

Major California faults are smooth across multiple scales at seismogenic depth

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Supplementary Material

This PDF file includes:

Table S1

Figure S1-3

Other Supplementary Materials for this manuscript (available at <https://doi.org/10.5281/zenodo.7802678>):

Movies S1-2 Seismicity along the central San Andreas fault zone around Parkfield as Figure 1 in the main text. Shows rotating, lateral view around $\sim S40^{\circ}E$ for (Movie S1) NCSS-DD and (Movie S2) NLL-SSST-coherence. See Figure 1 caption in the main text for key to figure elements.

Movie S3-7 Animated, rotating views of NLL-SSST-coherence relocations of seismicity other than Parkfield presented in this study.

Movie_S1_Parkfield_2022_sect_DD_movie_20230401.mp4

Movie_S2_Parkfield_2022_sect_NLL-SSST-coherence_movie_20230401.mp4

Movie_S3_S_Calaveras_2022_NLL-SSST-coherence_movie_20230401.mp4 – Southern Calaveras Fault Zone

Movie_S4_Mendocino_2021_NLL-SSST-coherence_movie_20230401.mp4 – Cape Mendocino

Movie_S5_MountLewis_1986_NLL-SSST-coherence_movie_20230401.mp4 – Mount Lewis

Movie_S6_SW_SanFrancisco_NLL-SSST-coherence_movie_20230401.mp4 - Southwest of San Francisco

Movie_S7_Calipatria_2021_NLL-SSST-coherence_movie_20230401.mp4 - Calipatria sequence

Datasets S1-5 CSV format catalogs of NLL-SSST-coherence relocation results presented in this study:

ds01_Parkfield_2004_NLL_SSST_coherence.csv - Parkfield

ds02_S_Calaveras_2022_NLL_SSST_coherence.csv – Southern Calaveras Fault Zone

ds03_Mendocino_2021_NLL_SSST_coherence.csv – Cape Mendocino

ds04_MountLewis_1986_NLL_SSST_coherence.csv – Mount Lewis

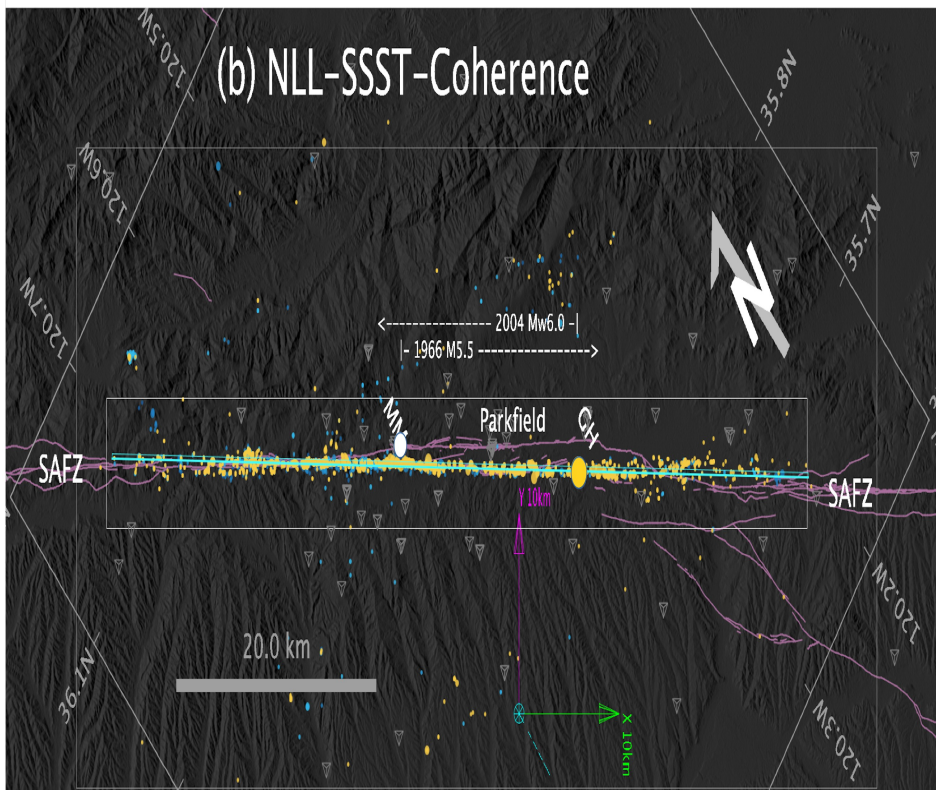
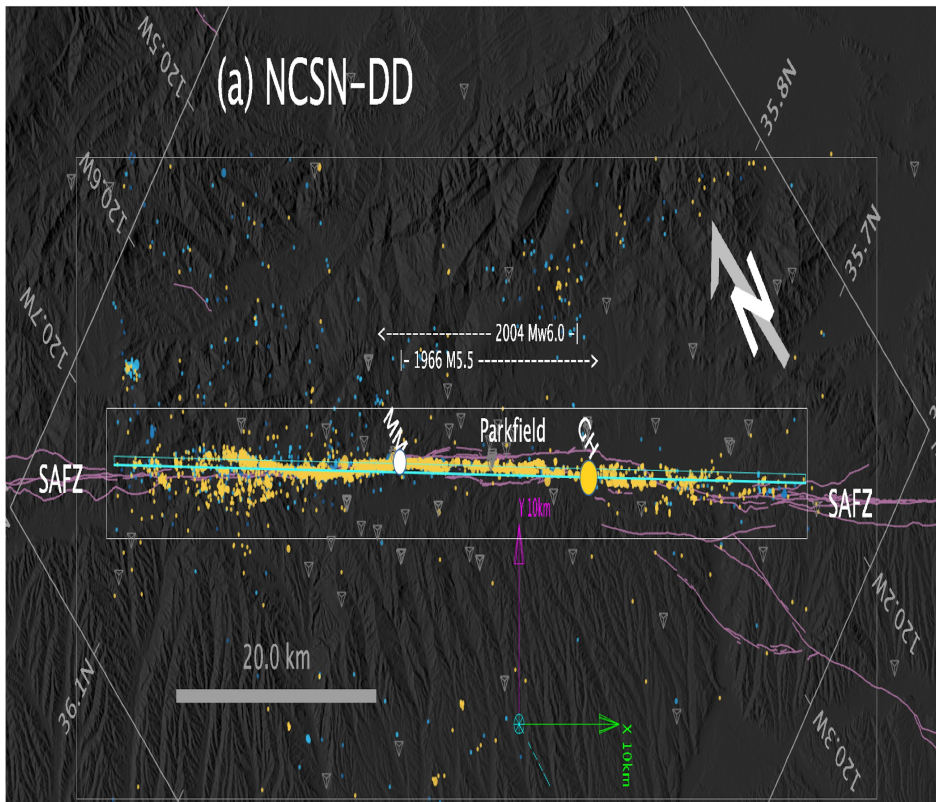
ds05_SW_SanFrancisco_2021_NLL_SSST_coherence.csv - Southwest of San Francisco

ds06_Calipatria_2021_NLL_SSST_coherence.csv - Calipatria sequence

File S1 (project_run_scripts.zip) Archive of run scripts and related set-up, configuration and other meta-data files for locations cases presented in this paper.

Table S1 NLL-SSST-coherence uncertainty estimates for the relocations presented in the main text. Formal posterior location uncertainties are shown using median horizontal (*errH*) and vertical (*errZ*) standard errors since mean errors can be biased upwards by poorly constrained events due to few available stations. There may be few stations early in each analysis period, or always few or no stations surrounding parts of the seismicity; both problems occur for Mendocino, especially offshore. A second, prior uncertainty estimate is derived from the highest frequency used for waveform coherence calculation (f_{\max}) as the corresponding $\frac{1}{4}$ wavelength for a seismic wave velocity of 4 km/s representative of typical P (5 km/s) and S (3 km/s) in the crust. Excluding the Mendocino results, the listed values for both types of uncertainty estimate suggest a NLL-SSST-coherence relative locations accuracy (precision) of as low as 100-200 m.

<i>Relocation Case</i>	<i>median errH</i> (m)	<i>median errZ</i> (m)	<i>coherence</i> f_{\max} (Hz)	$\frac{1}{4}$ <i>wavelength</i> @ 4 km/s (m)
Parkfield	59	87	10	100
S_Calaveras	124	264	10	100
Mendocino	798	754	10	100
Mount Lewis	116	204	20	50
SW San Francisco	187	239	10	100



