

# In situ data for Land Surface Phenology (LSP)

Lars Eklundh

LSP is the observation of phenology from Earth  
Observation data

## Joint needs for development, validation and interpretation of land surface phenology products

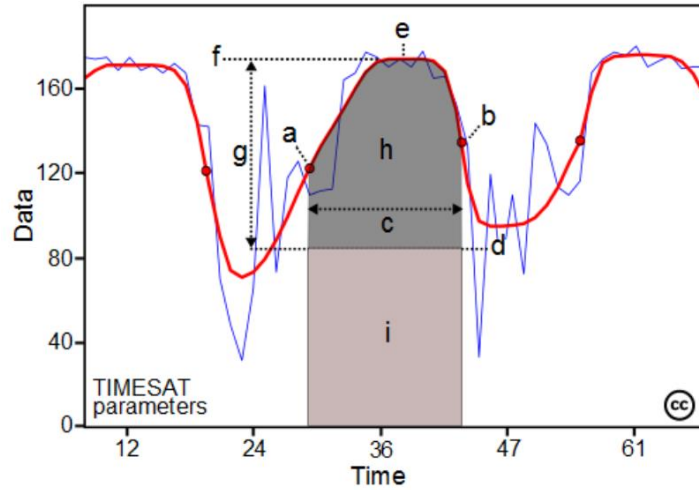
- CLMS: High Resolution Vegetation Phenology and Productivity (HRVPP): Europe 10 m
- CGLOPS: Global LSP: Global 300 m
- ESA RAMONA: Africa LSP 10 m
- EEA MR-VPP: Europe LSP 250 m
- Research projects



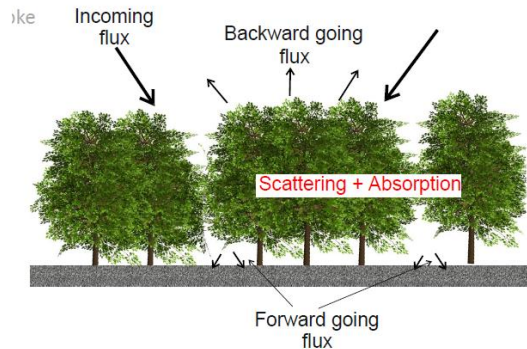
<https://land.copernicus.eu/en/products/vegetation>



