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Inter-comparison of High-Resolution SST Climatology data sets over the Australian region

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Introduction

Sea surface temperature (SST) climatology datasets provide the reference for observations of ocean anomalous events such as coastal upwelling and Marine Heat Waves (MHWs), which may have significant effects on the local marine ecosystem. The representativeness of the SST climatology datasets of the historical and current ocean surface states is essential to identify and predict anomalous events. Here we compare four high resolution SST climatology datasets around the Australian coast to investigate uncertainty introduced by reference SSTs to estimates of SST anomalies. The datasets studied are: (i) 0.05-degree SST Climate Change Initiative (CCI) global daily climatology for 1981-2016, 1985-2012, 1992-2016 and 1994-2016, calculated by this study from the ESA SST CCI Analysis product version 2.0 (Rayner et al., 2019), a satellite-only SSTdepth analysis created by the UK Met Office OSTIA SST analysis system from SST CCI Along Track Scanning Radiometer (ATSR) and SST CCI Advanced Very High Resolution Radiometer (AVHRR) products (1981-2016); (ii) 0.02-degree SST Atlas of the Australian Regional Seas (SSTAARS), a pixel-wise daily climatology for 1992-2016 (Wijffels et al., 2018), based on the 0.02-degree bias-corrected version 2 Integrated Marine Observing System (IMOS) one-day composite night-time AVHRR SST; (iii) 0.05-degree NOAA Coral Reef Watch (CRW) global monthly climatology for 1985–2012 (https://coralreefwatch.noaa.gov/satellite/coraltemp.php), derived from the MyOcean OSTIA Reanalysis (1985-2002) and NOAA Geo-Polar Blended SST reanalysis (2002–2012), and (iv) 0.1-degree BRAN SST daily climatology for 1994-2016, derived from the BRAN_2016 ocean reanalysis data generated by the Ocean Forecasting Australian Model version 3 (OFAM3) ocean model (Oke et al.,2013). Three climatology comparison groups based on these four SST products are formed (Table 1) and statistical analysis of the differences in each climatology comparison group are conducted followed by the in-situ validation using TAO/TRITON mooring SST1m climatology (https://www.pmel.noaa.gov/gtmba/taotriton-collaboration).

Inter-Comparison Groups

In this study we define CCI as the a reference to compare with CRW, SSTAARS and BRAN climatology datasets, with all comparisons performed over the SSTAARS domain (Figure 4). Groups CCI_1985 – CRW, CCI_1992 – SSTAARS and CCI_1994 – BRAN are compared to reduce potential impact of the reference period on SST differences in each CCI related group. The comparison groups from (a) to (c) are listed in Table 2 together with the five main factors affecting the comparison, including whether day and night data were included, reference period, data central year, climatology calculation algorithm and whether or not the climatology represents the same SST depth.

Statistical Analysis

Differences of each comparison group are calculated along with temporal relative bias (Figure 1) and standard deviation (STD, Figure 2) in each valid SSTAARS grid cell. Density distributions of differences within time bins are then calculated. The SST differences are first classified in time bins based on the corresponding spatial resolution. The density of SST differences in each time bin is then calculated and form a density distribution over the year (Figure 3). In the process of density calculation, the 4.5*STD threshold is used in each bin to remove the edges of the distribution.

Table 1. Main attributes of the climatology datasets

Climatology Datasets	Attributes				
	Spatial Resolution	Temporal Resolution	Reference Period	Data Source	Calculation Algorithm
CCI **CCI_1985** **CCI_1992** **CCI_1994**	0.05°(~5 km)	Daily Monthly	1981-2016 (36 years) 1985-2012 (28 years, Re-centered 1988 + 2/7) 1992-2016 (25 years) 1994-2016 (23 years)	Climate Change Initiative (CCI) SST version 2 analyses (daily SST0.2m)	Daily and Monthly averaging
CRW	0.05°(~5 km)	Monthly	1985-2012 (28 years, Re-centered 1988 + 2/7)	OSTIA Reanalysis (1985 - 2002) NOAA Geo-Polar Blended SST reanalysis (2002 – 2012) (daily night-time SST0.2m)	• Linear interpolation • Monthly averaging • Bias adjustment
SSTAARS	0.02°(~2 km)	Daily Monthly	1992-2016 (25 years)	Bias corrected version 1 and version 2 IMOS one-day composite night-time AVHRR SST0.2m L3S data (quality level ≥ 4)	• Parametric model fitting • Climatology reconstruction
BRAN	0.1°(~10 km)	Daily Monthly	1994-2016 (23 years)	BRAN_2016 ocean reanalysis (daily SST2.5m)	Daily and Monthly averaging

Table 2. Experiment groups of the climatology comparison and the main control factors of the differences (match: √ and mismatch: ×).

