Seismic wave **P**ropagation and **I**maging in **C**omplex media: a **E**uropean network

Rolf Sidler
Early Stage Researcher

Host Institution: OGS Trieste
Place of Origin: Zürich, Switzerland
Appointment Time: January 2005

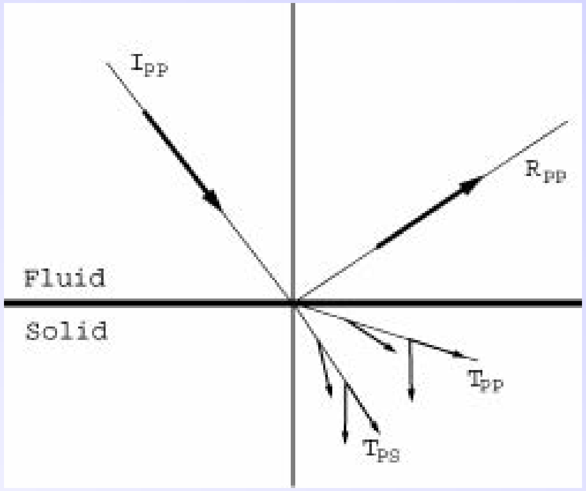
Project: Wave reflection on an anelastic transversely isotropic ocean bottom.

Task Groups: TG mushy seafloor (Small Scale)

Cooperation: ETH Zürich

P-wave reflection coefficient

The P-wave reflection coefficients is the portion of the amplitude of a incident P-wave that is reflected as a P-wave.



The P-wave reflection coefficient is a 'function' of ocean bottom parameters.

Inversion of measured P-wave reflection coefficients may give evidence about ocean bottom parameters.

Wave reflection at an anelastic anisotropic Ocean Bottom

P-wave reflection coefficients can be:

- *theoretically computed using the plane wave approximation.*
- *estimated from seismograms slightly above an interface*

We compare P-wave reflection coefficients from synthetic seismograms to theoretically computed ones. The goal is to verify the modelling algorithm and to identify ambiguities in the plane wave solution.

Plane wave reflection coefficient

The incident plane wave has the form

$$v_{P_I} = i\omega \begin{pmatrix} \beta \\ \xi \end{pmatrix} exp[i\omega(t - s_1 x - s_{3P_1} z)]$$

The boundary conditions for a fluid / solid interface require continuity of

$$v_z, \sigma_{zz} \text{ and } \sigma_{xz} = 0$$

The stress strain relations, the plane wave equations for incident and transmitted waves and the boundary conditions generate the following equation system (Graebner, 1992):

$$\begin{pmatrix} \xi_{P_1} & \xi_{P_2} & \xi_{S_2} \\ Z_{P_1} & -Z_{P_2} & -Z_{S_2} \\ 0 & W_{P_2} & W_{S_2} \end{pmatrix} \cdot \begin{pmatrix} R_{PP} \\ T_{PP} \\ T_{PS} \end{pmatrix} = \begin{pmatrix} \xi_{P_1} \\ -Z_{P_1} \\ 0 \end{pmatrix}$$

