An Overview of the Rangelands Atmosphere-Hydrosphere-Biosphere Interaction Study Experiment in Northeastern Asia (RAISE)

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Introduction

Intensive observations, analysis and modeling within the framework of the Rangelands Atmosphere-Hydrosphere-Biosphere Interaction Study Experiment in Northeastern Asia (RAISE) project, have allowed investigations into the hydrologic cycle in the ecotone of forest-steppe, and its relation to atmosphere and ecosystem in the eastern part of Mongolia. In this region, changes in the climate have been reported and a market oriented economy was introduced recently, but their impact on the natural environment is still not well understood. Thus the outcome will be presented of the studies carried out by six groups within RAISE, namely, (1) Land-atmosphere interaction analysis, (2) Ecosystem analysis and modeling, (3) Hydrologic cycle analysis, (4) Climatic modeling, (5) Hydrologic modeling, and (6) Integration. The results are organized in five relevant categories comprising (i) hydrologic cycle including precipitation, groundwater, and surface water, (ii) hydrologic cycle and ecosystem, (iii) surface-atmosphere interaction, (iv) effect of grazing activities on soils, plant ecosystem and surface fluxes, and (iv) future prediction.

Please note that this article is a short version of Sugita et al. (2006). For further details, please refer this reference.

RAISE Project: Design and Implementation

The Khelren river basin located in eastern Mongolia with a catchment area of approximately 1.225 10^5 km^2 (total area within Mongolia), 7.15 10^4 km^2 (upstream area of Choybalsan,) or 3.94 10^4 km^2 (that of Underhaan), was selected as the target of the intensive observations (Fig.1).

As mentioned, IMH deploys and maintains a network of observation stations throughout Mongolia. In addition to the existing IMH stations, three flux stations and four automatic weather stations (AWSs) were set up for the purpose of obtaining continuous measurements within the experimental area (Figs. 1-

2). One flux station (to be referred to hereafter as station FOR) was established in a mildly hilly area some 25 km northeast of Mongenmoryt (MNG) village in the upper river basin (Li et al., 2005a) while two others were set up within an extensive steppe area in Kherlenbayan-Ulaan village (KBU) (Fig. 2). At KBU, one station called A1was located within the natural, pastoral steppe, while another essentially identical station called A2 was placed within a 200 m by 170 m fenced area to prevent grazing to take place since September of 2002. In addition, at four locations geographically spread within the steppe region of the experimental area (Fig.1, BGN, DH, JGH, and UDH), basic variables of radiation, meteorology and hydrology have been observed since April of 2003.

In order to obtain more detailed information which the continuous, routine observations outlined above may not be capable to provide, five intensive observation periods (IOPs) were scheduled in 2003 to capture the different stages in vegetation growth. For purposes of further study and possibly future prediction, mainly three models were developed, namely a regional climate model TERC-RAMS (Sato and Kimura, 2005a, 2005b, Sato et al., 2006), a grassland ecosystem model Sim-CYCLE Grazing (Chen et al., 2006) and a distributed hydrological model.

Results

(1) Hydrologic Cycle

Sato and Kimura (2005a) have successfully demonstrated through numerical experiments with their TERC-RAMS model that the presence of the Tibetian plateau, which heats the atmosphere and creates the upward convective motion of the air which in turn induces the downward flow in northern part of the plateau, is the main cause of the dryness of this area. Another question is where the origins of the precipitation are located. An isotopic analysis by Yamanaka et al. (2006) gives a partial answer on this issue. Tsujimura et al. (2006a) indicate from a regression analysis between altitude and $\delta^{18}O$ in the precipitation that the main stem of the Kherlen river is fed by precipitation fallen in the headwater region above 1650 m asl, where the annual precipitation is larger around 250-300 mm. Water balance considerations of the Kherlen river watershed (Kamimera et al., 2005) tend to support this idea.

Isotopic analysis of shallow groundwater, springs, and rivers by Tsujimura et al. (2006a) has indicted that there is essentially no interaction between the river flow and the surrounding area and that the shallow groundwater and the river water are essentially uncoupled from each other over most of the middle to lower parts of the watershed.

(2) Hydrologic Cycle and Ecosystem

Iwasaki (2005, 2006) have shown through analysis of the meteorological data at 97 IMH stations that there is a fairly strong correlation between vegetation activity and the monthly averages of the temperature and the precipitation. Asano et al. (2006) made a detailed survey of soil profiles at five locations with annual precipitation ranges from about 130 to 200 mm. Mariko et al. (2006) studied experimentally the effect of water on the CO_2 and CH_4 fluxes at the soil surface at KBU.

