Towards a fully coupled ice dynamic - 3D GIA model for Antarctic ice sheet evolution

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- Feedback between Glacial Isostatic Adjustment (GIA) and the evolution of the ice sheet
- Development of a new method to couple a state of the art ice dynamic model and a state of the art 3D GIA model using the forward modelling approach
- Results of the Last Glacial Maximum Antarctic ice sheet evolution using a 1D GIA model
- Preliminary results using a 3D GIA model containing different rheologies

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Method

New forward modelling method using:

- ANICE (de Boer et al., 2014)
- GIA model: Finite Element Model using Abaqus (Blank et al., 2020)

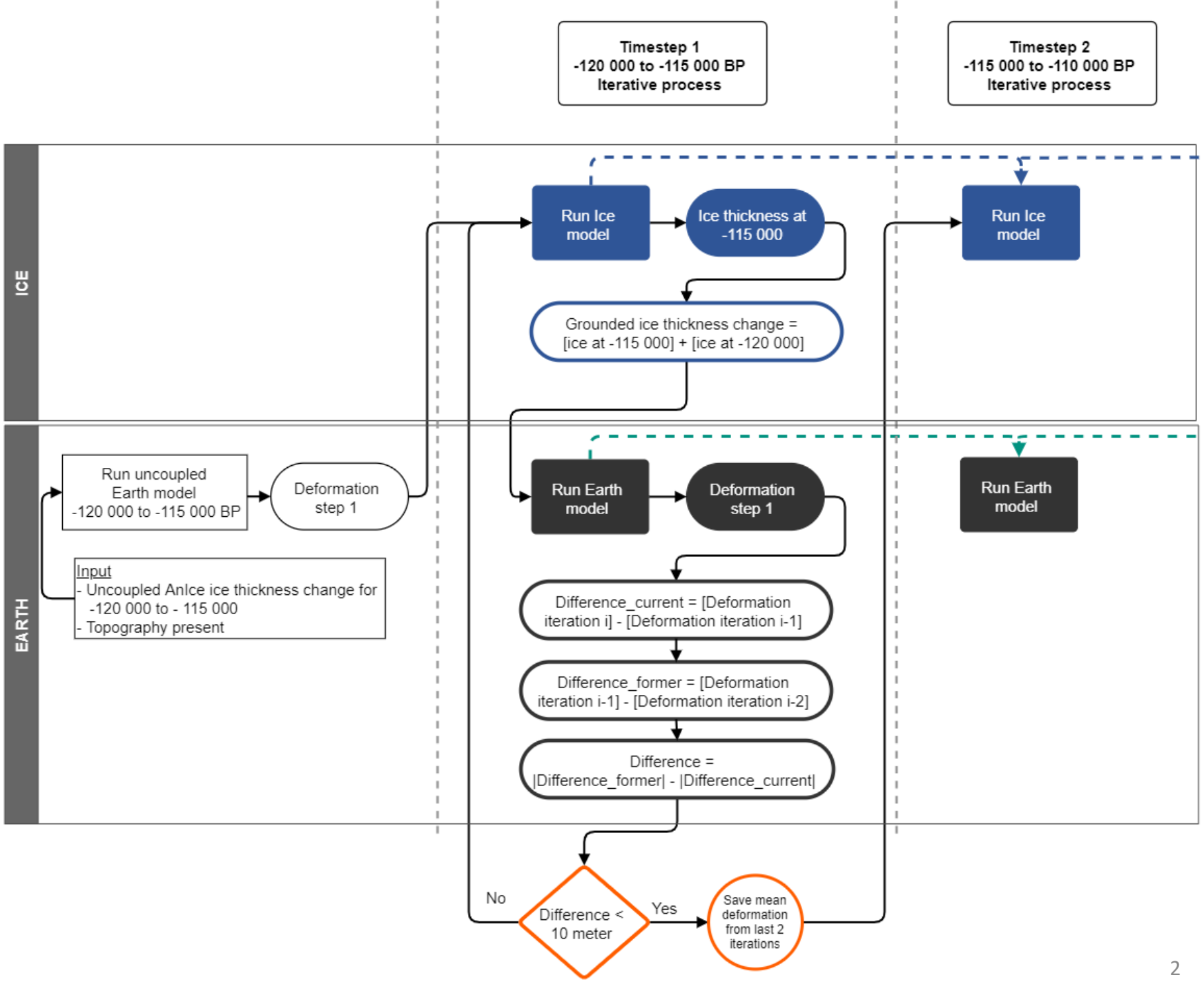
Two different timesteps:

- 5000 years between 120 000 and 20 000 years before present (BP)
- 1000 years between 20 000 years BP and present day.

Multiple iterations between ice dynamic model and GIA model within one timestep.

- Convergence criterium is met with maximum 3 iterations.

3 simulations are done using 3 different rheologies for the GIA model.



