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Geoscientific Model Development Discussions
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Interactive comment on "A global,spherical,finite-element model for postseismic deformation using ABAQUS" *by* Grace A. Nield et al.

Anonymous Referee #1

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The authors used ABAQUS —a commercial finite-element software package— to simulate postseismic deformation on the self-gravitating earth model. They have benchmarked their results for both coseismic and postseismic deformations with semianalytical solutions.

The article's subject matter is interesting and relevant to the journal of Geoscientific Model Development (GMD). The results for the given examples look excellent. I have the impression that the overall content of the article could be improved. I have a few concerns.

- The authors used the finite-element method, which is also clearly implied from the

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title. However, I do not see any related finite element formulations. I expect at least the strong and weak forms of the governing equations with necessary boundary conditions so that the work is entirely reproducible. For example, implementing full gravity and solid-fluid coupling is known to be challenging for global problems. I am curious about how those aspects are implemented. In my view, a proper section for appropriate formulations would make this article complete.

- The most basic and widely used Earth model is the Preliminary reference Earth model (PREM, Dziewonski, A. M. & Anderson, D. L., 1981). I wonder why authors chose to use a simple three-layered model instead of the PREM. Furthermore, they mention in the abstract "the model can be easily adapted to include different rheological models and lateral variations". In this context, at least one example with the lateral variation of viscosity (e.g., Latychev et al., 2005) would be interesting.

- Although not explained in the article, it seems that the mesh contains the nonconforming elements when transitioning from course to fine elements as shown in Figure 1. But then in Section "2.1 Model Geometry and Mesh" the authors mention, "The element type used is an 8-node linear brick element"! How is it possible to use an 8-node brick element for nonconforming elements? Do you use a discontinuous Galerkin method? Please clarify.

- Authors have frequently used the term "flat earth." I think "homogeneous halfspace" or "layered halfspace" is probably a more appropriate term.

Given the above comments, I would recommend this article for a moderate to major revision.

Minor comments follow. In the comments below, P refers to the page number, and L refers to the line number.

P4L29: "..on the likely Earth structure..." What do you mean by "likely Earth structure"?

P2L34: "flat-Earth." "Homogeneous halfspace" or "layered halfspace"?

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P3L92: “a fault plane within the mesh.” Given that you use the brick elements, accommodating the realistic and complex faults may be very difficult with this approach. Alternatively, one can use the so-called moment-density tensor approach.

P3L96: “...using surface-to-surface tie constraints. . .” Please write appropriate equations for these constraints.

P4 Section 2.3: These boundary conditions are best to be represented by appropriate equations!

P6L165: “...as the fault is not allowed to open.” Realistic faults may have some opening as well. How do you accommodate that kind of scenario?

P6L181: “500 km.” Given that the total depth of the model is 670 km, how does this large element behave?

P7L185: “... simple Earth structure”. Why not use a more common Earth model PREM?

P7 Section 4.2 Coseismic Results Can you show the snapshots of the surface displacement?

P7 Section 4.3 Postseismic Results Can you show the snapshots of the surface displacement at selected time steps?

P7L214: “...less coseimic dispalcemetn from the ABAQUS. . .” What is the reason for less coseismic displacement for ABAQUS?

P9L251: “...an approximation of all the fault planes into a single geometry would be required..” I don’t think this is a reliable way. A better alternative is to use the moment-density tensor approach.

Figure 1: This figure may be sharper and better in black and white.

Figures 3-5: Showing the depth only to 100 km is confusing. Either show the full depth

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or explain it in the captions.

Figures 3-7: Figures look low in quality. It may be better to save those figures in vector graphics, if possible.

Finally, the following references are worth citing. References: Al-Attar, D. & Tromp, J., 2014: Sensitivity kernels for viscoelastic loading based on adjoint methods Geophysical Journal International, Oxford University Press, 196, 34-77

Dziewonski, A. M. & Anderson, D. L., 1981: Preliminary reference Earth model Physics of the Earth and Planetary Interiors, 25, 297-356

Latychev, K.; Mitrovica, J. X.; Tromp, J.; Tamisiea, M. E.; Komatitsch, D. & Christara, C. C., 2005: Glacial isostatic adjustment on 3-D Earth models: a finite-volume formulation Geophysical Journal International, Blackwell Science Ltd, 161, 421-444

Zhong, S.; Paulson, A. & Wahr, J., 2003: Three-dimensional finite-element modelling of Earth's viscoelastic deformation: effects of lateral variations in lithospheric thickness Geophysical Journal International, 155, 679-695

Best regards,

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