OPTIMISE data for understanding phenology and carbon cycling

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Contents

- Spectral data collection networks
- Projects gaining from spectral data sampling in OPTIMISE

OPTIMISE Final Conference 21-23 February 2018

A collaborative network for spectral data collection: NordSpec

- Inspired by **SpecNet, EUROSPEC** and **OPTIMISE**
- In collaboration with **ICOS Sweden** and **SITES**
- For satellite data validation and improved process knowledge
- http://nordspec.nateko.lu.se

Eklundh et al. 2011, *Sensors*, 11, 7678-7709.

Site name	Vegetation type	Lat.	Fluxes?
Svalbard	Polar tundra	78°	Yes
Zackenberg	High Arctic fen	74°	Yes
Abisko	Arctic birch forest and alpine heath	68°	No
Abisko Stordalen	Dry and wet peatland	68°	Yes
Tarfala	Alpine heath	68°	No
Svartberget	Boreal pine forest	64°	Yes
Degerö	Boreal peatland	64°	Yes
Röbäcksdalen	Agriculture	64°	No
Hyytiälä	Boreal pine forest	61°	Yes
Erken	Lake	60°	Yes
Norunda	Boreal mixed coniferous forest + clearcut	60°	Yes
Grimsö	Mixed coniferous	60°	No
Skogaryd	Hemi-boreal spruce forest	57°	Yes
Asa	Spruce forest	57°	Yes
Fäjemyr	Peatland	56°	No
Hyltemossa	Temperate spruce forest	56°	Yes
Lönnstorp	Agriculture	56°	No
Senegal	Savanna	13°	Yes
Sudan	Savanna	11°	No
Kenya	Savanna and agriculture	1°	Yes

SITES – Swedish infrastructure for Ecosystem Science

SITES

A nationally coordinated infrastructure
for terrestrial and limnological field research.
http://www.fieldsites.se/

SITES Spectral 2015 - 2022

Data collection on vegetation state and seasonal variations:

- Year-round multispectral measurements
- Seasonal drone flights
- Phenology cameras
- Satellite imagery

Free and open data policy

Ground measurements in NordSpec and SITES

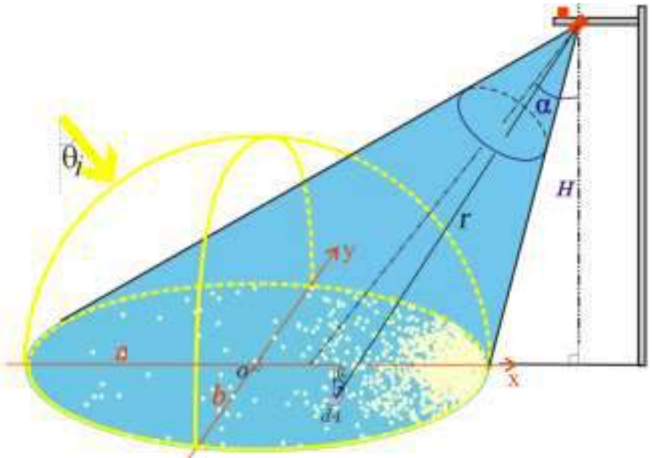
Mountain heath (Tarfala)

Sub-arctic forest (Abisko)

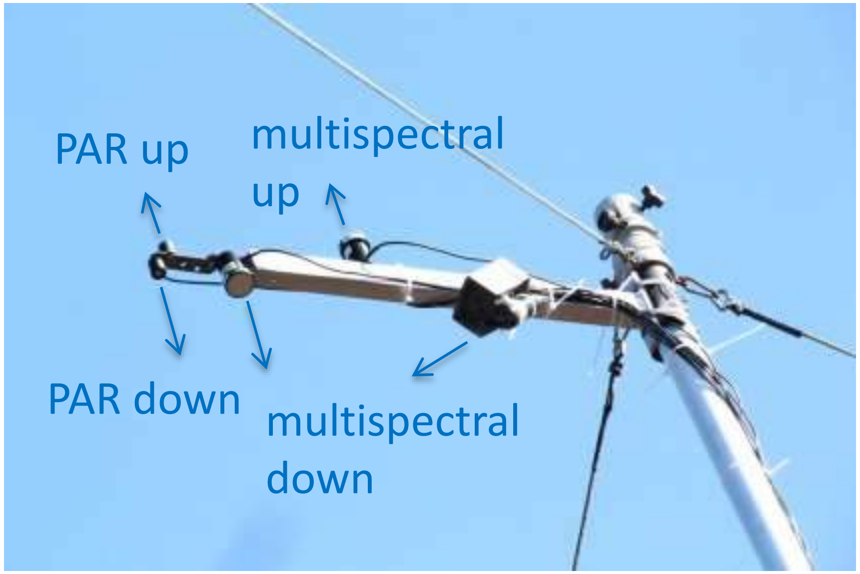
Sub-arctic bog (Stordalen)

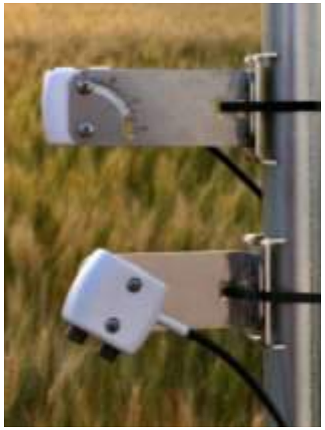
Boreal forest (Norunda)

Spectral measurements



Outdoor reflectance calibration
(Jin and Eklundh, 2015, 2018)



