EGU2020-13978, updated on 29 Oct 2020
https://doi.org/10.5194/egusphere-egu2020-13978
EGU General Assembly 2020

Bayesian joint inversion of muographic and gravimetric data for the 3D imaging of volcanoes, case study of the Puy de Dôme

Anne Barnoud[1,2], Valérie Cayol[1], Peter Lelièvre[3], Valentin Niess[2], Cristina Cârloganu[2], and Eve Le Ménédeu[2]
[1]Université Clermont Auvergne, CNRS, IRD, OPGC, Laboratoire Magmas et Volcans, F-63000 Clermont-Ferrand, France (anne.barnoud@uca.fr)
[2]Université Clermont Auvergne, CNRS/IN2P3, LPC, F-63000 Clermont-Ferrand, France
[3]Memorial University of Newfoundland, St. Johns, Newfoundland and Labrador, A1B 3X5, Canada

We present a method to jointly invert muographic and gravimetric data to infer the 3D density structure of volcanoes.

Muography and gravimetry are two independent methods that are sensitive to the density distribution. The gravimetric inversion allows to reconstruct the 3D density variations but the process is well-known to be ill-posed leading to non unique solutions. Muography provides 2D images of mean densities from the detection of high energy atmospheric muons crossing the volcanic edifice. Several muographic images can be used to reconstruct the 3D density distribution but the number of imagdes is generally limited by instrumentation and field contstraints.

The joint inversion of muographic and gravimetric data aims at reconstructing the 3D density structure of an edifice, benefiting from the advantages of both methods. We developed a robust inversion scheme based on a Bayesian formalism. This approach takes into account the data errors and a priori information on the density distribution with a spatial covariance so that smooth models are obtained. The a priori density standard deviation and the spatial correlation length are the two hyperparameters that tune the regularization, hence that control the inversion result. The optimal set of hyperparameters is determined in a systematic way using Leave One Out (LOO) and Cross Validation Sum of Squares (CVSS) criteria (Barnoud et al., GJI 2019). The method also allows to automatically determine a constant density offset between gravimetry and muography to overcome a potential bias in the measurements (Lelièvre et al., GJI 2019).

The case of the Puy de Dôme volcano (French Massif Central) is studied as proof of principle as high quality data are available for both muography (Le Ménédeu et al., EGU 2016; Cârloganu et al., EGU 2018) and gravimetry (Portal et al., JVGR 2016). We develop and validate the method using synthetic data computed from a model based on the Puy de Dôme topography and acquisition geometry, as well as on real data.