Introduction

We demonstrate that strong shallow velocity reductions change amplitude and phase of long-period seismic waves.

Velocity changes are related to:
- Earthquakes - Source effects and soil response.
- Volcanic Activity - Seismic waves are related to volcanic activity.
- Seasonal variations - Precipitation and temperature.

The location and extent of the region sustaining velocity perturbations is inferred from the periods of seismic waves:
- Shallow – strong ground motion
- Deep – source effects

Long-period observations can be misinterpreted to occur at seismogenic depths.

3D Wave Propagation Simulations

2 simulations of 10 earthquakes:
- 1 in the reference model.
- 1 in the perturbed model.

Simulations use Hercules:
- Up to 0.25 Hz, 16 PPW, and 100 s.

Data Processing

Measure the time delay in the frequency-time phase spectrum $\varphi_{sp}(\omega, t)$.

The relative velocity change is

$$\frac{dv}{v} = -\frac{dt}{t}.$$

The time shift is

$$dt(\omega, t) = \frac{\varphi_{sp}(\omega, t)}{\omega}.$$

The amplitude anomaly is

$$\delta A = -\frac{\log(A_1/A_2)}{\omega}.$$

Period-Dependent Effects of Shallow-velocity Reductions

Relative velocity perturbations and amplitude anomalies are observed at periods of 5, 10, and 20 s.

Conclusions

- Shallow localized velocity perturbations can account for phase and amplitude changes at long periods.
- Measurements are comparable with observational studies of velocity changes.
- The localized shallow velocity reduction is detected over the entire simulation domain.
- Shallow localized velocity perturbations can account for phase and amplitude changes at long periods.
- Measurements are comparable with observational studies of velocity changes.
- Strong ground motions can cause shallow velocity reductions. Thus, long-period observations can be misinterpreted to occur at seismogenic depths.
- In observational studies there is measurement uncertainty due to the dynamic nature of the changes and the rapid recovery at seismogenic depths.
- Low velocities in the shallow surface are often ignored in waveform tomography at long periods. However, they can produce apparent anomalies everywhere in the domain.

Reference


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