CAU
Christian-Albrechts-Universität zu Kiel

Bayesian inversion of magnetic data:

A case study of Australia

Yixiati Dilixiati, Wolfgang Szwillus, Jörg Ebbing

Institute of Geosciences, Kiel University, 24118 Kiel

Introduction

Christian-Albrechts-Universität zu Kiel

- Motivation: simultaneous inversion of magnetic susceptibility and magnetic bottom with respect to the crustal filed

- Problems of conventional deterministic inversion approach

1. Model geometry has to be predetermined (usually approximated by Moho)
2. or magnetic bottom is estimated by magnetic spectral method
3. difficult to handle the uncertainty in the input data

Inversion method

Christian-Albrechts-Universität zu Kiel

- Monte Carlo Markov Chain method

$$P(\chi, T, \theta|\hat{b}) = \frac{P(\hat{b}|\chi, T, \theta)P(\chi, T, \theta)}{P(\hat{b})}.$$

χ, T *susceptibility* and *magnetic bottom* of the model

$\hat{b}$ *input magnetic field*

$$\vec{\theta} = (\chi_0, T_0, \sigma_\chi^2, \sigma_T^2, \nu_\chi, \nu_T, \rho_\chi, \rho_T, E)$$

hyperparameters including two parameters that describe the starting reference model, six parameters that describe the spectral correlation of susceptibility and magnetic bottom and last one denotes the uncertainty of input magnetic field

- forward operation is linearized with respect to reference model
- fractural distribution of susceptibility is integrated into MCMC in the form of Matern covariance

Inversion method

Christian-Albrechts-Universität zu Kiel

- Monte Carlo Markov Chain method

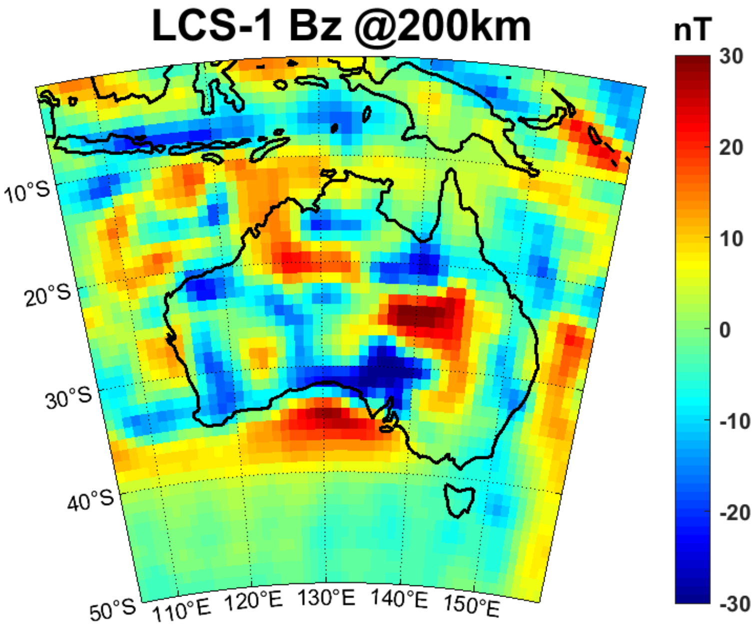
$$P(\chi, T, \theta|\hat{b}) = \frac{P(\hat{b}|\chi, T, \theta)P(\chi, T, \theta)}{P(\hat{b})}.$$

