Read-me-first note for SMOS Level 2 Sea Surface Salinity data products	
Processor version	Level 2 OS version 622
Release date by ESA	Release 1: 7 May 2015, valid only for the operational data set Release 2: 2 March 2016, valid for both the operational and reprocessed data set
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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 v3.11 available here: https://earth.esa.int/web/guest/-/data-types-levels-formats-7631 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 v8.1 available here: https://earth.esa.int/web/guest/-/data-types-levels-formats-7631 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: www.argans.co.uk/smos
Contact for 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 allow identifying problems, please contact: mailto:PSpurgeon@argans.co.uk, MArias@argans.co.uk

1. Introduction

This note summarises the quality of the SMOS Level 2 Sea Surface Salinity data products generated by the version 622 of the Level 2OS Operational Processor (L2OS OP).

The version 622 of the Level 2 Sea Surface Salinity data product is now available for the entire SMOS mission life time with the following file class and version:

File class	File version	From	To
REPR	V622	1 June 2010	14 July 2015
OPER	V622	15 July 2015	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 is only available upon request and should not be used for long term data exploitation.

The SMOS data users are invited to use this new data set, which supersedes the previous one generated by the algorithm baseline version 550 and to read this note carefully to ensure optimum exploitation of the version 622 data set. Further information on the quality of the data set can be found in the reprocessing QC report available here: https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/smos/content/-/asset_publisher/t5Py/content/data-quality-7059)

This note is organised as follows:

- Main improvements in the L2OS version 622 data set
- L2OS version 622 performances and caveats
- Forthcoming algorithm modifications

2. Main improvements in the L2OS version 622 data set

The major improvements introduced in the currently operational version 622 of the SMOS Level 2 sea surface salinity processor are the following:

- New forward model for galactic signal correction (Geometric Optics model), which has been empirically adjusted to fit SMOS observations separately for ascending and descending passes. The model benefits from a wind speed dependence in the scattered brightness temperature of the reflected galactic signal.

- Updated empirical roughness model 3. The empirical pre-launch roughness impact correction proposed by the Barcelona Expert Centre (BEC) has been reviewed and reanalysed. A new model for the ocean surface emissivity modulation at L-band due to rough sea surface was derived with the help of a

simple neural network by Guimbard et al. (2012), see link below, using selected and corrected (for systematic error patterns) residual (roughness-induced) SMOS brightness temperatures, and considering incidence angle and wind speed as model parameters. For further details about the computation of the roughness model 3, see the IEEE TGRS paper available here: http://www.argans.co.uk/smos/docs/papers/Guimbard_TGRS_2012.pdf

- In version 550, an improved brightness temperature (TB) measurement selection (see Section 3.5 of the ATBD) was implemented. Nevertheless, anomalously low sea surface salinity remain on the borders of Radio Frequency Interference (RFI) contaminated regions (e.g. North Atlantic, North-west Pacific). In version 622, the filtering strategy changed: instead of filtering TBs, retrieved sea surface salinity were filtered based on the self-consistency of TBs along a dwell line. Although the latter was already applied in version 550, it was discovered that the pre-filtering of TBs before SSS retrieval worsened the efficiency of the sea surface salinity filtering (Chi2_P flag). As a result, the filtering of sea surface salinity with Chi2_P flag is more stringent in version 622 than in version 550 close to RFI regions and during periods with large heterogeneity along a dwell line, like the winter in the northern hemisphere during descending orbits.

- New Ocean Target Transformation (OTT) post-processor (OSCOTT) corrects drift daily. To minimise the temporal drifts of the systematic biases in the SMOS Field of View (FOV), the OTT applied to the SMOS L1c data introduced in previous processor versions is now calculated daily instead of monthly or every 15 days. This is done by means of a post-processor (OSCOTT) that takes into account the brightness temperature measurements acquired during the 10 days preceding the day when the correction is applied.

- TEC retrieval from SMOS third Stokes polarimetric measurements used for descending orbits (for both sea surface salinity retrievals & OTT computation) and for ascending orbits (only for OTT computation) to provide an improved Faraday rotation determination.

