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Marchenko-based target replacement in laterally varying media: A geophysical way of replacing layers in a pre-baked cake

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1. Introduction

Seismic time-lapse studies are generally concerned with variations in a specific target zone, situated inside an otherwise static medium. Ideally only the response of the target zone is remodeled, which is then inserted into the stationary response of the surrounding medium (Figure 1). Wapenaar and Staring (2018) show how to do this in layered media.

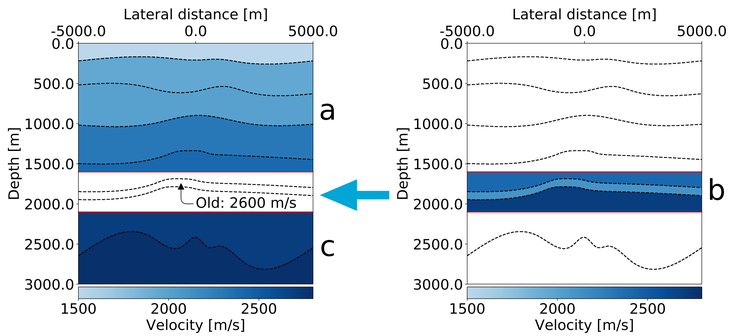

FIGURE 1 *The principle of target replacement: the over- and underburden responses (a and c) are extracted from the original reflection response (left). Next, the response of the new target zone (b) is inserted (right).*

2. Target Extraction

The first step is to extract the reflection and transmission responses from units a and c using the original reflection response and Marchenko redatuming. One datum right below unit a and one above unit c allows us to retrieve three reflection responses ($R_A^{\cup}$, shown Figure 2, $R_A^{\cap}$ and $R_C^{\cup}$) as well as two transmission responses (T_A^- and T_A^+).

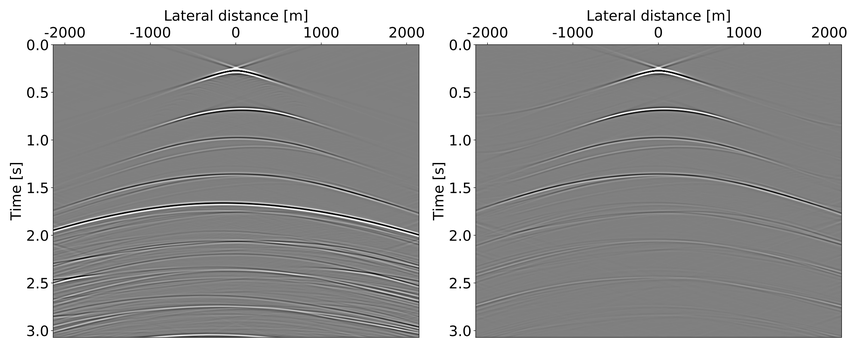

FIGURE 2 *The original reflection response ($R_C^{\cup}$) modeled with finite differences (left), from this the reflection response, **including multiples**, of unit A ($R_A^{\cup}$) is extracted (right). The velocities are shown in the left of Figure 1.*

3. Target Insertion

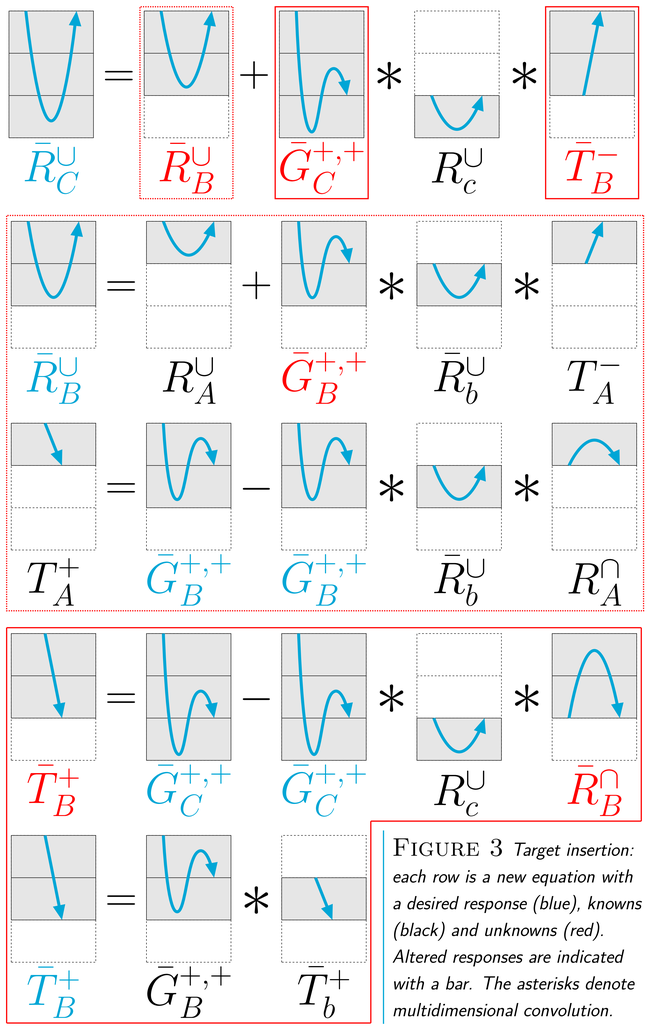

FIGURE 3 *Target insertion: each row is a new equation with a desired response (blue), knowns (black) and unknowns (red). Altered responses are indicated with a bar. The asterisks denote multidimensional convolution.*

4. Results

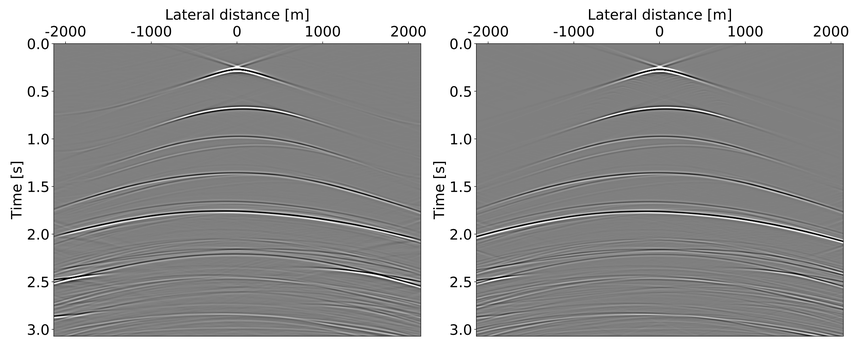

FIGURE 4 *The new reflection response ($\bar{R}_C^{\cup}$) retrieved with Marchenko-based target replacement (left) and reference modeled with finite differences (right). The velocities are shown in Figure 1.*

Figure 1 shows the 2D model that is considered for the 2D target replacement. The middle layer had a velocity of $2600\ m/s$ that was decreased to $2100\ m/s$ in the new target zone, similarly the density of this layer is changed from $3000\ kg/m^3$ to $2500\ kg/m^3$. Next, the stationary responses are extracted from the old reflection response (shown on the left of in Figure 2) using Marchenko redatuming. Note that this method includes all the internal multiples in the retrieved responses. Then, the reflection and transmission response of the new target zone are modeled ($\bar{R}_b^{\cup}$ and $\bar{T}_b^+$). Finally, the new target zone is inserted into the medium as shown in Figure 3. The final results of this replacement is shown on the left in Figure 4, the right side shows the reference that was obtained by remodeling the entire medium. Since some of steep arrivals get lost in the target replacement due to the limited aperture, a weak fk-filter was applied for a better comparison. Most of the events are accurately recovered by the scheme. However, near the edges the scheme is a little less accurate. Moreover, there are some differences in the retrieved amplitudes. In conclusion, we found that Marchenko-based target replacement can be used to accurately find the full response of the medium, while only the changing target zone has to be remodeled. This allows for a more effective modeling for time-lapse monitoring.

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References

Wapenaar, K. and Staring, M. (2018). Marchenko-Based Target Replacement, Accounting for All Orders of Multiple Reflections. Journal of Geophysical Research: Solid Earth, 123(6):4942–4964.