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Automated measurement of differential P and S times for imaging near-source Vp/Vs ratio with moving-window cross-correlation analysis

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A high-resolution imaging of Vp/Vs ratio is crucial to understand fluid content in active faults and volcanoes. Lin & Shearer (2007, BSSA) recently developed a methodology to obtain near-source Vp/Vs ratios in individual similar earthquake clusters, based on differential P and S wave measurements. We here present an automated procedure to estimate differential P and S times by exploiting temporal properties of delayed time for pairs of seismograms with a moving-window cross-correlation analysis (e.g., Snieder, 2002, Phys. Rev. E; Niu et al. 2003, Nature). Our approach is based on the principle that the delayed time for the direct S wave differs from that for the direct P wave. After two waveforms are aligned by the direct P wave (i.e. differential P time), the temporal evolution of delayed time shows a step function and the onset time of its discontinuity corresponds to the arrival time of the direct S wave, in an ideal case. The offset of the step function represents the differential S-P time, and the differential S time is thus calculated from the differential P and S-P times. We perform a numerical experiment with the 3-D finite-difference code, SOFI3D (Bohlen, 2002, Computers & Geosciences) to address the effects of coda waves in the differential time measurement. We find that the differential S time measurement with the direct S-wave part is perturbed due to P coda, introducing a bias in the resulting Vp/Vs measurement. Our numerical experiment shows that the differential time measurement is more robust with the S coda. We apply our automated procedure for seismic data recorded at the Geysers geothermal field, California, and present a spatial variation of Vp/Vs ratio at this geothermal field.