REPRESENT PRECIPITATION IN 1998 SUMMER OVER THE TIBETAN PLATEAU USING REMO

XUEFENG CUI
Max Planck Institute for Meteorology, Bundesstrasse 53, Hamburg, D-20146, Germany
LASG, Institute of Atmospheric Physics, P.O. Box 9804, Beijing, 100029, P. R. China

HANS-F. GRAF
Center for Atmospheric Sciences, University of Cambridge, Downing Place, Cambridge, CB2 3EN, UK
Max Planck Institute for Meteorology, Bundesstrasse 53, Hamburg, D-20146, Germany

BAERBEL LANGMANN
Max Planck Institute for Meteorology, Bundesstrasse 53, Hamburg, D-20146, Germany

WEN CHEN AND RONGHUI HUANG
LASG, Institute of Atmospheric Physics, P.O. Box 9804, Beijing, 100029, P. R. China

The variation of precipitation in summer of 1998 over the Tibetan Plateau is studied using a regional climate model called REMO with a horizontal resolution of 1/6° driven by European Centre for Medium-Range Weather Forecast (ECMWF) reanalysis data ERA40. In comparison with in situ observational data from the TIPEX-GAME/Tibet, it is found that REMO captures successfully the most major precipitation cases and reproduces the monsoon onset date. The simulation also shows clear spatial characteristic of daily precipitation pattern over Tibet, which is dry in the west and wet in the east, except unrealistically large rainfall at the southern side of the Himalayas. Therefore, REMO can be used to investigate the water cycle and energy budget over this region in future studies.

INTRODUCTION

The Tibetan Plateau (hereafter referred as Tibet), with elevation above 4000m a.s.l., has been thought to play a very important role in the progress of the Asian monsoon (e.g. Ye and Gao, 1979; Ye and Wu, 1998; Zhou et al., 2000). Quantitative estimates of area distribution of precipitation over Tibet are one of the important aspects for estimating latent heat flux, understanding the water cycle processes and evaluating water resources for major rivers that originate from the plateau, e.g. the Huang He River, the Changjiang River and the Mekong River. The precipitation over Tibet is weak and frequent and it is less in the west and north and more in the east and south (C.F. Ye and Gao, 1979; Ueno, 2001).

However, one of the main problems in understanding consistent plateau-wide precipitation analyses is the inadequate number of surface observation points in such
extensive and remote areas, especially those in the western plateau and mountainous regions (Ueno, 1998; Zhou et al., 2000). In addition, there are high uncertainties within the current observational data (Ueno and Ohata, 1996). The second Tibetan Plateau Experiment of atmospheric science (TIPEX; Tao and et al., 2002) and the China-Japan cooperative experiment GAME/Tibet were performed from May to September in 1998, under the framework of the World Climate Research Programme (WCRP) / Global Energy and Water Cycle Experiment (GEWEX) Asian Monsoon Experiment (GAME) (GAME/Tibet synthesis report, 2001). Field observations under a wide range of meteorological and hydrological conditions enable the development and evaluation of regional models which simulate soil moisture and temperature profiles, flux exchanges at the surface-atmosphere interface, boundary layer flux profiles, radiation transfer, cloud formation and rainfall (GAME/Tibet Synthesis, 2001).

The difficulties are also due to the considerable problems in representing complex terrain in current general circulation climate models (GCMs). As is stated in Houghton et al. (1990), the reliability of GCM prediction is still low on a regional scale owing partly to simplified land surface processes in complex topographic areas, especially over Tibet. The topographic and altitudinal effects on climate over mountainous regions are lost due to the smoothing effect. Therefore, regional climate model (RCM) has become a powerful tool downscaling the climate information originating from GCMs to a regional scale. The regional climate model REMO, used in this study, was developed at the Max Planck Institute for Meteorology, together with Deutsches Klimarechenzentrum (DKRZ), Forschungszentrum Geesthacht (GKSS) and Deutscher Wetterdienst (DWD) (Jacob and Podzun, 1997). REMO has successfully been used to investigate the water budget over Baltic Sea region and also some other regions (Jacob et al., 2001; Langmann and Graf, 1997). More details can be found at: http://www.mpimet.mpg.de/en/depts/is/rc/index.php.

In this study, REMO with a horizontal resolution of 1/6º (~18km) is first time applied to study daily precipitation over Tibet. Details of the simulations are discussed in Section 2. In section 3, we mainly analyze the results by comparison with in situ observational precipitation data and Monsoon onset date in literature. Section 4 draws the main conclusions and summary.

