Postglacial changes in relative sea level: a comparative study for the Baltic Sea and the South China Sea

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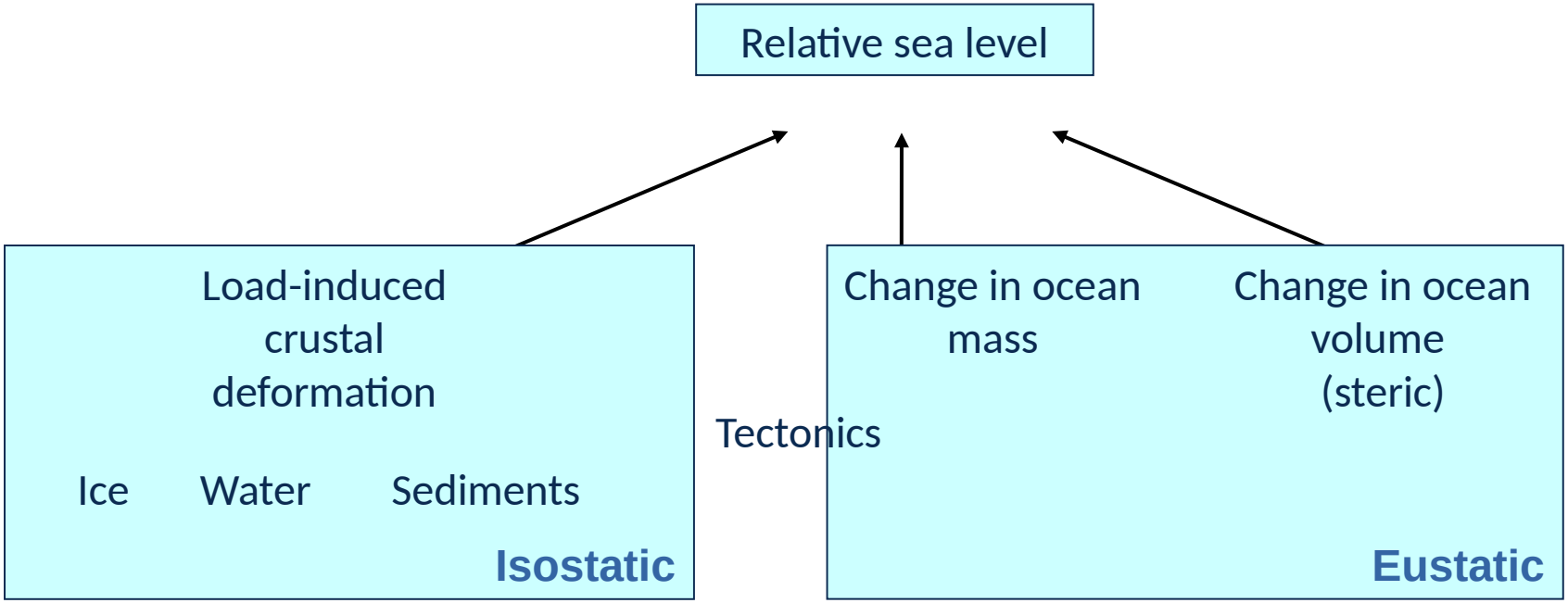
Marginal Seas - Past and Future

Online Conference | 16 December 2020

Introduction

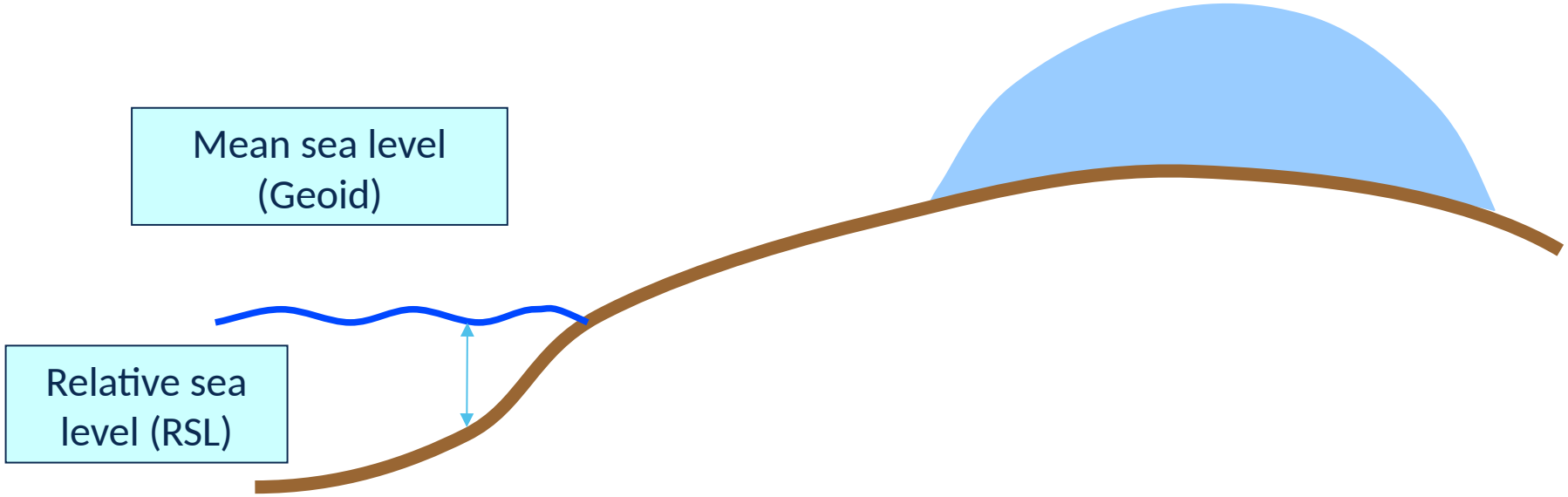
- Key drivers of past and present changes in relative sea level (RSL)



