Ecological model and observations to study grazing and climatic impacts on Mongolian rangeland

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Introduction

Mongolia is in the center of the Asian continent which leads to and extreme continental climate and very low precipitation, and primarily a mountain country, on average 1580 m above sea level varying from 533 to 4355 m. A woodland-rangeland-desert ecotone is formed along a steep gradient in the geographical and climatic conditions. An ecotone is generally regarded as a sensitive region for climate and vegetation change (Di Castri, 1988). In addition, overgrazing causes deterioration of ecosystems (desertification) in arid and semi-arid areas. It is necessary to understand the responses of water/carbon cycle processes in the Mongolian ecosystems to climatic change and human disturbance for their sustainable management. The RAISE project as an interdisciplinary study of the Mongolian ecotone is important for regional and global scale climatic change. In the RAISE project, we will make an integrated ecological study on the impacts of grazing and climatic on Mongolian rangeland. The present paper introduces our research plan and reports some results from this-year researches in Mongolia.

Research plan

Our primary study site is a rangeland at Kherlen Bayaan-Ulaan, 100 km east of Ulaanbaatar, and is grazed by livestock all the year around. In the RAISE project, this site is the Flux/Biology Site for an interdisciplinary study. The main aims of our research are:

1) to clarify the impact of grazing on vegetation structure, physiological properties of dominant plants, and soil properties
2) to understand how atmosphere/vegetation/soil interacts as to water and carbon
3) to evaluate water/carbon cycle in Mongolian rangeland using a process-based model

Three study groups, including vegetation/soil group, soil group and model group, are organized in order to achieve these aims. Figure 1 shows a linkage among these study groups. Researchers of each group combined to make a field experiment on grazing impact. In the grazing experiment, control plot, 200 m x 170 m, was enclosed by a 1.5 m-high fence in summer, 2000. We will study the properties of vegetation and soil, and water and carbon cycle inside and outside the fenced plot after the next year, and clarify the grazing impact on the Mongolian rangeland. The data from the field studies are incorporated into a process-based model for simulation of carbon/water cycle, which will be described in the next chapter. Model analysis predicts

the impacts of grazing and climatic change on the carbon/water cycle in the Mongolian rangeland.

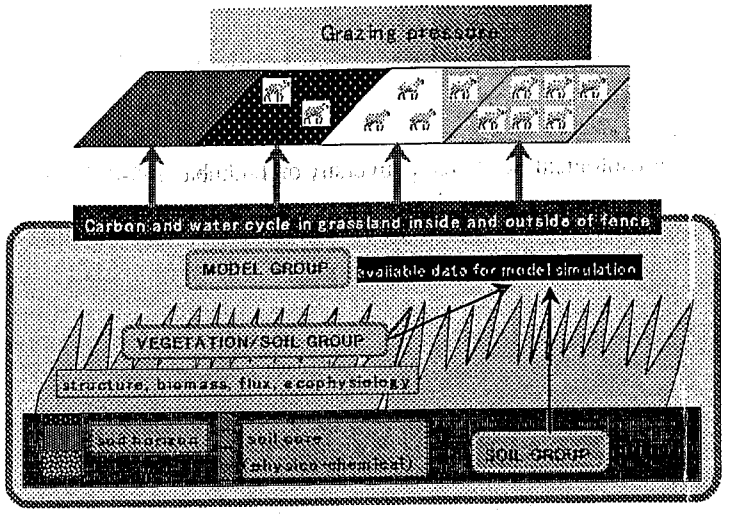

Figure 1. Schematic diagram of the ecological research in the RAISE project.

Model description

An ecological model used for our research is an improved Sim-CYCLE, developed by Ito (2000). This model consists of three submodels for plant growth, microclimate, and soil eco-physiology and considers fluxes of carbon and water (Figure 2). The system includes the vegetative compartments (foliage, stem and root) and its microclimate, the soil organic matter (litter and mineral soil) in the main rooting zone.

