Overview of WECNoF/CREST project from 2003 to 2005

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Introduction

Boreal forests distribute between 40 ° – 70 ° N and occupy one-third of the global forest area (about 10 % of the surface of globe). This region agrees with the zone in which monthly mean air temperature is 13 – 18 ℃ in July. The forest structure is simple and the spices of trees are homogenous comparing with temperate and tropical forests. However, the meteorological conditions is widely distributed; annual mean air temperature is -10 to 5 ℃, and annual precipitation is ranged from 200 to 1000 mm.

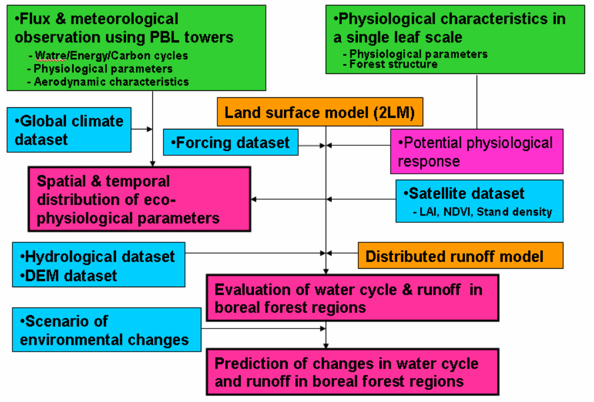

Figure 1 Goal and strategy of WECNoF/CREST

The effects of vegetations on water cycle has been investigated since the beginning of 1990s, however a lot of issues have not been well known yet because the history of researches is not long and the observation sites are sparse in this region.

The Water and Energy Cycles in Northern Forests (WECNoF) / Japan Science and Technology (JST) projects which has been started in November 2002 focuses on the effects of forests on water cycle systems in boreal areas. The observation sites are installed not only in a boreal zone but also in a border of boreal forest areas and a temperate forest in this project.

The goal and strategy of this project is shown in Figure 1. The *in situ* measurements are carried out both in a single leaf scale and a stand scale of typical forest type in each climate zone. The results obtained from these observations are reflected to a land surface model and a distributed runoff model. The current condition will be evaluated and the variation of water cycle in the boreal zone will be predicted using these two models.

The major results obtained from the first half of this project are briefly introduced in this report.

Site Description

There are four areas including five tower observation sites in this project. There are two sites (larch and pine) in Yakutsk, eastern Siberia of boreal forests, two sites (burch and mixed) in Moshiri, northern Japan of a southern border of boreal forests, and one site (mixed forest) in Seto, central Japan of a temperate forest. Only the observation and analysis in a single-leaf scale are carried out in Esso, Kamchatska. Single-leaf scale measurements were carried out in each site. Each forest is a typical forest type in each climate. Figure 2 shows the location of each site.

Figure 2 Observation sites of WECNoF/CREST

Major results

Differences of energy and water exchanges among the sites

The seasonal variations of the sensible and the latent heat fluxes were different from each other regions observed in the WECNoF/CREST project.. The sensible heat flux was about two times larger than the latent heat flux in the Yakutsk sites even in the plant growing season. On the other hand, the opposite was true in the Seto site. The sensible heat flux showed the maximal values at the end of March, and dropped after that. The latent heat flux simultaneously increased rapidly. The magnitude of the sensible and the latent heat fluxes during the mid growing season were about 100 and 300 W m-2, respectively. In the Moshiri sites, the magnitudes of the both fluxes were similar to each other through periods observed.

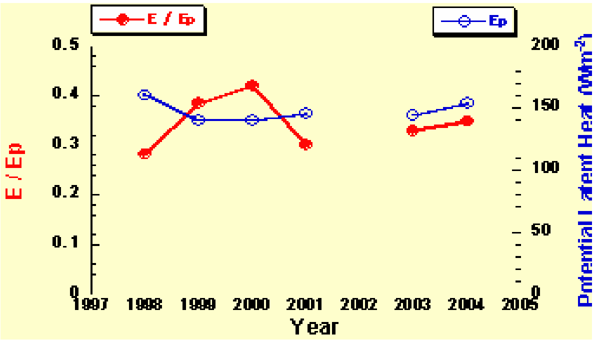

Figure 3. Inter-annual variation of the ratio of actural evapotranspiration (*E*) to the potential evapotranspiration (*Ep*) above the larch forest canopy in Yakutsk during June, July and August.

