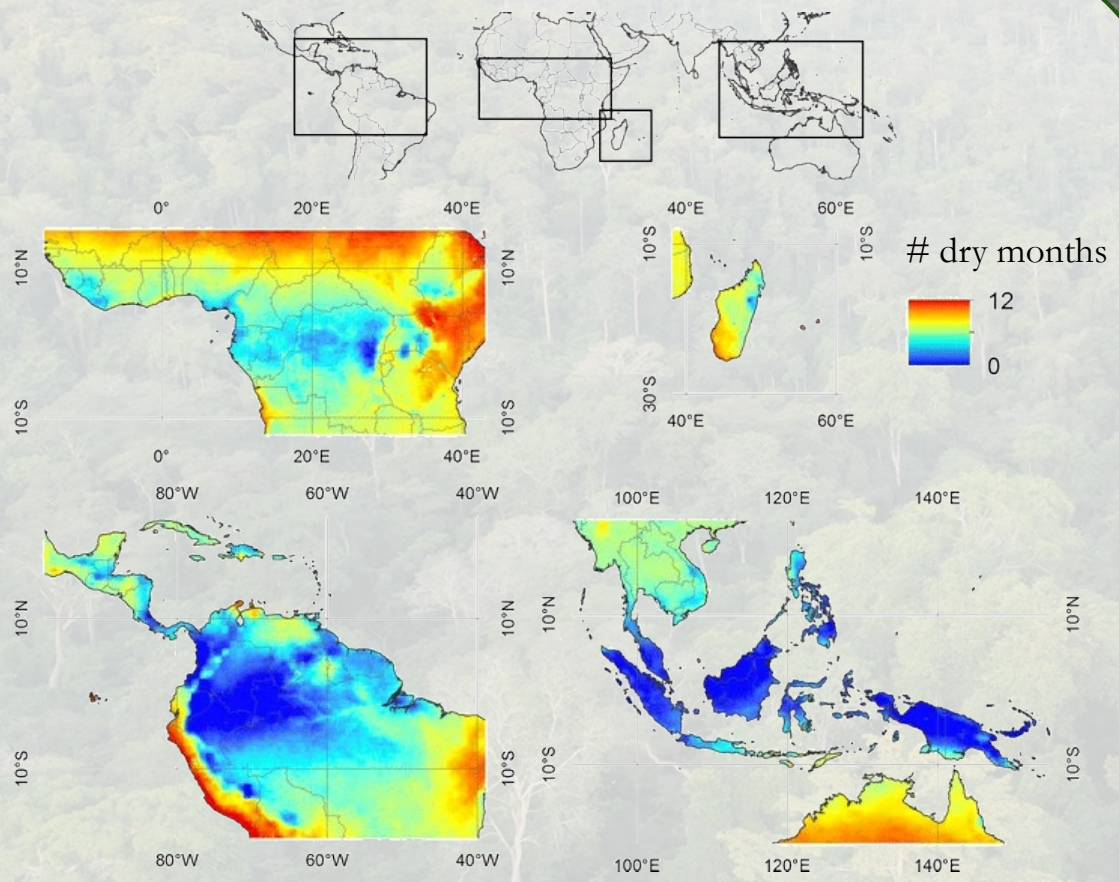
Pheno 2025 – 29 July 2025

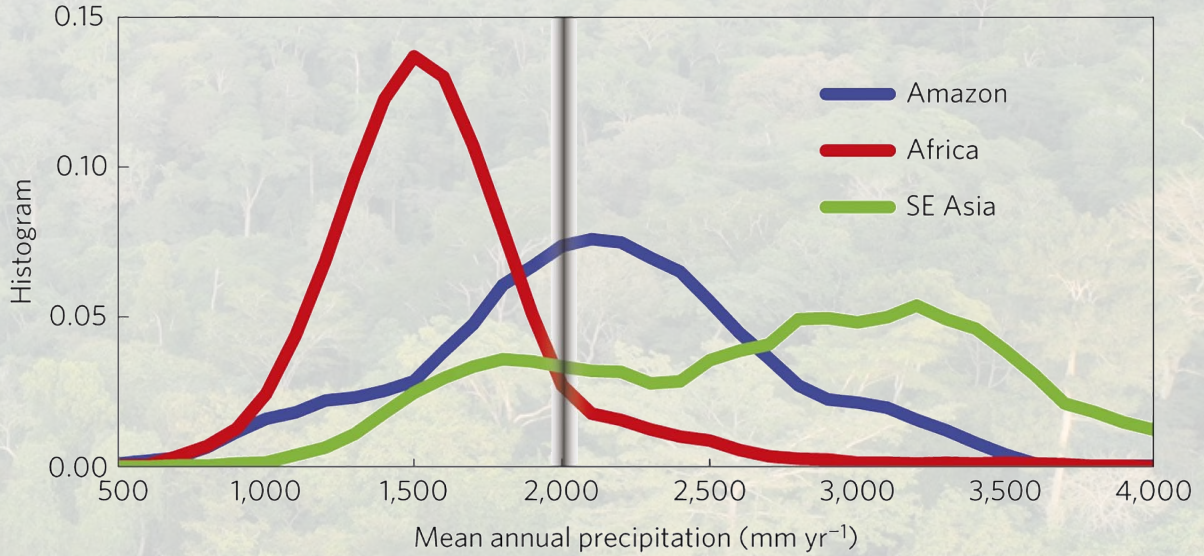
Canopy deciduousness patterns in central Africa explored with phenocams

Presented by Marjane Kaddouri
Promotors : Pr. Adeline Fayolle, Pr. Katharine Abernethy & Pr. Jean-François Bastin

