e-PHENO

Monitoring plant phenology in the Western Alps

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(and the e-Pheno team)

Aosta Valley Environmental Protection Agency
ARPA VdA

Ceresole Reale

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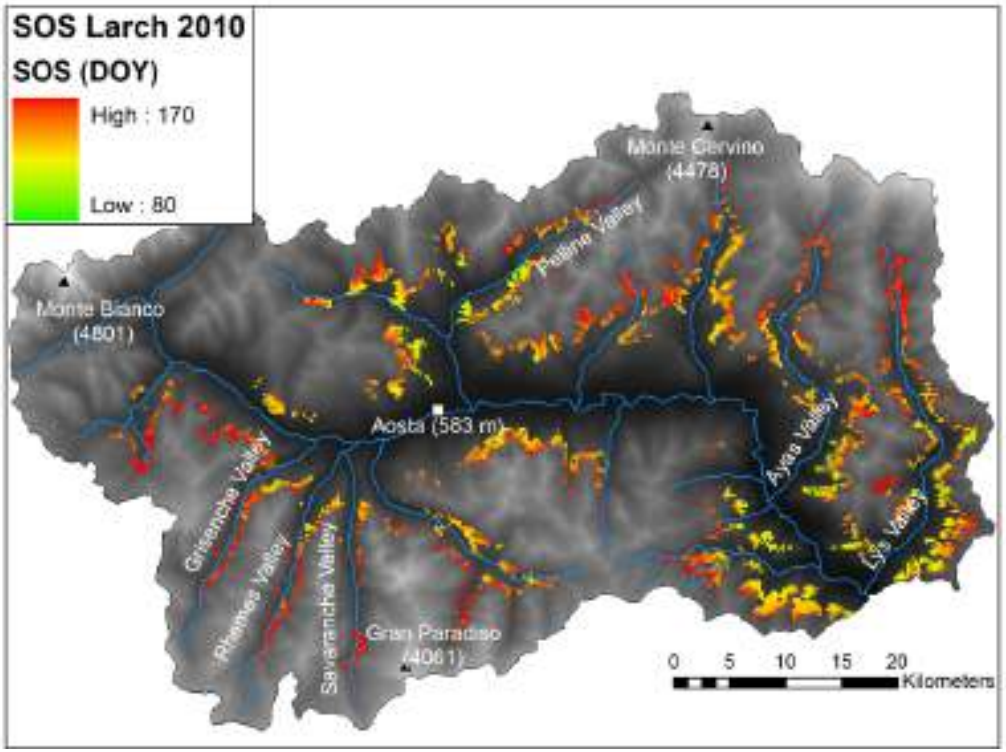
Phenology

- The rhythm of the seasons (Morisette et al 2009, Front. Ecol. Env.)
- It responds relatively fast to weather and climate changes
- It is easy to measure
- The study of phenology has a long tradition
- Phenology is the simplest process in which to track changes in the ecology of species in response to climate change (IPCC, 2007)
- In mountain ecosystems, phenology matters even more

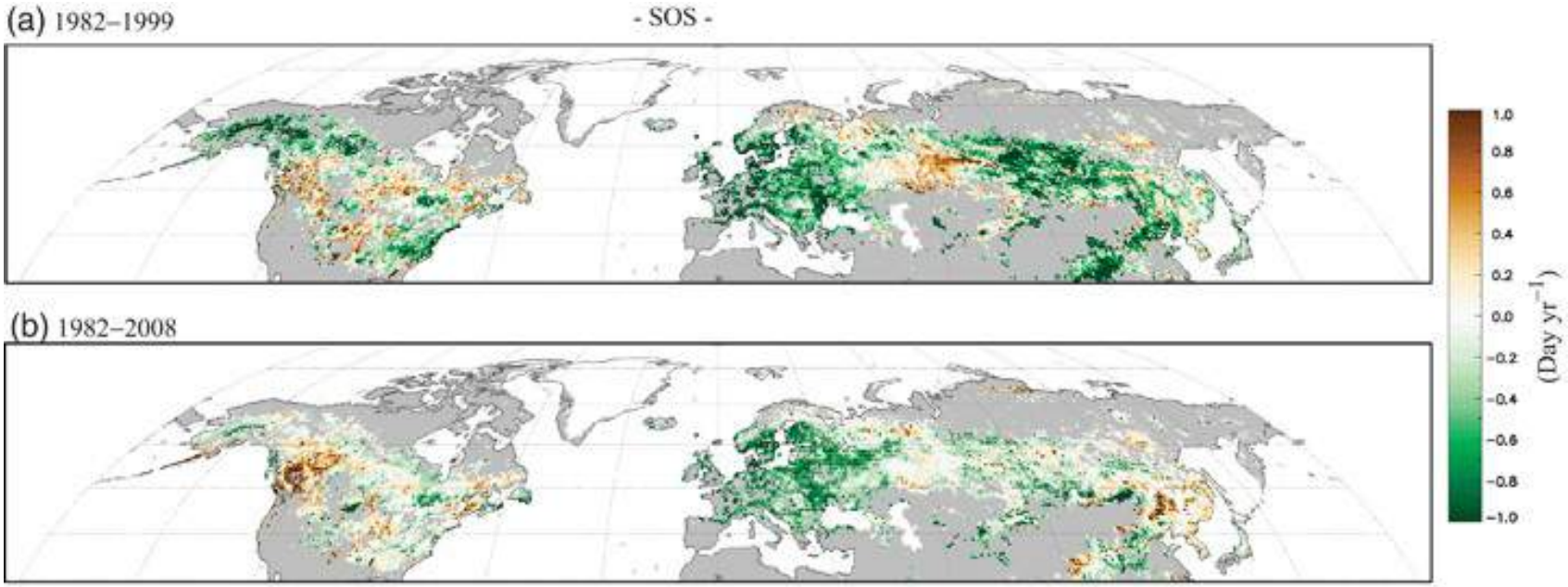
Phenology in mountains

Leaf emergence in Larch in Aosta Valley can vary by some 90 days in a single year



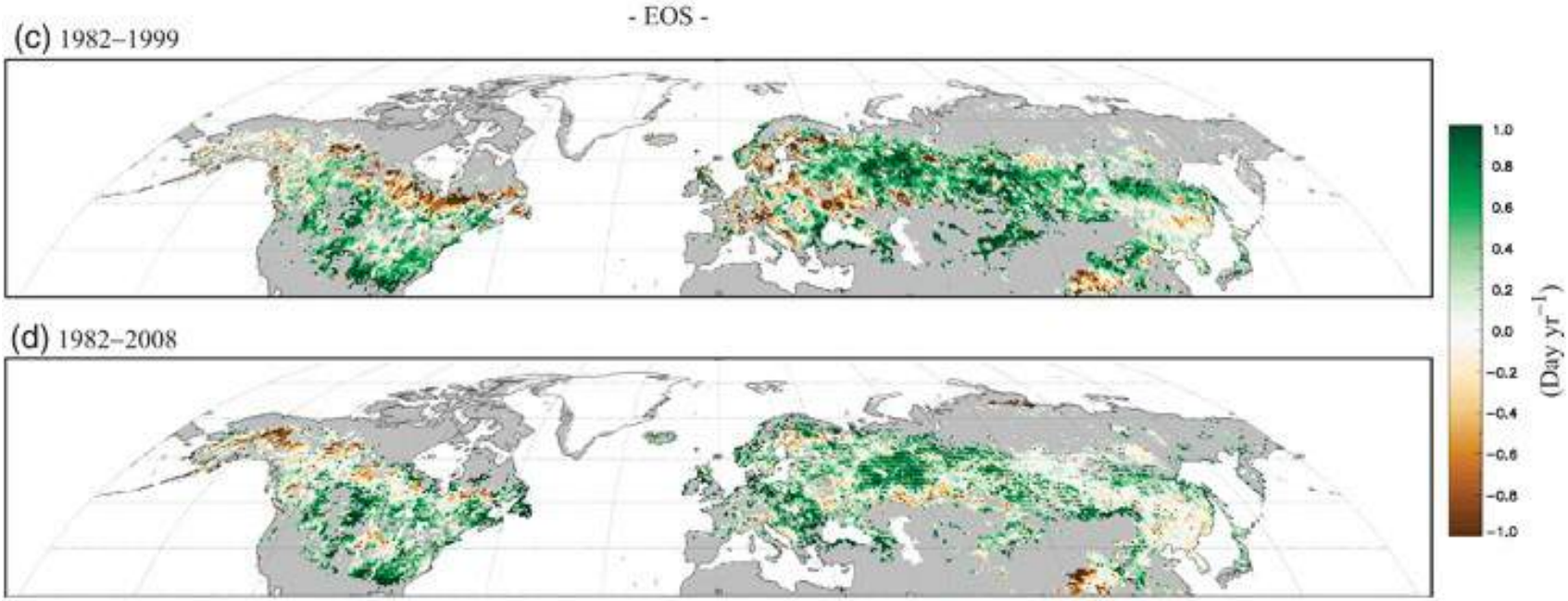
Elevation, Continentality, Aspect, Precipitation, etc.