Experiment Groups	Control Factors				
	Day and Night	Reference Period	Central Year	Calculation Algorithm	SST depth
(a) CCI_1985 – CRW	×	√	√	√	√
(b) CCI_1992 – SSTAARS	×	√	√	×	√
(c) CCI_1994 – BRAN	√	√	√	√	×

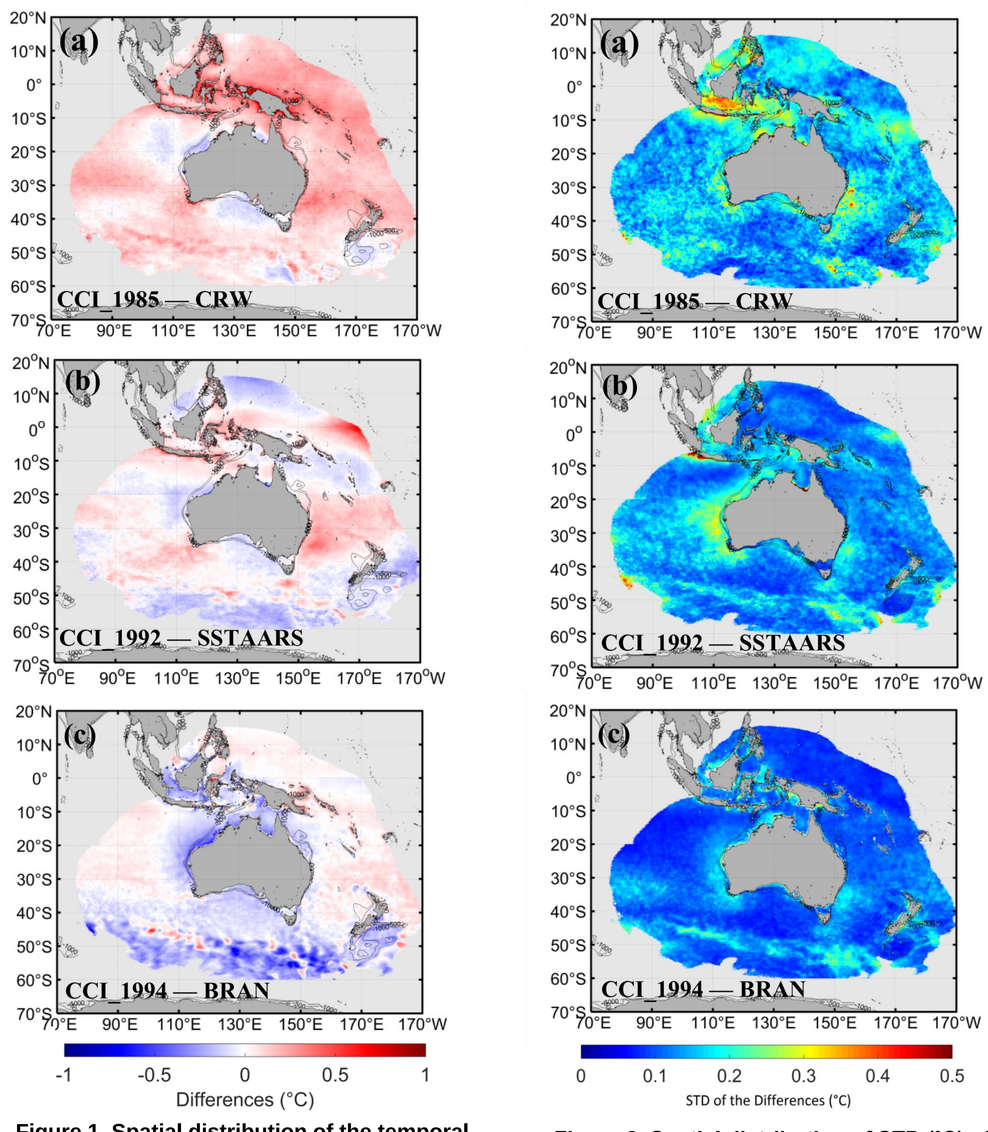

Figure 1. Spatial distribution of the temporal relative bias (ºC) of group (a) CCI_1985 – CRW, (b) CCI_1992 – SSTAARS and (c) CCI_1994 – BRAN.

