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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.

M. Thoma et al.

malte.thoma@awi.de

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> 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 ayer, 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) ?

According to the cited article, tidal deformation can be measured on the floating ice above Subglacial Lake Vostok. The vertical displacements are in the order of a few centimetres. In contrast to more erratic changes in air pressure the harmonic cyclicity of tides could impose an additional signal to water circulation in the lake. A few years ago, we investigated the relative impact of this forcing on the overall flow regime for Subglacial Lake Vostok. We concluded that this impact is negligible in SLV, compared to the magnitude of the lake circulation, which will certainly hold for the significantly smaller SLE.
In addition, during the field campaig no tidal signal effect could be resolved with the DGPS.

> 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.

This might be an interesting investigation, but is far beyond the
subject of this study.

> p. 1007: The estimated ice passage time of 3 kyr is much shorter than the
> esti- mated 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?

The reviewer highlights an important point. However, how the subglacial

mass balance influences the transient behaviour of the ice sheet requires
a fully coupled ice-sheet–lake-flow model which is currently developed
(compare first comment to M.Kennicutt review). This subject is ongoing
work in our department as part of the EU-project ice2sea and the German
REKLIM-project, where we apply synthetic geometries at present.

> Technical remark: p. 1013: "and two anonymous reviewers for helpful
> comments and discussions" – at least one reviewer is not anonymous.

Corrected

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