(3) Atmosphere-surface Interactions

A series of studies (Li et al., 2005a, 2005b, 2005c, 2006a, 2006b, 2006c, and 2006d) have shown that there is a distinctive difference in the interaction features between the larch forest in the upper watershed and the steppe grassland, although the general seasonal trend is essentially the same. A Keeling plot analysis with stable isotopes (Tsujimura et al., 2006a) has indicated that 60-70% of the total evapotranspiration is the transpiration at FOR while it is only 30-60% at KBU. Also at FOR, it was found (Li et al., 2005c) that water used by the larch trees originate from the upper 30-cm surface layer of the soil when the precipitation input was large and the soil moisture was relatively high while it came from the deeper layers when the water supply in the upper soil layer was limited.

Asanuma (2006) utilized a large aperture scintillometer which allows evaluation of the sensible heat flux *H* averaged over a distance of up to 5 km near the A1 station at KBU. Kotani and Sugita (2006) explored this through the application of variance methods with data observed by the aircraft in the convective boundary layer (CBL). Matsushima (2006) utilized the GOES9 and MODIS satellite data to estimate the solar radiation, the surface temperature and LAI.

(4) Effect of Grazing Activities on Soils, Plant Ecosystem and Surface Fluxes

The protection of the fenced area from grazing animals started in 2002, and thus the results obtained so far (Kato, 2006, Kato et al., 2005, Urano et al., 2005) are still preliminary in nature, but they already show a remarkable difference between the two sites. Results of field surveys of the vegetation differences between these two sites have been presented by Urano et al. (2005), Li (Unpublished data, 2005) and Hoshino (2006).

Soil surveys (Hoshino, 2006) during three years of 2002-2005 have shown that there are not substantial changes in soil physical properties. In terms of chemical properties, however, notable changes were observed which can be explained in terms of grazing activities. A preliminary analysis (Kato et al., 2005, Kato, 2007) has indicated the difference of the heat and water balance between the protected and pastoral sites.

Studies of Onda et al. (2006) and Nishikawa et al (2005) have estimated the runoff generation and the sediment discharge, i.e., the amount of water erosion of soils at two contrasting small experimental watersheds at KBU and BGN in terms of grazing pressure. The wind erosion in this area has been found to be smaller.

(5) Future Predictions

Sato et al. (2006) have estimated the current and future regional climate, with the main focus on the summer precipitation, of this region by means of the dynamical downscaling method (Houghton, et al., 2001) with the GCM outputs and reanalysis data as two means of inputs into a computational model.

Chen et al. (2006a) and Chen et al. (2006b) studied the sustainable grazing pressure on the grasslands by means of their ecosystem model for a range of stocking rates and for the climatological conditions given as the 10-year averages of the IMH Meteopost at KBU.

Concluding Remarks

The observations, analyses and modeling activities of the RAISE projects have provided unique opportunities to study the hydrologic, atmospheric and ecological processes and interaction among them in the rangelands-forests ecotone located in northeastern Asia. However, there is still a profound lack of understanding of these processes and their mutual interactions and of information in this area in comparison with other rangelands in the world. Thus the results presented here needs to be compared and integrated with the results obtained elsewhere.

Note that this article is a short version of Sugita et al. (2006).

