



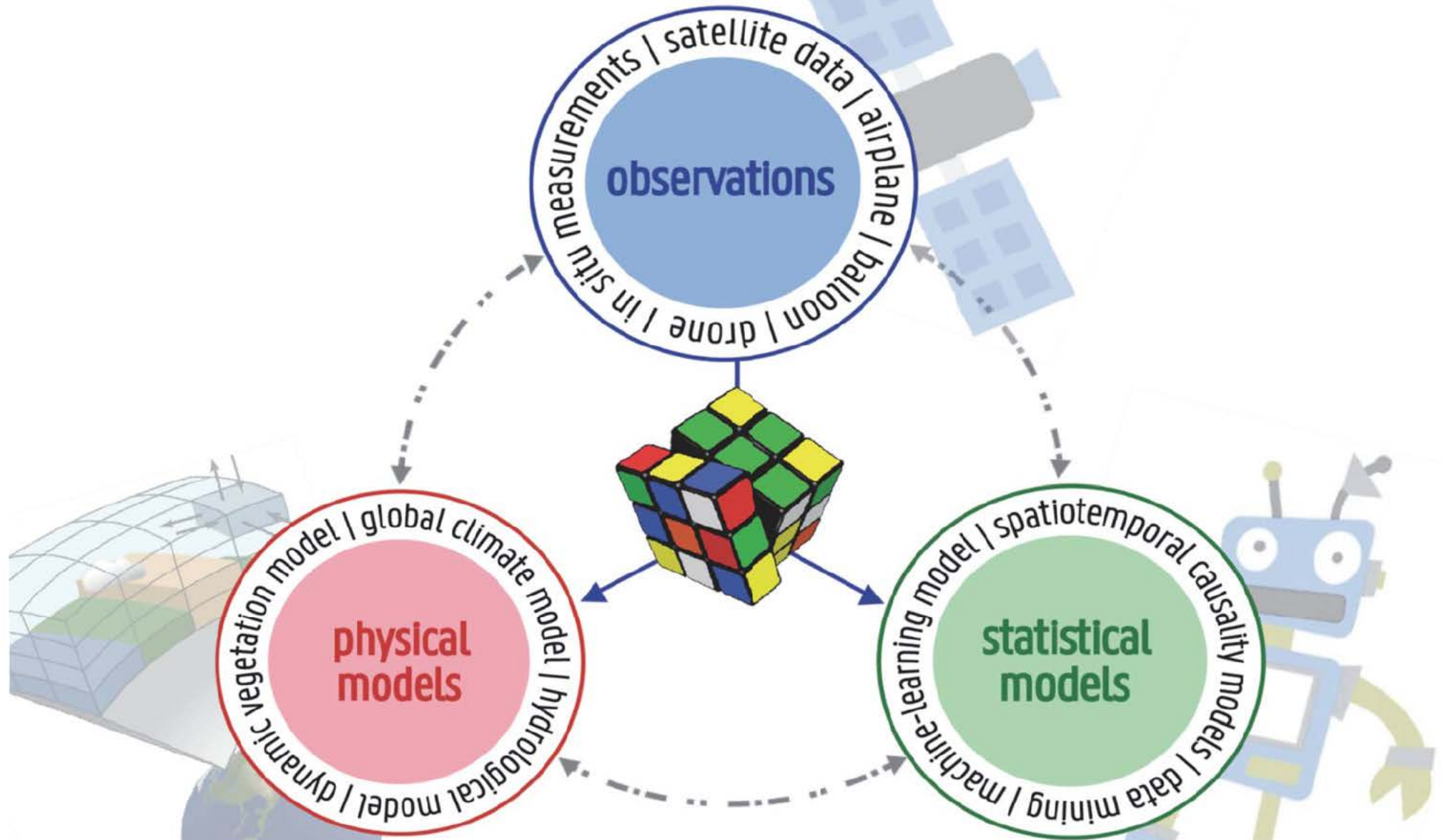
A data-driven perspective on global biosphere–climate interactions

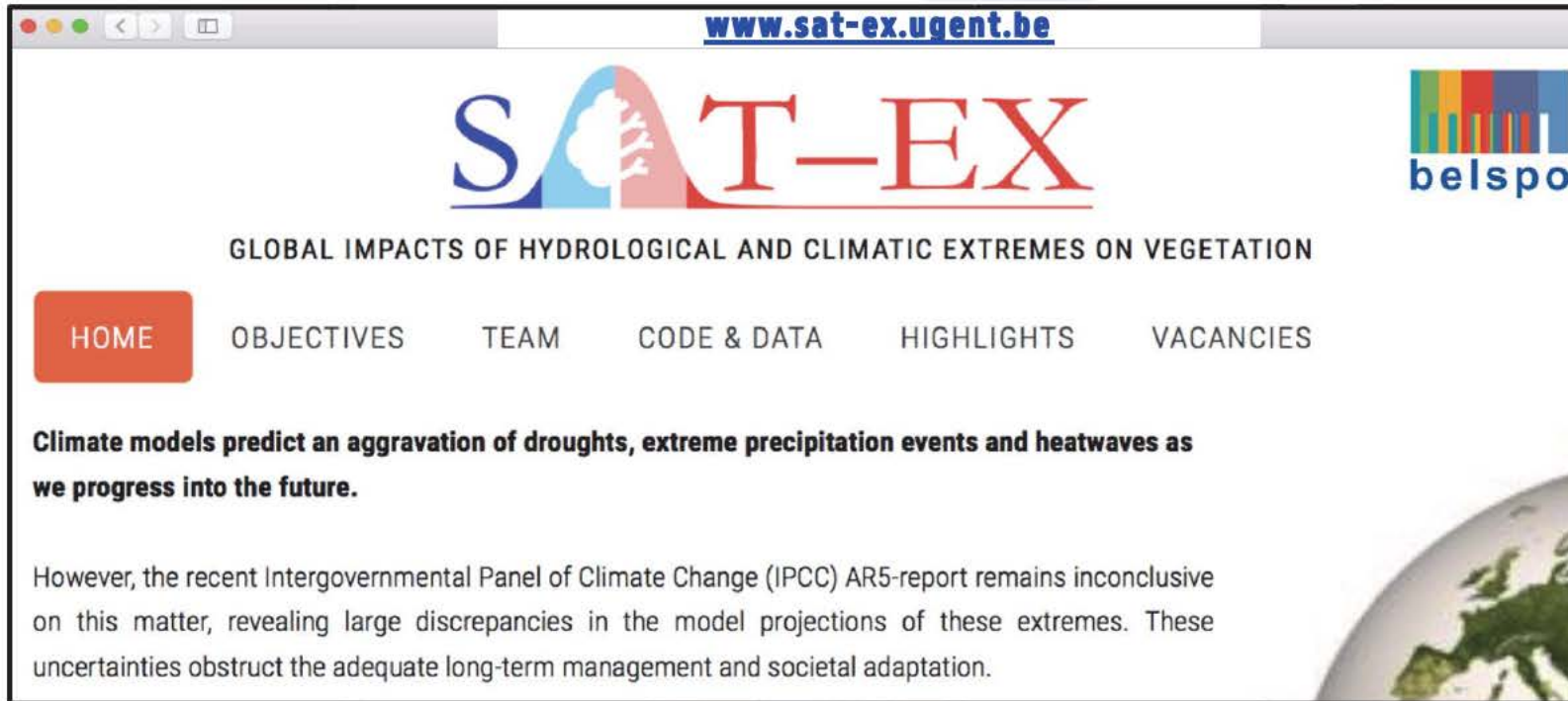
Diego G. Miralles

(on behalf of the SAT-EX consortium)



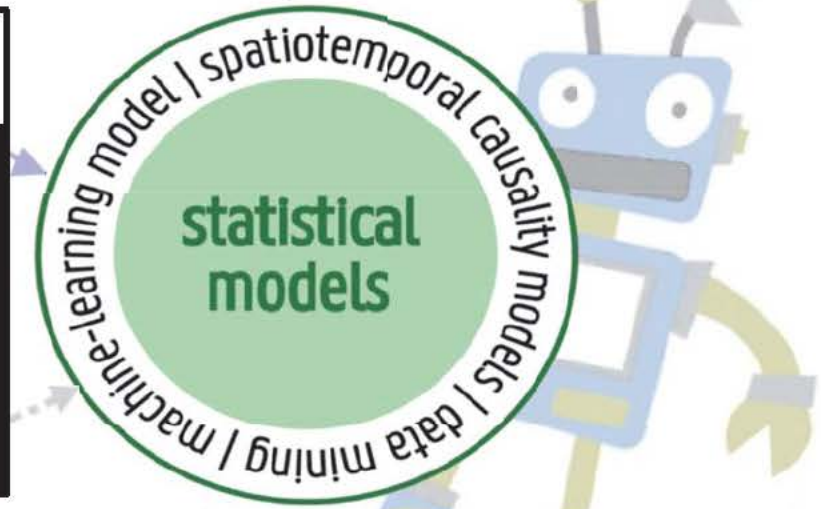


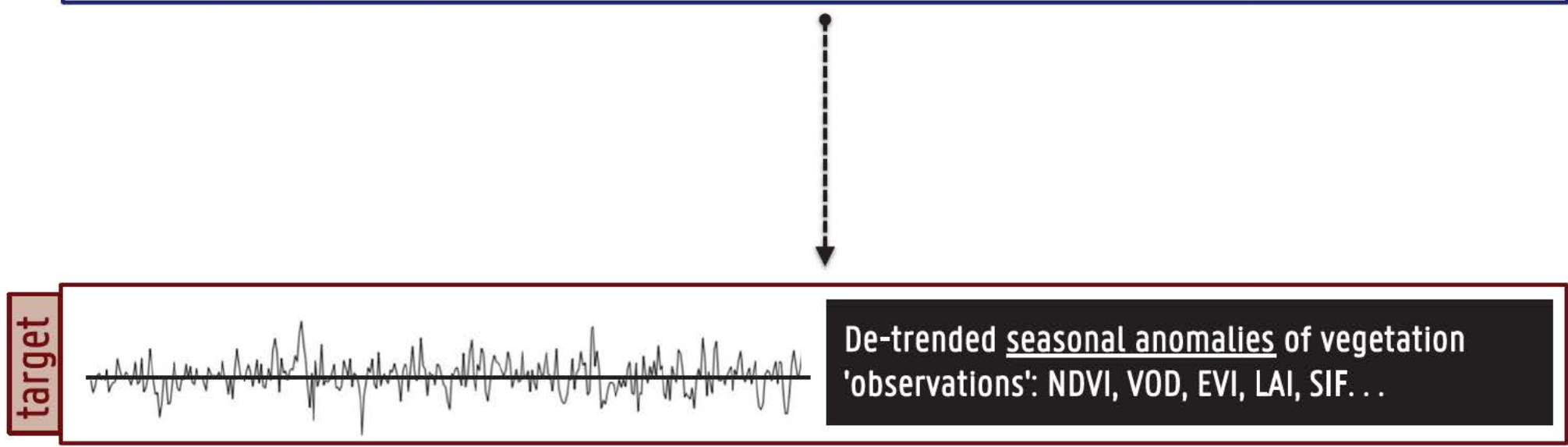
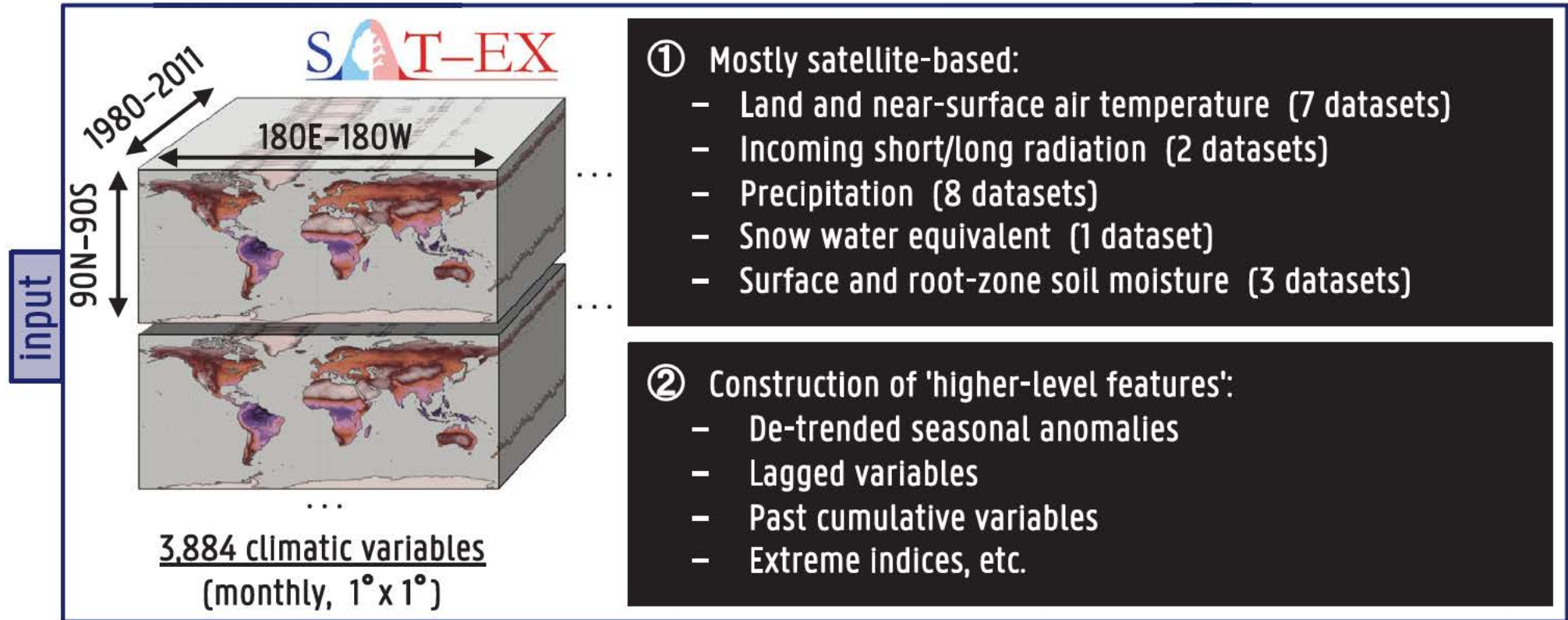


