P2.8 Effect of the Tibetan snow on the East Asia summer monsoon with global and regional models

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1. Introduction

More than a century age, Blanford (1884) suggested that the varying extent and thickness of the Himalayan snow cover can exert influence on the climatic conditions and weather over the plains of India. He associated the increased winter snow cover in the north-west Himalayas with decreased rainfall over the plains of western India. Numerous research papers have been published investigating the snow-monsoon relationship through both observational analyses and sensitivity experiments using general circulation models (GCM).

Wu and Qian (2003) classified the spatial distribution of Tibetan winter snow anomalies into three typical patterns and reported that a more (less) Tibetan snow anomaly linked to the formation of negative (positive) tropospheric atmospheric temperature anomaly over the Tibetan Plateau (TP), the weak (strong) land-sea thermal contrast over south Asia, and the weak (strong) south Asian summer monsoon circulation. However, the summer precipitation anomaly is rather complicated over East Asia. It is analyzed that there is a clear positive correlation between the Tibetan winter snow and the subsequent summer rainfall from the middle and lower reaches of Yangtze River valley, China, to Japan. The observation analysis by Zhang and Wang (2004) supported that a close relationship exists between the interdecadal increase of snow depth over the TP during spring and a wetter summer rainfall over Yangtze River valley, including the effect of the SST warming in the Indian Ocean and Maritime Continent.

Various GCM modeling studies indicate theoretical support for the snow-monsoon hypothesis (Bamzai and Marx, 2000).These studies indicate that the GCMs are able to reproduce an inverse snow-monsoon relationship to varying degree. However, the relationship between the Eurasian snow and the Asia summer monsoon has been studied focusing on the Indian and South Asian monsoon and the associated physical processes over the East Asian summer monsoon (EASM) have not been clarified yet.

Above-normal rainfall and below-normal temperature over central China, Korea and Japan appear in 2003 summer. This study investigates the dynamical characteristics associated with abnormal wet summer monsoon over the Korean peninsula in 2003.

2. East Asia summer monsoon in 2003

Excessive rainfall appears from the Yangtze River basin to the Korean Peninsula and southern Japan, whereas precipitation deficits appear to the south of these regions during the summer monsoon season of 2003 (Fig. 1a). Analysis of large-scale circulations in East Asia reveals that the weakening of the Tibetan high (TH) prevails throughout the summer (Fig. 1b).

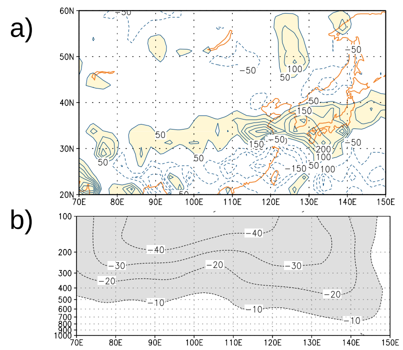

Fig. 1. (a) Precipitation anomaly and (b) longitude-pressure section of the height eddy anomaly at 40°N for June-July-August (JJA) in 2003.

These unusually persistent negative height eddy anomalies suggest that the upper-level trough over Korea and Japan is deeper than normal and it may lead to the intrusion of cold air into the monsoon area in summer of 2003. In addition, the stronger western Pacific subtropical high leads to the increase of warm moisture supply into the EASM region. Between the two major air masses, favorable conditions for abnormal precipitation are formed in central China, Korea, and Japan. In association with the wet climate extreme in East Asia, the snow over the TP shows a significant increase in May 2003.

3. Model and experimental design

a. GSM/RSM

The global/regional spectral model (GSM/RSM) used in this study is a version of the National Centers for Environmental Prediction (NCEP) Medium-Range Forecast (MRF) model with the physics package that was operational as of January 2000. GSM has a horizontal resolution corresponding to the spectral truncation of T62 and a vertical resolution of 28 terrain following sigma layers. RSM domain covers East Asian monsoon region including the TP. The number of grid points in Cartesian coordinates is 109 (west-east) by 86 (north-south) and a 50-km resolution is chosen.

The physical package employed in this study is as follows: The United States Geological Survey (USGS) (Chen and Dudhia, 2001) data for land surface process is used and YonSei University (YSU) scheme (Hong et al, 2006) for boundary layer and the revised SAS scheme (Byun and Hong, 2006) for deep convection, Chou (1999) scheme for long wave radiation are used.

b. Experimental design

Four runs are designed to examine possible roles of Tibetan snow in forming such a climate extreme in East Asia (Table 1).

Table 1. A summary of experiments. A dash means the same setup as in theGCTL experiment.

	snow	sst
GCTL	2003	2003
GSNO	climatology	-
RCTL	2003	-
RSNO	climatology	-

The observed and climatological snow depth boundary values are forced during the simulation period for both GSM and RSM runs. The NCEP/DOE reanalysis data are used for initial and boundary condition. For GSM experiments, 10-member ensemble runs are performed starting from 0000 UTC 1 May to 0000 UTC 10 May with 24-hr interval. The RSM are running during the same period.

4. Results

Figure 2 shows the changes of the precipitation and TH from the GSM runs due to the positive snow anomaly. The features of precipitation found in the observation are also fairly reproduced over Korea and Japan. However, the opposite signals are shown over the Yangtze River basin compared with the observation. The height eddy anomaly from the GSM runs also shown similar feature to the precipitation.

The RSM runs produce some different results from the GSM (Fig. 3). The decrease of precipitation over Korea and Japan and increase over the northern region of the Yangtze River are shown. In addition, the opposite response of height eddy anomaly is produced to the GSM runs.

a)

b)

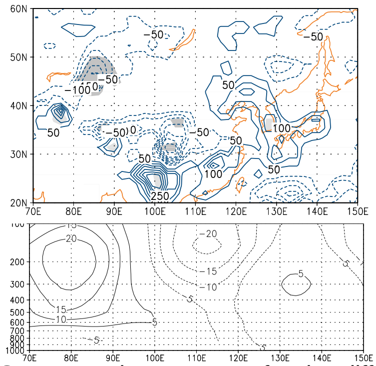

Fig. 2. Same as Fig. 1, except for the differences between the GCTL and GSNO experiments.

a)

b)

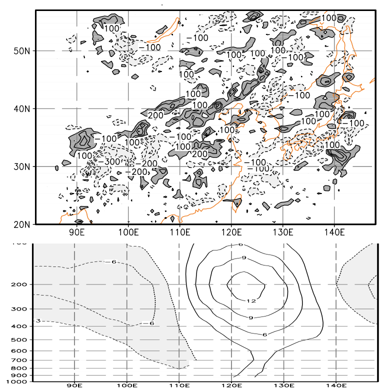

Fig. 3. Same as Fig. 1, except for the differences between the RCTL and RSNO experiments.

Acknowledgements

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