Classification of Different Irrigation Cases at Field Scale Using Annual Time-Series of Remote Sensing Data

H2020-MSCA-RISE-2018, 2019- 2023 Grant agreement no: 823965

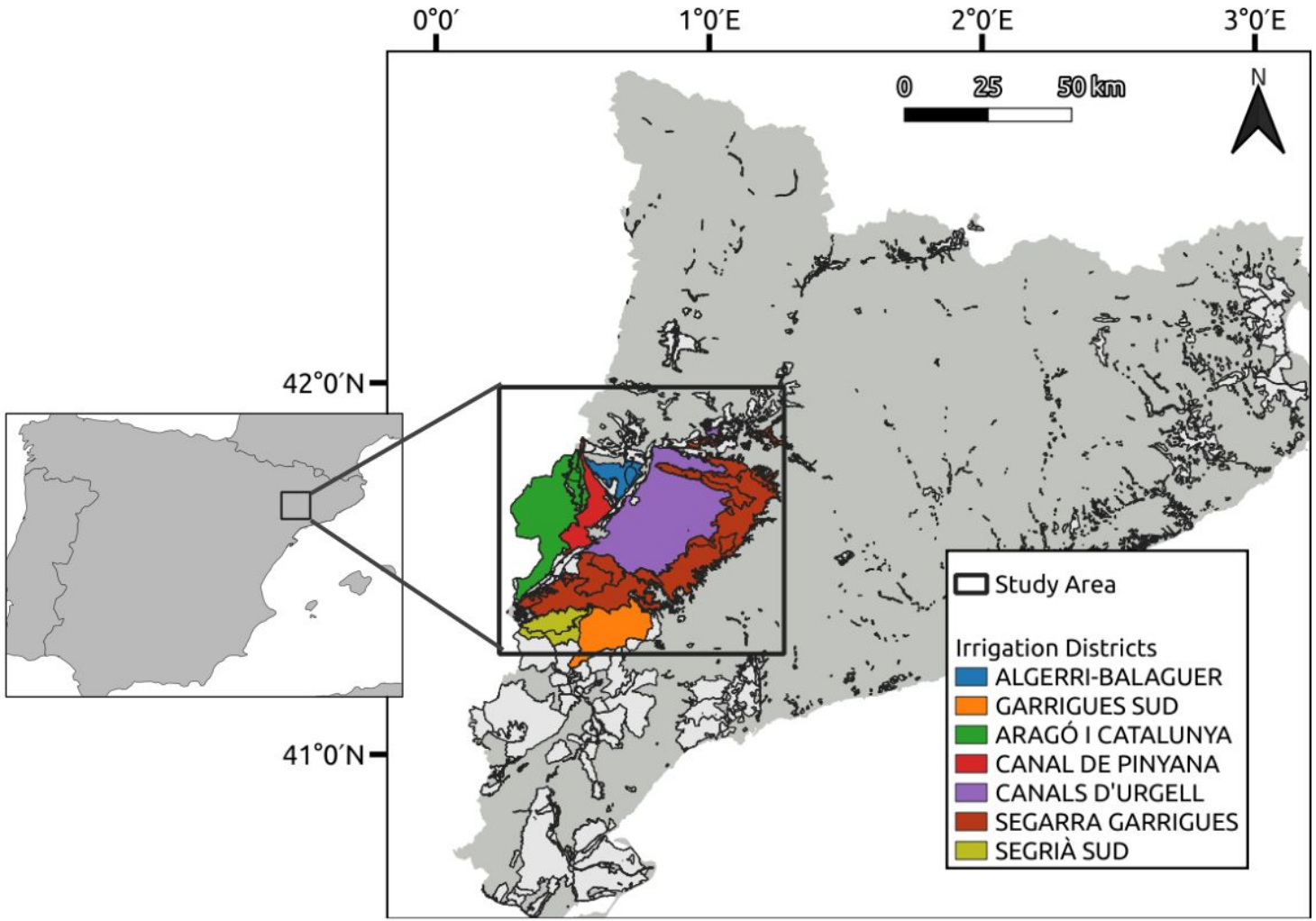
Open Project Day

isardSAT, Barcelona | March 11th, 2022

Marie Curie Actions

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION HORIZON 2020

Study Area

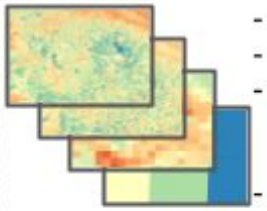

0°0′
1°0′E
2°0′E
3°0′E
0
25
50 km
N
42°0′N
41°0′N
Study Area
Irrigation Districts
ALGERRI-BALAGUER
GARRIGUES SUD
ARAGÓ I CATALUNYA
CANAL DE PINYANA
CANALS D'URGELL
SEGARRA GARRIGUES
SEGRIÀ SUD

Framework

Input Data

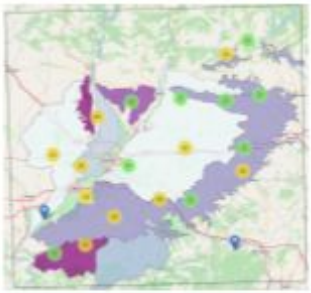
HYDROLOGICAL VARIABLES

MODELLED DATA
- Actual ET
- Dispatch SM
- LAI
- Ks



RAW DATA
- NDVI
- SMAP SM
- ET0
- LST

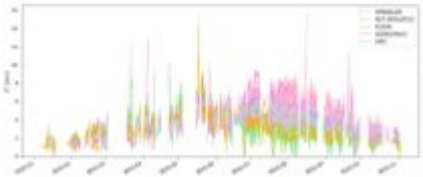
GROUND TRUTH



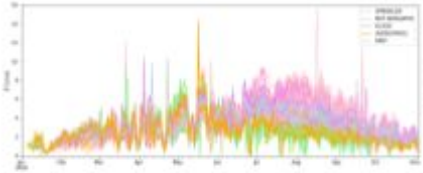
Processing

1. Extracting ground truth field (shapes from SIGPAC)

2.Extracting Annual Time-series



3. Gap Filling

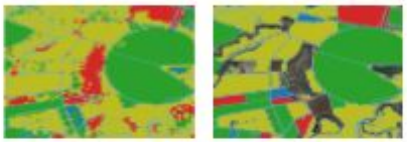


Classification

1. Different Models:
   - Time series Forest
   - ROCKET
   - ResNET (Deep Learning)
2. Train + Test with around 300 fields (3 different years: 2018 - 2019 - 2020)
3. Prediction (classification of unseeing time-series)
4. Outputs:
   - NOT IRRIGATED
   - DRIP
   - SPRINKLER
   - FLOOD

