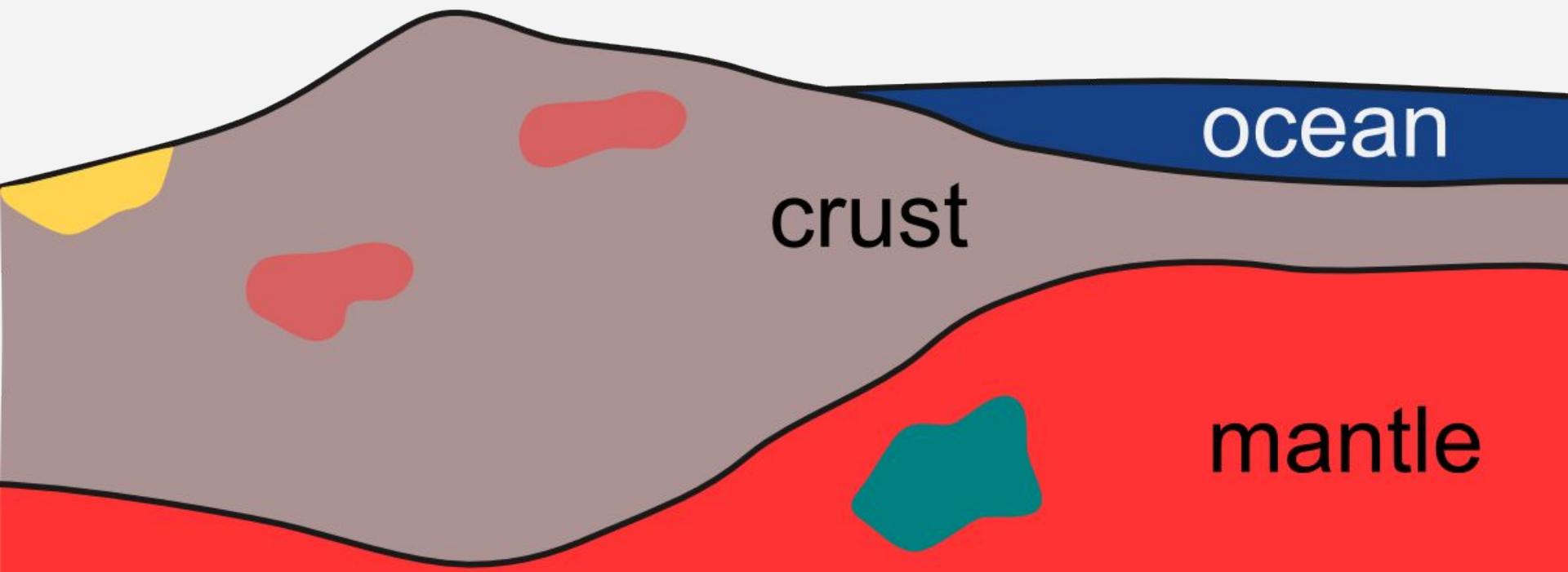


Inverting gravity to map the Moho

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

gravity
inversion

g_P

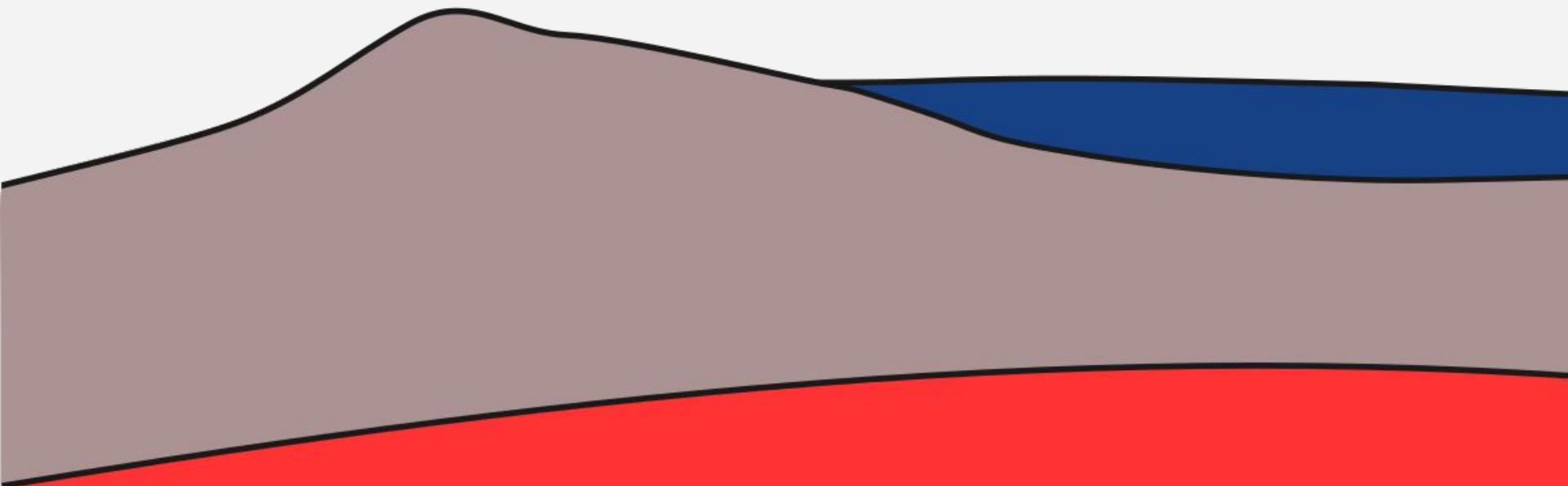


γ_P

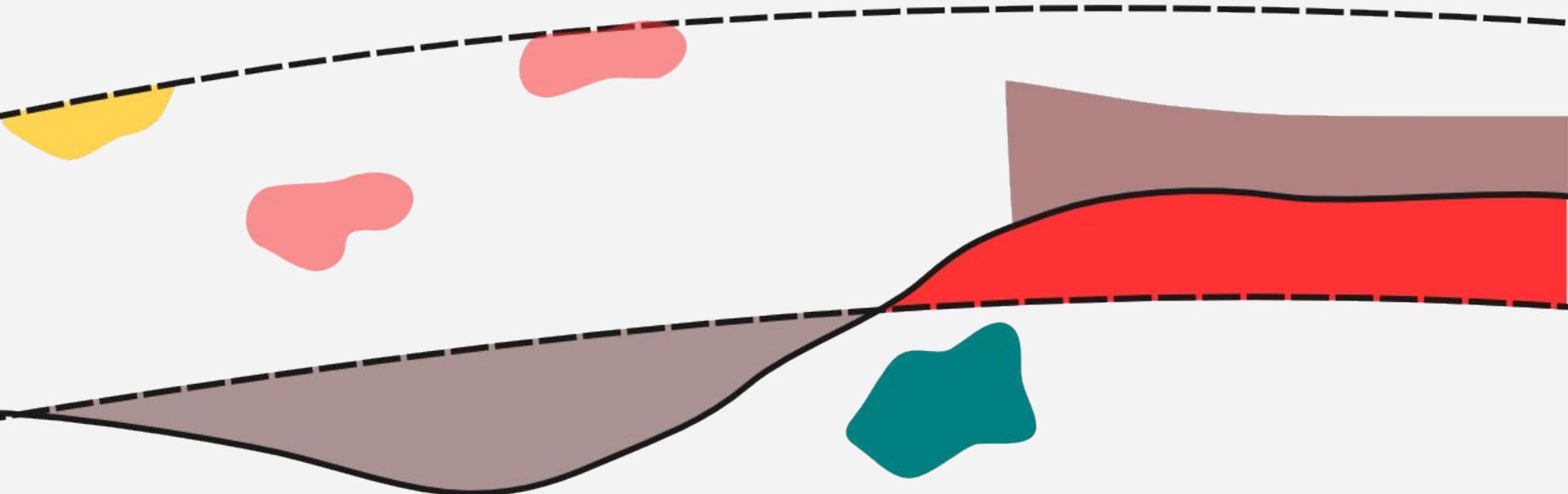
crust

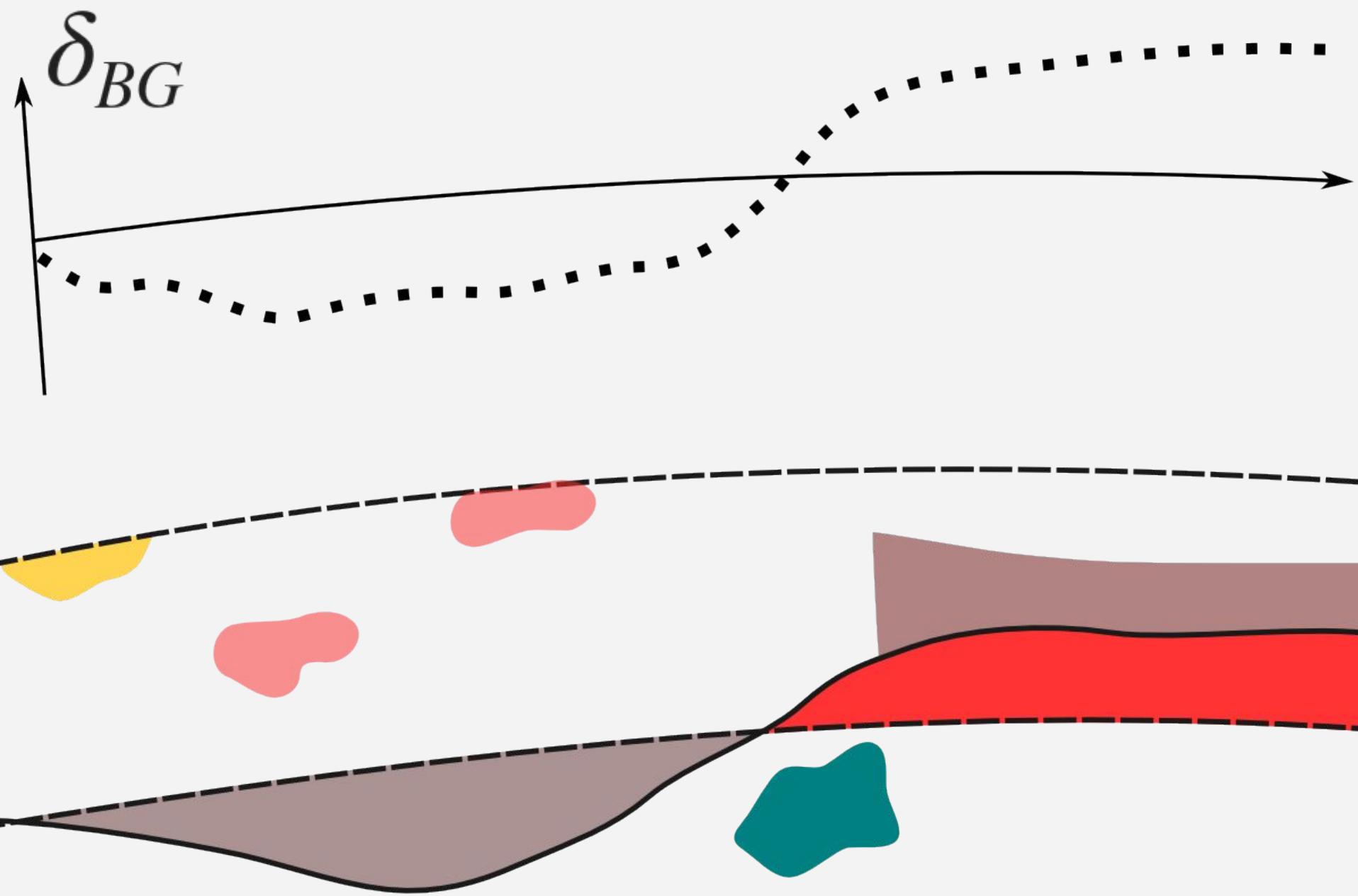
mantle

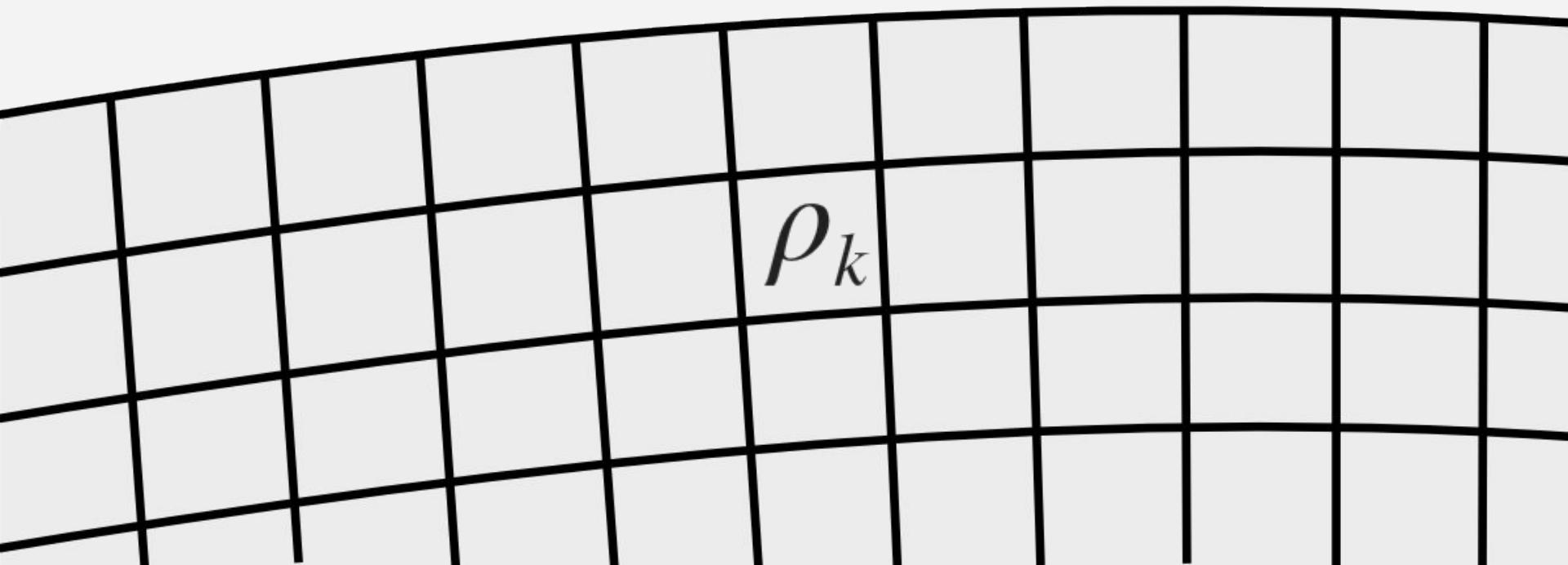
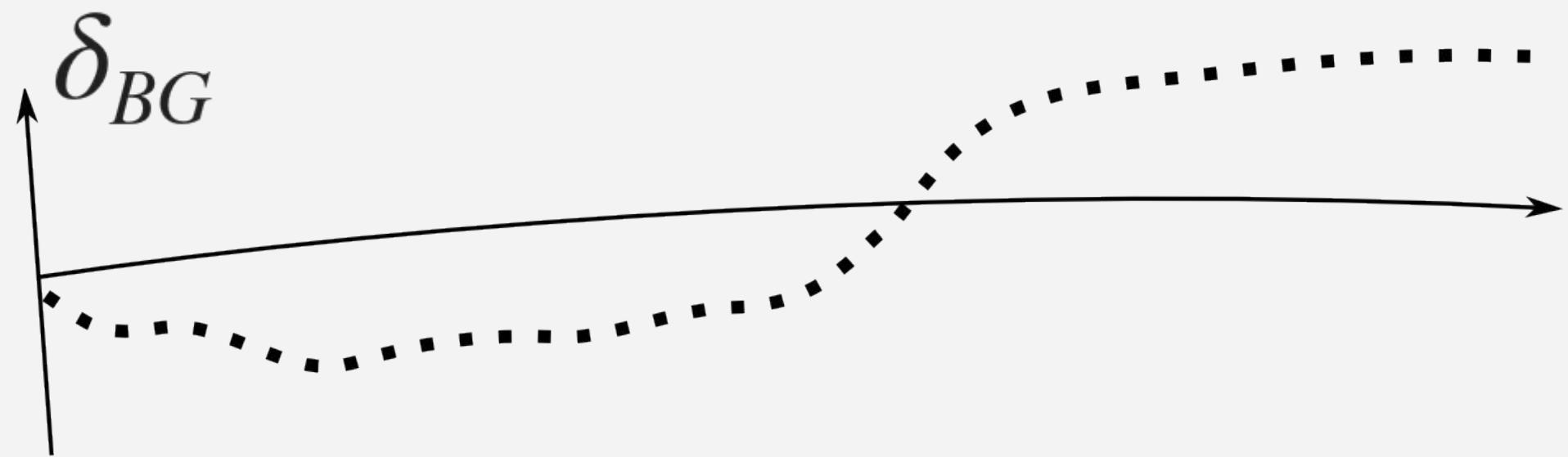
