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Joint inversion for crustal structure in Dronning Maud Land

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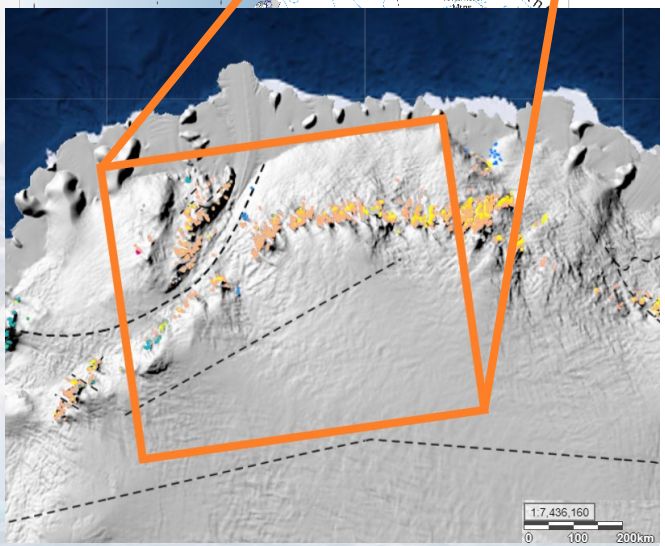
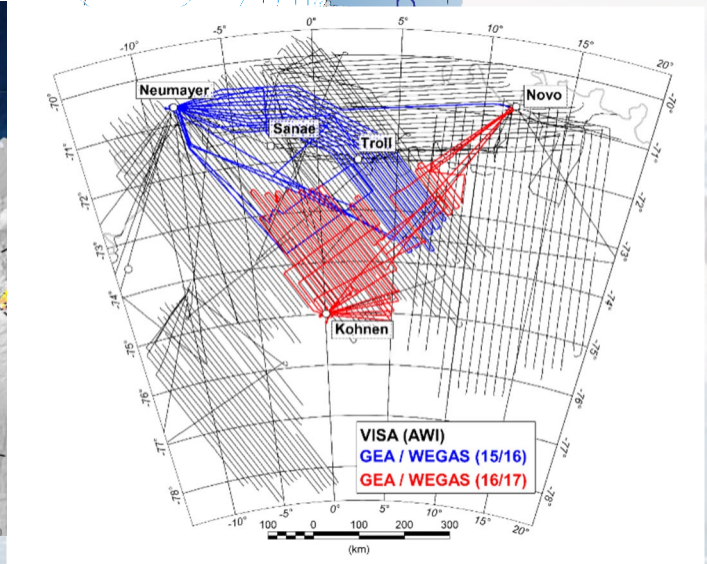
Introduction



The SCAR GeoMAP (Cox et al. 2023)



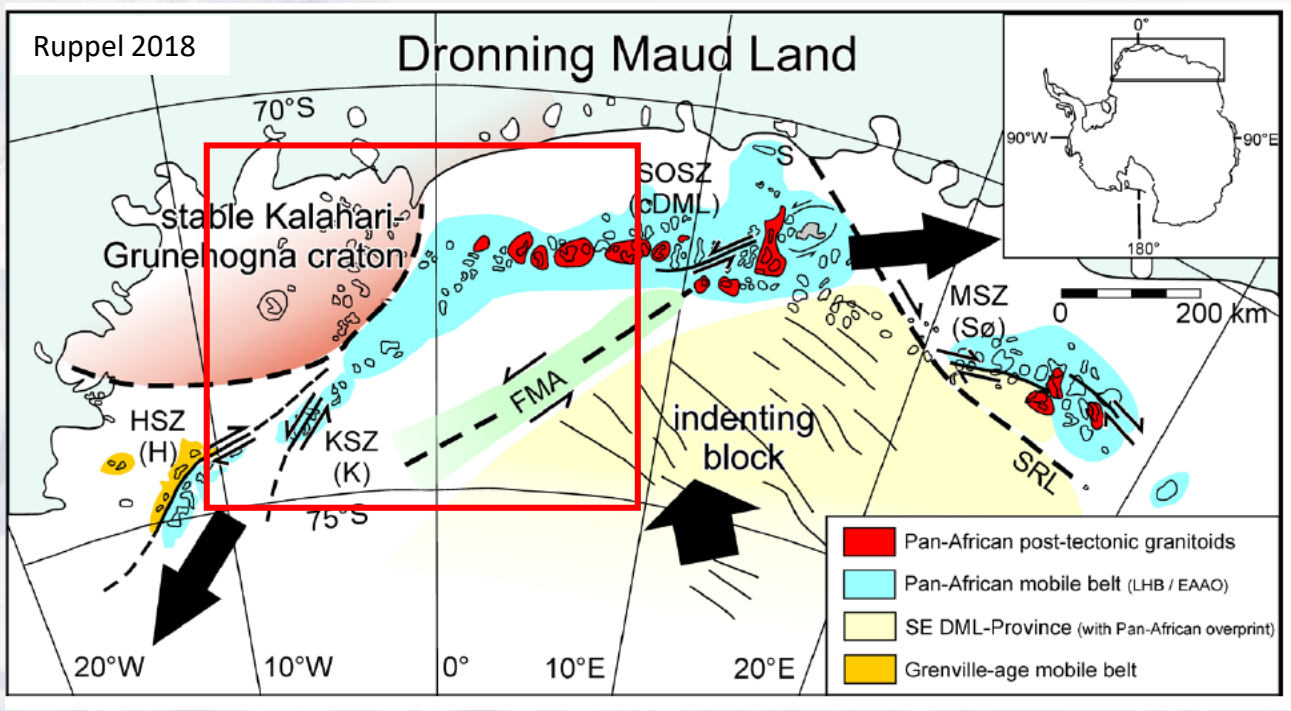
- Study of the Dronning Maud Land (DML) is crucial for understanding connection between Antarctica and South Eastern Africa.

