Finite Difference elastic modeling of the topography and the weathering layer

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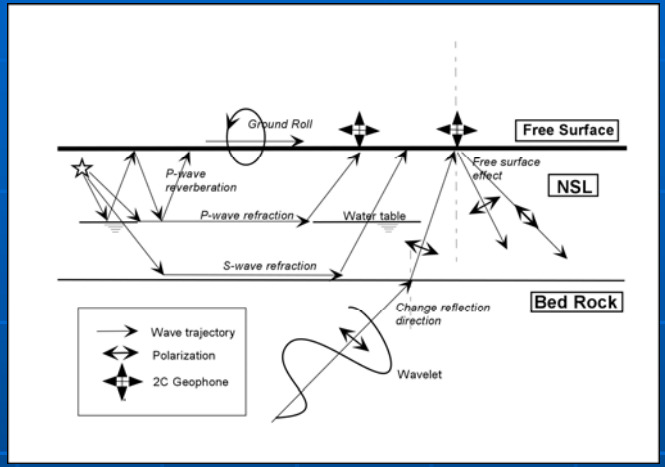
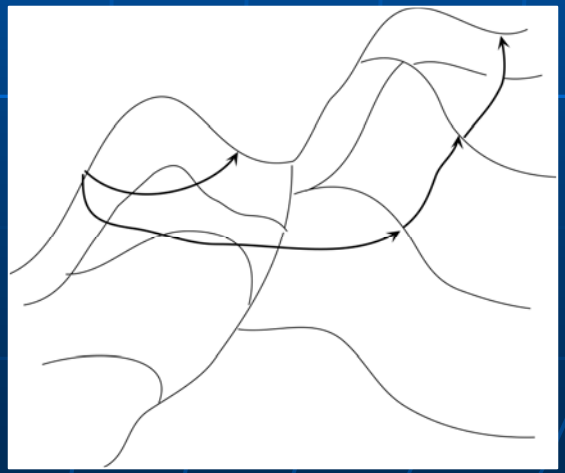
Outline

- Near surface issues and FD modelling.
- Example 1: Models with sloping flat surface.
- Example 2: Models with real topography.
- Discussion and final remarks.

Near surface layer issues

- Delay caused by Topography, heterogeneity in thickness and velocities (Statics).
- **Critical for converted waves**: time delays can be about 100 ms.
- Noise generated at the NSL: Rayleigh waves and so on.
- How to overcome these issues?

