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# Remote sensing data for drought impact assessment

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# Sentinel 2 data for local assessments

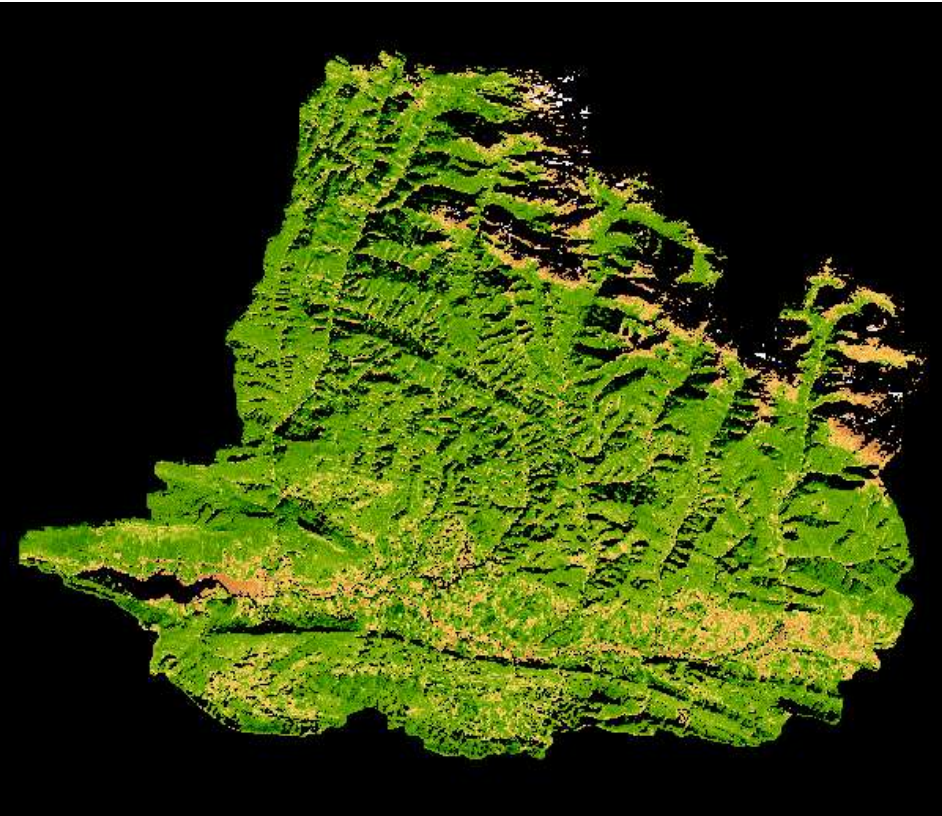
## Sentinel-2 a and b

- 13 spectral bands (Vis-NIR-SWIR)
- 10-60 m ground resolution
- 3-5 days temporal resolution