- Modified Level 2 Sea Surface Salinity User Data Product (UDP) format, please see table below. For further details see section 5.1 of the L2OS processor software release note available here: http://www.argans.co.uk/smos/docs/deliverables/delivered/OPSRD/SO-RN-ARG-GS-0019_L2OS-OPSRD_v2.17_130227.pdf and the Input/Output Data Definition Document (IODD) available here: http://www.argans.co.uk/smos/docs/deliverables/delivered/IODD/SO-TN-ARG-GS-0009_L2OS-IODD_v2.25_140905.pdf

New field added in version 622	**Field NOT available in version 622 (removed from version 550)**
X_swath	Sigma_SST
Dg_RFI_X/Y	Sigma_WS
Dg_RFI_probability	Dg_galactic_noise_pol
Dg_RFI_L1	Dg_RFI_L2
Flag: Fg_ctrl_rfi_prone_X	Science Descriptors Section

Flag: Fg_ctrl_rfi_prone_Y	Flag: Fg_ctrl_sel_gp
Flag: Fg_ctrl_adjusted_ra	Flag: Fg_ctrl_gal_noise_pol
Moved Field	
Dg_sky from the science descriptors in version 550 to product confidence descriptors in version 622	

- Bug fixes:
  a) In the iterative scheme exit condition (preventing occasional premature exit from convergence under specific geophysical conditions);
  b) In the computation of UDP fields TB_42.5X/Y/H/V (previous versions used priors instead of retrieved geophysical parameters);
  c) In galactic noise flagging (erroneously setting Fm_gal_noise_error, accumulated in the UDP Dg_Galactic_Noise_Error counter, resulting in unnecessary removal of valid salinity retrievals when filtering).

- Improved Acard filtering near ice: by retrieving grid points nearer to the Arctic and Antarctic, and reducing measurement discrimination during Acard retrieval, we are now able to better detect ice and icebergs in these regions.

- Configuration of switches and filters used in the data processing. For further information see the section 2.4.6 of the Table Generation Requirement Document available here: http://www.argans.co.uk/smos/docs/deliverables/delivered/TGRD/SO-TN-ARG-GS-0014_L2OS-TGRD_v3.11_150311.pdf

Besides these L2 algorithm modifications, improvements made at L1 processing also impact the now operational version 622 of the sea surface salinity products. For further details on the new L1 data sets see the L1 data version 620 read-me-first note available here: https://earth.esa.int/web/guest/-/data-processors-7632.

3. L2OS version 622 performances and caveats

An analysis has been performed of several reference datasets of the sea surface salinity products generated using versions 620 of the Level 1 processor and version 622 of the Level 2 processors. The analysis has been carried out to asses both i) the impact of Level 1 changes in L2OS products, and ii) the Level 2 changes themselves, by comparing the new output products to the old ones, to the Argo in-situ optimally interpolated maps (ISAS) and to the World Ocean Atlas climatology. The impact has been analysed through Level 3 sea surface salinity maps for different combinations of L1 and L2 versions:

- L1 version 620 and L2 version 622 vs. L1 version 505 and L2 version 550
- L1 version 620 and L2 version 622 vs. L1 version 505 and L2 version 622
- L1 version 505 and L2 version 622 vs. L1 version 505 and L2 version 505

to separately estimate the impact of the L1 and L2 modifications and to have the global comparison between the previous operational products version 550 and current operational products version 622. The technical note available here:

http://www.argans.co.uk/smos/docs/technotes/SO-TN-ARG-GS-0094_L2OS_v62x_ESL_Evaluation_141003.pdf provides a detailed summary of the results of the analysis. The user can see tabulated results of the comparison between currently operational products version 622 and the old products version 550 in terms of differences to World Ocean Atlas climatology and Argo ISAS maps, separately for ascending, descending and mixed orbits, and for open ocean, coastal regions (with expected land contamination) or globally. As derived from the statistical results, the new products evidence an improvement in terms of sea surface salinity maps quality.

Some improvements are observed with the use of the currently operational L1 processor version 620 (mainly a reduction of the latitudinal drift), but the strongest impact on sea surface salinity retrieval comes from L2OS processor version 622, and likely by the mitigation of fluctuating biases due to the application of a daily Ocean Target Transformation (OTT) correction. The comparison to Argo ISAS indicates an improvement of the sea surface salinity maps quality in terms of mean and standard deviations of the differences. Regional biases are much reduced in ascending (A) and descending (D) overpasses; slightly improved standard deviation (mainly in D, thanks to the TEC retrieval). It should be noted that differences in the ITCZ region are consistently negative in A and D (likely due to an effect of rain captured by SMOS). The new RFI detection strategy (see ATBD section 3.5 available here: https://earth.esa.int/web/guest/-/data-processors-7632) results in a decrease of the number of Level 1C data being included in the L2 sea surface salinity retrieval, but this impacts positively the overall quality of the sea surface salinity maps.

