Evaluation of Distributed Acoustic Sensing Phase Pick Quality and Performance for Operational Earthquake Monitoring

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Introduction

Over the past several years, distributed acoustic sensing (DAS) has been gaining use in seismology research and even seismic monitoring, turning fiber optic cables into strain sensors. The Southern California Seismic Network (SCSN) recently started incorporating DAS data into our routine regional seismic monitoring operations.
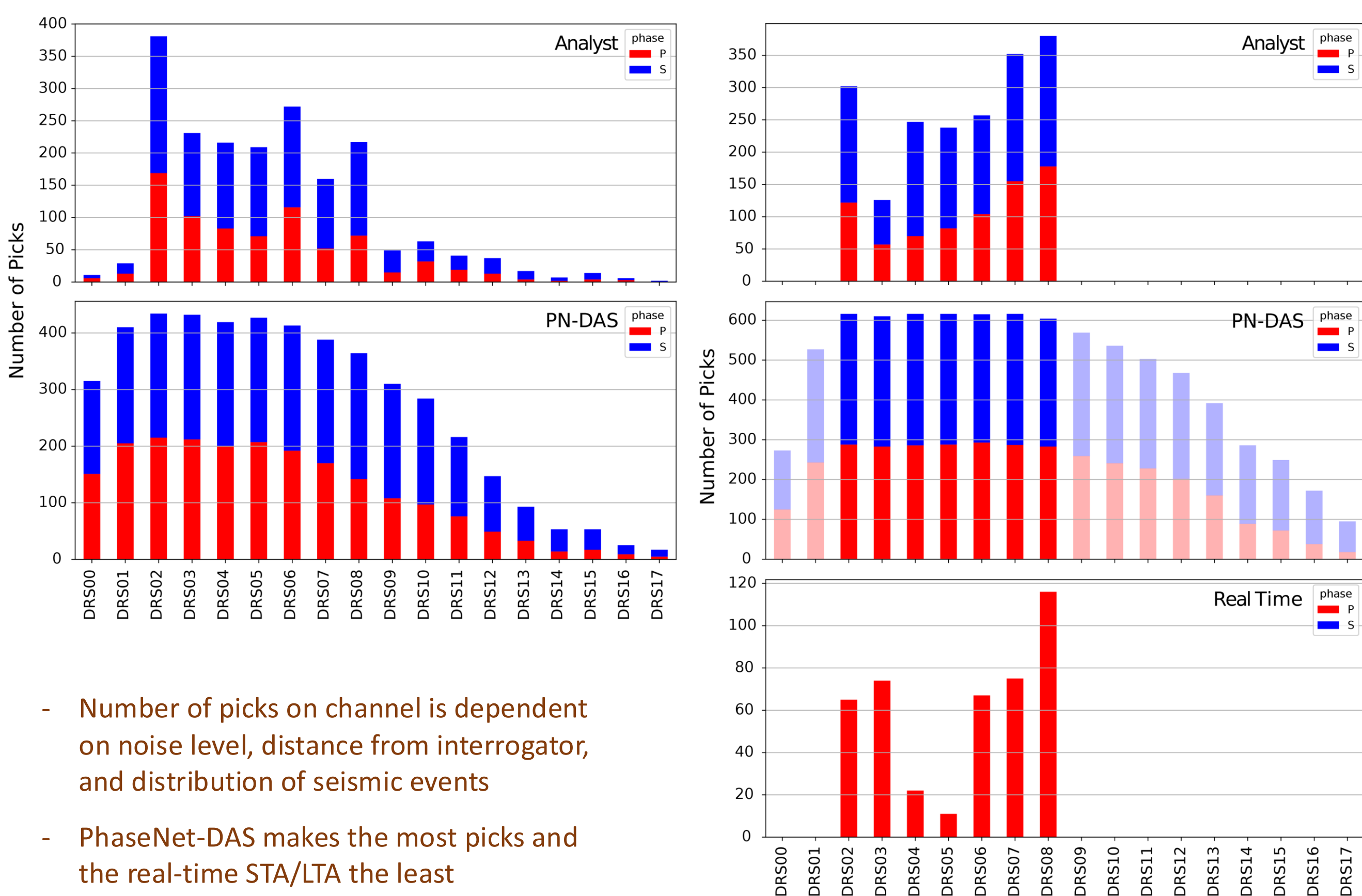
In this project, we aimed to:
- Test the potential impacts and effects of bringing DAS into operational monitoring