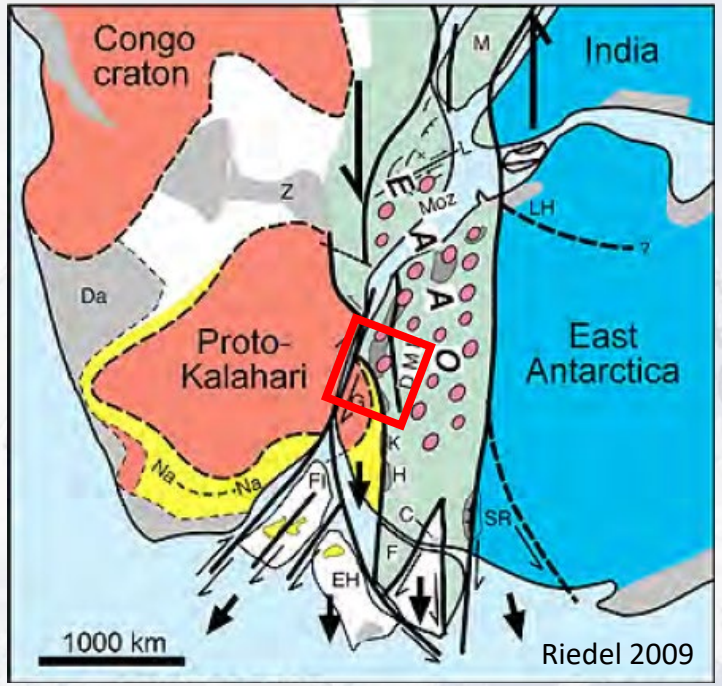
Challenge:

- Lack of geological outcrops
- Patchy airborne data coverage
- Massive ice sheets

- We perform a joint inversion scheme using jif3D (Moorkamp 2021), where sources of the gravity and magnetic field are combined through a coupling method which decreases the variation of information (VI).

