Monitoring of global SST by the Advanced Microwave Scanning Radiometer-E

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Abstract – The Advanced Microwave Scanning Radiometer – E (AMSR-E) aboard the NASA Aqua has been operated for almost 3 years since July 2002. Sea surface Temperature (SST) retrieved from AMSR-E is accurate as can be used for operational purposes. AMSR-E SST also can be used for monitoring of global SST in climate studies. To satisfy a requirement in climate studies, AMSR brightness temperature (Tb) should be calibrated accurately as error less than 0.1K. A technique of calibrating AMSR Tb is proposed.

Keywords: SST, passive microwave radiometer, 6GHz, wind effect, AMSR-E.

1. INTRODUCTION

Passive microwave radiometers have a merit of measuring sea surface temperature (SST) under clouds. Adequate frequencies to measure SST are from 4 to 10GHz. In 2002, two identical microwave radiometers were launched: one is the Advanced Microwave Scanning Radiometer for Earth Observing System (AMSR-E) on the AQUA launched by the National Aeronautics and Space Administration (NASA) on May 14, 2002, and the other is AMSR on the Advanced Earth Observing Satellite-II (ADEOS-II) launched by the Japan Aerospace Exploration Agency (JAXA) on Dec. 14, 2002. AMSR/AMSR-E (hereafter AMSRs) were made by JAXA. AMSRs have 6GHz frequency, and we can expect accurate SST (unfortunately, ADEOS-II stopped on Oct. 25, 2003, due to unknown failure of solar panel power).

In an algorithm of retrieving SST from 6GHz, a removal of wind effects is the most difficult one among other corrections. On the ADEOS-II, SeaWinds, a NASA scatterometer, is loaded, and the SeaWinds data are very helpful for understanding a change of 6GHz due to ocean wind.

The AMSR-E has been operated for almost 3 years since July 2002. SST retrieved from AMSR-E is accurate as can be used for operational users such as the Japan Meteorological Agency (JMA) and Japan Fisheries Information Service Center (JAFIC). In addition to operational uses, AMSR-E SST will be used in monitoring of global SST. To do this, the brightness temperature (Tb) of AMSR-E should be calibrated as accurate as less than 0.1K.

2. AMSR SENSOR

AMSRs are forward-looking conically scanning radiometers at the constant incident angle of 55.0 degree (Kawanishi et al., 2003). Frequencies of AMSR are 6.9, 10.7, 18.7, 23.8, 36.5, 50.3, 52.8, and 89.0 GHz, and those of AMSR-E are the same except for no two 50 GHz. We have two polarizations (V-pol and H-pol) at frequencies except for two 50GHz, and only V-pol at two 50GHz. A spatial resolution on the earth surface at 6GHz is 40 by 70 km for AMSR, and 43 by 75 km for AMSR-E. A spatial sampling interval on the earth surface is 10 km at all frequencies except for 89GHz with 5km. A temperature resolution for one sampling at 6 GHz is 0.42 K (measured at 300K) for both AMSRs. In our studies, we used geophysical data (wind speed and direction) of SeaWinds on ADEOS-II. SeaWinds is the NASA scatterometer operating at 13.4GHz, and observes the ocean surface at two constant incident angles of 47 degree (H-pol) and 55 degree (V-pol).

3. SST ALGORITHM

We retrieve SST from 6GHz V-pol (hereafter, 6V, and so on). In addition to SST, 6V contains various signals concerned with other parameters. These are (a) atmospheric effect, (b) wind effect, (c) salinity effect, (d) land contamination, (e) sea ice contamination, and (f) sun glitter contamination. Among the former three effects, (c) is very small. We can correct (c) by using monthly climate salinity. Effects (a) and (b) are large, and we will explain a method of correcting (b) in section3. Contaminations by (d)-(f) are large, and we eliminate contaminated areas as much as possible. In our algorithm, missing areas due to (d) are within about 100km from shorelines, and missing areas due to (f) are within angles of 25 degrees made by AMSRs viewing direction and the sun glitter direction. In (e) sea ice case, if sea ice is detected in AMSRs pixels, we eliminate those pixels.

We retrieve SST from the corrected 6V, by using a relation of 6V to SST. Fig.1 shows this relation (10V is shown in comparison with 6V). Curves shown in Fig.1 are obtained by using the Fresnel formula, at the incident angle of 55.0 degree, with the salinity of 3.5%. The complex dielectric constant of the ocean water is from Klein and Swift (1977).

