Advanced Prediction System and Counter Measures of Regional- and Meso-scale Water Cycle

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The spatial and temporal distribution of rainfall variability is crucial in determining the socioeconomic conditions in the arid regions of the world. A reliable prediction of the rainfall variability is thus an important component of a disaster mitigation system. In addition, analysis of the underlying processes of such natural variability in the regional hydrological cycle provides clues to understand the mechanism of the desertification. In the present study, we discuss the region called "Asir" in the southwestern part of the Kingdom of Saudi Arabia to understand the influence of soil and vegetation on the rainfall variability. The Asir region enjoys a relatively good seasonal rainfall in spring and summer. Some stations at the higher altitude near the Red Sea coast record the country's highest rainfall. For example, three stations, Al-Amir, Abha and Beljurshi, have annual rainfall of more than 360 mm with relative humidity of more than 80%.

The southern part of the study region exhibits higher amount of interannual variability, most of which is confined in the first half of a year. The tropical climate variability from the Indian and Pacific Oceans, *viz.* the Indian Ocean Dipole and the El Niño-Southern Oscillation, dominantly influence the rainfall patterns through the atmospheric teleconnections. Besides, the changes in the Mediterranean Sea and the variability originating from the extra-tropical regions are found to influence the rainfall anomalies of the region.

We are now undertaking numerical simulations of rainfall and meteorology using a regional atmospheric model (RAMS) and NCEP data in 2000, under three kinds of soil and vegetation conditions; the first one is the validation simulation with the present "desert" condition, the second and the third are for "low grass" and "short tree" conditions respectively in a control area of 5625 square kilometers.

Together with this regional modeling effort, we will include in our study a range of ocean and atmosphere models with regional to global extent. The synergic effort will provide us a better basis for understanding as well as predicting the climate variability in the study region. The knowledge gained from the study will be helpful in designing a new system for ameliorating socioeconomic as well as agricultural conditions in semi-arid and arid regions.

Keywords: Water cycle, rainfall, meteorological model, parallel computing, desert, Asia monsoon

Report

The preliminary calculated results indicate that there is a possibility to enhance a rainfall in this area by 20% when vegetation category change from desert to short grass, as shown in Fig. 1.

The "Earth Simulator" provides us a scope to resolve complicated terrains and complex surface conditions in supper-high resolution (1km x 1km), using our original parallel computing scheme called "Time Splitting" method. The TS method divides a total simulation period into a combination of the same number of simulation tasks as the number of CPU clusters, and performs each task of a fine grid independently with initial and boundary conditions supplied from a large grid simulation of the conventional nesting scheme, as shown in Fig. 2. The computational speed of TS method is linearly proportional with the number of CPU clusters, as shown in Fig. 3. It was found that the calculated results by the Time Splitting method agreed well with the surface observed meteorological data and the conventional parallel computing scheme of domain decomposition method, as shown in Fig. 4.

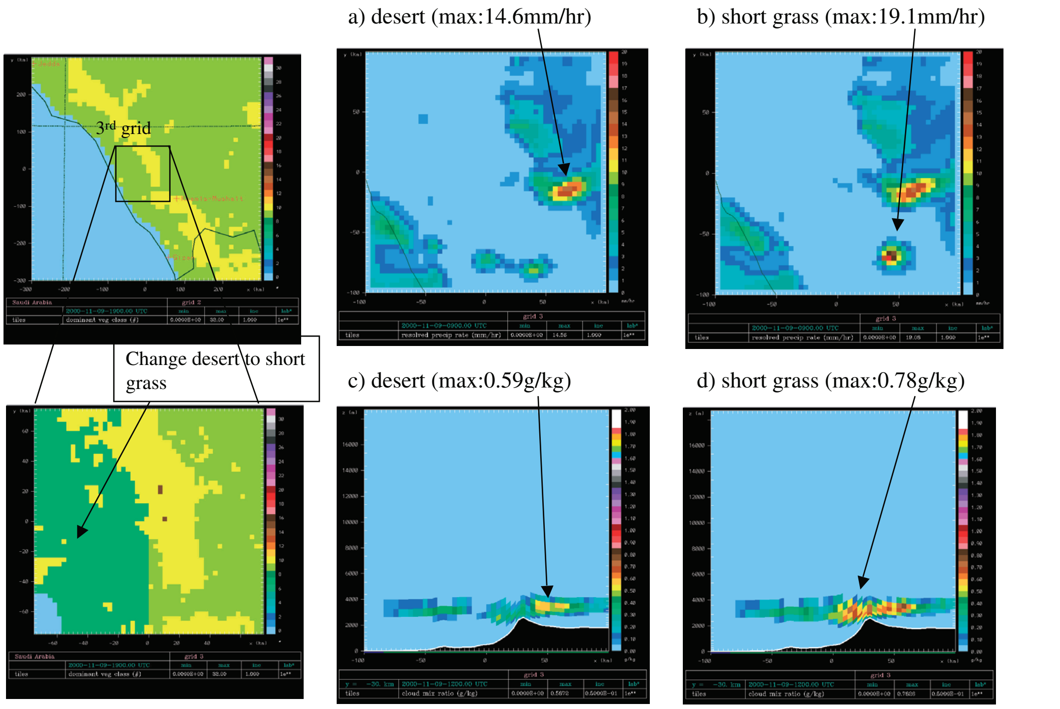

Fig. 1 a) and b): Horizontal distribution of rain fall, and c) and d): vertical distribution of cloud mixing ratio, calculated by RAMS

