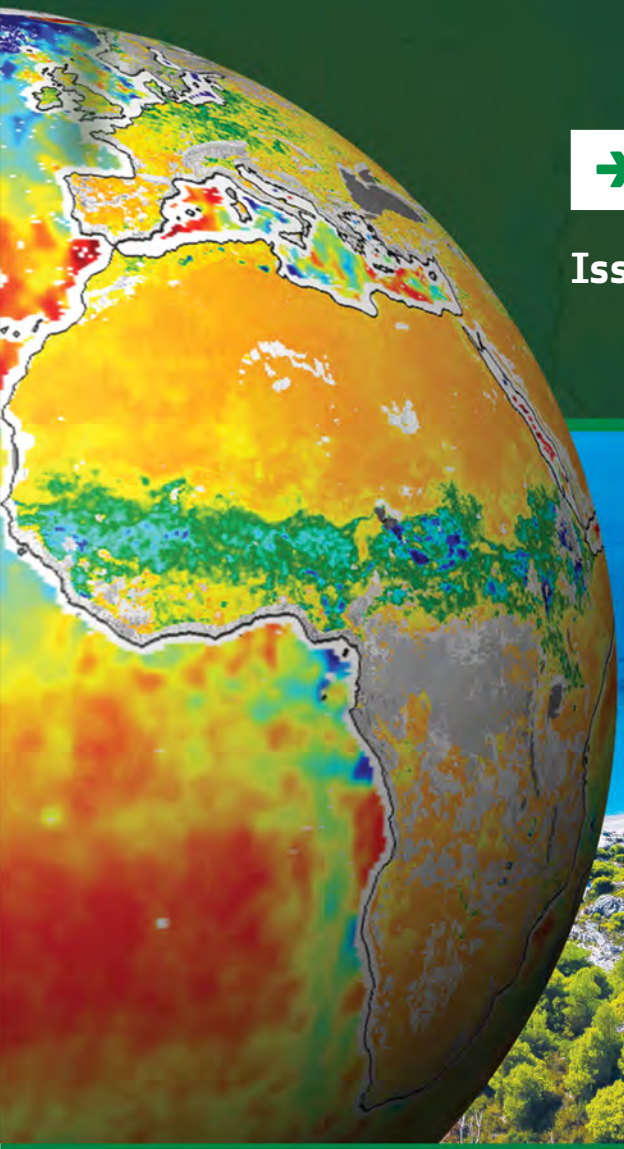
→ SMOS DATA PRODUCTS

Issue November 2017



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 m3m-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.

→ INSTRUMENT DATA PRODUCTS

Level 1A data product:

Reformatted and calibrated observation and housekeeping data in engineering units. Scientific SMOS Level 1A products are the so-called calibrated visibilities between the individual antenna receivers prior to applying image reconstruction and in full polarisation, provided in pole-to-pole (half orbit) time-based segments and on request only. The latency of the products is 6-8 hours.

Provider: ESA
Data format: EEF
Data portal: http://smos-diss.eo.esa.int

→ BRIGHTNESS TEMPERATURE DATA PRODUCTS

Level 1B Brightness Temperature product:

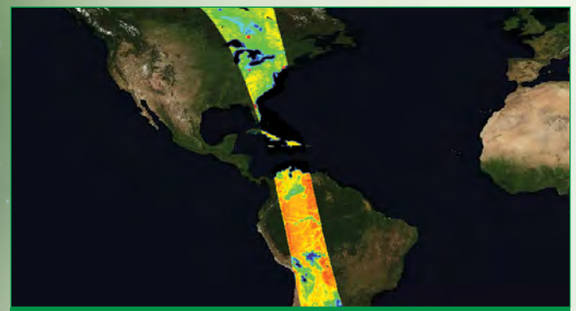
Output of the image reconstruction of the SMOS observation measurements and consisting of the Fourier components of brightness temperatures in the antenna polarisation reference frame. The latency of the products is 6-8 hours.

