Comments from Public Consultation on ECV Requirements 13/01 – 13/03 2020 for:

# Sea surface salinity

## ECV Product: Uncertainty Metrics

### Comment 1

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| Author: Christoph Waldmann | Email: christoph.waldmann.bremen@gmail.com |
| The specification of uncertainties for in-situ collected ocean data, in particular those used for ECVs, is highly relevant to allow for the assessment of long-term trends and also for the reuse of data in the framework hindcast and forecast models. The task is to clarify the concept of uncertainty for ocean parameters providing reference to procedures being used in atmospheric science and by the remote sensing community. There are some specific aspects of the concept of uncertainty that are still not resolved if it comes to in-situ ocean data and it appears necessary to generate agreement on the adequate workflow for the estimation of uncertainty within the ocean science community.  People with interest in that topic are requested to indicate their willingness to contribute to this discussion to come up with an implementation strategy for a harmonized approach in regard to the estimation of uncertainty of ECVs. It is also welcome if interested parties share their view and experiences that they have collected while exploring this theme.  Best regards,  Christoph Waldmann, Bremen University, Germany | |

## ECV Product: Sea surface salinity

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| **Name** | Sea surface salinity | | | | |
| **Definition** | Salinity of seawater, at or near the surface - Salinity is unitless, and is expressed with the suffix psu (practical salinity unit, PSS-78). | | | | |
| **Unit** |  | | | | |
| **Note** |  | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 10  Coastal: 1 |  |
| B |  |  |
| T | 100  Coastal: 10 |  |
| **Vertical Resolution** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** | day |  | G | 1 |  |
| B |  |  |
| T | 7 |  |
| **Timeliness** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Required Measurement Uncertainty** | cm |  | G |  |  |
| B |  |  |
| T |  |  |
| **Stability** | cm |  | G |  |  |
| B |  |  |
| T |  |  |
| **Standards and References** |  | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  |  | | |
| **Extremes[3]** |  |  |  | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

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| Author: Rafaël Catany | Email: rjaumecatany@gmail.comt |
| Hello Valentin,  What are the requirements to access and edit the table of the ECV-Salinity. Do you have a control of whom is filling the table?  Thank you for the information and for writing me to my work email (rcatany@argans.co.uk). The google account just allow me to access using my gmail (personal) account.  All the best,  Rafael | |

### Comment 2

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| Author: Valentin Aich | Email: vaich@wmo.int |
| Coordinated response from ESA's Climate Change Initiative (CCI) working group on Sea Surface Salinity (http://cci.esa.int/salinity):  The results of the CCI SSS survey are:  Horizontal resolution: global coverage with at least 0.25°  Temporal resolution: at least 3-7 days resolution  Acceptable global mean SSS accuracy (based on their resolution requirements and keeping in mind the capapility of satellite SSS measurements): 0.1  Furthermore we asked which product the users prefer based on their requirements and also here, most of the users prefer a product with high temporal and spatial resolution (weekly, 0.25°), but low accuracy.    Requirements depend on the users application category: the more small scale the variability of interest, the more higher the required resolution. Therefore, the requirements of the participants are not substantially different from the GCOS, GOOS requirements and former user requirement studies. | |

### Comment 3

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| Author: Jacqueline Boutin | Email: Click here to enter text. |
| Coordinated response from Jacqueline Boutin:    The Sea Surface Salinity (SSS) measurement by remote sensing has been initially motivated by the need of better monitoring, understanding and constraining the marine component of the water cycle which represents about 3/4 of the global hydrologic cycle and the associated ocean general circulation. SSS is an Essential Climate Variable. It is an active player of the ocean circulation as it controls, with temperature, sea water density. At the ocean surface, in cold water (T = 2°C) a 0.11pss SSS change is equivalent, in term of density, to a change of 1°C in sea surface temperature (SST). This is why SSS variations drastically constraint the global thermohaline circulation, which allows to transport waters between the surface ocean and the deep ocean. In warm waters (T=28°C), a larger change of 0.44pss is equivalent to a 1°C change in SST.  Weaker variations in SSS may however modify the vertical stratification of the water density and hence greatly influence the air-sea exchange via the development of barrier layers. In addition, SSS is considered as a passive tracer of fresh water fluxes originating from river discharges, ice melting and air-sea exchanges (evaporation-precipitation). The role of air-sea exchanges on the global hydrological cycle has been understimated in the past, in particular because of the few number of observations above ocean. (Rodell et al., 2015) estimate that about 85% of evaporation and 78% of precipitations take place above ocean. However, evaporated waters above ocean are transported by atmospheric circulation above continents.  