Dry and seasonal climate of central Africa

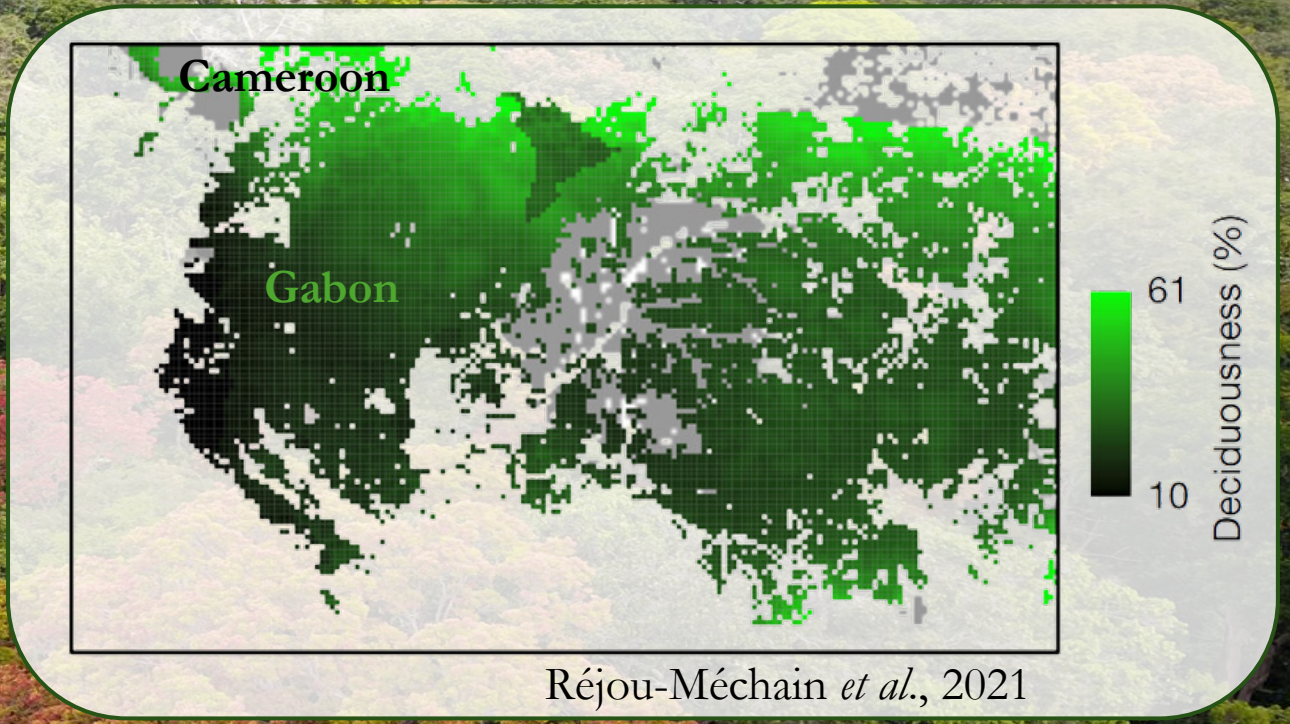


Couvreur, 2015



Guan et al., 2015

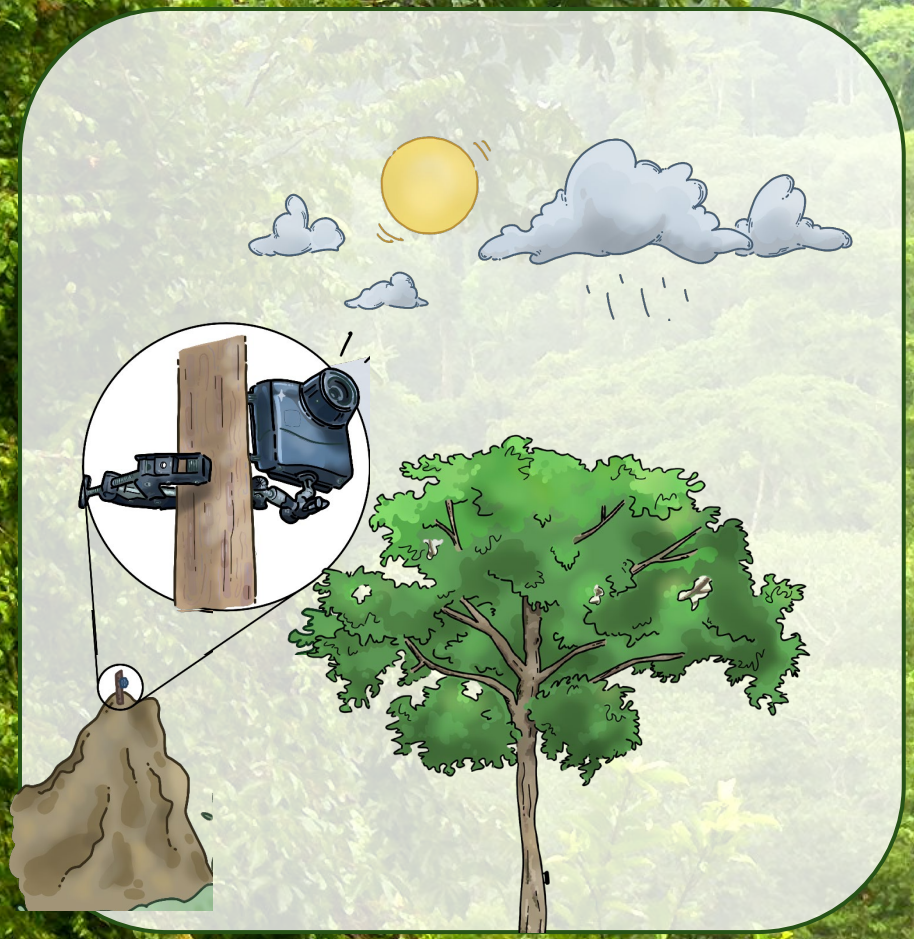
Deciduousness & diversity of leaf phenology strategies

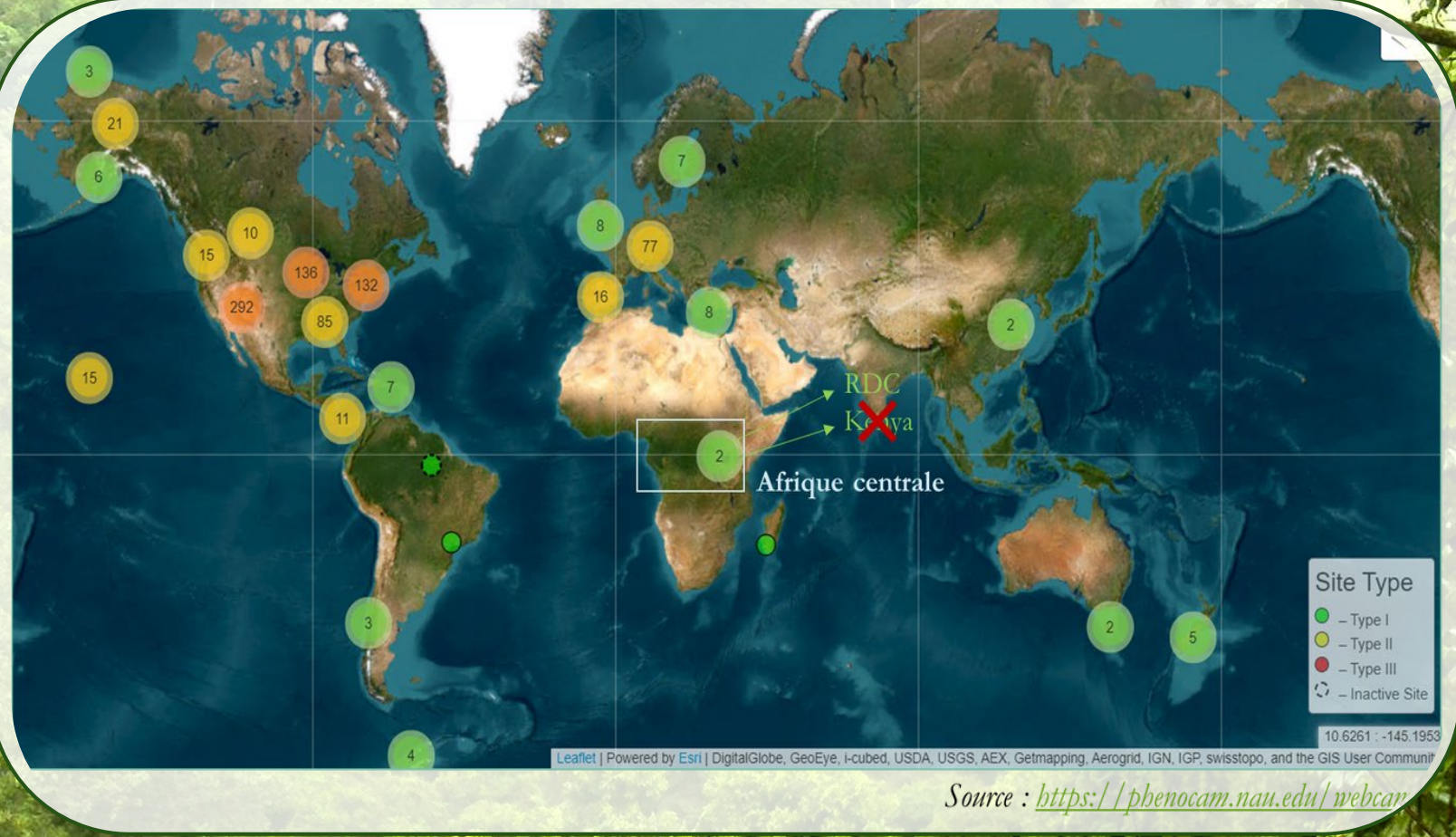


Réjou-Méchain *et al.*, 2021

"Tropical tree phenology is neither dualistic nor simple, but a complex mosaic of coexisting strategies."

Tracking leaf patterns with Phenocams





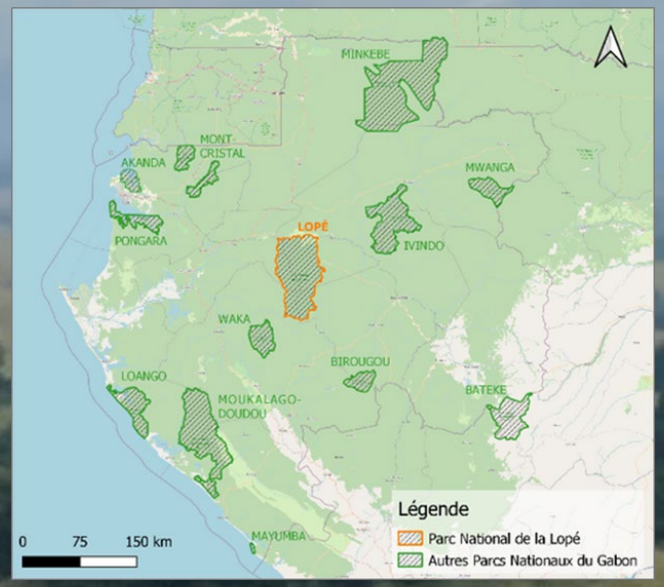
Source : https://phenocam.nau.edu/webcam

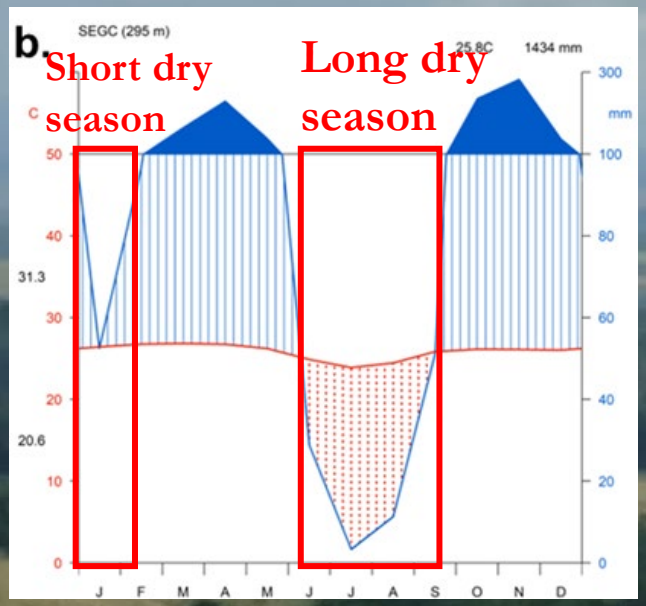
Aim and Research questions

Canopy deciduousness & diversity of phenological strategies

1. Phenological patterns
2. Climatic drivers : dry season response
3. Signal analysis : color intensity (red, blue, green)