Provider: ESA
Data format: EEF
Data portal: http://smos-diss.eo.esa.int

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: http://smos-diss.eo.esa.int



Example of SMOS swath-based L1C brightness temperature product.
Credits ESA

Level 1C Brightness Temperature in near-real time (NRT) products:

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. http://smos-diss.eo.esa.int
  2. 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);
  3. WMO GTS: please send a request to the SMOS Mission Manager (Susanne.Mecklenburg@esa.int) for authorisation.

Level 3 Brightness Temperature products:

Two different products are available:
The **L3 BT** 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.

The **L3 TB in stereopolar projection** product, which is similar to L3 BT but provided in polar stereographic projection. The product includes all brightness temperatures acquired daily over the poles, transformed from the antenna frame (ESA L1B) to ground polarisation reference frame, binned and averaged into fixed angle classes. Orbit from equator to equator, and only in full polarization.

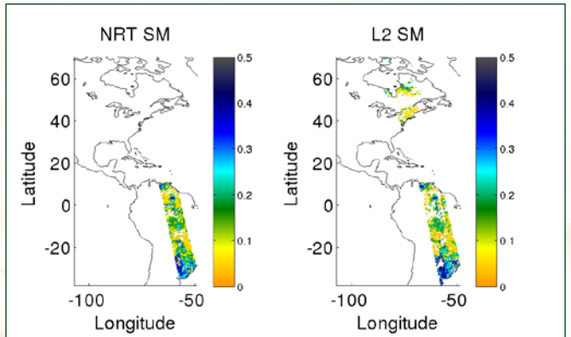
Spatial resolution of grid: ~25 km (EASE grid version 2)
Provider: CATDS-CPDC
Data format: NetCDF
Data portal: www.catds.fr/Products/Available-products-from-CPDC

→ DATA PRODUCTS OVER LAND

Level 2 Soil Moisture, Vegetation Optical Depth and Ancillary Land product:

The product contains 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 and NetCDF
Data portal: http://smos-diss.eo.esa.int



Soil moisture data products: Near-real time (NRT SM; left) and Nominal Level 2 (L2 SM; right). Units are m^3/m^3. Credits CESBIO, ECMWF, ESA

Level 2 Soil Moisture in near real time (NRT) product:

The product contains swath-based soil moisture comparable, over a slightly reduced swath to the Level 2 soil moisture product. The product is derived from ESA L1C NRT product and based on the usage of statistical algorithm, i.e. neural network trained on SMOS L2 soil moisture data. The data volume is below 5 MB/orbit. The product is available within three hours from sensing.

Spatial resolution of grid: 15 km (ISEA 4H9 grid)
Provider: ESA
Data format: NetCDF
Data portals:
1. http://smos-diss.eo.esa.int
2. 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);
3. WMO GTS: please send a request to the SMOS Mission Manager (Susanne.Mecklenburg@esa.int) for authorisation.

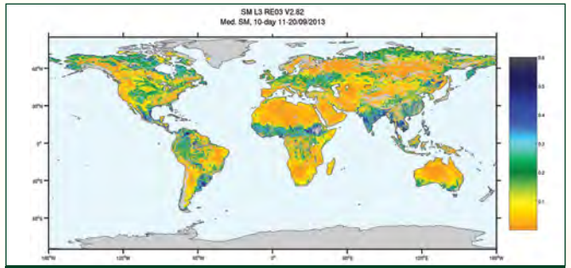
Level 3 CATDS Soil Moisture, Vegetation Optical Depth and Ancillary Land products:

The **daily product** contains global map of soil moisture, vegetation optical depth, surface roughness and dielectric constant for ascending and descending orbits. The product is derived from the ESA L1B product with a multi-orbit approach. The retrieval is 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.

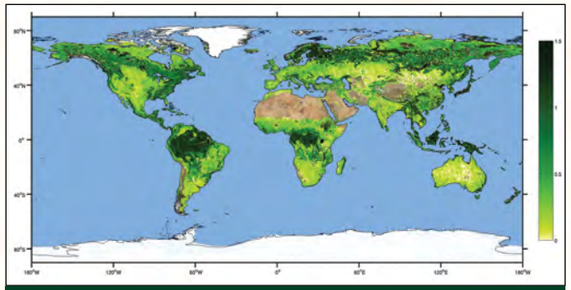
The **3-day, 10-day and monthly products** contain global map of soil moisture, vegetation optical depth, surface roughness and radio frequency interference (RFI) statistics for ascending and descending orbits. The products are produced by performing a temporal aggregation of the L3 CATDS daily product. In the case of the 3-day product a moving window is used, resulting in daily availability of global maps. The 3-day product additionally contains dielectric constant data. The 10-day product additionally contains minimum, maximum and median values of soil moisture.