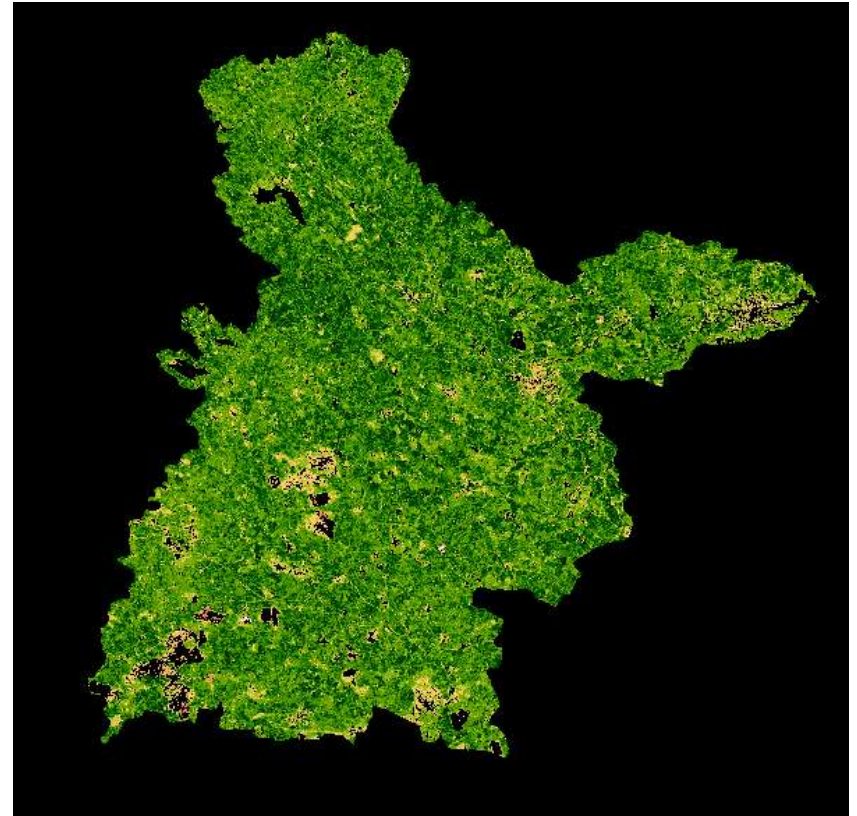


Source: ESA 2015

# Sentinel-2 seasonal dynamics



Aragon



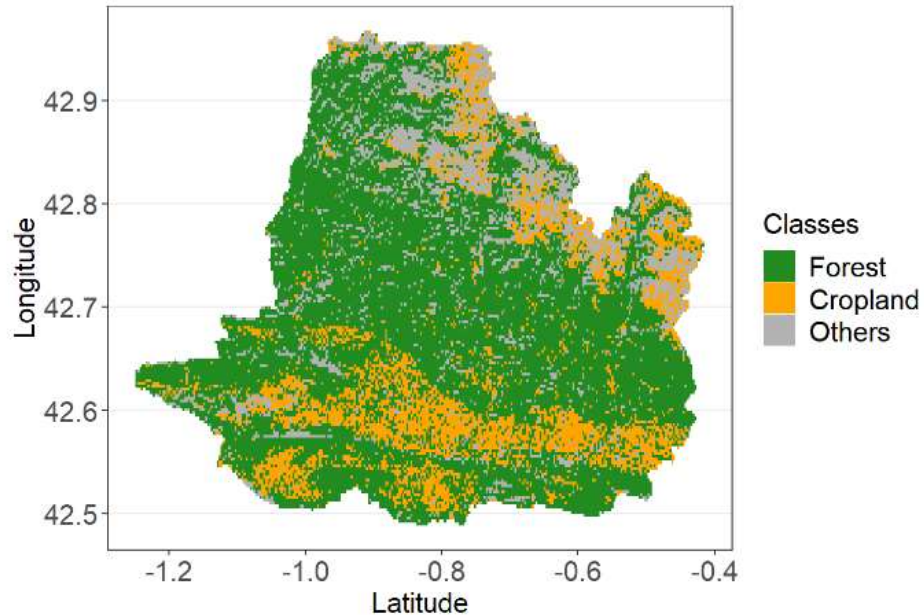
Boyne

Mean monthly EVI2 composites during 2017-2019

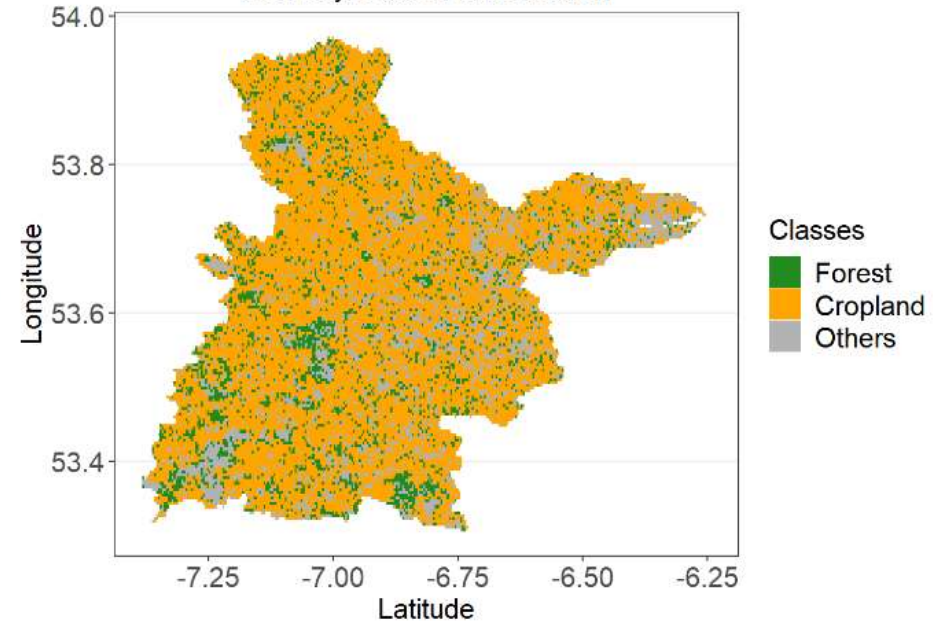


# Classification of cropland and forest

Spanish Aragon basin classification



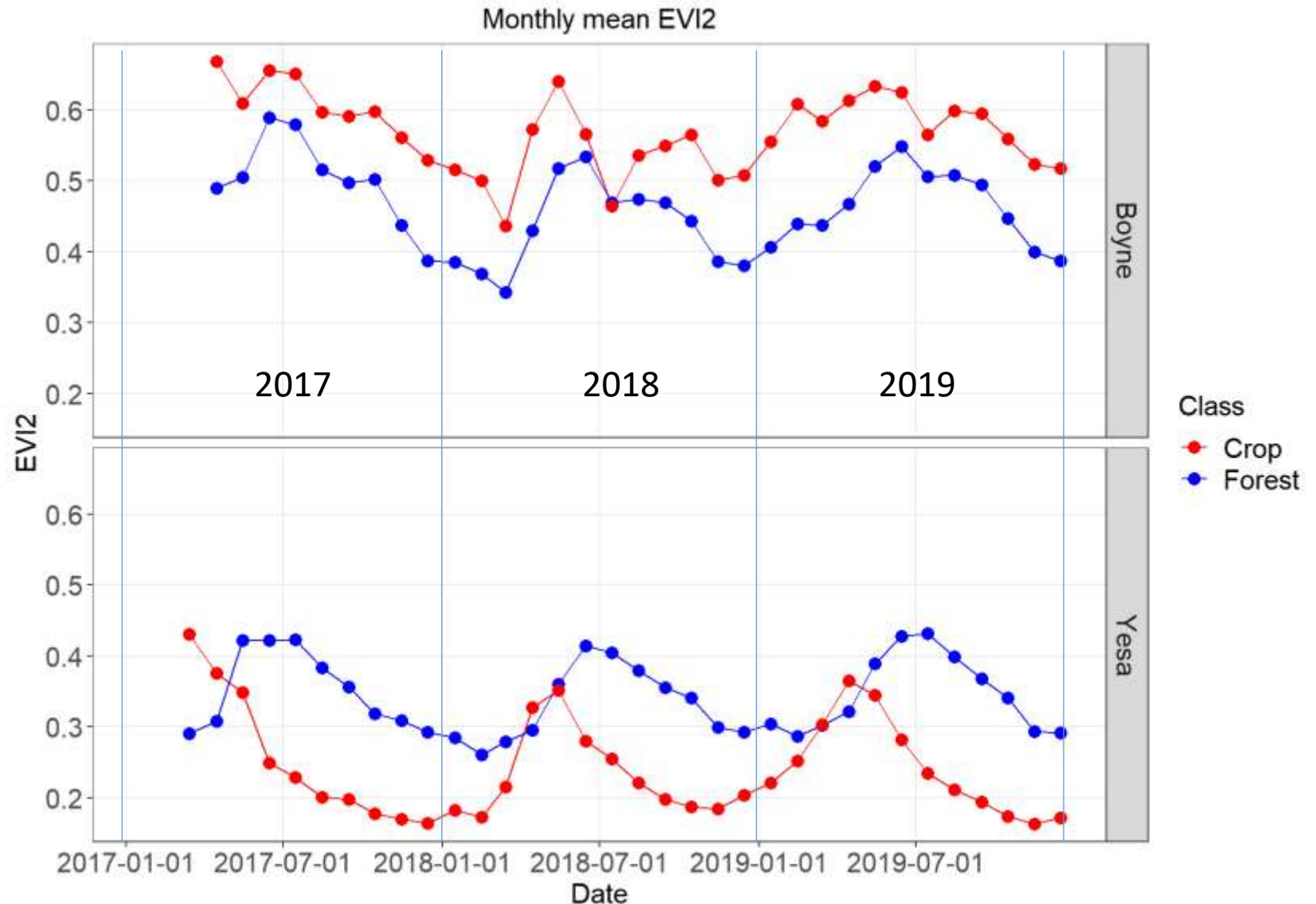
Irish Boyne basin classification



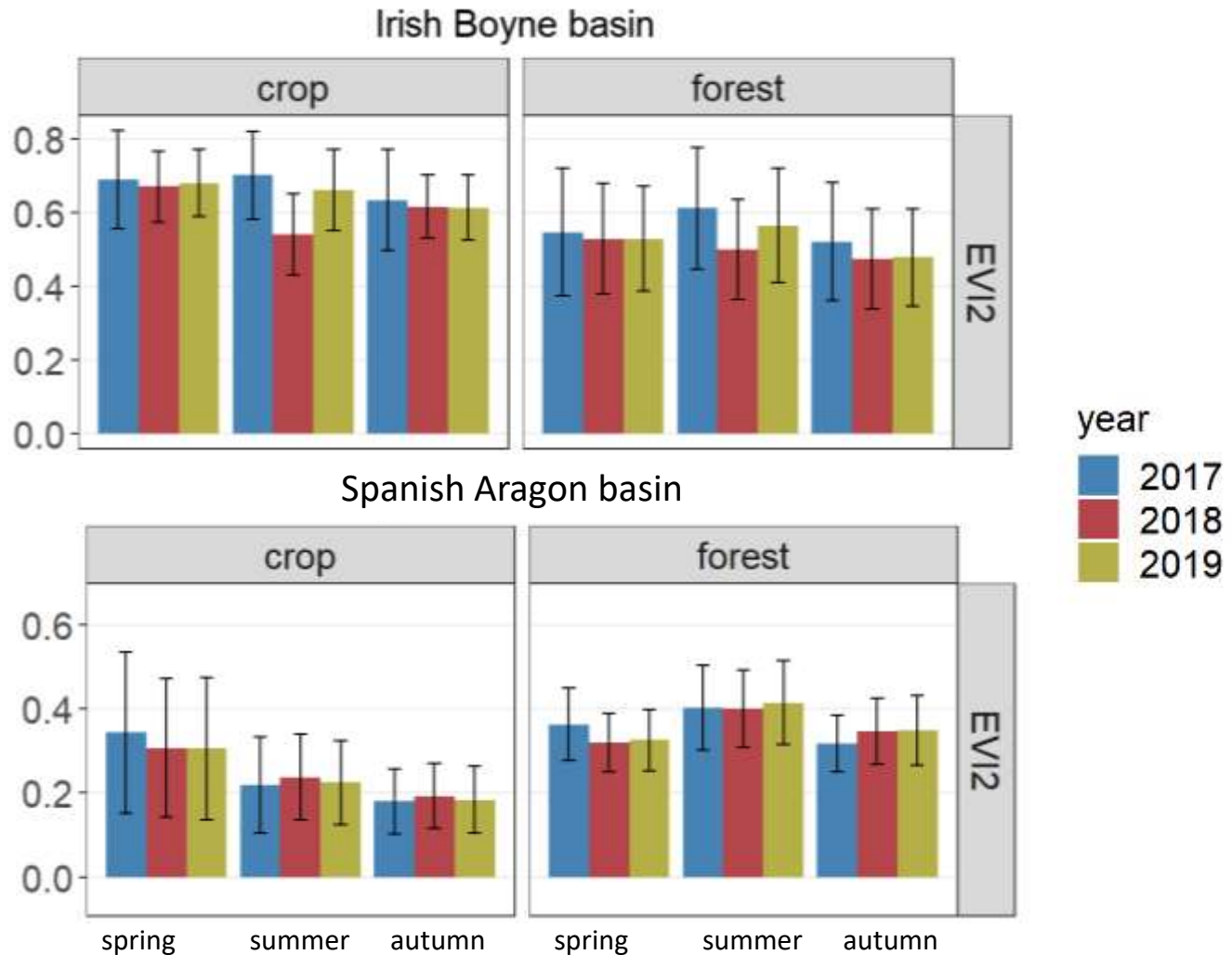
Note: very preliminary (no training data)



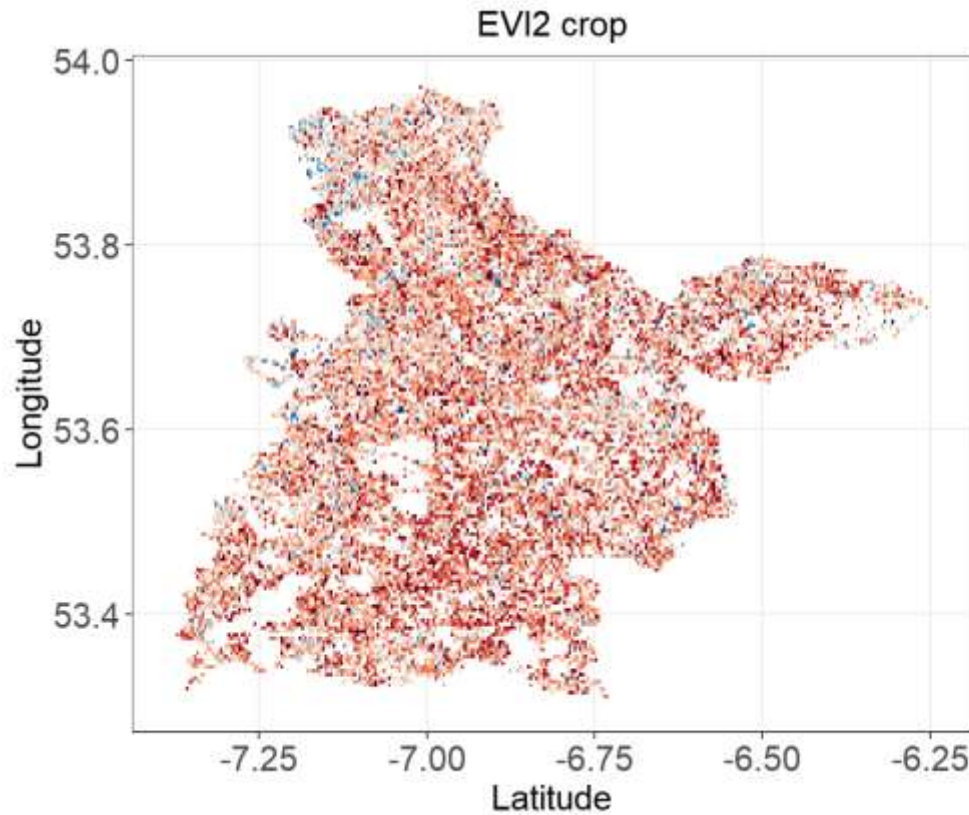
# Monthly seasonal dynamics 2017-19



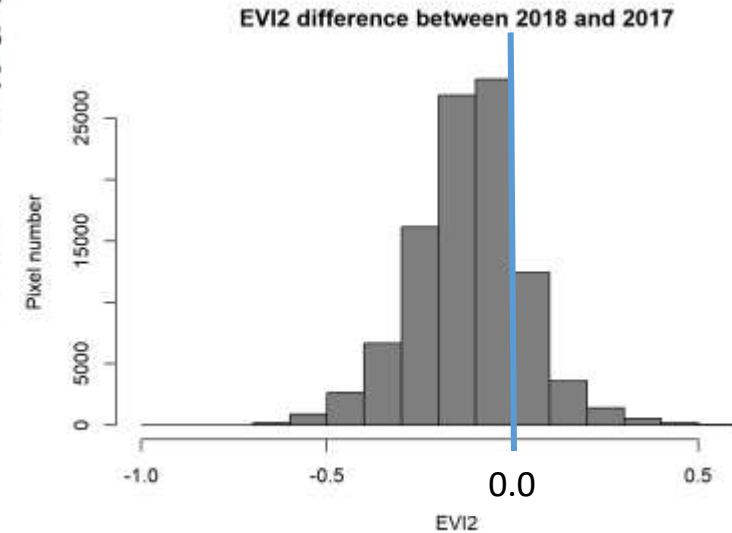
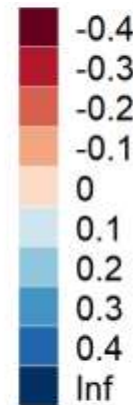
# Comparison year by year 2017-19



