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On the development of the 3D model of methane evolution in the Arctic Ocean.

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Recent observational studies (e.g. Shakhova and Semiletov, 2007) indicate high concentrations of methane in shelf waters of Arctic Ocean. Bottom methane releases and advection of methane ejected by Siberian rivers are considered as the most probable reasons. Regardless the mechanisms of methane generation many studies assumed that all methane ejected at the bottom reaches the atmosphere. This precludes the possibility of taking into account methane bubbles dissolution in oceanic water, methane oxidation and subsequent ocean acidification effects.
Some previous modeling studies (McGinnis et al., 2006, Yamamoto et al., 2009) explicitly considering rising bubble evolution in water column lacked full interaction between bubble and diffusive transport and didn't focus at Arctic Ocean. Thus, the objective of this work is to develop a model of methane transport and sink in ocean that could be used climate models.

To develop the methane block the 1D thermodynamic model of water reservoir LAKE was used (Stepanenko et al., 2011), to calculate inter alia vertical profiles of dissolved methane, and its emission to the atmosphere. The model includes the block of biogenic production of methane in soil that was previously calibrated using observations at thermokarst lake Shuchi in North-Eastern Siberia. The LAKE model was adapted appropriately to account for thermodynamics of saline water. It was forced by profiles of temperature, salinity, horizontal velocities from 3D ocean dynamics model FEMAO-1 (Iakovlev, 2012). The bubble methane-oxygen-carbon dioxide model (McGinnis et al. 2006) was coupled with the LAKE model to explicitly account for methane bubble transport and its interaction with dissolved methane. Preliminary experiments showed that for typical Arctic shelf depths the fraction of methane reaching the atmosphere varies in a wide range (42-88%), depending on parameters' values.

The version of coupled ice-ocean model FEMAO-1 (Iakovlev, 2012) was coupled with the bubble model to estimate the fate of dissolved methane (released both from bottom, bubbles and rivers) and bubbles during 1948-2011, and to estimate the methane fluxes to atmosphere under the conditions of the prescribed atmospheric forcing, and during varying ice cover.

The new 1D methane evolution model will be embedded in the INM RAS Earth System model (Dyanskii, et. al., 2010) to evaluate positive feedbacks of the methanehydrates degradation.

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