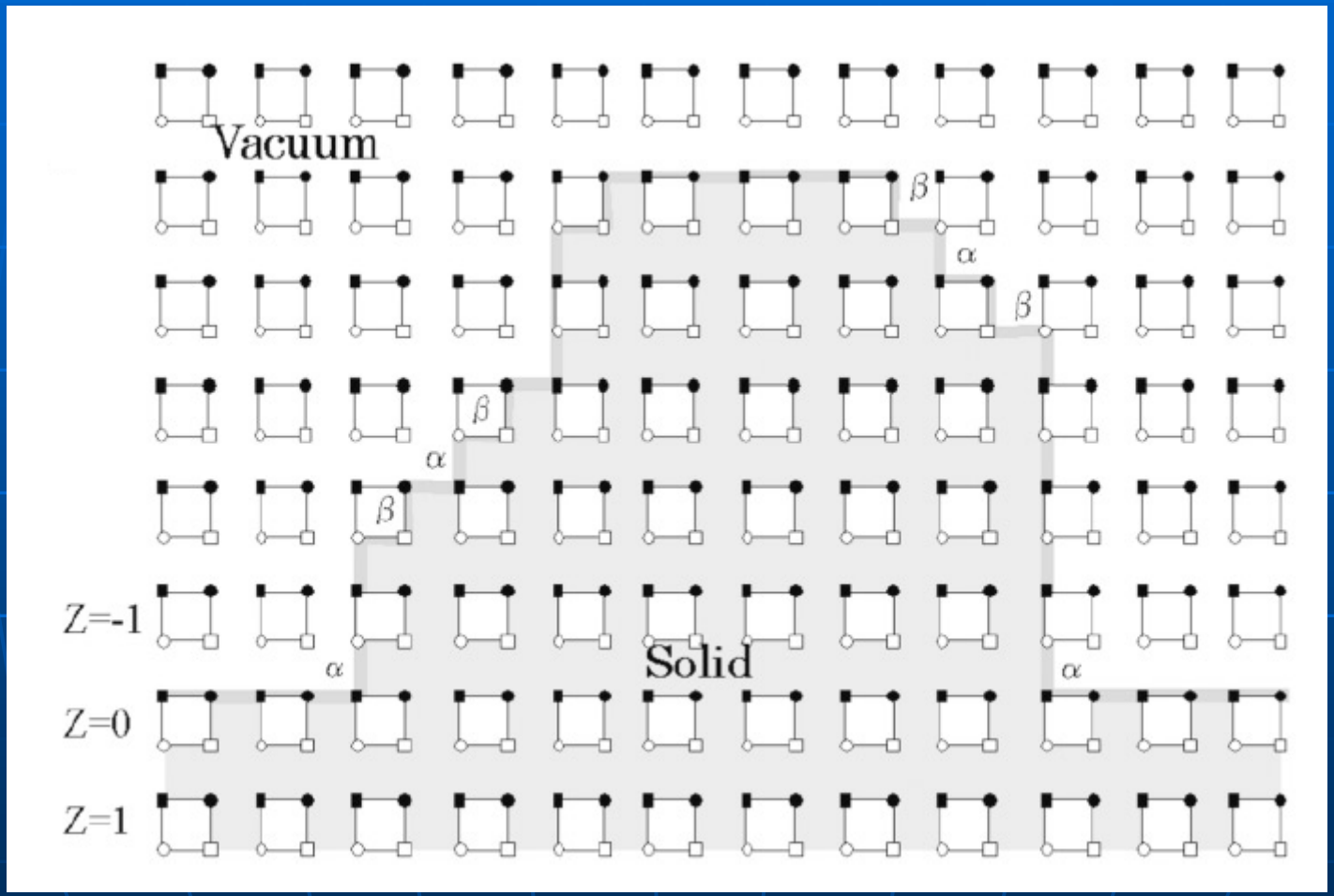




FD 2D Elastic modelling

- Finite difference corresponds to the wave equation: P, Sv, Rayleigh.
- Topography can be implemented.
- Realistic.
- Methods for analysis and filtering can be tested.

Topography implementation

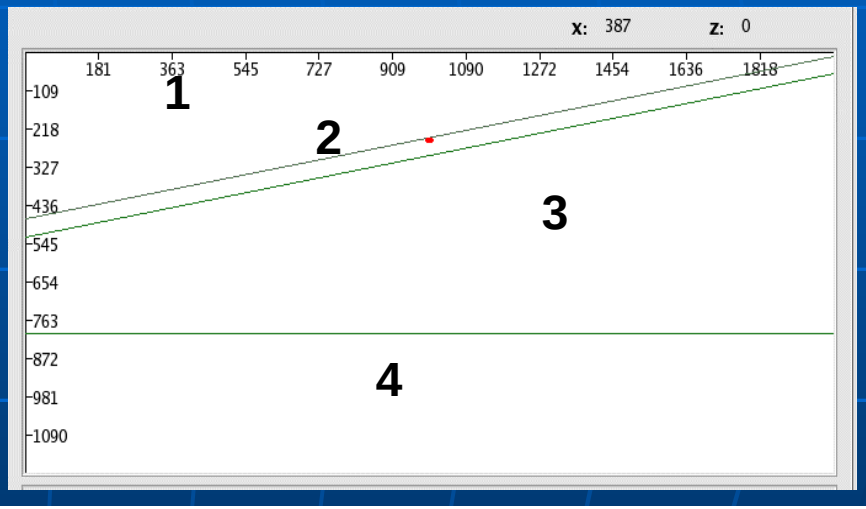


Stencil: staggered grid by Levander, 1988.
Topography by Hayashi *et al*., 2001.

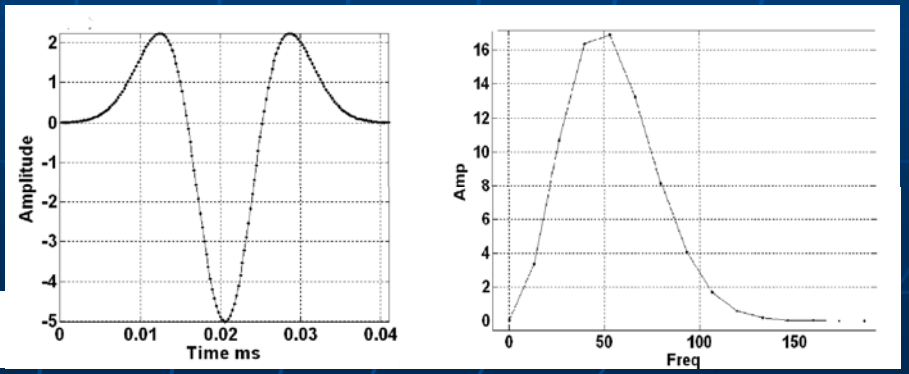
Models tested

- Not horizontal surface.
- Near Surface Layer about 40 m in thickness
- Near Surface Vp about 900 m/s.
- A flat reflector.

