EVLA Memo #128
Frequency-Variable Sensitivity of the EVLA at C-band

Emmanuel Momjian and Rick Perley
NRAO

September 4, 2008

Abstract

Past observations have shown a cyclic variation in sensitivity at C-band on the EVLA antennas, with a ~ 90 MHz period and $\sim 10\%$ amplitude. Here we report on observations made at all frequency bands to look for similar variations. We find no frequency-dependent oscillations in sensitivity at any other band. The EVLA C-band variations suggest a standing wave origin with reflection points separated by ~ 1.7 m-about the length of the feed horn.

1 Introduction

Frequent, multi-band test observations carried out using the VLA/EVLA (commonly known as "Stress Tests") show a distinct and consistent difference in the sensitivity of the EVLA antennas at C-band between the IF pair A/C (i.e., the two polarizations of IF 1) and the IF pair B/D (i.e., the two polarizations of IF 2), with the 1st IF pair being more sensitive than the 2nd pair by about 10%. In these "stress test" observations at C-band, the first IF pair is tuned to 4885 MHz and the second IF pair is tuned to 4835 MHz. This observed mismatch in the sensitivity is a real frequency effect, since swapping the frequency values of the IF pairs kept the sensitivity difference between the two observed frequencies intact. Initial C-band test observations carried-out to address this issue showed a frequency-dependent variability in sensitivity on the EVLA antennas only with a periodicity of $\sim$ 90MHz, placing the 4885 MHz and the 4835 MHz data points almost on the peak and the trough of the observed sinusoidal pattern, respectively. If this observed periodic variability in sensitivity were due to a standing wave, it would correspond to a physical length of 1.67 m, which is comparable to the length of the feed horns of the EVLA C-band receivers. This finding prompted us to carry out a survey at all bands to look for similar behavior and establish whether this was a common problem in all EVLA bands that use feed horns or a unique problem to the C-band receivers.

Here we report on the results obtained from multi-band survey observations that used all the VLA/EVLA receivers from L- to Q-band.

2 Test Setup and Observations

Multi-frequency observations were carried out at L, C, X, K, and Q bands using all available VLA and EVLA antennas. The observed frequency range in each band was set by assuming that the frequency based variability in the sensitivity phenomenon is due to a standing wave associated with the feed horn, and by appropriately scaling the effect seen at C-band to the other frequency bands (i.e. scaling inversely by the sizes of the feed horns). For proper sampling, each of the frequency ranges were observed using 24 to 34, equally separated, frequency settings. Each frequency setting was observed for about a minute. X-band reference pointing scans were carried out before both K- and Q-band observations.

The observations were taken on 24 August 2008. The source observed in all bands was the quasar 1800+784, which is one of the two standard calibrators used in the periodic, multi-band, "stress test" observations. Table 1 lists the parameters used to setup these observations. Column (1) shows the name of the band. Column (2) lists the periodicity of the "oscillation" expected for each band if it were to be due to a standing wave arising in the feed horn using the equation:

$$\Delta\nu = \frac{150}{L_{\mathrm{m}}} \ \mathrm{MHz}, \tag{1}$$

where L_{m} is the length of a given feed horn in meters, and $\Delta\nu$ is the periodicity of a standing wave that would arise in this feed horn. Column (3) is the frequency range used for each band in these observations. These values were chosen to be at least twice as wide as the periodicity of the potential standing wave listed in column (2), and to correspond to frequencies for which both the VLA and the EVLA antennas can be tuned to. Column (4) lists the number of equidistant frequency settings used in the targeted frequency range of each band in order to provide sufficient data points for the proper sampling of the variation in the sensitivity, if any. Column (5) lists the bandwidths used for each of the individual frequency settings. These bandwidths were chosen to avoid smoothing that could suppress a sinusoidal wave-pattern in the observed frequency ranges.

Band	Variability Cycle† (MHz)	Freq. Span (MHz)	Number of Freq. Settings	BW per Freq. Setting (MHz)
L	32	1378–1451	24	3.125
C	90	4698–4907	30	6.25
X	153	8294–8606	26	12.5
K	413	22393–23268	35	25
Q	765	42790–44490	34	50

Table 1: The setup parameters of the August 2008 multi-band observations.
†Based on the characteristics of the phenomenon seen at C-band and using the physical lengths of the feed horns of the other bands.

