A new era of global soil moisture - release of ESA CCI SM v04.2

The ESA CCI Soil Moisture team is pleased to announce the latest product release, ESA CCI SM v04.2. This release is an advancement of the most comprehensive global time series of satellite based soil moisture.

ESA CCI SM v04.2 is a global soil moisture time series providing 35 years of data until December 2016. ESA CCI SM v04.2 is advancing the previous version by merging all active and passive L2 products directly to generate the COMBINED product (previously, the ACTIVE and PASSIVE products were created separately, and then merged). The illustration provides an overview of the three-step blending approach from original products to the final blended ACTIVE, PASSIVE, and COMBINED microwave soil moisture products (Illustration adapted from Liu et al. 2012 [D. Chung et al. 2018]).

Download ESA CCI SM v04.2 here: www.esa-soilmoisture-cci.org/dataregistration
In addition, to the advanced versions, v04.2 makes soil moisture uncertainties globally available for all sensors except SMMR, also showing spatial gaps in the triple collocation based Signal to Noise Ratio (SNR) estimates. They are now filled using a polynomial SNR-VOD regression. Lastly, unreliable retrievals are masked before the merging of Level 2 products. More information about merging active and passive soil moisture retrievals and the difference between advanced versions and the new ESA CCI SM v04.2 can be found in “The Algorithm Theoretical Baseline Document (ATBD), D2.1 Version 04.2” available from the ESA CCI soil moisture project website.

For more information please refer to: Algorithm Theoretical Baseline Document

Furthermore, a recent publication shows the 'Triple Collocation-Based Merging of Satellite Soil Moisture Retrievals'.

**ESA CCI SM at a glance**

The ESA CCI SM soil moisture dataset contributes to knowledge sharing, enabling critical evaluation.

The ESA CCI soil moisture dataset (ESA CCI SM) has become a well-established dataset within the scientific climate community. Temporal coverage, currently spanning over 35 years (1987-2016), and global spatial coverage have been identified by our users as the main features for choosing ESA CCI SM. The long temporal coverage is an essential prerequisite for robust trend assessments and the investigation of soil moisture drivers, while the spatial coverage has allowed for studies in previously data-poor regions, or regions where access to ground-based data is difficult. A new publication in Remote Sensing of Environment highlights the CCI soil moisture dataset and its applications more in detail.

Just as essential as the long temporal and global spatial coverage is the public access of the ESA CCI SM soil moisture dataset. Being publicly available allows for a critical and qualitative evaluation process of the data suitability and is therefore a central part within the ESA CCI project to enhance a progressive development of state of the art sensor data. In addition to the assessment process, the public availability of the data facilitates knowledge sharing and can contribute to the further development of the sensor data community.

The following overview shows key issues identified by our users. It includes the motivation for using the ESA CCI SM dataset and the main limitations identified.

**Motivation**
- Long temporal coverage
- Large spatial coverage
- Can function as an independent reference dataset
- Constraining errors in models
- Reduce uncertainties

**Limitations identified**
- Data gaps in time and space, especially prior to 1992
- Changing data quality and coverage over time
- No representation of root-zone soil moisture
- Evaluation of absolute values not possible
- Dependency on GLDAS-Noah as scaling reference

**The future**
- Higher spatial resolution, either by including observations with higher native resolution (e.g. SAR, thermal infrared) or by downscaling
- Filling of data gaps
- Improved temporal sampling
- Improved product accuracy
- Improved blending methods
- Improved temporal consistency
- Shorter latency times between data acquisition and data availability
- Independence of LSMs
- Creation of a root-zone soil moisture product
An in-depth look into the soil moisture user community

More than 4,700 users have registered for obtaining the ESA CCI SM soil moisture dataset over the past 6 years.

With more than 5 new user registrations per day since the beginning of this year, the upward trend in user registrations seems to continue and even enhance in 2018. The amount of user registrations has doubled since the beginning of 2018 compared to the amount of monthly registered users in the same time period last year. In general, distinct peaks in user registrations can be seen with each new data release, but this latest release has even enhanced the steady upward trend.

