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Diurnal variation in net ecosystem methane exchange over tropical peatand forest in Southeast Asia

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The east coast of Sumatra, Indonesia, comprises of an extensive complex of wetland ecosystems with peatlands at the core of these environments. In the recent past some of the peatland landscape was developed for industrial agriculture – largely oil palm and tree plantations – with the major concern being climate change. This project aims to provide some baseline information of ecosystem-scale greenhouse gas (carbon dioxide, methane and nitrous oxide) flux. Reported here are the preliminary results for methane.
Wetlands are the largest natural source of atmospheric methane and high carbon stock under waterlogged-anaerobic condition favors methane production. Methane is known to be emitted via diffusion from soil and the water surface, ebullition from the water surface, or transport through vegetation (both herbaceous plant and tree). To support the development of consistent policies for climate change mitigation, assessment of the net greenhouse gas balance for different management interventions is essential. We measured net ecosystem methane exchange using the eddy covariance technique over three major land uses. The first – an ecosystem restoration forest; the second – plantation forestry; and the third – a mixed land use area (forest, plantations and scrub forests). The eddy covariance instruments were installed above-canopy, therefore measurements incorporated all existing methane sources and sinks within the flux footprint. Groundwater level was measured every 30-min using a water level data logger.
30-min eddy covariance data showed a diurnal cycle in the net ecosystem methane exchange when the groundwater level persisted at <50 cm. Daytime net ecosystem methane exchange values were up to 9 times larger than those at the nighttime. This cautions that sampling bias (e.g. only daytime measurements) can overestimate up to 80% of the daily net ecosystem methane exchange. Higher daytime net ecosystem methane exchanges were ascribed to the vegetative transport of dissolved methane via transpiration and air-filled tissue. There was no clear relationship between soil temperature and net ecosystem methane exchange.
Net ecosystem methane exchange decreased exponentially as groundwater level declined ($r2 = 0.62$, $p < 0.0001$). High groundwater level enhances methane oxidation in the upper oxic peat layer. Further, high groundwater level might relocate methane production below the root zone, resulting insufficient methane in the root zone to be taken and transported to the atmosphere. Vegetative transport of methane requires additional evaluation of the role of different species and their root characteristics.
Results from the plantation site showed that mean net ecosystem methane exchange was 44% lower than that at the ecosystem restoration forest site for the same months. It should be noted that the plantation forest site flux footprint included the canal water surface (up to 2% of the flux footprint). Overall measured net ecosystem methane exchange rates were 6-9 times higher than the IPCC's methane emission factor for tropical peatlands in Southeast Asia.
Our results can help improve estimates of regional greenhouse gas balance associated with land use changes.