Geo-Academy Summer School 2025

Analysing vegetation trends and properties from space

Rolf Niemann

Based on material from the Dept. of Physical Geography and Ecosystem Science
Lund University

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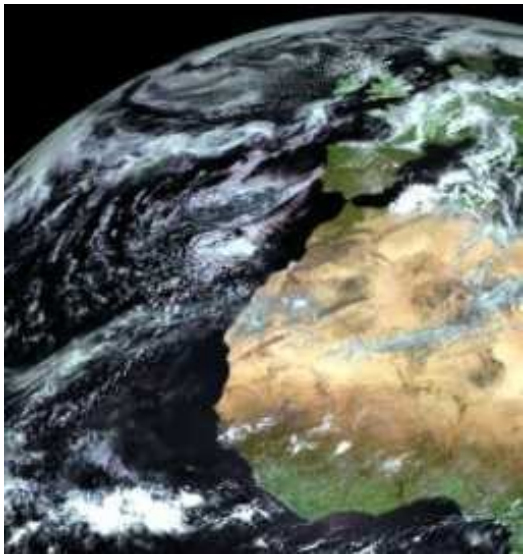
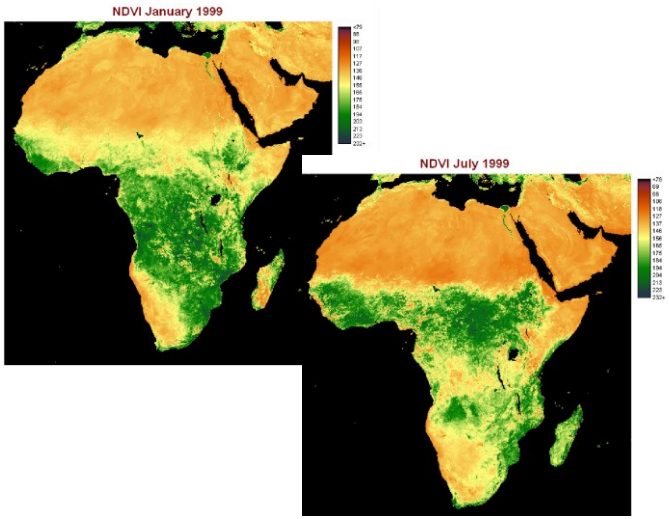
Images from space help us understand the Earth

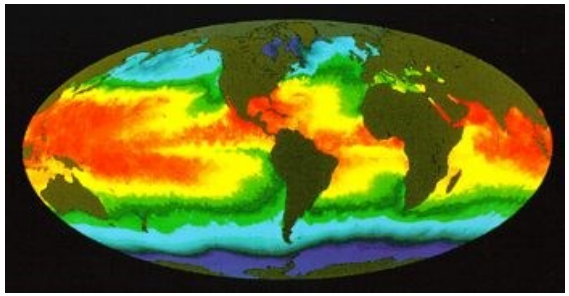


Weather systems

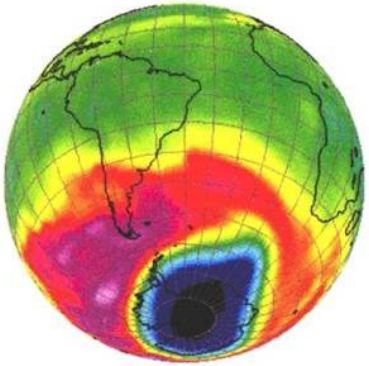
Ice fields



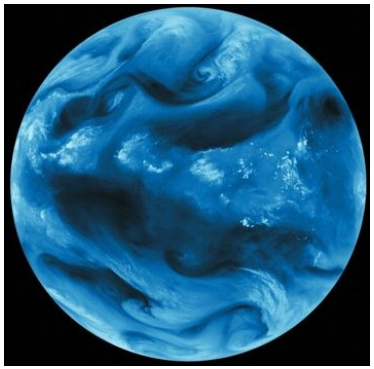
Global vegetation



Ocean temperature

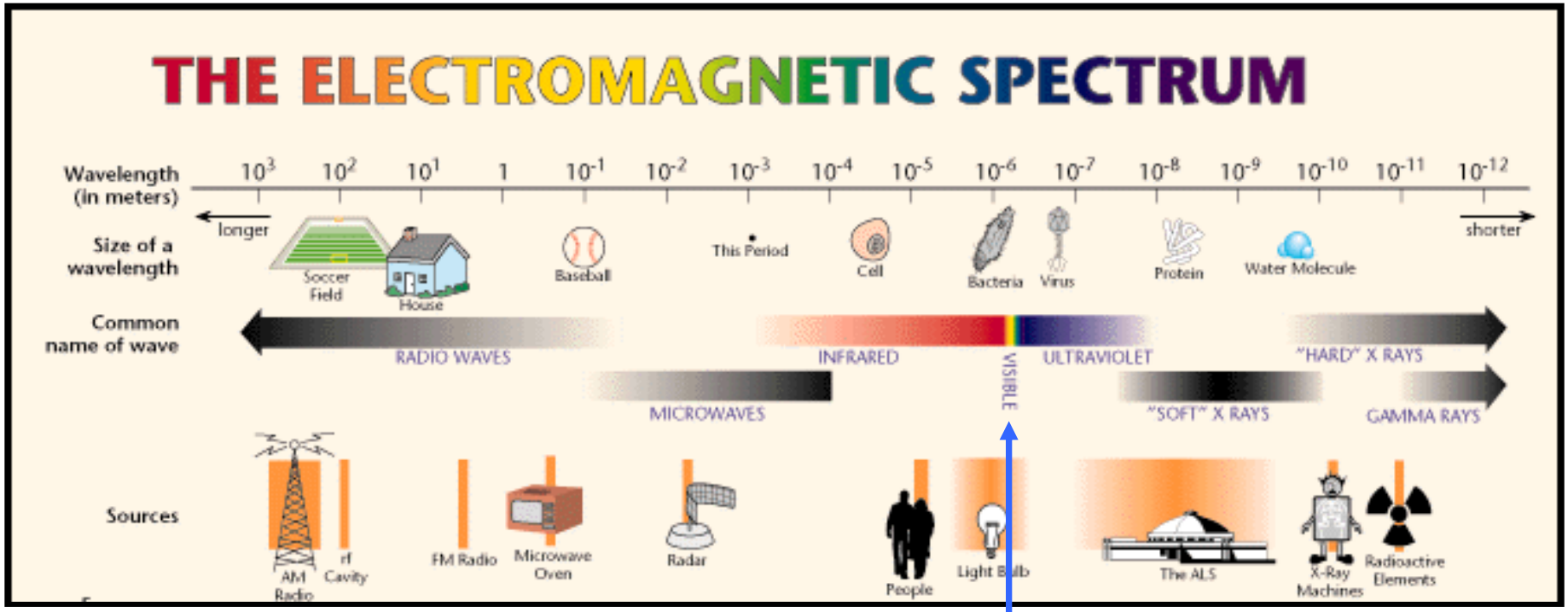


Composition of our atmosphere



Human impact

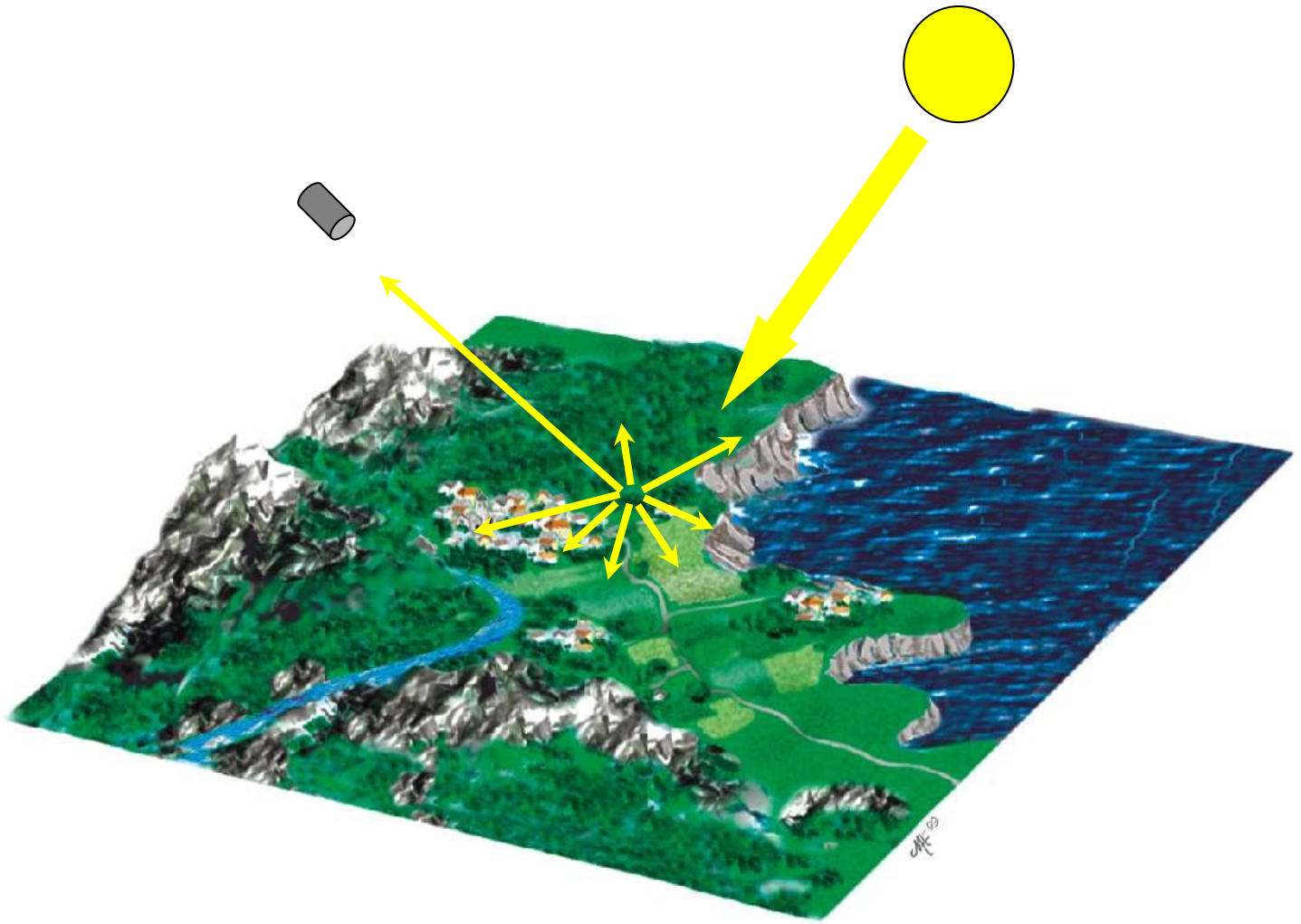
Electromagnetic energy – different wavelengths



