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A machine learning alternative to sparseness

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Abstract

Radon transform (RT) allows the mapping of different seismic events using different basis functions. By merging RT with Machine Learning (ML) in the same workflow, we aim to uncover previously unnoticed nonlinearities within these solutions, extending our insights beyond traditional geophysical theory. This approach becomes particularly valuable in scenarios where achieving complete spatial separation is challenging, for example in the case of multiple or ground roll overlapping primary reflections. Our numerical experiments focus on assessing the U-Net's efficacy in discerning the distinct characteristics of ground roll and multiples, employing various workflows. These include a bridge approach between hyperbolic and parabolic RT, aiming to complement and enhance multiple prediction in synthetic data. Additionally, we deploy the Hybrid RT methodology on the Spring Coulee dataset to forecast ground roll attenuation in the frequency domain and examine comparisons, often referred to as crosstalk, between linear and parabolic RT spaces. The outcomes illustrate that the U-Net has a certain capability in predicting and attenuating ground roll. However, persisting challenges lie in completely isolating reflections from the ground roll due to shared features within the Linear RT space, compounded by spatial aliasing and the irregular geometry inherent in field data.

Example 1: RT Bridge

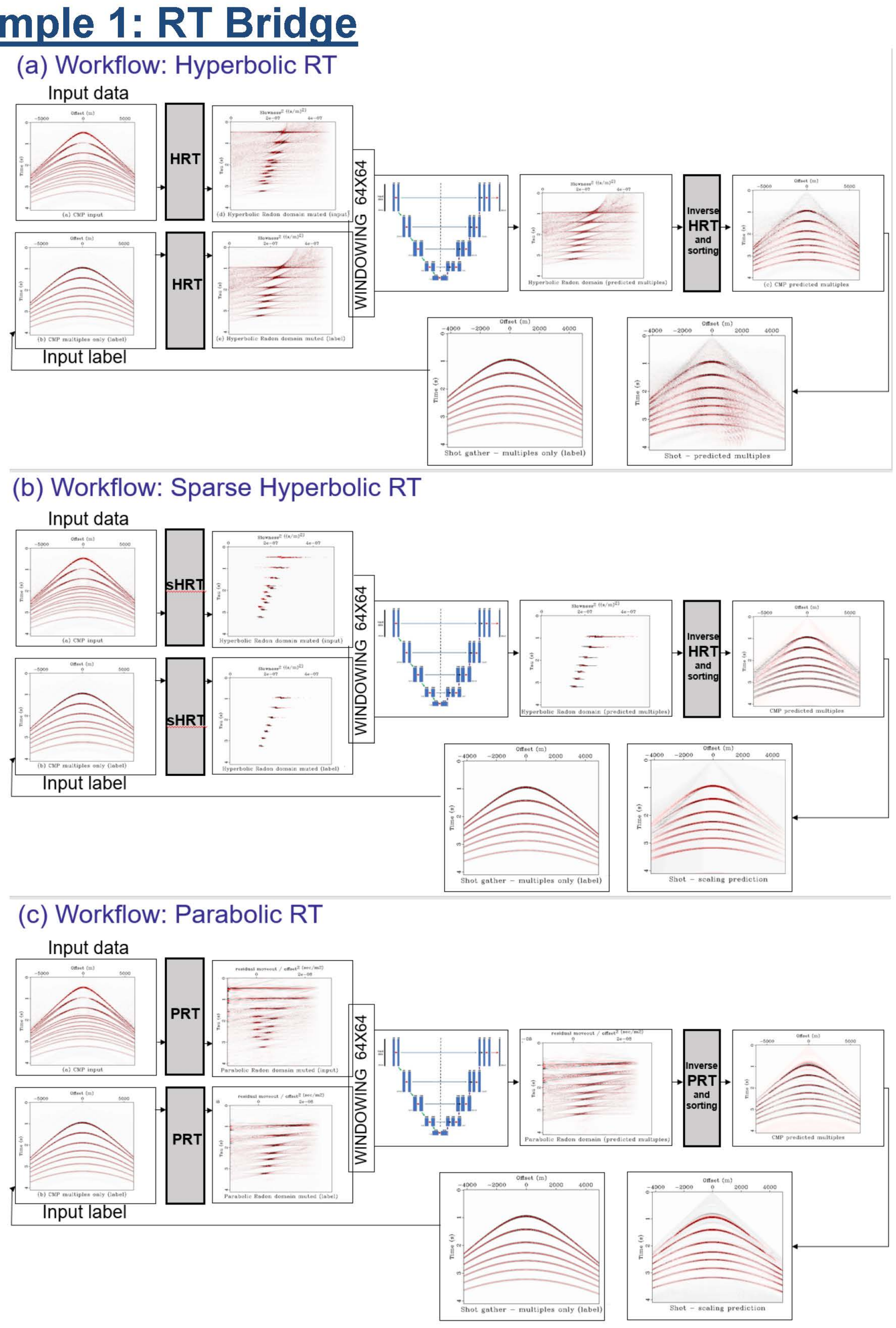

Figure 1: Workflow for (a) Hyperbolic RT, (b) sparse Hyperbolic RT and, (c) Parabolic RT. All of them have an input shot with primaries and multiples and, input label the shot with multiples only.

