SAT-EX

Sensing the impact of global climate and climate extremes on vegetation

BEODAY – 08/12/2016

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GHENT UNIVERSITY · ULB · UNIVERSITY OF EXETER · VU · TU WIEN TECHNISCHE UNIVERSITÄT WIEN

the team

GHENT


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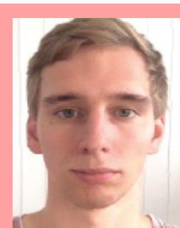
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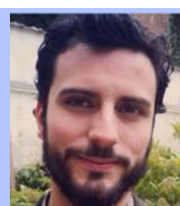
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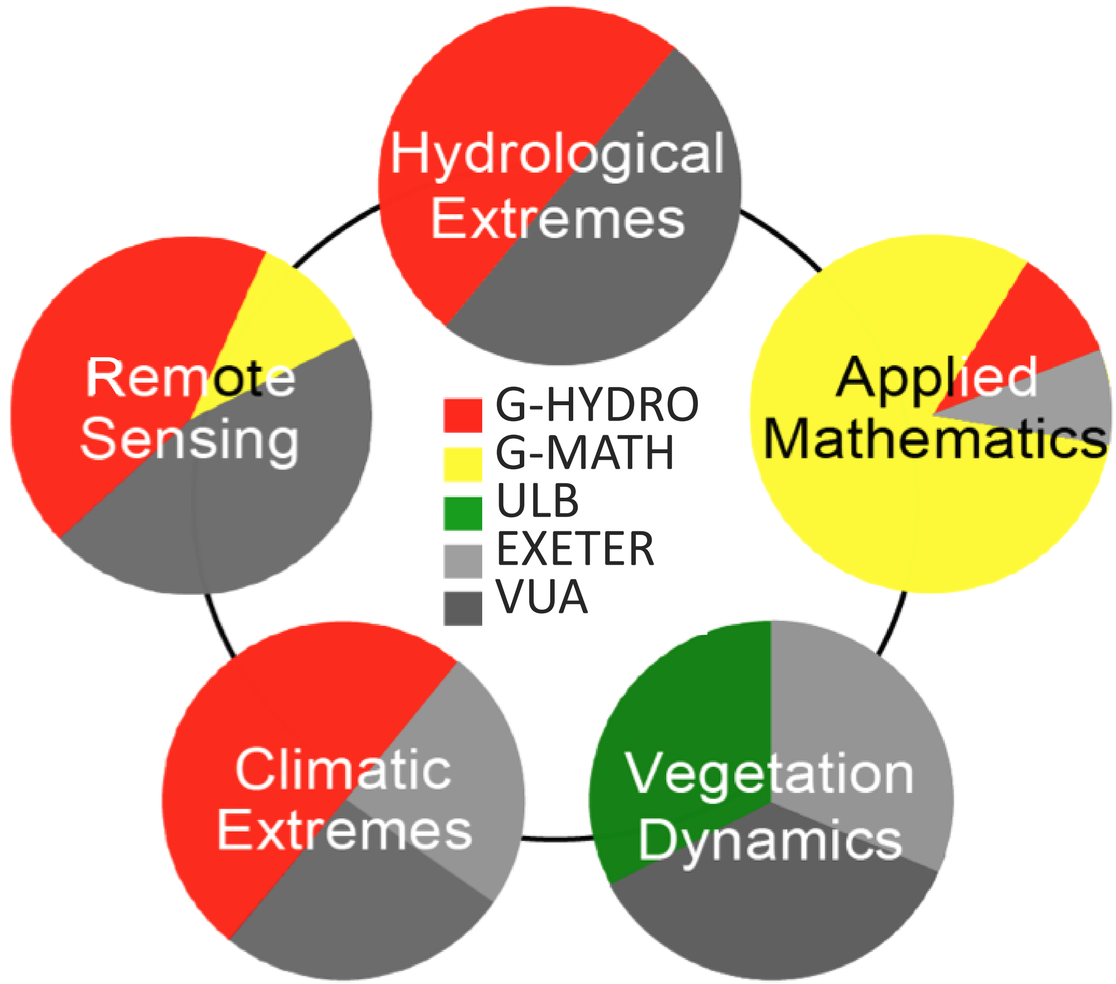

SAT–EX

① To provide new **<u>observational evidence of how hydro-climatic extremes have changed</u>** over the satellite era globally

② To provide new insights into **<u>past changes in vegetation and their sensitivity to climate and climate extremes</u>**

③ To test the extent to which **<u>ESMs reproduce these changes</u>** in the climatic extremes and their impact on vegetation

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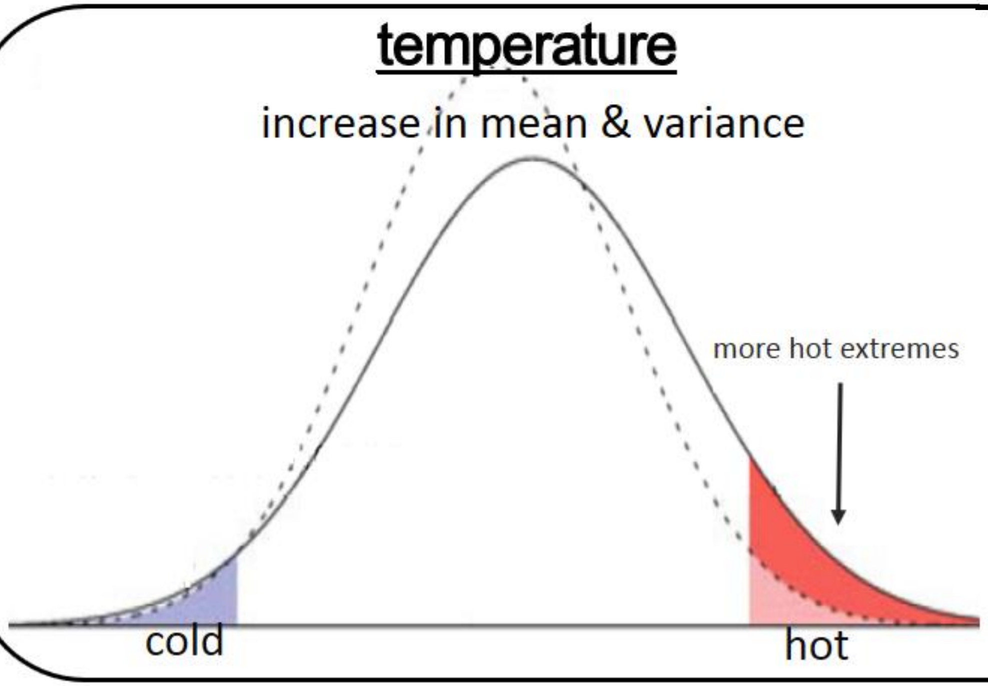
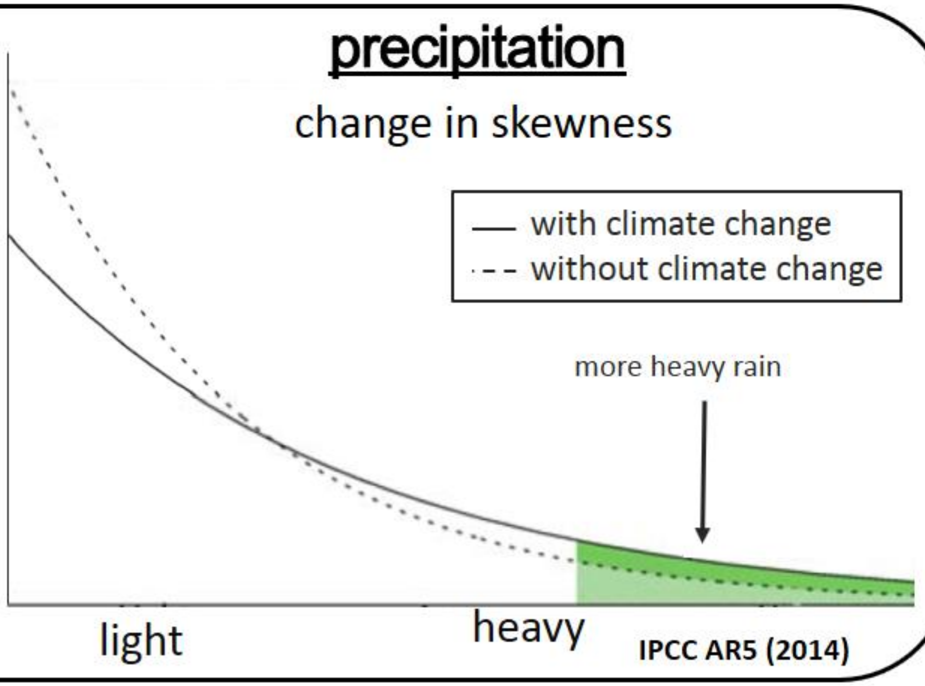




