Solid Earth Discussions

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Comment on se-2021-36

Lorenzo Colli (Referee)

Referee comment on "Numerical solutions of the flexure equation" by David Hindle and Olivier Besson, Solid Earth Discuss., https://doi.org/10.5194/se-2021-36-RC2, 2021

This manuscript focuses on the numerical solution of the thin-plate equation for the elastic flexure of the lithosphere with variable flexural rigidity. In particular, the authors compare two finite-difference schemes: the commonly used “whole station method” and an already known but overlooked “half station method”. They conclude that the half station method is more stable and should be preferred to the whole station method.

Overall, I think that this manuscript is well written and its main conclusion regarding the superiority of the half station method is broadly correct and of practical use for studies of lithospheric flexure. However, the title of the manuscript is overly general with respect to its content. Moreover, I think the manuscript should characterize better the difference between the two methods in terms of convergence to the analytical solution and in terms of computational efficiency.

The whole station method is able to handle smooth variations of flexural rigidity. But, with the exception of idealized infinitely sharp discontinuities, any variation of flexural rigidity can be represented smoothly if the computational grid is sufficiently fine. So the whole station method should be able to handle even large spatial gradients of flexural rigidity, if the gradient per gridpoint is small enough. The difference between the two methods becomes one of degrees of accuracy and of computational efficiency. In many instances accurate solutions are possible even with the whole station method. On the other hand, there are geophysically interesting problems (some of which are presented by the authors) that feature exceedingly sharp variations of flexural rigidity, such that an accurate solution with the whole station method is impractical. This is an important distinction. The authors make some overly general statements that may lead to a fundamental misunderstanding of the validity of published results based on the whole station method.

Some more tests and examples featuring rapid variations of flexural rigidity should be carried out where analytical solutions are compared against numerical results using the two methods with coarser and finer discretizations. This would strengthen the manuscript considerably. On this note, while analytical solutions for arbitrary loads are hard to come by, it is relatively easy to “backward engineer” an analytical solution by plugging into equation 2 arbitrary ad-hoc functions of deflection and flexural rigidity, obtaining the corresponding causative load.

Regarding the title, if the authors want to keep the current one they should expand the scope of the manuscript considerably, including a discussion of other numerical methods (e.g., finite elements) and of 2D and 3D systems. Otherwise, they should modify the title to reflect better the contents of the manuscript.

Regards,

Lorenzo Colli

Minor comments and typos:

Line 56: The q in eq. 3 is not the same q of equations 1 and 2. Please use a different letter/symbol.

Line 131: “no third OR fourth derivative terms”

Line 134: typo in “arbitrary”

Lines 156-158: please plot the resulting solution for the whole station method in a supplementary figure.

Figure 1: the restoring force from the mantle is k * u * Delta x. The missing u should appear in the equations at the bottom of the figure, too.