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Christian-Albrechts-Universität zu Kiel

TU Delft

DTU Space
National Space Institute

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Kick-off meting
GOCE+ Antarctica

Dynamic Antarctic lithosphere

Prepared by

J. Ebbing (CAU), F. Pappa (CAU), W. v.d. Wal (Delft), F. Ferraccioli (BAS), R. Forsberg (DTU Space)

Timeline

Activity	Venue	Milestone	Target date
Kick-off meeting	ESTEC/Telecon (TBD)	KO	January 2016
Progress meeting 1	Kiel	PM1	May 2016
Mid-term review	ESTEC	MTR	October 2016
Progress meeting 2	BAS	PM2	February 2017
Final Reporting	ESTEC	FR	June 2017

		1Q/2016	*2Q/2016*	*3Q/2016*	*4Q/2016*	*1Q/2017*	*2Q/2017*
Kick-off meeting	KO						
Progress meeting 1	PM 1						
Mid-term review	MTR						
Progress meeting 2	PM 2						
Final Reporting	MTR						
Management and reporting	WP 100						
State-of-the-art, data assembly	WP 200						
Bedrock topography	WP 300						
Lithospheric modelling	WP 400						
GIA modelling and analysis	WP 500						
Conclusions and recommendations	WP600						

WP100 Management and reporting

- ESA-CAU contract is signed (18/01/2016)
- Sub-contacts with BAS, DTU, TU Delft
- Johannes Bouman is added as associated project member
- Monthly progress reports- first one sent

WP 200 State-of-the-art, data assembly, modelling

Ice thickness

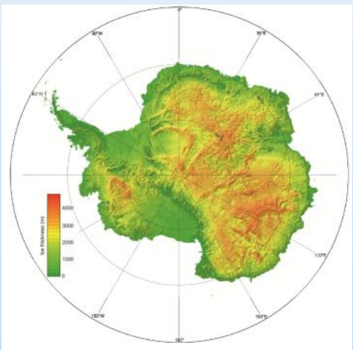


Fig. 8. Bedmap2 ice thickness grid.

Fretwell et al., 2013

(Sub-glacial) bed elevation

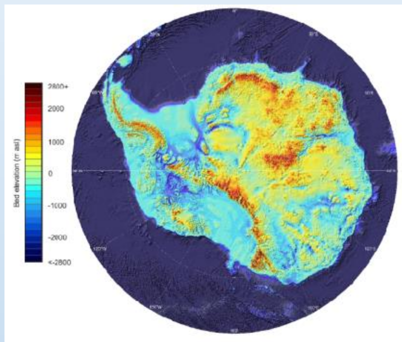
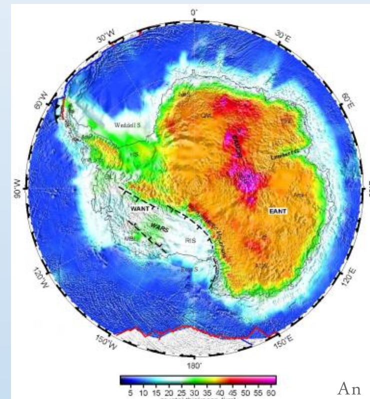
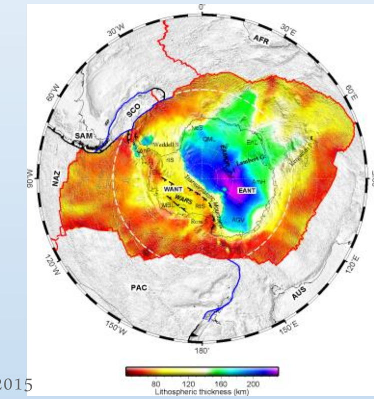


Fig. 9. Bedmap2 bed elevation grid. Although difficult to see at this scale, the bed elevation in areas where the main source of bed elevation data is gravimetric has inherited roughness from the surface grid.

