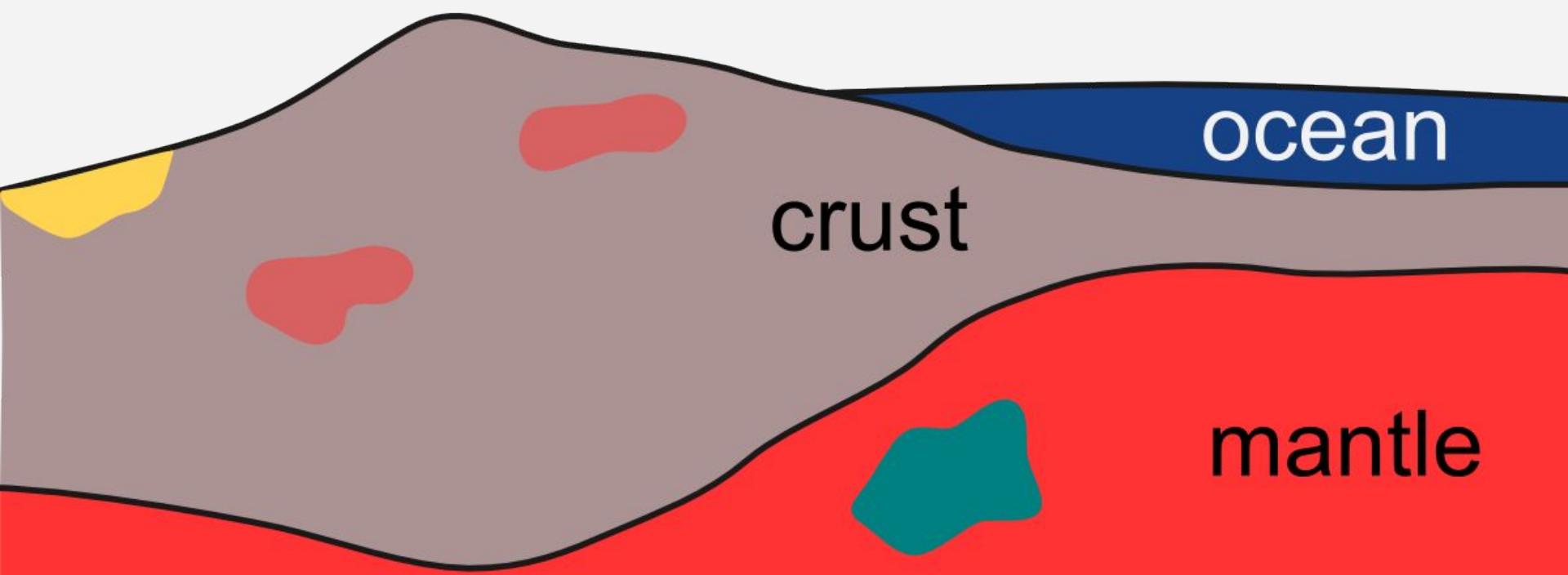


# Inverting gravity to map the Moho

A new method and  
the open-source software that made it possible

gravity  
inversion

$g_P$

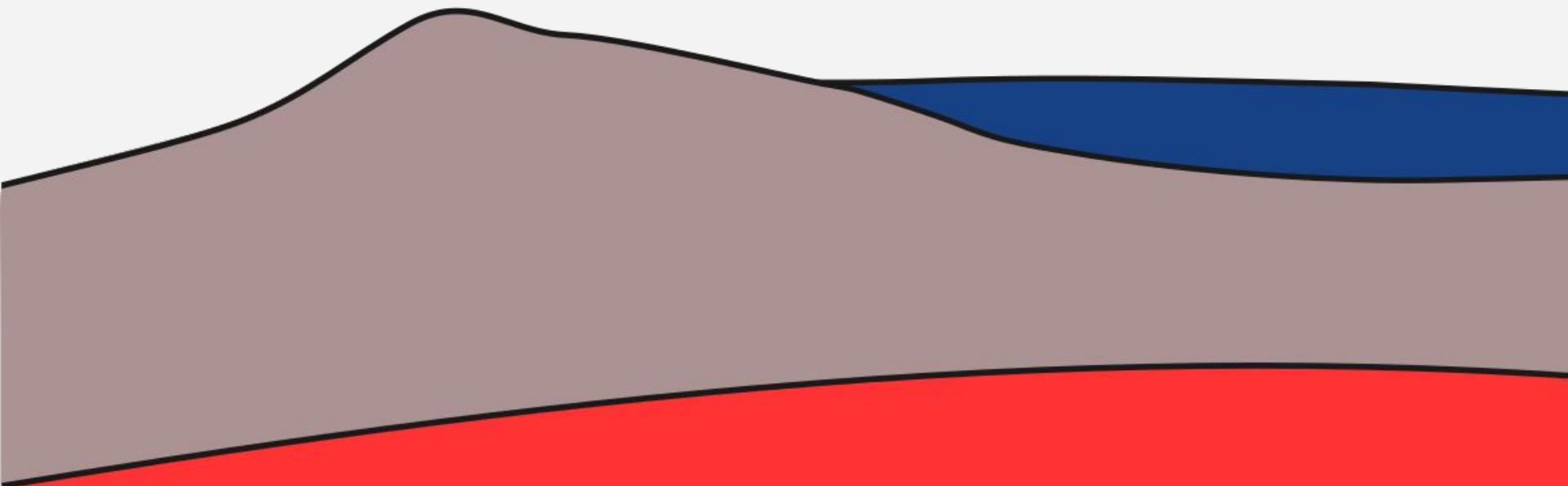


$\gamma_P$ 

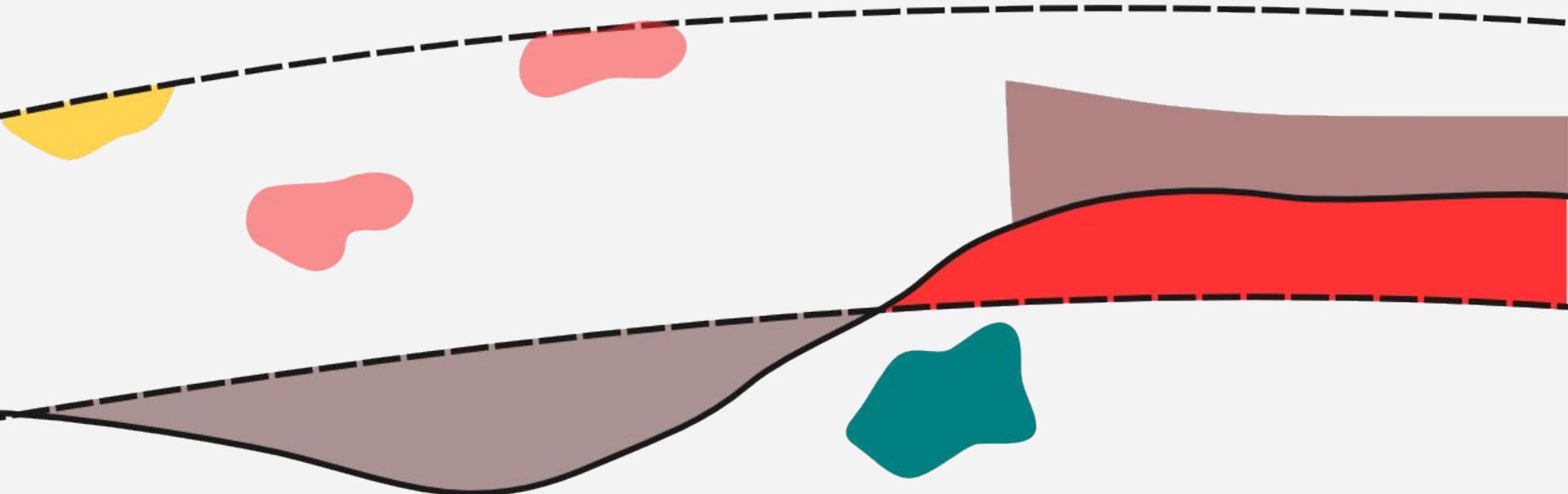
crust

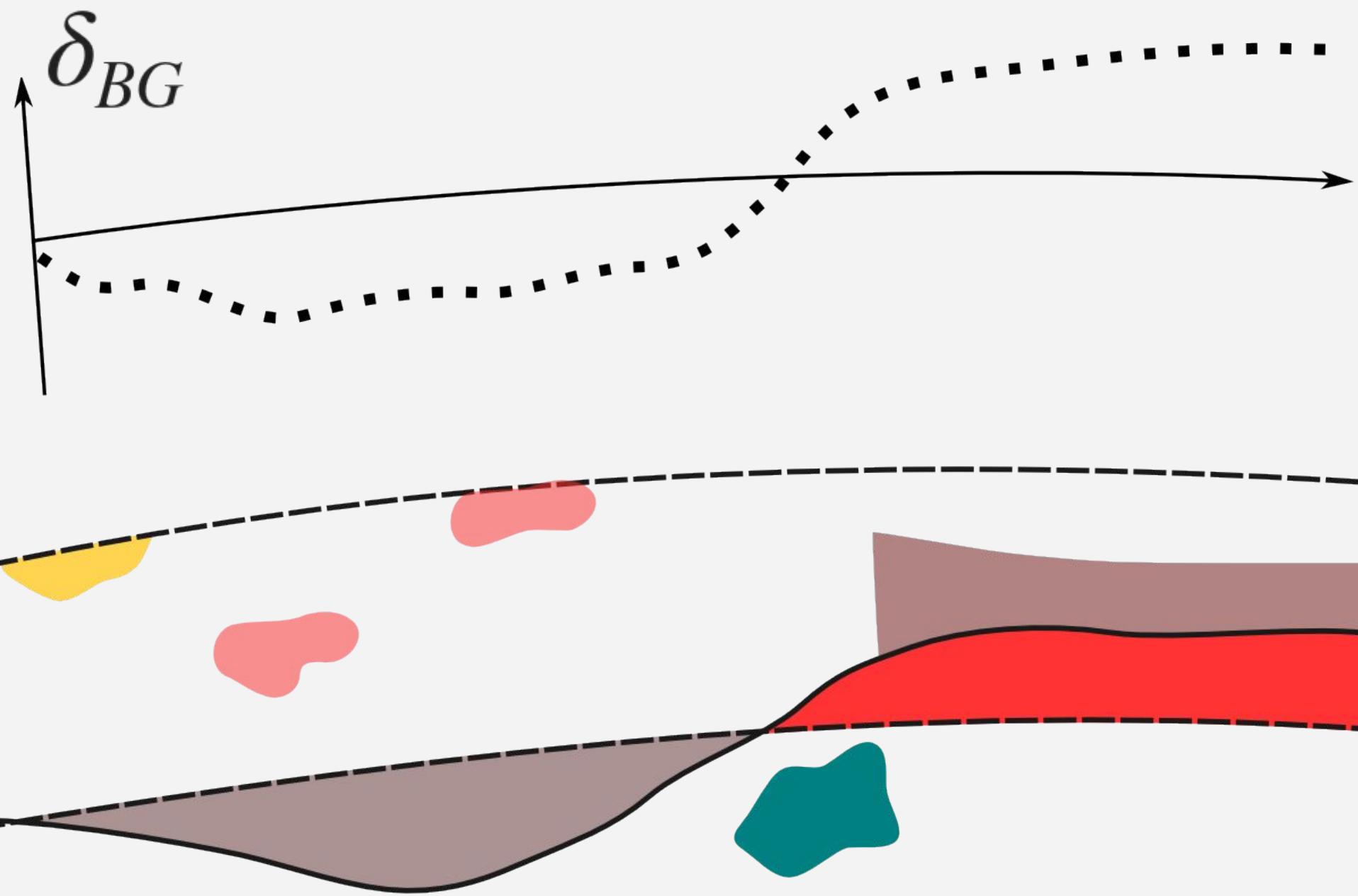
mantle

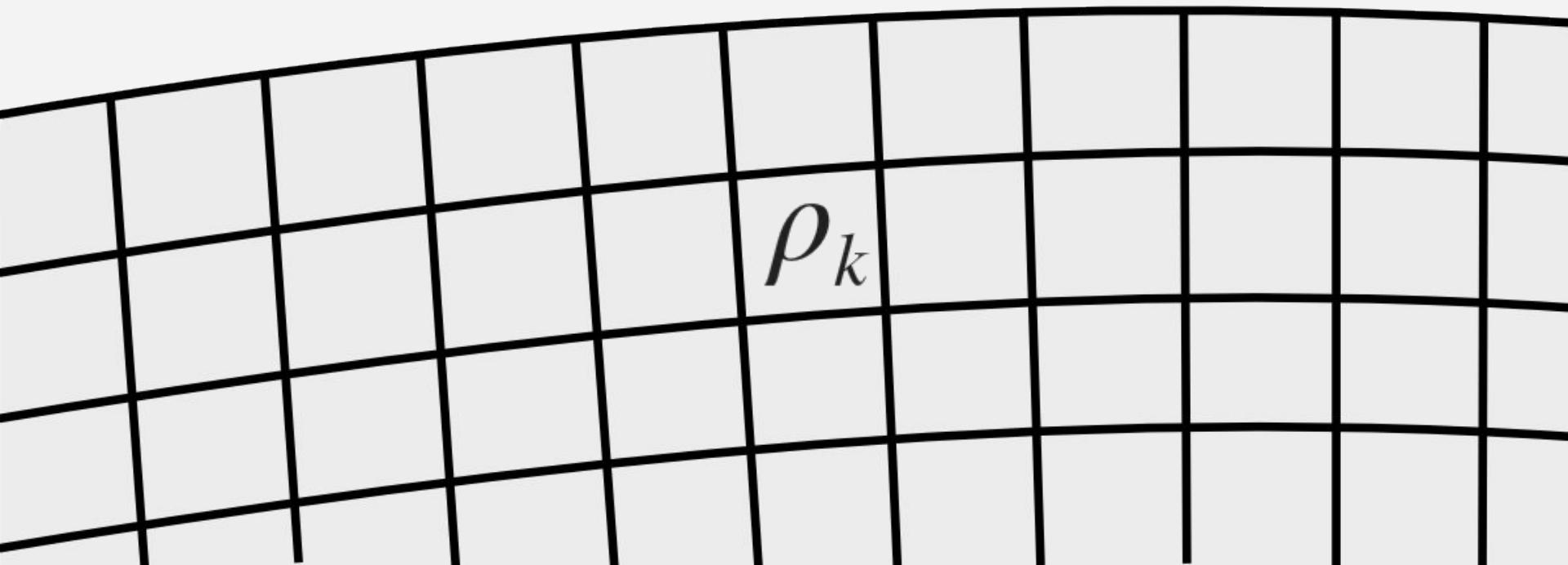
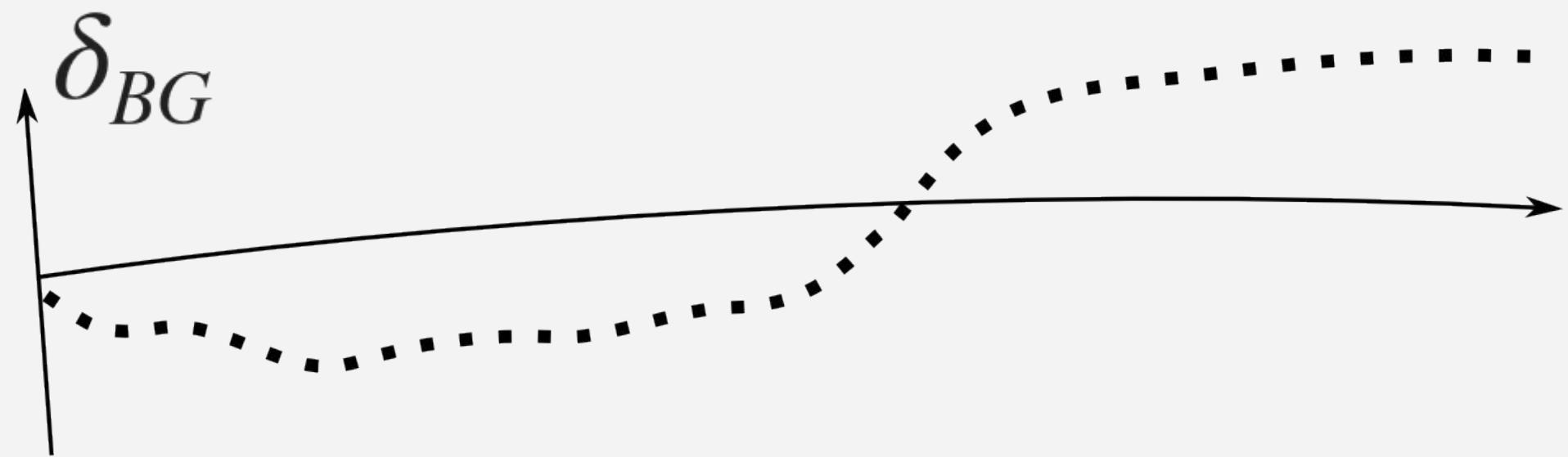
$$\gamma_P + 2\pi G \rho h$$