$$\gamma_P + 2\pi G \rho h$$

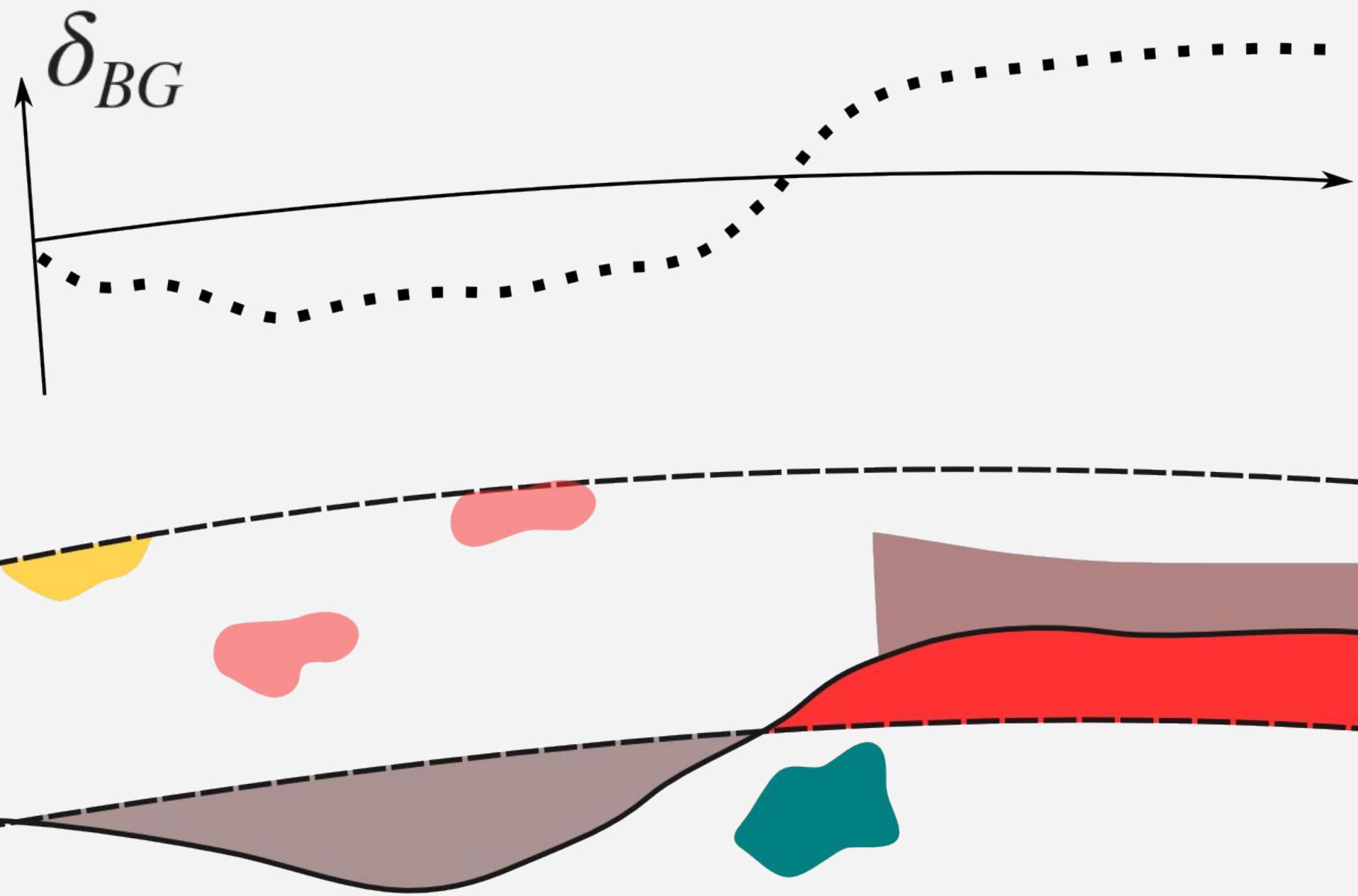


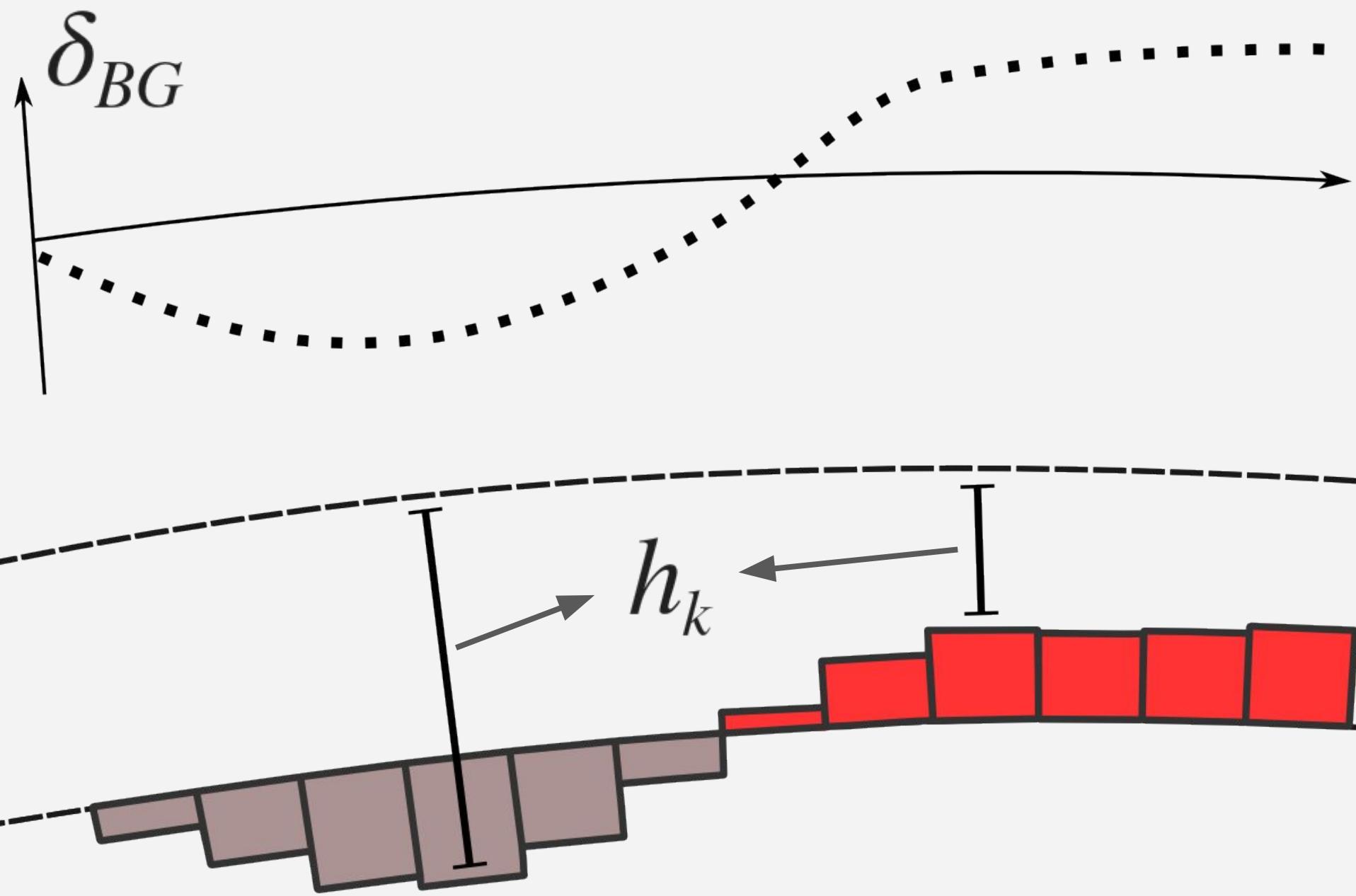
$$\delta_{BG} = g_P - (\gamma_P + 2\pi G \rho h)$$







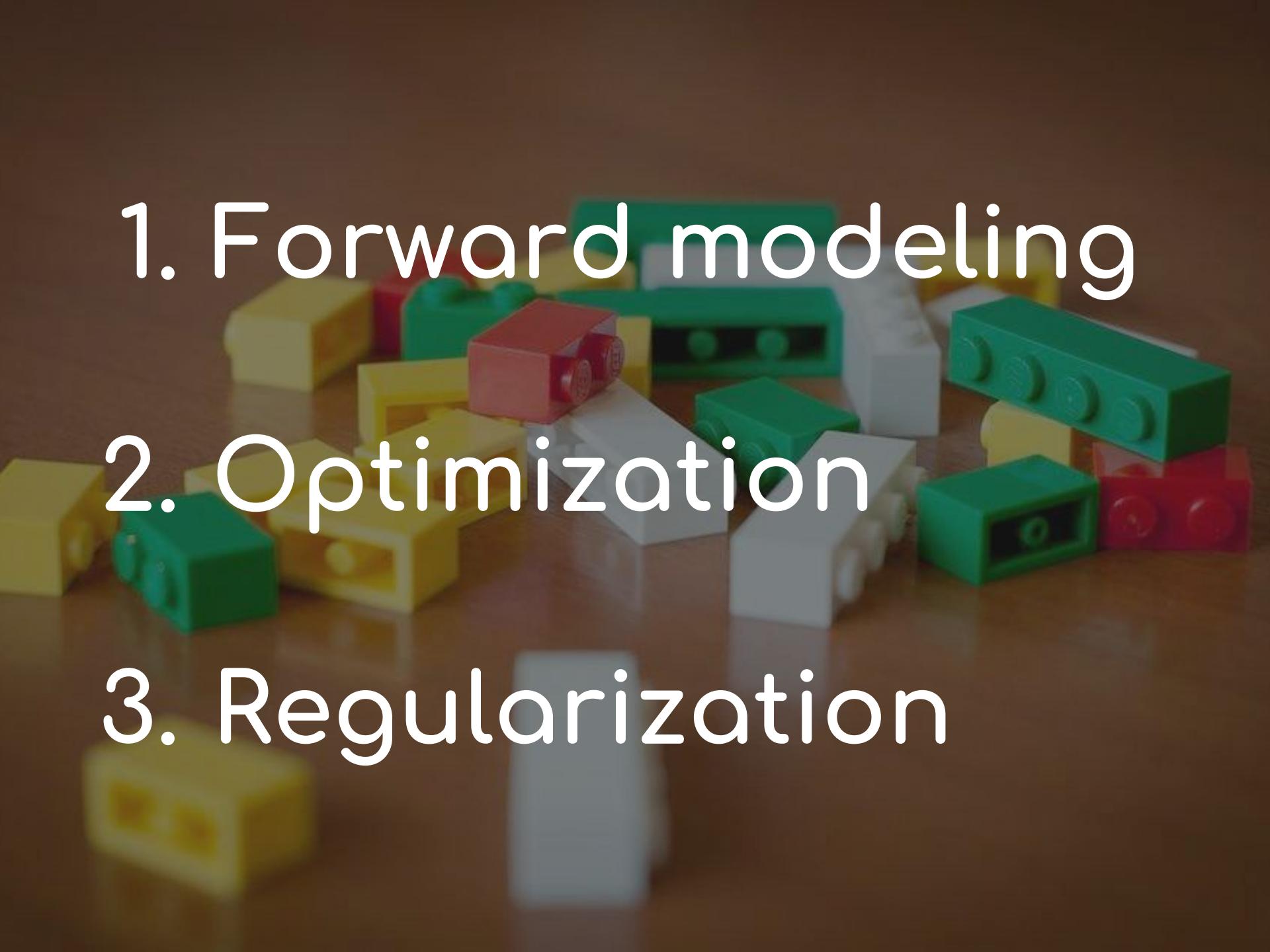




linear

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

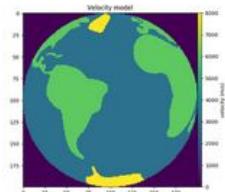
Example Gallery

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.

