Validation of Met Office OSTIA Diurnal Analysis Using Argo Floats – An Update

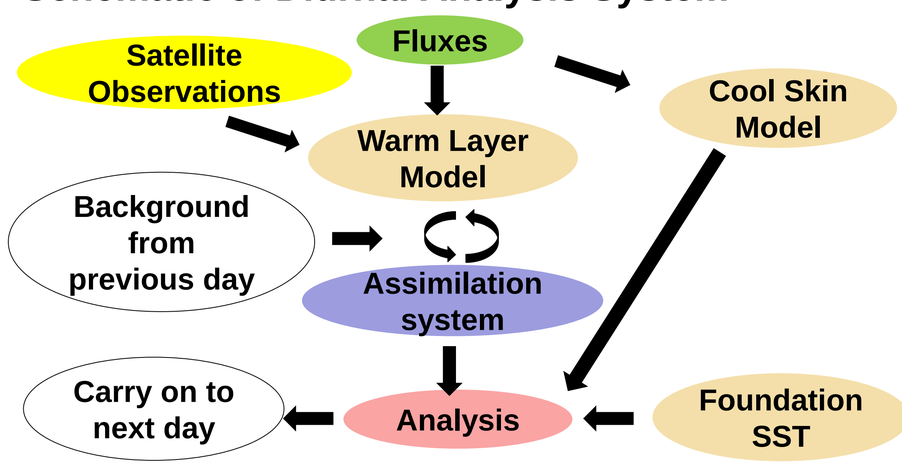
Chongyuan Mao, James While, Matthew Martin and Simon Good

Introduction

The Met Office has developed a new analysis product of the diurnal cycle of skin sea surface temperature (SST, While et al., *in prep*), **made freely available through the Copernicus Marine Environment Monitoring Service (CMEMS): http://marine.copernicus.eu/**. This product is a combination of the Operational Sea surface Temperature and Ice Analysis (OSTIA; also available from CMEMS) foundation SST, a warm layer model and a cool skin component. Observations from the satellite instruments SEVIRI, GOES-W and NOAA-AVHRR are assimilated into the warm layer model using a 4DVar like scheme.

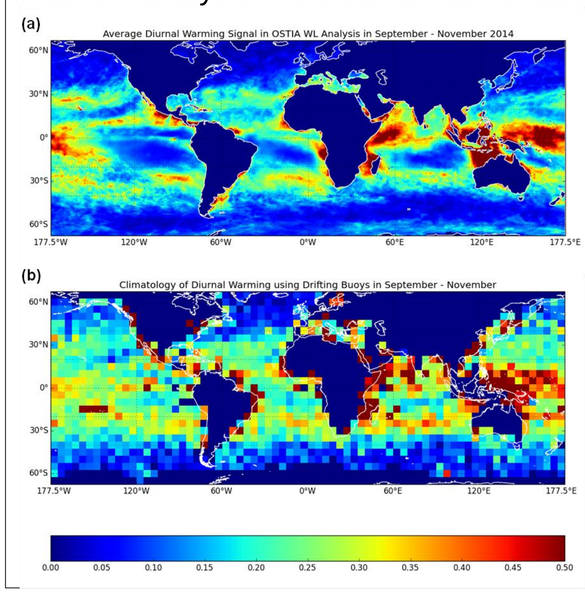
Warm layer SSTs from a three month test run (referred to below as VALRUN), September – November 2014, were compared against a climatological diurnal temperature range (DTR) field, which was calculated as the difference between the maximum and minimum of the mean diurnal cycle climatology (Kennedy et al. 2007). Assimilated satellite data and Argo Near-Surface Temperature (NST) profiles were also used for validation. For the Argo NST validation, the warm layer model is assessed using Receiver Operating Characteristic (ROC) methods.

