Effect of Irrigated Agriculture on Low-level Cloud in the Chukurova Plain, Turkey

Toshichika Iizumi[1], Toshihisa Fujiwara[1], Takehiro Yuyama[2], and Fujio Kimura[3]

[1] Graduate School of Life and Environmental Sciences, University of Tsukuba,

[2] Master's Program in Environmental Sciences, University of Tsukuba

[3] Terrestrial Environment Research Center, University of Tsukuba

1-1-1 Tennodai, Tsukuba, 305-8572, Japan

1. Introduction

Southern Turkey is dominated by the Mediterranean climate. Precipitation in summer is less 50 mm/month (Turkes, 1996). However, Chukurova Plain, which locates lower Seyhan River Basin, is often covered by low-level clouds even in dry summer season (Fig. 1).

The observed clouds are expected to be shallow cumulus clouds, and these clouds are sensitive to land surface condition in comparison with high-level clouds. In Chukurova Plain, current water consumption for agricultural irrigation reaches to 440 million m^3 during August (Nagano and Donma, 2004). Since total irrigated croplands is 90 thousands ha (Kameysma, 2004), the irrigation water fed to a unit square cropland can be estimated to 489.8 mm/month (= 15.8 mm/day). This amount of irrigated water is comparable to 70% of the annual precipitation in this area. Considering such background, the clouds may be affected by the large-scaled and intensive irrigation. Thus, this study aims to reveal the effect of irrigated agriculture on the clouds by using a Regional Climate Model (RCM).

2. Data and methods

2.1. Satellite image data

The satellite images are used to validate the reproductivity of the RCM as an observational data. The Moderate Resolution Imaging spectrometer (MODIS) data were obtained from the MODIS Rapid Response System (NASA/GSFC, 2006). Adapted data is the near-real-time true-color products in the archive of the "AERONET_IMS-METU_ERDEMLI" Subset. The subset covers southern Turkey with a 250m spatial resolution. The satellites of Terra and Aqua observed Chukurova Plain once a day; the Terra observes in a morning, mostly at 1000 Local Standard Time (LST) to 1200 LST; the Aqua observes in an early afternoon, mostly at 1200 LST to 1430 LST.

2.2. Numerical experiments

A RCM (TERC-RAMS) was adapted to reproduce the clouds and to simulate the effect of irrigated agriculture. The TERC-RAMS is a version of the Regional Atmospheric Modeling System modified by the Terrestrial Environmental Research Center, University of Tsukuba (Sato and Kimura, 2005). The RCM has a two-way nested grid system; the outer domain covers Turkey with a grid interval of 16 km; the middle one covers entire Chukurova Plain with a grid interval of 4 km; the innermost one covers western part of the plain with a grid interval of 1 km (Fig. 2). Every domain includes 46 layers in the terrain following vertical coordinate system. The lowest layer is located 90 m up from the screen height. The RCM used no convective parameterization in the innermost domain, thus the model works as a cloud resolution model.

Two sensitivity analysis was conducted; (1) the actual land-use ("CTL-run"), the land-use data was given by the 30 second grid land cover and land use data of the U.S. Geological Survey (USGS); (2) the spatially-uniform short grass ("UNI-run"). The soil types are silt roam in both runs.

The initial boundary conditions for the outer domain were fed by the global reanalysis data provided by the National Center for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) and monthly mean sea surface temperature (Reynolds et al., 2002). The integration period is 23 hours from 2100 LST in 6 August to 2000 LST in 7 August, 2004.

3. Results

3.1. Validation of the reproductivity in the RCM

The model simulates the spatial pattern of clouds comparatively well. At the snap shot of 1100 LST in the model, the simulated clouds along the east coast of the plain agree with those observed by the satellite (Fig. 3). The model also simulates the clouds in western plain fairly well; however, the simulated clouds are less than those in the satellite image. In addition, the model fails to simulate the haze, which distributed the entire plain. At 1200 LST in the model, the model simulates well the clouds distributed along the western coast.