# HRVPP start of season date

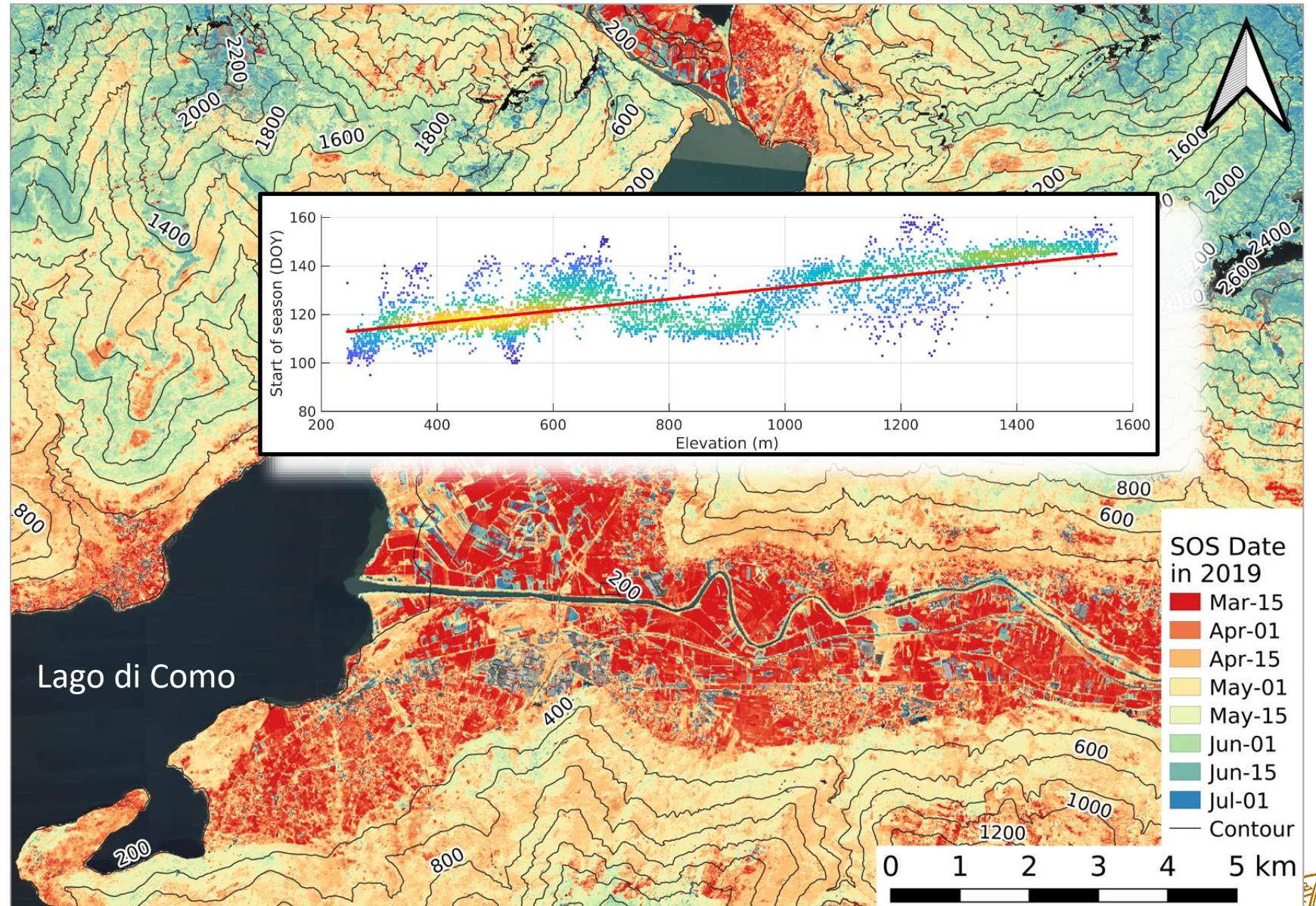


<https://web.nateko.lu.se/timesat/timesat.asp>



Plant Phenology Index (PPI)

