

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.

B. Hillebrand et al.

b.hillebrand@uu.nl

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We thank the reviewer for the constructive comments leading to improvements of our paper.

1) The referee says: "... Nevertheless, examples 3.2 and 3.3 have three materials. It is not trivial how to extend the Level Set approach to multiple materials ..."

This is briefly mentioned in section 2.1.2 and it is discussed for example 3.2 in that section. The level set function configuration in example 3.3 is however indeed not discussed. Therefore we have added the following to section 3.3: It contains two level set functions which partly overlap, one tracking the interface between the air and the

C864

mantle/lithosphere and one tracking the interface between the slab and the air/mantle. The zero level sets of the two level set functions can be seen in Fig. 6 and Fig. 7.

2 and 4) The referee asks how and if the FE integration scheme is modified for the interface locations and if this differs for the diffuse and sharp boundary methods. Based on the level set function values at the nodal points of the elements we assign the nodal points density and viscosity values. We then interpolate these nodal point values to the Gaussian integration points of the finite elements. This integration scheme does not differ between the two boundary methods. The stabilizing effect that the diffuse boundary method has comes from the fact that this reduces the sharp boundaries within elements. We have added information about the integration scheme to section 2.1.

3, 5) The referee cautions us: "... it should be noted that the level set function is interpolated within elements using the Finite Element (FE) shape functions (usually linear). This fact could (and likely will) provide an interface location with a similar or larger uncertainty compared to markers. Nevertheless it is true that level sets provide a sharp location ...".

As a result of this the referee also mentions that the final separation of the zero level set, which we use as determination for detachment, can also be considered a numerical artifact. We agree, indeed, with different grid resolution the timing would differ. With this in mind we have made a small change to the introduction and adjusted our statement in section 4.4: A particular benefit of using the level set method in monitoring slab necking is that the moment the zero level set splits into two disjoint domains can be used as a determination of the time of detachment.

6) The referee reminds us: "... some situations, for example if rheology is history dependent, require the tracking of materials ...".

It is indeed true that the recording of history is an advantage of the tracer method. We have added this to the part in the introduction where tracers are discussed: While the

C865

tracer method tracks materials and has as the added advantage that it can record its history, it however does not track the interface between the materials.

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C866