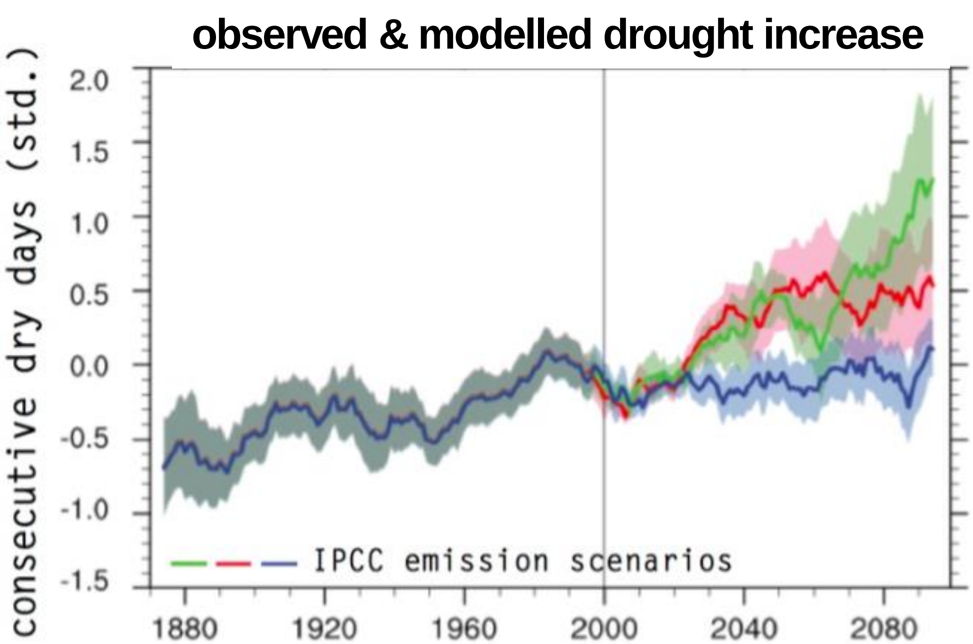
climate extremes

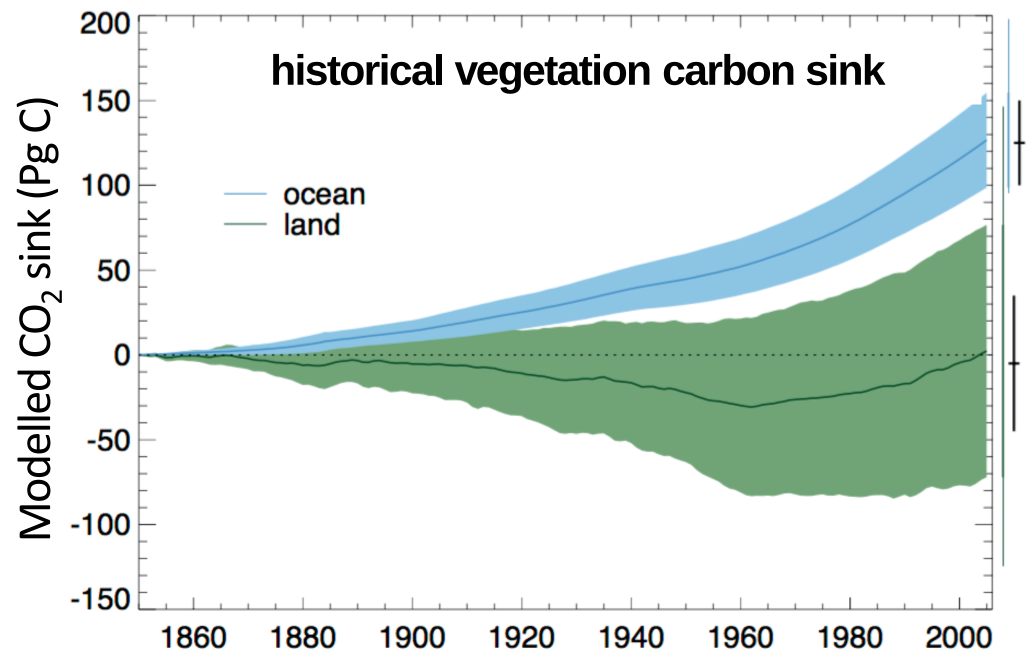
- More frequent and intense **heatwaves**
- Overall water cycle intensification: stronger **storms and floods**
- Dry areas become drier: **droughts** more persistent and severe – feedback on **heatwaves** intensification
- Widening of tropics, water cycle reorganisation: **droughts** at mid-latitudes
- Intensified (?) El Niño and monsoons

✓ **Impacts on global vegetation**

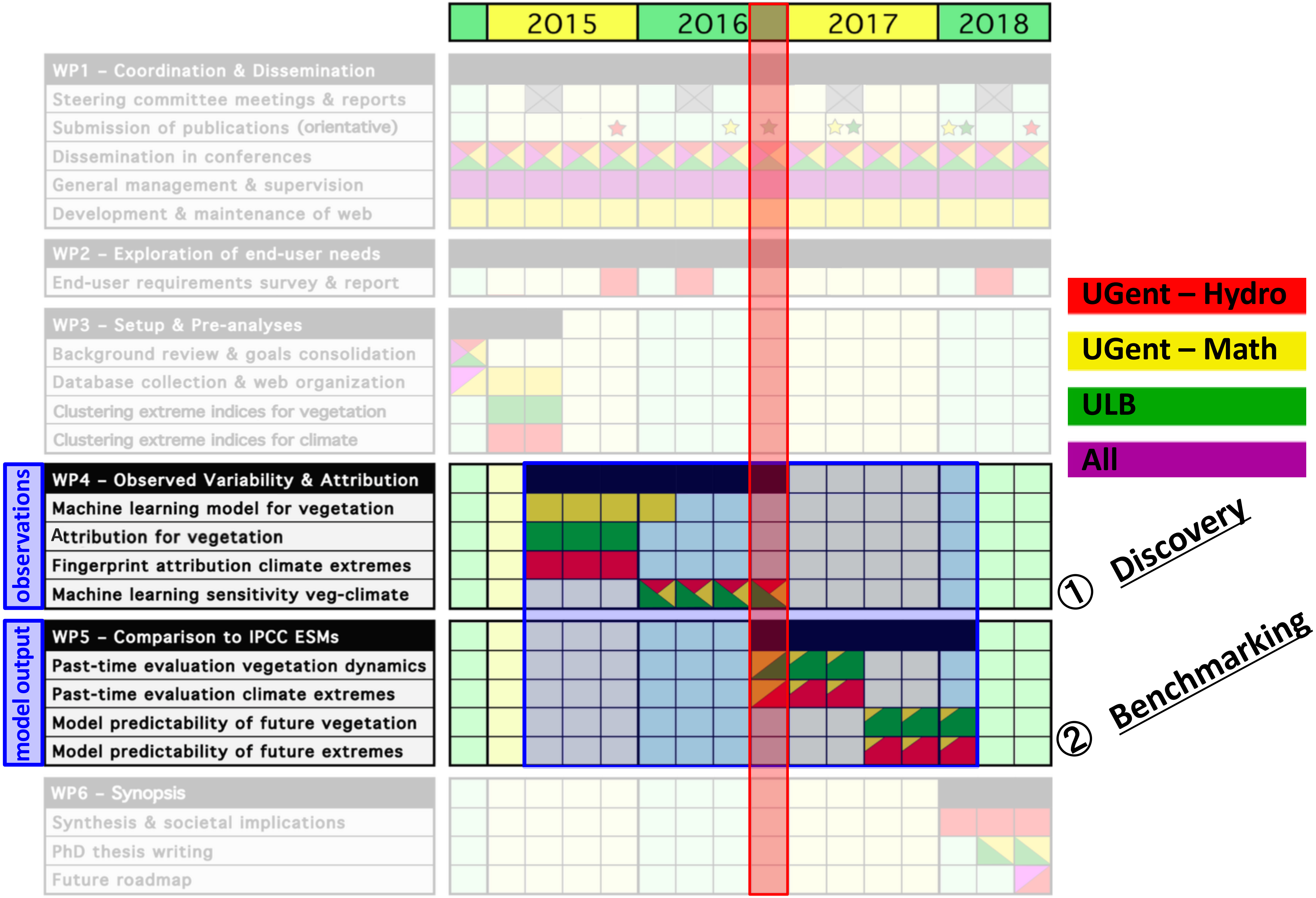
- **Large uncertainty** in terrestrial carbon sinks (vegetation) and how they are impacted by climate extremes
- Call for observational evidence (WCRP) to **<u>(1) improve understanding</u>** and **<u>(2) benchmark models</u>**

