The Effect of Runoff Scheme Modification on the Summer Rainfall Simulation in East Asia

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Abstract

The runoff generation mechanism in the Biosphere-Atmosphere Transfer Scheme (BATS) has been modified in the regional climate model RegCM_NCC. The difference between the modified and original runoff scheme in BATS is that the former accounts for the simultaneous happening of the two surface runoff generation mechanisms.

The abnormal heavy rainfall process over the Yangtze River valley in summer 1998 has simulated with the RegCM_NCC by using the modified and original runoff scheme. Primary results have shown that by using the modified runoff scheme, the fraction of runoff in the simulated water cycle partitioning has been effectively modified. The runoff is increased, correspondingly the evaporation and soil moisture are decreased, the surface temperature and sensible heat are increased. The precipitation is differently modified in different regions, but is more consistent with the observation. The land-surface change also has an impact on the circulation over middle-lower troposphere layer (the highest at 700hPa).

Key Words: Runoff scheme, regional climate model, precipitation, land-surface hydrology

1. Introduction

According to the hydrology, there are two important surface runoff generation mechanisms, i.e., the infiltration and saturation excess runoff processes, which are also called as Philip and Horton runoff respectively. As an important part of the hydrological cycle in the model, the unreasonable simulation of the runoff will affect the portioning of the precipitation into the other variables (such as the evaporation and soil moisture), and then affect the energy and mass exchange. So it's necessary to couple the hydrological with the climate model.

The importance of the runoff for the land-surface model and atmospheric model has also been highlighted (e.g., Koster and Milly, 1997). But the results of the PILPS (Project of Intercomparison of the Land Process Scheme) have shown that runoff is one of the simplest treatment parts in the land surface model (Liang et al., 1998). And the difference of the hydrological partitioning between various land-surface models might be even larger than the

actuary runoff and drainage (runoff+ drainage, PILPS 2(c), Anderson et al., 2003). There are some gaps between the hydrological model and atmospheric models because of the scale mismatch and coupling, this deficiency will significantly impact the hydrological cycle, and even the mass and energy exchange in the land-atmosphere interactive system.

Some efforts have been made on the coupling of the hydrology and climate model, or the improvement of the hydrological cycle in the climate model during these years (e.g., Kim et al., 2001; Liang and Xie , 2001; Xie et al., 2003, and Zeng et al., 2003). In this context, we study the effect of the improvement of the runoff scheme in the land-surface scheme (BATS) in the regional climate model RegCM_NCC on the model performance.

2．Model Description

The regional climate model RegCM_NCC used in this study has been developed based on the RegCM2 during 1996-2000, by modifying the physical process parameterization schemes, with the support of the “95” National Key project “Studies on short-term climate prediction system for China”. The detailed description of the model is not listed here, which can be referred to as Ding et al. (2000).

The runoff generation mechanism has adopted part of the New Runoff Model (NRM) of Liang and Xie (2003), which is characterized by incorporating two excess runoff generation mechanisms (Horton and Dunne) at the same time. The heterogeneity of the sub-scale grid is not considered currently in this study.

3．Model experiments and results analysis

The case study is the abnormally heavy rainfall over the Yangtze River valley during the summer 1998. Two simulations have been made, that is, the control experiment (CTL) with the original runoff scheme in BATS, and the modified experiment (RUN1) with the modified runoff scheme in BATS. The observed precipitation is from the observations over the 160 stations in China.

Figure 1 shows the differences between the RUN1 and CTL during June 1998. We can see that by using the modified runoff scheme, the simulated runoff (Fig.1(a))has been increased in most of the model regions, especially in the rainfall center along the mid-low reach of the Yangtze River Valley (YRV). Correspondingly, the simulated ground temperature (Fig.1(b)) is increased in most of the regions. As for the precipitation, the difference between the RUN1 and CTL is not so uniform(Fig.1(c)). The precipitation in RUN1 is decreased in areas both the north of the YRV and the south of the YRV. Since the precipitation is overestimated in most regions in the CTL simulation (figures omitted), so by modifying the

runoff scheme, the RUN1 simulation seems more consistent with the observations in both the location of the rain-belt and the magnitude, except that the rainfall amount is underestimated in the regions north to the SYR center(figures omitted).