Post-processing

Aggregating at field scale (shapes from SIGPAC)

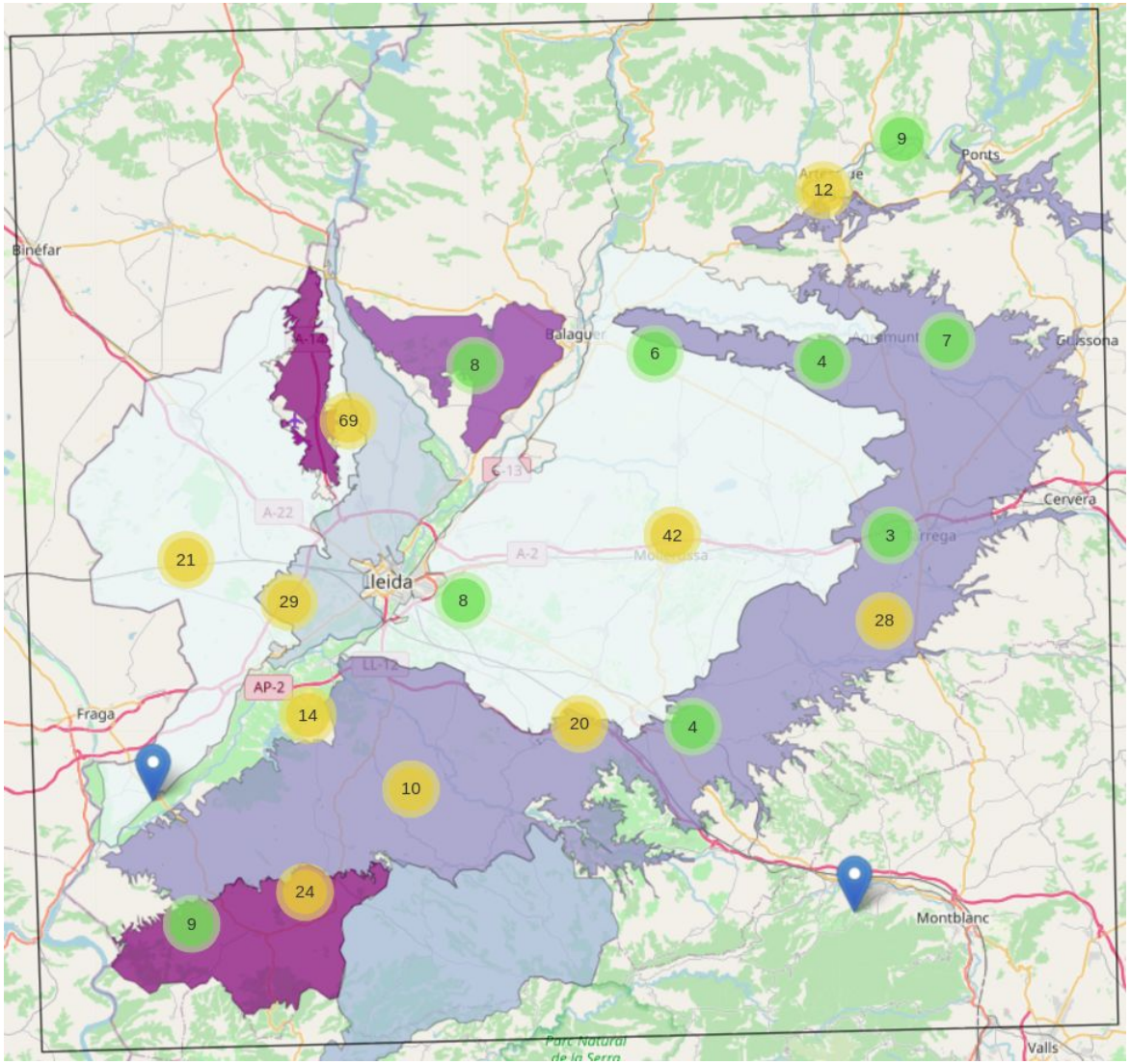


Temporal Post-processing

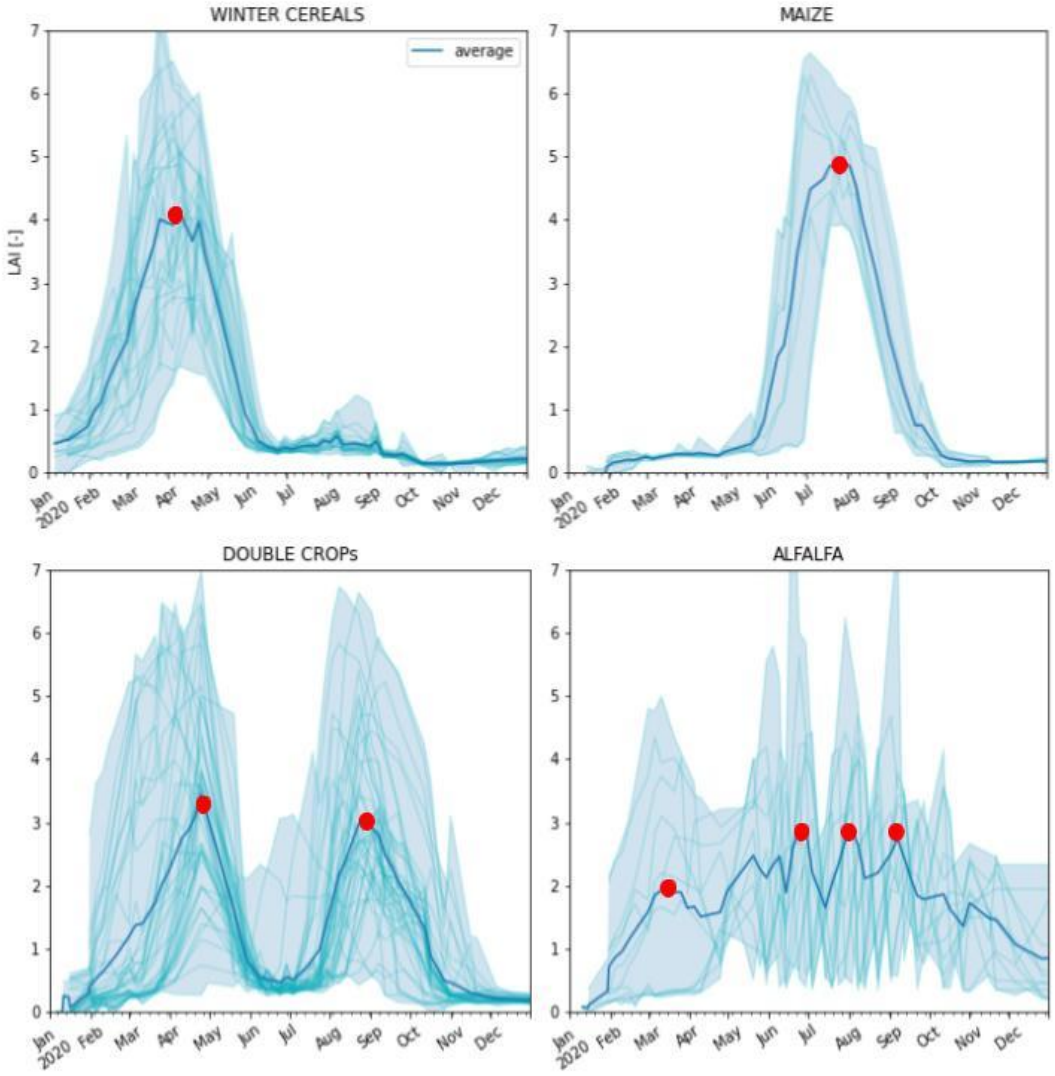
Correct one year if it shows unrealistic irrigation types when compared to other years.

