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TAKING THE PULSE OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

Comparing irrigation quantification approaches developed within the Irrigation+ project

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Wednesday, 25th of May

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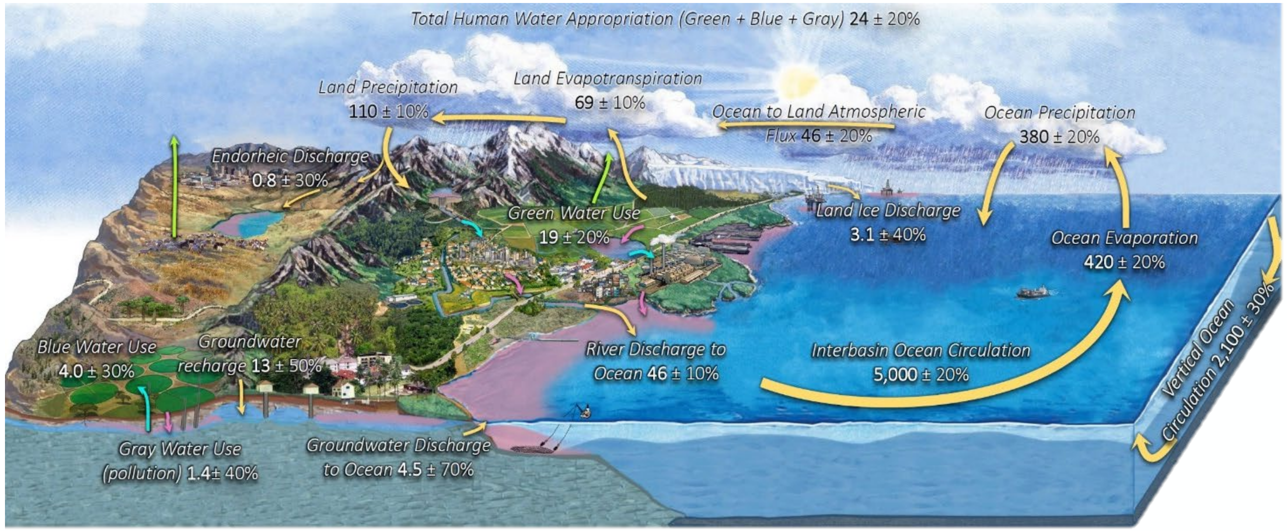
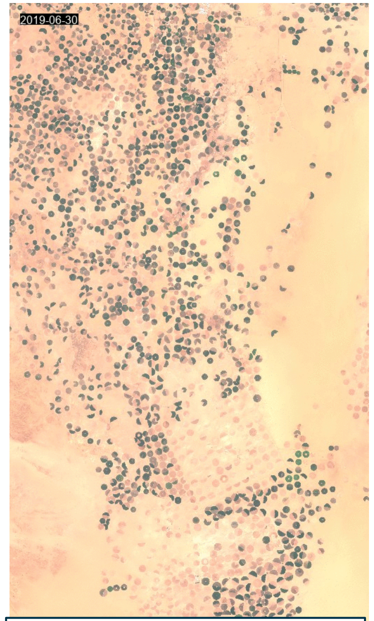
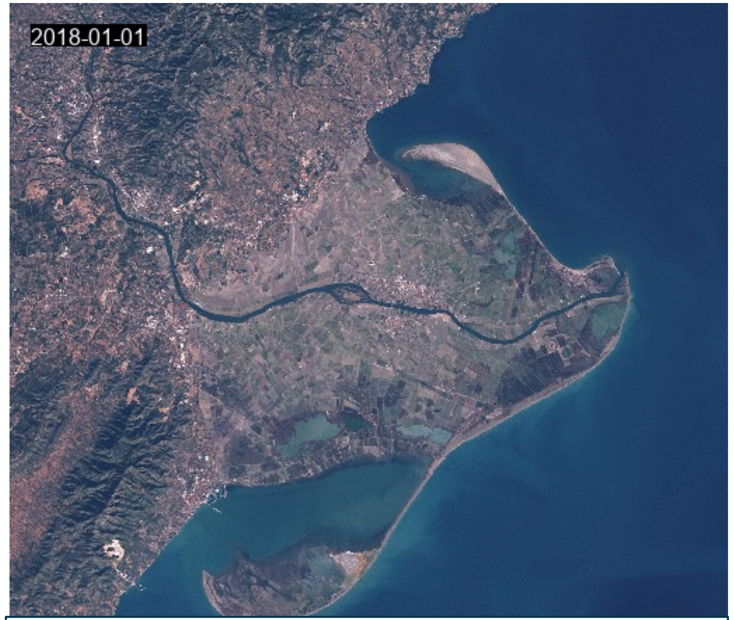
Why Focusing on Irrigation?



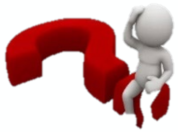
Anthropogenic interventions on the hydrological cycle have reached such a magnitude that even the way we represent the hydrological cycle needs to be updated by involving human activities.
(***Abbot et al., 2019***, https://doi.org/10.1038/s41561-019-0374-y).



Pivots in Saudi Arabia, 2019-2020



Rice fields in the delta of the Ebro river in Spain, 2018



Key questions:

Do we know when and where irrigation practices actually occur?

How much water is used for irrigation?

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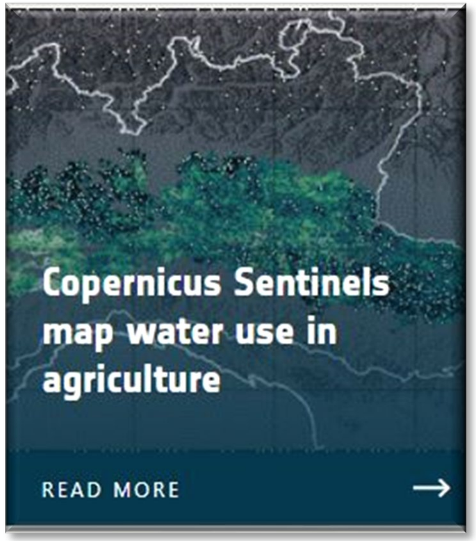
The IRRIGATION+ Project