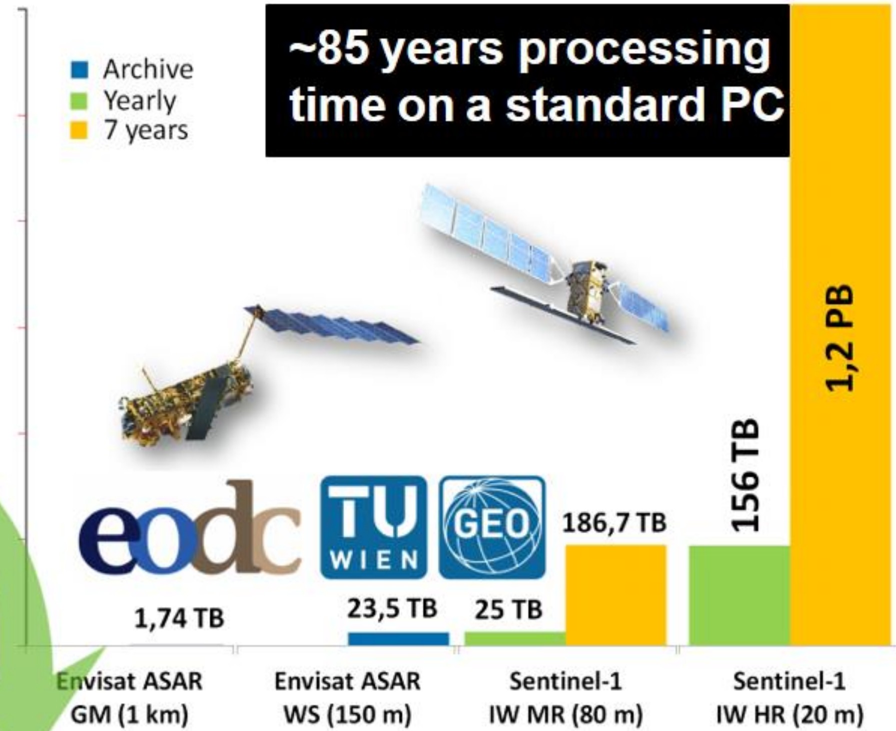
✓ **<u>Can satellites respond to this call?</u>**





the approach




Archive
Yearly
7 years
~85 years processing
time on a standard PC
1,2 PB
156 TB
186,7 TB
25 TB
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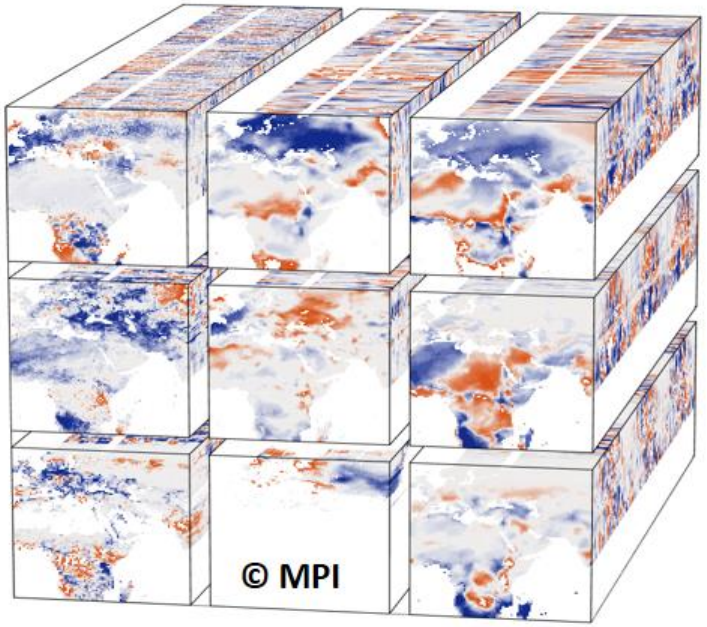
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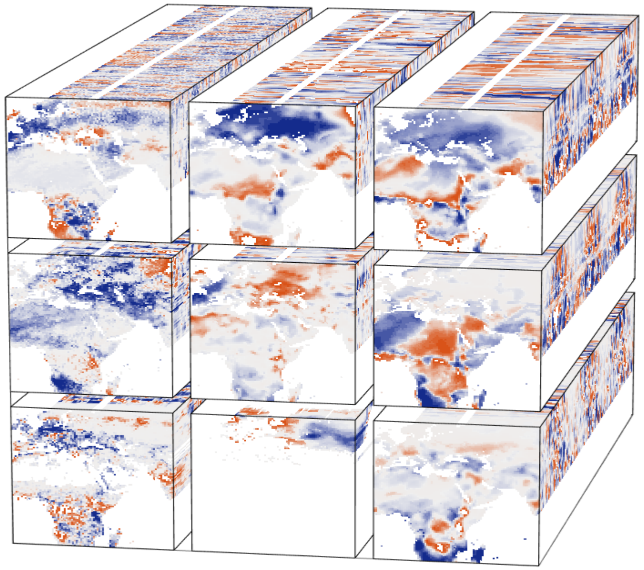
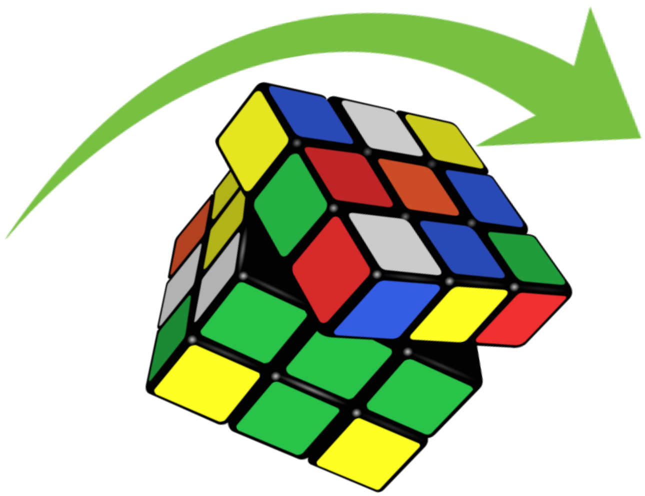
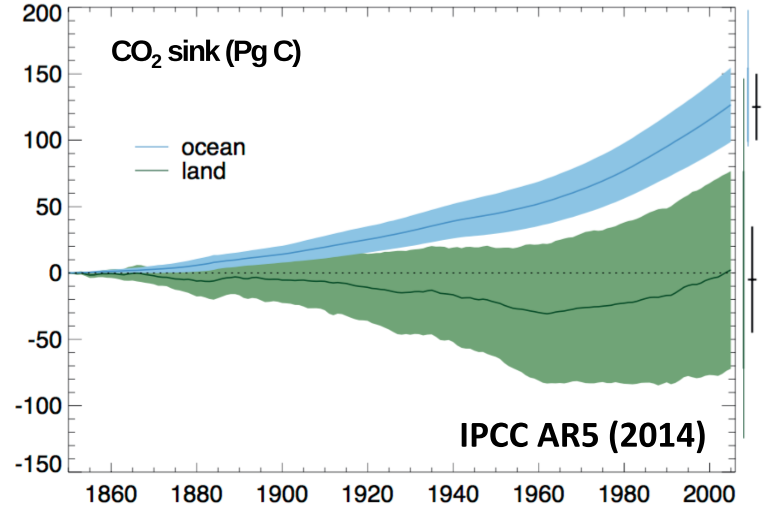
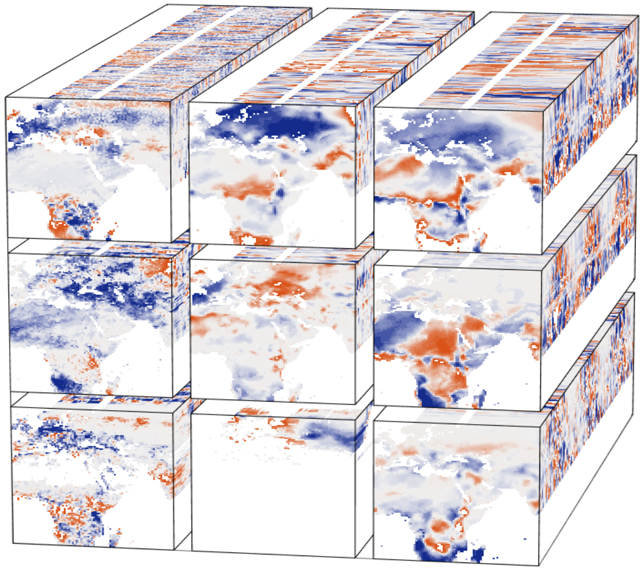
VSC