The **3-day dielectric constant product** contains global map of dielectric constant and optical thickness for ascending and descending orbits. The same temporal approach is used as for the L3 CATDS 3-day soil moisture product, giving daily-available map. The product is derived from L3 CATDS daily product using the cardioid model as well as the L-MEB model.

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



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



10-day global composite of L3 vegetation optical depth. Credits CATDS/CESBIO

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

The **daily product** contains global map of soil moisture, vegetation optical depth and dielectric constant for ascending and descending orbits. The product is available on a 15 km (ISEA 4H9) grid and on a 25 km (EASE) grid. The product on ISEA 4H9 grid is derived from the ESA L2 soil moisture data without spatial or temporal averaging. The product on EASE grid is derived by quality-filtering, quality weighting and re-gridding the ESA L2 soil moisture data.

The **3-day, 9-day, monthly and annual products** are produced by performing a temporal aggregation of the L3 BEC daily products on a 25 km (EASE) grid for ascending and descending orbits.

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

Level 4 CATDS Ancillary Land products:

The Level 4 CATDS Ancillary Land products consist in data obtained from SMOS L3 CATDS products combined with data from other sensors or models. Four L4 Ancillary Land products are available:

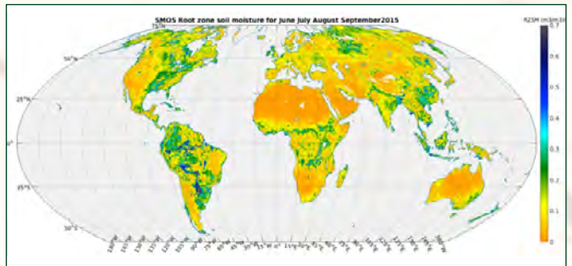
The **root zone daily product** contains global map of root zone soil moisture for 0-1 m soil depth, for ascending and descending orbits. The product is derived from the L3 CATDS soil moisture data and through the usage of surface temperature information from ECMWF model reanalysis.

The **agriculture drought index daily product** contains global map of root zone soil moisture anomaly for 0-1 m soil depth, for ascending and descending orbits. The product is based on the combination of L3 CATDS soil moisture data and the usage of a hydrological model.

The **synergy soil moisture daily product** contains global map of AMSR-E retrieved soil moisture for the period 2003 – 2010 and SMOS L3 retrieved soil moisture for the period 2010 – 2017. The AMSR-E retrieved soil moisture is based on the usage of a statistical algorithm i.e. neural network trained on SMOS data.

The **surface roughness product** contains global soil surface roughness estimations at L-band. One single product has been generated based on one year of SMOS dataset (2011).

Spatial resolution of grid: 25 km (ISEA grid)
Provider: CATDS
Data format: NetCDF
Data portal: www.catds.fr/Products/Available-products-from-CEC-SM/L4-Land-research-products

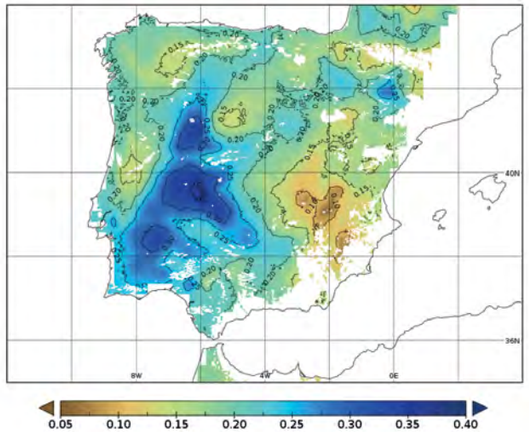


4-months composite of L4 root zone soil moisture daily products. Credits: CATDS/CESBIO

Level 4 BEC High Resolution Soil Moisture over Iberian Peninsula product:

The product contains daily map of soil moisture over the Iberian Peninsula at 1km of spatial resolution for ascending and descending orbits. The product is derived from ESA SMOS L1C brightness temperature data and the use of land surface temperature and vegetation index obtained from models (ECMWF ERA-interim) and satellite observations (NASA Terra/Aqua MODIS).

