WG3: Ecosystems, Weathering and Climate Change

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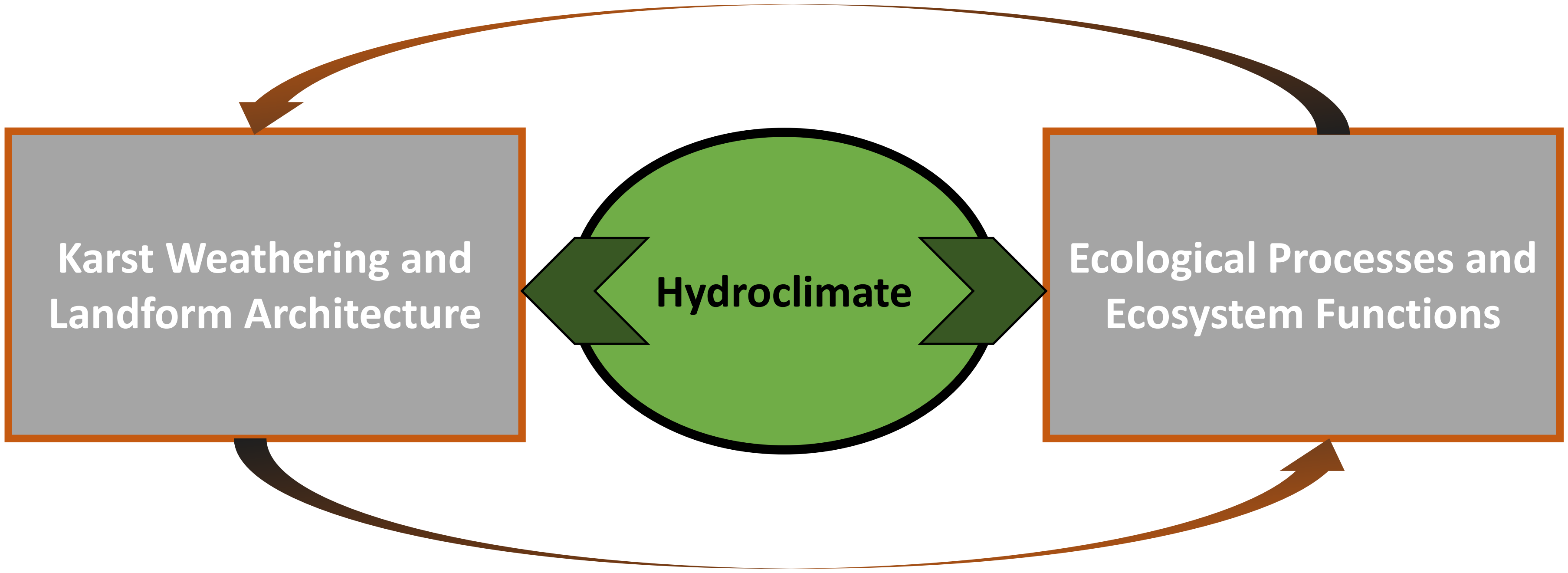


Karst is Biogeomorphic

Question #1: How does ecosystem carbon cycling control karst weathering rates.

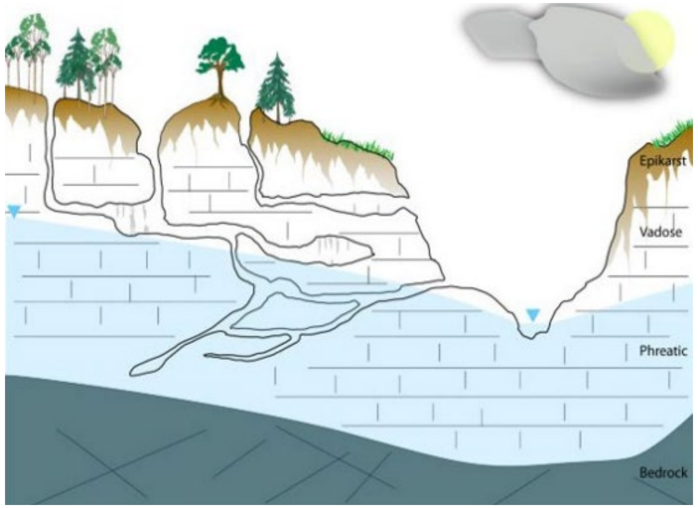
Across a continuum of carbonate critical zones…

