Production of Multi-sensor SST with High Resolution over East Asia at KMA

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Abstract

KMA has been produced the SST (sea surface temperature) from geostationary and polar orbit satellite data. To study the NWP model and climate change, gap-free SST with high resolution in time and space is needed. In this study, we investigated two methods to produce a gap-free SST with high resolution in time and space over East Asia and evaluated their accuracy. The algorithms by merging of multi-sensor SSTs and by assimilation of NWP-OML (Numerical Weather Prediction-Ocean Mixed Layer) coupled model based on various multi-sensor SSTs were developed successfully. The accuracy of these SST shows reasonable results comparing to buoy SST.

INTRODUCTION

The SST is a very important factor in the forecasting system and a global climate change. The global SST can be obtained from satellite, however, the SST derived from IR and MW sensors produces an interrupted view of SST due to cloud, rainfall, fog and aerosol etc. Thus, two methods have been studied to produce a gap-free SST with high resolution in time and space over East Asia at KMA/NIMR. One of the gap-free products is generated by merging of multi-sensor SST, which have about 5 km spatial resolution in daily basis. The satellite data used to merge are MTSAT-1R, AMSR-E and AVHRR data. The other is predicted by data assimilation of NWP-OML coupled model based on various satellite SSTs. The spatial and temporal resolutions of the predicted SST are about 25 km and 30 minute. The NWP-OML coupled model with DA is able to produce a reliable SST by optimal merging of satellite-derived SST and the model-predicted SST including understanding the air-sea interaction by investigating the forcing factors influencing SST. The products by coupled model were tested for four months through nudging the before-mentioned satellite SSTs. Currently AMSR-E data is not available, as a substitution, the new multi-sensor SSTs with COMS, AVHRR and MODIS SST is studied in this year.

DATA AND METHOD

To merge the multi-sensor SSTs, we selected the MTSAT-1R, AVHRR/NOAA-17&18 data which is directly receiving at KMA and AMSR-E/Aqua data was collected via ftp L2 products derived using Wentz Algorithm from NSIDC (National Snow and Ice Data Center. The merging method is used the objective analysis approach based on the Gauss-Markov theory and the merged SST is produced in daily basis with about 5 km space. The merging process is showed in Figure 1(a). This method is referenced as same by Guan and Kawamura (2004) as same except different satellite-derived SSTs. The concept of model-predicted SST shows in Figure 1(b). The satellite-derived SST considering diurnal variation is assimilated into NWP-OMLM coupled model using nudging method. The initial SST of predicted SST by data assimilation of NWP-OML coupled model were used same data in merging process. The spatial and temporal resolutions of this product are about 25 km and 30 minute.
MERGING OF MULTI-SENSOR SSTs

NIMR merged SST is generated by merging of multi-sensor SST, which have about 5 km spatial resolution in daily basis. To validate the merged SST, the drifting buoys and OSTIA (Operational SST and Sea Ice Analysis) data are used.

In comparison with buoy SST, bias and RMSE are 0.12 °C and 1.34 °C, respectively. The right panel in Figure 2 shows the scatter plot between the merged SST and the buoy SST.

The OSTIA SST with about 6 km (1/20°) was remapped to have the same grid point as merged SST. In comparison with the OSTIA SST, bias and RMSE are -0.12 °C and 0.94 °C. The mean distributions of the merged SST and the OSTIA SST for 2007-2009 are shown in Figure 2 with their difference.

Figure 3 shows a preliminary result of new NIMR merged SST using COMS, AVHRR and MODIS SST. The accuracy is about 1.6 °C for January 2012. This study is ongoing project.
The NWP-OML coupled model with DA (Data Assimilation) is able to produce a reliable SST by optimal merging of satellite-derived SST and the model-predicted SST including understanding the air-sea interaction by investigating the forcing factors influencing SST. The products by coupled model were tested for four month through nudging method the before-mentioned satellite SSTs and also show good agreement with buoy and OISST. Table 1 explained the information of NWP-OML model.

<table>
<thead>
<tr>
<th>OML model</th>
<th>WRF model</th>
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<tbody>
<tr>
<td>Domain</td>
<td>East Asian region [100 - 150°E, 11 – 61°N]</td>
</tr>
<tr>
<td>Horizontal grid</td>
<td>25km</td>
</tr>
<tr>
<td>Vertical grid</td>
<td>100 layers (Δz = 1m)</td>
</tr>
<tr>
<td>I.C, B.C</td>
<td>NCEP Final Analysis (1° resolution, every 6 hours), climatological temperature profile.</td>
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</tbody>
</table>

Table 1: The specification of combined NWP-OML model.

Figure 4 shows diurnal variation of predicted SST and scatter plot between daily temperature range (dSST) of model SST and dSST of regression SST on 23 July, 2008 (NIMR, 2010). The diurnal variation of predicted SST from NWP-OLM model is well represented comparing with the regression model (Kawai et al, 2003).

\[
\Delta SST = a(MS+H+e)^2+c[ln(U)]+c(MS+H+e)^2[ln(U)]+d
\]

MS : the daily mean solar radiation (W m\(^{-2}\))
H : the daily mean latent heat flux (upward is negative, W m\(^{-2}\))
U : the daily mean wind speed (m s\(^{-1}\))
a, b, c, d : the regression coefficients

Figure 4: The coupled model with a new mixed layer model produces the diurnal variation of SST, \(\Delta SST\) on 23 July, 2008, that is in good agreement with the regression model.
Figure 5 shows the predicted SST by data assimilation based on MTSAT-1R and the results comparing with OISST on January 4, 2008 and 24 July 2008. In comparison with NGSST (NFRDI/Korea & Tohoku University/Japan), RMSE shows from 1.0°C to 1.4°C for daily SST in January and July, 2008. In comparison with buoy SST, RMSE shows from 1.09°C to 1.17°C for daily SST in January, April, July and October, respectively (NIMR, 2011).

CONCLUSION

The retrieval algorithm of high resolution multi-sensor SST with various IR and MW data has been developed at KMA/NIMR. The new multi-sensor SST with COMS, AVHRR and MODIS SST is produced for the same temporal and spatial resolution and will be evaluated the accuracy using buoy SST for the period from April 2011 to August 2012. The products by coupled model show a good agreement with buoy SST and OISST. The predicted SST from coupled model shows strong improvement after 1st DA (1day DA) and weak improvement after 2nd DA (1day DA + 30min DA). And the effect of DA is stronger in summer than in winter.

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REFERENCE