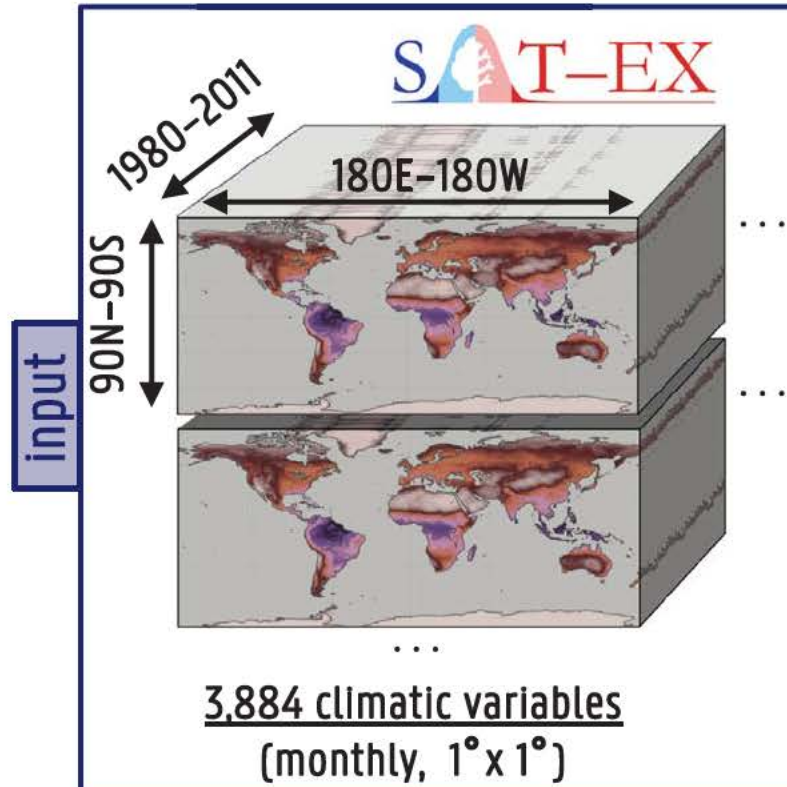


Objectives

- ① To provide new evidence of how hydro-climatic extremes have changed over the satellite era
- ② To provide new insights into past changes in vegetation and their sensitivity to climatic extremes
- ③ To show the extent to which ESMs reproduce these



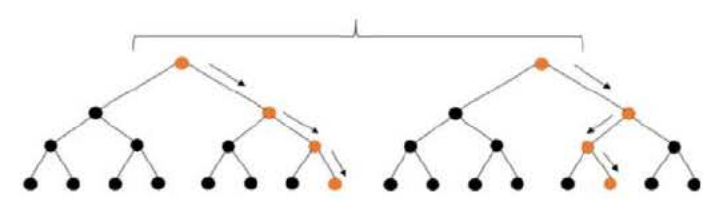




- ① Mostly satellite-based:
- Land and near-surface air temperature (7 datasets)
 - Incoming short/long radiation (2 datasets)
 - Precipitation (8 datasets)
 - Snow water equivalent (1 dataset)
 - Surface and root-zone soil moisture (3 datasets)

- ② Construction of 'higher-level features':
- De-trended seasonal anomalies
 - Lagged variables
 - Past cumulative variables
 - Extreme indices, etc.

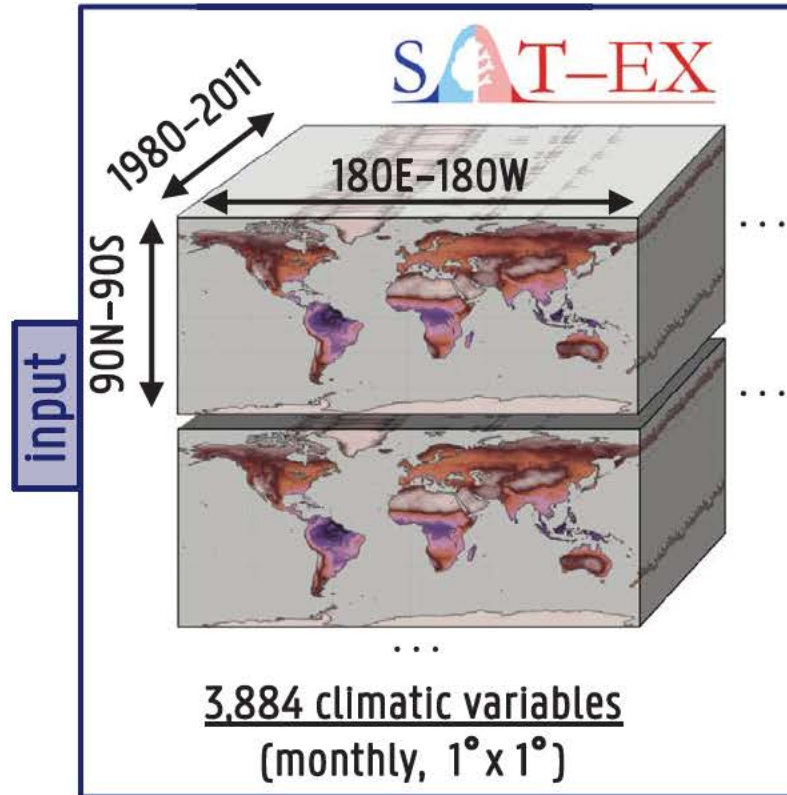
- Nonlinear Granger-causality framework
- Baseline prediction model based on past vegetation
 - Full random forest model based on past vegetation plus the whole input data-cube



model



De-trended seasonal anomalies of vegetation 'observations': NDVI, VOD, EVI, LAI, SIF...



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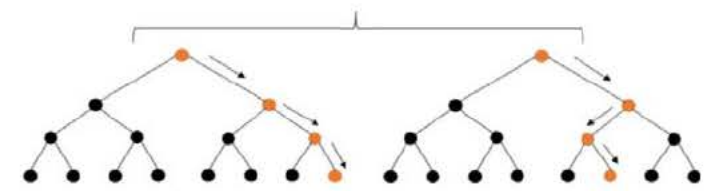
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Geosci. Model Dev., 10, 1945–1960, 2017
 www.geosci-model-dev.net/10/1945/2017/
 doi:10.5194/gmd-10-1945-2017
 © Author(s) 2017. CC Attribution 3.0 License

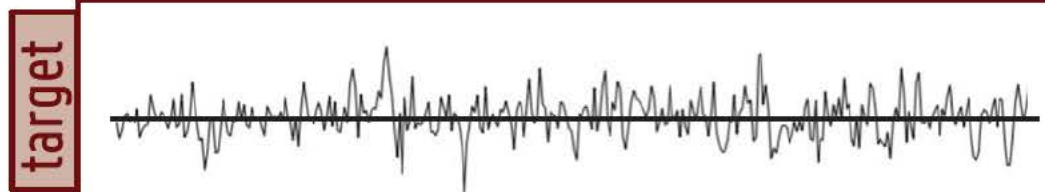


A non-linear Granger-causality framework to investigate climate-vegetation dynamics

Christina Papagiannopoulou¹, Diego G. Miralles^{2,3}, Stijn Decubber¹, Matthias Demuzere², Niko E. C. Verhoest², Wouter A. Dorigo⁴, and Willem Waegeman¹



model



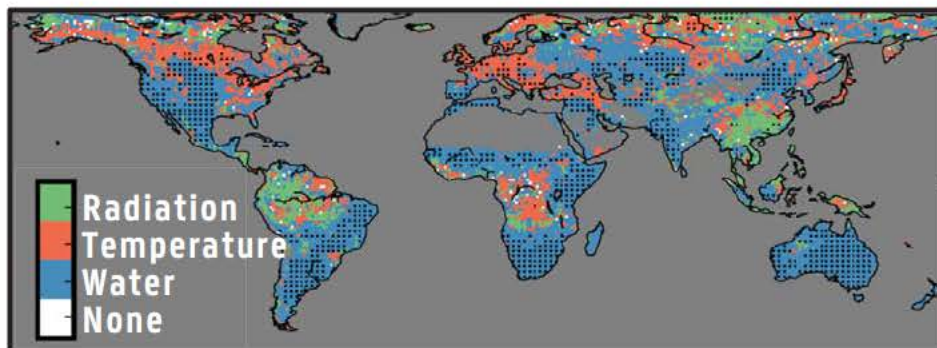
De-trended seasonal anomalies of vegetation 'observations': NDVI, VOD, EVI, LAI, SIF...

target

Potential to isolate the effect of ...

- ① Particular climatic variables
- ② Past time lags & cumulative periods
- ③ Hydro-climatic extremes

Main controls over vegetation



Environmental Research Letters

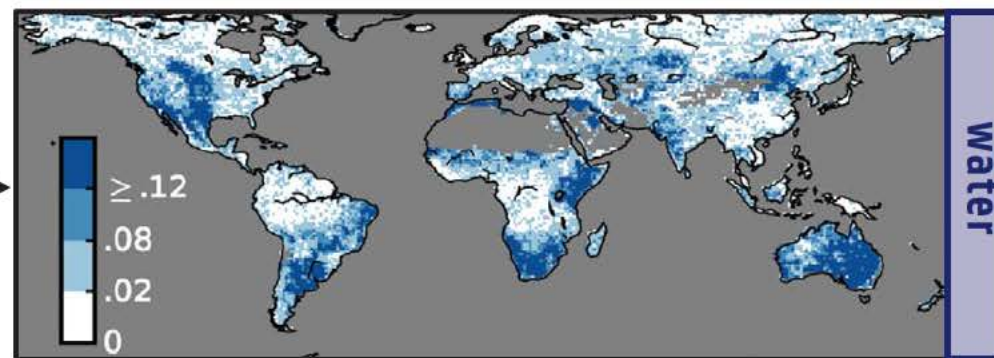
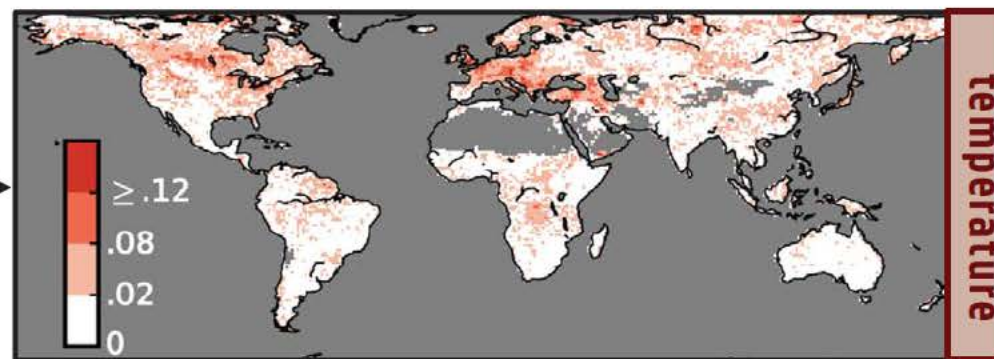
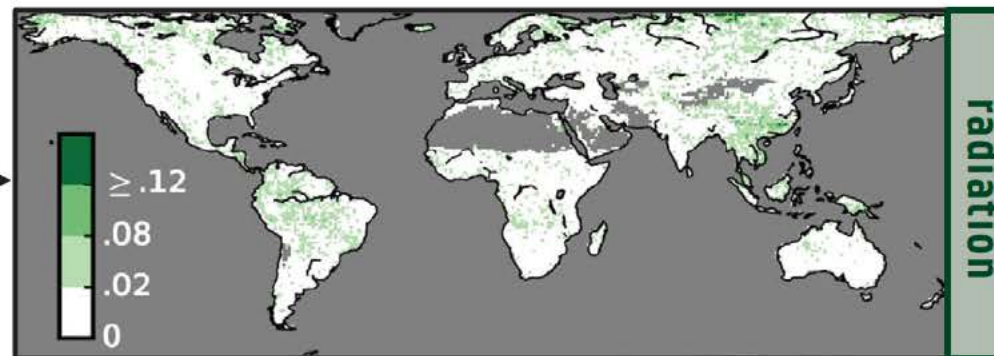


