A-147

Updates and Evaluations of the Southern California Regional Earthquake Catalog and Related Products

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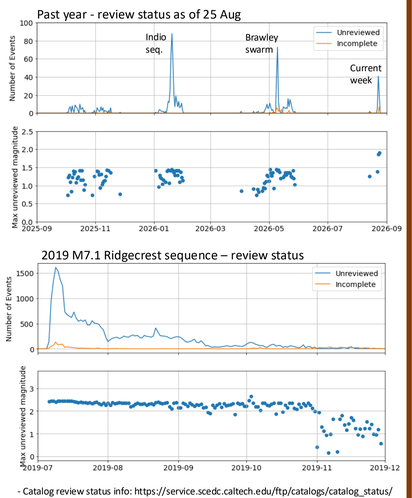
Introduction – SCSN/SCEDC Seismic Event Catalog

Since 1932, the Southern California Seismic Network (SCSN) has been maintaining a manually-reviewed earthquake catalog for Southern California as the regional earthquake authority. The catalog now contains over 1,000,000 seismic events. Recorded events are primarily local earthquakes (~875,000) but also include other seismic sources, such as quarry blasts and nuclear tests. Over the past 3 years, we've implemented machine-learning algorithms and distributed acoustic sensing (DAS) into our monitoring tools and catalog production workflows.

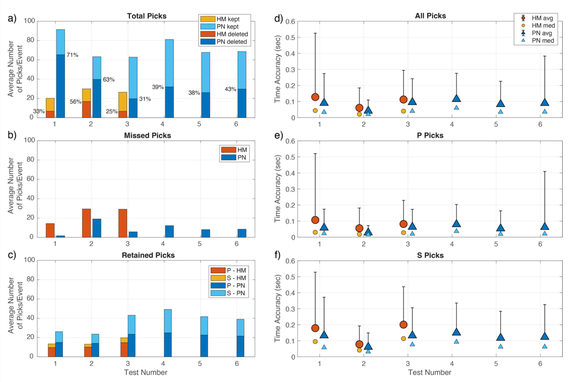
With the growth and improvement of the seismic instrument network, we've been able to detect smaller earthquakes. While this results in a more complete catalog, it also produces more work for analysts and takes longer for the catalog to be reviewed, especially during large sequences and swarms. By using modern tools, like machine-learning algorithms, and by adding in new sensor types, we hope to both improve the quality of our regional event catalog and reduce (or at least maintain) analyst workloads.



- Catalog review status info: https://service.scedc.caltech.edu/ftp/catalogs/catalog_status/

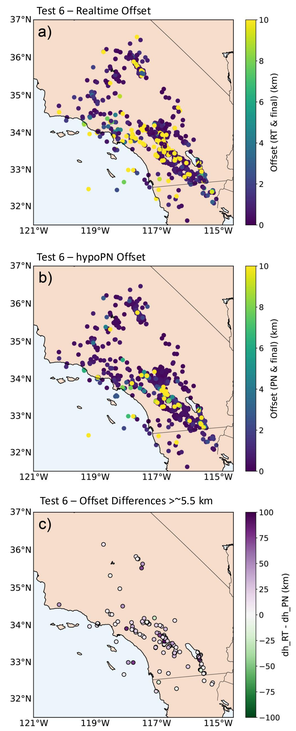
Machine Learning Algorithms

In Dec 2023, we began using the deep-learning picker PhaseNet in our post-processing to repick events detected by the real-time system. This new hypoPN pipeline was implemented after thorough testing.