On the other hands, there was no significant difference of the energy exchanges between the sites of different forest types in the same region. These results imply that the response of forests on the water and energy cycles will be more strongly controlled by the meteorological conditions than by the forest types and/or the tree species.

Evapotranspiration was much smaller in the both Yakutsk sites. Figure 3 shows the inter-annual variation of the ratio of actual evapotranspiration (E) versus the potential evapotranspiration (*Ep*) of the larch site in Yakutsk during June, July and August. The values of E/Ep ranged from 0.28 to 0.44, and these ratios were very small comparing with that obtained in temperate and tropic forests, 0.7. This result shows that evapotranspiration was significantly controlled by land surface processes including the vegetation effects in the Yalkutsk sites. The land surface processes become more important for the water and energy exchanges in boreal forests.

A single-leaf scale measurement for stomatal conductance

Two methods were used for single-leaf scale measurement; one is carried out under a natural environmental condition using intact leaves, and another in a controlled environmental condition using cut brunch samples. The latter is called “controlled measurements” (CM), and the former “natural measurements” (NM). A sample brunch was put in water for one night in order to be free from water stress.

The results obtained from burch forests are shown in Figure 4 (Kato et al., 2005). The stomatal responses to photosynthesis active radiation (PAR), leaf temperature (T_l), and atmospheric water vapor deficit (D) obtained from “natural measurements” were quite different from each other. The stomatal conductance obtained in Yakutsk site was very low with the same values of environmental variables, comparing with that in the other sites. However, the differences of stomatal conductance between the sites became a little in the “controlled measurements”. These results imply that the responses of stomatal conductance under the natural environmental conditions will be appearance ones, and that the potential responses will be similar in spite of the climate condition within a same species.

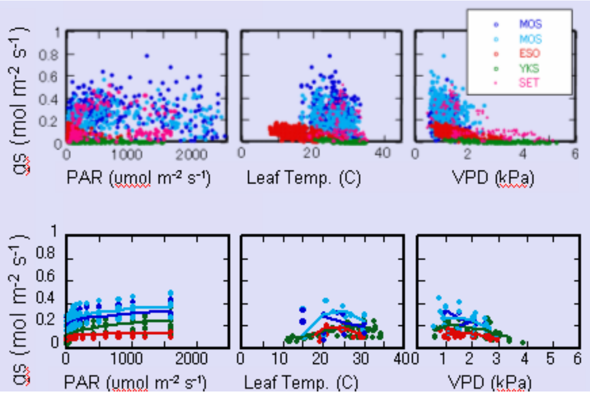

Figure 4. The relatiohships between the environmental factors and the stomatal conductance. The top figure: in NM. The bottom figure: in CM

A stand scale measurements for canopy condactance

The responses of canopy conductance were investigated in the five tower sites using the Jarvis-type conductance model (Matsumoto et al., in preparation). Figure 5 shows the relationships between the environmental factors and the canopy conductance. The responses to PAR, air temperature (T_a) and D were similar between the sites in spite of the forest types in the same area, but there were significant differences of the responses to each environmental variable between the climate zones.

The response curves for each variable seemed to be quite different from each other as mentioned above. The ranges of environmental variables observed were also different, especially for D and θ. Then, we pool the data obtained at the all sited in one graph and reanalyzed them. It was found in Figure 6 that there was an upper limited line including all data obtained in the five sites for each variable. Thus, one characteristics can totally represents the physiological response in each site. And the difference of gcmax seemed to be strongly controlled by soil moisture content (θ).

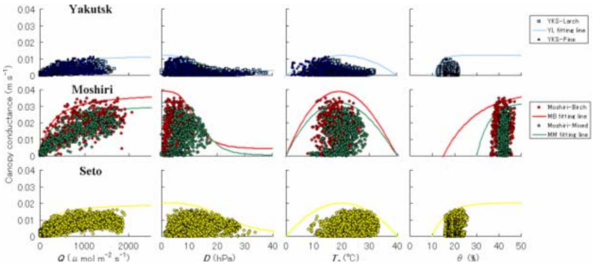

Figure 5 Relationships between the environmental factors and the canopy conductance In the top figure: larch and pine stands in Yakutsk, in the middle figure: burch and mixed stands in Moshiri, in the bottom figure: a mixed stands in Seto.

