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Ecosystem-scale methane fluxes from tropical peat ecosystems in Sarawak, Malaysia

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Tropical peatlands of Southeast Asia, widely distributed in Malaysia and Indonesia, are a globally important carbon reservoir, storing an enormous amount of soil organic carbon as peat. In recent decades, however, the peatlands have been threatened with rapid land cover changes. Owing to the huge soil carbon stocks, high groundwater levels (GWLs) and high temperatures, tropical peatlands potentially function as a significant source of methane (CH_4) to the atmosphere. However, chamber studies of soil CH_4 flux have reported that CH_4 emissions from tropical peat swamp ecosystems were negligible. On the other hand, recently, it was reported that some tree species growing in peat swamp forest emit considerable CH_4 from their stems. Thus, ecosystem-scale flux measurement is essential to quantify the CH_4 balance of tropical peat ecosystems.

In this 3-year study (February 2014 to January 2017), using the eddy covariance technique, we measured the net ecosystem exchange of CH_4 (F_{CH4}) above three different tropical peat ecosystems in Sarawak, Malaysia. The three sites were different in disturbance; namely an undrained peat swamp forest (UF), a relatively disturbed secondary peat swamp forest (DF) and an oil palm plantation (OP) established on peat. Our objectives were to: (1) quantify the F_{CH4} of each site; (2) examine the response of F_{CH4} to GWL; and (3) compare F_{CH4} among the three ecosystems and discuss the inter-site difference of CH_4 balance. The F_{CH4} was determined half-hourly as the sum of eddy CH_4 flux and CH_4 storage change and summed up annually after gap filling.

The daily mean F_{CH4} was positively correlated to the GWL in the UF and DF, in which GWL governed the production and oxidation of CH_4 in peat. In contrast, the F_{CH4} was almost independent of GWL in OP; the GWL was lowered by drainage. The monthly mean F_{CH4} was always positive even in the drained OP. The ecosystem-scale CH_4 emission from UF was lower than those from mid-latitude peat ecosystems, though it was much higher than soil CH_4 emissions measured by the chamber technique in tropical peat swamp forests. The inter-site differences in emissions were explained by a significant positive exponential relationship with the GWL. This relationship indicates that the conversion of a peat swamp forest to an oil palm plantation decreases CH_4 emissions, because the land conversion accompanies drainage. Although the annual emissions do not exceed those from mid- and high-latitude peatlands, our result suggests that tropical peat swamp forest can be one of the major natural CH_4 sources in the tropics.