Dear Copernicus editorial team,

We have addressed the concerns of Reviewer 2 regarding the impacts of our closed model design, and have made several small edits to the text to fix typos or improve clarity, including a small stylistic change to the abstract.

Comment from reviewer 2: This is my second review of this paper and I think my previous concerns have been mostly clarified. I still have a concern about the largely curved slab (slab rolling back to the lower side) in many models with relatively high slab stiffness, because this case is rarely observed in nature. I am wondering whether the 'impermeable' lower boundary condition strongly controls this phenomenon. Such a style of slab geometry and kinematics is mostly predicted in the 3D analogue models with rigid lower boundary or 2D/3D numerical models with either free slip or rigid lower boundary. In contrast, most of the models with a phase transition at 660 km do not produce such a strong rolling back structure (just my impression; should be clarified). On the other hand, the interaction between subducting slab and 660D strongly controls the slab morphology as already discussed in several review papers. Thus, I would suggest discussing the limitations of lower boundary condition (as the free slip or rigid boundary is a great simplification of the 660D). As a summary, this study clarifies many detailed aspects of plate rheology on the subduction dynamics; thus, I think it should be worthy for publication.

We agree that the free-slip boundary at 660 km affects model behavior and should be addressed more explicitly in the text. We have improved our discussion of this effect in two locations:

On lines 343 through 345, after discussion of the high subduction velocity reached by the overturned slabs, we have included the sentence:
"The free-slip boundary at the bottom of the models likely exacerbates this acceleration, as other implementations of the transition zone might provide more resistance to lateral sliding of the slab at 660 km."

And in the discussion, near line 407, we have included the paragraph:

It should be noted here that our models approximate the base of the upper mantle as a hard boundary, which undoubtedly has an impact on slab morphology and subduction dynamics once the slab tip reaches the bottom of the model. For this reason, divergence from realistic behavior at the later stages of our experiments cannot be entirely attributed to high slab stiffness. If the models presented here had a viscosity contrast at 660 km depth, rather than a hard boundary, the creep-governed slabs may have penetrated the mantle transition zone. Sufficiently stiff slabs in the models of Garel et al. (2014) approach the transition zone bent, like our slabs, but, upon reaching 660 km depth, continue vertically downwards or undergo trench retreat to bend forward. On the other hand, in the 3-dimensional models of Stegman et al. (2010), which also simulate a viscosity contrast at 660 km depth, slabs with sufficiently low Stokes buoyancy, and with comparable stiffness to our creep-governed slabs ($\eta_{slab} /\eta_{mantle} (H_{slab}/H_{mantle})$^3 = 1-100), overturn, similar to our models. It is difficult to know which morphology our slabs would exhibit if our models had included a lower *mantle. Regardless, our overturned, creep-governed slabs appear unusually stiff, despite moderate (< 80 km) effective thicknesses.*

We again thank the reviewer for their insightful feedback. It has considerably improved the quality of our manuscript. We would also like to thank the editorial team for their help throughout the revision process, and Reviewer 1 for their feedback on our first revision.

-Natalie Hummel, on behalf of the authors