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Three-dimensional spectral element modelling of gravity anomalies in the Pyrenees and Southwest Europe using seismic constraints, dense ground arrays and GOCE satellite gravity data

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The ultimate goal of lithosphere imaging is to jointly constrain densities and seismic wave velocities (P and S) with a fine resolution to get insights into the composition and thermal state of the lithosphere. In this perspective we have developed forward modeling and inversion methods based upon the spectral-element method to handle gravity and full waveform data. One of the main advantage of these methods is that they can handle the topography of the free surface in the same spectral-element distorted mesh that is used to solve the wave equation, without performing extra interpolations between different grids and models. This procedure opens the possibility to invert both teleseismic and gravity data on the same finite-element grid. We present here a model of gravity anomalies (free air, complete Bouguer and isostatic anomalies) computed at the scale of southwest Europe with a resolution of 1 mn. We use models ETOPO1 and $ETOPO_2$ for topography/bathymetry and the WGS84 reference ellipsoid for the curvature of the Earth. The topography is described with a non-regular spectral-element distorted mesh. The computational domain covers a region of [-15°, 15°]x[32°,56°], from North Africa to northern France, and from the Atlantic ocean to the eastern Alps. On the continent we use 364 000 gravity measurements randomly distributed in France and Spain. They are complemented by GOCE satellite data and DTU15 marine gravity data in the mediterranean sea and the Atlantic ocean. Different Moho compensation depths varying from 30 km to 50 km are considered for the computation of isostatic anomalies. Gravity disturbances and free-air anomalies are mainly driven by the topography effects and compare well to BGI/Bureau-gravimétrique international gravity anomalies computed by numerical integration with spherical harmonics. In the context of the OROGEN project, we also performed a 3D modelling of gravity anomalies at the scale of the Pyrenees. The map of isostatic anomalies emphasizes the short wavelength density anomalies, revealing the non-cylindrical architecture of the Pyrenees.