EGU22-11148
https://doi.org/10.5194/egusphere-egu22-11148
EGU General Assembly 2022

Disentangling direct and indirect soil moisture effects onecosystem carbon uptake with Causal Modeling

Christian Reimers[1], Alexander Winkler[1], Vincent Humphrey[2], and Markus Reichstein[1]
[1]Max Planck Institute for Biogeochemistry, Biogeochemical Integration, Jena, Germany (creimers@bgc-jena.mpg.de)
[2]ETH Swiss Federal Institute of Technology Zurich, Zurich, Switzerland

Soil moisture affects gross primary production through two pathways. First, directly through drought stress and second, indirectly through temperature via evaporative cooling of the near-surface atmospheric layer. Because it is not possible to disentangle these effects experimentally at a biome level, Humphrey et al. (2021) has used Earth system model experiments in which soil moisture is fixed to its seasonal cycle and evaluated the effects on gross primary production. In contrast, we aim to use causal modeling to infer impacts directly from observation. To predict the effects of soil moisture anomalies on gross primary production, we extend existing causal modeling frameworks to cover situations where two variables influence one other. A major challenge in applying causal modeling here lies in the bidirectional relationship between soil moisture and temperature via evapotranspiration. On one hand, higher temperature leads to higher evapotranspiration and thus lower soil moisture. On the other hand, lower soil moisture leads to lower evapotranspiration and thus higher temperatures. Therefore, neither soil moisture nor temperature can

be adequately modeled as a function of the other. To address this challenge, we extend existing causal modeling frameworks to account for these situations where the variables are not functions of each other but are determined by equilibrium. We show that our method identifies the correct links between variables in synthetic data. We further evaluate whether our new approach is consistent with the results of Humphrey et al. (2021) based on idealized counterfactual experiments using Earth system models. To this end, we use the control runs of the models to directly predict the results of the idealized counterfactual experiment as proof-of-concept. Finally, we apply our method to observations and determine the direct and indirect effect of soil moisture anomalies on gross primary production.

References:
Vincent Humphrey, Alexis Berg, Philippe Ciais, Pierre Gentine, Martin Jung, Markus Reichstein, Sonia I Seneviratne, and Christian Frankenberg. Soil moisture–atmosphere feedback dominates land carbon uptake variability. Nature, 592(7852):65–69, 2021.