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Diagnosing environmental properties of the July 2018 Heavy Rainfall Event in Japan

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Background

In July 2018, heavy rainfall occurred over widespread areas and caused a large number of fatalities and severe damage. The year 2018 was marked not only by this July Heavy Rainfall event but also by the subsequent extreme hot weather and a number of extreme typhoon landfalls. As a preliminary study, we diagnose and document the environmental properties of the July 2018 Heavy Rainfall event in Japan by examining gridded analysis data and comparing the properties of the present case with those demonstrated for warm-season, stationary/slow-moving convective systems (called as quasi-stationary convective clusters (QSCCs) in Unuma and Takemi 2016).

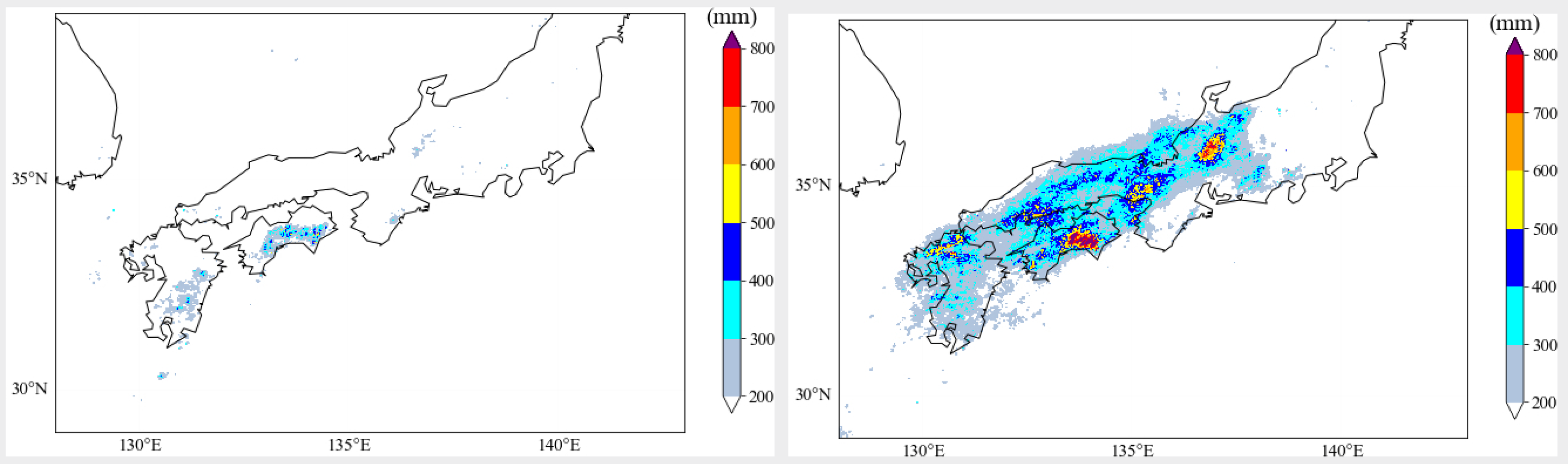

Figure 1: The accumulated rainfall amount during the period (left) from 0000 JST 3 July to 2350 JST 4 July 2018 and (right) from 0000 JST 5 July to 2350 JST 7 July 2018.

Environmental parameters

Three-hourly analysis data from the Mesoscale Model (MSM) of the Japan Meteorological Agency (JMA) were used to describe the environmental properties in July 2018 with temporal averaged fields during the heavy rainfall event.