Crustal thickness

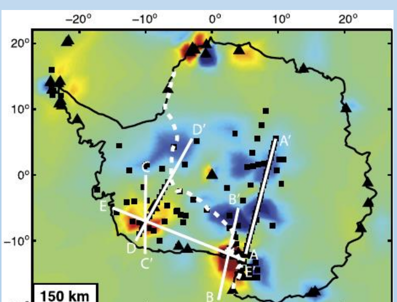


Lithospheric thickness



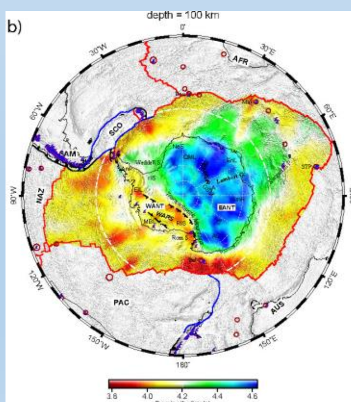
An et al., 2015

P-wave velocity

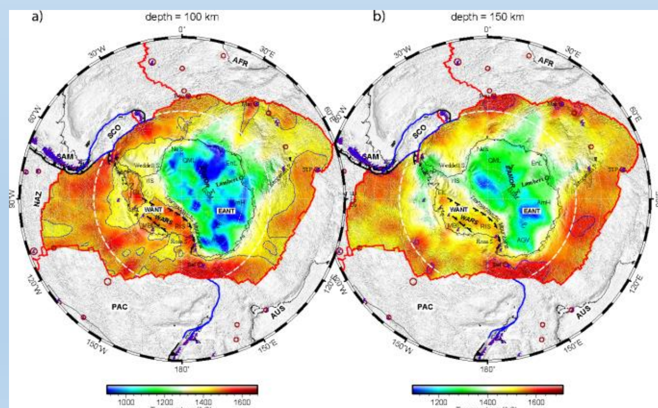


Hansen et al., 2014

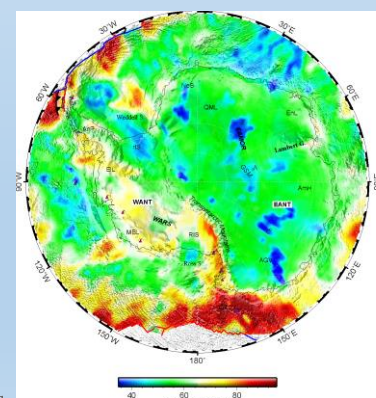
S-wave velocity



Temperature

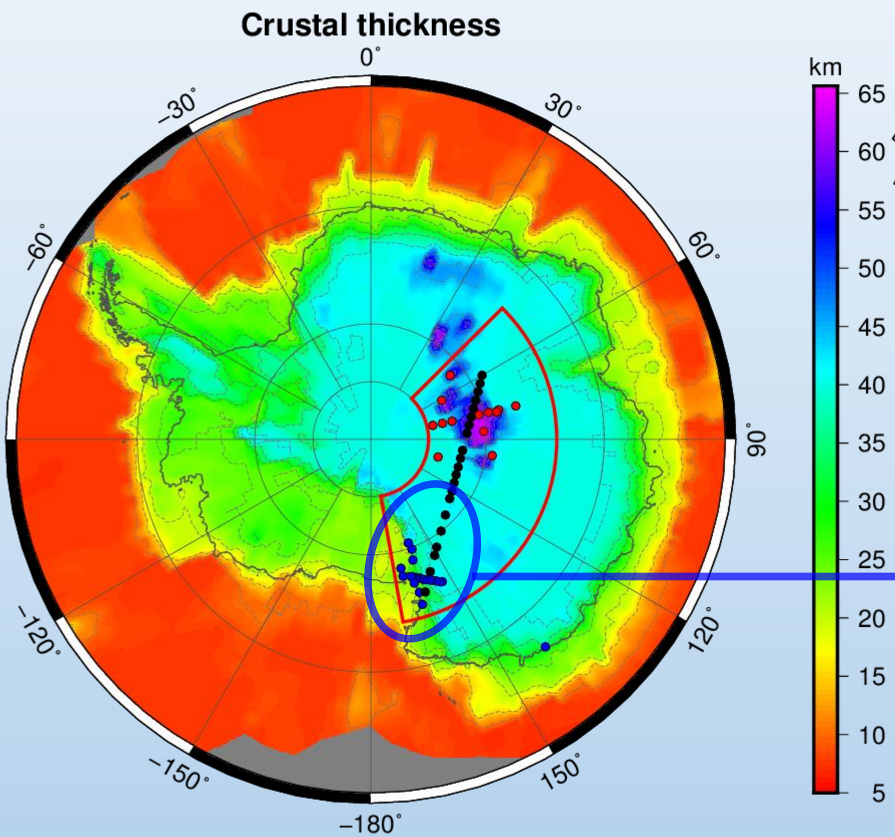


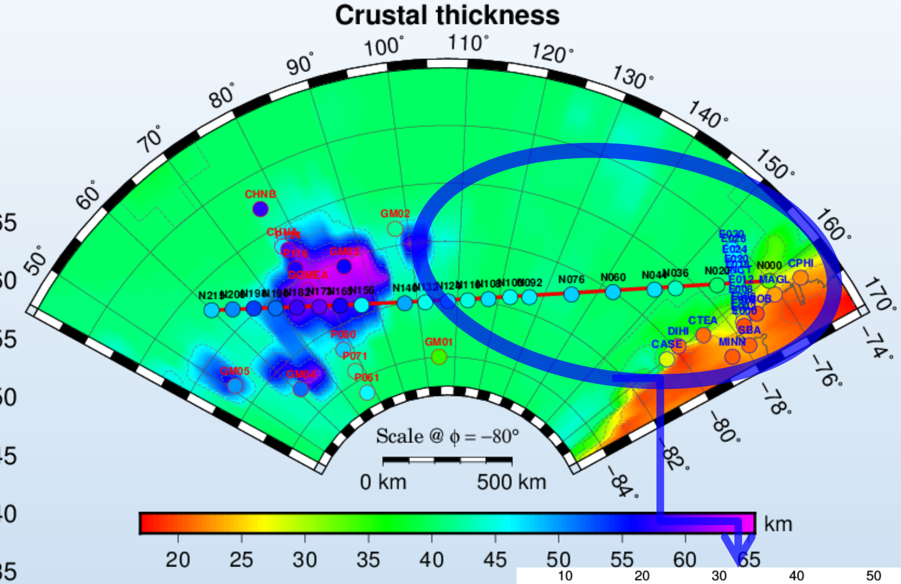
Heat flow

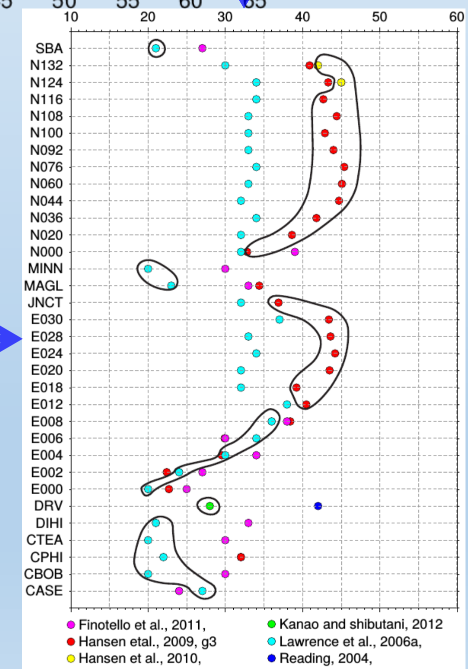


An et al., 2015

Accuracy of seismic estimates