Phenology and Climate Change



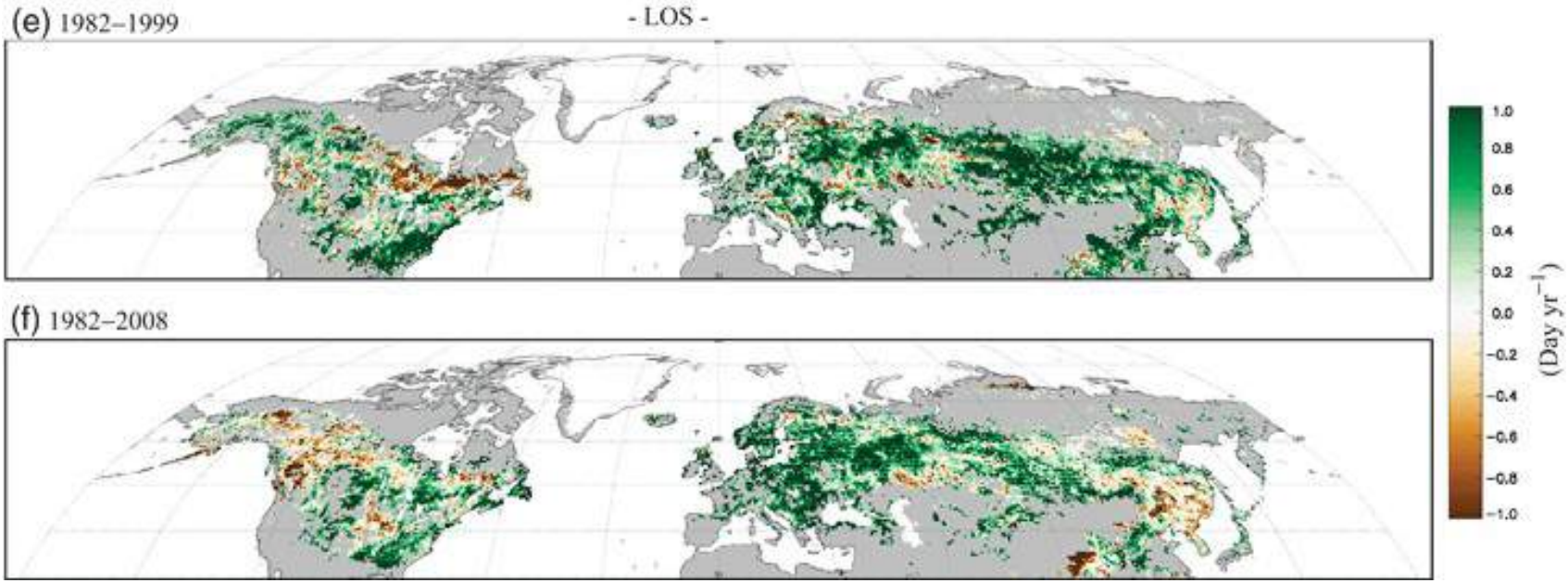
Spring onset is occurring earlier (Jeong et al 2011, Glob. Ch. Biol.)

Phenology and Climate Change



Fall onset is occurring later (Jeong et al 2011, Glob. Ch. Biol.)

Phenology and Climate Change



Growing seasons are becoming longer (Jeong et al 2011, Glob. Ch. Biol.)

Shifts in Phenology are clear!

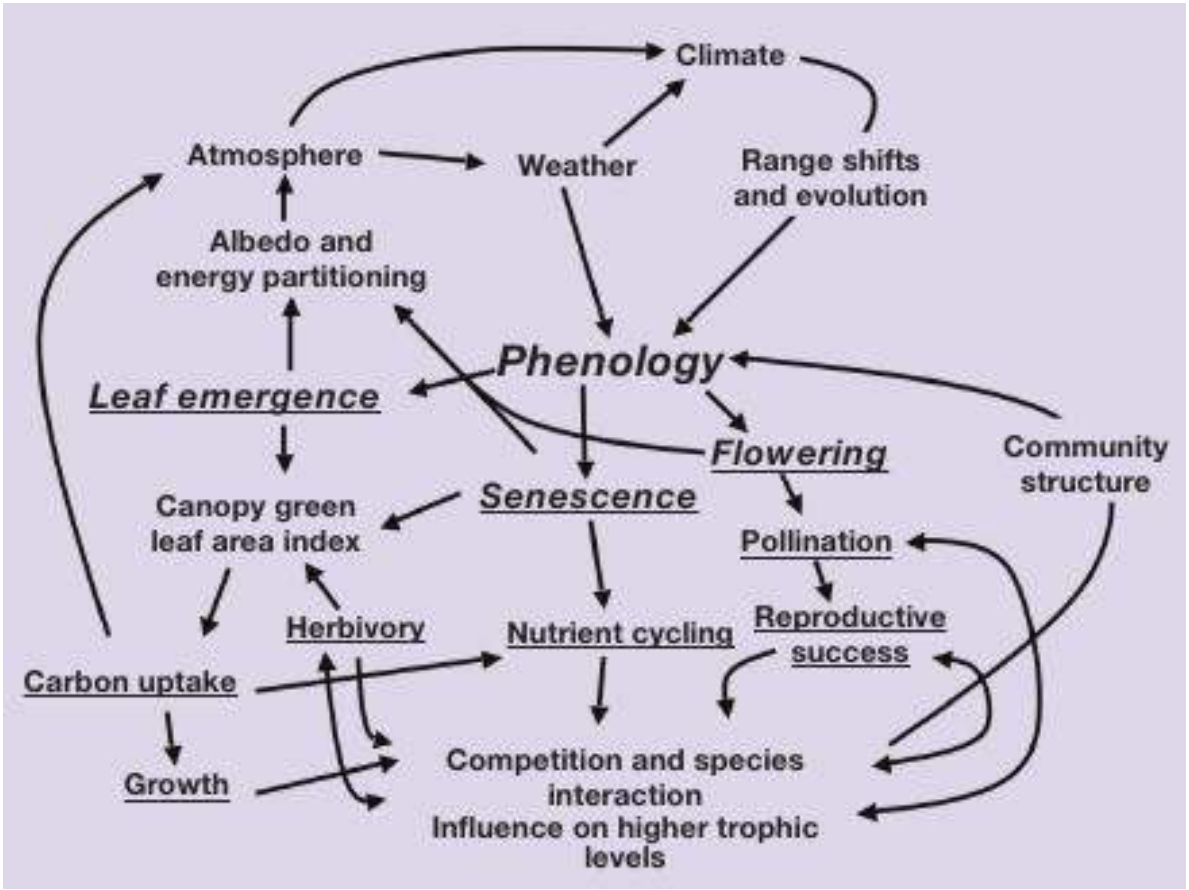
Most recent studies clearly demonstrated that plant phenology is shifting, and such shifts are very unlikely due to natural variability/fluctuation only.

Hence, scientists agree on the existence of an anthropogenic component to climate change.

Phenology is an useful tool to track the impact of climate change on natural ecosystems.

Phenology and its feedbacks

Morisette et al 2009, Front. Ecol. Env.



- Weather and climate control phenology
- Phenology feedbacks on atmosphere and the climate system
- Shifts in phenology act on community structure, hence biodiversity

Keep an eye on Phenology

But from how far?

- Field observer (precise, on single individuals, on single phases, expensive)
- Remote sensing (spatially integrated, poor spatial and time resolution, noisy signal)
- Near remote sensing (spatially integrated, high resolution, unmanned, cheap, need of some infrastructure)

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What do we measure?

We decided to focus on two instruments: NDVI and Webcams.

