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Sensitivity analysis of satellite-retrieved SST using IR data from COMS/MI

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Abstract : Sea Surface Temperature (SST) is the temperature close to the ocean's surface and affects the Earth's atmosphere as an important parameter for the climate circulation and change. The SST from satellite still has biases from the error in specifying retrieval coefficients from either forward modeling or instrumental biases. So in this paper, we performed sensitivity analysis using input parameter of the SST to notice that the SST is most affected among the input parameter. We used Infrared (IR) data from the Communication, Ocean, and Meteorological Satellite (COMS)/Meteorological Imager (MI) from April 2011 to March 2012. We also used the Global Space-based Inter-Calibration System (GSICS) correction to quality of the IR data from COMS. SST was calculated by substituting the input parameters; IR data with or without the GSICS correction. The results of this sensitivity analysis, the SST was sensitive from -0.0403 to 0.2743 K when the IR data were changed by the GSICS corrections.

Key Words : SST, COMS/MI, sensitivity analysis, GSICS correction

1. Introduction

Sea Surface Temperature (SST) is the sea temperature close to the ocean's surface and affects the Earth's atmosphere as an important parameter for monitoring the climate circulation and change (Park *et al*., 2013). The global determination of climate change through the SST is an important aim of satellite remote sensing (Park *et al*., 2013; Smith *et al*., 1996). In previous study, the SST estimation from satellite have been performed for the accuracy improvement. To evaluate the quality of SST production, Park *et al*., (2011) assessed the SST error from between the National Oceanic and Atmospheric Administration (NOAA) satellite (NOAA-15, 17, 18 and 19) and the drifting data. O'Carroll *et al* (2012) produced the SST from the Meteorological Operation (MetOp)/Infrared Atmospheric Sounding Interferometer (IASI) and Advanced Very High Resolution Radiometer (AVHRR) sensors. Although the SST measurement need accurate data for climate model, the SST from satellite still has biases from the error in specifying retrieval coefficients from either forward modeling or instrumental biases (Merchant and Borgne, 2004; Merchant *et al*., 2009). Furthermore, to produce high quality of the SST products, radiometric calibration was also conducted

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by Sohn *et al*. (2010). To assess the quality of products or input data, sensitivity analysis of input parameters from atmospheric correction was performed by Lee and Han (2009) by using fixed values of parameters except one parameter: object of analysis. Ha *et al*. (2006) were also conducted the sensitivity analysis about input parameter of aerosol, especially IR channel. Changes of Brightness Temperature Difference (BTD) were analyzed by changing the seven variables. In this paper, to assess the sensitivity of the SST products, we performed sensitivity analysis using input parameter of the SST. We used the Infrared (IR) data from the Communication, Ocean, and Meteorological Satellite (COMS)/Meteorological Imager (MI) from April 2011 to March 2012. And the quality of level 1 data, we used the Global Space-based Inter-Calibration System (GSICS) correction, which initiated by the World Meteorological Organization (WMO) in 2005 (Goldberg *et al*., 2011). We produced the SST by substituting the input parameters; IR data with or without the GSISC correction and viewing zenith angle (VZA) and monitored changes of values of the SST. Finally, we assessed that how sensitive is the SST, which were calculated by changing the input parameters; such as by changing at 10 K intervals of the IR1 data.

2. Data and Method

Sensitivity analysis of SST in this paper included the GSICS correction, which provides coefficients to the user to applying their geostationary satellite (Goldberg *et al*., 2011). IR data from COMS/MI were corrected by the GSICS correction for quality of input parameter and effects on SST. The location of the GSICS correction for IR channels from COMS/MI and IASI were at the latitude of 40°S ~ 40°N, the longitude of 63 ~ 192°E. Match-up data set were composed up the COMS/MI and IASI data, whose locations were same each other. The equation for the GSICS correction of COMS/MI IR channels is expressed as

Table 1. Coefficients of the GSICS correction for IR1 and IR2

	a_0	a_1
IR1 (10.8 μm)	1.008	-2.439
IR2 (12.0 μm)	1.007	-1.350

Table 2. Information about COMS/MI Meteorological Imager

Channel	Center Wavelength (μm)	Wavelength range(μm)	Spatial resolution (km)
Visible	0.675	0.55-0.8	1
Shortwave Infrared	3.75	3.5-4.0	4
Water vapor	6.75	6.5-7.0	4
Infrared 1	10.8	10.3-11.3	4
Infrared 2	12.0	11.5-12.5	4

$$Y_\lambda = a_0 + a_1 X_\lambda \tag{1}$$

where X_λ is the values of IR observed by the COMS/MI sensor, Y_λ is the values of IR corrected and a_0 and a_1 are correction coefficients. The correction coefficients were shown Table 1.

COMS is Korea's first geostationary multi-purpose satellite which was launched in 27 June, 2010 (Lee *et al*., 2005; Park *et al*., 2011). The COMS has MI sensor, which is composed of five channel imager: one Visible (VIS) channel and four infrared channels (Table 2). The four IR channel include infrared 1 (IR1, 10.3-11.3 μm) and infrared 2 (IR2, 11.5-12.5 μm). We used the IR1, 2 data from COMS/MI sensor from April 2011 to March 2012. The location of SST estimation were same as that of the GSICS correction, because IR data with or without the GSICS correction were used for calculating SST.

SST products were calculated by the COMS/MI IR data using Multi-channel sea surface temperature 45 (MCSST45), which was developed by the National Environmental Satellite, Data, and Information Service (NESDIS) of the NOAA (McClain *et al*., 1985; Emery *et al*., 2001a).

$$\begin{aligned} SST = {} & C_0 + C_1\, IR1 + C_2\,(IR1 - IR2) \\ & + C_3\,(IR1 - IR2)(\sec(\theta) - 1) \end{aligned} \tag{2}$$

where θ is VZA; C_0, C_1, C_2, and C_3 are the empirical

Table 3. Coefficients of COMS/MI MCSST algorithm for both daytime and nighttime SST

	Daytime SST	Nighttime SST
C_0	-0.321399	-0.031189
C_1	0.985098	0.975640
C_2	2.338343	2.496965
C_3	0.545135	0.353631

coefficients for day and night (Table 3), which use regression analysis between IR channels and the SST from buoys (Smith *et al*., 1996; Emery *et al*., 2001b). SST calculated in this paper did not considered cloud condition.

3. Results and Discussion

Residuals of BTD according to IR1 were represented in Fig.1 Patterns of circle were original BTD and those of diamond were BTD from the GSICS correction. The residuals of the BTD were calculated by original BTD minus corrected BTD, patterns of triangle, and had values around 0.68-0.78 K in overall. When the IR1 range were 190-280 K, the BTD values were between 0.5-1.5 K, however when the IR1 range were more than 280 K, the BTD values were abruptly increased but residuals were decreased. Because the IR1 range more than 280 K was more used for calculation SST, we should take note of the increase. To evaluate the impact of error from IR data, we produced SST from the COMS/MI IR data with or without the GSICS correction.

In Fig.2, SST were produced by the COMS/MI IR data with or without the GSICS correction, which were represented original SST (without the GSICS correction, patterns of circle) and corrected SST (with the GSICS correction, patterns of gray diamond). The SST were produced on conditions that BTD and VZA were 1 K and 40° respectively. The median value of 1 K was fixed for the BTD since the BTD from 0 to 2 K account for 50 percent of the whole match-up dataset.

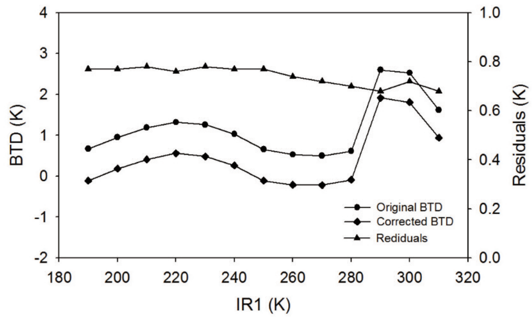

Fig.1. BTD changes according to IR1 values from 190 to 310 K. Patterns of circle were original BTD and those of diamond were corrected BTD. Residuals (difference between original BTD and corrected BTD) were represented by the patterns of triangle.

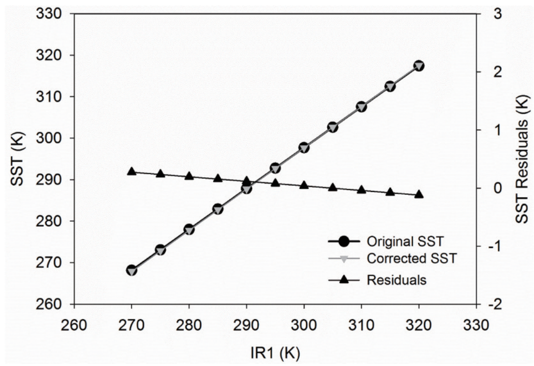

Fig.2. SST changes according to IR1 values from 270 to 320 K. Patterns of circles were original SST and those of diamond were corrected SST. Residuals (difference between original SST and corrected SST) were represented by the patterns of triangle.

The VZA value was 40° which is from the median of the VZA of the COMS/MI sensor. The SST according to IR1 was increased at regular intervals, but residuals between original SST and corrected SST (patterns of triangle) were decreased according to increase of the IR1. The decrease in residuals between original SST and corrected SST were considered that lower values of SST were influenced the GSICS correction than higher values of SST. The values of residuals were shown in Table 4. When the IR1 values were 310 K, the residuals had smallest values. In Table 4, although the IR1 differences were subtle, the SST residuals were decreased.

The SST residuals between original SST and corrected SST according to the BTD values were

Table 4. SST residuals according to IR1 values

IR1 (K)	SST Residuals (K)
270	0.2743
280	0.1956
290	0.1170
300	0.0383
310	-0.0403

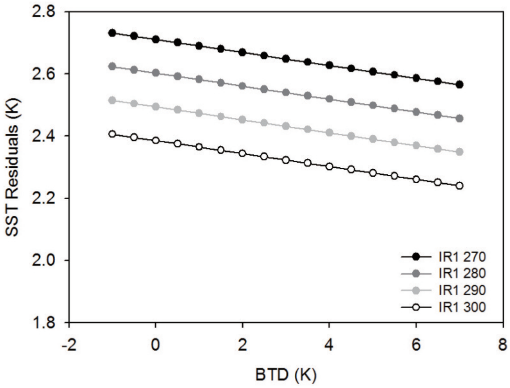

Fig.3. SST residuals according to BTD and IR1 values.

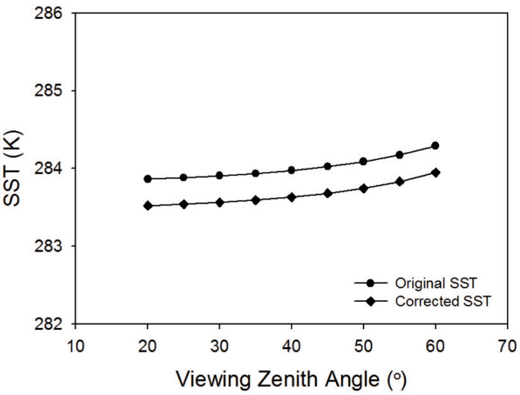

Fig.4. SST changes according to VZA. Patterns of circle were original SST (upper line) and those of diamond were corrected SST (lower line).

illustrated in Fig.3. When the IR1 values were fixed like Fig.3, the SST residuals were decreased according to increase of the BTD values. Since the BTD range of 0-2 K were more than half from the entire data, the residuals were 2.34-2.71 K in only the BTD range of 0-2 K. Furthermore, the IR values were increased by 10 K, the SST residuals were decreased by 0.1084 K.

The SST according to VZA were shown in Fig.4, and calculated on condition that BTD and IR1 were 1 K and 270 K respectively. Original SST and corrected SST were represented in patterns with circle and diamond respectively. As seen in Fig.4, the SST values according to the VZA were slightly increased. And the residuals between original SST and corrected SST were shown at 0.196 K.

4. Conclusion

We performed the sensitivity analysis of SST using IR data from COMS to know that how sensitive is the SST, which were calculated by substituting the input parameters; such as IR data with or without the GSICS correction, BTD and VZA. The results of this paper is that the SST was most sensitive when the IR data were changed by the GSICS corrections (Fig.2, below 0.8 K). Depending on these results, the IR data should be more considered influential parameter when the SST was produced. The residuals of IR data (between original and corrected IR data) affected calculation of SST from -0.0403 to 0.2743 K. SST residuals were also amplified from 2.2399 to 2.7317 K according to BTD and IR1 values. The results from this paper will be efficacious aids to other researches, which are related to accuracy of the SST and analysis input parameter of the SST. In future studies, more detailed changing of input parameter should be considered than this paper, and furthermore more variable input parameter should be regarded.

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