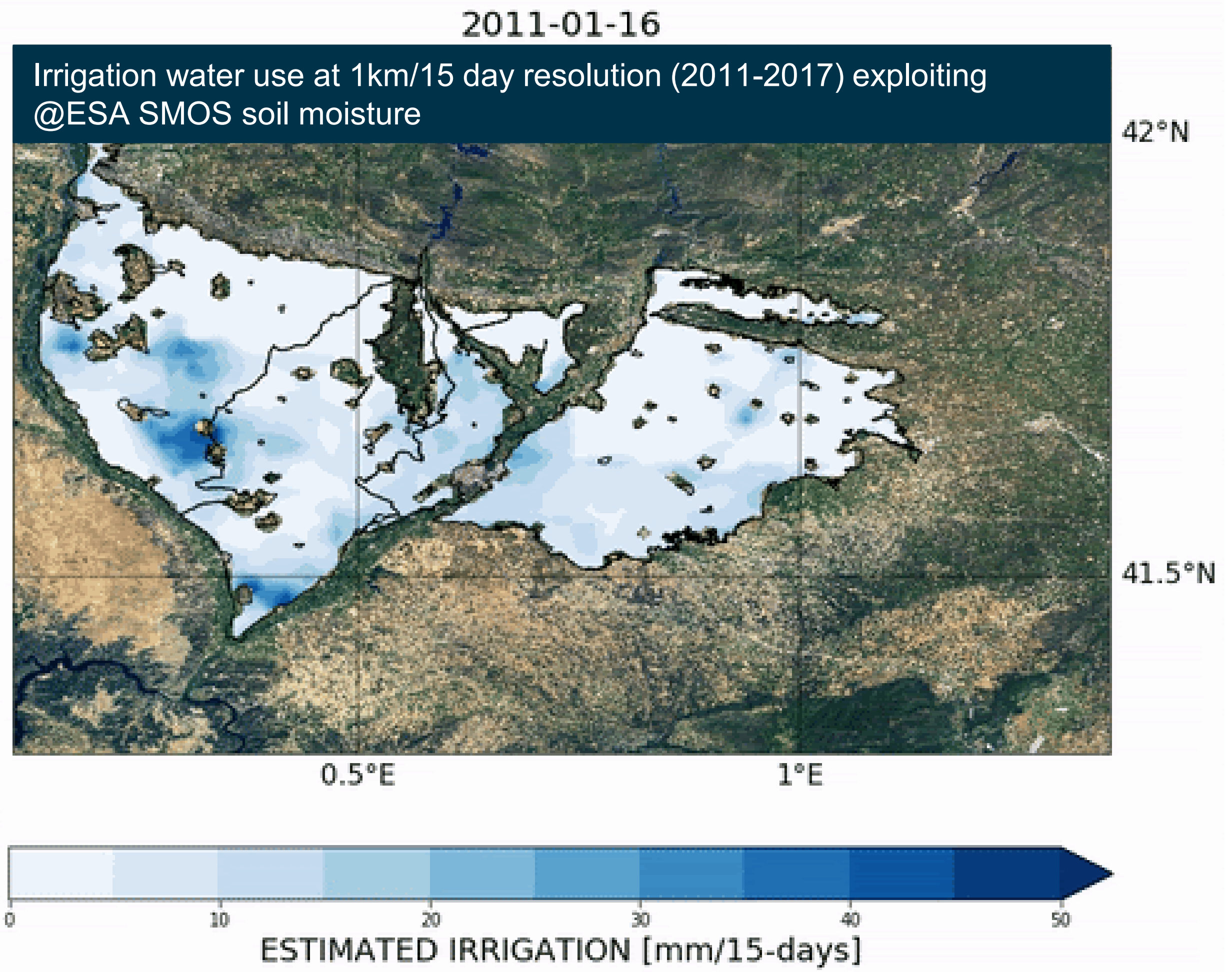
The **IRRIGATION+** ESA project aims to explore, develop and validate advanced EO-based algorithms and techniques for irrigation mapping, quantification and detection of seasonal timing of irrigation from field to regional/global scale.

IRRIGATION+

Sentinel Success Stories

https://sentinels.copernicus.eu/web/success-stories/-/copernicus-sentinels-map-water-use-in-agriculture/2.4





(***Dari et al., 2020***, https://doi.org/10.3390/rs12162593)

SM-based inversion approach: Setup

$$nZ\frac{dS(t)}{dt} = i(t) + r(t) - g(t) - sr(t) - e(t)$$

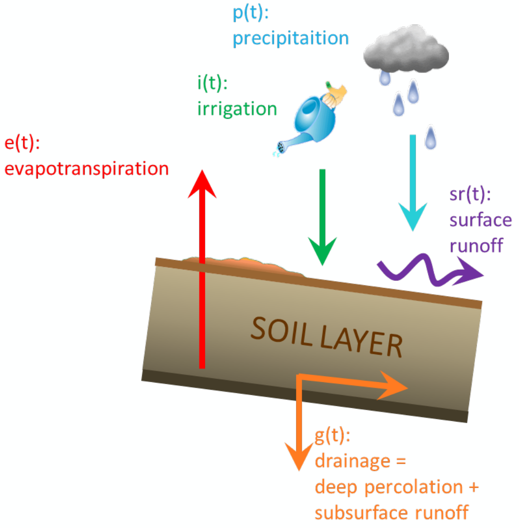
$$g(t) = aS(t)^b$$

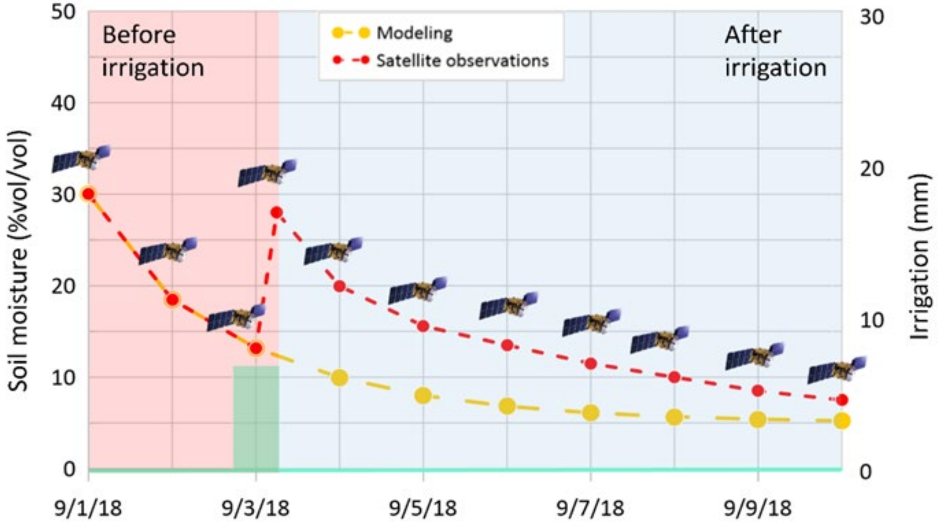
$$sr(t) = 0$$

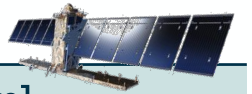
$$e(t) = F * S(t) * PET(t)$$

$$W_{in}(t) = nZ\frac{dS(t)}{dt} + aS(t)^b + F * S(t) * PET(t)$$

$$W_{in}(t) - r(t) = \boldsymbol{i(t)}$$







Remote sensing data sets	
Soil moisture	RT1 S1 [1 km]
Potential evapotranspiration	GLEAM v3.5b [0.25°]

