USAGE OF MULTI-SATELLITE DATA FOR ESTIMATION OF DAILY MEAN VALUE FOR OCEAN SURFACE PARAMETERS

Masahisa. Kubota* and Hiroyuki. Tomita

Tokai University, JAPAN

1. Introduction

We usually use temporal and spatial mean data for geophysical parameters for convenience of our research. There exist several global data sets for satellite-derived latent heat flux, e.g. Goddard Satellite-Based Surface Turbulent Fluxes: GSSTF (Chou et al., 1997), Hamburg Ocean Atmosphere parameters and Fluxes from Satellite Data: HOAPS (Schulz et al., 1997) and Japanese Ocean Flux Data Sets with Use of Remote Sensing Observations: J-OFURO (Kubota et al., 2002). Temporal and spatial averaging is used in all data sets. For example, GSSTF provides daily-mean values with 1 degree by 1 degree grid.

We basically need three kinds of geophysical parameters such as wind speed, saturated specific humidity and specific humidity for estimation of latent heat flux if we use a bulk formula. At present wind speed can be observed by three satellite sensors, i.e. a microwave altimeter, a microwave radiometer and a microwave scatterometer. However, a microwave altimeter is not used for estimation of global latent heat flux because the distribution of the measurement is far form adequate.

Defence Meteorological Satellite Program (DMSP) / Special Sensor Microwave Imager (SSMI) wind speed data are used in GSSTF, HOAPS and J-OFURO for estimation of latent heat flux, since specific humidity derived from DMSP/SSMI data is also used in all products. However, DMSP is a sun-synchronous satellite and observe wind speed only two times per one day at the same place. Therefore, the accuracy of daily-mean wind speed data expected to be low, in particular for the place where diurnal variation is large. Also most of satellite sensors observing wind speed over the ocean are carried on sun-synchronous satellites. Consequently the accuracy of a daily-mean value is considered to strongly depend on the satellite observation time.

Our first objective is to clarify the dependence of accuracy of a daily-mean value on the satellite observation time. Second objective is to evaluate an impact of multi-satellite data on the accuracy of a daily-mean value. Our data and method are described in section 2. The accuracy of a daily-mean wind speed value corresponding to satellite observation time is investigated in section 3. The capability of multi-satellite data is examined in section 4.

*Corresponding author address: Masahisa Kubota, School of Mar. Sci. and Tech., Tokai University
Shimizu-Orido, Shizuoka, Shizuoka, JAPAN 424-8610,
e-mail:Kubota@mercury.oi.u-tokai.ac.jp

2. Data and method

It should be noted that we use not real satellite data but meteorological buoy data conducted by Japan Meteorological Agency (JMA). Three JMA buoys were located around Japan. The locations are shown in Fig.1. A schematic diagram of Fig.2 describes the method. First, we estimate a wind speed value observed at satellite observation time by interpolating JMA buoy wind speed data. As a result we obtain two wind speed data within one day. Then, two data are averaged to estimate a daily-mean value. The value is called as a satellite (daily-mean) value, e.g., DMSP/SSMI F-13 value, in this study. On the other hand, we calculated a daily-mean value using all wind speed data observed by JMA buoy. We assume the daily-mean value to be a true value and evaluate the satellite daily-mean value by the true value.

The list of nine satellites and related wind speed sensors observing wind speed over the global ocean is given in Table 1. Also the observation time is given in the Table 1. It should be noted that the observation time of most of satellites is after five o'clock except Aqua/AMSR-E. Also the observation times by DMSP/SSMI are limited around 6 o'clock. In this study we use only the satellite observation time data shown in Table 1. We use eight kinds of satellite observation time data because the observation time of ADEOS-II is the same as that of ERS-2.

3. Accuracy of a daily-mean value for each satellite

DMSP/SSMI F-13 is a familiar sensor for estimation of global latent heat flux (Kubota et al., 2002). Figure 3a shows a scatter diagram between a true value and a DMSP/SSMI F-13 value. The accuracy seems to be fairly high, since the correlation coefficient is 0.928 and the RMS error is 1.23m/s. However, the accuracy is relatively low compared with the results for Aqua given in Fig. 3b. The statistics for each satellite is given in Table 2. Though DMSP/SSMI wind speed data are generally used for estimation of global latent heat flux, the accuracy of all DMSP/SSMI values is low compared with other satellite. On the other hand, Aqua/AMSR-E gives extremely high accuracy, the correlation coefficient is 0.985 and the RMS error is 0.54 m/s. However, this result does not guarantee that Aqua give us the best result everywhere. The accuracy might be affected by regional characteristics of wind speed variation. Important thing is that the difference of the RMS error between them is large, 0.7 m/s. This result is consistent with daily variation of the RMS error (Figure 4). The RMS error is calculated by estimating a difference between the true daily-mean value and the daily-mean value obtained by averaging the two values for the same time in the morning and afternoon. We can see remarkable daily variation for the RMS error in this figure. Also we found our results shown in Table 2 are consistent with the daily variation given in Fig. 6. It is concluded that the accuracy of daily-mean wind speed derived from satellite data strongly depend on the observation time and the maximum difference between each satellite reaches to 0.8 m/s. Also it should be noted that the accuracy of DMSP/SSMI daily-mean value is low here.