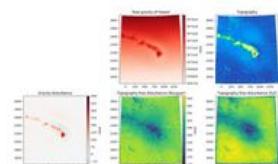
Note

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

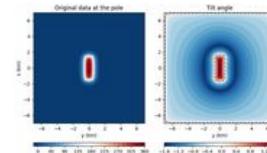


Create a model based
on an image file

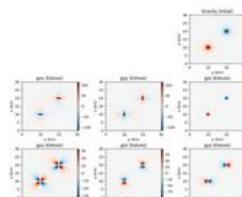


Hawaii gravity data

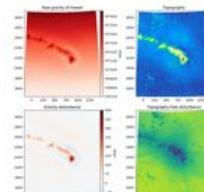
Gravity and magnetics



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



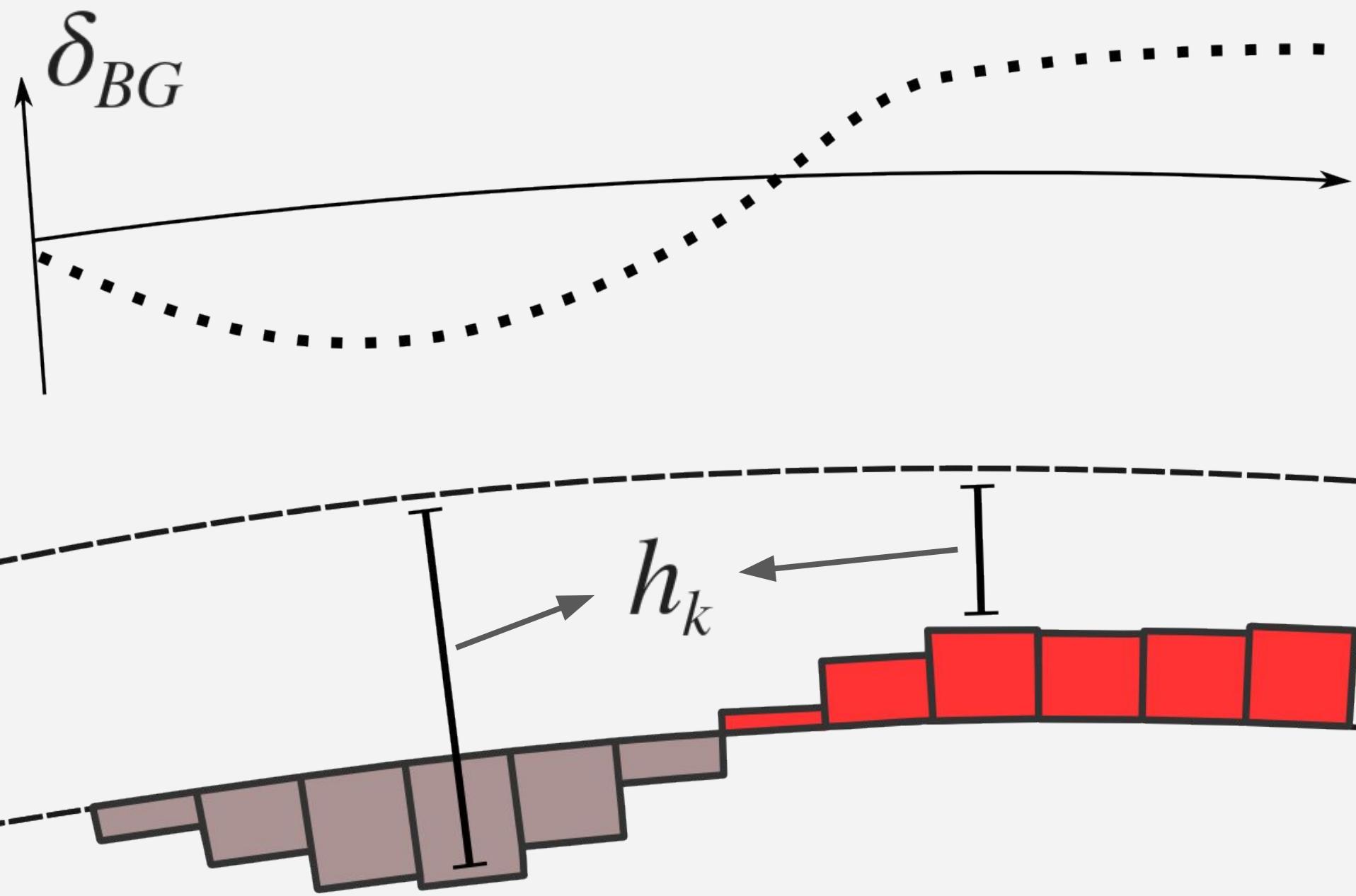
Contributors

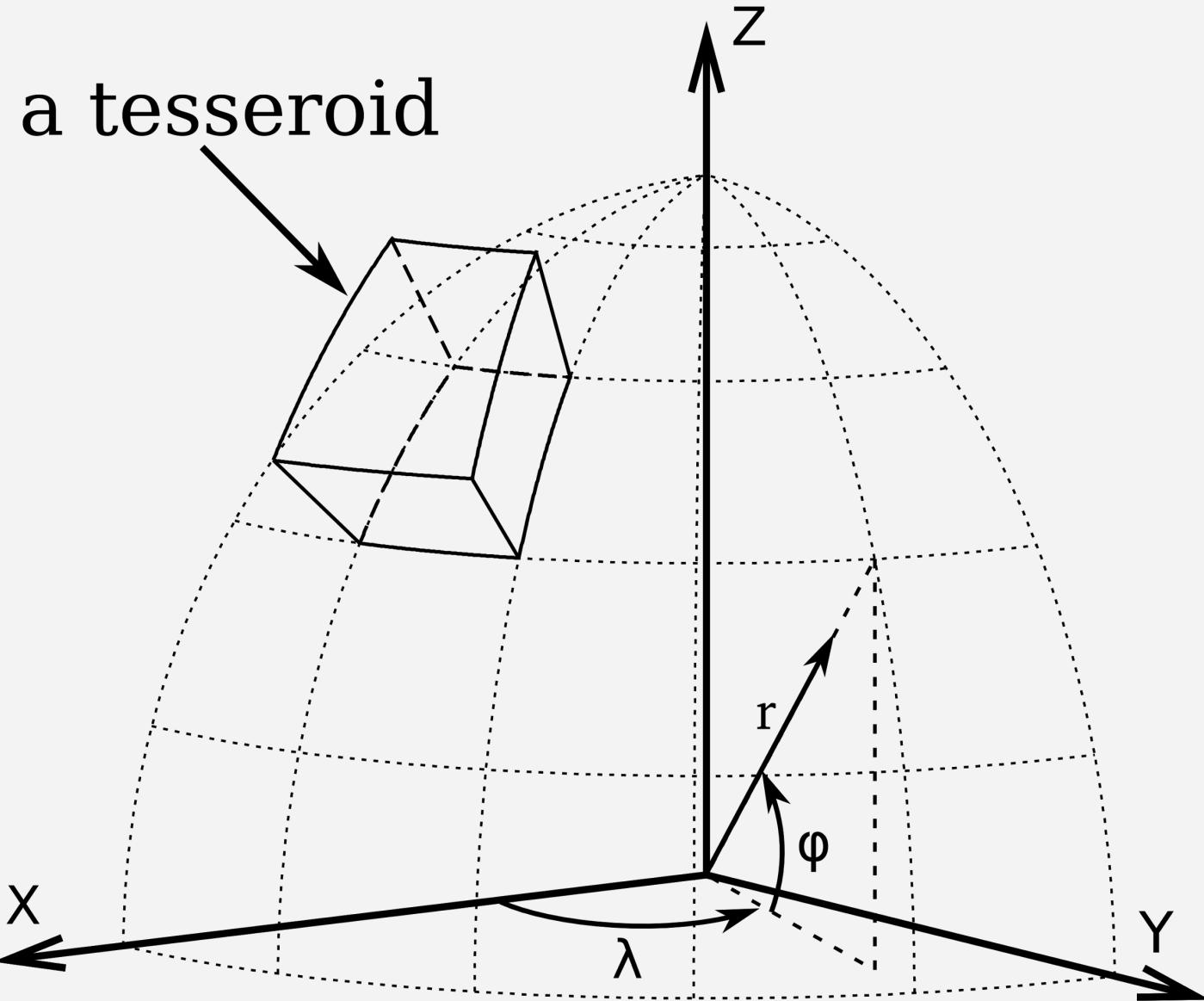
A (hopefully) updated list of people who contributed to Fatiando a Terra:

- [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

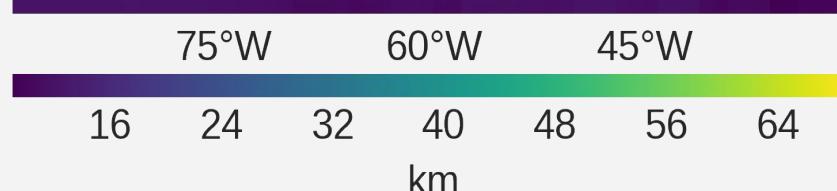
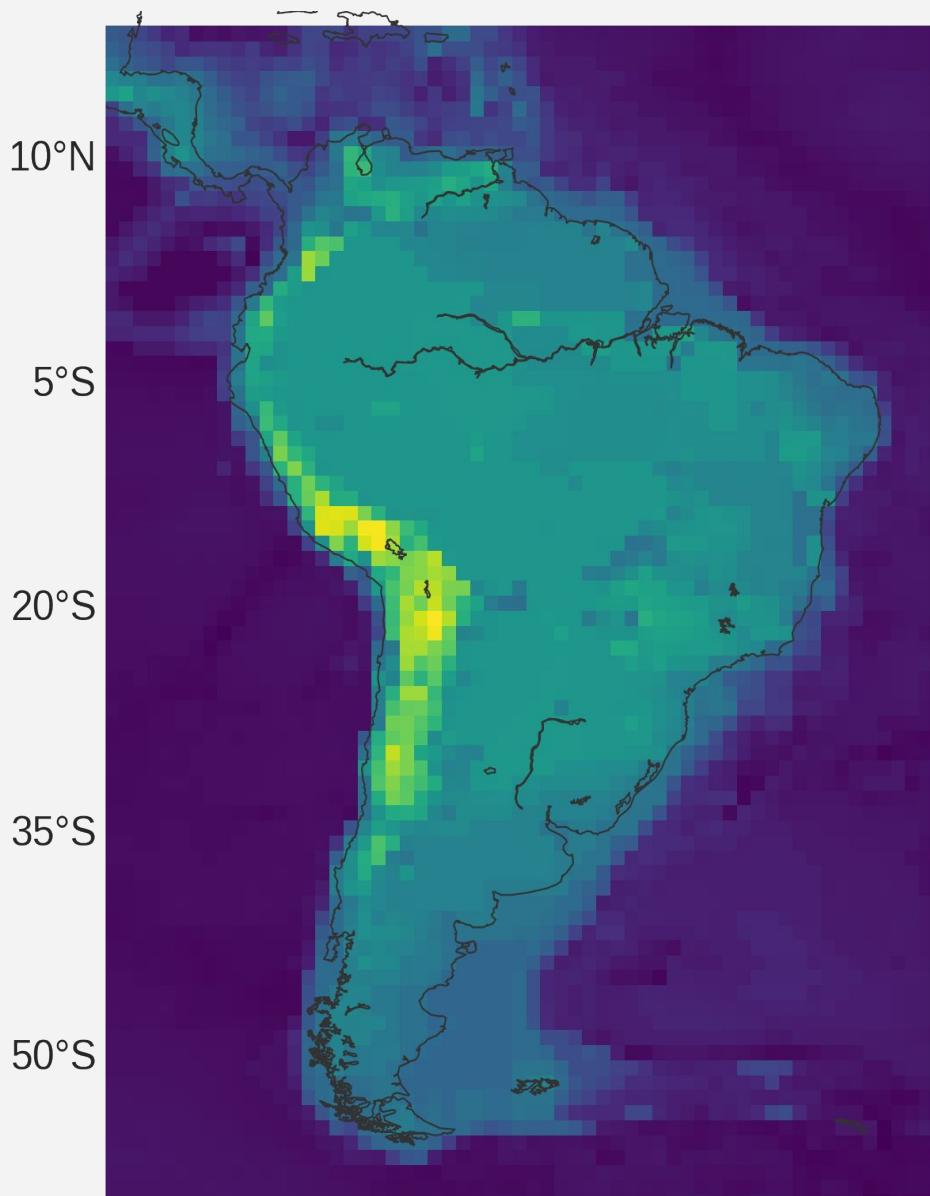
$$[\tilde{A}^T \tilde{A} + \mu W] \Delta p^k = \tilde{A}^T [\textcolor{red}{d}^o - \textcolor{magenta}{f}(p^k)] - \mu W p^k$$

