Simulation of Southeast Asia Rainfall using RegCM3 and Problems

Kieu Thi Xin, Le Duc & Ho Thi Minh Ha, Vietnam National University of Hanoi.

Abstract

The Indochina Peninsula (IP) lies under main flow parth of the indian monsoonal westerlies. Whose moisture is vital for this region, at the same time causes heavy rainfall leading to severe flooding for IP and adjacent countries, makes it extremly important to improve seasonal rainfall prediction in genereal. In this paper, as the first step, the Regional climate model of the thirth generation (RegCM3) has been experimentelly used in seasonal simulation of Southeast Asia Rainfall with using reanalysis of NCEP, ECMWF and ERA-40 as lateral boundary and initial conditions for driving the RegCM3. The later has a 56 km horizontal resolution, 18 vertical levels with the model domain of 10^0S – 30^0N, 70^0E – 130^0E is chosen. The model is intergrated during two rain seasons of 1996 and 1997 as typical wet and dry year, with different convection schemes, in oder to determine the optimal model conditions for the Southeast Asia region where rainfall causes most by deep convection originated from tropical oceans. The preliminary results have shown that the precipitation was better simulated over IP using ERA-40 reanalysis data than using NCEP or ECMWF reanalysis.

RegCM3 reproduce some main features of observed average temperature, precipitation and local circulations., but underestimates temperature by ~2 ^{0}C degrees and the simulated horizontal and vertical transport is normaly too active for Southeast Asia region.

When ERA-40 reanalysis as initial and lateral and boundary conditions was used the simulated rainfall field was more closer to analysis using Grell convection scheme with Arakawa- Shubert closure assumption (Grell-AS) and Zeng Ocean Flux Model, howerver not only rainfall but also temperature are underestimated. Our funding show that all current convection schemes in RegCM3 are not enough good working for the Southeast Asian region. So we have inserted the convective parameterization scheme of Tiedtke (1989) in RegCM3 leading to improving considerably simulated temperature field and rainfall distribution over Southeast Asian region.

Keyword: Rainfall, convection, seasonal simulation.

1. Introduction

The rain season in IP normaly started at the onset of the southwest monsoon, begin of May, and closes at the ende of Desember. The moisture of the indian monsoonal westerlies is vital for IP, at the same time leading to severe flooding causing a lot of damage to the crops and people for the IP.

The heavy precipitation regimes of IP characterised by combined impact of quite different weather systems such as monsoon trough, Intertropical Convergence Zone (ITCZ), northeast and southwest monsoon in combination with the ITCZ and also to TCs originating mostly from South China Sea region and is currently quite poorly predicted. It is extremly important for IP to improve the seasonal precipitation prediction. Based on advantages of regional climate models possible to be applied to seasonal prediction the RegCM3 is used to simulate seasonal climate regime of the Southeast Asia region with concentration on the IP for understanding the ability of the RegCM3 to capture the main circulation features of the region and the pattern of temperature and precipitation over IP and Southeast Asia region.

2. Experiment design

2.1. Regional climate model RegCM3

RegCM3 is the latest version of ICTP, originated from NCAR-RegCM. It contains numerous options for different applications.

- Dynamics of RegCM3 based on MM4/5 - hydrostatical, lateral boundary conditions relaxation.
- Physics in RegCM3 : Radiation scheme (Kiehl et al, 1996); BATS land surface model (Dickinson et al, 1993); Non-local planetary boundary layer scheme (Holtslag et al, 1990); Different convective precipitation schemes [Kuo-Anthes scheme (Anthes, 1977), Grell scheme (Grell 1993) with Fritsch & Chappell closure assumption (FC-80) or Arakawa &Schubert closure assumption (AS-80)].
- BATS1E vs. Zeng Ocean Flux Model (Zeng et al, 1998).
- SUBEX large-scale precipitation scheme (Pal et al, 2000).
- In this study we are trying to use the convective parameterization scheme of Tiedtke (1989) instead of Grell scheme with Arakawa-Shubert closure assumption (Grell-AS) .

