# A - 140 Interdisciplinary 3D potential field modelling of complex lithospheric structures by IGMAS+

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GFZ Helmholtz Centre Potsdam · CAU Kiel University Christian-Albrechts-Universität zu Kiel · MB 4D Mountain Building Processes in 4D · AlpArray




## Abstract

We introduce an approach for 3D joint interpretation of potential fields and its derivatives under the condition of constraining data and information. The interactive 3D gravity and magnetic application IGMAS (Interactive Gravity and Magnetic Application System) has been around for more than 30 years, initially developed on a mainframe and then transferred to the first DOS PCs, before it was adapted to Linux in the '90s and finally implemented as a cross-platform Java application with GUI. Since 2019 IGMAS+ is maintained and developed in the Helmholtz Centre Potsdam – GFZ German Research Centre by the staff of Section 4.5 – Basin Modelling and ID2 – eScience Centre. The core of IGMAS+ applies an analytical solution of the volume integral for the gravity and magnetic effect of a homogeneous body. It is based on the reduction of the three-folded Integral to an integral over the bounding polyhedrons that are formed by triangles. Later the algorithm has been extended to cover all elements of the gravity tensor as well and the optimized storage enables fast least-squares inversion of densities and changes to the model geometry and this flexibility makes geometry changes easy. Because of the triangular model structure of model interfaces, IGMAS can handle complex structures (multi-Z surfaces) like the overhangs of salt domes and variable densities due to voxelization. To account for the curvature of the Earth, we use spherical geometries. Therefore IGMAS+ is capable to handle models from big-scale to regional and small-scale models (meters) used in Applied Geophysics.


## References and contacts


- Götze, H. J., & Lahmeyer, B. (1988). Application of 3D interactive modeling in gravity and magnetics. Geophysics, https://doi.org/10.1190/1.144254.
- Schmidt, S., Anikiev, D., Götze, H.-J., Gomez Garcia, À., Gomez Dacal, M. L., Meeßen, C., Plonka, C., Rodriguez Piceda, C., Spooner, C., Scheck-Wenderoth, M.: IGMAS+ – a tool for interdisciplinary 3D potential field modelling of Complex geological structures., EGU General Assembly 2020, doi.org/10.5194/egusphere-egu2020-8383,


**IGMAS+ Homepage:** https://www.gfz-potsdam.de/igmas


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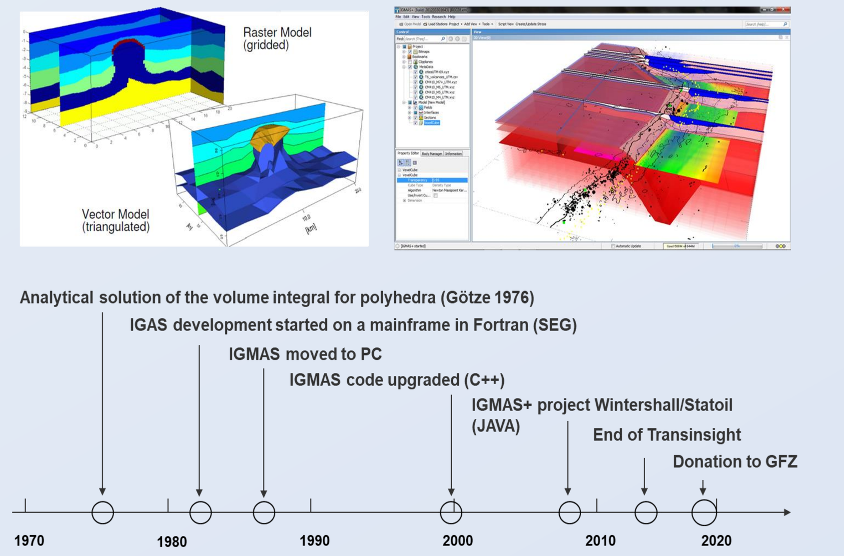
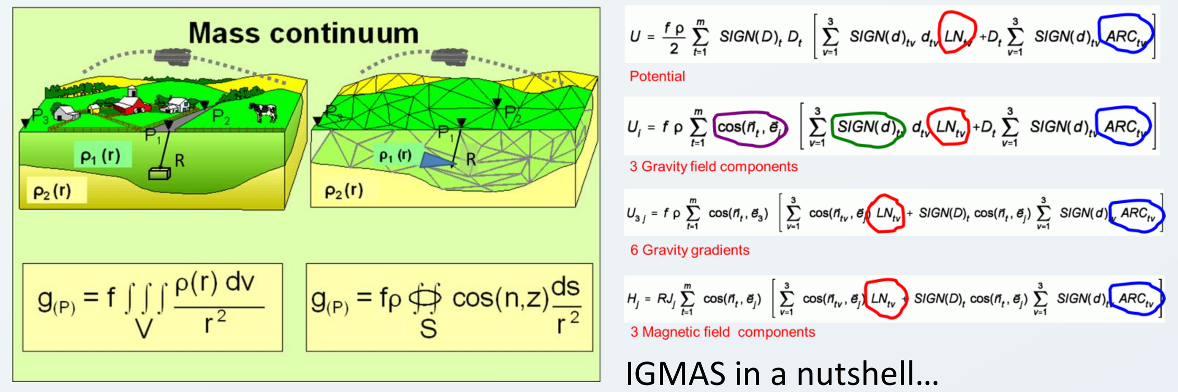
## The timeline of IGMAS+ development