- They consist of robust, simple sensors
- They are good indicators of the seasonal development of the vegetation cover
- We have (or are currently developing) the know-how to handle these data
- They are fairly inexpensive

NDVI: Rationale

- One or two bands sensors: NIR, R, G, B, ... (Skye)
- Upward e downward sensors connected to datalogger
- Possibility to calculate different indices (eg $NDVI = \frac{NIR-R}{NIR+R}$), PRI, ...)

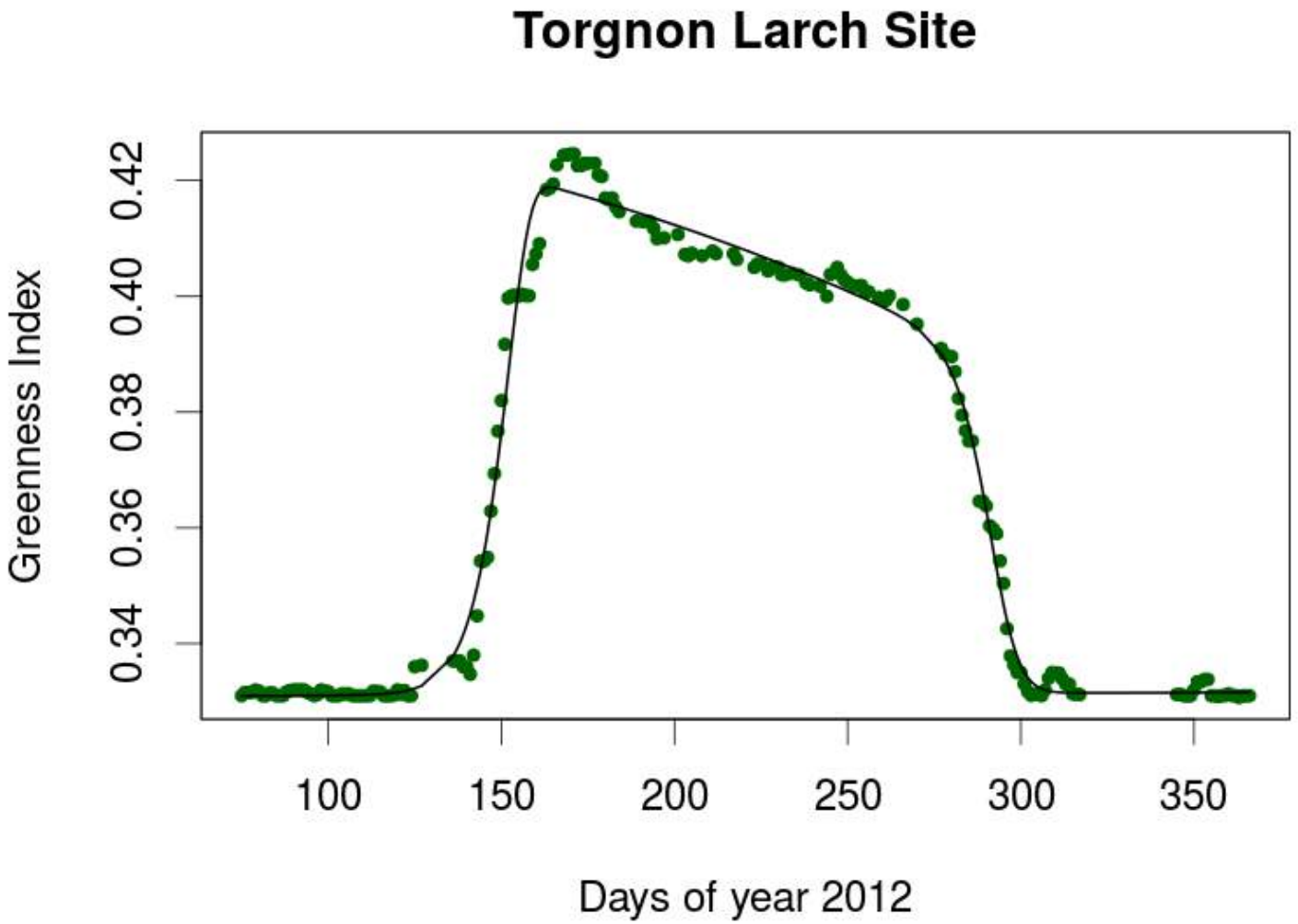
NDVI seasonal trajectories can be associated to plant development and, thereby phenology.

Webcams: Rationale

Torgnon Larch stand, 2100 m ASL

Webcams: seasonal trajectory

From the red green and blue coordinates of a given number of pixels an Index of greenness is computed



The project

- started in 2008
- cooperation project Italy-France (Interreg Alcotra)
  - PhenoAlp (2008-2011) www.phenoalp.eu
  - e-Pheno (2012-2014) www.epheno.eu
- Italy - Aosta Valley (ARPA, Parco Naturale Mont Avic, Parco Nazionale Gran Paradiso)
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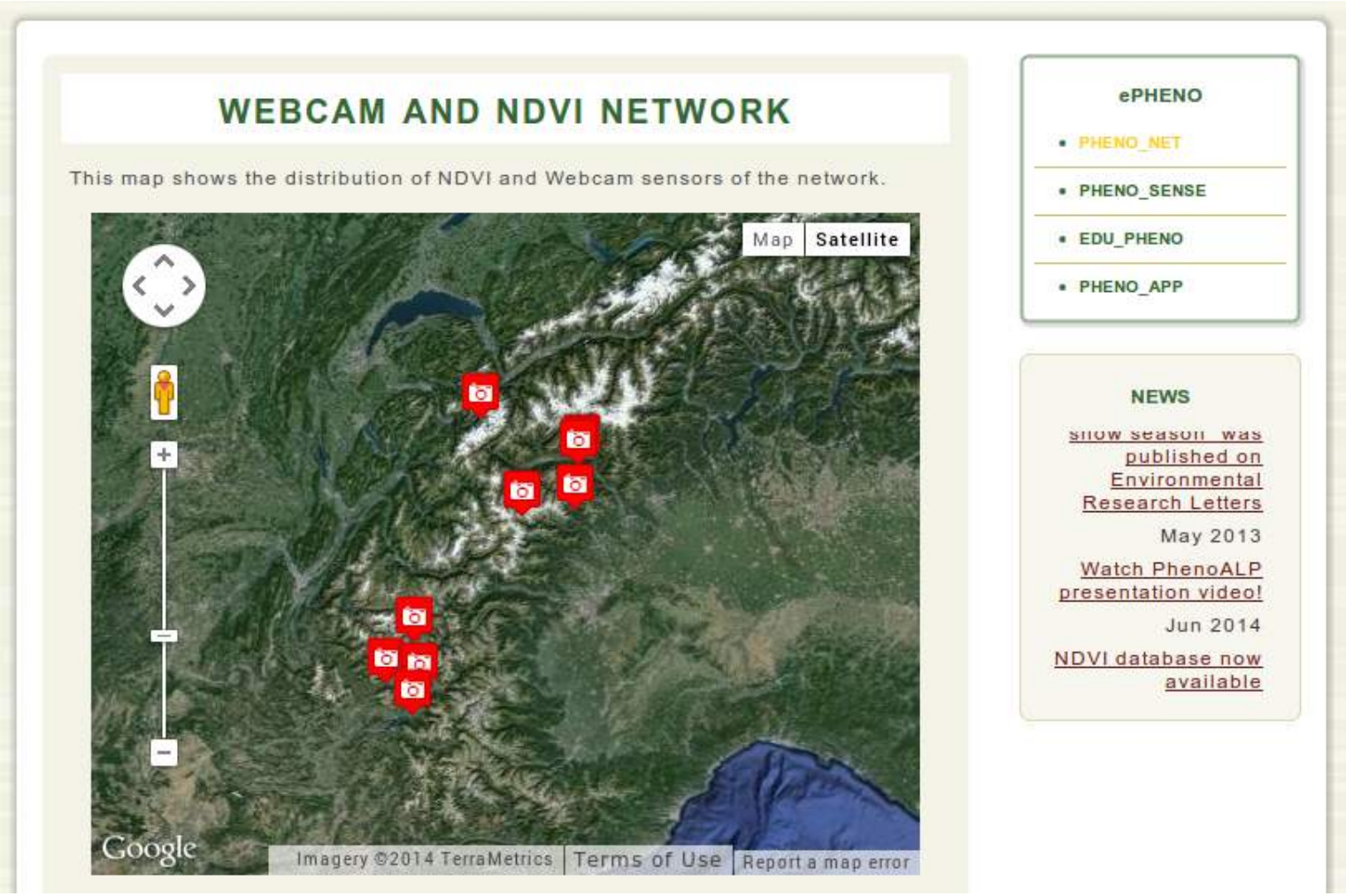