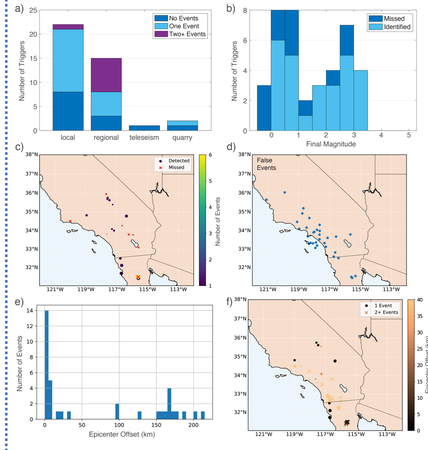


Our testing and analyses showed that PhaseNet (and hypoPN) was capable of making many more phase picks than the previous system with slightly more accurate pick times compared to human analysts. While the increase in picks meant that fewer picks were missed, there were a larger number of incorrect/bad picks that need to be removed by analysts.
(In above figure, PN=PhaseNet/hypoPN, HM=hypomag/STA-LTA)

The improved number and accuracy of picks resulted in more accurate locations compared to those finalized by analysts (e.g., maps a-c). This has led to more events meeting the quality requirements for finalization without adjustment, saving analyst time.

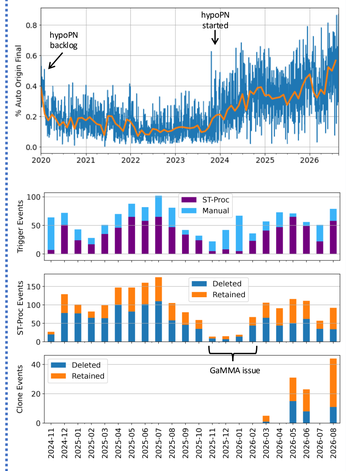


After the success of hypoPN, we developed another pipeline to find events that the real-time system missed using PhaseNet and the machine-learning associator GaMMA, either from subnet triggers (ST-Proc) or within detected event windows (clone). These pipelines were implemented in Nov 2024 and Mar 2026, respectively.



ST-Proc was thoroughly tested before implementation. It typically detects ~2/3 of events that are pulled from triggers with an acceptable rate of false events. The above figure shows analysis results from a test on a swarm in Baja California – a difficult region due to relatively sparse stations that can result in larger magnitude events being missed than in other parts of the network. The same pipeline is used to pull clones from detected event waveforms but is only run manually.

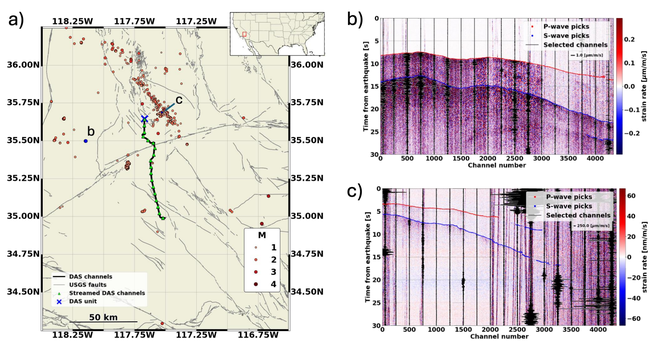
The implementation of machine-learning algorithms in our monitoring systems has helped to improve automatic event quality, reduce analyst workloads, and get a more complete catalog more quickly.



HypoPN is also useful for reviewing backlog events (primarily from the 2019 Ridgecrest sequence) more quickly. Analysts were able to finalize 45% and 52% of remaining events without adjustment to hypoPN origins for Jan 2020 and Dec 2019, respectively. However, hypoPN performance hasn't been tested yet for very high event rates yet.

