Climatic impacts on greenhouse gas emissions in rice paddy fields

Shujiro Komiya[A], Yuki Shoji[B], Kosuke Noborio[A], Tomotsugu Yazaki[C], Theerayut Toojinda[D] and Meechai Siangliw[D]

[A]School of Agriculture, Meiji University, Kanagawa, Japan, Email ef60113@isc.meiji.ac.jp, noboriok@isc.meiji.ac.jp
[B]NTC International Co., Ltd, Tokyo, Japan.
[C]National Agricultural Research Center for Hokkaido Region, Sapporo, Hokkaido, 062-8555 Japan.
[D]National Center for Genetic Engineering and Biotechnology, Kasetsart University, Kamphaengsaen, Nakhonpathom 73140, Thailand.

Abstract
Greenhouse gas emissions from rice paddy fields may be influenced by climatic or soil environment conditions. In this study, we investigated greenhouse gas emissions associated with climatic impacts. Experiments were conducted in Thailand and Japan. Emissions of CO_2, CH_4 and N_2O in rice paddy fields were continuously measured using the relaxed eddy accumulation method. As factors affecting greenhouse gas emissions, air temperature, humidity, soil temperature, soil redox potential and net irradiance were measured as well. This paper presents the behaviour of greenhouse gas flux in Thailand and Japan.

Key Words
Rice paddy field, CO_2, CH_4, N_2O, net irradiance, soil temperature.

Introduction
Global warming is an important issue for humans. A major attributor of global warming is increases in greenhouse gases. Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are considered as major greenhouse gases. The global warming potential in CH_4 and N_2O are 21 times and 296 times respectively, so that CH_4 and N_2O are important gases. Anthropogenic greenhouse gas emission for CH_4 and N_2O accounts for 70% and 46% in the total greenhouse gas emission (IPCC 2001). Methane emission from paddy field makes up 29% of the total of CH_4. Also N_2O emission from agricultural land makes up 52% of the total of anthropogenic N_2O. So, greenhouse gas emissions from rice paddy fields are considered as one of the most important emission sources. Methane emission from rice paddy fields is high in a flooded field, but decreases in a drained field. Nitrous oxide emission from rice paddy fields is little in flooded, but increases sharply in drained fields. It is reported that the factors affecting CH_4 and N_2O emissions are soil temperature, soil redox potential, net irradiance and organic matter (Hou *et al.* 2000). Since the area in rice cultivation spread from the tropical region to the cool-temperate region, it is expected that those factors vary in each climate zone. The objective of this study was to investigate climatic impacts on greenhouse gas emissions in rice paddy fields.

Methods
Field experiments were conducted at an experimental field for rice plants, Kasetsart University, Kamphaengsaen, Thailand and a rice farming field, Hiratuka, Japan. Gas fluxes (CO_2, CH_4, N_2O) were continuously measured with 20 min intervals using the relaxed eddy accumulation method (McInnes and Heilman 2005) developed recently. Gas concentration (CO_2, CH_4, N_2O) was analysed by a photoacoustic field gas-monitor (model 1412, Innova Air Tech Instruments, Denmark). Air temperature, humidity, soil temperature, soil redox potential and net irradiance were also continuously measured with 5 min intervals.

Results
In Hiratuka, CO_2 flux started to increase in the afternoon and reached a maximum in the midnight (Figure 1). In Thailand, CO_2 flux reached a maximum in the daytime, but the temporal change in CO_2 flux was the opposite variation relative to Hiratuka. CO_2 flux increased with the decrease in the net irradiance in Hiratuka, which indicates the respiration of rice plants was more active during the night. CH_4 flux in Hiratuka was lower than in Thailand during an anthesis period. In Thailand, CH_4 flux started to increase in the early morning with the net irradiance increasing and reached a maximum, but the temporal change in CH_4 flux in Hiratuka was smaller than in Thailand (Figures 2 and 4). The behaviour of N_2O flux in two sites was similar to CH_4 flux in Thailand (Figure 3). Soil surface temperature was strongly influenced by net irradiance in Thailand (Figures 4 and 5). It is expected that the rapid rise of soil temperature in Thailand stimulated the activities of soil microorganisms and as a result, larger flux of CH_4 and N_2O occurred.

1 – 6 August 2010, Brisbane, Australia. Published on DVD.

