Converted wave receiver statics correction using surface domain pre-stack data

Saul E. Guevara and Gary F. Margrave*
seguevar@ucalgary.ca

SUMMARY
A method for receiver statics correction of converted waves (PS-waves) is proposed here. It is based on the surface consistent model applied to Common Receiver Gathers (CRG), a surface domain. Stacking of PS-waves it is not required, therefore the method does not depend on Vc (stacking velocity for converted wave) or on assuming a simplified stacking model such as *asymptotic binning*.

THEORETICAL BASIS

The PS-wave events involved in this method are illustrated in Fig. 1. The surface consistent equation (eq. (1)) allow separating the components of the events arrival time. Then the differential delay time corresponding to receiver statics can be separated and obtained using equations (2) and (3).

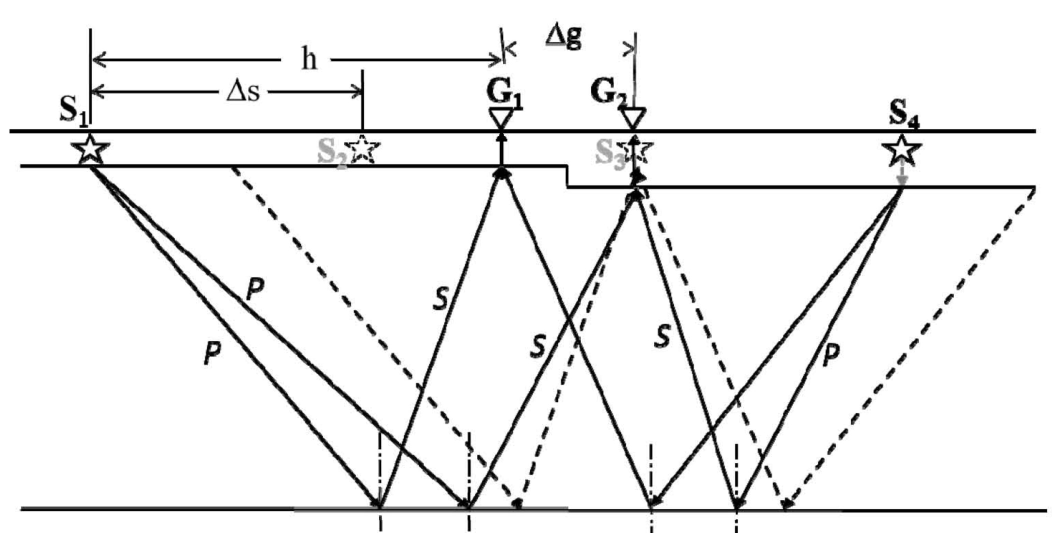

Figure 1. The PS-wave events that arrive to two adjacent receivers (G_1 and G_2) with a differential time delay δR (*statics*) between them, illustrated by raypaths. The events generated by different sources (S_1 and S_4) should have the same differential delay δR. However there is an additional delay generated by the different offset h. The dashed rays however have the same offset, and interpolation is proposed to obtain them.

The PS-wave events involved in this method are illustrated in Fig. 1. The ***Surface consistent equation*** of the arrival time τ_{ijk} for source i, receiver j and depth reflection k, is:

$$\tau_{ijk} = S_i + R_j + G_k + M_k \quad (1)$$

where
S_i : Source statics.
R_j : Receiver statics.
G_k : Structural geology time delay.
M_k : NMO time delay.

- We assume that the source statics have been already applied.
- It is possible to assume that G_k (geology delay) is small, since the distance between reflections is small.
- The NMO effect can be meaningful (see Fig. 5). We use trace interpolation to overcome it.

Crosscorrelation allows to obtain the delay time of maximum similarity between two traces (Fig. 2). It reads:

$$C^h{}_{j,j+1}(\tau) = \sum_t \frac{D^h{}_j(t)D^h{}_{j+1}(t+\tau)}{\sqrt{\sum_t D^h{}_j(t)^2 \sum_t D^h{}_{j+1}(t)^2}} \quad (2)$$

Where h is offset, and j is a receiver. Then δR can be obtained by stacking crosscorrelations:

$$\delta R_j = max \sum_h C^h{}_{j,j+1}(\tau) \quad (3)$$

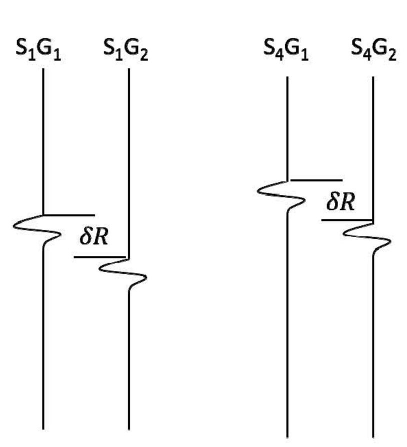

Figure 2. The PS-wave events of Fig. 1.

