Traceable Climate Change and its Impact on the Finger Lakes region of New York: Early Interpretations and Potential Consequences on Long-Term Biogeochemical Cycles.

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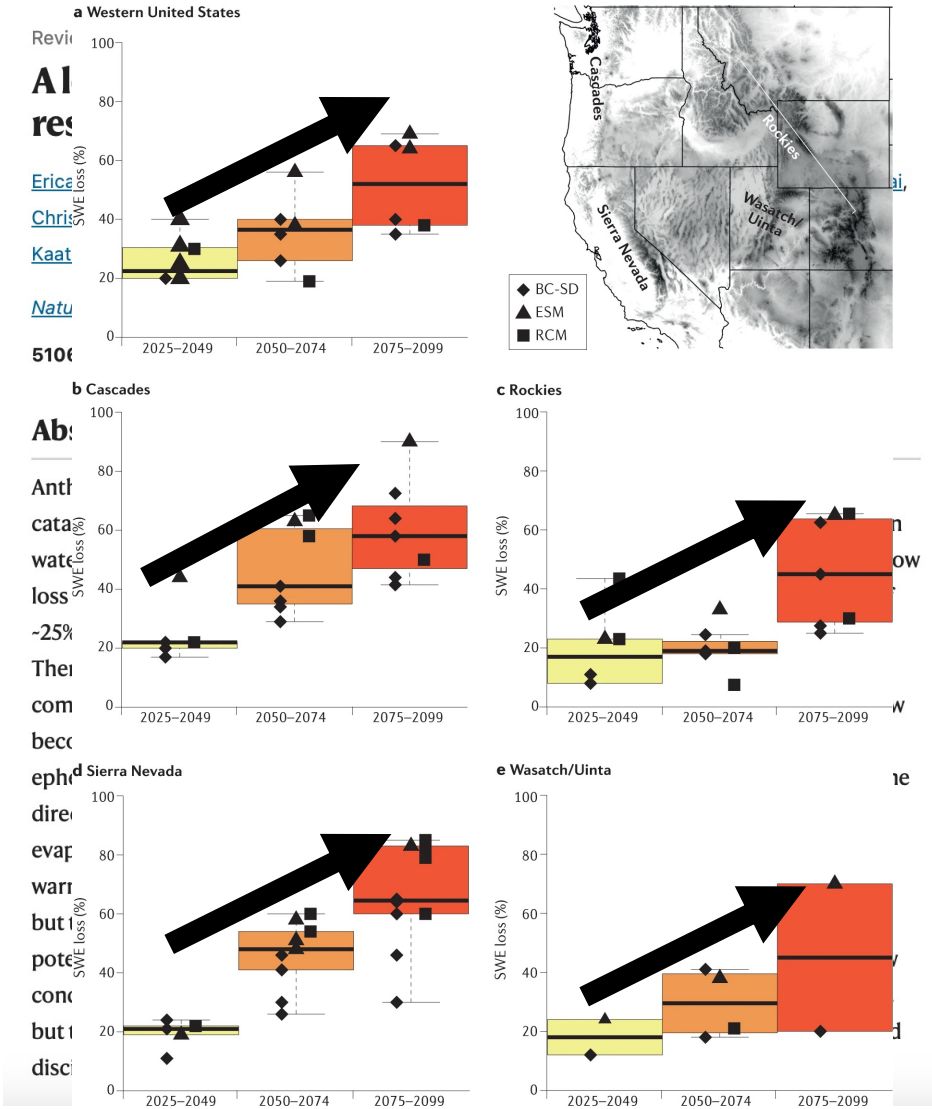
Cornell University

- Montane Environments are expected to see less snow and more rain as global temperatures rise
- This trend is prominent in the Western United States where snowlines have been rising
- As a result, the hydraulic budget of these watersheds are shifting to being more rain dominated than snow dominated



(Siirila-Woodburn *et al.*, 2021)

- The Northeast United States also is seeing a similar transition
  - Extreme precipitation events are increasing in frequency and amounts
  - Total snowfall is decreasing
- However less is known about <u>how sensitive northeastern watersheds are to these transitions</u>

The Washington Post
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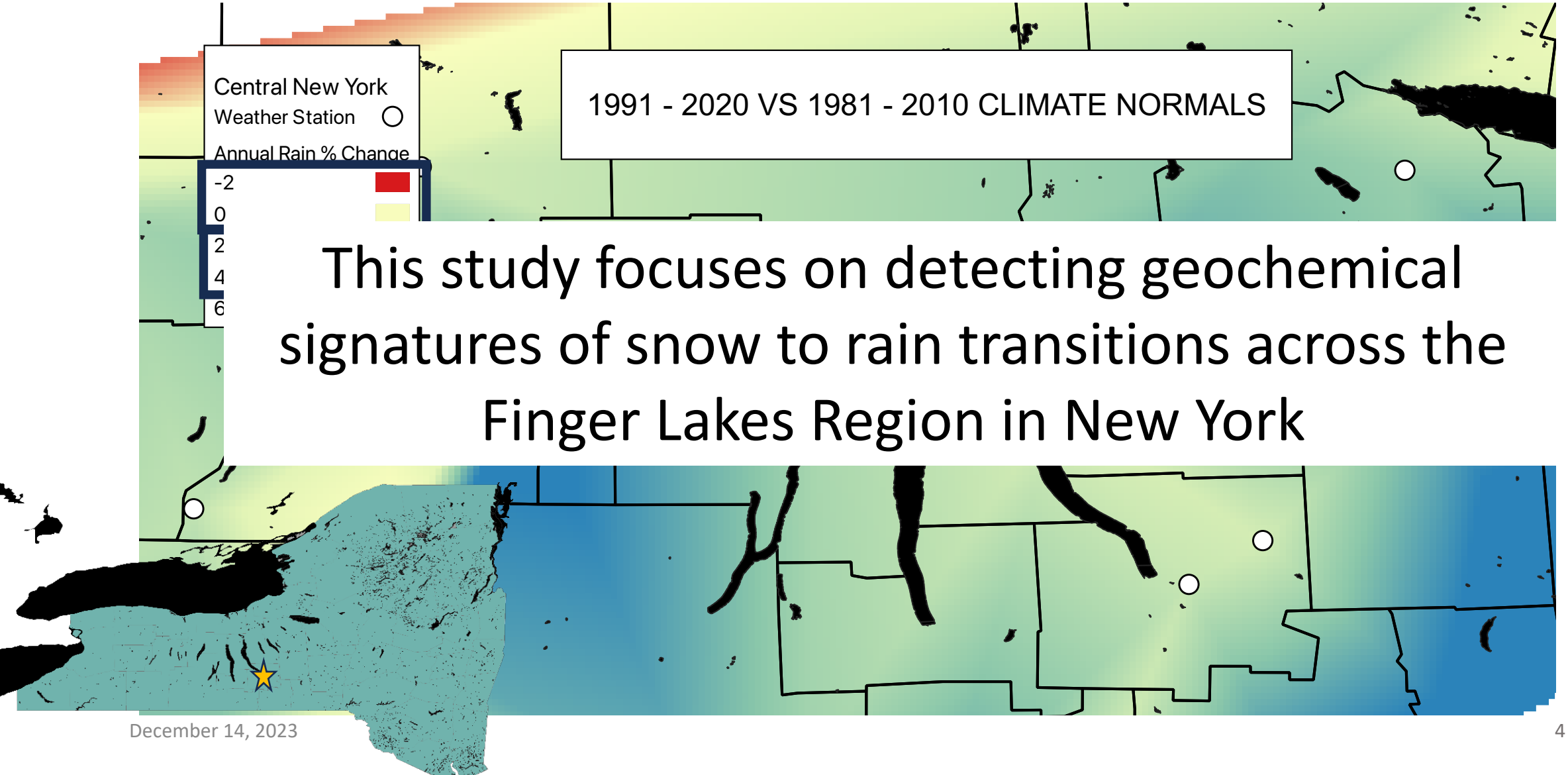
Snowless New York City sets record for lack of accumulation