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- Webcam sensors (10 sites: 5IT, 5FR)
- most sites installed in 2012-2013
- ecosystems: grasslands (1800-2400 m asl) and subalpine ($<$ 2000 m asl) larch forests
- common protocols and set-up but different cameras
- storing and processing strategy under discussion

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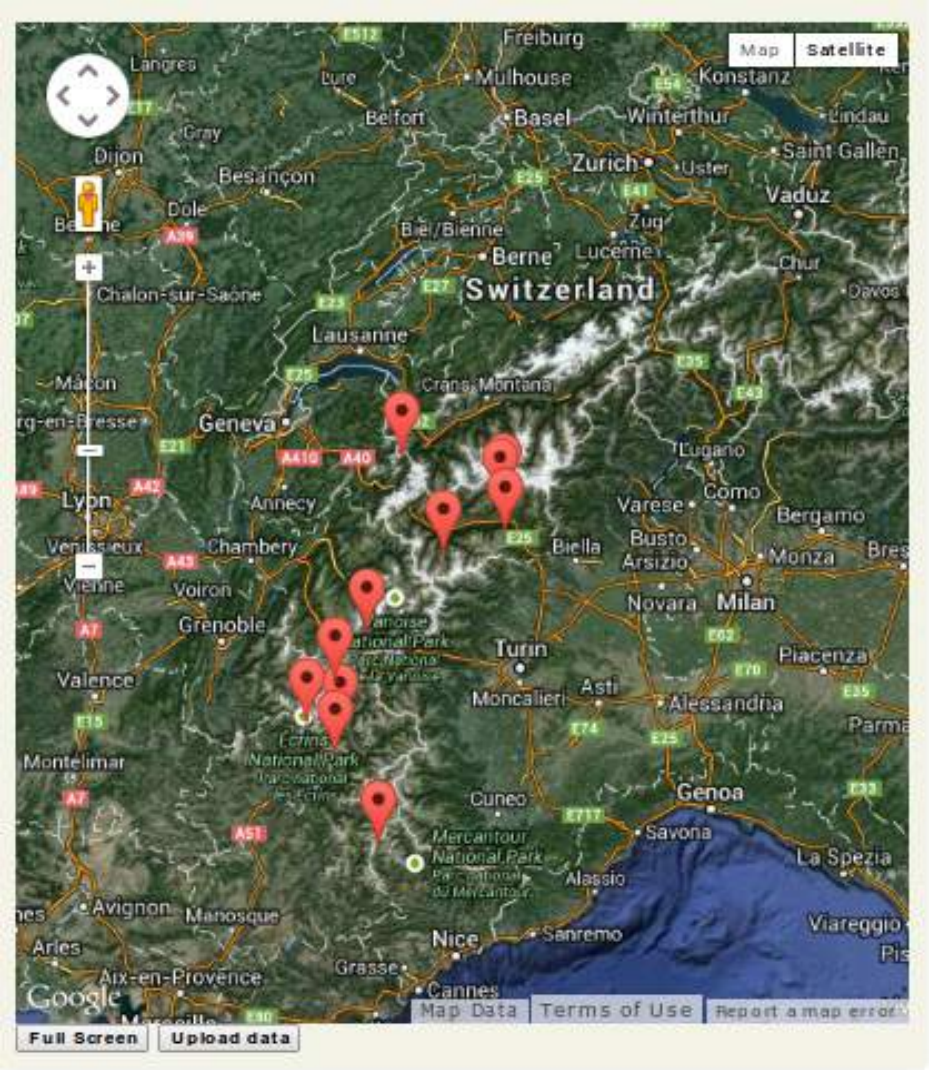

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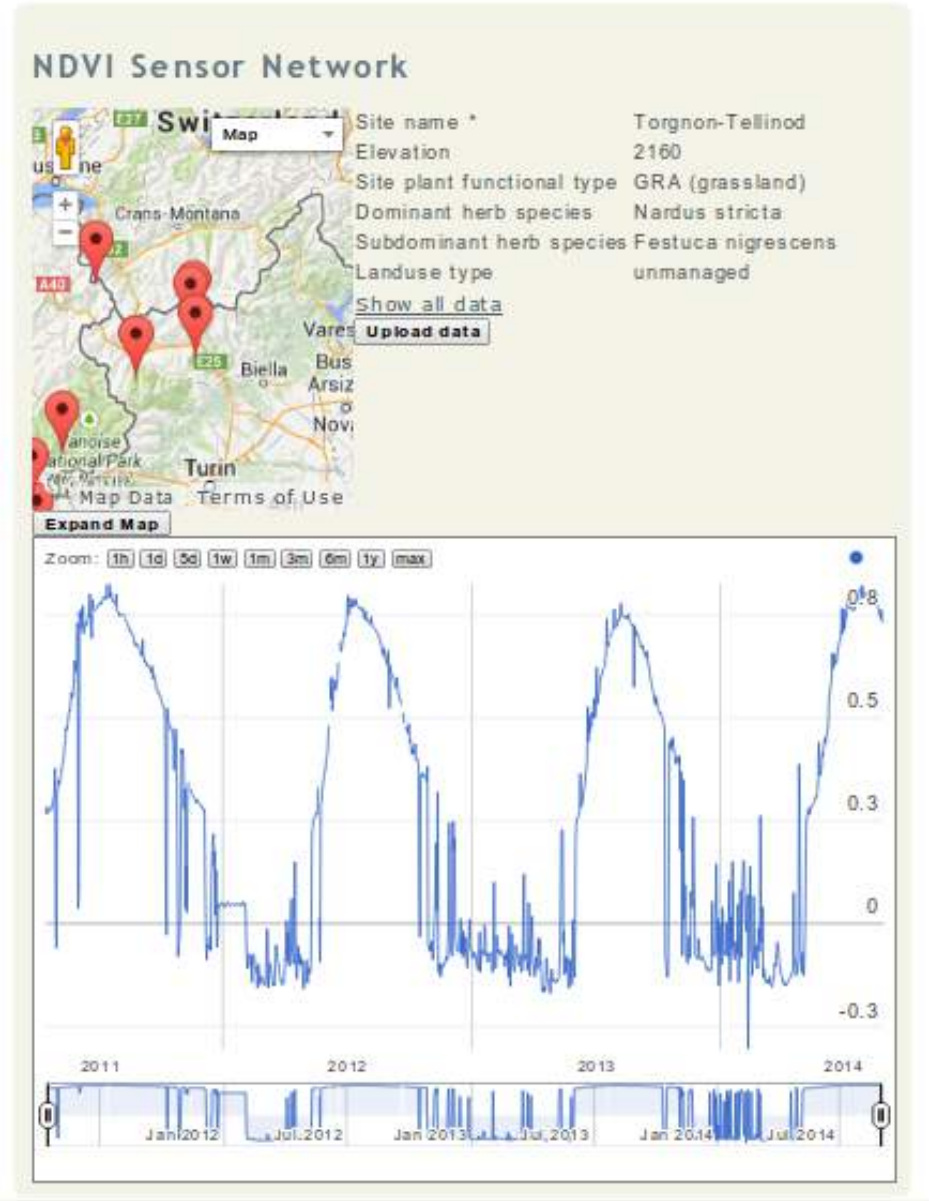