The data were loaded into AIPS as correlation coefficients, and for each frequency band, the calibration was performed independently for the EVLA and the VLA antennas in all four IFs. The resulting gain solutions were converted to effective system temperature (T_{sys}/efficiency; see EVLA memo #127). The results from all 4 IFs were consistent, therefore, here we show those obtained from the data of IF A (i.e. IF 1 with right-hand circular polarization).

3 Results and Discussion

Figures 1 shows the sensitivity in units of effective system temperature (T_{sys}/efficiency) at C-band for both the VLA (*left*) and the EVLA (*right*). All the EVLA antennas at this band clearly show a frequency-dependent wave pattern in the sensitivity with a periodicity of $\sim$ 90 MHz and an amplitude of 10%. This sinusoidal wave-pattern is not seen on the VLA antennas at C-band.

Figures 2 to 5 show the sensitivity for L, X, K and Q bands, respectively, for both the VLA (*left*) and the EVLA (*right*). None of these plots show any trend of a frequency-variable sensitivity on either type of antennas. We note that in Figure 4, the slope seen in the sensitivity of both the VLA and the EVLA antennas at K-band is due to the $\sim$ 1 GHz wide 22.4 GHz atmospheric water-line emission that is raising the effective system temperature for almost half of the frequency range observed at this band.

The results reported here clearly suggest that the C-band feeds on the EVLA antennas are introducing a standing wave with reflection points between the feed window and the base of the horn, which has a length of ~ 1.7 m.

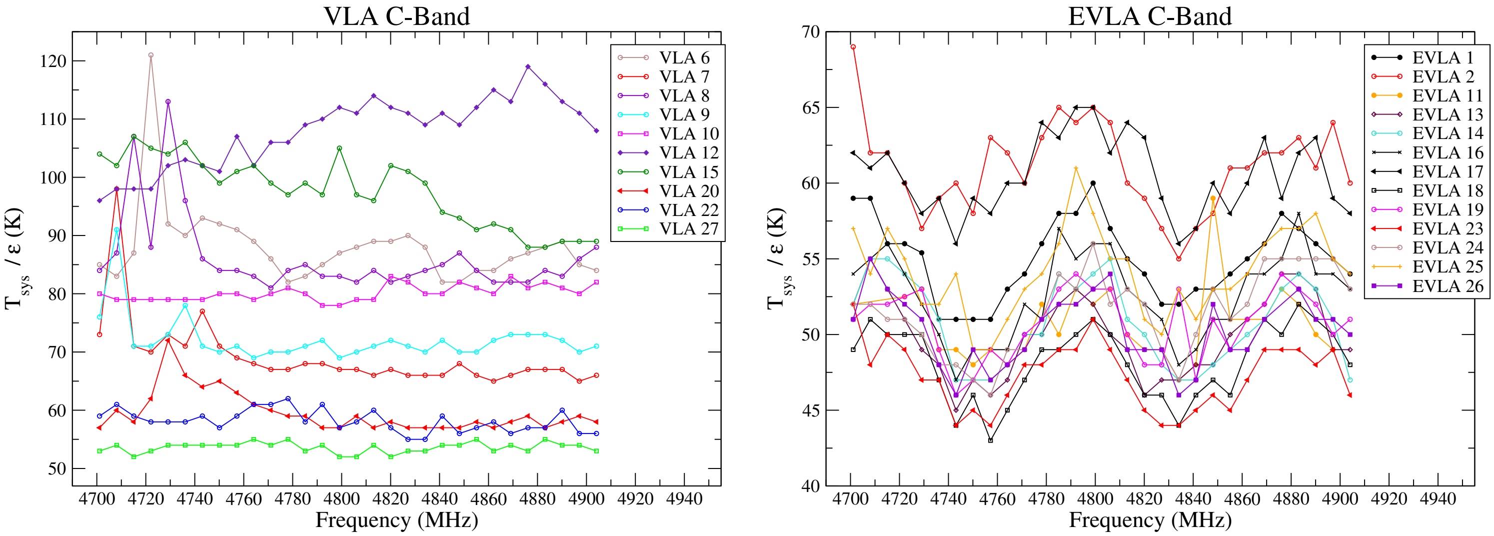

Figure 1: Effective system temperature values vs. frequency at C-band for both the VLA (*left*) and the EVLA (*right*) antennas. A total of 30 frequency settings were used to span the frequency range between 4698 and 4907 MHz with a frequency interval of 7 MHz. The instantaneous bandwidth of each frequency setting is 6.25 MHz.

