ESA CCI SST L2 CDRs from Passive Microwave observations and impact on L4 analysis

Jacob L. Høyer[1], Emy Alerskans[1], Pia Nielsen-Englyst[1], Chelle L. Gentemann[2], Mark Worsfold[3] and Simon Good[3],
[1] Danish Meteorological Institute (DMI), Denmark
[2] Earth and Space Research, USA
[3] UK Metoffice, England

1. Introduction

Sea surface temperature (SST) is an essential climate variable that is critical for assessing the climate system and its changes. A global L2P SST Climate Data Record (CDR) from AMSR-E and AMSR2 has been constructed within the ESA CCI SST project. A consistent retrieval algorithm has been developed for AMSR-E and AMSR2, using the ESA CCI Multi-sensor Matchup Database.
The passive Microwave (PMW) SSTs are validated against drifting buoy measurements covering the whole CDR period, showing very good performance, and the impact of the L2P records on the ESA CCI L4 system has been assessed.

2. Data

ESA-CCI Multi-sensor Matchup Dataset (MMD6C):

- AMSR-E L2A brightness temperatures from RSS (NSIDC) version 7.
- JAXA L1R brightness temperatures, version 2
- *In situ* SST from drifting buoys, Argo floats, GTMBA, radiometer, ships, XBT, CTD, bottle and animal.
- Auxiliary data – ERA-Interim NWP data.

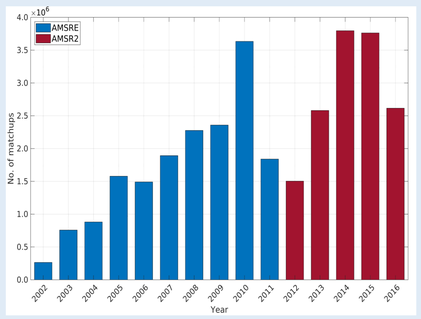


Figure 1. Number of matchups

3. PMW retrieval algorithm

The SST retrieval algorithm is a 2-step multiple linear regression model with localized retrieval algorithms:

$$SST_r = a_0 + \sum_{i=1}^{12} a_i t_i + b_i t_i^2 + c\theta_{EIA} + dWS + \sum_{j=1}^{2} e_j \cos j\varphi_{REL} + f_j \sin j\varphi_{REL}$$

where
$t_i = T_{Bi} - 150$ for all channels except the 23.6 GHz channels.
$t_i = -\ln(290 - T_{Bi})$ for the two 23.6 GHz channels.
i denotes the summation over 12 AMSR-E and AMSR2 channels; 6.9, 10.7, 18.7, 23.6, 36.5, 89.0 GHz.
1st step: Initial retrieval of SST using localized latitude and orbit-wise algorithms.
2nd step: Final retrieved SST using localized SST and wind speed algorithms.

The SST uncertainty retrieval algorithm is a multiple linear regression model:

$$\varepsilon_{SST_r} = f(SST_r, WS, \theta_{SZA}, \phi_{AMSR-E}, \varphi_{REL})$$

4. RFI/QC filter

A RFI and QC method has been developed. That uses retrieved SST from two additional algorithms:

- -10GHz: no 10 GHz channels.
- -18GHz: no 18 GHz channels.

Observations are discarded when the differences between retrieved SST and SST from -10GHz and -18GHz exceed 3σ

$$|(SSTr_{-10} - SSTr_{baseline}) - \mu_{-10}| > 3\sigma_{-10}$$
$$|(SSTr_{-18} - SSTr_{baseline}) - \mu_{-18}| > 3\sigma_{-18}$$

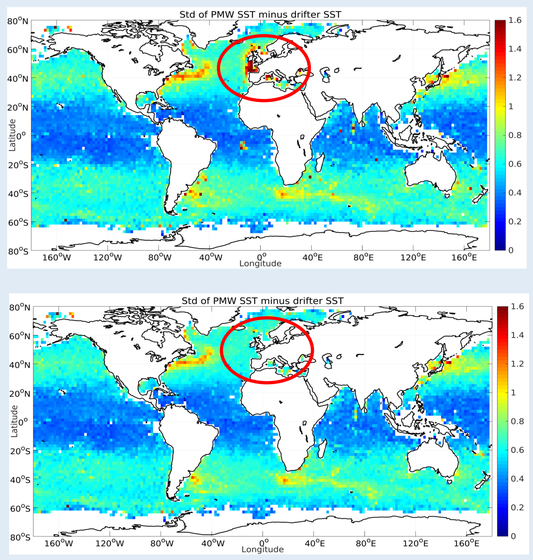


Figure 2. Gridded standard deviation of baseline PMW SST minus *in situ* SST without (upper) and with (lower) RFI/QC filter.

5. Validation of SST and Impact on L4

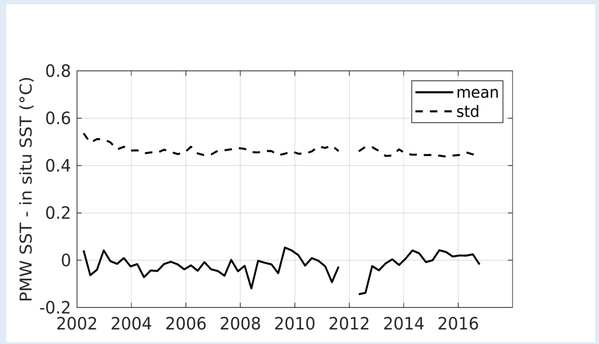


Figure 3. Mean (solid) and standard deviation (dashed) of PMW SST minus *in situ* SST.

