EGU21-9248
https://doi.org/10.5194/egusphere-egu21-9248
EGU General Assembly 2021

Estimating root zone storage capacity from flux measurements

Francesco Giardina[1,5], Pierre Gentine[2,3], Alexandra G. Konings[4], and Benjamin D. Stocker[1,5]
[1]Department of Environmental Systems Science, ETH Zürich, Zürich, Switzerland (fgiardina@ethz.ch)
[2]Department of Earth and Environmental Engineering, Columbia University, New York, NY, USA
[3]The Earth Institute, Columbia University, New York, NY, USA
[4]Department of Earth System Science, Stanford University, Stanford, CA, USA
[5]Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland

Terrestrial evapotranspiration (ET) is a key factor in the global energy and water cycles. It is constrained by the transport of moisture from the soil and from vegetation to the atmosphere. The water storage capacity in the root zone (S_r) is an important parameter in land-atmosphere water exchanges, defining how long vegetation is able to transpire during drought. However, S_r is hard to measure directly, being associated with the depth of plant roots actively involved in water uptake and the potential of tap roots accessing deep water and enabling sustained transpiration during drought.

In this study, we present a method to estimate S_r from flux measurements, based on a deep neural network approach trained on eddy covariance (EC) data, multiple soil moisture datasets and a remotely sensed index of vegetation greenness. We derive a soil moisture stress function (fET) that isolates the control of soil moisture on ET. We then use EC data to estimate S_r by investigating how it relates to the climatology of the maximum cumulative water deficit (CWD, defined as the cumulative difference between actual ET and precipitation) experienced by the vegetation across different sites. We hypothesize that plants exposed to high CWD develop higher S_r (acclimation to water stress) and that maximum CWD is thus a good estimator of S_r. To identify root zone water storage from flux measurements, we regress the output of fET against CWD and estimate the maximum CWD for stress by calculating the intersection of the regression line with the x-axis. The apparent sensitivity of fET to CWD and its correlation with the maximum CWD across sites are indicative of adaptation to the prevailing climate and drought regime.

We find that for many sites, particularly in seasonally dry climates, fET does not exhibit a continuous decline with increasing CWD, but follows a step-change and levelling off. That is, at the high end of the CWD spectrum, fET no longer appears sensitive to further increases in CWD. This suggests that plants may have access to deep water reservoirs during the unfolding of a drought event, indicating that plant access to water becomes decoupled from water use.

This study highlights the need to investigate the representation of plant access to deep water reservoirs during drought in terrestrial ecosystem models. These findings could improve our understanding of land-climate interactions, particularly under water-limited conditions.