Ensuring Timing from Nodal and Network Seismic Systems is Synchronized

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Abstract

The ability to combine nodal deployments with continuously operated network stations can provide significant resolution enhancement for local seismicity. In order to ensure accurate timing and locations, we use data collected during a seismic survey to compare times at permanent stations. The Source Physics Experiment (SPE) conducted a seismic survey in Rock Valley, NV during the spring of 2021. The survey was deployed along roads, with 188 three-component receivers at 100-m offset and 553 source locations at 25-m offset, a configuration nick-named LASSO (Large Array for Seismic Sensing and Observations). Data from five accelerated-weight-drop hits were collected with the source in the vertical position, and five at 45 degrees to vertical, perpendicular to the source line in both directions, for a total of fifteen hits at each source point. Two permanent stations, RTPP and RVEE, also recorded signals from the sources within 0.5 km of the station. The permanent stations have instruments placed both at the surface and in a borehole (~90 m below the surface). As expected, when the source distance decreased, we observed a dramatic increase in correlation. A ring of hits was also conducted around each station. These provided a mechanism to verify the orientations of the sensors and to verify each borehole instrument's position with respect to the well casing. In addition, we look at velocity anomalies associated with the direct arrivals and compare to the velocity models generated by other studies.

Nodal Deployments

Table 1. Deployments completed using Large Array for Seismic Sensing and Observations (LASSO)

Deployment	# of Collects	# of Nodes	# of Days	Data Volume (TB)	Duration
DAG	4	500	84	30.5	2019 April-December
Monte Cristo Range	4	48	84	1.8	2020 May-July
RV Mini-array at RTPP	3	48	63	3	2020 July 2021 April 2021 August
LSECE	1	450	21	4.12	2020 November
U1a	34	48	714	13.5	2020 November - present
Aqueduct Mesa	14	48	294	6.4	2021 Jan - present
RV/DC Array	2	188	42	3.8	2021 April 2021 August
Burro Schmidt	1	48	21	0.5	2021 September
RV Persistent	2	48	42	1	2022 January - present
			Total:	**64.62 TB**	

Figure 1. The LASSO deployments across Nevada. The deployments are for Site Directed Research and Development (SDRD), programmatic work, and collaboration with other seismic observatories. Deployments at U1a, Aqueduct Mesa and Rock Valley have near-continuous recordings for extended time periods, and are ongoing. Additional LASSO deployments will be completed during scheduled experiments.