The model also simulates the diurnal change of the clouds (no figure); the diurnal change is derived from the sea breeze, and the simulated change agrees well with the results of continuous photographic observation from the ground surface (Iizumi et al., 2005).

3.2. Effects of irrigation agriculture on low-level clouds

At 0900 LST in the model, the amount of simulated clouds in the CTL-run is significantly greater than that in the UNI-run (Fig. 4). The result in the CTL-run shows much clouds in western and eastern part of plain, and the area around the lake created by the dam. The spatial pattern of the clouds in the CTL-run agrees with that of irrigated cropland (no figure). Such tendency is consistently observed in before noon in the model; however, the difference between two runs becomes unclear in afternoon.

4. Discussion

As the mechanism of the low-level clouds enhancement, following factors are assumed to play important roles i.e., (1) the supply of water vapor from the irrigated croplands to the atmosphere through evapotranspiration; (2) the strong sensible heat flux from the ground surface derived from sufficient radiation. Since, the factors enhance the depth of the mixed layer and height of thermals, then, the clouds are formed at the top of the thermals. However, the result in UNI-run shows that the clouds in southern plain appear even in drier land surface condition. It suggests that the clouds in Chukurova Plain are formed by multiple mechanisms depending on the area.

5. Conclusion

The RCM simulates well the characteristics of the low-level clouds in spatial pattern and diurnal change. The spatial pattern of the clouds in before noon agrees with that of irrigated cropland. Thus, large-scaled and intensive irrigated agriculture is certainly one of factors to form the clouds. However, simulation results suggest that the clouds are formed by other mechanisms as well the irrigation depending on the area in the plain.

6. References

Iizumi, T., T. Fujiwara, and F. Kimura, 2005: Consecutive photographic observation of the low-level clouds covering over Chukurova Plain in summer, In: The Progress Report of ICCAP, 19-20.

Kameyama, H., 2004: The climate change impact on cropping pattern, In: The Interim Report of ICCAP, RIHN, Kyoto, 127-130.

Nagano, T., and S. Donma, 2004: Cropping pattern and water use in the Lower Seyhan irrigation Project, In: The Interim Report of ICCAP, RIHN, Kyoto, 93-96.

NASA/GSFC, 2006: MODIS Rapid Response System, In: http://rapidfire.sci.gsfc.nasa.gov.

Reynolds, R.W., N.A. Rayner, T.M. Smith, D.C. Stokes, and W. Wang, 2002: An improved in situ and satellite SST analysis for climate. *J. Climate*, 15, 1609-1625.

Sato, T., and F. Kimura, 2005: Diurnal cycle of convective instability around the central mountains in Japan during the warm season, *J. Atmos. Sci.*, 62, 1626-1636.

Turkes, M., 1996: Spatial and temporal analysis of annual rainfall variations in Turkey, *Int. J. Climatology*, 16**,** 1057-1076.