Geology of the region

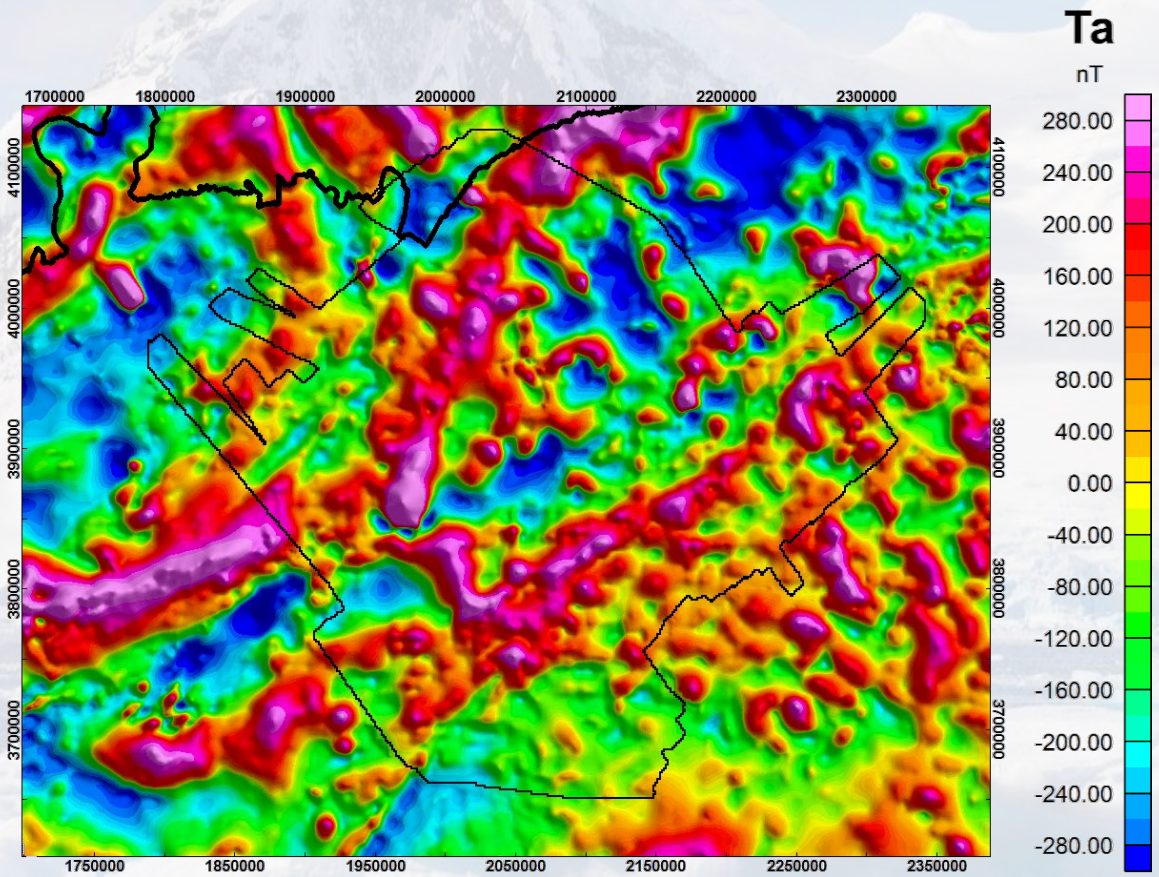




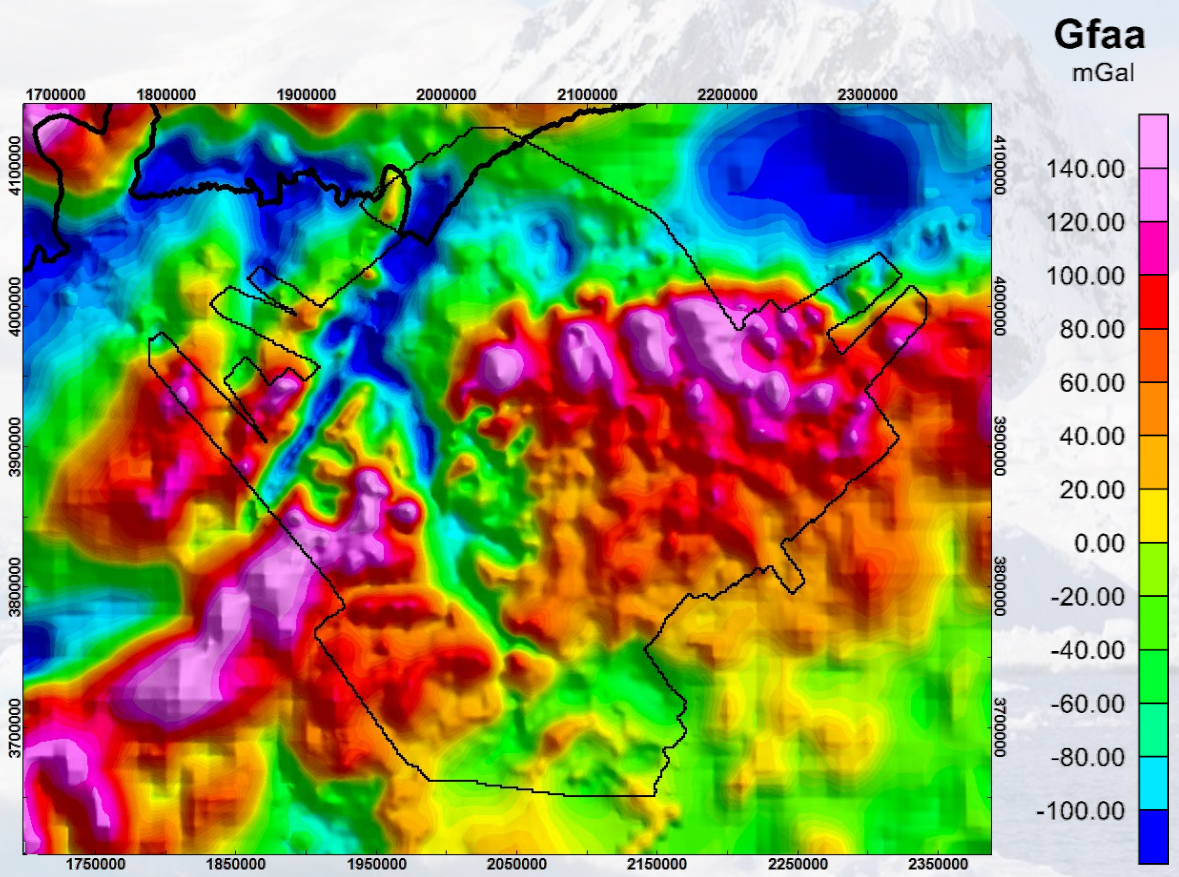
- Crustal evolution of DML and SE Africa were quite similar from Archean until Mesozoic times;
- The East African Antarctic Orogen (EAAO) – collisional orogen along which Gondwana formed;
- Western DML – the Grunehogna Craton parted from a the Kalahari-Kaapval-Craton during Gondwana breakup;
- Central DML – Grenvillian structures of the EAAO covered by melted crystalline basement.

Data

Regional compilations were used outside the survey area.