SIMULATIONS

Contribution to regional model errors can in fact be not only due to inadequacies in the model physics, but also due to the effects of the Lateral Boundary Conditions (LBC). Therefore, it is always necessary to test the model first using analysis of observations, i.e., so-called “perfect boundary conditions”, before application of the regional model in a new region (Giorgi and Mearns, 1999). The domain of the regional model should be large enough to allow full development of internal model meso-scale circulations and include relevant regional forcing. Additionally, the resolution of regional model has to be high enough to adequately capture the scale and effects of such local forcing as topography and land-surface processes.
To meet such request mentioned above, two nested REMO simulations are performed over Tibet. It is first applied over a larger domain (5.5°N-55.5°N, 60.5°E-132.5°E, referred as REMO1/2; see Figure 1) with ½° (~55km) horizontal resolution and also applied covering nearly all Tibet (25°N-43°N, 75°E-107°E, referred as REMO1/6, see also Figure 1). REMO1/2 is run from April 01, 1998 to October 31, 1998 in the forecast mode (restart every 24 hours) initialized and driven (nudged at the lateral boundary every 6 hours) by the European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis (ERA-40), which is regarded as a “perfect” model output. The output from REMO1/2 is used to initialize and drive REMO1/6 in the climate mode for the same period, i.e. no restart only nudge at the lateral boundary every 6 hours for the whole simulation period. For REMO1/6, output is made every 3 hours.

Figure 1. Geographical map of the Tibetan Plateau. Topography is drawn by global gridded elevation and bathymetry (ETOPO30) and topographic contours higher than 1500m are shown. The regions above 3000m, 4500m and 5000m are shaded. Dotted line shows the boundaries of nations. REMO1/2 represents the domain of REMO1/2 run, while REMO1/6 stands for REMO1/6 run.

ANALYSIS

To evaluate REMO1/6 performance over Tibet, comparison is carried out with in situ observational data from TIPEX-GAME/Tibet. Figure 2 shows daily precipitation
comparison at station MS3543 (31.58°, 91.9°) between model output at one grid cell and observation from May 01, 1998 to September 30, 1998. REMO1/6 reproduces main precipitation cases on: June 18, June 28-29, July 5-8, July 20-August 18, August 25-September 01. It is found that REMO overestimates the amplitude of rainfall, especially on July 3-5. However, it should be taken into consideration that output at one grid cell from REMO1/6 represents average characteristic of 18×18km², while observational data measured with rain gauge can represent only a very limited region in complex terrain like Tibet.

Figure 2. Daily precipitation variation comparison between model one grid output (top) and on-site observation data from TIPEX-GAME/Tibet (bottom) at station MS3543 (31.58°, 91.9°) with height of 4624 a.s.l.. Shaded rectangle represents no observational data during the period at this site.

Another similar comparison at station D66 (35.52°, 93.78°) is showed in Figure 3. The precipitation at D66 is weaker than that of MS3543. The total amount of observational rainfall for June to August period at D66 is 101 mm (143mm, simulated by REMO1/6), while MS3543 is 366mm (574mm, simulated by REMO1/6) at MS3543. The comparisons (other stations not shown) of model grid output with in situ observations show that REMO1/6 can reproduce the daily variation of precipitation over certain
regions of Tibet and the station to station variability, except that the amplitudes are slightly overestimated.

![Figure 3. Same as Fig.2 except for station D66 (35.52°, 93.78°) with height of 4600m.](image_url)

The precipitation over Tibet shows characteristics of a rainy monsoon season and a dry season (c.f. Yeh and Gao, 1979; Ueno et al., 2001). Monsoon onset date is important to explore the precipitation processes over monsoon region and is also a key measure for model performance. Fig. 4 shows the longitude-time section at 30°N-35°N and latitude-time section at 89°E-94°E of daily precipitation. It clearly shows on about June 10, 1998 precipitation abruptly expands to nearly all Tibet with increased amount, which is in good agreement with June 13, 1998 monitored using daily radar reflectivity (Yamada et al. 1999). Figure 4 also clearly shows the spatial pattern of precipitation over Tibet: drier in the west and north, wetter in the south and east. Unrealistically large rainfall is always simulated by REMO at the southern side of Himalayas, which is probably because the extreme steep slope in this region cannot be resolved by the model.
CONCLUSIONS AND SUMMARY

REMO is used to study the variation of precipitation in 1998 summer over Tibet with a high horizontal resolution of 18km. To evaluate model performance, intensive high resolution observational data with relative good quality are an urgent need. In this study, in situ observational daily precipitation data from TIPEX-GAME/Tibet is used to be
compared with model grid output. It is found that REMO is relatively suitable to reproduce the daily precipitation over Tibet except that the amplitudes are slightly on the higher side. Moreover, REMO can simulate quite well the monsoon onset date and spatial pattern of daily precipitation: drier in the west and north, wetter in the south and east. In future studies, evaporation, clouds, as well as heat flux at the surface would be studied to investigate the water cycle and energy budget over Tibet. Long-time period simulations up to 10 years are also considered in the future.

ACKNOWLEDGE

The authors are grateful to the TIPEX-GAME/Tibet for supplying the observational data. This work is funded by Max Planck Society (MPG) - Chinese Academy of Sciences (CAS) cooperated project EHTEAM.

REFERENCES