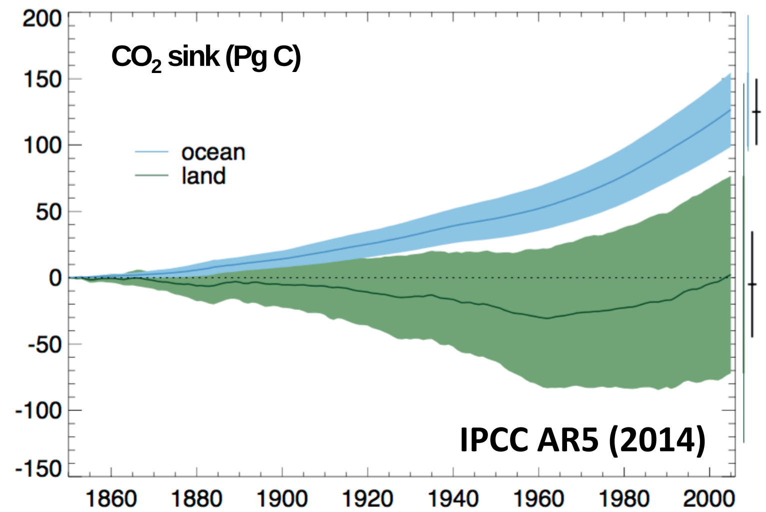
early results – Discovery



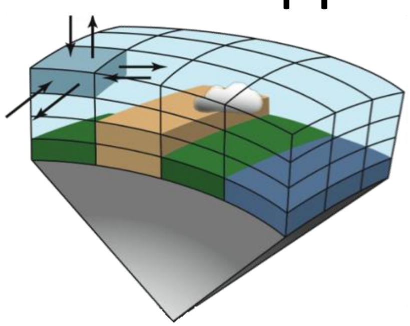




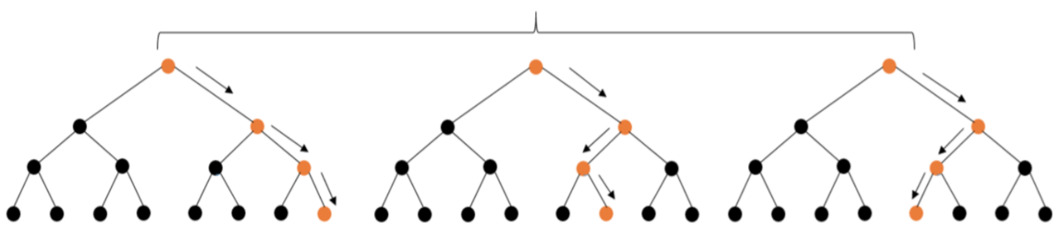




Process–based approaches



Data–driven approaches



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Contribution of water-limited ecoregions to their own supply of rainfall

Diego G Miralles[1,2], Raquel Nieto[3], Nathan G McDowell[4], Wouter A Dorigo[5,2], Niko EC Verhoest[2], Yi Y Liu[6,7], Adriaan J Teuling[8], A Johannes Dolman[1], Stephen P Good[9] and Luis Gimeno[3]

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Manuscript under review for journal Geosci. Model Dev.
Published: 16 November 2016

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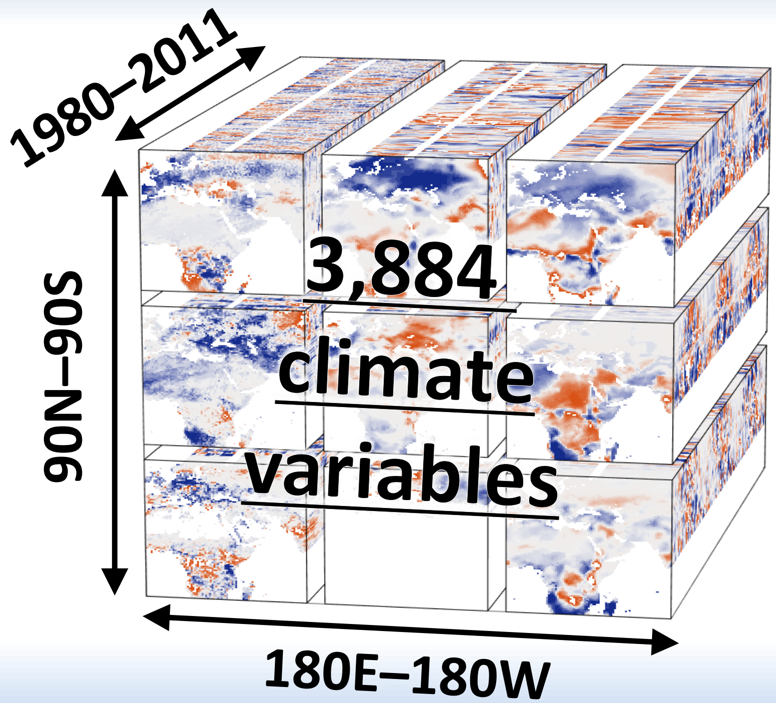
A non-linear Granger causality framework to investigate climate–vegetation dynamics

Christina Papagiannopoulou[1], Diego G. Miralles[2,3], Niko E. C. Verhoest[3], Wouter A. Dorigo[4], and Willem Waegeman[1]

early results – Discovery

inputs



Climate Variables

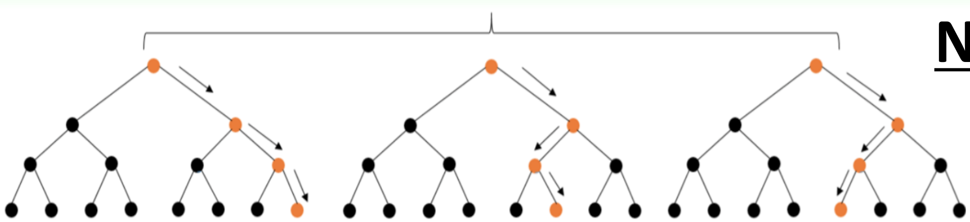
① **Satellite-based datasets**

radiation, temperature, precipitation, soil moisture, snow cover...etc.

② **Higher-level features from them**

anomalies, climatologies, lagged variables, past cumulative values, extreme indices, etc.

