

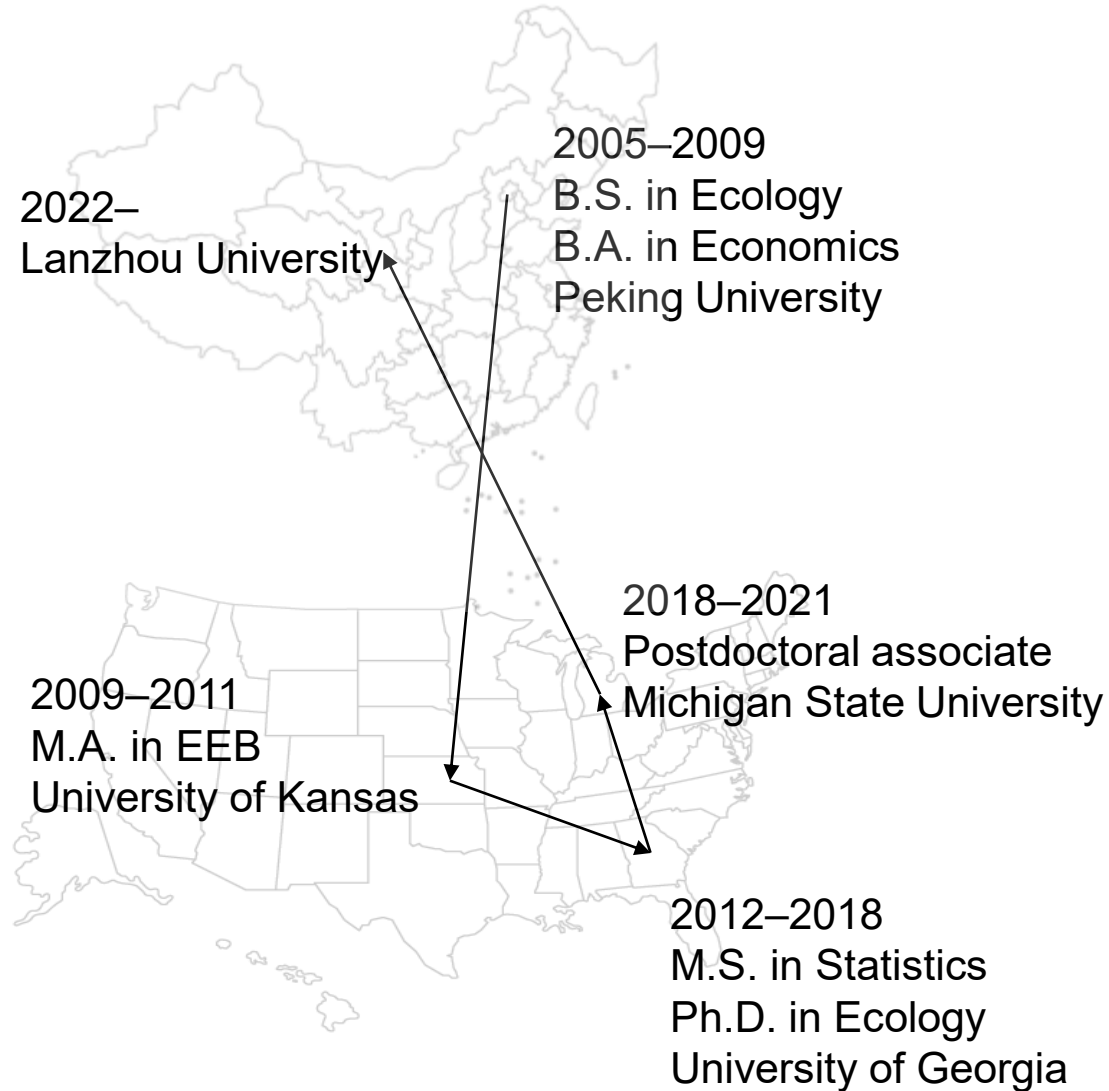
Continental-scale decrease in net ecosystem productivity in streams due to climate warming

