Sensagri

Sentinels Synergy for Agriculture

2019 IACS workshop

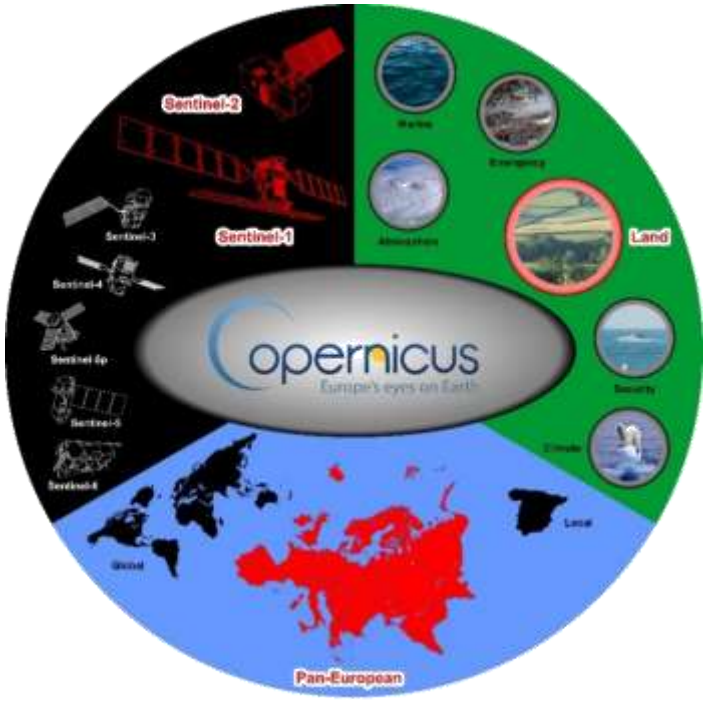
10-11 April 2019, Valladolid, Spain

HORIZON 2020 Copernicus

The research leading to these results has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement no 730074

SENSAGRI goals

- Produce **prototypes** for improved and novel Copernicus upstream services combining **Copernicus Sentinel-1 radar with Sentinel-2 optical** and in-situ data, to develop new EO applications for the European agricultural sector
- **Validate delivered services** and establish **service demonstration cases** to show the large application potential of the new upstream data products



Sentinels Synergy for Agriculture

H2020 EO-3-2016: Evolution of Copernicus services

GA 730074

Start: Nov 2016

End: Oct 2018

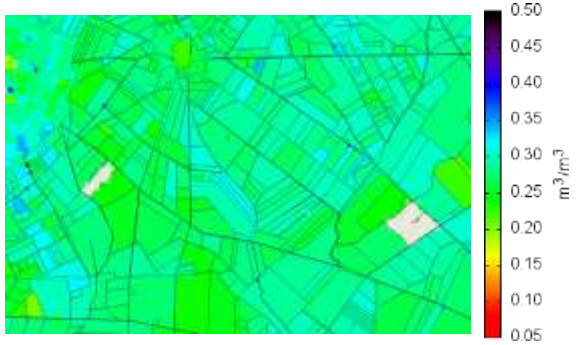
SENSAGRI team

- Three Research centers with solid background and previous developments (SMOSAR, ARTMO, Sen2Agri)

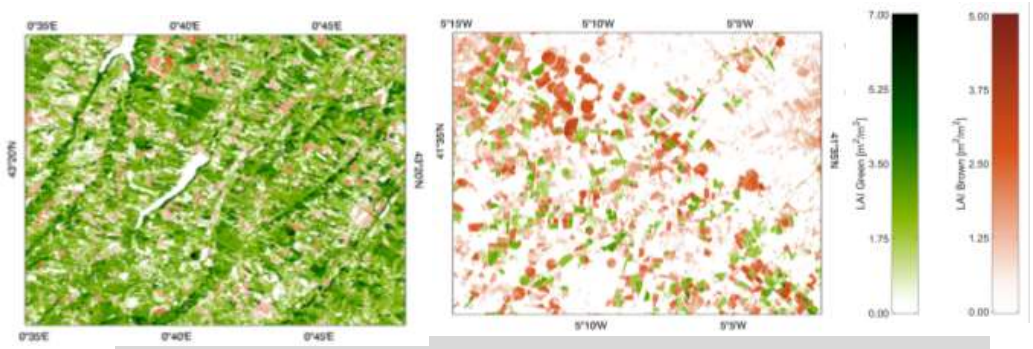
- Three technological centers with experience in EO applications in agriculture and tight links with stakeholders
- One CAP paying agency

SENSAGRI services

- Targeted for agricultural applications (CLMS Pan-European)

