LAND ICE CESM WORKSHOP JUNE 2024

TEXAS
The University of Texas at Austin

IMPACT OF NON-NEWTONIAN RHEOLOGY ON EARTH'S RESPONSE TO ANTARCTICA ICE MASS FLUX

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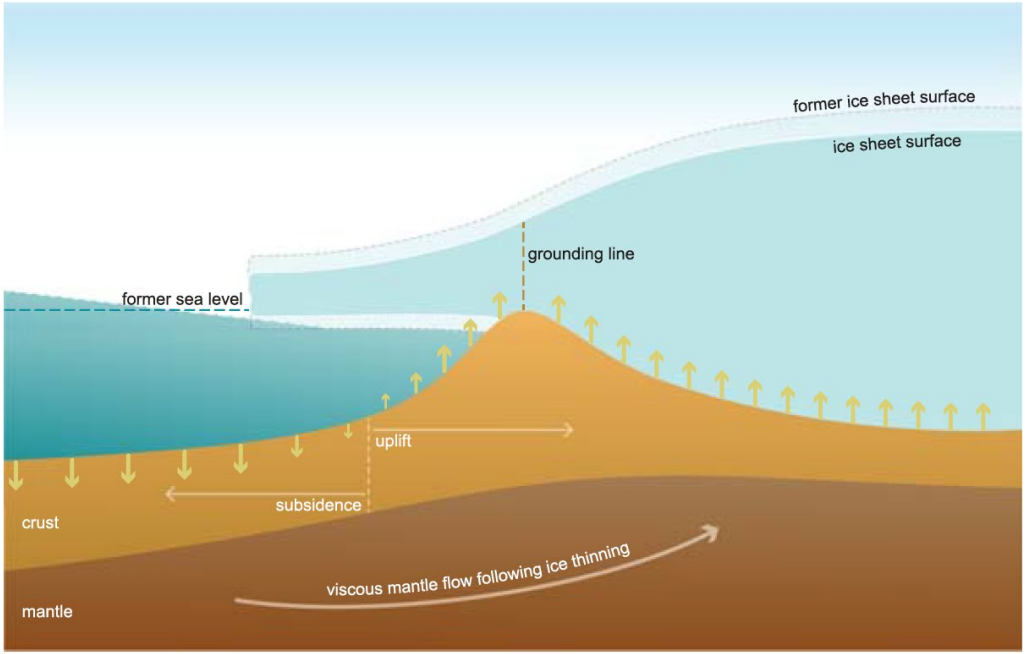
GIA (Glacial Isostatic Adjustment): dynamical interplay among ice, ocean and solid Earth

Sea surface adjustment

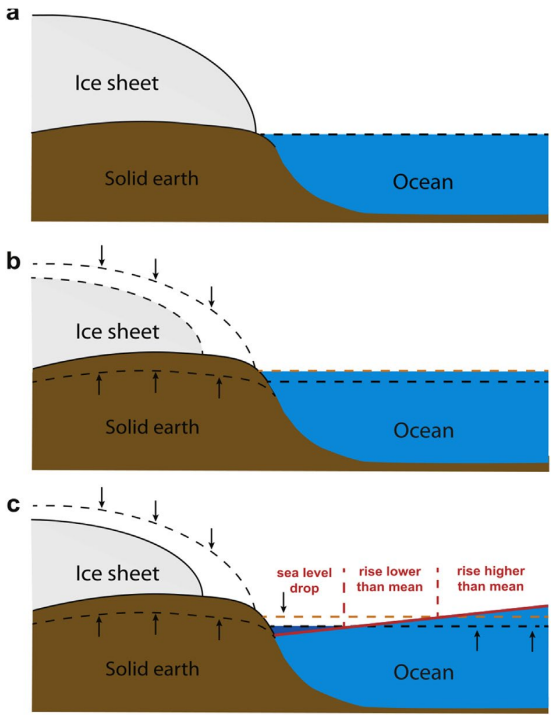


Ice shrinks

Bedrock uplift
Sea floor subsidence

Nobel et al. 2020

Gravitational self-consistent ocean



De Boer et al. (2018)

