STUDY ON MERGING MULTI-SENSOR SSTs OVER THE EAST ASIA

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Abstract

KMA has been produced the SST (sea surface temperature) from geostationary and polar orbit satellite data. In this study, we investigated the merging method using the SSTs derived from infrared and microwave sensor data and evaluated their accuracy. The SSTs retrieved from different satellite sensors were first produced based on the multi-channel regression, called multi-channel SST (MCSST) from MTSAT-1R, NOAA/AVHRR data from March 2006 to February 2008 over the East Asian region. For the SST from Aqua/AMSR-E, the Wentz algorithm has been used. The multi-sensor satellite-derived SSTs show different characteristics in time and space. In comparison with buoy SSTs for validation, the RMSE from the MTSAT-1R, AVHRR and AMSR-E are 0.75 °C, 0.62 °C and 0.90 °C, respectively. The error characteristics were applied for the merging process. The objective analysis approach based on the Gauss-Markov theory is used for merging, and the combined SST is produced in daily basis with 25 km in space for 2007. In comparison with OISST which is daily mean data with same spatial resolution, the bias and RMSE of merged SST are -0.15 °C and 0.81 °C. In this year, the spatial resolution is improved about 5 km for same period. And the bias and RMSE are -0.05 °C and 1.04 °C comparing with buoy SST.

INTRODUCTION

Satellite-based sea surface temperature has been used for ocean and atmospheric forecasting system and a study on the global climate change as an important variable to better understand interactions between the ocean and atmosphere.

Thus, this study has been performed to combine multi-sensor satellite-derived SSTs over the East Asia in framework of GHRSSST (Group for High Resolution SST).

The GHRSSST is an international collaboration for ocean forecasting activities to address an emerging need for accurate high resolution SST products. The aim of GHRSSST is to provide the best quality sea surface temperature data for applications in short, medium and decadal/climate time scales in the most cost effective and efficient manner through international collaboration and scientific innovation.

The multi-sensor satellite derived SSTs show different characteristics in time and space. The SST retrieved from infrared instruments has a high spatial resolution but cloud detection is a difficult problem. The other hand, the microwave data has a capability to see through clouds, thereby providing an uninterrupted view of global SST and surface wind fields but these products have a low spatial resolution.

Therefore, the final purpose in this study develops merged infrared and microwave SST products to make full use of the positive characteristics of each sensor types. In this study, we evaluated SSTs derived from MTSAT-1R, AVHRR/NOAA-17, 18 and AMSR-E/Aqua satellite data from March 2006 to February 2008 over the East Asian region. Also, the merged SST with 25km and 5km resolution was derived by the objective analysis method based on the Gauss-Markov theory (Guan and Kawamura, 2003). The advantage of the merged SST is making full use of empty area where single-sensor satellite SST is not produced by cloud, rainfall, fog and aerosol etc.

DATA

The information and coverage of the satellite-derived SSTs used in this study show in Table 1 and Figure 1. To merge multi-sensor SSTs, we selected the MTSAT-1R, AVHRR/NOAA-17&18 and AMSR-E/Aqua sensor data which is possible to receive direct at KMA.
The MCSST (Multiple-Channel Sea Surface Temperature) was calculated from MTSAT-1R and AVHRR data. To derive MCSST from the MTSAT-1R satellite data, the brightness temperature for two thermal infrared channels was used. The central wavelength for each channel is 10.8 µm and 12.0 µm. The MCSST data retrieved from MTSAT-1R over the East Asian region was obtained every 30 minutes. The coefficients used to calculate the MCSST were obtained using linear regression of the brightness temperatures and buoy SST.

To derive the MCSST from AVHRR, the coefficients were applied the values of NOAA/NESDIS (National Oceanic & Atmospheric Administration/National Environmental Satellite, Data, and Information Service).

The SST from AMSR-E data was collected via ftp L2 products derived using Wentz Algorithm from NSIDC (National Snow and Ice Data Center).

The characteristics for the each satellite data are explained more detail in table 1. The RMSEs of SST derived from MTSAT-1R, AVHRR and AMSR-E are 0.75 K, 0.62 K and 0.9 K in East Asian region from March 2006 to February 2008, respectively. The results are shown in table 2.