Operational Network

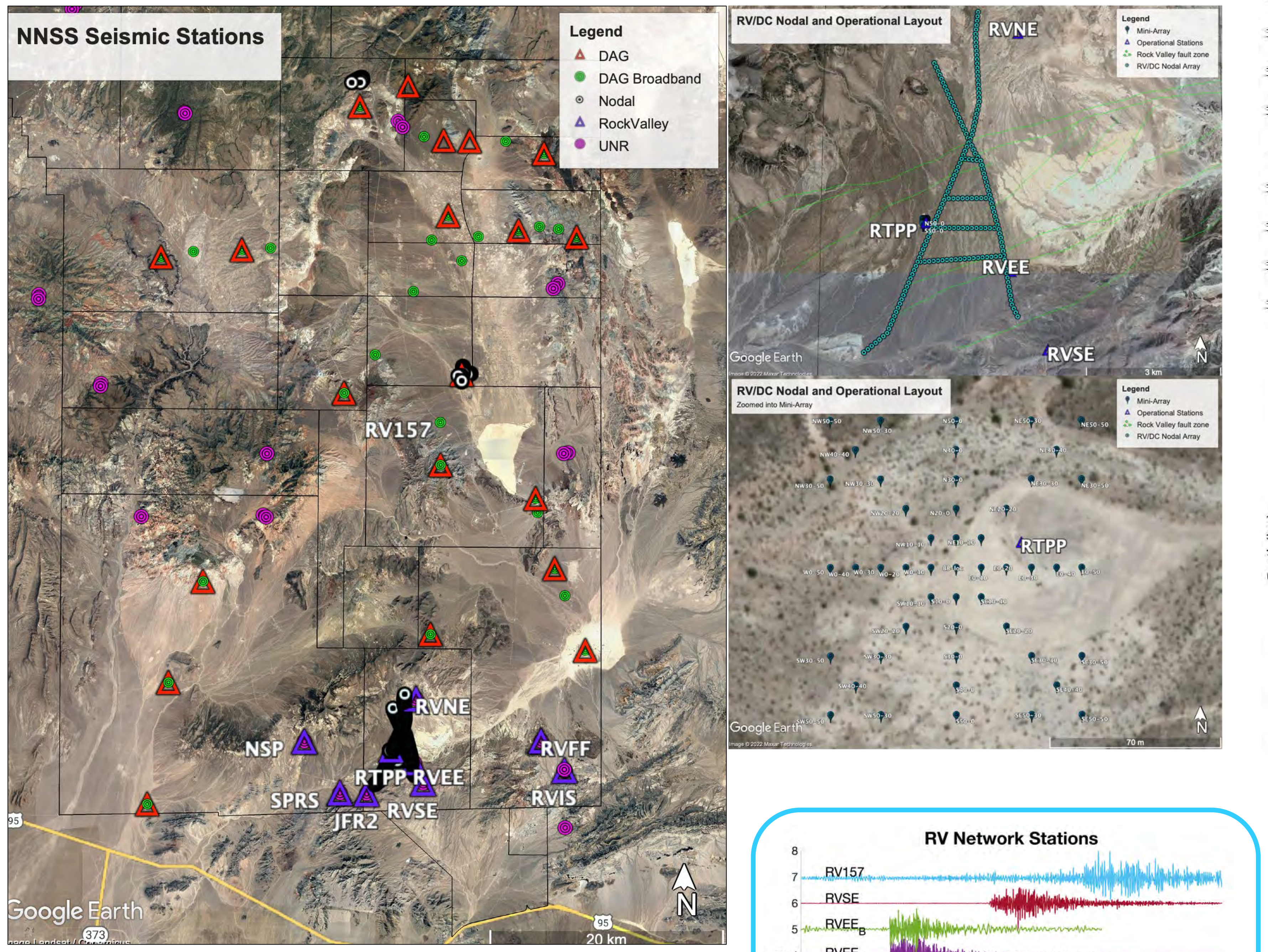

Figure 2. The operational network as currently planned; additional stations will be installed for RV/DC. Right maps show LASSO in Rock Valley (top is full array and bottom is mini-array).