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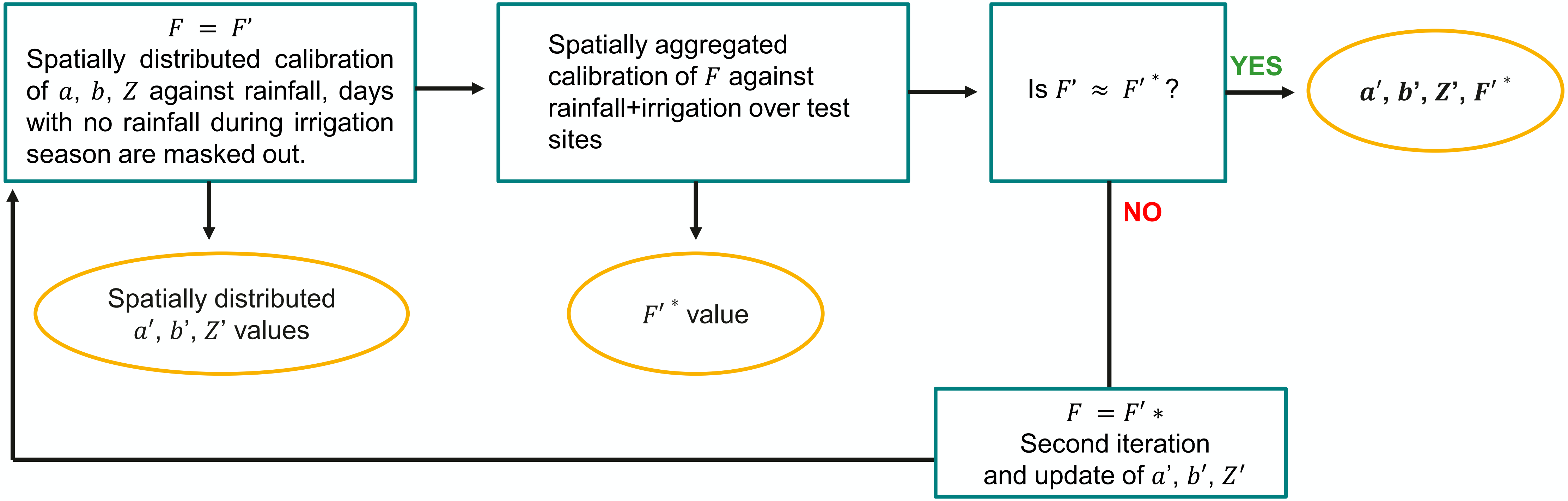
SM-based inversion approach: Calibration

Parameters: a, b, Z, F

Period 2016-2017



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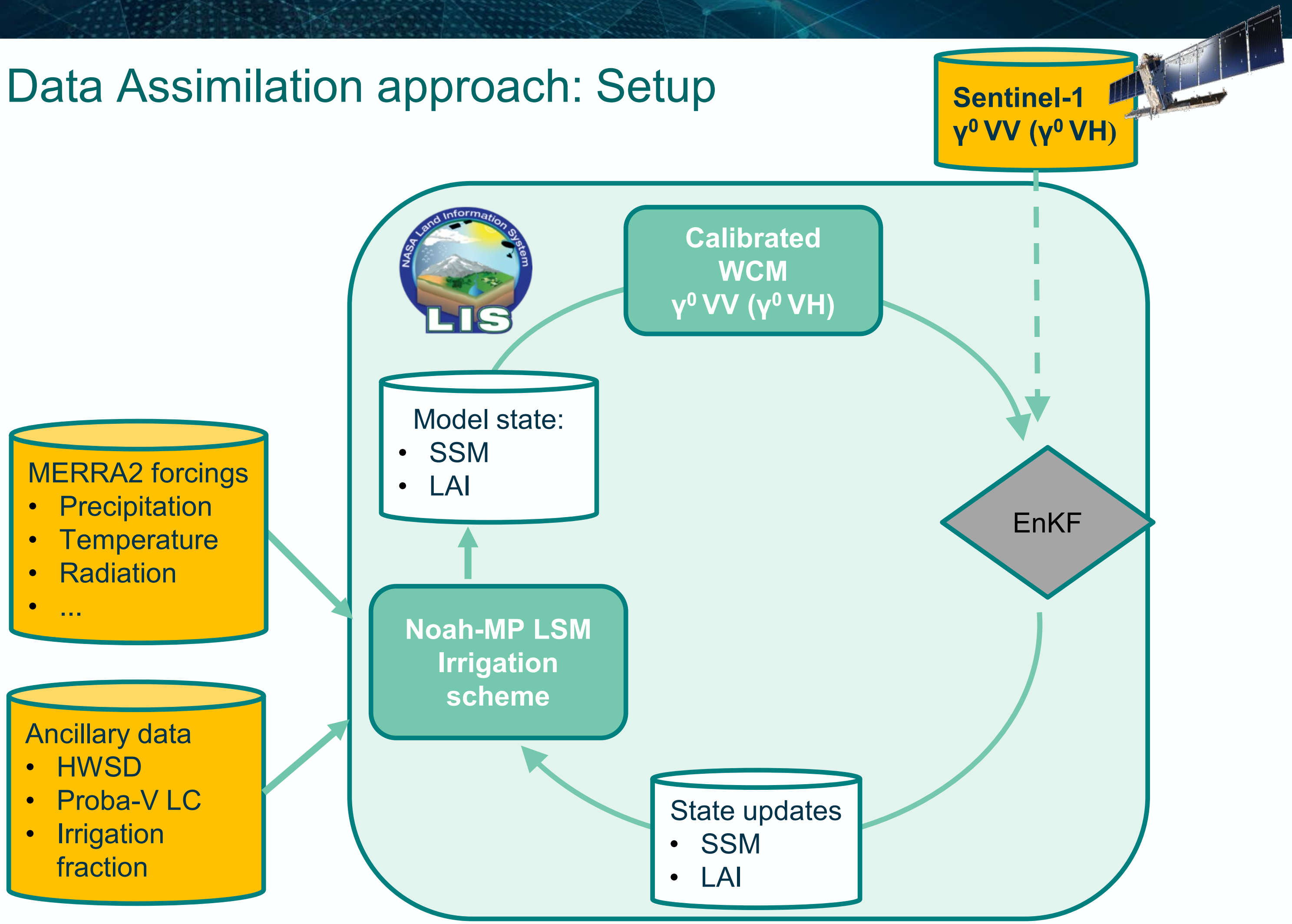
Data Assimilation approach: Setup