Corrections happens when the exception is:
- Modern Irrigation (if it is not the last year available)
- Traditional Irrigation OR Not Irrigated (if it is not the first year available)

Field Campaign - Distribution of Fields



Field Campaign - Crop Detection



Field Campaign - Number of Fields

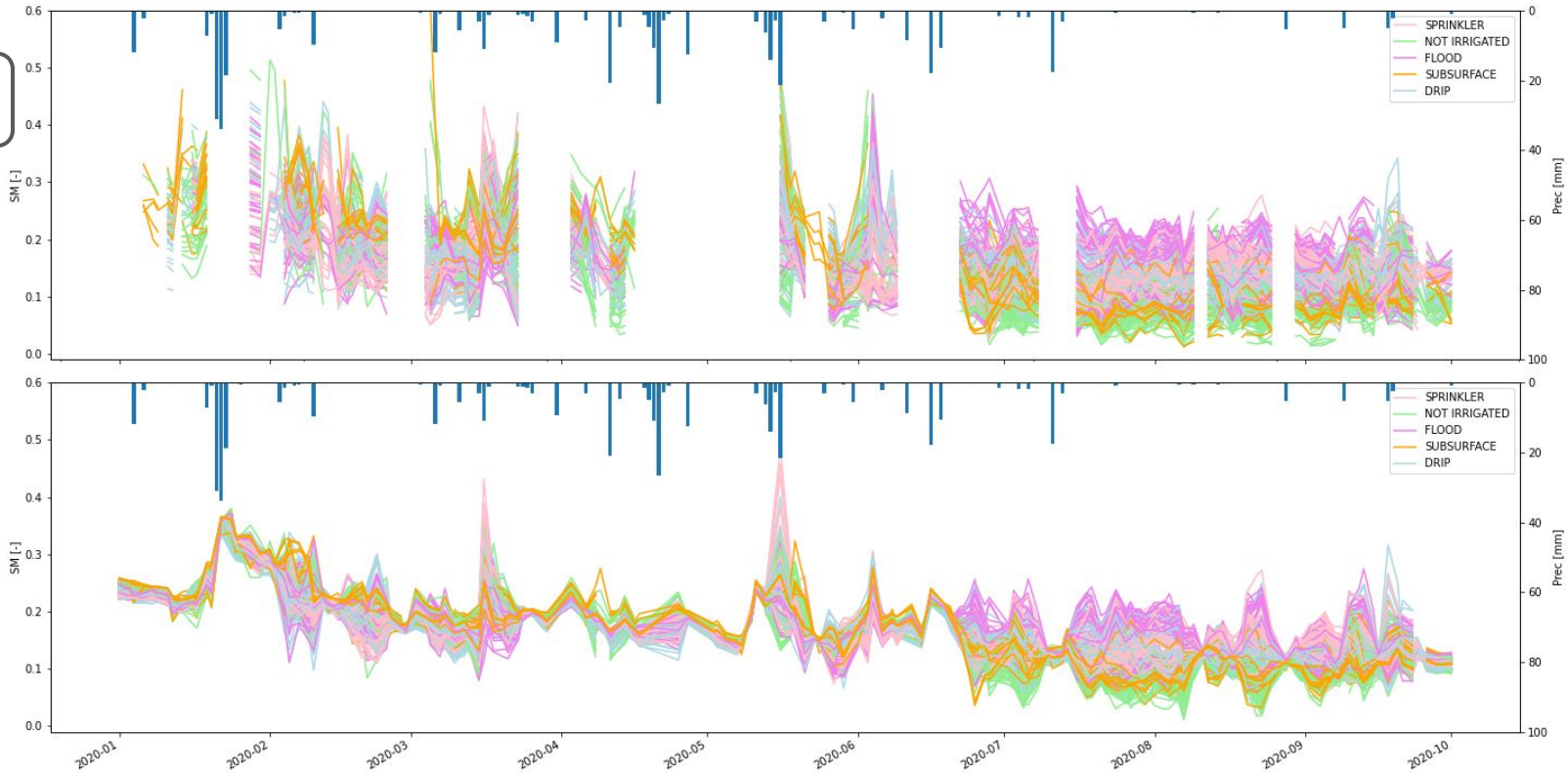
CROP TYPE	IRRIGATION TYPE	Number of Fields			FIELDS TOTAL	PIXELS TOTAL
		2018	2019	2020		
WINTER CEREALS	NOT IRRIGATED	40	36	40	116	27584
	FLOOD	9	9	9	27	444
MAIZE	SPRINKLER	8	8	8	24	10950
	FLOOD	14	14	13	41	1322
DOUBLE CROPS	SPRINKLER	55	56	56	167	43849
	FLOOD	32	33	33	98	5859
ALFALFA	SPRINKLER	7	7	7	21	3777
	FLOOD	9	9	9	27	2733
TREEs	NOT IRRIGATED	13	13	13	39	1578
	DRIP	78	78	78	234	24201
	FLOOD	18	18	18	54	1734
VINEYARD	NOT IRRIGATED	7	7	7	21	867
	DRIP	12	12	12	36	4599
OLIVE	NOT IRRIGATED	17	17	17	51	6231
	DRIP	11	11	11	33	3201
TOTAL		330	328	331	989	138929

