Experimental study on N_2O and CH_4 fluxes from the dark coniferous forest zone soil of the Gongga Mountain, China

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Abstract The static closed chamber technique is used in the study on the CH_4 and N_2O fluxes from the soils of primeval *Abies fabri* forest, the succession *Abies fabri* forest and the clear-cut areas of mid-aged *Abies fabri* forest in the Gongga Mountain from May 1998 to September 1999. The results indicate the following: (i) The forest soil serves as the source of atmospheric N_2O at the three measurement sites, while the fluxes of CH_4 are all negative, and soil is the sink of atmospheric CH_4. The comparative relations of N_2O emissions between the three sites are expressed as primeval *Abies fabri* forest > clear-cut areas > succession *Abies fabri* forest, and those of CH_4 consumption fluxes are primeval *Abies fabri* forest > succession *Abies fabri* forest > clear-cut areas. (ii) Significant seasonal variations of N_2O emission at various sites were observed, and two emission peaks of N_2O occurr during summer (July—August) and spring (February—March), whereas N_2O emission is relatively low in winter and spring (mid March—April). Seasonal variations of CH_4 consumption at each measurement site fluctuate drastically with unclear regularities. Generally, CH_4 consumption fluxes of succession *Abies fabri* forest and clear-cut areas are higher from mid May to late July but lower in the rest of sampling time, while the CH_4 flux keeps a relatively high value even up to September in primeval *Abies fabri* forest. In contrast to primeval *Abies fabri* forest, the CH_4 absorbabilities of succession *Abies fabri* forest and clear-cut areas of mid-aged *Abies fabri* forest are weaker. Particularly, the absorbability of the clear-cut areas is even weaker as compared with the other two sites, for the deforestation reduces the soil absorbability of atmospheric CH_4. (iii) Evident diurnal variation regularity exists in the N_2O emissions of primeval *Abies fabri* forest, and there is a statistic positive correlation between the fluxes of N_2O and air temperature (R=0.95, n=11, $\alpha < 0.01$), and also the soil temperature of 5-cm layer (R=0.81, n=11, $\alpha < 0.01$), whereas the CH_4 diurnal variation regularities are unclear and have no significant correlation with the soil temperature of 5-cm layer and air temperature.

Keywords: Gongga Mountain, mountain dark coniferous forest, soil, CH_4, N_2O, flux.

The increasing concentration of greenhouse gas in the atmosphere and their resultant climatic and environmental changes have been drawing much attention of the governments of various countries in recent years. The sphere of global influence and the complicatedness of the study processes have also made it become the current core subject of many international research programs (IGBP-WCRP-IHDP) and the major topics of numerous international negotiations on environmental issues.

Forest is the most extensively distributed vegetation type in the world and its total area on the globe accounts for 1/3 of the earth total land area (4.1×10^9 ha)[1]. It is one of the most important component of terrestrial ecosystem that plays an extremely important role in the source and sink function of greenhouse gases. Internationally, since the 1970s substantial research work has been carried out one after another on sources and sinks of greenhouse gases of forest ecosystems[2—6]. In China, the work on forest ecosystem started relatively late, but great progress has been made in the past more than ten years and a wealth of experimental results have been obtained. On the whole, however, the existing research work on greenhouse gas fluxes of forest ecosystems in China is still relatively weak, the previous work on forest ecosystem is mostly concentrated on forest biomass and net primary productivity, namely, on the absorption and fixation of atmospheric CO_2 by forest. Even if greenhouse gas fluxes from forest soils are involved, studies have been mostly focused on CO_2[7—10] and there are few data reported on CH_4 and N_2O fluxes from forest ecosystem in China. Forest is extensively distributed in China and the forest coverage is 13.9%[11]. Therefore, the measurement of CH_4 and N_2O fluxes *in situ* is of great significance to the accurate estimation of the impact of China's forest ecosystem on global greenhouse effect. In view of the above-mentioned reasons, this paper selected well preserved typical subalpine dark coniferous forest belt in Gongga Mountain among the subtropical forest ecosystems where the present research is relatively weak in our country as principal experimental area. Dark coniferous forest is extensively distributed in the Hengduan Mountains where dark coniferous forest belt is the dominant belt amongst mountainous vertical vegetation spectrum. This dark coniferous forest belt abounds with rich forest resources and is the key part of China's second largest forest area—the Southwest Forest Area[12]. Simultaneous measurements of soil CH_4 and N_2O fluxes in the selected area were carried out together with the comparative studies of the soil CH_4 and N_2O flux regimes under anthropogenic disturbances to different degrees, for the purpose of providing certain basic data for accurate forecasting future climate change.