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



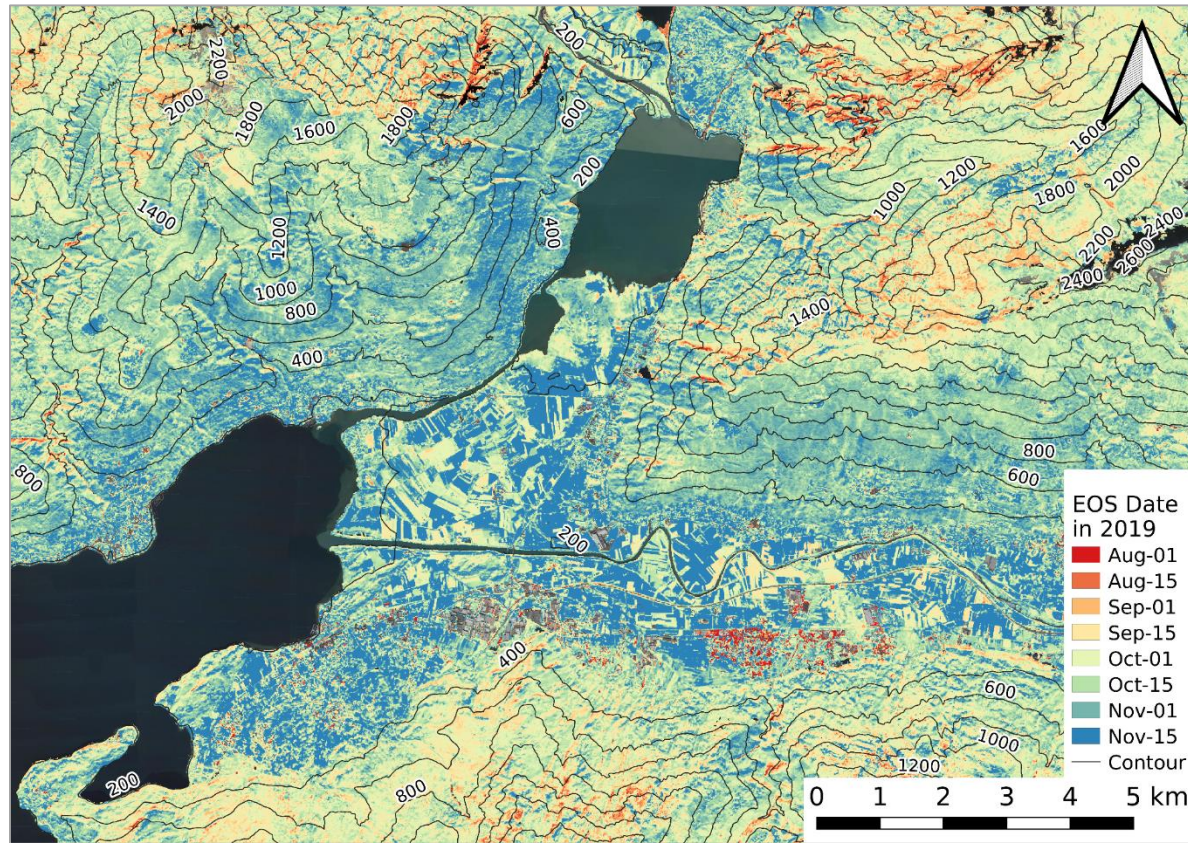
<https://land.copernicus.eu/en/products/vegetation>

