2-D Phase-Velocity Maps Using Data from a Regional Event Recorded by a Dense Network

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1. Introduction

We obtain 2-D Rayleigh wave phase velocity maps using data from the high density (10–30 km spacing) 104-station HLP broadband deployment coupled with EarthScope TA data (70 km spacing). WSJ08 (Warren et al., 2008) calculated interstation fundamental-mode Rayleigh-wave phase velocities in this region using events through 2007/02 — with less than 15 HLP stations deployed. Their subregion G2 (Figure 1) included almost all the HLP network stations. The epicenter of the 2008/02/21 M=6.0 Wells earthquake in northwest Nevada occurred in the southeast corner of subregion G2 and had 188 interstation paths among 78 stations with centers in G2 with a near-station epicentral distance of at least 200 km, a common great-circle path such that the differential station-station and station-epicenter backazimuth was ≤ 3 degrees, and an interstation distance of ≥ 200 km. We present here results from a method for creating 2-D phase-velocity maps at fixed period by contouring the calculated phase velocities at the centers of each interstation path.

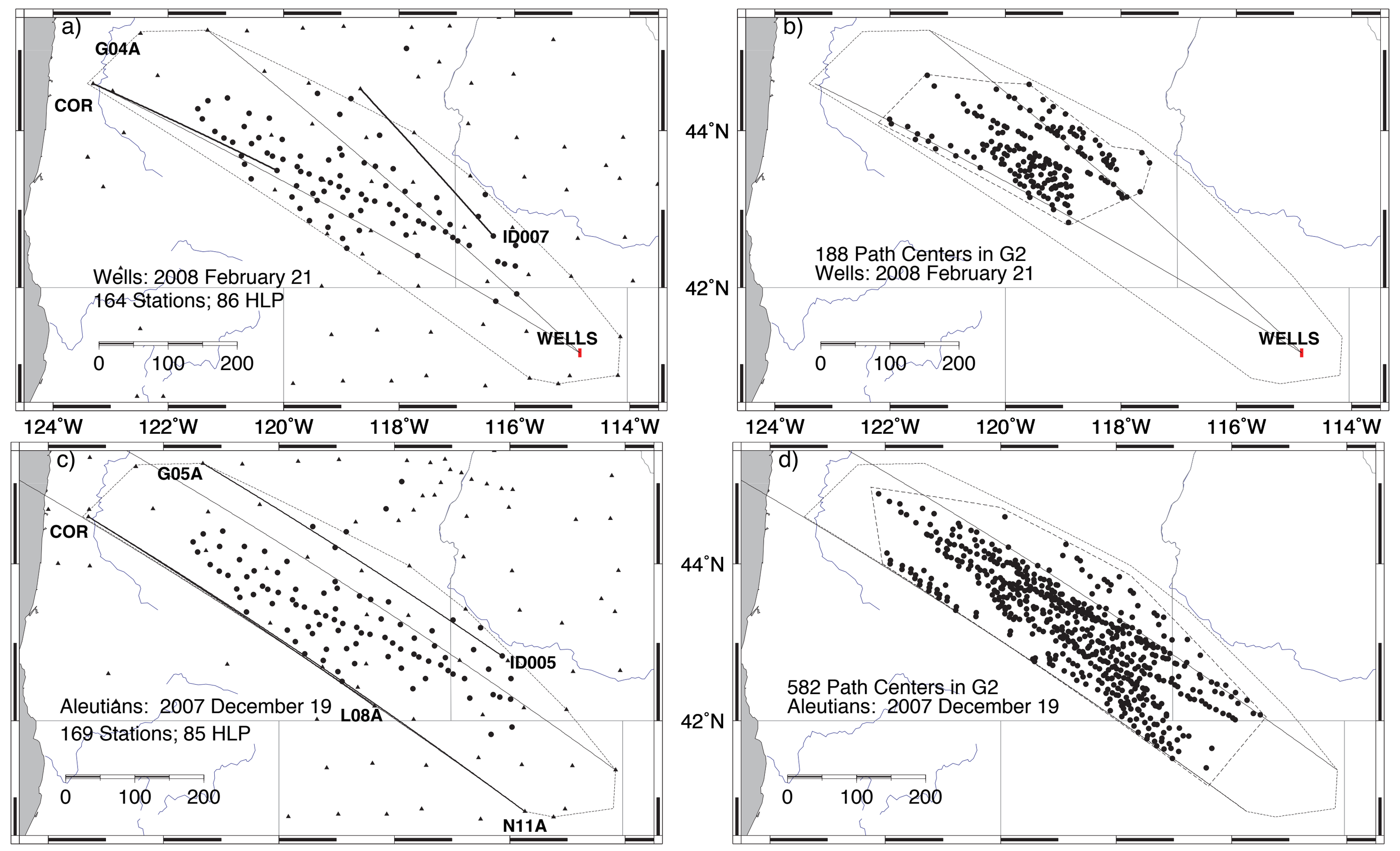

Figure 1: Station distribution and path centers for the 2008/02/21 Wells earthquakes (a, b) and the 2007/12/19 Aleutian event (c, d). HLP stations are plotted as circles; stations from other networks are plotted as triangles. The dashed line outlines the WSJ08 subregion G2. Thin solid lines indicate great-circle paths. Thick solid lines in (a) and (c) indicate GCPs between labeled stations. The thick dashed line in (b) and (d) encloses the path centers.

2. Synthethic Tests

We created waveform synthetics for the Wells hypocenter using the G2 velocity model to test the effect on our surface-wave analysis of small epicentral distances. At periods greater than 50 s, the calculated phase velocities differ systematically from true velocities for smaller distances (Figure 2). The 2-D phase velocity map at 73 s period (Figure 3a) shows that the calculated velocities at greater epicentral distances approach the true values. Also, at the longest periods, s (the standard deviation of the estimated errors) is significantly larger than σ (the standard deviation of the data). These large values of s appear to result from limited coherency, caused by distance/wavelength effects of the small epicentral distances. For the period range 32.0 s to 46.5 s, the calculated and actual phase velocities deviate and the errors are significantly larger than at shorter periods. The 2-D map at 39.4 s (Figure 3b) shows a distance-dependent pattern typical of those periods, but with a total variation over the entire region on the order of (a less-than-significant) 0.01 km/s. For periods shorter than about 30 s, the true and calculated phase velocities are the same and the error estimates are effectively zero.

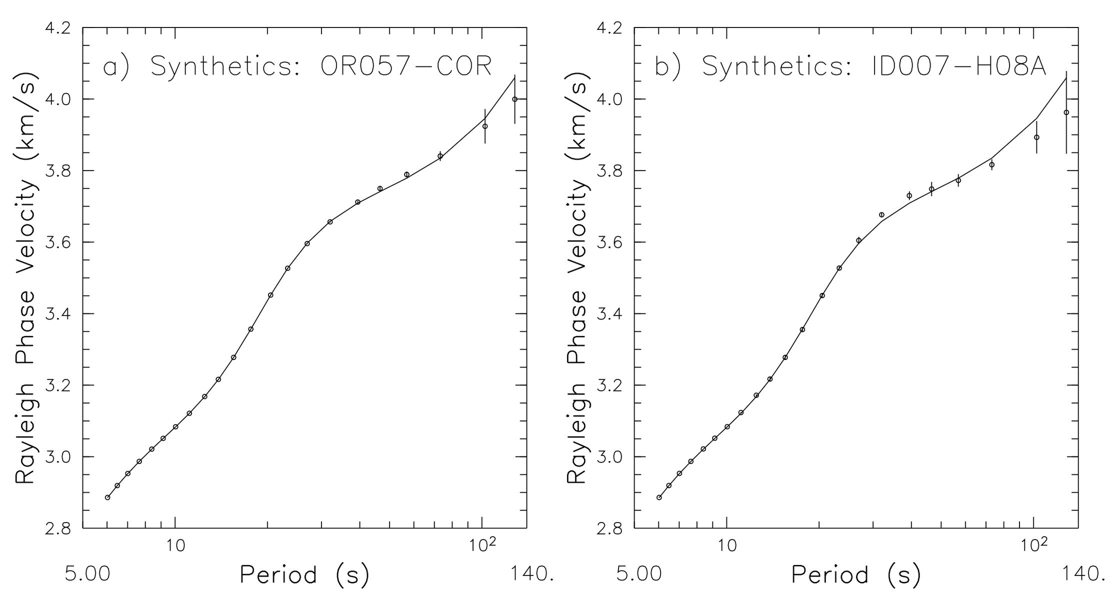

Figure 2: Synthetic interstation phase-velocity spectra for the two interstation paths shown in Figure 1a: **(a)** OR057-COR (path center with an epicentral distance of 640 km), and **(b)** ID007H08A (383 km). Estimated errors are based on the coherence of the two waveforms. The solid line is the phase-velocity curve for the G2 velocity model that was used to create the synthetics.

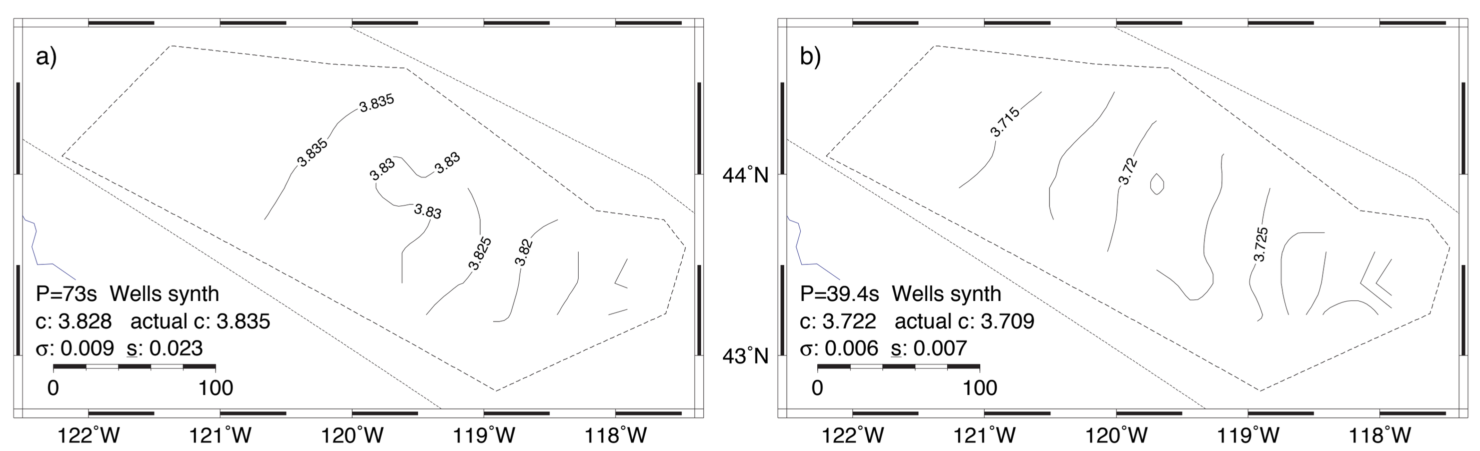

Figure 3: Contoured phase velocities for the Wells earthquake using fundamental-mode synthetics waveforms at the specified periods. The thin dashed lines mark the boundaries of subregion G2. Text on each subplot indicates the the WSJ08 G2 phase velocity at that period, the calculated average phase velocity, its standard deviation (σ), and the standard deviation of the errors (s). The thick dashed line bounds the 188 interstation-path centers (Figure 1b). The epicenter of the Wells earthquake is at 114.87°W and 41.15°N, so epicentral distance increase towards the northwest.

3. Application to the Wells Data

The average velocities in G2 from analysis of the Wells data are consistent with those reported in WSJ08, and the high path density allows us to obtain well-constrained measures of velocity heterogeneity. Results at longer periods (Figure 4a) are consistent with those for the synthetics. An increase in phase velocities towards the northeast is observed for periods from 7 s to 32 s with the strongest trend at 17.7 s period (Figure 4b,c,d). Consistent behavior at shorter periods is observed for two-statioon paths along the northeast and southwest boundaries of G2 (Figure 5).

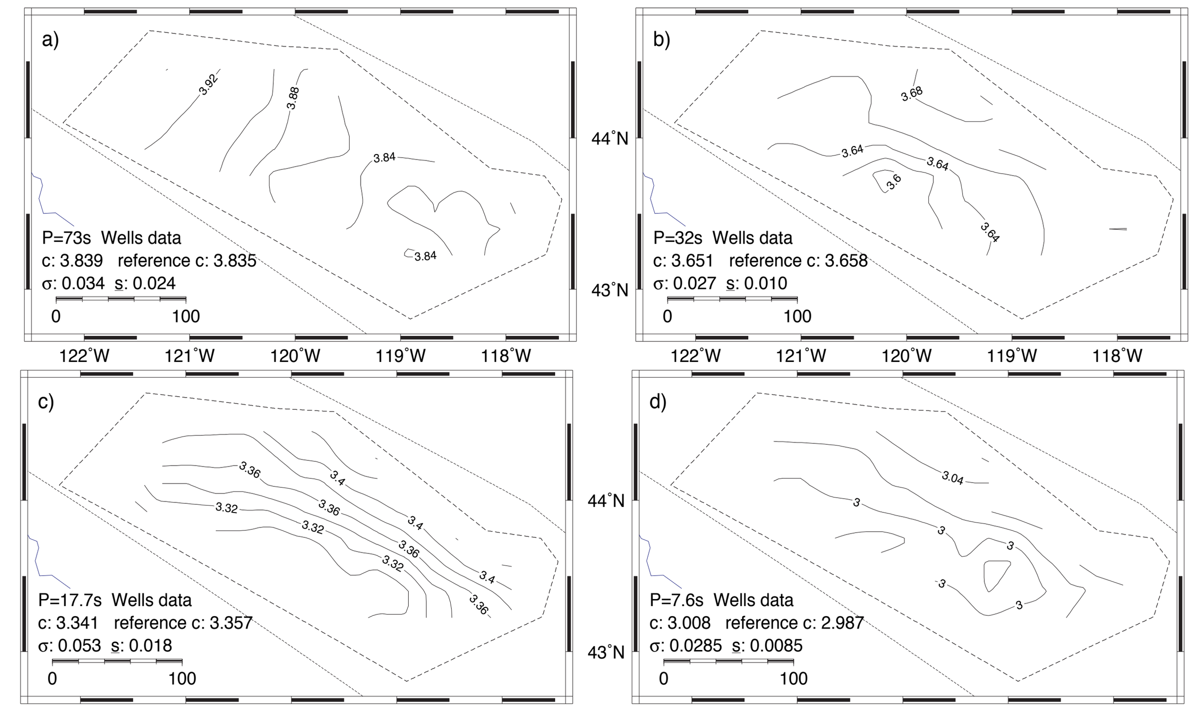

Figure 4: Contoured phase velocities at specified periods for the Wells earthquake using data waveforms.

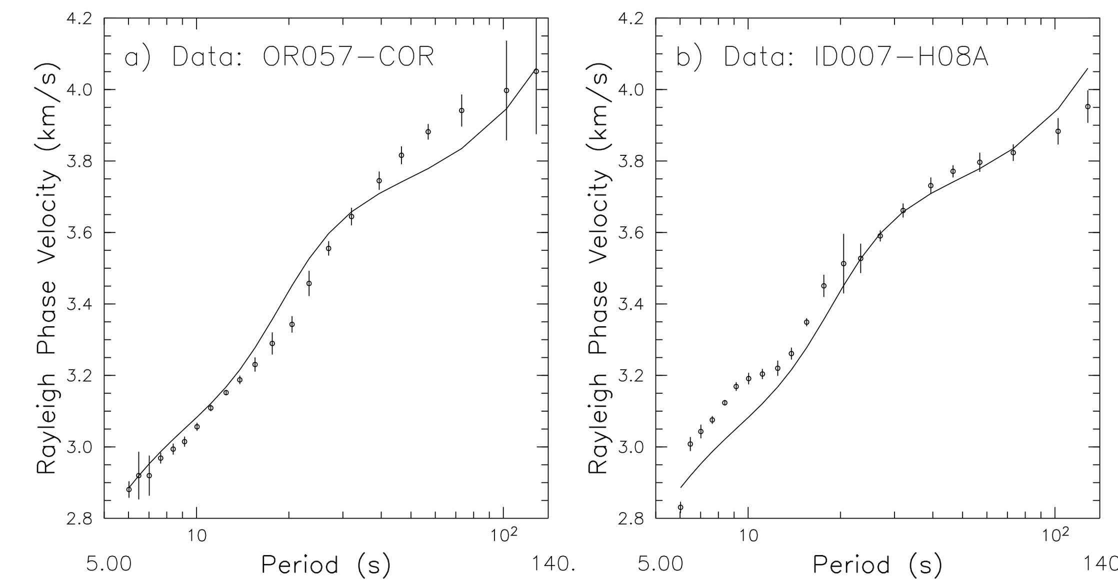

Figure 5: Interstation data phase-velocity spectra for the two paths shown in Figure 1a as in Figure 2.

4. The 2007/12/19 Aleutian Event

This event has an almost identical location to three of the events used by WSJ08, which was the basis for the G2 regional boundaries. At longer periods, the coherency is poorer than for the Wells data, and there are no patterns in the 2-D plots. At 17.7 s (Figure 6), the phase-velocity pattern is similar to that for the Wells event.

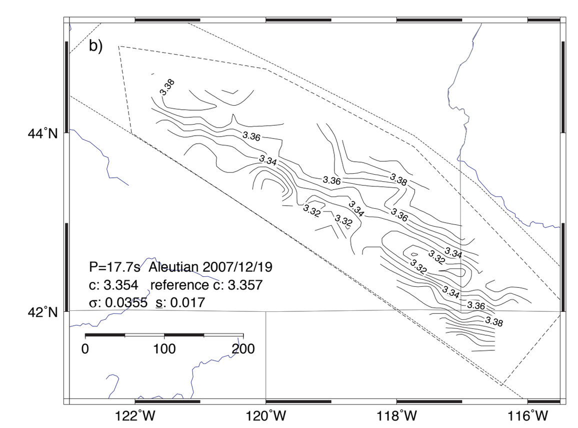

Figure 6: Phase-velocity contours calculated for the 2007/12/19 Aleutian event.

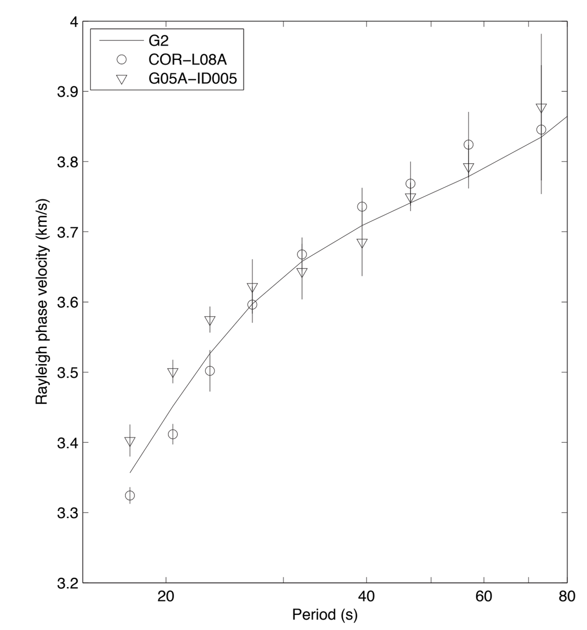

Figure 7: Interstation phase-velocity estimates vs. period for the paths between stations labeled in Figure 1c. Interstation path lengths are 482 km (COR–L08A) and 494 km (G05A–ID007).

5. Conclusions

- The smaller epicentral distances for the regionally-recorded Wells event permit surface-wave analysis down to ≈7 s period, in contrast with the ≈17 s for teleseismic events such as the 2007/12/19 Aleutian earthquake (Figure 8).
- In all cases, both regionally and teleseismically, high station density allows us to place close constraints on subregional velocity variations. The higher coherency for the regional Wells event provides more reliable phase velocity measurements for periods < 30 s.

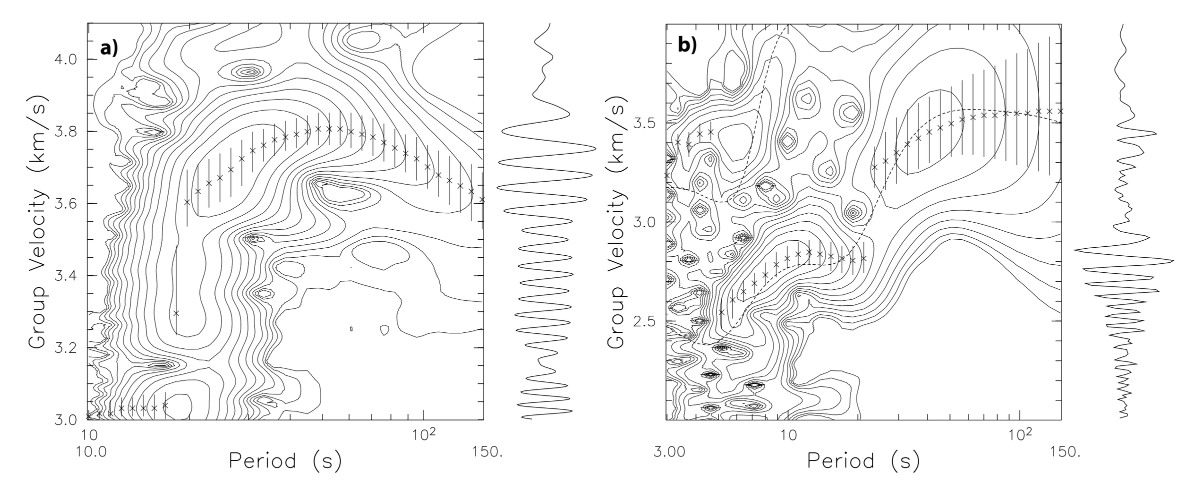

Figure 8: Single-station FTAN group velocities vs. period for the (displayed) vertical-component waveforms **(a)** at station N11A from the 2007 Aleutian earthquake (see Figure 1c) with an epicentral distance of 4,096 km, and **(b)** at station GO4A from the Wells earthquake (see Figure 1a) with an epicentral distance of 765 km. In (b), the entire path within G2, and the dashed lines show the predicted G2-velocity-model group-velocity curve for the Rayleigh-wave fundamental and first higher modes.