Impacts of precipitation variability on carbon budgets of global semi-arid savannas

Laura Nadolski [1,2]*, Marieke Wesselkamp[1], Tarek El Madany[1], Markus Lange[1], Arnaud Carrara[3], Jacob Nelson[1], Aleksander Wieckowski[4], Anke Hildebrandt[2,5], Markus Reichstein[1], Sung-Ching Lee[1]

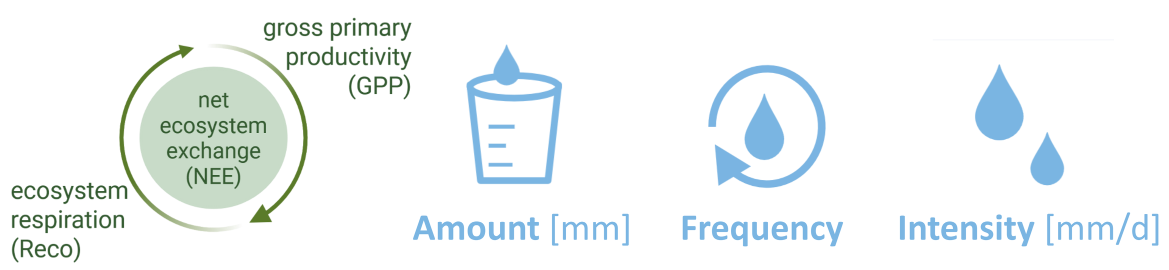
MAIN FINDINGS

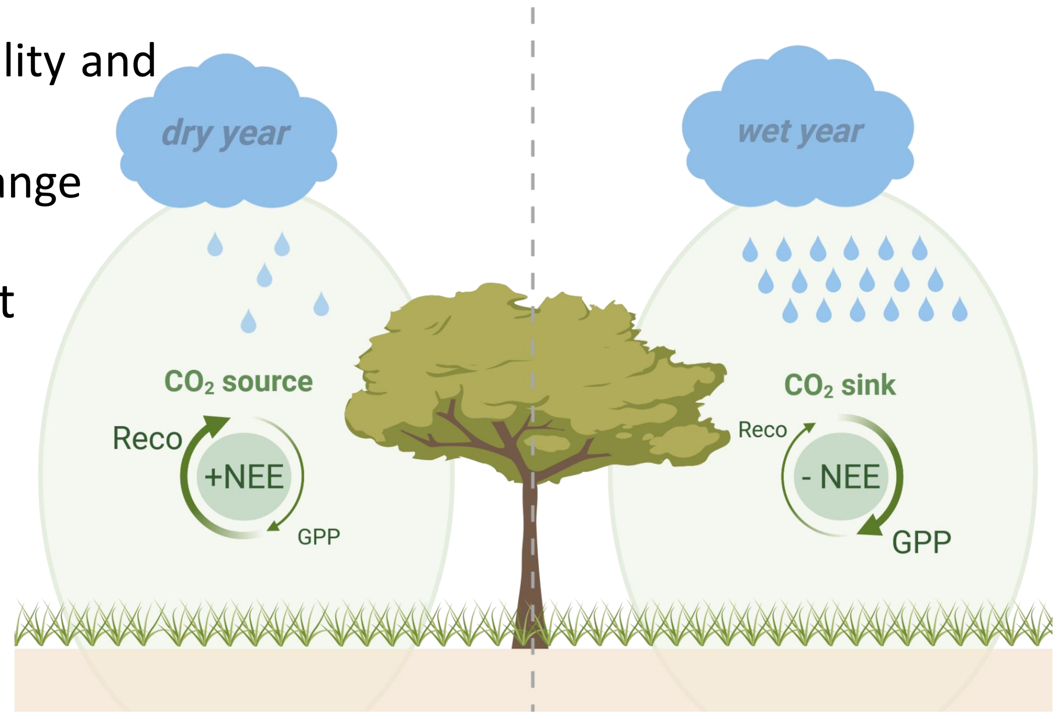
1. **Annual scale**: increasing precipitation metrics mostly lead to increases in both GPP and Reco, with differing effects on NEE between sites
2. **Seasonal scale**: all precipitation metrics together explain most variation in NEE
3. Analyzing different phenological seasons gives more insights into ecosystem dynamics
4. Season-dependent indirect effects of precipitation via soil water content and air temperatures

MOTIVATION

- Semi-arid ecosystems contribute most to trend and inter-annual variability of the land carbon sink → still, not very well represented in models
- Their carbon cycle is very sensitive to water availability and precipitation.
- Precipitation variability is increasing with climate change

→ How does changing precipitation variability affect CO_2 fluxes in semi-arid savannas?