Spatial resolution of grid: 1 km
Provider: BEC
Data format: NetCDF
Data portal: http://bec.icm.csic.es/land-datasets



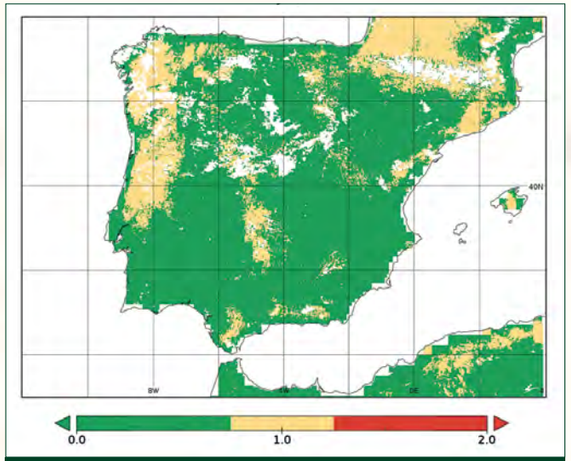
Level 4 SMOS soil moisture map at 1 km spatial resolution over the Iberian Peninsula (17 February 2017). Empty areas in the image correspond to clouds masking MODIS observations or quality filtered SMOS brightness temperature. Credits: BEC

Level 4 BEC fire risk index over Iberian Peninsula product:

The product contains daily map of fire risk over the Iberian Peninsula at 1 km spatial resolution.

The product is derived from L4 BEC soil moisture data and land surface temperatures from models (ERA-interim) and satellite observations (NASA Terra/Aqua MODIS).

Spatial resolution of grid: 1 km
Provider: BEC
Data format: NetCDF
Data portal: http://bec.icm.csic.es/land-datasets



Level 4 SMOS fire risk index at 1 km spatial resolution over the Iberian Peninsula (5 February 2017). Credits: BEC

FORTHCOMING PRODUCTS

Level 3 SMOS INRA-CESBIO Soil Moisture and Vegetation Optical Depth product (available from 2018):

The product contains daily global map of soil moisture and vegetation optical depth, for ascending and descending orbits. The product is derived from the L3 CATDS brightness temperature product. The retrieved soil moisture is based on the use of the L-MEB model inversion (similar to L2) applied over pixels consider homogeneous and on the use of a reduced set of auxiliary information.

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

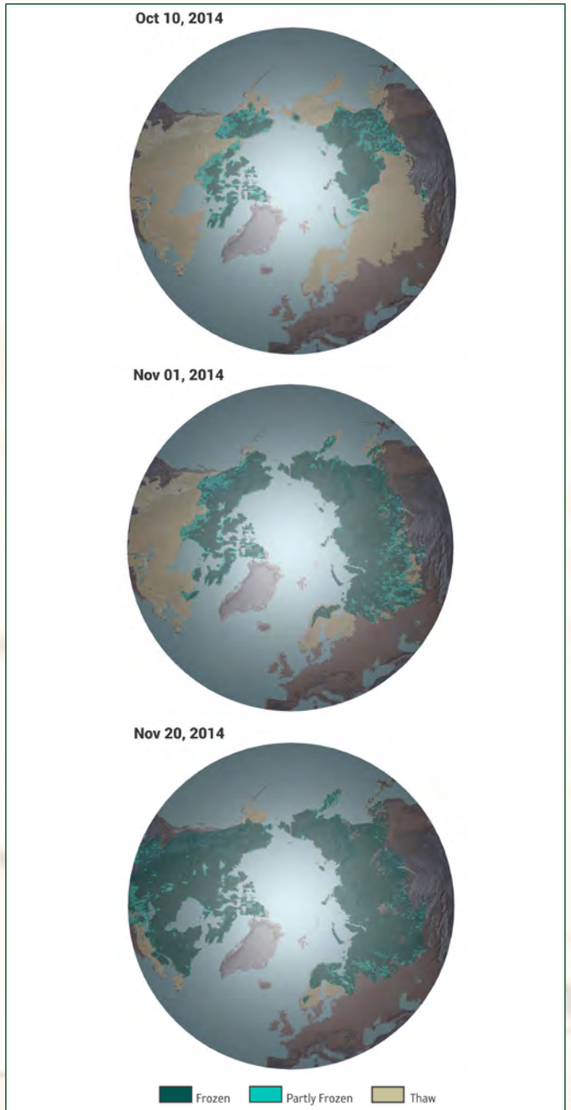
Level 4 CATDS High Resolution Soil Moisture product (available from end 2017):

