ISA

Vegetation Monitoring with UAVs and LiDAR

Module 3: Optical and Spectral Sensors for vegetation monitoring

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OLÁ!

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Practical Work

Monitoring Phenology through photographs

General Rules:

- **Groups:** The work must be carried out in groups of 3 students. Groups should be formed during the first class of the module (20/05/2026)
- **Evaluation:** The assignment will account for **30% of the final grade**, the assessment will be based on the submission of a document (**70%**) and (**30%**):

  -**oral presentation** (03/06/2026) or

  -**in class "offline" activity** (01/06/2026)

Students can participate in both activities only the best score will be considered

The practical work must be submitted by **12/06/2026** in **PDF format** on the **Fenix platform**.
Students must also attach the **R script** used to perform the analysis

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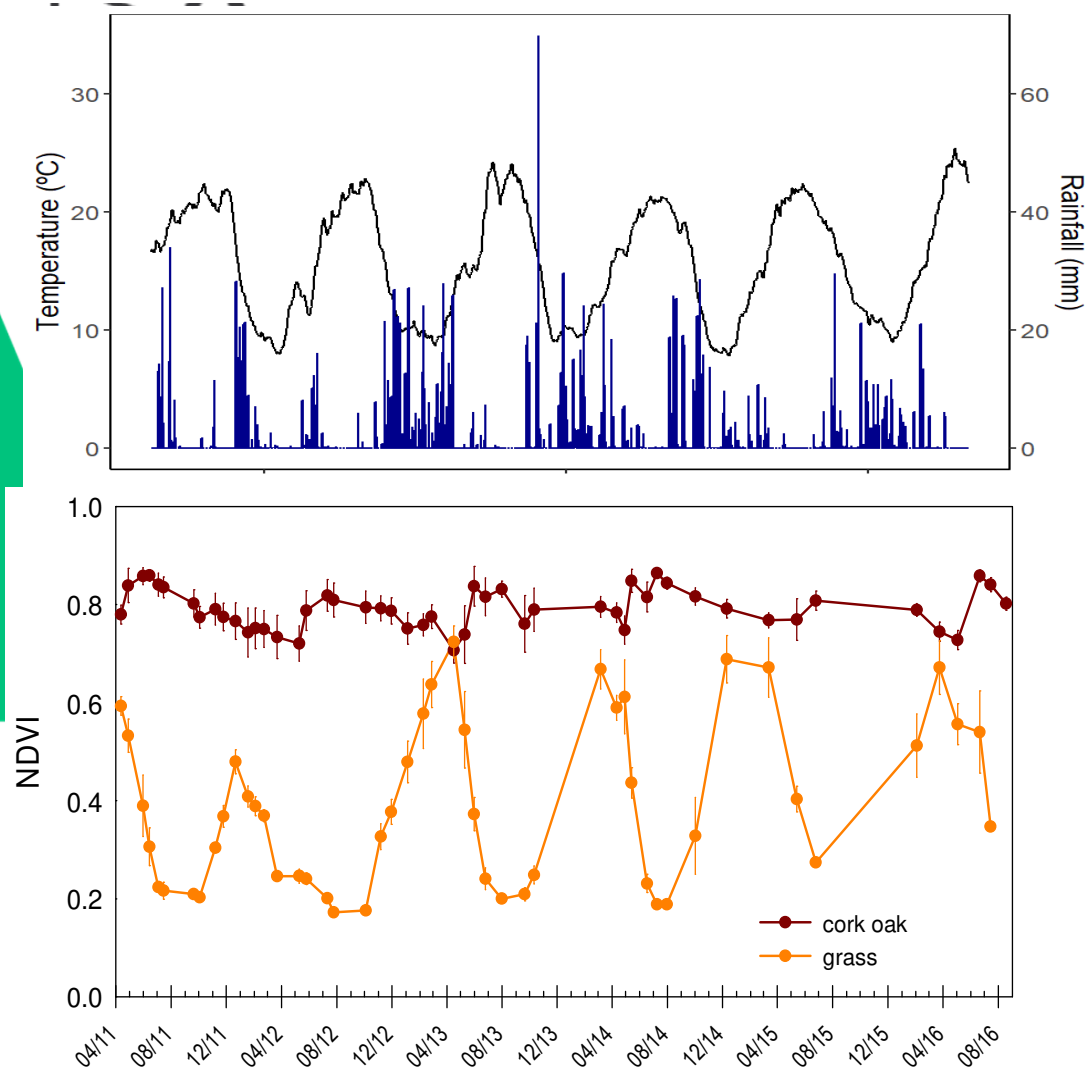
- TIME SERIES FOR MONITORING VEGETATION DYNAMICS
- METHODS AND STEPS IN PHENOLOGY STUDIES
- THE PHENOCAM NETWORK

LECTURE 1 -20/05/2026

WHY TIME SERIES?



Observe differences between trees and grass. Can you identify any seasonal trend? Any difference among years?

