

On the Importance of Studying Data Gaps in Satellite Soil Moisture Registries

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Abstract

Important progress has been made in recent years in characterizing surface soil moisture (SSM) at regional scales, through remote sensing estimates and the implementation of new in situ networks. Each of these sources of information has intrinsic features, such as the dynamic range of the SSM and the temporal frequency of acquisition. Another relevant factor is the period of data availability. Improving the knowledge of the limitations and biases of these features is crucial to increase the potential and the consistency of data sources validations. As a case of study we considered an agricultural area in the Argentinean Pampas, characterized by a sub-humid climate with a marked seasonal dynamic. It also holds a synchronized cropping rhythm and is subject to flooding and waterlogging that can last from days to months. The features mentioned above and considering that the region is almost devoid of irrigation, offer a natural laboratory that is distinguished by a wide dynamic range of SSM conditions. In this context, we analyze and expose different sources of SSM data gaps over long periods of time, using information from in situ stations and from the SMOS and SMAP satellite systems, during 2015-2019. We found SMAP data gaps resulting from the filtering of high SSM signals that are not spurious but typical for this flood-prone region. Reports from national institutions and comparison with other data sources allowed us to identify that high soil water content in the same period in which the data gaps occurred. In a different way, the SMOS register has a low-frequency range of data due to radio frequency interference over the study area. This data gap occurs during a long-anomalously wet period and it is relevant to take it into account when analyzing SMOS data for the full period. Our study shows the importance of using multiple sources of information and the relevance of examining the availability of data.

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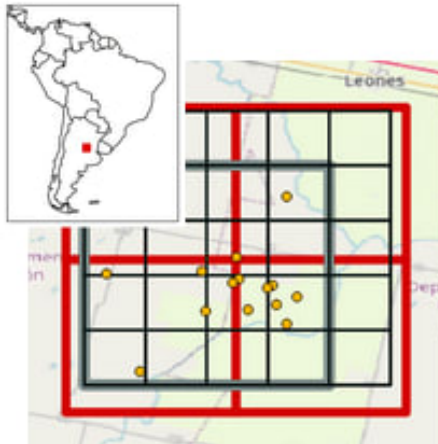
I- BACKGROUND

Soil water storage plays a key role in hydrological processes in ecosystems and regulates water and energy exchanges between the surface and the atmosphere. Each soil moisture (SM) database, e.g., in situ sensors or satellite missions, has intrinsic characteristics, such as the dynamic range of SM and the temporal frequency of acquisition. Another relevant characteristic is the period of data availability.

Data gaps in SM sources are often ignored, for example, when calculating representative statistical values, which can distort the results. The above led us to ask: What could be the underlying causes of prolonged periods of SM data gaps? What information do these data gaps report?

II- STUDY SITE, MATERIALS AND METHODS

Figure 1. Study domain and distribution of information sources: **in situ sites** (14), **SMOS25** grids (4 grids), **SMAP36** (1), and **SMAP9** (25).



The study site is located in the southeast of the Córdoba province within the **Argentinean Pampean Plains** (Fig. 1). It is a flat sedimentary region with stagnant hydrological systems and shallow groundwater. It is also homogeneous in terms of land types and land use, without irrigation and drainage canals. The study period covers **April 2015–November 2019**.

This work focuses on **SM at the surface layer** (top ~5 cm). We examined **SM from in situ stations and satellite systems**. The satellite data is from the Soil Moisture and Ocean Salinity (**SMOS**, 25 km resolution) and the Soil Moisture Active Passive (**SMAP**, 9 and 36 km resolution) satellite missions. For each source of information, a SM time series was calculated through daily averages over the in situ sites and the satellite grids.

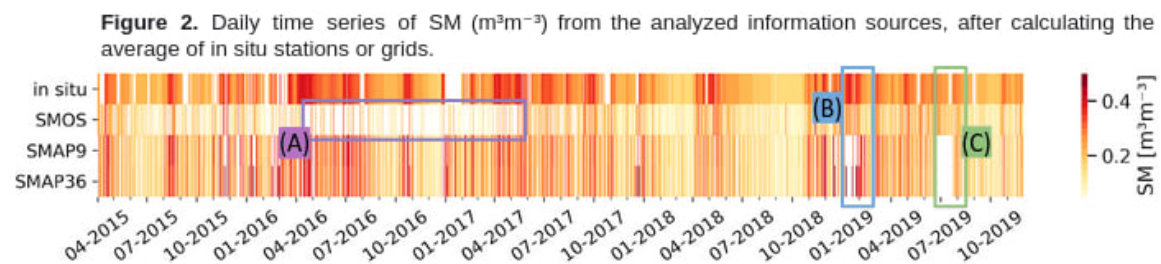


Fig. 2 shows that SMOS has a lower data frequency from March 2016 to May 2017 (A). SMAP has two long data gaps: one in January 2019 (B), followed by the period from 20 June 2019 to 23 July 2019 (C).

