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Density Imaging of Puy de Dôme Volcano with Atmospheric Muons in French Massif Central as a Case Study for Volcano Muography

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High energy atmospheric muons have high penetration power and are naturally present in the Earth atmosphere, rendering them appropriate for geophysical studies. The atmospheric muon flux transmittance through an edifice can be measured with muon telescopes deployed at various distances from the target (up to few kilometres). From this measurement a radiographic (2D) image of the edifice density structure can be inferred provided that high energy, ballistic muons can be efficiently selected among all the charged particles measured by the telescopes [F Ambrosino et al., 2015] .

The muography is potentially a high resolution imaging (better than 10 mrad x10 mrad) though the angular resolution is artificially degraded in order to preserve the resolution of the density measurement. Indeed, larger the imaged depth, higher the minimal energy of the muons that can be used is. The atmospheric muon flux falling rapidly with muon energy and the density measurement being driven by the number of muons recorded, the telescopes need to acquire data over very long time periods or, conversely, the measurements need to be averaged over larger solid angles.

This contribution presents the first muographic imaging of Puy de Dôme obtained with data taken from several locations between 2013 and 2018. The data sets obtained from both surface and underground sites and with telescopes operated in different modes allow a robust validation of the methodological aproach used to reconstruct the densities from the muon counts (muographic inverse problem, Niess el al, 2018). The main uncertainties affecting the measurement are discussed. They are mainly linked to the telescope working performance and to residual contamination of the data with non ballistic muons, but uncertainties on the atmospheric muon flux and muon transport model through the edifice play also a role.

Different geological models of the volcano were tested in a robust way, independently of any ill posed tomographic reconstructions. A 3D reconstruction can also be attempted through a 3D joint inversion [A Barnoud et al, 2018, P Lelièvre et al. 2018] of the muographic and gravimetry data [Portal et al, 2016].

Ambrosino, F., et al. (2015), Joint measurement of the atmospheric muon flux through the Puy de Dôme volcano with plastic scintillators and Resistive Plate Chambers detectors, J. Geophys. Res. Solid Earth, 120, doi:10.1002/2015JB011969
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