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ON A ROLE OF SEASONALLY FLOODED FORESTS IN METHANE CYCLE

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The methane is an important greenhouse gas which contributes to climate warming. The largest natural methane sources in the boreal latitudes are wetlands. By now a lot of studies have been carried in those areas (Alm et al., 1999; Gal'chenko et al., 2001; Glagolev et al., 2010), but still there are issues concerning other natural methane sources. The soils of periodically flooded forests may be one of them. The indications that forest soils contribute to the atmospheric methane balance, not only through the soil sink but also due to episodic emissions in wet conditions were given in publications repeatedly (Harriss et al., 1982; Lohila et al., 2016; Глаголев и др., 2017). The area and period of temporal forest flooding may be estimated by a hydrological model that uses meteorological information for a particular year. But what part of periodically flooded forests area may become a methane source even under optimal conditions? Apparently, this question can not be solved by one-time measurements of the methane fluxes. Indeed the forest may be not under optimal (for emission) hydrothermal conditions at the time of a site visit and instead of the emission, it may appear to be the methane sink. To understand long term site conditions we measure profile of the methane concentration in soil. It is obvious that at the same surface methane flux the concentration profile is to have a qualitative difference when: (i) there are only methanotrophs in the soil and (ii) when there are methanogens, under the methanotrophs layer, that may provide sufficient methane emission in the optimal conditions.

The measurements were carried out in July and August 2016 in south taiga zone of Western Siberia. Six sites were located from south to north in the transect from "ryam" (pine-shrub-sphagnum ecosystem) through open meso-oligotrophic mire (Fig. 1c – 2 sites: D375 and D35), further through the periodically flooded forest with dominance of birch *Betula pendula* – Fig. 1b: Tr.PWF (56.83113° N, 82.85278° E) and Tr.PWF_2 (56.83128° N, 82.85150° E) – to forest/oligotrophic bog boundary – Fig. 1b: Tr.WF/RB2 (56.8315° N, 82.85133° E) and Tr.WF/RB1 (56.83169° N, 82.85122° E). The points were set so as to cover at range of water table depths and plant associations of the ecotone under study. Additionally, the measurements were carried out in the periodically flooded forest at 40 km to the Southwest from above mentioned sites (Fig. 1a). The sites D375 and D35 have been already studied and described earlier (Глаголев, Шнырев, 2007), as well as Tr.PWF, Tr.WF/RB2 and Tr.WF/RB1 (Глаголев и др., 2017).