With tagged data





Lopé national parc

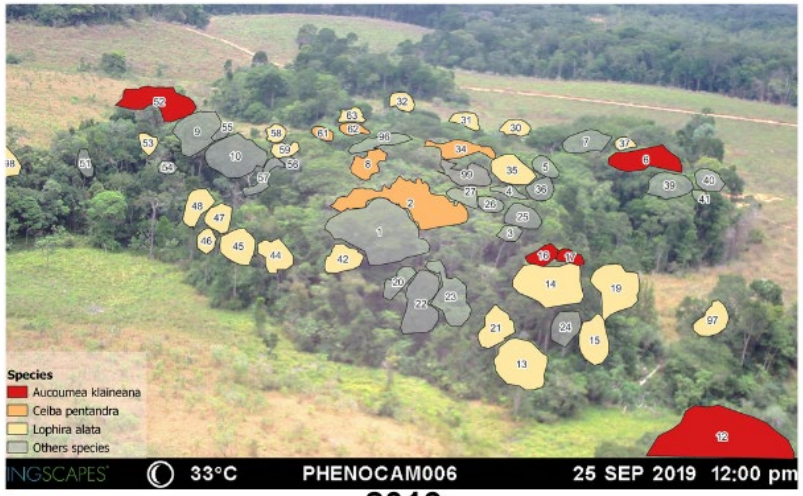
Forest-savanna mosaic

2 Phenocams installed from 2019 to 2023

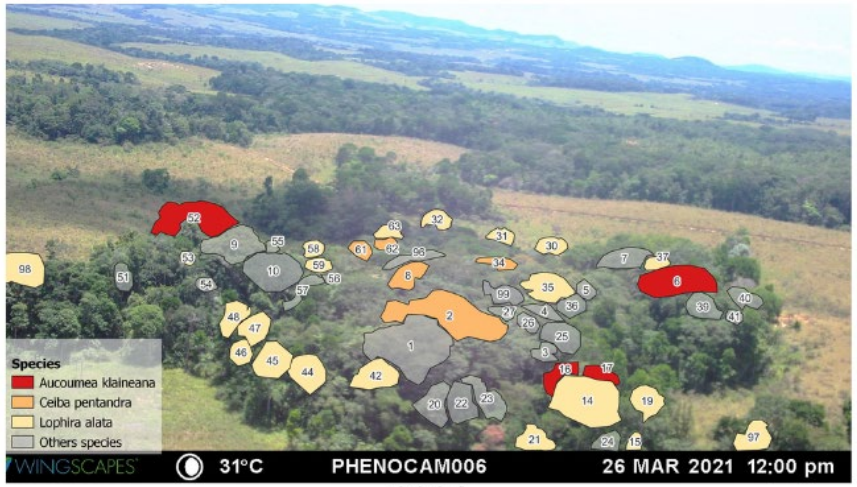
2 images each day at 11 and 12 AM

Image cleaning and segmentation

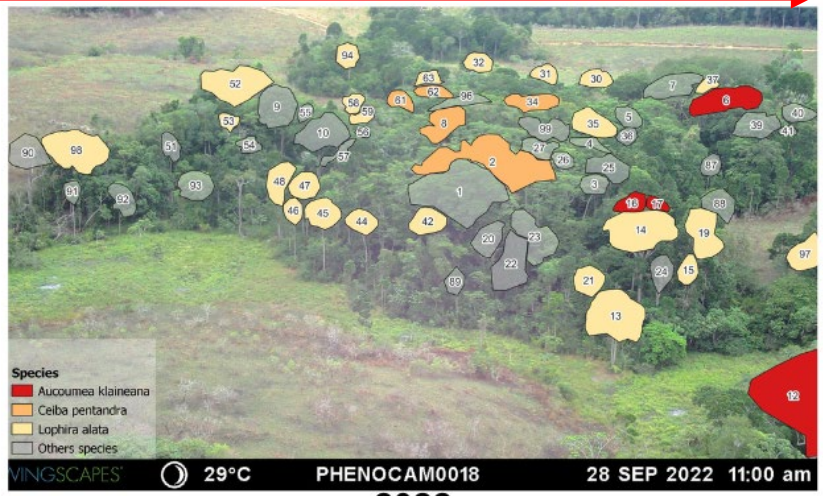
Shift of field of view



2019



2021



2022

4221 images out of 4668 after cleaning

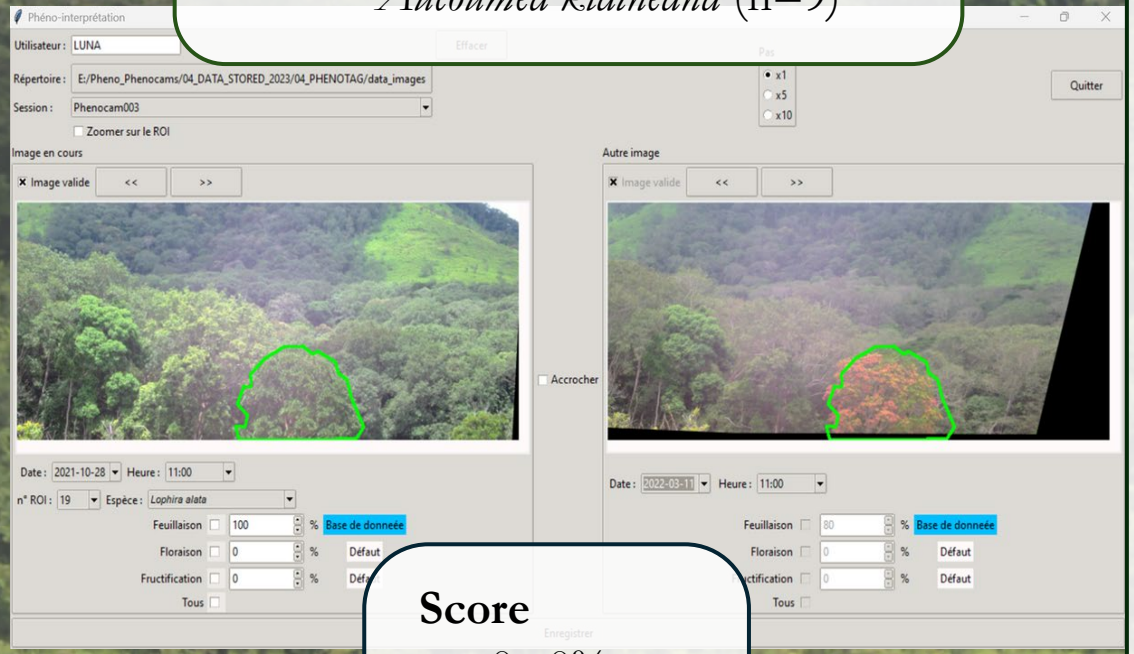
ECC-AKAZE calibration

Crown segmented for 90 trees belonging to 13 species

Phenological patterns and climate drivers

Focus on 3 species

- *Ceiba pentandra* (n=6)
- *Lophira alata* (n=30)
- *Aucoumea klaineana* (n=9)

