Merged Satellite and In-situ Data Global Daily SST (MGDSST)

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1 Introduction

High resolution SST products are required for the monitoring of the ocean conditions, ocean assimilation system and numerical weather prediction models. Japan Meteorological Agency (JMA) started the daily SST analysis for the global ocean in April 2004. SST grid point values with 0.25° resolution are generated in near real time. This product was named 'Merged satellite and in-situ data Global Daily SST (MGDSST)'.

SSTs derived from AMSR-E boarded on the AQUA have been available since July 2002. It is the biggest advantage of AMSR-E to be able to estimate SSTs even in cloud-cover area and to enable more frequent observations than AVHRR (Fig. 1). However, spatial resolution of AMSR-E is about 40 km and it is much lower than that of AVHRR (less than 4km). In addition, the bias between AMSR-E and AVHRR is not clear, but AVHRR SSTs have a low bias relative to in-situ SSTs due to cloud and aerosol contamination. These biases should be eliminated for climatological use.

A new technique of merging AMSR-E and AVHRR is introduced to MGDSST analysis with considering the difference of spatial resolution of sensors and biases between them.

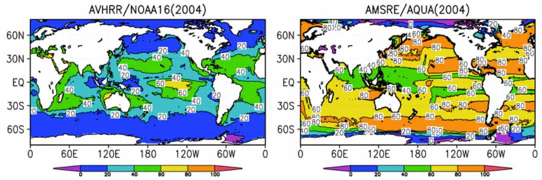

Fig. 1 SST availabilities (%) of AVHRR (left) and AMSR-E (right) for 2004.

2 Data used in the analysis

The level-2 SST products of AMSR-E are provided by JAXA. Global Area Coverage (GAC) level-1b data from AVHRRs on NOAA-16 and -17 are obtained from the Comprehensive Large Array-data Stewardship System (CLASS) of NOAA through the Internet. Meteorological Satellite Center (MSC) of JMA receives High Resolution Picture Transmission (HRPT) data of AVHRRs which cover the area around Japan.

The CLAVR-1 algorithm (Stowe et al., 1998) is applied to AVHRR data for cloud screening. Then, split-window MCSSTs are calculated separately for daytime and nighttime using coefficients provided by NESDIS/NOAA. SSTs are binned into 0.25° x 0.25° grid and converted into daily composite after day-night difference check. Quality controls are applied by comparing with a daily climatology and time-filtered AMSR-E SST for the daily composite data.

In-situ data (buoys, floats and ships) are obtained mainly through the Global Telecommunication System (GTS) also facsimile, e-mail and postal mail directly from domestic oceanographic organizations.

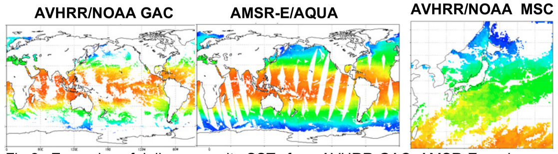

Fig.2 Examples of daily composite SSTs from AVHRR-GAC, AMSR-E, and AVHRR-MSC.

3 Analysis method

• Decomposition of satellite data

SST anomaly (SSTA) is calculated as a deviation from the daily SST climatology and decomposed into two temporal-scale and three spatial-scale : components long and short timescales with a cutoff period of 53 days, and large, middle and small scales with cutoff wavelengths of 580 km and 143 km (Fig. 3). Gaussian filter is adopted for the decomposition.

The small-scale component is aimed to represent meso-scale signals, which are detected only from AVHRR SST because of the low spatial resolution of AMSR-E. The short-timescale SSTs are analyzed only from AMSR-E, because the observations by AVHRR are less frequent in most of the region (Fig. 1). The signals varying with shorter period than 27 days are cut off, because the noise of the data is considerably large in those frequencies.

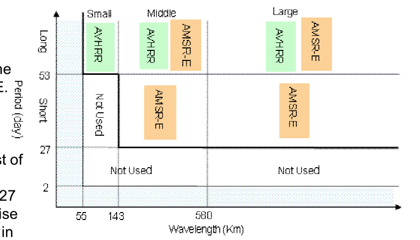

Fig.3 Diagram of decomposition for satellite data. Blue shaded area shows less than nyquist period and wavelength, which cannot be analyzed.

• Bias correction of satellite data

The large-scale, long-timescale SSTAs from AMSR-E and AVHRR have significant geographical differences between them (Fig. 4 left). Biases between satellites vary with time and regions. We regard in-situ SSTs as 'truth', and each SSTA is adjusted to SSTAs of in-situ observation before applying the optimum interpolation (OI). This adjustment is done using Poisson's equation with the in-situ SSTAs as the internal boundary conditions. The method was proposed by Reyolds et al. (1994). This procedure reduces not only biases between satellite and in-situ data but also biases among satellites.

