Characteristics and Environmental Properties of Warm-Season, Quasi-Stationary Mesoscale Convective Systems in Japan

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Mesoscale convective systems (MCSs) are one of the major mesoscale disturbances and sometimes spawn heavy rainfall/snowfall and high winds locally. MCSs occur over the various regions of the world in any season and take various forms such as a circular shape and a linear shape. Because of their potential impacts on the human society, diagnosing and predicting the development of MCSs are very important. For this purpose, it is required to obtain basic understandings on the characteristics and environmental properties of MCSs. We conducted statistical analyses by using operational radar and radiosonde data in order to reveal the characteristics and environmental properties of stationary or slow-moving MCSs during a warm season in Japan from a climatological point of view (Unuma and Takemi 2016a, 2016b). The analysis period was from May to October, referred to as the warm season here, during 8 years of 2005-2012. It was found that the MCSs in Japan have smaller spatial scales than those in midlatitude continental regions. We call such warm-season, stationary MCSs as quasi-stationary convective clusters (QSCCs). The environmental conditions for the development of QSCCs were described through a comparison with those for no-rain cases. With the use of an automated QSCC identification method by Shimizu and Uyeda (2012), 4133 QSCCs were extracted over the Japanese major islands. It was found that QSCCs are typically meso-β-scale phenomena. From the analyses of the shapes of QSCCs with the use of an automated shape-determining algorithm, it was shown that most of QSCCs have an elongated structure with the southwest—northeast orientation. The environmental analyses indicated that low-level moisture content controls the stability condition for the development of the QSCCs, and that the differences in the magnitude and directional shear of horizontal winds in the lower troposphere characterize the kinematic environments for QSCCs. An increased amount of the middle-level moisture was found for the QSCC environments, suggesting that atmospheric moistening is an important factor for the development of QSCCs. The vertical shear in the lower troposphere also controls the shape of QSCCs: circular mode versus elliptical mode. From the examination of the relationship between radar precipitation intensity and environmental conditions, it was found that the precipitation intensity has a higher correlation with the convective instability, whereas the precipitation area with the shear intensity. From the analyses, it was indicated that a stability condition plays a role in determining intensity of QSCCs while a shear condition tends to control the shape of QSCCs. This feature led us to conclude that a parameter combining shear and stability, i.e. bulk Richardson number, clearly distinguishes between the organization modes. It is suggested that the back-building process is one of the key factors in determining the organization mode. We have shown that the operational meteorological data are quite useful in studying the characteristics of MCSs. With the further advances of observation techniques and numerical modeling in accuracy and spatio-temporal resolution, the analyses on the characteristics and environmental conditions of MCSs and their precipitation characteristics are expected to be extended to MCSs for various regions of the world.

Keywords: convection, precipitation, environmental condition