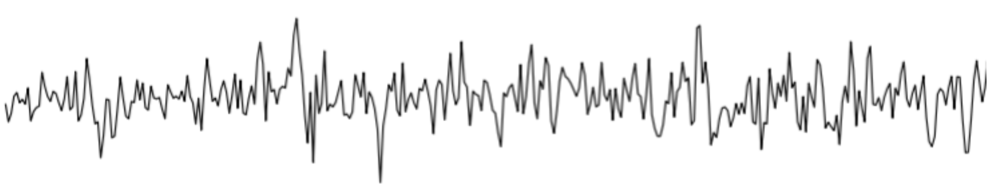
model



Nonlinear Granger-causality

based on a **Random Forest** predictive model

target



Vegetation anomalies

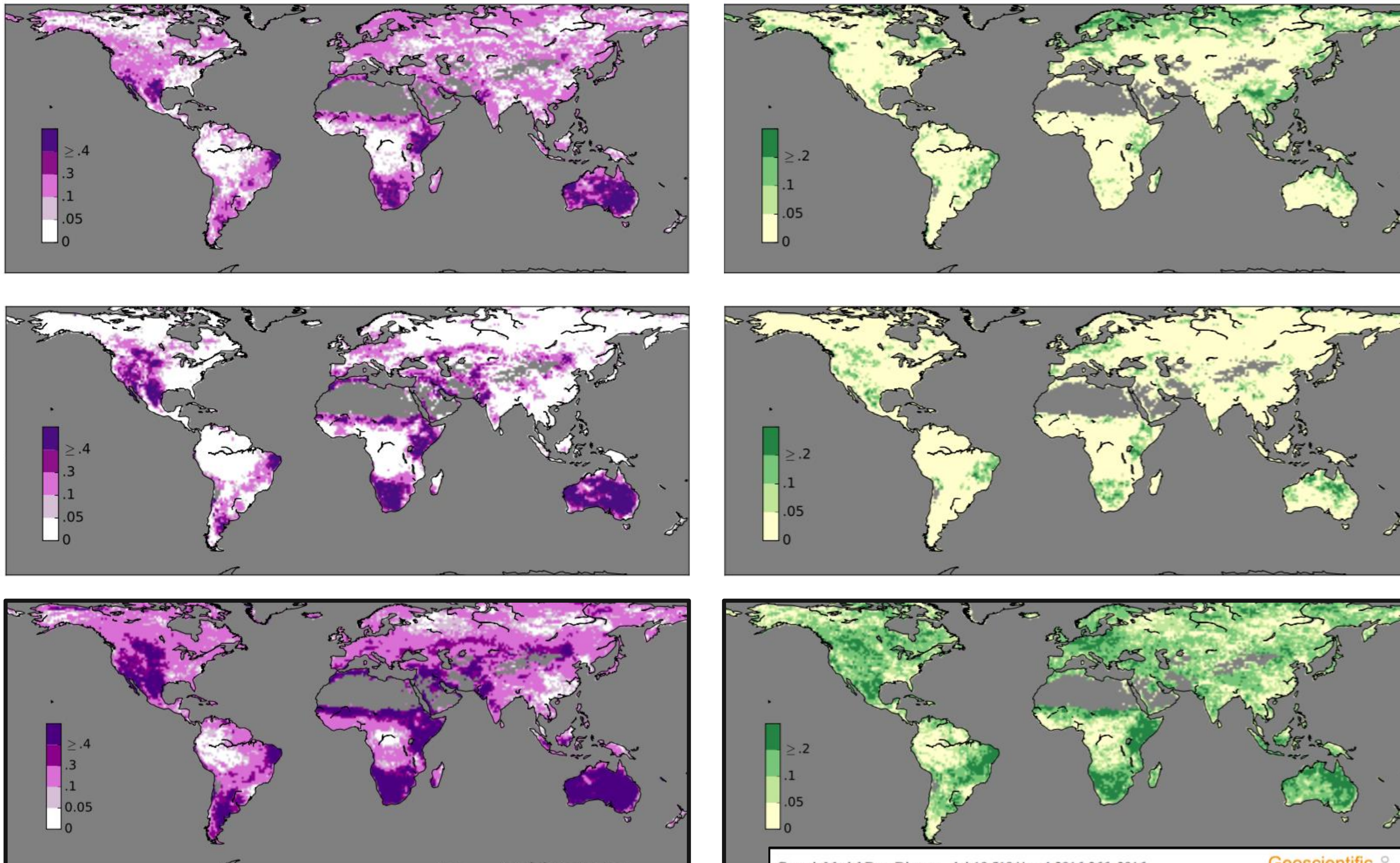
time series of **observed** NDVI, VOD, LAI per pixel

Explained vegetation variance → **Granger causality**

Linear correlation

Linear regression

Non-linear Random Forest



✓ vegetation response to climate
highly non-linear

Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-266, 2016
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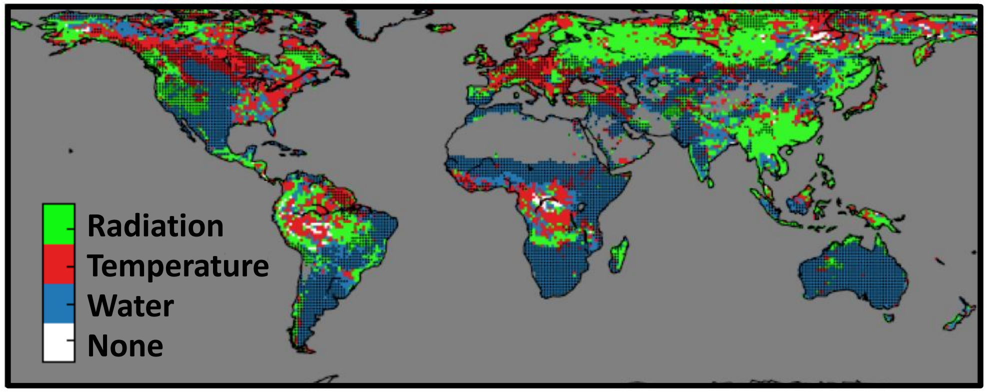
A non-linear Granger causality framework to investigate climate–vegetation dynamics

Potential to **isolate the effect** of…

① climate variables
② climatic **extremes**
③ antecedent periods

Main controls over vegetation



Papagiannopoulou *et al.*, *in review* (ERL)

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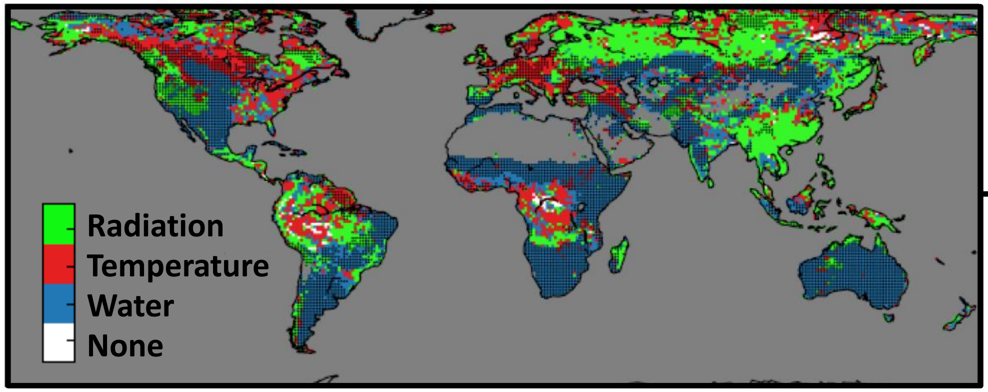
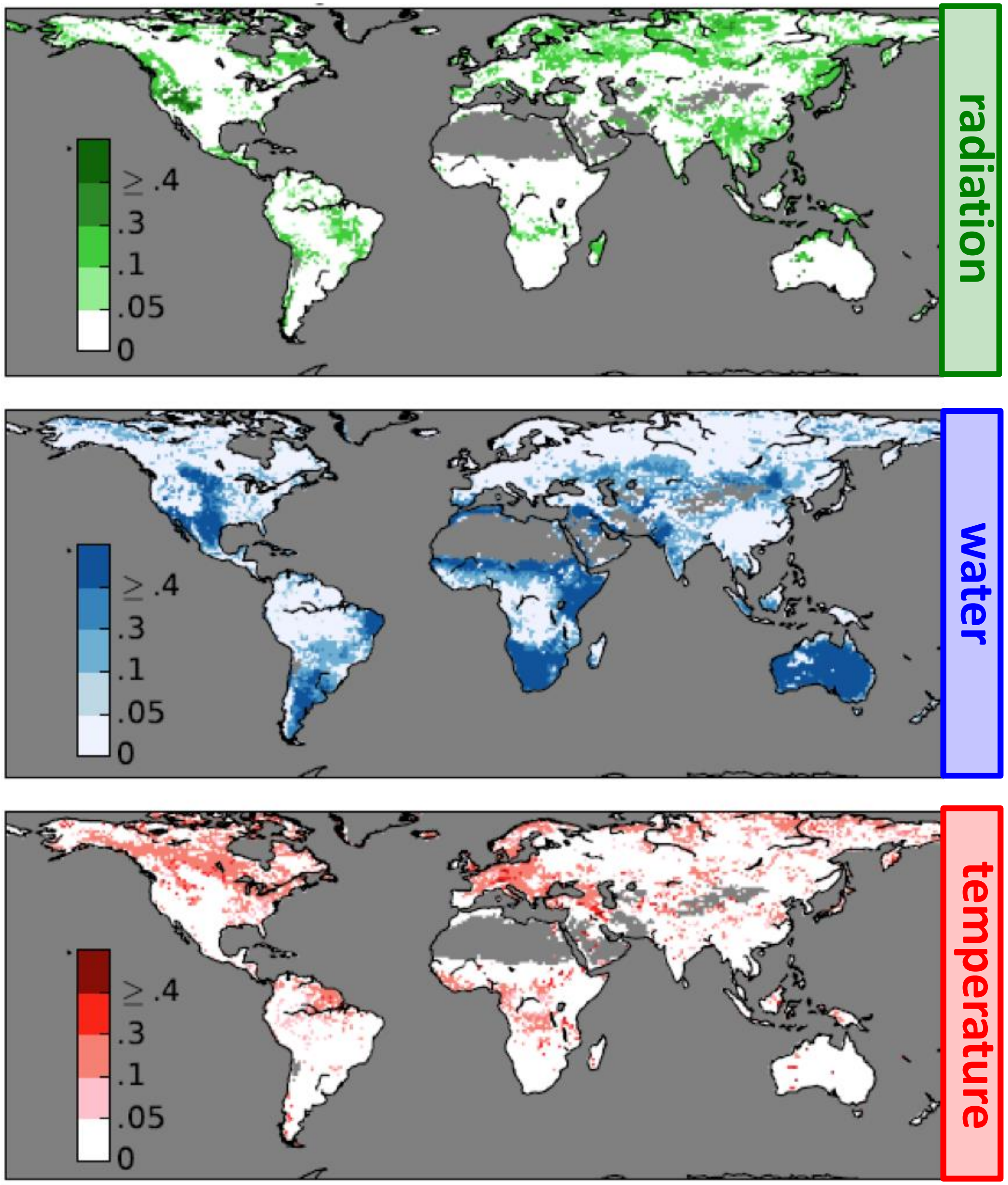


