Global Environment Research Account for National Institutes

Long-term monitoring on impacts of climate change in indicator ecosystems in terrestrial Asia
（Abstract of the Interim Report）

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1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) reports recently that based on direct measurements and other platforms, it is unequivocal that the climate system is warming[6]. The IPCC report emphasizes that recent changes in climate have caused impacts on natural systems on all continents. Terrestrial ecosystems are of great spatial heterogeneity and temporal variation in terms of not only their local climate but also the climatic impacts, or the response of ecosystems. To predict the impacts of climate changes on terrestrial ecosystems, it is necessary to understand the current relationship between climate changes and their impacts. Long-term field observation is always one of the most important approaches for this purpose.

Terrestrial Asia has various ecosystems, including those located in extreme environments such Qinghai-Tibetan Plateau, which is the highest terrestrial ecosystem in the world. In comparison with many other terrestrial ecosystems in the world, we have relatively less long-term knowledge on the Asian terrestrial ecosystems, in particular on those in developing countries.

In this study, we focus our attention on the long-term changes of physical environments and their effects on the changes in plant species diversity, plant growth, plant phenology and other ecological properties in typical Asian terrestrial ecosystems including dry grassland, alpine meadow and wetland on the Tibetan and Mongolian Plateau, alpine shrub and meadow in Japan and tropical rain forest in Malaysia. We consider these ecosystems as indicating ecosystems for climate change in this area because either that they are located under some extreme climate where climate changes are supposed to be easily detected, or/and that the ecosystems, particularly alpine ecosystems tend to be sensitive to climatic changes.

2. Research Objective

The first objective in the project is to obtain long-term observations on and to assess changes in bio-physical environments in representative indicating ecosystems.

Our second objective is to observe and to assess ecological changes in the indicating ecosystems. Our observation variables include changes of plant species diversity, plant population dynamics, plant growth and plant phenology, as well as major ecosystem functions such as CO_2 and H_2O fluxes.

The third purpose in this project is to scale up the local observations into regional change patterns in both physical environments and in ecosystem properties. The approaches include mainly the analysis of remote sensing data, and ecological modeling.

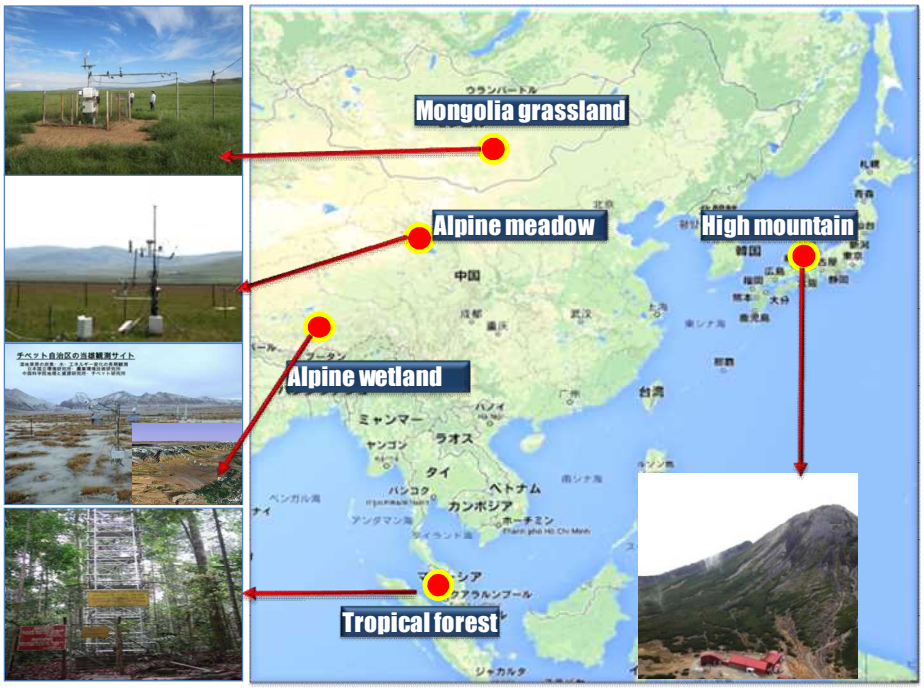

Figure 1. Locations of the long-term observation on physical environmental changes and their ecological consequences in terrestrial Asian ecosystems

3. Major results

Establishment and management of the long-term monitoring network for climate change and its effects on the indicator ecosystems in terrestrial Asia:

To understand the climate change and its effects on terrestrial ecosystems, we established long-term monitoring network at five sites in four countries by 2014, and we are continuing the long-term observation and assessment on bio-physical environments and changes in ecosystem structure. Current working sites with different starting years are as followings: Haibei site in Qinghai, China from 2001; Dangxiong site in Tibet, China from 2006; KBU site in Mongolia from 2013; Pasoh site in Malaysia from 2013 and Norikura site in Japan from 2014 (Fig. 1). These monitoring sites cover wider-ranging ecosystems from a tropical forest in Malaysia to the grassland at lat. 47°N in Mongolia. The altitudes of these sites extend from the sea level to the alpine ecosystem in Tibet at the elevation as high as 5500m. The routing observations on physical environmental variables include solar radiation, air and soil temperature and moisture, and precipitation. Biological observation are conducted on the changes of plant species diversity and ecosystem functions including plant phenology, CO_2 and H_2O fluxes, and other ecological variables[5), 7), 8), 9), 10), 13)] . To extend the observational results, we have also developed a series of approaches using remote sensing data to scale up both temporal and spatial observations[11), 12)].

