Biome respiration is less sensitive to warming than expected

Sun, W., Luo, X., Fang, Y., Shiga, Y. P., Zhang, Y., Fisher, J. B., Keenan, T. F., & Michalak, A. M. (2023). Biome-scale temperature sensitivity of ecosystem respiration revealed by atmospheric CO_2 observations. *Nature Ecol. Evol.*, doi:10.1038/s41559-023-02093-x

Science Questions

- As climate warms, how much more carbon dioxide (CO_2) will plants and soils emit through respiration?
- Does respiration in different biomes respond differently to temperature?

Analysis

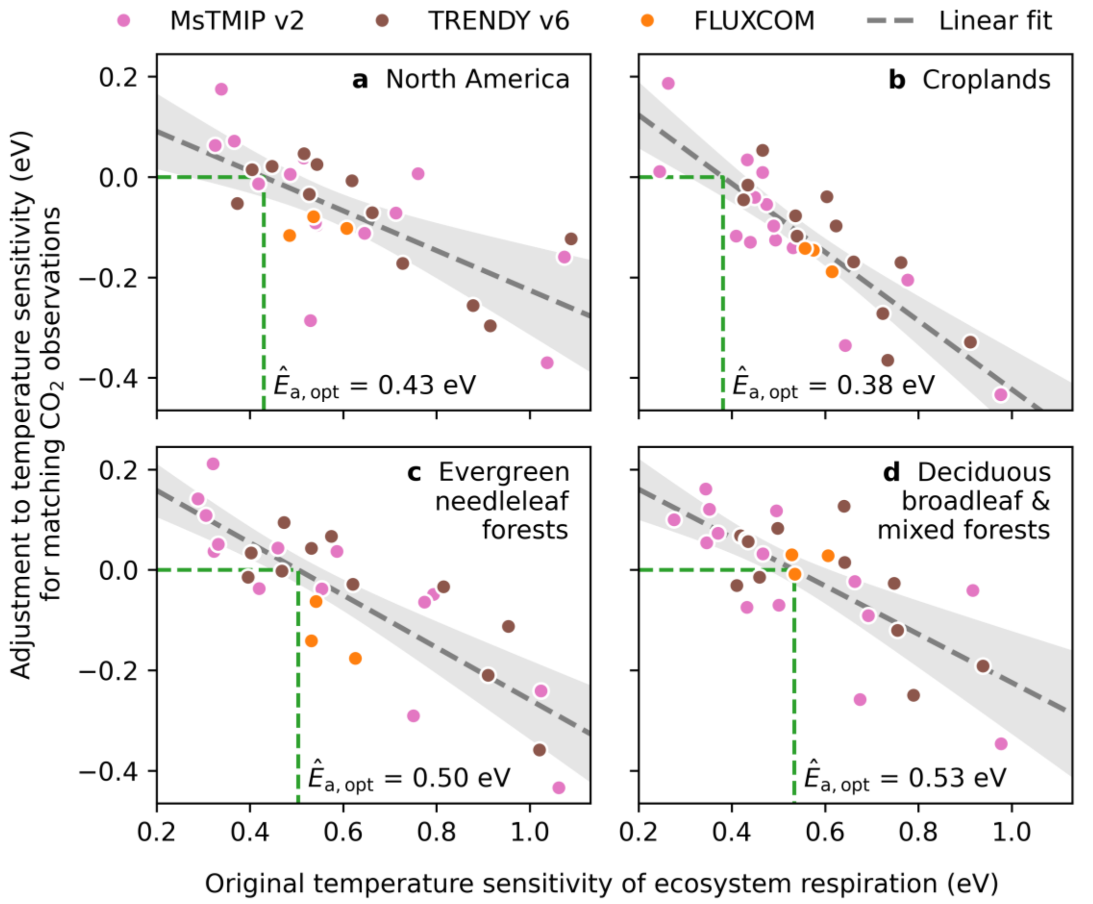
- We leveraged atmospheric CO_2 concentration measurements from a few dozen tall towers across North America to understand how ecosystem respiration responds to temperature at the biome scale.
- We adjusted temperature sensitivity of ecosystem respiration reflected in models to align these models' carbon flux estimates with atmospheric CO_2 observations. This yielded biome-scale temperature sensitivity estimates.

Results

- At the scale of entire North American biomes, ecosystem respiration is less sensitive to temperature than suggested by previous plot-scale studies.
- Forests and croplands differ in the temperature sensitivity of respiration.
- Most terrestrial biosphere models represent a higher temperature sensitivity than indicated by atmospheric CO_2 observations.

Significance

This study is the first to infer temperature sensitivity of ecosystem respiration directly at the biome scale using scale-relevant observations. The lower biome-scale temperature sensitivity compared with plot-scale estimates implies that the terrestrial carbon sink may be more resilient to warming than expected.



Atmospheric observations reveal temperature sensitivities of ecosystem respiration for North America (a) and major biomes therein (b–d). Original temperature sensitivity estimates (horizontal axes) diagnosed from models (colored dots) inversely correlate with the necessary adjustments to these estimates for matching atmospheric CO_2 measurements (vertical axes). These correlations allow us to draw the best-fit lines (gray dashed lines) to infer the actual temperature sensitivities for these study domains (green vertical lines).

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Abstract: The temperature sensitivity of ecosystem respiration regulates how the terrestrial carbon sink responds to a warming climate but has been difficult to constrain observationally beyond the plot scale. Here we use observations of atmospheric CO_2 concentrations from a network of towers together with carbon flux estimates from state-of-the-art terrestrial biosphere models to characterize the temperature sensitivity of ecosystem respiration, as represented by the Arrhenius activation energy, over various North American biomes. We infer activation energies of 0.43 eV for North America and 0.38 eV to 0.53 eV for major biomes therein, which are substantially below those reported for plot-scale studies (approximately 0.65 eV). This discrepancy suggests that sparse plot-scale observations do not capture the spatial-scale dependence and biome specificity of the temperature sensitivity. We further show that adjusting the apparent temperature sensitivity in model estimates markedly improves their ability to represent observed atmospheric CO_2 variability. This study provides observationally constrained estimates of the temperature sensitivity of ecosystem respiration directly at the biome scale and reveals that temperature sensitivities at this scale are lower than those based on earlier plot-scale studies. These findings call for additional work to assess the resilience of large-scale carbon sinks to warming.