Sea Level Equation:

$$L_{\text{sea level}}(\theta,\varphi,t) = [N(\theta,\varphi,t) - U(\theta,\varphi,t) + c(t)]O(\theta,\varphi,t)$$

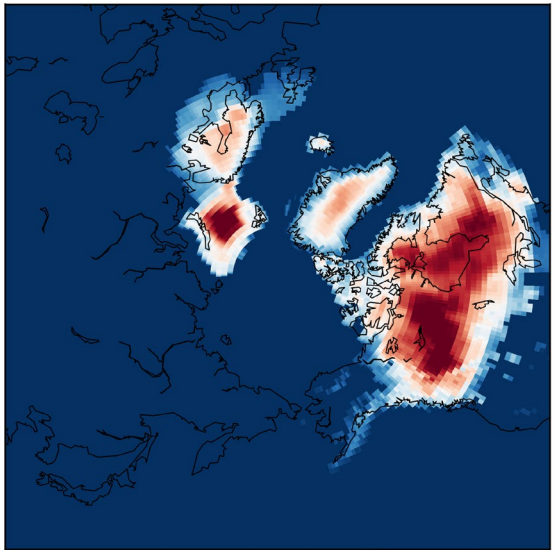
Sea surface — **Bedrock topography** — **Ocean mask**

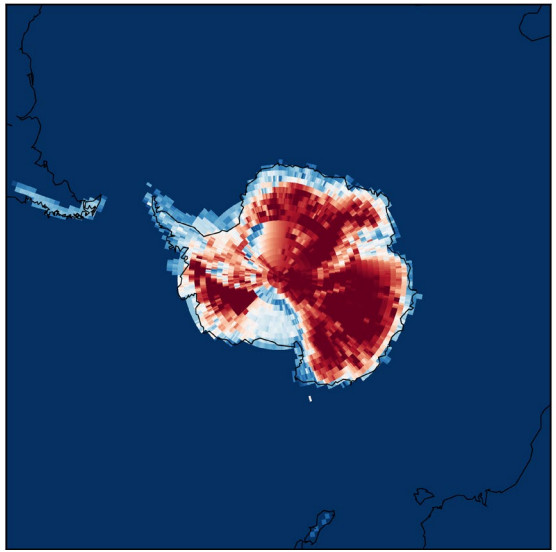
- Shoreline migration
- Ocean influx and outflux in the regions of retreating marine-based ice sheets

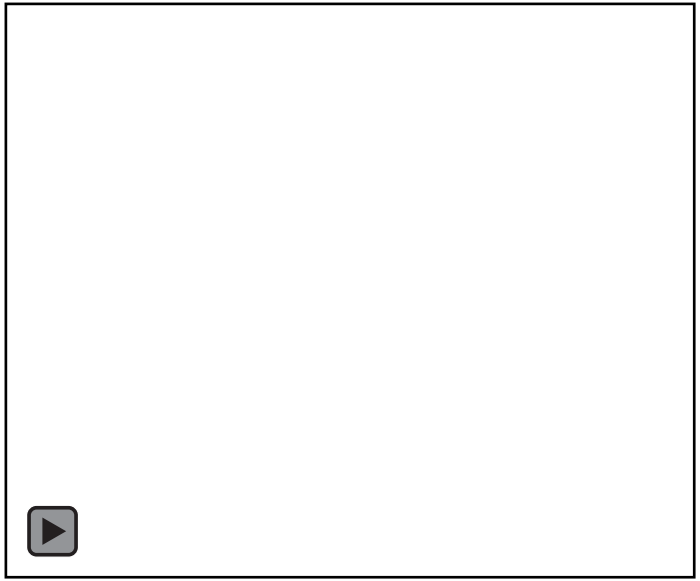
[e.g., Farrell and Clark. 1976 ; Milne et al., 1998; Mitrovica et al.,2003; Kendall et al., 2005]

Model setup: ICE loads

The (de) glaciation history in ICE6G: (global model with 1-degree latitude/longitude grid)