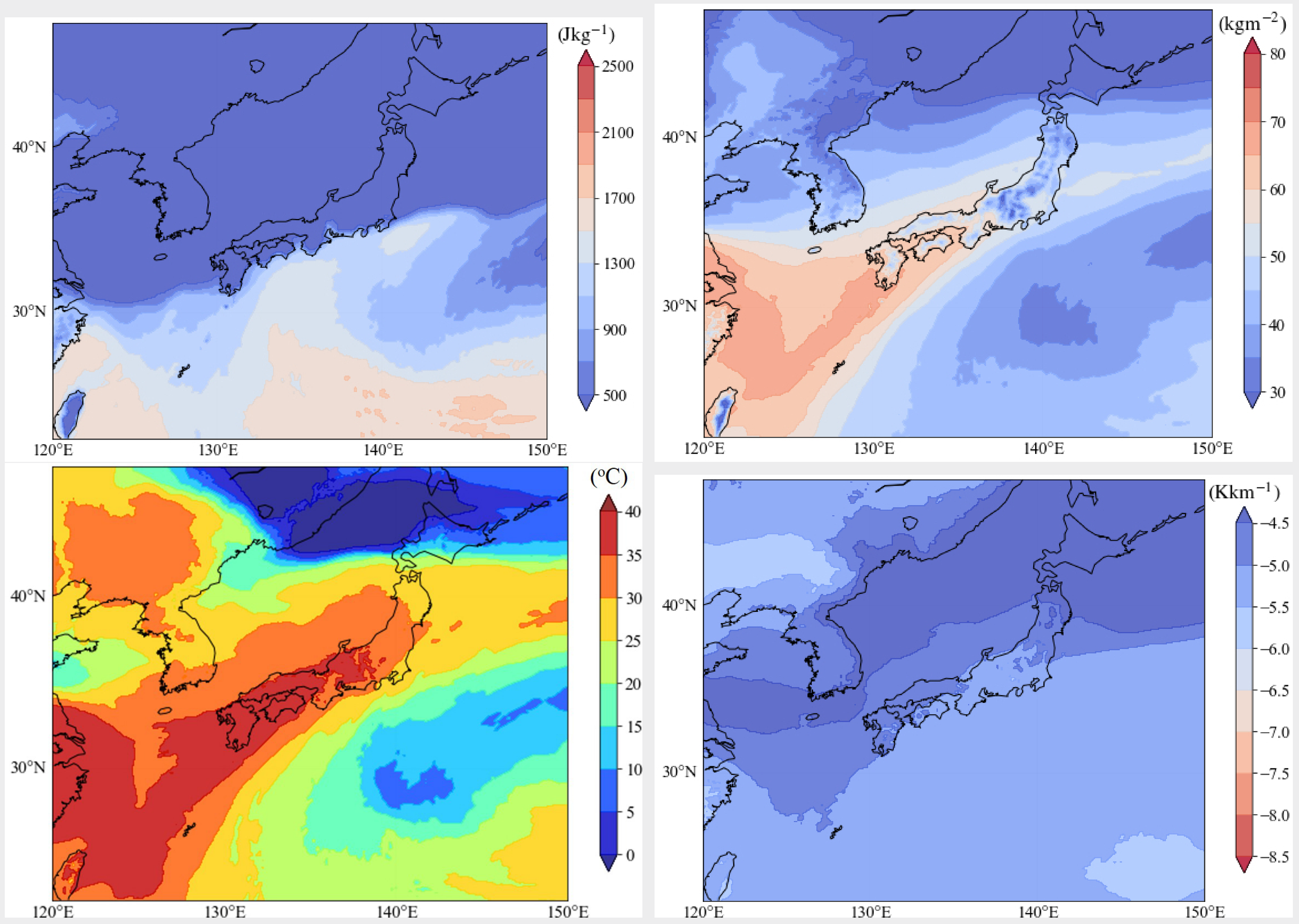

Figure 2: The temporal mean fields of (upper left) convective available potential energy (CAPE) (J kg^{-1}), (upper right) precipitable water vapor (PW) (kg m^{-2}), (lower left) K Index (KI) (degree C), and (lower right) temperature lapse rate between the levels of 850 hPa and 500 hPa (TLR) (K km^{-1}) averaged during the period from 0000 JST 5 July to 0000 JST 8 July 2018.

The analysis of the environmental parameters typically used to diagnose potential for convective development indicated that PW is significantly larger than that found for the QSCC environment.
Higher KI was found to correspond well with the region of the heavy rainfall. Because the temperature lapse rate in a convectively unstable layer was not significant, the high RH condition at the middle-levels led to the higher value of KI.