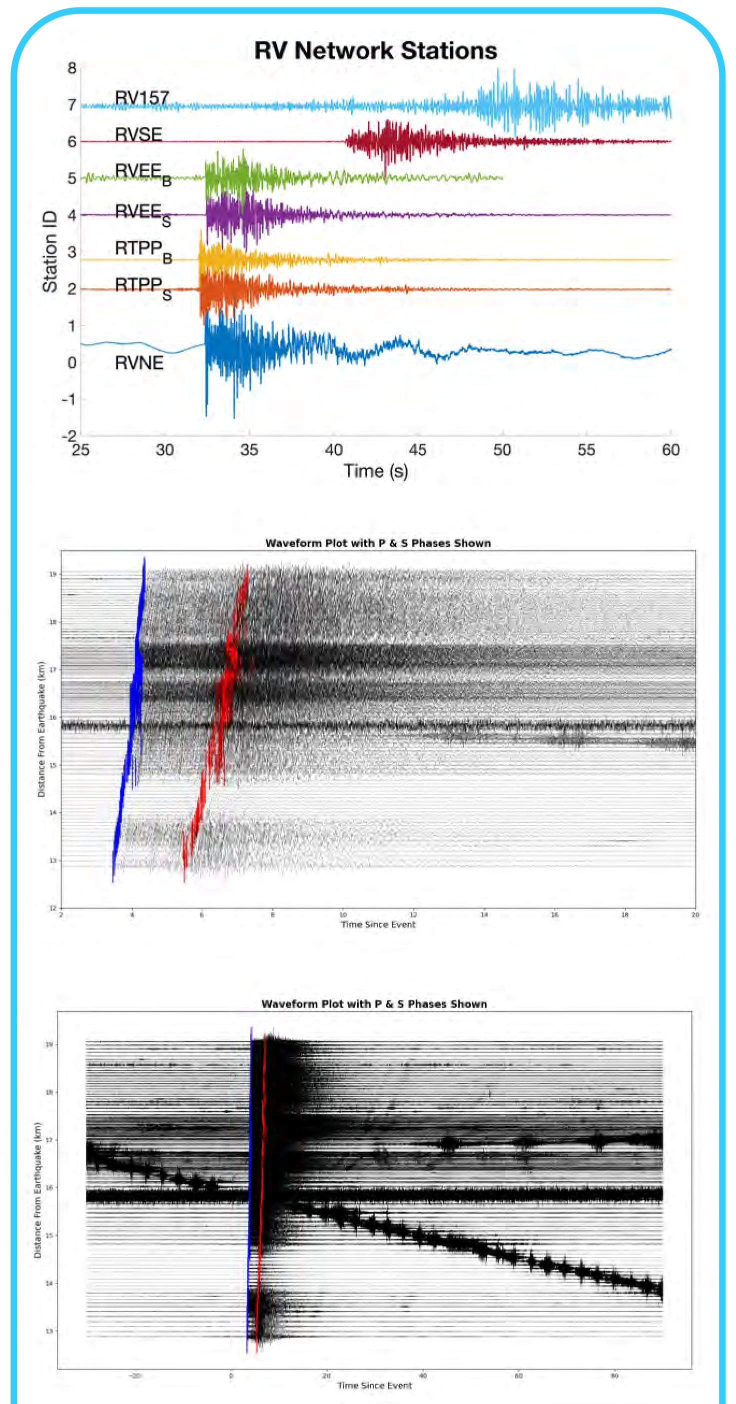

Figure 3. Micro seism (M_L 0.25) in Rock Valley recorded on network (top), full array event M_L 1.5 (middle), and full array 2 minute window (bottom).

