

Interactive comment on “Mathematical modelling of positive carbon-climate feedback: permafrost lake methane emission case” by I. A. Sudakov and S. A. Vakulenko

Anonymous Referee #1

Received and published: 19 May 2012

This manuscript presenting a mathematical model of thermokarst lakes expansion and methane emissions from these lakes. However problem of this work is that apparently authors have a very poor understanding of the physical process of thermokarst lake appearance, expansion, and processes which drive methane emissions from these lakes. I won't put doubts on mathematical part of the work, but model they have presented simply doesn't reflect the actual natural processes. I haven't even found words "ice wedge", "yedoma", "ice complex", "organic carbon" in the text. For authors consideration I will provide a short tutorial on methane emission from thermokarst lakes. 50-20 thousand years ago in the north of Siberia and Alaska formed massive 15-60m thick loess sediments. Local name yedoma or "ice complex". It is rich with organic

C175

carbon (mostly roots remains). Besides that yedoma has very high ice content. Ice in these sediments is located in the form of net of polygonal ice wedges with average size of 10-20 meters. The more to the north the thicker are the ice wedges. In the New Siberian islands ice content can reach 90%. So basically it is a "glacier" with columns of organic rich soils, which is covered with 1-2 meters of modern Holocene soils. These top soil protects yedoma from thawing. But if climate warms or, top layer is removed, or fire occurred, then active layer (top layer of soil which thaw each summer, and freeze back in the winter) increase, and ice wedges begin to thaw. Ice melts and escape. Modern soil above thawing ice wedges subside, appear the depression. Little pond appear in the depression, this additionally warm the permafrost underneath, ice wedge continue to thaw, depression expand in all directions. Lake appear. Bottom of this lake wouldn't be flat. It would be a net of 5-10 meter wide hills (former frozen soil columns). Lake bottom would subside until all ice wedges thaw entirely. For example if yedoma thickness in this area is 40 meters and ice content is 50% then depression wouldn't be more then 20 meters, and if this depression is filled with water to the half then lake depth would be 10 meters. Thermokarst lakes tend to migrate. They "eat" the shore. In this place cliff appear. On the other side of the lake it would retreat and create swampy alas. Migration can continue until lake meet the creek or depression then lake drains, or until for some reasons shore sediments would crumble covering ice wedges and stopping further expansion. Now methane emissions. There is no methane in the yedoma. There is only organic carbon. The total content of organic carbon in the north of Siberia is 500 Pg C. Don't know where did authors took value 80×10^{15} kg. This is basically an order higher. When lake appear it thaws the permafrost underneath. Water escape and thawed sediments under the lake are called "talik". This talik is organic rich and thawed, therefore methanogenesis take place. Concentration of methane in the sediments increase to the point of appearing of bubbles. These bubbles tend to migrate to the surface of the lake bottom, where it quickly transports to the atmosphere. Bubbles tend to reach surface via well established paths (like a big river with a big net of smaller channels). Locations of such an active methane emission path are called

C176

hot spots. These hotspots are usually located near the shore which is most actively eroding. Therefore methane emissions within one lake is very non uniform.

This are very basics of permafrost studies, but reading this manuscript I had a feeling that authors are not familiar with them. For example equations of methane emission. Most importantly it must depend on content of labile fractions of carbon in the lake sediments, and this content decay with time decreasing emissions. And thermokarst lakes emission have really low dependence on temperature. In talik temperature have very low range and very low seasonal dynamic. I support the idea of creating a thermokarst lake model. But I would really encourage authors to invite specialist in the field who would be able assist them in the work to create the model which actually reflects the physical processes.

Interactive comment on Earth Syst. Dynam. Discuss., 3, 235, 2012.