Reproduction of Detail Rainfall Distribution in the Mekong River Basin

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The rainfall distribution in the lower part of the Mekong River basin was reproduced by using Cloud Resolvable Storm Simulator (CReSS). The amount of reproduced rainfall was not similar as the amount of measured by raingage. During doing the reproduction, it seemed that there are some problems which is difficult to solve. In this paper the brief explanation of CReSS, boundary data were shown as well as the way to overcome the difficulty to use the Earth Simulator. Then, this paper mentioned the way to compare the result of CReSS and one of the measured data.

Keywords: Numerical Weather Reproduction, Mekong River, flood, CReSS

1. Introduction

The Mekong river is source of life. The Mekong river is as long as 4,000 to 4,500km from origin in China to river mouse in Veit Nam and it is as large as 800,000km^2 which is more than double of total area of Japan. The tropical monsoon delivers the rainfall that is 1,000mm/year to more than 4,000mm/year to the Mekong river basin. The lower part of Mekong river basin has paddy field of 3,000,000ha.

However, living in the Mekong river basin means living with flood. In flood season, the water level of Mekong river especially Tonle Sap lake increase more than 10m from dry season. Especially, the lower part from Cambodia has usual flood. The rainfall information for them is highly expected.

Currently, the rainfall information in the Mekong river basin is much courser than required one. The rainfall distribution in the Mekong river basin is thought to be no uniform. We will show the rainfall distribution of very short time in the Mekong river basin by this project.

Therefore, this paper is intended as an introduction of investigation of making the rainfall distribution data by using numerical meteorological model and evaluating the result of rainfall distribution data. We would like to show a new method to evaluate the result of rainfall distribution and we show the necessity of analysis the statistical structure to considering the long-term trend of rainfall distribution that must be affected by global warming.

2. Brief introduction of CReSS and TRMM

In this study, Cloud Resolvable Storm Simulator (Tsuboki and Sakakibara., [1]) (here after CReSS) is used to reproduce the rainfall distribution as well as all kind of atmospheric variables, such as temperature, pressure, wind speed, water vapor, ice particle.

The CReSS uses basic equations of fully compressible with a map factor. The other spec of CReSS is as follows; the vertical coordinate of the equations is terrain following, vertical grid structure is Lorenz type, horizontal grid structure is Arakawa C, sound waves is treated by horizontally explicit and vertically implicit (HE-VI) scheme. Leap frog scheme is used for larger time scale and forward-backward scheme for explicit horizontal grid and Crank-Nicolson scheme for implicit vertical grid are used. Turbulent closure is according to Smagorinsky [2] and Lilly [3]. Cloud microphysics is to predict mixing ratio of water vapor, cloud drop, rain drop, cloud ice, snow and graupel; The boundary layer, land surface process and ground temperature are treated as the same manner of Japan Spectral Model (Segami et al. [4]); lower boundary condition is rigid; upper boundary condition, Rayleigh friction layer; lateral boundary, Orlanski open.

For reproduction of rainfall distribution, the result of routine global circulation model of Japan Meteorological Agency (format is GRIB) is used as the initial and boundary condition. The result of routine global circulation model is called GANAL. The spatial resolution of GANAL is 1.25 degree, and the temporal resolution of GANAL is six hours. By using GANAL, the 2.5km horizontal mesh grid CReSS is calculated. After the calculation, the 2.5km mesh grid atmospheric variables of every one hour is obtained.

TRMM, Tropical Rainfall Measuring Mission, is a satellite for obtaining the rainfall data [5]. PR, Precipitation

Radar, is a sensor that is launched on TRMM. The data called 2a25 of PR is used for evaluating the rainfall distribution. Spatial resolution of 2a25 is 4.25km horizontally, 250m vertically. However, temporal resolution is so course that TRMM takes a snap shot of twice a day.

