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The Cryosphere Discussions

Interactive comment on "The "tipping" temperature within Subglacial Lake Ellsworth, West Antarctica and its implications for lake access" *by* M. Thoma et al.

Anonymous Referee #2

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The paper is original, well written and of significant scientific interest. Publication in "The Cryosphere" is recommended. The decision on additions or modifications is left to the authors.

Comments and questions:

The authors provide a study of the Antarctic subglacial Lake Ellsworth (SLE) which, by their prediction, exhibits an exceptional circulation regime because the temperature of maximum density (TMD) of liquid water is crossed within the water body of the lake, in other words, is in between its minimum and maximum temperature. Given that, one expects that high-density water of that well-defined TMD is located in the near-bottom

layer, while less dense water – either warmer or colder or both – forms the upper layers where significant lateral temperature (rather than density) gradients may exist. Colder water may be produced by cooling from the ice above, warmer water may form by geothermal heating from below, modified by latent heat of freezing or melting on either side. Along potential front zones between cold and warm upper layers of equal density, by isopycnal mixing high-density water may emerge and drive thermal convection cells such as those shown in Fig. 2 of the Supplement.

p. 1006: Did the authors estimate the effect of tidal forces on the water circulation in their model (Geophys. J. Int. 161 (2005) 41, doi:10.1111/j.1365-246X.2005.02575.x) ?

The study of SLE may also serve as a valuable paradigm for systems in the Earth's inner core where e.g. silicate minerals are suspected to possess higher densities in the liquid than in the solid phase (Nature (2011), doi:10.1038/nature09940), similar to water in the cryosphere. For this purpose it would be of interest if the authors were able to estimate the net vertical heat transport across the lake (i.e. the cooling rate of the bottom or the heating rate of the ceiling) as a result of their circulation model, displayed in a 5th plot of Fig. 2, in comparison to the geothermal flow of 50 mW/m2 (p. 1007) at the bottom, the advected heat transport rate by the ice flow, and the conducted heat by the ice cover of 20 mW/m2 (p. 1007) at the ceiling. The integral of local heat flows extended over the lake's closed surface should vanish in a stationary regime.

p. 1007: The estimated ice passage time of 3 kyr is much shorter than the estimated lifetime of 35 Myr of those lakes (Nature 469 (2011) 275, doi:10.1038/469275a), and still much shorter than the glacial cycle of 100 kyr (Nature 472 (2011) 429, doi:10.1038/nature09983). One would thus expect that the lake's surface geometry is in a long-term balance with surrounding ice flow, accretion and melting. While the ice flow is suggested here to be horizontal, the melting and accretion rates in Fig. 2b indicate an ongoing vertical displacement and deformation of the lake as a whole, apparently not in balance with the ice flow. If so, this would raise questions: Is the lake a transient phenomenon rather than a stationary one? How will the lake look like after a passage time of 3 kyr, as a result of the model data, provided a fixed cover thickness? How did it look 6 kyr back at the beginning of the interglacial? Is there any chance at all that such a transient lake may preserve paleosediments?

Technical remark:

p. 1013: “and two anonymous reviewers for helpful comments and discussions” – at least one reviewer is not anonymous.

Interactive comment on The Cryosphere Discuss., 5, 1003, 2011.