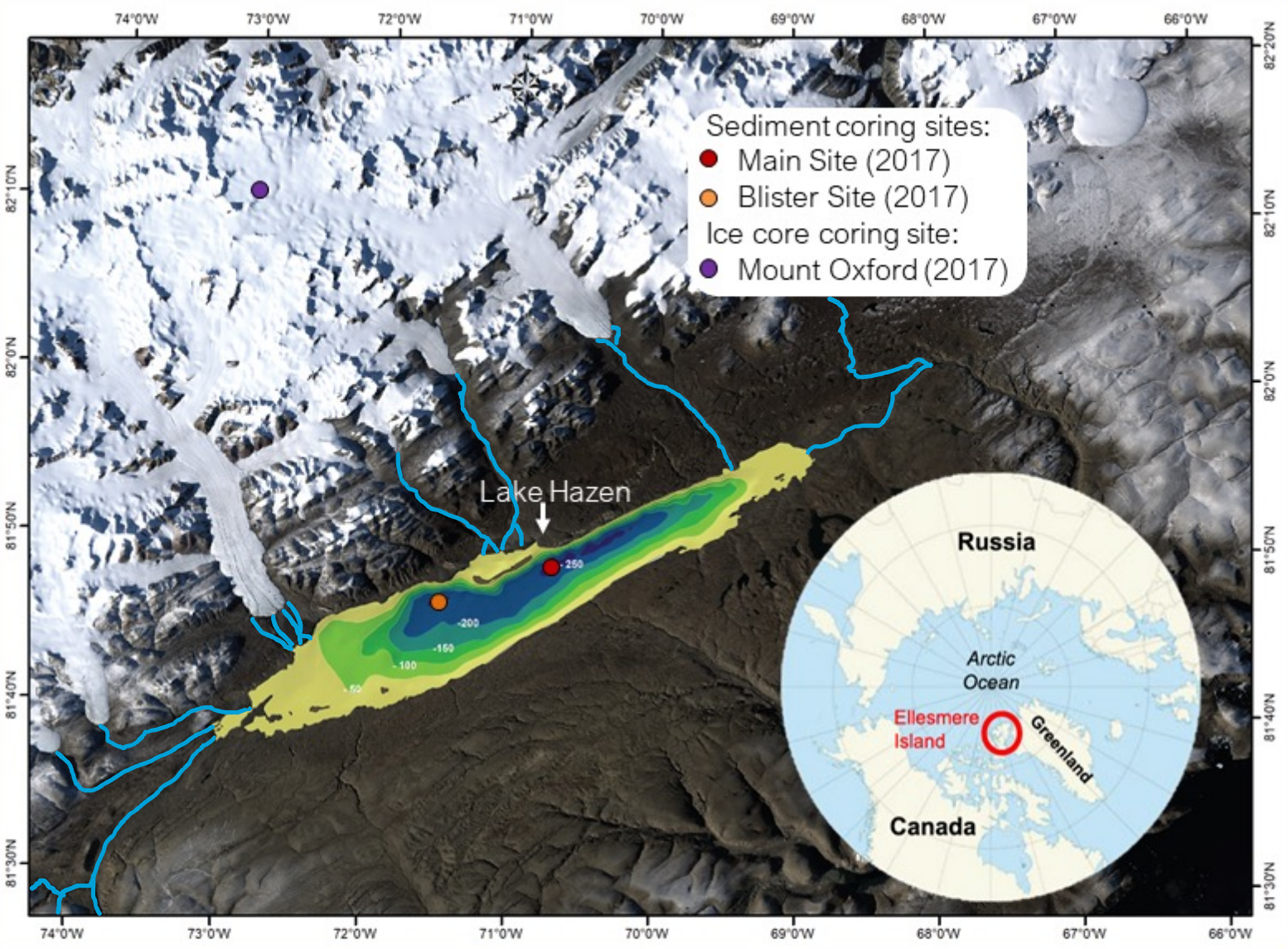
Gilman River, Lake Hazen watershed
Photo: Kyra St. PIerre

Introduction

- Lakes receive inputs of Hg from both atmospheric and catchment (remobilized soil/sediment) sources
- Climate change may be altering the relative contribution of those sources to Lake Hazen
- Ice core record - atmospheric signal
- Sediment record - both catchment and atmospheric inputs



