The control of groundwater convergence zones on photosynthesis

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1. Context

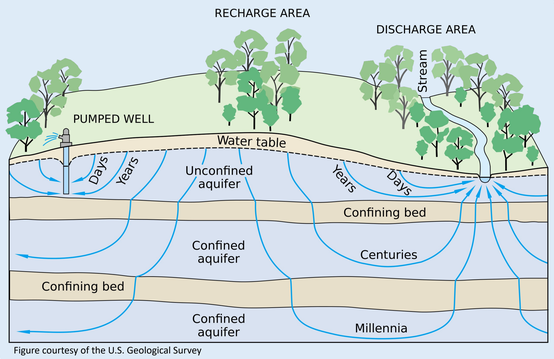
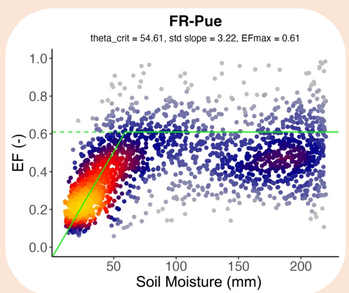


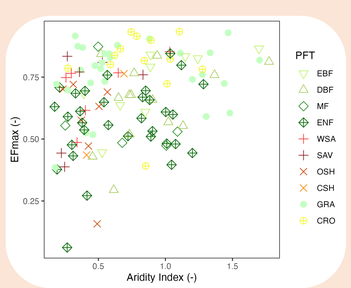
Figure courtesy of the U.S. Geological Survey

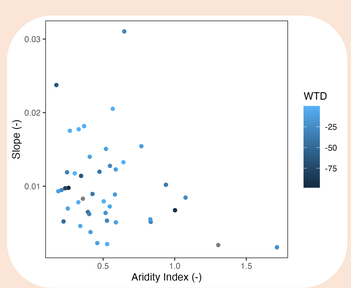
- **Climate factors** that control the spatial and temporal variations of photosynthesis have been well studied (e.g. precipitation and vapor-pressure deficit).
- However, the influence of **water table depth** and **groundwater convergence** on this controlling effect has rarely been considered.

2. Analysis at the flux tower scale

- We analyzed the evolution of the **evaporative fraction** (**EF**, defined as the ratio between the latent heat flux and the available energy at the land surface) with **soil moisture (SM)** across a wide range of eddy covariance sites from FLUXNET2015, AmeriFlux and ICOS (250+ sites).



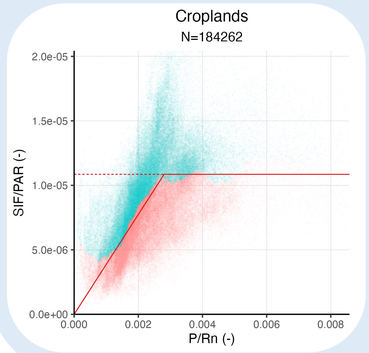


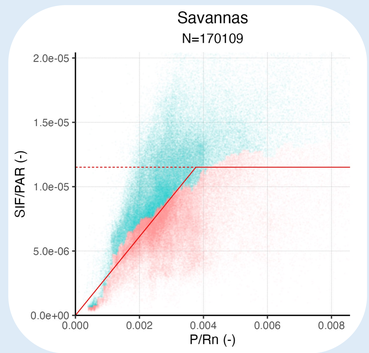


- Even when using an ensemble of different flux data products, there were not enough points to study how the EF vs SM relationship evolved with **water table depth** (**WTD**) and **plant functional type** (**PFT**).

3. Analysis at the global scale with remote sensing data sets

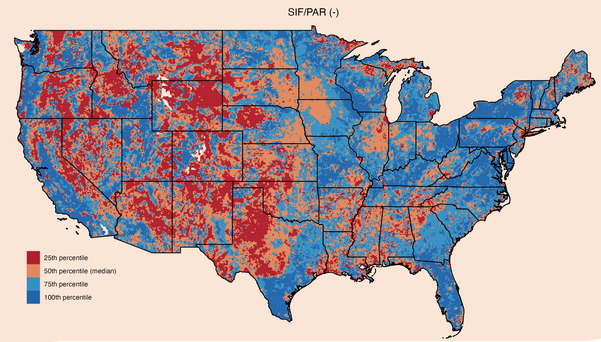
- We switched to remote-sensing data, using TROPOMI **SIF** divided by MODIS **PAR** (SIF/PAR) instead of EF. We quantified mean climate with MSWEP **precipitation** divided by ERA5-Land **net radiation** (P/Rn).

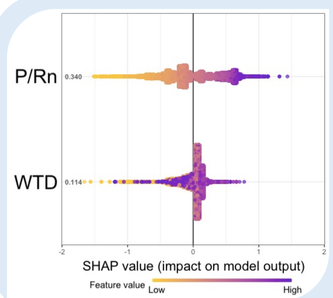




- We evaluated the evolution of SIF/PAR with P/Rn **per PFT group**.
- For every PFT, we identified points whose variance could not be explained by mean climate as points that could potentially be located in groundwater convergence zones (light blue points in scatter plots).

- When plotting those points on a map of the USA (blue points in the map), we found good agreement with a flow convergence map (Jasechko, S., Seybold, H., Perrone, D. *et al.* Widespread potential loss of streamflow into underlying aquifers across the USA. *Nature* **591**, 391–395 (2021)).





- To test the relative importance of P/Rn vs WTD in explaining the variance of SIF/PAR, we trained an extreme gradient boosting model and applied a **Shapley additive explanations framework**.
- We found a feature importance of **0.34** for P/Rn and **0.11** for WTD.

Water table depth is 1/3 as important as mean climate in determining the interannual variability of photosynthesis