4. Usage of multiple satellites

Next we investigate how to improve accuracy of daily-mean wind speed data using multi-satellite data. Three kinds of combination are examined in this study. We use three satellites usable in 1999 and 2004 in the first and second case, respectively. Moreover, we consider the case of using all satellites. The statistics are given in Table 3. We can see remarkable improvement of accuracy of daily-mean wind speed data comparing Table 3 with Table 2, if we use multi-satellites data. In particular, the results for the case of 2004 are extremely improved, the correlation coefficient is 0.998 and the RMS error is 0.19 m/s. The difference between the case of 1999 and 2004 is considerably large, 0.43 m/s. This may be due to including Aqua/AMSR-E or not, because the accuracy of Aqua/AMSR-E is extremely good.

Also it is interesting that the results for the case of 2004 are much better than that of all satellites. This is due to that the weight of DMSP/SSMI data is too heavy in the daily-mean value because four DMSP/SSMI satellites are included in the case of all satellites. We can understand an important matter from this result, that we cannot necessarily obtain better results, even if the number of a satellite used for estimation of daily-mean wind speed data increases.

5. Conclusion

We clarified the accuracy of daily-mean wind speed derived from satellite data strongly depend on the observation time and the maximum difference between each satellite reaches to 0.8 m/s. Also it is important that the accuracy of DMSP/SSMI daily-mean value is low, though DMSP/SSMI wind speed data are generally used to estimate global latent heat flux data. The accuracy of Aqua daily mean value is extremely high. However, it should be noted that the accuracy of each satellite varies depending on characteristics of daily variability of wind speed. The regional dependency of the accuracy should be investigated in the future.

Also we demonstrated the remarkable improvement of the accuracy of a daily mean wind speed if we use multiple satellites. The tandem mission of two identical scatterometers provides the temporal sampling requires to support critical applications in oceanic and ocean-atmosphere interaction studies not possible win only a single instrument(Milliff et al, 2001). However, we can use more sensors to estimate global latent heat flux because we need only a wind speed data for this purpose. In this study we demonstrated the effectiveness of usage of multiple satellites to obtain a daily mean wind speed and latent heat flux data. However, we should consider the weighting balance for each satellite data. For example, we cannot improve the accuracy, even if we use multiple DMSP/SSMI data.

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Table 1　List of satellites with related wind speed sensors and the observation time.

Satellite／Sensor	Observation time（Ascending）
DMSP/SSMI　F-11	18:25
DMSP/SSMI　F-13	18:14
DMSP/SSMI　F-14	20:24
DMSP/SSMI　F-15	21:32
ADEOS Ⅱ/AMSR,SeaWinds	22:30
Aqua/AMSR-E	13:30
QuikSCAT/SeaWinds	5:51
ERS-2/AMI	10:30
Envisat/MWR	22:00

Table 2　Statistics for each satellite.

	Bias（m/s）	Corr.	RMS error（m/s）
ADEOS Ⅱ/ERS-2	1.17E-03	0.971	0.75
Aqua	3.88E-02	0.985	0.54
Envisat	5.03E-03	0.968	0.78
QuikSCAT	-8.22E-02	0.936	1.16
DMSP/SSMI　F11	-0.0103013	0.916	1.35
DMSP/SSMI　F13	-7.00E-02	0.928	1.23
DMSP/SSMI　F14	-1.71E-03	0.908	1.34
DMSP/SSMI　F15	-2.21E-03	0.939	1.09

Table 3　Statistics for three kinds of a case.

	Bias（m/s）	Corr.	RMS error（m/s）
1999	-3.73E-02	0.980	0.62
2004	-3.94E-03	0.998	0.19
All satellites	-2.74E-02	0.993	0.36