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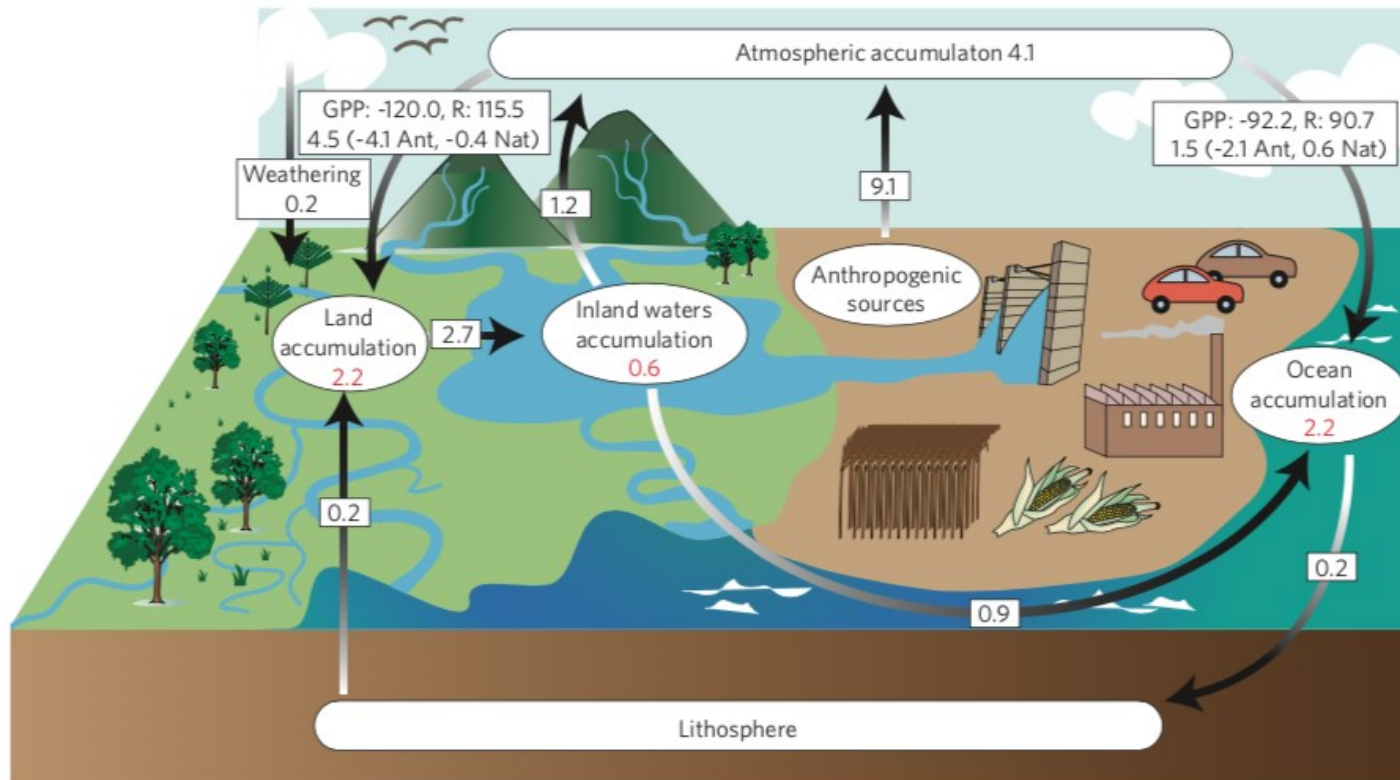
September 1, 2023

My academic background



Rivers in global carbon cycle

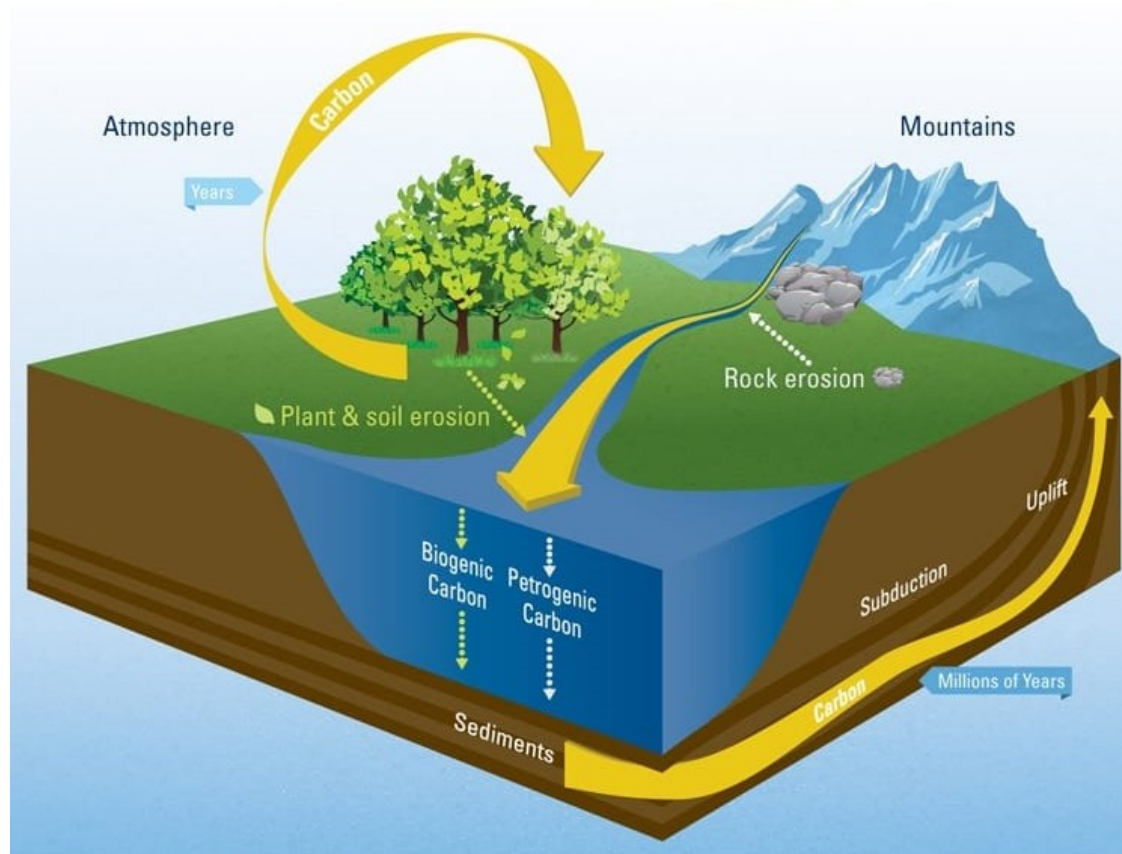
- Carbon cycle in streams and rivers is an integrated part of global carbon cycle.