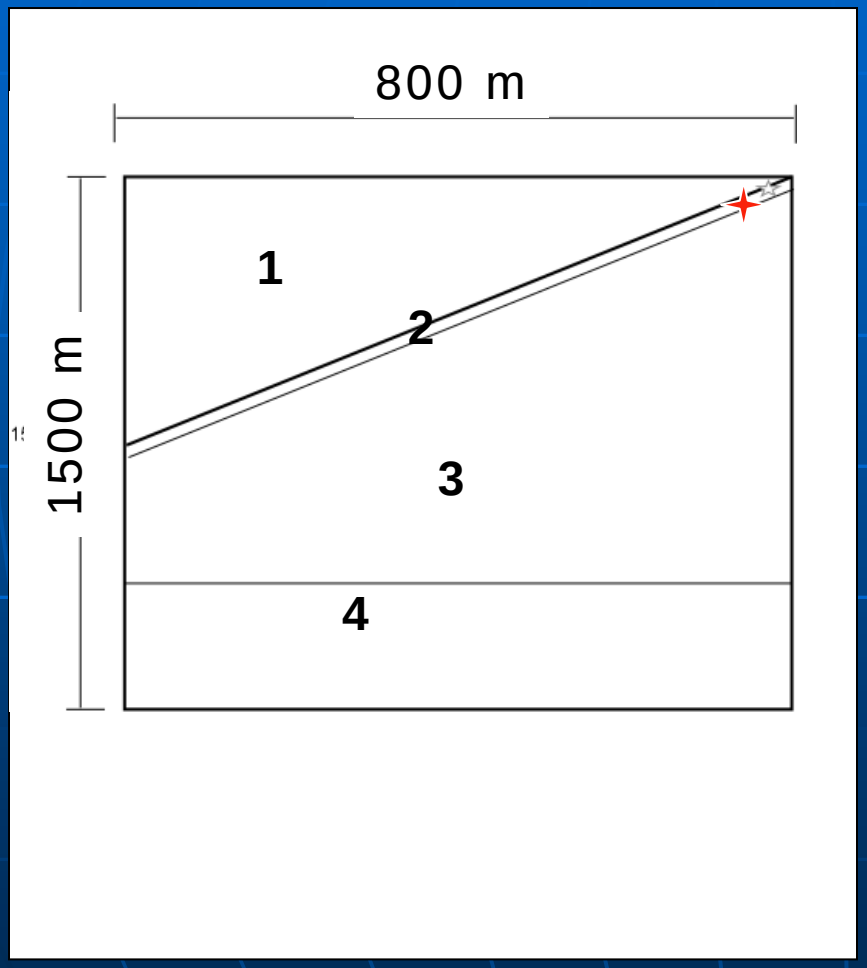
Layer	Thickness at the SP (m)	Vp (m/s)	Vs (m/s)	Density (Kg/m^3)
1	*Variable*	*0*	*0*	*0*
2: NSL	*40*	*900*	*450*	*2000*
3	*600*	*2000*	*1000*	*2400*
4	*150*	*2800*	*1400*	*2400*



