Downscaling of precipitation over Mongolia using regional climate model

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I Introduction

Mongolia locates in the vast arid and semi-arid region in northeast Asia. Southern Mongolia is a part of the Gobi desert where annual precipitation is less than 100 mm. On the other hand, short grassland covers in central part of Mongolian steppe. In northern Mongolia, annual precipitation exceeds 250 mm, covered by needle leaf forest in mountain area. Such drastic variation of vegetation type is one of the interesting natural features in Mongolia. This region faces with a possibility of desertification in the future by climate change due to anthropogenic or natural reasons. Thus, the monitoring of rainfall variation is very important in this region to understand the current status of it.

During the RAISE intensive observational period of 2003, heat flux and radiation energy budget observations were conducted in KherlenBayan-Ulaan (KBU) site which are essential to evaluate the model prognostics, and are important for model parameter tunings. In RAISE project, three kinds of models, global biosphere model, regional climate model and distributed hydrological model, are utilized to study the interactions among atmosphere, biosphere and hydrosphere systems. And further numerical study on future projection after global warming will be carried out in next year. The dynamic downscaling method by the regional climate model is conducted to estimate the variations of atmospheric system with a fine resolution. The simulated high-resolved meteorological variables are provided as input parameters of the biosphere model and hydrological model.

II Regional climate model

The Terrestrial Environmental Research Center-Regional Atmospheric Modeling System (TERC-RAMS, Sato and Kimura, 2004) is developed by replacing the physical parameterizations from the original RAMS (Pielke *et al*., 1992). Dynamic downscaling of the meteorological variables is achieved by this model using 6-hourly NCEP/NCAR reanalysis for IOP period. The outer six grids are assumed as a lateral boundary where reanalysis data is nudged by a linear coefficient. Coarse grid system is centered at 105° E 40° N with 80 × 60 grids of 150 km interval. And nested fine grid system with 102 × 57 of 30 km resolution is centered at 104° E 47° N covering Mongolian territory. The cumulus parameterization by Arakawa and Schubert (1974) and Microphysics parameterization presented by Walko *et al*. (1995) is adopted to calculate the precipitation. Currently, surface condition is assumed as short grass type uniformly, and initial soil moisture is assumed as constant value in the numerical domain. Numerical integration in July, when most rainfall occurs in Mongolia, is conducted during 1993 and 2003.

III Data

Monthly precipitation at 68 meteorological stations in Mongolia, which is provided by IMH, is used to validate the model result. Additionally, sensible and latent heat flux data and radiation data at KBU is used during RAISE-IOP as well as meteorological elements. The Global historical Climatology Network (GHCN) data provided by National Climatic Data Center (NCDC) is also used for extrapolating precipitation data at out of Mongolia.

IV Preliminary result

1. Precipitation

Simulated precipitation shows basically similar distribution with less than 20 mm in the south and more than 100 mm in mountain area in each year (Fig. 1). Interannual variation of averaged precipitation shows good correlation with the observation although 10-20 percent underestimation in most years is recognized compared with observed average precipitation (Fig. 2). The difference between the model simulation and observation is larger in rainy years in Mongolia like 1993, 1998.

2. Energy budget

Air temperature and surface temperature are compared with observed values in KBU and representative six stations in Mongolia. Daily minimum and daily maximum of each temperature in KBU agree well with observation in July although some stations show large differences. In April daily mean temperatures are in good agreement with observed values; however, daily amplitude is not simulated well.

Net radiation observed at KBU is reproduced well in the model both in April and July, which shows that the interception of the downward short wave radiation by the cloud is simulated well in the model.