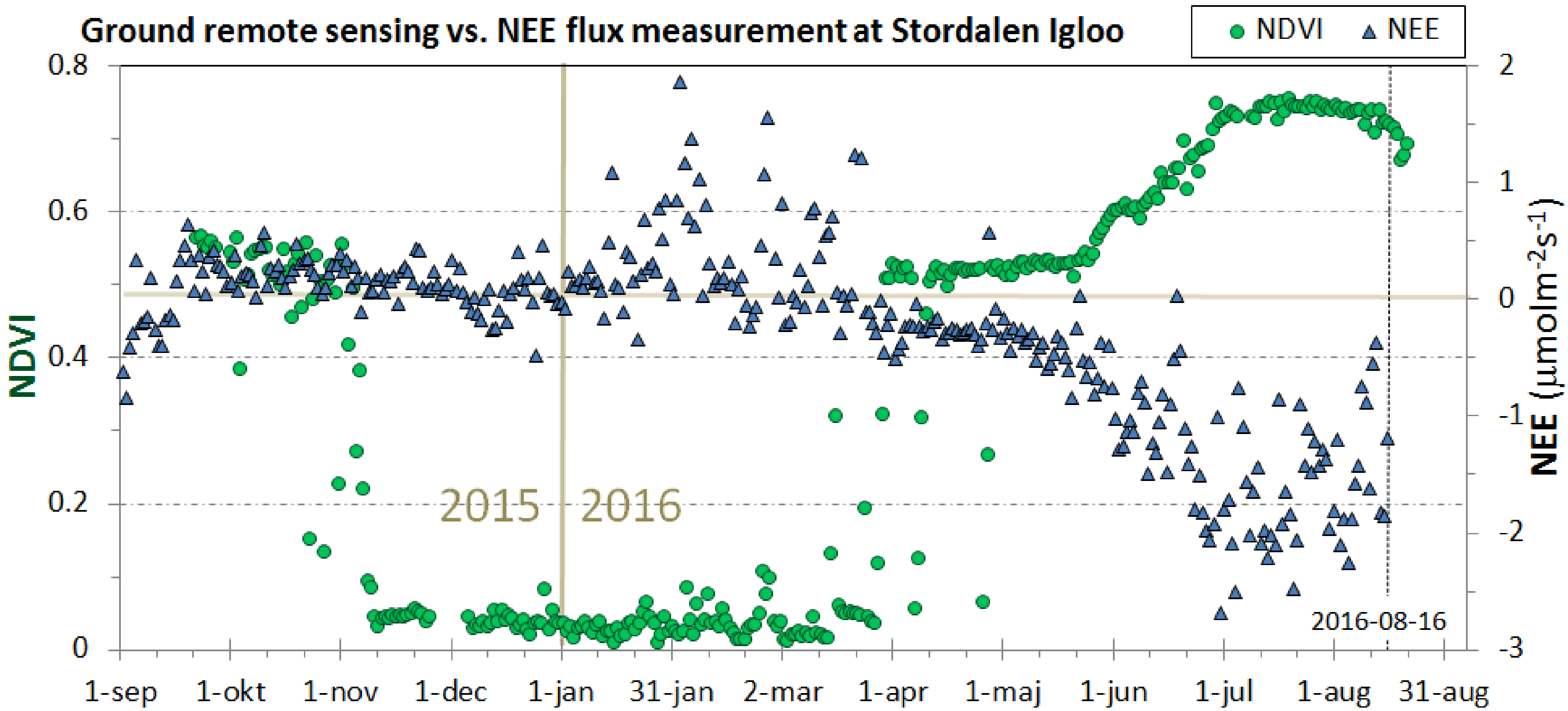


Decagon sensors

SKYE sensors

red, rededge, NIR, SWIR

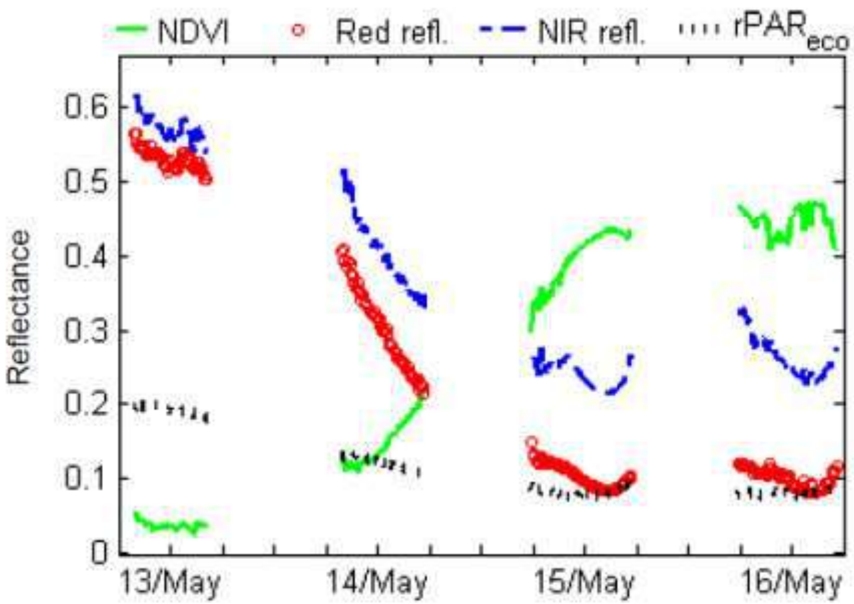
CO_2 and NDVI at Abisko ICOS-Sweden site



Flux data: Jutta Holst; NDVI: Hongxiao Jin

Snow effect on NDVI

Daily reflectance at Stordalen mire

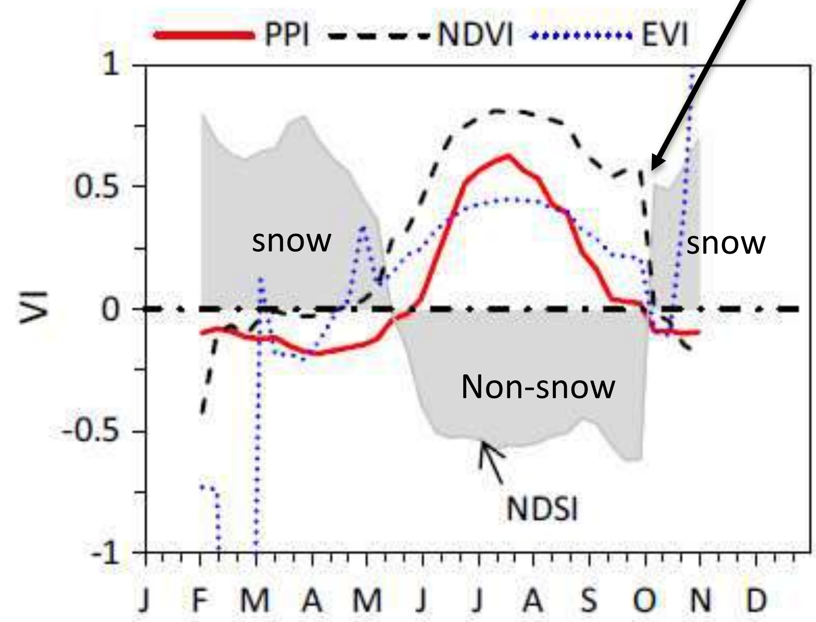


Eklundh et al.

