DATOS ÓPTICOS Y RADAR PARA DETERMINACIÓN DE FENOLOGÍA DE ESPECIES FORESTALES

Optical and radar data for characterization of forest species phenological traits

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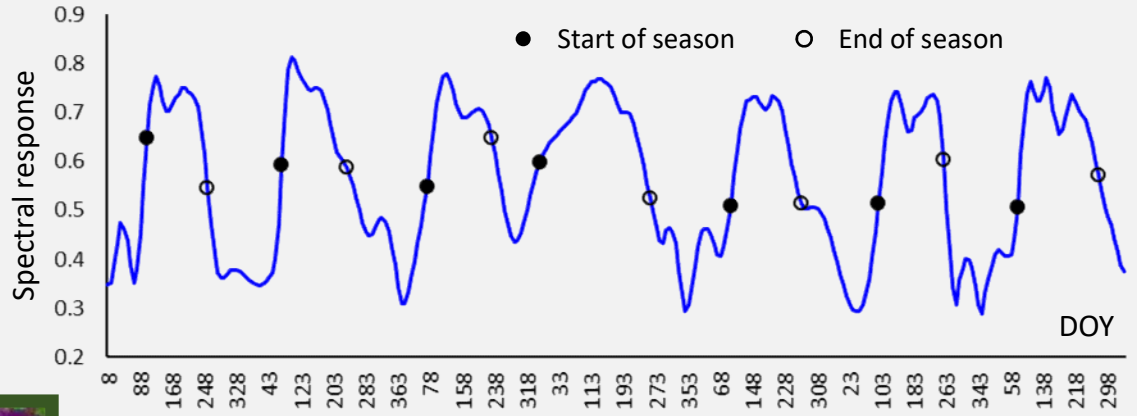
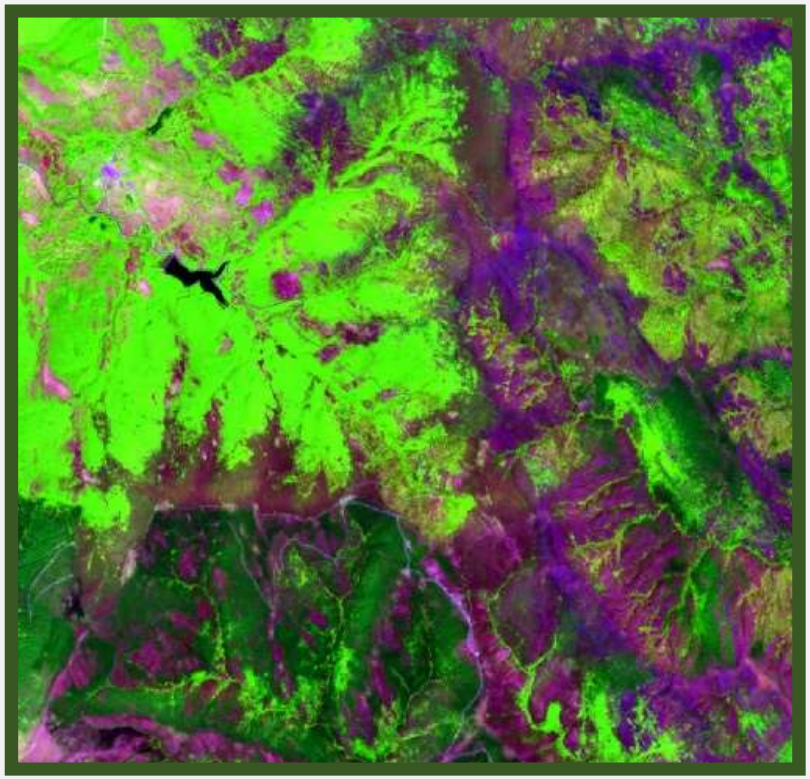
Datos: USGS, ESA, HISDESAT PAZ-CIENCIA

INTRODUCTION

Spectro-phenology





Sentinel-2 animation year 2017
Visualization R/G/B: 11/8/4

- ❖ **Identify / map species**
- ❖ **Comparation among locations**
- ❖ **Species dynamics**
- ❖ **Adaptation /resilience to changes**
- ❖ **Ecosystemic services**

APPROACH

- Time series of spectral data
- Vegetation indices / Backscattering coefficient
- Interpolation for completeness
- Curve fitting: Savitzky-Golay, Double logistic, Gaussian
- Extraction of spectro-phenological parameters
- Analysis in sample areas
- Mapping spectrophenology

SPECTROPHENOLOGY: Landsat and Sentinel-2

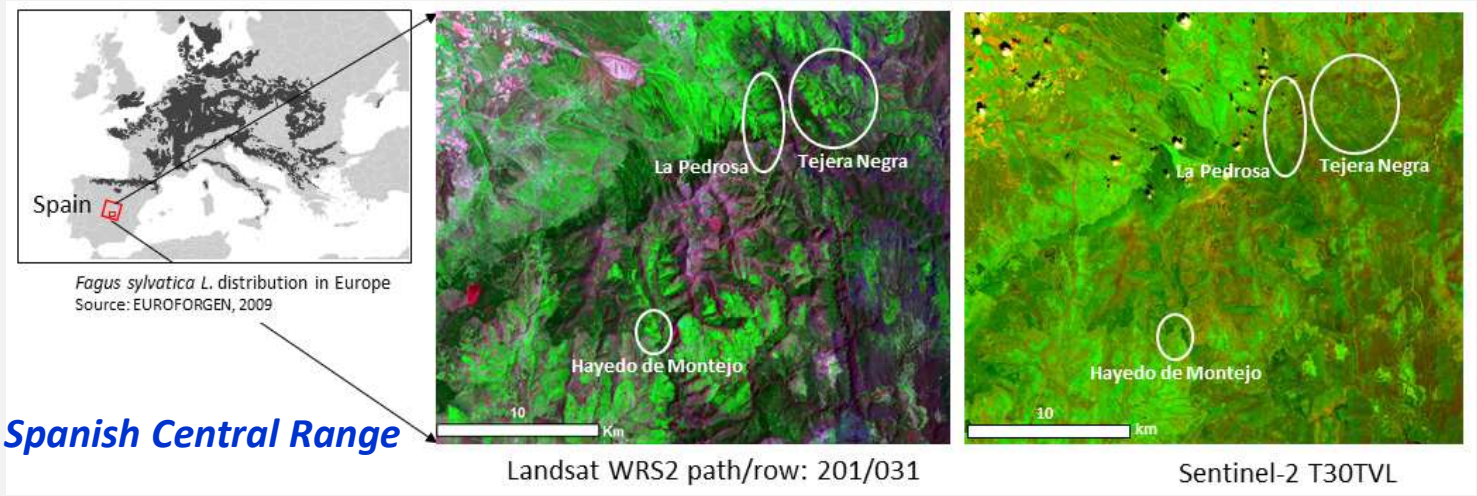
SPECTROPHENOLOGY: Landsat and MODIS

SPECTROPHENOLOGY: radar X-band PAZ

SPECTROPHENOLOGY: Landsat and Sentinel-2

OBJECTIVES:

- **Characterization** of spectral phenology
- **Compare** species spectrophenology
- Evaluate performance of different **vegetation indices**
- Assess historical species **dynamics**



Vegetation:

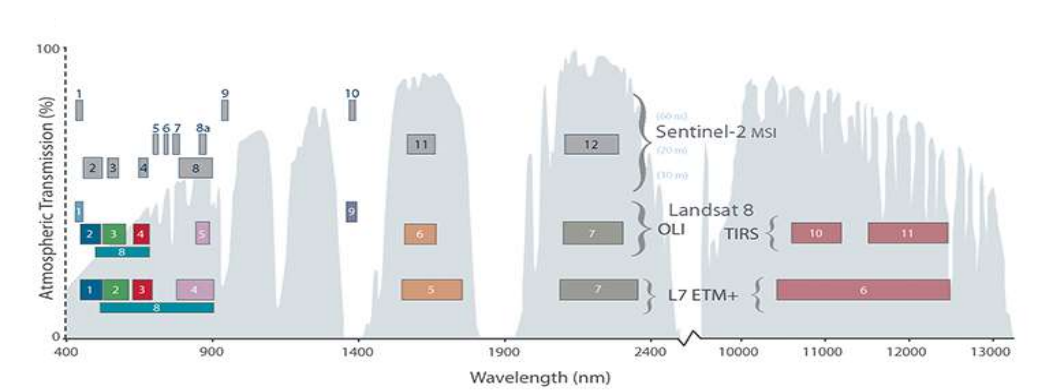
Quercus pyrenaica Willd.
Quercus petraea (Matt.), Liebl.
Quercus ilex L.
Fagus sylvatica L.

Pinus pinaster Ait.
Pinus sylvestris L.

Fraxinus angustifolia Vahl.
Fraxinus excelsior L.
Betula sp.
Sorbus aucuparia L.
Populus tremula L.

Shrubs
Pastures

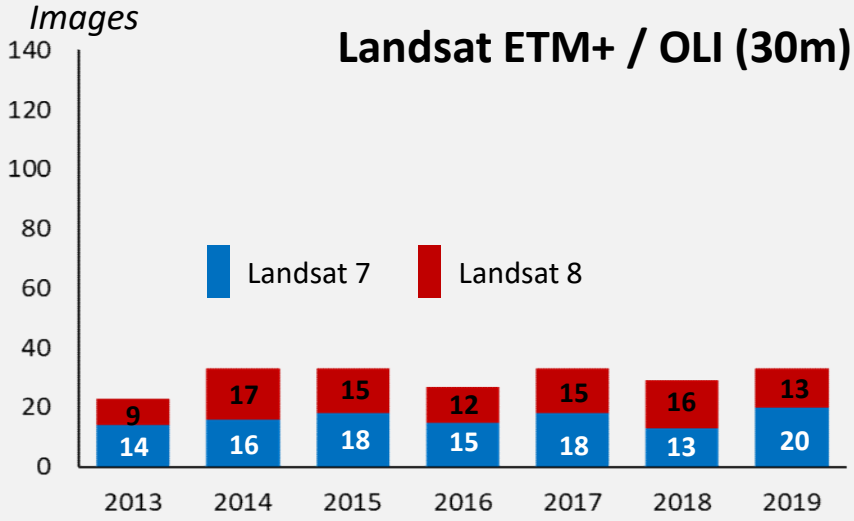
SPECTROPHENOLOGY: Landsat and Sentinel-2



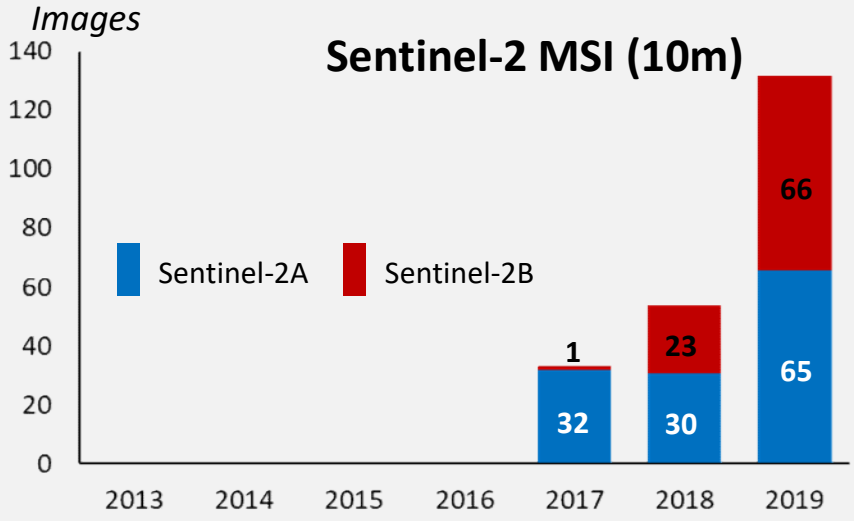
Source: https://landsat.gsfc.nasa.gov/wp-content/uploads/2015/06/Landsat.v.Sentinel-2.png

Landsat / Sentinel-2
(*virtual constellation*)