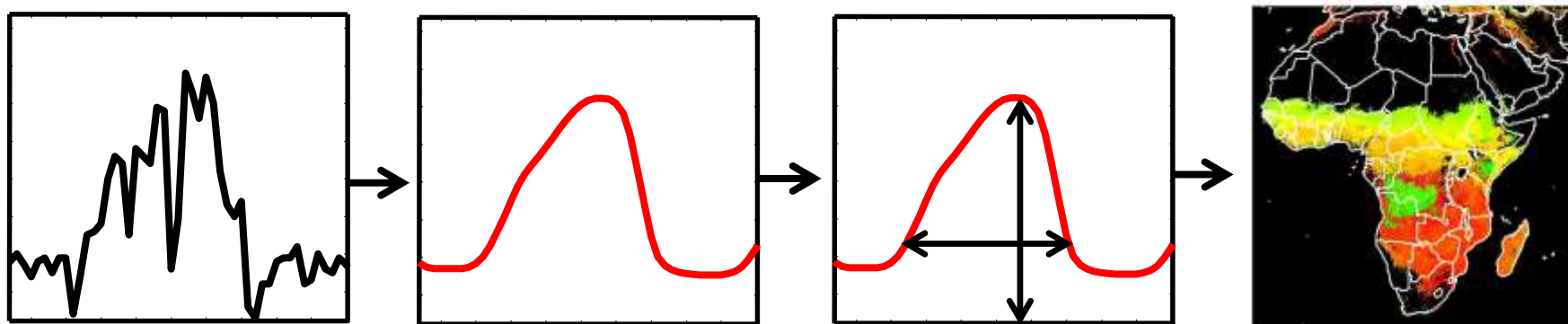
# Boyne basin vegetation difference 2018 vs 2017



EV12  
anomaly



# Data preprocessing with TIMESAT



- Smoothing of irregular and noisy data
- Extraction of seasonality (phenology) parameters

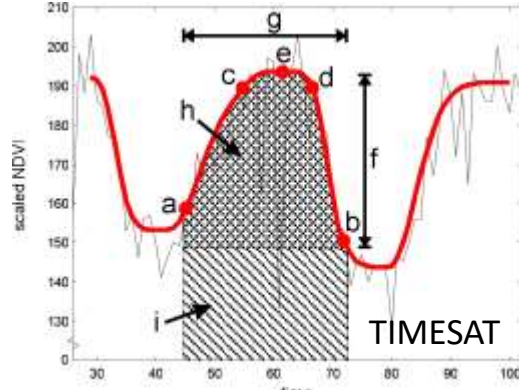
<http://www.nateko.lu.se/TIMESAT>

Jönsson & Eklundh 2002, 2004



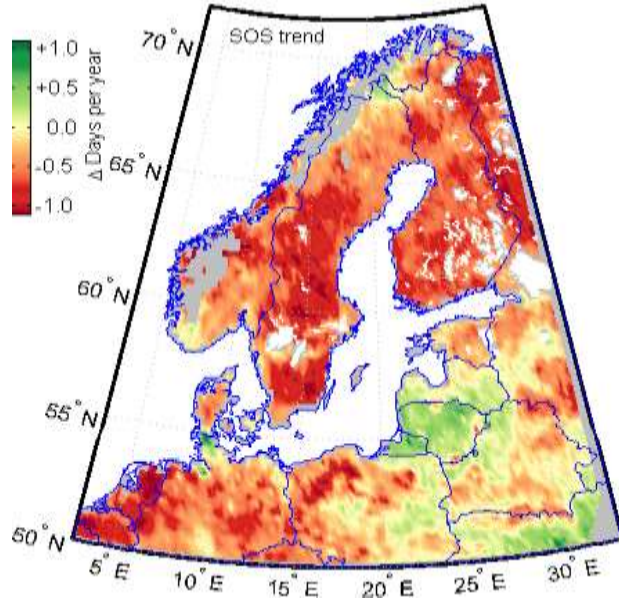
# Continental phenology studies

Phenological parameters



Jönsson & Eklundh 2002, 2004

SOS trend 2000-2016



- 0.3 d/year Jin et al. 2017, 2019

Start of growing season

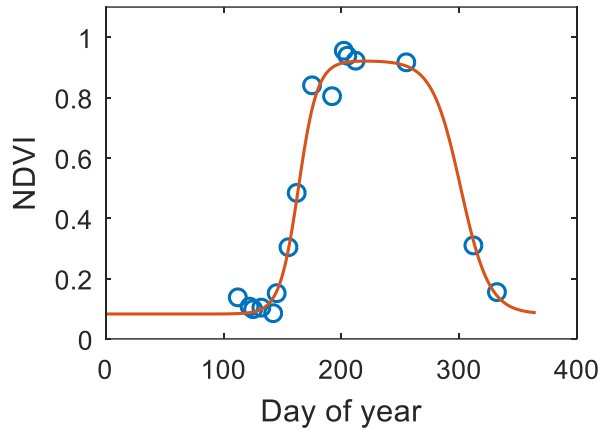


Phenology indicator 2000-2016  
for the European Environment Agency

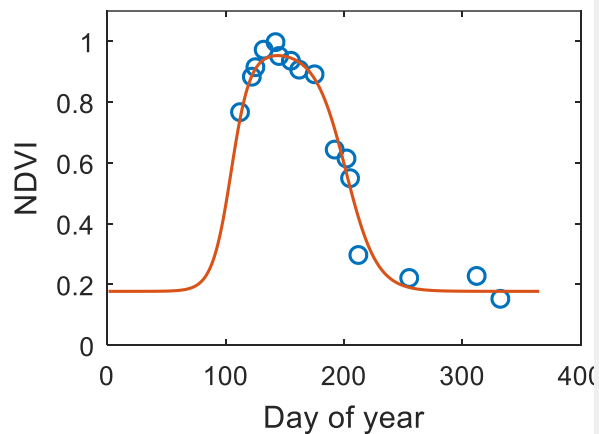
# Local phenology from Sentinel-2



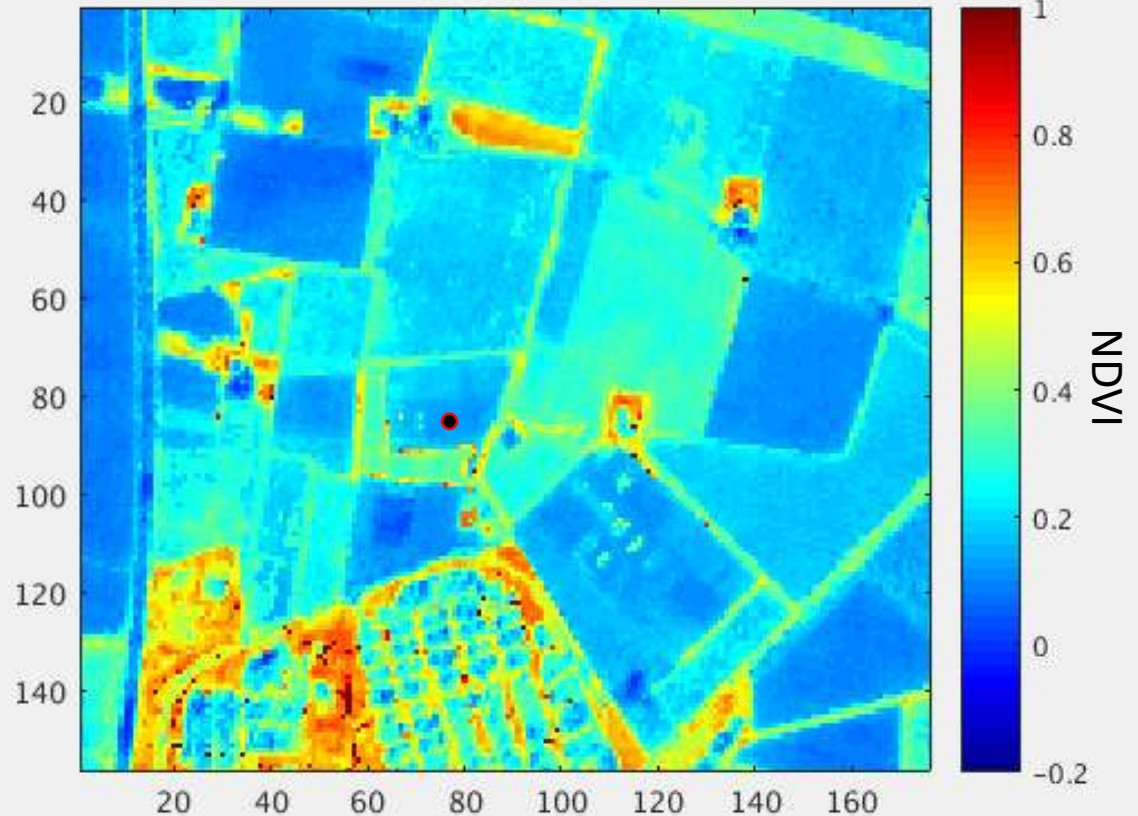
**Sugar beet**



**Winter wheat**



2016-01-01

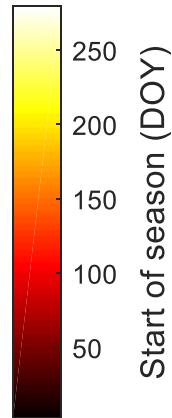
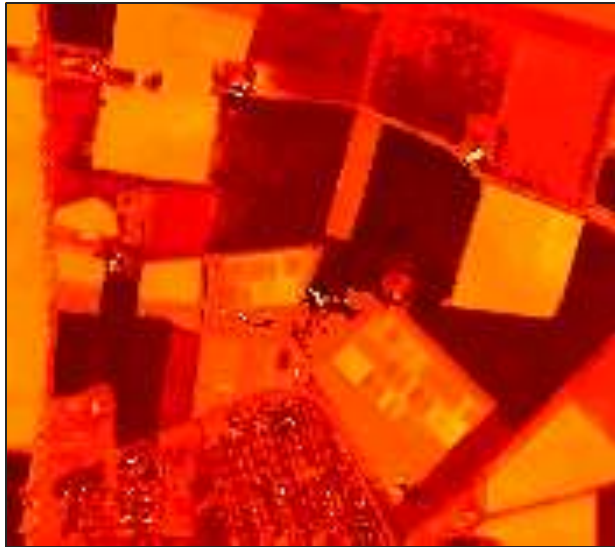