The product contains daily global map of soil moisture at 1km of spatial resolution for ascending and descending orbits. The product is derived from the ESA L2 soil moisture data. The retrieved soil moisture is downscaled by DISaggregation based on Physical And Theoretical scale Change (DISPATCH) algorithm and on the use of information for land surface temperature and vegetation index obtained from satellite observation (NASA Terra/Aqua MODIS).

Spatial resolution of grid: 1 km
Provider: CATDS
Data format: NetCDF
Data portal: www.catds.fr/Products/Available-products-from-CEC-SM/L4-Land-research-products

Level 3 Soil Freeze/Thaw State product (available from end 2017):

The product contains daily global map of soil freeze/thaw state estimate derived from L3 SMOS brightness temperature. Soil state is categorized into three discrete levels: 'frozen', 'partially frozen', and 'thaw', and accompanied with a quality data matrix estimating the data reliability for each freezing season separately. The product will be produced by FMI and will be disseminated by ESA.



Maps of SMOS soil Freeze/Thaw-state (F/T-state) estimates over the northern hemisphere on 10 October 2014, 1 November 2014 and 20 November 2014. Credits: FMI

→ DATA PRODUCTS OVER OCEAN

Level 2 Ocean Salinity product:

The product contains the retrieved swath-based sea surface salinity, the sea surface salinity anomaly with reference to the World Ocean Atlas (WOA) 2009 climatology, the corrected sea surface salinity, to mitigate the impact of the land/sea transition contamination along the coastline, the retrieved brightness temperatures at the top of atmosphere and at the sea surface with their corresponding uncertainties. The latency of the product is 8-12 hours.

Spatial resolution of grid: 15 km (ISEA 4H9 grid)
Provider: ESA
Data format: EEF and NetCDF
Data portal: http://smos-diss.eo.esa.int

Level 3 CATDS Ocean Salinity products:

Three different L3 ocean salinity products are available from CATDS:

The **CATDS-CPDC** products contain global map of sea surface salinity for daily, 10-day and monthly periods and for ascending, descending and combined orbits. The products are derived from the ESA L1B product and are available on EASE version 2 grid (~25 km). The spatial sampling resolution of the products are 25, 50, 100 and 200 km.

The **CEC-IFREMER** products contain global map of sea surface salinity for daily, 10-day and monthly periods and for ascending, descending and combined orbits. The products are derived from the ESA L1B product and are available on a rectangular grid at 0.25°, 0.5° and 1°spatial resolution.

The **CEC-LOCEAN** debiased product contains global map of sea surface salinity for 9-day and 18-day periods. The product is derived from ESA L1C product 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-IFREMER Ocean Salinity products:

The **weekly ocean salinity product** contains global map of sea surface salinity. The product is derived from SMOS CATDS L3 sea surface salinity product and in situ observations. The large-scale biases in SMOS L3 data are corrected using 50 km monthly objectively analysed in situ observations (OI) ISAS fields. The product also contains an ensemble of geophysical parameters, derived from well-acknowledged scientific products useful for synergistic science applications. These include Sea Surface Temperature (ECMWF), surface currents (OSCAR), rain (TRMM & CMORPH), evaporation (OAFLUX), surface wind stresses (ASCAT), mixed-layer depth from in situ OI (APDRC). Sea surface salinity from OI (ISAS) and salinity at the base of the mixed-layer depth estimated also from in situ OI.

