VALIDATION OF AATSR-DERIVED SEA SURFACE TEMPERATURE IN AUSTRALIAN WATERS

Ian Barton[(1)], Alan Pearce[(2)], Mike Mahoney[(3)], Lesley Clementson[(1)], and Marianne Edwards[(4)]

[(1)]CSIRO Marine Research, PO Box 1538, Hobart, Tasmania 7001, Australia, Email: ian.barton@csiro.au
[(2)]CSIRO Marine Research, PMB No. 5, Wembley, WA 6913, Australia , Email: alan.pearce@csiro.au
[(3)]Australian Institute of Marine Science, PMB No. 3, Townsville Mail Centre, Queensland 4810, Australia,

Under the joint agreement between CSRO Australia and the UK Department of Environment, Australian scientists are contributing to the geophysical validation of the sea surface temperature (SST) to be provided by the Advanced ATSR instrument flying on ESA's ENVISAT satellite. Three different operations are used to provide these validation data. Research vessels of opportunity are used to deploy the high quality CSIRO radiometer, the DAR011, in Australian coastal waters. In the other two operations autonomous radiometers are mounted on operational ferries to provide nearly daily coverage of the SST on transects between Townsville and Kelso Reef in the Great Barrier Reef, and Perth and Rottnest Island in Western Australia. Both radiometric and bulk SST are measured from all vessels, along with sky infrared radiance to allow for the non-unity sea surface emissivity correction required for the ship-mounted radiometers. Limited validation results are presented for both AATSR and ATSR-2.

1 INTRODUCTION

Australian scientists have been involved in the ATSR series of instruments since the start of the program in 1980. Part of that involvement has been in the supply of geophysical validation data for the sea surface temperature (SST) derived from these instruments. Details of such data collected for the first ATSR instrument are described in [1]. Further data were collected for ATSR-2 [2], and the latest contributions are for the AATSR on ENVISAT. Three separate activities are being undertaken to provide SST validation data for ongoing quality assessment of the AATSR SST products.

2 VALIDATION INSTRUMENTATION

2.1 DAR011 radiometer

The DAR011 radiometer is a single-channel, self-calibrating, infrared radiometer developed and built within CSIRO. The radiometer has a heritage going back many years and is the culmination of developments leading to a reliable accurate instrument. Full details of the instrument are provided in [3]. A rotating 45 degree plane mirror sequentially views the sea, a hot black body calibration target, the sky, and finally an ambient temperature black body calibration target. The incoming radiation is physically chopped against a second ambient temperature black body and the chopped radiation is focussed with a 45 degree parabolic front surfaced mirror onto a pyroelectric detector. Before reaching the detector the radiation passes through an interference filter that passes radiation with wavelengths between 10.5 and 11.5 μm. The temperatures of the two calibration black bodies are accurately monitored providing good absolute radiometric accuracy.

During 2001 the DAR011 radiometer was included in the Miami2001 infrared radiometer calibration and inter-comparison. The radiometer was calibrated against a NIST-designed black body target, and compared against other similar radiometers used for the validation of satellite-derived surface temperatures, and found to perform with a high degree of accuracy. Results from the Miami2001 exercise are reported in [4].

2.2 New Tasco-based radiometer in Perth

A new radiometer system has been developed for the Perth-Rottnest Island ferry. The system is based on a TASCO radiometer which is mounted in a housing that allows a view of the water outside the ferry wake in normal operations. The radiometer section can be fully sealed when the ferry is in port allowing fresh water washing of the system. While under way a fan provides a positive pressure within the housing and the air stream expressing from the view port prevents ant water or spray from entering the unit. A GPS system is included for navigation and a platinum resistance thermometer in the cooling water inlet allows a measure of the bulk SST. Downwelling sky radiance is measured at a coastal site to give a correction for clear sky emissivity. The radiometer can be seen attached to the deck above the ferry's bridge in Fig. 1. Within the radiometer housing the TASCO radiometer is mounted in a detachable unit allowing easy replacement and laboratory calibration. The TASCO lenses are susceptible to degradation in a marine environment and are replaced at least once per month. Calibration is undertaken using a portable black body target. This can be done in situ (on the ferry) or in the laboratory. During the austral summer the DAR011 and Perth radiometer will be operated together on the ferry for a short time.