Vegetation anomalies caused by antecedent precipitation in most of the world

Christina Papagiannopoulou¹, Diego G. Miralles², Wouter Dorigo³, Niko Verhoest⁴, Mathieu Depoorter⁵, Willem Waegeman⁶

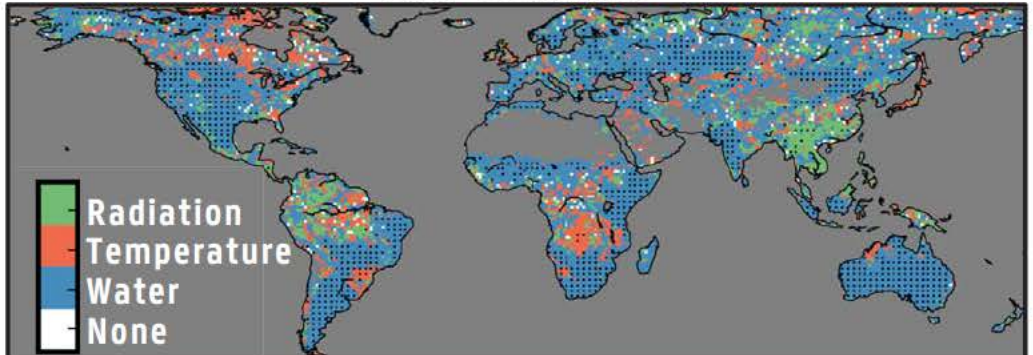
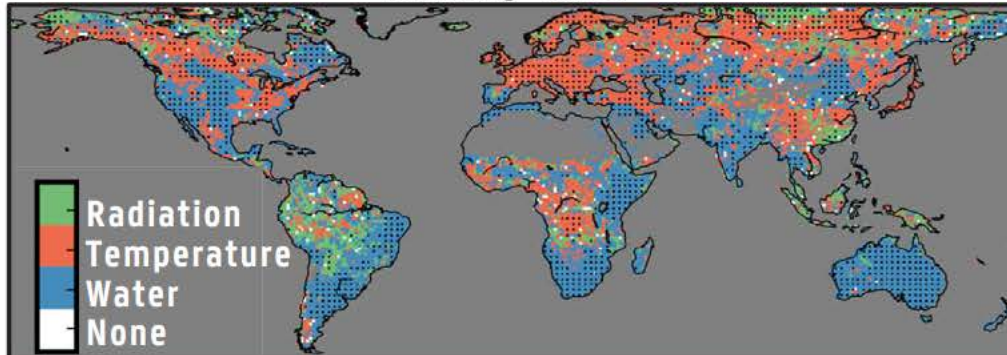
>60% of world's vegetated land primarily limited by water

Granger causality



January–June

July–December



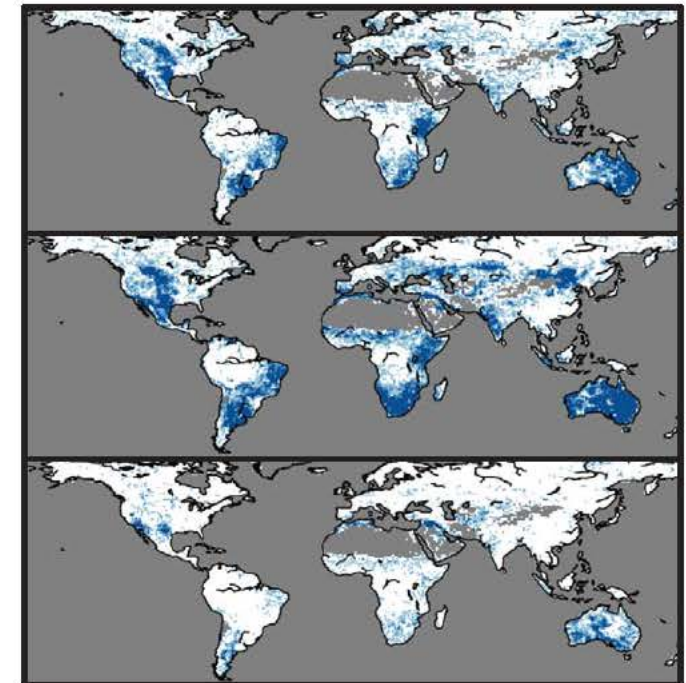
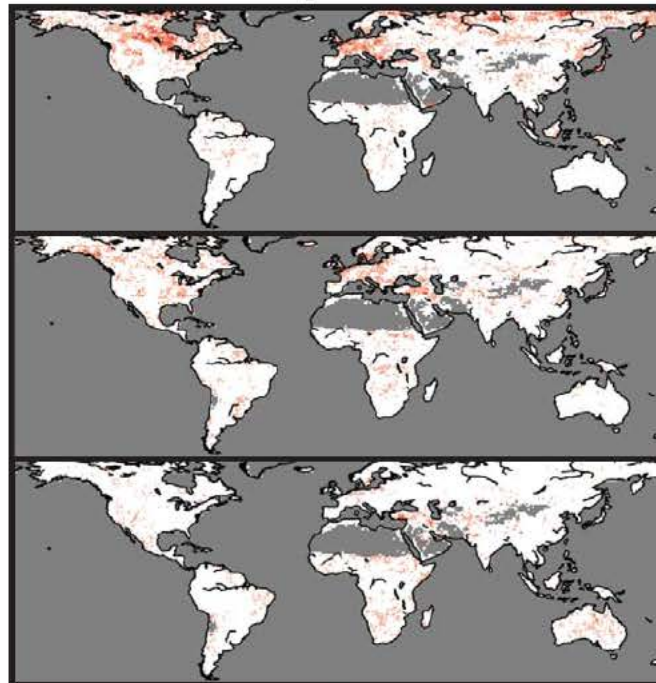
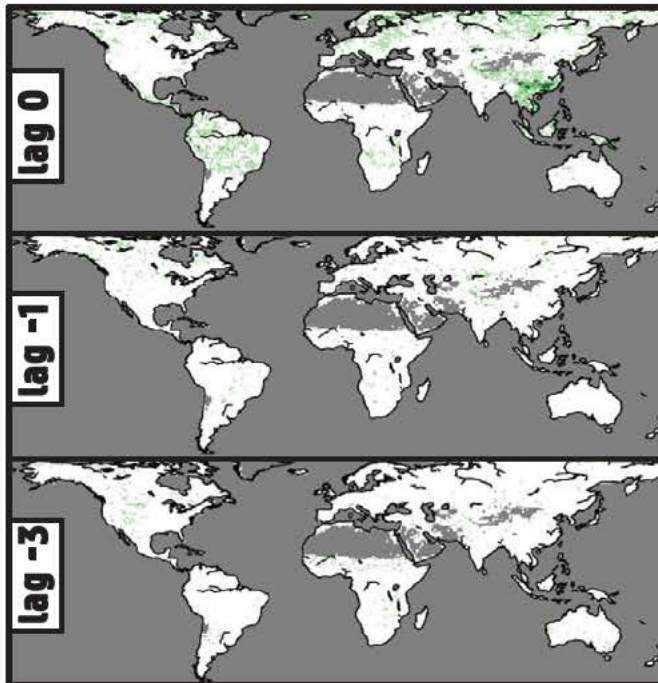
NH deciduous and mixed forests temperature-limited during growing season

But limited by antecedent precipitation during the senescence period

Radiation

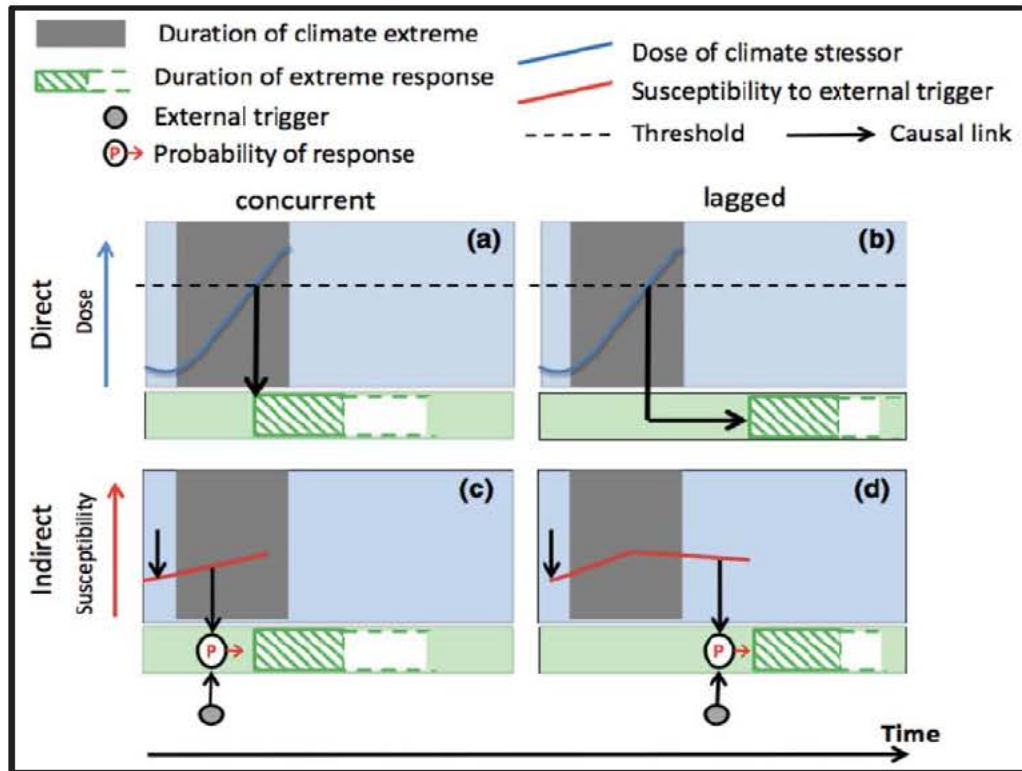
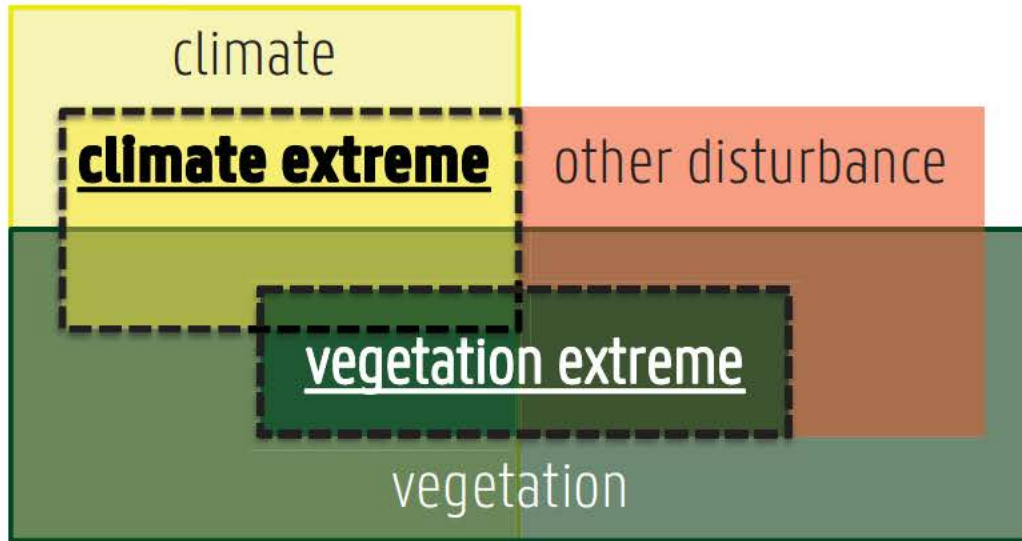
Temperature

