Land Surface Phenology

SPECIAL ISSUES

CEOS WORKING GROUP ON CALIBRATION & VALIDATION

Remote Sensing of Environment

- Development, Validation, and Application of Medium- and High-Resolution Satellite Products at Regional to Global Scales
  Deadline for manuscript submissions: **28 February 2026**

forests
an Open Access Journal by MDPI

- Forest Phenology Dynamics and Response to Climate Change
  Deadline for manuscript submissions: 16 June 2025
- Vegetation and Remote Sensing Phenology in Deciduous Forests
  Deadline for manuscript submissions: **31 October 2025**

remote sensing
an Open Access Journal by MDPI

- Remote Sensing of Land Surface Phenology II
  Deadline for manuscript submissions: 15 May 2025
- Applications of Remote Sensing in Vegetation Cover and Phenology Observation
  Deadline for manuscript submissions: **15 July 2025**
- Remote Sensing in Vegetation Phenology
  Deadline for manuscript submissions: **28 November 2025**
- Remote Sensing for Vegetation Phenology in a Changing Environment
  Deadline for manuscript submissions: **30 November 2025**
- Advances in Multi-Sensor Remote Sensing for Vegetation Monitoring
  Deadline for manuscript submissions: **29 December 2025**
- Advances in Detecting and Understanding Land Surface Phenology
  Deadline for manuscript submissions: **31 December 2025**

Land Surface Phenology

CONFERENCES

A.02.06 Advances in land surface phenology monitoring and applications

Oral sessions (Hall L1/L2):

PART 1. Wednesday. 25-06-2025. 8:30 – 10:00
PART 2. Wednesday. 25-06-2025. 11:30 – 13:00

Poster sesión (X5 – Poster Area – Zone P-Q):

Wednesday. 25-06-2025. 17:45 – 19:00

PHENO 2025

Venue
São Pedro, SP, Brazil

Save the date
2025, Jul 28th - Aug 01st

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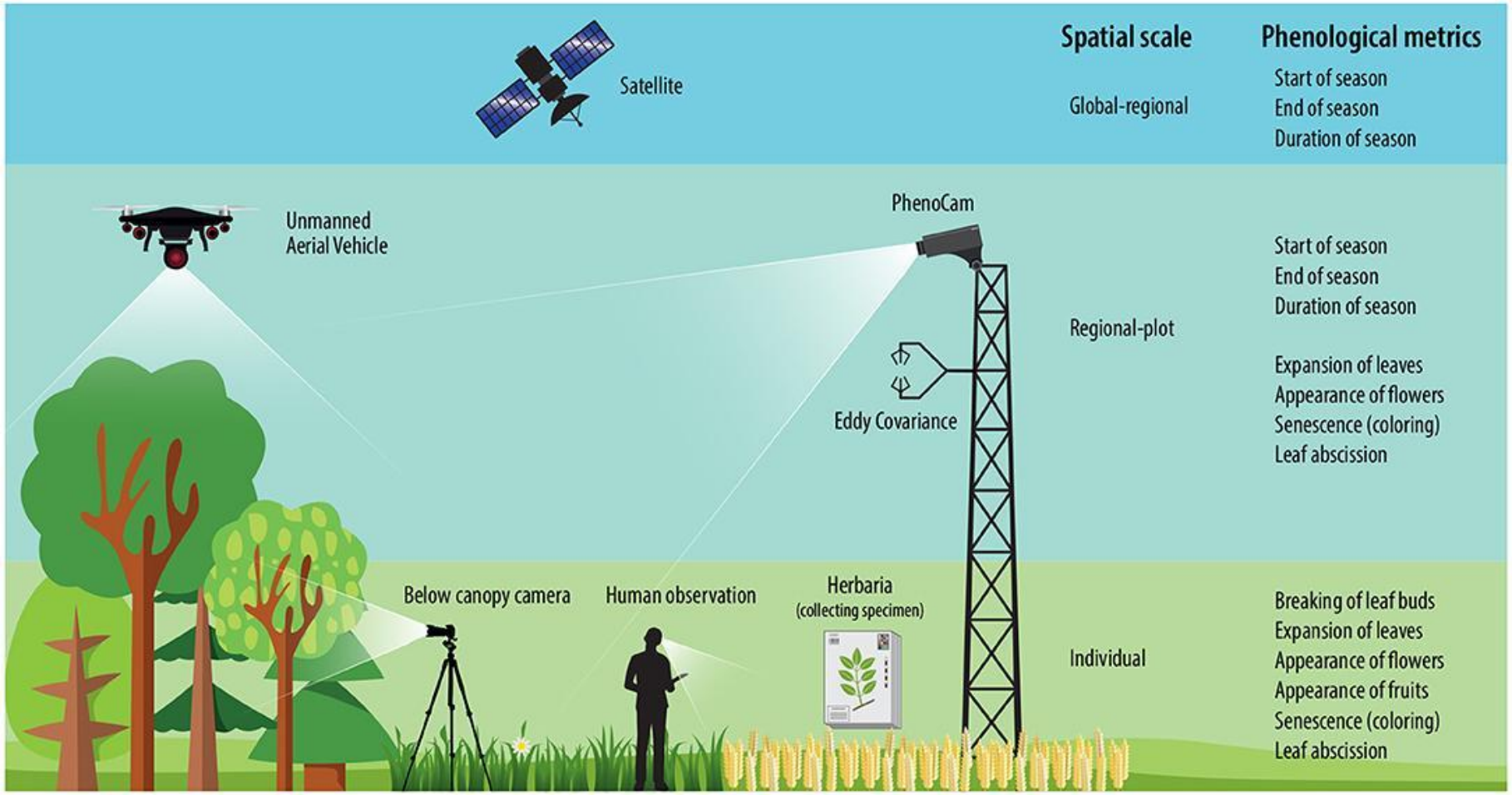
Challenges in validating Land Surface Phenology

Approaches for monitoring phenology



Katal, N., Rzanny, M., Mäder, P., & Wäldchen, J. (2022). Deep Learning in Plant Phenological Research: A Systematic Literature Review. Frontiers in Plant Science, 13

Ground/human observations

Developmental stages for cherry.

