EGU General Assembly 2020
Sharing Geoscience Online

ICOS INTEGRATED CARBON OBSERVATION SYSTEM

Diverging impacts of extreme summers on European C-cycling from different regional and seasonal compensation effects

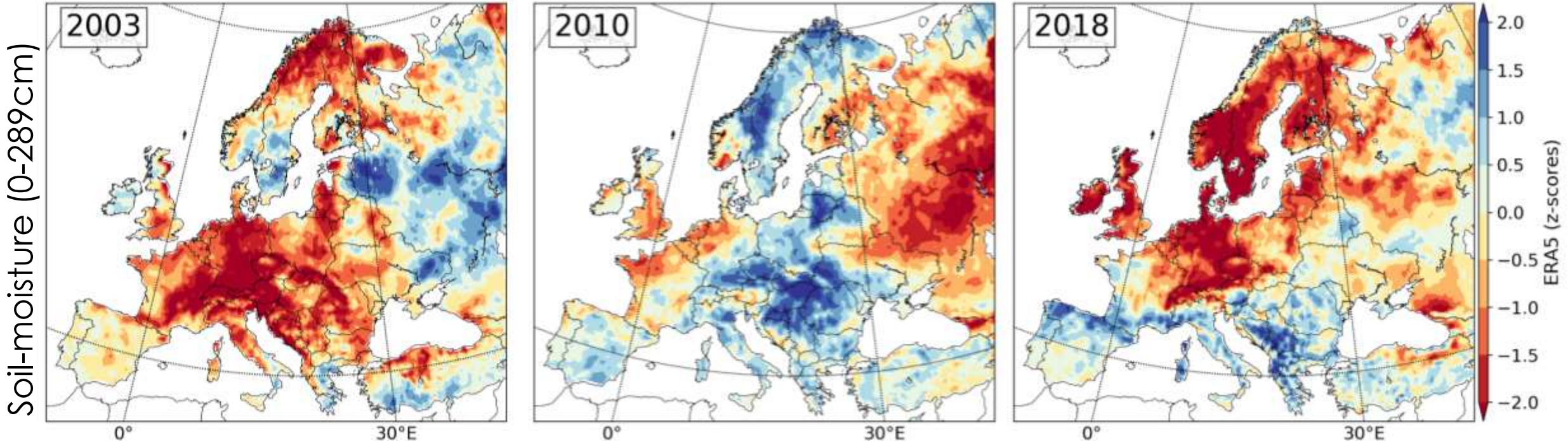
A. Bastos, Z. Fu, P. Ciais, S. Sitch, P. Friedlingstein, J. Pongratz, Ulrich Weber, Markus Reichstein, P. Anthoni, A. Arneth, V. Haverd, A. Jain, E. Joetzjer, Jürgen Knauer, S. Lienert, T. Loughran, Ryan Padrón Flasher, P.C. McGuire, W. Obermeier, H. Tian, N. Viovy, Sönke Zaehle, Lei Fan, Jean-Pierre Wigneron

Max Planck Institute for Biogeochemistry

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

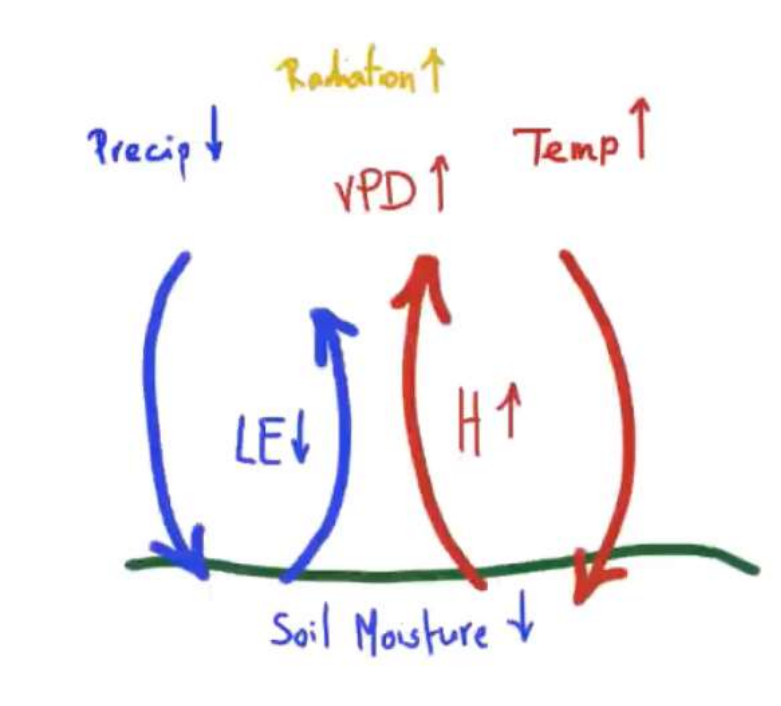
Extreme summers in Europe

Soil-moisture anomalies for summer (JJA) from ERA5 reanalysis during extreme summers in Europe in the past two decades.