The Big Apple has never previously gone this deep into winter without measurable snow

By Ian Livingston

January 30, 2023 at 11:44 a.m. EST



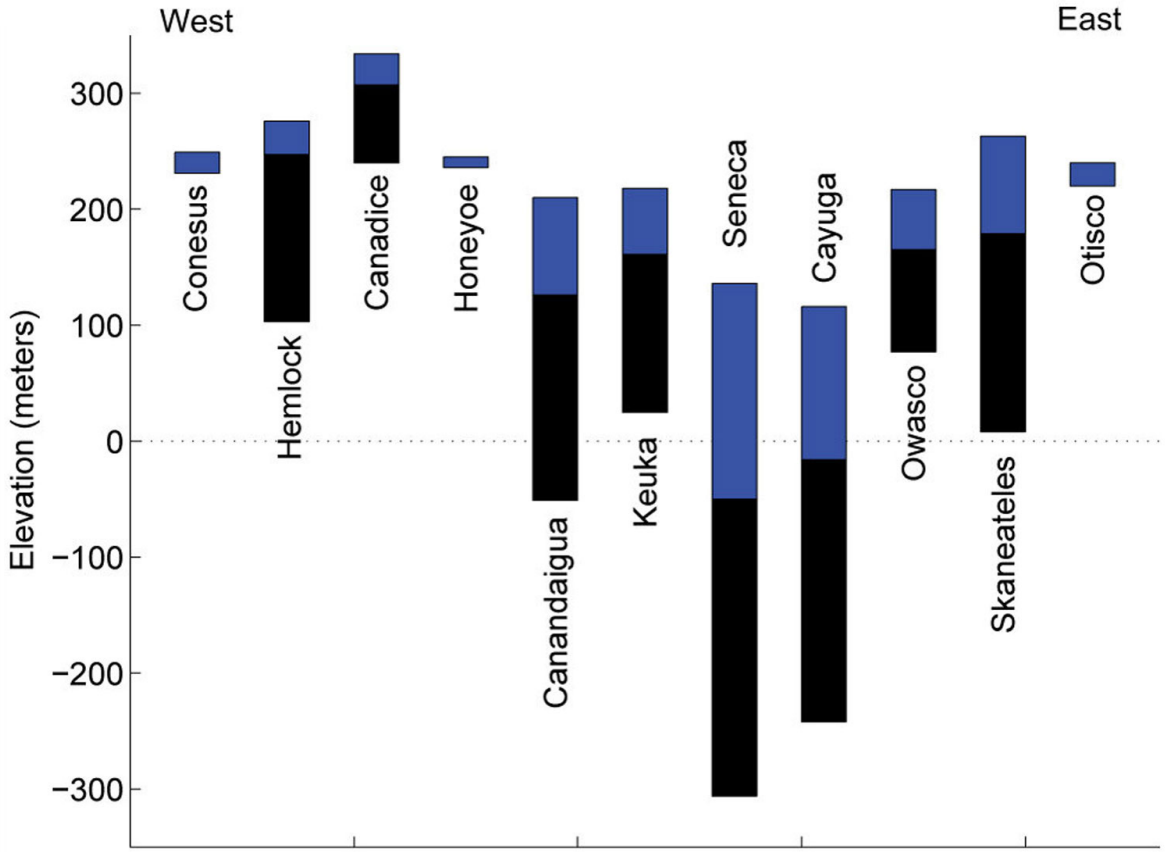
This study focuses on detecting geochemical signatures of snow to rain transitions across the Finger Lakes Region in New York

Aim of Study

Attempt to look at the sensitivity of the Finger Lakes to climate change using 2 basic geochemical tools:

1. Hydrogen ($\delta^{2}H$) and oxygen ($\delta^{18}O$) stable isotopes
2. Concentration-Discharge (C-Q) relationships of tributaries feeding the lakes


Lake Ontario
Rochester
Syracuse
Buffalo
Lake Erie
Conesus Lake
Canadice Lake
Canandaigua Lake
Skaneateles Lake
Otisco Lake
Owasco Lake
Hemlock Lake
Honeoye Lake
Keuka Lake
Seneca Lake
Cayuga Lake
Ithaca
New York
Pennsylvania


West
East
Elevation (meters)
300
200
100
0
−100
−200
−300
Conesus
Hemlock
Canadice
Honeyoe
Canandaigua
Keuka
Seneca
Cayuga
Owasco
Skaneateles
Otisco


