COMPARISON OF GLOBAL SEA SURFACE TEMPERATURE PRODUCTS

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ABSTRACT
NOAA operational bulk SST product (Reynolds et al, 2002) is very popular global SST data sets and is extensively used for various studies. However, the original time resolution is weekly and relatively large. On the other hand, there exist many new global SST data sets at present. In this study, we compare many global SST data sets including NOAA operational bulk SST product, CAOS OI SST product, Microwave Optimum Interpolation (MWOI) SST, Real Time Global (RTG) SST and JMA merged satellite and in situ Global Daily (MGD) SST.

KEY WORDS: CAOS OI SST, MWOI SST, RTG SST, MGD SST

1. INTRODUCTION

Sea surface temperature (SST) is one of key parameters to understand global climate system because heat transfer between ocean and atmosphere strongly depends on SST. Global SST data sets have been basically constructed using an infrared radiometer such as NOAA/AVHRR. However, there is a serious problem on the remote measurement of SST using infrared radiometers. The problem of obscuration of sea surface by cloud is a strong constraint on the SST derivation. Recently there are some microwave radiometers (ADEOS/AMSR, Aqua/AMSR-E, TRMM/TMI etc.) can observe SST even below a cloud. It should be pointed out the spatial resolution of a microwave radiometer is low compared with an infrared radiometer.

The NOAA operational bulk SST product (Reynolds et al., 2002) is famous as a global SST data set and is widely used in many fields, e.g., numerical climate model (Saha et al, 2006) and surface heat flux estimation (Kubota et al, 2002). The SST product is made by blending satellite-based and in-situ SST data on a 1° x 1° grid at weekly intervals. On the other hand, recently several new global SST products can be used. Some of those products include SST data observed by a microwave radiometer and high temporal resolution data compared with the NOAA operational bulk SST product. There are various differences in the algorithm or the original data between each global SST product. Therefore, it can be expected there are some considerable differences between each SST product. It is most important to clarify the characteristics of each SST product and the differences for our research.

In the following, the data sets compared in this study are described in section 2, and the comparison results are given in section 3. Finally some conclusions are offered in section 4.

2. DATA

We compare five kinds of global SST product. The NOAA operational bulk SST product (Reynolds SST) has been widely used in the scientific community. Reynolds SST is a weekly 1° spatial resolution optimum interpolation (OI) SST analysis using in situ and satellite data (NOAA/AVHRR data). There are errors in the first version (Reynolds and Smith, 1994) due to an undercorrection of satellite bias and the choice of the sea ice to SST conversion algorithm. Reynolds et al. (2002) presented a new version of the OI analysis that reduces the errors. Microwave' (MW) OI SST is constructed and provided by Remote Sensing Systems (http://www.ssmi.com/sst/microwave_oi_sst_data_description.html). Only two microwave sensors of TMI and AMSR-E are used in MW OI SST. Using a diurnal model, all MW SSTs are normalized to a daily minimum SST, defined to occur at approximately 8 AM, local time. The SSTs are blended together using the OI scheme described in Reynolds and Smith (1994). Correlation scales of 4 days and 100 km are used in determining the weights used in this methodology. Center for Atmospheric and Oceanic Studies (CAOS) also provided high-resolution SST data (http://www.ocean.caos.tohoku.ac.jp). In this product not only infrared sensors such as NOAA/AVHRR, ERS/ATSR and TRMM/VISR but also microwave radiometers such as TRMM/MI and Aqua/AMSR-E. The spatial resolution of 0.1° is smaller than that of other products. Recently NOAA constructed a new high-resolution blended real-time global (RTG) SST analysis (Thiebaux et al, 2003). The SST analysis has been implemented in NOAA's operational forecast suite with daily products. Moreover, Japanese Meteorological Agency constructed new merged daily global (MGD) SST analysis by merging satellite and in situ data (Kurihara et al., 2006). . OI is also used in this analysis. However, OI is applied after separating satellite data into several components depending on temporal and spatial scales. Also in situ data is used bias corrections of satellite data. We compare each SST analysis after transforming all products into a daily-mean value. The analysis period is 2003-2004.