WAVELET



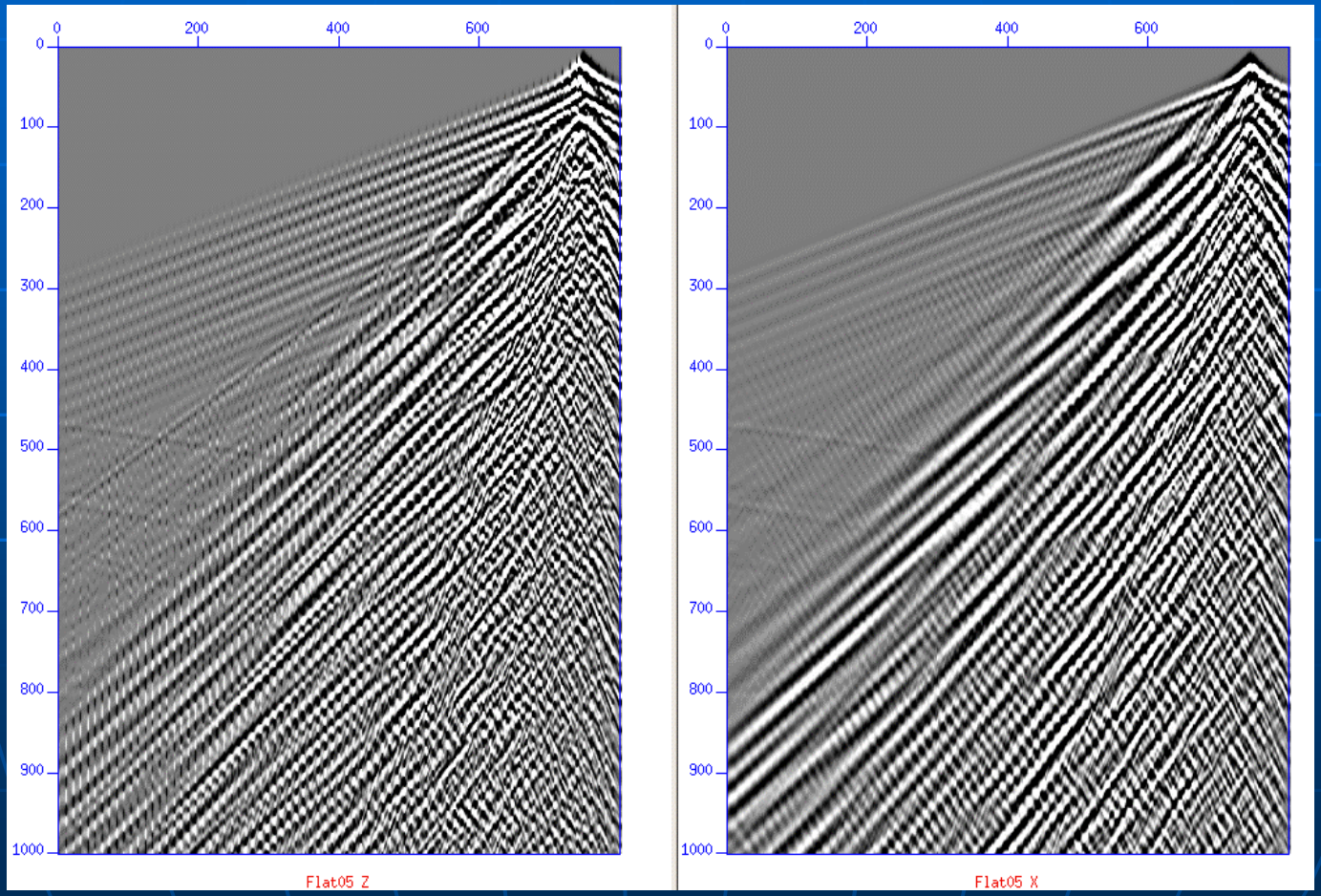
EXAMPLE 1: Sloping flat surface



Source Freq=20 Hz
Slope=~45°

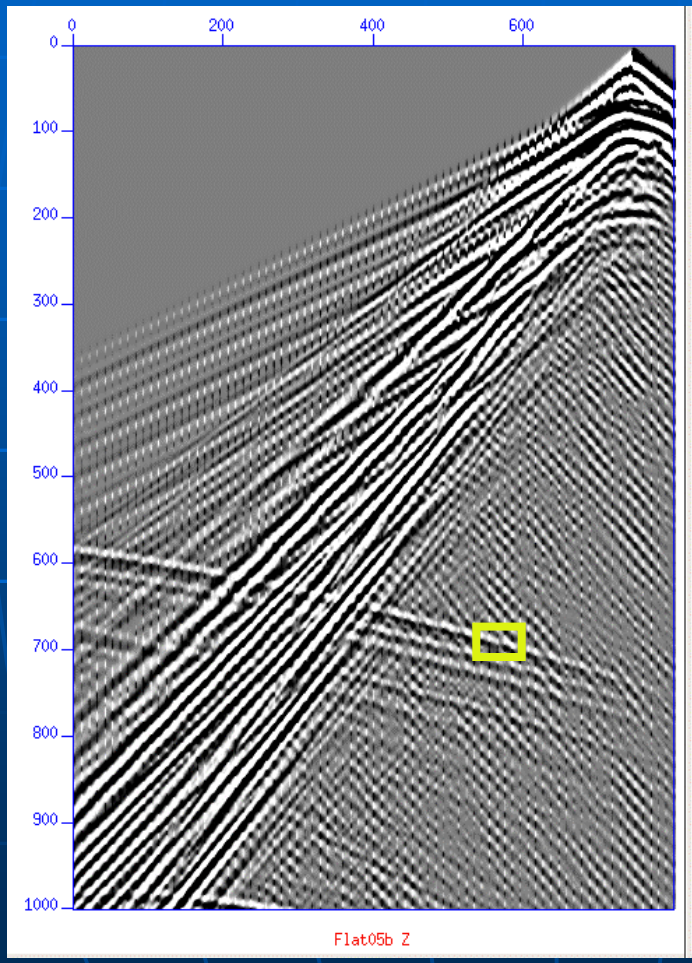
NSL Case 1: Thickness 20 m Vp/Vs=4

Case 1: Thickness 20 m

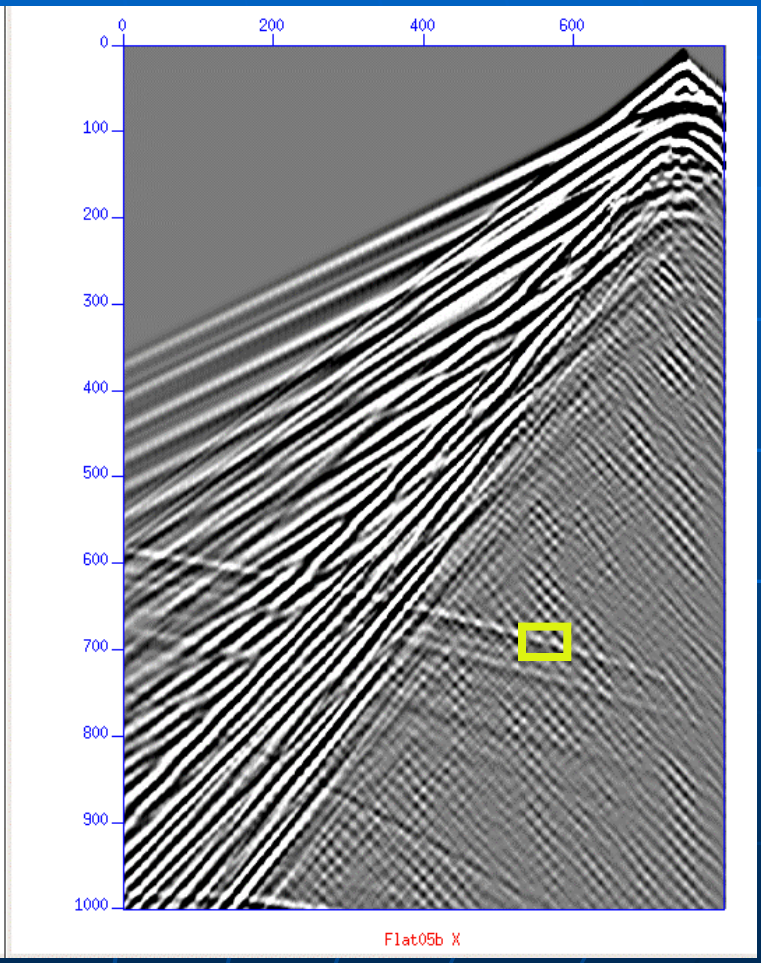


Case 2: Thickness 50 m Vp/Vs=2

NSL Case 2: Thickness 50 m Vp/Vs=2