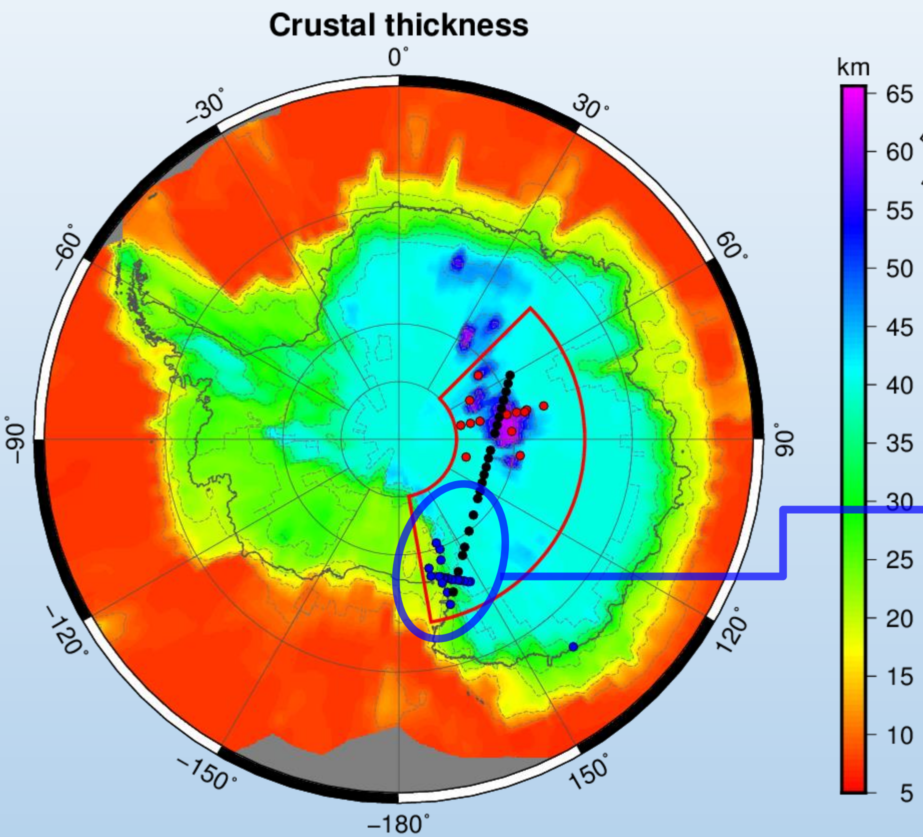


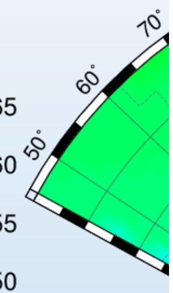


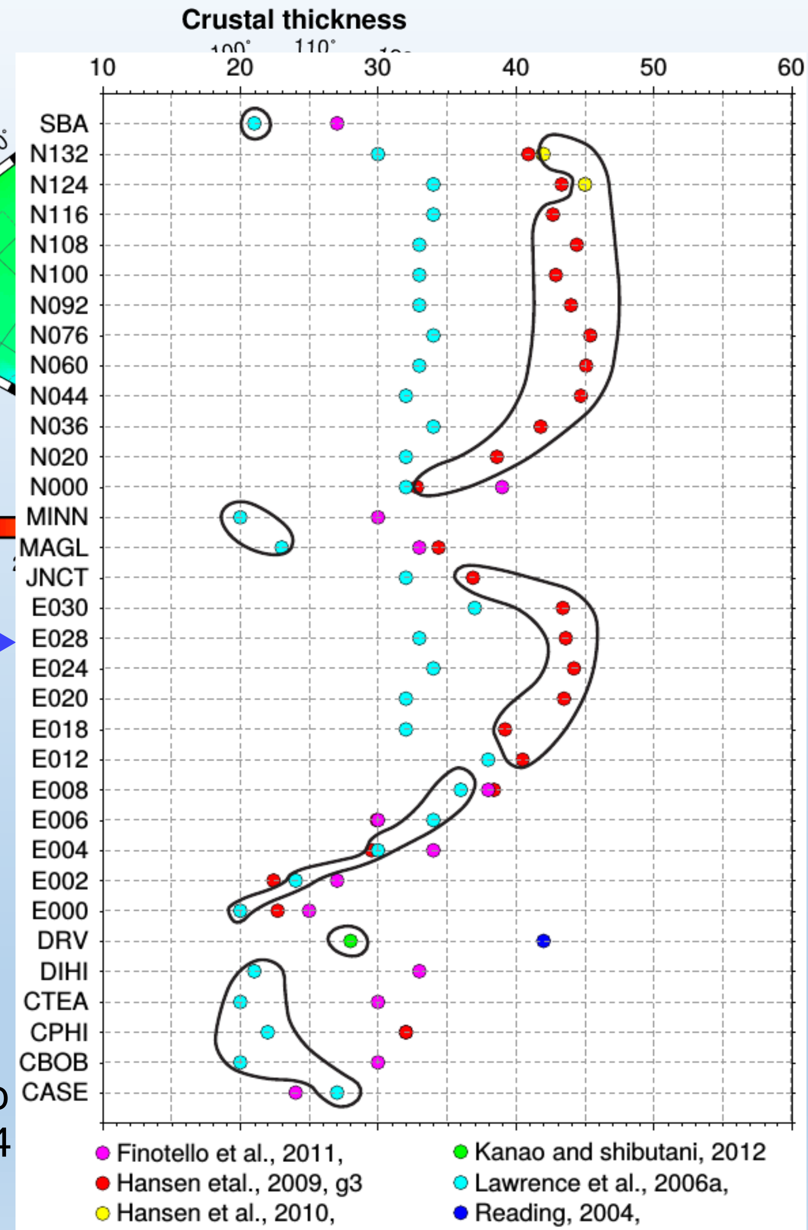


Up to 10km discrepancy in Moho depth.
→ Shallow (~30km) or deep (~40km) Moho?

Accuracy of seismic estimates



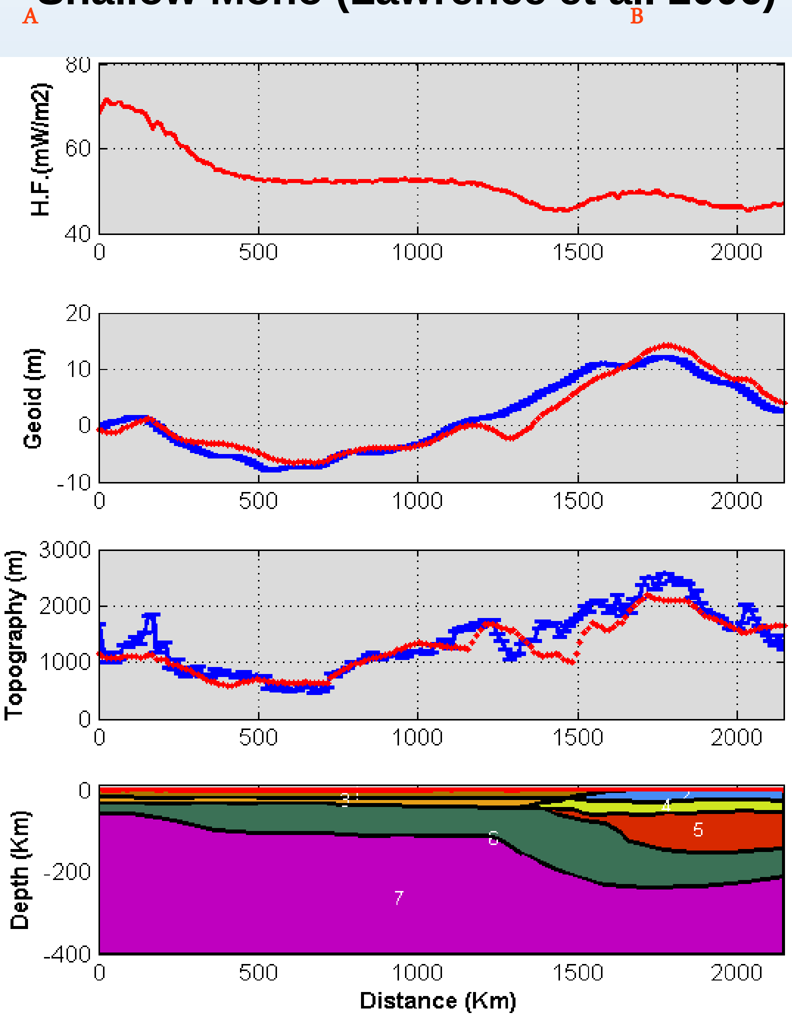


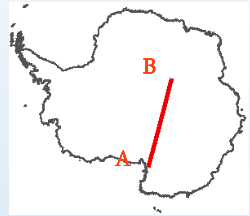


Up to 10km discrepancy in Moho
→ Shallow (~30km) or deep (~4

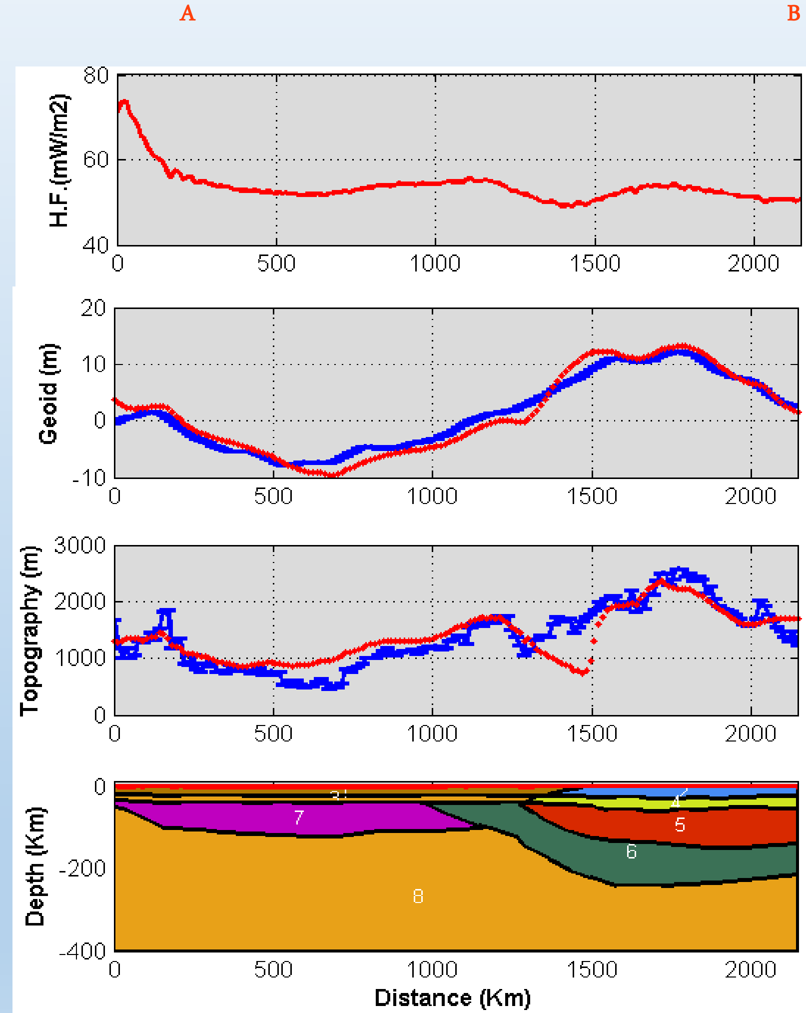
Sensitivity to Moho depth estimates

Shallow Moho (Lawrence et al. 2006)





