Cycle skipping and uncertainty estimation in full waveform inversion

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Full waveform inversion (FWI) has became an important model building technique in both exploration and global seismology over the past ten years. Compared to classical ray-based travel time tomography, FWI enables us to obtain higher-resolution subsurface images. Although recently FWI has been successfully applied in many synthetic and field data experiments, there are still a number of theoretical and practical challenges. In this talk, we will focus on two challenges in the current developments of FWI: Cycle skipping and uncertainty estimation.

In order to tackle challenges associated with cycle skipping and local minima problems, we propose a misfit function based on adaptive matching filtering, which is designed to measure time varying phase differences between observations and predictions. Compared to classical least-squares waveform differences, this misfit function behaves as a smooth, quadratic function with broad basin of attraction. Numerical results show that the proposed misfit function helps us to build good starting models for FWI, particularly when low frequency signals are absent in recorded data.

For estimating uncertainty/resolution in FWI, we use a Bayesian inference framework and assess a posteriori covariance, evaluating in the vicinity of the maximum a posteriori model. A randomized singular value decomposition approach is invoked to analyze the spectrum of the prior-preconditioned data misfit Hessian. strong decay of the singular values indicates that data are mostly informative about a low dimensional subspace of model parameters. 2D numerical examples are used to confirm that this method can help us to estimate uncertainty/resolution for FWI.