Figure 2. Spatial distribution of STD (ºC) of group (a) CCI_1985 – CRW, (b) CCI_1992 – SSTAARS and (c) CCI_1994 – BRAN.

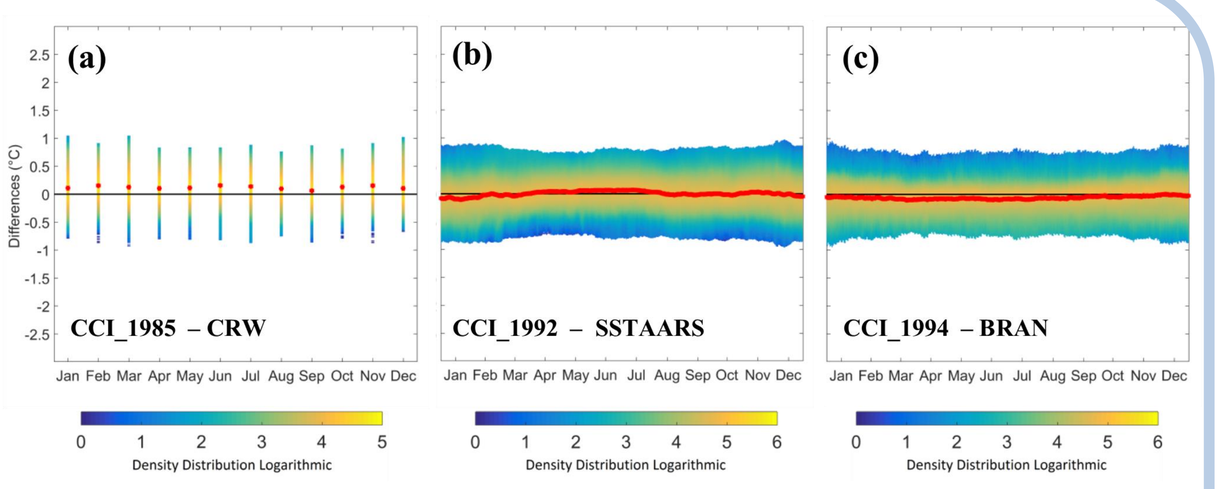

Figure 3. The density distribution of group (a) CCI_1985 – CRW, (b) CCI_1992 – SSTAARS and (c) CCI_1994 – BRAN. within corresponding time interval × 0.01°C (Temperature) bin (ºC), the red line is the relative bias in each time interval bin. A logarithmic density distribution is used.

In-situ Validation

The long-term in-situ hourly daily SST mooring measurements from the NOAA Pacific Marine Environmental Laboratory (PMEL) Global Tropical Moored Buoy Array (GTMBA, https://www.pmel.noaa.gov/gtmba/taotriton-collaboration) are used here to validate the accuracy of the climatology datasets. A daily mooring climatology time series is generated at each platform location by averaging data values with highest quality code (QC) 1 and 2 over similar time period as the other climatologies. For CCI, SSTAARS and BRAN, a group of time series at each grid cell matching the corresponding TAO/TRITON array platform measurement location are generated. Differences are calculated by subtracting mooring measurements from the corresponding time series of each gridded climatology (Figure 5), then mean bias, STD and correlation coefficient (R value) are calculated at each platform location (Table 3).

Table 3. Statistical parameters (Bias, STD, R at 95% confident level and standard error value from the SSTAARS climatology data sets (Error)) of gridded climatology minus in-situ climatology, with large bias and high error value highlighted in red due to low data density of the input data in SSTAARS.

