The sensitivity analysis in accordance with the resolution of the satellite sea surface temperature data

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***Abstract*— It is important to improve ocean initial fields through the assimilation of high resolution observation data in order to enhance predictability of ocean model. The reproducibility of the ocean models are improved through the observation data assimilation in several studies (e.g., Wang et al., 2006; Oey et al., 2005a; Larsen et al., 2007). By applying a variety of observations and data assimilation techniques, many operational institutions are performing ocean forecasting. However, the extremely high resolution as compared to the model grid may result in a waste of computational resources due to the increased operation time when the data assimilated in model. Also it can be a reason to decrease accuracy of model. In this study, the sensitivity of analysis fields of data assimilation system according to subsampling interval of GHRSST L2P data is analyzed using the global ocean circulation forecasting system. The assimilated satellite observed SST data were AVHRR NOAA-18G and AVHRR MEOP-A. To examine the proper spatial resolution of these data for the data assimilation system, we performed two experiments of Exp.MDT (Moderate Density Test) and Exp.LDT (Low Density Test). The resolutions of assimilated SST data for each experiment are shown in table 1. First, we collect the data from GHRSST L2P ftp site. Secondly, the contaminated data is removed in accordance with flags (e.g., proximity flags, confidence flag, ice, and land masked). And we reduce data quantity using simple thinning method. Analysis areas are global region and regional areas (e.g., Agulhas return, Cold tongue, Gulf stream, Kuroshio extension) showing strong horizontal gradient in sea surface temperature with more than 1 degree (Lei and Kawamura, 2003). In the result of Taylor diagram analysis, the values of both experiments are close to the reference. And the normal standard deviation is close to zero. So, we can confirm that the performance of data assimilation of both experiments is excellent. There was no big difference between two experiments in correlation coefficient with maximum of 0.01. However, the comparison with observation data (e.g., in-situ, AVHRR NOAA-18G and AVHRR METOP-A) show that the Exp.LDT has lower RMSE than that from the Exp.MDT. In the global region, the RMSE of Insitu in Exp.MDT, Exp.LDT is 0.45, 0.41, that of AVHRR NOAA-18G is 0.45, 0.43, and that of AVHRR METOP-A is 0.64, 0.63, respectively. The RMSE difference reaches about 0.04°C in the global region. These results also appear in the region where a strong horizontal gradient exists, such as Kuroshio-Extension, Gulf-stream, and Cold tongue. As a result, it is considered that the low-resolution data is proper to assimilate for data assimilation system assimilation. However, it is considered to require additional experiment results for high density test (Exp.HDT). In the future, we have a plan for deriving a proper subsampling resolution considering accuracy of model and computational cost.**

Keywords*—*data assimilation; GHRSST-L2P; subsampling

I. Introduction

Improvement of initial field through the assimilation of observational data is one important step in enhancing the prediction of the model. In recent years, research for increasing the reproducibility of the model with assimilation of different observations has been actively carried out because of development of high resolution numerical model and advanced modeling techniques (e.g., Wang et al., 2006; Oey et al., 2005a; Larsen et al., 2007).

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However, in the case of assimilating excessive high resolution as compared to the model grid, it is possible to be a reason to attenuate accuracy of model. And it can result in a waste of computational resources due to an increase in the calculation time (Ramachandran et al., 2005). Thus, the process of removing redundant data is required prior to the data assimilation.

Redundant data refers to observed data has a density that exceeds the resolution of the grid model or show the characteristics of the linear dependence (Zavodsky et al., 2008). There are variety methods to remove redundant data; superobbing, estimation error analysis, density adjustment data thinning algorithm, density-balanced data thinning (Ramachandran et al.,2005; Ochotta et al., 2007; Zavodsky et al., 2008; Lazarus and Splitt, 2010). UK Meteorological Office (UKMO) has produced Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA; Donlon et al., 2012) data with assimilation of various satellite and insitu data. By selecting the appropriate resolution to OSTIA grid, the volume of observational data was adjusted.

National Institute of Meteorological Research (NIMR) is developing the global ocean data assimilation system to increase ocean predictability of operational model. GHRSST-PP L2P (Group for High Resolution SST Pilot Project Level 2 Preprocesses) data was assimilated for sea surface temperature (SST). However, the data is frequently updated; it is vast amount of data. It is essential to remove the redundant data considering the resolution of the model.

The purpose of this study is to analyze the sensitivity of the SST analysis field to subsampling interval of GHRSST L2P data (AVHRR NOAA-18GAC, AVHRR METOP-A) using global ocean data assimilation system.

II. Data

GHRSST L2P data used in this study are generated at both Regional Data Assembly Centres (RDAC) sites and at a single Global Data Analysis Centre (GDAC) located at the NASA PO.DAAC and can be downloaded from the ftp server or OPeNDAP of GHRSST GDAC and RDAC (http://ghrsst-pp.metoffice.com). This data is open to the public in (near) real time and historical data. In this study, we used the AVHRR NOAA-18GAC data and AVHRR METOP-A material that covers the global area. Accuracy of data is known as 0.4 ~ 0.8 K rms in several studies (Donlon et al., 2012). The data are divided into daily observations, the format of the data is available in NetCDF format. The characteristics of the two materials are shown in Table 1.

A. AVHRR NOAA-18G

It is satellite that was developed and launched by the US Naval Oceanographic Office (NAVOCEANO) to analysis and forecasting of ocean. Horizontal resolution is about 8.8 km, the time resolution is designed to pass through the same point twice during the day and night. When it passes the atmosphere without cloud, relatively noise-free SST is observed. Because there is a little absorb by atmosphere. This is because there is little absorption by the air.

B. AVHRR METOP-A

This satellite was developed by ESA and EUMETSAT jointly. This is a resource exploration and meteorological satellites for Climate monitoring and weather forecast improvement. It usually observes at one point two times a day, and the horizontal resolution is 1.1 km from the nadir.

III. Model and Experiment Method

A. Global Ocean Assimilation System

Configuration of the global ocean data assimilation system used in this study is as follows:

- Hydrodynamic model : NEMO ver.3.2
- Sea-ice model : CICE
- Data assimilatiom : NEMOVAR
- Quality control : NEMOQC
- Domain : ORCA025L75

B. Experiment Design

The experiment was carried out 2 weeks 2 to 15 June 2014. And from the experiment, daily average SST and sea-ice analysis fields were produced. The startdumps data of UKMO for June 2, 2014 was used as initial field data. The every 3hours heat and salinity flux, and wind forcing of KMA (Korea Meteorological Administration) UM (Unified Model) are applied as boundary condition. In addition to satellite observed SST, in-situ SST, temperature-salinity profile, SSH (Sea Surface Height) and sea ice concentration is assimilated in the system.

C. Method

To apply Satellite SST data to NEMOVAR, preprocess step is performed; converting the data format, performing quality control, and subsampling the data. We collected the data in 00 ~ 24UTC of the data received through a time window check. First of all, we check time window. SST is modified as (1). The SST is the final result, Kelvin temperature; sst is Celcius temperature. In view of the scale factor and add offset value, SST is converted. SSES (Single Sensor Estimate Statistics) is a bias error of the observed sea surface temperature satellite data and field observations. If you are using the data of multiple sensors together, use the SSES

Table 1. Characteristics of data used in the KMA system

Sensor (Platform)	Type /Orbit	Resolution	Files per day	File Size (MB)	Time Series
AVHRR (NOAA18-GAC)	Infra –red / polar	~ 8.8 km	~ 15	~ 30.0	2006 – present
AVHRR (METOP-A)	Infra –red / polar	~ 1.0 km	~ 450	~ 5.0	2009 - present

Table 2. Data resolution of assimilated SST

	AVHRR NOAA-18GAC				AVHRR METOP-A			
	Horizontal resolution	Interval	File size(MB)	Average number of OBS	Horizontal resolution	Interval	File size(MB)	Average number of OBS
Exp.HDT	8.8 km	1 x 1	~ 20	1,085, 963	10 km	10 x 10	~ 6.5	358,666
Exp.LDT	17.6 km	2 x 2	~ 5	271,518	25 km	25 x 25	~ 1.5	87,947

can compensate for vulnerabilities, such as inhomogeneous distribution of the material.

$$SST \;=\; sst \;\text{x}\; scale\_factor + \; add\_offset \text{ - } SSES \qquad (1)$$

Contaminated materials in consideration of the flag of the data was missing treatment. First, with reference to l2p_flag, the points of microwave, land, sea ice, lake and (river) removed. The SST is removed when the ice_fraction is greater than zero. With reference to the quality level indicating the degree of quality, only points that greater than level 4, acceptable quality, are used.

Exp.MDT (Moderate Density Test) of relatively high resolution and Exp.LDT (Low Density Test) of relatively low reolution, two experiments were performed. The resolution of data and results according to the experiment are shown in Table 2.

IV. RESULTS

In this study, the middle, and low-resolution data was assimilated to analysis ocean analysis field (SST) according to resolution of satellite SST data. The analysis field produced by assimilation of each data was compared with observational data. RMSE (Root Mean Square Error) and Taylor Diagram analysis was mainly used for analysis. Study areas are global region and regional areas (e.g. Kuroshio-extension, Gulf stream, cold-tongue, Agulhas Return) showing strong horizontal gradient in SST (Lei and Kawamura, 2003). The study areas are in shown in Fig.1.

Overall, most of the results that are close to the reference point and the normal standard deviations are close to 0 in the Taylor diagram (Fig.3). So, both Exp.MDT and Exp.LDT can

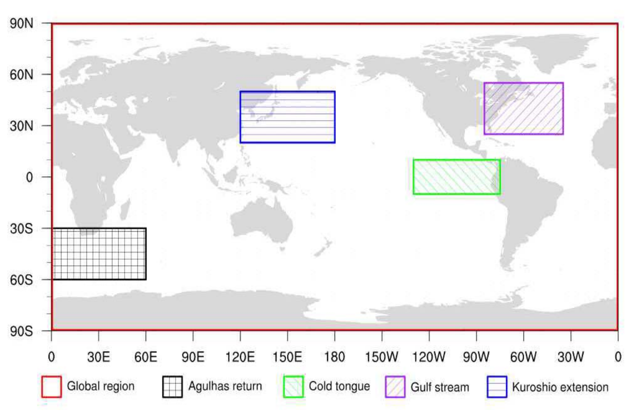

Fig. 1. Study area.

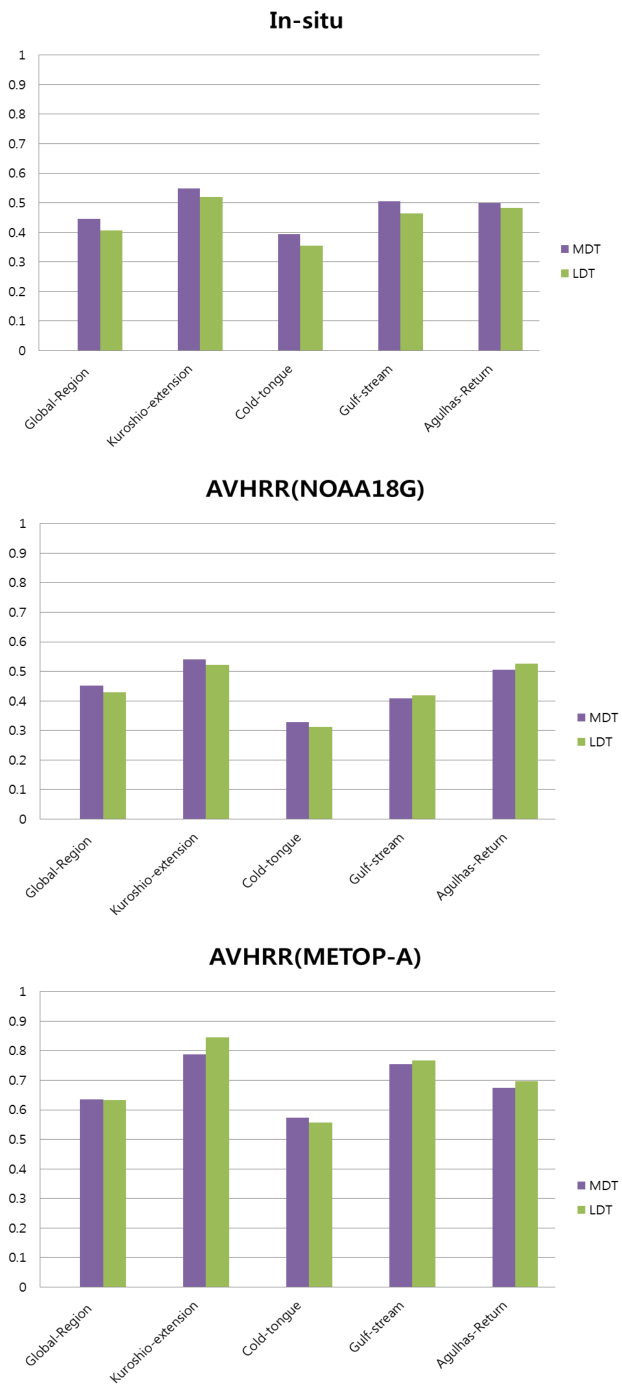

Fig. 2. RMSE of SST between analysis and observation.

be seen excellent performance data assimilation. There is no significant difference in correlation coefficient between in-situ, AVHRR NOAA-18G and AVHRR METOP-A with maximum of 0.01.

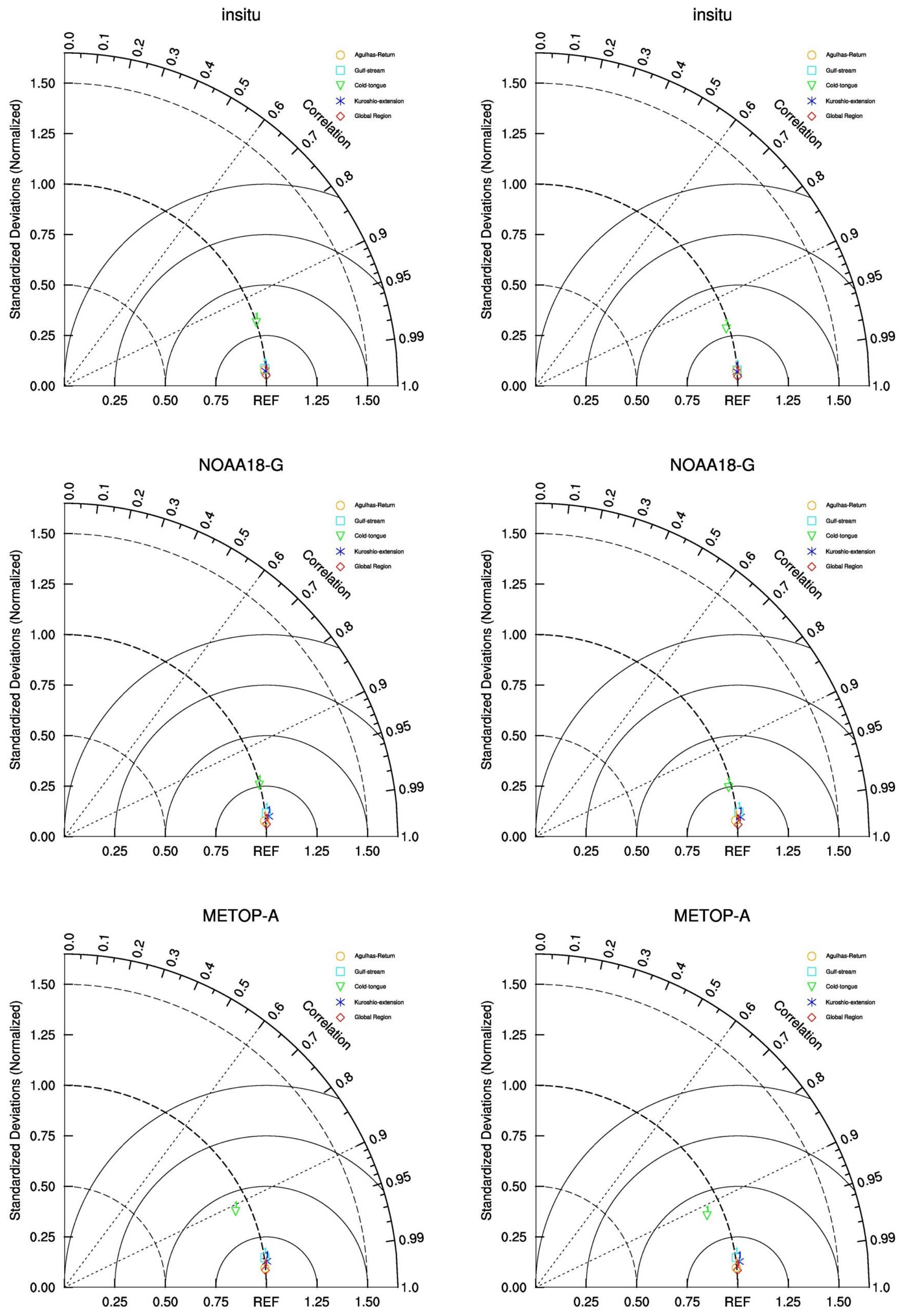

Fig. 3. Taylor diagram. (left) Exp.MDT, (right) Exp.LDT

In the global region, the RMSE of Exp.MDT and Exp.LDT is 0.45, 0.41, respectively for the in-situ, 0.45, 0.41 respectively for AVHRR NOAA-18GAC, and 0.64, 0.63 respectively for AVHRR METOP-A (Fig.2). All three data have a lower value of RMSE in Exp.LDT than Exp.MDT. For in-situ data, the value of RMSE appears relatively low compared to Exp.MDT in all study areas.

This result that the RMSE of Exp.LDT is lower than that of Exp.MDT is also shown in the regional study area where a strong horizontal gradient exists. As a result, the quality of the analysis field appears close to observational data when low-resolution SST data is assimilated. It plans to perform more tests of various resolutions in the future to derive the appropriate resolution to improve the prediction of the model also reduce the computation cost.

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