Assimilation of ACSPO VIIRS and REMSS AMSR2 into OSTIA

Emma Fiedler, Simon Good

Met Office, Exeter, UK

Introduction

OSTIA is the Met Office Operational SST and Ice Analysis system

- L4 (gap-free analysis), global, daily
- Foundation SST (uses all nighttime observations and daytime observations only when wind speed >6 m s^{-1} to remove diurnal warming effects)
- 1/20^{o} grid resolution
- Optimal Interpolation type assimilation scheme
- Validates well against other analyses (compared to independent near-surface Argo observations)

Introduction

SST observation types used in OSTIA (prior to update 15 March 2016):

- NOAA-18 and 19 AVHRR
- MetOp AVHRR
- SEVIRI
- GOES-E
- In situ (ships, drifters, moored buoys)

OSTIA performs a bias-correction of satellite data to a reference dataset of all in situ data and a high-quality subset of MetOp AVHRR.

Methods

The effect of assimilating NOAA/NESDIS/STAR ACSPO VIIRS L3U and REMSS AMSR2 L2P SST products into OSTIA was tested.

Four runs were conducted:

- Operational configuration (control)
- Assimilating AMSR2 (+AMSR2)
- Assimilating VIIRS (+VIIRS)
- Assimilating both AMSR2 and VIIRS (+AMSR2, VIIRS)

Methods

Similar to the other satellite data types, the observation error variance for the new data types was taken from the SSES standard deviation estimate.

The SSES bias estimate was removed from the observations before any bias correction using the OSTIA reference dataset was applied.

The data were subsampled to the OSTIA grid size (1/20^{o} ; ~6 km)

Methods

Validation was conducted against near-surface Argo observations.

- Used shallowest observation between 3-5 m depth (shown to be good representation of foundation temperature)
- Independent from the analysis
- Sourced from Met Office Hadley Centre EN4 database (includes QC; available with ~2 month delay)

Results are given for January 2016. The runs each had a 2 week spin-up period prior to this.

Results

Argo minus OSTIA for January 2016, global statistics

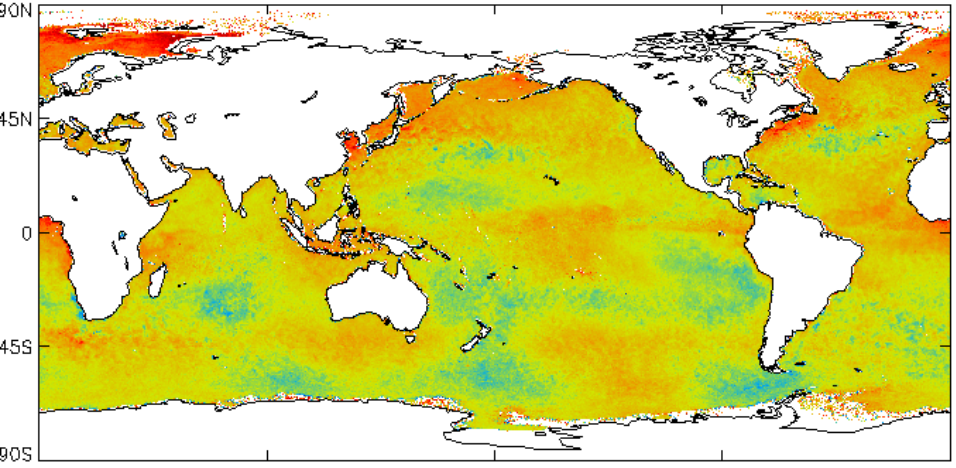
Experiment	Mean diff to Argo (K)	Standard deviation of diff to Argo (K)	RMS diff to Argo (K)
Control	0.12	0.49	0.50
+ AMSR2	0.12	0.43	0.44
+ VIIRS	0.10	0.43	0.44
+ AMSR2, VIIRS	0.11	0.41	0.42

