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Hydrology in Lena River Basin —— Preliminary Rresults of GAME-Siberia Project —— (Extended Abstract)

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1. Introduction

GAME-Siberia is one of regional study group in the GAME (GEWEX Asian Monsoon Experiment), which is one of Global Energy and Water Experiment projects under the World Climate Research Program. The project started in 1996 funded by Ministry of Education, Sports and Culture, and the phase I ended in the fiscal year of 2001. More than 50 scientists and students are involved in this project. Here the primary results of the GAME-Siberia project are shown. The detail information on individual studies is summarized in the activity reports (see References).

2. Objectives

The Siberia regional study group have set the following four scientific objectives and two operational objectives: 1) Clarify the physical processes of the land-surface/atmosphere interacting system; 2) Clarify the characteristics and variability of regional energy/water cycle; 3) Obtain the climate trend land-surface change during the past 50 years and evaluate possible feedback processes; 4) Improve and develop models describing the energy/water exchange and atmosphere-land surface systems; 5) Collection and archive of regional ground based/satellite data; 6) Establishment of observational network for long-term variation study, and development of hardware.

3. Structure

3.1. Observation site

Three observational sites are chosen for typical land conditions in Siberia: Tiksi as a tundra site, Yakutsk for flat taiga, and Tynda for mountainous site (Fig. 1).

3.2. Project groups

In order to implement the project, researchers are grouped to the following: Tundra Group; Plain Taiga Group; Alas Group; Mountainous Taiga Group; Regional Observation Group; Airborne Observation Group; Modeling Group; Satellite Group.

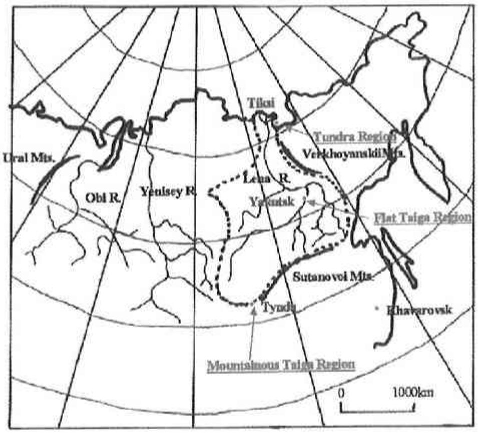


Fig. 1. Eastern Siberia and regional observation site

Fig. 2. Snow drift in May (upper) and July (lower)