The impact of the daily OTT computation has been analysed by processing all South Pacific orbits for one year (April 2011 to March 2012), extracting sea surface salinity for a small 10 x 10 degree region (120-130W, 25-35S) and computing a 9-day running average. Results show improved tracking of Level 1C bias in version 620 in both ascending and descending orbits, resulting in smaller salinity deviations from climatology.

Note that in this version of the processing, the Level 1C version 620 data are still highly contaminated by land-sea transitions, which still generate biases and errors in the salinity retrieval at Level 2 within about 1000 km from the coasts, despite having been reduced compared to L2OS version 550. New processor versions (currently being finalized) will provide significant improvements with regard to this aspect. In the meantime the users have to be aware of this caveat and probably discard the contaminated data for most of the scientific applications along the coastlines.

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 selections used by the L2OS Expert Support Laboratories for generating salinity maps as described in the mentioned technical note. (http://www.argans.co.uk/smos/docs/technotes/SO-TN-ARG-GS-0094_L2OS_v62x_ESL_Evaluation_141003.pdf)

As previously mentioned, thermal effects in the antennae are the origin of a degradation of the SSS retrievals during winter time in the Northern Hemisphere. The timeframe over which this phenomenon occurs is called "eclipse period" (being related to the relative position of the instrument with respect to the sun), and has significant impact in the L1 TBs used in the L2OS processor, especially over 30ºN. The filtering proposed above will remove significant amounts of SSS data in the indicated time and location. Further details about this issue can be found in the following presentations:

- Bias trends in the 1-slope and L1 brightness temperatures (slides 36-47): https://smos.argans.co.uk/docs/technotes/jtenerelli_cal11.pptx.

- ESL Evaluation of L2OS v62x:
  - https://smos.argans.co.uk/docs/technotes/SO-TN-ARG-GS-0094_L2OS_v62x_ESL_Evaluation_141003.pdf.

Users of version 550 will notice a reduction in the number of retrievals obtained during the eclipse period when using the current version 622 baseline. The reduction is due to a better filtering strategy being applied to the data. Whilst version 550 was providing more retrievals, the obtained SSS was more biased. In version 622 there are less retrievals in this period of time, but with better quality. Further details of this approach can be found in the following document:

- L2OS Thresholds optimization: https://smos.argans.co.uk/docs/presentations/thresholds3_jlv.ppt.

The lack of sea surface salinity retrievals due to this filtering strategy, in relation to the eclipse period, impacts the descending passes of SMOS. It is recommended to use ascending passes to obtain SSS data over the eclipse period and the highlighted region.

4. Forthcoming algorithm modifications

As mentioned, main improvements in version 622 concern a decrease of seasonal and latitudinal systematic errors, flagging of RFI and correction for Faraday rotation. Nevertheless, systematic errors depending on latitude and season and within 1000 km from large land masses remain. The SMOS L2 OS Team has been working to improve the quality of the sea surface salinity retrievals, especially concerning the correction of Land/Sea contamination and filtering. As a result of this work, a new version of the sea surface salinity products is expected to be available late 2016 with noticeable improvements for these aspects. In detail, the following features will form part of the next version of L2OS processor:

- Empirical Land/Sea contamination correction.
- Scene-based L1c data filtering, which will further help to remove RFI and sun-contaminated measurements.

- Using a unique roughness model for the sea surface salinity retrieval, providing a single sea surface salinity as:
    - sea surface salinity mitigated for land/sea contamination
    - sea surface salinity without mitigation of land/sea contamination
    - sea surface salinity anomaly

Below the list of improvements for future versions of the processor. These features are at different degrees of maturity and expected for more advanced version of the L2OS processor. They are classified in terms of relevant development priorities.

Priority 1:

- Dielectric constant model evolution
- Improvement of the nonlinear roughness corrections

Priority 2:

- Refinement of the OTT strategy
- Improvement in glint models
- Development of an inversion-based quality control
- Assessment of alternatives for the retrieval: Test of various L2OS configurations for retrieving sea surface salinity; Two-step retrieval; Monte Carlo approaches
- TEC follow-up and product definition

Priority 3:

- Assessment of auxiliary data dependencies and SMOS/Aquarius consistencies
- Characterization of unaccounted geophysical effects (e.g., rain)