Read-me-first note for SMOS Level 2 Sea Surface Salinity data products	
Processor version	Level 2 OS version 662
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Further information	Details on the processing algorithms can be found in the Algorithm Theoretical Baseline Document (ATBD): ▪ SO-TN-ARG-GS-0007_L2OS-ATBD v3.13 available here: https://earth.esa.int/documents/10174/1854519/SMOS_L2OS-ATBD Information about the L2 sea surface salinity products structure can be found in the SMOS Level 2 and Auxiliary Data Products Specifications document: ▪ SO-TN-IDR-GS-0006 v8.5 available here: https://earth.esa.int/documents/10174/1854583/SMOS_L2_Aux_Data_Product_Specification Information on how to access the SMOS data can be found here: https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/smos/content/-/asset_publisher/t5Py/content/how-to-obtain-data-7329 Additional information, including documentation, product thumbnails and FAQs, can also be found on the SMOS L2OS website: https://smos.argans.co.uk/
Contact helpline	For all issues related to data access, formats, read/write, processors etc. please contact ESA's HelpDesk at eohelp@esa.int.
Comments to Level 2 Ocean Salinity team	The Level 2 Ocean Salinity team would like to receive your feedback to help identify problems, please contact: MArias@argans.co.uk, mailto:PSpurgeon@argans.co.uk, RDavies@argans.co.uk

1. Introduction

This note summarises the quality and major features of the SMOS Level 2 Sea Surface Salinity data products generated by version 662 of the Level 2OS Operational Processor (L2OS).

Version 662 of the Level 2 Sea Surface Salinity data product is now available for the SMOS mission lifetime with the following file class and version:

File class	File version	From	To
REPR	V662	1 June 2010	09 May 2017
OPER	V662	10 May 2017	present

The data set acquired during the SMOS mission commissioning phase (from January 2010 to 31 May 2010) has been acquired during periods when the MIRAS instrument underwent several tests and was operated in different modes, causing drifts not fully compensated by the on-ground calibration processing. For that reason, this data set has not been reprocessed with the latest version of the L2OS processor.

The SMOS data users are invited to use this new data set, which supersedes the previous one generated by the algorithm baseline version 622 and to read this note carefully to ensure optimum exploitation of the version 662 data set. Further information on the quality of the data set can be found in the reprocessing reports for data quality control available here: https://earth.esa.int/documents/10174/477987/SMOS-L2-OS-v662-Reprocessing-QC-Report and for data verification available here: https://earth.esa.int/documents/10174/477987/SMOS-Level-2-Ocean-Salinity-v662-Reprocessing-Report

2. Main improvements in the L2OS version 662 data set

The major improvements introduced in the currently operational version 662 of the SMOS Level 2 sea surface salinity processor are:

1. Modified User Data Product (UDP) containing salinities retrieved using only the **roughness model** previously known as model 1, or SSS1, which has now been selected as the **reference** model for estimating the sea roughness contribution to brightness temperature. Salinities retrieved using roughness models 2 and 3 are still available in the Data Analysis Product (DAP).

2. A new salinity product **corrected for land-sea contamination (LSC)** (SSS_corr). Contamination of L1 brightness temperatures when the instrument images a scene that includes a land-sea transition in the FOV (up to 1000 km from the coast) has been shown to introduce significant errors (up to 2 pss) in salinity fields. For a full description, see Annex 5 in the Algorithm Theoretical Baseline Document (ATBD), available here: https://smos.argans.co.uk/docs/deliverables/delivered/ATBD/SO-TN-ARG-GS-0007_L2OS-ATBD_v3.13_160429.pdf. Bias correction LUTs (so-called mixed-scene LUTs) have been generated from a long time series of L1 data for both ascending and descending orbits and are applied to L1 brightness temperatures before retrieval of SSS_corr. The method used to derive these land-sea

contamination correction LUTs is described in section 2.2.8 of the Table Generation Requirement Document (TGRD), available here: https://smos.argans.co.uk/docs/deliverables/delivered/TGRD/SO-TN-ARG-GS-0014_L2OS-TGRD_v3.14_160708.pdf. If land-sea contamination correction has been applied to any of the measurements used during SSS_corr retrieval, a flag (Fg_ctrl_mixed_scene) is set. Salinities retrieved without land-sea correction (SSS_uncorr) are also available in the UDP.