• Spectral mast

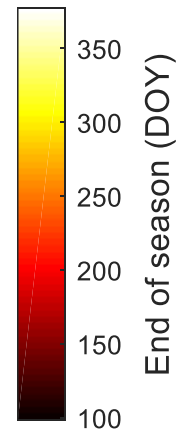
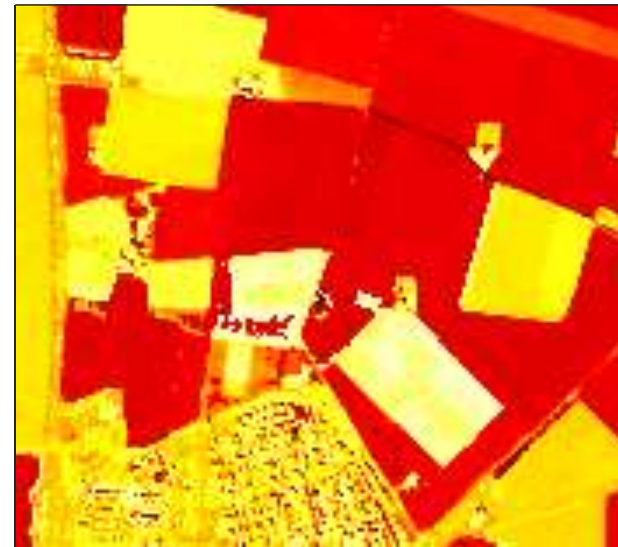


# Mapping the agricultural phenology

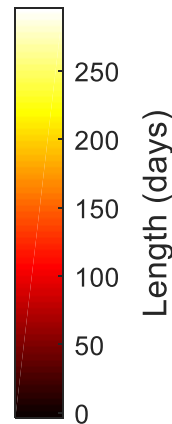
Start of season



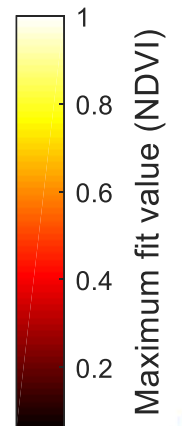
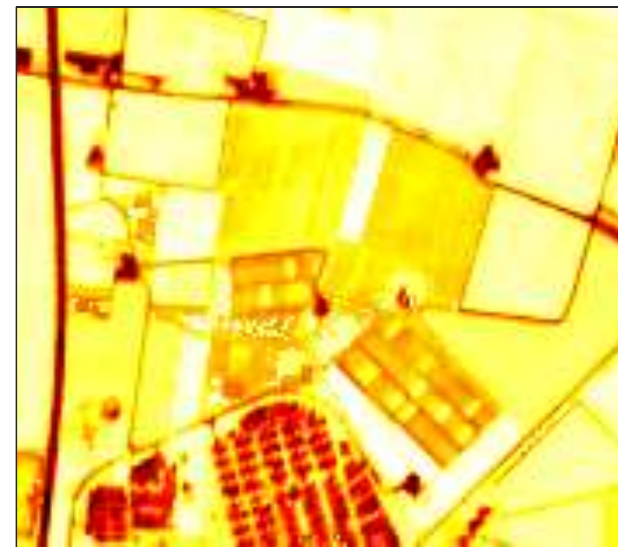
End of season



Length of season



Seasonal maximum





# Possible contributions to CROSSDRO

- Vegetation state at daily to monthly time step
- Phenological parameters
- Drought response for individual land units / vegetation types
- Area statistics
- Relationships with hydrological/meteorological conditions
- ...



# European scale satellite data processing

Data from the MODIS sensor

500 m spatial resolution, 2001 - presently

Daily data

Vegetation indices (VI) formed from reflectance bands, e.g.

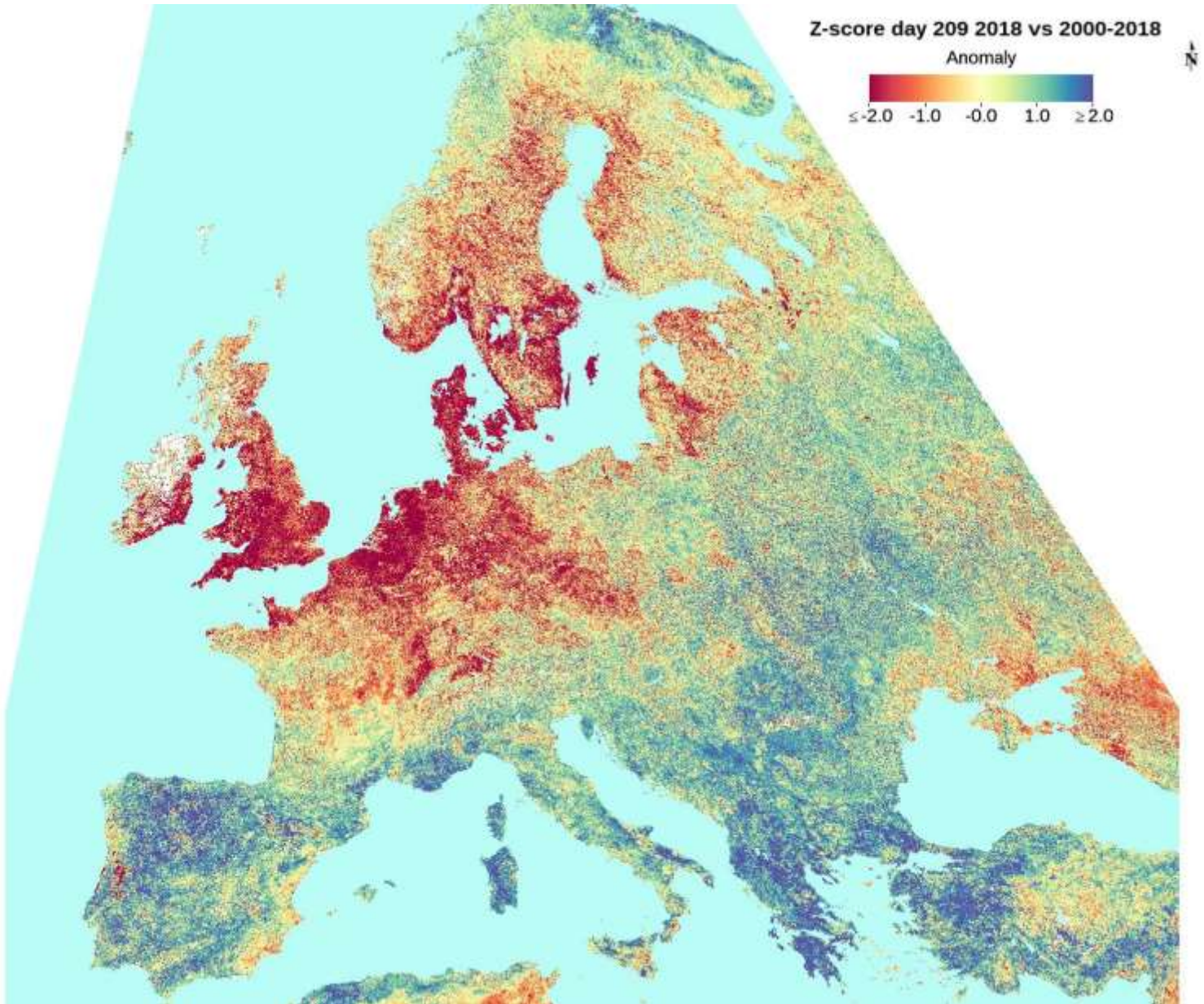
$NDVI = (NIR - red) / (NIR + red)$

Z-score anomalies:  $(VI_{2018} - \text{mean}) / \text{std}$

where mean and std are computed from VIs for 2000-2018



# NDVI anomaly 2018





# Indices for investigating vegetation drought response

## Hypothesis

Vegetation index      Proxy for:

NDWI response → vegetation canopy moisture

EVI2 response → vegetation productivity

PPI response → green leaf area index

↓  
*drought  
impact  
severity*

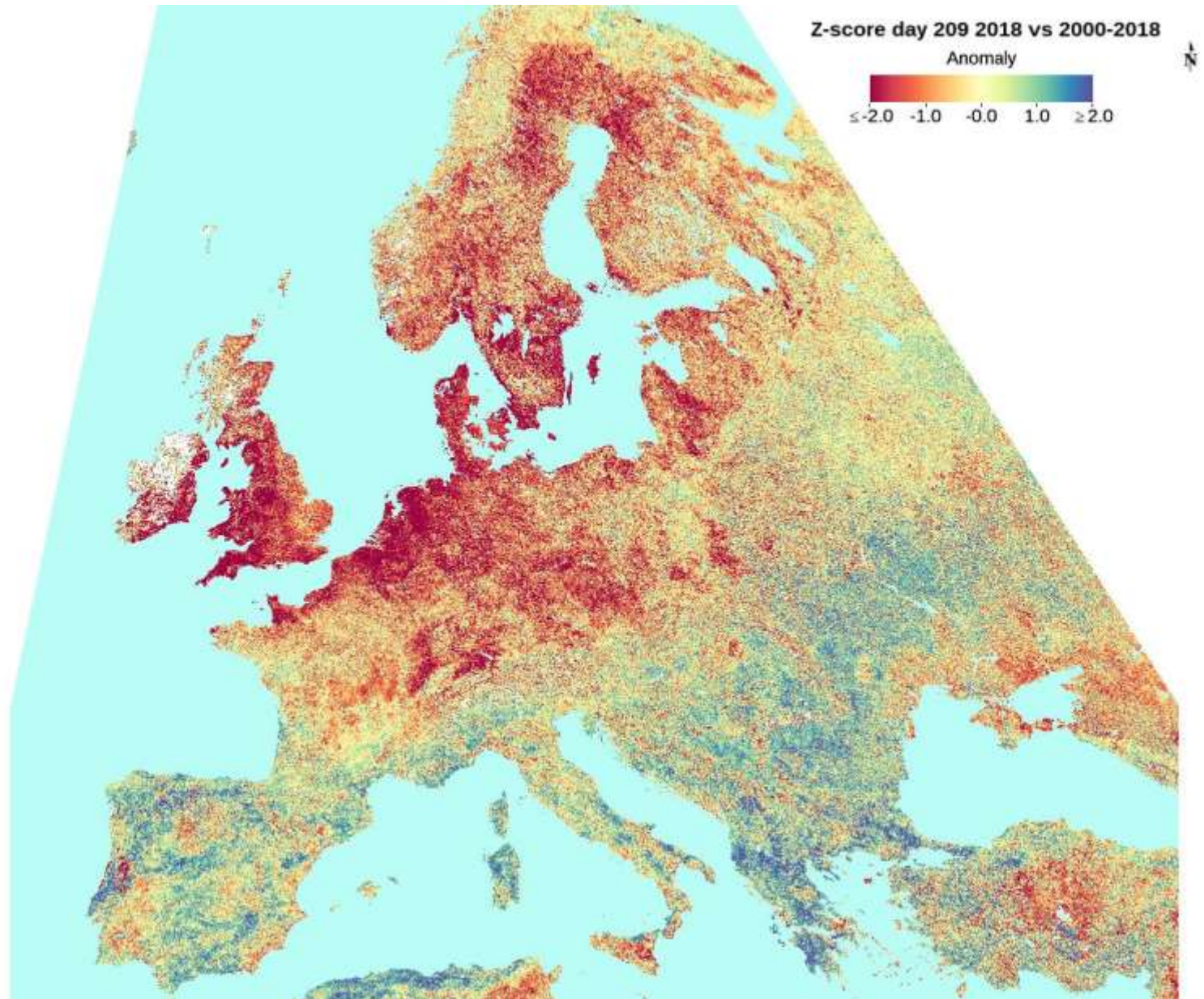
NDWI:      normalized difference wetness index