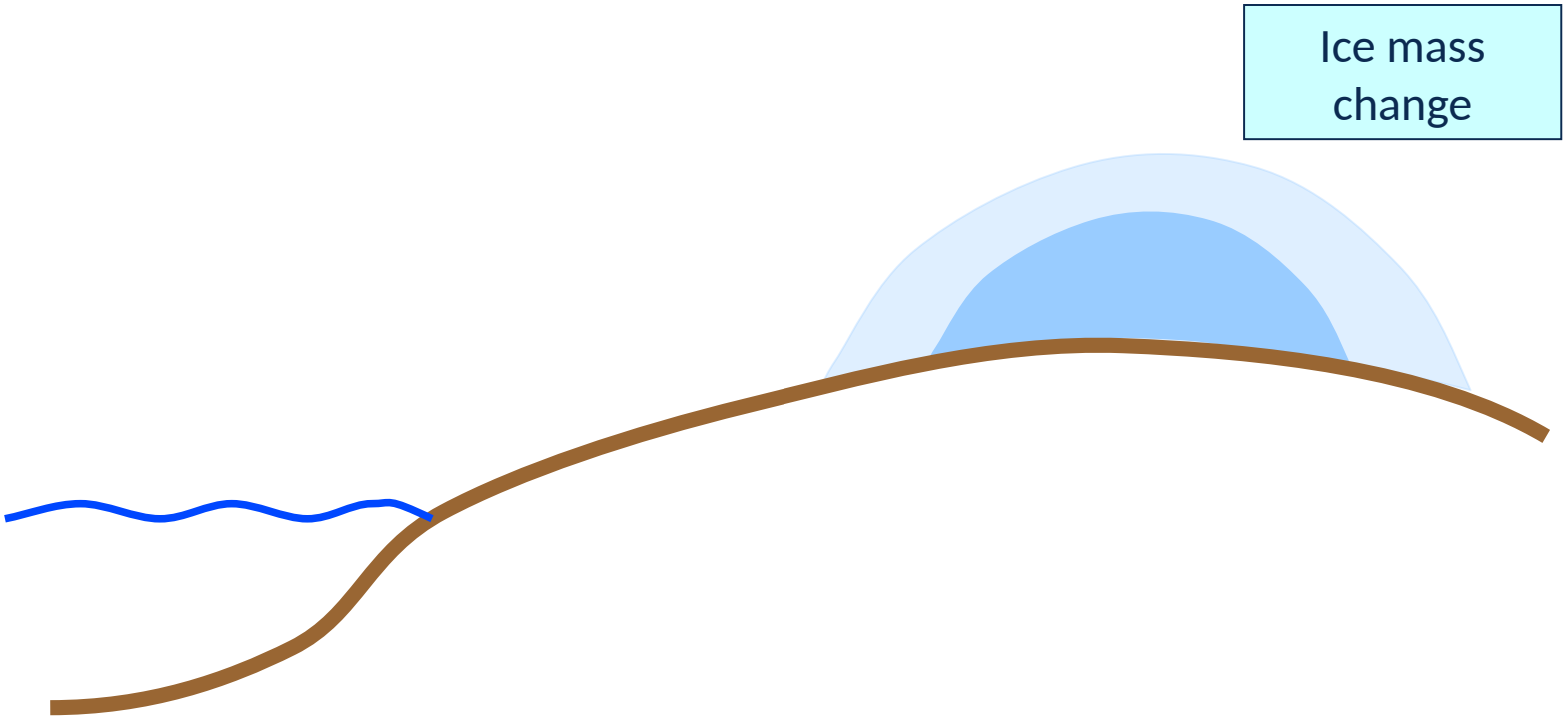
Focus of this talk:

- **Modelling of Glacial Isostatic Adjustment**
- **RSL changes caused by past ice and sediment loads**
- **RSL changes due to present-day ice loading**

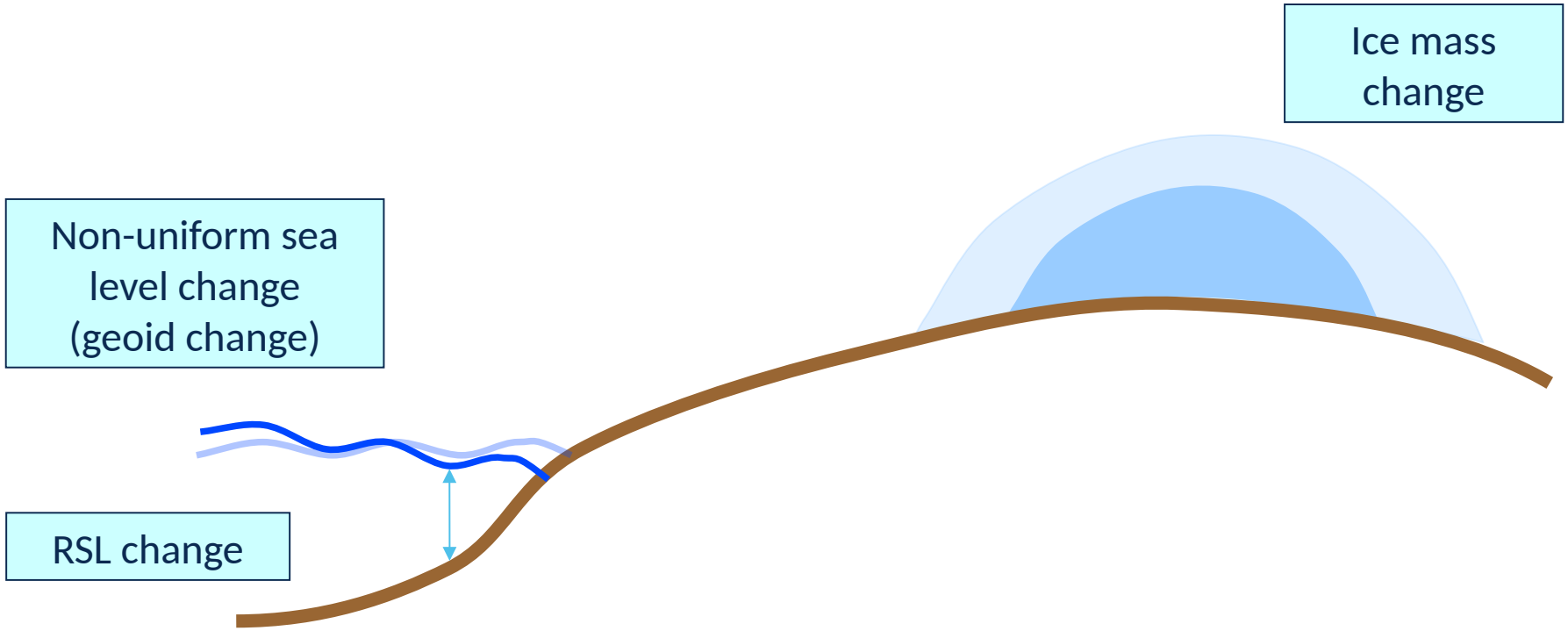
Sea level change and crustal deformation