User communities

The climate community, for which this dataset was initially designed within the CCI, is still the largest user group.

However, an increasing number of scientific communities are applying for the ESA CCI SM surface soil moisture dataset, which indicates its wider scope and usage.

There is a steady increase in applications especially within the agriculture, ecosystems and water domain. Topics such as disasters, energy, weather and health are also increasingly mentioned in user applications.

The broad range of application areas highlights the acceptance of the dataset within the wider scientific community, as well as the maturity of the dataset.

Geographical distribution of the user community

Originally most users originated from Europe (v0.1). Over the past years the outreach of the ESA CCI SM soil moisture datasets has expanded and caught the attention of the global user community. Initially, with the first version, ESA CCI SM v0.1, 87 countries were represented. In 2018 users come from 113 different countries.

As the ESA CCI SM dataset has become more known there has been a strong increase in registered users, especially from Asia and North America.

In Europe most users are from the UK and Germany, followed by the Netherlands, France, Italy and Spain. In Asia, most users come from China and India, followed by Iran, Japan and South Korea.

The global interest in the ESA CCI SM dataset from all over the world shows that ESA CCI SM has come a long way and has become a well-established dataset globally.
ESA CCI soil moisture fields of application

The ESA CCI soil moisture dataset long temporal and global spatial coverage have been identified by our users as the main features for choosing ESA CCI SM.

Long temporal coverage is essential for robust trend and driver assessment, but can also be used for researching vegetation activity, investigating fire activity or the creation of a precipitation dataset, while global coverage allows investigations into areas where previously no observations were available. The long temporal and global spatial coverage also makes ESA CCI SM a prime candidate to function as a global independent reference for land surface model and reanalysis evaluations. The following studies exemplify fields of applications of the ESA CCI SM dataset.

Robust trend and driver assessments

ESA CCI SM has been featured in the Bulletin of the American Meteorological Society (BAMS) reports for 7 consecutive years. BAMS is the yearly returning authoritative summaries of the global climate, and are led by the US National Oceanic and Atmospheric Administration. The report features a global overview of recent and historical variations of climatological variables, and since 2010 includes soil moisture from the ESA CCI SM dataset for the chapter on global soil moisture (De Jeu et al. 2011; De Jeu et al. 2012; Dorigo et al. 2014; Dorigo et al. 2015a; Dorigo et al. 2016; Dorigo et al. 2017b; Parinussa et al. 2013). ESA CCI SM shows a strong similarity with related terrestrial water cycle components such as terrestrial water storage, precipitation, the self-calibrating PDSI, and terrestrial evaporation. In the figure we show the global soil moisture anomalies from the 1991-2014 baseline for 2015 (left) and 2016 (right).

ESA CCI SM included in the Copernicus Climate Data Store will improve latency – the case of Soil moisture anomalies in Italy

With the inclusion of ESA CCI SM in the ECMWF Copernicus Climate Data Store, part of the Copernicus Climate Change Services, an operational product with a latency of 10 days is foreseen. The latency time between data acquisition and data availability has been identified as a current limitation for embedding satellite derived soil moisture in operational services, for example drought monitoring and early warning systems. With the acceptance of ESA CCI SM to the Copernicus Climate Data Store a shortened latency allows for ESA CCI SM to be embedded in monitoring and operational services, e.g. for drought monitoring and flood forecasting. The now reduced latency will enable new applications for ESA CCI SM. E.g., recently Luca Brocca (from Italy’s Research Institute for Geo-Hydrological Protection of the National Research Council, IRPI-CNR) together with project partners used near real-time soil moisture data to monitor drought in Italy. The data were compiled by the ESA CCI SM project. They showed that in many regions August 2017 was exceptionally dry, similarly to the conditions of 2012.
User workshops

Two soil moisture workshops brought 110 scientists from 21 nations to Vienna

About 110 scientists from 21 nations participated to the ESA CCI Soil Moisture user workshop and the Soil Moisture Validation and Application Workshop held in Vienna from 18th to 20th September 2017. The aim was to share latest scientific insights in the retrieval, validation, and use of satellite-derived soil moisture.

