ESA's Soil Moisture and Ocean Salinity (SMOS) mission provides global measurements of L-band brightness temperatures, resulting in soil moisture and ocean salinity data sets from space. The mission objectives are: (1) To provide global volumetric soil moisture estimates with an accuracy of 0.04 m$^3$m$^{-3}$ at a spatial resolution of 35-50 km and a temporal sampling of 1-3 days and (2) To provide global ocean salinity estimates with an accuracy of 0.1 practical salinity scale units for a 10-30 day average for an open ocean area of 200 x 200 km$^2$, and (3) to provide daily sea ice thickness estimates based on MIRAS observations for the Northern hemisphere with a spatial resolution of a 10,000 km$^2$ up to maximum values of 50 cm. SMOS observations additionally provide valuable information on vegetation and snow covered surfaces.

The payload of SMOS consists of the Microwave Imaging Radiometer using Aperture Synthesis (MIRAS) instrument, a passive microwave 2-D interferometric radiometer, operating in L-band (1.413 GHz, 21 cm) within a protected wavelength/frequency band. The SMOS mission is based on a sun-synchronous orbit (dusk-dawn 6am/6pm). SMOS measurements are made over a range of incidence angles (0 to 55°) across a swath of approximately 1000 km with a spatial resolution of 35 to 50 km. MIRAS can provide measurements in dual and full polarisation, with the latter being its present operating mode.
BRIGHTNESS TEMPERATURE DATA PRODUCTS

Level 1B Brightness Temperature product:
Output of the image reconstruction of the SMOS observation measurements and consisting of the Fourier components of brightness temperatures in the antenna polarisation reference frame. The latency of the products is 6-8 hours.

Level 1C Brightness Temperature product:
Multi-incidence angle brightness temperatures at the top of the atmosphere, geolocated in an equal-area grid system. Separate datasets are available for sea and for land pixels. Information is available per pixel and per snapshot. For each Level 1C product there is also a browse product containing the brightness temperatures averaged for an incidence angle of 42.5°. The latency of the products is 6-8 hours.

Spatial resolution of grid: 15 km (ISEA 4H9 grid)
Provider: ESA
Data format: EEF
Data portal: https://earth.esa.int/web/guest/-/how-to-obtain-data-7329

Brightness Temperature products in near-real time (NRT):
Brightness temperature data similar to the L1C product but adjusted to requirements of operational meteorological agencies. Data are available within three hours from sensing, as two different products:

The full NRT product contains multi-angular brightness temperatures at the top of the atmosphere (antenna reference frame). The data are geo-located in an equal-area grid system (15 km ISEA 4H9), with reduced spatial resolution over the ocean (30 km ISEA 4H8 grid). The data volume is ~ 300 MB/orbit.

The NRT light product contains multi-angular brightness temperatures at the top of the atmosphere. However, this product consists of land pixels only and is geo-located on a N256 Gaussian grid with a spatial resolution in the range of 30-50 km. The data volume is ~ 30 MB/orbit.

Spatial resolution of grid: depends on product, see above
Provider: ESA
Data format (both): BUFR
Data portals:
- Full NRT BUFR products are available from ESA directly: please send a request to the SMOS Mission Manager for authorization.
- NRT Light BUFR products are available via the following routes:
  1. EUMETCast Europe: access to ESA registered users will be granted by the EUMETSAT User Service Helpdesk, after registration on the EUMETSAT Earth Observation Portal (https://eoportal.eumetsat.int);
  2. WMO GTS: please send a request to the SMOS Mission Manager (Susanne.Mecklenburg@esa.int) for authorisation.
More information at https://earth.esa.int/web/guest/-/how-to-obtain-data-7329

Level 3 Brightness Temperature product:
Daily, global-coverage product which includes all brightness temperatures acquired on a particular day, transformed from the antenna frame (ESA L1B) to ground polarisation reference frame, binned and averaged into fixed angle classes. Ascending and descending orbits are processed separately, and only in full polarisation.

