Microwave SST Single Sensor Error Statistics

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Introduction

We have calculated Single Sensor Error Statistics (SSES) for satellite-borne microwave sensors capable of retrieving SST. The SSES values apply to the SST retrievals performed at Remote Sensing Systems and provided to the MISST project. Accurate bias and standard deviation estimates can now be assigned to each and every SST retrieval from these instruments.

Methods

The SSES behavior was investigated as a function of SST and wind speed by comparing the satellite retrievals with *in situ* SST values obtained from moored and drifting buoys. The buoy data were obtained from the USGODAE project, and come from the "SFCOBS" dataset. This dataset also includes ship measurements and CMAN stations. These were excluded because they are typically of lower quality.

We constructed a complete set of buoy-satellite collocations subject to the following conditions:

- The buoy was located inside the 0.25 x 0.25 degree satellite grid cell.
- The buoy measurement was within 30 minutes of the satellite overpass.
- No rain was detected in the collocated satellite cell, or in any of the 8 adjacent cells.
- Only "night-time" (4 PM to 10 AM Local Time) were used. This reduces the effects of diurnal warming.
- The quality control value for the buoy observation is less than or equal to 0.7. Analysis shows that the standard deviation of the satellite-buoy differences starts to increase above this value.

The wind speed was determined by satellite retrieval. Every rain-free SST retrieval also has a collocated wind retrieval from the same microwave instrument.

This resulted in a large number of collocations for each satellite. The table below show the overall statistics for each satellite.

Satellite	Number of Collocations	Mean Bias (C)	Std. Dev. (C)
AMSR-E	409913	-0.0107	0.562
AMSR2	191697	0.0542	0.559
WindSat	330967	-0.0029	0.559
GMI	44330	0.0860	0.903
TMI	395531	0.0104	0.636

GMI and TMI lack the low-frequency 6.9 GHz channel that the other satellites have. This lack leads to reduced performance in cold water, which is particularly important for GMI which samples most of the global oceans. TMI does not sample cold water because of its equatorial orbit. Both satellites show increased standard deviation relative to satellites with the low frequency channel.

The SST performance is strongly dependent on SST and Wind Speed. To study this dependence, we bin the collocated results by Wind Speed and SST and calculate the statistics in each bin.

Number of AMSR-E Collocations

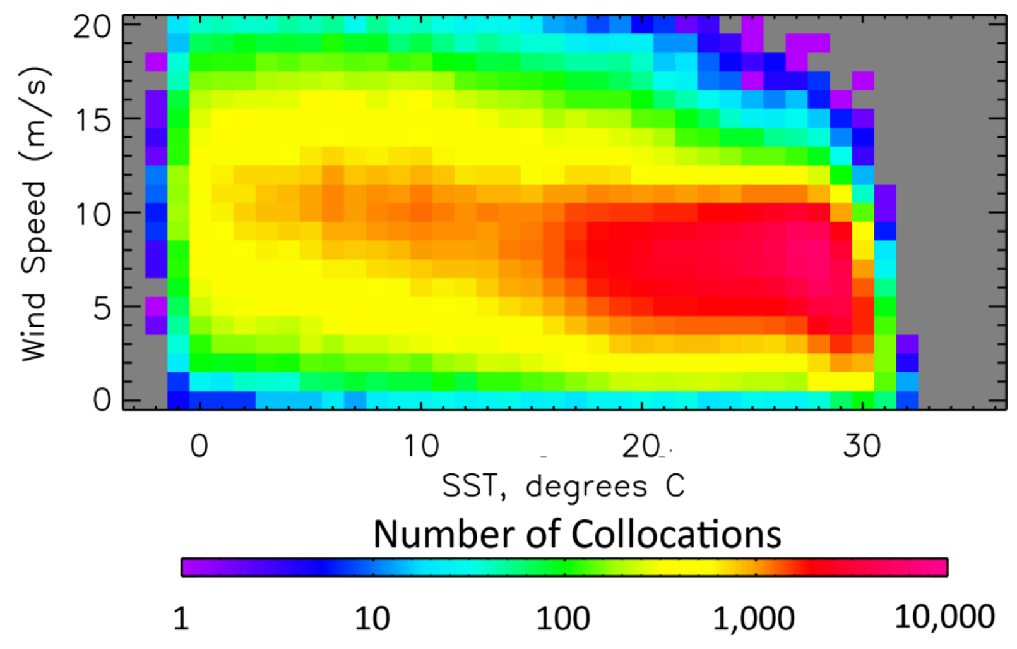

Fig. 1. Number of collocations as a function of SST and Wind Speed.