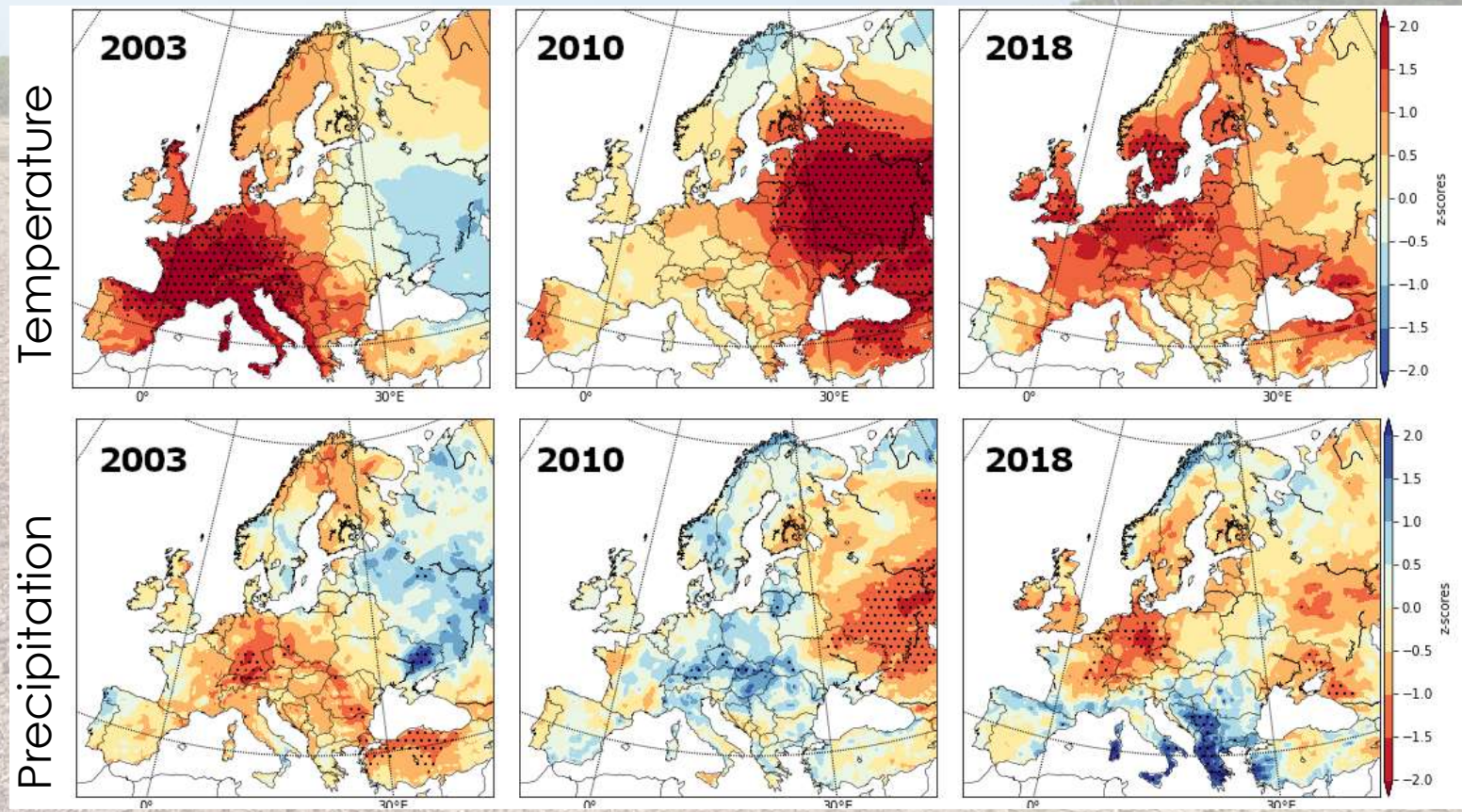


2018: largest extent affected by extreme drought

Extreme summers in Europe



Temperature and precipitation anomalies for summer (JJA) from ERA5 reanalysis during extreme summers in Europe in the past two decades.