Spectrally	similar
Spatially	30 / 10 m
Temporally	8 / 2-3 days



211 images April 2013 – December 2019
30 / season Collection 1 level 2



217 images April 2017 – December 2019
70 / season MSIL2A

SPECTROPHENOLOGY: Landsat and Sentinel-2

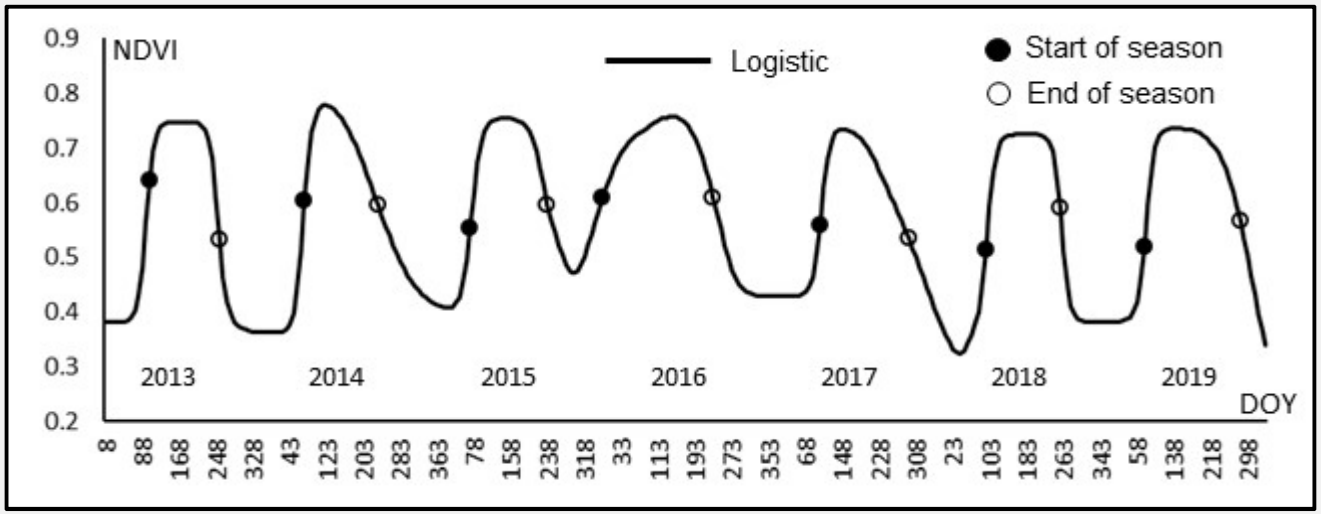
VEGETATION INDICES

	Equation	Reference
Landsat and Sentinel-2	**NDVI** = (NIR – Red) / (NIR + Red)	Tucker, 1979
Landsat	**TCW** = 0.0315 × Blue+0.2021 × Green +0.3102 × Red+0.1594 × NIR+0.6806 × SWIR1-0.6109 × SWIR2	Crist, 1985
Landsat	**TCA** = atan (TCG/TCB) TCB = 0.2043 × Blue+0.4158 × Green+0.5524 × Red+0.5741 × NIR+0.3124 × SWIR1+0.2303 × SWIR2 TCG = -0.1603 × Blue-0.2819 × Green-0.4934 × Red+0.7940 × NIR+0.0002 × SWIR1-0.1446 × SWIR2	Powell et al., 2010
Sentinel-2	EVI = 2.5. × [(NIR - Red)/(NIR + 6 × Red - 7.5 × Blue+1)]	Liu and Huete, 1995
Sentinel-2	**NDWI** = (NIR -SWIR3)/(NIR + SWIR3)	Gao, 1996

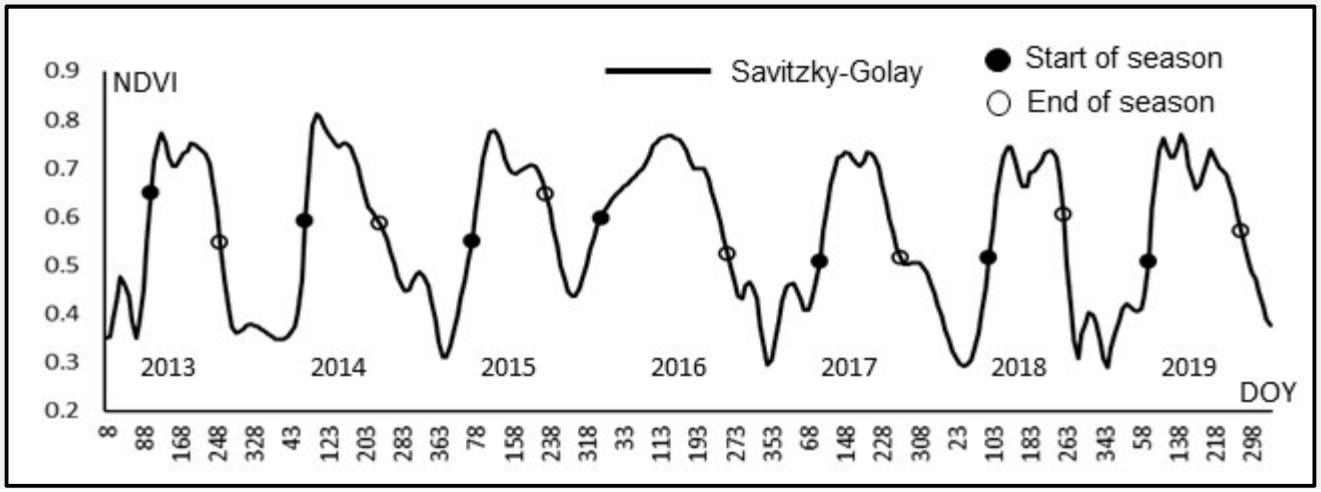
SPECTROPHENOLOGY: Landsat and Sentinel-2

CURVE FITTING

Double logistic ➡ Generalization phenological curves ➡ **Overall patterns**



Savitzky-Golay ➡ Smoothly follow seasonal variations ➡ **Punctual anomalies**



SPECTROPHENOLOGY: Landsat and Sentinel-2

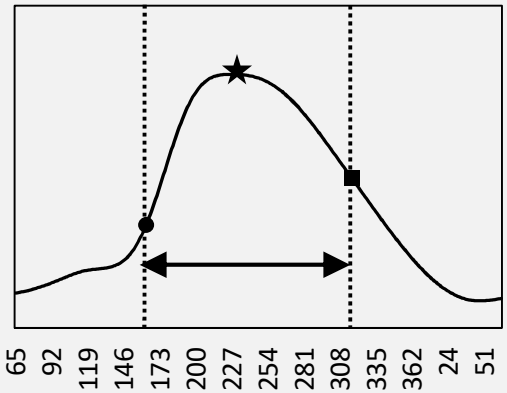
PHENOLOGICAL PARAMETERS

SOS: Start Of Season ●

EOS: End Of Season ■

Season Length ⟷

Peak time ★



TCA

- Later SOS
- Peaks later
- Generally shorter than NDVI

Landsat

***Fagus sylvatica* phenological parameters**

	SOS (DOY)		EOS (DOY)		Length (days)		Peak (DOY)	
	NDVI	TCA	NDVI	TCA	NDVI	TCA	NDVI	TCA
2013	138	142	344	336	206	194	245	244
2014	124	127	336	337	212	210	221	222
2015	125	125	317	312	191	188	217	217
2016	80	87	326	329	246	242	197	205
2017	118	131	348	349	231	219	228	235
2018	136	144	331	332	195	187	235	242
2019	130	139	350	349	220	210	240	248
Average	122	128	336	335	214	**207**	226	230