3. New (experimental) **salinity anomaly** product (SSS_anom) computed from SSS_corr and WOA 2009 climatology (SSS_anom = SSS_corr minus WOA 2009). Daily interpolated climatology is computed from the monthly WOA 2009 LUT before extracting SSS_anom. ESLs plan to develop a SMOS-based climatology to be used in future versions of the L2OS processor, with the objective of providing a de-biased SSS anomaly field.

4. New **scene-based filtering** algorithm to mitigate contamination from RFI and other sources (e.g., sun), based on a set of metrics comparing differences between brightness temperatures of successive snapshots including a complete polarization cycle (so-called scenes). A scene is defined in section 2.2.8.2 of the TGRD, and the scene-based filtering algorithm is described in section 2.2.8.4 of the TGRD, available here: https://smos.argans.co.uk/docs/deliverables/delivered/TGRD/SO-TN-ARG-GS-0014_L2OS-TGRD_v3.14_160708.pdf.

5. New **sun glint model** and sun brightness temperatures LUTs used as part of the forward model, and to set sun glint flags more accurately. Operational (OPER) products use a constant sun brightness temperature, whereas the reprocessed products (REPR) use a daily estimated L-band sun brightness temperature LUT for orbits prior to 22 November 2016.

6. **Roughness model 1** LUT has been **updated** by ESL, improving the estimation of forward model roughness brightness temperatures at wind speeds > 12 m/s.

7. **TEC retrieved** from SMOS 3rd Stokes polarimetric measurements used for both ascending and descending orbits (for both sea surface salinity retrievals and OTT computation), to provide an improved Faraday rotation estimation.

8. **Acard** parameter computed with land-sea corrected L1 brightness temperatures and the complete forward model including flat sea, roughness model 1, galactic and sun glint components.

9. Modified **UDP format**: see Tables below. Land sea contamination corrected salinities and associated fields/flags have suffix '_corr'; uncorrected salinities have suffix '_uncorr'; whilst anomalies have suffix '_anom'. For further details of the new UDP format see tables 47, 48 and 49 in section 3.2.6 of the Input/Output Data Definition Document (IODD) available here: https://smos.argans.co.uk/docs/deliverables/delivered/IODD/SO-TN-ARG-GS-0009_L2OS-IODD_v2.32_160708.pdf.

Field in version 662	Corresponding field in version 622
SSS_corr / Sigma_SSS_corr	SSS1 / Sigma_SSS1
Dg_quality_corr / Dg_ch2_corr / Dg_chi2_P_corr / Dg_num_iter_corr	Dg_quality_SSS_1 / Dg_chi2_1 / Dg_chi2_P_1 / Dg_num_iter_1
SSS_uncorr / Sigma_SSS_uncorr	SSS2 / Sigma_SSS2
Dg_quality_uncorr / Dg_ch2_uncorr / Dg_chi2_P_uncorr / Dg_num_iter_uncorr	Dg_quality_SSS_2 / Dg_chi2_2 / Dg_chi2_P_2 / Dg_num_iter_2
SSS_anom / Sigma_SSS_anom	SSS3 / Sigma_SSS3
Dg_quality_anom	Dg_quality_SSS_3
WS_corr / Sigma_WS_corr	Dg_chi2_3 / Dg_chi2_P_3
Coast_distance	Dg_num_iter_3
SSS_climatology	Dg_quality_Acard
Flags: Fg_ctrl/sc corr/uncorr/anom	Fg_ctrl/sc 1/2/3

Flag in version 662	Corresponding flag in version 622
Fg_ctrl_contaminated	None
Fg_ctrl_mixed_scene	None
None	Fg_ctrl_quality_Acard
Fg_sc_ecwmf_land	None

10. Updated configuration of **switches and filters** used in the data processing. For further information see the section 2.4.7 of the TGRD, available here: https://smos.argans.co.uk/docs/deliverables/delivered/TGRD/SO-TN-ARG-GS-0014_L2OS-TGRD_v3.14_160708.pdf

The L2OS version 662 data set has been generated using the same L1c data set as the previous L2OS version 622 data set: i.e., L1c data version 620. For further details on the L1c data sets see the L1c data version 620 read-me-first note available here: https://earth.esa.int/documents/10174/1854503/SMOS_L1OPv620_release_note

3. L2OS version 662 performance and caveats

The reprocessed data set has been analysed by ESLs and ARGANS. The reference document is mentioned above. The main conclusions are:

- Land-sea contamination corrected salinities (SSS_corr) almost cancel the global mean bias in near-to-coast regions (> 40 km and < 800 km) compared to SSS_uncorr. Also, there are more valid SSS_corr retrievals near to the coast than in SSS_uncorr (the LSC correction allows retrieval of previously contaminated pixels). However, in regions with high RFI (e.g. China seas, NW Indian Ocean, DEW line - see RFI probability maps from CESBIO: http://www.cesbio.ups-tlse.fr/SMOS_blog/smos_rfi/) or natural geophysical variability (e.g. river plumes), land-sea contamination correction is either unavailable (due to insufficient data to compute the land-sea correction LUT) or unreliable (due to a mismatch between WOA climatology and rapid salinity variability). In these regions, SSS_corr is prone to inaccuracies (see also plots in Section 5 below).

- Globally, the novel scene-based filtering and updated roughness model 1 determine an increase in the number of retrievals in both ascending and descending orbits. The new sun glint model also allows an increase in the number and quality of retrievals at the edge of the swath during periods of high sun glint (e.g., western edge of southern hemisphere descending orbits, in November-January) and high sun L-band intensity (2012-2015).

- The new experimental salinity anomaly product is still experimental, as the WOA 2009 climatology is not always directly related to SMOS surface salinities, especially in regions of high variability (e.g., ITCZ). ESLs plan to derive a SMOS-based climatology for future anomaly products, to provide a field intrinsically devoid of systematic errors. The El-Nino event of 2015-2016 is visible in Pacific region ascending and descending orbit Hovmoller plots (see Section 2.4.1 in the L2OS v662 reprocessing verification report).

- Across-track biases and ascending-descending differences still remain. Retrievals near to the edge of the swath (x_swath > ±~350 km) have higher uncertainties due to the smaller number of measurements, and contamination from various sources, especially sun aliases and associated ripples (tails). Ascending orbits have less bias than descending (see across-track Hovmoller plots in the L2OS v662 reprocessing verification report), while descending passes have stronger biases during January-March and October-December periods.

- ESLs have reported that there is evidence of residual inaccuracies in salinity retrievals due to TEC and galactic glint modelling issues. Therefore, users should be aware that salinities retrieved during periods of high TEC activity (corresponding to high solar activity, especially for descending orbits) and high galactic glint (see sections 5.2 and 5.5 in the L2OS Reprocessing Report) are less accurate.

- Strong latitudinal bias in SSS_corr can be seen in the Northern Hemisphere during March-May in both ascending and descending orbits (see global Hovmoller plots in figures 18 and 20 in the L2OS v662 reprocessing verification report), but these are not visible in SSS_uncorr. Similar latitudinal biases can also be seen in SSS_anom for Pacific and Atlantic regions (see Hovmoller plots in figures 35-39 in the L2OS v662 reprocessing report). Therefore, land-sea contamination corrected salinities (and anomalies) above 30N during these periods exhibit worse performance than elsewhere or in different periods of the year.

4. Filtering retrievals

We strongly recommend users to filter L2OS sea surface salinity retrievals using one of the following set of criteria:

1. For best quality data: Dg_quality_SSS < 150

2. For more data but with lower quality: Fg_ctrl_poor_geophysical = 0 and Fg_ctrl_poor_retrieval = 0

3. Other combinations of UDP flags and filters including at least Fg_ctrl_chi2 = 0 or Fg_ctrl_chi2_P = 0

4. Other filters used by the L2OS Expert Support Laboratories for generating Level 3 salinity maps as described in the L2OS v662 reprocessing verification report sections 2.1 and 2.2, available here: https://earth.esa.int/documents/10174/477987/SMOS-Level-2-Ocean-Salinity-v662-Reprocessing-Report

5. Examples of global performance

The following plots compare global SMOS L2OS salinities with ISAS at level 3, over the entire 6-year reprocessing window, showing the mean bias (SMOS minus ISAS) and standard deviation of the difference (SMOS minus ISAS) computed over this timeframe. They can be used as a basis for user data selection.