Bridge 2: Input Hyperbolic RT, Label Parabolic RT

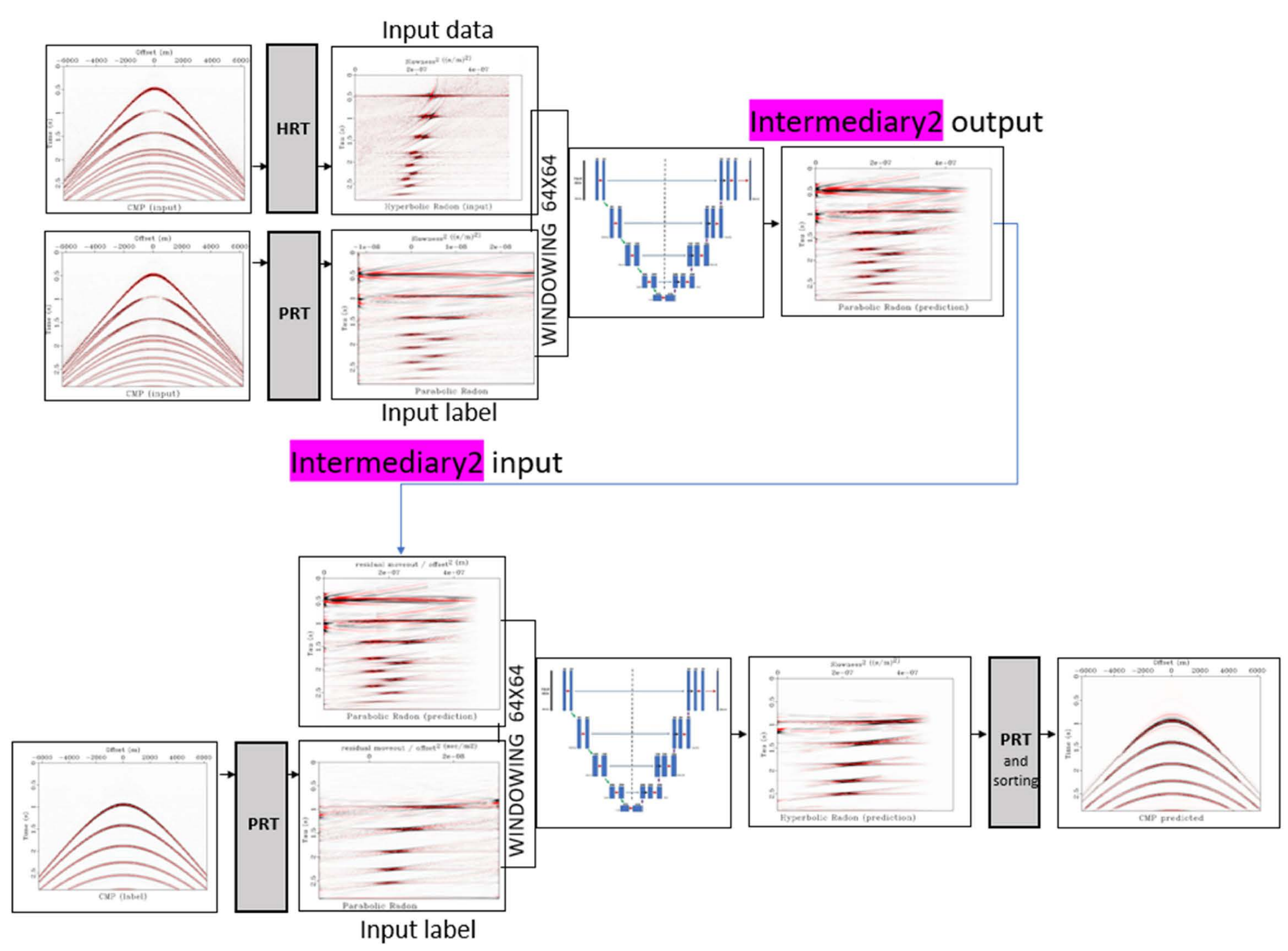

Figure 2: Bridge 2 as the workflow that uses Parabolic RT as label

Example 2: Hybrid RT

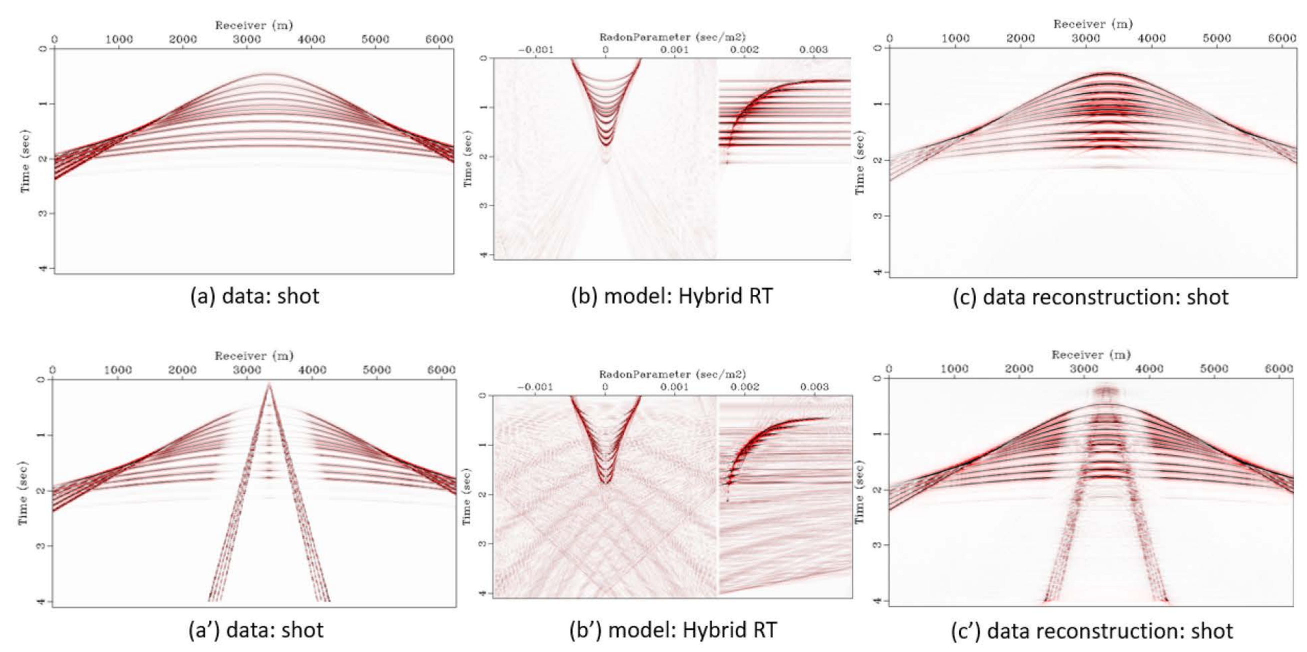

Figure 3: Synthetic shot (using the convolutional model) with reflections only (a) and with ground roll (a') using velocity model and geometry from Spring Coulee field data; Hybrid (Linear and Parabolic) RT of reflections only (b) and its reconstruction (c). Hybrid RT of reflections and ground roll (b') and its reconstruction (c').