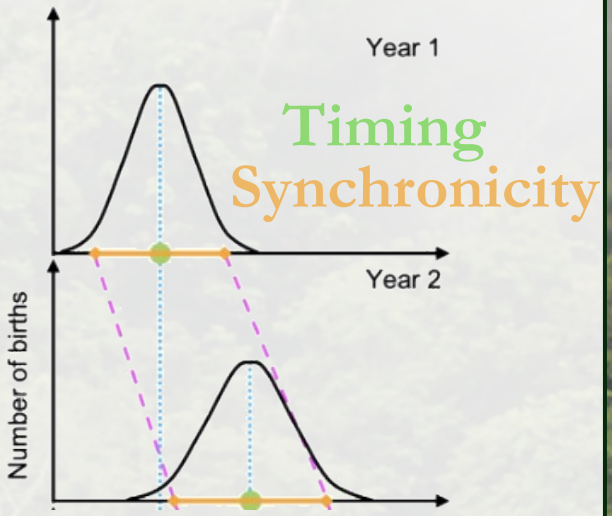


Score

- 0 : 0%
- 1 : 1-25%
- 2 : 26-50%
- 3 : 51-75%
- 4 : 76-99%

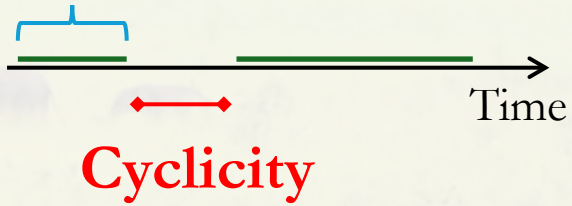
Tutin et al., 1991

Leaf loss analysis < 75%

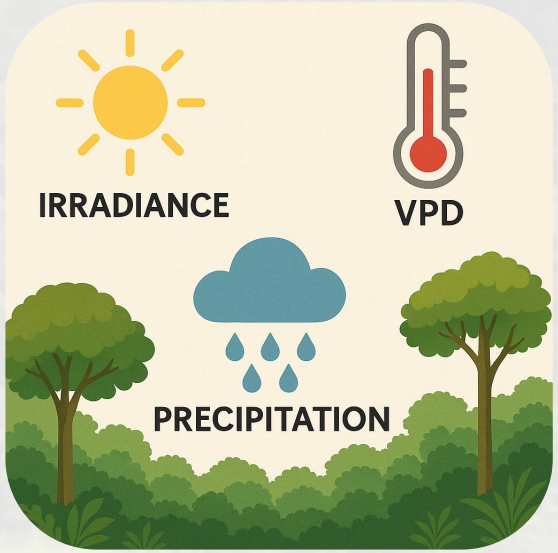


Thel et al., 2022

Duration



Link with climate drivers

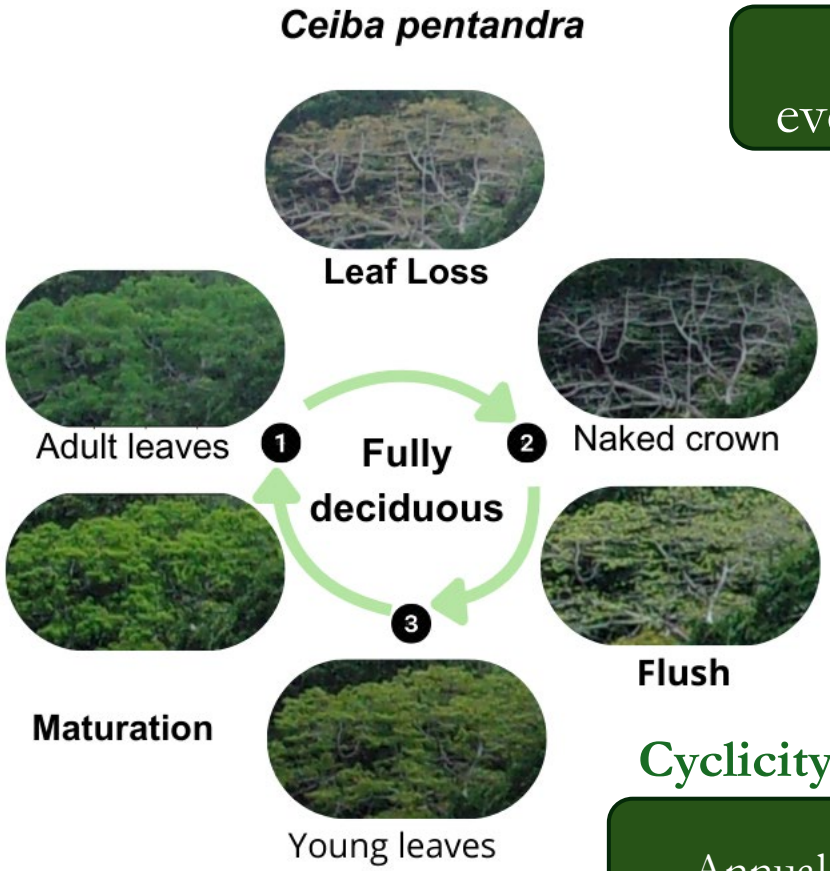


Test of Wilcoxon

15 days before and after events

Results

1 Phenological patterns



27 leaf loss events for 6 trees

Timing

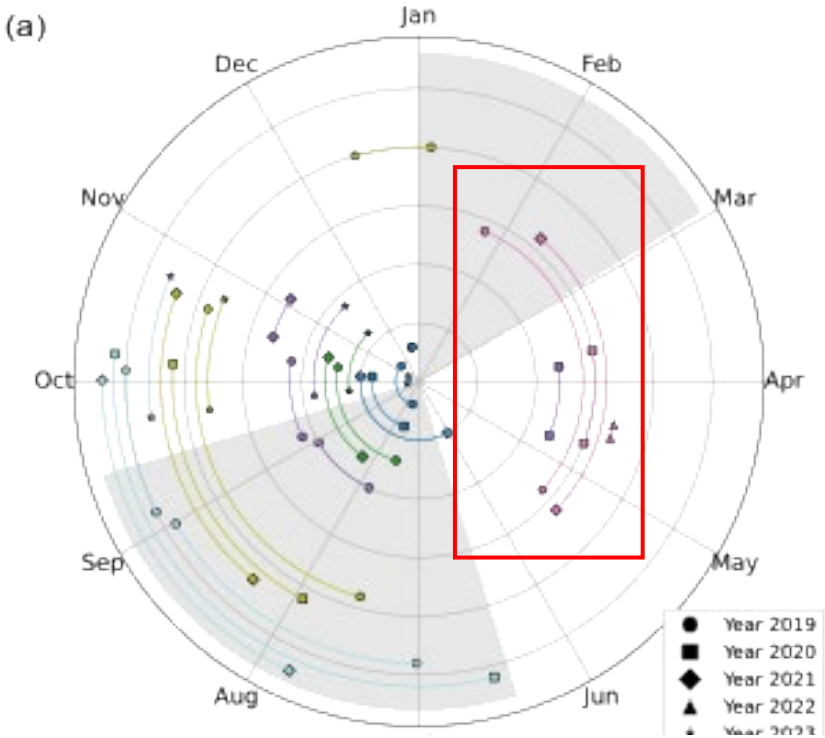
June - October

Duration

Mean of 2 months (3-128 days)

Cyclicity

Annual (215-325 DOY)



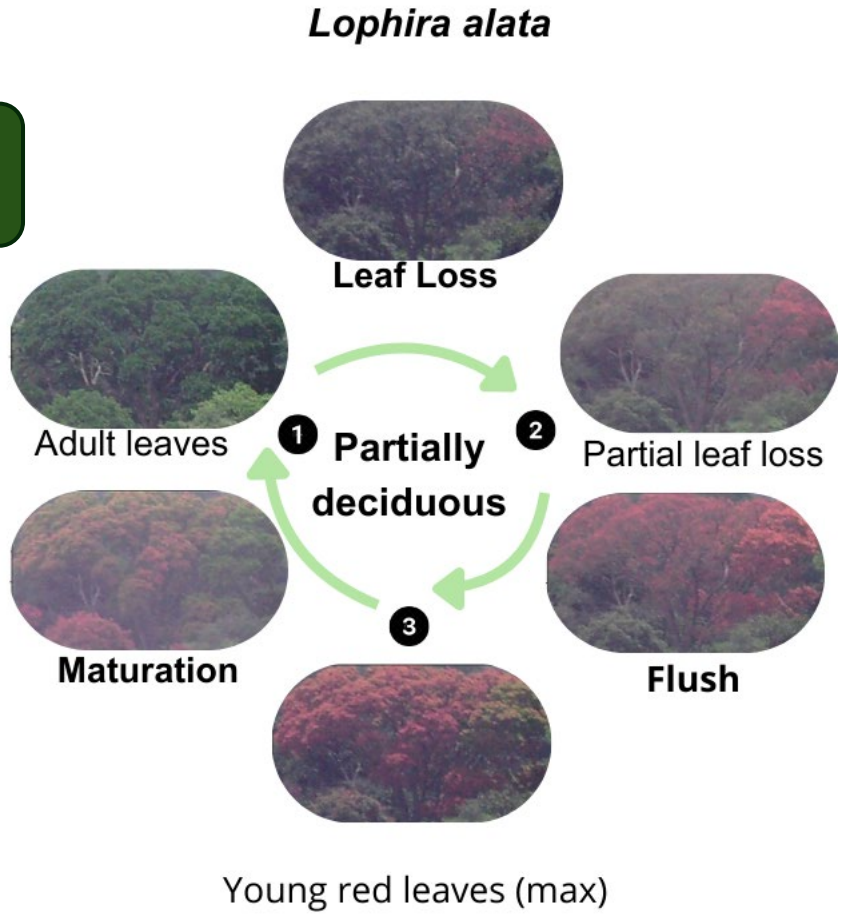
Results

Phenological patterns

Cyclicity

One year in mean (27-677 days)

75 leaf loss events on 27 trees



Duration

Mean of 20 days of duration (4-107 days)