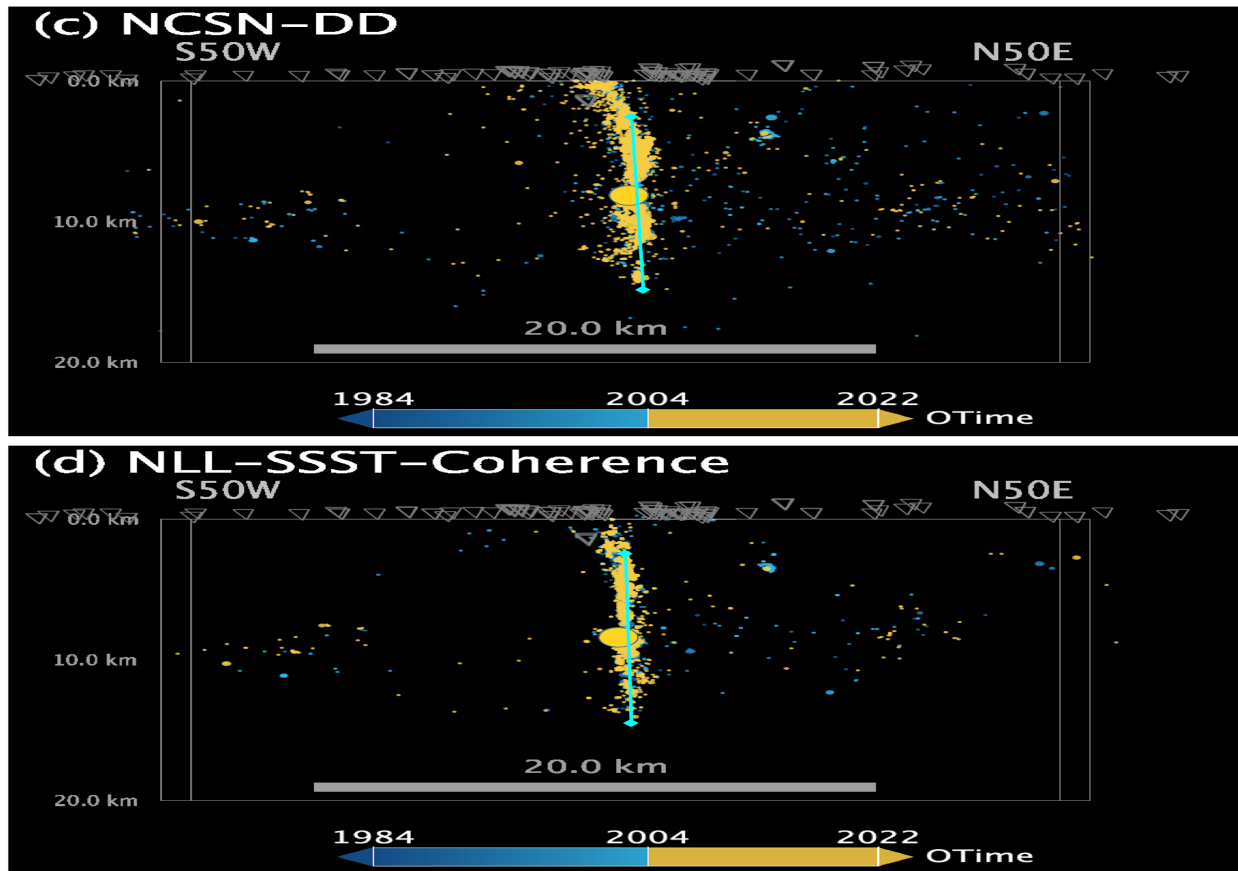


Figure S1 Seismicity along the central San Andreas fault zone around Parkfield. Same as Figure 1 in the main text with images stretched 2X perpendicular to the SAFZ to more clearly show differences in geometry of seismicity between NCSN-DD and (b) NLL-SSST-coherence. Shown are map view images stretched 2X up-down for (a) NCSN-DD and (b) NLL-SSST-coherence relocations, and lateral view images from $\sim S40^\circ E$ stretched 2X left-right for (c) NCSN-DD and (d) NLL-SSST-coherence. Cyan lines show best fit SVD plane corresponding to each catalog; heavy line in map view indicates top of SVD plane. See Figure 1 caption in the main text for other figure elements.