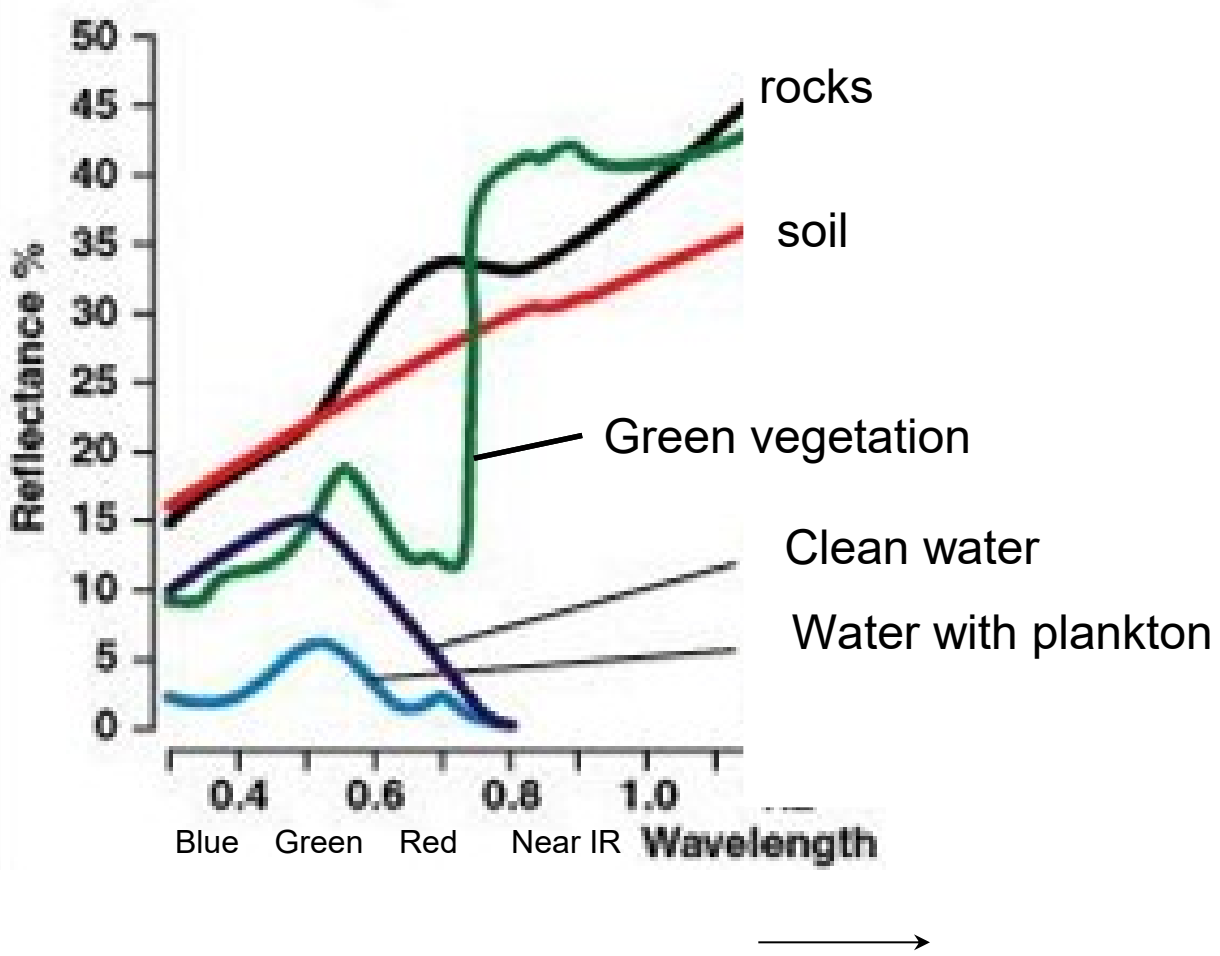
Visible light
only a small part

Satellites capture images in
visible, **infrared** och **microwave** parts

Solar radiation is absorbed and reflected from the ground



Different materials reflect light in different ways



Remote sensing from different platforms

← **Air photos**

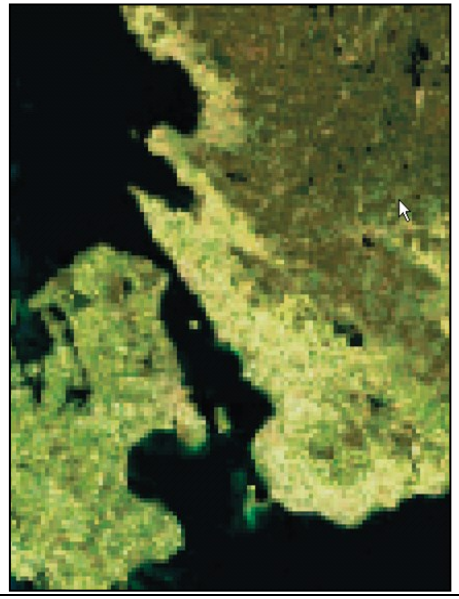
High-resolution satellite data →

High spatial detail but irregular frequency and expensive

10-50 cm 0.5-2 m

← **Medium resolution satellite data**

Low resolution satellite data →



Low spatial detail but regular frequency and free

10-30 m 5-15 days

250-1000 m daily

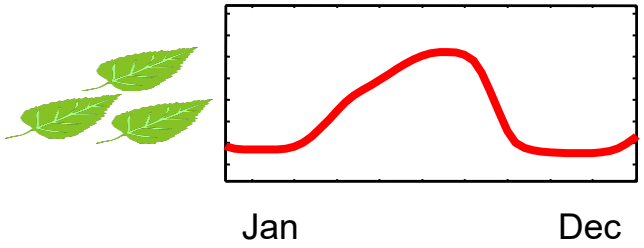
Colour aerial photo – IR photo

Data domains

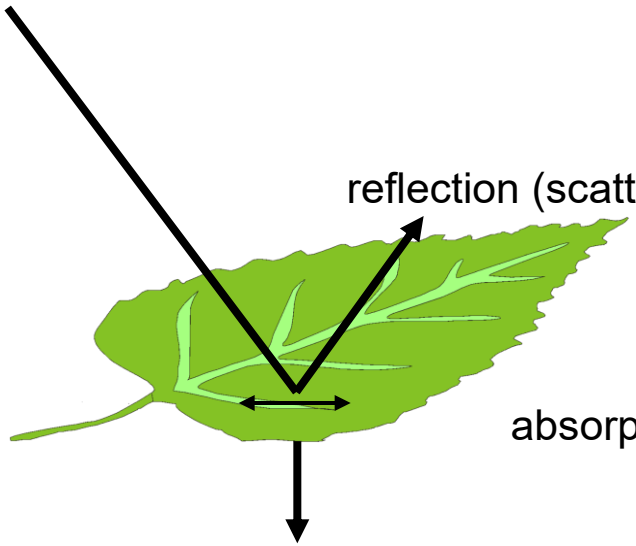
- Spectral domain

- Spatial domain

- Temporal domain

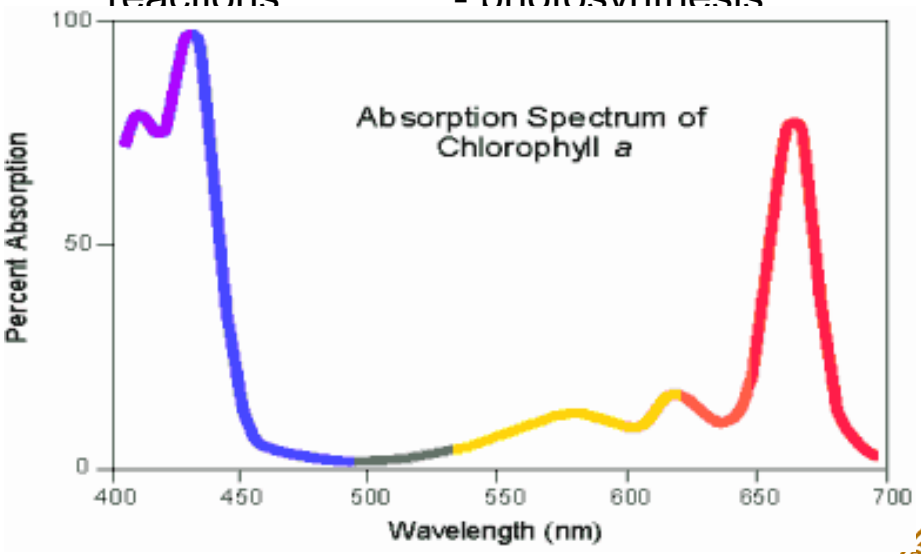


Scattering and absorption of radiation by a leaf



absorption

- heat dissipation - thermal emission
- fluorescence emission - VIS, NIR
- photochemical reactions - photosynthesis



Akly, C., 2005, http://www.clas.ufl.edu/jur/200509/papers/paper_akly.html

Fluorescense of chlorophyll

1. Materials

- some green leaves (e.g. basil or spinach)
- ethanol (95%) or hand sanitizer
- 1 mortar
- 1 mortar pestle
- 1 transparent glass beaker
- 1 filter
- 1 funnel
- 1 lamp
- 1 uv-lamp (or blue laser)

2.

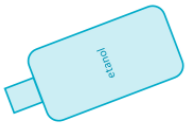
Tear the leaves into small pieces,

put them in a mortar...

... and crush the leaves into a mushy paste.

Fluorescense of chlorophyll

3. Pour ethanol over the leaves until they are covered and stir.



4. Place the filter in the funnel over the beaker, pour the leaf mash into the filter ...

...and wait until the liquid has flowed through.

5.

Shine with a regular lamp, than with UV light or a blue laser on the extract.

What happens?

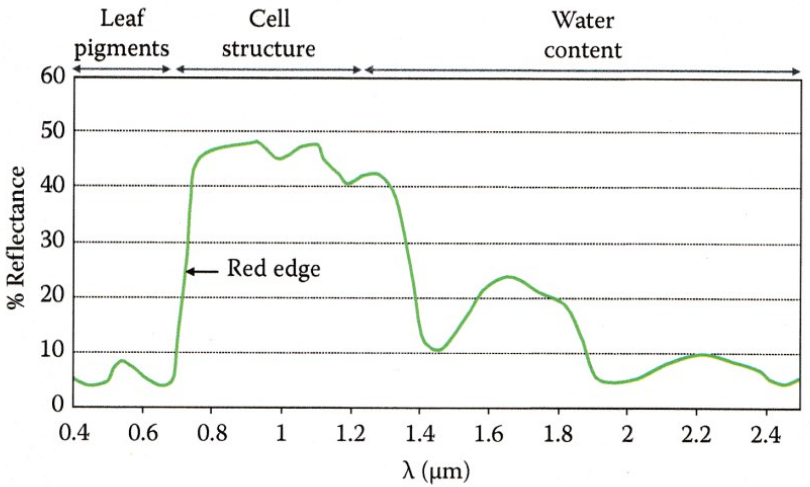
When you shine a UV light or with a blue laser on the liquid, it glows in a strong red color.

If you only have a regular lamp, the extract will also look reddish, but not as clear.

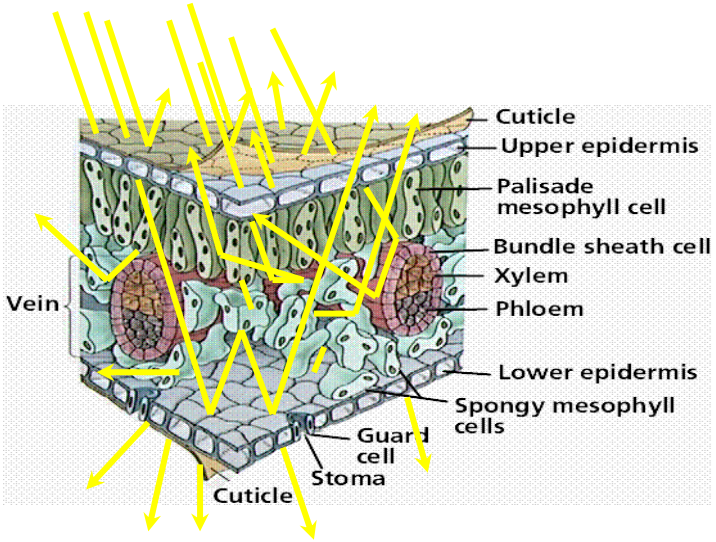
Explanation

By mashing the leaves and mixing the mash with ethanol, you release the pigment chlorophyll. When you direct the UV light at the chlorophyll extract, the molecules in the mixture become electronically stimulated: the electrons in the molecules are raised to a higher energy level. However, this is an unstable state. When the electron returns to the ground state, the molecules release the newly gained energy. The process takes place with the emission of light. This phenomenon is called fluorescence.

