Characteristics of Quasi-Stationary Mesoscale Convective Systems during the Warm Season in Japan

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1. Introduction

Meso-beta scale quasi-stationary mesoscale convective systems (QSMCSs) are well-known phenomena as a cause of heavy rainfall in Japan. In particular, long-lived MCSs often produce the large amount of rainfall over Japan, and the mechanism of the extreme events have been studied from observational and numerical point of view. On the other hand, the question of "Why do MCSs become long-lived ?" leaves the important problem untouched. We would like to focus attention on the difference of duration time of MCSs, and investigate significantly difference between long-lived and short-lived MCSs by using the observation data.

2. Data

✓ We use the 1 km-resolution of the operational radar data that provide Japan Meteorological Agency and sounding data that provide Wyoming University for analysis of the environmental conditions.

✓ Analysis period: during warm season (April—November during 2005—2012)

✓ Sounding observations are used at 09 and 21 JST. (JST: Japan Standard Time)

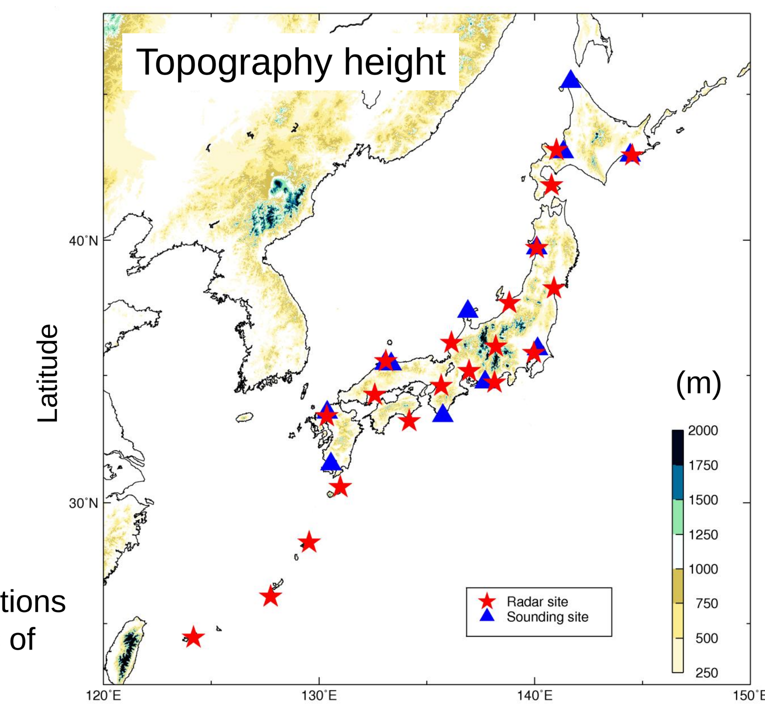
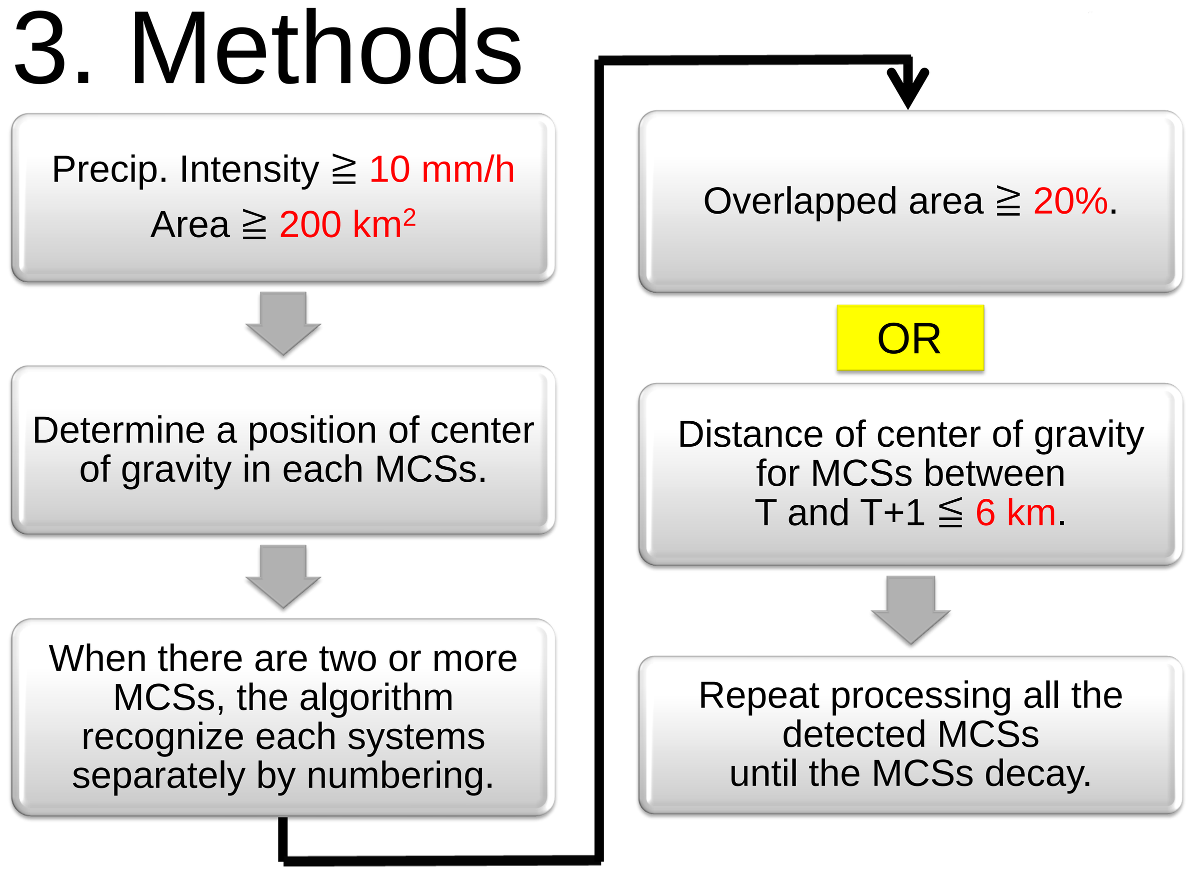


