DYNAMIC STABILITY MONTHLY REPORT

SOUTH ISLAND – NOVEMBER 2024

Transpower New Zealand Limited
November 2024

Keeping the energy flowing




TRANSPOWER

Transpower New Zealand Limited The National Grid

Version	Date	Change
1.0	21/07/2025	Final Local OHB-OHC mode 9/11/24

	Position	Date
Prepared By:	Power Systems Engineer	9/06/2025
Reviewed By:	Richard Sherry, Principal Engineer	21/07/2025

Contents

1 Executive summary

1.1 Purpose

The low frequency dynamic oscillatory stability of the power system has been analyzed using phasor measurement unit data.

These monthly reports can be used to track significant changes over time specifically aimed at documenting ‘normal’ system oscillation behaviour and identifying any changes.

If some oscillation modes have changed significantly, or there is evidence of poor damping events, a more detailed investigation would be required to identify the cause (e.g. load growth, new generation, machine or plant controller, system topology/outages, etc.)

The reporting from 2024 onwards is modified to a more “by exception” approach. The normally observed oscillation behaviour for the Island is quite well known from a number of years of reporting. This is summarized in section 2.1. Any new or unusual behaviour observed in the month is then reported in section 2.2

1.2 Revisions from January 2024

The report format has been updated for 2024. The histograms of recorded data are retained, but the previous time trends have been replaced with a new formatting of the data which also captures, in the time series trend, the behaviour of all identified oscillations across the frequency spectrum (of 0.04 to 4 Hz) rather than presenting just the largest mode within a number of specified frequency bands.

The new format contains more information, a summary of how to interpret the new plots has been included along with a comparison of how the pre-2024 trend would look.

2 Oscillation Behaviour

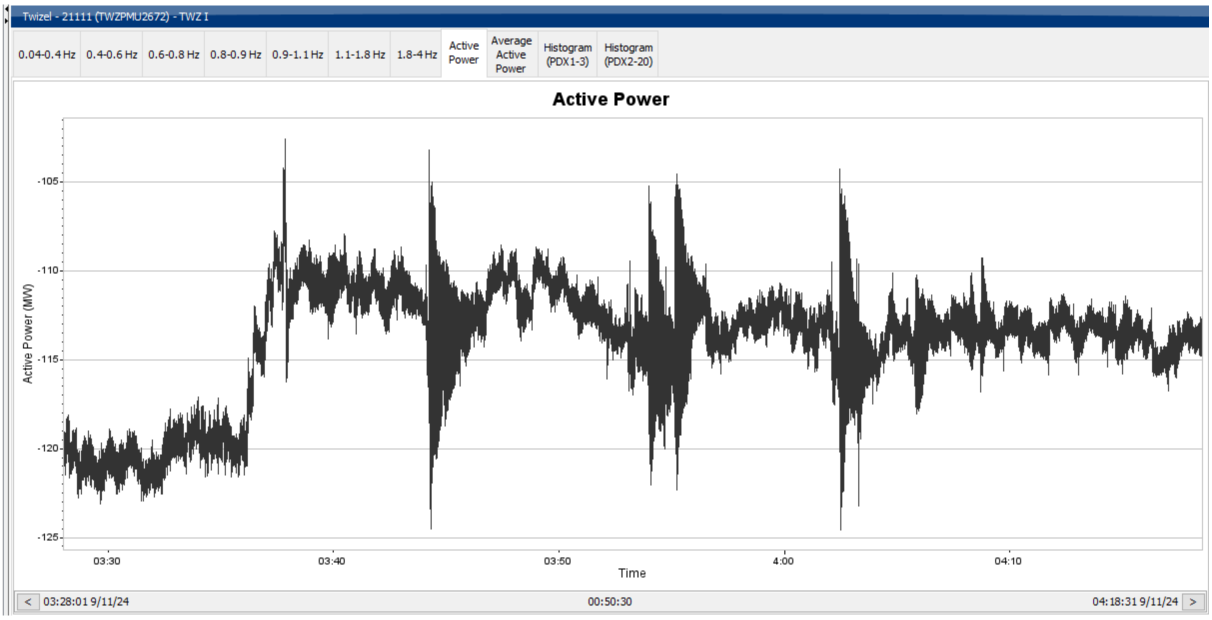
2.1 Typical Modes observed on the Island

Mode freq.	Signal	Comments	Typical behaviour
0.04 Hz	All-f All-P	Low frequency hydro governor mode Well damped but detected almost continuously	Frequency analysis - at all sites Magnitude observed is in the 10 to 70 mHz range, decay time in the 10 to 30s range (which is only approx. 1 cycle at this frequency) MW analysis – Magnitude is typically up to 2 or 3 MW but varies at different sites and can be up to 6 MW, decay time in the 10 to 30s range
0.25 Hz	All-f	Consistently observed but the cause has not been identified Can have periods of very low damping, but remains at low magnitude. Will be investigated if the magnitude increases	Frequency analysis - at all sites Magnitude observed is in the 1 to 5 mHz range, decay time can be up to 100s (or more) MW analysis – mode is detected with similar long decay times, but magnitude is very low, less than 1 MW
0.5–0.6 Hz	NMA-f All	Not continuously observed, but very common. Some instances of increased magnitude appear to be related to the TWI load Could also be an inter-area mode but not identified by linear analysis. High decay times observed (>30s)	Frequency analysis - Magnitude up to 6 mHz at NMA, 2 or 3 mHz elsewhere, decay time typically 50 to 60s. MW analysis – Magnitudes below 1 MW at all sites, decay times similar to the frequency analysis
0.8–1.0 Hz	All-f All-P	Inter-area modes associated with Manapouri station. A number of modes exist, the mode observed will vary with generation dispatch and system outages	Frequency analysis - Magnitude up to 5 mHz, decay time typically below 10s but can be up to 30s. MW analysis – Magnitudes typically below 1 MW at all sites,

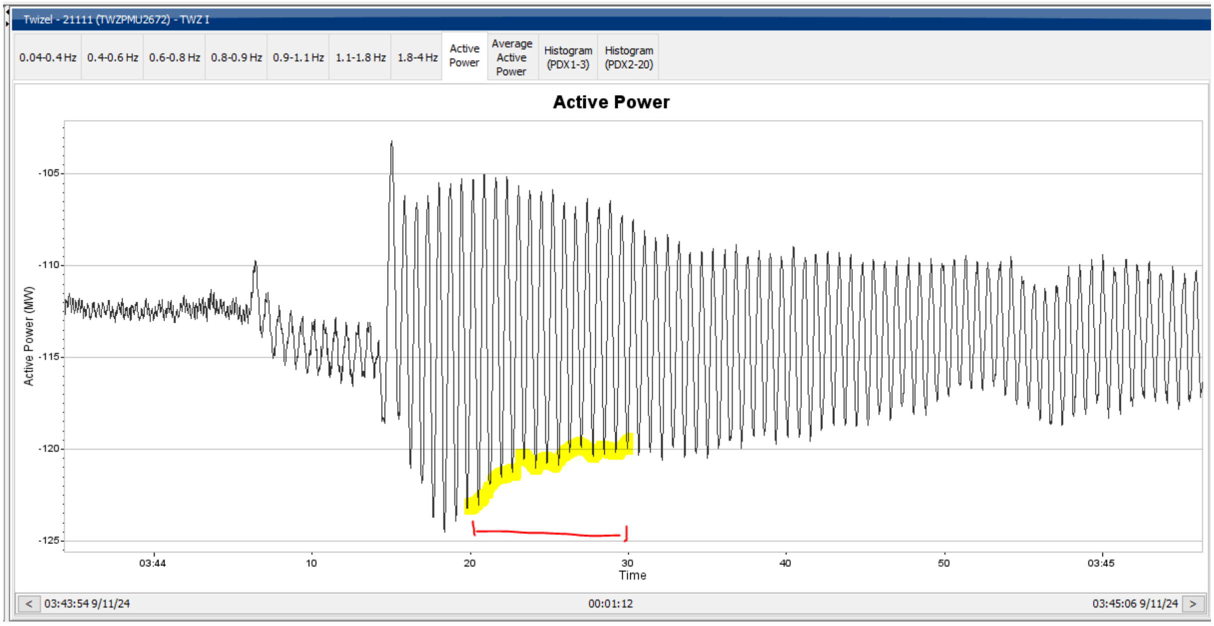
			decay times similar to the frequency analysis
1.0–1.5 Hz	All-f All-P	Local and inter-area modes. Commonly observed at all sites, such modes exist for all synchronous generation	Frequency analysis - Magnitude up to 3 mHz, decay time typically 20s. MW analysis – Magnitudes up to 2 MW at all sites, decay times up to 40s.
>2.0 Hz	KIK-f ISL-f All-f	Controller modes Well damped, possibly associated with SVC and STC control as it is observed most in KIK-f and ISL-f	Frequency analysis - Magnitude up to 3 mHZ at KIK and ISL, up to 1 mHz elsewhere, decay time typically 20 to 30s. Magnitude and decay times reduce at more southerly sites MW analysis – rarely observed, magnitudes will be very low, decay times similar to frequency analysis.

2.2 Unusual Behaviour Observed this month

On Saturday 9th November between 03:30 and 04:15 there were a number of "ring-down" oscillations observed particularly at Twizel in the MW data. These events excited local mode oscillations of around 1.5 Hz with a higher than usual amplitude.

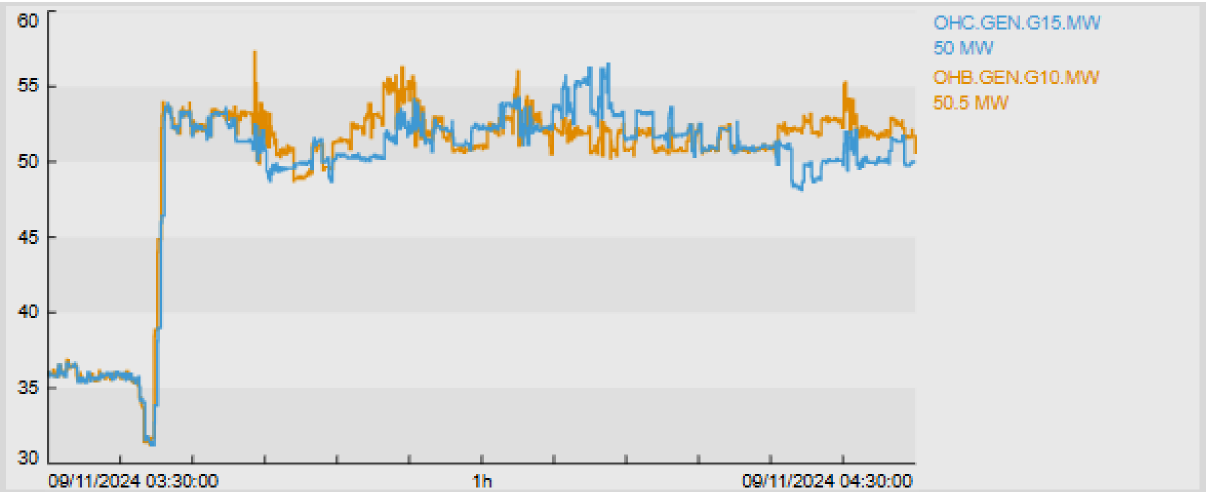


Each event was quite similar with an initial oscillation around 15 MW peak to peak, which decayed away in 20 or 30 seconds.



Although unusual to capture these in this monthly monitoring (because the decay times are usually quite significantly shorter) these are still quite typical responses of the power system to sudden disturbances. The poor damping will be due to the time (03:30 on a November Saturday morning) when there would be less generation running.

SCADA data indicates only one machine at each of OHB and OHC stations. The inter-station mode between these stations is close to 1.5 Hz and any power oscillation would pass through TWZ. There is evidence of this oscillation in the 4 second SCADA data.



There was no change in power transmission on the grid before and after the disturbances and no record of switching or faults on the grid at the times.

The events are assumed to be due to disturbances at Ohau or at a lower voltage level. No further investigation is required for this behaviour.

3 How To Interpret the Graphical data

The reporting is done in various plots, which are explained in this section.

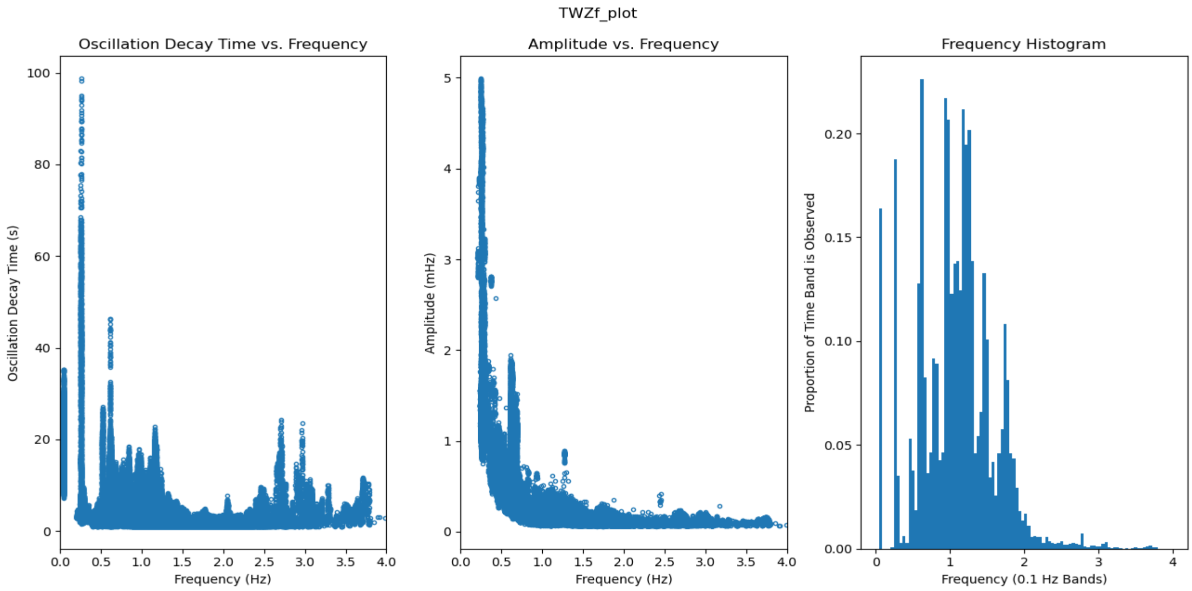
The analysis is done on two power system variables : frequency (Hz) and Real Power (MW)

At PMUs measuring reactive power devices (such as ISL and KIK) only frequency is analyzed, so in the South Island reports there are 6 locations for frequency and 4 locations for MW.

Section 4.1 has histogram plots. These show the decay time (1st plot) and magnitude (middle plot) of every recorded oscillation mode (the frequency of the mode is the x-axis in 0.1 Hz increments). These do not show when the particular points were recorded.

The 3rd plot is a cumulative frequency plot to indicate how often each particular modal frequency (in 0.1 Hz bands) was reported. The source software reports on the modes it detects, updated at 20 second intervals, and it can identify from 0 to 5 modes at each time. For a 31 day month there would be 133,920 results (= 3*60*24*31) with 0 to 5 modes in each – and the histogram is showing the proportion of the 133,920 results which contained this mode frequency.

Example below is the TWZ frequency analysis histograms :

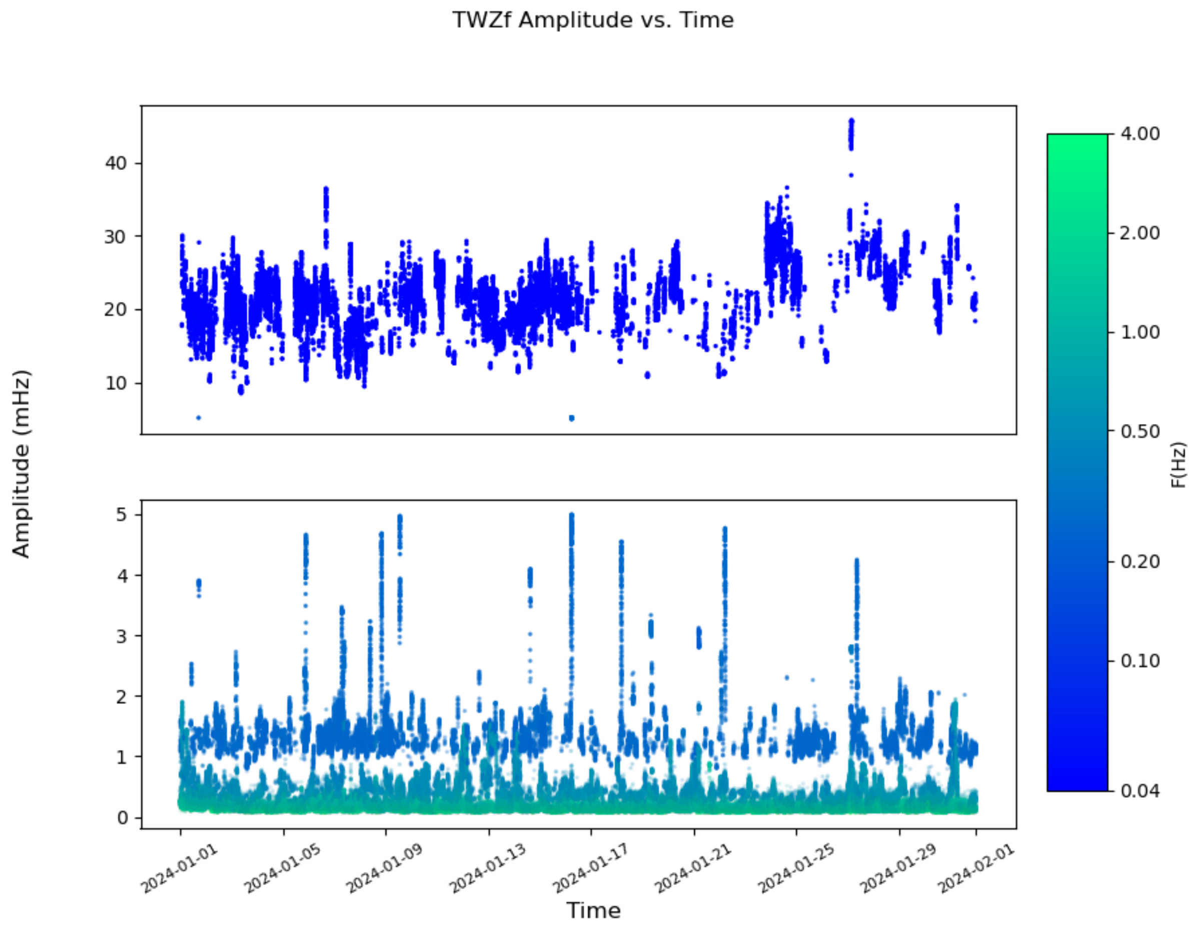


Note that the magnitude plot in the frequency (mHz) histograms is scaled to show the typical range of amplitude and does not usually show the 0.04 Hz mode amplitude as it is above the scale. This amplitude is shown in the time series data.

Section 4.2 has time series plots. These show the results plotted against the day of the month along the x-axis. The plots use a colour coding (heat scale) for each data point to represent the mode frequency.

For each variable analyzed there are 3 time series plots, the first just shows the mode frequency detected (the heat scale does not add any information to this plot but is retained for consistency), the second shows the amplitude recorded and the 3rd shows the decay time expressed as the number of oscillation cycles at that modal frequency. Expressing the decay time in cycles provides a better indication of whether the decay time is a problem or not.