1 km spatial resolution

PERFORMED EXPERIMENTS

1. Sentinel-1 γ^0VV DA to update SSM and LAI;
2. Sentinel-1 γ^0VH DA to update SSM and LAI.

$$\widehat{x_i^+} = \widehat{x_i^-} + K_i\left[\boxed{y_{obs,i}} - \boxed{h_i(\widehat{x_i^-})}\right]$$

Sentinel-1 γ^0 VV (γ^0 VH)

Noah-MP+ WCM

WCM CALIBRATION:
Modanesi et al. 2021
https://doi.org/10.5194/hess-25-6283-2021

DATA ASSIMILATION:
Modanesi et al. 2022 ***(under review)***
https://doi.org/10.5194/hess-2022-61

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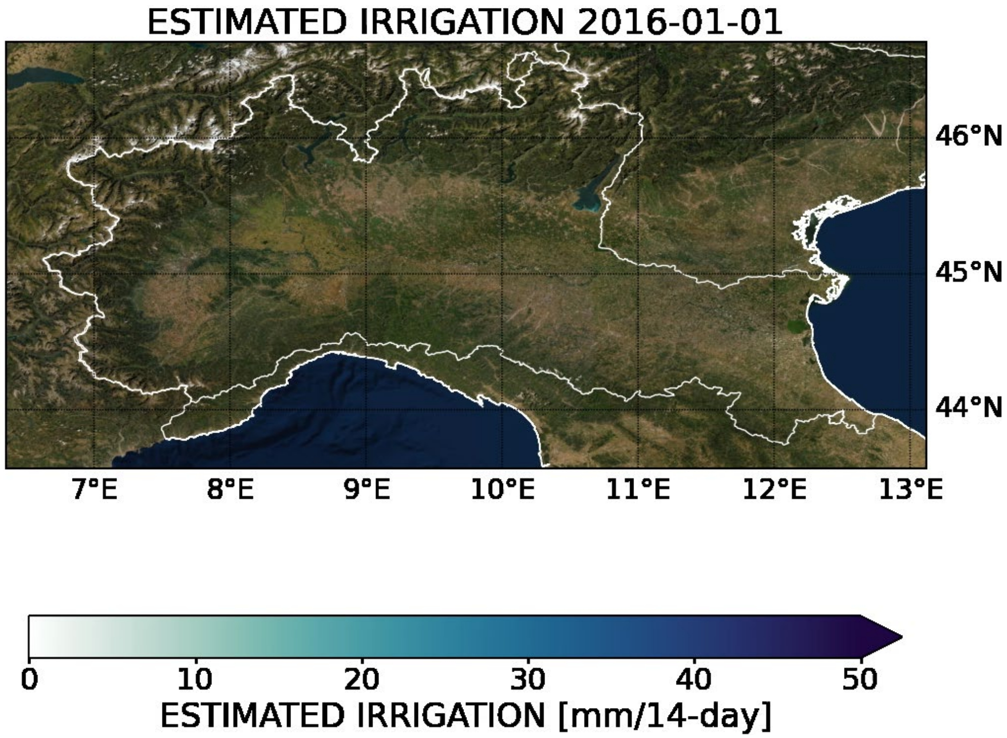
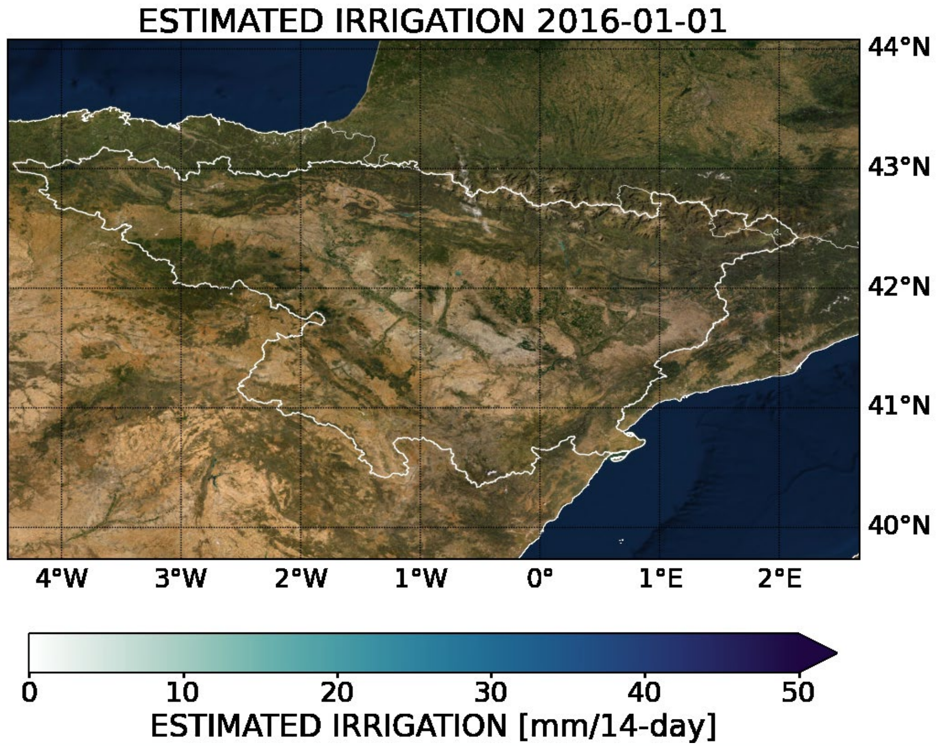
SM-based inversion approach: Results

Irrigation products at regional scale over the Po river and the Ebro river basins:

- Period: 2016 – 2020 (July)
- Spatial resolution: 1 km
- Temporal resolution: daily