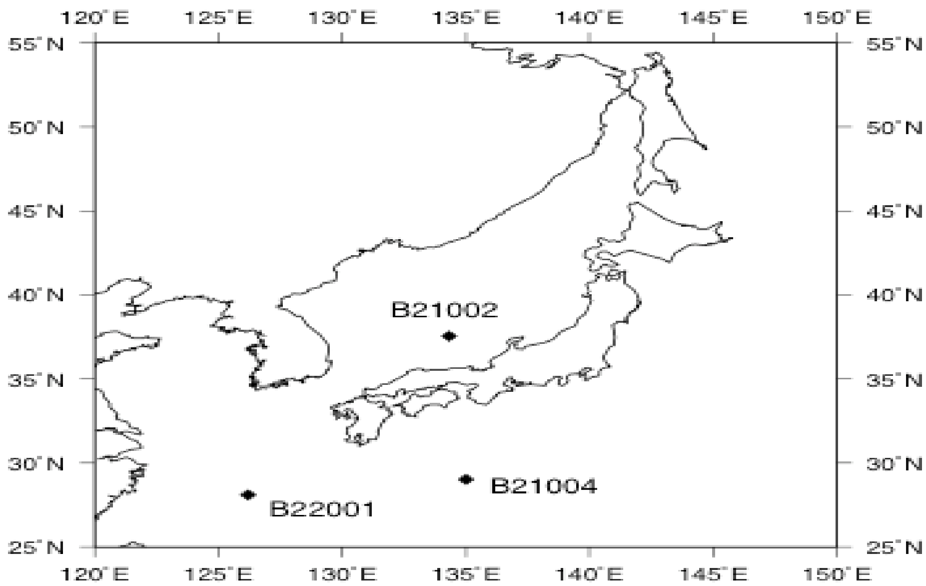

Figure 1. Locations of Japan Meteorological Agency buoys used in this study.

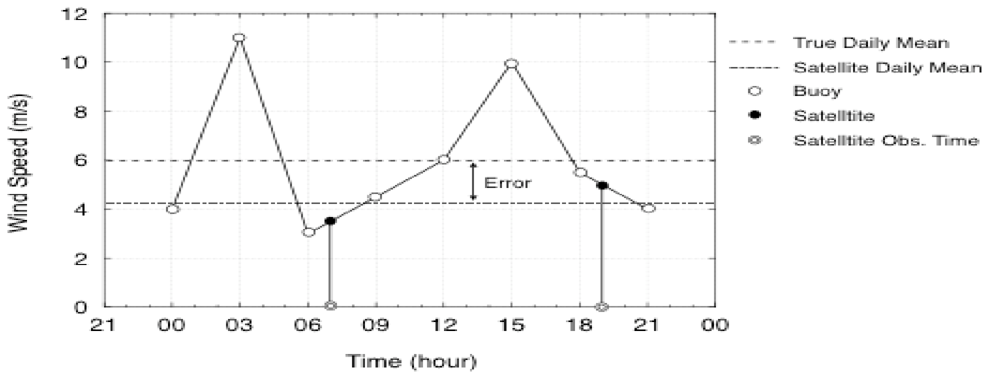

Figure 2. Schematic diagram of the present analysis.

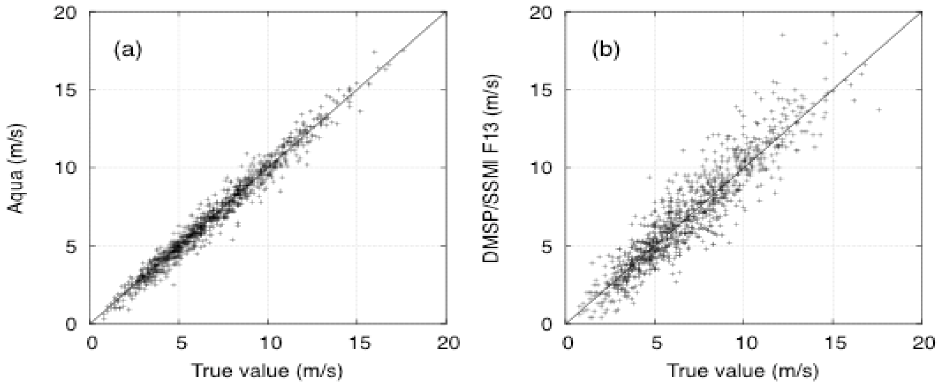

Figure 3. Scatter diagram of between true daily mean values and (a) Aqua and (b) DMSP/SSMI F-13 satellite daily mean values.

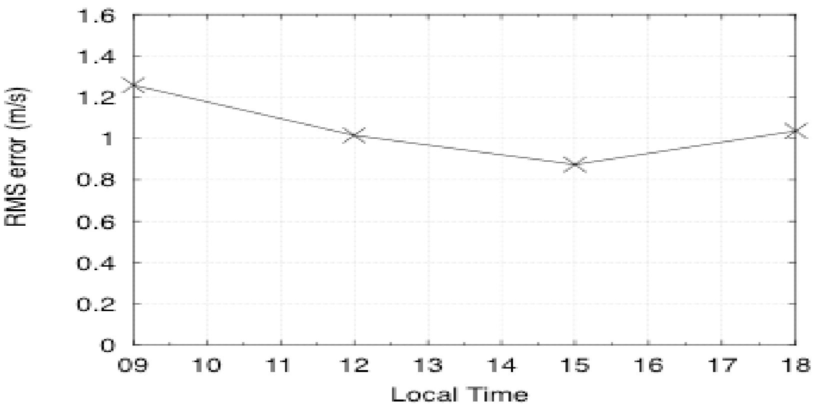

Figure 4. Daily variation of RMS errors for each observation time.