Lake Ontario
Rochester
Skaneateles Lake
Syracuse
Canandaigua Lake
Conesus Lake
Canadice Lake
Buffalo
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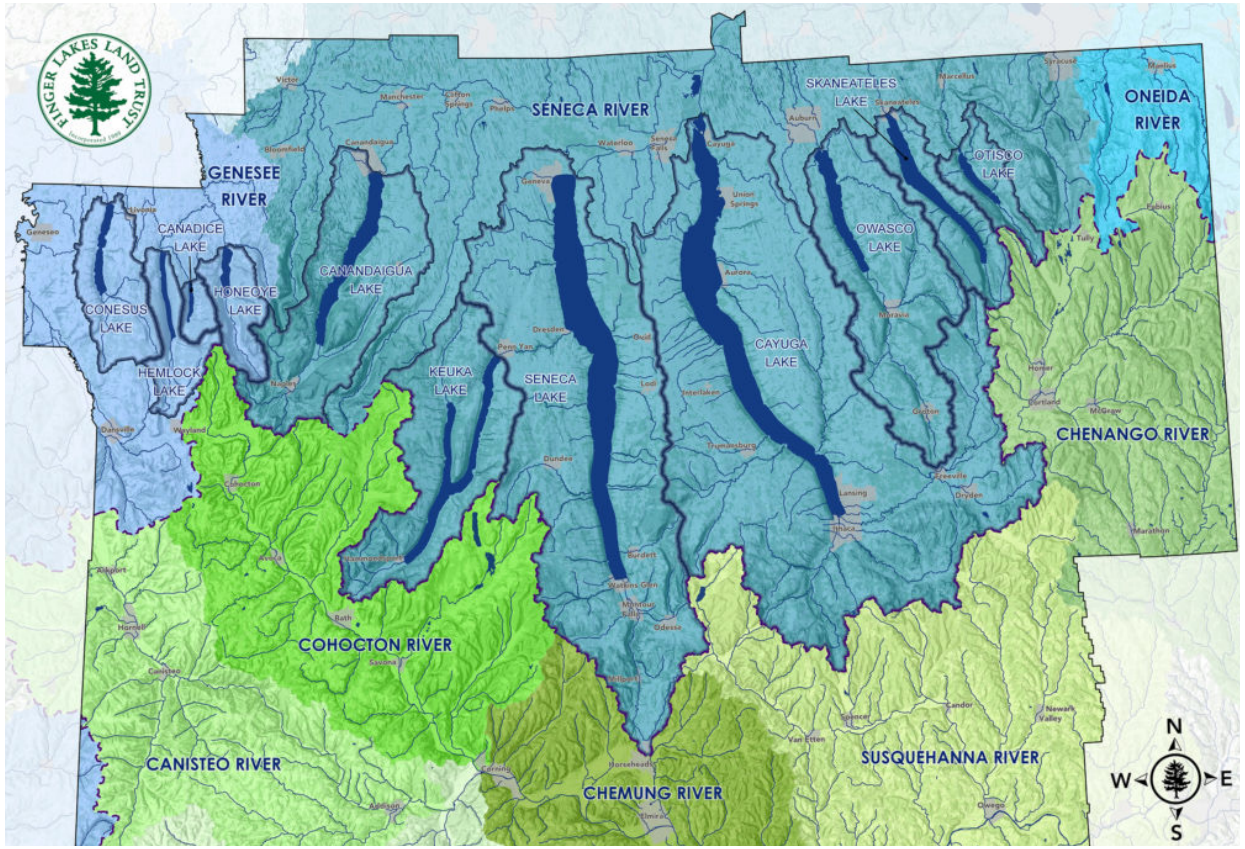
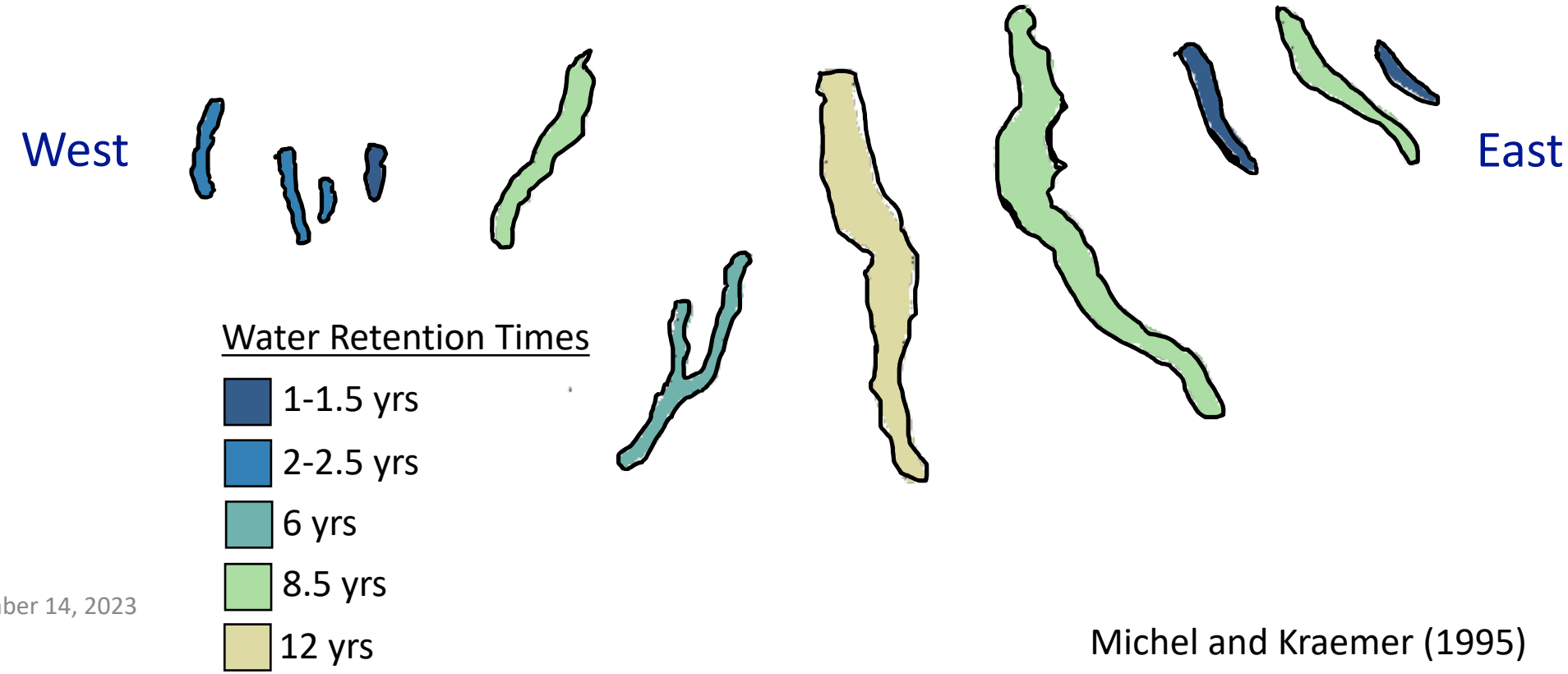
Ithaca
Keuka Lake
Cayuga Lake
Seneca Lake
New York
Pennsylvania


FINGER LAKES LAND TRUST
SENECA RIVER
SKANEATELES LAKE
ONEIDA RIVER
GENESEE RIVER
OTISCO LAKE
CANADICE LAKE
OWASCO LAKE
CANANDAIGUA LAKE
HONEOYE LAKE
CONESUS LAKE
CAYUGA LAKE
HEMLOCK LAKE
KEUKA LAKE
SENECA LAKE
CHENANGO RIVER
COHOCTON RIVER
CANISTEO RIVER
SUSQUEHANNA RIVER
CHEMUNG RIVER
N
W
E
S

- Tritium analysis by Michel and Kraemer (1995), and USGS data suggests the lakes hold water for short periods of time.
- The water in the lakes today should be different than in 1991



Michel and Kraemer (1995)

- δ^2H and $\delta^{18}O$ are commonly used as tracers in hydrology.
- Both δ^2H and $\delta^{18}O$ are linearly related in global precipitation
  - Forming what is called the '*Global Meteoric Water Line*'
  - δ^2H and $\delta^{18}O$ show sensitivities to temperature, evaporation, and precipitation type
- Generally, an increase in δ^2H and $\delta^{18}O$ values mean more Deuterium, and Oxygen-18