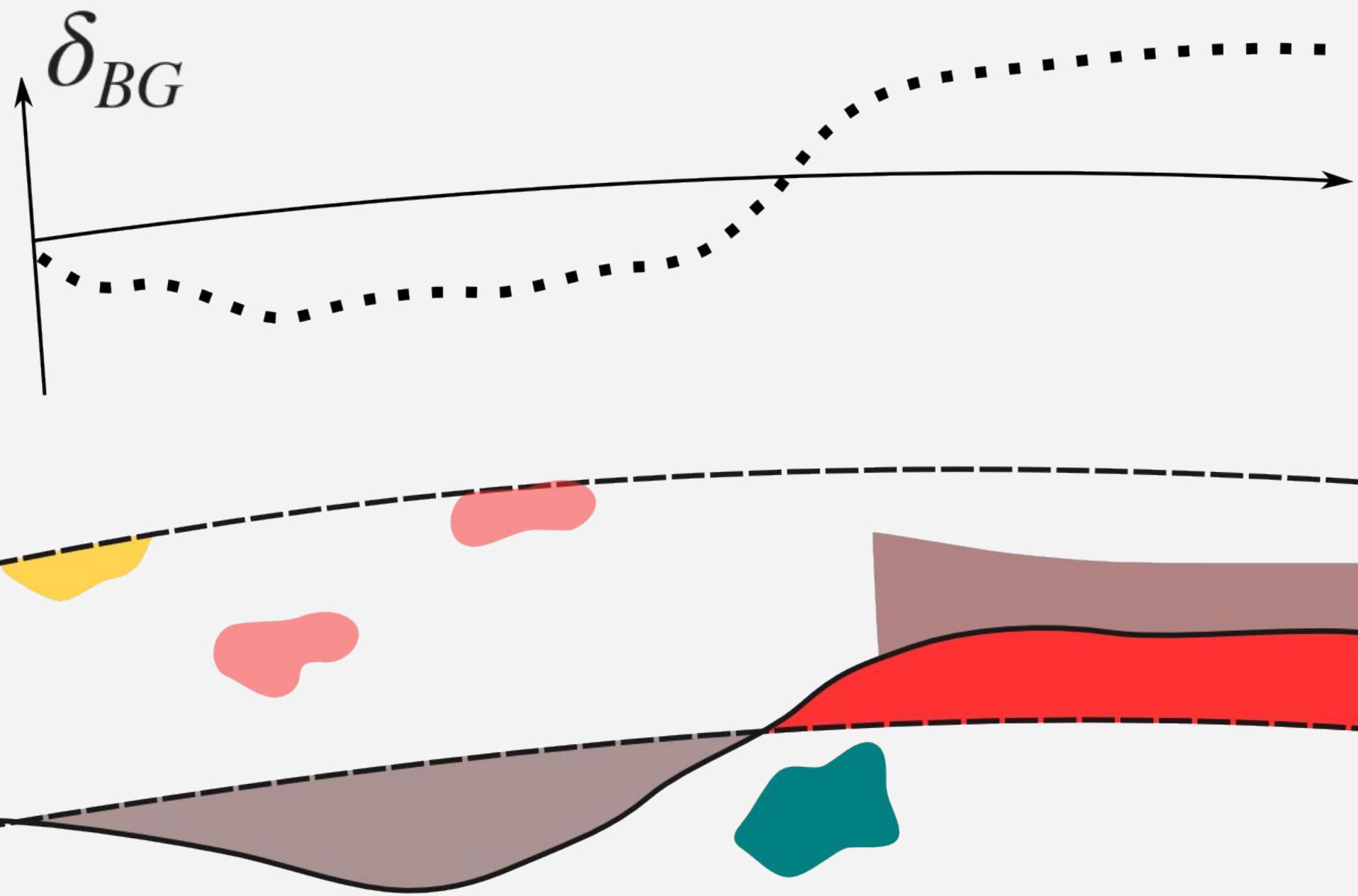


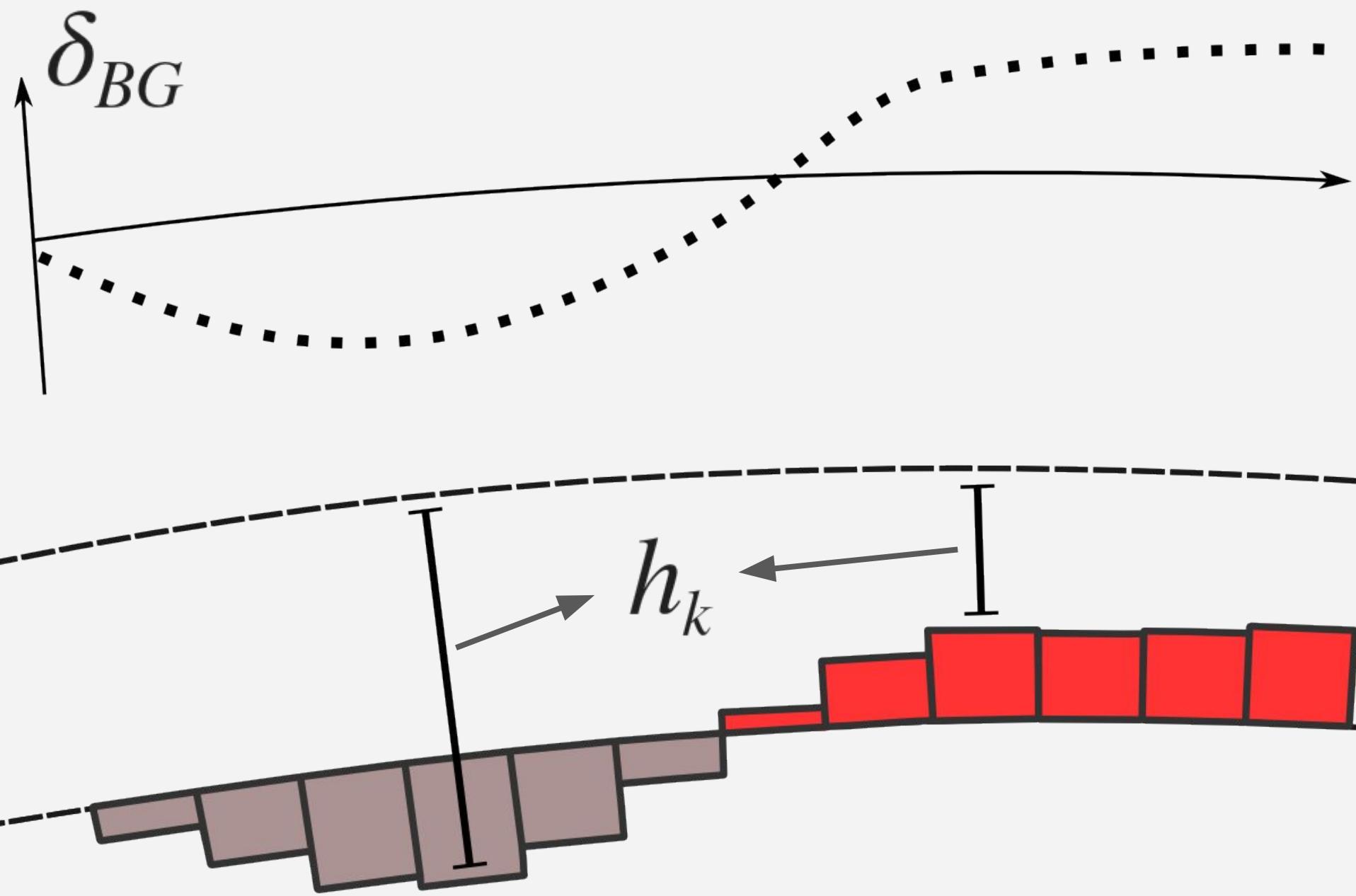
$$\delta_{BG} = g_P - (\gamma_P + 2\pi G \rho h)$$







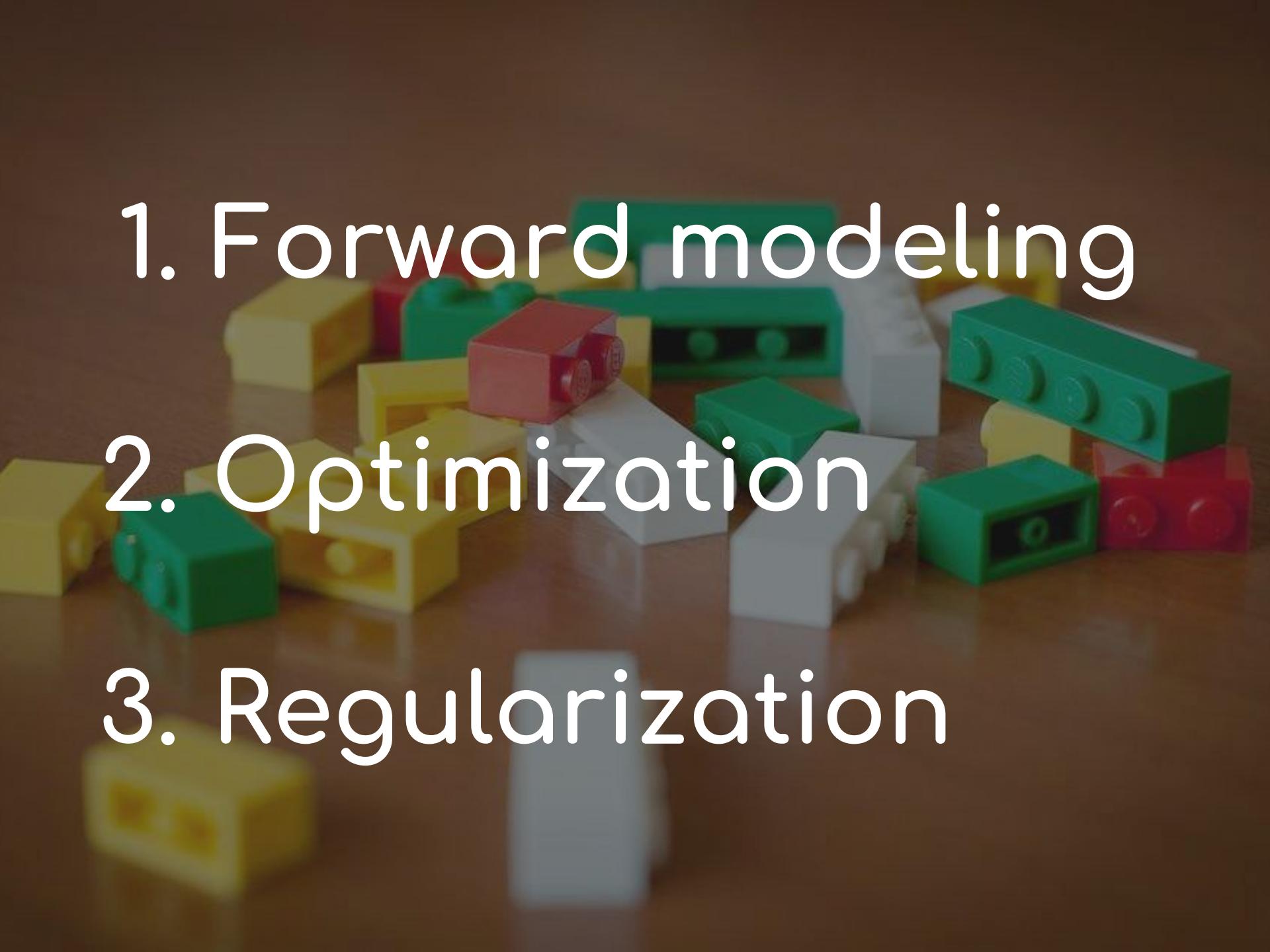




linear

vs

non-linear

- 
1. Forward modeling
  2. Optimization
  3. Regularization

software



fatiando a terra  
modeling and inversion for geophysics

open-source  
Python library



# live demo

Oh demo Gods bless me with working code!



# fatiando a terra

An open-source Python library for modeling and inversion in geophysics.

Our goal is provide a comprehensive and extensible framework for geophysical data analysis and the development of new methodologies.

## Research

Make your research more **reproducible** by writing a Python script or [Jupyter notebook](#) instead of clicking through complicated menus.

## Development

Don't start from scratch! Build upon the existing tools in Fatiando to develop new methods.

