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The response of sun-induced chlorophyll fluorescence to remotely sensed surface soil moisture and terrestrial water storage

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Recent work has suggested that droughts and moisture limitation have sizeable effects on terrestrial carbon exchange (Green et al., in press) and that current Earth system models might actually be underestimating them at the global scale (Humphrey et al., 2018). Current representations of water limitation on photosynthesis rates are primarily driven by root-zone soil moisture content. However, there is both observational and model-based evidence that interactions with groundwater and other water reservoirs could potentially play an important role (e.g. Miller et al., 2010; Miguez-Macho & Fan, 2012). This might occur for instance through the horizontal and vertical redistribution of water, or when stressed ecosystems are able to access groundwater via deeper roots.
Satellite microwave measurements of surface soil moisture (SSM) and gravity-based estimates of terrestrial water storage (TWS) are two complementary datasets which we use to investigate this question. SSM and TWS provide the upper and lower bound of water storage variability, ranging from a short-term signal that is highly responsive to weather changes, to a long-memory signal integrating meteorological anomalies often over more than a year.
Using satellite sun-induced fluorescence (SIF) observations, we identify which ecosystems respond more closely to anomalies in SSM versus TWS. We identify regional differences as well as seasonal shifts in these dependencies which are partially in line with the hypothesized behavior that stressed ecosystems respond more strongly to TWS.
Finally, a filtering approach is used to identify a best-fit between SIF anomalies and reconstructed water storage variations that have spectral properties covering the whole SSM to TWS range (from short-term to long-term variability). This enables us to provide regionally resolved estimates of the fraction of terrestrial water storage (in mm) available to ecosystems.

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