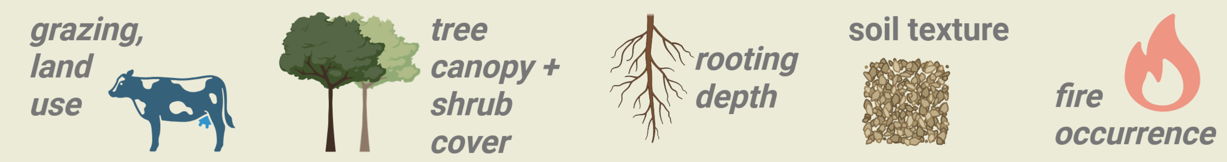




NEXT PROJECT

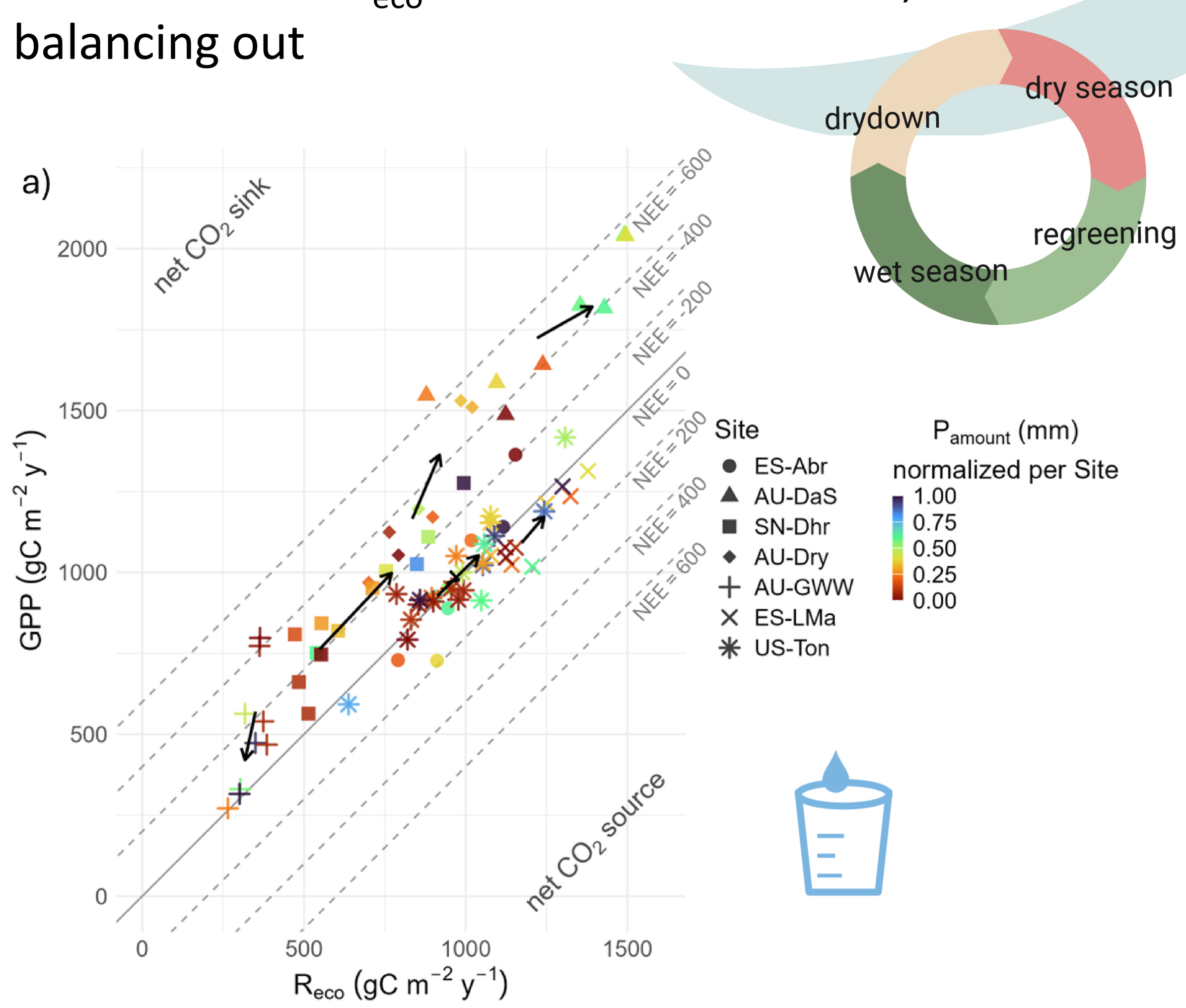
- Which site characteristics (e.g. shrub coverage, rooting depth, soil texture) determine how the ecosystem's CO_2 fluxes are influenced by changing precipitation variability?
- Which site characteristics affect the source – sink behavior of (semi-arid) savannas?

