Corrections for distortion in polarization of reflected shear-waves in isotropic and anisotropic media

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The problem

THE PROBLEM

In general, a polarized shear wave undergoes significant distortion of that polarization upon reflection regardless of the symmetry of the propagating media (even in purely isotropic media).

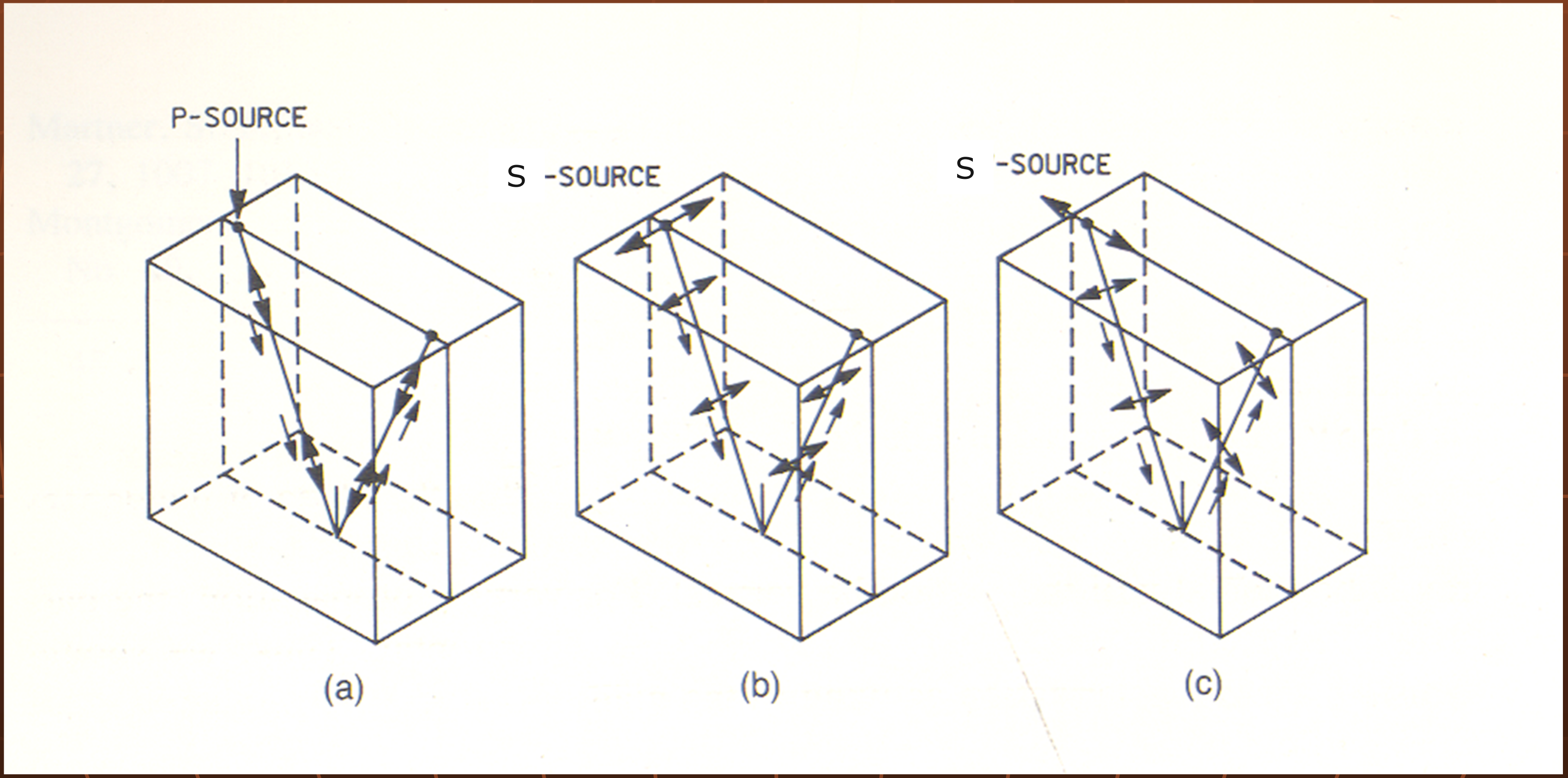
THE CONSEQUENCES

This distortion complicates analysis of the reflection data for extracting medium properties from polarization information

Talk Outline

- S waves
- Polarization distortion
- Addressing the problem
- Previous work
- Reflection polarization vs. incidence angle
- Future Work
- Questions