Papagiannopoulou *et al.*, *in review* (ERL)

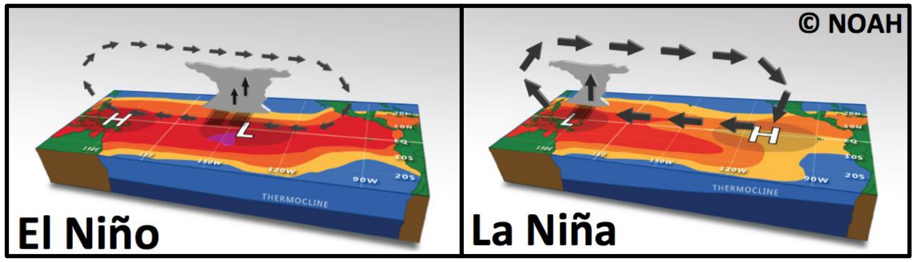
Explained variance per climate driver

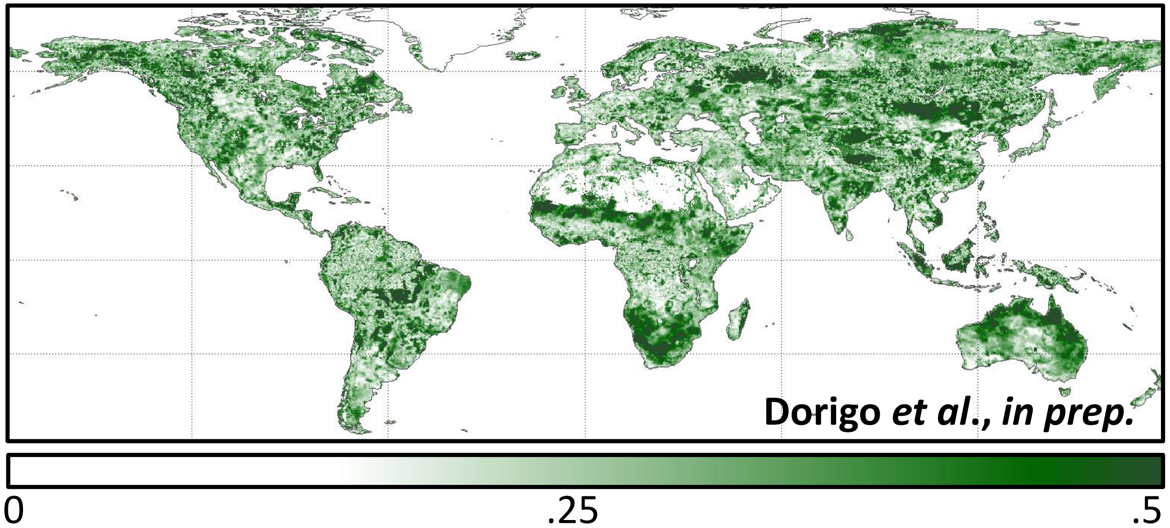


✓ **over 50% of world's vegetated areas primarily limited by water**

Explained variance by climatic oscillations

Oscillations: recurrent changes in ocean–atmosphere circulation, that **also affect vegetation**





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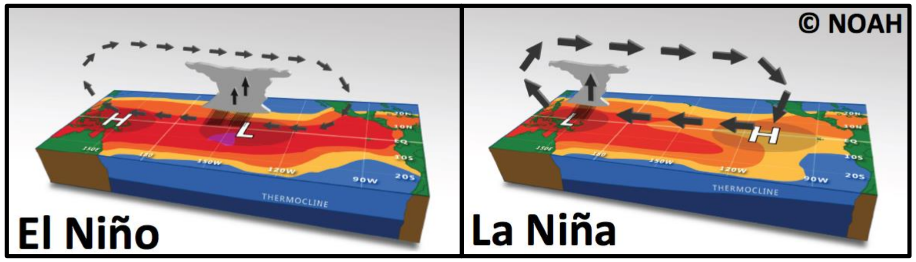
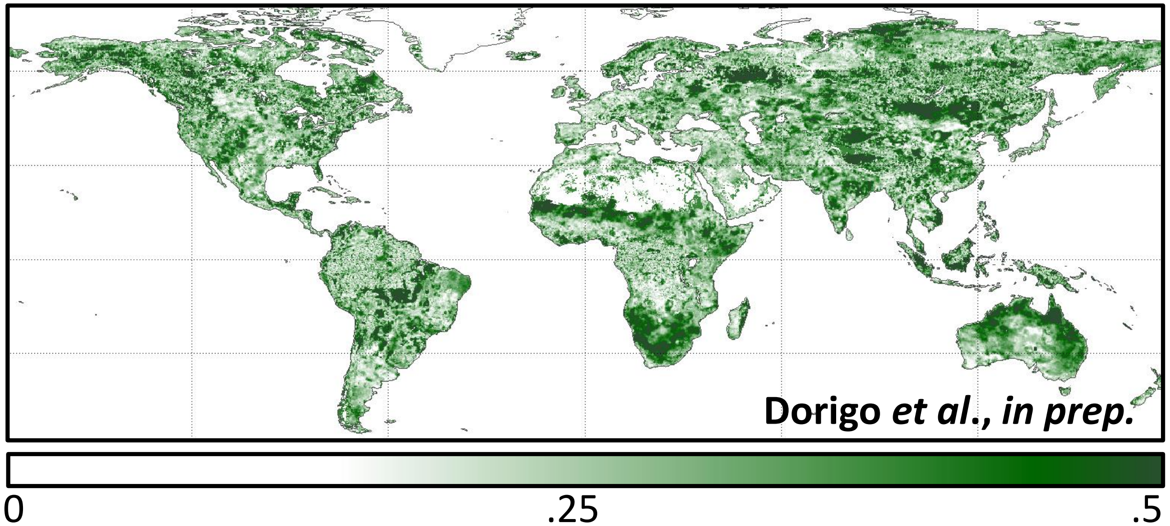
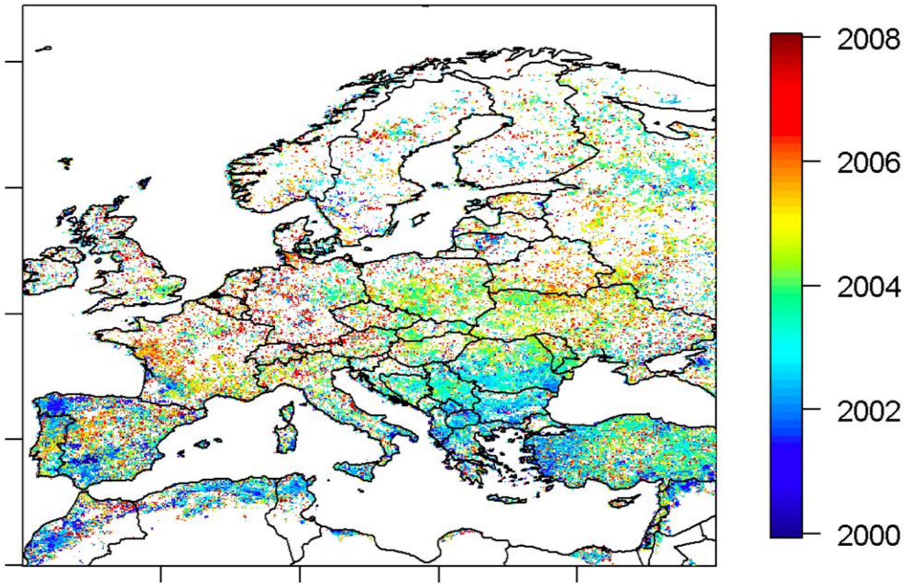