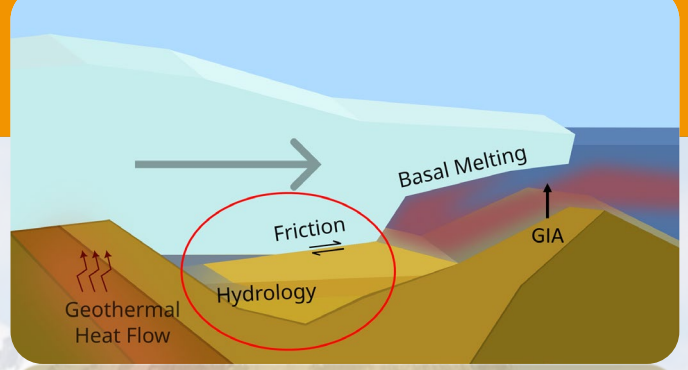
Magnetics merged

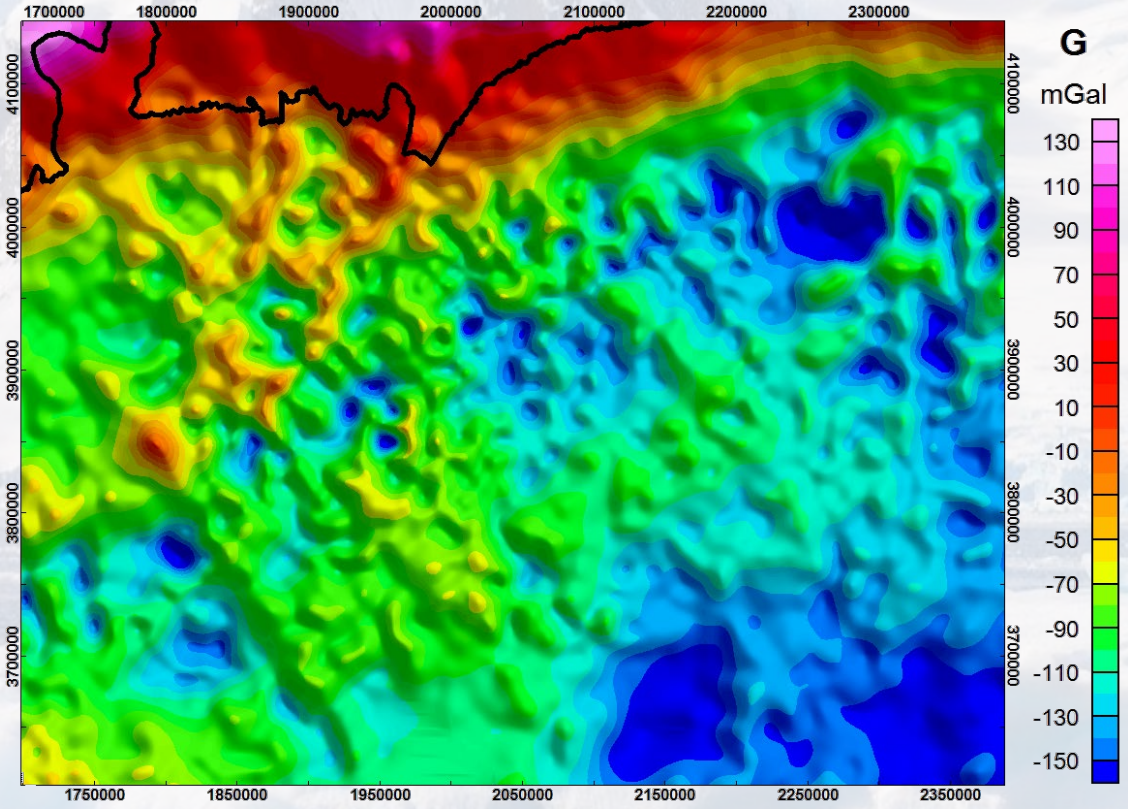


Gravity FAA merged

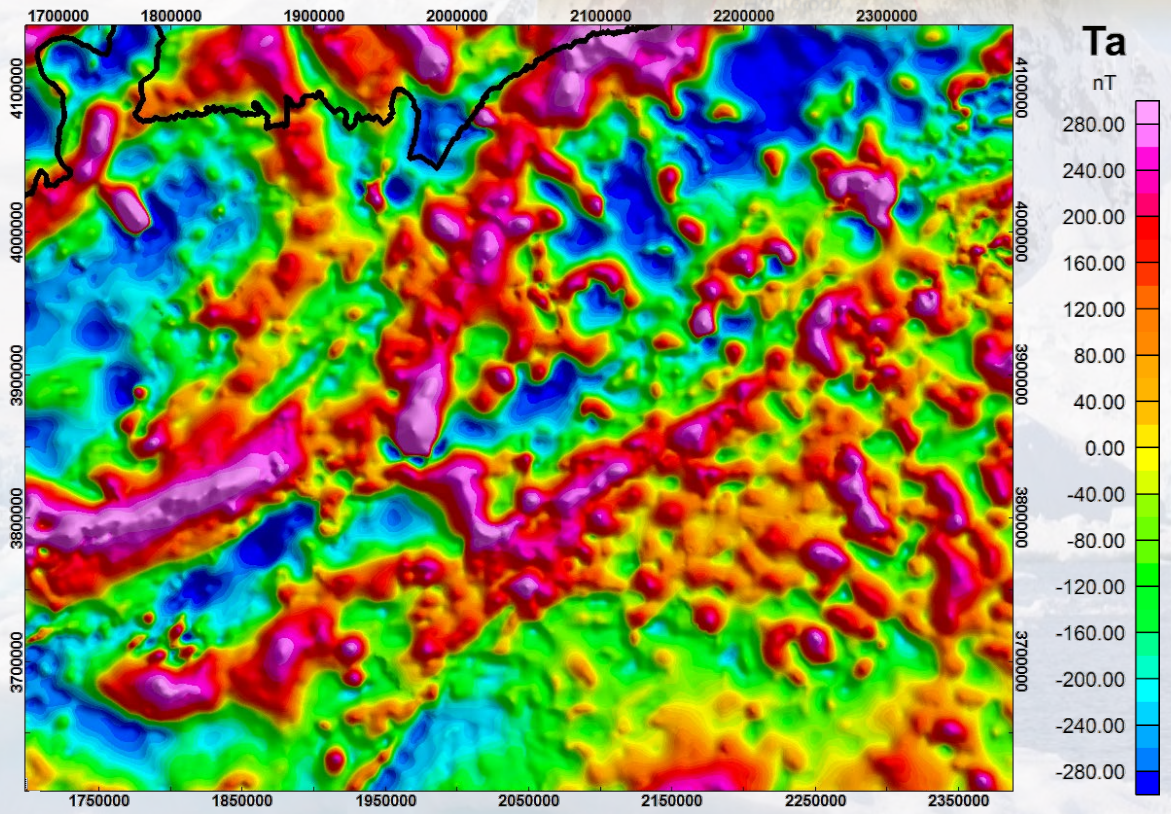
Input data for the inversion

The total magnetic field and isostatic residual gravity were chosen as input data for the joint inversion as the main target is the sub-glacial geology.





Gravity isostatic residual



Magnetic total field anomaly

