P5.9 ON-ORBIT CALIBRATION OF AMSR-E AND THE RETRIEVAL OF OCEAN PRODUCTS

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1. INTRODUCTION

The Advanced Microwave Scanning Radiometer (AMSR-E) was launched on May 4, 2002, aboard NASA's Aqua spacecraft. The National Space Development Agency of Japan (NASDA) provided AMSR-E to NASA as an indispensable part of Aqua's global hydrology mission. Over the oceans, AMSR-E is measuring a number of important geophysical parameters, including sea-surface temperature (SST), wind speed, atmospheric water vapor, cloud water, and rain rate. A key feature of AMSR-E is its capability to see through clouds, thereby providing an uninterrupted view of global SST and surface wind fields.

2. ON-ORBIT CALIBRATION

AMSR-E has an on-board 2-point calibration system that continuously compensates for variations in the radiometers gain and noise temperature. The two vital components of this calibration system are the cold mirror and the hot reference load. The cold mirror provides a clear view of deep space, which is at a known temperature of 2.7 K. The hot reference load acts as a black-body emitter and its temperature is measured by precision thermistors. Unfortunately, the design of the AMSR-E hot load is flawed. During the course of an orbit, large thermal gradients develop within the hot load due to solar heating making it difficult to determine the average effective temperature from the thermistor readings.

Shortly after launch, a solution to the hot load problem was found. Using the existing network of satellite radiometers, we developed a technique for estimating the effective temperature of the AMSR-E hot load. Remote Sensing Systems (www.remss.com) maintains a real-time database containing daily observations from U.S. operational satellites. These satellite observations are collocated in time and space with the AMSR-E observations. The collocated observations are then processed by a radiative transfer model that computes the intensity of radiation entering the AMSR-E feedhorns. In essence, this process provides an earth-target calibration point. A 2-point linear extrapolation based on the cold mirror and earth-target calibration points yields the desired quantity: the effective temperature for the hot load. The effective temperature is then correlated with variations in the hot load thermistors, and an expression is found that gives the effective temperature as a function of the thermistor array. This methodology is depicted in Figure 1.

A preliminary set of ocean retrievals has been produced using this on-orbit calibration technique. Early validation results for these retrievals (see below) are very encouraging, exhibiting accuracies that meet original expectations. Although more analysis is required, these preliminary results suggest that the design problem for AMSR-E hot load will not noticeably degrade the Aqua mission.

3. VALIDATION OF SST AND WINDS

A preliminary validation of the AMSR-E SSTs and wind speeds has been completed. The SSTs are compared with the Reynolds Optimum Interpolation (OI) weekly SST fields that are at a 1-degree latitude/longitude resolution. The rms difference between AMSR-E SST retrievals (instantaneous, 50 km resolution) and the Reynolds SST (interpolated in time and space to the AMSR-E footprint location) is 0.76°C over the 3-month period from June through August 2002. Some of the difference is due to the relatively low spatial/temporal resolution of the Reynolds' product as is clearly shown by difference maps of the AMSR-E minus Reynolds SST. Figure 2a shows the joint probability density function (pdf) for the AMSR-E and Reynolds SST.

The wind validation was done by comparing the AMSR-E winds with winds coming from four other satellite microwave radiometers (three SSM/Is and TRMM TMI), and with winds from the satellite microwave scatterometer QuikScat. A collocation window of 25 km and one hour is used. The agreement with the other radiometers is quite good, showing an rms difference of 0.51 m/s over the 3-month period from June through August 2002. Unfortunately the collocation between AMSR-E and QuikScat is not very good because their equator node times are about 6 hours different. The few good collocations that do exist are in the extreme northern and southern latitude. For these collocations the rms wind difference is 0.92 m/s and there is an offset of 0.57 m/s (AMSR-E high) that is yet to be explained. Figure 2b shows the pdf for the AMSR-E and SSM/I-TMI wind. Figure 2c is the same as Figure 2b except the comparisons are for the scatterometer winds.