III- SOURCES OF SM DATA GAPS

Data frequency in SMOS is lower for over one year. SMOS is sensitive to radio-frequency interference (RFI), so we examined the RFI probability product. The amount of SMOS SM data for the data gap period is 71.75 % (Fig. 3a) and 94.54 % for the rest of the period (Fig. 3b). For these same intervals, the RFI probability is 0.33 and 0.07 (Figs. 3c and 3d). This indicates that **the low number of SM SMOS data during March 2016-May 2017 is due to RFI over the study area. This data gap can't be used as information, but since it occurs during a long-anomalously wet period** (see Fig. 2, in situ and SMAP data), **it is relevant to take it into account when analyzing SMOS data for the full period.**

Figure 3. Percentage (%) of the amount of SM SMOS data available in the period March 2016 - May 2017 (a) and 2015 - 2019 without March 2016 - May 2017 (b). (c) and (d) correspond to the probability of RFI SMOS in the period March 2016 - May 2017 and in 2015 - 2019 without March 2016 - May 2017.

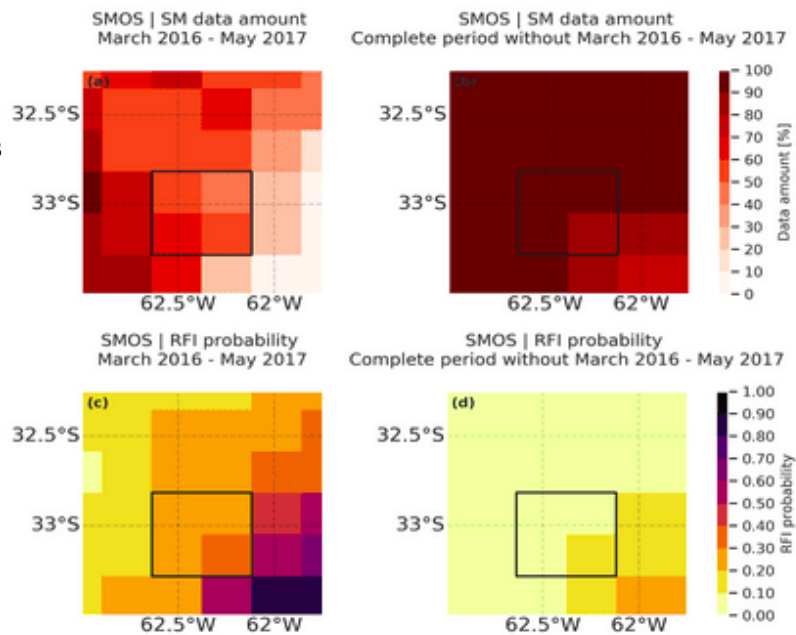
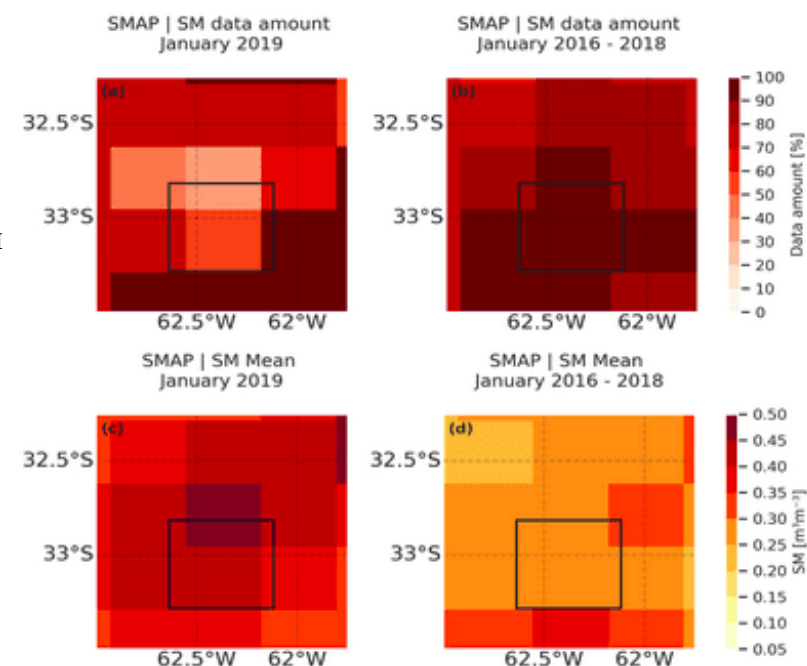


Fig. 4 shows the data gap of SMAP in January 2019. According to the metadata, the dynamic range of SMAP has a maximum of $0.50 \text{ m}^3\text{m}^{-3}$, so values greater than this threshold were removed. The analysis of unfiltered data reveals that there is no gap in January 2019. Examining **this case made it possible to identify the response of the SMAP36 system to high and long-lasting water content in soil, which generates values of SM that exceed the valid limits. This SMAP data gap resulted from the filtering of high SM signals that are not spurious but typical for this flood-prone region, and it is an example of a data gap that contains information about very wet soil.** The other SMAP data gap, 20 June 2019–23 July 2019, is due to a shutdown of all SMAP instruments during this period (<https://nsidc.org/data/smap/news>).

Figure 4. (a) and (b) show the percentage amount of SM SMAP36 data (%) available in the period January 2019 and January 2016 - 2018. (c) and (d) correspond to the mean field SM SMAP36 (m^3m^{-3}) in the period January 2019 and January 2016 - 2018.



IV- SUMMARY

This work shows that long SM data gaps can be due to several reasons, using information from in situ sensors and from the SMOS and SMAP satellite systems. In addition, data gaps that are often ignored contain useful information about the state of the study site, such as signal values. For example, they may help to identify extreme events such as floods. Our study shows the importance of using multiple sources of information and the relevance of examining the availability of data.



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