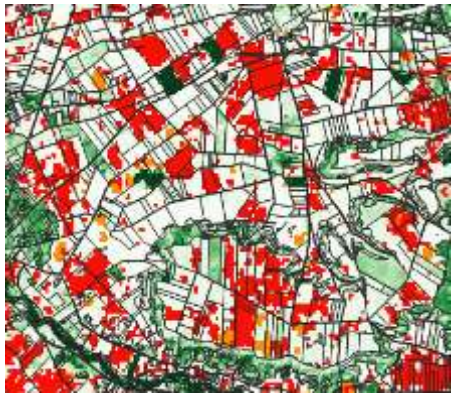


Soil Surface Moisture (SSM)

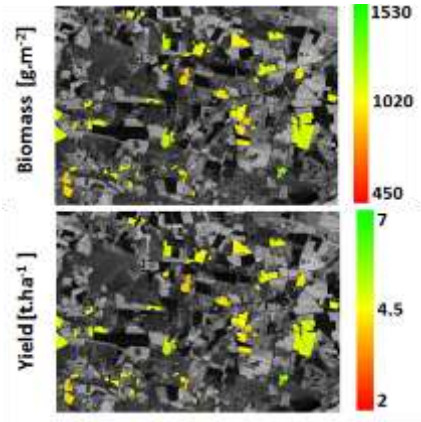


Green & Brown Leaf Area Index (LAI)

Irrigation / not irrigation



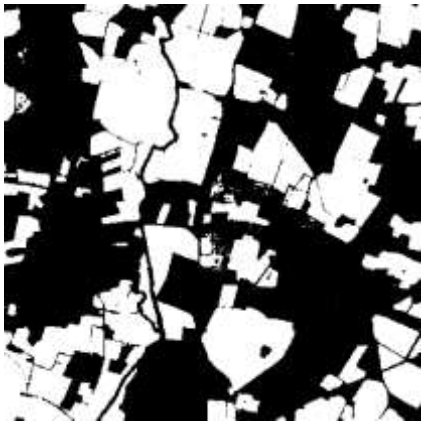
Tillage change



Biomass / Yield model

SENSAGRI services – Seasonal Crop Map

- Integrating **Sentinel-1** and **Sentinel-2** data
- **Binary crop mask** and **crop type map**
- **2 or 3 times** per year
- Tested with **different training datasets** (including LPIS-IACS and ancillary data)
- **Early in the season map** based only in information from previous year(s)



France 2017
Crop Mask

France 2017
Crop Type

Spain 2018
Land cover map

Validation strategy

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

Services	Ground Variable	Time
SSM	Volumetric Soil Moisture at 0-5 cm depth	• Continuous monitoring • 3 measurement campaigns at critical stages and during irrigation season
LAI	Leaf Area Index, with LAI-2000 Plant Canopy Analyzer	3 measurement campaigns at critical stages and during growing season
Seasonal Crop Mapping	Crop types	3 measurement campaigns in March, June and September
Irrigated areas	Irrigated and not irrigated fields	3 measurement campaigns in March, June and September
Tilled areas	Tilled and not tilled fields	
Yield	Commercial yield	1 measurement campaign at crop harvest
Intermediate crops	Crop types	2 measurement campaigns in March and July

CLC agricultural classes. Source: EEA

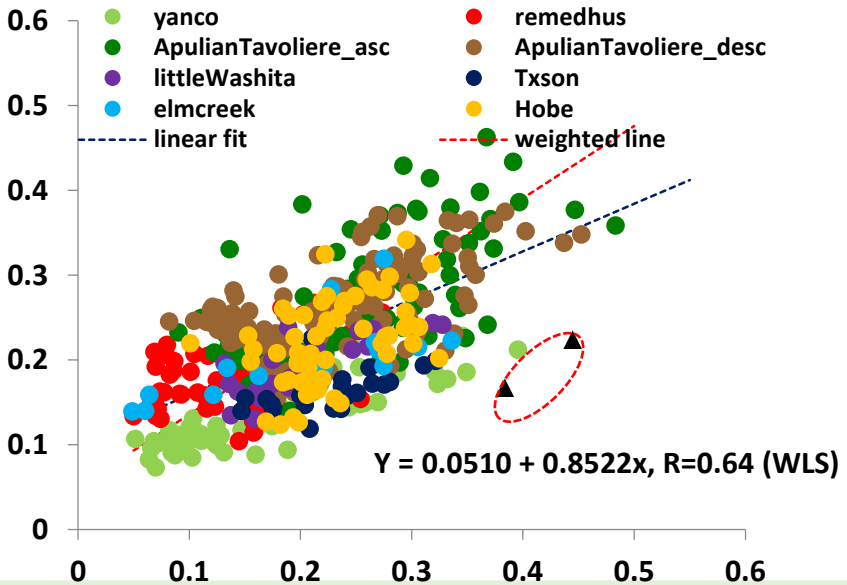
Three non-European test sites

Argentina: INTA – Hilario Ascasubi
Two JECAM sites (South Africa and Ukraine)