Deep Moho (Hansen et al. 2009)



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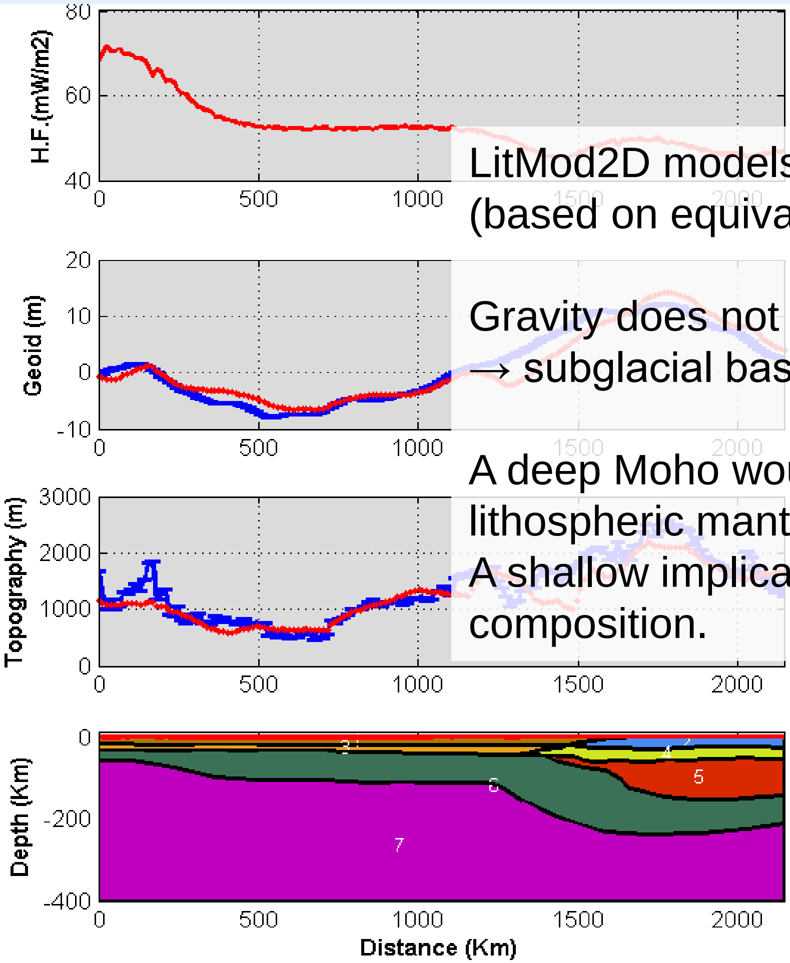
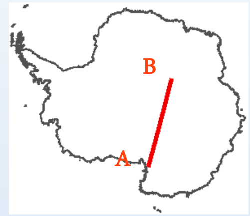
Shallow Moho (Lawrence et al. 2006)





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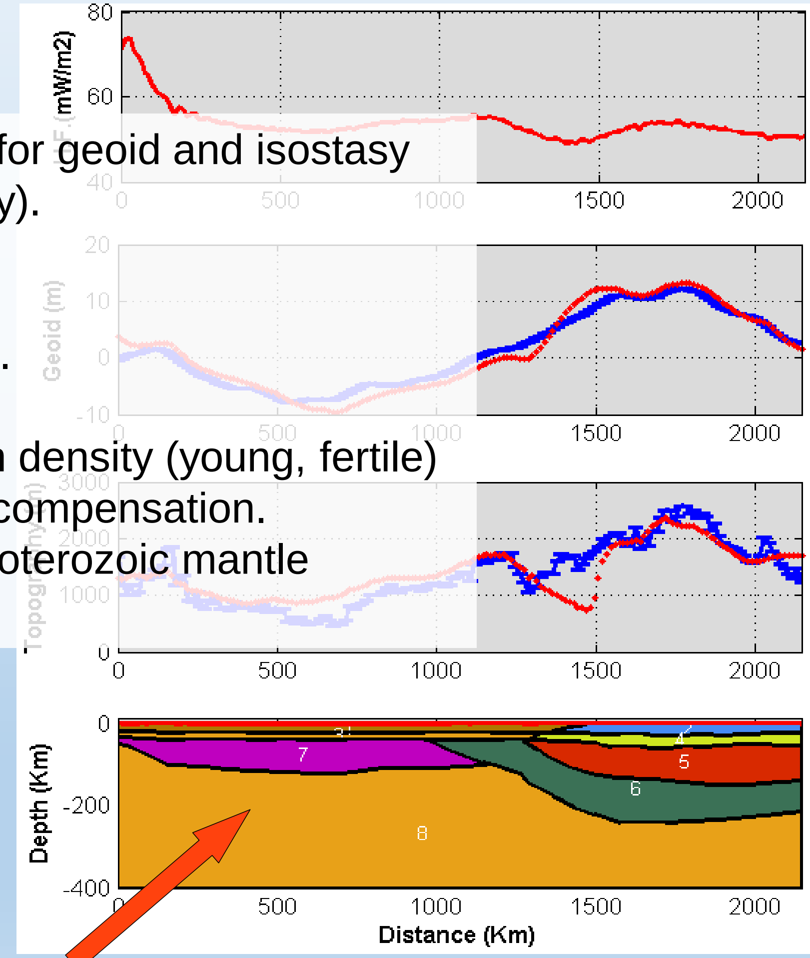

LitMod2D models fitted roughly for geoid and isostasy (based on equivalent topography).

Gravity does not fit
→ subglacial basin not modeled.

A deep Moho would require high density (young, fertile) lithospheric mantle for isostatic compensation.
A shallow implicates average Proterozoic mantle composition.

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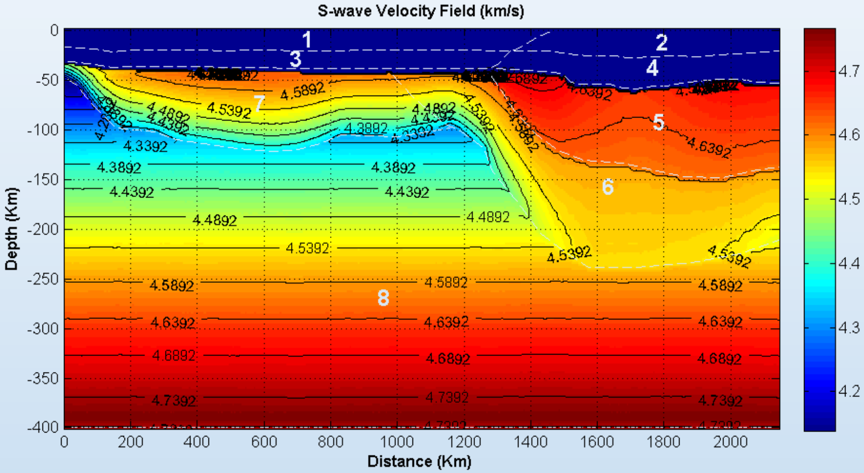
Comparison of S-wave velocities