Plane wave reflection coefficient

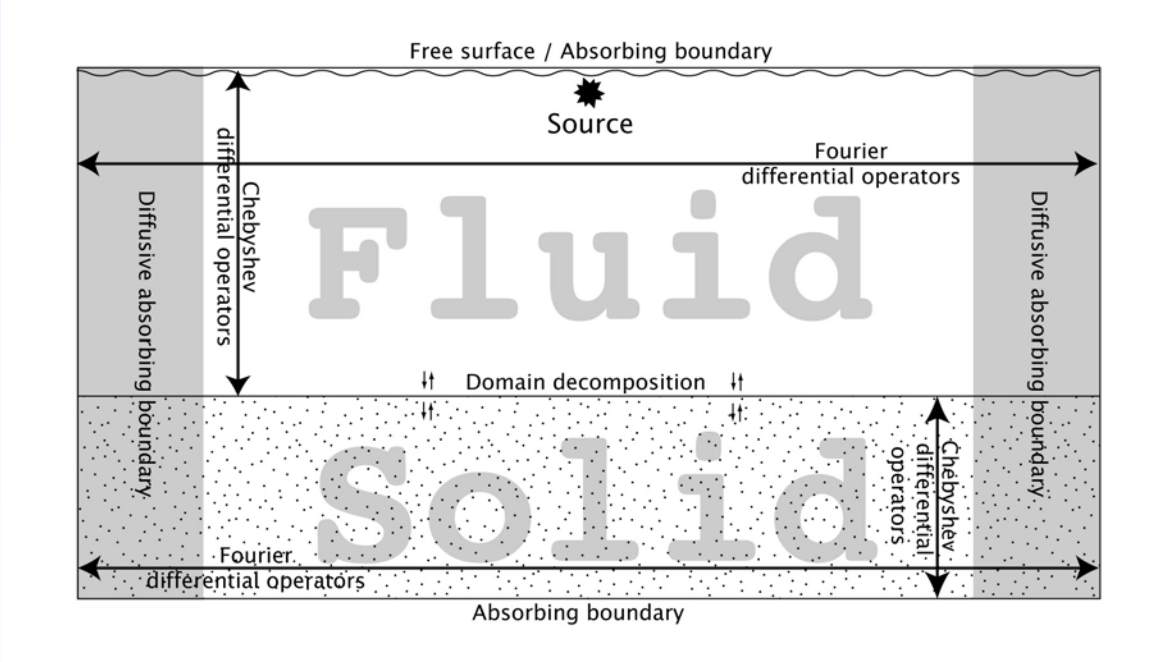
The reflection and transmission coefficients can be computed by solving the equation system for each angle separately.

1. *Snell's law for visco-elastic media states the horizontal slowness the same for all waves. The horizontal slowness can be computed for the incident wave depending on the incidence angle.*
2. *Calculate the vertical slowness, the W, Z and ξ's*
3. *Numerically solve the equation system.*

For more detail see Carcione (2007)

Seismic modelling

We use a 2D pseudo spectral code with a domain decomposition at the fluid solid boundary



Numerical Method

1. *Generate synthetic seismograms slightly above the interface*
2. *Compute seismograms at the same location without interface*
3. *Perform the difference between the first and the second seismograms to get the reflected field only.*
4. *Perform a 2D fourier transform of the incident field.*
5. *Perform a 2D fourier transform of the reflected field.*
6. *The ratio between the reflected and the incident field is the reflection coefficient*