NDVI sensors comparison

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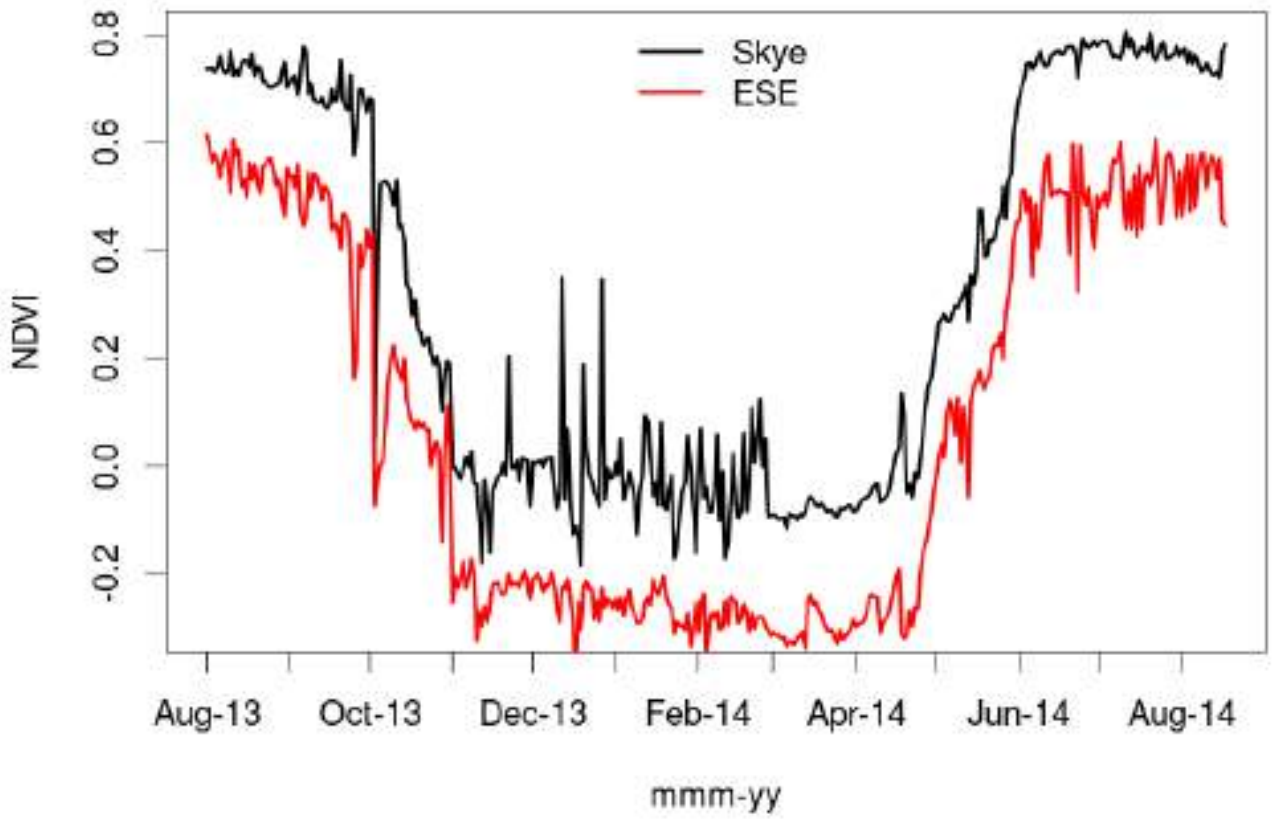
Torgnon Larch stand



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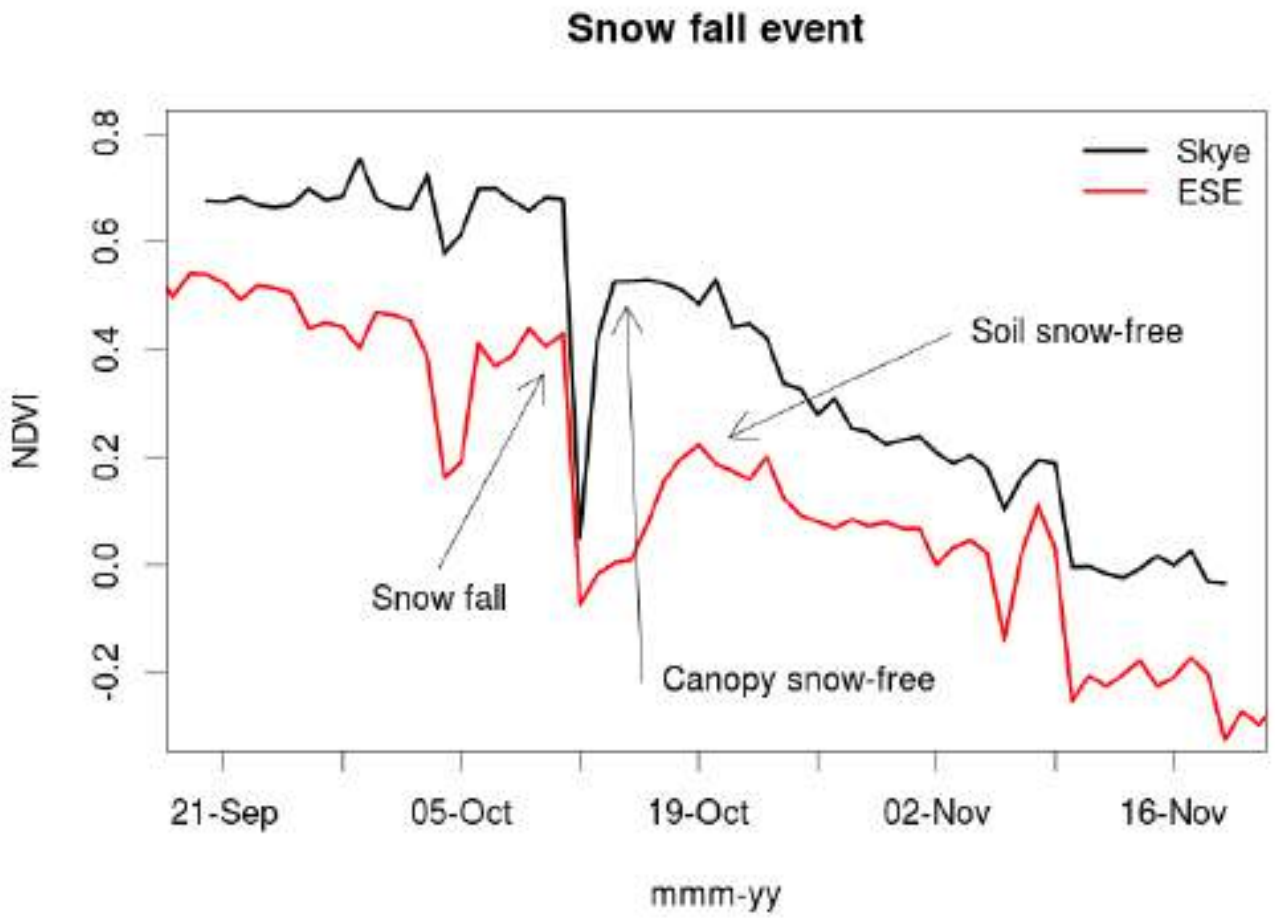


Image Processing package

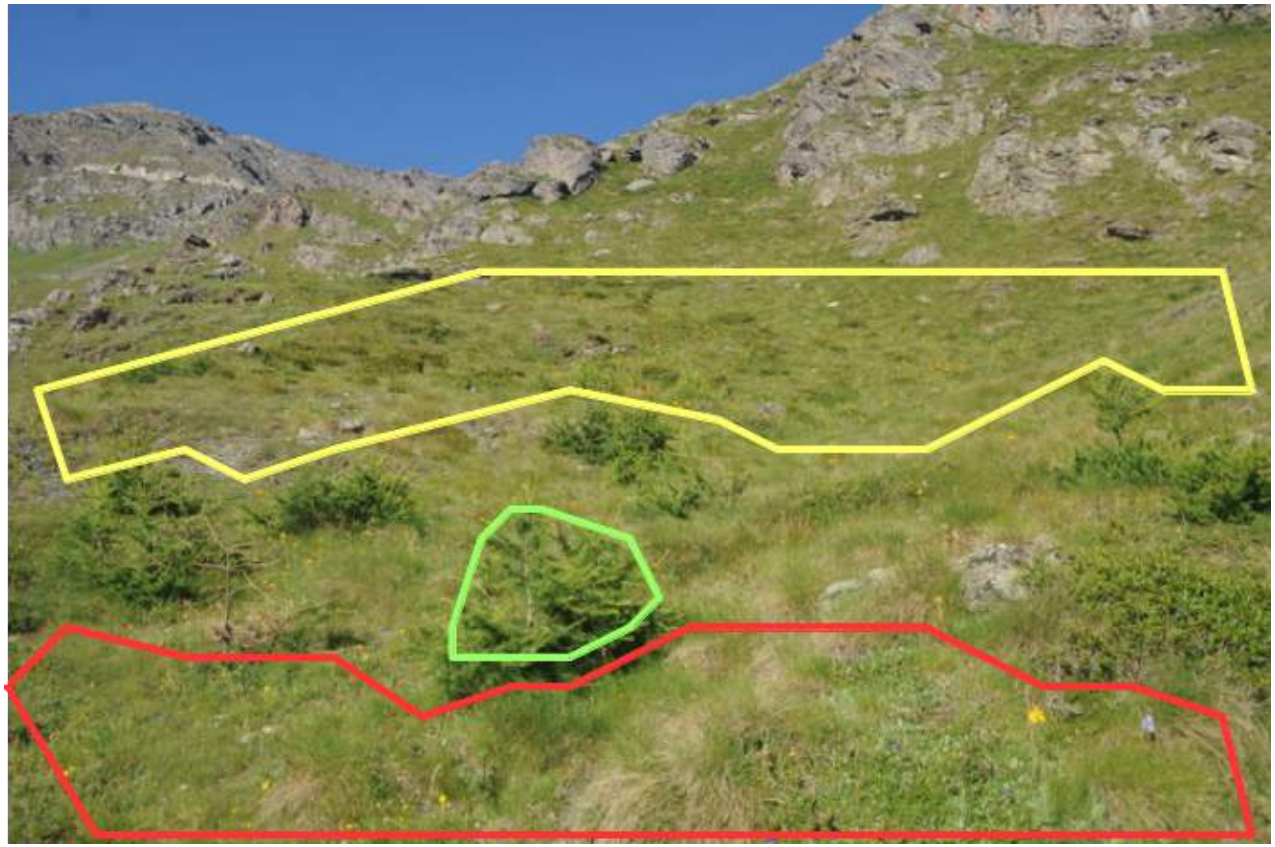
A package in the popular software for statistical computing **R**