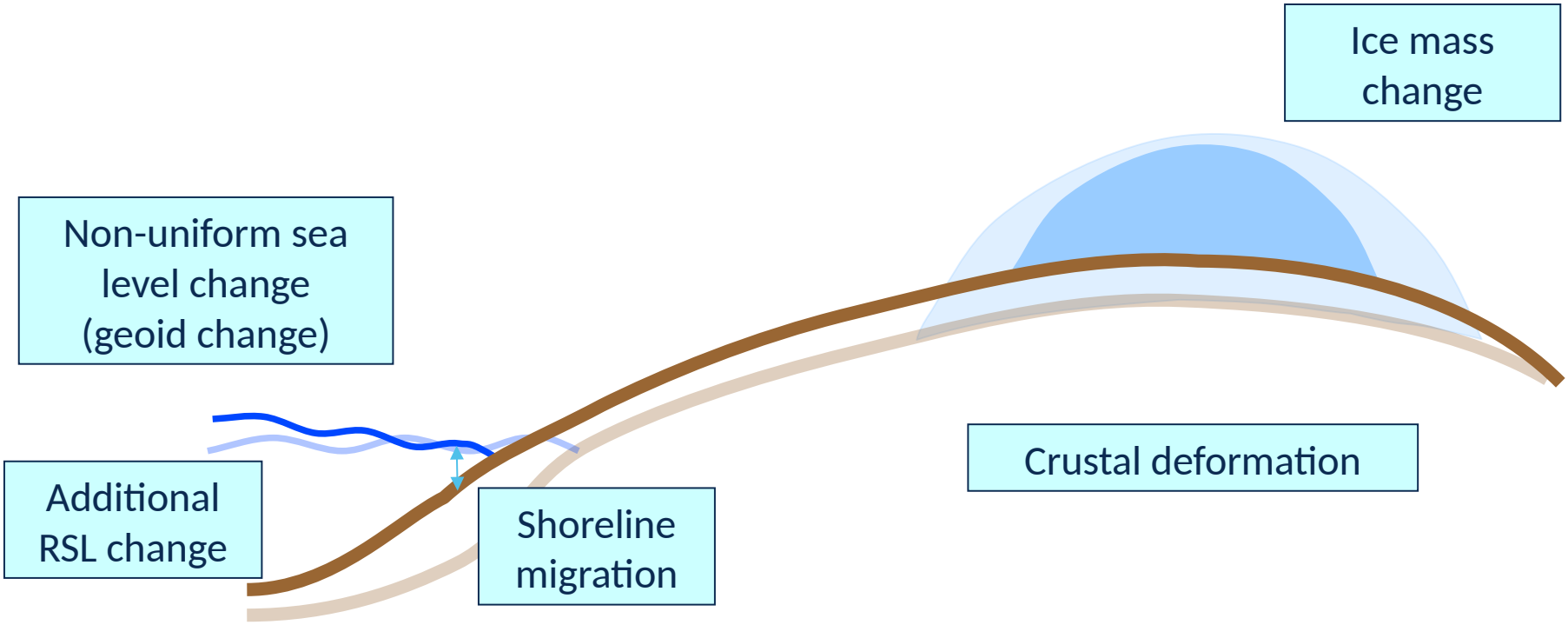
Sea level change and crustal deformation



Sea level change and crustal deformation



Sea level change and crustal deformation



The sea level equation (SLE)

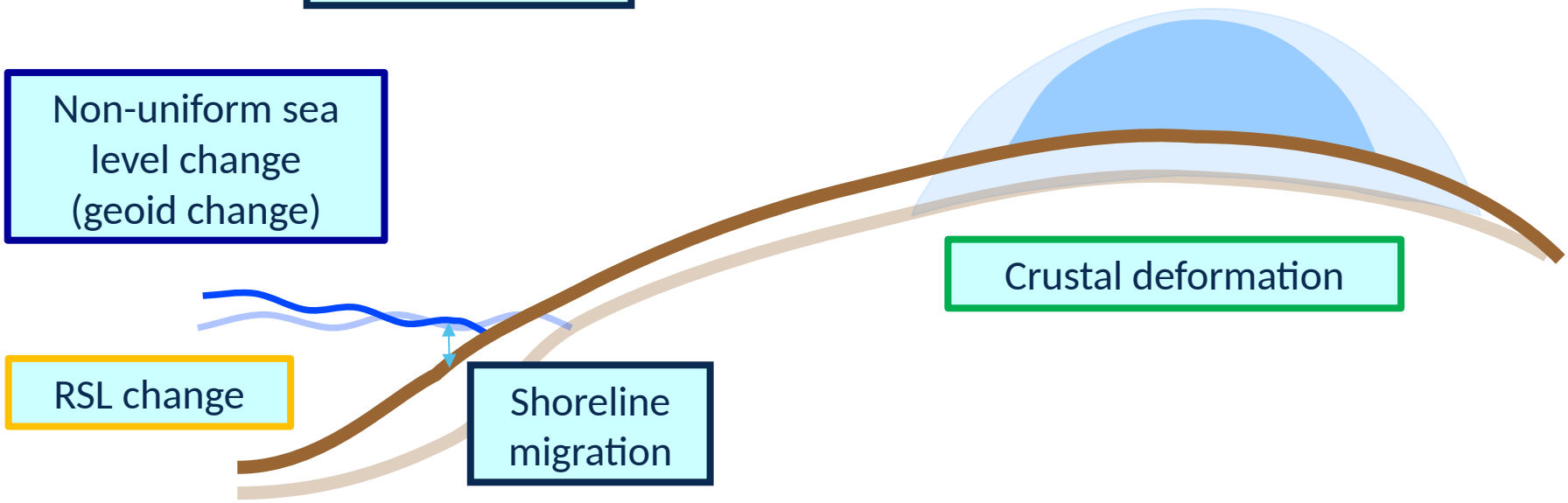
Basic idea formulated by Woodward (1888):

$$\delta S(\varphi,\lambda,t) = C(\varphi,\lambda,t) \cdot \{ \delta G(\varphi,\lambda,t) - \delta R(\varphi,\lambda,t) \}$$

Ocean function:
1: ocean
0: land

Ice mass change

Non-uniform sea level change (geoid change)



Crustal deformation

RSL change

Shoreline migration

The sea level equation (SLE)

Basic idea formulated by Woodward (1888):

$$\delta S(\varphi,\lambda,t) = C(\varphi,\lambda,t) \cdot \{ \delta G(\varphi,\lambda,t) - \delta R(\varphi,\lambda,t) \}$$

$$= C(\varphi,\lambda,t) \cdot \{$$

$$\int [\iint (g^{-1}\Phi(\psi, t-t') - \Gamma(\psi, t-t')) \cdot L(\varphi',\lambda',t') \, d\sigma] \, dt'$$

$$+ g^{-1} \Delta\Phi(t) \}$$

Surface load history (ice, water)