The work described here is different from previous estimates provided to the GHRSST project because:

- More satellites are included (GMI)
- More years of data are included for WindSat and AMSR-E
- The estimated statistics no longer depend on time. Analysis showed that the time dependence the statistics for buoy-satellite differences was mostly caused by changes in the mix of buoy locations in the SFCOBS dataset and thus unlikely to be caused by changes in satellite performance

Results

AMSR-E Results

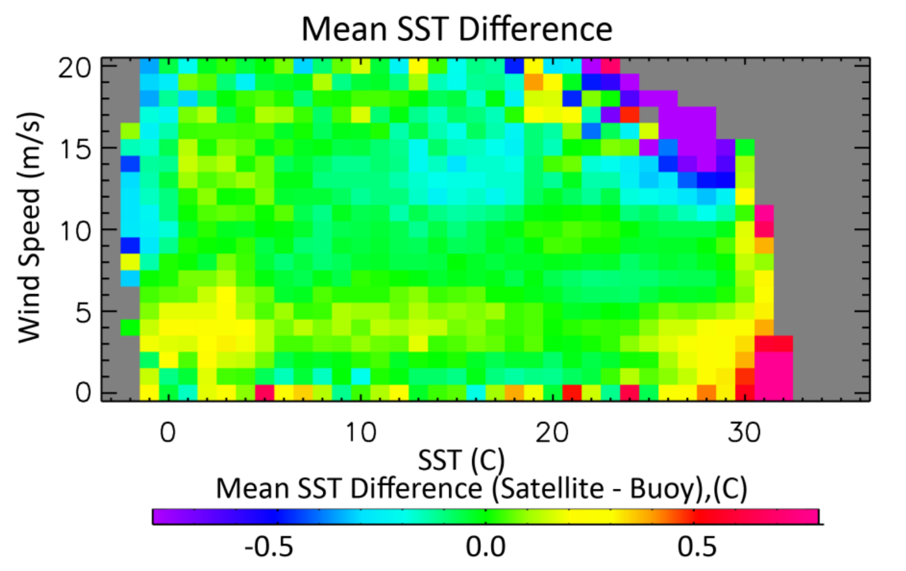

Figure 2. Mean AMSR-E minus Buoy SST difference

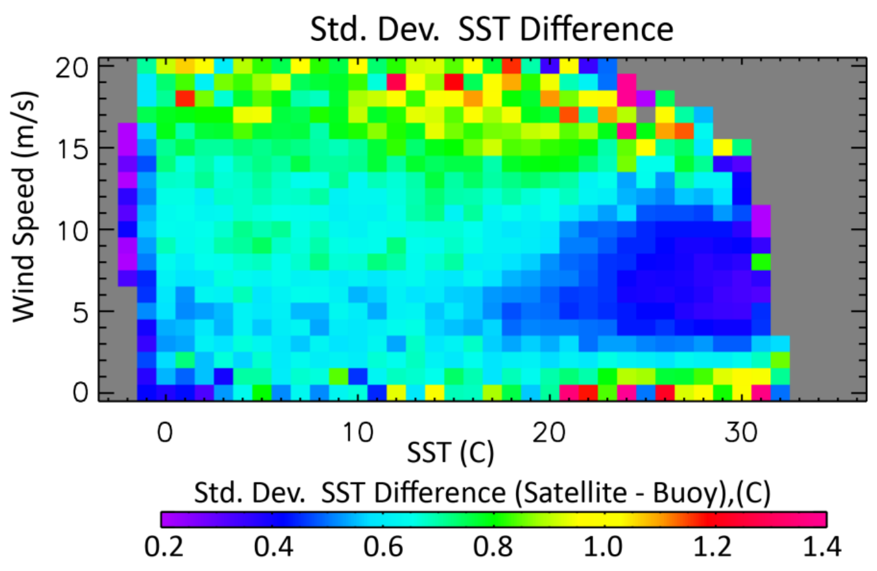

Figure 3. Std. Dev. AMSR-E minus Buoy SST difference

The most precise retrievals occur at warmer SSTs and moderate wind speed. Results for AMSR2 and WindSat are very similar, and we don't show them here.