1. Extend dataset of (semi-arid) savanna flux sites
 → **looking for more sites!**
2. Collect site "trait" data
 → **curious to hear about your ideas!**



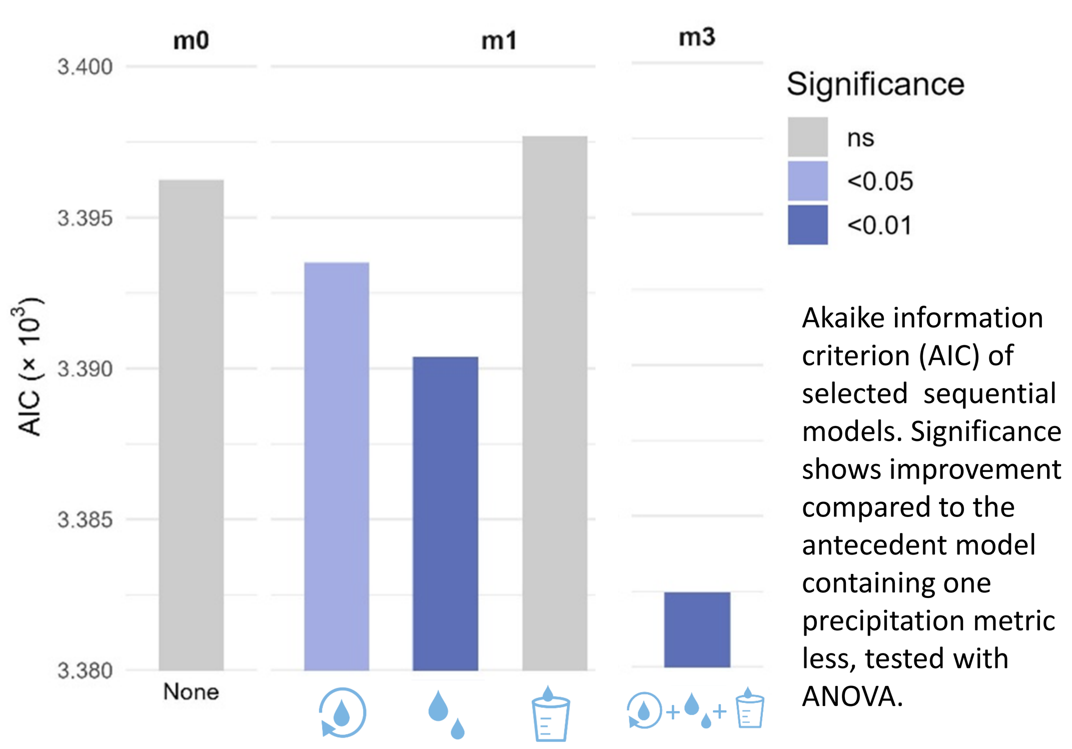
RESULTS

1 Annual scale: Increasing precipitation amount enhances both R_{eco} and GPP at most sites, often balancing out



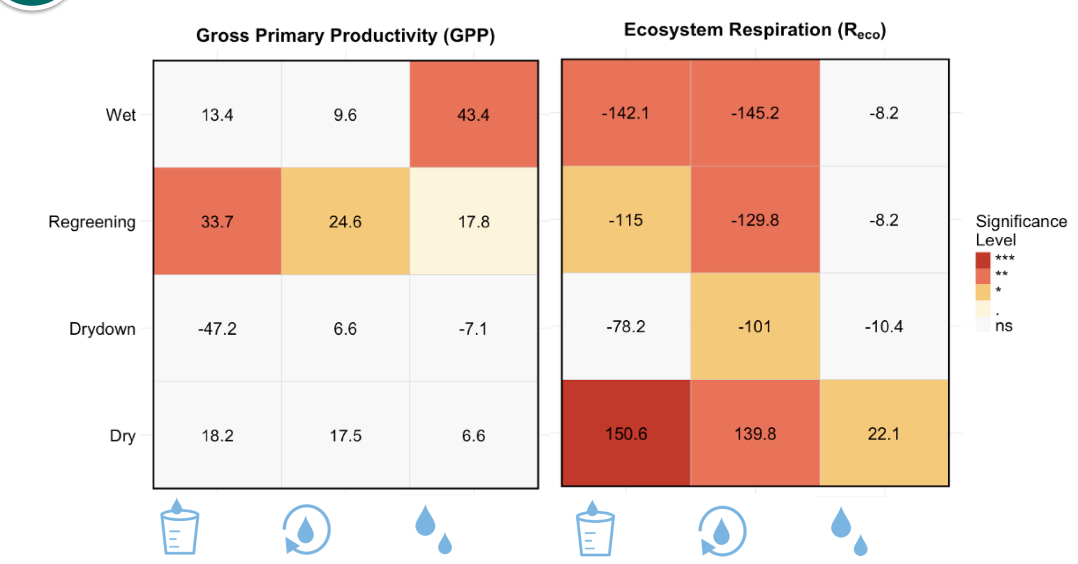
Balances between GPP and Reco on the scale of hydrological years across the sites (shapes) AU-DaS, AU-Dry, ES-Lma, US-Ton, ES-Abr, AU-GWW and SN-Dhr. Colors indicate the normalized precipitation amount per site. Arrows show from the average flux of the drier half of the years (split at the median value) to the average flux of the wetter half of the years to indicate the precipitation amount – CO_2 flux relationship.