	BBCH	Description			
	61	Beginning of flowering: about 10% of flowers open	Début de la floraison : environ 10% des fleurs sont ouvertes	Comienzo de la floración: aproximadamente el 10% de las flores están abiertas	Blühbe-ginn; 10% der Blüten offen
	65	Full flowering: at least 50% of flowers open, first petals falling	Pleine floraison: au minimum 50% des fleurs épanouies, les premiers pétales tombent	Plena floración: por lo menos 50% de las flores están abiertas, los primeros pétalos caen	Vollblüte; 50% der Blüten offen
	67	Flowers fading: majority of petals fallen	La floraison s'achève, la plupart des pétales sont tombés	Se termina la floración, la mayoría de los pétalos han caído	Abgehende Blüte, meisten Blütenblätter abgefallen
	69	End of flowering: all petals fallen	Fin de floraison: tous les pétales sont tombés	Final de floración: todos los pétalos se han caído	Blühende, alle Blütenblätter abgefallen
	72	Green ovary surrounded by dying sepal crown, sepals beginning to fall	Ovaire vert entouré de sépales fanés, les premiers sépales tombent	Ovario verde rodeado de una corona de sépalos marchitos, los primeros sépalos caen	Grüner Fruchtknoten von absterbenden Kelchblattkranz umgeben
	85	Maturity base on colouring	Maturité évaluée par la couleur	Maduración basada en el color del fruto	Fortgeschrittene Fruchtausfärbung
	92	Senescence: Leaves begin to discolour, at least 10% of yellow leaves	Sénescence : début de décoloration des feuilles, au moins 10% de feuilles jaunes	Senescencia: Inicio de la decoloración de las hojas, por lo menos 10% de hojas amarillas	Beginn der Laubblattverfärbung

Wenden, B., Barreneche, T., Meland, M., & Blanke, M.M. (2017). Harmonisation of phenology stages and selected cherry cultivars as bioindicators for climate change. In, Acta Horticulturae (pp. 9-12)

Illustrations of vegetative phenology of almond (*Prunus dulcis*) according to BBCH scale.

A = dormant bud.
B = leaf bud swelling.
C = first leaves separating.
D = first leaves unfolded.
E = more leaves unfolded.
F = all leaves unfolded.
G = beginning of shoot growth.
H = shoots reached 90% of final length.
I = leaves start to fade color.
J = beginning of senescence.
K = 50% of leaves are fallen.
L = leaves fall ending.

Credit: Brian Powell

Sakar, E.H., El Yamani, M., Boussakouran, A., & Rharrabti, Y. (2019). Codification and description of almond (Prunus dulcis) vegetative and reproductive phenology according to the extended BBCH scale. Scientia Horticulturae, 247, 224-234

Uncertainties in using ground observations to validate LSP

- The spatial distribution of ground phenological observation stations is still very unequal at the European level. These observations are largely concentrated in small and localized areas of a few countries (e.g. Germany, Austria, France, Sweden, France, Spain). Hence, they have lower spatial coverage than LSP data.
- Spatial heterogeneity of vegetation types in a satellite sensor pixel.
- Different phenological phenomena measured.
- Limited observations or spatial coverage.
- The species monitored may or may not represent LSP (points versus pixels); a single-point observation may not be representative of the overall pixel characteristics including different climate regimes in regions with significant relief.
- Unknown measurement accuracy and errors in data. The ground phenological observations may be over- or under-estimated depending on the frequency of observations during the week.

LAND SURFACE PHENOLOGY

VALIDATION INITIATIVE:

Validation of Copernicus High Resolution Vegetation Phenology and Productivity (HRVPP-1) in the mediterranean

Land Surface Phenology

Advancing Satellite Land Surface Phenology Validation with UAV-borne Sensing: Best Practices and Protocol

Elias Fernando Berra, Magdalena Smigaj, Dominic Fawcett,
Victor Francisco Rodriguez Galiano

Aim: To compile recommendations on **best practices for collection of UAV time series data**, describing how UAV-derived LSP can serve as a reference dataset to validate with satellite-based LSP products.

Why a protocol? Growing interest in the field
> need for standardised approaches.

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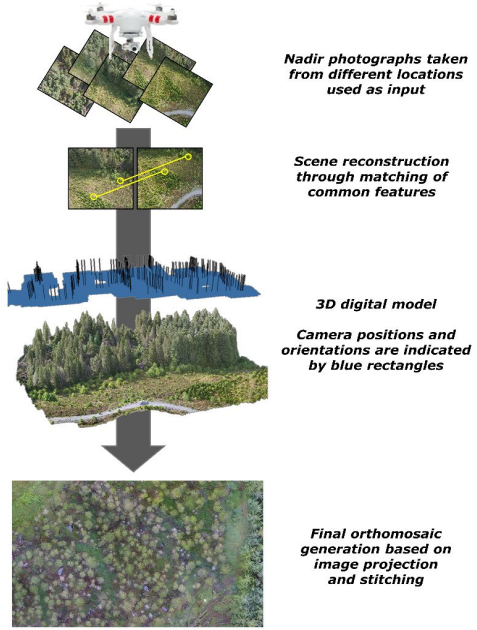
Land Surface Phenology