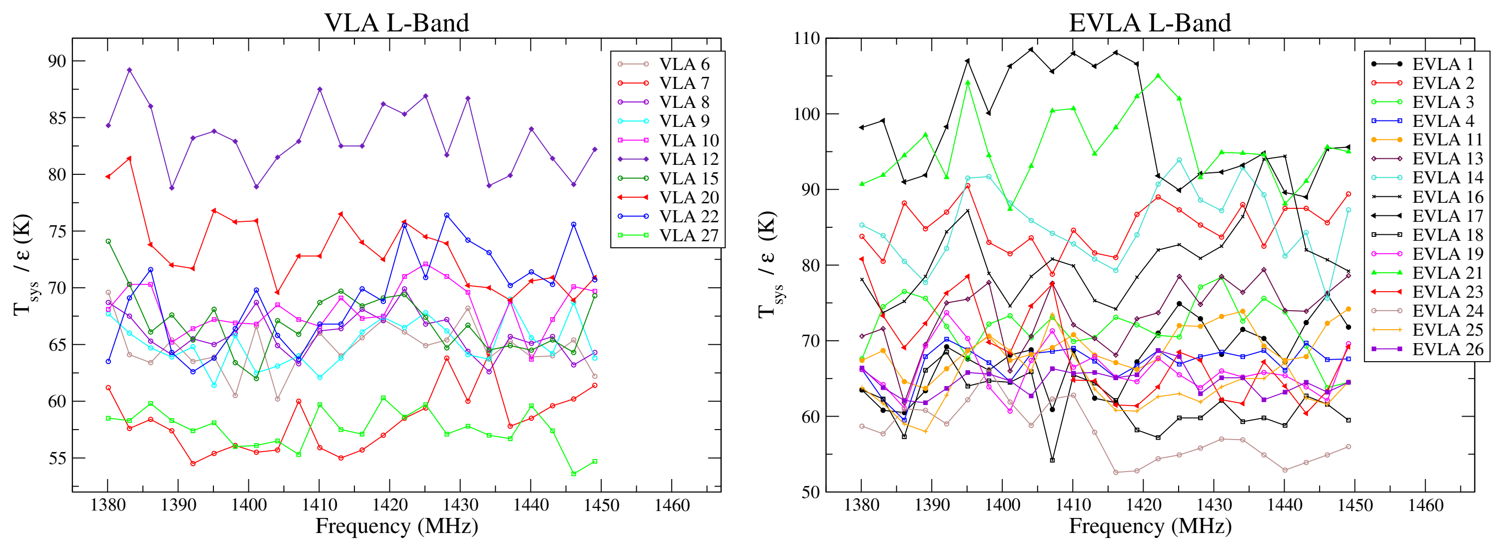

Figure 2: Effective system temperature values vs. frequency at L-band for the VLA (*left*) and the EVLA (*right*) antennas. A total of 24 frequency settings were used to span the frequency range between 1378 and 1451 MHz with a frequency interval of 3 MHz. The instantaneous bandwidth of each frequency setting is 3.125 MHz.