Results

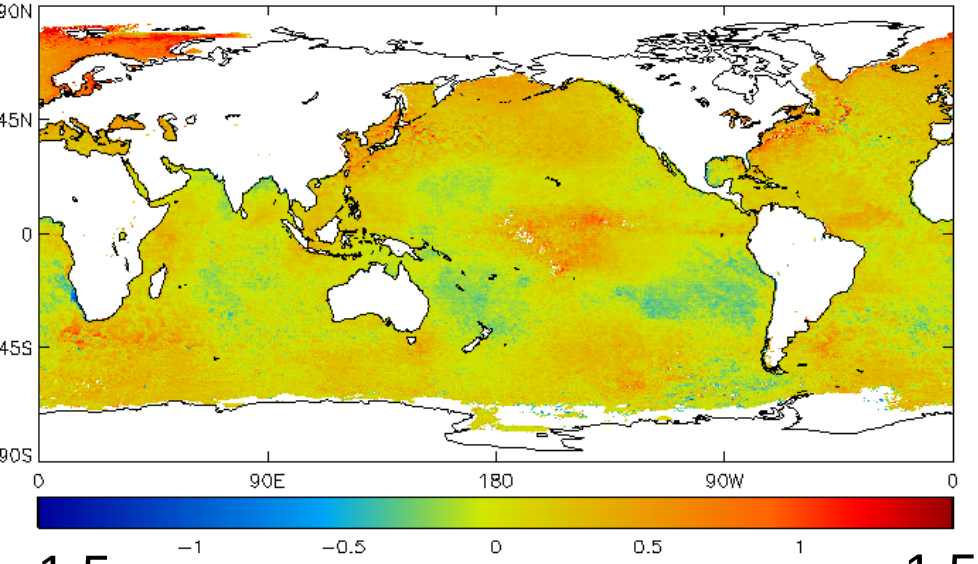
- Sizable improvement of 0.08 K in the RMS difference to Argo for the analysis + AMSR2 and VIIRS, to 0.42 K.
- Well within OSTIA target uncertainty of 0.50 K RMS (Donlon et al. 2012)
- RMS difference to Argo for run including both new datasets is lower than for either individual run
  - → indicates overall improvement is due to effect of both datasets together and not one or the other
- Improvement consistent across all regions
  - Largest magnitude decrease in RMS of 0.11 K in South Atlantic
  - Smallest magnitude decrease in RMS of 0.03 K in Tropical Atlantic
- Minor changes in mean difference (both +ve and -ve)

Results

AMSR2 minus OSTIA mean diff, Jan 2016 (K)



VIIRS minus OSTIA mean diff, Jan 2016 (K)



-1.5 1.5

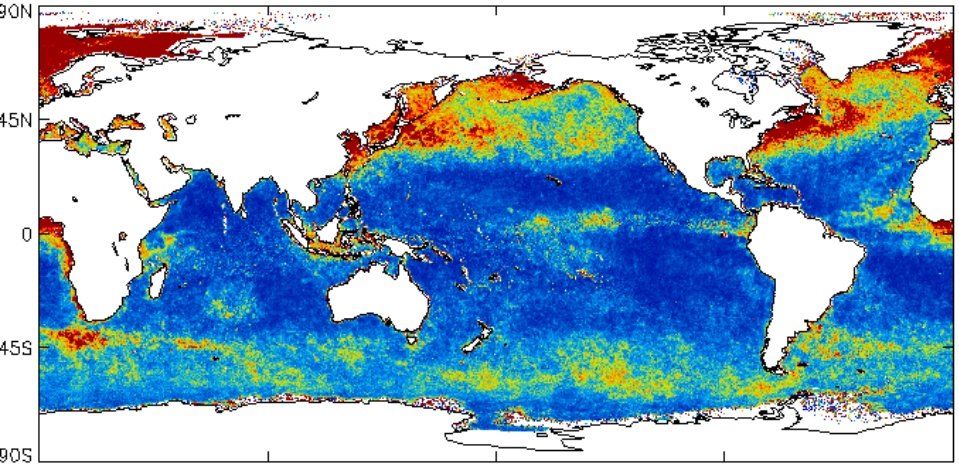
Mean of differences to analysis generally small, with exception of the Arctic, for both datasets, where the observations are warmer.

Differences to analysis in central Pacific correspond to region of low number of observations in both datasets.