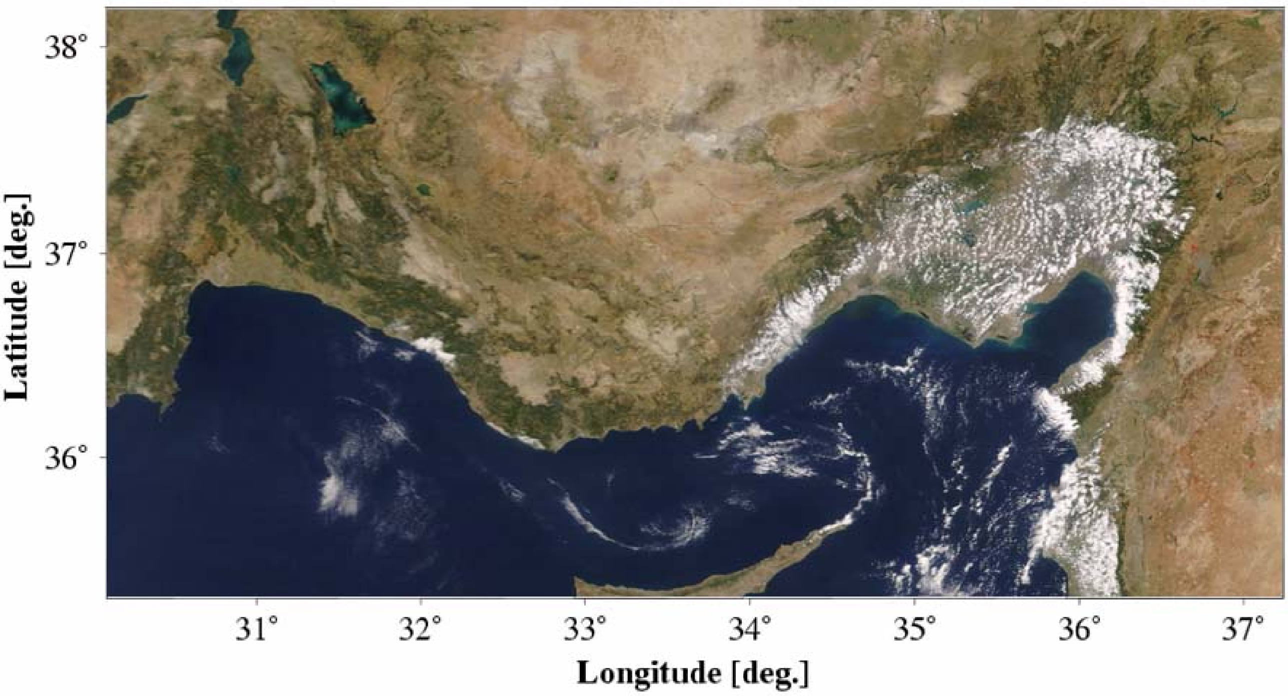

Fig. 1. Typical low-level clouds observed by the MODIS/Terra at 1008 LST (0808 UTC) on 01 July, 2005.