Study Site: Lake Hazen Watershed, Nunavut (Canada)



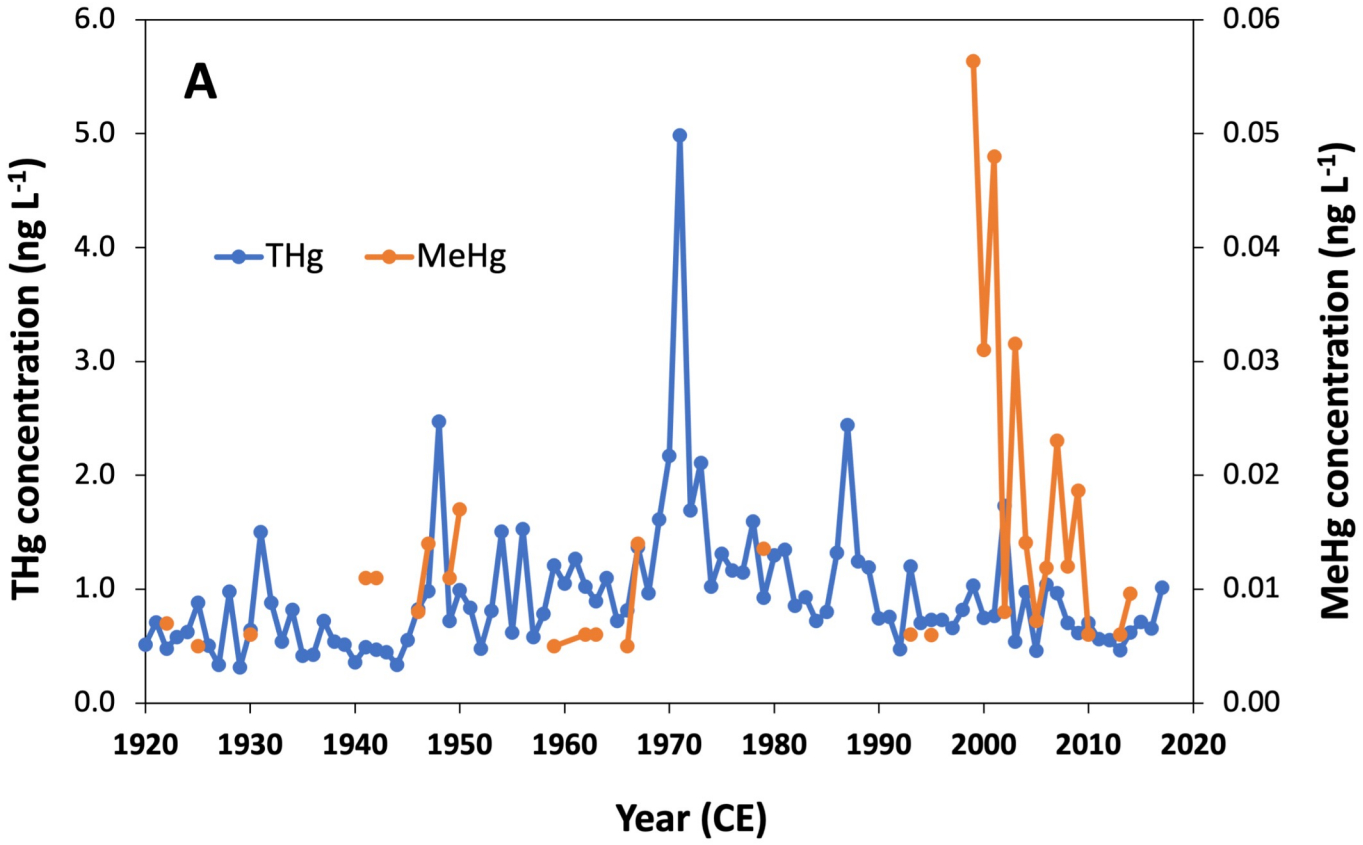
Watershed and lake characteristics:

- Watershed is 40% glaciated
- Geochemical inputs to lake dominated by glacier-fed rivers

Impacted by climate change
(see Lehnherr et al., 2018, Nature Communications):