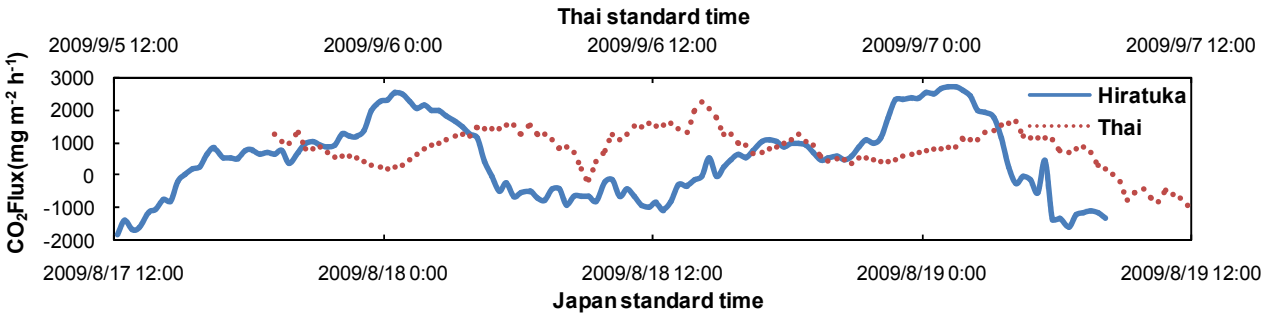

Figure 1. Temporal changes in CO_2 flux during anthesis.

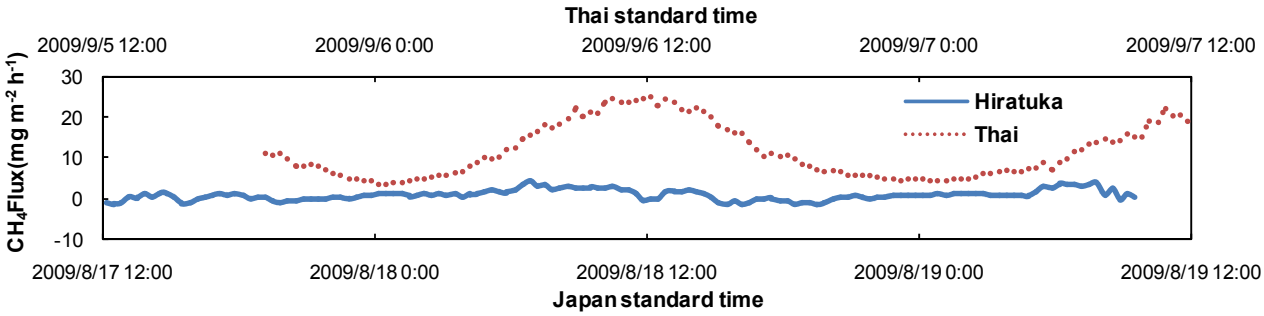

Figure 2. Temporal changes in CH_4 flux during anthesis.

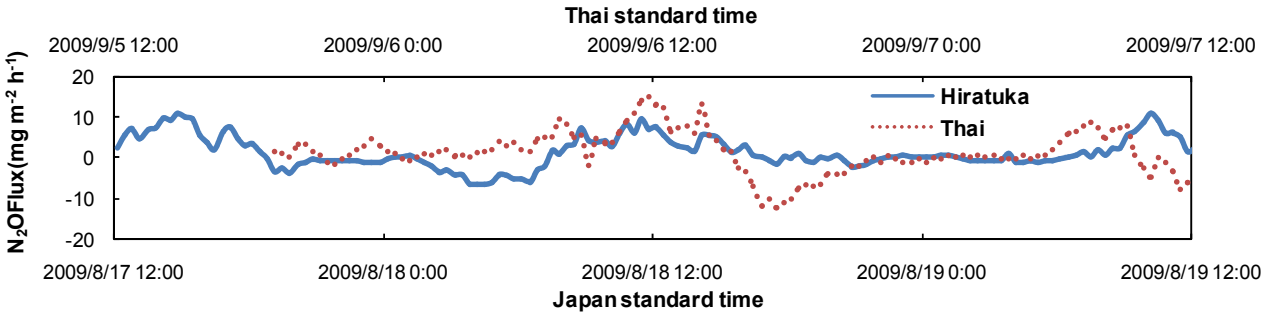

Figure 3. Temporal changes in N_2O flux during anthesis.