For the same TWZ frequency results as shown in the histograms above the amplitude time series plot is shown below (note the y-axis scale is split into 2 plots to show the higher magnitude of the 0.04 Hz mode) :

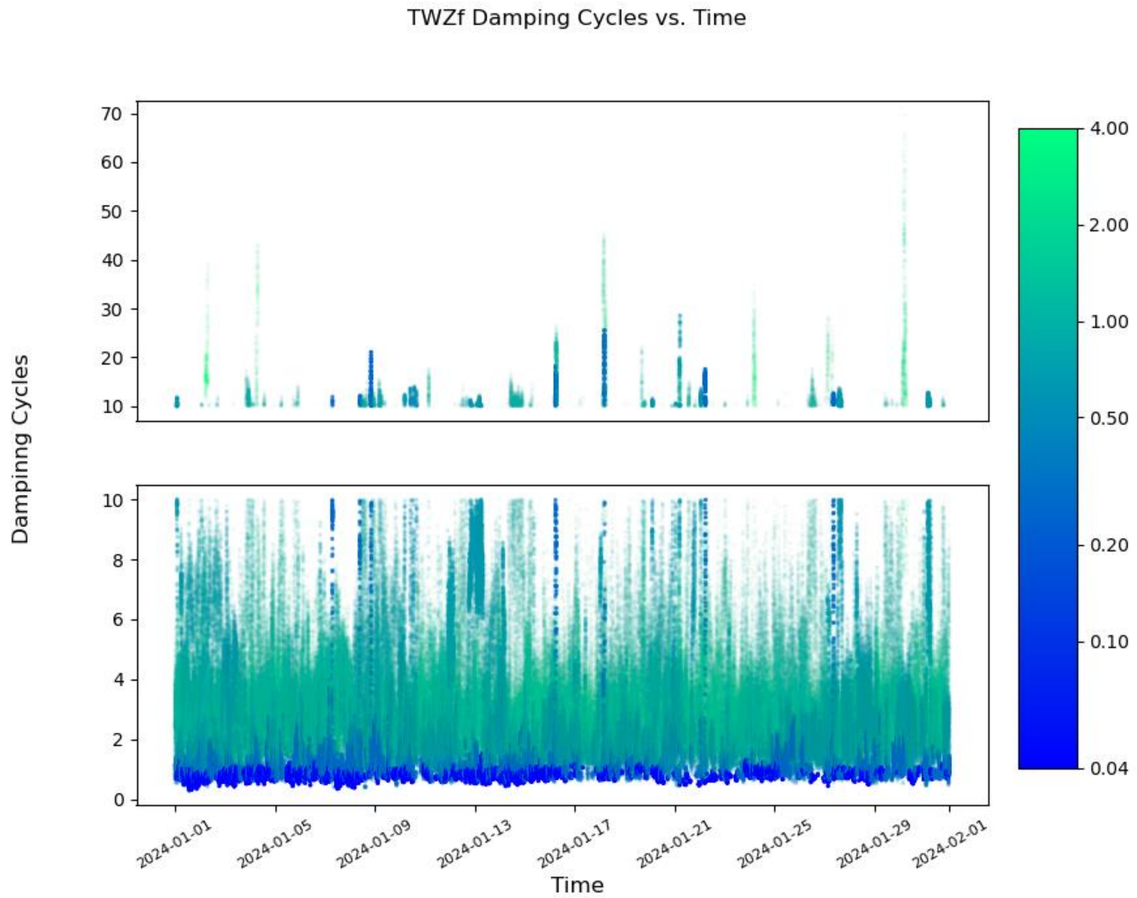


The heat scale shows the modal frequency of the particular amplitude result, in this case the 5mHz peaks are all at or close to the 0.25Hz mode.

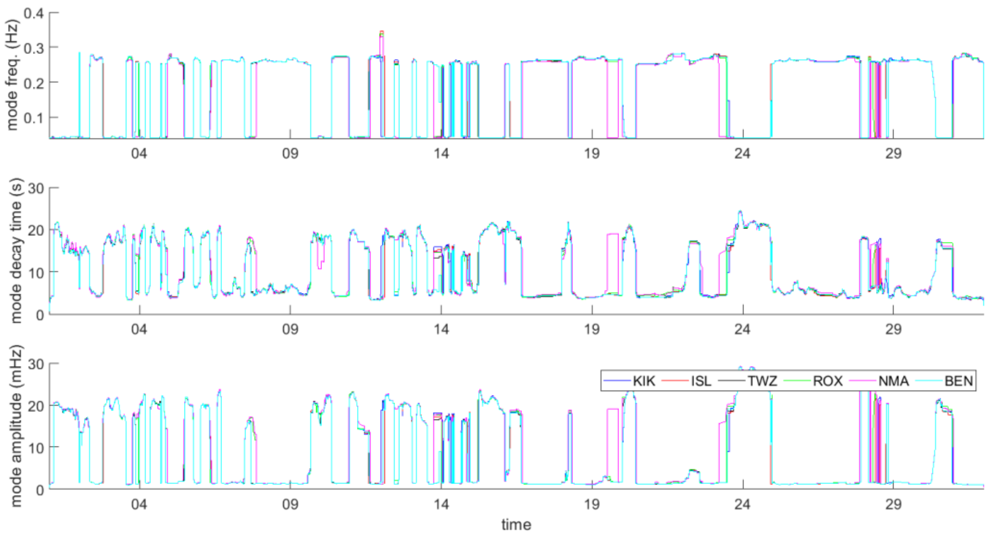
The histogram identifies that there are results with 5 mHz amplitude at this frequency - the time series plot indicates the spread of these peak occurrences through the month and also shows any other characteristics at that frequency – such as the 'normal' amplitude.

The corresponding damping cycles time series plot is shown below.

The relatively high decay times of the 0.04 Hz mode are seen to be all below 2 cycles at that modal frequency. When decay times are say 40 or 50 cycles at a particular modal frequency there may be more cause for concern.



The pre-2024 monthly reports would have displayed the time series data as a smoothed trend with a frequency band (with all sites plotted together) i.e for the 0 to 0.4 Hz band :



The new method of plotting shows all the data – this shows the full-month time series behaviour of all modes – and overcomes the issue of only showing the 'worst' result within a band (which causes the plot above to alternately show the 0.04 Hz mode and the 0.25 Hz mode).

4 Detailed plots for November 2024

4.1 Mode frequency histograms

Remark: the frequency histograms are shown for a frequency range [0.04 4Hz]

4.1.1 PMU Frequency Data

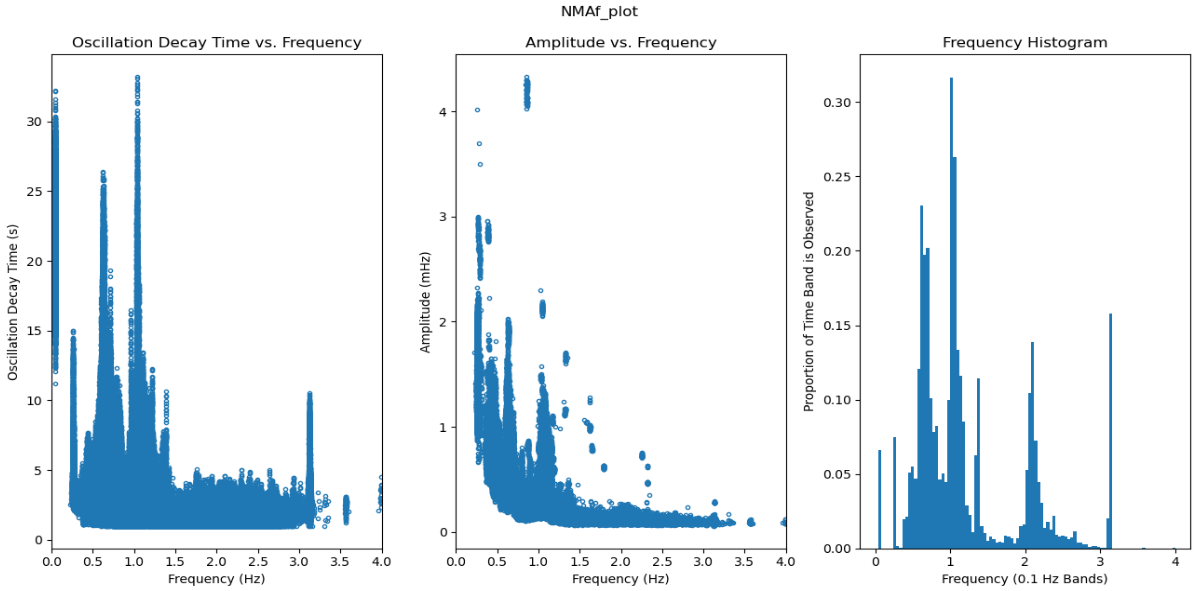


Figure 1: North Makarewa mode damping, mode amplitude, and frequency histogram using frequency data

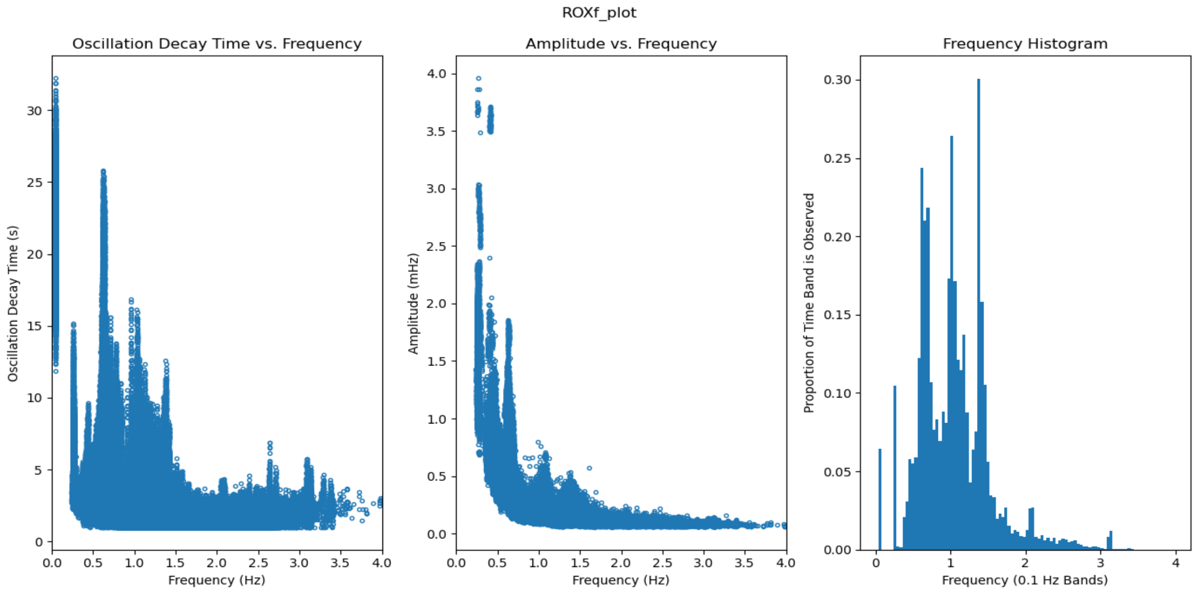


Figure 2: Roxburgh mode damping, mode amplitude, and frequency histogram using frequency data

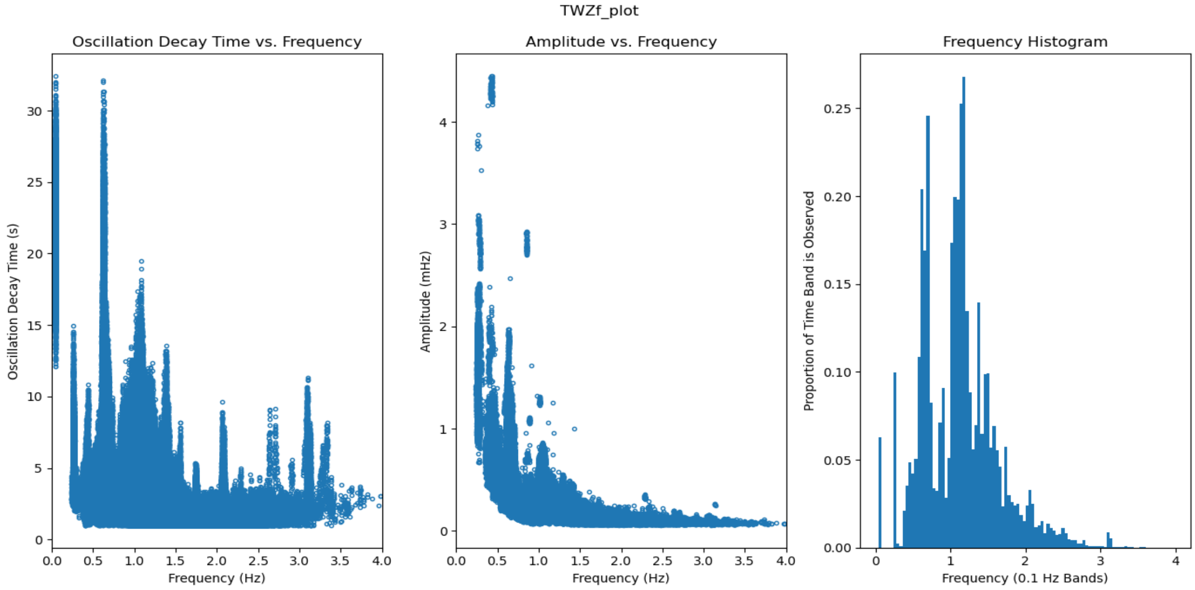


Figure 3: Twizel mode damping, mode amplitude, and frequency histogram using frequency data

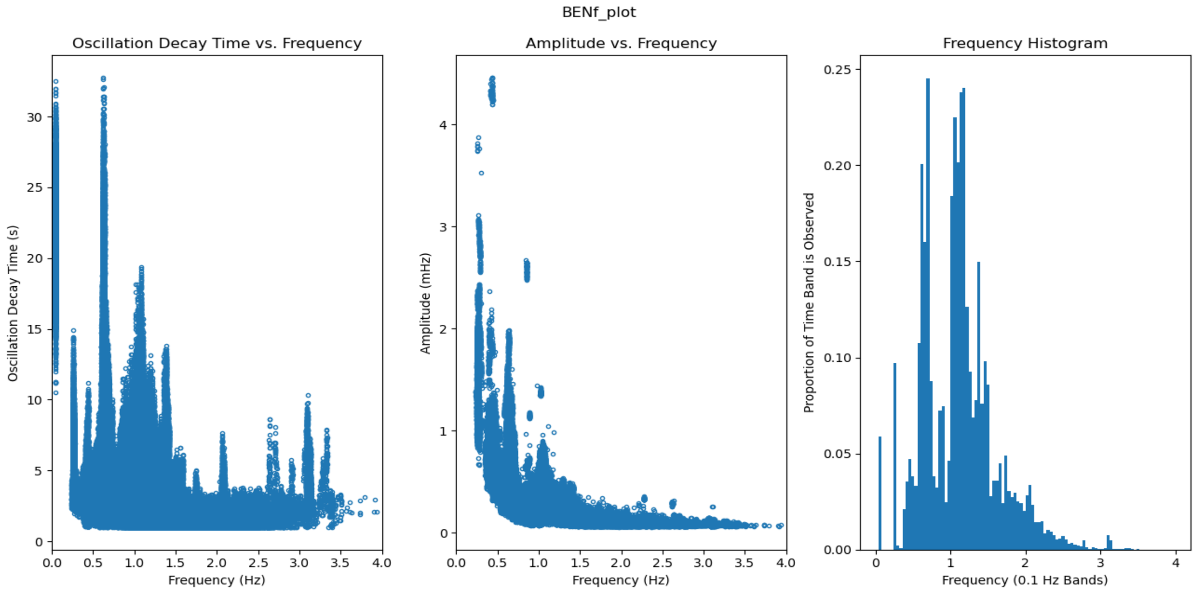


Figure 4: Benmore mode damping, mode amplitude, and frequency histogram using frequency data

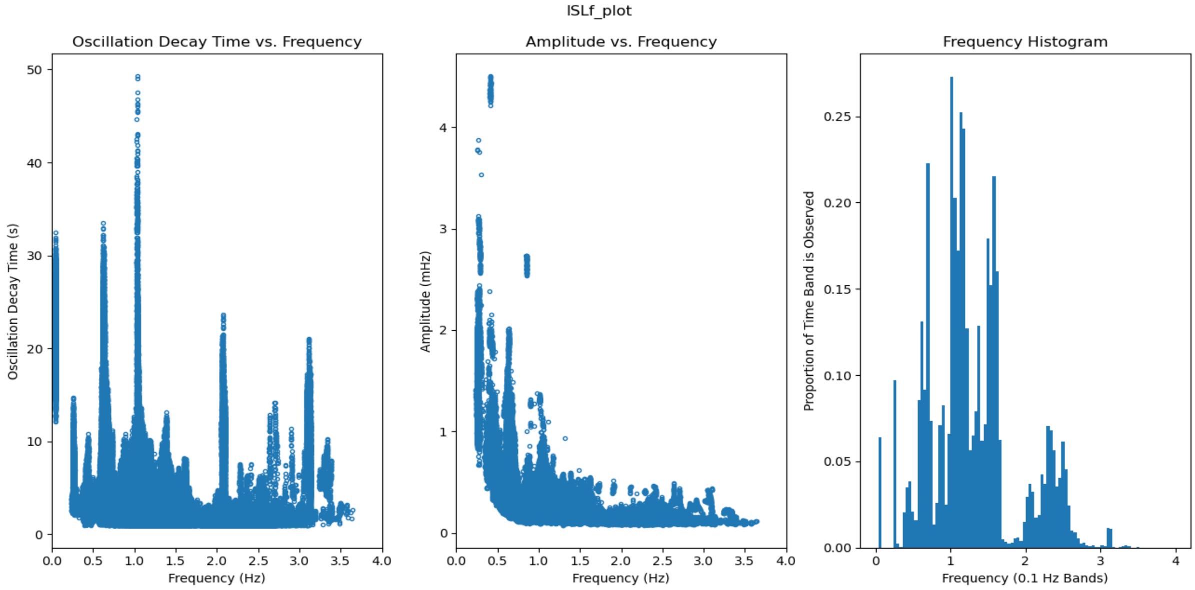


Figure 5: Islington mode damping, mode amplitude, and frequency histogram using frequency data