1 Experiments and measurements

1.1 General situation of the experimental area

The measurement sites were located in mountainous dark coniferous forest 3000 m to 3150 m in altitude in the Gongga Mountain. Gongga Mountain is located in the transitional belt between China's eastern monsoon subtropics and frigid area of the Qinghai-Tibetan Plateau and lies between 29°00′—30°20′N and 101°30′—102°15′E. A complete natural vertical spectrum ranging from subtropics to frigid zone was very well developed in the area. There are rich species resources with strong primary ecological environment and well preserved original conditions. This provides ideal sites for scientific research of background regimes of forest ecosystem greenhouse gas fluxes and their comparative studies under different anthropogenic disturbances. The annual mean air temperature of this area is 3.8℃, mean air temperature of January is −4.3℃ and that of July is 11.9℃. The annual average precipitation is 2175.4 mm, mostly concentrating in June—September and accounting for 60.6% of the year's total.

CH_4 and N_2O fluxes were measured from May 1998 to September 1999 in the above area, the study selected three types of forest land at different growth stages, i.e. three types of anthropogenic affected forest communities to different degrees. The three types of forest communities include the undisturbed primeval *Abies fabri* forest (the tree age is about 160 a), moderately disturbed succession mid-aged *Abies fabri* forest (the tree age is 78 a), and intense anthropogenic disturbed clear-cut area of *Abies fabri* forest (by clear-cutting in 1995). With the exception of clear-cut area, the constructive species of the other two plant community sites are *Abies fabri* , what is different is the community compositions induced by anthropogenic disturbances to different degrees. The basic situations of different plant communities are described as follows.

1.1.1 The primeval *Abies fabri* forest. The constructive species of primeval forest is *Abies fabri* with a total canopy density of about 0.7. There are two vertical parts in the arbor layer. *Abies fabri* constitutes the upper layer, the tree height is about 31—38 m, the breast-height diameter (b.h.d.) is 50—80 cm, and the canopy density of this layer is about 0.6. The second layer mainly consists of broad-leaved trees, having *Betula utilis*, *B. insignis* and *Sorbus hemsleyi* as the common tree species. The tree height is 15—20 m, the breast-height diameter (b.h.d.) is 20—35 cm, and canopy density is 0.4. The scrubs under the arbor layer are mostly *Bashania fangiana* with a cover degree of about 60%. There are diverse species in the herbaceous layer, but they are sparse and unevenly distributed with a total cover degree of only about 30%. *Smilacina japonica, S. paniculata* and *Cardamine tangutorum* are the common species of this layer. The ground layer of the primeval *Abies fabri* forest is about 15 cm thick, and the plant species are mainly mosses, such as *Abietinella abietina, Actinothuidium hookeri* and so on.

1.1.2 The succession *Abies fabri* forest. Rooted in the blank of primeval *Abies fabri* forest destroyed by the debris flows, the succession forest has developed into the mid-aged forest with a tree age of 78 a following plant succession. The total canopy density is relatively high, being about 0.8. The constructive species is also *Abies fabri*. In addition, there still remain a few pioneer tree species of *Populus purdomii* during the succession. The *Abies fabri* is about 18 m high and the breast-height diameter is 20—30 cm. Under arbor layer, there are some sparse scrubs and herbage with cover degree being smaller than 30% each. The scrubs include *Rhododendron pachytrichum, Euonymus porphyreus* and *Clematoclethra scandens. Oxalis griffithii*, *Galium aparine* and *Cucubalus baccifer* are the main species in the herb layer. The species of moss in the ground layer are similar to those of the primeval *Abies fabri* forest, but the thickness is only about 7 cm.

1.1.3 The clear-cut area. The clear-cut area came into being after the clear-cutting of the mid-aged succession *Abies fabri* forest in 1995. The vegetation of the clear-cut area is mainly

Cacalia davidii. There are still a few young pioneer trees such as *Populus purdomii* and *Salix rehderiana* in this area. The biomass of pioneer community is only about one thirty-fifth of that of the succession *Abies fabri* forest.