![Figure 1 : The box is the coverage of MTSAT-1R and dot is buoy stations.](image)

<table>
<thead>
<tr>
<th>Retrieval</th>
<th>MTSAT-1R Retrieval (MCSST)</th>
<th>AVHRR /NOAA-17,18 Retrieval (MCSST)</th>
<th>AMSR-E /Aqua Collection (Wentz al. V2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbit/sensor</td>
<td>Geostationary /Infrared</td>
<td>Polar /Infrared</td>
<td>Polar /Microwave</td>
</tr>
<tr>
<td>Depth</td>
<td>~µm</td>
<td>~µm</td>
<td>1 mm</td>
</tr>
<tr>
<td># of Passed /Time</td>
<td>44 times/day Per every 30 min.</td>
<td>3~4 times/day N17 : 00, 12 UTC N18 : 06, 18 UTC</td>
<td>3~4 times/day 01:30 UTC</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>5 km</td>
<td>1 km</td>
<td>25 km</td>
</tr>
<tr>
<td>Retrieval of cloudy region</td>
<td>clear sky</td>
<td>clear sky</td>
<td>clear &amp; cloudy sky</td>
</tr>
</tbody>
</table>

*Table 1 : The Information of Geostationary and Polar orbit satellites used in this study.*
Satellite | Bias (Sat-Buoy) | RMSE | NOBS
----------|----------------|------|------
MTSAT-1R  | 0.14           | 0.75 | 94537
AVHRR    | -0.09          | 0.62 | 8784
N17      | 0.02           | 0.58 | 4222
N18      | -0.19          | 0.65 | 4562
AMSR-E   | -0.1           | 0.90 | 28460

*Table 2*: The accuracy for the satellite-derived SST over East Asian region from March 2006 to February 2008, respectively.

**MERGING PRECESS**

Figure 2 shows a availability of satellite-derived SSTs. AMSR-E SST is useful 40% on average and it is lowest in summer because of rainy season from June to September.

The objective analysis approach based on the Gauss-Markov theory is used for merging, and the merged SST is first produced in daily basis with 0.25 degree ($\approx$ 25km) in space. The merging process is showed in Figure 3 and Figure 4. This method is referenced as same by Guan and Kawamura (2003) as same except different satellite-derived SSTs.
VALIDATION OF MERGED SST

In last year, the merged SST was retrieved for the 2007. To evaluate the merged SST, we used drifting buoy and OISST data retrieved from NOAA/NESDIS. The spatial and temporal resolutions of OISST are 25 km and daily SST. First, OISST and merged SST were resampled to have the same latitude and longitude. In comparison with OISST, bias and RMSE are -0.087 °C and 0.83 °C. To validate using the buoy SST, the merged SST is averaged the data within 0.05° with buoy as the center. To calculate a daily mean of buoy SST, the number of buoy observations during a day is more than 10 and the distance of these data is less than 0.25°. The annual average distributions of OISST and merged SST and the scatter plot between merged SST and buoy SST are shown in Figure 5. In comparison with buoy SST, bias and RMSE are -0.15 °C and 0.81 °C.

Figure 5: The annual average distribution of OISST/NESDIS, satellite-based multi-sensor SST/NIMR, the difference distribution between merged SST and OISST and scatter plot between buoy and merged SST in 2007.
In 2010, the spatial resolution of merged SST was improved about 5 km using same approach. To investigate the accuracy, we validated merged SST using the drifting buoy and OSTIA (Operational SST and Sea Ice Analysis) data retrieved from Met Office. The spatial and temporal resolutions of OSTIA SST are about 6 km (1/20°) and daily SST. The OSTIA SST and merged SST were also resampled to have the same grid points. In comparison with OSTIA SST, bias and RMSE are -0.05 °C and 0.96 °C. To validate using the buoy SST, the merged SST is averaged the data within 0.05° with buoy as the center. To calculate a daily mean of buoy SST, the number of buoy observations during a day is more than 10 and the distance of these data is less than 0.05°. In comparison with buoy SST, bias and RMSE are -0.05 °C and 1.04 °C. Figure 6 showed the annual average distributions of OSTIA SST and merged SST and the scatter plot between merged SST and buoy SST.

Figure 6 : The annual average distribution of OSTIA/Met-Office, satellite-based multi-sensor SST/NIMR, the difference distribution between merged SST and OSTIA SST and scatter plot between buoy and merged SST in 2007.

SUMMARY

The RMSE of SST derived from MTSAT-1R, AVHRR and AMSR-E are 0.75 K, 0.62 K and 0.9 K in East Asian region from March 2006 to February 2008, respectively. In 2009, it was used objective analysis approach to merge multi-sensor SSTs in daily basis with 25km spatial resolution. The accuracy of the merged SST is about 0.81 °C against the buoy SST. In comparison with OISST, RMSE is about 0.83 °C. In 2010, the spatial resolution of merged SST was improved about 5km and the comparison result with buoy SST and OSTIA SST are about 1.04 °C and 0.96 °C. In the validation results according to the latitude, it is showed that the RMSE has been increasing in high latitudes. To improve the accuracy for the high resolution SST, it should be considered the different characteristics of multi-sensor SSTs in time and space such as diurnal variation and satellite zenith angle.

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REFERENCES