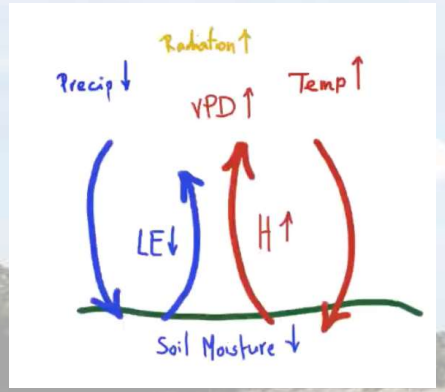


… but summer 2018 temperature and rainfall anomalies not as extreme

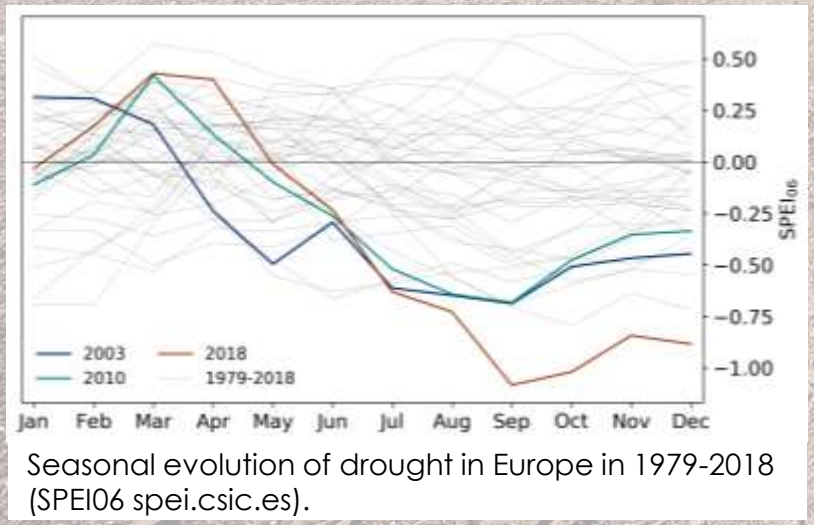
The exceptional **spring** of 2018

Max Planck Institute for Biogeochemistry

ICOS | LMU

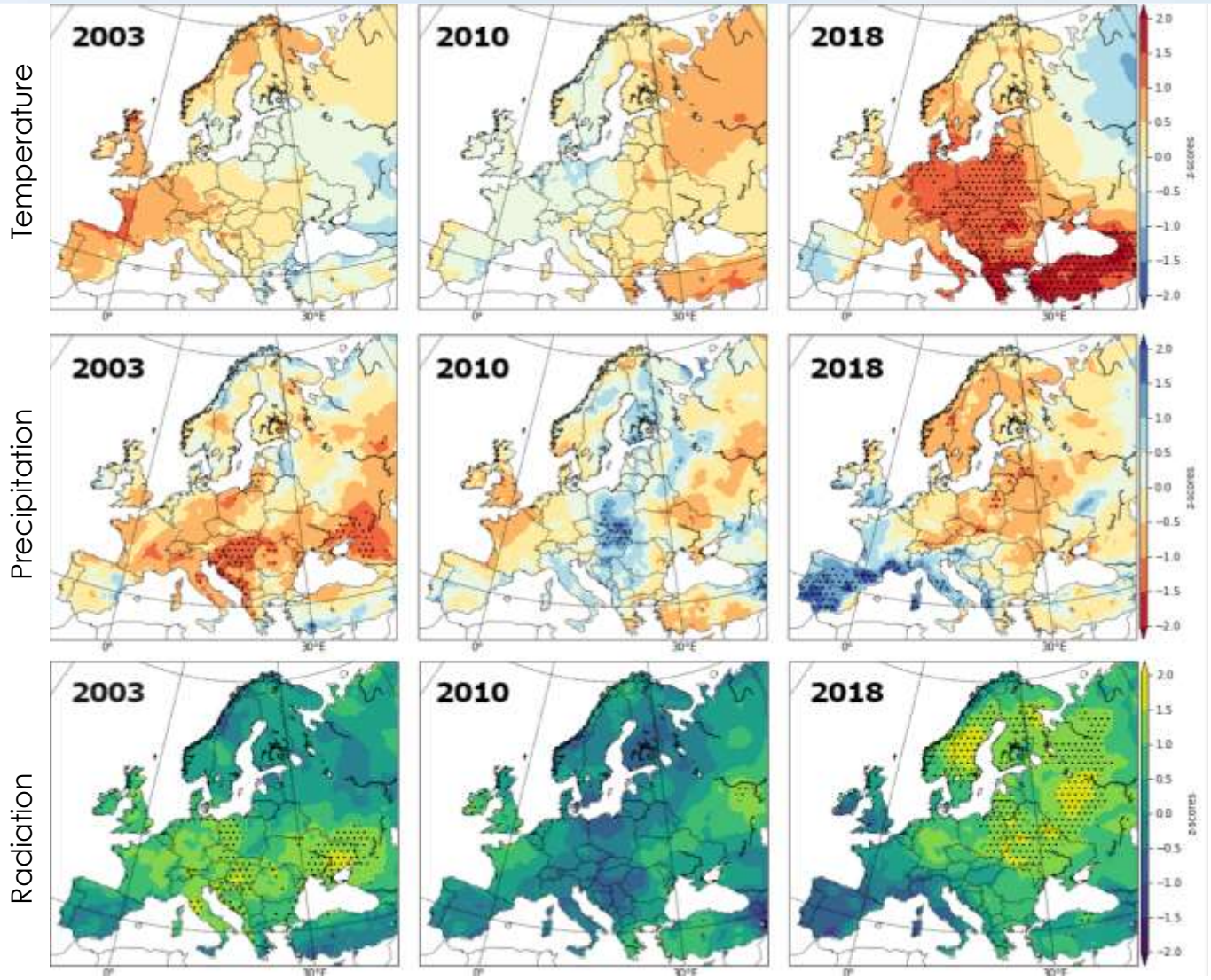


