ESA CCI Soil Moisture: Current Status and Future Direction

The ESA CCI soil moisture product (esa-soilmoisture-cci.org) is a multi-decadal global satellite observed soil moisture dataset combining various single-sensor active (scatterometric) and passive (radiometric) microwave soil moisture data sets into three products: ACTIVE, PASSIVE and COMBINED (Fig. 1). The products are continually updated with new scientific advancements.

1. ESA CCI Soil Moisture - current status

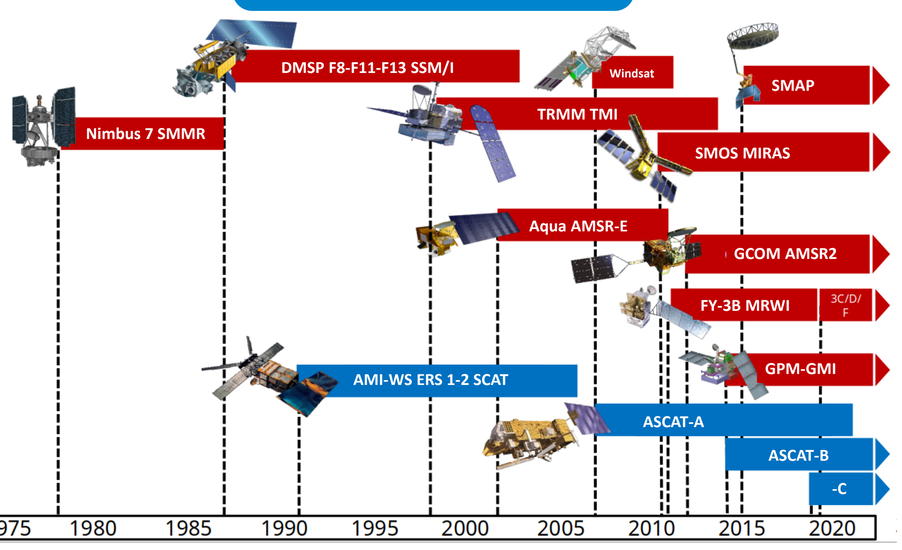


Figure 1: Timelines of the satellite products used in all products; active sensors are represented in blue, passive in red.

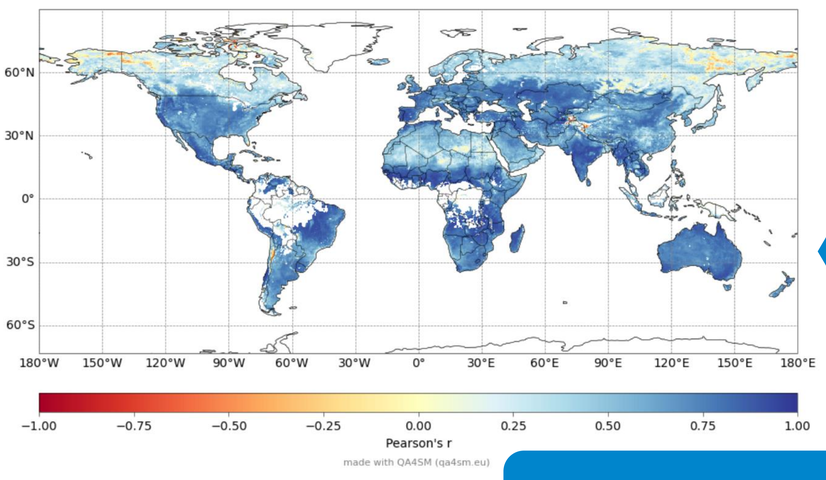


Figure 2: Correlation of the gridded soil moisture COMBINED v06.1 product with the ERA5-Land reanalysis data (created with QA4SM.eu)

Customized validations of the CCI products, for instance against in-situ measurements from the International Soil Moisture Network (ISMN; ismn.geo.tuwien.ac.at Dorigo et al., in review) or modelled ERA5-Land data (Fig. 2), can be freely performed through the qa4sm.eu platform (qa4sm.eu).

2. Data Processing and Quality Assurance

The COMBINED product offers the best predictive skill against in-situ data, and consistently improving at each new product version (Fig. 3).