Platform Code	Latitude (°N)	Longitude (°E)	CCI_A			SSTAARS				BRAN		
			Bias	STD	R	Bias	STD	R	Error	Bias	STD	R
52318	0	147	-0.01	0.06	0.88					-0.03	0.07	0.87
52317	0	156	-0.06	0.07	0.86	-0.16	0.14	0.57	0.07	-0.04	0.07	0.80
52321	0	165	-0.05	0.08	0.84	-0.53	0.23	0.80	0.11	-0.04	0.11	0.73
52307	2	137	-0.03	0.08	0.90	-0.12	0.16	0.70	0.06	-0.02	0.08	0.86
52301	2	147	-0.07	0.08	0.79	-0.08	0.13	0.62	0.06	-0.08	0.07	0.80
52011	2	156	-0.03	0.07	0.89	-0.06	0.14	0.69	0.07	-0.05	0.06	0.89
52001	2	165	-0.05	0.06	0.93					-0.02	0.08	0.92
52012	-2	156	-0.02	0.06	0.89	-0.08	0.12	0.66	0.06	0.01	0.07	0.85
52002	-2	165	-0.05	0.07	0.87	-0.31	0.22	0.59	0.10	-0.04	0.07	0.83
52314	5	137	-0.03	0.10	0.94					-0.04	0.08	0.95
52302	5	147	-0.03	0.08	0.93	0.02	0.10	0.90	0.07	-0.03	0.07	0.90
52084	5	156	-0.08	0.10	0.88	-0.05	0.13	0.70	0.08	-0.05	0.07	0.90
52086	-5	156	-0.03	0.08	0.95	-0.11	0.13	0.81	0.06	-0.02	0.06	0.96
52004	-5	165	-0.03	0.07	0.87	-0.13	0.12	0.70	0.07	-0.01	0.07	0.83
52007	-8	165	-0.03	0.09	0.96	0.02	0.11	0.90	0.06	-0.06	0.06	0.97
Total			-0.04	0.08	0.93	-0.13	0.21	0.67	0.08	-0.03	0.08	0.92

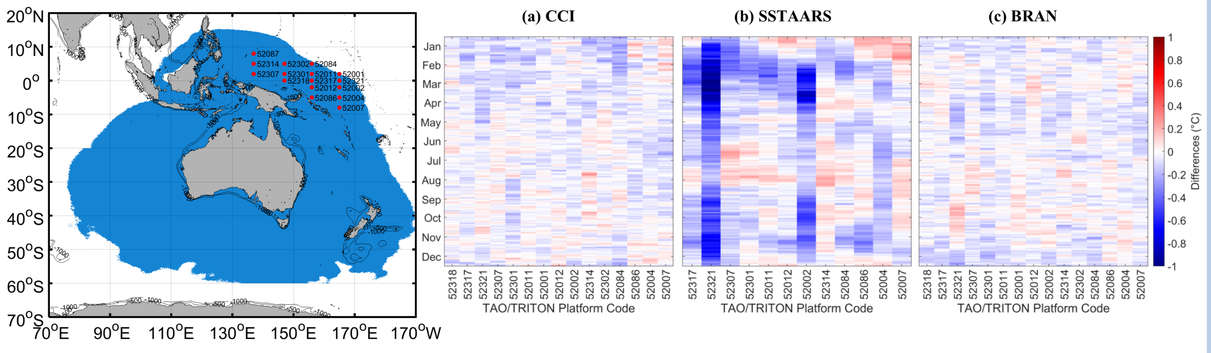

Figure 4. TAO/TRITON Platform Code and location (red) and SSTAARS domain (blue).

Figure 5. Daily difference between in-situ climatology and gridded climatology data sets at each platform location.

Summary

- SSTAARS and BRAN agree more closely than CRW with a climatology formed from SST CCI analysis version 2.0 over the same time period.
- Over the north-east region, SSTAARS shows discrepancies with climatologies formed from CCI and TAO/TRITON mooring SST, associated with higher standard errors in the SSTAARS SST values caused by low input data density.
- BRAN and CCI have similar agreement with a climatology formed from TAO/TRITON mooring data, however the mooring SST were ingested into BRAN and therefor do not represent an independent validation.
- SSTAARS, BRAN and CCI climatology data sets are suitable for a study of anomalous SST around Australia's coast.

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