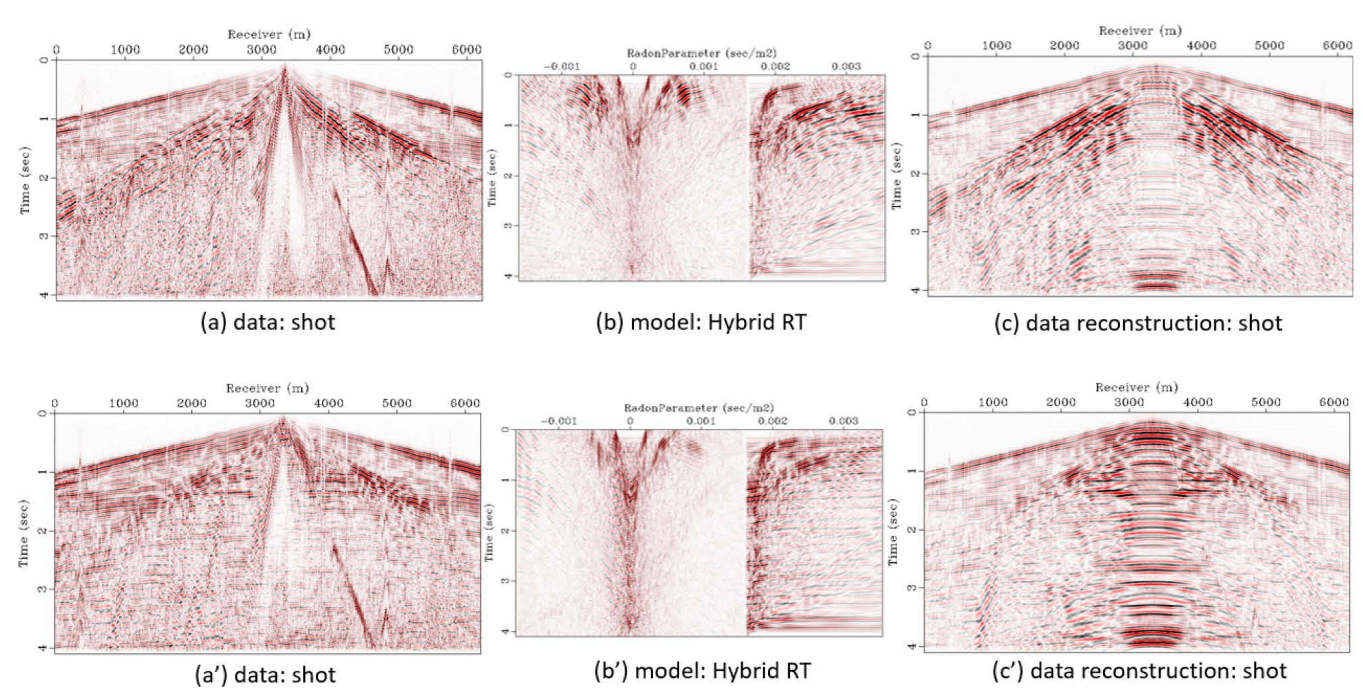

Figure 4: (a) original Spring Coulee shot with visible ground roll and some reflections, its (b) Hybrid (Linear and Parabolic) RT and its (c) shot reconstruction. (a') Spring Coulee original shot after being FK filtered in Vista with more visible reflections, its (b') Hybrid (Linear and Parabolic) RT and its (c') shot reconstruction.

