Seasonal water storage and delayed evapotranspiration across continents

Patterns and drivers

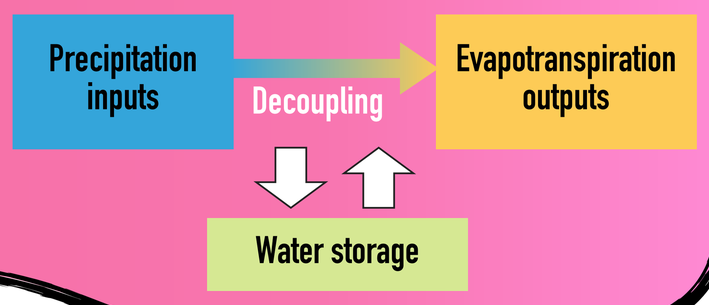
Sylvain Kuppel [1], Ying Fan [2], and Esteban G. Jobbágy [1]

[1] Grupo de Estudios Ambientales, CONICET & Univ. Nacional de San Luis, Argentina

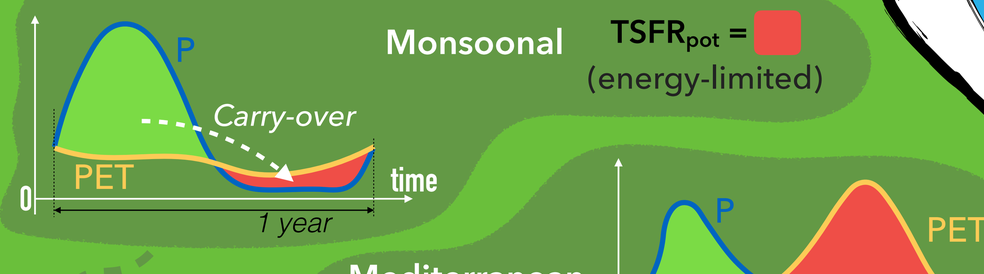
[2] Department of Earth & Planetary Sciences, Rutgers University, USA

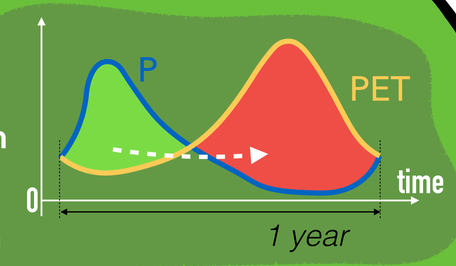
Introduction

Storage and delayed evapotranspiration (ET) of precipitation (P) inputs regulate the timing and stability of plant production and the multiple ecological and economic processes that it supports. The extent to which actual ET (AET) can decouple from P inputs depends on the ecohydrologic system capacity to store water. This decoupling and its associated storage requirement is particularly relevant at the seasonal scale in regions where, for instance, rainfalls are highly seasonal and/or P and potential ET (PET) are seasonally out of phase. We explore where on Earth seasonal water carry-over is expected from a climate perspective, and assess to which extent and land surface processes alter this "potential" hydrologic buffer.
This analysis helps outlining the expected seasonal response of the land water cycle in the frame of likely climate and land use changes.