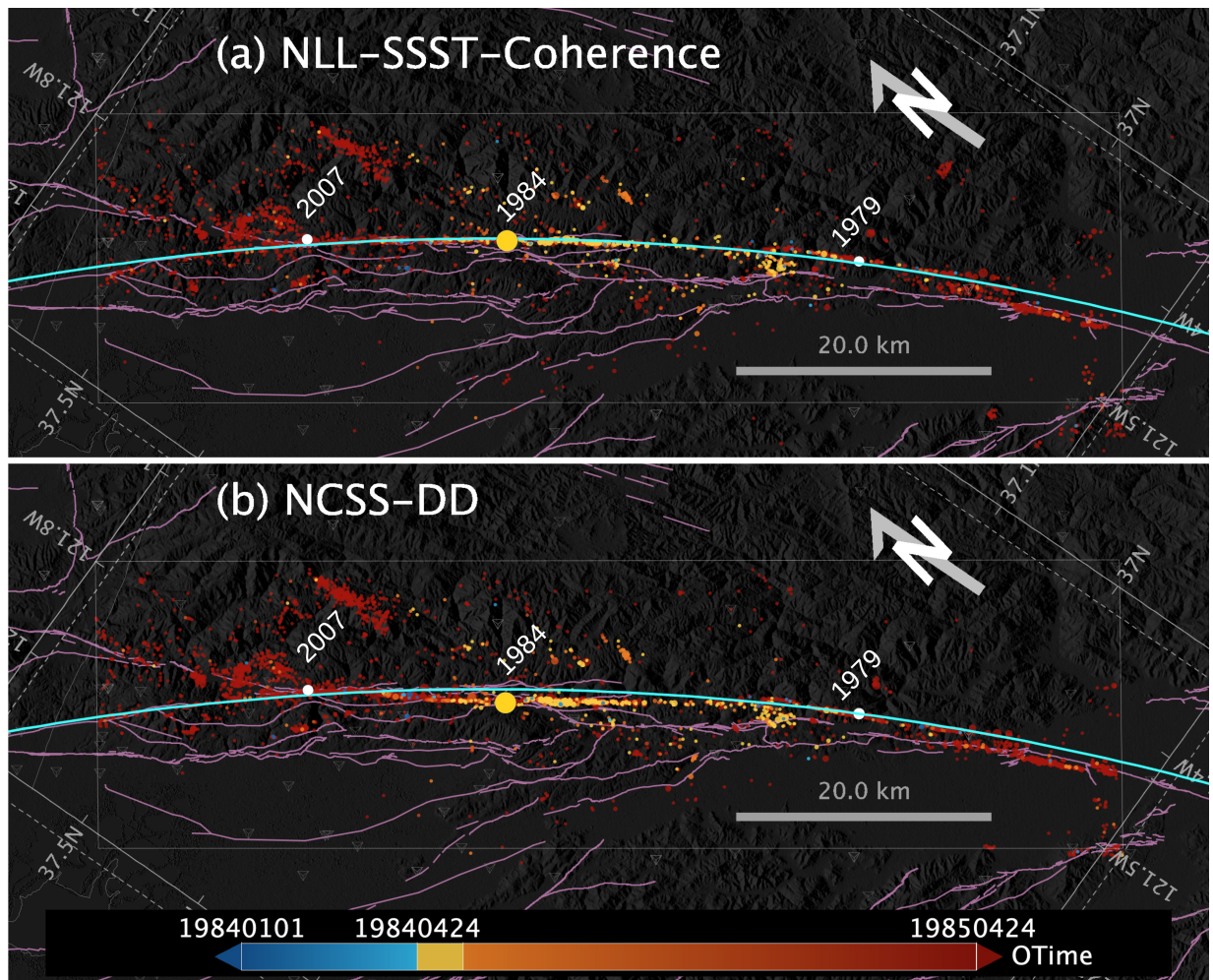
