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Seismoacoustic background noise variations and state of health assessment across a geographically diverse sensor network in Nevada

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Initial Assessments:

Several management practices were implemented to assess station state of health and quality control across a large seismoacoustic network. Three methods were used to assess station health: a real-time viewer, daily power spectra density plots (Fig. 1), and daily root-mean-squared (RMS) amplitude plots (Fig. 2). Through these tools, we assessed which stations were operational or degraded. The status of each individual station was captured in periodic reports that summarized network status over time (Fig. 3).

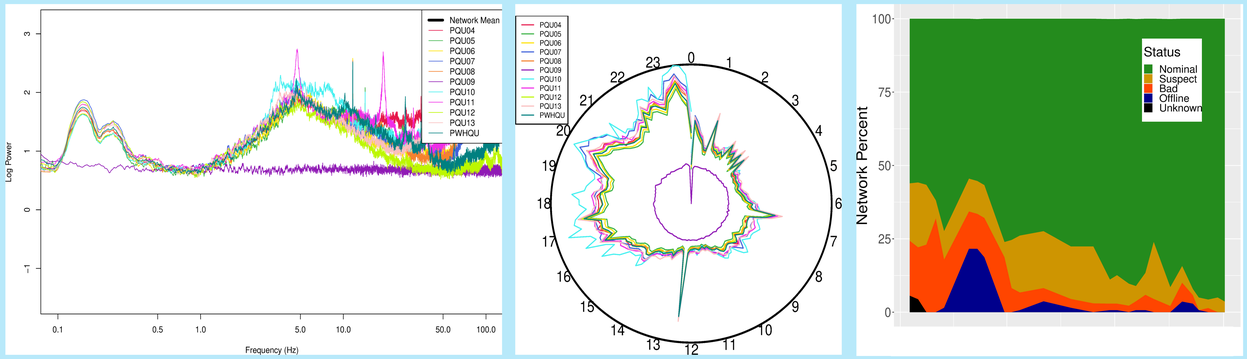

Figure 1 (left): Spectra for one day on east component of a geophone array. Note the down channel in purple. Figure 2 (middle): Corresponding RMS wheel. Figure 3 (right): Network status over time.

Observations:

Over the course of assessing station health, we noted distinct patterns being recorded on the network. Some noise recorded on stations were indicative of sensor health (Fig. 1), whereas some noise followed diurnal wind patterns (Fig. 4) or anthropogenic noise (Fig. 5). In some cases, the strong presence of microbarom or microseism signals could be noted (Fig. 6) and were used to understand nominal sensor operations.

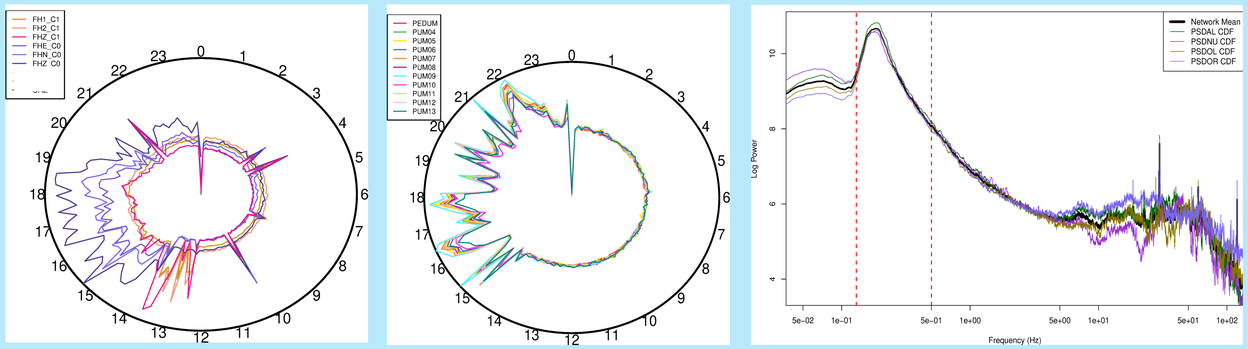

Figure 4 (left): Comparison of wind noise between an accelerometer emplaced at the surface (FH*_C0) with co-located borehole accelerometer (FH*_C1). Figure 5 (middle): Geophone array near active road showing increased noise during working hours. Figure 6 (right): Strong microbarom signal on infrasound sensors before a storm.

Motivation:

As part of the larger seismoacoustic network, we deployed a small acoustic network in complex topography near an active facility (Fig. 7). We noticed systematic variations in background noise over 24-hour periods (Fig. 8 & 9). We hypothesized that these variations were related to complex wind patterns in the canyons and ridges occupied by the stations, combined with the pattern of life at the facility.

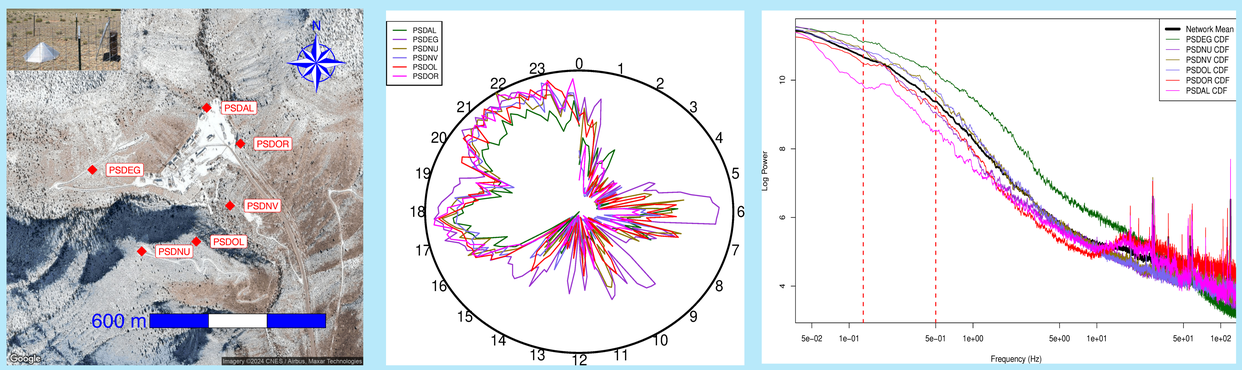

Figure 7 (left): The small acoustic network, with a typical station shown in the inset. Figure 8 (middle): RMS wheel for one day. Figure 9 (right): Corresponding spectra for one day.