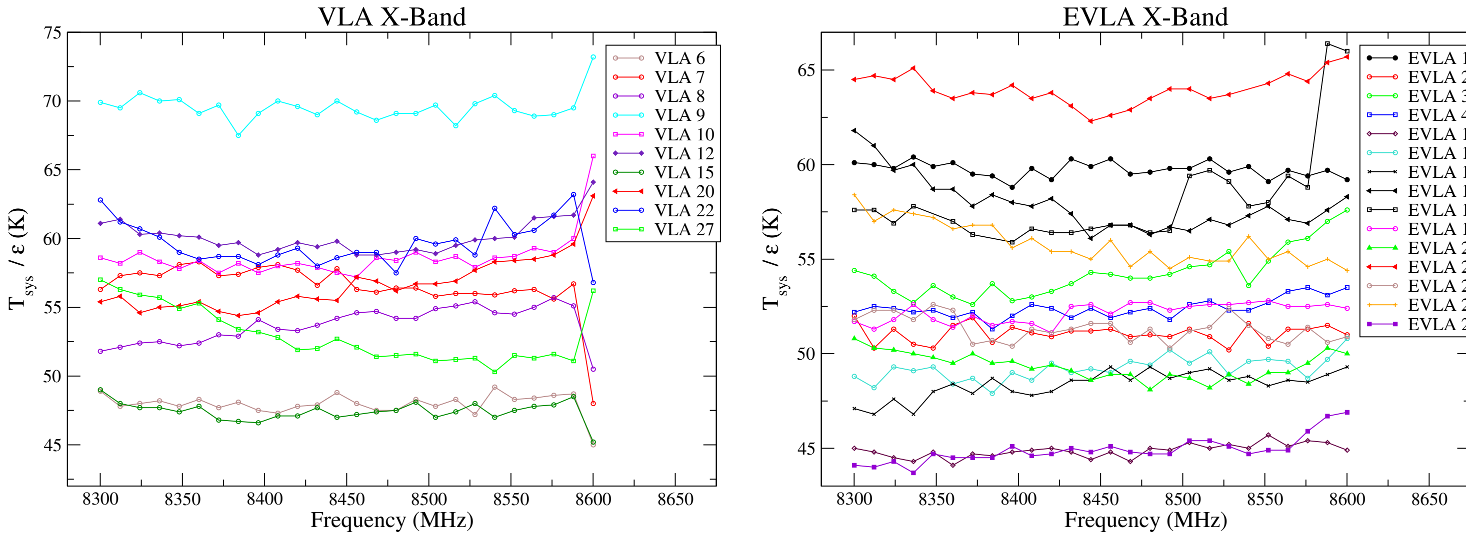

Figure 3: Effective system temperature values vs. frequency at X-band for both the VLA (*left*) and the EVLA (*right*) antennas. A total of 26 data points were used to span the frequency range between 8294 and 8606 MHz with a frequency interval of 12 MHz. The instantaneous bandwidth of each frequency setting is 12.5 MHz.