Fig. 1: Topography height, the locations of sounding sites and the locations of radar sites over Japan.

3. Methods



We developed new detect- and track-algorithm for QSRSs based on AITCC (Shimizu and Uyeda 2012).
Fig. 2 indicate flow chart of process of a MCSs identification and the process of tracking a MCS.

Why 10 mm/h?: → ~ 39.7 [dBZ]
30 ~ 40 [dBZ] → Convective storm (Dixon and Wiener, 1993)

Why 200 km²?: The target is NOT a convective cell BUT a MCS.

Why 20%?: Results of try and error.

Why 6 km?
6 km = 6000 m
= 600 [sec] × 10 [m/s]
= 10 [min] × 10 [m/s]

Fig. 2: Flow chart showing the process of MCSs identification and the process of tracking MCSs.

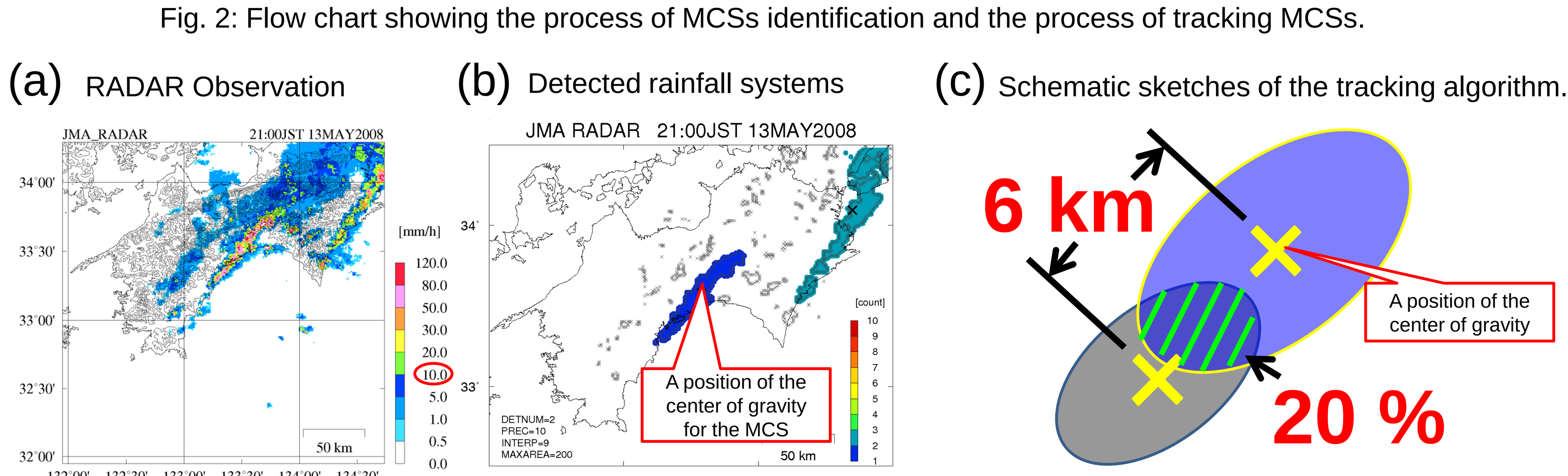


Fig. 3: (a): Results of detected and tracked convective cells in Shimizu and Uyeda (2012 JMSJ).
(b): Observation of precipitation intensity that estimated by observed reflectivity at the height of 2 km.
(c): Example of detected rainfall systems by the use of modified methods in this study.

✓ Detect and track cells embedded on rainfall systems taking into account cell-merging and -splitting in AITCC. NOT for cells BUT for MCSs applying this method to this study.

We use the t-test statistic (T) to verify the statistical significance. Test statistic is defined as:

$$T = (X_A - X_B)\left(\frac{\sigma_A^2}{N_A} + \frac{\sigma_B^2}{N_B}\right)^{-1/2}$$

where X_A and X_B are indicated the category A and B, respectively, σ_A and σ_B are shown the standard deviations, N_A and N_B denote the number of cases in each category. In this test, if T is larger than 1.96, a significant difference between the categories is statistically indicated. Otherwise, there is no significant difference between each category. A larger value of T means that the difference between each category is more significant.

4. Results

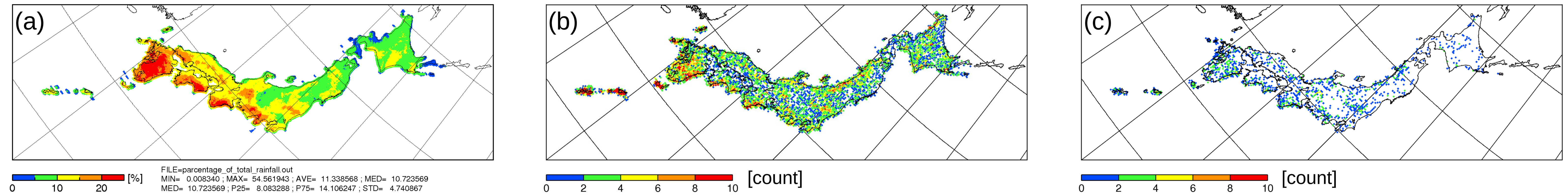


Fig. 4: (a): The percentage of the total rainfall that estimated by the operational radar data among the detected MCSs. The locations of the detected MCSs in the duration (b) less than 60 min and (c) larger than 60 min.

