Assessment of the Impact of Sentinel-3A And -3B SLSTR L2P Sea Surface Temperature Data on OSTIA

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Introduction

The Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) system produces daily, globally complete, near real time (NRT) analyses on a 1/20 degree (~6 km) grid. Data production, maintenance and development of the system are supported by the Copernicus Marine Environment Monitoring Service (CMEMS). Data are made available from their website (marine.copernicus.eu).Sentinel-3A (S3A) SLSTR data are assimilated operationally from **March 2019** (OS42), with Sentinel-3B (S3B) SLSTR being tested additionally in a pre-operational suite from **April 2019** (+S3B_NOAA20). The test run is the first time that two dual-view sensors are being used in OSTIA. The impact of ingesting two Sentinel-3 SST products in OSTIA is examined using independent Argo floats and in the Met Office Numerical Weather Prediction (NWP) system.

Two methods of skin-to-bulk adjustment (Skin2Bulk) for Sentinel-3 SSTs are investigated in preparation for using Sentinel-3 SSTs as the reference used to bias correct the other satellite data: a constant 0.17 K adjustment and wind dependent adjustment introduced in Donlon et al. (2002, hereafter WD method). The outputs from two test runs (S3A_Ref_Fix and S3A_Ref_WD) during June – July 2018 indicated similar results, and both were comparable to the pre-operational OSTIA at the time (became OS42 in March 2019). Note the two OS42 test runs used Sentinel-3A SLSTR SST as the reference, whilst OS42 used ASCPO L3U VIIRS SST as the reference.

System Guide

OSTIA system	Reference[1]	Skin2Bulk Method
OS42	SNPP VIIRS	Fixed 0.17 K
S3A_Ref_Fix	Sentinel-3A SLSTR	Fixed 0.17 K
S3A_Ref_WD	Sentinel-3A SLSTR	Donlon wind speed based method
+S3B_NOAA20	SNPP & NOAA20 VIIRS	Fixed 0.17 K

[1] The satellite product listed here is used together with in situ observation from moored and drifting buoys to form the reference dataset in OSTIA

Preliminary Sentinel-3A SLSTR reference test

Table 1. Argo-minus-OSTIA statistics for Sentinel-3A experiments and Operational OSTIA

Region	Mean difference (K)			Standard deviation differences (K)			Num. matchups
	OS42	S3A_Ref_Fix	S3A_Ref_WD	OS42	S3A_Ref_Fix	S3A_Ref_WD	
Global Ocean	0.05	**0.01**	**-0.01**	0.40	0.40	0.40	19879
North Atlantic	0.02	**-0.13**	**-0.15**	0.56	0.55	0.55	3477
North Pacific	0.04	-0.04	**-0.07**	0.42	0.42	0.42	4667
Tropical Atlantic	0.11	**0.03**	**0.02**	0.31	**0.27**	**0.27**	1565
Tropical Pacific	0.03	**-0.01**	-0.03	0.21	0.21	0.21	4576
Indian Ocean	0.13	**0.04**	**0.03**	0.37	0.36	0.36	3262
South Atlantic	0.04	**0.09**	**0.07**	0.43	0.43	0.43	2384
South Pacific	0.03	**0.07**	**0.06**	0.26	0.27	0.27	6180
Southern Ocean	0.05	**0.11**	**0.10**	0.38	**0.40**	**0.40**	4824

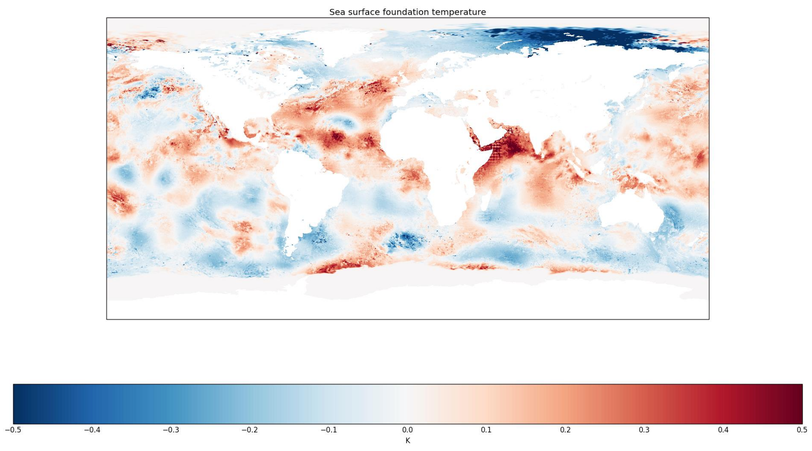

Figure 1. Differences between OSTIA foundation SSTs when using SLSTR and VIIRS as reference. Result showing here is $OSTIA_{SLSTR}$ minus $OSTIA_{VIIRS}$ on a single day (end of Aug 2018)

- Use S3A SLSTR as reference improves the mean difference to Argo **globally,** especially in the **tropical regions** and the **Indian Ocean**
- Degradation is seen in **southern ocean basins**, as well as in the **North Atlantic**
- The standard deviation of Argo-minus-OSTIA are **comparable** when using VIIRS and SLSTR as reference
- Figure 1 suggests using SLSTR as reference leads to **warmer** OSTIA foundation SST in the **tropics** and **colder** SST in **the Arctic**, compared to run using VIIRS as reference. The magnitude of differences can reach 0.5 °C in some regions in this example