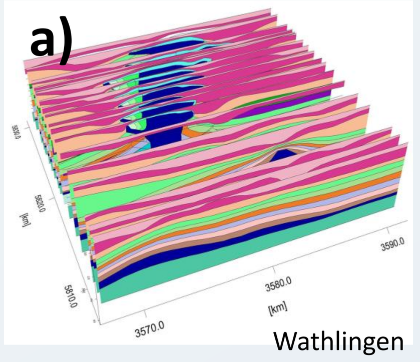



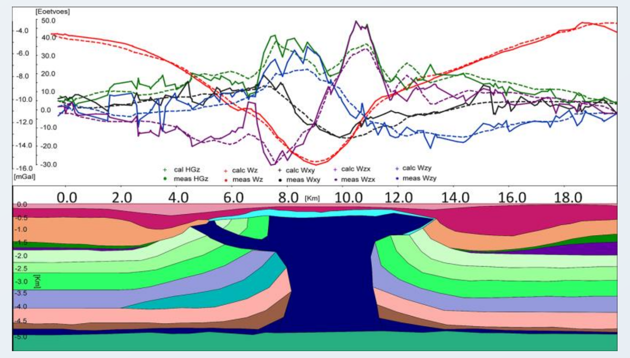
IGMAS in a nutshell...

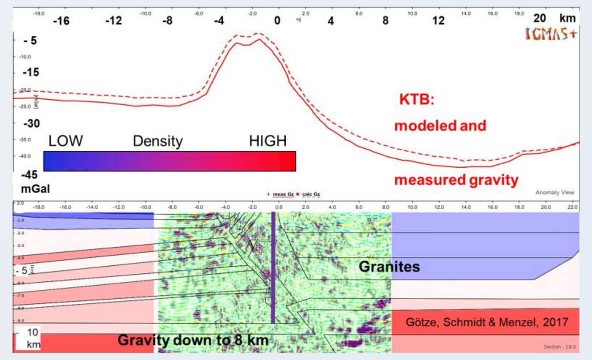
### *How to build up an IGMAS+ model:*

Depending on the user's objectives, there are basically three different ways of building up an initial 3D density/susceptibility model:

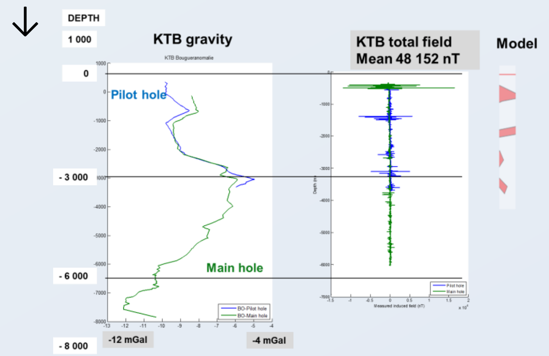
a) "Defining (vertical) sections" approach: Define working sections before loading or creating model vertices,
b) "Loading layers/interfaces/horizons" approach: Load point sets forming body interfaces before defining working sections and
c) "Loading a voxel cube" after defining the model space according (a) or (b)

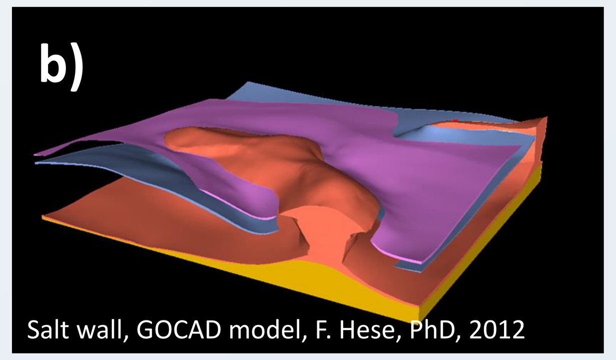


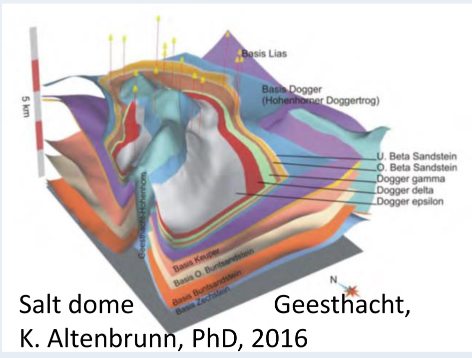






Borehole gravity & magnetics, KTB

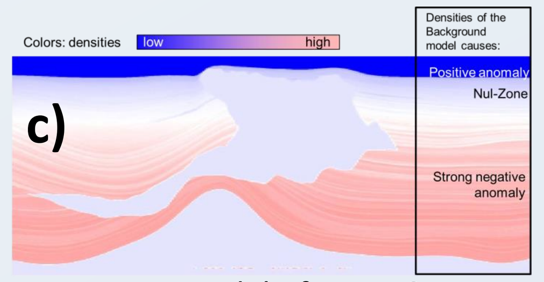


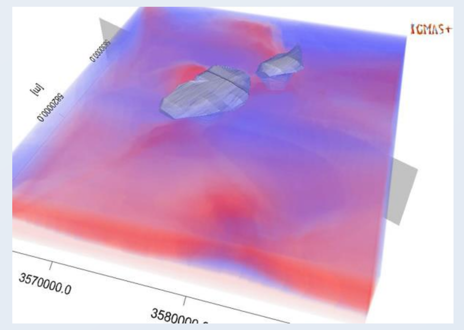




< Input of GOCAD models of NW German Basin.

