TEMPERATURE CONTROLS ECOSYTEM CO_2 EXCHANGE IN AN ALPINE MEADOW ON THE QINGHAI-TIBETAN PLATEAU

Y. Tang[1], T. Kato[2], S. Gu[3], M. Hirota[4], M. Du[5] and X. Zhao[6]

[1]*National Institute for Environmental Studies, Onogawa 16-2, Tsukuba, Ibaraki 305-8506, Japan; tangyh@nies.go.jp*

[2] *Frontier Research, System for Global Change, Yokohama 3173-25, Kanagawa 236-0001, Japan; t_kato@jamstec.go.jp*

[3]*Northwest Plateau Institute of Biology, Chinese Academy of Sciences, Xining 810001, PR China; gusong@mail.nwipb.ac.cn*

[4]*National Institute for Environmental Studies, Onogawa 16-2, Tsukuba, Ibaraki 305-8506, Japan; hirota.mitsuru@nies.go.jp*

[5]*National Institute for Agro-Environmental Sciences, Kannondai 3-1-3, Tsukuba, Ibaraki 305-8604, Japan; dumy@affrc.go.jp*

[6]*Northwest Plateau Institute of Biology, Chinese Academy of Sciences, Xining 810001, PR China; xqzhao@mail.nwipb.ac.cn*

ABSTRACT
We examined CO_2 flux over an alpine meadow on the northeastern Tibetan Plateau to elucidate how temperature controls the carbon dynamics. The CO_2 flux was measured in a *Kobresia* meadow at an elevation of 3200m above sea level from 2002 to 2004 using the eddy covariance technique. The alpine meadow was a weak sink of atmospheric CO_2 with net ecosystem production (NEP) of 193 g C m^{-2} yr^{-1} for 2004, which was about twice of that for the other two years. Both the low ecosystem respiration (ER) and high gross primary production (GPP) contributed the high NEP in 2004. The annual GPP was 34g Cm^{-2} and 105 g C m^{-2} higher in 2004 than 2003 and 2002, respectively. The lowest GPP of 2002 was clearly due to the low GPP in the autumn season when remarkably high air and soil temperature were recorded. The low ER in 2004 was due to mainly the small ER in the summer period when temperature was much lower than other years. In 2004, the growing season was estimated to be about two weeks longer than the other two years. The advance of growing season in 2004 corresponded well to the temperature elevation in the spring season. Further analysis showed that the day/night difference in soil temperatures was positively correlated to the daily net ecosystem CO_2 exchange. The study suggests that temperature environment plays the major role in the annual variation of NEP in the alpine meadow ecosystem.

INTRODUCTION
The Qinghai-Tibetan Plateau extends more than 2.5 million km^2, with its 60% of the total area being covered by various grasslands. These grasslands have developed at elevations higher than 3000 m and some alpine steppe can even be found at elevations above 5000 m. The soil carbon density of the alpine grasslands is much higher than other lowland grassland in the world [see *Kato et al*. 2004], although low temperature may limit largely the carbon sequestration. With its high elevation, the large carbon stock in the extensive plateau is considered one of the most ecologically fragile and sensitive carbon pools in response to global warming. Among the grasslands, alpine meadows are often found in areas with a mean annual rainfall of more than 400 mm and experience high daytime temperatures during the growing season. All these environmental conditions would seem to favor a high photosynthetic CO_2 uptake by plants. On the other hand, the low nighttime temperatures and long, cold winters might limit the decomposition of organic matter in these ecosystems. Therefore, the alpine grassland ecosystems might have a high potential to absorb CO_2 from the atmosphere. We examined the correlation between the daily

net ecosystem CO_2 exchange, and the day/night difference of air temperature and that of soil temperatures at different depths. We tried to elucidate how the temperature environment affects the CO_2 exchange in the alpine meadow ecosystem.

STUDY SITE AND FLUX MEASUREMENTS

Measurements of CO2 flux were conducted at the Haibei Alpine Meadow Ecosystem Research Station (37°29–45'N, 101°12–23'E; 3250 m a.s.l.). The climate at the site is characterized by low temperature with an annual mean temperature being –1.7 °C and annual precipitation being 561 mm averaged for the period from 1981 to 2000. The soil is a clay loam with its average thickness is about 65 cm and the surface 5–10 cm horizons being classified as Mat Cry-gelic Cambisols. The plant community is dominated mainly by three major perennial sedges, *Kobresia humilis*, *K. pygmaea*, and *K. tibetica* (Cyperaceae). We measured CO_2 and H_2O flux with the open-path eddy covariance method at 2.2 m with an open-path Infra Red Gas Analyzer (CS-7500, Campbell Scientific Inc.). Wind speed and sonic virtual temperature were measured at 2.2 m above the ground with a sonic anemometer (CSAT-3, Campbell Scientific Inc., Logan, UT, USA). Fifteen-minute averages of all data were logged by an analog multiplexer (AM416) and a digital micrologger (CR23X, Campbell Scientific Inc.), which sampled the data at a rate of 10 Hz [for details see *Gu et al.* 2003; *Kato et al.* 2004].

MAJOR RESULTS

The net ecosystem production (NEP) was 79, 92 and 193 $gCm^{-2}\ yr^{-1}$ for 2002, 2003 and 2004, respectively. Most NEP accumulated during the summer season from June 1 to August 31, with NEP being 149,143 and 211gCm^{-2} for the three consecutive years, respectively. The duration for the ecosystem showing net absorption of CO_2 lasted for 178 days in 2004, which was about two weeks longer than the other two years. The advance of growing season in 2004 was evident with the growing degree-days being 10 days earlier in 2004 than the other two years. The growing season advance corresponded well to the increase period of the green above ground biomass that estimated from NDVI, as well as to the elevation of temperature during the spring season. Nighttime net ecosystem respiration showed an exponential relationship to soil temperature with the annual ecosystem respiration at 10 °C being 1.58, 1.89 and 1.80 μmol $Cm^{-2}s^{-1}$ and the annual active energy being 81519, 93821 and 69864 $Jmol^{-1}$ for the consecutive three years, respectively. We examined the correlation between net ecosystem CO_2 exchange and the day/night temperature difference. The soil temperature at 5cm showed a high correlation with the temperature differences either between daily maximum and minimum, or between daytime mean and nighttime mean.

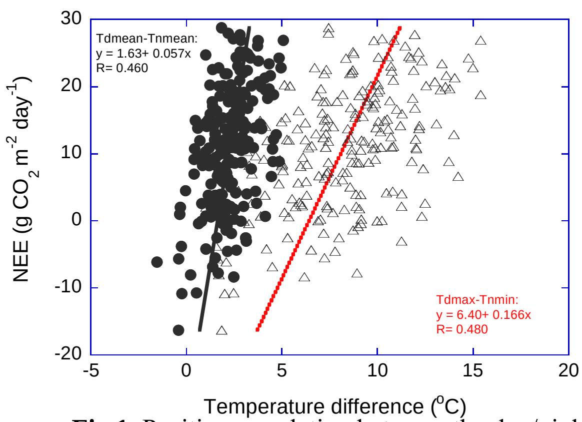

Fig.1. Positive correlation between the day/night difference of soil temperature at 5cm depth and net ecosystem CO_2 exchange in an alpine meadow.

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