Simplified body wave travel time tomography of a synthetic subduction zone

Scripts:
'single_tomography inversion.m'
'loop_tomo_for_Lcurve_damp.m'
'loop_tomo_for_Lcurve_smooth.m'

Introduction:
Simple versions of body wave travel time tomography with teleseismic (distant) earthquakes, local slab earthquakes, or both will be used to explore the strengths and weaknesses of the methods for imaging subduction zone structure. We will begin with a few guided examples of how to use the scripts, then individuals/groups will have time to explore. In the last ~20 minutes, we will see the true structure and try to understand the origin of artifacts (false features) in each of the different inversions.

The script 'single_tomography inversion.m' has an already calculated travel time sensitivity matrix (G) and data vector (d_obs). You can quickly run tomography inversions using the sparse least squares solver called LSQR. The inversion assumes ideal sampling of teleseismic ray paths with P arrivals from earthquakes at epicentral distances greater than 30 degrees. The synthetic seismic array is optimistic with regular 10 km station spacing along a 500-km transect normal to the simplified plate boundary. It is analogous to many settings where only land-based seismometers are available.

To answer the questions below you will need to run several inversions. You can switch the regularization parameters and record the results for each run. For more extensive searching of different regularization parameters in teleseismic tomography, the scripts called 'loop_tomo_for_Lcurve_damp.m' and 'loop_tomo_for_Lcurve_smooth.m' will be helpful.

Questions:
1. What are the minimum, maximum, and standard deviation of the residual times in the data vector (d_obs), which has units of seconds? How about for the misfit vector after the inversion (misfit)? Revisit these questions after adjusting the inversion parameters in the subsequent questions.

2. Based on the dimensions (numbers of rows and columns) of G.
a) How many travel time measurements are included in the inversion for each data type?
b) How many parameters are in the model space?

3. Examine, and modify if you want, tradeoff curves ('L-curve') for the norm of the misfit vector and the damping & smoothing scalars. What do you consider to be optimal damping & smoothing scalars (or an optimal range for each)?

4. Let kd be the optimal damping scalar and ks be the optimal smoothing scalar (from #3 & #4). Try 5 different inversions: 1-Use kd and ks; 2-increase kd and ks by a factor of 5; 3-decrease kd and ks by a factor of 5; 4-increase kd by a factor of 5 and use ks, 5-increase ks by a factor of 5 and use kd
a-d) For each of inversions 2-5 please describe what is different about the tomography result compared to inversion 1. Your comparison should consider the misfit norm and an assessment of what changed in the image (e.g., how did the geometry, size, and magnitude of different structures change). A tomography image should accompany each of your answers for a-d.

5. a) Estimate the maximum depth of the high-velocity slab.
b) Do you think the high velocity slab is continuous or two distinct segments?

6. Estimate the peak magnitude of the low-velocity anomaly above the slab in the mantle wedge (e.g. -1%).