NTT oscillations

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During January 2009, the azimuth (AZ), altitude (ALT), and AZ and ALT corrections applied by the motor servos were logged in files on the TCS machine (`tcs@wt5tcs.ls.eso.org`)[1]. The sampling step is $\Delta t = 1$ sec. From these logs the oscillation frequency and maximum amplitude were extracted by averaging within a window of 30 sec and in steps of 15 sec. The frequencies were defined by computing the power spectrum through a Fast Fourier Transform (FFT) and taking the frequency giving the maximum power. However note that most of the times the spectrum shows a fast frequency mode modulated by a slower one (see Fig. 1). The investigation was done while IqEye observations were on-going in parallel. As shown in Fig. 2, a variation of frequency ~ 0.2 Hz is detected in the flux arriving at the SPADs, similar to what we observe. In that particular case no 0.4 Hz oscillation is seen. Moreover a flux variation having a frequency of ~ 40 Hz is also seen in the IqEye data, but this cannot be checked by us because of our large 1 sec sampling bin.

To understand better the telescope behaviour, in the following figures the frequencies and amplitudes are plotted in the (AZ, ALT) plane, and as a function of AZ, ALT, and time. From the plots one can draw the following conclusions:

- The ALT frequency decreases towards the meridian, but within an angle of $\sim 10^\circ$ the motion becomes chaotic, without a well-defined frequency.
- Below a given ALT, f(AZ) increases towards the meridian, while above some ALT the frequency decreases. The transition ALT is not well defined, though, varying between 60° and 70°.
- The amplitude of AZ oscillations increases towards the meridian, but the largest oscillation that is reached depends on ALT. At higher ALT larger amplitudes are reached.
- In general the amplitude of ALT oscillations decreases towards the meridian, but within $\sim 10^\circ$ there can be larger oscillations, in particular below an ALT of $\sim 40^\circ$. This is the same zone where the ALT motion becomes chaotic.

[1] For the record, the file names are of the kind `wt5tcs.2009-01-ddThh:mm:ss_PosError.samp`.