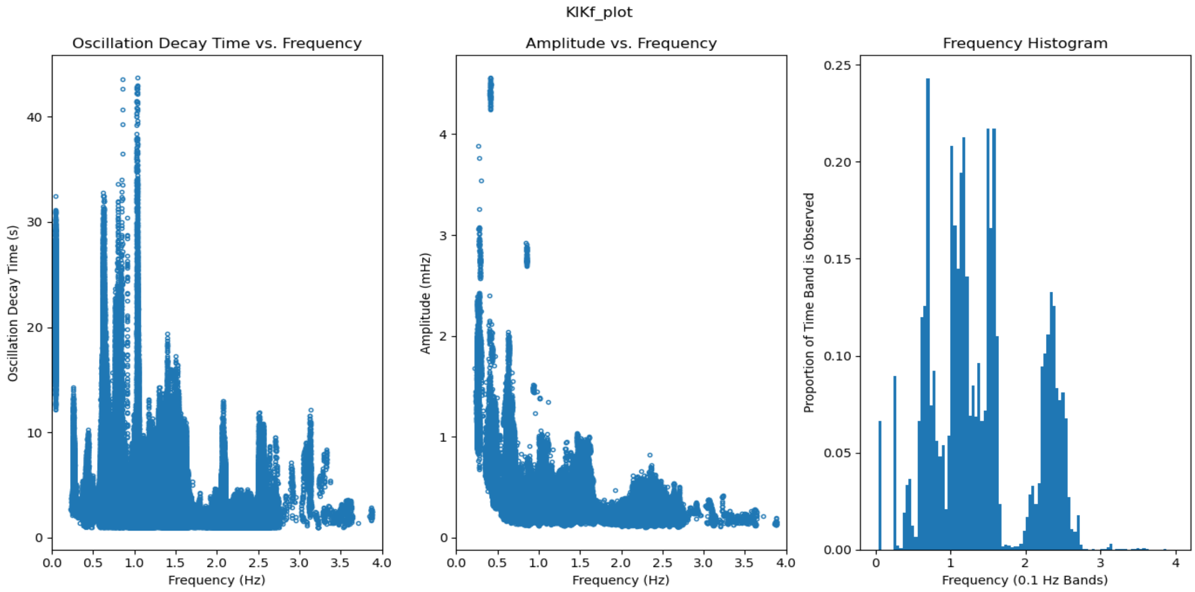


Figure 6: Kikiwa mode damping, mode amplitude, and frequency histogram using frequency data

4.1.2 PMU Active Power Data

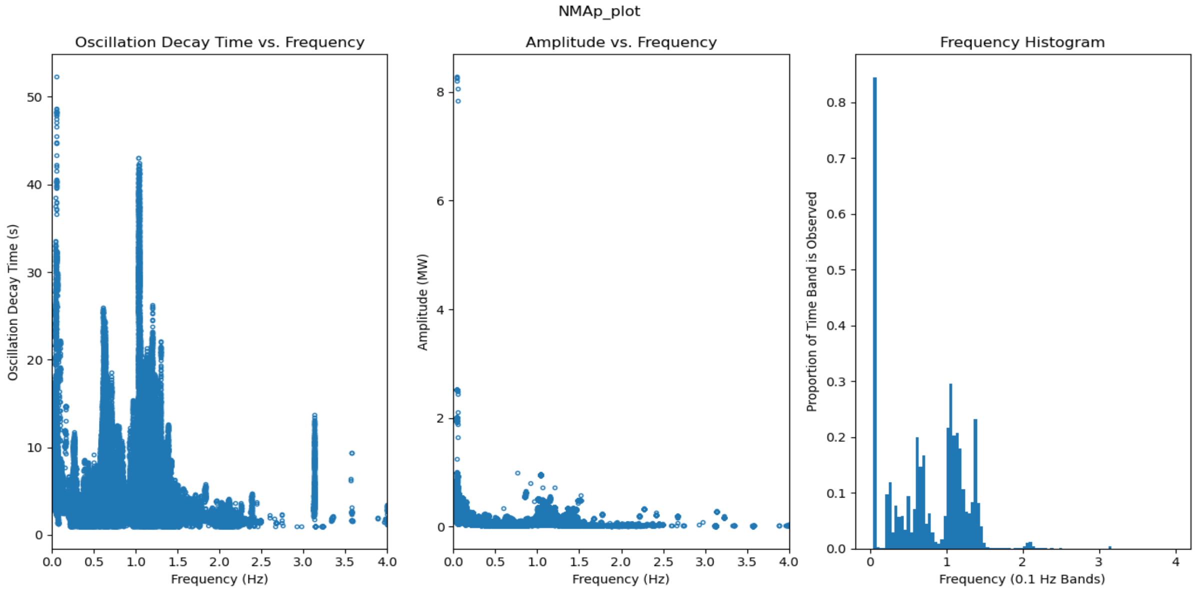


Figure 7: North Makarewa mode damping, mode amplitude, and frequency histogram using active power data

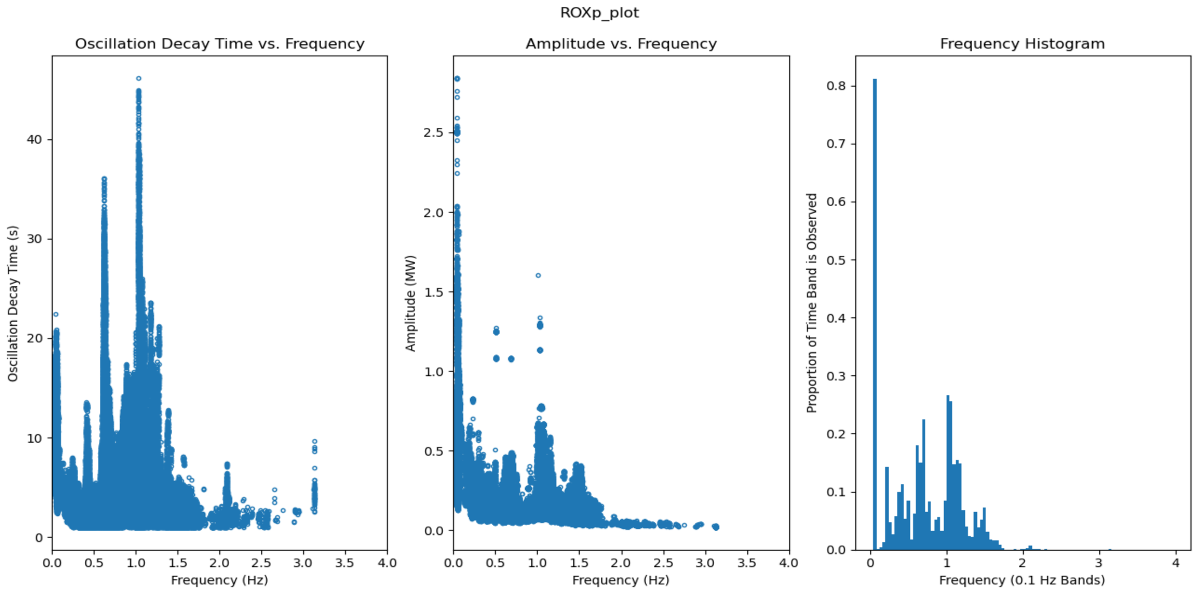


Figure 8: Roxburgh mode damping, mode amplitude, and frequency histogram using active power data

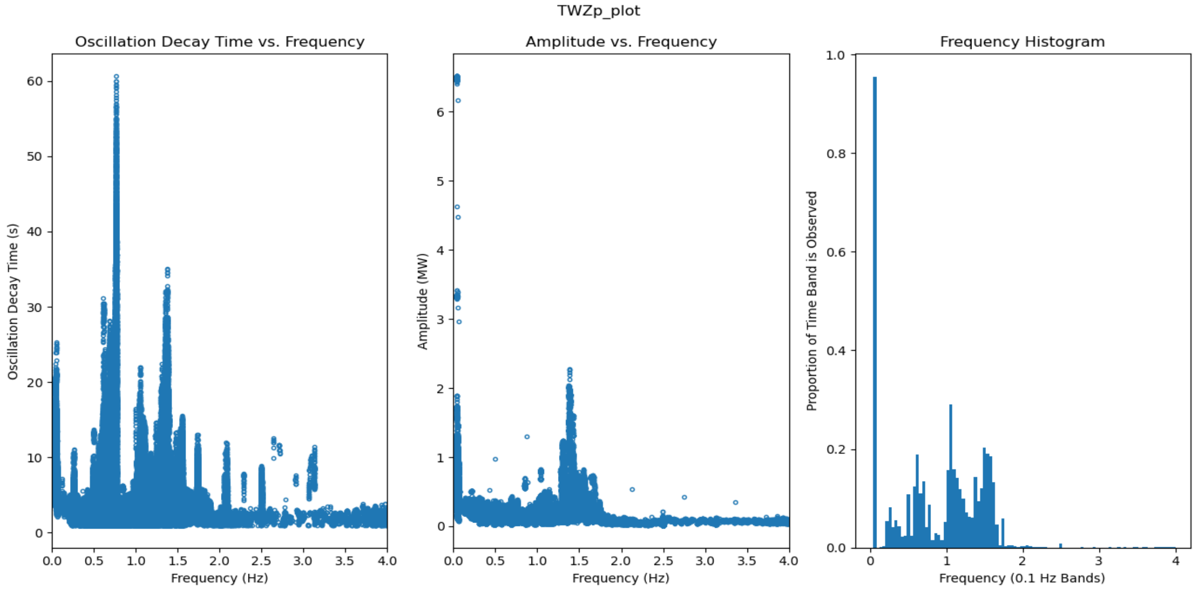


Figure 9: Twizel mode damping, mode amplitude, and frequency histogram using active power data

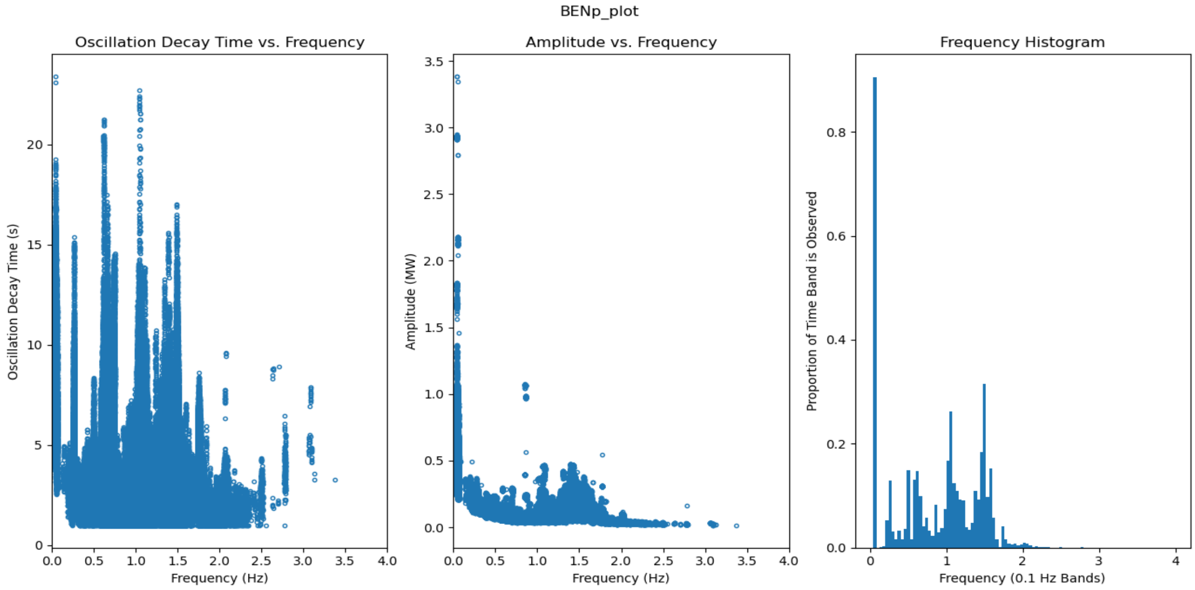


Figure 10: Benmore mode damping, mode amplitude, and frequency histogram using active power data