SPECTROPHENOLOGY: Landsat and Sentinel-2

PHENOLOGICAL PARAMETERS

***Fagus sylvatica* phenological parameters**

Sentinel-2

	SOS (DOY)		EOS (DOY)		Length (days)		Peak (DOY)	
	NDVI	EVI	NDVI	EVI	NDVI	EVI	NDVI	EVI
2017	103	119	323	297	220	178	208	205
2018	99	104	312	274	213	169	199	189
2019	90	97	289	284	199	187	186	190
Average	97	107	308	285	**211**	178	198	195

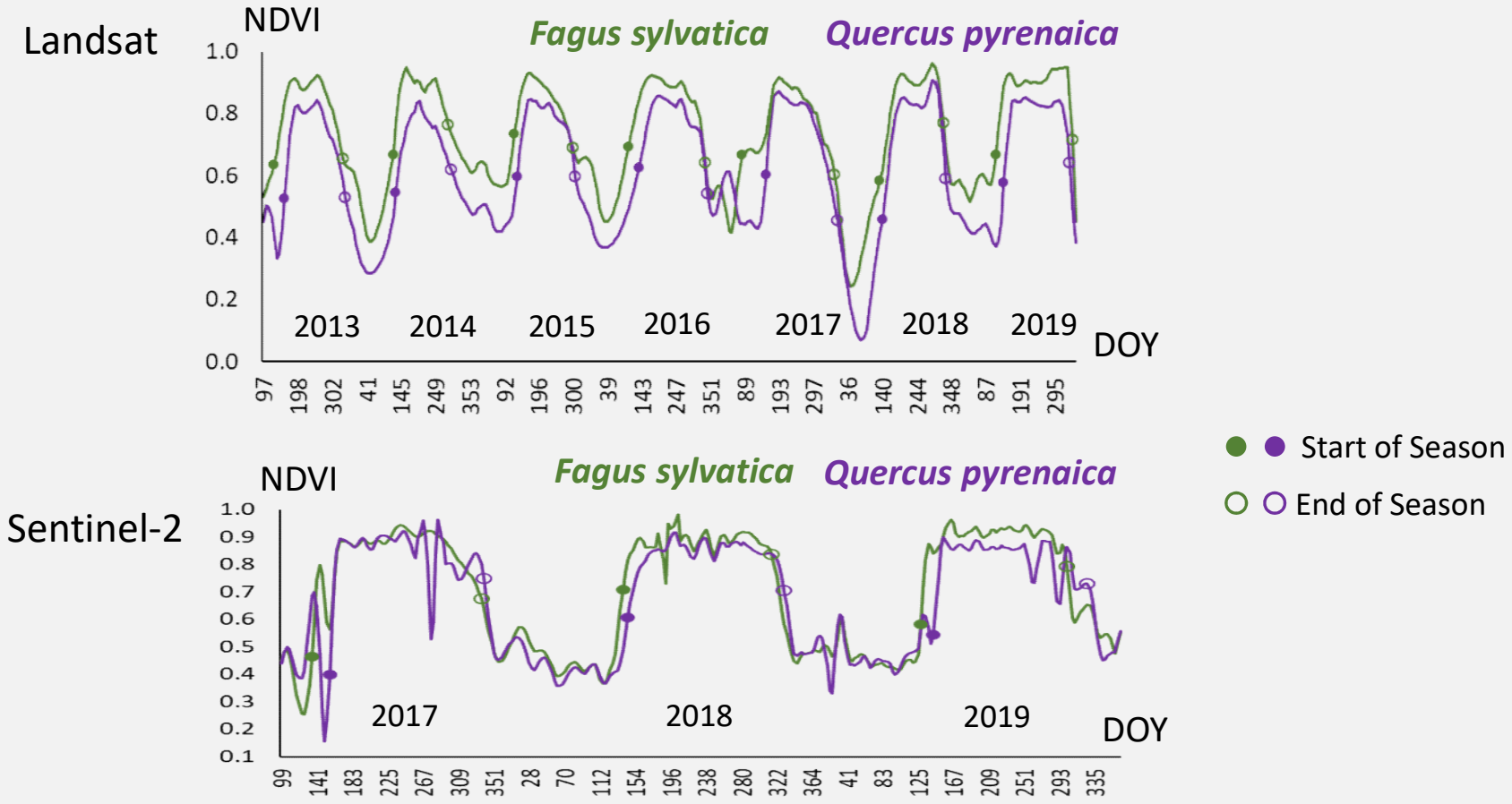
Landsat

	SOS (DOY)		EOS (DOY)		Length (days)		Peak (DOY)	
	NDVI	TCA	NDVI	TCA	NDVI	TCA	NDVI	TCA
2017	118	131	348	349	231	219	228	235
2018	136	144	331	332	195	187	235	242
2019	130	139	350	349	220	210	240	248
Average	128	138	343	343	**215**	205	234	242

- Similar length
- Sentinel: earlier SOS and EOS

SPECTROPHENOLOGY: Landsat and Sentinel-2

COMPARISON BETWEEN SPECIES



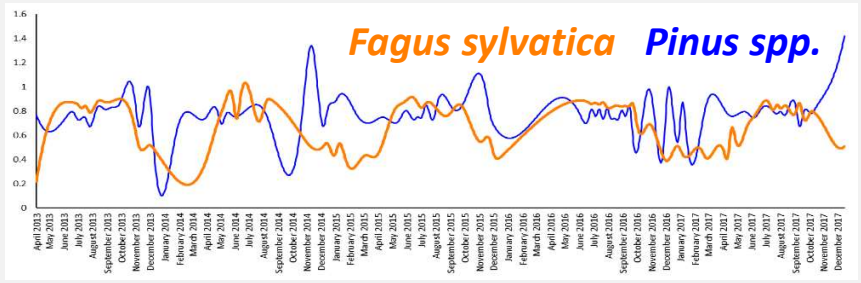
- SOS: *Fagus sylvatica* earlier than *Quercus pyrenaica*
- Length: *Fagus sylvatica* longer than *Quercus pyrenaica*