TMI Results

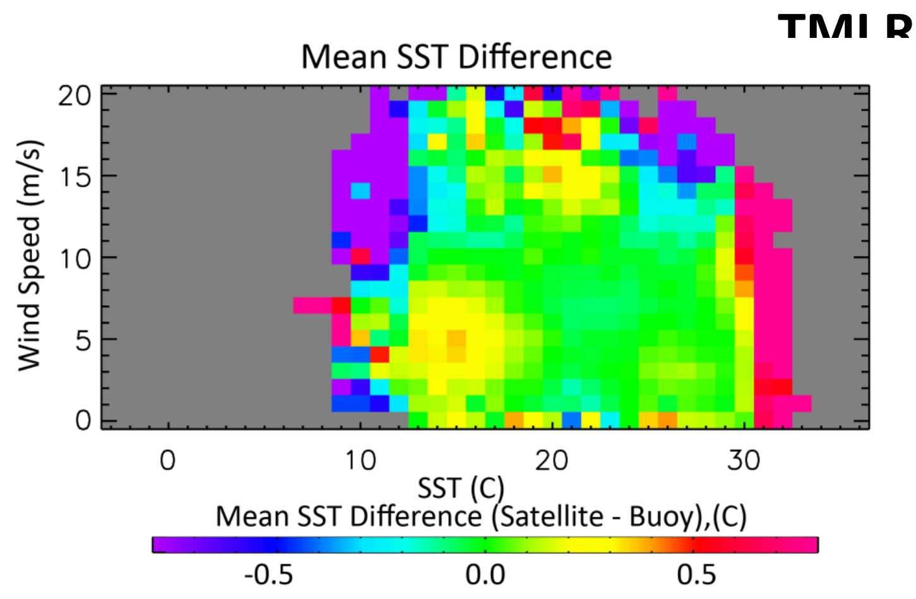

Figure 4. Mean TMI minus Buoy SST difference

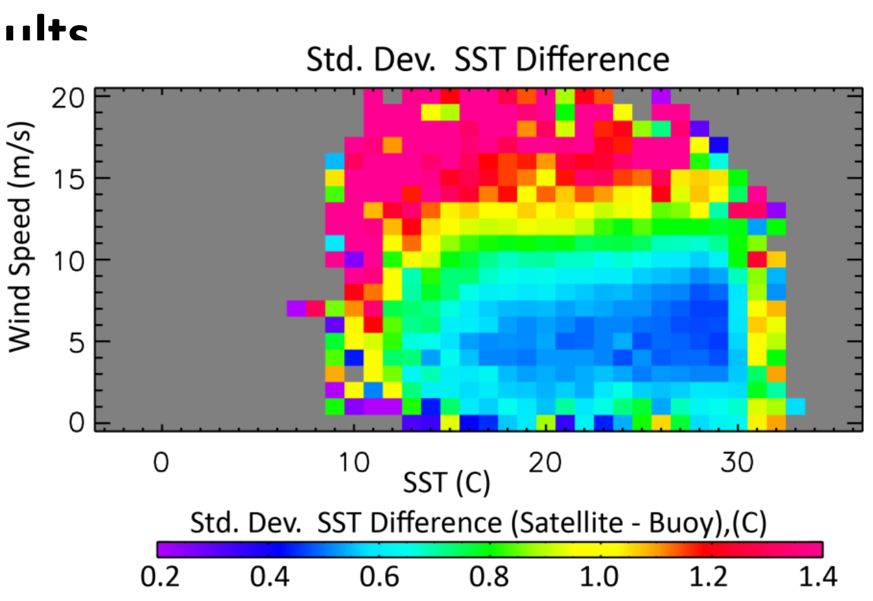

Figure 5. Std. Dev. TMI minus Buoy SST difference

TMI only samples equatorward of 38 degrees and thus SSTs less than ~10K are not sampled. The lack of a low frequency (6.9 GHz) channel leads to increased standard deviation at wind speeds > 12 m/s and at low values of SST. The large biases at the edges of the distribution are likely a statistical effect and should not be taken seriously.