1. tesseroids

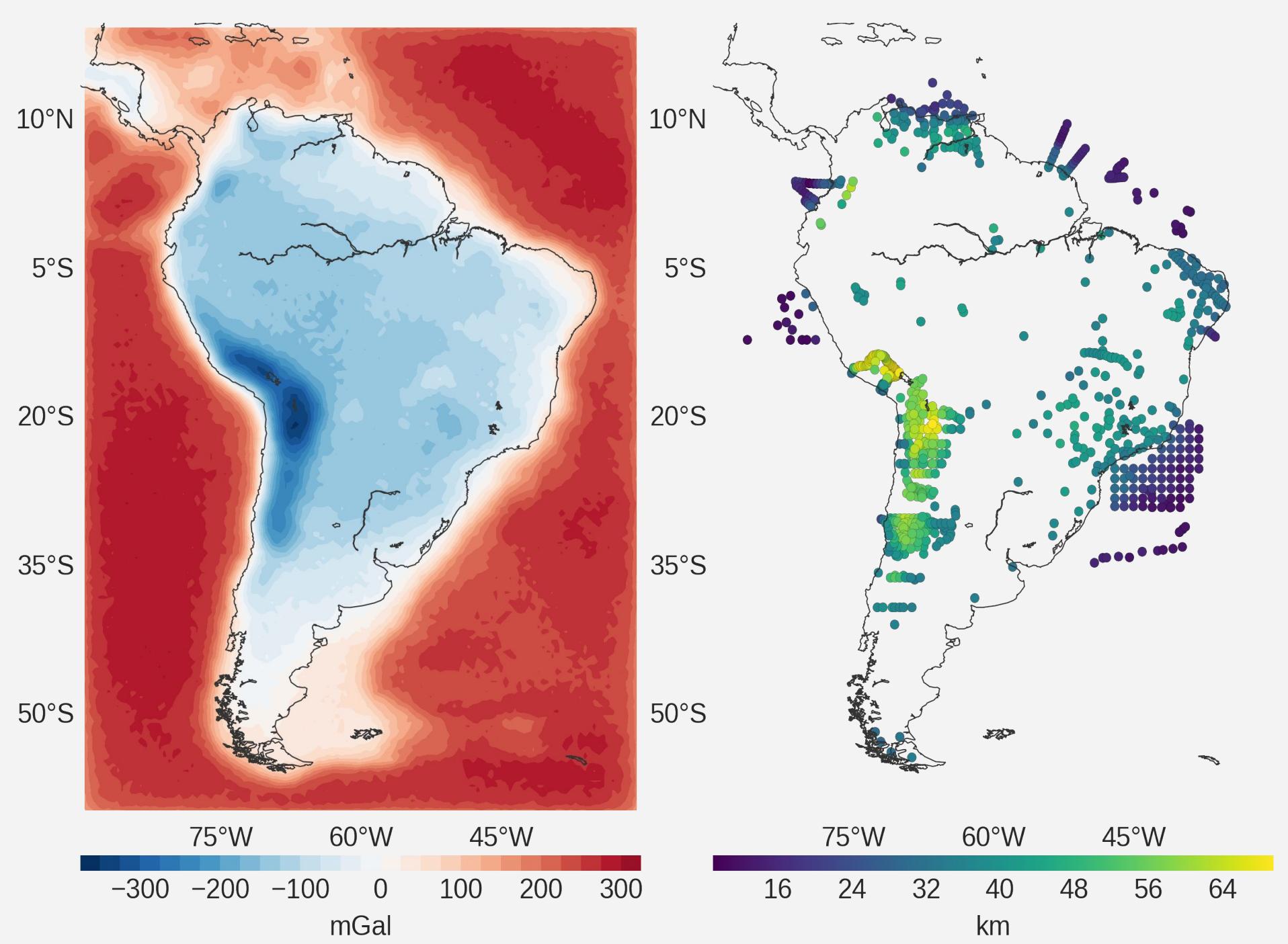
2. Bott + GN

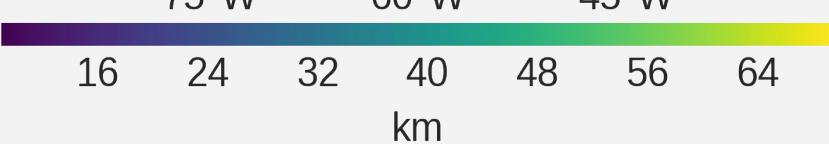
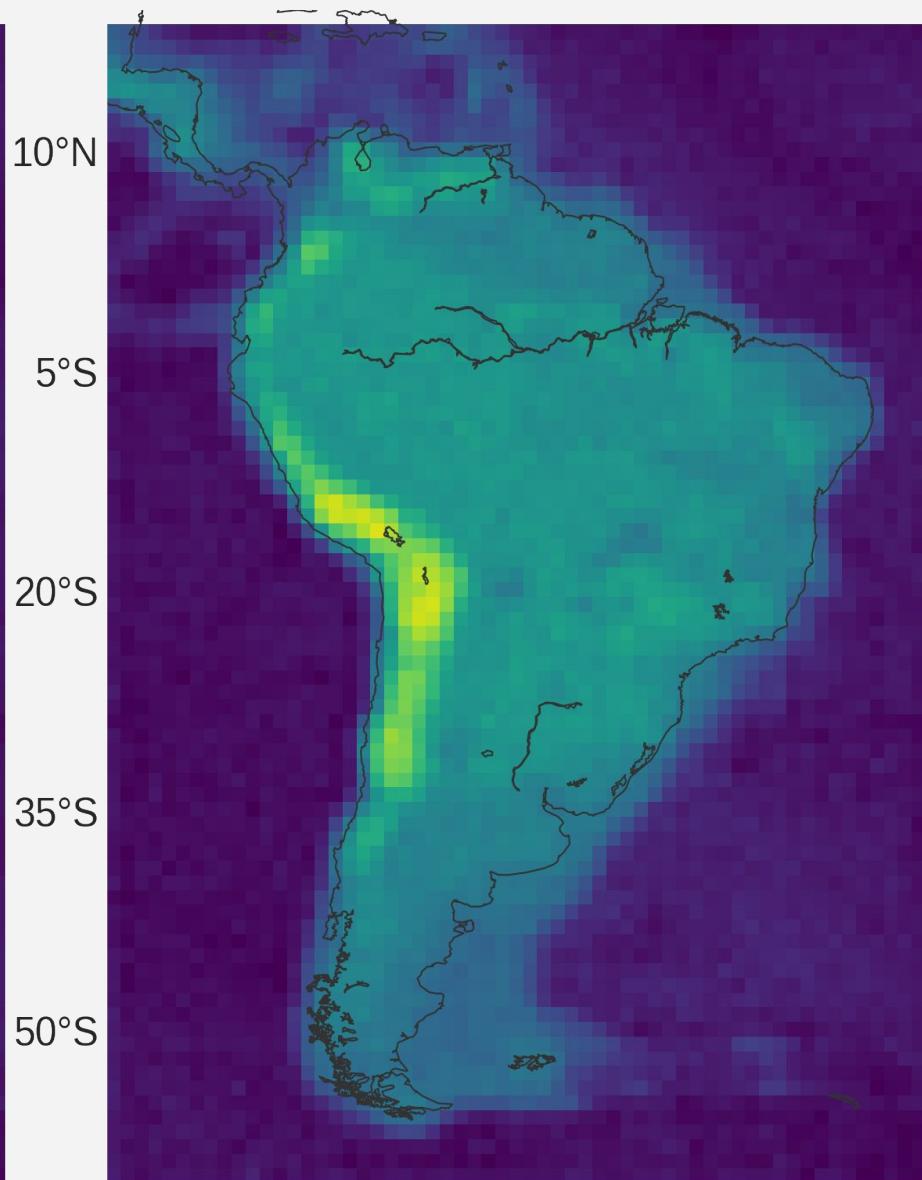
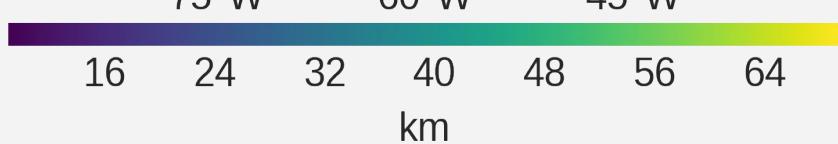
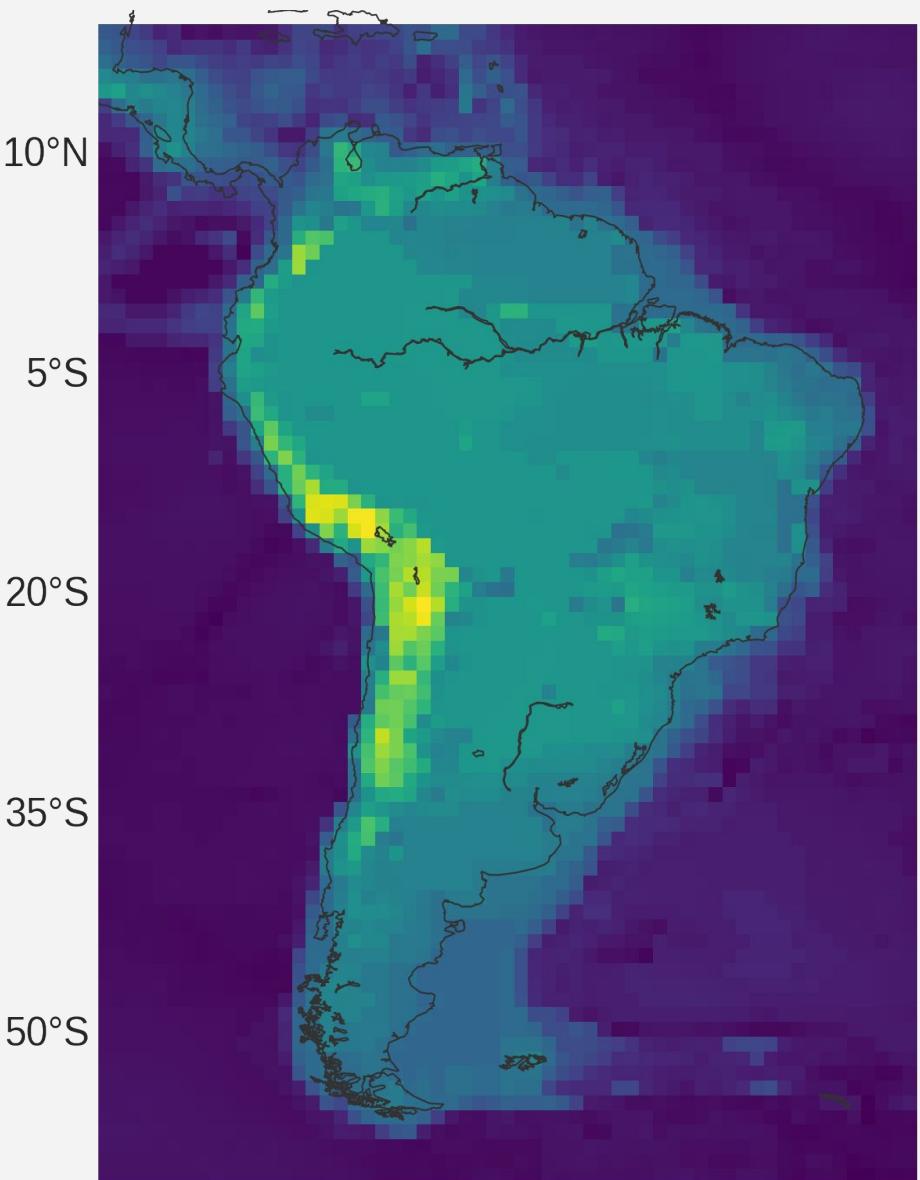
3. regularization