- Evaluate the performance of DAS once incorporated into the real-time system
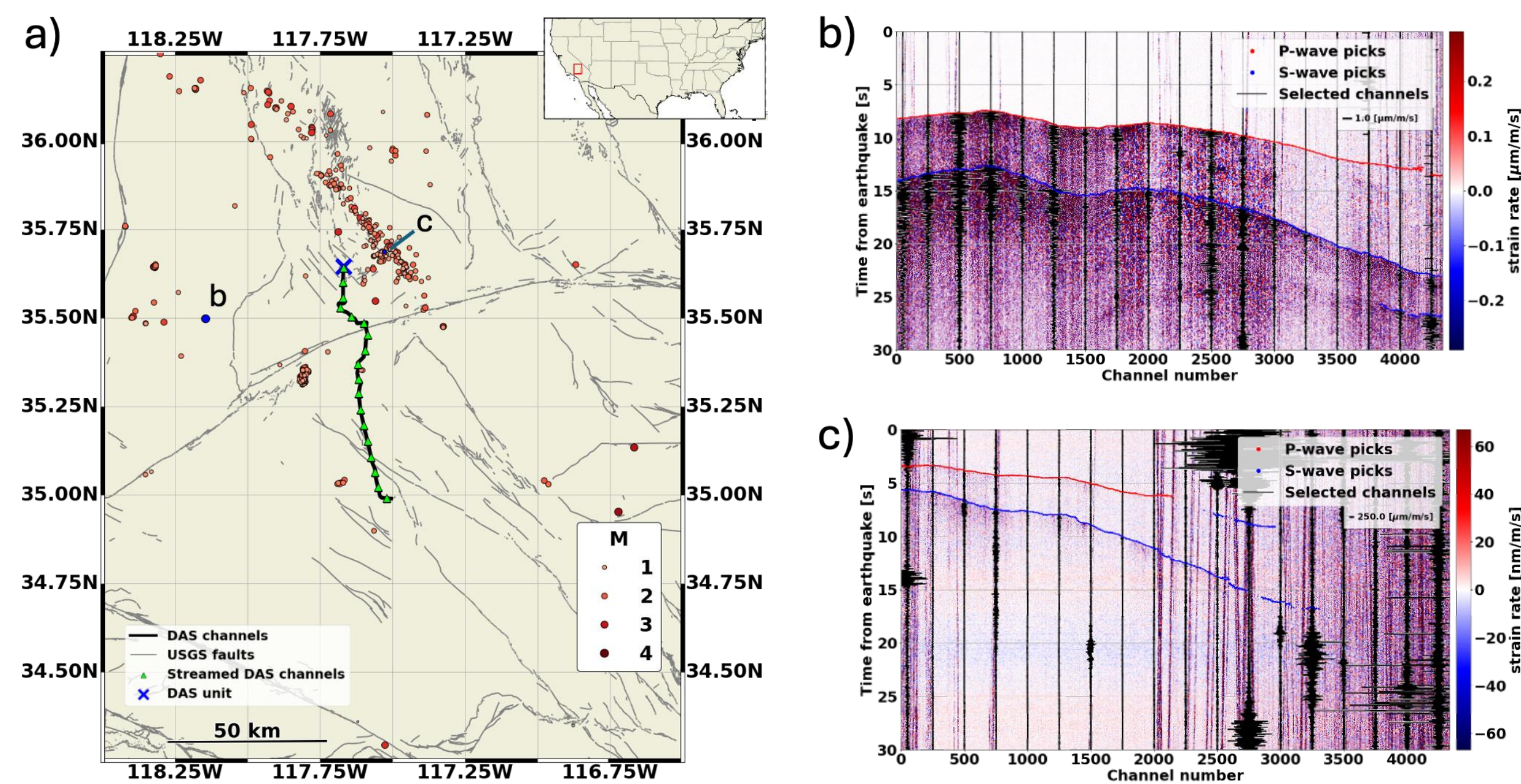
a) Location of the Ridgecrest DAS array (black line) with the considered DAS channels currently being tested for earthquake monitoring operations (green triangles). The blue cross depicts the interrogator instrument deployment position. The red dots depict the local seismicity from the SCSN catalog with DAS detections in our tests. PhaseNet-DAS picking examples for a local (b) M3.4 (52 km distance) and (c) M1.0 (40 km distance) earthquake. Red and blue points/lines show P and S phase picks, respectively.