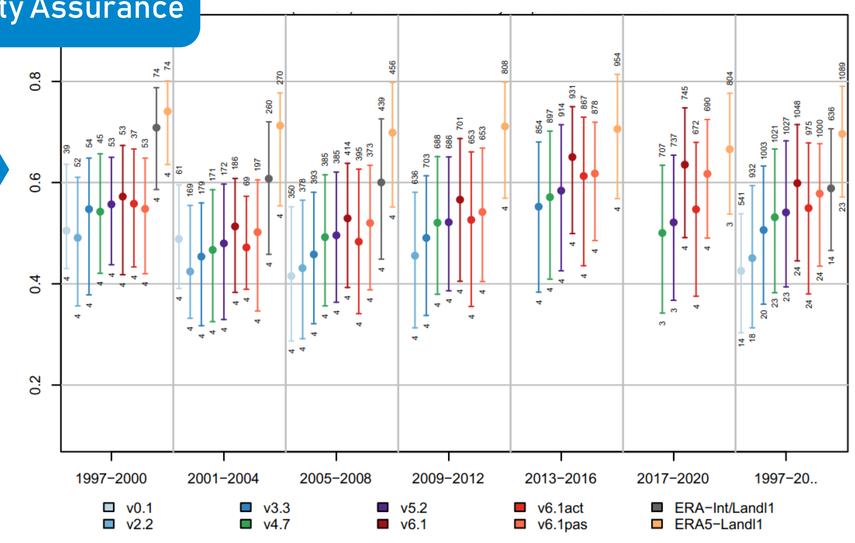


Figure 3: Correlation of the gridded soil moisture products as compared to in-situ station observations in 5 and 10 cm depth for the full year for the US. Subdivided in consecutive 4-year periods (1997-2000, 2001-2004, 2005-2008, 2009-2012, 2013-2016 and 2017-2020) as well as for the longest period data available. The number of considered stations and years are indicated (resp. above and below the bars).

- 12000+ registered data users
- Over 128 publications in 2020 included CCI Soil Moisture data!
- Data used in the BAMS as well as the European State of the Climate reports each year (Fig. 4)

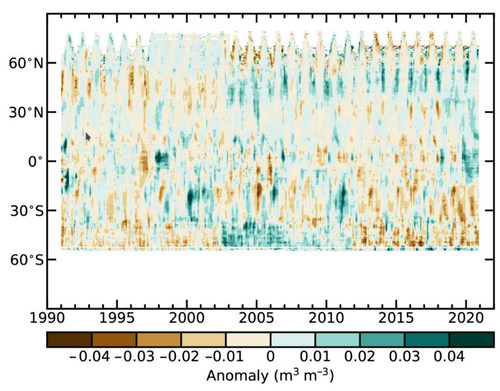


Figure 4: Time–latitude diagram of surface soil moisture anomalies (m3 m−3) with base period 1991–2010, after retrieval and quality masking. Reproduced from van der Schalie et al. (2021).

3. Outreach

Copernicus Europe's eyes on Earth

Climate Change Service climate.copernicus.eu

ESA CCI SM is also available as an operational product in near real time via the Copernicus Climate Change Service (C3S) Data Store (cds.climate.copernicus.eu).

4. Research & Development

V07 product outlook

- Inclusion of day time observations with the goal to produce a sub-daily product (Fig. 5)
- Improved flagging of bare soils (Fig. 6)

Ongoing research and future direction

- Improved precipitation filtering
- Independency from land surface model used as scaling reference
- Towards a gap-free product
- Increased spatial resolution to 0.10° with operational focus
- Inclusion of new sensors: CIMR, FENYUN 3E, AMSR3…
- Improved uncertainty estimates
- And much more…

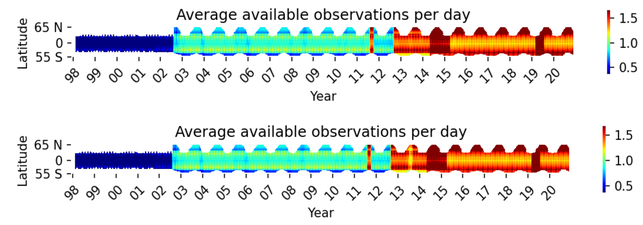


Figure 5: overview of the daily available observations considering ascending and descending satellite overpasses.