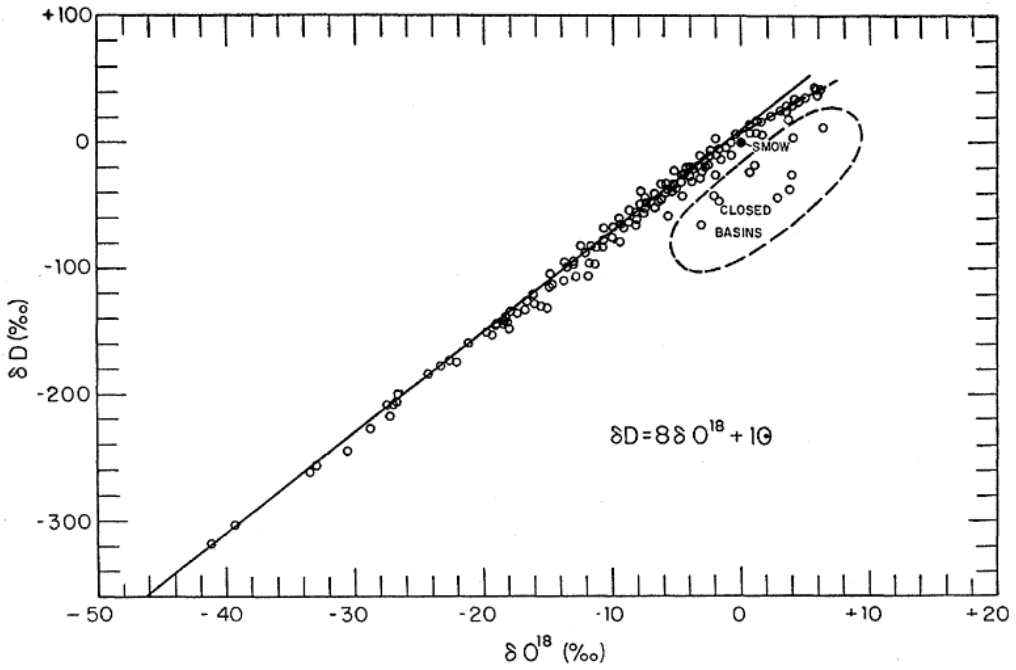
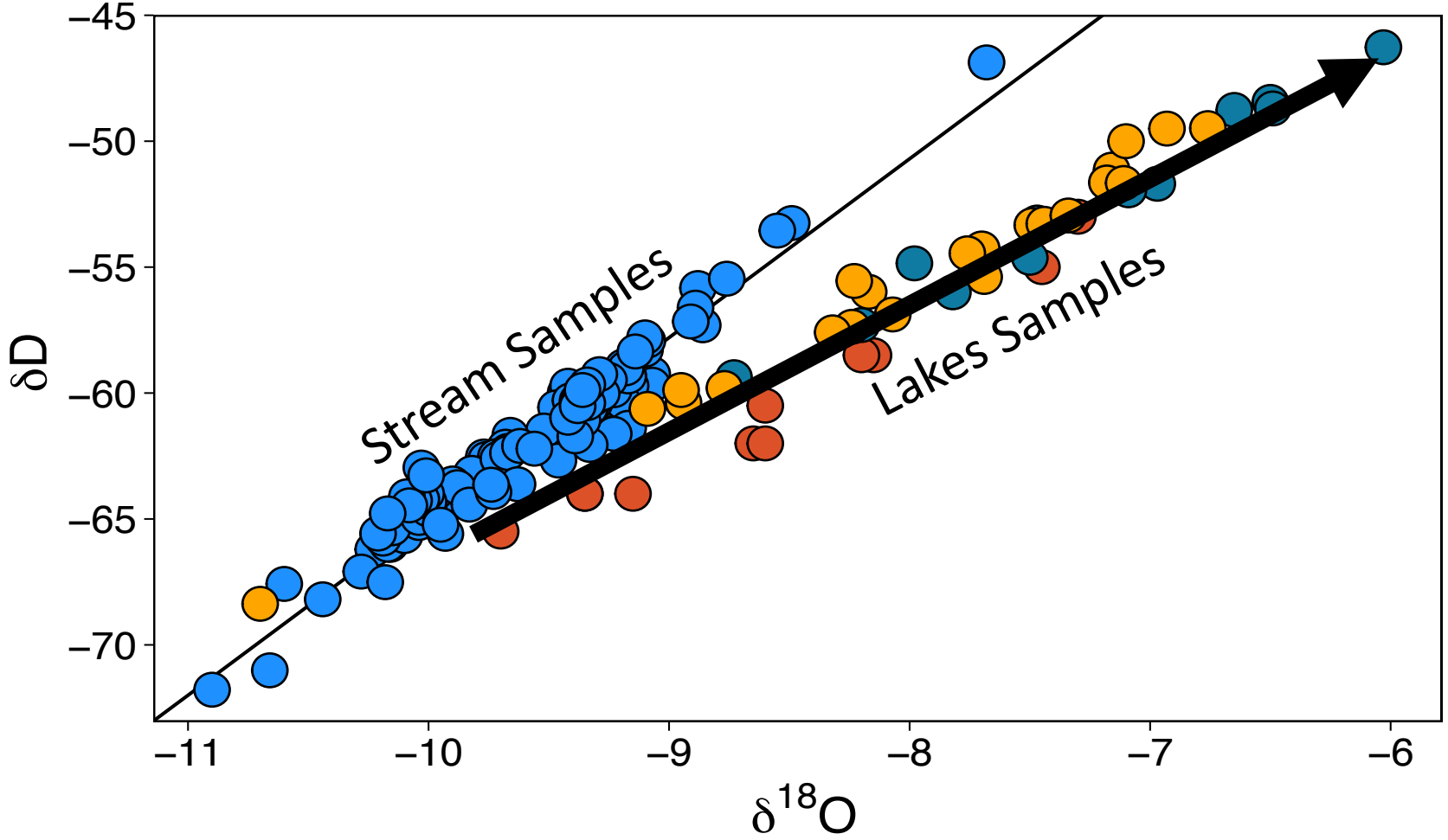
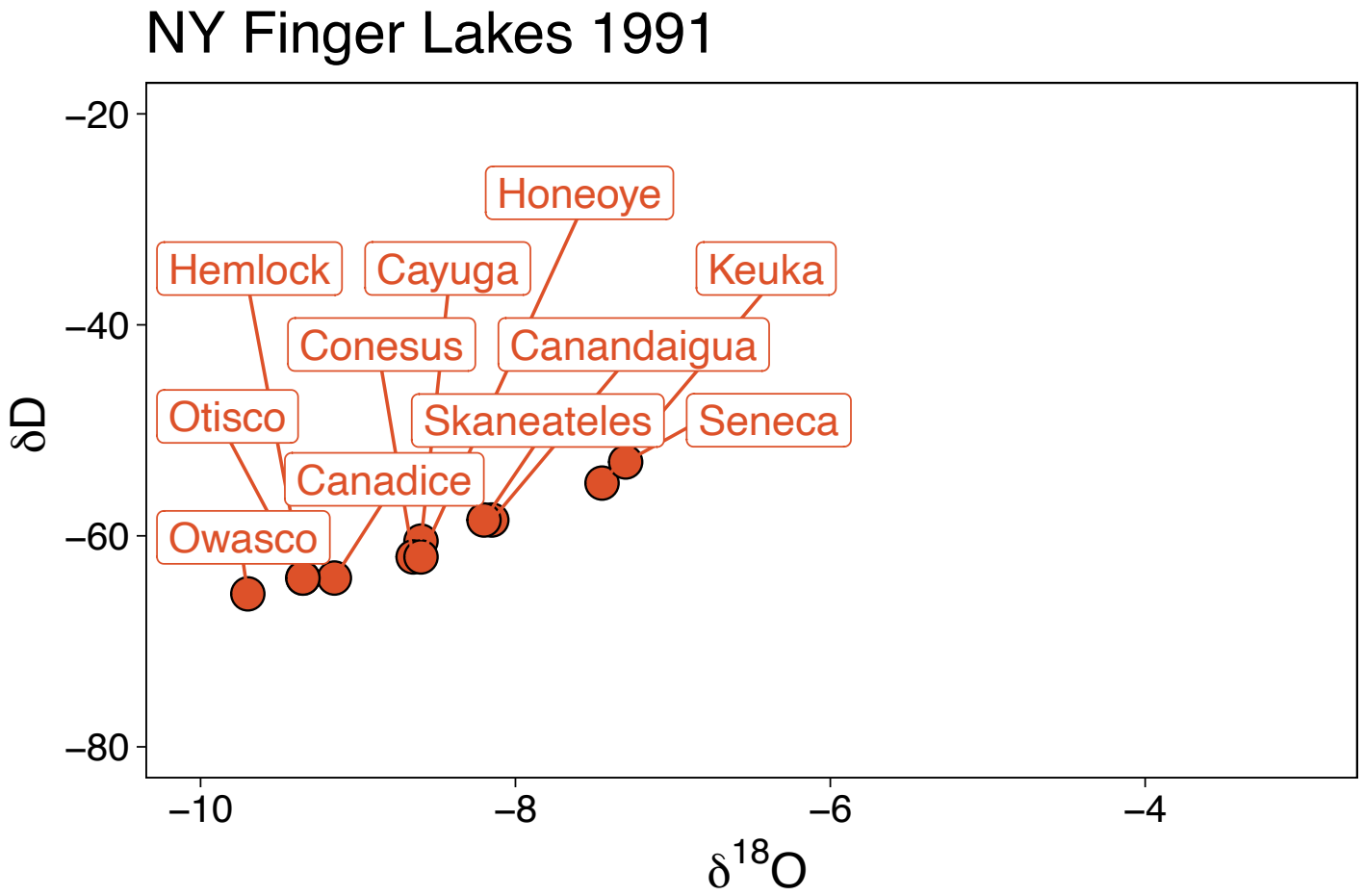


Fig. 1. Deuterium and oxygen-18 variations in rivers, lakes, rain, and snow, expressed as per millage enrichments relative to "standard mean ocean water" (SMOW). Points which fit the dashed line at upper end of the curve are rivers and lakes from East Africa.