Numerical Method

1. *Generate synthetic seismograms slightly above the interface*

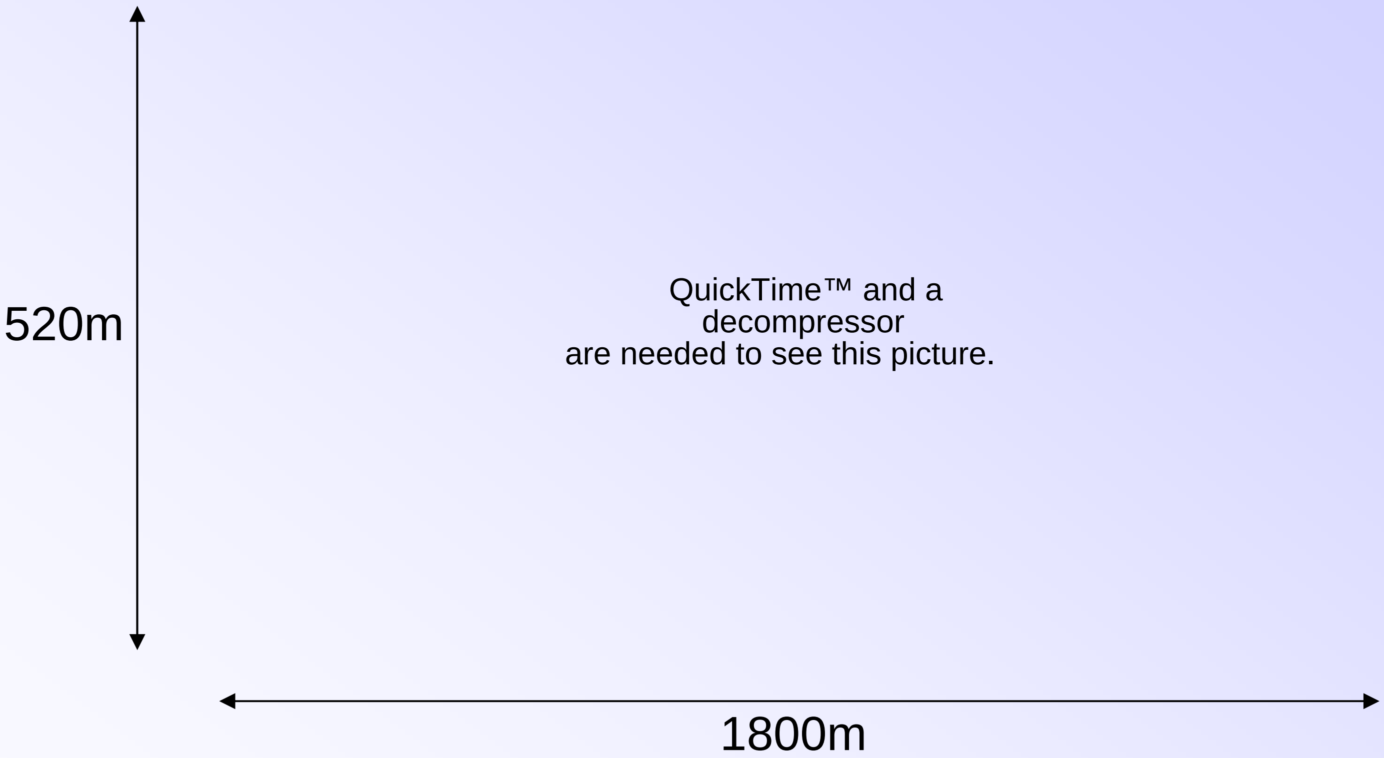
520m

QuickTime™ and a
decompressor
are needed to see this picture.

1800m

Numerical Method

2. Compute seismograms at the same location without interface



Numerical Method

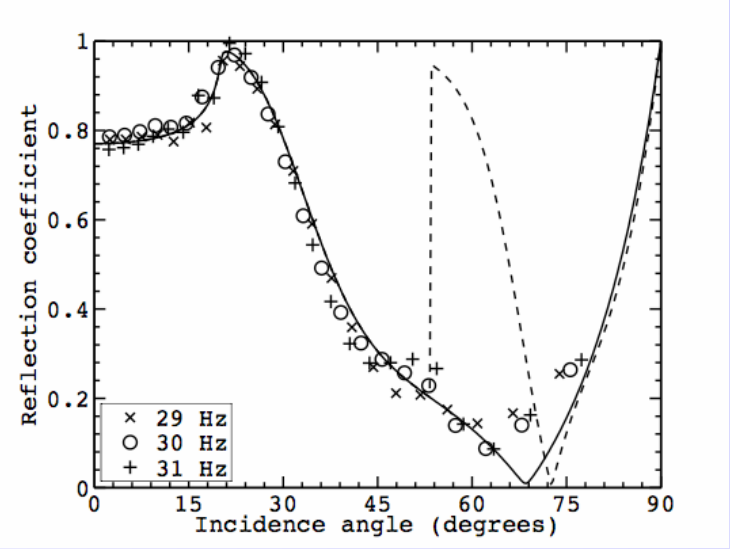
3. *Perform the difference between the first and the second seismograms to get the reflected field only.*

Reflected wave above the interface

20m

QuickTime™ and a decompressor are needed to see this picture.

1800m



Conclusions

We have simulated the reflection coefficients at a fluid / anisotropic-anelastic solid inderface. The modeling code with pseudospectral operators and a domain decomposition at the fluid / solid boundary showed accurate results.

The cross check between the numerical and the analytical solution allows to identify ambiguities that arrise in the analytical solution when choosing the wrong sign for the vertical slowness.