Radiation reflectance from leaf and canopy

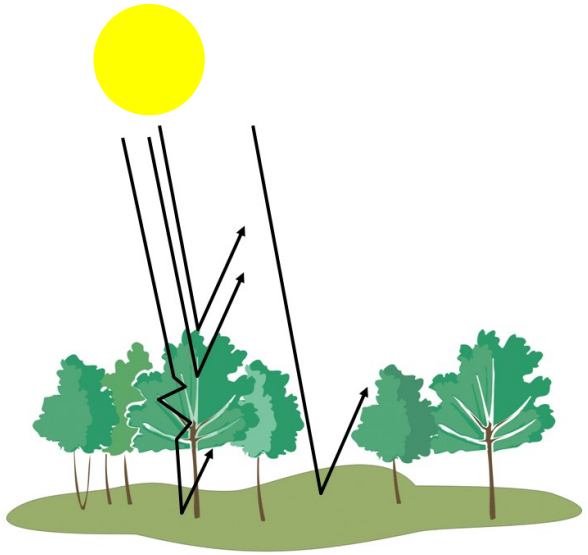


Chuvieco, E., 2016, fig. 2.11



In a **plant canopy**, many factors influence the spectral response:

- Leaf constituents (pigments, water, structure)
- Leaf volume / leaf area index
- Leaf shapes and angles
- Visible soil; soil color
- Ground vegetation (weeds?)
- Viewing and sun angles
- Structural elements (stems, branches...)
- Atmospheric conditions (especially satellite)

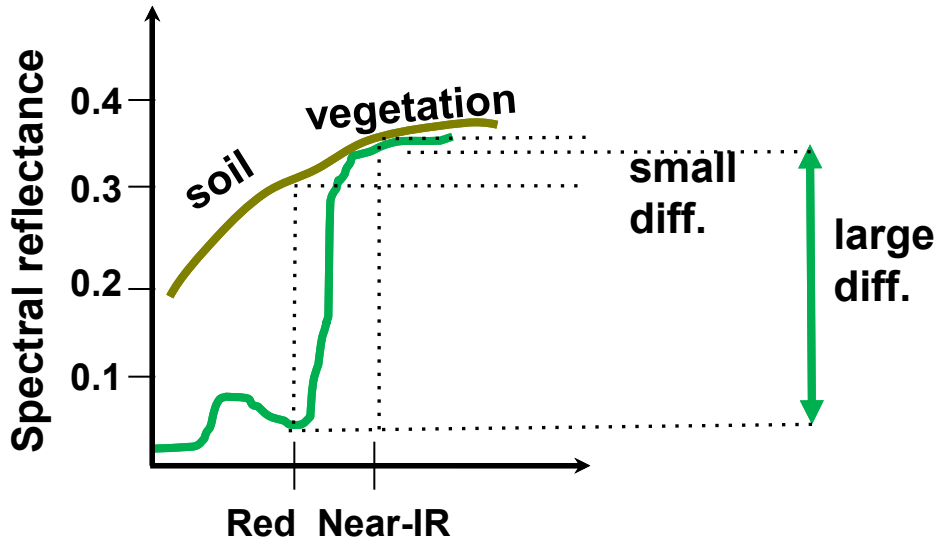


Vegetation with different structure

Landsat TM
false colour composite
(NIR, red, green)

Vegetation indices

Example: Difference vegetation index (DVI) = R_{NIR} - R_{red}

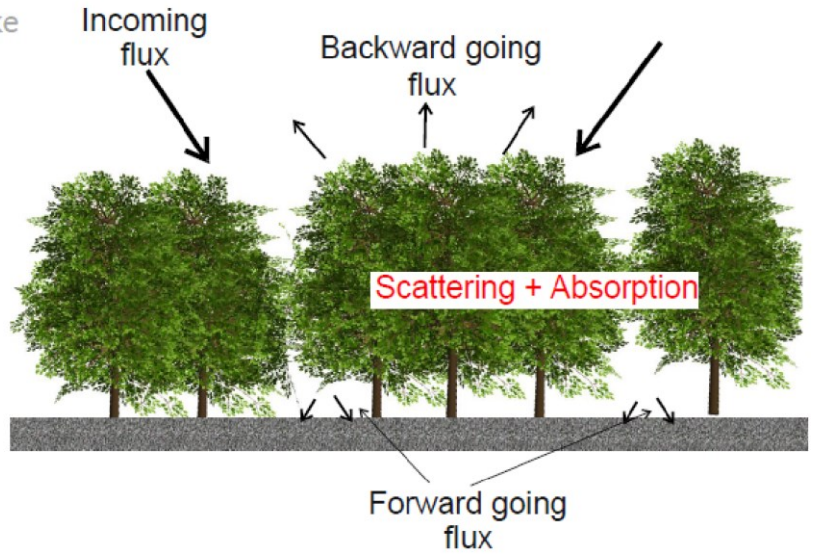


- Vegetation indices **increase the contrast between vegetation and ground**
- Nearly all vegetation indices utilize **spectral differences or ratios**

PPI : Plant Phenology Index (made in Lund!)

- Uses red and NIR reflectance
- Derived from diffusive reflectance theory

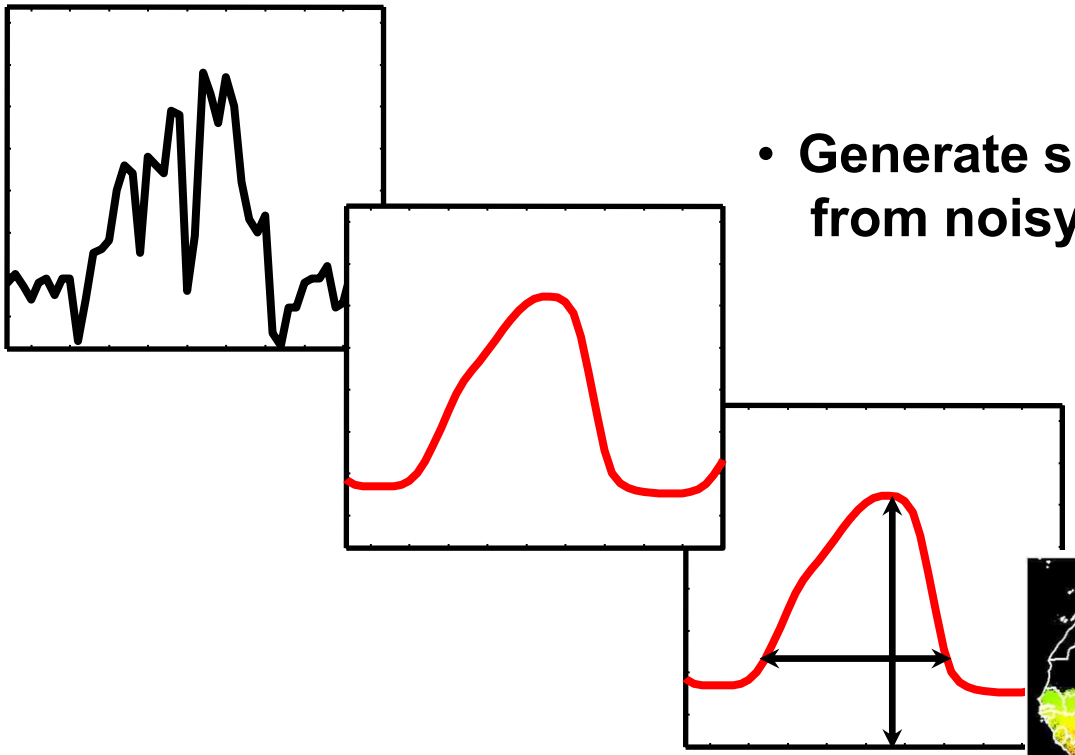
$$PPI = -K \times \ln \frac{DVI_M - DVI}{DVI_M - DVI_{Soil}}$$



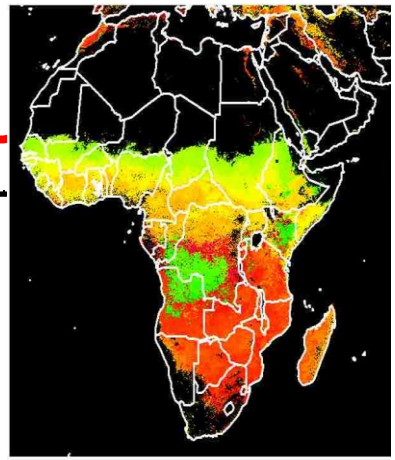
DVI	Difference vegetation index: $R_{NIR} - R_{red}$
DVI_{Soil}	DVI for soil
DVI_M	Maximum DVI for canopy
K	Extinction coefficient

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

Modelling phenology: TIMESAT



- Generate smooth model functions from noisy satellite sensor data
- Extract parameters that describe the seasons