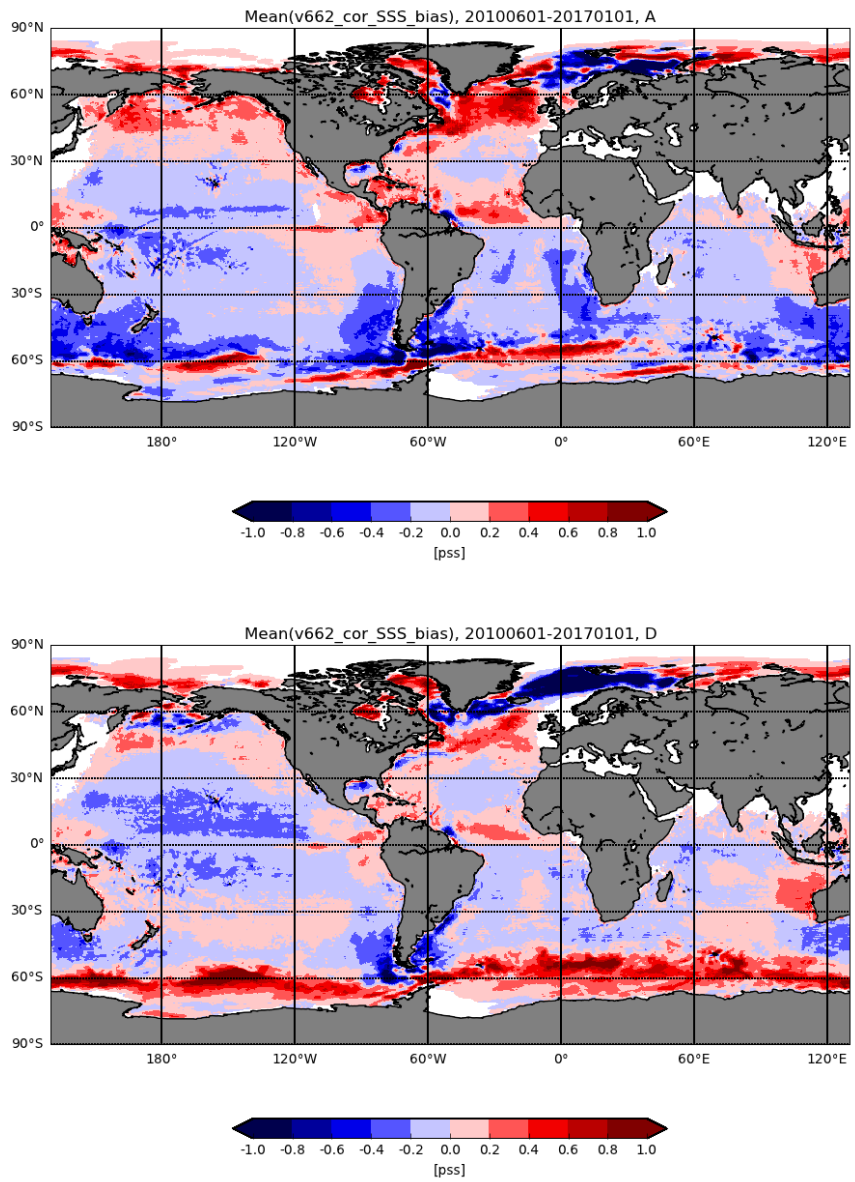

Figure 1: SSS_corr global bias for ascending (top) & descending (bottom) orbits