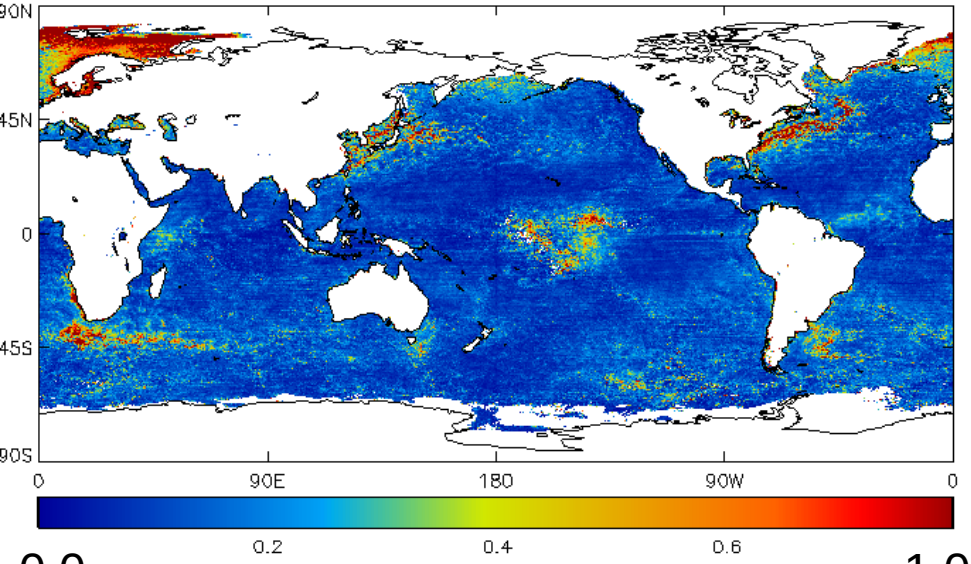
AMSR2 provides more observations than other datasets at very high latitudes, important for analysis as observations sparse here.

Results

AMSR2 minus OSTIA RMS, Jan 2016 (K)



VIIRS minus OSTIA RMS, Jan 2016 (K)