Moreover, we validate each SST product with use of SST data observed by buoys. The first buoy data set is from the Tropical Atmosphere Ocean/Triangle Trans-Ocean Buoy Network (TAO/TRITON) in the tropical Pacific Ocean (McPhaden et al., 2001). The second buoy data set is from Pilot Research Moored Array (PIRATA) in the Tropical Atlantic (www.brest.ird.fr/pirata/piratafr.html). Final buoy data is from the Kuroshio Extension Observatory (KEO) mooring located east of Japan (http://www.pmel.noaa.gov/keo/index.html). The buoy locations are shown in Fig.1.

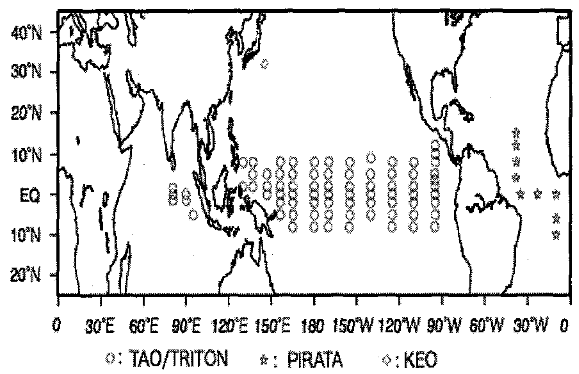

Figure 1. Buoy locations.

3. RESULTS

Figure 2. shows average differences between Reynolds SST and other SST products. CAOS and MWOI products overestimate SST in the eastern tropical Pacific compared with Reynolds data. Also MWOI product underestimates SST in the western and central North Pacific and the northern Indian Ocean. The difference there is considerably large. MWOI SST seems to be different compared with other products. On the other hand, the average differences between Reynolds and, MGD or RTG products are not so large. However, we can find relatively large difference in the Polar Regions between them

Figure 3. shows Root mean square (RMS) differences between Reynolds and other SST products. We can find large RMS differences in the western boundary current regions such as Kuroshio and Gulf Stream. Moreover, there exist large differences in the mid- and high-latitudes in the Southern Ocean. In particular, the difference between Reynolds and MWOI products is quite large. On the other hand, the difference between Reynolds and MGD products is relatively small. This is due to following two reasons: The original time resolution of the Reynolds product is weekly. And one kind of low-pass filters is applied to MGD product.

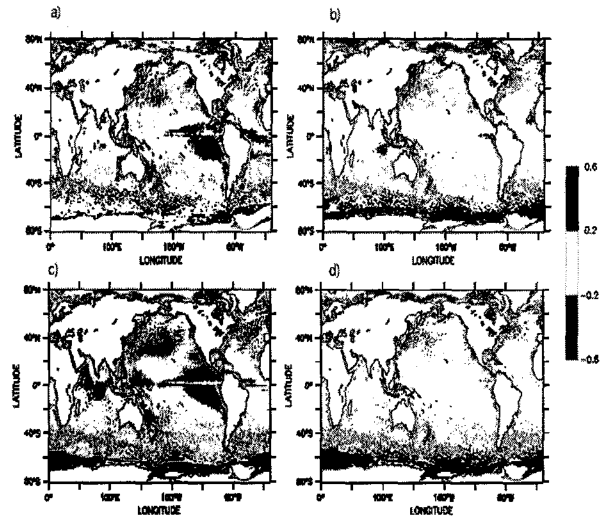

Figure 2. Average differences between Reynolds and other products. a) CAOS-Reynolds, b) MGD-Reynolds, c) MWOI-Reynolds, and d) RTG-Reynolds