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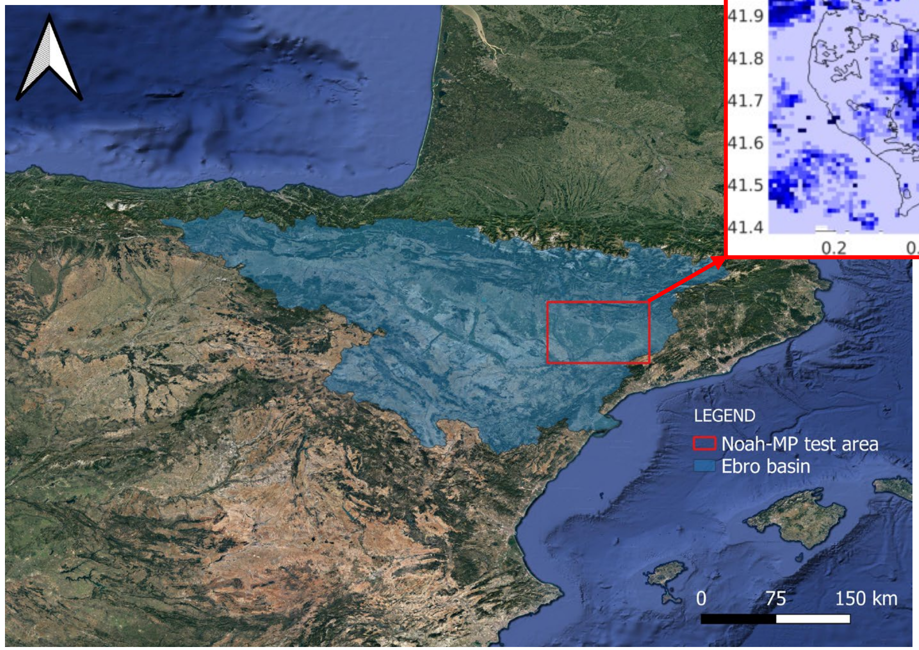
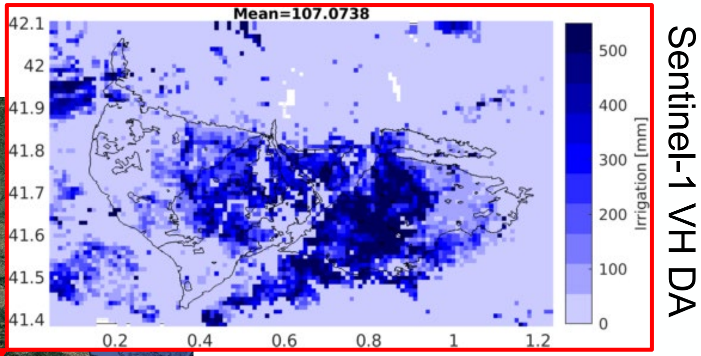
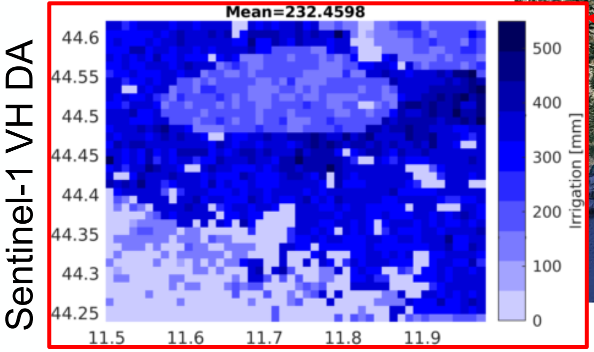
Data assimilation approach: Results

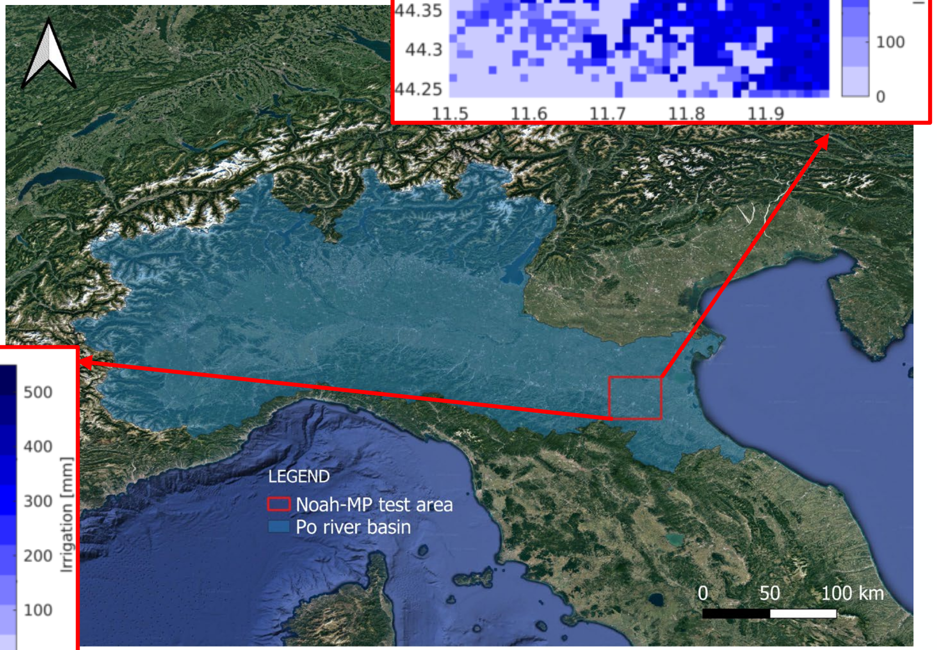
Irrigation products over portions of the Po river and the Ebro river basins:

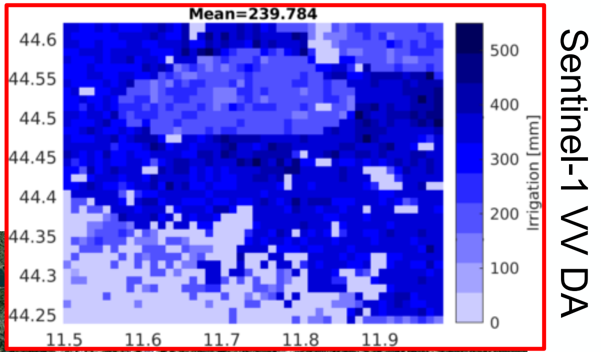
- Period: 2015 – 2020
- Spatial resolution: 1 km
- Temporal resolution: daily