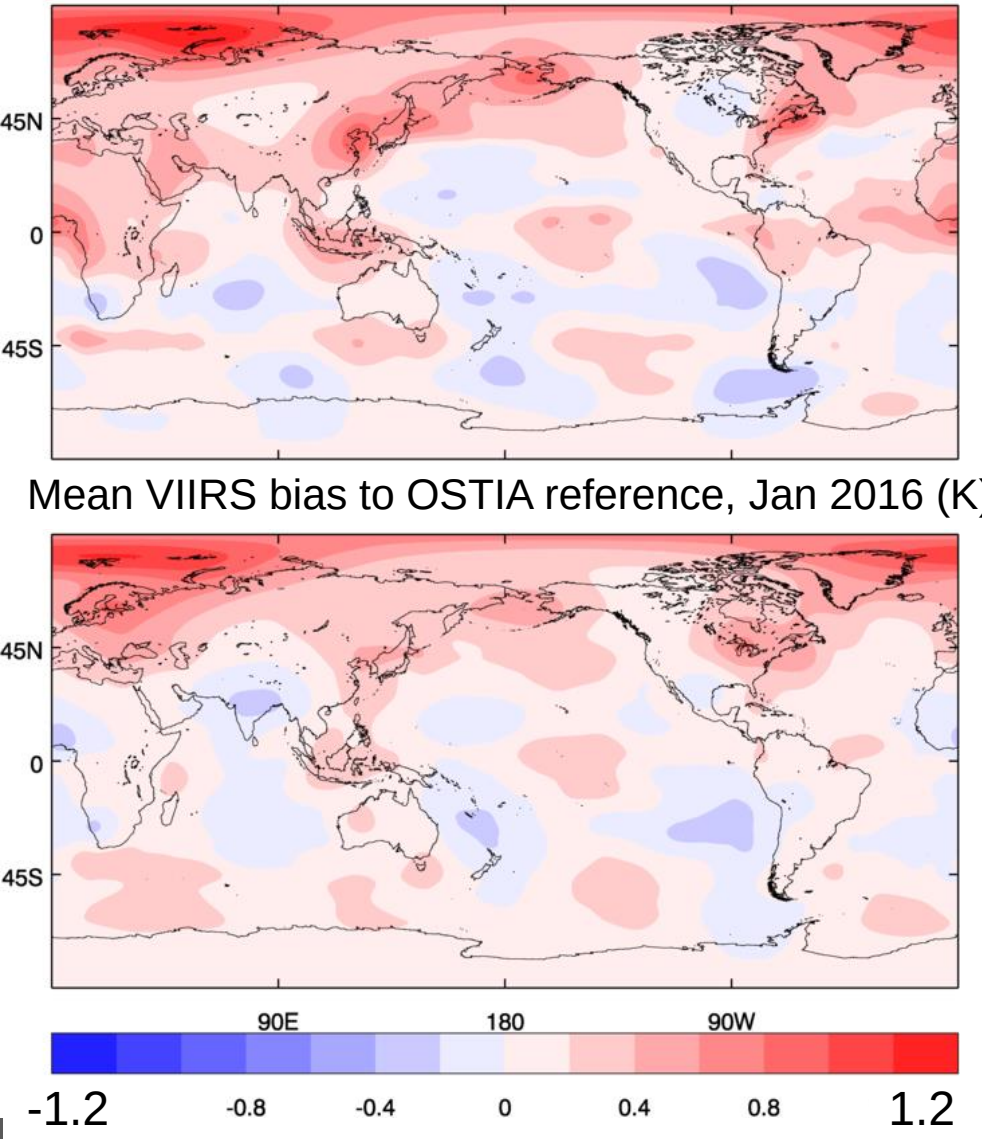


For VIIRS, RMS difference to the analysis is generally small outside high SST variability regions, except for the Arctic (and region of reduced data volume in central Pacific).

More spatial noise in the AMSR2 RMS differences to the analysis compared to VIIRS, particularly in North Atlantic and North Pacific.

Results

Mean AMSR2 bias to OSTIA reference, Jan 2016 (K)



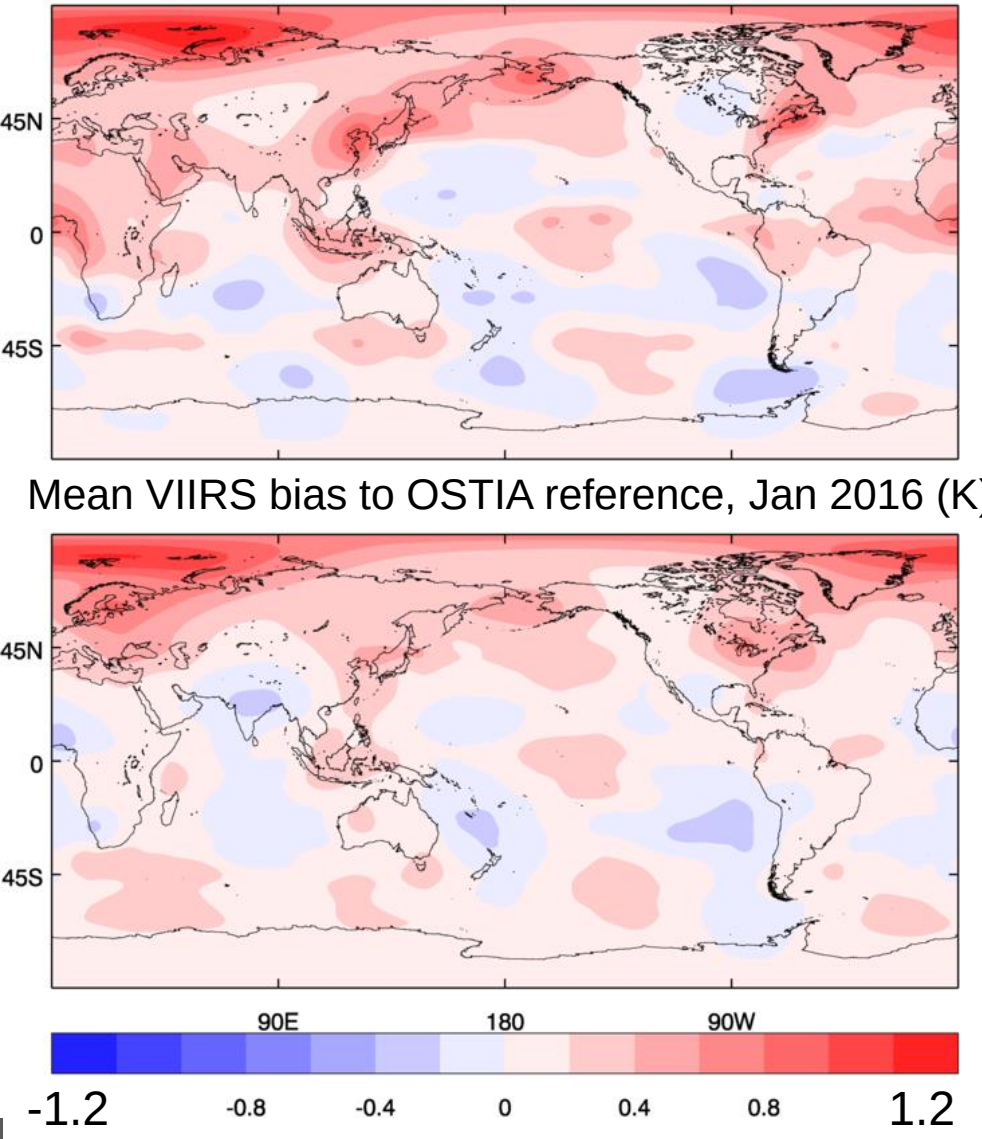
Mean VIIRS bias to OSTIA reference, Jan 2016 (K)