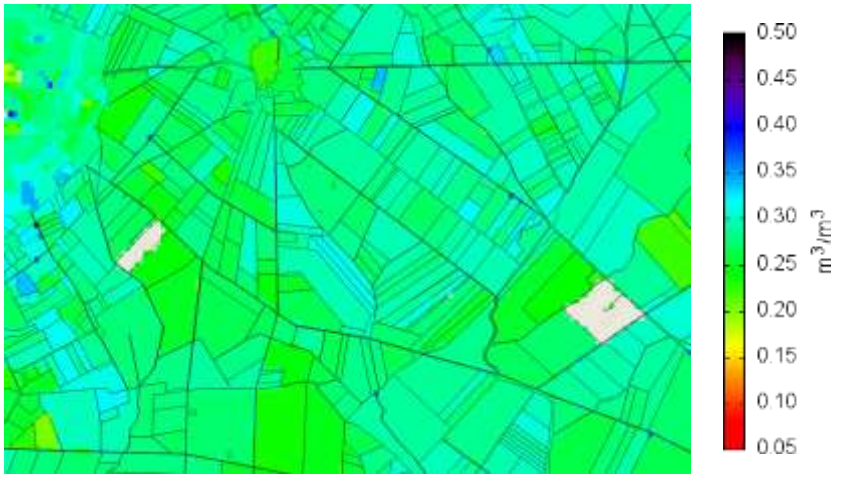
Soil Surface Moisture (SSM)

- SMOSAR processor. Algorithm based on Short Term Change Detection (STCD) approach using S1
- S2 (NDVI) allows masking abrupt changes (harvest, fire…)
- At 1 km spatial resolution. Up to 100 m or higher if parcel map is available

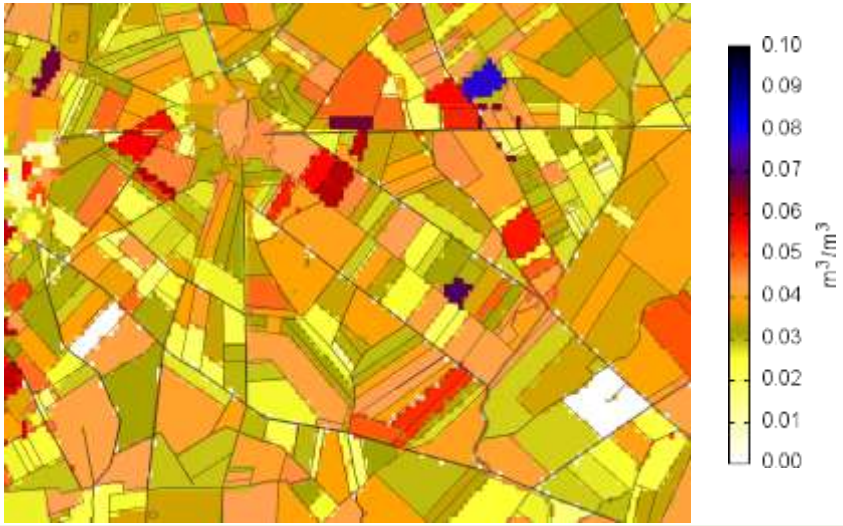
Retrieved vs observed SSM [m3/m3] at site scale