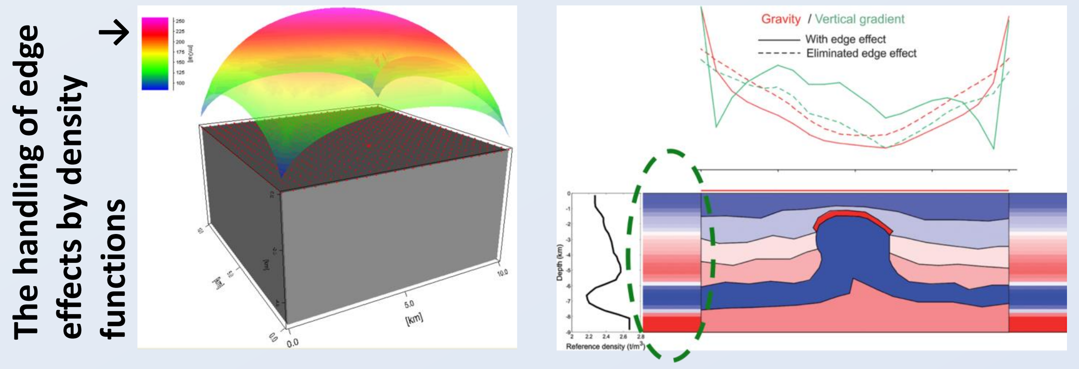
3D plot of a complex salt structure. >

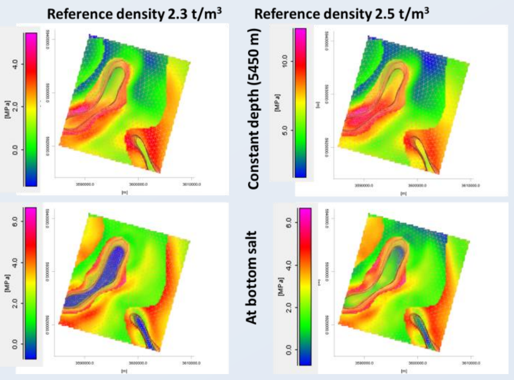


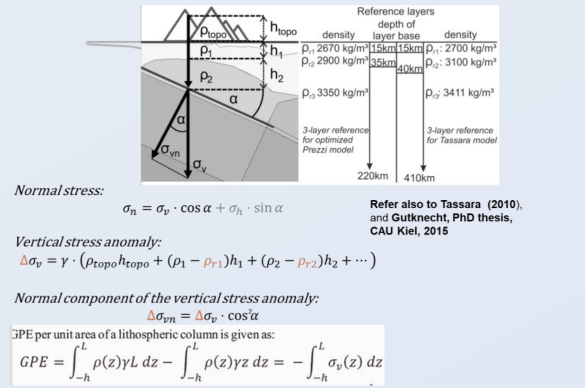



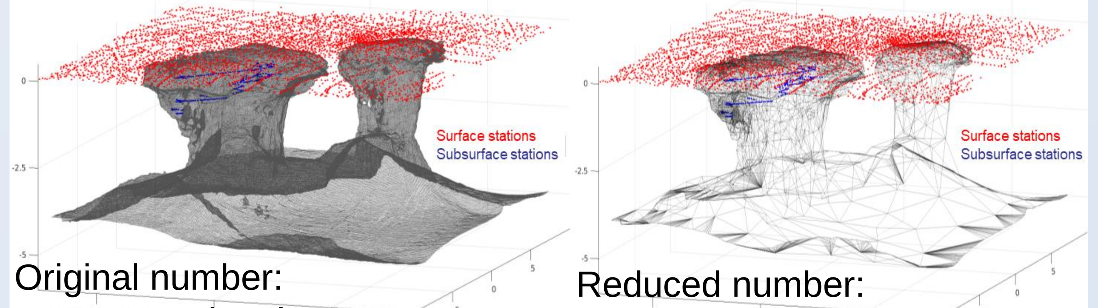
3D - SEAM model of EAGE & SEG

The complete 3D velocity model of the Gifhorn Trough – transferred into a 3D voxel density model which surrounds the fixed density polyhedron model of the salt dome. ↑




Original number: 370 000 triangles

Reduced number: 13 900 triangles

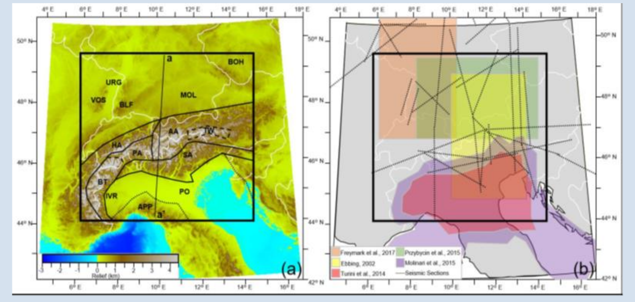
Parameter reduction: here reduction of triangles – without loss of gravity modelling precision which is smaller than 1 % ...

