Tomography through Bayesian inversion - can we afford it ?

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Introduction

Tremendous progress in seismology over last years is greatly due to availability of high quality seismic waveforms. Their availability prompts for the new mathematical and numerical algorithms for their more detailed analysis. This analysis usually takes a form of the inverse problems: estimation of physical parameters from seismic waveforms. Currently, the classical approach, which relays on finding the best model fitting the recorded data is not sufficient any more. We need to know how plausible the obtained model is or, in other words, how large the uncertainties are in the final solutions . This task can hardly be addressed in the framework of the classical optimization approach. Estimating of the inversion uncertainties requires not only finding the optimum model but also how ``large'' the region of plausible models is.

Fast Sweeping Eikonal Solver

$$\left(\frac{\partial T}{\partial x}\right)^2 + \left(\frac{\partial T}{\partial y}\right)^2 + \left(\frac{\partial T}{\partial z}\right)^2 = \frac{1}{V^2(x,y,z)}$$

$$T(x_o, y_o, z_o) = 0$$

Discretization: first order upwind schemata

$$\frac{\partial T}{\partial x} \approx \frac{(T_i - T_{min})^+}{h}$$

$$T_{min} = \min(T_{i-1}, T_{i+1}) \qquad (x)^+ = x \text{ if}(x > 0) \text{ else } 0$$

Solution

$$\tilde{T}_{i,j} = \begin{cases} \min(T_{xmin}, T_{ymin}) + s_{i,j}h & |T_{xmin} - T_{ymin}| \geq s_{i,j} \\ \frac{1}{2}\left\{T_{xmin} + T_{ymin} + \sqrt{2s_{i,j}^2 h^2 - (T_{xmin} - T_{ymin})^2}\right\} & |T_{xmin} - T_{ymin}| < s_{i,j} \end{cases}$$

