Refinement of prediction system of global water cycle

Project Representative

Hiromasa Ueda Kyoto University

Authors

R. Ohba *1, T. Hara *1, T. Adachi *1, R. Hutjes *2, T. Maat *2, B. Bisselink *2,
T. Matsuura *3, M. Fujita *3 and S. Iizuka *3

*1 Mitsubishi Heavy Industries

*2 Alterra Research Center, Wageningen UR

*3 National Research Institute for Earth Science and Disaster Prevention

This study conducted the following two simulations to investigate and predict a mesoscale water cycle in Asia-monsoon area, considering the global climate change.

(1) Simulation by mesoscale model of water cycle (West Asia)

Improvement and validation study were conducted for meso and local scale water cycles. Using this improved model, the candidate site for greening in Arabian Peninsula was selected, and effect of rain enhancement by greening was investigated.

(2) Simulation by integrated global circulation model of atmosphere and ocean (East Asia)

We performed a deforestation scenario experiment changing to the cropland from the tropical forest for Southeast Asia by a high resolution CGCM (T213) that includes the SiB land-surface scheme (Sellers et al., 1986). In this paper, we report the effects of a vegetation change on the local seasonal climate of Indochina Peninsula through comparing between the control simulation and the deforestation simulation.

Keywords: RAMS, mesoscale, GCM, vegetation, Asia-monsoon

Scientific Achievements:

1. Simulation by mesoscale model of water cycle (West Asia)

On 16 March 2000, in the satellite image (INDOEX) a curved-shaped cloud system occured over the Arabian Sea (circle). A curve-shaped rainband is also found in the RAMS map. In the TRMM maps, small cells with rainfall were lined up in the middle of the curved-shaped cloud. (Fig. 1)

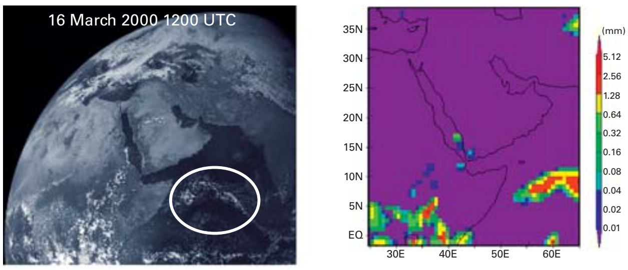

Fig. 1 INDOEX visible satellite picture compared with RAMS rainfall simulations (mm) for the same time

(1) Original run

The modeled results of wind speed are not in good agreement with observations, except for Abha. In Gizan even a negative correlation is observed. (Fig. 2) In general, the correlations for temperature demonstrated that modeled results are in good agreement with observations. However, large departures, either above or below this line, highlight discrepancies in the realism of the RAMS (original parameterization) - ECMWF relationships.

(2) Improved run

In the original run with original parameterization, the performances of the RAMS model failed in some cases. We improved the parameterization of RAMS model from original one, as follows.

a) Different interpolation scheme for topography: RAMS uses 4 different ways of interpolating topography. In the improved model topography has been interpolated using the 'conventional mean'-method.

b) A new cloud microphysic is parameterizised: The shape parameter of the gamma distribution is changed to a higher value, which means that the cloud spectrum is much narrower.

c) Nudging model with ECMWF data on all 3 grids: The nudging of the ECMWF input file in the underlying grids fails after 6 hours simulation. To make sure the ECMWF input file is available in the underlying grids the model is nudge with ECMWF data on all 3 grids.