Location Comparison

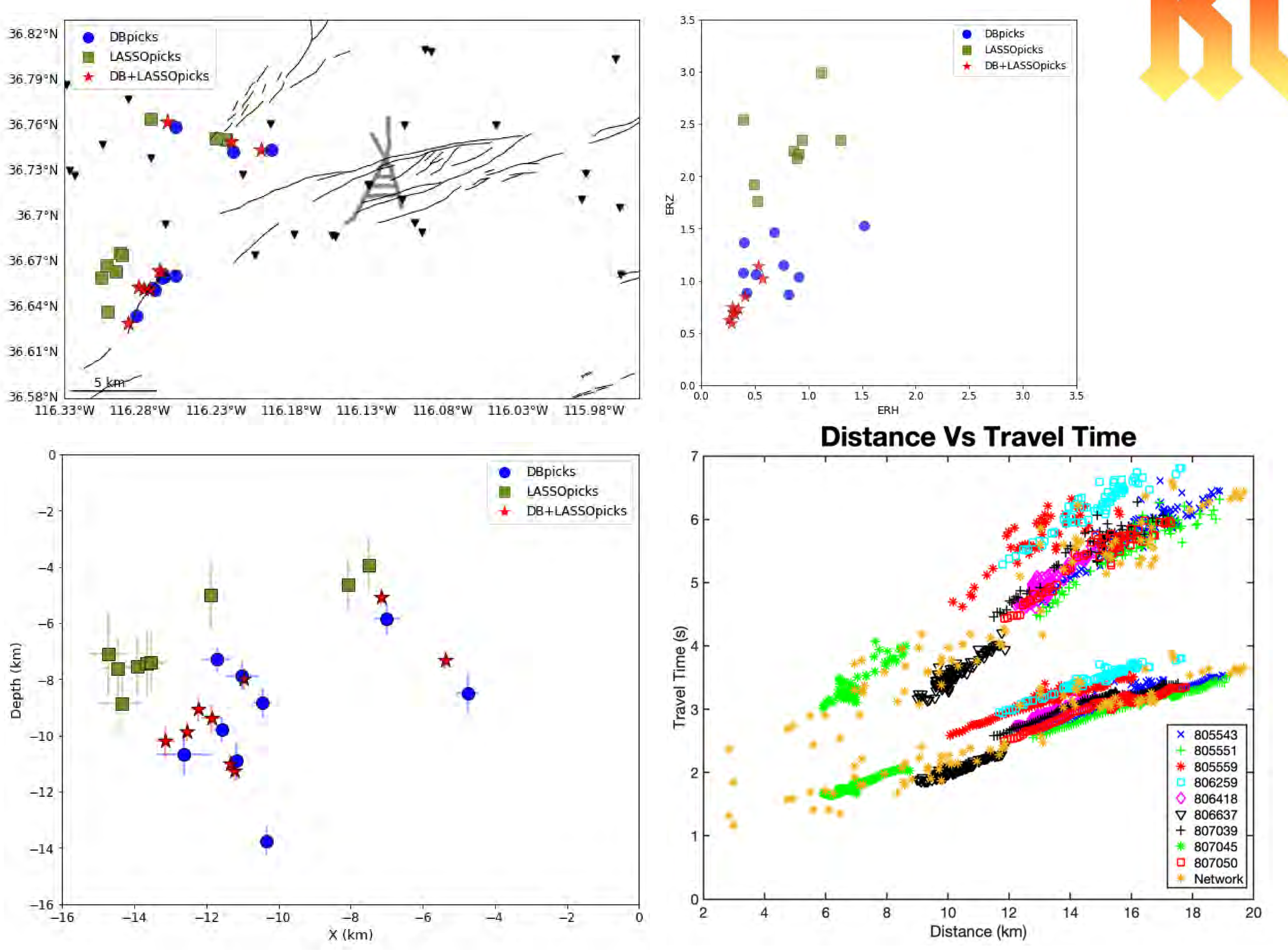

Figure 4. Comparison of relocations computed for individual and combined arrivals (top left). The depth uncertainties are greatest for the nodal arrivals, but decrease significantly for the combined locations (bottom left). The location errors are greatest for depth and similar for epicenter when using the individual arrival set (top right). The depths are shallowest for the nodal arrivals (bottom left). Overall, the distance vs. travel time is similar (bottom right), however, the added nodal coverage provides a more continuous velocity profile.

Table 2. Event list for network and LASSO picks.

EVID	Year	JDay	Hr	Min	Sec	Lat	Long	Z	M_L
805543	2021	112	17	3	14.83	36.66	-116.28	6.3	1.5
805551	2021	112	18	15	1.80	36.65	-116.28	5.4	0.59
805559	2021	112	19	57	50.05	36.67	-116.25	7.0	0.31
806259	2021	121	6	33	8.24	36.65	-116.26	9.2	-0.41
806418	2021	124	4	57	18.01	36.76	-116.26	8.0	-0.11
806637	2021	126	17	6	31.78	36.75	-116.23	4.1	0.12
807039	2021	132	0	15	54.37	36.66	-116.26	8.8	1
807045	2021	132	1	18	52.37	36.74	-116.19	7.4	0.25
807050	2021	132	2	33	53.60	36.67	-116.27	8.5	1.29

