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The Cumulus and its role in the atmosphere over the Tibetan Plateau

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Cumulus (Cu) can transport heat and water vapor from the boundary layer to the free atmosphere, leading to the redistribution of heat and moist energy in the lower atmosphere. This paper uses the fine-resolution CloudSat–CALIPSO product to characterize Cu over the Tibetan Plateau (TP). It is found that Cu is one of the dominant cloud types over the TP in the northern summer. The Cu event frequency, defined as Cu occurring within 50-km segments, is 54% over the TP in the summer, which is much larger over the TP than in its surrounding regions. The surface wind vector converging at the central TP and the topographic forcing provide the necessary moisture and dynamical lifting of convection over the TP. The structure of the atmospheric moist static energy shows that the thermodynamical environment over the northern TP can be characterized as having weak instability, a shallow layer of instability, and lower altitudes for the level of free convection. The diurnal variation of Cu with frequency peaks during the daytime confirms the surface thermodynamic control on Cu formation over the TP. The thermodynamic effects of Cu on the atmospheric environment and impacts on the large-scale atmospheric circulation are also studied using the Community Atmospheric Model, version 5.3. It is found that the model can reasonably simulate the unique distribution of diabatic heating and Cu over the TP. Shallow convection provides the dominant diabatic heating and drying to the lower and middle atmosphere over the TP. A sensitivity experiment indicates that without Cu over the TP, large-scale condensation and stratiform clouds would increase dramatically, which induces enhanced low-level wind and moisture convergence toward the TP, resulting in significantly enhanced monsoon circulation with remote impact on the areas far beyond the TP. Cu therefore acts as a safety valve to modulate the atmospheric environment that prevents the formation of superclusters of stratiform clouds and precipitation over the TP.