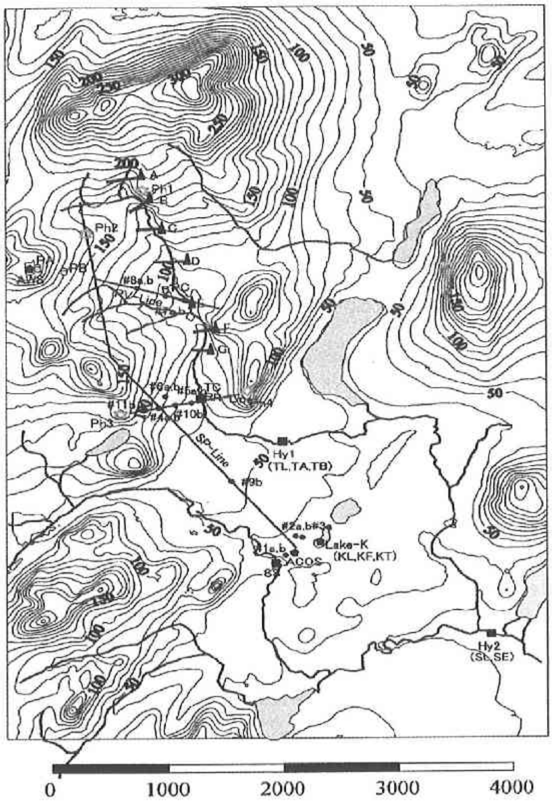


Fig. 3. Map of the tundra site

3.3. Promoting committees and institutes

The main promoting organization is the Japan National committee for GAME-Siberia and Russian National Committee for GAME, which deals with the promotion, control and funding of the project. Several memorandum of understanding and agreements are made between the committees and institutes for implementing the project. The institutes in Japan are: Institute for Hydrospheric-Atmosphere Sciences, Nagoya University, Nagoya; Institute of Geosciences, Tsukuba University, Tsukuba; Faculty of Agriculture, Iwate University, Morioka; Institute of Low temperature Science, Hokkaido University, Sapporo; Faculty of Agriculture, Tokyo University of Agriculture and Technology, Fuchu; Faculty of Science, Tohoku University, Sendai; Faculty of Agriculture, Okayama University, Okayama; Center for Ecological Studies, Kyoto University, Ohtsu; Faculty of Agriculture, Mie University, Tsu; Frontier Research System for Global Change, Yokohama. The Russian institutes are: Institute of Geography, RAS, Moscow; State Hydrological Institute, St. Petersburg; All Russian Research Institute of Hydrometeorological Information-World Data Center, Obninsk; Central Aerological Observatory, Moscow; Permafrost Institute, RAS, Yakutsuk; Institute of Biology, Siberian Brunch, RAS; Institute of Cossmophysics and Aeronomy, RAS, Yakutsk ; Faculty of Science, Moscow State University, Moscow ; Institute of Atmospheric Physics, RAS, Moscow ; Institute of Geography, Siberian Branch, Irkutsk.

4. Preliminary Results

4.1. Tundra

Tundra site is characterized by permafrost, tundra vegetation and snow drift (Fig. 2)

The objectives of Tundra group are : 1) Seasonal and inter-annual variation of water balance of tundra watershed ; 2) Seasonal variation of 1-dimensinal energy and water fluxes ; 3) Spatial distribution of surface and soil conditions. The experimental watershed was established and a meteorological mast was erected to observe one-dimensional water and energy fluxes (Fig. 3).

Study on the seasonal variation of heat balance over tundra (Fig. 4) showed that 30% of net radiation goes for warming atmosphere, 50% for evapo-transpiration and 20% to ground. Those fluxes are dependent on the wind directions : Large sensible heat flux, cold air temperature for NE on-shore wind and small sensible heat flux, high air temperature and large vapor deficit for SW wind.

Table 1 water balance for the tundra watershed. By Kodama *et al.*

Year	Period	*P*	*M*	*E*	*Q*	*dS*
1997	6/18-9/4	220*1	187*2	67*3	381*1	−41*4
1998	6/18-9/4	76*1	120*2	44*3	148*1	5*4
1999	6/13-9/8	99*1	65*5	55*6	110*1	− 1*4
	average	131	124	55	213	−13
	Std.Dev.	77	61	11	146	24

*1Observed, *2Degree day Method, *3Bulk Method
*4Recession Analysis, *5Residual, *6Penman Method

Table 1 lists the summer water balance componets of the experimental watershed (Fig. 3) of 5.5 km^2 for 3 years from 1997 to 1999. The inter-annual deviation in precipitation (P) snow accumulation/melt (M) and discharge (Q) are large, whereas that of thc evapo-transpiration is small.

4.2. Plain taiga

The objectives of the plain taiga research group are : 1) to determine the characteristics of seasonal variation in one dimensional heat and water fluxes over larch and pine forests ; 2) phenology and physiology of trecs and their relationship to fluxes ; 3) modeling of the water and heat fluxes ; 4) to dctermine the characteristics of water cycle using stable isotopes.

Plant activity strongly affects the energy balance above larch forest (Fig. 5). Larger sensible heat flux is observed before foliation, and smaller during foliation. Bowen ratio is smaller During foliation and larger in other periods. Soil moisture does

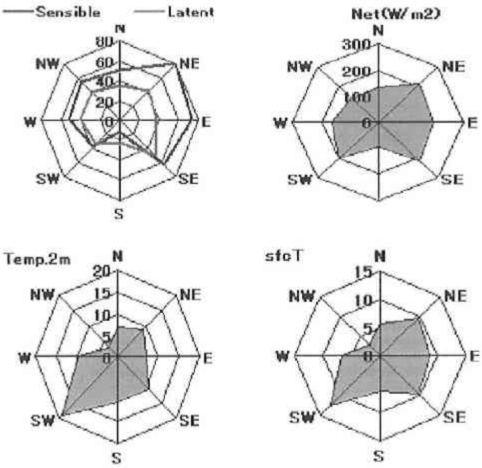


Fig. 4. Wind directional dependency of turbulent fluxes, net radiation, vapor deficit and air temperature. By Kodama *et al*.

