High Resolution Radon Transform Based on a Matching Pursuit Method

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1. Introduction:

The Radon transform (RT) is a mathematical techniques developed by J. radon in 1917. It has become very popular in seismic data processing, image processing, tomography, etc. There are 3 different implementations of the Radon transform, linear τ-p, parabolic τ-p and hyperbolic τ-p In seismic data processing. The introduction to linear and parabolic RT follows mainly from Zhou and Greenhalgh (1994) and Sacchi and Ulrych (1995, 1996).

Different approaches have been investigated and applied to the multiple attenuation problem, including the Radon transform, which is an industry standard workflow and has been attracting lots of attention in the last two decades. In this study, Radon transform techniques are reviewed and analyzed and a new Radon algorithm, the high resolution Radon transform based on a Match-Pursuit method, will be introduced.

2. Principle:

Johan Radon established the Radon transform, as a function that integrates some physical property of a medium along a particular path. In seismology, the generalized Radon transform is defined as an integral of amplitudes:

$$u(\tau,p) = \sum_{x=-K}^{K} d(t=\tau+p\varphi(x),x)$$

where $d(t,x)$ is the original seismic data in time-space domain; $u(\tau,p)$ is the radon transform; x is offset; $\varphi(x)$ defines the curvature upon which the transform curve is defined; p is the slope of the curvature; τ is the intercept time and t is the two-way travel time; $2K+1$ is the window size.

Considering a reflection point on a horizontal layer generates a hyperbolic event on a CMP gather, the hyperbolic Radon transform over the CMP gathers should be:

$$u(\tau,p) = \sum_{x=-K}^{K} d(t=\sqrt{\tau^2+px^2},x)$$

where $p = 1/v_{rms}^2$ and the summation path is defined by $t=\sqrt{\tau^2+px^2}$, which implies a hyperbolic curve.

Hampson (1986) showed that multiple reflections on an NMO-corrected CMP gather can be approximately seen as parabolic. A parabolic Radon transform can then be built on a NMO-corrected CMP gather, where $p = 1/2t_0 v_{resid}^2$ and $t=\tau+px^2$.