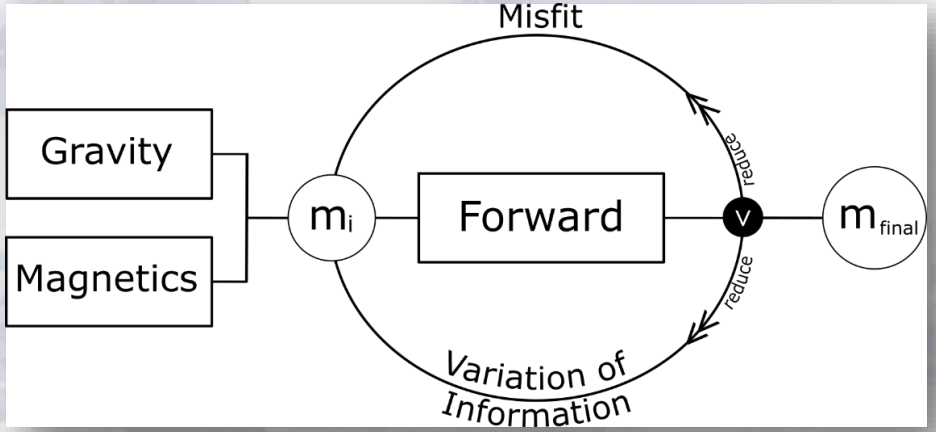
Joint Inversion based on Variation of Information

Joint inversion for gravity and magnetic data

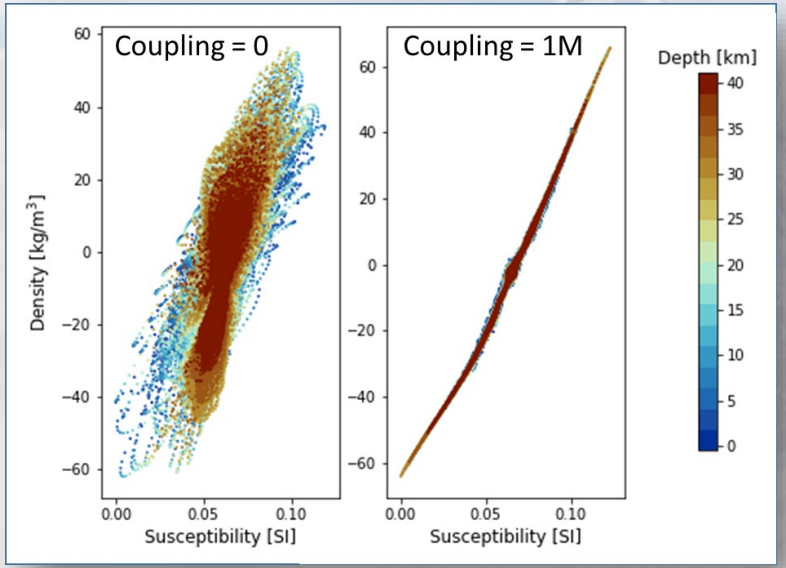
- Assuming coincident boundaries of sources
- Objective function

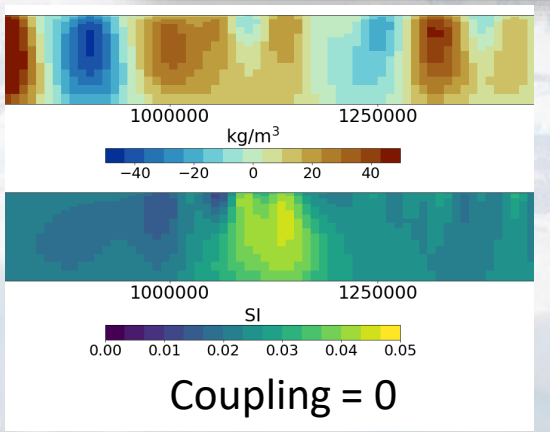
$$\Phi_{\text{joint}}(\mathbf{m}) = \Phi_{\text{data}}(\mathbf{m}) + \lambda\Phi_{\text{reg}}(\mathbf{m}) + \nu\Phi_{\text{coupling}}(\mathbf{m})$$

