Sub-mesoscale variability of Sea Surface Temperature: implications for satellite retrievals and quality of drifting buoys

Alexander Easton, Christoforos Tsamalis and Peter Weston

Rationale

Sea surface temperature (SST) retrievals from satellites can be calibrated using in-situ observations, while their quality is validated against in-situ observations. In both cases some predefined collocation criteria in space and time with in-situ observations are needed. The aims of this study are to:

- determine the limits of the collocation criteria both in space and time for which the comparison of SST measurements between satellite and in-situ is within a certain threshold of accuracy, and
- estimate the random uncertainty of the drifting buoys.

Collocation criteria

Fig. 1 shows that despite the advanced quality control of HadIOD there are still outliers especially at small distances for both mean absolute and standard deviation of SST differences. Elimination of outliers was performed by applying a 1.5 K threshold, while in order to account for the systematic and random uncertainties of the drifting buoys the factors 0.08 K and 0.02 K have been subtracted, respectively. The desirable levels for accuracy and precision of SST observations are 0.1 K and 0.2 K, respectively. The first is achieved for a window 10 km-3 h, indicating that instruments with large footprint can not reach this level (Figs. 1, 2). Regarding precision, although the SST variability is below 0.2 K for 6 km-2 h, a better window is 4 km-1 h in order to offer some margin for the random uncertainty of the instruments (Figs. 1, 2). Both windows are slightly smaller to those suggested previously [2].

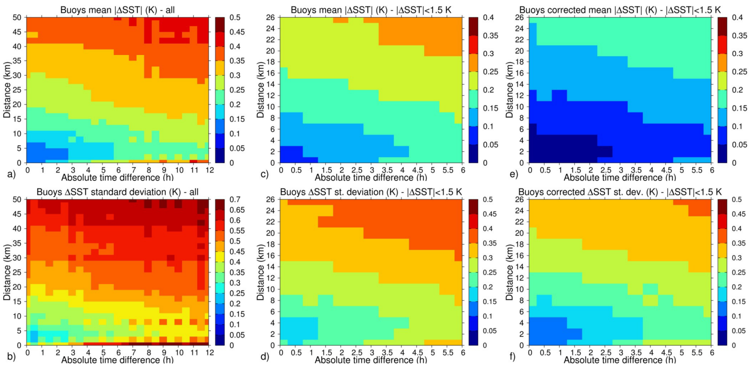

Fig. 1: Mean absolute (top) and standard deviation (bottom) of SST difference versus distance and time. (c, d, e, f) Only pairs with difference less than 1.5 K are kept. A correction of 0.08 (0.02) K has been applied to panel e (f).

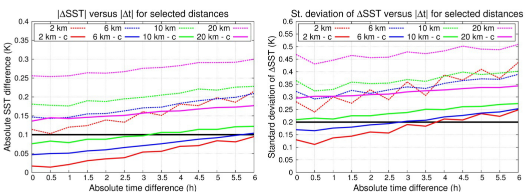

Fig. 2: Time evolution of mean absolute (left) and standard deviation (right) SST difference for four windows with (solid) and without (dashed) correction.

Conclusions

- Accuracy to 0.1 K is achieved for collocations within 10 km-3 h, with MW instruments intrinsically not reaching this level, while precision of 0.2 K is better achieved within 4 km-1 h.
- The random uncertainty of drifting buoys is at most 0.1 K, especially for the periods 1990-91 and after 2005.

References

[1] Atkinson et al. (2014), An integrated database of ocean temperature and salinity observations, JGR, 119, 7139–7163, doi:10.1002/2014JC010053.

[2] Minnett (1991), Consequences of sea surface temperature variability on the validation and applications of satellite measurements, JGR, 96, 18475–18489, doi:10.1029/91JC01816.

[3] O'Carroll et al. (2008), Three-way error analysis between AATSR, AMSR-E, and in situ sea surface temperature observations, JAOT, 25, 1197–1207, doi:10.1175/2007JTECHO542.1.