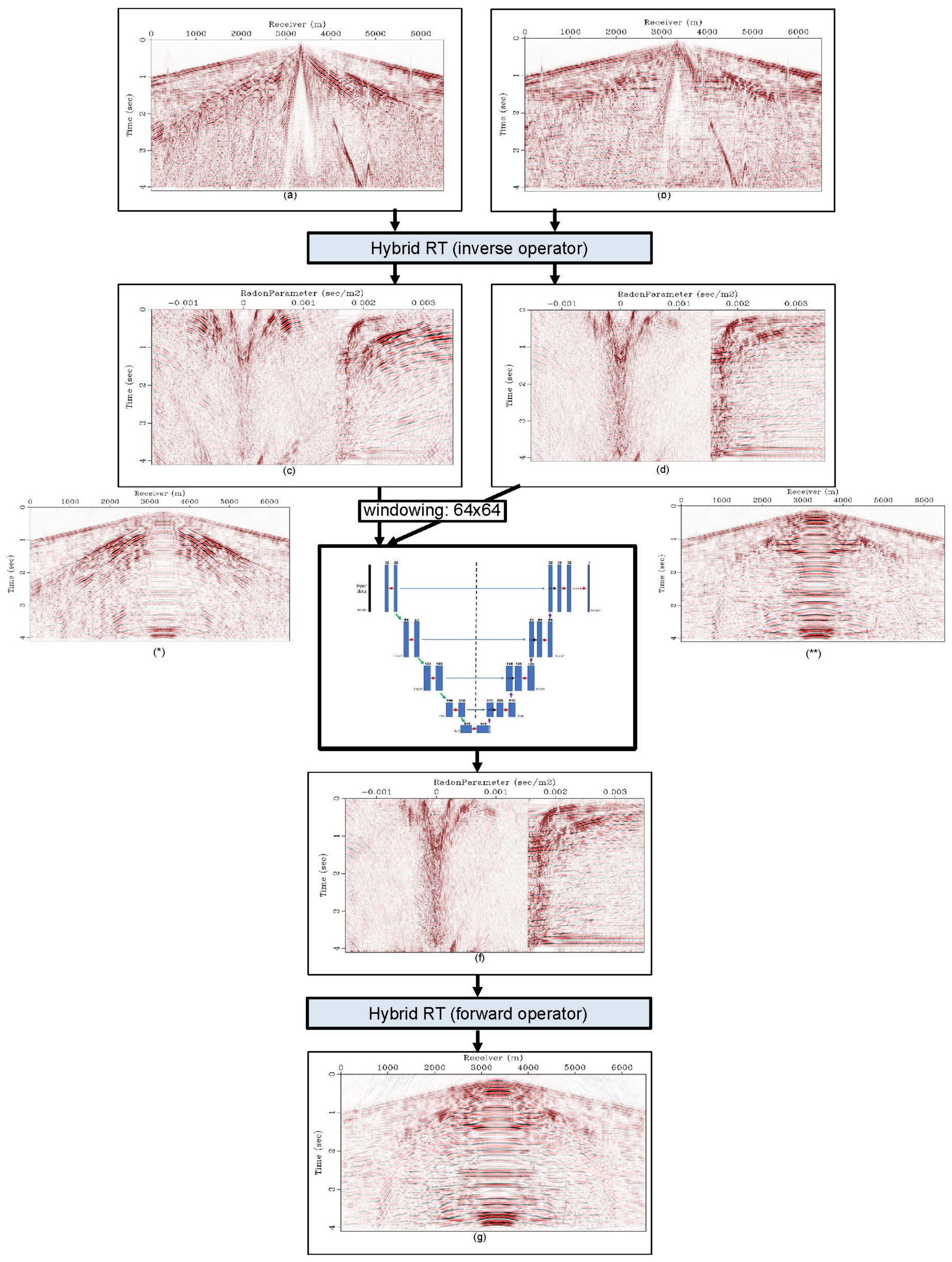

Figure 5: Hybrid RT one channel workflow: Spring Coulee shot gathers are the input data (a), with the ground roll and primaries and, the input label (b), with the original being FK filtered in Vista to approximate a label ~reflections only. Then the Hybrid RT (inverse operator) is applied to generate the hybrid panels of the input (c) and label (d) to feed the U-Net (e). The network then predicts, after training, the hybrid panels with ~reflections only (f), attenuating the ground roll. The inverse Hybrid RT (forward operator) using the adjoint operator is then applied to return the data to the shot domain (g).

