Refinement of Prediction System of Global Water Cycle

Project Representative

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We conducted the following simulation to investigate a regional water cycle in Asia- monsoon area, considering the global climate variance ([1] Arun, 2005).

We performed the simulation using mesoscale model (RAMS, The Regional Atmospheric Modeling System) to investigate a 'greening' effect on atmospheric moisture.

Keywords: RAMS, mesoscale, desert, rainfall, greening

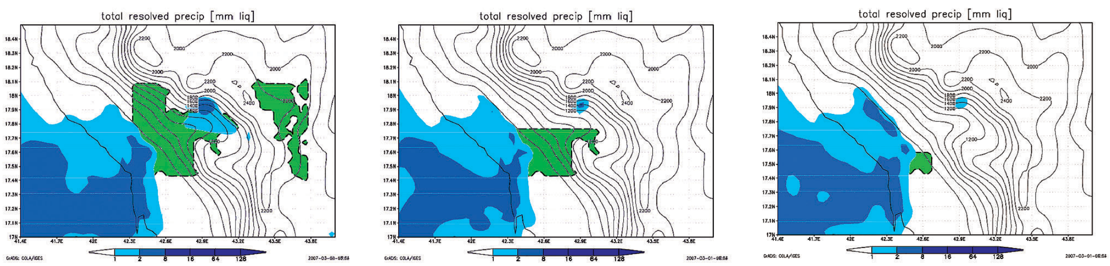
1. Introduction

In this study, the target area of greening was the desert in the southwest coastal region of Saudi Arabia. Fog and cloud were observed sometimes near mountain top in this region. We assumed that some shrubs and irrigation were in the greening area. The leaf area index (LAI) of the shrub is 5.1 m/m and the vegetation cover fraction is 63%. We took 3 runs by the difference of the 'greening' area.

2. Result

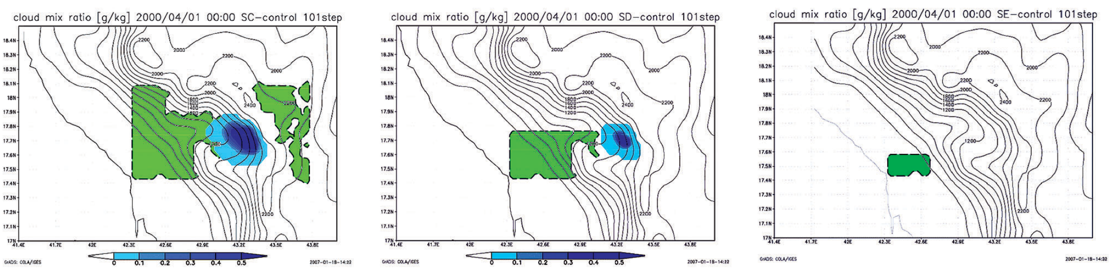
Monthly accumulated rainfall is shown in Fig.1. Although there is no rainfall on the greening region, several rainfalls are present in the mountain region. Hourly cloud water calculated is shown in Fig. 2, in the same way as rainfall. There is more than 10 g/kg cloud water near greening region in the Case1.

At 1200UTC 26 April, when sea breeze strongly blows, the



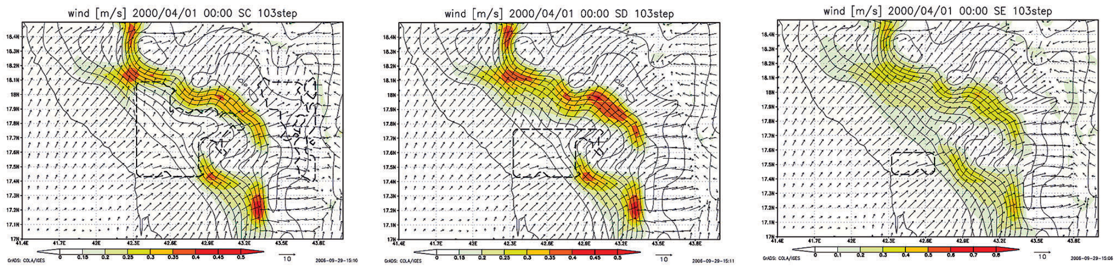
Case 1   Case 2   Case 3

Fig. 1 Monthly accumulated rainfall (mm) (Apr 2000)
(shade: cloud water, contour: elevation, dotted line: greening region
Case1 (150*75km), Case2 (75*37.5km), Case3 (37.5*18.8km))



Case 1   Case 2   Case 3

Fig. 2 Fog (ground level cloud water) (g/kg) at 0000UTC 26 Apr 2000
(shade: cloud water, contour: elevation, dotted line: greening region)



Case 1 Case 2 Case 3

Fig. 3 Vertical and horizontal wind velocity (m/s) at 1200UTC 26 Apr 2000 (48m AGL)
(vector: horizontal, shade: vertical, contour: elevation, dotted line: greening region)