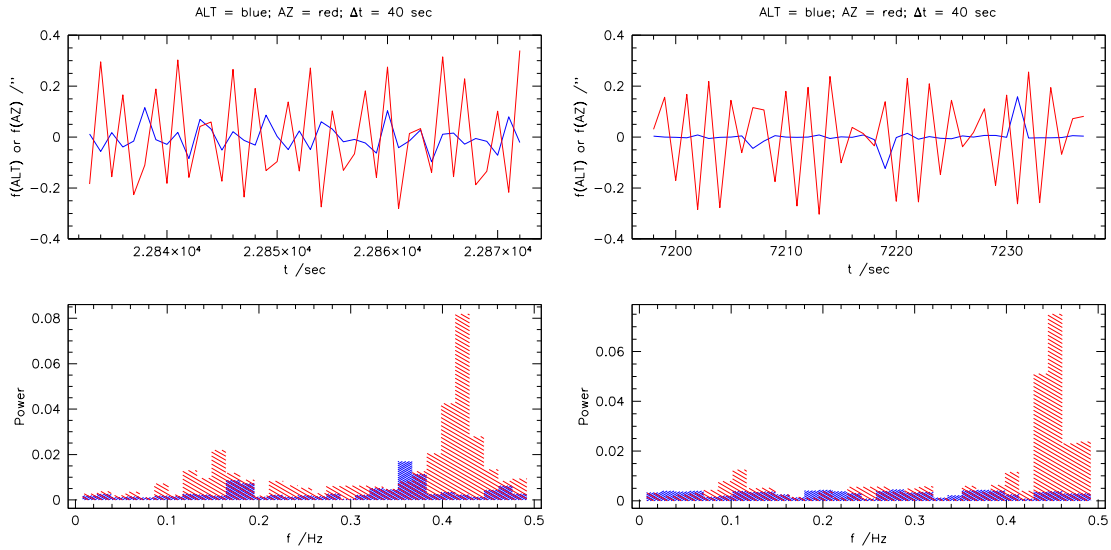

Figure 1: Illustration of two regimes of oscillation of the NTT. The AZ oscillations (red color) are always present and larger than the ALT oscillations (blue color). For AZ angles $> \pm 10^{\circ}$ (left panels) oscillations in both directions happen with a faster frequency containing most of the power (at ~ 0.4 Hz) modulated by a slower frequency of ~ 0.2 Hz). The two frequencies are not constant, and depend on AZ and ALT themselves. The right panels show that close to the meridian the ALT oscillations become smaller and chaotic (no defined frequency).

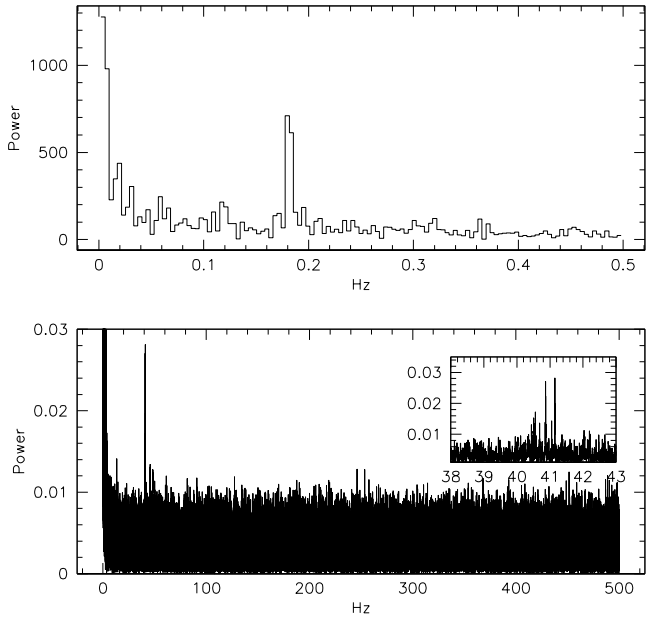

Figure 2: Frequency spectrum extracted from one of the IqEye observations. The top panel is obtained by rebinning the data with a step of 1 sec, while in the bottom panel the bin is 10^{-3} sec. The inset is a zoom into the ~ 40 Hz range.

