TRUE AMPLITUDE MIGRATION: Shot profile migration

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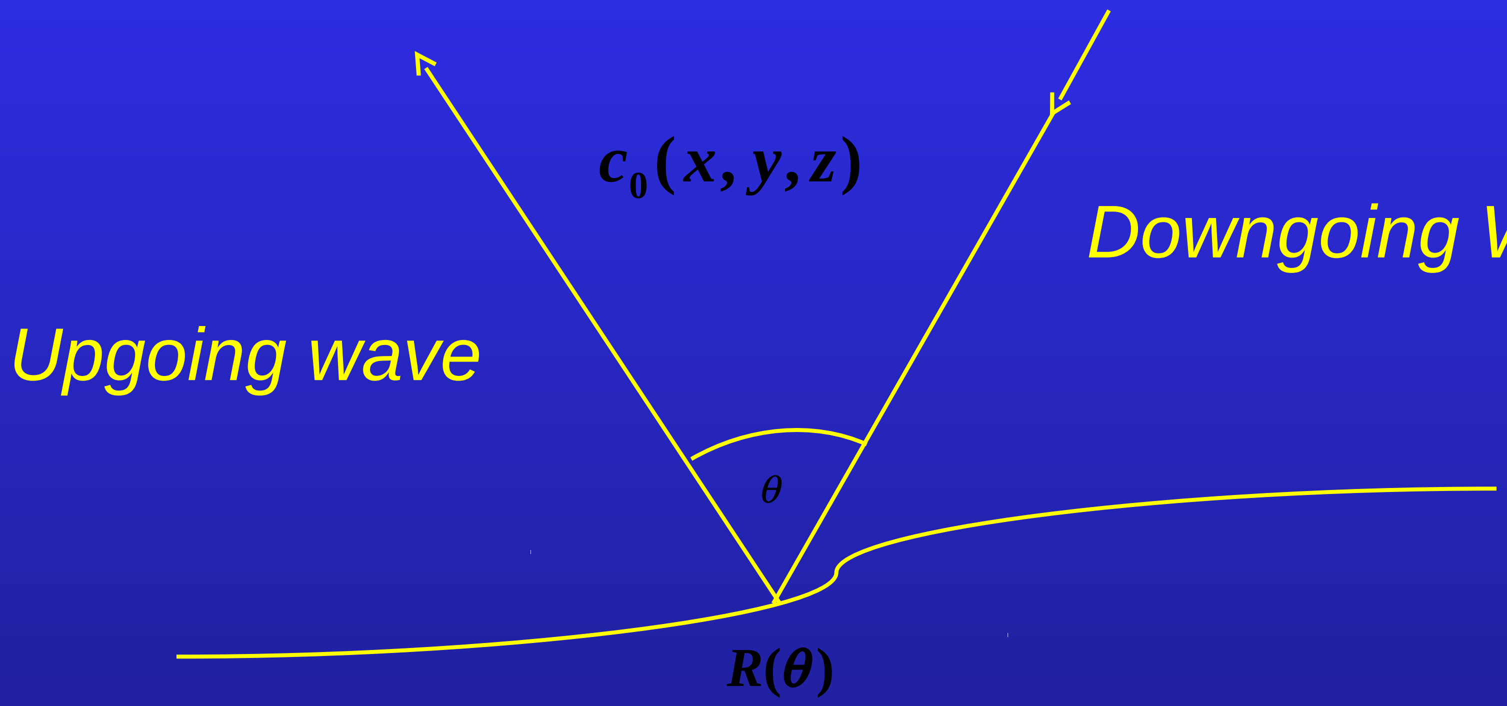
OVERVIEW

- Introduction
- True-amplitude shot-profile migration
- Numerical examples
- Conclusions

INTRODUCTION



$R(\theta)$: Uknown reflection coefficient

θ : Angle

$c_0(x, y, z)$: Smooth known background velocity

INTRODUCTION

- Well developed methodology for ray methods
  - Angle migration (Ursin, 2004)
- Wave methods
  - Classical shot-profile migration (Claerbout,1971)
  - Angle transform (De Bruin et al, 1990)
  - Cross-correlation (Zhang and Bleistein, 2007)

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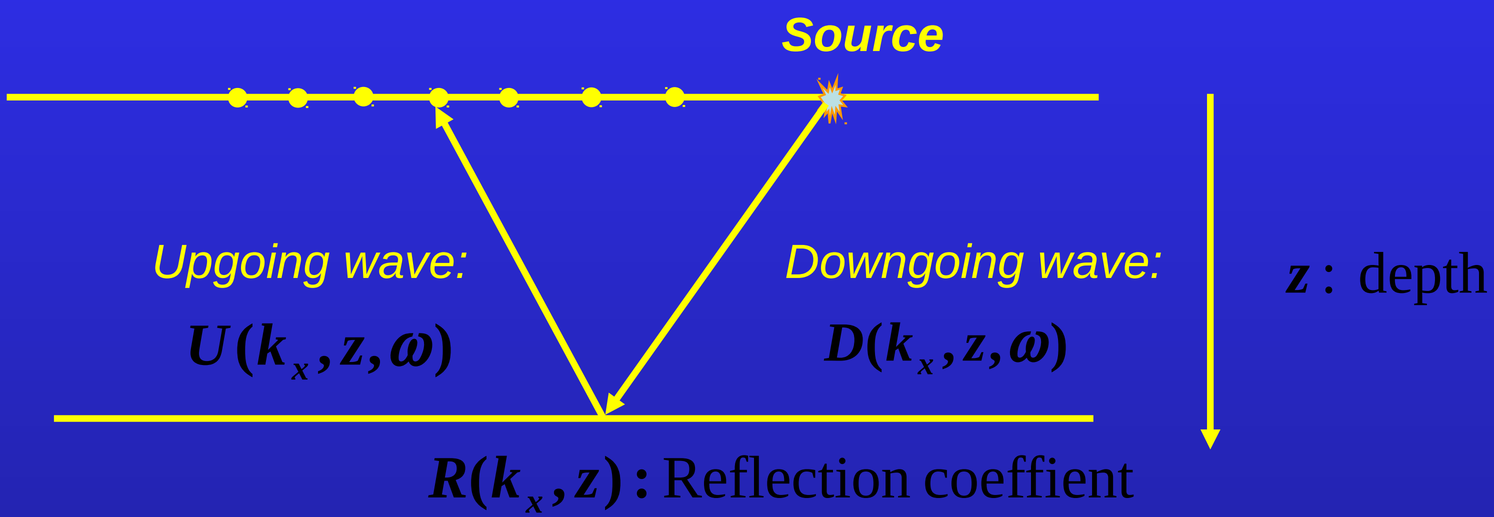
PLANE LAYER MODEL



