Geophysical Research Abstracts, Vol. 9, 01071, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-01071

Methane release on the Arctic East Siberian shelf

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The extensive Russian arctic shelves may play an especially important role in methane (CH_4) cycling because of their large area, shallow sea depth, and huge storage of organic matter buried in onshore and offshore permafrost, which can be involved in modern biogeochemical cycles under warming conditions. Arctic shelf and slope areas containing a major proportion of the organic carbon pool represent more than 86.5% of the Arctic Ocean sedimentary basin (called "Arctic carbon hyper pool", Gramberg et al., 1983; Gramberg and Laverov, 2000). Until recently, due to slightly negative annual temperatures within the water column and the lid-type coverage of shelf sediments by sub-sea permafrost, old organic carbon buried on the Siberian Arctic shelf was considered completely isolated from the modern carbon cycle. However, our recent study in the Laptev Sea and the East-Siberian Sea (LESS) showed that CH_4 supersaturation of surface water reached up to 10,000 %, implying that strong air-to-sea fluxes must occur at times.

In this report we present three years of CH_4data obtained in the air-sea system during the late summer period (September of 2003, 2004, and 2005) for the East Siberian Arctic shelf. The observed distribution of dissolved methane and possible mechanisms of CH_4 release in connection with observed dynamics of coastal environments suggest that this area is an important natural source of CH_4 to the atmosphere and that it tends to be affected by ongoing global change. Extreme CH_4 anomalies in plume areas indicate the presence of both surface and bottom CH_4 sources, perhaps reflecting geological, hydrological, and climatic factors. The rivers are a strong source of surface dissolved methane which comes from watersheds which are underlain with permafrost (see details in Shakhova and Semiletov, same volume). Anomalously high concentra-

tions (up to 154 nM or 4400% supersaturation) of dissolved methane in the bottom layer of shelf water at a few sites suggest that the bottom layer is somehow affected by near-bottom sources. The net flux of methane from this area of the East Siberian Arctic shelf can reach up to 13.7×10^4 g CH_4 km^{-2} from plume areas during the period of ice free water, and thus is in the upper range of the estimated global marine methane release. Ongoing environmental change might affect the methane marine cycle since significant changes in the thermal regime of bottom sediments within a few sites were registered. Correlation between calculated methane storage within the water column and both integrated salinity values (r=0.61) and integrated values of dissolved inorganic carbon (DIC) (r=0.62) suggest that higher concentrations of dissolved methane were mostly derived from the marine environment, likely due to in-situ production or release from decaying submarine gas hydrates deposits. The calculated late summer potential methane emissions tend to vary from year to year, reflecting most likely the effect of changing hydrological and meteorological conditions (temperature, wind) on the East Siberian Arctic shelf rather than riverine export of dissolved methane. We point out additional sources of methane in this region such as submarine taliks, ice-complex retreat, submarine permafrost itself and decaying gas hydrates deposits. Our recent onboard data show that Arctic air-sea interactions have a substantial impact on overlying atmospheric CH_4composition. Vertical profiles of air CH_4 obtained in the late September 2006 using the helicopter survey also point out that the sea surface is the source of CH_4 (and CO_2) into the atmosphere. The LESS area, representing only $\sim$13% of the global area of the coastal seas (27×10^6 km^2), would generate up to 50% of the 1 Tg CH_4yr^{-1} flux given in Cynar and Yayanos (1993) for the total coastal seas area. Note that this estimate does not include the maximum flux for plume areas which is orders of magnitude larger.