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Interactive comment on "A hierarchical mesh refinement technique for global 3-D spherical mantle convection modelling" *by* D. R. Davies et al.

D. R. Davies et al.

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We would like to thank Prof. King for his constructive review. Whilst mainly positive, he has highlighted a few issues, which we discuss in further detail below:

1.(Comment) It is not clear to me based on the results of Table 1 or Table 2 that the authors see a significant improvement in the global solution parameters with the non-uniform grid for a similar number of nodes, which is disappointing. For example, it is not clear to me that D13(5) is any better than D13(2).

(Response) As the reviewer points out, the results of our uniform and non-uniform cases are generally consistent in Table 1. Indeed, if you compare the RMS velocities and Nusselt numbers of all D13(5) cases with all D13(3) cases, they are almost indistinguishable. Nonetheless, as is demonstrated in Table 2, the results for the D13(5) simulations are achieved in approximately 50% of the CPU-time (and from Table 3, using approximately 50% of the RAM). Therefore, whilst the technique does not increase accuracy, it does allow one to achieve solutions of similar accuracy, in far less time (whilst also requiring less RAM).

2.(Comment) In Figure 4, the error for the l=16 case is enormous and I am not sure why. If I compare with Zhong et al. 2008, while they do not show relative error, their results appear to track the analytic solution regardless of harmonic degree.

(Response) The Zhong et al. (2008) study does not show convergence plots for these propagator matrix tests. They do, however, state that the resolution of their propagator matrix tests is 12(64$\times$64$\times$64) elements, for most of their cases (i.e. 3.14 $\times$ 106 elements in total). Without convergence plots, it is difficult for us to undertake a direct comparison between various diagnostic outputs. However, assuming that their cases with mid-mantle perturbations at spherical harmonic degree (SHD) 15 (the Zhong et al. 2008 study did not give results at degree 16) were run at the aforementioned resolution, their relative errors are between 3-4%, for characteristic velocities and topography. If we consider our SHD=16 values, for simulations at mt=64 (1.35 $\times$ 106 nodes in total) and mt=128 (10.65 $\times$ 106 nodes in total), our results are consistent. We note that the results of Zhong et al. (2008) show larger relative errors for finer scale (higher spherical harmonic degree) spherical harmonic perturbations, which is consistent with what we, and other studies (e.g. Burstedde et al. 2013) observe. Therefore, contrary to the reviewer's statement, there is a dependency upon the spherical harmonic degree.

3.(Comment) My only other comment is that the level of detail in this paper could be improved, specifically with regard to exactly how the diagnostics are measured (i.e., equations and formulas).

(Response) We have added equations for the diagnostics quantities used in Tab. 1

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Interactive Comment

(Nusselt Numbers and RMS Velocity) to the manuscript, as suggested (Eqs. 5 → 7). We should not have omitted these in our original submission and thank the reviewer for requesting this clarification.

Interactive comment on Geosci. Model Dev. Discuss., 6, 2249, 2013.