Model:

$$U(k_x, z, \omega) = R(k_x, z) D(k_x, z, \omega)$$

frequency

Horizontal wavenumber

Inversion for R:

$$R(k_x, z) = U(k_x, z, \omega) / D(k_x, z, \omega)$$

UNSTABLE!!!!

PLANE LAYER MODEL

z

Source pulse

$$D(k_x, z, \omega) = \underbrace{\exp(-ik_z z)}_{\text{Extrapolator}} \underbrace{\left(\frac{S(\omega)}{2ik_z} \right)}_{\text{Point source wavefield}}$$

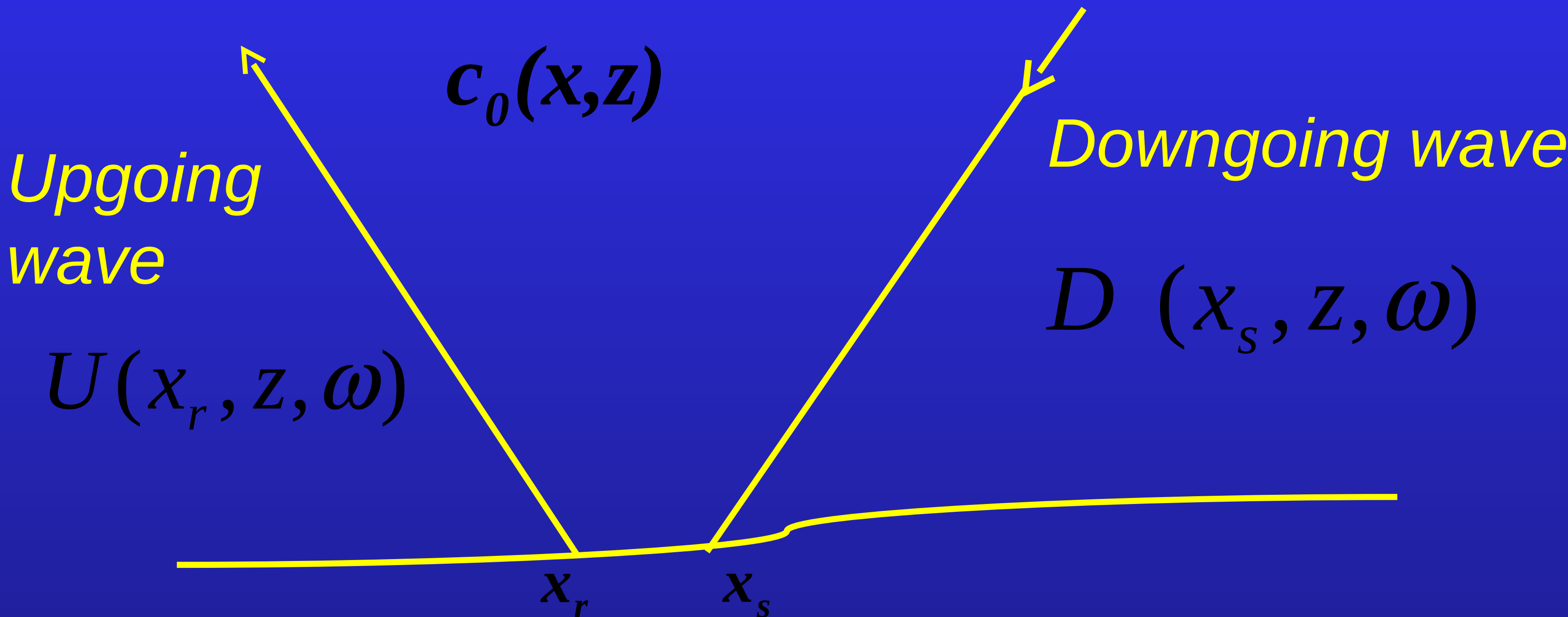
$$k_z = \sqrt{(\omega / c_0)^2 + k_x}$$

$$R(k_x, z) = U(k_x, z, \omega) / D(k_x, z, \omega) = U(k_x, z, \omega) D'^{*}(k_x, z, \omega)$$

STABLE!!!!

$$D'^{*}(k_x, z, \omega) = \underbrace{\exp(ik_z z)}_{\text{Extrapolator}} \underbrace{\left(\frac{2ik_z}{S(\omega)} \right)}_{\text{Modified source wave-field}}$$