Mean SSM

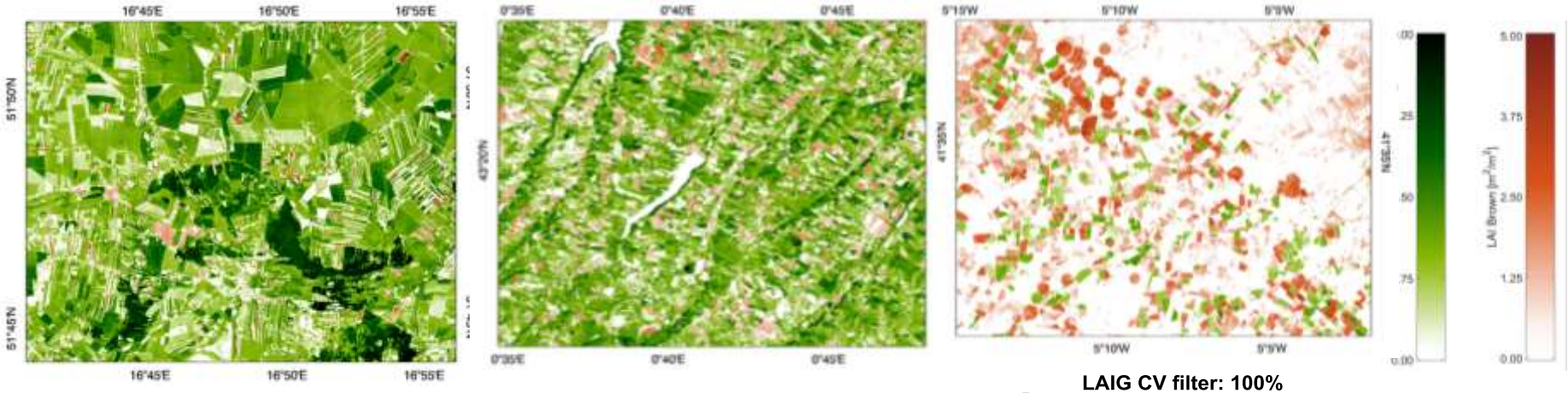


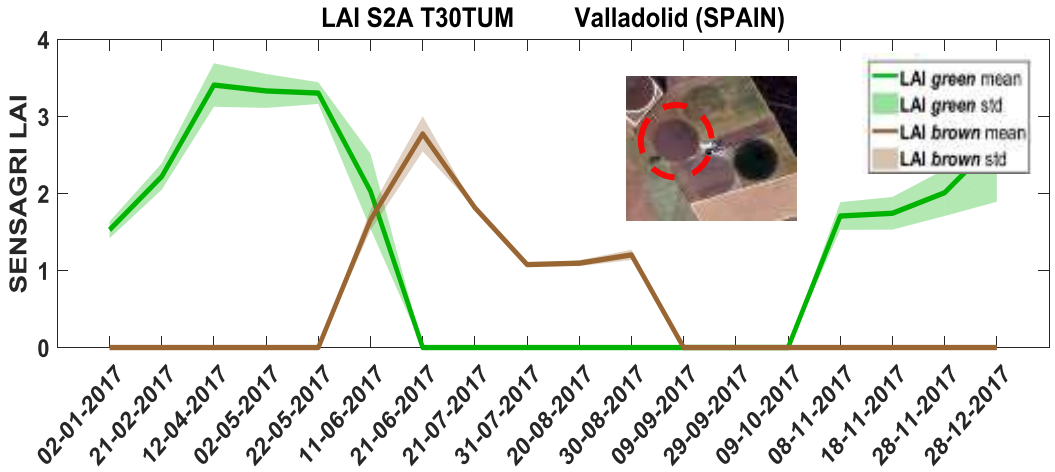
Related standard deviation

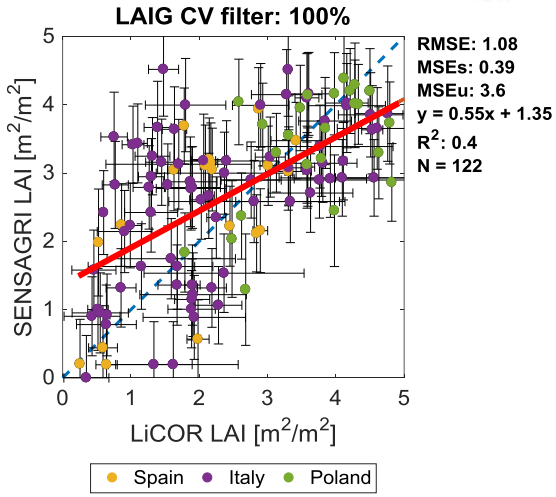


Leaf Area Index (LAI)

- **LAI** (**green & brown**) processor based on Gaussian processes regression (GPR)



