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DOI
10.5194/egusphere-egu21-15773

Publication date
2021

Document Version
Final published version

Citation (APA)
van Calcar, C. J., de Boer, B., Blank, B., van de Wal, R. S. W., & van der Wal, W. (2021). *The effect of the GIA feedback loop on the evolution of the Antarctic Ice sheet over the last glacial cycle using a coupled 3D GIA – Ice Dynamic model*. 1-1. Abstract from EGU General Assembly 2021. https://doi.org/10.5194/egusphere-egu21-15773

EGU21-15773
https://doi.org/10.5194/egusphere-egu21-15773
EGU General Assembly 2021

The effect of the GIA feedback loop on the evolution of the Antarctic Ice sheet over the last glacial cycle using a coupled 3D GIA – Ice Dynamic model

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The Earth's surface and interior deform due to a changing load of the Antarctic Ice Sheet (AIS) during the last glacial cycle, called Glacial Isostatic Adjustment (GIA). This deformation changes the surface height of the ice sheet and indirectly the groundling line position. These changes in surface height and grounding line position influence the evolution of the AIS and consequently, again the load on the Earth's surface. As a result, GIA operates as a negative feedback loop and could stabilize the evolution of the AIS. This feedback maybe particularly relevant for relatively low viscosities of the mantle in West Antarctica which lead to a relatively fast response time of the bedrock due to changes in the West Antarctic Ice Sheet loading. Most studies capture this process by ignoring lateral variations in the viscosity of the mantle and the stabilizing GIA feedback loop. Here we present a new method to couple an ice sheet model to a GIA model at a variable timestep in the order of a thousand years. Several experiments have been done using different radial and lateral varying rheologies for simulations of the last glacial cycle. It is shown that the effect of including lateral variations and accounting for the stabilizing GIA feedback is up to 80 kilometers for the grounding line position and 400 meters for the ice thickness. The largest differences are observed close to the grounding line of the Ronne ice shelf and at several locations in East Antarctica. The total ice volume of the AIS increases by 0.5 percent over 5000 years when including the 3D GIA feedback loops in the coupled model. These results quantify the local importance of including GIA feedback effects in ice dynamic models when simulating the Antarctic Ice Sheet evolution over the full glacial cycle.