GENERAL MODEL

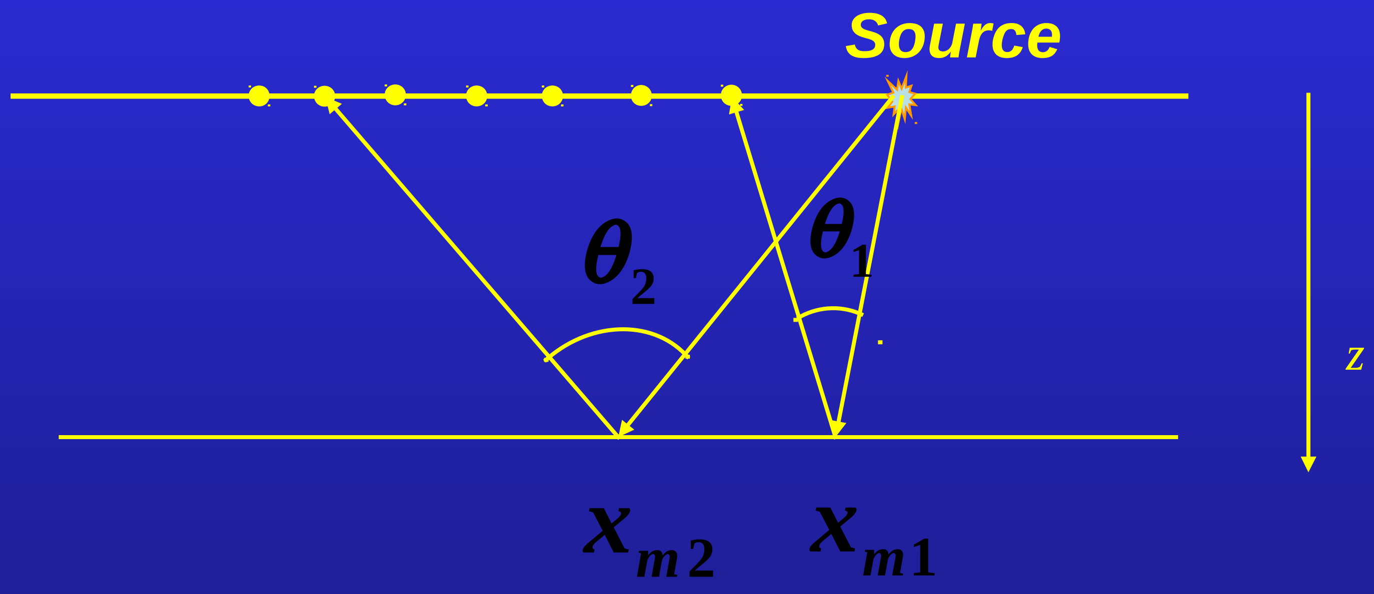


$$R(x_r, x_s, z) = \int d\omega \, U(x_r, z, \omega) D'^{*}(x_s, z, \omega)$$

Reflection matrix

Modified source

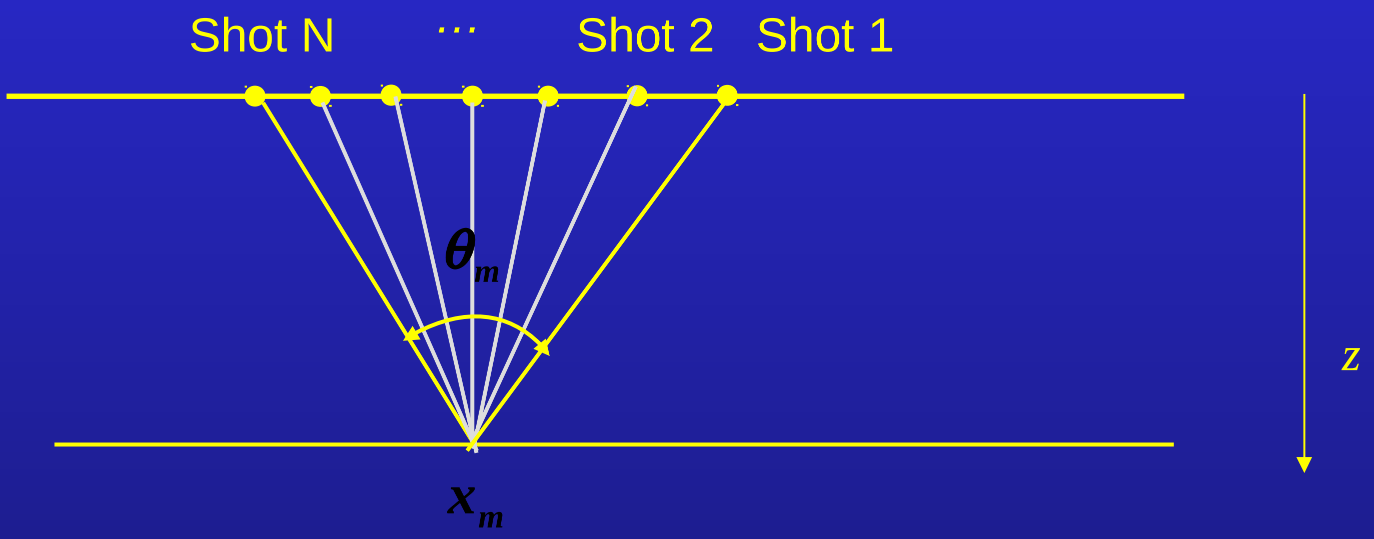
ANGLE GATHERS



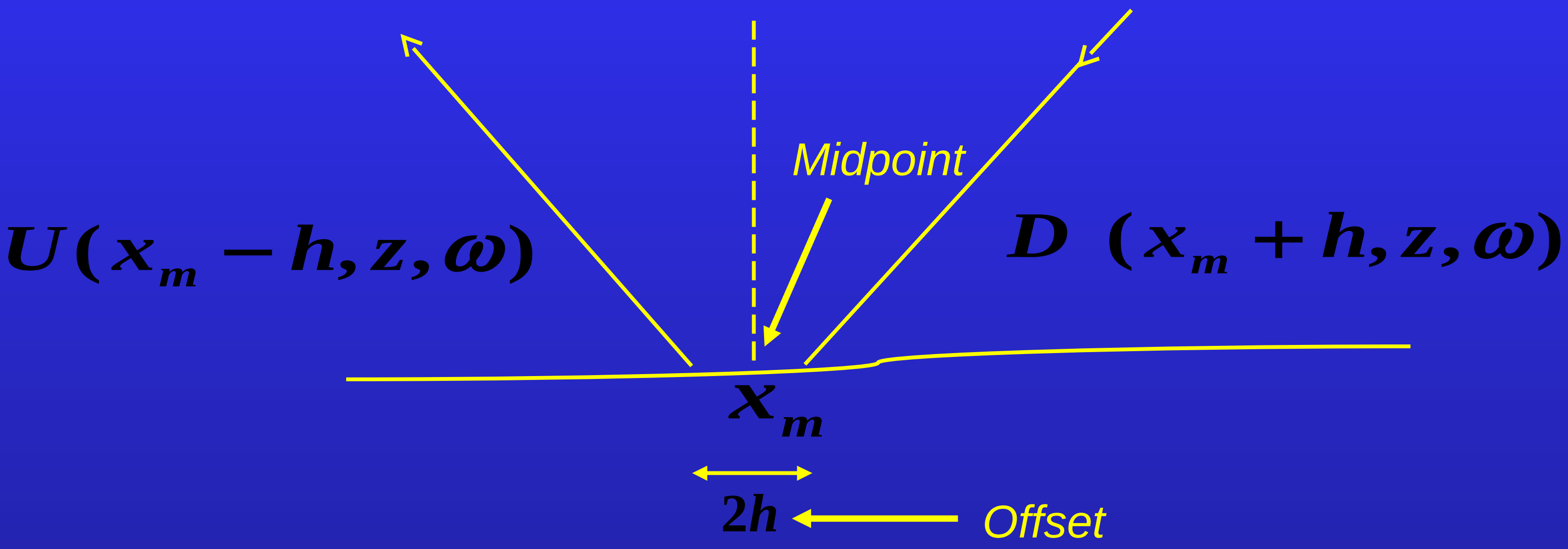
Single shot gives limited angle information

ANGLE GATHERS

Need many shots to get full angle coverage at single position



ANGLE GATHERS



Reflection matrix as function of offset and midpoint:

$$R(x_m, h, z) = \int d\omega\, U(x_m - h, z, \omega)\, D^{'*}(x_m + h, z, \omega)$$

Reflection matrix as function of slowness (angle) and midpoint:

$$R(x_m, p_h, z) = \int \mathrm{d}\omega \int dh\, \exp(i\omega p_h h)\, U(x_m - h, z, \omega) D^{'*}(x_m + h, z, \omega)$$