Sensors, 2011

MODIS data at birch forest site

Note rapid decrease



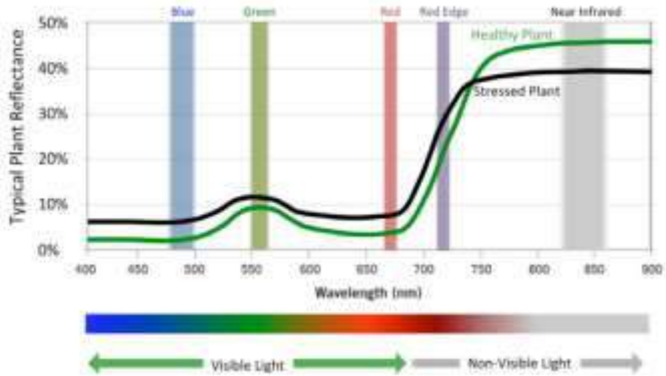
Jin and Eklundh

RSE, 2014

Multispectral UAV imaging in SITES Spectral

Regular flights throughout the growing seasons

3DR Solo



Multispectral cameras

www.micasense.com

RGB camera

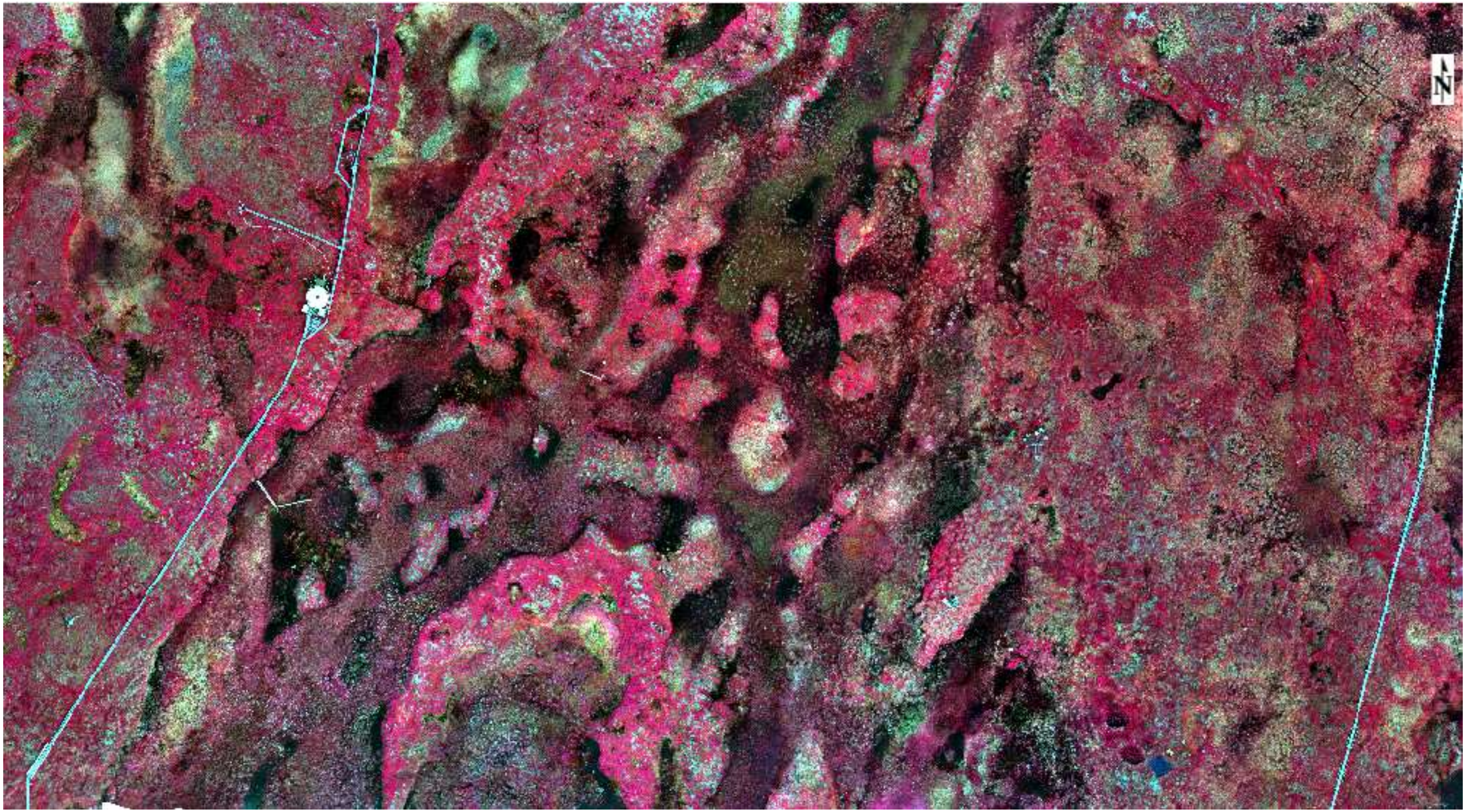
www.sony.com

Pitchup Explorian

Thermal camera

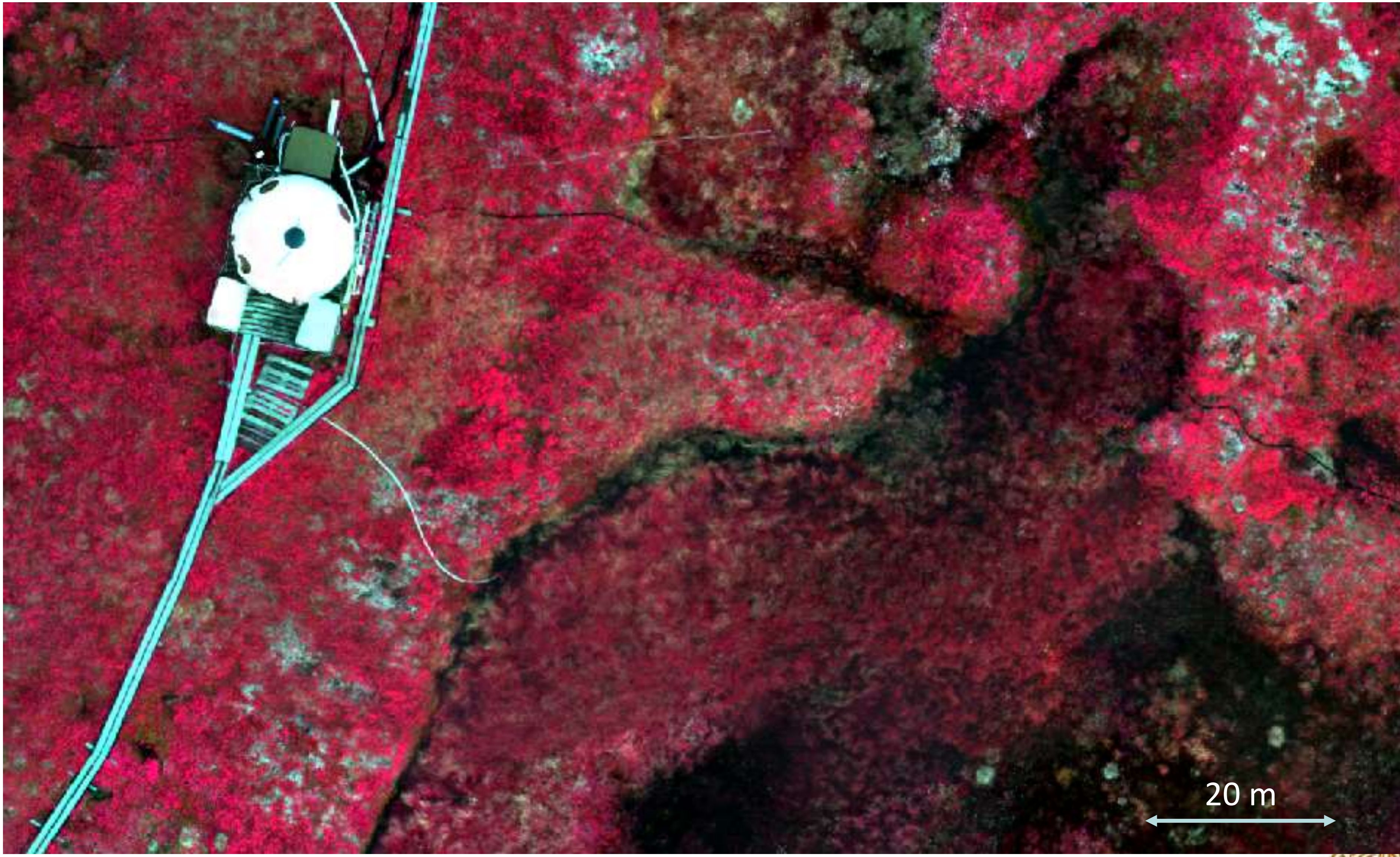
www.flir.se

Stordalen mire, lat. 68° from UAV

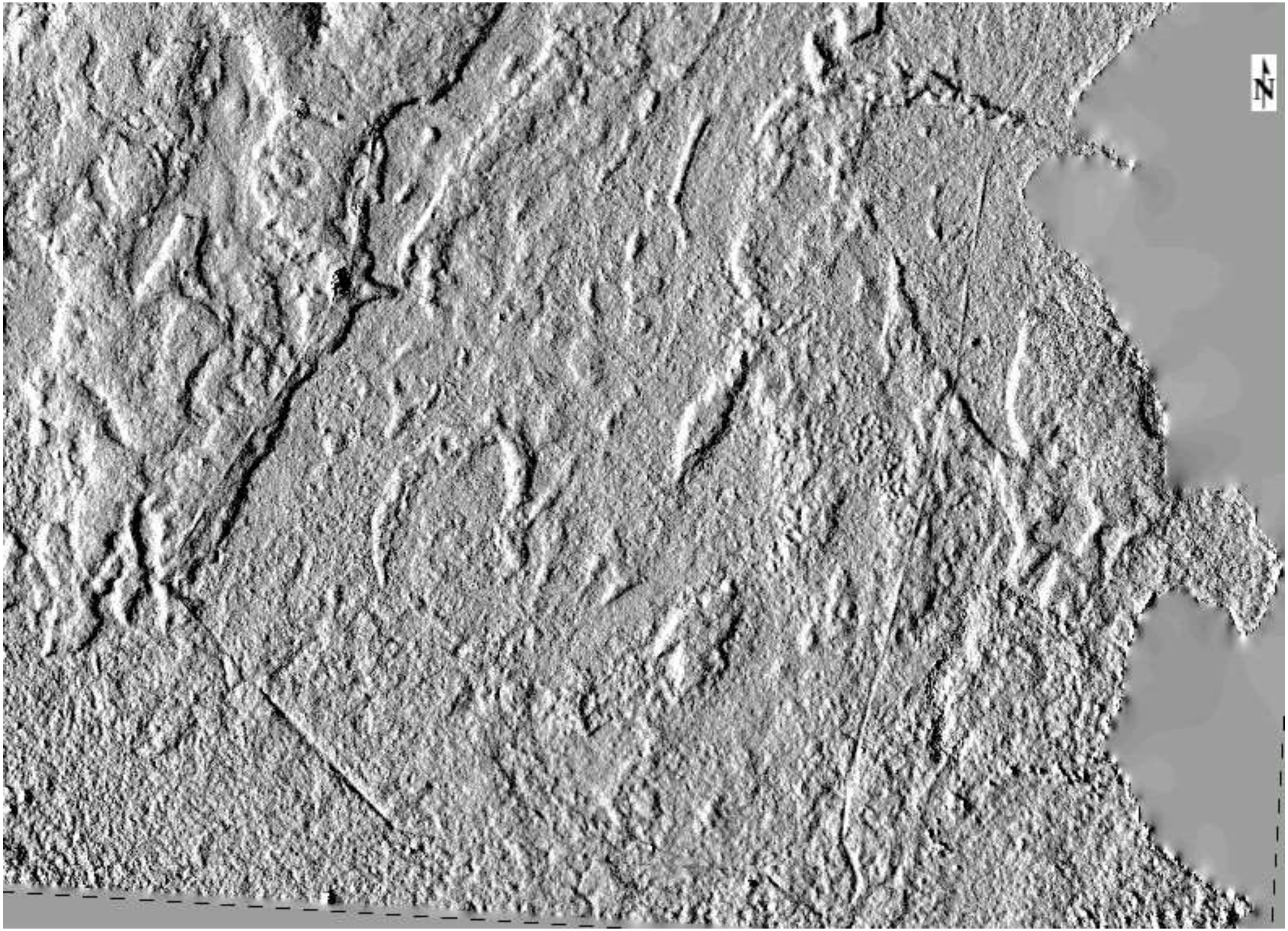


675 m

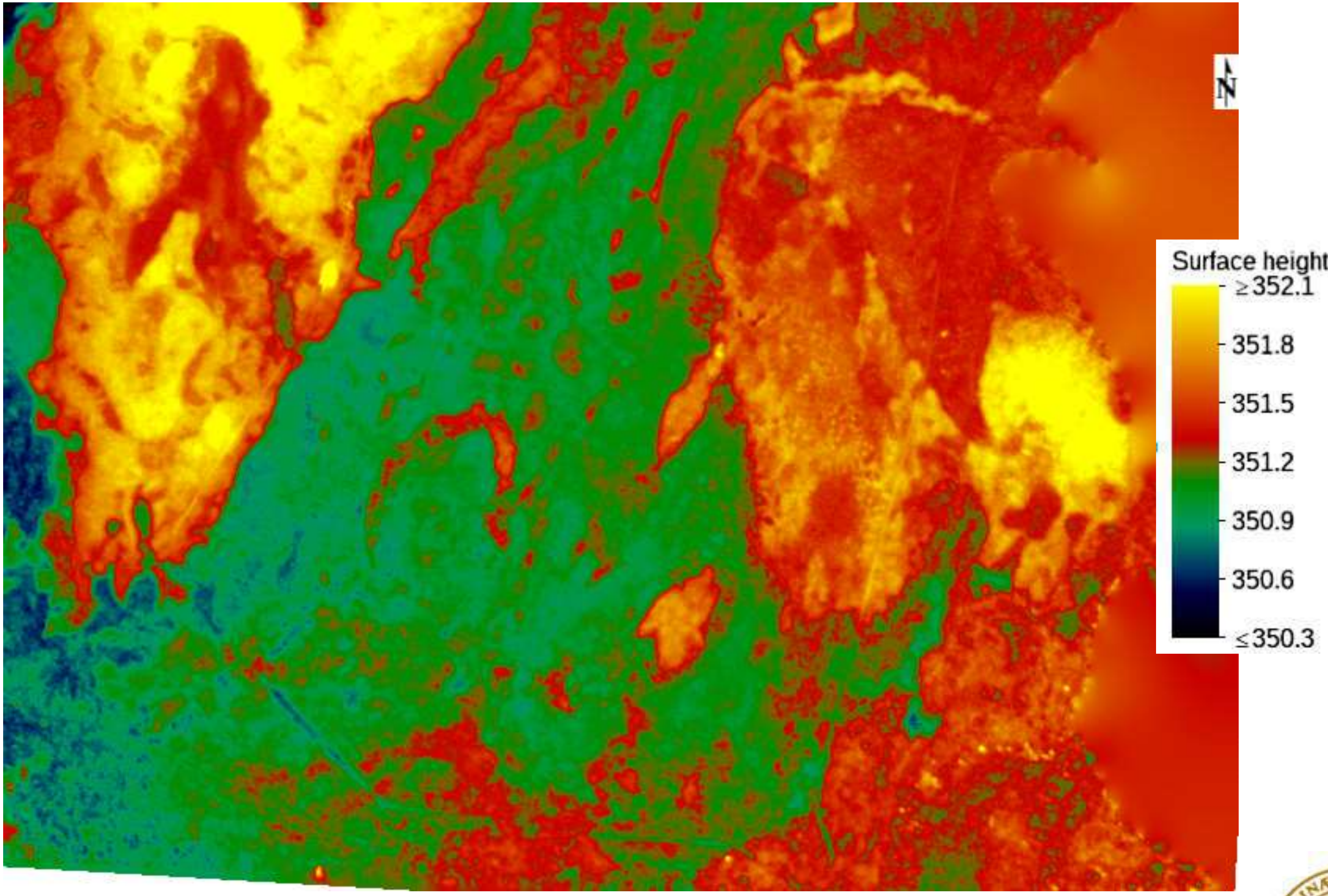
Detail



Stordalen hillshading (UAV data)



Stordalen elevation (UAV data)