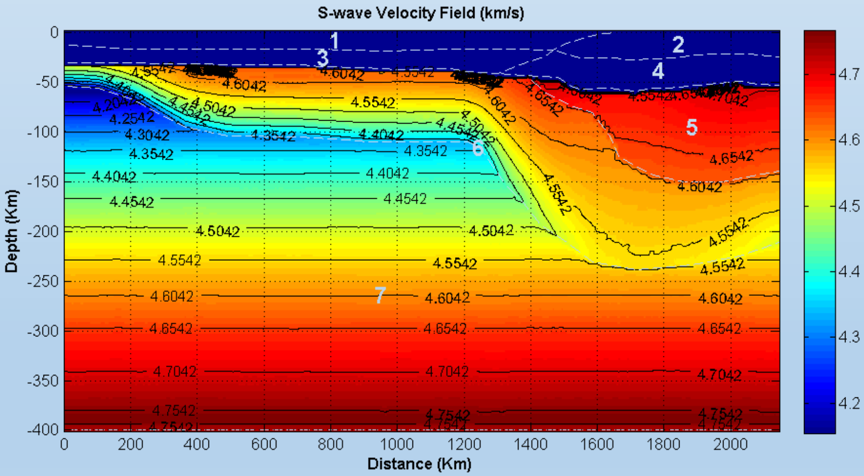
LitMod model with deep Moho



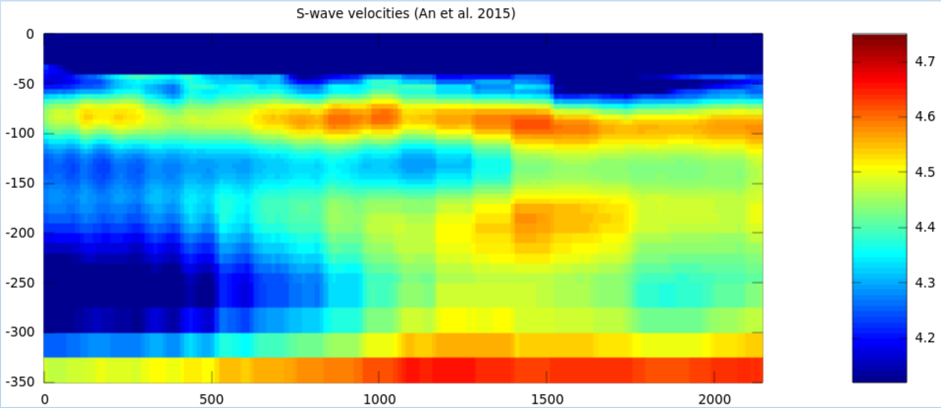
Fitting the models to topography and geoid results in reasonable velocity patterns. (However, there are still huge differences compared to the data.)

Neither a deep nor a shallow Moho setting can be yet excluded by the modelling of mantle velocities.

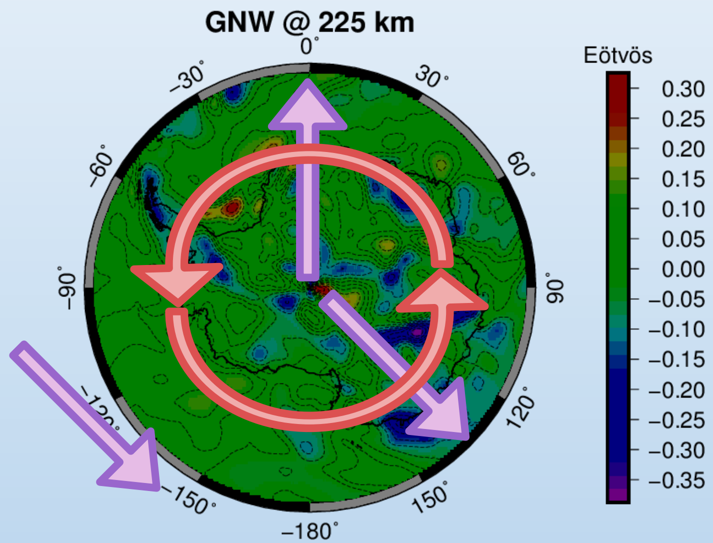
LitMod model with shallow Moho



Model "AN1-VS" from An et a. 2015



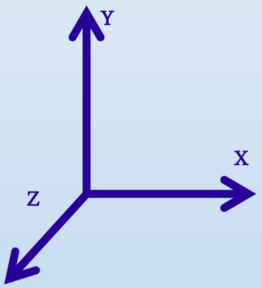
Gravity gradient modelling



Local north-oriented frame

“NWU” is not appropriate for intuitive interpretation of gravity gradients in polar regions.

We want:

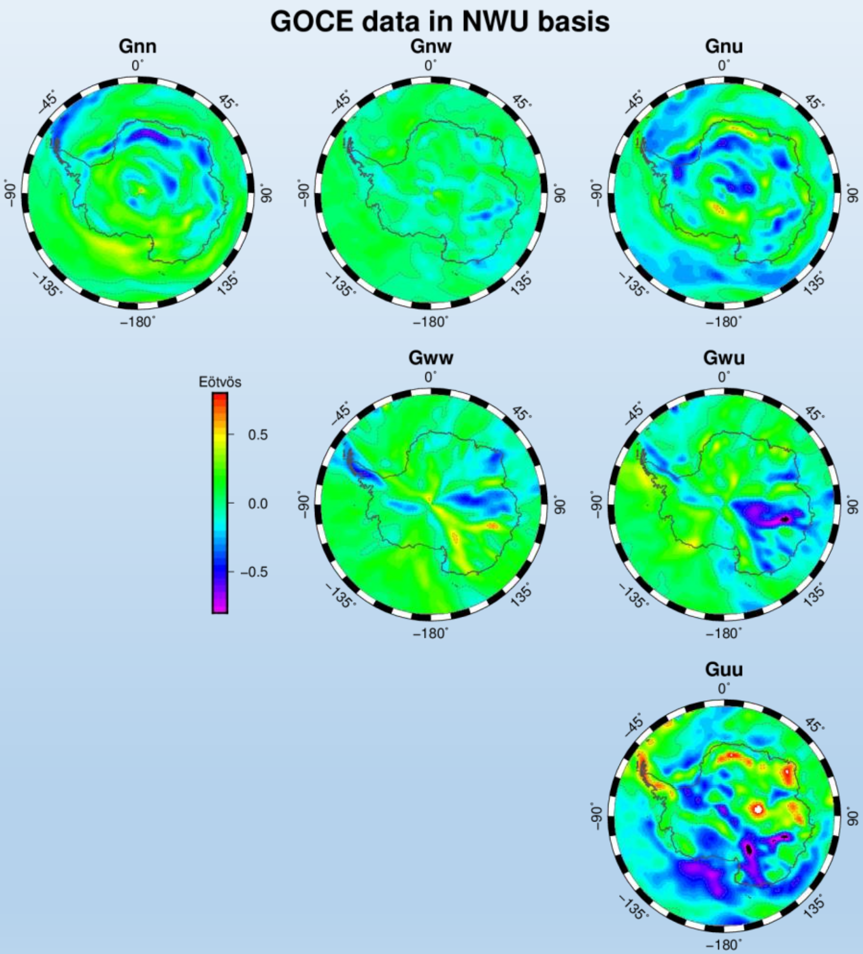


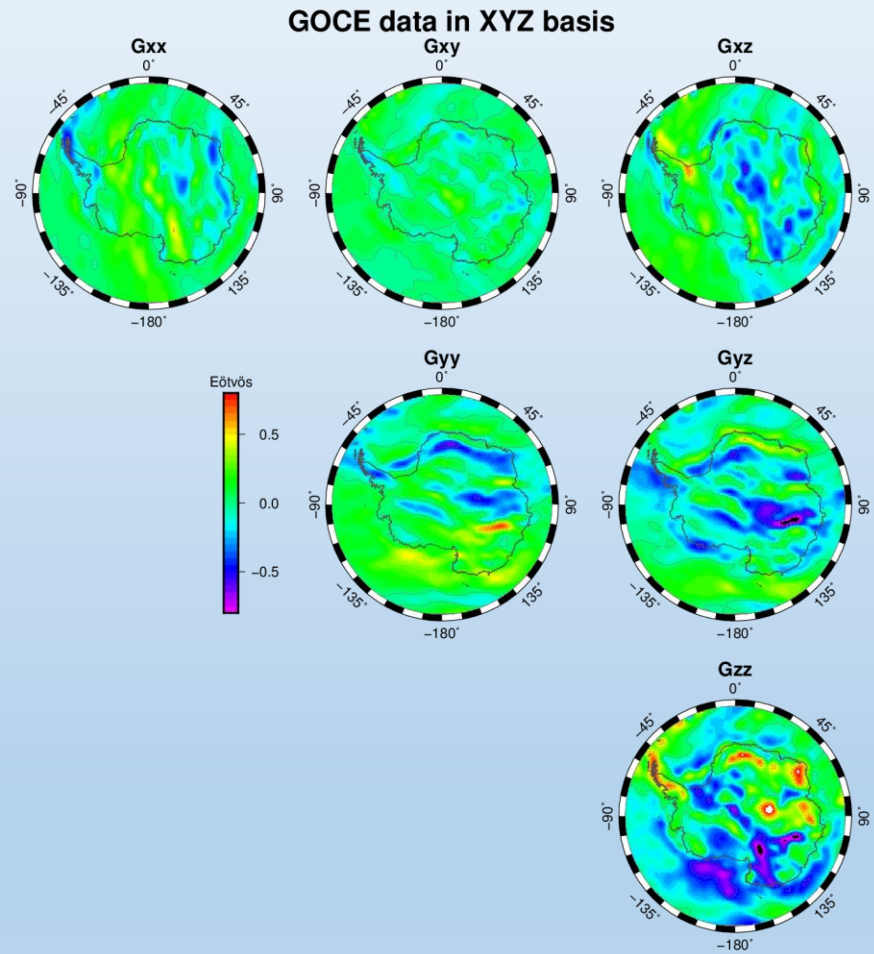
in polar stereographic map view.

For the future, we refer to this by:
“Indian Atlantic Up” (IAU).

(Pointing to the Indian Ocean, the Atlantic Ocean and Upward.)

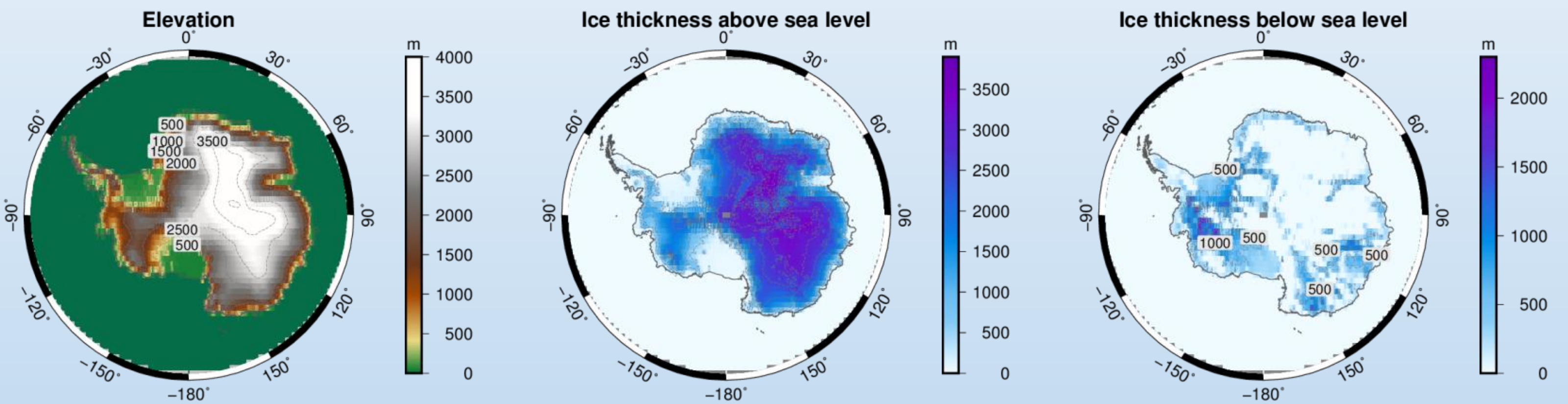
NWU (LNOF) → tensor basis change → IAU (to right, to top, up)

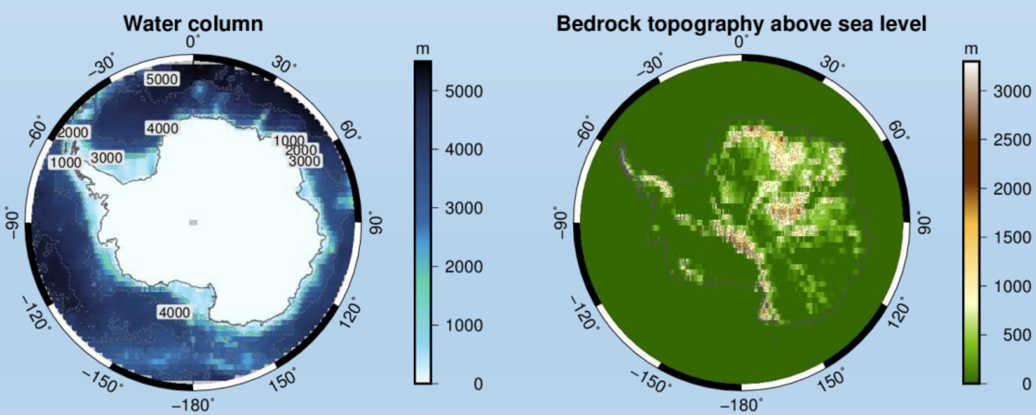




Topographic mass reduction

Calculation of gravity effect of ice, water and bedrock topography
→ correction of GOCE's gradient tensor → intracrustal and subcrustal effects