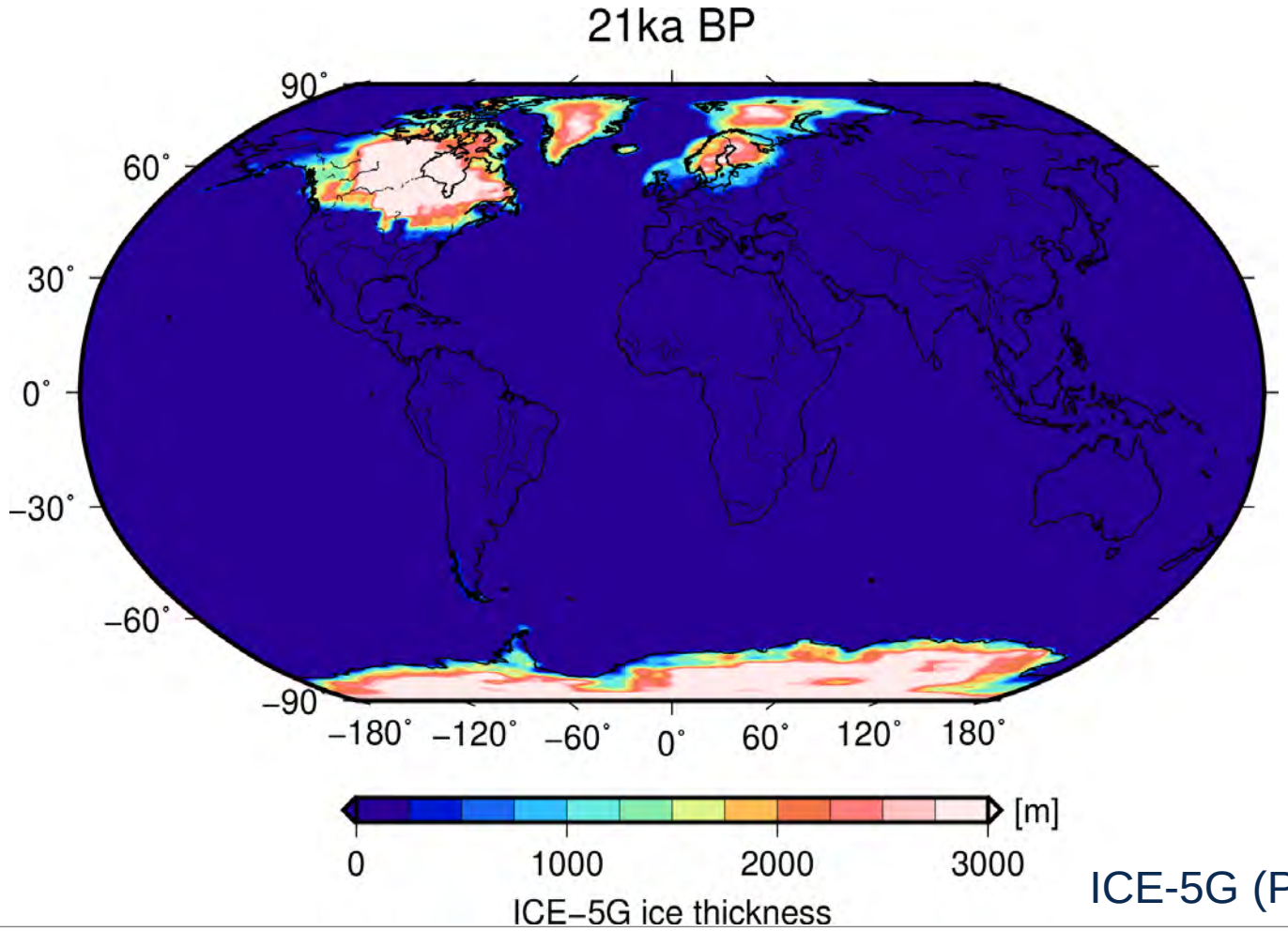
Green functions for the gravitational potential

Green functions for the crustal deformation

(Peltier, 1998)

Ice load history

- Derived from globally distributed geological or geomorphological sea-level indicators
- Global ice load histories: ICE-5G, ICE-6G (Peltier et al.), ANU (Lambeck et al.)
- Regional load histories, e.g. for Antarctica: IJ05 (Ivins & James), W12a (Whitehouse et al.)



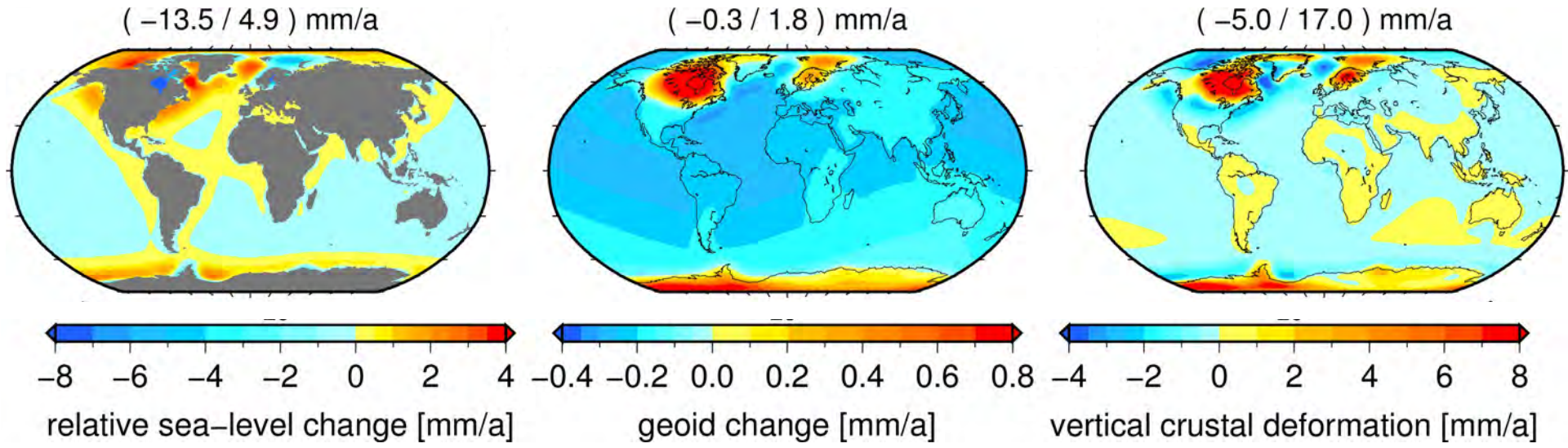
ICE-5G (Peltier, 2004)

Solving the SLE

- ICE-5G (VM2)
- Freely available software package SELEN (Spada and Stocchi 2004)
- Non-rotating Earth, fixed ocean function

Present-day RSL changes induced by GIA

$$\delta S(\varphi,\lambda,t) = C(\varphi,\lambda,t) \cdot \{ \quad \delta G(\varphi,\lambda,t) \quad - \quad \delta R(\varphi,\lambda,t) \}$$