Li et al. (2016) recently suggest significant correlations between SSS anomalies in the northern Atlantic and rain anomalies in  Sahel lagged by several months suggesting that large scale SSS anomalies can be used as precursor indicators of rain anomalies on the continents.  User requirements with respect to SSS are highly diverse, due to the variety of applications and spatial scales involved. In the following, they have been divided into the following subtopics: i) “air-sea interaction”, ii) “ocean circulation”, iii) “fresh water fluxes’’, iv) ‘’carbon cycle and biochemistry”, and v) “extreme events”.  References  L. Li, R.W. Schmitt, C.C. Ummenhofer, and K.B. Karnauskas. “North Atlantic salinity as a predictor of Sahel rainfall”. Science Advances 2: e1501588 (2016)  M. Rodell, H. K. Beaudoing, T. S. L’Ecuyer, W. S. Olson, J. S. Famiglietti, P. R. Houser, R. Adler, M. G. Bosilovich, C. A. Clayson, D. Chambers, E. Clark, E. J. Fetzer, X. Gao, G. Gua, K. Hilburn, G. J. Huffman, D. P. Lettenmaier, W. T. Liu, F. R. Robertson, C. A. Schlosser, J. Sheffield, and E. F. Wood, “The Observed State of the Water Cycle in the Early Twenty-First Century”. Journal of Climate 28, 8289-8318 (2015) 1.1.1.   Air-Sea Interaction Applications included in the “air-sea interaction” subtopic have been divided into the following categories:  “climate change”, “Climate Variability: ENSO, IOD anomalies” and “barrier layers”. 1.1.1.1.  Climate Change (>10 years) During the last decade, owing to ship and more recently ARGO floats monitorings, there has been increasing evidence of multi-decadal trends observed on sea surface salinity (SSS), e.g. the western tropical Pacific has become fresher (Cravatte et al., 2009) and the subtropical North Atlantic has become saltier (Gordon and Giulivi, 2008).Shifts in the oceanic distribution of saline and fresh waters are occurring worldwide suggesting links to global warming and possible changes in the hydrological cycle of the Earth (Curry et al. 2003; Durack et al. 2016; Von Schuckmann, K. et al. (2016); GIEC, chapter 3.3, 2013). The observed trends (Terray et al. 2012, Durack et al. 2015) are on the order of 0.1pss in ten years over large regions, so that detecting them by remote sensing requires long term monitoring with a very well calibrated instruments or to combine satellite with in situ measurements.     | **EO Level Product** | **Threshold** | | | **Breakthrough** | | | **Goal** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **S** | **T** | **A** | **S** | **T** | **A** | **S** | **T** | **A** | | 4 | 10º | 1y | 0.01 | 5º | 1y | 0.005 | 5º | 1 month | 0.015 | | **SRL** | **ARL** | **Latency** | | **References/ATBD** | | | **Uniqueness of L-Band/ Alternative products** | | | | 4 | 3 | 6 months | | Durack et al. 2015  Von Schuckmann et al. 2016 | | | No/ in situ (Argo+ship) | | |   Table 15 Requirement Table for long term SSS change  References:  Curry R, Dickson B, Yashayaev I. 2003. A change in the freshwater balance of the Atlantic Ocean over the past four decades. Nature. 426:826–829. doi:10.1038  Durack PJ. 2015. Ocean salinity and the global water cycle.Oceanography. 28:20–31. doi:10.5670/oceanog.2015.03.  Durack PJ, Lee T, Vinogradova NT, Stammer D. 2016. Keeping the lights on for global ocean salinity observation. Nat Clim Chang. 6:228–231. doi:10.1038/nclimate2946.  Terray, L., L. Corre, S. Cravatte, T. Delcroix, G. Reverdin, and A. Ribes (2011), Near-Surface Salinity as Nature’s Rain Gauge to Detect Human Influence on the Tropical Water Cycle, Journal of Climate, 25(3), 958-977.  Von Schuckmann, K. et al. (2016) The Copernicus Marine Environment Monitoring Service Ocean State Report, Journal of Operational Oceanography, 9:sup2, s235-s320, DOI: 10.1080/1755876X.2016.1273446 1.1.1.2.  Climate Variability: ENSO, IOD anomalies The El Niño–Southern Oscillation (ENSO) cycle of alternating El Niño and La Niña events is the dominant year-to-year climate signal on Earth. ENSO originates in the tropical Pacific through interactions between the ocean and the atmosphere, but its environmental and socioeconomic impacts are felt worldwide (agriculture, marine ecosystems, health…).  Efforts to understand the causes and consequences of ENSO reveal the breadth of ENSO's influence on the Earth system and the potential to exploit its predictability for societal benefit (Mc Phaden et al. (2006)). Similar to ENSO, the Indian Ocean Dipole (IOD) is the main large scale anomalies occurring in the tropical Indian Ocean through ocean-atmosphere interactions and has large socio-economic impacts.  In situ measurements have revealed that ENSO events are characterized by displacements of atmospheric convection cells and by large ocean surface water masses (e.g. western equatorial Pacific warm pool associated with large anomalies in sea surface temperature, sea surface salinity (Delcroix et al. 1998; Singh et al. 2014), currents as well as wind anomalies and that these events have also strong impacts on the biogeochemistry (Rodier et al. 2000). However, the spatio-temporal resolution of in situ measurements is often too crude to allow detailed process studies on the role of air-sea interaction on the development of ENSO events.  While the anomalies in SST, ocean currents, atmospheric rain and wind speed are relatively well known owing to long term monitoring by satellite measurements, it is only recently that the detailed spatio-temporal distribution of the SSS anomalies have been revealed by satellite, enhancing for instance the movements of the South Pacific Convergence Zone (Hasson et al. 2014), the sharpness of horizontal SSS fronts in the vicinity of barrier layers (Qu et al. 2014) or the contrasted SSS patterns in the Indian Ocean associated with IOD (Durand et al. 2014).  