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Solid Earth Discussions

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Interactive comment

Interactive comment on "Numerical simulation of mantle convection using a temperature dependent nonlinear viscoelastic model" *by* M. Norouzi et al.

Anonymous Referee #2

Received and published: 22 February 2016

I have a number of serious issues with this work, as summarized below.

To start with, the pdf does not have figures which makes it hard to review it. Apart from this sloppiness, there are a large number of other issues that I believe are serious and as such this is not publishable in its current form.

1) Lack of literature review The authors give a very rather incomplete review of previous work on mantle convection, for which an enormous amount of literature exists (interestingly they miss seminal work by McKenzie, Christensen, Tackley, Moresi, Solomatov and many others). I strongly suggest that they read up on the topic, for example by reading textbooks by Schubert, Davies, or some of the many review papers (by Tackley, Bercovici, Ricard, many of which are available online).

As the current paper deals with viscoelastic convection, I had expected at least a com-

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Discussion paper

plete review of existing work on this topic which is however also not the case, which shows a rather large ignorance towards previous work.

Thielmann, M., Kaus, B., and Popov, A.A., 2015, Lithospheric stresses in Rayleigh–Bénard convection: effects of a free surface and a viscoelastic Maxwell rheology: Geophysical Journal International, v. 203, no. 3, p. 2200–2219, doi: 10.1093/gji/ggv436.

Beuchert, M.J., and Podladchikov, Y.Y., 2010, Viscoelastic mantle convection and lithospheric stresses: Geophysical Journal International, v. 183, p. 35–63

Muhlhaus, H.-B., Davies, M., and Moresi, L., 2006, Elasticity, Yielding and Episodicity in Simple Models of Mantle Convection: Pure and Applied Geophysics, v. 163, no. 9, p. 2031–2047, doi: 10.1007/s00024-006-0111-5.

Muhlhaus, H.-B., and Regenauer-Lieb, K., 2005, Towards a self-consistent plate mantle model that includes elasticity: simple benchmarks and application to basic modes of convection: Geophysical Journal International, v. 163, no. 2, p. 788–800..

Moresi, L., Dufour, F., and Muehlhaus, H.B.M.X., 2002, Mantle Convection Modeling with Viscoelastic/Brittle Lithosphere: Numerical Methodology and Plate Tectonic Modeling: Pure and Applied Geophysics, v. 159, no. 10, p. 2335–2356, doi: 10.1007/s00024-002-8738-3.

and this should certainly include the pioneering work of Harder in this respect: Harder, H., 1991, Numerical-Simulation of Thermal-Convection with Maxwellian Viscoelasticity: Journal of Non-Newtonian Fluid Mechanics, v. 39, no. 1, p. 67–88.

2) Gravity Some of the other reviewers were a bit annoyed of your use of a depth-varying g, yet your polynomial does indeed reproduce the depth dependent effect of g on Earth, if I plot it on MATLAB, using the following lines:

```
» y=[1:3000]/1000; » g=-0.118*y.ˆ6+ 0.602*y.ˆ5 - 1.006*y.ˆ4 + 0.6884*y.ˆ3 - 0.3708*y.ˆ2 + 0.167.*y - 9.846; » plot(g,y*1000), axis ij
```

The point is, however, that the variation of g within the Earth's mantle is very minor which your expression also shows, which is why it is usually assumed to be constant.

3) Employed constitutive relationships All above mentioned papers employ linear viscoelasticity, for the simple reason that there is not much data to support the use of more complicated elasticity models for applications on the scale of a convecting mantle (apart maybe from using a Kelvin body for bulk deformation). One can ofcourse come up with arbitrary complex constitutive relationships but if there is no data to back it up you are not modelling a problem that is geoscientifically relevant. It is unclear to me why the Giesekus model should be relevant for geoscientific applications and you don't give a justification for that which implies that your paper is simply irrelevant for geoscientific purposes.

4) Viscous dissipation Different than what you claim, viscous dissipation has been studied in the context of mantle convection models since at least the mid-80ies (please look at classical papers by Christensen and the above mentioned textbooks). Importantly, you should include adiabatic heating if you include viscous dissipation as they are of similar order of magnitude.You don't do that here.

5) Inertial terms Mantle convection is low Reynolds number fluid flow; yet you include inertial terms in your formulation. You can use that to model mante convection but you would have to employ a very small timestep; moreover, you should first demonstrate that your code actually reproduces normal viscous convection for example by reproducing the Blankenbach benchmarks.

6) Missing figures the uploaded pdf has no figure which makes it impossible to review it. Yet, from the text alone it is clear that this work is currently very far removed from being publishable in an Earth Science journal.

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