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Using a simple model to measure the differences between climate model land surface simulations and FLUXNET observations

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Complex numerical models of climate consist of simulation of fluid dynamics and thermodynamics on a discrete grid, and parameterizations, which are algorithms that approximate processes smaller than gridscale. Because parameterizations of a given process may be written as different functions of different, potentially non-observable variables, it can be difficult to quantify the process differences between individual climate models and between climate models and the real world.

Here, we attempt to write down a simple linear model that represents the response of the Earth's tropical land surface to atmospheric forcing on monthly timescales in terms of the same observable variables using a technique called continuous structural parameterization. Simulated data are taken from complex General Circulation Models (GCMs) run under the AMIP protocol and a CESM2 perturbed physics ensemble (PPE) of our own devising; observed measurements are taken from FLUXNET flux tower sites. We find that the simple model captures land surface behaviour well except in mountainous regions.

Establishing a generalised parameter space, we see that most GCMs are in reasonable agreement with FLUXNET at FLUXNET sites, although there is evidence that GCMs consistently slightly overestimate the response of surface turbulent fluxes to downward radiation. Further, it is found that the differences between structurally different AMIP models are considerably greater than the differences between CESM2 PPE members -- even though the PPE parameters are varied across their realistic domain. If the simple model is trained only at GCM spatial gridpoints that contain a FLUXNET site, there is little degradation in simple model performance compared with global training, suggesting that even the few available tropical FLUXNET sites are useful for constraining land surface model response throughout the tropics. This is of course contingent on whether or not point measurements taken by FLUXNET are representative of the wider area around FLUXNET sites.