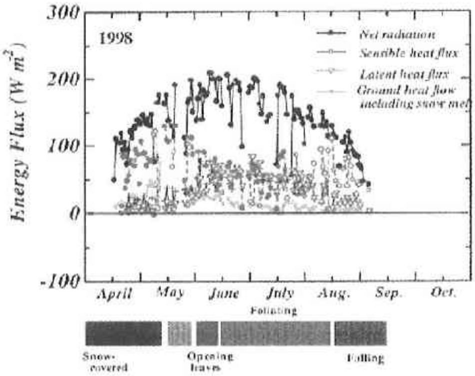


Fig. 5. Energy fluxes of larch forest By Ohta *et al*.

not control the transpiration rate. The dryer soil and larger transpiration in August, 1998 than 1997. Stable isotope study reveals water from permafrost thawing is used for transpiration in dry year.

Heat balance study over pine forest revealed: 1) seasonal variation of latent heat flux was similar to sensible heat flux, 2) after rainfall, latent heat flux becomes large, 3) small evapo-transpiration in rainless periods, 4) understory evapo-transpiration is 40% of that of above canopy, 5) the mean evapo-transpiration was 1.7 mm day^{-1} for pine forest, whereas for larch forest was 1.5 mm day^{-1}.

4.3. *Alas*

Heat and water balance study (Fig. 6) over larch forest near alas site revealed: 1) Before foliation, sensible heat flux is larger than latent heat flux, thus larger Bowen ratio,

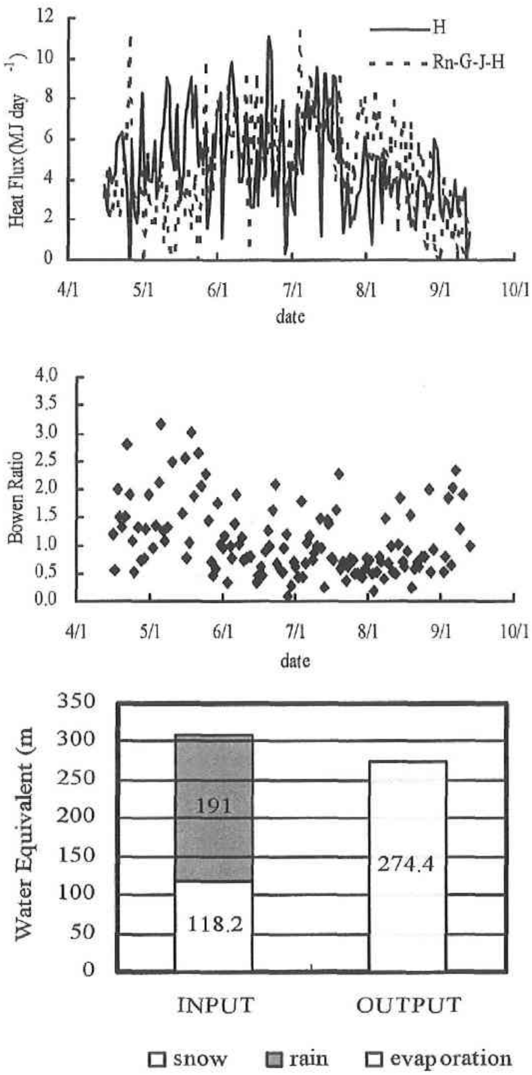


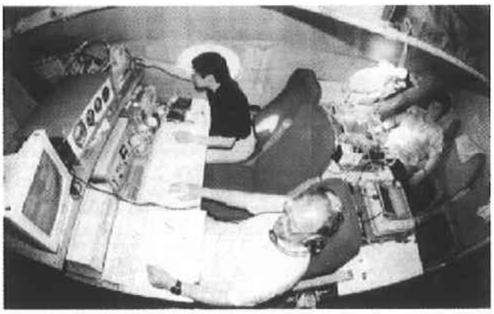
Fig. 6. Heat and water balance over larch forest near alas site. By Tanaka *et al.*

2) During foliation, latent heat flux becomes larger and sensible heat flux has small variation, thus smaller Bowen ratio. 89% of rain and snow is the evapo-transpiration in the water balance.

