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Interactive Comment

Interactive comment on "Effect of glacial-interglacial sea-level changes on the displacement and stress field in the forearc and along the plate interface of subduction zones" *by* T. Li and A. Hampel

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We thank referee #1 for his positive comments on our manuscript. His/her main concern is that we did not consider the rheological stratification of the mantle beneath the lithosphere in our models. In the following, we provide two main arguments why we think that our approach is justified in the case of our study (apart from the fact that is a necessary technical simplification to make the models computationally feasible).

1.) Displacements at the base of the lithosphere: Referee #1 points out that studies on postglacial isostatic adjustment have shown that the relaxation time of the sub-lithospheric mantle is of the order of kilo-years and that therefore the response of the mantle cannot be neglected especially during rapid sea-level rise. Although we agree that the timescales of sea-level rise and viscous response of the mantle are similar, we note that the response of the sub-lithospheric mantle does not only depend on the relaxation time but also on the spatial distribution and magnitude/thickness of the load, because these factors control the displacement at the base of the lithosphere that may provoke the potential flow in the sub-lithospheric mantle. Studies on postglacial isostatic adjustment (e.g., Wu, 1995; Lambeck et al., 1998; Milne et al., 2004; Steffen and Kaufmann, 2005; Steffen et al., 2006; Steffen and Wu, 2011) usually derive the viscosity structure of the sub-lithospheric mantle beneath regions that were formerly covered by >1.5-km-thick continental ice sheets. A numerical model for the Fennoscandian ice sheet (Steffen et al., 2006) shows that its weight displaces the Earth's surface vertically by 400-500 m (H. Steffen, personal communication, January 2012). As the lithosphere is implemented as elastic layer in these models, the same displacement occurs at the bottom of the lithosphere (H. Steffen, personal communication, January 2012). In contrast, the water load in our model is only 125 m and occurs uniformly over $\sim$1200 km on the oceanic plate and over $\sim$100 km on the submarine forearc. Hence, the induced displacement at the base of the lithosphere is much smaller than in the GIA models. This renders it unlikely that the displacements induced by sea-level changes can provoke a significant viscous response of the sub-lithospheric mantle even if the time scale of the sea-level rise is similar to the Maxwell relaxation time of the mantle.

2.) Viscosity structure of sub-lithospheric mantle in subduction zones: The constraints on the rheological stratification of the sub-lithospheric mantle mentioned by referee #1 were mainly derived from the postglacial isostatic adjustment of continental shields (Scandinavia, North America). The viscosity structure of the mantle beneath these stable regions cannot be directly applied to subduction zones. Rather, the rheological structure of the sub-lithospheric mantle in subduction zones is more complicated and laterally inhomogeneous because it is controlled - among other factors - by the age and temperature of the subducting slab and the subduction angle (e.g., Billen and Gurnis, 2001; Manea and Gurnis, 2007). As a) our study focusses on the displacements and stresses in the forearc and the seismogenic part of the plate interface and b) the adequate implementation of the viscosity structure beneath the lithospheric plate into our model is difficult, we followed the approach by previous numerical modelling studies (e.g., Cattin et al., 1997; Hassani and Chery, 1997; Branlund et al., 2000; Fischer, 2005) and do not consider the rheological stratification of the sub-lithospheric mantle.

In the revised manuscript we will include the following sentence in the model setup (after line 97 of the original manuscript): "Our model does not include the sub-lithospheric mantle, i.e. we assume that glacial-interglacial sea-level changes do not induce a significant viscous flow in the sub-lithospheric mantle."

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