## Teaching

Combine Fatiando with the [Jupyter notebook](#) to make rich, interactive documents. Great for teaching fundamental concepts of geophysics!

## Overview

### Gravity and magnetics

Modeling, inversion, and processing for potential field methods.

*3D forward modeling with prisms, polygonal prisms, spheres, and tesseroids. Handles the potential, acceleration, gradient tensor, magnetic induction, total field magnetic anomaly.*

### Seismology and Seismics

Simple modeling functions for seismics and seismology.

*Toy problems for: Cartesian straight-ray tomography, VSP, epicenter estimation. Experimental finite-difference wave propagation.*

## Example Gallery

Datasets packaged with  
Fatiando

Gravity and magnetics

Grid generation and  
manipulation

Seismology and seismics

Visualization

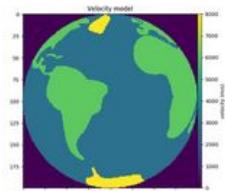
# Example Gallery

Click on any image below to see a full sized image and the code that generated it, with links to download the code as a Python `.py` script or as a [Jupyter](#) (formerly IPython) notebook.

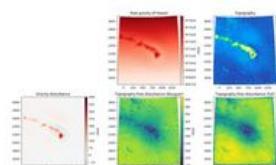
### Note

The Gallery is a work in progress. We need **your help** to make it better! You can contribute by sending us your scripts for beautiful plots. Write to the [mailing list](#) or send us a [pull request](#) on [Github](#).

## Datasets packaged with Fatiando

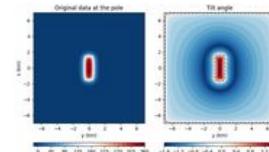


Create a model based  
on an image file

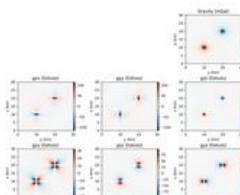


Hawaii gravity data

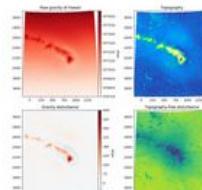
## Gravity and magnetics



Tilt angle of magnetic  
anomalies



Forward modeling  
gravity data using  
spheres in Cartesian  
coordinates



Gravity corrections  
(normal gravity and  
Bouguer)



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 leouleda committed on GitHub	fatiando.test raises exception if tests fail (#376)	...	Latest commit 26b268d 5 days ago
 .github	Remove the unused requirements.txt file (#330)		5 months ago
 benchmarks	Switching over to setuptools (#294)		8 months ago
 ci	fatiando.test raises exception if tests fail (#376)		5 days ago
 cookbook	Rewrite the from_image function in datasets (#363)		3 months ago
 doc	Normalize the colorbar in the seismic_image plot (#366)		3 months ago
 fatiando	fatiando.test raises exception if tests fail (#376)		5 days ago
 gallery	Normalize the colorbar in the seismic_image plot (#366)		3 months ago
 .gitattributes	Added versioneer support		3 years ago
 .gitignore	Start defining the API reference as a single page (#353)		3 months ago
 .travis.yml	Refactor datasets into a package + add Hawaii gravity data (#355)		3 months ago
 CITATION.rst	Update citation information to cite the Scipy proceedings		a year ago
 LICENSE.txt	Update year in the license file (#339)		3 months ago
 MANIFEST.in	Replace Cython sphere modeling code with numpy (#364)		3 months ago
 Makefile	Make griddler into a package (#297)		3 months ago
 README.rst	Add AppVeyor badge to README (#372)		10 days ago
 appveyor.yml	fatiando.test raises exception if tests fail (#376)		5 days ago
 environment.yml	Refactor datasets into a package + add Hawaii gravity data (#355)		3 months ago
 setup.ini	Make griddler into a package (#297)		3 months ago



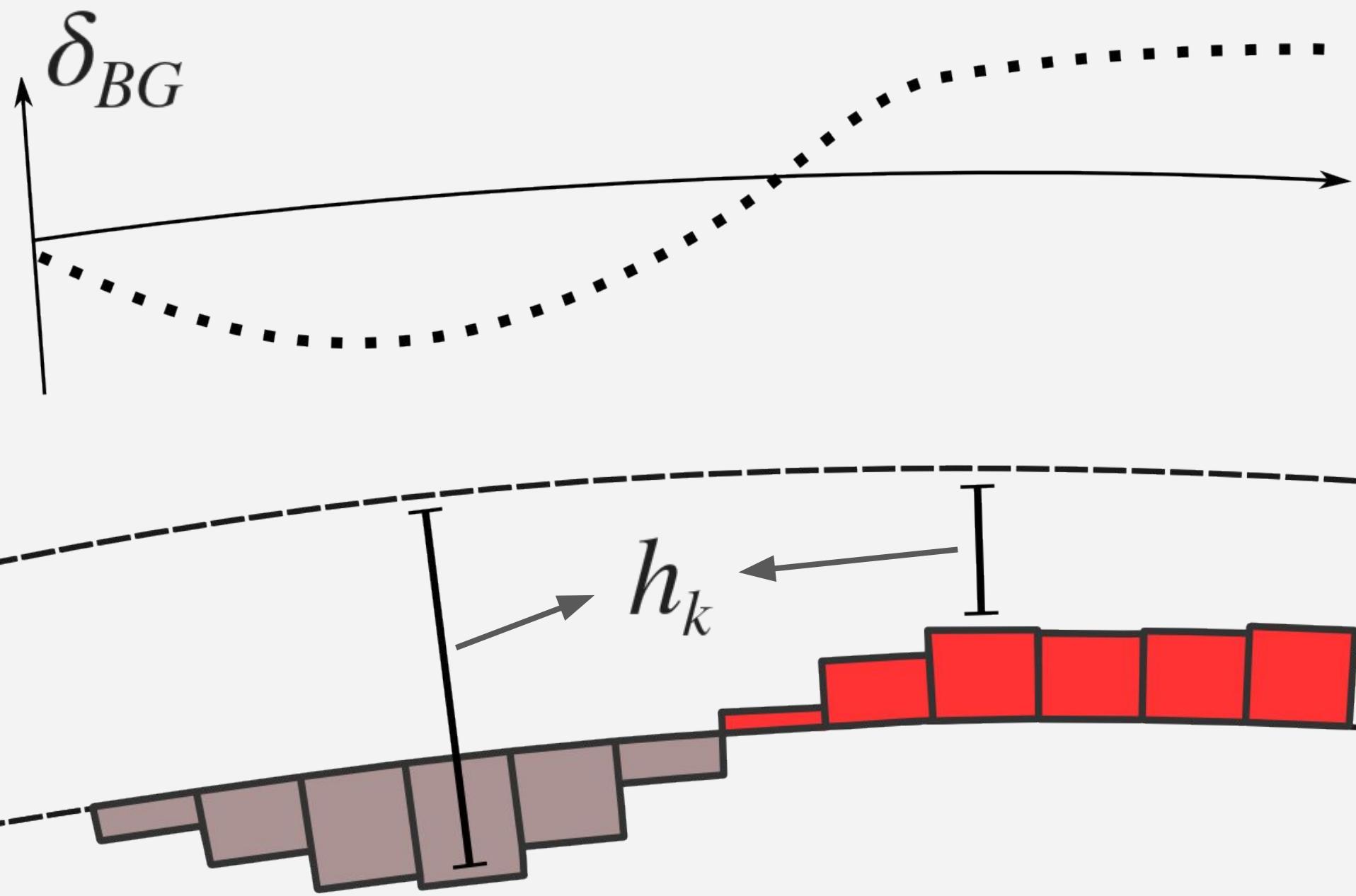
# Contributors

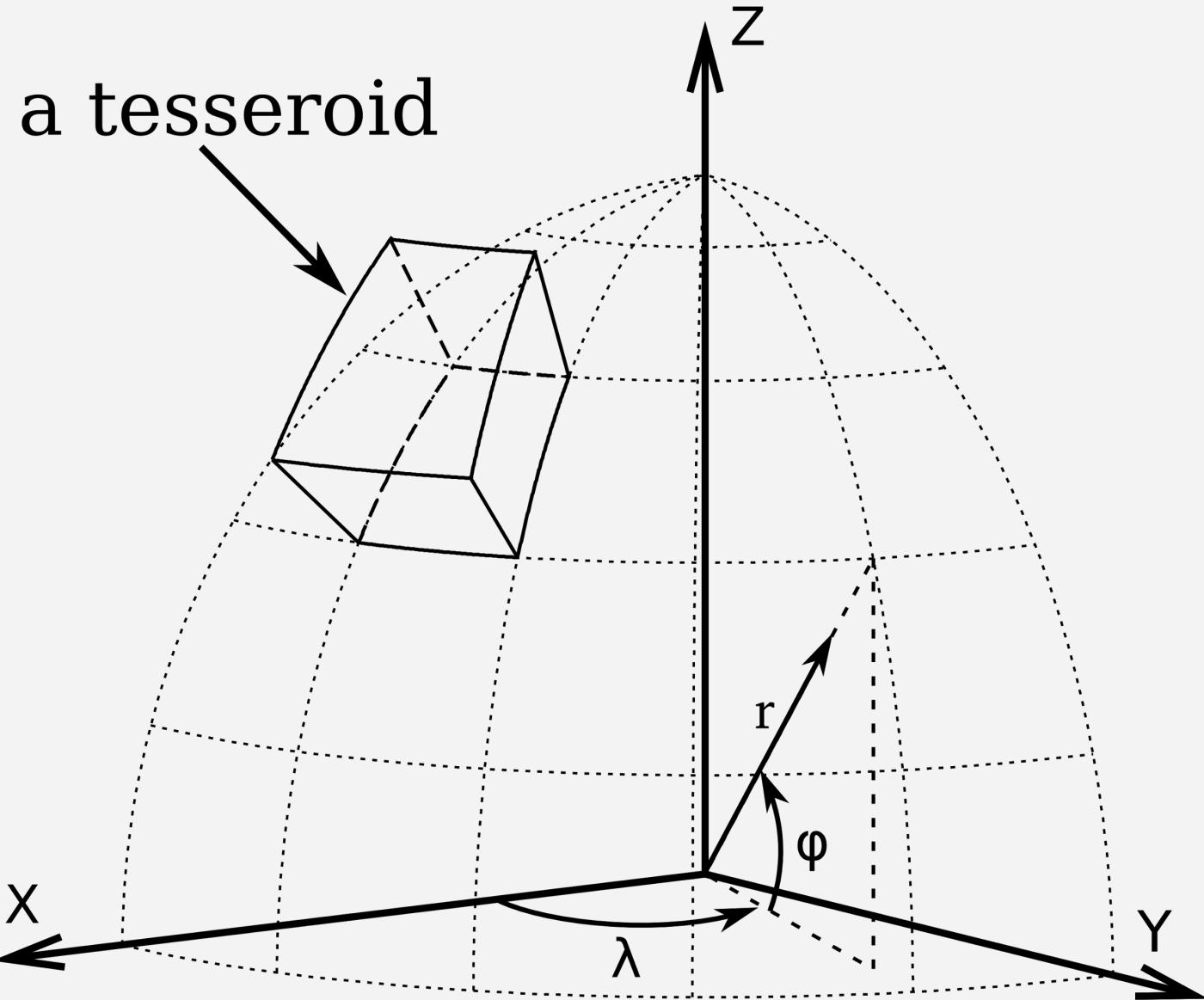
A (hopefully) updated list of people who contributed to Fatiando a Terra:

- [Leonardo Uieda](#) - UERJ, Brazil and Observatório Nacional, Brazil
- [Vanderlei Coelho de Oliveira Junior](#) - Observatório Nacional, Brazil
- [José Fernando Caparica Junior](#) - LENEPE, Brazil
- [Henrique Bueno dos Santos](#) - UNICAMP, Brazil
- [André Ferreira](#) - ANP, Brazil
- Graham Markall - Continuum Analytics, Inc.
- [Martin Bentley](#) - Nelson Mandela Metropolitan University, South Africa and AEON, South Africa
- [Victor Almeida](#) - UERJ, Brazil.
- [M. Andy Kass](#) - United States Geological Survey, USA
- Piotr Kurnik - United Kingdom
- [Rafael M. Silva](#) - São Paulo, Brazil
- [Santiago R. Soler](#) - IGSV, Universidad Nacional de San Juan, Argentina
- [Christian Meeßen](#) - GFZ Potsdam, Germany

# mapping the Moho

Uieda and Barbosa (2017) | doi.org/10.1093/gji/ggw390





# non-linear

$$(A^{k^T} A^k) \Delta p^k = A^{k^T} [d^o - f(p^k)]$$

# Bott's method

$$\Delta p^k = -\frac{d^o - f(p^k)}{2\pi G\rho}$$

Bott = GN

$$\tilde{A} = \begin{bmatrix} 2\pi G\rho & 0 & \cdots & 0 \\ 0 & 2\pi G\rho & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & 2\pi G\rho \end{bmatrix}$$

