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A Bayesian transdimensional algorithm for earthquake location and 1D velocity model determination

P. Arroucau (1), J. Davies (1), T. Bodin (2), M. Sambridge (3), and G. Vlahovic (1)

(1) Center for Research Excellence in Science and Technology, North Carolina Central University, Durham, NC, United States, (2) Berkeley Seismological Laboratory, U.C. Berkeley, Berkeley, CA, United States, (3) Research School of Earth Sciences, The Australian National University, Canberra, ACT, Australia

Routinely used earthquake location algorithms generally rely on linearized inverse approaches in which the objective function measuring the distance between observed and calculated arrival times is minimized through an iterative procedure with a fixed 1D velocity model. Here, we present a Markov chain Monte Carlo (MCMC) inversion scheme to address the problem of jointly inverting for both hypocentre and 1D velocity model parameters from P- and S-wave arrival time observations. MCMC algorithms offer an interesting alternative to linearized methods as they sample the parameter space according to the posterior probability distribution, without any need for regularization, by combining a priori information with the information contained in the data. Such algorithms also have the property of showing no dependence on the initial model configuration and are furthermore well known to provide more realistic estimates of the parameter variance and covariance. A feature of our algorithm is that, besides P- and S-wave velocity values in each layer, the number of layers itself, as well as their respective thicknesses, are also considered as unknowns and inverted for in the procedure. This is achieved by means of transdimensional partition modelling and yields a parsimonious solution whose complexity (the number of layers in the model) is driven by the data and their associated uncertainties. Such an algorithm can be useful to analyse observations from temporary arrays deployed in regions where little is known about the velocity structure, and can also be used to determine 1D velocity models for 3D tomographic inversion.