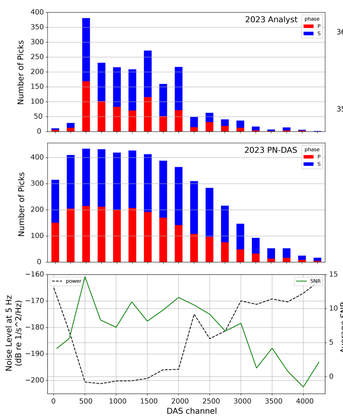
Distributed Acoustic Sensing Data

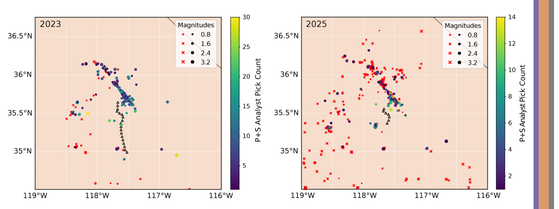
We began ingesting DAS data into our real-time monitoring system in May 2025. It is currently only being used for phase picks, although we hope to add it to the magnitude calculations in the future. Phase picks are being made in the real-time system (STA/LTA) and post-processing (PhaseNet) on single channels only. We may add the capability for real-time PhaseNet-DAS picks, utilizing all DAS channels simultaneously, which has been developed but needs testing.



Currently, we're using one DAS array in operations that runs south from Ridgecrest for ~100 km. There are 5,000 channels streamed in real time (1 sec data packets) with a selected 18 channels ~5 km apart for use in monitoring. Only 7 channels are currently used in SCSN's real-time earthquake system (as of May 2025) due to waveform quality.

The "pickability" of DAS channels is largely dependent on the noise level, which typically increases with distance from the interrogator (below left plots). However, larger magnitude events and events closer to the array can be more easily detected regardless (below maps). Because the array is mostly located along a highway (except channels ~500-2000), noise levels are also dependent on the time of day. PhaseNet-DAS produces more picks than analysts, in part because it uses all 5,000 channels together and can interpolate picks. Comparing analysts and automatic methods, pick times are mostly within +/-0.3 sec for P and +/-0.5 sec for S.





Overall, we didn't find any notable changes in location by adding picks from the Ridgecrest DAS array, although some event locations did meaningfully improve. The regular seismic network is already pretty good in this region, particularly in the areas that see most of the seismicity (e.g., 2019 Ridgecrest aftershocks).

DAS picks made on the 7 real-time channels as part of routine monitoring are available along with the traditional seismic picks downloaded from the SCEDC. Waveforms for the 7 real-time channels can be accessed similarly to other SCSN waveform data.

SCEDC/SCSN User Survey

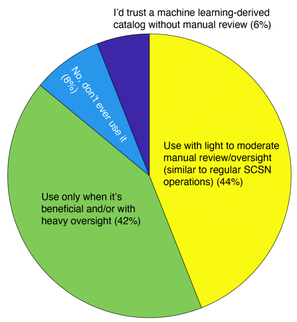
Asked 21 questions, primarily about waveform data and the regional seismic event catalog

Total of 51 respondents from the research community (+19 general public, hobbyist, etc.)
- 51% research scientist/engineer, 25% faculty, 10% grad student. 8% post-doc, 6% undergrad
- approx. even split between career levels (early, mid, late)
- 61% moderate or heavy SCSN data use, 22% a little use, 17% haven't used but interested

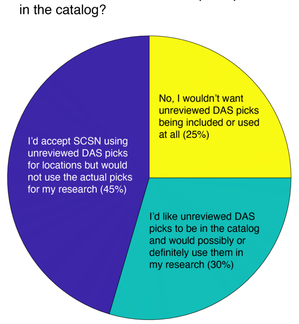
75% of users who have published studies using our data reported including a citation/reference with DOI

Most popular cut-off magnitude for event review: 2.0 (36%) – we currently prioritize events M1.5+

How do you feel about the use of well-vetted machine learning tools in the construction of official event catalogs?

