EGU2020-12662
https://doi.org/10.5194/egusphere-egu2020-12662
EGU General Assembly 2020


# The Characteristics of Multi-layer Clouds in Summer over Tibetan Plateau Based on CloudSat Measurements

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The characteristics including cloud occurrence frequencies, vertical structure, configuration of cloud type, and microphysical structure of single-layer and multi-layer clouds in Tibetan Plateau (TP) in summer (June-August) during 2007-2010 are investigated based on the CloudSat merged data. The results indicate that cloud over the TP is mainly in the form of single-layer cloud with occurrence frequency of 56.86%, and then followed by the form of double-layer cloud with 24.47%. The spatial distribution of occurrence frequency shows that the single-layer cloud is mainly located in the northern plateau, and fraction of multi-layer cloud decrease gradually from the southeast to the northwest. Single-layer clouds mainly consist of stratocumulus (22.71%), and then followed by altostratus (19.98%) and nimbostratus (19.42%). As for the multi-layer clouds, the upper layers mainly consist of cirrus and altostratus, and the middle layers are mainly dominated by altostratus, cirrus and altocumulus. The lower layers mainly consist of stratocumulus, altocumulus and cumulus. The vertical structure indicates that the averaged cloud thicknesses of single-layer are larger compared with multi-layer clouds. The distributions of microphysical characteristics of multi-level clouds and single-layer clouds are similar, while the averaged values of microphysical characteristics including particle number concentration, cloud water content and effective radius of single-layer are larger. Moreover, the microphysical variable values of upper cloud are lower compared with lower cloud, which are related to the cloud types. The precipitation is mainly in the form of liquid precipitation, and then followed by the solid precipitation, and the drizzle. Furthermore, the drizzle occurs mainly in the multi-layer clouds. The single-layer fraction in the daytime (62.99%) is larger than that at night (51.00%), whereas, multi-layer clouds are opposite. The fraction of liquid precipitation and deep convection are larger during the daytime than those at night. Conversely, the fractions of drizzle and nimbostratus are larger at night. In addition, higher surface temperature, larger surface specific humidity and higher surface pressure is found to be contributed to the formation of multi-layer clouds.