COMPARISON OF TEMPERATURE DERIVED FROM THE MICROWAVE SOUNDING UNIT AND MONTHLY UPPER AIR DATA.

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Abstract

We compared the satellite observed temperature with the radiosonde observed temperature in the Korean Peninsula. The radiosonde observed data were obtained from four upper air observation stations in the Korean Peninsula from 1981 to 1998, and that was compared with the satellite observed data of the channel-2 and channel-4 of microwave sounding unit(MSU) on board NOAA series of polar-orbiting satellites. The radiosonde data were reconstructed into monthly radiosonde T_b using MSU weighting function. The monthly climatology shows radiosonde T_{b2} is higher than MSU T_{b2} in summer. The correlation between MSU T_{b2} and radiosonde T_{b2} is 0.72-0.76 and 0.73-0.81 between MSU T_{b4} and radiosonde T_{b4}.

Key Words : MSU, Radiosonde observation, Korea

1. Introduction

Atmospheric temperature is one of the most important parameters in climate system. But the measurement of Atmospheric temperature is very difficult. The radiosonde observation is an accurate method to measure the atmospheric temperature, but it is difficult to monitor the temperature distribution over the whole Earth surface because of geographical restriction. More recently, the satellite observation of the microwave sounding unit(MSU) on board NOAA series of polar-orbiting satellites has been carried out since 1978. The satellite enables to timely observe the whole Earth surface as well as, to measure the altitude profile of the temperature via multichannel observation.

It becomes important to reveal the correlation between the MSU data with the radiosonde observated data to tuning the atmospheric temperatures measured by the above two different observation. Spencer and Christy(1990, 1992a) compared the MSU T_b(brightness Temperature) with radiosonde calculated T_b. Hurrell and Trenberth(1992, 1996) studied the correlation in accordance with European center for medium-range weather forecasts model. Basist *et al.*(1995) compared the MSU data with the global data assimilation system data. Yoo *et al.*(1998a, 1998) analyzed the sea surface temperature, MSU T_b and atmospheric model altogether.

In this study, we have investigated the atmospheric temperature in the Korean Peninsula. The radiosonde observed data during the last 18 years was compared with the satellite observed data from the MSU channel-2 and channel-4. The correlation between the two observation data was analysed, and the time-series analysis was applied to determine the long-term change of the atmospheric temperature.

2. Data processing

The radiosonde observation stations in the Korean Peninsula listed in Table I, which locations illustrated in Figure 1.

In this study, we focused on the correlation between the radiosonde observation and the satellite observation from the MSU channel-2 and channel-4. The MSU channel-2 of 53.74 GHz detects the thermal radiation from O_2 near the higher pressure level of 500 hPa in the middle troposphere, and it is stable irrespectively to the change in vapor, cloud, and precipitation(Yoo, 1992). The MSU channel-4 of 57.95 GHz monitors the temperature near the lower stratosphere of 70 hPa.

The radiosonde calculated T_b was obtained by applying the MSU weighting function to the observation data using the equation of

$$T = \frac{\sum_{i=1}^{N} w_i T_i \ln(p_1/p_2)}{\sum_{i=1}^{N} w_i \ln(p_1/p_2)},$$

where T_i and w_i are the average temperature and the average weight value of the ith pressure level, respectively, and p_1 and p_2 are the boundary pressures of the upper and lower levels, respectively(Spencer and Christy, 1993).

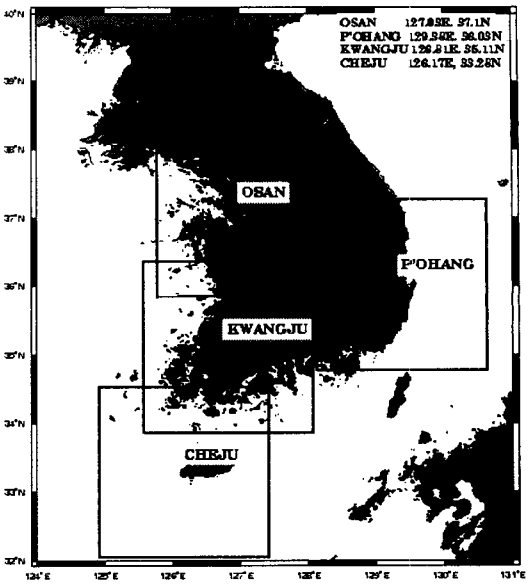

Fig. 1 Location of observation stations of Osan, Pohang, Kwangju, and Cheju in the Korean peninsula. Four square boxes are MSU analysis areas.