- warming of air, water and soils
- increased glacial melt and runoff
- permafrost degradation
- decreased seasonal lake ice-cover
- rising lake water levels and shorter water residence time

Mt Oxford ice core record of Hg Concentrations (1920-2016)



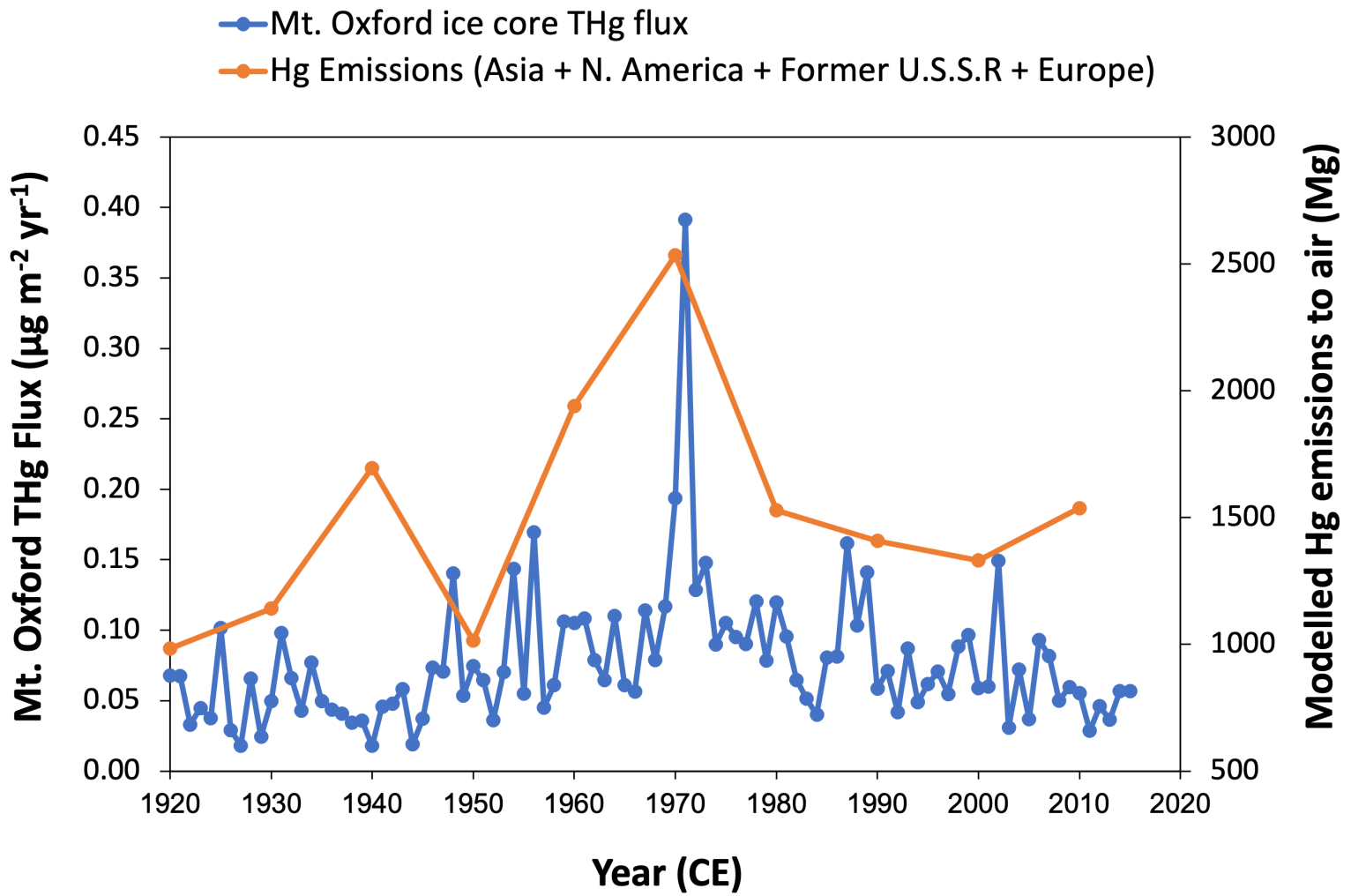
THg:

- No evidence of any long-term increases
- Elevated peak in the early 1970s
- Median = 0.81 ng/L

MeHg:

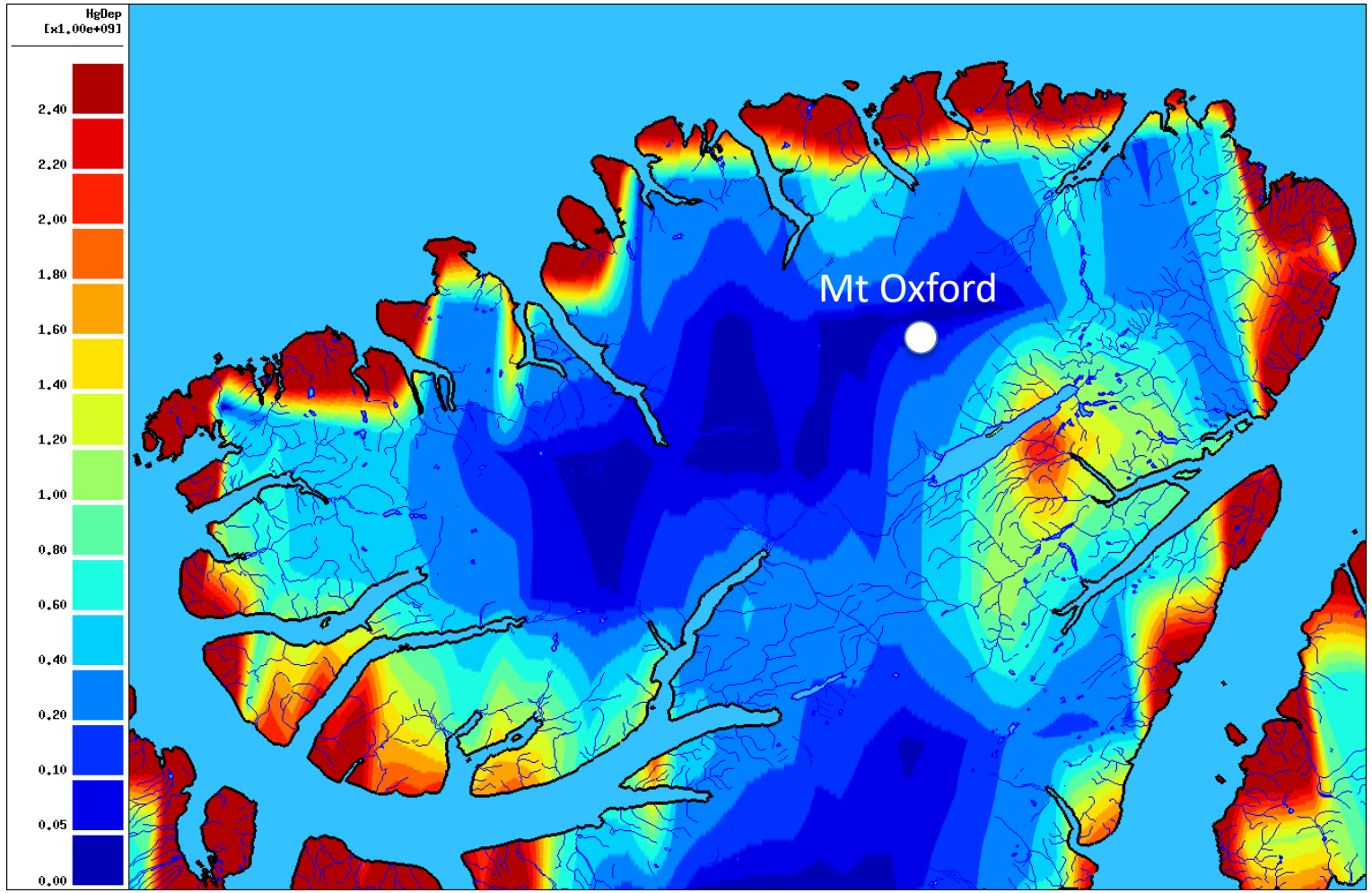
- Only detected in 43% of samples measured
- All elevated concentrations from the same time period (1999-2009)
- Temporal trend does not follow pseudo-first order decay (e.g., due to (photo)demethylation)