Horizontal slowness

IMAGING CONDITIONS

Claerbout's (1971) classical imaging condition:

$$R_c(x_m, h=0, z) = \int \mathrm{d}\omega\, U(x_m, z, \omega)\, \underbrace{D^*(x_m, z, \omega)}_{\text{Point-source}}$$

Extended to include offset (Rickett and Sava, 2002):

$$R_{RS}(x_m, h, z) = \int \mathrm{d}\omega\, U(x_m + h, z, \omega)\, \underbrace{D^*(x_m - h, z, \omega)}_{\text{Point-source}}$$

New imaging condition:

$$R(x_m, h, z) = \int \mathrm{d}\omega\, U(x_m + h, z, \omega)\, \underbrace{D'^*(x_m - h, z, \omega)}_{\text{Modified source}}$$

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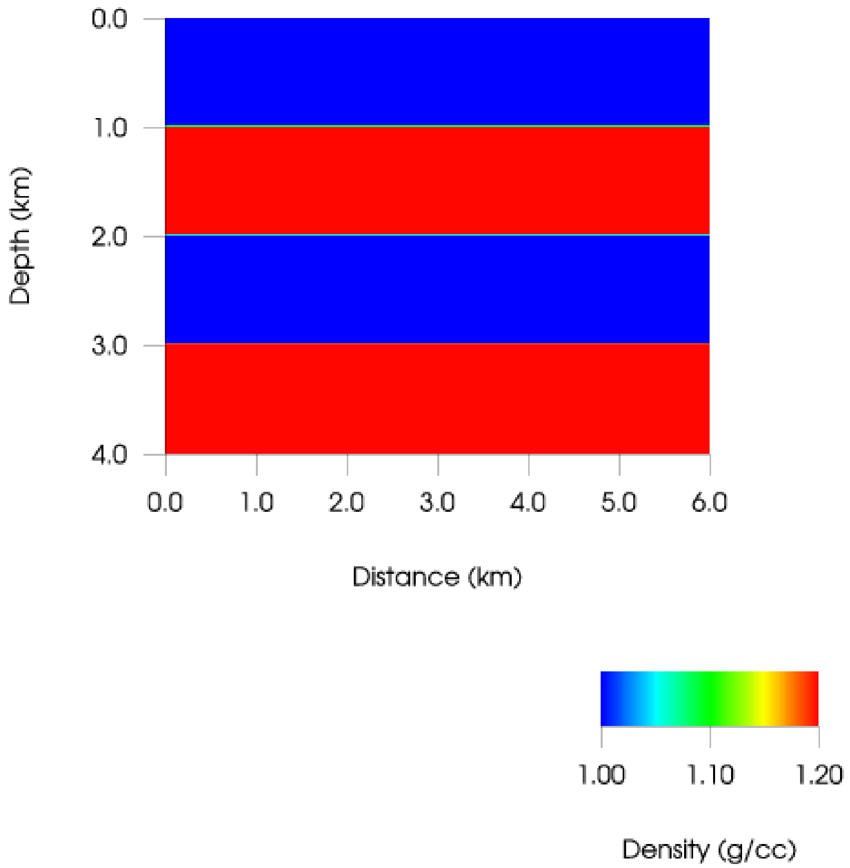
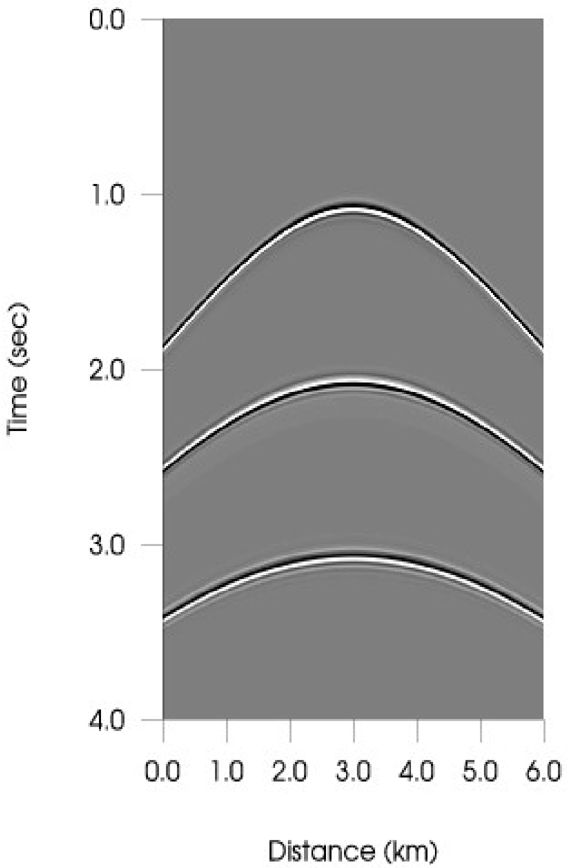
Density contrast

Model



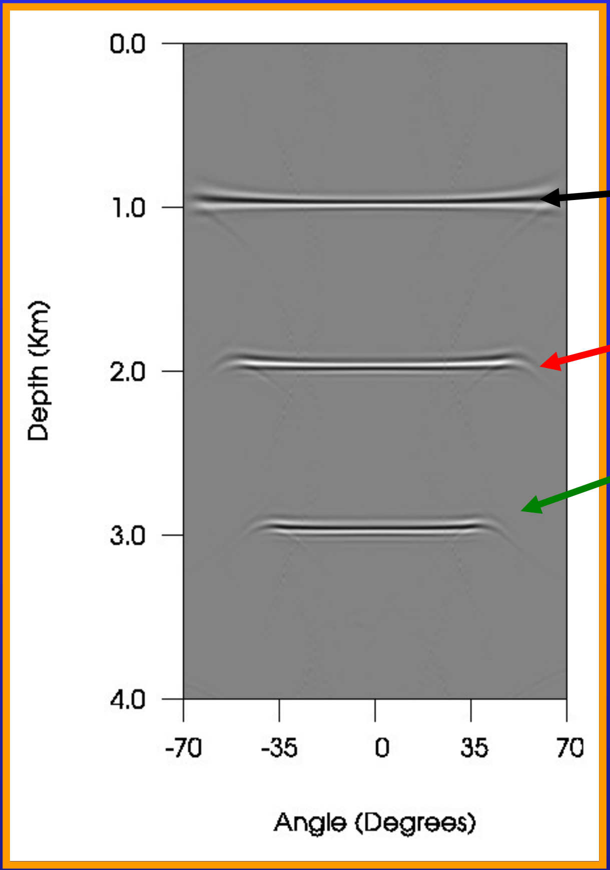
Shot gather



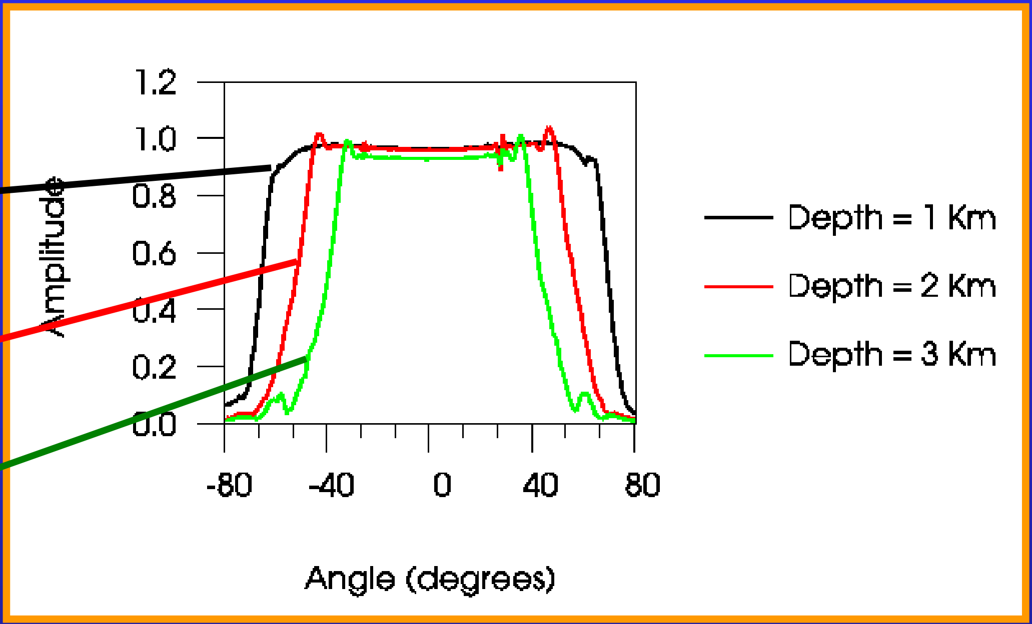
Density contrast only = angle independent reflection coefficients