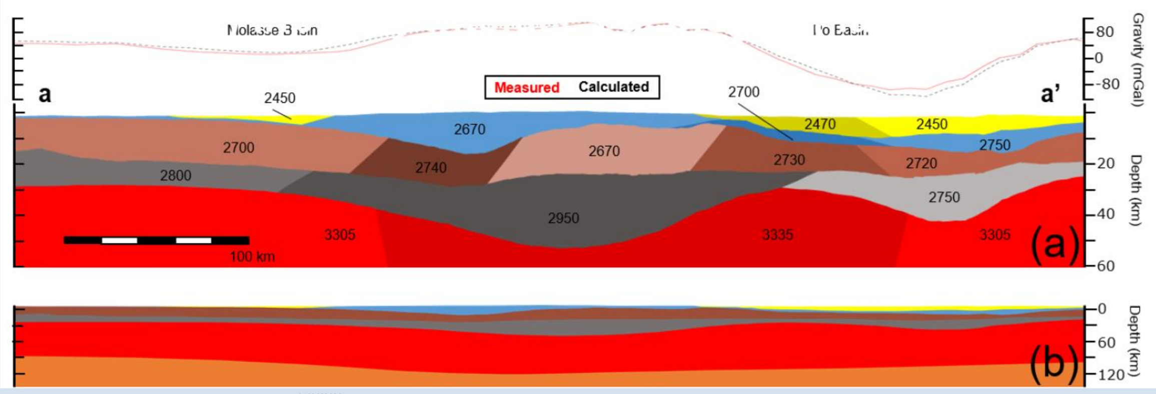
(P. Menzel, PhD 2016; Götze, Schmidt & Menzel, 2017)

Cameron Spooner et al. (2019):

N-S cross-section along approx. of 10° longitude of a constrained density model (AlpArray).

