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Constructing new satellite-only time series of global mean, sea surface temperature data for climate from ATSR data

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The Along Track Scanning Radiometers (ATSRs) have provided a near-continuous record of sea surface temperature (SST) data for climate from the launch of ATSR-1 in 1991 to the loss of the Advanced ATSR (AATSR) in April 2012. The intention was always to provide an SST record, independent of in situ data, to corroborate and improve climate data records in recent times. We show that the ATSR record provides a very suitable data set with which to study the recent climate record, particularly during the ATSR-2 and AATSR periods (1995 to 2012) in three major respects. First, ATSR climate time series achieve anomaly accuracies of better than 0.05 K (and high stability). Second, the overlap between instruments allows for excellent determination and removal of biases; between ATSR-2 and AATSR, these are less than 0.05 K for the highest accuracy SST data. Finally, uncertainties on global monthly mean data are less than 0.02 K and hence comparable to those achieved by in situ analyses such as HadSST3.

A particular hallmark of the ATSR instruments was their exceptional design for accuracy incorporating high accuracy radiometric calibration, dual-view of the Earth's surface and the use of three thermal emission channels; additional channels are included for cloud clearing in this context. The use of dual-view and multiple thermnal wavelengths allows a number of combinations for retrievals of SST, the most accurate being the dual-view, three-channel retrieval (D3) at nighttime. This restriction is due to the use of the 3.7 micron channel which is sensitive to solar radiation during the day. Extensive work has resulted in a major advances recently resulting in both an operational V2.0 SST product and a further improved ATSR Re-analysis for Climate (ARC) product, a particular feature of the latter being the development of a depth SST product in addition to the skin SST directly determined from satellite data. We will discuss the characteristics of these data sets in terms of accuracy, stability and inter-instrument calibration. We will further describe the methods we use to construct global monthly time series of SST anomalies from ATSR data, noting particularly the significance of sampling maps in quantifying the "global" coverage.

For a climate data record, estimation of uncertainty is as important as the parameter values themselves. We will discuss measurement errors, time sampling errors and effects of error correlation in determining the final uncertainty budgets. For use of the D3 ATSR product as the basis for the climate time series, time sampling is the dominant error particularly due to restrictions on valid data points in cloudier regions such as the Pacific at northern mid-latitudes. It will be shown that the overall error budget for the satellite-only data is highly suitable for an independent climate record.

The ATSR studies described in this paper mark the culmination of two decades of effort to deliver high accuracy SST data from satellite sensors, giving high confidence also in our understanding of the current in situ record. We conclude that climate-quality must be achieved by the Sea and Land Surface Radiometer (SLSTR) due to be launched on Sentinel-3 in 2014 and we note the importance of gap-bridging and gap-filling between AATSR and SLSTR.