Density contrast

New imaging condition



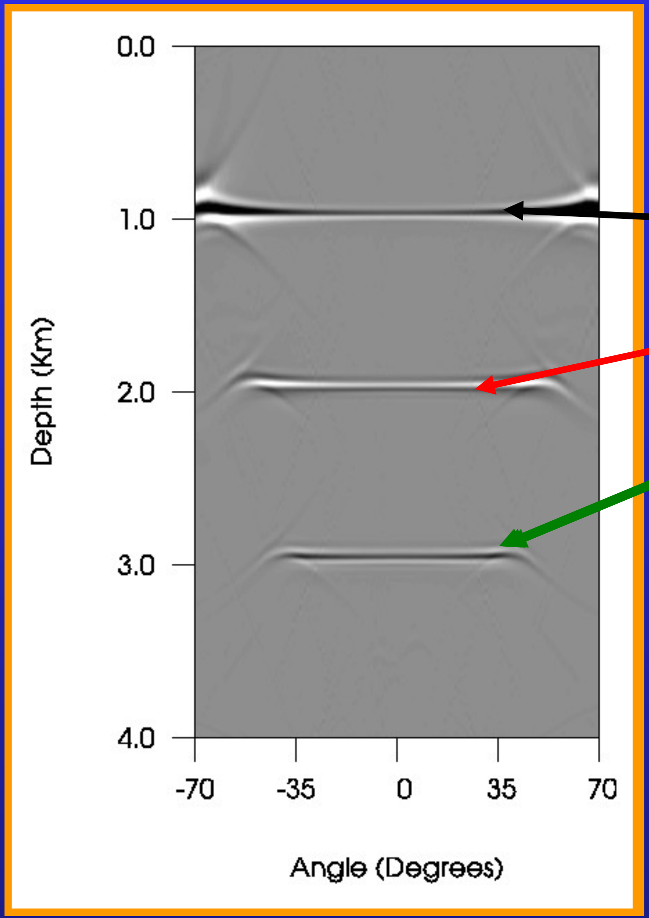
Amplitude picks



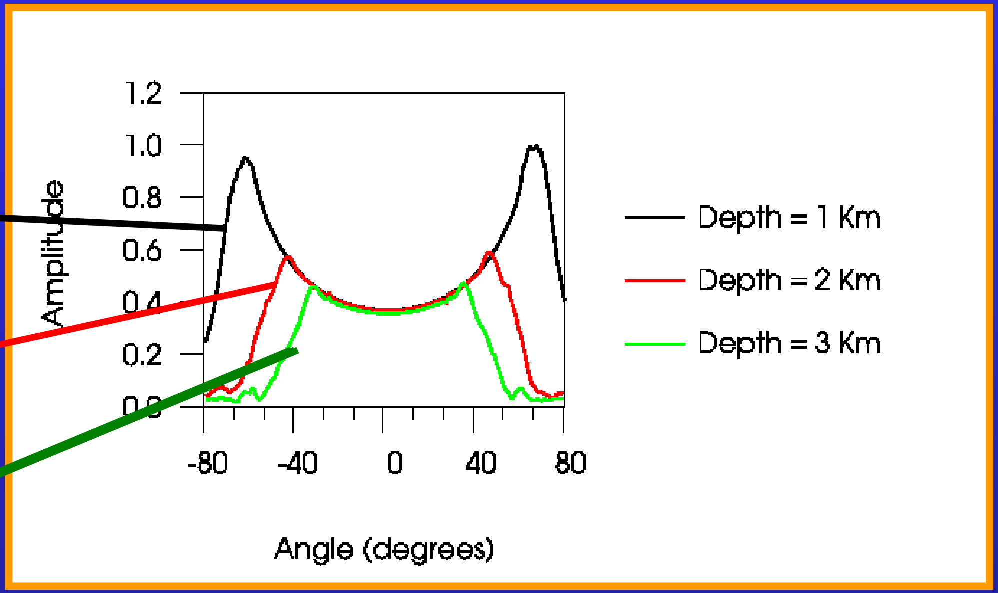
Density contrast only = *angle* ***independent reflection coefficients***

Density contrast

Rickett and Sava (2002)



