Field-experiment constraints on the enhancement of the terrestrial carbon sink by CO_2 fertilization

Liu, Y. *et. al., Nature Geoscience.* 12 809-814 (2019) doi: 10.1038/s41561-019-0436-1

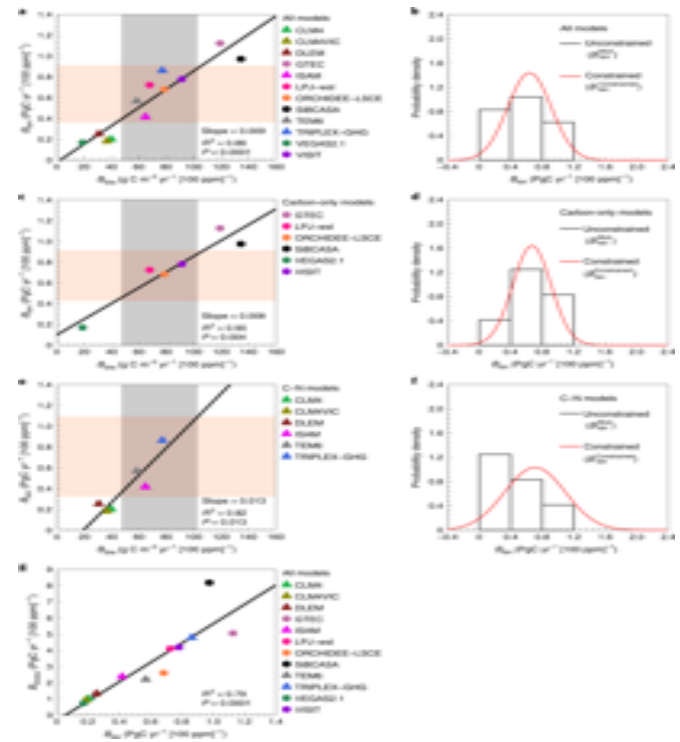
Background: Human activities between 1750 and 2015 have resulted in the emission of an estimated 600 PgC to the atmosphere, profoundly altering the global carbon cycle. It is estimated that almost one-third of those emissions were absorbed by terrestrial ecosystems. Not only have terrestrial ecosystems played a key role in mitigating the effects of human activities on atmospheric CO_2 levels, but, the terrestrial CO_2 sink has also increased over time with an estimated doubling between the 1960s (period 1960–1969) and the current decade (2007–2016). Terrestrial ecosystem model simulations have indicated that increasing CO_2 (eCO_2) is the main driver of the increase in the terrestrial carbon sink, but the magnitude of eCO_2 fertilization differs strongly between models.

Methods: This study constrains the sensitivity of the terrestrial carbon sink to eCO_2 over the temperate Northern Hemisphere for the past five decades, using 12 terrestrial ecosystem models and data from seven CO_2 enrichment experiments. This constraint uses the heuristic finding that the northern temperate carbon sink sensitivity to eCO_2 is linearly related to the site-scale sensitivity across the models.

Results:

- The emerging data-constrained eCO_2 sensitivity is 0.64 ± 0.28 PgC yr^{-1} per hundred ppm of eCO_2.
- Extrapolating worldwide, the terrestrial carbon sink is projected to increase by 3.5 ± 1.9 PgC yr^{-1} for an increase in CO_2 of 100 ppm.
- This value suggests that CO_2 fertilization alone explains most of the observed increase in global land carbon sink since the 1960s.

Significance: More CO_2 enrichment experiments, particularly in boreal, arctic and tropical ecosystems, are required to further explain the underlying processes responsible for the sensitivity of the terrestrial carbon sink to eCO_2 .



Emergent constraints on the sensitivity of the Northern Hemisphere temperate terrestrial carbon sink to eCO2. a, Relationship between the NH temperate zone and the site-scale responses to eCO2 (BNH and BSite) for 1959–2010 across the MsTMIP models. The light red area shows FACE data-constrained BNH b, Probability density function for BNH. The histogram indicates the probability density function of unconstrained BNH in the MsTMIP models assuming they are Gaussian distributed. The red line indicates the probability density function of BConstrained NH I . c,d, Same as a and b but using the carbon-only models. e,f, Same as a and b but using only the C–N models. g, Relationship between the NH temperate zone and global responses of the terrestrial carbon sink to eCO2 for 1959–2010 across the MsTMIP models. In a,c,e and g, the solid lines indicate unconstrained linear regressions and the triangles indicate the models with dynamic nitrogen cycles.