ESA CCI Soil Moisture: Current Status and Future Direction

European Space Agency

1 ESA CCI Soil Moisture

The ESA CCI soil moisture product (http://www.esa-soilmoisture-cci.org) is a multi-decadal global satellite observed soil moisture dataset. The product combines various single-sensor active and passive microwave soil moisture products into three harmonised products: ACTIVE, PASSIVE and COMBINED. Since the start of the ESA CCI, five versions of the product have been produced.

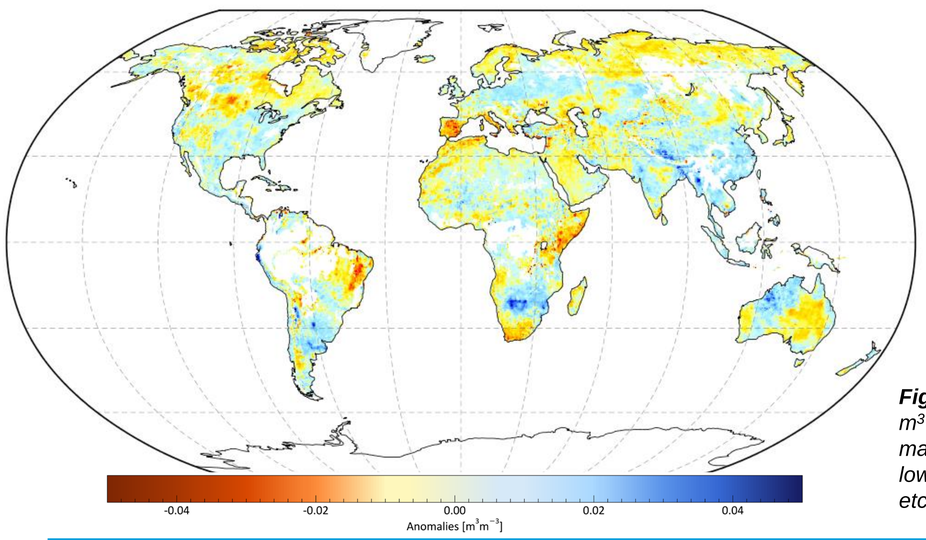


Figure 1: *Average ESA CCI SM anomalies (in $m^3 m^{-3}$) for 2017 (base period: 1991-2016. Data masked where retrievals are not possible or of low quality (dense forests, frozen soil, snow, ice, etc.). From: Dorigo et al. (2018).*

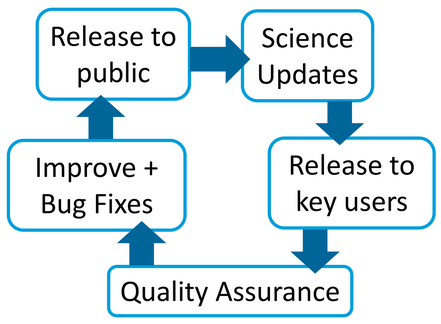


Figure 2: *Development cycle of the ESA CCI SM product. Development cycle lasts approx. 1 year.*

The ESA CCI SM product is continually updated with new scientific advancements and improvements to the processing scheme. The release cycle lasts one year, and goes through several stages,.

2 User Community and Engagement

- 4,600 registered data users
- Dedicated website continuously maintained with data accessed through FTP
- Newsletters provided summarising scientific advancements and applications
- > 100 scientific peer-reviewed articles have been published citing the use of the dataset
- Dataset utilised in the high profile BAMS State of the Climate report each year
- Continuous outreach undertaken including workshops, TV interviews, news articles, etc.
- Technical and scientific support provided to users

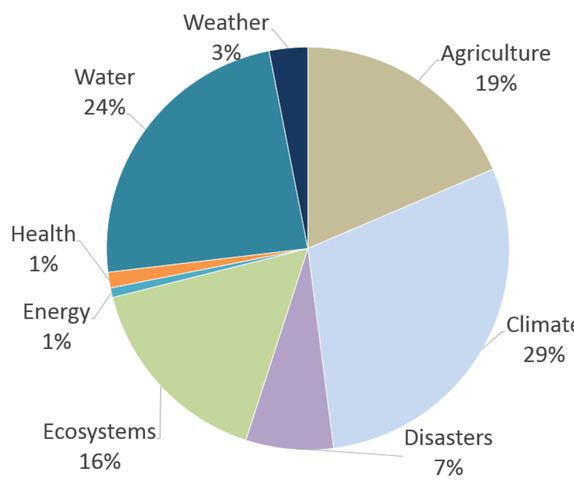


Figure 3: *Applications in which the dataset is intended to be used as declared by users.*