Radiometric calibration

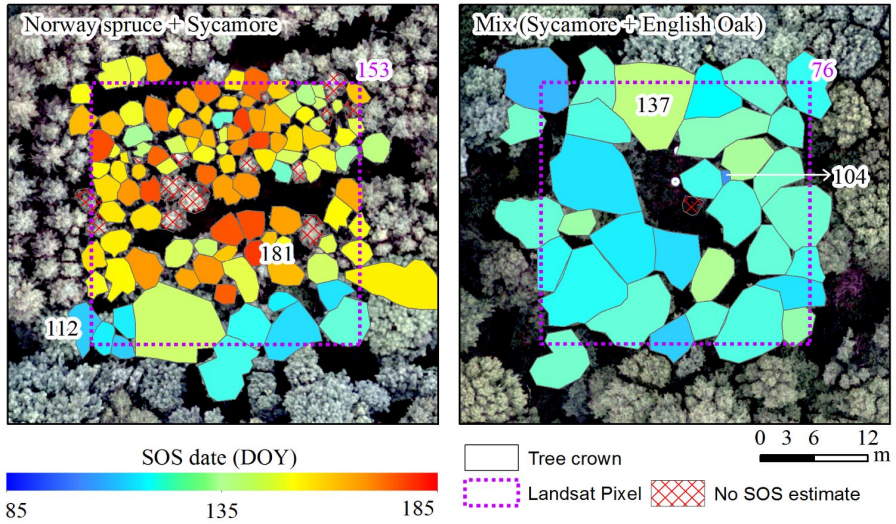
Georeferencing

Species- and tree-level acquisition

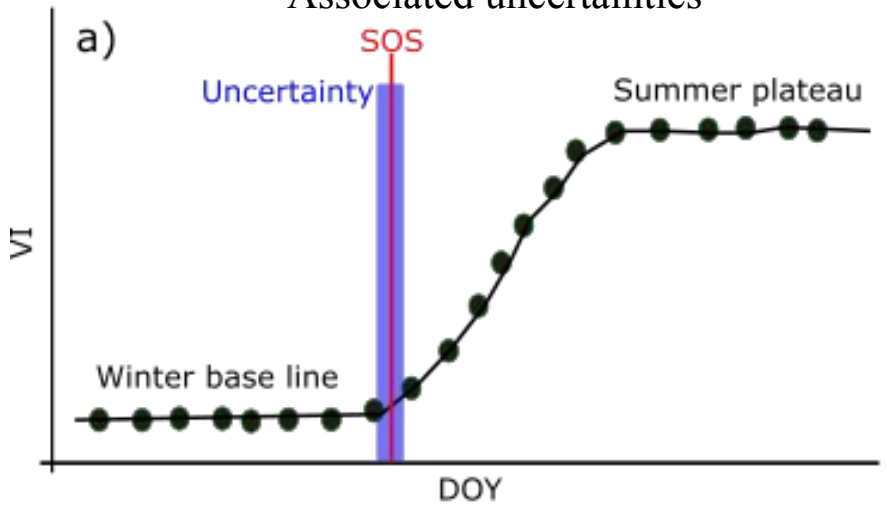
UAV image processing



Species representativeness within satellite pixel; UAV vs satellite intercomparison



Consistent temporal resolution and length; Associated uncertainties



PROTOCOL CHAPTER:

Advancing Satellite Land Surface Phenology Validation with UAV-borne Sensing: Best Practices and Protocol

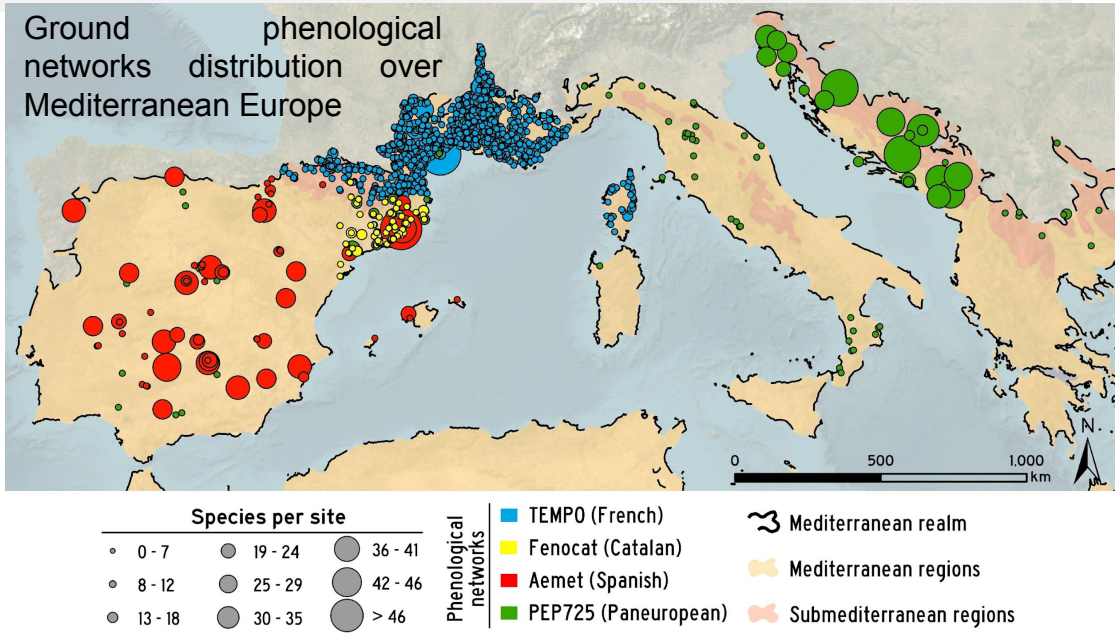
LAND SURFACE PHENOLOGY

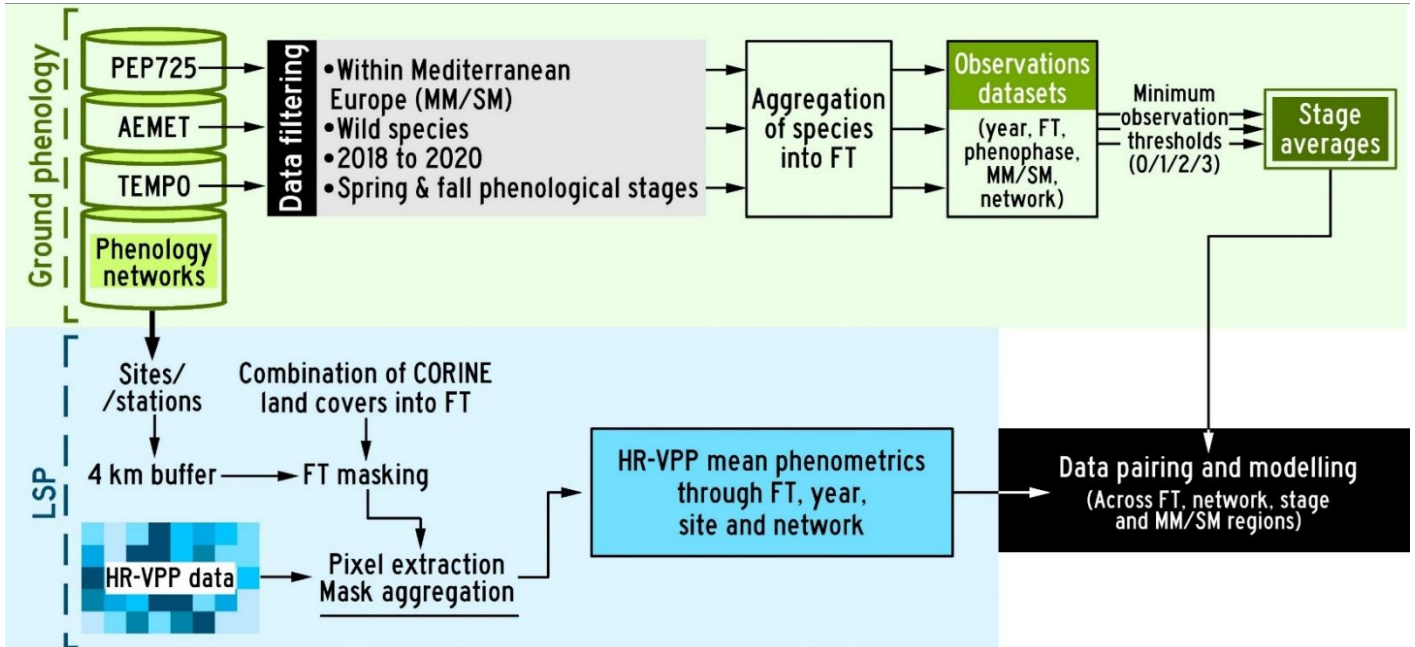
Validation of HRVPP-1 in the mediterranean