(Battin et al, 2009, Nature Geoscience)

Rivers in global carbon cycle

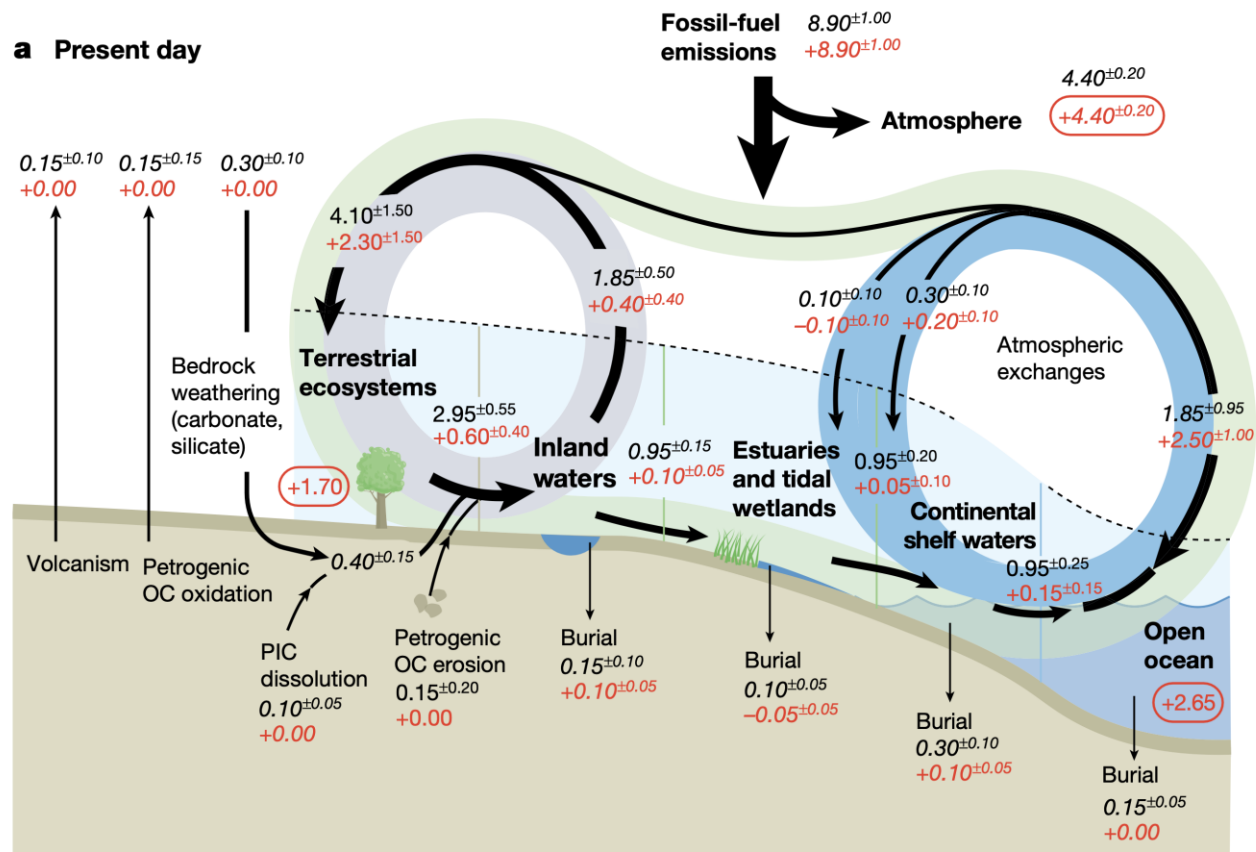
- Riverine carbon cycle connects terrestrial and oceanic systems.