00UTC and 12UTC data were selected for the calculation of radiosonde T_b of three upper air observation station except Osan station where 00UTC, 06UTC, 12UTC, 18UTC data were used. Radiosonde T_{b2} was calculated using a weighting function having an maximum at 500 hPa in the range from 925 hPa to 250 hPa for the comparison with MSU channel-2. The radiosonde T_{b4} was calculated using another weighting function having an maximum at 70 hPa in the range from 250 hPa to 10 hPa for the comparison with MSU channel-4.

Table I. List of stations in the Korean peninsula

Station No.	Station	Lat.(N)	Long.(E)	Height above Mean Sea Level	Analysis period
47122	Osan	37° 06′	127° 02′	52m	January 1981~December 1998 (216 months)
47138	Pohang	36° 02′	129° 23′	6m	January 1981~December 1998 (216 months)
47158	Kwangju	35° 07′	126° 49′	13m	January 1981~December 1998 (216 months)
47185	Cheju	33° 17′	126° 10′	72m	May 1988~December 1998 (128 months)

3. Results and discussion

Monthly climatology

The monthly Climatology in the atmospheric temperature was investigated by examining both the radiosonde observation and the MSU observation. Figure 2 shows the monthly climatology of the atmospheric temperature at (a) Osan, (b) Pohang, (c) Kwangju, and (d) Cheju, respectively. The values were determined by averaging the data from the corresponding months of every years under examination. The square symbols with solid line in fig. 2 show MSU T_{b2}, while the circular symbols with dashed line show radiosonde T_{b2}. And, the upper triangular symbols with solid line show MSU T_{b4}, while the lower triangular symbols with dashed line show radiosonde T_{b4}.

Both MSU T_{b2} and radiosonde T_{b2} increase in summer and decrease in winter, which is accordant to the change in the surface temperature. Radiosonde T_{b2} is generally higher than the MSU T_{b2}, and the difference is greater in summer than winter. It can be understood because the MSU data has a error as a result of the extinction due to hydrometeors in the atmosphere(Yoo, 1992). Both MSU T_{b4} and radiosonde T_{b4} show the minimum in summer and the maximum in winter. which is opposit to T_{b2}.

The correlation between the MSU T_{b2} and the radiosonde T_{b2} was found to be 0.74, 0.72, 0.76, and 0.73 for Osan, Pohang, Kwangju, and Cheju, respectively(Fig. 3). The monthly anomaly of MSU T_{b2} and radiosonde T_{b2} shows the similar trend but the amplitude of radiosonde T_{b2} is greater than MSU T_{b2}. The previous studies(Spencer and Christy, 1990) show the amplitude difference is less than 1℃. This difference are maybe caused by the difference in the measurement areas, the individual measurement errors in the balloon thermometer, the random noise of a single MSU measurement, and the time mismatch between the satellite