13.1 M obs. 200 spp. 155 sites in Mediterranean Europe

2.7 M obs. 11 k sites < 117 species

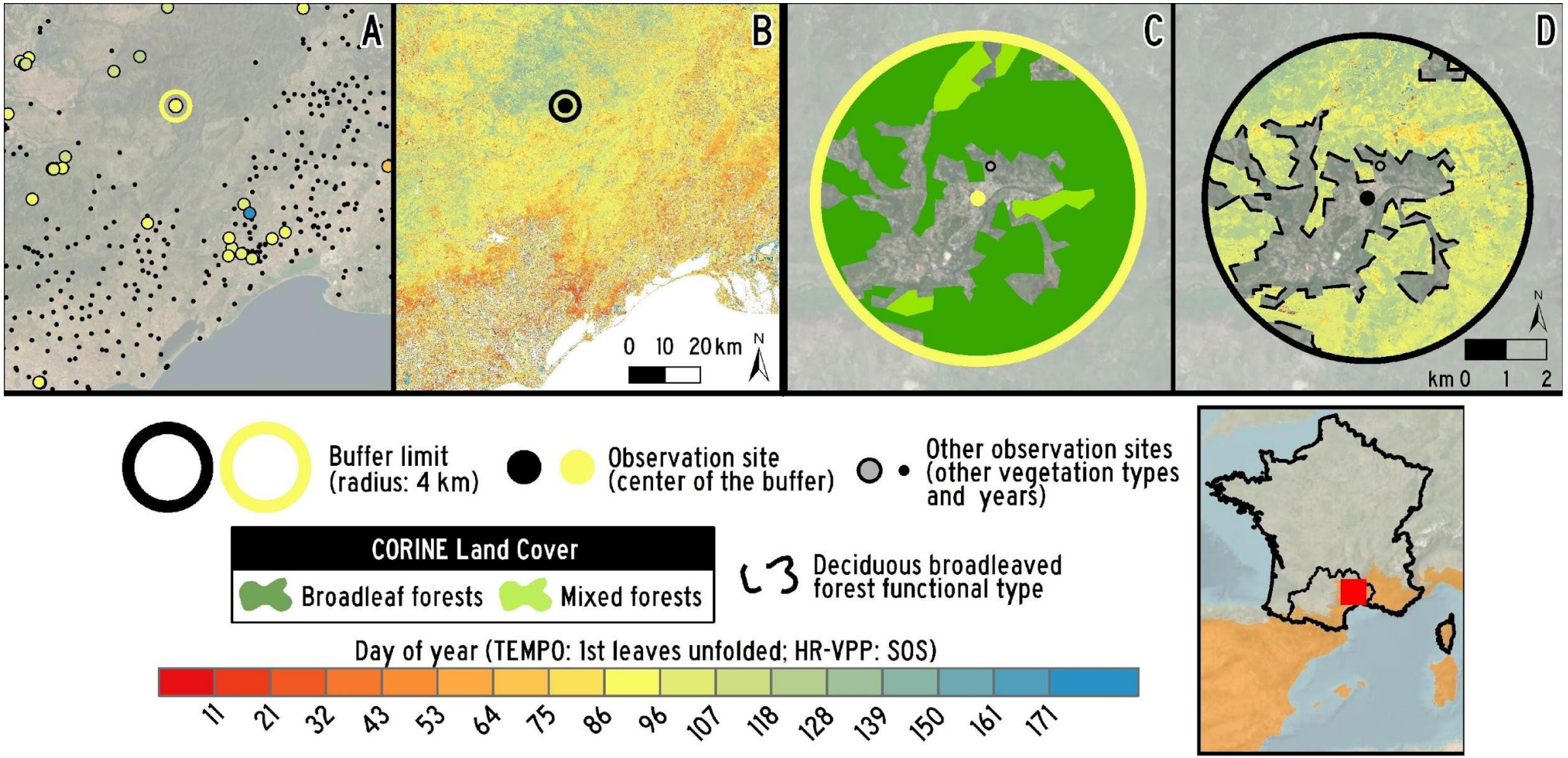
35 k obs. 91 sites. 96 species





To be submitted to RSE special issue on: “Development, Validation, and Application of Medium- and High-Resolution Satellite Products at Regional to Global Scales”

Land Surface Phenology



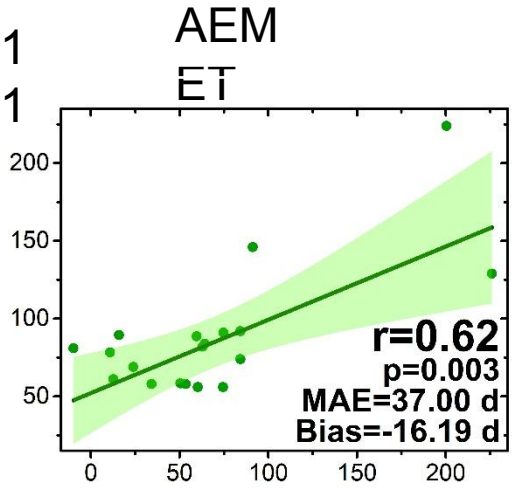
Sampling, masking and matching design in a 4 km buffer zone around a ground observation station in Occitania (Southern France). A) Ground observations scattered through the region showing the mean SOS of deciduous broadleaved trees and shrubs for a given year. B) HR-VPP mean SOS across the region. C) CORINE land covers matching the deciduous broadleaved functional type within a 4 km radius around the observation site. D) Masked HR-VPP SOS values within the same radius.