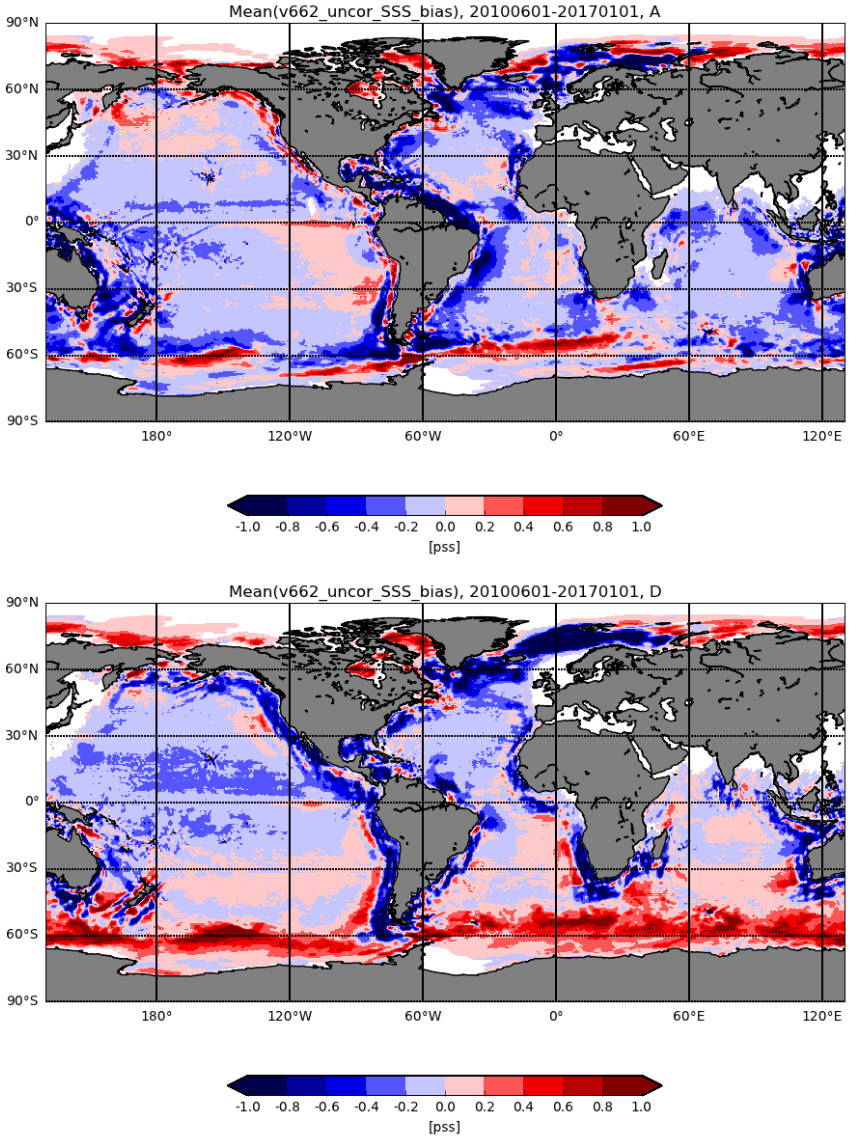

Figure 2: SSS_uncorr global bias for ascending (top) & descending (bottom) orbits