Reddish colors: Upper mantle

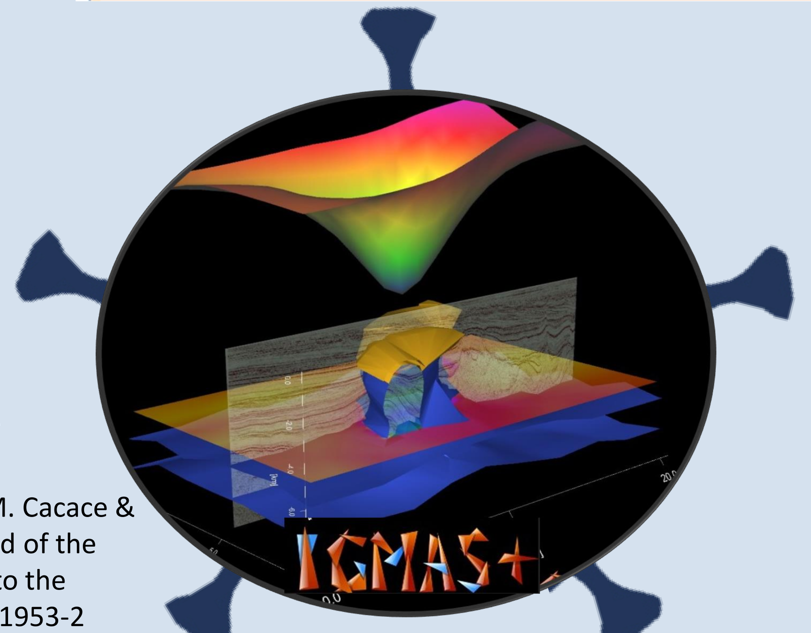




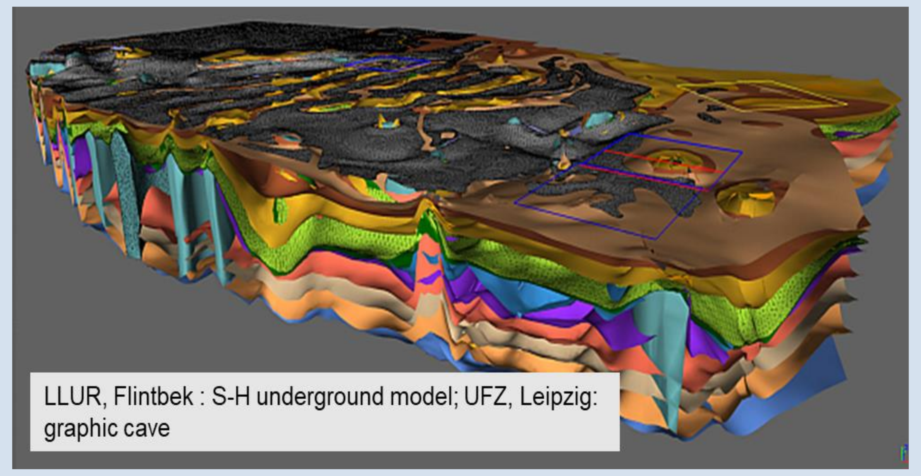

*Modelling the Alps*;
the density model served as input for 3D thermal modelling.

C. Spooner, M. Scheck-Wenderoth, M. Cacace, H.-J. Götze & E. Luijendijk (2020), https://doi.org/10.1016/j.gloplacha.2020.103288

Spherical modelling of the down going Pacific Plate, western South America

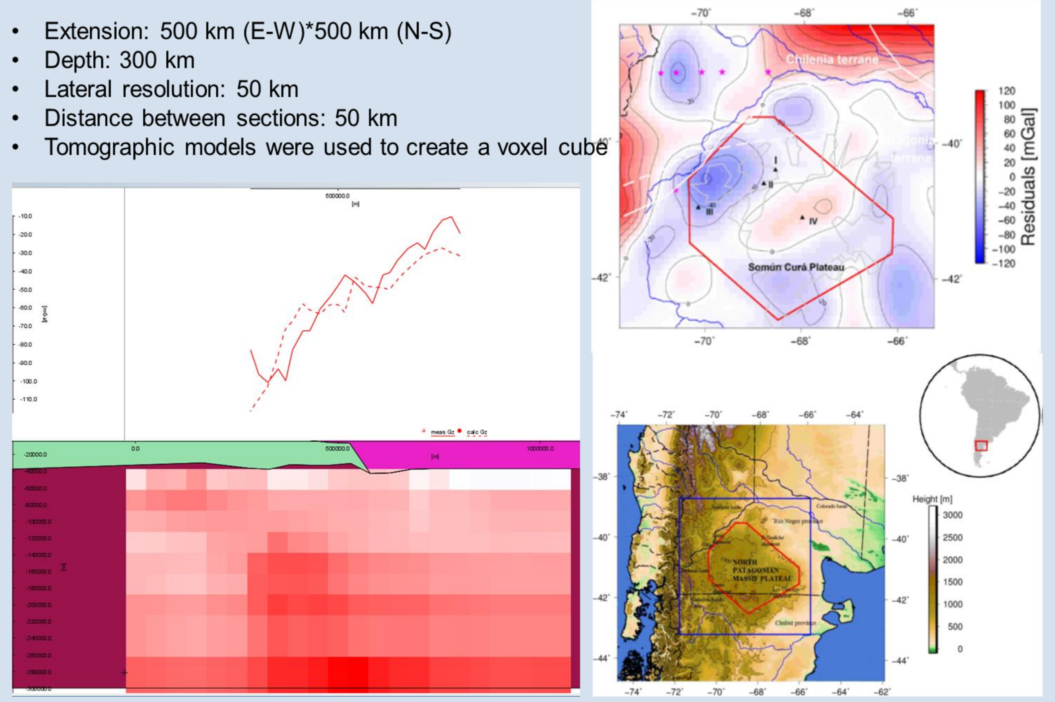
*Modelling the subsurface of Schleswig-Holstein*