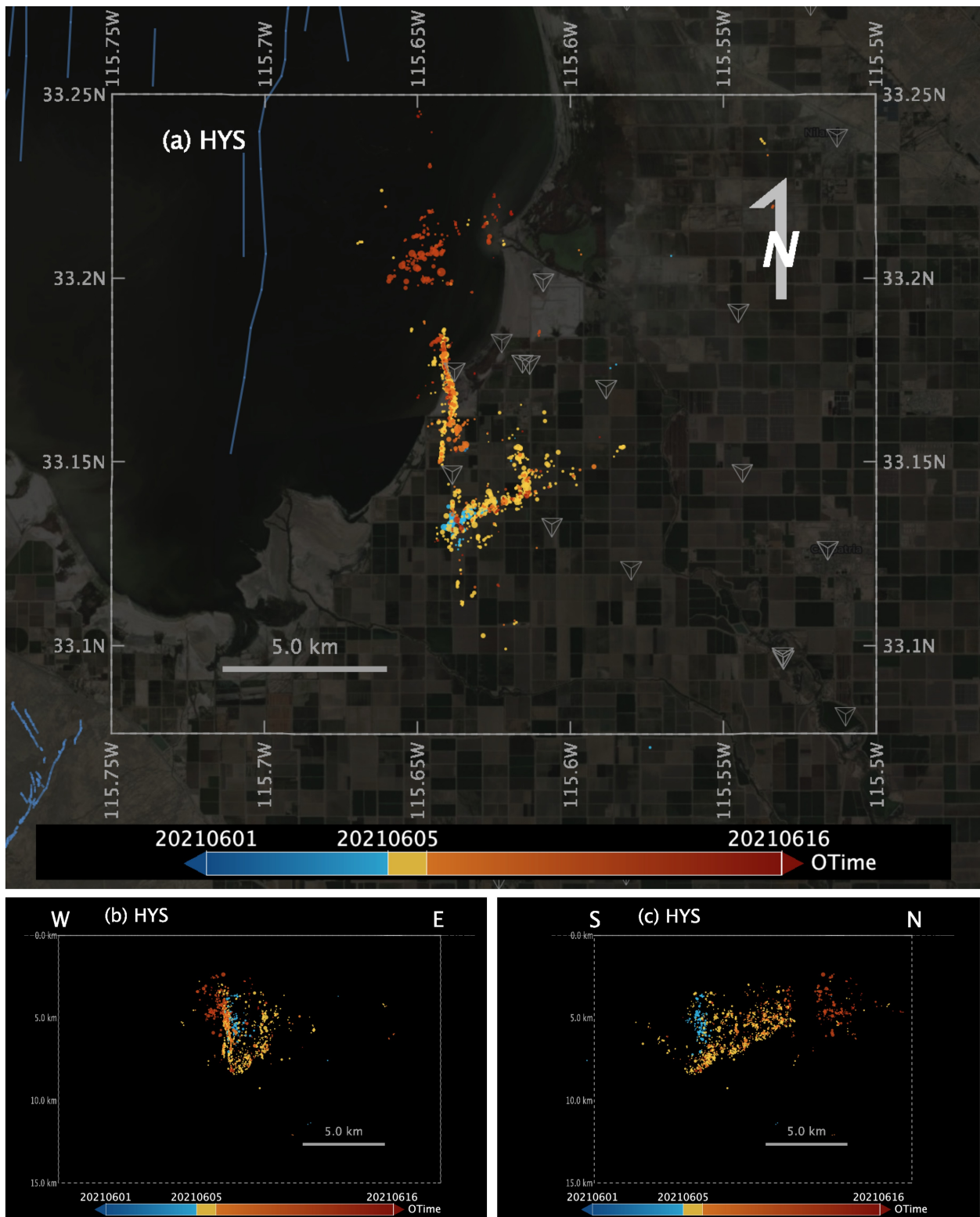