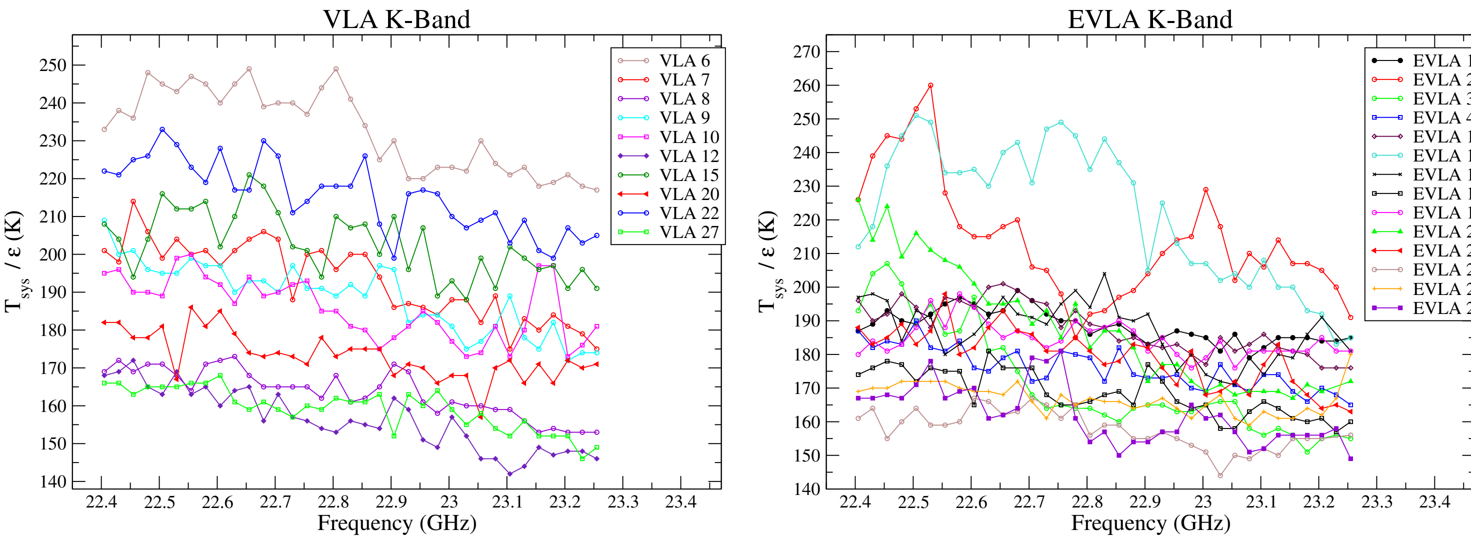

Figure 4: Effective system temperature values vs. frequency at K-band for both the VLA (*left*) and the EVLA (*right*) antennas. A total of 35 data points were used to span the frequency range between 22393 and 23268 MHz with a frequency interval of 25 MHz. The instantaneous bandwidth of each frequency setting is 25 MHz. The slope seen in the sensitivity of both the VLA and the EVLA antennas is due to the $\sim$ 1 GHz wide 22.4 GHz atmospheric water-line emission that is resulting in higher system temperature values for almost half of the frequency range observed at K-band.

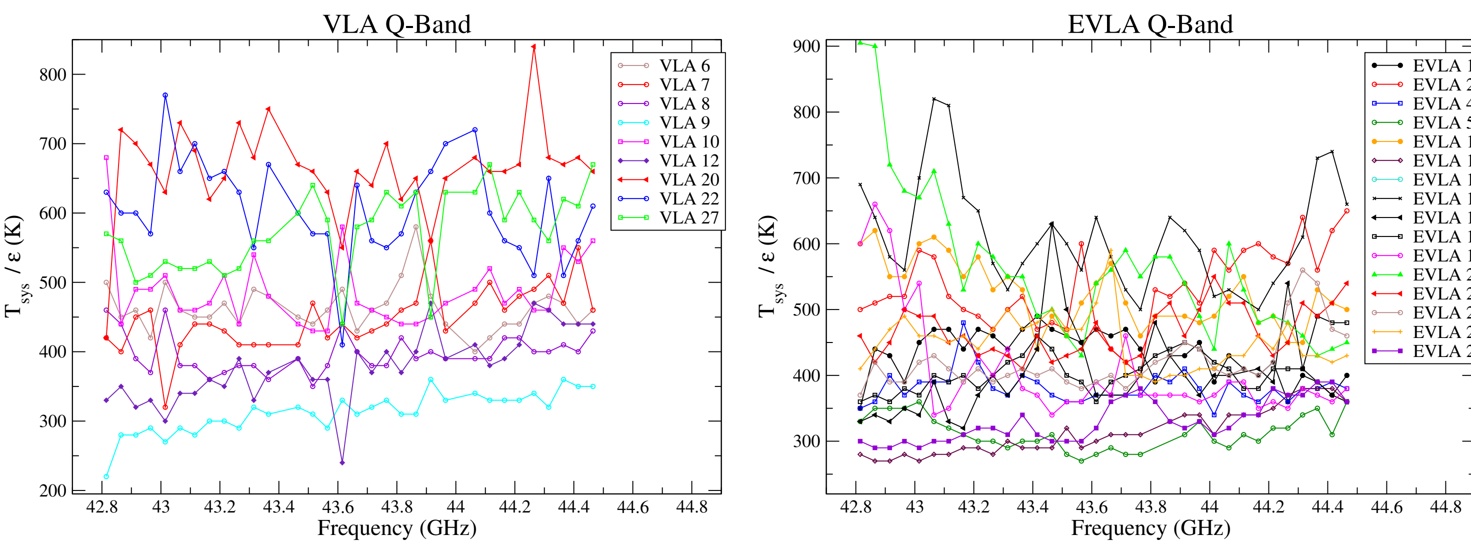

Figure 5: Effective system temperature values vs. frequency at Q-band for both the VLA (*left*) and the EVLA (*right*) antennas. A total of 34 data points were used to span the frequency range between 42790 and 44490 MHz with a frequency interval of 50 MHz. The instantaneous bandwidth of each frequency setting is 50 MHz.