Stability parameters by t-test statistic

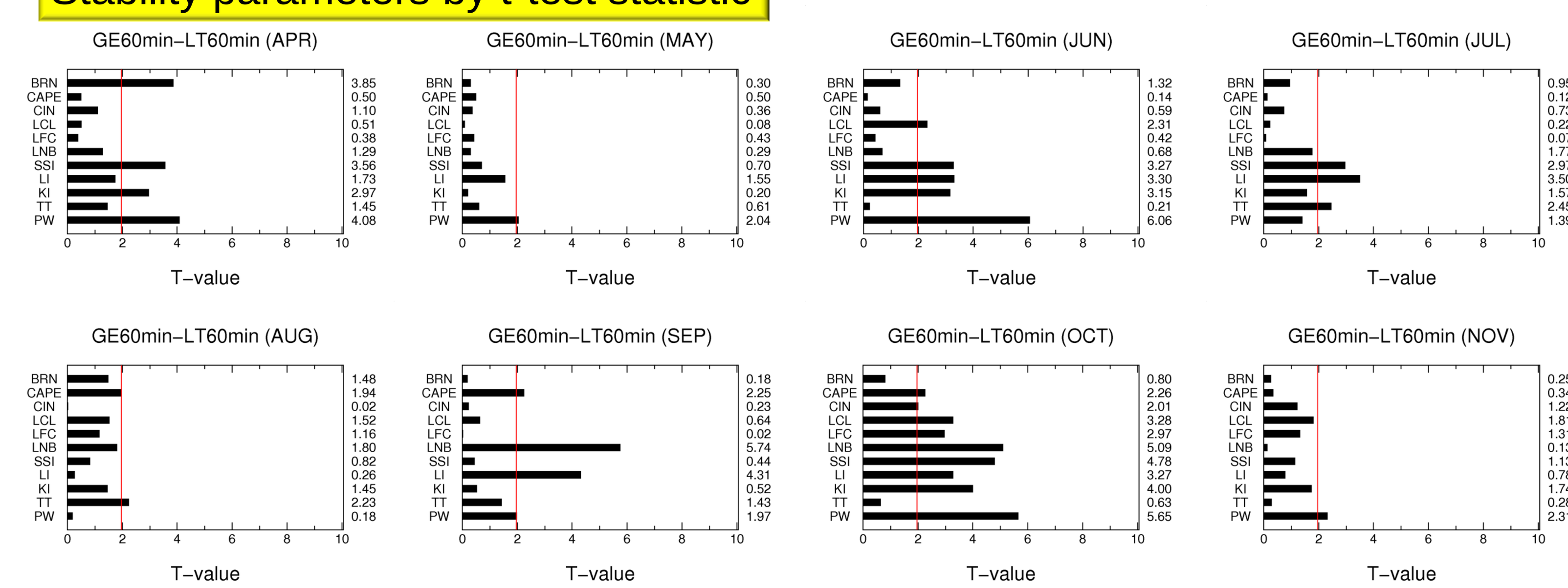


Fig. 5: Results of the stability parameters by t-test statistic in each month. The threshold for the statistical significance is shown by red line.

