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Including magnetotelluric data into multi-observable probabilistic inversion: implications for the physical state and water content of the continental lithosphere

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Multi-observable probabilistic inversion [e.g. 1,2,3] is providing new insights into the physicochemical structure of the lithosphere and its complex interaction with the underlying convecting upper mantle. Of particular importance is the inclusion of 3D magnetotelluric (MT) data into the joint inversion, as it provides complementary information not only on the thermal structure but also on water content and fluid pathways, which are difficult to constrain with other observables. MT holds, therefore, great potential for understanding and imaging the complex fluid-rock interactions responsible for mineralization events due to its sensitivity to water and other volatiles. However, in order to isolate the effect of fluids from other potential compositional and thermal "background" effects, MT data needs to be informed by other data sets such as seismic and gravity data.

In order to implement MT data into multi-observable probabilistic inversions for the 3D imaging of deep thermo-chemical anomalies and fluid pathways in the Earth, we first need to solve the problem of computational efficiency in solving Maxwell's equations in 3D in a probabilistic way. For this, we combine state-of-the-art probabilistic inversion methods, parallel MT solvers [4] and advanced reduced order modelling techniques to obtain fast, yet accurate, solutions to both the MT inversion and the full 3D joint inversion problem, which typically includes the solution of seismic, gravity, heat transfer, and mantle convection forward problems [e.g. 3]. Such a probabilistic formalism offers a natural framework to assess non-uniqueness and uncertainties affecting the inversion, which are otherwise hard to quantify using traditional inversion methods.

In this contribution we report on recent progress made towards the above goals, including thorough benchmarks, illustrative examples and preliminary results of a case study. These results indicate that a conceptual and numerical platform capable of including 3D MT data into multi-observable probabilistic inversions is a reachable aim.

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