GMI Results

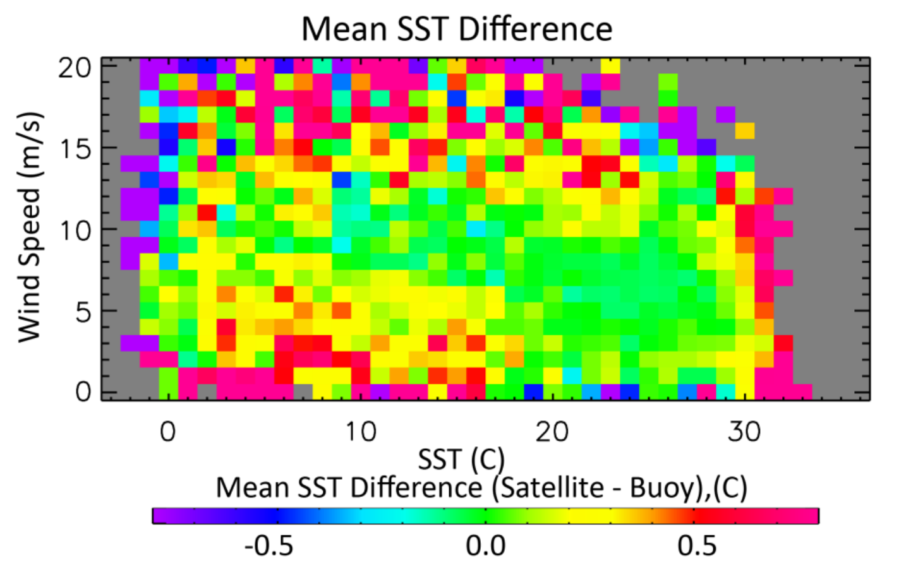

Figure 6. Mean GMI minus Buoy SST difference

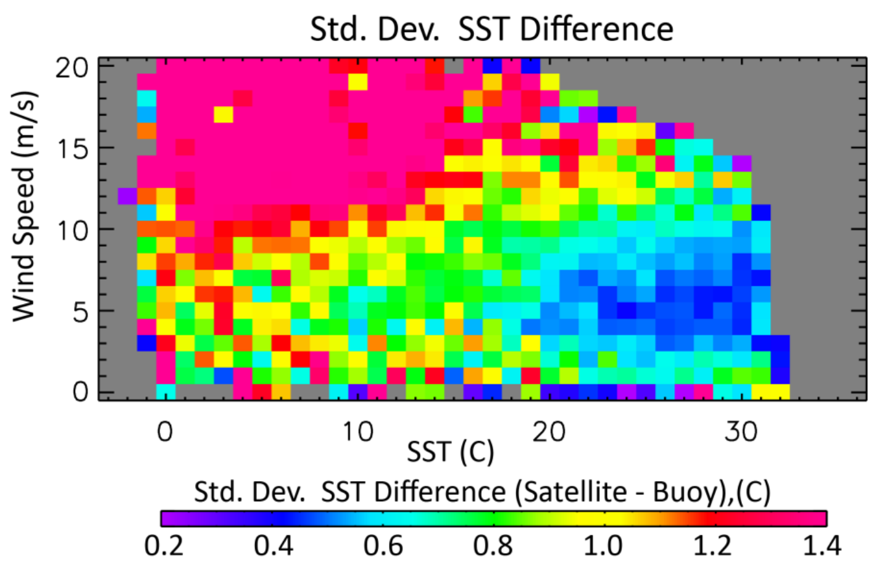

Figure 7. Std. Dev. GMI minus Buoy SST difference

GMI lacks a low frequency channel, but samples cold water because of its more inclined, higher latitude orbit. The standard deviation is considerably larger than AMSR-E in cold water, especially at high wind speed. The results appear more noisy because there are fewer GMI collocations due to its shorter (so far) mission lifetime.

SSES Estimation Algorithm

The SSES Estimation Algorithm is based on look-up tables for Bias and Standard Deviation. The values the tables above are less reliable near the edges of the distribution, where there are fewer collocations. We calculate smoothed versions of these tables for use in the SSES algorithm.