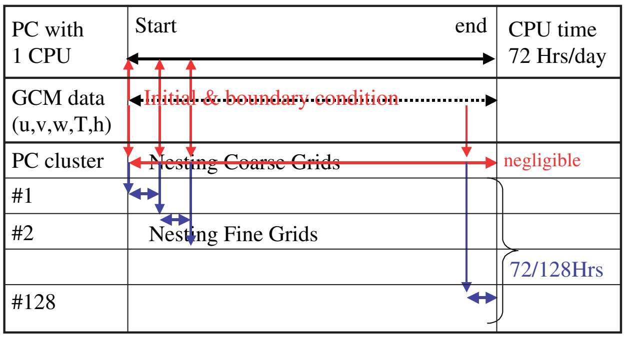

Fig. 2 High-speed parallel computing scheme by using PC-cluster of multi CPUs (Time Splitting method)

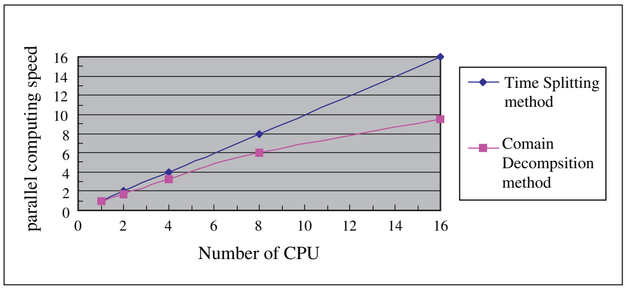

Fig. 3 Performance of Time Splitting and Domain Decomposition methods

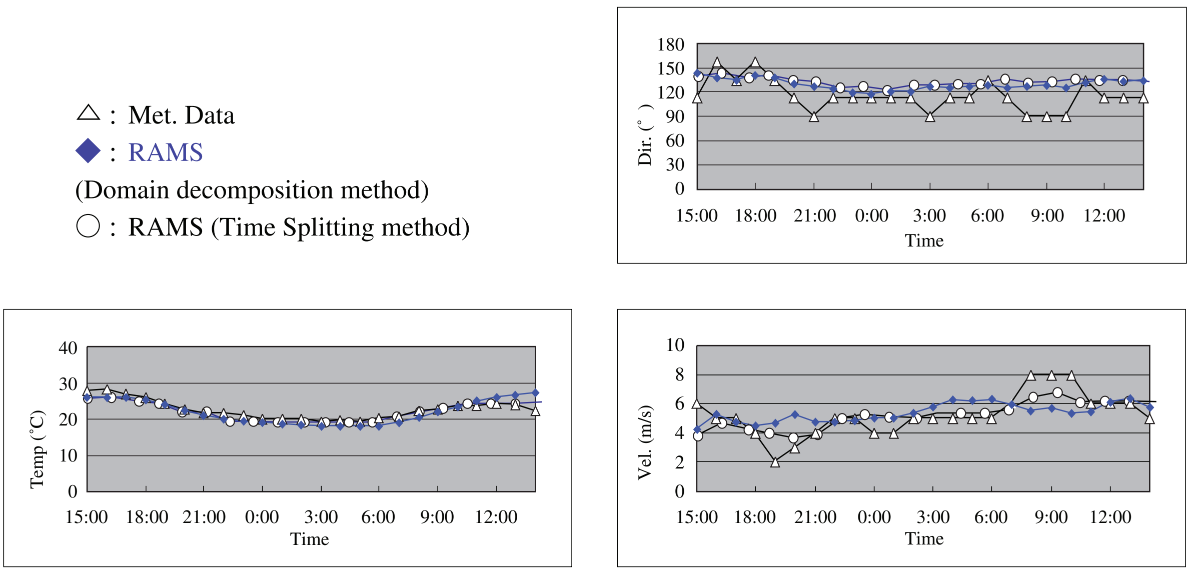

Fig. 4 Comparison of Time Splitting method with meteorological data

広域水循環予測および対策技術の高度化

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世界の乾燥地域における社会経済学的条件を決定する上で、降雨量の空間および時間的分布は、非常に重要である。従って、降雨量変化の信頼できる予測は、砂漠環境改善の重要な要素である。加えて、領域規模の水循環における自然変動プロセスの解析は、砂漠化メカニズムを理解するための手がかりとなる。本研究では、地質と植生の変化が降雨量に及ぼす影響を理解するために、サウジアラビアの南西部にある「Asir」という領域を研究対象とする。Asir地域は、春と夏にある程度の降雨がある。紅海沿岸の高山地帯にある観測局では、サウジアラビアの最高雨量を記録している。たとえば、Al-Amir,AbhaおよびBeljyurshi観測局は、80%以上の相対湿度と360mm以上の降雨量を記録している。

我々は、現在、領域大気モデル（RAMS）と2000年のNCEPデータを用いて、3種類の地質・植生条件で、降雨と気象の数値計算を実施している。第一の条件は、現在の地質条件である砂漠であり、2番目と3番目の条件は、低い草地と低い樹木である。これらの条件変更面積は、5,625平方kmである。

キーワード：水循環、降雨、気象モデル、並列計算、砂漠、アジアモンスーン