Schematic of Diurnal Analysis System



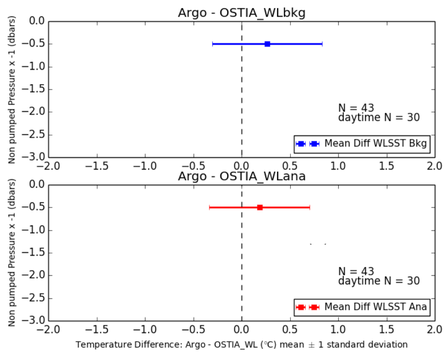
Validation of VALRUN SST against diurnal climatology

- Hourly resolution in 5º× 5º grid boxes across the globe
- Averaged DTR over September – November 2014 was calculated for the VALRUN analysis in the same manner as described in Kennedy et al., (2007)



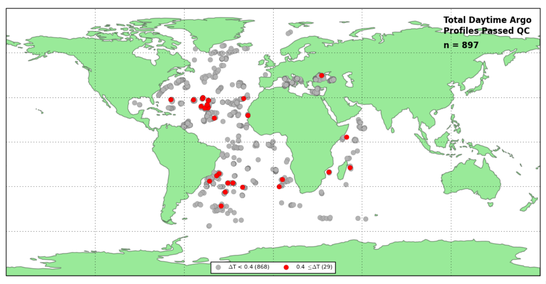
- The general spatial patterns of VALRUN and climatology agree well
- Strong diurnal signals are observed in the western tropical Pacific, central tropical Pacific, western Indian Ocean as well as coastal regions in the subtropical Atlantic and Pacific
- In regions of weak diurnal warming (high latitudes, the southern tropics in all three oceans) the diurnal signal tends to be larger in the climatology than in VALRUN

Validation of VALRUN SST against Argo NST profiles



- Argo dSST = Argo $SST_{0\text{-}1}$ minus Argo SST_4 (closest to 4 dbar in 3-5 dbar range)
- Use daytime Argo floats showing significant diurnal signal (Argo dSST > 0.4 ºC) are used in bin-averaged calculation (red points)
- Argo dSSTs are warmer than ΔT_{VALRUN}, suggesting the diurnal system underestimates the diurnal signal

Distribution of daytime Argo NST



Statistics of Comparison between Argo NST and OSTIA SSTs

Statistics	Warm Layer Background (dSST)	Warm Layer Analysis (dSST)
	DW Argo	DW Argo
Mean Difference	0.26	0.18
Standard Deviation	0.57	0.52

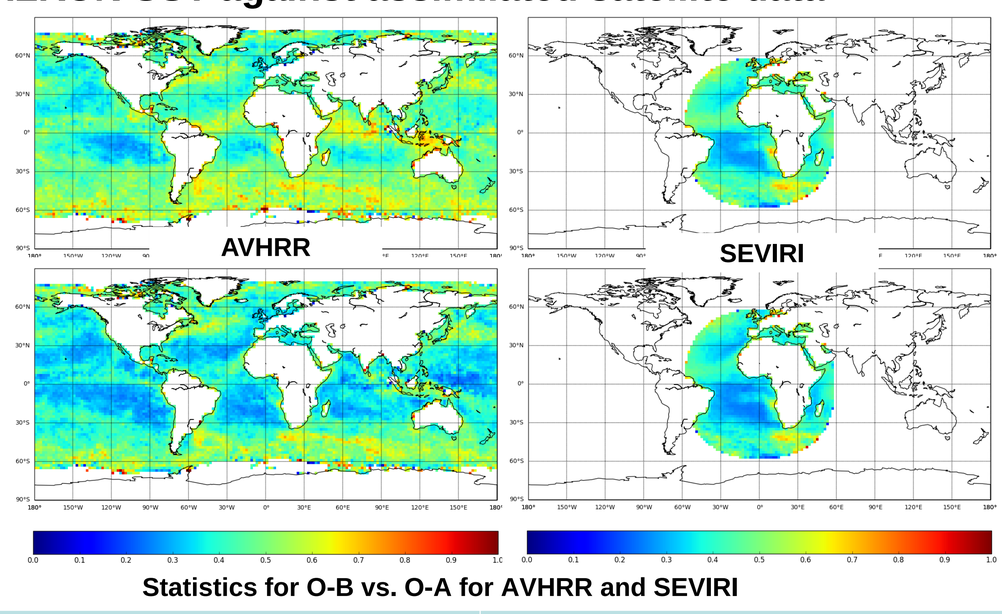
Conclusions

- Diurnal Temperature Range (DTR) calculated using VALRUN analysis agrees well with the climatology in regions with strong diurnal signal, less well in regions with weak signal
- Data assimilation improves the RMS and mean difference of the diurnal analysis system compared to assimilated satellites, as well as bin-averaged statistics at locations with significant diurnal signal
- Data assimilation has improved the system's ability to reproduce an observed diurnal signal, although it sometimes erroneously increases ΔT_{VALRUN} at locations of the floats