Owing to the much better spatio-temporal coverage of satellite versus in situ SSS measurements, Hackert et al. (2014) found that coupled experiments initialized by assimilation of satellite SSS outperformed in situ SSS assimilation for forecast lead time greater than 5 months.  For these reasons, the international project Tropical Pacific Observing System 2020 in charge of redifining the ocean observation strategy in the tropical Pacific Ocean (TPOS 2020, Cravatte et al. 2016) underlines the need to pursue SSS satellite measurements as they are the only one allowing to monitor the variability of fine scale SSS structures in the vicinity of fronts and the sharp meridional gradients that come from the variability of the ocean circulation and of the atmosphere.  Table below summarizes the requirements for satellite SSS to bring crucial additional information to existing in situ measurements.   | **EO Level Product** | **Threshold** | | | **Breakthrough** | | | **Goal** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **S** | **T** | **A** | **S** | **T** | **A** | **S** | **T** | **A** | | 3 or 4 | 2° | 1month | 0.2 | 1° | 8d | .2 | .25° | 4d | 0.1 | | **SRL** | **ARL** | **Latency** | | **References/ATBD** | | | **Uniqueness of L-Band/ Alternative products** | | | | 7 | 6 | 1week (Near real time if assimilated in forecast models?) | | Hasson et al. 2014, Durand et al. 2012, Hackert et al. 2014, Maes et al. 2002, Qu et al. 2014 | | | No/ in situ (Argo+ship) | | |   Table 16 Requirement Table for ENSO, IOD events monitoring  References:  Cravatte, S., W. S . Kessler, N. Smith, S. E. Wijffels, and Contributing Authors, 2016: First Report of TPOS 2020. GOOS-215, 200 pp. [Available online at <http://tpos2020.org/first-report/>.]  Delcroix, T., and J. Picaut (1998), Zonal displacement of the western equatorial Pacific “fresh pool”, J. Geophys. Res., 103(C1), 1087–1098, doi:10.1029/97JC01912.  Durand F., G. Alory, R. Dussin and N. Reul, 2013. SMOS reveals the signature of Indian Ocean Dipole events. Ocean dynamics, DOI 10.1007/s10236-013-0660-y.  Hackert, E., A. J. Busalacchi, and J. Ballabrera-Poy (2014), Impact of Aquarius sea surface salinity observations on coupled forecasts for the tropical Indo-Pacific Ocean, J. Geophys. Res. Oceans, 119, 4045–4067, doi:10.1002/2013JC009697.  Hasson, A., T. Delcroix, J. Boutin, R. Dussin, and J. Ballabrera-Poy (2014), Analyzing the 2010–2011 La Niña signature in the tropical Pacific sea surface salinity using in situ data, SMOS observations, and a numerical simulation, Journal of Geophysical Research: Oceans, 119(6), 3855-3867, doi:10.1002/2013JC009388.  McPhaden, M. J. , S. E. Zebiak, M. H. Glantz, 2006, ENSO as an Integrating Concept in Earth Science, Science: 1740-1745.  Qu, T., Y. T. Song, and C. Maes (2014), Sea surface salinity and barrier layer variability in the equatorial Pacific as seen from Aquarius and Argo, J. Geophys. Res. Oceans, 119, 15–29, doi:10.1002/2013JC009375.  Rodier, M., Eldin, G. & Le Borgne, R., 2000, The Western Boundary of the Equatorial Pacific Upwelling: Some Consequences of Climatic Variability on Hydrological and Planktonic Properties Journal of Oceanography 56: 463. doi:10.1023/A:1011136608053.  Singh, A., T. Delcroix, and S. Cravatte (2011), Contrasting the flavors of El Niño-Southern Oscillation using sea surface salinity observations, J. Geophys. Res., 116, C06016, doi:10.1029/2010JC006862. 1.1.1.3.  Barrier Layer It is more and more recognized that SSS has an active role in the dynamics of the ocean surface layers and that there are retroactions of SSS on the water cycle. In case of large freshwater flux (precipitation or river runoff), a large haline vertical stratification (barrier layer) may suppress vertical mixing, decrease the mixed layer depth and modify exchanges with the atmosphere. In some tropical regions, it has been suggested that the SSS stratification of the surface layers could intensify the water cycle (e.g. Shenoi et al. (2002)) ; under cyclones, the haline stratification limits the vertical mixing and hence limits the cooling of the surface ocean that acts on the development fo the cyclones themselves (e.g. Sengupta et al. (2008)). These processes have been clearly evidenced in the analysis of SMOS data (Grodsky et al., 2012 ; Reul et al., 2014) combined with satellite observations of SST and in situ measurements of Argo profilers.  The barrier layer is believed to play a role in the maintenance and temporal evolution of the western Pacific warm pool. Results from a coupled ocean-atmosphere general circulation model have clearly demonstrated that by isolating the mixed layer from the entrainment cooling at depth and by confining the response of westerly wind events to a shallow mixed layer, the barrier layer favors the eastward displacement of the warm pool during the onset of El Niño (Maes et al., 2002). In the absence of salinity stratification, the eastward displacement of the warm pool was reduced, which in turn led to a reduced El Niño or a return to the mean seasonal cycle of the model.  Table below indicates the requirements for detecting barrier layers from satellite measurements. It is important to notice that L-band measurements provide SSS in the first top surface ocean layer contrary to in situ measurements mostly at a few meters depth.   | **EO Level Product** | **Threshold** | | | **Breakthrough** | | | **Goal** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **S** | **T** | **A** | **S** | **T** | **A** | **S** | **T** | **A** | | 3 or 4 | 1.5° | 1month | 0.1 | 0.5° | 1week | 0.1 | 0.25° | 1week | 0.02 | | **SRL** | **ARL** | **Latency** | | **References/ATBD** | | | **Uniqueness of L-Band/ Alternative products** | | | | 4 | 3 | Near real time (for ENSO forecast) to a few weeks for scientific applications | | De Boyer Montegut, 2004, Maes et al. 2002; Qu et al. 2014 | | | Combination with in situ measurements (but most of them are deeper than 2m depth, and hence may miss the upper layer stratification) | | |   Table 17 Requirement Table for barrier layer monitoring    References:  De Boyer Montégut, C., G. Madec, A. S. Fischer, A. Lazar, and D. Iudicone (2004), Mixed layer depth over the global ocean: An examination of profile data and a profile-based climatology, J. Geophys. Res., 109, C12003, doi:10.1029/2004JC002378.  Grodsky Semyon A., Reul Nicolas, Lagerloef Gary, Reverdin Gilles, Carton James A., Chapron Bertrand, Quilfen Yves, Kudryavtsev Vladimir N., Kao Hsun-Ying (2012). Haline hurricane wake in the Amazon/Orinoco plume: AQUARIUS/SACD and SMOS observations . Geophysical Research Letters , 39(L20603), 1-8 .  Maes, C., J. Picaut, and S. Belamari, 2002, Salinity barrier layer and onset of El Niño in a Pacific coupled model, Geophys. Res. Lett., 29(24), 2206, doi:10.1029/2002GL016029.  Qu, T., Y. T. Song, and C. Maes (2014), Sea surface salinity and barrier layer variability in the equatorial Pacific as seen from Aquarius and Argo, J. Geophys. Res. Oceans, 119, 15–29, doi:10.1002/2013JC009375.  Reul Nicolas, Quilfen Yves, Chapron Bertrand, Fournier Severine, Kudryavtsev Vladimir, Sabia Roberto (2014). Multisensor observations of the Amazon-Orinoco river plume interactions with hurricanes . Journal Of Geophysical Research-oceans , 119(12), 8271-8295 . Publisher's official version : <http://doi.org/10.1002/2014JC010107>.  Sengupta D.,Bharath R.G., Anitha D. S.  (2008), Cyclone-induced mixing does not cool SST in the post-monsoon north Bay of Bengal, Atmos. Sci. Let.,9, 1-6.  Shenoi, S. S. C., D. Shankar, Differences in heat budgets of the near-surface Arabian Sea and Bay of Bengal: Implications for the summer monsoon, J. Geophys. Res., 107(C6), doi:10.1029/2000JC000679, 2002.   1.1.2.   Fresh Water Fluxes Applications included in the “fresh water fluxes” topic were river plumes”, “rain” and ”ice melting”, which are based on  ... 1.1.2.1.  River Plumes Variations of precipitations above continents lead to variations of river discharges that induce variations in river plumes (Amazon/Orinoco, Congo, Niger, Mississipi).  Measuring sea surface salinity first contribute to observe river plume dynamics and Regions of Freshwater Influence (ROFI). Spatial scales considered are depending the river (from large river like Amazon and Congo rivers to small rivers). The details of the SSS spatial structures at kilometer scale is most of the time not reachable while it strongly affects the ocean circulation on a large part of shelves. Today only very sparse measurements of the plume extent can be obtained in situ either from ship campaigns limited in time or from moorings/autonomous instruments which spatial distribution is very incomplete except through ocean colour - suspended particulate matter - (strong cloud limitation in some regions) are available. In situ observations show that fronts related to river plume can reach several psu over few hundred of meters. The temporal variability of these features is related to the wind forcings and can vary from few hours to days.  Signature of large river plumes have been much better documented than before thanks to SMOS measurements in the tropics (e.g. Reul et al. 2014a,b ; Hopkins et al., 2013 ; Grodsky et al., 2012 ;2013 ; Korosov et al., 2015 ; Fournier 2014; Fournier et al. 2015,2016). At high latitudes, combining SMOS SSS with CDOM estimated from ocean color has recently permitted to estimate the origin of the interannual variability of the waters in the Mackenzie river mouth (contributions of ice melting with respect to river discharge) (Matsuoka et al. 2016).   | **EO Level Product** | **Threshold** | | | **Breakthrough** | | | **Goal** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **S** | **T** | **A** | **S** | **T** | **A** | **S** | **T** | **A** | | 2-3 | 1° | month | 1 | 0.5° | 8d | 0.2 | 1km | 1d | 1 | | **SRL** | **ARL** | **Latency** | | **References/ATBD** | | | **Uniqueness of L-Band/ Alternative products** | | | | 7 | 6 |  | | Reul et al 2014b, Fournier et al. 2014, 2015 | | | Uniqueness | | |   Table 18 Requirement Table for SSS in river plumes  References:  Fournier S., Lee T., Gierach M. (2016). Seasonal and interannual variations of sea surface salinity associated with the Mississippi River plume observed by SMOS and Aquarius. Remote Science of Environment, Remote Sensing of Environment, 180, 431-439.  Fournier S., Chapron B., Salisbury J., Vandemark D., Reul N. (2015). Comparison of spaceborne measurements of Sea Surface Salinity and colored detrital matter in the Amazon plume. Journal of Geophysical Research,vol 120.  Fournier S., (2014)Spatio-temporal  coherence  between  spaceborne  measurements of  salinity  and  optical properties   in   the   Amazon-Orinoco   plume   region, PhD thesis, UBO, Brest, France.  