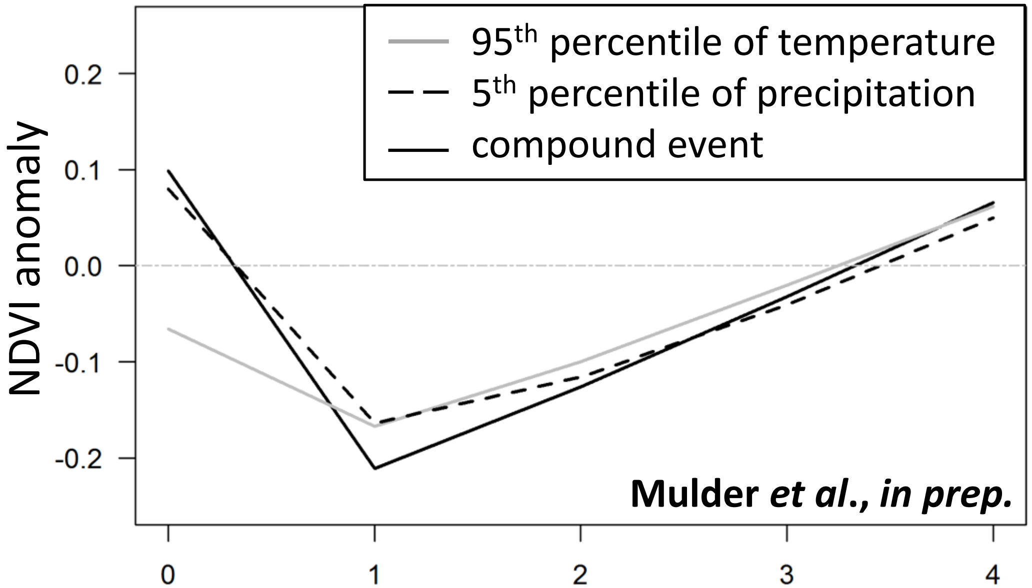


Identification of vegetation extremes



timing of break points in the NDVI record

Response to extreme climate events

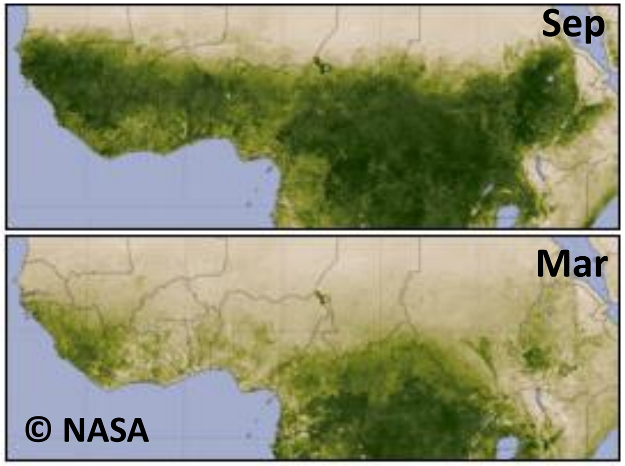


months after climate extreme (Europe)

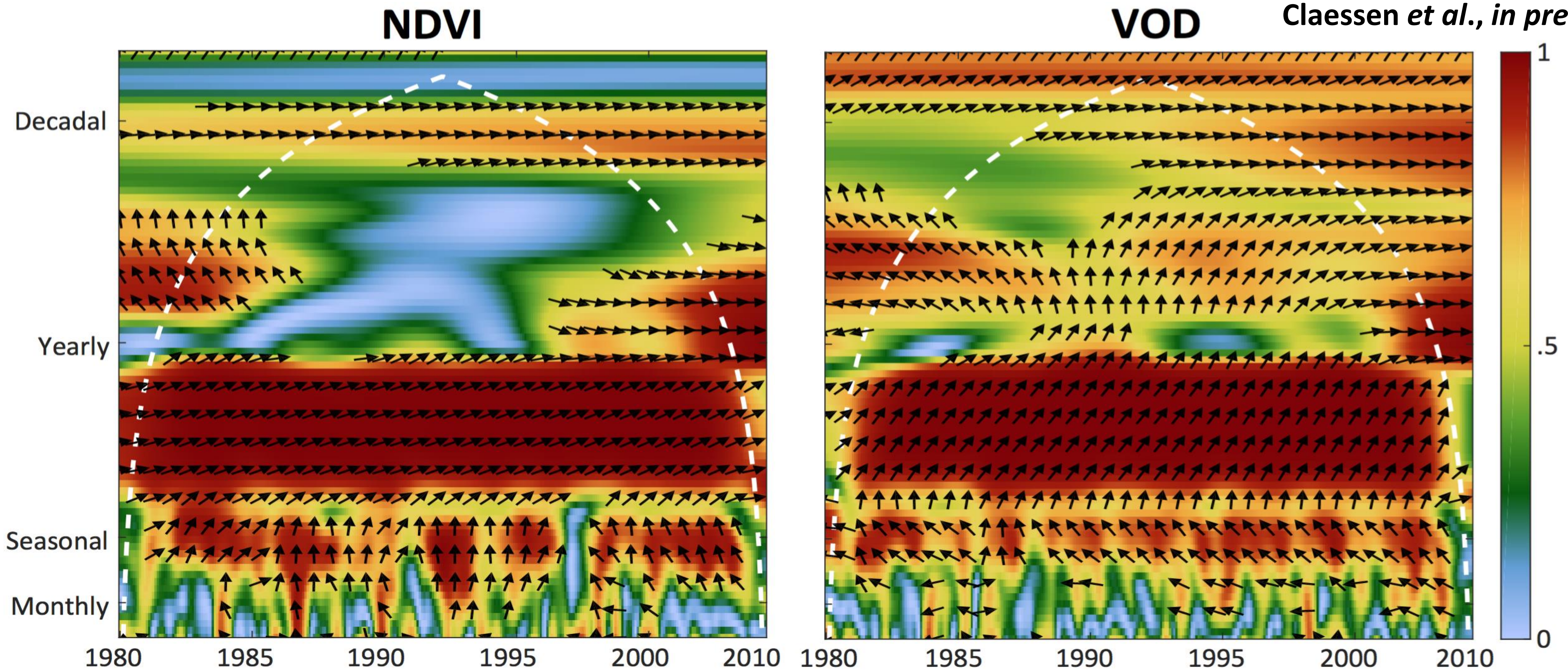
Sensitivity at different periods and scales

Wavelet coherence to:

- Quantify sensitivity at various scales
- See changes in sensitivity through time
- Testing various vegetation indices: NDVI, VOD, LAI, GPP
  - ✓ Example: **sensitivity of Sahel vegetation to rainfall**



Claessen *et al.*, *in prep.*



inputs

Climate Variables

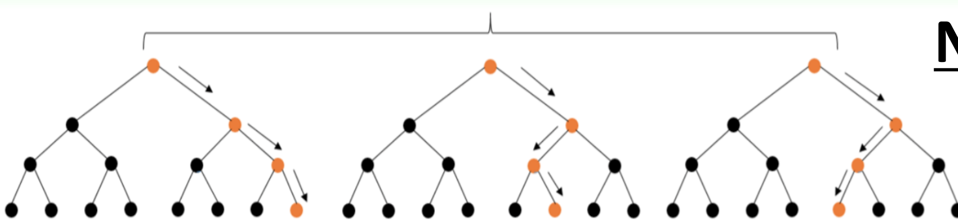
① **CMIP5 ESM outputs**

radiation, air temperature, surface temperature, precipitation, soil moisture, snow cover...etc.