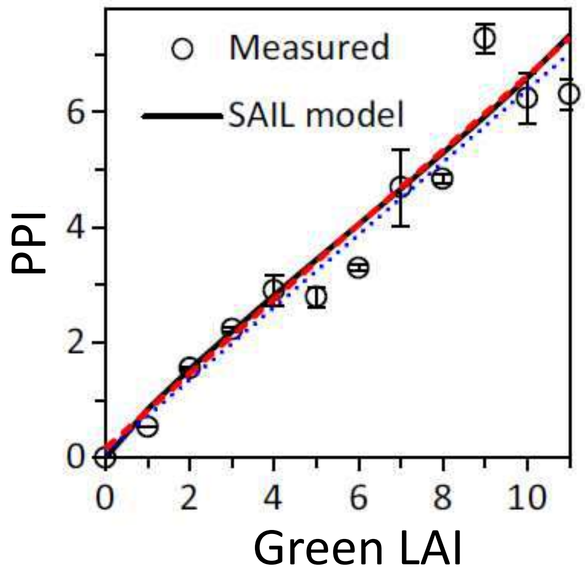


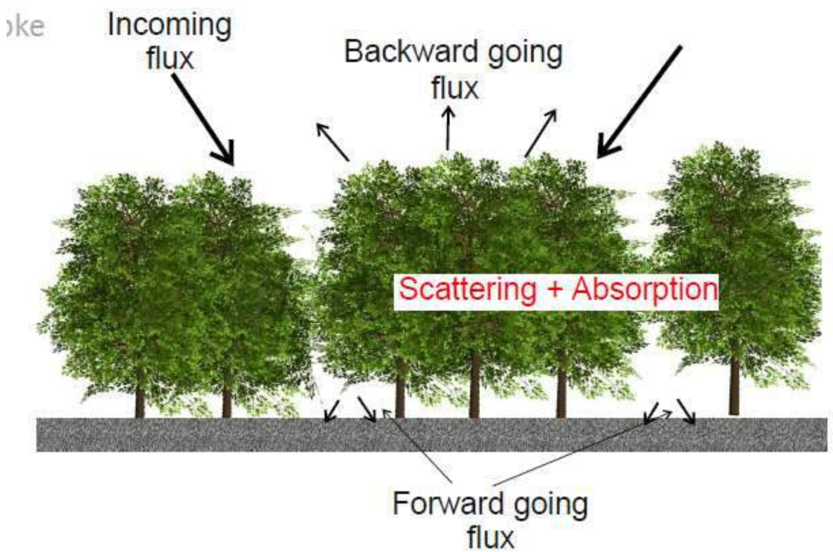
Some research lines based on multispectral data

1. Development and testing of new vegetation index: the Plant Phenology Index (PPI)
2. Development of methodology for time-series analysis of remotely sensed data
3. Development of methods for upscaling flux tower data to larger areas
4. Improved understanding of vegetation productivity, phenology, and the links to climate and meteorology

PPI Plant Phenology Index

Jin and Eklundh, 2014, **A physically based vegetation index for improved monitoring of plant phenology**. *Remote Sensing of Environment*, 152.