A role of middle-level relative humidity

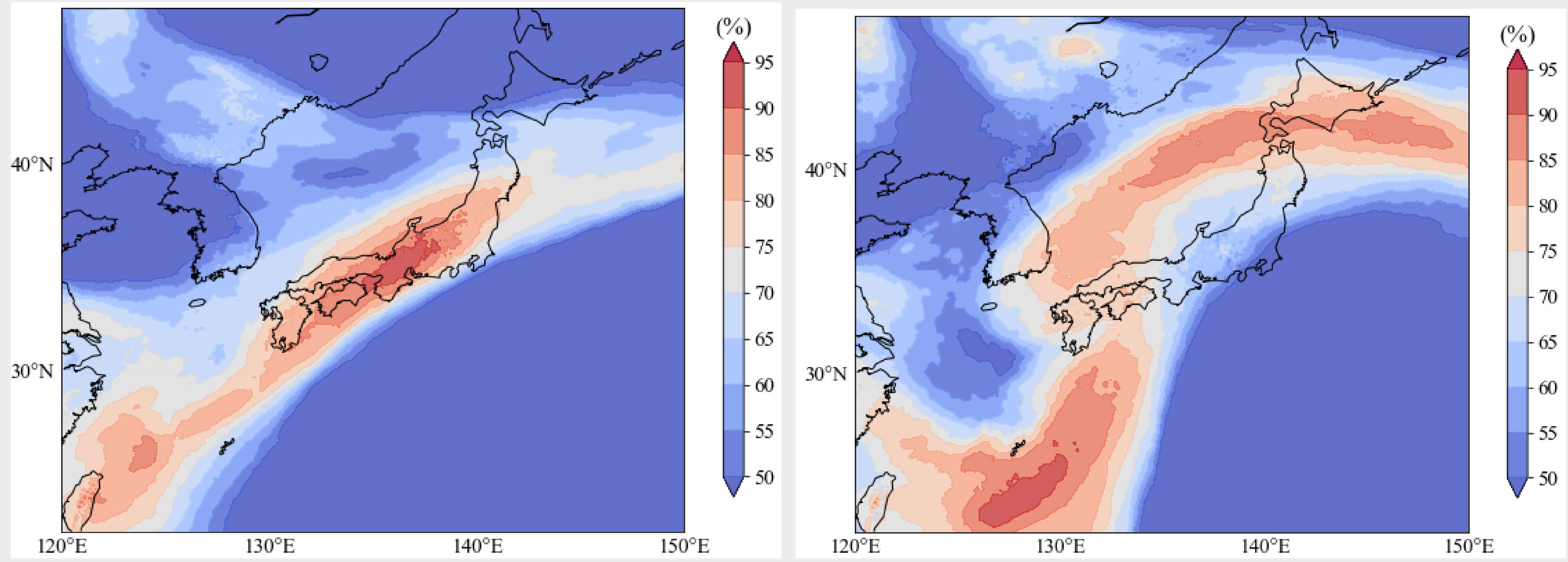

Figure 3: The temporal mean fields of middle-level relative humidity (vertically averaged in the 700-300 hPa layer) averaged during the period (left) from 0000 JST 5 July to 0000 JST 8 July and (right) from 0000 JST 3 July to 0000 JST 5 July 2018.

An extremely humid condition at middle-levels was identified as a characteristic feature for the high PW condition.

