Supporting Information for

Seismic discrimination of controlled explosions and earthquakes near Mount St. Helens using P/S ratios

Ruijia Wang[1*], Brandon Schmandt[1], & Eric Kiser[2]

1. Department of Earth and Planetary Science, University of New Mexico, Albuquerque, NM, 87131, USA.

2. Department of Geosciences, University of Arizona, Tucson, AZ, 85721, USA.

Contents of this file

Additional Supporting Information (Files uploaded separately)

Introduction

This supporting information provide additional details on our velocity model (Figure S1) and data quality (Figure S2). Figure S3 presents the station coverage and magnitude information for the high P/S ratio earthquakes. A simple bootstrapping resampling analysis on a nearly co-located pair of earthquake and explosions is provided to show that fewer stations could be sufficient to discriminate explosive sources (Figure S4). Finally, complete header information for the explosions (i.e., shots), earthquakes and broadband stations are included in Table S1. All waveform data are openly available from the IRIS DMC.
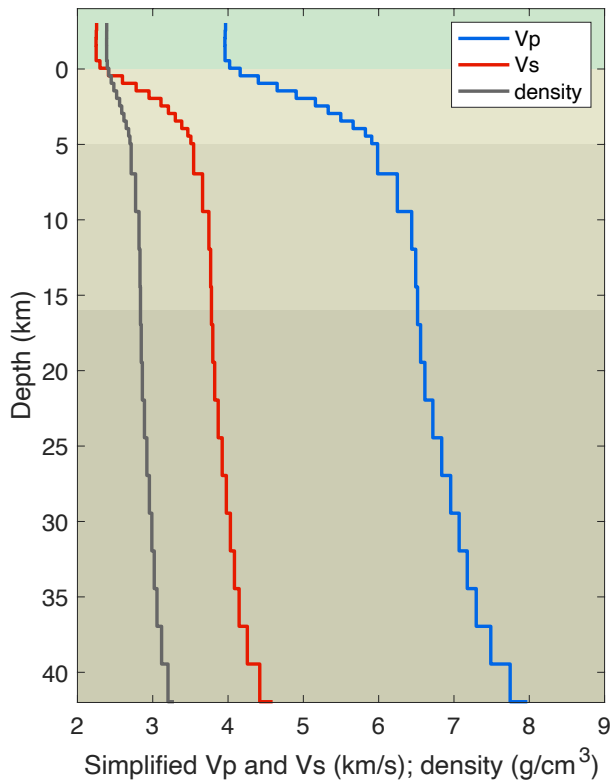
Figure S1. Simplified 1D P and S velocity model for Mount St. Helens (Kiser et al., 2016). The depth is relative to sea level.
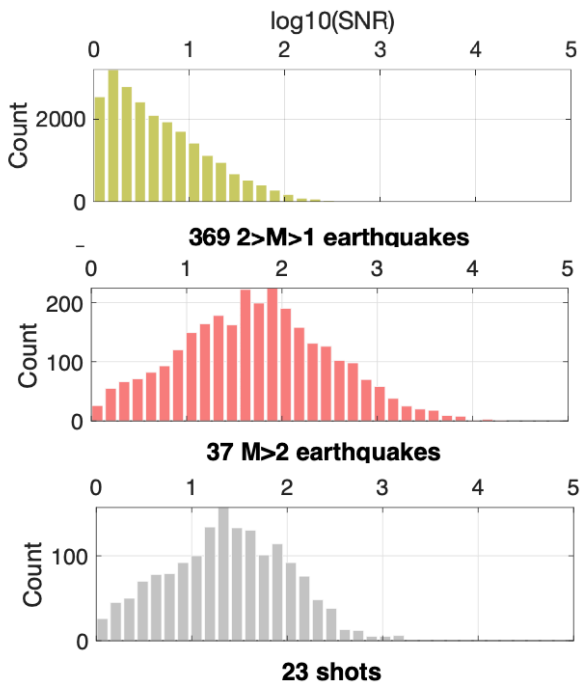

Figure S2. SNR distribution of earthquakes and shots in log scale, where a cutoff of SNR=2 is around 0.3 in log scale. Each measurement is for a single source-receiver pair from the broadband array.
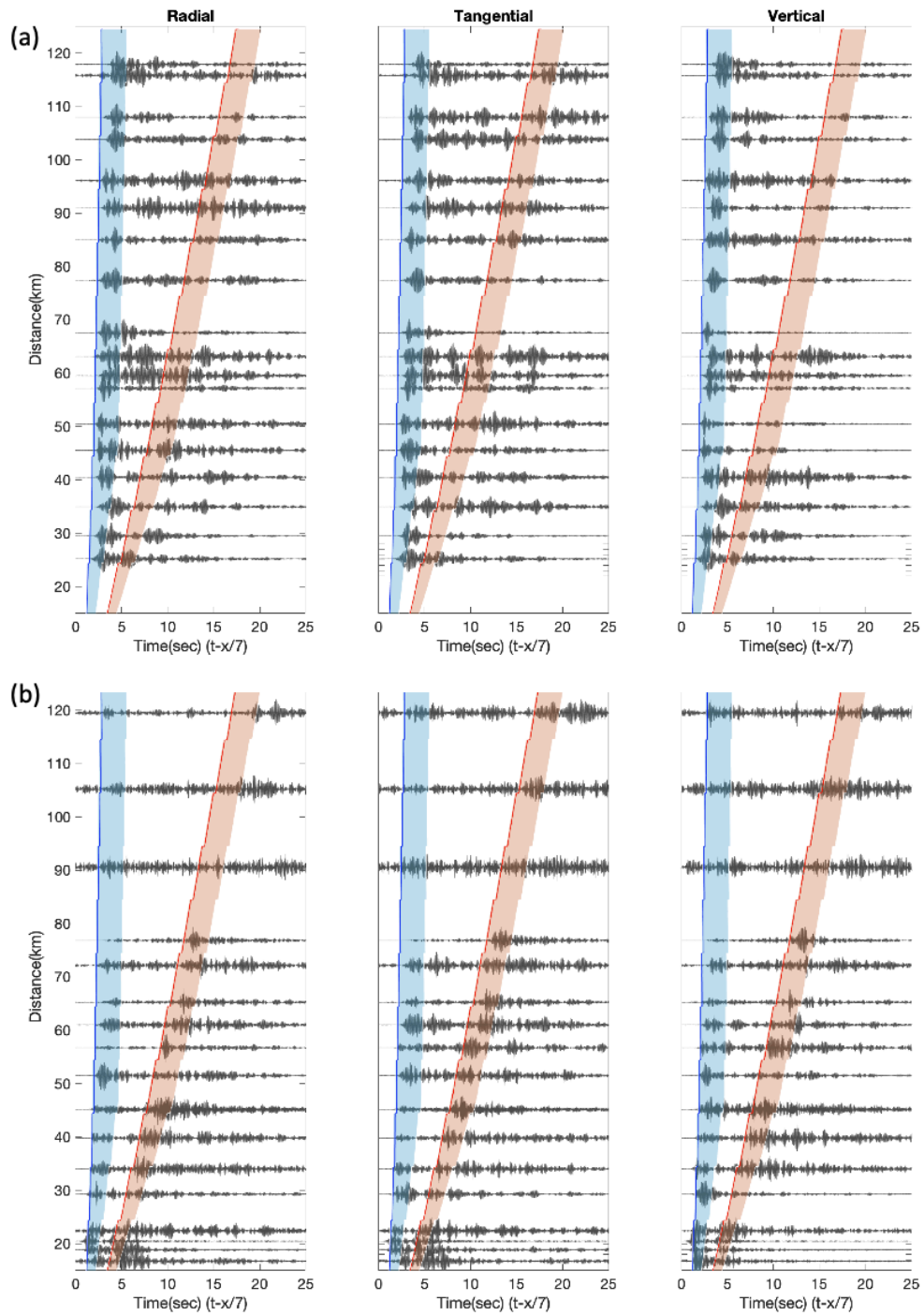
Figure S3. Same as Figure 2 in the main text but with filter range of 10-18 Hz.
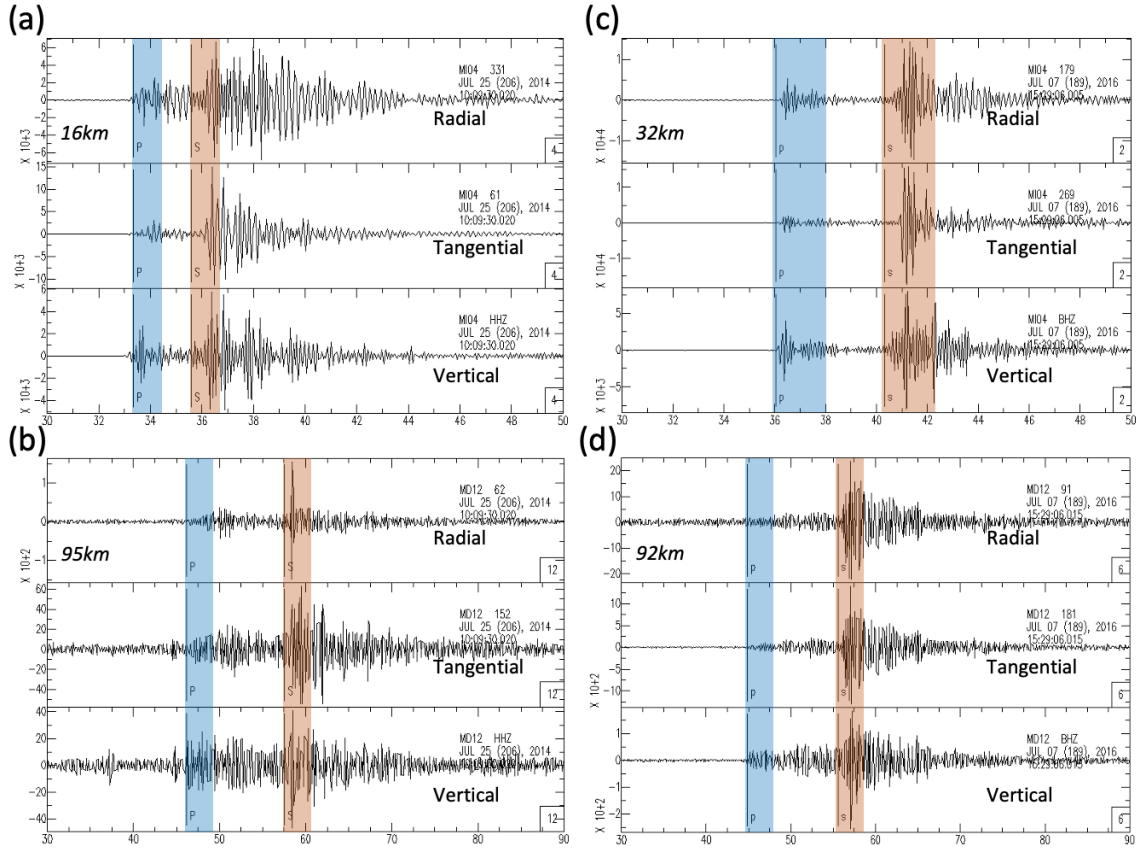
Figure S4. Example of phase windowing on unfiltered waveforms. (a) and (b): explosive source (X4, M$_L$1.3; also see Figure 1 and Table S1) recorded at near and far source stations. (c) and (d) earthquake (2016/07/07 15:29:36 UTC, M$_L$2, depth=18.2 km; also see Table S1) recorded at near and far source stations. Note in (b) & (d), the time scales are 3 times of (a) & (c) and the phase windows are bounded by 3 sec.
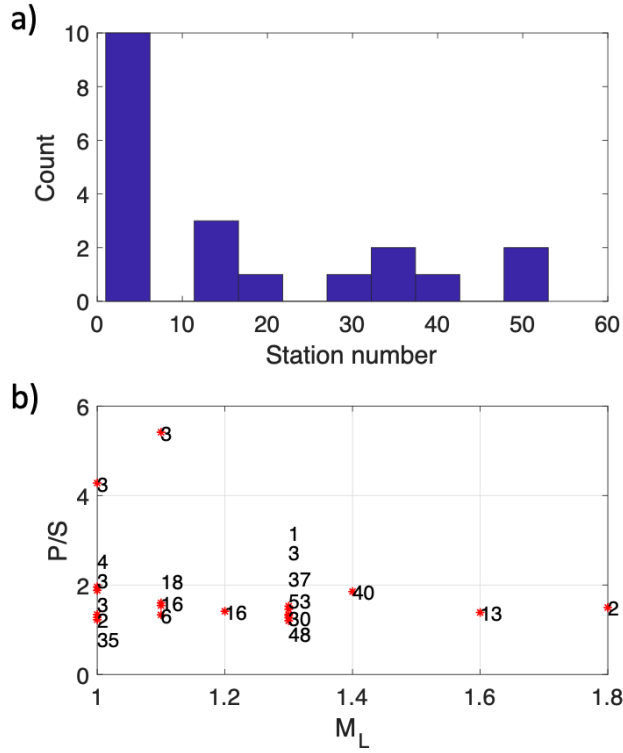
Figure S5. Station coverage of the high P/S ratio earthquakes that lead to false positive explosion classifications (see Figure 11 in the main text). A) Histogram showing number of valid stations used to calculate the median value. B) Event P/S vs. magnitude with number of valid stations labeled. Note that these 20 earthquakes are sparsely located around Mount. St. Helens with depth ranging from 0 to 20 km.
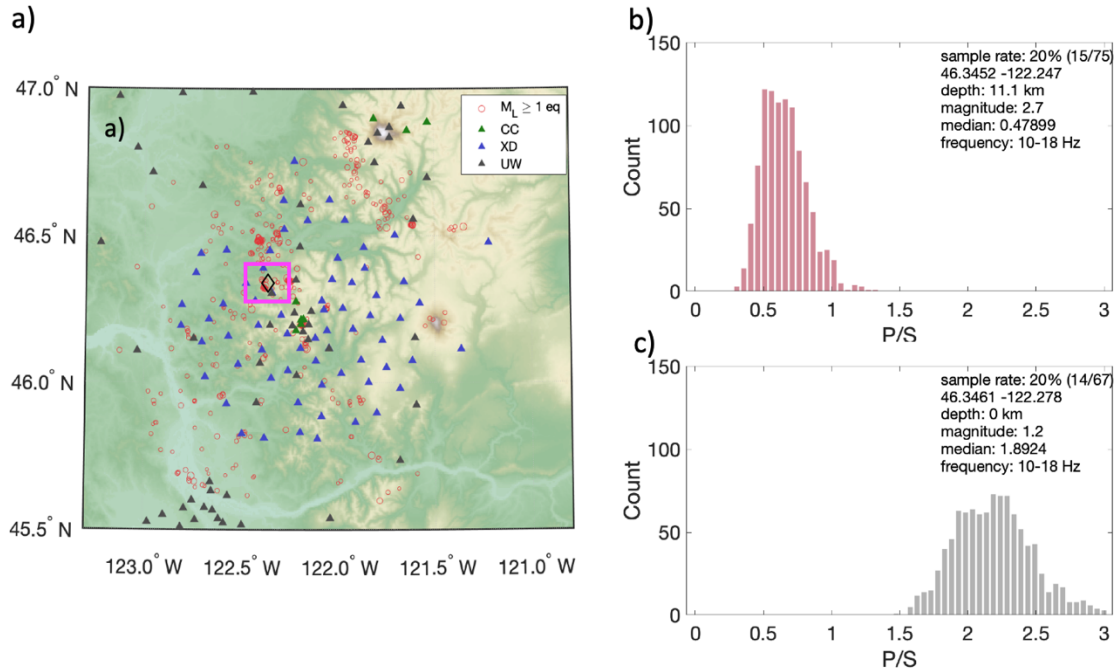
Figure S6. Bootstrap resampling test for a pair of co-located earthquake and explosion. A) location of the pair (magenta box); shot name "Y6". The horizontal distance between the sources is 2.4 km and the depth difference is 11.1 km. B) and C) Histograms for the P/S ratio determined from randomly selected (no repeat) ~20% of the stations recording the pair.

Table S1. Event and station information (files uploaded separately)

   Sheet1-Shot: time, location, magnitude and yield for all explosions

   Sheet2-earthquake: all earthquakes within 75km of Mount St. Helens requested from PNSN catalog; only $M_L \geq 1$ earthquakes are used in this study.

   Sheet3-broadband array: broadband stations from net code XD, CC and UW.