Reference

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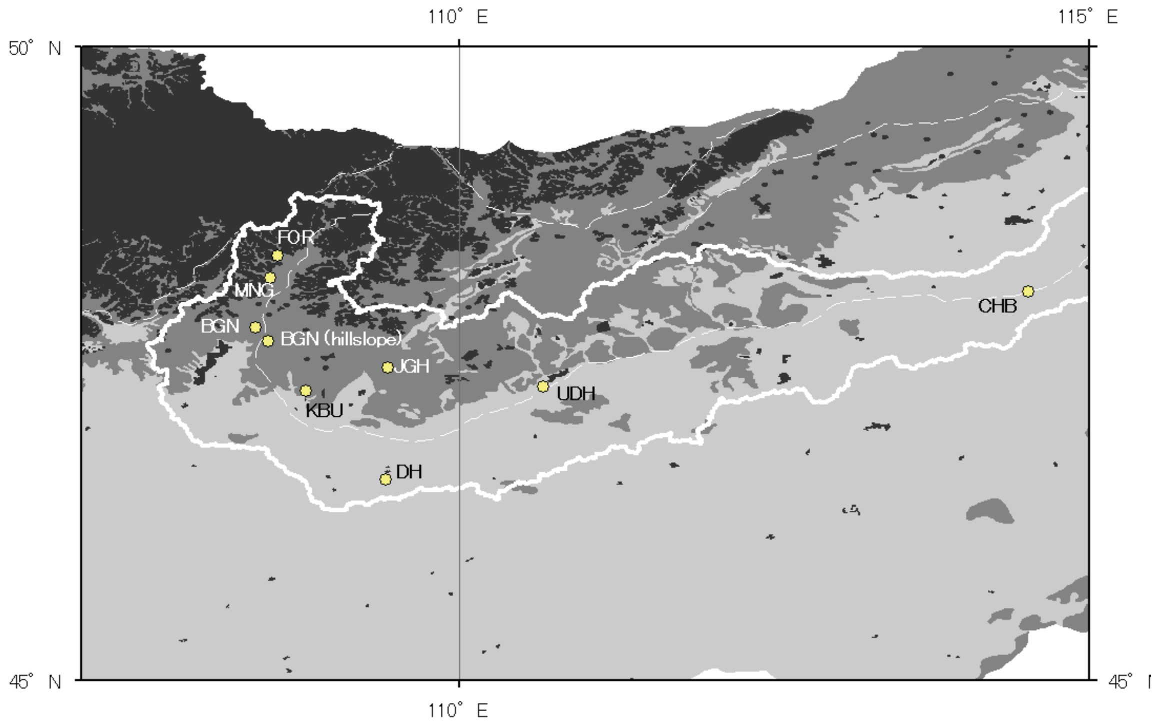

Fig.2 Kherlen river basin with vegetation and station locations. Dark color indicates forest, dark gray the mountain steppe area, and th

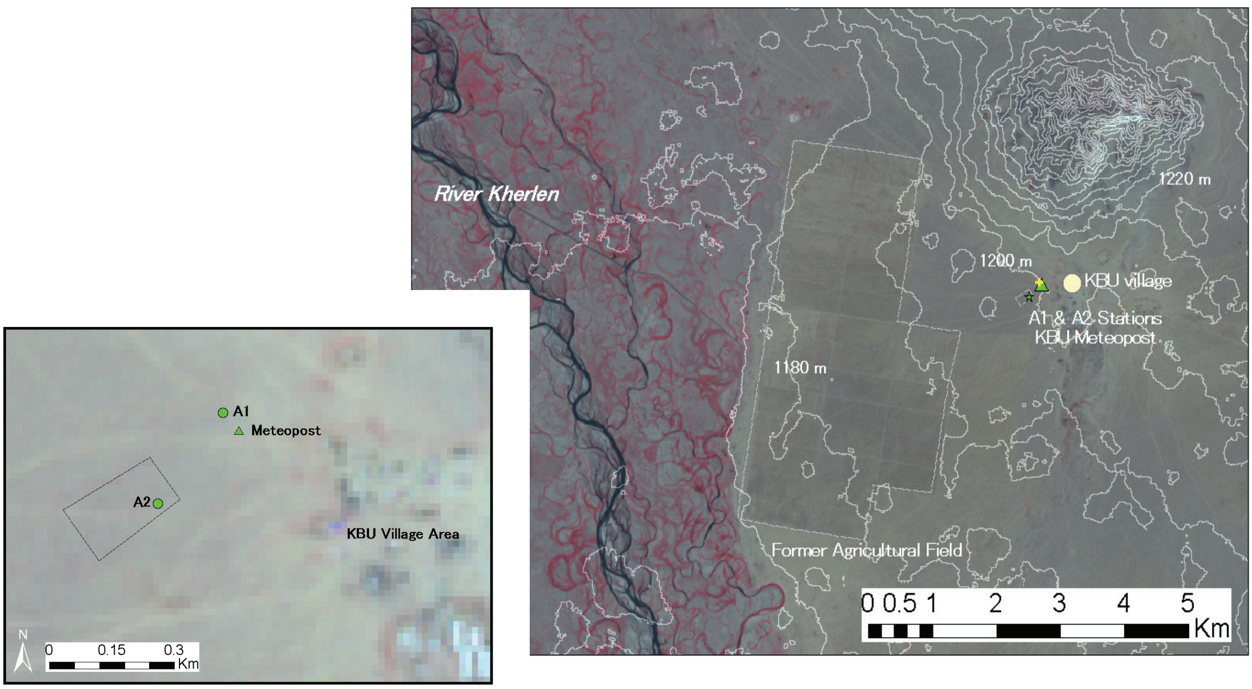

Fig. 2 KBU area. The station area is expanded and shown in the left.