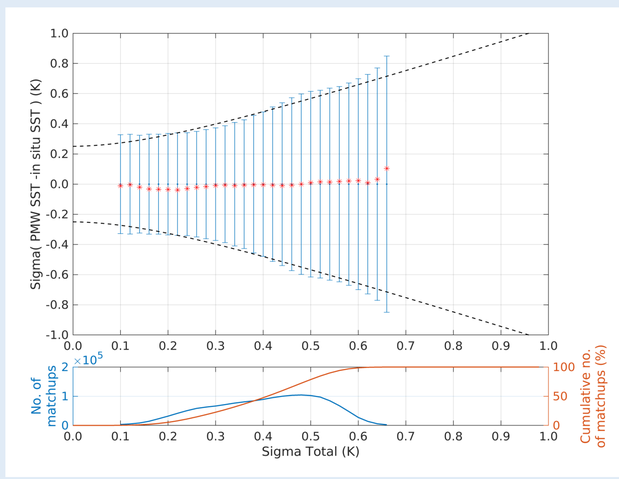


Figure 5. SST uncertainty validation against *in situ* drifter SST. Dashed lines show the ideal uncertainty model accounting for uncertainties in drifter SST and the sampling error. Solid black lines show one standard deviation of the PMW minus *in situ* differences for each 0.02 K bin and the red symbols mark the mean bias. The bottom plot shows the number of matchups (blue) and the cumulative percentage of matchups per bin (red).

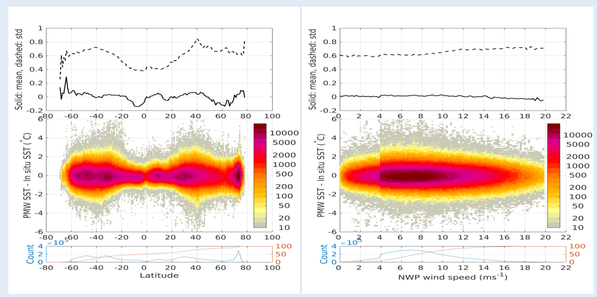


Figure 4. PMW SST minus *in situ* SST as a function of (left) latitude; and (right) NWP wind speed. Top panel shows the mean and standard deviation of the difference, mid panel shows distribution of matchups and bottom panel shows number of matchups per bin.

Sensor	Quality level	Mean Drifter (K)	Std Drifter (K)	No. of matchups	Mean Argo (K)	Std Argo (K)	No. of matchups
AMSR-E	3	0.02	0.64	2,763,087	0.01	0.62	39,939
	4	-0.01	0.51	4,399,894	-0.00	0.50	60,398
	5	**-0.03**	**0.37**	**2,753,625**	**-0.02**	**0.36**	**48,558**
	4-5	-0.02	0.46	7,153,519	-0.01	0.44	108,956
AMSR2	3	0.02	0.64	1,729,073	0.03	0.62	37,273
	4	0.01	0.52	2,549,348	0.02	0.51	57,343
	5	**-0.00**	**0.45**	**2,000,938**	**0.00**	**0.34**	**60,089**
	4-5	0.00	0.35	4,550,286	0.01	0.43	117,432

Table 1. Validation of AMSR-E and AMSR2 SSTs against independent observations from drifting buoys and Argo floats and for different quality levels

Effect on L4

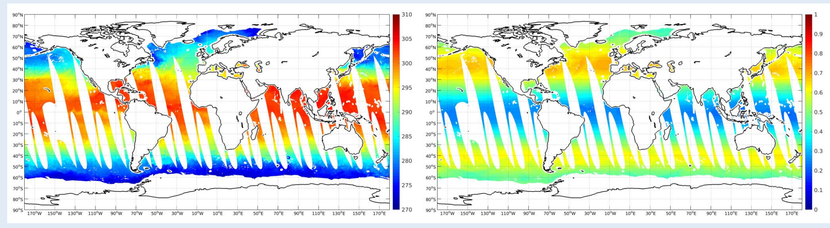
Sensor	IR Only: Mean Diff	IR Only: Mean Stddev	IR + PMW: Mean diff	IR + PMW: Mean Stddev	No. of matchups
AMSR-E	-0.065	0.445	-0.040	0.415	473987
AMSR2	0.053	0.452	0.026	0.395	337634

Table 2. Impact of L2P PMW SSTs on ESA CCI L4 product, for AMSR-E (2002-2011) and AMSR2 (2012-2016) against Argo observations**. See Poster by M. Worsfold for more details.**

6. ESA CCI PMW products (SST + Wind speed)

2010-06-10

Figure 6: Example of one day) of ascending AMSR-ESST (left) and uncertainties (right**)**



Product Description	Data coverage	Spatial resolution	Product grid resolution
AMSR-E L2 SST + Wind Speed	June 1, 2002– October 4, 2011	75 x 43	10 km
AMSR-2 L2 SST + Wind Speed	July 2, 2012 – October 26, 2017	62 x 35	10 km
L4 SST Analysis including IR L3U and PMW L2P data	June 2, 2002– December 31, 2016	-	0.05 degreee

7. Conclusions

- Consistent SST and Wind speed retrievals developed for AMSR-E and AMSR2
- New efficient RFI/QC filter applied
- Good agreement between observed and retrieved uncertainties.
- CDRs produced from 2002 to 2017 of PMW SST + Wind Speed
- Significant positive impact on L4 product (see also poster by M. Worsfold)
- Data sets available from : www.neodc.rl.ac.uk

Contact: Jacob L. Høyer (jlh@dmi.dk)

Acknowledgements

This research is supported by the ESA Climate Change Initiative (ESA-CCI) SST project.