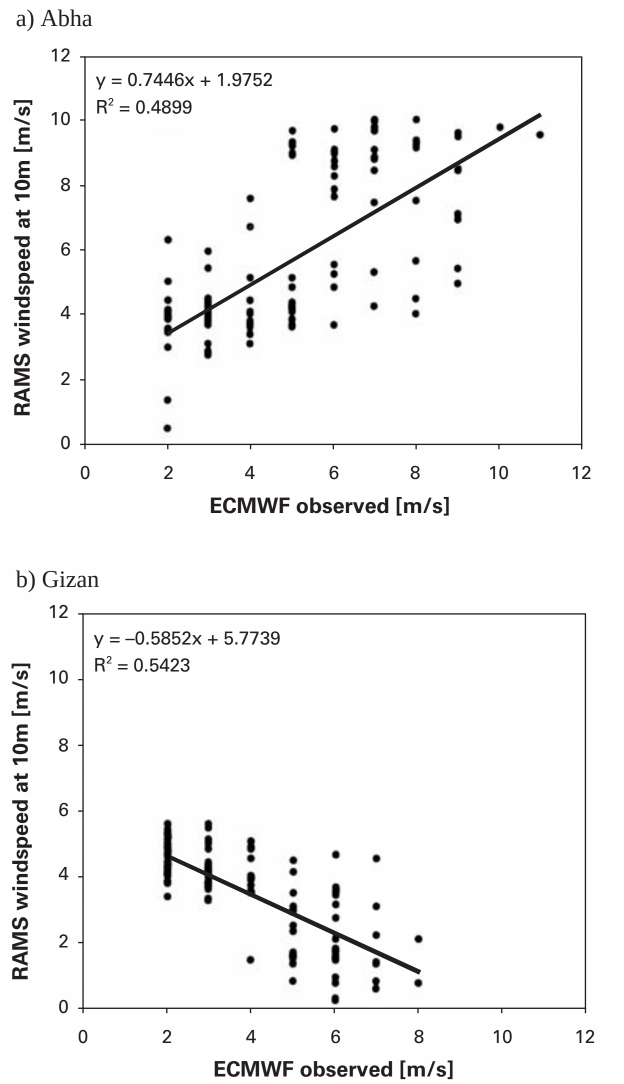

Fig. 2 Correlation of observed data and modeled one for wind speed at 10 m for (a) Abha and (b) Gizan from 21 February 2000 to 30 March 2000.

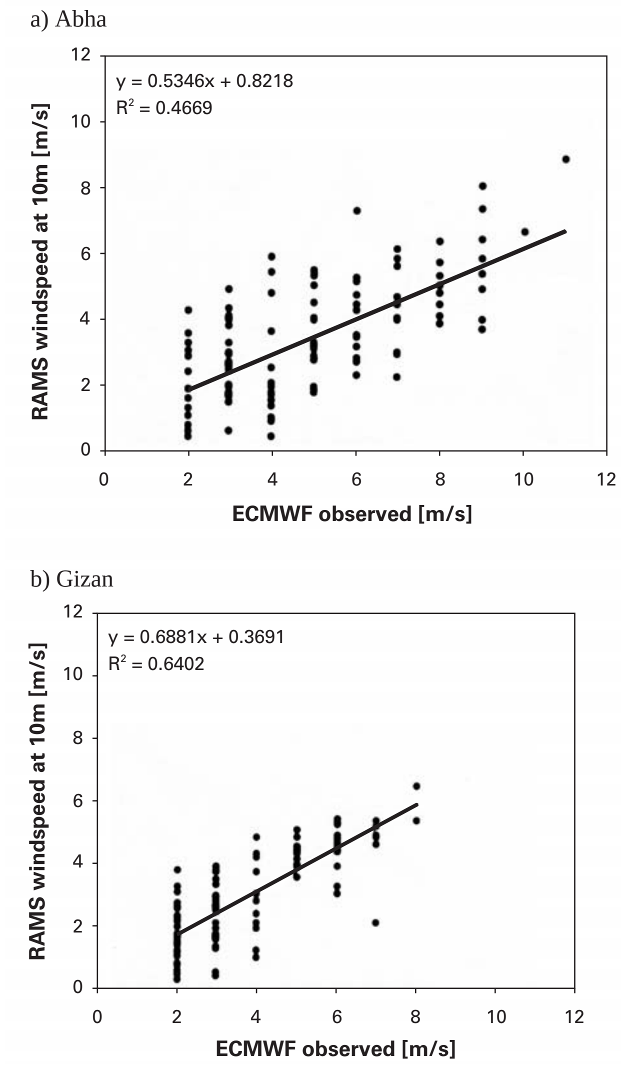

Fig. 3 Correlation of observed data and improved model one for wind speed

As a results of these improvements, the temperature and the wind results shows better agreement with the observations, than original one, as shown in Fig. 3.

