Addressing non-stationary shear wave statics in the rayparameter domain

Raul Cova*, David Henley and Kris Innanen
rjcova@ucalgary.ca

Abstract

When velocity contrasts at the base of the near-surface layer are small, or when it shows some degree of structural complexity, delay times of wavefronts transmitted through this layer may become raypath dependent. In order to remove this effect we transform the data to a domain in which amplitudes are a function of the raypath angle. Processing the statics in the radial trace (RT), Snell trace (ST) and τ-p domain achieve this goal, but with different degrees of accuracy. Since the first two domains involve only a very simple remapping of the amplitude from the original x-t domain they are free of the numerical problems experienced with the τ-p transform. However, the RT and ST transformations require that some assumptions about the subsurface velocity model must be made. On the other hand, the τ-p transform automatically scans the data in order to capture the rayparameter values that were actually recorded. The surface correction of synthetic data in a depth-varying velocity medium showed that the solutions obtained in the ST and τ-p domain are very similar, while common offset and RT solutions still show some unresolved problems. Further analysis was performed using real data from the Hussar experiment. Results showed that the τ-p solution provided a better stacking power in the deeper part of the section. In the shallow part the RT and ST solution seem to have better resolution. Further work is needed to reduce the artifacts present in the τ-p transformation. Trying a high resolution τ-p transform will be the next step in this research.

Domain Transformation

τ-p Transform

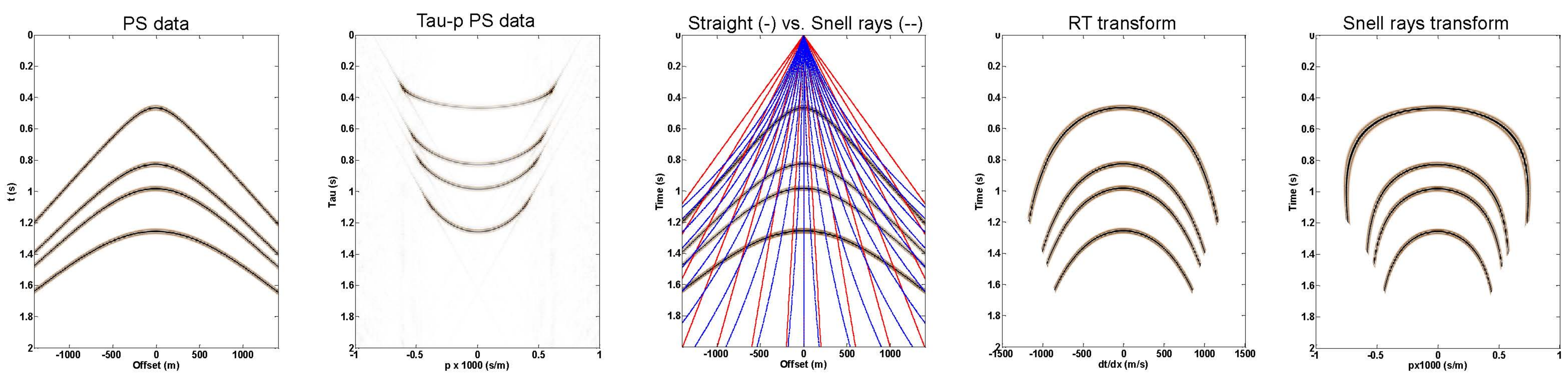
Amplitudes are stacked along lines ($t = \tau + px$). As a result, "p" values recorded in the data can be extracted.

Radial Trace Transform

Remaps amplitudes along straight lines in x-t. In a constant velocity medium the slope of each line is related to a raypath angle

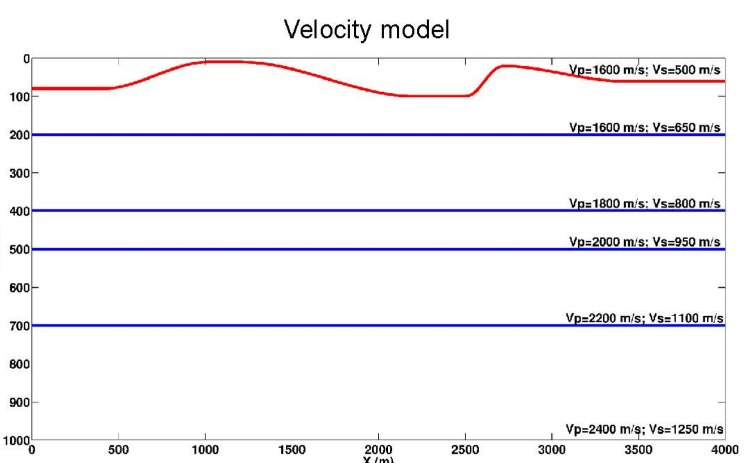
Snell's Ray Transform

Remaps amplitudes along curved trajectories in x-t, following Snell's law. A velocity model must be input to map the "p" values