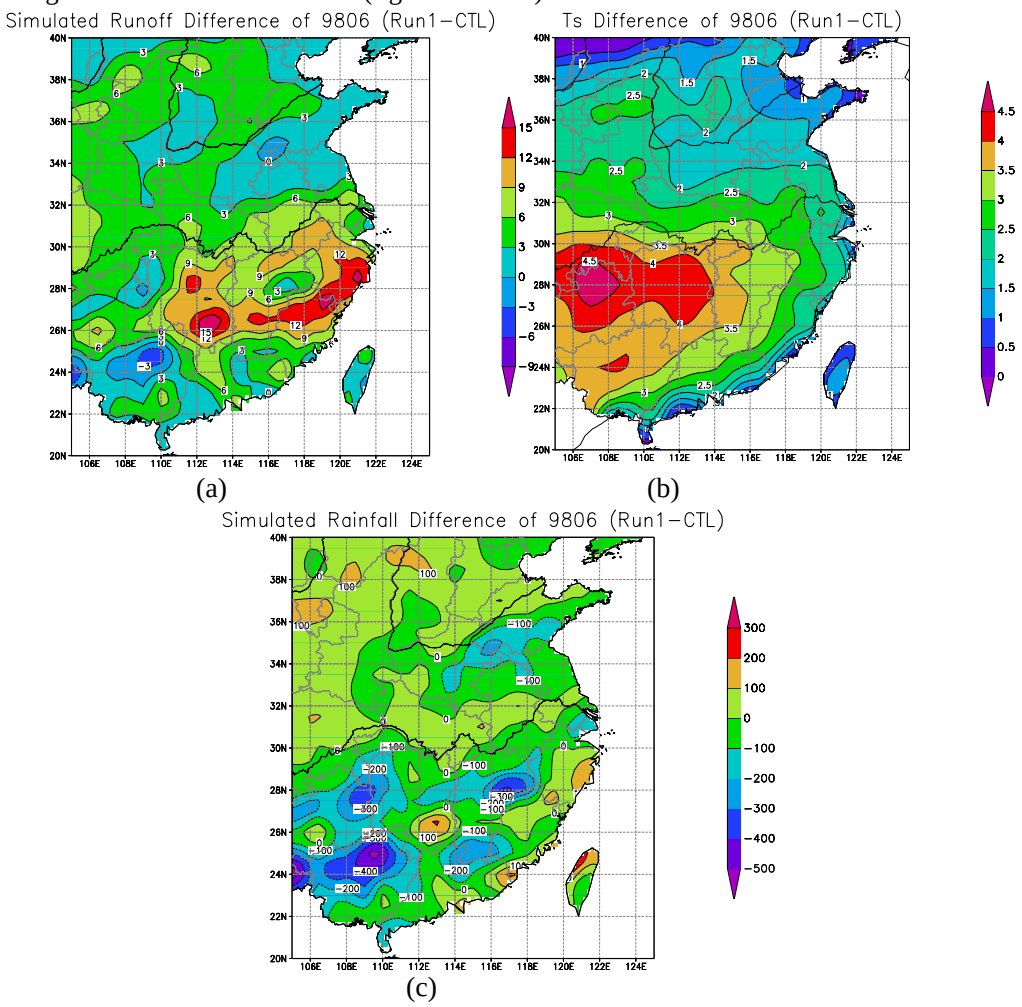

Fig.1 The simulation differences between RUN1 and CTL in June 1998

((a) Runoff, (b) Ts, and (c) precipitation)

The land-surface change of the heat and moisture will also have an impact on the atmosphere over higher levels. Comparison of the RUN1 and CTL experiment results, we found that the distinguished difference is temperature of the mid-lower troposphere. This difference can reach the height of 700hPa (Figures omitted).

4. Summary and discussion

The effect of the modified runoff generation mechanism of the land-surface scheme in the RegCM_NCC on the model performance has been studied. The results have shown that:

(1) By accounting for the two runoff generation schemes simultaneously, the simulated

runoff has increased, accordingly, the partitioning of the precipitation into the evaporation and soil moisture has decreased, so the ground temperature is increased. The simulated precipitation has also changed because of the feedback processes, with the rainfall pattern being more consistent with the observation.

（2）The changes of the land-surface hydrology also have certain affect on the variables over the mid-lower troposphere. As for the temperature, the impact can reach as high as 700hPa.

In this study, only the runoff generation scheme is modified, such other important factors, such as the heterogeneity of the sub-scale grid is not accounted, which will be our next research work.

5. References

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