Input Dispatch SM

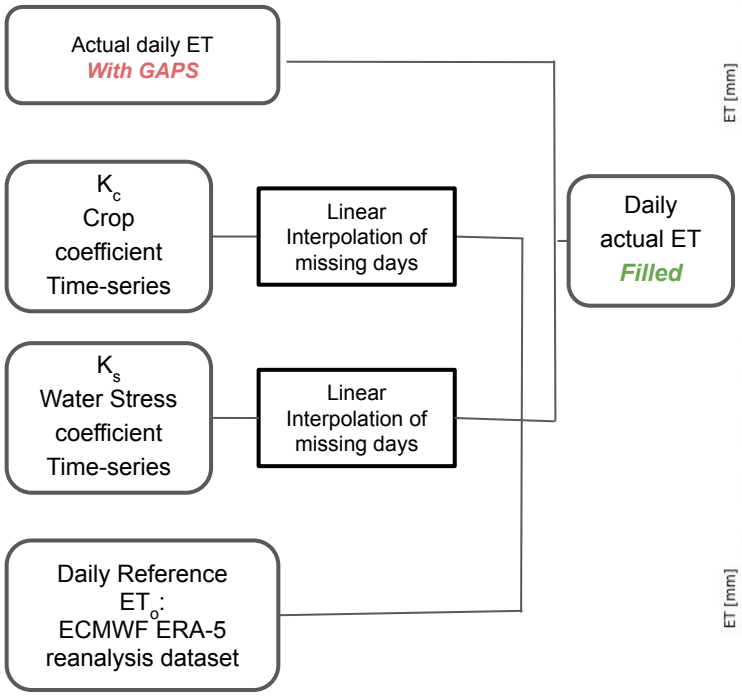
Dispatch 20m SM
With GAPS

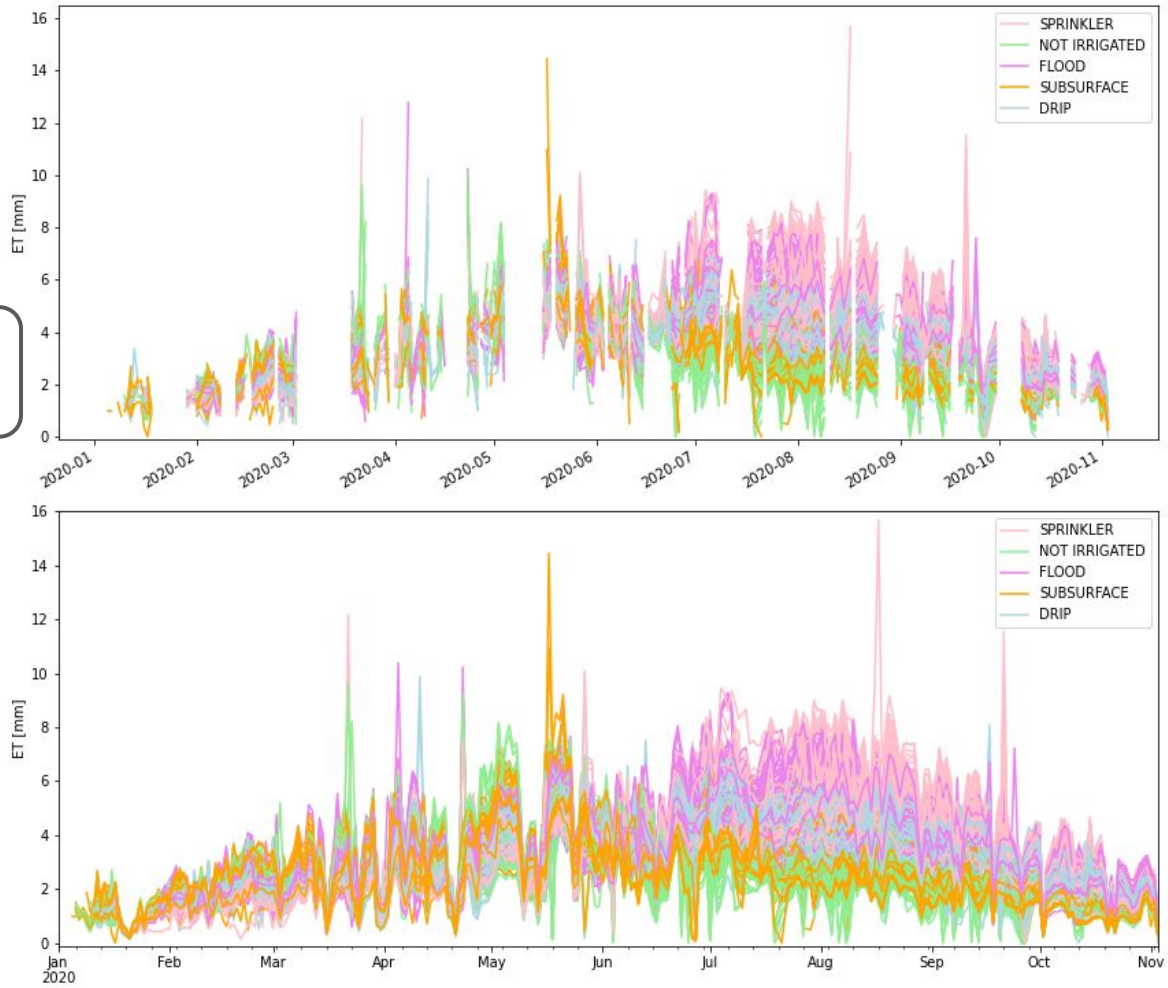
SMAP 9 Km SM

Dispatch
20m SM
Filled



Input ETact


Actual daily ET
With GAPS
K_c
Crop
coefficient
Time-series
Linear
Interpolation of
missing days
K_s
Water Stress
coefficient
Time-series
Linear
Interpolation of
missing days
Daily Reference
ET_o:
ECMWF ERA-5
reanalysis dataset
Daily
actual ET
Filled