Therefore, we have to make a fine resolution rainfall distribution. Moreover, we have to slough off the grid basis rainfall evaluation because the basin is more important than grid. Finally, the numerical simulation must have error. We are planning to understand the statistical structure of rainfall distribution by using long-term rainfall distribution. The statistical structure of rainfall distribution is thought to be useful for making fine resolution rainfall distribution from one of course resolution.

3. Using Earth Simulator

By using the earth simulator, calculation for lower part of the Mekong river basin which requires 2,048 (5,120km) times 640 (1,600km) times 64 (18,991m) grids for x (west to east), y (south to north) and z (vertical) axis respectively. The huge area could not be solved by using the other computer than the earth simulator. Firstly, we tried to calculate the total area of the Mekong river basin. However, the area contains the Tibetan plateau and the Himalaya Mountains. Therefore, the program did not run well because of the very steep slope. Moreover, the time consuming of the calculation for lower part of the Mekong river basin was 1,240 CPU hours for time integration for three days. It means that we could calculate only 4.5 days when the area was four times horizontally larger by using 124 CPU times 10 hour limited calculation and total calculation was approximately 13 days for 3,010 CPU hours.

The most inconvenient situation was made by our mistake for writing the name of directory in NQS scripts. The earth simulator inform us that the program did not run because of wrong setting after one week. However, a NQS script checker prevented us from visiting the Earth Simulator Center for rerun the same program.

The other problem for us who made huge size of data was downloading the data. The transportation rate from "moon2" to client personal computer was about 2Mbps to 0.2Mbps. When we tried to send the 100GB data, it took 50,000sec (more than 5days) to download. We solve to use many ftp protocols in one client PC. When we use 10 ftp protocols we can download it within a day.

Unfortunately, the analysis of the data was not completed yet. However, it was enable to show the result by using GrADS in our lab. Figure 1 shows the result of wind field on Jun 27, 1983 03:00 UTC. Moreover, Fig. 2 shows the strong rainfall which is more than 50 mm during 20 minutes on Jun 27, 1983 03:00 UTC. Therefore, the analysis will be done and the result will be shown in near future.

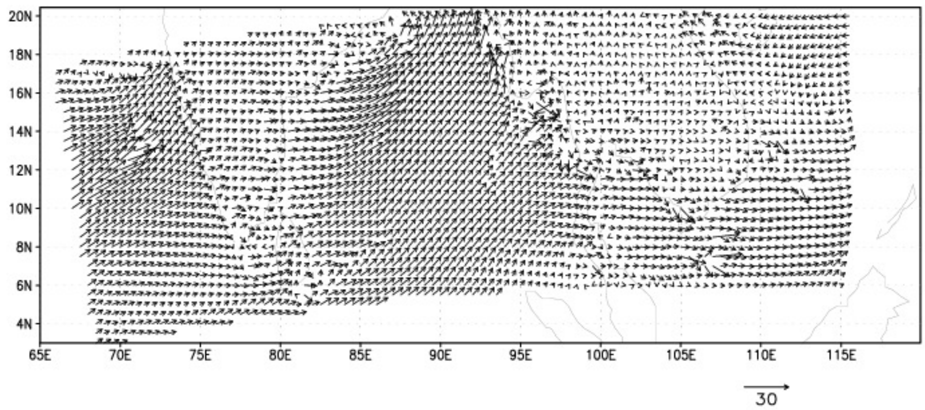

Fig. 1 Result of wind field on Jun 27, 1983 03:00 UTC.