Grodsky, S.A., G. Reverdin, J.A. Carton, and V. Coles (2013).Year-to-year salinity changes in the Amazon plume: contrasting 2011 and 2012 Aquarius/SACD and SMOS satellite data. In Press, Rem. Sens. Environ., doi:10.1016/j.rse.2013.08.033.  Jo Hopkins, Marc Lucas, Claire Dufau, Marion Sutton, Jacques Stum, Olivier Lauret, Claire Channelliere, Detection and variability of the Congo River plume from satellite derived sea surface temperature, salinity, ocean colour and sea level, Remote Sensing of Environment, Volume 139, December 2013, Pages 365-385, ISSN 0034-4257, <http://dx.doi.org/10.1016/j.rse.2013.08.015>.  Korosov, A., F. Counillon, and J. A. Johannessen (2015), Monitoring the spreading of the Amazon freshwater plume by MODIS, SMOS, Aquarius, and TOPAZ, J. Geophys. Res. Oceans, 120, 268–283, doi:10.1002/2014JC010155  A. Matsuoka, M. Babin, and E.C. Devred,”A new algorithm for discriminating water sources from space: A case study for the southern Beaufort Sea using MODIS ocean color and SMOS salinity data”. Remote Sensing of Environment 184, 124-138 (2016)  Reul Nicolas, Quilfen Yves, Chapron Bertrand, Fournier Severine, Kudryavtsev Vladimir, Sabia Roberto (2014a). Multisensor observations of the Amazon-Orinoco river plume interactions with hurricanes . Journal Of Geophysical Research-oceans , 119(12), 8271-8295. Publisher's official version : <http://doi.org/10.1002/2014JC010107>.  Reul Nicolas, Fournier Severine, Boutin Jacqueline, Hernandez Olga, Maes Christophe, Chapron Bertrand, Alory Gael, Quilfen Yves, Tenerelli Joseph, Morisset Simmon, Kerr Yann, Mecklenburg Susanne, Delwart Steven (2014b). Sea Surface Salinity Observations from Space with the SMOS Satellite: A New Means to Monitor the Marine Branch of the Water Cycle . Surveys In Geophysics , 35(3), 681-722 . <http://doi.org/10.1007/s10712-013-9244-0> 1.1.2.2.  Rain While more than 75% of precipitations occur over the ocean, using satellite salinity as a rain gauge is challenging because both freshwater fluxes and ocean dynamics govern sea surface salinity variability (see for instance Hasson et al., 2014, Yu et al. 2015, Guimbard et al. 2016). On another hand,  when looking at very short time scales (typically 30mn) in tropical regions, strong correlations exist between SSS freshenings and instantaneous rain rates, similar in magnitude to the ones expected from earlier conceptual modelling studies (see a review in Boutin et al. 2016).  Although RR accumulation obtained from various rain rates (RR) products tend to agree on average in the tropics (Adler et al. 2012), locally there are still disagreement (e.g. Liu and Zipser (2014)  found significant differences in the tropical ITCZ between radar RR and microwave RR). With that respect, RR derived from SSS could bring an independent additional constraint over the ocean, where very few in situ RR measurements exist.  In addition, SMOS and SMAP measurements are in 40% of cases at further than 0.5h from Global Precipitation Mission (GPM) microwave radiometers hence providing new constraints for characterizing the variability of this very intermittent process, as shown by Supply et al. (2017).     | **EO Level Product** | **Threshold** | | | **Breakthrough** | | | **Goal** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **S** | **T** | **A** | **S** | **T** | **A** | **S** | **T** | **A** | | 2 | 0.5° | <1hr | 1 | 0.1° | <1hr | 1 | .1° | <1hr | 0.2 | | **SRL** | **ARL** | **Latency** | | **References/ATBD** | | | **Uniqueness of L-Band/ Alternative products** | | | | 5 | 5 | Near real time if assimilation in operationnal models | | Supply et al. 2017 | | | Alternative products: microwave radiometer participating to GPM constellation | | |   Table 19 Requirement Table for rain rate derivation from SSS  References:  Adler, R.F., G. Gu, and G.J. 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Ballabrera-Poy (2014), Analyzing the 2010–2011 La Niña signature in the tropical Pacific sea surface salinity using in situ data, SMOS observations, and a numerical simulation, Journal of Geophysical Research: Oceans, 119(6), 3855-3867, doi:10.1002/2013JC009388.  Liu, C., & Zipser, E. (2014). Differences between the surface precipitation estimates from the TRMM precipitation radar and passive microwave radiometer version 7 products. Journal of Hydrometeorology, 15(6), 2157-2175. DOI: 10.1175/JHM-D-14-0051.1  Supply, A., J. Boutin, J.-L. Vergely, N. Martin, A. Hasson, G. Reverdin, C. Mallet, N. Viltard (2017), Precipitation estimates from SMOS sea-surface salinity. Q.J.R. Meteorol. Soc.. doi:10.1002/qj.3110. 1.1.3.   Ocean Circulation Applications included in the “ocean circulation” topic were “mesoscale eddy propagation”, Tropical Instability Waves, AMOC, and “density compensation”. 1.1.3.1.  Mesoscale Eddy Propagation Meso-scale and sub-mesoscale processes are responsible for large gradients of physical and biogeochemical properties (see a review in Lévy et al. 2012) that may influence the transport of ocean properties within the ocean. The role of the submesoscale structures in the salinity budget, like for instance their role relative to the maintenance of the maximum salinity in the north subtropical region is very significant as hown in the SPURS campaigns. In addition, simulations have shown that including eddies in ocean circulation models modify the low frequency variability and the transport of water masses (Penduff et al. 2011, Deshaye et al. GRL 2013). As a consequence, the french operational ocean modelling community foresee to reach a resolution of 1/36° (~3km) in 2024 (prospective oceanographie operationnelle available on <http://www.mercator-ocean.fr/fre/science/gmmc/Prospective-Oceanographie-Operationnelle>). The validation of such models require measurements having similar resolution. The horizontal gradients of sea surface temperature (SST) are relatively well monitored owing to infrared and visible satellite images, although they are limited to non cloudy areas. It is expected that high resolution altimetry (SWOT) will provide high resolution geostrophic currents; however the geostrophic hypothesis does not always hold in the open ocean so that monitoring density at the ocean surface requires a measure of the SSS et high resolution.  