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3. AIR-SEA INTERACTION AS SEEN BY AMSR-E

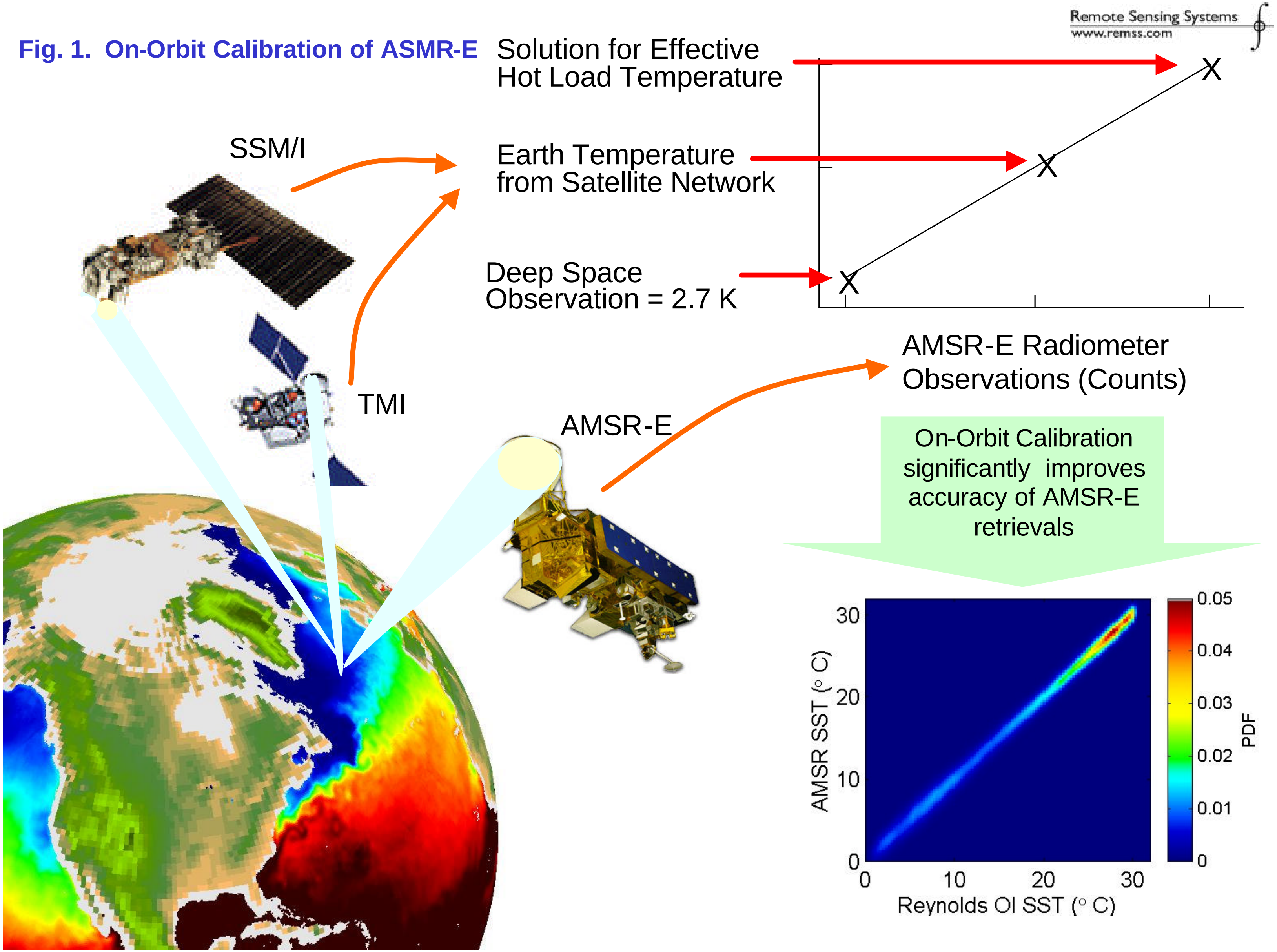
Accurate through-cloud SST retrievals were first provided by the TRMM microwave imager (TMI) launched in 1997. However, TRMM is in an equatorial orbit, and its observations are restricted to latitudes between 40 S to and 40 N. For the first time, AMSR-E is now providing through-cloud SSTs over the northern and southern oceans, where clouds often obscure the surface for extended periods of time.