3. Theoretical Anapysis:

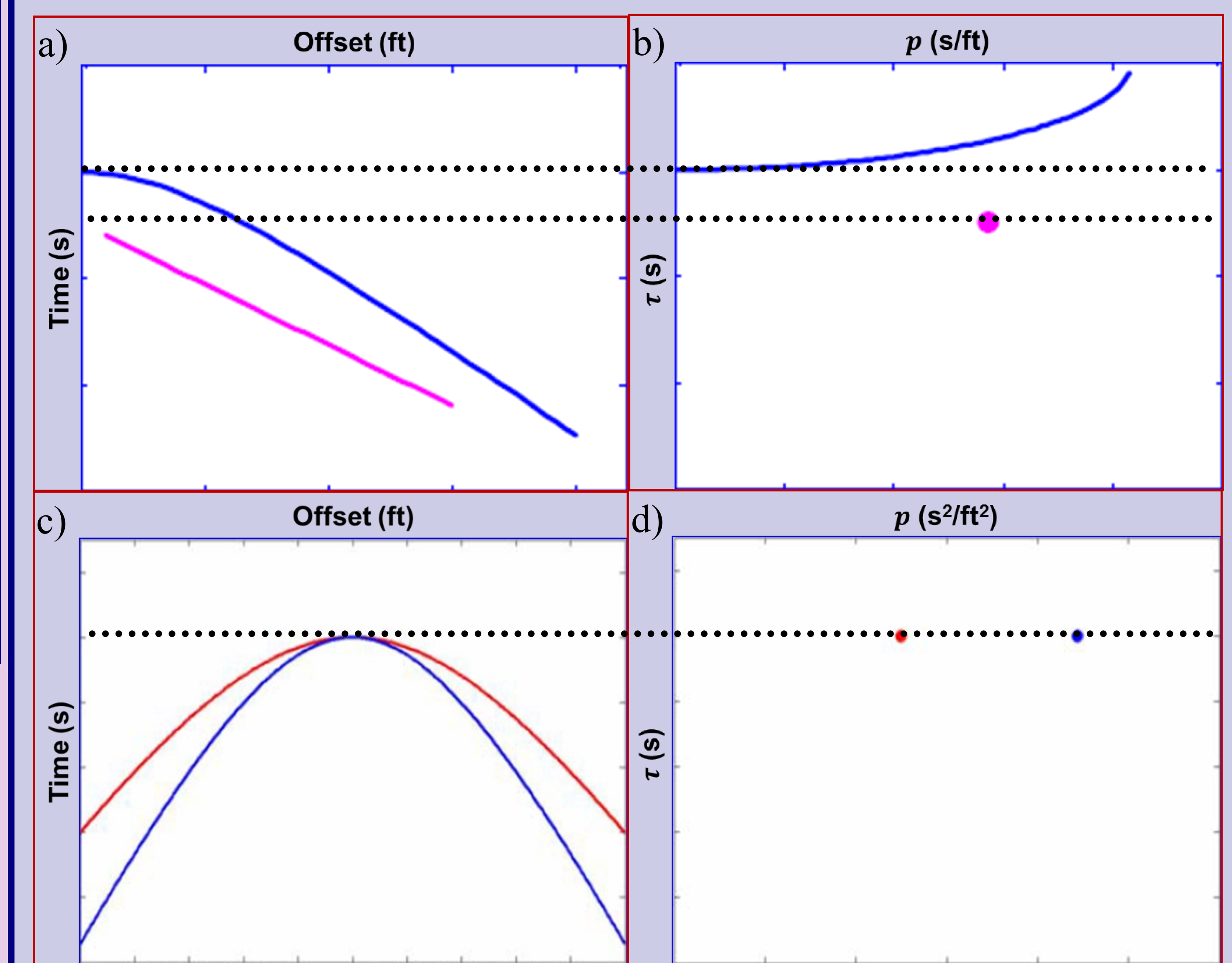


Figure 1: The linear and hyperbolic events in the CMP gather (a) and its linear Radon transform (b); Hyperbolic events in the CMP domain (c) are mapped to focused points in the Radon domain (d) by the hyperbolic Radon transform.

