Effects of global warming on moisture and temperature profile of vadose zone in western Tokyo

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Introduction

The impact of global warming is widely known to be a threat to sustainability of crop productions and to preservation of biodiversity (IPCC,2007). Though the impact of global warming on transport phenomena in soils are significant issue for managing agriculture and ecosystem, researches focusing on the effects of global warming on heat and mass transport phenomena in vadose zone have rarely been performed yet comparing with researches focusing on phenomena of land surface, atmosphere and deep geological zone.

The objective of this study is to predict the impacts of global warming on the heat and water transport phenomena in vadose zone quantitatively. To achieve the purpose, numerical simulation has been conducted by using modified HYDRUS 1-D (Saito et al.,2006).

Materials and methods

Continuous monitoring has conducted at Field Science Production Center of the University of Tokyo (UT-FSPC) at western suburb of Tokyo under two surface cover, weed grass and bare for six months. Meteorological data was obtained from UT-FSPC and AMeDAS station located at Fuchu city, near the field.

Numerical simulation employed the governing equation considering liquid and vapor water movement in non-isothermal unsaturated soil. Heat transport took latent and sensible heat transport with liquid and vapor water movement into account. Boundary condition for water flow considered precipitation and evaporation. The model always satisfied energy balance equation to estimate heat and vapor flow across the soil surface.

Parameters for soil hydraulic function, van Genuchten-Mualem model, were determined by inverse analysis method with laboratory evaporation experiment. Chung and Horton (1987) model was used for soil thermal conductivity. Parameter of the equation was calibrated by laboratory experiment. To validate the model, simulated results first compared with field monitoring data including soil moisture, soil temperature, hourly solar radiation, and ground heat flux. Daily data was used for input boundary condition and hourly output data for validation. Then, simulation with future climate change scenario proposed by Japan Meteorological Agency (2005) was conducted.

Results and discussion

The simulation could describe the seasonal variation of soil moisture and soil temperature well and the calculated solar radiation agreed the observed hourly data. Predicted ground heat flux partly agreed with the monitored data. When soil water suction was between 100 and 300cmH_2O, latent heat flux fluctuated irregularly, and this led the mismatching of the monitored and predicted ground heat flux. However, disagreement of the ground heat flux was canceled immediately and the energy balance of a day was always almost zero.

With the assumption of temperature rise, predicted soil temperature of each depth showed two to twenty degrees of elevation. Related to the soil moisture, the rate of evaporation tended to be faster. In the prediction, it also overestimated latent heat flux as it had happened in the model validation.

Conclusion

We simulate the impacts of global warming on vadose zone as the problem of simultaneous heat and water movement in non-isothermal unsaturated porous medium. The response of 1 to4 degrees rise of air temperature caused 2 to 20 degrees rise of soil temperature. However, to improve the simulation, modification of latent heat flux model inclusion of soil water hydraulic function may be required.

References

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