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Max-Planck-Institut für Biogeochemie
Dr. Eberhard Fritz

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Do not forget moisture in climate-carbon cycle responses

The land carbon turnover times shape the response of the land surface to changes in climate. Therefore, understanding and quantifying the carbon turnover's temperature sensitivity is key in the context of climate change. A study published in Nature Geoscience now shows that moisture conditions strongly modify the apparent temperature sensitivity of carbon turnover times. The study team was led by Nuno Carvalhais and Naixin Fan from the Max Planck Institute for Biogeochemistry, Germany. Their results highlight the influence of hydrometeorological factors, in addition to that of temperature, on the response of carbon turnover times to long term climate variability.

Understanding and quantifying the sensitivity of the carbon cycle to long-term climate change is paramount to better predict how the functioning of terrestrial ecosystem will change in the context of global warming. However, the carbon cycle's response to temperature is subject to substantial uncertainty. This study addressed the role of confounding factors to determine the magnitude of the temperature-carbon cycle feedback dynamics in Earth system sciences.

In a new study published in Nature Geoscience, the research team investigated the role of hydrometeorological factors (H-factors) in shaping the spatial variability of carbon turnover times from global to latitudinal scales. The team used an observation-based ensemble of global carbon turnover estimations at large scales as well as estimates derived from in-situ measurements at more than 200 geographical sites. They provide a full investigation on the responses of carbon turnover to the spatial gradient of temperature as well as well as H-factors at different scales.
Global analysis shows that hydrometeorological processes modulate the temperature sensitivity of land carbon turnover. Landscape in Portugal symbolizing water and carbon cycle.

"It is surprising that hydrometeorology is almost equally important as temperature in shaping the spatial pattern of ecosystem carbon turnover", says Naixin Fan, first author of the study, a doctoral candidate at the Max Planck Institute of Biogeochemistry and now researcher in the Department of Photogrammetry and Remote Sensing at the Technical University Dresden. There is a general consensus among previous studies that temperature is the main driver of terrestrial carbon turnover. However, the new study shows that H-factors can explain 40% of the global variability in contrast to the 60% that can be explained by temperature alone. This provides strong evidence that hydrometeorological and hydrological processes are also important. "It is known that the processes that shape carbon turnover on land are simultaneously affected by multiple environmental factors. This research provides a perspective on how balanced the role of temperature is to that of moisture, it argues for comprehensive and multi-variate approaches in determining the sensitivity of the carbon cycle to climate change", says Dr. Carvalhais.

The response of terrestrial carbon turnover to climate is one of the most uncertain processes that is simulated in current Earth System Models (ESMs). The projected changes in carbon turnover times among different ESMs are characterized by a large spread in the magnitude, even sometimes with opposite sign. This study suggests that the carbon turnover process may strongly depend on changes in the hydrometeorological or hydrological cycle. The estimated values of temperature sensitivity of carbon turnover with the influence of different climate variables can also provide insight and even improve the simulation of feedbacks between the carbon cycle and the climate.

wissenschaftliche Ansprechpartner:

Dr. Nuno Carvalhais
Group Leader
+49 3641 57-6225
nuno.carvalhais@bgc-jena.mpg.de

Naixin Fan
Doctoral Researcher
nfan@bgc-jena.mpg.de

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This landscape in Portugal symbols the interplay between water and the carbon cycle.
Naixin Fan
MPI-BGC