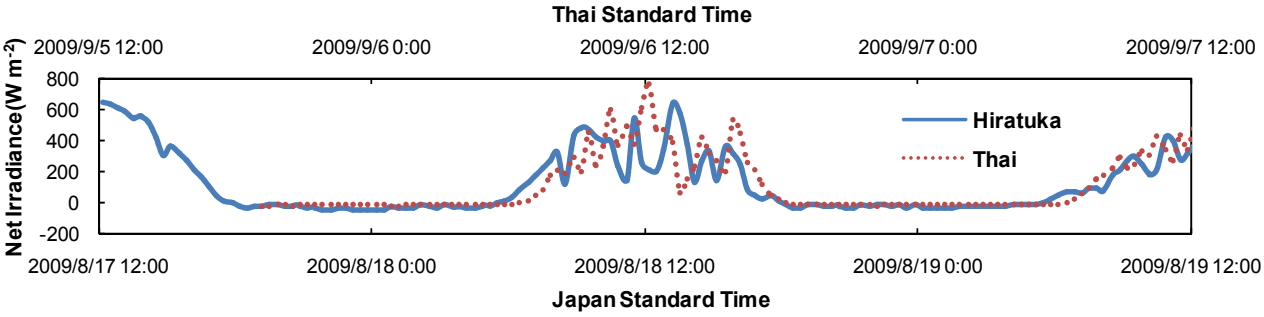

Figure 4. Temporal changes in net irradiance during anthesis.

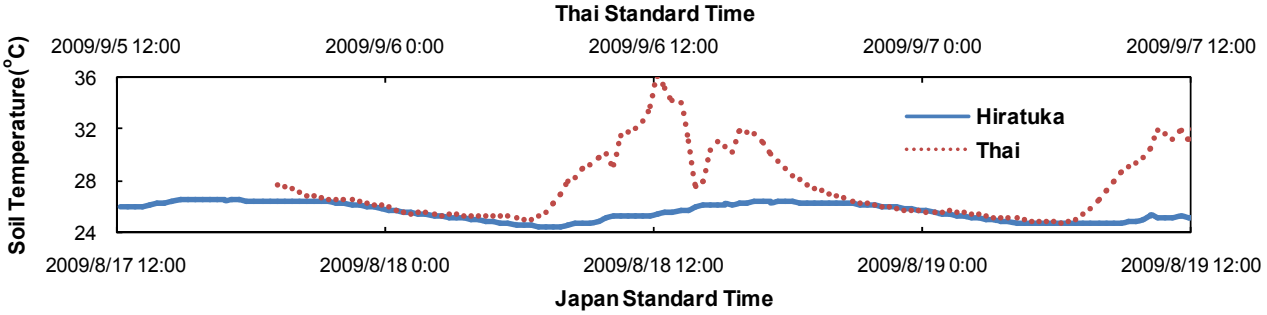

Figure 5. Temporal changes in soil surface temperature during anthesis.

Conclusions

The study showed the behaviours of CO_2, CH_4 and N_2O flux are affected by net irradiance in anthesis. Specifically, the impacts of the net irradiance to greenhouse gas flux in Thailand was stronger than in Hiratuka, so it is possible that the net irradiance is one of the important factor affecting greenhouse gas emission in the tropical region.

Acknowledgements

This research was partly supported by Grant-In-Aid for Scientific Research (A)(18208021) by Japan society for the Promotion of Science.

References

IPCC (2001c) Climate Change 2001: Rediative forcing of climate change. Available at: http://www1.ipcc.ch/ipccreports/tar/wg1/pdf/TAR-06.PDF.

Hou AH, Chen GX, Wang ZP, Van Cleemput O, Patrick WH Jr (2000) Methane and nitrous oxide emissions from a rice field in relation to soil redox and microbiological processes. *Soil Science society of America Journal* **64,** 2180-2186.

McInnes KJ, Heilman JL (2005) Relaxed eddy accumulation. In 'Micrometeorology in agricultural systems'. (Eds JL Hatfield *et al.*) pp. 437-453. (ASA-CSSA-SSSA Publishing: Madison, WI, USA).