Water

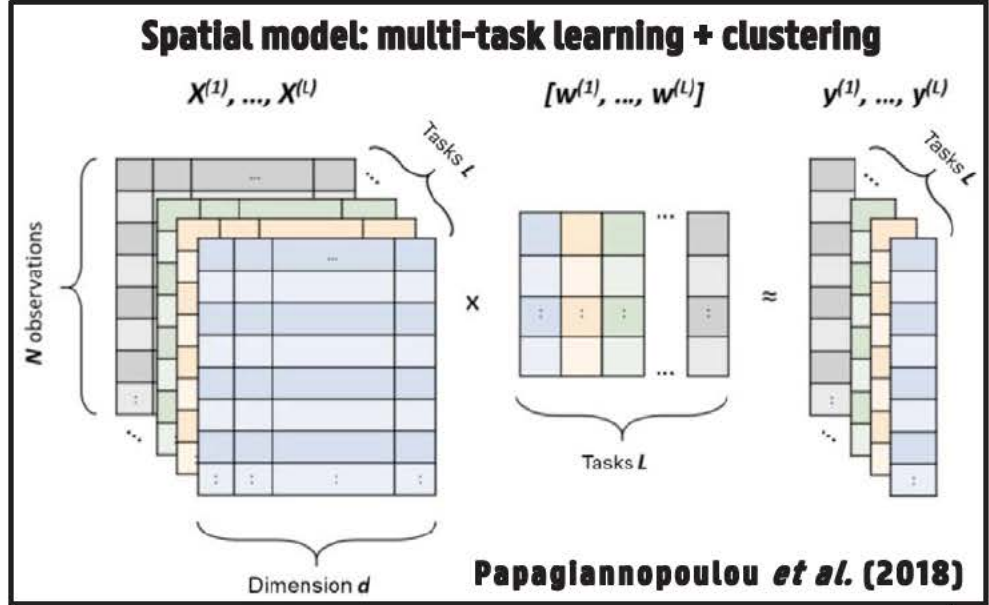
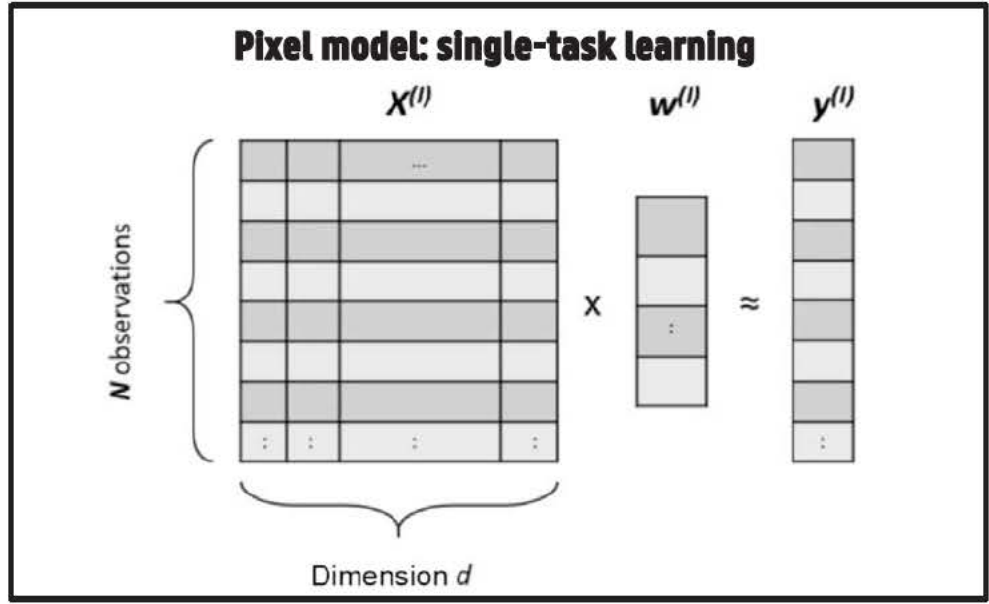


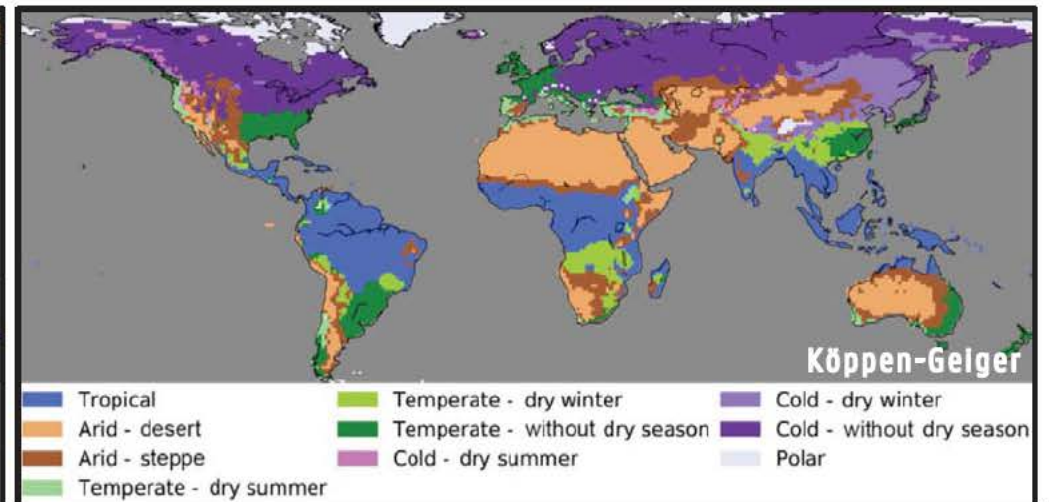
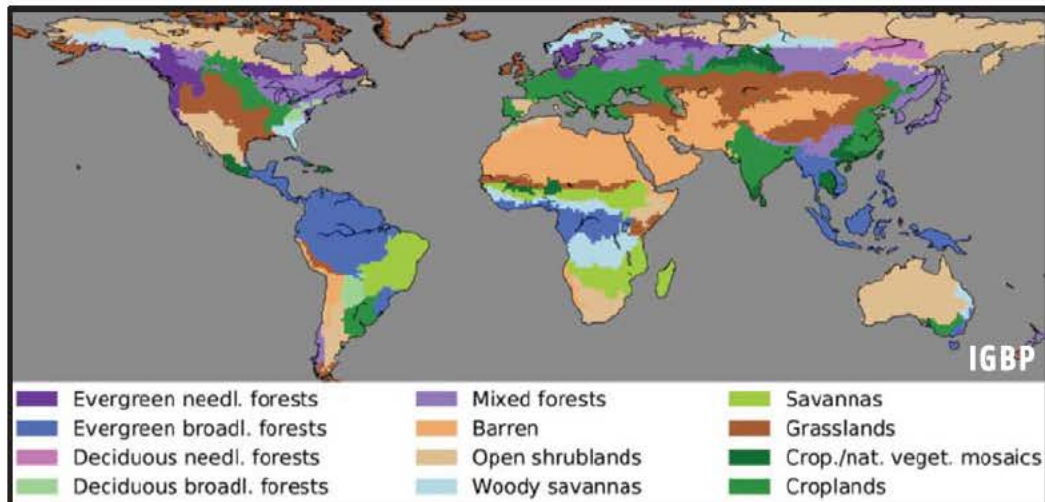
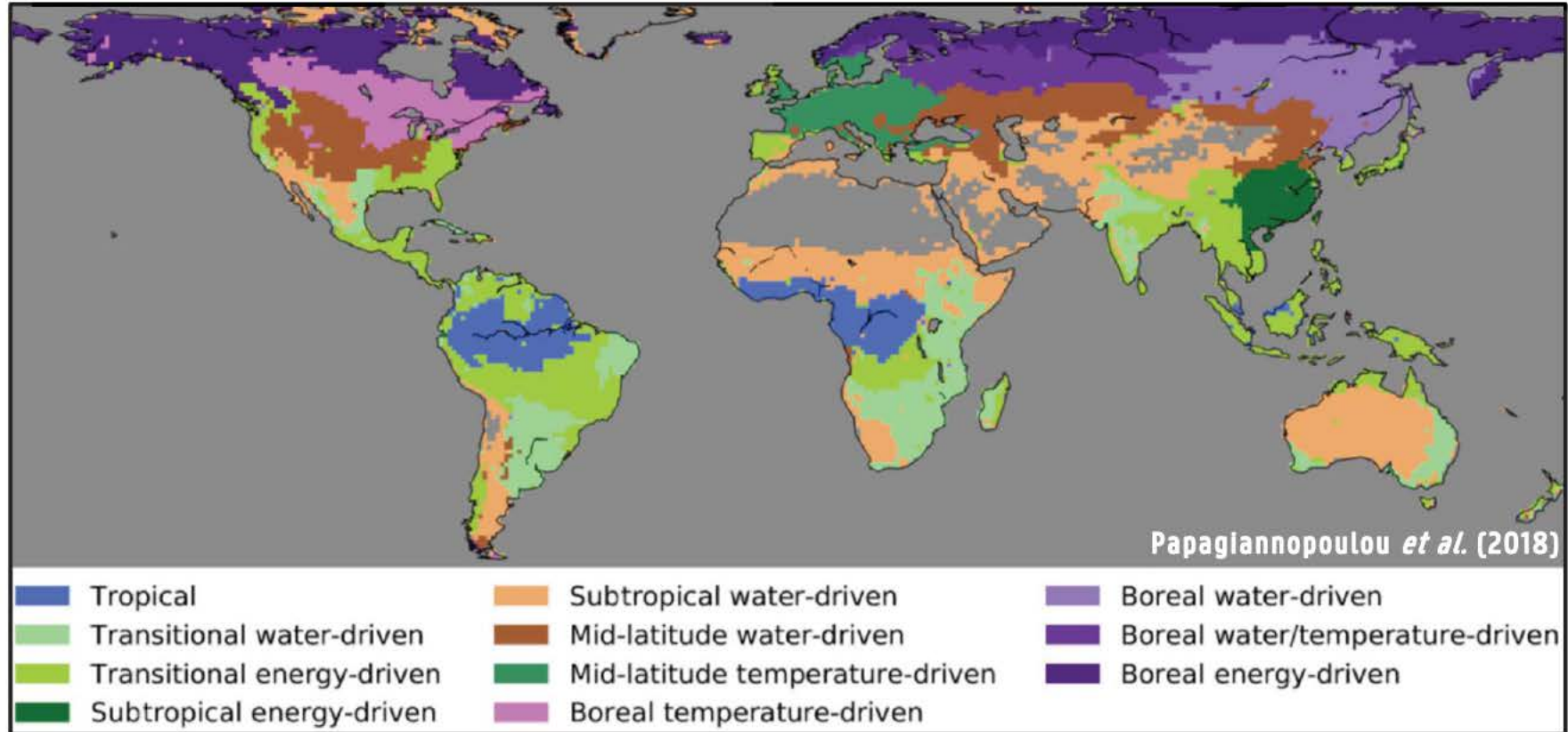
Radiation and temperature yield immediate anomalies