② **Higher-level features from them**

anomalies, climatologies, lagged variables, past cumulative values, extreme indices, etc.

model



Nonlinear Granger-causality

based on a **Random Forest** predictive model

target

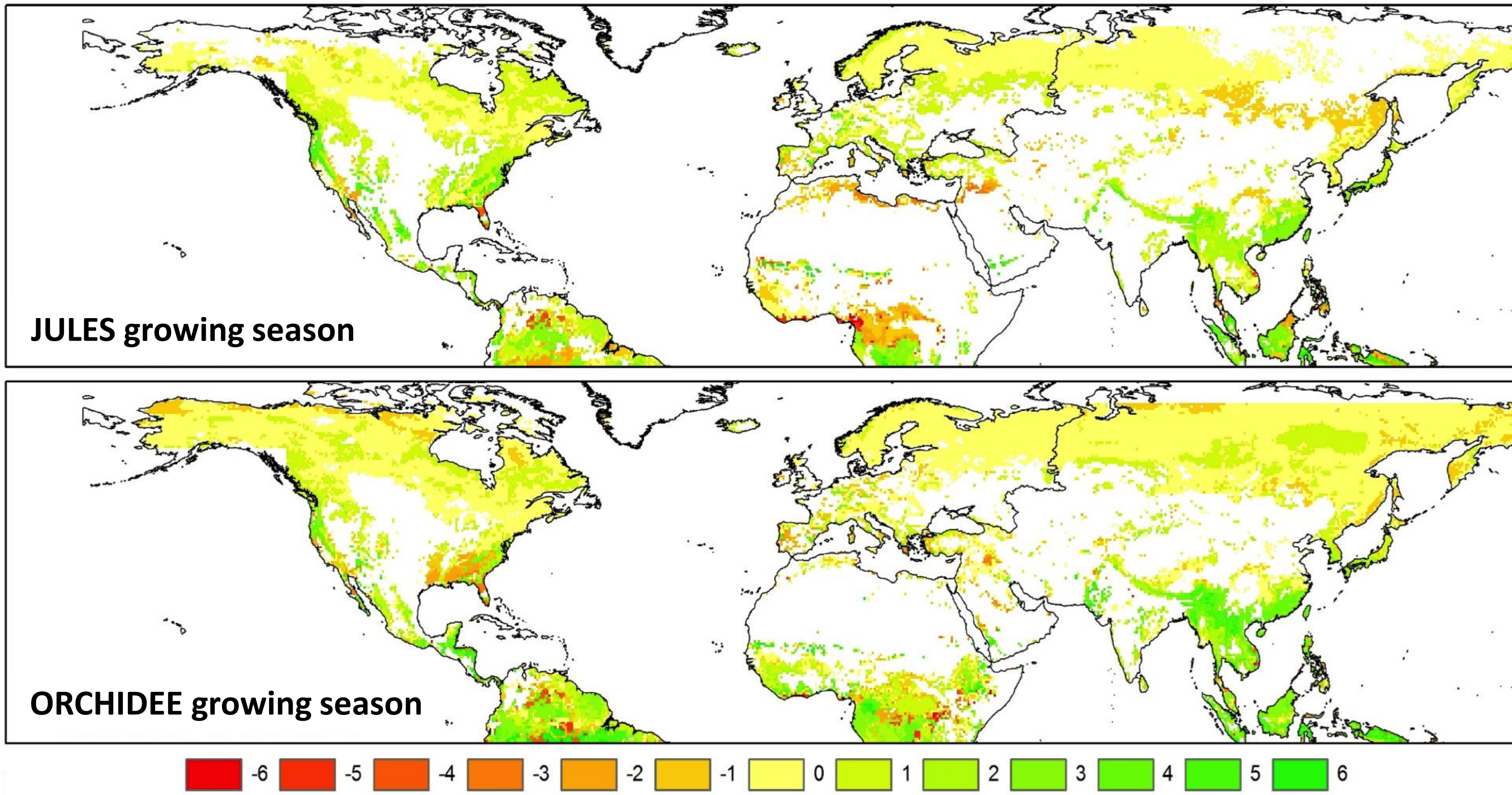
Vegetation anomalies

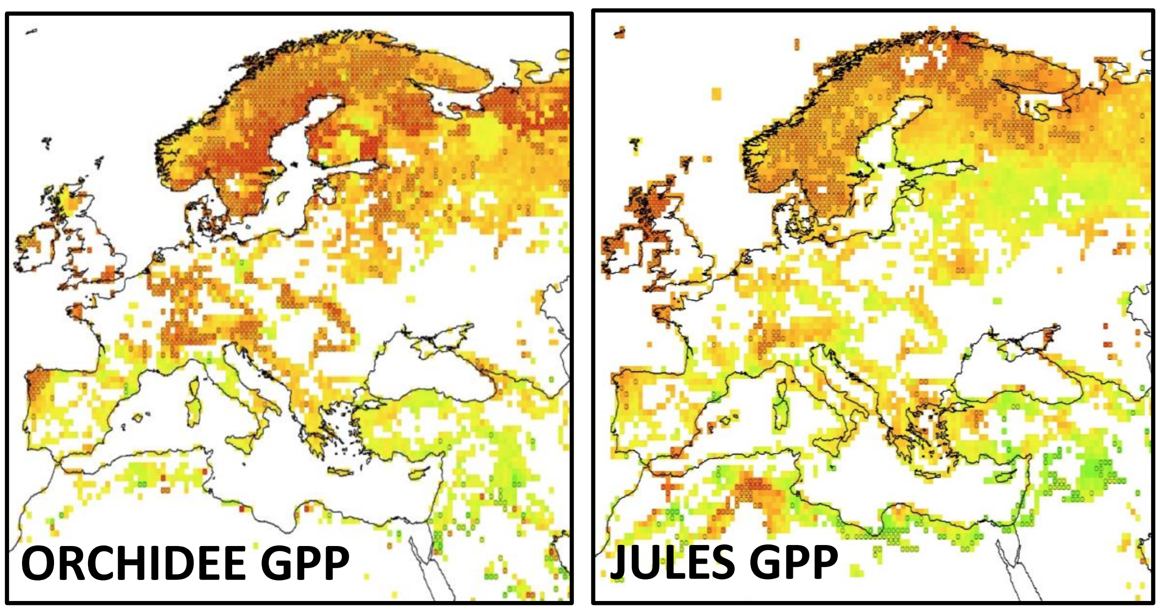
time series of **predicted** **LAI** at each pixel

<u>Some pre-analysis...</u>

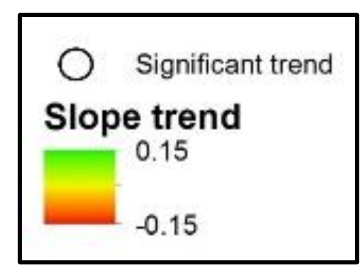
① **Can ESMs reproduce peaks** in growing season?

② **Can ESMs reproduce trends** in 10th percentile extreme occurrence?





van Eck *et al., in prep.*



Lessons to be learnt from benchmarking:

① Is vegetation in our ESMs the same **sensitive to climate and climate extremes** than in nature?

② Are **extremes in vegetation and carbon storage** caused by the same climatic factors?

③ Which **models are more adequate** to represent these changes and why?

④ What do **these 'good' models predict** in terms of future vegetation and climate extremes?

⑤ Can we **predict future vegetation with a data-driven method**?

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