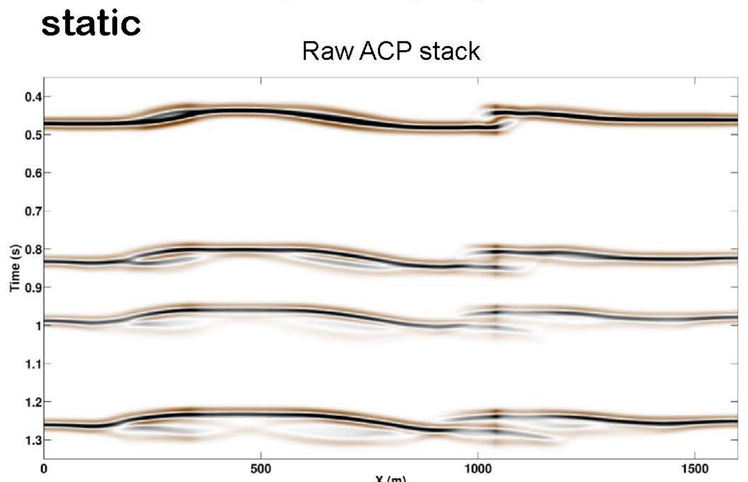


Synthetic Data Analysis

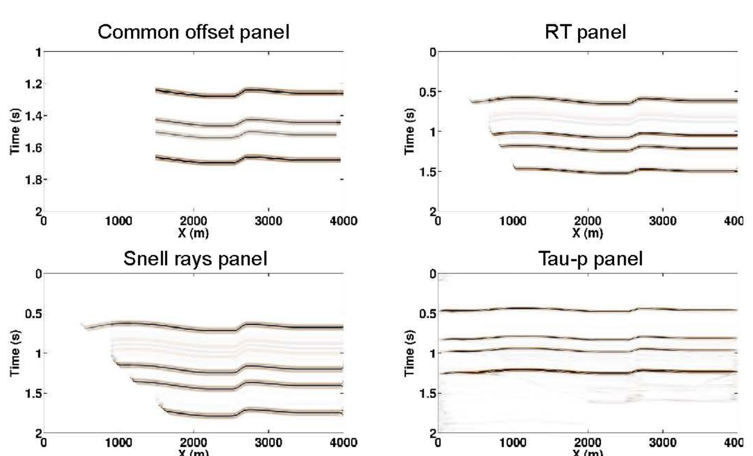
1. Velocity model used to compute synthetic PS-traces using raytracing.



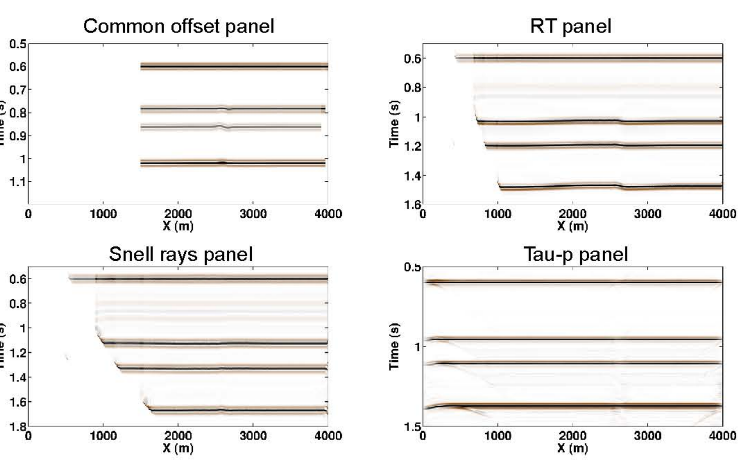
2. ACP Stack without static corrections. Notice the depth-varying effect of the static



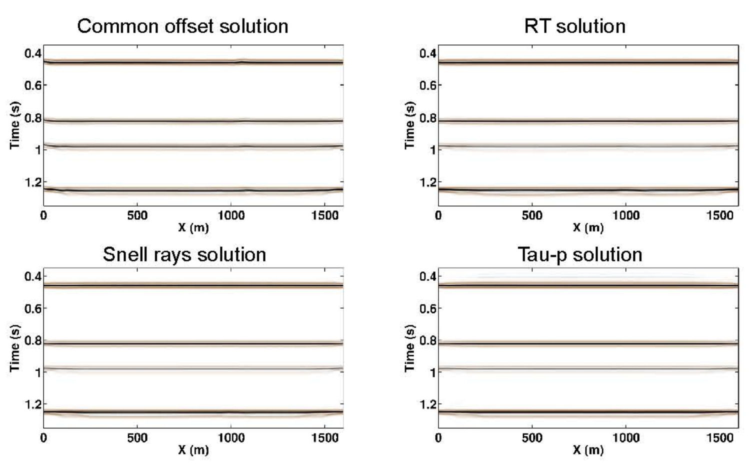
3. Common trace panels after domain transformations