(Illustration by Eric Taylor, Woods Hole Oceanographic Institution)

Rivers in global carbon cycle

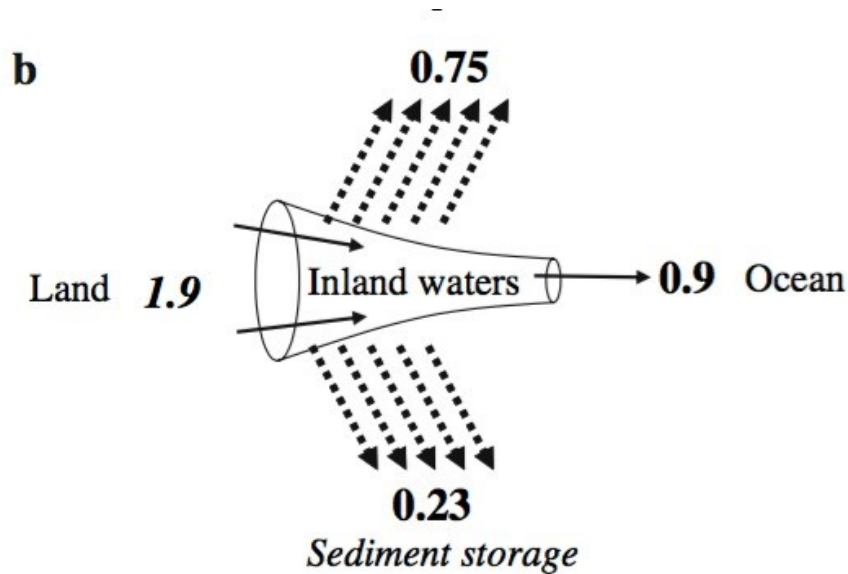
- Accounting for riverine carbon dynamics is critical for accurate global carbon accounting.



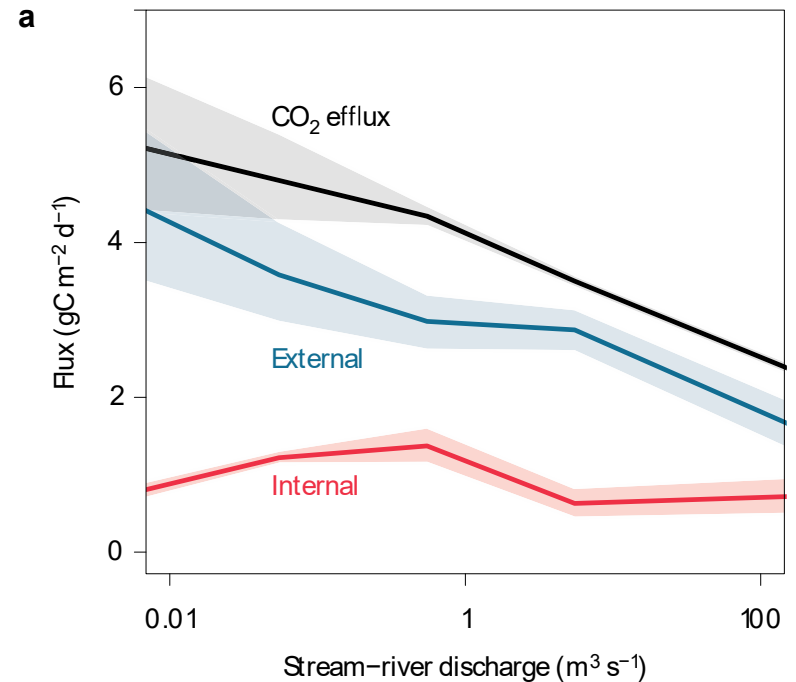
(Regnier et al 2022, Nature)

Stream metabolism in global carbon cycle

- Stream metabolism is a significant component of carbon cycle;