4.2 Time Series Plots

4.2.1 PMU Frequency data

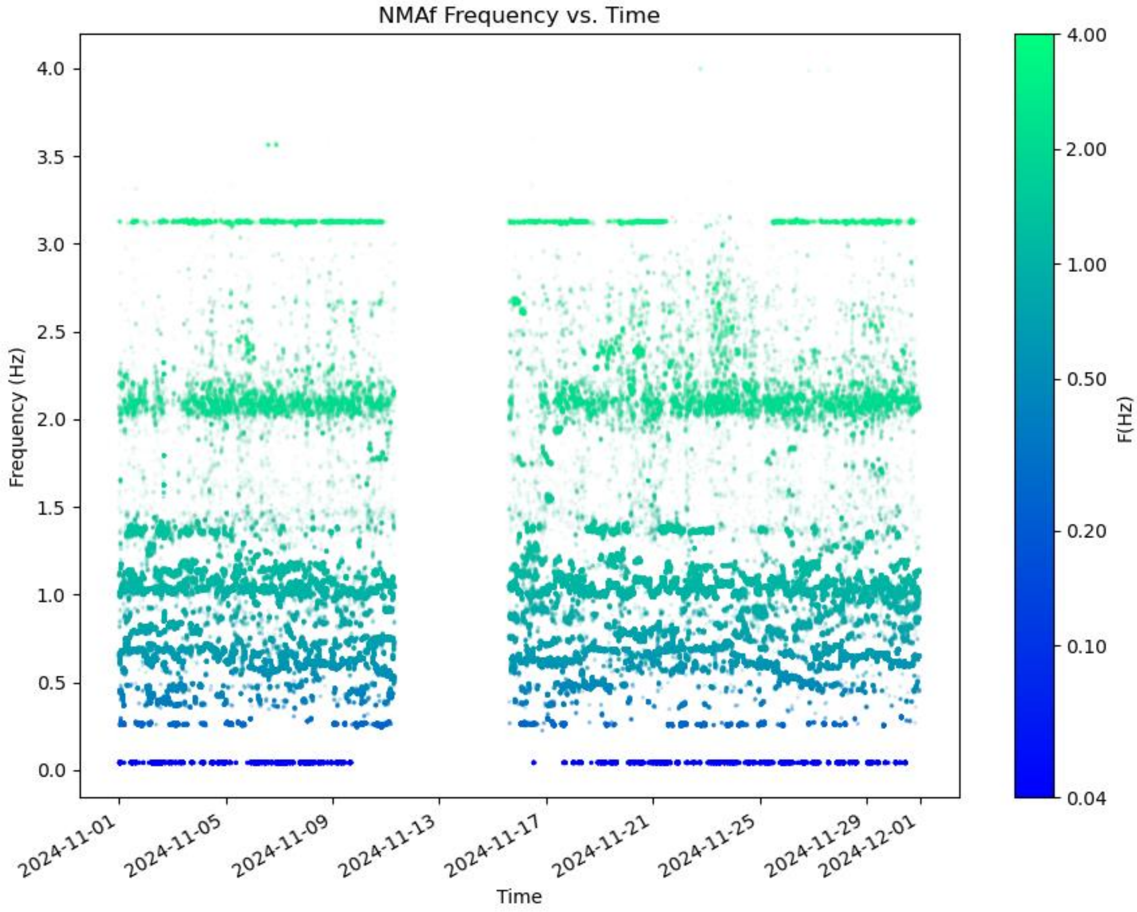


Figure 11: North Makarewa

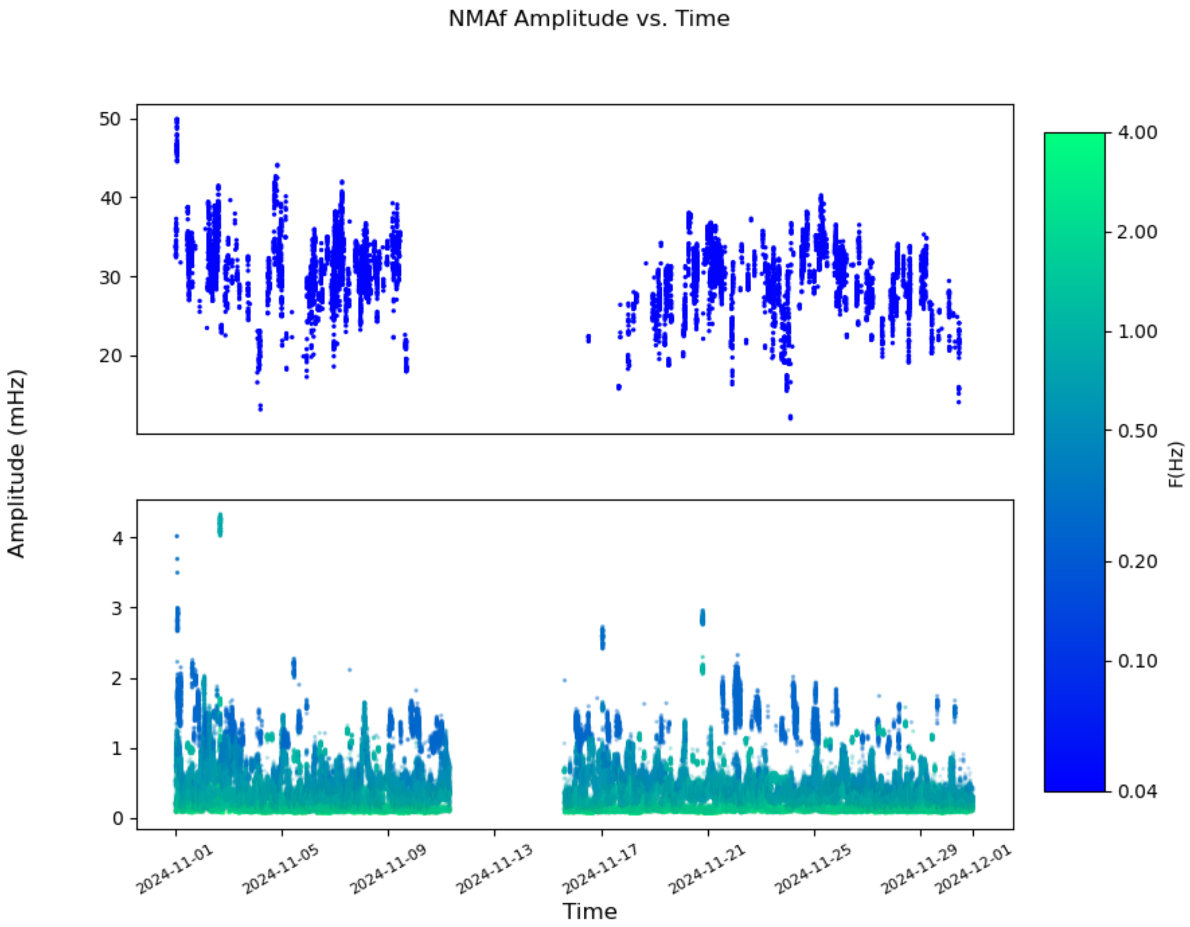


Figure 12: North Makarewa

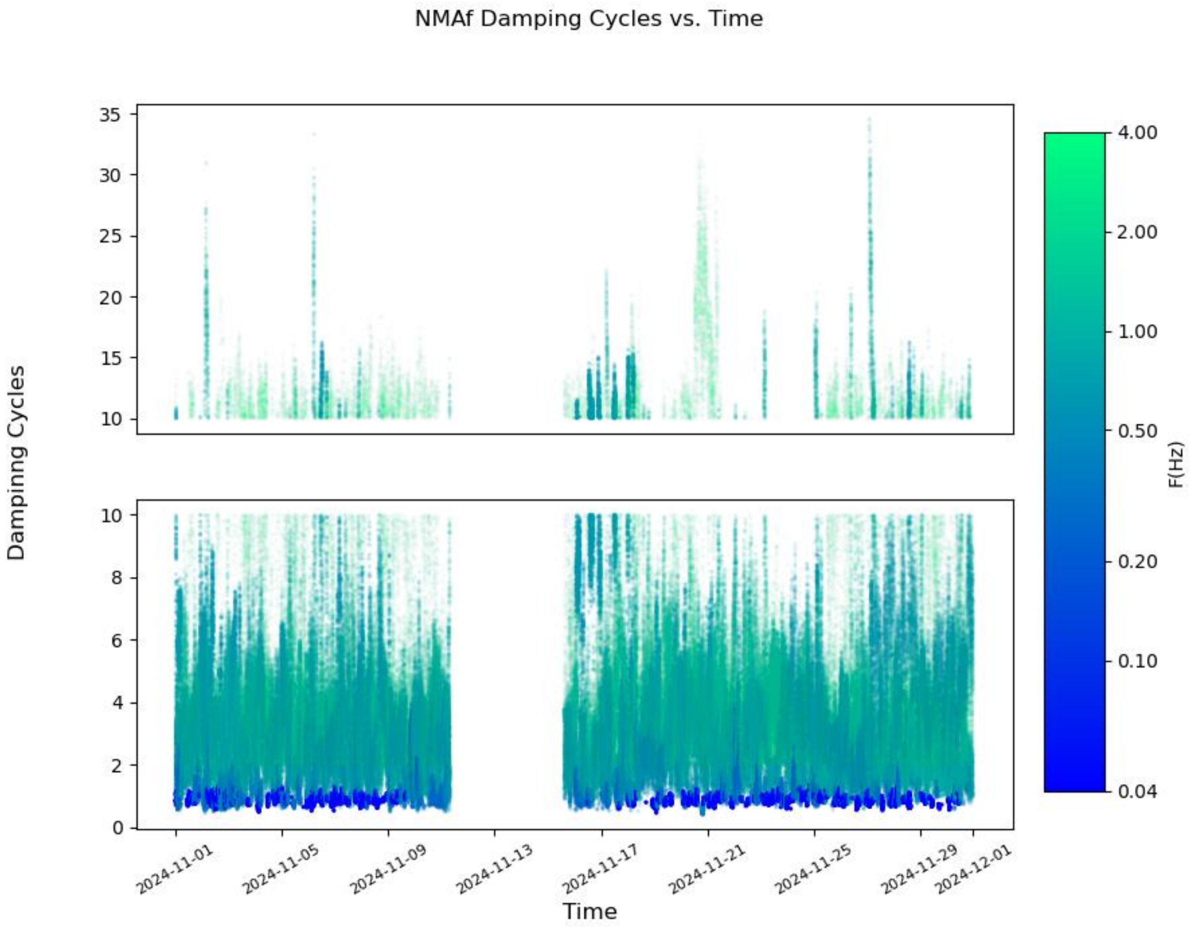


Figure 13: North Makarewa

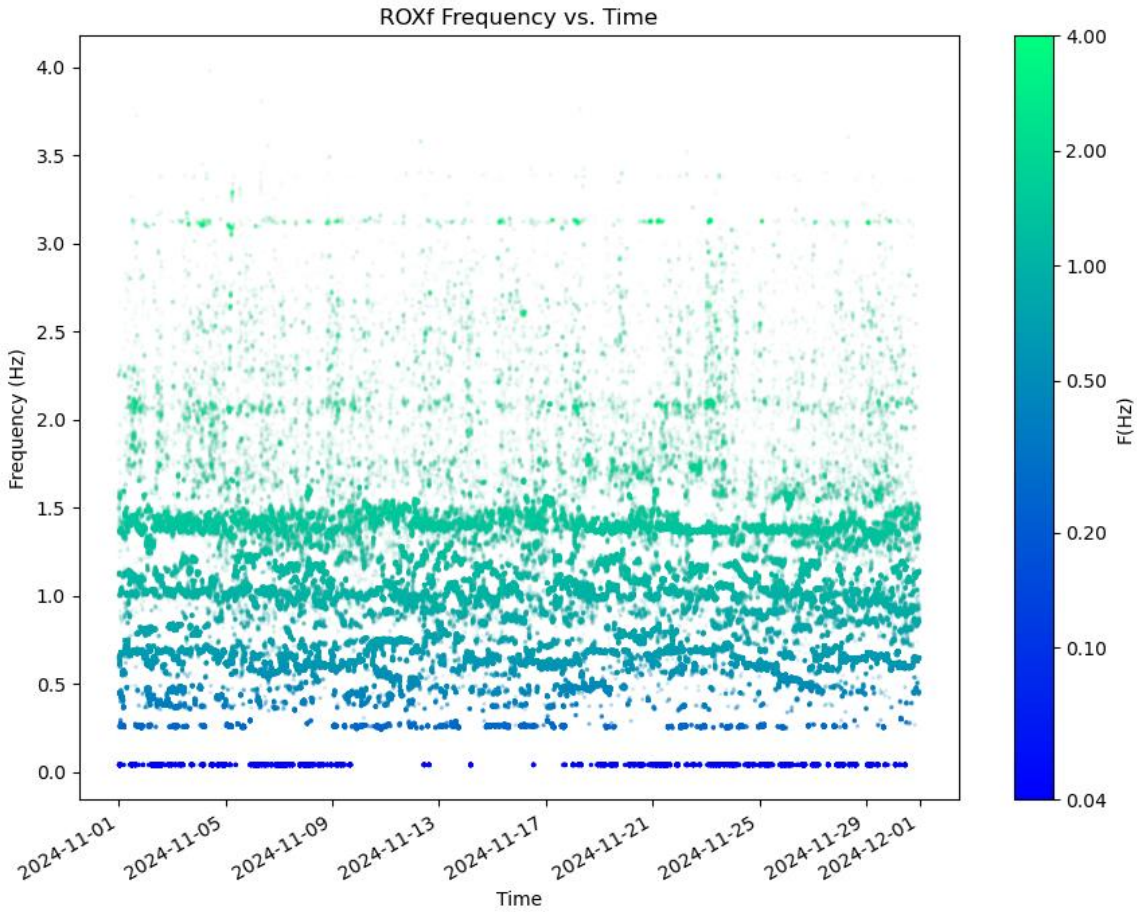


Figure 14: Roxburgh

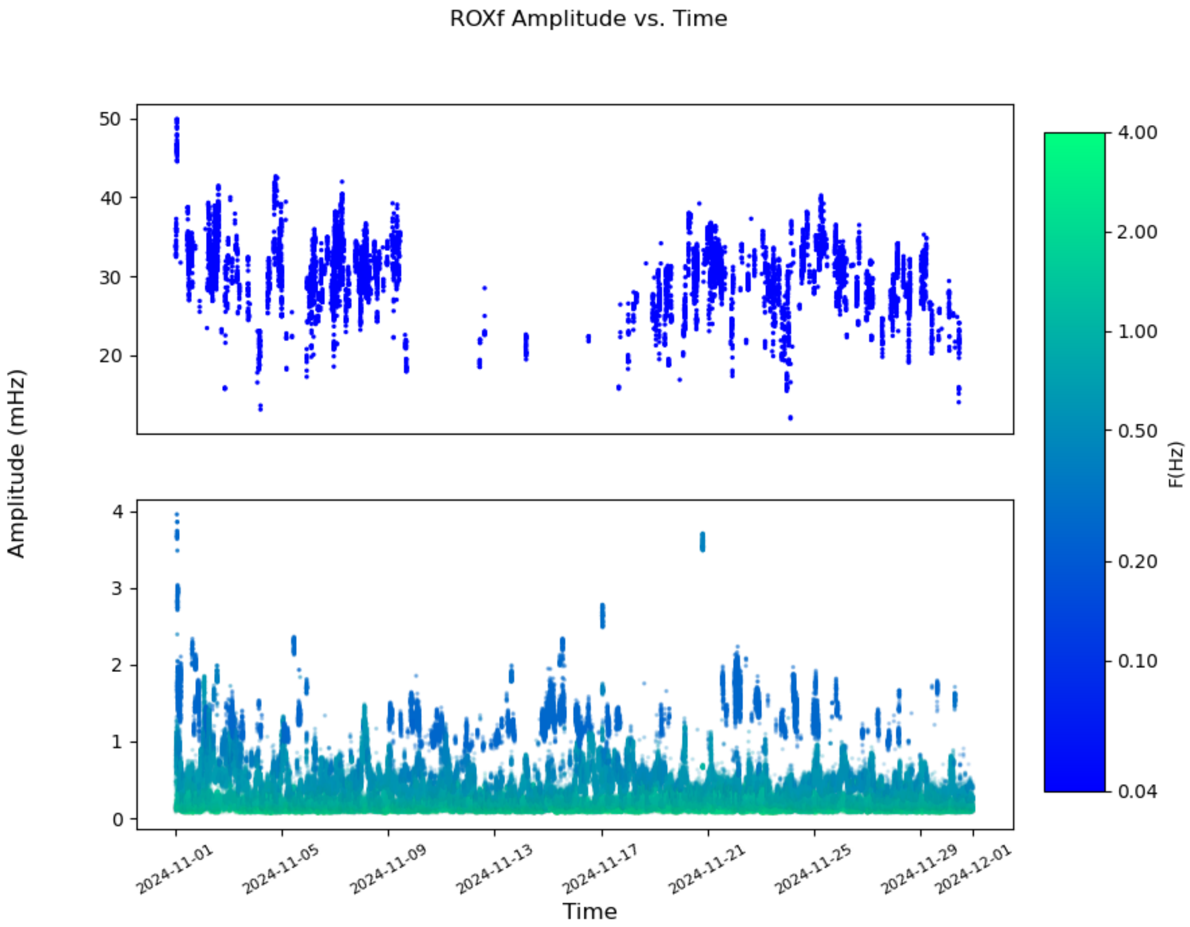


Figure 15: Roxburgh

