Have we been underestimating the impacts of drought on terrestrial primary production?

Dr Beni Stocker and Colin have teamed up again, alongside other long-standing collaborators on a new research paper published in *Nature Geoscience*, that demonstrates that current methods that are based on satellite data have been underestimating the impacts of drought on vegetation and the carbon cycle.

Obtaining accurate estimates of photosynthesis and vegetation productivity across large spatial scales is important for many reasons. It is needed for practical purposes such as to monitor yields in agriculture and forestry, but also for the scientific understanding of the drivers of the terrestrial carbon balance and changes in the carbon cycle. This, in turn, is needed for accurate predictions of future conditions under various climate scenarios.

Drought can have huge impacts on the mortality rates of plants and on the so-called gross primary production (GPP), that is the rate at which an ecosystem assimilates CO_2 from the atmosphere through photosynthesis. Data derived from satellites are the most common and effective way of monitoring global terrestrial photosynthesis and primary production and take into account vegetation greenness, incoming radiation from the sun, temperature and the humidity of the atmosphere (quantified by the so-called vapour- pressure-deficit, VPD). Although soil moisture is known to affect the vegetation and reduces GPP, no direct measurement for soil moisture is factored into satellite-based GPP estimates. This is due to a lack of suitable observational datasets for the whole globe. Instead, VPD is used as a proxy for overall dryness and, until now, it has been assumed that this provides sufficient information to accurately estimate the responses of plants to drought. However, Beni Stocker, Colin Prentice and colleagues have shown in earlier research that a deficit in soil moisture has a direct impact on vegetation which is independent of the VPD because of plant physiology and varying stomatal and biochemical responses to drought. Furthermore, the more intense the drought, the more decoupled the remotely sensed data is from GPP. The new paper by Beni Stocker, Colin Prentice and colleagues now shows that this neglect of direct soil moisture information leads to a systematic bias in satellite-based GPP estimates. As a result, these methods systematically underestimate the impacts of drought on GPP.

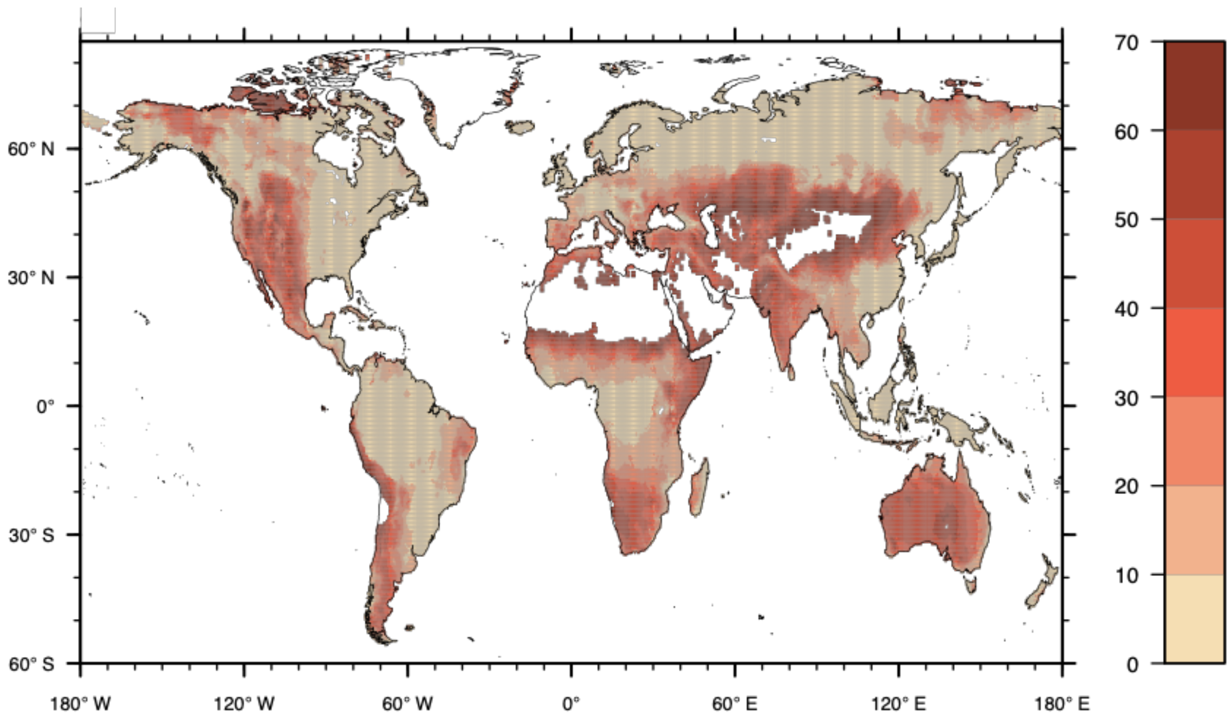

Figure: Reduction of annual gross primary production (GPP) due to soil moisture stress (in percent). Estimates that do not account for soil moisture stress miss this reduction. It can be expected that such methods have a bias that is similar in size and distribution to the GPP reduction shown here. Figure from Stocker et al. (2019) Nature Geosci.

This has implications not only for estimated vegetation productivity, but also for impacts of extreme events. Dry and hot periods like last year's summer in northern Europe can negatively affect the C balance of a whole continent and thereby accelerate the man-made increase in atmospheric CO_2. The new paper by Stocker, Prentice, and colleagues shows that the size of such anomalies, and therefore the magnitude of disruption of the C cycle, is substantially underestimated when the additional effect by soil moisture stress is neglected. This clearly points to the need for revising satellite-based monitoring of vegetation productivity and to develop new methods for including information on how soil moisture varies across space and time and how this affects vegetation productivity. Addressing this challenge is important as with a changing climate, periods of drought may become more frequent, intense and prolonged and we need to have a better grasp of how this affects ecosystems and the carbon cycle.

The full paper can be assessed here: (will add in the link when the paper is published online)