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Massive joint inversion of seismological and gravity data on multi-core processors

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In order to obtain accurate and reliable estimation of the major lithological properties of the rocks within a studied volume, geophysics uses the joint information provided by different geophysical data sets (gravimetric, magnetic, seismic, etc.). The representation by probability density functions (pdfs) of the different types of information entering the problem may provide the mathematical framework to formulate their combination. The resulting joint posterior pdf is composed of two factors: the joint likelihood function, which is the product of independent likelihood functions associated with each geophysical data set, and the joint prior pdf (JPD). The Maximum Likelihood Estimator of the JPD leads to the solution of the problem. Nevertheless, one key problem appear to limit the use of this solver to an extensive range of real applications: information coming from potential fields which implies the presence of dense matrices into the resolving estimator. It is well known that dense matrix systems challenge rapidly both the algorithms and the computing platforms and are not suited to high resolution 3D geophysical analysis. In this paper we show how we parallelize our code and obtain fast and reliable solution of the JPD in presence of large data-sets and information coming from potential fields (e.g. the gravity field). Analysis of the correctness of results and performance on different parallel environments show the portability and the efficiency of the code. The code is applied to a real experiment, where we succeed in recovering a 3D density distribution within the crust and upper mantle, beneath the European continent, constrained by both seismological and gravity data.