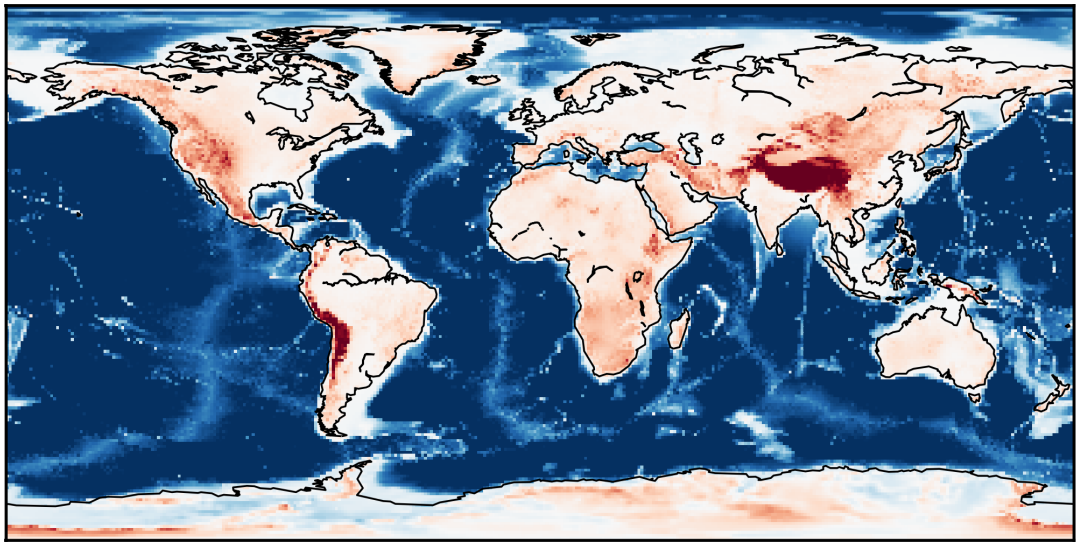


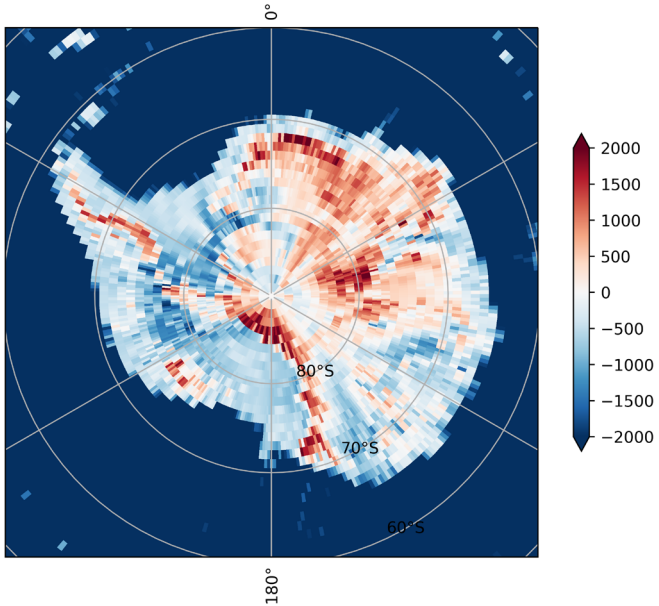




Model setup: Initial topography

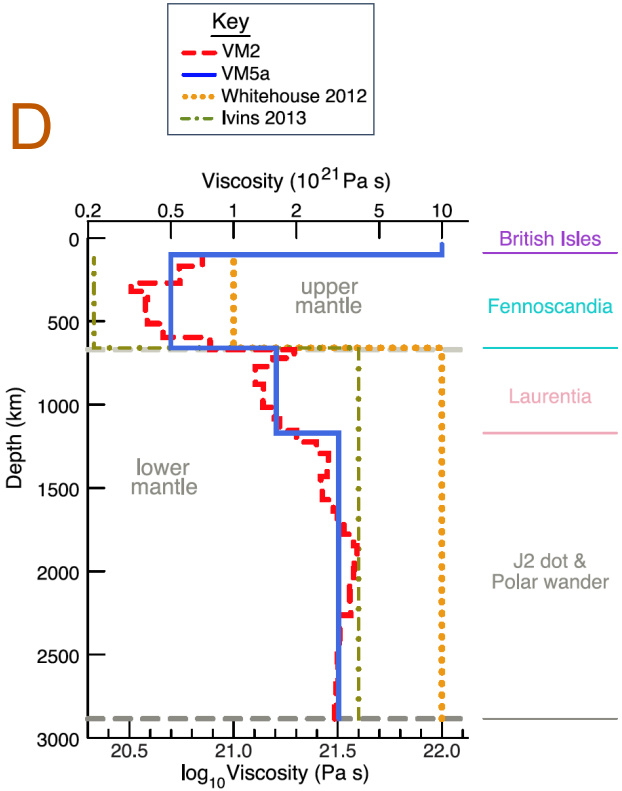
ETOPO2: Topography and Bathymetry model (2-minute latitude/longitude grid ~ 3-4km)
Bedmap2: Ice bed, surface and thickness datasets for Antarctica (1km grid spacing in Antarctic Polar Stereographic projection)