SPECTROPHENOLOGY: Landsat and Sentinel-2

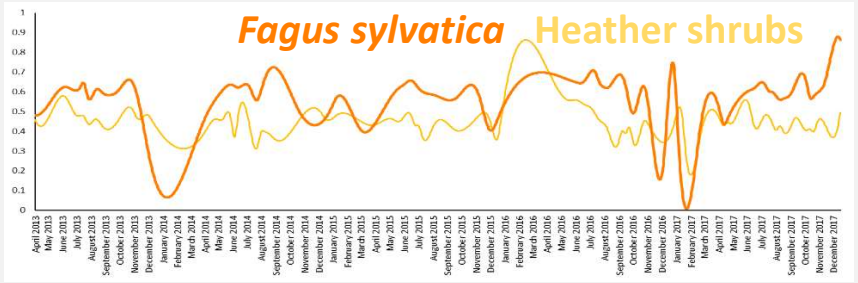
SPECTROPHENOLOGY OF BEECH EXPANSION: DYNAMICS

2013-2017 OLI / ETM+ 148 images

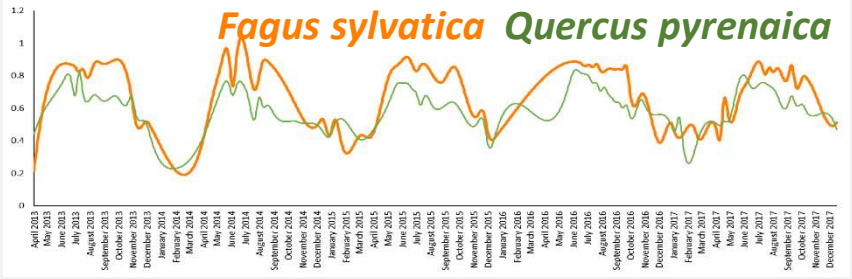
Expansion in pine



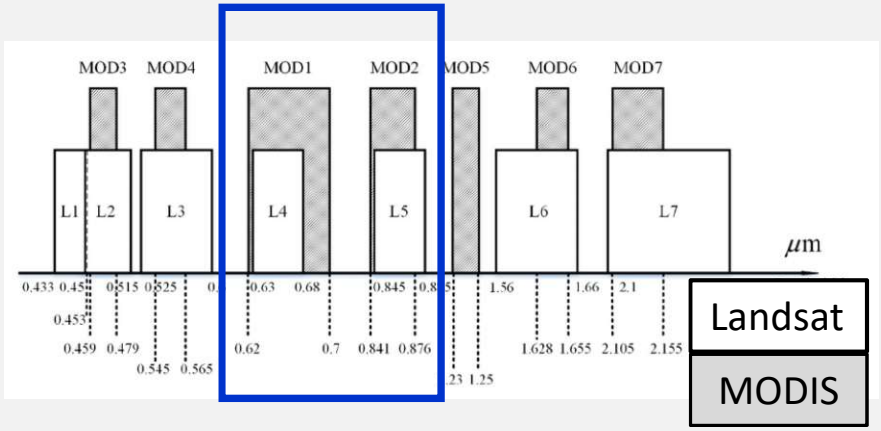
Expansion in shrubland



Expansion in oak forest



SPECTROPHENOLOGY: Landsat and MODIS

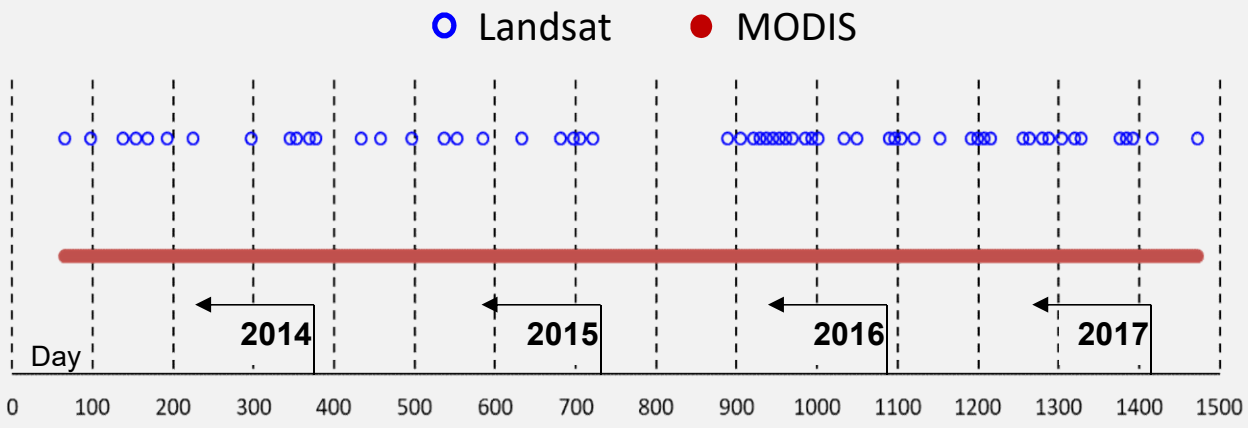


Landsat / MODIS

Spectrally	compatible
Spatially	30 / 250 m
Temporally	8 / 1 day

GOAL: assessment of a late frost effect on landscape spectrophenology

SPECTROPHENOLOGY: Landsat and MODIS

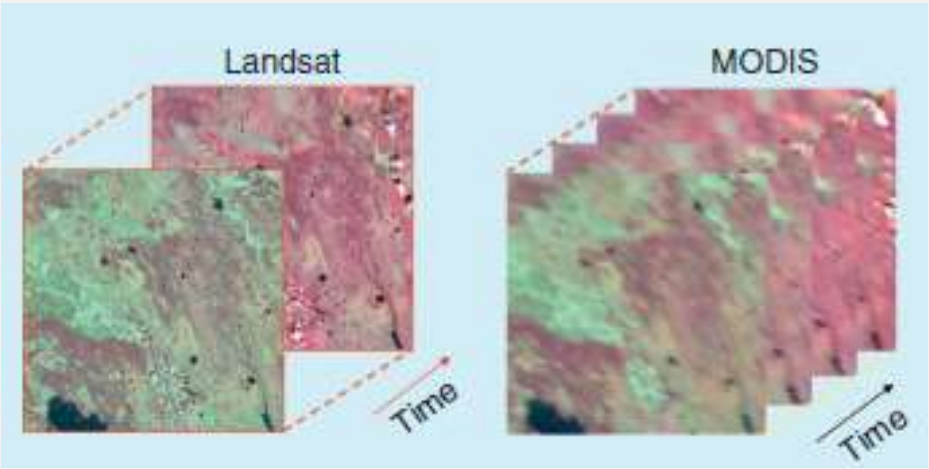


6 March 2014 - 12 January 2018

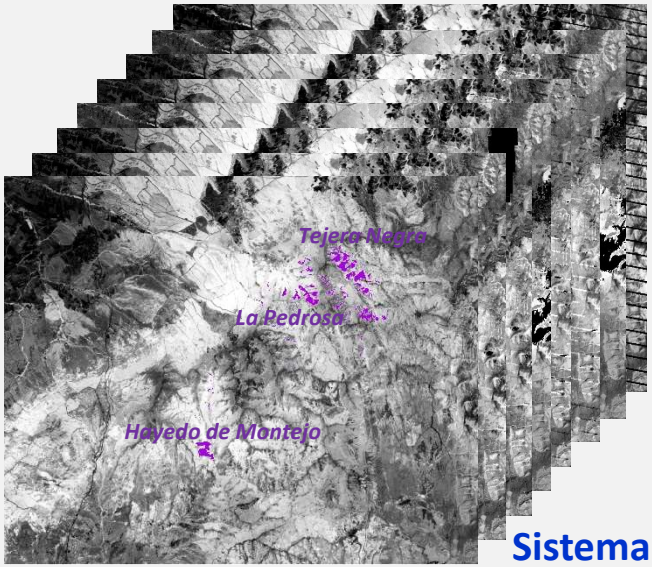