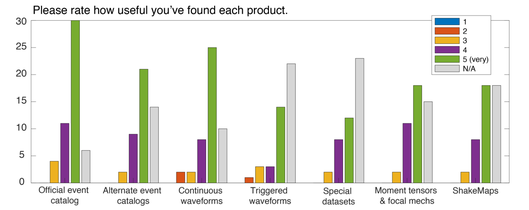


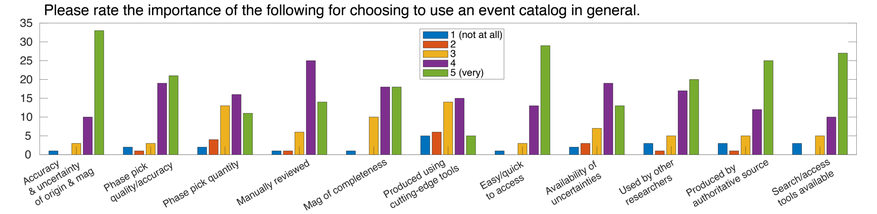
If we were to expand how DAS is used, how would you feel about having up to thousands of unreviewed automatic DAS picks per event in the catalog?



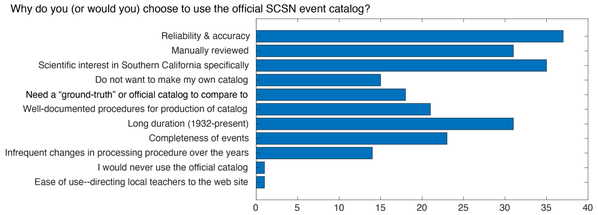
Most used products:
- official seismic event catalog (77%)
- continuous waveforms (71%)
- moment tensors/focal mechs (50%)

Most wanted future products:
- official double-difference catalog (72%)
- rapid response waveforms (55%)
- official machine-learning catalog (53%)





Why do you (or would you) choose to use the official SCSN event catalog?



Most common preferred waveform source:
- ObsPy (39%)
- SCEDC website/FDSN webservices (20%)
- AWS Open Dataset (14%)

Most common ways of accessing the catalog:
- USGS ComCat (63%)
- SCEDC website/FDSN webservices (40%)
- ObsPy (33%)

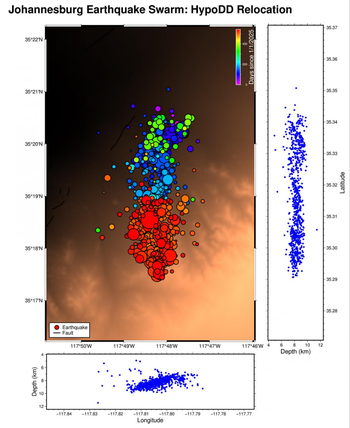
Double-Difference Relocations

DD catalogs now produced after notable sequences & swarms. Initial locations may include unreviewed events.

- 2-D and 3-D maps posted on SCSN earthquake pages: https://www.scsn.org/index.php/earthquakes/latest-earthquake-information/
- Catalogs posted as SCEDC special datasets: http://scedc.caltech.edu/data/alt-SCSN-dd.html
  - 4 catalogs currently available (Indio – Jan 2026, Johannesburg – Jan-Aug 2026, Brawley – May-Jul 2026, Coso – Aug 2026)

Hauksson DD catalog updated in Feb 2026 along with the associated focal mechanism catalog

- Download from SCEDC alternate catalogs page: https://scedc.caltech.edu/eq-catalogs/altcatalogs.html



Summary & Future Projects

- Machine-learning algorithms in post-processing have been useful for improving automatic event quality, reducing analyst workloads, and getting a more complete catalog more quickly
  - More info: Tepp et al., Scientific Reports, 2025
- Current Ridgecrest DAS array provides limited improvements, but the structure for operational, real-time DAS is now in place and working as expected
  - More info: Tepp et al., Seis. Res. Lett., 2026 & Biondi et al., Seis. Res. Lett, 2026
- Double-difference relocation catalogs are now available shortly after notable sequences & swarms along with the annually-updated Hauksson DD catalog
- Survey shows most users find current products useful and are favorable or open to the use of machine-learning and DAS data in the event catalog generation and future products
- Future Projects:
  - Official, unreviewed, near-real-time machine-learning-based catalog (see poster A-149)
  - Near-real-time double-difference catalog
  - More DAS arrays, in particular offshore (e.g., future Los Angeles-Catalina Island fiber)