Spring 2018: heatwave & sunny conditions → fast water depletion



Seasonal evolution of drought in Europe in 1979-2018 (SPEI06 spei.csic.es).

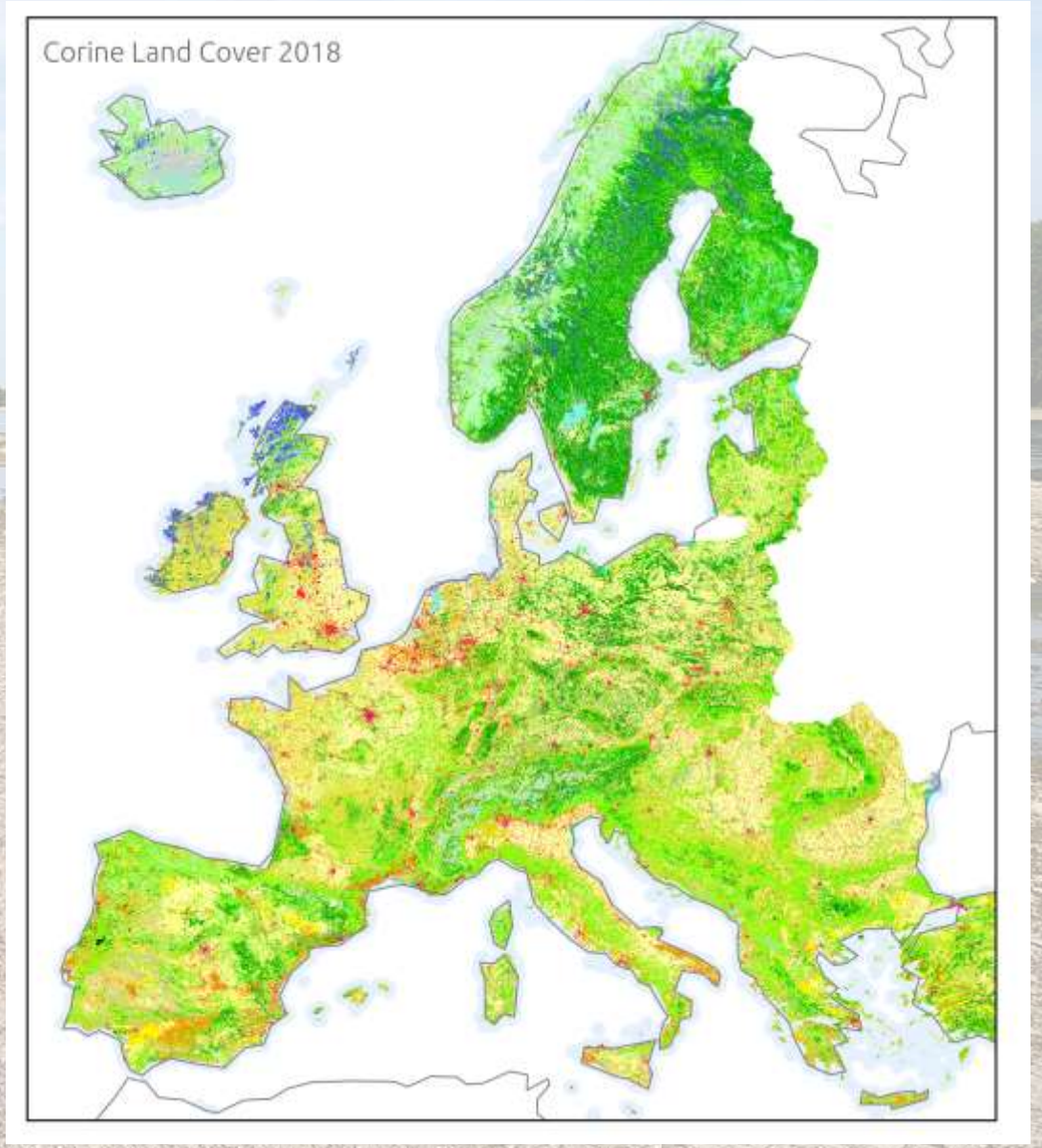
Anomalies (standardized) in temperature, precipitation and radiation in spring (MAM) from ERA5.