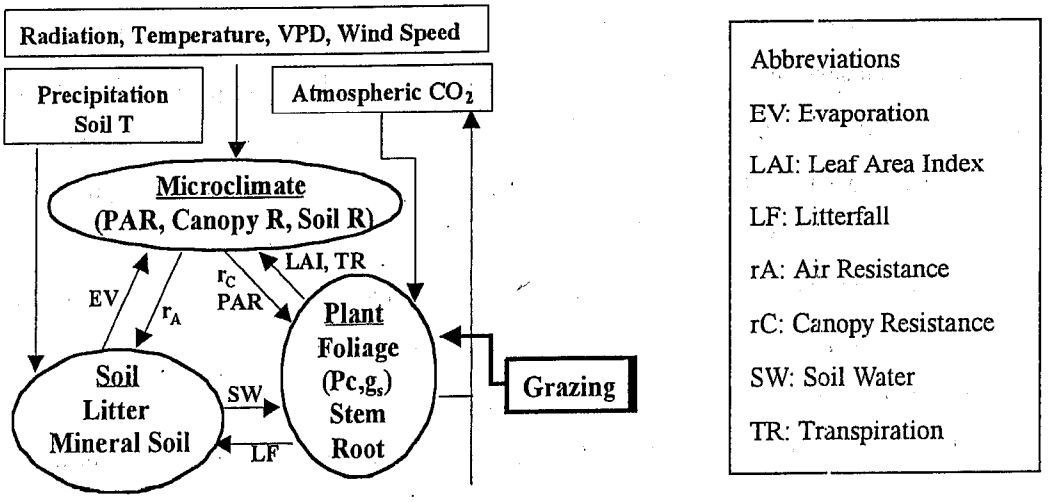

Figure 2. Schematic diagram of the ecological model for simulating carbon/water cycle in an ecosystem.

This model is based on the dry-matter production theory (Monsi and Saeki, 1953; Oikawa, 1985), which enabled us to integrate eco-physiological findings into a simple scheme of plant growth (Monsi, 1960), scaling up from single leaf to canopy scale. The basic formulas of this model on plant physiological characteristics such as photosynthesis and respiration, and ecological characteristics such as LAI, plant growth, soil character etc. were used from adapted formulas on Sim-CYCLE (Ito and Oikawa 2000). The model is a process based model, its estimates net primary production (NPP) and net ecosystem production (NEP) by explicitly calculating such carbon fluxes as gross primary production, plant respiration, and soil decomposition on an hourly time-step. This new simulator enables us to predict a daily change of carbon and water fluxes throughout a year under a given hourly environmental condition. Sim-CYCLE-Eddy employs hourly mean climatic variables such as Ground-Surface Temperature (T_G, °C), Air Temperature at 1.2 m height (T_A, °C), Soil Temperature at 5 cm and 50 cm depths (TS_5 and TS_{50}, °C), Total Precipitation (PR, mm), Wind Velocity (WND, m/s), and Radiation(W/m2) from microclimate tower (necessary) , and CO_2 Concentration (1.2m, ppmv), Vapour Pressure Deficit (VPD; hPa) from eddy covariance technique(for comparing).

Results

Our this-year study at Kherlen Bayaan-Ulaan (August 9-13) covered vegetation structure (species component, height and cover degree, biomass), ecosystem carbon flux, soil carbon flux, carbon and nitrogen contents in soil, temperatures of air and soil, and soil moisture. We report here some of these data.

Vegetation census showed that our study site is covered by *Artemisia*-dominated steppe vegetation, which included two Compositae herbs, *A. adamsii* and *A. frigida* A few C4 plants were observed; e.g. Salsola collina, Cleistogenes squarrosa. Salsola species are the plants most resistant to ecological stress and conditions in highly arid regions with less than 100 mm of annual precipitation. The percentage of C4 to C3+C4 plants was 10%. In Mongolia, 80 species are found among 8 families, and the proportion of C4 species increases with decreasing geographical latitude and along the north-to-south temperature gradient (Pyankov *et al.* 2000). According to Pyankov *et al.*, the north-eastern part of Mogolia includes about 30% of C4 plants. Therefore, our site seems to be less in C4 proportion. Aboveground biomass of vegetation was less than 100 g d.w. m^{-2}, an average among 12 quadrats of 1 m x 1 m. This value is close to that in desert steppe rather than typical steppe in inner Mongolia, which is attributed to the difference in not plant coverage but plant height. Since biomass was measured in a late growing season, annual ANPP is estimated to be less than 100 g d.w. m^{-2} y^{-1}.

Hereafter, we will analyze the remaining data of carbon fluxes and C/N contents in plants and soil, and improve the Sim-CYCLE model to be able to simulate the impact of grazing on the carbon/water cycle in Mongolian rangeland.

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