Spatial resolution of grid: ~25 km (EASE grid version 2)
Provider: CATDS-CPDC
Data format: NetCDF
Data portal: http://www.catds.fr/Products/Available-products-from-CPDC
Level 2 Soil Moisture, Vegetation Optical Depth and ancillary land products:

Contain the retrieved swath-based soil moisture, vegetation optical depth and other ancillary data derived during processing (surface temperature, roughness parameter, dielectric constant and brightness temperature retrieved at top of atmosphere and at surface) with their corresponding uncertainties. The latency of the products is 8-12 hours.

Spatial resolution of grid: 15 km [ISEA 4H9 grid]
Provider: ESA
Data format: EEF
Data portal: https://earth.esa.int/web/guest/-/how-to-obtain-data-7329

Soil Moisture product in near-real time *(available from summer 2015 onwards)*:

The NRT soil moisture product is comparable to the Level 2 soil moisture product. It has been produced through a statistical algorithm, i.e. a Neural Net, which was trained with SMOS L2 soil moisture data. It is provided on the ISEA 4H9 grid for a slightly reduced swath width within three hours from sensing. The data volume will be below 5 MB/orbit.

Spatial resolution of grid: 15 km (ISEA 4H9 grid)
Provider: ESA
Data format: NetCDF
Data portal: Dissemination planned through EUMETCast and GTS, details TBC on https://earth.esa.int/web/guest/-/how-to-obtain-data-7329

Level 3 Soil moisture, vegetation optical depth and other land data products are available from the Centre Aval de Traitement des Données SMOS (CATDS) and from the SMOS Barcelona Expert Centre (SMOS-BEC). The products differ in e.g. algorithm, spatial/temporal sampling resolution and choice of grid. An overview is given below.

Level 3 CATDS Soil Moisture, Vegetation Optical Depth and ancillary land products:

The daily product contains filtered data processed from the ESA L1B product. The L3 processing algorithm involves the use of a multi-orbit approach, in which retrievals are done using three successive orbits within a seven-day moving window. When several retrievals are available for a given day, the best estimation of soil moisture is selected for each grid point. Besides soil moisture, the vegetation optical depth, surface roughness and dielectric constant are also included in the final global-scale product.

The 3-day, 10-day and monthly products are produced by performing a temporal aggregation of the daily global maps, after filtering for detected events. In the case of the 3-day product a moving window is used, resulting in daily availability of global maps. All products contain soil moisture, vegetation optical depth and radio frequency
interference (RFI) statistics. The 3-day product additionally contains dielectric constant data. The 10-day product additionally contains surface roughness data, and minimum, maximum and median values of soil moisture.

The **3-day dielectric constant product** is produced using the cardioid model as well as the L-MEB model. The same temporal approach is used as for the 3-day soil moisture product, giving daily-available global maps of dielectric constant and optical thickness.

For all the above L3 CATDS products, ascending and descending orbits are processed separately.

Spatial resolution of grid: ~25 km (EASE grid version 2)
Provider: CATDS-CPDC
Data format: NetCDF
Data portal: http://www.catds.fr/Products/Available-products-from-CPDC

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**Level 3 SMOS-BEC Soil Moisture, Vegetation Optical Depth and ancillary land products:**

Level 3 SMOS Barcelona Expert Centre (SMOS-BEC) **daily maps** of soil moisture, vegetation optical depth and dielectric constant are available on a 15 km (ISEA 4H9) grid; daily maps of soil moisture are also available on a 25 km (EASE) grid. The former (ISEA 4H9 grid) are generated from the ESA L2 soil moisture data set without spatial or temporal averaging. The latter (EASE grid) are generated by simple spatial averaging of the ESA L2 soil moisture data set, taking into account only the last orbit measurements in each grid cell. In both cases, ascending and descending orbits are processed separately and the maps are provided at global scale.