The purpose of the Satellite Soil Moisture and Application Workshop was to discuss and reconcile recent methodological advances in the development, validation and application of global satellite soil moisture data. The workshop series is unique by bringing together satellite soil moisture users and developers to focus on both the derivation and exploration of soil moisture data from passive or active microwave satellite missions (SMAP, SMOS, ASCAT, AMRS-2, Sentinel-1, and other legacy missions). Following research questions were addressed during this workshop:

- What is the quality of the current satellite products and what can we expect in the near future?
- What is information content at Level 1 and how to exploit the availability of multiple satellites?
- Who is using satellite soil moisture data and for what purpose?
- What are the best practices in validating soil moisture products?
- What are the main limitations of satellite soil moisture data from a user’s perspective?
- What is the future of satellite-based soil moisture remote sensing?

The workshop follows up workshops held at the European Space Agency in Frascati (Italy, in 2013), at the Royal Netherlands Academy of Arts and Sciences in Amsterdam (Netherlands, in 2014) and at the Millenium Broadway Hotel in New York (USA, in 2016). The report from the 3rd workshop was published in the GEWEX News November 2016.

The CCI Soil Moisture User Workshop is similar in scope but particularly invites users of the CCI Soil Moisture products. Users from any relevant application area are invited to present their experiences with the data and provide ideas for future product improvements. The CCI Soil Moisture User Workshop is an event organized within the framework of ESA’s Climate Change Initiative (CCI).

Upcoming events

5th Satellite Soil Moisture and Application Workshop

24 to 25 October 2018 at George Mason University (Fairfax Campus), Washington DC

This workshop series is unique by centring attention on soil moisture applications. It brings together satellite and in situ soil moisture users as well as developers to focus on both the derivation and exploration of soil moisture data from both passive and active microwave satellite missions (SMAP, SMOS, ASCAT, AMRS-2, Sentinel-1, and other legacy missions) and electro-optical instruments (MODIS, VIIRS, Landsat et al.).

The 5th Satellite Soil Moisture and Application Workshop emphasizes especially on:

1. Climate and natural hazards,
2. Hydrological and agricultural applications,
3. Energy and ecosystem applications,
4. Innovations at the nexus of Food, Energy and Water System
5. Soil Moisture Demonstration Project (SMDP).
Recent science result

A drought event composite analysis


Within this recent article, the ESA CCI SM dataset was used to investigate land-vegetation-atmosphere dynamics at the global scale. With drought being a globally relevant hazard, they focus their study on quantifying the relationship between soil moisture drought and temperature, precipitation, evapotranspiration and various vegetation indices during the peak of the growing season.

Shown here are the results for the Western and Central US, from 4 weeks prior till 4 weeks after the drought peak (at t=0). At the peak of the soil moisture drought, daily maximum temperature (Tx) shows a clear positive anomaly for the grassland and shrub land areas, while evapotranspiration (ET) shows a negative anomaly. Precipitation (P) deficits are observed preceding the drought peak, with a return to normal directly after the peak, indicating P to be the driving factor of the drought. Vegetation (NDVI, FPAR and LAI) shows a delayed response to soil moisture drought, with largest anomalies for grassland areas. The delayed response is likely related to the fact that vegetation can access deeper layers which still contain plant-available water.

Regarding land cover, the weaker response to soil moisture drought for forests, in particular compared to grasslands, is likely related to the fact that forests can access deeper soil layers and are better able to save water during dry conditions. In contrast the strong response in grasslands to soil moisture drought indicates the relevance of water availability in the top layer for grasslands.

These results illustrate the importance of ESA CCI SM as a new independent observation for studying land-vegetation-atmosphere dynamics at the global scale. Allowing for unprecedented drought-monitoring capabilities, as well as for the development of drought management and mitigation strategies.