ET [mm]
SPRINKLER
NOT IRRIGATED
FLOOD
SUBSURFACE
DRIP
2020-01
2020-02
2020-03
2020-04
2020-05
2020-06
2020-07
2020-08
2020-09
2020-10
2020-11
Jan
2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov

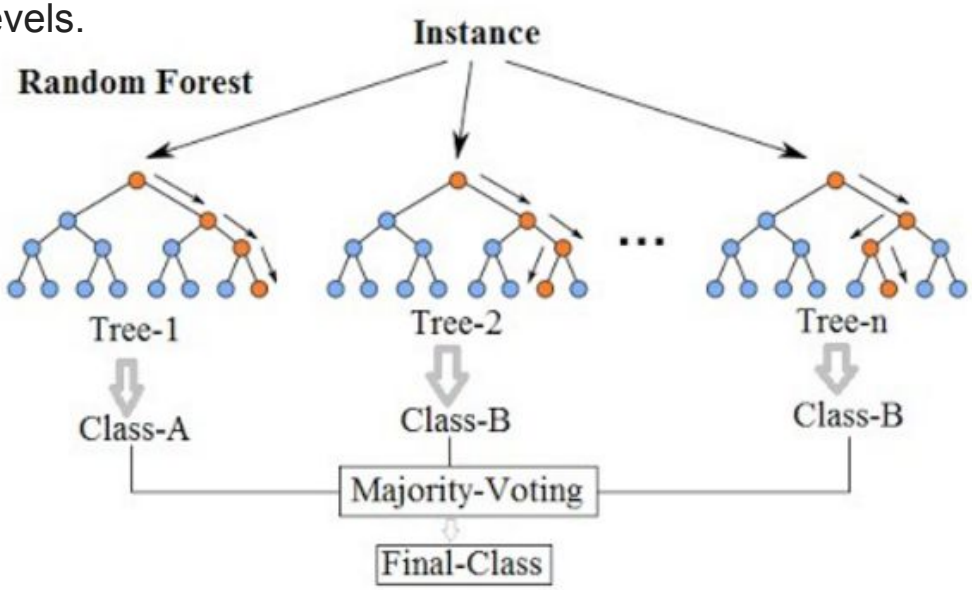
AI Models

Time Series Forest

Time series forest is a random forest adapted to detect temporal features.

Selected because:

1. Widely used: used as a **benchmark** to test more advanced model(s).
2. **Computationally efficient**.
3. **It avoids overfitting** (using strategies like bootstrap and random interval selection).
4. **Easy to inspect results**: Feature extraction = Interpretability.
5. **Easy to quantify results**: Confidence levels.



Source:
Deng, H., Runger, G., Tuv, E., & Vladimir, M. (2013). A time series forest for classification and feature extraction. Information Sciences, 239, 142-153.

Input ETact

Rocket (RandOm Convolutional KErnel Transform)

It is a kernel-approach classification inspired by convolutional neural network. It has only a single layer of convolution (NO learning of the weights) but with a large number of kernels, with their parameters randomly initialized (length, dilation, padding, weights and biases).

Selected because:

1. **State-of-the-art accuracy**
2. **Low computational requirements**.
3. Only one Hyperparameters (number of kernels).

	ROCKET
length	$\{7, 9, 11\}$
weights	$\mathcal{N}(0, 1)$
bias	$\mathcal{U}(-1, 1)$
dilation	random
padding	random

Source:
Dempster, A., Petitjean, F., & Webb, G. I. (2020). ROCKET: exceptionally fast and accurate time series classification using random convolutional kernels. Data Mining and Knowledge Discovery, 34(5), 1454-1495.

AI Models

ResNET

It is a Deep Neural Network.

Selected because:

- **State-of-the-art accuracy**
- **Best performing** in tests with different number of databases from different disciplines.
- Can retrieve very complex features, it works very well with **large Datasets**.

