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Modeling and Inversion of three-dimensional crustal structures beneath the Pyrenees and their foreland basins based upon geological, gravimetric and seismological data

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Our goal is to obtain a three-dimensional (3D) model of mass density and seismic velocities beneath the Pyrenees and their foreland basins (Aquitaine and Ebro basins), which accounts for all the geological and geophysical information available for that region. This model covers the whole mountain range going from the Atlantic Ocean to the Mediterranean Sea, and from the Iberian range to the Massif Central. The model is described by different units: the lower, middle, and upper crusts, the accretionary prism, and the consolidated and unconsolidated sediment layers. Furthermore, a sub-continental, serpentinized European mantle is introduced to describe the exhumed mantle bodies which are responsible for the positive Bouguer gravity anomalies in the western Pyrenees.
We build a first 3D model using all the geological information: drill-hole surveys, seismic sections, and the geological map. We use the potential field method implemented in Geomodeler to interpolate these geological data. However, these data are too sparse to build a model that explains seismic travel times or gravimetric data, especially the Labourd and the St. Gaudens Bouguer gravity anomalies. In addition, inconsistencies between the different data sets exist. We thus add by trial and error additional data points, comparing modeled and observed Bouguer gravimetric anomalies. The result of this procedure is a 3D geological model that respects the geological data and explains the measured Bouguer gravimetric anomalies.
In a second step, we use this model to determine the average density and seismic velocities inside each geological unit assuming uniform layers. To constrain the seismic velocities we use travel time picks extracted from the bulletin of the Pyrenean seismicity released by the Observatoire Midi Pyrenées.
In a third step, we use this 3D a priori model in a Monte Carlo inversion to invert jointly gravimetric data and seismic travel times from the bulletin. This probabilistic approach yields detailed information about the sedimentary foreland basins and the crustal structures beneath the Pyrenees.
We will present and discuss different key steps of the construction of the 3D model of the Pyrenees. We will also compare selected cross-sections extracted from this model to the ECORS profiles, as well as CCP stacks of receiver functions along several PYROPE transects.

Keywords: Pyrenees, 3D modeling, gravity, seismic tomography, joint inversion