1.2 Methods

Simultaneous measurements of CH_4 and N_2O fluxes were carried out at each site with a frequency of 15 days once. Seasonal variation and diurnal variation of CH_4 and N_2O fluxes were studied. Meanwhile, environmental factors such as soil moisture, soil nutrient, air temperature and soil temperature were also measured simultaneously. Vegetation types and soil physiochemical properties at each site are listed in table 1.

Table 1 Vegetation types and soil physiochemical properties at measurement sites

Forest type	Soil type	Soil layering[a)] /cm	Available N /mg • kg^{-1}	Total N /g • kg^{-1}	Organic matter /g • kg^{-1}	pH (H_2O)	pH (KCl)
Primeval *Abies fabri* forest	dark brown forest soil	0 — 10	1062.2	18.8	536.4	4.8	3.8
		10 — 16	500.3	5.8	163.7	4.8	4.0
		16 — 40	129.3	1.6	83.1	6.2	5.0
Succession *Abies fabri* forest	skeleton soil	0 — 9	824.2	19.8	565.3	5.4	4.2
		9 — 30	32.62	0.2	9.2	6.7	5.1
Clear-cut area of mid-aged *Abies fabri* forest	skeleton soil	0 — 10		4.9	234.6	7.0	
		10 — 20		0.8	17.5	7.4	

a) Soil layering also includes the thick ground layer and the humic litter on top soil layer.

1.3 Flux measurement and techniques

Gas fluxes were measured using an enclosed static chamber technique. The enclosed chamber was made from 5-mm-thick acrylic material. The base area of the chamber is 48.4 cm×43.8 cm. The chamber is 40 cm high. During the period of the measurements, the chamber is inserted into the soil of 5 cm in depth and sealed with earth at four sides. When gas was gathered the box was lidded and the lid was fitted with an air mixture fan, a temperature sensor and a 3-way sampling stopcock. For each flux measurement (generally between 09:00 and 12:00 a.m.), 500 mL headspace gas was extracted from the chamber with a Teflon-covered membrane pump five times within half an hour (at 0, 5, 10, 20 and 30 min respectively after being lidded), then they were pumped into polyethylene-coated aluminum bags for further concentration analysis of CH_4 and N_2O.

CH_4 and N_2O concentrations were analyzed immediately after the field experiments by a GC (type: Hewlett-Packard 5890II), which was equipped with a flame-ionization detector (FID) and an electron capture detector (ECD). For CH_4, the GC had a Porapak Q column (80—100 mesh, 3.15 mm in o.d. and 3.68 m in length), and the oven temperature was held at 90°C. The carrier gas was N_2 with a flow rate of 23 mL/min, and the FID temperature was maintained at 150℃. Analysis for each CH_4 sample can be finished within 2 min. For N_2O, the GC had a backflush system consisting of a stainless steel precolumn (3.2 mm in o.d. and 1.84 m in length) and an analytical column (3.2 mm in o.d. and 3.68 m in length) packed with Porapak Q, with 80—100 mesh for both, and the oven temperature was held at 90℃. The ECD temperature was maintained at 330℃. The carrier gas (5% CH_4 in Ar) flow rate was adjusted to 26 mL/min through the analytical column, and that of the backflush gas to 40 mL/min through the precolumn. Analysis for each N_2O sample can be finished within 5 min.

1.4 Flux calculation.

The gas flux represents unit time and unit area change of the gas quality inside the chamber. The positive value denotes the gas emission into atmosphere from soil and the negative value represents the gas flow from air to soil or soil absorption of this gas from atmosphere. The flux of gas (N_2O or CH_4) can be given from the following formula[13]:

$$F = \frac{\Delta m}{\Delta t} \cdot D \frac{V}{A} = hD \frac{\Delta m}{\Delta t},$$

where F refers to flux of a gas (N_2O or CH_4), V is the volume of the chamber, A the earth area sealed the chamber at four sides, D is the gas density of the chamber ($D = n/v = P/RT$, mol/m^3, P the air pressure, T the temperature inside the chamber and R the air constant), $\triangle m/\triangle t$ denotes linear slope of concentration change with time over measurement period and h represents the height of the chamber.