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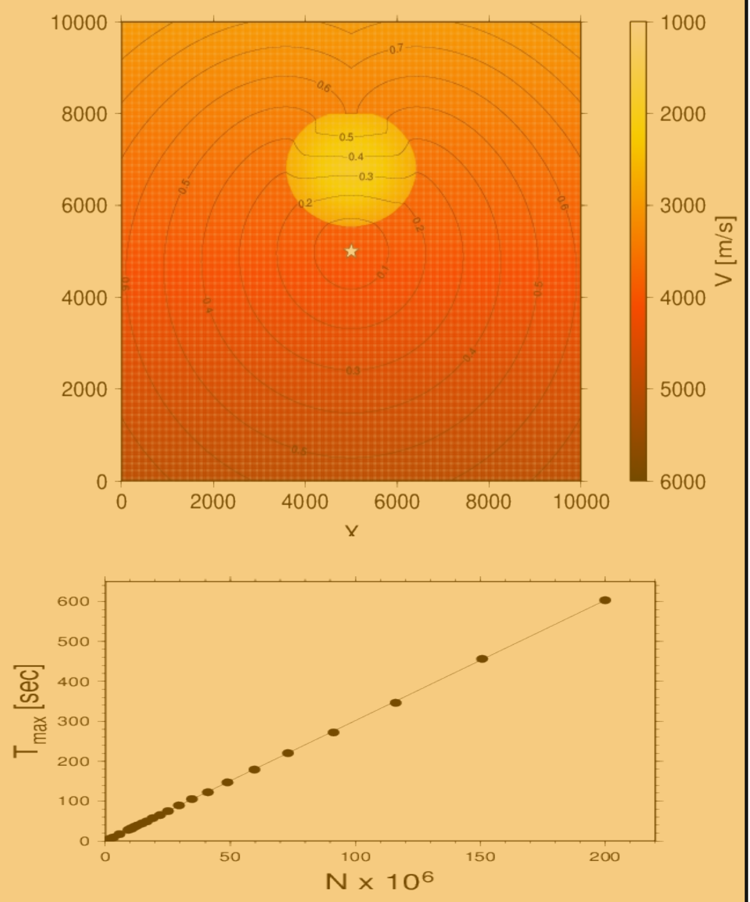
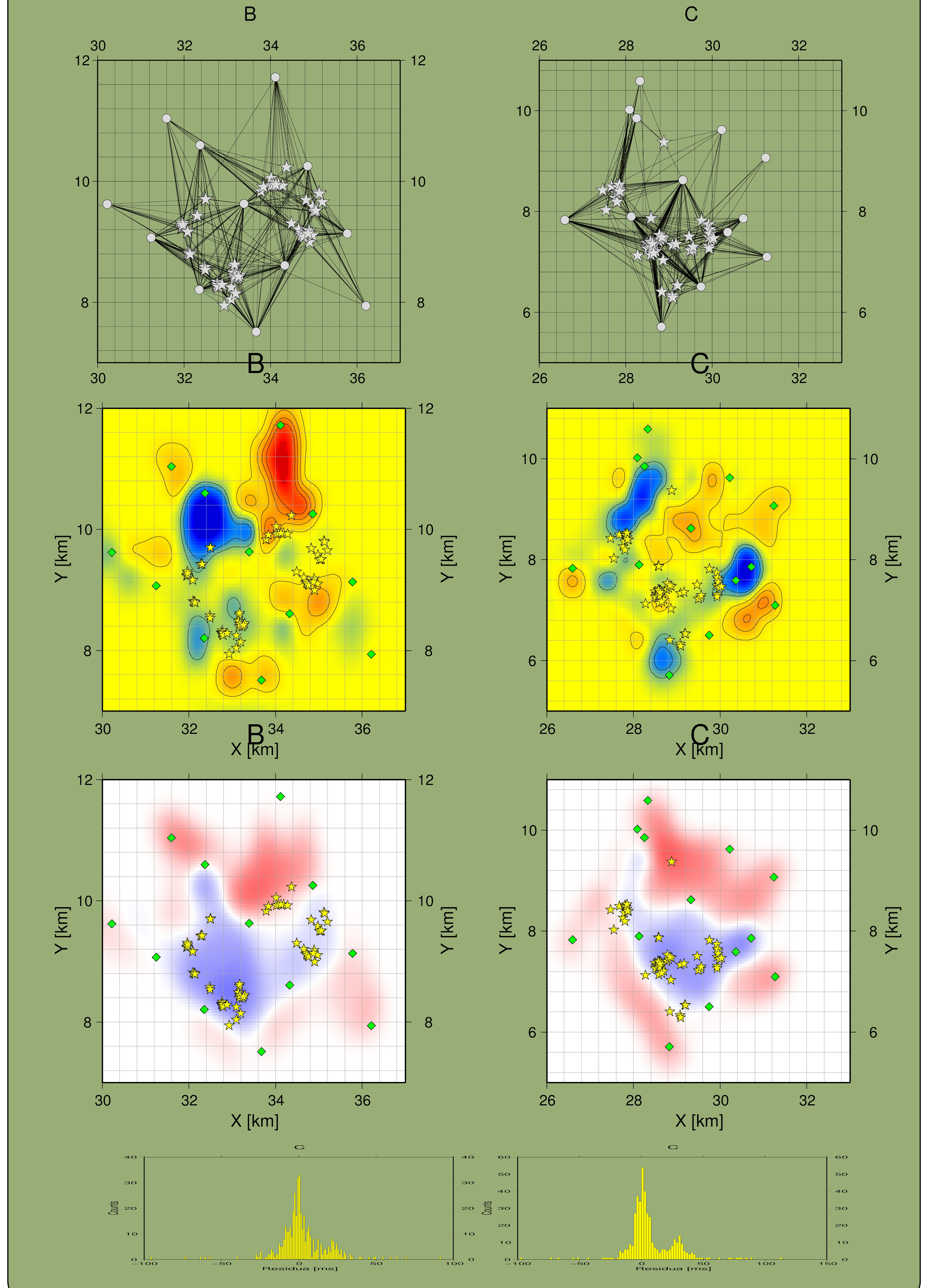
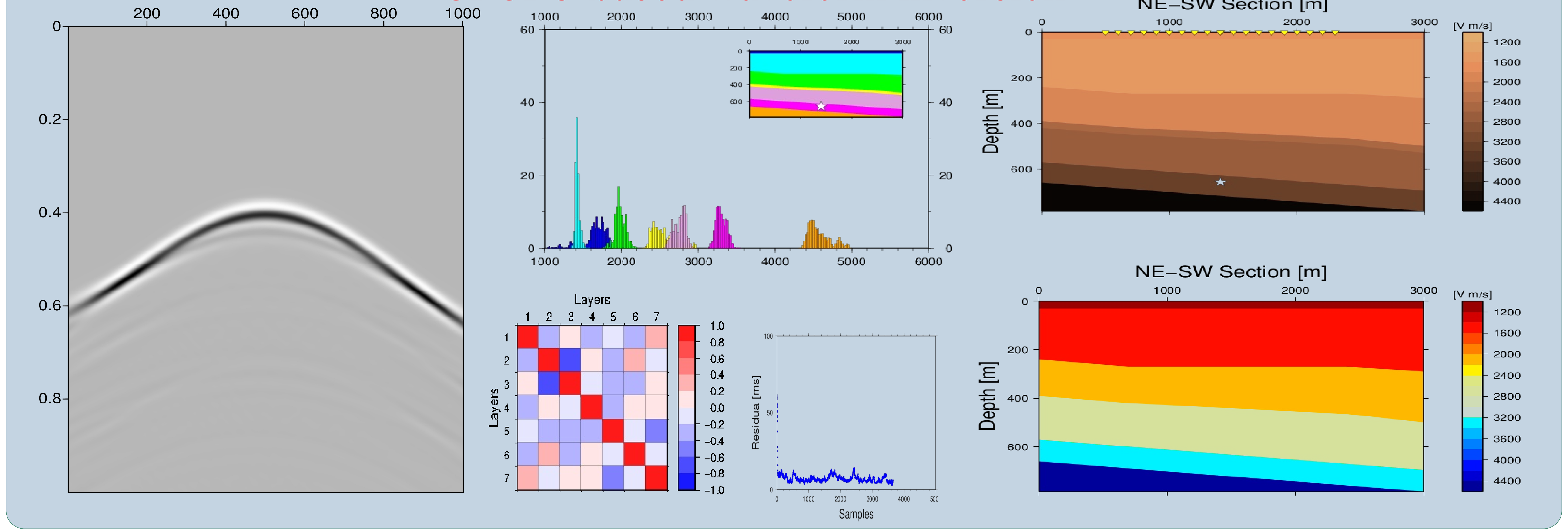