Possible models are updated using Metropolis-Hastings algorithm

By using a Gibbs-sampler to convert the original problem to 2-step MCMC

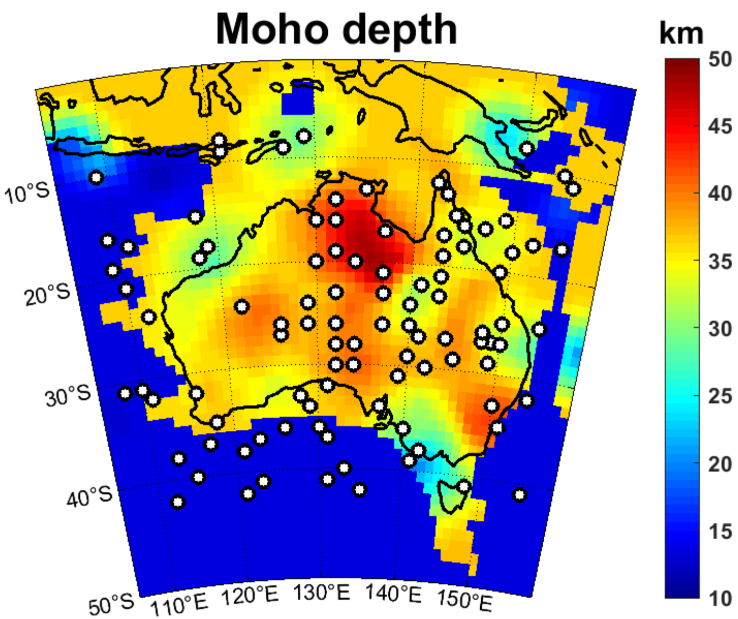
1. finding the hyperparameter θ according to the given input field b
2. finding the susceptibility and magnetic bottom according to given input field b and hyperparameter θ from first step

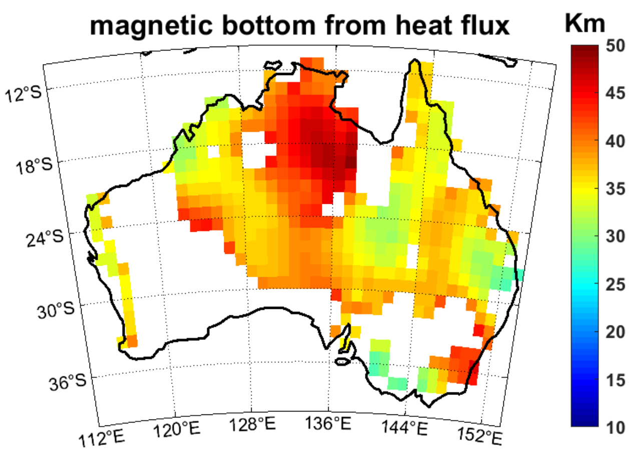
Data



- input field b calculated in 1° resolution at 200 km above the surface using spherical harmonic coefficients from LCS-1 satellite model
- model laterally extended to reduce the edge effect due to fact that neighboring magnetic sources were not take into account in the inversion.

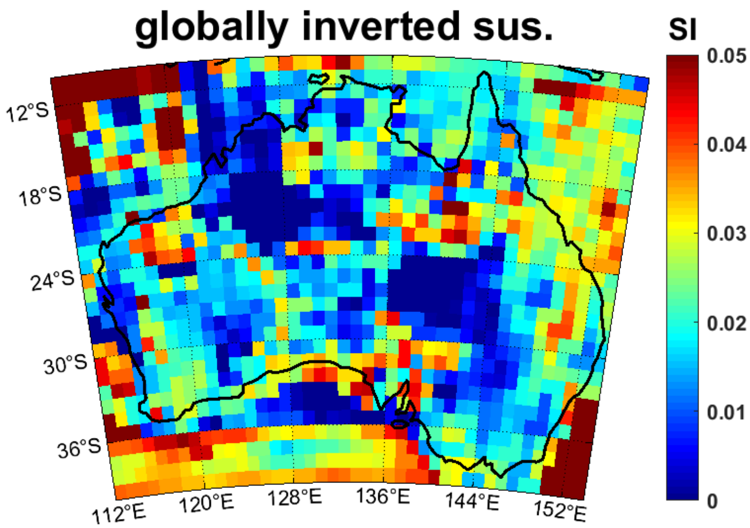
Data





- 100 points of depth to the magnetic bottom values were used as a priori information.
- 50 points of constraints were selected from Moho depth estimated by W Szwillus et al. (2019) outside the mainland Australia
- 50 points of constraints that were derived from heat flux data were selected inside the mainland Australia
- Magnetic bottom was estimated as 580° isotherm from heat flux data (http://heatflow.org) using simple 1-D constant heat production model (e.g. M Lösing et al. 2020).

