Variability in fractional changes in velocity structure (dv/v) using a repeating source and a small-aperture broadband posthole array

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Fractional changes in arrival times from the late arriving coda of seismic signals in repeated sources can provide details of time dependent seismic velocity changes (dv/v) in the shallow subsurface in response to numerous tectonic and environmental processes. Despite the significant insights that measurements of dv/v have provided, constraints on the spatial variability of these measurements are uncommon, in part because the wide aperture of seismic station locations limit spatial resolution. To assess lateral and vertical variability of dv/v measurements we make use of a novel repeating 4-12 Hz signal from a strong electromagnetic source pulse and take advantage of a small-aperture (~600 m) posthole (2.6 m depths) array of 6 sensors and a borehole sensor (90 m depth) operating at the Albuquerque Seismic Laboratory (ASL). Using the Moving Window Cross Spectrum (MWCS) technique to measure dv/v, we find seasonal trends of +/- 0.2% are broadly present on the stations (Fig. 1). The novel repeating source removes the possibility of a contribution to the dv/v signal from changes in the noise source distribution. Lag times between the posthole and borehole stations may provide useful information into the depth dependent response to annual environmental changes. For instance, the lag may be associated with hydrologic diffusivity within the material along the ~87.4 m path from the posthole sensors to the borehole sensor. The array stations are generally positively correlated in their signal, however spatial variability exists suggesting sensitivity to slight variations at sites within hundreds of meters and providing insight into the lateral sensitivity at each site. These results could serve to inform future dv/v studies and provide a priori information for emerging dv/v techniques.

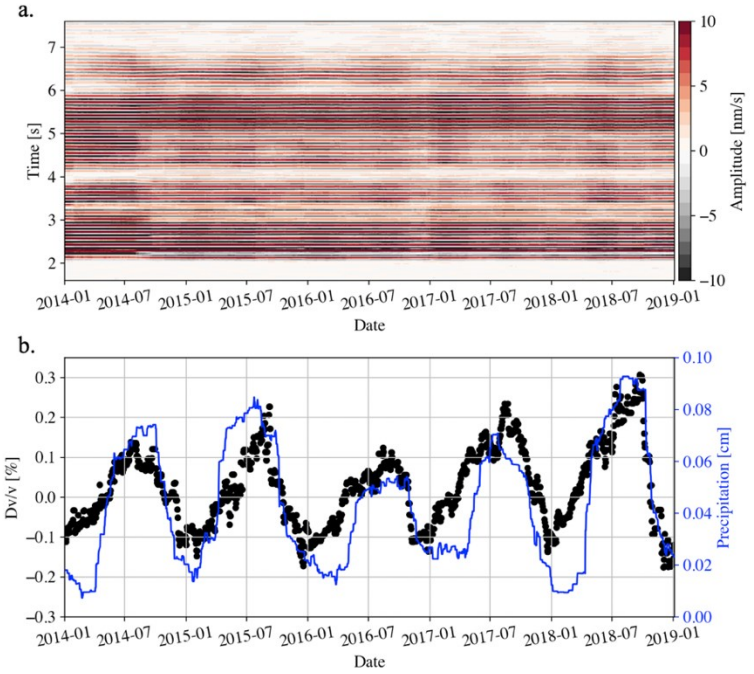

Figure 1. Velocity changes through time at the ANMO borehole station. a) Daily 90-day moving window vertical component stacks of the 4-12 Hz signal. Long-term stability of the source signal is clear and systematic seasonal amplitude and arrival time changes can be seen in the late arriving coda between 6 and 7s. b) Velocity variations through time (dv/v) compared to 90-day moving average precipitation.