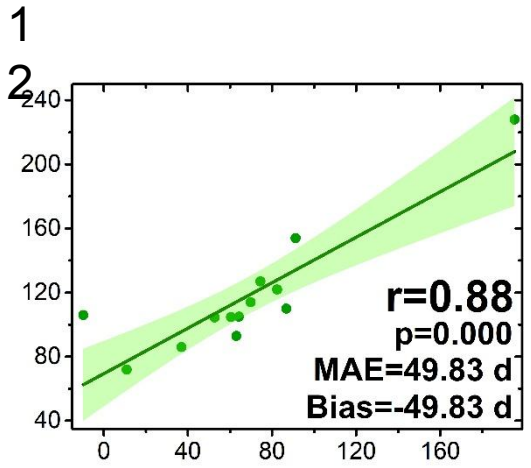
Land Surface Phenology

Correspondence between field phenology stages and LSP phenometrics

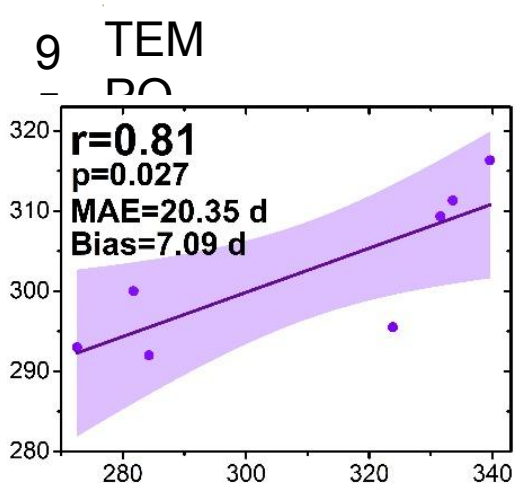
Phenological network	Stage code	Sate description	Phenometric
AEMET	11	First leaves unfolded	SOS
	12	Second leaves unfolded	
	94	Leaf coloring (50 %)	EOS
	95	Leaf fall (50 %)	
TEMPO	11	Leaf unfolding (10 %)	SOS
	15	Leaf unfolding (50 %)	
	95	Leaf coloring (50 %)	EOS
PEP725	11	First true leaf/leaf pair/whorl unfolded. First leaves unfolded	SOS
	205	Autumnal coloration (50%)	EOS
	95	50 % of leaves fallen	

Evergreen broadleaved trees and shrubs (EB)

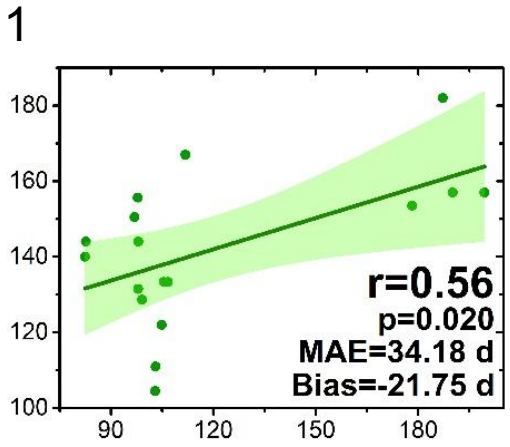




Deciduous coniferous trees and shrubs (DC)

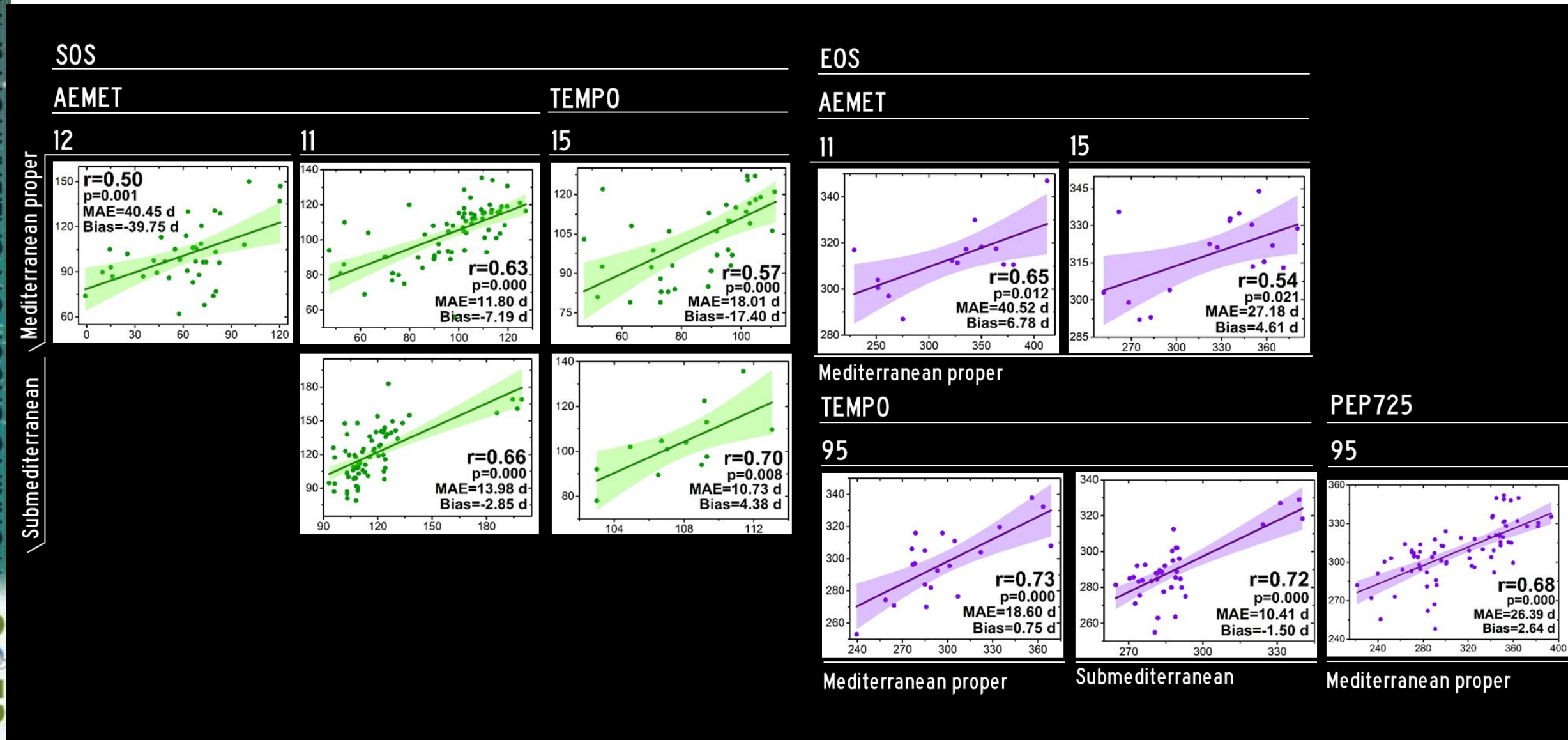


Evergreen coniferous trees and shrubs (EC)