Credit: Zhanzhang Cai

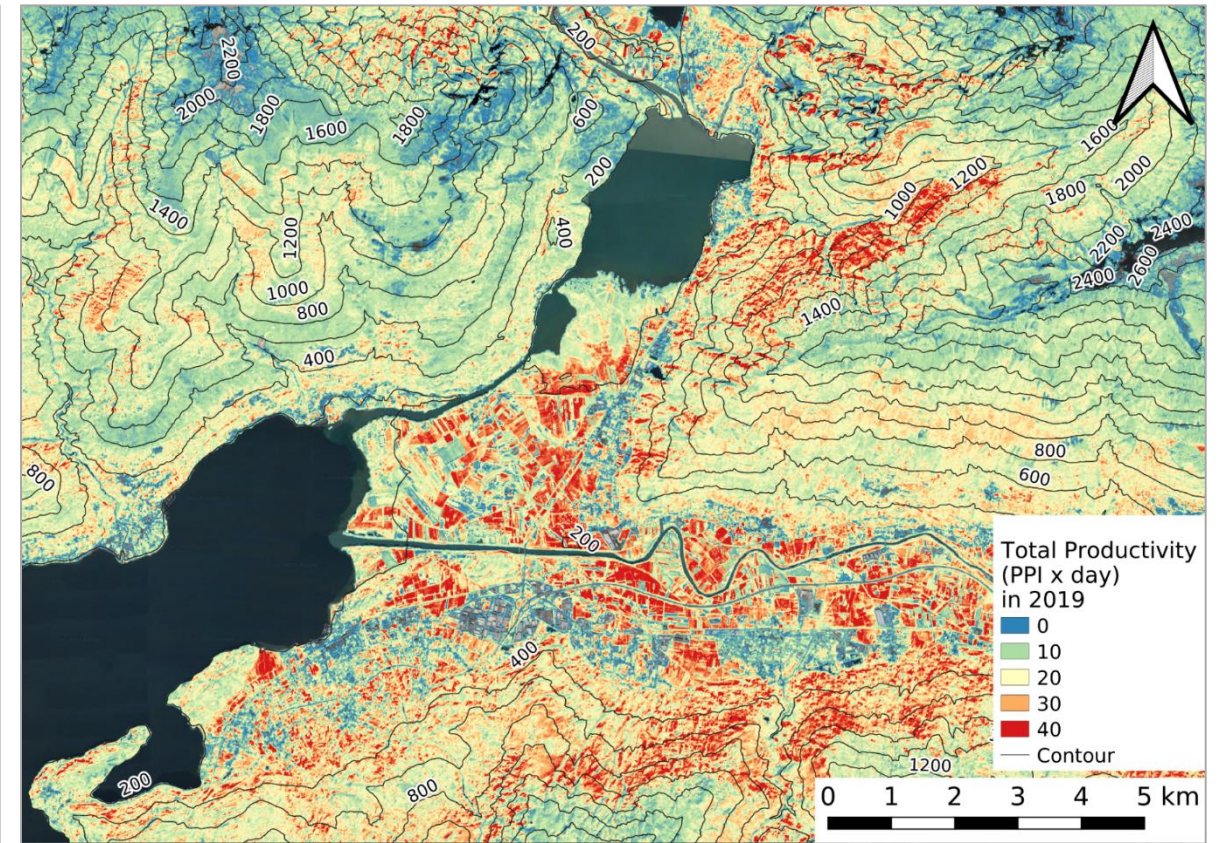




## End of season date



## Total productivity



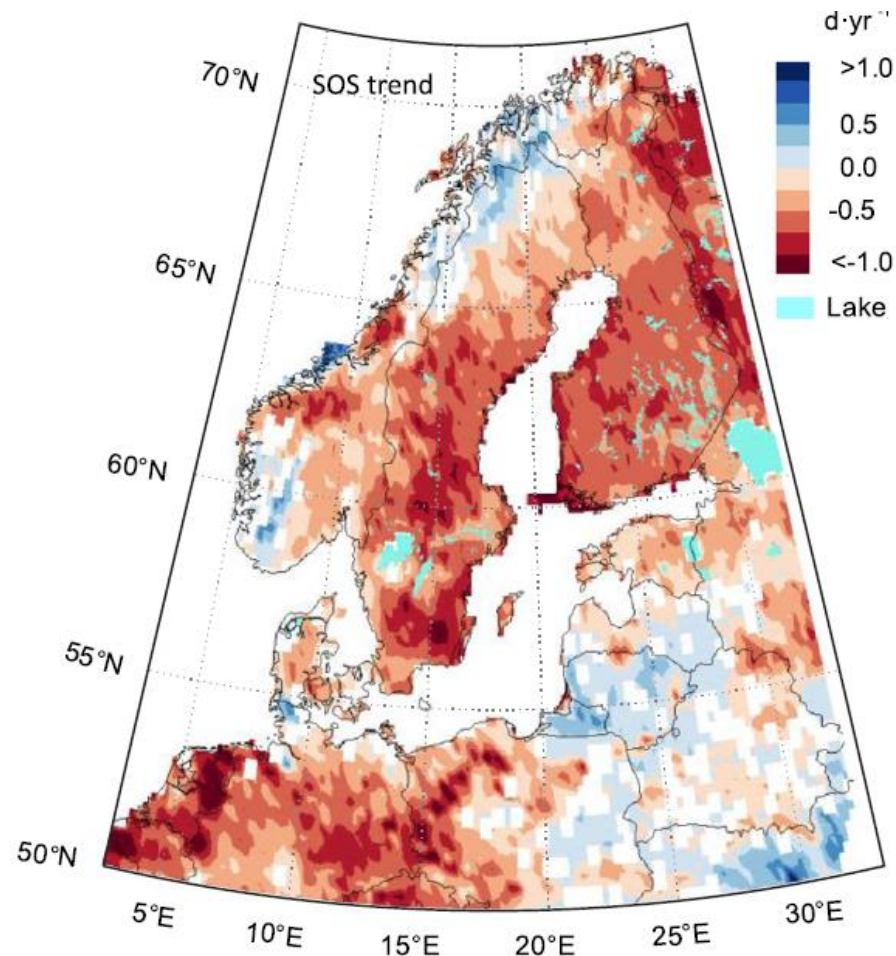
...and 10 more parameters

<https://land.copernicus.eu/en/products/vegetation>