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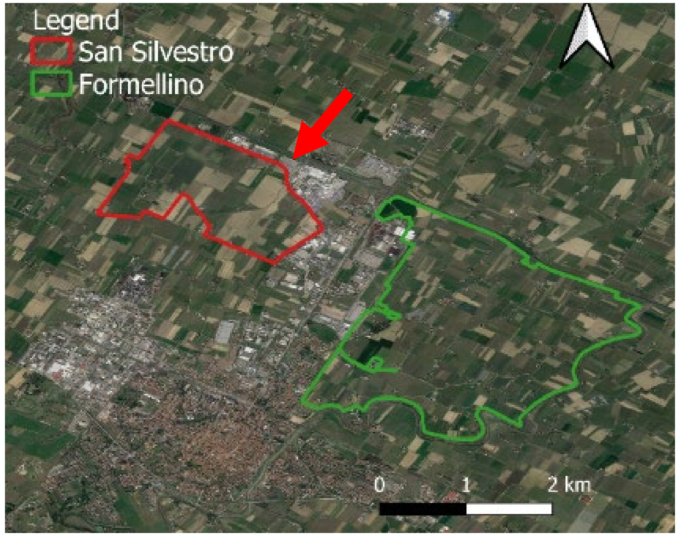
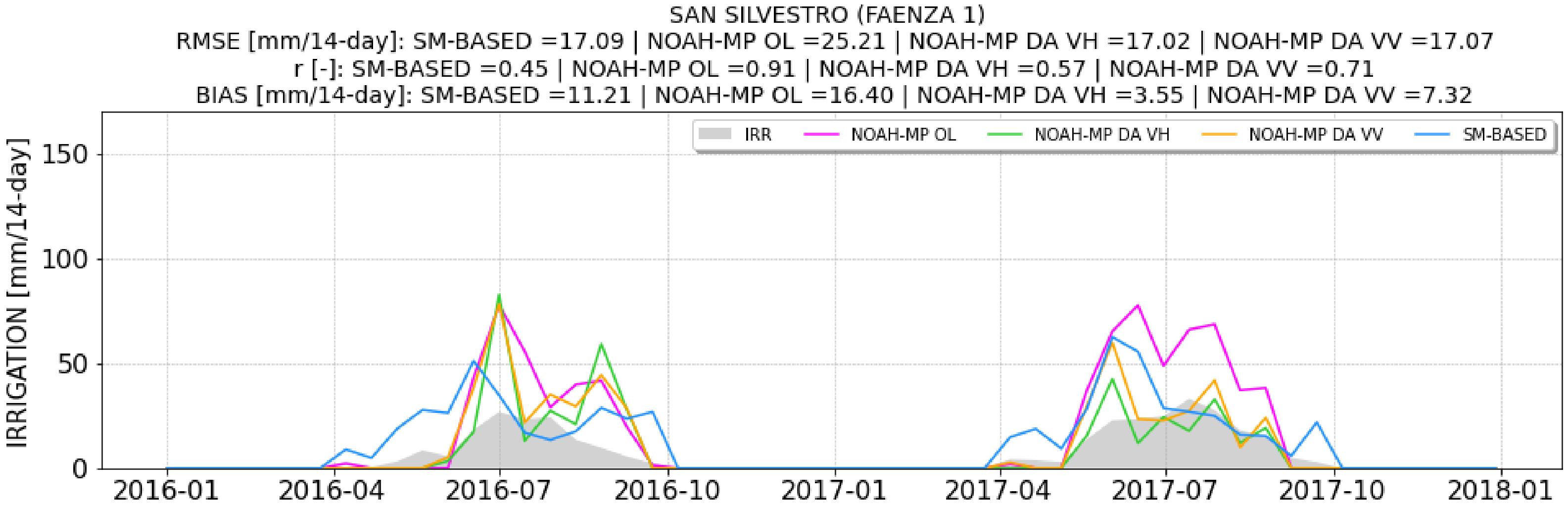
Comparison of irrigation quantification approaches

Faenza





SM-based approach VS **NOAH-MP OL** VS **NOAH-MP DA VH** VS **NOAH-MP DA VV**

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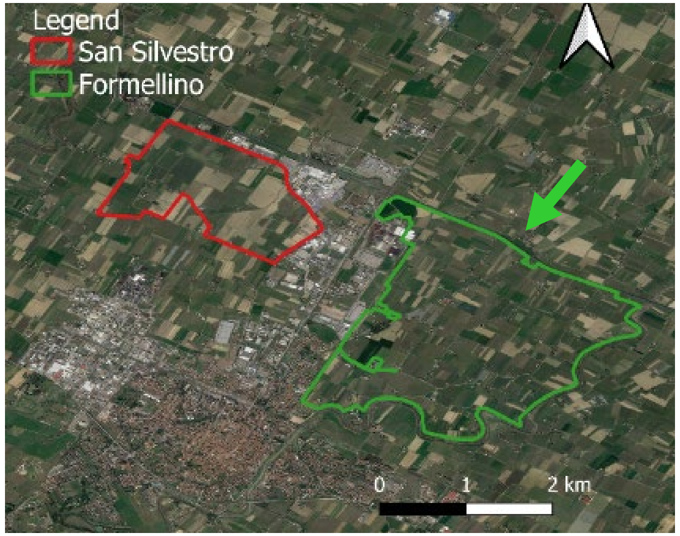
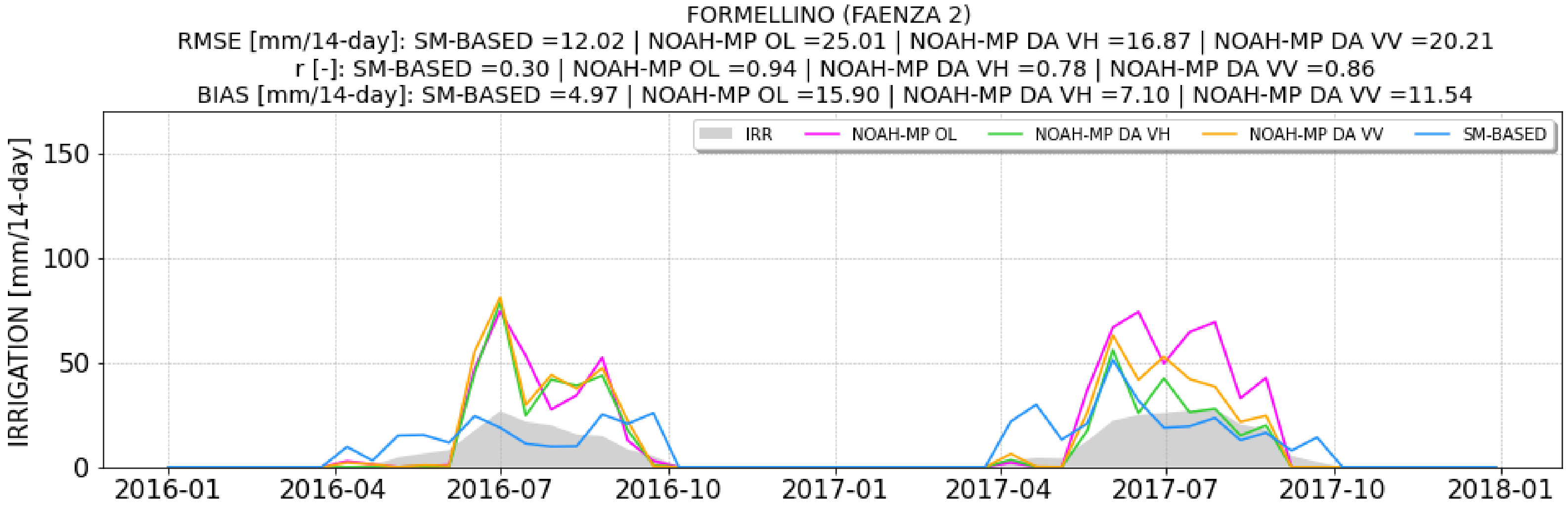
Comparison of irrigation quantification approaches