2.3 New AIMS radiometer

A new radiometer system has also been developed for the Townsville operation. The system incorporates an Everest radiometer and two calibration targets held at ambient temperature and ambient temperature plus 10^{o}C. Bulk SST is measured and an upward looking pyrgeometer is used for the sky correction. The radiometer has been operated alongside the DAR011 during a 9-day cruise on the RV Lady Basten during June 2002. Excellent agreement was obtained between the two radiometers. The two radiometers are shown mounted on the port-side railing of the RV Lady Basten in Fig. 2. Early in the new year the DAR011 radiometer will be deployed alongside the new AIMS radiometer on the tourist ferry. This will ensure that the data collected have some consistency, and that the radiometer calibration is accurate.

3 CAMPAIGNS

3.1 DAR011 cruises

For the validation of the Sea Surface Temperature provided by the AATSR the DAR011 has been deployed on four cruises of the AIMS RV Lady Basten. Each cruise was for a period of nine days and between 2 and 5 validation coincidences were obtained on each cruise. The first two cruises were held late in May and June and were right at the start of the AATSR commissioning period. Unfortunately there were some days when good ship-based data were collected, but the instruments in ENVISAT were not operating. The data collected during the first two cruises were also used to validate the ATSR-2 derived SST.

3.2 Perth-Rottnest Island transect

The new Perth radiometer has had some teething problems but radiometric and bulk SST data have been collected since October 10, 2002. These measurements will be compared with the satellite-derived SST when these data become available.

3.3 Townsville-Kelso Reef transect

The Townsville ferry radiometer has been delayed due to a malfunction in the Everest radiometer which is at the heart of the instrument. The radiometer was deployed alongside the DAR011 on one of the Lady Basten cruises and found to operate extremely well, with almost perfect agreement between the two radiometers. When the radiometer is eventually deployed it will provide regular radiometric data for ongoing SST validation during the extended AATSR mission.

Fig. 1. The new Perth radiometer mounted on the ferry “Sea Flyte”.

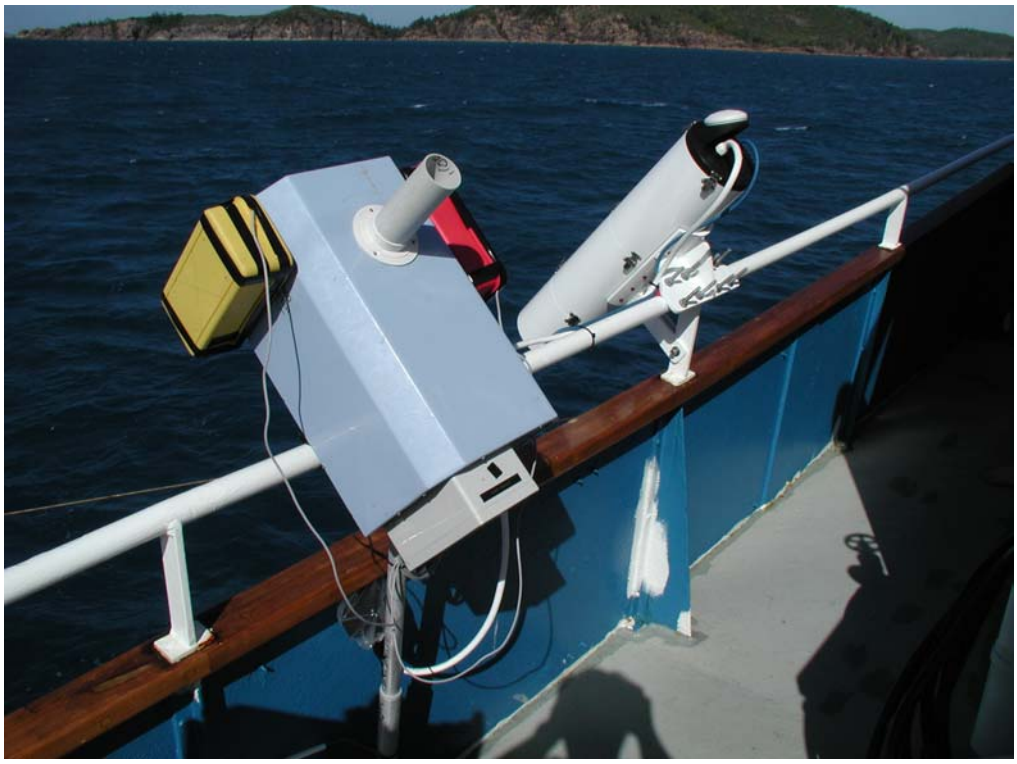

Fig. 2. The DAR011 (left) and the AIMS radiometer (right) mounted on the RV Lady Basten.

