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Comparison of environmental and mesoscale characteristics of two types of mountain-to-plain precipitation system in the North China

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North China, is a metropolis area and locates in a region of complex terrain with high mountain ridges to the northwest and open the Bohai Sea to the southeast. The origin of convective storms occurring on the plains can mostly be traced to the upstream mountains. Under weakly forced conditions, for the most storms, they mainly evolve into squall lines (SL) and convective clusters (CC) when reaching the plains. In this study, we analyse 18 SL and 15 CC storm systems which occurred during the period between May 2008 and September 2013, and also discuss the environmental and mesoscale differences between the two type of the storms. Firstly, we analyse that the main differences between in the frequency of convective occurrence for the two types of storm system based on composite radar reflectivity from six operational radars is the spatial distribution. For SL cases, the main precipitation mainly locates at the south of Beijing while for CC cases, that main locates at the center of Beijing. Secondly, we discuss their mean environmental conditions and mesoscale flow patterns which are obtained from storm-scale reanalysis data produced by a rapid-update 4-dimensional variational analysis system (VDRAS) that assimilates Doppler radar observations. Using a set of null cases (storms which remains in the mountains and could not arrive at the plains) and a warm season average as baselines, clear characteristics of the SL and CC storms are shown in terms of their convective environments and mesoscale structures, such as the cold pool, horizontal wind convergence, and humidity distribution. It was found the low CIN over the plains and high low-level wind speed are common to both SL and CC, whereas the high vertical shear over the plains and stronger wind speed in both mountains and plains distinguishes SL from CC. And we also show that the different mesoscale features of the two types of storm explain the different locations of high-frequency convection. The stronger wind and vertical shear in SL generate stronger and more organized downdrafts, which in turn produce a deeper cold pool and its associated large outflow. The strong outflow results in larger convergence ahead of the cold pool, which explains the formation of the secondary center of high convection frequency in addition to the high-frequency center near the southern border of Beijing. In contrast, the cold pool produced in CC is shallower and weaker, which results in weaker outflow and convergence. Consequently, the convective activities are centered only in the southern part of Beijing. And a comparison of the occurrence frequency of near-surface warm air and moist in the two storm types demonstrates that the warm and moist tongue extends farther into the foothills in CC, providing more favorable thermal conditions for CC storms that tend to be less organized.