2. Simulation by integrated global circulation model of atmosphere and ocean (East Asia)

The simulated impacts of tropical deforestation on the local climate system will be examined for Southeast Asia. In the SiB land surface scheme of CGCM, the forest region in Southeast Asia (8°N- 30°N, 87.5°E- 109°E) is replaced by winter wheat and broadleaf-deciduous trees as shown in Fig. 4 (within red square regions).

The CGCM was used to carry out two simulation cases: the current surface cover simulation (Case I) and the deforestation scenario simulation (Case II). The deforestation change means physically to increase albedo, to reduce roughness length, and to reduce soil moisture- holding capacity. Under these conditions, we show the difference in atmospheric temperature at 2 m (T2M), sea-level pressure (SLP), precipitation (RAIN), and surface winds at 10 m (WIND) between Case I and Case II in the rainy season and in the dry season.

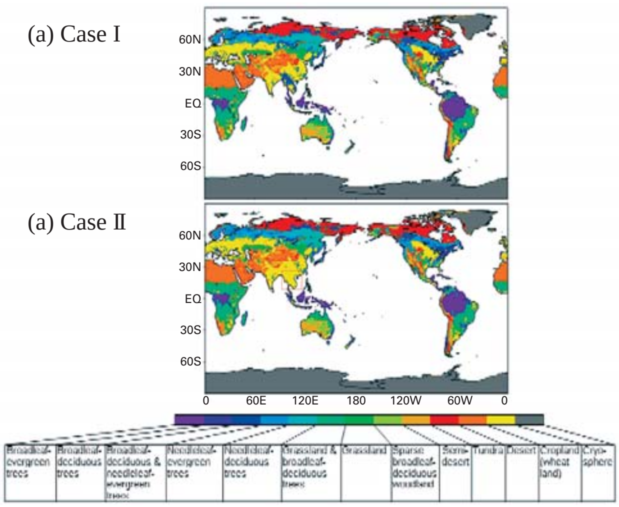

Fig. 4 Vegetation type of SiB land-surface scheme.
(a) Control run (Case I) and (b) deforestation scenario run (Case II).

The difference values of atmospheric temperature at 2 m

(T2M), sea-level pressure (SLP) between in March and in September are shown in Figs. 5a and b. In the representative dry season (March), the minus values of 3°C to 6°C, which are the difference in T2M between the current surface cover simulation (Case I) and the deforestation scenario simulation (Case II), appear over the area from 18°N to 24°N (Fig. 5a) in the Southeast Asia. Simultaneously, the difference in SLP increases by between 1.5 hPa to 3.5 hPa. The difference values of T2M over the current cropland are small by between -1.0°C and -2.0°C.

In the representative rainy season (September), the difference values of T2M increase by between 3°C and 8°C corresponding to the replaced place of the vegetation type. For RAIN, there is not so much difference between Case I and Case II during the dry season. During the rainy season, however, the rainfall increases at eastern side of Indochina Peninsula and decreases at western side (cf. Fig. 5c and d). We select two local areas: area A (97.5°- 105.0°E, 8.0-18.0°N) and area B (105.0°- 109.0°E, 8.0°- 18.0°N), to analyze more in detail.

The Chao Phraya river basin is included in area A and its current vegetations are almost cropland, that is, no deforested area (cf. Fig. 4). The variations of T2M in Case II are amplified rather than in Case I (Fig. 6a). Since the negative values of T2M in the dry season are canceled by the positive values in the rainy season, however, the mean values of two cases for 30 years differ only 0.3°C: 25.2°C for Case I and 25.5°C for Case II (Fig. 6a). For RAIN, there is almost no difference between Case I and Case II in the dry season and it decreases for Case II in the rainy season (Figs. 6c and d). This is because the summer monsoon winds strengthen over the land in the rainy season (see Fig. 5d). Then, the evapotranspiration increases and the precipitation decreases.