2.2. Model configuration and Data

The model configuration (domain, resolution, and the relation between them…) is an important issue for regional climate modeling (Seth & Giorgi 1998, Giorgi (2004)), but it is duficult to determine a suitable model configuration for this region because of the local typical orography such as the mountain *Hymalya* on the northwest of model domain... The experiments were performed with domain size and location so that main large-scale forcings as ITCZ,

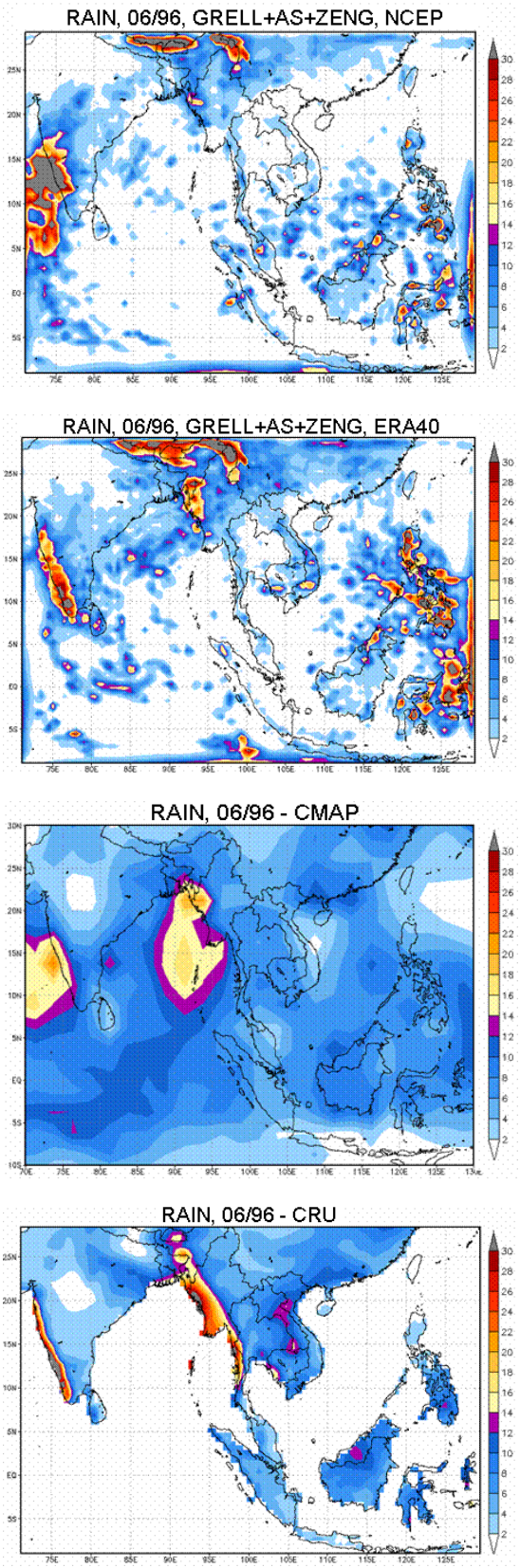

Fig. 1: Simulated Rainfall of June 1996, by RegCM3 with NCEP reanalysis (top), ERA40 reanalysis (second) to compare with CMAP analysis (third) & CRU -analysis (bottom).