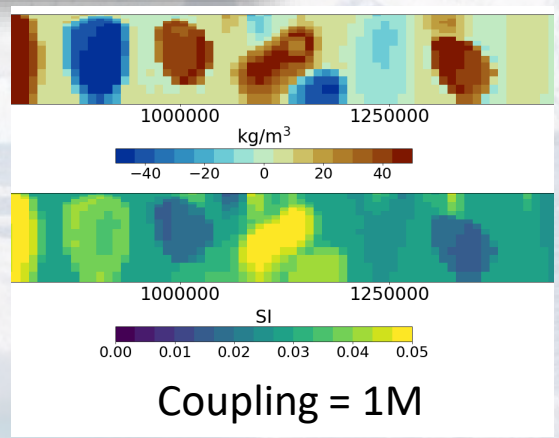
- Minimize entropy of joint probability distributions by calculation of mutual information (reducing the variation of information)



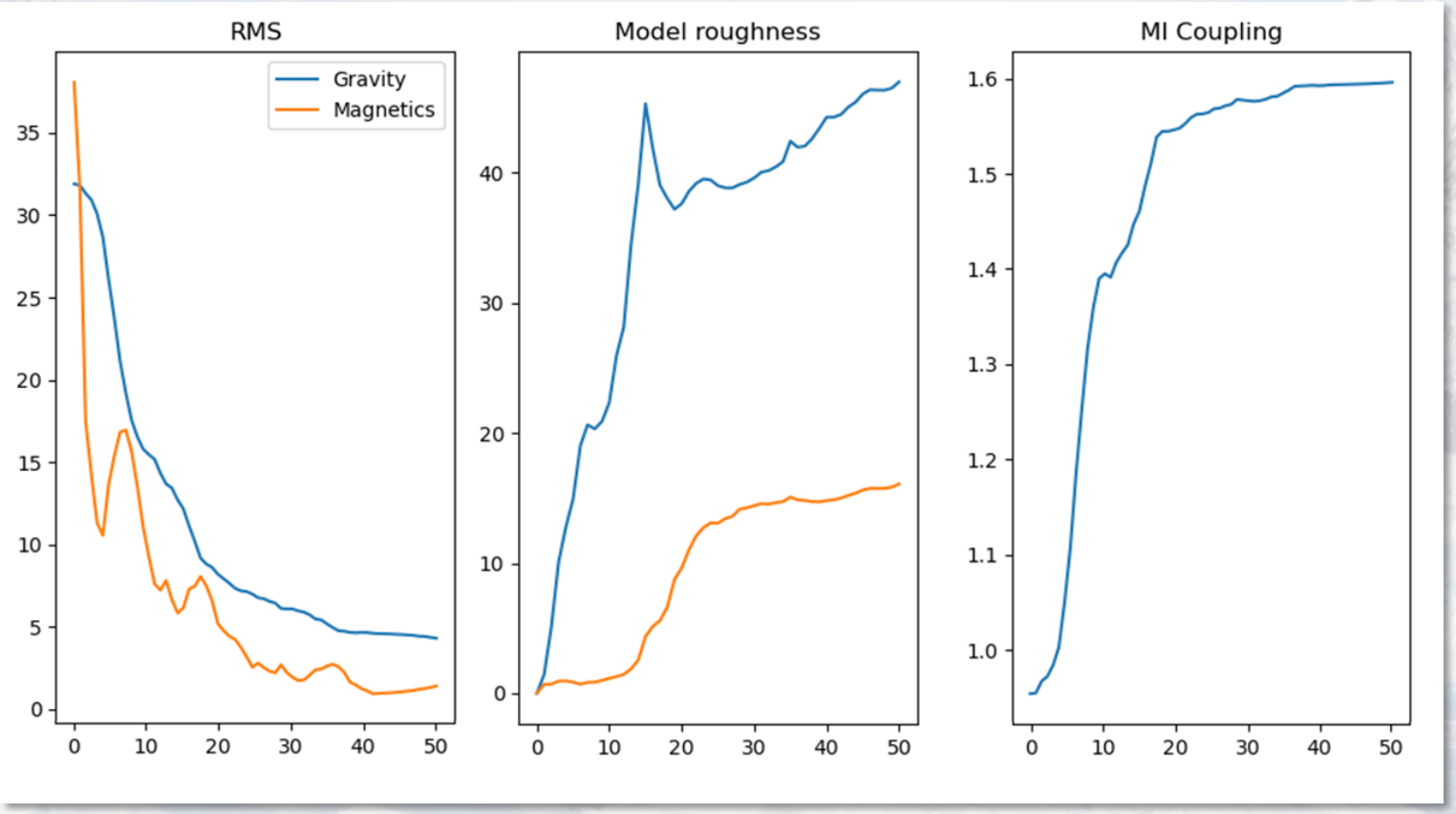
- Higher coupling forces structural similarity
- For method and application to Antarctica, see Lösing et al. 2023