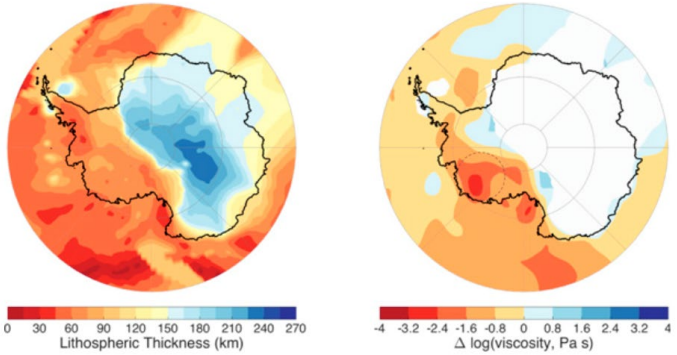
Model setup: Earth interior material properties

1D



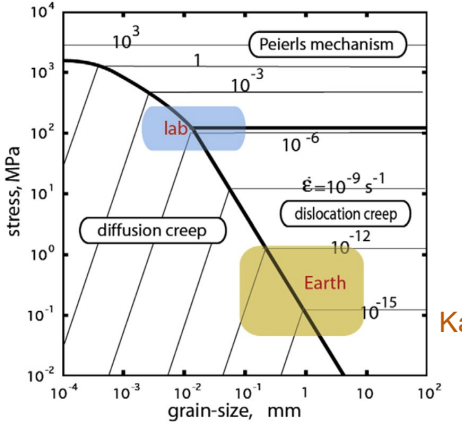
Argus et al., 2014

3D



Hay et al., 2017

Newtonian
vs.
Non-Newtonian
rheology



Karato et al., 2010

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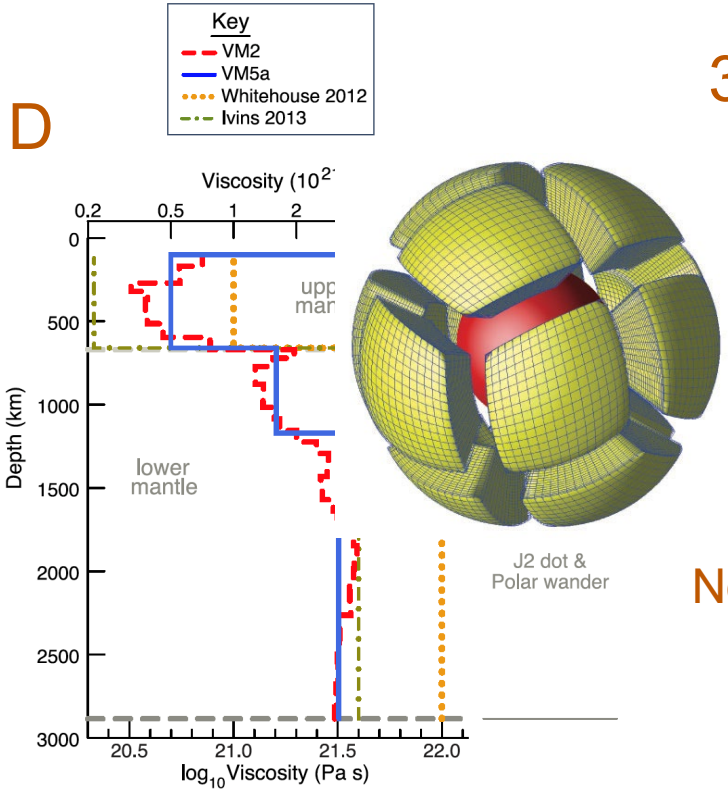