Relationship between rainfalls and middle-level relative humidity

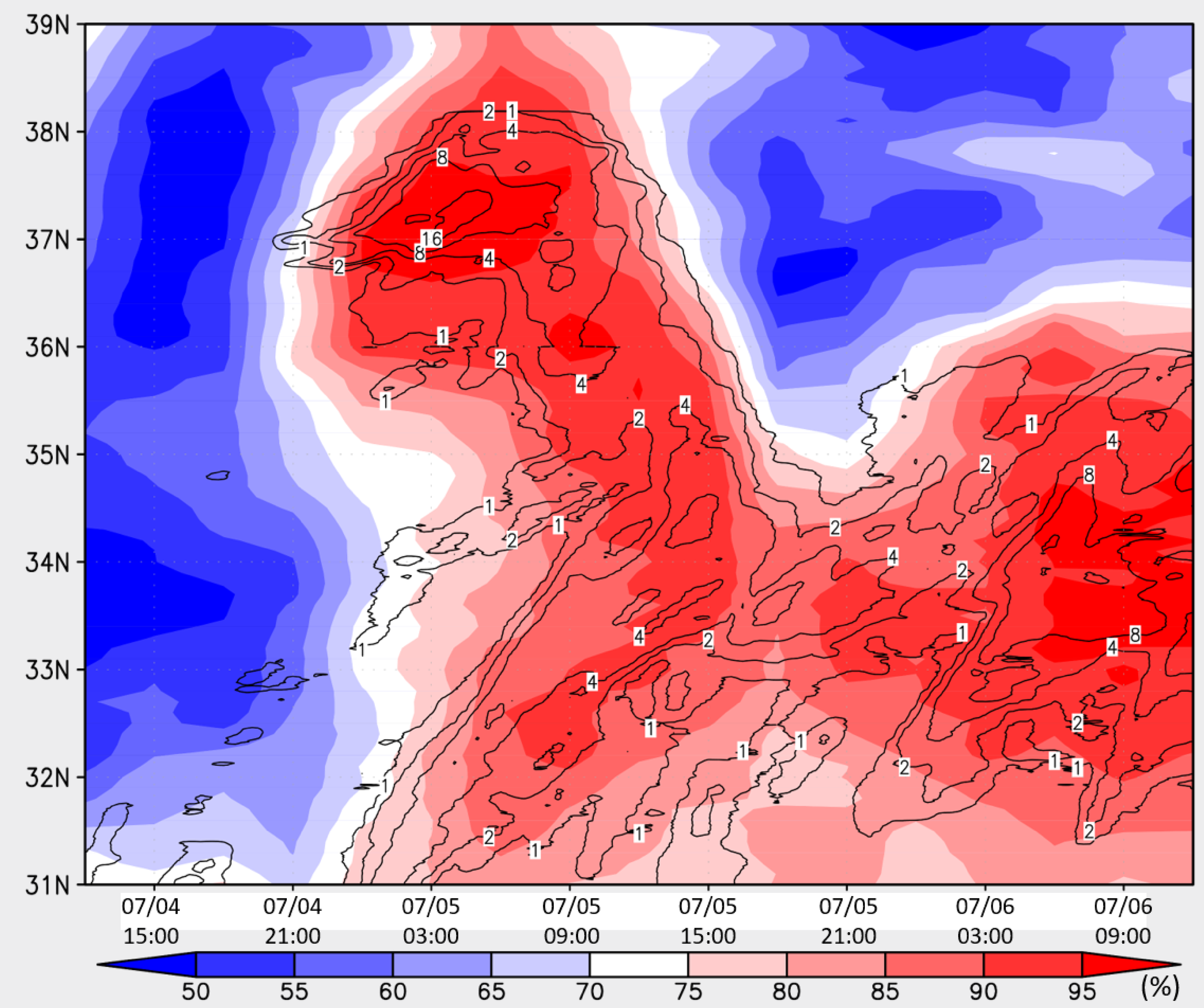

Figure 4: The time and latitude section of middle-level relative humidity (%) (vertically averaged in the 700-300 hPa layer and horizontally averaged in the 130–132.5°E longitude) as well as the analysis hourly rainfall (mm) zonally averaged in the 130–132.5°E longitude. Note that the analysis rainfall is the hourly accumulated value.

The extremely moist middle layer during 5–8 July is seen to be resulted from the merger of middle-level moist regions from the north and the south as seen in the period from 0000 JST to 1200 JST 5 July; after this period the condition of higher RH becomes stationary in the latitudinal region of 32°N and 36°N.
After the merger of the two moist regions, higher rainfall intensities are seen after the time when the middle-level RH exceeds 90%.

Acknowledgment

We thank Mr. Kentaro Hase for his help in processing the MSM data. The MSM data were obtained from the database of Research Institute for Sustainable Humanosphere, Kyoto University. This work was supported by the MEXT TOUGOU program and JSPS Kakenhi 16H01846 and 18H01680.