Body Waves with associated polarization



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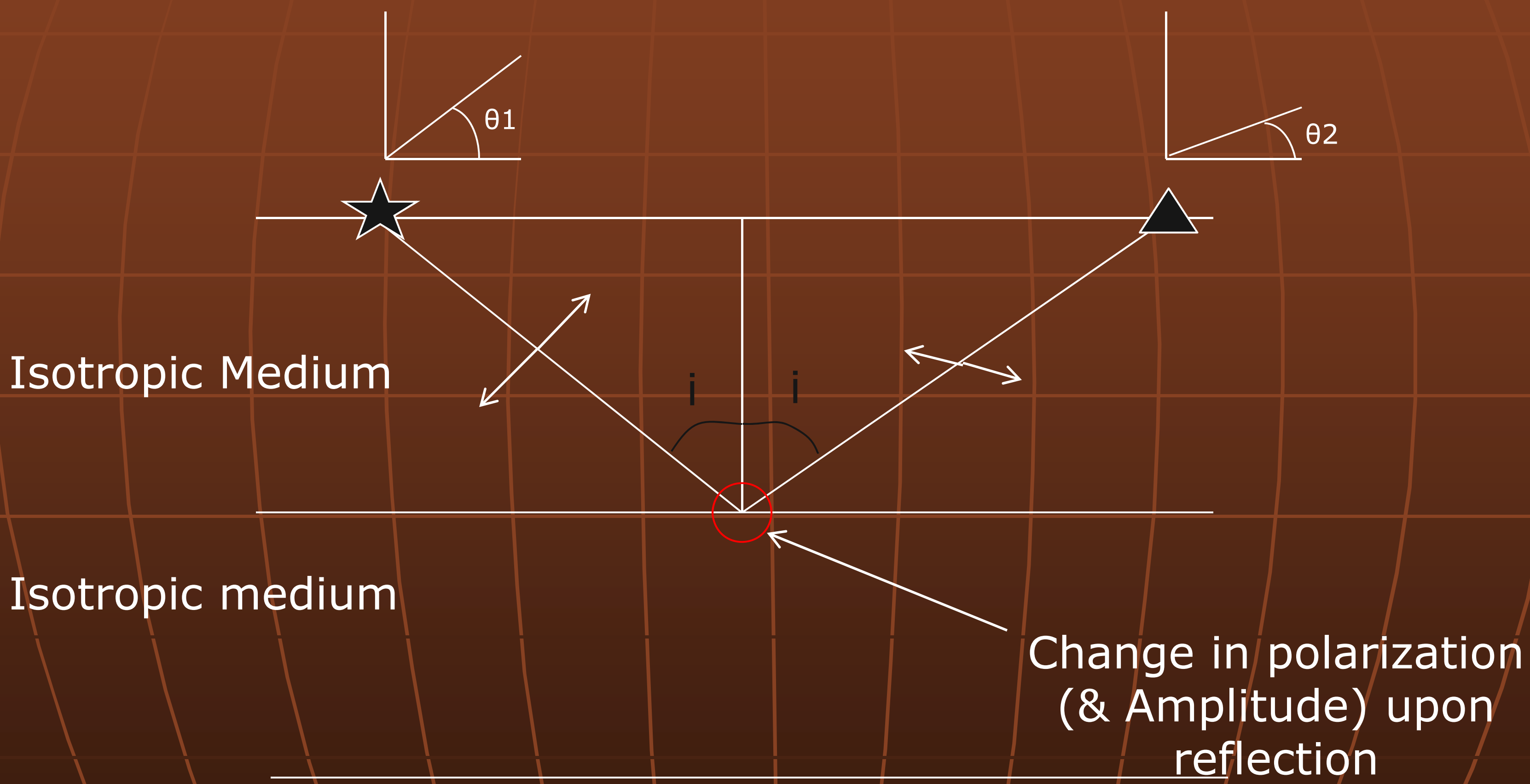
Polarization distortion isotropic media



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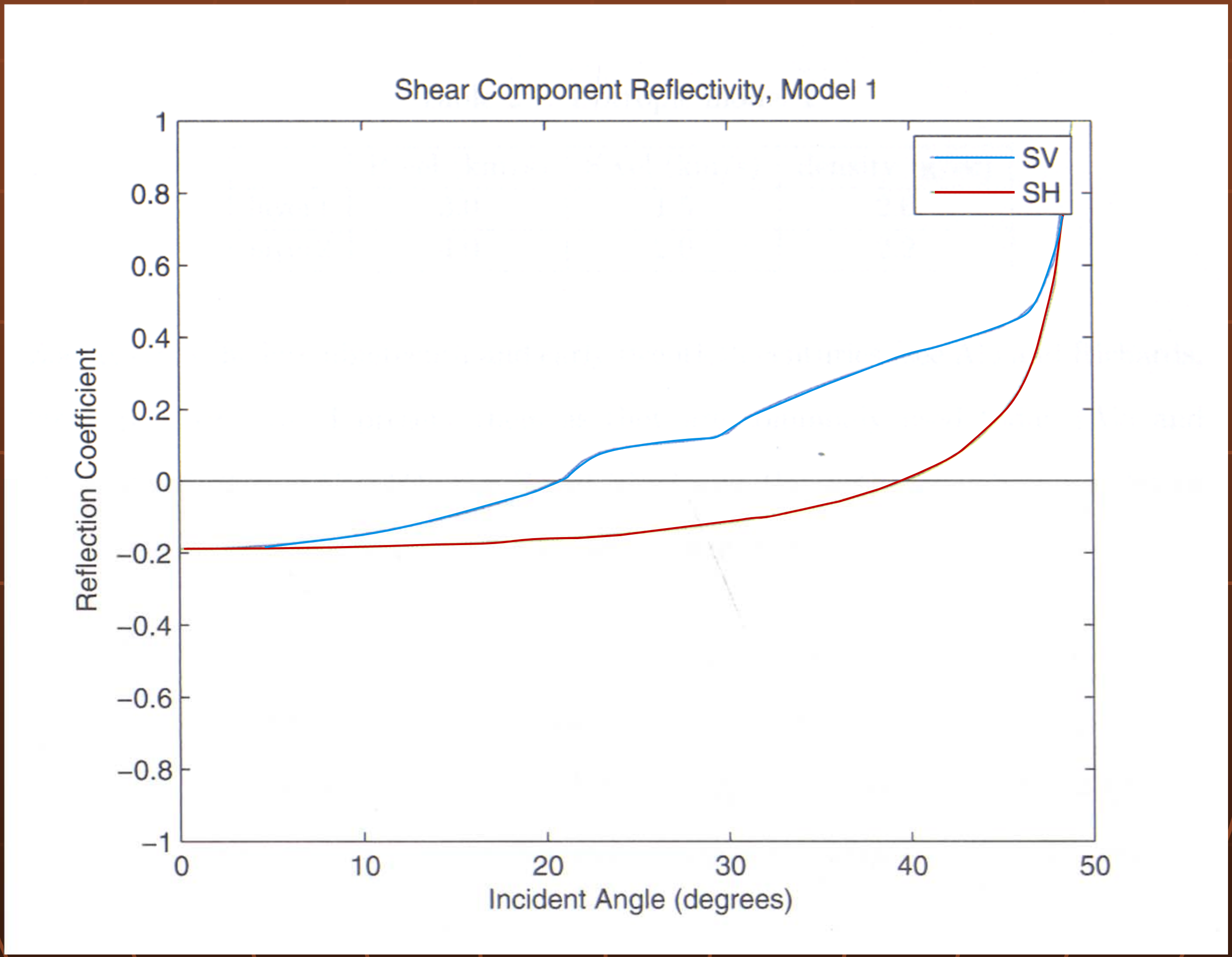
Isotropic model

