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Interactive comment on "Lithosphere and upper-mantle structure of the southern Baltic Sea estimated from modelling relative sea-level data with glacial isostatic adjustment" *by* H. Steffen et al.

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Comments to the reviewers' report on 'Lithosphere and upper-mantle structure of the southern Baltic Sea estimated from modelling relative sea-level data with glacial isostatic adjustment' by Holger Steffen, Georg Kaufmann and Reinhard Lampe to Solid Earth.

We have revised the paper taking into account both reviewers' comments. Below follows a detailed list of how we have responded to the individual comments (marked

in *italics*) by Patrick Wu. The revised manuscript has been attached as supplement. Changes are marked in bold letters.

General statements:
This reviewer finds the comparison between the inferred variation in lithospheric thickness with those obtained from thermal and seismic data interesting. Although he states that the results and their interpretation are reasonable he criticizes that not all the assumptions are clearly stated and recommends a revision especially in view of that.

The following points should be addressed or clarified in the revision:

1. *Kaufmann & Wu (2002, EPSL 197:1-10) showed that if the ice history is known, then the current method of detecting lateral changes in lithospheric thickness with 1-D earth models by dividing RSL data into regional subsets, can give accurate estimation only if there is no lateral change in mantle viscosity below the lithosphere – otherwise the inferred lateral variations in lithospheric thickness can only be estimated qualitatively. Since both conditions are not met here, it is unclear how accurate are the estimated lithospheric thicknesses. In any case, the paper should include a discussion of this important point.*
   This important point raised by the reviewer is included in the discussion and conclusions of the revised manuscript.

2. *What is the justification of not considering the presence of an asthenosphere in the modeling? For sure, this part of Northern Europe is not that close to the continental margin as in Barents Sea, but can you be sure that it can be neglected here? In any case, some discussion is necessary. If the data can justify the absence of an asthenosphere, that would be even better.*
   Steffen and Kaufmann (2005) investigated the presence of the asthenosphere

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using a large set of Scandinavian RSL data and applying the Neighbourhood Algorithm. There was no clear indication of an asthenosphere in Fennoscandia. We also note that the depth and time range of the southern Baltic Sea data is, as written in the manuscript, much lower than other RSL data in Fennoscandia, e.g. along the Norwegian coast or around the Gulf of Bothnia. Therefore, these data cannot provide sufficient information to accurately determine the asthenosphere or low-viscosity zone. Due to that, the focus of this study is on finding common three-layer models for regional subsets of the SW part of Fennoscandia.

3. *I understand that the RSL data are sub-divided in regional subsets according to Lambeck et al. (1998) and Vink et al. (2007), but what are the criteria for assigning certain RSL data to a particular regional subset? For example, why are the sites in northern Denmark grouped with those of Oslo Graben? Or why not group those in SW Sweden with those in Oslo Graben? And how does assigning some of them to another subset affect the inferred lithospheric thickness? In addressing this issue, you compared the results of Lambeck et al. (1998), but it is not clear if those differences are due to the "new" data or the grouping. So, it would be useful to show the effect with the data in this paper, at least for a few cases.*
   Agreed, we provide results for different groupings now. The grouping follows known geologic bodies and crustal differences. We have clarified this in the text.

4. *Would be useful to have a map that shows the location of places like Fyn High, Rugen Island, Darss Peninsula, Danish Great Belt, etc.*
   Information has been added to Figure 1.

5. *In what ways are the three models in Fig. 5 different from each other physically? It might be useful to know why does the model of Priestly & McKenzie (2013) seem to better agree with the result inferred from RSL data, but not the other two models.*

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Information to each model has been extended.

6. *Fig. 3 shows that the lithospheric thickness (under the German Baltic Sea coast west of Darss and Poland) inferred from RSES ice model is different from that from ICE-5G. In Fig. 5, it is not clear which lithospheric thickness (from which ice model) is used? Also the effect of ice models on the finding should also be discussed more clearly.*
   It is the RSES ice model, which has been added. We also discussed the effect of the ice models.

7. *Page 3, lines 234: Not clear what the sentence mean. Do you mean the relation between terrigeneous influx and sealevel rise?*
   No. This relates to the water depth of the Great Belt in Denmark. It is so low (25 m) that there was a much smaller sea-level rise in all other Baltic Sea area than the eustatic sea level indicates. See sentences following the one mentioned. *Line 239: For the benefit of the readers, please explain what is "threshold depth" and "Index points". For the RSL data, how are the ages calibrated? And how are the "errors" in age determination taken into account or represented?*
   Threshold depth is the deepest depth possible for a sea-level indicator in the Baltic Sea (25 m), index point is the same as sea-level indicator, we change that. Time errors are first converted to U/Th, and then converted into an additional height error (Lambeck et al. 1998) to ease a misfit calculation. The height error then includes the effect $|dh/dt|_t \sigma_t$ (Lambeck et al. 1998), where $|dh/dt|_t$ is the rate of sea-level change at time t and σ_t the age error. Hence, the height error becomes larger while the time error is set to zero.

Minor comments:

- *First paragraph in Abstract can be condensed*
  Paragraph condensed.

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- *Line 44, reference for 10oC lower than today*
  Reference added.
- *Line 47, replace "suppressed" by "deformed"*
  Changed as suggested.
- *Line 50, peripheral bulge is formed because of mantle flow from under the load to the outside and accumulate near the ice margin*
  Changed to "the bending of the elastic lithosphere outside the ice-covered area".
- *Line 338, replace "can be spotted" by "was located"*
  Changed as suggested.
- *Line 387, "160 km and more"?*
  Added as suggested.
- *Line 459-498, would be nice to supplement this discussion with a figure comparing the results of the two studies. Actually, a table that compares the results of this study with previous studies would be very beneficial to the readers.*
  A figure will not as beneficial as hoped by the reviewer, but we agree to add a table to compare the results.

Please also note the supplement to this comment:
http://www.solid-earth-discuss.net/5/C1135/2014/sed-5-C1135-2014-supplement.pdf

Interactive comment on Solid Earth Discuss., 5, 2483, 2013.