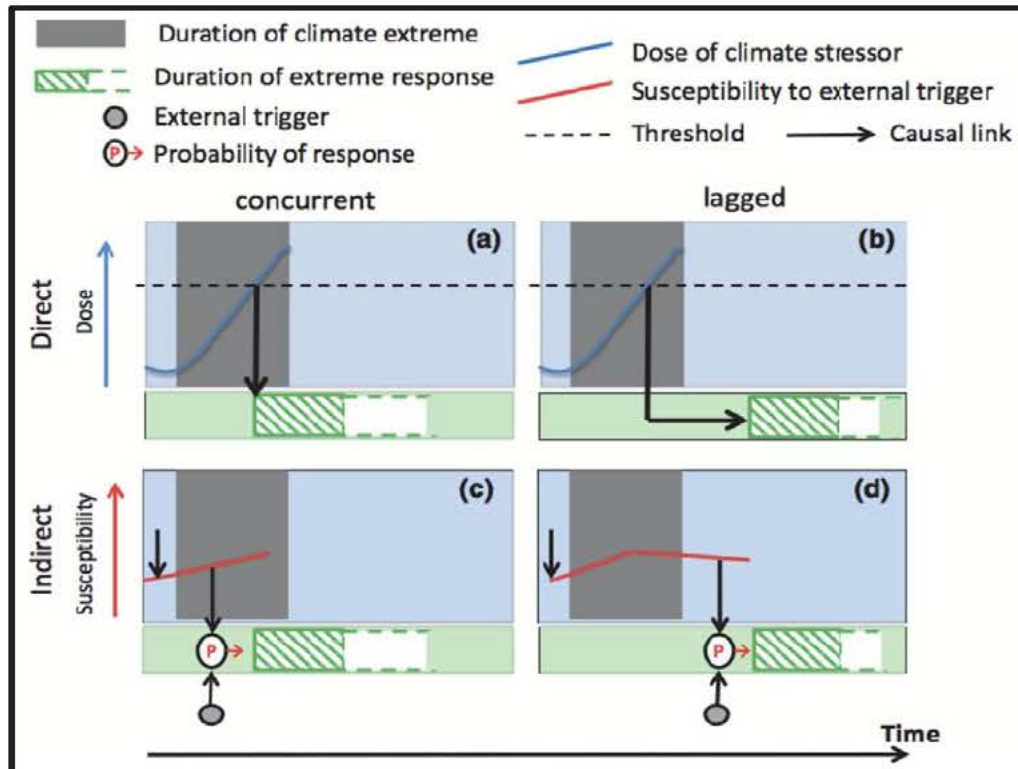
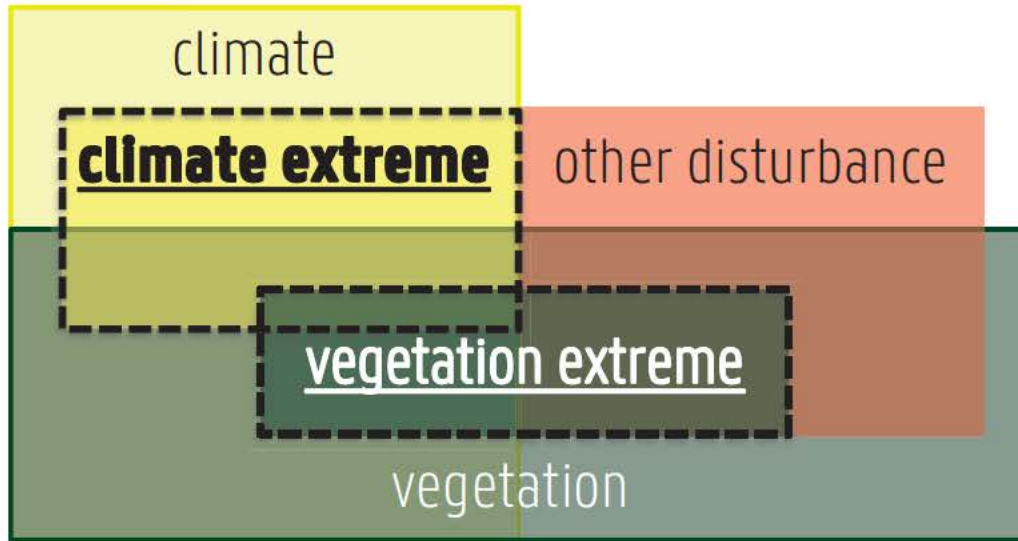
Their effects dissipate shortly, contrary to water



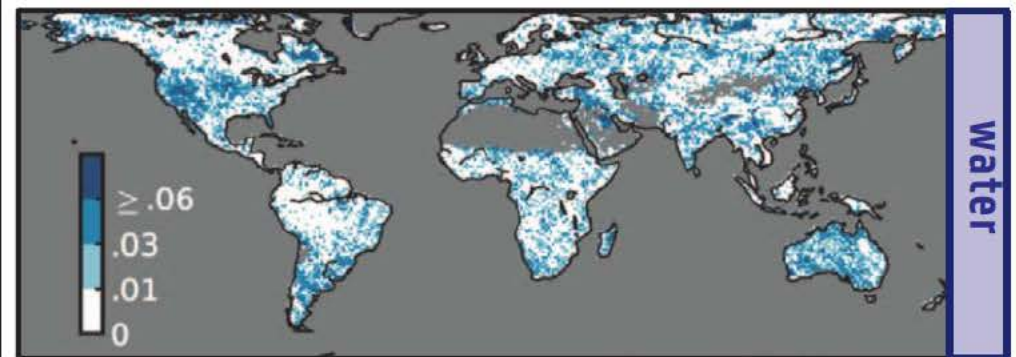
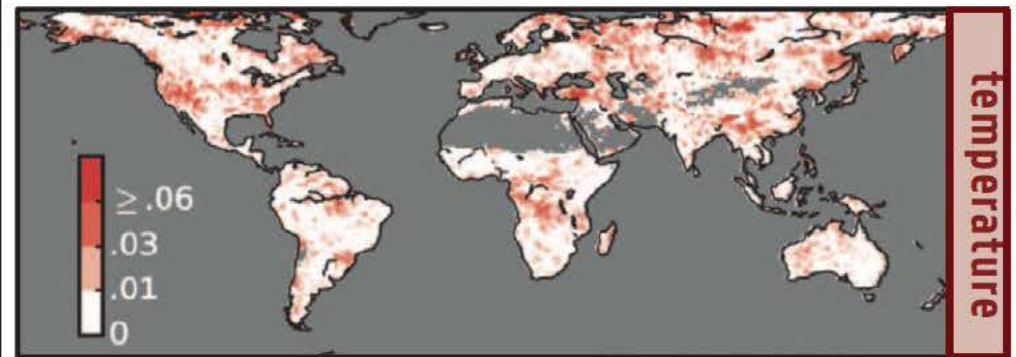
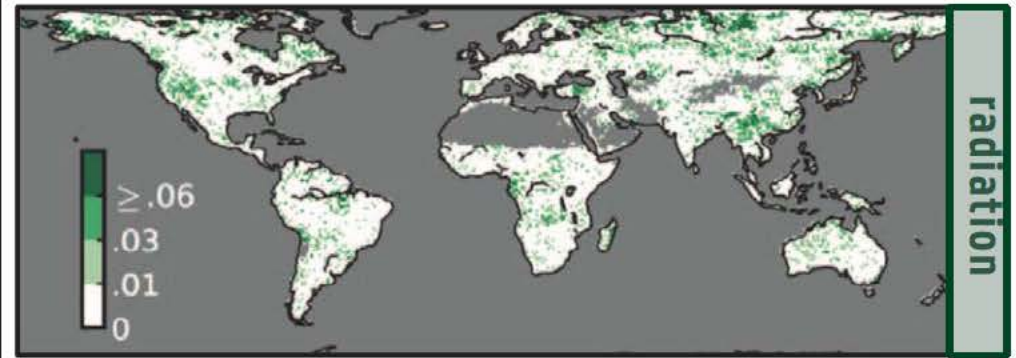
Need for reference region definition





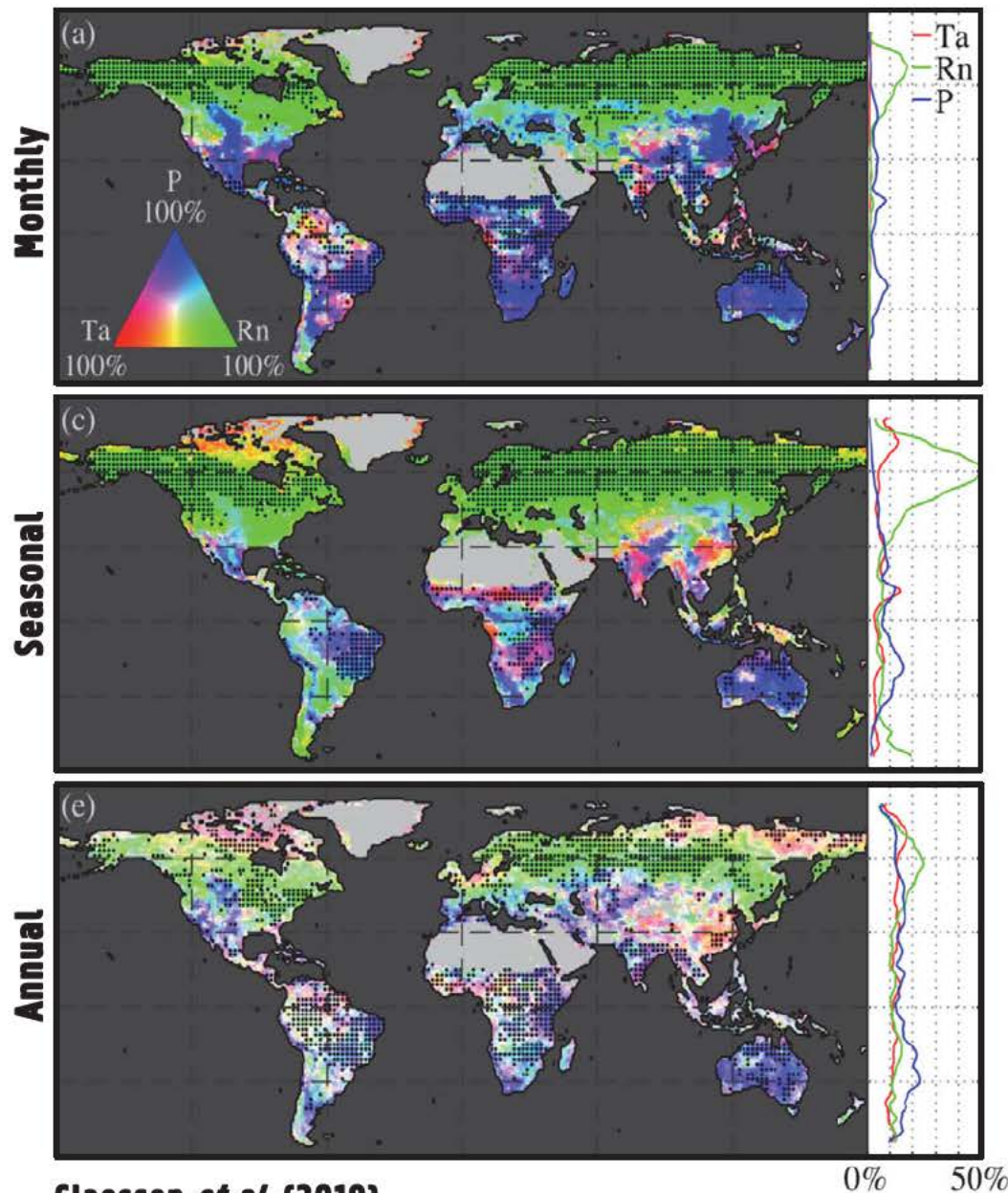


Granger causality



Papagiannopoulou *et al.* (2017)

