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Elevation dependency of recent and future climatic warming over the Tibetan Plateau and its surroundings

Xiaodong Liu, Zhigang Cheng, Libin Yan

Institute of Earth Environment, Chinese Academy of Sciences, Xi'an, 710075, China (liuxd@loess.llqg.ac.cn / Fax: +86 29 88320456)

The Tibetan Plateau (TP), located in central Asia with a mean elevation of more than 4000 meters above sea level and an area of about 2.3 X 106 km2, is well known for its impacts on regional climate through thermal and dynamic forcing mechanisms as a major geomorphic unit on the Eurasian continent. In spite of significant impacts of the TP on the atmospheric general circulation and hydrological cycles, knowledge of climatic change over the TP is limited for a long time due to lack of sufficient observational data. In the present study, we collected 1961-2006 daily maximum (daytime), minimum (nighttime) and mean surface air temperature records from 116 stations on eastern TP and its neighborhood (87o-107oE, 27o-41oN) and examined the recent trends and variation patterns of the temperatures. Analyses of the temperature time series show that the main portion of the TP has experienced statistically significant warming during the past 46 years, especially in winter. The increase in monthly mean minimum temperature (Tn) is the most notable, with linear warming rates of 0.42˚C/decade for the annual mean and 0.61˚C/decade for the winter mean averaged for 66 stations above 2000m. Moreover, there exists a tendency for the warming trend to increase with the elevation in the TP and its surrounding areas, i.e., the elevation dependency of climatic warming. It has been found that linearly-increasing rates of winter-mean Tn are 0.12, 0.34, 0.40, 0.50, 0.36, 0.60, 0.54, 0.57, 0.57 and 0.85 ˚C/decade averaged for stations at 0-500m, 500-1000m, 1000-1500m, 1500-2000m, 2000-2500m, 2500-3000m, 3000-3500m, 3500-4000m, 4000-4500m and 4500-5000m, respectively. These updated observational results are consistent with previous relevant studies (e.g., Liu and Chen, 2000: Internal Journal of Climatology,

20, 1729-1742).

We also examined the projection of climate change over the TP under future global warming condition on the basis of climate modeling output. In the 1% per year CO2 increasing experiment with the high-resolution (T85, ∼140km horizontal resolution) version of fully coupled Community Climate System Model (CCSM3) developed by the National Center for Atmospheric Research (NCAR), the surface warming generally increases with elevation over the whole TP and its surroundings (70o-105oE, 26o-42oN). The linear warming rates are 0.31, 0.30, 0.32, 0.31, 0.33, 0.34, 0.37, 0.41, 0.46, 0.54, 0.54 oC/decade for annual-mean Tn averaged for 11 topography-category regions with elevation in the range of 0-500m, 500-1000m, 1000-1500m, 1500-2000m, 2000-2500m, 2500-3000m, 3000-3500m, 3500-4000m, 4000-4500m, 4500-5000m and 5000-5500m, respectively. Meanwhile, we used the high-resolution (∼20 km) modeling output with a physically-based downscaling technique (Ghan and Shippert, 2006: J. Climate, 19, 1589-1604) to analyze the future projection of regional climate change over the TP under the A1B scenario of the IPCC (Intergovernmental Panel on Climate Change) Fourth Assessment Report. The surface air temperature will remarkably rise over the TP in the future. As identified in the above observation analysis, more pronounced warming occurs at higher elevations and in winter. With respect to the period 1980–99, increases in annual-mean Tn over the TP and its surroundings during the period 1930–49 reach 1.59, 1.34, 1.42, 1.50, 1.50, 1.60, 1.73, 1.78, 1.87, 1.98, 2.06 and 1.80 oC for 12 elevation classification zones of 0-500m, 500-1000m, 1000-1500m, 1500-2000m, 2000-2500m, 2500-3000m, 3000-3500m, 3500-4000m, 4000-4500m, 4500-5000m, 5000-5500m and 5500-6000m, respectively. These modeling results also reveal a strong elevation dependency of climatic warming around the TP and suggest that the TP is one of the most sensitive areas responding to global climate change.