- Filtering of high energy noise and amplitude correction are appropriate, as it is selection of an appropriate data gate.

SYNTHETIC MODEL

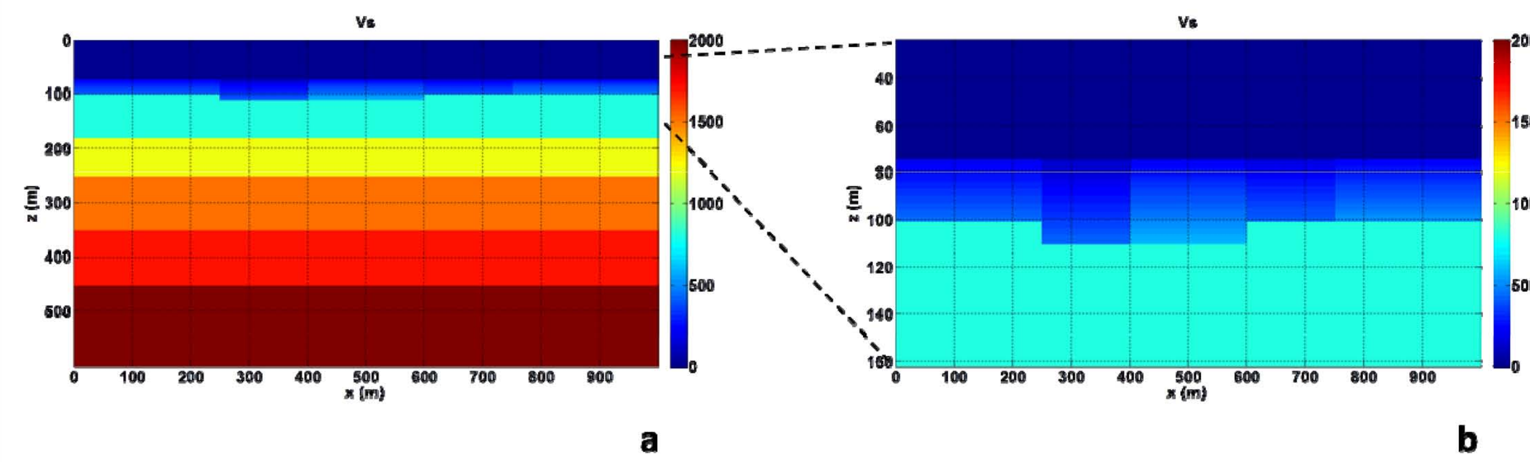

Figure 3. Synthetic model: (a) velocity model of S-wave. The free surface is at z=75 m. (b) A close-up with details of the near surface. The near-surface layer has lateral velocity variation in five zones and a velocity gradient increasing with depth.

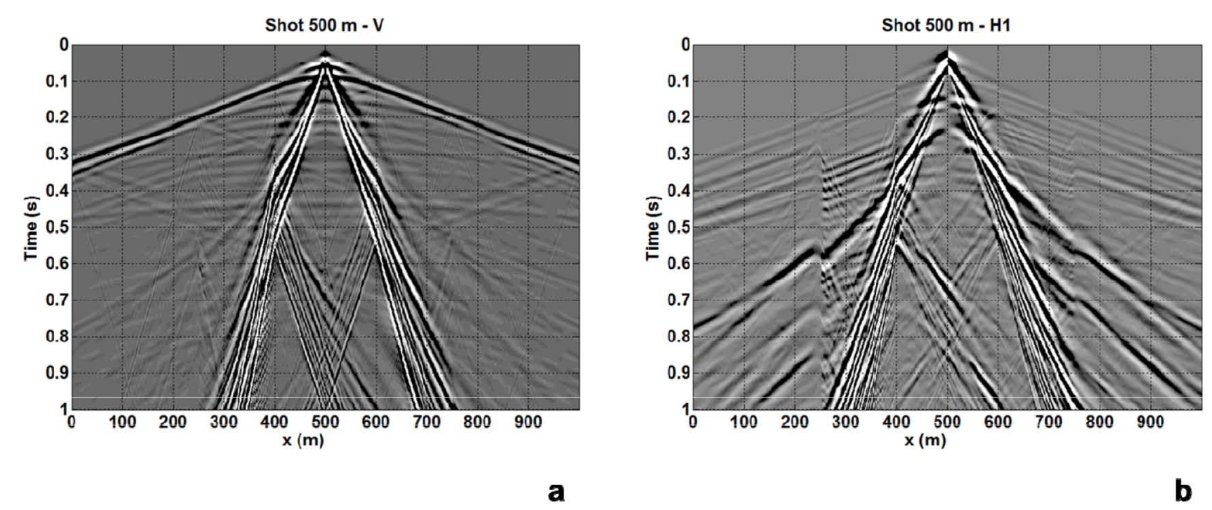

Figure 4. Synthetic model shot gathers: (a) Vertical component and (b) horizontal component.