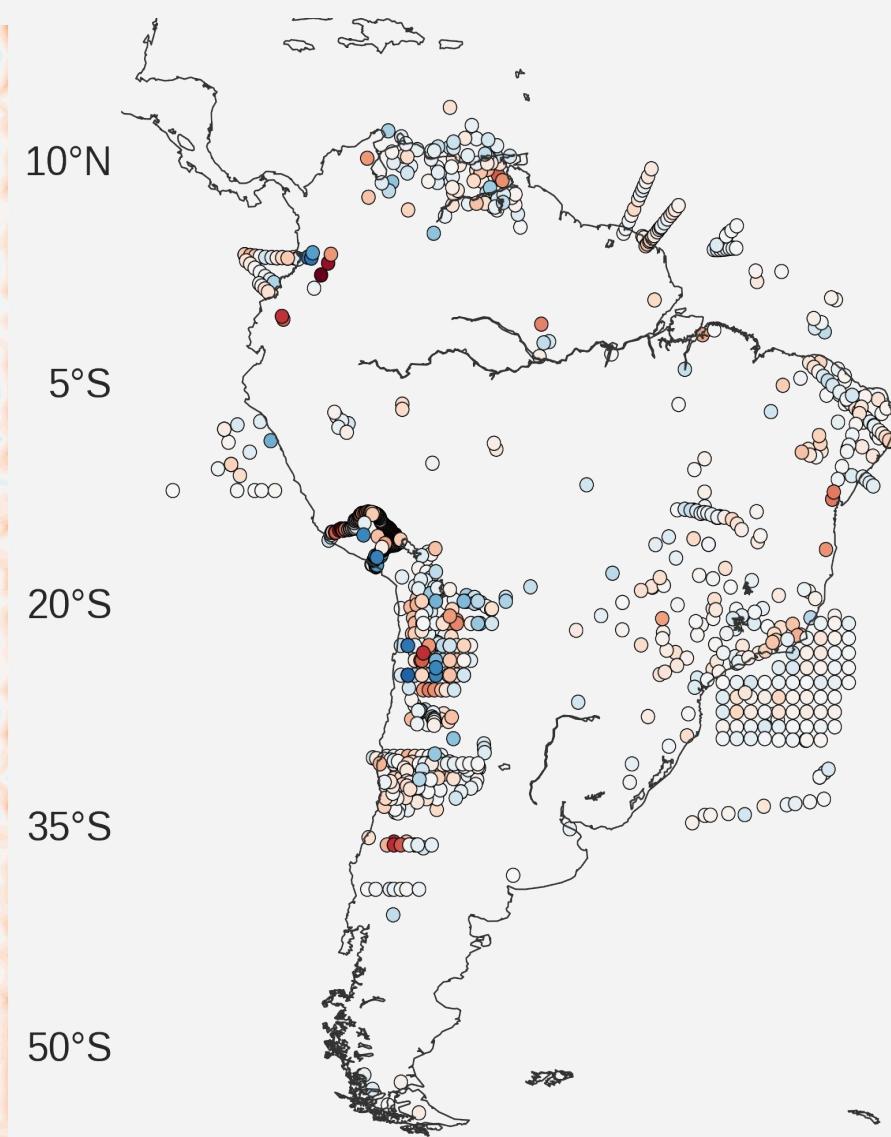
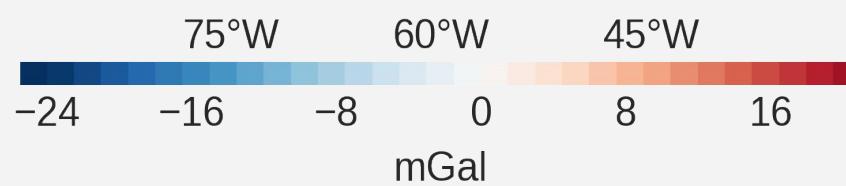
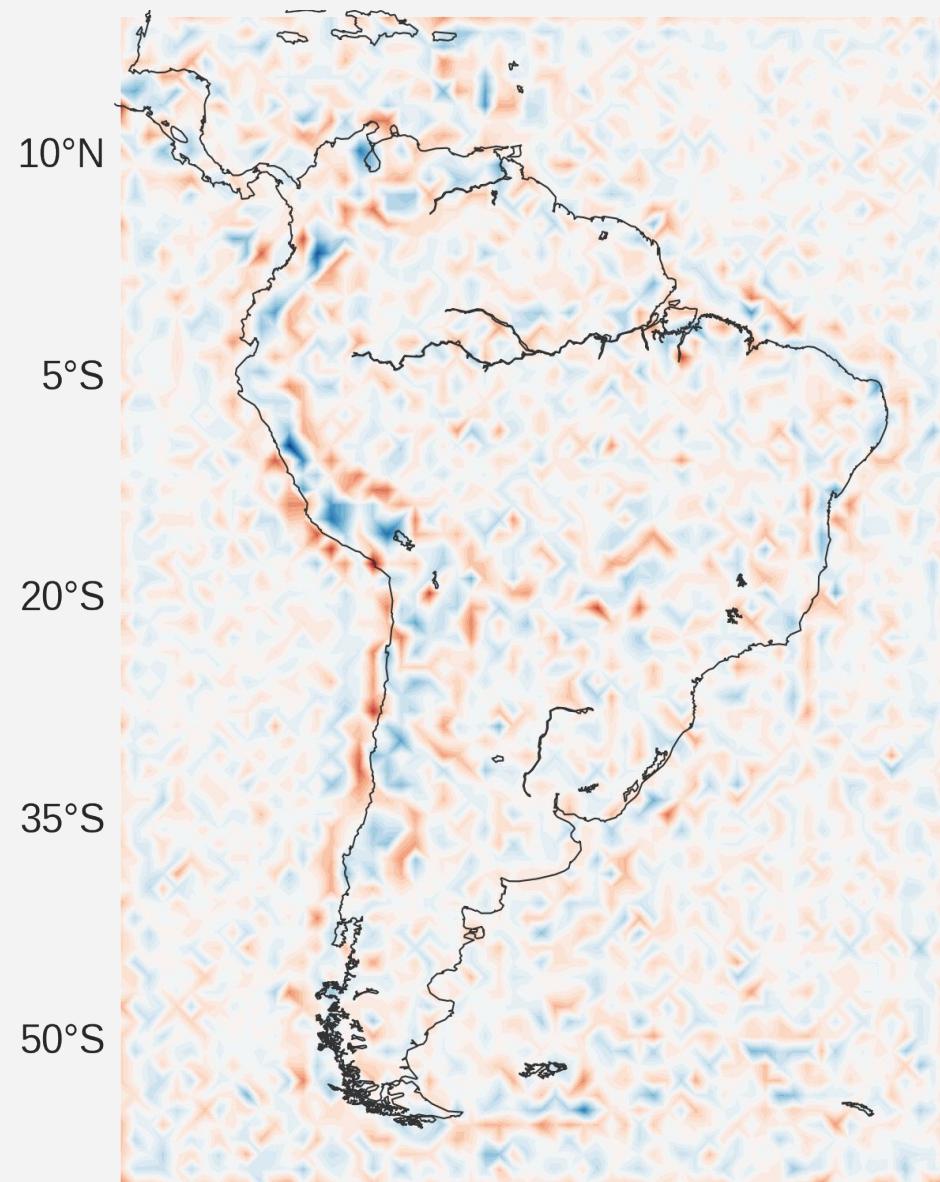
4. validation



CRUST1.0
(Laske et al. 2013)

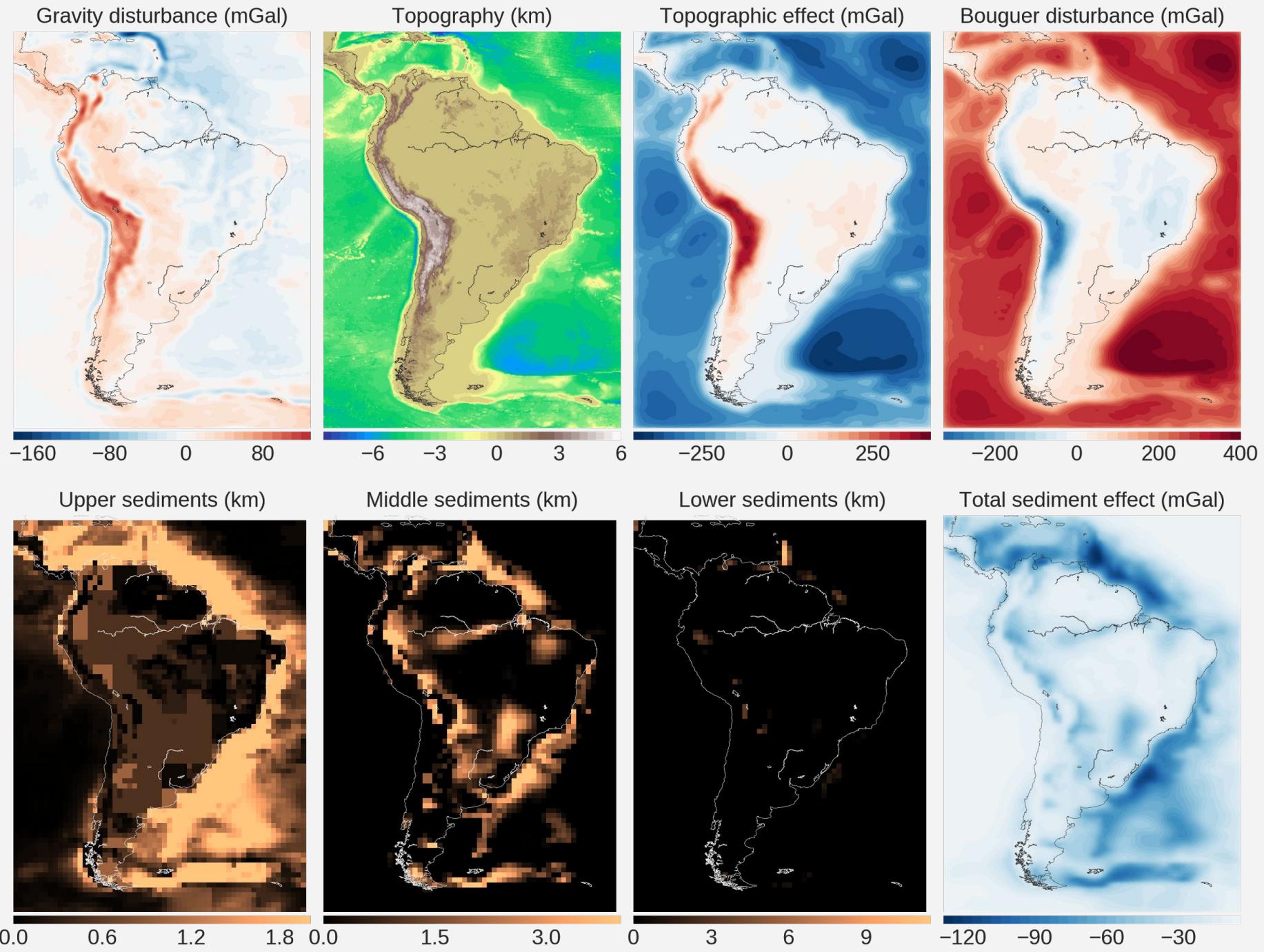


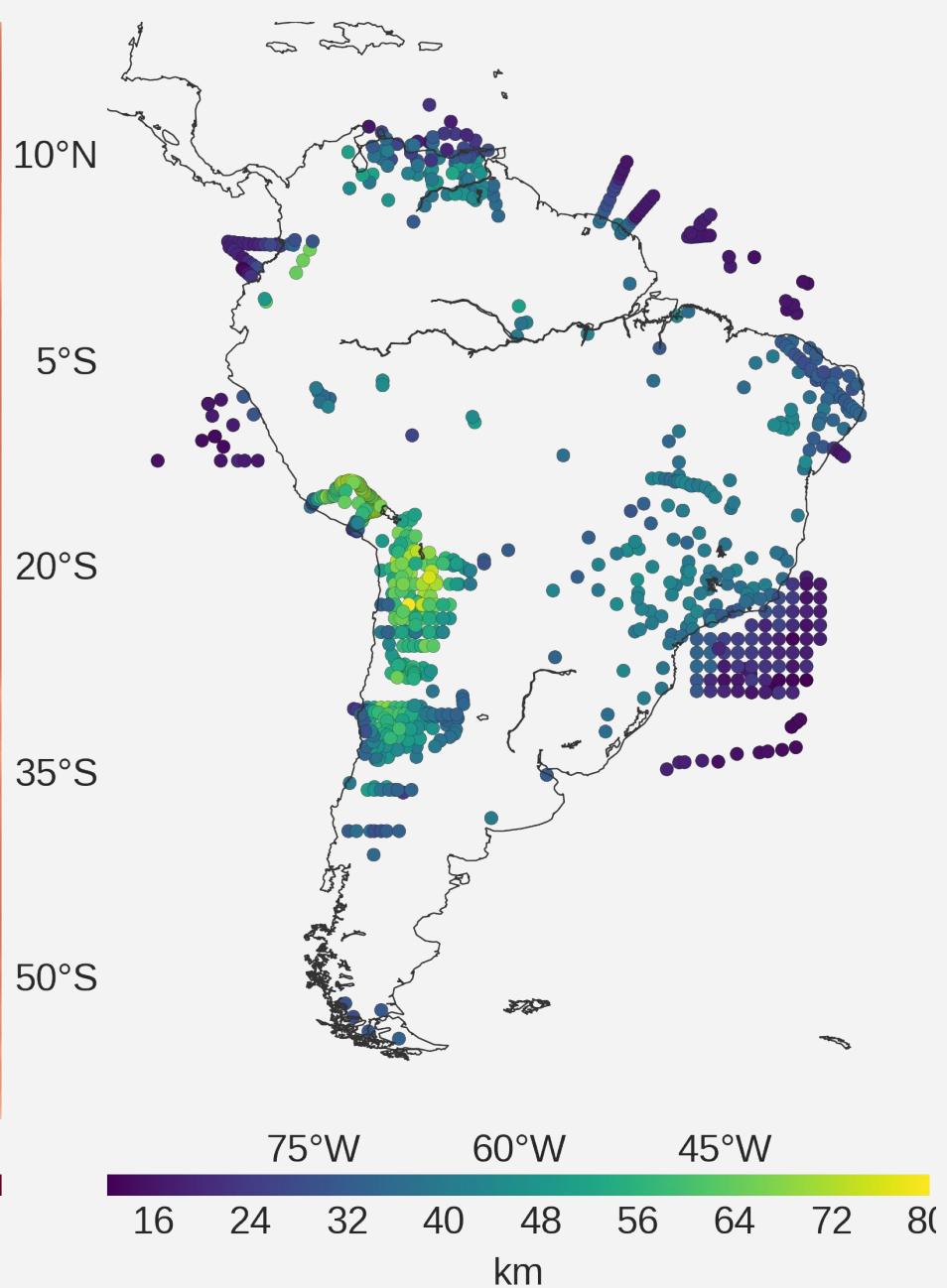
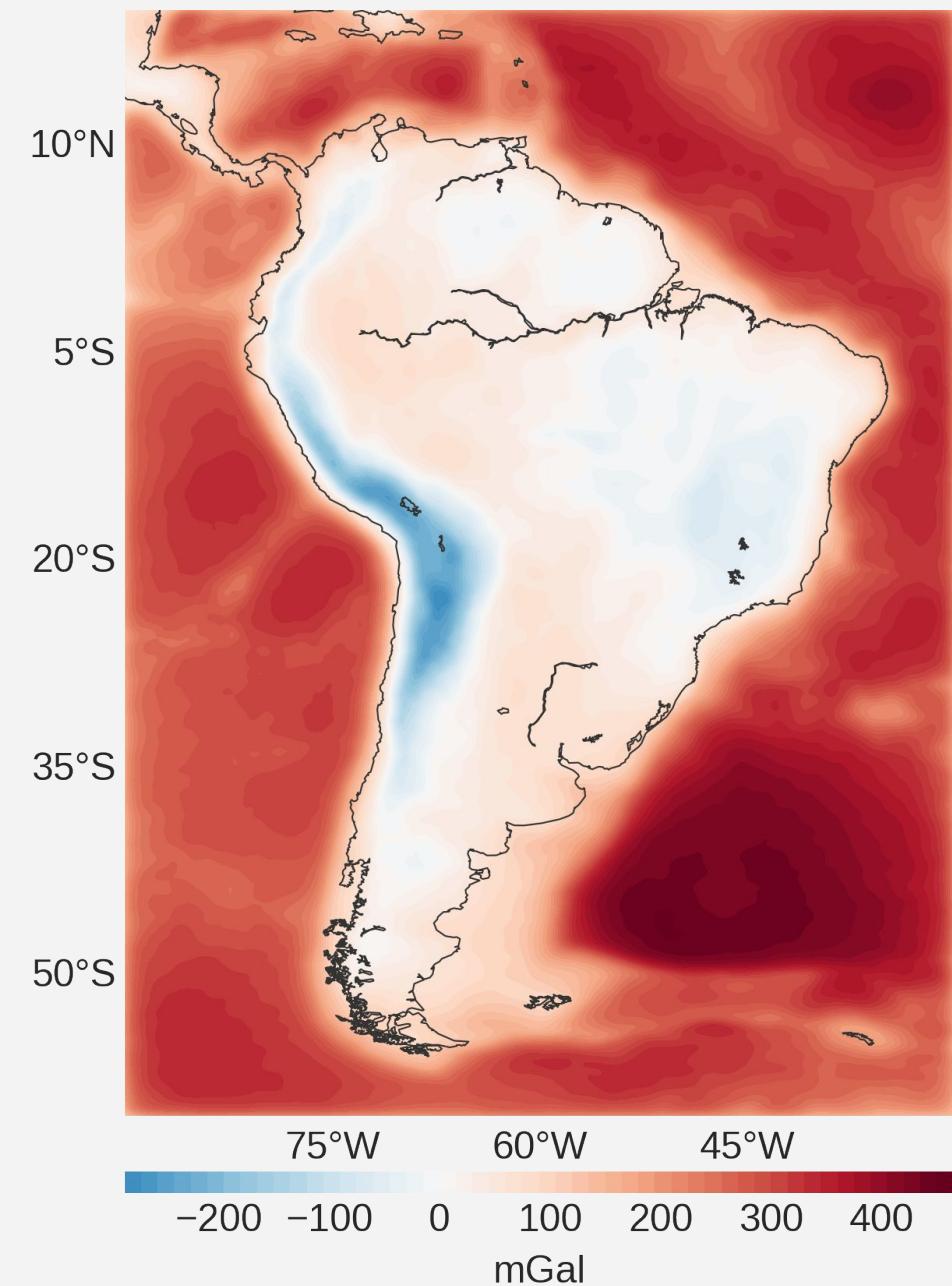