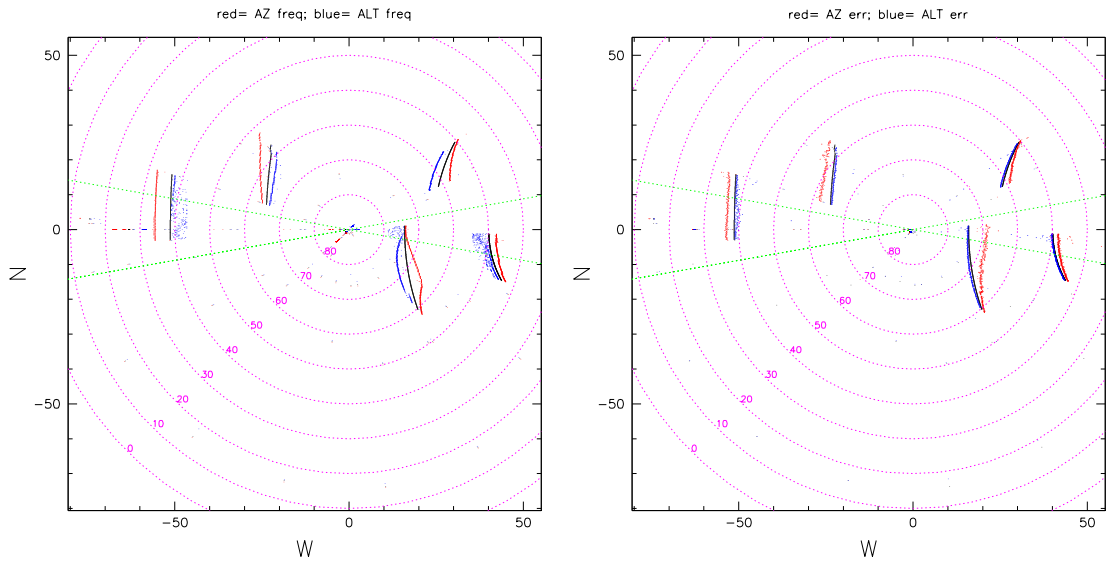

Figure 3: These plots show how frequencies (left panel) and amplitudes (right panel) depend on the telescope position. Amplitudes and frequencies are arbitrarily scaled and added to the ALT coordinate, in order to show them in the graphs. The green lines mark the $\pm 10^{\circ}$ cone near the meridian. The date is January 19.

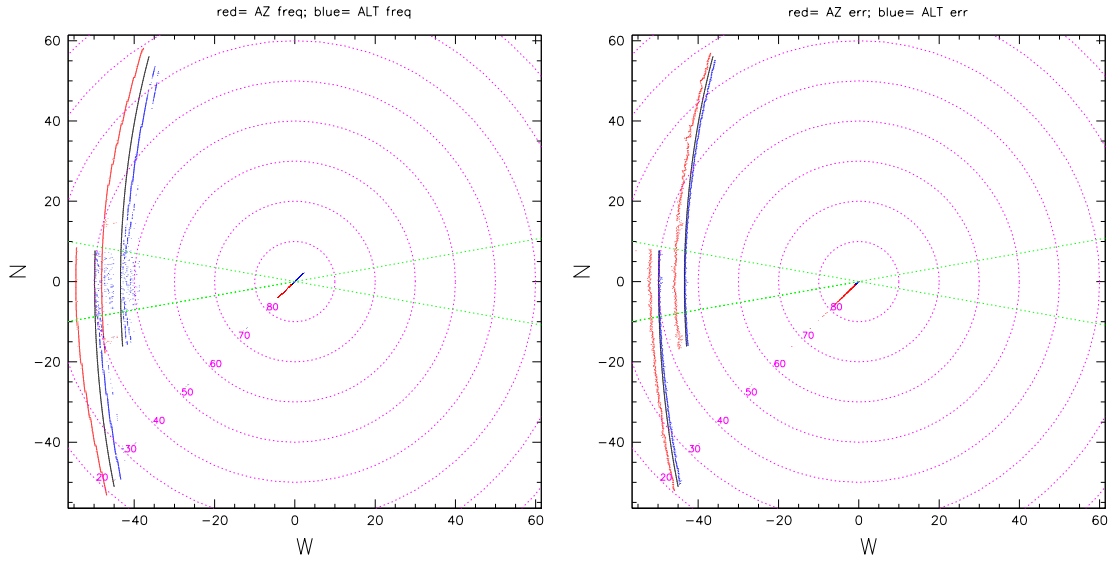

Figure 4: Same as Fig. 3 for the night of January 22.