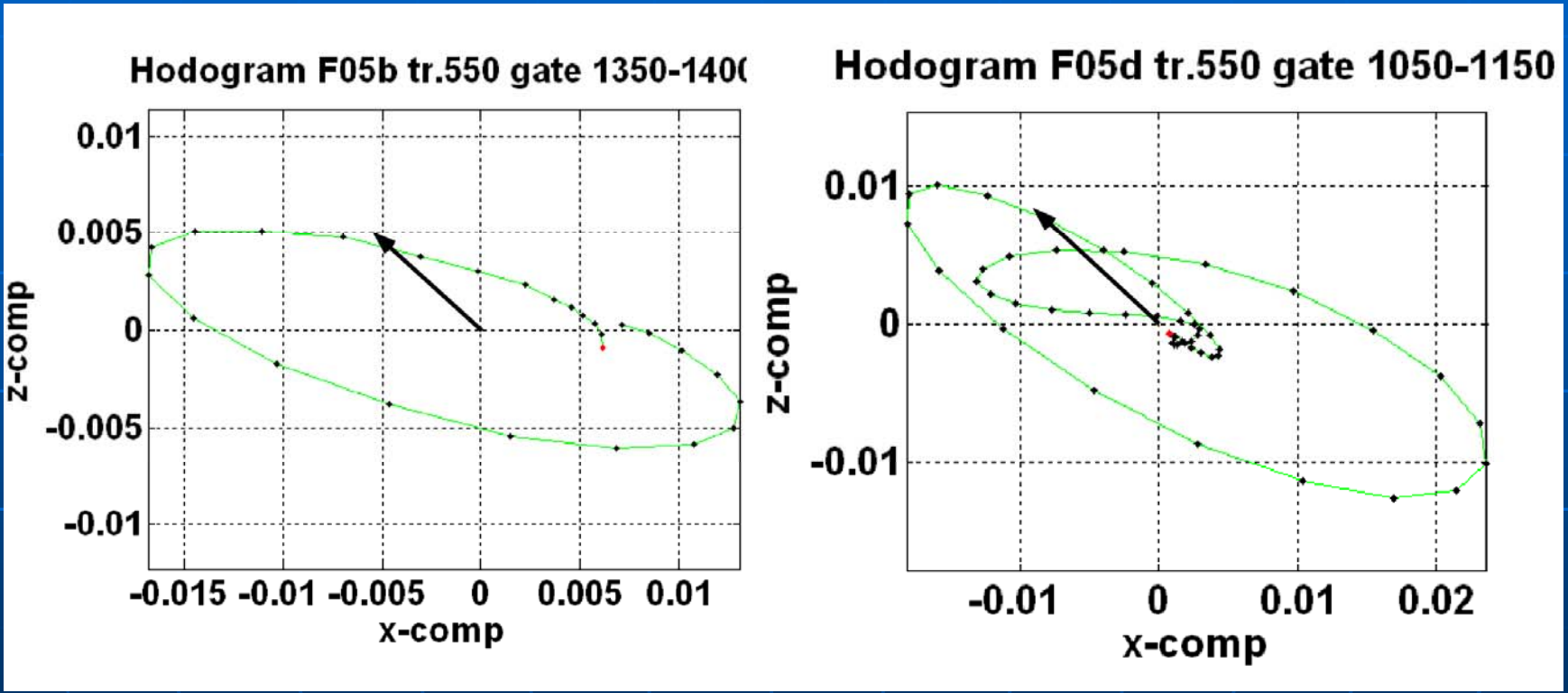


Z-component



X-component

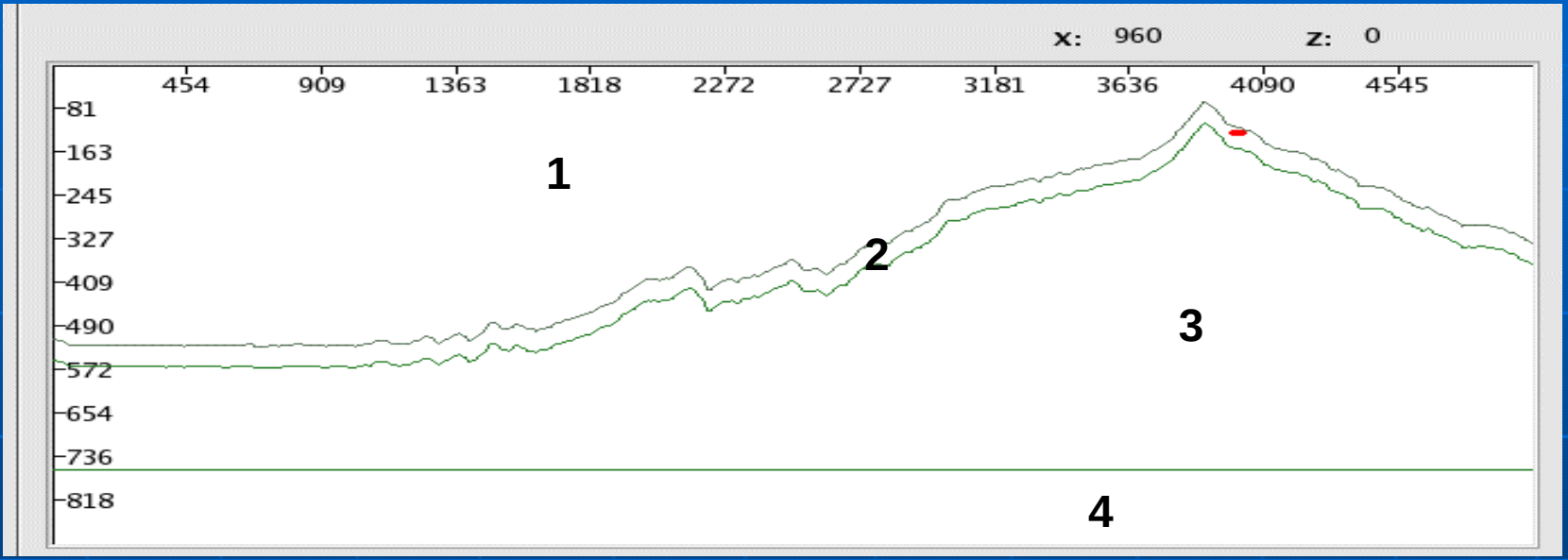
Flat slope: Polarization analysis



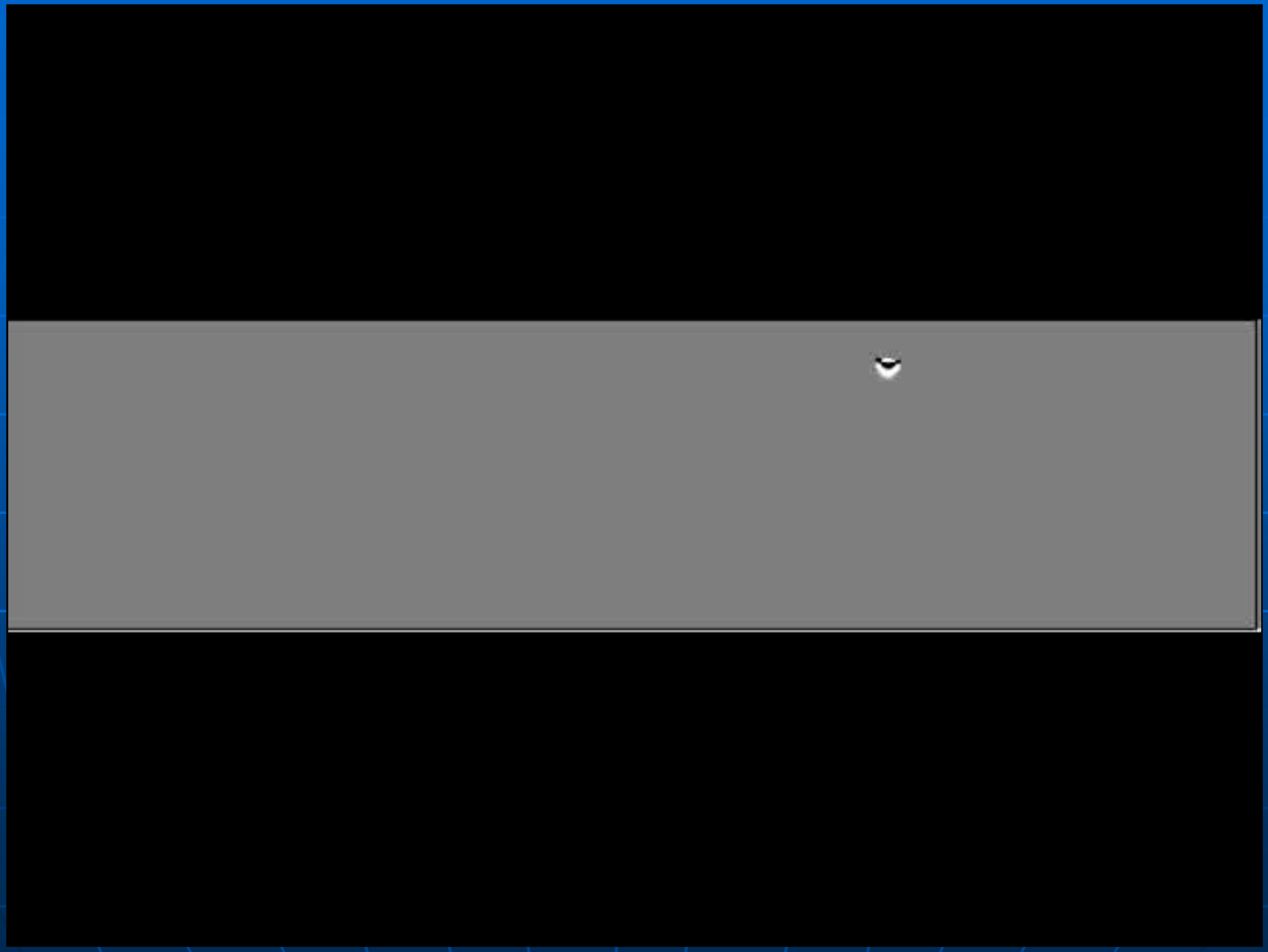
With Near surface layer

Without Near surface layer

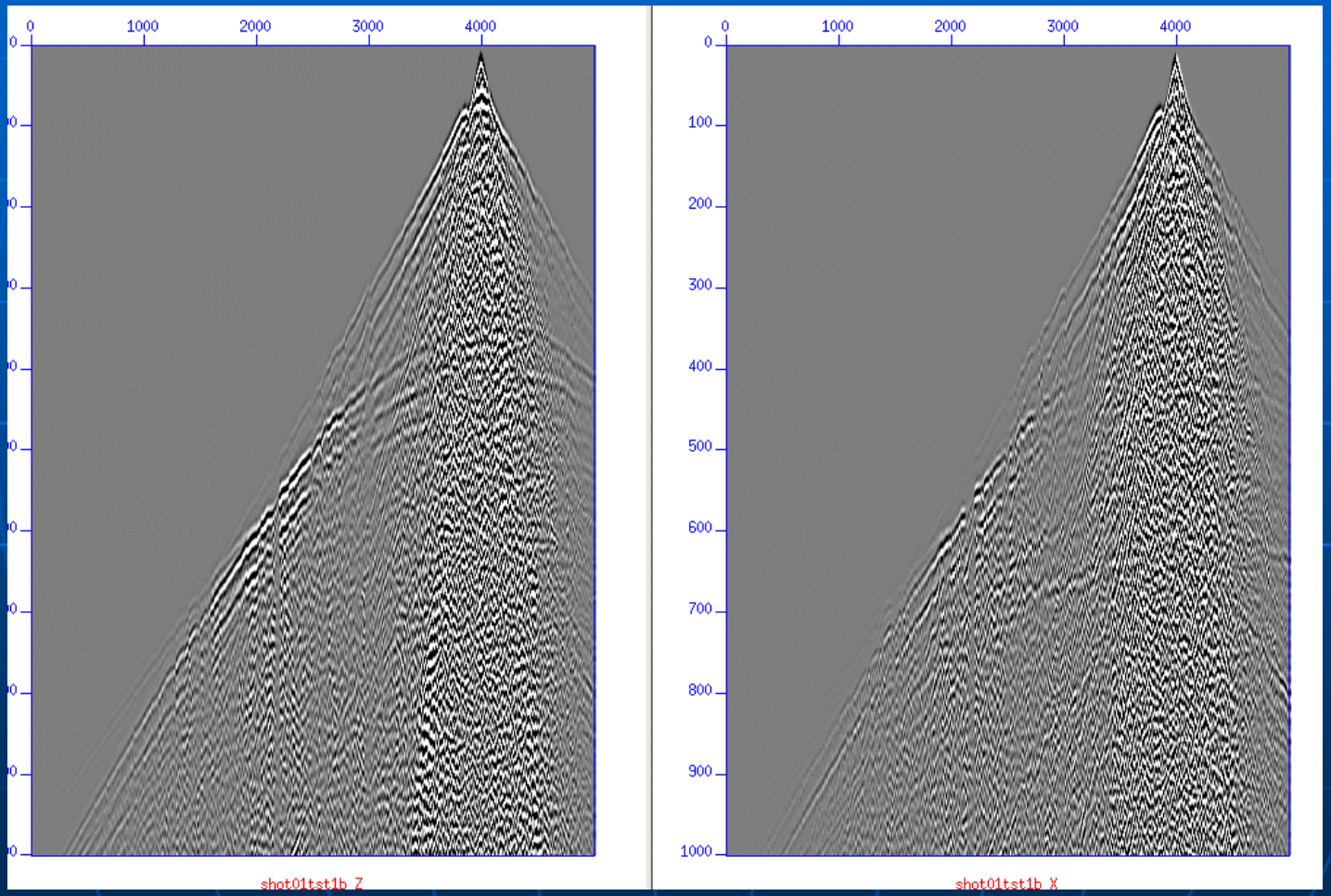
EXAMPLE 2: Real topography modelling



- **Based on a real setting in the Andes (Colombia).**



