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A benchmark study of numerical implementations of the sea-level equation in GIA modelling

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The sea-level load in glacial isostatic adjustment (GIA) is described by the so called sea-level equation (SLE), which represents the mass redistribution between ice sheets and oceans on a deforming earth. Despite various teams independently investigating GIA, there has been no systematic intercomparison amongst the solvers through which the methods may be validated. The goal of this paper is to present a series of synthetic examples designed for testing and comparing numerical implementations of SLE in GIA modelling. Ten numerical codes tested combine various time and spatial parameterizations. The explicit time-domain discretization or the Laplace-domain transformation are applied to evolve the SLE in time, while spherical harmonics, finite differences or finite elements parameterize the field variables spatially. The surface load distribution and solid Earth's topography are represented spatially either on the grid of the Gauss-Legendre longitudinal nodes and equal-angle latitudinal nodes, or equal-area, icosahedron-shaped, spherical pixels. Comparisons are made in a series of five benchmark test cases with an increasing degree of complexity. Due to the complexity of SLE, there is no analytical solution to it. The accuracy of the numerical implementations is therefore assessed by comparison of the differences of individual solutions with respect to a chosen solution. The benchmark study does not result in GIA predictions for a realistic loading scenario, but we establish a set of agreed results that can be extended in future by including more complex case studies such as the solution with a realistic loading scenario, the rotational feedback in the linear momentum equation and three-dimensional viscosity structure of the Earth's mantle. The current benchmark study is a follow-on to the Spada et al. (2011) benchmark study of various GIA modelling codes and mathematical formulations in which here the comparison is made for the case of surface mass loading by the SLE. In spite of the significant differences in the implementations of the SLE, the test computations performed so far show a very good agreement between the results and their ability to capture the main features of sea-level change and viscoelastic behaviour of the Earth.

Literature G. Spada, V. R. Barletta, V. Klemann, R. E. M. Riva, Z. Martinec, P. Gasperini, B. Lund, D. Wolf, L. L. A. Vermeersen, and M. A. King, 2011. A benchmark study for glacial isostatic adjustment codes. Geophys. J. Int. 185: 106-132 doi:10.1111/j.1365-246X.2011.04952.x