Dependence of GIA-induced gravity change in Antarctica on viscoelastic Earth structure

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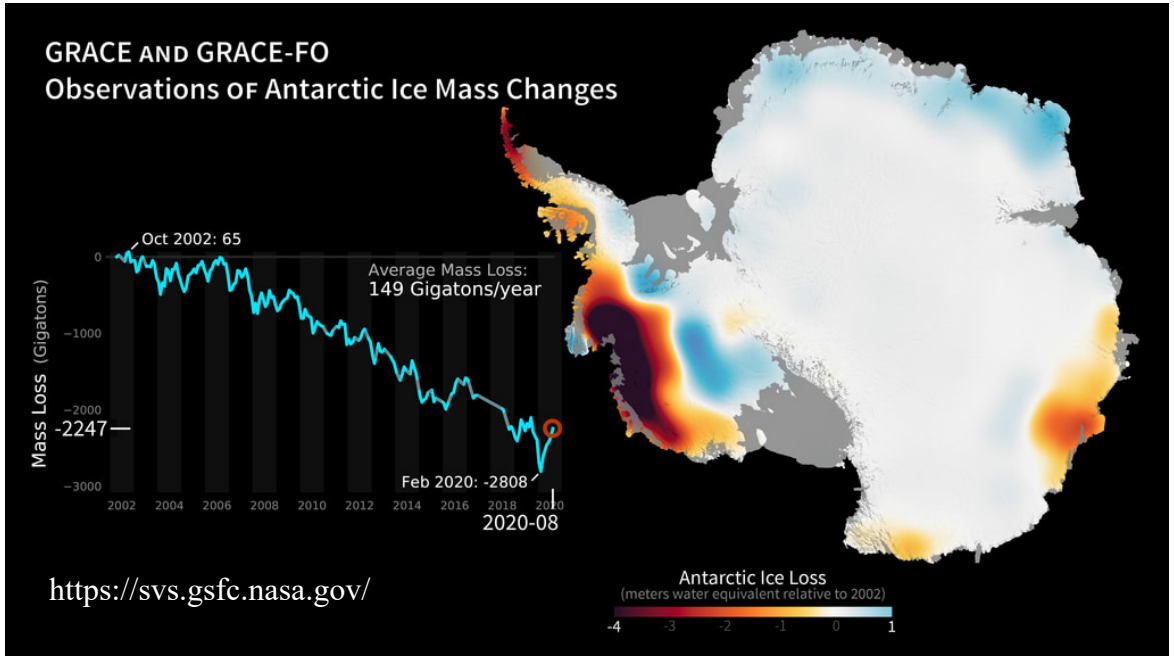
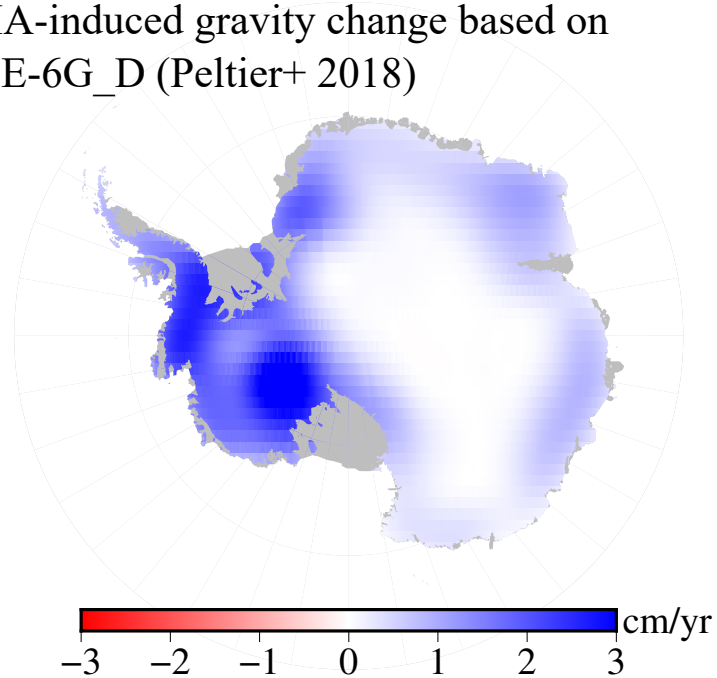
Introduction: Estimate of Antarctic ice mass loss & GIA correction

- Antarctic ice mass loss (~100±50 Gt/yr) has been estimated from gravity change by GRACE (e.g. The IMBIE team 2018).
- The estimate includes "**GIA correction**" (~50±30 Gt/yr).
- The GIA correction has been derived from forward models with 1D (radially varying) Earth structures.



