

# Proyecto SENSAGRI H2020: Nuevos servicios Copernicus para aplicaciones agrarias

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*Jornada técnica sobre innovación en gestión de regadíos mediante redes agroclimáticas, imágenes de satélite y Sistemas de Información Geográfica*

*Madrid, 28 de noviembre de 2019*



# Sentinels Synergy for Agriculture

H2020 EO-3-2016: Evolution of Copernicus services



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Junta de Castilla y León  
Consejería de Agricultura y Ganadería



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HORIZON 2020



Jornada Técnica CENTER Regadíos

Madrid 28/11/19

## Objetivos de SENSAGRI (2016-2019)

[www.sensagri.eu](http://www.sensagri.eu)

- Desarrollar nuevas aplicaciones para el sector agrícola europeo, combinando datos de los satélites del programa **Copernicus, Sentinel-1 (radar), Sentinel-2 (óptico)** y datos in-situ.
- Desarrollar **prototipos de servicios Copernicus** para humedad del suelo (**SSM**), índice de área foliar (**LAI**) y **mapas de cultivos estacionales**, y usar esos prototipos para implementar **servicios agrícolas avanzados (“prueba de concepto”)**.
- **Validar los servicios** y establecer **casos de demostración** en áreas test, para mostrar el potencial de éstos como futuros servicios Copernicus (**Core – Land – Pan-European**)
- **Interaccionar con Copernicus y con el sector agrícola** para dar a conocer y enfocar adecuadamente los servicios propuestos.

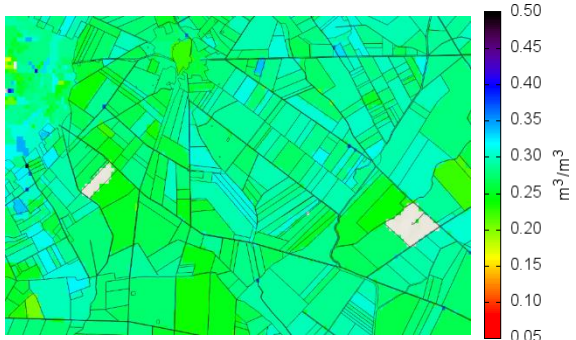


# Consorcio SENSAGRI

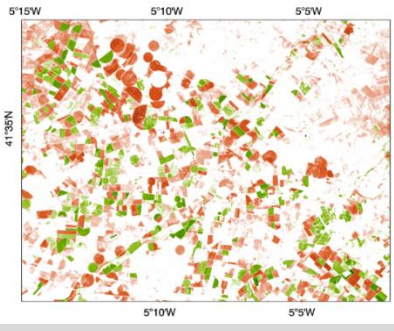
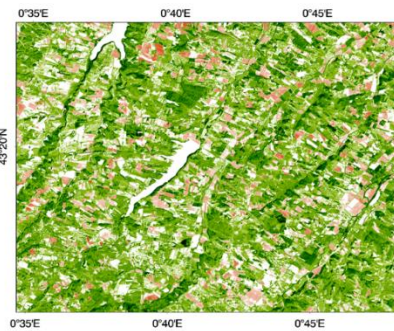


# Servicios SENSAGRI

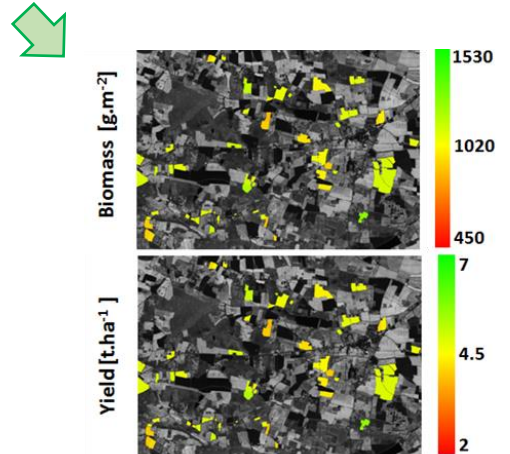
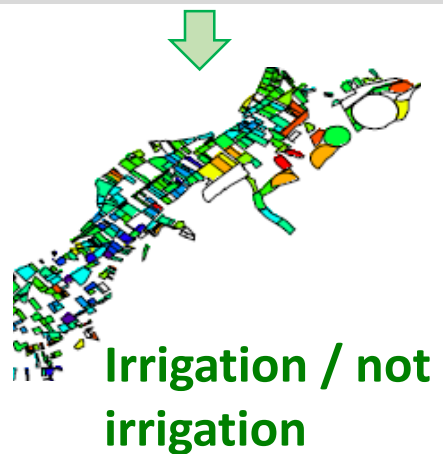
➤ Orientados a aplicaciones agrarias (CLMS Pan-European)



**Soil Surface Moisture (SSM)**

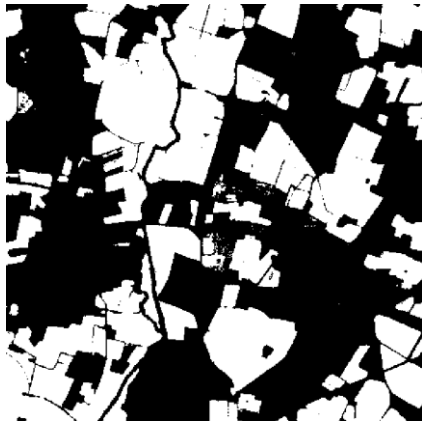


**Green & Brown Leaf Area Index (LAI)**

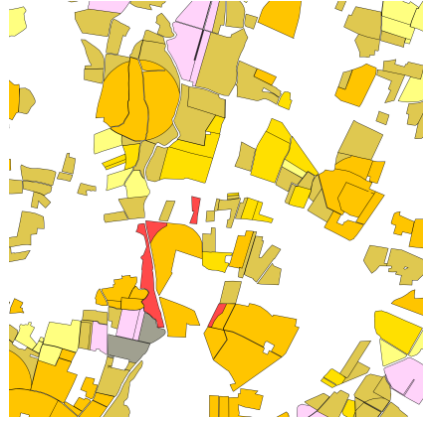


# Servicios SENSAGRI – Seasonal Crop Map

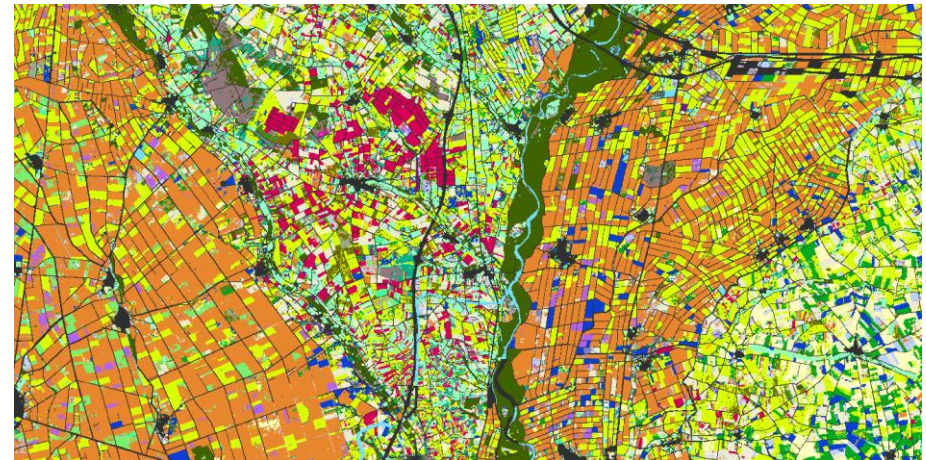
- Integra **Sentinel-1** y **Sentinel-2**
- Procesado contnuo de series temporales. **2 - 3 mapas** por año
- Probados con diferentes conjuntos de **datos de entrenamiento** (incluyendo LPIS-IACS)
- **Mapas al comienzo de la temporada** basados únicamente en información de años previos



France 2017  
Crop Mask



France 2017  
Crop Type



Spain 2018  
Land cover map

# Estrategia de validación

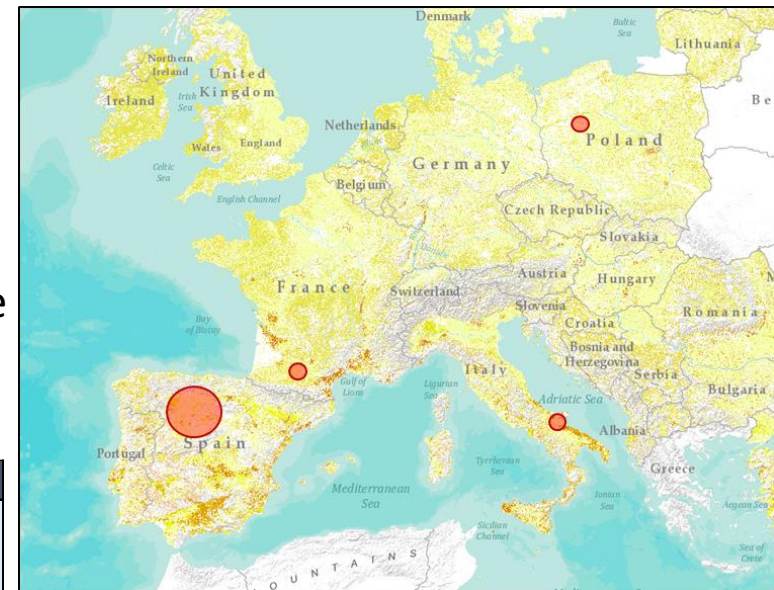
## Four European agricultural test sites