Present-day RSL changes induced by GIA

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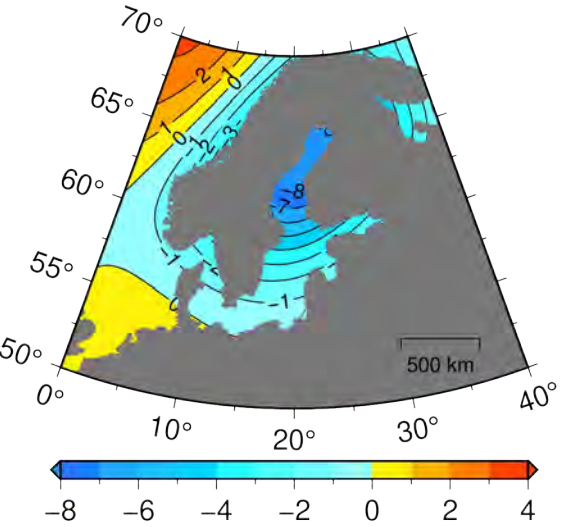
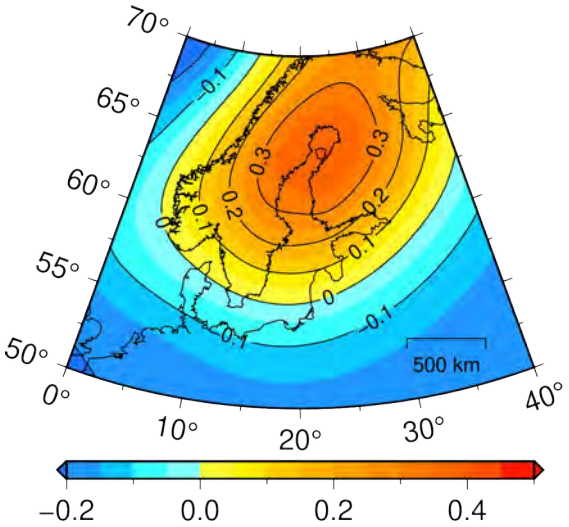
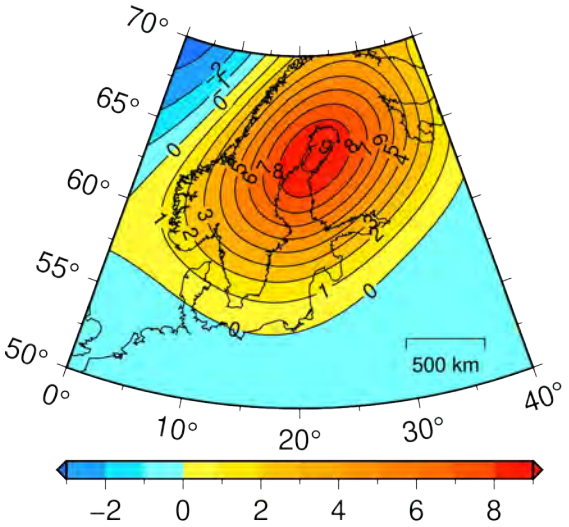
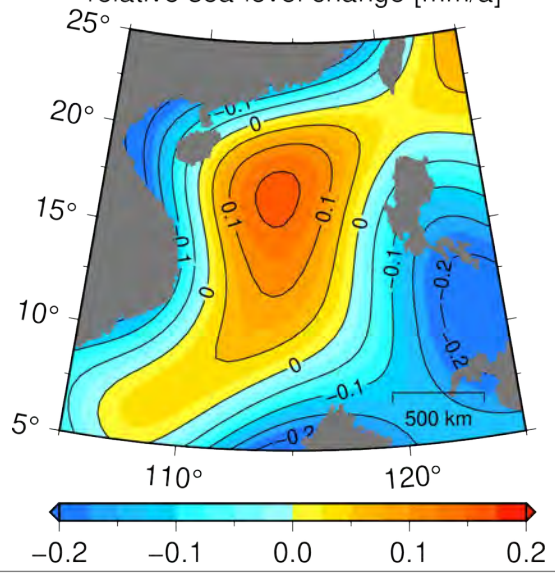
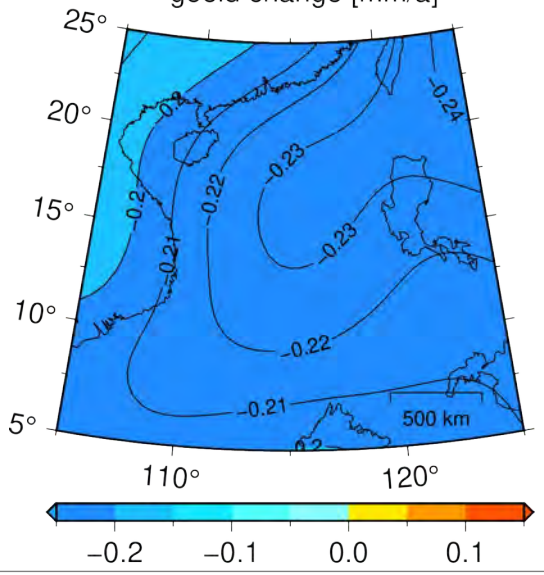


