Geophysical Research Abstracts,
Vol. 10, EGU2008-A-04541, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-04541
EGU General Assembly 2008

Modeling tempo-spatial characteristics of energy and energy budgets in the Eastern Siberia

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A major concern of the research that investigates the interaction in biosphere-atmosphere system extrapolates how vegetated surface responses to climate change in the future. Land surface model is a useful tool to meet the need. A land surface model (LSM) that infers the spatio-temporal fluxes of heat and water in a biosphere-atmosphere system was developed, applied to the eastern Siberia, and examined the tempo-spatial variations of the energy budget and evapotranspiration (ET) over the period of 1986–2004. The evaluation was focused on the Lena and Kolyma watersheds, which are underlain by continuous permafrost and have somewhat different land surface characteristics. Station data were used to compile gridded time series of forcing data of 0.5º $\times$ 0.5º at the area of 40 - 72ºN and 90-180ºE.

The energy budget showed a clear contrast in the spatial distribution: latent heat flux (Q_E) was higher in forested areas, while sensible heat flux (Q_H) was significant in the tundra. The same result was clearly found in the seasonal variation, although there was a very pronounced growing season of $<$150 days. In the Kolyma watershed, Q_H worked as the dominant factor of the energy budget during the short growing season. On the other hand, the Lena watershed exhibited a higher Q_H in the spring and a higher Q_E in the summer. The different seasonal energy budgets in the Lena and Kolyma watersheds clearly account for the difference in the type of land surfaces in

the two watersheds.

The Lena and Kolyma watersheds exhibited a summer maximum in both precipitation (P_G) and *ET*. The absolute value of *ET*, as well as *ET*/P_G, was also higher in the Lena watershed than in the Kolyma one. However, the seasonality of *ET* components was different between the two watersheds. In the Lena watershed, the major component of *ET* during spring was evaporation from soil surface (E_S). This changed to transpiration (E_T) during the summer. In the Kolyma watershed, E_S was the dominant factor of *ET* during the entire growing season. The water-year time series of P_G and *ET* indicated an increasing trend in the Lena and Kolyma watersheds during 1986–2004. However, there was a decrease in E_S in the watersheds where there was an inverse relationship with P_G. The correlation between *ET* and P_G in the Lena and Kolyma watersheds was actually low. Meanwhile, *ET* showed a high correlation with the air temperature during the growing season. Early snowmelt also increased *ET* during the growing season. On the basis of our findings, we would suggest that an increase in temperature, leading to early snowmelt and a thick active layer, would increase *ET* over eastern Siberia. Although an enhanced P_G, enhanced permafrost melting, and an extended growing season counterbalance such a response to climate change, our study suggests that the stable *ET* variation in eastern Siberia may be extremely vulnerable to future climate change.

There are many difficulties in assessing the energy budget and *ET* in continental scales in regions such as eastern Siberia. One of the difficulties is that methods based on model calculations need to be validated through measurements. There are also questions regarding the quality of the gridded precipitation data sets, especially with respect to bias corrections (Serreze et al., 2003). Moreover, the available measurements for the continental or watershed scale are very few. Therefore, the calculated *ET* was compared with the values based on atmospheric reanalysis, water budget, and station tower measurements. The comparison indicated that the model provided a reasonable calculation of *ET*. From this study, it was found that the autumnal P_G last year and the thawing permafrost influenced *ET*. However, further studies are required in this regard.