Spain: ITACYL - Duero River-basin

France: UPS-CESBIO - OSR Auradé and Lamasqère

Italy: CREA/CNR - Apulian Tavoliere

Poland: IPP/NRI – Winna Góra



CLC agricultural classes. Source: EEA

Services	Ground Variable	Time
<b>SSM</b>	Volumetric Soil Moisture at 0-5 cm depth	<ul style="list-style-type: none"> <li>• Continuous monitoring</li> <li>• 3 measurement campaigns at critical stages and during irrigation season</li> </ul>
<b>LAI</b>	Leaf Area Index, with LAI-2000 Plant Canopy Analyzer	3 measurement campaigns at critical stages and during growing season
<b>Seasonal Crop Mapping</b>	Crop types	3 measurement campaigns in March, June and September
<b>Irrigated areas</b>	Irrigated and not irrigated fields	3 measurement campaigns in March, June and September
<b>Tilled areas</b>	Tilled and not tilled fields	
<b>Yield</b>	Commercial yield	1 measurement campaign at crop harvest
<b>Intermediate crops</b>	Crop types	2 measurement campaigns in March and July

## Three non-European test sites

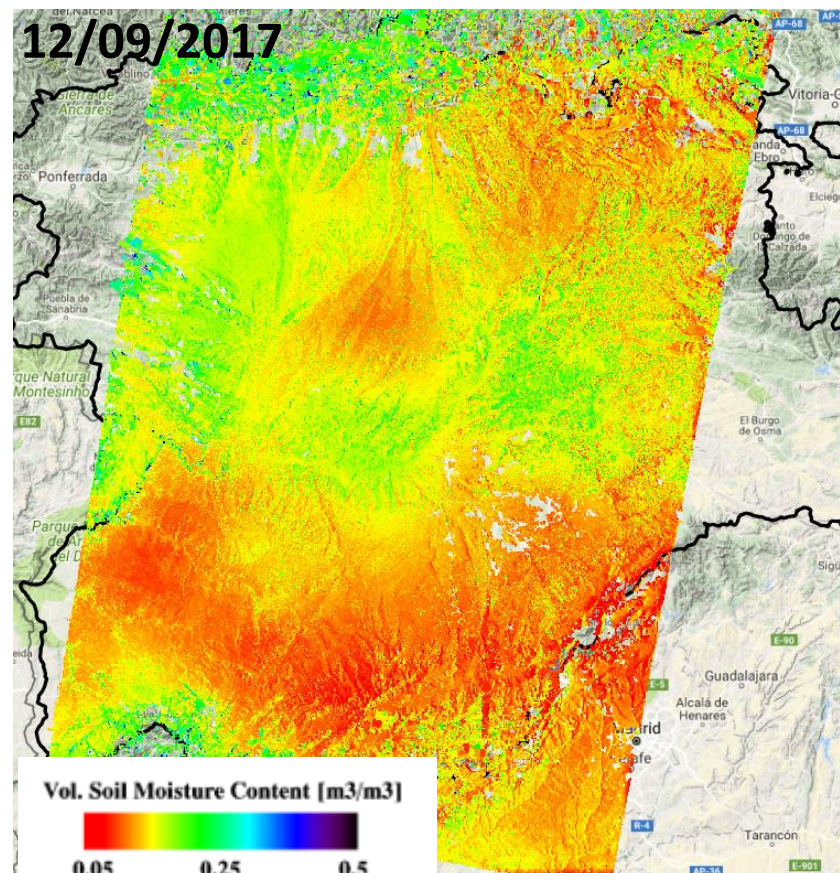
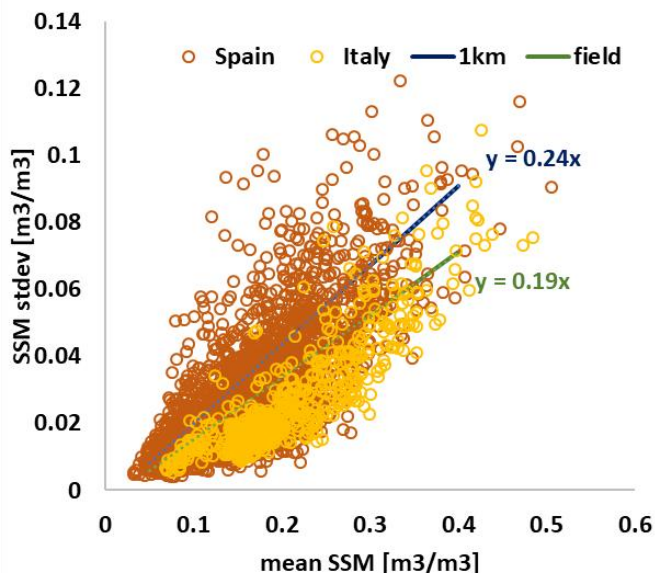
Argentina: INTA – Hilario Ascasubi

Two JECAM sites (Morocco and Tunisia)

# Humedad del suelo (SSM)

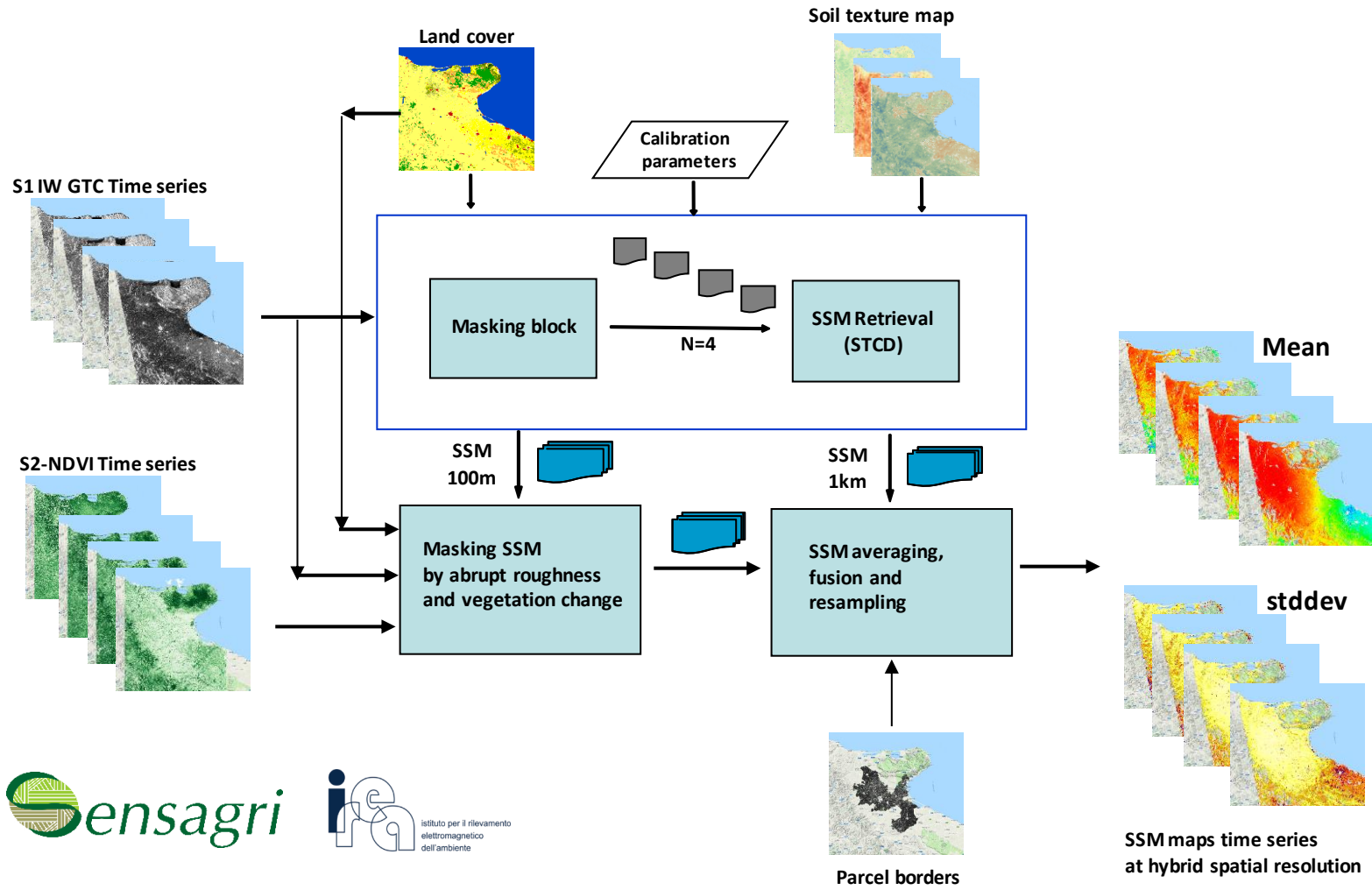


- Procesador SMOSAR basado en detección de cambios (STCD) en imágenes radar (S1)
- S2 (NDVI) permite enmascarar cambios abruptos de la vegetación (cosecha, quemas...)
- Resolución a 1 km o a 100 m con mapa de parcelas