Timing

September - January

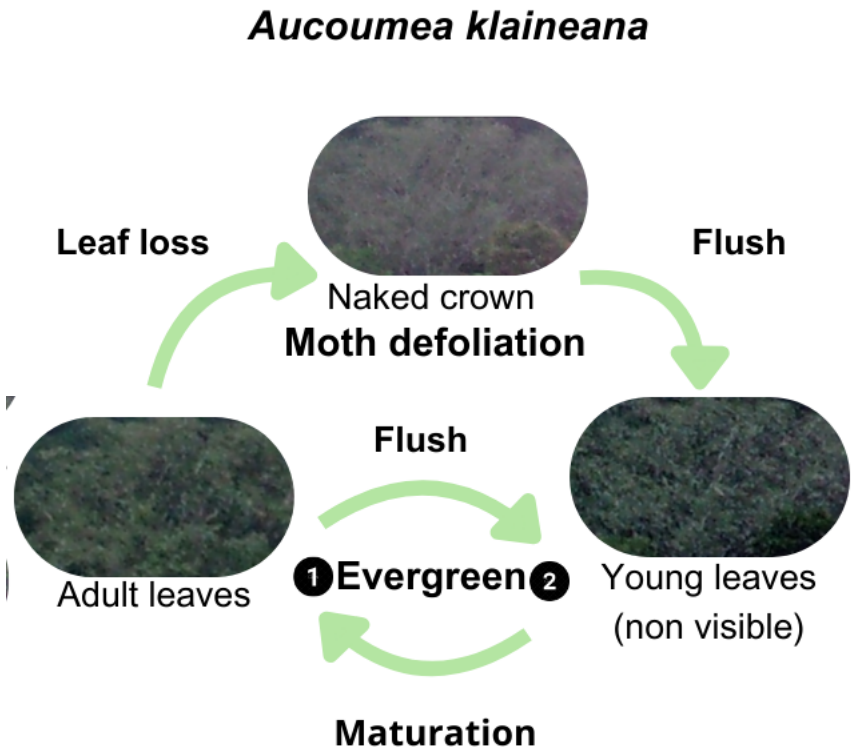
Results

Phenological patterns

13 leaf loss events across 7 trees

Rainy season

Mean of 50 days of duration (3-128 days)



Results

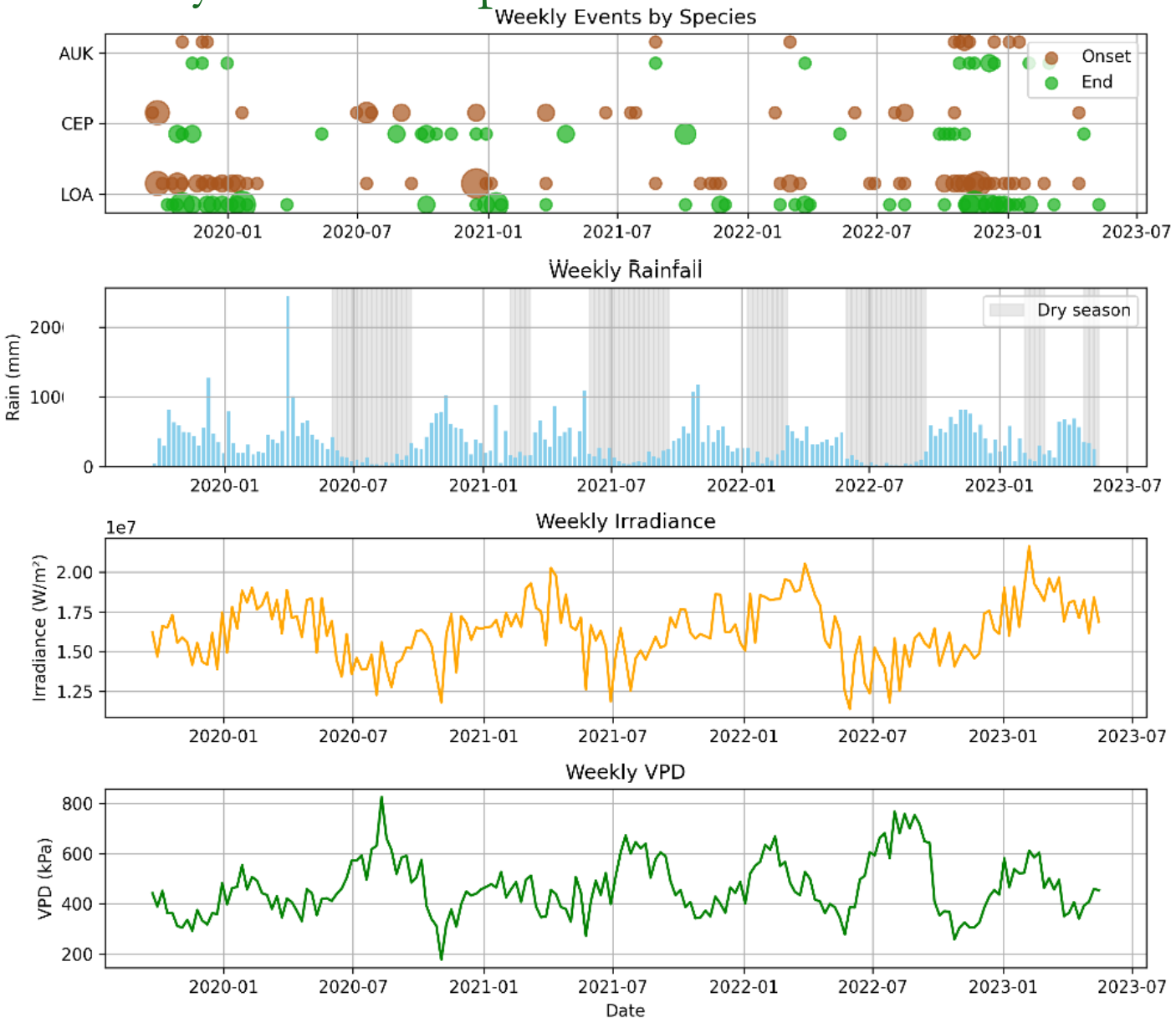
Climatic drivers : dry season response

Aucoumea Klaineana

Events inthe rain season

Ceiba pentandra

Start in the dry season
End in the rain seaon



Lophira alata

Sensible to irradiance variability

Aim and Research questions

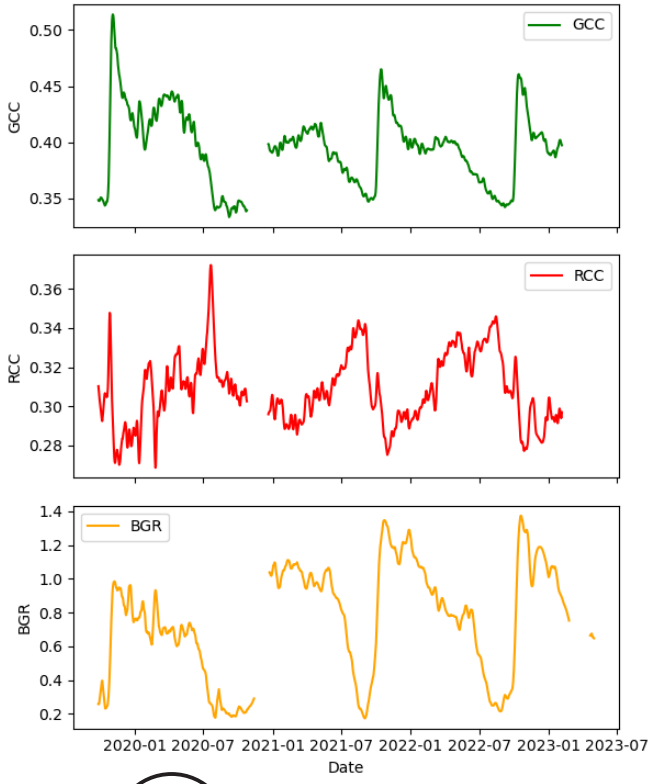
Canopy deciduousness & diversity of phenological strategies