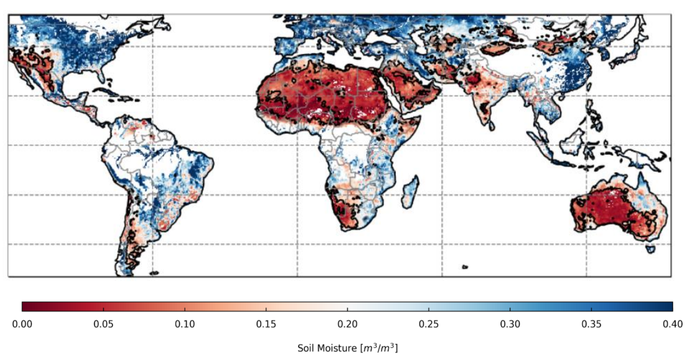


Figure 6: Flagging of barren ground conditions in ESA CCI PASSIVE based on a brightness temperature range.

5. Advancing research beyond CCI SM

As contract change notice (CCN) follow-up activity from ESA CCI SM two new products are in development: a global root zone soil moisture (RZSM) dataset and a high resolution soil moisture product from Sentinel data (HRSMS).

Root-zone CCI Soil Moisture

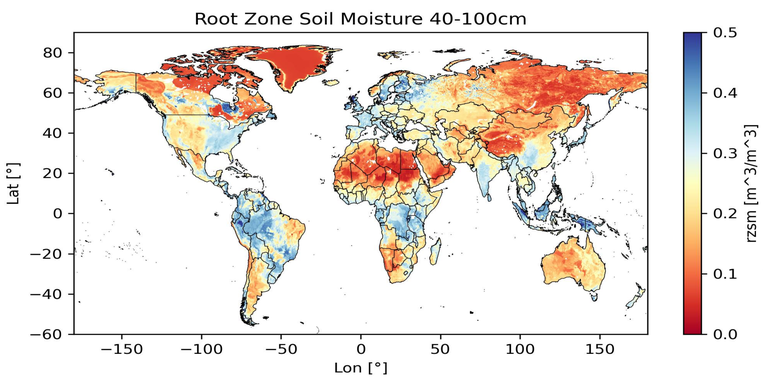
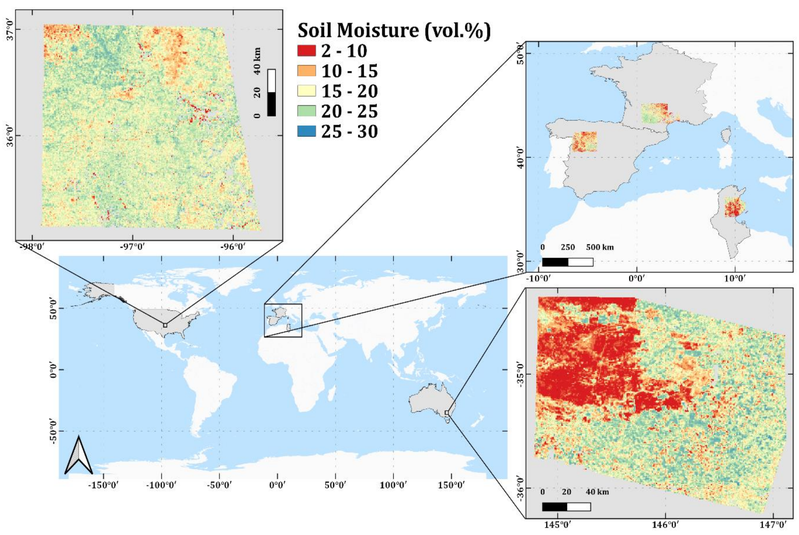


Figure 7: Root zone soil moisture as calculated by ISBA assimilating ESA CCI SM v6.1 and CGLS LAI v2 on 12 Dec 2019.

The RZSM product is generated by the assimilation of different satellite based datasets (ESA CCI SM, VODCA Vegetation Optical Depth (Moesinger et al. 2020), and Leaf Area Index from Copernicus Global Land Service) into the land surface models ISBA and Noah-MP. The initial conditions are obtained by several decades of spin up runs and ERA5 data is used as meteorological forcing. The resulting product provides global daily information for three soil layers (0-10cm, 10-40cm, and 40-100cm) from 2002-2019 (Fig. 7).

Figure 8: Test sites of the high resolution soil moisture product.



High Resolution CCI Soil Moisture

In the frame of the HRSMS it is aimed to develop an operational methodology based on the use of Sentinel data to estimate surface soil moisture at 1km resolution. Two approaches are tested for this purpose: 1. a radar signal inversion algorithm based on neural networks 2. a hybrid approach of artificial intelligence and a physically based model. The dataset will be produced for five regions on four Continents (Fig. 8) from 2017 to 2019 with a temporal repeatability of less than a week.

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