DAS Data & Phase Picks

- DAS array runs south from Ridgecrest for ~100 km
    - Divided into 18 channels ~5 km apart for use in monitoring with 7 channels currently used in SCSN's real-time system (as of May 2025)
- Made phase picks on two sets of events from 2023 and 2025 by analysts, PhaseNet-DAS (deep-learning picker), and the real-time system (2025 only)
    - Test set: 28 May – 31 July 2023 (left figures)
    - Production set: 6 May – 8 July 2025 (right figures)
   - Picked out to 100 km distance from event (typical for SCSN catalog review)

- Number of picks on channel is dependent on noise level, distance from interrogator, and distribution of seismic events
- PhaseNet-DAS makes the most picks and the real-time STA/LTA the least
- For 2025, analysts made more picks on channels farther from the interrogator due to the event distribution

	PhaseNet-DAS		Analyst		Realtime (STA/LTA)	
	# Events	# Picks	# Events	# Picks	# Events	# Picks
2023 18 chan	226	2102 P 2698 S	228	776 P 1186 S	--	--
2025 7 chan	323	1973 P 2187 S	316	767 P 1134 S	165 (15 RT-only)	339 P

Detection Thresholds

Considered all possible event-channel pairs for both datasets combined to evaluate how well DAS could detect events based on distance and magnitude