The analysis of ship measurements (Delcroix et al., 2005), and later of satellite measurements have demonstrated a natural variability of the SSS much larger than 0.1pss in regions caracterized by large mesoscale variations (see Boutin et al. 2016). In these regions, satellite SSS have a much better precision than the one obtained in averaging data issued from the Argo network and allow to monitor SSS variability in regions caracterized by high mesoscale activity (Reul et al. 2012, Kolodziejczyk et al. 2015, Isern-Fontanet et al. 2016).     | **EO Level Product** | **Threshold** | | | **Breakthrough** | | | **Goal** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **S** | **T** | **A** | **S** | **T** | **A** | **S** | **T** | **A** | | 3 or 4 | 100km | 1month | 0.2 | 25km | 1week | 0.1 | 3km | 1week | 0.05 | | **SRL** | **ARL** | **Latency** | | **References/ATBD** | | | **Uniqueness of L-Band/ Alternative products** | | | | 4 | 3 | Near real time if to be assimilates in ocean model | | Reul et al. 2012, Kolodziejczyk et al. 2015, Isern Fontanet et al. 2016 | | | Uniqueness | | |   Table 20 Requirement Table for mesoscale eddy  References:  Isern-Fontanet J., E. Olmedo, A. Turiel, J. Ballabrera-Poy, and E. García-Ladona (2016), “Retrieval of eddy dynamics from SMOS Sea Surface Salinity measurements in the Algerian Basin (Mediterranean Sea)”. Geophys. Res. Lett. 43,  doi:10.1002/2016GL069595.  Kolodziejczyk, N., O. Hernandez, J. Boutin, and G. Reverdin (2015), SMOS salinity in the subtropical North Atlantic salinity maximum: 2. Two-dimensional horizontal thermohaline variability, Journal of Geophysical Research: Oceans, doi:10.1002/2014JC010103.  Lévy, M., R. Ferrari, P. Franks, A. Martin and P. Rivière (2012), Bringing physics to life at the submesoscale, GRL frontier article, 39, L14602, doi:10.1029/2012GL052756  Reul, N., B. Chapron, T. Lee, C. Donlon, J. Boutin and G. Alory, 2014. Sea Surface Salinity structure of the meandering Gulf Stream revealed by SMOS sensor, Geophysical Research Letters, 41(9), 3141-3148, doi:10.1002/2014gl059215. 1.1.3.2.  Tropical Instability Waves Tropical Instability Waves (TIWs) are westward-traveling waves associated with shear instabilities of the equatorial current system, and are observed at the edges of the equatorial cold tongues in the Pacific and Atlantic Oceans. TIWs have average wavelengths of 1000-2000 kilometers, periods of 20-40 days, and phase speeds of 0.3-0.5 m/s. These waves redistribute various ocean properties, including temperature, salinity, and nutrients. They interact with ocean currents and large-scale climate variability, such as the El Niño-Southern Oscillation, and influence marine ecosystems and the carbon cycle.  Before satellite sea surface salinity measurements, TIWs have been observed by satellite observations of sea surface temperature, sea level, ocean surface wind, and ocean surface chlorophyll-a and sparse direct ocean measurements. Salinity has been found to play an important role in the physics of these waves, and observations of the salinity structure are important to understanding TIWs and their impact on climate variability and biogeochemistry. However, in situ salinity observations of TIWs have been limited to very sparse direct ocean measurements. Aquarius (Lee et al. 2012) and SMOS (Yin et al. 2014) have open a new era in the monitoring of these waves and have shown interannual variability of their phase speed at the equator in relation with ENSO.     | **EO Level Product** | **Threshold** | | | **Breakthrough** | | | **Goal** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **S** | **T** | **A** | **S** | **T** | **A** | **S** | **T** | **A** | | 3 or 4 | 100km | 8d | 0.2 | 50km | 8d | 0.1 | 25km | 4d | 0.1 | | **SRL** | **ARL** | **Latency** | | **References/ATBD** | | | **Uniqueness of L-Band/ Alternative products** | | | | 4 | 3 |  | | Lee et al. GRL 2012  Yin et al. JGR 2014 | | | Uniqueness for spatial monitoring / moorings for temporal monitoring | | |   Table 21 Requirement Table for TIW  References:  Lee, T., G. Lagerloef, M. M. Gierach, H.-Y. Kao, S. Yueh, and K. Dohan (2012), Aquarius reveals salinity structure of tropical instability waves, Geophys. Res. Lett., 39, L12610, doi:10.1029/2012GL052232.  Yin, X., J. Boutin, G. Reverdin, T. Lee, S. Arnault, and N. Martin (2014), SMOSSea Surface Salinity signals of tropical instability waves, Journal of Geophysical Research: Oceans, 119(11), 7811-7826, doi:10.1002/2014JC009960.   1.1.3.3.  AMOC The deep convection contributing to the Atlantic Meridional Overturning Circulation (AMOC) strongly influences the global climate system. With global climate models projecting surface ocean warming, freshening and increasing stratification at high latitudes, and weakening of the AMOC [e.g., Collins et al., 2013], it is important to have ongoing robust observations of various aspects of the AMOC, including water mass production, properties and transformation rates in major deep convection areas. As reviewed in Yashayaev et Loder 2016, recent studies indicate that the AMOC and its variability are extremely complex. It has temporal variability on a wide range of time scales (Srokosz and Bryden, 2015), and there are uncertainties regarding the linkages between deep convection and the AMOC, and the origin and structure of AMOC variability.  