Structural imaging of the Powder River Basin with fundamental and higher mode surface waves

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Fundamental mode surfaces waves are often utilized to obtain crustal and mantle shear wave velocity structures while higher mode surface waves are usually overlooked due to the difficulty of extracting coherent signals and separating them from the fundamental mode. In 2010, a large active and passive seismic experiment incorporating different types of seismic instruments, including broadband, short period and 4.5 Hz vertical component Texans, was conducted in Wyoming and Montana, covering the broad region of Powder River Basin, Bighorn Arch and Bighorn Basin. The goal of this experiment was to provide seismic insights into the mechanism behind Laramide shortening and basement-cored uplift of the Bighorn Arch mountains. Here, we aim to investigate the upper crustal shear velocity structure of the Powder River Basin using both fundamental and higher mode surface waves extracted from the continuous noise data from the experiment.

We cut the continuous noise data into 5-minute long segments and followed Bensen et al., (2007) for the ambient noise data pre-processing. Then, the 5-minute long data were cross-correlated between broadband, short period and Texans for the period of 6 months, which were stacked to obtain vertical component Green's function. A clear separation between the fundamental and higher mode signals can be observed in the plot of cross-correlation sorted by distance. Noise source distribution estimated by the beamforming technique indicates that most of the noise sources at 3 to 8 s periods originate from the Cascadia, southern California and Baja California. Fundamental and higher mode surface waves can be separated based on theoretical group velocities and ellipticity of particle-motion. We implement both methods to sperate the higher modes from the fundamental mode, which are further inverted for a 3-D upper crustal shear wave velocity structure of the Powder River Basin.