- Analyzed the total number of picks per event by analysts & PhaseNet-DAS compared to magnitude and distance to closest channel (left & center plots)
    - For 2023 data, number of picks seemed most dependent on magnitude for both picking methods
    - For 2025, PhaseNet-DAS did similar to 2023 but analysts made more picks on closer events
        - Possible reasons are event distribution or analyst confidence
- Analyzed pick-channel pairs by analysts & PN-DAS comparing magnitude of source event and distance to channel (right plots)
    - Calculated median, minimum, and maximum magnitude in 5 km distance bins for detected and missed picks
    - PhaseNet-DAS had lower median mag picked than analysts
    - Max mag picked and min mag missed similar for both analysts & PN-DAS
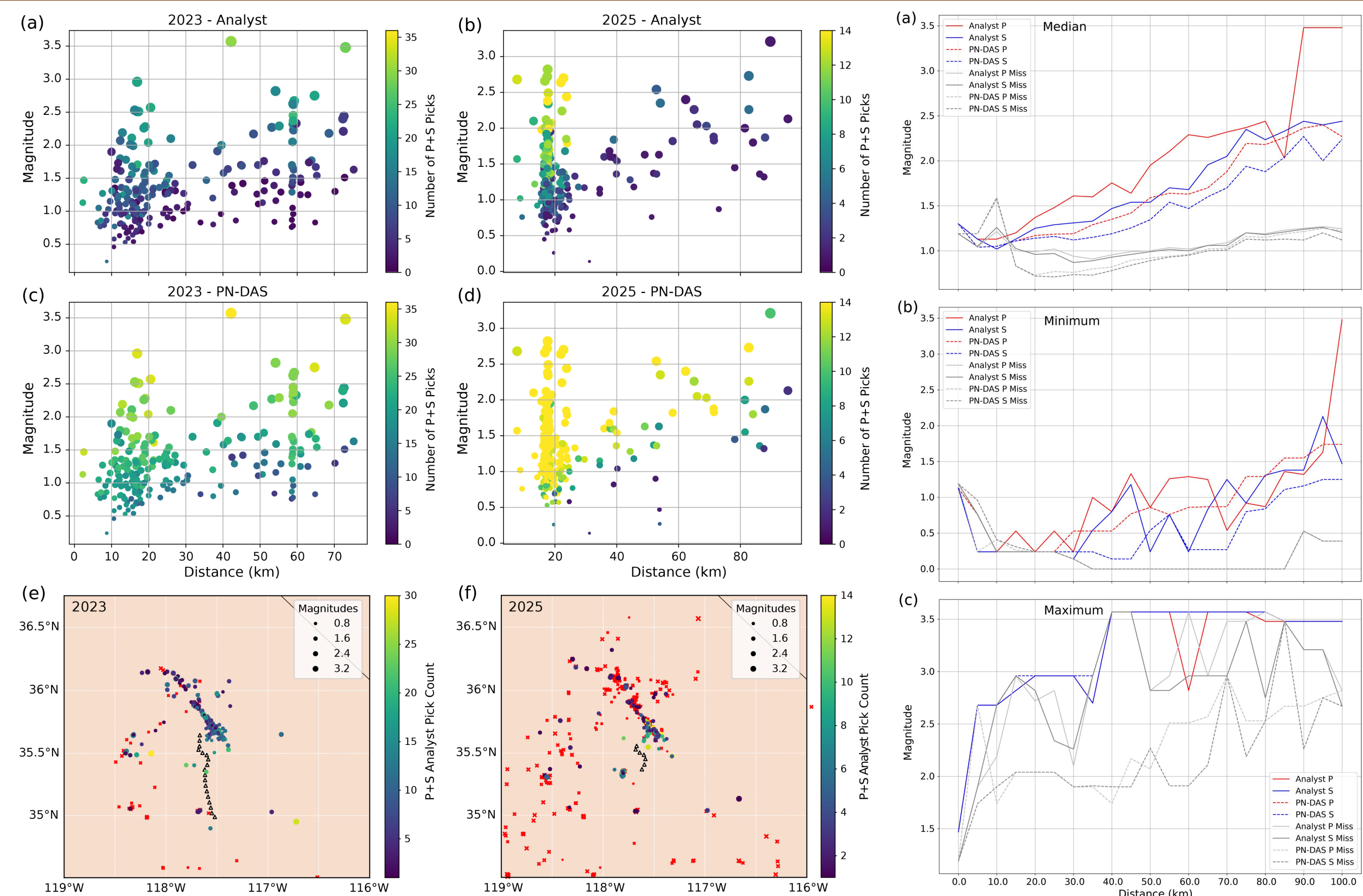
Phase Pick Quality