3 Data Processing and Quality Assurance

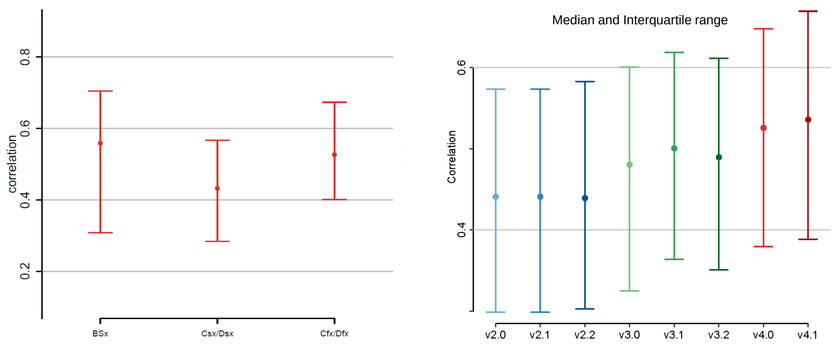


Figure 4: *Comparison of ESA CCI SM COMBINED product against in-situ observations from the ISMN **(left)** for v03.2 for different climate classes (based on the Köppen Geiger classification) and **(right)** for several publically released versions of the dataset to show evolution over time.*

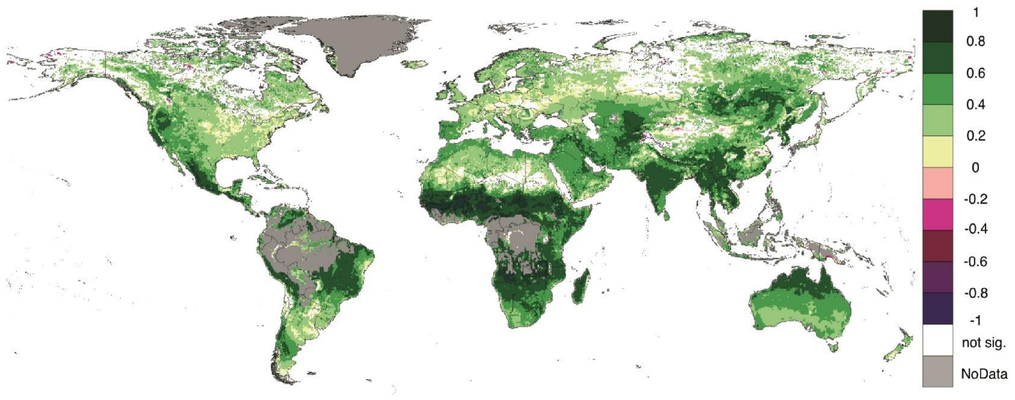


Figure 5: *Pearson correlation over the period 1997-2013 of ESA CCI SM COMBINED v03,2 soil moisture and GPCP 1DD precipitation. White areas indicate where correlations are not significant (p > 0,05). From: Dorigo et al. (2017)*

The ESA CCI SM product is generated through the inclusion of Level 2 soil moisture products for passive and active sensors, which are spatially and temporally resampled to 0.25 degrees and 00:00 UTC. These datasets are then scaled (if required) to ensure they are within the same range as one another. Triple collocation is then used to provide weightings for the blending / merging process.

In addition to daily images provided to the user, other products are generated including both monthly and yearly anomaly products and monthly averages. These products are used as input to climate studies and model inter-comparison activities.

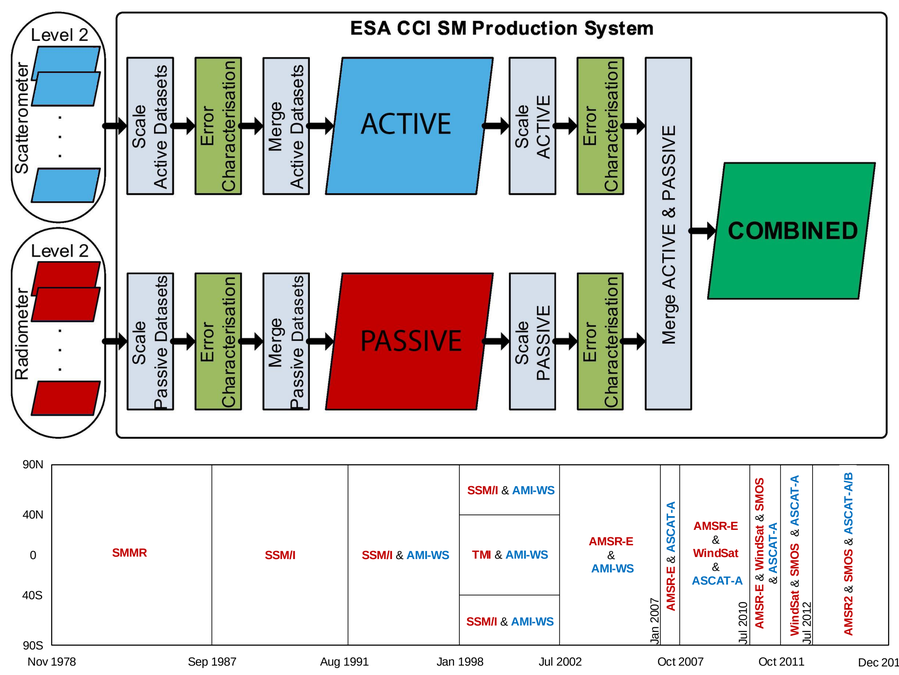


Figure 6: *Processing scheme **(above)** and sensor time periods **(below)** used in the generation of the ESA CCI SM product. Passive sensors are in red, active sensors in blue.*