Data

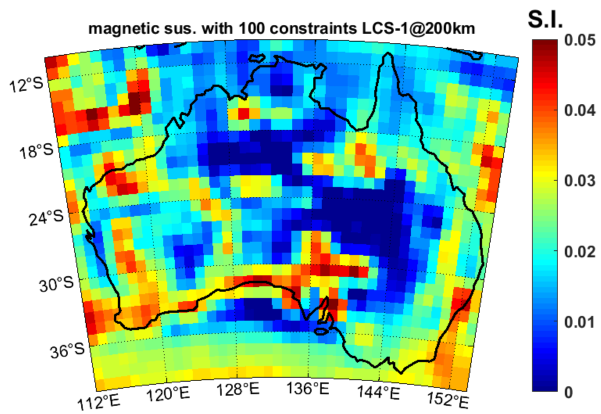


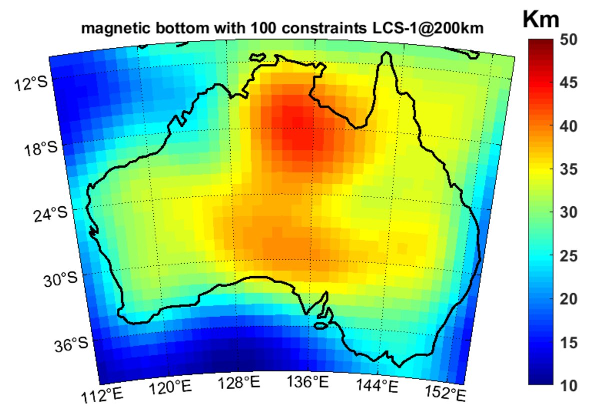
- We used the previous study of global magnetic susceptibility model from E Baykiev et al. (2020) for comparing the inversion result of this study.

Results

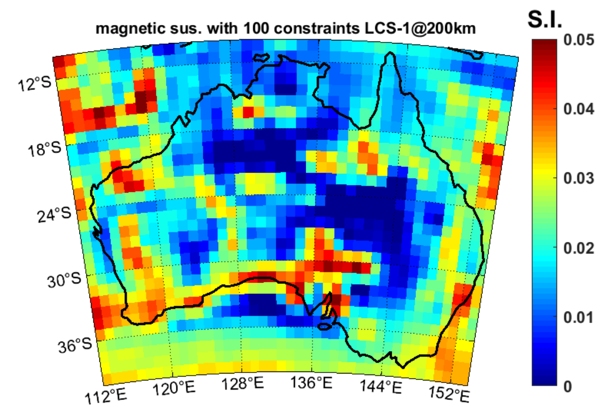
Christian-Albrechts-Universität zu Kiel

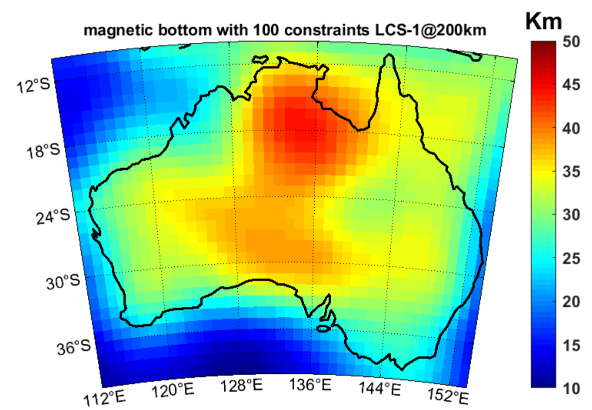
MCMC results using only Moho as constraints





MCMC results using 50 points from Moho depth outside Australia and 50 points from heat flux estimation of magnetic bottom inside Australia as constraints