Location x (m)	$\bar{V_S}$ - Left (m/s)	$\bar{V_S}$- Right (m/s)	δR (s)
250	340	255	0.019
400	255	380	-0.025
600	380	315	0.009
750	315	393	-0.012

Table 1. Theoretical differential time delay δR between near surface zones, calculated from the near-surface velocity model.

TEST RESULTS

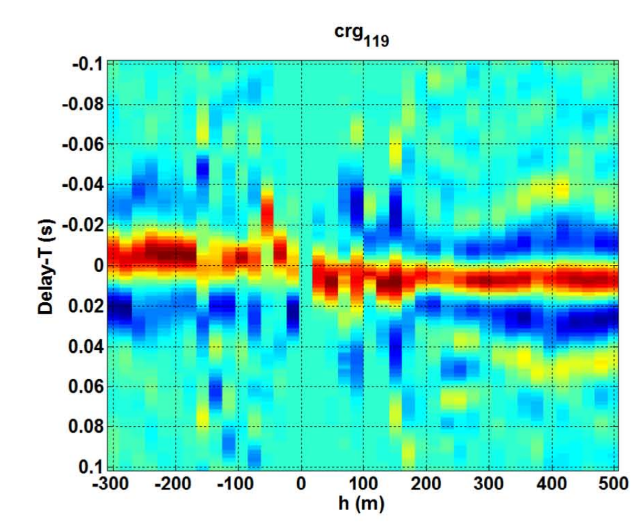

Figure 5. Resulting of same source crosscorrelations for a CRG located at x=600 m. Notice the trend difference between negative and positive offsets, caused by the NMO differential as illustrated in Fig. 1. Trace interpolation to obtain same offsets in both adjacent CRGs overcomes this issue.

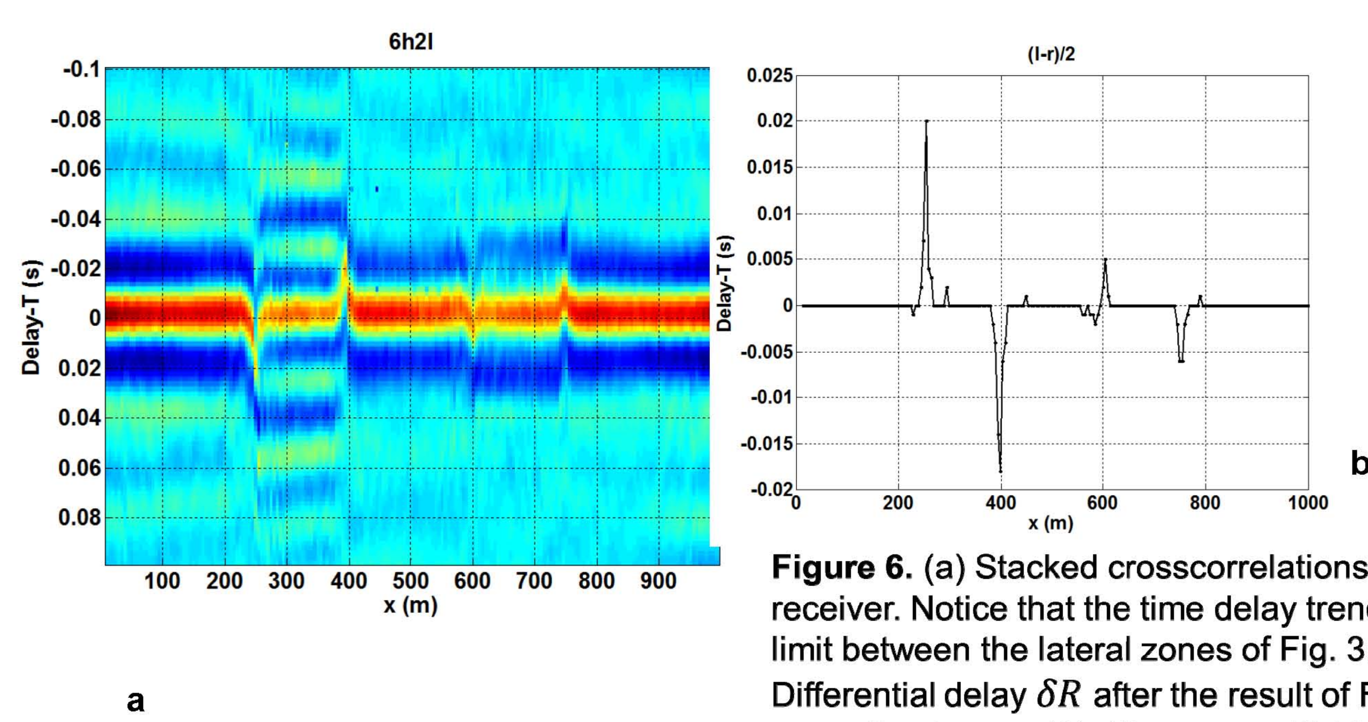

Figure 6. (a) Stacked crosscorrelations for each receiver. Notice that the time delay trends at the limit between the lateral zones of Fig. 3. (b) Differential delay δR after the result of Fig. (a), according to eqn. (3). (Compare with Table 1)