**3-days average, 9-days average, monthly and annual maps** of soil moisture are constructed by simple spatial averaging of ESA L2 data using all available orbits. The spatial averaging is computed in a 25 km (EASE) grid. Ascending and descending orbits are processed separately and the maps are provided at global scale.

Spatial resolution of grid: depends on product, see above
Provider: SMOS-BEC
Data format: NetCDF
Data portal: http://cp34-bec.cmima.csic.es/land-datasets/

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10-day global composite of L3 soil moisture. Credits CATDS/CESBIO

10-day global composite of L3 vegetation optical depth. Credits CATDS/CESBIO
Level 2 Ocean Salinity products:

Swath-based ocean salinity products containing three ocean salinity values derived using different assumptions for the surface roughness correction, as well as brightness temperatures retrieved at the top of atmosphere and at the sea surface (with their corresponding uncertainties). The latency of the products is 8-12 hours.

Spatial resolution of grid: 15 km (ISEA 4H9 grid)
Provider: ESA
Data format: EEF
Data portal: https://earth.esa.int/web/guest/-/how-to-obtain-data-7329

Level 3 CATDS Ocean Salinity products:

Three different ocean salinity products are available from CATDS: an operational product from CATDS-CPDC and two research products from CATDS-CEC. The three products differ in e.g. algorithm, wind model, calibration and resolution as outlined in a pdf document available on www.catds.fr/Products/Available-products-from-CEC-OS.

The CPDC operational products provide global-scale average salinity for daily, 10-day and monthly periods. The spatial sampling resolutions of the averaged salinities are 25, 50, 100 and 200 km. The products are generated from the ESA L1B product. Data products are available for ascending, descending and combined orbits. They are produced on a ~25 km grid (EASE version 2).

The CEC-IFREMER research product is generated from the ESA L1B product, using daily composites of ascending and descending passes. The final products are available on daily, 10-day and monthly timescales, for the period June 2010 - December 2014 at present (status May 2015). The products are available on a rectangular grid at 0.25°, 0.5° and 1° spatial resolution.

The CEC-LOCEAN research product is generated from the ESA L1C product by averaging on 10-day and monthly timescales, over 100x100 km². The final data grid is rectangular and has a spatial resolution of 0.25°.

Spatial resolution of grid: depends on product, see above
Provider: CATDS-CPDC/CATDS-CEC
Data format: NetCDF
Data portal CPDC: www.catds.fr/Products/Available-products-from-CPDC
Data portal CEC: www.catds.fr/Products/Available-products-from-CEC-OS

Level 4 CATDS Ocean Salinity products:

This L4 weekly ocean salinity product is produced by merging SMOS and in situ observations: Large-scale biases in SMOS L3 data are corrected using 50 km monthly objectively analysed in situ observations (so-called ISAS fields). The products also include an ensemble of geophysical parameters, derived from well-acknowledged
Level 3/4 SMOS-BEC Ocean Salinity products:

These ocean salinity products are available as a reprocessed dataset or as a NRT dataset. Both datasets are created for various averaging periods: 3 days, 9 days, monthly, seasonal (quarterly) and annual. In all cases except the 3-day averaging, three different processing techniques (binning, optimal interpolation and fusion) are used, each resulting in a separate data product. Each of these data products is available for ascending, descending, and combined ascending-descending orbits. The NRT Dataset is based on the ESA L2 Ocean Salinity User Data Product (UDP) and Ocean Salinity Data Analysis Product (DAP). These L2 data are first filtered, then aggregated over a 0.25° grid. The L3/4 NRT products are generated about 3 days after the L2 data become available. The Reprocessed Dataset is based on the ESA L2 Ocean Salinity User Data Product (UDP) and Ocean Salinity Data Analysis Product (DAP). These L2 data are first filtered, then aggregated over a 0.25° grid. These UDP and DAP files are generated by ESA in periodic reprocessing campaigns.

The Auxiliary Dataset contains auxiliary products used in the Level 3/4 products generation.