Land Surface Phenology

Deciduous broadleaved trees and shrubs (DB)

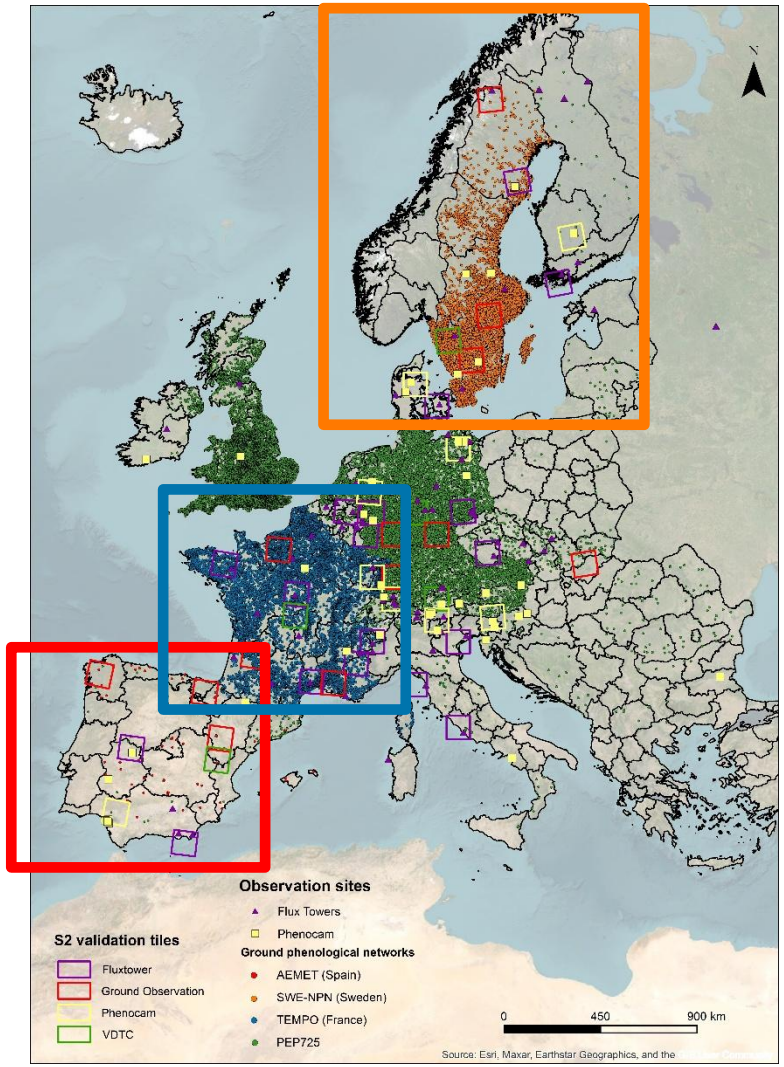


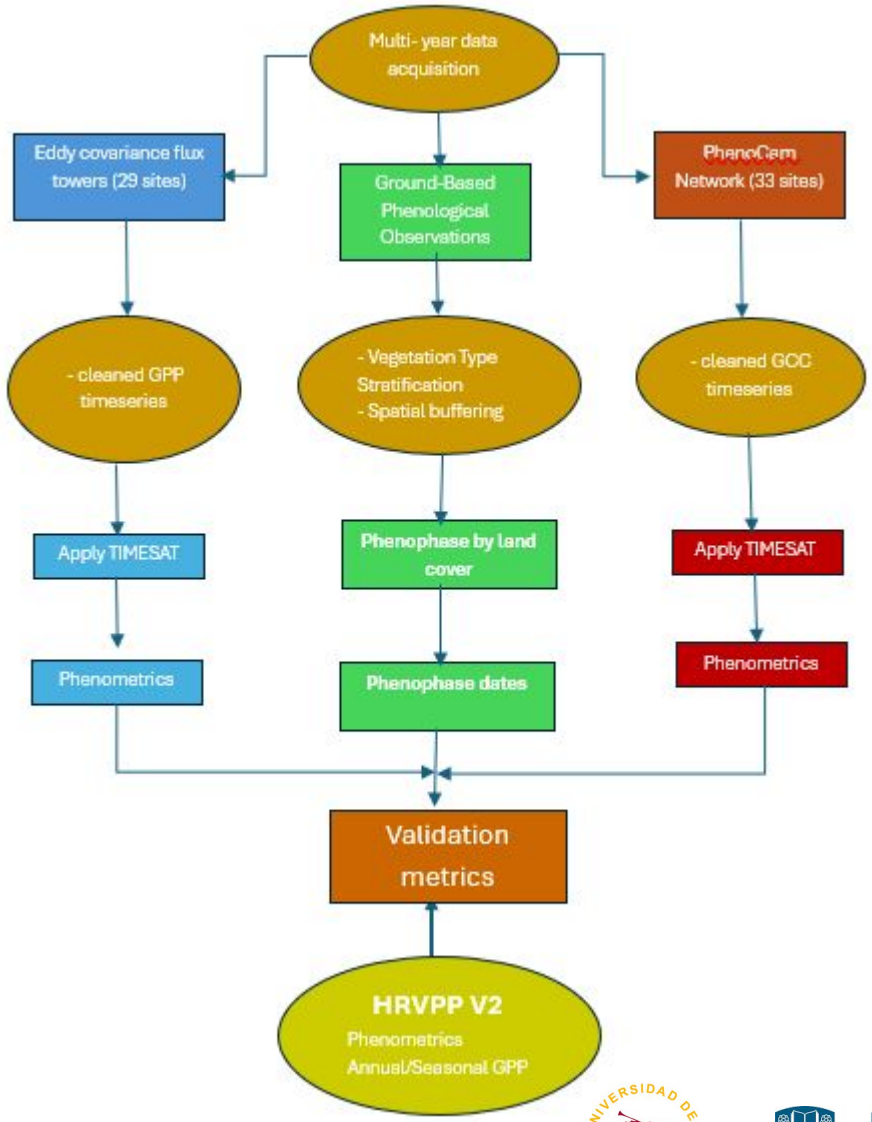
LAND SURFACE PHENOLOGY

VALIDATION INITIATIVE:

Validation of Copernicus High Resolution Vegetation Phenology and Productivity (HRVPP-2)

Land Surface Phenology





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Land Surface Phenology

Ground Observations

STEP 1

Creation of a buffer zone
A buffer zone is created around each ground-based phenological observation station

STEP 2

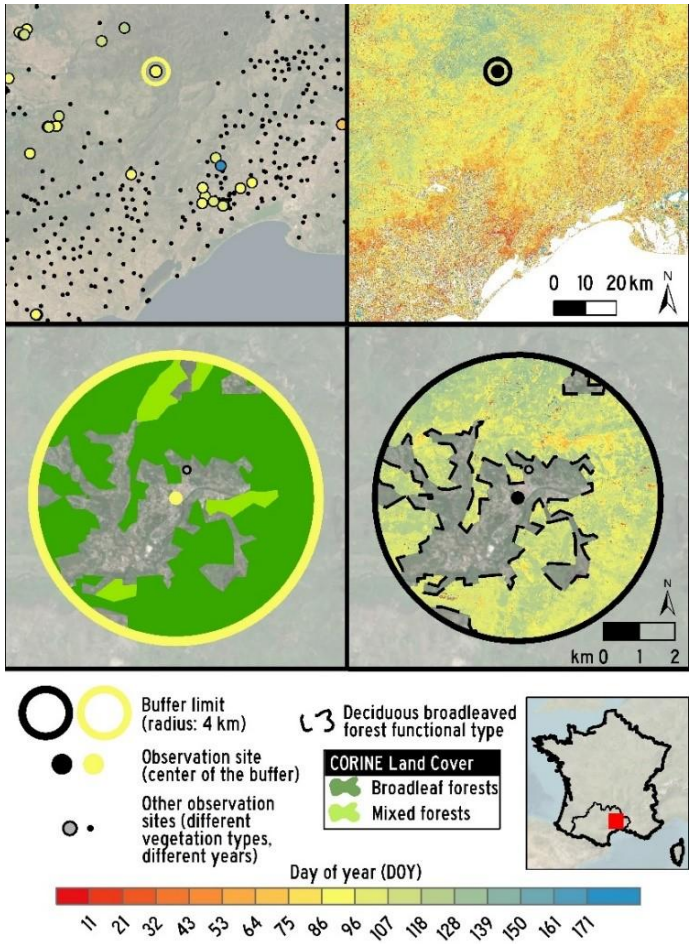
Averaging phenophase dates for each buffer
The Julian day of each phenophase is averaged for every buffer, considering the correspondence between genera and the following different vegetation groups.

STEP 3

Averaging HR-VPP product pixels for each buffer
The HR-VPP product pixels of each buffer plot are averaged for the same vegetation groups, using different land-cover masks.

STEP 4

Calculation of validation metrics
Various validation metrics are calculated to quantify the agreement between the two phenological approaches: Pearson correlation coefficient (r value), RMSE (Root Mean Square Error) and MAE (Mean Absolute Error).



The validation methodology is based on Tian et al. (2021).

Land Surface Phenology

Flux Towers (ICOS)

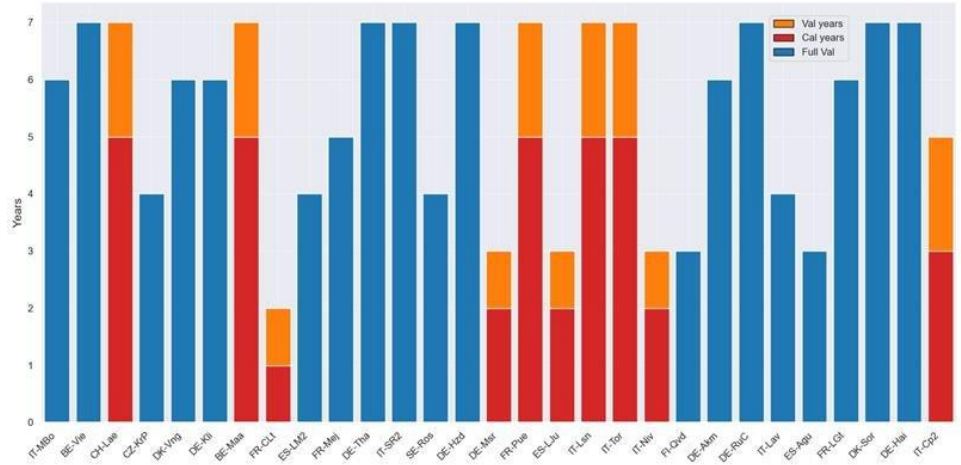


Fig. Number of **years** with available flux tower data per site, illustrating the temporal coverage of data to be used for validation.

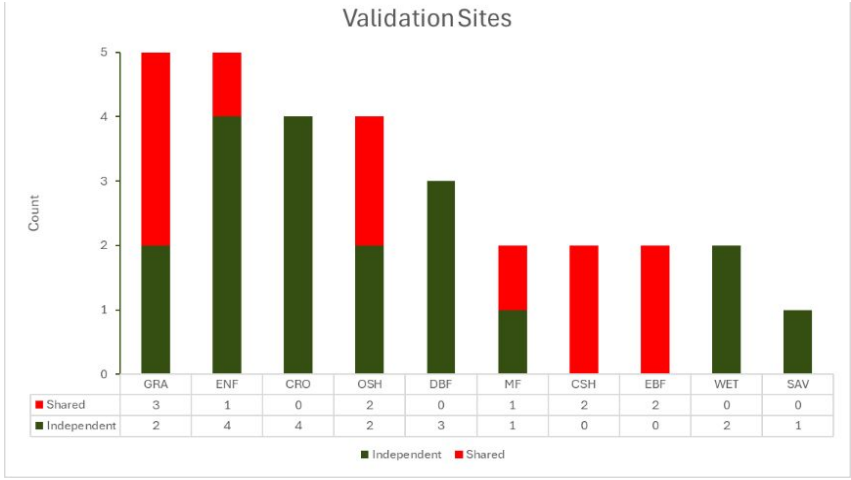
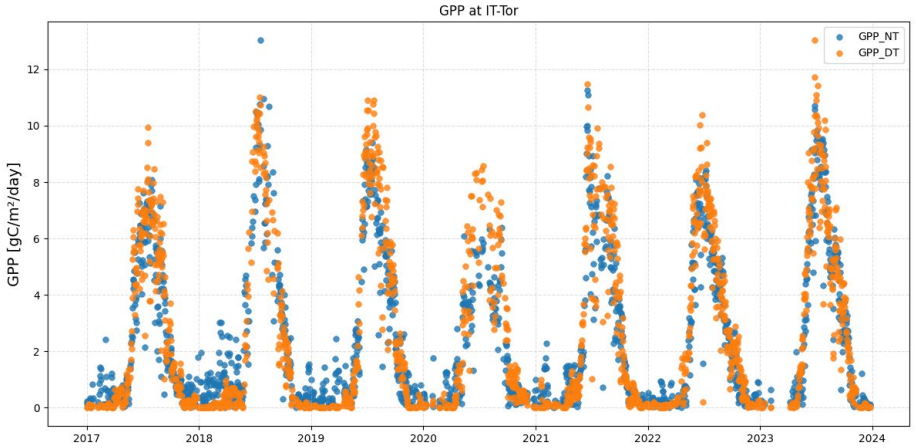