Figure S2 Fit of a circular arc to NLL-SSST-coherence relocations, southern Calaveras fault zone. (a) Map view plunging 84° NE of NLL-SSST-coherence relocations of events of $M \geq 1.5$, 1984 to 2022. Cyan curve shows the circumference of a circle at depth 6 km, with radius 428 km, and center to the south-southwest at latitude 36.205° , longitude -123.635° . This circular arc passes closely along the main, smooth, arcuate lineation of NLL-SSST-coherence seismicity, including much of the 1979 M 5.8, 1984 Mw 6.2 and 2007 M 5.4 aftershock zones. (b) Map view plunging 81° NE of NCSS-DD relocations plotted with the same circular arc. The central part of the NCSS-DD seismicity, including the 1984 Mw 6.2 aftershock zone bends away from and is clearly offset from the circular arc. For both sets of relocations the arcuate seismicity south of the right step southeast of the 1979 M 5.8 epicenter and rupture is clearly offset by about 1.5 km to the southwest from the plotted circular arc. Other map elements as in Figure 4 in the main text.



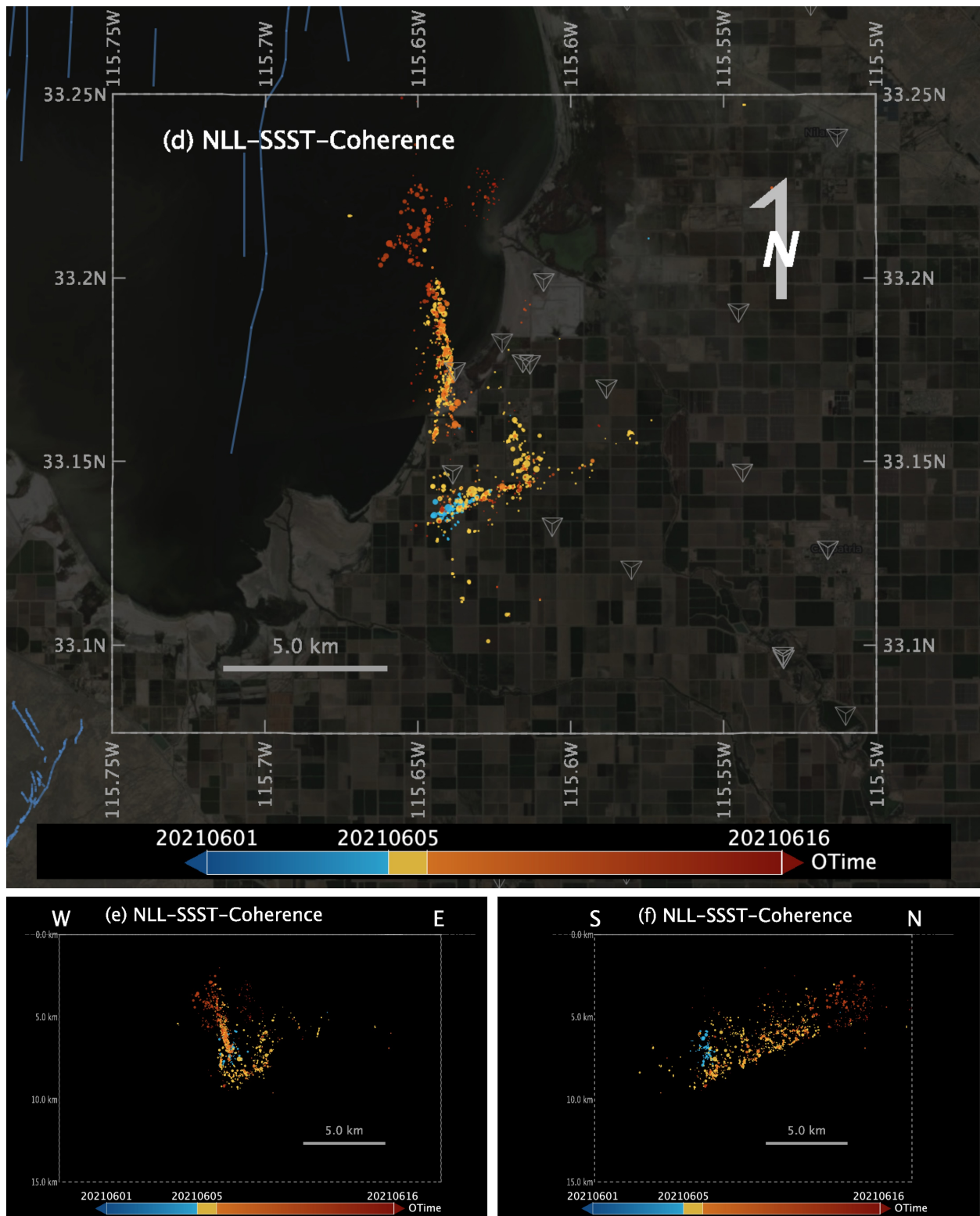


Figure S3 2021 Calipatria sequence relocation from 2021-06-01 to 2021-06-16 for (a-c) 1551 GrowClust relocations from the 2023 update of the HYS catalog (Hauksson *et al.* 2012) and (d-f) 1706 NLL-SSST-coherence event relocations (68% confidence ellipsoid semi-axis ≤ 1.0 km).

Hypocenter color shows origin time (cyan events show foreshocks before the M 5.3 Calipatria mainshock, yellow events the first day of aftershocks), symbol size is proportional to magnitude. Inverted pyramids shows nearby seismic stations used for relocation. Blue lines show faults from the USGS Quaternary fault and fold database for the United States Background satellite image from leafletjs.com.

References

Hauksson, E., Yang, W. & Shearer, P.M., 2012. Waveform Relocated Earthquake Catalog for Southern California (1981 to June 2011). *Bulletin of the Seismological Society of America*, **102**, 2239–2244. doi:10.1785/0120120010