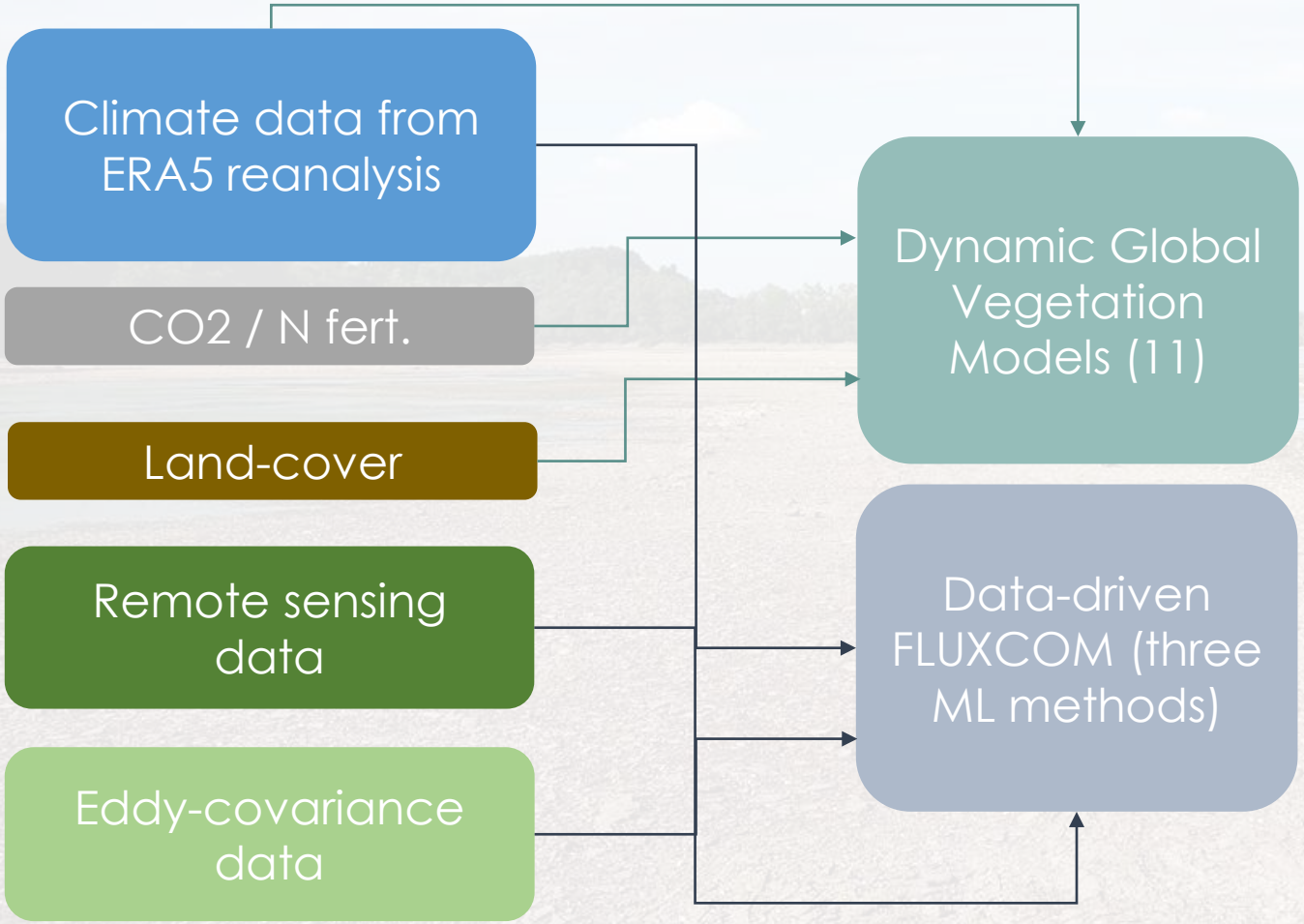
Motivation

Each of the three extreme summers in Europe affected **different climatic regions** with distinct **biomes** and land cover **composition**. They can, therefore, be used as **"natural experiments"** to improve our understanding of ecosystems' responses to climate conditions that will become more frequent in the coming decades. Here, we want to:

1) **Quantify the impacts** of the 2003, 2010 and 2018 summers on ecosystems' seasonal and annual C fluxes;
2) Understand **regional asymmetries** in C flux anomalies during extreme summers;
3) Assess the contribution **of seasonal and regional compensation effects** to the observed asymmetries during extreme summers.



Data & Methods