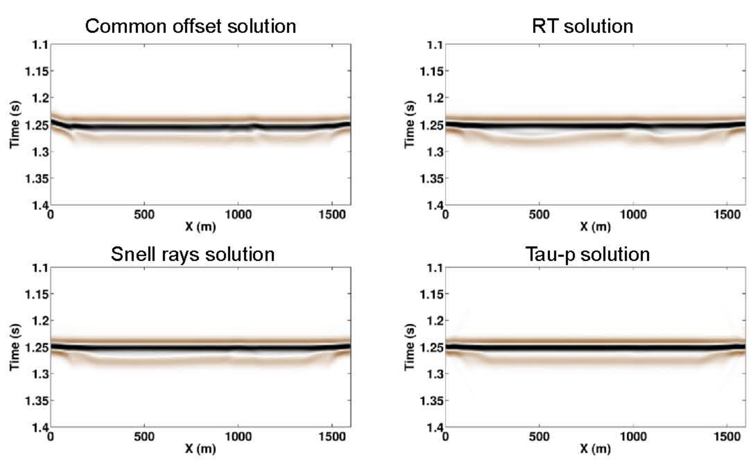
4. Stationarity test. Data were flatten around the shallowest reflector. If delays are stationary all reflectors should be flattened.



5. ACP Stacks after static corrections. Residual static problem still present in the data.

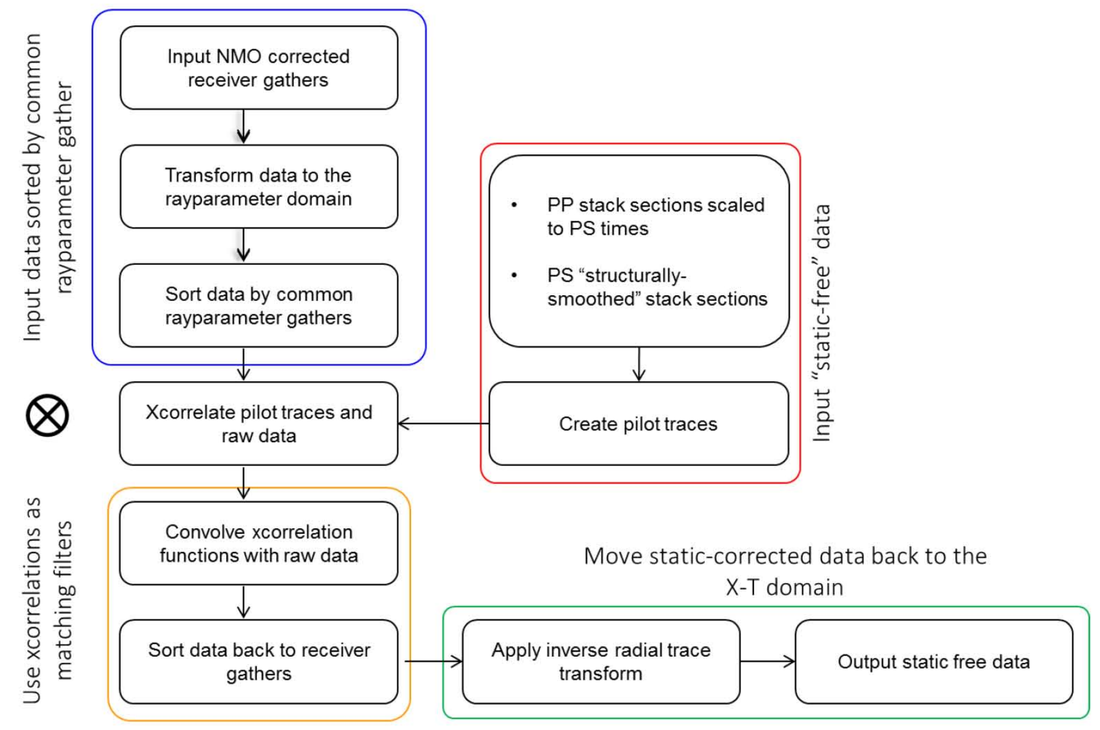


7. Zoom around the deep reflector. The solution in the τ-p domain provided better coherency

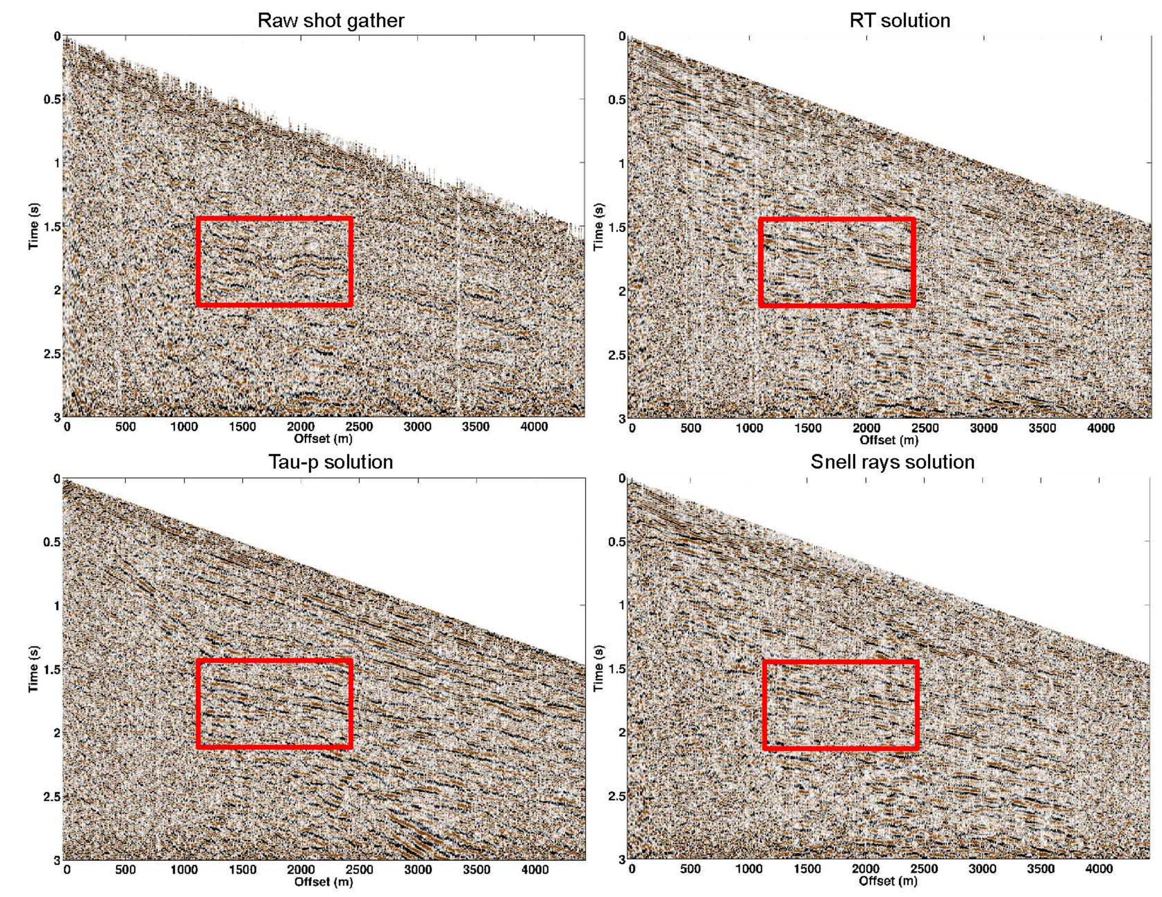


Real Data Analysis

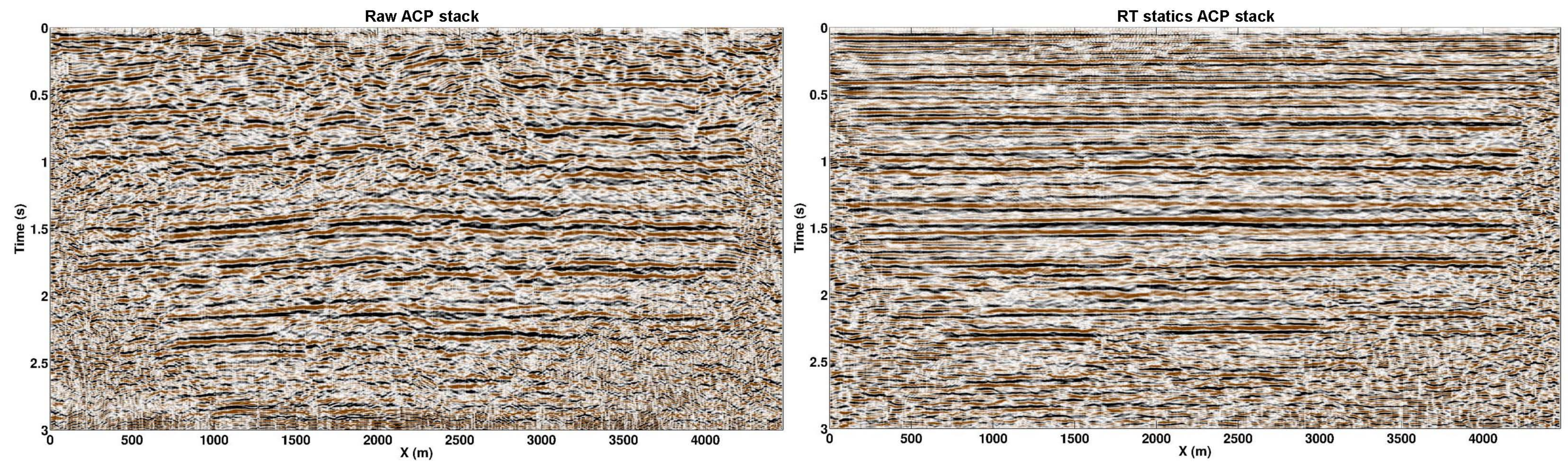
- Interferometric static correction workflow.



