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Quantifying the effects of uncertainty and prejudice in seismic velocity models

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All real data are subject to measurement uncertainty caused by a range of issues including bandwidth, resolution and ambient noise. Equally data are normally incomplete due to sparse sampling and inherent null space in the technique. For a given dataset, we generate a model or interpretation that satisfies what data we have by trading uncertainty, introducing prior information and applying prejudice to drive the model in the direction to satisfy our scientific objective (hypothesis testing). The resulting scientific paper presents the data, the model and the hypothesis, but issues on the reliability are typically limited or, worse still, completely ignored. In this paper I use seismic refraction and reflection data to derive a velocity model of the Earth's crust and upper mantle using tomography. I then use the Metropolis method as a means to evaluate how uncertainty and prejudice colour that interpretation by examination of the posterior distribution. Simple measures of misfit (chi-squared) are not sufficient to discriminate between models, as this measure does not truly represent the ability of a model to satisfy all the picked travel-time data. So the likelihood for a model has to be conditioned to use both chi-squared and the number of travel-time picks. Also the definition of the freedom parameters and how the model is up-dated are issues in achieving efficient searching of the model-space without wasting computational time. I use the 'burn-in' period to optimise the freedom parameters and update the model in time-velocity space to minimise the impact of local changes on the global fit. The results show that for a 2-D model with many layers the spread of results reflects the constraints imposed by the data. Layers with good sampling typically have errors of +/- 5%. Though this error increases dramatically for poorly constrained layers or those introduced to test a particular geological objective.