Skin2Bulk adjustment test

S3A_Ref_WD vs. S3A_Ref_Fix

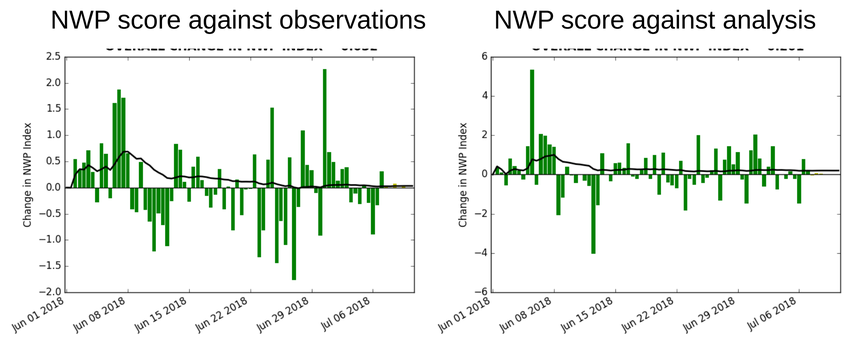

Figure 2. NWP index timeseries for S3A_Ref_WD in reference to S3A_Ref_Fix when compared against observations (left) and analysis (right). Statistics are from the period of 1 June – 15 July 2018.

- Statistical comparison against Argo floats is shown in Table 1. The two methods were only tested when using S3A SLSTR as the reference in OSTIA
- The Argo statistics for two S3A_Ref runs with different Skin2Bulk adjustment methods are **similar**, which is also confirmed by the NWP trial (Figure 2). Positive numbers indicate better statistics for S3A_Ref_WD run

Conclusions and Future Work

- Assimilating S3B SLSTR data in addition to S3A SLSTR leads to **neutral impact** in OSTIA, when compared against the Argo observations
- It is planned to ingest S3B SLSTR SST **operationally** in the next system upgrade, scheduled to go live in **November 2019**
- Additional work planned to test **using SLSTR SSTs in the reference dataset** (with or without VIIRS)
- Further investigation of skin2bulk adjustment methods

Assimilation of Sentinel-3B SLSTR SST in OSTIA

- The +S3B_NOAA20 run assimilates S3B SLSTR SST product from 1st April. The reference dataset used in this run contained both SNPP and NOAA20 VIIRS data.
- Table 2 shows the statistical comparison against Argo floats using OS42 and +S3B_NOAA20 during April 2019.
- The impact of adding NOAA20 VIIRS to the reference dataset is neutral hence not presented separately here.

Table 2. Argo-minus-OSTIA statistics for +S3B_NOAA20 experiment and OS42

Region	Mean difference (K)		Standard deviation differences (K)		Num. matchups
	OS42	+S3B_NOAA20	OS42	+S3B_NOAA20	
Global Ocean	0.09	0.10	0.32	0.33	10842
North Atlantic	0.06	0.06	0.41	0.42	2596
Tropical Atlantic	0.18	0.17	0.28	0.27	776
South Atlantic	0.11	0.10	0.35	0.35	1130
North Pacific	0.13	0.14	0.29	0.29	2409
Tropical Pacific	0.09	0.09	0.20	0.19	2401
South Pacific	0.09	0.09	0.26	0.26	3131
Indian Ocean	0.11	0.12	0.26	0.25	1254
Southern Ocean	0.10	**0.12**	0.36	0.36	2527

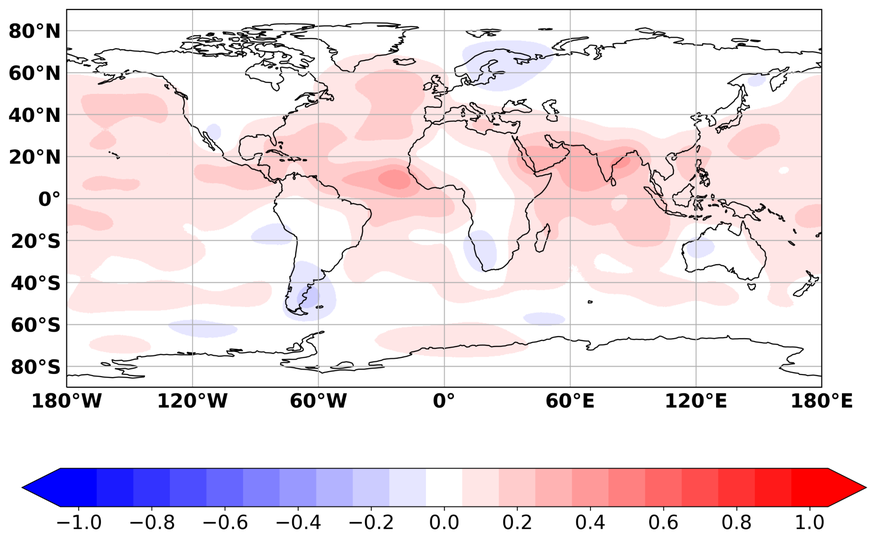

Figure 3. The average bias field of Sentinel-3B SLSTR SST against the reference dataset for 1 April – 26 May 2019

- The Argo statistics for OS42 and +S3B_NOAA20 are very comparable, with **neutral results** across all regions. Note the reference datasets for the two runs are not identical: +S3B_NOAA20 includes NOAA20 VIIRS in the reference, whilst OS42 used only SNPP VIIRS in the reference
- The bias fields for S3A and S3B SLSTR against the reference dataset (SNPP and NOAA20 VIIRS) are very similar, here shows only the bias field for S3B SLSTR
- S3B (and S3A) SLSTR data are generally warmer than the VIIRS dominated reference dataset, especially in the tropics. This is potentially due to the impact from aerosol in these regions hence VIIRS being too cold.

Reference: Donlon., C. J. et al., 2002: Toward Improved Validation of Satellite Sea Surface Skin Temperature Measurements for Climate Research. *J. Climate,* **15**, 353 - 369

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