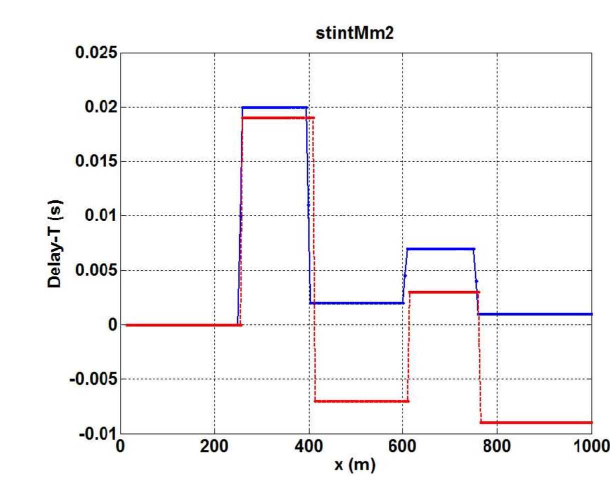

Figure 7. Statics after the differential delay of Fig. 6(b) (blue line) compared with the theoretical (red line).

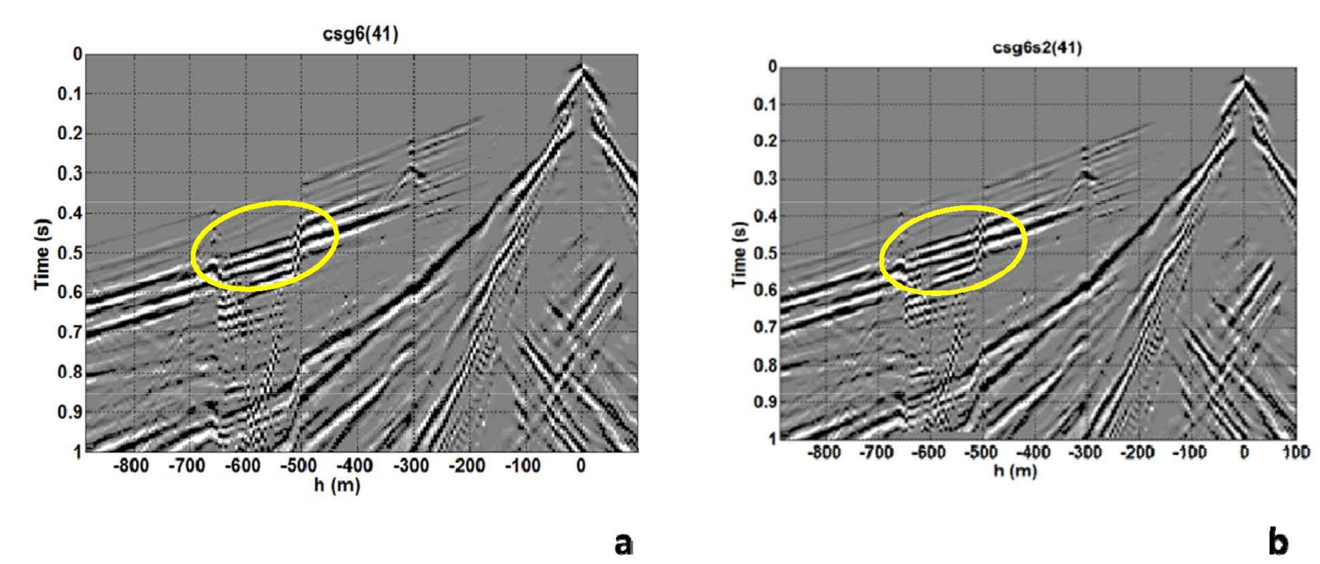

Figure 8. Seismic data in the source domain after the application of the receiver statics correction of Fig. 7. (a) Before statics (b) after receiver statics application. Notice the continuity of the events.

CONCLUSIONS

- We proposed a method for PS-wave receiver statics correction that is automatic and does not require Vc, and we applied it to synthetic data, with promising results. The method could provide short wavelength receiver statics, and be applied to complex geological settings.

ACKNOWLEDGMENTS
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