(Craig 1961)


−45
−50
−55
−60
−65
−70
δD
−11
−10
−9
−8
−7
−6
δ18O
Stream Samples
Lakes Samples

Finger Lakes show **enrichment over time** while also exhibiting **inter-seasonal dynamics**



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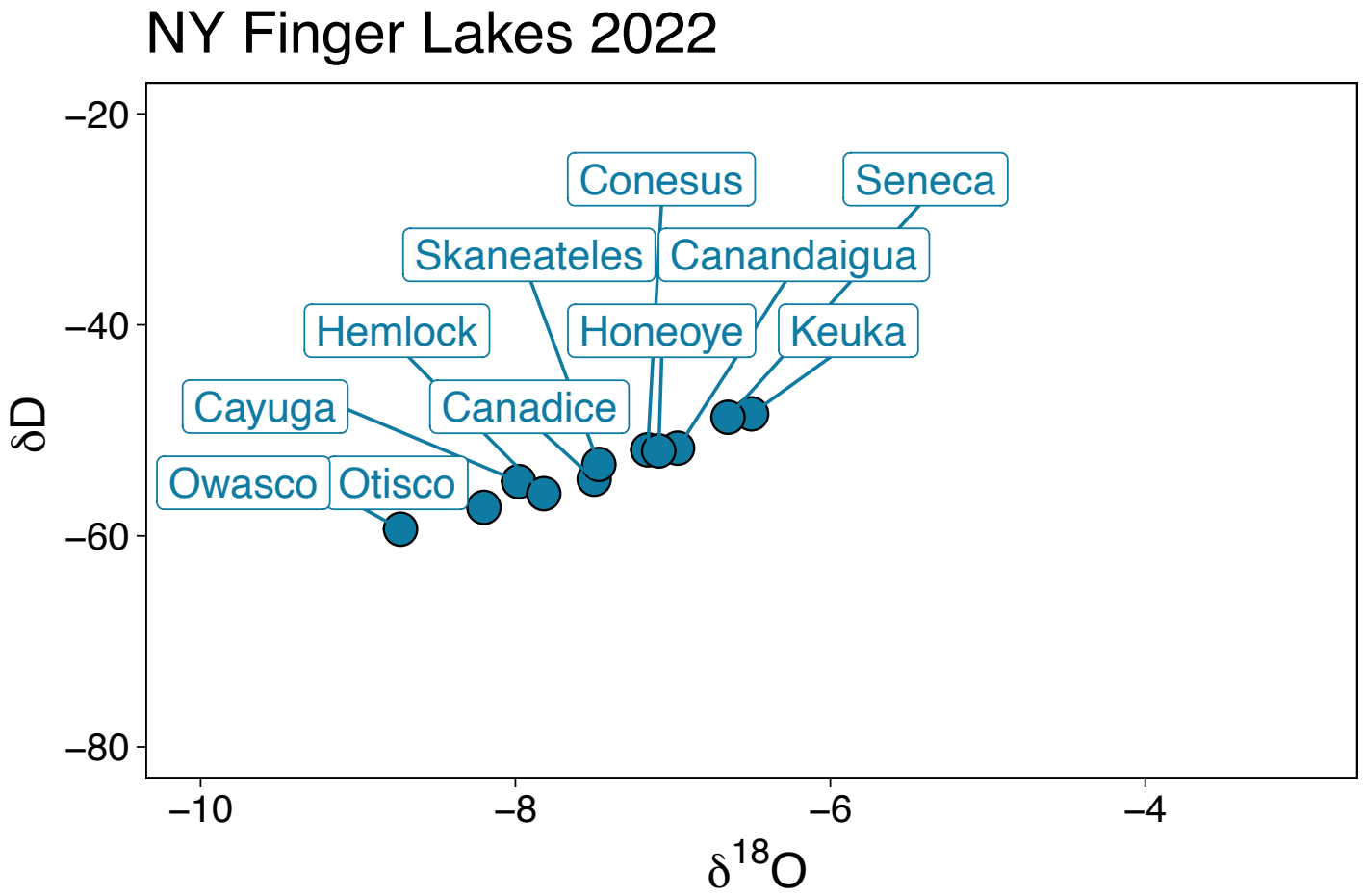