4 RESULTS

The ground-based measurements taken on the Lady Basten enable the geophysical validation of the SST derived from both ATSR-2 and AATSR data. The initial analysis has been with ATSR-2 data, although a limited number (two) of ship-AATSR coincidences have also been analysed. Note ATSR-2 is in an orbit which is 30 minutes behind ENVISAT, so the ship data can be applied to both satellite instruments.

The results for ATSR-2 validation for the first two Lady Basten cruises are given in Table 1 and Fig. 3. The results show good agreement between the DAR0911 and TASCO measurements of the skin SST confirming that the TASCO radiometer- if handled carefully – can supply good validation data. The bulk SST was sampled with a Platinum Resistance Thermometer which was deployed away from the side of the vessel and sampled the water at a depth close to 0.05 m. As expected the bulk SST is slightly warmer than the radiometric skin SST due to the skin effect. However, there were times when these two values were close together indicating either a weak skin effect or a near surface gradient in the upper ocean layers. For the two AATSR coincidences the agreement between ship and satellite measurements is excellent, suggesting that the AATSR is performing well within the design parameters (see Table 4).

The ship SST values were compared with four different ATSR-2 SST products. First they were compared with the nadir (NAD) and dual view (DUA) SST as supplied by the ATSR-2 standard analysis. The agreement between NAD and the DAR011 was extremely good suggesting that ATSR-2 is still providing SST values well within the mission requirements. However, the agreement with the DUA product was not good and was found to be due to poor co-location of the nadir and forward views. This problem has existed since ERS-2 platform anomaly that occurred on January 17, 2001. The last two columns provide 4- and 6- channel SSDT from ATSR-2 data but with careful co-location of the nadir and forward views. When this is done the agreement again becomes very good. The results are plotted in Figure 3.

Table 1. Validation data collected during cruises LB0102 and LB0202. The SST values derived for ATSR-2 data are also included.

Date dd/mm	Time (local)	Latitude (^{O}S)	Longitude (^{O}E)	PRT (^{O}C)	DAR (^{O}C)	Tasco (^{O}C)	NAD (^{O}C)	DUA (^{O}C)	SST4 (^{O}C)	SST6 (^{O}C)
28/05	2247	-17.038	147.168	26.53	26.26	26.22	26.44	26.75	26.54	26.49
31/05	2253	-19.037	146.861	25.40	25.25	25.15	25.24	25.95	26.50	25.75
07/06	2232	-20.339	149.755	24.75	24.72	24.55	24.76	27.55	24.49	24.72
10/06	1015	-20.521	149.132	23.46	23.25	23.22	23.34	24.08	23.37	00.00
10/06	2237	-20.393	149.251	23.80	23.70	23.38	23.72	24.12	23.65	23.77
13/06	1021	-19.099	147.142	24.17	24.15	24.00	24.10	23.48	24.13	00.00

NOTES:
Dates and times are local. EST is 10 hours ahead of UTC.
PRT is bulk SST from Platinum Resistance Thermometer
DAR is sky-corrected skin SST from DAR011 radiometer
Tasco is sky-corrected skin SST from Tasco radiometer
NAD is nadir-only ATSR-2 SST from *.GSST-LXC file
DUA is dual-view ATSR-2 SST from *.GSST-LXC file
SST4* is four-channel ATSR-2 SST with manual alignment of two views
SST6* is six-channel ATSR-2 SST with manual alignment of two views

* Merchant SST coefficients used.

The results obtained during ENVISAT overpasses during the third and fourth cruises are given in Tables 2 and 3 respectively. The sky view of the DAR011 radiometer gives a good assessment of whether the skies are clear or cloudy. A uniform cold brightness temperature suggests a clear sky while rapidly varying temperatures are indicative of cloud cover. All three coincidences for the third cruise are in clear skies as well as four for the fourth cruise.

