Changes in the Concentration of Carbon Dioxide in the Air

Damdinsuren Sodov,* Ariuntuya Nyamsambuu

Laboratory of Biophysics, Department of Biology, School of Science and Arts, National University of Mongolia

We are measuring the diurnal and seasonal changes in the concentration of carbon dioxide in the air of different natural zones of Mongolia from 2009. The carbon dioxide in air decreased in the daytime and increased in the nighttime during the vegetation period. The changes in the concentration of carbon dioxide in the air were high in vegetation period, in steppe and in rainy summer. It was concluded and confirmed that the changes in the concentration of carbon dioxide in the air controlled by the balance between the photosynthetic uptake and respiratory emission of carbon dioxide.

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INTRODUCTION

The concentration of carbon dioxide in atmosphere is changing always (Figure 1). This picture adopted from Dlugokencky and Tans [1]. There are dramatic seasonal changes in the concentration of carbon dioxide in air of northern hemisphere, where located our country. The summer decrease related to the photosynthetic uptake and winter increase related to the respiratory emission of carbon dioxide. To build this three dimensional distribution of seasonal changes of carbon dioxide in atmosphere used data from various monitoring sites of carbon dioxide.

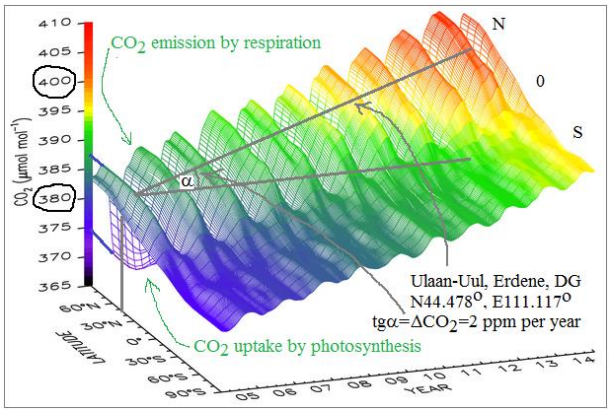

Figure 1. Carbon dioxide observations from 2004 to 2014 showing the seasonal variations and spatial distribution of the difference between northern and southern hemispheres.

There are three different monitoring sites of carbon dioxide in air: First one is continuous measurements of carbon dioxide in Earth's atmosphere in sites far as possible far from living things such as Mauna Loa Observatory in Hawaii Islands and South Pole Station in Antarctica, which was initiated and started by prof. Charles David Keeling from Scripps Institution of Oceanography at UC San Diego in 1958. Second one is flask sites such as Ulaan-Uul near to the center of Erdene sum, Dornogovi aimag, Mongolia. Two flask of air samples taking ones for every week in the morning, which was started in 1992 [http://cdiac.ornl.gov/trends/co$_2$/noa$_2$/ula-tre.htm]. The aim of these sites is to monitor mixing ratio of carbon dioxide in earth's atmosphere. The third one are CO_2 flux sites, such as Mungunmorit (2004) and Udleg (2009-) in forest at the south edge of Siberia and Herlen Bayan Ulaan (2006-) in pasture land of Mongolia. The aim of these sites is to monitor photosynthetic uptake and respiratory emission of carbon dioxide (CO_2 fluxes) to estimate selected site is CO_2 sink or CO_2 source [2-4].

The objective of our studies was to measure diurnal and seasonal changes in the concentration of carbon dioxide in the air of different natural zones of Mongolia and compare the results with results of CO_2 flux experiments.

METHODS OF MEASUREMENTS

The air sample took with DC pump from 1.5 m height to measure carbon dioxide in the flow through infrared gas analyzers (LI-840A, Qubit S151 and TIM10). The flow rate of air was 0.25 L min^{-1}. The air pressure and temperature were measured simultaneously.

The CO_2 fluxes (ecosystem photosynthesis and ecosystem respiration) was measured with closed chamber with 0.25 m^{-2} base area and 0.35 m height. The CO_2 flux between the air and plant-soil system was calculated as CO_2 changes per unit time and per unit area in the closed chamber using the following formula (1) for ideal gases:

* Electronic address: damdinsuren@num.edu.mn

$$CO_2\ flux = \frac{PH}{RT}\frac{dCO_2}{dt} \quad (1)$$

The CO_2 flux in the light is negative or less than zero showing CO_2 uptake by photosynthesis of plants, which we call as ecosystem photosynthesis. The CO_2 flux in the dark is positive or more than zero showing CO_2 emission by respiration of soil and plant system, which we call as ecosystem respiration.