2 Results and discussions

2.1 Comparison of N_2O and CH_4 fluxes from forest land types disturbed to different degrees

Table 2 indicates the annual average fluxes of N_2O and CH_4 from all the measurement sites. In the table we can find the emission results from the N_2O exchanges between soil and atmosphere at each site and soil is the source of atmospheric N_2O. Annual N_2O emissions of different sites vary significantly (F=13.61, P<0.01), of which soil N_2O emission is the highest from primeval *Abies fabri* forest where the annual average emission rate is 51.21 μg N_2O • m^{-2} • h^{-1}; soil N_2O emission intensity from clear-cut area is much lower than that of primeval *Abies fabri* forest, but higher than that of succession *Abies fabri* forest with N_2O emission being 13.41 μg N_2O • m^{-2} • h^{-1}; and the N_2O emission from succession *Abies fabri* forest (the tree age is 78 a) is 7.98 μg N_2O • m^{-2} • h^{-1}, the lowest amongst various measurement sites. The reasons accounting for the above-mentioned results may probably be associated with differences in soil physiochemical properties and community compositions of each site. Analysis of table 1 indicates that the soil of primeval *Abies fabri*

Table 2 N_2O and CH_4 fluxes of different forest types

Forest type	Annual mean N_2O emission /μg N_2O • m^{-2} • h^{-1}	Annual mean CH_4 flux /μg CH_4 • m^{-2} • h^{-1}
Primeval *Abies fabri* forest	51.21±41.68 (20)a)	−79.45±65.92 (23)
Succession *Abies fabri* forest	7.98±6.82 (20)	−45.35±41.44 (23)
Clear-cut area of *Abies fabri* mid-aged forest	13.41±9.05 (20)	−32.51±41.60 (23)

a) Annual mean flux ± standard deviation (the No. of measurement times).

forest is the mountain dark brown forest soil that has integrated structure and thick ground layer and humic litter layer. The resultant higher contents of the available N, total N and organic matter of primeval *Abies fabri* forest provide sufficient reactive substrate for soil nitrifying and denitrifying microorganisms[14]. Meanwhile, the acid environment of top soil layer is also favorable for N_2O generation and emission. According to the research results of Pertti et al. (1993), under aerobic conditions, when pH is 4, both N_2O generation rate and nitrification rate are greater than those when pH is 6. The amount of N_2O generation when pH is 4 reaches as high as 4—6 times of that when pH is 6[15]. Previous research data obtained by Nagele (1990)[16] and Weier (1986)[17] also proved this result. In addition, the age of primeval *Abies fabri* forest community is about 160 a and it is stepping in the climax forest stage gradually, the structure in the community of the arbor, scrub and herbaceous layers is reasonable, which results in the reasonable distribution of solar energy, the air temperature near the ground can rise fairly quickly and the soil temperature is also propitious to the production and emission of N_2O. That is why the N_2O emission is far higher than those of the other two measurement sites. For the succession *Abies fabri* forest, the soil type is the same as that of the clear-cut area, both belonging to skeleton soil type with disintegrated structure. The A horizon is thin and the B horizon has not yet formed, hence content of soil N in parent material is relatively low. In contrast to the clear-cut area, although the contents of total N and organic matter in top soils are higher than the clear-cut area, yet the canopy density of the succession *Abies fabri* forest is higher (total density being about 0.8) because of being in a vigorous growth period and thus the top soil temperature rises slowly. However, there are only sparse shrub and grass vegetation on ground surface of the clear-cut area where the top soil temperature rises quickly[18]. Results of variance analysis of the 5-cm soil temperatures of succession *Abies fabri* forest and clear-cut area throughout the measurement period indicate that the 5-cm soil temperatures of the sites differ much greatly (F = 10.54, P < 0.01). During the measurement, the 5-cm soil temperature of the clear-cut area is much higher than that of simultaneously measured succession *Abies fabri* forest, the higher temperature accelerates the soil N_2O generation and emission. Thus, during the period of experiencing quick temperature rise again from early-May to late-July there is also a significant difference in the N_2O emissions between the two measurement sites (F=4.99, P < 0.05). In the other period, the N_2O emissions of the clear-cut area are nearly as much as those of the succession *Abies fabri* forest. To take one with another, the annual emission of clear-cut area is slightly higher than that of the succession *Abies fabri* forest. The contrast relations of N_2O emissions of the three sites can be described as primeval *Abies fabri* forest > clear-cut area > succession *Abies fabri* forest.