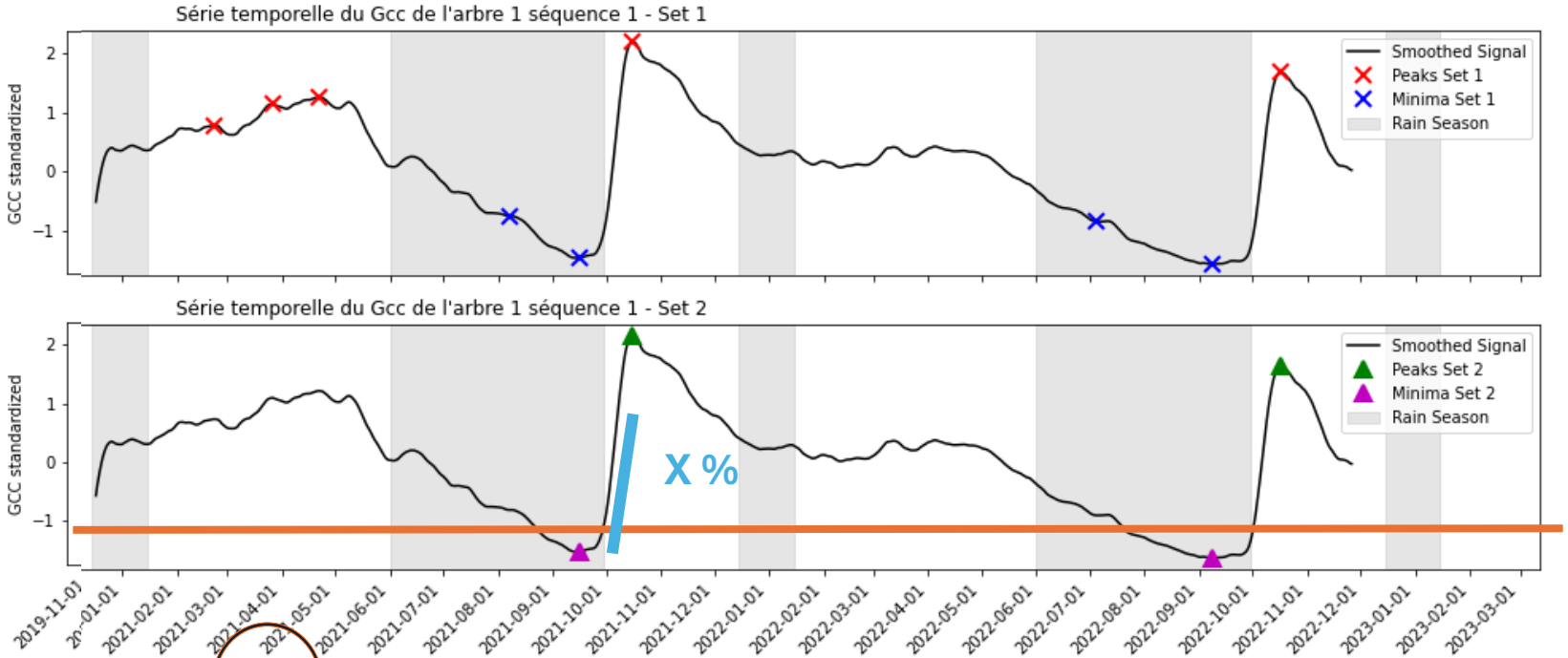
1. Phenological patterns
2. Climatic drivers : dry season response
3. Signal analysis : color intensity (red, blue, green)

With tagged data

Leaf loss detection

species-specific algorithm





1 **3 metrics**

2 **Minimal threshold (-2 to 0.4)**

3 **% of the peak-to-minima distance (0 to 0.5)**

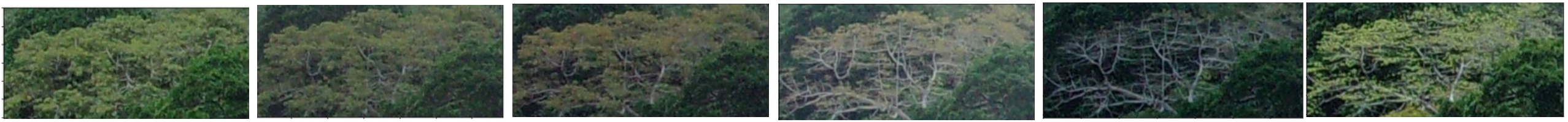
Tagged data (% leaves) →

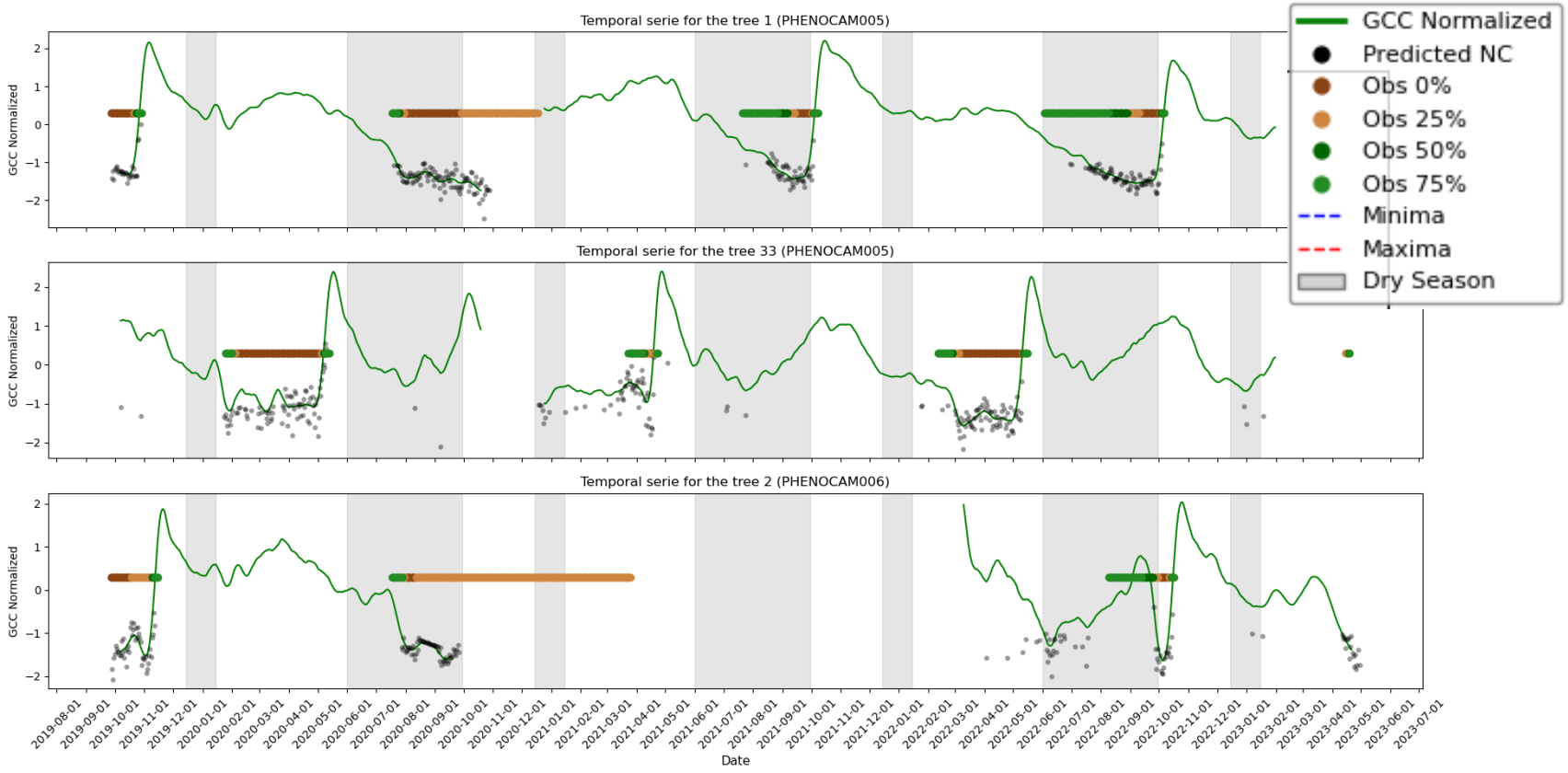
$$Precision = \frac{TP}{TP+FP} \qquad Recall = \frac{TP}{TP+FN} \qquad F1\text{-score} = 2 \times \frac{Precision \times Recall}{Precision+Recall}$$

TN = True negative
TP = True positive

Results

Leafy Tree **Leaf shedding** **Leaf Flush**



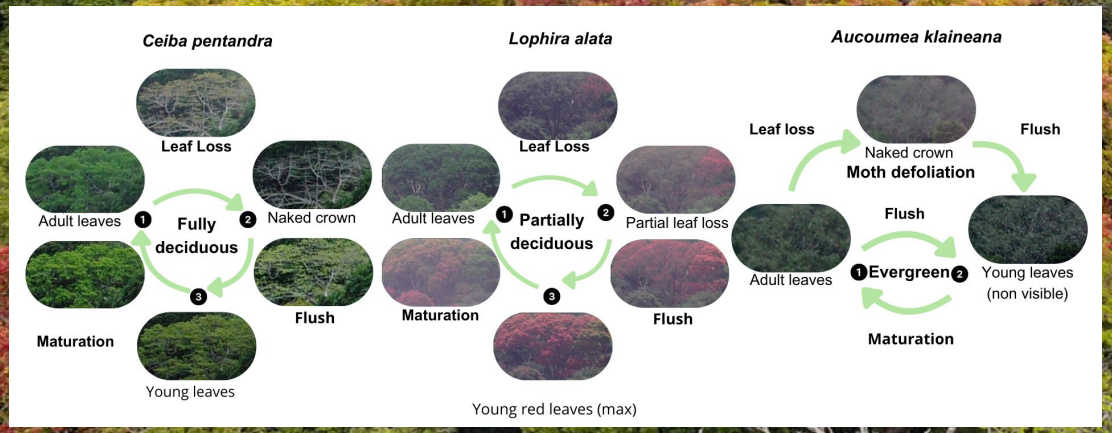


80 % of prediction accuracy

Take home message

Canopy deciduousness & diversity of phenological strategies

1. Phenological patterns : **High intra and inter species variability**
2. Climatic drivers : **Species-specific response**
3. Signal analysis : **Early stage of species-specific algorithm leaf loss**

