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Observations of land-atmosphere interactions using satellite data

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Observations of land-atmosphere interactions using satellite data

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Previous studies of global land-atmosphere hotspots have often relied solely on data from global models with the consequence that they are sensitive to model error. On the other hand, by only analyzing observations, it can be difficult to distinguish causality from mere correlation.

In this study, we present a general framework for investigating land-atmosphere interactions using Granger Causality analysis applied to remote sensing data. Based on the near linear relationship between chlorophyll sun induced fluorescence (SIF) and photosynthesis (and thus its relationship with transpiration), we use the GOME-2 fluorescence direct measurements to quantify the surface fluxes between the land and atmosphere. By using SIF data to represent the flux, we bypass the need to use soil moisture data from FLUXNET (limited spatially and temporally) or remote sensing (limited by spatial resolution, canopy interference, measurement depth, and radio frequency interference) thus eliminating additional uncertainty.

The Granger Causality analysis allows for the determination of the strength of the two-way causal relationship between SIF and several climatic variables: precipitation, radiation and temperature. We determine that warm regions transitioning from water to energy limitation exhibit strong feedbacks between the land surface and atmosphere due to their high sensitivity to climate and weather variability. Tropical rainforest regions show low magnitudes of causal feedback likely due to other factors influencing the land surface such as phenological controls (e.g. leaf area index), nutrient limitations or soil texture.

These results were then compared to CMIP5 GCM results using GPP in place of SIF. GCM results varied greatly between models as well as with the observational data analysis indicating deficiencies in the representation of certain modeled phenomena such as low level clouds and boundary layer development.

This study highlights the need for GCM improvement to more accurately capture the feedbacks between the land and atmosphere. These results have the potential to improve our understanding of the underlying mechanisms between land and atmosphere coupling, which could ultimately be used to improve weather and climate predictions.