Experimental study of methane emission from lake seeps of Western Siberia permafrost zone

Liudmila Krivenok¹, Vladimir Kazantsev¹, and Yury Dvornikov²
¹A.M. Obukhov Institute of Atmospheric Physics RAS, Moscow, Russian Federation (krivenok@ifaran.ru)
²Earth Cryosphere Institute of Tyumen Scientific Centre SB RAS, Tyumen, Russian Federation

Methane is one of the most potent greenhouse gases affecting climate change. According to different estimates, natural sources contribute 35–50% to global CH₄ emission. Among them, the third-biggest source is lakes emitting to the atmosphere 10–50 TgCH₄ per year [Anderson et al., 2010].

We have discovered two gas seeps during the summer 2019 field campaign within the lake near the Vas'kiny Dachi research station (Central Yamal, Western Siberia). Measurement of the ebullition intensity in tenfold replicate and gas sampling were carried out using a bubble trap of the original design. The concentration of methane in seep gas was determined by a Crystal 5000.2 gas chromatograph with a flame ionization detector; each sample was diluted tenfold with air. We calculated the annual CH₄ flux from seep to the atmosphere with the consideration of the intensity of seep ebullition and the methane concentration in gas equal during the year. To determine the potential source of the gas, we analyzed the isotopic composition of CH₄ (δ¹³C and δD) by a Delta-V mass spectrometer.

The values (median ± SD) of the gas ebullition are 175 ± 26 mL/min and 127 ± 10 mL/min for the first and second seeps respectively. The methane concentration in gas is 95–100%. The intensity of CH₄ emission from the first seep is 89.7 thousand L or 64 kg per year; from the second seep is 65.1 thousand L or 46.5 kg per year.

Analysis of the content of δ¹³C and δD isotopes in methane gives the following results.

- For the first seep: δ¹³C vs VPDB, ‰ = −75.73, δD vs VSMOW, ‰ = −226.68.
- For the second seep: δ¹³C vs VPDB, ‰ = −76.97, δD vs VSMOW, ‰ = −222.31.

According to the classification from [Whiticar, 1999], seep methane is of biogenic origin. Potentially, gas could migrate to the lake surface through sub-lake talik from the underlying geological horizon containing methane hydrates in self-preserved form as widely documented for this area [Chuvilin et al., 2000].

To summarize, lake seeps of the Western Siberia tundra zone have been studied as a source of the atmospheric methane for the first time. Considering the occurrence of methane hydrates withing
permafrost in the study area, we describe a path of the CH₄ release from decomposing gas hydrates into the atmosphere in the northern part of Western Siberia.

The study was partially supported by the RAS Program no. 20 and the state contract of the IAP RAS no. 075-03-2019-628.

References:

