This folder contains the Matlab scripts necessary to recreate the synthetic model inversions in the paper.

Be sure to add the EKIFaultFold and RelatedScripts folders to the Matlab path before running these scripts. Please run the scripts in the order they are listed here, first Setup, then Running Inversions, and finally Plotting Results.

**Setup:**

**MakeReferenceModel\_Deformed** and **MakeReferenceModel\_Flat**: These make reference fault models in the deformed and restored states based on information in the ForwardModel folder, which contains the horizon and fault geometry for the model shown in Figure 1 of the paper. MakeReferenceModel\_Deformed makes the model in the deformed state for use with the restoration method (such as by Run\_All\_Inversions\_Restoration), while MakeReferenceModel\_Flat makes the initial (restored) state of the same model for use with the forward modeling method (such as by Run\_All\_Inversions\_Forward). The reference model is used to define any parts of the fault and horizon geometry that are not being fit for and to define the size of the fault grids.

**MakePriorEnsembles**: This makes the prior ensembles and data realizations for the dense data case (described in section 4.1 of the paper) and stores them in the PriorEnsembles folder. The file names such as N100, N200, etc. refer to the number of models in each ensemble. It should be run before running the inversions.

**MakeSparseDataRlzts:** This makes the data realizations for the sparse data case (described in section 4.2 of the paper). It should be run before running either of the sparse data inversions. This makes only a single ensemble size (default 200, but it can be changed with the N variable in this file), and the results are stored in the file SparseDataRlzts.

**Running Inversions:**

The inversion scripts below take some time to run. For each one of the scripts, we report the time it takes to run in a computer with the following specifications: AMD Ryzen 9 3900X CPU, 64 GB RAM, Microsoft Windows 10 Pro operating system.

**RunInversion:** This runs a single inversion for the synthetic model. The default is for the dense data case, using the forward modeling method, with 200 ensemble members. Switch between the different options files for the dense or sparse data cases and forward modeling or restoration methods by uncommenting one of the lines 6-9 and commenting out the rest. Change these options files to make changes to the setup (e.g. to change the number of ensemble members change opt.N in one of the options files). This file produces figures showing (1) The ensemble mean restored-state depths of the two horizons in the initial (prior) and final ensembles and the difference between them, (2) The ensemble mean deformed-state depths of the two horizons in the initial and final ensembles and the difference between them, (3) The ensemble standard deviations of the restored-state depths of the two horizons in the initial and final ensembles and the difference between them, (4) The ensemble mean of the fault surface function f(u,v) in the initial and final ensembles, the difference between them, and the truth, (5) The ensemble standard deviation of the fault surface function in the initial and final ensembles and the difference between them, (6) The ensemble mean of the fault displacement in the initial and final ensembles, the difference between them, and the truth, (7) The ensemble standard deviation of the fault displacement in the initial and final ensembles and the difference between them, (8) Histograms of the dummy parameter in the initial and final ensembles, (9) Histograms of the fault asymmetry (γ) and reverse drag radius (R) in the initial and final ensembles, and (10) Histograms of the maximum fault displacement (dmax) in the initial and final ensembles. The RunInversion script takes about 2 minutes to run on a computer with the specifications mentioned earlier.

**Run\_All\_Inversions\_forward** and **Run\_All\_Inversions\_restoration:** These scripts produce the results shown in Figure 2 of the paper. They run the inversions for different ensemble sizes and with and without inflation and localization for either the forward modelling method or the restoration method. Result file names are of the form N#\_method, where # is the number of ensemble members and method is Forward or Restoration. Results are saved in the four \_Results folders, which correspond to the four columns of Figure 2. The Run\_All\_Inversions\_forward script takes about 2 hours to run. The Run\_All\_Inversions\_restoration script takes about 11 hours to run.

**RunInversion\_scattered:** This runs a single inversion of the synthetic model using the scattered data (described in section 4.2 of the paper) and saves the results. Comment or uncomment one each of lines 6-7 and 11-12 to switch between the forward modelling and restoration methods. The results of this script are shown in Figure 6 of the paper. Note: To run the MakeParameterKDEPlots\_Scattered script, you will need to run the RunInversion\_scattered script in both forward and restoration modes. The RunInversion\_scattered script takes 1 minute to run in forward mode, and 8 minutes to run in restoration mode.

**Plotting Results:**

**CompareMethodsFigure:** This script makes Fig. 2 based on the results of Run\_All\_Inversions\_forward and Run\_All\_Inversions\_restoration.

**MakeParameterKDEPlots:** This script makes Fig. 3 based on the results in the N200\_Foward.mat and N200\_Restoration.mat models in the DMCBootInflSigma06\_Results folder, which are produced by Run\_All\_Inversions\_forward and Run\_All\_Inversions\_restoration.

**MakeParameterKDEPlots\_Scattered:** This script makes Fig. 6A based on the results from the RunInversion\_scattered script (run for both the forward modeling and restoration methods), which are stored in the files N200\_Forward\_scattered.mat and N200\_Restoration\_scattered.mat.

**PlotMeanFields\_Forward:** This script makes Figs. 4 and 5 based on the results from the N200\_Forward.mat model in the DMCBootInflSigma06\_Results folder.

**PlotMeanFields\_Restoration:** This script makes Figs. S1 and S2 based on the results from the N200\_Restoration.mat model in the DMCBootInflSigma06\_Results folder.

**PlotMeanFields\_Scattered\_Forward:** This script makes Fig. 6B based on the results in the N200\_Forward\_scattered.mat file produced by RunInversion\_scattered with the forward modelling method chosen.

**PlotMeanFields\_Scattered\_Restoration:** This script makes Fig. S3B based on the results in the N200\_Restoration\_scattered.mat file produced by RunInversion\_scattered with the restoration method chosen.