P wave Velocity – 3.0 km/sec
S wave velocity - 1.5 km/sec
Density - 2.0 g/cc

P wave Velocity – 4.0 km/sec
S wave velocity - 2.0 km/sec
Density - 2.2 g/cc

Rss vs Incidence Angle



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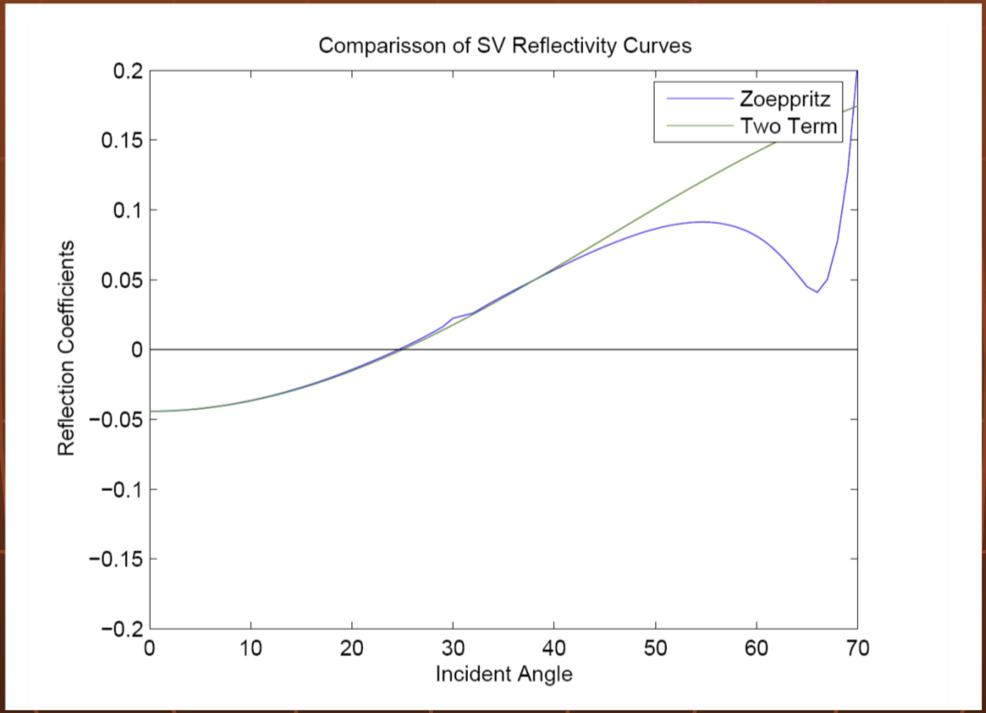
Approximations to simplify Zoeppritz equations

- The coefficient of the second term is that combination of elastic properties which can be determined by analyzing the offset dependence of event amplitude in conventional multichannel reflection data
- Assumes small contrasts in density and velocity

Source	Receiver P	Receiver S_v	Receiver S_h
P	$R_p + (R_p - 2R_s)\sin^2\theta$	$-2R_s \sin\theta$	—
S_v	$-2R_s \sin\theta$	$-R_s + \left[7R_s + \frac{1}{2}\left(\frac{\Delta\rho}{\rho}\right)\right]\sin^2\theta$	—
S_h	—		$-R_s + \frac{1}{2}\left(\frac{\Delta V_s}{V_s}\right)\sin^2\theta$

Spratt (1993) shows other reflection coefficients for different sources and different receivers

Comparing Zoeppritz equation to the two term linear approximation



Comparing the full Zoeppritz equations to a two term $\sin^2$ approximation, describing *SV* motion (Spratt, 1993)

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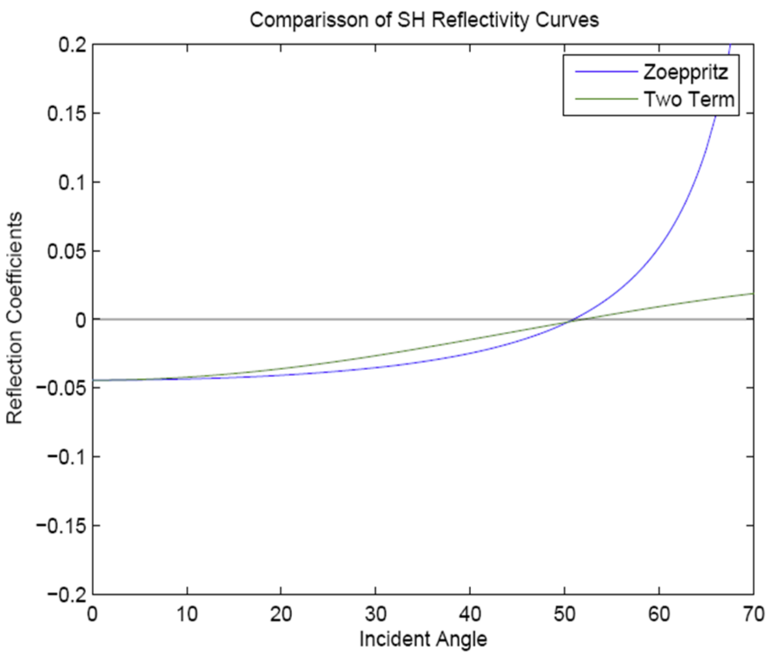
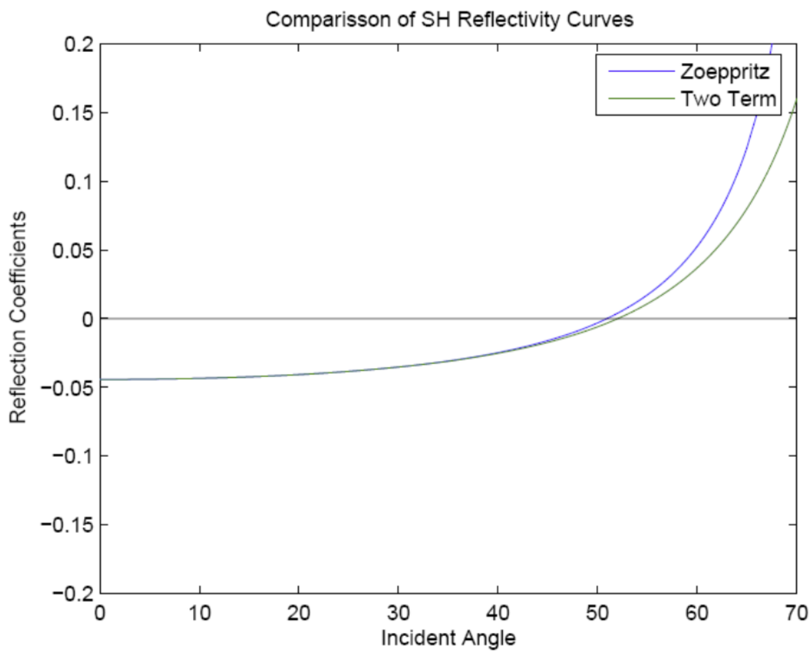
Comparing Zoeppritz equation to Spratt's and Lyons linear approximation



Comparing the full Zoeppritz equations to a two term Sin^2 approximation, describing *SH* motion. There is poor agreement between the two approximations



Comparing the full Zoeppritz equations to a two term $\tan^2$ approximation, describing *SH* motion. There is excellent agreement between the two through an incident angle of 50*(*Lyons, 2006*)*

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Approximation to simplify Zoeppritz equations

- Calculate a gradient value for Spratt's approximation correct SV AVO with [A + B $\sin^2(\Theta)$] form
- Assume zero crossing at 20 deg A=1, to leave normal incidence unchanged therefore:
- [1 + B $\sin^2(20)$] = 0; B_{sv}=-8.5486
- Calculate a gradient value for Spratt's approximation correct SH AVO with [A + B $\tan^2(\Theta)$] form
- Assume zero crossing at 40 deg A=1, to leave normal incidence unchanged therefore:
- [1 + B $\tan^2(40)$] = 0; B_{sh}=-1.4203;

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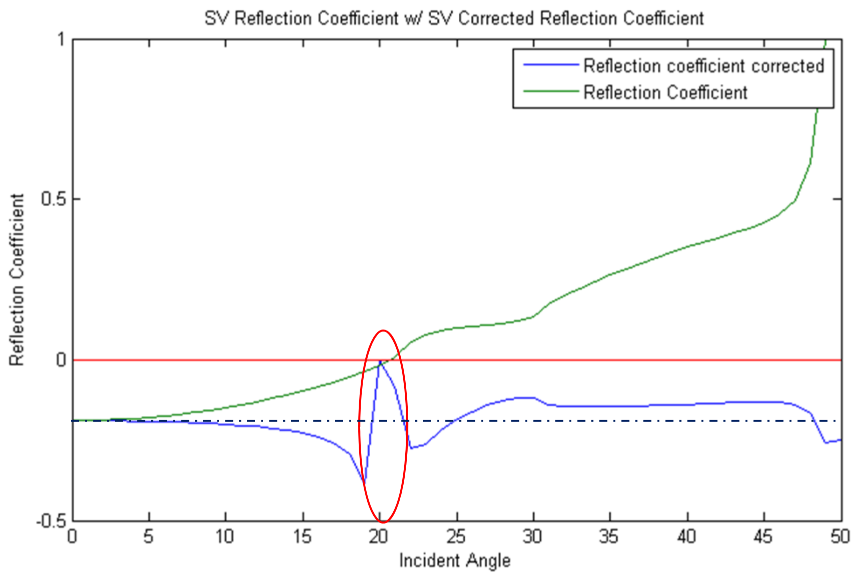
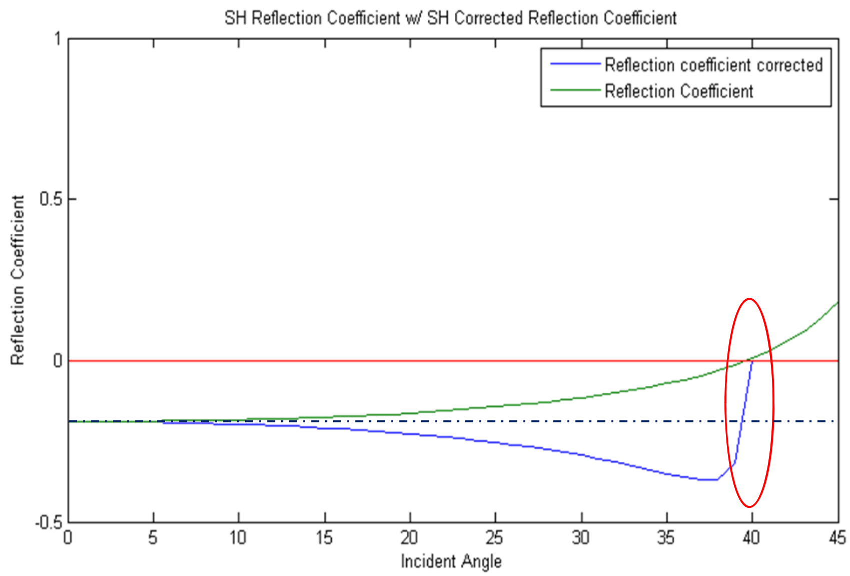
Corrected reflection coefficient to minimize amplitude change

$SS_{SVcorrected} = SS_{SV} * (1/ (1+Bsv*\sin^2\theta))$

$SS_{SHcorrected} = SS_{SH} * (1/ (1+B_{SH}*\tan^2\theta))$





Singularity at 18-22 degrees

Singularity at 38-42 degrees

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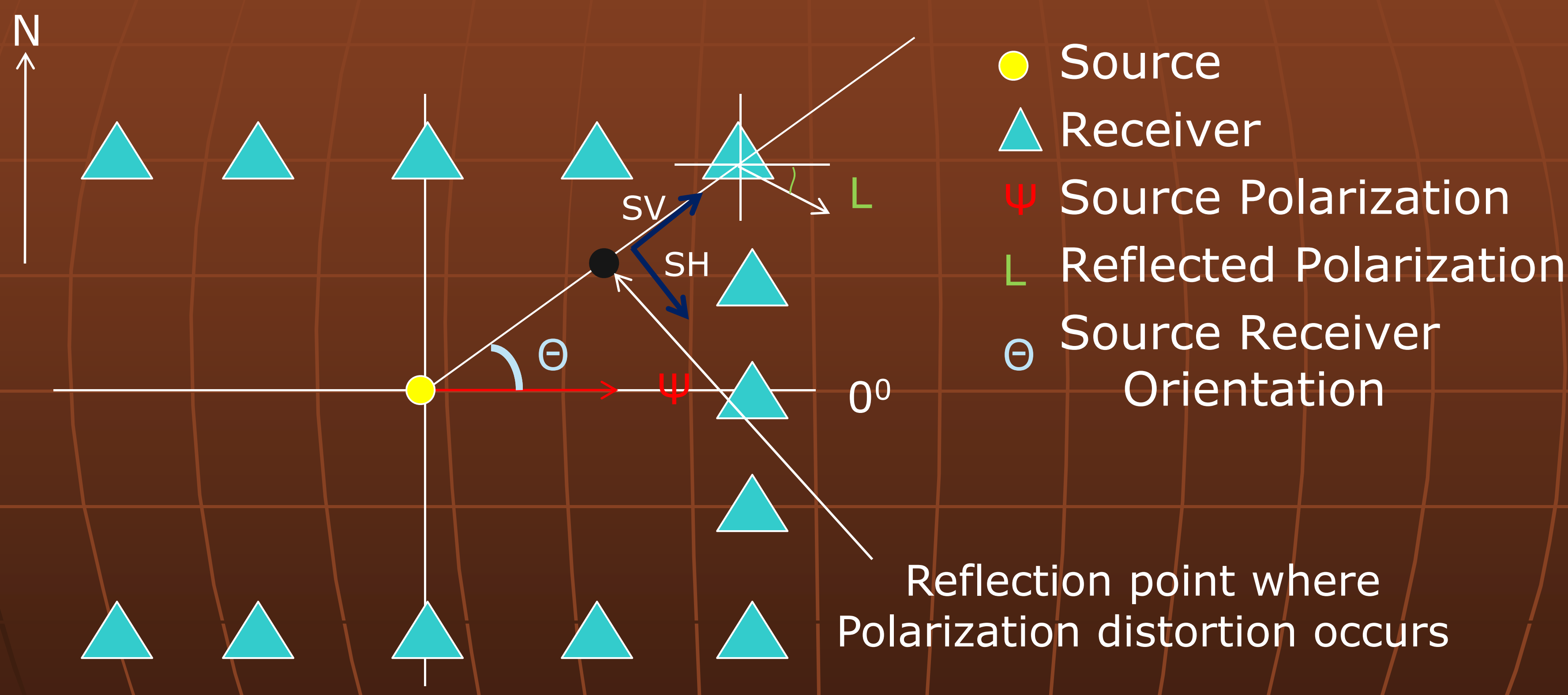
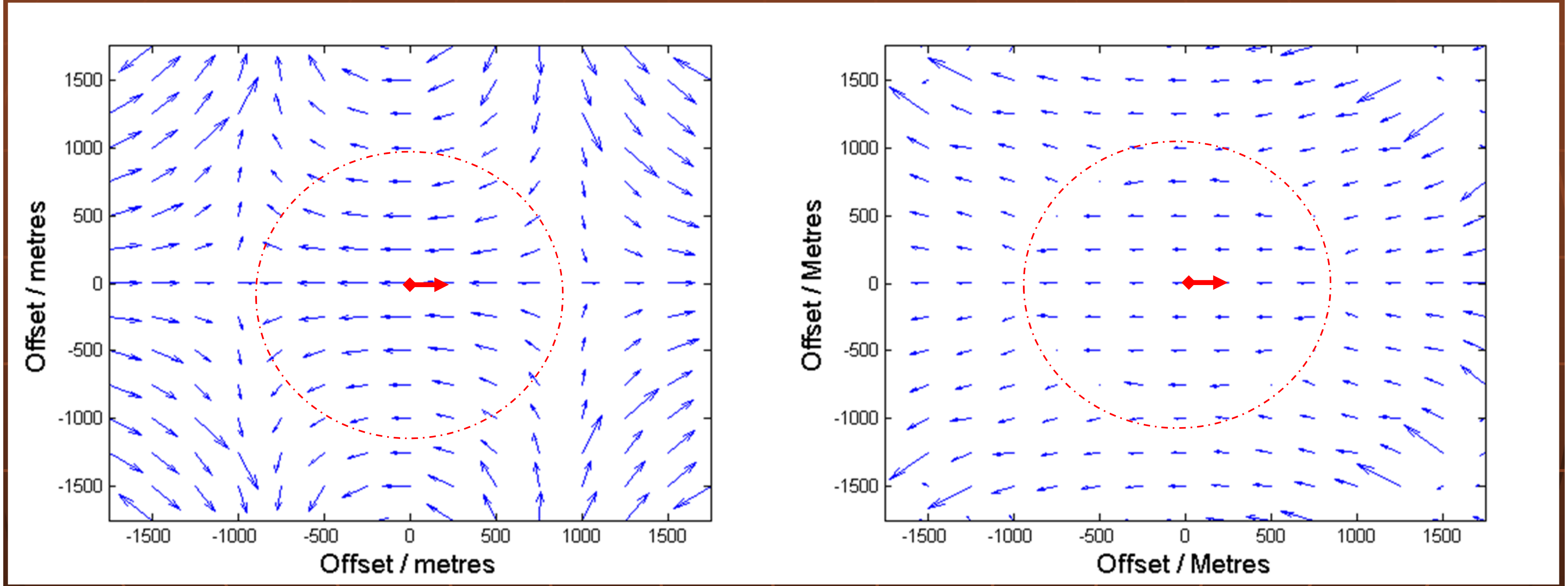
Theoretical Survey Design



Polarization plot (3D survey)



$L = \arctan[\cos(\Theta-\Psi)SV/\sin(\Theta-\Psi)SH] + (\Theta-90)$

$L = \arctan[\cos(\Theta-\Psi)Sv_{corrected} / \sin(\Theta-\Psi)SH_{corrected}] + (\Theta-90)$

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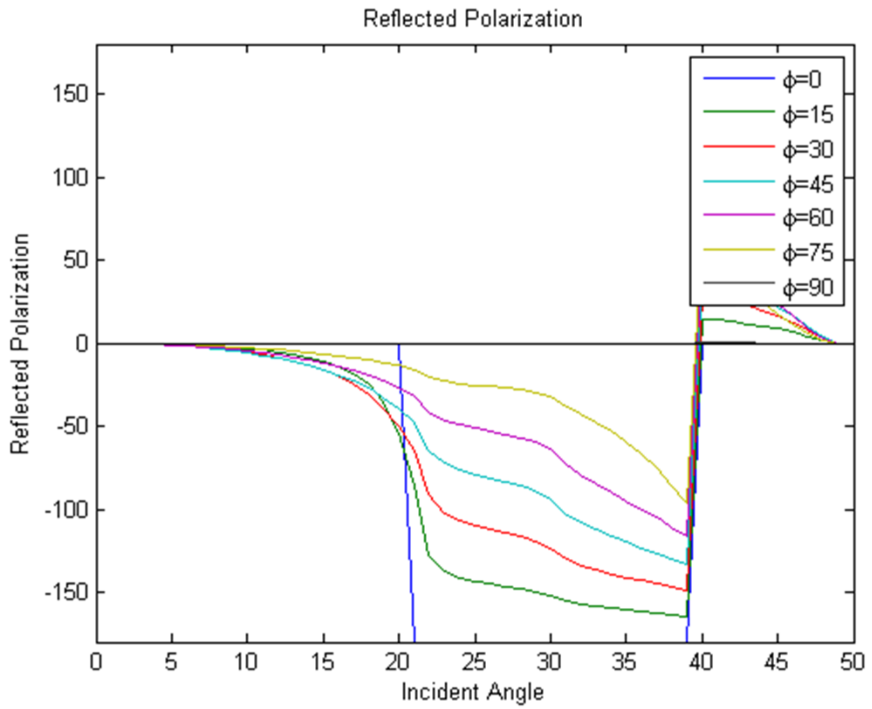
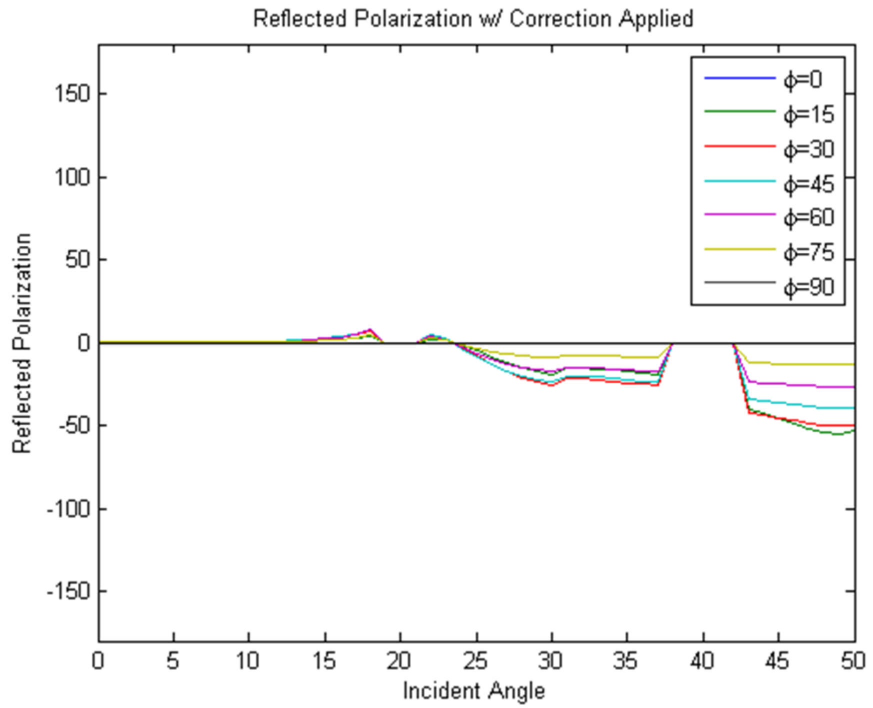
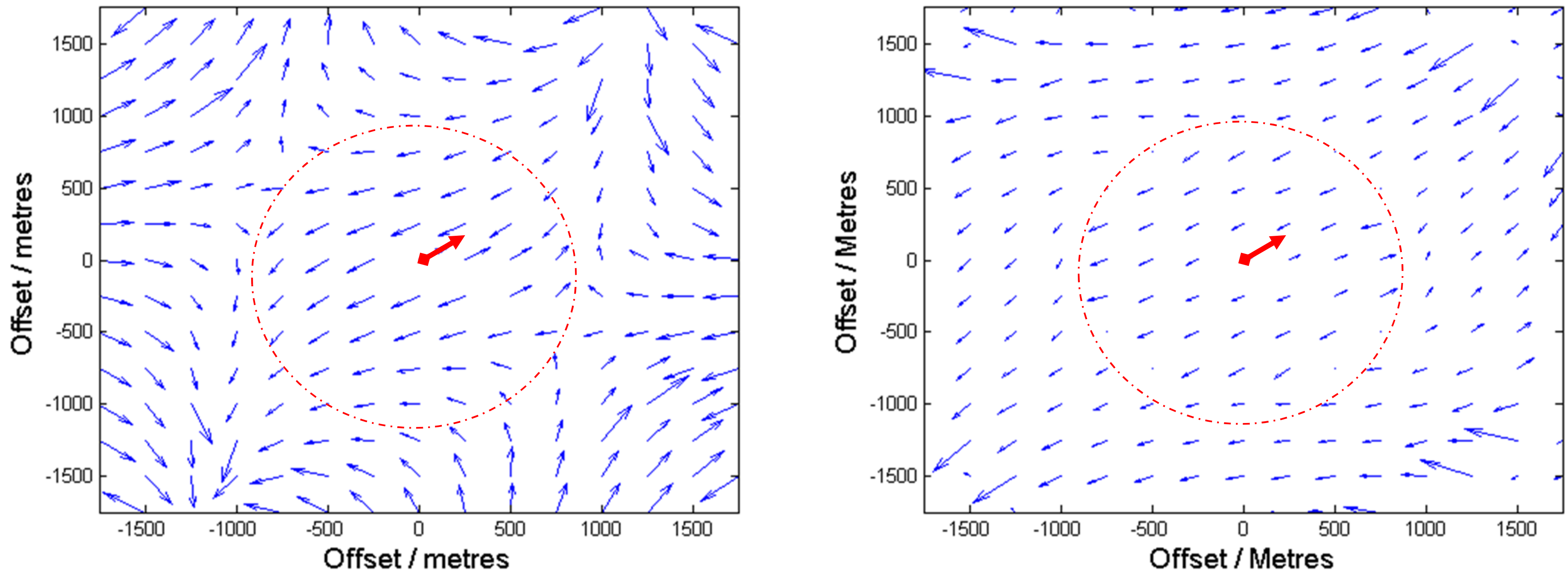
Polarization plot





Polarization plot (3D survey)



Source polarized 30^0 North of East

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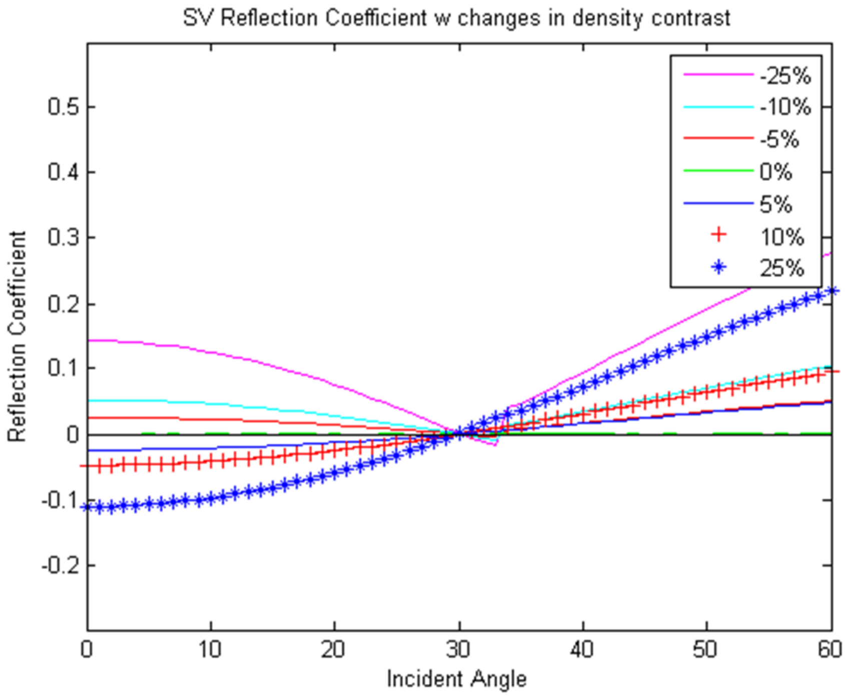
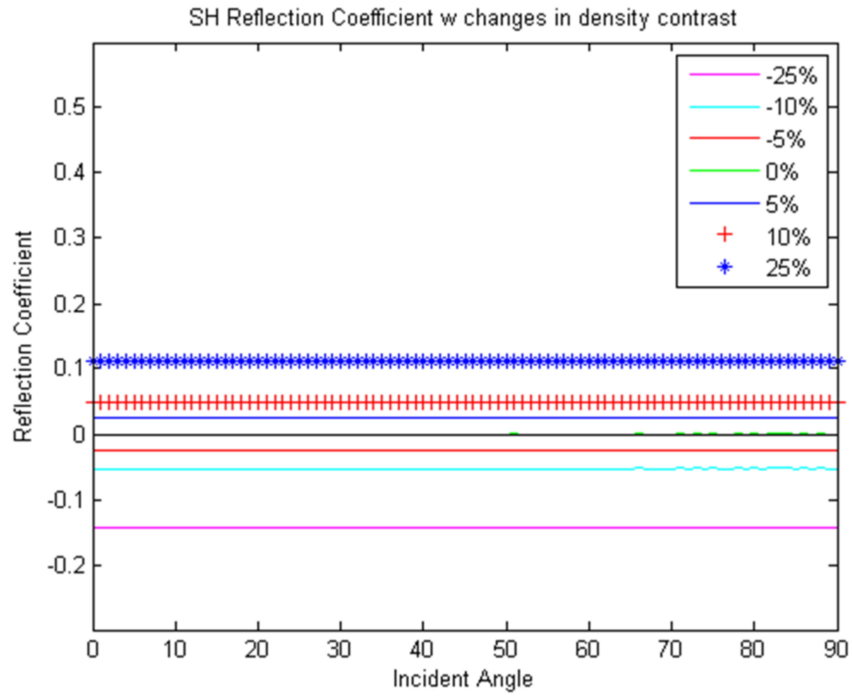
Sensitivity Analysis

- Sensitivity analysis performed to understand changes in SV and SH reflection coefficients with changes in Density and S-wave velocity
- SH reflection coefficient changes but they are insensitive to changes in incidence angles
- SV reflection coefficient is very sensitive to changes in density and incidence angles
- Zero crossing for SV and SH are relatively constant to changes in shear wave velocity