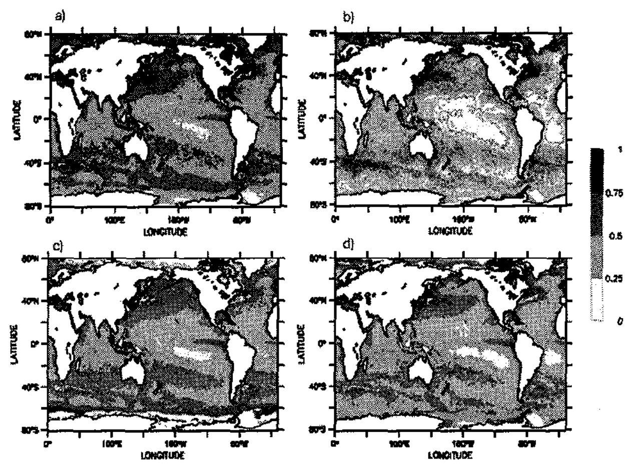

Figure 3. RMS differences between Reynolds and other products. . a) CAOS-Reynolds, b) MGD-Reynolds, c) MWOI-Reynolds, and d) RTG-Reynolds

Finally we validated each SST products with buoy data. Gridded SST data are linearly interpolated into a value on the buoy location. The bias is given in Fig. 4. Most SST products are less than buoy SST data, except KEO buoy. It is surprising that MGD product shows bets statistics, even though a low-pass filter is applied to the data. Also it should be noted that MWOI shows extremely good for KEO buoy, although MWOI gives worse results for other buoys. Since TAO (Pacific) SST data are probably assimilated into Reynolds and RTG products, the bias is relatively small. Figure 5 shows RMS errors between buoy data and each product. The RMS errors for KEO buoy are extremely large compared with other buoys. The large errors depend on the large time variability of SST in the region around KEO buoy. It is surprising that the RMS errors for MGD product are the smallest because MGD product is low-pass filtered data. In order to investigate the reason, time variation of

SST. and difference between KEO buoy and, CAOS or MGD SST data. It should be noted that the high-pass filter is applied to all of data in Fig.6. The analysis period is from June 2004 to January 2005. As expected, the MGD product shows very small variation, while there exists very vigorous high-frequency variation in both of KEO buoy and CAOS SST data. However, it is interesting that the difference between KEO buoy and MGD SST data is smaller than those between KEO buoy and CAOS SST data. The reason is that the accuracy of CAOS SST products is not so good for high-frequency variation. Therefore, although MGD does not reproduce actual high-frequency variation, the overall accuracy is better than other products.

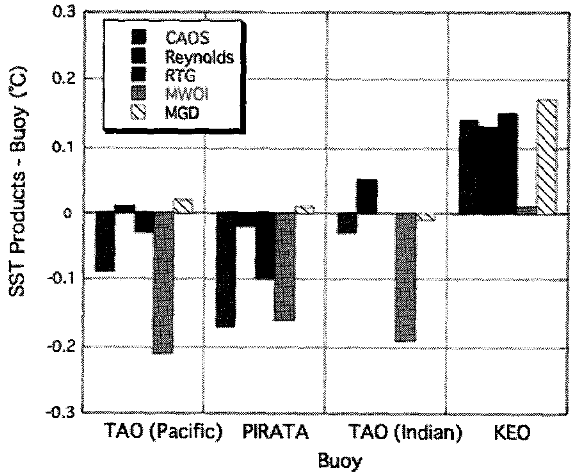

Figure 4. Bias between buoy SST data and each product.

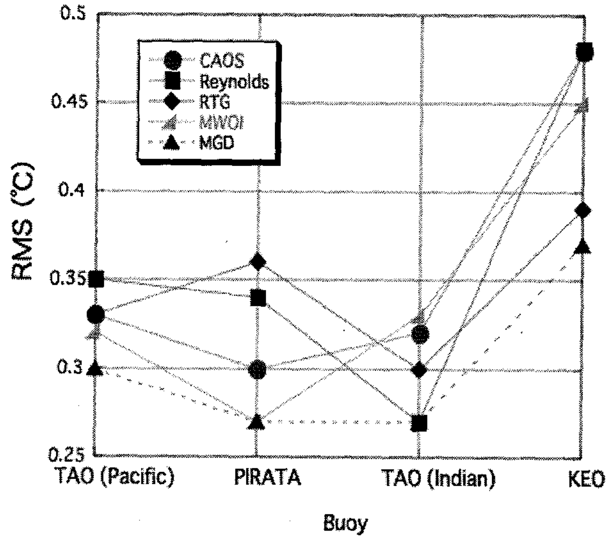

Figure 5. RMS error between buoy SST data and each product.

3. Conclusion

We compared five kinds of global SST products of CAOS, Reynolds, RTG, MWOI and MGD SST products. Generally there are large average differences in the high-latitudes of the Southern Ocean between Reynolds and other products. Also the average differences between MWOI and Reynolds products are large compared with other products in the tropical regions. The RMS differences between Reynolds and other SST products are large in the western boundary current regions and in the mid-latitudes of the Southern Ocean. The RMS differences between Reynolds and MGD SST products are relatively small depending on the removal of high-frequency variation in both of two products.

Moreover, we validated each SST products using KEO, PIRATA and TAO/TRITON buoy data. MGD products show good accuracy compared with other products. However, the MWOI product gives the smallest bias for the KEO buoy, though MWOI product gives the largest bias for other buoy data.

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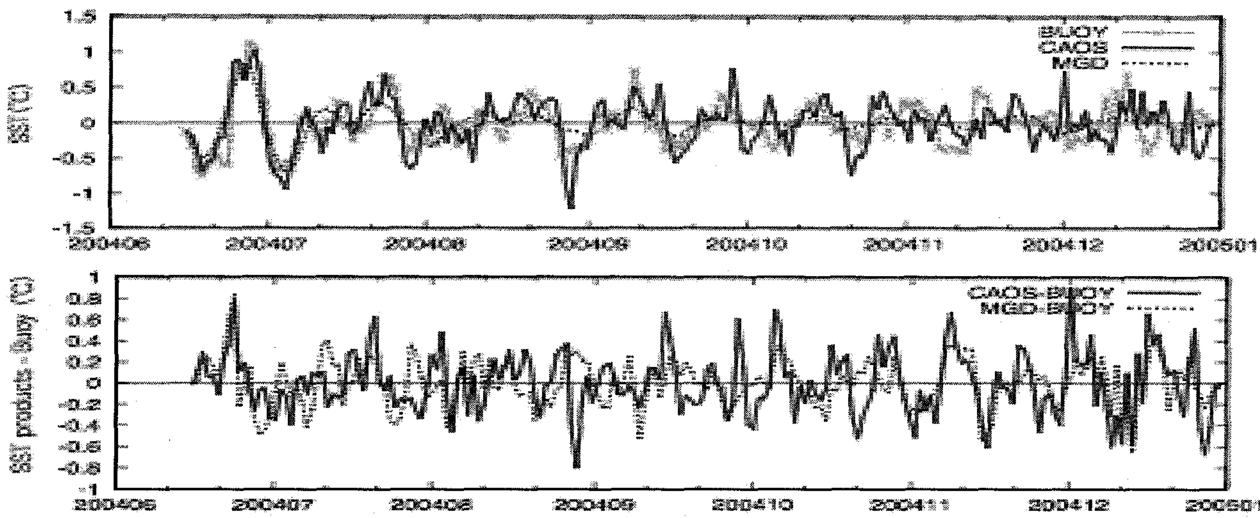

Figure 6. High-frequency time variation of KEO buoy, CAOS and MGD SST data (upper) and differences between KEO buoy and SST products (lower).