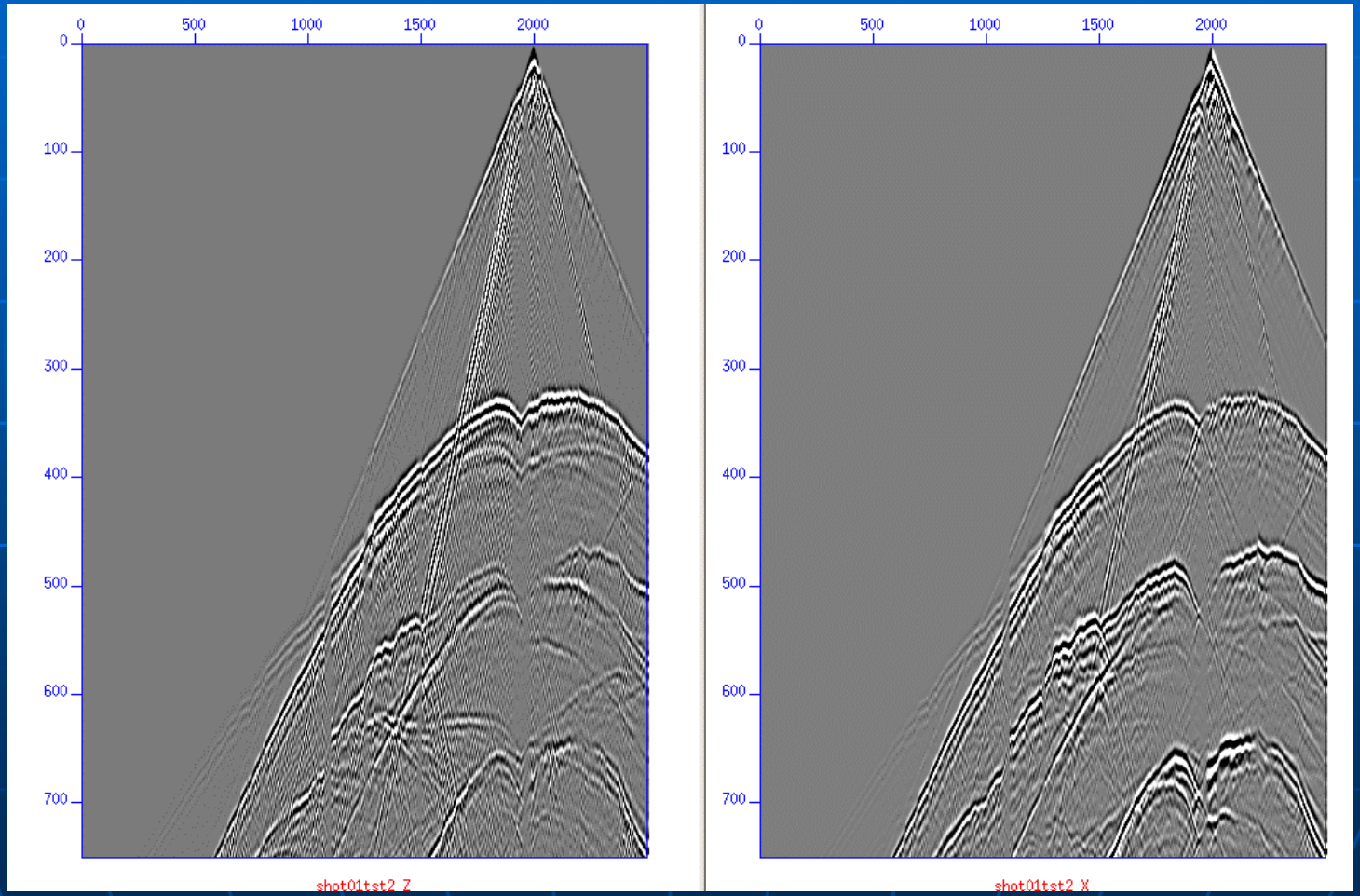
Seismogram: real topography



Vertical Component

Horizontal Component

Comparison: Seismogram without a Near Surfave low-velocity Layer



Vertical Component

Horizontal Component

Discussion

- Noise generated by the Near Surface Layer shows relation to velocities, thickness, source signature.
- How real are these results?
- Some effects can be related to the algorithm implementation: 2D elastic, discretization (surface).
- Required testing of algorithms.
- Also required improvement in geological models.

Final remarks

- FD is a valuable tool to study the characteristics of real seismograms related to Near surface problems and to test processing methods.
- Viscoelasticity and anisotropy can have meaningful effect, and could be implemented in FD.
- Shortcoming: Computer cost.
- The results agrees with real data that, under some conditions, seismic events (specially converted waves) are difficult to observe.

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