4.4. Airborne observation

Aircraft observations were carried out with cooperation with the Central Aerological Observatory, Moscow for 9 days from before the foliation to during the foliation in 2000. CO_2 profiles (Fig. 7) showed the smaller CO_2 profiles after foliation. The wind speed and other atmospheric variables (Fig. 8) indicates there might be a local circula-

Color Plate v IL.YUSHIN-18 used for the aircraft observation in IOP and the crew, technicians and scientists in front. Refer Figure 1 on the page 46.



Color Plate vi The working space in the research aircraft IL.YUSHIN-18.

Fig. 7. Aircraft and researchers for airborne observation By Hiyama *et al.*

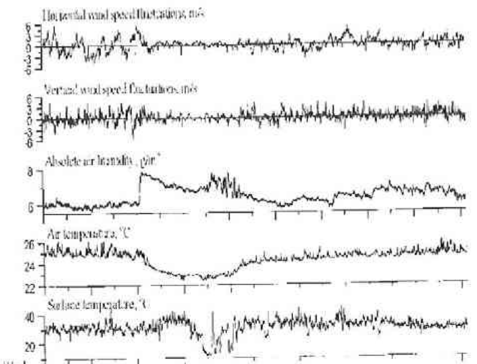


Fig.2 An example of the surface temperature distribution. Also shown in the figure are the horizontal wind speed fluctuations, vertical wind speed fluctuations, absolute air humidity, and air temperature obtained from Russian devices.

Fig. 8. Results of aircraft measurements. From the top, horizontal wind speed fluctuations, vertical wind speed fluctuations, absolute humidity, air temperature, surface temperature and surface conditions are shown. By Hiyama *et al.*

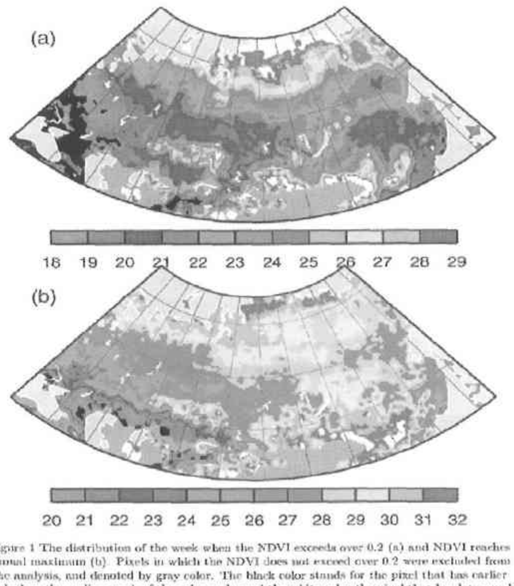


Fig. 9. The distribution of the week when the NDVI exceeds 0.2 (a), and the NDVI reaches the annual maximum (b). By Suzuki *et al*.

tions due to the special thermal characteristics of Lena River flood plain.

4.5. *Satellite imagery studies*

The normalized difference vegetation index was studied using AVHRR images. Fig. 9 shows the distribution of the week of the year when the NDVI exceeds 0.2 (a) and the NDVI reaches the ual maximum over Eurasian continent (b). The both figures indicates that the vegetation is activated earlier in the western part of the Eurasia than the eastern part.

In order to detect the snowmelt distribution, the brightness temperature difference between 19GHz and 37GHz of AVHRR (DT) was calculated and then $\{(DT)_{evening}-(DT)_{morning}\}$ was plotted in Fig. 10. The melting area is shown by red color.