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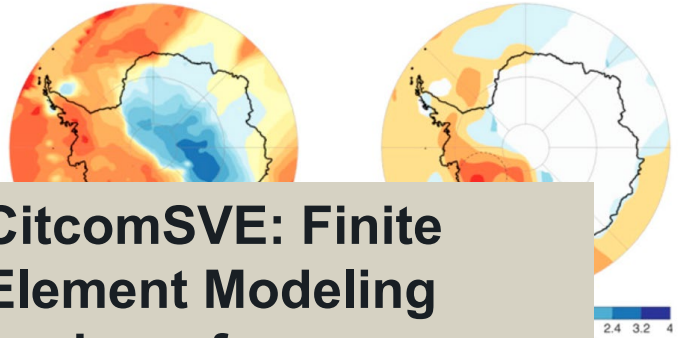

CitcomSVE: Finite Element Modeling package for geodynamics problem

Hay et al., 2017

Newtonian
vs.
Non-Newtonian
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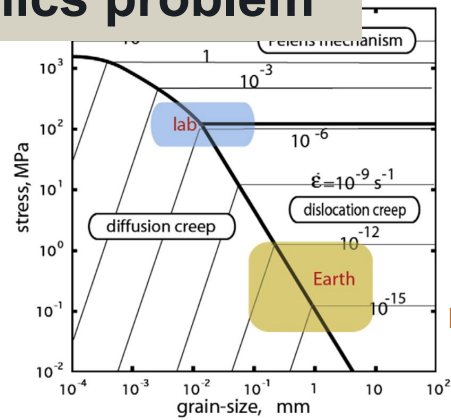
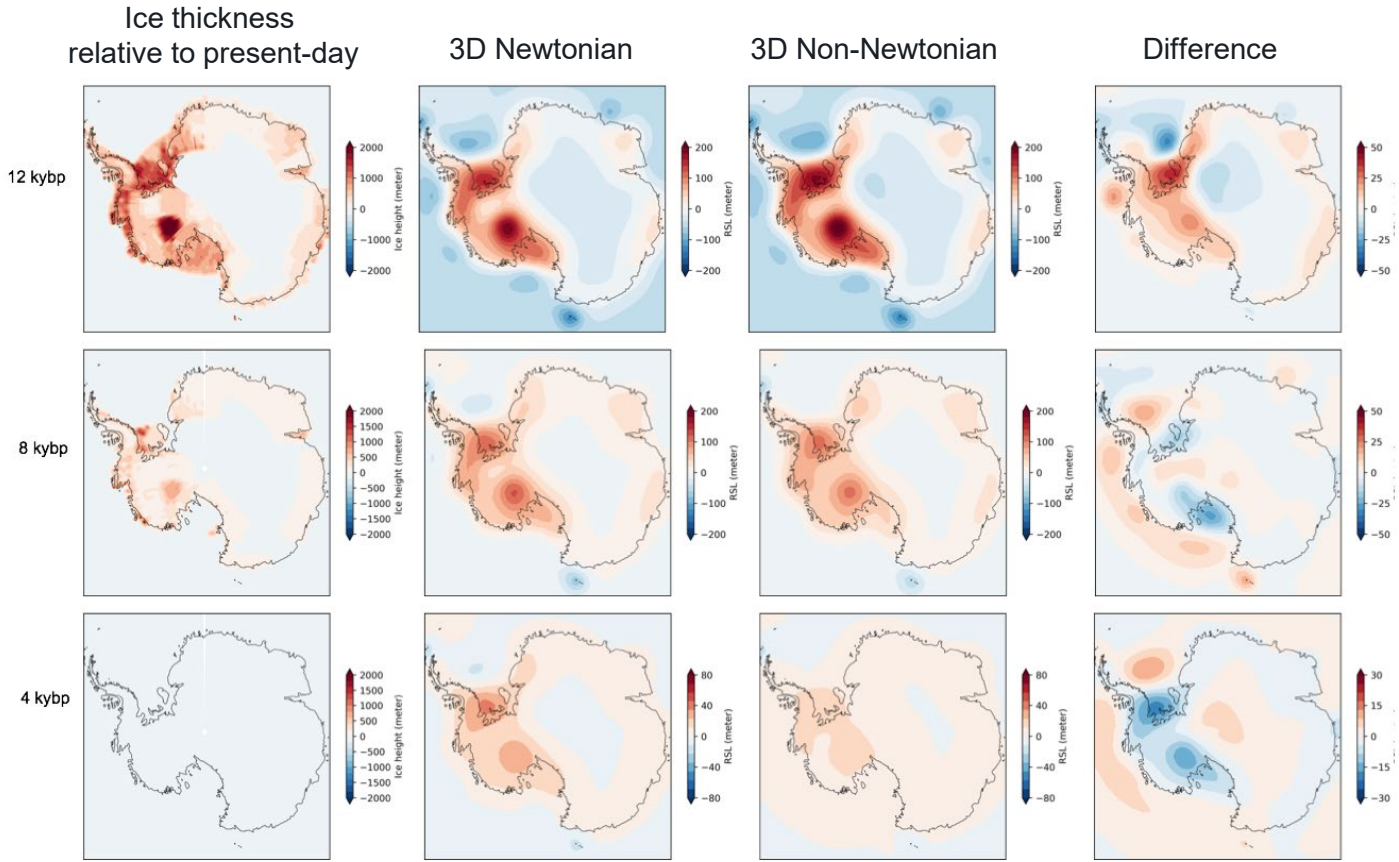