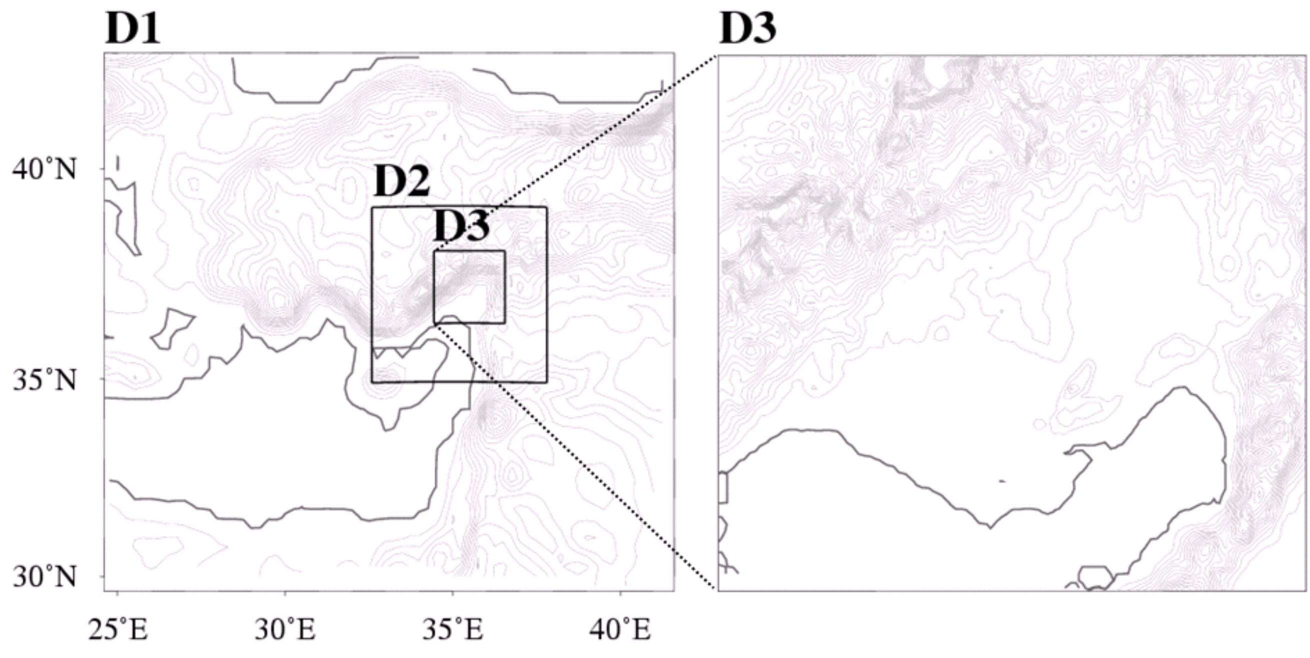

Fig. 2. RCM domains; the bold lines show elevation of 0 m in the RCM, while the thin lines show that of 100 m.