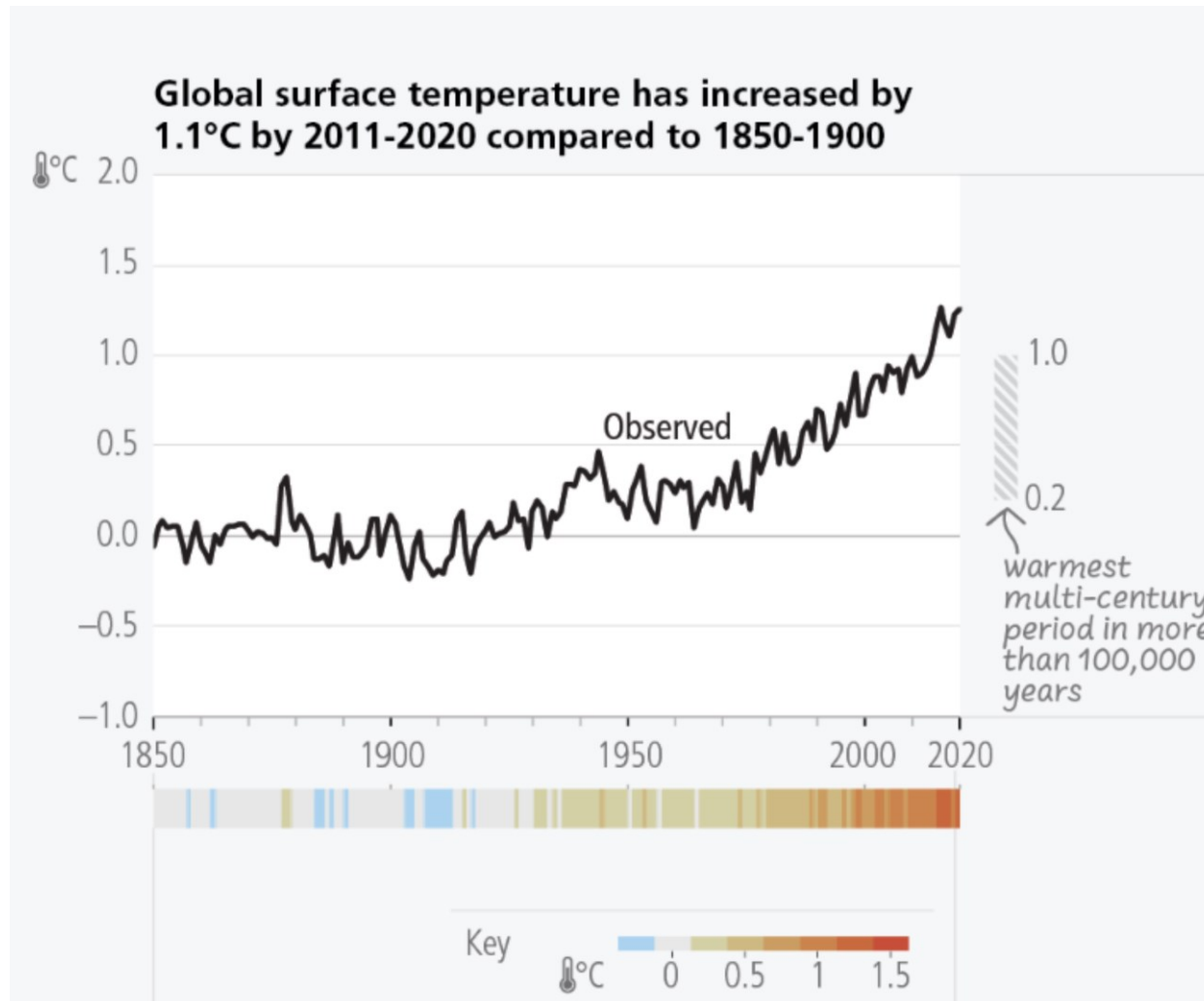


(Cole et al. 2007, Ecosystems)



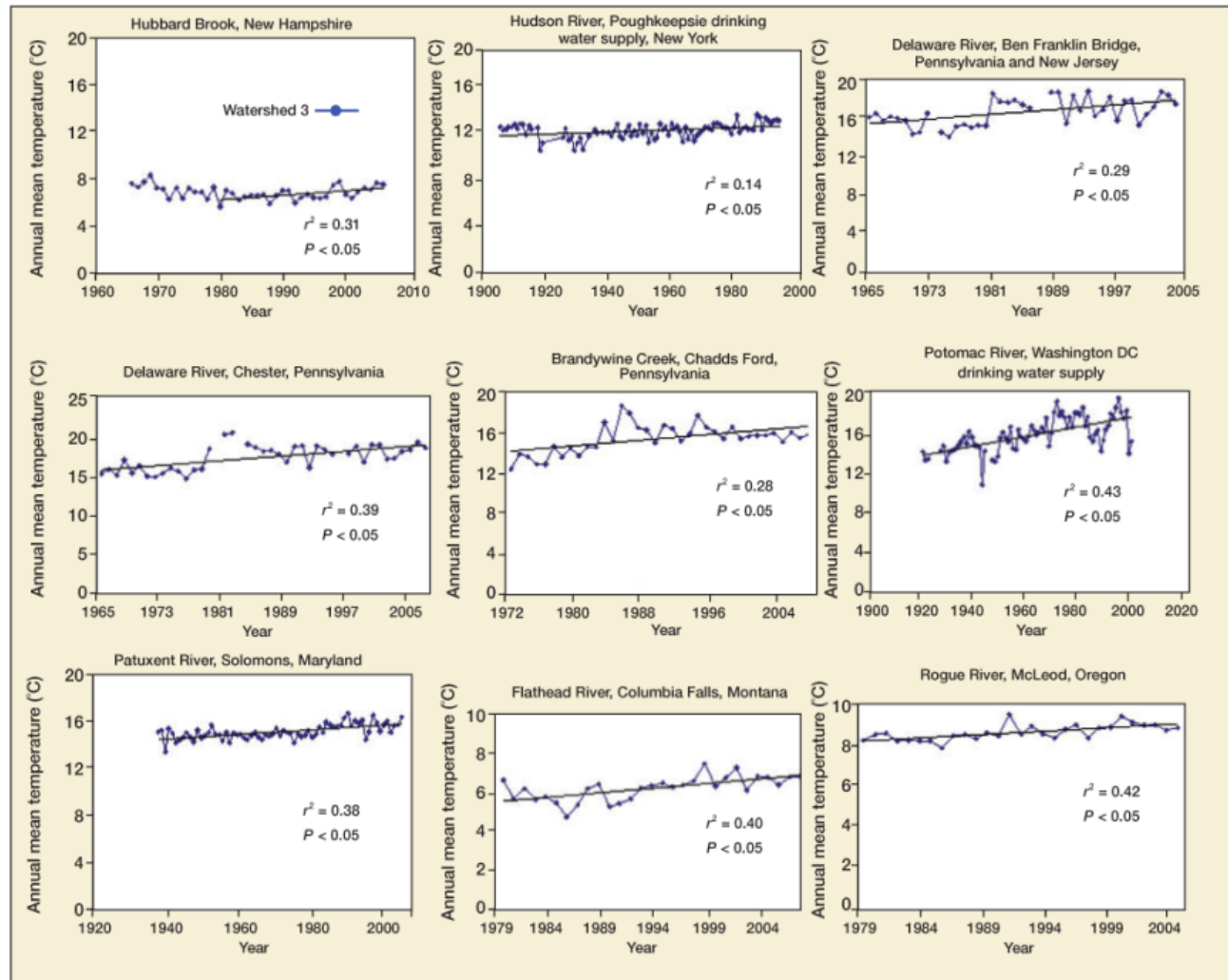
(Hotchkiss et al. 2015, Nature Geoscience)