# Bott + GN + Smooth

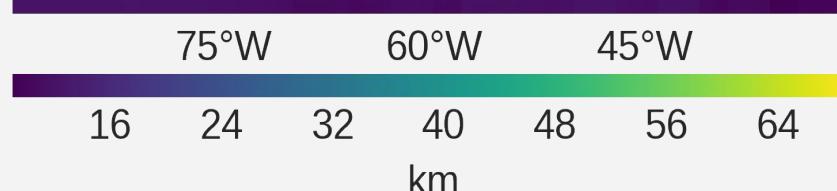
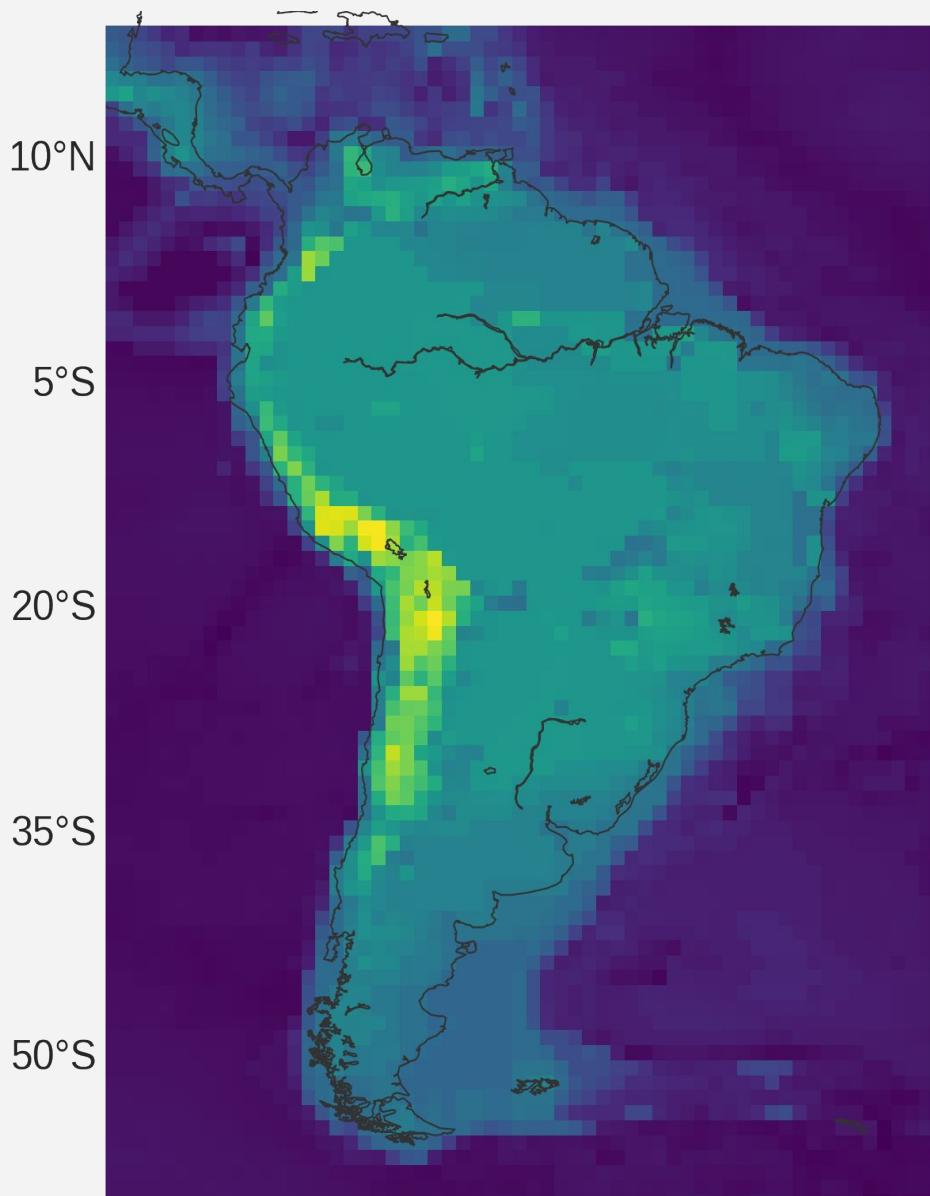
$$[\tilde{A}^T \tilde{A} + \mu W] \Delta p^k = \tilde{A}^T [\textcolor{red}{d}^o - \textcolor{magenta}{f}(p^k)] \\ - \mu W p^k$$

1. tesseroids

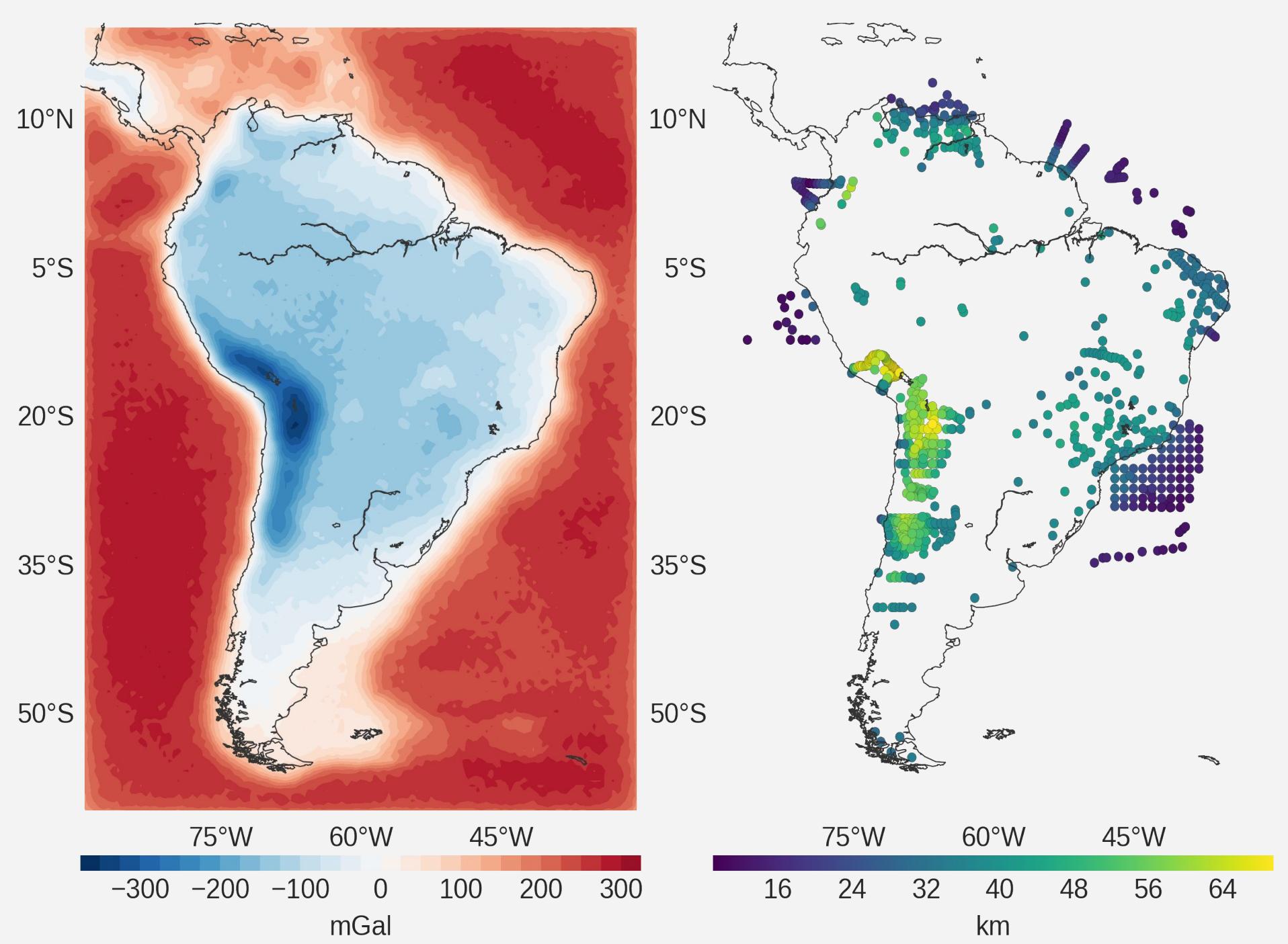
2. Bott + GN

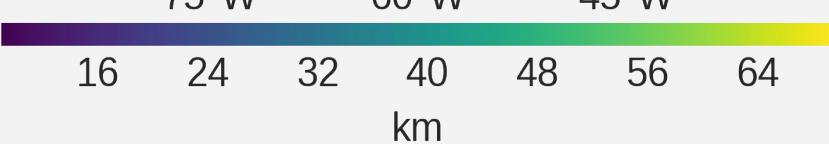
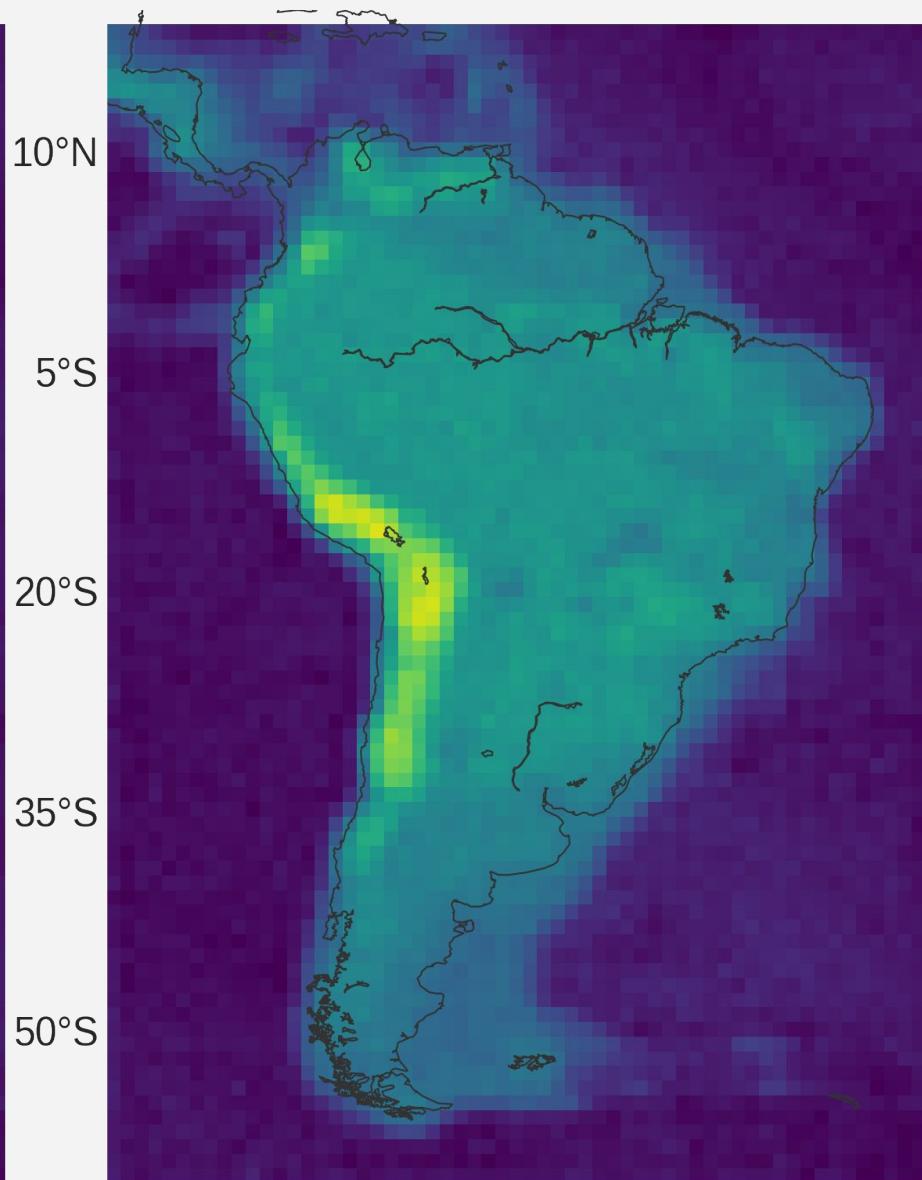
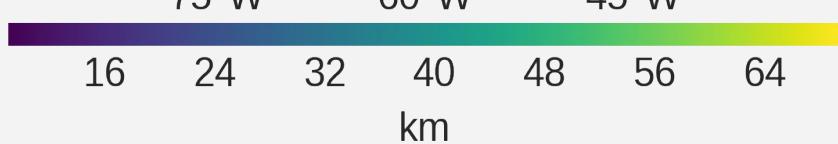
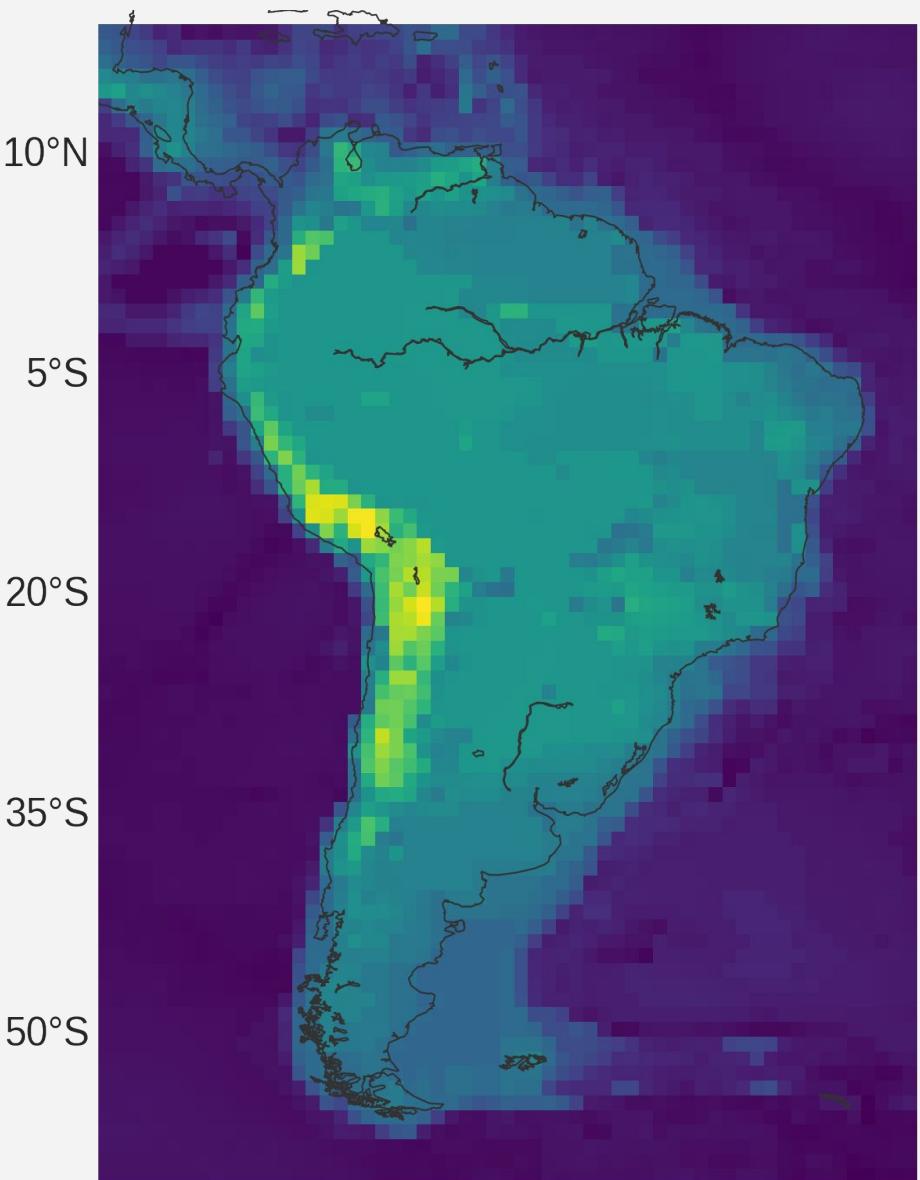
3. regularization