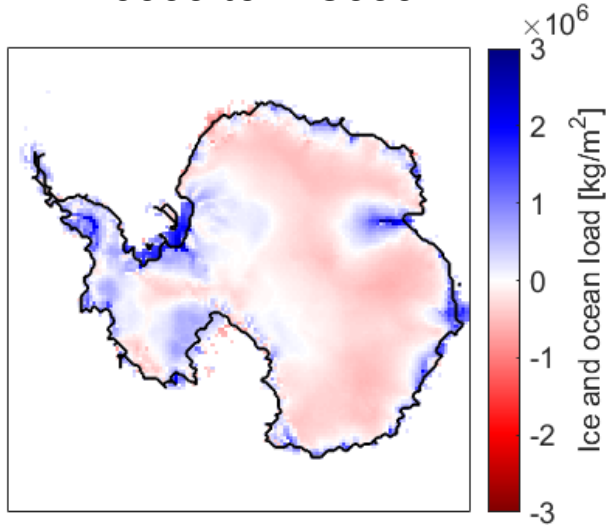
Preliminary results

Deformation

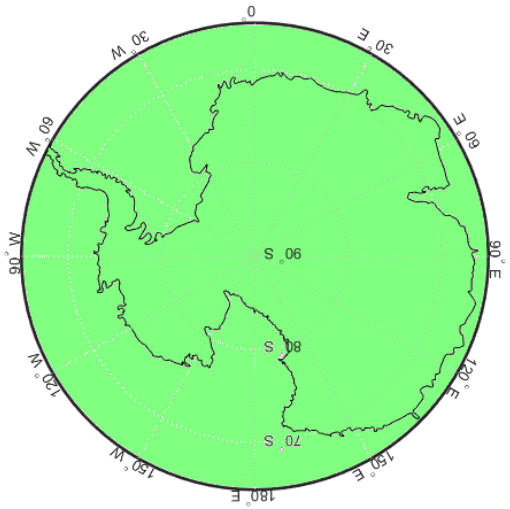
- The results of 3 simulations of the first timestep (iteration 0) are shown here.
- The ice load is equal for each simulation and shown in the bottom left corner.
- The viscosity is shown at a depth of 246 km but 3D rheology models vary radially.
- The deformation is shown for the 1D and 3D model.

Change in load

120000 to 115000 BP

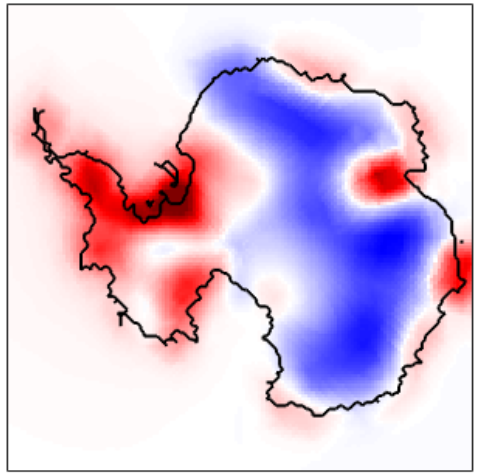


1D rheology



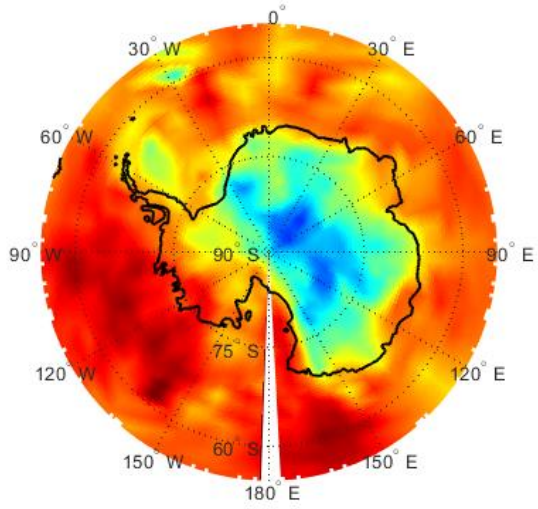
Deformation

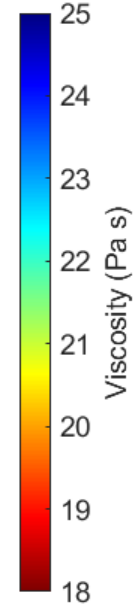
120000 to 115000 years BP



3D rheology

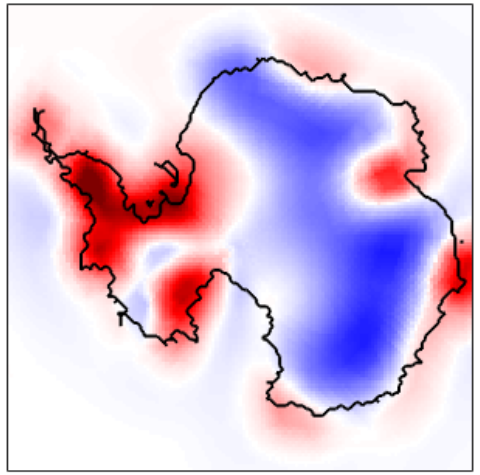
Lloyd et al (2019) seismic model, dry olivine