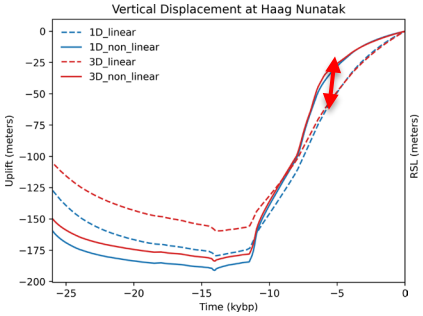
Karato et al., 2010

Relative Sea Level predictions by 3D Newtonian and Non-Newtonian GIA model

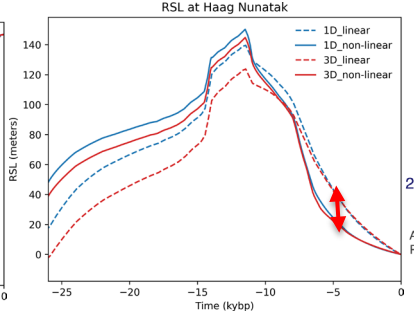


Time variations in bedrock motion and RSL change

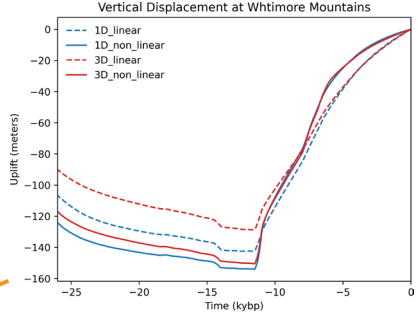
Bedrock motion

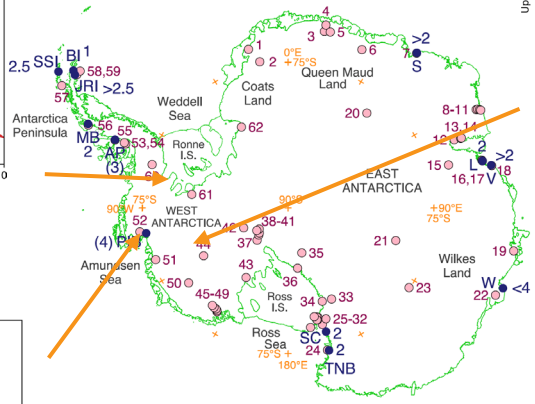


Relative sea level

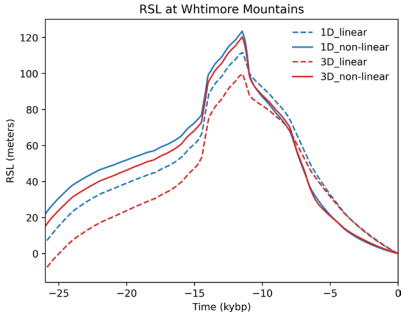


Bedrock motion

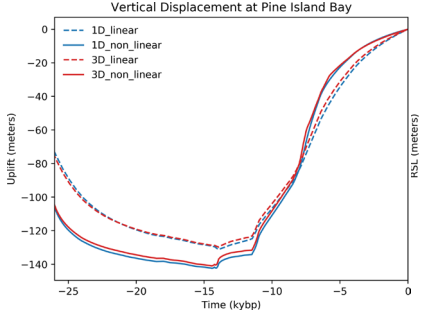




Relative sea level



Bedrock motion