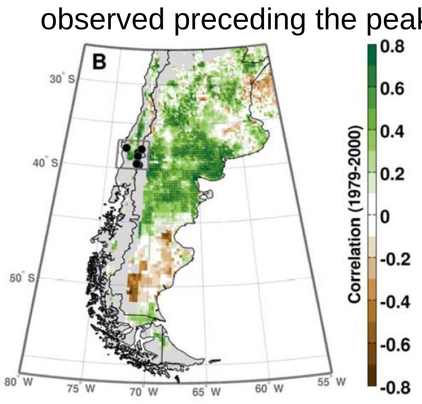
The product is compared against in-situ, globally distributed observations from the International Soil Moisture Network (ISMN) (https://ismn.geo.tuwien.ac.at) (Dorigo et al. (2011)). The ISMN data is provided with a series of ancillary fields, including land cover and climate classes, which allow assessment of the performance of the product under different conditions.

The product is also compared against ERA-Land (Balsamo et al. (2015)) to allow a global assessment as well as products of other related variables.

4 Climate Assessment

Two examples of use of the data in climate studies are presented here; for a comprehensive overview, see Dorigo et al. (2017).

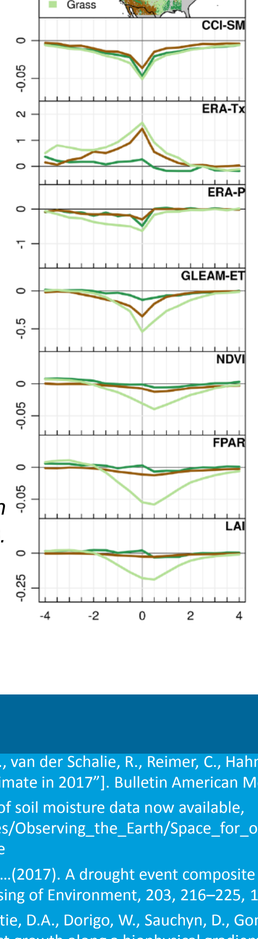
Nicolai-Shaw et al. (2017) used the data to quantify the relationship between anomalies of soil moisture drought and temperature (T), precipitation (P), evapotranspiration (ET) and vegetation indices. The results, 4 weeks before and after a drought (at t = 0), show a clear +ve anomaly for T while ET shows a –ve anomaly; P deficits are observed preceding the peak, indicating P to be the driving factor,



Muñoz et al. (2014) showed that temporal variations in tree growth are largely driven by soil moisture variability through comparing the two between 1979-2000 for the summer months.

Figure 8 (right): *Drought composite analysis in western and central US. From: Nicolai-Shaw et al. (2017).*

Figure 7 (left): *Correlation of the first Empirical Orthogonal Function (EOF) of six updated tree ring chronologies and summer soil moisture variability. From: Muñoz et al. (2014).*



5 Future Plans

The ESA CCI product will be included in the ECMWF Copernicus Climate Change Service (C3S) Data Store (https://climate.copernicus.eu/) as an operational product with a latency of 10 days. Such a reduced latency will enable new applications for ESA CCI SM including inclusion in drought monitoring, flood forecasting and early warning systems.

Several potential improvements to the product have been identified for future version, including:

- Higher spatial resolution (0.1°), either by including observations with higher native resolution (e.g. SAR, thermal infrared) or by downscaling
- Inclusion of new sensors: SMAP, MetOp-C and Sentinel-1
- Increased temporal (sub-daily) resolution
- Creation of a root-zone soil moisture product
- Independency of Land Surface Models (LSMs) by using L-band climatology as scaling reference
- More comprehensive quality assurance procedures

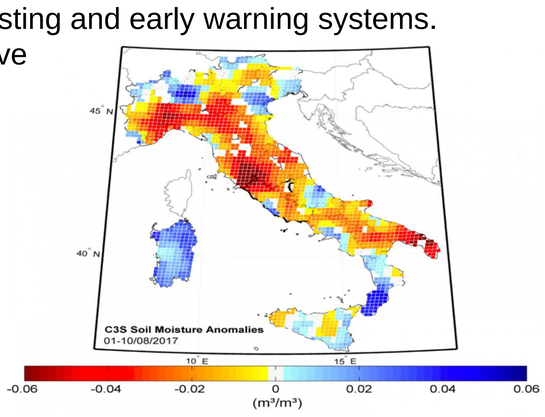


Figure 9: *The operational C3S product has been recently used to monitor drought in Italy. The data shows that many regions of Italy were exceptionally dry, showing similar conditions to the 2012. From: ESA (2017)*

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