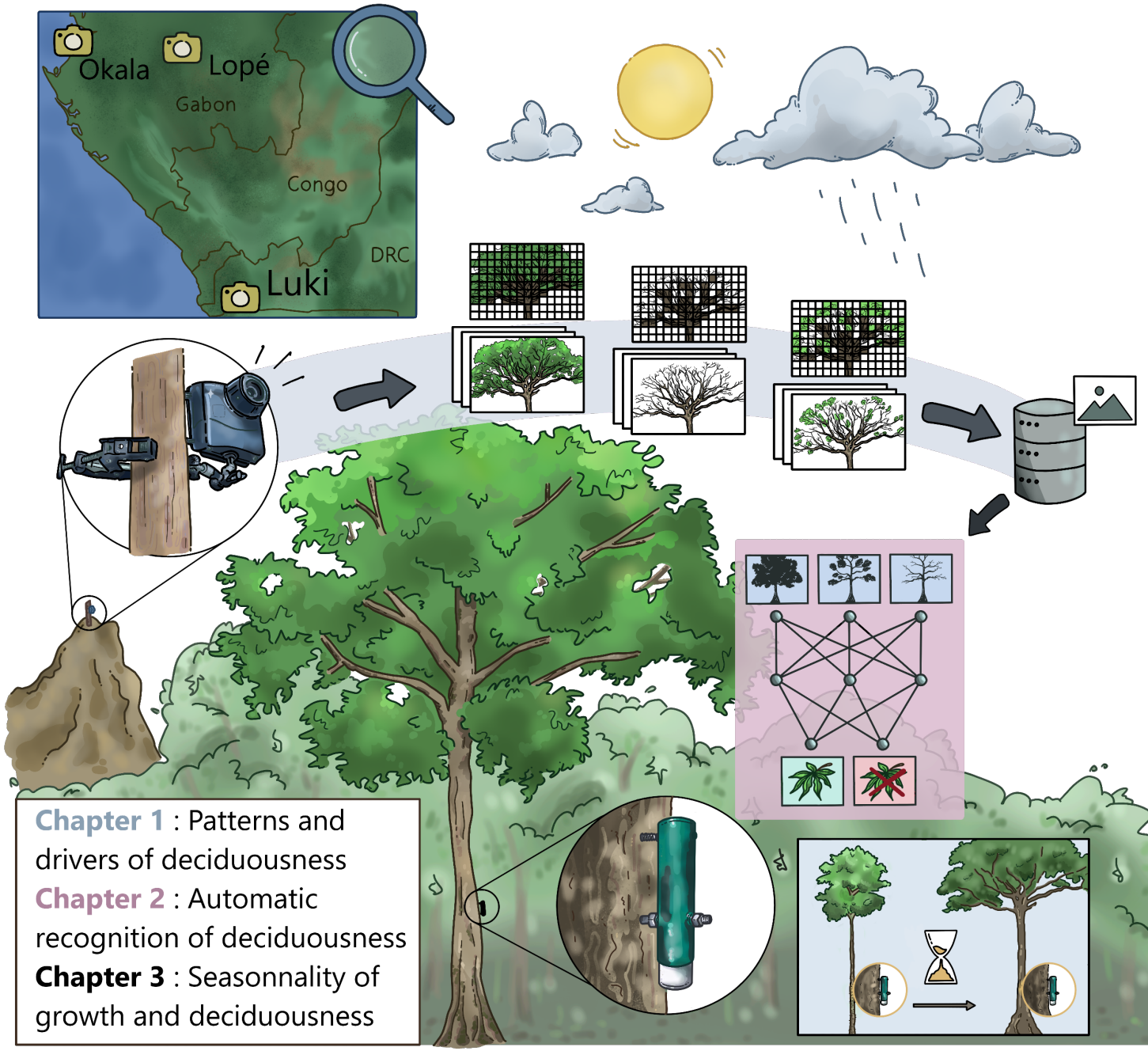


Email : marjane.kaddouri@uliege.be
Linkedin : Marjane Kaddouri

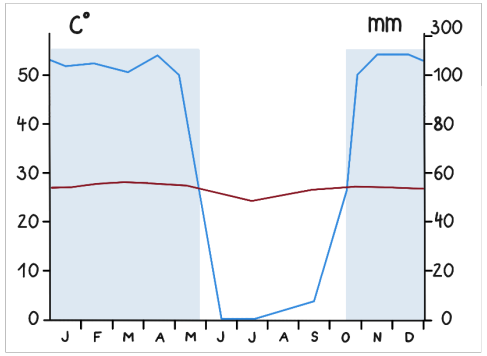
Thank you for your attention !

Thanks to all the co-authors : Dr. Anais Gorel, Pr. Rodolphe Weber, Pr. Katharine Abernethy, Loic Makaga, Dr. Fidele Evouna and Pr. Adeline Fayolle

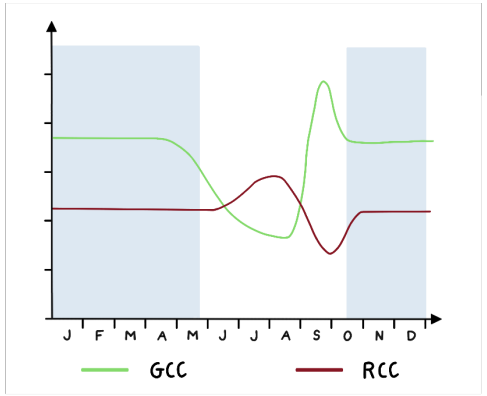
Thanks to all the Canopi project members and particularly to the field techniciens : Eddy Milamizokou, Arthur Dibambouboussebaand Cressy Milami-Ndzoko



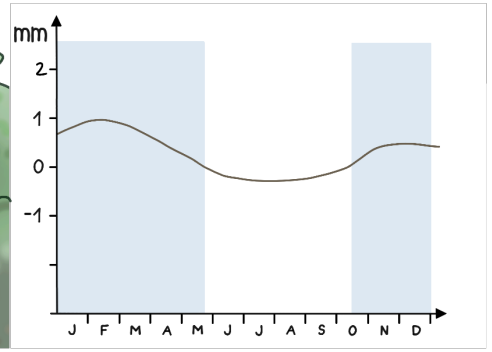
Climat



Deciduousness

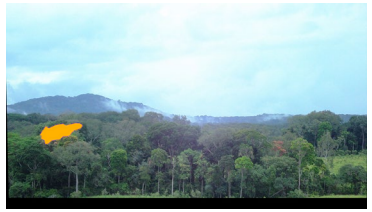


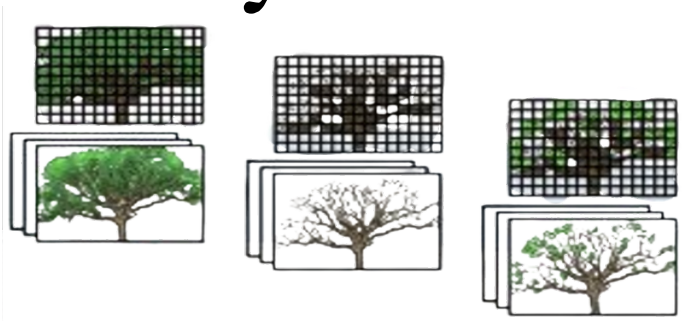
Growth

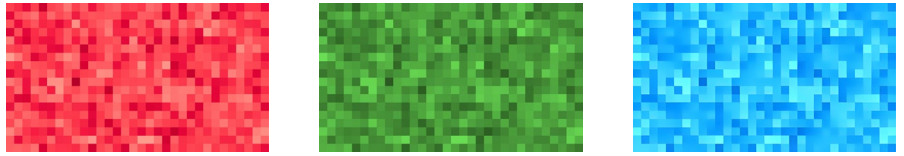


Chapter 1 : Patterns and drivers of deciduousness
Chapter 2 : Automatic recognition of deciduousness
Chapter 3 : Seasonnality of growth and deciduousness