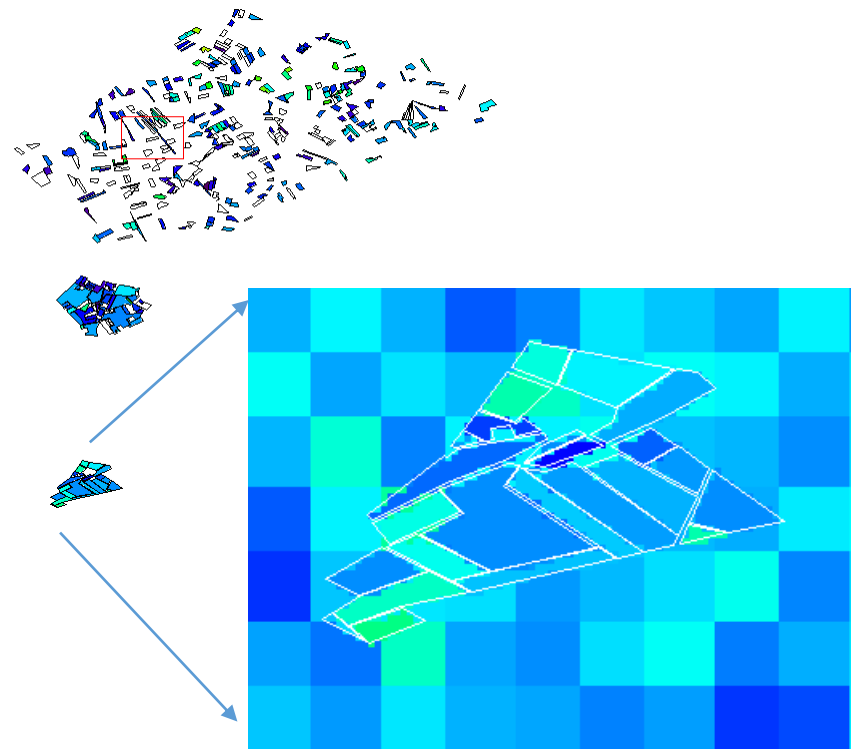


# Humedad del suelo (SSM)

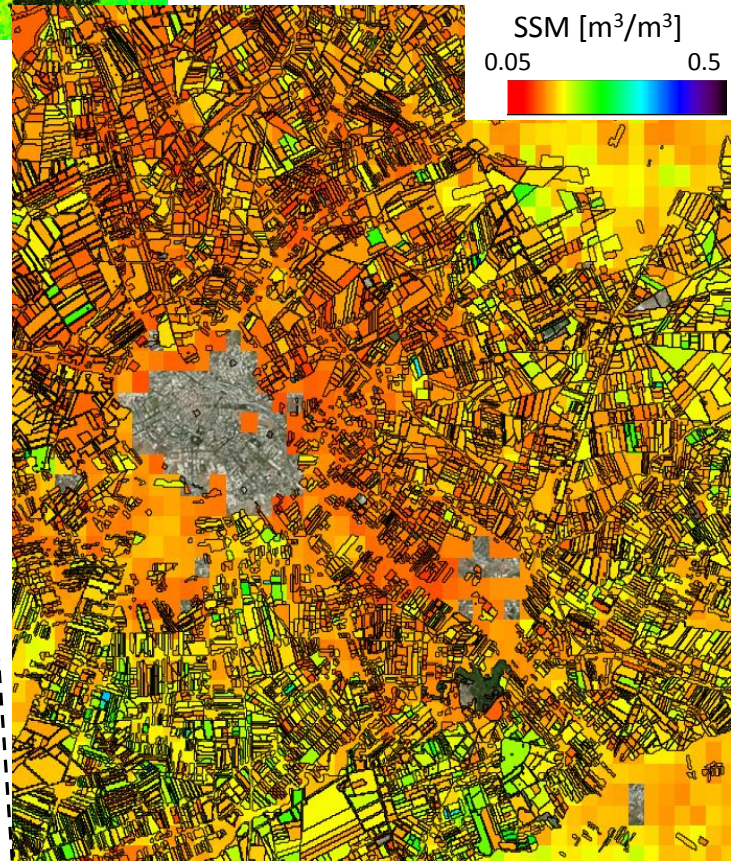
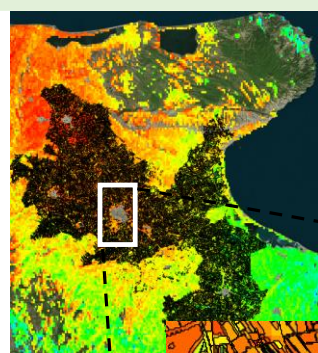


# Humedad del suelo (SSM)

SSM average at field scale



Fused SSM product (50m pixel)

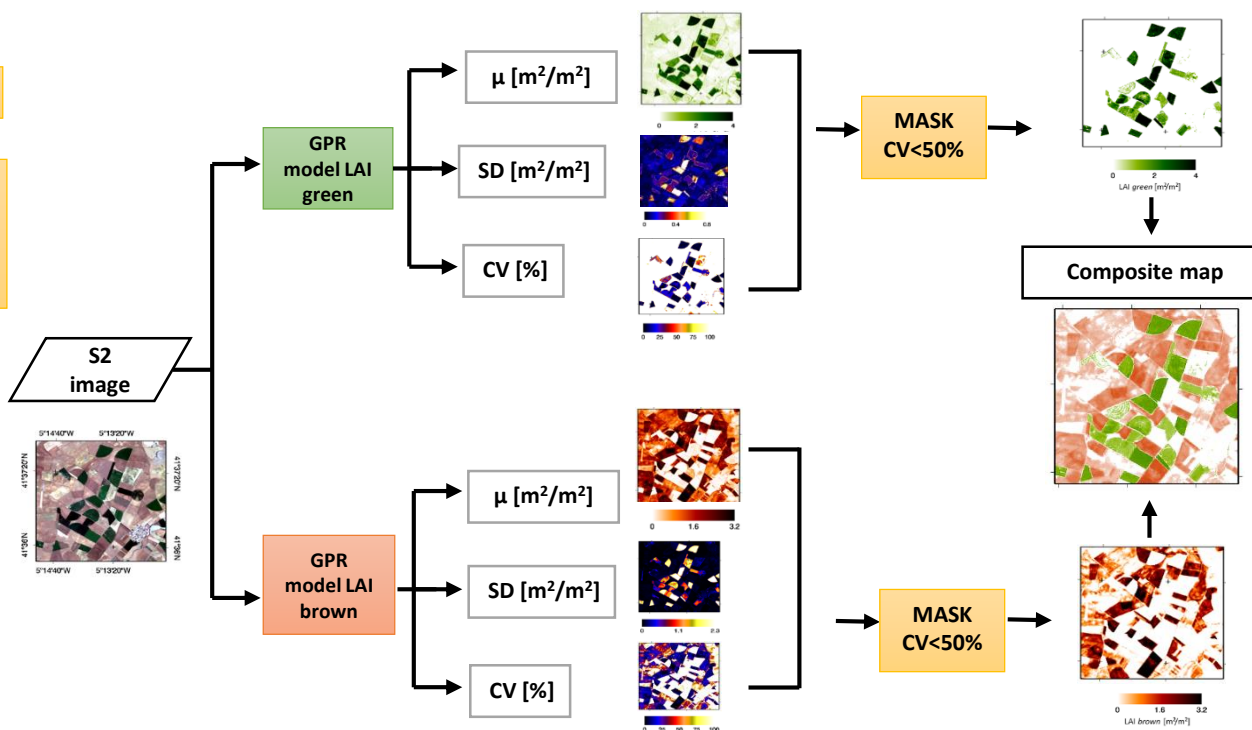


# Índice de Área Foliar (LAI)

- Basado en S2 y Machine Learning (*Gaussian Processes Regression*)
- Separa LAI “verde” y “marrón”
- 20 m de resolución espacial

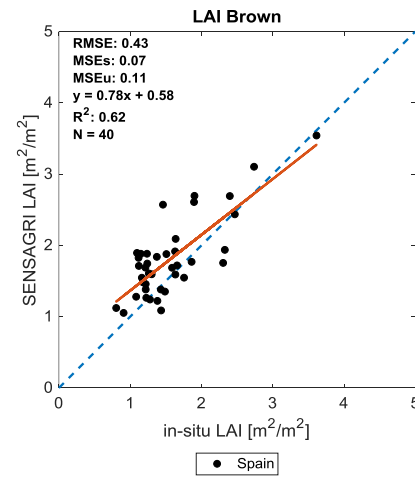
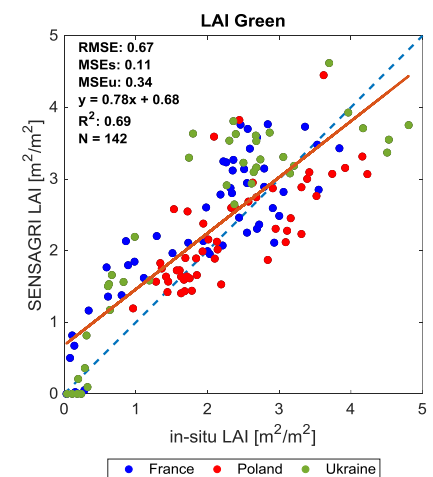
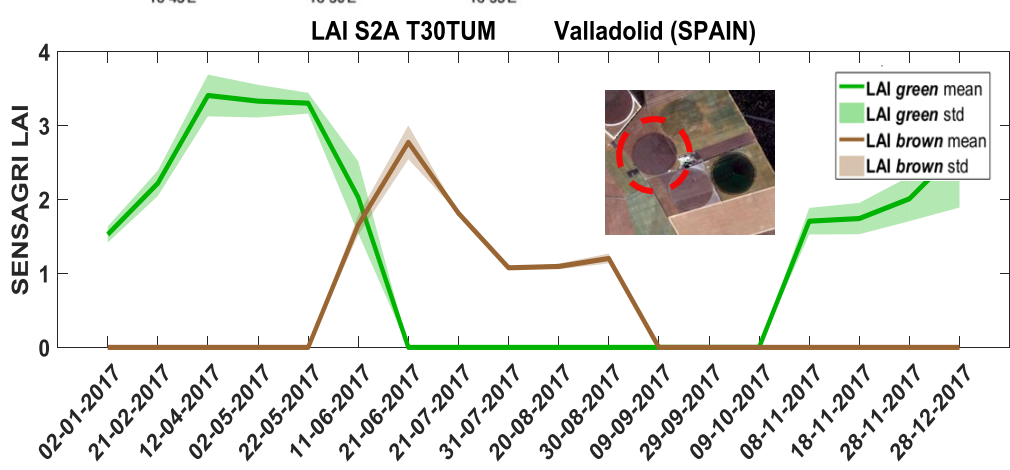
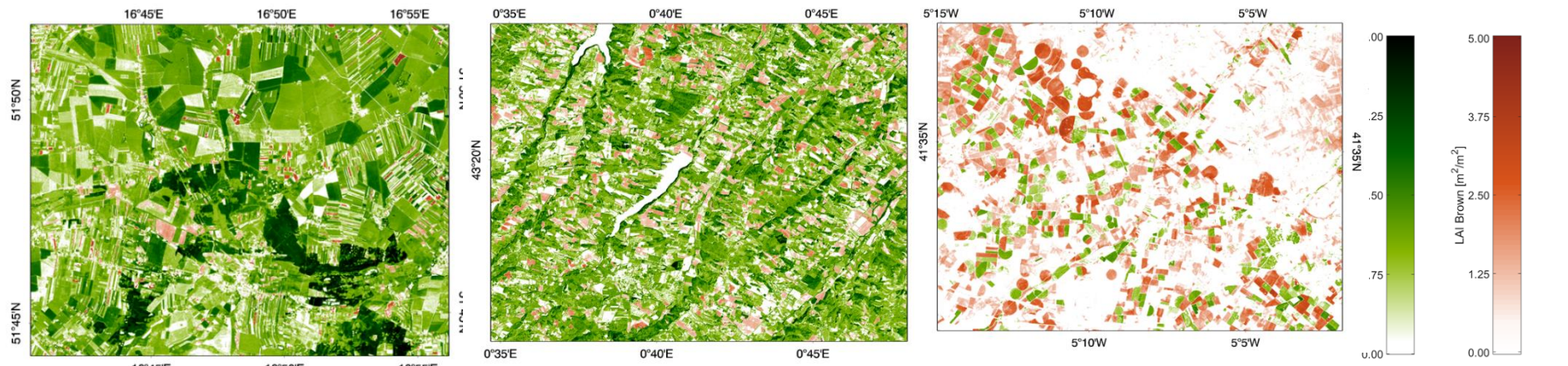
$$CV = \left(\frac{SD}{\mu}\right) * 100$$

