Gaseous composition of smoke samples obtained at a tropical peatland fire

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Abstract
Tropical peatland in Indonesia is one of the most important atmospheric carbon sources due to rapid peat decomposition and frequent wildfire. To obtain a basic data to evaluate the influence of fire on carbon and greenhouse gas release from peatland, gaseous composition of smoke samples were analysed. The concentrations of carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4) and nitrous oxide (N_2O) were determined and compared with each other. The concentrations of CO and CH_4 were highly correlated to that of CO_2. The ratio of CO_2 : CO : CH_4 = 1.0 : 0.38 : 0.026. The concentrations of CO_2 and N_2O also had a high correlation, showing a slightly different trend from the other two gases.

Key Words
Carbon monoxide, greenhouse gas emission, Indonesia, peatland fire, tropical peatland.

Introduction
Tropical peatland soil is one of the most vulnerable carbon sources in the world. In recent decades, huge area of tropical peatland has been developed, deforested, and degraded. For example, Page *et al.* (2002) evaluated that 13–40% of the mean annual global carbon emissions from fossil fuels was released from Indonesian peatland combustion. Compared to gas flux observation under normal condition, on-site gas emission measurement from a burning tropical peatland is still limited. In this paper, we report the composition of major gaseous components in smoke samples obtained from a latest peatland fire in Southeast Asia.

Materials and Methods
Site description
The study site is located near Palangka Raya (2°S 114°E), Central Kalimantan, Indonesia. This area is the northern edge of the Mega Rice Project. During this project, many canals and ditches were constructed to drain peatland area. After the project was frustrated, vast devastated peatlands were left. Because of extremely dry conditions, peatland fire frequently occurs in dry season, especially in El Niño and Southern Oscillation (ENSO) years (Hirano *et al.* 2007). Incomplete burning of peat generates much smoke to cause dense haze, which has recently become a serious social problem. During the fieldwork of this study (late September to early October, 2009), the study site had many smoking spots and was covered by dense haze.

Measurement of gas concentration
The concentration of major gaseous components released by peatland fire was measured. Smoke samples were collected to individual plastic bags in the field. The concentrations of carbon dioxide (CO_2) and carbon monoxide (CO) in these samples were determined in a laboratory of the Center for International Co-operation in Sustainable Management of Tropical Peatland (CIMTROP), University of Palangka Raya (UNPAR). A non-dispersive infrared sensor (ZFP9GC11, Fuji Electric, Tokyo, Japan) and a controlled potential electrolysis sensor (CO-85FL, Riken Keiki, Tokyo, Japan) were used for the analysis of CO_2 and CO, respectively. Before this measurement, a small portion of each smoke sample was transferred into a pre-evacuated glass bottle. These bottles were then shipped to Hokkaido University, Japan to determine methane (CH_4) and nitrous oxide (N_2O) concentrations. Two devices of gas chromatography, GC-8A with a flame ionization detector (Shimadzu, Kyoto, Japan) and GC-14B with an electron capture detector (Shimadzu, Kyoto, Japan), were used for CH_4 and N_2O measurement, respectively.

Results
The result of the measurement is shown in Figure 1. The concentrations of CO, CH_4, and N_2O were plotted against that of CO_2 because of their highly correlated relationships. The concentrations of CO_2 and CO in smoke samples reached to 1000–2500 ppm, while those of CH_4 and N_2O were less than 100 ppm and 1 ppm, respectively.

The correlations between CO_2 and the other gases are summarized in Table 1. The values of R^2 were high (0.77–0.97) and all the correlations were statistically significant ($P < 0.001$). The X-intercepts of CO and CH_4 were similar to normal atmospheric concentration of CO_2, whereas that of N_2O was far from the value suggesting a different generation process for N_2O. Based on the slopes of the linear relationship, molar ratio of carbon was CO_2 : CO : CH_4 = 1.0 : 0.38 : 0.026 = 71.0% : 27.1% : 1.9%. Such a high proportion of CO to CO_2 reflects imperfect combustion of peat. In case of normal forest fire, for example, Statheropoulos and Karma (2007) reported 0–44 ppm of maximum CO concentration with 350–800 ppm of maximum CO_2 concentration at the flame-front of a forest fire in Greece.

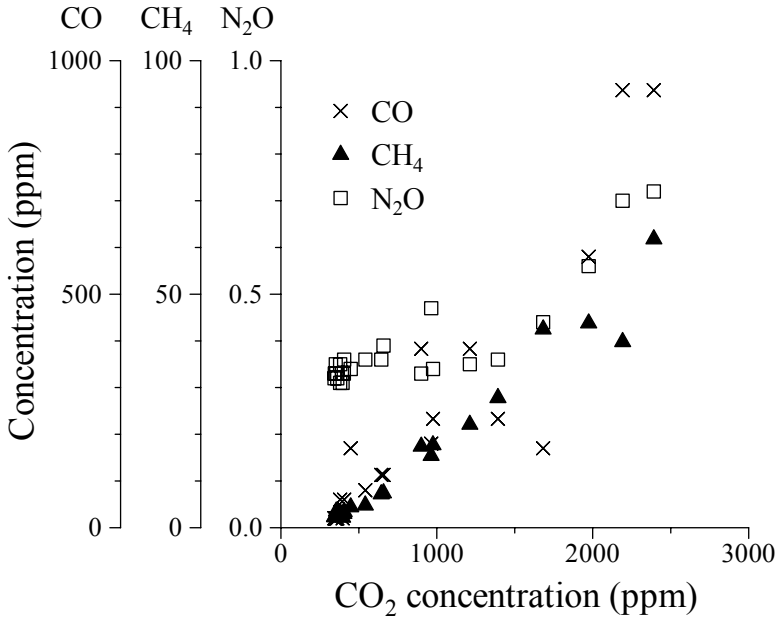

Figure 1. Concentration of major gases in peatland fire smoke samples plotted against that of CO_2.

Table 1. Results of linear regression analysis between the concentration of CO_2 and those of other major gases in peatland fire smoke samples.

Gas	*n*	Slope	Y-intercept (ppm)	X-intercept (ppm)	R^2
CO	23	3.82×10^{-1}	–117.5	401.7	0.8290 ***
CH_4	24	2.61×10^{-2}	–7.6	308.9	0.9676 ***
N_2O	24	1.57×10^{-4}	0.3	–1091.1	0.7736 ***

*** Significant at the 0.001 probability level.

Conclusion

Burning of tropical peatlands releases much amount of CO as well as major greenhouse gases. The role of CO in chemical reactions in the atmosphere is complex and still unclear, so CO emission from peatland fire is important not only for health condition of inhabitants but for potential influences on atmospheric chemistry and the global climate. Continuous and multi-site observation is needed for more detailed understanding.

References

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