Observed global warming



(IPCC 2023, Synthesis report of the IPCC sixth assessment report)

Temperature increase in streams and rivers



(Kaushal et al. 2010, Frontiers in Ecology and the Environment)

Temperature sensitivity of metabolism

- Temperature response of a reaction can be described by Arrhenius equation, where activation energy characterizes the temperature dependence

$$K = Ae^{\frac{-E_a}{RT}}$$

- Quantifying activation energy is necessary to predict the effects of warming on stream metabolism.

How to quantify temperature sensitivity?

- Incubation or mesocosm experiment at different temperatures.



(Yvon-Durocher et al. 2010, Philosophical Transactions of the Royal Society B)

How to quantify temperature sensitivity?

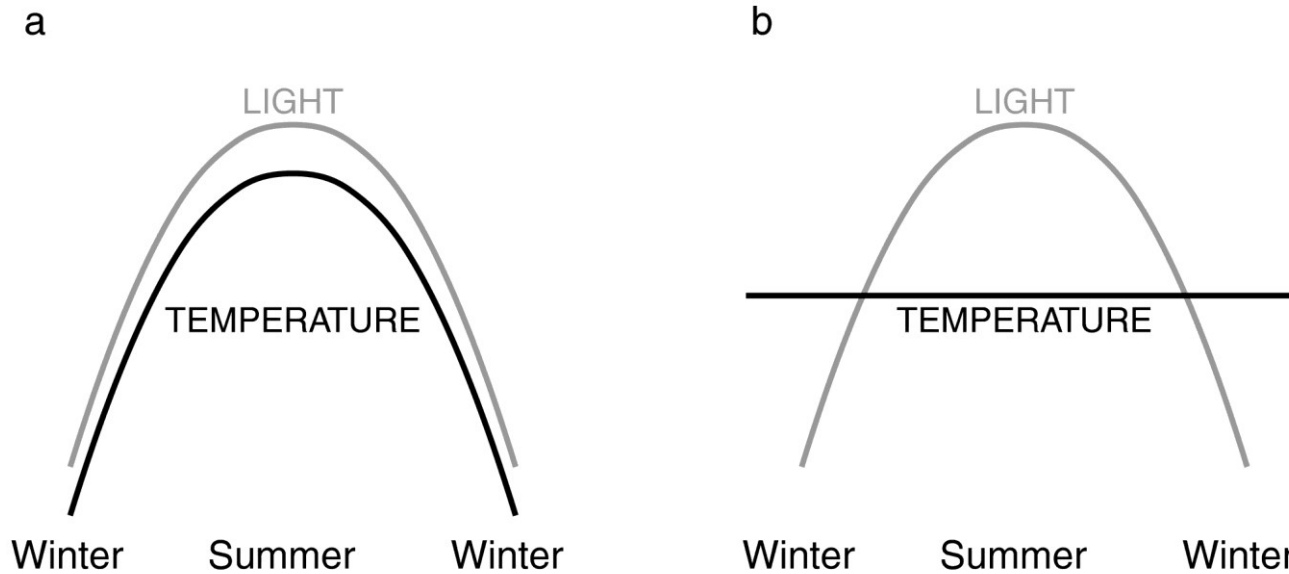
- Whole system warming experiment



(Nelson et al. 2016, Global Change Biology)

How to quantify temperature sensitivity?

