

Interactive comment on “SELEN⁴ (SELEN version 4.0): a Fortran program for solving the gravitationally and topographically self-consistent Sea Level Equation in Glacial Isostatic Adjustment modeling” by Giorgio Spada and Daniele Melini

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This manuscript details the background and significant improvements to an open-source implementation of the sea-level equation. As solutions to this equation are essential to understanding relative sea level and geodetic evolution, the open-source method and documentation are welcome and the changes - including the physics of rotation and shoreline migration and the modularization of the code - warrant publication.

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In addition, I believe the inclusion of the derivation to be useful to the community. Pursuant to that, there are areas where the derivation could be made even clearer, as noted below. Occasionally, a proliferation of variable definitions and abbreviations clouds the exposition, and a simplification would be welcome.

Finally, as the authors have just used this code's predecessor to participate in the benchmarking exercises of Martinec, et al. 2018, I think updating the contributed results with the new capabilities is warranted. In particular benchmark E, in which it seems they did not participate. As this is perhaps a more technical detail, I think it should be satisfactory to put this in the supplement, with perhaps a comment in the introduction to section 3. To this end, it would also be very interesting to see some discussion of how the included physics of rotation affect the results of those benchmarking cases.

All further comments are presented in page-line format

Specific Comments

1-15: I would like to mention that the python module, giapy, which was benchmarked in the Martinec, et al. 2018 paper (including shoreline migration and iteratively determined initial topography, though without rotation) is available for download, open-source (from <https://github.com/skachuck/giapy>), and similarly uses any normal-mode form love numbers. It is safe to say, however, that it has not yet been as comprehensively documented in its open-source release as SELEN.

2-15: "viscoelastic rheology...properly taken into account" see note to 1-15

4-12: Could you use $\$S\$$ instead of $\$B\$$ to keep it all consistent?

4-2: "ice and by the water in the ocean" refers to ice on the continent and water in the ocean, which is the basis for equation (2). Equation (1) refers to ice and water over the surface of the earth, i.e., $\$_e\$$.

4-13: given the detail of the surrounding derivation, could you spare a few words giving

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a precise definition of “topography”?

5-4: The meaning of “plausible” is not addressed in the referred paper beyond setting the integrated mass load variation, or equivalently the zero-degree coefficient, to zero.

5-6: Could more interpretable labels be given to the components of the load variation than a, b, and c?

5-10: The repeated definition of the variation variables gets confusing. Could the font used throughout be defined as the variation with respect to some reference level?

5-19: Can you give a physical meaning to the height variable Q ? “Auxiliary variable” and “arbitrary reference density” are a little confusing and undermotivated. If you selected $\rho_r = \rho_w$, then it takes the form of a free water column, positive where there is liquid water, negative where the water is frozen, and zero otherwise.

7-9: Throughout, when referring to equations in the supplement, could you refer to specific equations?

9-12: Could you briefly describe the significance of the external and internal iterations?

16-12: You could cite somewhere the work done by Barletta and Bordoni (2013) on the effects of implementation of ice histories.

17-27: see note to 1-15.

Table 2: For clarity, you might articulate that these are piecewise constant layers whose upper radii are given by the variable r .

Figure 4: Is the ordering significant? If so, state what guides it. The non-numerical ordering makes it difficult to locate them from the text quickly.

Figures 5 and 6: the color scale looks different between these figures for the resolutions in the manuscript draft. Make sure to check this as it goes through editorial.

Technical corrections

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2-2: “available since” is a bit awkward, consider “dating from”

2-10: “Despite GIA is now tightly” missing clause between “Despite” and “GIA”

2-16: “limited the” missing word “to”

2-16: “elastic rheology” to “elastic deformation”

2-20: “Love numbers” to “Love number”

2-28: “is hosting” to “has hosted” for tense agreement

2-30: “Since year” missing work “the”

3-24: “taken by the SLE” to “the SLE takes”

3-24: remove “an”

6-6: Should $\ss be $\se ?

8-25: “accomplished projecting” missing word “by”

11-14: “with origin in the whole Earth’s. . .” to “with the origin at the Earth’s. . .”

12-7: “from high-resolution but also from” to “from both high-resolution and”

12-21: The first clause “Differently...program” is awkward to read and the sentence would be fine without it.

13-5: The meaning of the word “safely” is not clear.

13-25: “since” used twice in one sentence.

13-27: Consider adding “and shown in Figure 7” at the end of that sentence for a smoother transition.

13-30: The sentence beginning with “Further results” could be revised to “Dashed curves show results obtained with the traditional theory.”

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14-9: Inconsistent abbreviations in section headings; “GIA versus “Glaical Isostatic Adjustment”

14-25, 14-31: “regardless the” missing word “of”

15-3: “very affected by” to “sensitive to”

16-8: “Disclosing” to “Tracing”

17-6: “which has been” to “which was”

17-14: move “in SELEN” to the end of the sentence

17-15: “increased physical realism” is a little odd

Figure 7: label ‘x’ and ‘y’ in the right-hand panel.

Interactive comment on Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2019-183>, 2019.

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