Table 2. Validation data collected during LB0302 during clear-sky overpasses of ENVISAT

Day of year	Date dd/mm	Time (Local)	Latitude (^{O}S)	Longitude (^{O}E)	Wind m/sec	Direction	PRTair (^{O}C)	PRTsea (^{O}C)	DAR BT (^{O}C)	DARSST (^{O}C)
204	23/09	2208	18.724	148.018	5.0	055	23.98	24.65	23.94	24.55
207	26/09	0951	18.180	147.073	7.5	115	25.40	25.54	25.00	25.60
207	26/09	2213	18.833	147.492	7.5	135	24.42	24.94	24.15	24.75

Table 3. Validation data collected during LB0402 during clear-sky overpasses of ENVISAT (* possibly cloudy)

Day of year	Date dd/mm	Time (Local)	Latitude (^{O}S)	Longitude (^{O}E)	Wind m/sec	Direction	PRTair (^{O}C)	PRTsea (^{O}C)	DAR BT (^{O}C)	DARSST (^{O}C)
* 232	21/10	1005	18.249	147.263	4.0	325	25.53	25.71	25.40	25.85
232	21/10	2227	18.297	147.321	6.0	360	25.32	25.92	25.31	25.86
* 236	25/10	0939	20.003	149.130	0.0	0	27.45	27.20	26.80	27.30
236	25/10	2202	20.069	149.528	4.0	045	25.15	25.98	25.27	25.76
239	28/10	0945	20.366	149.111	7.5	180	25.54	25.75	25.11	25.74
239	28/10	2208	20.182	148.733	10.0	135	24.71	26.17	25.60	26.10

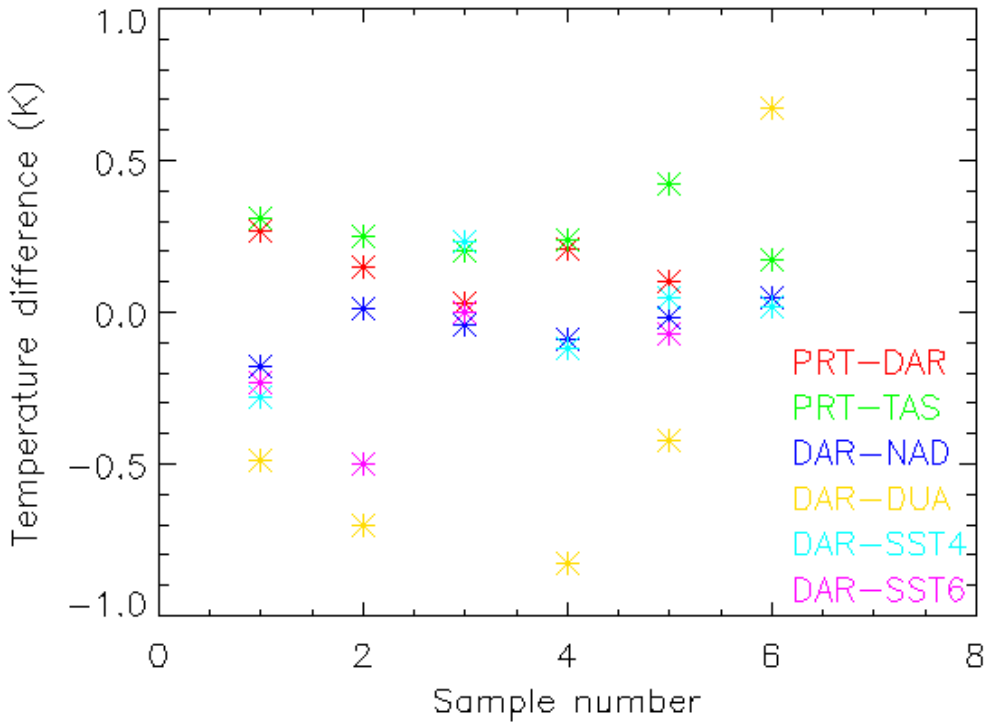

Fig. 3. Validation results for ATSR-2 data from LB0102 and LB0202

Table 4. AATSR SST match-ups with the ship data given in Tables 2 and 3.

Date dd/mm	Time (Local)	BulkSST (^{O}C)	SkinSST (^{O}C)	AATSR SST (^{O}C)	AATSR-Skin (^{O}C)
23/09	2208	24.65	24.55	24.40	–0.15
21/10	2227	25.92	25.86	25.82	–0.04

5 CONCLUSIONS

The Australian AATSR SST validation campaigns have already supplied some high quality data that can be used to assess the final accuracy of the AATSR products. The data have also been useful to confirm that the ATSR-2 instrument on ERS-2 is till supplying accurate measurements of SST after being in orbit for over seven years. The research vessel results show that both radiometers and bulk-measuring devices can supply useful validation data for satellite-derived SST. Initial comparisons between ship and AATSR measurements of SST suggest that the AATSR is performing extremely well.

The two ferry systems in Perth and Townsville have been slow to start their AATSR validation operations, but will be able to provide long term data for the ongoing monitoring of the AATSR SST product.

6 ACKNOWLEDGEMENTS

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