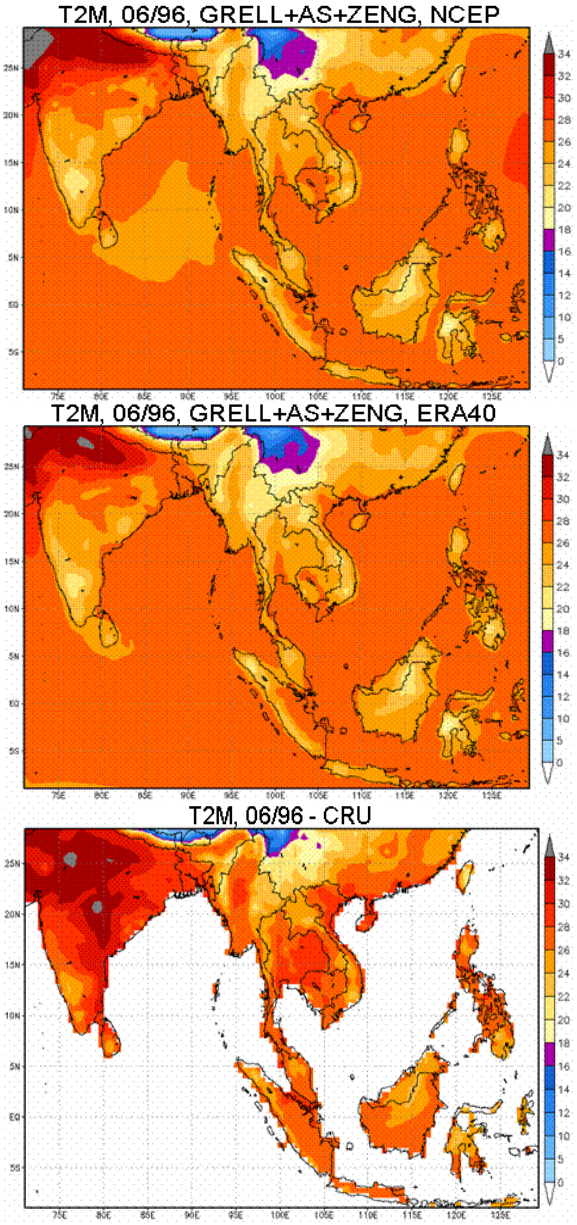

Fig. 2: Simulated temperature of June 1996 by RegCM3 with NCEP reanalysis (top), with ERA40 reanalysis (middle) to compare with CRU-analysis (bottom).

monsoons, TCs…to be included. The results show that the model solution is sensivitive to domain size and location. In this study we use the model configuration of 56 km horizontal resolution, 18 vertical levels over the domain of 10^0S –30^0N, 70^0E – 130^0E. NCEP, ERA-40 reanalysis fields are used to provide initial and boundary conditions for the atmosphere and sea surface temperature (SST) fields.

3. Preliminary Results

3.1. Case study A

Three different reanalysis were used as lateral boundary and initial conditions for driving the

