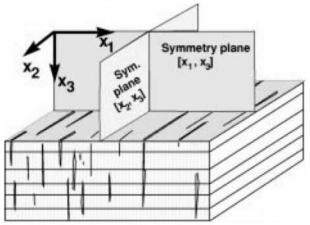
Anisotropic Simulations

SAND2019-2582C

Modeling SPE experiments with 3-D orthorhombic elastic and acoustic full waveform simulations

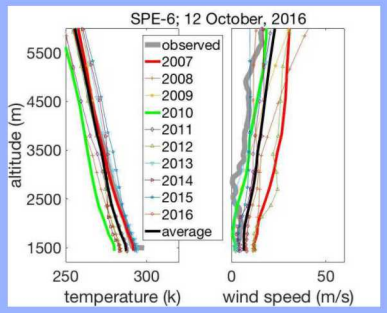
Background/State of the Art



A physical mechanism leading to orthorhombic anisotropy. From Tsvankin, 1997, *Geophysics*.

- Typically, full waveform modeling assumes seismic isotropy or fixed acoustic media for simplicity, computational speed, and because these parameters are usually poorly known
- Linear seismic source inversions may erroneously map atmospheric or anisotropic effects into the source. Deriving a physics-based source model requires these effects to be accounted for.

Innovation



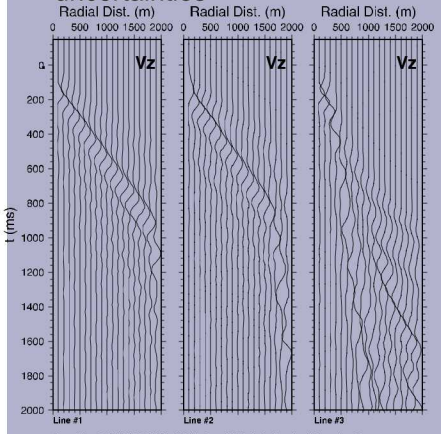
Atmospheric profiles for SPE-6

- Model acoustic and seismic data from SPE experiments and use comparisons to improve modeling capabilities (underway)
- Provide linear seismic source equivalents for SPE and define their limitations

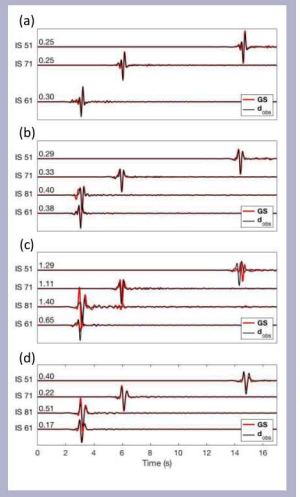
Approach, Metrics and Outcomes

MAIN ACHIEVEMENT

- Modeling SPE sources, acoustic and seismic data within uncertainties



Simulated orthorhombic seismic traces of SPE-1.



Observed (black) and simulated (red) acoustic traces of SPE experiments.

HOW IT WORKS

- Explicit time-domain 3-D finite-difference using 4th order spatial and 2nd order temporal accuracy
- Both codes incorporate 3-D media variations and topography. Acoustic code can also incorporate winds.
- Comparisons with SPE acoustic and seismic data will provide a real-world validation of the code capabilities

ASSUMPTIONS AND LIMITATIONS

- Limited by the accuracy of the earth and atmospheric model parameters, which are usually poorly known
- Computational effort increases rapidly as frequencies increase
- Assumes linear wave motion. Thus, permanent deformation, fracture, etc., are not modeled

Impact

- The 3-D orthorhombic and moving media acoustic codes are generally applicable to any full waveform simulation scenario, including non-proliferation, tunnel detection, source characterization. Many stakeholders in the DOE, DoD, and others could benefit.
- Understanding the limitations on using linear source models have application in non-proliferation and forensics, etc.

TRLs (start and finish) Starting TRL: 3, Final TRL : 6

Publications

Poppeliers et al. (2018), Bull. Seis. Soc. Am., 109(1) 463-475.

Goals/Action Plan

Current FY

- Complete 3-D atmospheric models of SPE phase 1 using observed weather data
- Build improved 3-D orthorhombic elastic model of SPE and DAG sites
- Simulate SPE phase 1 experiments using observed weather data
- Predict and invert DAG-4 waveforms
- Investigate limitations of using linear seismic source models using SPE data
- Investigate impact of acoustic-only model simplifications

Team

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Defense Nuclear Nonproliferation R&D