3. Heat flux

Sensible and latent heat flux are in good correlation with the observation at KBU in April. Overestimation of the precipitation in April is found in the model which often causes the increase of latent heat. The improvement of the accuracy in precipitation forecast will conduct the proper

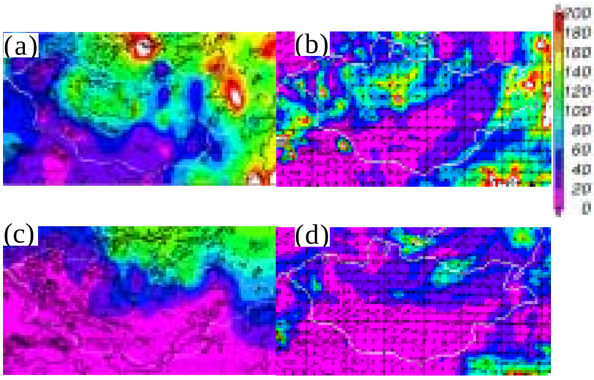

Fig. 1 Monthly mean precipitation in July. (a) 1998, observed (b) 1998, simulated, (c) 2000, observed, (d) 2000, simulated.

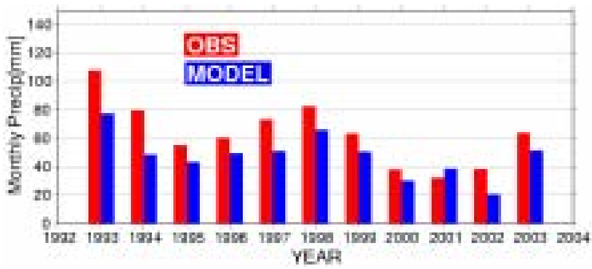

Fig. 2 Interannual variation of averaged precipitation in July.

estimation of the heat flux in April. The sensible heat flux simulated in July shows fairly larger amount compared with observation. It is speculated that the difference is caused by the horizontal homogeneous distribution of the initial soil moisture and vegetation type. These results indicate the importance of soil moisture assimilation in the IOP reanalysis experiment.

V Conclusions

Soil moisture assimilation will improve the surface heat flux estimation in July. Snow cover distribution data may also improve the forecast of daily maximum and minimum temperature in April. The reanalysis experiment of RAISE-IOP will be carried out using NCEP/NCAR reanalysis data as a boundary condition after above mentioned revisions. Further experiment of precipitation using 6-hourly GCM output will be carried out in next year in order to evaluate the regional effect of global warming in Mongolia.

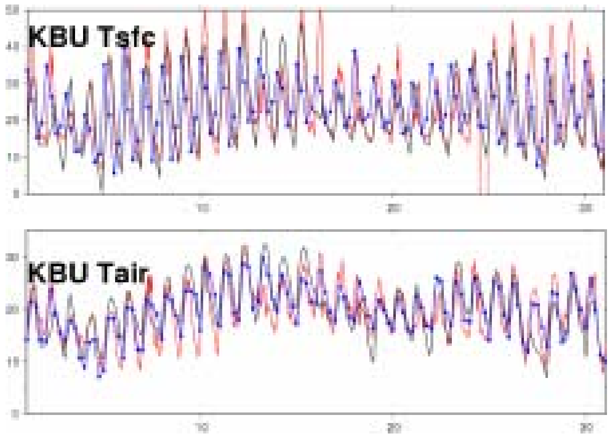

Fig. 3 (upper) Surface and (lower) air temperature at KBU in July.

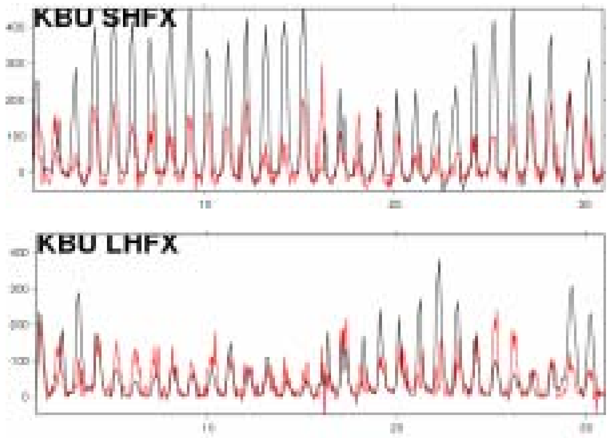

Fig. 4 (upper) Sensible and (lower) latent heat flux at KBU.

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