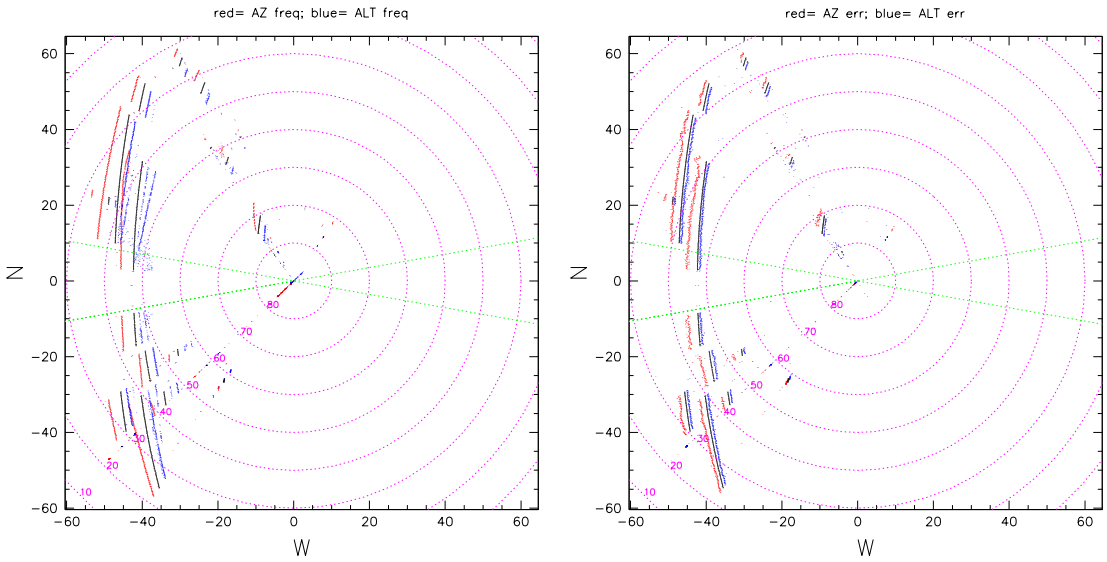

Figure 5: Same as Fig. 3 for the night of January 23.

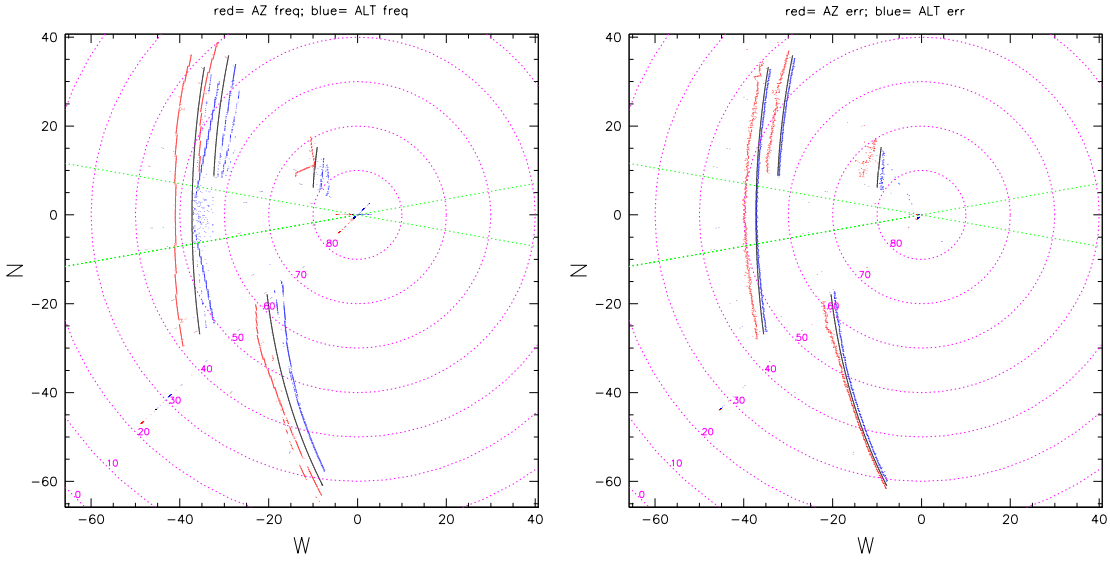

Figure 6: Same as Fig. 3 for the night of January 24.

