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Markov Chain Monte Carlo (MCMC) inversion of hillslope elevation and soil thickness data for the baselevel history

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Hillslope topography and soil thickness respond to changes in river incision or deposition. For example, accelerated river incision leads to a wave of steepening and soil thinning that begins at the channel and moves upslope [1]. Because of the coupled response of topography, soil thickness and channel incision or deposition rates, it may be possible to use hillslope properties to reconstruct the erosional or depositional history of channels. A prerequisite for such inversion of hillslope properties to reconstruct historical landscape dynamics is a method that allows one to quantify both the most likely channel history as well as the uncertainties in changing channel erosion or deposition rates through time. Here we present robust methods ideally suited for this purpose: Monte Carlo Markov Chain (MCMC) methods. Specifically, MCMC methods [2] involve (i) taking some assumed base level history, (ii) perturbing that history (iii) running a forward model to estimate new hillslope profiles (iv) choosing whether to accept the new history by a Metropolis-Hastings Algorithm (v) storing the favoured history and repeating. In this way we iterate towards the most likely channel history whilst exploring parameter space in such a way that confidence intervals can quantified. Here we demonstrate how this approach returns not only a best estimate history, but also credibility intervals which reflect the progressive loss of information with time. These techniques are generic and should be employed more generally within geomorphology.

[1] Mudd, S.M., and D.J. Furbish (2007), Responses of soil mantled hillslopes to transient channel incision rates, Journal of Geophysical Research-Earth Surface, 112, F03S18.
[2] K. Gallagher, K. Charvin, S. Nielsen, M. Sambridge and J. Stephenson (2009) Markov chain Monte Carlo (MCMC) sampling methods to determine optimal models, model resolution and model choice for Earth Science problems, Marine and Petroleum Geology 26(4).