2 Seasonal scale: Precipitation amount only is not sufficient to explain NEE variance. Amount + Frequency + Intensity together explain most variance.



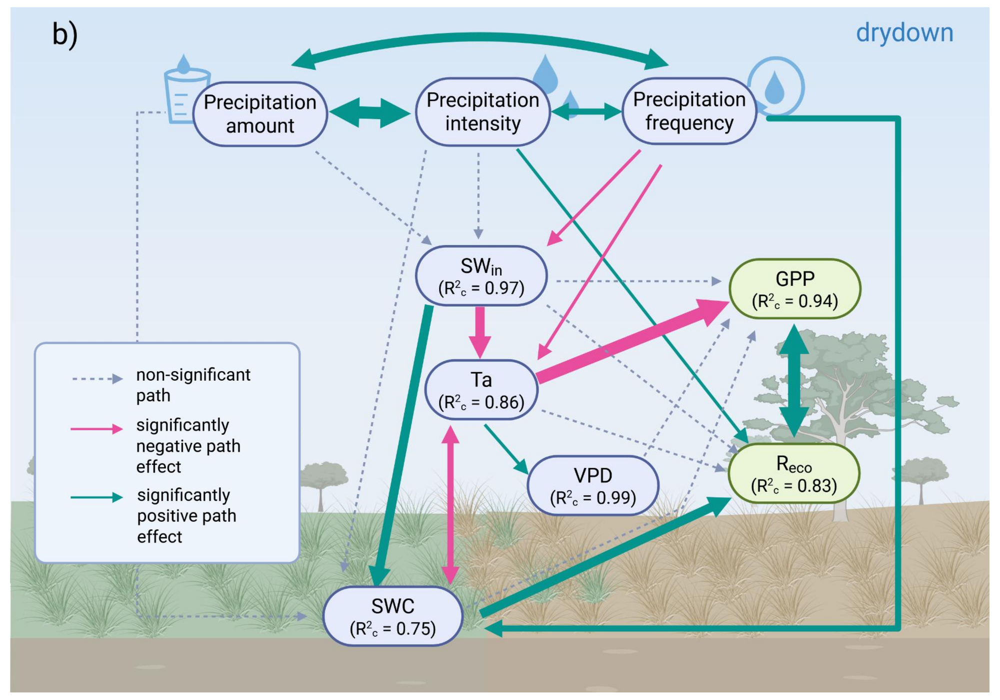
Akaike information criterion (AIC) of selected sequential models. Significance shows improvement compared to the antecedent model containing one precipitation metric less, tested with ANOVA.

3 Effects differ between seasons



Effects of precipitation amount, frequency and intensity on the CO_2 fluxes in phenological seasons. Individual effect sizes were derived post-hoc from linear mixed effect model interaction estimates.