The **weekly ocean salinity anomaly product** contains global map of sea surface salinity anomaly. The product is derived from CATDS L4 weekly ocean salinity product by removal of an annual-averaged reference weekly composite field evaluated by averaging SMOS data over 5 years (2010 to 2014). The product also contains various thematic fields such as (list not exhaustive): ECMWF sea surface temperature anomaly, cumulative evaporation anomaly from OAFlux, cumulative precipitation anomaly from TRMM3B42 and CMORPH, etc.

Spatial resolution of grid: 50 km rectangular grid
Provider: CATDS-IFREMER
Data format: NetCDF
Data portal CATDS-IFREMER:
www.catds.fr/Products/Available-products-from-CEC-OS/Ifremer-L4-Products

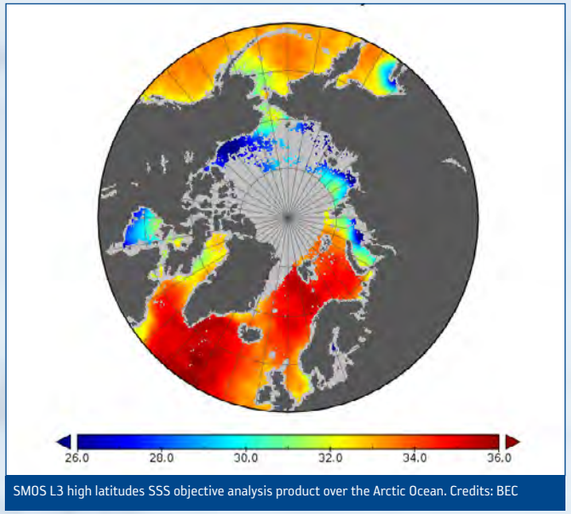
Level 3 BEC Ocean salinity products:

Two different sea surface salinity products are available from BEC:

The **nominal products** contain global map of sea surface salinity for daily, 9-day and monthly periods. The daily product is available for ascending and descending orbits, the 9-day and monthly products are available for combined ascending/descending orbit. The products are derived from ESA L2 sea surface salinity product and the usage of binning and objective analysis algorithms.

The **advanced products** contain daily global and local (Mediterranean Sea, high latitudes and Arctic) map of sea surface salinity. The products are derived from ESA L1B product and the use of a methodology which allows the retrieval of sea surface salinity very close to the coasts and at high latitudes.

Spatial resolution of grid: 0.25° for daily and 9-day maps and 1° for monthly maps.
Spatial resolution of grid (only high latitudes product): 25 Km (EASE-NL)
Provider: BEC
Data format: NetCDF
Data portal: http://bec.icm.csic.es/ocean-datasets

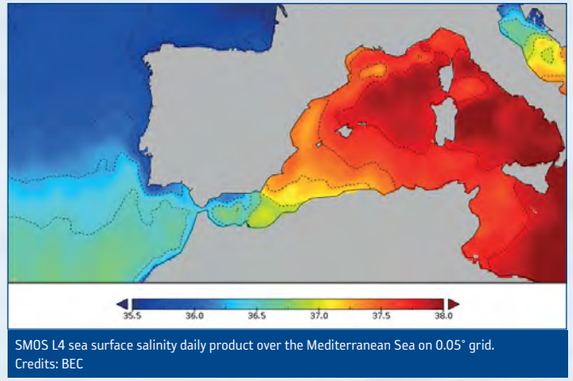


SMOS L3 high latitudes SSS objective analysis product over the Arctic Ocean. Credits: BEC

Level 4 BEC Ocean salinity product:

The product contains daily global map of sea surface salinity. The product is derived from BEC L3 9-day nominal and advanced products and the use of sea surface temperature and sea ice analysis daily maps at 0.05°x0.05° from OSTIA. The data fusion with OSTIA allows the daily temporal resolution and the increased spatial resolutions.

