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Stable isotope ratios of atmospheric CO_2 and CH_4 over Siberia measured at ZOTTO

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The boreal and arctic zones of Siberia housing the large amounts of carbon stored in the living biomass of forests and wetlands, as well as in soils and specifically permafrost, play a crucial role in earth's global carbon cycle. The long-term studies of greenhouse gases (GHG) concentrations are important instruments to analyze the response of these systems to climate warming. In parallel to GHG observations, the measurements of their stable isotopic composition can provide useful information for distinguishing contribution of individual GHG source to their atmospheric variations, since each source has its own isotopic signature. In this study we report first results of laboratory analyses of the CO_2 and CH_4 concentrations, the stable isotope ratio of δ^{13}C-CO_2, δ^{18}O-CO_2, δ^{13}C-CH_4, δD-CH_4 measured in one-liter glass flasks which were obtained from 301 height of ZOTTO (Zotino Tall Tower Observatory, near 60˚N, 90˚E, about 20 km west of the Yenisei River) during 2008 – 2013 and 2010 – 2013 for stable isotope composition of CO_2 and CH_4.

The magnitudes of δ^{13}C-CO_2 and δ^{18}O-CO_2 in a seasonal cycle are -1.4±0.1‰ (-7.6 – -9.0‰) and -2.2±0.2‰ (-0.1 – -2.3‰), respectively. The δ^{13}C-CO_2 seasonal pattern opposes the CO_2 concentrations, with a gradual enrichment in heavy isotope occurring during May – July, reflecting its discrimination in photosynthesis, and further depletion in August – September as photosynthetic activity decreases comparatively to ecosystem respiration. Relationship between the CO_2 concentrations and respective δ^{13}C-CO_2 (Keeling plot) reveals isotopic source signature for growing season (May – September) -27.3±1.4‰ and -30.4±2.5‰ for winter (January – March). The behavior of δ^{18}O-CO_2 associated with both high photosynthetic rate in the June (enrichment of atmospheric CO_2 by ^{18}O as consequence of CO_2 equilibrium with "heavy" leaf water) and respiratory activity of forest floor in June – October (depletion of respired CO_2 by ^{18}O because of the use of "light" soil water by microorganisms).

There is large temporal variation of δ^{13}C-CH_4 (-50.0 – -46.1 ‰) with clear minimum in the late summer (August) that corresponds to CH_4 concentration maximum and reflects biogenic sources of methane in the surrounding peatbogs. The δD-CH_4 varies from -77.4 to -110.2 ‰ and showed no seasonal cycle with many irregular spikes throughout a year. Keeling plot analysis between the CH_4 concentration and isotopic composition revealed that isotopic signature of source in the winter (December – February) is -61.3±2.2‰ and -247.5±17.7‰ for δ^{13}C-CH_4 and δD-CH_4, respectively. For growing season (June –September) the corresponding values for δ^{13}C-CH_4 and δD-CH_4 are -76.4±2.6‰ and -342.2±14.8‰The strong depletion of methane in heavy isotopes throughout a year is the indication of continuous CH_4 emissions from biogenic sources.

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