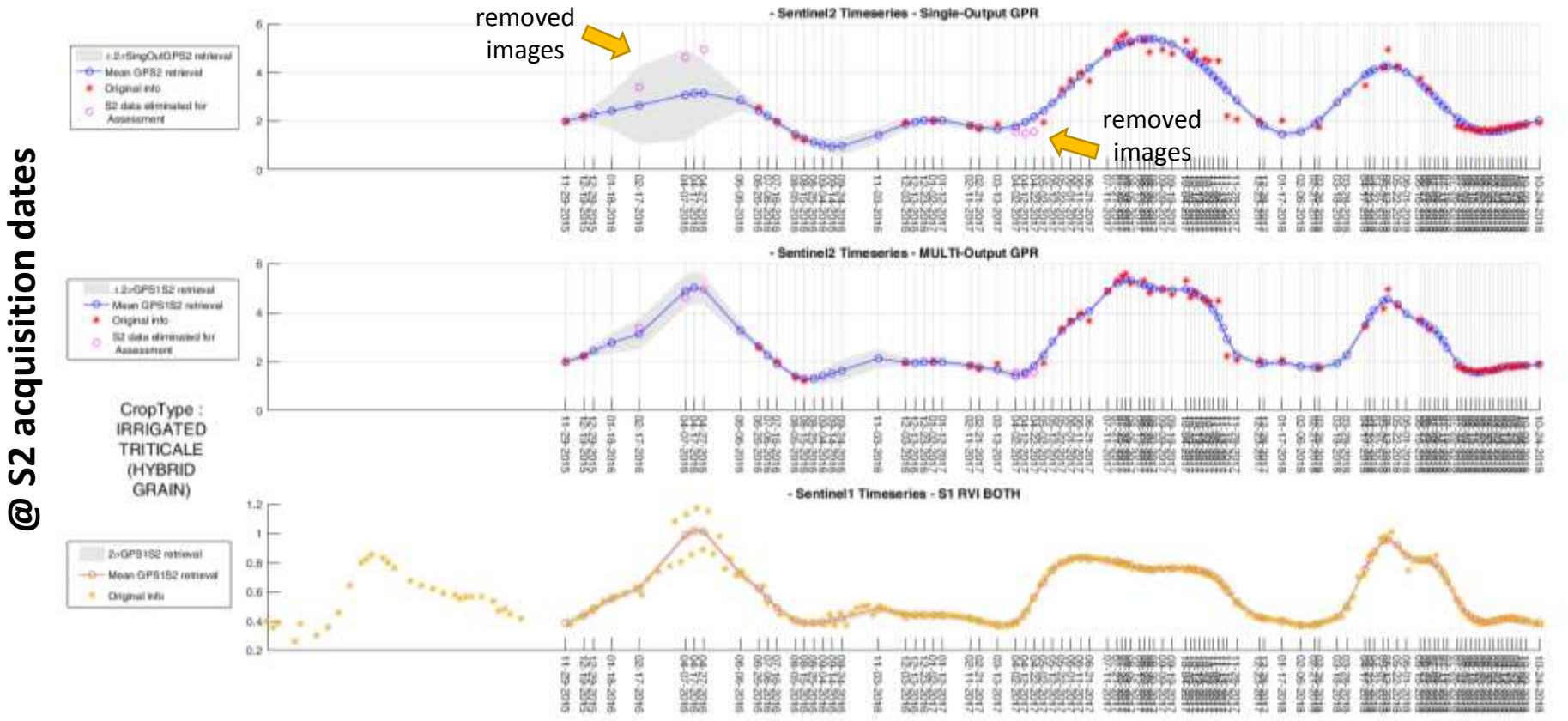




Fused LAI retrieval algorithm using Sentinel-1

- Time series reconstruction from the synergy S1 + S2 data
- Multi-Output Gaussian Process[1] Gap-filling
- LAIG temporal profile reconstruction over a homogeneous crop