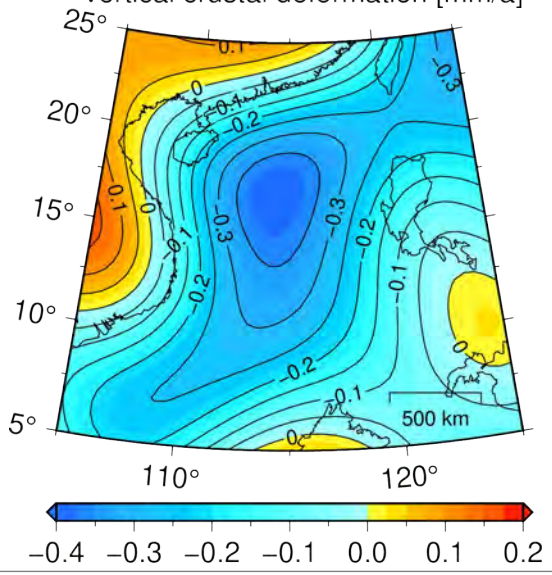




Baltic Sea



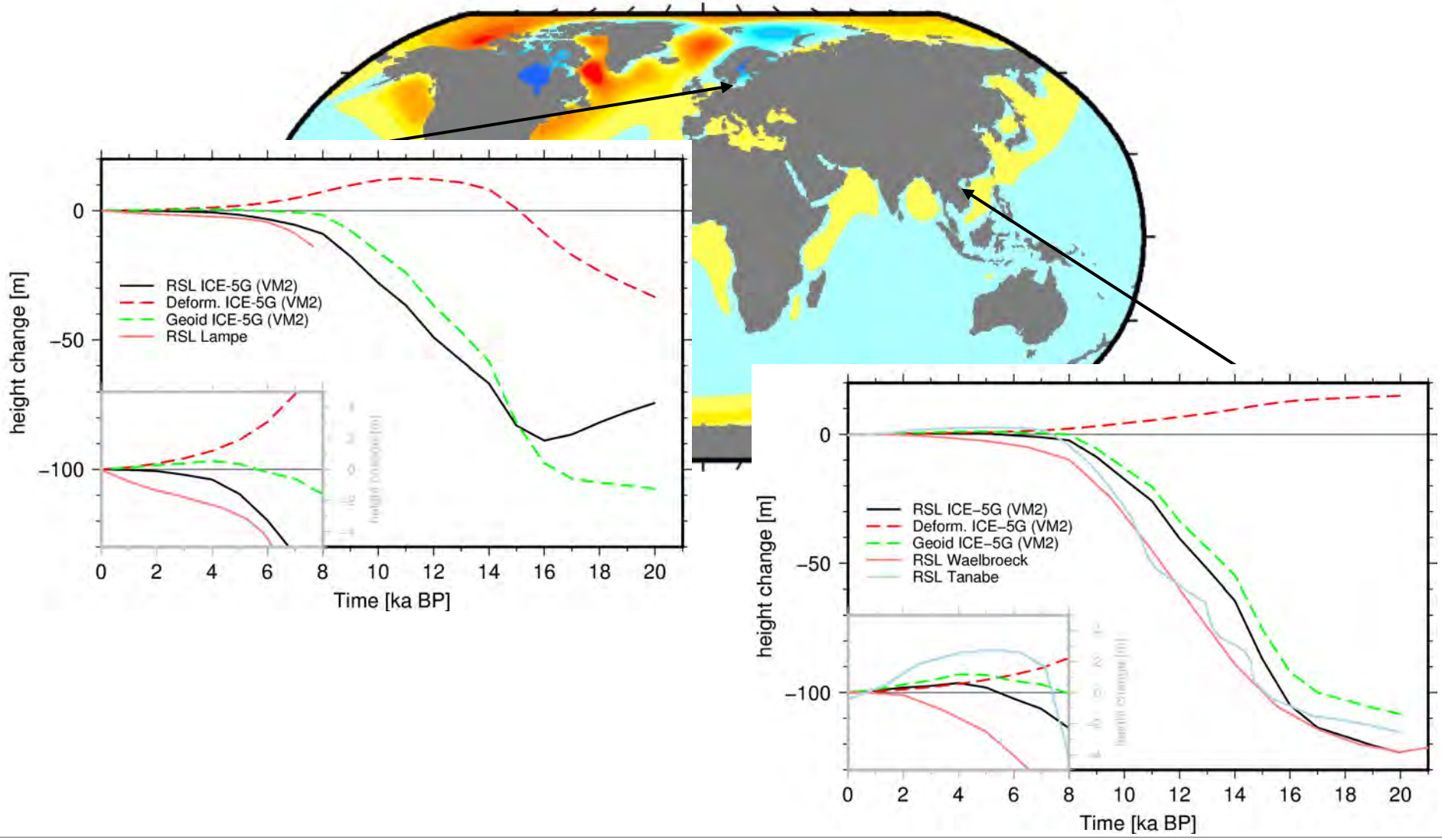




South China Sea

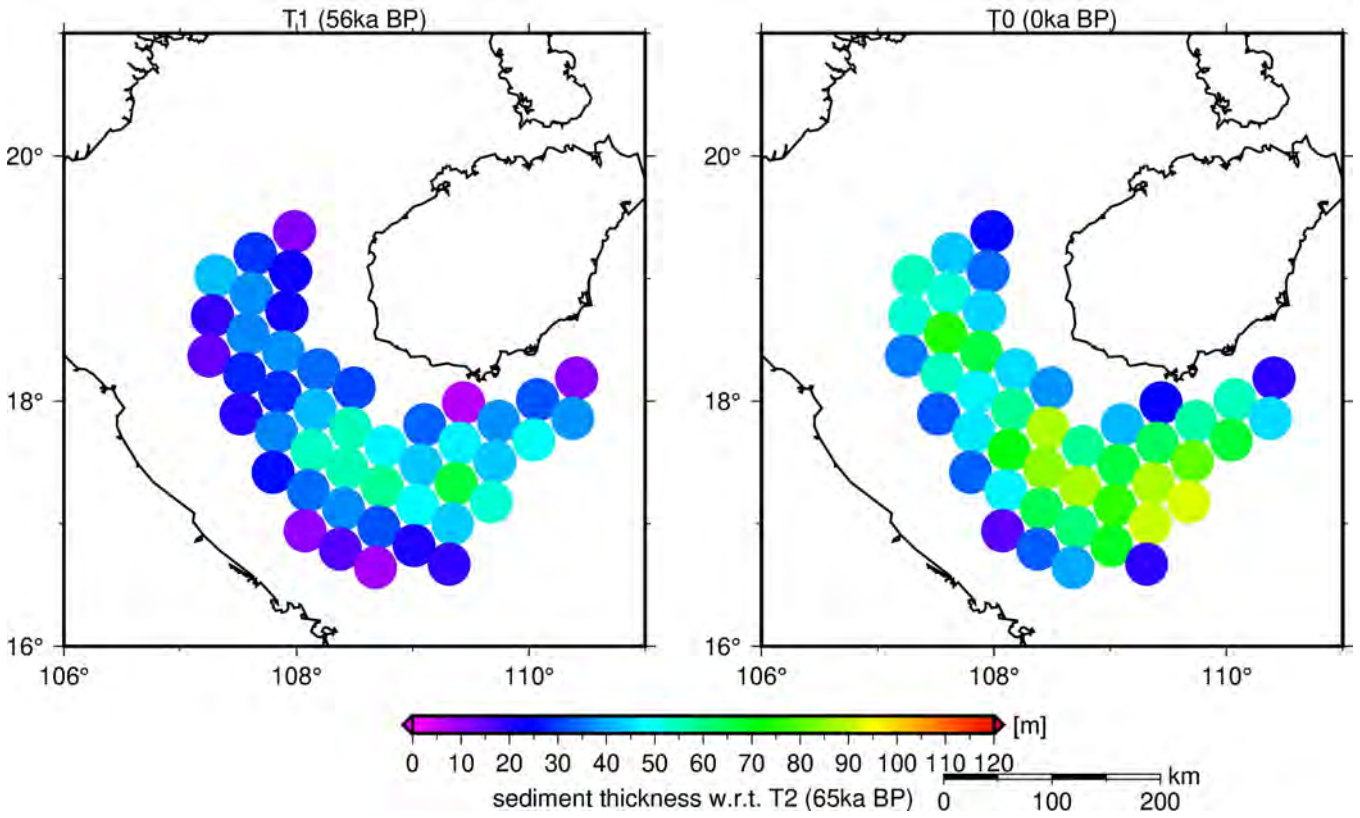
Past RSL changes induced by GIA

- Models predictions vs. observations



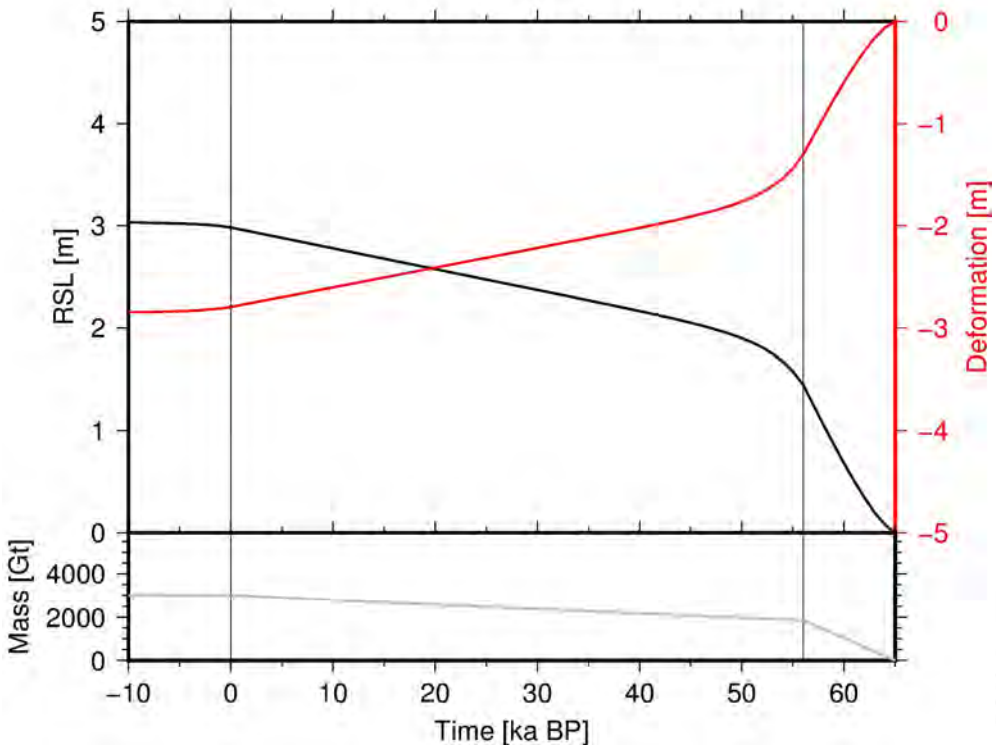
RSL changes induced by sediment loads