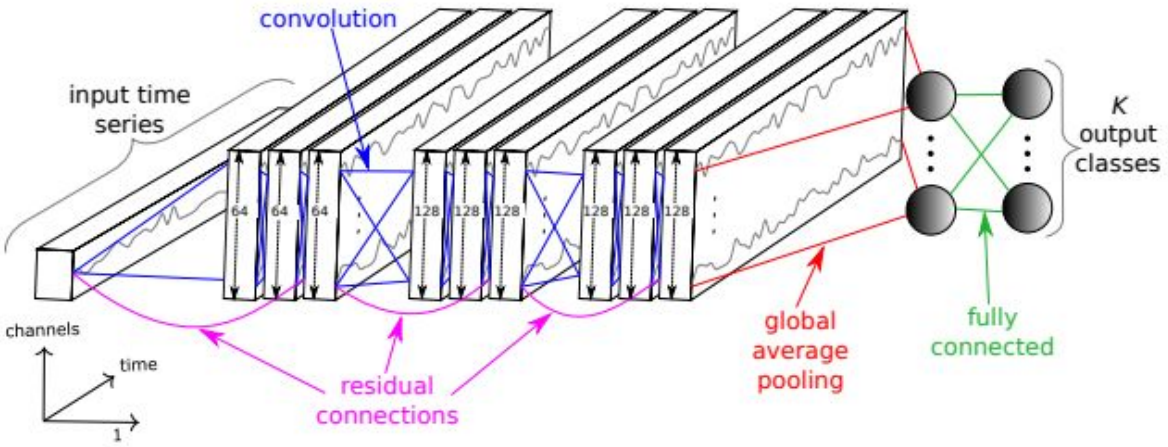


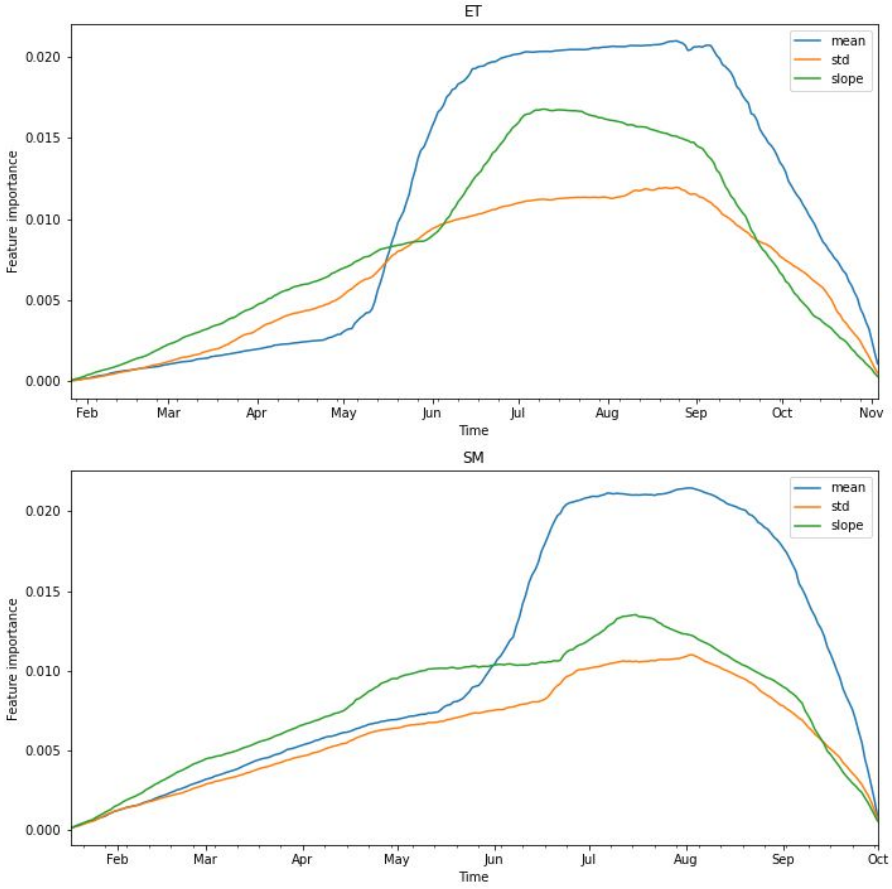
Fig. 6: The Residual Network's architecture for time series classification.

Source::
Wang Z, Yan W, Oates T (2017b) Time series classification from scratch with deep neural networks: A strong baseline. In: International Joint Conference on Neural Networks, pp 1578–1585.

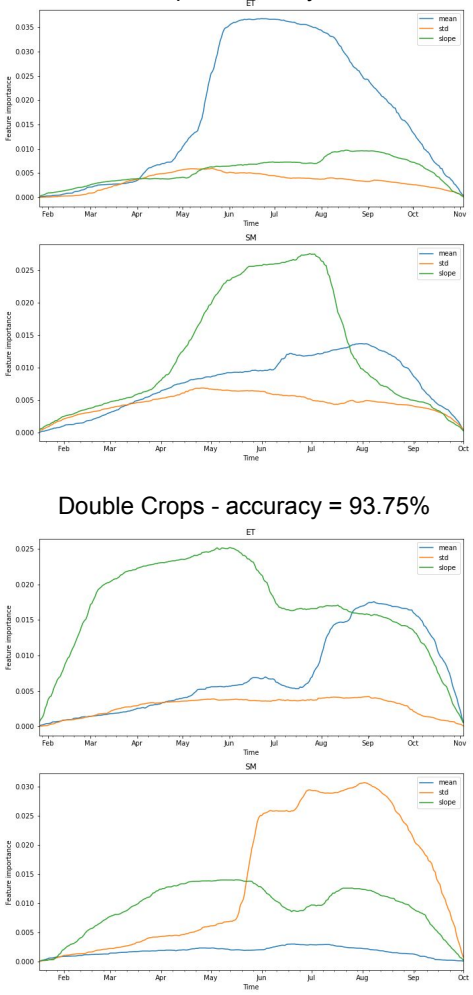
Results I

Variables	Crop types							RESULTS	
	Winter Cereals	Maize	Double Crops	Alfalfa	Fruit & Nut Trees	Olives	Vineyards	Aggregated Models	General Model
ET_a-TSEB	81.25%	48.82%	91.67%	72.00%	74.88%	**74.33%**	96.19%	78.15%	79.33%
ET_a-TSEB cropped	73.37%	58.82%	89.58%	70.00%	72.33%	70.00%	94.76%	75.41%	-
SM Dispatch	88.75%	**76.47%**	91.67%	66.67%	73.18%	73.33%	80.95%	78.36%	74.25%
SM Dispatch cropped	82.88%	70.00%	91.67%	66.67%	75.58%	64.67%	80.95%	78.26%	-
ET_a+*SM*	**90.62%**	70.00%	**93.75%**	**73.33%**	**81.71%**	69.67%	96.67%	**83.39%**	**81.89%**
ET_a+*SM* cropped	86.88%	68.82%	91.67%	66.67%	78.45%	65.33%	**100.00%**	81.47%	-