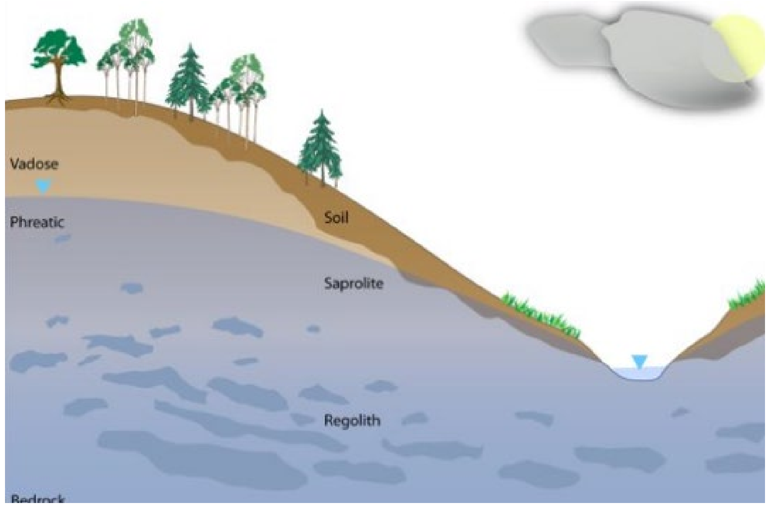
Q1a: What is the magnitude of biological control on karst weathering rates? **Q1b:** What is distribution of OM storage and remineralization, and how does variation control patterns of karst weathering?

> **Justification**: Organisms force chemical transformations that impact bedrock dissolution via production of CO2 and other acids. The spatial (vertical, landscape) patterns of OM storage and remineralization are poorly constrained but critical for determining the mode and magnitude of biological influence on weathering.

Q2: What is the relative importance of chemolithotrophic processes compared to organic carbon oxidation?

> **Justification**: Microbial Fe and S oxidation are important for rock weathering in silicate-dominated landscapes (granite [Napieralski et al. 2019], shale [Sullivan et al. 2016]). Carbonate minerals are susceptible to dissolution by strong acids, so these processes may be more important in carbonate critical zones, despite less Fe and S substrate.



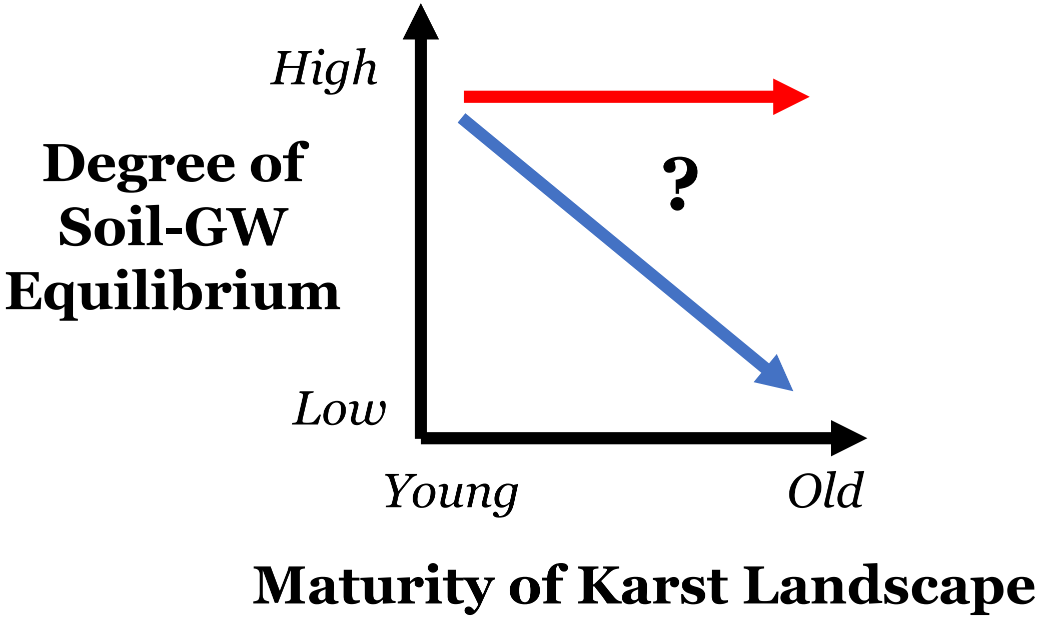


Question #2: Is groundwater CO_2 (at springs) the mean soil CO_2 integrated across karst landscapes? How does any mismatch vary with maturity and climate regimes?