In Figure 3 and 4 we show an example of how the AMSR-E SST and wind retrievals are helping researchers to better understand air-sea interactions. Figure 3 shows the wave structure in the SST field resulting from the confluence of the Brazil and Malvinas Currents. The Brazil Current brings warm water down from the tropics while the Malvinas Current brings cold polar water northward. Figure 4 shows the AMSR wind speed in the same region with AMSR-E SST contours (gray lines) superimposed. Red indicates high wind speeds, while blue/green are low wind speeds. Over areas of warm water, the rising warm air increases the vertical mixing in the atmospheric boundary layer. As a result of the increased vertical mixing, the winds aloft are more closely coupled with the surface. Hence, as the figure shows, higher surface winds are associated with warmer SSTs. The reverse is true for areas of cold SST. Winds over the cold Malvinas Current are much lower than over the warm Brazil Current. The global observations of AMSR-E provide an uninterrupted view of this air-sea interaction.

4. AVAILABITY OF ASMR-E OCEAN PRODUCTS

The ASMR-E Ocean Products are now available at www.remss.com for browsing, downloading, and evaluating. The products include SST, wind speed, water vapor, cloud water, and rain rate. Ice edge information is also available. These retrievals have been inter-calibrated with the SSM/Is and TMI. The AMSR-E products are usually available in a few hours after the observation time. The entire AMSR-E dataset starting on June 1 is stored on-line for immediate downloading. We welcome your feedback on the accuracy and utility of these products for your research.