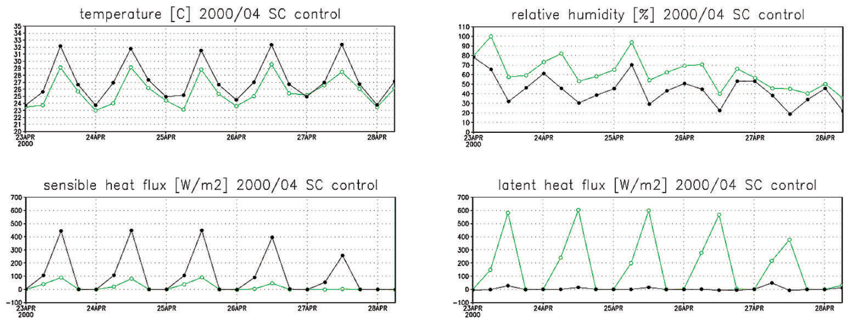


Fig. 4 Time series of temperature, relative humidity, sensible heat flux and latent heat flux
from 0000UTC 26 Apr to 0600UTC 28 Apr in greening (42.6E, 17.6N)
(black line: control run, green line: green run)

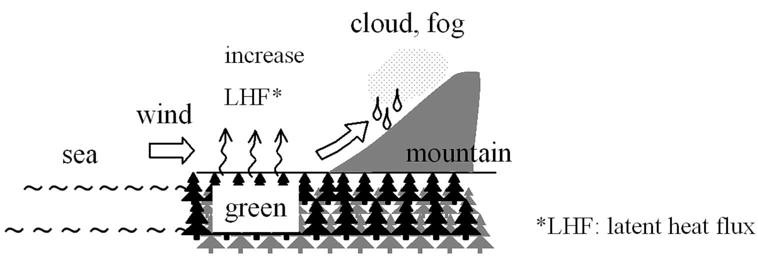


Fig. 5 Cloud development process by greening.

westerly wind blows to the slope of the mountain and vertical velocity is occurred due to orographic effects (Fig. 3).

That vertical velocity region shows the same pattern as the rainfall and cloud water distribution. Relative humidity increase 10 to 20% and temperature decrease 2 to 3 degrees are due to the increase of soil and atmospheric water component (Fig. 4.).

The sea breeze blows to the greening area with moisture. The latent heat flux is increased by that moisture. Then the rising of wet wind by the mountain slope generates the cloud and fog (Fig. 5.).

3. Conclusion

The modeling approach using mesoscale model (RAMS) was applied to the planning of 'greening' effect in desert region.

It was concluded as follows.

(a) The increase of atmospheric water component appeared not only rainfall but also cloud (fog). The 'greening' effect leads the increase of atmospheric moisture about 10 g/kg per hour.

(b) The latent heat energy increased in the 'greening' region.

(c) Because of the temperature decrease vertical convectional velocity was kept small in the 'greening' region, while the vertical convectional velocity increased in the mountain slope.

(d) The cloud was developed by wet sea breeze blowing to the mountain slope.

It needs more examination how to increase the atmospheric moisture effectively. The key points are as follows.

(1) Effective composition of small 'green' area (about 10–10 km)

It will be more effective to set mosaic-like 'greening' than uniform one, because of the thermal convection mechanism.

(2) Effective moisture supply to atmosphere.

The amount of moisture supplied by 'greening' have limit, thus other origins of moisture should be used. For example if we will be able to use a wet type cooling tower using sea water for the condensation of steam at thermal power station, we will increase the supply of the same amount of moisture as Case2.

(3) Long term change of environment by greening.

We simulated about 2 month to confirm the effect of greening. It is necessary to investigate the long term simulation (several years or decade) for continuous greening, considering the effect of climate variance.

Acknowledgments

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広域水循環予測システムの高度化

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本研究は、京都大学防災研究所、防災科学技術研究所を中心とした共生PJ課題5グループの水循環研究と地球フロンティアの全球気候モデル研究を連携させせることで、全球的な水循環に関するメカニズムとその変動の解明と、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、流域規模水循環の解明及び予測のため、次のモデル実験を行った。

・領域モデルによる実験

サウジアラビアの南西海岸部に位置する砂漠においては、領域モデル上で砂漠を緑化することにより、月数mm程度の降水量増加の可能性が示唆されている([1] H.W. Ter Maat他, 2006)。そのため、本研究では、同地域を対象に領域モデルによる計算を行い、緑化に伴う降雨促進メカニズムの解析を行った。その結果、緑化により大気中の水分は増加し、時間によっては1時間に10g/kg程度の霧水量が発生した。この大気中の水分増加は、緑化領域上で増加した水分が、海風によって山岳地帯まで運ばれ、山の斜面によって上昇することで発生することがわかった。

計算は、米国コロラド州立大学で開発されたRAMS (Regional Atmospheric Modeling System) を使用して、オランダWageningen大学で降雨モデルを改良し、三菱重工と共同で実施した。現在の領域気象モデルでは灌漑による蒸発量を組み込むことができないため、本研究では、灌漑と同量の降水を地面境界条件に与えている。本プロジェクトでは、再生可能エネルギーを利用した海水淡水化装置を利用して生活用水を確保し、この生活廃水を処理した灌漑水に利用する方法を検討している。

参考文献

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キーワード：RAMS, メソスケール, 砂漠, 降雨, 緑化