Mean of both AMSR2 and VIIRS bias to the OSTIA reference dataset (in situ and high quality subset of MetOp AVHRR) demonstrates lack of agreement between the observations and the reference dataset in the Arctic. (NOAA AVHRR also shows a weaker warm bias in the Arctic.)

The agreement of independent datasets (IR and MW) suggests the MetOp AVHRR reference data is too cold in the Arctic.

Results

Mean AMSR2 bias to OSTIA reference, Jan 2016 (K)



Mean VIIRS bias to OSTIA reference, Jan 2016 (K)

Note also the large positive bias compared to the reference data off the coast of Africa for AMSR2. This is likely linked to the presence of Saharan aerosols.

The microwave AMSR2 instrument is not sensitive to aerosols, unlike the reference AVHRR. The microwave dataset is therefore providing additional information here but this is being “corrected” out by comparison to the reference infra-red dataset.

Results

Analysis Name	Global standard deviation of diff to Argo (K)
CMC	0.36
Updated OSTIA	0.42
FNMOC	0.44
K10_SST	0.46
OSTIA	0.49
GAMSSA	0.52
RSS mw	0.52
MGDSST	0.54
Reynolds	0.55
RTG	0.63
RSS mw_ir	0.87

Statistics for January 2016, from the GMPE (GHRSST Multi-Product Ensemble) system

The effect of adding VIIRS and AMSR2 into OSTIA improves its accuracy compared to other global SST analyses. (Argo data are independent from all analyses.)

Conclusions

Results from assimilation experiments are very good so ACSPO VIIRS and REMSS AMSR2 were added into OSTIA operationally on 15 March 2016.

Other data types were tested at the same time but not included in OSTIA operationally:

NOAA/NESDIS GOES-W did not improve the analysis according to our usual measures (but may still provide extra information for e.g. feature resolution so plan to look at this again)