We used ensembles of 11 process-based and three data-driven machine learning + two flux partitioning methods to calculate carbon and water fluxes in Europe between 1979-2018, all forced with the improved reanalysis from ECMWF (ERA5, 0.25° hourly).

For the Dynamic Global Vegetation Models, **factorial simulations** were additionally performed to **isolate the individual effects of spring and summer**, and their **legacy effects** on carbon and water fluxes in subsequent seasons.

Continental-scale C-balance

Max Planck Institute for Biogeochemistry

ICOS

LMU

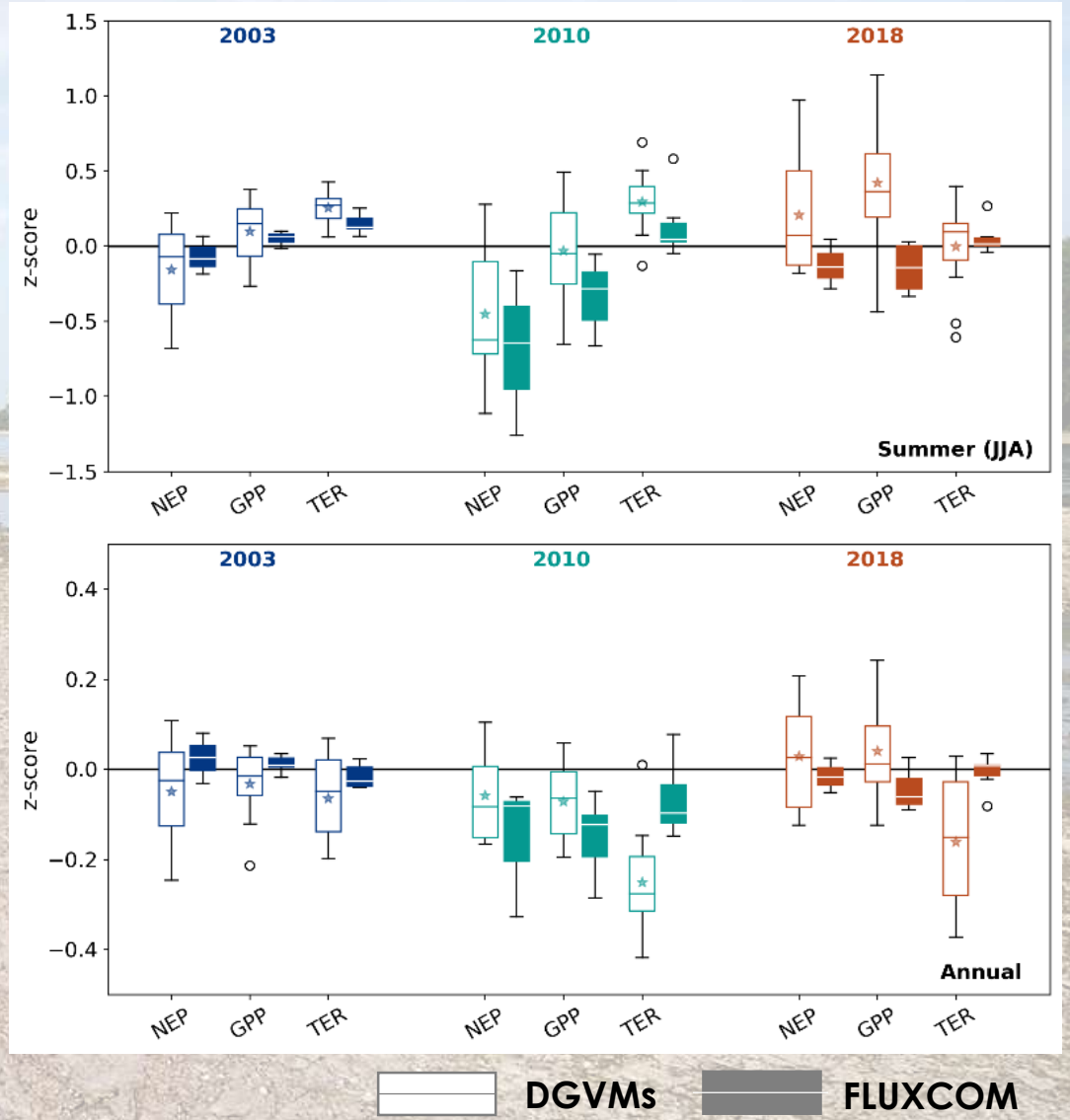
Continentally aggregated standardized anomalies in Net Ecosystem Productivity (NEP), GPP and Total Ecosystem Respiration (TER), estimated by the ensembles of 11 DGVMs and of FLUXCOM RS+METEO for the three extreme summers (top) and the corresponding annual balance (bottom).