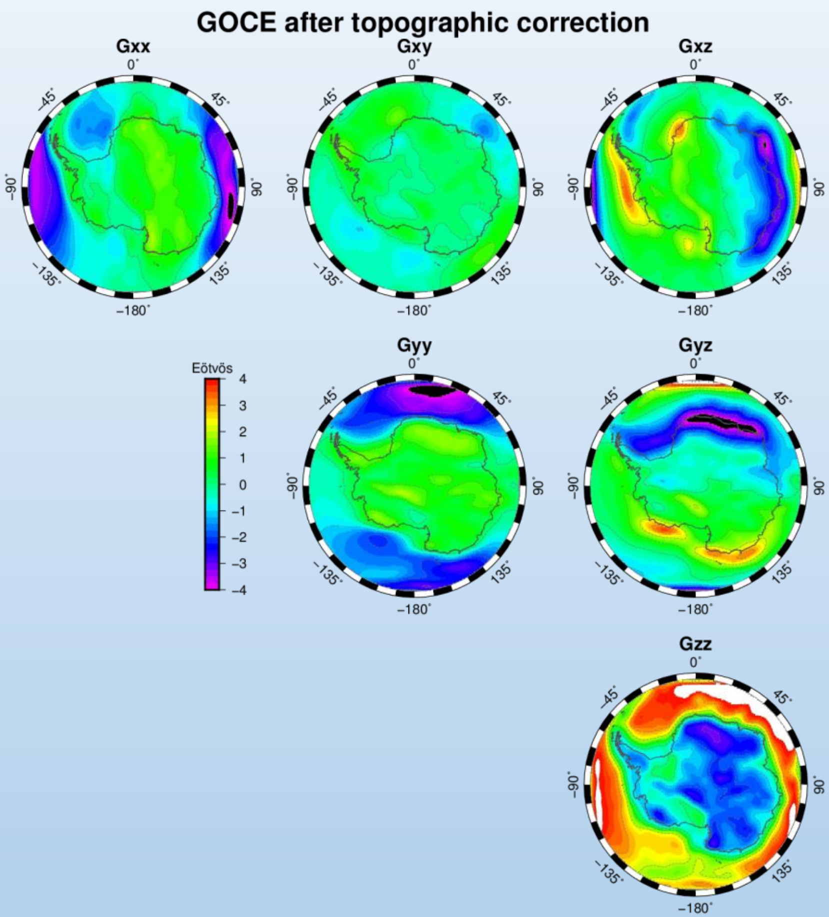


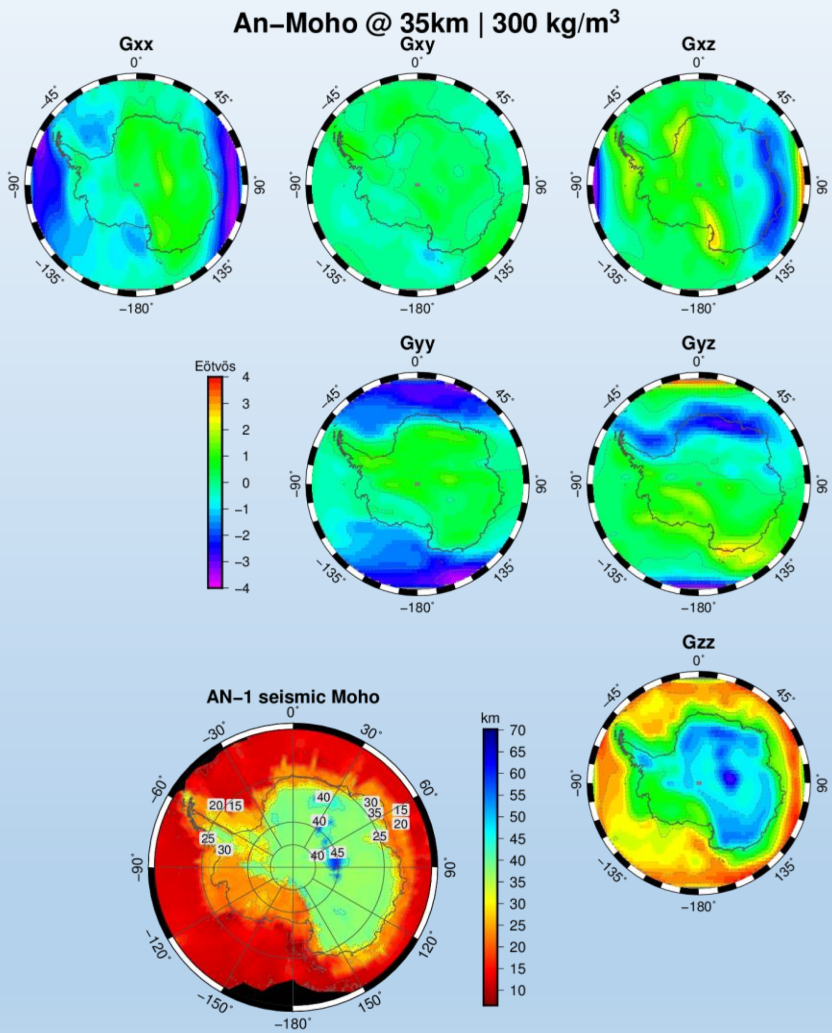


<u>Densities</u>

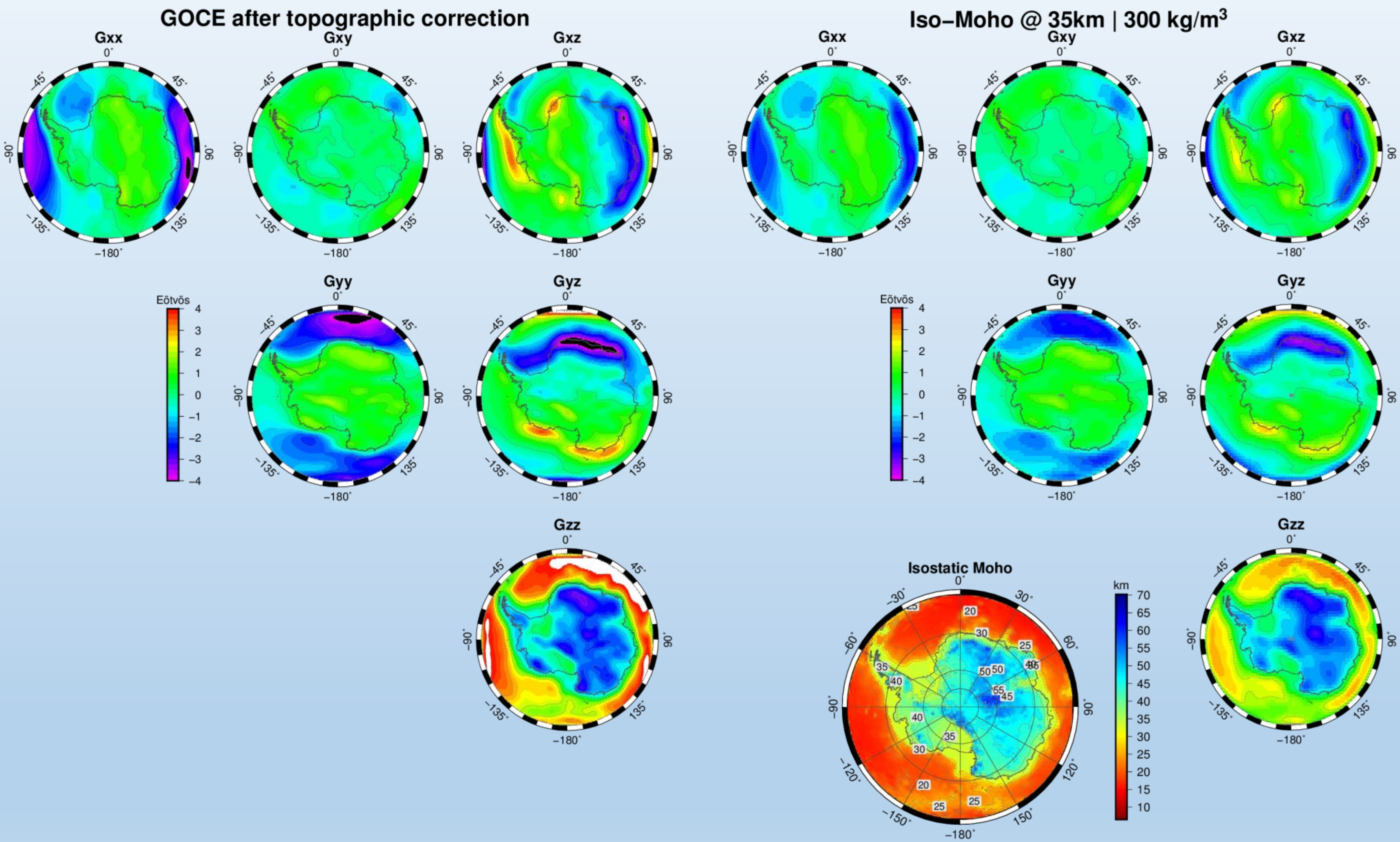
- ice above SL: 910 kg/m³
- ice below SL: -1760 kg/m³
- water: -1640 kg/m³
- bedrock topography: 2670 kg/m³