Fig. 1. On-Orbit Calibration of ASMR-E



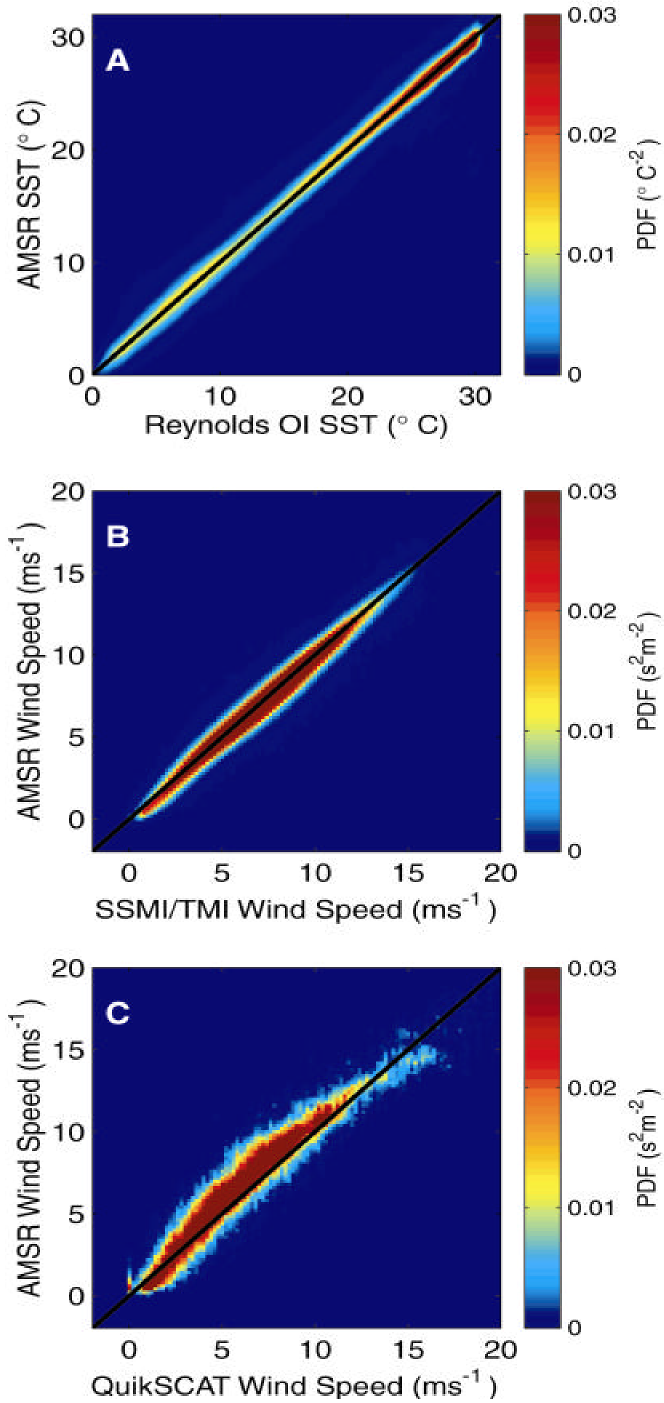


Fig. 2. Preliminary validation of AMSR-E SST and wind. Each of these images shows a scatter plot in terms of the joint probability density function (pdf). Image A compares the ASMR-E SST with Reynolds OI SST. The rms difference is 0.76 C. Image B compares the AMSR-E wind speed with collocated wind speeds from three SSM/I's and TMI. The rms difference is 0.51 m/s. Image C compares the AMSR-E wind speed with collocated wind speeds from the scatterometer QuikScat. The rms difference is 0.92 m/s and there is a bias of 0.57 m/s, with ASMR-E being high.

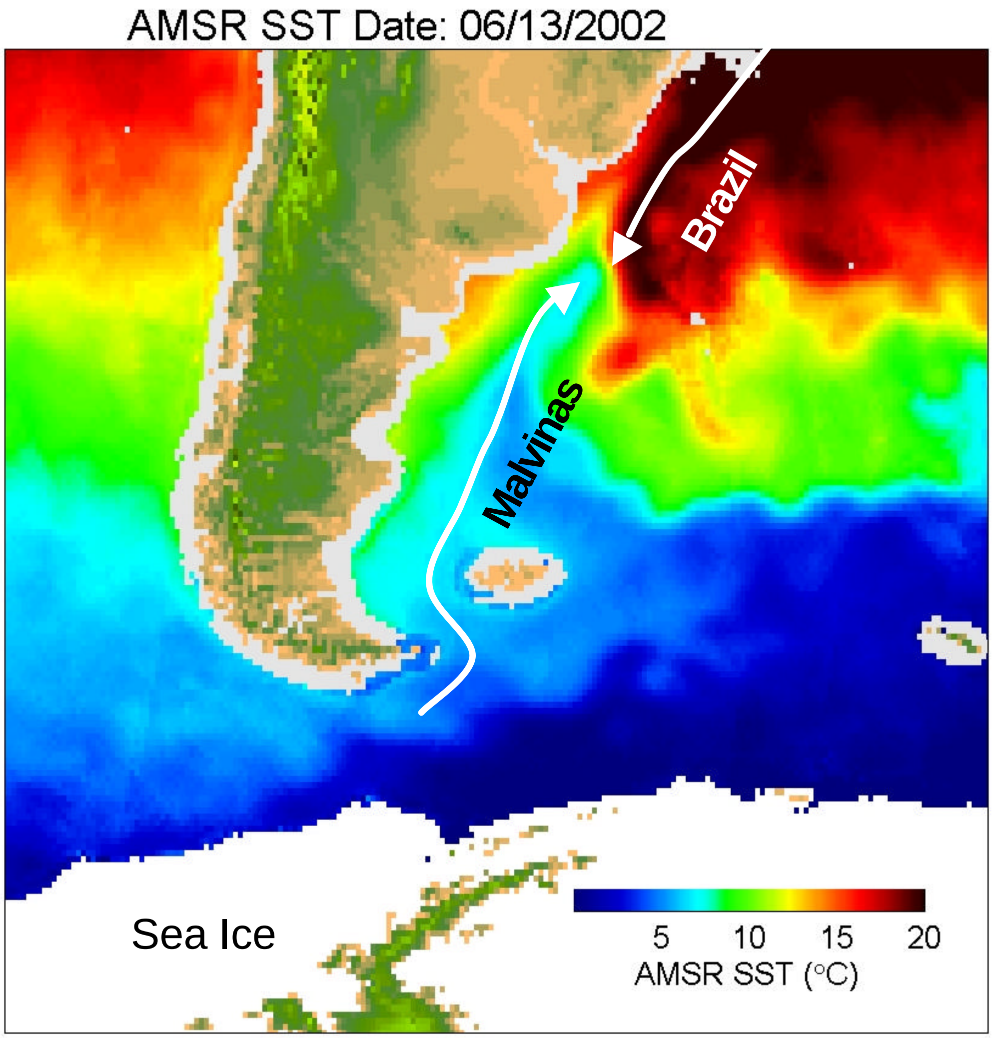


Fig. 3. The confluence of the Malvinas and Brazil Currents as seen by ASMR-E on June 13, 2002. The microwave emission measured by AMSR-E easily penetrates clouds, thereby giving an uninterrupted view of the sea-surface temperature (SST) in areas of persistent cloud cover.

