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Quantifying uncertainty in velocity models for seismic imaging using a Bayesian approach with application to the Mentelle Basin - Australia

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Determining the depths of key horizons from seismic reflection data is one of the most important aspects of exploration geophysics. Here, we present Bayesian methods based on an elicitation tool and Gaussian processes to build a detailed and robust velocity model of the Mentelle Basin, located south west of Australia, with the ultimate goal to identify possible drilling targets for the Integrated Ocean Drilling Program (IODP).

The Mentelle Basin is a deep water sedimentary basin located between the Naturaliste Plateau and the southern part of the Western Australian Shelf. It is among the few regions of the world where we can investigate the effects of the Cretaceous hot-house and its collapse at high latitude. The Mentelle Basin hosts a continuous shale sequence for this period that it is over a kilometer thick, the study of which, is crucial for the correlation between the paleoclimate conditions and the tectonic history of the region.

By reprocessing 2D multichannel seismic reflection profiles around the proposed drill - sites, we create a detailed subsurface velocity model which is used as a priori input to the Bayesian approach. The final goal is to build a multi-layered model to estimate the depth and the root mean square velocity of each layer, both for the isotropic and anisotropic cases in terms of a multivariate posterior distribution. Having determined the RMS velocities for each layer, we can calculate, by inference, their interval velocities and finally estimate the depth of each sequence of interest with improved accuracy.

The key advantage of the Bayesian approach and the major difference compared to the traditional semblance spectrum velocity analysis procedure is the calculation of uncertainty of the output model. As a result, our statistical approach can construct a robust velocity model which encompasses the noise and the band-limited nature of the data as an error function. We use this model to control the depth migration of the seismic data and estimate the depths and its uncertainty to the drilling targets.