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Methane flux and its stable isotope ratios in a taiga-tundra ecotone in East Siberia

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One of the major sources of CH_4 is natural wetland and CH_4 is partly absorbed into forest soil. These CH_4 exchange between soil and the atmosphere is known to be spatially variable to great extent (*Sachs et al., 2010*). Wetland is broadly distributed in the Arctic (*Aselmann & Crutzen, 1989*) and taiga-tundra ecotone (low and high shrub tundra) also covers significant area in the region (*Kaplan & New, 2006*). The vegetation in the taiga-tundra ecotone might be changed by climate change such as enhanced warming in the Arctic (*Walker et al., 2006*) and eventually CH_4 flux as well, which is a strong greenhouse gas. In order to estimate CH_4 emission from a region in the taiga-tundra ecotone, it is necessary to observe CH_4 flux not only at a typical tundra site but also at multiple sites including taiga area. Such observation had been carried out in other region such as West Siberia (*Flessa et al., 2008*), but not yet in East Siberia. The objective of this study is (1) to establish new observation sites in a taiga-tundra ecotone in East Siberia and observe CH_4 flux at each vegetation landscape and (2) to clarify the controls of CH_4 flux in the ecosystem.

We observed CH_4 flux by closed chamber method in Jul 2009-2011 at 4 new sites (separated for tens of km) with different vegetation in the taiga-tundra boundary of Indigirka lowland near Chokurdakh (70N, 148E), Russia. The region has a typical tundra station, where CH_4 flux had been observed since 2004 (*van Huissteden et al., 2005*). We set new sites denoted as V (taiga-like), K (typical boundary), B (tundra-like), where tree mounds with moss cover (*Sphagnum spp.*) and with larch, wet area with sedges (or *Sphagnum*) and frequently with surface water were distributed in a patchy way. We also set site F (floodplain) in 2010. Along with flux observation, we measured oxidation reduction potential (ORP), soil temperature, soil moisture, and thaw depth as potential controls of CH_4 flux. In 2011, we also measured CH_4 concentration in surface water and in soil pore (at ca. 15 cm) in wet areas, and delta-13C and delta-D of these dissolved CH_4 and emitted CH_4 to clarify the production, transport, and oxidation process. GC-FID was used to analyze CH_4 concentration and GC/GC/C(TC)/IRMS for delta-13C and delta-D of CH_4.

The observed CH_4 flux was -0.23˜7.0 mgC m^{-2} h^{-1} and different among vegetation types. At tree mounds and river terrace (F site), the soil was drier with relatively higher ORP than wet areas and CH_4 emission wasn't observed. At K wet area (sphagnum/sedge), where dead larch with flat Sphagnum cover on ground could be seen and regarded vegetation succession was taking place, small CH_4 emission was observed (2.1 mgC m^{-2} h^{-1} at maximum). At V, B sedge wet area, the largest emission was observed (0.05˜7.0 mgC m^{-2} h^{-1}). CH_4 flux didn't correspond with CH_4 concentration in surface water, but the flux was large when CH_4 concentration in soil pore was high, indicating that the contribution of CH_4 diffusion throughout surface water is small and that CH_4 could be emitted from soil through vascular plants. CH_4 flux was positively correlated with soil temperature at wet areas, as well as CH_4 concentration in soil pore. CH_4 flux at K sedge wet area, however, was almost constant and had no correlation with CH_4 concentration in soil pore. In 2011, when the water level of the river system was remarkably high and the soil was wet, the largest CH_4 flux was observed with low ORP. The observed delta-13C of CH_4 in soil pore was extremely high (-59˜-47 per mil), which indicates the delta value was affected by diffusion or oxidation in the soil. Delta-D-delta-13C plot supported the CH_4 transportation by plants. To estimate CH_4 flux of the region, it's necessary to consider not only tree mound and sedge wet area but also vegetation succession. If vegetation changes from tree mound to succession area, or from succession area to sedge wet area, regional CH_4 flux might increase and cause positive feedback on climate.

Keywords: methane, taiga-tundra ecotone, East Siberia, Arctic, carbon isotope ratio, hydrogen isotope ratio