**MASK**  
Uncertainty threshold = CV < 50 %



# Índice de Área Foliar (LAI)

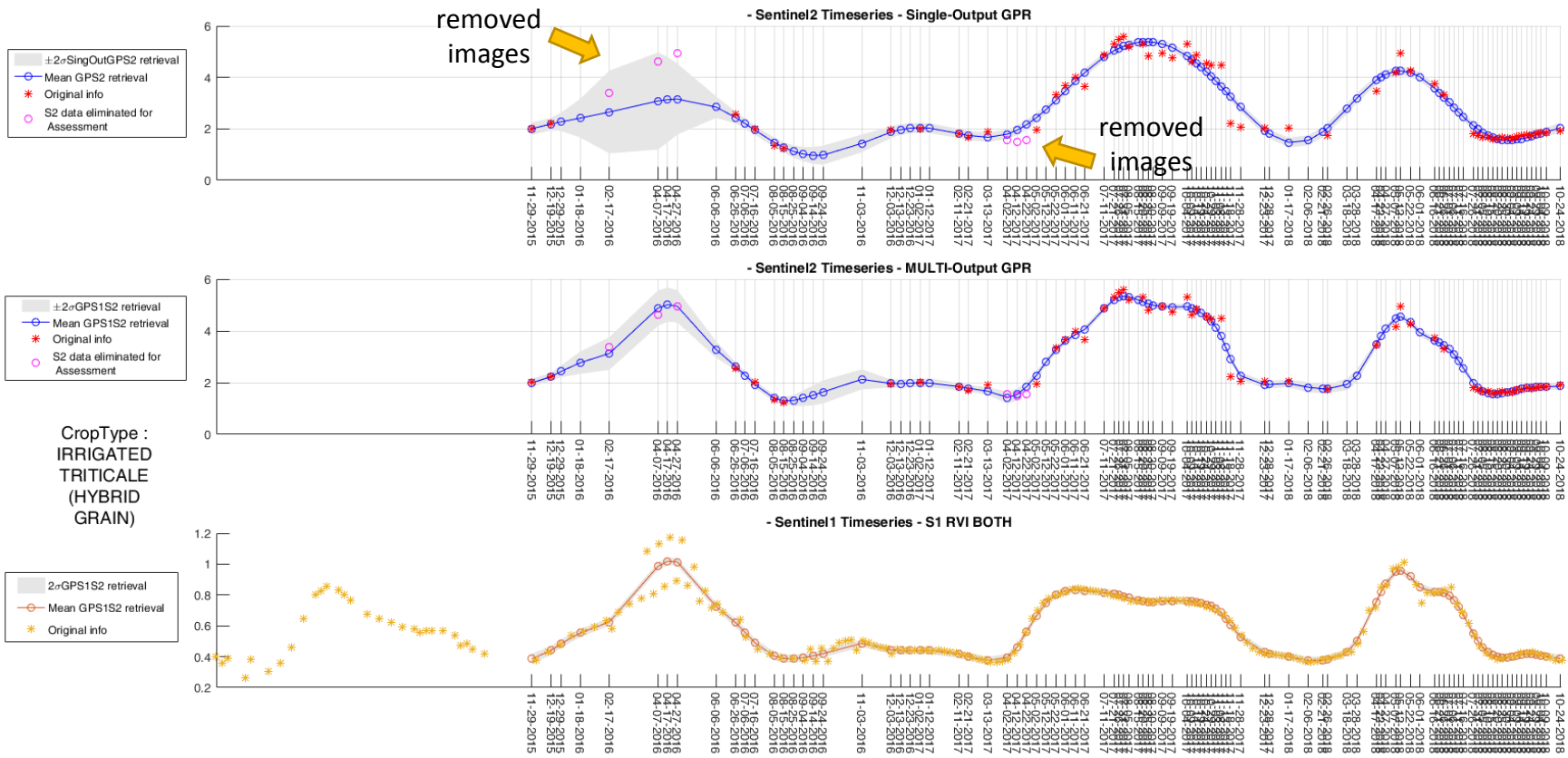
- LAI (green & brown)



# Índice de Área Foliar (LAI)

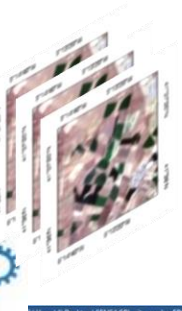
- Sinergia con S1 (radar) para relleno de series de LAI S2 (óptico)

@ S2 acquisition dates

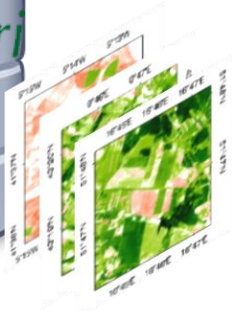


<sup>1</sup> M.A. Álvarez, L. Rosasco, N.D. Lawrence, "Kernels for Vector-Valued Functions: a Review, *Foundations and Trends in Machine Learning* 4, pp 195-266. Library available at <https://github.com/SheffieldML/GPy>

# Índice de Área Foliar (LAI)



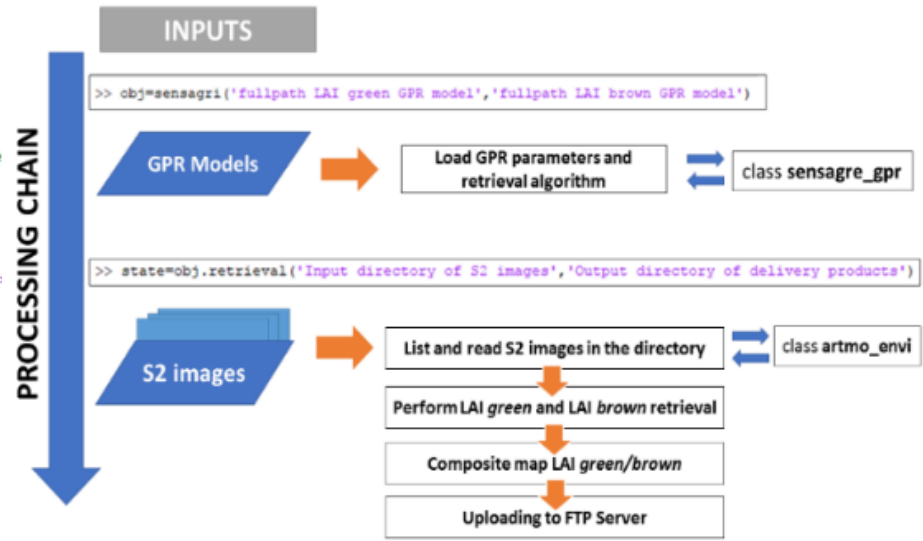
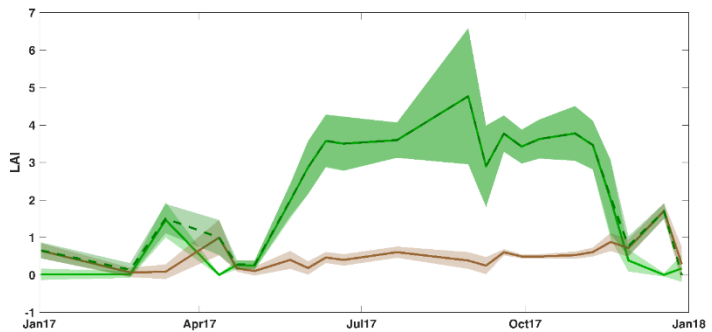
MATLAB