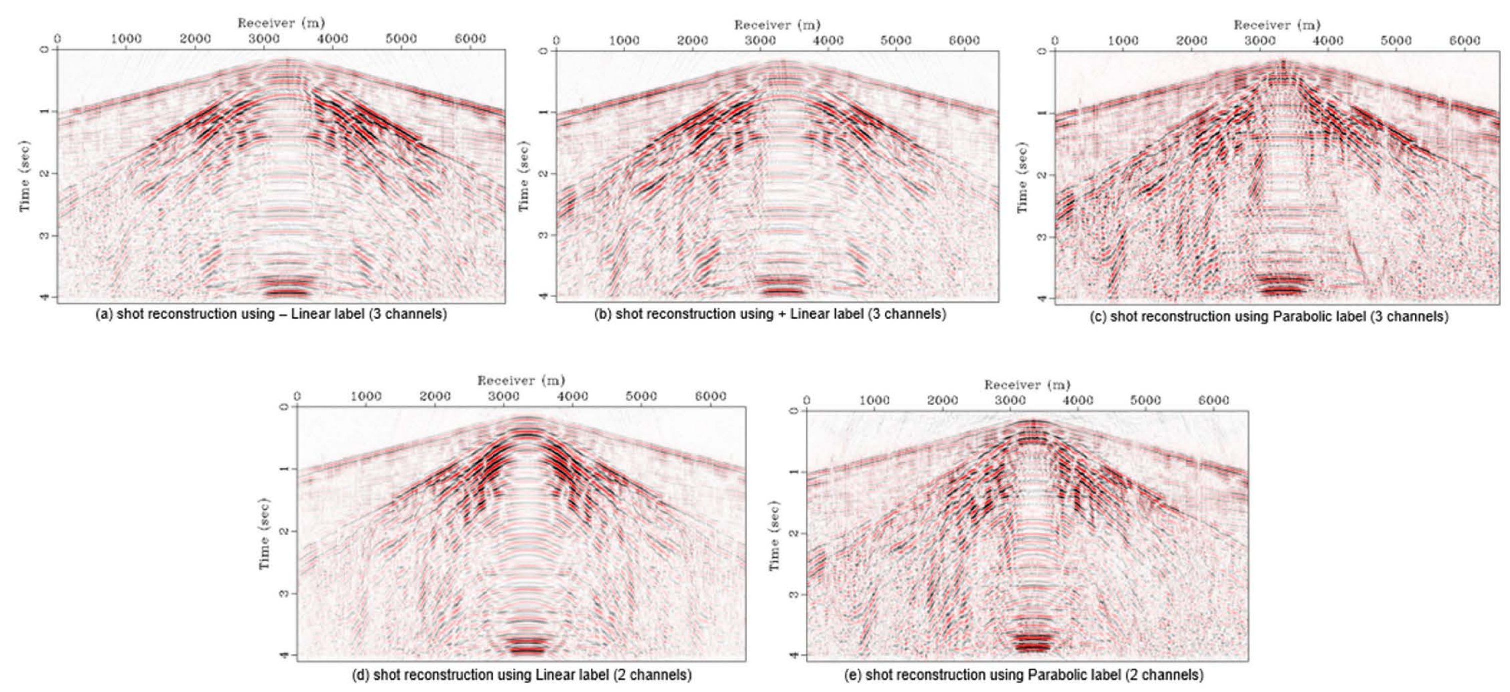

Figure 6: Results using 3 channels: (a) reconstruction of the prediction using -Linear RT as the label, (b) reconstruction of the prediction using +Linear RT as label and, (c) reconstruction of the prediction using Parabolic RT as the label. 2 channels: (d) reconstruction of the prediction using Linear RT as label and, (e) using Parabolic as the label.

Acknowledgments

The sponsors of CREWES are gratefully thanked for continued support. This work was funded by CREWES industrial sponsors, NSERC (Natural Science and Engineering Research Council of Canada) through the grant CRDPJ 543578-19. One of the authors of this report was supported by the CSEG Foundation. We also thank Kai Zhuang and Ivan Sanchez for their discussions, brainstorming about the topics covered in this report and help with Madagascar.

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