Diurnal and seasonal greenhouse gases exchange in a salt marsh in central Japan

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Abstract
Diurnal and seasonal fluctuations of greenhouse gas (GHG) exchange in a salt marsh were measured using the closed chamber method. The salt marsh sediment seemed to act as the source for CO_2 and N_2O and as a sink for CH_4 during winter but as a source during summer. With diurnal fluctuation of water level at the salt marsh, methane and nitrous oxide were emitted all day long whereas carbon dioxide was absorbed.

Key Words
Carbon dioxide, nitrous oxide, methane, redox potential, electrical conductivity, closed chamber method.

Introduction

Salt marshes may exist in any estuaries where a big river flows into sea. River water transports large amounts of nutrients from upper streams and deposits them in salt marshes in estuaries. Nutrients involving nitrate nitrogen (NO_3^--N), plant residues, and organic mattes may result in greenhouse gas (GHG) emissions in salt marshes. Soil in salt marshes located in a tidal effect area may become alternately aerobic and anaerobic conditions. Under such conditions, nitrous oxide (N_2O) and methane (CH_4) gases tend to be emitted (Hou *et al.* 2000). These gases are considered as very strong GHGs relative to carbon dioxide (CO_2) gas. Salinity and sulfate ion in sea water are reported to suppress the emission of N_2O and CH_4 gases (Supparattanapan *et al.* 2009; Martens and Berner 1974). In contrarily, Oremland *et al.* (1982) reported that CH_4 production and sulphate reduction simultaneously occurred in salt marsh sediments.

Methods

GHG sampling
Four samples of GHG were collected with 10 min intervals using a syringe with a closed chamber (144 mm in dia., 235 mm high) for seasonal measurement inserted about 50 mm into sediment. For diurnal measurement, larger chambers (600 mm long, 300 mm wide, 1,060 mm high) were used. The gas chambers were quadruplet. Gas sampling was duplicated or triplicated. Gas samples collected were stored in vials that were kept in a cooler box during transporting to the laboratory. The gas samples were analysed for CO_2, N_2O, and CH_4 using a gas chromatography with FID and ECD (model 6890N, Agilent Technologies, CA).

GHG flux estimation
Gas flux, J_g (mg/m^2/h), was estimated as (De Mello and Hines 1994):

$$J_g = 1000\frac{V}{A}\left.\frac{dC(t)}{dt}\right|_{t=0} \quad (1)$$

where V is the flux chamber volume (m^3), A the flux chamber basal area (m^2), and $[dC(t)/dt]_{t=0}$ is the slope of a gas concentration change curve at time t=0 (g/m^3/h) as expressed in Eq. (2). Temporal changes in gas concentration in the flux chamber covering on the soil surface may be expressed (de Mello and Hines, 1994) as:

$$C(t) = C_{\max} - (C_{\max} - C_0)\exp(-kt) \quad (2)$$

where $C(t)$ is the gas concentration (g/m^3) in a closed chamber at time t after deployment, C_{max} the maximal concentration (g/m^3) reached when the gas concentration in the closed chamber equilibrates to the gas concentration of soil pores, C_0 the gas concentration (g/m^3) at t=0 in the closed chamber, and k a rate constant. Differentiating Eq. (2) with respect to t and providing t=0 to the resultant are:

$$\left.\frac{dC(t)}{dt}\right|_{t=0} = k(C_{\max} - C_0) \quad (3)$$

in which the values of k, C_{max}, and C_0 are estimated by fitting Eq. (2) to gas concentrations measured with time. A curve fitting procedure was performed using the solver function of Excel spreadsheet software in a similar manner that reported by Wraith and Or (1998).