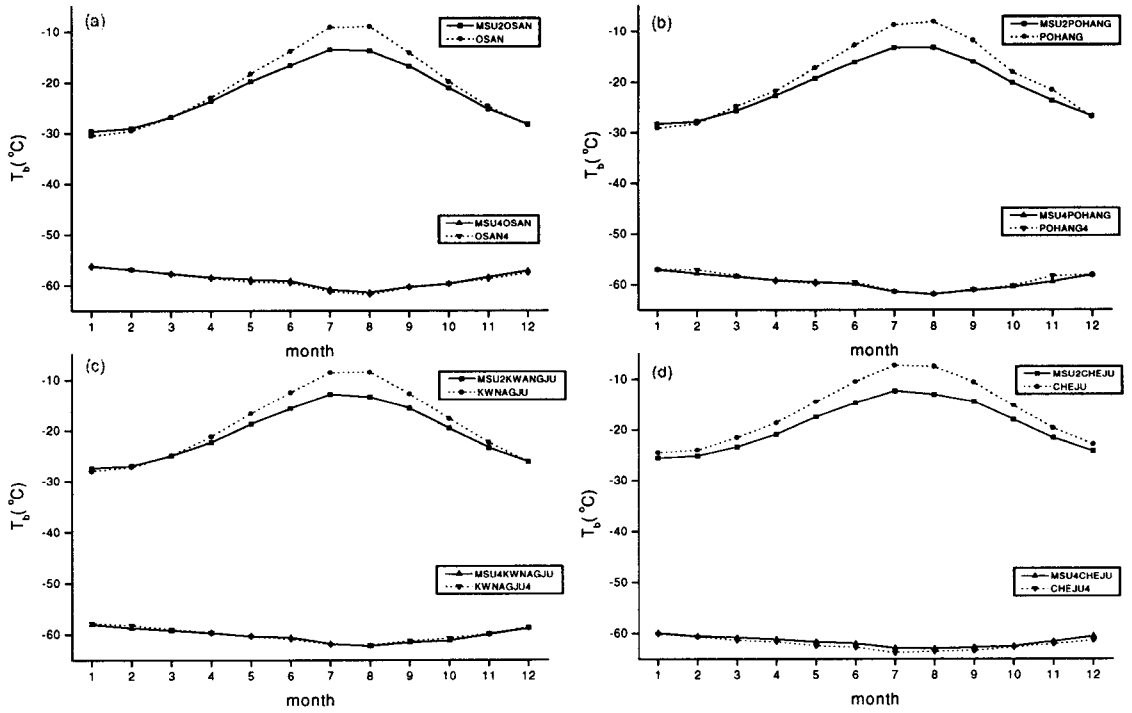

Fig. 2 The monthly change in the atmospheric temperature averaged over the last 18 years (1981 - 1998) monitored by the MSU channel-2, channel-4 and the weighted radiosonde observations for the stations of (a) Osan, (b)Pohang, (c) Kwangju, and (d) Cheju, respectively.

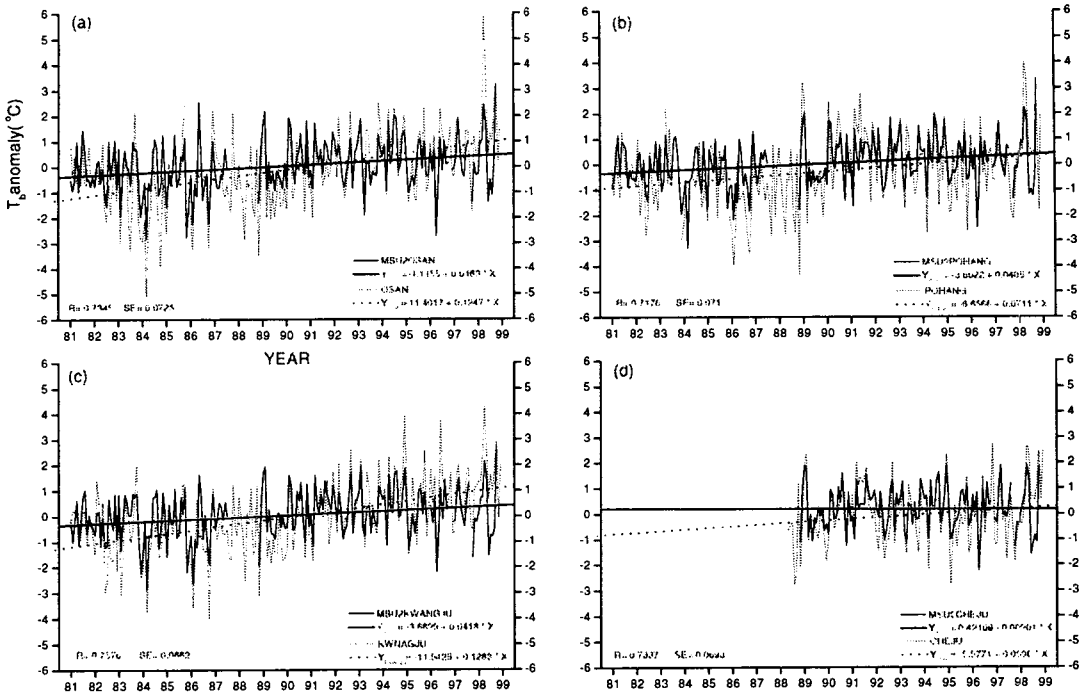

Fig. 3 Comparison of MSU channel 2 data(solid line) and upper air data(dot line) weighted from 925hPa to 250hPa. (a) OSAN, (b) POHANG, (c) KWANGJU, (d) CHEJU.

