Geophysical Research Abstracts, Vol. 7, 04399, 2005
SRef-ID: 1607-7962/gra/EGU05-A-04399

Spatial distribution of atmospheric methane over Lake Baikal surface

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Methane is the most important of organic substance in the atmosphere, and its concentration significantly exceeds the concentration of other organic compounds. The contribution from methane to the greenhouse effect is about 30 % of that from carbon dioxide. On the global scale, natural sources of methane are wetlands, rice fields, cattle, biomass burning, as well as gas-hydrates.

The discovery of natural methane gas-hydrates sparked the increased interest in gas-hydrates and was followed by a series of investigations, by which enormous fuel reserves were discovered in the form of gas-hydrates stored in the bottom of the world ocean. Gas-hydrates attract a lot of scientific attention, not only because they can be used as fuel and chemical raw material, but also in the context of possible emissions of the methane into the atmosphere. Gas-hydrate crystals in Lake Baikal have been found quite recently. Lake Baikal is a convenient object for the investigation of gas hydrates and of gas vents at the lake floor. The aim of this work was to find anomalies in the methane distribution in the atmosphere over Lake Baikal surface using a high-sensitivity laser methane detector.

The methane detector employs a GaInPAs diode laser as a source of radiation. The diode laser operates in the range from 6000 to 6080 cm-1 (1.645-1.666 μm), which includes rather strong absorption lines of methane. The detector was calibrated by a nitrogen-methane mixture with a methane concentration of 2.0 ppm. The detection limit (standard deviation) was 0.037 ppm, and time constant of the methane detector on the whole (with the allowance for the pump productivity and cell volume) was 99

s (spatial resolution of 450 m).

The measurements of the methane content in the atmosphere over Lake Baikal were conducted by means of continuous air sampling from a height of 2-10 m above the water level from aboard R/V Vereshchagin in the periods of 10-16 August 2003 and of 16-24 June 2004. The coordinates of the measurement points were determined by the shipboard GPS system.

Analysis of the data obtained in the course of the August 2003 expedition has shown that the methane concentration in near-surface air all along Lake Baikal averaged 2.001(0.16) ppm ; the standard deviation did not exceed 0.2 ppm. A distinctive and considerable (5.5 ppm) anomaly was observed near a shallow-water seep near the Selenga River inflow. Methane concentration distribution in near-surface air along the vessel's track of 15 August 2003 showed a sharp peak that was limited in space and time.

The average methane concentration in near-surface air over the South and Central Baikal Basins during the June 2004 expedition was 1.91(0.07) ppm and distinctive and considerable (more than 2.4 ppm) anomalies were observed at six areas in the Central Baikal Basin. Methane concentration distribution in near-surface air along the vessel's tracks of 16-24 June 2004 was similar to the one obtained in 2003, with sharp peaks that were limited in space and time. Maximum air methane concentration (30 ppm) was detected near the Selenga shallow-water seep. In contrast to data obtained in August 2003 in the areas of visible methane escapes (Selenga River inflow and Babushkin village) groups of closely set methane escapes were observed. The distinctive and considerable (4 ppm) peak of the near-surface air methane concentration was observed near Mishicha, at a water depth of about 1000 m.

The direct measurements of methane fluxes are very important for assessment of global fluxes of methane from water surface to the atmosphere. These measurements were carried out on vessel board for the first time. The most intensive fluxes (maximum methane flux was 2.12 E-9 kg/s m2) were observed near Babushkin village, where also maximum values of methane concentrations in near-surface water were detected. The typical magnitude of methane flux in most areas was within the limits of 1-3 E-12 kg/s m2. We also observed small inverse methane fluxes from the atmosphere to the lake water (0.5(1) E-12 kg/s m2). Measurements of dissolved methane were conducted by gas chromatography (Pacific Ocean Institute, Vladivostok) and this allowed us to compare the results obtained by gas chromatography and diode laser detector. Intercomparison has shown good agreement; the difference did not exceed the standard deviation of measurements.

This work was supported, in part, by the INTAS (grant No. 01-2309) and the Program of Basic Research of Division of Physical Science RAS (Project No. 2.10.1 "High-Resolution Spectroscopy")