4. Resolution Problem:

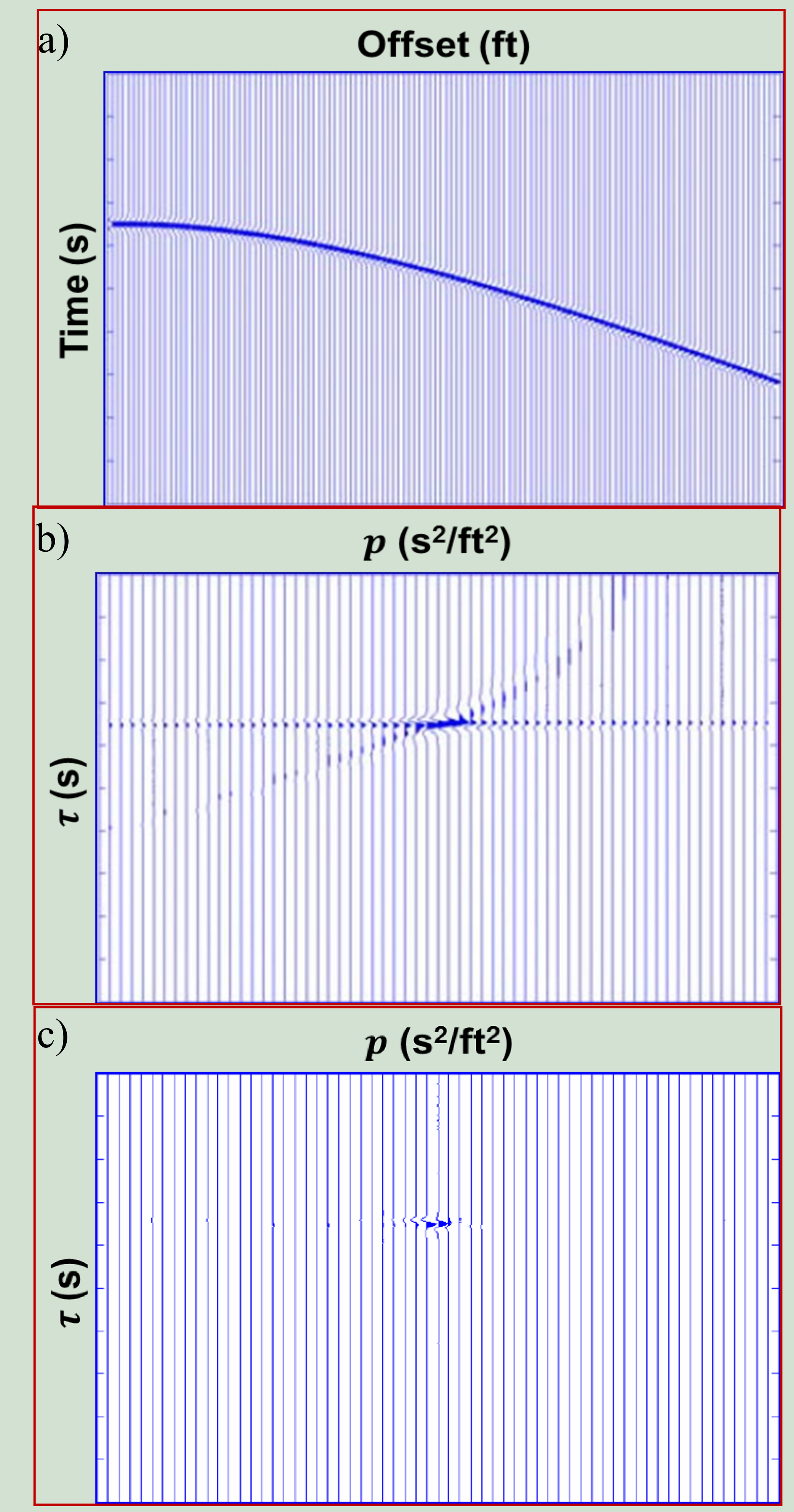
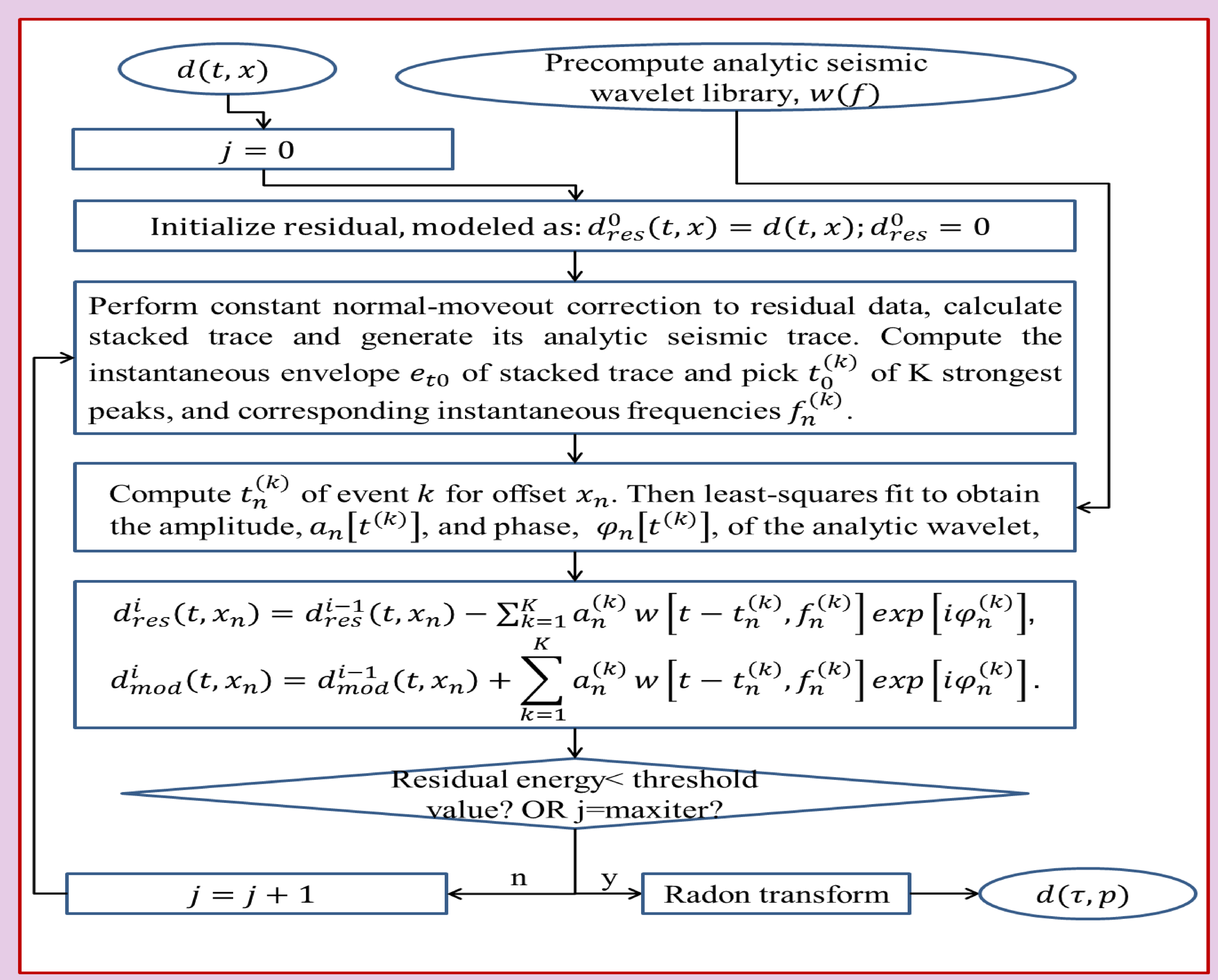


Figure 2: (a) A hyperbolic event in the time-space domain; and its Radon panel by (b) conventional hyperbolic Radon transform and (c) by the semblance-weighted Radon solution.

5. Workflow:



6.Conclusions:

- Radon transform is an effective way to suppress multiple reflections in exploration seismology.
- Lots of methods are applied to solve the resolution problem of Radon transform, the matching pursuit algorithm, which has been well used in spectral decomposition, NMO correction, etc, will be a better method de-multiple processing.

7.Acknowledgements:

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