Moment tensor inversions for *Tape et al.* (2018)

Vipul Silwal

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Overview

This document is part of the collection of *Silwal* (2018), which is a supplement to *Tape et al.* (2018). The results here show how two choices impact the moment tensor inverions: (1) the bandpass for filtering seismograms, and (2) the source duration used for calculating synthetic seismograms.

Description of figures

- Figure M1: grid search for best-fitting source duration and bandpass for the 2015 VLFE. Here we interpret some of the patterns in Figure M1.

  - Within the upper left triangle we see poor fits (low VR and high magnitudes). The poor fits arise because the long source durations have low-pass-filtered the synthetics whereas the bandpass for the data (and synthetics) has not.
  - VR decreases and M_{w} increases as the bandpass frequency center decreases (moving downward on the plot from the star), because the noise-to-signal increases for longer periods.
  - To the right of the lower dashed line, the source duration is playing little to no role, since the source duration "filter" is acting on higher frequencies than those that are removed by the bandpass.

  Note that the maximum variance reduction (VR) does not necessarily provide the "best" bandpass and source duration, since VR will generally increase with longer periods, where the approximation of a 1D reference model is more valid (e.g., *Silwal and Tape*, 2016). But the grid search provides a good guide for inferring the bandpasses and source durations to consider.

- Figure M2: grid search for best-fitting source duration and bandpass for the 2013 VLFE.

- Figures M3 and M4 are for earthquakes and are useful for comparison with the VLFE in Figure M1. In general, the high-amplitude long-period signal in the VLFE leads to the option of considering a longer source duration.

- Figure M5: best waveform fits for the 2015 event (based on Figure M1)

- Figures M6–M8. We were interested to see what magnitude would be estimated if we restricted the bandpass to the longest periods. The noise increases at longer periods, but the magnitude estimate is stable.

- Figures M9–M11. The influence of using different source durations for a fixed bandpass. (A short source duration has no impact when the bandpass is filtering out all short periods.)

- Summary points:
  - For the VLFE there is signal up to $\sim$100 s at some stations.
  - The magnitude of the VLFE is stable at M_w 3.8. Increasing the source duration and bandpass periods increases the magnitude slightly to M_w 3.9, but the fits are worse (Figure M7).
  - The grid search is probably not the best approach for estimating duration of an event, though it seems to provide a maximum allowable duration. (This is tricky business!)
- Figure M12: waveform fits for the 2015 VLFE (periods 20–50 s)
- Figure M13: waveform fits for the 2016 earthquake.
- Figure M14: waveform fits for the 2015 earthquake, used for comparison in Figure S6.
- Figure M15: waveform fits for the 2013 VLFE. The signal is barely above the noise level for this bandpass (25–40 s).

Grid search of bandpass and source duration

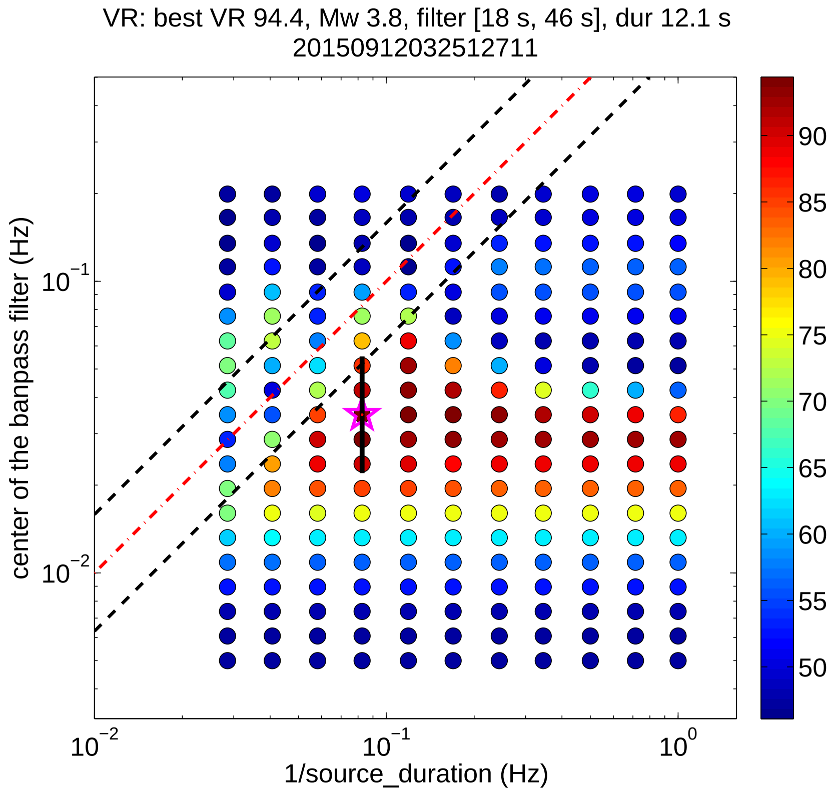
References

Silwal, V. (2018), Seismic moment tensors for six events in the Minto Flats fault zone, 2012–2016, ScholarWorks@UA: descriptor file, text file of catalog, figures with waveform fits, and input weight files.

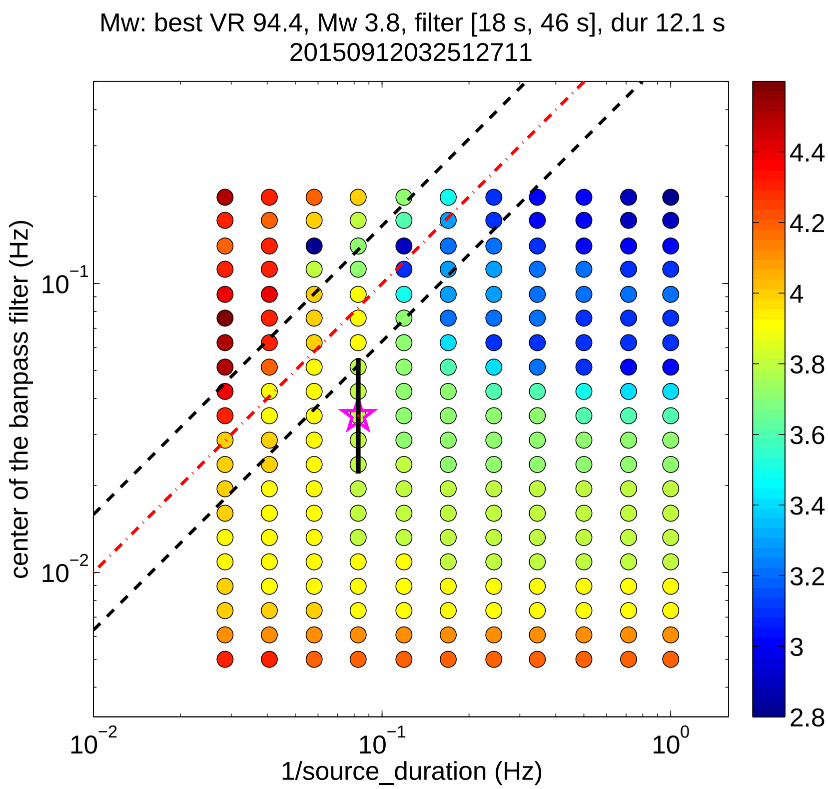
Silwal, V., and C. Tape (2016), Seismic moment tensors and estimated uncertainties in southern Alaska, *J. Geophys. Res. Solid Earth*, *121*, 2772–2797, doi:10.1002/2015JB012588.

Tape, C., et al. (2018), Earthquake nucleation and fault slip complexity in the lower crust of central Alaska, *Nature Geoscience* (in review).

Figure M1 [FOLLOWING PAGE].
Estimation of magnitude and source duration for the 2015 event. Each point in the grid represents a set of waveform fits using a particular bandpass and using a particular source duration. The center frequencies for each bandpass are uniformly spaced on a logarithmic scale, and the width of each bandpass is indicated by the vertical black segment. The source durations τ are chosen such that $1/\tau$ are uniformly spaced on a logarithmic scale. The source mechanism is fixed for each set of waveform fits, so only the magnitude M_w is allowed to vary. (a) Variance reduction VR for waveform fits; the best combination of M_w and τ is represented by the star with highest VR. The dashed red line represents the values where the center frequency of the bandpass is the same as $1/\tau$; the black dashed lines provide the bandpass limits. (b) Best-fitting M_w for each combination of bandpass and source duration.



(a)



(b)

Figure M1: Caption on previous page.

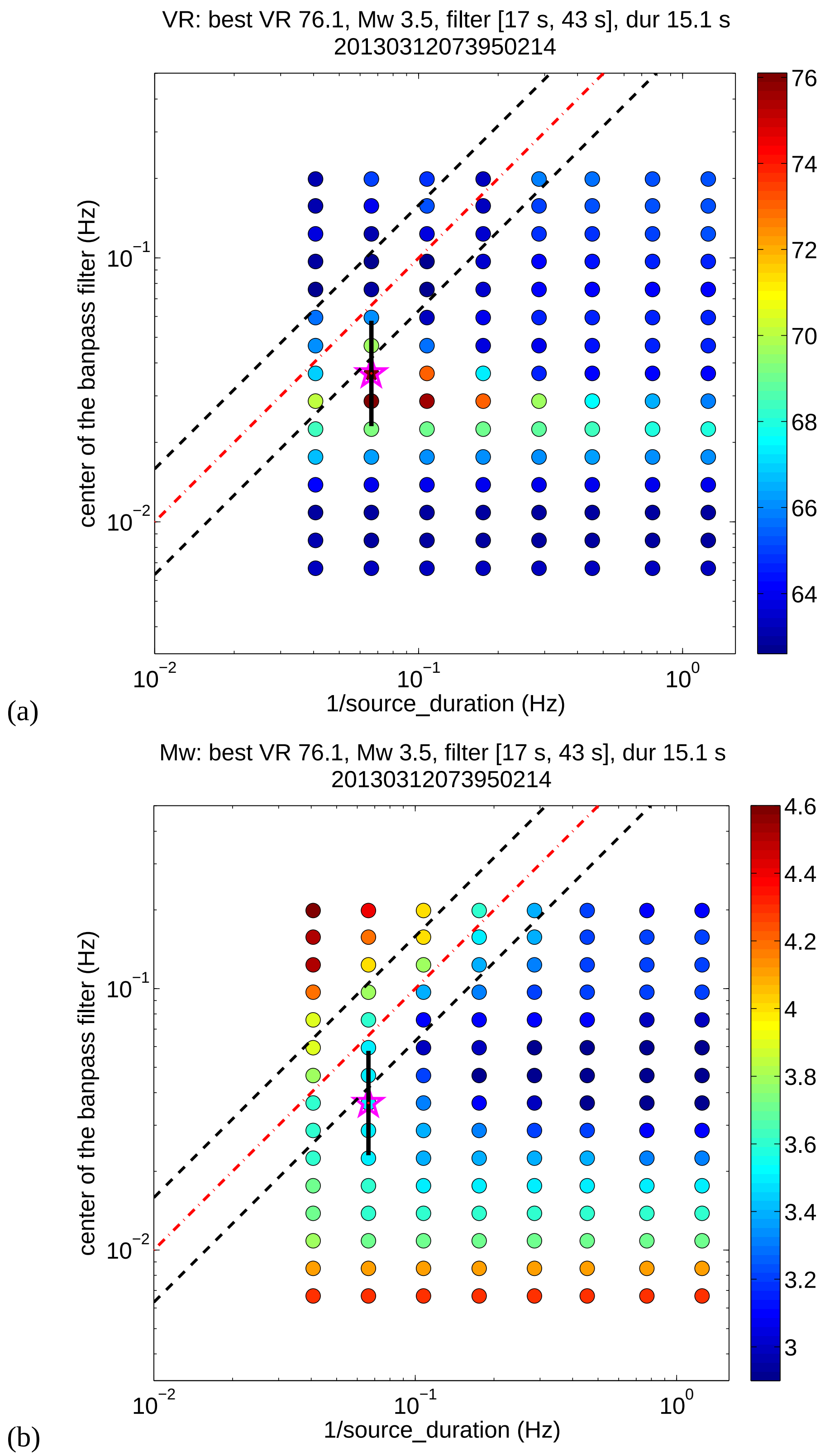
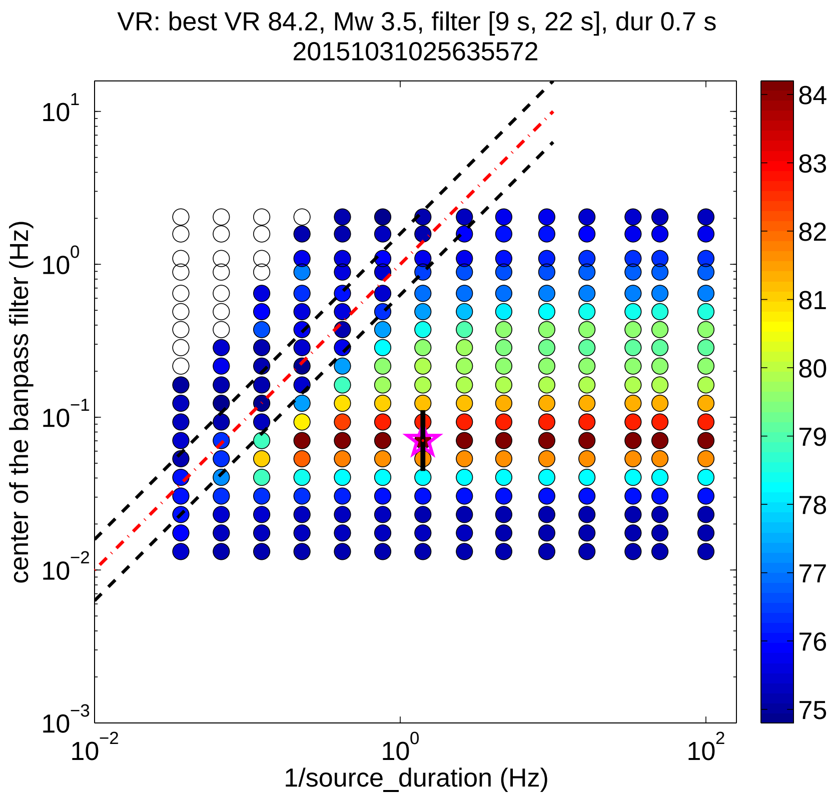
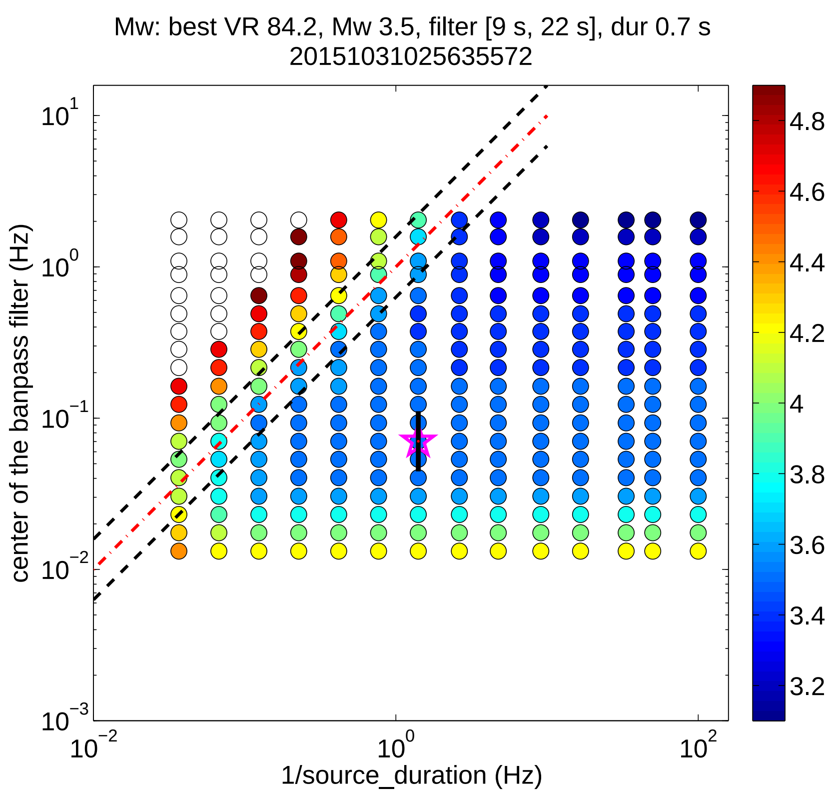


Figure M2: Same as Figure M1 but for the 2013 M_{w} 3.5 VLFE.

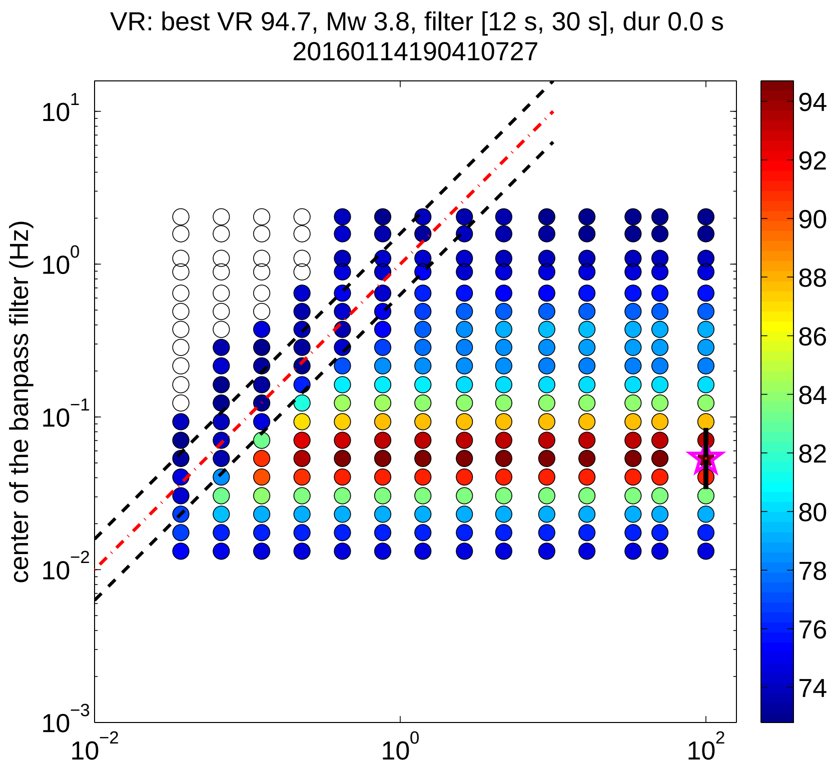


(a)

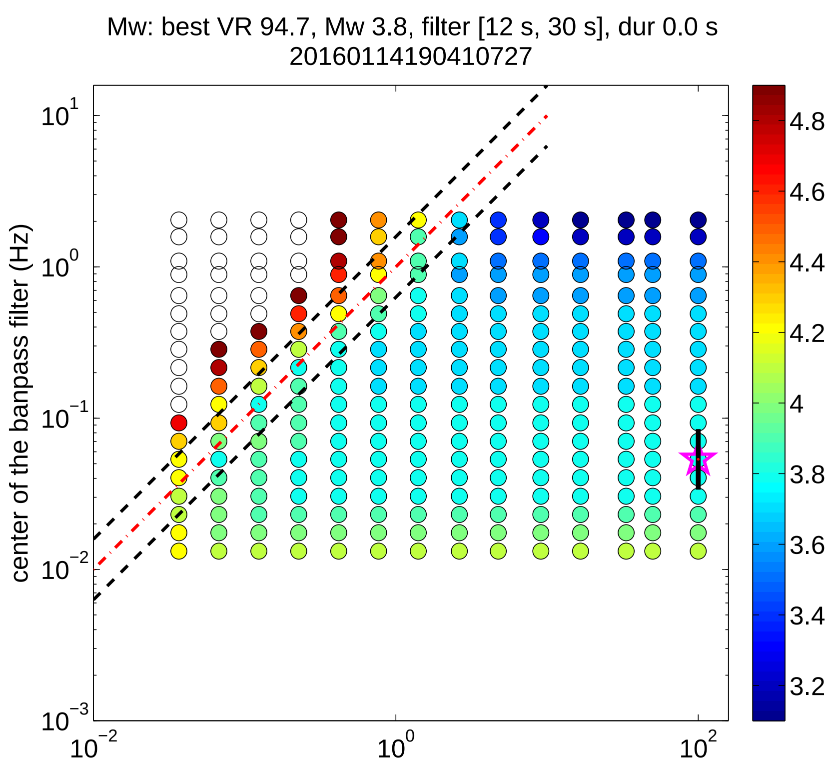


(b)

Figure M3: Same as Figure M1 but for the 2015-10-31 M_w 3.5 earthquake.



(a)



(b)

Figure M4: Same as Figure M1 but for the 2016 M_{w} 3.7 earthquake.

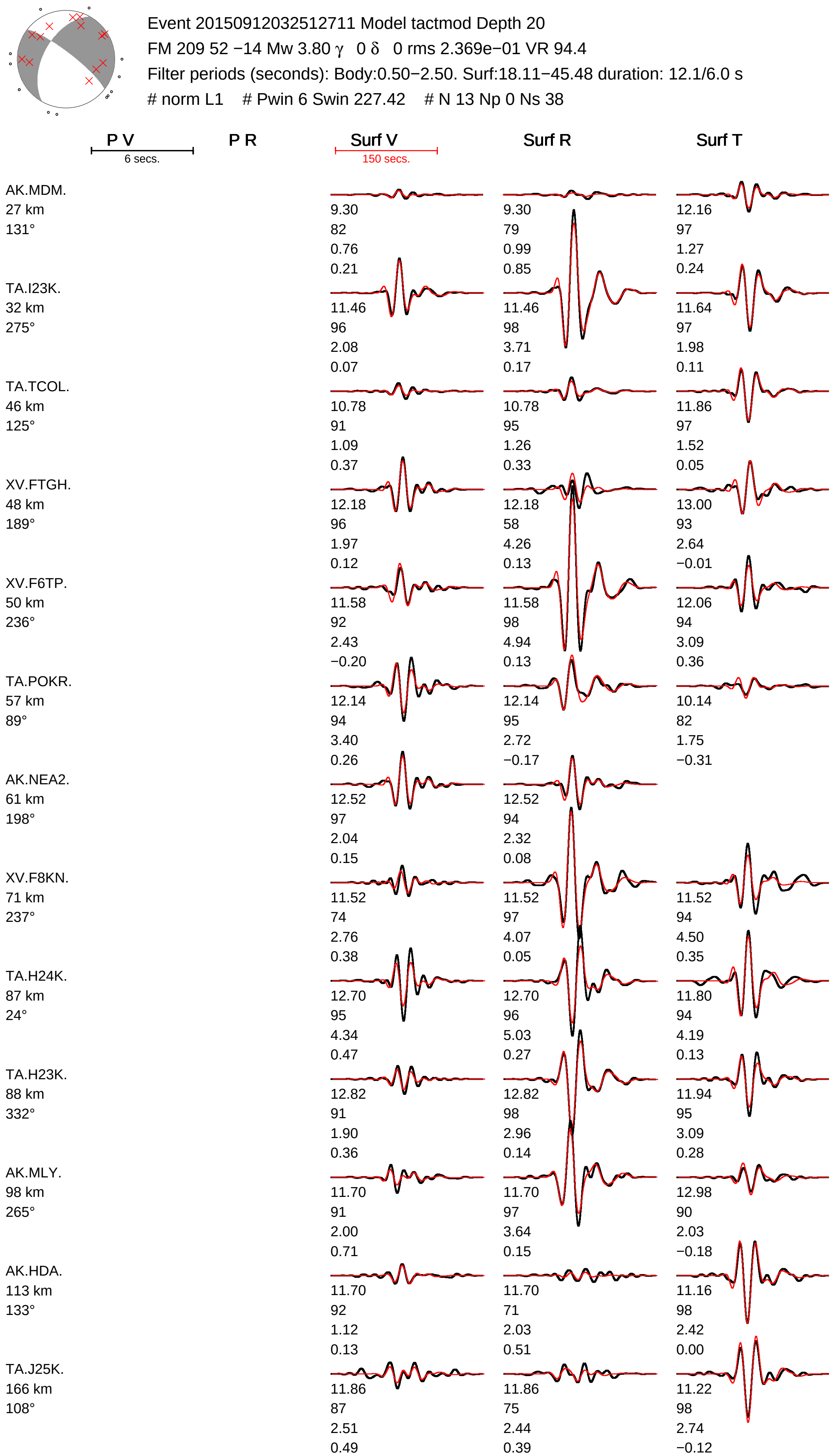


Figure M5: 2015 VLFE: best-fitting bandpass (18–46 s) and source duration (12 s).

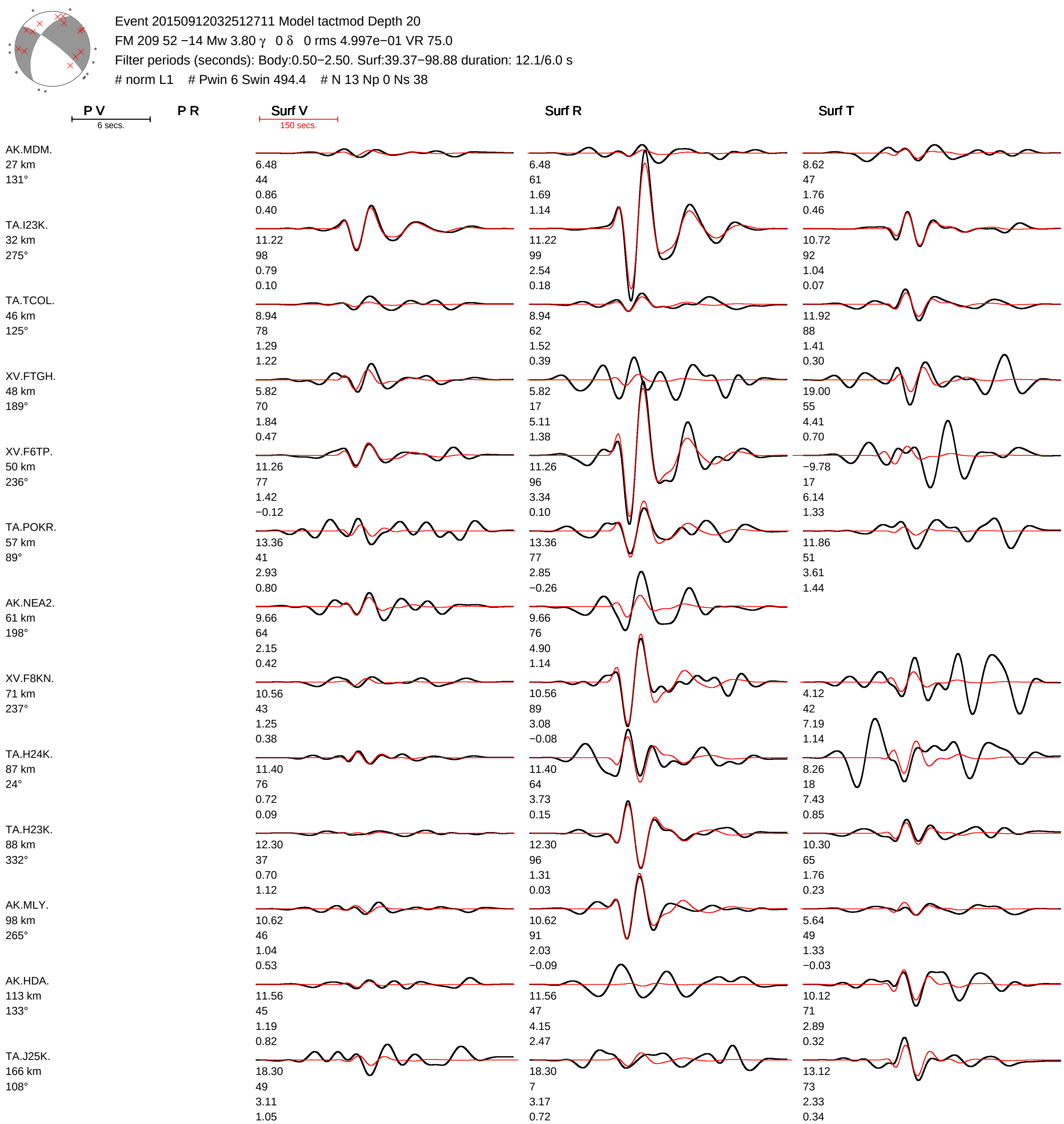


Figure M6: Same as Figure M5 but for longer periods (39–99 s). M_w 3.8

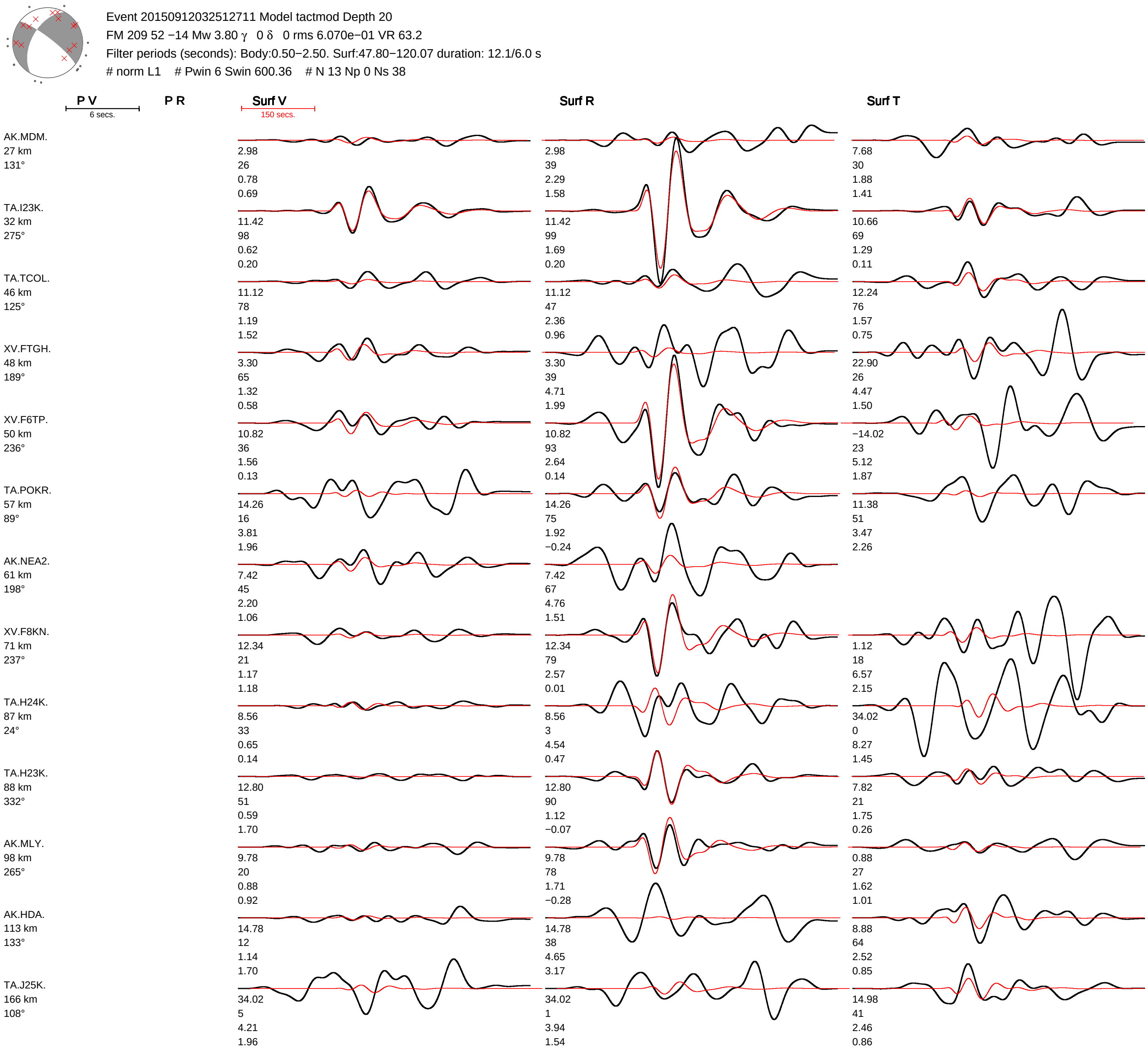


Figure M7: Same as Figure M5 but for longer periods (48–120 s). $M_{\rm w}$ 3.8

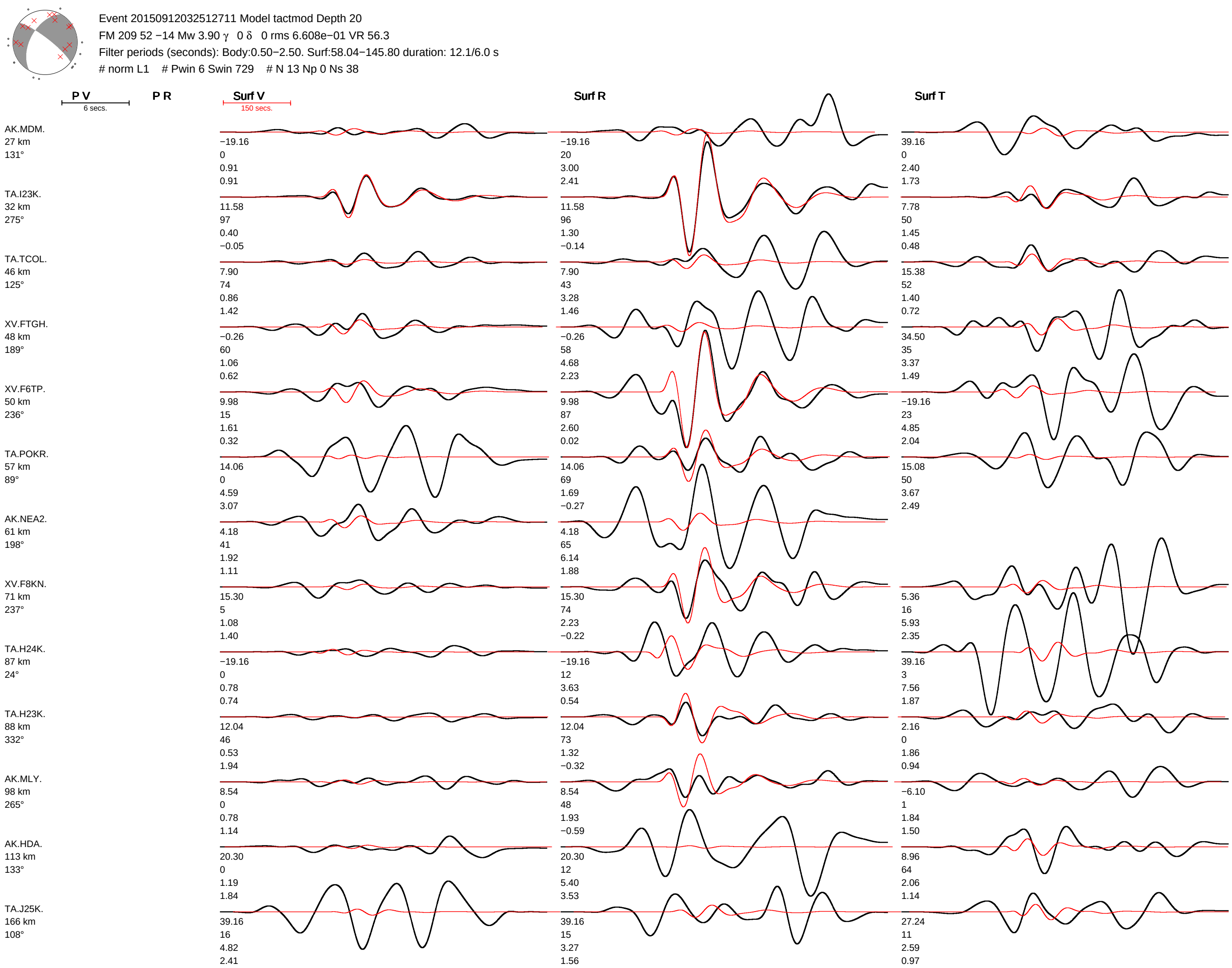


Figure M8: Same as Figure M5 but for longer periods (58–146 s). M_w 3.9

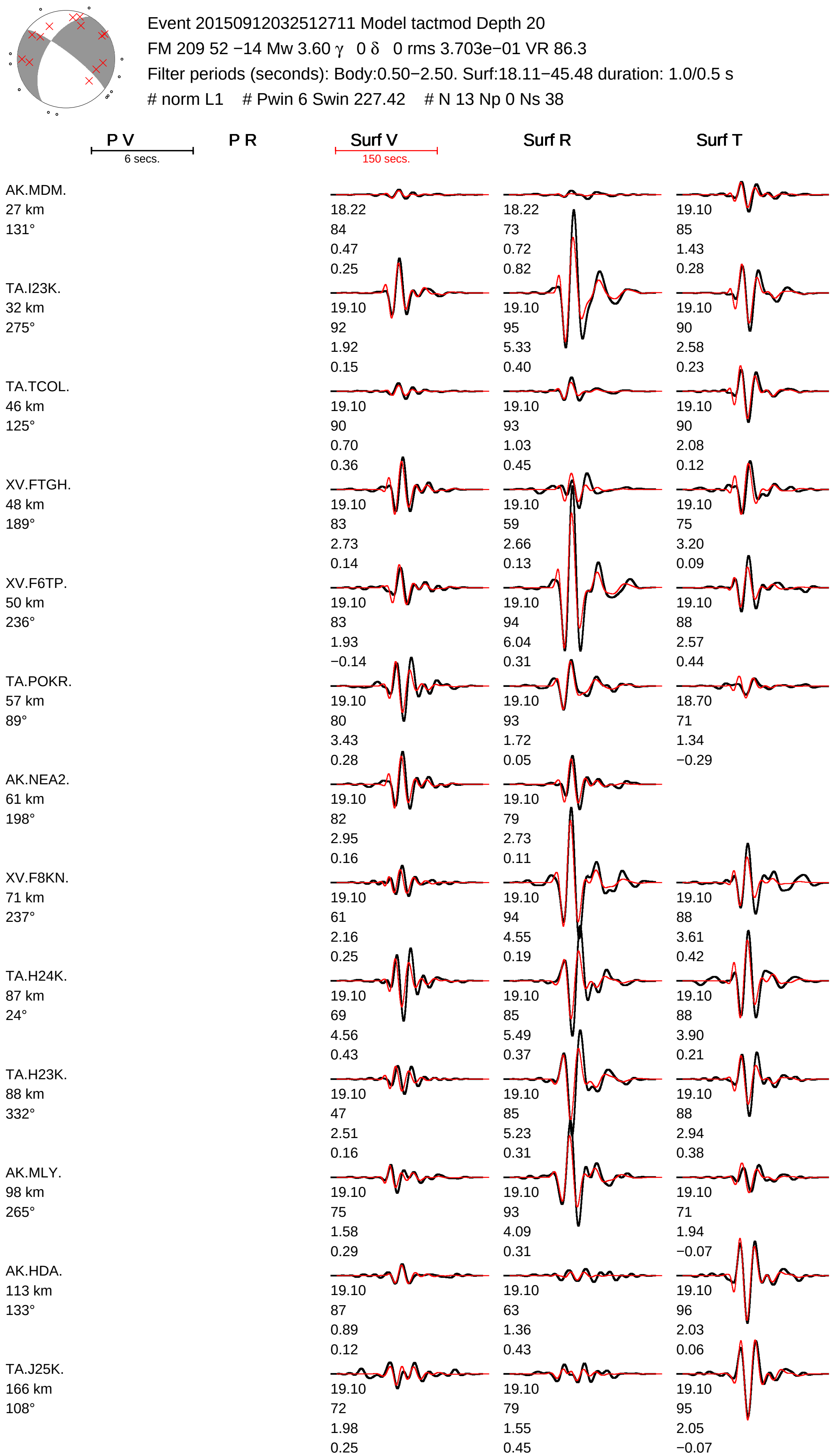


Figure M9: Same as Figure M5 but for a different source duration (1.0 s).

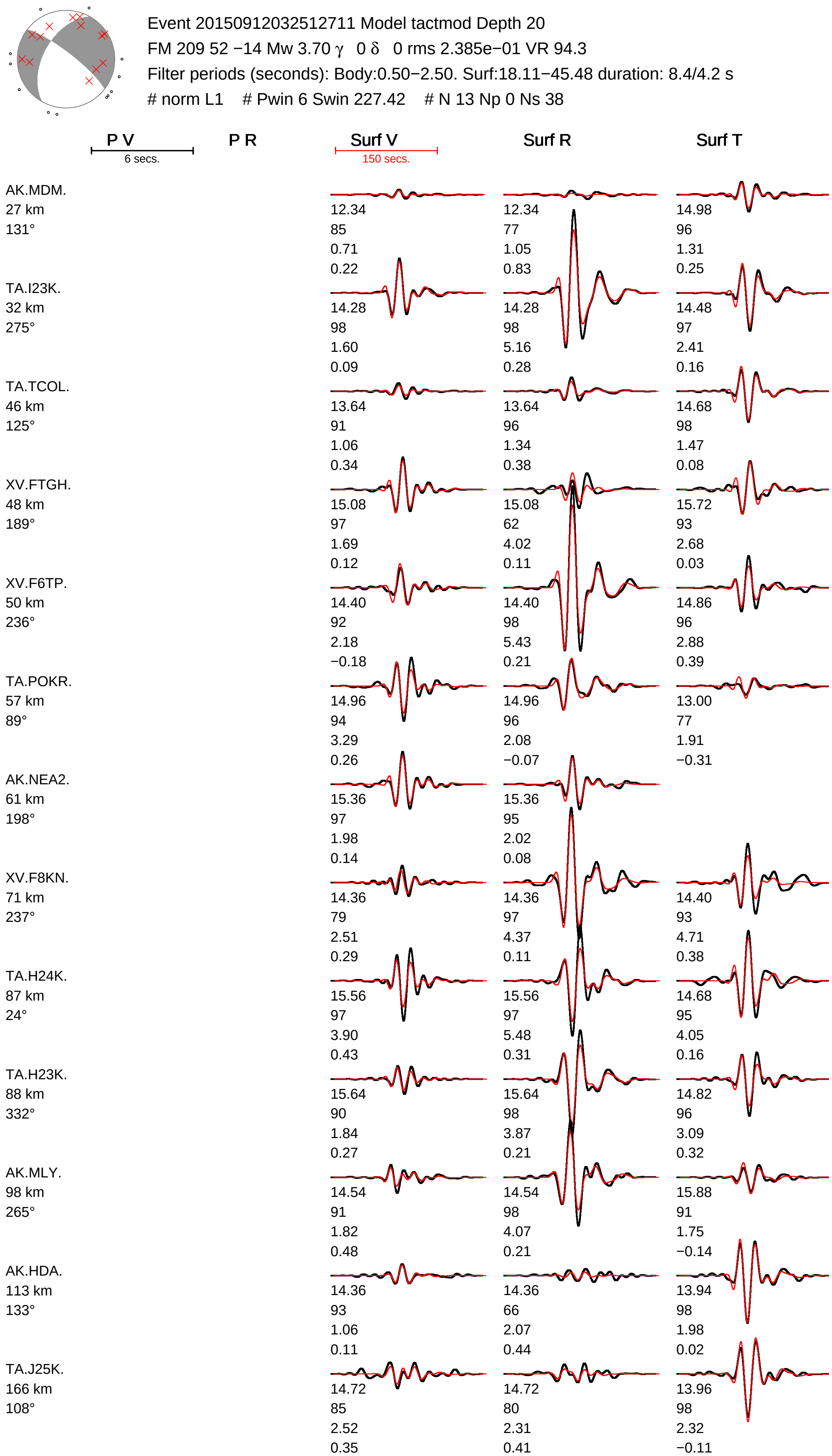


Figure M10: Same as Figure M5 but for a different source duration (8.4 s).

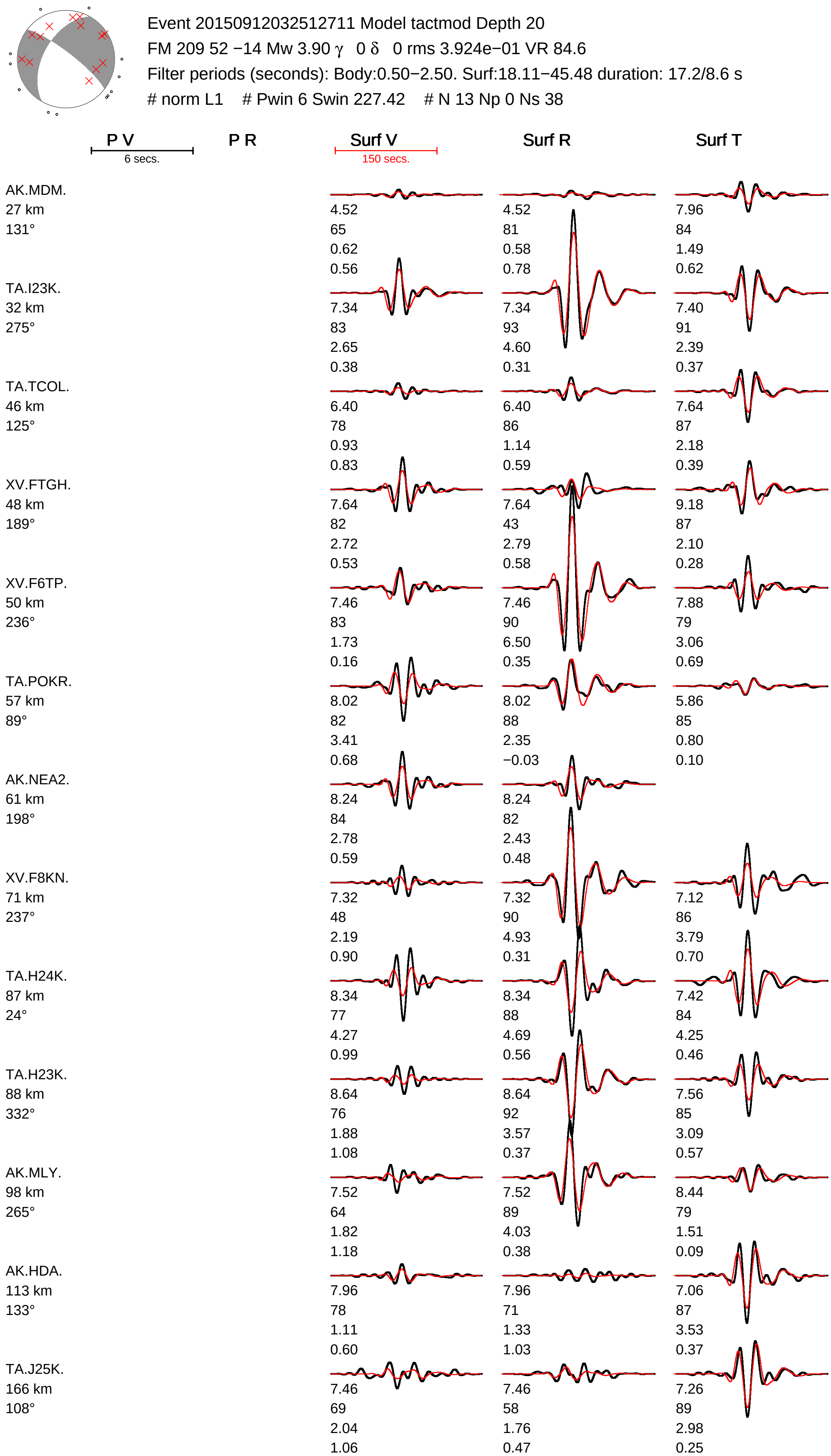


Figure M11: Same as Figure M5 but for a different source duration (17.2 s).

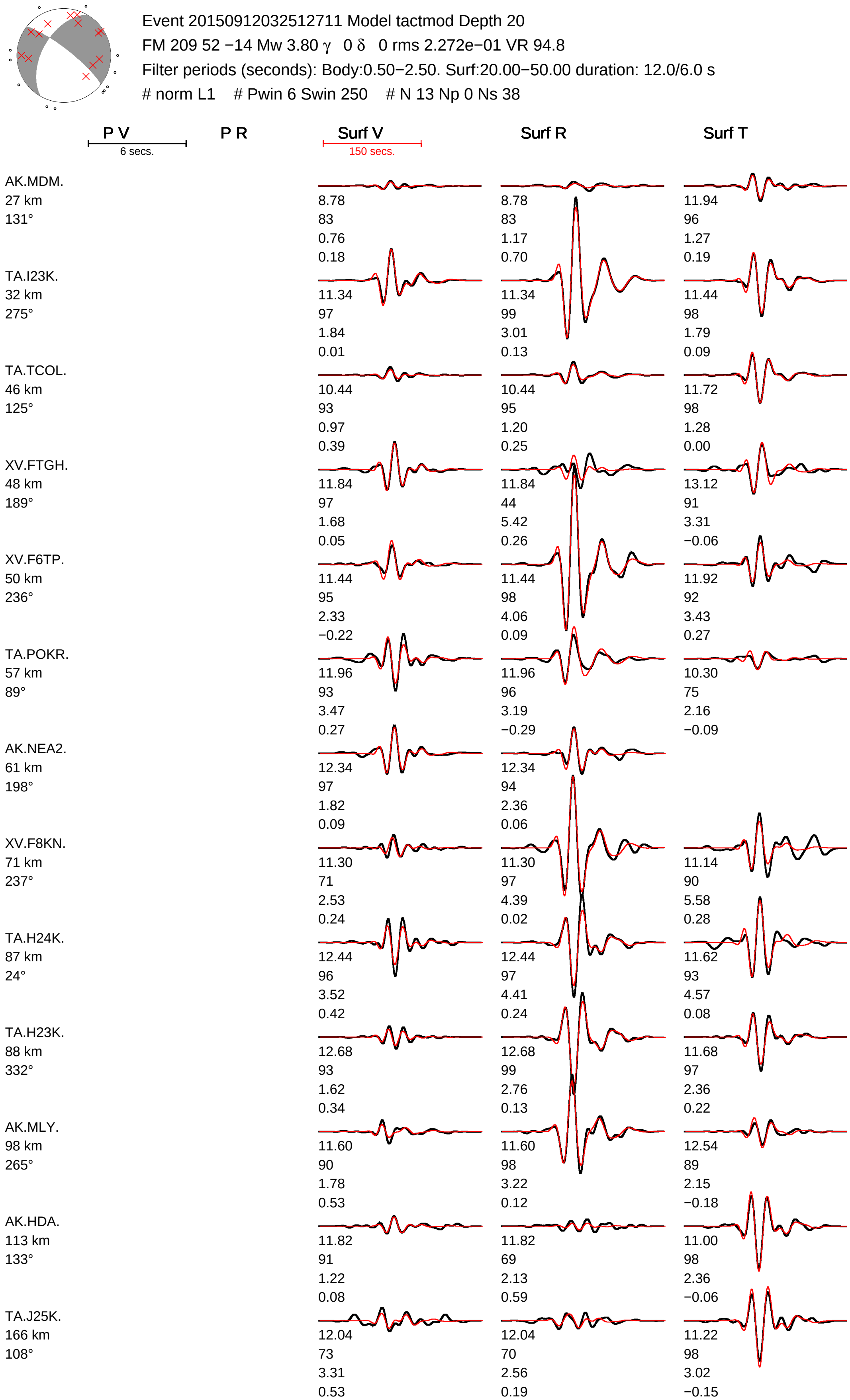


Figure M12: 2015 VLFE: best-fitting bandpass (20–50 s) and source duration (12 s).

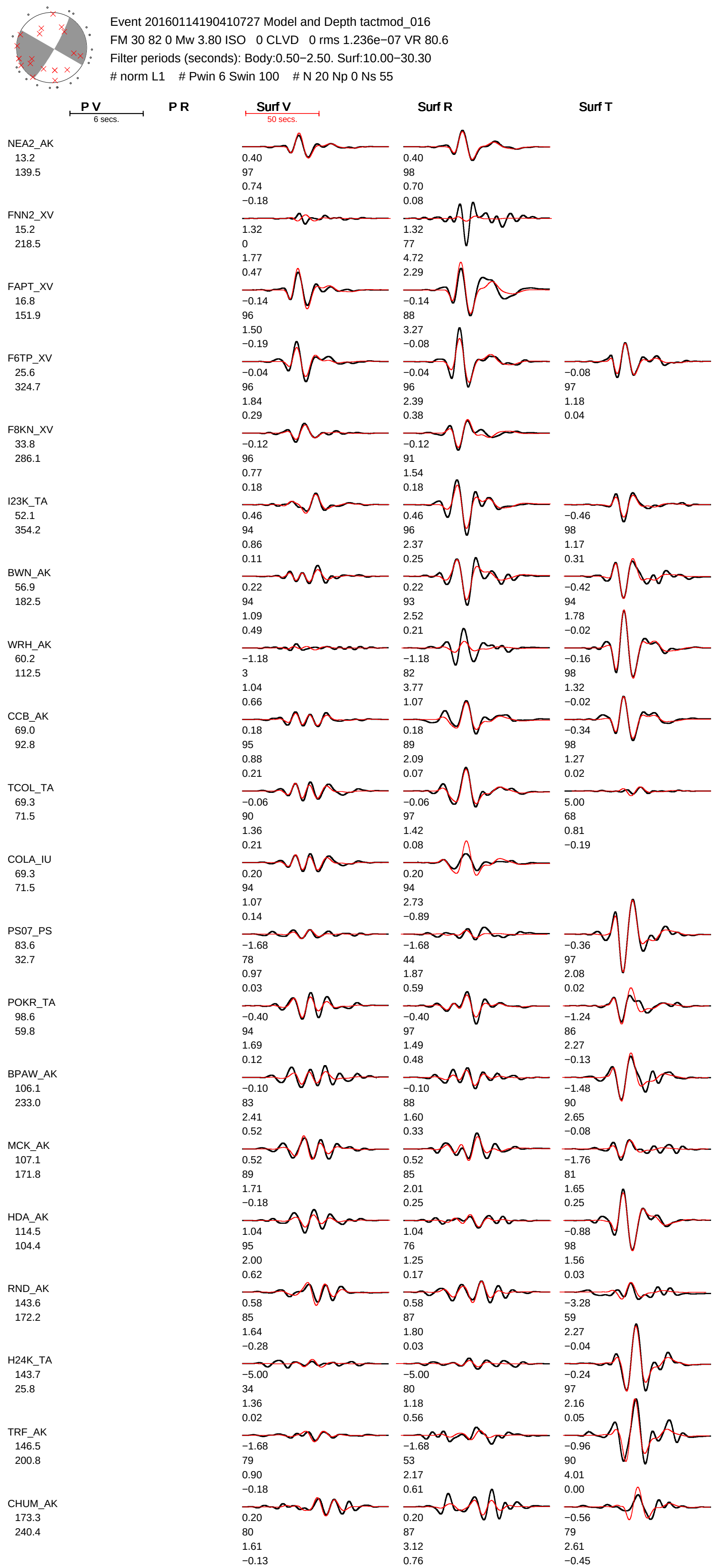


Figure M13: Moment tensor solution and waveform fits (10–30 s) for the 2016 event. The estimated magnitude is M_w 3.7; the best-fitting depth is 17 km (Figure S2B).

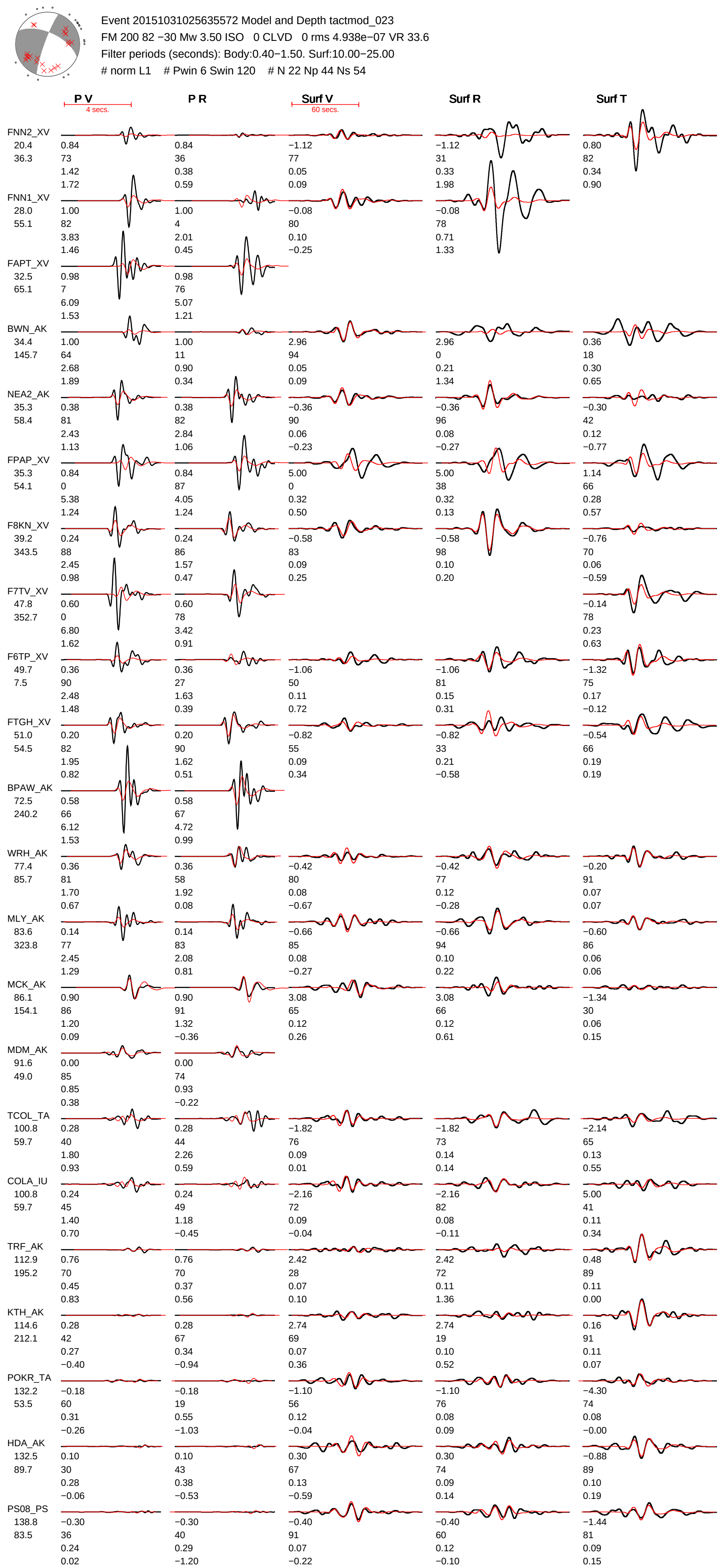


Figure M14: Moment tensor solution and subset of waveform fits for the 2015-10-31 earthquake.

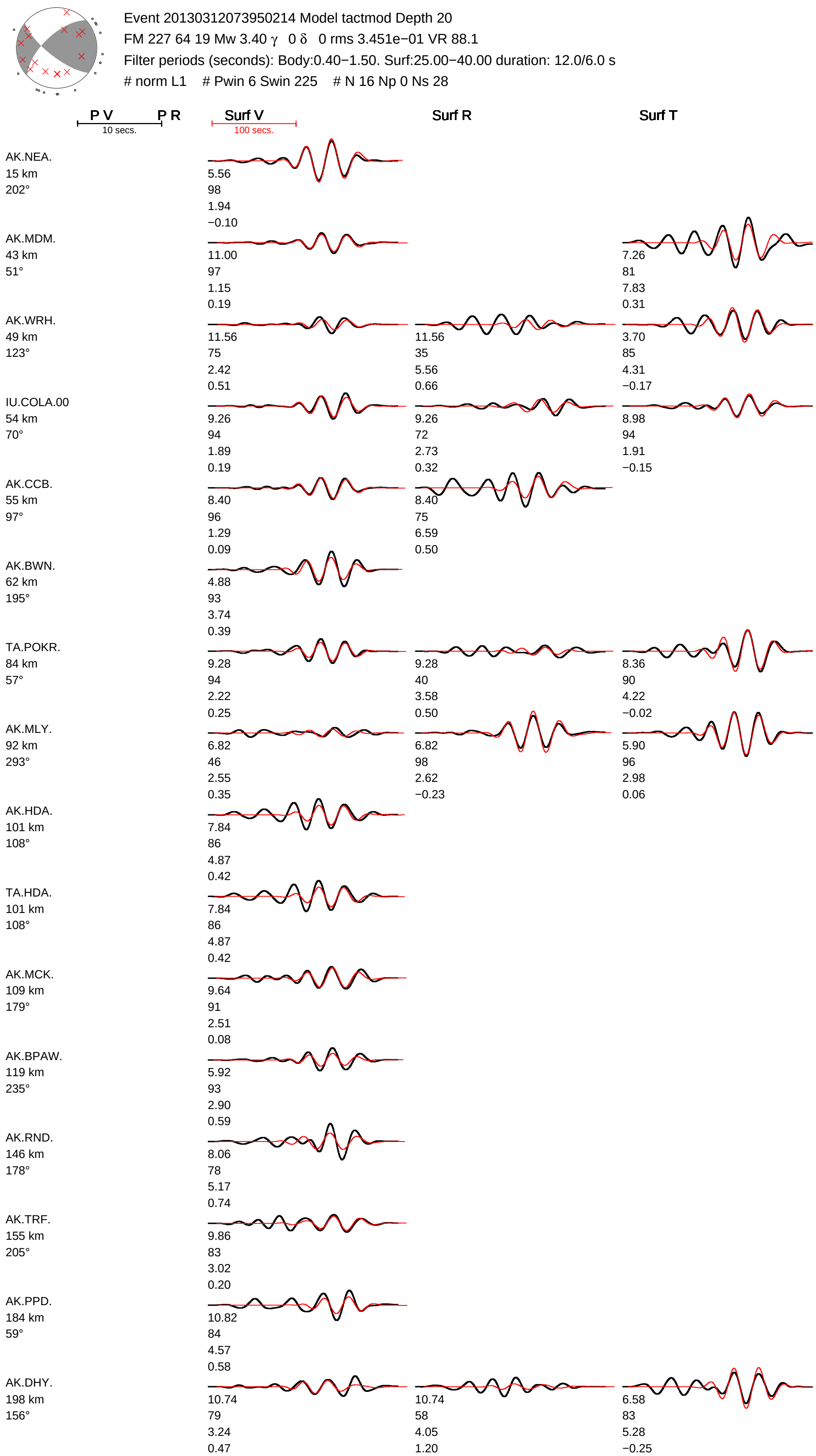


Figure M15: Moment tensor solution and waveform fits (25–40 s) for the 2013 event. The estimated magnitude is M_w 3.5; the estimated duration is 12 s. The best-fitting depth is 23 km (Figure S2c).

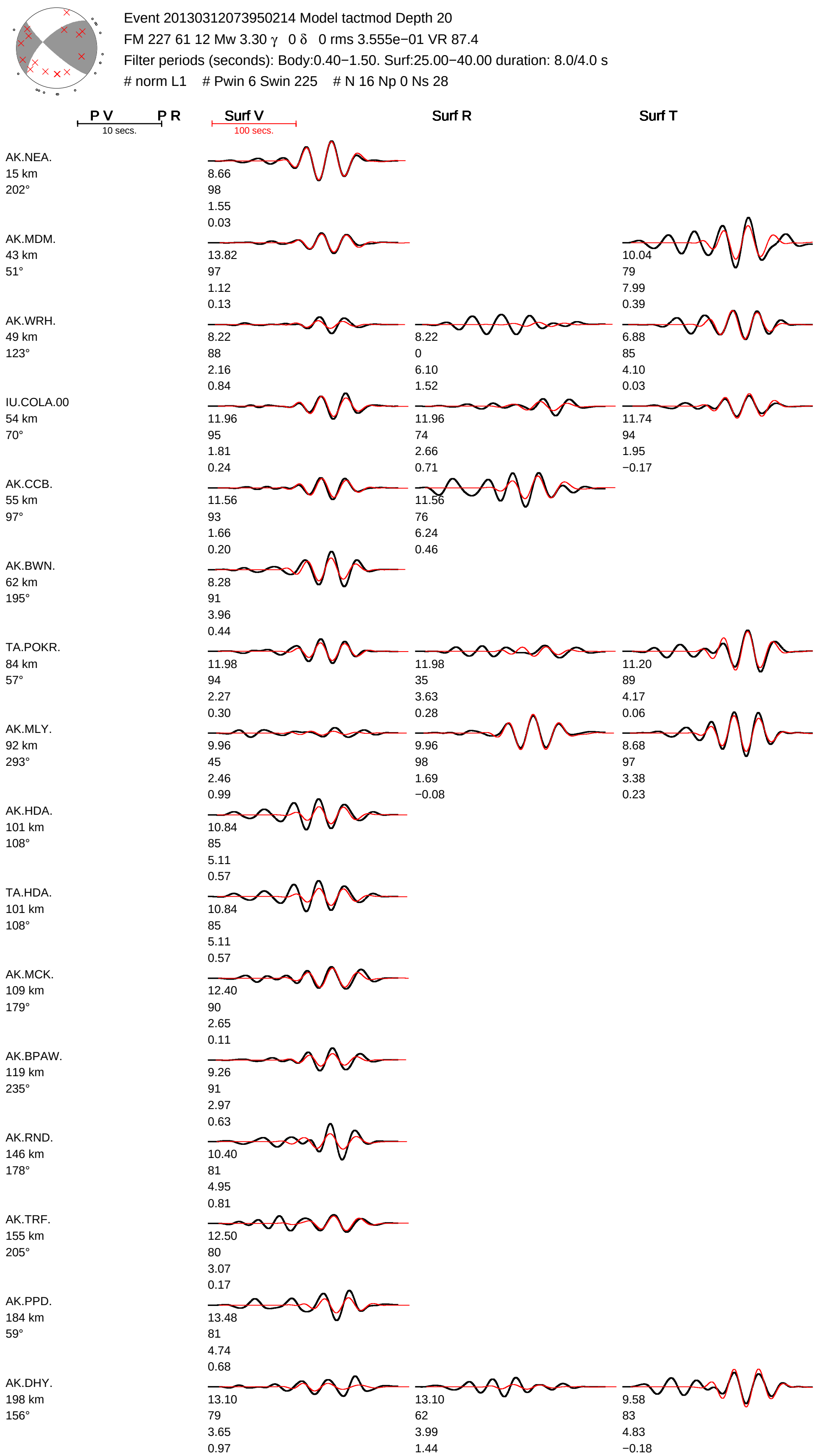


Figure M16: Same as Figure M15 but for duration 8 s.

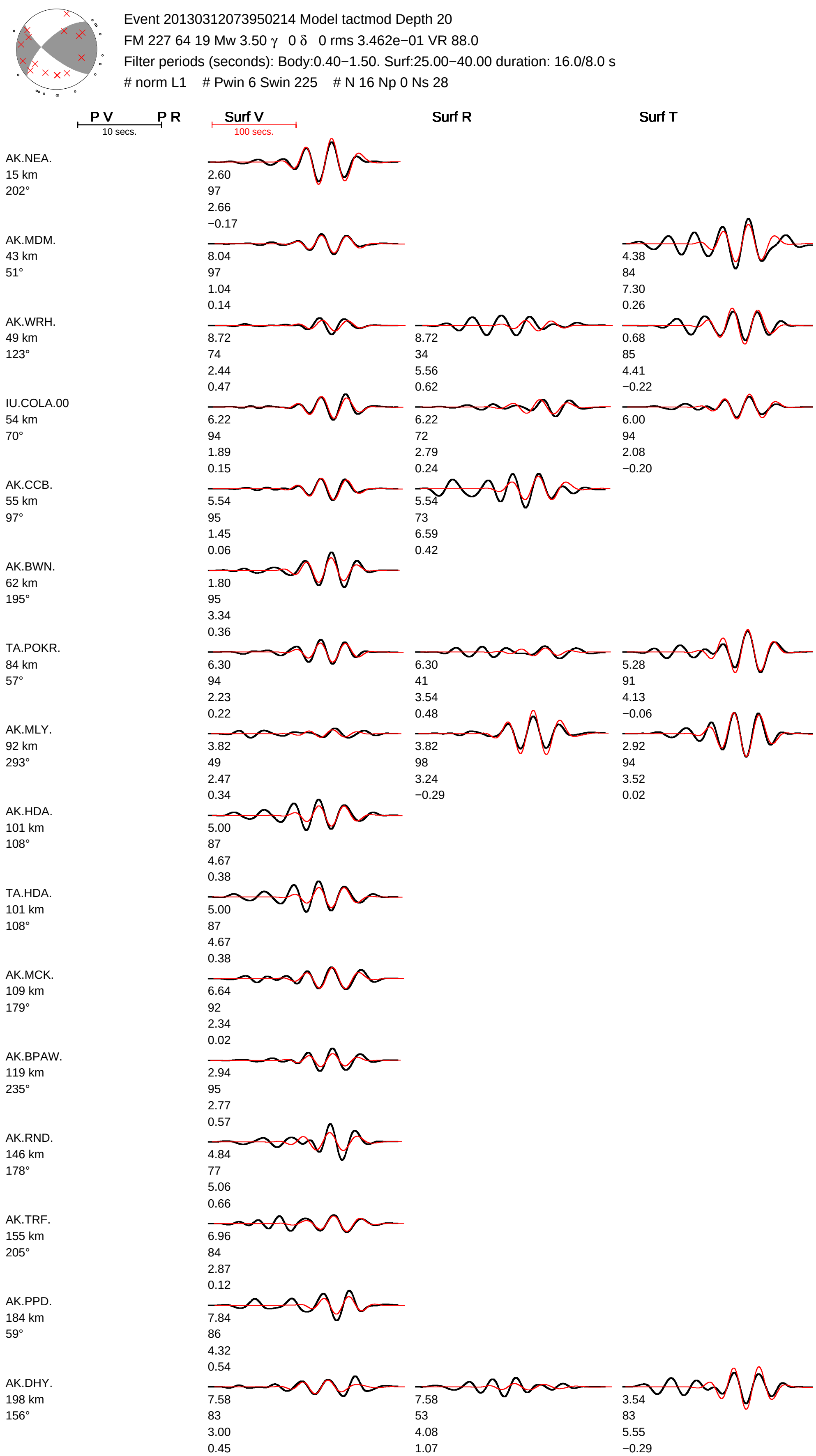


Figure M17: Same as Figure M15 but for duration 16 s.