Landsat ETM+ / OLI level 2
58 images (15/season)
Red, NIR
Cloud free

MODIS MOD09GQ V6
1472 images (365/season)
Band 1 (red, 620-670 nm)
Band 2 (NIR, 841-876 nm)
Quality band

STARFM (Spatial and Temporal Adaptive Surface Reflectance Model)



Source: Gao et al. 2015



Sistema Central

SPECTROPHENOLOGY: Landsat and MODIS

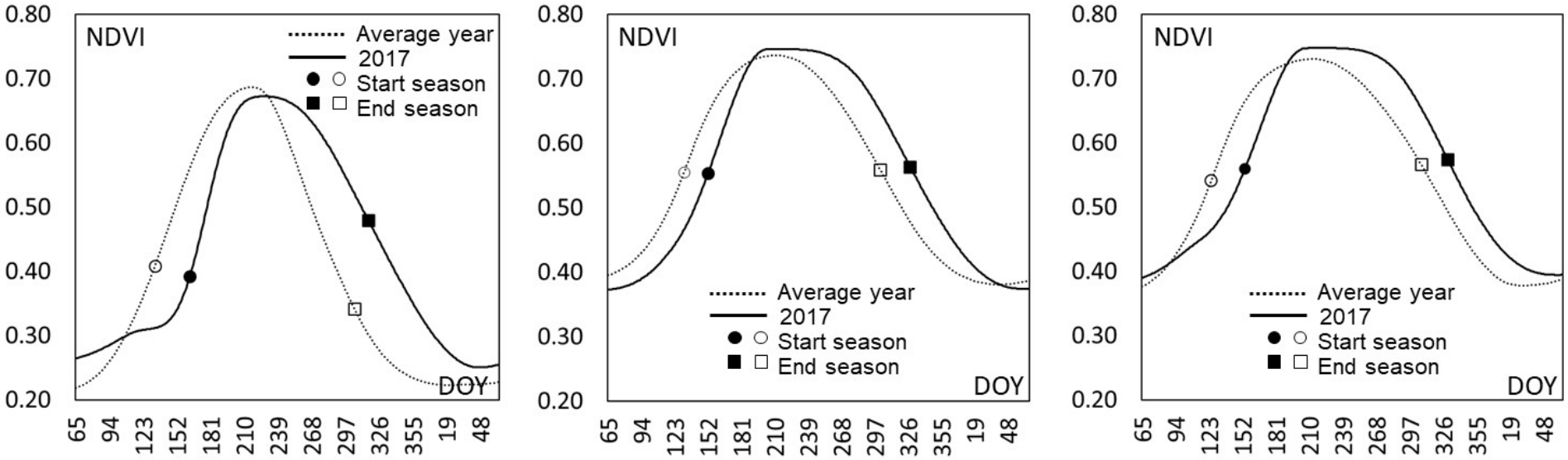
PHENOLOGICAL PARAMETERS

2017 / *average 2014-2016*

	Overall forest	*Fagus sylvatica*	*Quercus petraea*
SOS	163 / *133* (+30)	152 /*131* (+21)	154 /*125* (+29)
EOS	317 / *305* (+12)	328 / *302* (+26)	330 / *307* (+23)
Length	154 / *172* **(-18)**	176 / *171* (+5)	176 / *182* (-6)
Peak time	232 / *209* (+23)	234 / *211* (+23)	238 / *213* (+25)