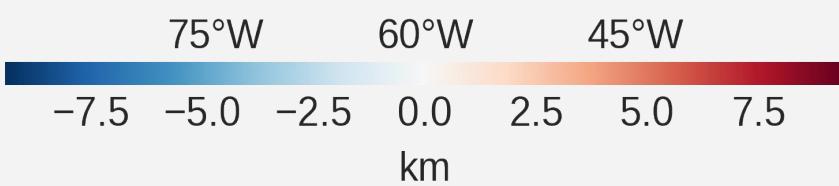
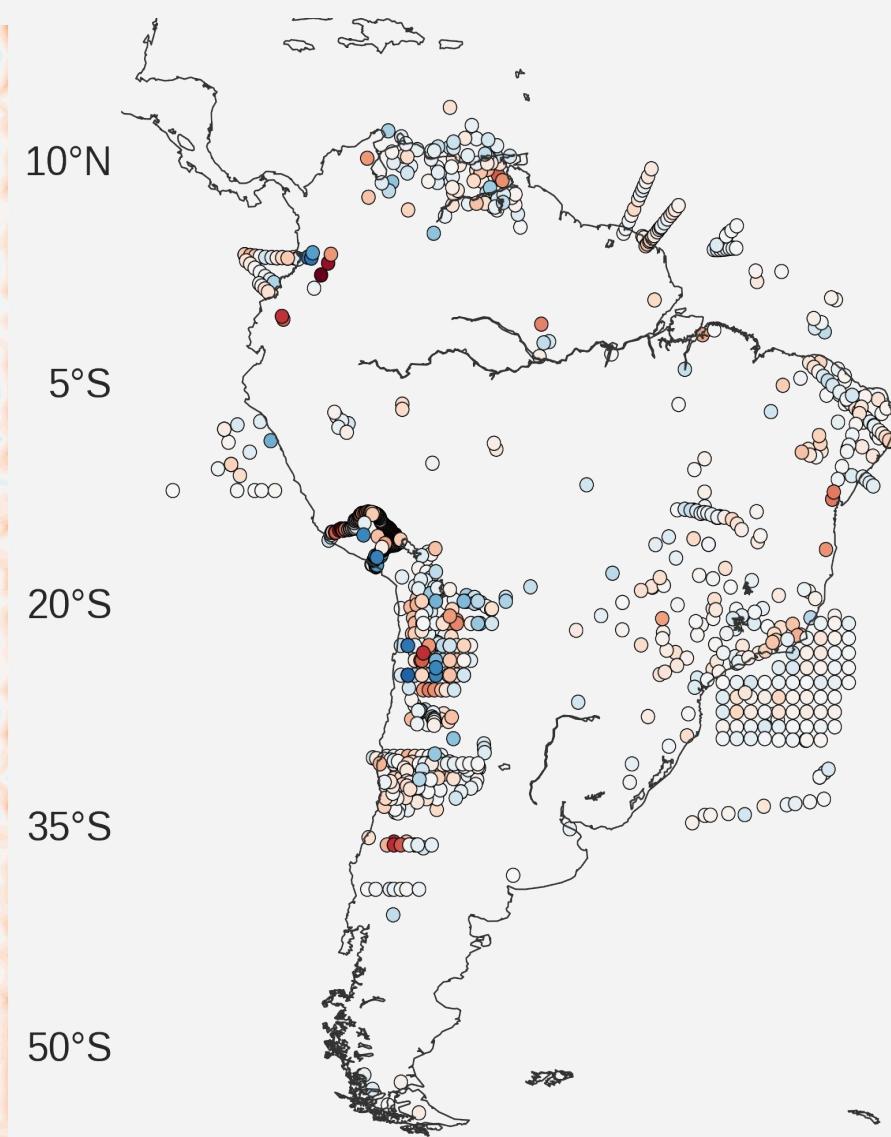
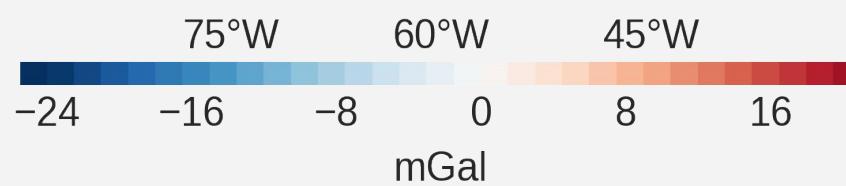
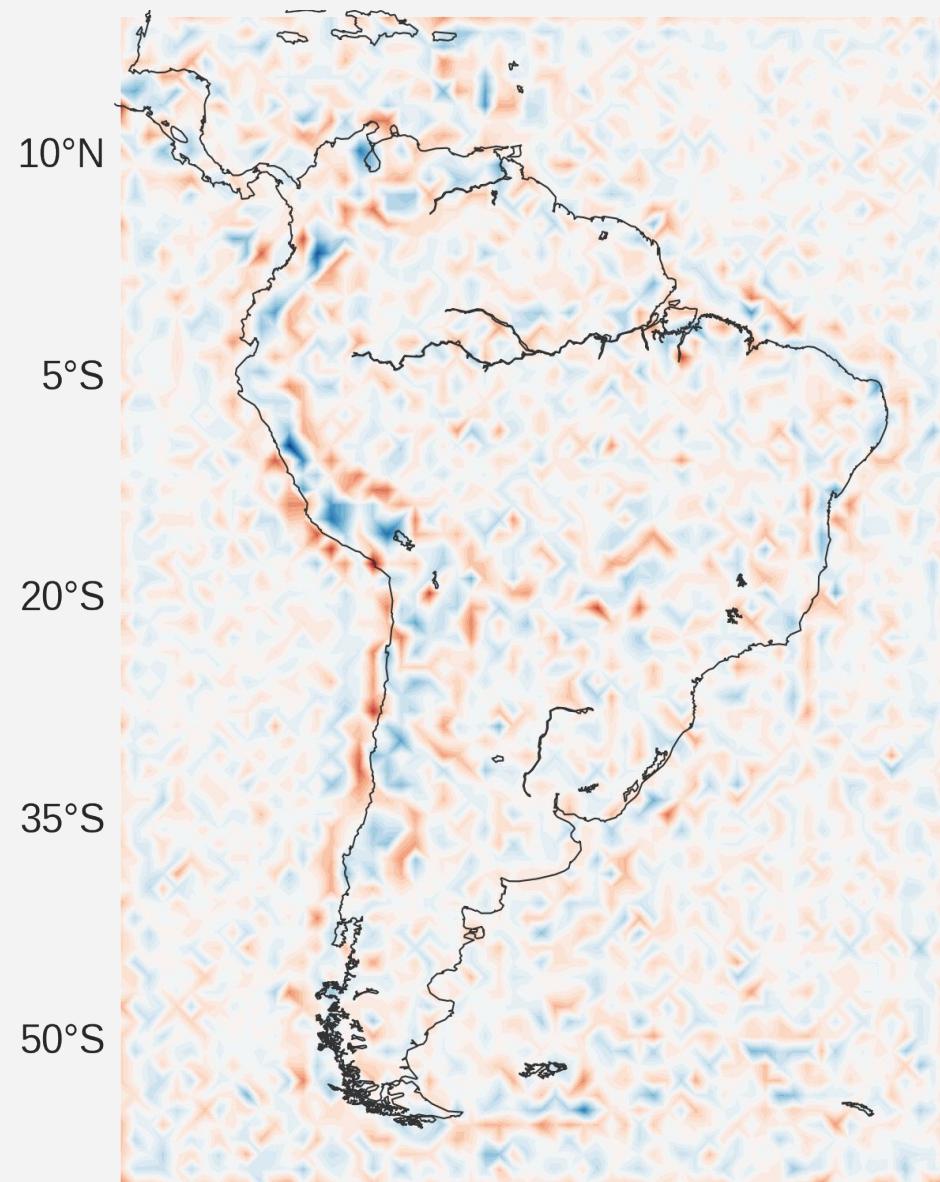
4. validation



CRUST1.0  
(Laske et al. 2013)