Continental-scale summer NEP_{anom} strongly negative in 2010, but close to neutral fluxes in other summers *…

… because of regional compensation in C fluxes between wet/dry dipoles (slide 8)

Annual C balance close to 0 or even slightly positive (except 2010)…

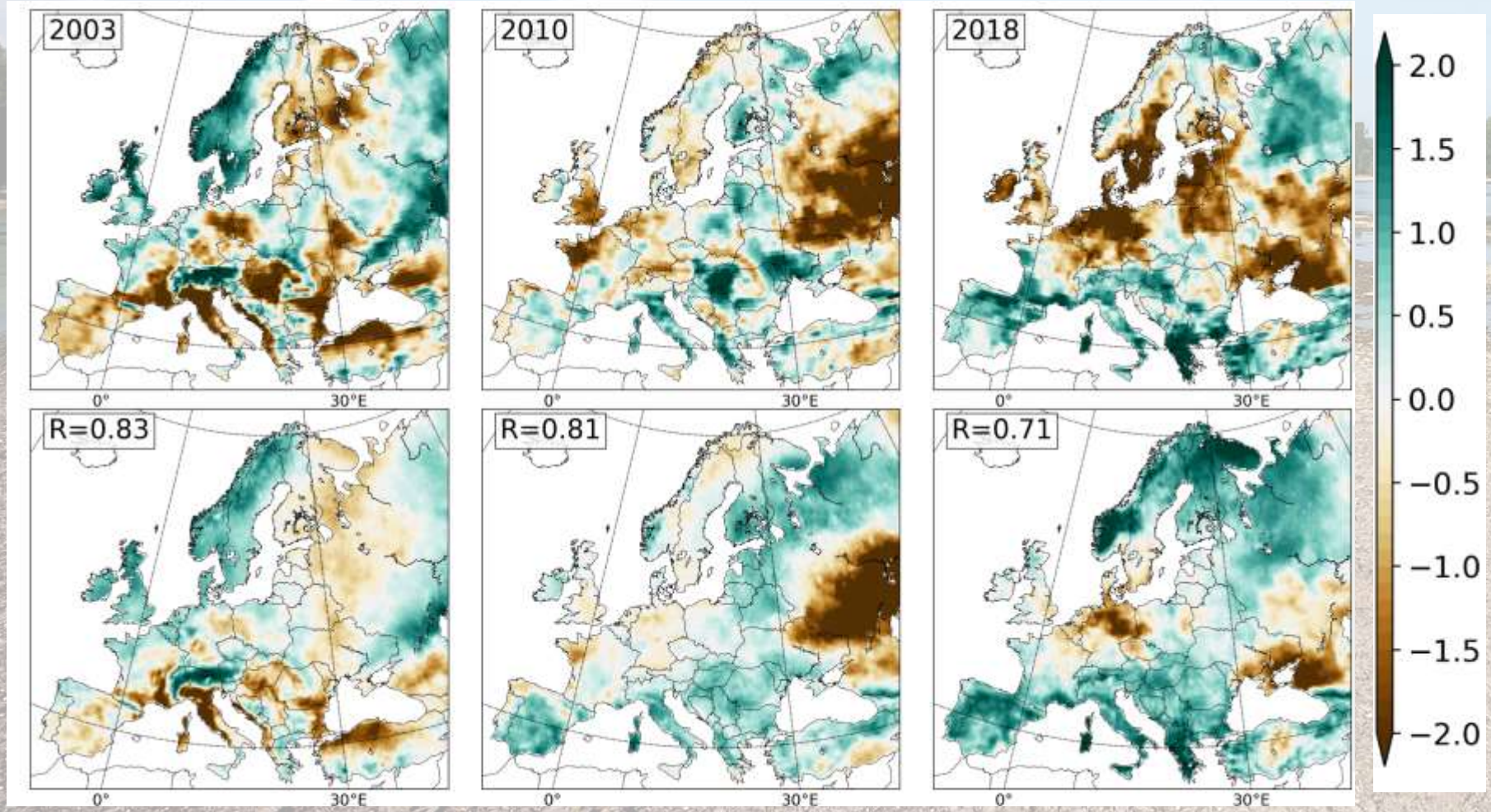
… because of seasonal compensation in C fluxes between wet/dry dipoles (slide 9)