- Later SOS
- Later EOS
- Later peak time
- *Length

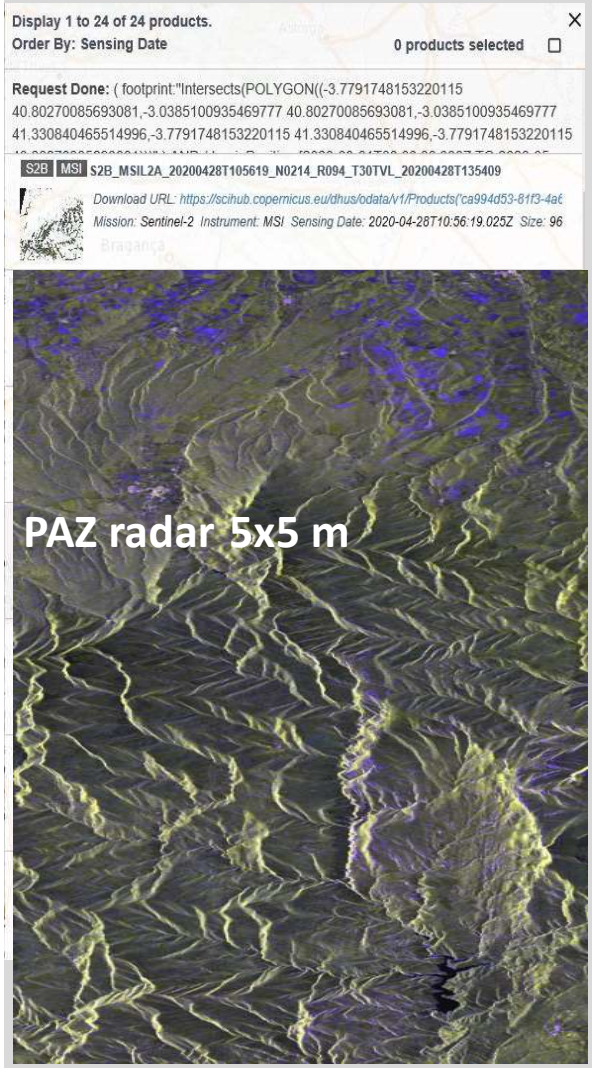
Gaussian fitting



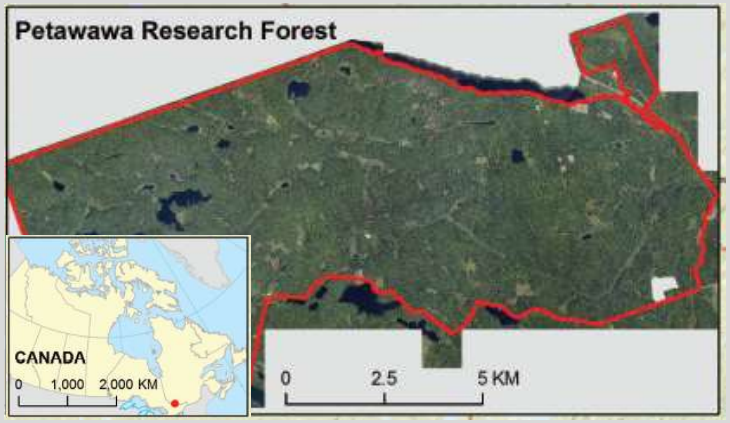
Overall forest | *Fagus sylvatica* | *Quercus petraea*

SPECTROPHENOLOGY: radar X-band PAZ

GOAL: assess X-band radar PAZ capacity for characterization of forest phenology



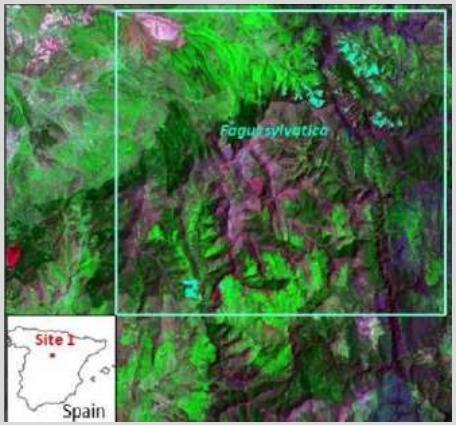
Canadian site



100 km^2

Quercus rubra
Populus tremuloides
Pinus strobus
Pinus resinosa

Spanish site



375 km^2

Quercus pyrenaica
Quercus petraea
Fagus sylvatica
Quercus ilex
Pinus pinaster
Pinus sylvestris
Fraxinus angustifolia