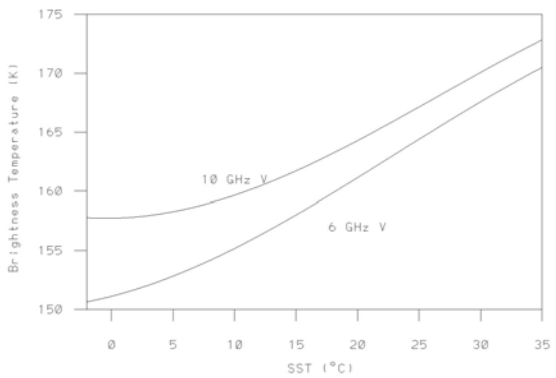

Fig.1 Relation between 6V (10V) and SST

4. CHANGES OF 6GHZ DUE TO OCEAN WIND

On ADEOS-II, AMSR and SeaWinds are observing the ocean surface almost at the same time. Fig. 2 is made from composite data of AMSR and SeaWinds in a period between Apr. 11 and 30,

2003. Data are sub-grouped into four SST regions; below 2.5 C, between 7.5 and 12.5 C, between 17.5 and 22.5 C, and above 27.5 C. It is noticed that 6V doesn't change in a range of 6H less than 3.8 K = (z0), and both 6V and 6H increase above z0. A slope of 6V/6H increasing, sp, ranges around 0.5. In these figures, three cases of relative wind directions are shown; upwind, crosswind, and downwind. The relative wind direction is determined by the SeaWinds wind direction and AMSR's viewing direction. The value of sp in upwind case is the largest, and other two cases are almost the same. Among four SSTs, the values of sp are almost same except for above 27.5C, and the one of above 27.5C is smaller than other SSTs.

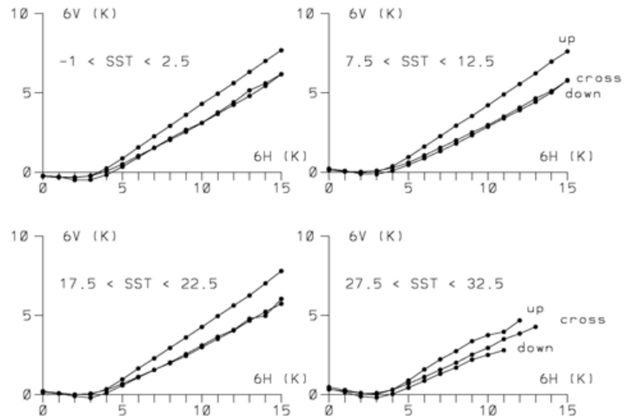

Fig.2 Relation between 6V and 6H

From Fig.2, we can calculate an amount of wind effect on 6V, Inc_6V, as shown in eq. (1).

$$\begin{aligned} Inc\_6V &= 0 \quad \text{for 6H less than z0} \\ &= (6H - z0) * sp \quad \text{for 6H greater than z0} \qquad (1) \end{aligned}$$

A method of determining the relative wind direction by only AMSR's data is described in [Shibata, 2004].

5. VALIDATIONS OF AMSRs SST

We have compared AMSRs SST with buoys SST in the global ocean. Buoy data are collected through the Global Telecommunications System (GTS). Root mean square (rms) of difference between AMSR and buoy SST is 0.59C averaged during 18 months since July 2002 for AMSR-E, and 0.74C averaged during 7 months since April 2003 for AMSR.

We have checked cross-talk of SST with four parameters; water vapor content (WV), cloud liquid water content (CLW), wind speed, and relative wind direction, and noticed no significant cross-talk with those parameters.

6. AMSR-E SST FOR CLIMATE RESEARCH STUDIES

SST changes from the climate averages are usually small, such as 0.1 - 1C. To use AMSR-E SST in climate research studies, Tb of AMSR-E should be calibrated accurately as error less than 0.1K. The achievement of this accurate calibration may be difficult by using only AMSR-E data. Therefore, we should check AMSR-E data by other data source.

A proposed method is as follows; average globally 6V data already corrected for atmospheric and wind effects, against the reference SST of 0, 10, 20, and 30 C. Here, the reference SST is taken from the Reynolds weekly SST (AMSR-E SST is not used in Reynolds SST). Table 1 shows monthly average of 6V for three years.

Table 1 Monthly average of 6V

Jul. 2002	158.16K
Jul. 2003	158.11K
Jul. 2004	158.11K

Table 1 indicates that it is possible to use AMSR-E in climate research studies.

7. CONCLUSION

AMSR-E aboard NASA/Aqua has been operated for almost 3 years since July 2002. We have developed SST algorithm using 6V of AMSRs, and validated AMSR SST using the ocean buoys. AMSR-E data are stable for this period, and we will be able to use AMSR-E SST in climate research studies. At the present, no abnormal signals are reported from AMSR-E.

8. ACKNOWLEDGEMENTS

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