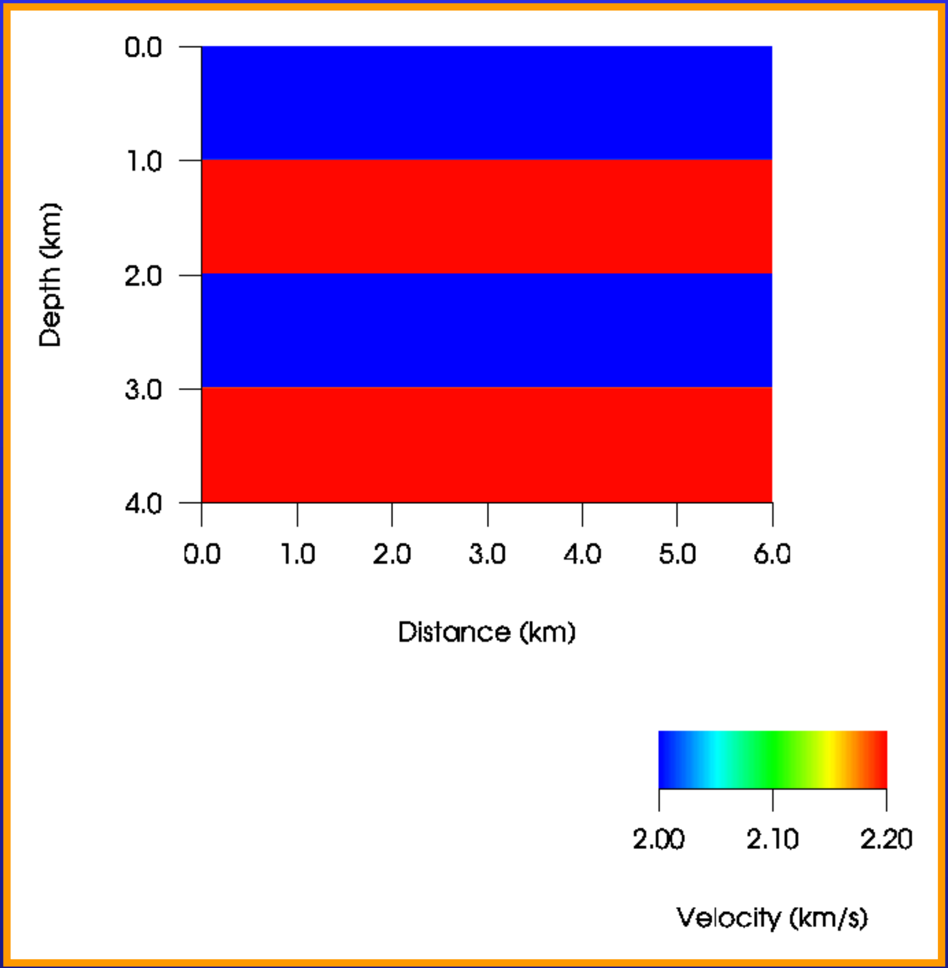
Amplitude picks



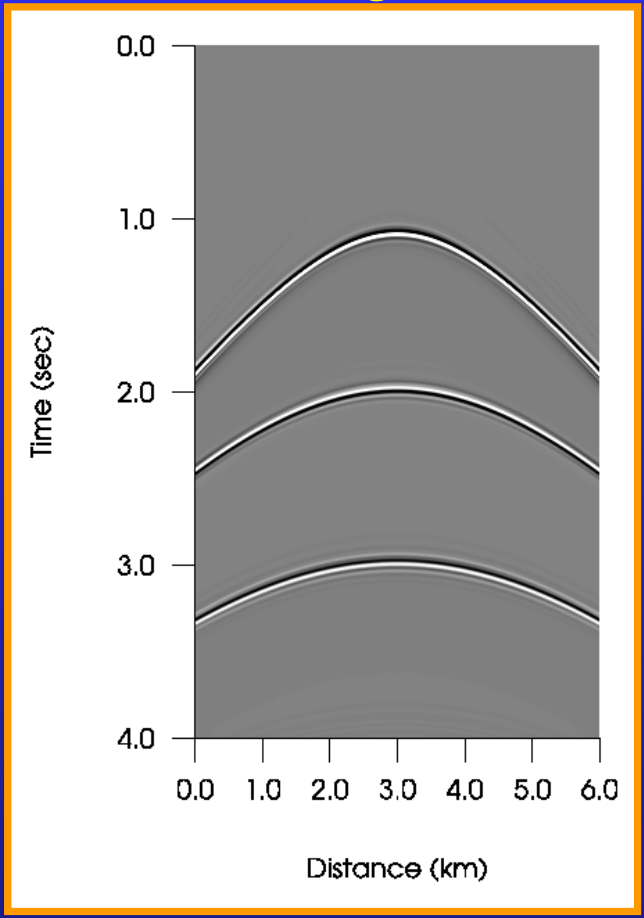
Density contrast only = angle independent reflection coefficients