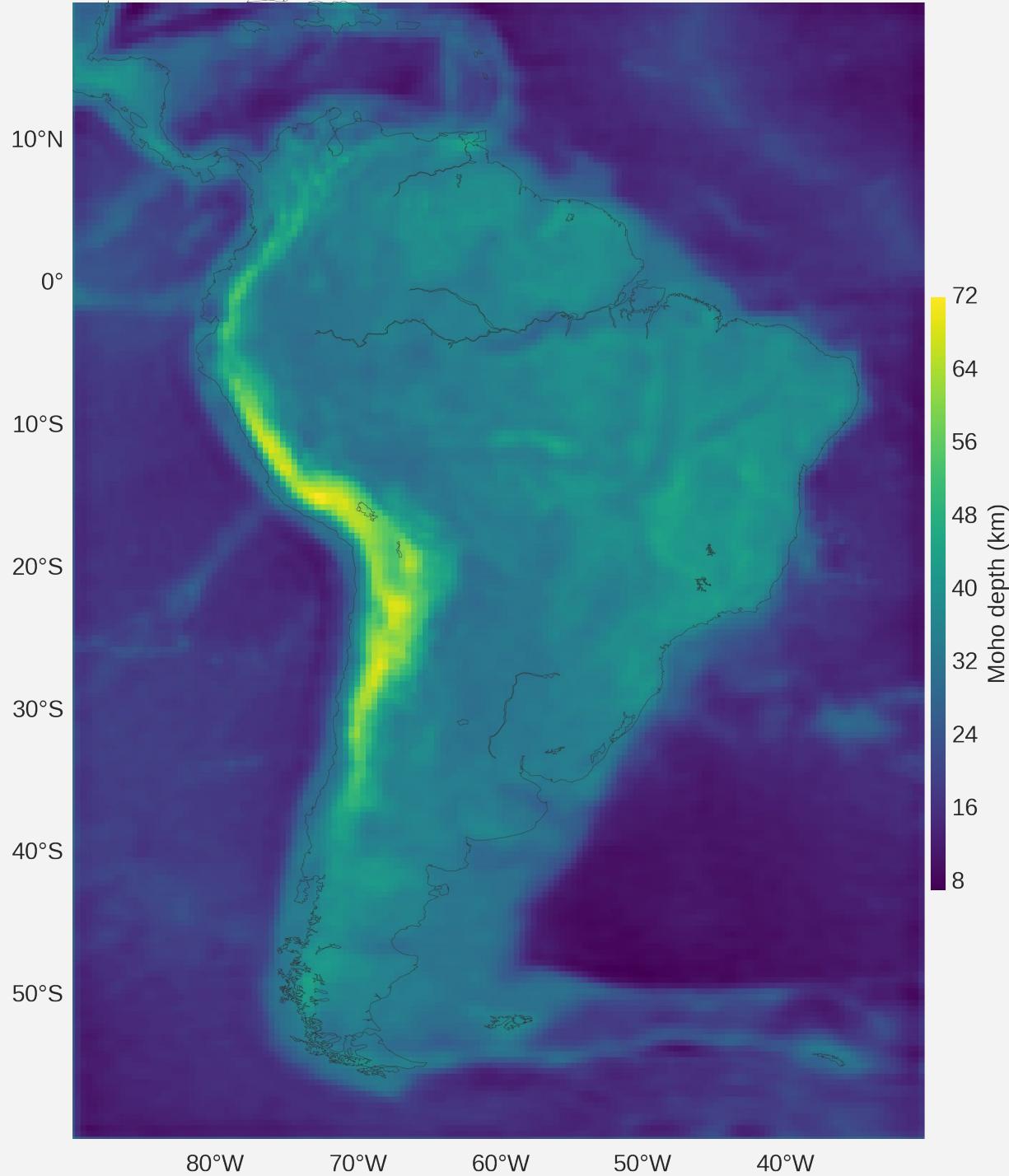
South America GOCO5S data

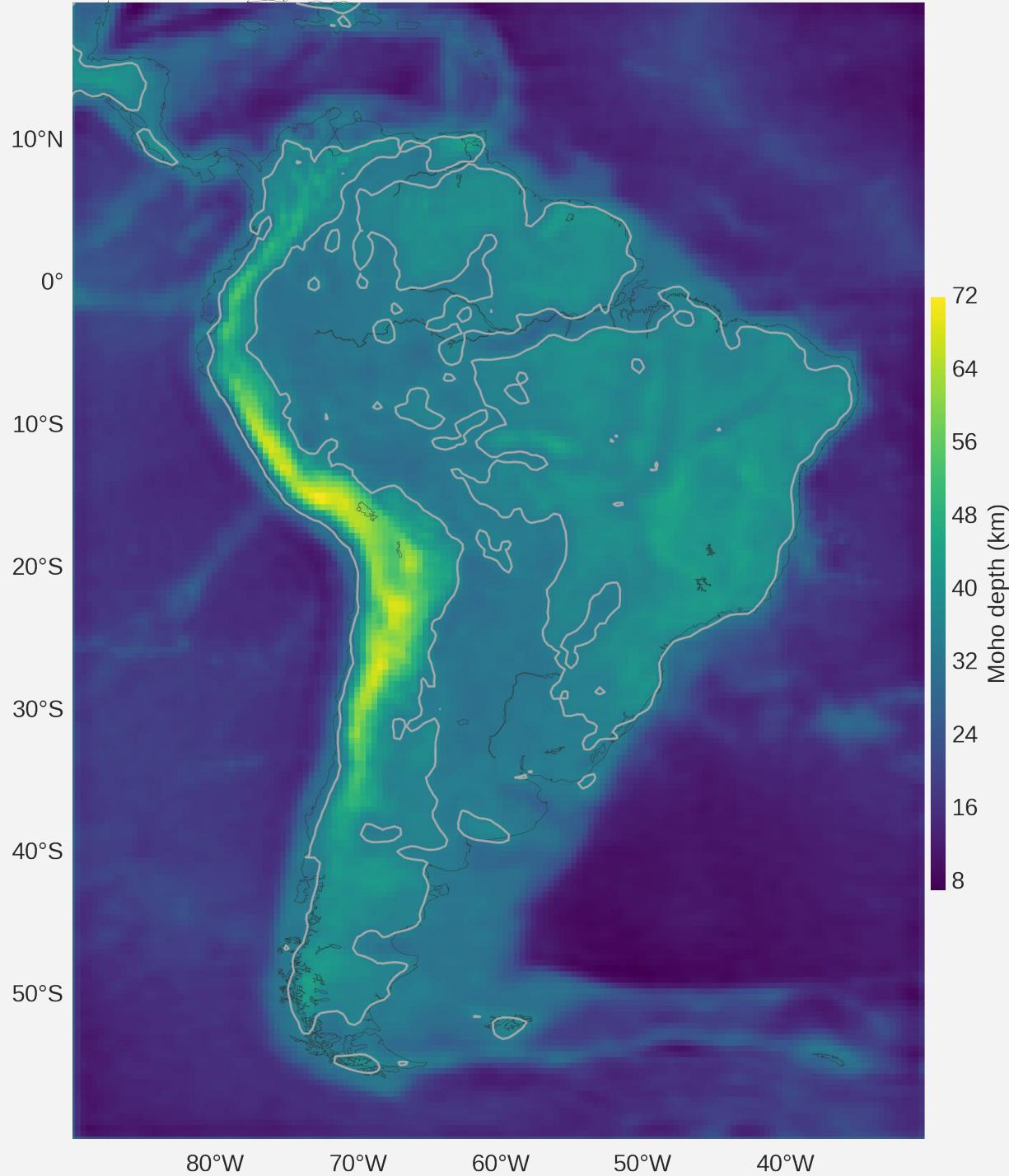
Mayer-Guerr et al. (2015)

