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Climatological characteristics of deep and shallow precipitation clouds in summer over the Tibetan Plateau

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The Tibetan Plateau (TP) is the highest plateau with complex terrain in the world, and it can affect the weather and climate of many regions through its mechanical and thermal effects. The precipitation types over TP are divided into deep (strong deep convection and weak deep convection) and shallow precipitations, according to the particular atmospheric vertical structures of TP. The climatological characteristics of the deep and shallow precipitations including their horizontal distributions, infrared signal characteristics of clouds, vertical structures, diurnal variations and local phase shifts over TP are investigated by utilizing combining measurements of the tropical rainfall measuring mission (TRMM) precipitation radar (PR) and visible and infrared scanner (VIRS) in summer from 1998 to 2007. The results show that the precipitation over TP is mainly in the form of weak deep convection, which occupies 67.8% of total rain, then followed by shallow precipitation with 26.4% and the strong deep convection with 5.8%. The clouds for strong deep convection and weak deep convection are mainly composed of ice and ice-water mixed particles, respectively. The vertical profiles of deep precipitations firstly increase, and then decrease from the storm top altitude to the ground level, with maximizing at about 7.5 km altitude. In contrast, the vertical profile of the shallow precipitation only has an increasing process. The deep precipitations have significant diurnal variations. The precipitation frequencies for strong deep convection and weak deep convection both peak at 16 local time (LT), while the rain intensities for them peak at 13 and 18 LST, respectively. Furthermore, the rain intensity for strong deep convection is characterized by a secondary peak at 00 LT. For the shallow precipitation, the diurnal variation is relatively weaker. The precipitation frequency and intensity both peak at 20 LT, presenting the characteristic of night rain. The diurnal variations of cloud radiant temperature for deep and shallow precipitation are similar, with minimizing around 19 LT, a few hours later than the peaks of the frequency and intensity. The phases of deep precipitations exhibit dramatic eastward shift, with frequency broadening and moving eastward from middle to the eastern TP from afternoon to evening. However, the phase of shallow precipitation does not have the characteristic of eastward shift.