3D crustal density investigation via Bayesian level-set inversion of Bouguer gravity: application to the western Alps (Europe)

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Résumé

The 3D western alpine crust presents a complex multi-scale structure, following the continental collision between the European plate and the Adria micro-plate. Outstanding geophysical anomalies, such as the Ivrea body, present mantle-like densities and seismic velocities up to few kilometers depth below the surface. In addition, mantle and lower crustal outcrops are exposed at the surface in the northern portion of the chain.
Aiming at closing in on the relation between surface geological and subsurface geophysical observations, we propose and apply new techniques to combine gravity and seismic data. We set up a Bayesian inversion of Bouguer gravity anomaly data (Zahorec et al. 2021), for the 3D distribution of density at crustal scales. We introduce prior information based on existing seismic tomography models (e.g. Nouibat et al. 2022), to guide the exploration of model geometries. We also use flexible physical constraints based on known ρ-vS conversion laws (e.g. Brocher 2005).

In particular, we implement a Markov chain Monte Carlo (McMC) algorithm. We adopt a level-set approach to parameterize 3D volumetric structures, exploiting prior crustal knowledge from tomographic models with a low number of parameters. The probabilistic approach allows to tackle the non-uniqueness of the gravity inversion problem and highlight existing trade-offs between model density and geometry.
We obtain a 3D density model for the western alpine crust, including the Ivrea body at the boundary between the European and Adriatic plates, allowing for quantitative comparison with local seismic tomography models. We also observe heterogeneous agreement among gravity and seismic data constraints along the alpine arc, allowing to target and foster future geophysical investigations for the understanding of the western Alps.

Mots-Clés: Continental collision, Ivrea body, Bouguer gravity anomaly, Bayesian inversion, Crustal structure, Density, Alps

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