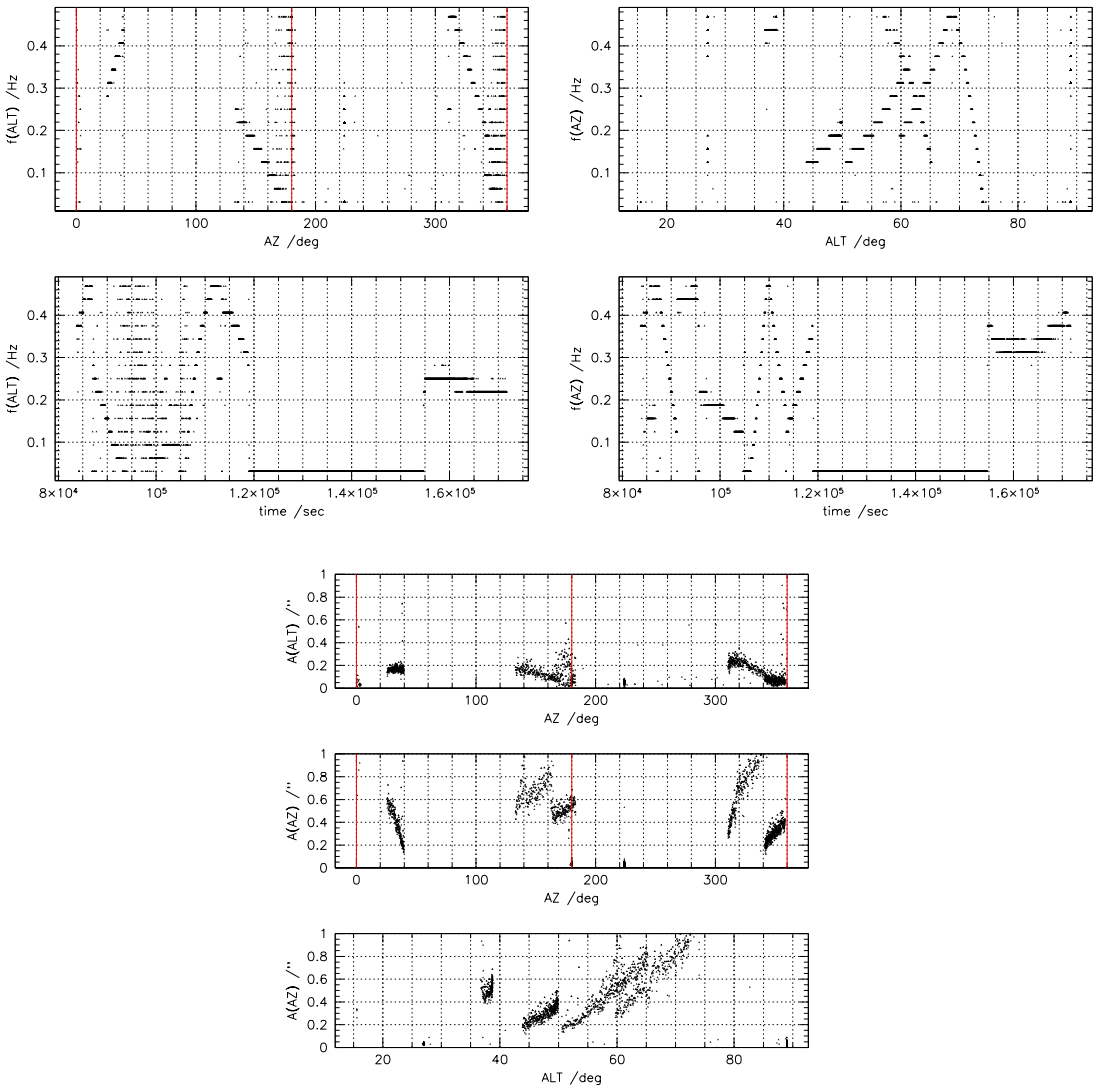

Figure 7: In the top panels f(ALT) vs. AZ and vs. time are shown (left), as well as f(AZ) vs. ALT and vs. time (right). AZ and ALT amplitudes are plotted vs. AZ and ALT coordinates in the bottom panel. The red vertical lines mark the position of the meridian. The date is January 19.