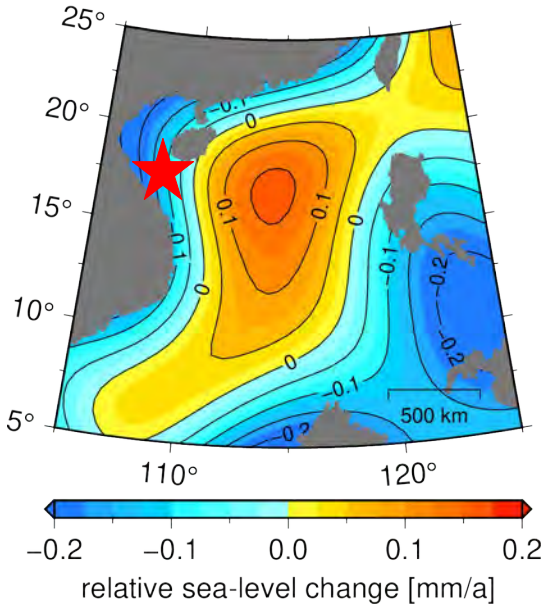
- Beibou Gulf / South China Sea
- Thickness of sediment layers between 65ka, 56ka BP and present day from seismic observations and sediment cores (Xiong et al. 2020) – Polish-Chinese-German co-operation within the ERES research project