Smoothed and Extended AMSR-E Results

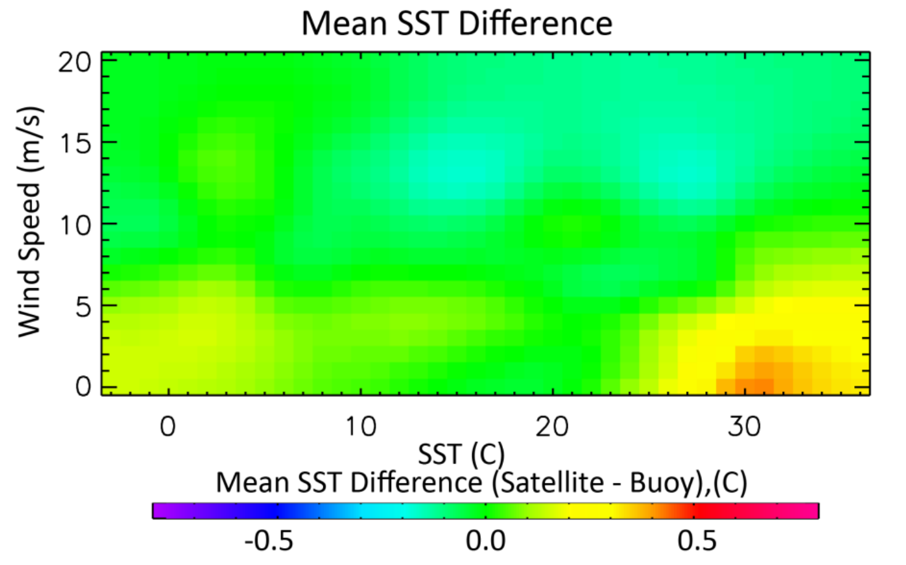

Figure 8. Smoothed AMSR-E minus Buoy SST difference

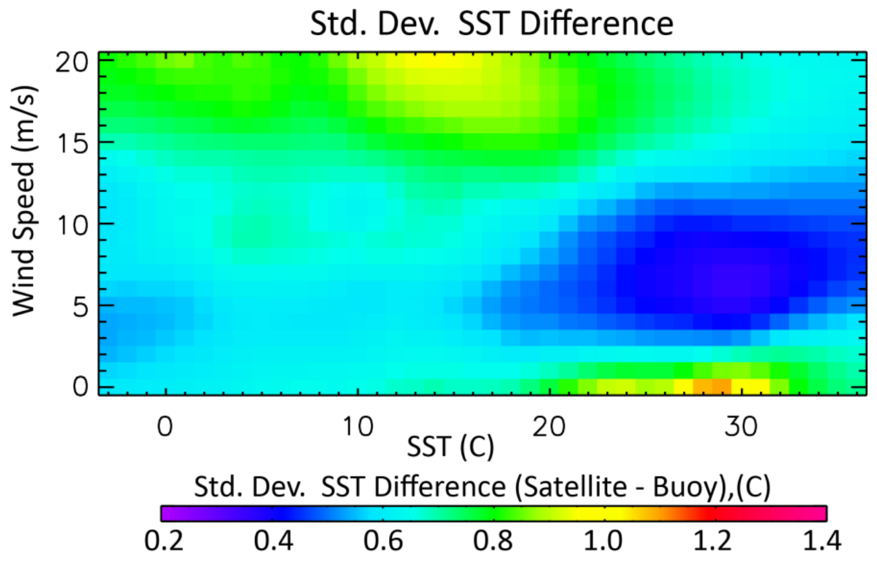

Figure 7. Smoothed AMSR-E minus Buoy Std. Dev.

(Compare these two figures to Figs. 2 and 3)

The results were smoothed using a non-parametric variational analysis that simultaneously minimized difference from the measured values, and the smoothness of the final result. Measured values were weighted by the number of values in a given bin, which de-emphasizes the anomalous results near the edges of the distribution. In the final algorithm, the standard deviation is also adjusted for buoy errors by subtracting the estimated buoy standard deviation (0.22 C) in quadrature.

Conclusion

We expect to reprocess all data by August 2017 and then continue forward processing using the new estimates for WindSat, AMSR2, and GMI.

Acknowledgments

This project was supported by NASA and NOAA