Compared arrival times for picks on each event-channel pair

- Most automatic picks are within ~0.5 sec of analyst picks for P phases and ~1 sec for S phases
- More variability in 2023 dataset may be due to event distribution or the way in which the analyst(s) picked phases
- Real-time STA/LTA was accurate for picks in common with other methods (but had more false picks)
- Note: a few outliers not plotted
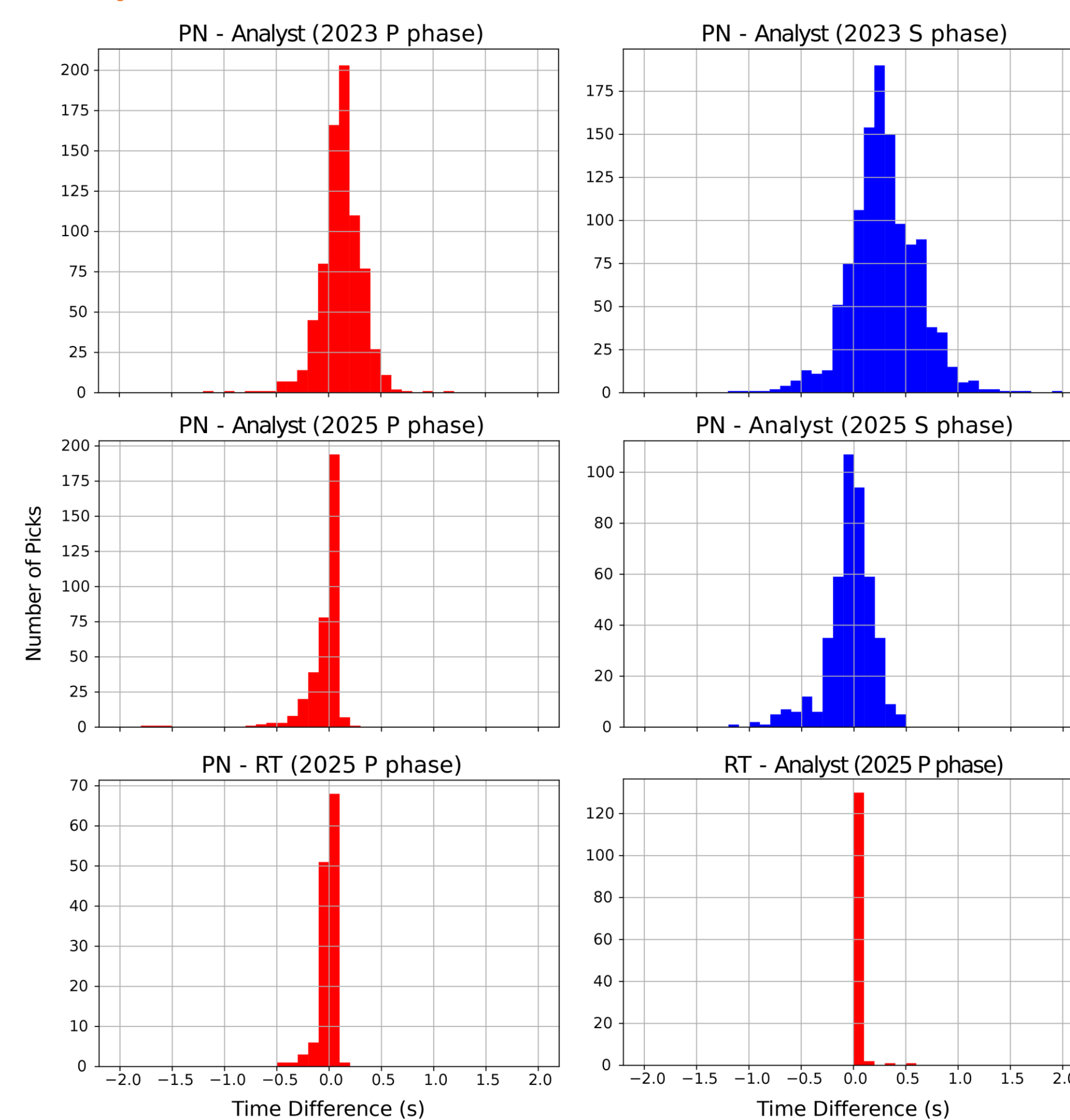
Conclusions

- Tests with DAS data on events from 2023 showed good quality picks with no significant downside for earthquake monitoring
- DAS data successfully integrated into SCSN's real-time system in 2025 with similar performance to test
- PhaseNet-DAS (using all available DAS channels) made more picks than analysts and the real-time STA/LTA and seemed to be accurate compared with analyst picks
    - Not yet being used in the real-time operational system but is in testing
- "Pickability" of an event is dependent on channel noise level, event location, and event magnitude
    - Channels farther from interrogator have fewer picks as do the very closest
    - Channels not near highways or roads consistently produce the most picks, especially from analysts
- Adding DAS picks to the real-time seismic picks didn't have much effect on locations, often making them slightly worse for events in the test dataset (possibly due to epicenter locations)

Effects on Epicenter Accuracy

Compared epicenters from the catalog (final), real-time seismic system, and RT seismic + DAS picks for the 2023 test dataset

- Adding DAS picks did not significantly affect the locations
- Overall, locations with DAS picks were a little worse than the real-time seismic-only locations
- Lower percentage of DAS picks less likely to affect location
- Most events in dataset were north of array which may have biased results
- Seismic station coverage already decent in area with most events from dataset
- Final locations were also seismic only