Application of WRF into the Yellow River basin in the period of 1980-1997

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Abstract

The Yellow River is one of the largest rivers in the world, which originates from the Qingzang Plateau and empties into the Bohai Sea. Its drainage area locates within $96-119^{\circ}E$ and $32-42^{\circ}N$. The main river length is over 5,000 km and the basin area is about 750,000 km^2. In the past 27 years from 1972 to 1998, the event of zero-flow in the downstream occurred in 21years with a total duration of 1051 days. To evaluate the change of water resources over the Yellow River basin, an examination of precipitation was carried out using the Weather Research and Forecasting (WRF) model over the Yellow River domain from 1980 to 1997. The results show that the inter-annual variations of precipitation could be represented compared with a dataset based on gauge record at four watersheds over Sanmenxia. The simulated precipitation at two watersheds in upper reaches is in agreement with observed values. There is underestimation at other watershed in middle reaches. The distribution of annual precipitation over the whole basin is almost reproduced. The estimated decreasing areas of precipitation between the period of 1980-1989 and 1990-1997 also agree well with the dataset.

1 Introduction

Precipitation as a main input item plays an important role in water budget. The variation of precipitation in the Yellow River basin was very large. Especially, a decrease tendency was continued from 1990. Therefore, how to understand the precipitation system is a one of the key points to understand the water resources change in the Yellow River basin.

In this paper, the Weather Research and Forecasting (WRF) model (http://wrf-model.org), a next-generation mesoscale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs was used. For easy comparing, four watershed regions above the Sanmenxia hydrological station were selected, namely, Tangnaihai watershed (W1), Tangnaihai-Lanzhou watershed (W2), Lanzhou-toudaoguai watershed (W3) and Toudaoguai-Sanmenxia watershed (W4) from upper reaches to lower reaches (Fig. 1). A 0.1-grid resolution precipitation data set, one of the products of the Yellow River project based on gauge observation data cover the Yellow River domain was used to evaluate the WRF performance in the basin in the period of 1980-1997

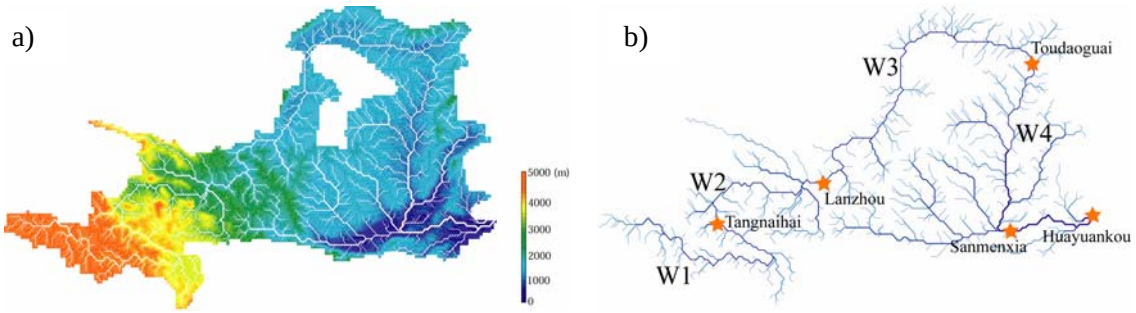

Figure 1 Elevation map of the Yellow River basin (a) and location of the 4-watershaed (b).

2 Model setting

The calculation domain was showed in Figure 2, the center point was set to be $35.5^{\circ}N$ and $105^{\circ}E$. Horizontal resolution was set to be 20 km, and there are 160 and 92 grids in x- and y-axis, respectively. NCEP reanalysis dataset in 6 hour interval is used as the lateral boundary condition. A sensitivity experiment was carried out to check to the performance for each microphysics and cumulus scheme in two wet years (1989 and 1992) and two dry years(1986 and 1997). Two cases are selected to run in whole period. The model was run in 60 seconds time step under the SGI Altix 4700 system.

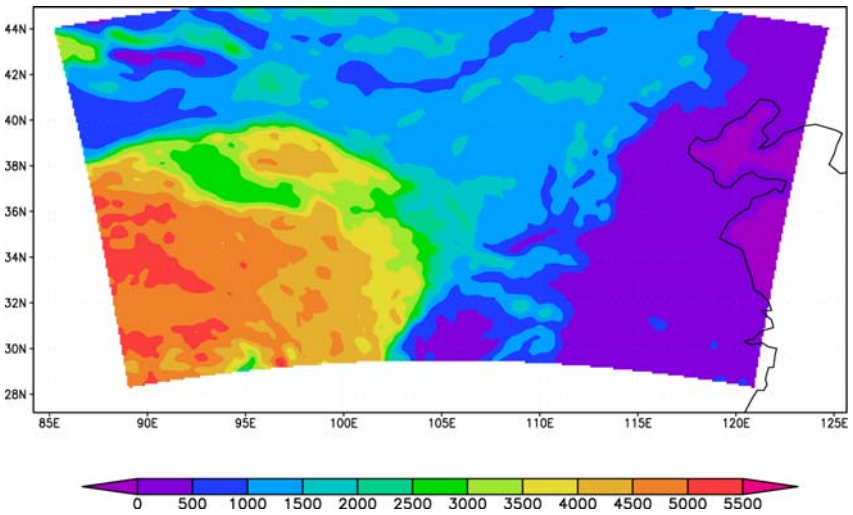

Figure 2 Map of the calculation domain selected in this study (unit: m)

3 Results

Two-case run results are shown in Figure 3. In case 1, WSM 6-class graupel scheme and Kain-Fritsch scheme are used as microphysics and cumulus. A combined of Lin et al. scheme and Kain-Fritsch is used in Case 2. A 0.1-grid precipitation, one of the products of the Yellow River Project (YRP) based on gauge data is used as observed value in this study.