EVI2:      2-band enhanced vegetation index

PPI:      plant phenology index

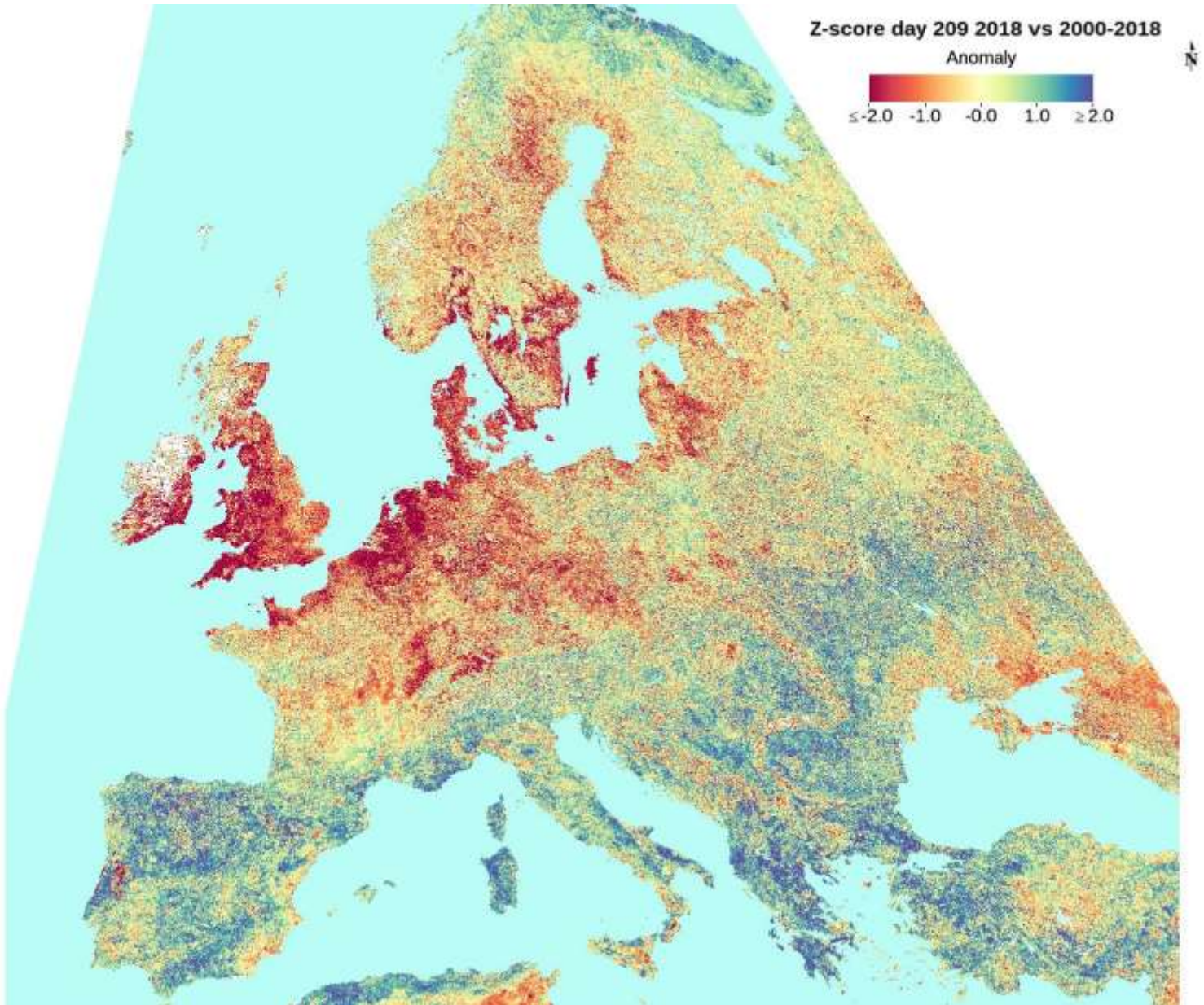


# NDWI anomaly 2018



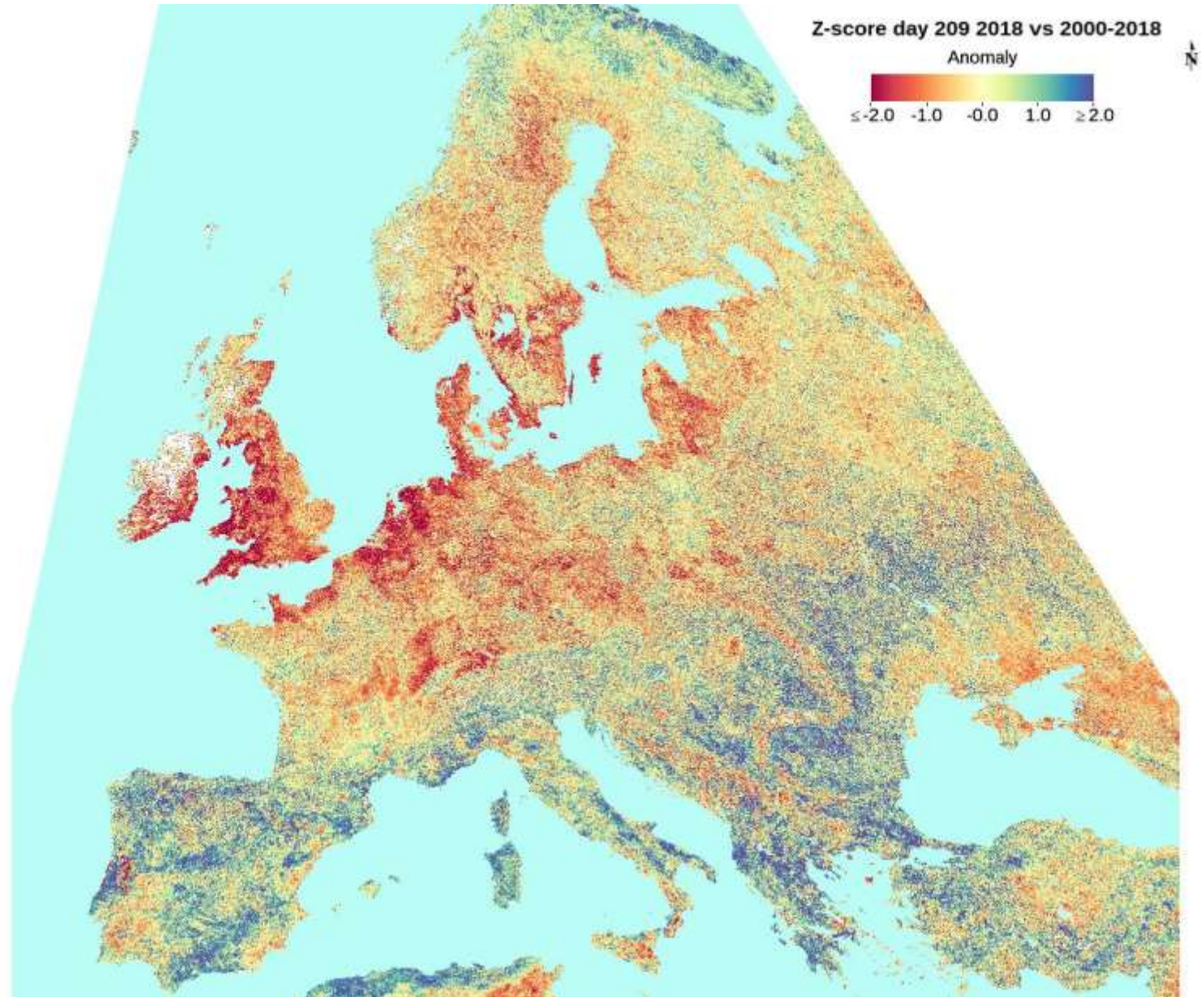


# EVI2 anomaly 2018





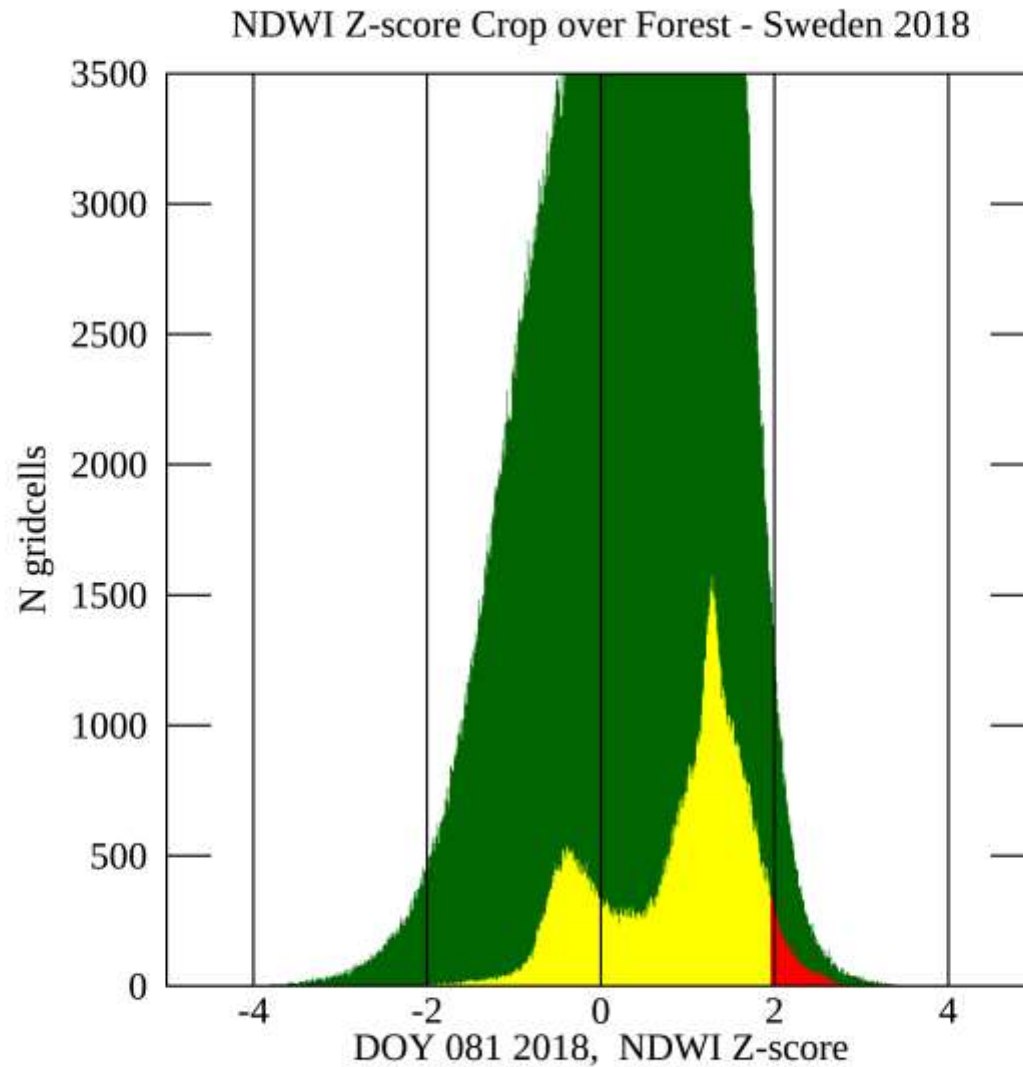
# PPI anomaly 2018



# NDWI for agriculture and forest in Sweden vs SPEI

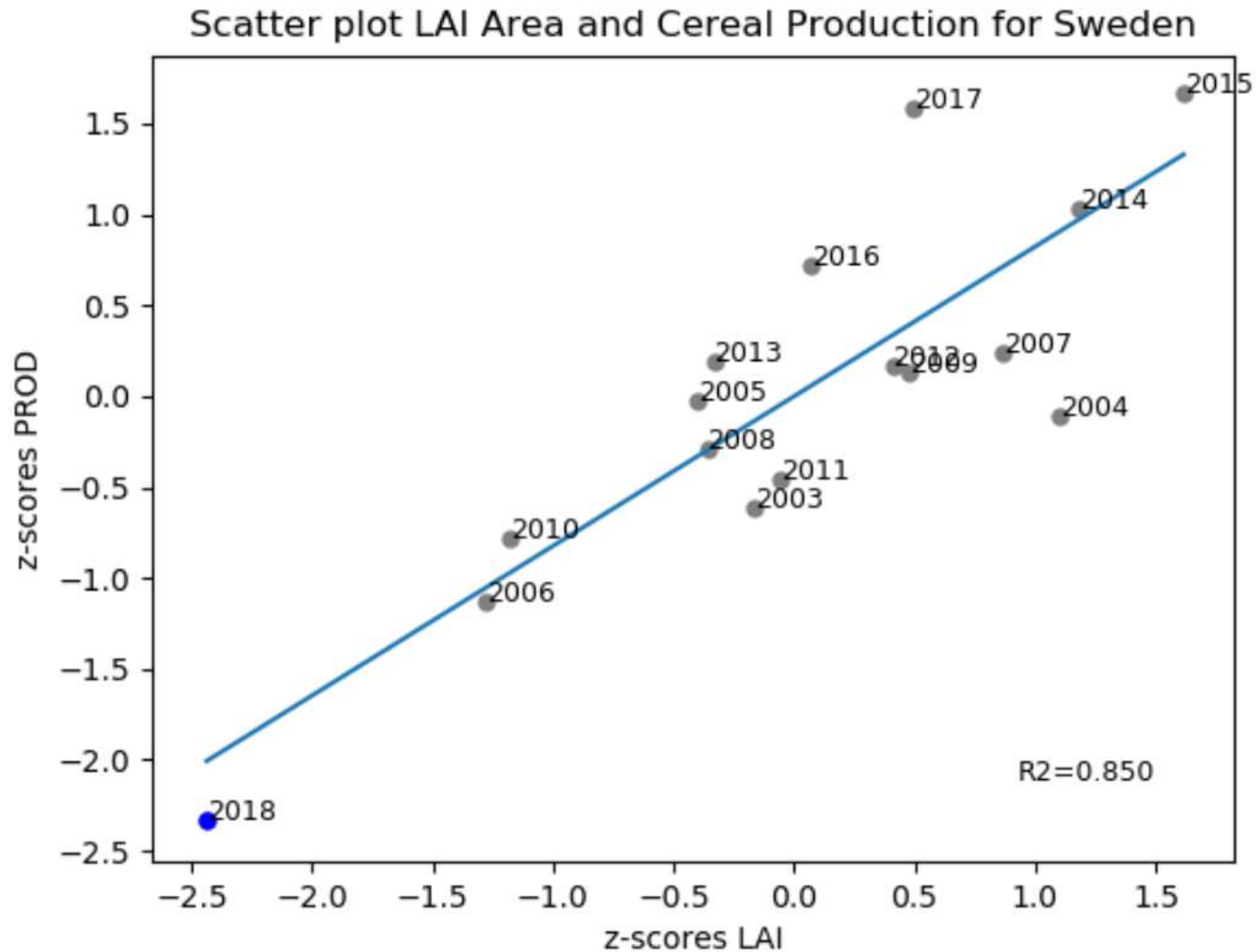


# Seasonal NDWI anomalies





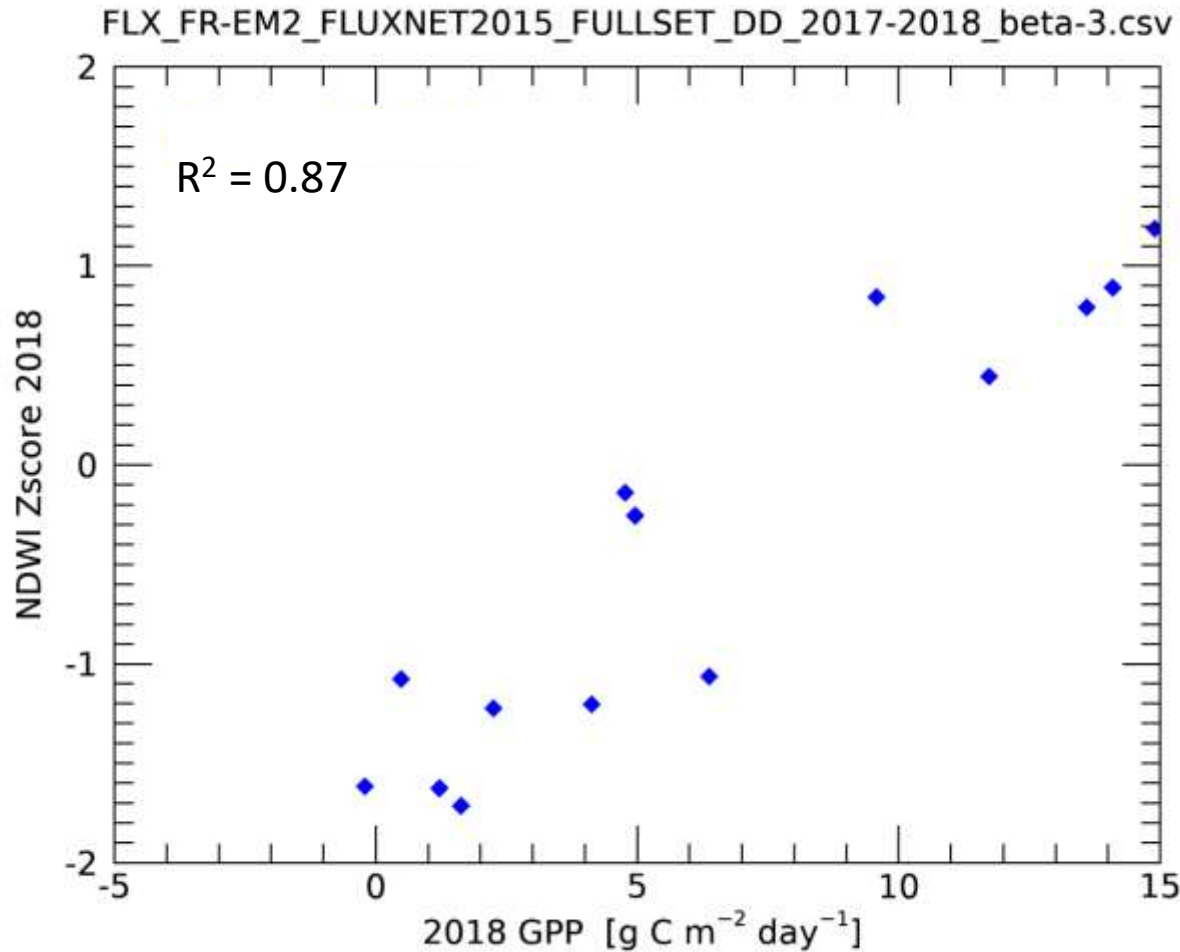
# MODIS observed LAI vs crop yield statistics



Data from EUROSTAT and MODIS.