Deformation

120000 to 115000 years BP



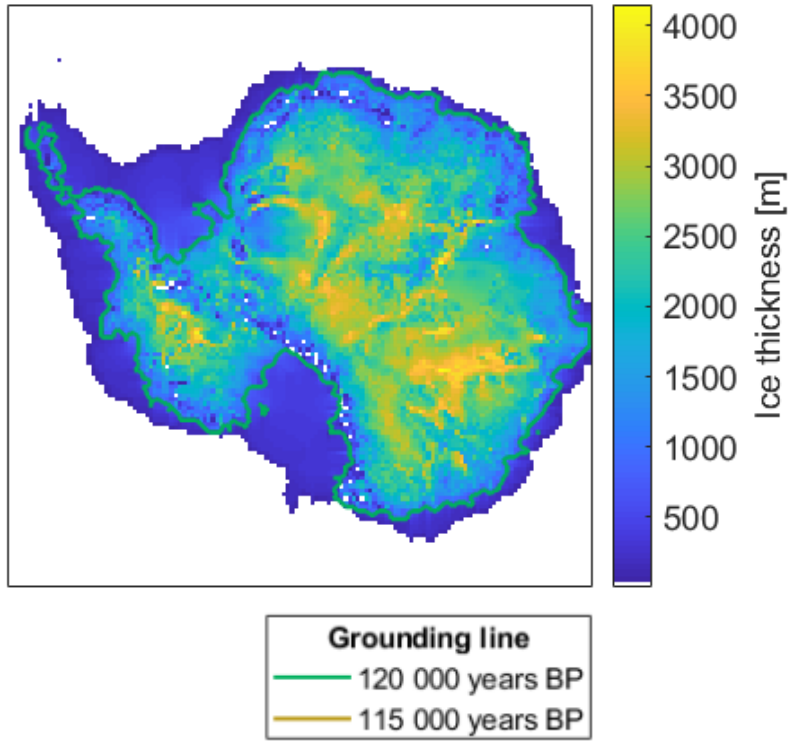
Preliminary results

Grounding line migration

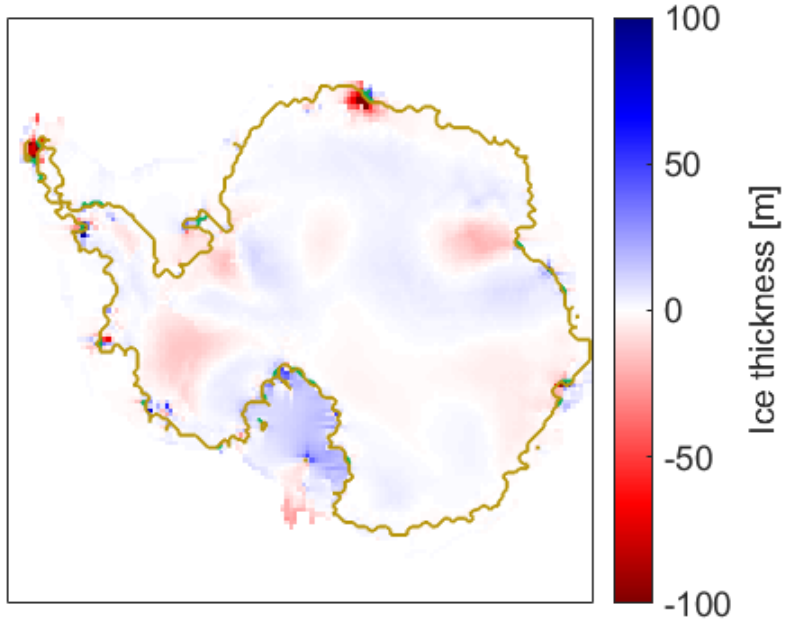
- The ice thickness is shown at 115 000 years (iteration 1) before present (BP) using deformation with 2 different rheologies.
- Compared to a 1D model, ice thickness can increase and decrease hundreds of m, in West and East Antarctica
- The grounding line extends more when ice grows thicker.

Ice thickness (Hi)

Using deformation from 1D rheology



Ice thickness (3D) – (1D)



References

- Blank, B., Barletta, V., Hu, V., and van der Wal, W. (2020). Evaluation of differences between 1D, 3D and 4D models in the Amundsen Sea Embayment Region by use of Finite Element Based GIA models. In preparation.

- de Boer, B., Stocchi, P., and van de Wal, R. S. W. (2014). A fully coupled 3-D ice-sheet-sea-level model: algorithm and applications. *Geoscientific Model Development*, **7**, 2141–2156. doi: 10.5194/gmd-7-2141-2014

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