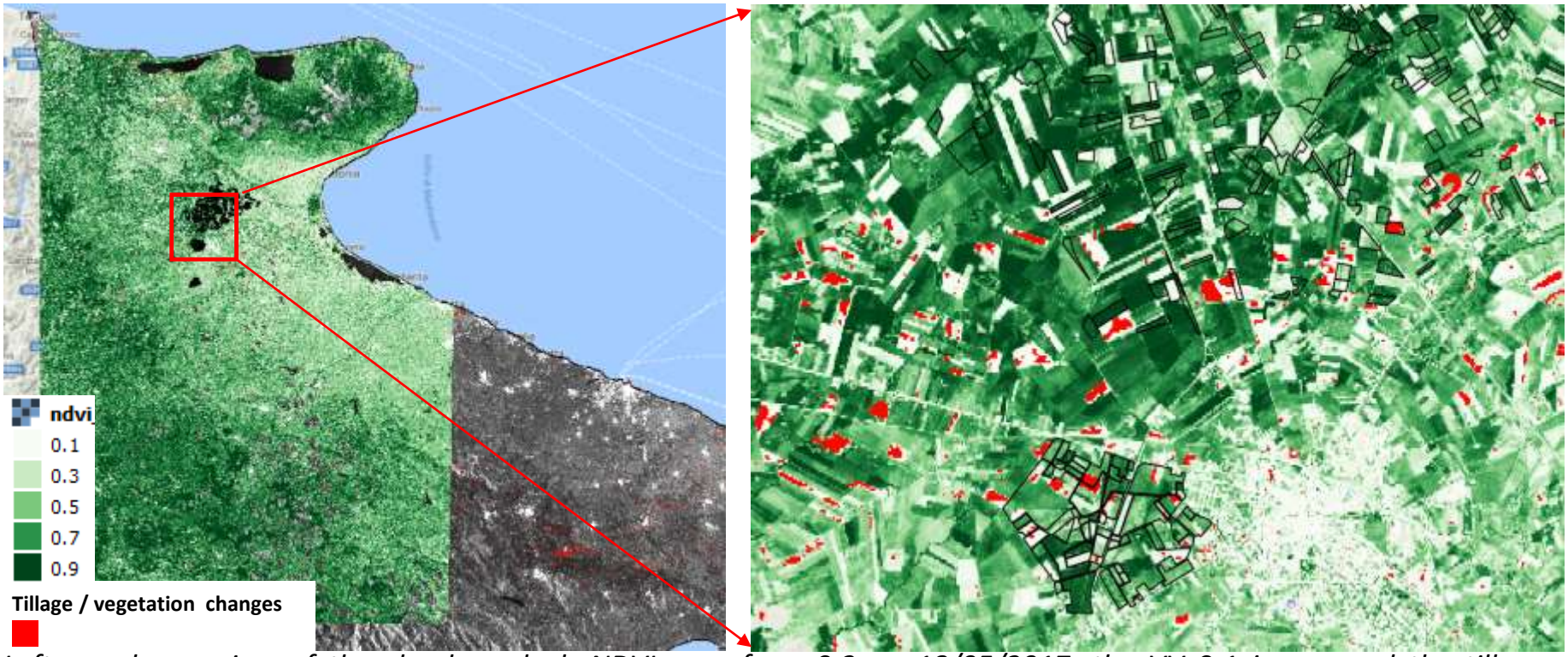
Crop area



[1] 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

Tillage change detection

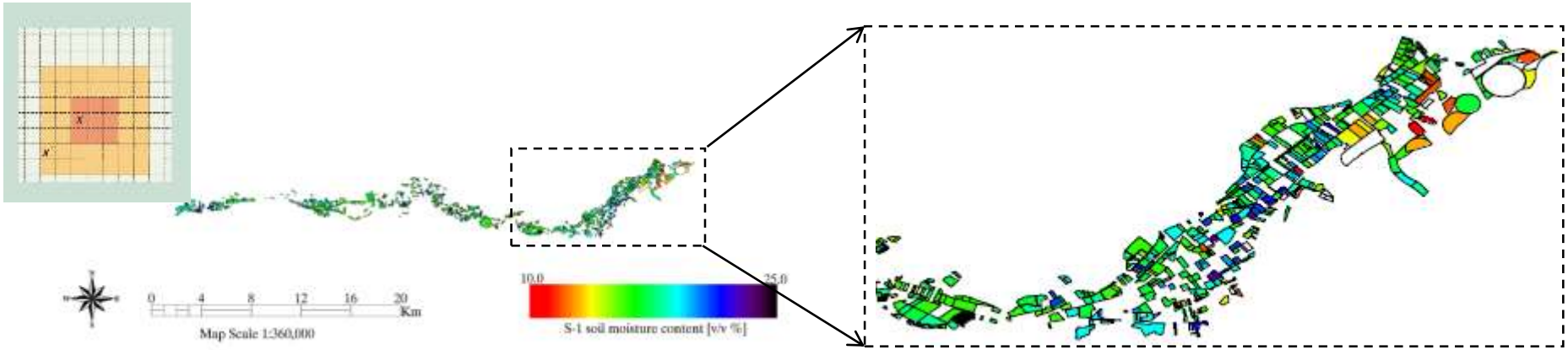
- Multiscale thresholding approach applied to the temporal change of VH S1 backscatter of bare or scarcely vegetated fields (i.e. S2 NDVI < 0.3)
- 40 m spatial resolution



Left panel: overview of the cloud masked- NDVI map from S-2 on 18/05/2017, the VV S-1 image and the tillage or vegetation abrupt changes from VH S-1 changes (12-20/05/2017) at 40m. Right Panel: details over the Capitanata plain.

Irrigated/not irrigated area

- Based on the exploitation of local statistics computed, at different scales, for each high resolution SSM map.

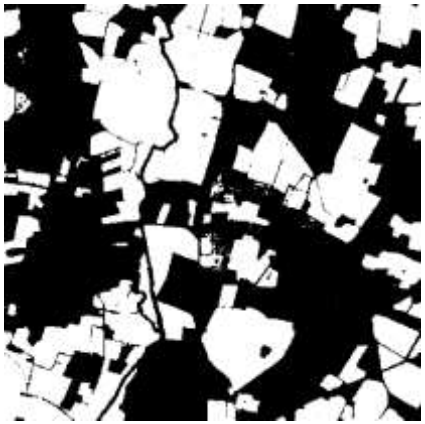


Example of irrigated/not-irrigated map obtained on the Riaza district on 9th April 2017.