# Drought effect on carbon fluxes



Cropland site, France



Tall flux tower,  
Norunda, Sweden

# Possible contributions to CROSSDRO

- Impact of climate signals on vegetation response
- Severity of drought impact
- Lag time of drought response
- Effects on carbon uptake, agricultural production, tree growth, water resources (streamflow)
- Recovery time
- Carry-over effects between years
- ...





# Thank you!

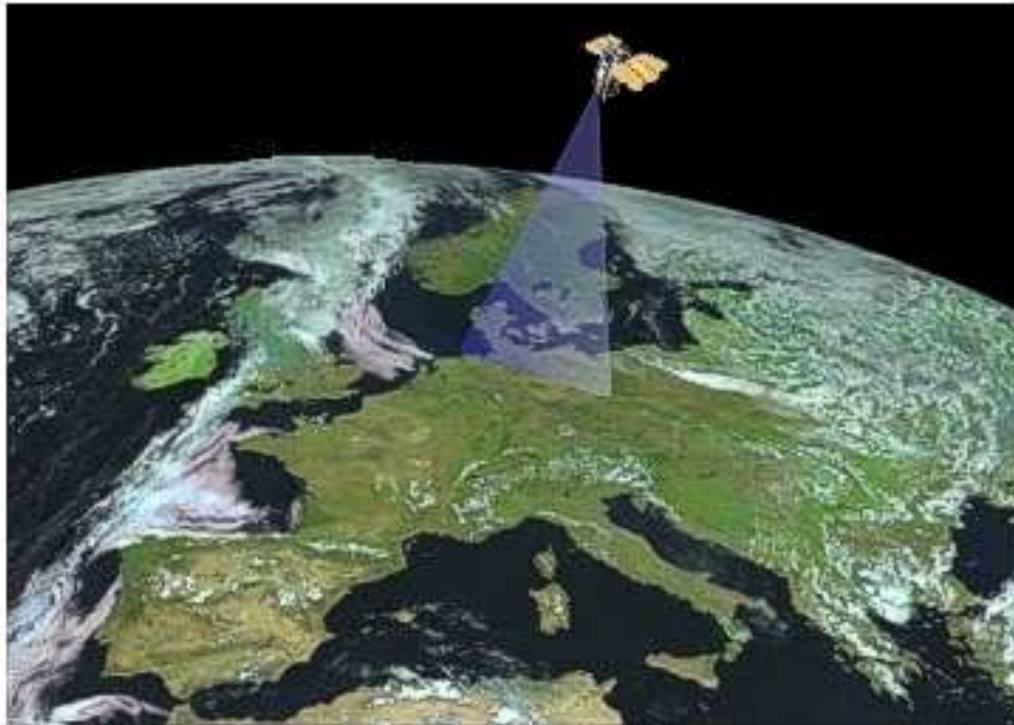


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# Satellite vegetation index for phenology

## PPI: Plant Phenology Index

- Based on radiative transfer theory by Hapke (1993)
- Uses BRDF-corrected red and NIR reflectance
- Maximizes seasonal signal from photosynthetic leaf foliage

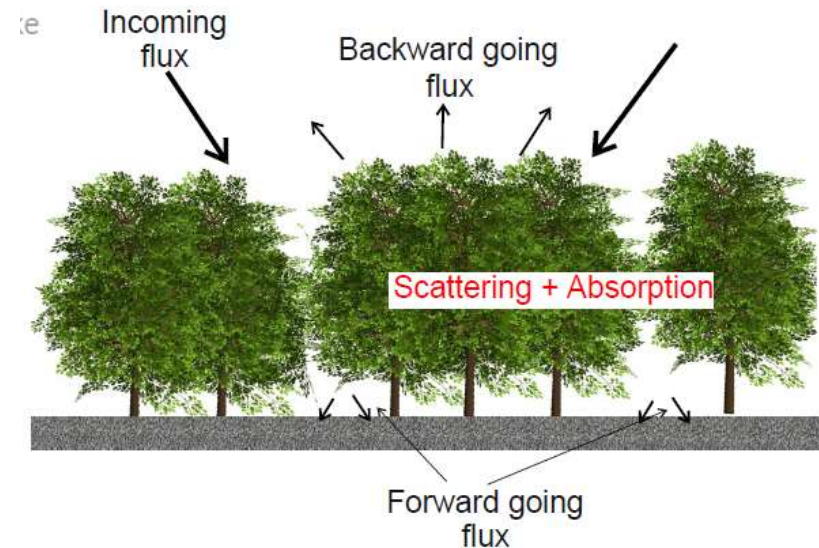
$$PPI = -K \times \ln \frac{DVI_M - DVI}{DVI_M - DVI_{Soil}}$$

$DVI$  Difference vegetation index:  $R_{NIR} - R_{red}$

$DVI_{Soil}$   $DVI$  for soil

$DVI_M$  Maximum  $DVI$  for canopy

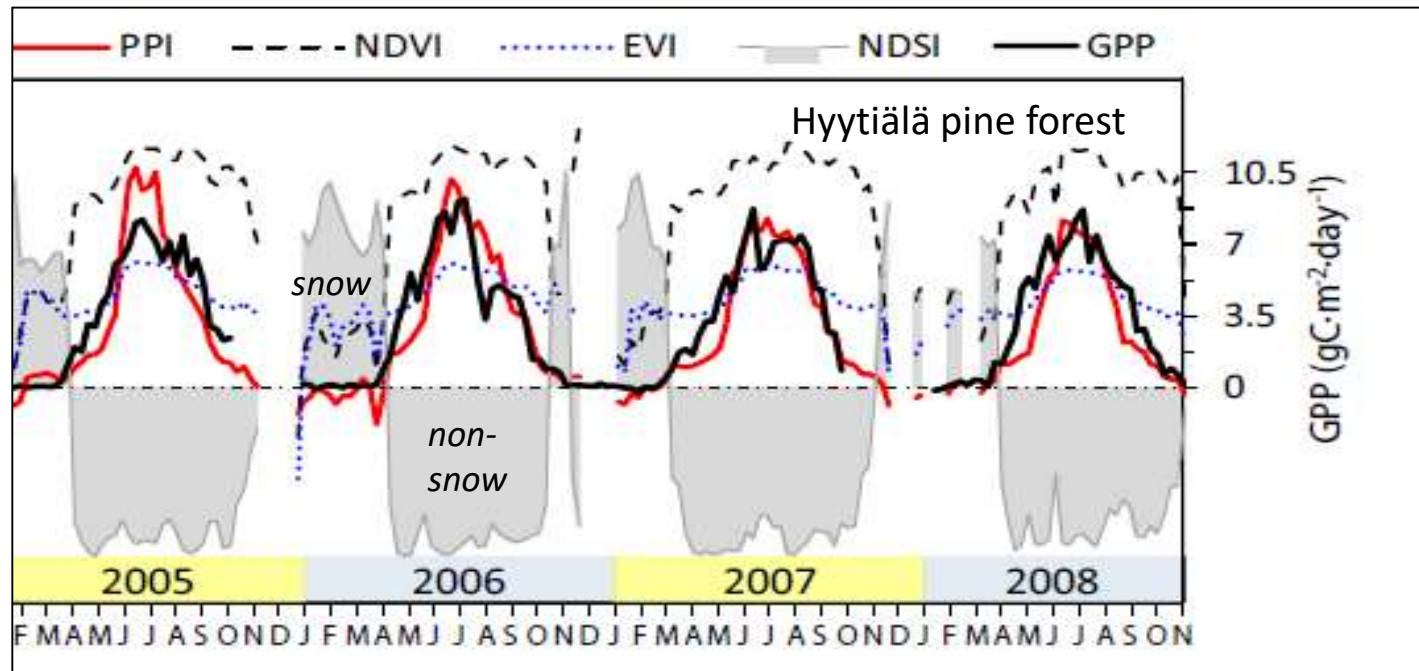
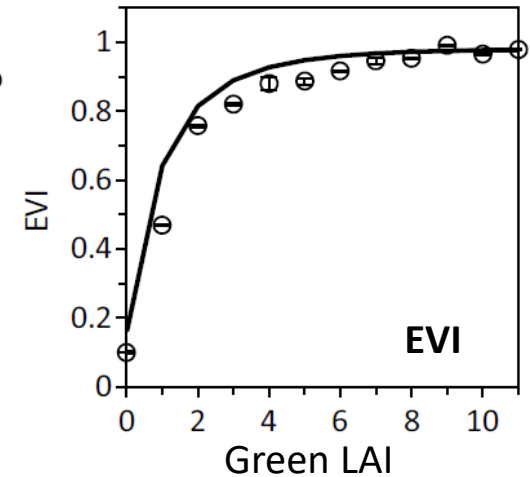
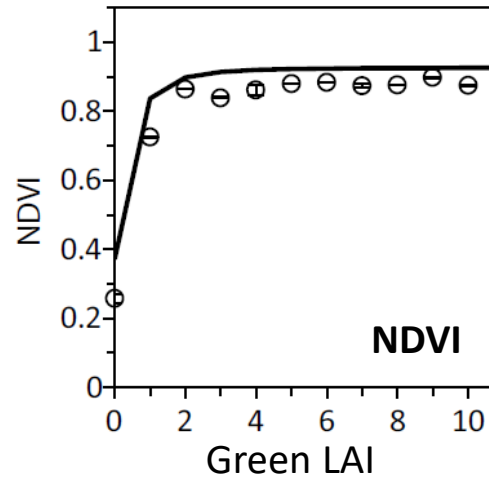
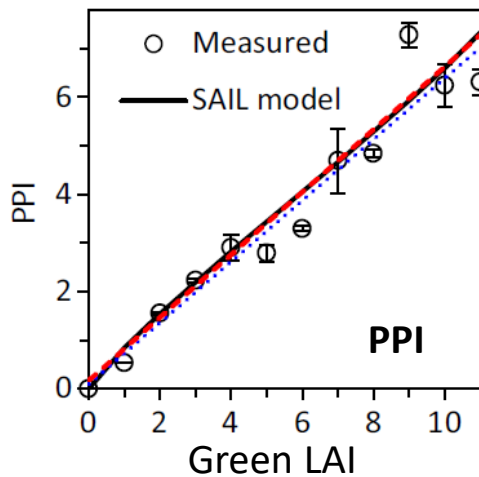
$K$  Extinction coefficient



Jin and Eklundh, 2014, **A physically based vegetation index for improved monitoring of plant phenology**. *Rem Sens Env*, 152.

