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Resolvability of regional density structure and the road to direct density inversion - a principal-component approach to resolution analysis

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Lateral density variations are the source of mass transport in the Earth at all scales, acting as drivers of convective motion. However, the density structure of the Earth remains largely unknown since classic seismic observables and gravity provide only weak constraints with strong trade-offs. Current density models are therefore often based on velocity scaling, making strong assumptions on the origin of structural heterogeneities, which may not necessarily be correct.

Our goal is to assess if 3D density structure may be resolvable with emerging full-waveform inversion techniques. We have previously quantified the impact of regional-scale crustal density structure on seismic waveforms with the conclusion that reasonably sized density variations within the crust can leave a strong imprint on both travel times and amplitudes, and, while this can produce significant biases in velocity and Q estimates, the seismic waveform inversion for density may become feasible.

In this study we perform principal component analyses of sensitivity kernels for P velocity, S velocity, and density. This is intended to establish the extent to which these kernels are linearly independent, i.e. the extent to which the different parameters may be constrained independently. We apply the method to data from 81 events around the Iberian Penninsula, registered in total by 492 stations. The objective is to find a principal kernel which would maximize the sensitivity to density, potentially allowing for as independent as possible density resolution.

We find that surface (mosty Rayleigh) waves have significant sensitivity to density, and that the trade-off with velocity is negligible. We also show the preliminary results of the inversion.