Comparing Seismic Imaging Methods (Pre & Post Stack)

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Outline

1 Introduction
2 Channel model
3 Marmousi model
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1 Introduction

• Migration of seismic data can move dipping events to their correct positions, collapse diffractions and increase spatial resolution.
• In pre-stack migration, seismic data is adjusted before stacking sequence occurs.
• Post-stack migration operates on the stacked section which is assumed to be zero-offset section.
2 Channel Model

- Horizontal layers without dips or lateral velocity variations
- 40 sources: $\Delta s = 4m$
- 250 receivers: $\Delta r = 24m$
- Stability condition:
  $$dt_{step} \leq \sqrt{\frac{3}{8V_{\text{max}}}} \frac{dx}{V_{\text{max}}}$$
  $$dt_{step} = 0.2ms, dx = 2m$$
  $$V_{\text{max}} = 4500 \text{ m/s}$$
- Kirchhoff time migration
Pre-stack Migration

10th shot record

10th migrated shot record

10th shot record after gain

Pre-stack Migration Image
Pre-stack Migration
Post-stack Migration
Comparison

- Pre and post migration both image three interfaces well.
- Pre and post migration both image the channel similarly.

2 Channel model
3 Marmousi Model

- Faults, unconformity, anticline
- 41 sources: $\Delta s = 100m$
- 1251 receivers: $\Delta r = 8.33m$
- PSPI depth migration
Pre-stack Migration Imaging Condition

Down-going field

source

D

U

r_s

receiver

ν_1

Up-going field

ν_2

U(\vec{x}, \omega) = R_T \frac{W_T(\omega)}{4\pi r_s^3} e^{i k r_s}

R_T \text{ True reflection coefficient}

W_T(\omega) \text{ True wavelet}

k = \frac{\omega}{\nu_1} \text{ Wavenumber}

D(\vec{x}, \omega) = \frac{W(\omega)}{4\pi r_s^3} e^{i k r_s}

W(\omega) \text{ Wavelet estimate}

Crosscorrelation (Gibbsian):

\begin{align*}
R_{cg}(x^2, \omega_P) & = \frac{W_T(\omega_P)W_T^*(\omega)W^*(\omega)}{r_s^3 (4\pi)^2 (4\pi)^2}
\end{align*}

Deconvolution (Stabilized):

\begin{align*}
R_d(\omega) & = \frac{U(\vec{x}, \omega) D^*(\vec{x}, \omega) W_T(\omega)}{D(\vec{x}, \omega)^2 + \mu_D m^* W(\omega)}
\end{align*}

\text{\mu \text{ stability factor}}
Pre-stack Migration
Cross-Correlation Imaging Condition
Pre-stack Migration
Stabilized Deconvolution Imaging Condition, $\mu=0.0001$
Pre-stack Migration

Stabilized Deconvolution Imaging Condition

\( \mu = 0.0001 \)

\( \mu = 0.01 \)
Post-stack Migration
Comparison

- Migration image has a higher resolution under deconvolution imaging condition than cross-correlation imaging condition.
- Pre-stack migration images better than post-stack migration.

3 Marmousi model
## Comparison of Calculation Time

<table>
<thead>
<tr>
<th>Calculation Time</th>
<th>Channel Model</th>
<th>Marmousi Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Kirchhoff time migration)</td>
<td>(PSPI depth migration)</td>
</tr>
<tr>
<td>Post-stack Migration</td>
<td>33 (s)</td>
<td>318 (s)</td>
</tr>
<tr>
<td>Pre-stack Migration</td>
<td>23.5*40=940 (s)</td>
<td>440*41=18040 (s)</td>
</tr>
</tbody>
</table>

- In both models, post-stack migration spends much less time than the corresponding pre-stack migration.
4 Conclusions

- For a simple model without dips or lateral velocity variations, post-stack migration and pre-stack migration have similar imaging results.
- For a complex model with large dips and strong lateral velocity variations, pre-stack migration images better than post-stack migration method.
- Muting migrated data correctly can improve imaging quality.
- Post-stack migration is much faster than the corresponding pre-stack migration.
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Questions & Comments