Motivation: Inverse models assume equilibrium between soil CO_2 and groundwater, but:

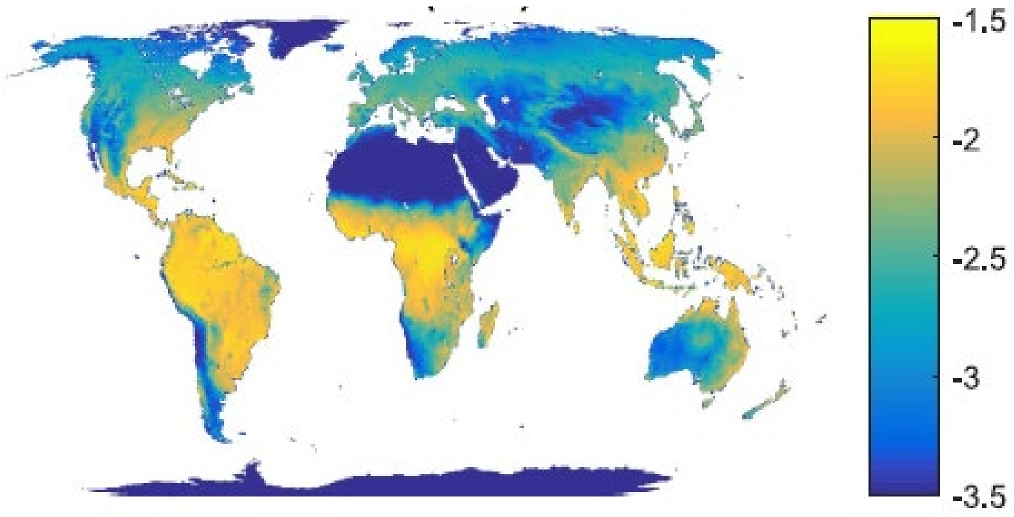
-Recharge and respiration are not evenly distributed in space
-Recharge and respiration are not evenly distributed in time

Prediction: Groundwater CO_2 depends on spatial/temporal pattern of soil respiration and recharge



Possible Outcomes: A predictive framework for future targeted instrumentation

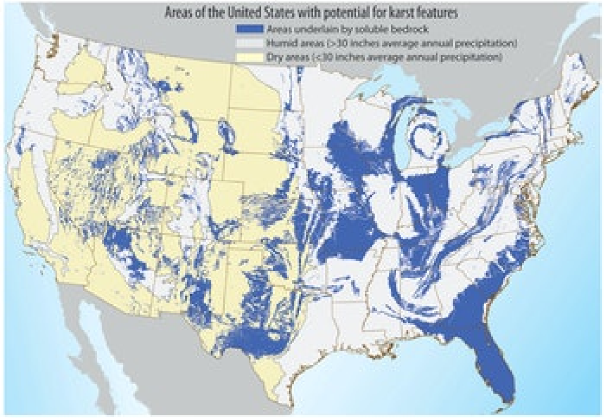
Spatial heterogeneity as a driver and/or effect of weathering patterns across karst landscapes

