Mechanism of precipitation system around Tibetan Plateau diagnosed by NHM

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1. Introduction

Precipitation systems in and around the Tibetan Plateau (TP) has been focused to evaluate atmospheric adiabatic heating, estimate the water resources, predict severe weather, etc. Traditional way of understanding the mechanism of convective activates over TP have been conducted using re-analysis or OLR data. After GAME-Tibet project in 1998, intensive in-situ or satellite observation have revealed unique mesoscale features, and are ready to be validated by numerical simulations. Cloud resolving model is a strong tool because three dimensional products are facilitated to diagnose the structure of precipitation system without dense in-situ observation network, such as on TP. In this presentation, recent achievements of precipitation system studies using non-hydrostatic numerical model (NHM) are introduced.

2. Study methods

Studies are conducted as following steps; first, extracting unique or representative precipitation events by data analysis, second, performing a NHM simulation with nesting to downscale on a focused region, and then performing sensitivity experiments by changing topography or soil moisture. Model products were compared with observational values, such as clouds in satellite images, sonde profiles, or surface measurements, and conceptual mechanism were proposed. Reanalysis data was not always perfect as boundary condition to represent the synoptic scale circulations around the TP and caused inaccurate development of cloud systems in NHM. Presence of cloud structure was also depending on land surface or planetary boundary layer scheme, and accurate estimates of soil moisture and vegetation distribution are required for model initialization.

3. Water vapor transportation and meso-synoptic interaction

To support the active convections with precipitations over the plateau, mechanism of water vapor supply into the high-elevations with systematic low-level convergences needs to be revealed. Sugimoto et al. (2008) demonstrated that water valor in the mid-troposphere could migrate to the south of TP in case of prevailing a synoptic scale trough, then diurnal thermal heating by Himalayas pumped up the water vapor into the plateau and accumulated them over southeastern parts due to northwesterly flows following the trough. Ueno et al. (2009) showed that nocturnal precipitation in a central plateau basin was caused by a synoptic scale zonal convergence when the thermal convections over mountains were weakened. Two

studies confirmed that meso- and synoptic-scale interactions are very important to establish a precipitation system, and NHM simulation with several nesting steps could capture the linkage among those different scale systems.

4. Land-surface interaction and orographic effects

TP is consisted with complex topography with heterogeneous land surface conditions, and effects of those factors can be revealed by NHM sensitivity studies. Sugimoto and Ueno (2010) clarified that large scale mesoscale convective system (MCS) was caused by low-level convergences associated with migrating thermally induced cyclonic vortex born in the western plateau a day before the MCS genesis. Sensitivity experiments confirmed that existing of longitudinal gradient of soil moisture played a fundamental role to maintain the MCS genesis over the eastern plateau. Ueno et al. (2010) also simulated a nocturnal MCS genesis with heavy rains over Sichuan basin, in the east of TP, and revealed important functions of topography to decide its location and timing of onset. As the MCS formation is quite sensitive to surface flux and soil moisture condition in cases for certain synoptic condition, more accurate boundary condition data are required for the simulation.

5. Future issues

As computational techniques are advancing, NHM will provide more dense and long-term output. To assimilate the surface condition into the model, high qualified initialize/forcing/boundary condition data are required. Establishment of surface observation network and data archive strategy has been started under the international projects, such as TPE program by China and CEOP-AEGIS program by EU. NHM would be a major tool to reveal the atmosphere land-surface interaction studies in high elevation areas.

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