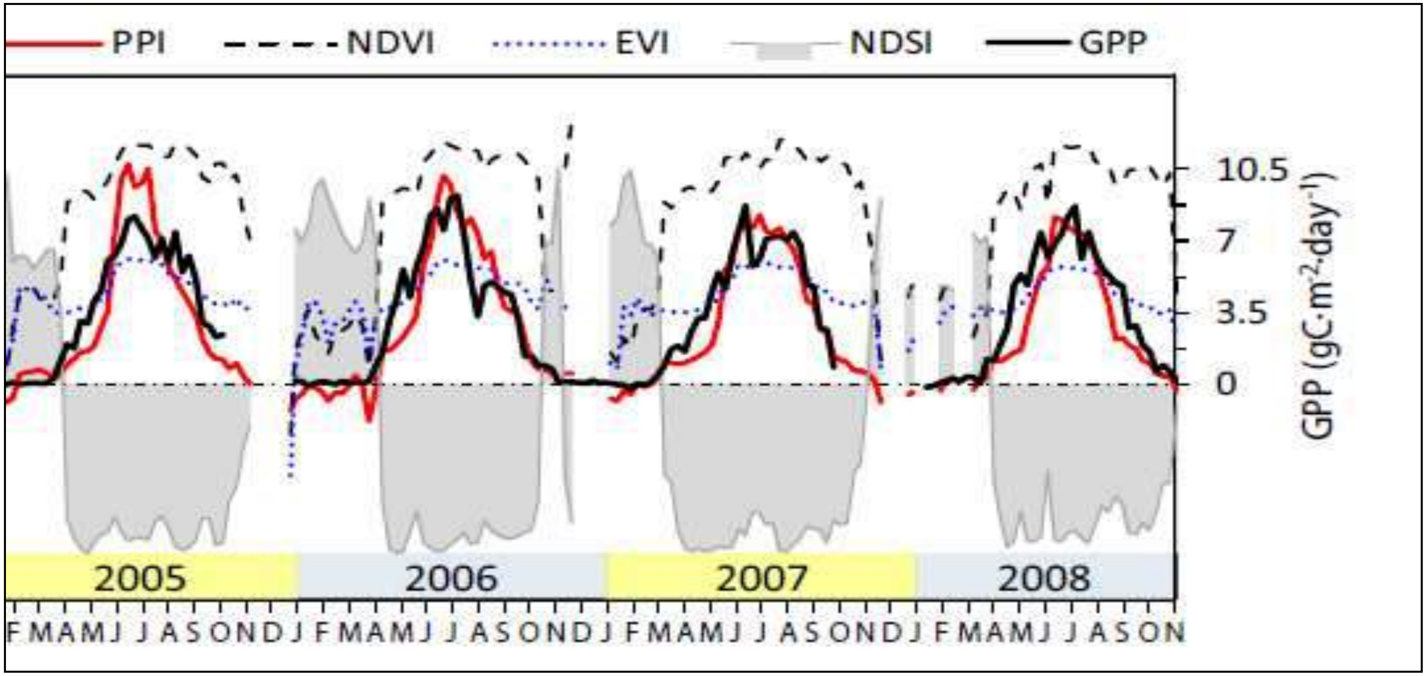
$$PPI = -K \times \ln \frac{M - DVI}{M - DVI_{Soil}}$$

DVI	Difference vegetation index: $R_{NIR} - R_{red}$
DVI_{Soil}	DVI for soil
M	Maximum DVI for canopy
K	Extinction coefficient

PPI for tracking Gross Primary Productivity

PPI properties

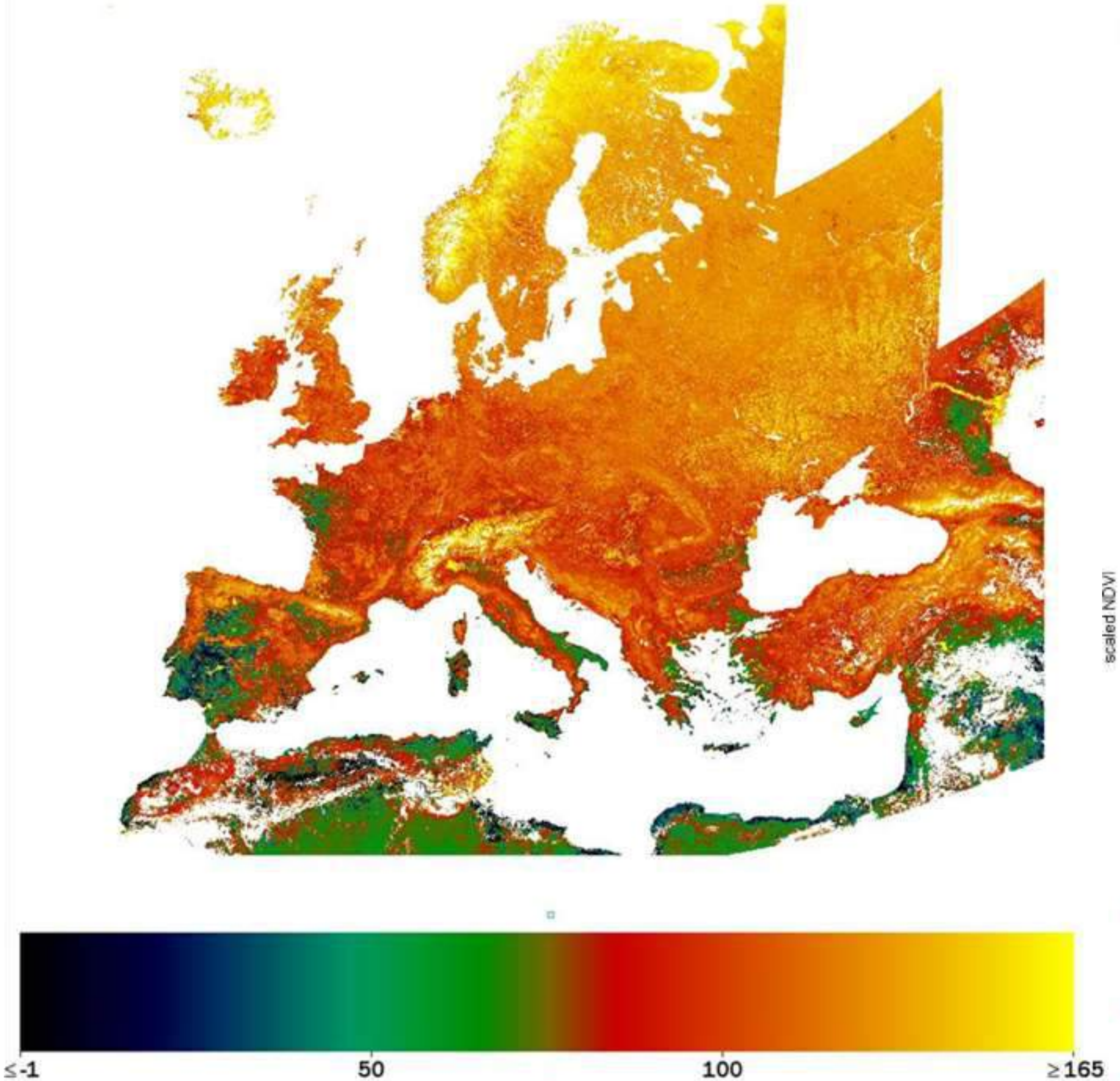
- Linear with green LAI
- Dynamic also in dense canopies
- Not sensitive to snow influence
- Found to be well related to GPP



Jin and Eklundh, 2014, **A physically based vegetation index for improved monitoring of plant phenology**. *Remote Sensing of Environment*, 152.