Vertical profiles of temperature and mixing ratio

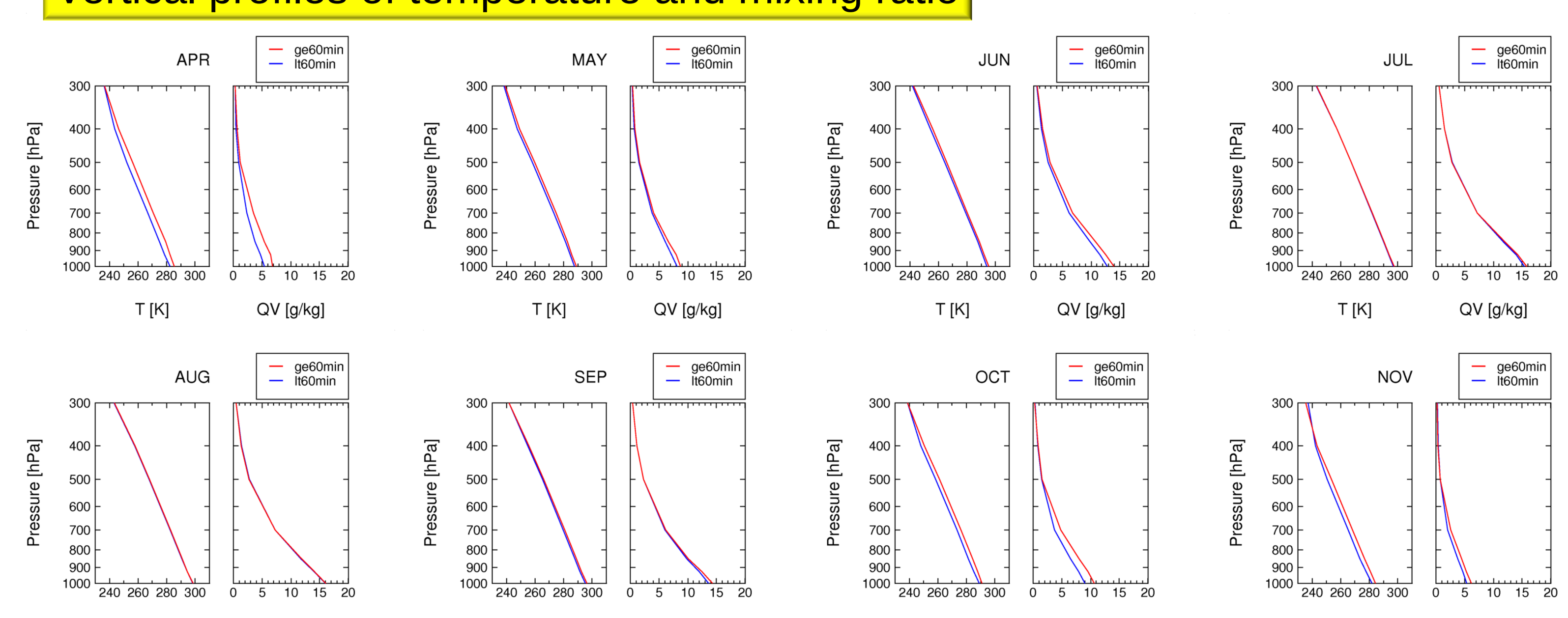


Fig. 6: The vertical profiles of (left panel) the temperature and (right panel) the mixing ratio both (red line) the Long-Lived MCSs and (blue line) the Short-Lived MCSs in each month.

Vertical profiles of temperature difference and mixing ratio difference

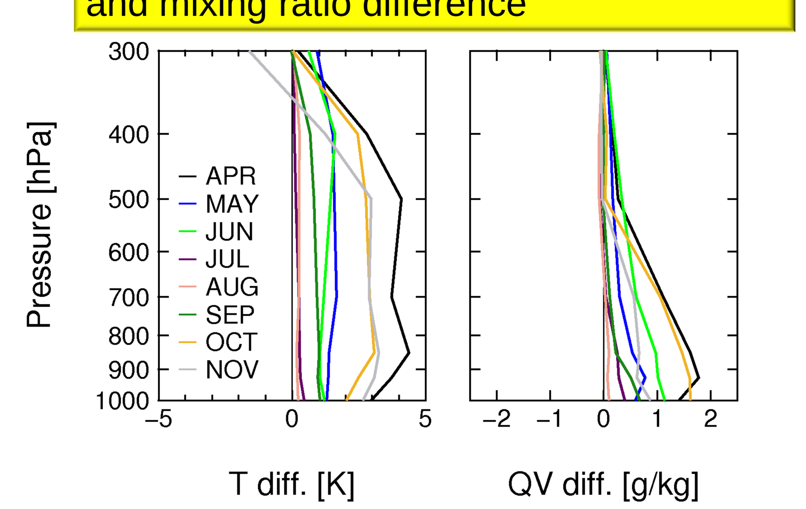


Fig. 7: The vertical profile of (left panel) the temperature difference and (right panel) the mixing ratio difference between the Long-Lived MCSs and the Short-Lived MCSs in each month.

Vertical profile of T values for temperature difference and mixing ratio difference

