EGU22-5146, updated on 02 Oct 2022
https://doi.org/10.5194/egusphere-egu22-5146
EGU General Assembly 2022

The use of Non-Linear Geometry (NLGEOM) and gravity loading in flat and spherical Finite Element models of Abaqus for Glacial Isostatic Adjustment (GIA)

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In geodynamic studies, most Finite-Element (FE) models in the commercial FE software Abaqus use elastic foundations at internal boundaries. This method works well for incompressible and so-called material-compressible material parameters but it is unclear if it works sufficiently well for implementing compressibility, especially in a 3D spherical model. The latter is of importance in investigations of glacial isostatic adjustment (GIA). A possible alternative method is based on a combination of explicit gravity loading with non-linear geometry (NLGEOM parameter in Abaqus) (Hampel et al., 2019). This method would remove the need to make a stress transformation to get the correct GIA stresses, and automatically accounts for the change in internal buoyancy forces that arises when allowing for compression, according to the Abaqus Documentation. We compared the method for (in)compressible flat (~half-space) FE models with existing numerical half-space and spherical (in)compressible codes and tested the applicability of this method in a spherical FE model. We confirm that this method works for multi-layer incompressible flat FE models. We furthermore notice that horizontal displacement rates of incompressible flat FE models match those of spherical incompressible GIA models below the current GNSS (Global Navigation Satellite System) measurement accuracy of 0.2-0.3 mm/a, but only for ice sheets that are smaller than 450 km in extent. For compressible models, disagreements in the vertical displacement rates are found between the flat NLGEOM model and the compressible Normal Mode code ICEAGE (Kaufmann, 2004). An extension of the NLGEOM-gravity method to a spherical FE model, where gravity must be implemented in the form of body forces combined with initial stress, leads to a divergence of the solution when viscous behaviour is turned on. We thus conclude that the applicability of the NLGEOM method is so far limited to flat FE models, and in GIA investigations for flat models the applicability further depends on the size of the load (ice sheet, glacier).

References:

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