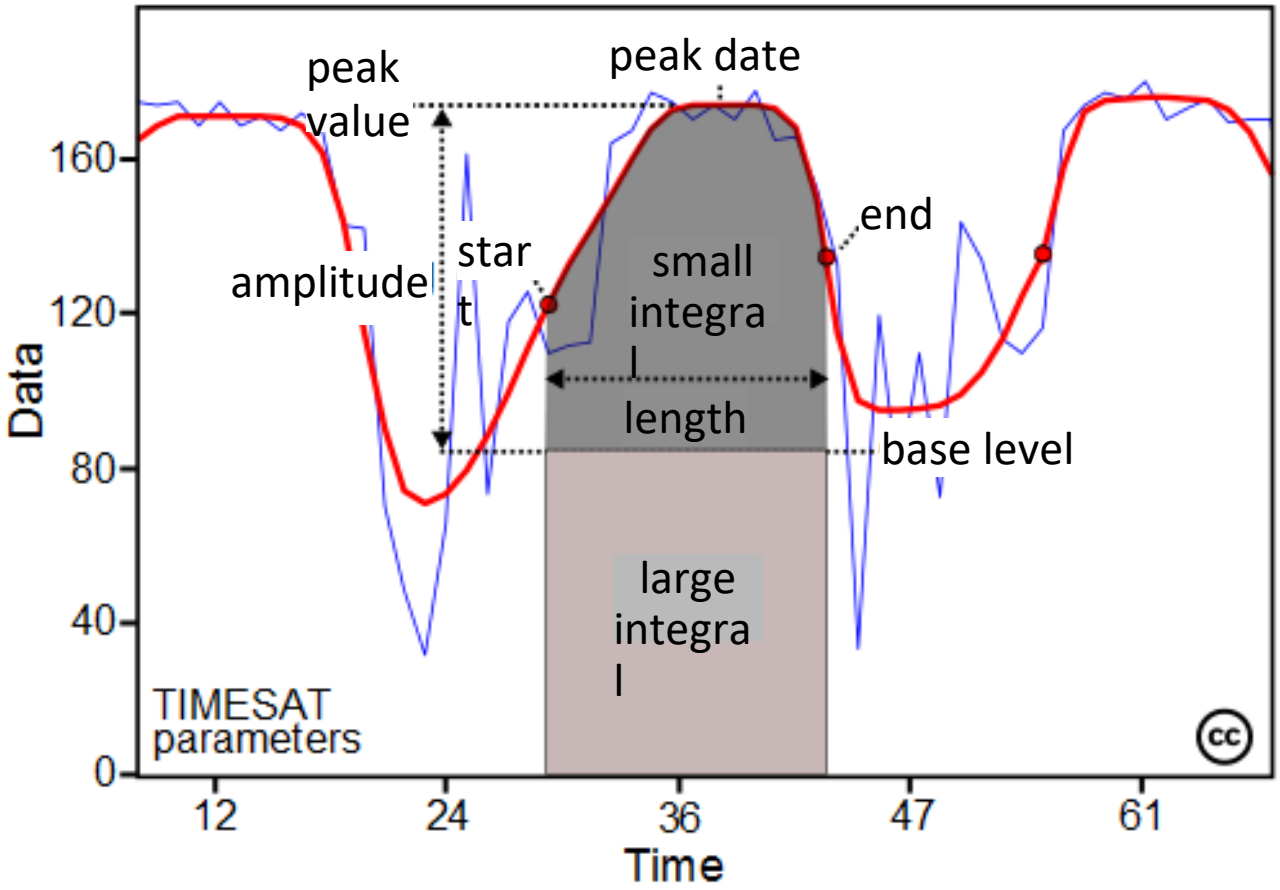


- Map the seasonality parameters

Jönsson & Eklundh 2004, *Comp. Geosc.*, 30

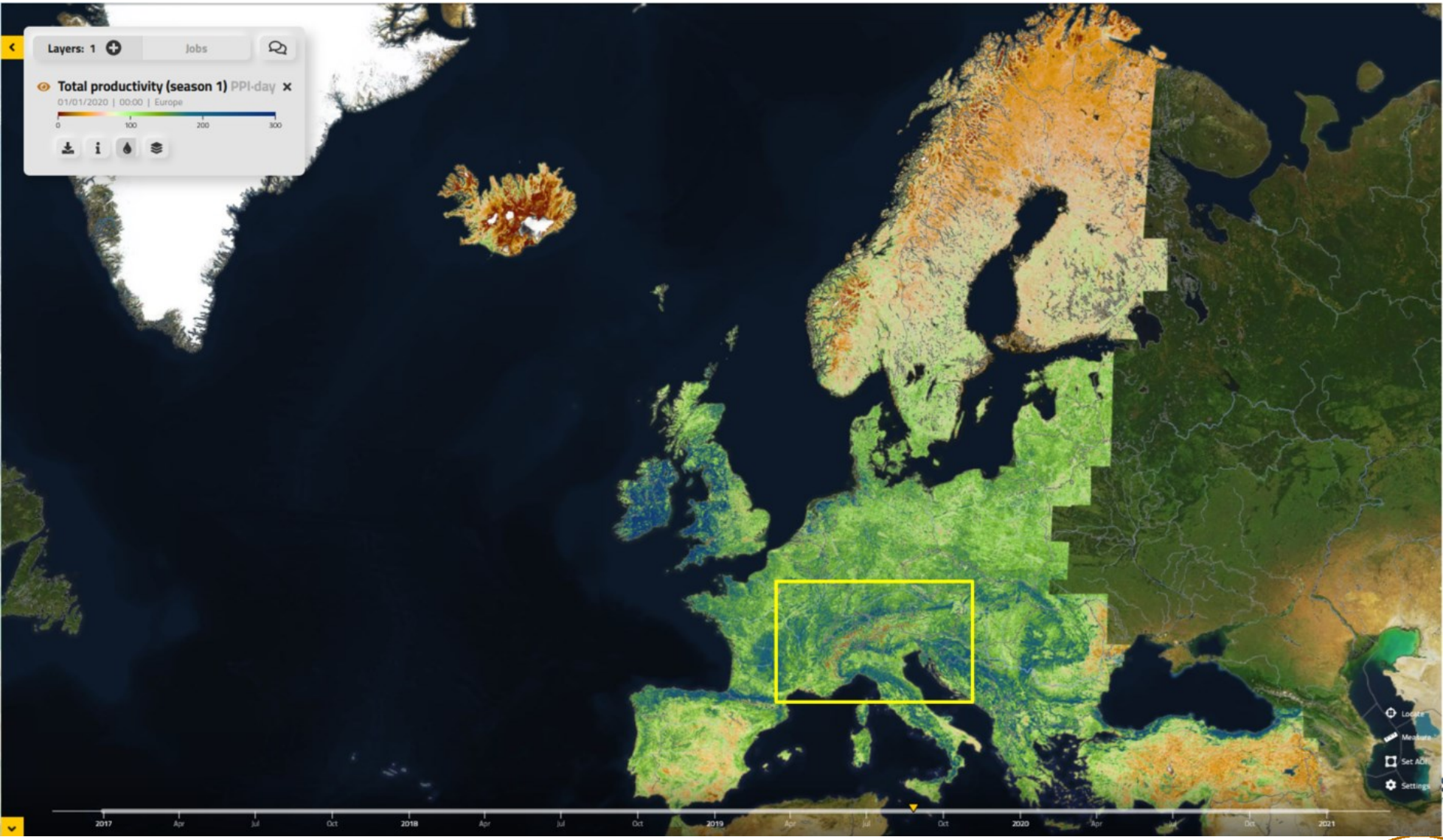
Freely available software:
http://www.nateko.lu.se/TIMESAT

Extracting seasonality parameters



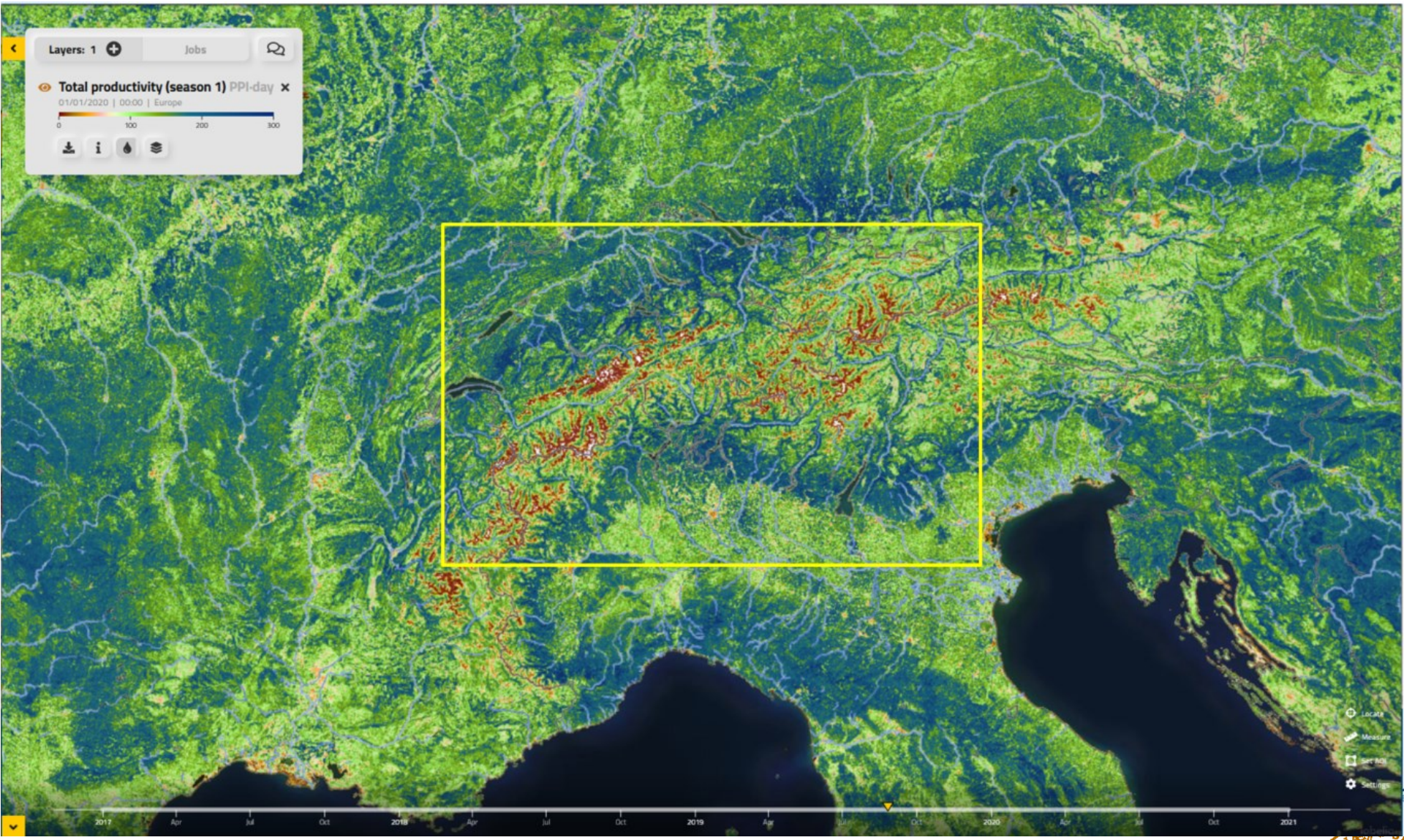
http://www.nateko.lu.se/TIMESAT

Phenology and Productivity from satellite



https://land.copernicus.eu/pan-european/biophysical-parameters/high-resolution-vegetation-phenology-and-productivity

Phenology and Productivity from satellite



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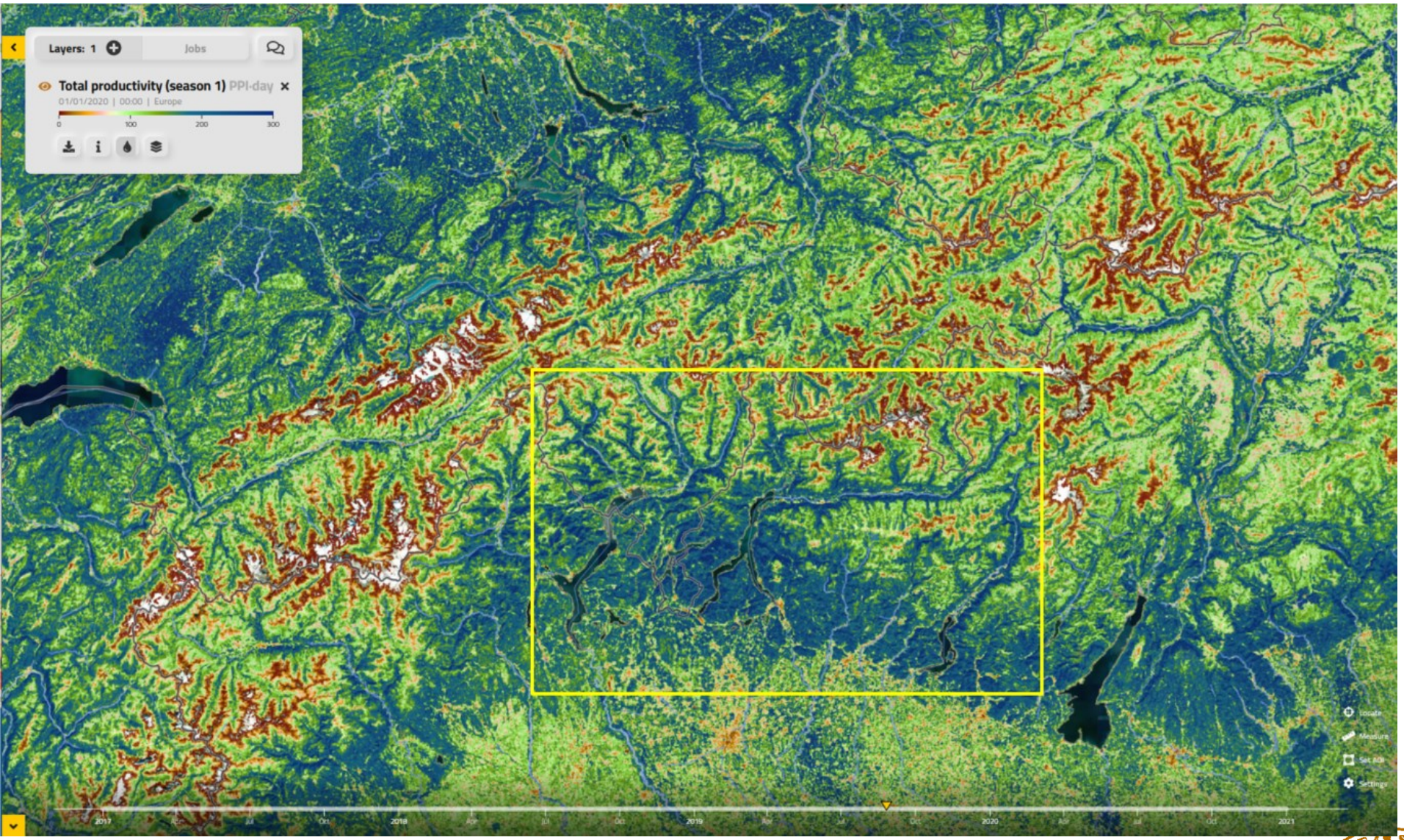
Phenology and Productivity from satellite