*** but large inter-model uncertainty!!!**

Regional compensation effects

Standardized anomalies in gross primary productivity (GPP) during extreme summers estimated by the ensemble mean of FLUXCOM RS+METEO (top) and of the 11 DGVMs (bottom). The labels show the correlation between the two datasets.



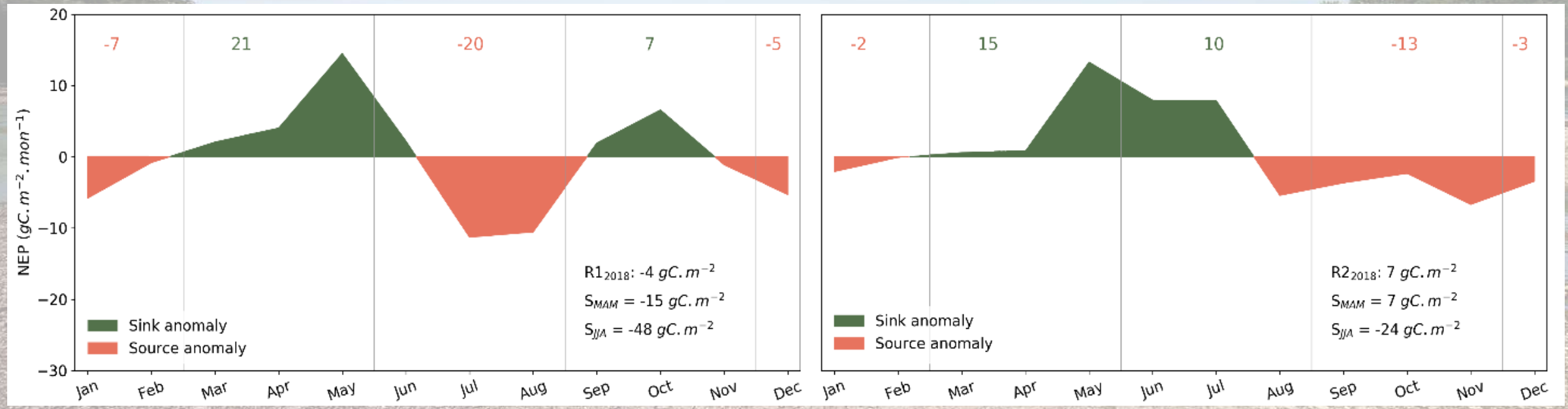
Above average GPP
Below average GPP

Strong regional contrasts in GPP anomalies

2018: GPP_{anom}>0 also in drought regions

Seasonal compensation

The figure below shows the results for the 11 DGVM ensemble mean, for the southern sector of the area affected by drought in 2018 (R1, left – central Europe and southern Sweden, with predominantly negative JJA GPP_{anom}; R2, right – central and northern Scandinavia, neutral or positive JJA GPP_{anom}, slide 8) The labels indicate the annual C balance corresponding to the reference simulation, and for the individual impacts of spring (S_{MAM}) and summer (S_{JJA}).



Enhanced NEP in spring is offset by reduced uptake in summer (R1) and autumn (R2)

Warm & bright spring support high summer NEP in R2 but amplify reduced summer NEP in R1

For more details, stay tuned:

Bastos et al. Philosophical Transactions of the Royal Soc. B (**Special Issue on Drought 2018** coming out in the next months…)

EGU General Assembly 2020

Sharing Geoscience Online

BG3.22

Live session: Tuesday, 5 May 2020, 08:30–10:15

abastos.at.bgc-jena.mpg.de

@Ana__Bastos