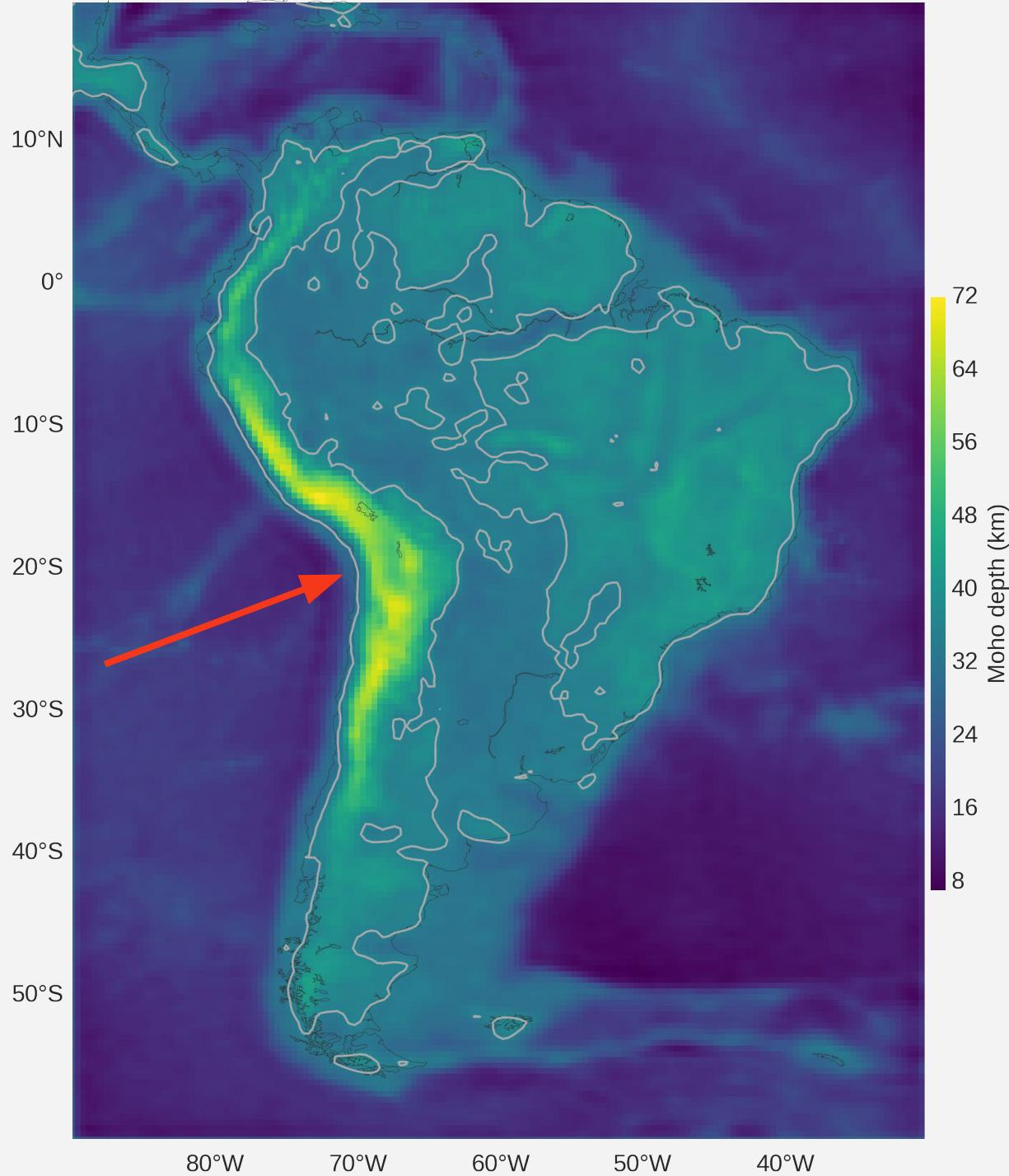


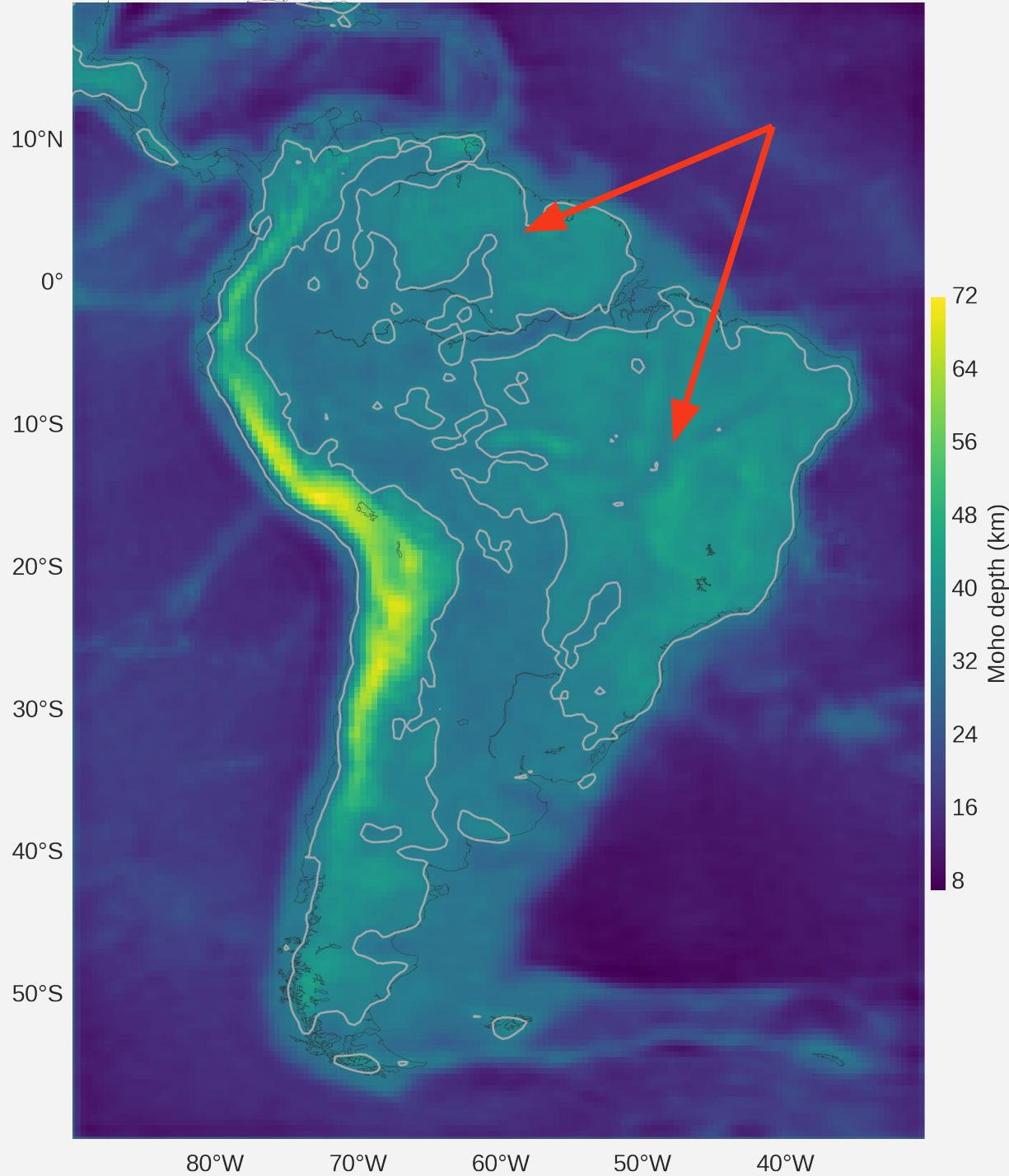


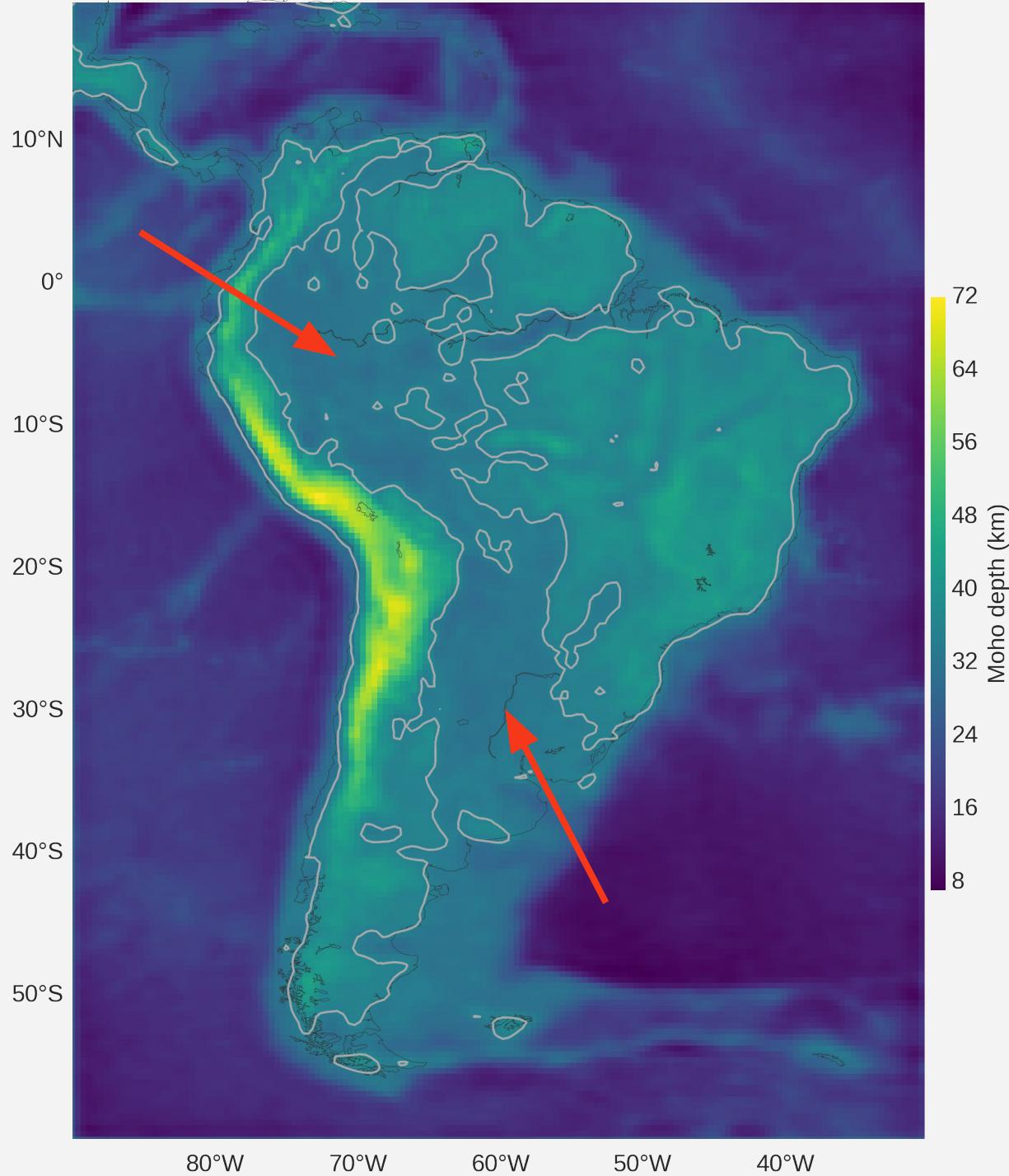
Assumpção et al. (2013)