Up to now, satellite salinities have provided very poor information onto AMOC variability due to the very large RFI pollution at high latitudes in the northern Atlantic Ocean and to the poor signal to noise ratio. On another hand, very few in situ measurements are available in these regions and, given the relatively large spatio-temporal variability observed in situ (e.g. Yashayaev et Loder 2016) and the high temporal revisit of satellite measurements at high latitudes, improved RFI filtered L-band measurements could improve the monitoring of AMOC variability.     | **EO Level Product** | **Threshold** | | | **Breakthrough** | | | **Goal** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **S** | **T** | **A** | **S** | **T** | **A** | **S** | **T** | **A** | | 3 or 4 | 100km | 2weeks | 0.2 | 100km | 1month | 0.05 | 100km | 2weeks | 0.02 | | **SRL** | **ARL** | **Latency** | | **References/ATBD** | | | **Uniqueness of L-Band/ Alternative products** | | | | 3 | 3 |  | | Yashayaev et Loder 2016 | | | Uniqueness | | |   Table 22 Requirement Table for AMOC  References:  Collins, M., et al. (2013), Long-term climate change: Projections, commitments and irreversibility, in Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, edited byT. F. Stocker et al., pp. 1029–1136, Cambridge Univ. Press, Cambridge, U. K.  Srokosz, M. A., and H. L. Bryden (2015), Observing the Atlantic Meridional Circulation yields a decade of inevitable surprises, Science, 348(6241), 1330, doi:10.1126/science.1255575.  Yashayaev, I., and J. W. Loder (2016),Recurrent replenishment of Labrador Sea Water and associated decadal scale variability, J. Geophys. Res. Oceans, 121, 8095–8114, doi:10.1002/2016JC012046.   1.1.3.4.  Density Compensation In the surface mixed layer, horizontal density fronts slump under gravity, which competes with the vertical shear and mixing thus induced by thermal wind (due to surface horizontal density gradient) and surface forcing. Vertical mixing diffuses the horizontal density field and reduces the horizontal density gradient [Young, 1994; Rudnick and Martin, 2002]. The net results are that density fronts are diffused while the temperature and salinity compensated fronts persist (see a review in Kolodziejczyk et al., 2015). Hence, the monitoring of sea surface temperature (SST) is not sufficient to monitor the variability of the density which is a major driver of ocean circulation and mixing.     | **EO Level Product** | **Threshold** | | | **Breakthrough** | | | **Goal** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **S** | **T** | **A** | **S** | **T** | **A** | **S** | **T** | **A** | | 3 or 4 | 0.5° | 1month | 0.3 | 0.25° | 8d | 0.15 | .01° | 1d | 0.05 | | **SRL** | **ARL** | **Latency** | | **References/ATBD** | | | **Uniqueness of L-Band/ Alternative products** | | | | 4 | 3 |  | | Kolodziejczyk et al., 2015 | | | Uniqueness at 50km resolution spatial scale | | |   Table 23 Requirement Table for Density compensation   1.1.4.   Ocean Carbon Cycle and Biochemistry Applications included in the “carbon cycle and biochemistry” topic were “CO2 fluxes” and “alkalinity” which are based on  ... 1.1.4.1.  Ocean CO2 Fluxes CO2 increase in the atmosphere is widely considered the main cause of current climate change. Since the industrial revolution, it is estimated (e.g. Sabine et al. 2004, Khatiwala et al. 2009) that the oceans have absorbed about 40–50% of the anthropogenic CO2 emissions to the atmosphere, thus mitigating the effect of human activity over the Earth climate system. Nevertheless, studies have suggested that the oceanic C sink may be decreasing for the last 50 years (Canadell et al. 2007, Lequéré et al. 2009). Whether these changes are caused from anthropogenic climate change or internal climate variability is still debated (e.g. Lequéré et al. 2009, Mc Kinley et al. 2016) but they could significantly impact future atmospheric CO2 levels.  The monitoring of air-sea CO2 fluxes at global scale strongly relies on in situ ocean CO2 partial pressure, pCO2, measurements (e.g. SOCAT data base, Bakker et al. 2016) and on their spatio-temporal extrapolation (e.g. Landschuster et al. 2014). Given the spatio-temporal undersampling of in situ pCO2, the extrapolation methods is a very critical step. With that respect, SSS information brings a strong constraints being both an tracer of oceanic circulation and of freshwater fluxes. In particular it has been shown that satellite SSS allows to better understand and constraint the spatio-temporal variability of the air-sea CO2 exchanges due to the freshwater fluxes (precipitations (Brown et al. 2015) and river plumes (Lefèvre et al. 2014, Ibánhez et al. 2017).  Regular in situ data are needed to verify the calibration of any synergy approaches that intends to extrapolate in situ ocean CO2 partial pressure across a range of oceanic regions.  This can be achieved using research and opportunity cruises that transect regular lines over the whole ocean in the northern and southern hemisphere, through measurements in near real time and the collection of additional water samples (for carbon analysis) during any salinity validation campaigns. Regular validation will be required to assess any changes in algorithm calibration and/or any real change in the carbon system.  