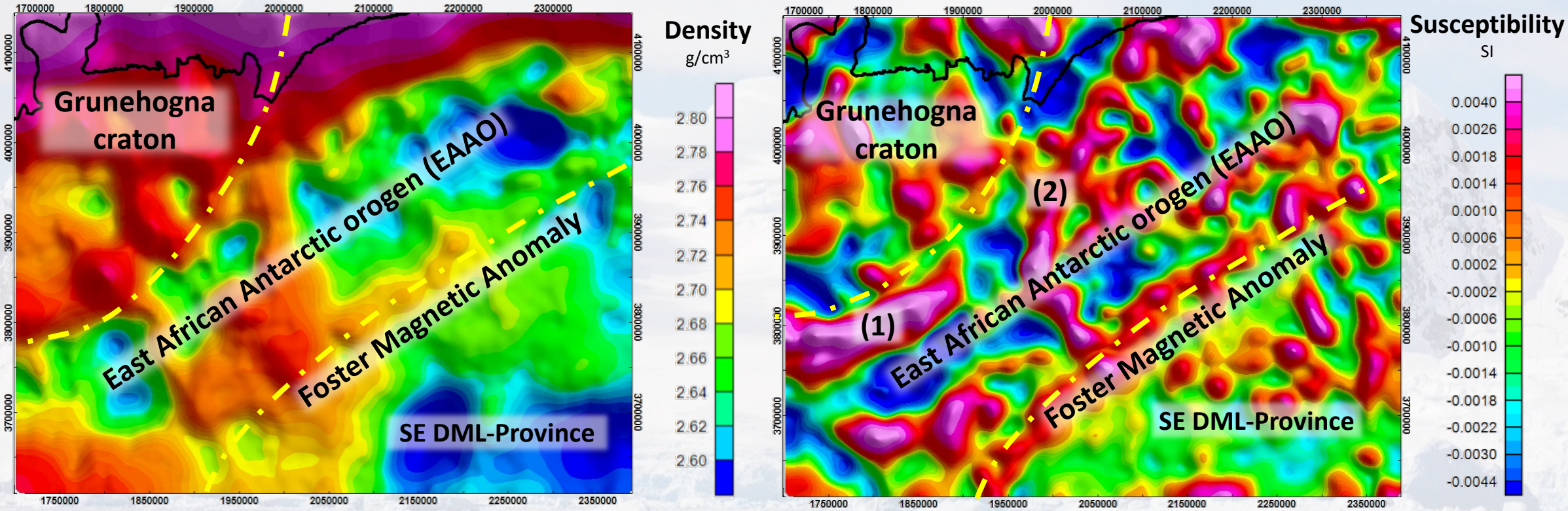


Joint Inversion based on Variation of Information



Joint inversion was run iteratively starting with a strong coupling, but smooth model and stepwise releasing the coupling.

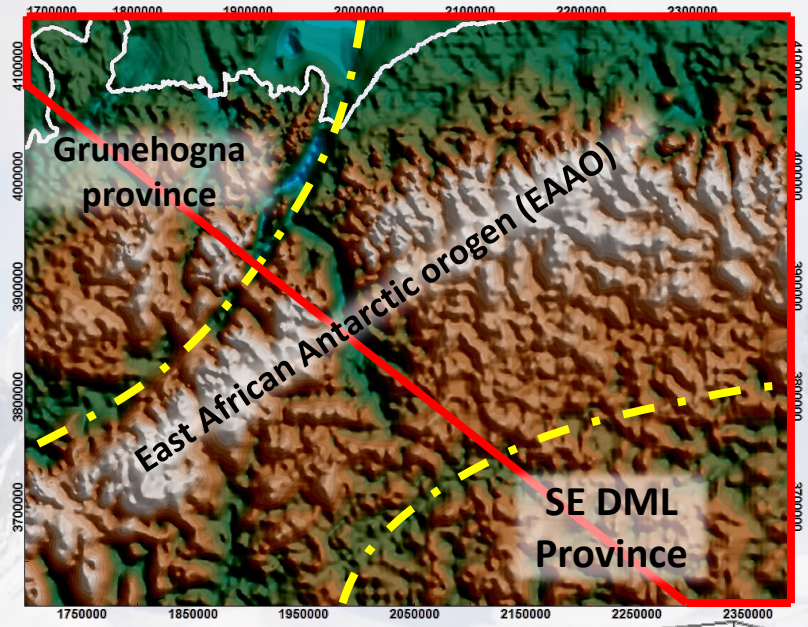
Density and susceptibility slice in 10 km depth