— LAI *green* mean  
— LAI *brown* mean  
- - Total LAI mean

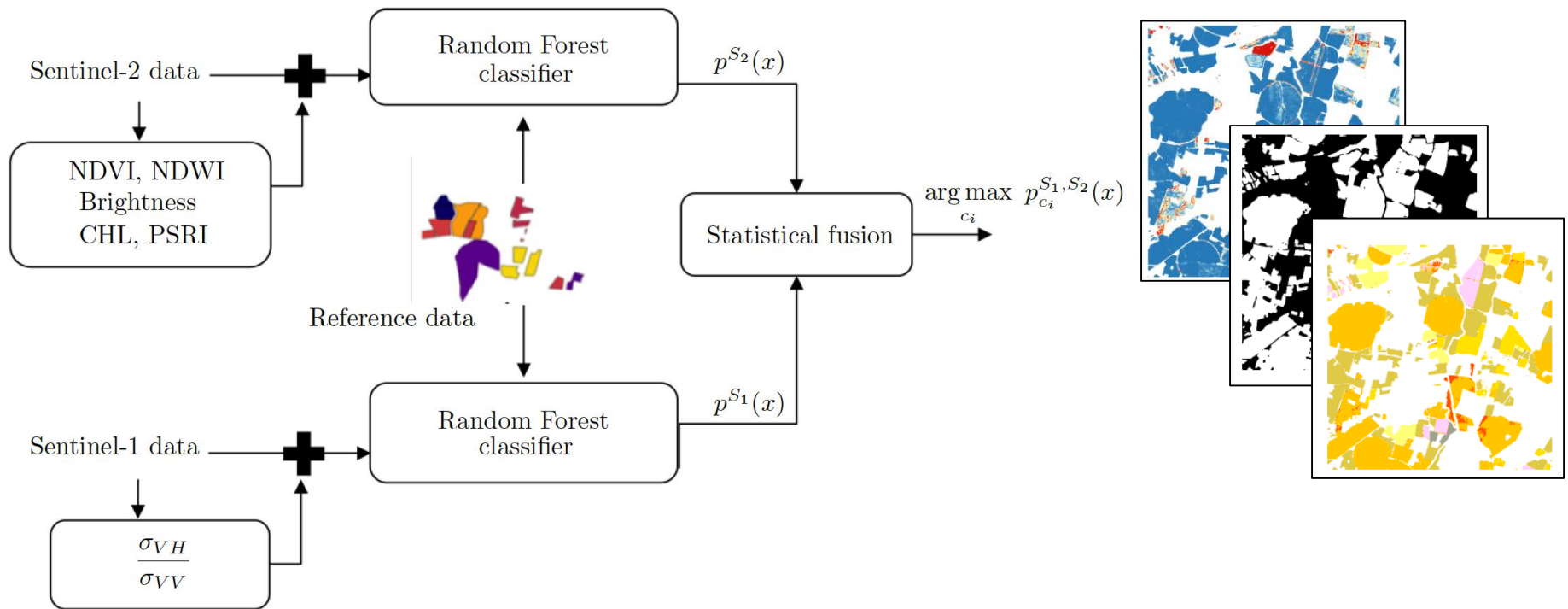
```

classdef sensagri
1  %UNTITLED Summary of this class goes here
2  % Detailed explanation goes here
3
4
5
6  properties
7      num_read_lines=100;
8      num_pixel_processing=inf;
9      image_factor_oconv=1.000;
10     nonnegative=0.000001
11
12     resolution=20;
13     mask_option=2;%0=no mask, 1=cloud mask, 2
14     umbralG=50
15     umbralB=50
16     colormapG
17     colormapB
18     transG =0.6
19     transB =0.4
20     winSCP_path='C:\Program Files (x86)\WinSC
    
```

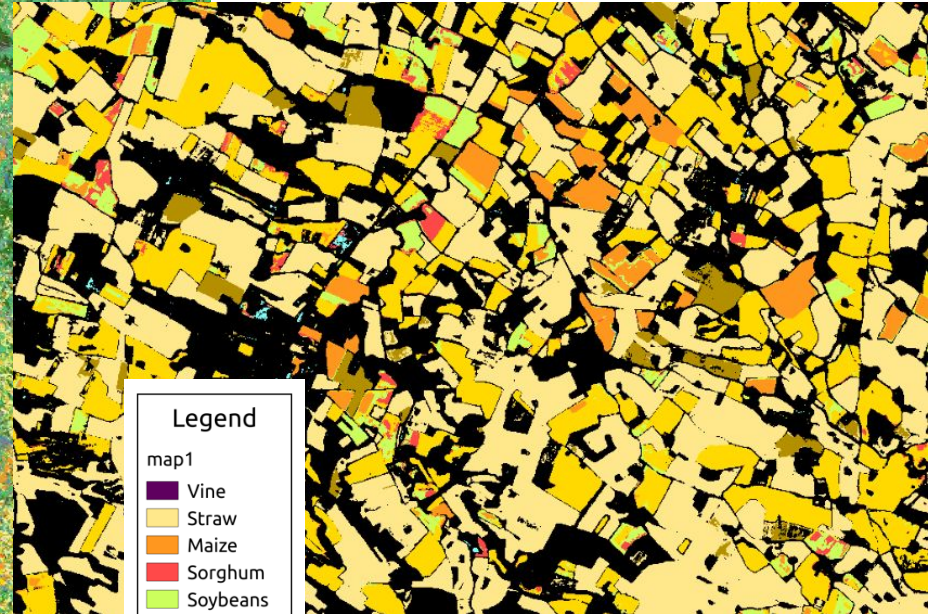
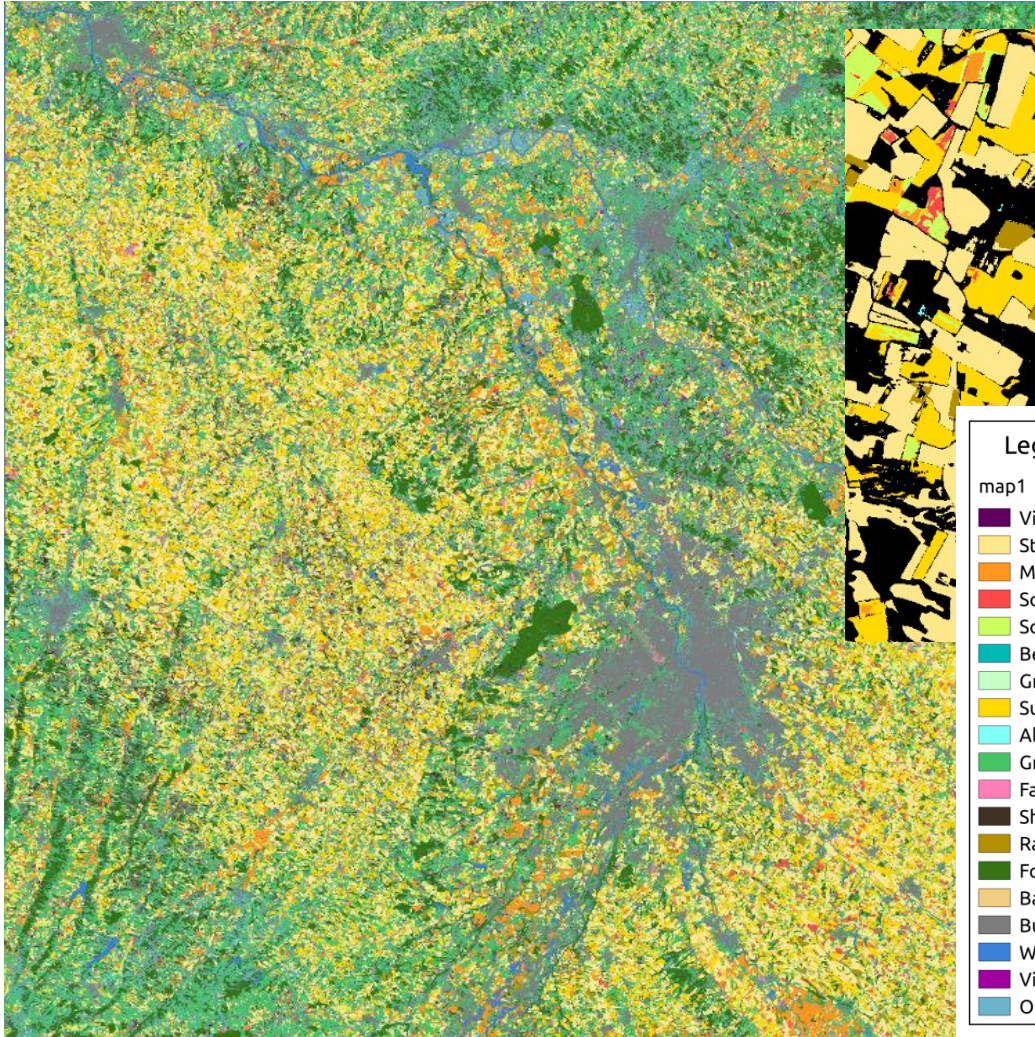


# Mapas estacionales de cultivos

- Clasificación supervisada automática (*Random Forest*): S1+S2
- Mapas estacionales durante año agrícola (feb – jun – ago...)



# Mapas estacionales de cultivos



Legend

map1

Vine
Straw
Maize
Sorghum
Soybeans
Beans
Grasses
Sunflower
Alfalfa
Grassland
Fallow
Shrubland
Raspseed
Forest
Bare Soil
Build Up
Water
Vine Grape
Orchard

Crop type at 10m resolution



# Mapas estacionales de cultivos



## Clasificación basada en objetos

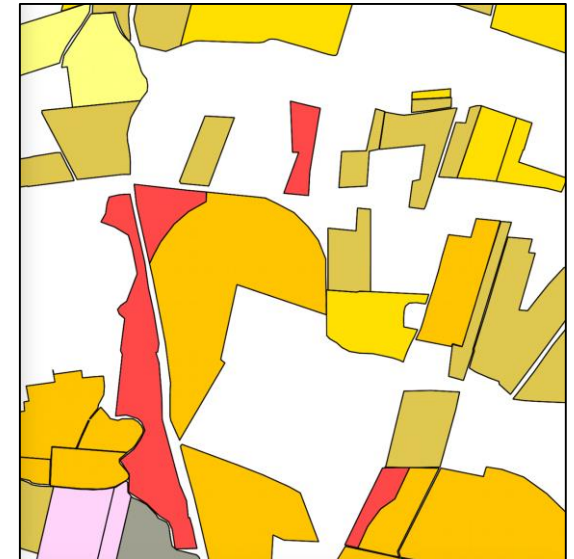
If reference parcel boundaries exist, they can be used to apply a majority-vote rule