Dataset

The HadIOD (v1) [1] climate dataset is used and more specifically match-ups between different drifting buoys. Drifting buoys are widely used for the calibration and validation of satellite SST retrievals because they are less biased than ships and they provide global coverage in contrast to moored buoys. The match-ups are restricted to the sub-mesoscale, i.e. 0-50 km and 0-6 h. The drifting buoy reports in HadIOD start in 1981, but the number of observations grows substantially since 2005 due to increased numbers of deployed buoys and observations reported by each of them.

Random uncertainty

According to previous studies [3] the random uncertainty of drifting buoys is about 0.2 K. Applying an approach similar to the semivariogram technique Fig. 3 presents the histograms of SST differences for six increasingly narrow windows. The standard deviation initially decreases but then increases indicating the existence of outliers. Eliminating the pairs with absolute differences ≥1 K and assuming that the SST natural variability is negligible for the window 2 km-30 min, the random uncertainty is calculated to be at most 0.1 K. However, this value is not constant in time as drifting buoys in 1995-96 have lower quality than in 1990-91 and after 2005 (Fig. 4). The geographical distribution of the differences for the window 10 km-3h indicates that there are still some issues with pairs found in the Arctic and coastal regions. As expected the SST variability is more important in the vicinity of ocean currents.

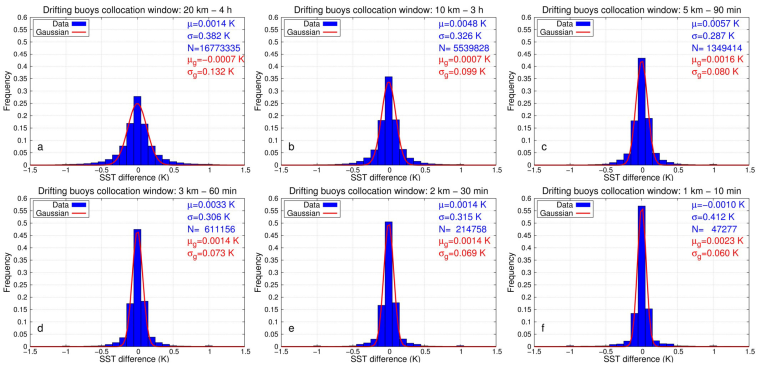

Fig. 3: Histograms of the SST differences for drifting buoy pairs inside six collocation windows during the period 1981-2014. The red line is the Gaussian fit using the nonlinear least-squares Marquardt-Levenberg algorithm. μ is the mean value and σ the standard deviation either for the dataset or for the Gaussian fit denoted by the subscript 'g', while N is the number of pairs.

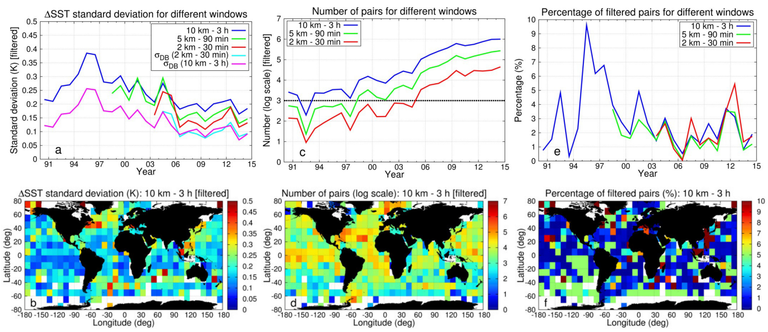

Fig.4: Time series for three collocation windows and geographical distribution for the collocation window 10 km-3 h. (a, b) Standard deviations of the SST differences, (c, d) number of pairs and (e, f) percentage of filtered pairs. In panel a also the random uncertainty of drifting buoys (σ_{DB}) is plotted.

Met Office FitzRoy Road, Exeter, Devon, EX1 3PB United Kingdom
Tel: +44 1392 886415
Email: **christoforos.tsamalis@metoffice.gov.uk**