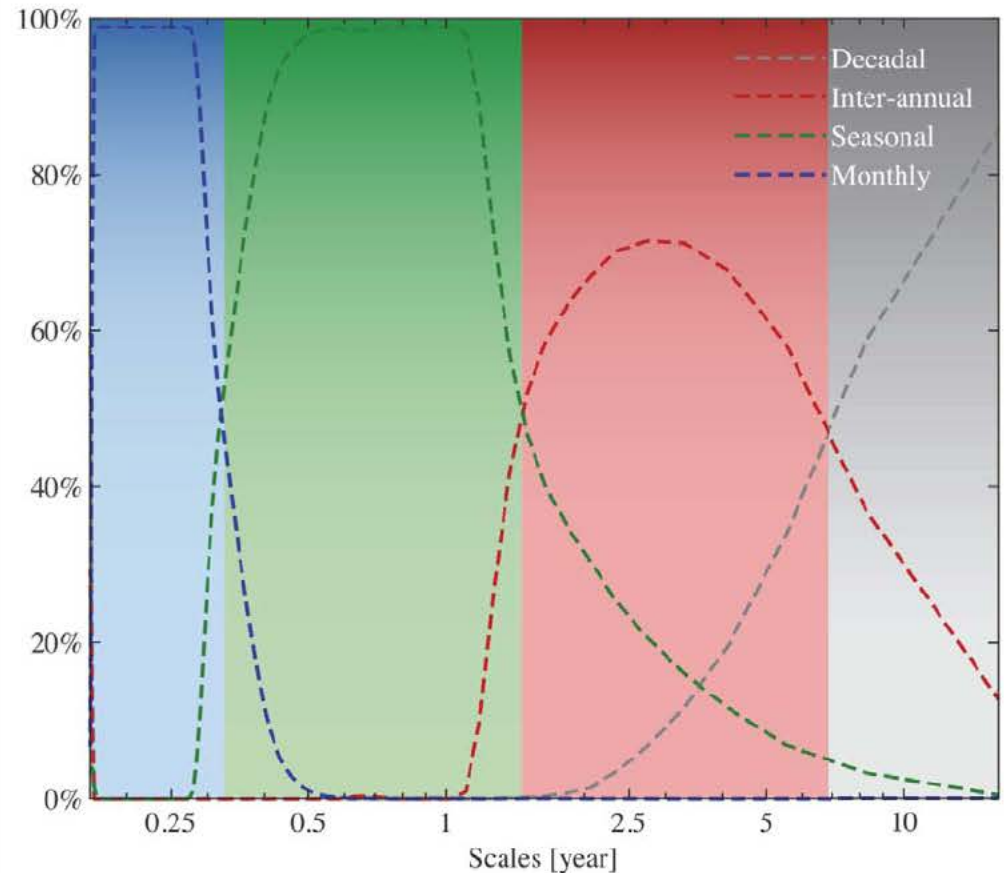
Observed biosphere drivers



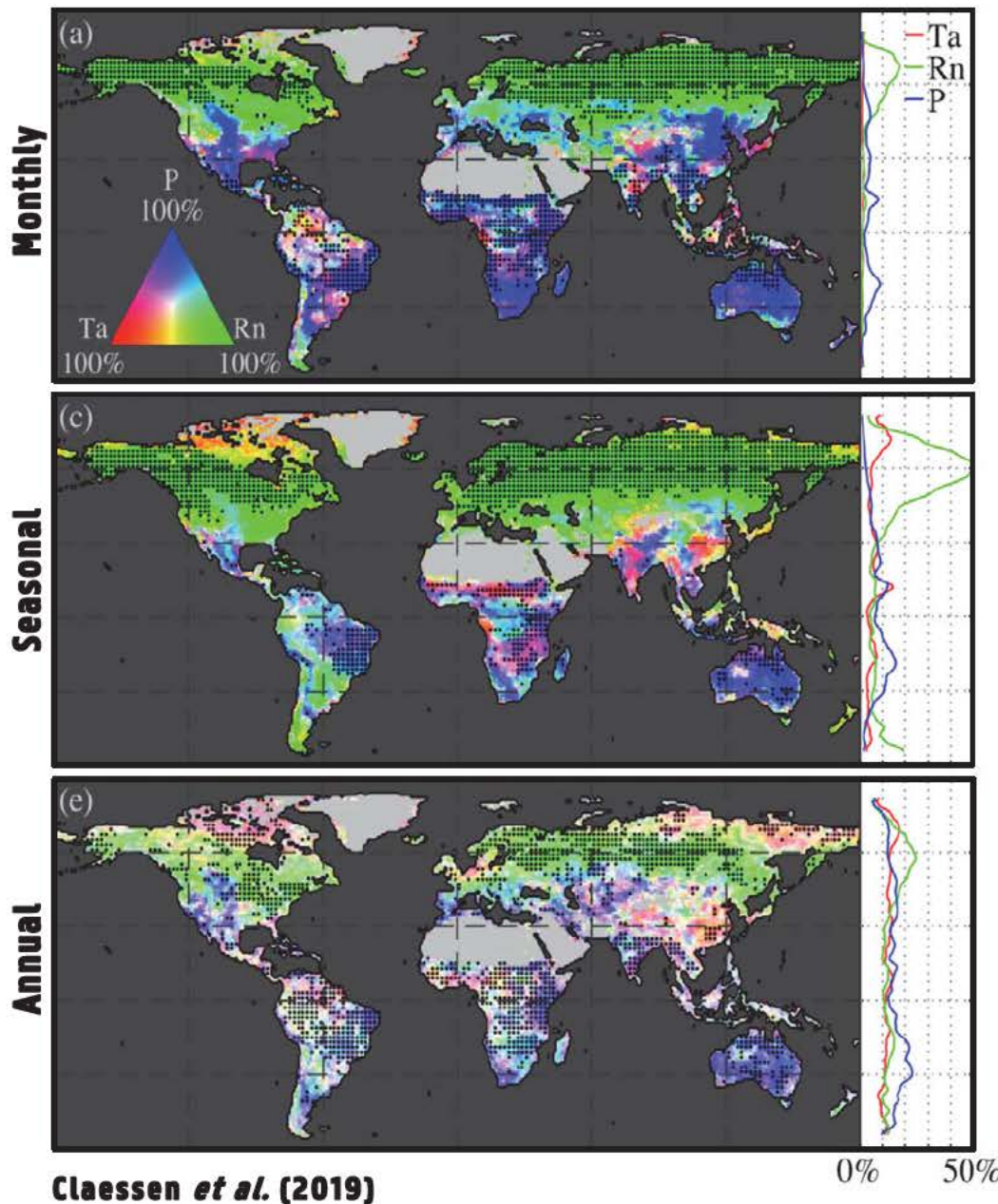
Claessen *et al.* (2019)

Spectral Causality Framework

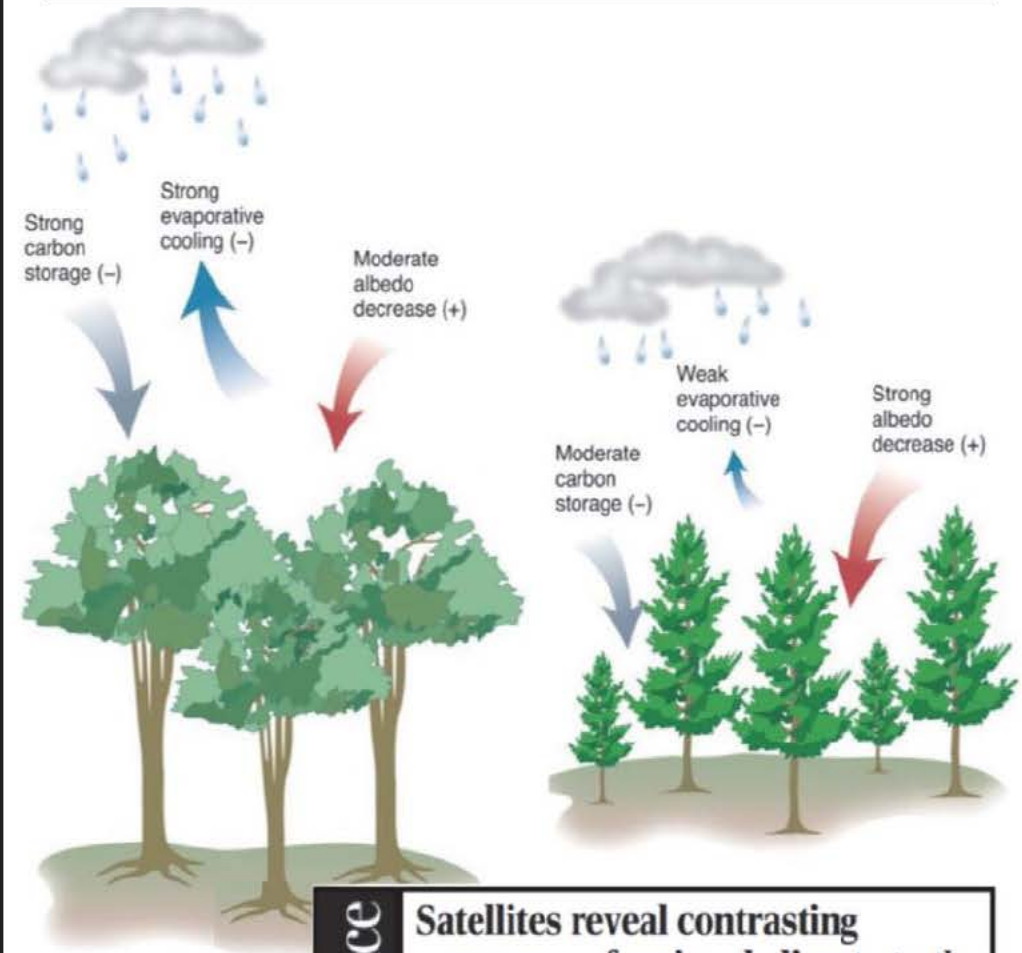
- ① Different continuous frequencies
- ② Changes in sensitivity in time
- ③ Bi-directional interactions