There exists the Annamitic Cordillera in the eastern side of the Indochina peninsula and then the topography is very different from the western side. The current vegetations in area B are broadleaf- evergreen trees, broadleaf-deciduous trees, and needleleaf-evergreen trees etc. The vegetation type is also very different between Case I and Case II. For T2M, there is negative difference in the dry season and there is positive difference in the rainy season (Fig. 6b). The 30-year mean of T2M for Case II is higher by 0.7°C than that for Case I. The amount of rain fall is more for Case II than for Case I, particularly in the rainy season. The summer monsoon winds including more moisture for Case II hit the Annamitic Cordillera and then there are heavy rains (cf. fig. 5d and Fig. 6d).

The deforestation in Southeast Asia shows that the surface atmosphere over the Indochina Peninsula is cooled in winter and is warmed in summer. As a result, the difference in surface temperature between the land and the sea is amplified, that is, both the north-east monsoon in winter and the south-east monsoon strengthen. The rainfall over the Chao Phraya river basin reduces due to the deforestation.

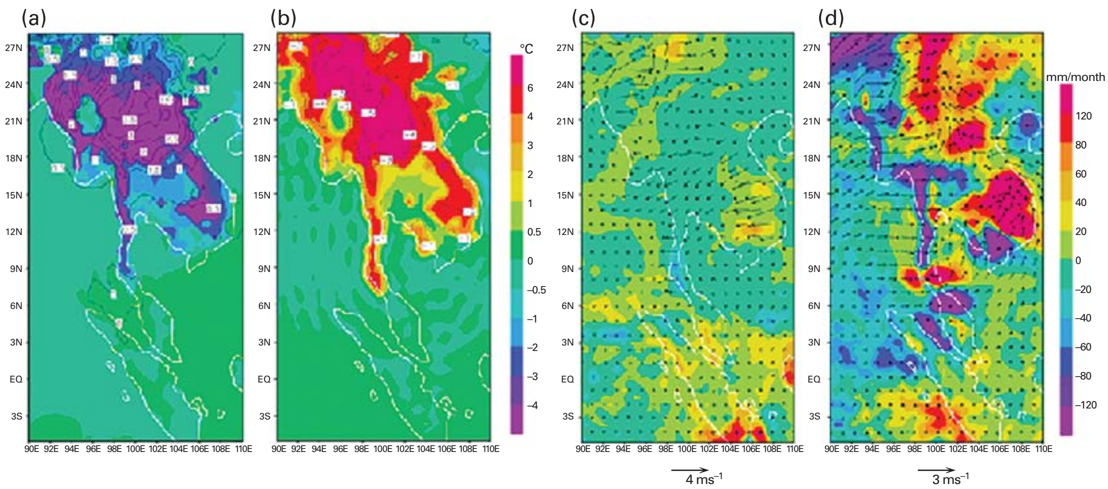

Fig. 5 Difference of model climate surface temperature at 2 m (T2M) and sea level pressure (SLP), and precipitation (RAIN) and surface wind vectors at 10 m (WIND) between case I and Case II. Contour interval is 1 hPa.
(a) T2M and SLP in March, (b) the same as (a) but in September, (c) RAIN and WIND in March, and (d) the same as (c) but in September