Faenza





SM-based approach VS **NOAH-MP OL** VS **NOAH-MP DA VH** VS **NOAH-MP DA VV**

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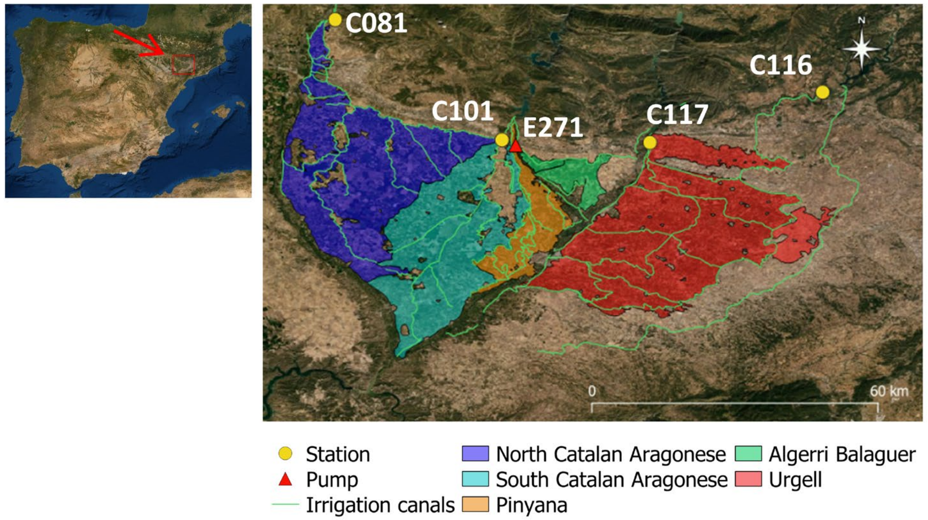
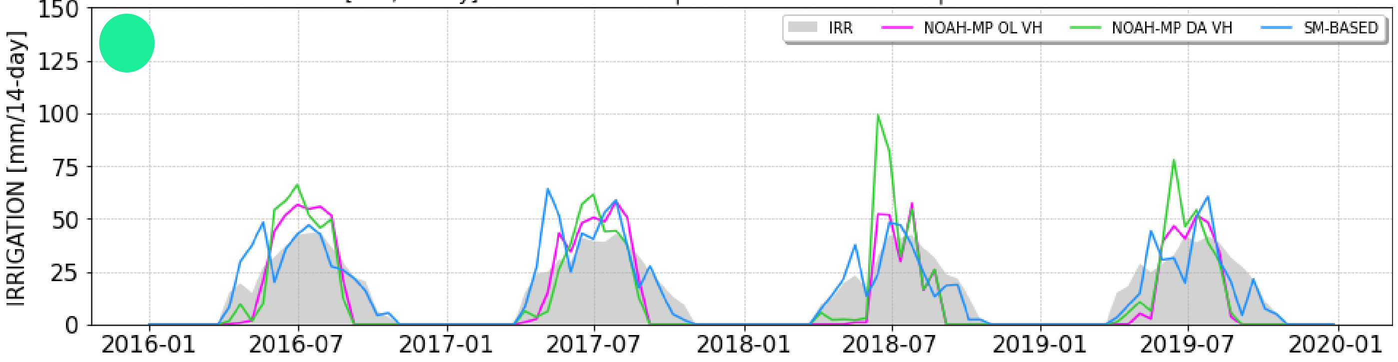
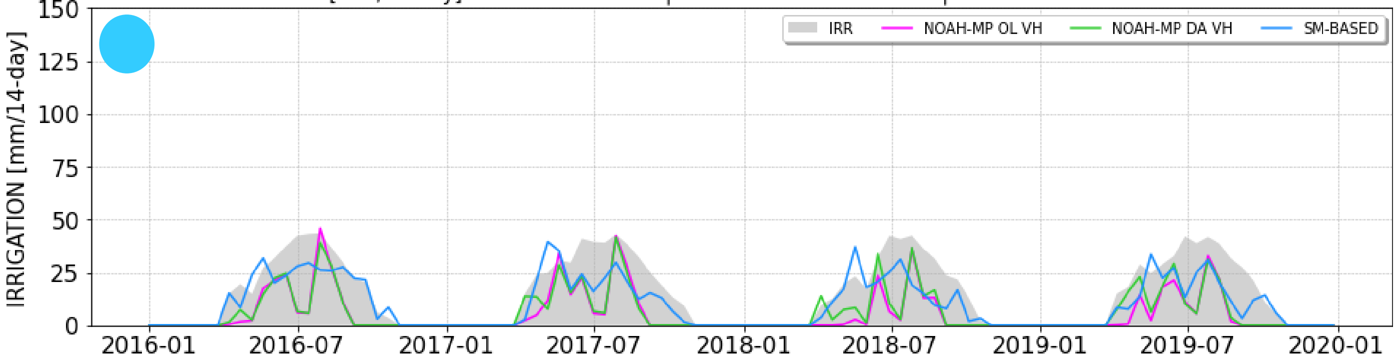
Comparison of irrigation quantification approaches



ALGERRI BALAGUER
RMSE [mm/14-day]: SM-BASED =16.37 | NOAH-MP OL VH =20.29 | NOAH-MP DA VH =25.54
r [-]: SM-BASED =0.48 | NOAH-MP OL VH =0.52 | NOAH-MP DA VH =0.34
BIAS [mm/14-day]: SM-BASED =0.14 | NOAH-MP OL VH =-4.87 | NOAH-MP DA VH =-3.12



SOUTH CATALAN ARAGONESE
RMSE [mm/14-day]: SM-BASED =12.85 | NOAH-MP OL VH =19.59 | NOAH-MP DA VH =18.48
r [-]: SM-BASED =0.61 | NOAH-MP OL VH =0.66 | NOAH-MP DA VH =0.60
BIAS [mm/14-day]: SM-BASED =-8.54 | NOAH-MP OL VH =-16.98 | NOAH-MP DA VH =-15.32