Climatic potential for seasonal carry-over



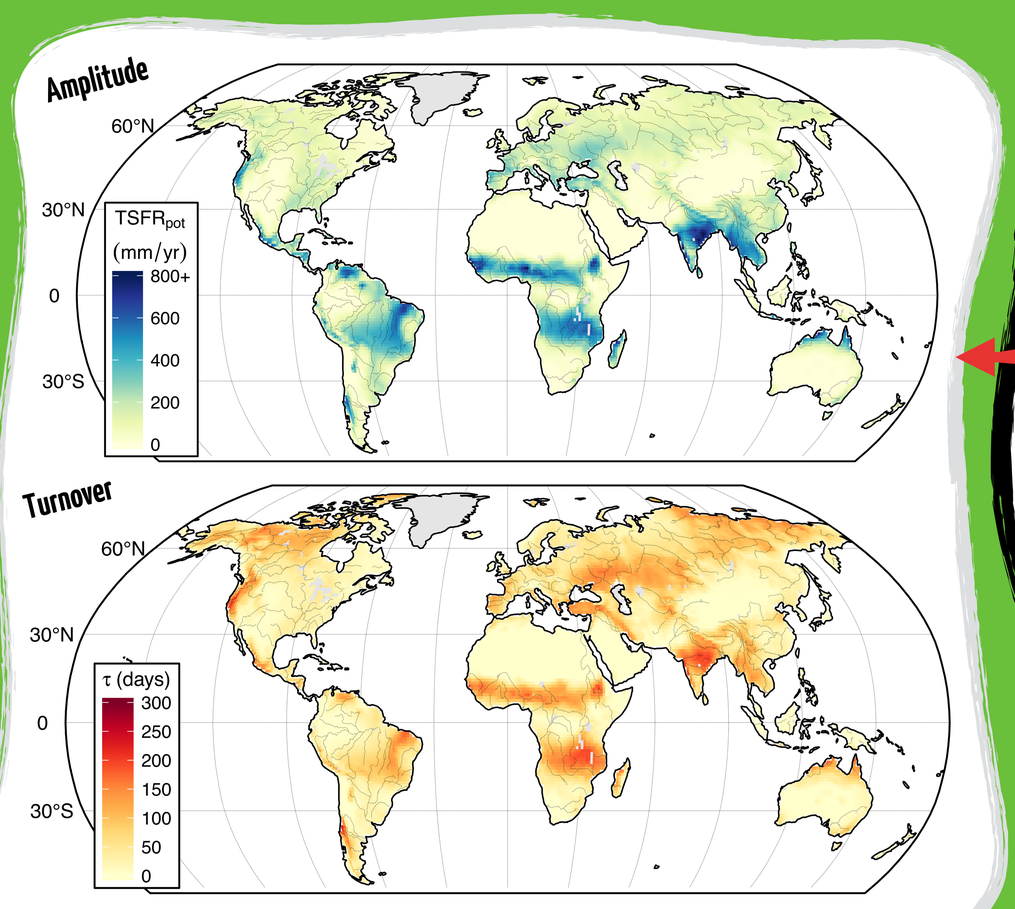


Examples

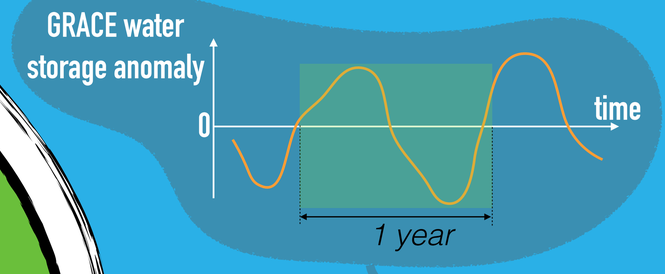
General formula

$$\text{Amplitude} = \min\left(\int_{P>PET}(P-PET)\,dt,\ \int_{PET>P}(PET-P)\,dt\right)_{\Delta t=12\,months}$$

$$\text{Turnover} = \frac{\text{Amplitude}}{\text{Mean annual P}}$$



"Observed" seasonal carry-over



$$\text{Amplitude} = \frac{1}{2}\left(\sum|\Delta TWS_a|\right)_{\Delta t=12\,months}$$

$$\text{Turnover} = \frac{\text{Amplitude}}{\text{mean}(F_{in}, F_{out})}$$

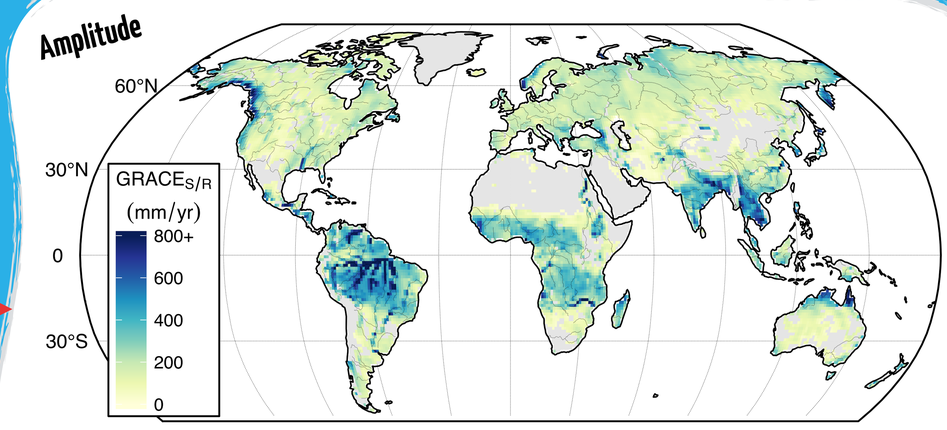
F_{in} = Mean annual P + Accum. monthly run-on
F_{out} = Mean annual AET + Acc. monthly run-off

