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Geoscientific Model Development Discussions

Interactive comment on "Global scale modeling of melting and isotopic evolution of Earth's mantle" *by* H. J. van Heck et al.

H. J. van Heck et al.

vanheckhj@cardiff.ac.uk

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We met the reviewer at a conference and discussed about where things are not clear.

We will first respond to the two main issues the reviewer mentioned.

They are: 1. Initial conditions are not clear; and 2. The tracers do not hold information on melting, and are not erupted on melting.

1. The initial conditions have 3 components.

First the temperature, we will add a more detailed description to section 2.2 "Calculation setup" to briefly describe the initialisation of the temperature and flow field. (Which is different from Xie&Tackley)

Second; bulk composition which is set up as just a homogeneous distribution of c=0.6 in all of the mantle. (Which was clear in the original version of the manuscript: personal communication with the reviewer.)

Lastly the trace elements. The initialisation was described in a fairly detailed way in the original manuscript but the order of writing might improve the clarity. All necessary information is in the manuscript (as agreed to by the reviewer; personal communication). We will rearrange sections 2.5 and 2.6 in order to find a more logical flow particularly in the initialisation of the trace elements.

2. Responding next to the comment that "the tracers do not hold (and save) information on melting history". We note that this is not required since melting is enacted in every time step. This is different to some earlier work where melting history was recorded at the particles and only sent to the surface after a certain amount of melt had been produced and a "melting-event" was triggered. Tracers hold information on the bulk composition, which is changed when melt is produced.

Our implementation does include what the review calls eruption, i.e. the movement of basaltic material to the surface on melting, and so is suitable for tracking degassing. What is different from other implementations (eg Christensen and Hoffman, Xie and Tackley and the papers by van Keken and colleagues) is that we transport the information carried by the particles instead of the particles themselves, as previous methods did. Our implementation has several advantages over the other techniques; we can model any degree of melting without being limited by the resolution of the number of particles; we do not have to gather enough melt before eruption can happen; our implementation is computationally easier in the sense that it requires much less communication between different parts of the grid; and melting does not lead to variations in the concentration of particles.

We will add to figure 1 an indication of the generation of oceanic crust to clarify. We will also expand the first paragraph of the discussion and add a description of the

differences and advantages of our implementation over previously published methods.

Response to the detailed comments (in the same order as written in the review):

* line 18-19. We will move the sentence to the end of the paragraph as the reviewer suggested.

* We will rewrite the last paragraph of the introduction.

* We changed the title of section 2.1 to “Numerical mantle convection simulations” as the reviewer suggested.

* We will add the equation for chemical composition to equations 1-3 as suggested.

* See main point 1.

* After personal communication with the reviewer we agreed that reordering sections 2.5 and 2.6 is sufficient.

* See main point 2.

* Equations 6 and 7 are equivalent, 7 is just more detailed. We will add a bit more text around equation 7 to clarify. The particles do not advect temperature.

* The solidus is roughly in line with experimental values; the slope is adapted to account for higher viscosity and thus thicker boundary layers. For the purpose of the present manuscript, testing the robustness of the method, we believe the exact values of the melting temperatures are not critical.

* Our formulation of equation 8 is standard to describe batch melting, and is equivalent to equation 15 in Christensen and Hoffman (1994).

* See main point 2. We will add more details to the first paragraph of the discussion.

Interactive comment on Geosci. Model Dev. Discuss., 8, 9553, 2015.