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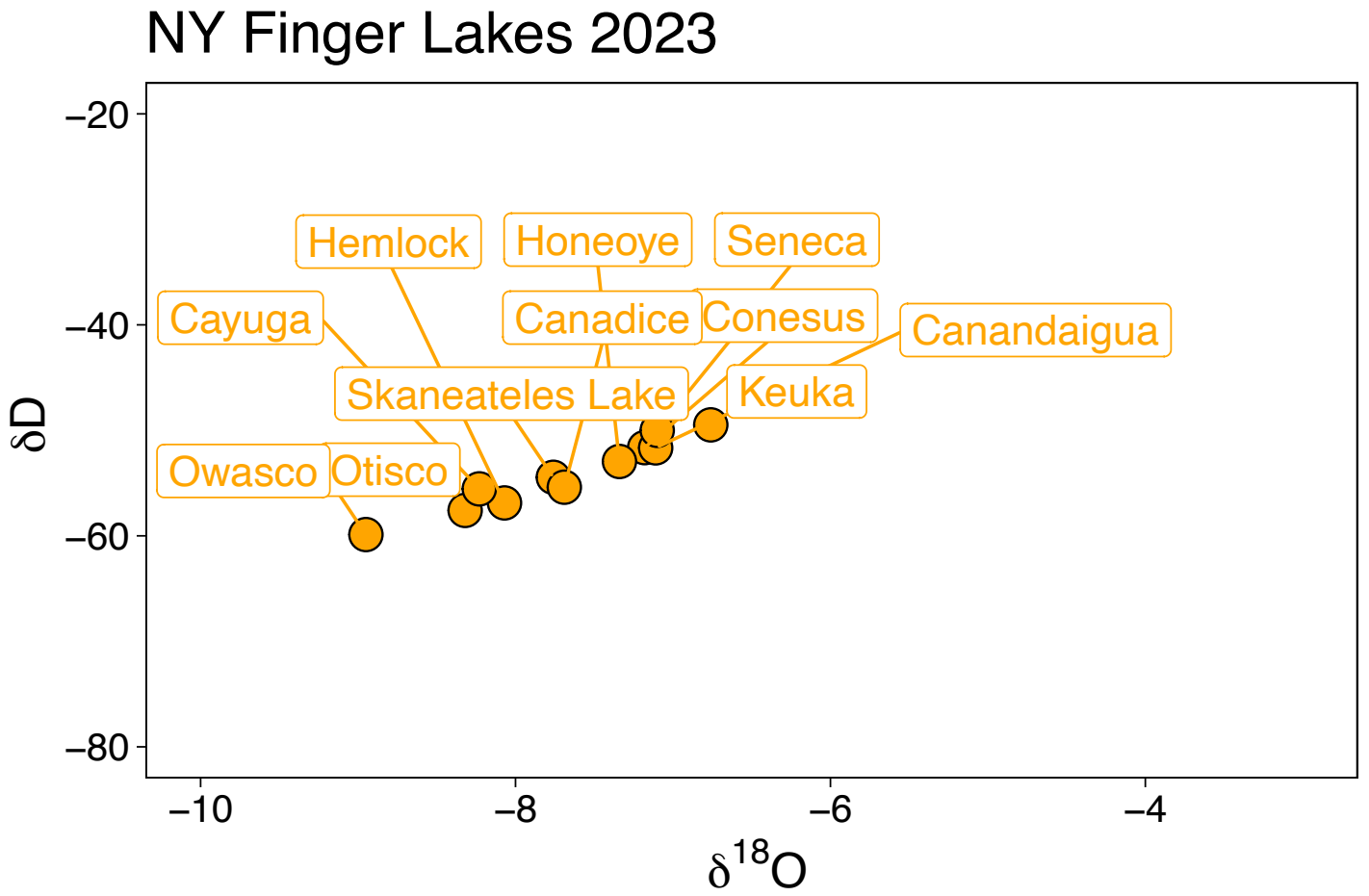