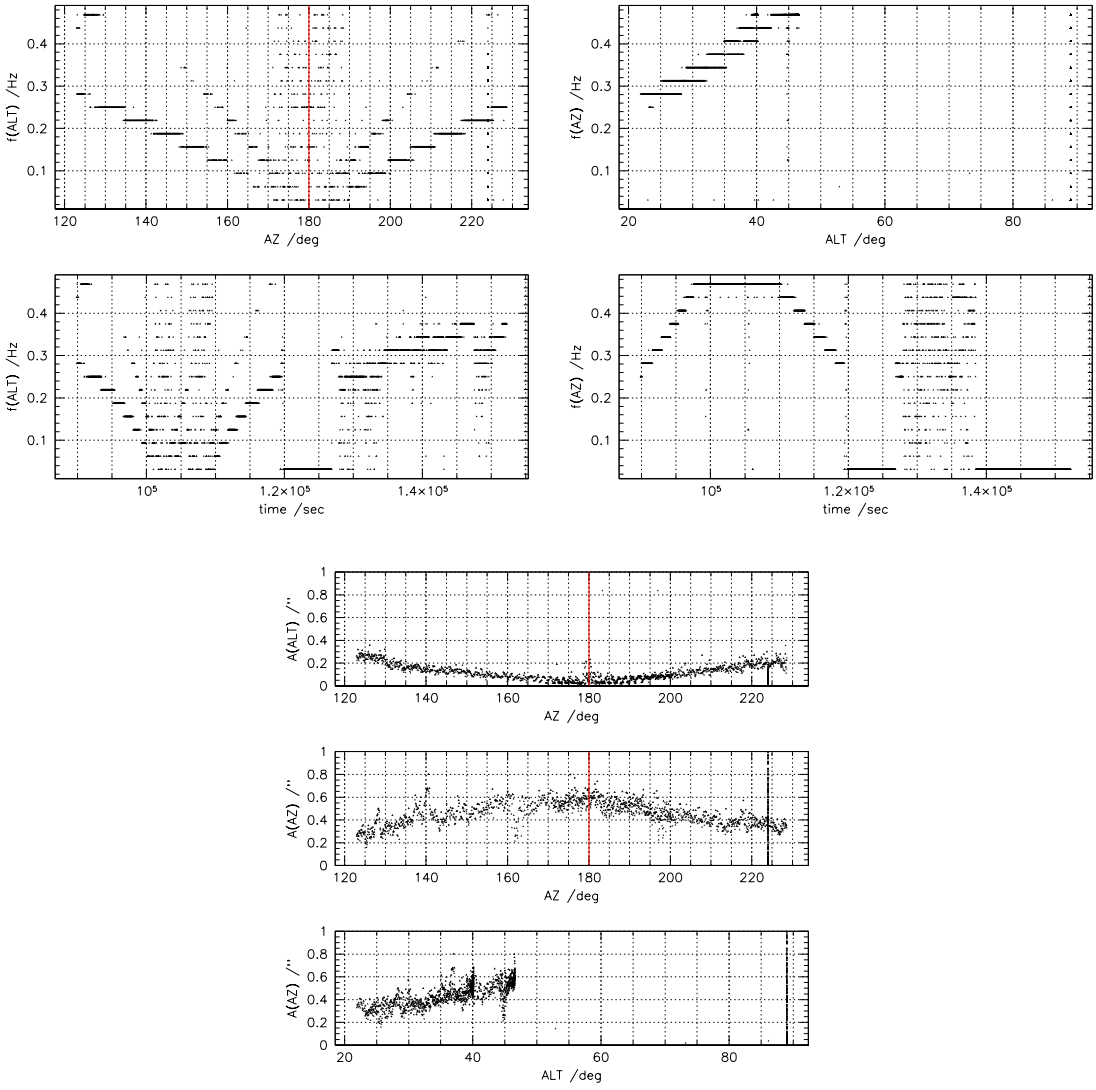

Figure 8: Same as Fig. 7 for the night of January 22.