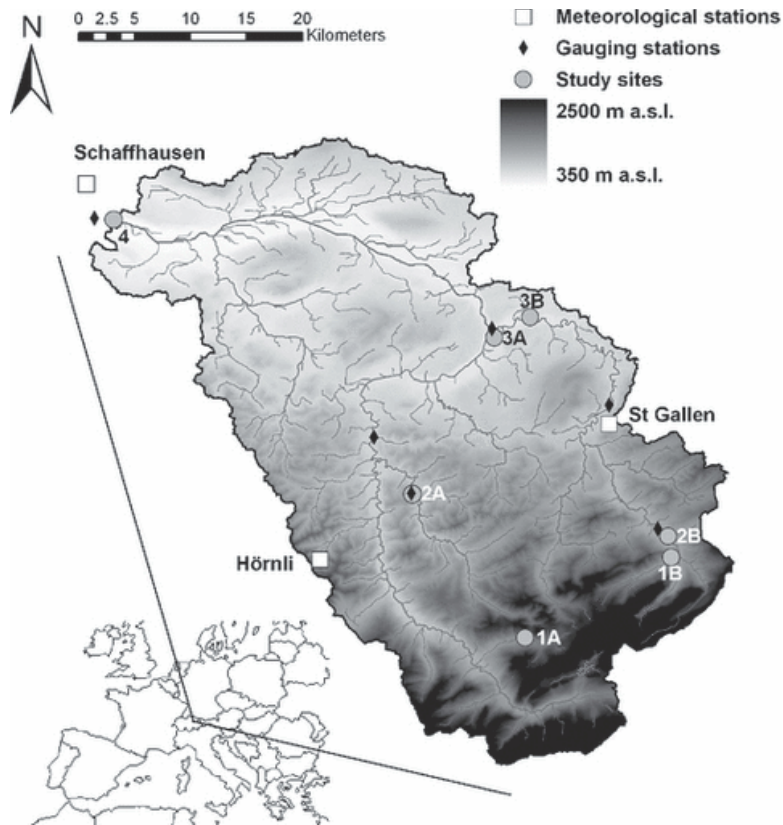
- Utilize seasonal temperature change.



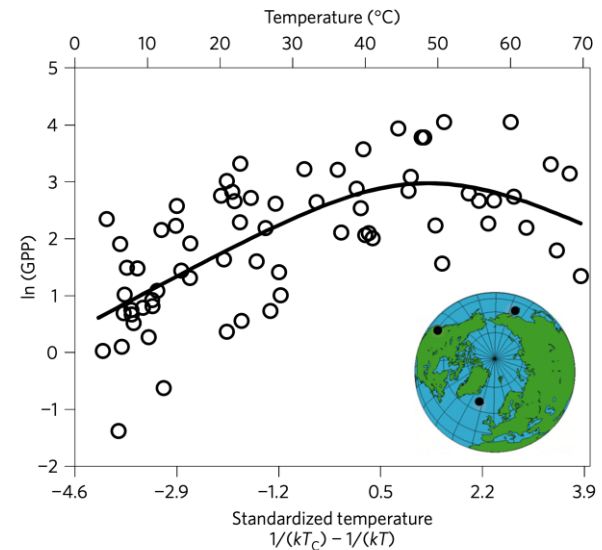
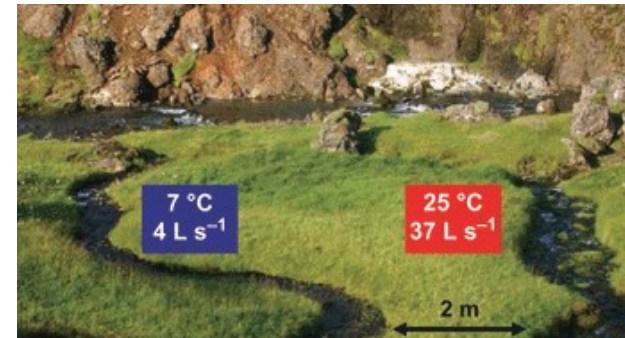
(Huryn and Benstead 2019, Ecology)

How to quantify temperature sensitivity?