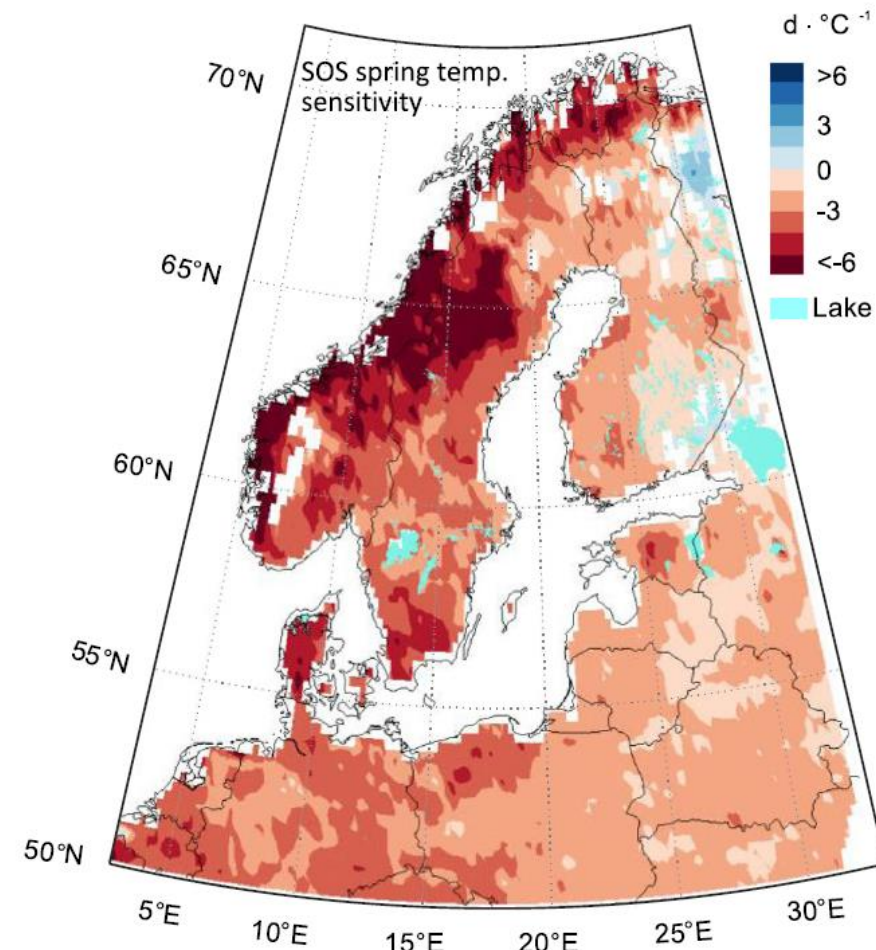
# Trends in vegetation seasonality 2000-2016

Start-of-season (SOS) trend (days/year)



Mean trend: -0.3 days/year

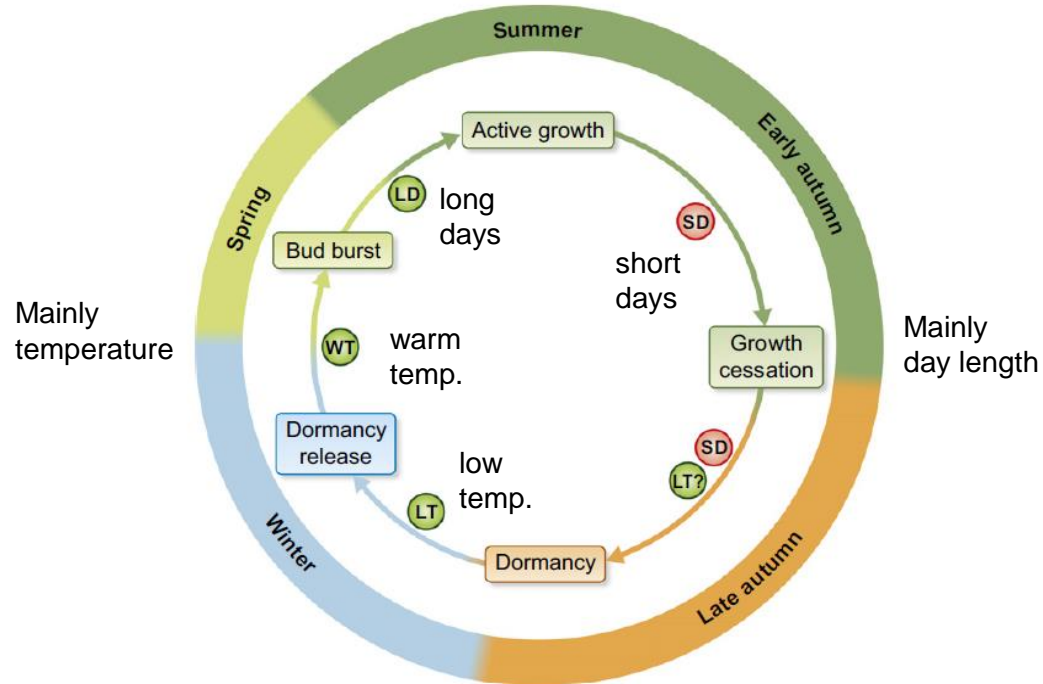
SOS spring temperature dependency (days/°C)



Mean dependency: -2.4 days/°C

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

# What plant phenology is



Modified from Singh et al. 2017, **Photoperiod- and temperature-mediated control of phenology in trees – a molecular perspective.** *New Phytologist*, 213, 511-524.