SENSAGRI crop type map



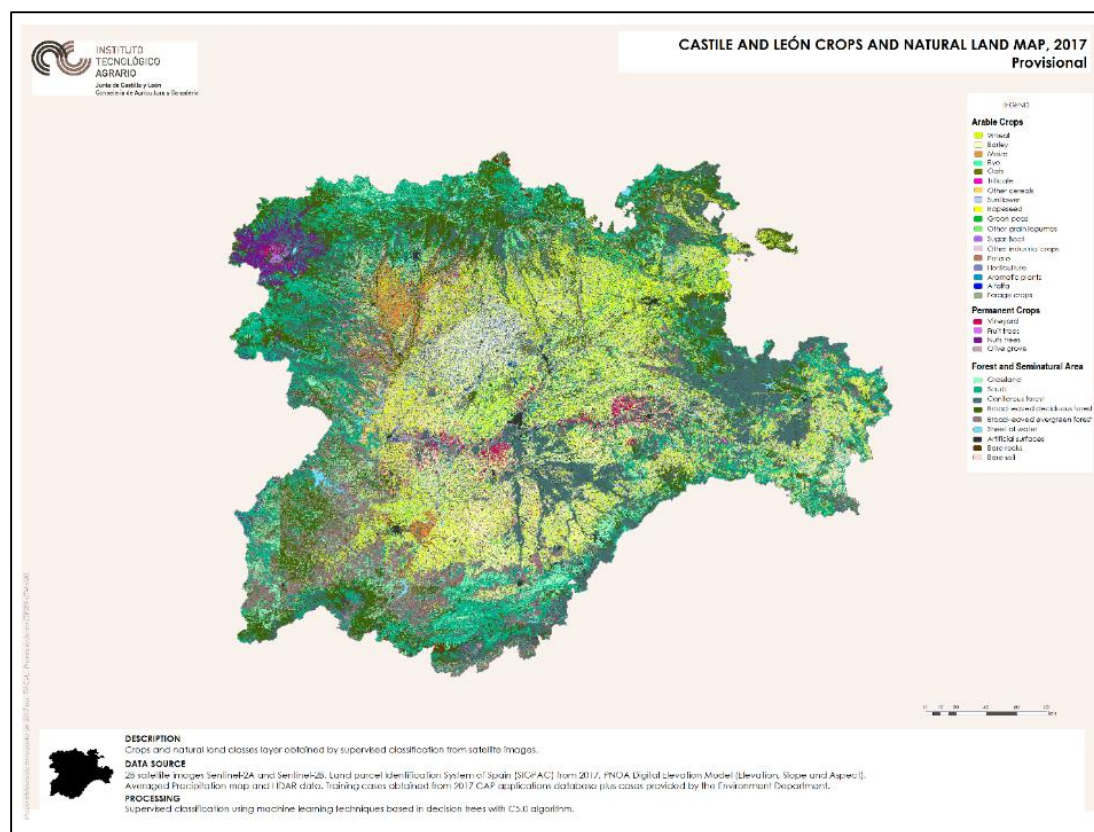
Reference parcel boundary



Majority – vote map

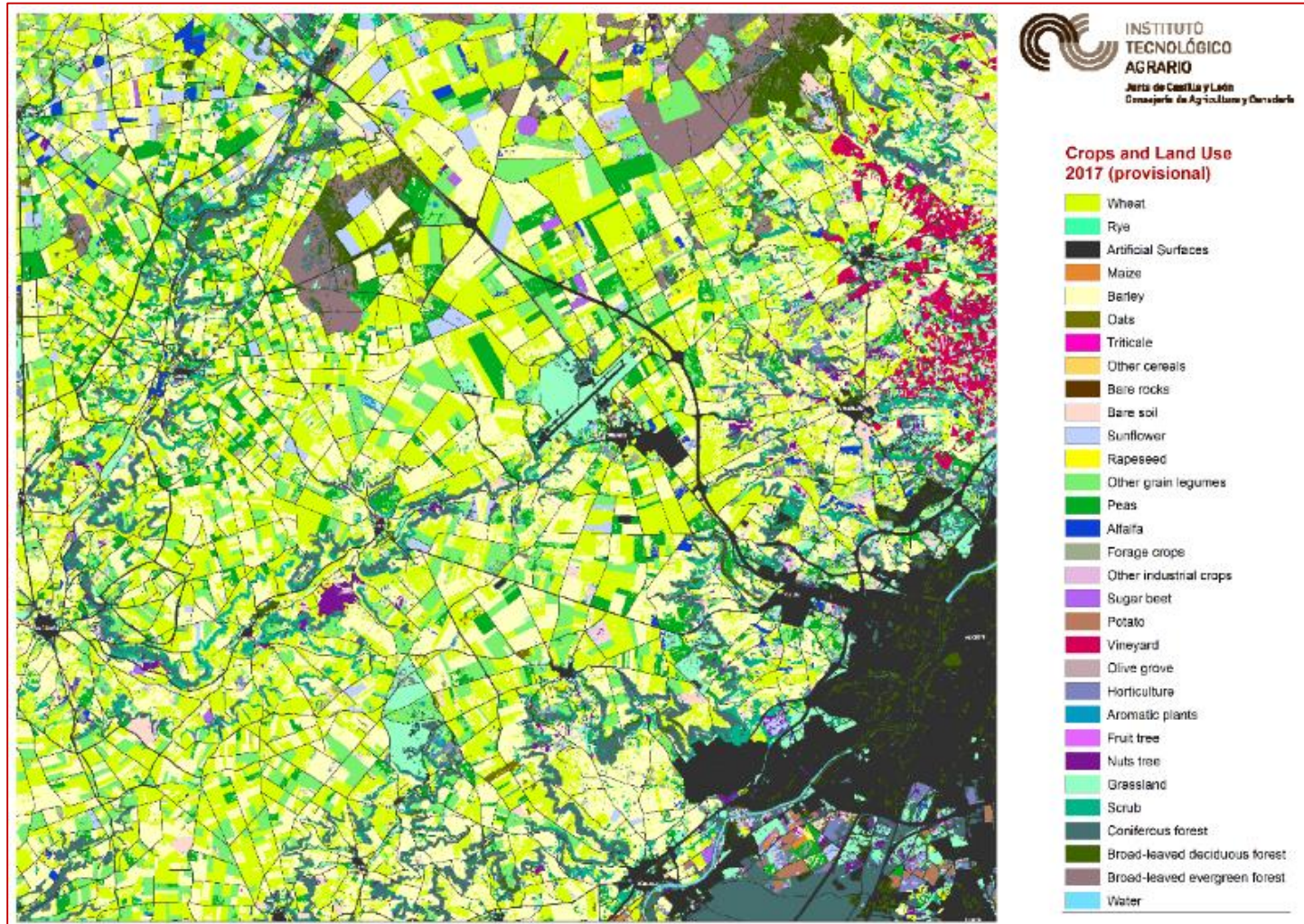
# Mapas de usos del suelo de Castilla y León

- Clasificación supervisada automática (*Data mining - ML*): S1+S2 + verdad-terreno (LPIS, aplicaciones agricultores PAC, LUCAS\*, MDT...)
- Mapas anuales detallados de cultivos y usos del suelo
- Operacional en CyL. Aplicado en SENSAGRI en Francia, Italia y Polonia (áreas test)

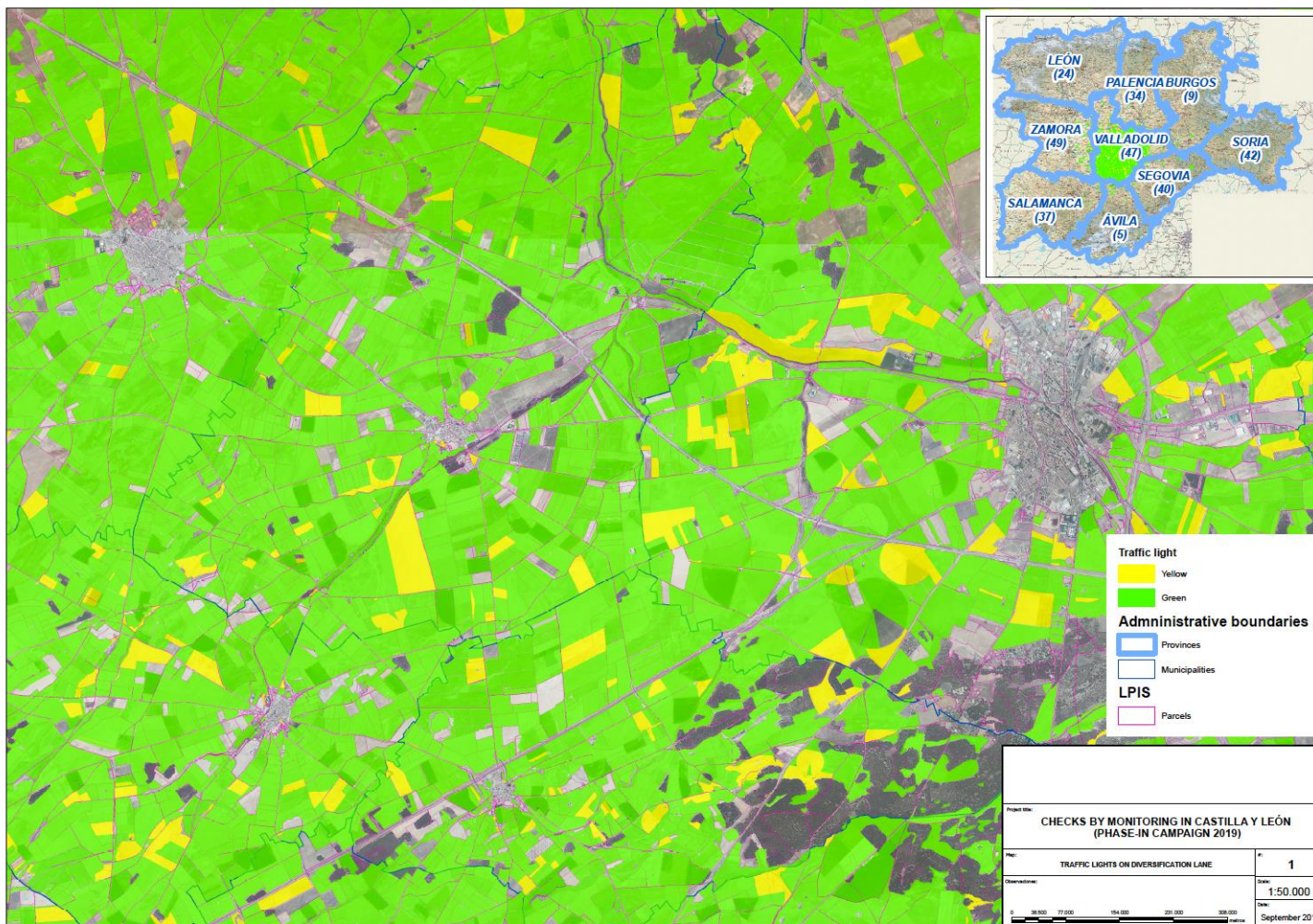


\* Land Use/Cover Area Frame Survey (EUROSTAT)