4.6. *Modeling studies*

Since no tall vegetation existed in tundra area, snowdrift is frequently observed, and a distributed hydrological model simulated runoff differently with and without snowdrift (Fig. 11). Fig. 12 display the comparison of observed and calculated diurnal variation of heat fluxes for the larch forest and the pine forest. The calculated sensible heat flux is overestimated for the larch forest, whereas it is reasonable for pine forest. The simulated latent heat flux is slightly smaller than the observed result in the afternoon for the pine forest, which might be due to the strong effect of vapor deficit.

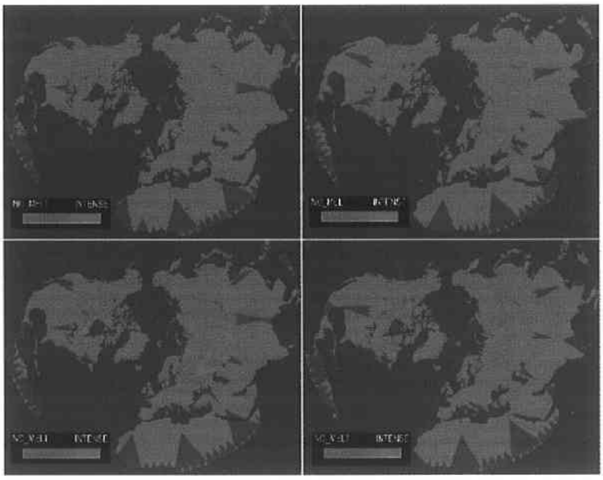


Fig. 10. An example of snowmelt detection by Ohno *et al*.

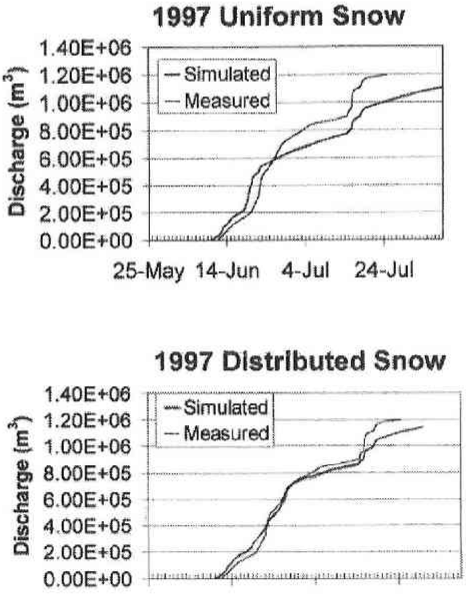


Fig. 11. A simulated results of accumulated runoff with uniform snow distribution (upper) and distributed snow (lower). By Hizman *et al*.

5. Concluding Remarks

1) Land surface conditions substantially influence the heat and water cycles. Especially plant activities affects largely the seasonal variation of them.

2) Frozen ground as well as active layer affects the hydrology of the basin.

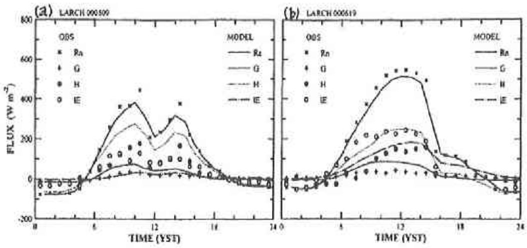


FIG. 1. Comparison of observed and calculated diurnal variation of heat fluxes at the larch site. (a) 9 May 2000 and (b) 19 June 2000.

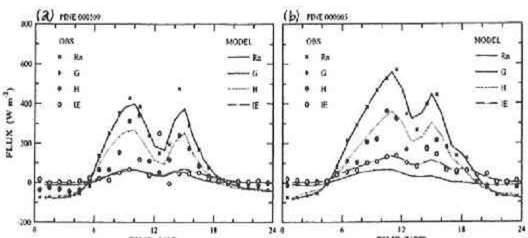


FIG. 2. Same as fig.1 but for the pine site. (a) 9 May 2000 and (b) 5 June 2000.

Fig. 12. Comparison of observed and calculated diurnal variation of heat fluxes at the larch site (upper) and the pine site (lower) for two different days. By Yamazaki.

Elevations of surface and frozen table are also important.

3) Snow and river ice influence the runoff response.

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