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A model study of mechanisms of methane transfer from Arctic shelf to the atmosphere

V.M. Stepanenko (1) and N.G. Iakovlev (2)

(1) Moscow State University, Russian Federation (vstepanenkomeister@gmail.com), (2) Institute for Numerical Mathematics RAS, Russian Federation (iakovlev@inm.ras.ru)

A possible positive feedback to rapid climate warming in Arctic – degradation of methane hydrates in the shelf bottom ground – has recently attracted attention of many research groups. This was primarily caused by new empirical evidence of very high concentrations of dissolved methane in Russian Arctic and methane fluxes to the atmosphere. A number of studies were conducted to access a possible effect of methane hydrates degradation in response to future warming of the ocean. Climate change scenarios were used to force the models of heat transfer in shelf ground. However, in majority of these works it was assumed that all methane released from shelf bottom reaches atmosphere. This precludes the possibility of taking into account methane bubbles dissolution, methane oxidation and subsequent ocean acidification effects. In this study we apply three modeling frameworks for quantifying these effects. First, one-dimensional (in vertical) model of water reservoir is used (Stepanenko et al. 2011), calculating vertical profiles of dissolved methane, bubbles' parameters and emission to the atmosphere. This model utilizes a bubble model by McGinnis et al. (2006), and diffusion-reaction equations for methane, oxygen and carbon dioxide concentrations in dissolved state. Thus, interaction between bubbles and dissolved gases and methane oxidation are described explicitly. Second, one-dimensional methane model is forced by temperature profile and eddy diffusion coefficients from 3D ocean dynamics model (Iakovlev 2009). And third, methane model is coupled to 3D ocean dynamics model allowing to reproduce advection of methane by oceanic currents in addition to above mentioned processes. This set of experiments allows to assess a significance of ocean dynamics for bottom-released methane transport and methane emission to the atmosphere. Since a number of parameters (e.g. initial bubble radius at the bottom, constants entering reaction rates formulae) are highly uncertain due to lack of relevant observational data, a sensitivity study if performed in respect to these parameters.

References

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