# Mapas de usos del suelo de Castilla y León

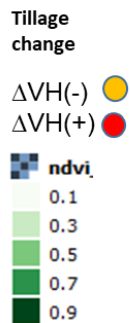
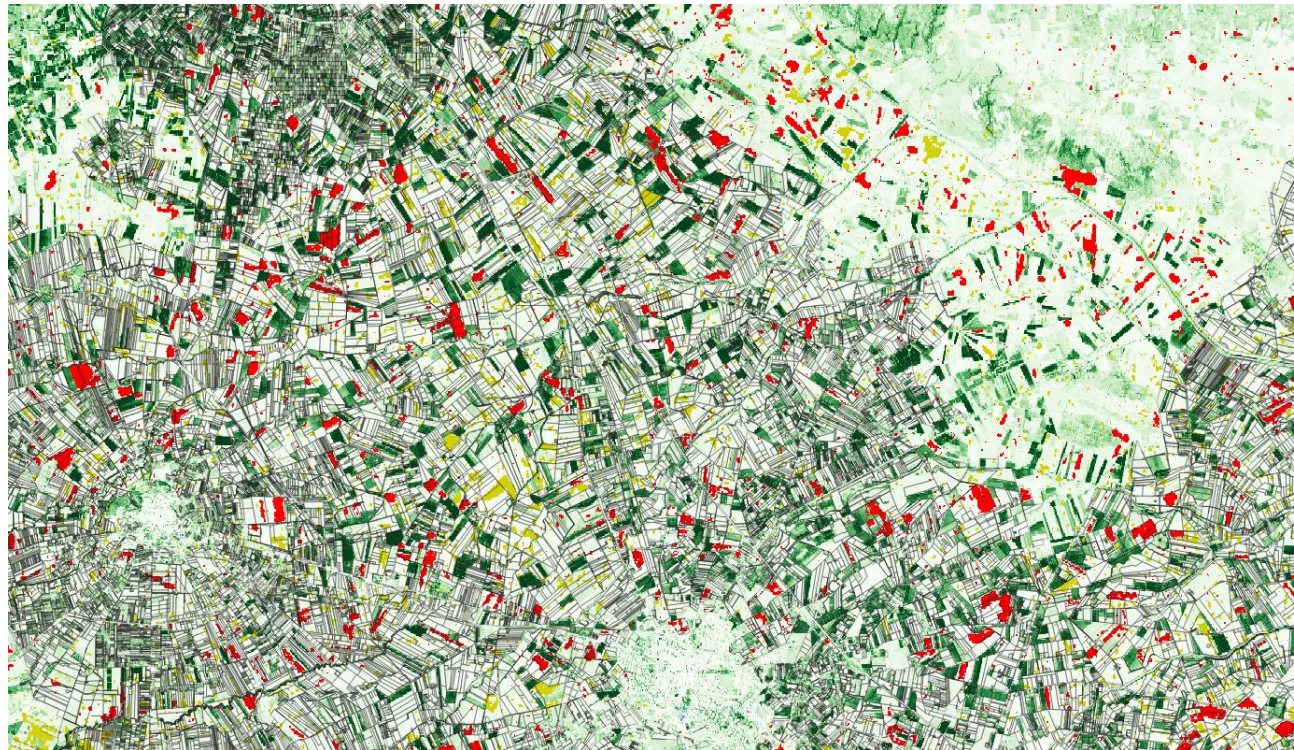
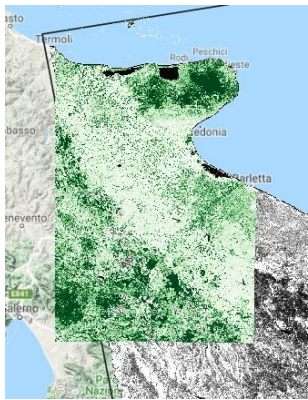


# Clasificación basada en objetos para CAP check monitoring



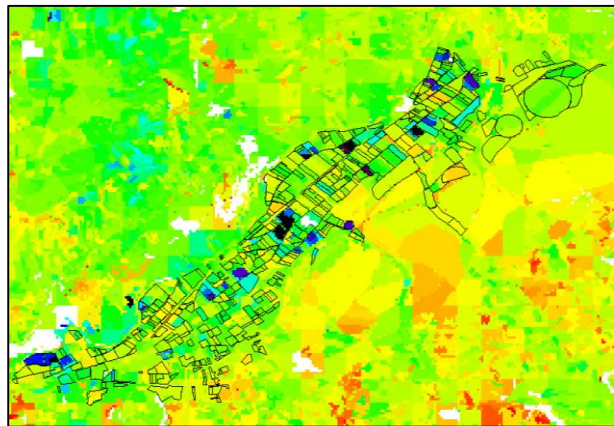
# Detección de laboreo (tillage change)

- Prueba de concepto. Uso de series temporales de S1 (VH) y S2 NDVI
- 40 m de resolución espacial

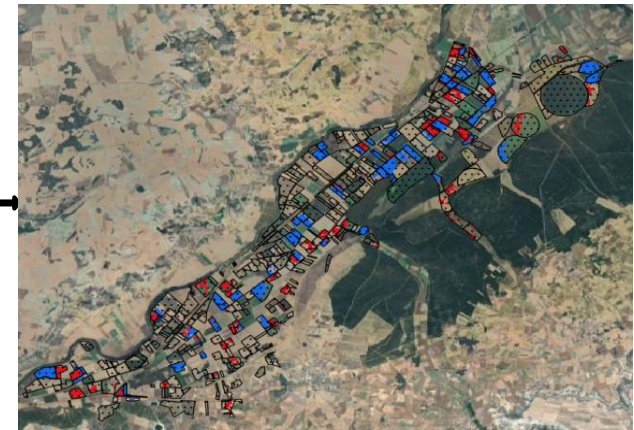
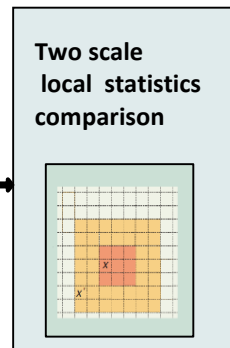


# Detección de episodios de riego

- Prueba de concepto. Basado en el contraste entre SSM “local” y “regional”
- Mapas a nivel de parcela. Útil para cultivos con riegos de apoyo



0.03 m<sup>3</sup>/m<sup>3</sup> 0.25  
 S1&S2 SSM map (09/04/2017)



Irrigated/ not-irrigated map

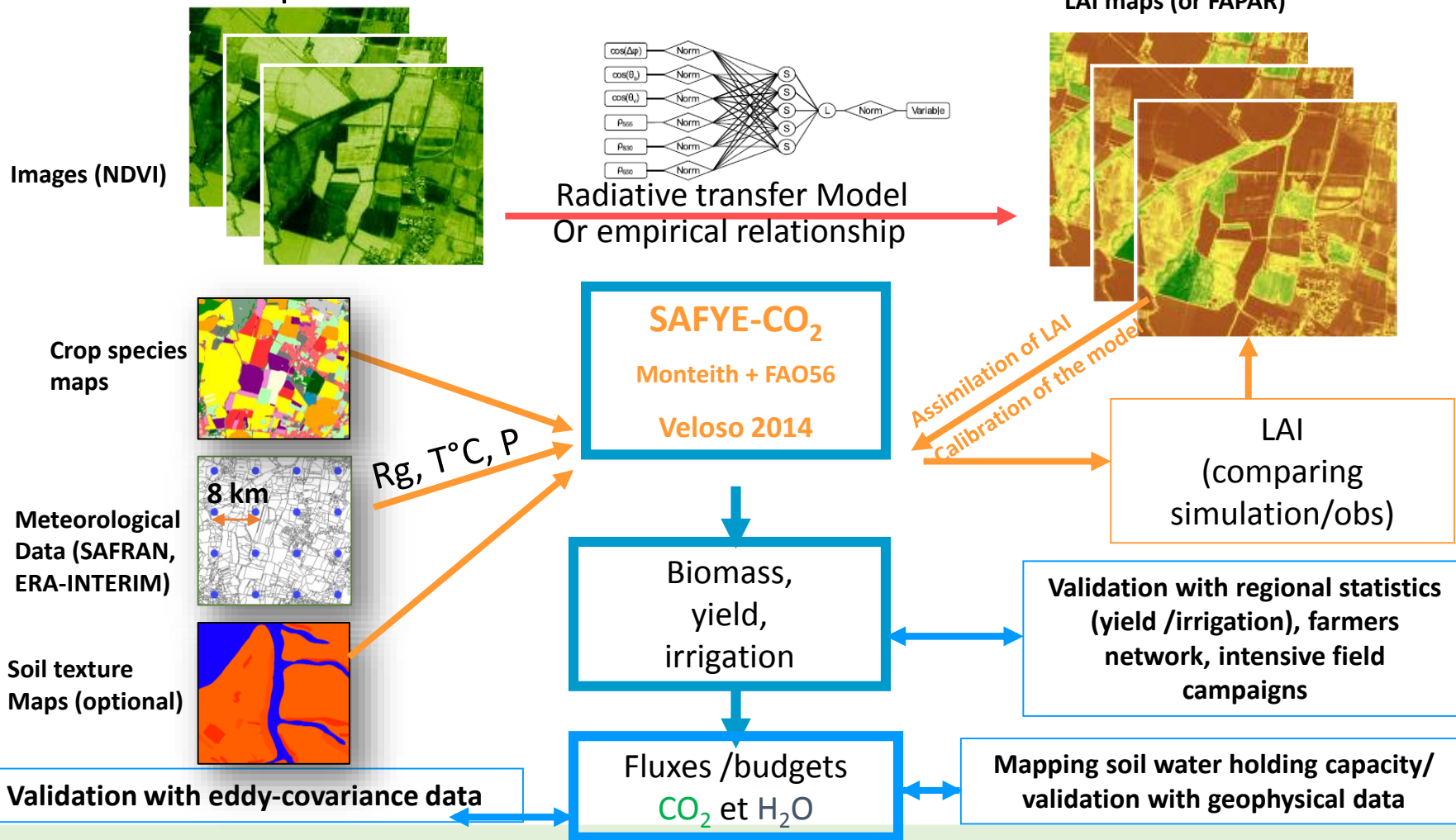
- Classified as irrigated :
- - irrigated in ground data
  - - not irrigated in ground data

