Increasing of Atmospheric Temperature in the Upper Troposphere and Cumulus Convection over the Tibetan Plateau

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Abstract

Tibetan plateau has been thought to be one of important components in the Asian summer monsoon. The atmospheric heating over the plateau is considered as heat source which drives the monsoon. In the spring and summer of 2004, intensive field observation were implemented in the eastern part of the plateau under the framework of CEOP. In this study, using the field observation data, satellite and reanalysis data, increasing of potential temperature (PT) and variation of the atmospheric conditions over the Tibetan plateau were investigated. Results of intensive radiosonde observation showed significant temperature rising attaining tropopause in April. Depth of the mixing layer estimated from vertical profile of PT was much smaller than the height of the temperature rising. This result indicated that such a temperature rise was not caused by only thermally induced dry convection. On the day with significant PT increasing in the middle-upper troposphere, strong cloud activity was observed. Cloud top height derived from GOES-9 and the radiosonde observation denoted active cloud convection coincident with the temperature rise in the middle-upper troposphere. On the other hand, in the case of small temperature rising, cloud top height is smaller.

Numerical simulations by regional atmospheric circulation model were also conducted using the radiosonde observation data as initial conditions. The results of numerical simulations about wet and dry case with ideal wind direction (no meridional wind component) showed that air is more efficiently warmed up in middle-upper troposphere by strong convection and cloud activity in wet case. In past studies, sensible heat is considered as a major component of atmospheric heating in spring, however, results of the observation analysis and the numerical simulations in this study presented that strong cloud convection has an important role in temerature rising before the beginning of rainy season over the Tibetan plateau.

In this study, seasonal variation of atmospheric temperature and cloud activity were also investigated for 2004, 2003 and 1998. Cloud activity was frequently observed with atmospheric heating from April to mid-May. From mid-May to mid-June, frequency of cloud activity decreased and the variation of atmospheric temperature was relatively small. Around the middle of June, increasing of atmospheric temperature and reactivation of cloud activity were recognized concurrently. In these three year, increasing of atmospheric temperature was larger with frequent cloud activity in early spring. These results suggests the importance of cloud convection in early spring as a factor of atmospheric heating over the Tibetan plateau.

Above-mentioned seasonal progression of cloud convection (active, break, reactivation) was investigated from the view point of atmospheric stability. In early spring, absolutely instable condition is formed by upper cold air and large heating near the surface, and strong convective activity is easily occured. In the break of cloud activity, atmosphere is conditionally instable but humidity is relatively small. Such an atmospheric condition causes decreasing of cloud event. In mid-June, water vapor increases over the plateau. Atmosphere is also conditionally instable, and often becomes nearly saturated. Then, cloud convection is reactiveted over the Tibetan plateau.