Crop map Products

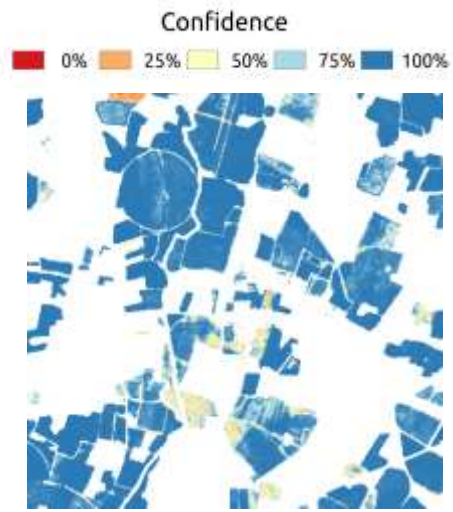
- Two products : A **binary crop mask** and a **crop type map**
- Spatial resolution 20m (**10m resolution**)
- Confidence map
- Temporal resolution **2 or 3 times** per year
- Pan-European hierarchical nomenclature based on JECAM

Straw Cereal
Maize
Sorghum
Soybeans
Vetch
Grain leguminous
Horse bean
Chickpea
Peas
Beet
Potatoe
Asperagus
Brocoli
Raspseed
Sunflower



France 2017
Crop Mask

France 2017
Crop Type



France 2017
Crop Type confidence

France 2017
Crop Mask (Vector format)

Comparison between exisiting Sentinel's classification system

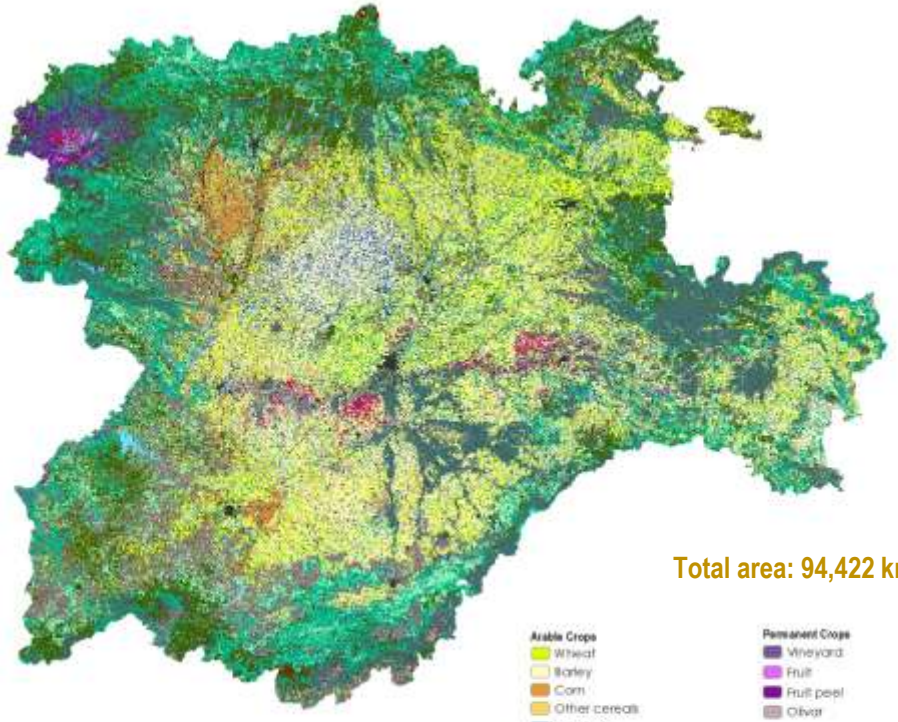
- S12 : The crop type map product produced by SenSAgri
- S2A: The ESA S2Agri crop classification processing chain by incorporating Sentinel-1 as input feature