SITES OF MEASUREMENTS

We selected following sites for measurements of carbon dioxide in air and carbon dioxide fluxes between the air and soil-plant system (Table 1 and Figure 2):

Table 1. Sites for measurements

#	Natural zone	Sites
1.	Forest steppe	Tujiin nars
2.		Tahiltiin davaa
3.		Udleg
4.	Steppe	Taliin shand
5.	Meadow steppe	Ugii nuur
6.		Elsen tasarhai
7.	Dry steppe	Sahiul
8.		Bayan tal
9.	Semi-desert	Ulaan-Uul
10		Tsogt-Ovoo
11.	Desert	Tsogttsetsei
12.		Hanbogd

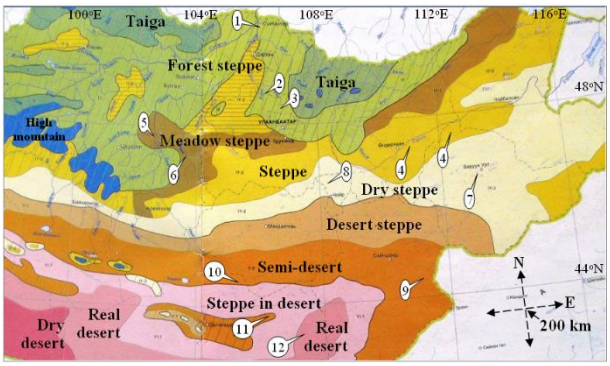

Figure 2. The sites of CO_2 concentration and flux measurements.

RESULTS AND CONCLUSIONS

We measured the diurnal changes of carbon dioxide concentration (CO_2) in air of different natural zones of Mongolia from 2009 [5-7]. During the vegetation period the CO_2 in air decreased from the morning and reached to a minimum steady state level in the daytime, which was donated as DCO_2. And it increased from the evening and reached to a maximum steady state level in the nighttime, which was donated as NCO_2. The relative increase of CO_2 (RI=100*(NCO_2-DCO_2)/DCO_2) was used as an indicator of diurnal changes of CO_2 in air (Figure 3).

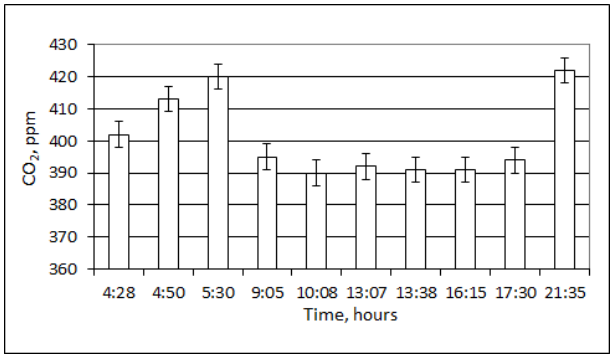

Figure 3. The diurnal changes of CO_2 in air of dry steppe in July 2009. The relative increase (RI) of CO_2 was 7.42%.

The seasonal changes of RI in air of forest steppe and steppe are shown in Figure 4. The RI was low in winter time and increased to a maximum level of 18% in the mid of July, because of the DCO_2 reached to the lowest and the NCO_2 reached to the highest value in the July.

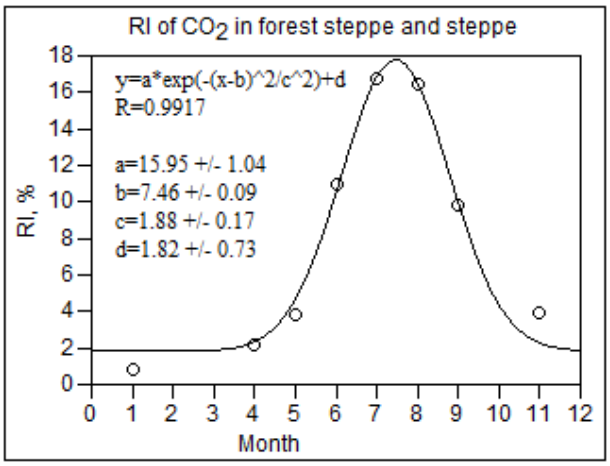

Figure 4. Seasonal changes of the relative increase of CO_2 in air (RI) of forest steppe and steppe. The solid line is Gaussian bell shaped curve fitted to the experimental values, which denoted as open circles.

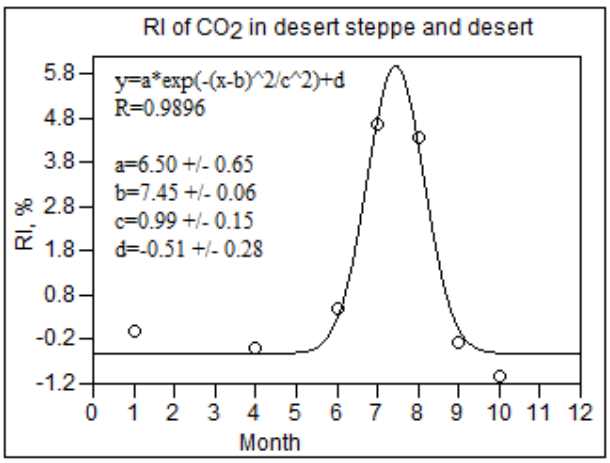

Figure 5. The seasonal changes of RI of CO_2 in air of dry steppe and desert. The solid line is Gaussian bell shaped curve fitted to the experimental values, which denoted as open circles.