SM-based approach VS NOAH-MP OL VH VS NOAH-MP DA VH

Conclusions

- The assimilation of the Sentinel-1 backscatter generally highly reduces the $BIAS$ but deteriorates the r.
- The SM-based inversion approach satisfactorily reproduces irrigation amounts in terms of $RMSE$ and $BIAS$. Low r values can be explained by the seasonality of the benchmark.
- Over San Silvestro (Faenza 1) the DA approach outperforms the SM-based inversion algorithm.
- Over Formellino (Faenza 2) the results of the SM-based inversion approach, despite a quite low correlation, reproduce the benchmark irrigation amounts better than the DA approach.
- Over the Spanish test sites the SM-based approach outperforms the DA approach.
- The DA approach is strongly affected by the parameterization of the irrigation scheme (which alone produces high over- or underestimation of irrigation), LSM input and the spatial scale of the test site.

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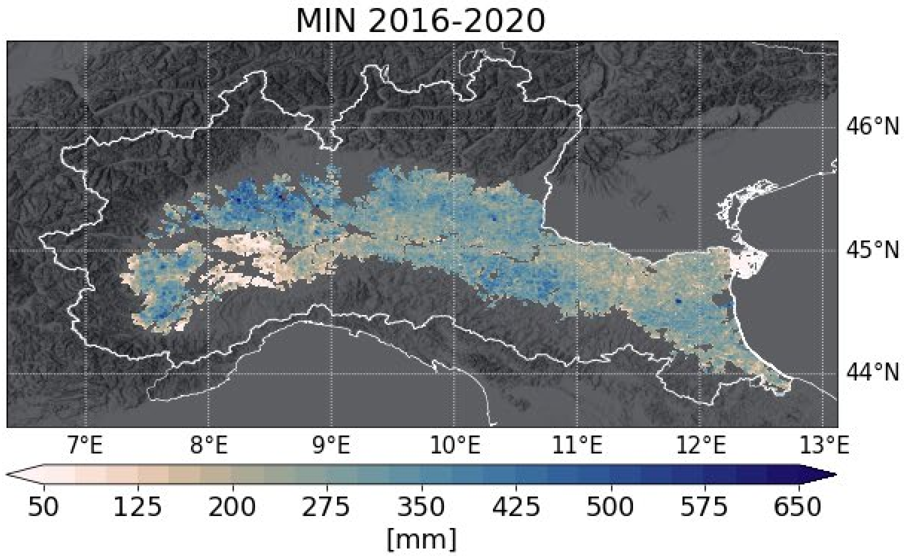
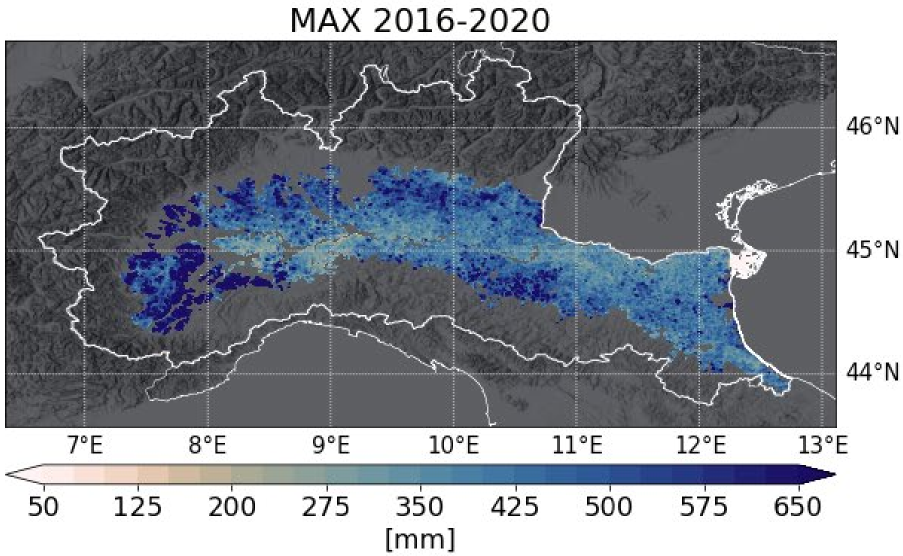
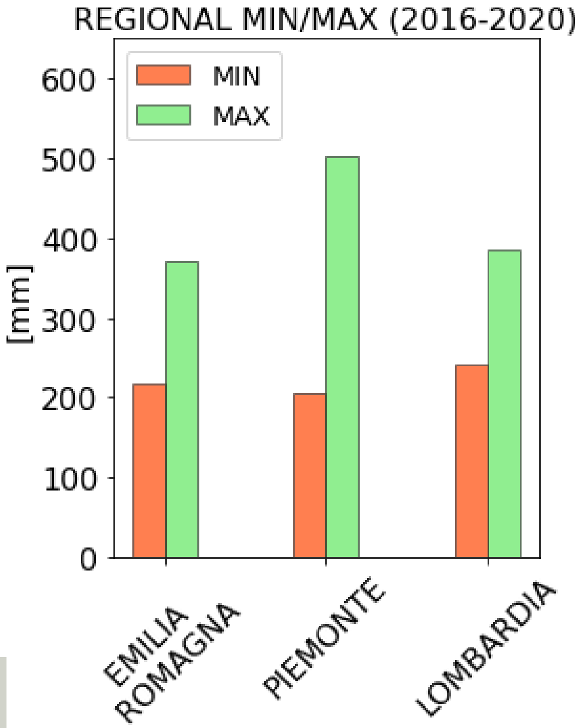
Future perspectives

Satellite-derived irrigation products can be the basis for developing operational services aimed at forecasting the agricultural water demand and rationally managing water resources in agriculture.







https://www.4dmed-hydrology.org/

Poster "4DMED-Hydrology: capitalizing high resolution Earth Observation data for a consistent reconstruction of the Mediterranean terrestrial water cycle" by Massari et al.

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…but there is a number of challenges to be still addressed!

SM-based inversion approach

- Need for products with spatial and temporal resolution matching with irrigation occurrence;
- reduction of the bias over non-irrigated areas and false irrigation alarms in winter;
- inclusion of higher resolution ET data (e.g., GLEAM 1 km).

Model-based approach

- Calibration of the irrigation scheme (avoiding large over-underestimation);
- improvement of LSM inputs (i.e., including dynamic crop maps);
- more sophisticated backscatter operators (i.e., machine learning).

https://esairrigationplus.org/

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