The emission measurements were conducted by the static chamber method as described in (Sabrekov et al., 2011). In addition the measurements of methane concentration in the soil air and water were carried out. Sampling was made with a metal tube (inner diameter – 2 mm). The lower end of the tube was submerged in the soil and the syringe was hermetically connected to the top part of the tube. Sampling was carried out every 5 cm up to the water table level (WTL), but not deeper than 35 cm. The samples were prepared and the concentration was calculated as described in (Repo et al., 2007). The concentration of the methane was analyzed using the modified gas chromatograph 'KhPM-4' ("Khromatograf" Co., Moscow, Russia) with a flame-ionization detector taken from the chromatograph 'LHM-80' ("Khromatograf" Co.). The analysis conditions are as
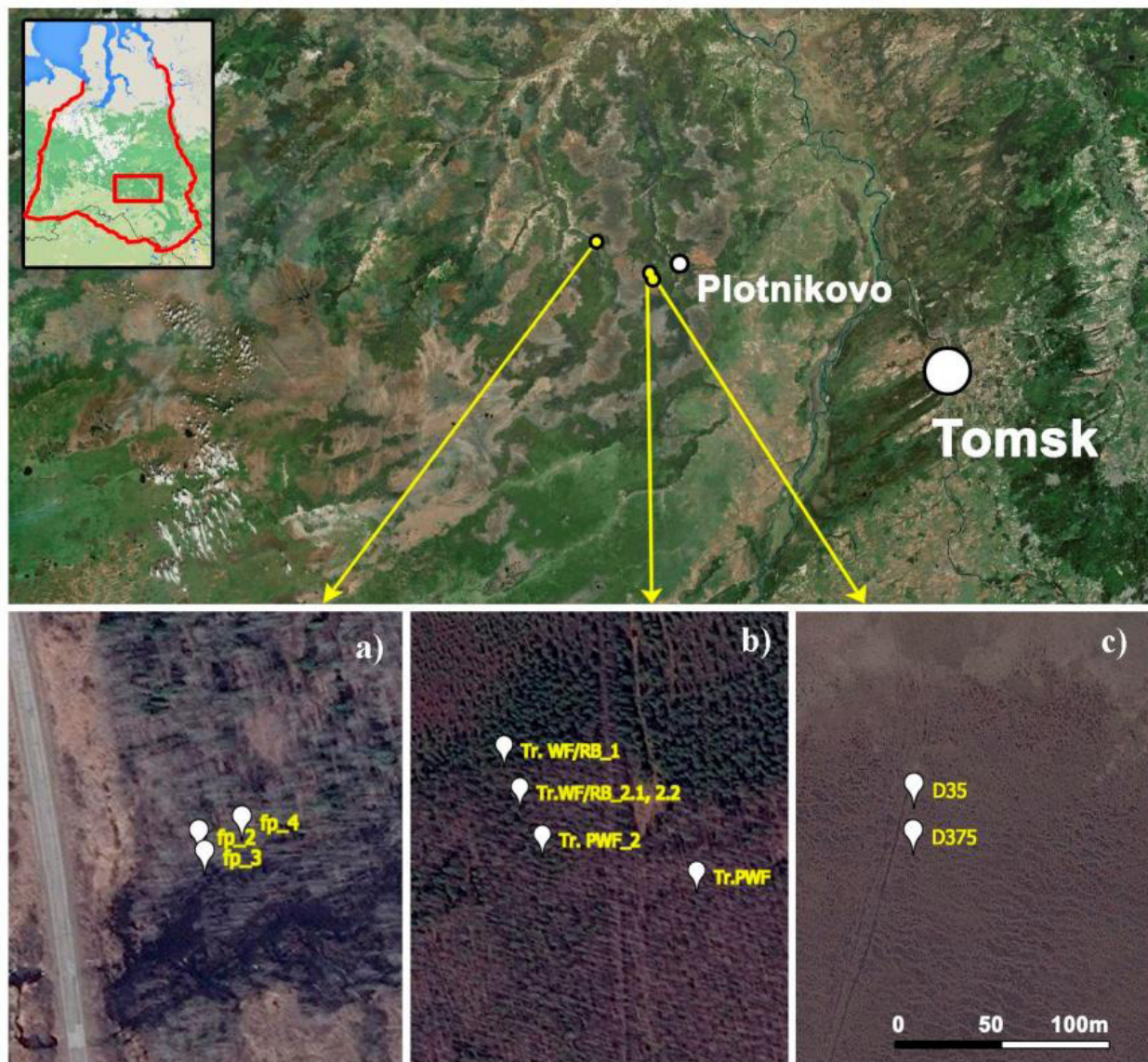
Fig. 1. *Locations of the study sites*

follows: steel column (1 m, diameter 2.5 mm) filled with Sovpol (80–100 mesh) at 35 °C with hydrogen as a carrier gas (flow rate of 5 ml/min), the loop volume was 0.5 ml. The standard gases with the methane concentration of 1.99 ± 0.01, 5.00 ± 0.01 and 9.84 ± 0.01 ppmv (National Institute for Environmental Studies, Japan) were used to calibrate the chromatograph.