Spatial resolution of grid: 0.25° (regular lat-lon grid)
Provider: SMOS-BEC
Data format: NetCDF
Data portal: http://cp34-bec.cmima.csic.es/ocean-datasets/

Spatial resolution of grid: 50 km rectangular grid
Provider: CATDS-CEC
Data format: NetCDF
Data portal CEC: www.catds.fr/Products/Available-products-from-CEC-OS

Spatial resolution of grid: 25 km (EASE grid)
Provider: University of Hamburg
Data format: NetCDF
Data portal: http://icdc.zmaw.de/las/getUI.do

Level 3 Sea Ice product:

Operational sea-ice thickness product based on the ESA L1C brightness temperature data. SMOS brightness temperatures can be used to retrieve sea-ice thickness up to a depth of ~ 0.5-1 m, using a semi-empirical method. The ice-thickness measurements are available mainly for the thinner and younger ice at the edge of the Arctic Ocean, during the period October-April. Daily maps are disseminated with a latency of 24 hours. The observations are complementary with measurements from ESA's CryoSat mission.
As science data are not available during calibration activities, data users should consult the calibration plan for data availability: https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/smos/available-data-processing

Monthly reports summarising significant events in the SMOS flight and ground segment, and SMOS data quality status: https://earth.esa.int/web/guest/-/data-quality-7059

▶️ USEFUL LINKS

SMOS mission webpage: https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/smos

SMOS blog: www.cesbio.ups-tlse.fr/SMOS_blog/

 ↔ GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>BUFR</td>
<td>Binary Universal Form for the Representation of meteorological data</td>
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<tr>
<td>CATDS</td>
<td>Centre Aval de Traitement des Données SMOS</td>
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<td>CEC</td>
<td>Centre d’Expertise du CATDS</td>
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<tr>
<td>CNES</td>
<td>Centre National d’Etudes Spatiales</td>
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<tr>
<td>CPDC</td>
<td>Centre de Production des Données du CATDS</td>
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<tr>
<td>DAP</td>
<td>Data Analysis Product</td>
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<tr>
<td>EASE</td>
<td>Equal-Area Scalable Earth</td>
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<tr>
<td>EEF</td>
<td>Earth Explorer File</td>
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<tr>
<td>EUMETSAT</td>
<td>European Organisation for the Exploitation of Meteorological Satellites</td>
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<tr>
<td>ESA</td>
<td>European Space Agency</td>
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<tr>
<td>GTS</td>
<td>Global Telecommunication System</td>
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<tr>
<td>IFREMER</td>
<td>Institut Français de Recherche pour l’Exploitation de la Mer</td>
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<tr>
<td>ISEA</td>
<td>Icosahedron Snyder Equal Area</td>
</tr>
<tr>
<td>L1, L2, L3, L4</td>
<td>Level 1, 2, 3, 4</td>
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<tr>
<td>lat</td>
<td>Latitude</td>
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<tr>
<td>L-MEB</td>
<td>L-band Microwave Emission of the Biosphere</td>
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<tr>
<td>LOCEAN</td>
<td>Laboratoire d’Océanographie et du Climat</td>
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<tr>
<td>lon</td>
<td>Longitude</td>
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<tr>
<td>MIRAS</td>
<td>Microwave Imaging Radiometer using Aperture Synthesis</td>
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<tr>
<td>NetCDF</td>
<td>Network Common Data Form</td>
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<td>NRT</td>
<td>Near Real Time</td>
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<td>RFI</td>
<td>Radio Frequency Interference</td>
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<td>SMOS</td>
<td>Soil Moisture and Ocean Salinity</td>
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<td>SMOS-BEC</td>
<td>SMOS Barcelona Expert Centre</td>
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<tr>
<td>UDP</td>
<td>User Data Product</td>
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<tr>
<td>VOD</td>
<td>Vegetation Optical Depth</td>
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<tr>
<td>WMO</td>
<td>World Meteorological Organization</td>
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