Observed biosphere drivers

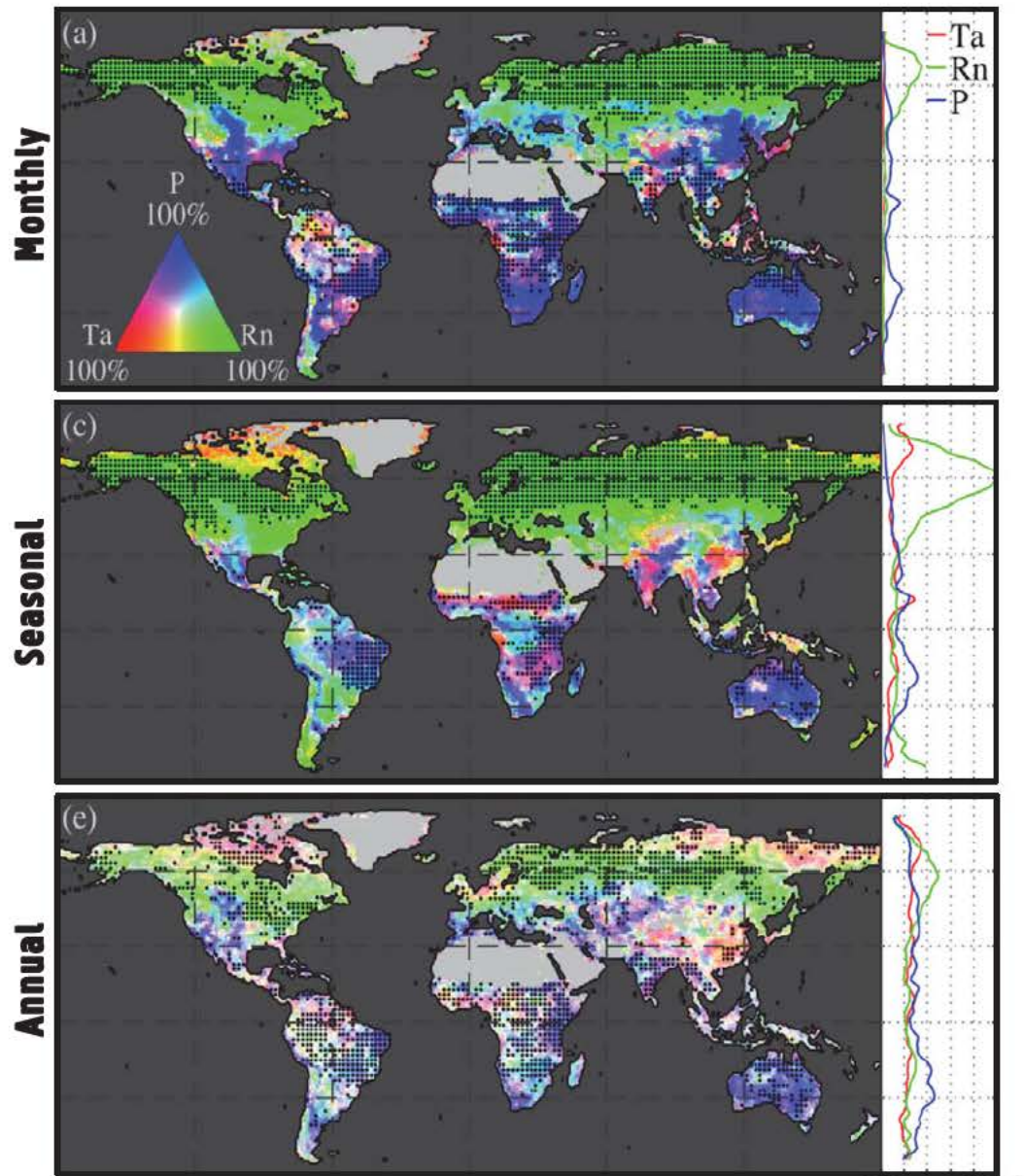


Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests
 Bonan (2013)  AAAS

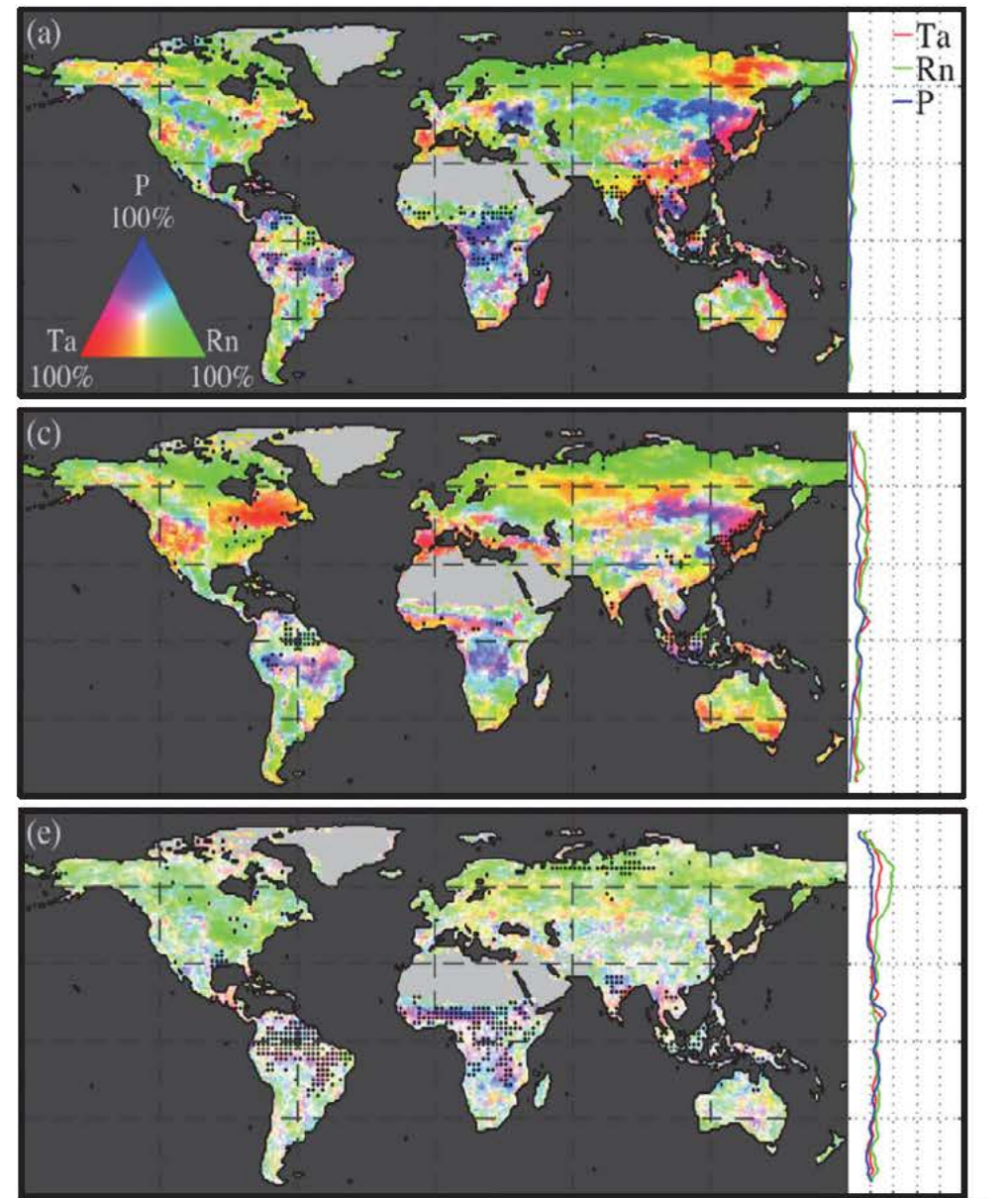


Science Satellites reveal contrasting responses of regional climate to the widespread greening of Earth
 Forzieri *et al.* (2017)

Observed biosphere drivers



Observed biosphere feedbacks



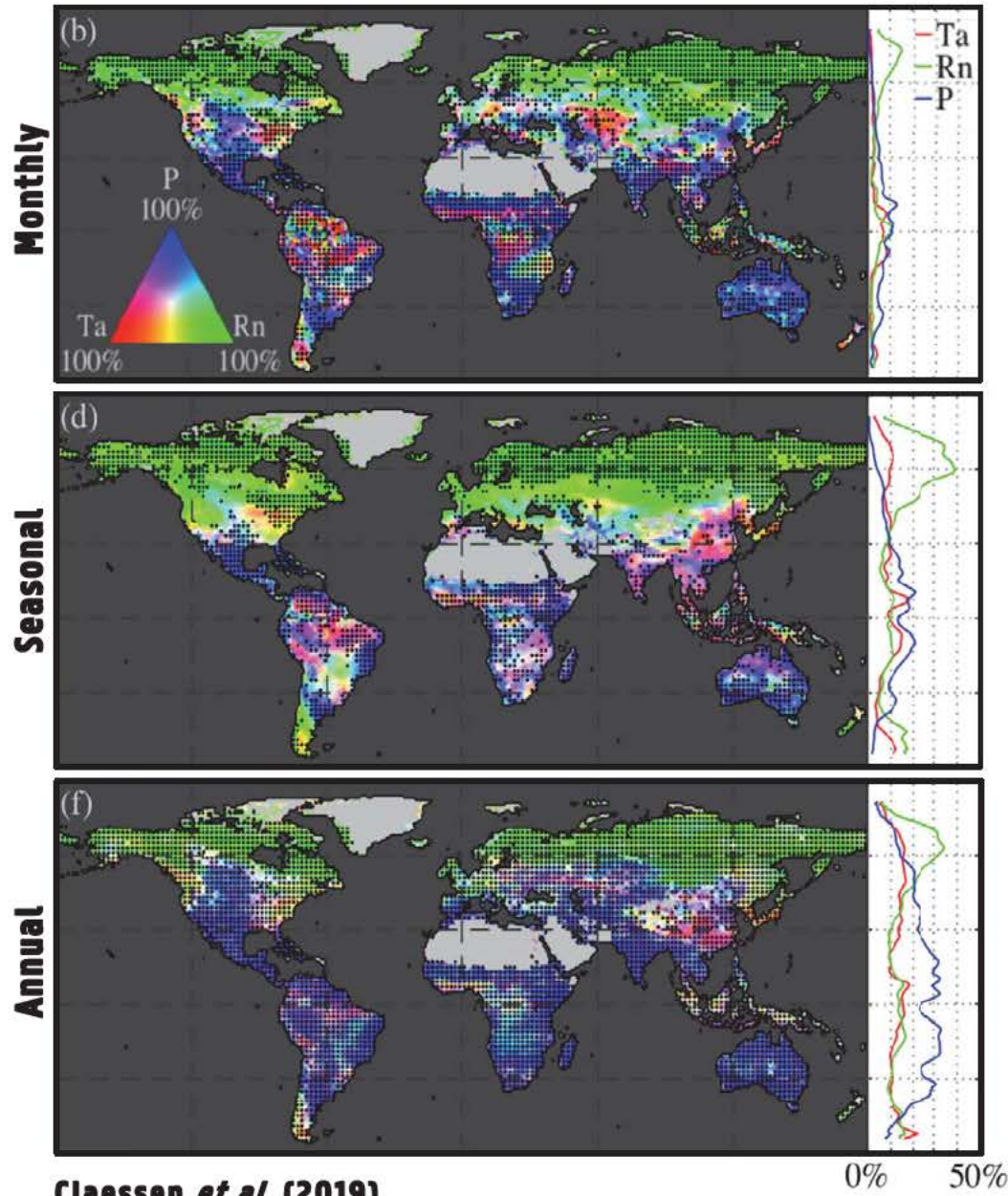
Claessen *et al.* (2019)