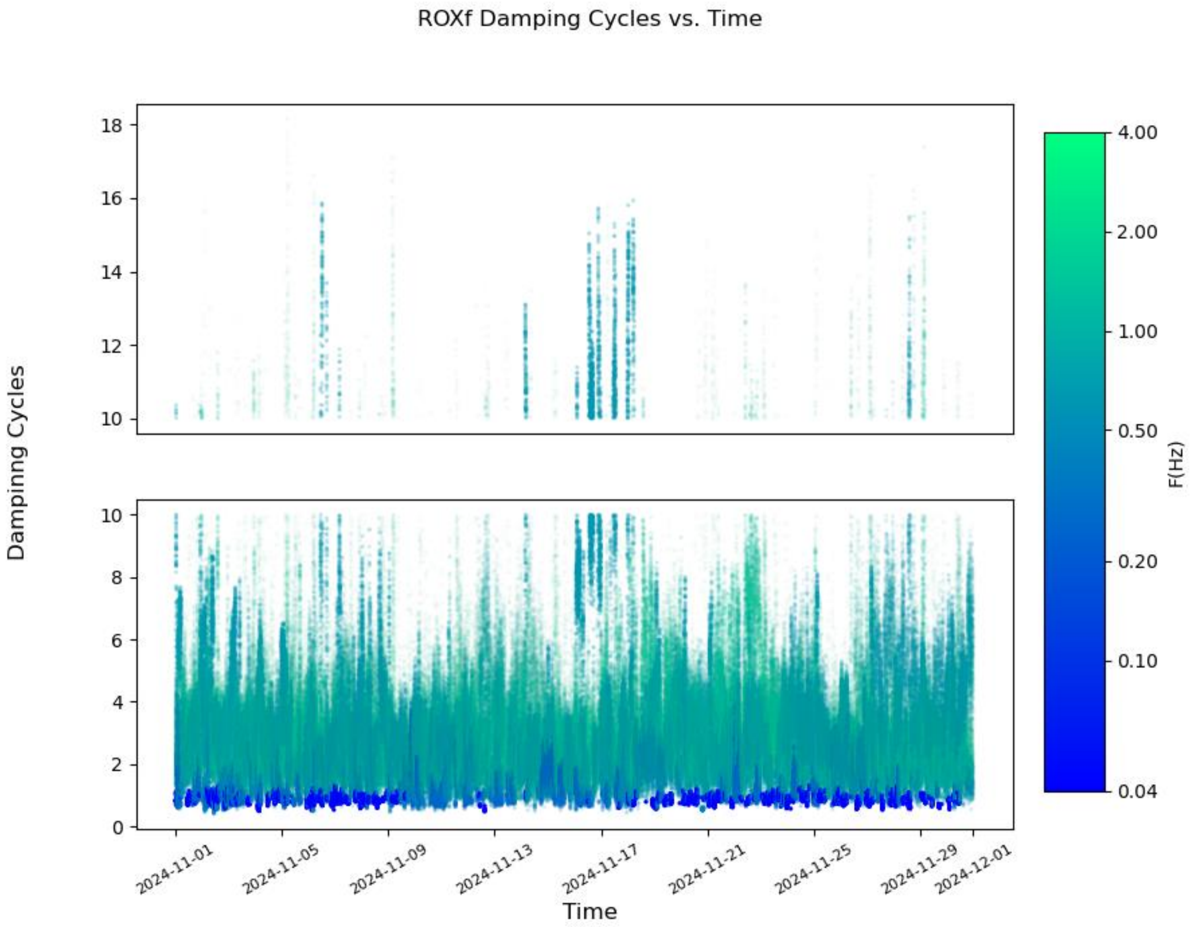


Figure 16: Roxburgh

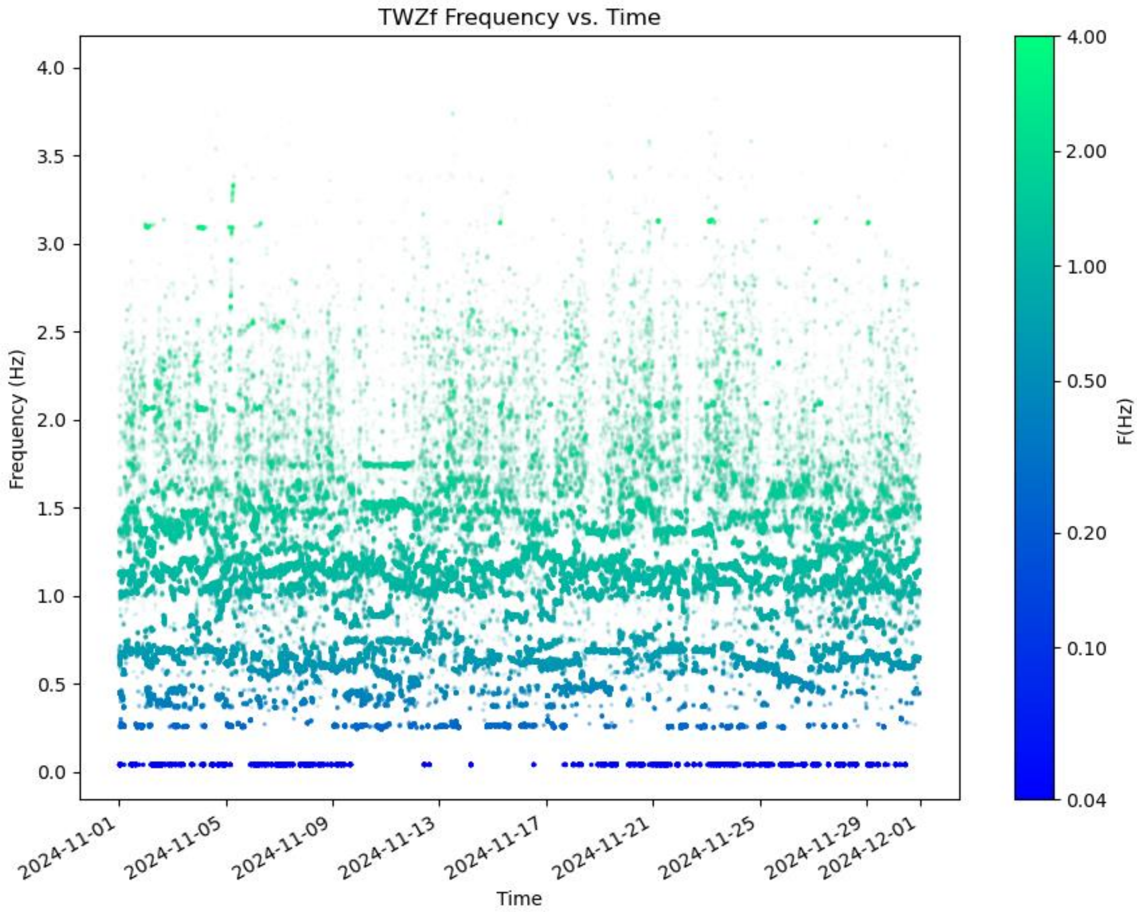


Figure 17: Twizel

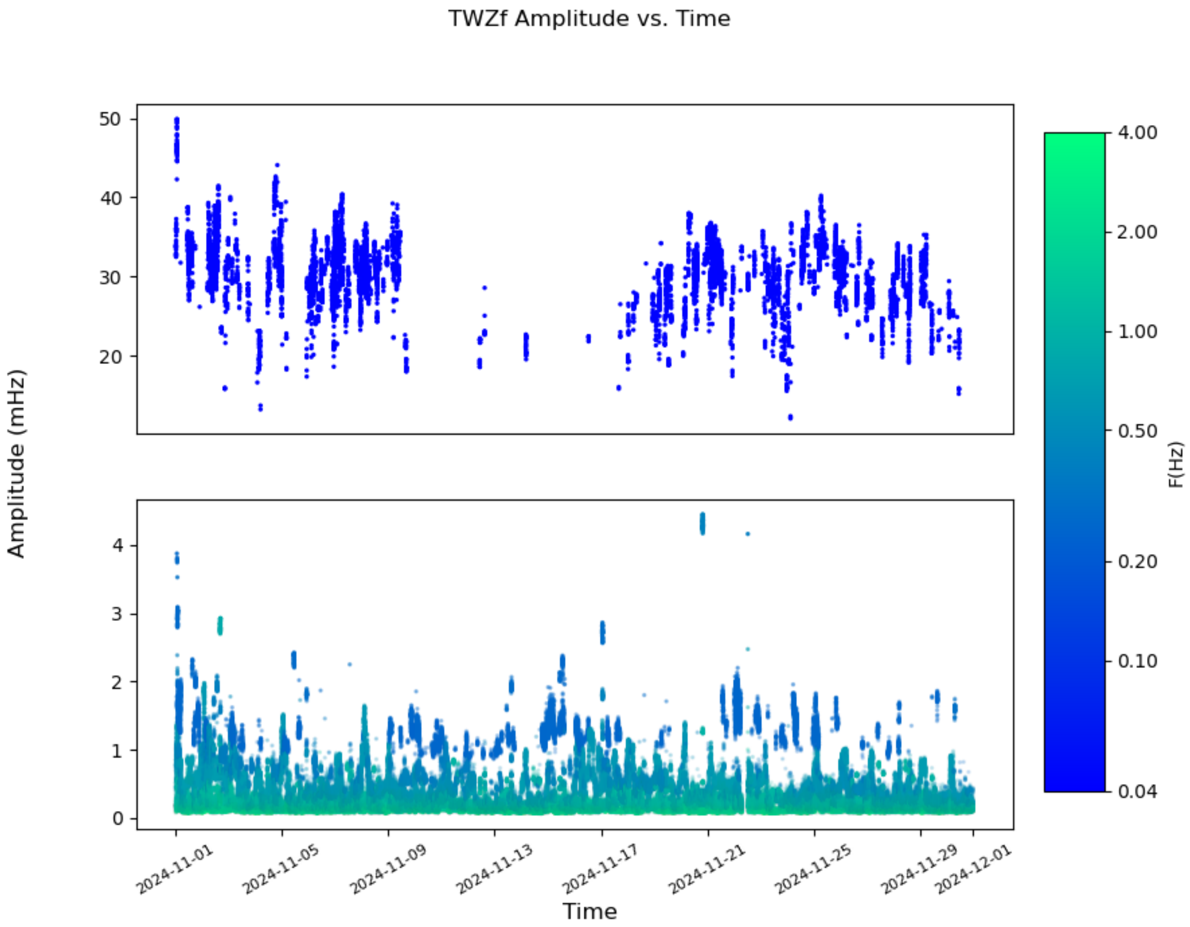


Figure 18: Twizel

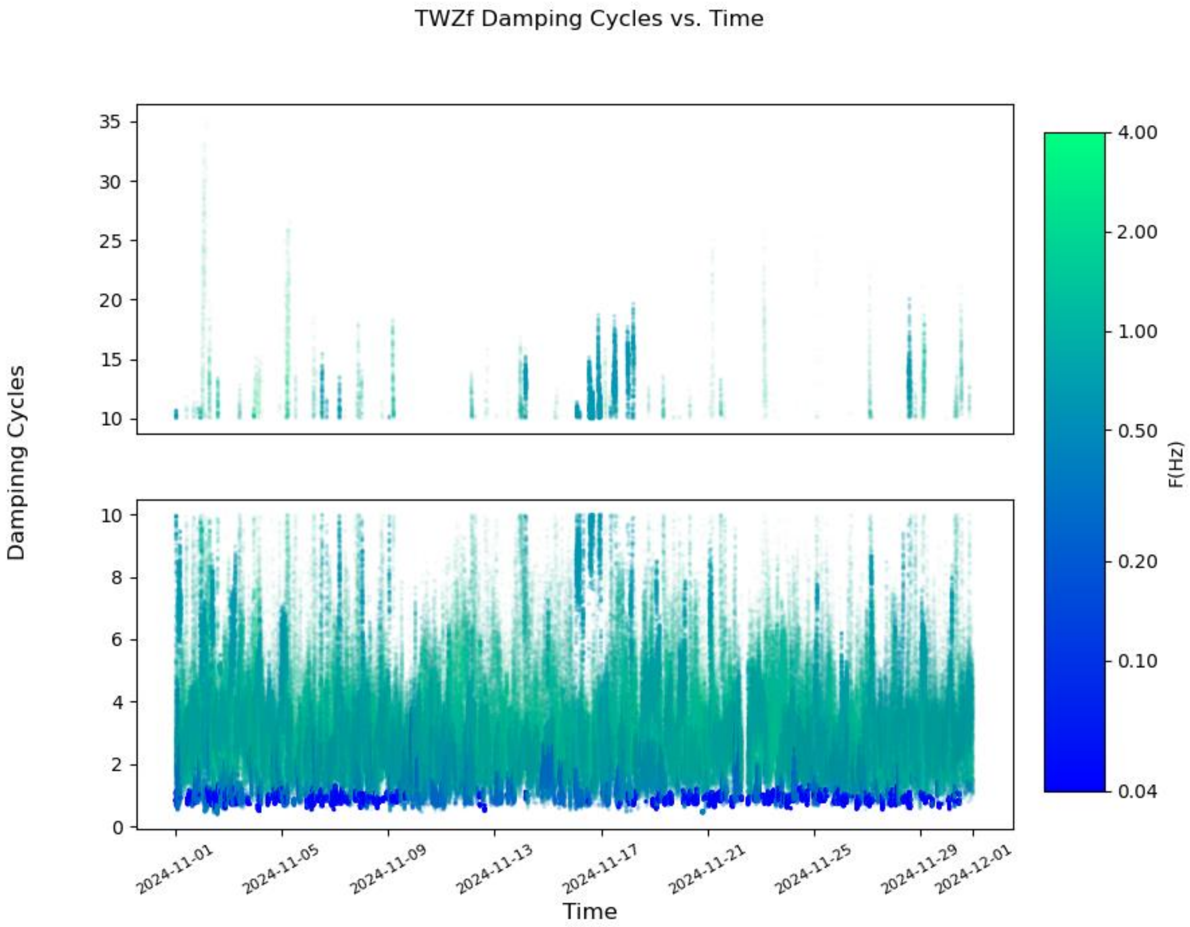


Figure 19: Twizel

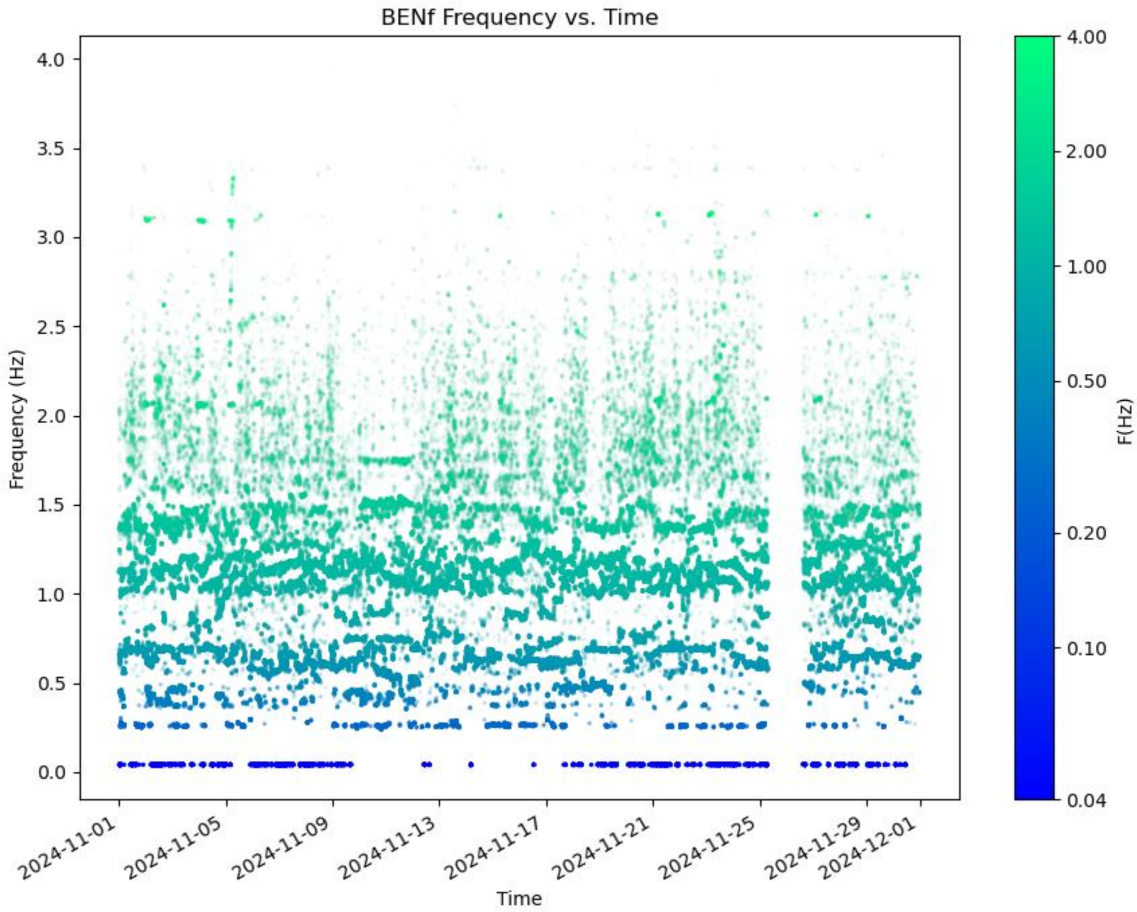


Figure 20: Benmore

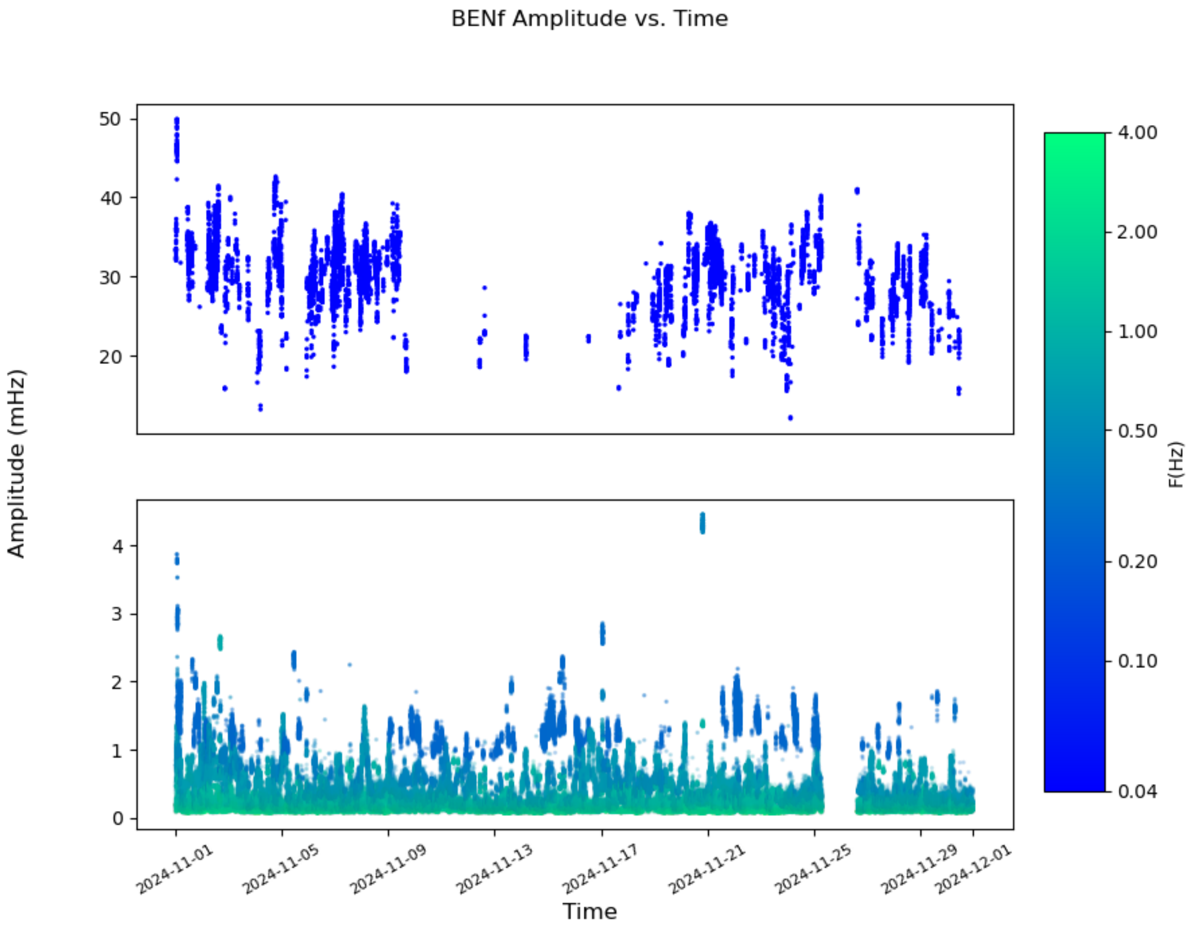


Figure 21: Benmore

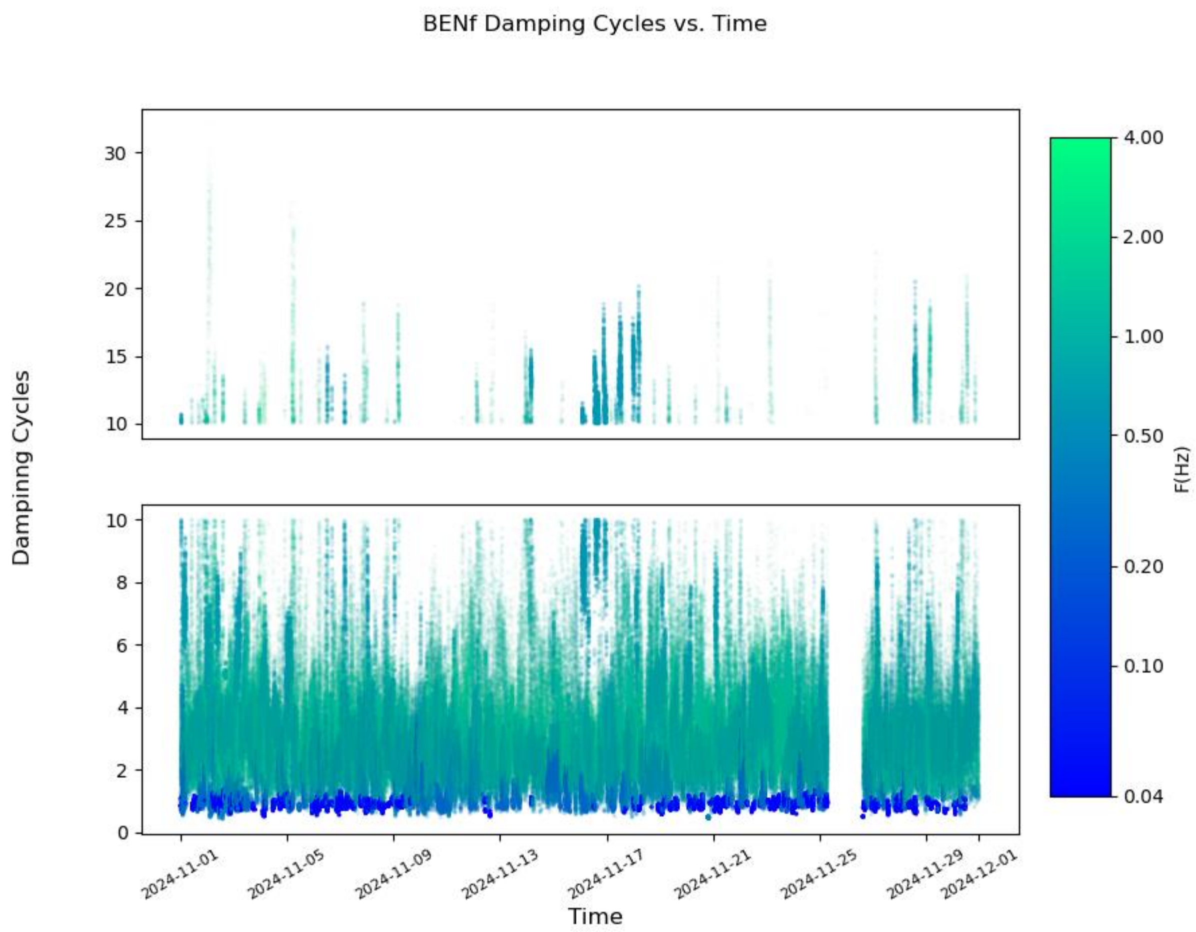