From table 2, we can see that CH_4 fluxes at the three measurement sites are negative values, namely, the CH_4 exchange between soil and atmosphere exclusively presents as a consumptive result, and soil is the sink of atmospheric CH_4. The CH_4 consumption flux displays a declining trend from the primeval *Abies fabri* forest, succession *Abies fabri* forest to clear-cut area. The reasons accountable for this are probably related to the gradual decline of the organic matter content of top soil layer at each site (see table 1). The same results can be seen in the researches of temperate forests conducted by Dong[19] and Sun[20]. According to these research results, oxidative consumption of CH_4 is related to the mineralization of soil organic matter, the lower organic matter content can outstandingly reduce the activity of CH_4 nutrient bacteria. The soil type of primeval *Abies fabri* forest is the mountain dark brown forest soil that has a higher content of organic matter while the soil types of the succession *Abies fabri* forest and the clear-cut area are both of skeleton soil where there is a rapid decrease of the organic matter under the 10-cm depth of soil. It is particularly so in the clear-cut area, where there are great changes in community composition and the situation of underlying surface after the clear-cutting of forest that results in the rapid loss of organic matter and other nutrients[21]. So, the organic matter in its top soil is also far lower than the other measurement sites. Anthropogenic disturbance to forest land has also lowered the soil oxidative absorbability to CH_4 to a certain extent. Hence with the gradual intensification of anthropogenic disturbance extent and the gradual decrease in top soil organic matter, the CH_4 absorptive ability also displays a decreasing trend from primeval *Abies fabri* forest, succession *Abies fabri* forest to clear-cut area. Anthropogenic disturbances have directly or indirectly changed the forest soil and atmospheric C exchange intensity.

2.2 Seasonal variations of N_2O and CH_4 fluxes

During the period of experiment (May 1998 to September 1999), the fluxes of N_2O and CH_4 at the three measurement sites fluctuate significantly with time (see figs. 1 and 2). The trend of seasonal variations of N_2O emission presents roughly as rising gradually from May to June, reaching the maximum from July to mid August (primeval *Abies fabri* forest reaching the maximum from February to March), and then declining slowly. N_2O emission also changes slightly during the period. N_2O emission maintains a lower level in winter from the end of October to early January next year, it then rises slowly after mid January and reaches the secondary high value in February (primeval

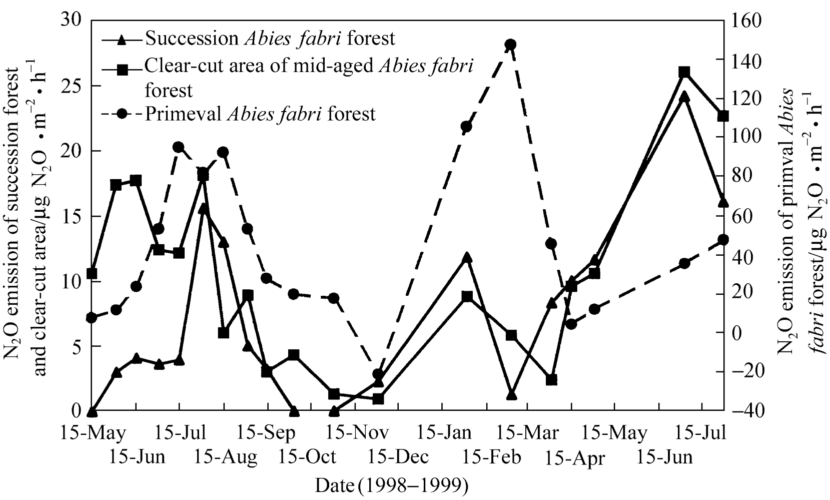

Fig. 1. Seasonal variations of N_2O emission at each measurement site.

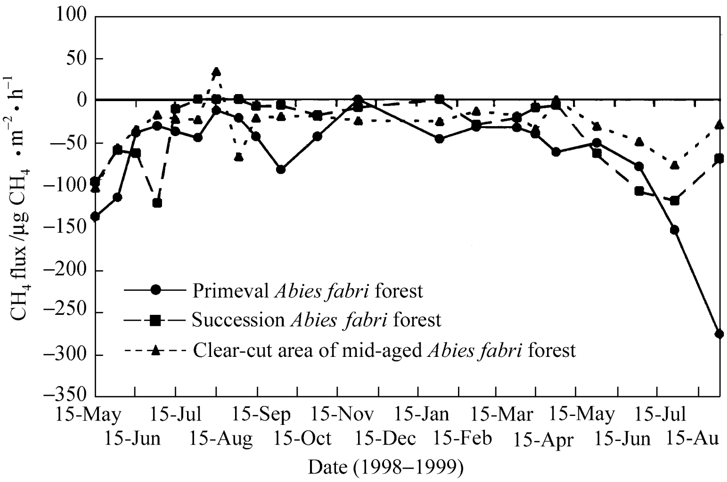

Fig. 2. Seasonal variations of CH_4 fluxes at each measurement site.