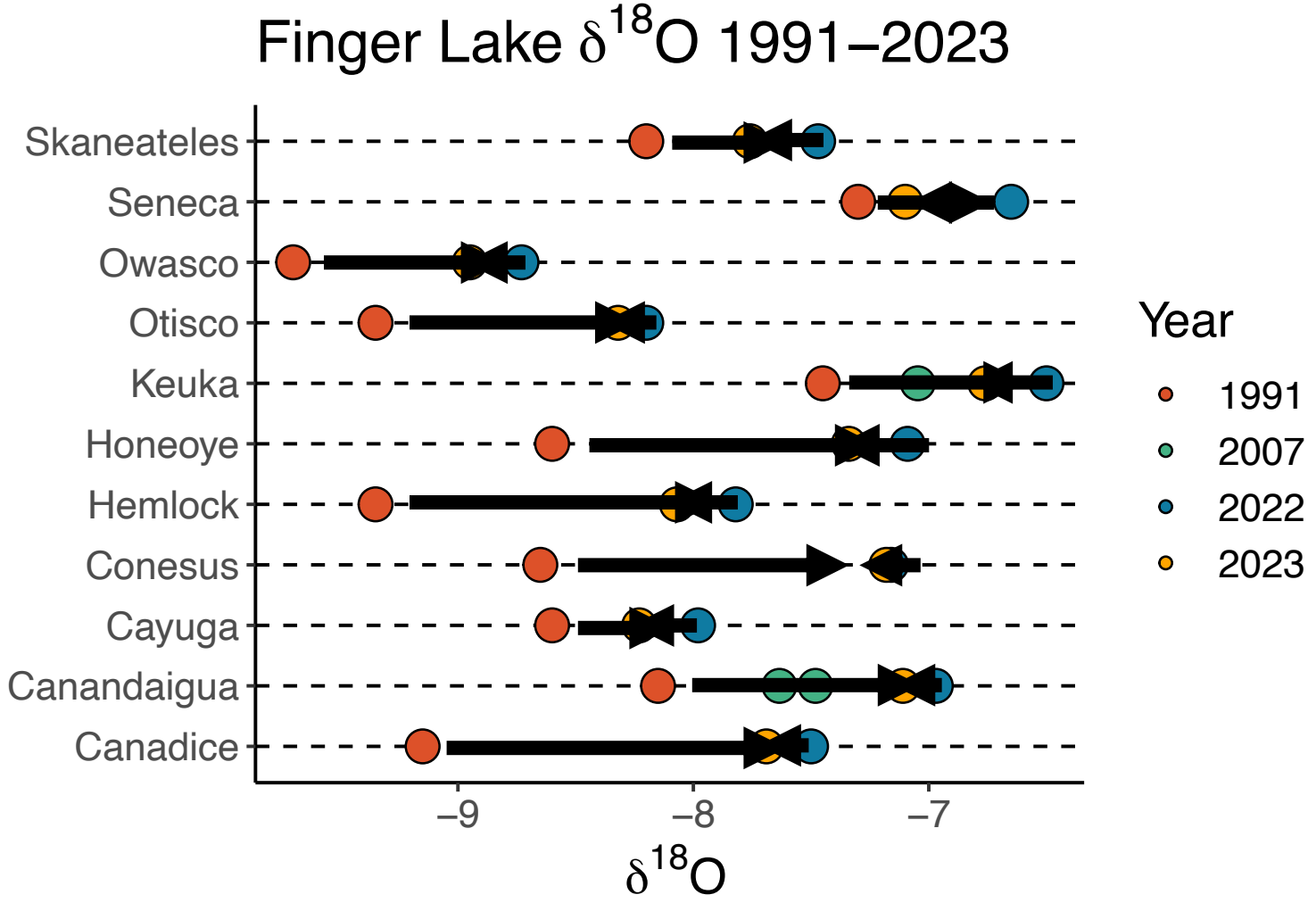
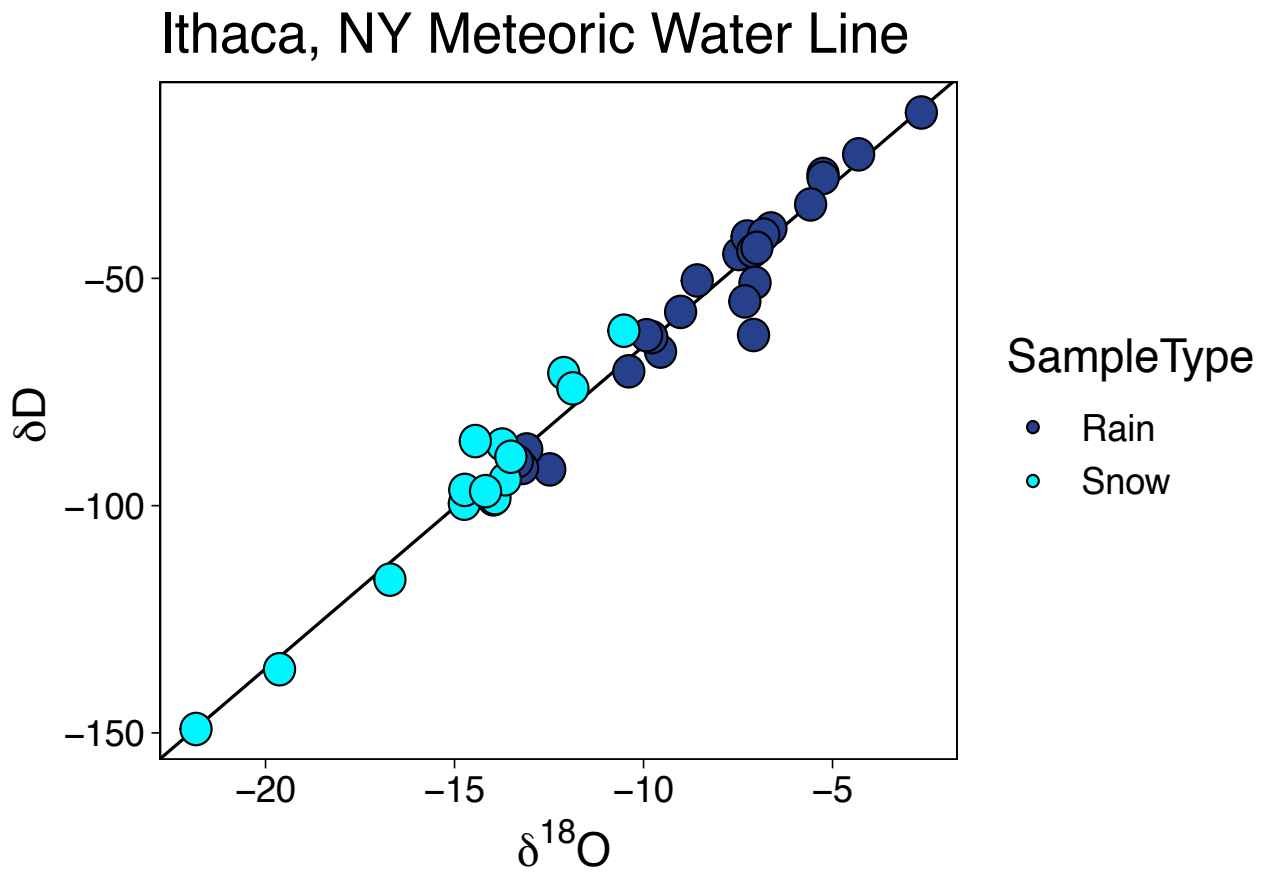
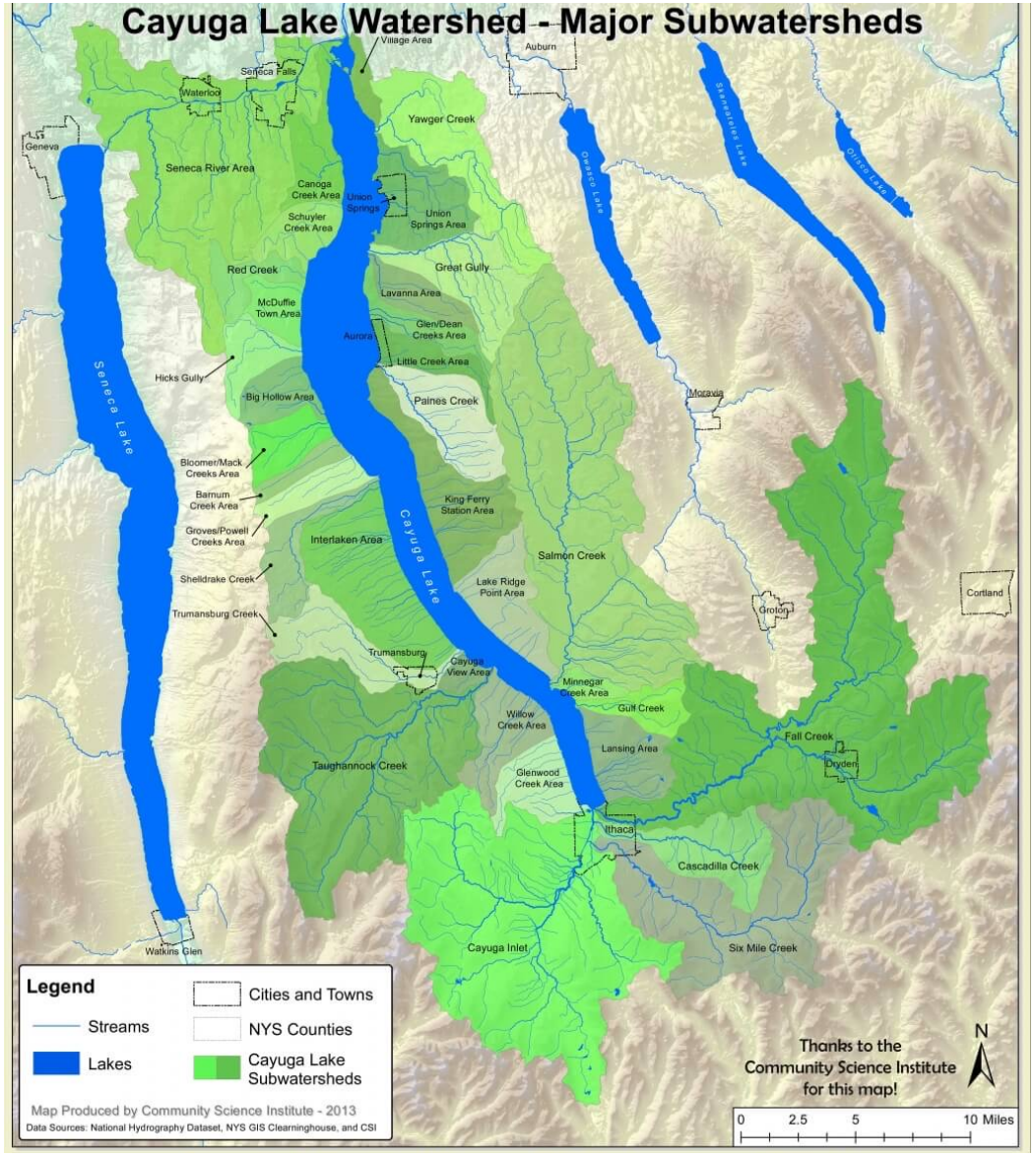