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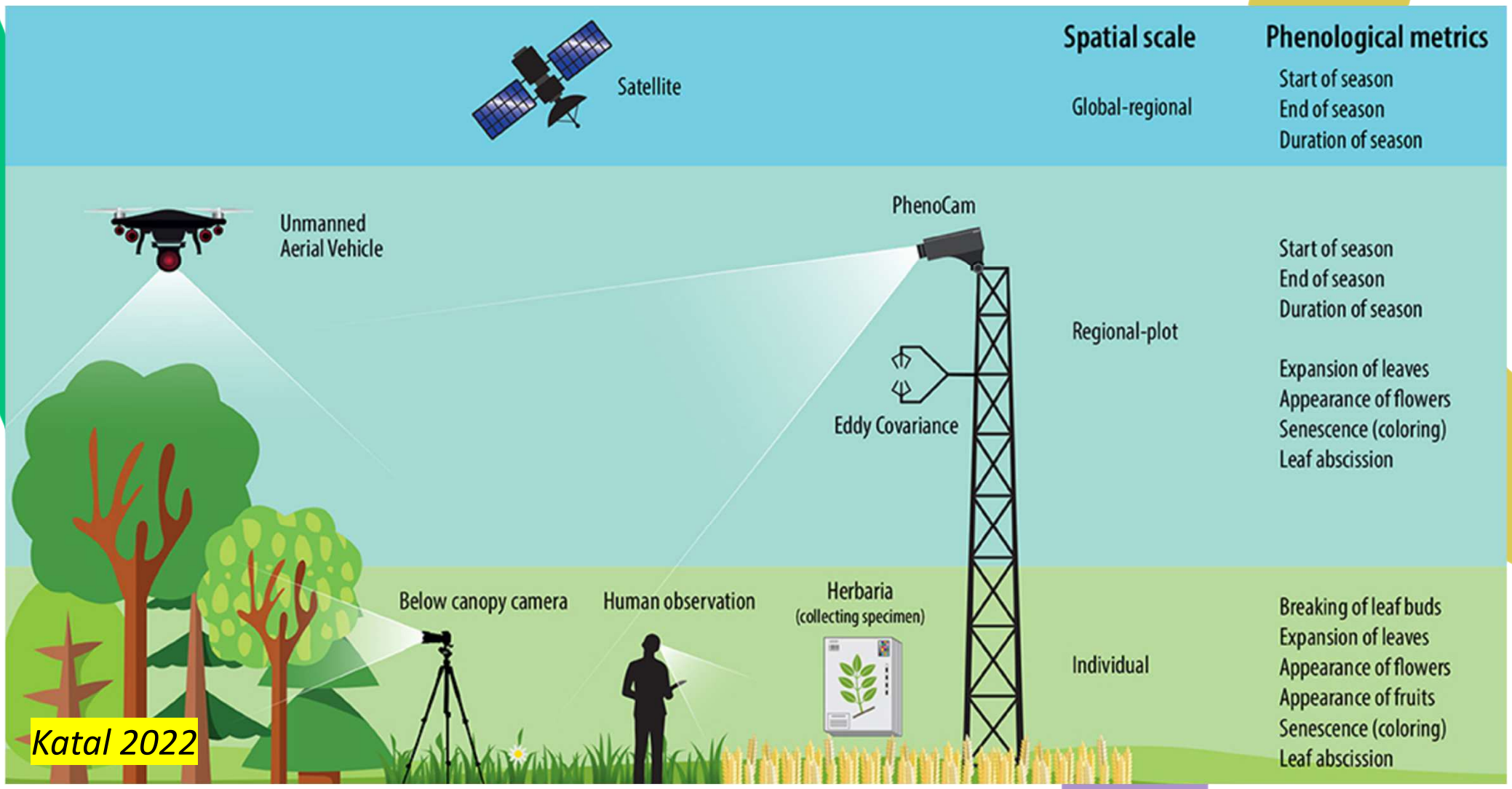
https://www.youtube.com/watch?v=_4uHLXL1yZA

DATA COLLECTION FOR PHENOLOGY STUDIES



Methods differ in: target, temporal resolution, phenological metrics

ROI: region of interest

HOW TO USE TIME SERIES OF DIGITAL PHOTOGRAPHS FOR PHENOLOGY STUDIES

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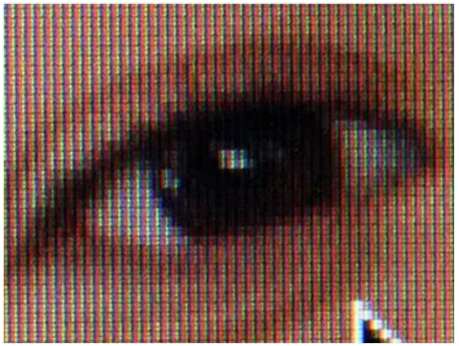

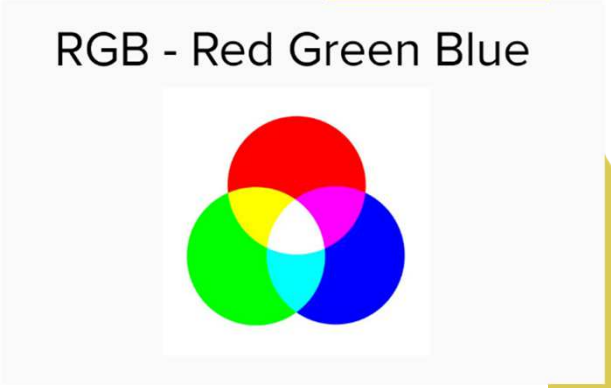

In digital images every pixels is composed of red, green and blue dots.

QUANTITATIVE ANALYSIS OF DIGITAL IMAGES

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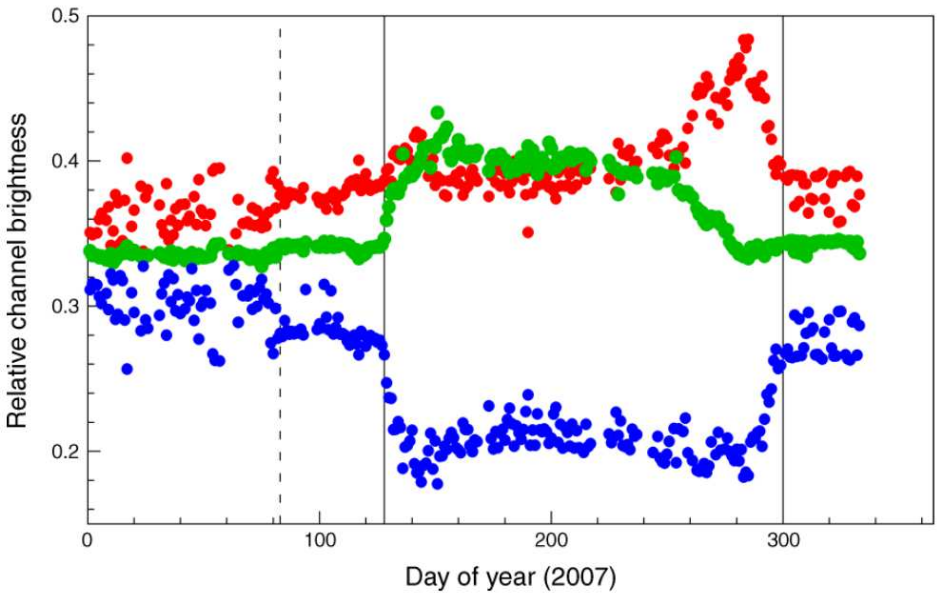
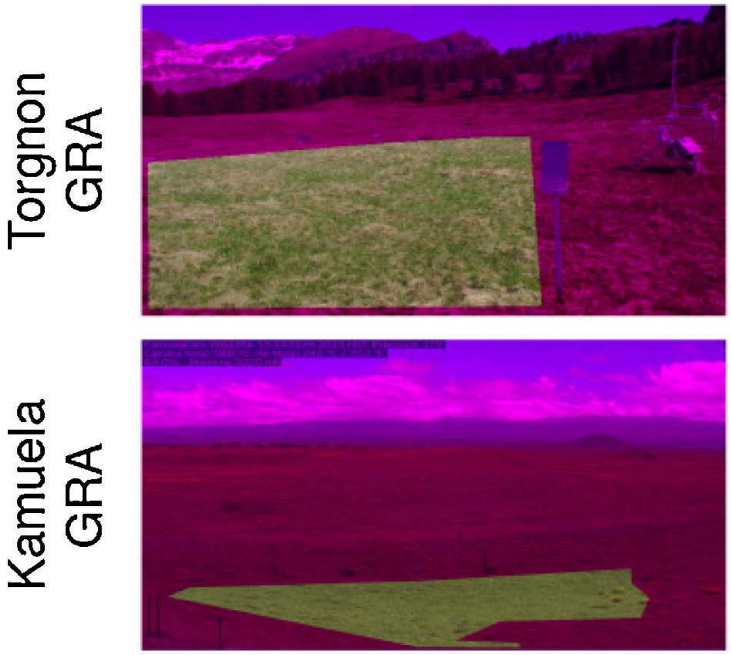
$$GCC = \frac{G}{R + G + B}$$