The typical observed concentration profiles are shown in the Fig. 2. At relatively high WTL (≈ 10 cm below the soil surface – Fig. 2B) the concentration increased immediately under the soil surface. The diffusive flux from the soil may be estimated approximately. The gradient (Fig. 2B) is $93 \div 116$ mgC/m^4. The diffusion coefficient in the atmosphere at 19 ºC is $D_O = 0.077$ m^2/h (Arah and Stephen, 1998). The ratio of the diffusion coefficient in the soil (D_S) to D_O varies from 0 to around 0.3 depending on the free porosity (Ревут, 1972). Therefore we may take $D_S/D_O \approx 0.15$ for our approximate calculations. Then the diffusive flux from the soil will amount to $1.1 \div 1.3$ mgC/(m^2·h). The measurements by the chamber method conducted on the site Tr.WF/RB_1 (for detailed results see Churkina et al., published in this Proceedings Book), gave the median 3.1 ± 1.4 mgC/(m^2·h). Considering the measurement error and tolerance of our calculation, the correspondence may be estimated as good. On the other side the diffusive flux may actually be less than total flux
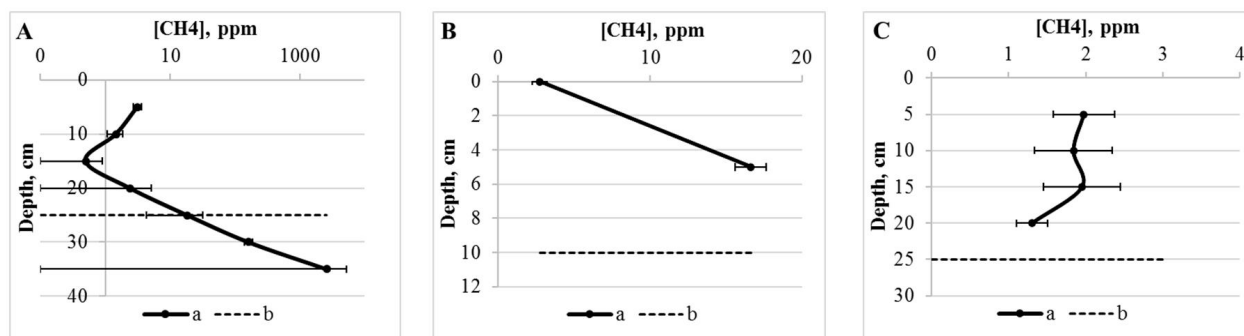
Fig. 2. *The methane concentration (a) in soil profile at different sites (A – Tr.PWF; B – Tr.WF/ RB_1; C – fp_2; --- denotes WTL)*

as the gas may volatilize not only due to the diffusion but as well to the convectional mechanism (for example, due to the pressure increase during the methanogenesis).

At deeper WTL (≈25 cm) two situations are possible. Firstly, presumably under the absence or low methanogenic activity in the underlying soil layers the methane concentration decrease with depth is observed in the soil profile in layer above WTL (Fig. 2B). The methane flux may be estimated approximately as before **corresponding to the profile in the Fig. 2B (but now it will be nega**tive flux – the flux in the soil instead of flux from the soil). It amounts from -0.02 mgC/(m²·h) to 0 (in the calculations we accepted the actual soil moisture as of 26 Jul 2016). The chamber method measurements on the site fp_2 in this day gave fluxes from -0.06±0.04 to 0.01±0.06 mgC/(m²·h).

Secondly, at sufficiently high methanogenic activity below WTL and methanotrophs activity above WTL, the methane concentration decrease is observed at the top of the profile which changes to increase when approaching to WTL (Fig. 2A). The methane concentration decrease in the surface layer is the evidence of flux from the atmospherewhich is confirmed by measurements with the chamber method. The theoretical calculations similar to the above mentioned give for the site Tr.PWF values from -0.39 to -0.07 mgC/(m²·h), while direct chamber measurements shows fluxes from -0.04±0.03 to 0.05±0.12 mgC/(m²·h). The considerable increase of the methane concentration in the lower part of the profile indicates that the methanogens activity is high in this location. It can not be observed on the surface because produced methane is consumed by the methanotrophs in top level of the soil profile. But with changes of the conditions (moisture increase or temperature decrease in the upper soil layer) the methanotrophs activity may decrease and the parts of the forest with nonmonotonic concentration profile described above are likely to become methane sources instead of sink.

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