Figure 22: Benmore

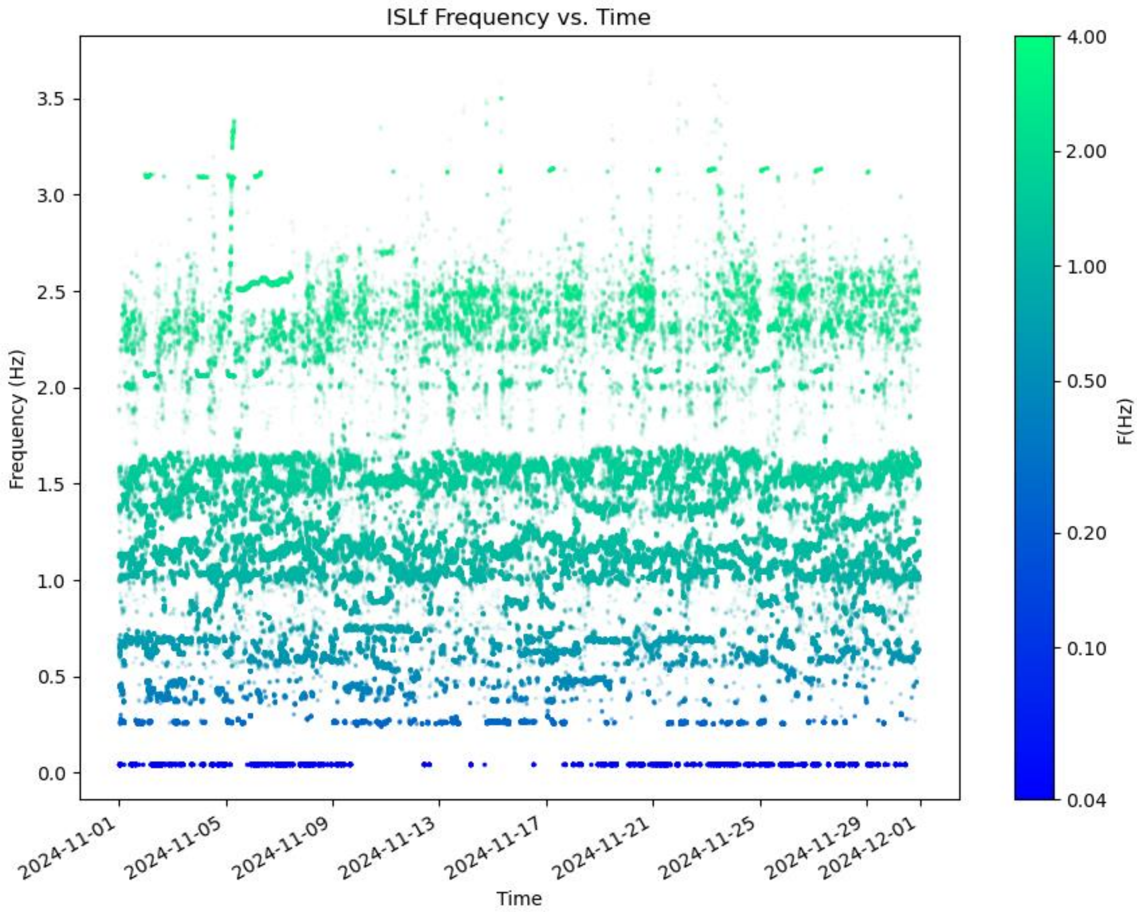


Figure 23: Islington

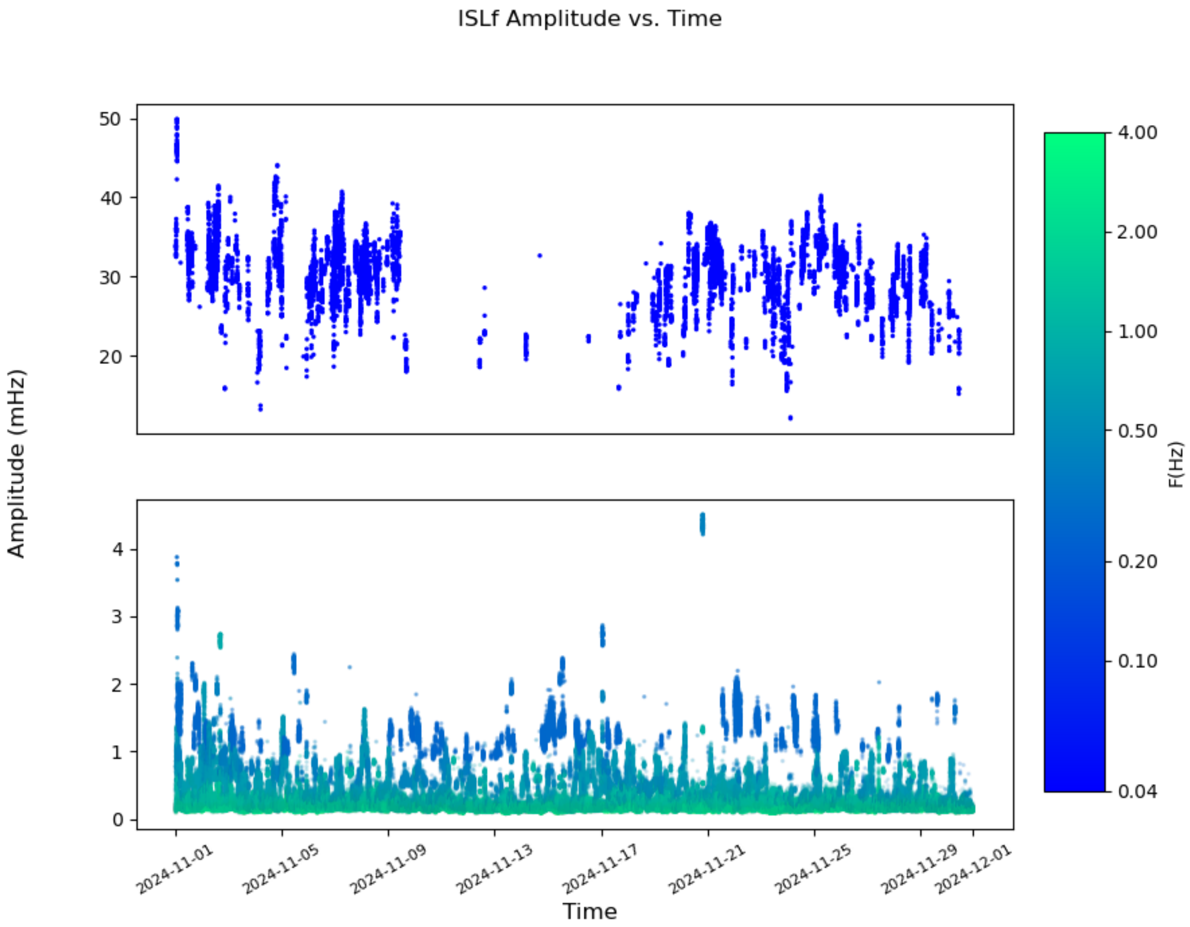


Figure 24: Islington

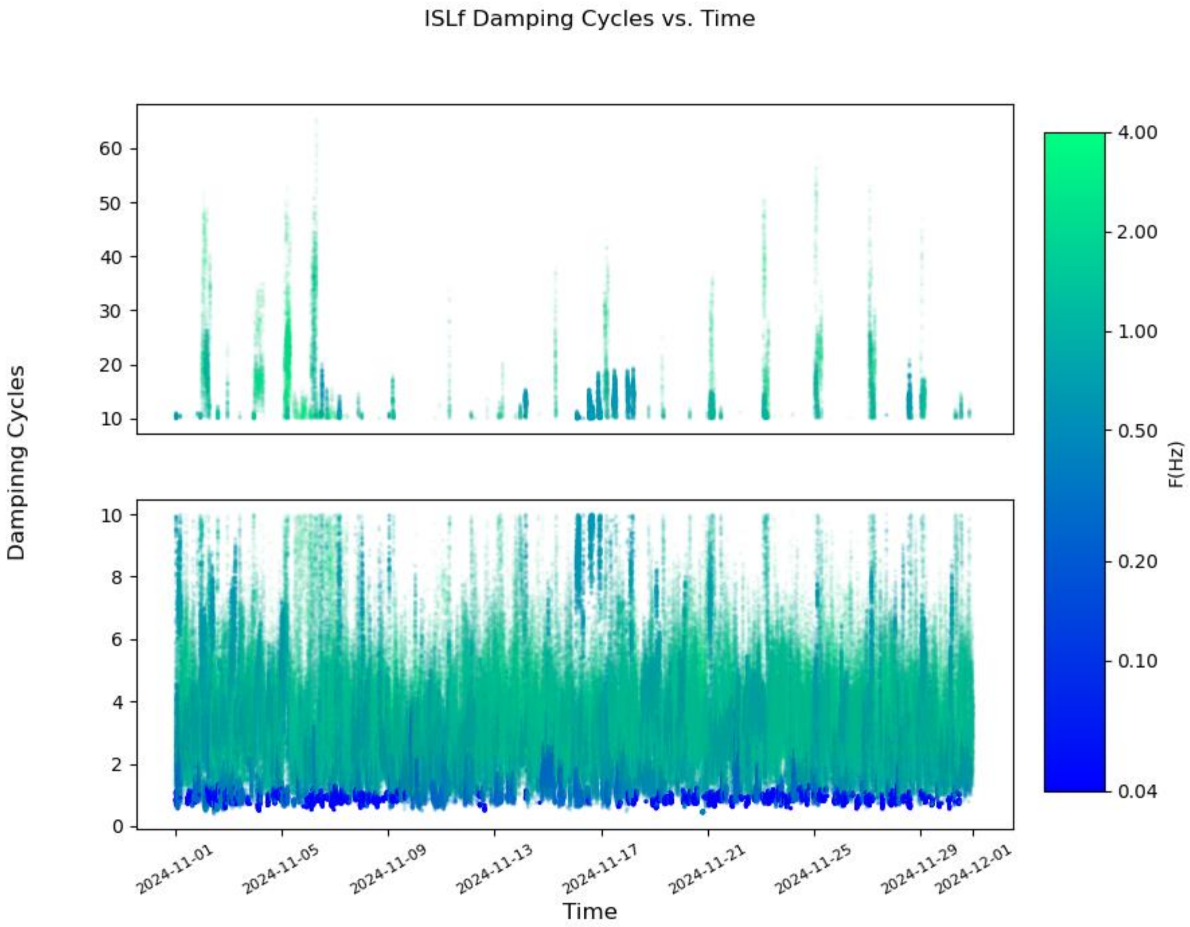


Figure 25: Islington

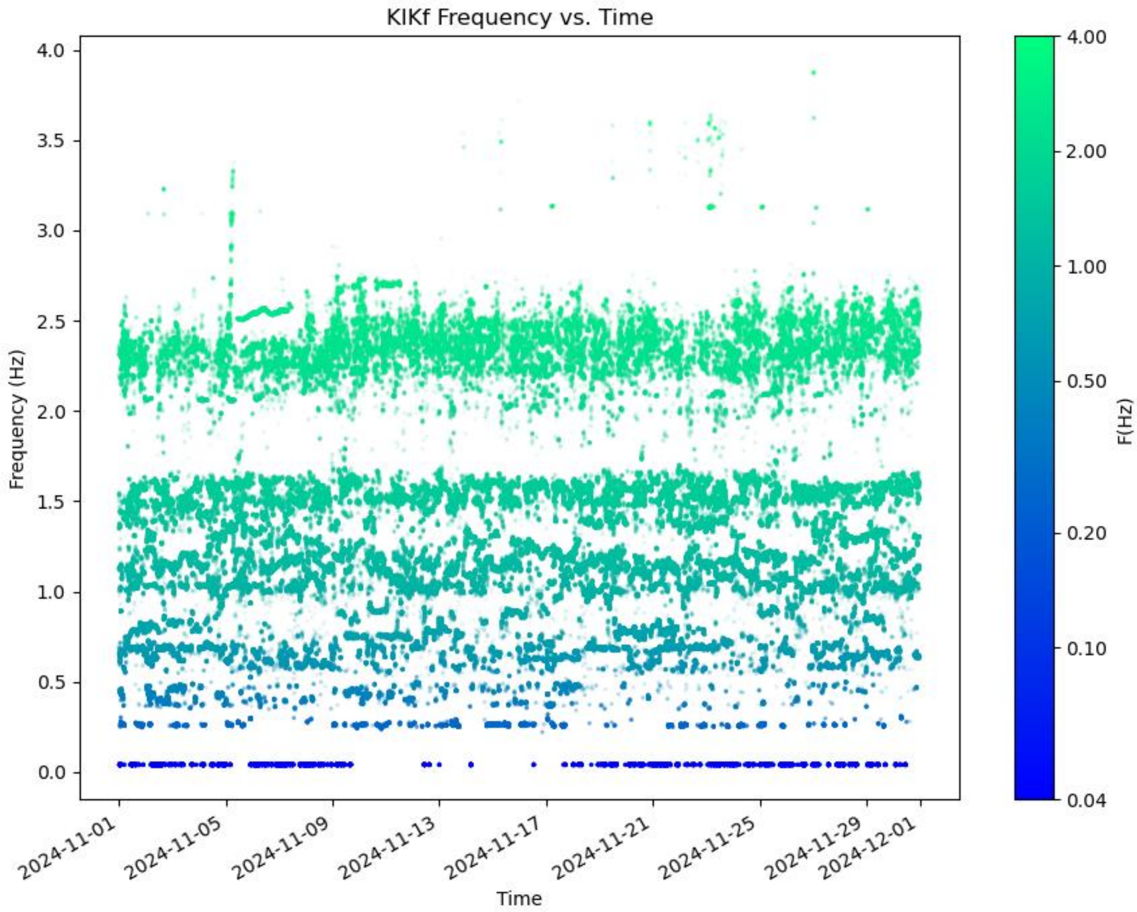


Figure 26: Kikiwa

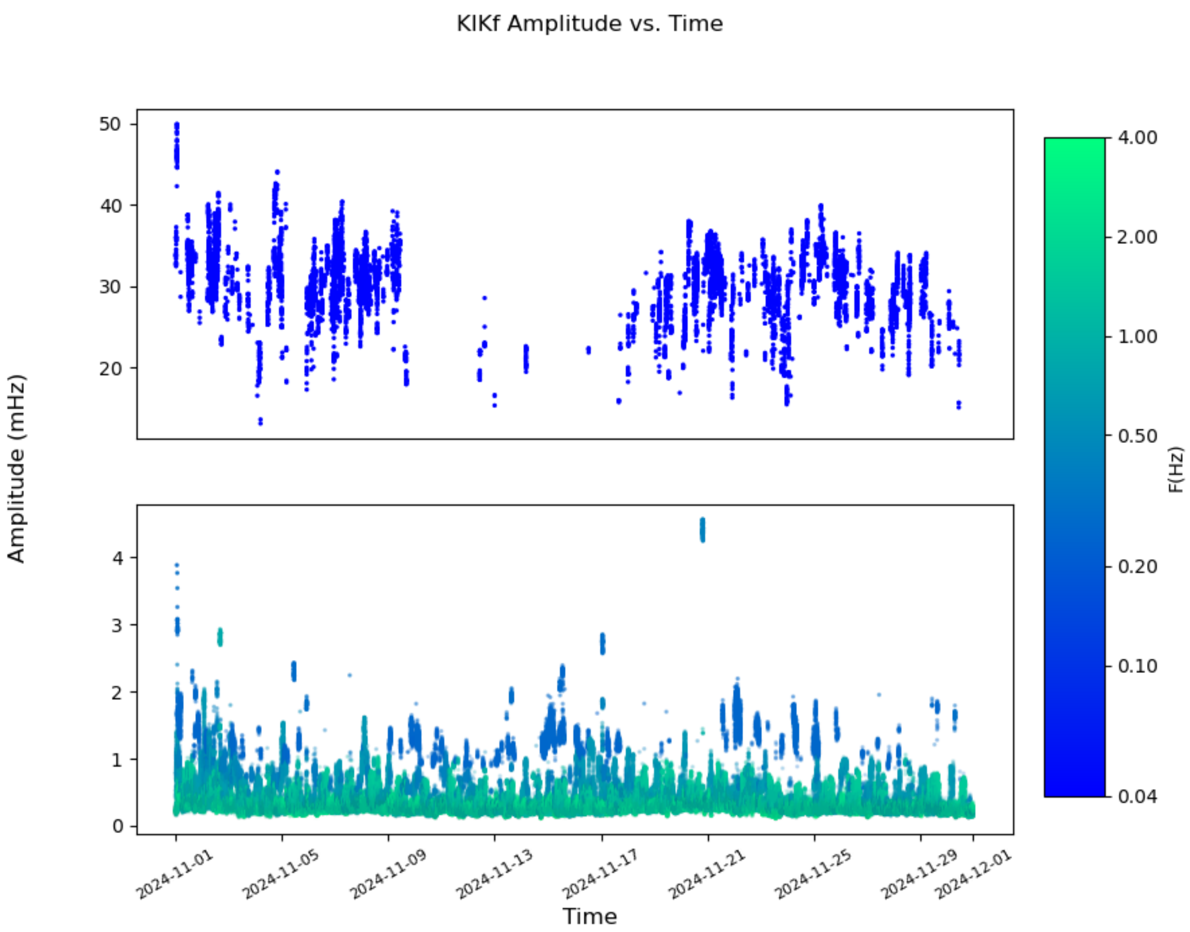


Figure 27: Kikiwa

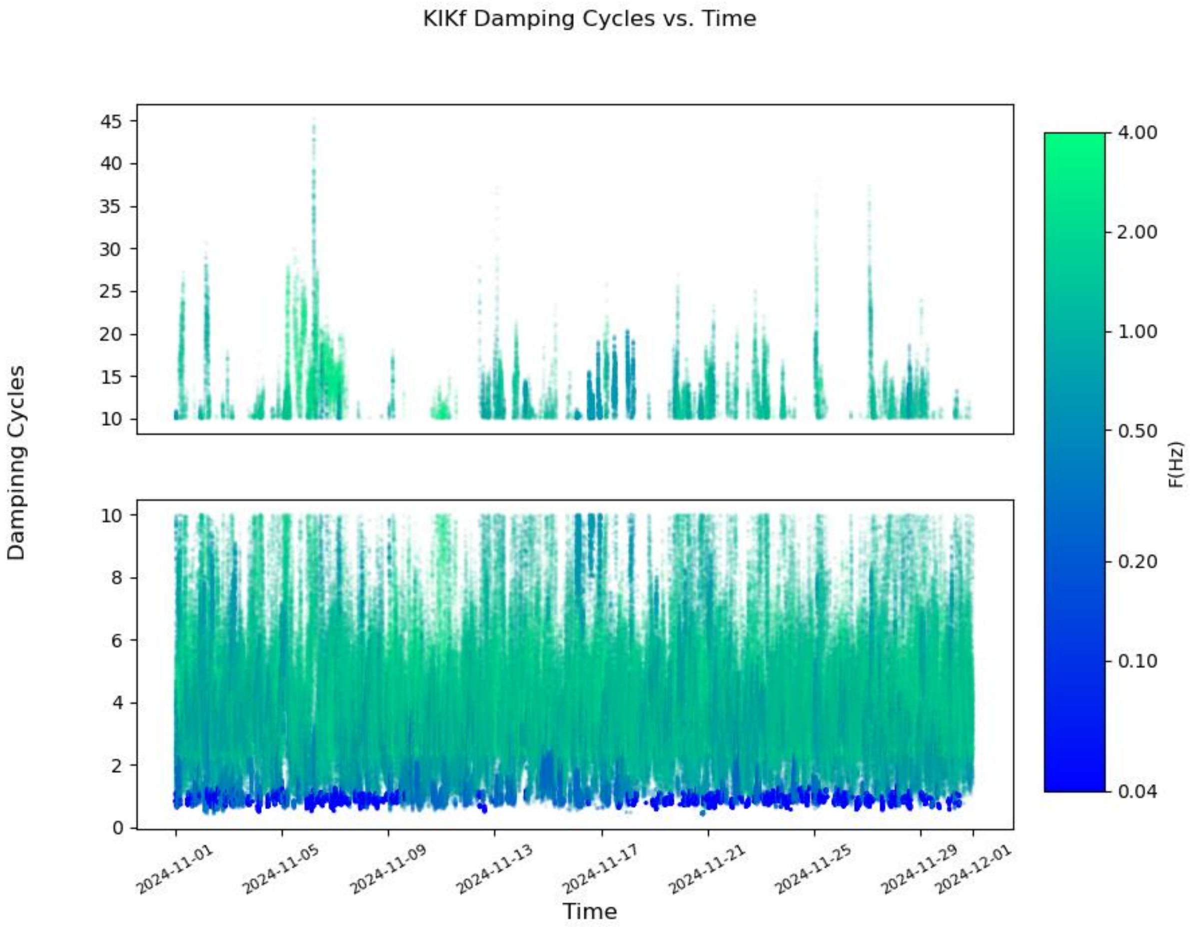


Figure 28: Kikiwa