GIA-induced gravity change based on ICE-6G_D (Peltier+ 2018)



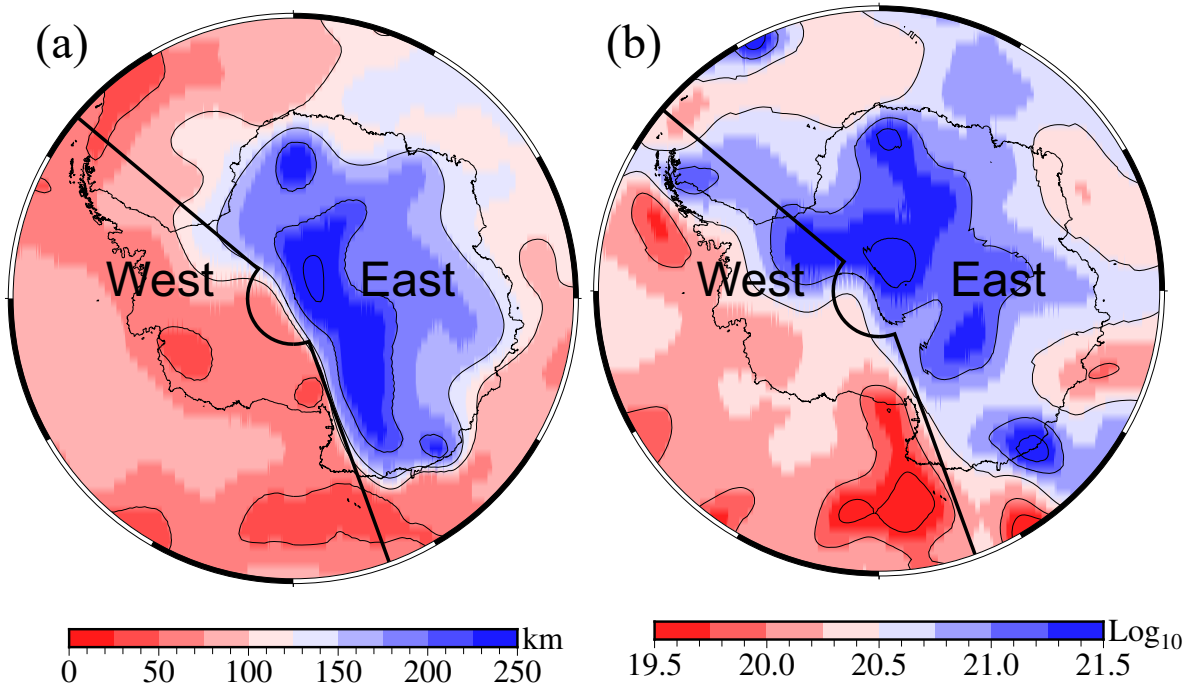
Introduction: Lateral variations in Earth structure beneath Antarctica

- Seismic studies beneath Antarctica suggest lateral variations in Earth structure.
  - West Antarctica has a thinner lithosphere & a lower viscosity.
  - East Antarctica has a thicker lithosphere & a higher viscosity.
- Recently, 3D GIA models are being developed to understand effects of the lateral variation in Earth structure on the GIA correction (e.g. van der Wal+ 2015).