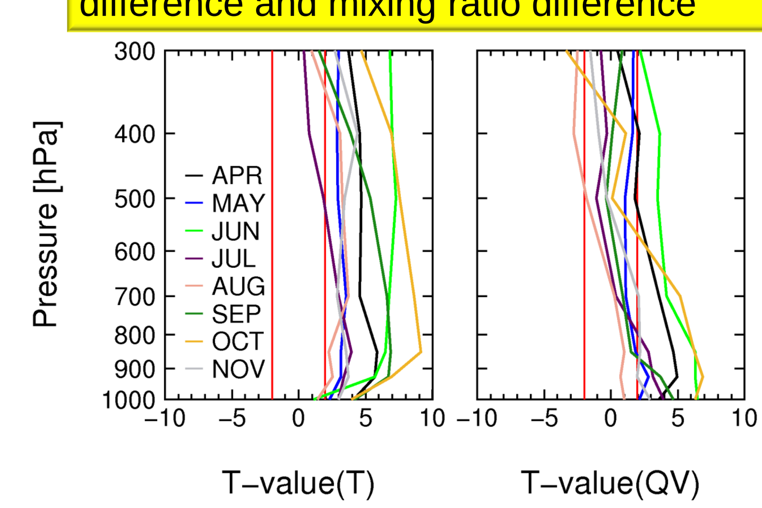


Fig. 8: Same as Fig.7, but the vertical profiles of T values for (left panel) the temperature difference and (right panel) the mixing ratio difference. The threshold for the statistical significance is shown by red line.

Figure 4a shows that the percentage of the total rainfall that estimated by the operational radar data among the detected MCSs. The mean and maximum percentage of the total rainfall among the detected MCSs were 11 % and 55 %, respectively. The MCSs are likely to develop near the coast lines both long-lived MCSs (the duration is equal or larger than 60 min) and the short-lived MCSs (the duration is less than 60 min) (Figure 4b, 4c).

The number of the MCSs extracted was 14,061 during the 8 years, while those of the long-lived MCSs, and the short-lived MCSs were 1,626 and 12,435, respectively. The threshold value (60 min) of duration time is based on a lifetime of a cumulonimbus. We verified the statistical significance between the long-lived MCSs and the short-lived MCSs by the use of the t-test statistic.

Figures 5 show the values of test statistic of the stability indices and parameters for differences in the mean values between the long-lived MCSs and the short-lived MCSs. PW indicates a significant difference in April, May, June, September, October, and November because their T values are larger than 1.96. On the other hand, TT only indicates a significant difference in July and August.

Figures 6 and figure 7 show the vertical profiles of the temperature and the mixing ratio and the vertical profile of the temperature difference and the mixing ratio difference. There are some differences in these profiles between the long-lived MCSs and the short-lived MCSs. We then calculate the test statistic T for these differences of temperature and the mixing ratio at each altitude between the long-lived MCSs and short-lived MCSs to examine the statistical significance.

Figure 8 shows the vertical profile of T values for the temperature difference and the mixing ratio difference between the Long-Lived MCSs and the Short-Lived MCSs. The T values larger than 1.96 for temperature are seen between the levels of 1000 and 400 hPa expect in July and August. The T values also larger than 1.96 for mixing ratio are seen under the level of 925 hPa expect in August. These results indicate that the temperature surplus at the middle and lower troposphere and the mixing ratio surplus at the bottom of troposphere in the long-lived MCSs shown in Figures 5 are sufficiently significant.

5. Summary and Conclusion

✓ A statistical analysis by t-test statistic was conducted to determine the significance of the different features of the stability parameters during warm season in Japan.

✓ PW is significantly different on the environmental conditions between long-lived MCSs and short-lived MCSs in April, May, June, September, October, and November. TT is significantly different on the environmental conditions in July and August.

✓ Temperature and mixing ratio surplus at the lower troposphere are sufficiently significant between the long-lived MCSs and the short-lived MCSs except in August.

Acknowledgement

I would like to thank Dr. Shingo Shimizu (National Research Institute for Earth Science and Disaster Prevention) who provide me the program of "*Algorithm for the Identification and Tracking of Convective Cells*" (AITCC).

Reference

Dixon, M., and G. Wiener, 1993: TITAN: Thunderstorm Identification, Tracking, Analysis, and Nowcasting--A Radar-based Methodology. *J. Atmos. Oceanic Technol.*, **10**, 785-797.

Shimizu, S., and H. Uyeda, 2012: Algorithm for the Identification and Tracking of Convective Cells Based on Constant and Adaptive Threshold Methods using a New Cell-Merging and -Splitting Scheme. *J. Meteor. Soc. Japan*, **90**, 869-889.