R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/

- Open source, cost free
- Highly flexible
- Available for download soon (1 month) at https://r-forge.r-project.org/

ROI (Region of Interest) definition

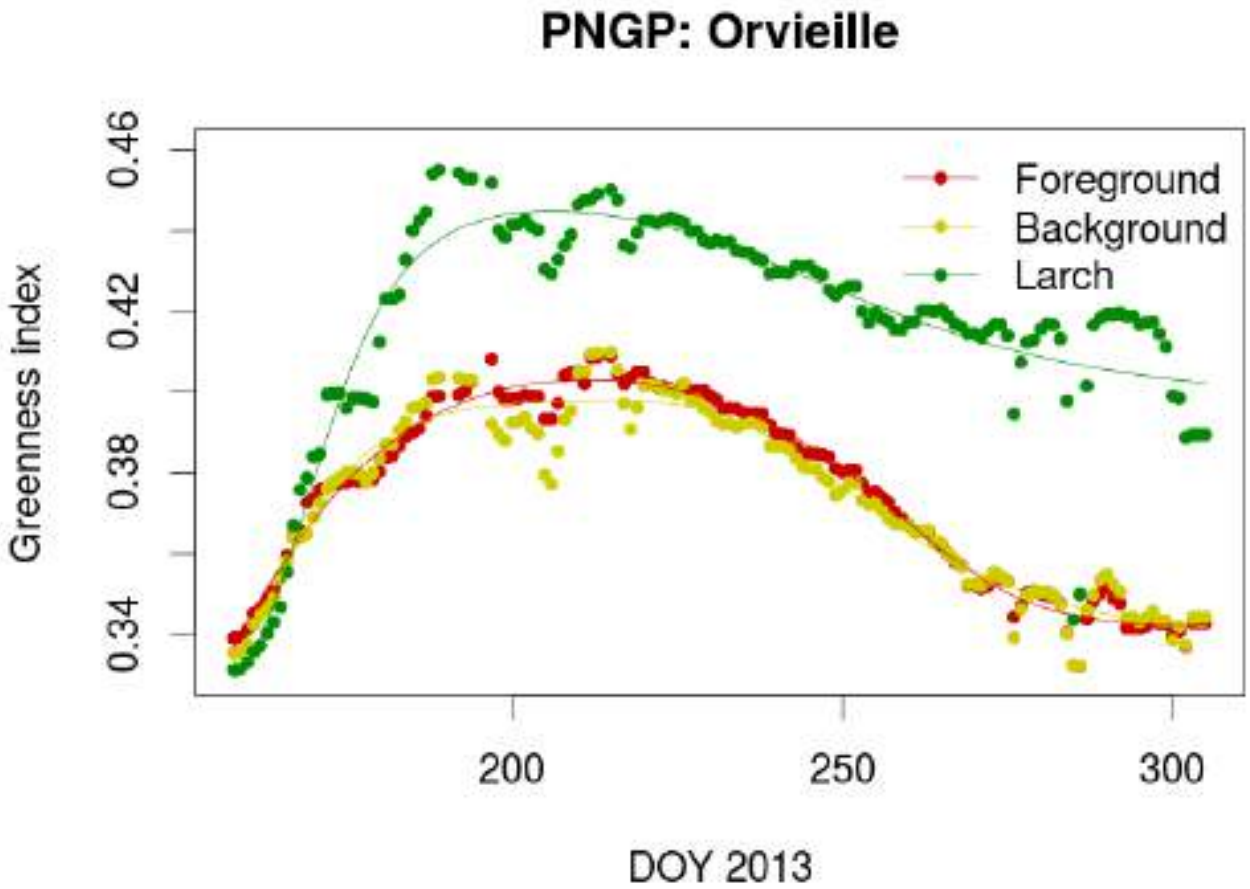
- User can define ROIs on a reference image clicking on ROIs vertexes



PNGP: Orvieille site

Data processing

- On each ROI for each date average RGB values are computed (but gridded analysis is under development)
- Greenees index (GI) is computed as G/(R+G+B)
- GI data is 'cleaned' with a sequential filtering procedure (low quality images, bad light, rainy days)
- Seasonal trajectories are modelled by means of various equations (double logistic equations)
- Phenological thresholds are extracted with various methods (fixed (i.e. half peak) or based on inflection points of derivatives)
- Uncertainty is computed bootstrapping the residuals



Orvieille 2012: Different ROIs with different trajectories

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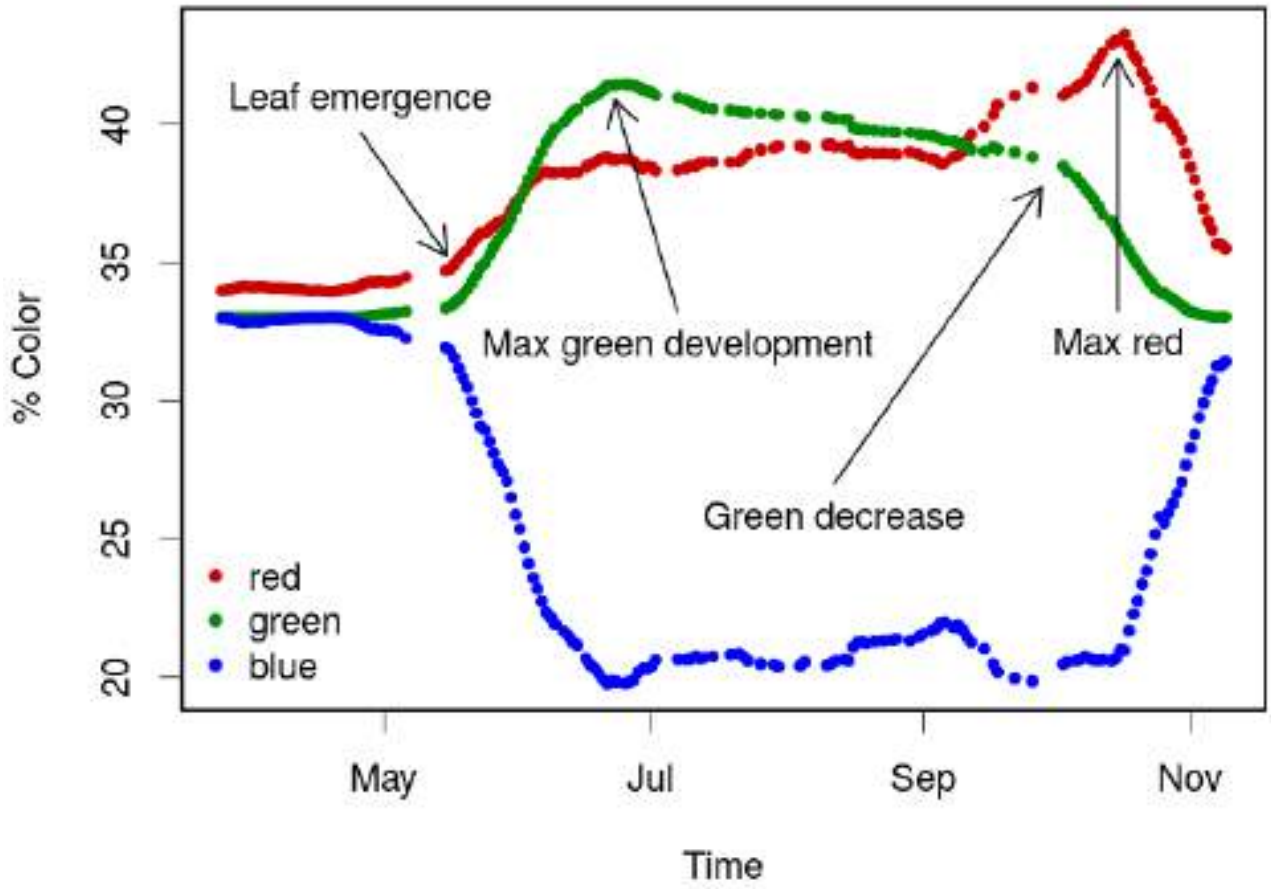