Finger Lake δ18O 1991–2023
Skaneateles
Seneca
Owasco
Otisco
Keuka
Honeoye
Hemlock
Conesus
Cayuga
Canandaigua
Canadice
–9
–8
–7
δ18O
Year
1991
2007
2022
2023

- Rainfall tends to be isotopically heavier than snowfall
- If **rainfall contributes a larger volume of water compared to snowmelt**, we can expect to see tributaries and **lake water to become more enriched** over time
- **Sourcing of snow and rain waters is important** to consider with regards to their isotopic signature, if sourcing of precipitation is changing, so too will their isotopic signatures



- While **δ^2H and $\delta^{18}O$** stable isotopes highlight the **transition of precipitation regimes** in systems with short residence times…
- **C-Q relationships** can highlight how **nutrient loading** is evolving in response to this change!



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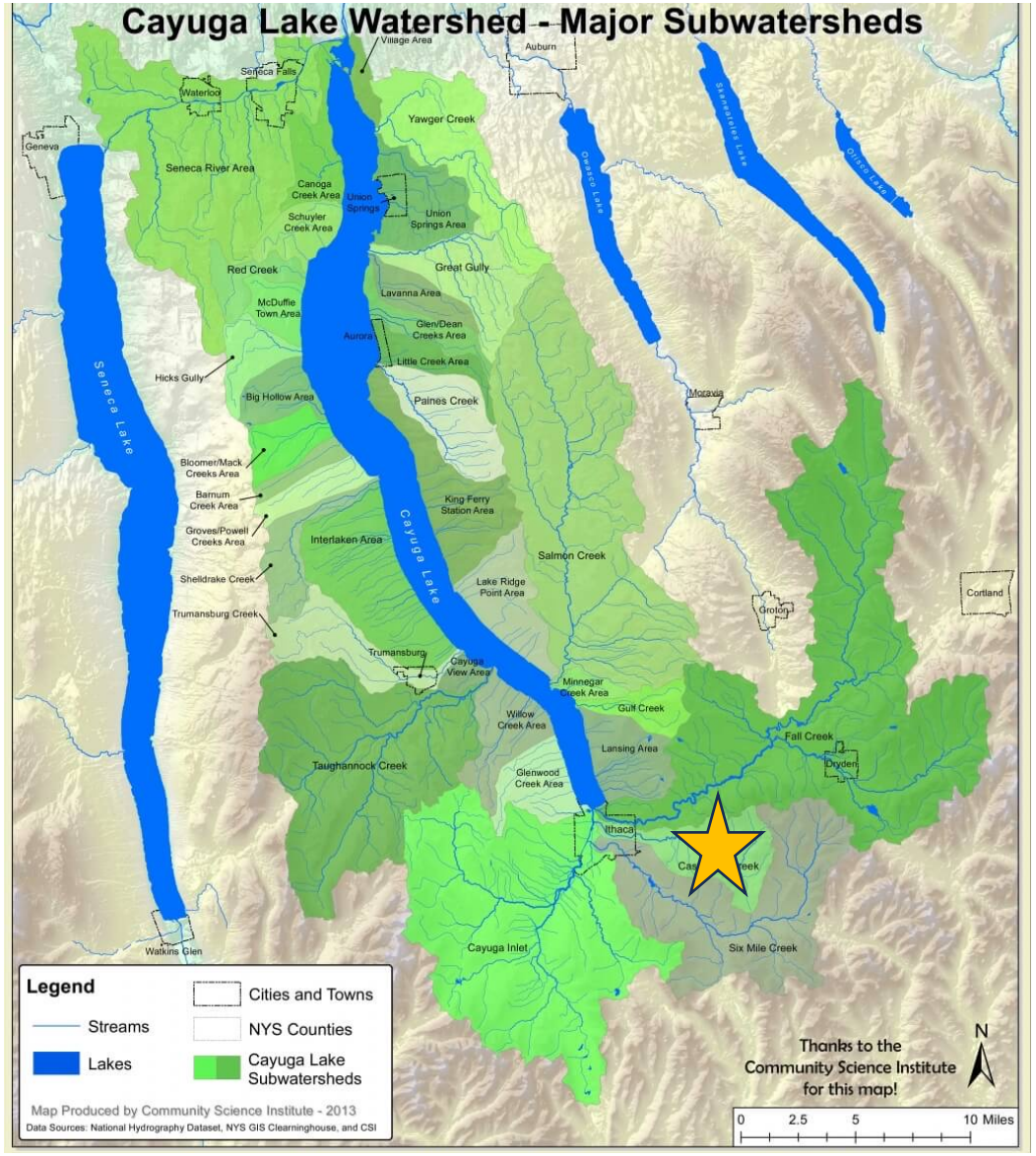
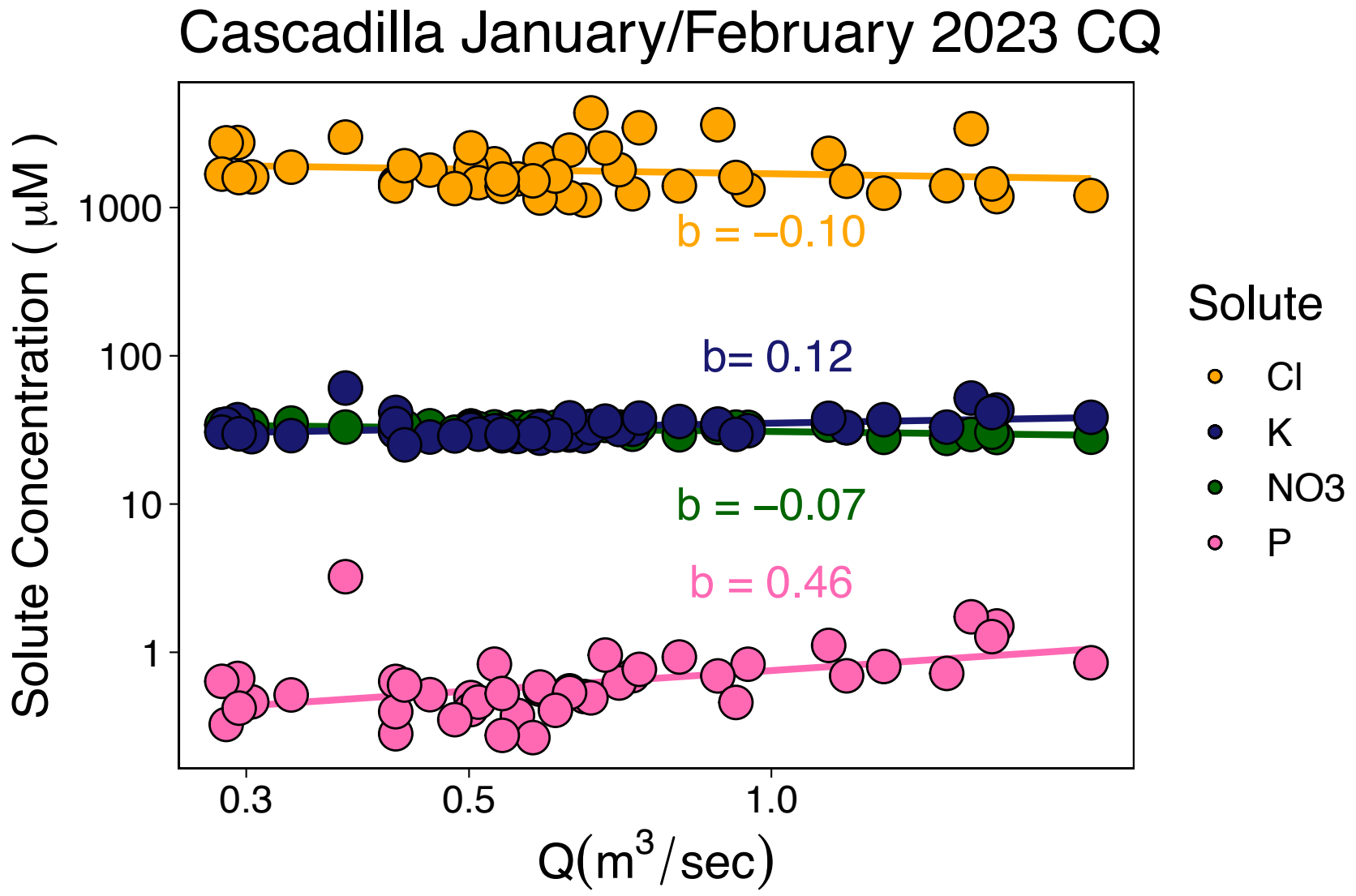
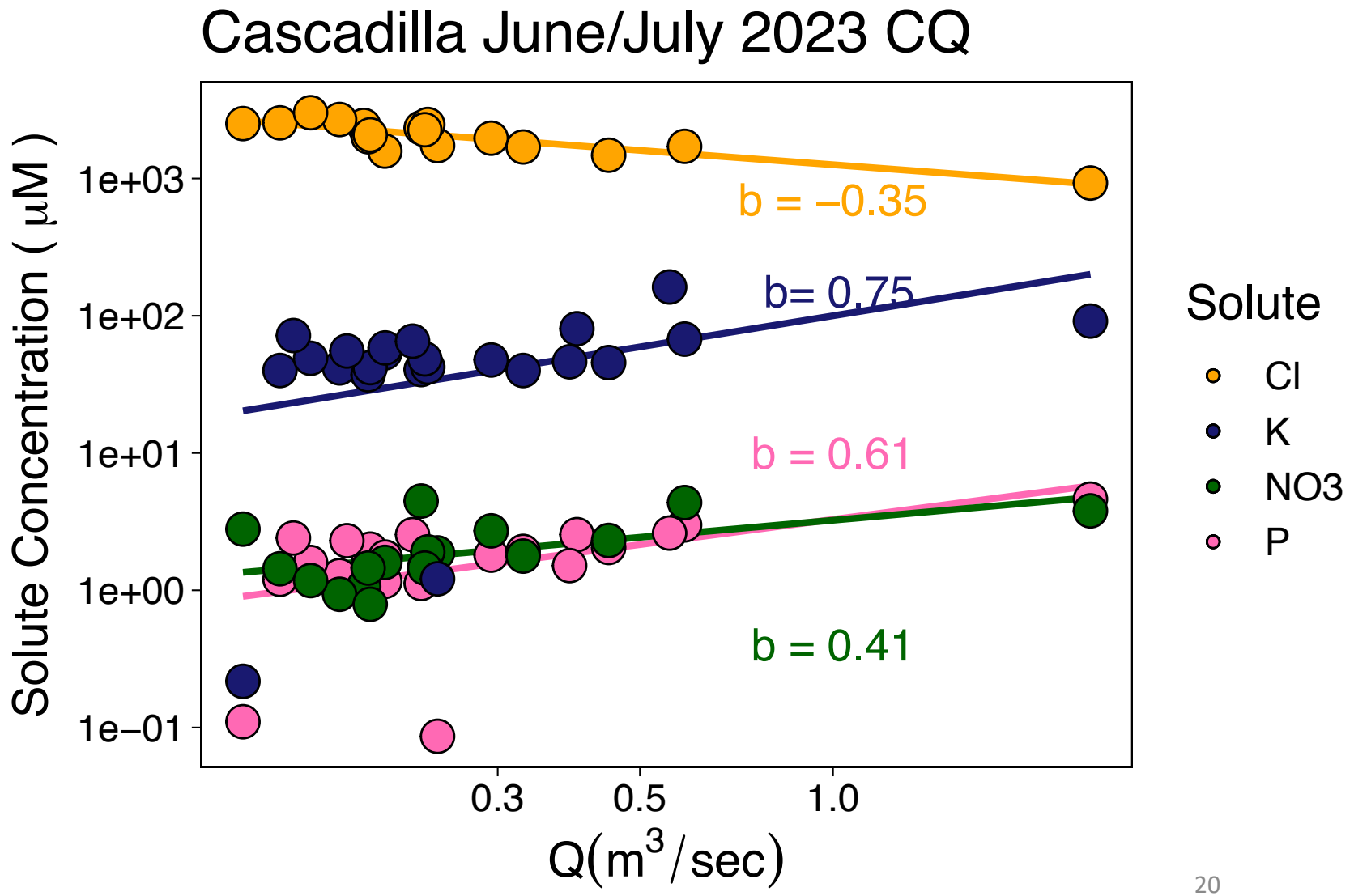


Snow dominated regimes exhibit mostly dilution to chemostatic behavior. While total dissolved P does show flushing behavior



- Rain dominated seasons show flushing behavior across NO3, P, and K
- **As rain becomes more dominant, flushing may increase**



- Future work will work on constraining Snow Water Equivalent (SWE) and volume of rainwater to look at mass balance contributions of isotopes
- Groundwater age dating of tributaries and lakes can provide insight to how changing precipitation regimes affects solute loading and water retention times of the lakes

Thank you!

Key Take Aways

1. Finger Lakes exhibit enrichment over time, that guides long-term trend of seasonal dynamics
2. Watersheds experiencing snow to rain transitions may reflect same long-term enrichment
3. Changing precipitation regimes can increase nutrient loading into lakes over time

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