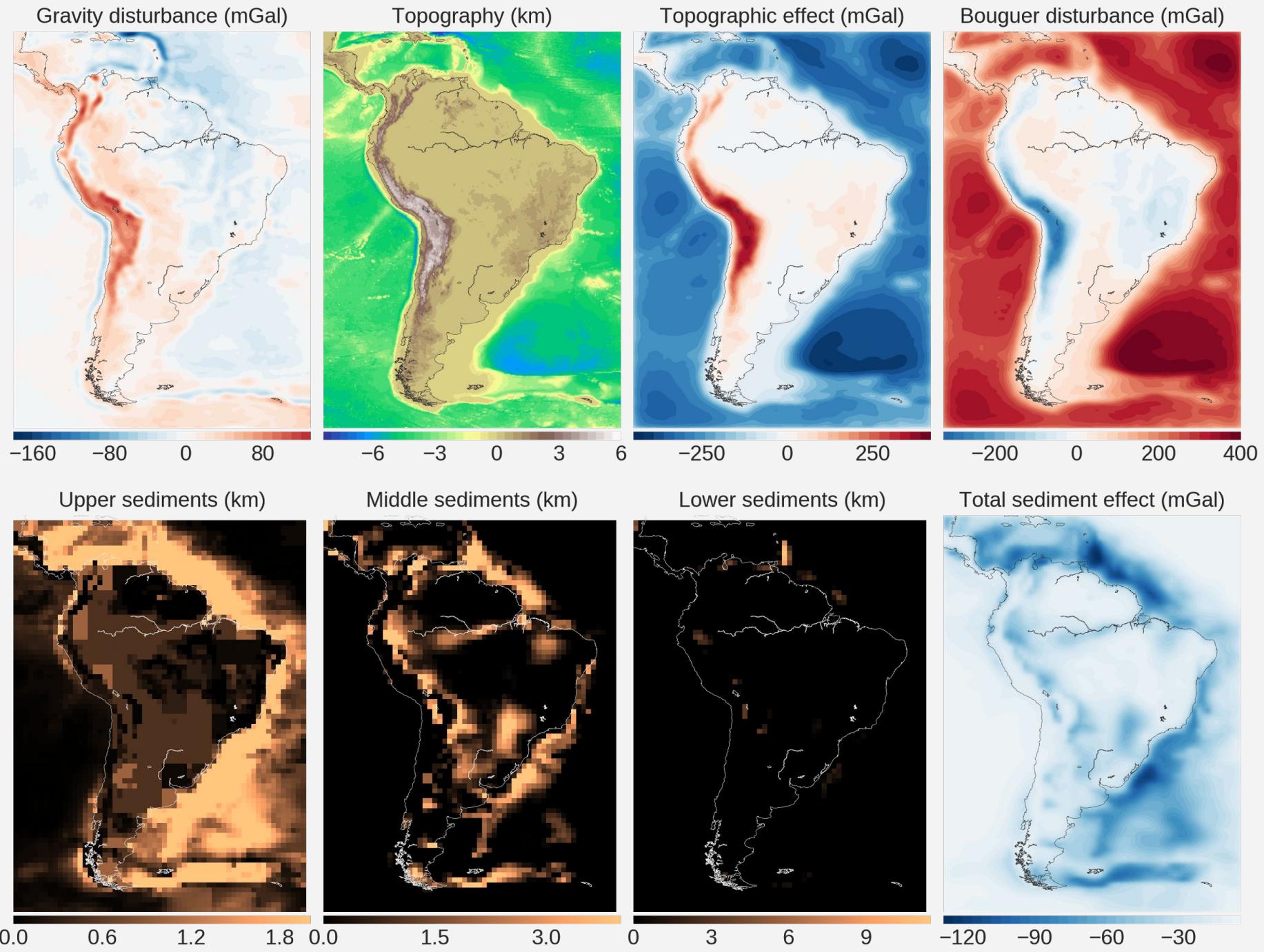


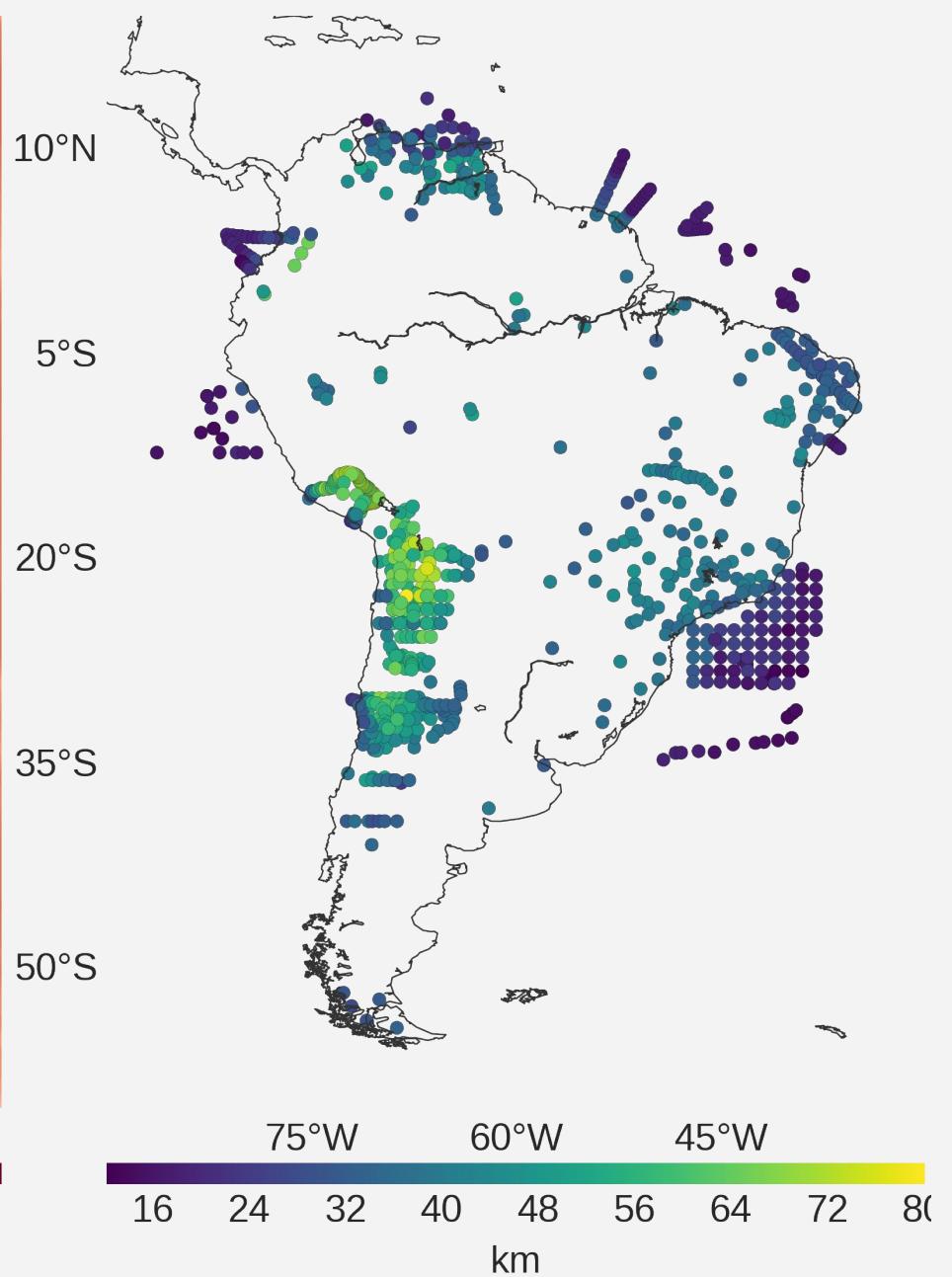
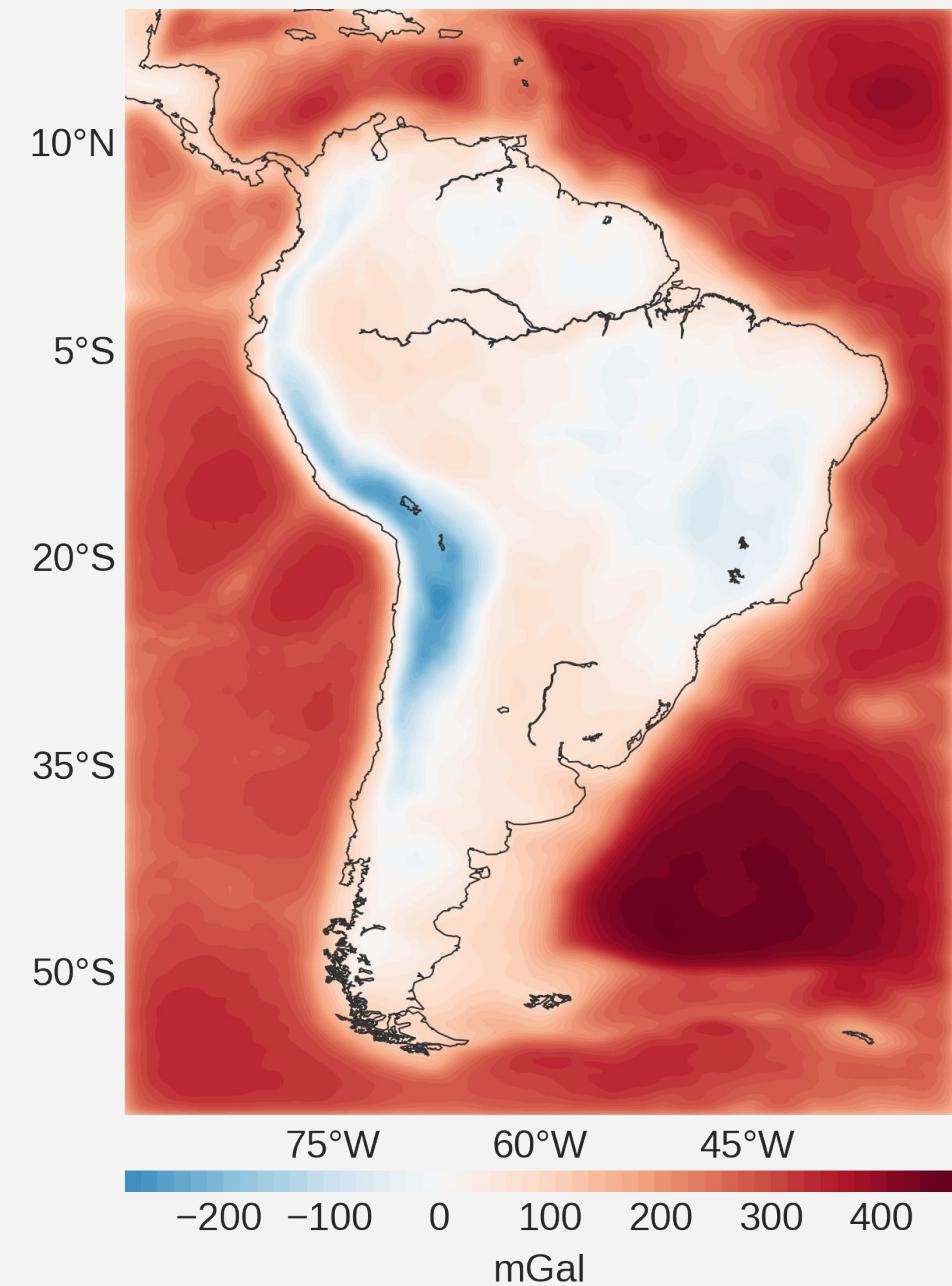




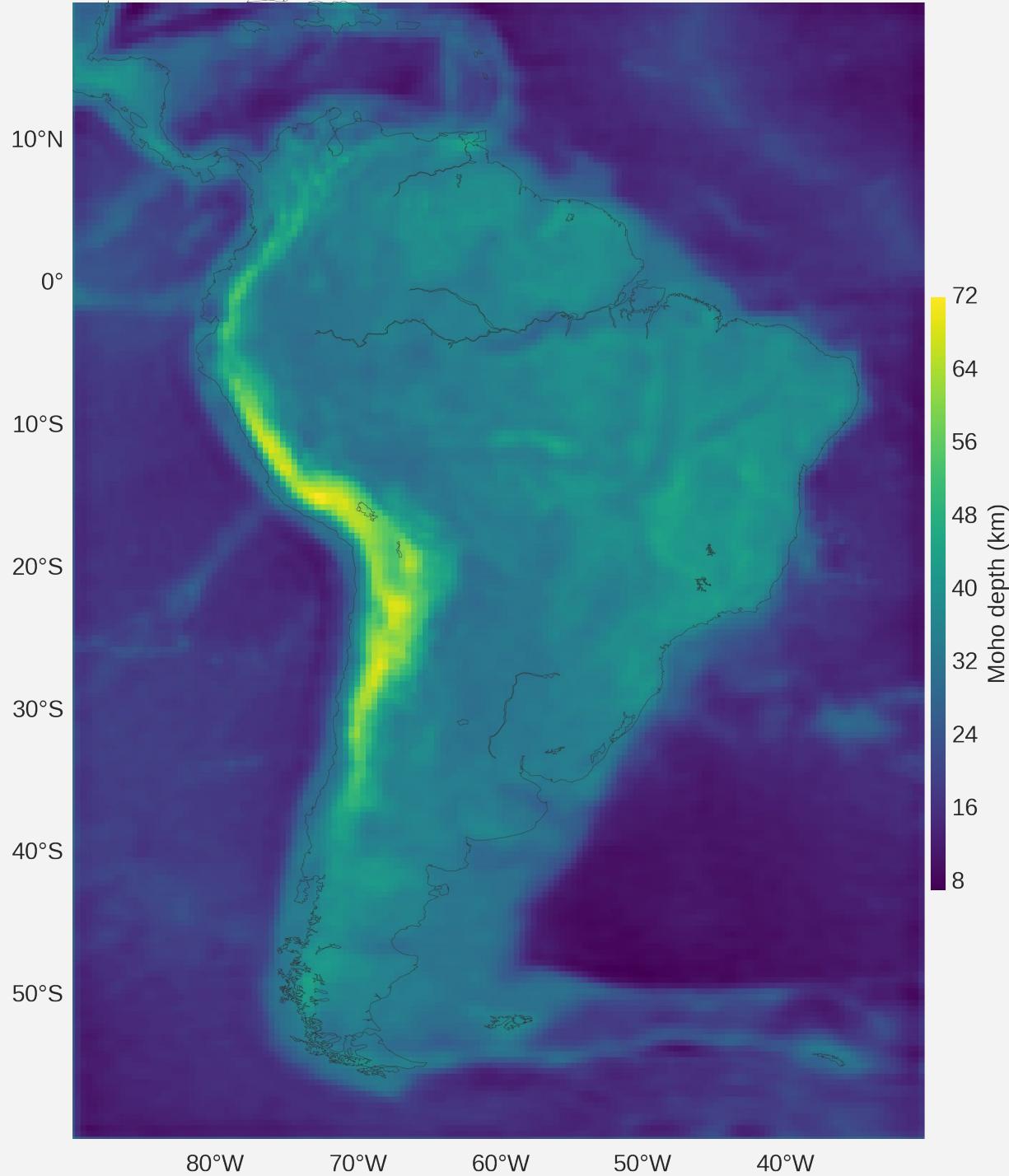
# South America GOCO5S data

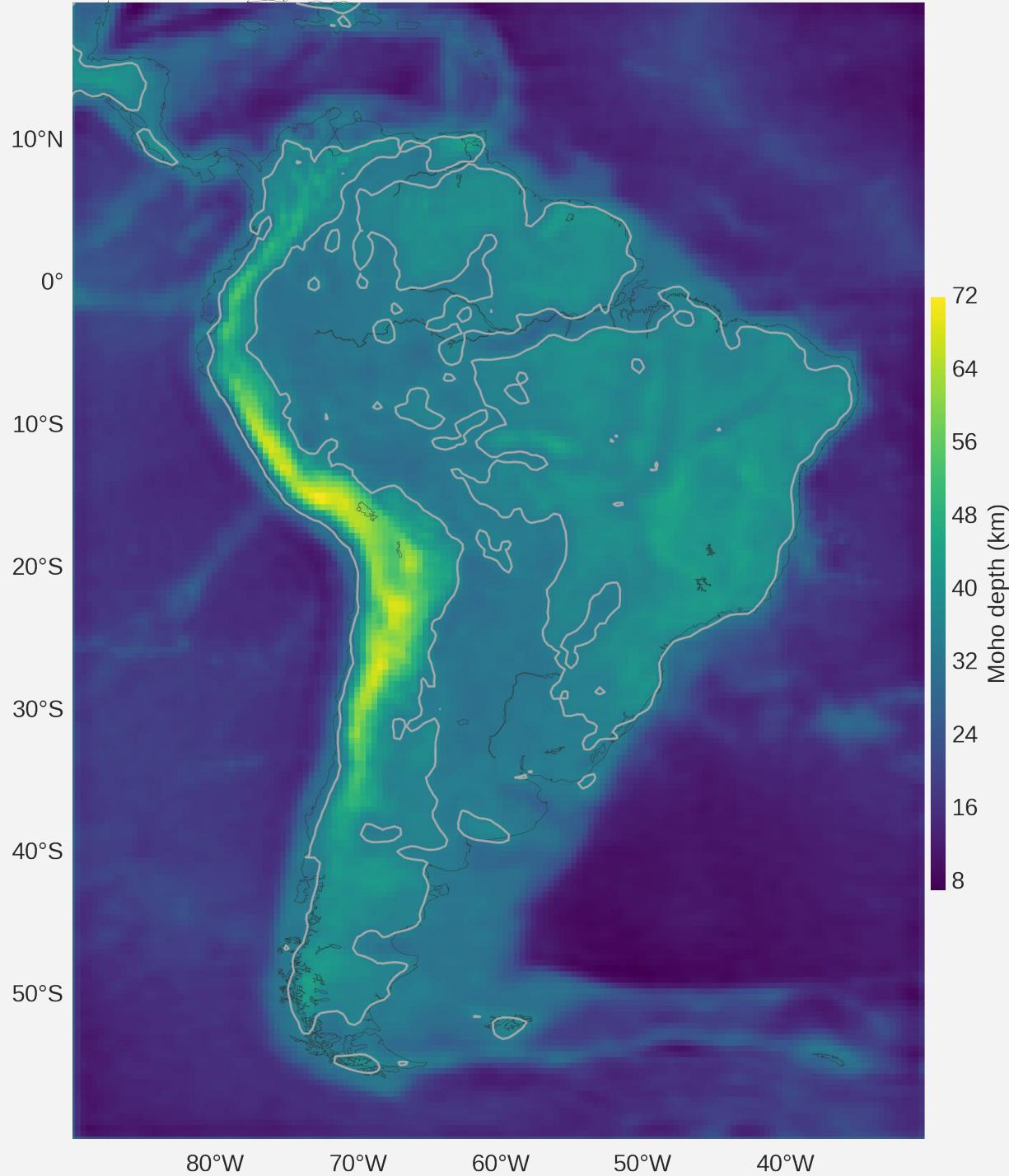
Mayer-Guerr et al. (2015)