Spatial resolution of grid: 0.05° for daily maps
Provider: BEC
Data format: NetCDF
Data portal: http://bec.icm.csic.es/ocean-datasets

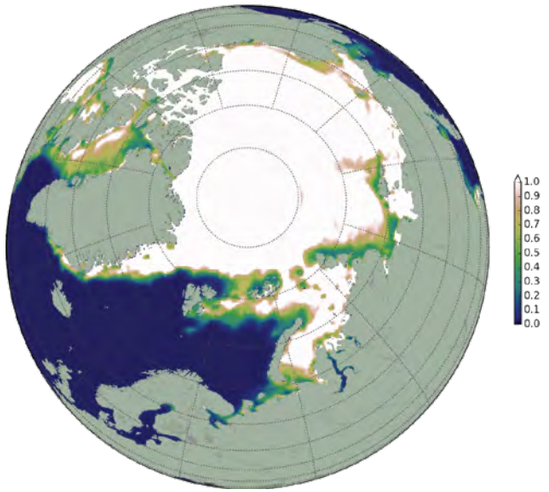


SMOS L4 sea surface salinity daily product over the Mediterranean Sea on 0.05° grid. Credits: BEC

Level 3 Sea Ice product:

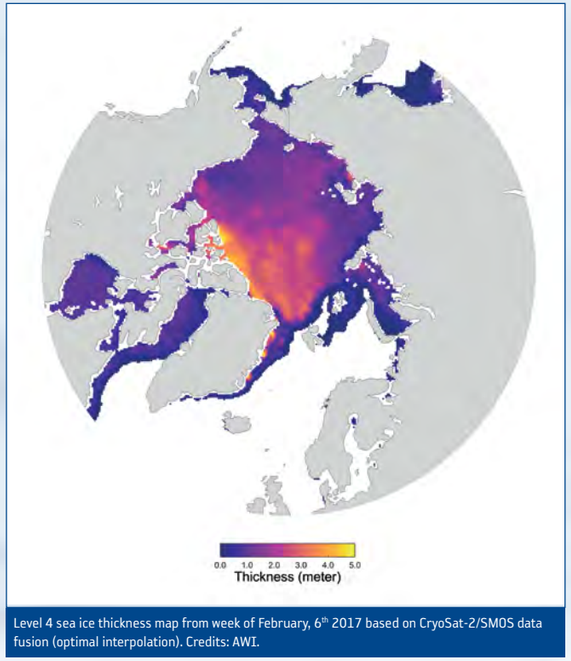
The product contains daily map of sea-ice thickness for the thinner and younger ice at the edge of the Arctic Ocean, during the period October-April. The product is derived from ESA L1C product. The sea-ice thickness is retrieved up to a depth of ~ 0.5-1 m, depending on the ice temperature and ice salinity. The product is complementary with sea-ice thickness measurements from ESA's CryoSat-2 and Sentinel-3 missions. Daily maps are disseminated with a latency of about 24 hours.

Spatial resolution of grid: 12.5 km (polar stereographic grid)
Provider: University of Hamburg
Data format: NetCDF
Data portal: http://smos-diss.eo.esa.int



Monthly sea-ice thickness over the Arctic Ocean. Credits University of Hamburg, ESA

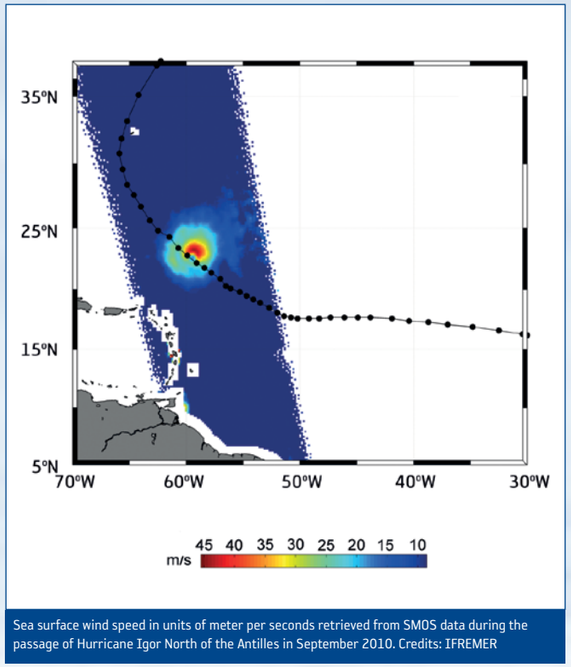
FORTHCOMING PRODUCTS



Level 4 sea ice thickness map from week of February, 6th 2017 based on CryoSat-2/SMOS data fusion (optimal interpolation). Credits: AWI.