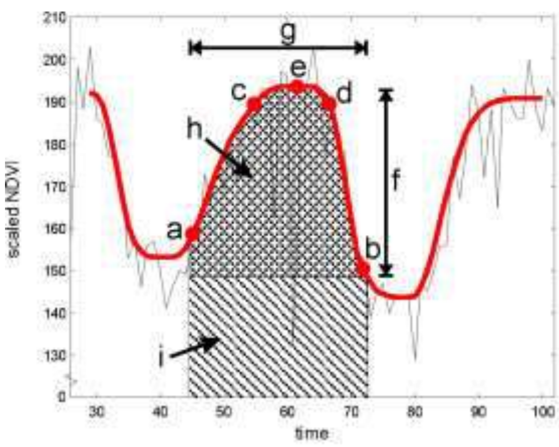
Phenology parameters based on PPI

Date of start-of-season (SOS) 2016

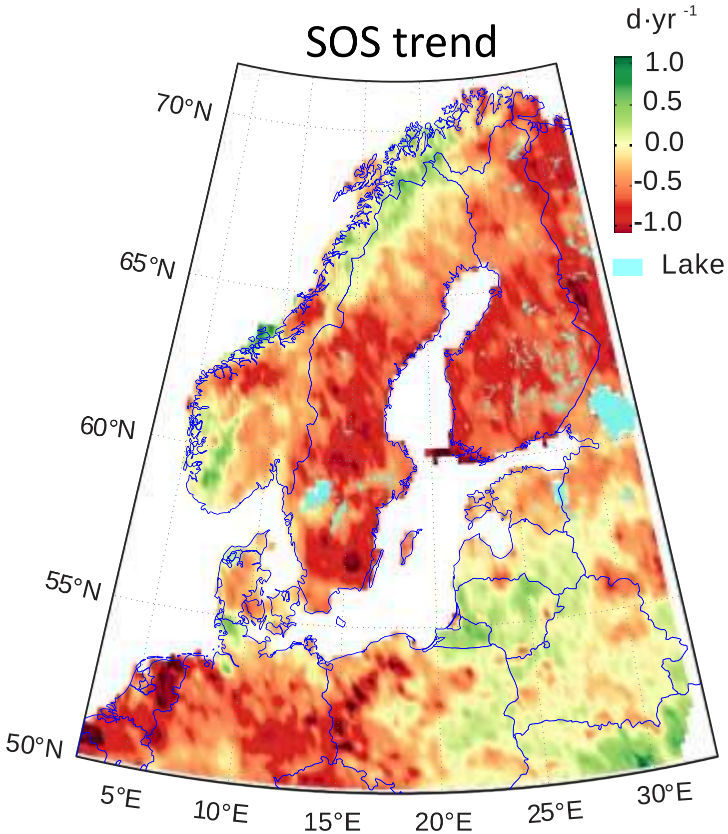


Product delivered to European Environment Agency (EEA) for creating a phenology indicator

TIMESAT

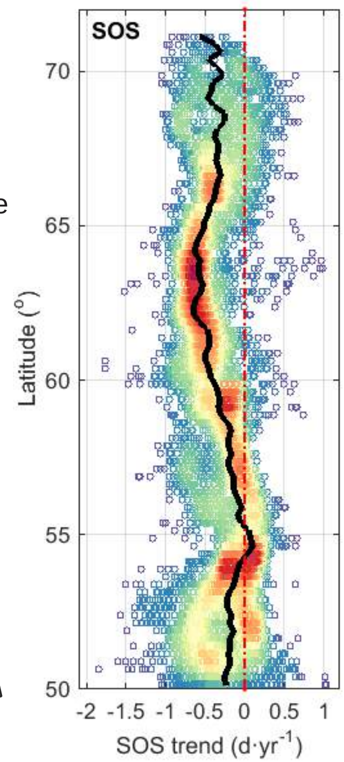


Phenology variations 16 years from MODIS PPI



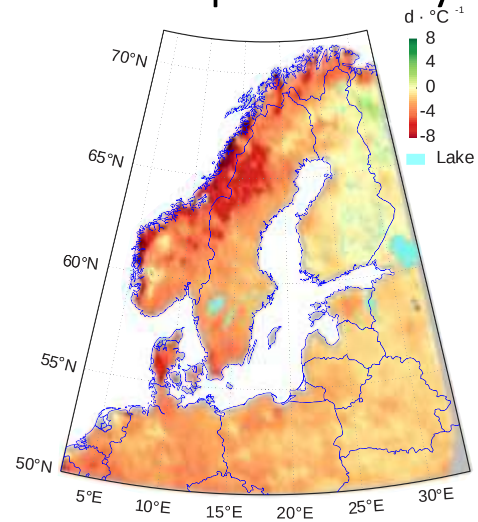
Overall trend:

0.3 d/y

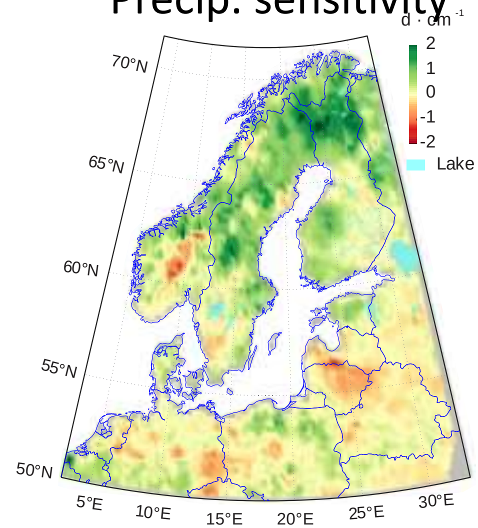


Latitudinal variation

Temp. sensitivity



Precip. sensitivity



Jin et al., 2017, 2018 manuscript

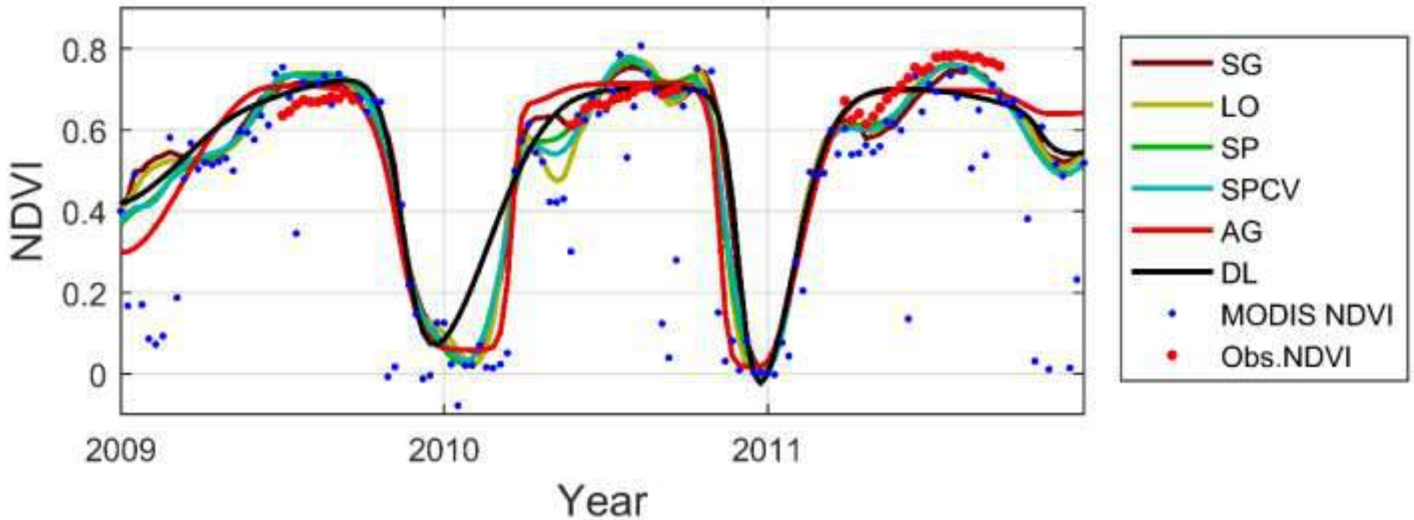
Using spectral data for time series model estimation