Velocity contrast

Model

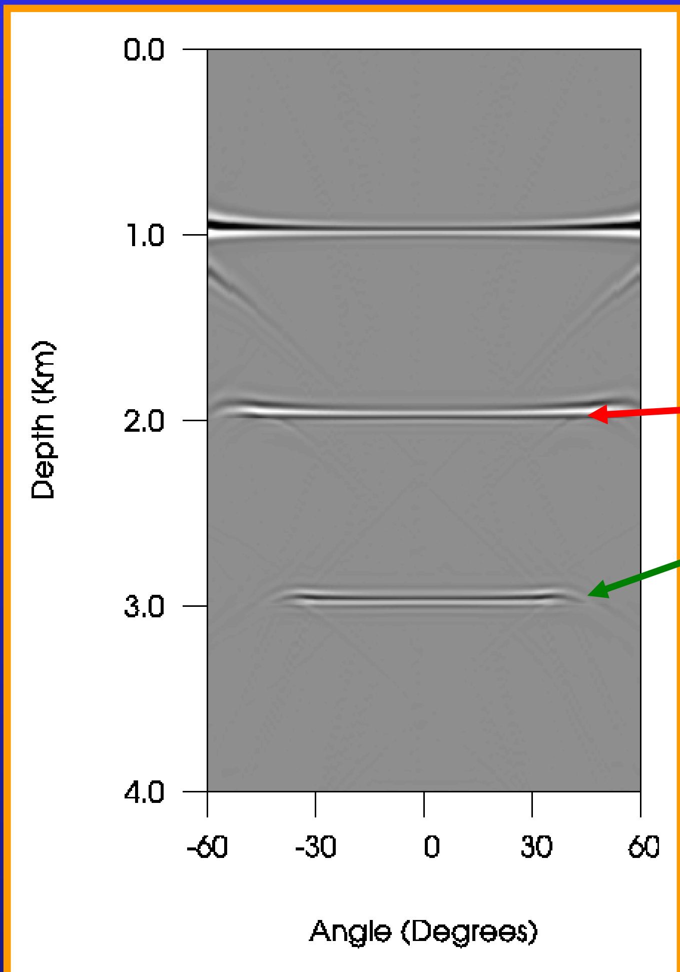


Shot gather

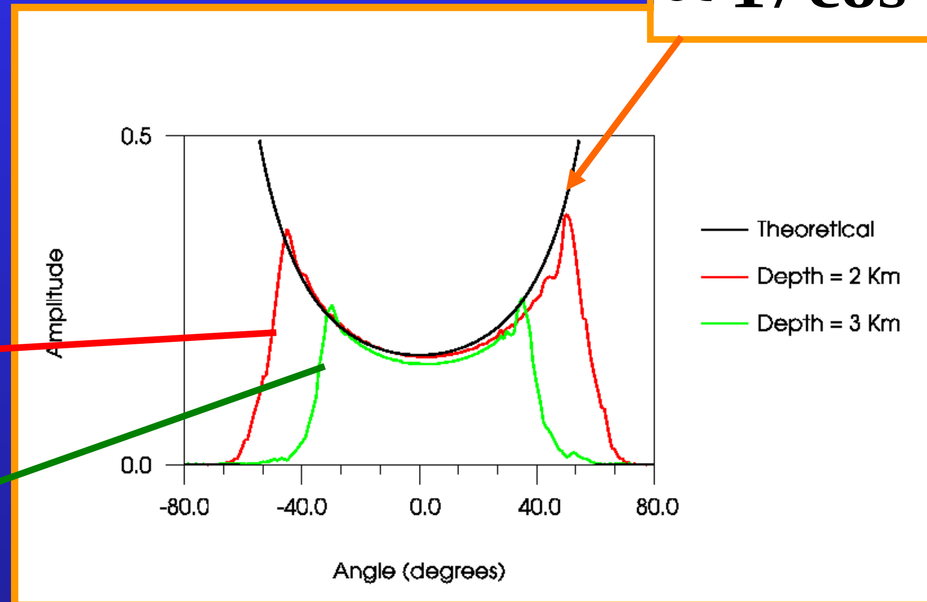


Velocity contrast

New imaging condition



Amplitude picks



Theoretical

$$\propto 1/\cos^2(\theta)$$

CONCLUSIONS

- Conventional shot-profile image conditions lead to incorrect angle dependence of the reflection coefficient
- New imaging condition with modified source gives correct angle dependence of reflection coefficient for plane layers

ACKNOWLEDGEMENTS

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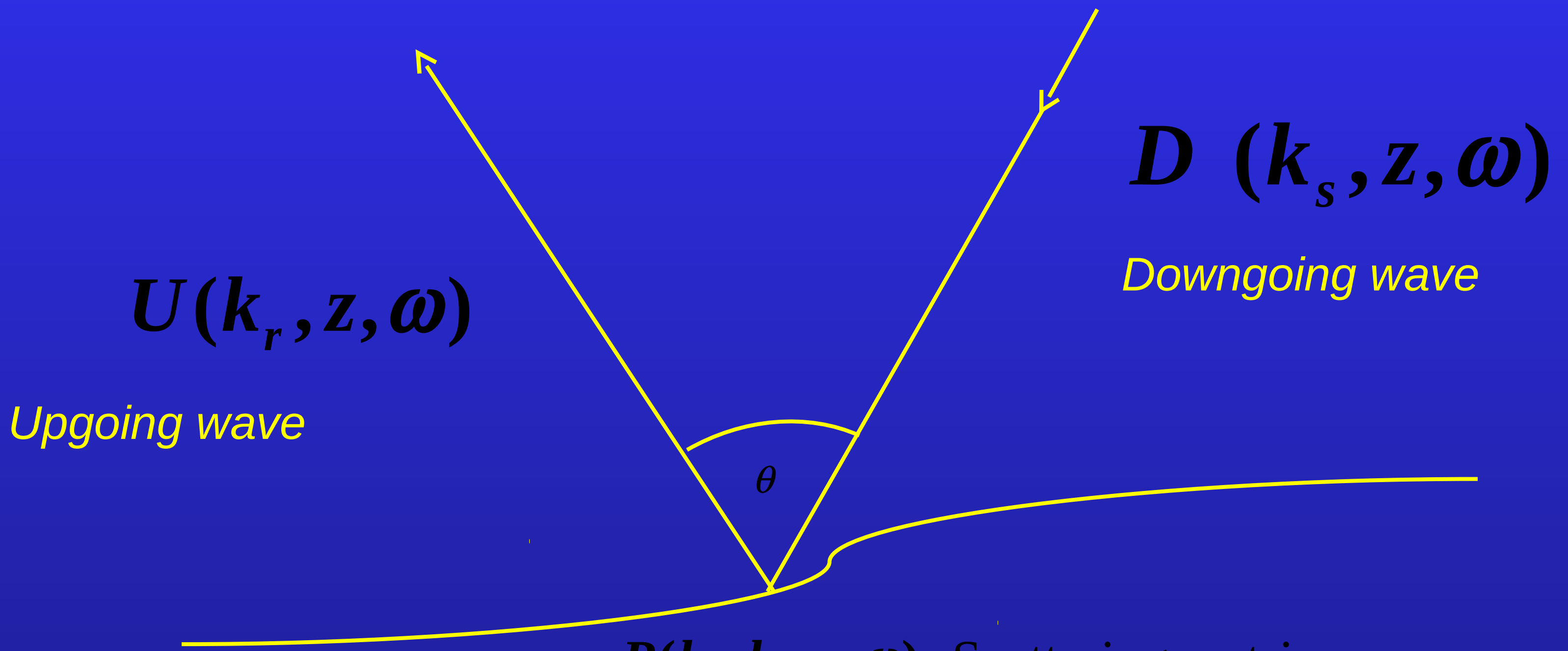
GENERAL MODEL



$R(k_r, k_s, z, \omega)$: Scattering matrix

$$U(k_r, z, \omega) = \int dk_s R(k_r, k_s, z, \omega) D^*(k_s, z, \omega)$$

$$R(k_r, k_{s,} z) = \int \mathrm{d}\omega\, U(k_r, z, \omega) D'^*(k_s, z, \omega)$$