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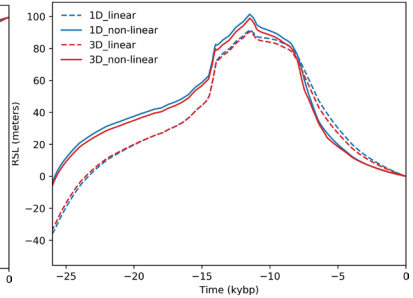
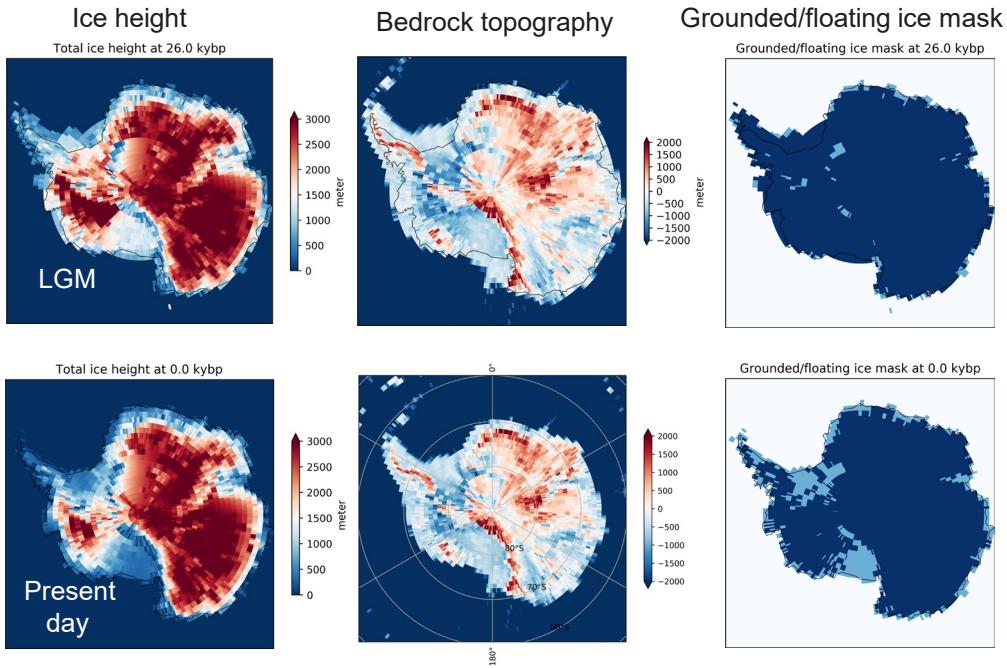


Model resolution

Low resolution (1°x1°) GIA modeling



High resolution (e.g., ~20km or less) GIA modeling and topography updating solution (e.g., ~ 5 km or less) experiment

Explore how predicted grounding line migration can affect Marine Ice Sheet Instability and sea level projection

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