Testing the efficiency of five processing methods for time-series smoothing implemented in TIMESAT:

Savitzky-Golay, Lowess, Splines, Asymmetric Gaussian and Logistic functions

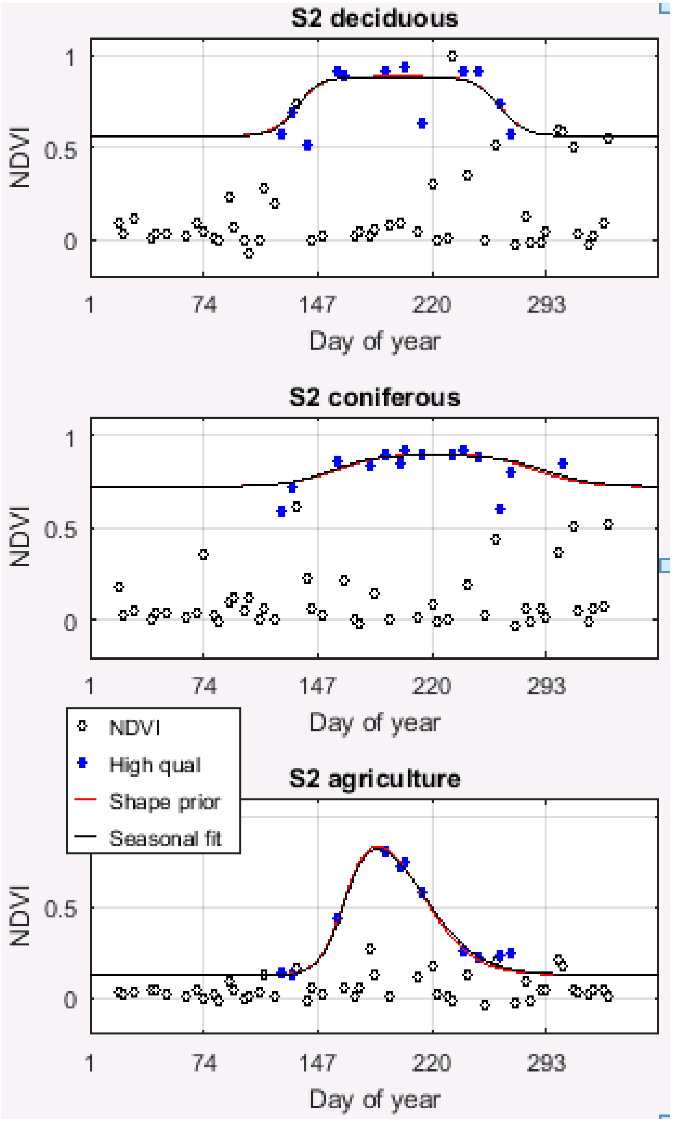
Comparison against spectral data at 10 sites

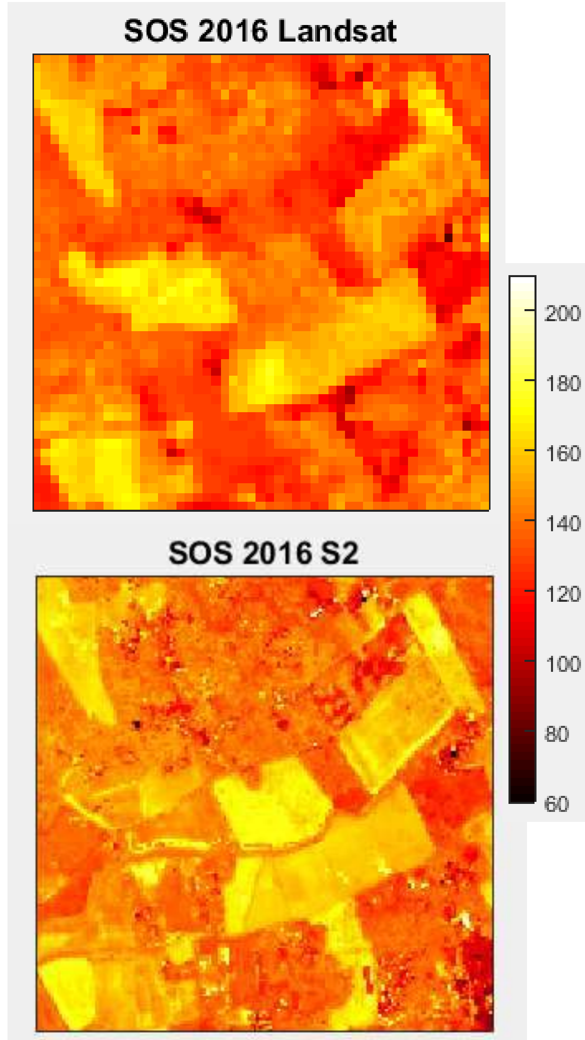
Site Fäjemyr



Cai, Z.; Jönsson, P.; Jin, H.; Eklundh, L. **Performance of Smoothing Methods for Reconstructing NDVI Time-Series and Estimating Vegetation Phenology from MODIS Data.** *Remote Sens.* **2017**, *9*, 1271.

New methods for processing Sentinel-2 and Landsat data in TIMESAT



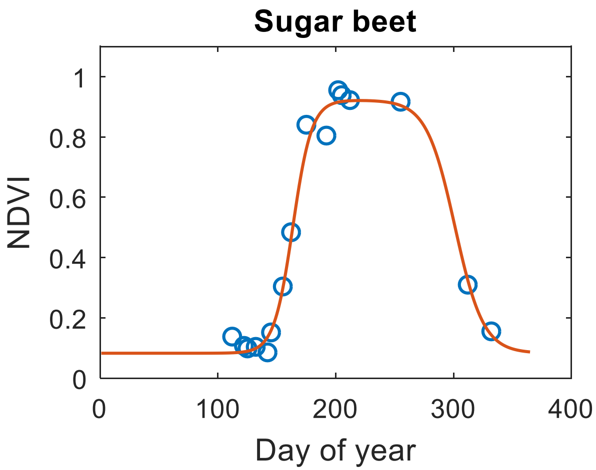


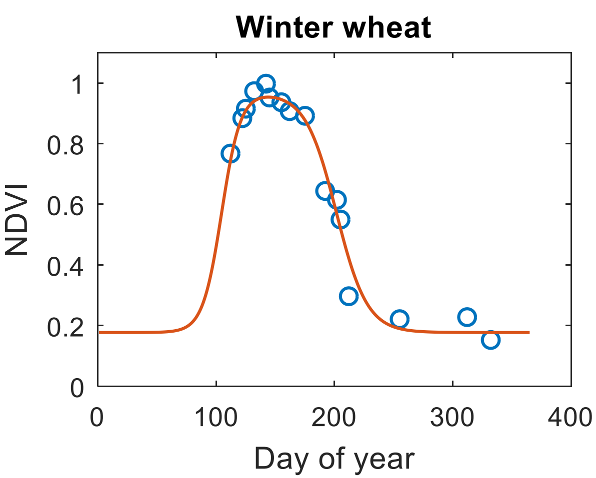
Box constrained separable least squares fits to logistic model functions