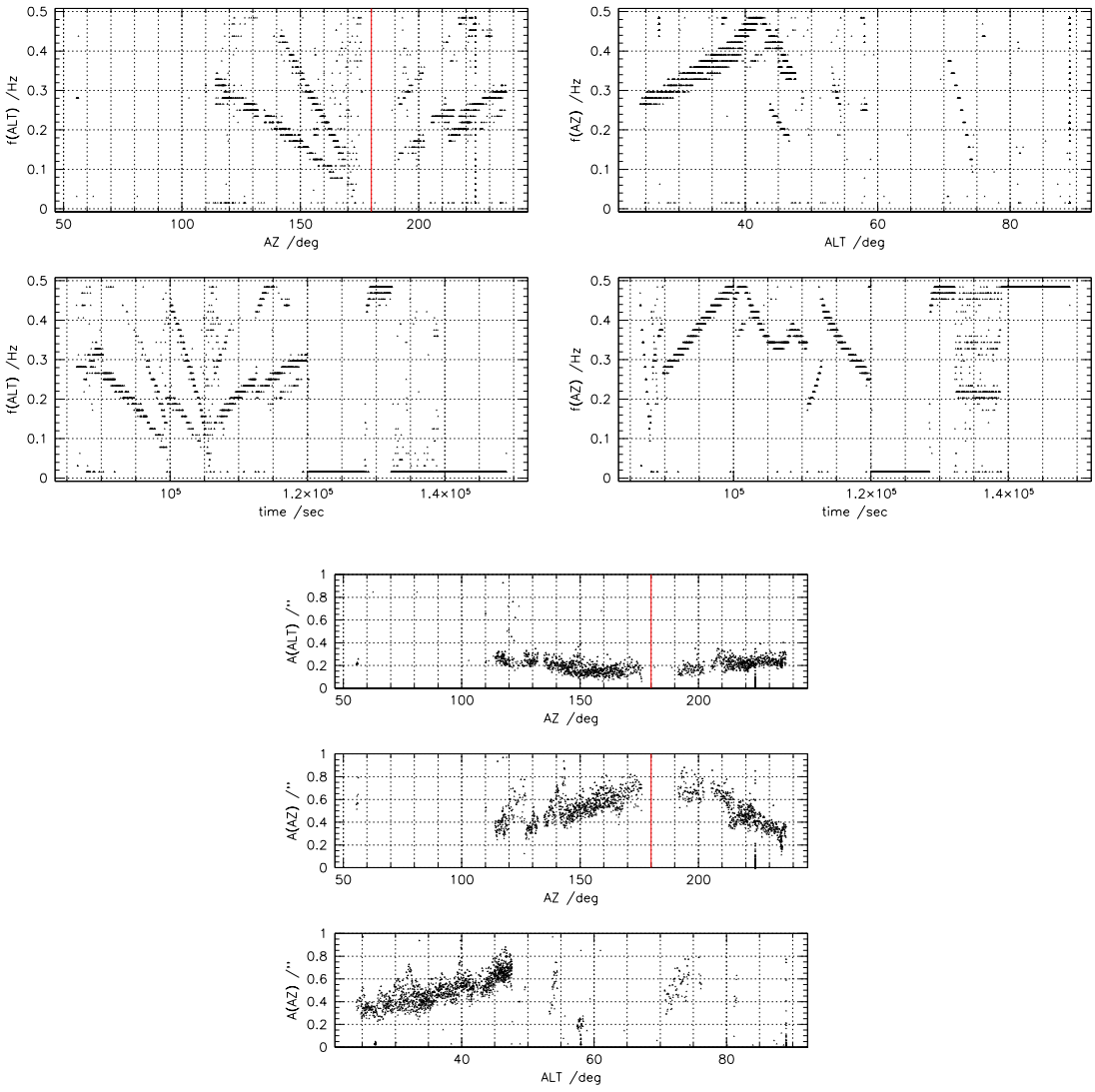

Figure 9: Same as Fig. 7 for the night of January 23.