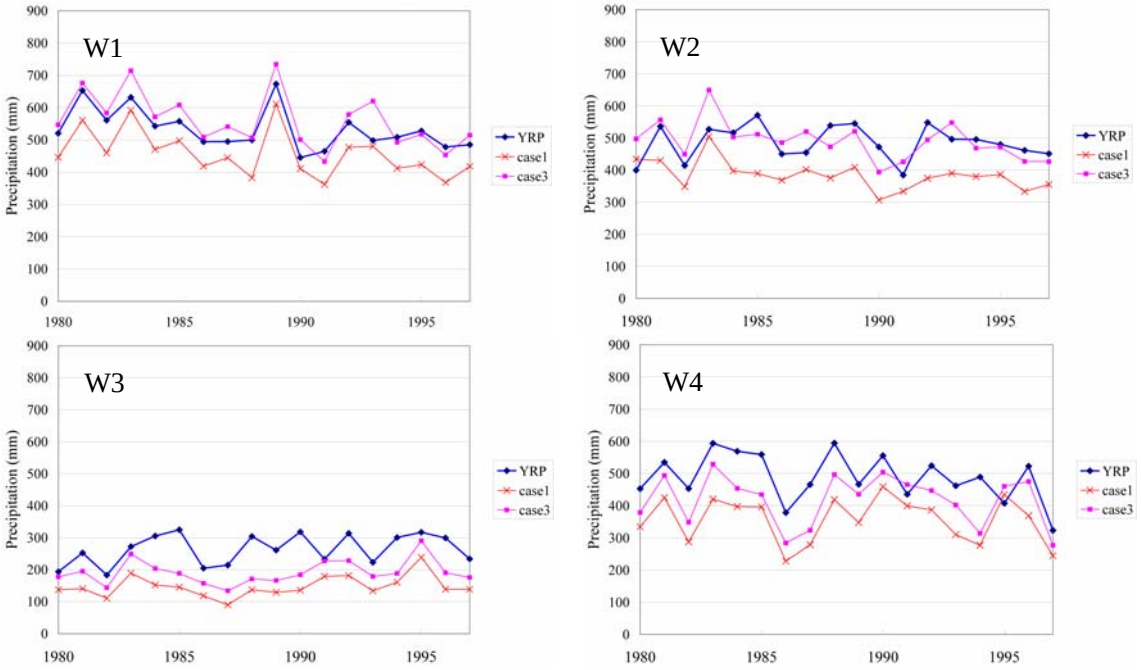

Figure 3 Comparison of annual precipitation at four watersheds of the Yellow River over Sanmenxia hydrological station between WRF output and YRP dataset from 1980 to 1997.

An inter-annual variation of precipitation was represented for all watersheds. The simulated precipitation at two watersheds in upper reaches (W1 and W2) is in agreement with observed values. There is underestimation at other watershed in middle reaches (W3 and W4). The distribution of annual precipitation over the whole basin is almost reproduced. The estimated decreasing areas of precipitation between the period of 1990-1997 and 1980-1989 agree well with the dataset (Figure 4).

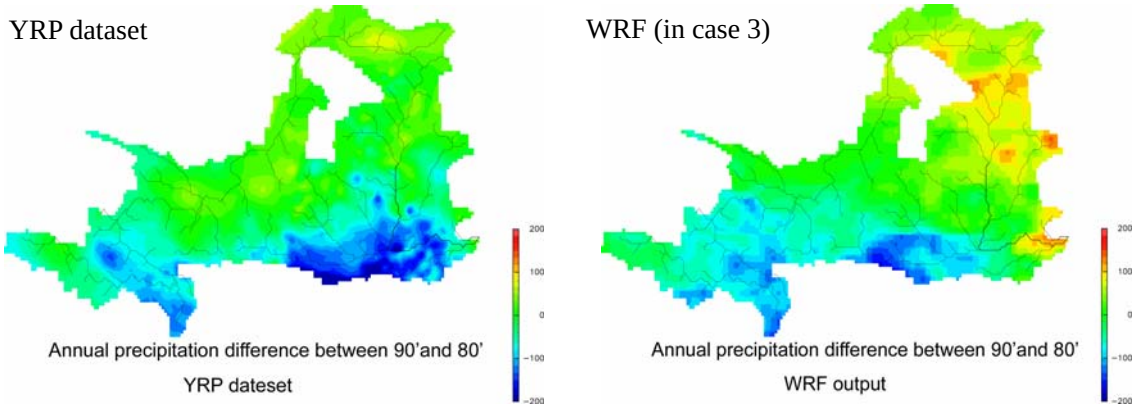

Figure 4 Comparison of precipitation difference between the period of 1990-1997 and 1980-1989 from YRP dataset and WRF (case 3) output (blue decrease and red increase, unit: mm).

For the watershed W3 and W4, more detailed investigation is required to improve the accuracy of precipitation modeling. An integrated water cycle simulation using a climate model and hydrological model will be done in the near future.