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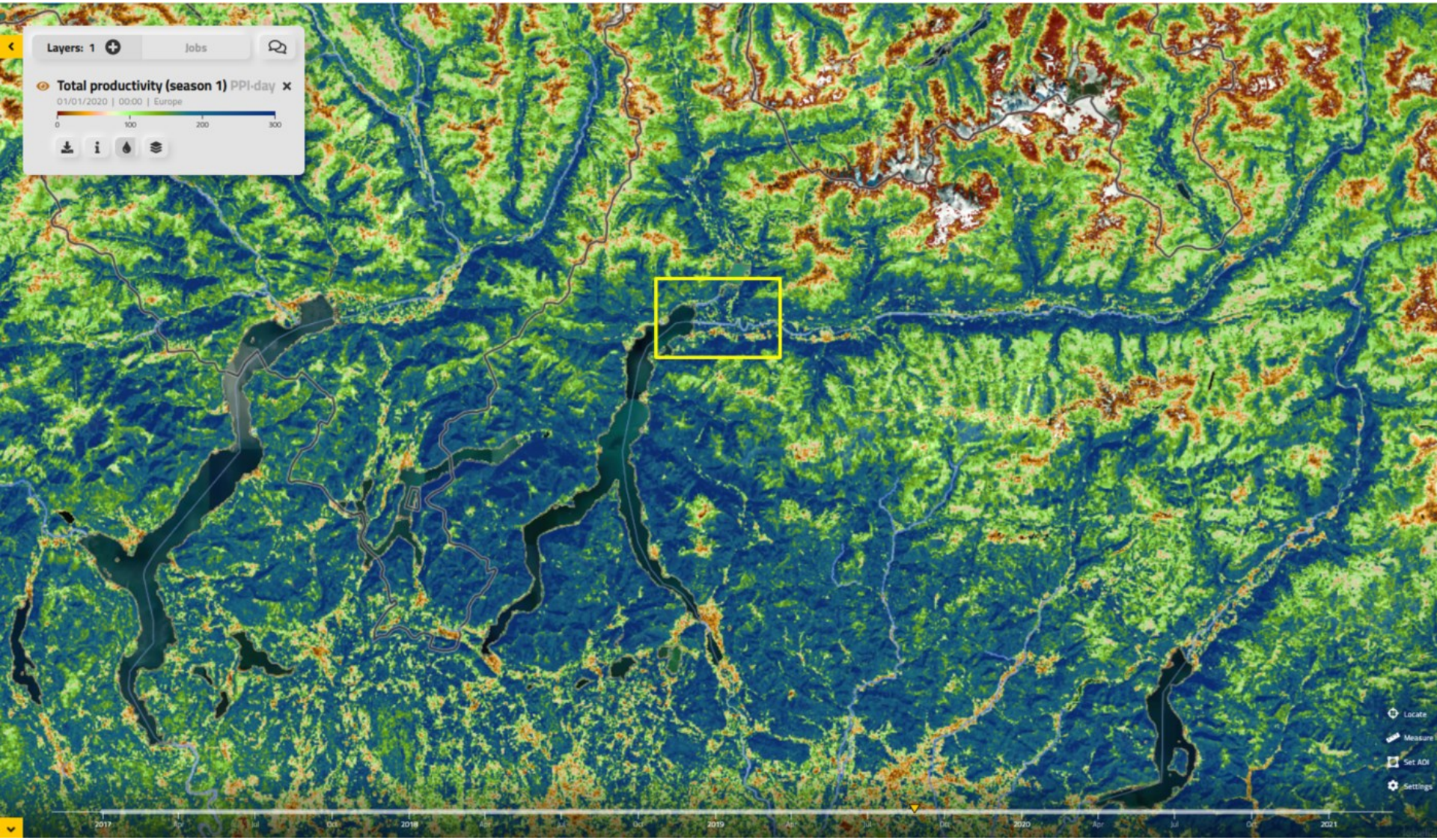

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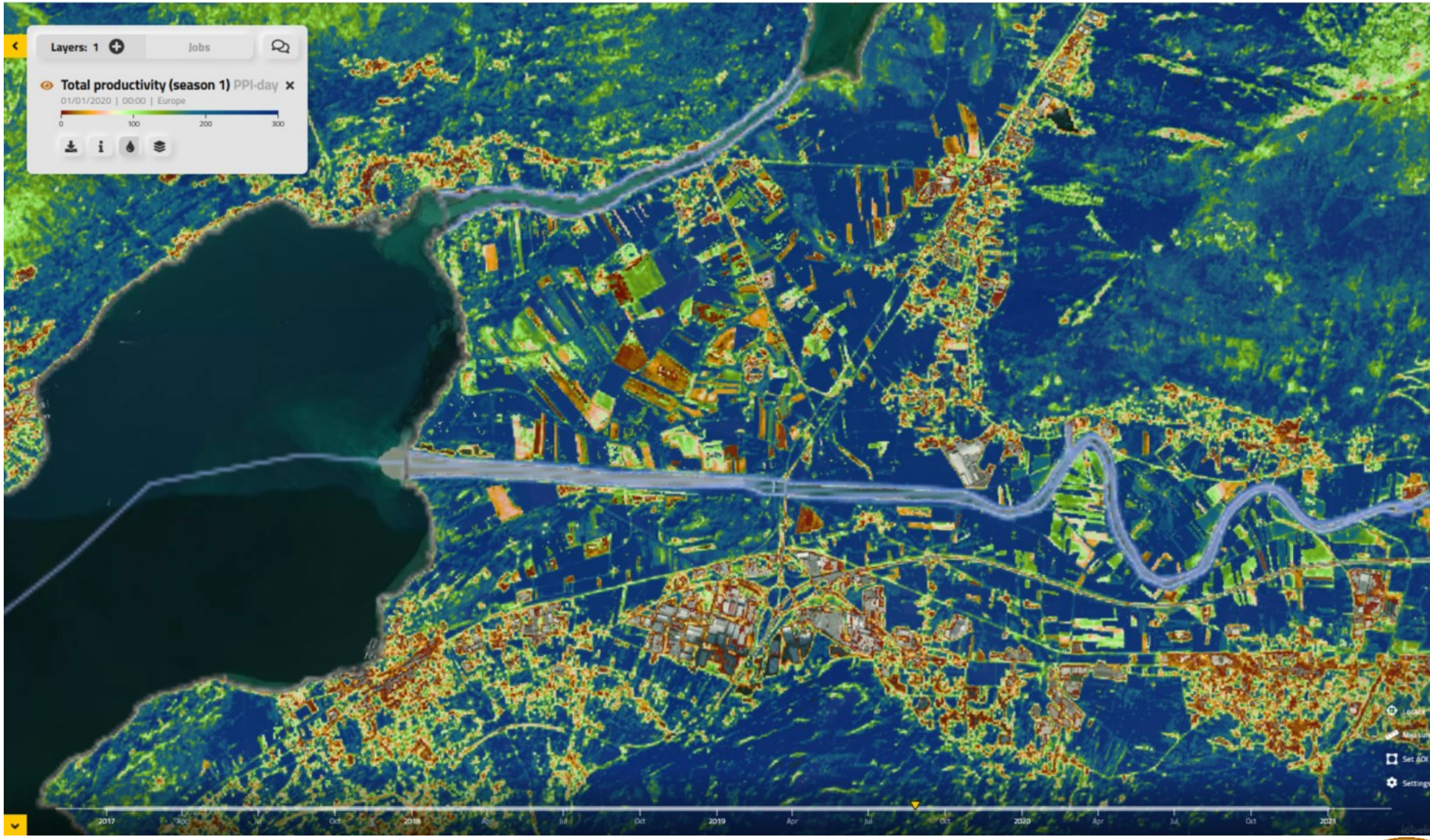
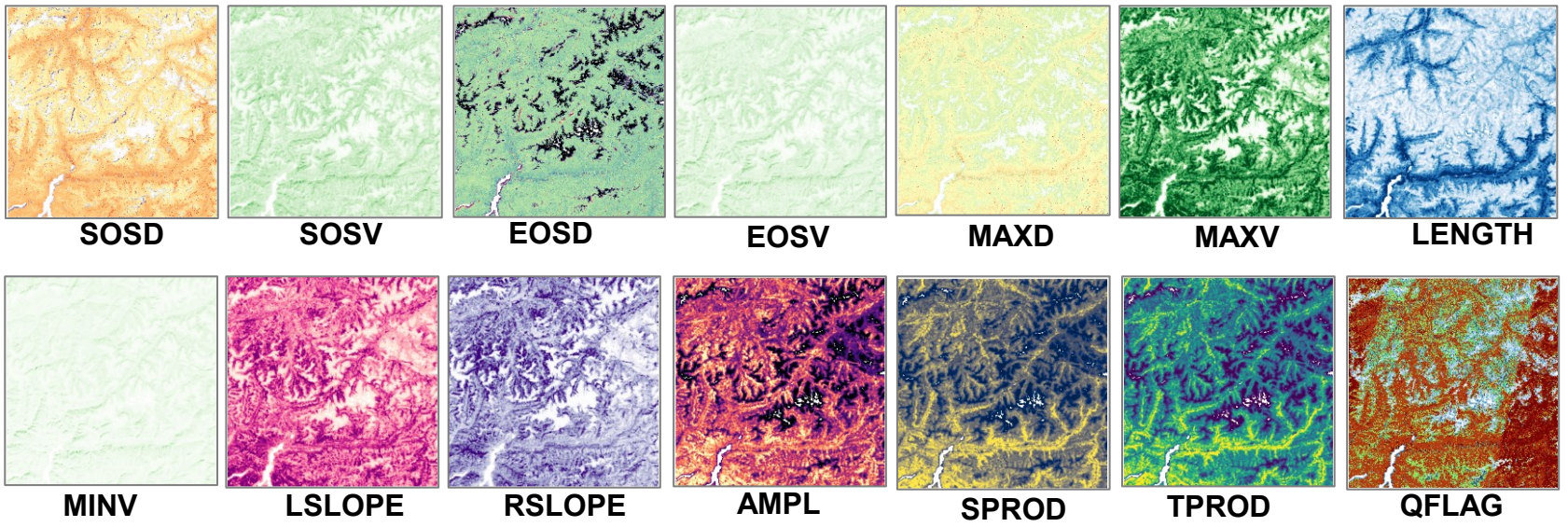
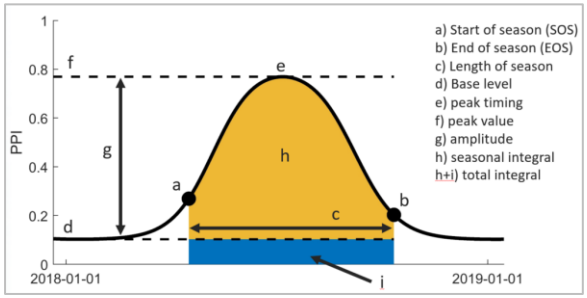
Phenology and Productivity from satellite

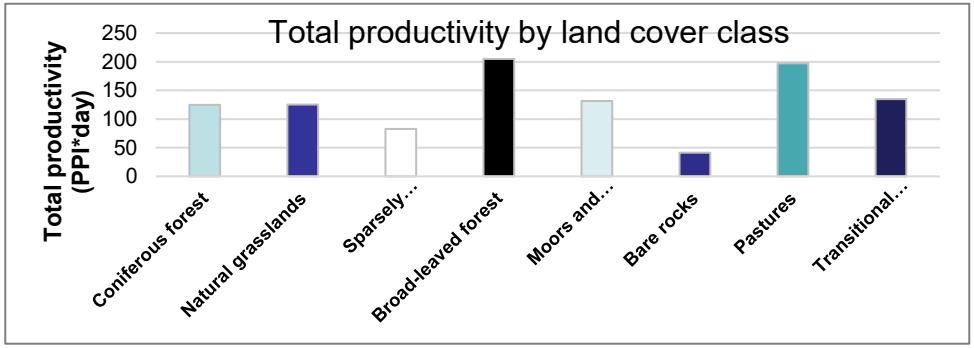


https://land.copernicus.eu/pan-european/biophysical-parameters/high-resolution-vegetation-phenology-and-productivity

Phenological parameters







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Start and End of Season Metrics

- **SOSD (Start Of Season Date):**
  The date (usually in day-of-year format) when the season starts, often defined as the point where the fitted curve rises above a specified percentage (e.g., 20%) of the seasonal amplitude during the green-up phase.
- **SOSV (Start Of Season Value):**
  The value of the time-series variable at the start of the season (SOSD).
- **EOSD (End Of Season Date):**
  The date when the season ends, defined as the point where the curve falls below the same threshold (e.g., 20% of amplitude) during the senescence phase.
- **EOSV (End Of Season Value):**
  The value of the time-series variable at the end of the season (EOSD).