$$CO = \frac{\langle SSM \rangle_{field}}{\langle SSM \rangle_{4x4 \text{ km scale}}}$$

# Biomasa / rendimiento de cultivos



- Prueba de concepto. Modelo SAFYE-CO<sub>2</sub>



# Validación de los productos

	SENSAGRI Prototype services		
Second Validation	Surface Soil Moisture SSM	Leaf Area Index LAI	Seasonal Crop Maps SCM
Validation sites	IT, SP, FR	FR, PO, Ukr, SP	FR, SP, IT
Product derived	SSM	LAI green LAI brown	Crop Mask Crop Type
Year	2017-2018	2018 (FR, PO, Ukr) & 2019 (SP)	2018 (FR&SP), 2017(IT*)
N/points for validation	At field scale: 4.040 SSM values from hydrologic networks (11 stations in IT, 38 stations in SP) : 2977 in SP, 931 in IT 132 gravimetric method samples At 1km: 87 SSM values from 5 stations in Fr	FR (G: 52 ESUs by DHP) PO (G: 50 ESUs by LICOR-LAI) Ukr (G: 40 ESUs by CANON) SP (B:40 ESUs by ACCUPAR)	FR18 (5.23 M pixels 10m) SP (4.45 M pixels 10m) IT (1.27 M pix 10m)
Metrics	Bias, root mean squared error (RMSE), unbiased RMSE, Pearson correlation coefficient (R) and linear regression	RMSE, systematic error (MSES) and unsystematic error (MSEU), R <sup>2</sup> and linear regression	Overall Accuracy (OA), CI Class-specific: Producer and User's Accuracies (PA, UA), F-Score
Follow ref.document on accuracy assessment?	Yes	Yes	Yes
Confidence Maps	Yes ( $\sigma$ )	Yes (CV, $\sigma$ )	Yes
Attained Accuracy	N=4040, R= 0.50, RMSE = 0.06 m3/m3 at field scale. Spatial Representativeness error for point-like measurements is addressed.	LAIG (n=142)/LAIB (n=40) RMSE = 0.67/0.43 m2/m2 MSEs = 0.11/0.07, MSEu = 0.34/0.11, R <sup>2</sup> = 0.7/0.62	FR18 (O.A. 90%)**; SP18 (O.A. 60%)* IT17 (O.A. 74%)
Resolution	~100m in agricultural areas 1 km other areas	20 m	10 m
Product format	Georeferenced multi-band data (ENVI format)	8-band GEOTIFF (G LAI, B LAI , Total LAI and precision parameters)	4-bands GeoTiff: crop mask, crop type map and both confidence maps Crop mask(B1): binary GeoTiff Crop type (B3): mosaiked 16-bit GeoTiff
Metadata	Yes (readme txt; hdr file)	Yes (txt)	No



# Validación de los productos

SENSAGRI Proof-of-concept services			
Second Validation	Irrigated/No-Irrigated maps	Tilled/No-tilled maps	Biomass/Yield maps <sup>#</sup>
<b>Validation sites</b>	SP	IT, SP	FR
<b>Product derived</b>	Irrigated/No-Irrigated maps	Tilled/No-tilled maps	Biomass/Yield
<b>Year</b>	2017&2018	2017&2018	2006-2014
<b>N/points for validation</b>	2017: 752 fields, 2637 ha, 22.185 irr. events, 23 SSMmaps 2018: 660 fields in 1877 ha, 13.132 events, 12 SSMmaps	Nº obs. matching the spatial and temporal extension of S1&S2 data / total number: 3689/5884 tilled/no-tilled fields: 968/1295 in IT and 2721/4589 in SP.	24 fields for yield and biomass for winter wheat (55 biomass samplings in total, 24 yield data); 13 fields for sunflower (44 biomass samplings, 13 yield data)
<b>Metrics</b>	Overall Accuracy (OA), Producer's and User's Accuracy (PA,UA)	Overall Accuracy (OA), Producer's and User's Accuracy (PA,UA)	Bias, RMSE, rRMSE, coefficient (R) and linear regression
<b>Follow ref.document on accuracy assessment?</b>	Yes	Yes	Yes
<b>Confidence Maps</b>	No	No	No
<b>Attained Accuracy</b>	PA <sub>irr</sub> ~95-85% in periods characterized by relatively high SSM contrast (Eg. April 17)	With the refined thresholds: OA, PA <sub>tilled</sub> and UA <sub>tilled</sub> are in IT: 82%, 81% and 98%, In SP: 68%, 67% and 90%.	For wheat biomass RMSE=201 g/m <sup>2</sup> , rRMSE=26%, R <sup>2</sup> =0.9, Bias=17g/m <sup>2</sup> ; For wheat yield RMSE=1.02 t/ha, rRMSE=21%, R <sup>2</sup> =0.79, Bias=0.04 t/ha; For sunflower biomass
<b>Resolution</b>	0.0004° (~100m of resolution and a pixel size of ~40m)	0.0004° (~100m of resolution and a pixel size of ~40m)	20m
<b>Product format</b>	Binary raster image files in ENVI-format (.img)	Binary raster images files in ENVI-format (.img)	Binary raster images files in ENVI-format (.img)
<b>Metadata</b>	Yes (hdr file)	Yes (hdr file)	No

## Resultados y productos disponibles

- Algoritmos de proceso **combinando S1 y S2**
  - S2 provides LAI / NDVI for masking S1 radar products (SSM, tillage, irrigation)
  - S1 for gap-filling of S2-based time series
  - S1 and S2 together in crop classification
- Un **conjunto de productos en áreas test en European** disponibles
- Productos accesibles a través de **web GIS** ([www.sensagri.eu](http://www.sensagri.eu))
- OGC **WMS services** – Permiten manejo de productos en SIG de usuario: [http://osr-cesbio.ups-tlse.fr/geoserver\\_sensagri/SENSAGRI/wms](http://osr-cesbio.ups-tlse.fr/geoserver_sensagri/SENSAGRI/wms)
- Productos **validados** con datos de campo. Buenos resultados finales.

# Resultados y productos disponibles

## Resolución espacial

<b>SENSAGRI product</b>	<b>TARGET</b>	<b>ACHIEVED</b>
<b>Surface soil moisture (SSM) service</b>	250-1000 m	0.1-1km
<b>Green and brown LAI service</b>	20 m	20 m
<b>Seasonal crop mapping service</b>	20 m	10m
<b>Dry Biomass &amp; Yield service</b>	20 m	20m
<b>Irrigated/not irrigated area</b>	250 m	0.1km
<b>Tillage change service</b>	250 m	0.1km
<b>Added-value crop classification service</b>	10 m	10 m

# Resultados y productos disponibles

## Resolución temporal

SENSAGRI product	TARGET	ACHIEVED	Comments
Surface soil moisture (SSM) service	weekly	6-day	
Green and brown LAI service	weekly	5-day	
Seasonal crop mapping service	2 or 3 per year	2 or 3 per year	The resulting crop maps could be easily updated after every Sentinel's image acquisition
Dry Biomass & Yield service	<ul style="list-style-type: none"> <li>•<u>Dry biomass</u>: weekly after the end of the season</li> <li>•<u>Yield</u>: yearly</li> </ul>	<ul style="list-style-type: none"> <li>•<u>Dry biomass</u>: weekly after the end of the season</li> <li>•<u>Yield</u>: yearly</li> </ul>	CO2 and water fluxes were also simulated on a daily time step C budget was calculated on a yearly basis
Irrigated/not irrigated area	3 or 4 per year	3 or 4 per year	
Tillage change service	5 or 6 per year	5 or 6 per year	

## Resumen

- **H2020 SENSAGRI** (nov. 2016 – oct. 2019) ha proporcionado prototipos para **nuevos servicios de Copernicus en agricultura** (Pan-European Land Core services).
- La **Universidad de Valencia** ha coordinado el proyecto y ha sido responsable del desarrollo del prototipo para **LAI Green & LAI Brown**
- Los servicios están enfocados para:
  - **Seguimiento y control**: Mapas de cultivos (detalle, estacionales), biomasa, humedad suelo.
  - **Prácticas agrícolas**: Detección de laboreo, fechas de cosecha, riegos de apoyo.
- **2019**: Mapas en áreas de test en Europa en web GIS. Documentos de diseño de algoritmos y de validación disponibles también.

# Proyecto SENSAGRI H2020: Nuevos servicios Copernicus para aplicaciones agrarias

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