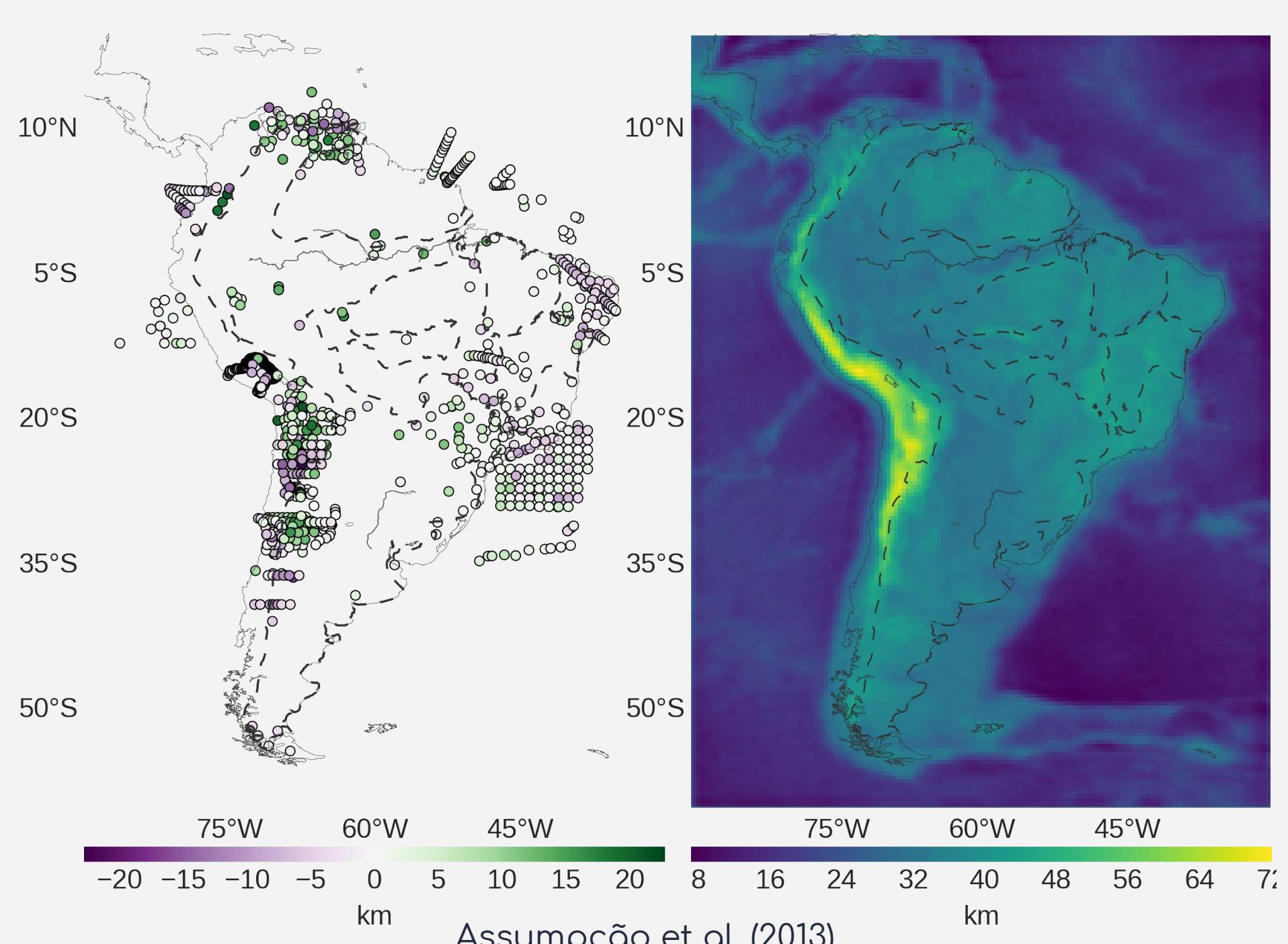


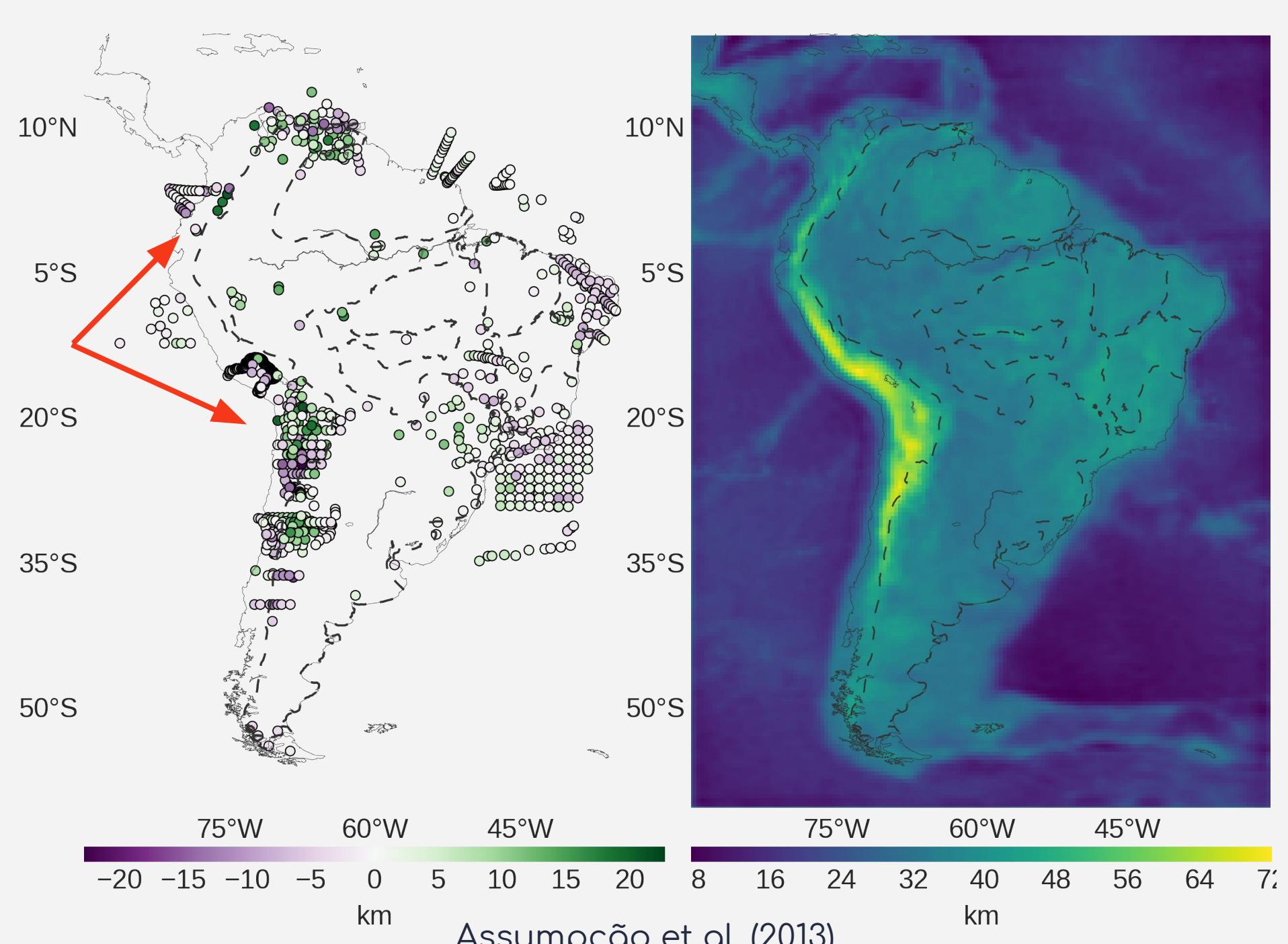


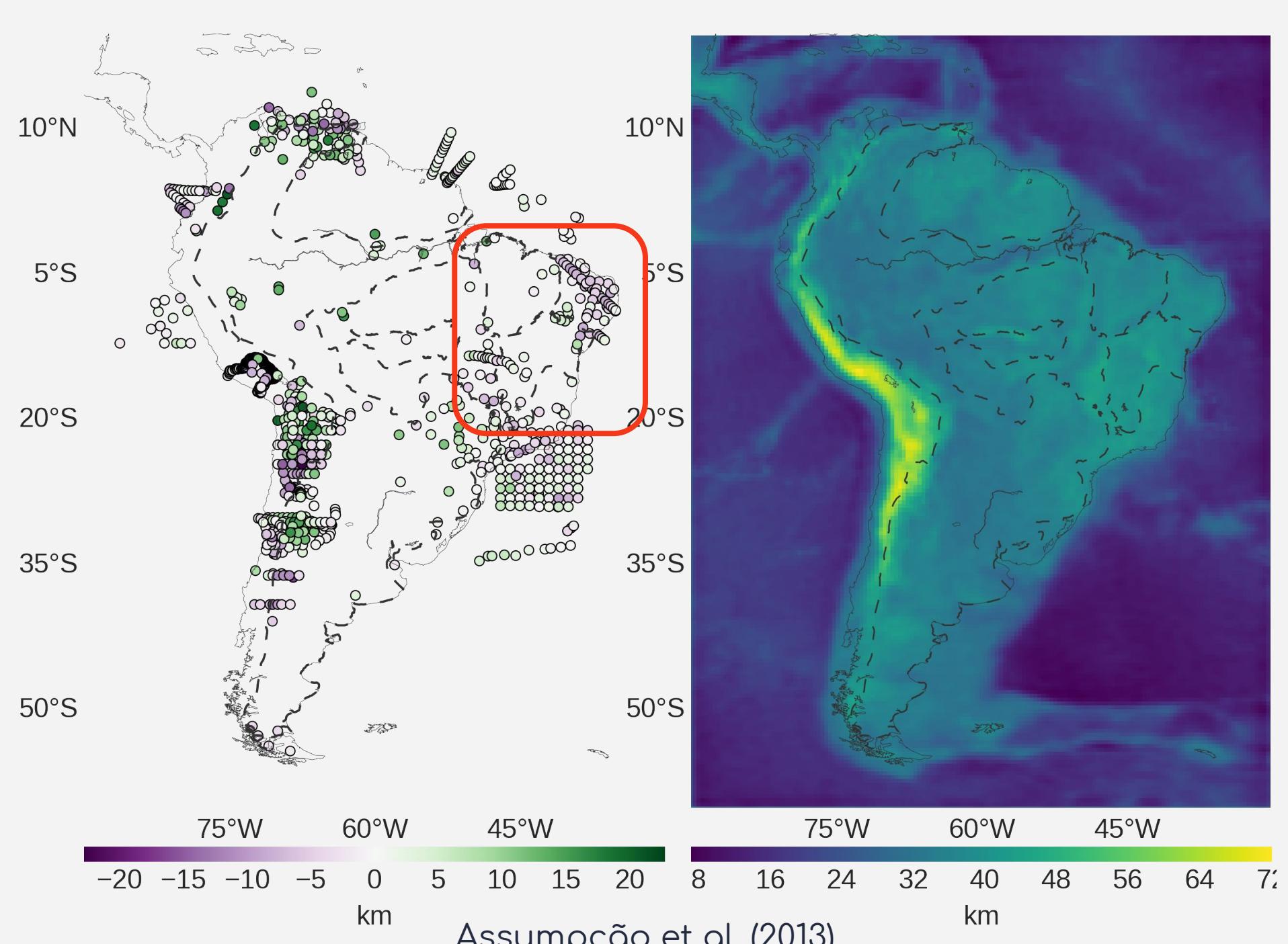


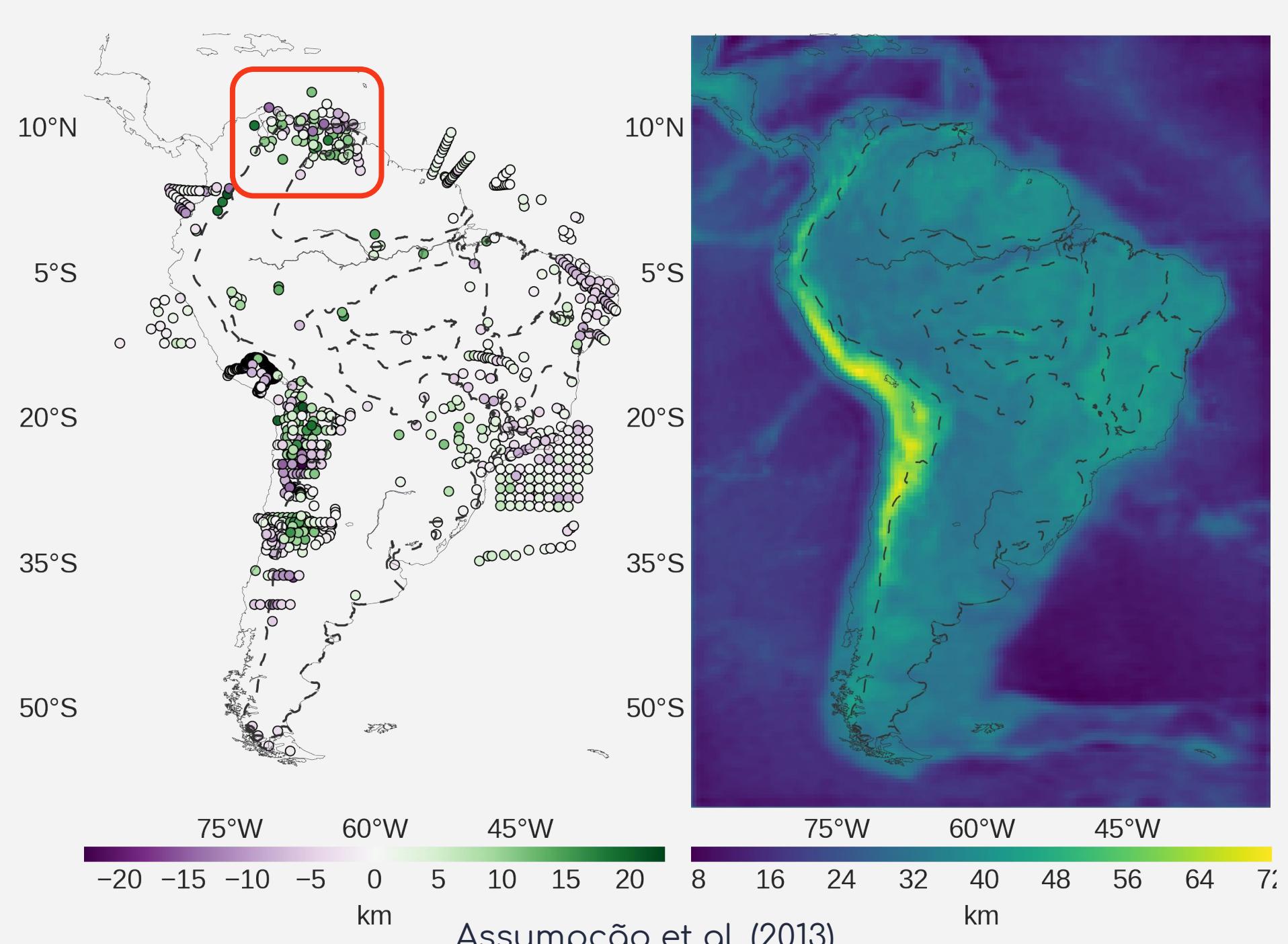


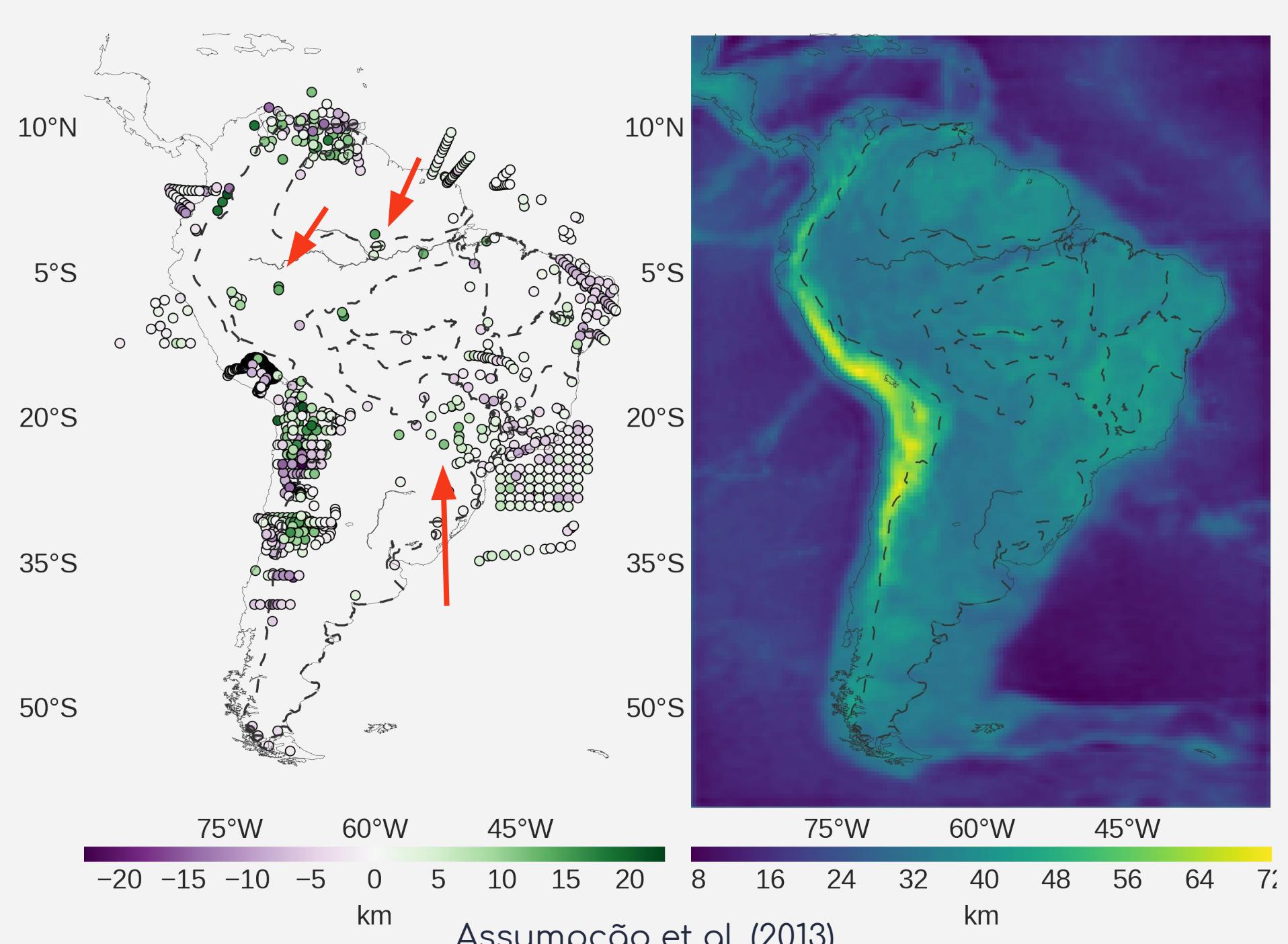












final
remarks

gravity
inversion
is hard

open

share

remix



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	code	Compliment and reorganize code README	5 months ago
	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
	.env	Environment file for autoenv	a year ago
	.gitignore	Simplify Makefile to make it run on windows	5 months ago
	LICENSE.md	Include binder figshare + personal site links	5 months ago
	README.md	Add publication doi	5 months ago
	environment.yml	Register exact versions of packages used	5 months ago
	screenshot-jupyter-notebook.png	Add a screenshot of the jupyter notebook	a year 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

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