Peak and Base Season Metrics

- **MAXD (Date of Maximum):**
  The date when the seasonal curve reaches its maximum value—representing peak vegetation greenness.
- **MAXV (Maximum Value):**
  The peak value of the variable during the season.
- **MINV (Minimum Value):**
  The minimum fitted value during the season, often representing the dormancy or off-season baseline.

Curve Shape and Season Dynamics

- **LSLOPE (Left Slope):**
  The rate of increase during the green-up phase (from SOS to peak). This indicates how rapidly vegetation develops at the start of the season.
- **RSLOPE (Right Slope):**
  The rate of decrease during the senescence phase (from peak to EOS). This reflects how quickly vegetation declines after peak growth.
- **AMPL (Amplitude):**
  The difference between MAXV and MINV. It measures the seasonal signal's strength or greenness contrast.

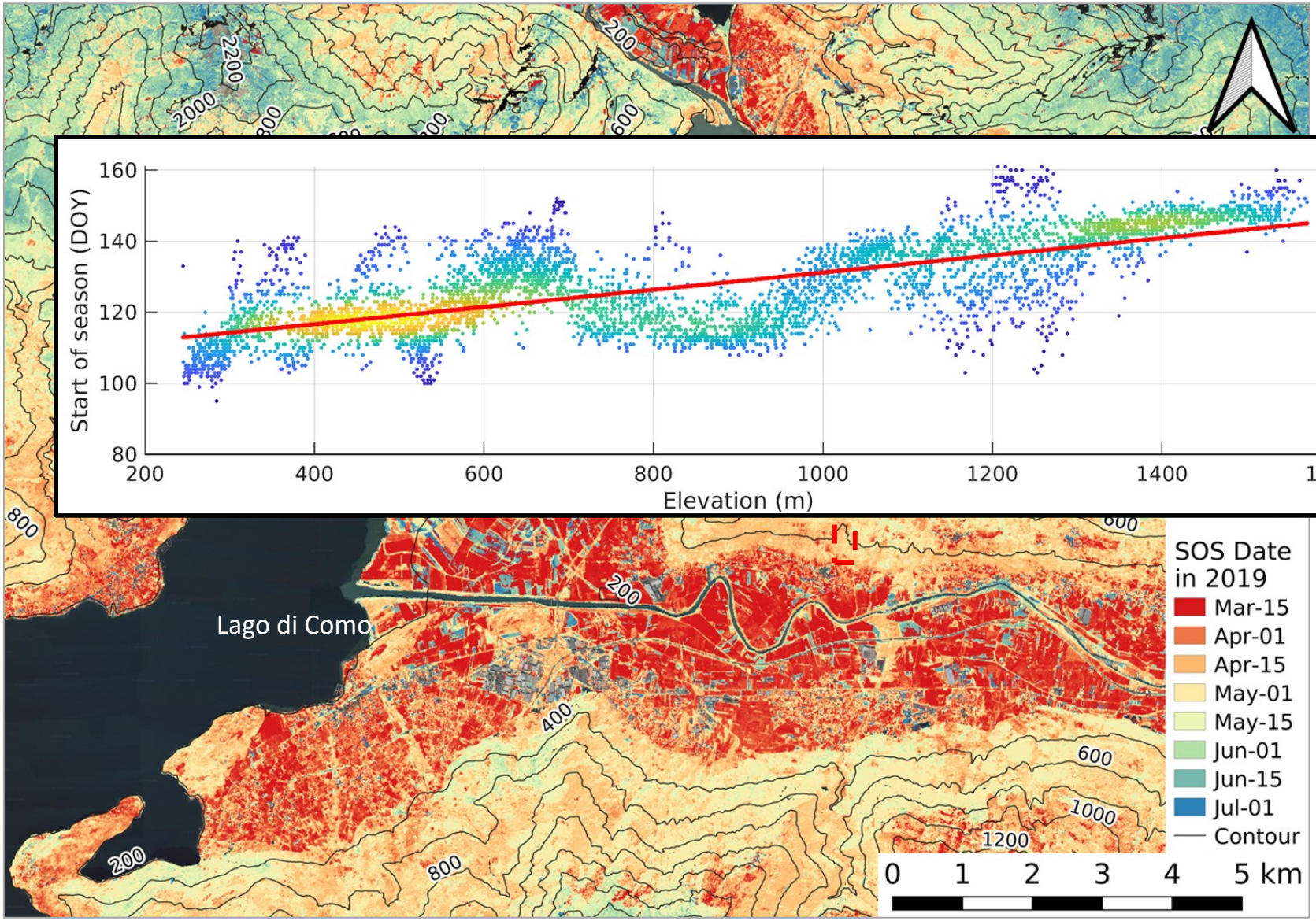
Productivity Indicators

- **SPROD (Seasonal Productivity):**
  The integral (area under the curve) between the season start and end dates. It approximates the productivity of the land surface during the growing season.
- **TPROD (Total Productivity):**
  The integral over the entire year (or time-series length). It captures cumulative productivity, including multiple growing seasons if present.

Quality Information

- **QFLAG (Quality Flag):**
  A binary or categorical flag indicating the quality or reliability of the seasonal metrics. It may denote poor curve fitting, excessive noise, or missing data.

Start of season date



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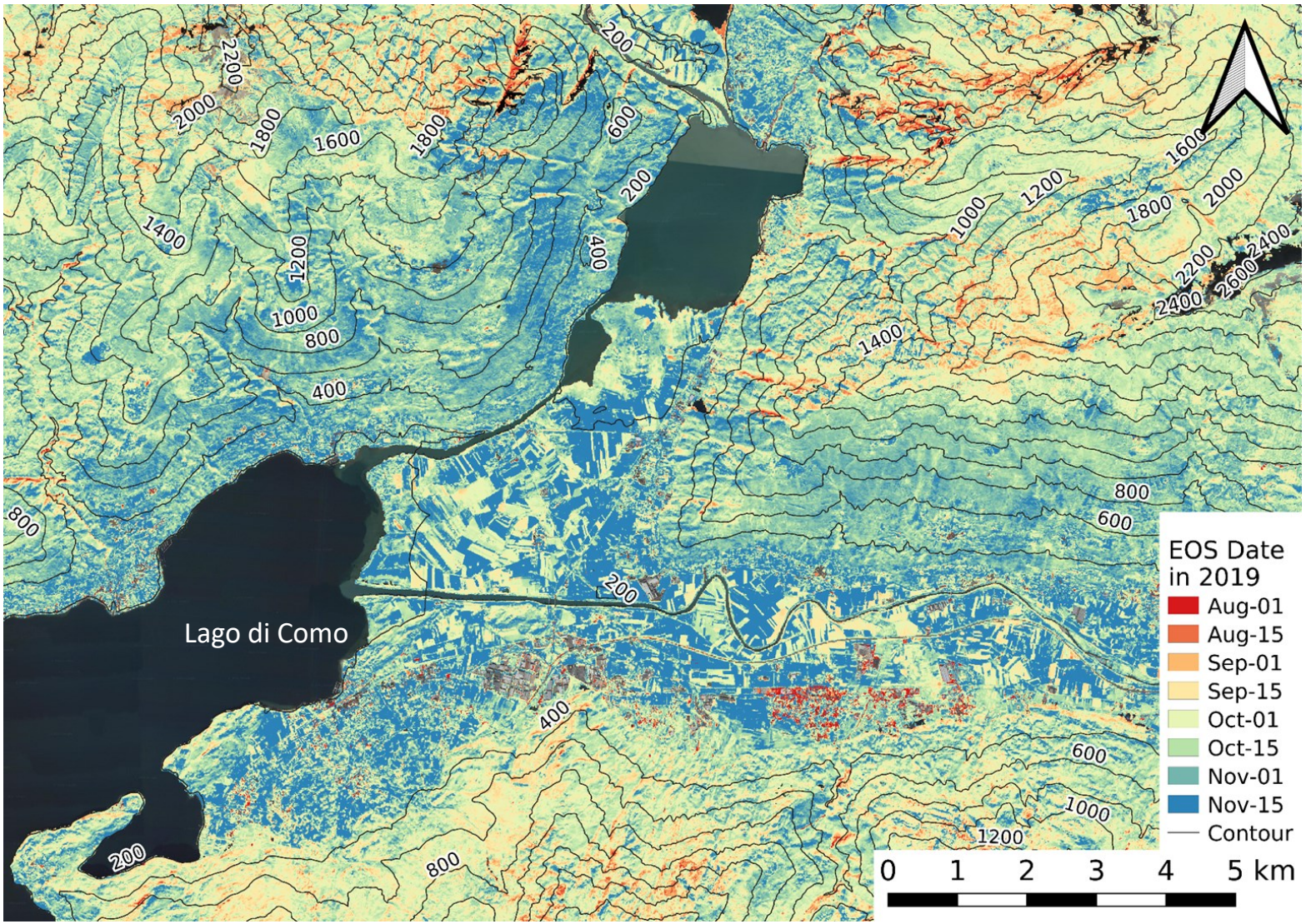
End of season date