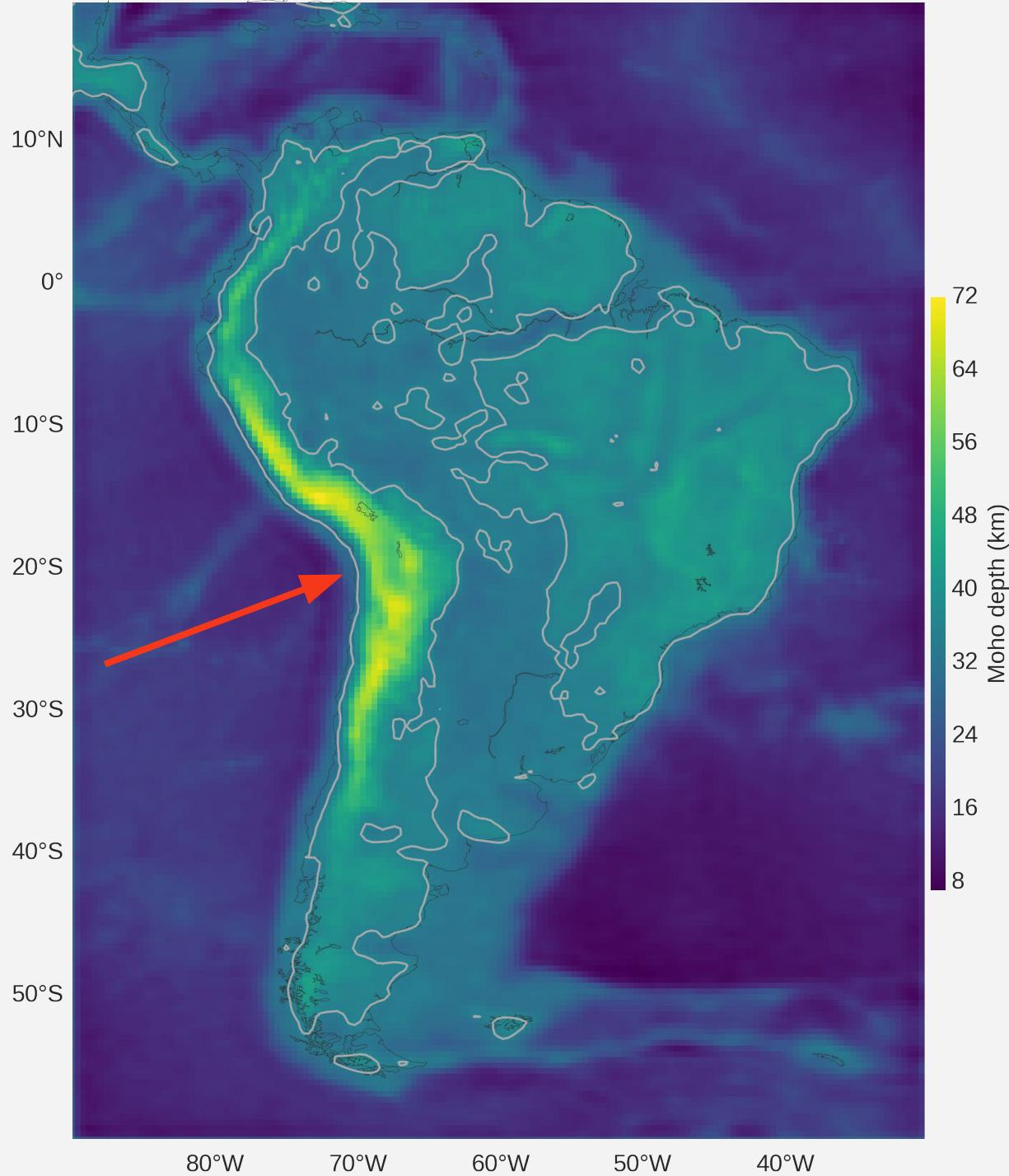


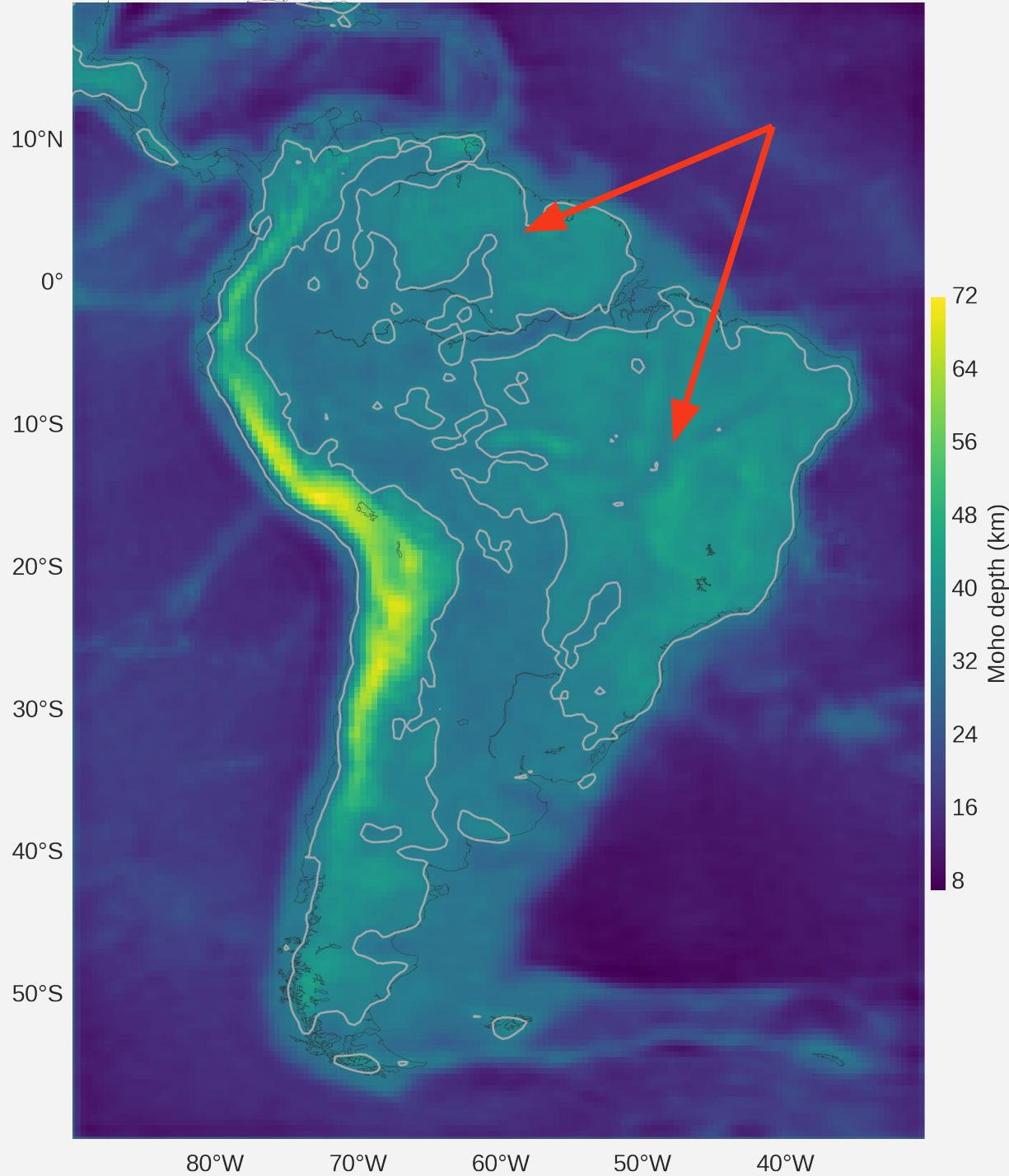


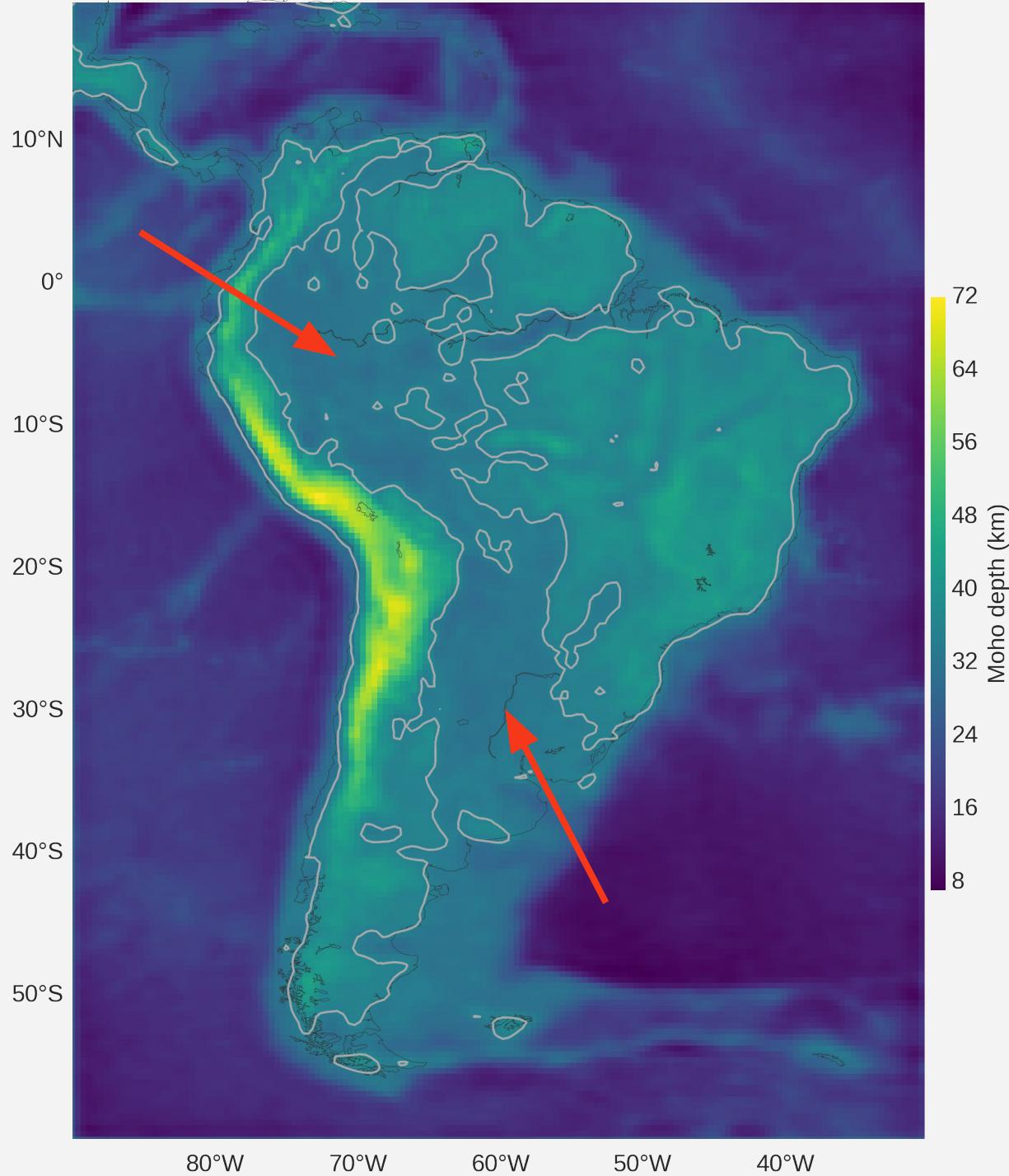
Assumpção et al. (2013)