Methods:

We calculated the median RMS values for every 10-minute time window for each day over the month of November 2023. The RMS values were calculated in the 1-10 Hz band. After converting the data to Pascals, the resulting waveforms were divided into one-hour sections, for a total of 24 sections per day, across the month of November 2023. A spectrum was generated for each of these one-hour sections using the multi taper method and then sections were averaged together to produce a Welch spectrum. Any section containing a data gap was not included in the average. One-hour sections corresponding to the same time of day were selected across the study period. We used the median log instead of the mean to ensure that outliers did not skew our results.

Results :

All sensors in this study are non-seismically decoupled Hyperion microbarometers sampled at 500Hz. The sensors PSDOL and PSDNU are both in a valley. The sensor PSDNV is in a valley and near a road. The sensor PSDEG is on a hillside. The sensors PSDAL and PSDOR are on flat surfaces near buildings.

The RMS plots show that PSDEG, PSDOL, PSDNU experienced greater noise during the day, while PSDNV, PSDOR, and PSDAL all have greater noise at night than during the day (Fig. 10). In the spectrogram wheels (Fig. 11), we see broadband wind noise and narrowband human noise varying with time of day. Wind noise is mainly in the 0.1 to 10 Hz band. As on the RMS wheels, PSDNU has greater wind noise during the day than at night.

The spectral wheels indicate that some stations are nosier at night that the RMS wheels would indicate. There is a reduction in spectral power around the time of the sunrise and sunset, which could be a possible wind reversal. Across all spectral wheels, each sensor records periodic noise in the 10 to 100 Hz frequency band, which could indicate human activity. For example, PSDAL and PSDOR (the stations closest to buildings) record enhanced spectral power above 10 Hz during work hours (16-0 UTC).

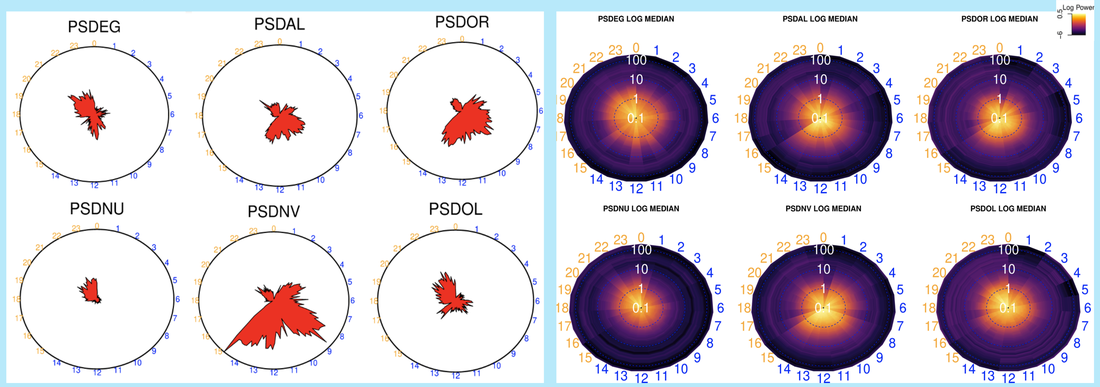

Figure 10 (left): RMS wheels for six stations. Figure 11 (right): Spectral wheels for six stations. The white numbers in the spectral wheels are indicative of frequency bands. The frequency (white) increases from center, and color indicates spectral power, with yellow being higher power and purple being lower power. All wheels are plotted in Coordinated Universal Time (UTC), but hours are shaded in orange for local daylight or blue for local nighttime based on the sunrise and sunset times for November 15, 2023.

Conclusions and Future Work:

Localized wind patterns and facility noise can be discerned at acoustic stations. These results highlight the impact of station placement on sensor performance as well as suggest new ways of monitoring local wind and variations in human activity. In the future, we aim to: Reduce the window size on spectrogram wheels from one-hour increments to improve resolution and compare temporal anthropogenic trends (Fig. 12), plus explore wind noise trends at sunrise, sunset, and solar noon across different topographic settings.

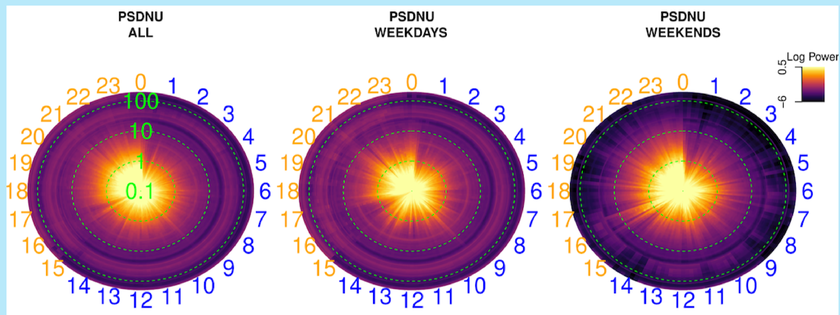

Figure 12 (above): PSDNU spectral wheels with refined window for all days (left), weekdays (middle), and weekends (left).

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