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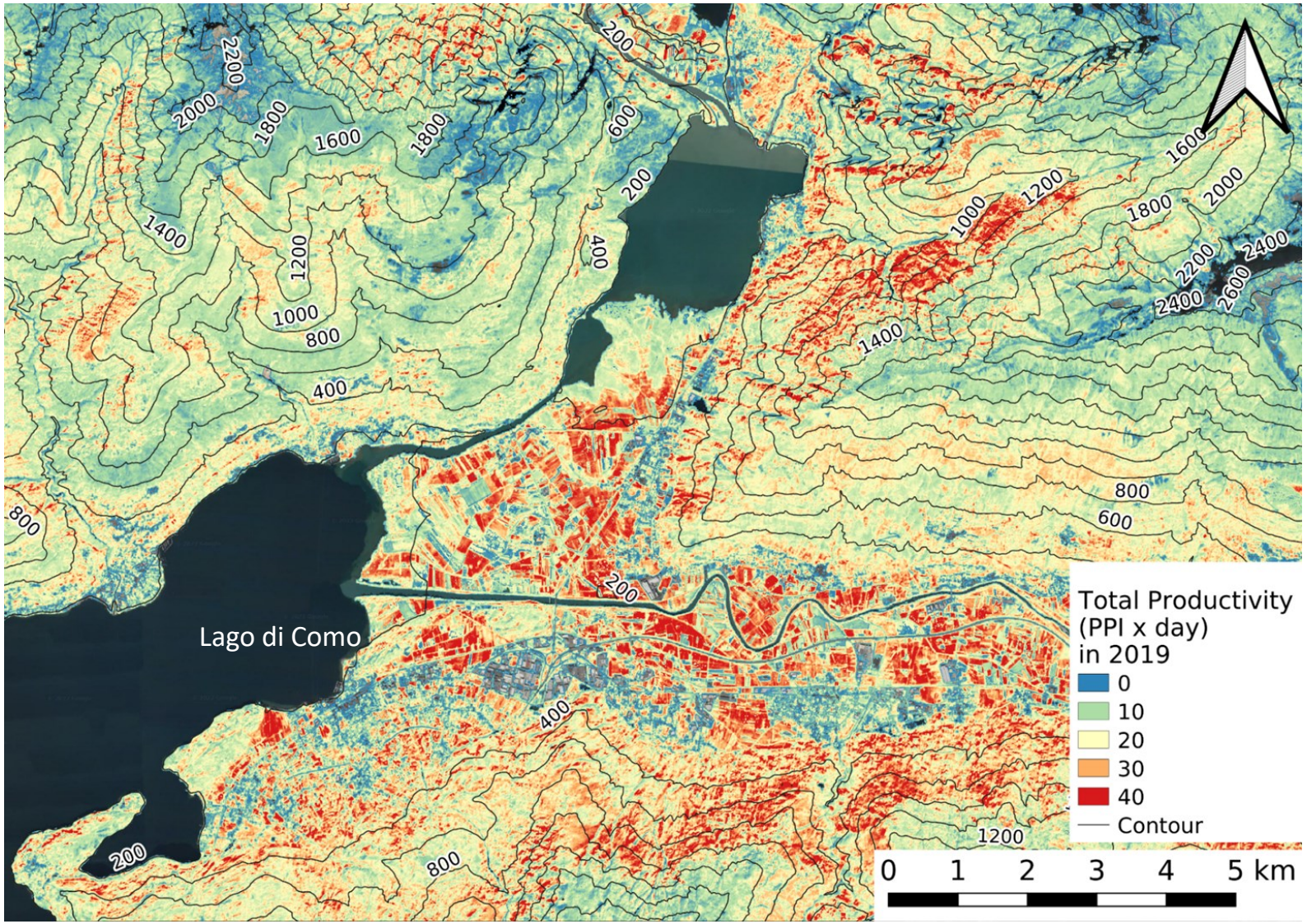
Total productivity



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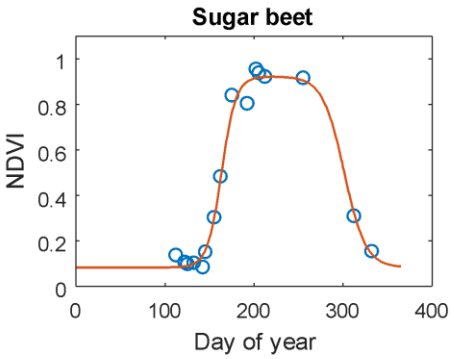
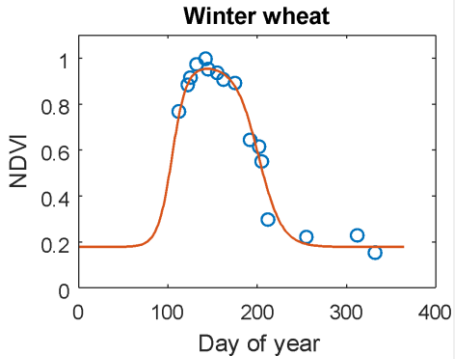
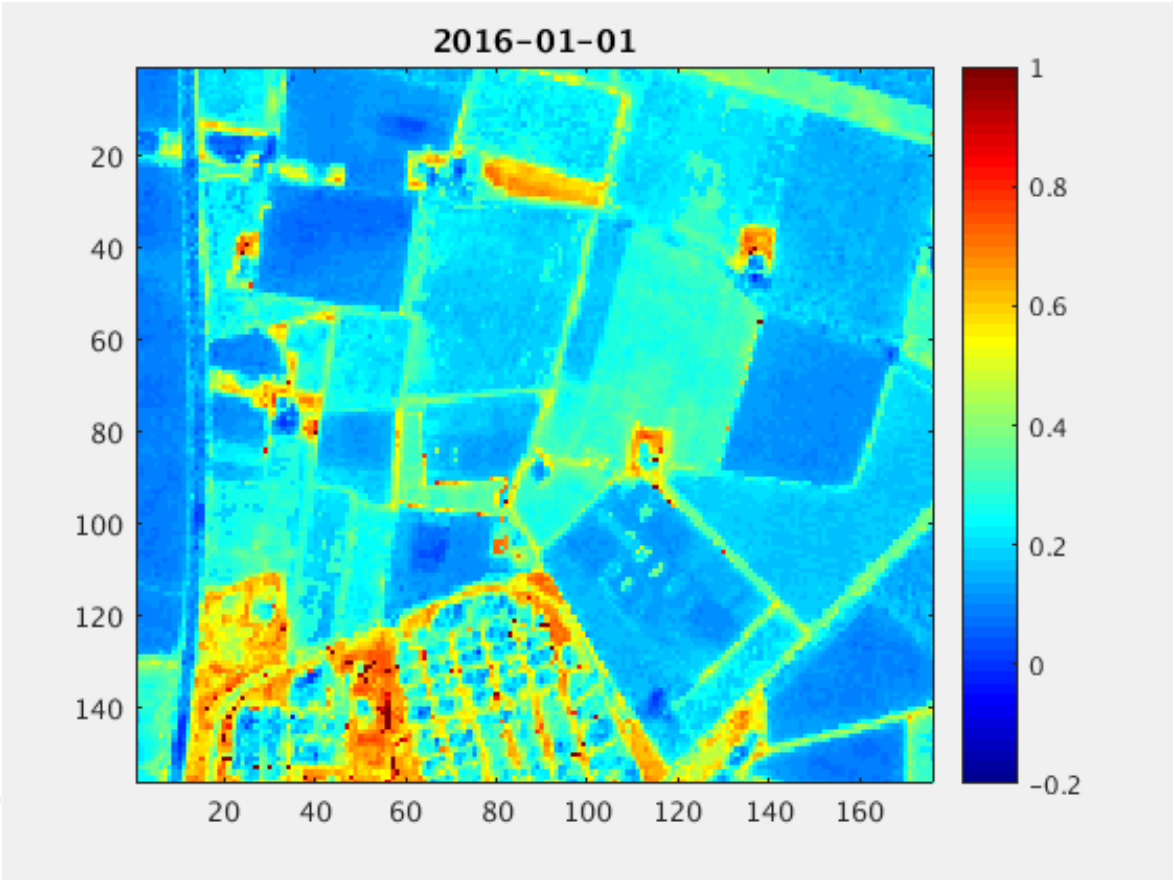
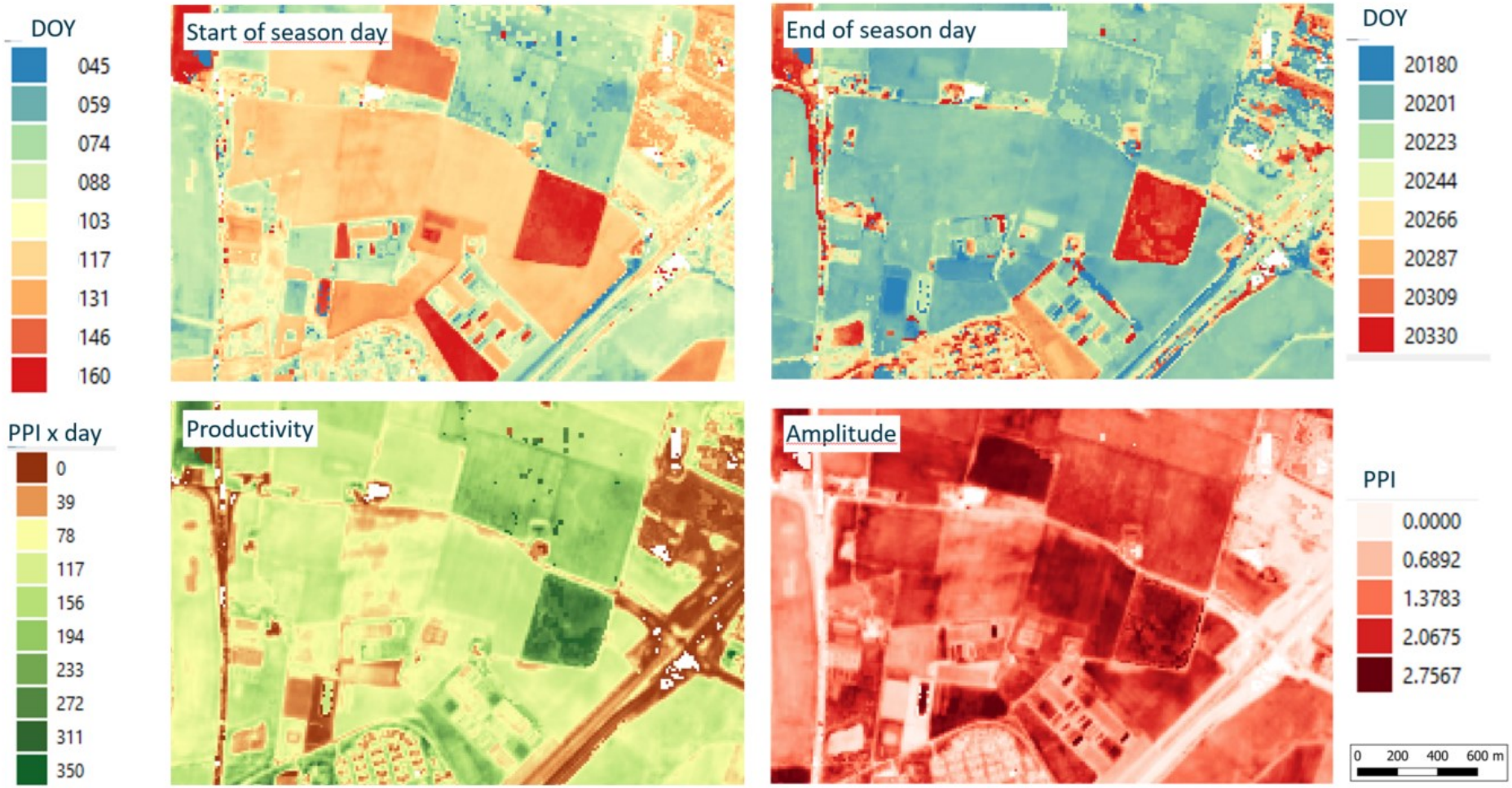
Agricultural development from satellite