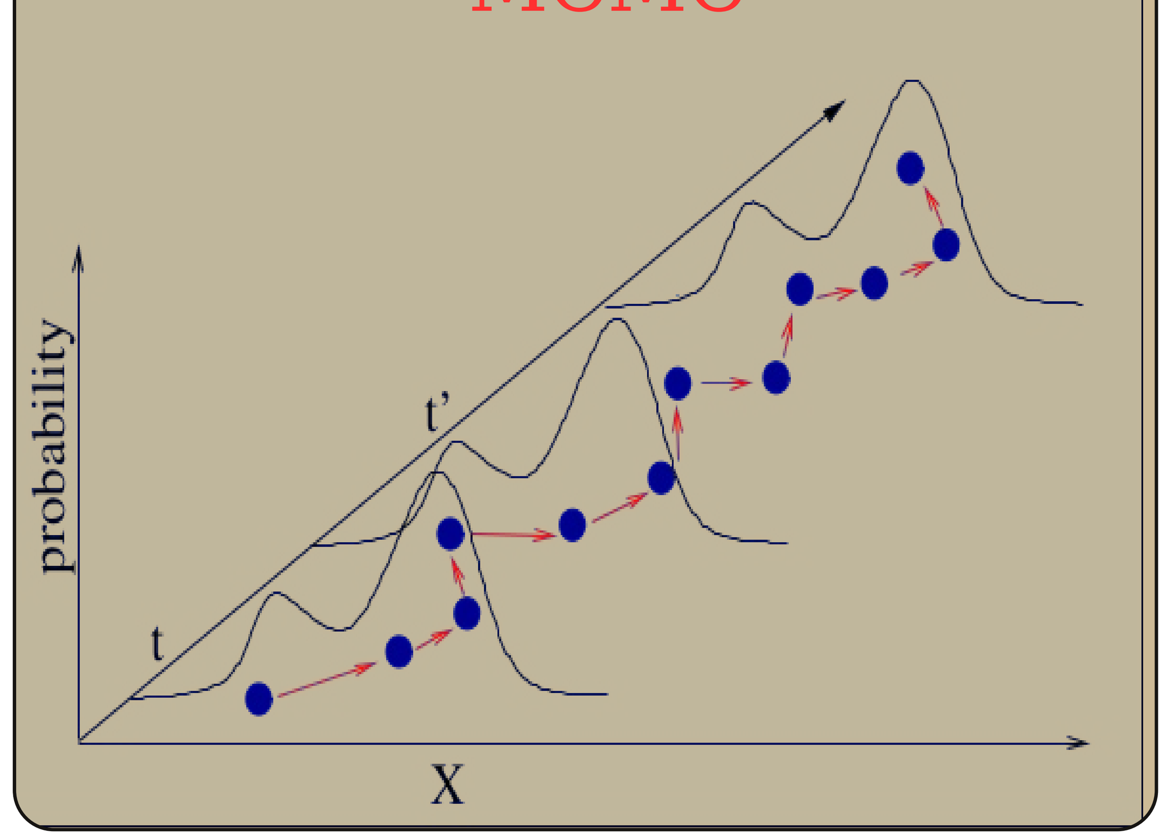
FSM based Vp tomography



GPGPU based waveform inversion



MCMC



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