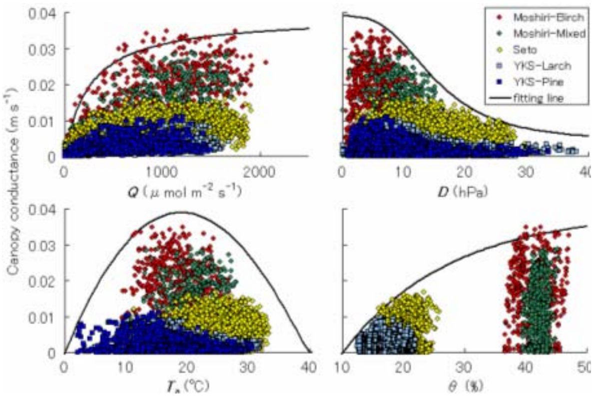

Figure 5. Relationships between the environmental factors and the canopy conductance The all data obtained at the 5 sites are pooled in a single graph for each environmental factor.

The canopy conductance was estimated by the two kinds of physiological response curves; one is obtained from the data in each site, and another is a common response obtained in the all data pooled in one graph. The later is also called a common potential response in a stand scale (CPR), and the former a site specific response (SSR) for this scale. The accuracy of the canopy conductance calculated by CPR was not worse that that by SSR. This result also implies that there will be a potential response of canopy conductance even in a stand scale, and that the canopy conductance can be estimated by the potential response in some broad region.

Land surface model analysis

Our results suggest that there will be the potential response of conductance both in a single-leaf scale and a stand scale. The energy balance components in the five sites are analyzed by a land surface model (2LM) using a single-leaf scale potential conductance of stomata (Yamazaki et al., 2005). The seasonal variation of the sensible and the latent heat fluxes at the five sites can be represented using the potential response, and the accuracy was similar to that calculated by the response obtained at each site separately.

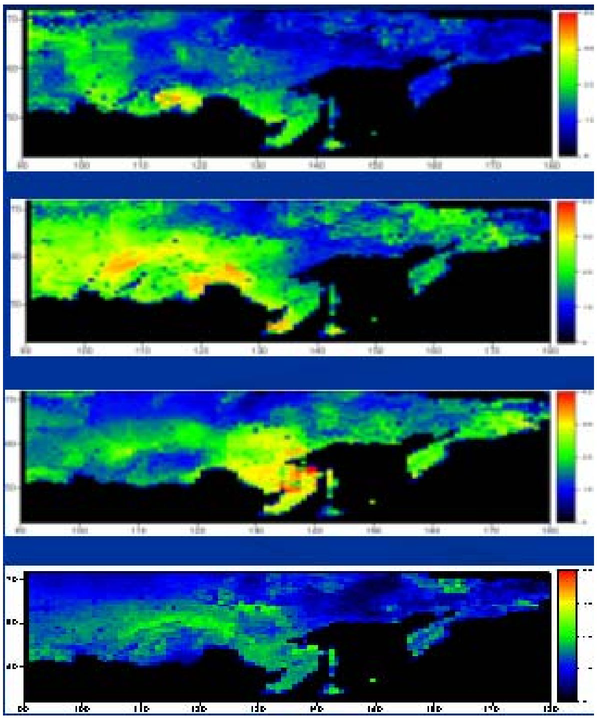

Figure 6. The spatial and temporal distributions of evapotranspiration calculated by the 2LM model expanded two-dimensionally. In the top figure: mean value of 26 – 30 May, 2000, in the 2nd figure: 16 – 20 June, 2006, in the 3rd figure: 26 – 20 July, 2000, in the bottom figure: 16 – 20 August, 2000.

The 2LM model was expanded to the north-eastern Asia, from 90 ° E to 180 ° E and from 30 ° N to 70 ° N (Park et al., 2005). The potential response of single-leaf scale was also used in this calculation. The spatial and temporal variation of energy and water cycles represented by this analysis is shown in Figure 7. It was found that the latent heat flux was strongly limited in the northern part from 60 ° N. And it was estimated that there was a high belt of the evapotranspiration along 60 ° N.

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