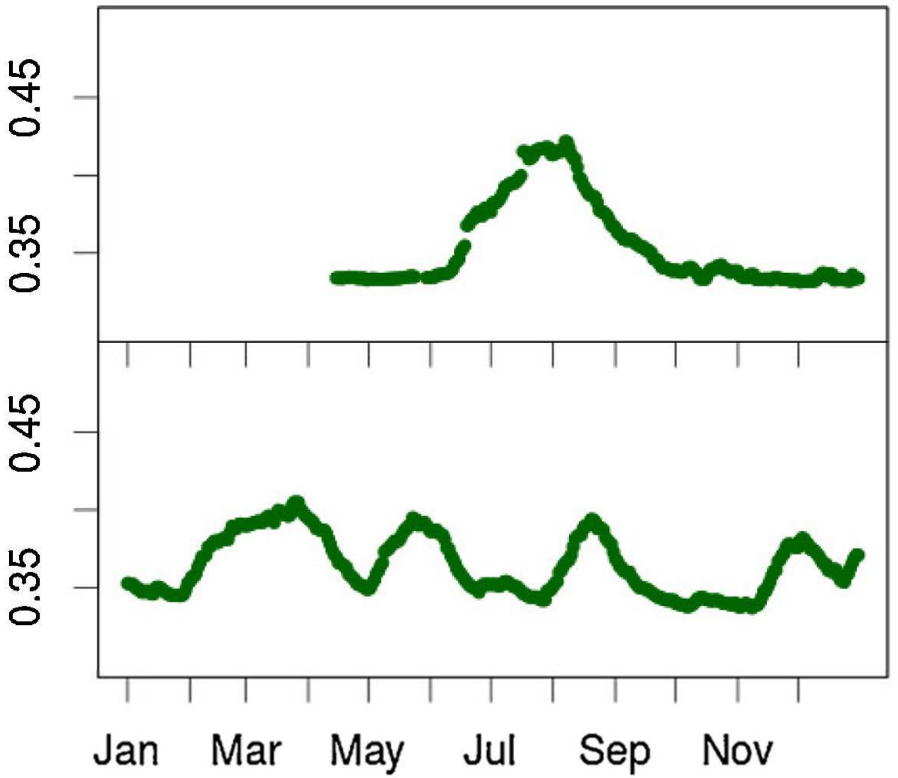


The phenopix package (R) quantifies the amount of red, green and blue dots in time-lapse digital photographs and returns and index: Green Chromatic Coordinates (GCC)