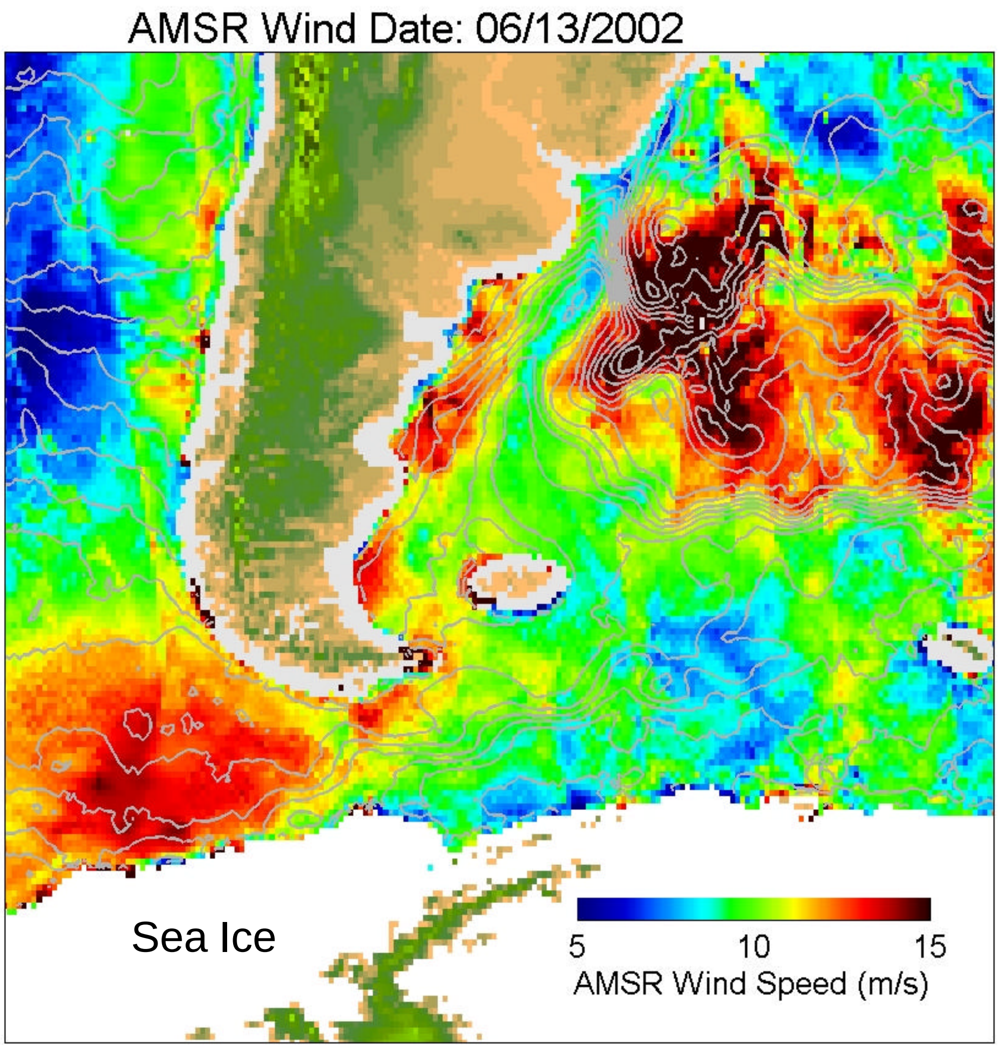


Fig. 4. The SST fields from Figure 3 are shown as gray contours in this figure superimposed on the ASMR-E wind field. Over the cold Malvinas Current, the wind speed is lower than over the warm Brazil Current waters. This is an example of the close coupling that exist between the surface wind and SST due momentum fluxes in the marine boundary layer.