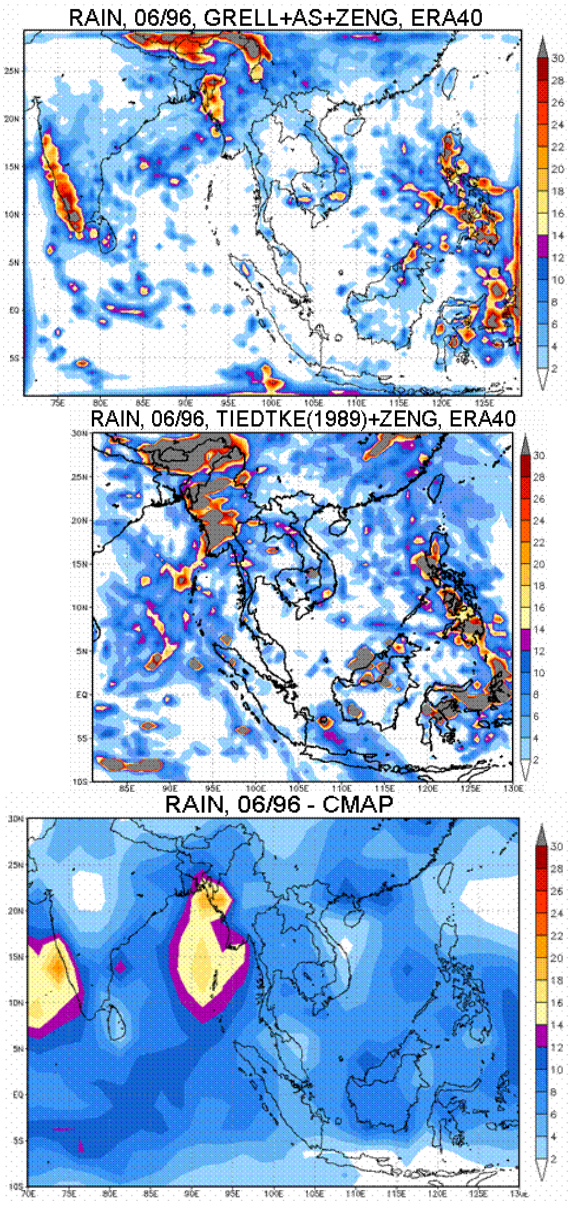

Fig.3: Simulated Rainfall of June 1996, by RegCM3 with ERA40 : using Grell - AS & Zeng in BATS (top), using Tiedtke scheme & Zeng in BATS (second) to compare with CMAP analysis (bottom).

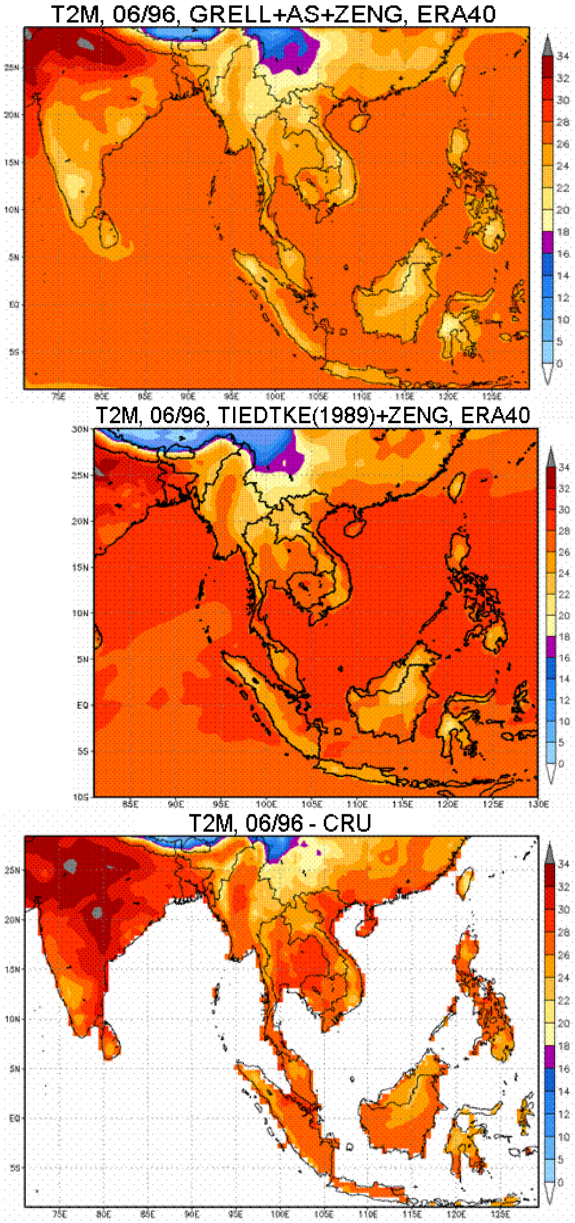

Fig.4: Simulated temperature of June 1996, by RegCM3 with ERA40 reanalysis: using Grell-AS & Zeng in BATS (top) , Tiedtke scheme & Zeng in BATS (second) to compare with CRU analysis (bottom).

RegCM3**.**

Fig.1 demonstrate simulated days means of rainfall of June 1996 by RegCM3 using NCEP & ERA40 reanalysis.