Purpose

- Although 3D modeling is important, **we focus here on fundamental effects of lithosphere thickness and mantle viscosity on the GIA correction from simple 1D model.**

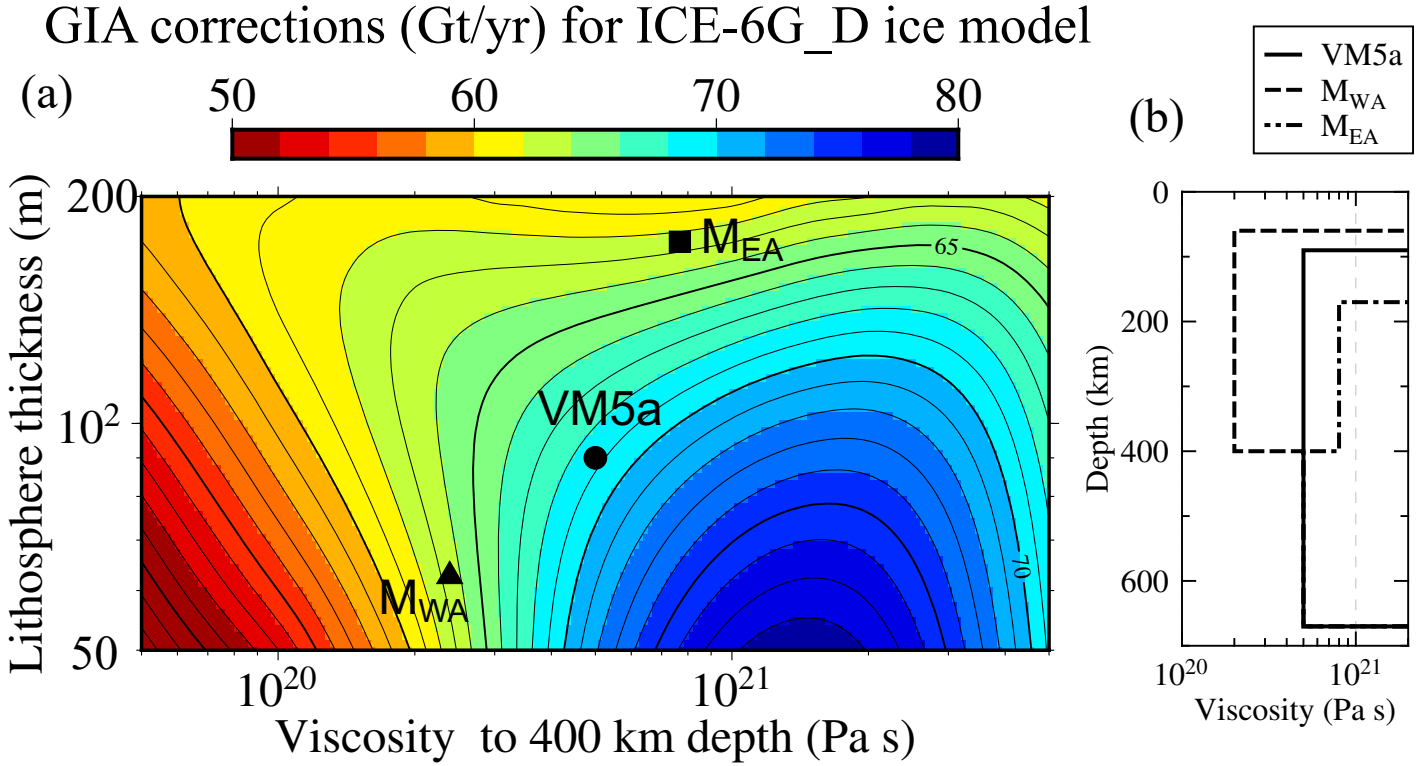
3D viscoelastic Earth model constructed from seismic velocities ($V3D_{RH}$ by Pan+ 2021)