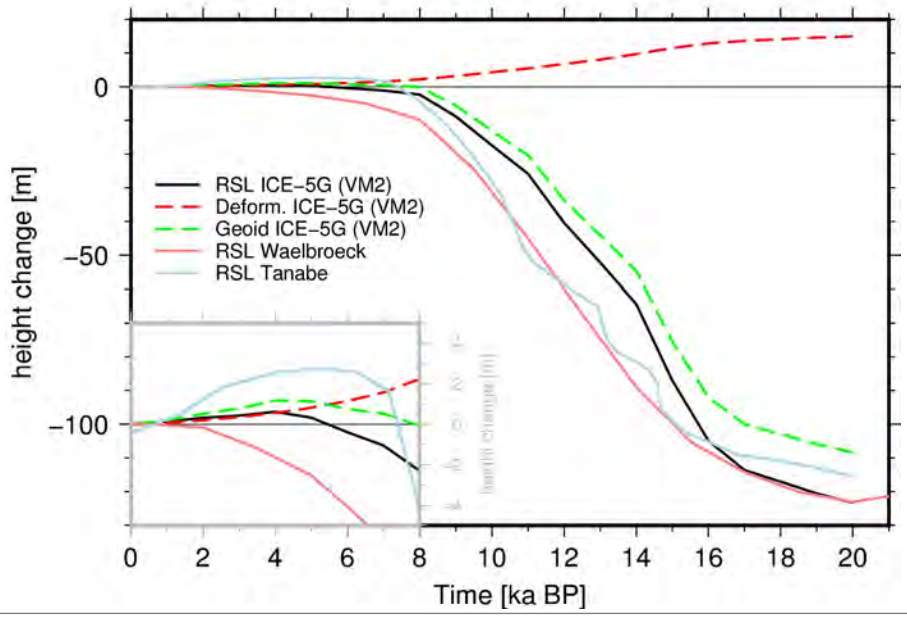


RSL changes induced by sediment loads

- RSL changes caused by sediment loads and GIA

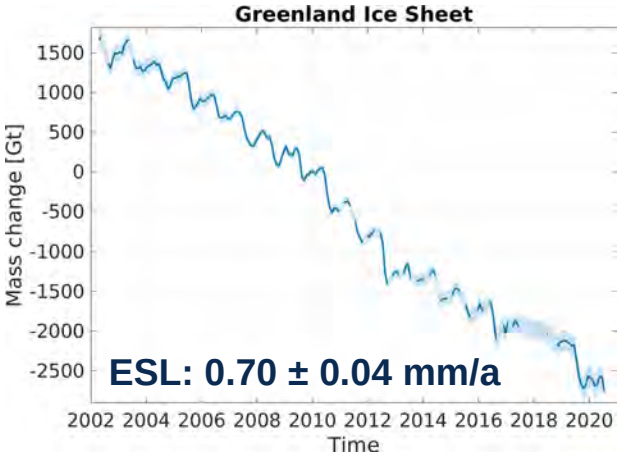


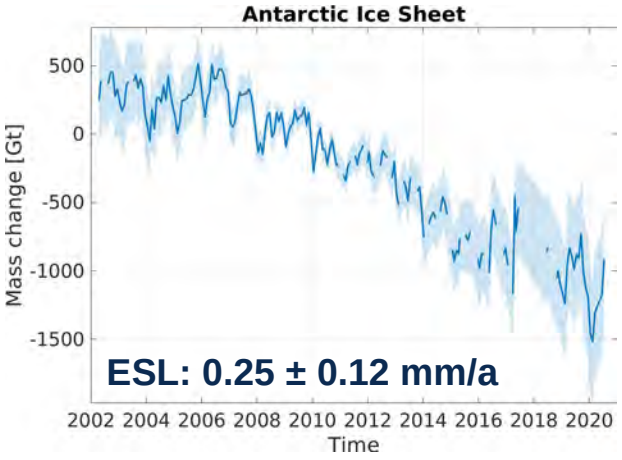


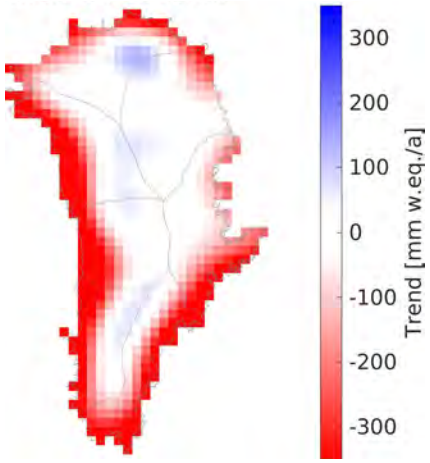


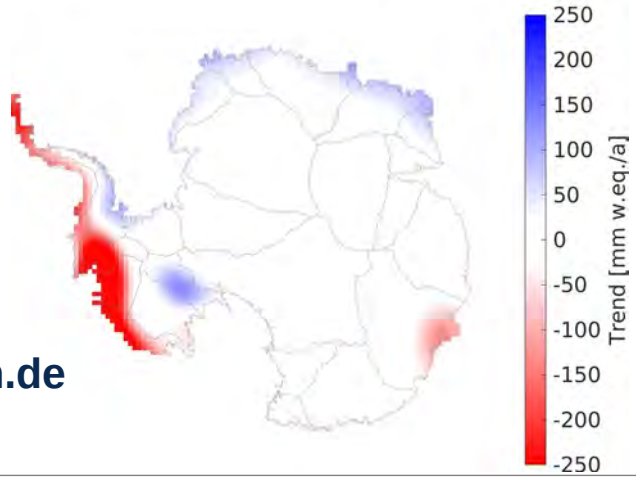
RSL induced by present-day changes in ice mass

- Antarctic and Greenland ice mass changes from satellite-observed gravity
- US-German Gravity Recovery and Climate Experiment (GRACE) mission and its follow-on mission (GRACE-FO)





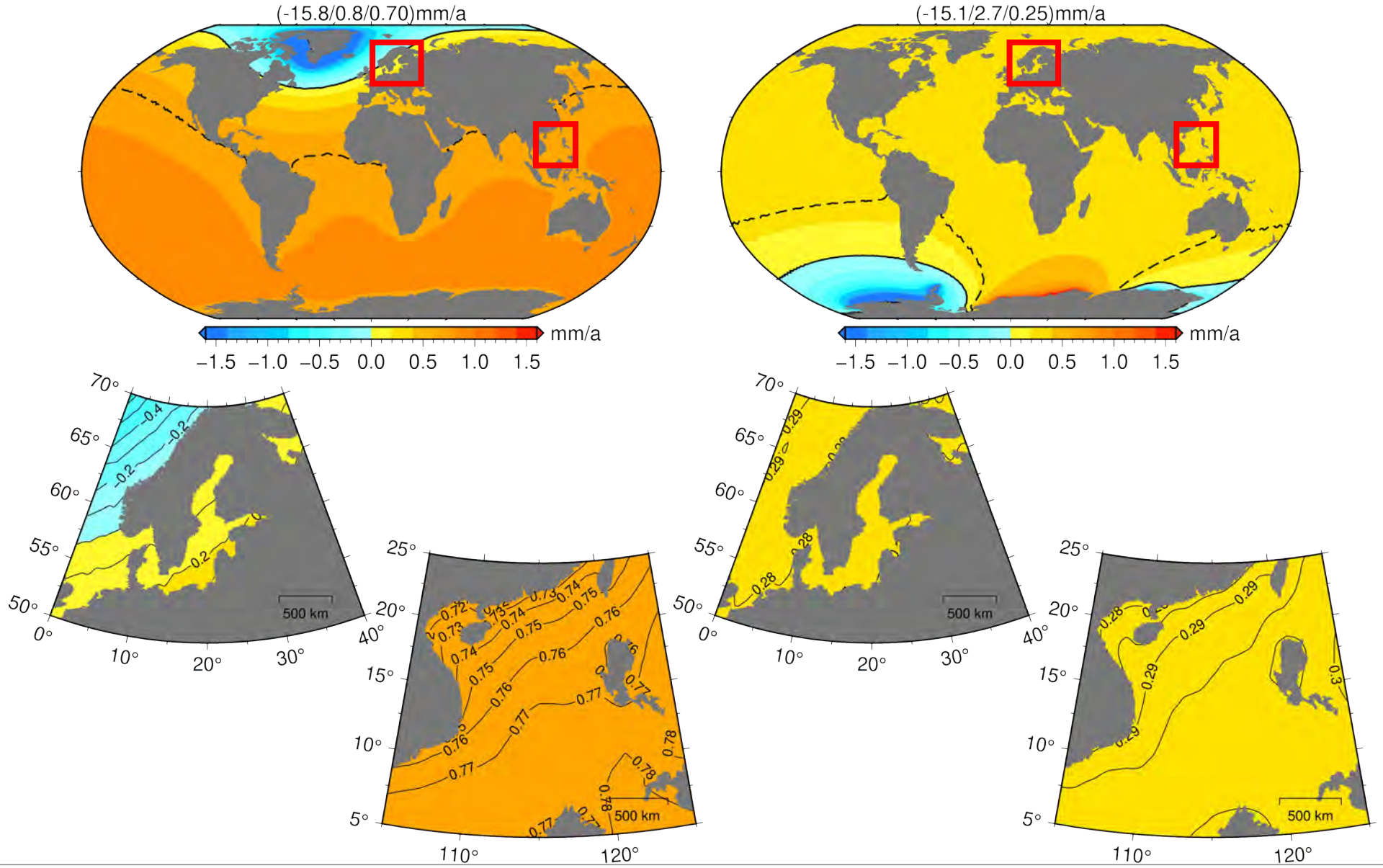




data1.geo.tu-dresden.de

(Groh and Horwath 2016)

RSL induced by present-day changes in ice mass



Summary

- GIA models provide valuable information on the development of marginal seas and their coastal zones
- Particularly import in the absence of data
- Newly acquired data may help to improve the models

Outlook

- Utilisation of most recent ice load histories (e.g. ICE-6G)
- Consideration of coastline migration
- Enhanced modeling (e.g. including rotational feedback)

Thank you for your attention!

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