The seasonal changes of RI in air of dry steppe and desert are shown in Figure 5. The RI was low in winter time and increased to a maximum of 5.8% in the mid of July, because of the DCO_2 reached to the lowest and the NCO_2 reached highest value in the July.

The annual changes of July RI are depicted in the Figure 6. The July RI was greater in the steppe (open circles) than that in the desert (closed circles). The July RI in steppe was high in 2013 and low in 2009-2010 and 2015. The July 2013 was more convenient for plant growth than July 2009-2010 and 2015 in steppe. The July RI in desert showed a tendency to decrease after 2009.

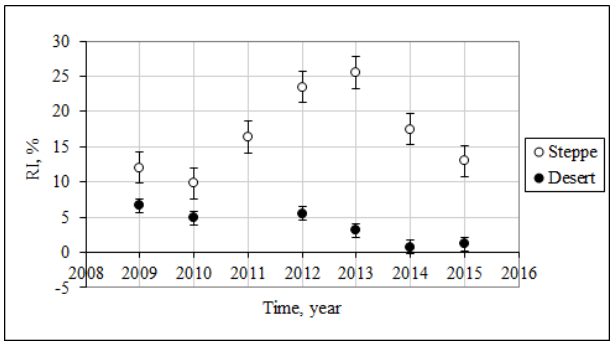

Figure 6. The annual changes of July RI in forest steppe, steppe (steppe) and dry steppe, desert (desert).

The diurnal, seasonal and annual changes of CO_2 in air led us to conclude that the RI should be related to the ecosystem photosynthesis and ecosystem respiration. This conclusion confirmed from the linear relation between the RI and ecosystem photosynthesis (Figure 7), and between the RI and ecosystem respiration (Figure 8).

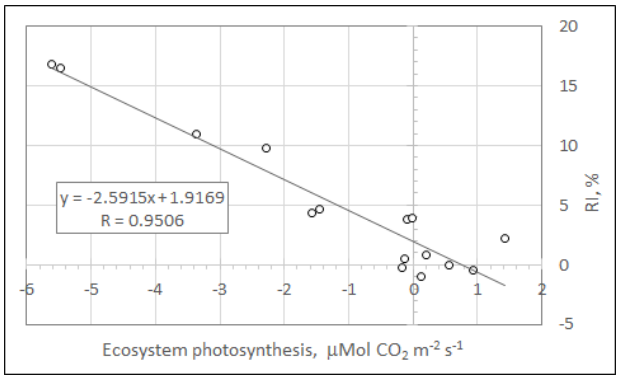

Figure 7. The linear relation between the diurnal changes of CO_2 in terms of the RI and ecosystem photosynthesis.

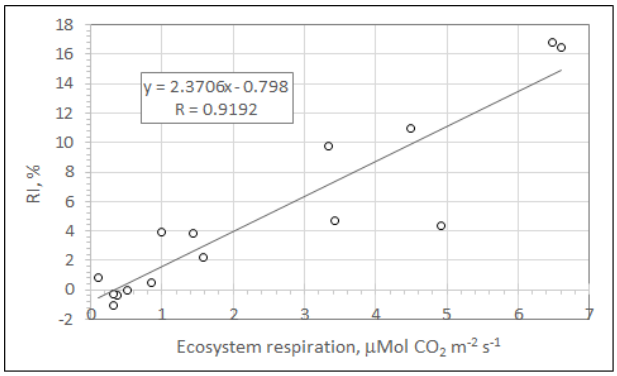

Figure 8. The linear relation between the diurnal changes of CO_2 in terms of the RI and ecosystem respiration.

The R_{crit} is 0.514 for n=15 and p=0.05, which was less than the calculated values of R=0.9506 and 0.9192. Therefore, it was concluded that the changes in the concentration of carbon dioxide in the air strongly related to the ecosystem photosynthesis and ecosystem respiration.

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Агаар Дахь Нүүрстөрөгчийн Давхар Ислийн Концентрацийн Өөрчлөлт

Содовын Дамдинсүрэн, Нямсамбуугийн Ариунтуяа

МУИС, ШУС, БУС, Биологийн тэнхим, Экологийн биофизикийн лаборатори

Товч утга

Бид говь ба хээрийн бүсийн агаар дахь нүүрстөрөгчийн давхар ислийн концентрацийн хоног, улирал ба жилийн өөрчлөлтийг 2009 оноос хойш хэмжиж байна. Ургамал ургаж байх үед агаар дахь нүүрстөрөгчийн давхар исэл өдөр багасаж, шөнө ихсэдэг. Агаар дахь нүүрстөрөгчийн давхар ислийн өөрчлөлт зун их өвөл бага, хээрт их говьд бага, зунтай жил их гантай жил бага байсан. Агаар дахь нүүрстөрөгчийн давхар ислийн өөрчлөлт нь фотосинтезд шингээгдэх ба амьсгалаар ялгарах нүүрстөрөгчийн давхар ислийн харьцаагаар тодорхойлогдоно гэсэн дүгнэлт гаргаад түүнийгээ батлав.