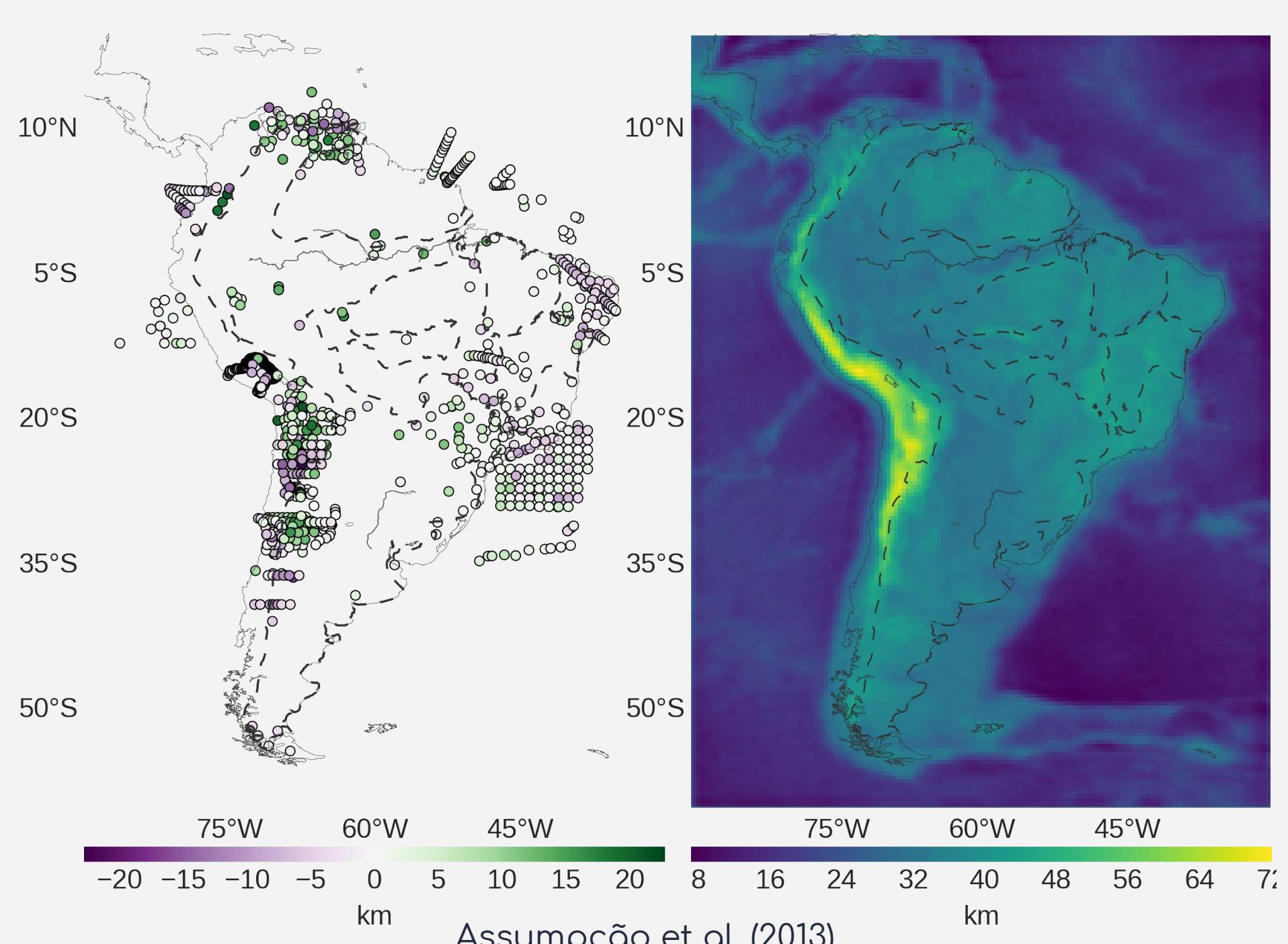


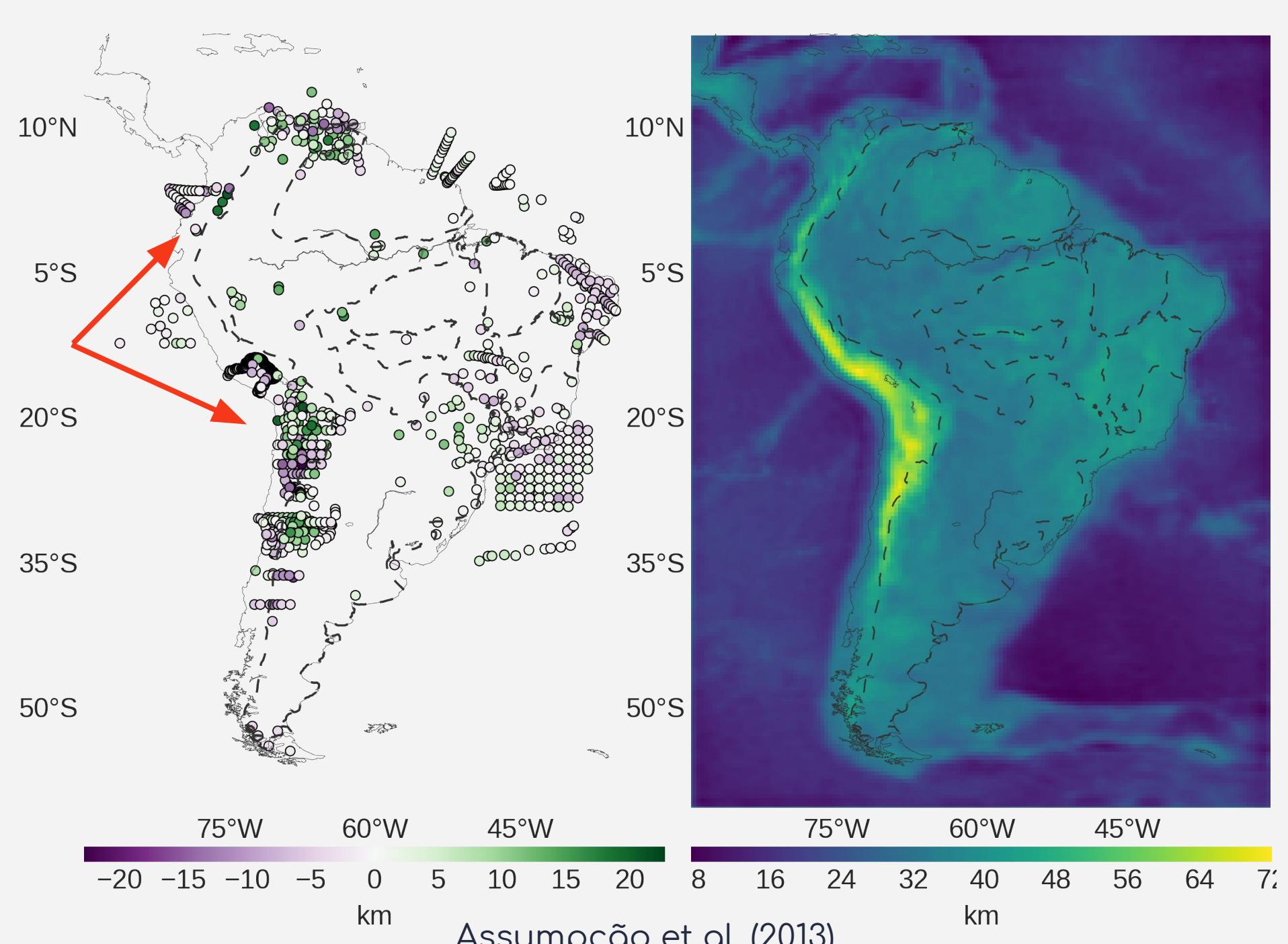


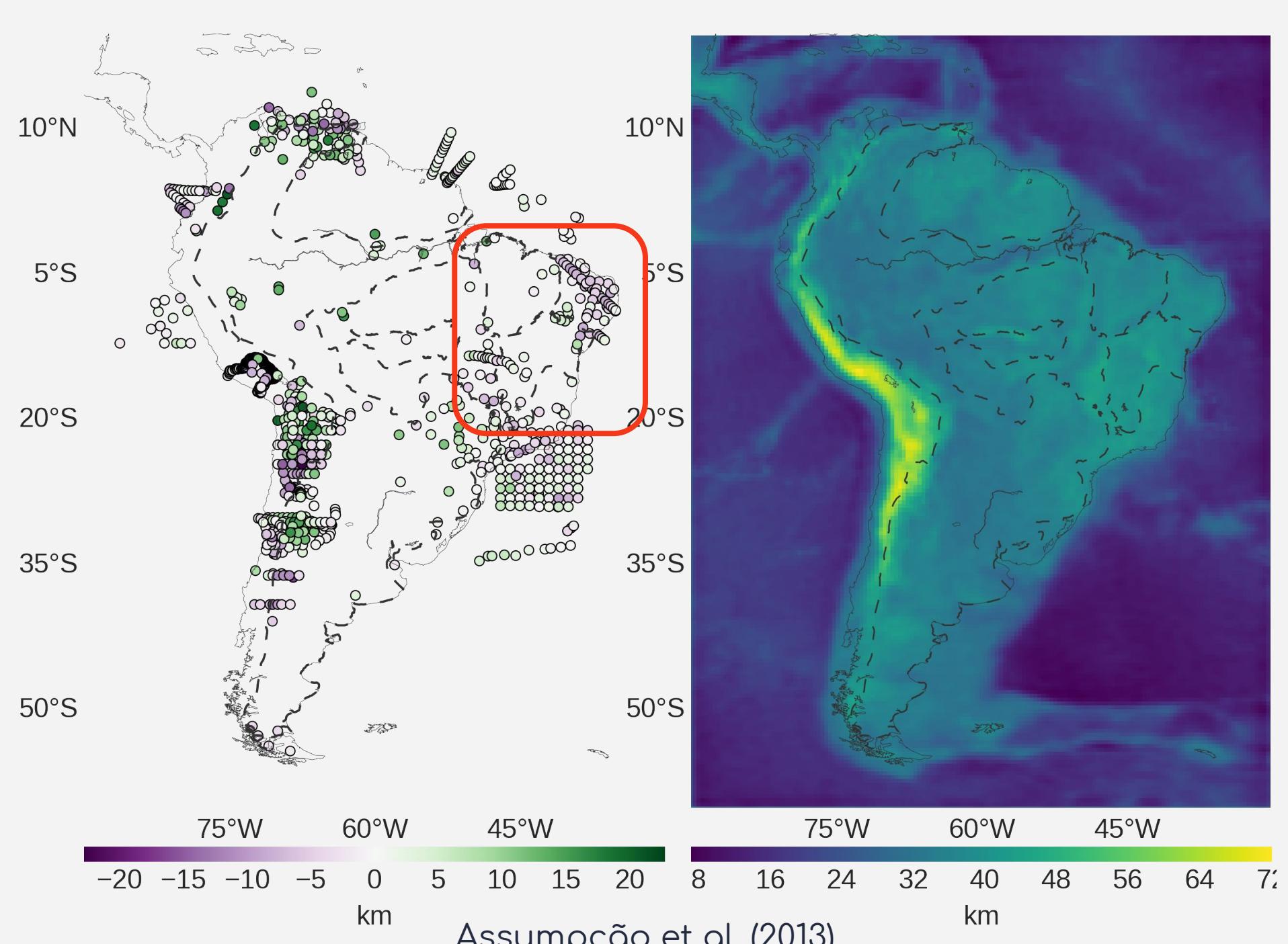


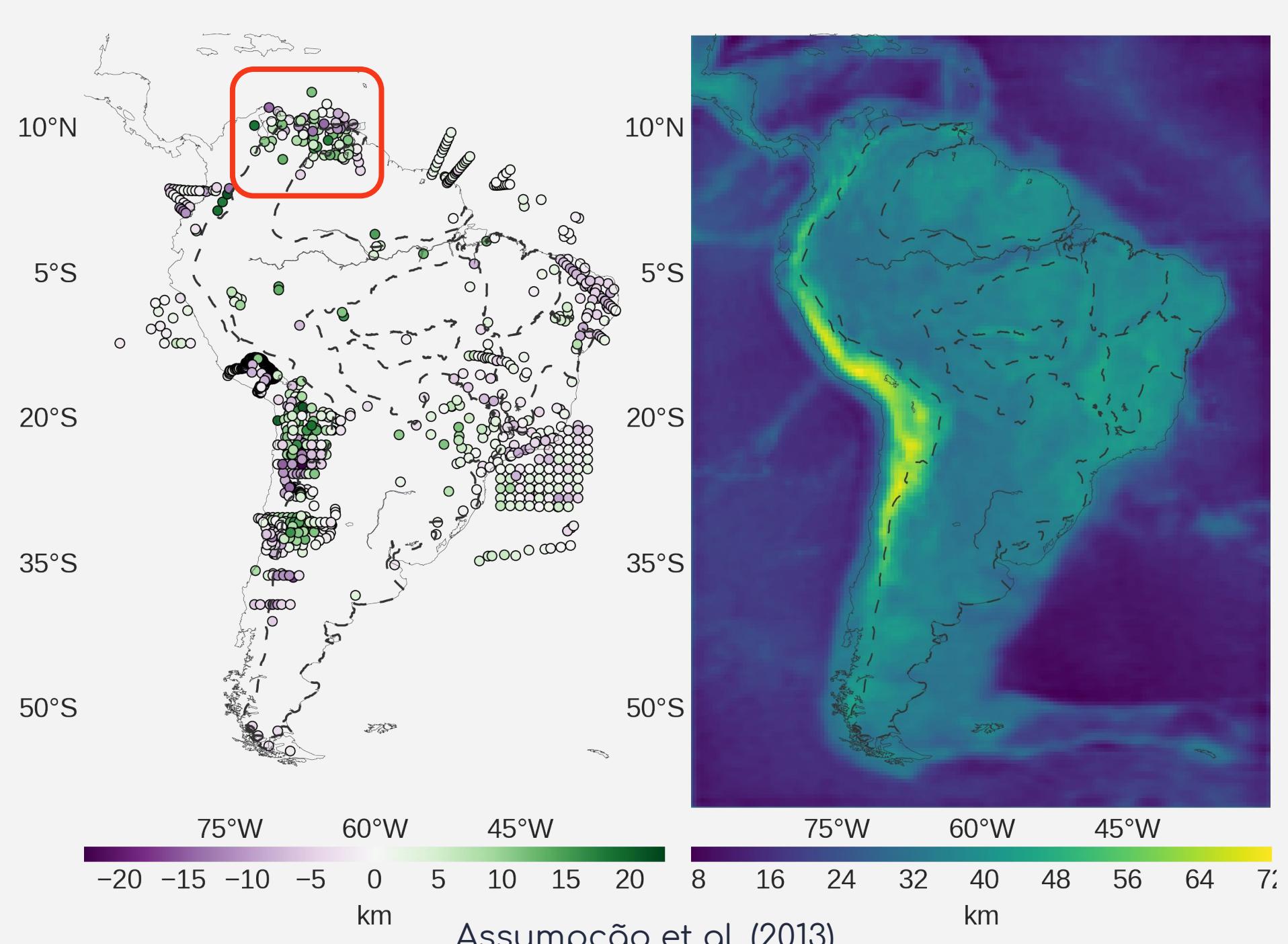


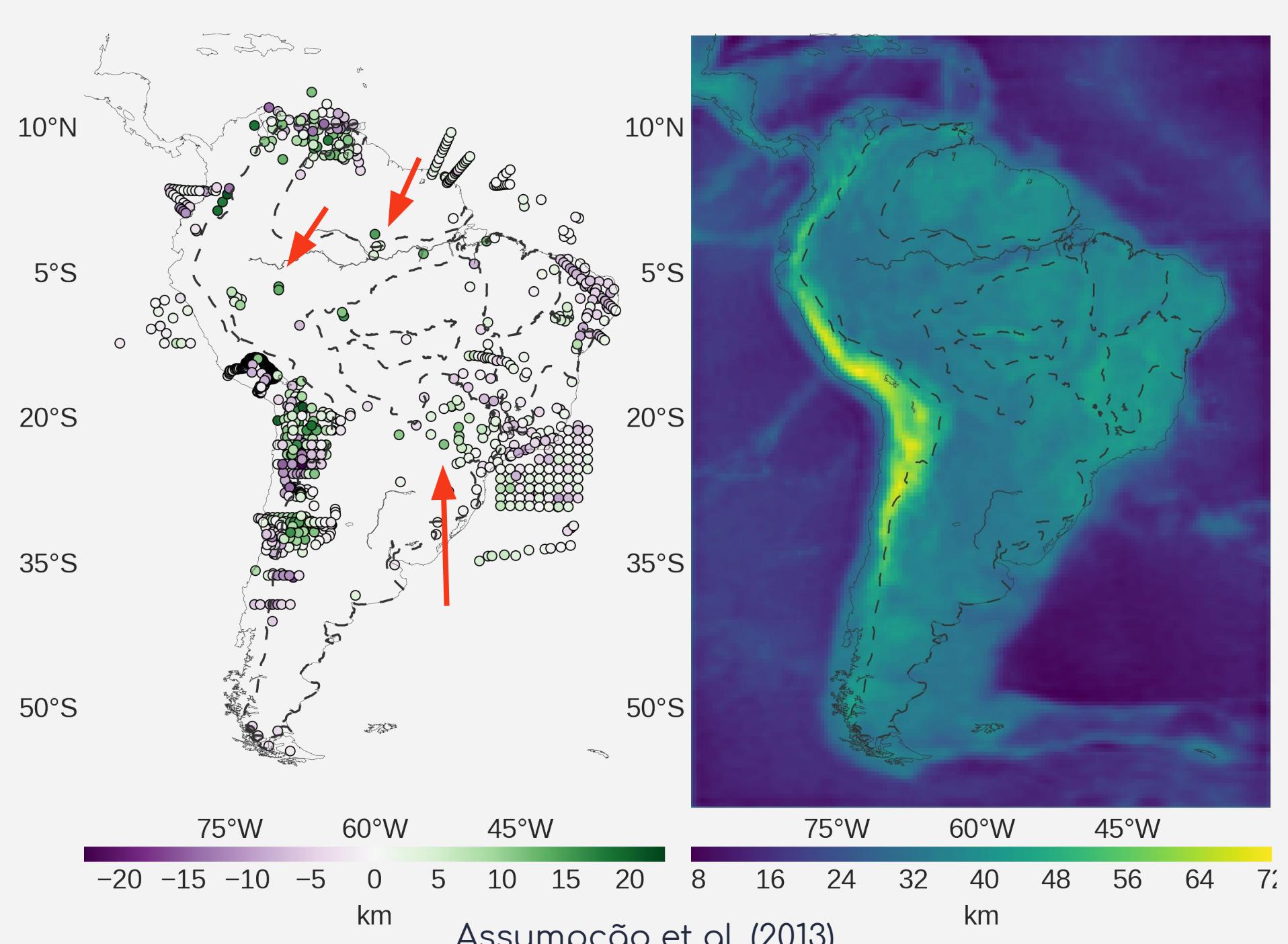












Assumpção et al. (2013)



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Source code, data, and model results for "Fast non-linear gravity inversion in spherical coordinates with application to the South American Moho". Published in the Geophysical Journal International. <http://dx.doi.org/10.1093/gji/ggw390>

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	data Update data README with all files	5 months ago
	manuscript Need to use wildcard instead of ls on Linux	4 months ago
	model Result fig with seismic diffs for README	5 months ago
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## Fast non-linear gravity inversion in spherical coordinates with application to the South American Moho

by Leonardo Uieda and Valéria C. F. Barbosa

Published in the Geophysical Journal International: doi:[10.1093/gji/ggw390](https://doi.org/10.1093/gji/ggw390)Click on this button to run the code online: [launch binder](#)An archived snapshot of this repository is available on figshare at doi:[10.6084/m9.figshare.3987267](https://doi.org/10.6084/m9.figshare.3987267) (the manuscript LaTeX sources are not included).A PDF of the article is available at [leouieda.com/papers/paper-moho-inversion-tesseroids-2016.html](http://leouieda.com/papers/paper-moho-inversion-tesseroids-2016.html)

final  
remarks

gravity  
inversion  
is hard

open

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