4.2.2 PMU active power plots

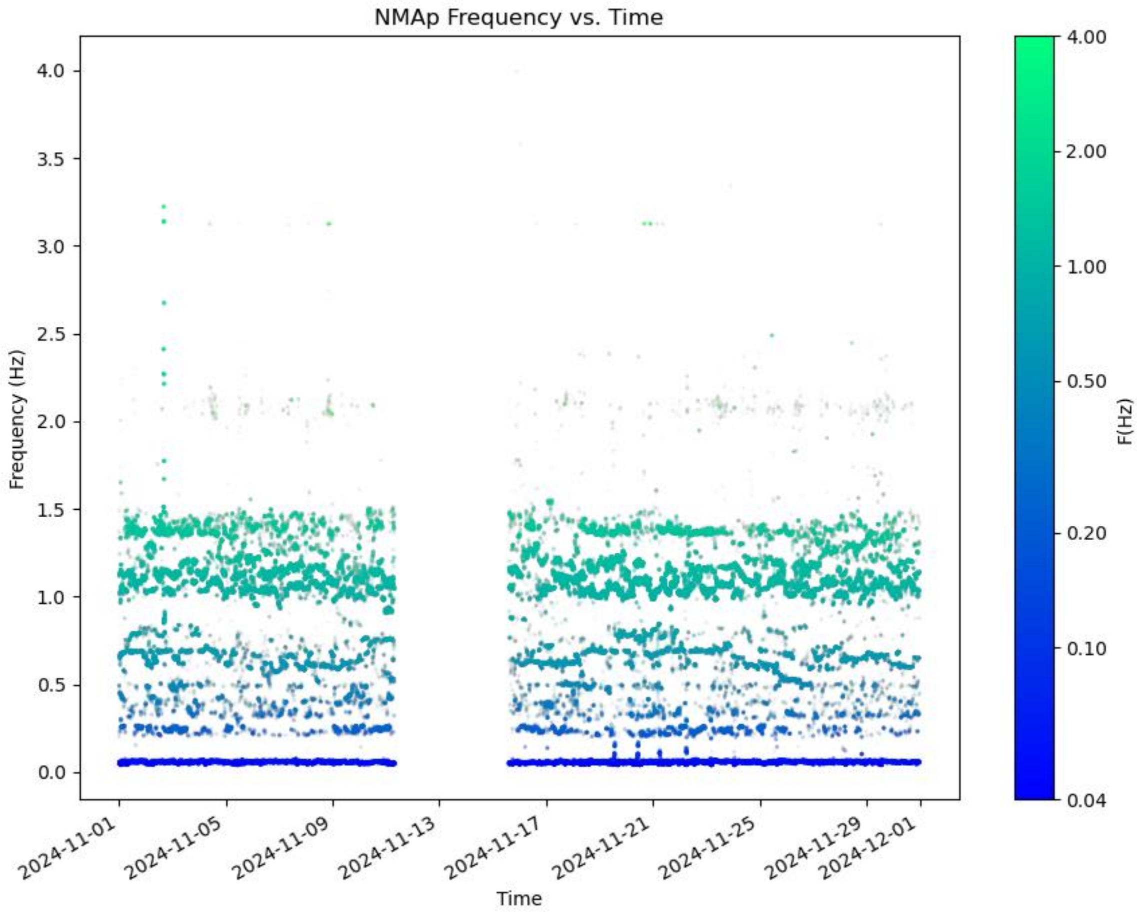


Figure 29: North Makarewa

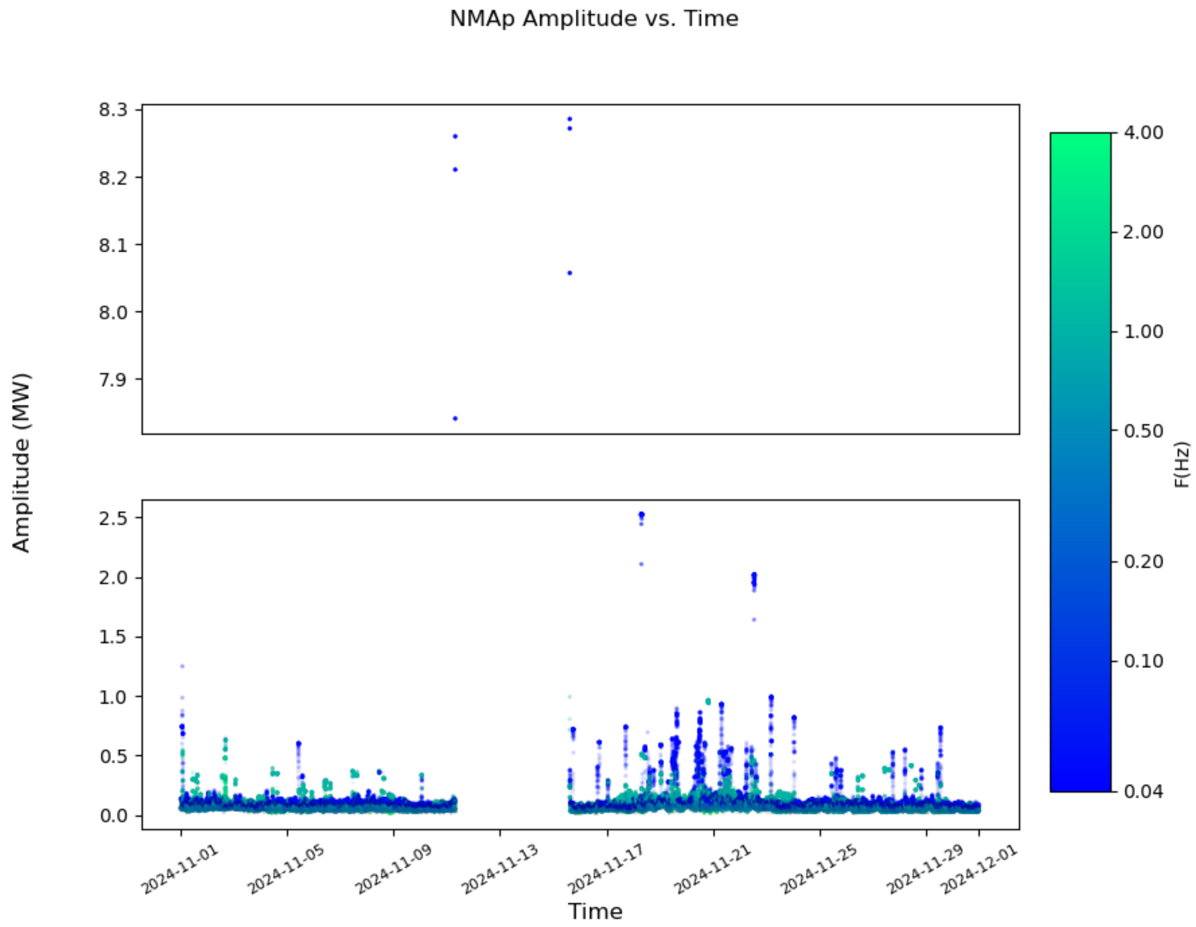


Figure 30: North Makarewa

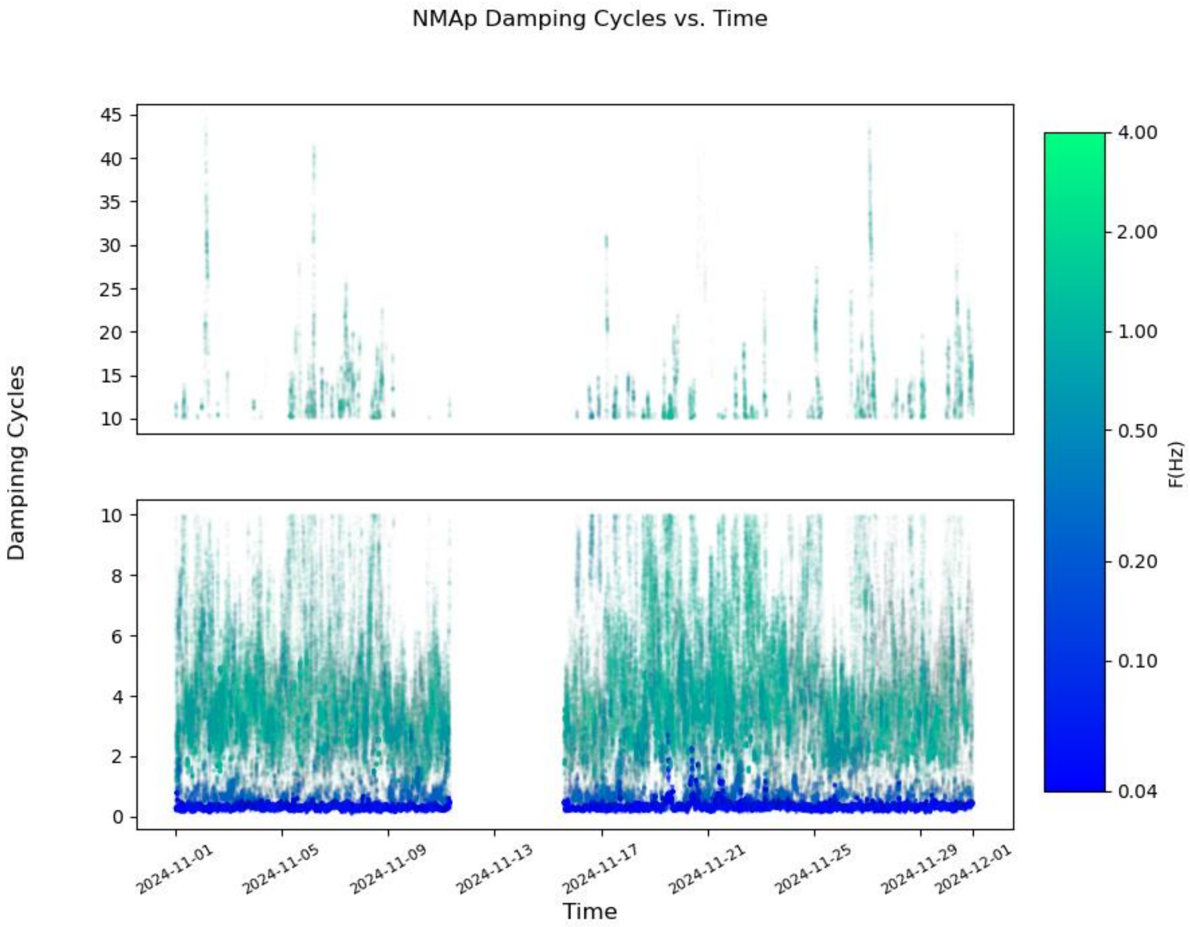


Figure 31: North Makarewa

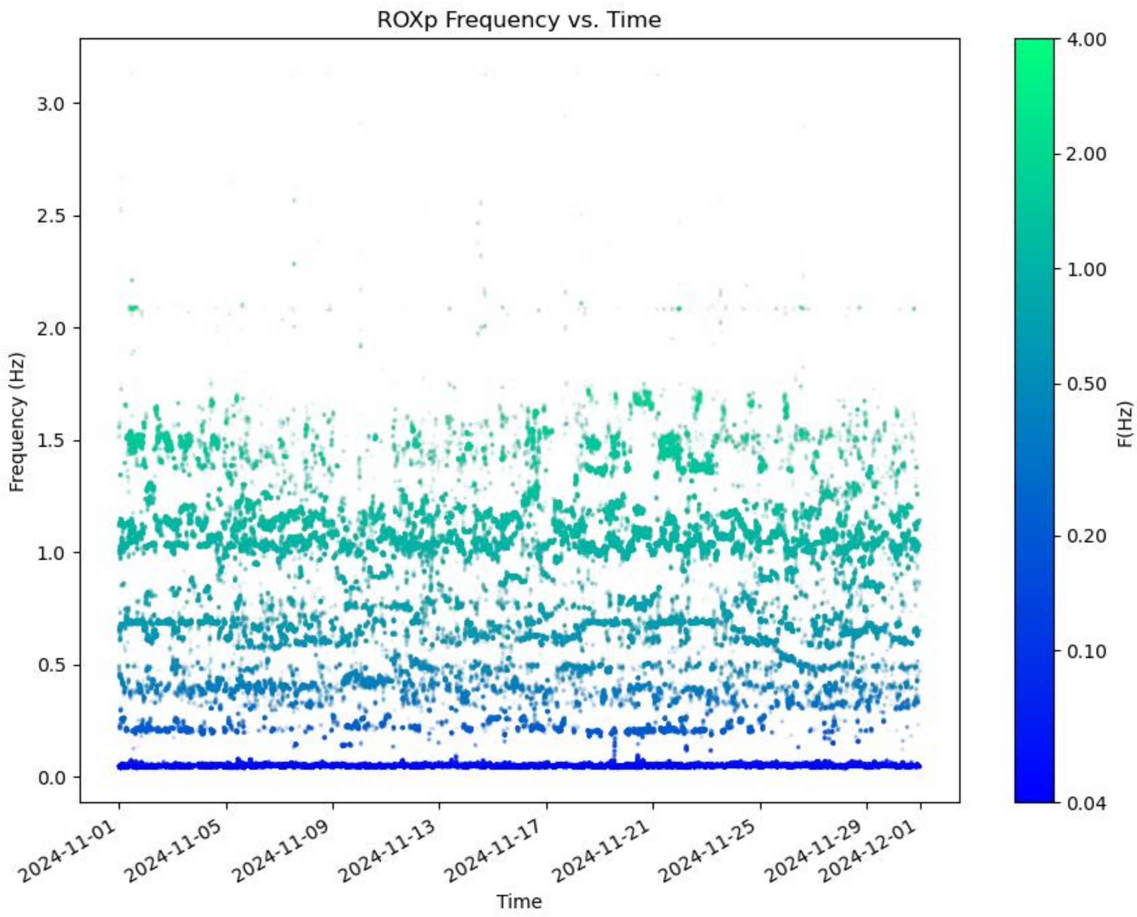


Figure 32: Roxburgh

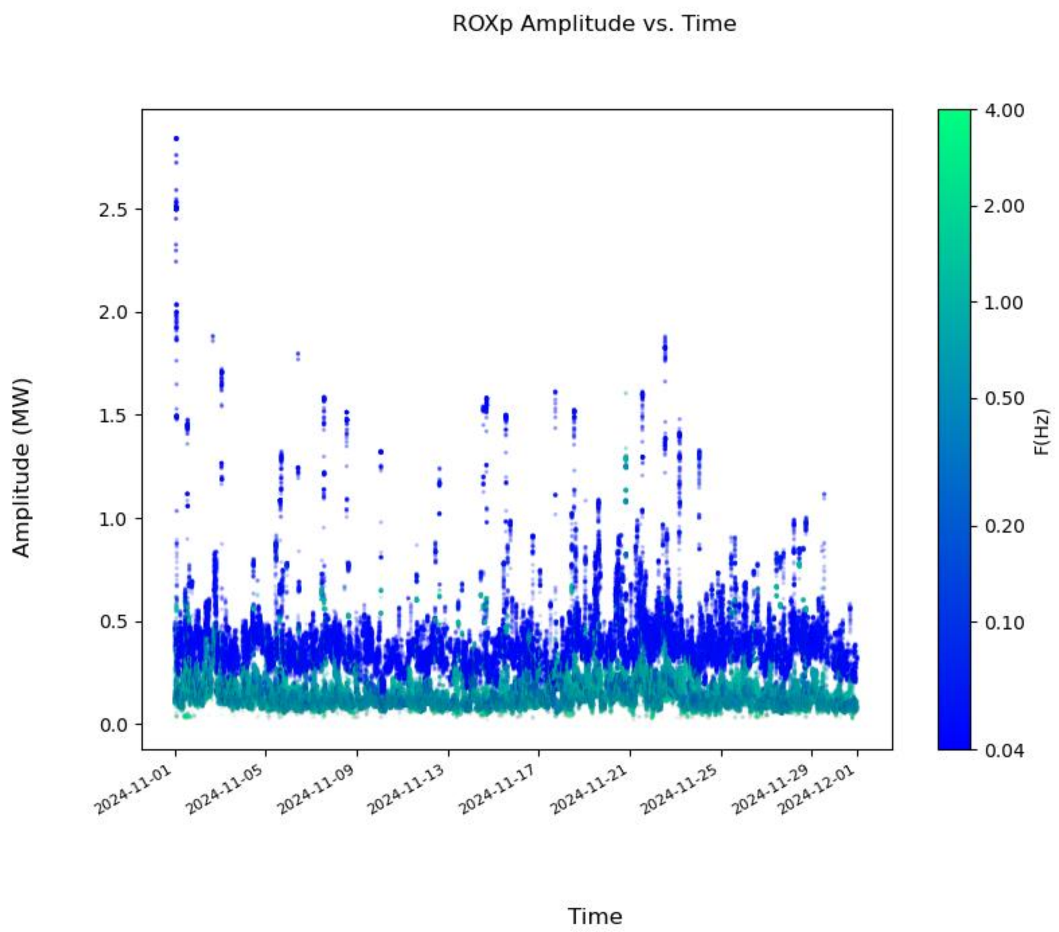


Figure 33: Roxburgh

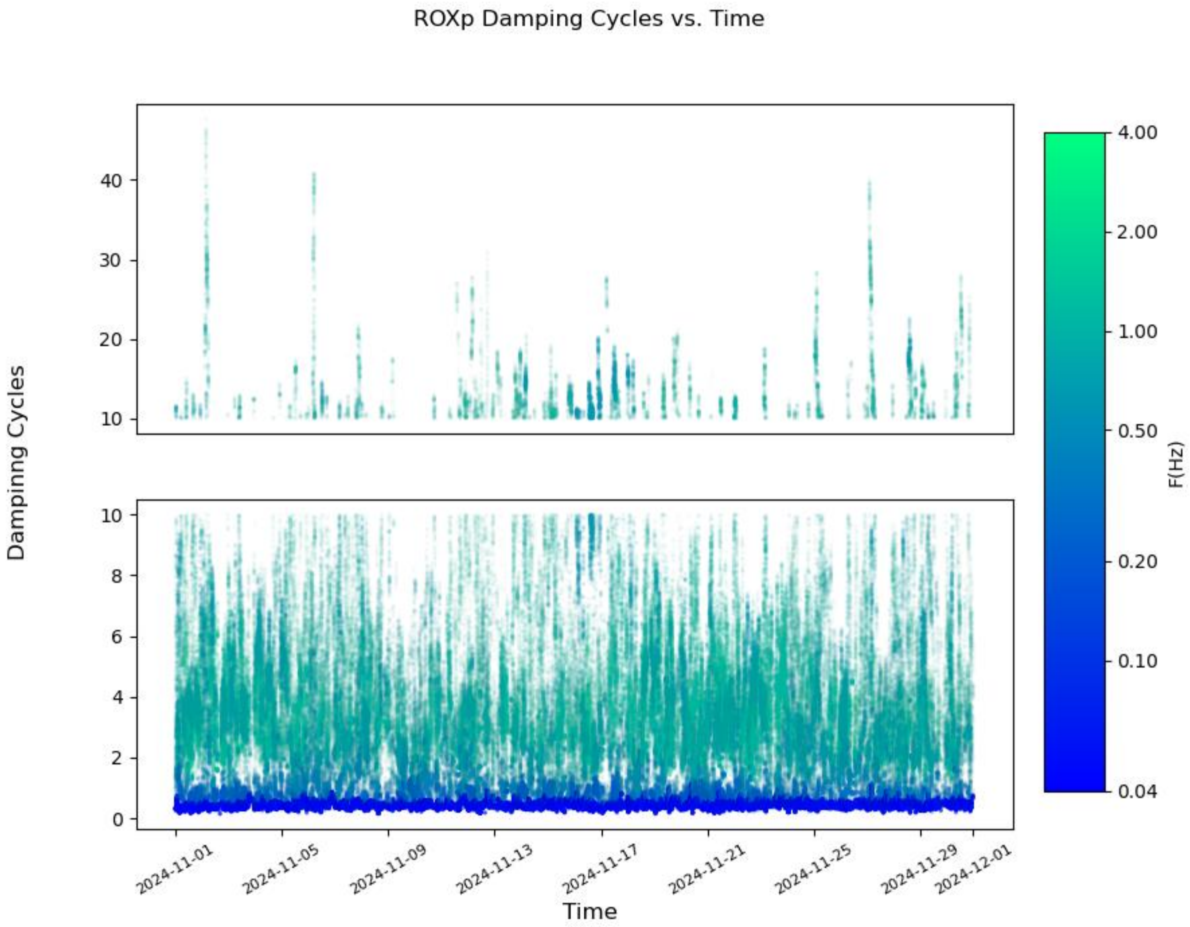