Major achievements and future prospects from the long-term monitoring network

1) At the KBU site in Mongolia, we have obtained a long-term monitoring data on the microclimate, the species composition, population dynamics and phenological events of grassland plants. We also obtained evidence to show the grazing effects on these major ecosystem traits in the KBU site, and also other two meadow sites as comparison.
2) At the Haibei site in Qinghai, China, the grazing effects on soil carbon and plant species diversity in alpine meadows have been revealed. These scientific findings should provide some important insights into working by new approaches for climate adaptation and grassland

managements.

3) At the Dangxiong site, Tibet, China, we are continuing a long-term monitoring on microclimate and various ecosystem properties along an altitudinal gradient from 4300m to 5500m from 2006, which is perhaps one of the highest elevated long-term monitoring system on climate change in the world. At this site, we found that leaf unfolding dates of dominant sedge and grass species synchronized with monsoon onset, regardless of air temperature. The arrival of monsoon rainfall is crucial for leaf unfolding when air temperatures were continuously above 0 °C. In contrast, the leaf unfolding in an early-emerging cushion species was earlier in warmer years regardless of precipitation. These findings also provide a basis for interpreting the spatially variable greening responses to warming detected in the world's highest grassland. We recently also found that the cushion plants play an important role for species diversity and plant invasion to high altitudes. These observational results provide critical information for conservation of alpine plants in the future.
4) At the Pasoh site, Malaysia, we are now monitoring the microclimate and population dynamics of tree seedlings. We found that the high CO_2 concentration at the forest floor contributed a significant part to the leaf carbon gain of tree seedlings, which may compensate carbon gain due to the limitation of low light for the leaves of tree seedlings under forests[14]. These findings should be considered in forest management in future high CO_2 world.
5) At the Norikura, Japan, we found that snow cover may determine phenological events in alpine vegetation. This finding is expected to provide tourists with more accurate information for sightseeing in those alpine sites with snow covers.
6) In order to scale up the local observational results on ecosystem changes, we have also developed methods for accurately estimating spring phenology in different ecosystems[1), 2)]. In particular, we focused our attention to develop methods for detecting vegetation changes in relation with snow activities[4), 5)]. A simple method called weighted cross-correlogram spectral matching—phenology (CCSM-P) was developed by cooperative researchers[3)]. This method combines CCSM and a weighted correlation system, for detecting vegetation phenological changes by using multiyear vegetation index (VI) time series. The method is expected to facilitate more reliable assessments of phenological changes in climate change studies.

4. Discussion

There are quite a lot of observations related to climate changes and ecosystem responses in terrestrial Asia, but it is also true that there are few observational systems with common observation items, both in terms of microclimate and ecosystem parameters, across a wide range of ecosystems. This project was trying to set up an observation network with similar monitoring items in different ecosystems covering an area as wide as possible. Although it is still far enough for understanding the climate change and its consequences around the vast terrestrial Asia, our project does provide some valuable information for future long-term monitoring on ecosystem responses to climate changes in this region.

Some findings from the projects, including the effects of livestock grazing on plant species diversity, carbon cycles in grasslands, the effects of high CO_2 on tree seedlings in tropical forest floor and some new methodology in analyzing phenological events from remote-sensing data can be used for future planning on climate change adaptation strategies.

On the other hand, we have also found that there are quite a lot of uncertainties in local meteorological changes and their impacts on ecosystem traits. Partly, the uncertainties can be clarified with future continuing observations, as well as further analysis on current data obtained in this project.

5. Other related activities in relation to the project (ripple effects)

1) With the establishment and continuous activity of the project, some data gaps for terrestrial ecosystems in particular for those fragile ecosystems in Asia have been filled both in terms of climatic factors and ecological responses. Some of the data are provide publicly and some are for scientific communities now. These data are expected to play more important role in the future, both for scientific studies and for policy makers.
2) A research paper from the project on plant phenological change in alpine meadow ecosystems,

which was published on Scientific Reports in 2016, has attracted wide public attention. We have also organized a successful symposium in international congress of ecology, in 2017, in Beijing.

3) All the published scientific paper from the project has provided some inputs to the projects like Global Earth Observation System of Systems (GEOSS) and Biodiversity Observation Network (BON). Further contributions are expected either from data providing and scientific publications from the project.

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