Sensitivity Analysis





V_p/V_s=1.8 Density variation +/- 25%

V_p and V_s remains constant

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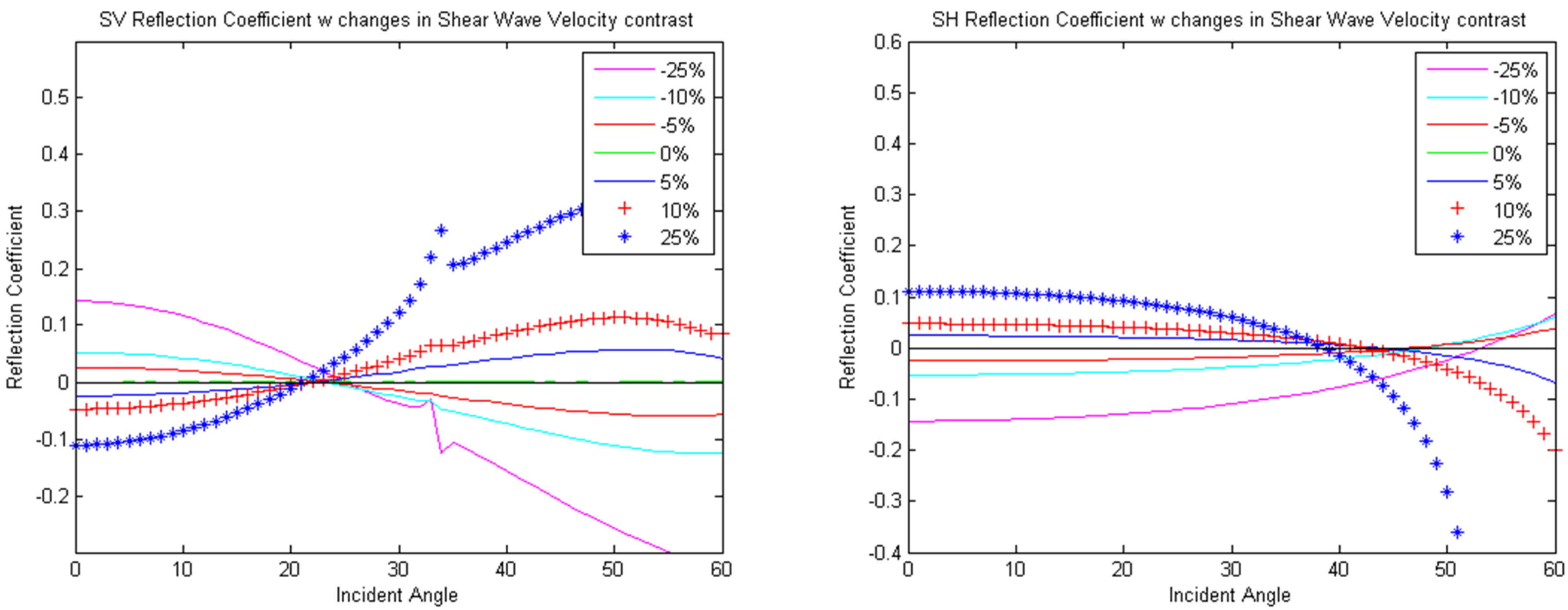
Sensitivity Analysis



Initial V_p/V_s=1.8, Density 2.2g/cc Shear wave velocity +/- 25%

V_p and density remains constant

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Next Steps

- Test sensitivity of corrections to estimates in velocity contrasts
- Apply correction to HTI anisotropy which may be applicable to real data
- Develop a process to incorporate correction for land data in pre-processing phase
- Possible land seismic data improvements for fracture characterization

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Conclusions

- Reflection process alters polarization of direct shear waves
- Land Seismic data is expensive and difficult to acquire
- Fracture characterization is important for reservoir architecture and improving anisotropic analysis

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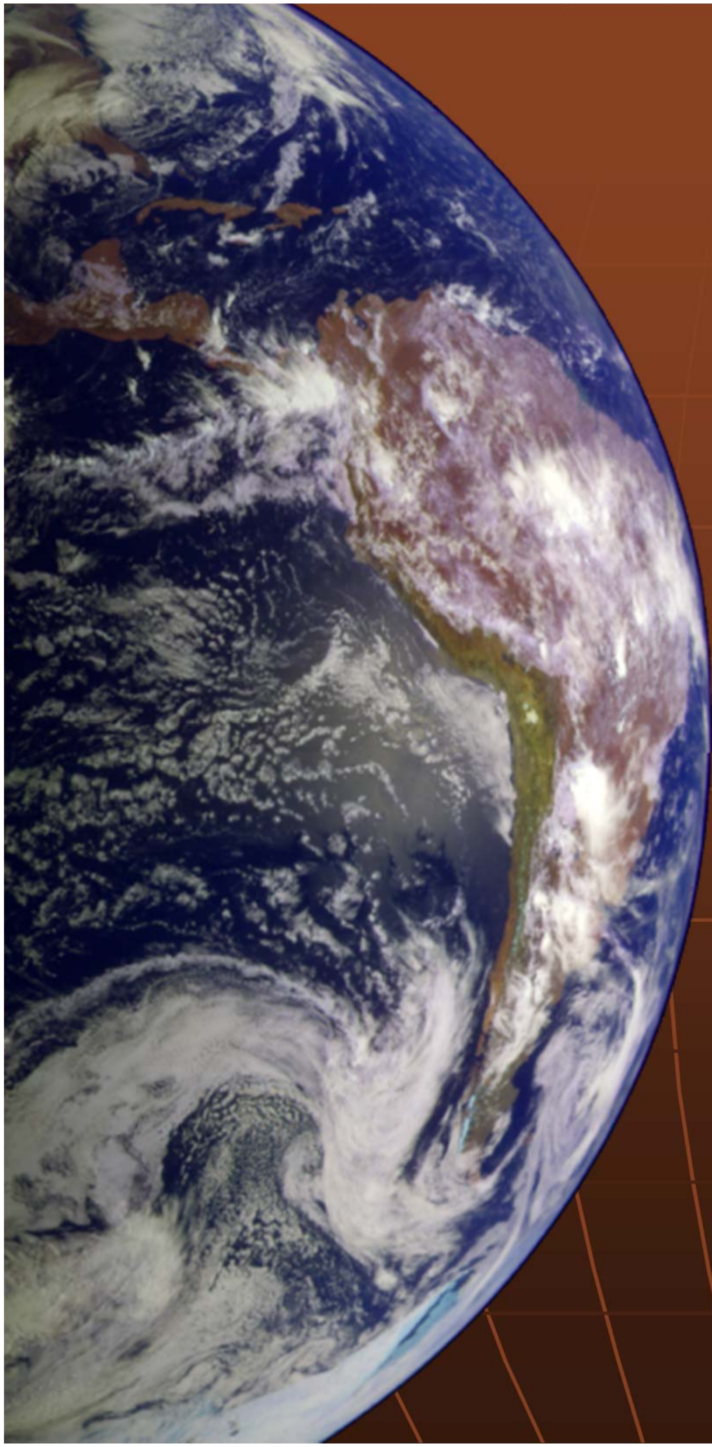

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Questions

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