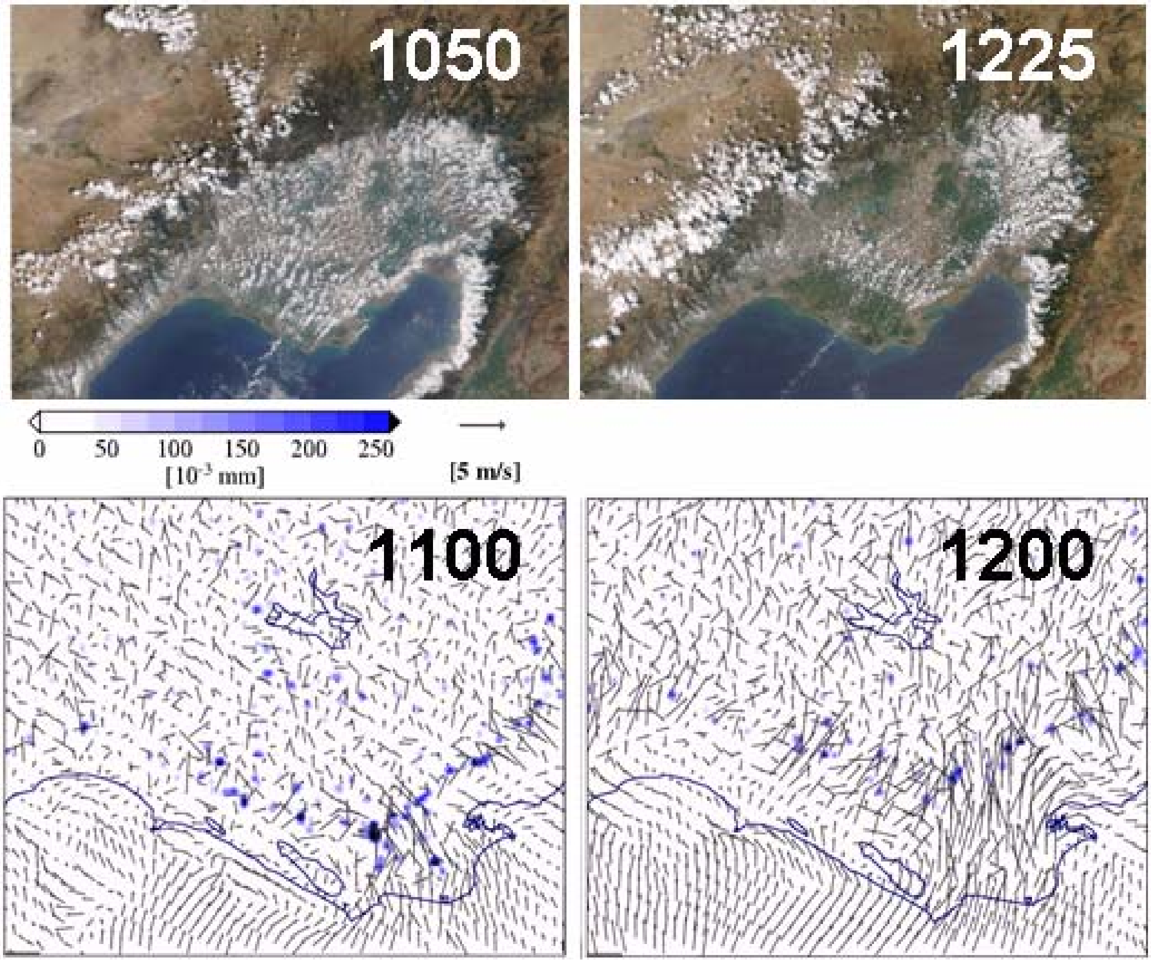

Fig. 3. Snap shots of clouds observed by the MODIS/Terra and Aqua at 1050 LST and 1225 LST on 07 August, 2004 (Top), and those of simulated clouds and wind systems at a height of 1100 m (bottom); The blue shades show the integrated cloud water amount (10^{-3} mm).

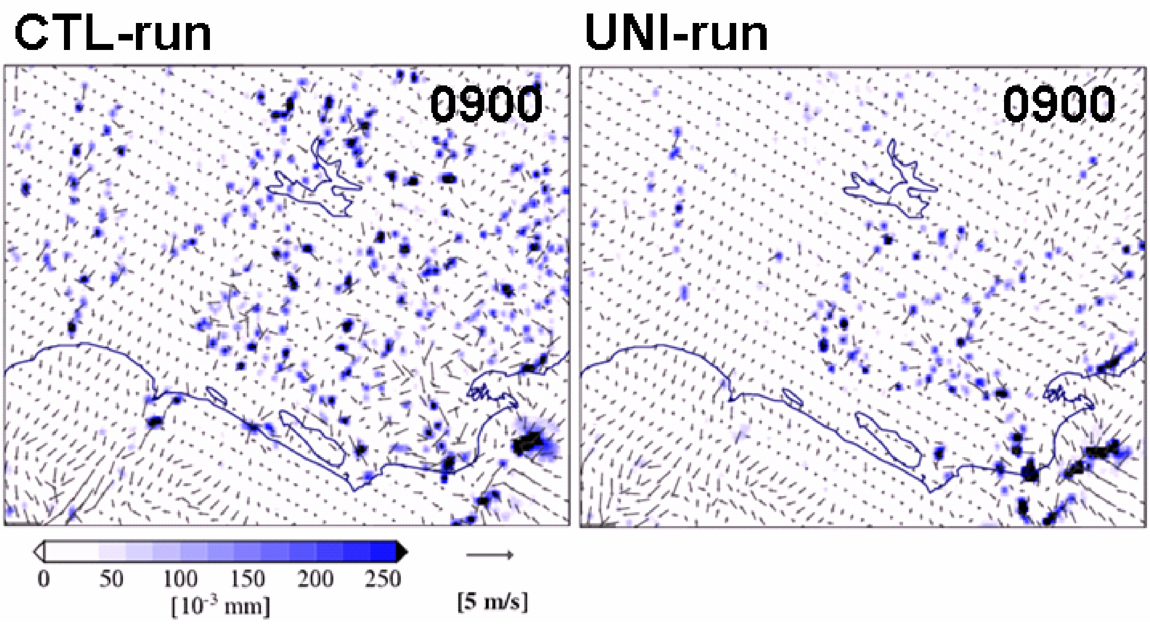

Fig. 4. Snap shots of simulated clouds and wind systems at height of 1100 m on 0900 LST in the CTL-run and UNI-run. The blue shades show the integrated cloud water amount (10^{-3} mm).