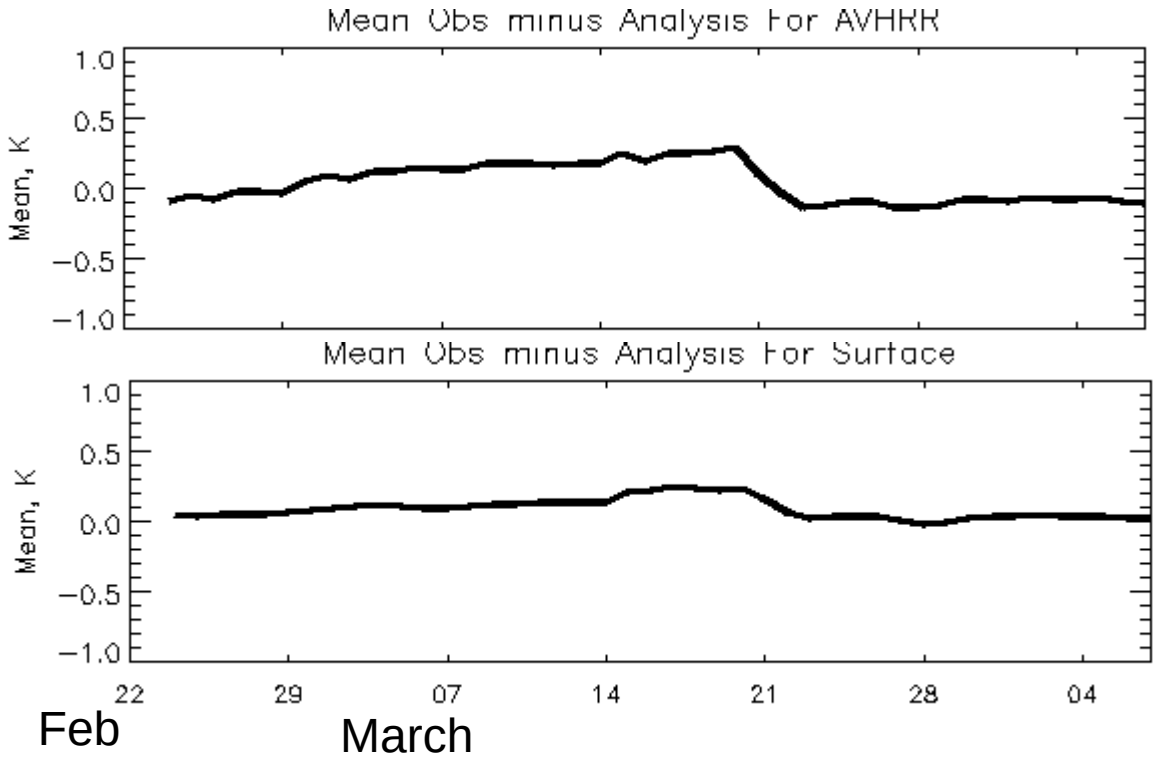
JAXA Himawari-8 needs more work on filtering observations (large errors outside centre of disk)

JAXA AMSR2 did not perform as well as REMSS AMSR2

EUMETSAT MetOp IASI results are promising but the number of observations is very small compared to other data types so has little effect on the analysis

Conclusions

Results from our testing phase (January 2016) have been shown here rather than from the operational system as statistics were complicated by feedback issue between MetOp-B AVHRR and OSTIA when it replaced MetOp-A AVHRR on 23 February 2016. Switched back to MetOp-A for bias correction 23 March.



Conclusions

OSI SAF have agreed to keep providing MetOp-A AVHRR for the time being (as we can't use MetOp-B for the bias correction) but we are looking into using VIIRS as a reference until SLSTR becomes available.

The bias correction to Metop AVHRR does do a reasonable job, as OSTIA compares well to Argo alongside other analyses. However, there is room for improvement in the OSTIA reference dataset, particularly in the high latitudes.

Met Office

Questions?

Results

Met Office

Near-surface Argo minus OSTIA SST analysis for the operational system (control), and a run with VIIRS and AMSR2 (January 2016; regional statistics).

Region (CMEMS definitions)	Mean diff to Argo (K)		RMS diff to Argo (K)	
	control	+VIIRS, AMSR2	control	+VIIRS, AMSR2
Global	0.12	0.11	0.50	0.42
North Atlantic	0.23	0.21	0.59	0.49
Tropical Atlantic	0.14	0.13	0.30	0.27
South Atlantic	0.02	0.03	0.56	0.45
North Pacific	0.20	0.18	0.50	0.44
Tropical Pacific	0.08	0.06	0.33	0.28
South Pacific	0.03	0.03	0.39	0.35
Indian Ocean	0.04	0.05	0.34	0.30
Southern Ocean	0.07	0.06	0.52	0.44

Results

Warm bias in Arctic present for AVHRR, but weaker than for VIIRS and AMSR2. Interesting pattern of cold bias 45N-45S!

Mean AVHRR bias to OSTIA reference, Jan 2016