Validation of Satellite-Derived Soil Moisture Products Using Ground Observations in Southern Europe

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A) Introduction / Research Motivation

Soil Moisture (SM) is a key hydrological variable that connects Earth's surface and atmospheric processes [1], indicating the water content within a specified soil layer.

A comprehensive understanding of SM status and dynamics is crucial for numerous **meteorological, climatological, and hydrological applications**. It also enhances our knowledge of **water, energy and carbon cycles** and aids in predicting **extreme climatic events** [1]. Consequently, exhaustive global monitoring of this parameter is required with reasonable temporal and spatial resolutions.

In this context, the present work aims to **validate** various **satellite products** using **field observations** in order to asses the accuracy and reliability of **near-surface SM** ($\sim 1 < z \leq 10$ cm) data provided by different spaceborne sensors.

Acknowledgements

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B) Materials and Methods

Our study focused on the **northeast of the Iberian Peninsula** and the **south of France** over a **7-year period** (from January 2015 to December 2021).

- **Ground data: 30 stations** of the **ISMN** (International Soil Moisture Network) *in situ* database [2].
- **Satellite data:** four microwave sensors, both passive and active, i.e., **ASCAT** (Advanced Scatterometer) [3], **SMOS** (Soil Moisture and Ocean Salinity) [4], **SMAP** (Soil Moisture Active Passive) [5], and **CCI** (Climate Change Initiative) [6].

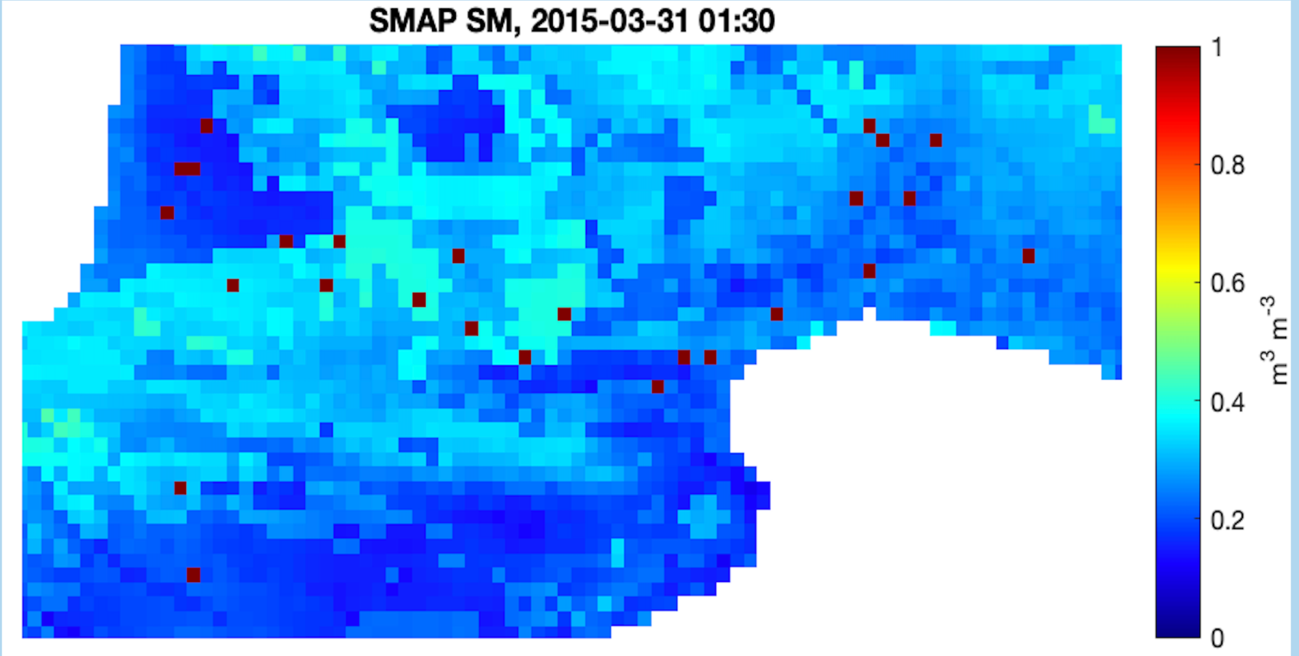

Figure 1. SMAP SM image over the ROI, with *in situ* stations in dark red

The followed **methodology** is outlined below.

i. **Satellite products processing**: image cropping to the ROI, application of Quality Flags (QF), time format standardization (dd-mm-yyyy hh:mm UTC), and extraction of variables for pixels matching field station locations.

ii. ***In situ* data processing**: QF application, averaging SM measurements located within the same pixel as the satellite images, and averaging SM measurements within the satellite data acquisition periods.

C) Results

After the download and processing of the satellite images and field observations, a rigorous **validation** method was applied, which primarily involved various statistical parameters, scatter plots, and linear fits between both time series.