- Use spatial temperature gradient



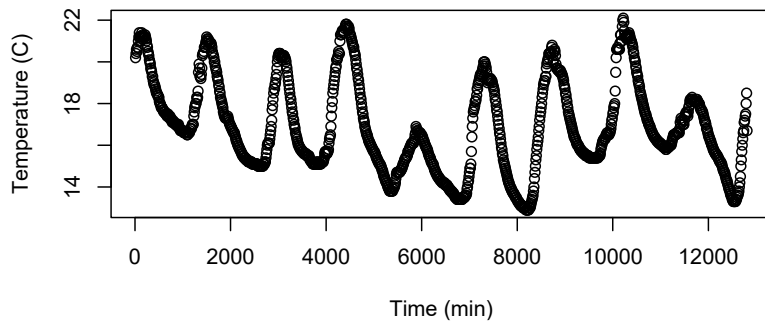
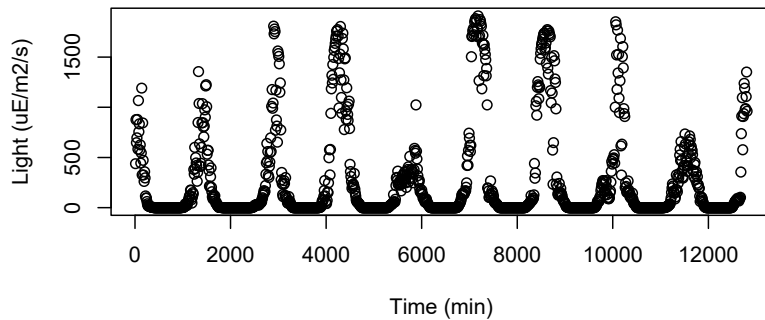
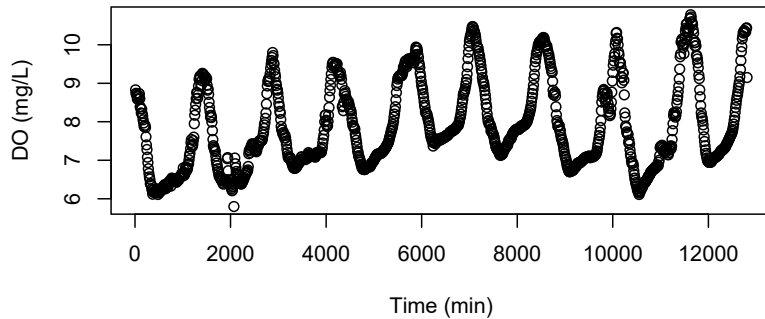
(Acuña et al. 2008, Freshwater Biology)



(Demars et al. 2016, Nature Geoscience)

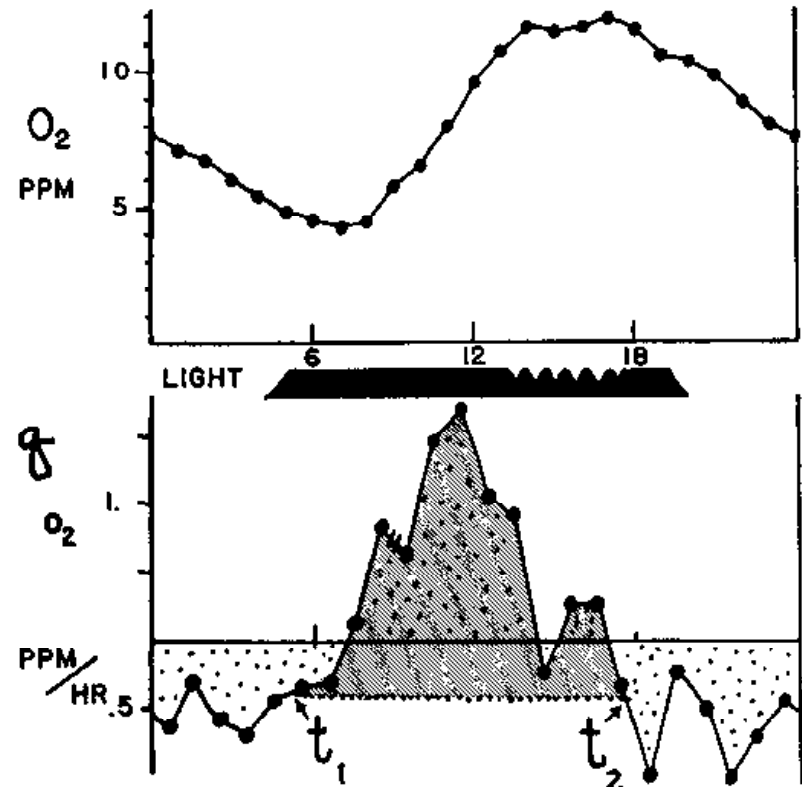
How to quantify temperature sensitivity?

- Estimate temperature sensitivity based on response of DO concentration to diel temperature variation



Open channel method to quantify metabolism

- Open channel method to quantify reach scale metabolism



(Odum 1956, Limnology and Oceanography)

Open channel method to quantify metabolism

- Modern open channel method employs the same basic idea, but utilizes dynamic models instead of simple calculation.

$$\frac{d[\text{O}_2]}{dt} = GPP - ER + K([\text{O}_2]_{sat} - [\text{O}_2])$$

$$GPP = P_{max} \tanh\left(\frac{\alpha I}{P_{max}}\right) e^{-\frac{E_{ap}}{R}\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

$$ER = R_{T_0} e^{-\frac{E_{ar}}{R}\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

$$K = K_{20} \times 1.024^{T-20}$$

Study sites

Andrews (AND)
Temperate forest
N 44.23°
W 122.18°

Konza (KNZ)
Tallgrass prairie
N 39.08°
W 96.36°

Arctic (ARC)
Tundra
N 68.63°
W 149.20°

Caribou Poker Creek (CPC)
Taiga
N 65.17°
W 147.54°

Australia (AUS)
Tropical savanna
S 13.10°
E 130.79°

Luquillo (LUQ)
Tropical forest
N 18.32°
W 65.75°