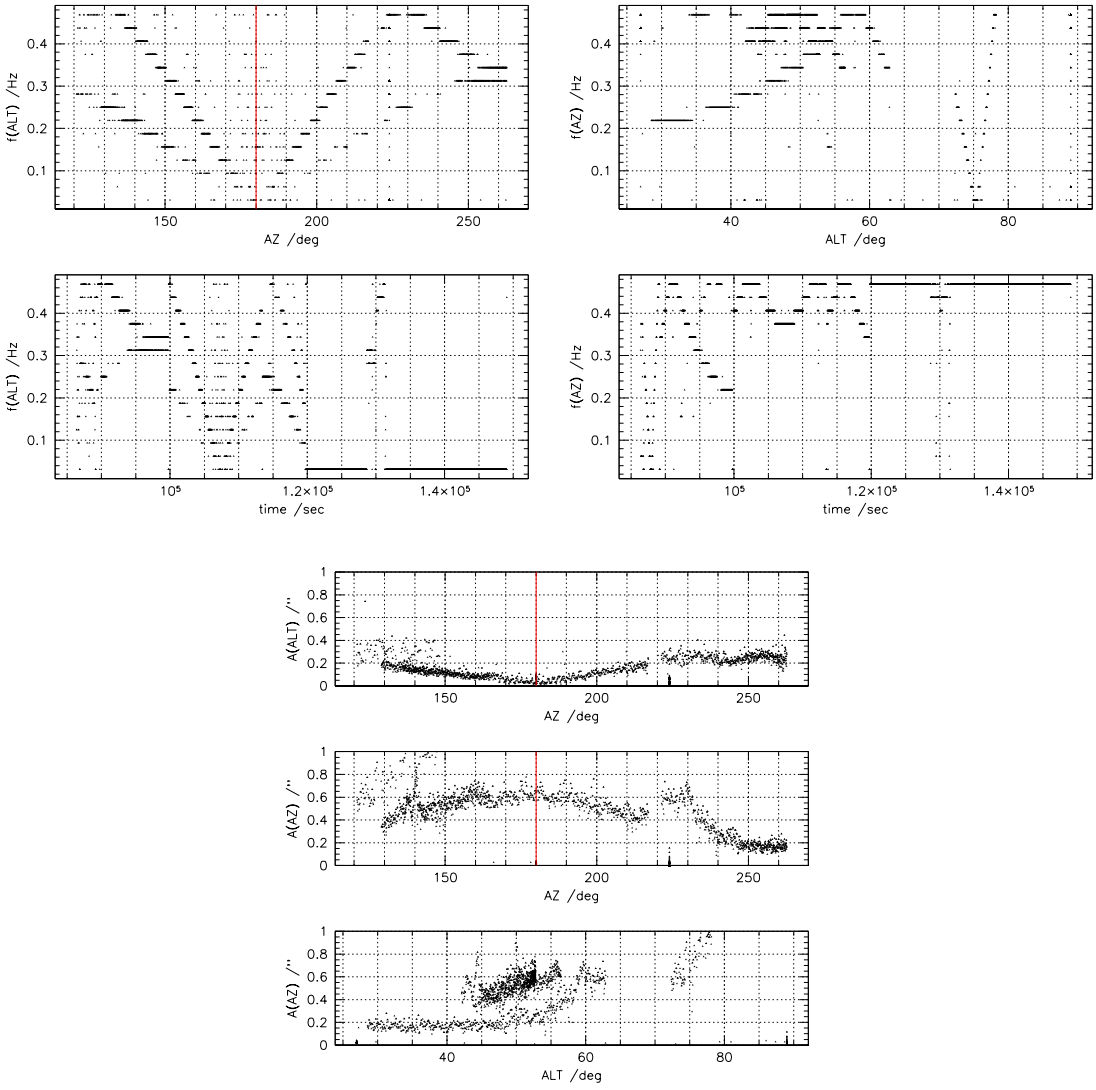

Figure 10: Same as Fig. 7 for the night of January 24.