Figure 34: Roxburgh

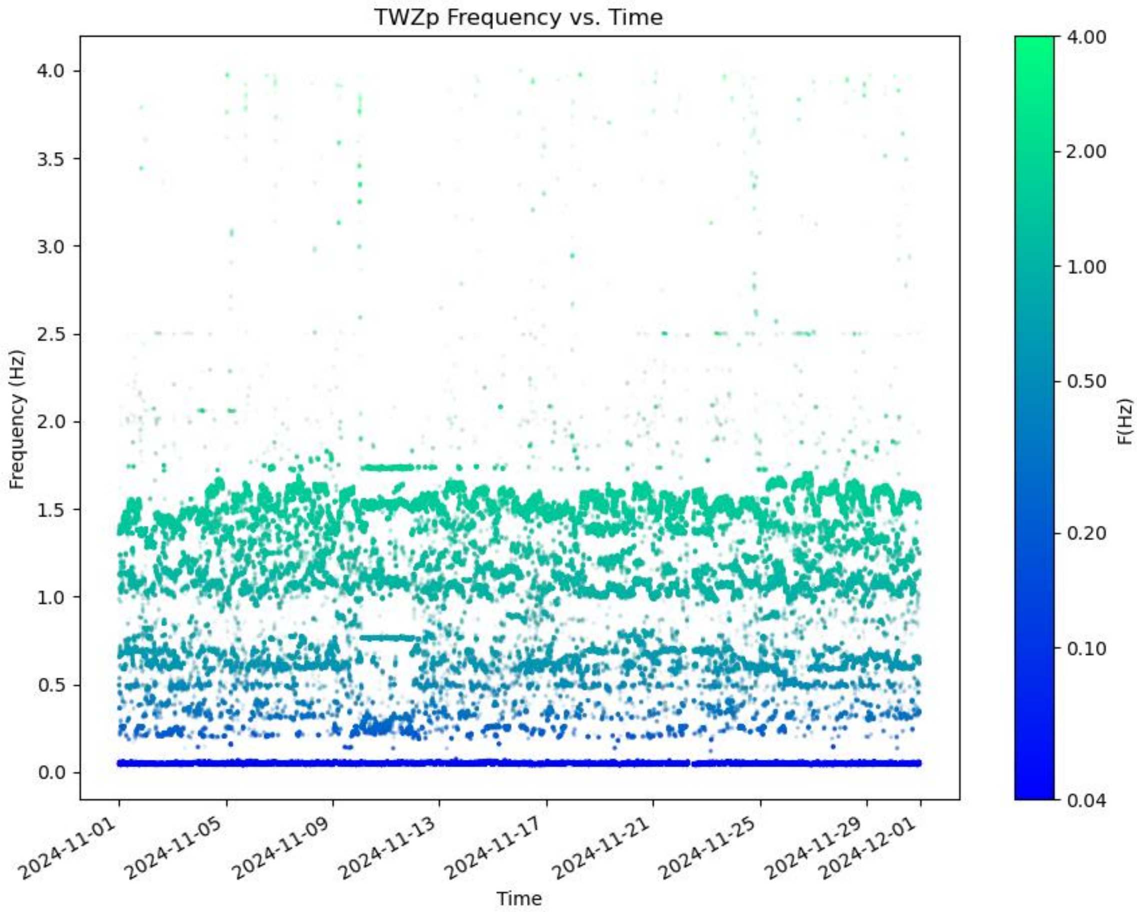


Figure 35: Twizel

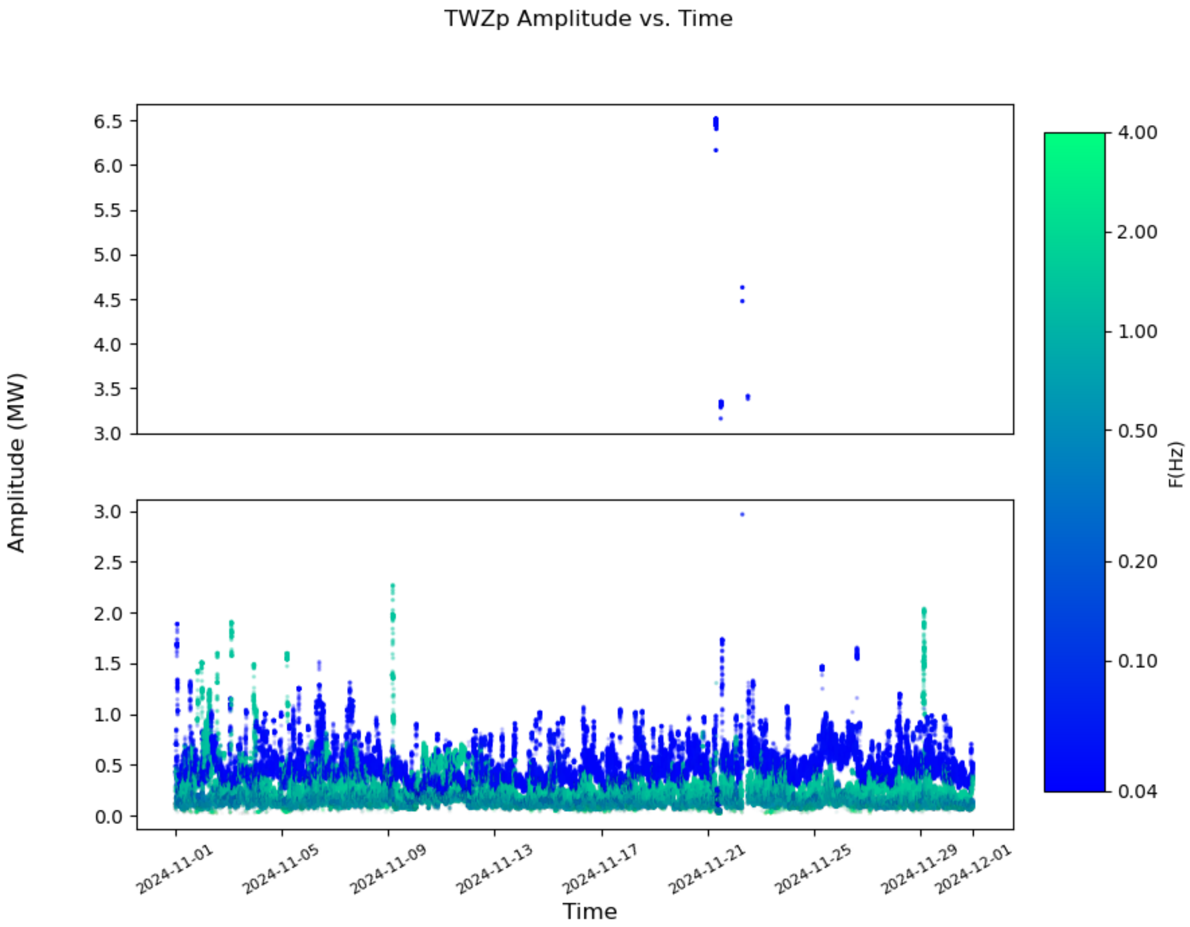


Figure 36: Twizel

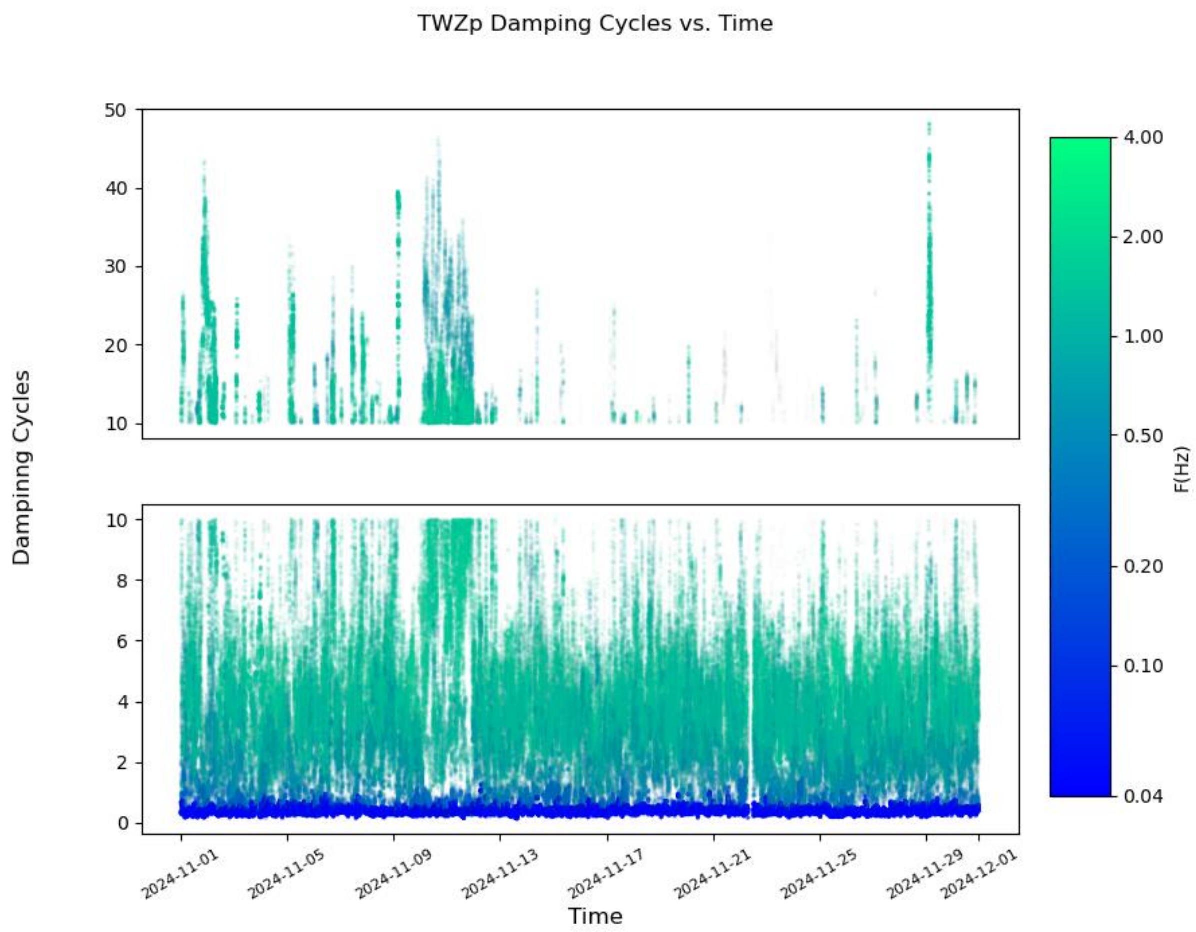


Figure 37: Twizel

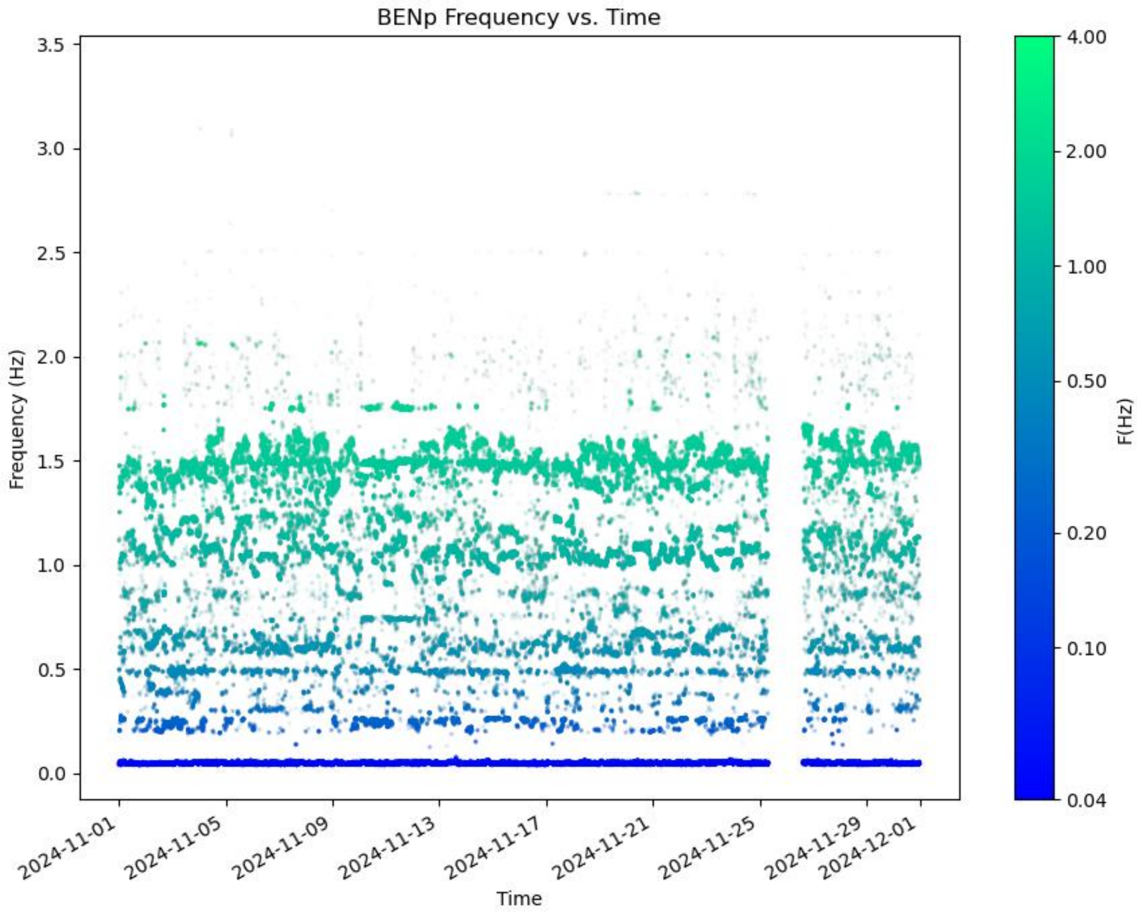


Figure 38: Benmore

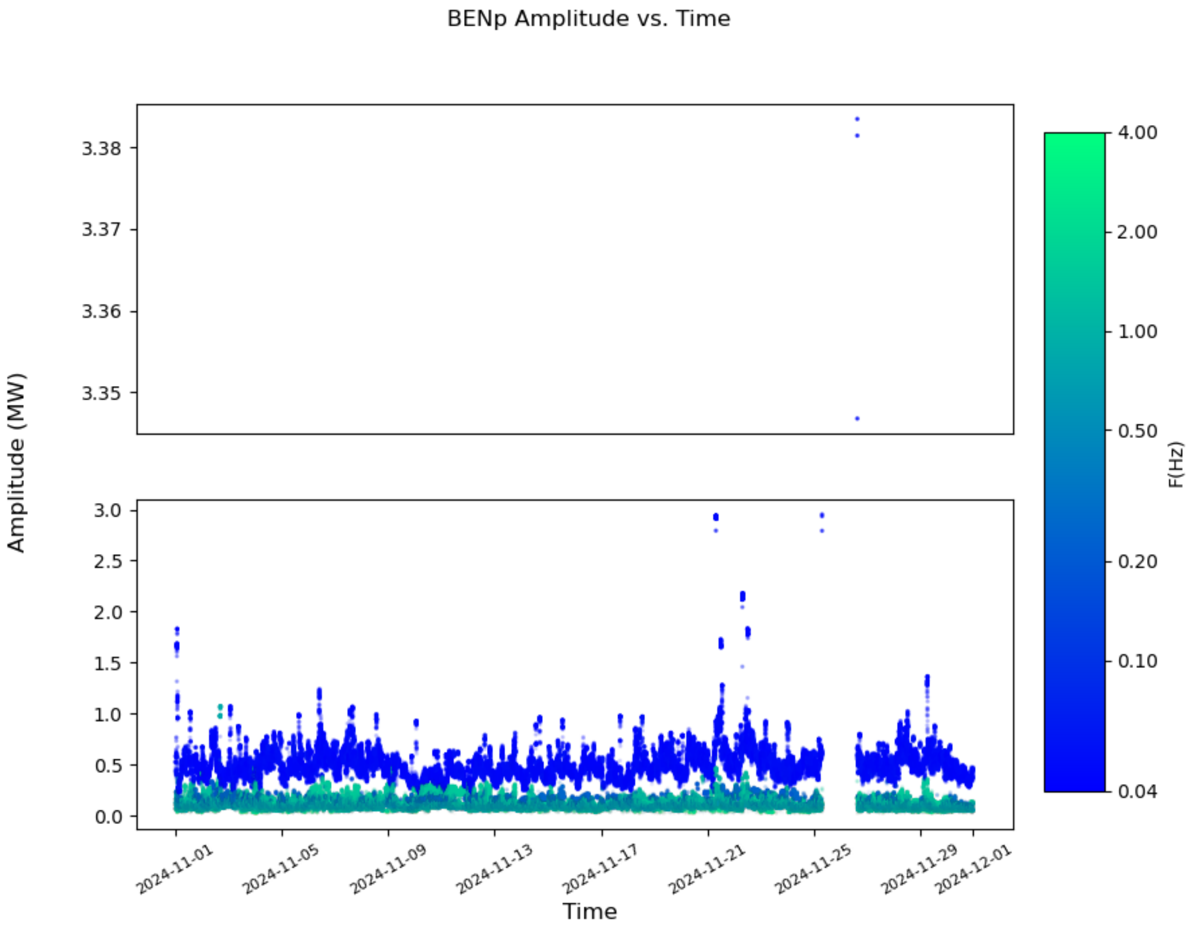


Figure 39: Benmore

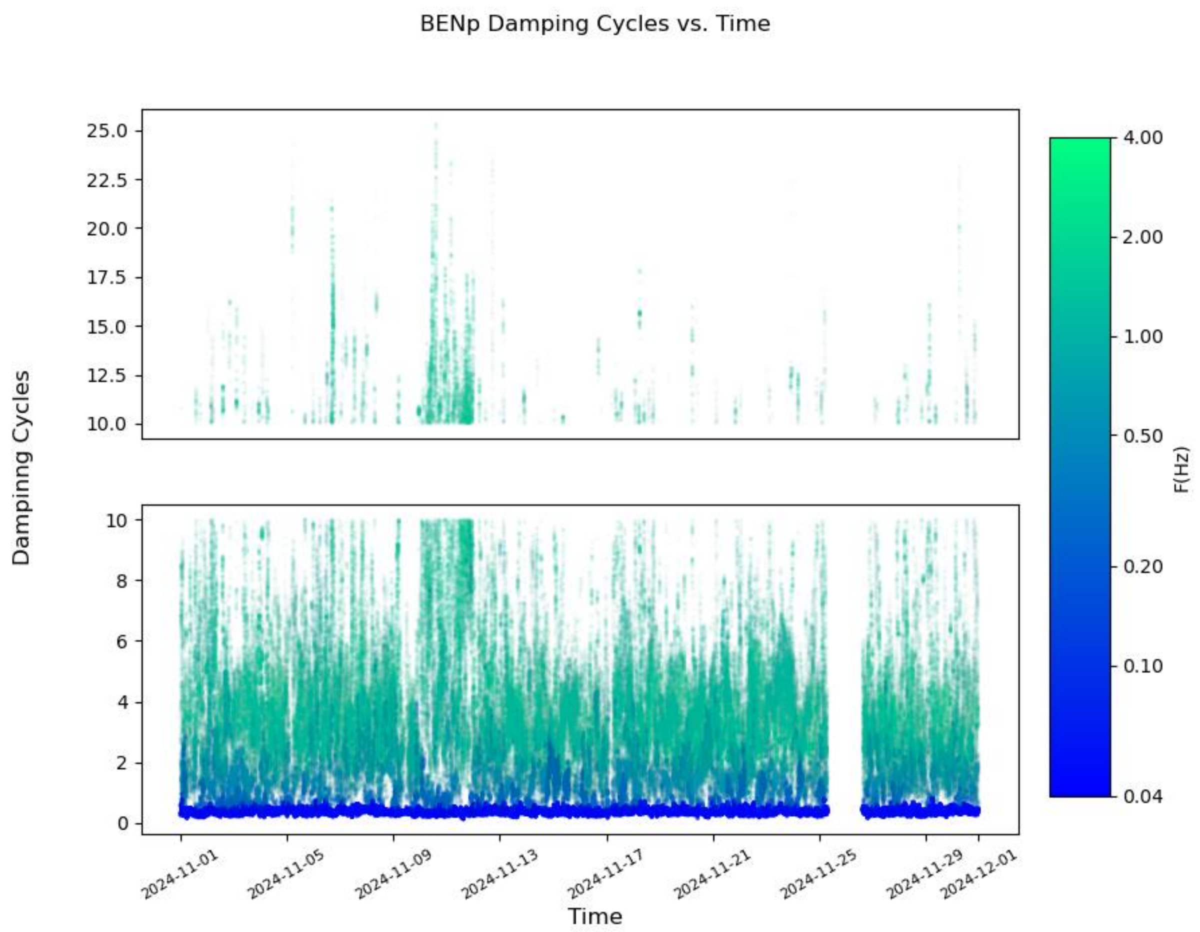


Figure 40: Benmore

