Assessing the impact of rainfall intensification on ecosystem productivity

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Increasing atmospheric CO2 levels, temperature, and atmospheric drought as well as changes in rainfall structure (event frequency, storm intensity) are expected to jointly alter ecosystem responses in the future. High-resolution convection-permitting models have been recently employed at continental scales to develop robust projections of climate, and particularly precipitation, at fine spatiotemporal scales (~1km, ~1hour) overcoming the documented limitations of larger scale general circulation models.

Climate projections at fine spatiotemporal scale can support robust quantification of ecosystem responses under a changing climate when used in conjunction with state-of-the-art terrestrial biosphere models resolving the soil – vegetation – atmosphere continuum processes at those scales. In this study, we assess the changes in ecosystem functioning for multiple biomes in North America. We use the 4km, 1-h future WRF continental-wide simulation over the US together with a state-of-the-art stochastic weather generator and the Tethys & Chloris ecohydrological model to investigate ecosystem responses for 33 sites where eddy covariance data exist (i.e., FLUXNET sites).

We designed a series of numerical experiments tuned to disentangle the roles of CO2, temperature and the structure of precipitation, while considering the effect of natural weather variability.

Our results reveal that the impact of mean annual rainfall is dominant in more arid sites, while sites of intermediate wetness are more sensitive to the temporal structure of precipitation at fine scales. Wet sites, which are energy limited, are more sensitive to temperature increase instead. The impact of rainfall is partly offset by increases in atmospheric drought. The fertilization effect of elevated CO2 levels is strong in this high-end (RCP 8.5) scenario across all sites. Fertilization is more pronounced for sites of low and intermediate wetness, where stomatal closure allows for positive feedbacks through water savings.