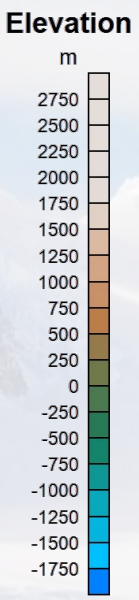


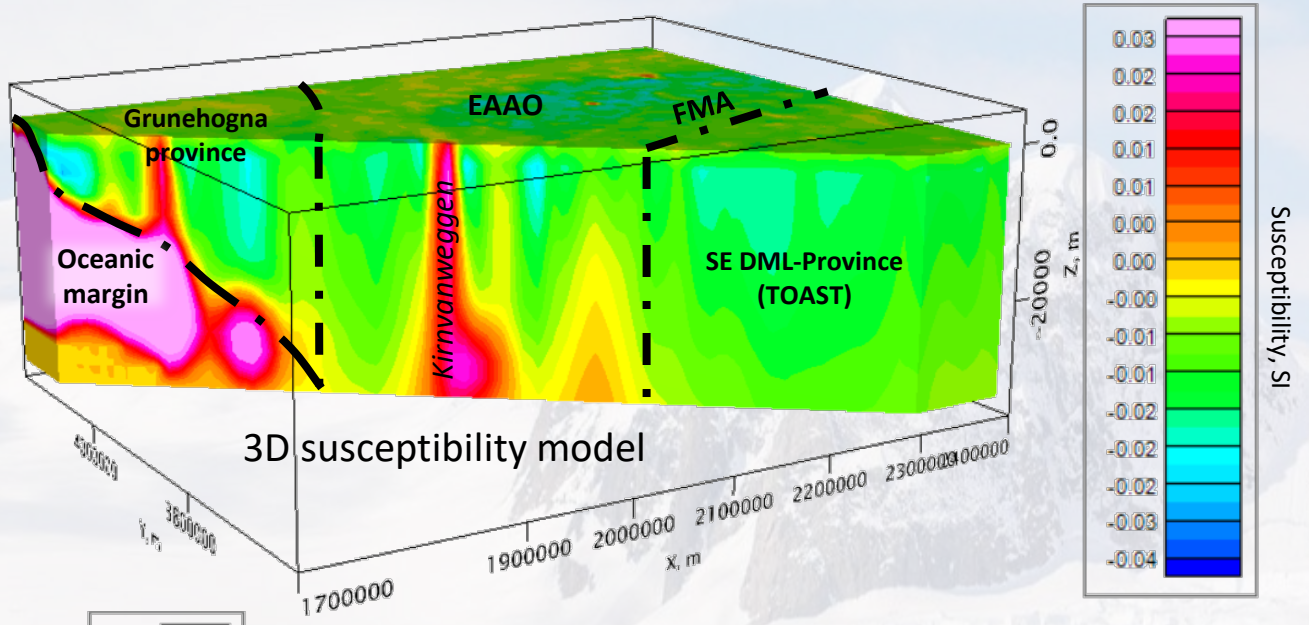
Main provinces can be highlighted by changes of density and susceptibility:

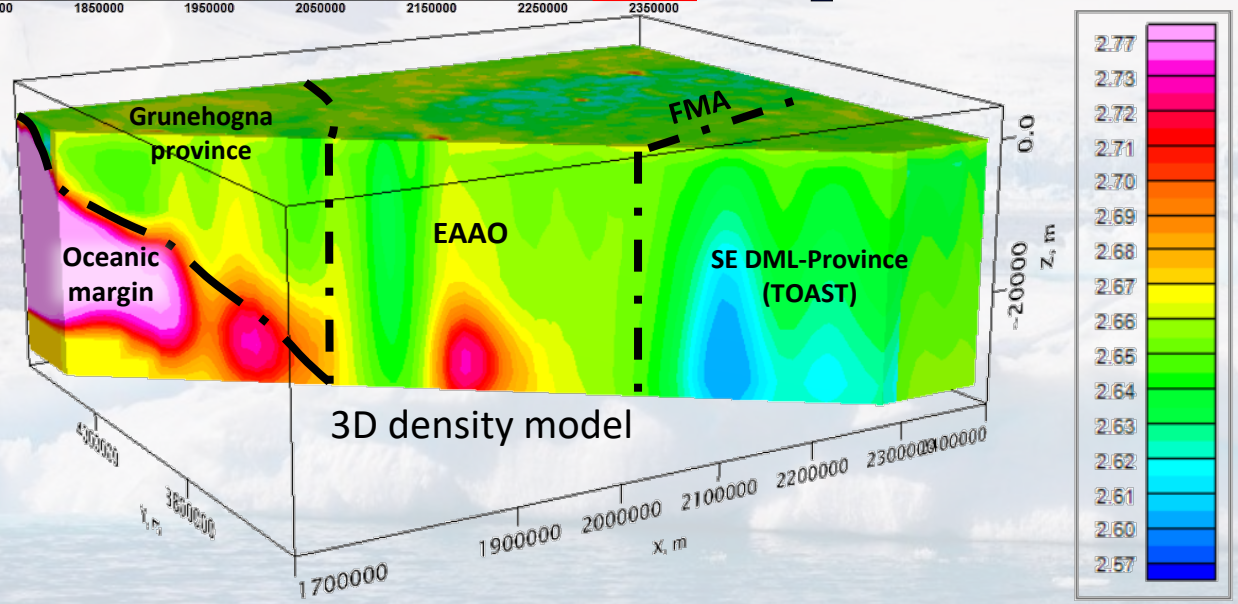
- The Grunehogna craton is shown with high density and relatively high susceptibility with several strong anomalies, which indicate various subunits of this structure;
- The Kirnvanveggen (1) and Sverdrupfjella (2) ridges mark the boundary of the influence of the EAAO;
- Foster Magnetic Anomaly (FMA) seems to be the western extent of the SE DML-Province, Neoproterozoic juvenile crustal additions within the East African-Antarctic Orogen (Ruppel 2018).

Density and susceptibility in 3D view









There is a sequence of the following units which were brought together during the Pan-African resulting in EAAO, and can now be clarified by joint inversion using jif3d

Summary

- We successfully use the joint inversion of potential field data to identify geological provinces and subdivisions;
- Obtained 3D models are in good agreement with previous observations;
- The results allow us to make further assumptions about the geological structure of this region and its units:
  - Grunehogna craton and subunits;
  - Maudheim province and subunits;
  - Foster Magnetic Anomaly;
  - SE DML Province.

Further steps:

- ❑ Use the petrophysical measurements to validate our 3D inversion model.

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