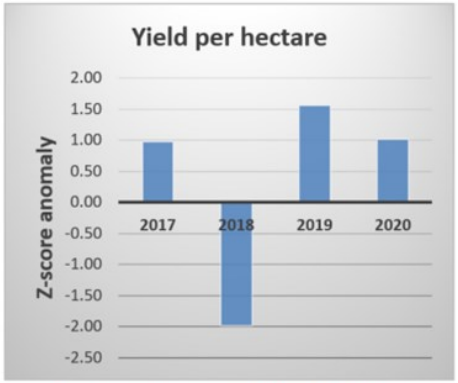




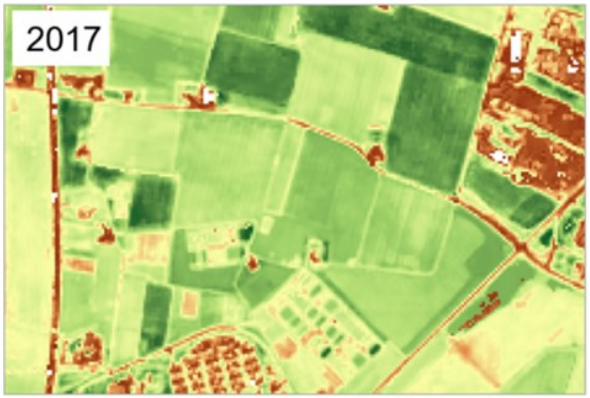
Phenological parameters at field scale

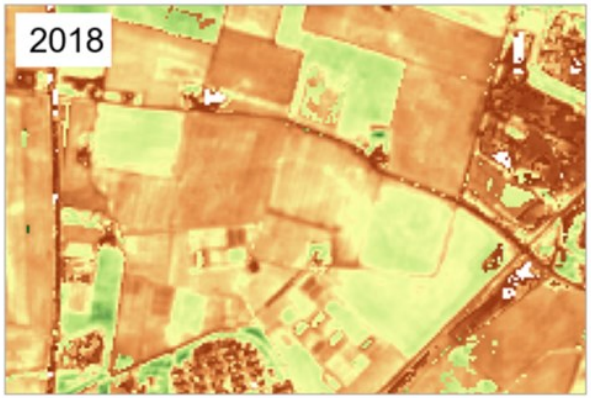


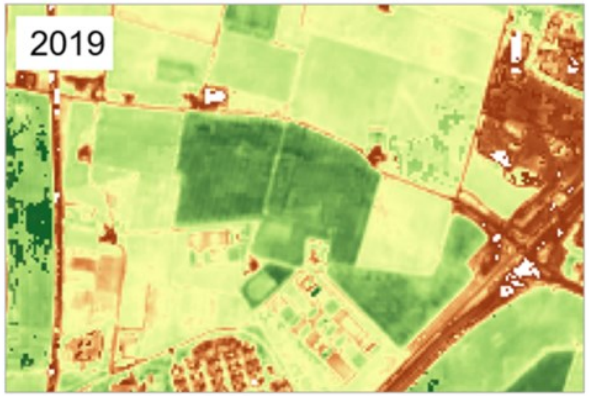
Annual productivity

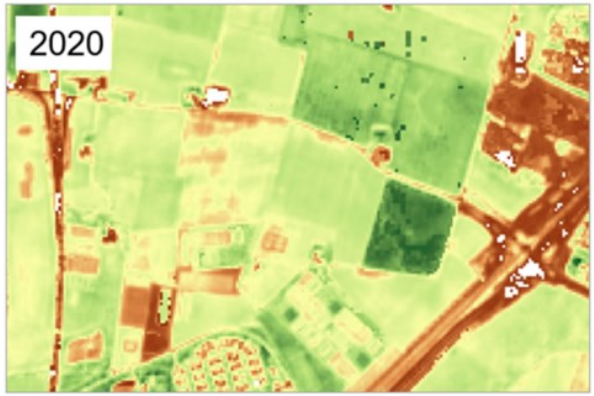


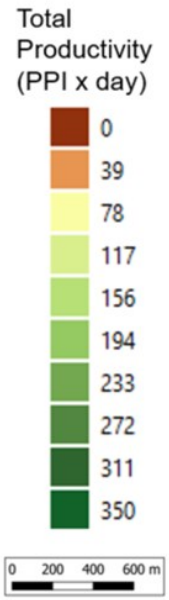
Regional crop yield statistics











Geo-Academy Summer School 2025

Practical exercise 1

Forest management in South America

*in **Google Earth** and **Global Forest Watch***

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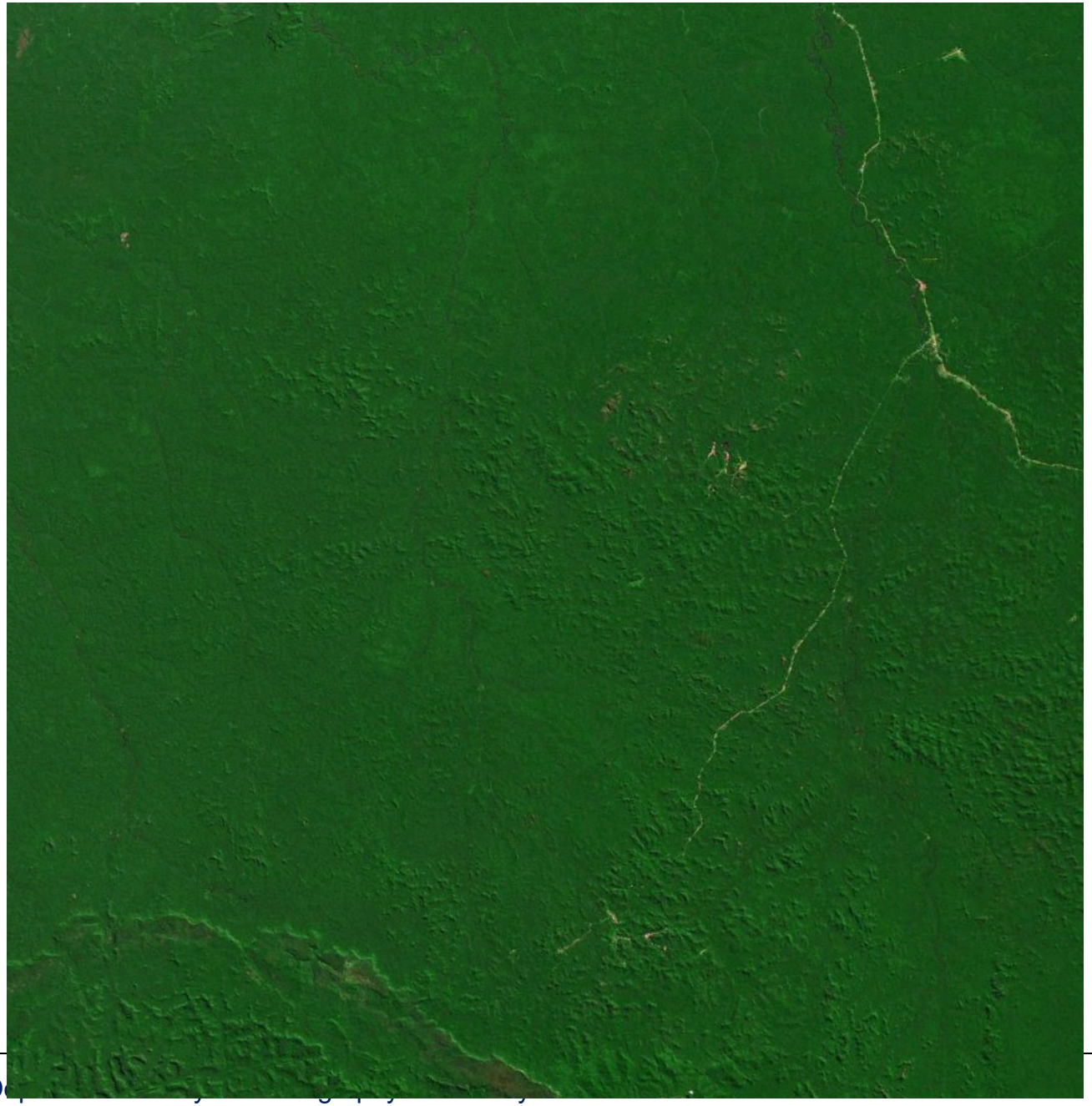
Forest in South America

Source: Google

Deforestation – Rondonia (Brasil)



juni 1975

juli 1989

sep 2001

aug 2008

Source:
Google maps

Deforestation – Rondonia (Brasil)

juni 1975

juli 1989

sep 2001

aug 2008

Källa:
Google maps

Deforestation – Rondonia (Brasil)

juni 1975

juli 1989

sep 2001

aug 2008

Källa:
Google maps

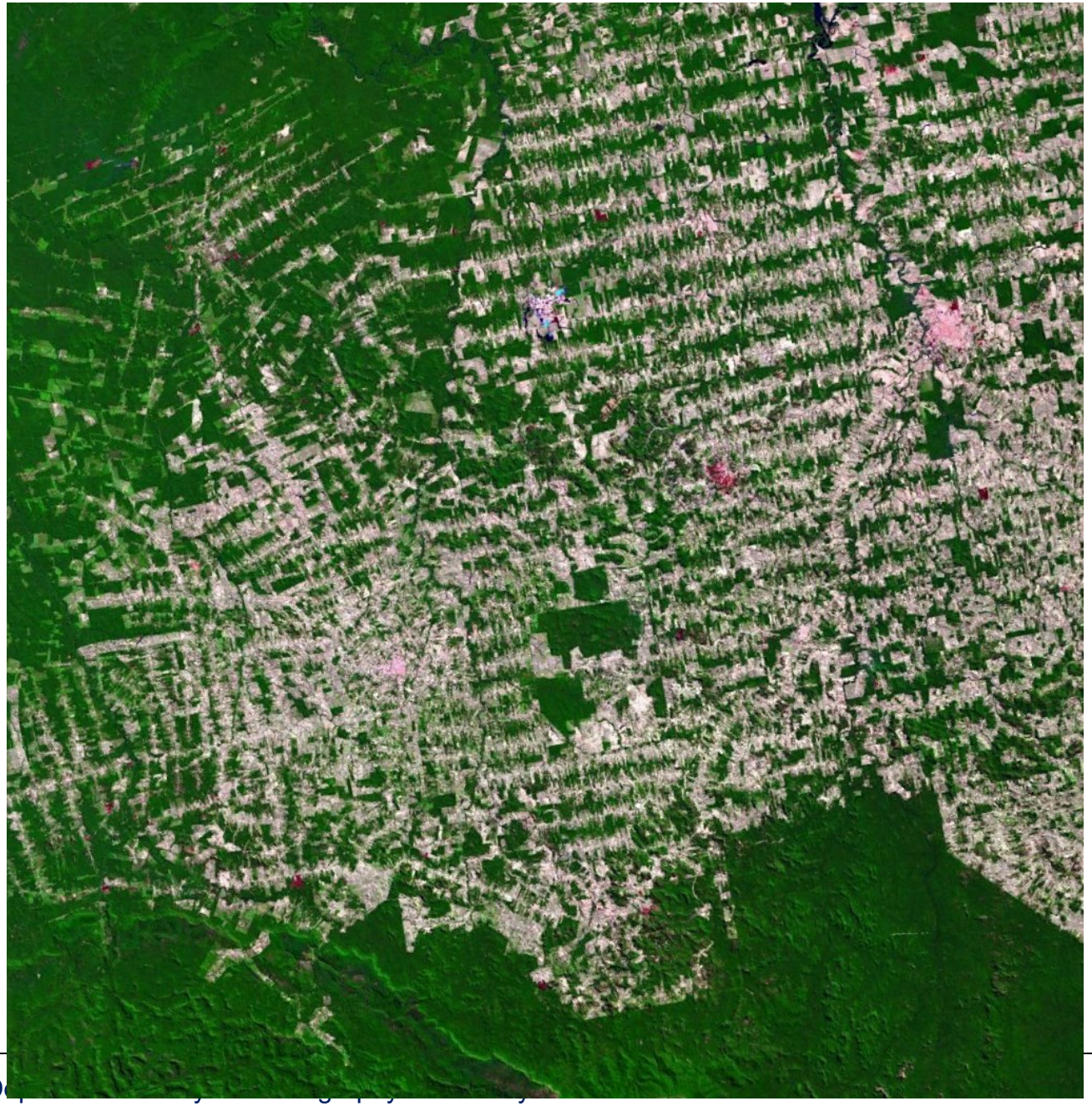
Deforestation – Rondonia (Brasil)

juni 1975

juli 1989

sep 2001

aug 2008



Källa:
Google maps

Geo-Academy Summer School 2025

Practical exercise 2

Vegetation dynamics in Europe

in on data viewer of the

Copernicus Land Monitoring Service

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Vegetation dynamics in Europe

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Monitoring Service