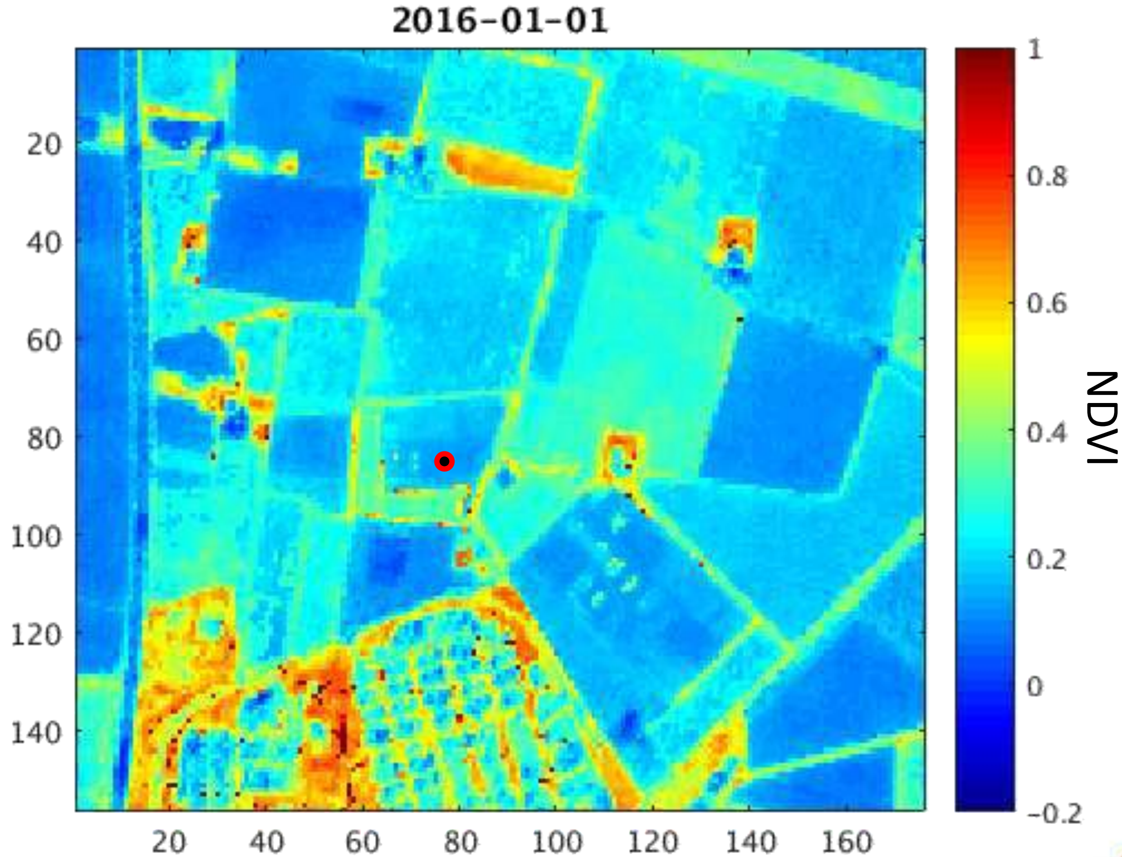
Robust to data gaps

Jönsson, Cai, Melaas, Friedl, Eklundh, 2018, **A method for robust estimation of vegetation seasonality from Landsat and Sentinel-2 time series data.** Submitted.

Vegetation dynamics from Sentinel-2

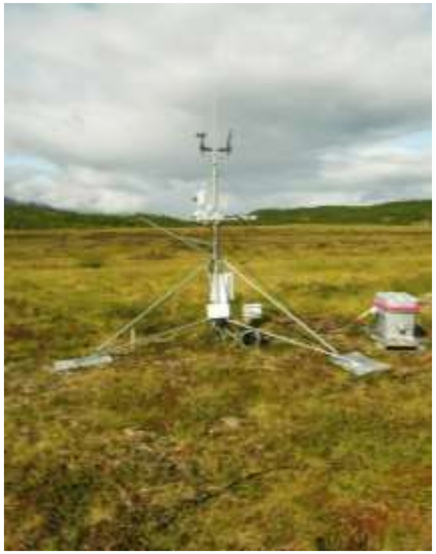


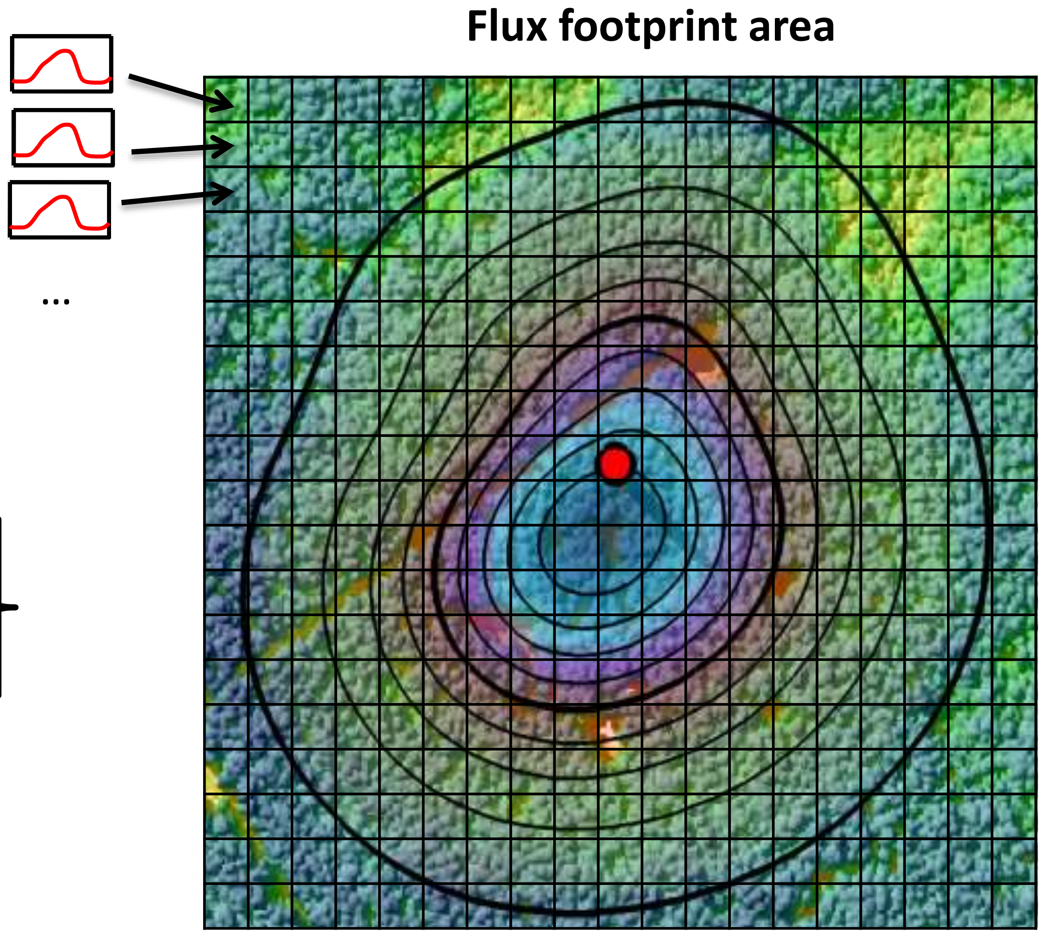




● Spectral mast

Upscaling carbon fluxes using flux footprint heterogeneity information





Satellite

UAV

Fixed sensors

FORMAS CarboScale
2017-19

Conclusions

1. OPTIMISE and the EUROSPEC have supported several lines of research that strengthen our ability to obtain and understand data on important relationships on the dynamic interactions of vegetation and climate across a wide range of global ecosystems

2. Networks for data exchange and collaboration are instrumental in pushing this research forward

Thank you!

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NordSpec: http://nordspec.nateko.lu.se

PPI formulation

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

DVI	Difference vegetation index: $R_{NIR} - R_{red}$
DVI_{Soil}	DVI for soil
M	Maximum DVI for canopy
K	Extinction coefficient

$$K = \frac{0.25 \cdot \cos(\theta)}{(1 - d_c) \cdot G + d_c \cdot \cos(\theta)} \times \frac{1 + M}{1 - M}$$

θ	Solar zenith angle
d_c	Diffuse fraction of solar radiation
G	Leaf angular distribution function

PPI needs reflectance data transformed to nadir viewing geometry