Validation of VALRUN SST against assimilated satellite data

RMS of Observation minus VALRUN SST **before** data assimilation

RMS of Observation minus VALRUN SST **after** data assimilation



Statistics for O-B vs. O-A for AVHRR and SEVIRI

Area Name	AVHRR					SEVIRI				
	Mean Difference		RMS		Number of Observations	Mean Difference		RMS		Number of Observations
	O- B	O-A	O-B	O-A		O-B	O-A	O-B	O-A	
Global Ocean	0.22	**0.13**	0.47	**0.39**	193974	0.08	**0.04**	0.41	**0.38**	242583
North Atlantic	0.15	**0.08**	0.44	**0.39**	20844	0.07	**0.03**	0.40	**0.38**	43913
Tropical Atlantic	0.26	**0.16**	0.45	**0.36**	14191	0.05	**0.02**	0.38	**0.35**	79637
South Atlantic	0.29	**0.14**	0.54	**0.43**	16258	0.11	**0.04**	0.42	**0.38**	58455

Validation of VALRUN SST against Argo NST profiles – ROC Table

- ROC = Receiver Operating Characteristic
- In this study ROC is used to estimate the performance of VALRUN in relation to its ability to produce the diurnal signal recorded by Argo floats at the correct time and location
- All available daytime Argo NST profiles are used (see Distribution of daytime Argo NST)
- Number of each event (defined in the table below) is counted for threshold 0.1, 0.2,..., 0.5 ºC

Hit (True Positive)	False Alarm (False Positive)
ΔT_{Argo} > threshold & ΔT_{VALRUN} > threshold	ΔT_{Argo} ≤ threshold & ΔT_{VALRUN} > threshold
Miss (False Negative)	**Hit (True Negative)**
ΔT_{Argo} > threshold & ΔT_{VALRUN} ≤ threshold	ΔT_{Argo} ≤ threshold & ΔT_{VALRUN} ≤ threshold

- VALRUN analysis shows more positive Hit (TP) events than the background, the difference between the two TPs decreases with increasing threshold
- VALRUN analysis has fewer Miss (FN) events than the background when a significant diurnal signal is observed
- VALRUN analysis also has more False Alarm (FP) events than the background

ROC Table of Results for Argo and VALRUN

Threshold (ºC)	ROC Table			
	Background		Analysis	
0.1	TP = 42	FP = 67	TP = 58	FP = 92
	FN = 32	TN = 756	FN = 16	TN = 731
0.2	TP = 21	FP = 40	TP = 26	FP = 60
	FN = 27	TN = 809	FN = 22	TN = 789
0.3	TP = 11	FP = 24	TP = 17	FP = 39
	FN = 25	TN = 837	FN = 19	TN = 822
0.4	TP = 9	FP = 12	TP = 14	FP =22
	FN = 20	TN = 856	FN = 15	TN = 846
0.5	TP = 7	FN = 9	TP = 8	FP = 15
	FN = 13	TN = 868	FN = 12	TN = 862

Acknowledgements: The authors would like to thank Fiona Carse (Met Office) and Justin Buck (BODC) for their advice on obtaining Argo data and associated data processing.

Reference:

While, J., and M. Martin (2013), Development of a variational data assimilation system for the diurnal cycle of sea surface temperature, J. Geophys. Res. Oceans, 118, 2845-2862, doi:10.1002/jgrc.20215

Carse, F., J. Buck and J. Turton (2012), Near-surface temperature profiles from pumped and un-pumped Argo measurements, poster at Argo Science Workshop, Venice, September 2012

While, J., C. Mao, M. Martin J. Roberts-Jones, A. McLaren and P. Sykes, An operational analysis system for the global diurnal cycle of sea surface temperature: implementation and validation, *in preparation*.

[1]**Met Office** FitzRoy Road, Exeter, Devon, EX1 3PB United Kingdom
Tel: +44 1392 885008 Fax: +44 1392 885681
Email: chongyuan.mao@metoffice.gov.uk