*Modelling the North Patagonian Massif*

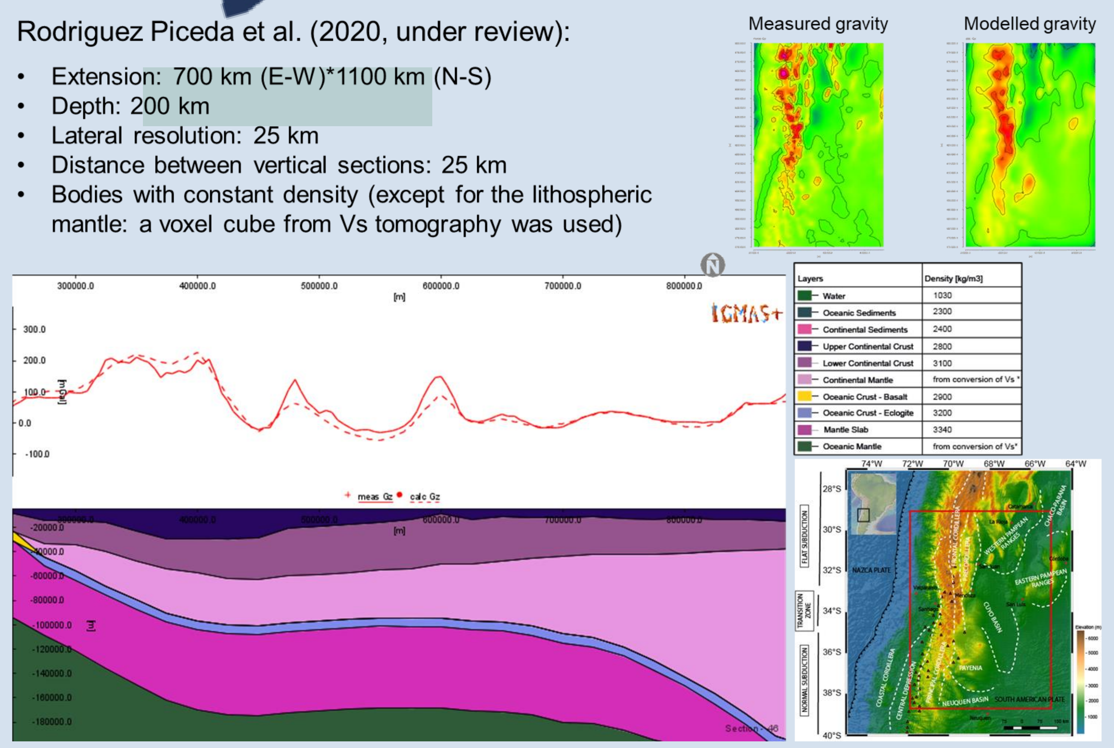
M.L. Gomez Dacal, M. Scheck-Wenderoth, E. Aragón, J. Bott, M. Cacace & C. Tocho (2020): Unravelling the lithospheric-scale thermal field of the North Patagonian Massif plateau (Argentina) and its relations to the topographic evolution of the area. Doi: 10.1007/s00531-020-01953-2
Structural model: GFZ Data Services, https://doi.org/10.5880/GFZ.4.5.2020.002

- Extension: 500 km (E-W)*500 km (N-S)
- Depth: 300 km
- Lateral resolution: 50 km
- Distance between sections: 50 km
- Tomographic models were used to create a voxel cube




Rodriguez Piceda et al. (2020, under review):

