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Report

STUDY OF THE WATER AND ENERGY CYCLE AND LAND SURFACE PROCESSES IN SIBERIA (GAME/SIBERIA)

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Abstract: There is a regional study proposed in Siberia region within the GAME (GEWEX Asian Monsoon Experiment) framework. The main target is to understand the processes of water/energy cycle in the land surface -atmosphere interacting system in the permafrost area, and the characteristics of their time variation. Observational and model studies, along with analysis of existing land-based data and satellite data will be made from 1996 to 2000, with intensive measurement sites in the Lena River basin.

1. Introduction

Regional study is proposed under the GAME (GEWEX Asian Monsoon Experiment) within the framework of WCRP/GEWEX (Global Energy and Water Experiment). This has been discussed by the Japan National Committee for WCRP since 1991 and in other Japanese forums. It was approved as one area of regional study as described by the JAPAN NATIONAL COMMITTEE for WCRP (1994). The detailed study plan of the Japanese University group is described in this report. A similar plan for Siberian Region Study has been reported (in Japanese) in OHATA and OHTA (1995).

2. Description of Regional Study in Siberia

2.1. Background and aim of study

The importance of land surface processes in the regional and global water cycle has been recognized in recent years. Many large projects investigating the relation of interactions in the low to highly vegetated land surface plus atmosphere system have been done and are also planned in various regions. However, such works have been limited for the permafrost area which dominates a large area on continents. Among such areas, Siberia, located in the northern half of the Eurasian continent, has the widest permafrost area, but has not been an object of investigation in the past.

The land surface in Siberia is characterized by tundra with scarce vegetation and taiga which mainly consists of coniferous tree belts. The surface layer of the permafrost, snow cover and vegetation contributes much to the water/energy fluxes and strongly regulates the various components of the water cycle such as evapotranspiration and run-off. The seasonal cycle and variation of the water cycle in this region are characterized by the interaction between the cryosphere, biosphere and atmosphere. Furthermore, the

large rivers which drain northward from this region contribute to fresh water supply to the Arctic Ocean which in turn modifies the hydrological and thermal conditions of the Arctic Sea. The variation of runoff of these large rivers is determined by the water cycle processes on land, and will influence climatic conditions in the Arctic. However, these processes have not yet been studied or clarified.

The present global warming since the beginning of the 1980s has been occurring most intensely in the northern part of the Eurasian continent over Siberia where the permafrost zone dominates. The spatial and temporal distribution of snow and ice will also change through interaction with the permafrost conditions. They will affect the water cycle through change in ground surface conditions, soil moisture, hydrology and evaporation. In order to understand the possible changes, processes needs to be modeled, but the land surface processes in taiga and tundra regions have not been clarified yet.

As there are quite urgent problems to be solved, there is a need for investigation of the characteristics of the water and energy cycle in the Siberian region under various spatial and temporal scales. The present study focuses on a study to clarify the physical processes related to water/energy fluxes and storage of water and heat on the land surface, the role of land surface processes including snow cover, permafrost and vegetation in the regional water cycle, and their variability. This study will primary be based on field observational study, analysis of conventional data sets, and modeling of these processes for variability study and climate models. This study is proposed as one of the core projects for the GAME which contributes to the main aim of GEWEX, that is, the global water-energy cycle, through the regional study of an area where it is characterized by seasonal snow cover and permafrost.

2.2. Main study themes

The main study themes are as follows:

1) Seasonal and inter-annual variation of the surface water/energy fluxes and surface conditions, and land surface - atmosphere interactions on representative surfaces in the tundra and taiga regions.

2) Seasonal variation of hydrological processes in a small drainage area in the tundra and taiga regions.

3) Long-term variation of regional climate, land surface conditions, and surface water/heat fluxes by use of existing data sets and an automatic station network.

4) Large-scale water/energy circulation in a large drainage area, and its relation to the thermal and thermodynamic conditions in the Arctic Ocean and influence on climatic variation.

2.3. Study regions and sites

The following drainage area and sites will be taken as the study area (refer to Fig. 1).

1) Drainage area: Lena, Enisei and Ob will be taken as a large drainage area.

Enisei, Ob: Drainage area analysis will be made by permanent station data.

Lena: Intensive land surface study and drainage area study will be made.

2) Study sites within Lena River basin:

a) Tiksi (72°N, 129°E): Tundra, small drainage area will be taken.

Fig. 1. Location of the study region and sites of intensive observations.
▨ : Proposed field site of intensive observations.

b) Yakutsk (62°N, 129°E): Taiga, small drainage area will be taken.

c) Nagorny (56°N, 125°E) or Aldan (58°N, 125°E) : Mountain taiga.

d) Tynda (55°N, 125°E): Mountain taiga.

a), b) and c) or d) will be considered as the intensive observation area. The height of trees in the taiga region is approximately 15 m.

2.4. Plan of investigation

The following will be the tentative observational and analytical study plan.

1) Measurement of land surface fluxes on different land surfaces (Spatial scale: less than 10 km^2) (Corresponds to study theme 1). Long-term data of atmosphere-land surface condition and one dimensional surface fluxes will be obtained by use of tower measurements. All the water/energy fluxes and storage components will be measured and modeled. The relation between the permafrost ground layer, forest and evapotranspiration will be investigated intensely. The duration of this measurement will be five years or more in order to clarify inter-annual variations.

2) Observation of hydrological cycle in small drainage area (spatial scale: 100 to 10000 km^2) (Corresponds to study theme 2). This is the main scale of the field observations. The method of study consists of establishment of a measurement network within the drainage area. Data from permanent stations, surface and ground measurements, airborne measurements and satellites will be analyzed. This scale will contribute to the establishment of the macro-hydrological model. Duration of this measurement will be 1

to 2 summer seasons.

3) Observation of atmosphere-land surface interaction (Corresponds to theme 1). The influence of land surface variation on the atmospheric conditions will be investigated by combination of radiosonde observations, aircraft and land-based measurements. The hydrological effect due to snow cover melting, characteristics of the atmospheric boundary layer and other causes will be clarified. Observations will be done in a few periods during one annual cycle including winter.

4) Data collection and analysis of water cycle components in the large drainage areas (Corresponds to study themes 3, 4). Study drainage will be Lena, Enisei, Ob. Analysis will be done for spatial distribution of precipitation, snow cover and river runoff and snow cover, and mapping the surface conditions from satellite data. Data collection of surface meteorological data , aerological data, land surface data and hydrological data.

5) Observation concerning interpretation of existing data and acquisition of surface meteorological data for spatial water/energy balance study (Corresponds to study theme 3 and others). Establish automated observation network as part of AAN (Asian AWS Network) needed for the regional water/energy balance evaluation and interpretation of the long-term data set. Data will be evaluated.

There will be cooperation with the modeling, satellite, data and AAN Group in finalizing the implementation plan.

3. Concluding Remarks

The Siberian Regional Study is just starting. Proposed time schedule of study period is Preparation period (1994–95), Phase 1 (1996–2000), Phase 2 (2001–2005).

Presently, researchers from seven universities are active in promoting this project. In the future, GAME itself will begin to take an international structure, and the study and implementation plan will be finalized. The final implementation plan will be prepared by GISP (GAME International Science Panel) which will be held at Tokyo, Japan in March, 1996. At that time, not only the content of the project, but also the number of contributing institutions will be increased. There should be a slight change in the details of the project at that time.

As GAME is international in character, it is necessary to collaborate and negotiate with the other international projects in the similar area, such as WCRP/ACSYS, IGBP/BAHC and NES (Northern Eurasian Study) and others. Also, there is a need to cooperate with existing national projects in Japan.

References

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