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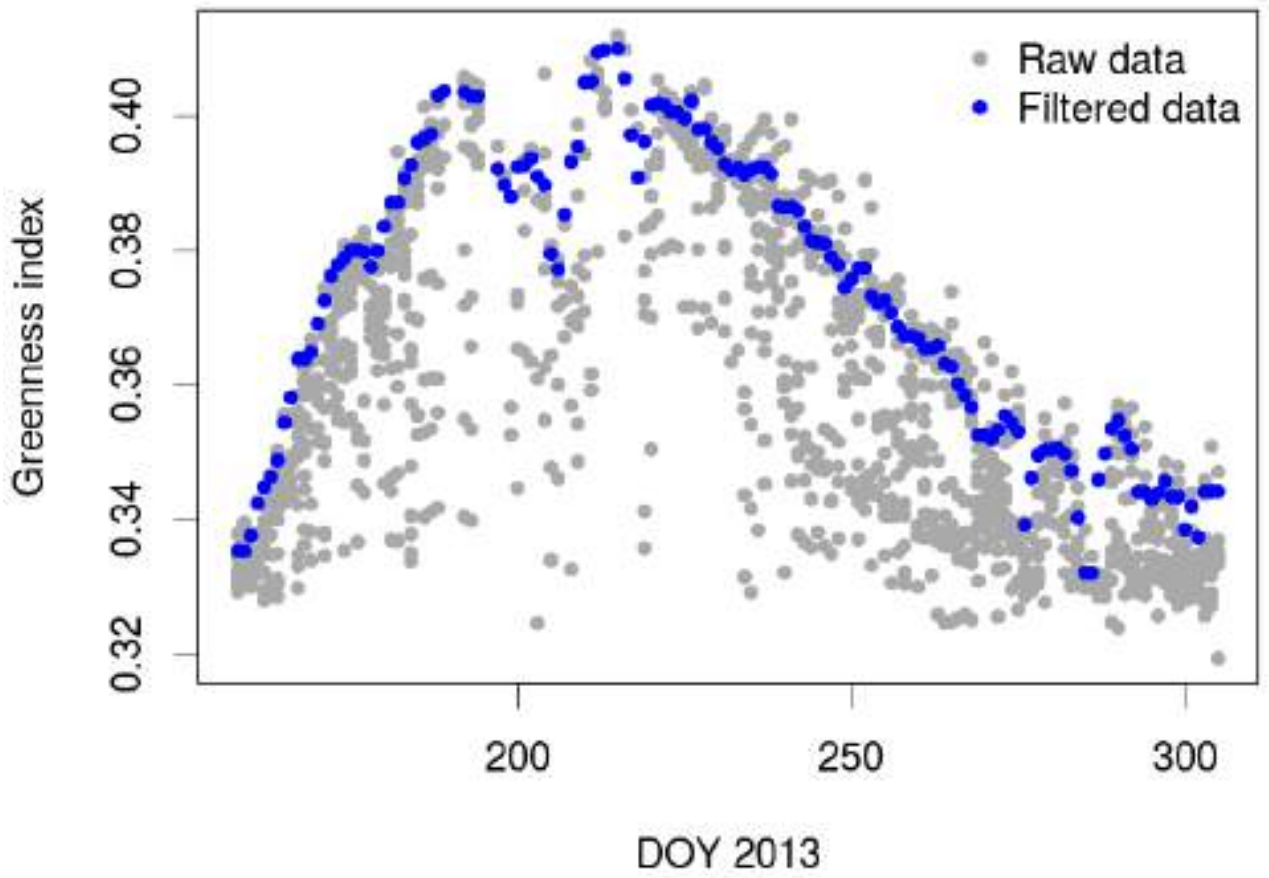

Filtering procedure applied to Orvieille 2012 raw data

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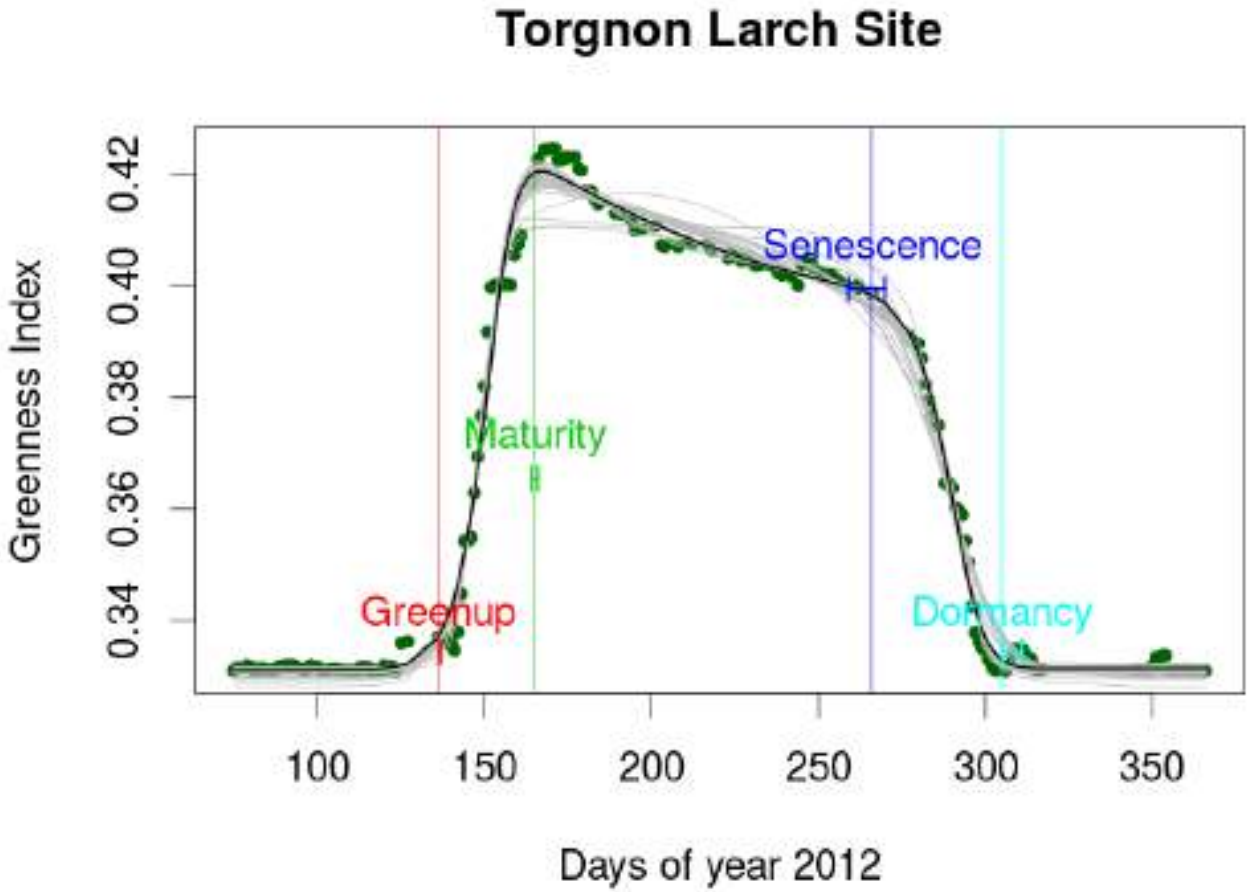