Brightness **(R + G + B)** is used to normalize light conditions

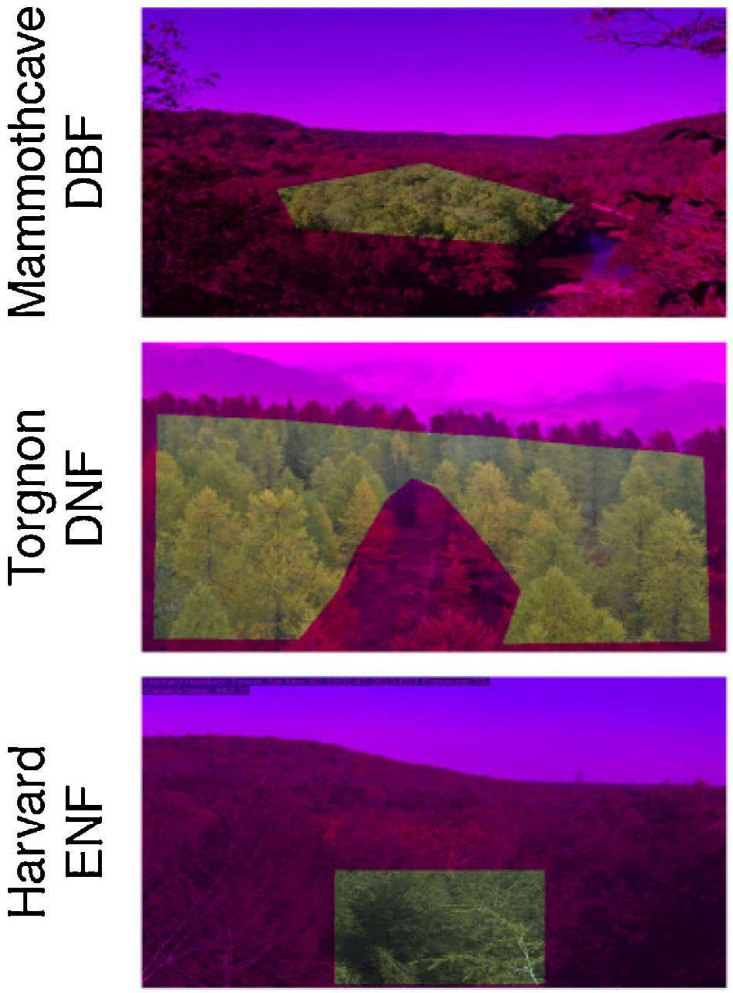
THE *PHENOPIX* PACKAGE

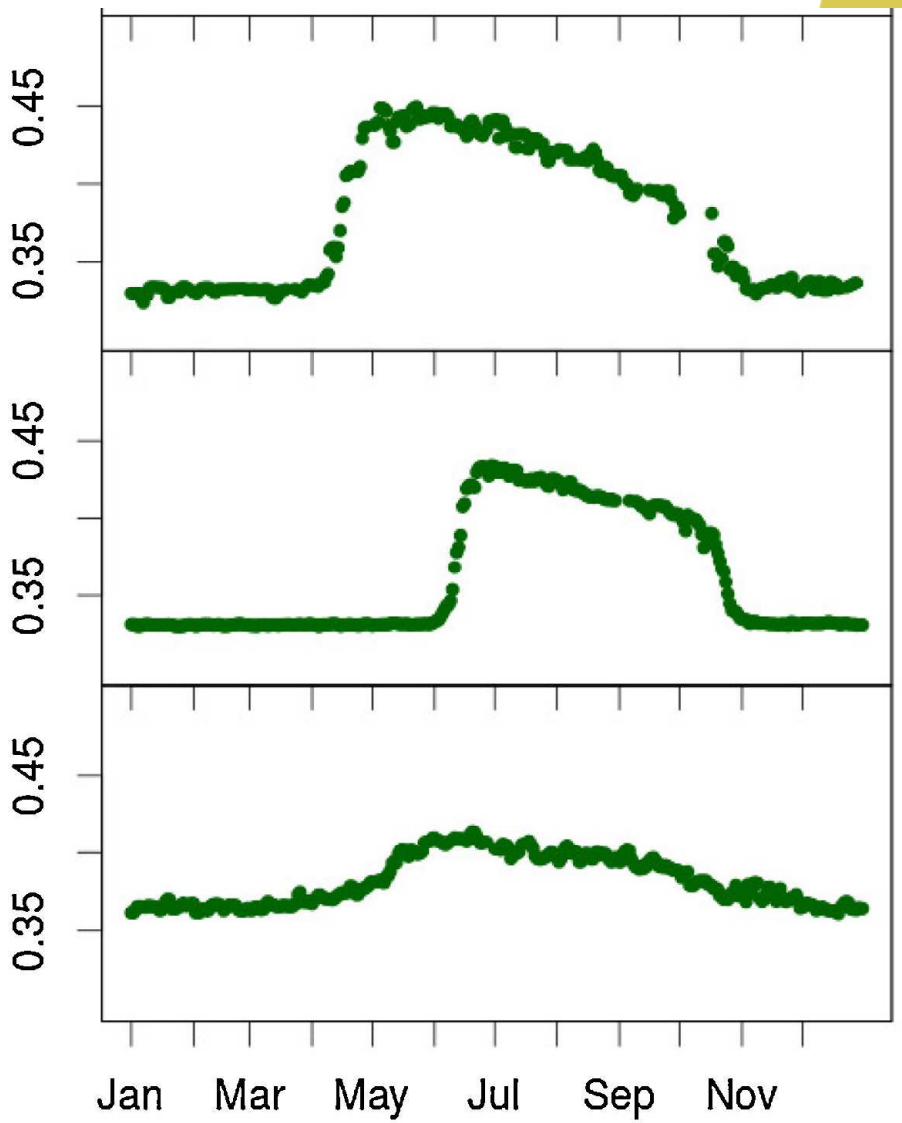




Torgnon- subalpine grassland

Kamuela – tropical grassland

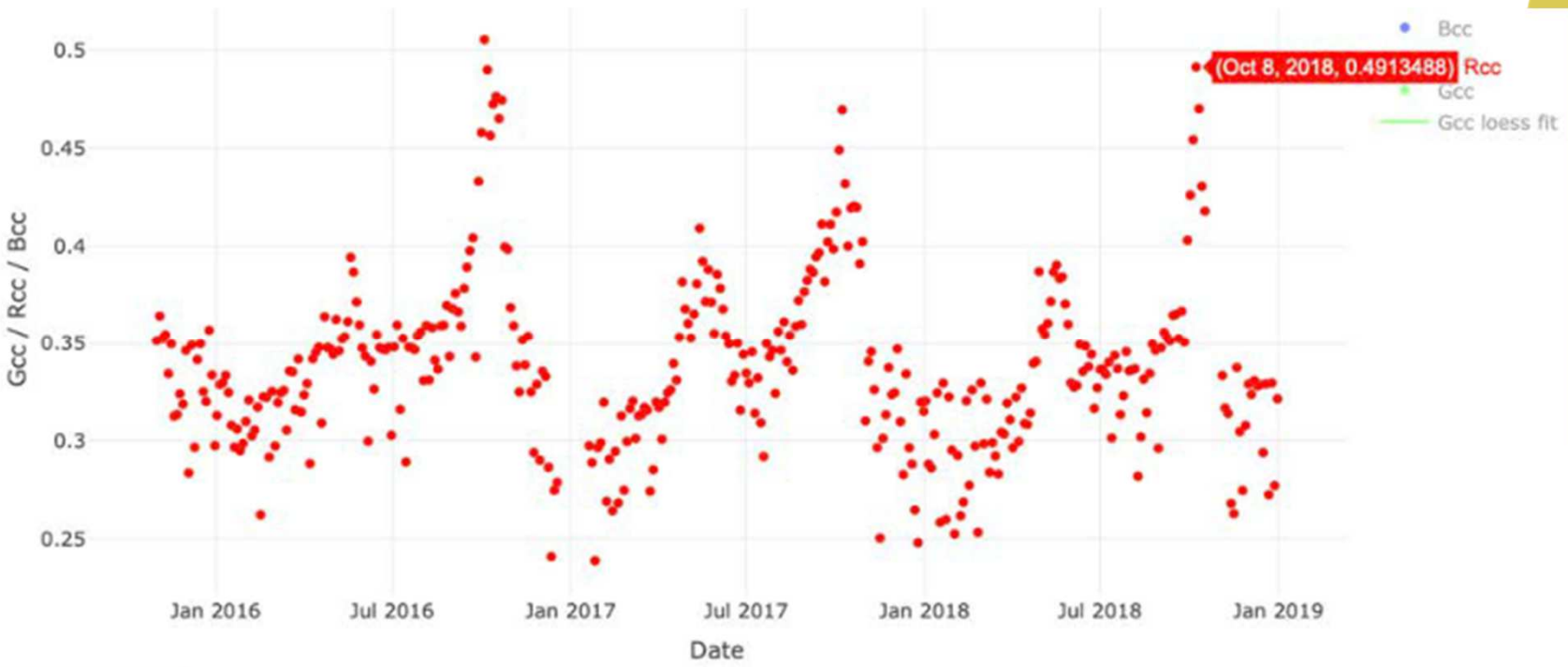




DBF: Deciduous Broadleaf Forest

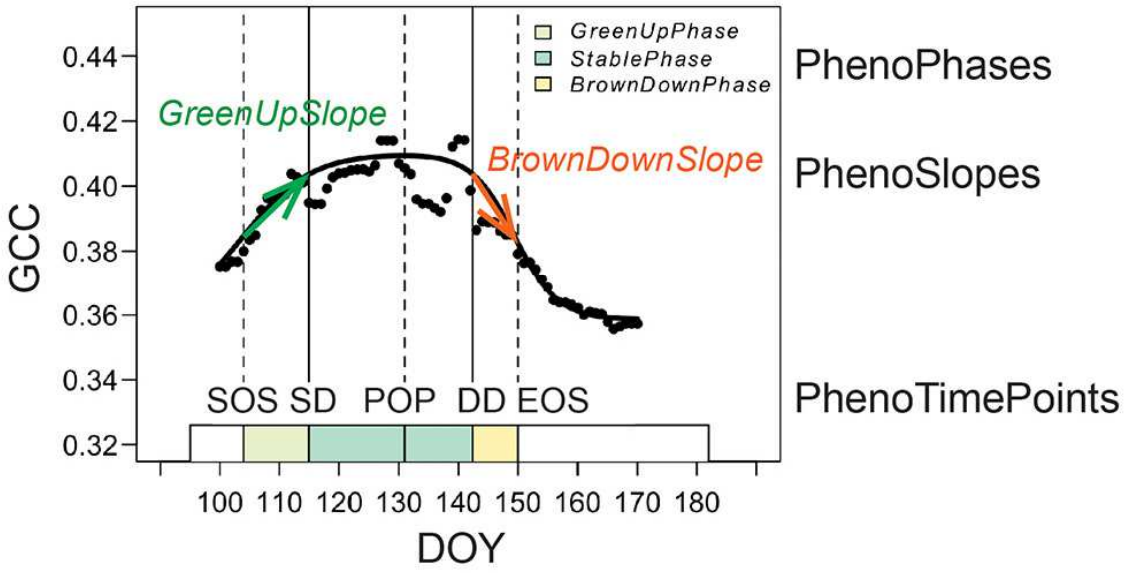
DNF: Deciduous Needle Forest

ENF: Evergreen Needle Forest



Sometime is also useful look to the RCC index, for example in spring when new leaves emerge and in autumn before leaf shedding

From images → to seasonal GCC & phenology



Liu et al. 2022

SOS: Start of the season

EOS: End of the season

LOS: Length of the Growing season LOS = EOS – SOS

POP: Position of peak greenness

THE ANALYSIS OF TIME SERIES ALLOWS TO EXTRACT PHENOLOGY TRANSITION DATES

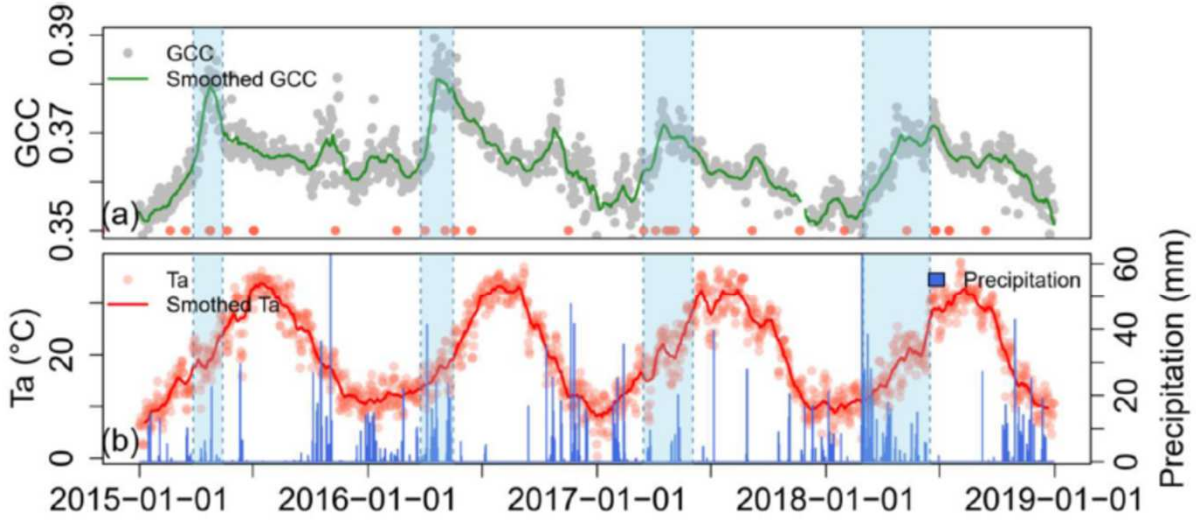


Fig. 1. Variation of (a) daily PhenoCam green chromatic coordinate (GCC) for evergreen oak trees, (b) daily mean temperature (Ta), and precipitation in the study area. The red dots in panel a) indicate the dates when leaf traits were measured. GCC and Ta time series were smoothed with a 20 days average moving window. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

1) Collect observations (grey dots)
2) Extract trends (green line)
3) Extract phenological metrics
4) Analyze seasonal and interannual trends

STEPS IN PHENOLOGY STUDIES

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Work Structure (70%)

1. **Identification** – Title, group members, course and ISA identification.
2. **Introduction** – Presentation of the vegetation and region selected.
3. **Methods** – Summary description of the methodology applied, detailing the steps taken in the analysis.
4. **Graphical Presentation of Results**
5. **Concise Discussion of the Results**
6. **Sources:** Cite any data source, method or document used to realize the work.