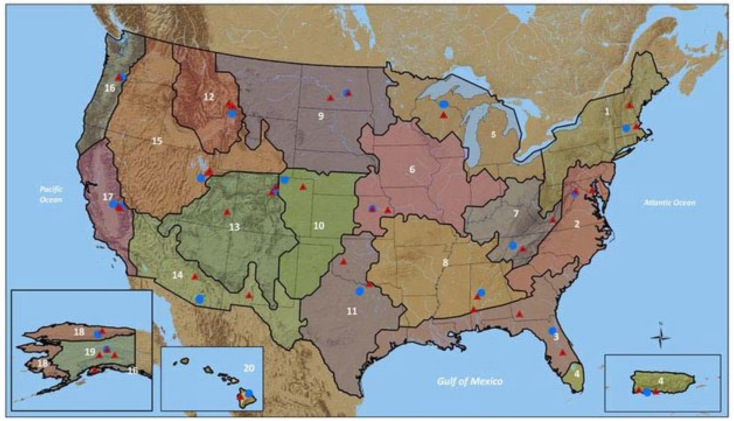


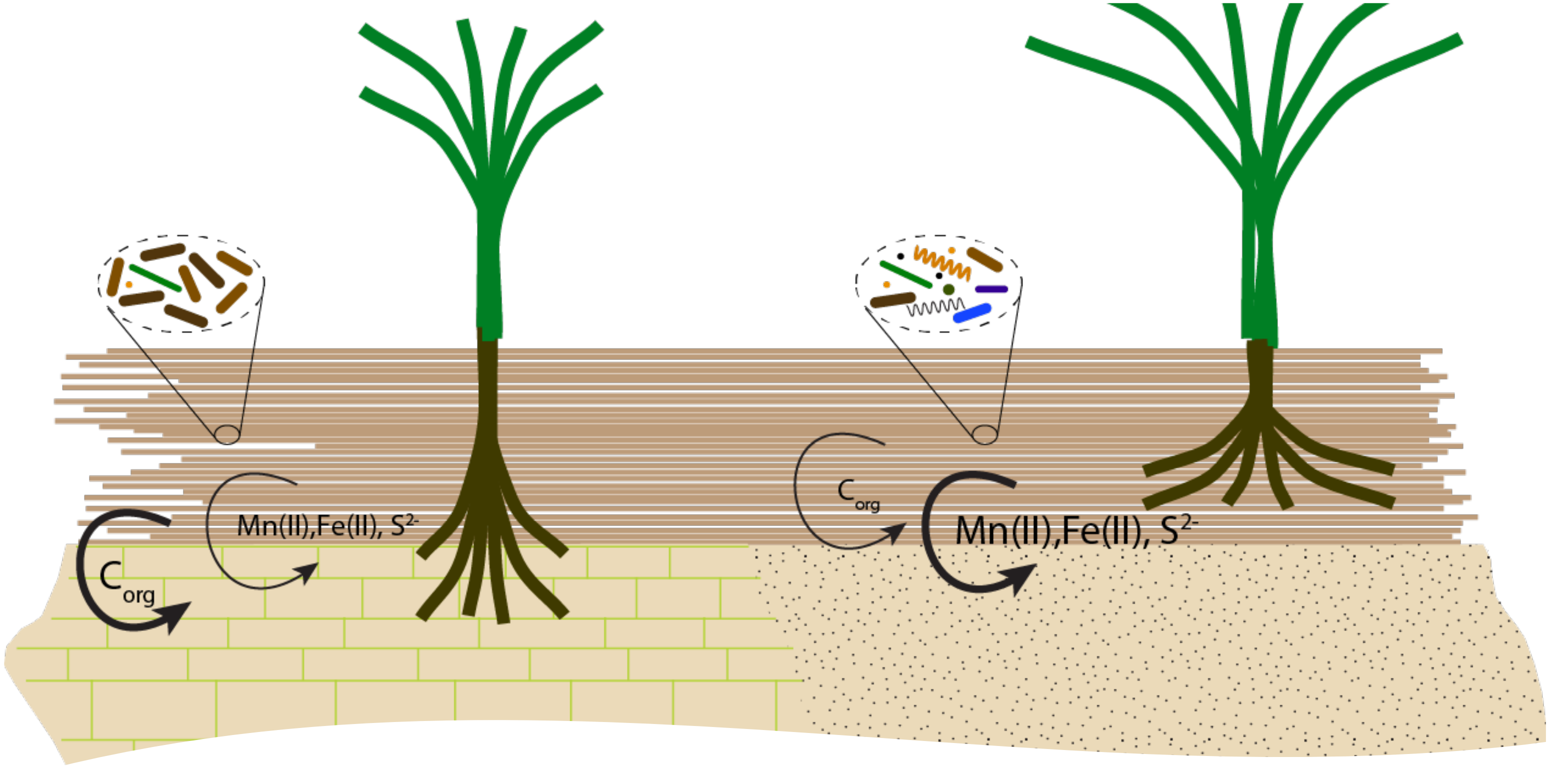
Annual example: Romero-Mujalli et al. (2019)

Question #3. Is there a biological signature of bedrock geology? Over what scales (micro to landscape) and organisms (microbes to trees)?