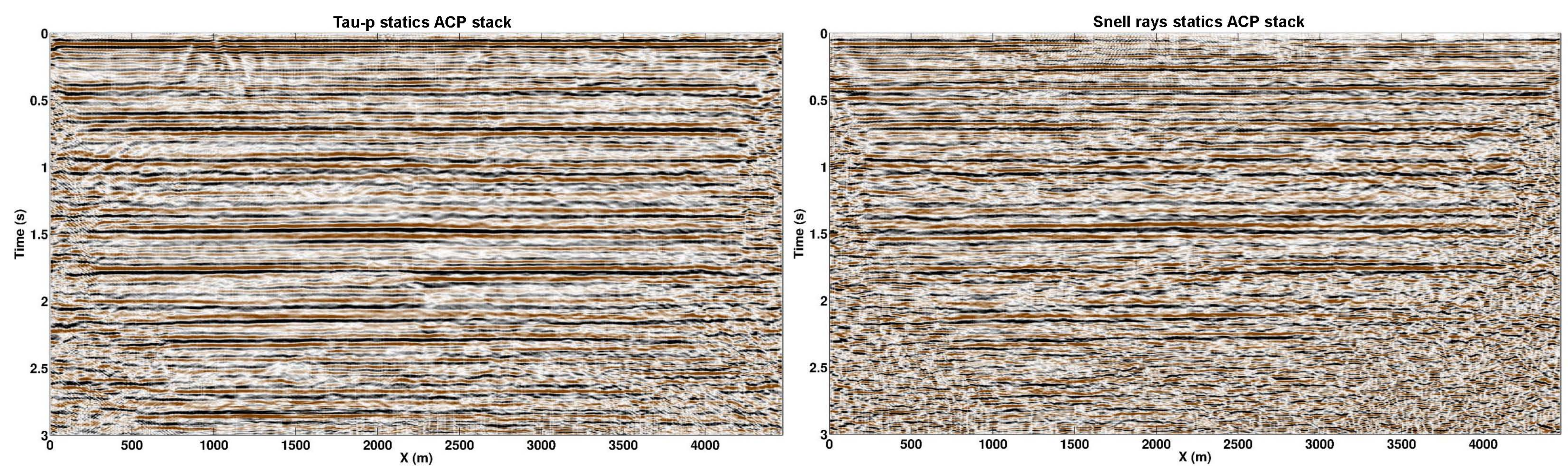
- Shot gathers before and after statics corrections in each domain.



- ACP Stacks after static corrections in each domain



- RT and Snell solutions provided better resolution in the shallower part of the section. τ-p solution shows higher coherency on most of the section and better stacking power in the deeper part.



Conclusions

The solution of the shear-wave static problem in a raypath-consistent framework provides important improvements in coherency and resolution on the stacked sections. The three different transforms compared here successfully achieved the goal of removing the reflection distortions caused by the near surface. However, better coherency for medium and deep events was provided by the solution in the τ-p domain.

The most important problem with the τ-p transformation resides in its invertibility. Due to the band-limited character and finite aperture of the data the inverse transform from the τ-p to the x-t domain loses resolution. For this reason the use of a high resolution τ-p transformation must be tested in future work.