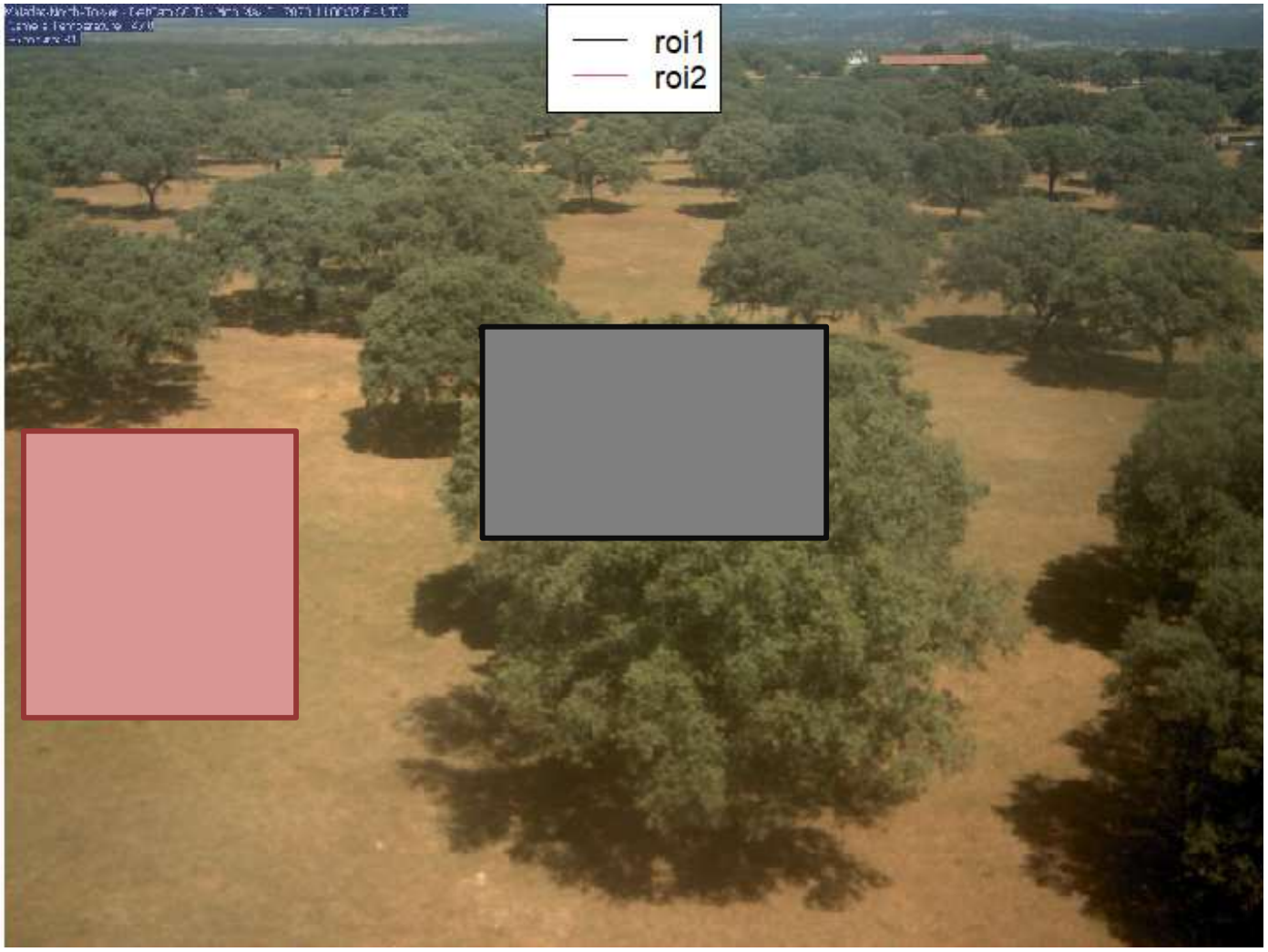
- PHENOPIX: INSTALL AND RUN THE TRAINING SET.
- HOMEWORK: SELECT A SITE AND DOWNLOAD PHOTOGRAPHS FROM THE PHENOCAM NETWORK

LECTURE 1 - PRACTICE

THE PHENOPIX PACKAGE

The phenopix package provides functions to:

1. Process digital images
2. Depict greenness index temporal trends
3. Extract relevant phenological stages



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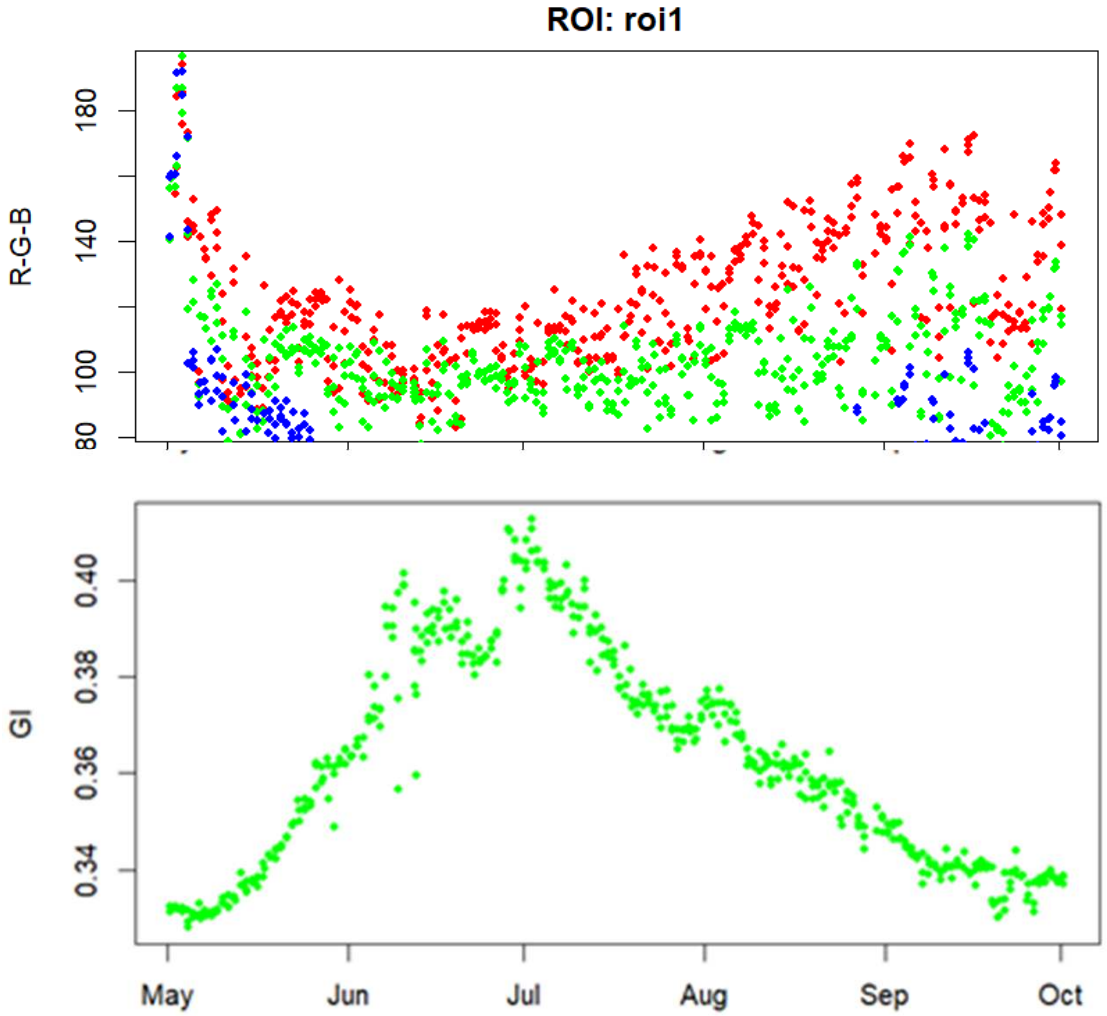
1. PROCESS DIGITAL IMAGES

DrawMULTIROI - Define one or more ROI on one single reference image (in the REF folder)



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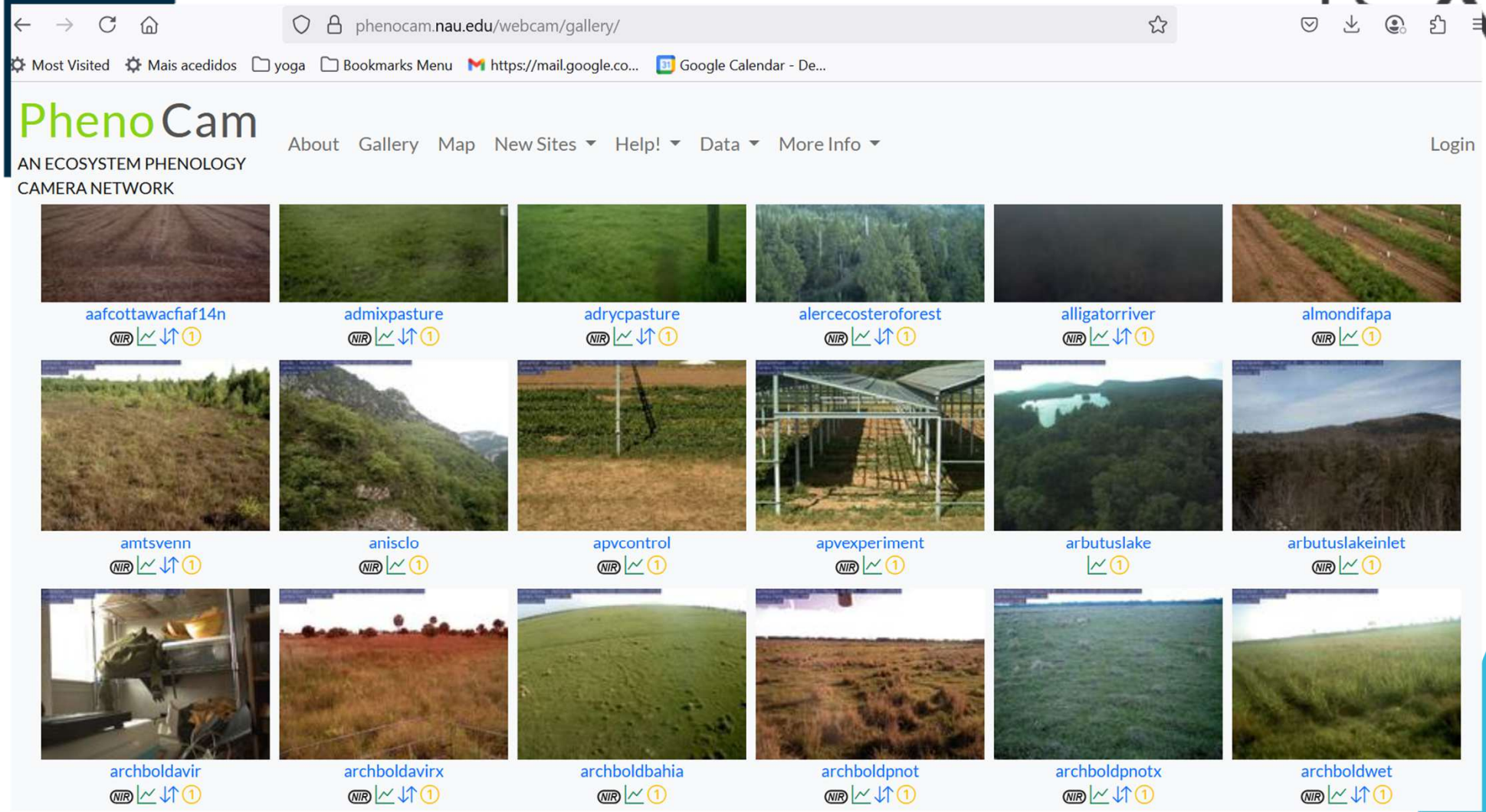
$$GCC = \frac{G}{R + G + B}$$