- "... the study of recurring plant and animal life cycle stages, especially their timing and relationships with weather and climate" (Lieth 1974)
- Plant phenology is fundamentally a molecular process related to the photosynthesis and dormancy of plants
- Controlled by factors like temperature, light and moisture
- Affected by local adaptation and genetic variations
- Used as an indicator of climate variability/change
- Gaps remain in understanding the biochemical and physiological mechanisms

# Observing phenology near the plants

## Manual /ground based observations

- Visible traits: plant growth stage; leaf development; flowering, coloration, leaf fall etc.
- Measurement of leaf/needle growth
- Crop stage observation (agriculture)



Source: <https://climate.axa>

## Visible time-series data

- Repeated canopy photographs ("phenocams")
- Spectral measurements of canopy reflectance



Source: <https://jrpb.stanford.edu>

## Process related measurements

- Gross Primary Productivity (GPP) from eddy covariance
- Dendrometers (stem size variations)
- Absorbed PAR fluxes



Source: <http://www.emsbrno.cz/>

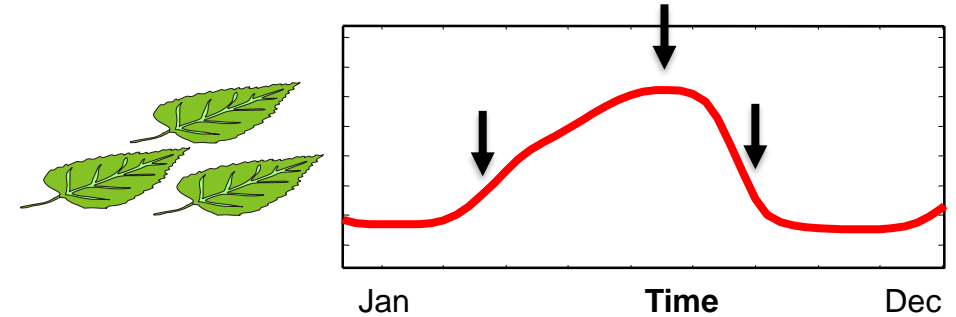


Source: Eklundh et al. 2011, Sensors, 11, 7678



# Considerations for cal/val of Earth Observation data

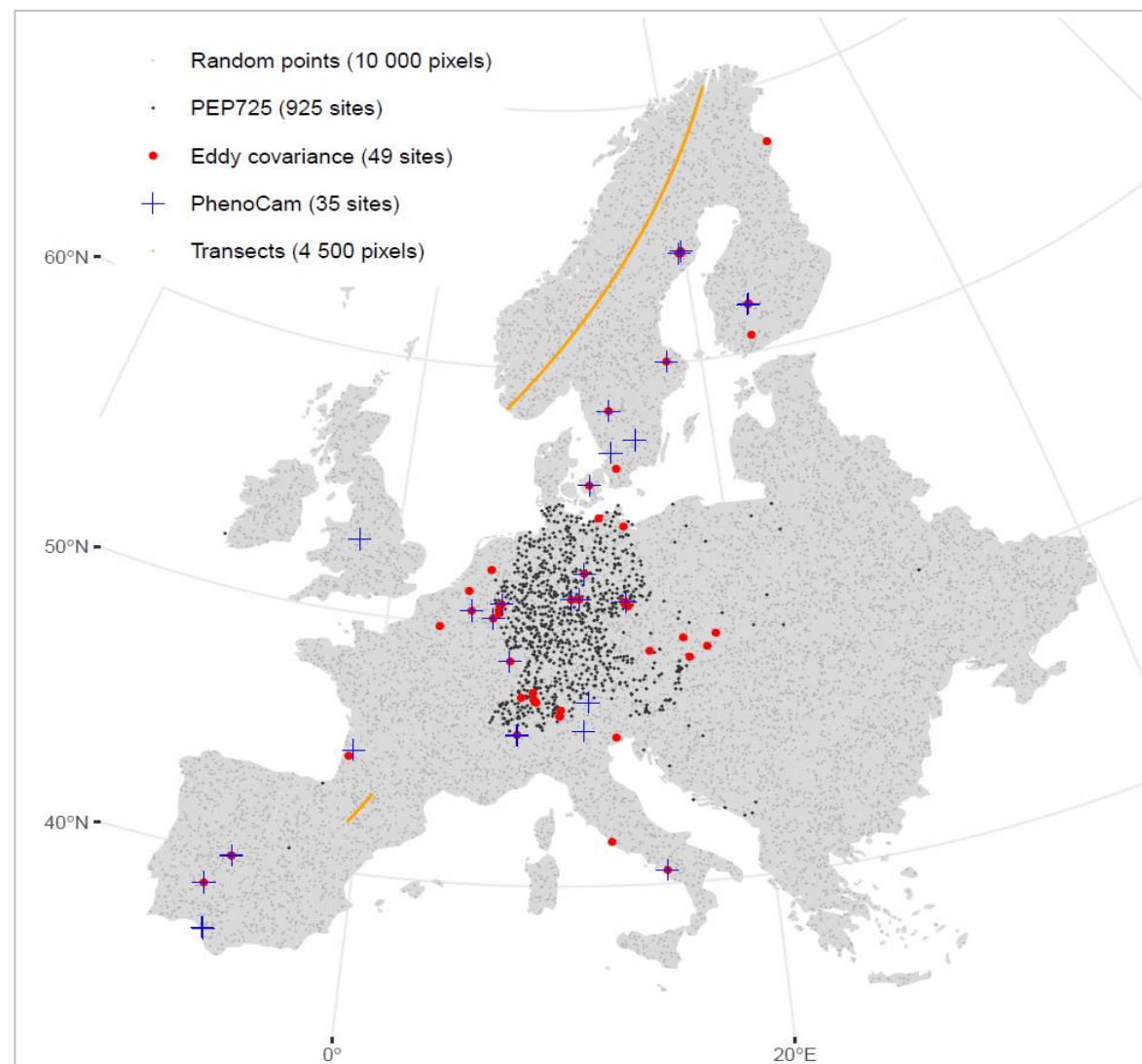
- LSP typically uses vegetation indices that respond to a combination of **process** (photosynthetic light absorption) and **structure** (leaf foliage area)
- Remote sensing **scale** is important: integrates over large area; often mixed vegetation
- Phenology may scale **non-linearly**: proper up-scaling needed
- **No single method** explains the phenological process cycle fully
- Ground validation networks are **heterogeneous** and not well distributed globally



## Example: data calibration for HRVPP

- PEP725 ground phenology observations: 925 points
- PhenoCam GCC time-series, 35 sites
- GPP from ICOS flux towers, 49 sites
- Agricultural reports, LPIS
- Geographical transects

Tian, et al. (2021) Calibrating vegetation phenology from Sentinel-2 using eddy covariance, PhenoCam, and PEP725 networks across Europe. *Remote Sensing of Environment*, 260, **112456**.