Moisture contribution against precipitable water vapor

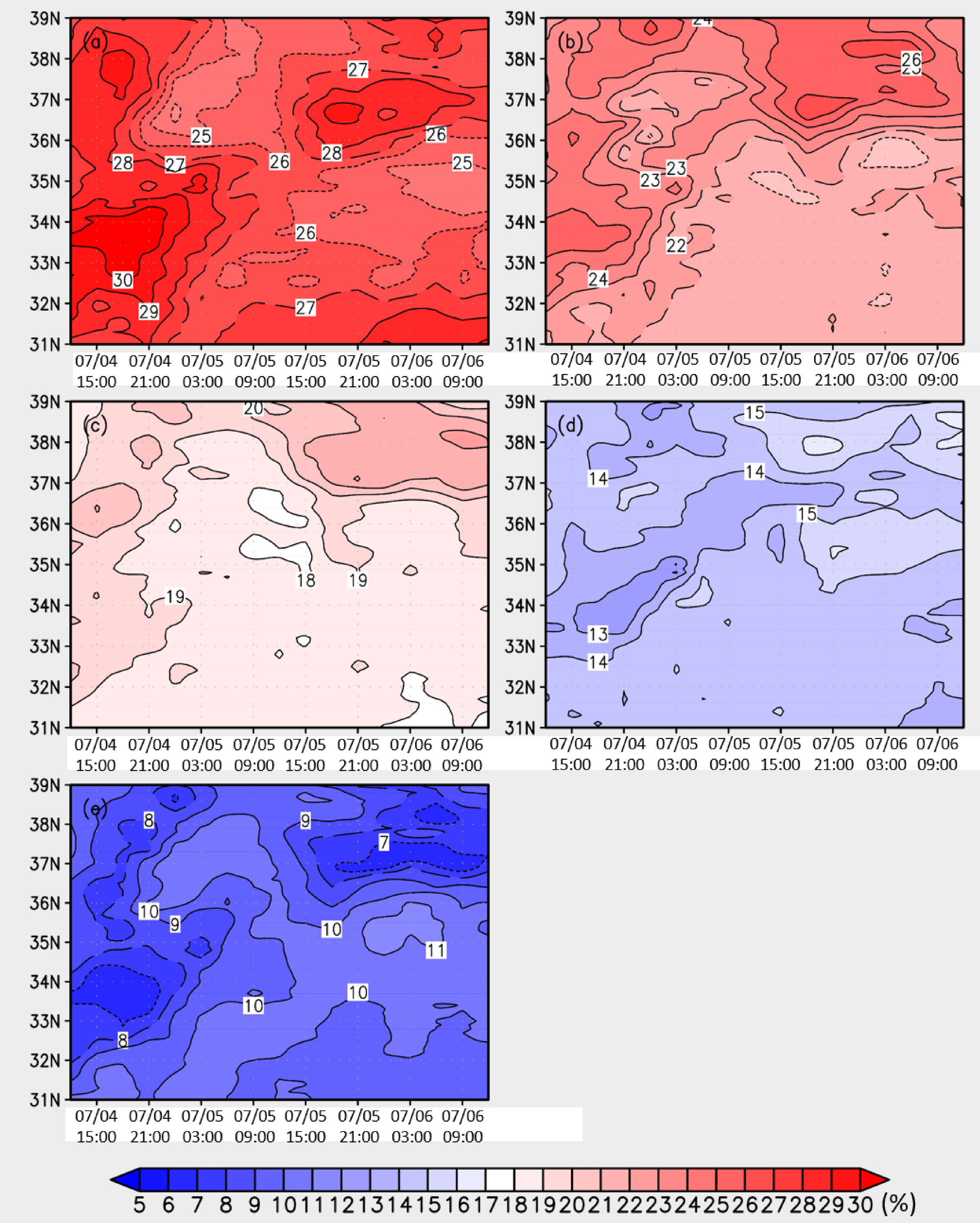

Figure 5: The time and latitude section of the total water vapor content over layers of (a) 1000–900 hPa, (b) 900–800 hPa, (c) 800–700 hPa, (d) 700–600 hPa, and (e) 600–500 hPa relative (%) to precipitable water vapor. As in Fig. 5, the values are zonally averaged in the 130–132.5 ° E longitude. Solid, dashed, and dotted contour lines indicate the values of the layer-total vapor contents relative to precipitable water being, respectively, larger than, equal to, and smaller than the modes of the QSCC environments in Unuma and Takemi (2016).

The contribution of a layer moisture content to PW in the around 15 and 10, higher than the modes for the QSCC cases. Although the moisture content itself is larger at the low-levels than at the middle-levels, the relative contribution of middle-level moisture is high, compared to the QSCC climatology.

Conclusion

- This study documented the environmental properties for the occurrence of convective systems that produced the extreme rainfall of July 2018 in Japan.
- The present analysis demonstrated that KI is useful in diagnosing the occurrence of the present heavy rainfall event. Practically, a combination of KI with other indices related to wind speed and/or vertical wind shear may help to increase the validity to diagnose the potential condition for the convective development.
- The higher moisture contents at the middle-levels should have contributed to the development of the convective systems whose precipitation intensity is stronger as a background environments.

References

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