Table 1. Linear fit parameters between *in situ* and satellite SM

Satellite	ASCAT	SMOS	SMAP	CCI
Slope	1.166 ± 0.006	0.437 ± 0.004	0.831 ± 0.001	0.956 ± 0.007
Intercept (m^3m^{-3})*	- 0.334 ± 0.004	0.1320 ± 0.0007	0.0221 ± 0.0003	- 0.071 ± 0.002
R	0.72	0.42	0.72	0.54

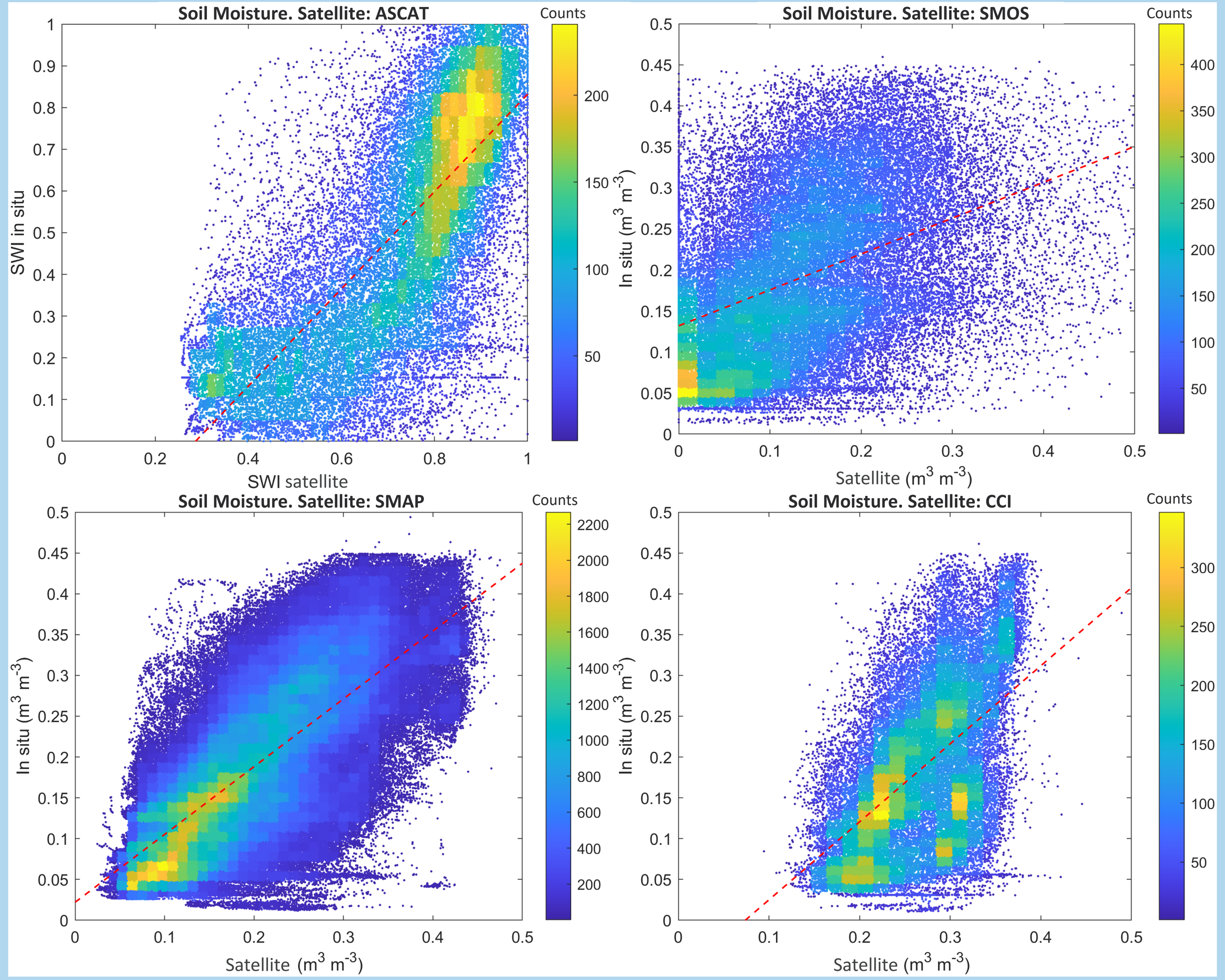

Figure 2. Scatter plots between *in situ* and satellite SM

Table 2. Validation statistics between *in situ* and satellite SM

Satellite	ASCAT	SMOS	SMAP	CCI
ME (m^3m^{-3})*	- 0.22	0.05	- 0.01	- 0.08
SD (m^3m^{-3})*	0.21	0.11	0.07	0.08
RMSE (m^3m^{-3})*	0.30	0.12	0.07	0.12
N. events	37606	49029	398185	41141

*Adimensional (Soil Water Index, SWI) for ASCAT

D) Discussion and Conclusions

- **SMAP** mission offers the **highest consistency and accuracy** (with an intercept close to the origin, a near-unity slope, R = 0.72, and RMSE = 0.07 m^3m^{-3}), **followed by the CCI**.
- In contrast, **ASCAT** and **SMOS** exhibit the **greatest uncertainties** and the **lowest correlation coefficients**, respectively.
- Despite significant efforts of the scientific community in global SM monitoring, further research is needed to **achieve field precision with satellite measurements**.

References

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