0% 50%

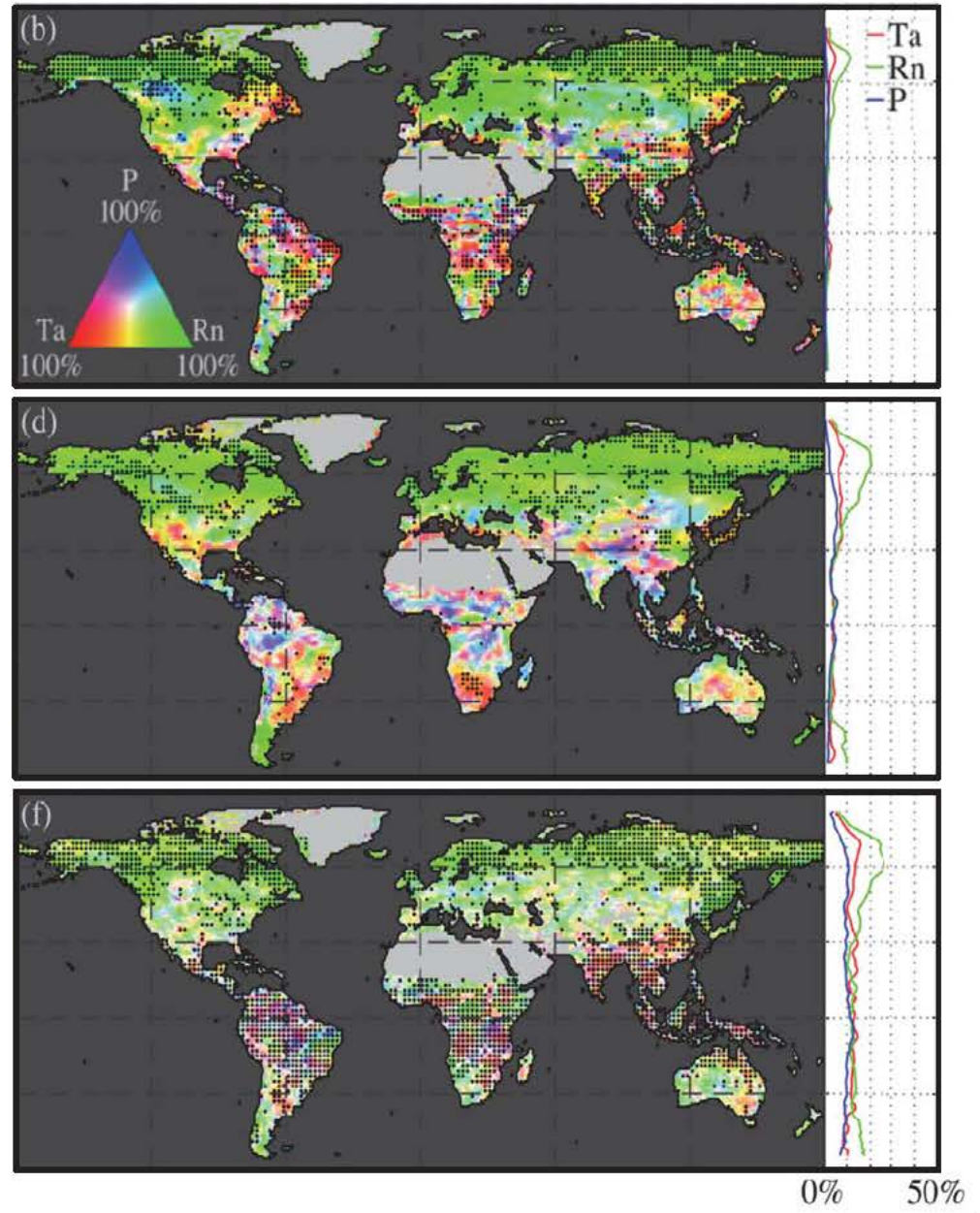
0% 50%

TRENDY

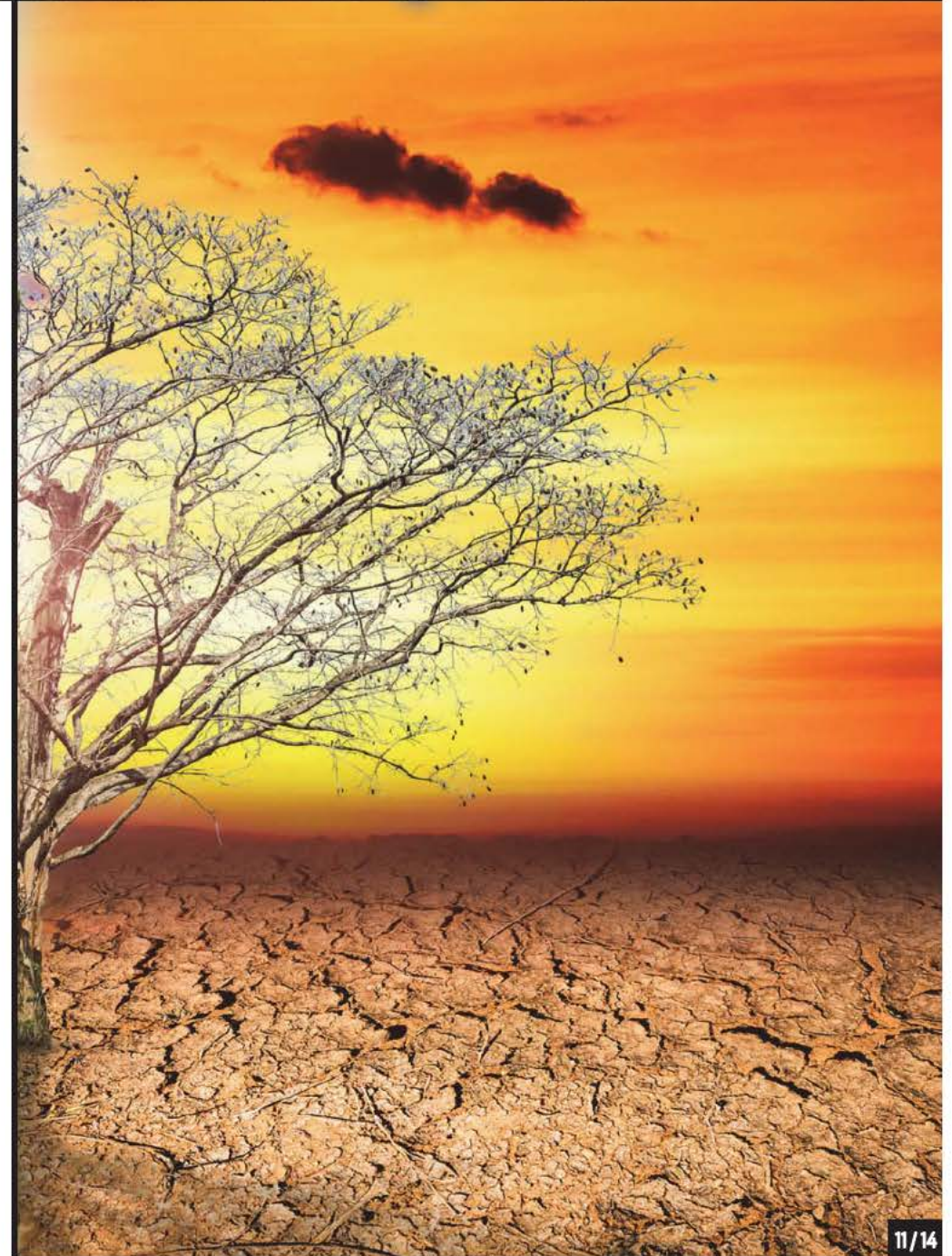
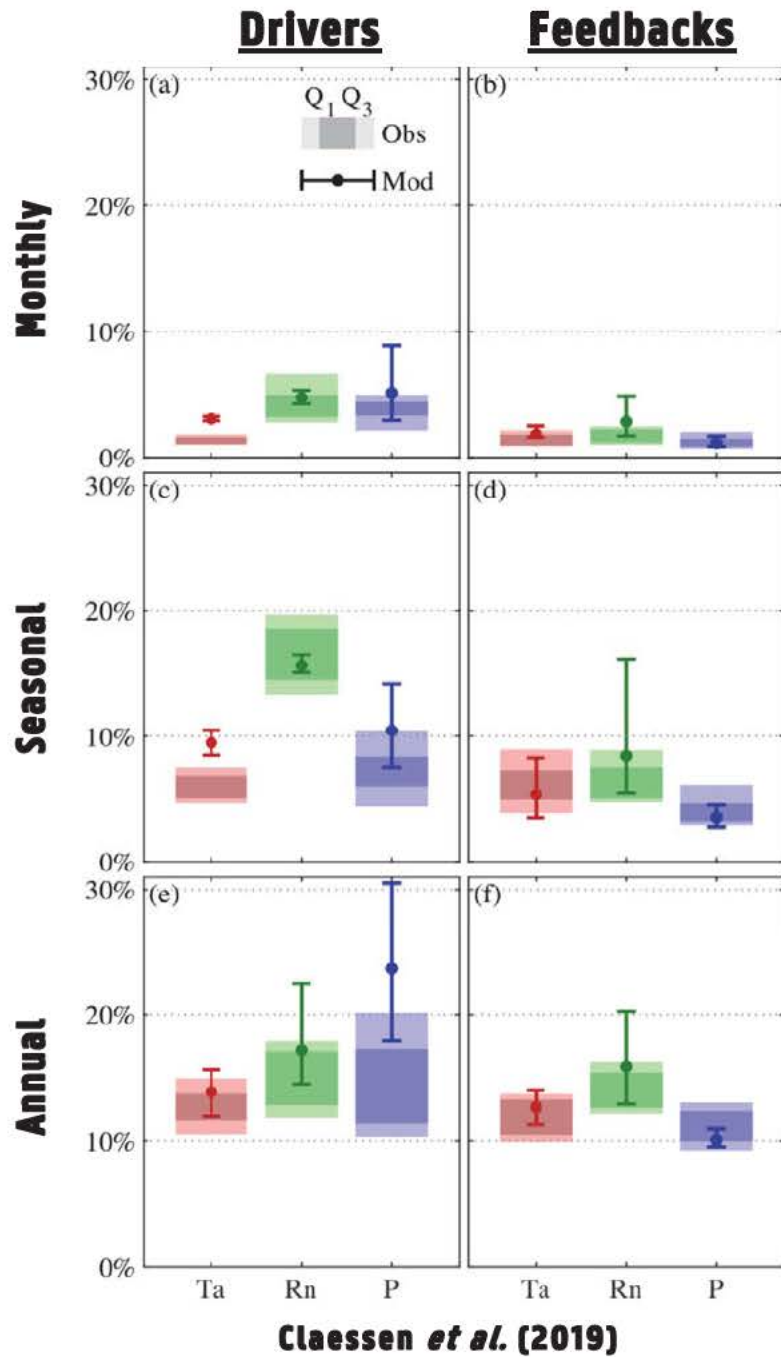
Modelled biosphere drivers



Modelled biosphere feedbacks



Claessen *et al.* (2019)

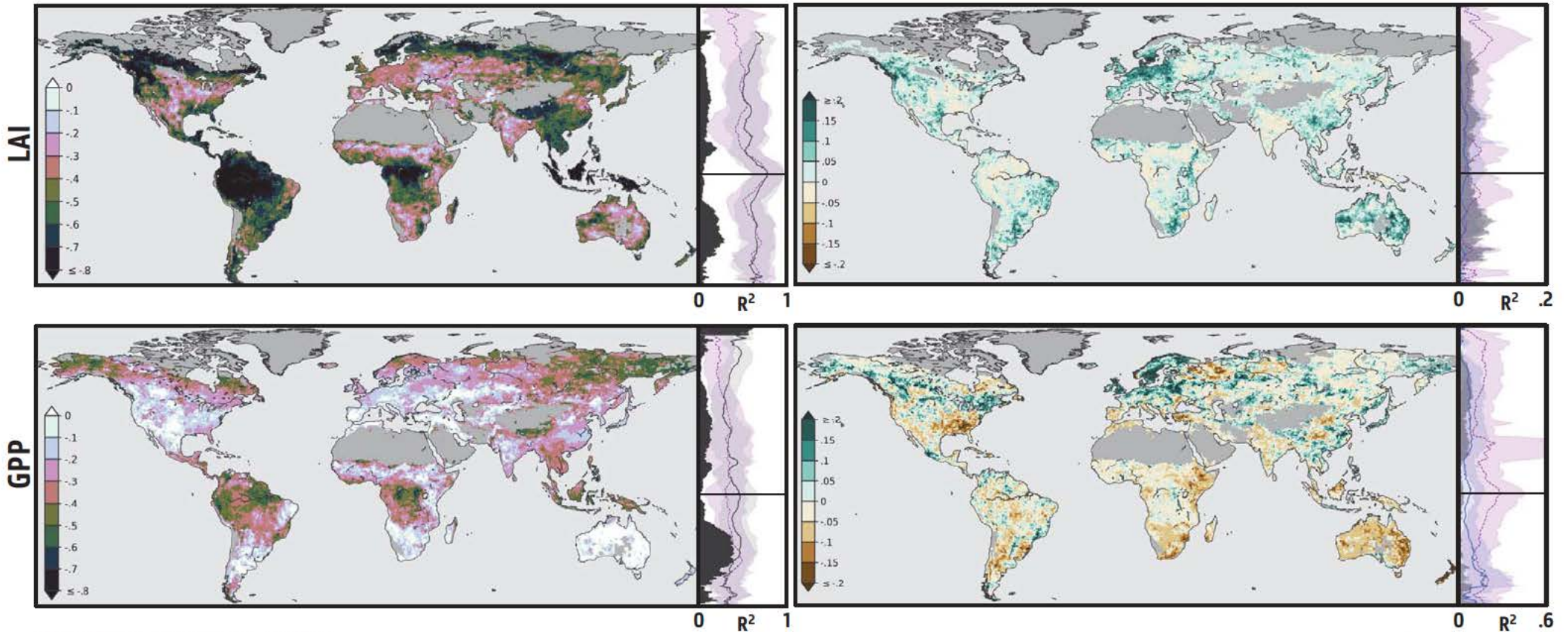




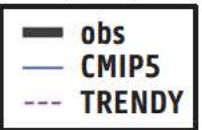
ONLINE	CCSM4	NorESM1-M	IPSL-CM5A	HadGEM2			
OFFLINE	CLM4.5		ORCHIDEE	JULES	LPJ-GUESS	OCN	VISIT

Vegetation autocorrelation observations – models

Climate impact on vegetation observations – models



Demuzere *et al.* (In prep.)

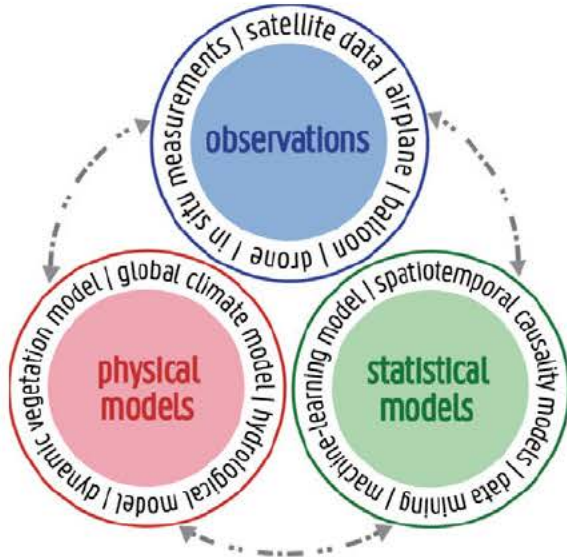
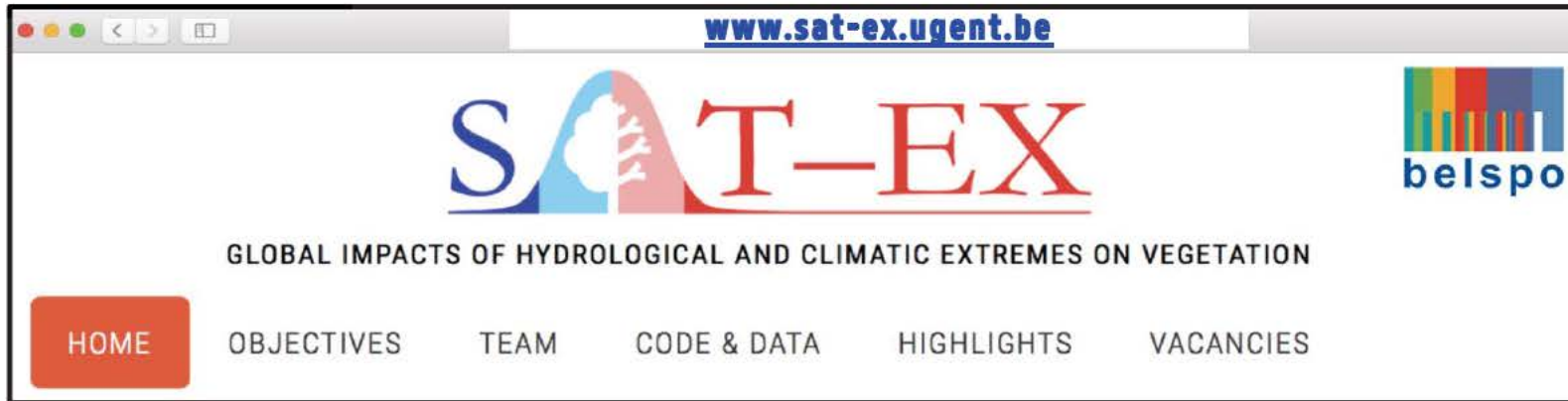




1st Workshop

Data-guided appraisal of biosphere–climate interactions

04–05 | October | 2018 Harmony hotel | Kraanlei 37, Ghent (BE)



- ① Multi-dimensional datacube to study the biosphere-climate interplay
- ② non-linear causality framework and spectral adaptations
- ③ observations confirm interactions are highly non-linear
- ④ Most land is driven by water availability depending on scale
- ⑤ Consistent hydro-climatic extremes supporting analysis of extremes
- ⑥ ESMs overestimate interannual water availability dependence.