Lithosphere thickness

Radially averaged viscosity above 400 km depth

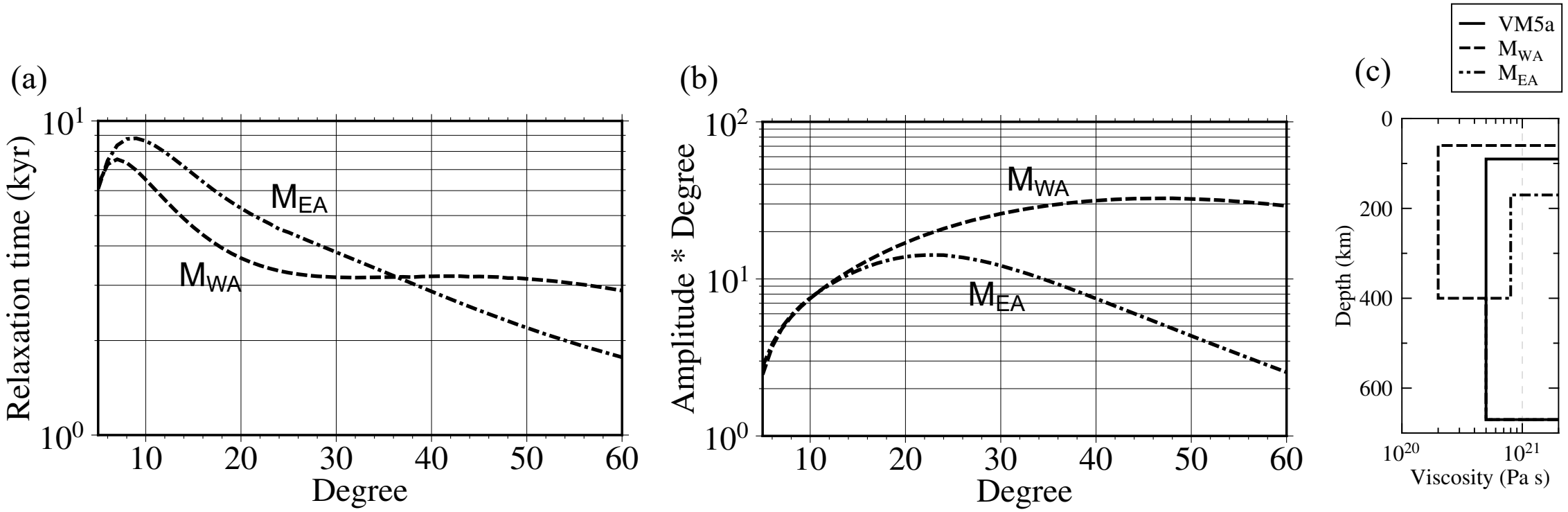
Main Result: Dependence of GIA correction on Earth structure



- The predicted value for M_{WA} (thinner lithosphere & lower viscosity) is similar to that for M_{EA} (thicker lithosphere & higher viscosity), although the two models have very different Earth structures.
- This means a "**trade-off**" between lithosphere thickness and mantle viscosity.
- The trade-off may somewhat reduce the effect of lateral variations in Earth structure on the GIA correction.

- ● is based on Earth model VM5a set for ICE-6G_D ice model (Peltier+ 2018).
- ▲ & ■ are based on lithosphere thickness and radially averaged viscosity above 400 km depth for 3D viscoelastic Earth model $V3D_{RH}$ by Pan+ (2021).
  - ▲ is the average over West Antarctica (referred to as M_{WA}).
  - ■ is the average over East Antarctica (referred to as M_{EA}).

Results: Relaxation spectrum



- To understand the reason for the trade-off, we show relaxation spectrum for M_{WA} & M_{EA}.
- The relaxation time for M_{WA} is smaller than that for M_{EA}. It follows that the present-day amplitude for M_{WA} is smaller than that for M_{EA}.
- The amplitude for M_{EA} is smaller than that for M_{WA} because loads is largely supported by thick lithosphere.
- M_{EA} (lower viscosity) and M_{EA} (thicker lithosphere) can result in the similar present-day amplitude.

Summary

- We examine effects of lithosphere thickness and mantle viscosity on the GIA correction using 1D model.
- There is a trade-off between lithosphere thickness and mantle viscosity.
- The the reason for the trade-off can be understanded by relaxation spectrum.
- The trade-off may somewhat reduce the effect of lateral variations in Earth structure on the GIA correction.
- In future work, we will need to check effects of the trade-off on 3D GIA model.