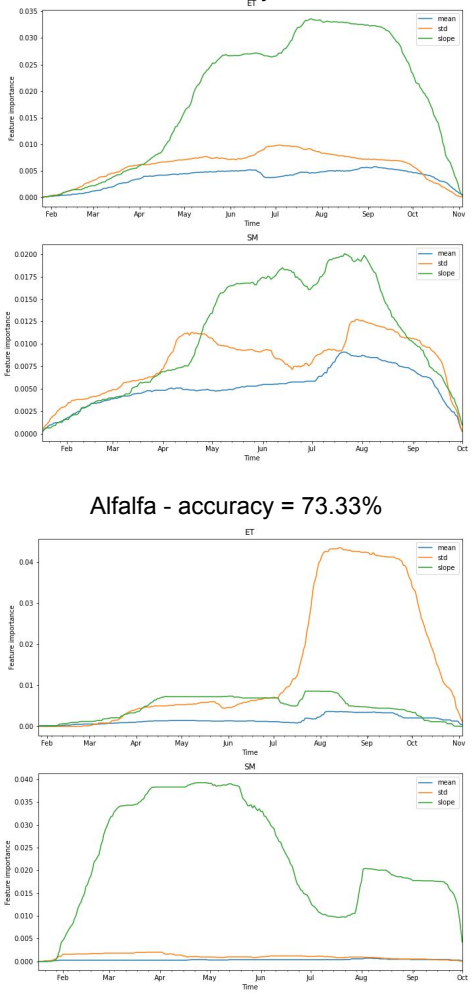
Results II



Winter Crops - accuracy = 90.62%



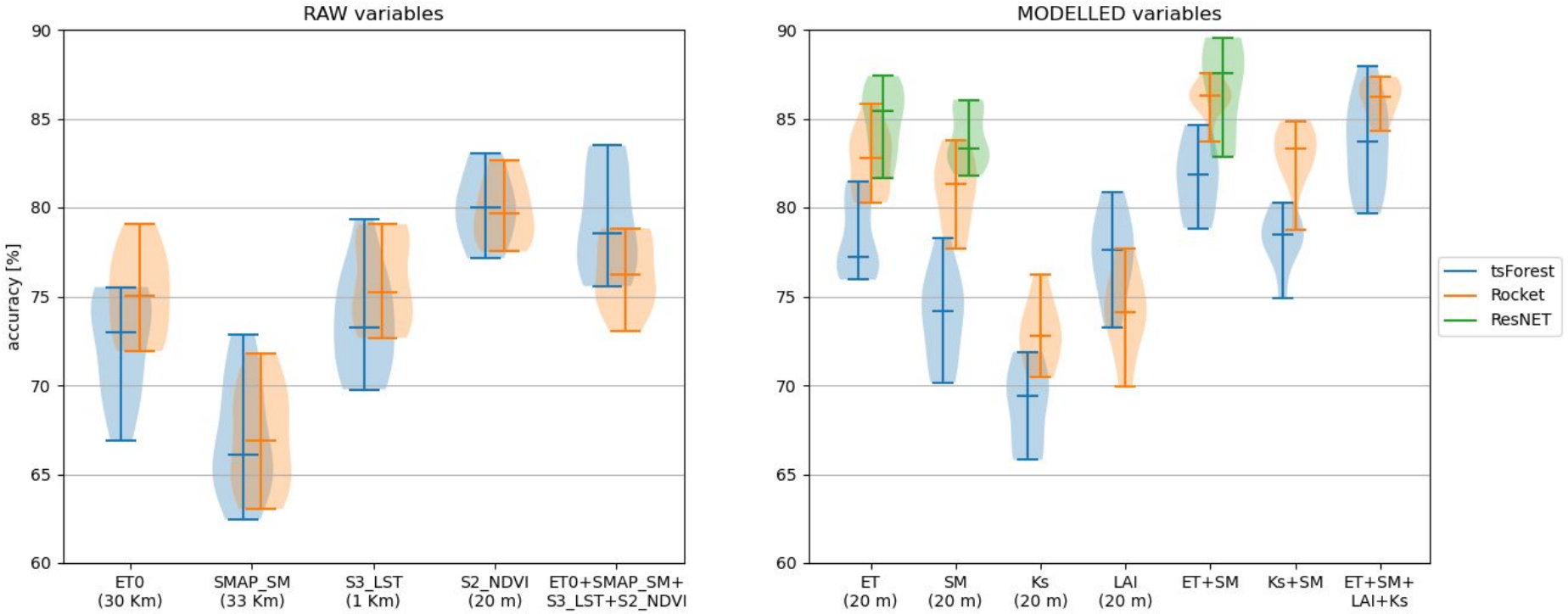
Maize - accuracy = 70.00%



Double Crops - accuracy = 93.75%

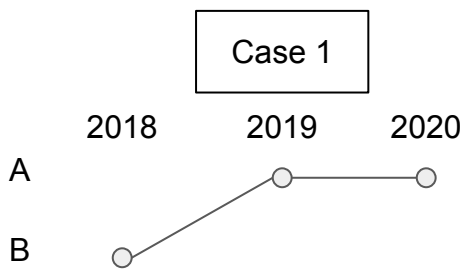
Alfalfa - accuracy = 73.33%

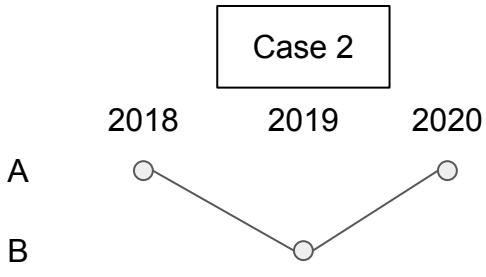
Results III

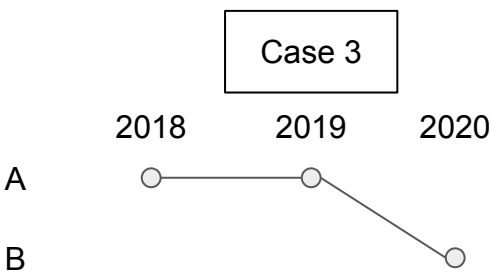


METRICS (%)	MODELS		
	tsForest	ROCKET	ResNET
Accuracy	81.59 +/- 2.14	82.45 +/- 1.62	**86.59** +/- 2.79
Precision	81.73 +/- 1.90	83.28 +/- 1.62	**87.39** +/- 2.26
Recall	81.59 +/- 2.14	82.45 +/- 1.62	**86.59** +/- 2.79
Kappa	73.77 +/- 2.84	74.64 +/- 2.33	**81.30** +/- 3.61

Post-Process



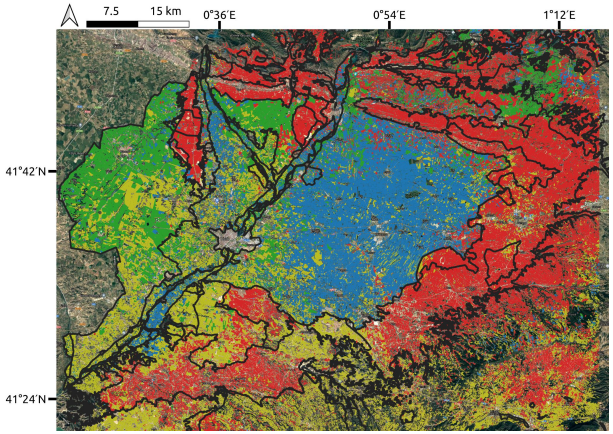




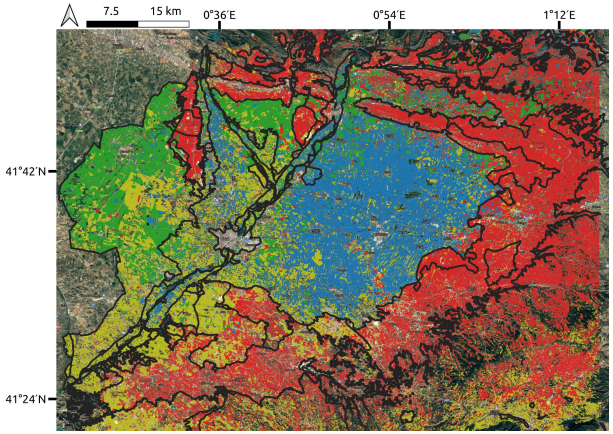
A \ B	0 - NOT IRRIGATED			6 - DRIP			3 - SPRINKLER			2 - FLOOD		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
0 - NOT IRRIGATED				X	V	X	X	V	X	V	V	V
6 - DRIP	X	V	X				X	V	X	X	V	V
3 - SPRINKLER	X	V	X	X	V	X				X	V	V
2 - FLOOD	V	V	V	V	V	X	V	V	X			

