Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

AHW07-01 Room:511 Time:April 29 09:00-09:15

Interannual variations and its control factors of evapotranspiration in a temperate Japanese cypress forest

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1.Introduction

Evapotranspiration from forests is a major factor affecting water yield and therefore water resources. Understanding the long-term impacts of variations of meteorological factors on variability of evapotranspiration is important, especially in the context of current and future climate change. Long-term continuous measurements of evapotranspiration using the eddy covariance method provide an opportunity to examine the response of forest ecosystem processes to climate change. We quantified the interannual variations of evapotranspiration, and examined its control factors using the multi layer model.

2.Material and methods

Observations were made in the Kiryu Experimental Watershed in the south of Shiga Prefecture, central Japan. The forest around the watershed comprises mainly 50-year-old Japanese cypress forest. A meteorological observation tower is located in the watershed. The fluxes of momentum, sensible heat, latent heat, and CO2 were measured using eddy covariance methods at a tower height of 28.5 m. Precipitation was observed at the open site.

We used the multi layer model to clarify the control factors of interannual variations of evapotranspiration. The model contained sub-models that calculated the gas exchange processes, including H2O and CO2 exchanges of leaves and the ground surface. This multi layer model simulates the above-canopy fluxes based on vertical profiles of meteorological factors. This model requires the above-canopy environmental variables as the input data. The parameters representing leaf gas exchange characteristics are determined by leaf gas exchange measurements. We used 7 years of eddy covariance data (from January 2001 to December 2007) in this study.

3.Results and discussion

Annual evapotranspiration for the seven years ranged between 715 (2001) and 780 mm (2004) with the average of 743 mm. Maximum interannual fluctuation in evapotranspiration was 75 mm.

Diurnal, seasonal, and interannual variations of evapotranspiration for the seven years were reproduced by a model simulation. This indicates that the model structure and parameterization are validated.

We calculated the components of evapotranspiration such as transpiration, evaporation, and soil evaporation. Each component shows interannual variations relating to meteorological factors. Wet years such as 2001 and 2002 had small annual evaporation and large annual transpiration. Dry years such as 2003 and 2006 had large annual evaporation and small annual transpiration. Both annual evaporation and transpiration were relatively large in 2004. Annual soil evaporation was slightly smaller than evaporation and transpiration. Interannual fluctuations in soil evaporation were also small compared with evaporation and transpiration.

We examined seasonal variations of evapotranspiration for the contrasting two years; 2004 and 2003 with maximum and minimum annual evapotranspiration simulated, respectively. The deviations of evapotranspiration for the two years were large in summer from June to August. Transpiration increased with vapor pressure deficit and solar radiation. Transpiration was relatively small in 2003, which had low vapor pressure deficit and solar radiation in the summer. Transpiration was relatively large in 2004, which had high vapor pressure deficit and solar radiation in the summer. Soil evaporation for the two years showed the similar seasonal variations with transpiration. Seasonal variations of evaporation were the similar to those of precipitation.

Each component of evapotranspiration showed different responses to the meteorological factors seasonally and annually. Interannual variations of evapotranspiration were almost explained by those of meteorological factors.

Keywords: Evapotranspiration, Interannual variation, Eddy covariance, Multi layer model, Japanese cypress forest