Abies fabri forest reaches secondary high in the pericod of July-August), it then drops slowly to reach secondary low value around April, and then begins to increase with the rise of temperature. Two N_2O emission peaks occurred during the whole measurement period. The reasons for the high N_2O emission from February to March at each site are probably related to the accelerated N_2O emissions in the experimental area where frozen soil begins to thaw during this period, the rising soil moisture content and temperature stimulate the activation of soil nitrifying and denitrifying bacteria enzyme, hence accelerating N_2O emission. Meanwhile, N_2O emissions in the freezing-thawing process are probably due to the fact that N_2O sealed in soils during freezing period or inactivated soil microorganism of the freezing period produced after experiencing nitrification or denitrification processes was emitted along with freezing-thawing process. Our results agree with the researches on farmland N_2O emission conducted by Huang[22]. From mid March to April, air temperature and soil temperature at each site is still relatively low, and the relatively low soil temperature restrains the activation of soil microorganisms, hence the N_2O generation is low correspondingly. At the same time the N_2O sealed in soils during freezing period has already basically been emitted, resulting in a soil N_2O emission lower than in February. In May, the clamite of the study area enters the rainy season, both soil moisture and soil temperature begin to go up again, so the slow rise of N_2O emission also occurs. In July and August, both soil temperature and soil moisture are favorable for soil nitrification and denitrification, which, accompanied with rising temperature, accelerates the decomposition of soil organic matter. The decomposed organic matter provides sufficient reactive substrate and energy for the nitrification and denitrification of microorganisms. In addition, oxygen consumption for decomposing organic matter also enhances the lack of oxygen in soil, speeding up denitrification of soils[14] and furthering soil N_2O production and emission. Upon entering October, the clamite of the measurement area gradually turns into dry season, the fairly quick decrease of soil moisture and gradual drop of temperature result in the gradual decline of the amount of N_2O produced, even negative emission occurs in a certain time (e.g. primeval *Abies fabri* forest, December 1998).

Fig. 2 shows that seasonal variations of CH_4 consumption fluxes at each site fluctuate drastically with unclear regularity. Generally speaking, however, CH_4 consumption fluxes of succession *Abies fabri* forest and clear-cut area are both relatively high from mid May to late July, but relatively low in the rest of the year. Particularly in winter, the CH_4 consumption ability is the weakest, while for the primeval *Abies fabri* forest, the CH_4 consumption flux in September still keeps a relatively high value. On the contrary, the CH_4 consumption abilities of succession *Abies fabri* forest and clear-cut area are relatively weak, particularly the case of clear-cut area. Because in the period from May to July when the consumption flux is relative high during a year, the consumption to CH_4 of the clear-cut area is still far lower than that of the primeval *Abies fabri* forest and succession *Abies fabri* forest; what is more, even positive CH_4 flux occurs in the individual measurement time intervals.

2.3 Diurnal variations of N_2O and CH_4 fluxes of primeval *Abies fabri* forest

In addition to the study on the seasonal variations of each site, we also conducted measurements about the diurnal variations of the N_2O and CH_4 fluxes at primeval *Abies fabri* forest measurement site which was minimally disturbed by anthropogenic activities. From fig. 3, we can find significant diurnal variations of N_2O emissions. In general, the N_2O emission is high at 10:00 a.m. and 18:00 p.m. during daytime while the minimum value is at 01:00 during the nighttime. There is a

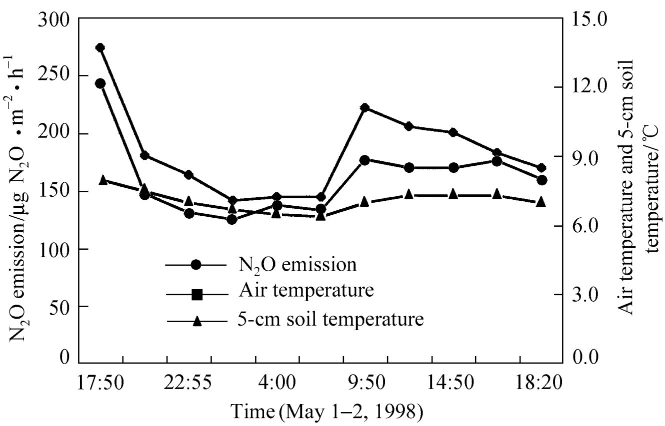

Fig. 3. The diurnal variation of N_2O emissions in primeval *Abies fabri* forest.

