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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.

**Anonymous Referee #2**

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The paper presents a brief introduction to the Level Set method and compiles a set of benchmarks that can be used to validate the proper behaviour of a multiphase code. These benchmarks are focused in geodynamical problems. Authors show that their implementation has similar accuracy than other previous codes. The paper is well written. I find it useful and recommend publication under minor revisions.

A list of comments (sorted by importance) follows:

1. Section 2.1.2 presents how to locate the interface of a two-phase problem using a Level Set function. Nevertheless, examples 3.2 and 3.3 have three materials. It is not trivial how to extend the Level Set approach to multiple materials. Do



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authors use several Level Set functions? This needs to be explained.

2. Two options –sharp boundary vs. diffuse boundary– are presented. I was surprised to read that they used the later for all benchmarks (except one). Why do the authors prefer the diffuse boundaries? Is this choice based only on numerical considerations? What is the meaning of having a "diffuse" Earth surface? The authors claim that the diffusive boundary has a "stabilizing effect", could this be related to the way they perform the integrals (see point 4)?.

3. When presenting marked-based methods the authors claim that "interface position remains approximate and is known with an uncertainty of the order of the tracer distance". While this is true, it should be noted that the level set function is interpolated within elements using the Finite Element (FE) shape functions (usually linear[1]). This fact could (and likely will) provide a interface location with a similar or larger uncertainty compared to markers. Nevertheless it is true that level sets provide a sharp location of the interface (even when it is not exact) not available using markers.

4. It will be interesting for readers wanting to reproduce the results to have some information on how the FE integration scheme is modified to account for the interface location. Is this the same with sharp and diffuse boundaries?

5. In Section 4.4 the authors state that "A particular result of using the level set method in monitoring slab necking is that the moment of final detachment is also recorded". There is a subtle issue with this statement. In this example probably it does not make any difference, but conceptually is important. The detachment described by the Level Set method is a numerical artifact. It detaches because the finite element interpolation is not able to describe smaller features than the

[1]Increasing the order of the interpolation of the Level Set function brings in complexities that heavily complicate the scheme.



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element size. It is not physical but numerical. If the finite element mesh is finer, the detachment time will probably be recorded by the level set (slightly) later. Again, I don't see any problem in this example, I believe it is fair to time the detachment based on the level set. I just would be careful on the writing.

6. At introduction the authors somehow present the interface-tracking as a better option to material-tracking. This dichotomy in not always real: some situations, for example if rheology is history dependent, require the tracking of the materials.

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