Gradient signals from seismic Moho

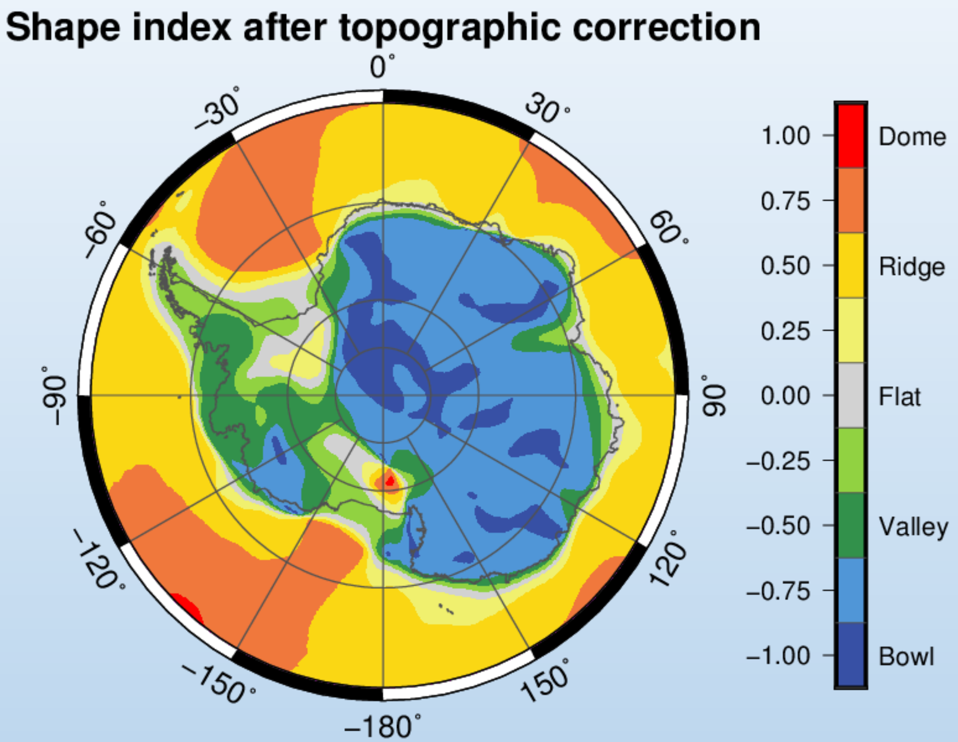




Gradient signals from isostatic Moho



Shape index of gravity gradients



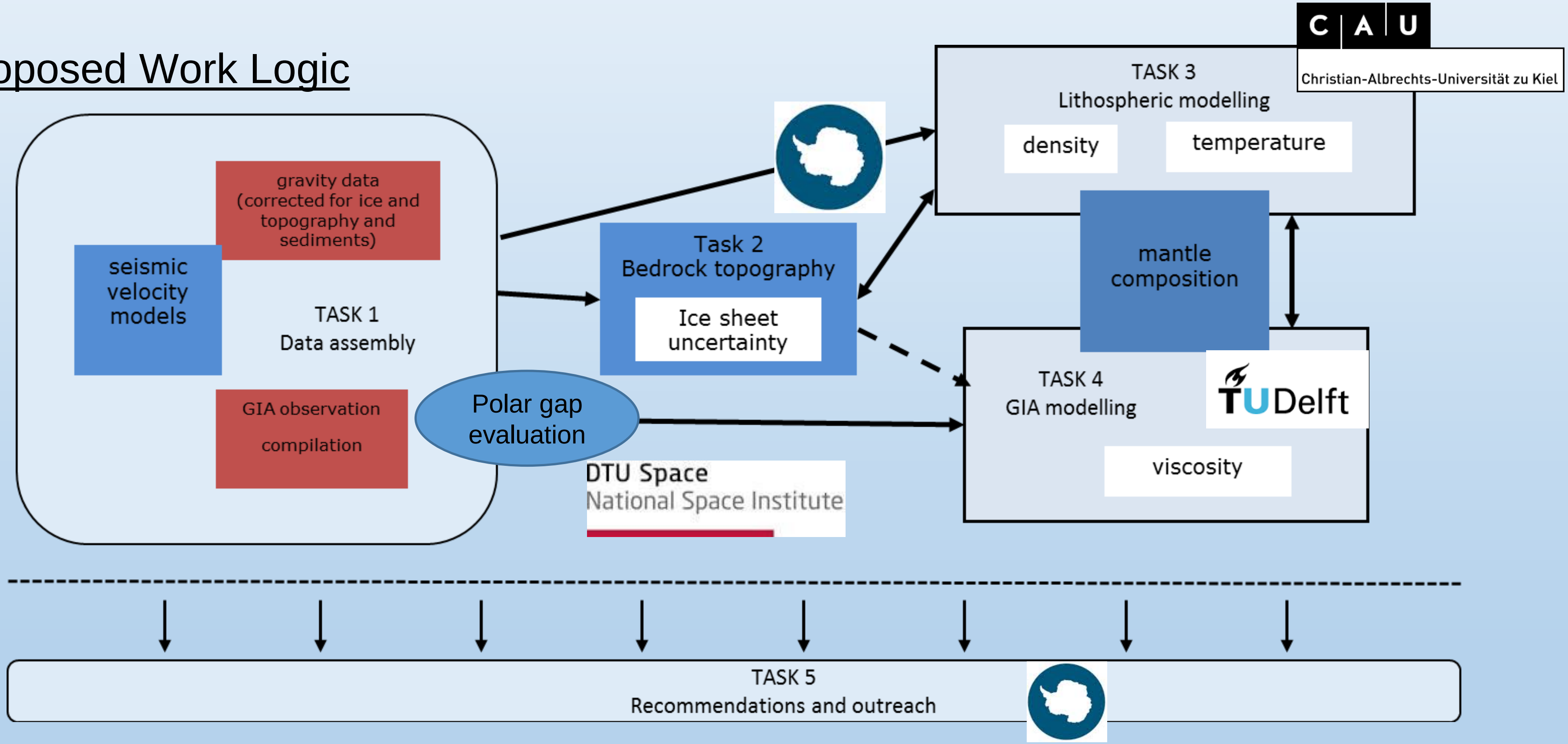
The shape index combines the minimum and maximum curvature of an equipotential surface (gravity potential) and can be expressed by the gradients.

Values and colours represent different morphologies of the equipotential surface, which would be difficult to identify in other images.

$$S_i = \frac{2}{\pi} \arctan \left(\frac{G_{zz}}{\sqrt{(G_{xx} - G_{yy})^2 + 4{G_{xy}}^2}} \right)$$

WP 300-500 have not yet started

Proposed Work Logic



WP600 Outreach and presentations

- Abstracts to ESA Living Planet Symposium-submitted
- Abstract to DGG, Münster -submitted
- Abstracts to EGU 2016- submitted
- Abstracts for SCAR and IGC 2016- submitted
- Webpage