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Research vessel-based accurate continuous observations of CH4 and δ13C-CH4 in the above-sea atmosphere of the Kara Sea (Arctic Ocean)

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Decreasing trends of Arctic Seas ice areas, recorded growth of sea surface temperatures, and the increasing influx of Atlantic water into the Arctic Ocean demonstrate progressing warming. According to the current knowledge, the Kara Sea is characterized by a presence of subsea permafrost only in the nearshore area west of the Yamal peninsula. Limited summertime data on dissolved methane (CH_4) dynamics indicate its low-moderate values in the shallow zone. In contrast to the deep subsea locations where CH_4 is mostly oxidized in the water column, an essential part of CH_4 that is released at the seafloor in the shallow Kara Sea emits into the atmosphere. Hence, accurate stationery and mobile observations of atmospheric methane over the above-sea layer might capture a portion of CH_4 signals that are related to specific patches of such emissions. This study was accomplished during/after fall convection which fully mixed the shallow water column characterized by the near background concentration of dissolved CH_4. Then to explain the “empty” dissolved CH_4 pool we suggested effective extraction of dissolved methane into the atmosphere during fall water mixing. Such a “dissolved methane ventilation phenomenon” caused by wind-driven mixing has been discovered in the shallow part of the Laptev Sea.

Accurate continuous observations of atmospheric CH_4 dry mole fractions and δ13C-CH_4 were made during the beginning of the freeze-up period - on October, 02 – November, 05 2021 onboard the research vessel "Academician Mstislav Keldysh" (AMK-86). Atmospheric measurements at 15 m of the above-sea layer were performed by a CRDS analyzer Picarro G2201-I (Picarro Inc., USA) that passed a regular calibration against WMO-traceable reference gases. Associated meteorological and geospatial records permitted screening and interpreting trace gas data series. Additionally, analysis of specific source regions of atmospheric air parcels moving downwind to the research vessel was based on the ARL NOAA HYSPLIT model.

Here we give an overview of CH_4 and δ13C-CH_4 fluctuations over the above-sea layer of the Kara Sea observed within longitudinal (60 – 84^o E) and latitudinal (70 – 82^o N) transects, summarize spatial features, and provide analysis of source regions contributed into the accurate continuous measurements. This study was funded by the Russian Foundation for Basic Research, Krasnoyarsk Territory, and Krasnoyarsk Regional Fund of Science, project number 20-45-242908, Russian Science Foundation (RSF) project 21-17-00163, and by the Max Planck Society (Germany). Fieldwork was funded by the RSF project 21-77-30001. IS and DK acknowledge the Ministry of Science and High Education (grant ID: 075-15-2020-928).