SPECTROPHENOLOGY: radar X-band PAZ

DATA ACQUISITION PLAN 2019-2022

- Acquisitions **2019-2020**

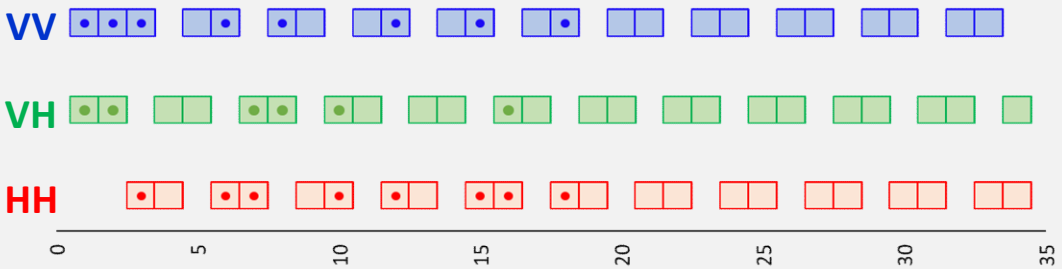
  Polarization: HH, VV, HV/VH

  33 times Spain

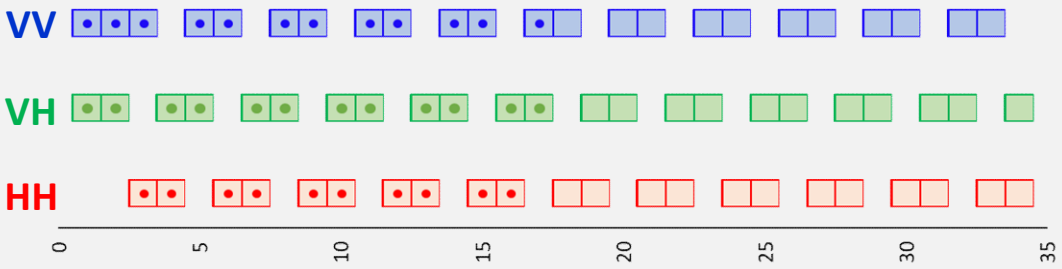
  33 times Canada

- Acquisitions 2020-2021
- Acquisitions 2021-2022

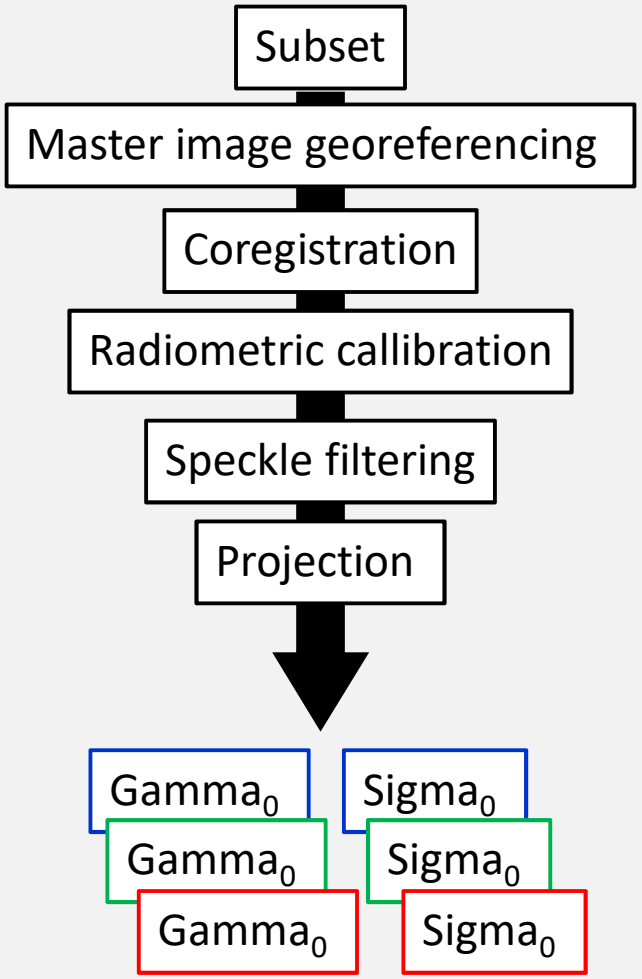
Spain



Canada



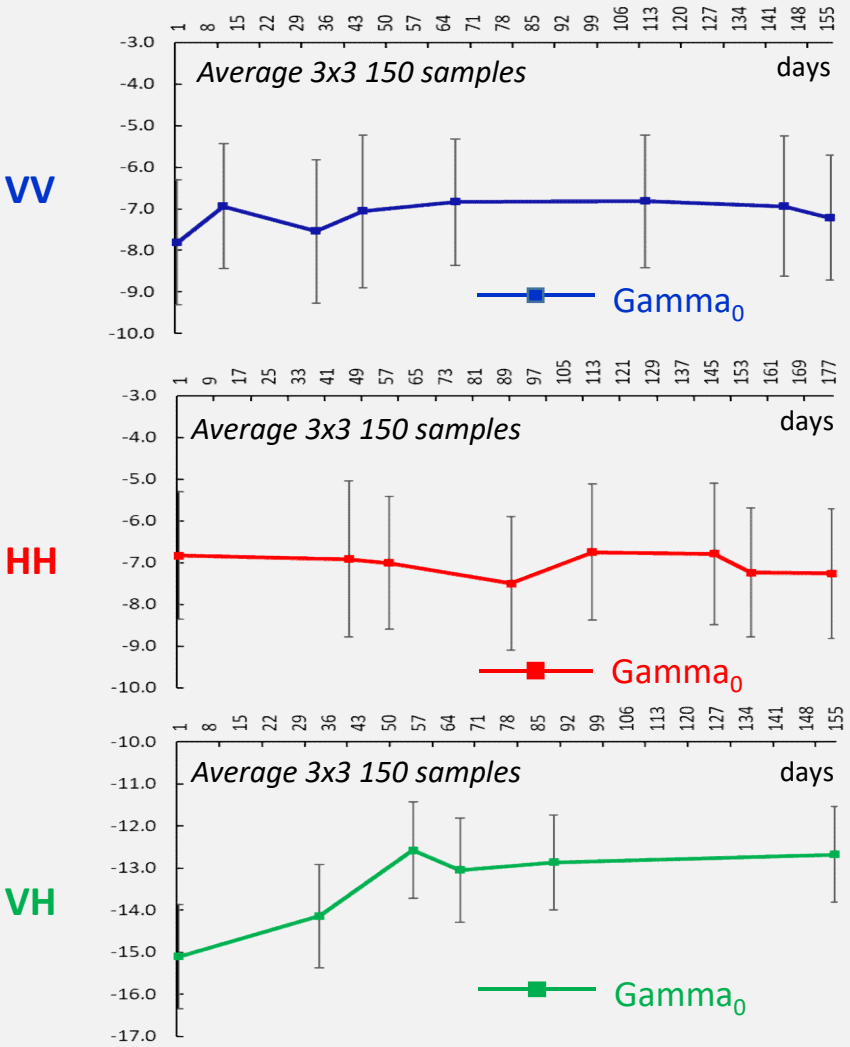
DATA PROCESSING



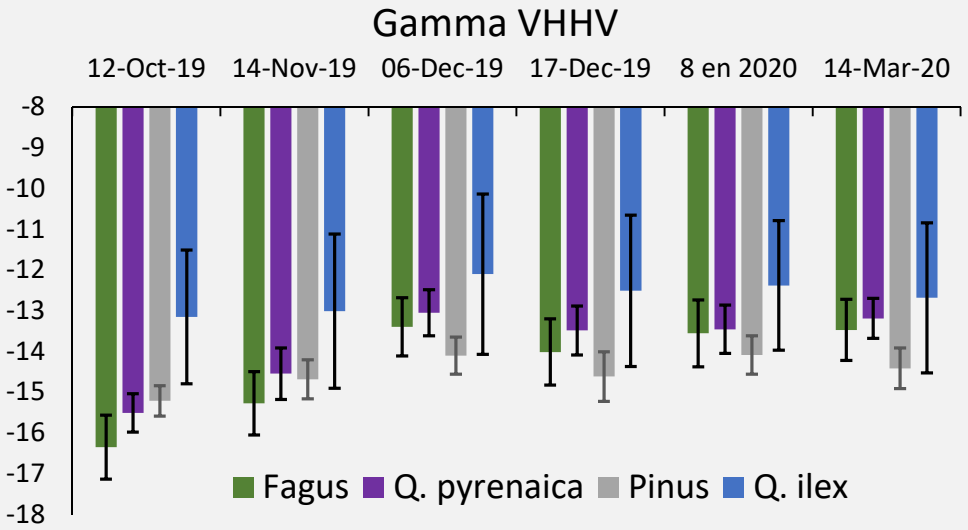
SPECTROPHENOLOGY: radar X-band PAZ

PRELIMINARY RESULTS

Fagus sylvatica time series



Comparison among species



- VHHV more sensitive than VV and HH
- $Gamma_0$ y $Sigma_0$ similar performance
- *Fagus* and *Q. pyrenaica* more dynamic range

Coming next:

- Complete series
- Select polarization
- Compare with Sentinel-1 (band-C) series

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