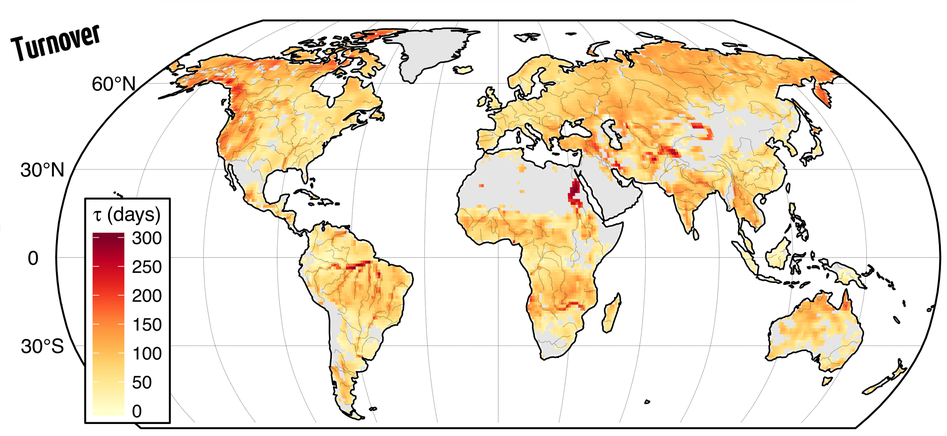
(monthly water balance eq., Q = ΔStorage + P - ET)

Datasets

Study period 2003 - 2010

P & Snowfall ERA-Interim/Land	Terrestrial water storage GRACE (arithmetic mean of CSR, JPL & GFZ RL05 solutions)
Potential ET CRU TS3.23	Actual ET ERA-Interim

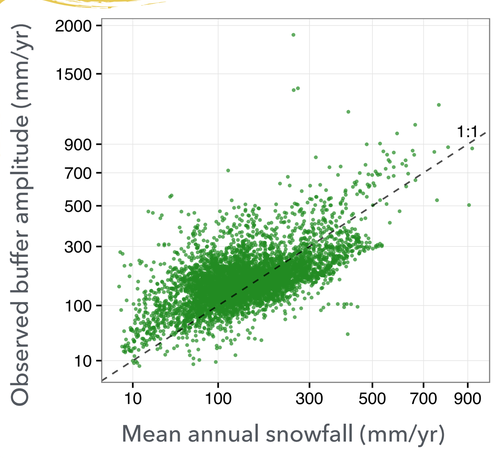




(Excluding locations where err$_{GRACE}$ > Amplitude/2)

Limited soil depth
Shallow roots
Lateral outputs
>
≠
<
Other storage pools
Lateral inputs
Human imprint

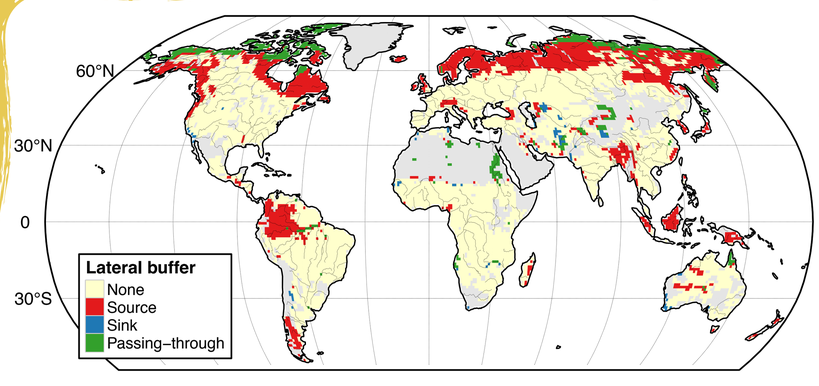
Snow storage



Locations where $\frac{\text{snowfall}}{P}$ >5%

R^2=0.36

Lateral carry-over



Classification

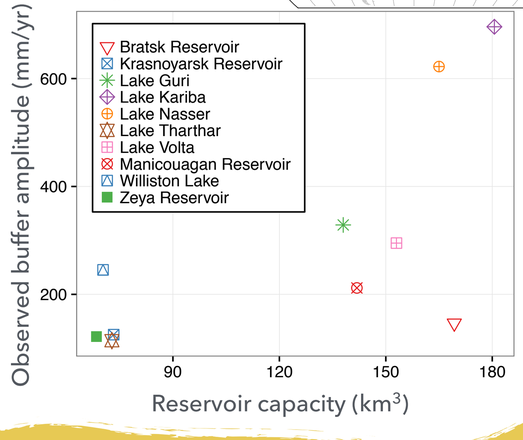
Source Accum. monthly run-off > Mean annual P / 2

Sink Accum. monthly run-on > Mean annual AET / 2

Passing-through Sink & Source

Surface buffer

10 largest reservoirs



References

Kleidon, A. and M. Heimann (1998), *Glob. Change Biol.*, 4(3), 275–286.
Lorenz, C. et al. (2014), *J. Hydrometeorol.*, 15(6), 2111–2139.

skuppel1@gmail.com