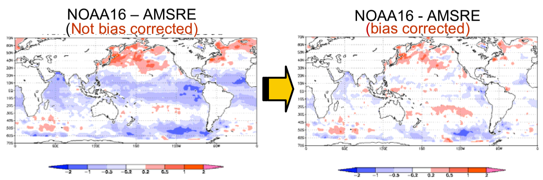

Fig. 4 Monthly mean difference between NOAA-16 and AMSR-E for August 2004.

• Optimal Interpolation (OI)

1) Space-time OI is applied to analyze SSTAs for each component.

2) First guess is zero anomaly value.

3) OI statistics (correlation-scale, RMS value of the first-guess error, RMS value of signal) are estimated a priori for

Long period ---- AVHRR Pathfinder ver.41 SST (1985-1999)

Short period ---- AMSR-E SST (2002-2004)

correlation coefficients are assumed 3D Gaussian function. $e^{-(ax^2+by^2+ct^2+dxy+eyt+ftx+g)}$

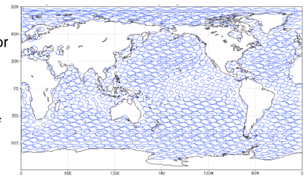

Fig. 5 Spatial scales for large-scale and long-period component. The elliptic contour lines show a range of the correlation coefficients of 0.9.

4) Analyzed SSTa are the sum of interpolated anomalies for the 5 components.

5) SSTs are masked in the sea ice area derived from MTSAT, NOAA for Okhotsk sea , SSM/I for the other area (the Arctic ocean, etc)

4 Validation

MGDSSTs are compared to moored buoys which are not used in the analysis form April 2004 to March 2005 (Fig. 6). Diurnal variations of buoy SSTs are ignored by daily-averaging. RMSE and bias are 0.38°C and +0.04 °C respectively. However, total numbers of the match-up data are limited, and locations of buoys are concentrated in the equatorial Pacific (or in the higher temperature range). So, we compared to all moored and drift buoys which are used for the bias correction. Fig. 7 shows the zonal mean of RMSE and bias. RMSE in the mid-latitude is worse than those in the low-latitude, especially in the Northern Hemisphere. The bias is generally positive and slightly higher in the mid-latitude of the Northern Hemisphere.

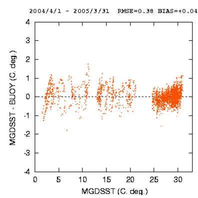

Fig. 6 Scatter diagram of MGDSST and difference of MGDSST minus independent buoy SSTs for the period April 2004 to March 2005.

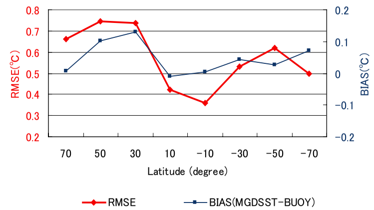

Fig. 7 Zonal mean of RMSE and bias between MGDSST and buoy SSTs for the same period as the Fig. 6.

Comparison with other products

NCEP RTG_SST is an operational daily global SST analysis with 0.5° grid resolution. MGDSST has a higher spatial resolution, especially around ocean fronts (Fig. 8). Monthly mean MGDSST are compared to monthly NCEP OI version2 SST (OISST2). MGDSST is consistent with OISST2 in the most of regions. However, the differences of two products are slightly large around the Arctic and the Antarctic. One of possible causes may be a difference of procedure near sea ice area.

The sea ice-to-SST conversion algorithm is adopted in OISST2 and SSTs near sea ice area are affected by simulated SSTs. On the other hand, MGDSST uses satellites' SST observations, but biases of those may not be corrected completely in the high latitude due to lack of in-situ data.

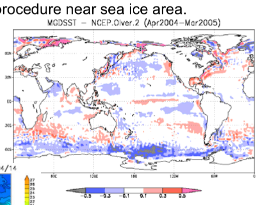

Fig. 9 difference between MGDSST and NCEP OISST ver.2 for the period from April 2004 to March 2005.

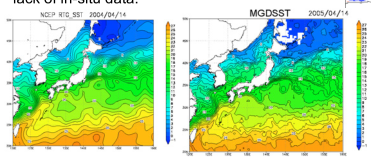

Fig. 8 Analyzed SST fields for 14 April 2004. RTG_SST (left), MGDSST(right).

5 Data distribution

・NEAR-GOOS Regional Real Time Data Base

http://goos.kishou.go.jp/

・JMA Japan-GODAE LIVE ACCESS SERVER

http://godae.kishou.go.jp/