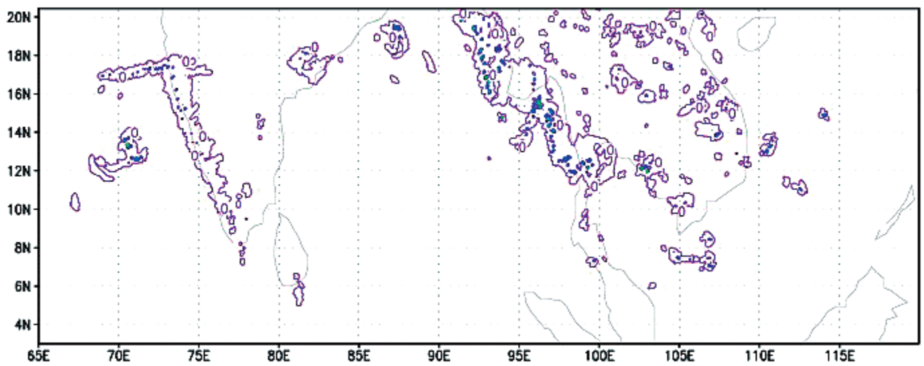

Fig. 2 Result of total rainfall amount during 20 minutes on Jun 27, 1983 03:00 UTC.

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Reference

[1] Tsuboki, K., A. Sakakibara and N. Kamiya (2000): Parallel Computing of High Resolution Cloud Model: Present Status and Future Plan, Proc. of the 2nd Int. Workshop on Next Generation Climate Models for Advanced High Performance Computing Facilities, 23–25 February 2000, Toulouse, France.

[2] Smagorinsky, J. 1963 General circulation experiments with the primitive equations: I. , The basic experiment. Mon. Wea. Rev. 91, pp.99–164.

[3] Lilly, D. K., 1962: On the numerical simulation of buoyant convection, Tellus, 14, pp.148–172.

[4] Segami, A., K. Kurihara, H. Nakamura, M. Ueno, I. Takano and Y. Tatsumi, 1989: Operational MesoScale Weather Prediction with Japan Spectral Model, J. Meteor. Soc. Japan, 67, 907–924.

[5] JAXA EORC: http://www.eorc.jaxa.jp/TRMM/gpm/

[6] Oishi, S., K. Kitani, E. Nakakita and S. Ikebuchi: Study on the effect of updraft to precipitation processes using Two-Dimensional cumulus mode, Annual Journal of Hydraulic Engineering, pp.255–260, 1995.

メコン川における降雨の詳細な分布の再現に関する研究

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雲解像豪雨シミュレータ(CReSS)を用いて、メコン川下流の降雨の詳細な空間分布を計算した。計算された全雨量は実際に雨量計で測定される全雨量とよく一致したとはいえなかった。また、地球シミュレータ使用上の問題もいくつか生じた。そこで、本研究では、CReSSの簡単な解説とともに地球シミュレータ使用上の問題点の克服方法と流域に注目した降雨データの比較方法について述べる。

キーワード: 数値気象予報, メコン川, 洪水, CReSS

メコン川は「命の源」である。中国の源流から4,000km～4,500kmも流れベトナムに注ぎ、その流域面積は800,000km^{2}に達し、日本の全面積の2倍強である。また、流域のほとんどは熱帯または亜熱帯モンスーン帯に属し、毎年1000mmから4000mmの降雨量があり、その水は下流の3百万haの水田を養っている。しかし、メコン川流域では洪水が頻発している。そこで、本研究では雲解像豪雨シミュレータ(CReSS)を用いてメコン川下流の降雨の詳細な空間分布を計算した。

本研究ではCReSSをもちいて東西2,048グリッド(5,120km)、南北640グリッド(1,600km)、鉛直64グリッド(18,991m)の領域で計算を行った。初期・境界条件には気象庁の全球客観解析(GANAL)を用い、音波の問題はHE-VI方式で解いた。この計算領域で4.5日を1,240CPU時間(10時間 × 124CPU)を要して解いたので、割り当てられた3,010CPU時間では理論的にも13日分、実際には8日分程度の計算が行えただけであったが、メコン川下流域を一気に計算することは今までにも行われていなかったので、その計算結果はきわめて興味深いものであった。

実際には現在解析中であるが、計算結果は研究室のPCを使って表示可能であり、今後の詳細な解析が待たれるところである。