Fig. Flux tower **sites** grouped by **land cover type**, showing spatial distribution and ecosystem representation that will be used in the validation.



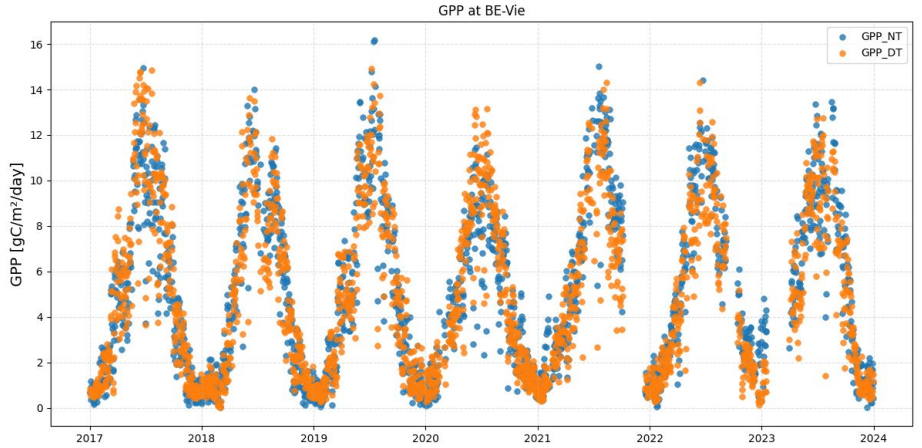


Fig. Daily cleaned Gross Primary Productivity (GPP) time series from two ICOS flux tower sites, illustrating seasonal vegetation productivity dynamics.

Land Surface Phenology

Phenology cameras

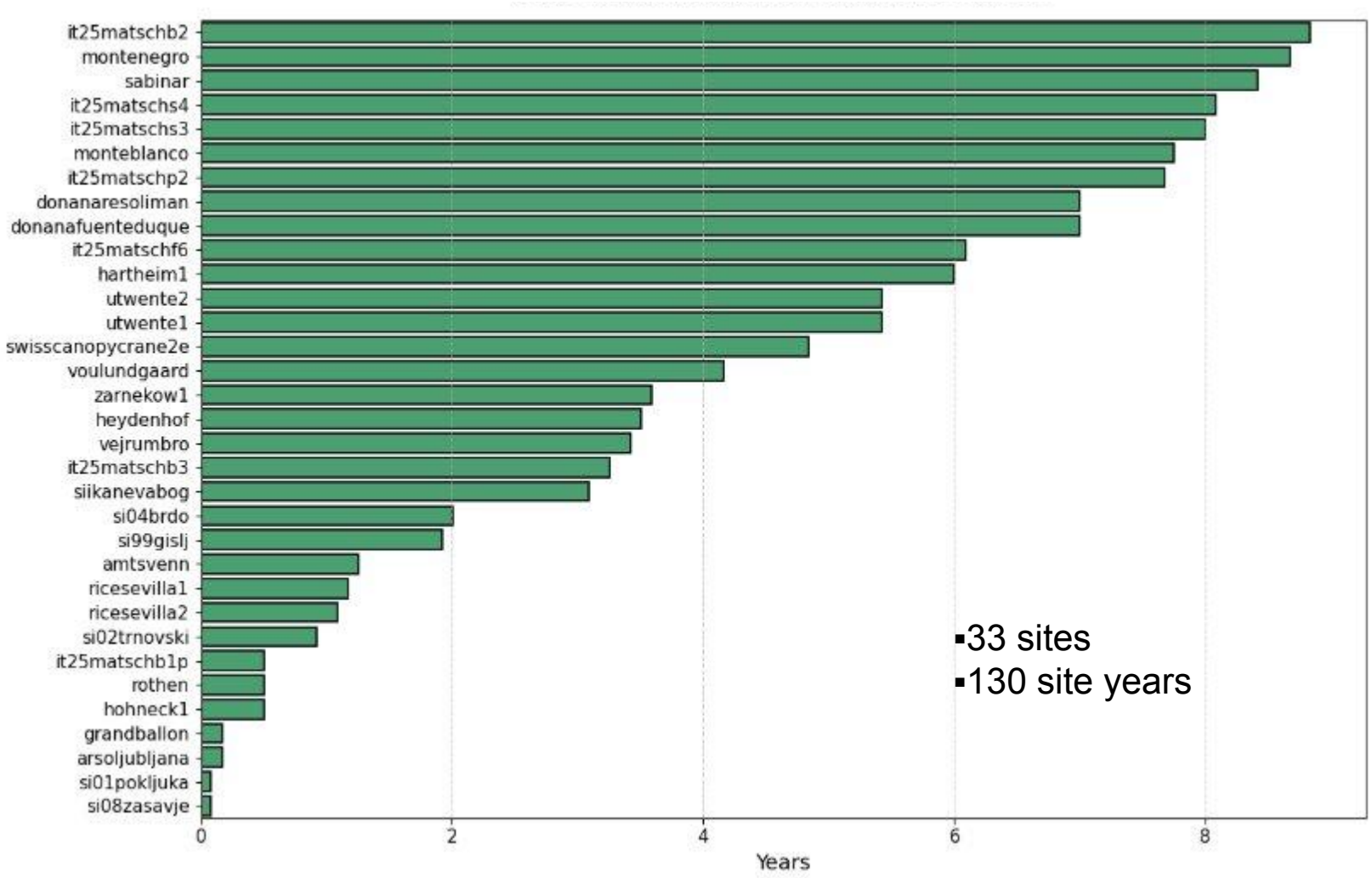


Fig. Number of years with available GCC data per each site.