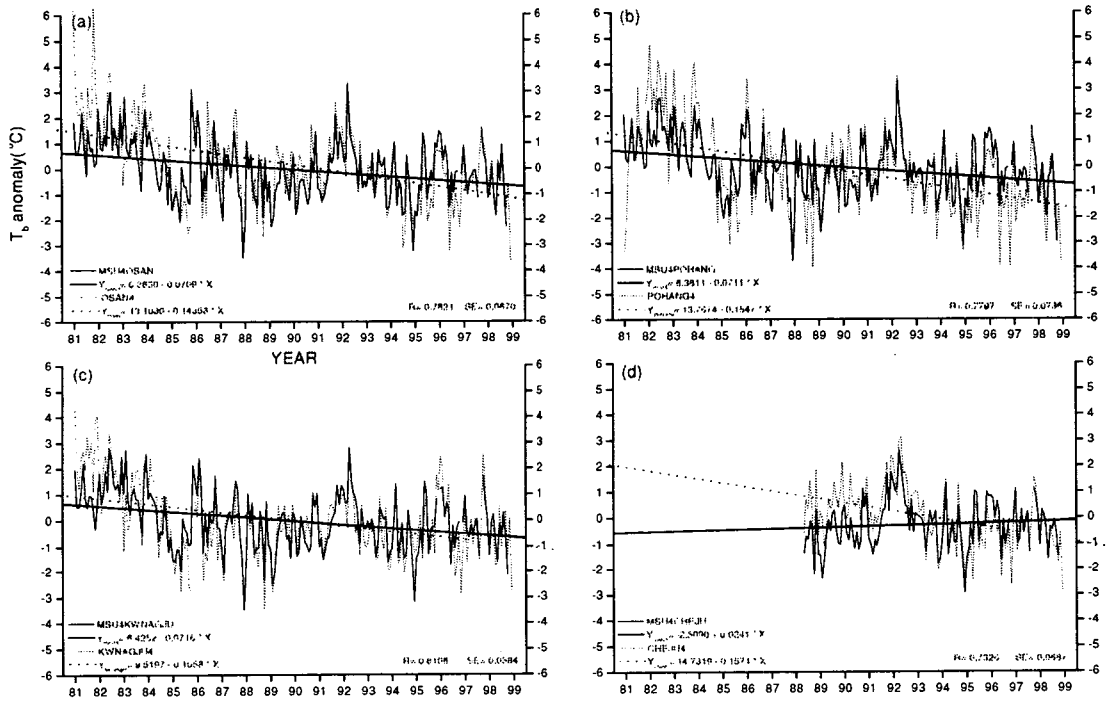

Fig. 4 Comparison of MSU channel 4 data(solid line) and upper air data(dot line) weighted from 250hPa to 10hPa. (a) OSAN, (b) POHANG, (c) KWANGJU, (d) CHEJU.

observation and the radiosonde observation (Spencer and Christy 1990).

The correlation between MSU T_{b4} and radiosonde T_{b4} was found to be 0.78, 0.78, 0.81, and 0.73 for Osan, Pohang, Kwangju, and Cheju, respectively(Fig.4). Both MSU T_{b4} and radiosonde T_{b4} show the maximum temperature on April 1992 due to the eruption of Pinatubo volcano(15.14N, 120.35E) on June 1991(Ahrens, 1994; Choi and Lee, 1996).

Long-term variation

Linear fitting of the middle tropospheric temperature(T_{b2}) shows the increasement of 0.04/year, while decrease of 0.07/year for lower stratosphere(T_{b4}) except Cheju.

This study suggests that MSU data can be used as a indicator of climate variation for the troposphere and lower stratosphere.

4. Summary

We Compared the satellite observed data with the radiosonde observed data in the Korean Peninsula. The monthly averaged radiosonde T_{b2} and T_{b4} calculated using MSU weighting function. The monthly climatology of MSU T_{b2} and radiosonde T_{b2} shows the latter is higher in summer due to the hydrometeors. The correlations of MSU T_{b2} and radiosonde T_{b2} are 0.72-0.76 and 0.73-0.81 for MSU T_{b4} and radiosonde T_{b4}.

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