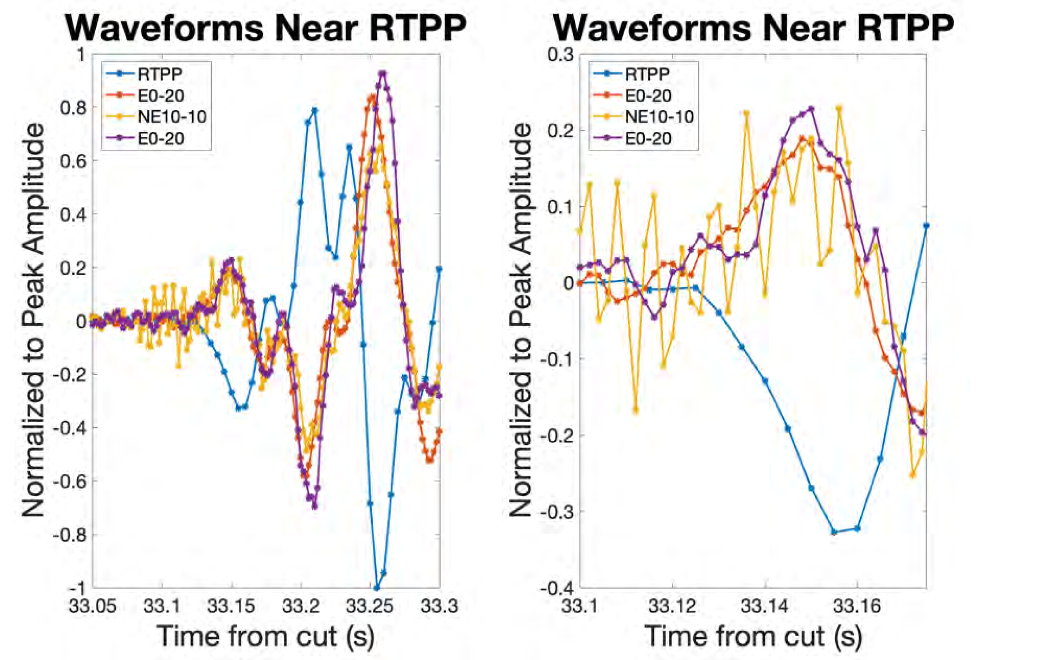

Figure 5. RTPP compared to nodal data show no systematic timing errors. The polarity difference is due to industry standard for geophone orientation and seismic observatory configurations.

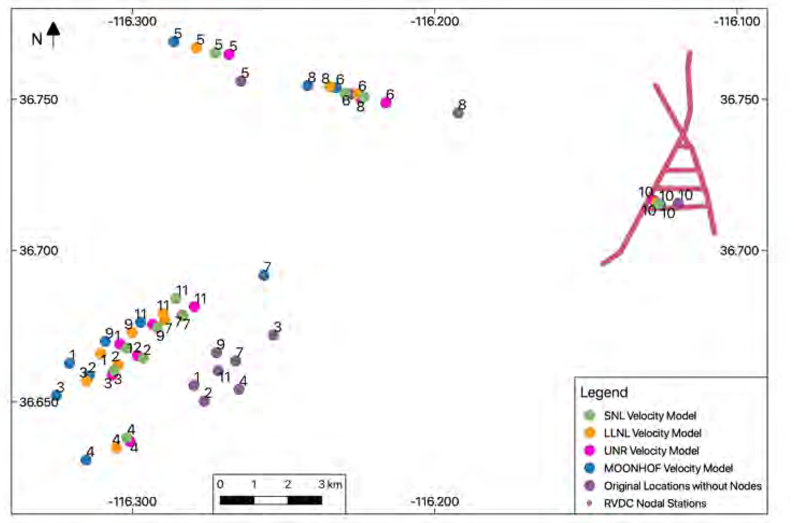

Figure 6. Comparison of the locations using the nodal arrivals and velocity models for the region. Typically we see a linear trend but the trend is different between azimuths.

Conclusions

- The volume of data becomes challenging to process when working with the nodal data manually.
- Initial integration of nodal and network data appears to be seamless for the timing of arrivals.
- Additional work is needed to determine the appropriate velocity model for nodal picks.

Future Work

- Test additional velocity models
- Identify and locate additional events
- Determine optimal station configuration to minimize arrivals
- Use data from AWD seismic survey
- Develop automated algorithm for picking

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