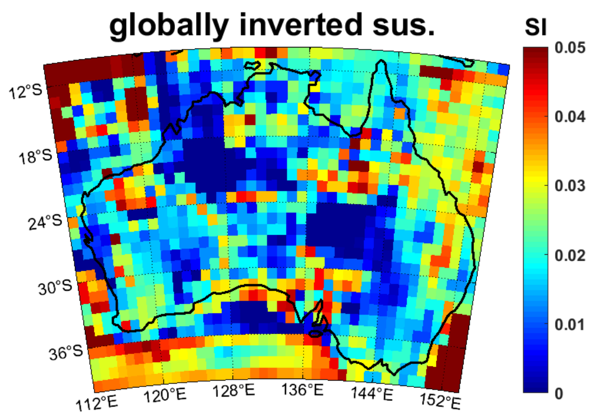


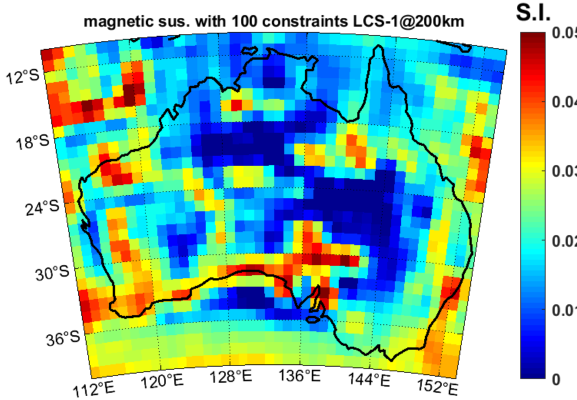


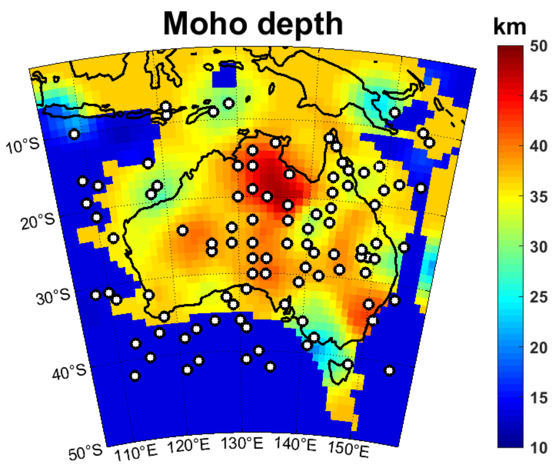
Results

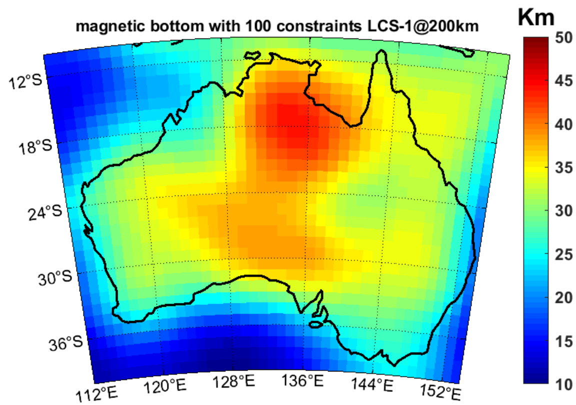
C | A | U
Christian-Albrechts-Universität zu Kiel

MCMC results using 50 points from Moho depth outside Australia and 50 points from heat flux estimation of magnetic bottom inside Australia as constraints









Conclusions

1. Preliminary results show a very good agreement with previous global susceptibly inversion result .
2. Susceptibility result from this study shows more “clean” patterns comparing to the global inversion result.
3. Magnetic bottom constrained by heat flux data is consistent with Moho depth that indicates the general correlation between density discontinuity and Curie depth.

Future steps

C | A | U
Christian-Albrechts-Universität zu Kiel

1. Uncertainty of the heat flux data should be take into account.
2. Besides pure satellite data, satellite and aeromagnetic combined data can be used as input crustal field at different height to improve the spectral sensitivity.
3. Error analysis should be conducted to have a robust understanding of the inversion results.

Thank you for your attention!

Please feel free to contact me via dilixiati.yixiati@ifg.uni-kiel.de if you have any questions.

DynamicEarth SPP 1788

stse support to science element