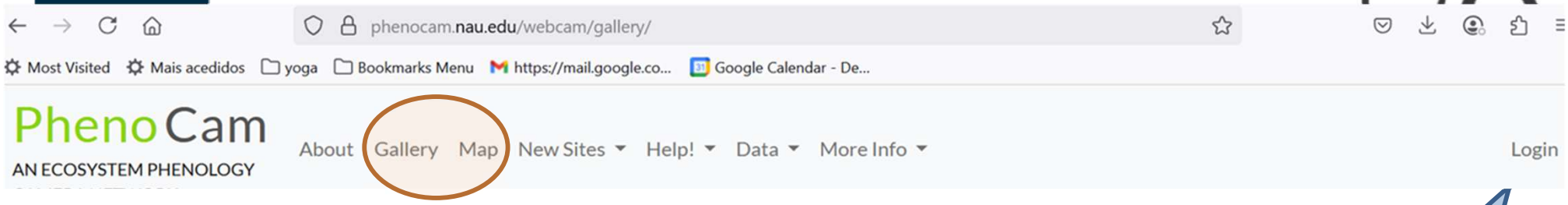
2. EXTRACT RED, GREEN AND BLUE DIGITAL NUMBERS-

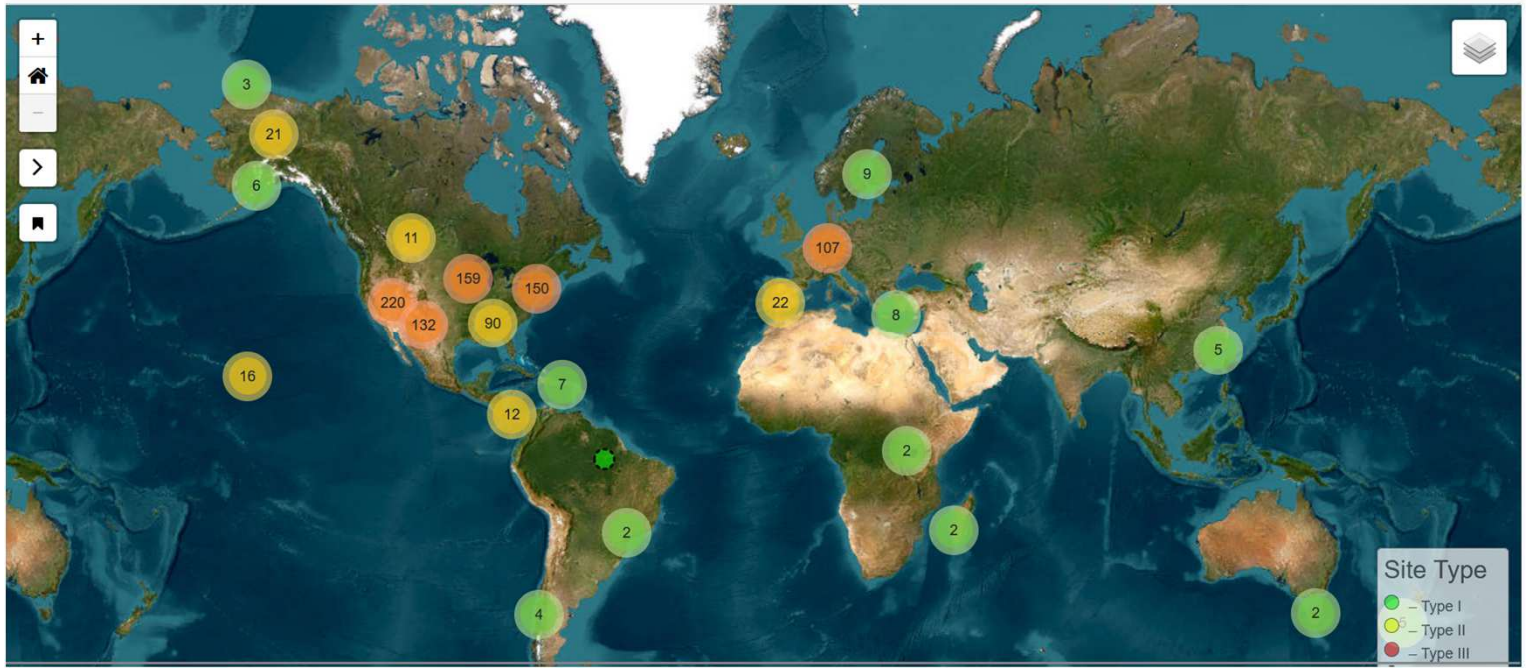
extractVIs - returns the average of R,G and B within the ROI for each image



https://phenocam.nau.edu/

EXPLORE THE PHENOCAM WEB SITE





Sign up and Log in to the web site

Select only **Site Type I or II** **(best quality data and less gaps)**

1) Use gallery or Map to browse different sites
2) Go to Data to download raw images

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REFERENCES lecture 1:

- Filippa, G. Cremonese, E., Migliavacca, M., Galvagno, M., Forkel, M., Wingate, L., Tomelleri, E., Morra di Cella, U., Richardson, A.D. 2016. Phenopix: A R package for image-based vegetation phenology. Agricultural and Forest Meteorology. Vol: 220,141-150. https://doi.org/10.1016/j.agrformet.2016.01.006.
- Richardson, A. 2021 How to access PhenoCam data and imagery: A tutorial. https://phenocam.nau.edu/education/PhenoCam_Access_Guide.pdf
- Lieth, H.H. 1976 Contributions to phenology seasonality research. Int. J. Biometeorol. 20, 197-199.
- Liu Y., Bachofen C., Wittwer R., Silva Duarte G.S.,, Sun Q., , Klaus V.H., Buchmann N., 2022. Using PhenoCams to track crop phenology and explain the effects of different cropping systems on yield. Agricultural Systems. Vol.:195. https://doi.org/10.1016/j.agsy.2021.103306