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Interactive comment on "Using the level set method in geodynamical modeling of multi-material flows and Earth's free surface" *by* B. Hillebrand et al.

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We thank the reviewer for the swift and helpful comments that helped us improve our paper.

1) The referee says: "The authors claim that level sets are not commonly used for geodynamical modeling. I have to disagree with that. ..."

We acknowledge that a few more articles exist where the level set method is used in geodynamical modeling and we have added these to the introduction. However compared to the large number of articles published in geodynamical modeling that use the tracer method we still feel our claim is pertinent. Concerning the suggestion that

ASPECT contains a level-set component: we know that the current user version is not equipped with a signed-distance level set function at this point.

2, 3) The referee says: "... a methodological paper should provide a detailed analysis of the chosen implementation in comparison to the state of the art in the field. Again numerous mathematical papers discuss the pros and cons about level-set implementations. (. . .) The authors also state that it is not necessary to use high-order schemes when implementing the advection equation for the level set. This is surprising in light of the conclusions from the two main textbooks (. . .) It is difficult to judge the quality or applicability of the implementation suggested by Hillebrand et al. ..." and "... the main computational challenge does not seem to be the tracking of the interface, but dealing with the material jumps across the interface. ..."

It is true that further improvements upon the presented level set method exist such as local level set and velocity extensions. To address this we have added a paragraph to section 2.1. To arrive at the current implementation of the level set method we have started with a simplified signed distance function with a simple advection equation and no upwind scheme or reinitialization scheme. Furthermore, we have progressively improved on that basing our choices on retaining simplicity and on the overall code structure of our modeling software SEPRAN. This led to an implementation that produced satisfactory results. To address the mass conservation issue we have performed an extra calculation of the slab detachment benchmark showing that there too mass is conserved well within 1%. We have removed the claim that it is not necessary to use high order advection schemes, which was based on our good results with simplified techniques, as we did not test the benefits of using such schemes. The above is also so true for how we deal with the material jumps across an interface. Further improvements, such as a volume of fluid method, are possible. The benchmarks are chosen either because they have been widely used or because they represent common geodynamical problems such as detachment, subduction and a free surface. The goal of our paper is to show that with a relative simple level set method implementation relevant

geodynamical benchmarks can be solved with acceptable precision as compared to other previous codes (as acknowledged by reviewer 2) and that, taking in regard the potential for improvements, it should be seriously considered in geodynamical codes. More error analysis is beyond this scope.

Added paragraph: The level set method is a well researched interface tracking technique which was originally devised by Osher and Sethian (1988). It tracks an interface by defining it as the zero valued isocontour of a smooth function. Since then several improvements and variations have been presented by several authors such as reinitialization (see below) extension velocities (e.g. Adalsteinsson and Sethian, 1999; Chopp, 2009), local level set methods (e.g. Sethian, 2000), hybrid particle level set methods (e.g. Enright et al 2002; Samuel and Evonuk, 2010), variational level set method (e.g. Duan et al, 2008) and the level set method combined with volume of fluid method (e.g. Fedkiw et al, 1999; Pijl et al, 2008)

Interactive comment on Solid Earth Discuss., 6, 1523, 2014.