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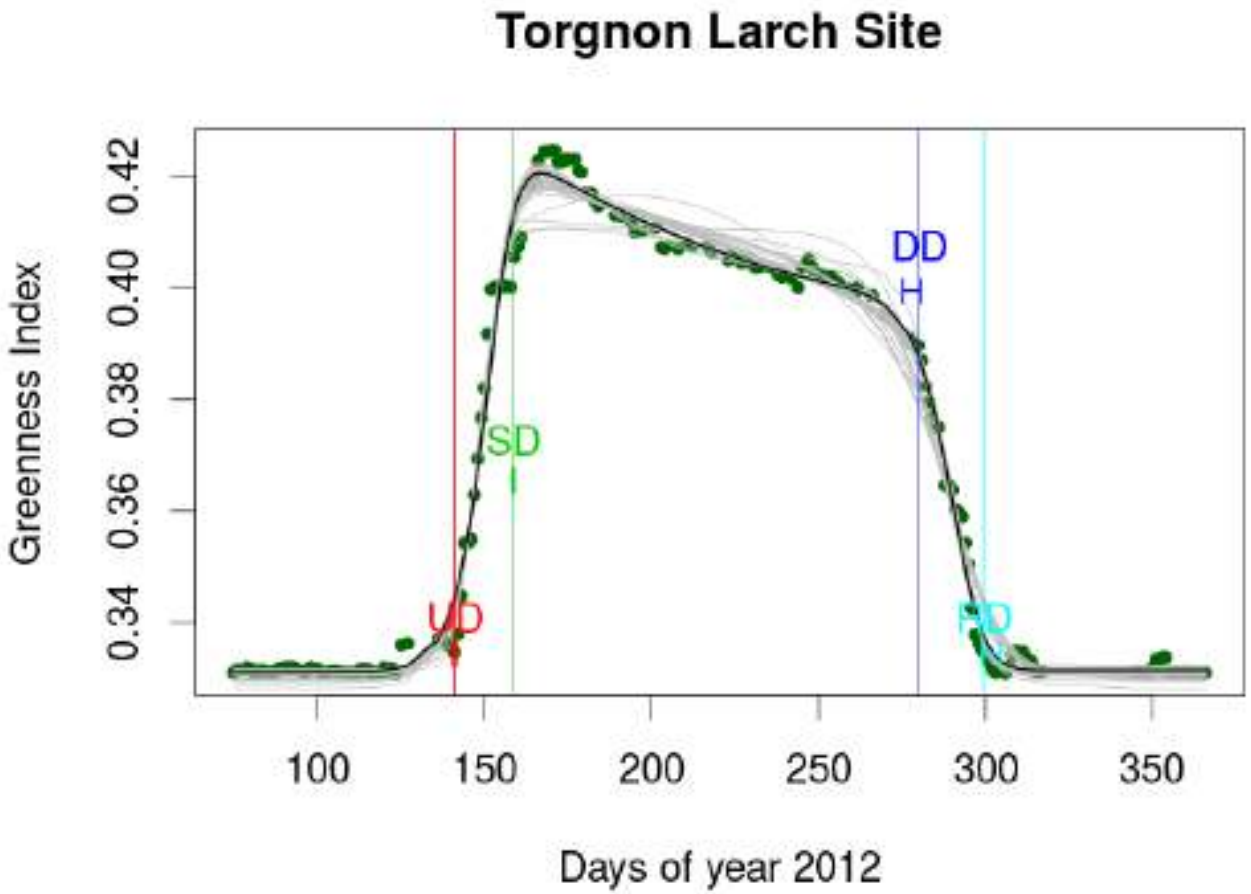

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The package

- Developed in collaboration with PHENOCAM (http://phenocam.sr.unh.edu/webcam/)
- Highly flexible (5 fitting methods, 5 thresholding approaches)
- Tested on a large database (250 site-years)
- Covering a wide range of ecosystems (from arid to alpine grasslands, from deciduous tropical to coniferous boreal forests)
- Designed to be user-friendly

Costs

- NDVI measurement system
  - The sensor itself (Skye)
  - Power supply (solar panel + battery)
  - Data logger

  Total: 3-3.5k Euro

- Webcam measurement system
  - The webcam itself (Reflex Nikon)
  - Power supply
  - Data logger and case

  Total: 4-5k Euro

Additional costs: biweekly/monthly visit to the site

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- A database was built to host NDVI data, and it is ready to include new sites
- A package software has been designed to process Webcam images
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Further steps

- Improve data intercomparison (different sensors, different set-up, etc.)
- Enlarge the network: incorporate existing sites, populate the database
- Enlarge the network: include new sites (e-Pheno is finishing, but the network goes on! Parks are welcome)
- Increase range of ecosystem types, climate, i.e. increase the representativeness of observation network
- Provide know-how and installation instructions for new partners/sites
- More info
  www.epheno.eu
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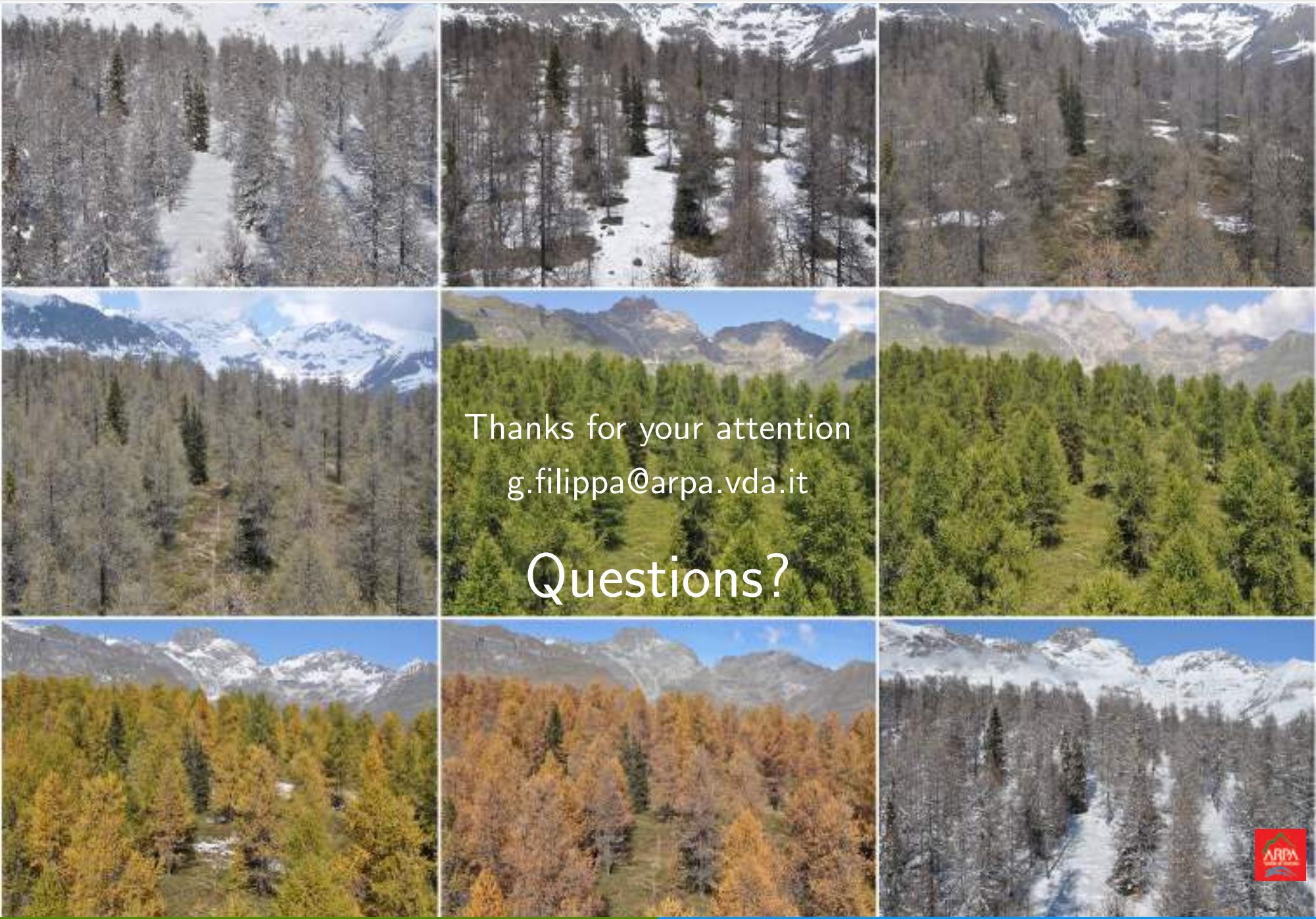

Thanks for your attention

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Questions?