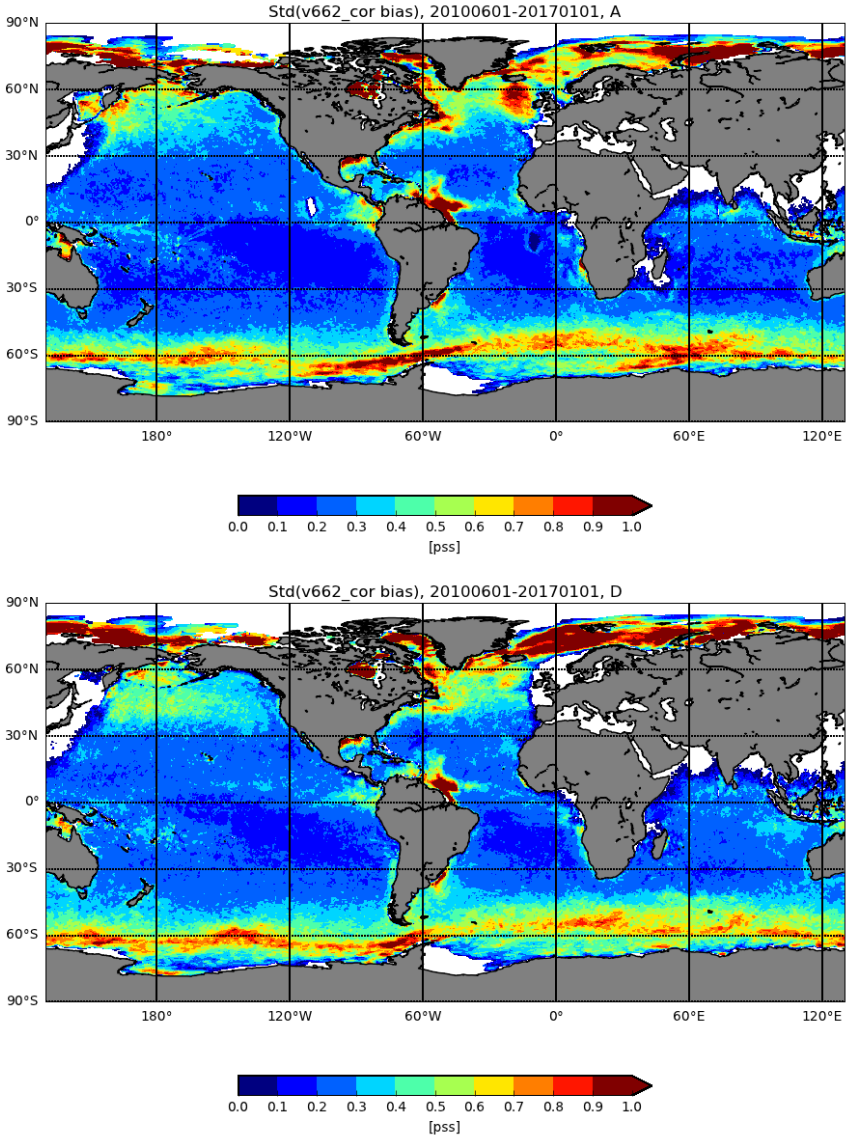

Figure 3: SSS_corr global std(SMOS minus ISAS) for ascending (top) & descending (bottom) orbits

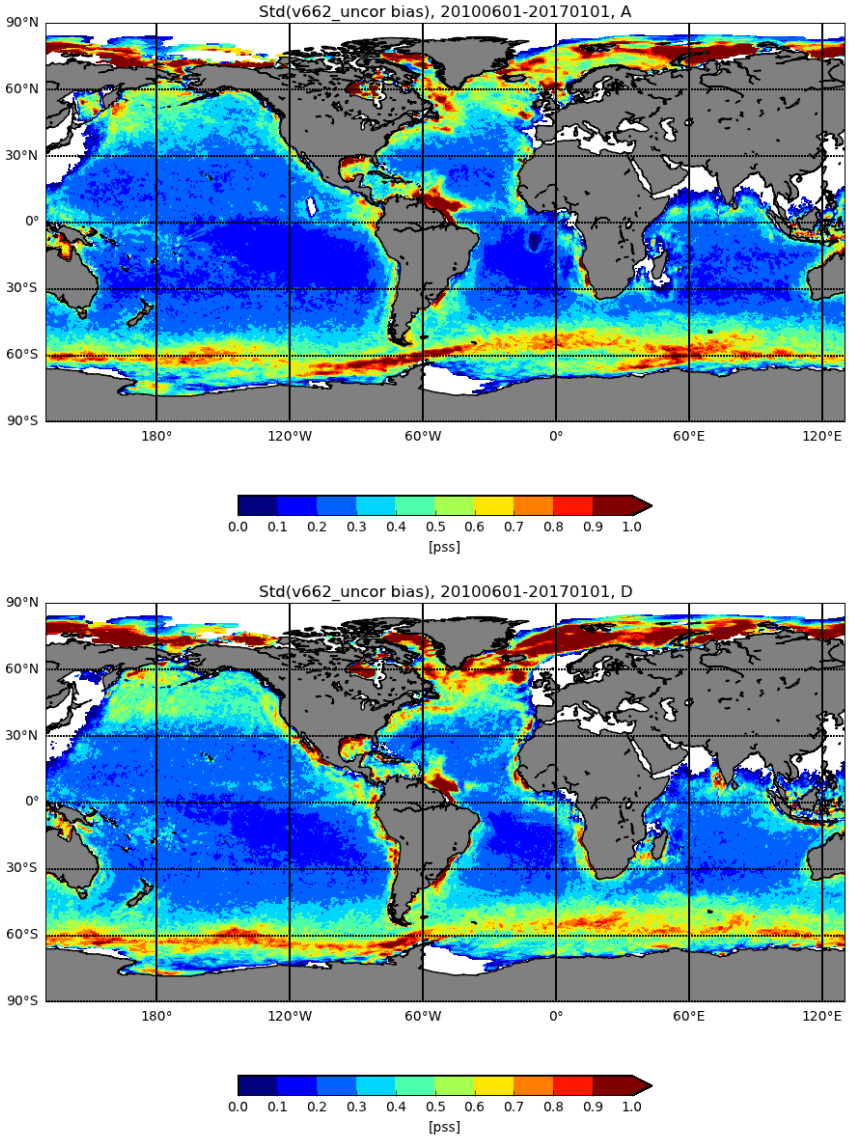

Figure 4: SSS_uncorr global std(SMOS-ISAS) for ascending (top) & descending (bottom) orbits