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Results

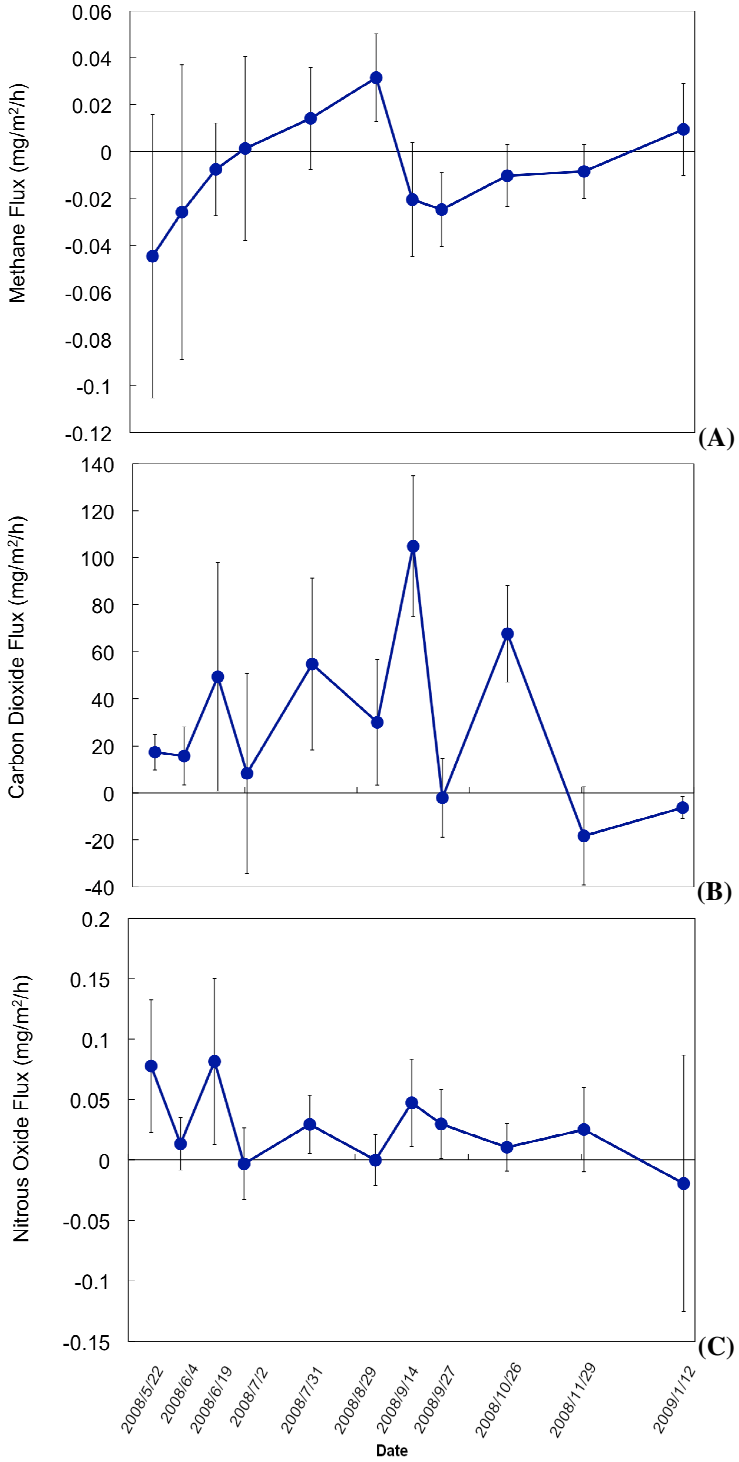

Figure 1. Seasonal changes in methane (A), carbon dioxide (B), and nitrous oxide (C) exchange between the atmosphere and the salt marsh sediment.

Methane emission was tended to increase during summer whereas its absorption increased during fall (Figure 1A). Carbon dioxide, on the other hand, was emitted mostly all year around with some fluctuations (Figure 1B). The degree of emission was tended to increase in summer and to decrease in winter. Nitrous oxide was emitted all year around with some fluctuations as well (Figure 1C). The salt marsh sediment seemed to act as the source for CO_2 and N_2O while as the sink for CH_4 during winter but as the source during summer.

