QA FOR SATELLITE SEA SURFACE TEMPERATURES USING THE ISAR SHIP-BORNE RADIOMETRIC SYSTEM

Werenfrid Wimmer[1], Ian Robinson[1] and Craig Donlon[2]

(1) National Oceanography Centre Southampton, Southampton, UK
(2) European Space Research and Technology Centre, ESA, Noordwijk, Netherlands

1. INTRODUCTION

Satellite measurements of global sea surface temperature (SST) distribution are increasingly recognised to have great importance for understanding changes in the world's climate, as well as for operational forecasting of the oceans and atmosphere. If satellite-derived SSTs are to provide the basis of an essential climate variable (ECV) it is necessary to establish methods for independently verifying their quality. Previously the validation of satellite SST products has been performed by comparison with sea temperatures measured by contact thermometers on the hulls of moored or drifting buoys or of ships. Such sensors operate below the sea surface, within the top few metres of the water column, recording what is now referred to [1] as SST_{depth}. Infrared radiometers on satellites measure the temperature of the surface skin of the ocean, referred to as SST_{skin}. However, significant uncertainties are introduced when validation is based on comparisons between SST_{depth} and SST_{skin} because the sea temperature is not uniform across the skin and the upper few metres, especially but not only because of diurnal variability. Such uncertainties can be eliminated by using *in situ* SST_{skin} measurements as the basis for a satellite SST validation approach which genuinely compares like with like. This paper describes the principles and results of such a system which has now been in place for five years. It has been used to validate SST measurements from the Advanced Along Track Scanning Radiometer (AATSR) on Envisat. Within the collaborative approach developed by the Group for High Resolution SST (GHRSST, [1]) for merging of complementary data from different satellites, the primary role of AATSR data is to provide a reference for bias adjustment of other data. Precise validation of AATSR measurements is therefore essential for maintaining the quality of other GHRSST products.

2. THE ISAR INSTRUMENT

The Infrared Sea surface temperature Autonomous Radiometer (ISAR, [2]) has been specifically developed for unattended operation on board ships of opportunity (SOO). The ISAR instrument is a single channel, scanning radiometer, which is self calibrating using an internal black body at ambient temperature and another heated to 12K above ambient temperature. It measures brightness temperature of the sea surface for the detector waveband of 9.6 to 11.6 micrometers. The ISAR is designed for autonomous deployments of up to three months, having a shutter system controlled by a rain detector to protect the instrument against sea spray and rain. ISAR instruments have been continuously deployed on the P&O ferry *Pride of Bilbao*, which travels between Portsmouth (UK) and Bilbao (Spain) on a three day round trip. One of two instruments is always in operation and is exchanged with the other at the first opportunity if telemetered diagnostic data reveal instrument malfunction or calibration abnormalities, or after three months of trouble-free operation. ISAR's radiometric performance is traceable to NIST standards. Before and after each deployment the ISAR is validated against a laboratory black body (CASOTS 2) which itself has been characterized against a NIST black body and therefore adheres to the QA4EO standards.

3. VALIDATION OF SATELLITE SENSORS.

The validation of sea surface temperature estimated by satellite sensors such as AATSR simply requires comparison between *in situ* and satellite samples of SST that are coincident within a suitable mach-up window. However, the specification of the match-up window is critical since the validation result will change depending on the match-up constraints selected. Validation results are presented for the (AATSR) in the English Channel and the Bay of Biscay from 2004 to 2008 using five different match-up windows. In addition we show how the uncertainty introduced by using the match-up window can be reduced by stratifying the match-up data in terms of match-up quality indicators.

3.1. Conventional validation

For the validation of AATSR we used five match-up windows which are shown in Table 1. Four of the match-up windows were designated for the routine validation of AATSR [3]. The fifth is the one specified by GHRSST for global datasets and is included for comparison and reference purpose. The results are stratified into day and night time mach-ups.

Grade	Time	Spatial
1	± 0.5 h	± 1 km
2a	± 0.5 h	± 20 km
2b	± 2.0 h	± 1 km
3	± 2.0 h	± 20 km
4	± 6.0 h	± 25 km

Table 1: Temporal and spatial limits for the match-up window defining coincidence between AATSR and in situ SST samples.

3.2. Quality indicators

The choice of match-up window influences the validation results and therefore the estimated bias and standard deviation. These constitute the sensor-specific error statistics (SSES), which are a mandatory field in GHRSST–specified SST products. Since the SSES influence the way the SST data are incorporated into the production of analysed SST fields or assimilated into ocean models, it follows that the choice of the match-up window can have an important impact on the downstream applications of the satellite data. For example, if the matching window is too wide, allowing matches between *in-situ* and satellite data acquired in quite different conditions, inherently good satellite SST retrievals may falsely appear as lower quality and be excluded from downstream application.

To reduce such uncertainty we first analysed the potential sources of the error associated with the match-up process and identified ways of estimating it using parameterisations using the SST fields and available ancillary data. The spatial mismatch error (E_S) is introduced by comparing two measurements which have not been acquired in the same geographical location. The temporal mismatch error (E_T) is introduced by comparing two measurements acquired at different local times. The instrument error (E_M) represents the *in-situ* instrument error. The point-in-area sampling error (E_P) is the error associated with using a single point sample from a ship to represent the average of a variable over the whole instantaneous field of view of a satellite sensor. The sampling depth error is introduced by using non SST_{skin} measurements (i.e. SST_{depth}) for validation, but is already eliminated by using the ISAR.

For every match-up pair a typical magnitude for each of these individual errors is estimated. By analysing the size of these error estimates in comparison with the actual mismatch between the ISAR and AATSR SST values, using four years of accumulated data, thresholds have been established by which an overall quality indicator can be assigned to each match-up pair according to the parameterised error estimates. The higher the quality indicator the smaller is the standard deviation of the AATSR-ISAR mismatch. To a certain degree this allows the inherent quality of the AATSR data to be distinguished from the uncertainty introduced by shortcomings in the match-up process.

4. CONCLUSION

The validation of AATSR with the ISAR instrument has shown very good agreement in the Bay of Biscay validation area. The ISAR systems has proven its reliability and accuracy over the last four year and now has one of the longest in situ SST_{skin} records.

5. REFERENCES

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