Mt. Oxford ice core record of Hg accumulation (1920-2015)



(from Streets et al. 2019)

Present-day modelled Hg deposition
(based on 2015 emissions)



Mt. Oxford (Ice coring site)	Mean Hg deposition (mg m^{-2} y^{-1}; ± Std Dev)
Ice core (2000-2015)	0.061 ± 0.031
Model (2000-2020)	0.071 ± 0.056

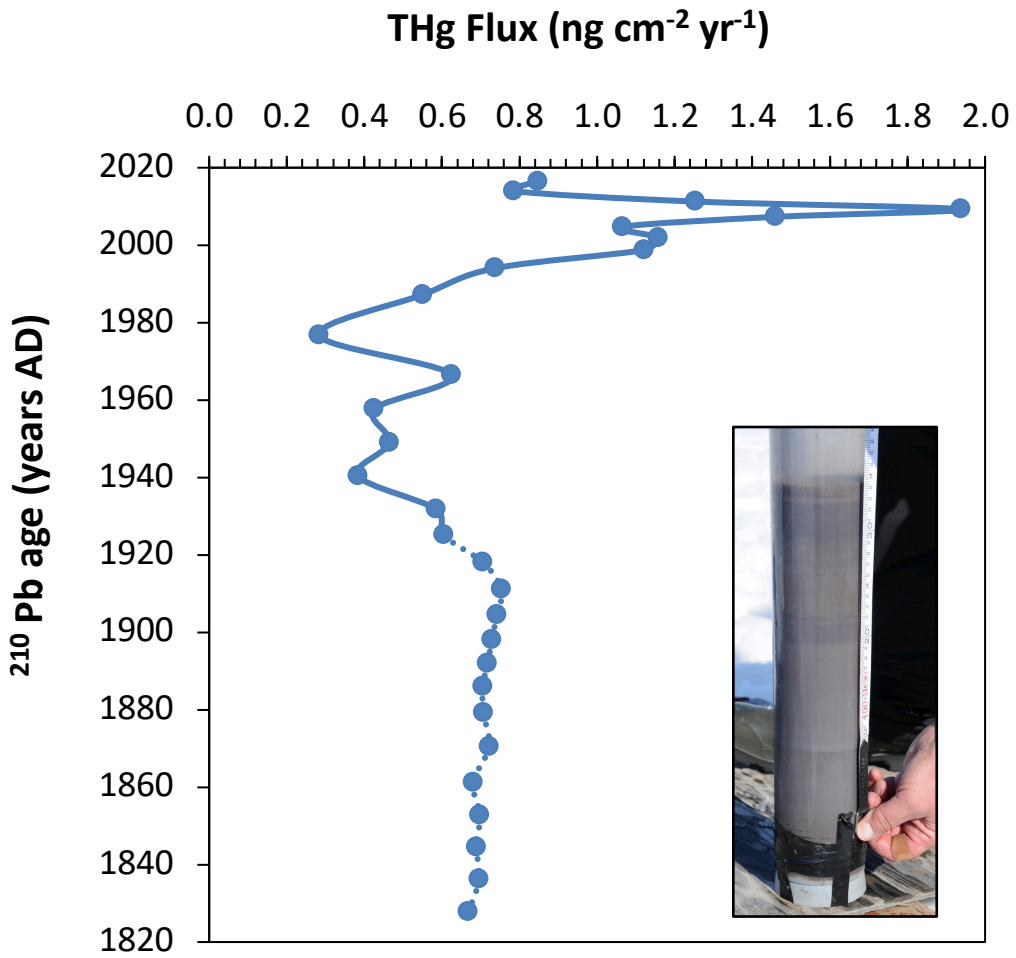
High spatial variability within the watershed:

- Mt. Oxford site and ice-core record not representative of whole-watershed
- Low net deposition at Mt. Oxford due to large re-emission term

Muted temporal signal:

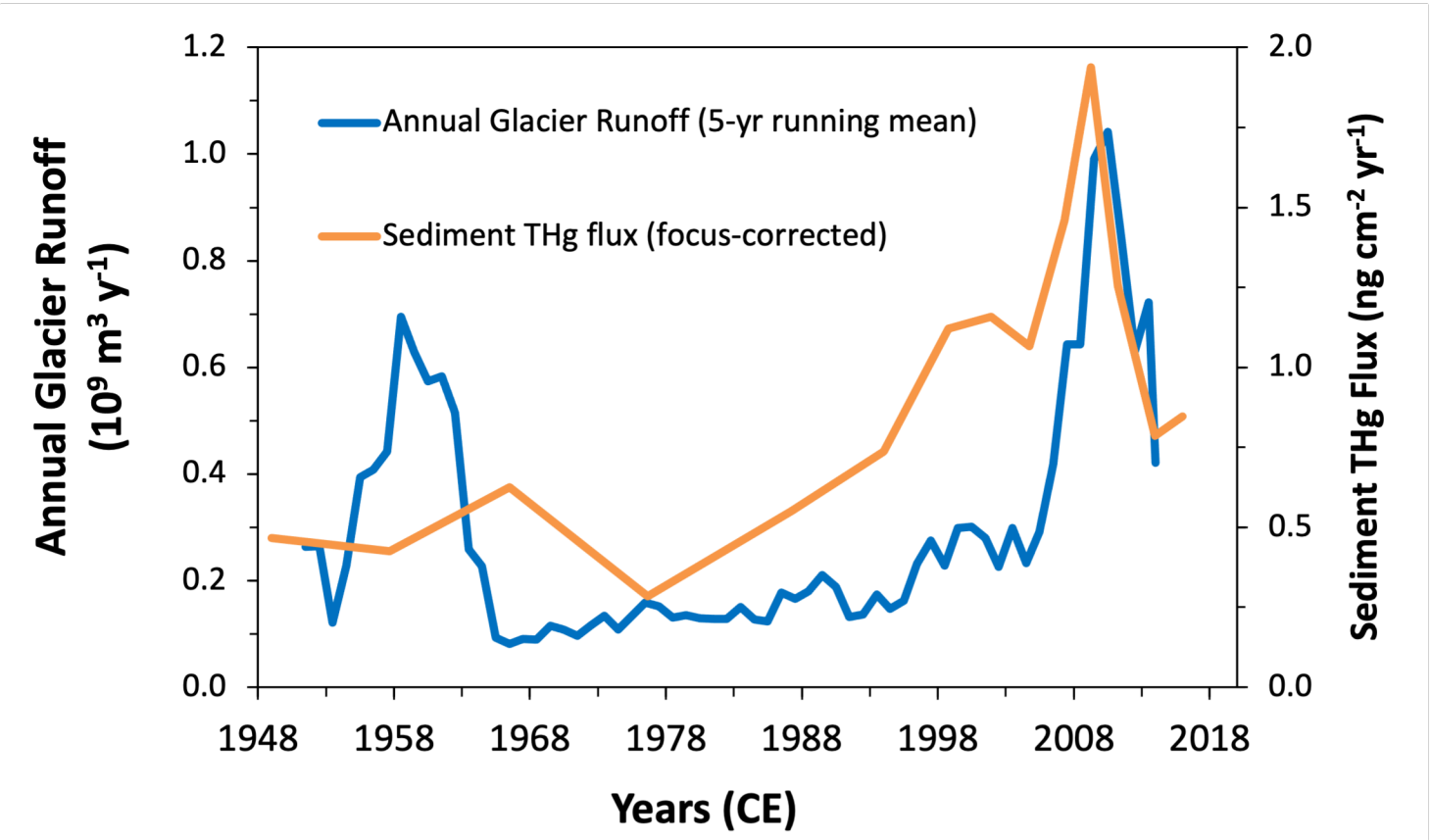
- Modelled Hg deposition suggests 1970 peak only ~20% higher than present

Sediment THg flux in Lake Hazen



- 4-fold increase between baseline of 1925-1994 and peak in 2009
- Site near major glacial river inflows had higher THg accumulation rates and 10x increase between baseline and peak
- Increase not synchronous with trends in emissions

