Mismatches between physics and operators for least squares Kirchhoff and Reverse Time Migrations

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ABSTRACT
Least squares migration is designed to calculate the reflectivity model that can best predict the data under the Born approximation assumption. This is achieved by iteratively modifying the reflectivity model with updates obtained by mapping the prediction errors from data to model space. This approach assumes that every error in prediction is due to an error in reflectivity. This assumption is wrong, except for the very special case of synthetic data and a matching modeling operator in LSMIG (wave equation instead of Born). Because LSMIG always assumes Born modeling, even for synthetic data the prediction error is always in part due to mismatches between “physics” and data. Therefore, each update to the reflectivity contains wrong components. The larger the mismatch, the larger the contribution of these wrong components. Usually, this noise is attenuated by model regularization, but not always effectively. Often the model regularization can be the dominant effect in the inversion, so instead of seeing the effect of inverting the Hessian, we may see the effects of filtering the noise. In this work, I compare several situations for LSMIG using both Kirchhoff and RTM operators. Also, I show the effect of residual adaptive filtering instead of model filtering as a possible way to remove the inversion noise.

Figure 1: RTM (left) vs LSRTM (right) with 9 iterations and 25 shots. Ideal conditions for LSMIG (no mismatches)

Figure 2. Kirchhoff migration and LSKirchhoff. Noise controlled by residual filtering.