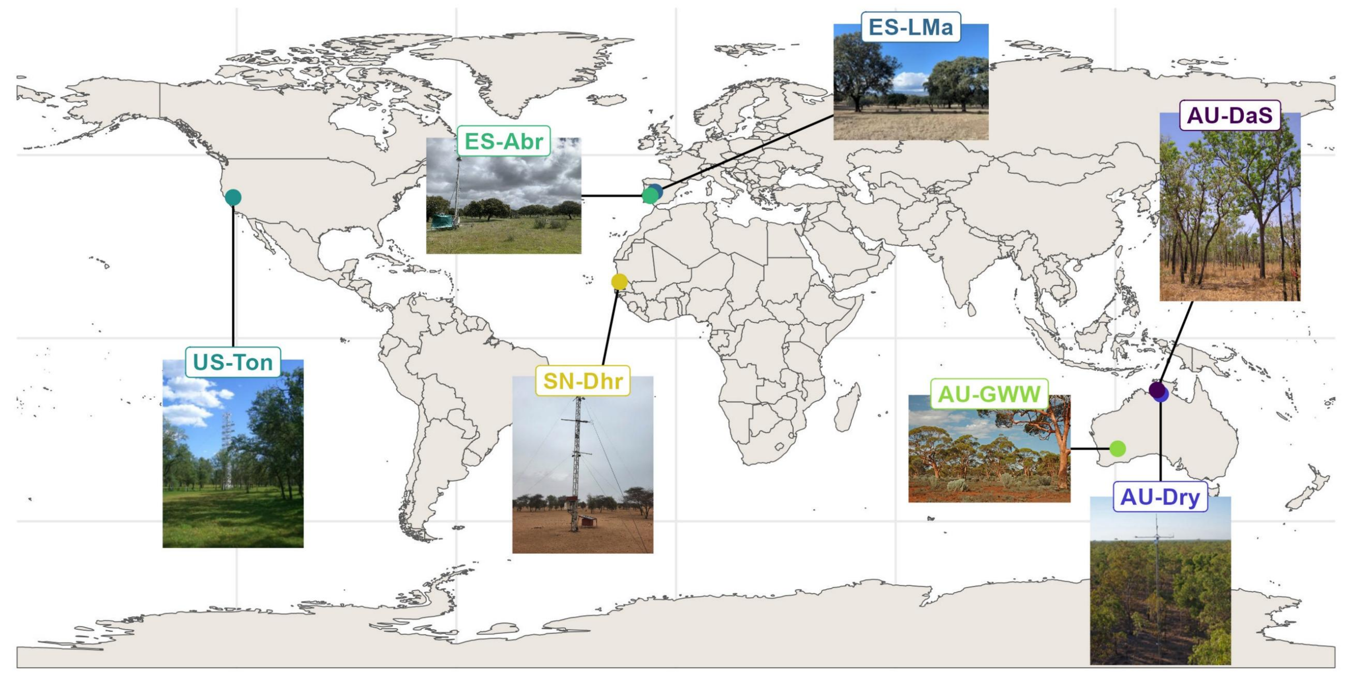
4 Soil moisture (SWC) is a main mediator between precipitation and ecosystem fluxes, in drydown season, air temperature (Ta) suppresses GPP



Structural equation model identifying direct and indirect effects of three precipitation metrics on seasonal GPP and Reco in the drydown season.

DATA

Eddy covariance + meteorological + soil data from tree-grass ecosystems with annual grass layer, distinct dry and wet season, >=10 years of data



Map of savanna (tree-grass) flux sites used for the data analysis in this study. They have a distinct dry and wet season and at least 10 years of data. Photo credits: Fluxnet, Ozflux.

MAX PLANCK INSTITUTE FOR BIOGEOCHEMISTRY
FRIEDRICH-SCHILLER-UNIVERSITÄT JENA
IMPRS gBGC

Affiliations: [1] Max Planck Institute for Biogeochemistry, Jena, Germany ; [2] Friedrich-Schiller University Jena; [3] Fundacion Centro de Estudios Ambientales del Mediterráneo (CEAM), Valencia, Spain; [4] Lund University, Sweden; [5] Helmholtz Centre for Environmental Research (UFZ), Leipzig, Germany

Soon to be published!
Manuscript accepted in Global Change Biology

lnadolski@bgc-jena.mpg.de
More info and links →