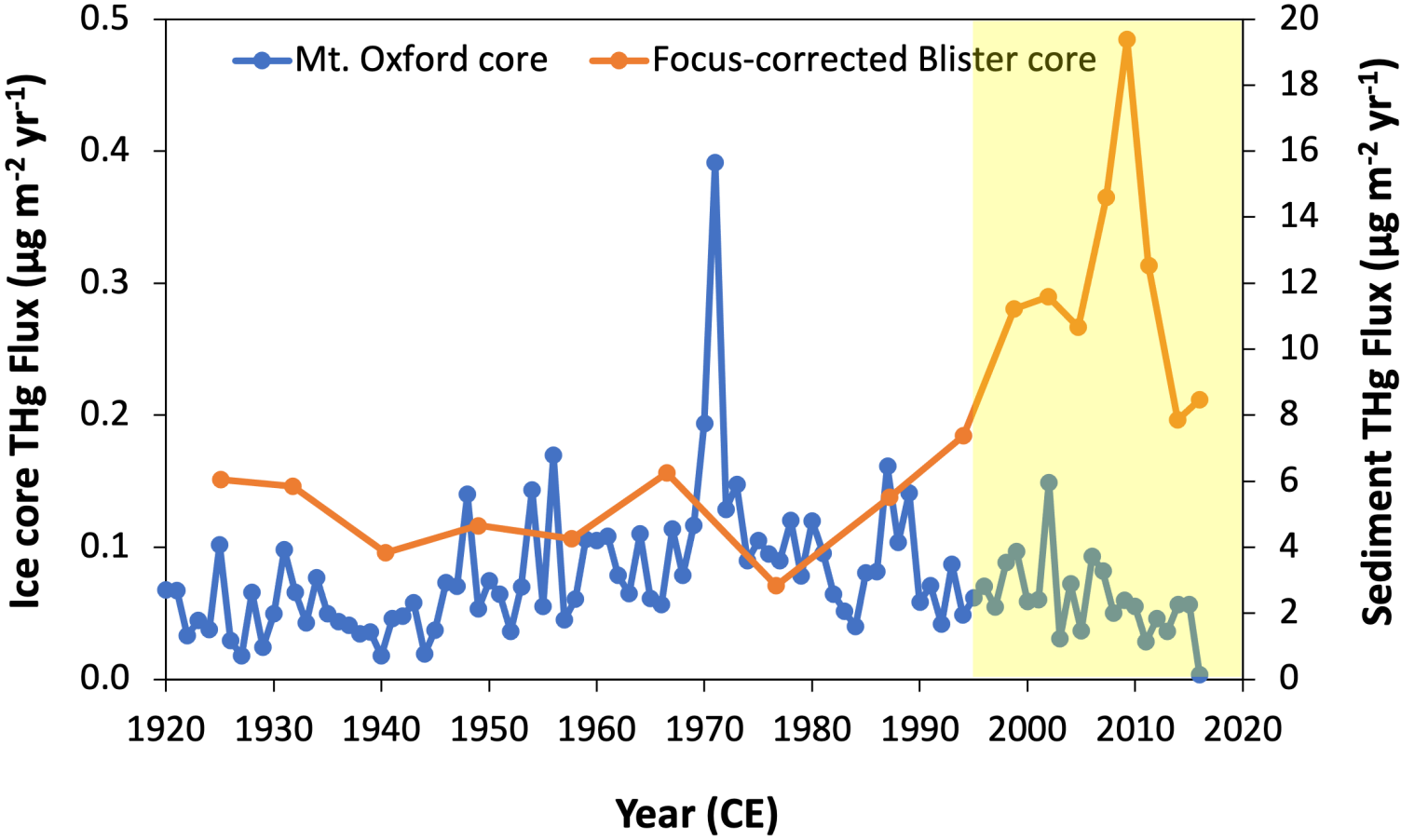
Climate change is primary driver of increased Hg Inputs into Lake Hazen



THg flux in sediment driven by increased glacial runoff

- Increased runoff = increased remobilization of terrestrial particulate-Hg (from soil/sediment) via glacial rivers
- Hg sources: erosion of riverbanks and deltas, thaw slumps along river valleys
- High particulate-Hg concentrations in glacial rivers (up to ~30 ng L^{-1})

Sediment record decoupled from atmospheric Hg inputs beginning in the 1990s



Increase in sediment Hg flux:

- Not driven by increasing atmospheric Hg deposition
- Driven by increased contribution of remobilized Hg from catchment sources

Significance

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

Thank you!

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Abstract

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