Signal analysis







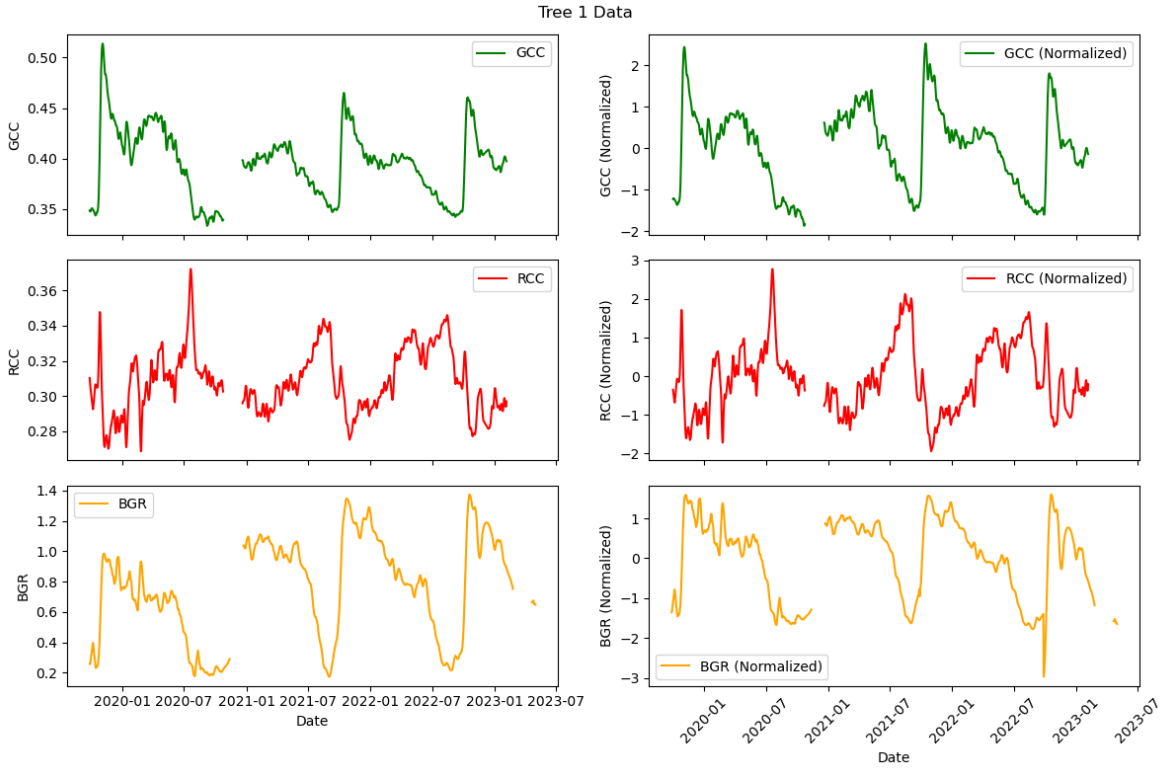
$$(Red, Green, Blue)$$

$$GCC = \frac{Green}{Green + Red + Blue}$$

$$RCC = \frac{Red}{Green + Red + Blue}$$

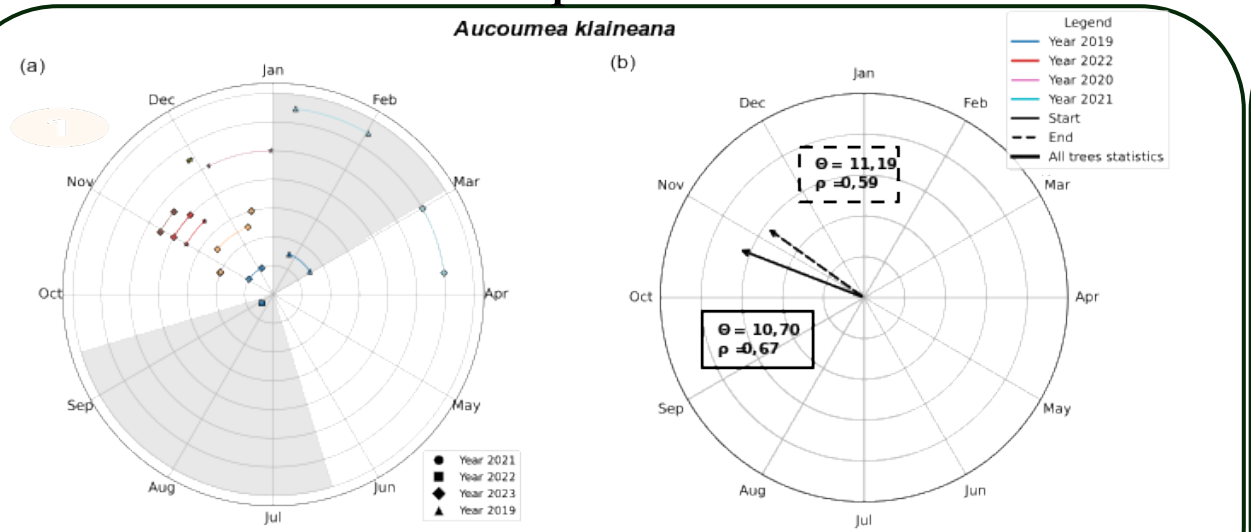
$$P_i = \frac{R_i}{\sum(R + G)'} \quad Q_i = \frac{G_i}{\sum(R + G)}$$

$$d_H(R, G) = \frac{1}{\sqrt{2}} \sqrt{\sum_i \left(\sqrt{P_i} - \sqrt{Q_i}\right)^2}$$



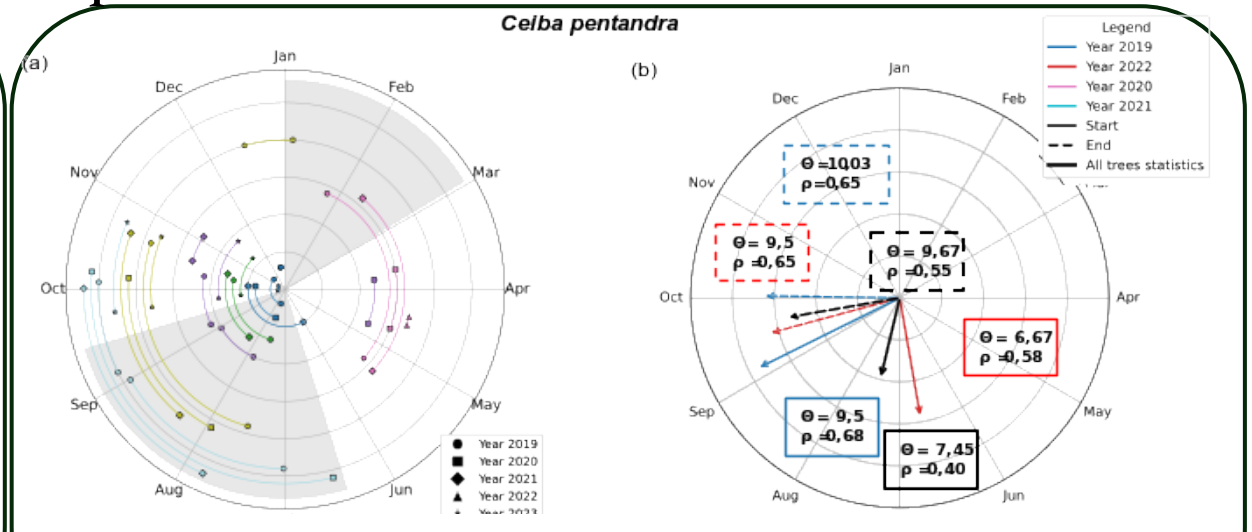
Results

2. What are the leaf loss patterns and the drivers of theses species ?

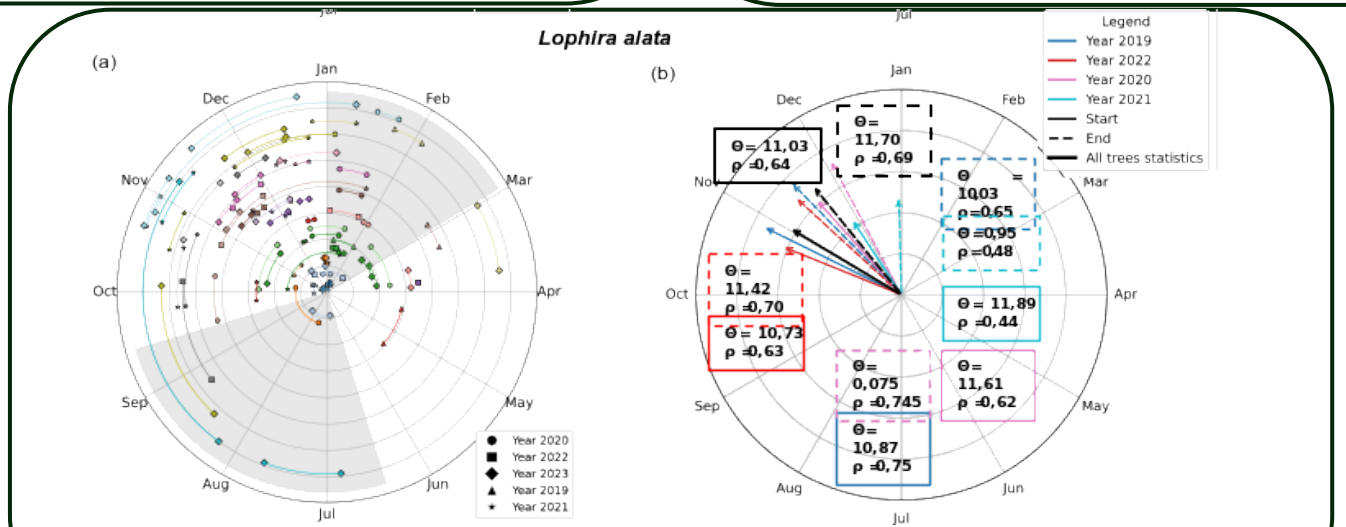


Duration : 1 to 38 days (m :17,92, std: 13,9)

Cyclicity : Rythmicity:



Duration : Cyclicity : Rythmicity:



Duration : Cyclicity : Rythmicity: