

# Supplementary Material for “Seismic and aseismic slip during the 2006 Copiapó swarm in North-Central Chile”

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Supplemental Material for this article includes additional figures that support the information provided in the manuscript.

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- Figures S1 to S16

## Figures

- **Fig. S1:** The cumulative number of earthquakes (blue line) and cumulative seismic moment (orange line) released in the area (longitudes: [-72.5, -68.5], latitudes: [-26, -28.5], see Fig. 1). We merged the USGS catalog from 1970-01-01 to 1999-12-31 and the CSN catalog from 2000-01-01 to 2020-01-01. The largest earthquakes  $M > 6.5$  that occurred in the area are indicated within the figure: 1983  $M$  7.4 and  $M$  6.7 events, 1987  $M$  6.5 event, 1988  $M$  6.7 event, 1993  $M$  6.7 event, and 2013  $M$  6.7 event. The seismic swarm episodes (1973, 1979, 2006, and 2015) and other seismic sequences (2002, 2011) are represented in gray areas.
- **Fig. S2:** Map of the seismic stations operated by the Chilean seismological service during the 2006 Copiapó seismic swarm (now CSN). The color scale shows the number of picks (either P or S phases) observed at each station. A total of 2470 phases associated with the seismic swarm were picked between February and June 2006. The largest number of phases were observed in the stations CDCH (Caldera, north-east of Copiapó, 468 phases), CPCH (Copiapó, 442 phases), CRCH (Chañaral, 441 phases), LCO (Las Campanas, 383 phases), TLL (Cerro Tololo, 308 phases) and CPN (Cerro Paranal, 146 phases).
- **Fig. S3:** S-P time performed in stations CDCH, CPCH, and CRCH. Bright cyan and purple diamond correspond to the 2006-04-30 19:17 and 2006-04-30 21:40 events, respectively. S waves for these earthquakes were not clearly picked in station CPCH. Therefore, the S-P time for those earthquakes was not calculated.
- **Fig. S4:** Stack of the EW component of spectra observed in the Copiapó seismic swarm at the closest station CDCH (Caldera). The spectra were smoothed using a Konno–Ohmachi filter, using a coefficient of 40 for the bandwidth (Konno & Ohmachi, 1998). The color scale for each spectrum corresponds to the local magnitude (Ml) reported by the CSN.
- **Fig. S5:** Three-component GPS time series for station COPO (blue lines) during 2002-07-01 and 2015-08-05. The orange area shows the whole period analyzed in this study between February and June 2006.

- **Fig. S6:** (a) Distribution of ENVISAT acquisitions as a function of time and latitude for track 96. The vertical red lines show the approximate extent of major earthquakes in the area (Copiapó swarm in 2006; Maule earthquake in 2010). (b) Perpendicular baseline as a function of time. Black lines show the network used for image co-registration with respect to the super-primary image. After estimating the co-registration parameters of the affine transformations on the black segments, all secondary images are co-registered with respect to the super-primary image by successively applying the affine transformations corresponding to the colored segments.
- **Fig. S7:** Examples of doublets for the Copiapó seismic swarm, with a correlation coefficient larger than 0.85 considering the three components of the closest stations to the seismicity area (CRCH, CPCH, and CDCH). Pair (2006-04-30 20:59:32, 2006-05-04 01:31:43) with  $cc_{mean} = 0.90$ . Pair (2006-05-02 02:58:28, 2006-05-01 10:57:51) with  $cc_{mean} = 0.85$ . Pair (2006-05-02 10:33:59, 2006-05-02 10:58:37) with  $cc_{mean} = 0.85$ .
- **Fig. S8:** Three-component regional waveforms recorded by stations CDCH (Caldera), CPCH (Copiapó), and CRCH (Chañaral) for the two largest earthquakes of this seismic sequence occurred on 2006-04-30 19:17 (bright cyan lines) and 2006-04-30 21:40 (purple lines). Raw waveforms detrended, resampled to 40 Hz, and bandpassed between 0.1 and 8 Hz. At the right-bottom position of the panel are the references for amplitudes (in count units) and time scales (in second units).
- **Fig. S9:** WCMT solutions (a) Centroid location grid search in XY components and Centroid time-shift search for the event occurred on 2006-04-30 19:17. (b) Centroid location grid search in XY components and Centroid time-shift search for the event occurred on 2006-04-30 21:40.
- **Fig. S10:** Comparison of recorded waveforms (black lines) and the corresponding synthetic waveforms (red lines) computed from the WCMT solutions for the event that occurred on 2006-04-30 19:17. Blue dots in the waveform bounded the W phase time window. The station component, azimuth ( $\varphi$ ), and epicentral distance ( $\Delta$ ) are indicated relative to the centroid location. The map next to each waveform fit shows the earthquake location (blue star), station dataset (orange circle), and analyzed station (red circle).
- **Fig. S11:** Comparison of recorded waveforms (black lines) and the corresponding synthetic waveforms (red lines) computed from the WCMT solutions for the event that occurred on 2006-04-30 21:40. Blue dots in the waveform bounded the W phase time window. The station component, azimuth ( $\varphi$ ), and epicentral distance ( $\Delta$ ) are indicated relative to the centroid location. The map next to each waveform fit shows the earthquake location (blue star), station dataset (orange circle), and analyzed station (red circle).
- **Fig. S12:** Time series of track 96 between 2004-02-09 and 2009-08-31 taking as reference the image (a) 2005-09-26, the closest of the pre-swarm images, which allows to distinguish the co-seismic phase, and the image (b) 2007-12-10, which allow to observe the effect of the post-seismic deformation.
- **Fig. S13:** Result of the parametric pixel-wise inversion of the InSAR time series. Left: constant component. Middle: “coseismic” component. Right: “postseismic” component.
- **Fig. S14:** Histograms for the origin time, latitude, longitude, and depth errors. The vertical black line of each panel represents the average error.
- **Fig. S15:** (a) Data, (b) Model, and (c) Residual of the “coseismic deformation” of the Copiapó seismic swarm from InSAR data.
- **Fig. S16:** (a) Data, (b) Model, and (c) Residual of the “postseismic deformation” of the Copiapó seismic swarm from InSAR data.

## References

- Konno, K., & Ohmachi, T. (1998). Ground-motion characteristics estimated from spectral ratio between horizontal and vertical components of microtremor. *Bulletin of the Seismological Society of America*, 88(1), 228-241.

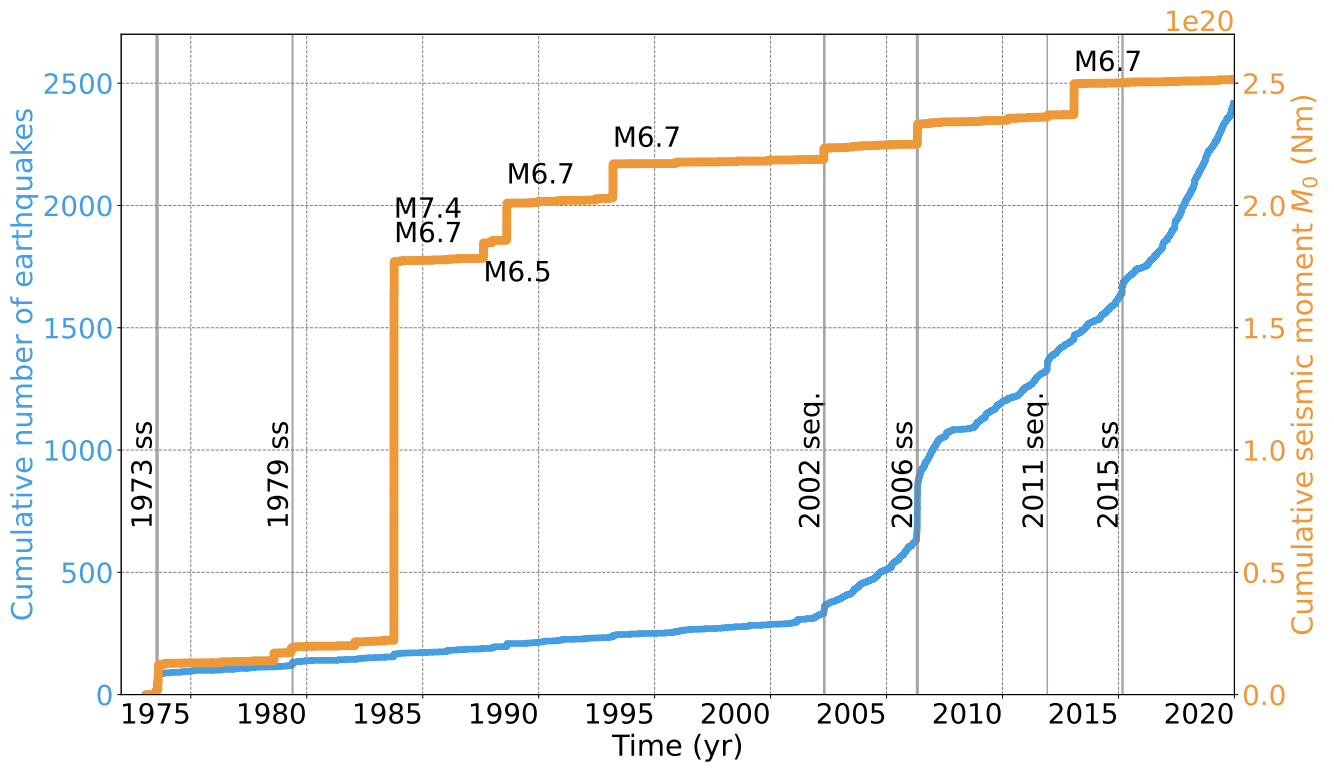


Figure S1

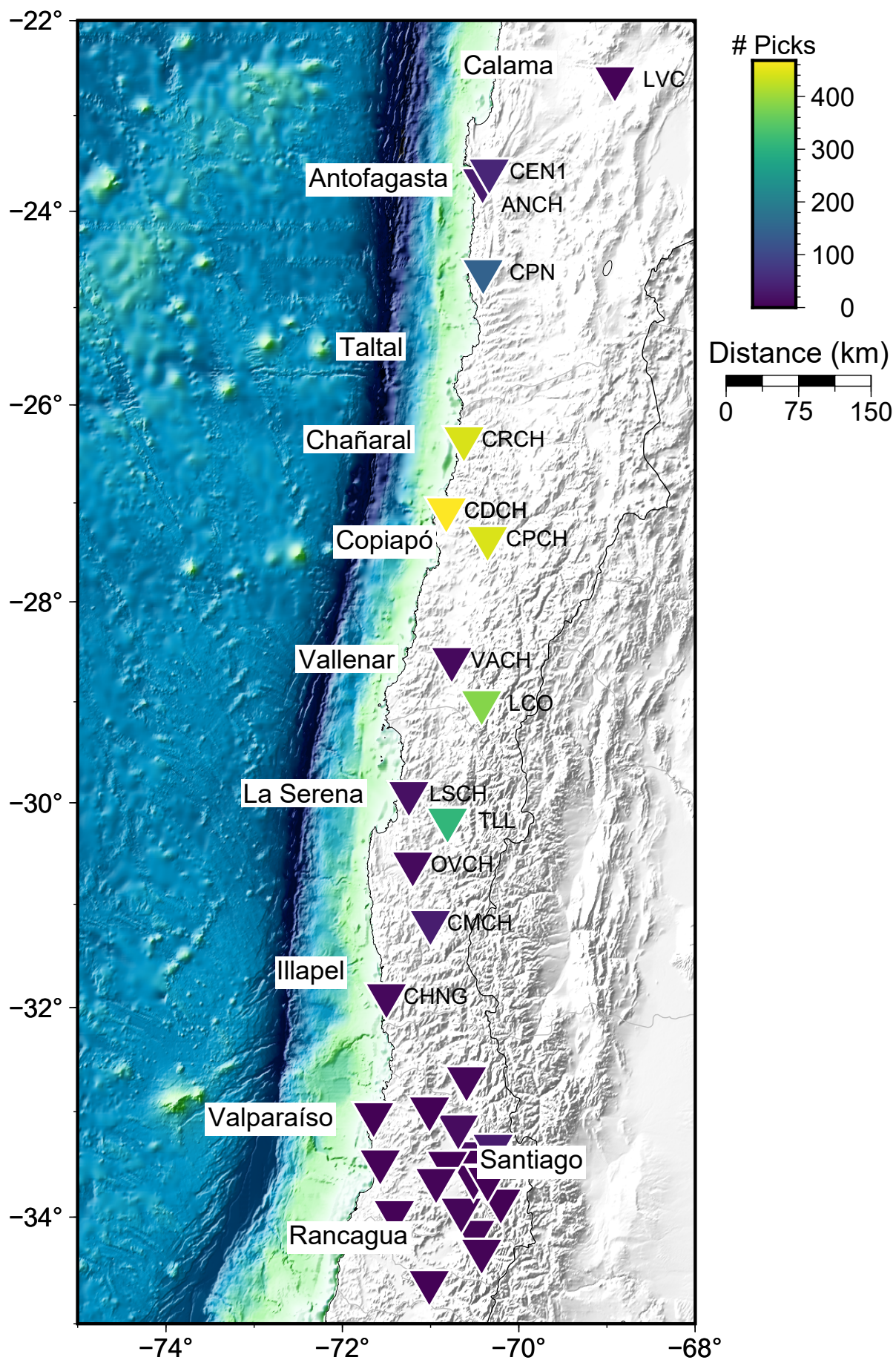


Figure S2



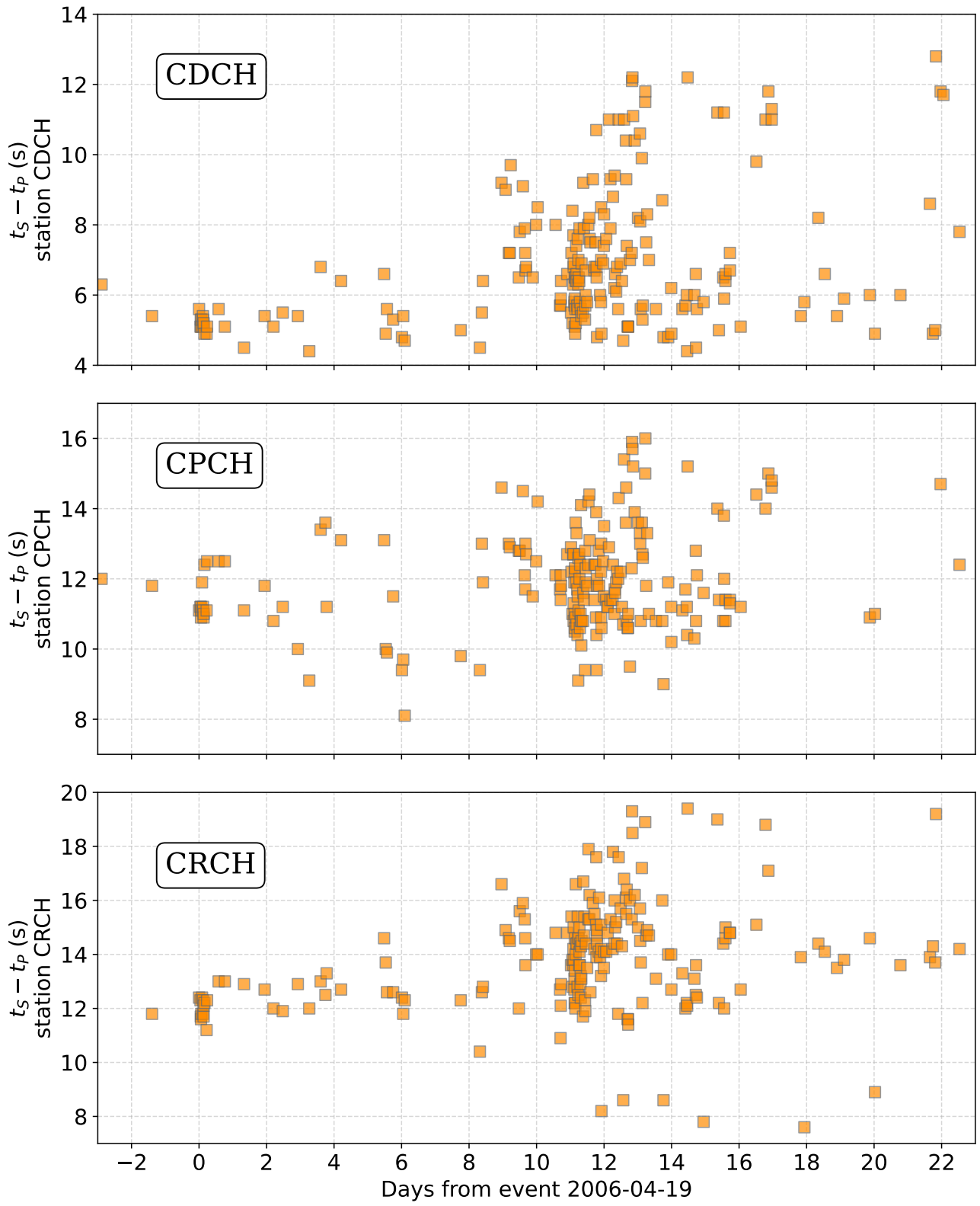


Figure S3

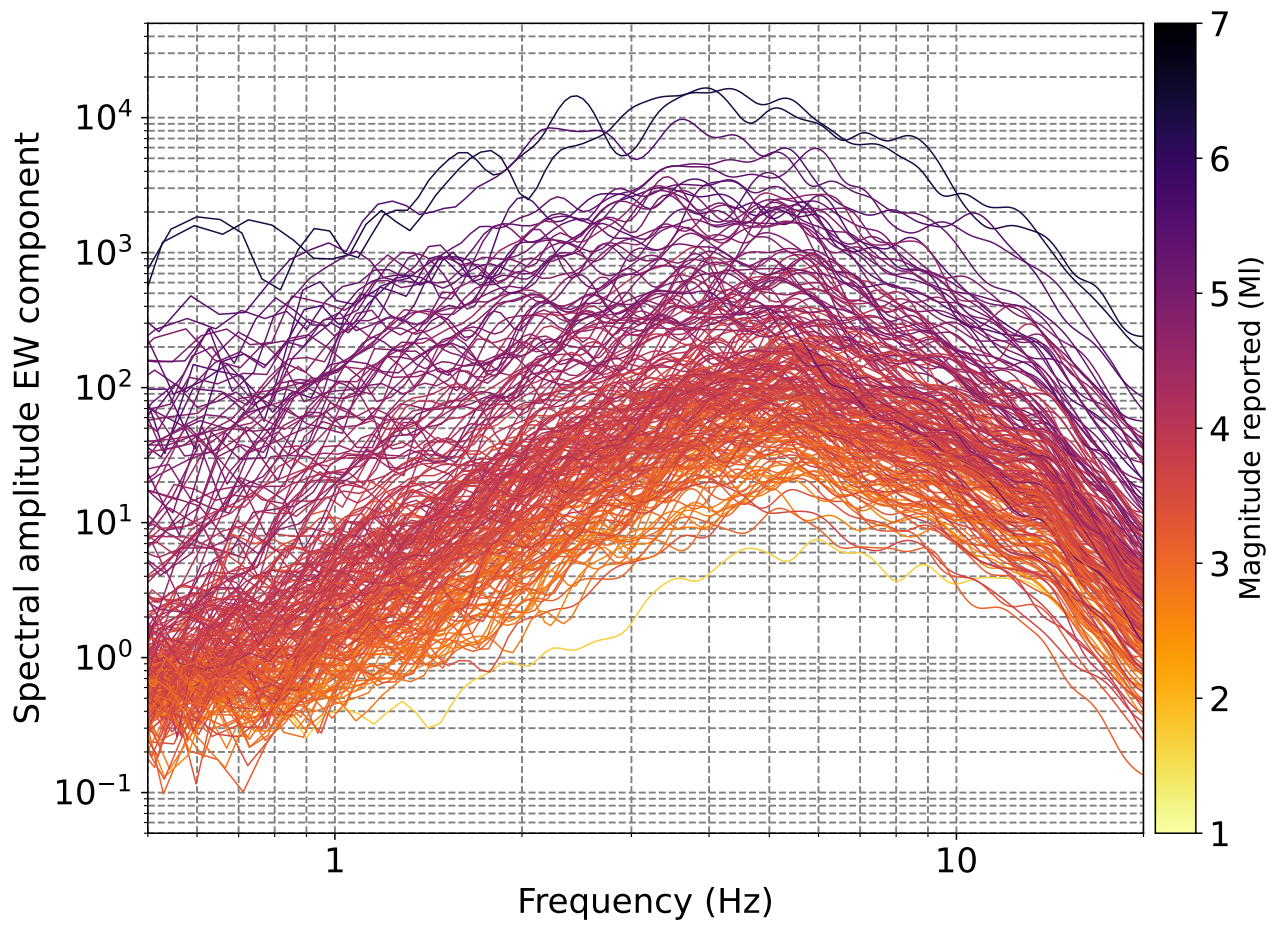


Figure S4

COPO time series

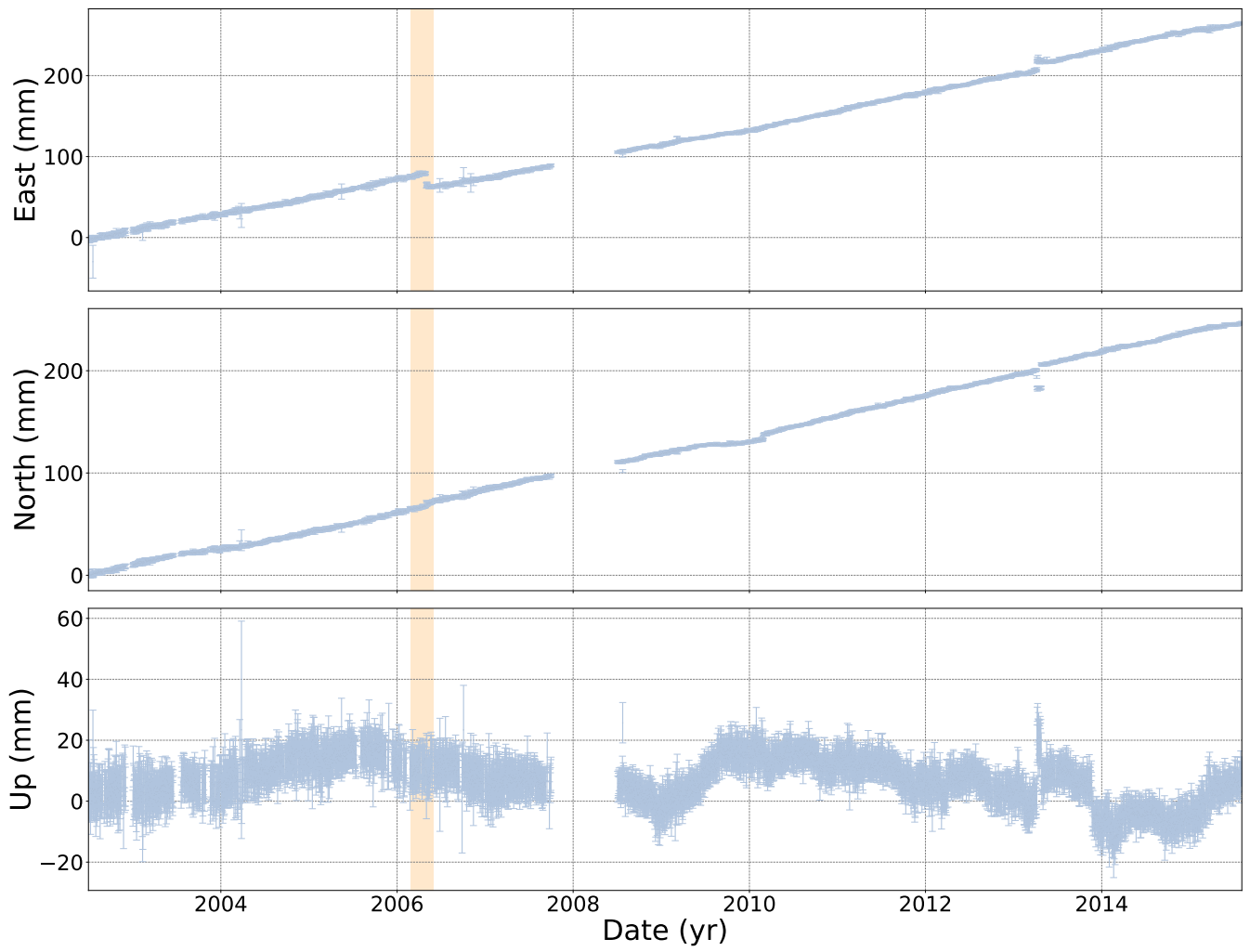


Figure S5

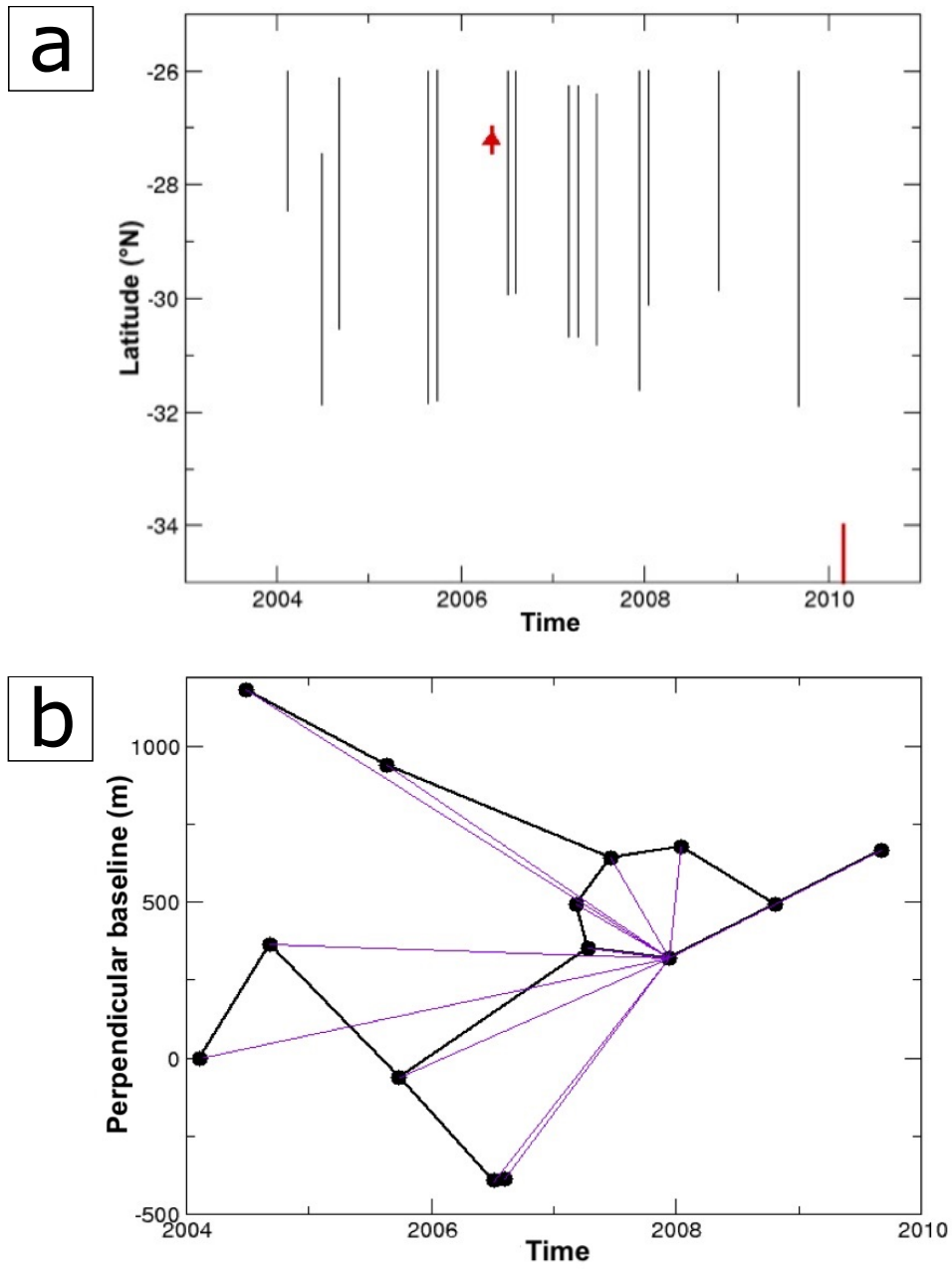


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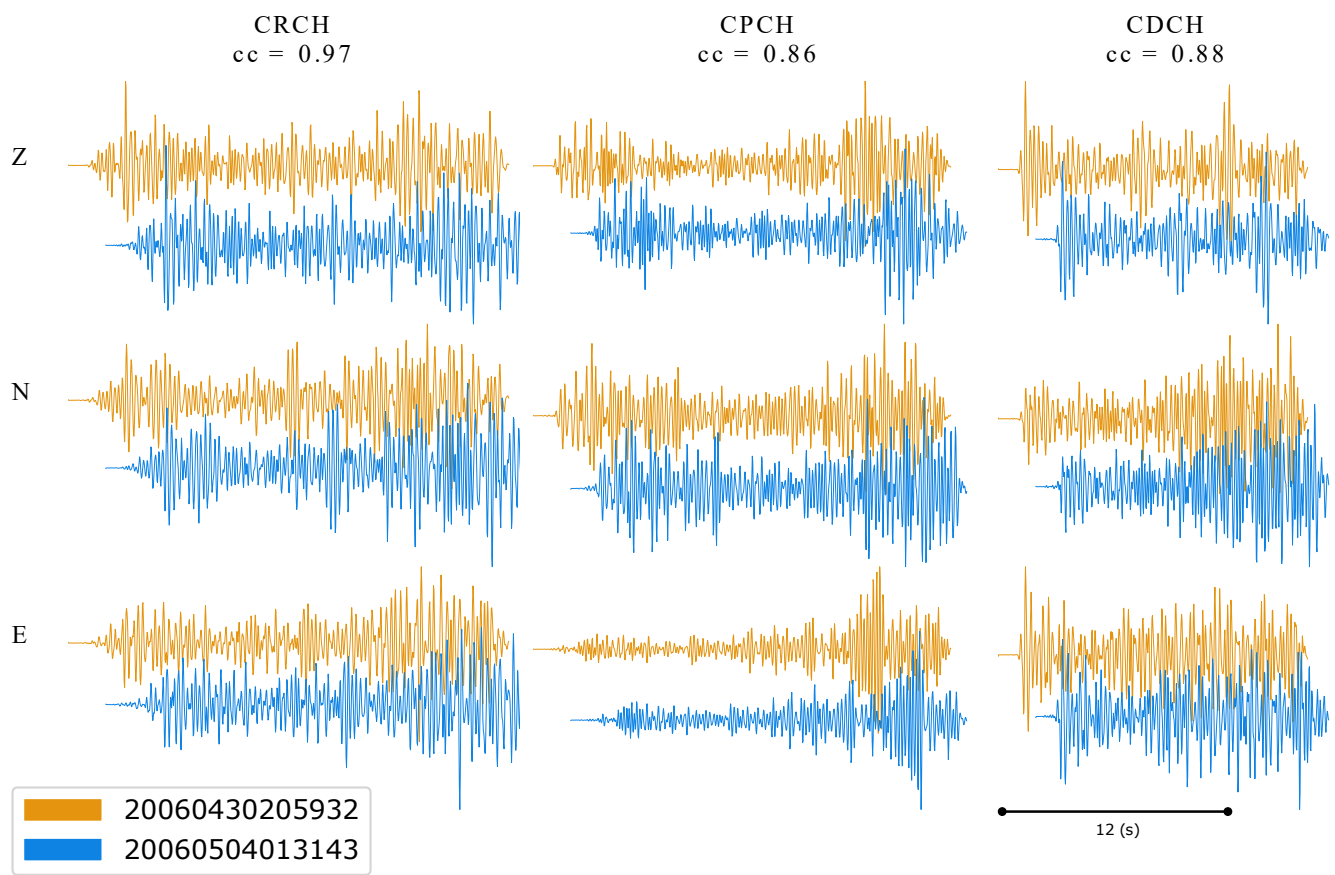


Figure S7



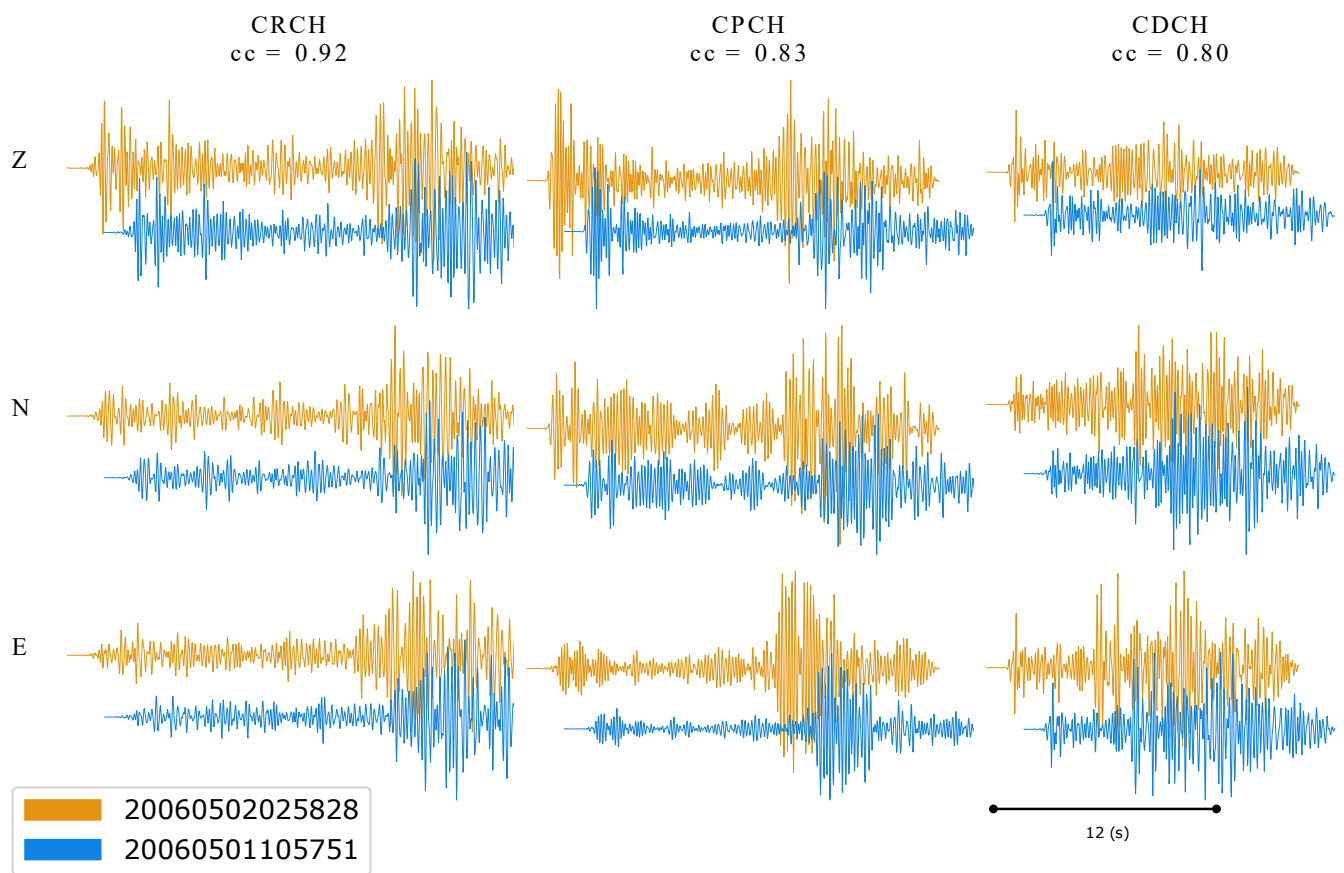


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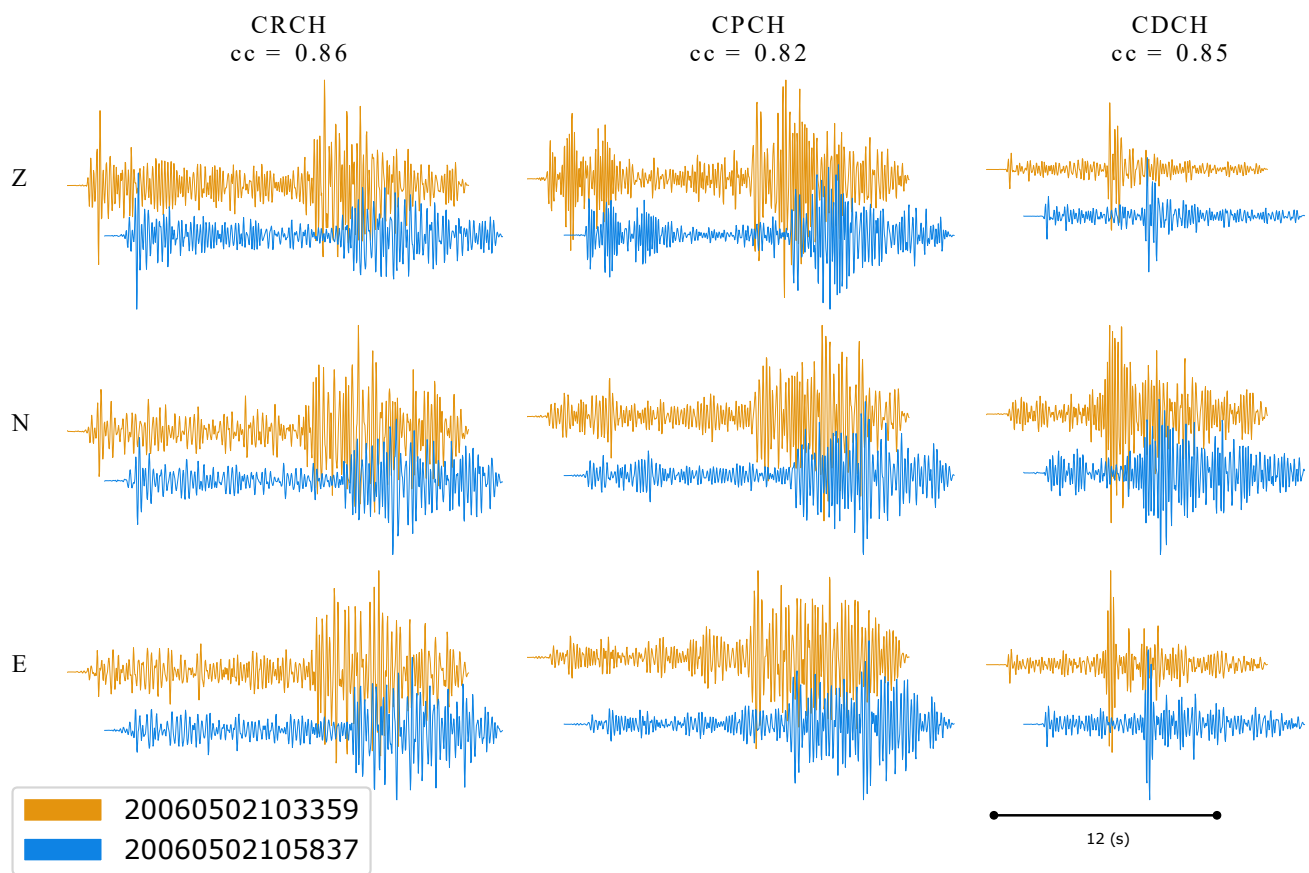


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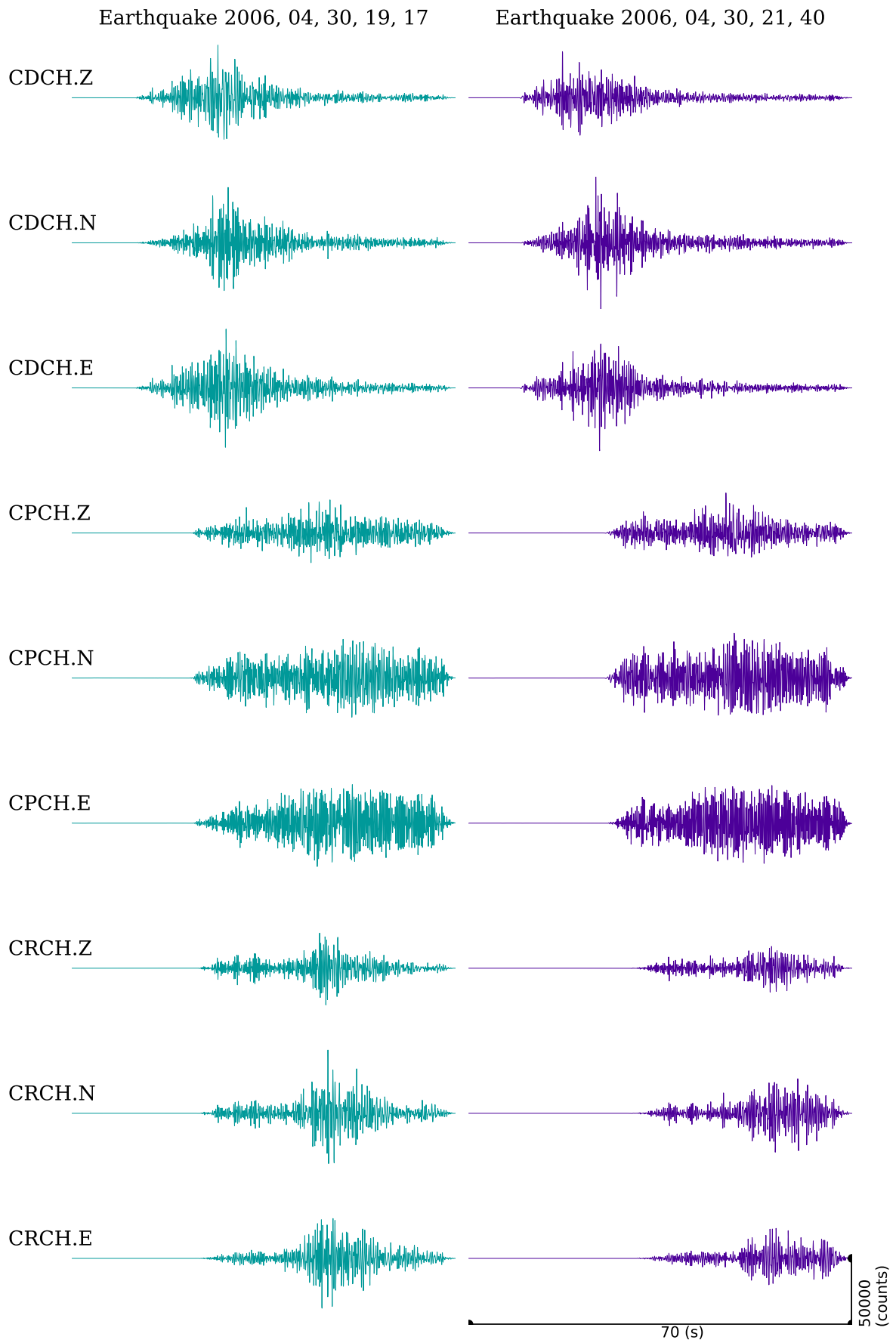


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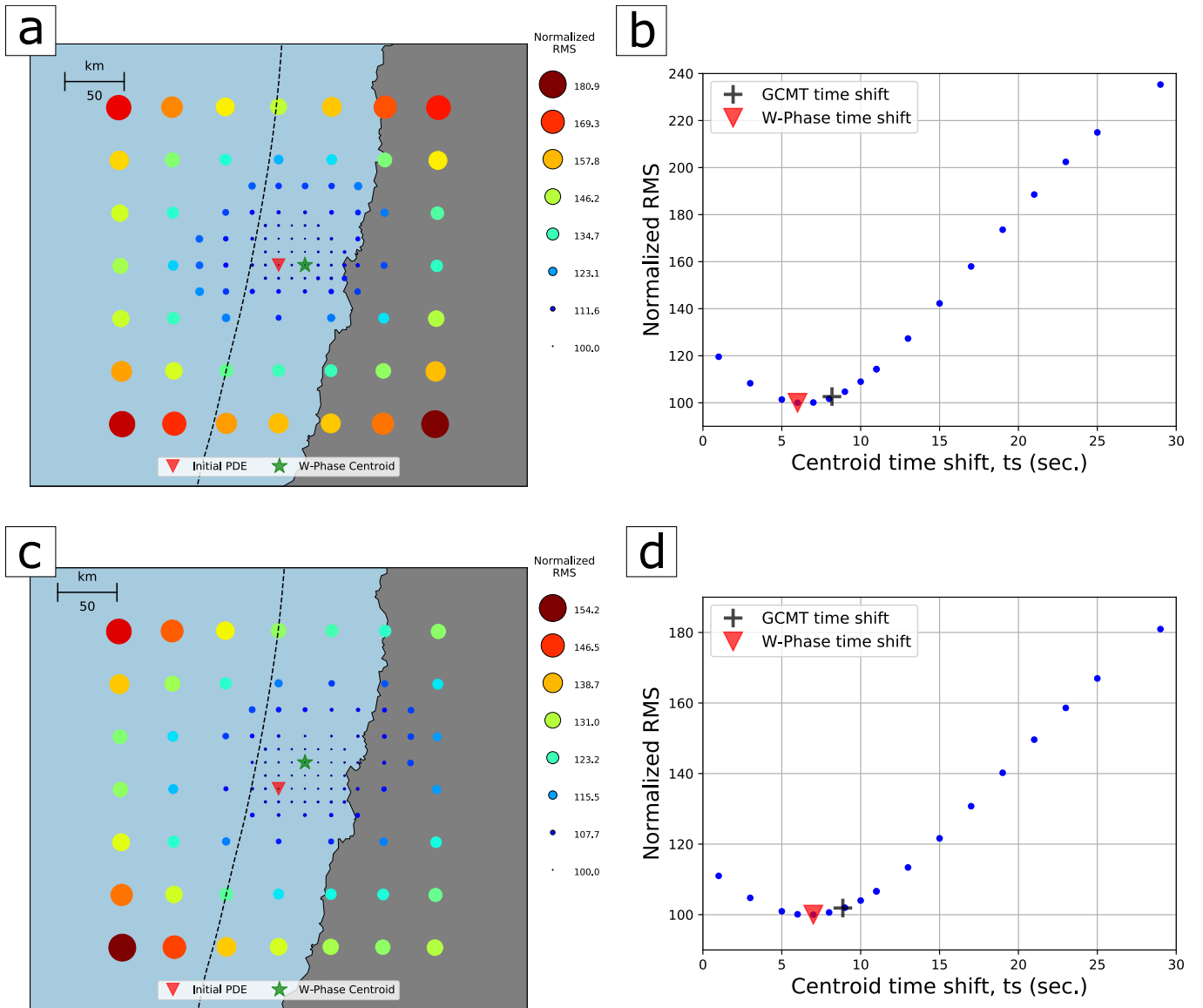


Figure S9

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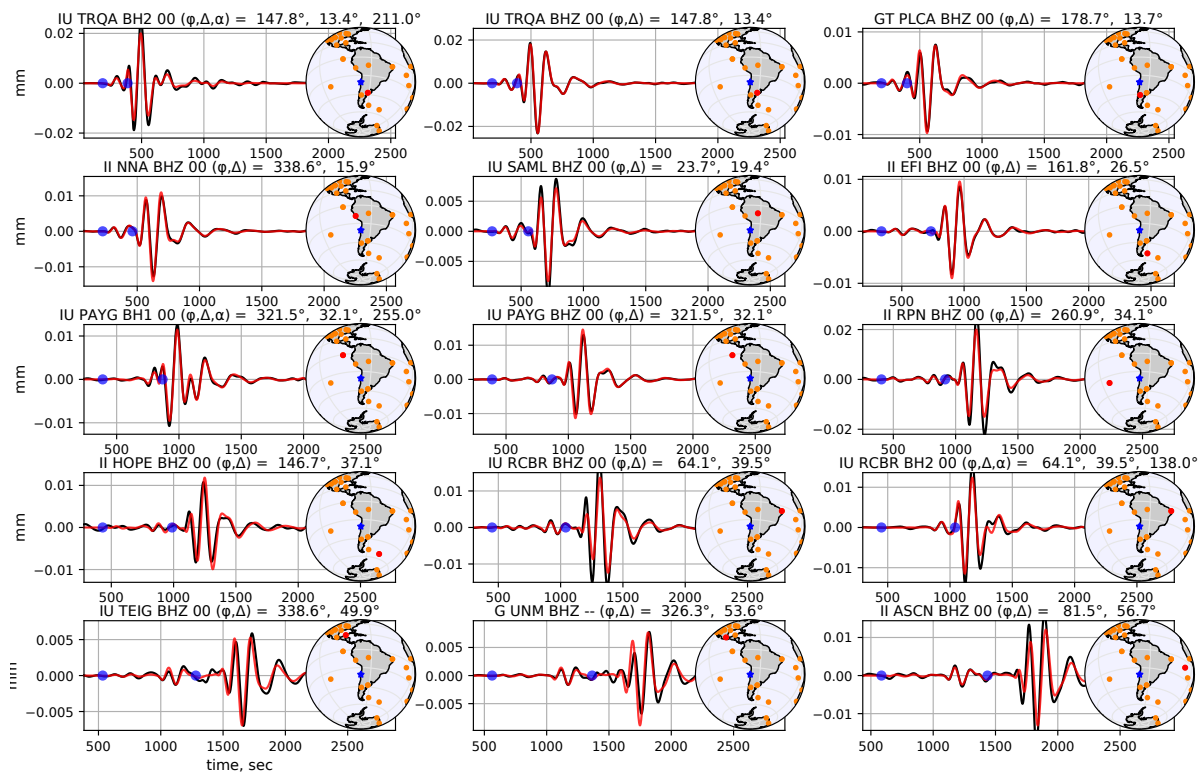


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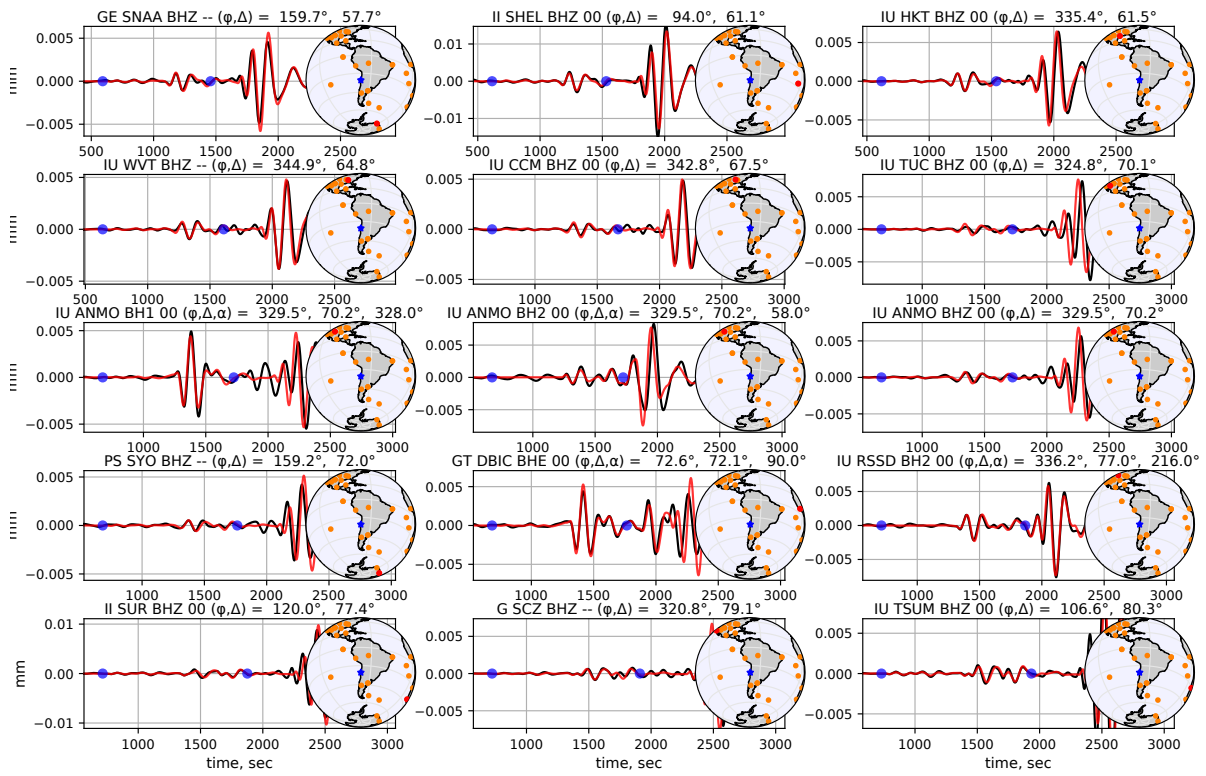


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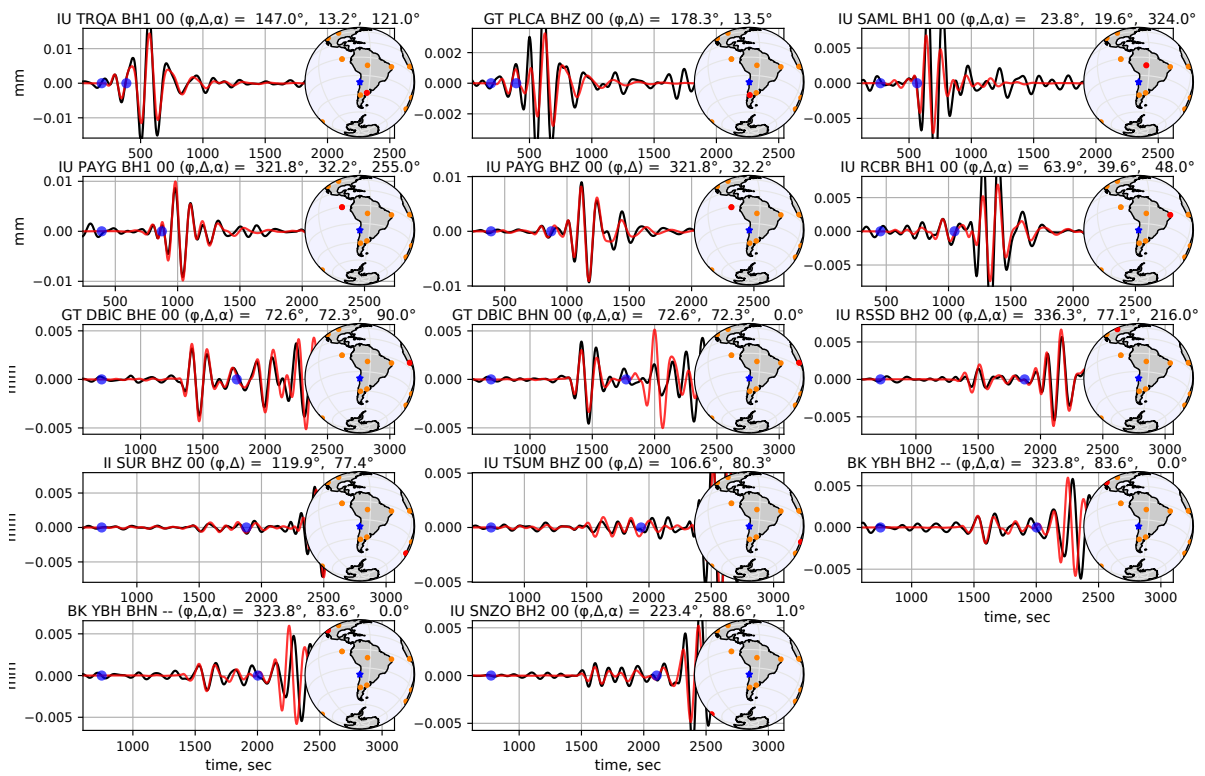


Figure S11

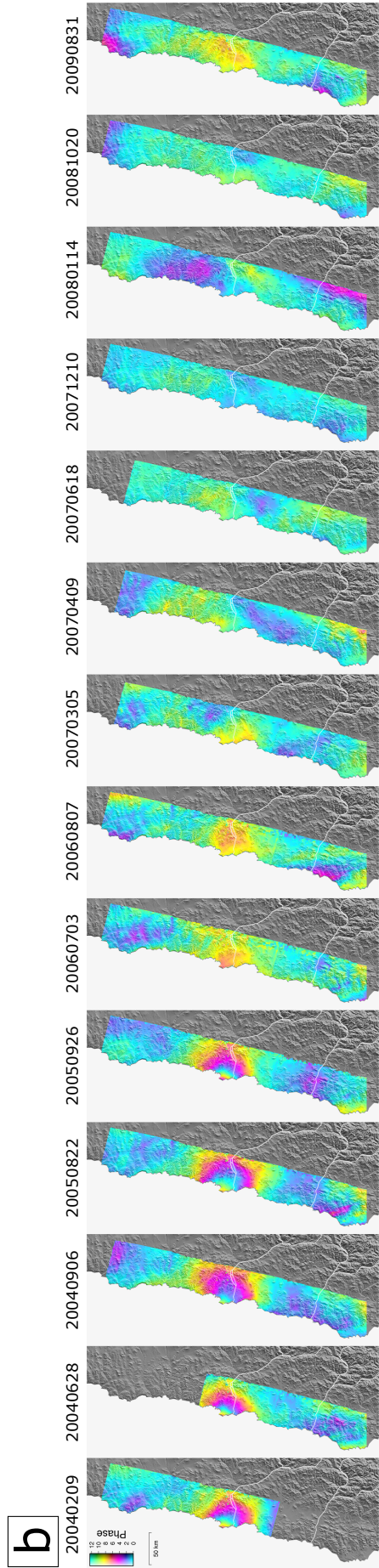
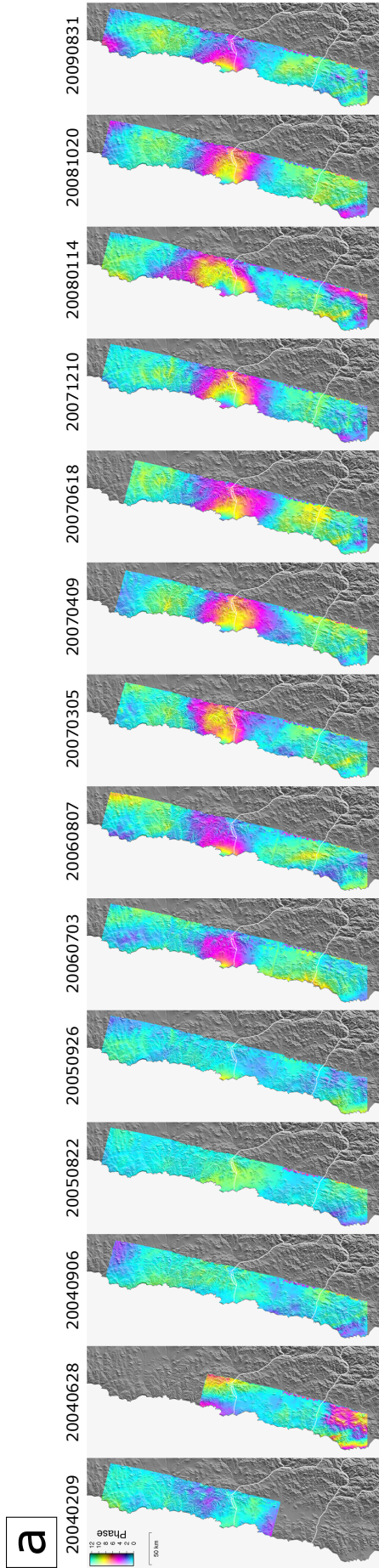


Figure S12  
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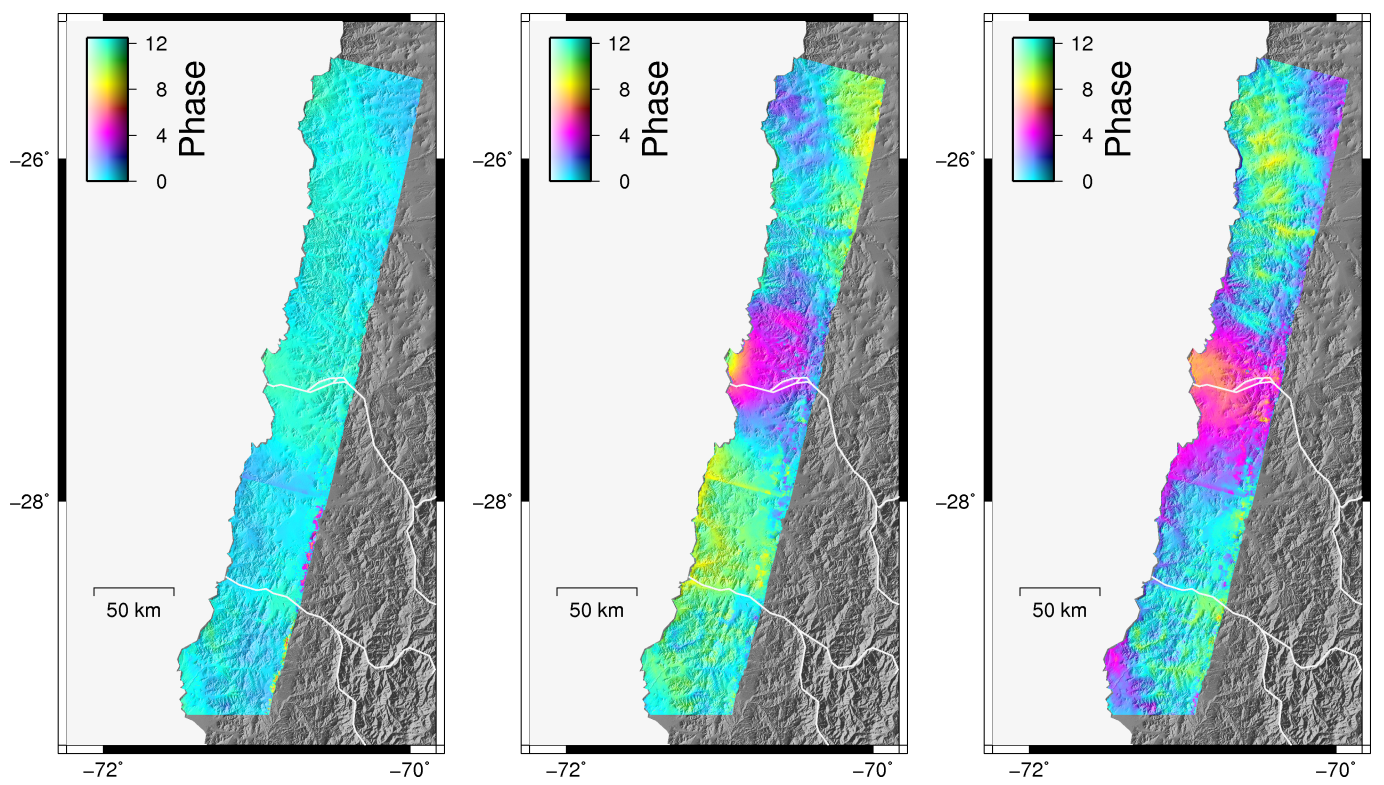


Figure S13

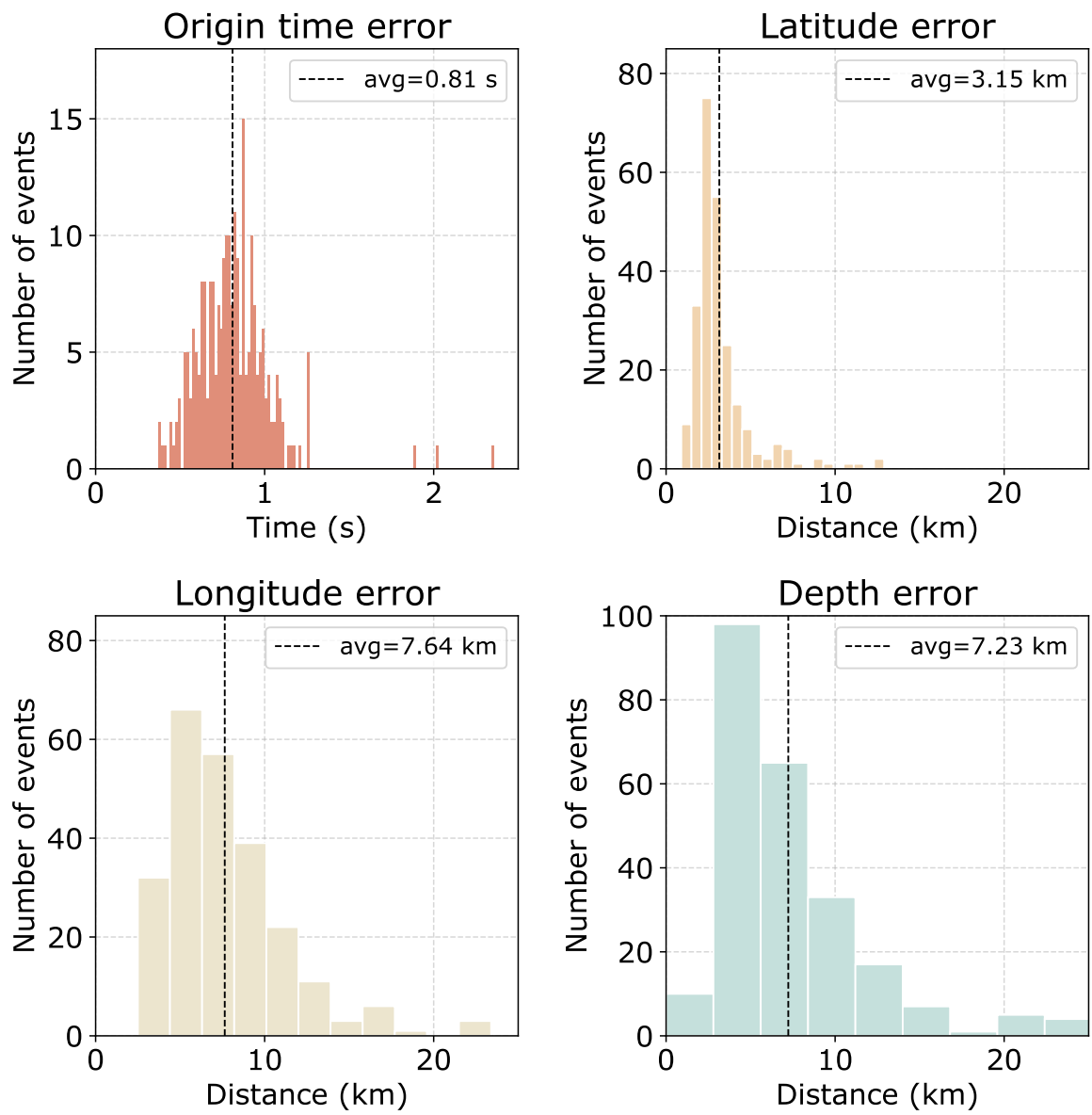


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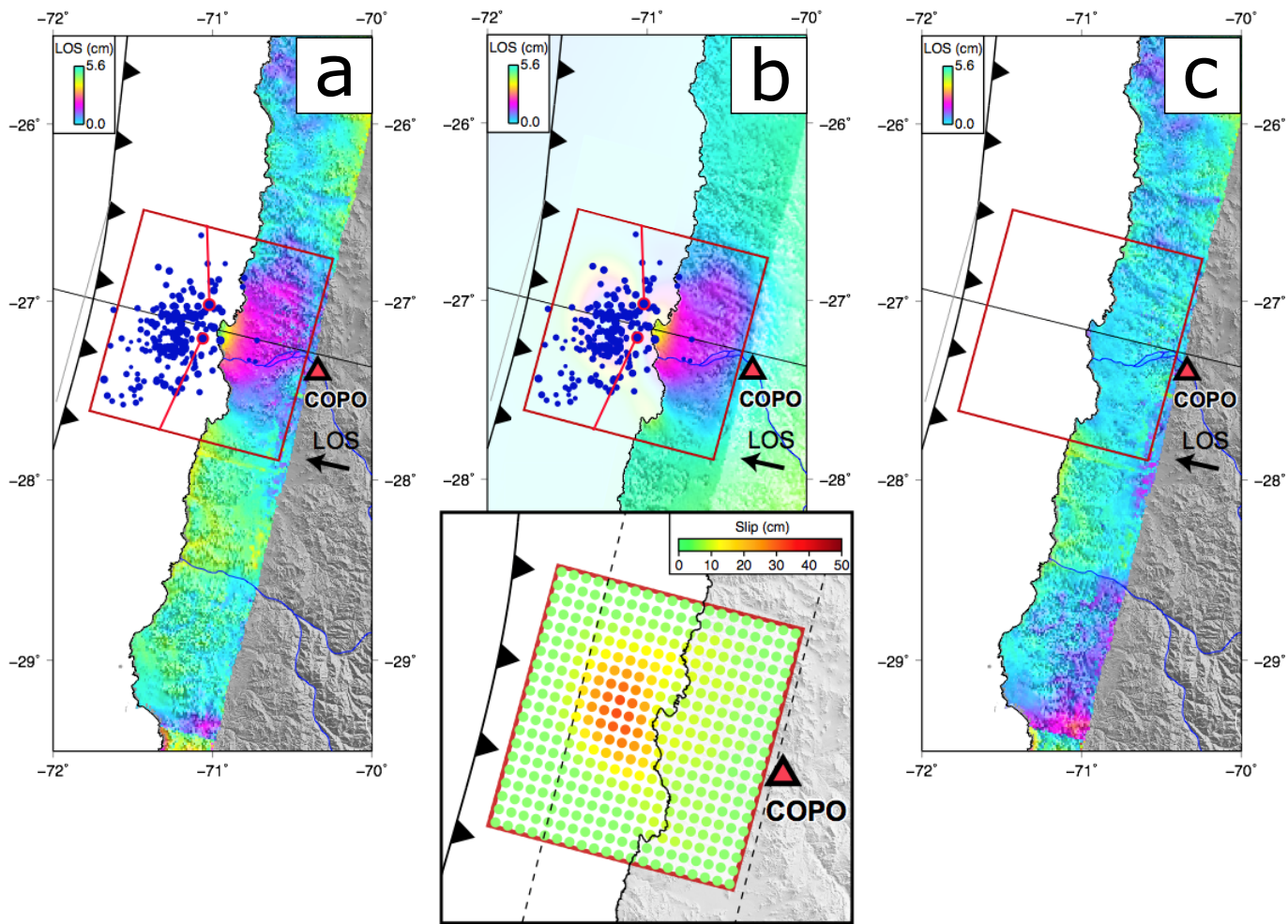


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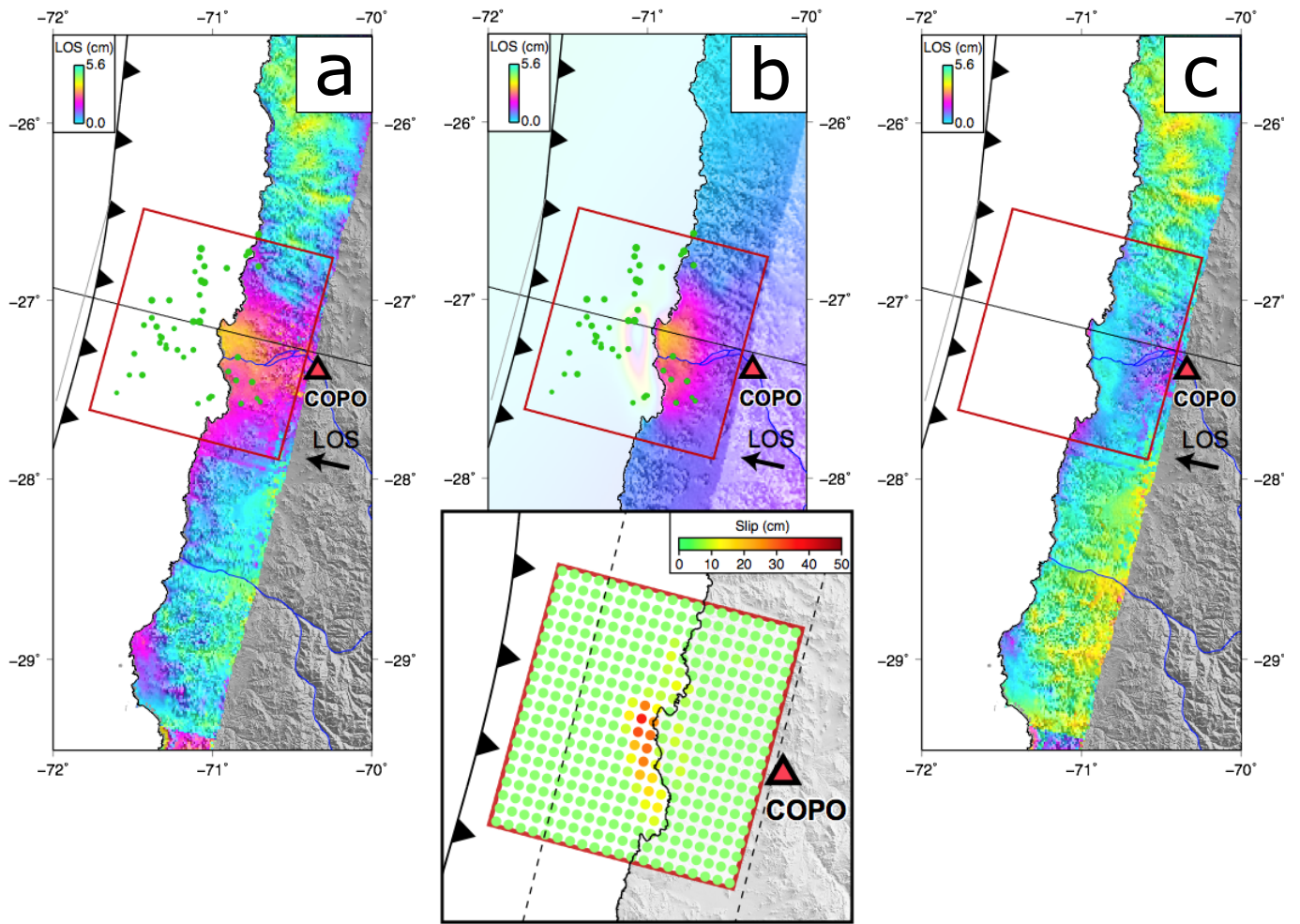


Figure S16