All carbon related algorithms require and exploit synergy approaches (i.e. additional observations are always required e.g. salinity + SST, or salinity + SST + ocean colour, or salinity + wind + SST etc).  Therefore for carbon research it is desirable to get all 'derived product data’ (e.g. salinity) available in the same data formats and projections recognized at the international level (e.g. Netcdf, ESA CCI format).     | **EO Level Product** | **Threshold** | | | **Breakthrough** | | | **Goal** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **S** | **T** | **A** | **S** | **T** | **A** | **S** | **T** | **A** | | 2, 3 or 4 | 100km | 1 month | 0.2 | 50km | 1month | 0.1 | 25km | 1week | 0.1 | | **SRL** | **ARL** | **Latency** | | **References/ATBD** | | | **Uniqueness of L-Band/ Alternative products** | | | | 4 | 3 |  | | Brown et al 2015 | | |  | | |   Table 24 Requirement Table for air-sea CO2 fluxes  References:  Canadell J. G. et al. . Contributions to accelerating atmospheric CO2 growth from economic activity, carbon intensity, and efficiency of natural sinks. PNAS 104, 18866–18870 (2007).  Khatiwala S., Primeau F. & Hall T. Reconstruction of the history of anthropogenic CO2 concentrations in the ocean. Nature 462, 346–349 (2009).  Landschützer P., Gruber N., Bakker D. C. E. & Schuster U. Recent variability of the global ocean carbon sink. Global Biogeochem. Cycles. 28, 927–949 (2014).  Le Quéré C. et al. . Trends in the sources and sinks of carbon dioxide. Nature Geosci 2, 831–836 (2009).  McKinley G. A. et al. . Timescales for detection of trends in the ocean carbon sink. Nature 530, 469–472 (2016).  Sabine C. L. et al. . The Oceanic Sink for Anthropogenic CO2. Science 305, 367–371 (2004).   1.1.4.2.  Alkalinity As stated in (Lee et al. (2006) and references herein), ‘identifying the controls on surface AT is becoming increasingly important for understanding the effects of ocean acidification resulting from the addition of anthropogenic CO2 into surface waters. However, determining the global distribution of surface AT is problematic because in many parts of the ocean AT data are severely limited compared to the SSS and SST data sets, which are several orders of magnitude larger.’  ‘Total alkalinity (AT) variability in the surface ocean is controlled mainly by freshwater addition (precipitation and sea-ice melting) or removal (evaporation and sea-ice formation) which also acts to change salinity. In the (Sub)tropical oceans (i.e., 30°N−30°S), surface AT variations associated with water balance-induced changes in salinity account for more than ∼80% of total variability in AT. At higher latitudes (i.e., north of ∼30°N or south of ∼30°S), a progressive increase in the convective mixing of deep waters rich in AT during seasonal cooling is an important additional factor that acts to increase surface AT concentrations. The greater the intensity of seasonal convective mixing; the higher the AT associated with the dissolution of CaCO3 and the lower the water temperature. In this case, AT is negatively correlated with sea surface temperature.’ …’Overall, variations in both sea surface salinity (SSS) and temperature (SST) can be good proxies for surface AT variations’.  Hence, using such relationships between AT, SSS and SST it is possible to reconstruct the spatio-temporal variability of AT (Land et al, 2015, Fine et al. 2017, Salisbury et al. 2015) from satellite SSS.  The requirements reported below have been estimated to get a primarily set by need to derive alkalinity and dissolved inorganic carbon (as a lower precision is needed for air-sea CO2 gas fluxes):  ·    Goal: 0.05 PSU (global, including the Arctic), this enables alkalinity to be determined within 4 umol/kg  ·    Breakthrough: 0.1 PSU (global, including the Arctic), this enables alkalinity to be determined within 8 umol/kg (this accuracy is comparable to the empirical algorithms used to calculate alkalinity).  ·    Threshold: 0.2 PSU (global, including the Arctic), this enables alkalinity to be determined within 16 umol/kg (useful for regions of strong variations e.g. the Amazon Plume).     | **EO Level Product** | **Threshold** | | | **Breakthrough** | | | **Goal** | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **S** | **T** | **A** | **S** | **T** | **A** | **S** | **T** | **A** | | 3 or 4 | 100km | 1month | 0.2 | 50km | 1month | 0.1 | 25km | 1week | 0.05 | | **SRL** | **ARL** | **Latency** | |  |  |  |  |  |  |   ... | |

### Comment 4

|  |  |
| --- | --- |
| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| See below Table | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | Sea surface salinity | | | | |
| **Definition** | Salinity of seawater, at or near the surface - Salinity is unitless, and is expressed with the suffix psu (practical salinity unit, PSS-78). | | | | |
| **Unit** |  | | | | |
| **Note** |  | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 5  Coastal: 1 |  |
| B |  |  |
| T | 100  Coastal: 10 |  |
| **Vertical Resolution** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** | day |  | G | 1 |  |
| B |  |  |
| T | 7 |  |
| **Timeliness** | day |  | G | 1 |  |
| B |  |  |
| T | 30 |  |
| **Required Measurement Uncertainty** | psu |  | G | 0.05 |  |
| B |  |  |
| T | 0.3 |  |
| **Stability** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Standards and References** |  | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  |  | | |
| **Extremes[3]** |  |  |  | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?