Results IV

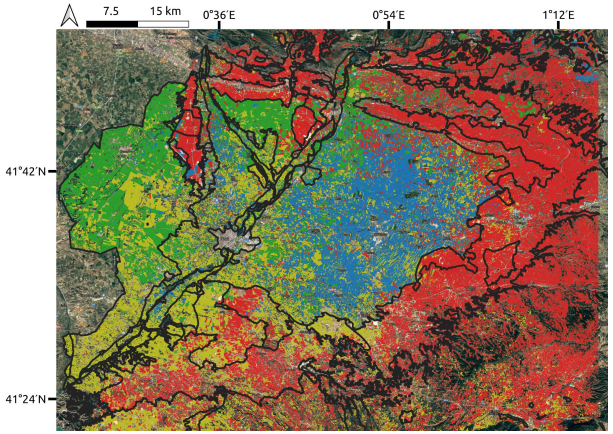
2018



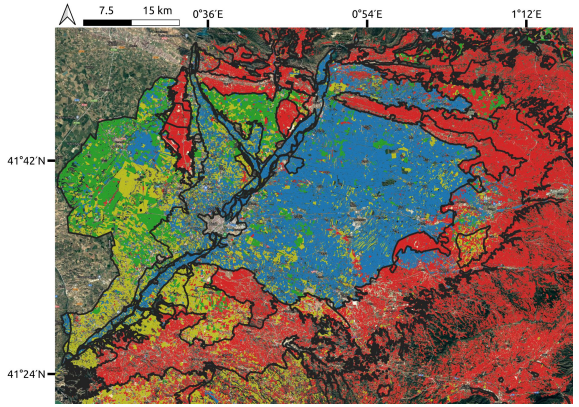
2019



2020

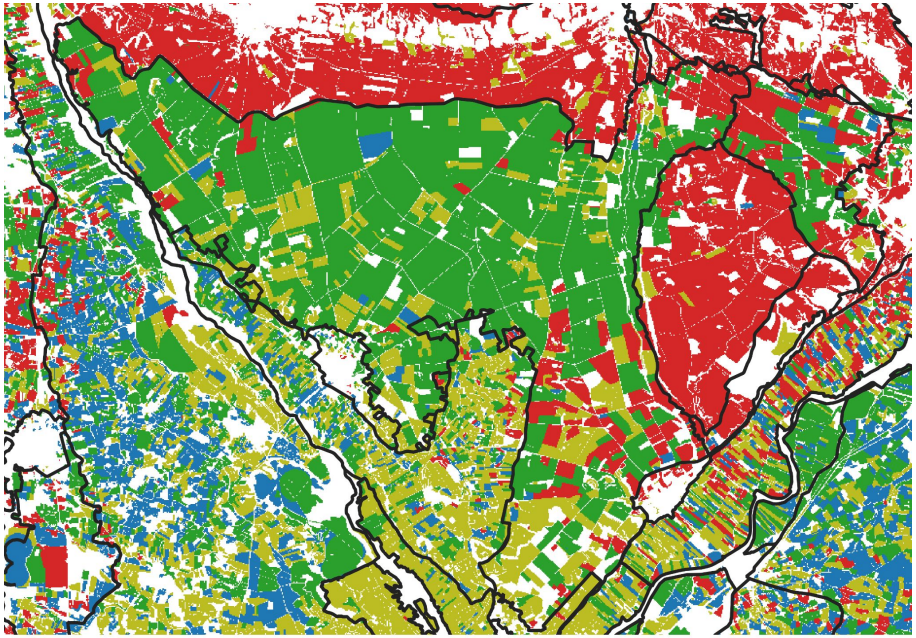


SIGPAC

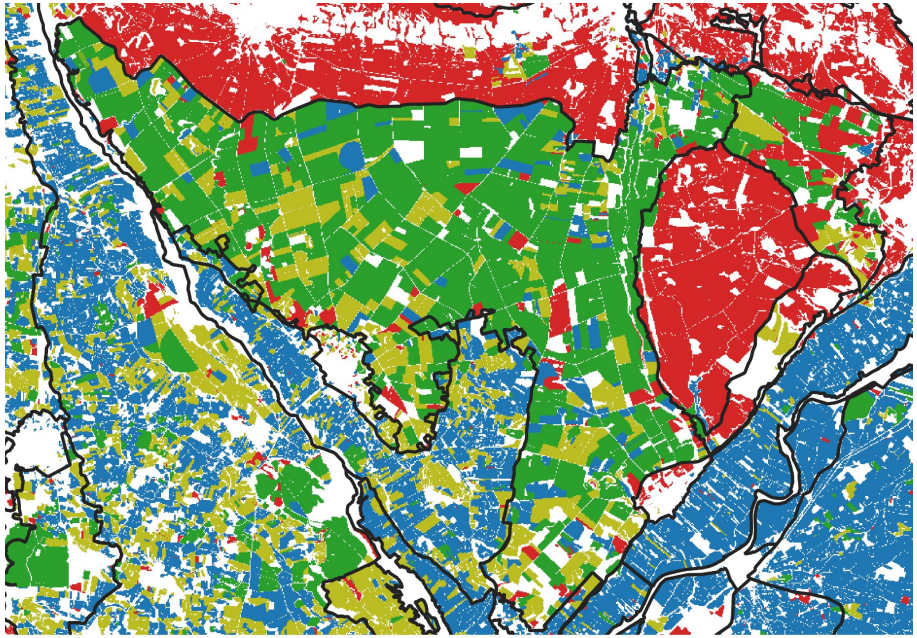


Results V - Algerri Balaguer

2020



SIGPAC



0 - NOT IRRIGATED

1 - DRIP

2 - FLOOD

3 - SPRINKLER

Thank you!