Level 4 Sea Ice product (available from end 2017):

The product contains weekly map of sea-ice thickness for Arctic region. The product is derived from L3 SMOS sea-ice thickness product and the use of CryoSat-2 sea-ice thickness information. The combination of both data is based on a statistical approach (optimal interpolation) and respective uncertainties for different thickness classes. The product will be produced by AWI and disseminated by ESA. For more information and example of research data visit the website: www.meereisportal.de/en.



Sea surface wind speed in units of meter per seconds retrieved from SMOS data during the passage of Hurricane Igor North of the Antilles in September 2010. Credits: IFREMER

Level 2 Ocean Surface Wind Speed in near-real time product (available from summer 2018):

The product contains the retrieved swath-based ocean surface wind speed. The product is derived from SMOS level 1 near-real time data. The product will be produced by IFREMER/ODL and disseminated by ESA to operational meteorological agency and hurricane centers within 3-4 hours from sensing. For more information and example of research data visit the website: www.smosstorm.org.

→ DATA PRODUCTS OVER CRYOSPHERE

Level 4 CryoSMOS products:

The L4 CryoSMOS products consist in data developed under ESA's funded CryoSMOS project. Four L4 research products are derived from SMOS L3 brightness temperature products over Antarctica:

The **internal ice-sheet temperature product** contains maps of ice-sheet temperature and related uncertainty estimated from surface (0 m) up to the bedrock (-4500 m) in step of 50m. One single product has been generated based on SMOS data from 2010 until 2015.

The **ice thickness product** contains yearly map of the ice thickness estimate and ice thickness estimate merged onto Bedmap2 ice thickness data.

The **ice shelves variability product** contains yearly map of mean and differential SMOS brightness temperature and surface type mask based on Bedmap2 data.

The **occurrence of surface melting product** contains daily map of melted / not melted surface status.

Spatial resolution of grid: ~25 Km (EASE grid version 2)
Provider: CryoSMOS, CATDS
Data format: NetCDF
Data portal: www.ifac.cnr.it/cryosmos/index.htm
ftp://ext-catds-cecsm:catds2010@ftp.ifremer.fr/Cryo_products

→ USEFUL LINKS

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

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

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

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

→ GLOSSARY

AWI	Alfred Wagner Institute
BEC	Barcelona Expert Centre
BUFR	Binary Universal Form for the Representation of meteorological data
CATDS	Centre Aval de Traitement des Données SMOS
CEC	Centre d'Expertise du CATDS
CNES	Centre National d'Etudes Spatiales
CPDC	Centre de Production des Données du CATDS
DAP	Data Analysis Product
EASE	Equal-Area Scalable Earth
ECMWF	European Centre for Medium-Range Weather Forecasts
EEF	Earth Explorer File
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
ESA	European Space Agency
FMI	Finnish Meteorological institute
GTS	Global Telecommunication System
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer
ISEA	Icosahedron Snyder Equal Area
L1, L2, L3, L4	Level 1, 2, 3, 4
lat	Latitude
L-MEB	L-band Microwave Emission of the Biosphere
LOCEAN	Laboratoire d'Océanographie et du Climat
LST	Land Surface Temperature
lon	Longitude
MIRAS	Microwave Imaging Radiometer using Aperture Synthesis
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Index
NetCDF	Network Common Data Form
NRT	aNear Real Time
OA	Objective Analysis
OSTIA	Operational Sea Surface Temperature and Sea Ice Analysis
RFI	Radio Frequency Interference
SMOS	Soil Moisture and Ocean Salinity
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
UDP	User Data Product
VOD	Vegetation Optical Depth
WMO	World Meteorological Organization

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