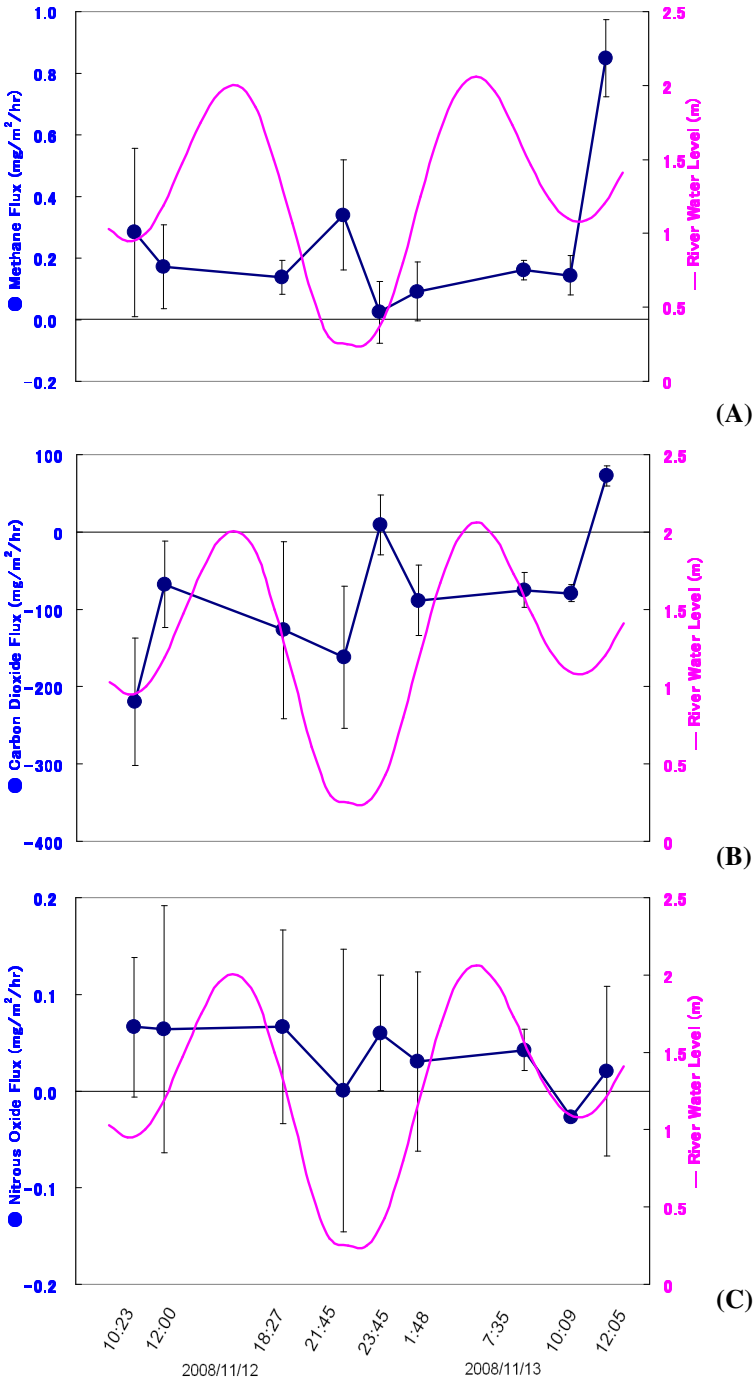

Figure 2. Diurnal changes on November 12th and 13th in water level at the salt marsh along with methane (A), carbon dioxide (B), and nitrous oxide (C) exchange between the atmosphere and the salt marsh.

Diurnal fluctuation of water level was apparent as shown in Figure 2 Methane and nitrous oxide were emitted (Figures 2A, 2B) all day long whereas carbon dioxide was absorbed (Figure 2B). Emissions and absorptions were larger as water level was lower. High tide seems to suppress the emission and absorption.

Conclusion

Salt marsh had dynamic exchange of GHG between the atmosphere and the sediment. It acted mostly as sources for CO_2 and N_2O whereas as a sink for CH_4 during winter. More comprehensive research is needed for further knowledge.

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