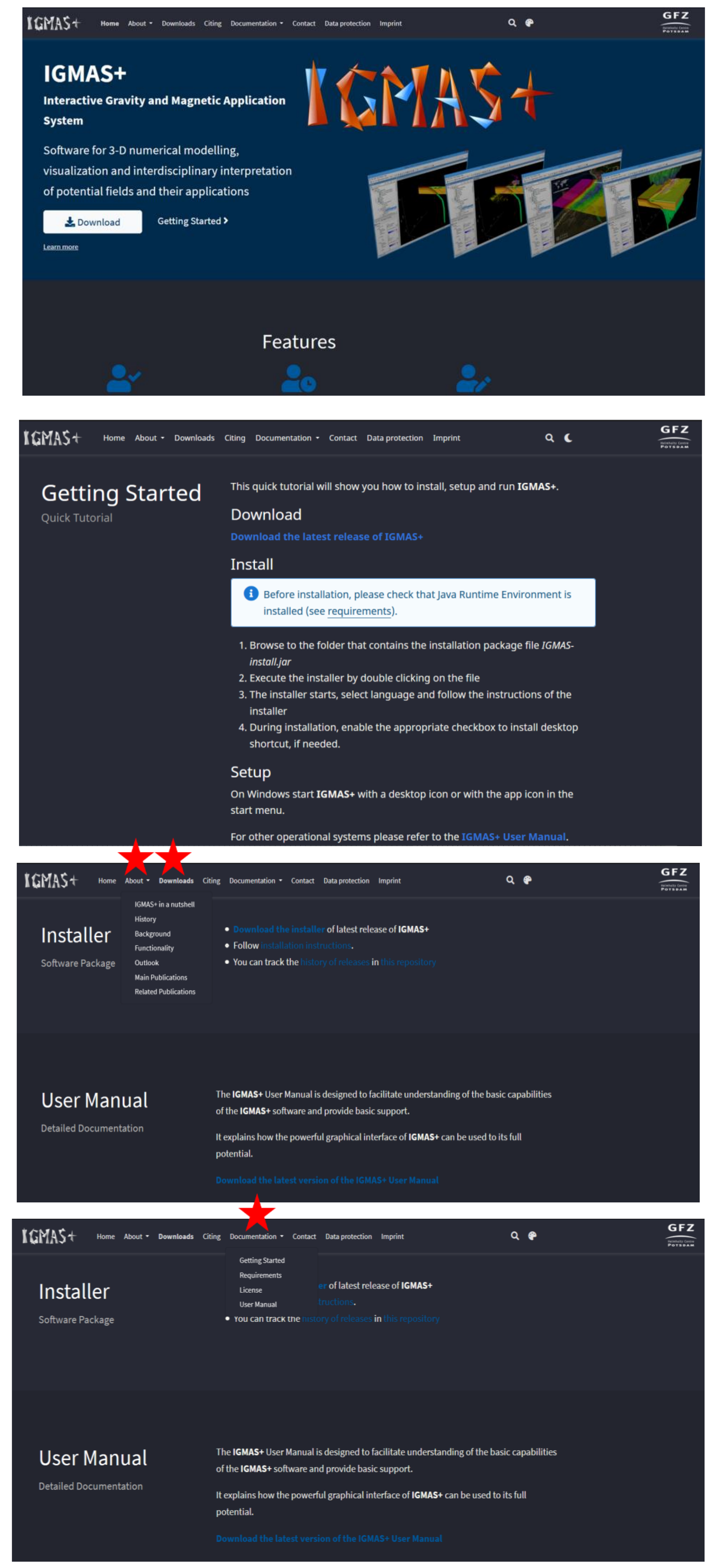
- Extension: 700 km (E-W)*1100 km (N-S)
- Depth: 200 km
- Lateral resolution: 25 km
- Distance between vertical sections: 25 km
- Bodies with constant density (except for the lithospheric mantle: a voxel cube from Vs tomography was used)




C. Rodriguez Piceda, M. Scheck Wenderoth, M. L. Gomez Dacal, J. Bott, C. B. Prezzi & M. R. Strecker (2020): Lithospheric density structure of the southern Central Andes constrained by 3D data-integrative gravity modelling. https://doi.org/10.1007/s00531-020-01962-1

## How to get access?

Software and manual are accessible through website




**Outlook:**

Interface to thermal modelling,
E.g. Spooner et al. https://doi.org/10.1016/j.gloplacha.2020.103288

Rock petrology
e.g. Wind (2015), Hagen (2021)

Uncertainty/sensitivity
RG F. Wellmann RWTH Aachen