- How do energy allocation or morphological traits vary for species growing across a lithological gradient? Why?
- How does microbial diversity and activity vary across a lithological gradients?



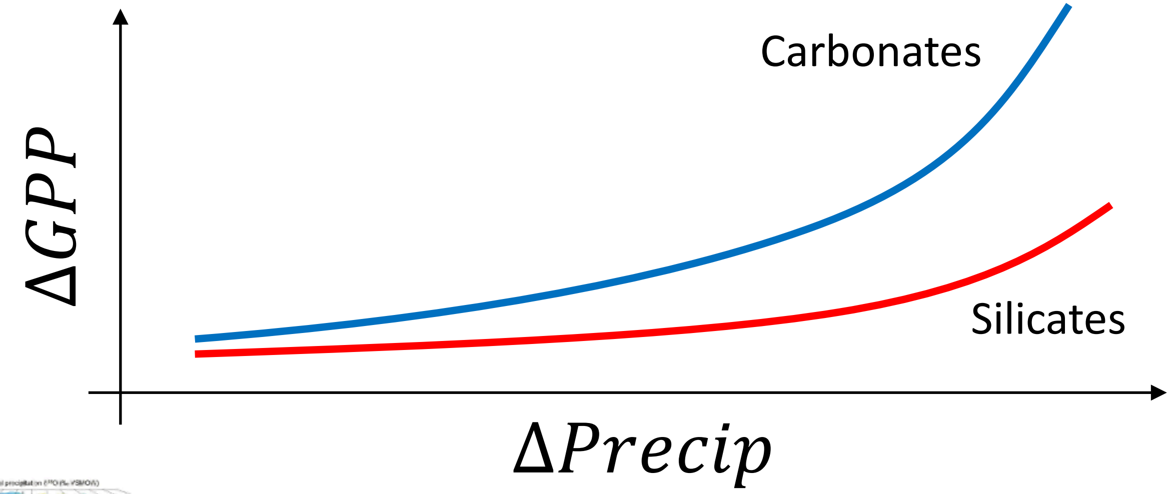




Question #4: How does lithology influence the sensitivity of ecosystem primary productivity to climate change?

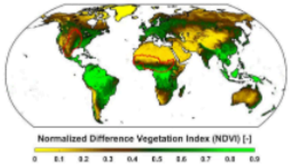
Hypotheses: Carbonate lithology amplifies the impacts of climate change on terrestrial production by reducing-regolith water holding capacity, and altering soil nutrient availability.

Specific prediction:

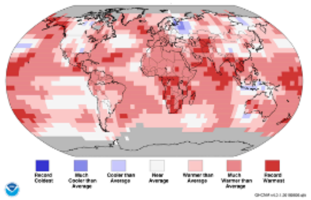


Approach and data:

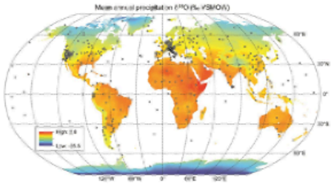
Data



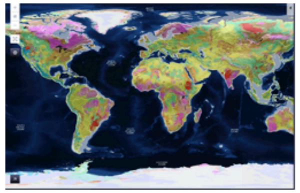
Global NDVI (~30yrs)



Global Temperature (~30yrs)



Global Precipitation (~30yrs)



Global Lithology Gradient /Ca^{2+} in streams

Model

$$NDVI_i \sim Normal(\mu_i, \sigma_{s,t})$$
$$\mu_i = \beta_{s,t} + \beta1_{s,t}T_i + \beta2_{s,t}P_i + \beta3_{s,t}L_i + \beta4_{s,t}L_iP_i + \beta5_{s,t}L_iT_i$$

Result