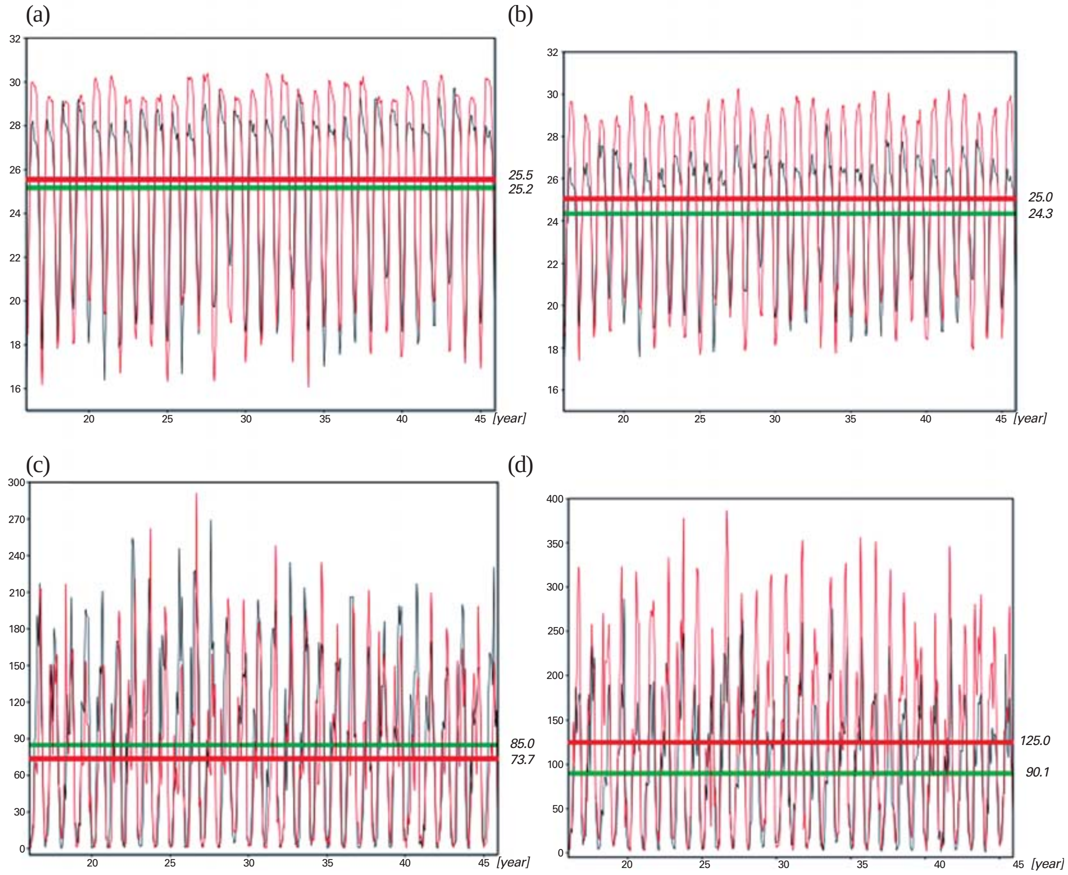

Fig. 6 Time series of surface temperature at 2 m and precipitation for Case I (black line) and Case II (red line) and thick solid lines are average of all of the 30 years for Case I (green line) and Case II (red line).
(a) T2M for area A (97.5°- 105.0°E, 8.0- 18.0°N).
(b) The same as (a) but for area B (105.0°- 109.0E, 8.0°- 18.0°N).
(c) RAIN for area A.
(d) The same as (c) but for area B.

広域水循環予測システムの高度化

プロジェクト責任者
植田　洋匡　　京都大学

著者
大場　良二[*1]，原　　智宏[*1]，足立　武司[*1]，R. Hutjes[*2]，T. Maat[*2]，B. Bisselink[*2]，
松浦　知徳[*3]，藤田　貢崇[*3]，飯塚　　聡[*3]
＊1　三菱重工
＊2　Alterra Research Center, Wageningen UR（オランダ）
＊3　防災科学技術研究所

本研究は、文部科学省の共生PJ課題5として、全球的気候変動を考慮したアジアモンスーン地域の領域規模水循環の解明および予測のため、次のモデル実験を行った。
(1) 領域規模水循環モデルによる実験（西アジア）
15年度研究に引き続き、領域／局所水循環モデルの構築と検証を進めた。この改良モデルを用いて、アラビア半島について緑化システム位置候補地の選定を行い、緑化に伴う気候、水文変化、特に降水量増加特性を調査した。
(2) 大気・海洋大循環統合モデルによる実験（東アジア）
15年度に統合化を図った各種予測モデル（高解像度大気海洋結合モデル、広域水収支モデル等）を用いて、植生変化に対する長期計算、中国長江流域の自然変動及び土地利用変化に伴う水災害の変化について予測計算を行った。

キーワード：RAMS，メソスケール，GCM，植生，アジアモンスーン