	1-Mar				5-Jul				2-Nov			
Class	S1	S2	S12	S2A	S1	S2	S12	S2A	S1	S2	S12	S2A
Straw Cereal	76.8	87.7	**89.9**	84.9	97.2	97.1	**97.7**	97.1	97.3	97.3	**98.0**	97.7
Maize	79.7	79.1	**82.8**	78.2	92.9	95.5	**95.9**	95.1	95.6	96.9	**97.3**	96.2
Sorghum	**18.8**	14.9	17.5	13.2	68.5	66.5	**75.4**	64.9	72.9	81.7	**82.9**	75.6
Soya beans	**10.0**	7.5	9.6	9.6	33.4	37.8	**44.7**	39.7	68.1	78.1	**79.8**	70.4
Peas	34.1	33.8	**40.6**	34.6	90.2	87.7	**91.1**	88.8	90.8	86.7	**91.5**	88.7
Rapeseed	64.2	74.0	**81.2**	68.7	96.9	91.6	**97.3**	95.9	96.9	91.0	**97.2**	95.5
Sunflower	57.4	68.3	**71.6**	67.2	92.9	93.1	**94.7**	94.3	95.6	96.5	**96.7**	96.3
OA	67.8	74.0	**77.9**	72.0	92.3	93.3	**94.6**	93.1	94.8	95.7	**96.5**	95.2
95 CI	0.53	0.45	0.55	**0.86**	**0.41**	0.34	0.38	0.38	**0.32**	0.28	0.28	0.29

Application in Castile and Leon

- Very detailed legend and overall accuracy
- Intense use of LPIS-IACS information

Classification land cover map 2017

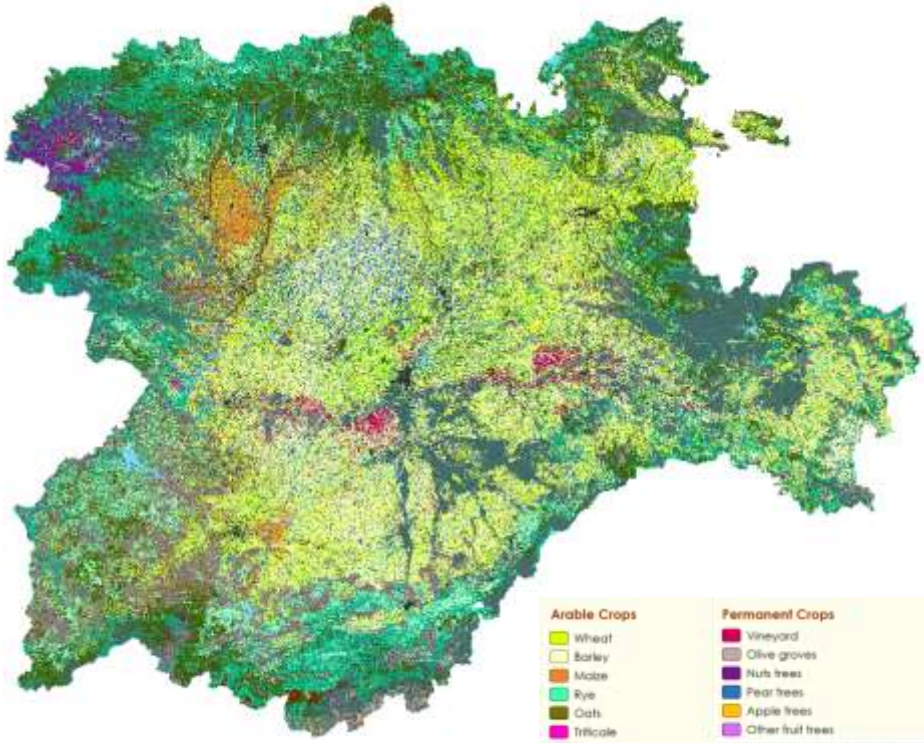


Total area: 94,422 km^2

Accuracy metrics

2017	Jul	Dec
Overall Accuracy	72.55	76.66
Kappa index	0.67	0.72

Classification land cover map 2018



Accuracy metrics

2018	Jul	Dec
Overall Accuracy	79.89	86.33
Kappa index	0.75	0.83

Project status. April 2019

- Improved versions of the algorithms **combining S1 and 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
- Comprehensive **set of products over European test sites** available
- Products accessible through **web GIS** (www.sensagri.eu)
- OGC **WMS services** - to display the data in user GIS solution: http://osr-cesbio.ups-tlse.fr/geoserver_sensagri/SENSAGRI/wms
- Second year of **validation campaigns** finalized
- First validation of prototypes performed. Good overall results.

Perspectives for future exploitation

Two complementary directions for the potential exploitation of SENSAGRI prototypes:

- Generation of **pan-European layers**
  - General application and consistent products
  - Homogeneous approach
  - Similar accuracy and level of detail all throughout the European territory.

- Response to the **new monitoring requirements of the Common Agricultural Policy (CAP)**:
  - Focus on **agricultural practices** and in **markers** of land use
  - Requires more flexible and locally tuned methods
  - Fits with the use of **DIAS** and with the **combination of several products** to derive added value data.

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