# PPI – properties

- Linear with green Leaf Area Index (LAI)
- Dynamic in dense canopies
- Insensitive to background snow
- Well correlated with GPP

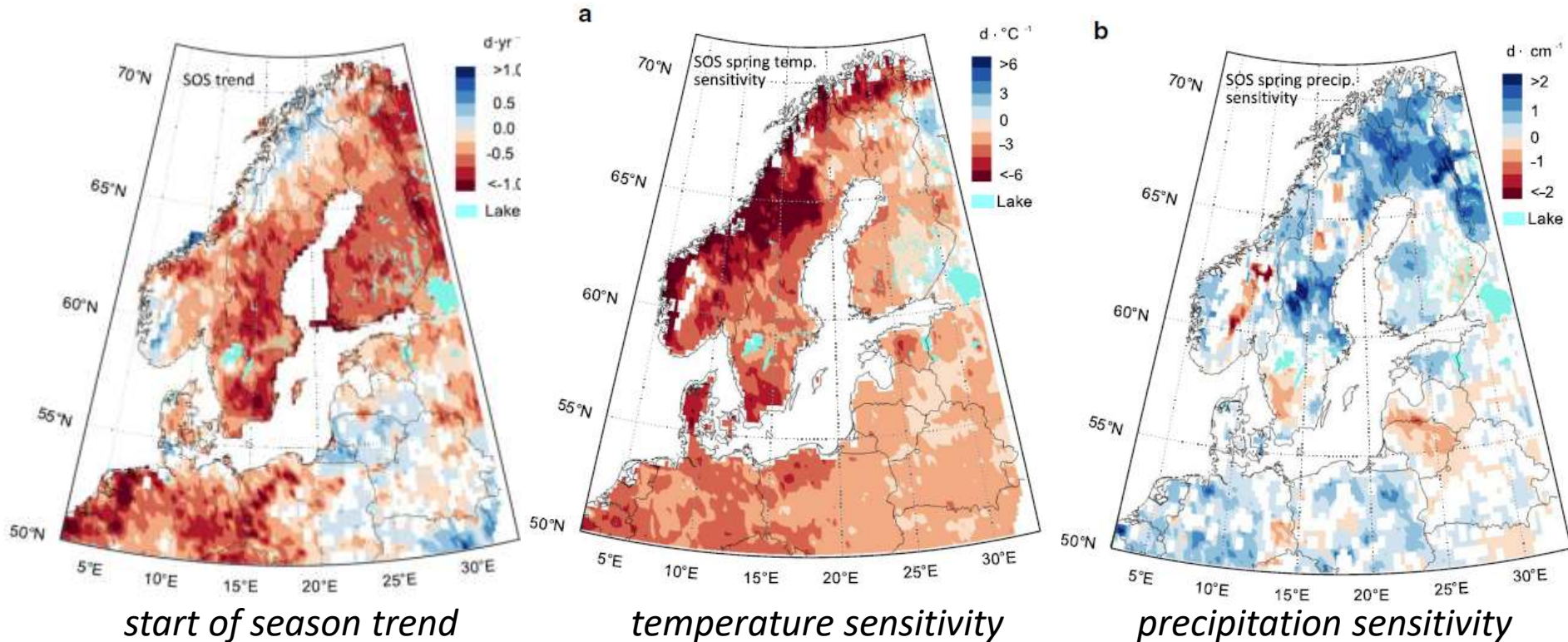


Jin and Eklundh, 2014





# Trend estimates 2000-2016



Trends estimated by robust panel analysis

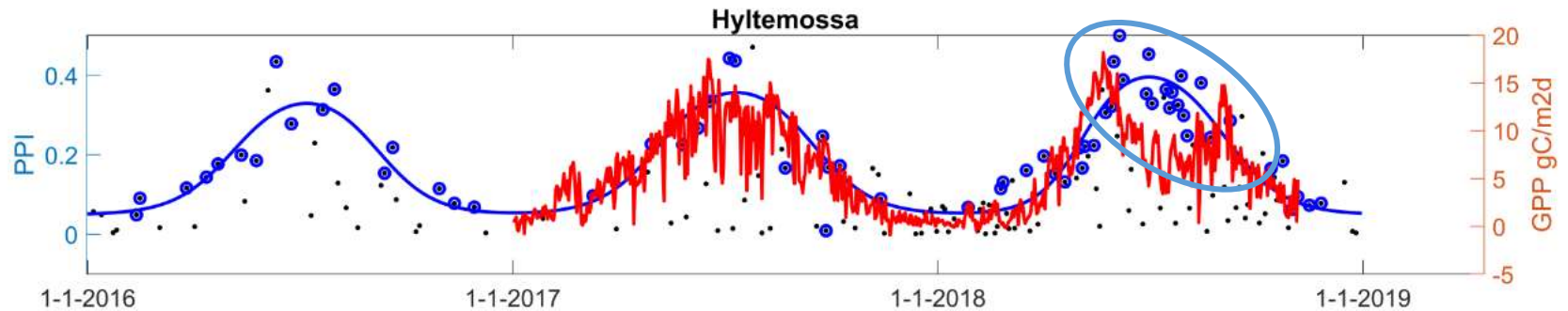
- Ca 0.3 days earlier start of season per year

Sensitivities of trend to temperature and precipitation estimated by first-order difference regression

- Strong sensitivity to spring temperatures: 2.5 d·°C<sup>-1</sup>
- Weak sensitivity to precipitation

Jin et al. 2019, *Int. J. Biometeorology*, 63, 763.

# Sentinel-2 to represent GPP during drought



Spruce forest in S. Sweden.

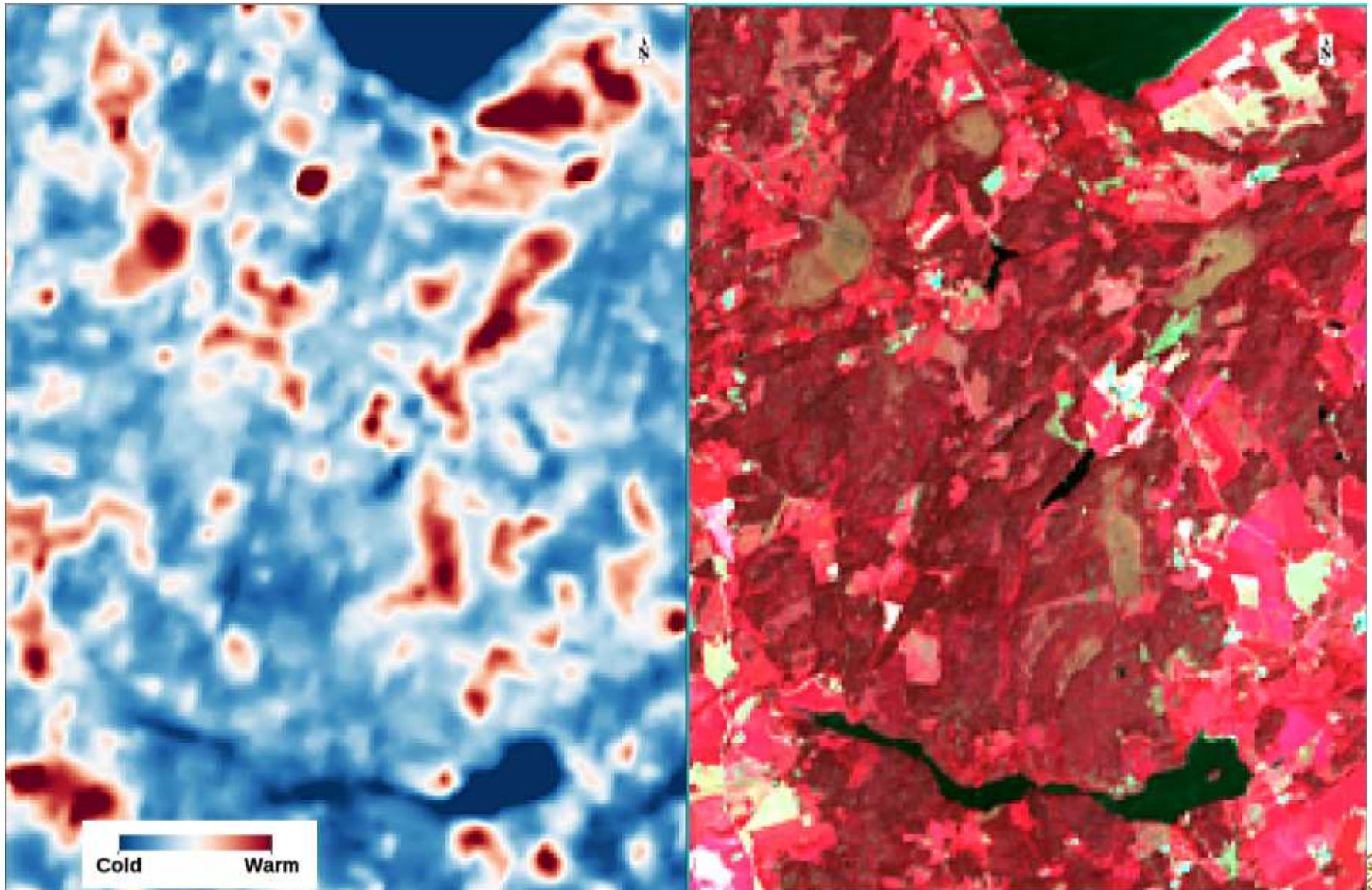
Blue = satellite data

Red = GPP from flux tower

Courtesy Hongxiao Jin



# Thermal data from Landsat



Landsat 2019-06-29