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Solid Earth Discussions

Interactive comment on "Using open sidewalls for modelling self-consistent lithosphere subduction dynamics" *by* M. Chertova et al.

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General Comments

This paper explores the influence of side-wall boundary conditions on the dynamics of subduction models in 2D. Specifically they test the difference in slab evolution and magnitude of trench motion and mantle flow in models with open side-walls compared to closed (free-slip) sidewalls. Open sidewalls are not commonly used in these types of subduction models, but the results here show that they provide a good alternative to using larger model domains with free-slip sidewalls. Importantly, they also show that when using models with different aspect ratios it is necessary to scale the velocity magnitude to take into account the box-size dependence of energy dissipation: without this scaling the velocity magnitudes in smaller boxes are too high because they do not

account for the work done by flow on the extensions of the plate outside the box. These results show that one must carefully select boundary conditions and box size in a way that best reproduces the specific geological conditions being modeled.

Specific Scientific Questions/Comments

1. While the aspect ratio of the box was varied in the model domain, the box depth was not and this can have an effect on how the flow couples to the side-wall conditions. In particular, in doing 2D kinematic models of subduction I found that slab evolution was very sensitive to the distance to the sidewalls if the box depth was 1500 km (slab curled backwards), but was not sensitive to the sidewalls if the box depth extended to the core-mantle boundary (2980 km) – this was for model widths of 4500 to 9000 km (see Appendix A of Billen & Hirth, G-cubed 2007). Clearly the flow is still constrained to be vertical at the sidewalls, which is not realistic and is a limitation of the models. Also, because they were kinematically driven, it was not possible to determine the effect on trench motion of mantle flow. I ask if the authors have considered deeper models?

2. Although open sidewalls provide less of a constraint on flow, the do still impose a constraint - that is that flow must be horizontal. They also imply that mantle flow outside the box is not constrained in any way by what else is going on in the model (large regions of upwelling driven by lower mantle structure, or the flow driven by another subduction zone). Therefore, we still need to be cautious interpreting and applying the results to the Earth, which does not have isolated slabs that are unaffected by the surrounding mantle. It may be useful to include such a discussion in the paper – any boundary condition is an approximation, and one must choose these carefully depending on the problem being considered.

3. Finally, while the flow magnitude and trench motion is different, the shape of the slabs are remarkably similar at similar stages of subduction (for example, figure 5). If models CO3 and CCR3 were allowed to run to similar stages, would the slab shapes be similar? If so, this suggests that while the background flow and rate of flow are

different depending on the boundary conditions, the deformation of the slab is mainly controlled by the its local buoyancy/strength balance?

Technical Comments

1. Appendix A: The velocity scaling calculation is a little hard to follow because the parameters in the equations are not labeled consistently (P vs. P_in ??). Also, it takes a second reading to see that you are scaling the velocities, plugging them into equation (A1) and then recalculating the power dissipation. You also don't define what j is, but one has figure this out that this is the iteration number.

2. Figures: the velocities are omitted or difficult to see in figures 1B, 4B, C, and D – while this illustrates the difference in magnitudes, its frustrating to not be able to see the flow pattern that is being discussed. I recommend using different scaling in these models so the velocity vectors are visible.

3. There are some typoe/grammar issues (needs to be read over again by authors) – in particular, use of words proof or proofs which should be prove of proves.

4. Some paragraphs combine multiple topics and are very long, the readability of the paper would be improved by carefully splitting some paragraphs

5. Abstract is wordy and repetitive – could be at least a 1/3 shorter.

Interactive comment on Solid Earth Discuss., 4, 707, 2012.