strong positive linear correlation between N_2O emission and air temperature (R = 0.95, n=11, $\alpha <$ 0.01) and also a relatively clear positive correlation between N_2O emission and soil temperature on 5-cm layer (R=0.81, n=11, $\alpha < 0.01$). In addition, we cannot find the significant peak at 18:00 on the second day from fig. 3. The reasons for the result are that it turned cloudy accompanying heavy fog after 13:00 on the second day, which resulted in indirectly the smooth changes of the air temperature and the soil temperature. Diurnal variation of CH_4 flux is similar to its seasonal changes (see fig. 4). There exist great fluctuations but no apparent regularity, and no significant correlations between CH_4 fluxes, air temperature and the soil temperature. But it shows the variation of CH_4 fluxes with higher consumption at nighttime and lower consumption during daytime, the results are similar to those obtained from the grassland of Inner Mongolia by Dong[13] and Wang[23]. However, the influencing

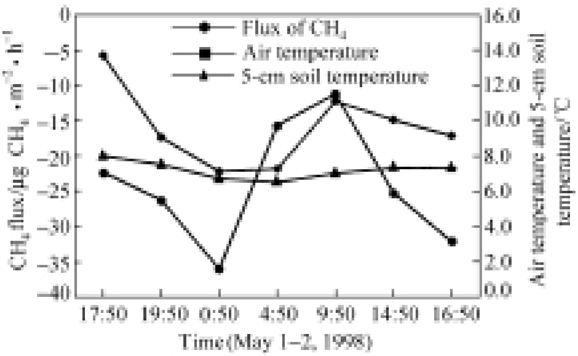

Fig. 4. The diurnal variation of CH_4 fluxes in primeval *Abies fabri* forest.

factors are still unclear, and more studies are needed.

3 Conclusions

(1) During the exchanges between soil and atmospheric N_2O at all measurement sites in the Gongga Mountain, soil serves as the source of atmospheric N_2O and sink of atmospheric CH_4. The flux relations of N_2O emission of all the measurement sites appear as primeval *Abies fabri* forest > clear-cut area of mid-aged *Abies fabri* forest > succession *Abies fabri* forest, and the CH_4 consumption flux as primeval *Abies fabri* forest > succession *Abies fabri* forest > clear-cut area. The existence of the above relations is related to soil physiochemical properties and differences of community compositions of various sites.

(2) Significant seasonal variations of N_2O emissions are found at all sites. In summer from July to August and spring period of February-March, N_2O emissions are high with the occurrence of two N_2O emission peaks. In winter and spring from mid March to April, N_2O emission is relatively low; seasonal variations of CH_4 sink intensity at the three measurement sites fluctuate drastically with insignificant regularity. Generally speaking, CH_4 consumption flux in the succession forest and clear-cut area is the highest from mid May to late July, relatively low in the remaining period, and the weakest in winter. CH_4 consumption flux of primeval *Abies fabri* forest still maintains a relatively high value in September. In comparison with primeval *Abies fabri* forest, CH_4 consumptive abilities of succession *Abies fabri* forest and clear-cut area are weaker, it is particularly so in the clear-cut area. As for the first two measurement sites, their CH_4 consumptive abilities are much weaker, even CH_4 positive flux occurs at individual measurement time intervals.

(3) There exists apparent diurnal variation of N_2O emission in the primeval *Abies fabri* forest, and N_2O emission is positively correlated with air temperature and 5-cm soil temperature. Diurnal variation regularity of CH_4 flux is not clear with unapparent correlations either with air temperature or soil temperature.

(4) Disturbances of anthropogenic activities and changes directly or indirectly resulting from them in forest community composition, forest vegetation, soil carbon pools, nitrogen pools and habitat will change not only apparently the C and N sources and sink intensity of the soil to the atmosphere but also the direction of the C and N source and sink of the forest to the atmosphere under certain circumstances.

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