Two first pictures of Fig.1 show that ERA40 provide more moisture for this region. Howewer, in both cases RegCM3 did not sumulate raifall area of Northeast of Vietnam and of South China coast and over ocean around IP.

By comparison of simulated temperature of June 1996 of RegCM3 with CRU-Analysis in Fig.2 it is found that temperature over large area of modell domain is underestimated $1 \sim 2^0 C$ with both reanalysis.

3.2. Case study B

From numerical weather forecasting using HRM for the Southeast Asian region we found that the convective parameterization scheme of Tiedtke (1989) is well working for the Southeast Asian region. In this case we performed an experiment using the convective scheme of Tiedtke (1989) instead of Grell -AS scheme in RegCM3 using ERA40 as initial and boundary conditions, but because of limited computer power at our university we used a smaller domain of 10^0S – 30^0N, 80^0E – 130^0E for this experiment.

Fig.3 presents the simulated days means of precipitation of June 1996 using Grell-AS scheme (first picture) andTiedtke scheme (second picture). By

comparison with CMAP analysis (bottom in Fig.3) we see that major featutes in precipitation were much more reasonably captured by RegCM3 using Tiedtke scheme than using Grell-AS scheme. These features include the rain bands from Southeast Phillipines to Southeast China and the rain bands from southwest area of model domain to the northeast coast of Bengal gulf, where there is normaly strongest rainfall of the world. The precipitation mount is overestimated in those rain bands but underestimated over ocean areas around of IP, where observations are very poor.

Considering temperature field in Fig.4 we can find that using Tiedtke convection scheme in RegCM3 leading to a considerable improvement in simulating temterature of 2 metter hight over the surface. While RegCM3 using Grell-AS scheme underestimates temperature nearly $1 - 2^0C$ (first picture in Fig.4), the simulated temperature by RegCM3 using Tiedtke convection scheme (the second picture in Fig.4) scheme is more closed to CRU analysis over land and 2^0C higher than one with Grell-AS convection scheme for the most areas of the model domain (the first picture in Fig.4) , what show the important role of the convection parameterization for tropical regions.

In both experiments there is always problems in simulated fields on the northwest boundary nearly to Hymalya area.
The runs for 1997 year show nearly the similar results.

Conclusions

- Our experiments have shown that the nested regional climate model RegCM3-ERA40 using Tiedtke convection parameterization scheme is capable in simulating major seasonal rainbelts over Southeast Asian region and promising to predict seasonal climate.
- To progress the seasonal prediction by RegCM3 it is very important to estimate a suitable model configuration fo this region.
- The improvement of analysis data by given observations is an important issue for climate modeling of Southeast Asian region.
- It is needed to perform more experiments.

Acknowledgements : We would like to express our sincere thanks to Prof. Fillipo Giorgi and his collaborators for their assistances and supply of data.

References

Giorgi, F., On the simulation of regional climate using a limited area model nested in a general circulation model. *J. Clim*., **3**, 941-963, 1990.

Giorgi, F., C. Shields, Tests of preciptation parameterizations available in lastest version of NCAR regional climate model (RegCM) over continental Unitd State. *J. Geophys. Res*. **104**, 6353-6375, 1999.

Giorgi, F., M.R. Marinucci , G. DeCanio, and G. T. Bates, Development of a second generation regional climate model (RegCM2) , Cumulus cloud and assimilation of lateral boundary conditions, *Mon. Weather Rev*., **121,** 2814-2832,1993.

Grell, G. A., Prognostic evaluation of assumptions used by cumulus parametrization, . *Mon. Weather Rev*., **121**, 764-787, 1993.

Small, E. E., F. Giorgi & L. C. Sloan, Regional climate model simulation of precipitation in central Asia : Mean and interannual variability, *J. Geopyss. Res.*, **104,** 6563-6582, 1999.

Tiedtke, M., A Comprehencive Mass flux scheme for cumulus parameterizatition in large scale models. *Month. Wea. Rev*. **117**, 1799-1801, 1989.