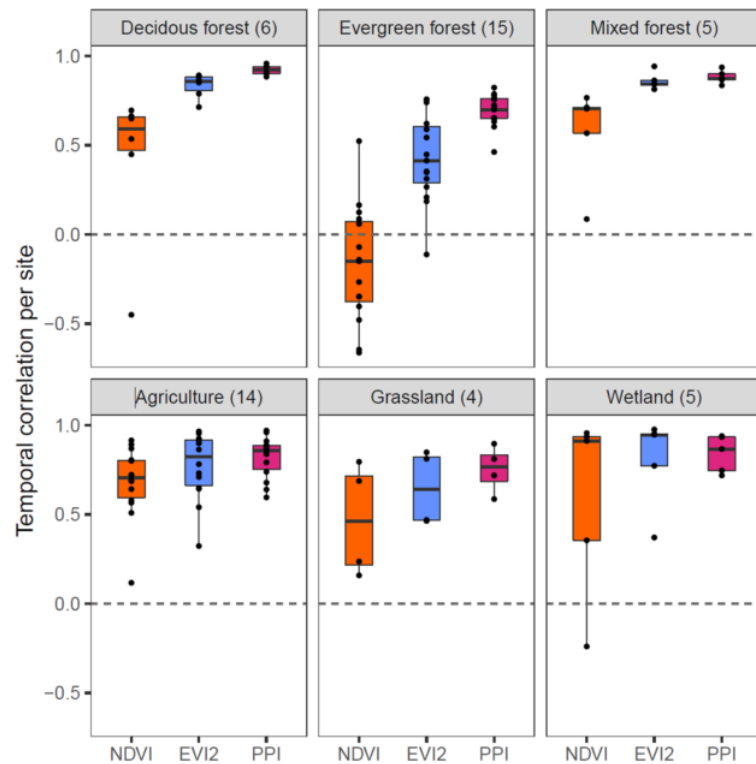
# Data analysis

## Aims to evaluate

- Vegetation index
- Processing methodology of time-series data
- Threshold values to decide on SOS and EOS
- Consistency of results

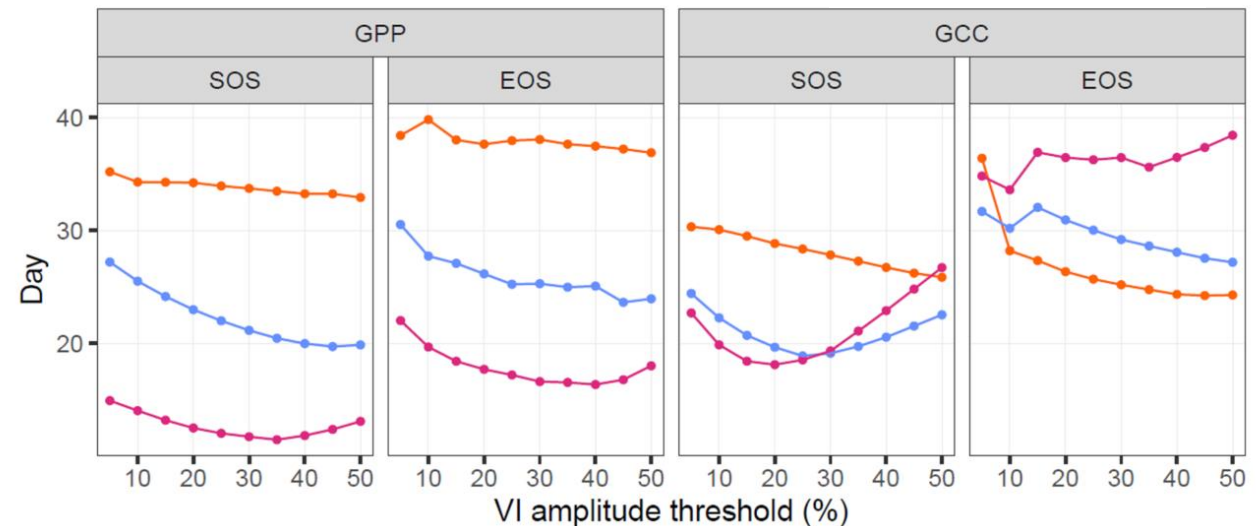
## GPP correlations

MI EVI2 PPI



## GPP bias

NDVI EVI2 PPI



# Lessons learnt

- Systematic, repeated measurements from the same sites is necessary
- Manual phenology observations carry large uncertainties, but link to human perception of phenology
  - Scale of observations
  - Precision in location and observations: professional observers is preferred
- Phenocam imagery show the color shifts of the canopy -> similar to human-perceived greenness
- GPP from flux data capture the photosynthetic growth process
- Combining several different measurement types provide a complementary view on phenology

It is ideal to have several types of complementary observations at the same stations (e.g. based at flux tower networks).





# Some existing networks (incomplete)

- PEP725: manual phenology observation for Europe
- Several national phenology networks (Australia, Canada, Sweden, UK, USA etc)
- NEON: 47 terrestrial sites: airborne mapping, GPP, phenocams and manual phenology observations of 90-100 plants/site
- ICOS: 87 stations: GPP, phenocam (some), spectral data (some)
- FluxNet: collection of regional flux networks; mix of data
- US phenocam network: 700 cameras across the US, collaborating with AmeriFlux
- European phenocam network: ca 40 cameras across Europe
- SpecNet: various spectral measurements, US and elsewhere
- SITES Spectral: Sweden 9 sites: phenocam, spectral measurements, drone flights, GPP (some), fAPAR (some)

**Note:** few have coordinated complementary measurements of phenologically relevant variables



# Thank you!

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SITES Spectral / ICOS: Abisko Stordalen