EDGES MEMO #250

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886

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Telephone: 617-715-5533
Fax: 781-981-0590

To: EDGES Group

From: Alan E.E. Rogers

Subject: RFI excision of FM Signals

The EDGES antennas at the MRO are subject to significant RFI from the FM band which covers 87.5 to 108 MHz. The potential problems with RFI were recognized early in the EDGES project. Memo #4 discusses the how to minimize signals arriving at low elevation by having the antenna low to the ground and being sensitive only to horizontal antenna without any vertical currents. It was clear that a remote site would be needed and the possibility of using Nightingale Island 20 miles from Tristan da Cunha was investigated. This site is more than 3000 km from the nearest FM transmitter at night. There is a FM station in Tristan which is turned off at night. A distance of more than 3000 km is needed to avoid the scatter of FM signals from meteors which burn up at about 100 km as discussed in memos 2, 52, 53 and 54.

In the end it was decided to deploy EDGES in Western Australia, first a Mileura and then at the MRO to take advantage of the infrastructure needed for a long term deployment of EDGES with both high and low band to cover 50 to 200 MHz.

A detailed study of the effects of RFI was reported in memo 244 which shows that while FM reflections from the moon, which can be avoided by limiting observations to time when the moon is blow the horizon, have an effect of about 50 mK in the EDGES spectrum. This memo looks at EDGES data without smoothing of the 6 kHz resolution to show that the FM band signals can be excised and have little, if any effect, on the final spectra. Figure 1 shows the residual spectra with 4 polynomial terms removed for the lowband1 data from 2016_251 to 2017_094 for 4 cases of RFI excision as follows:

1] First stage of RFI excision threshold set a 6.5 sigma in 12 hours of data from GHA=6 to 18 each day.

2] Same as in case 1 but with threshold at 2.5 sigma

3] As in case 1 but with second stage excision threshold at 3 sigma added for integration of all days

4] As in case 2 with second stage threshold of 3 sigma.

The plots are made for 6 kHz resolution with smoothing. Figure 2 shows the frequency range 85 to 90 MHz with slope removed to show that the residual FM RFI is relatively sparse so that its effect when smoothed or fit is under 30 mK. Figure 3 shows the same residual spectra as in Figure 1 with a smoothing factor of 64 which reduces the resolution from 6 to 391 kHz. The signature amplitude for a fixed center frequency of 78.5 MHz, FWHM of 18.9 MHz and flattening 7 for each case are given in Table 1 which shows that even with only first stage RFI

excision of 6.5 sigma which is well above the 2.5 sigma which is well above the 2.5 sigma used in standard processing the effect on the amplitude is only 20 mK.

Case	Resolution kHz	1st filter	2nd filter	amp K
1	6	6.5	None	0.52
2	6	2.5	None	0.47
3	6	6.5	3	0.51
4	6	2.5	3	0.47
1	391	6.5	None	0.52
2	391	2.5	None	0.47
3	391	6.5	3	0.51
4	391	2.5	3	0.47

Table 1. Signature amplitudes vs RFI filter and resolution.

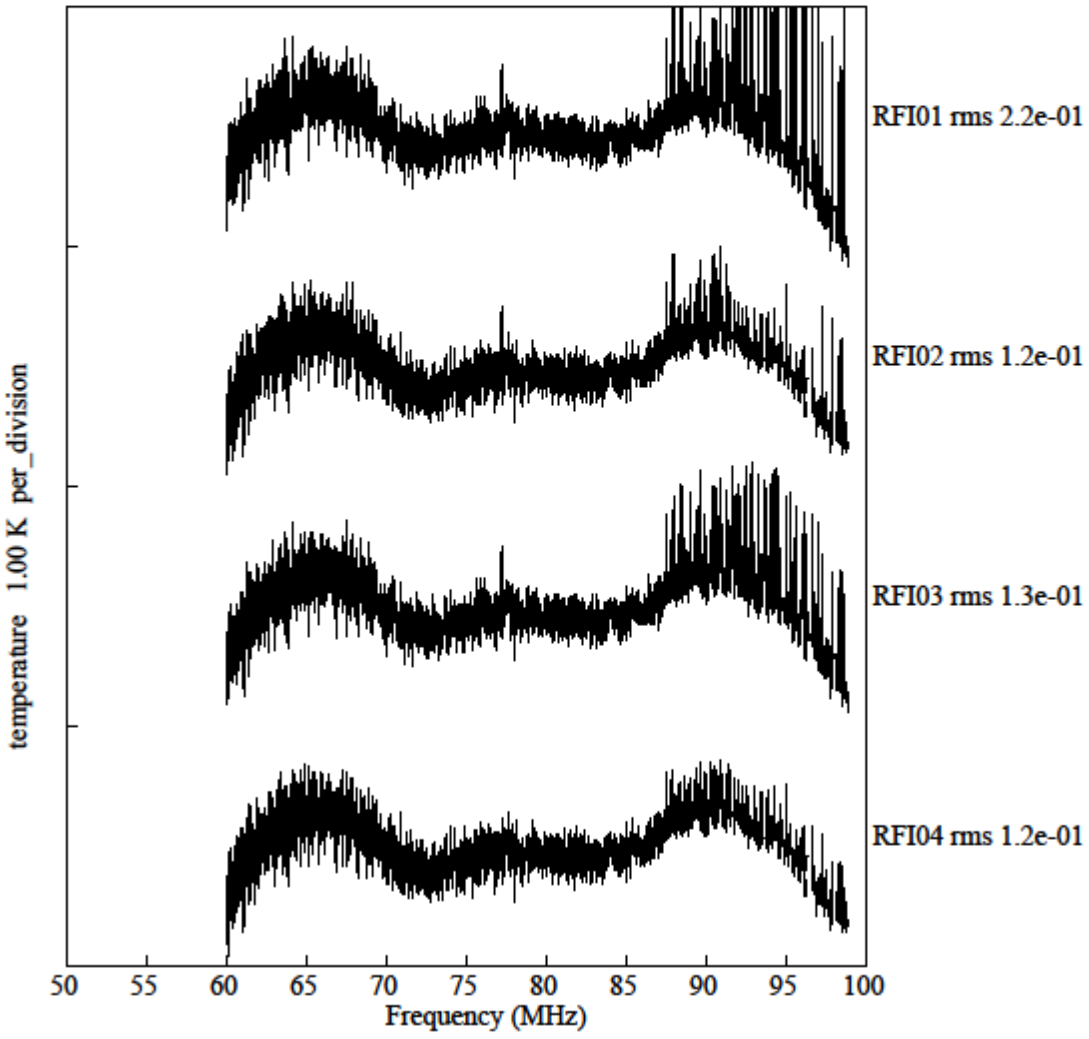

Figure 1. Residual spectra with 6 kHz resolution with 4 polynomial terms removed for lowband1 from 2016_251 to 2017_094 for various degrees of RFI excision.

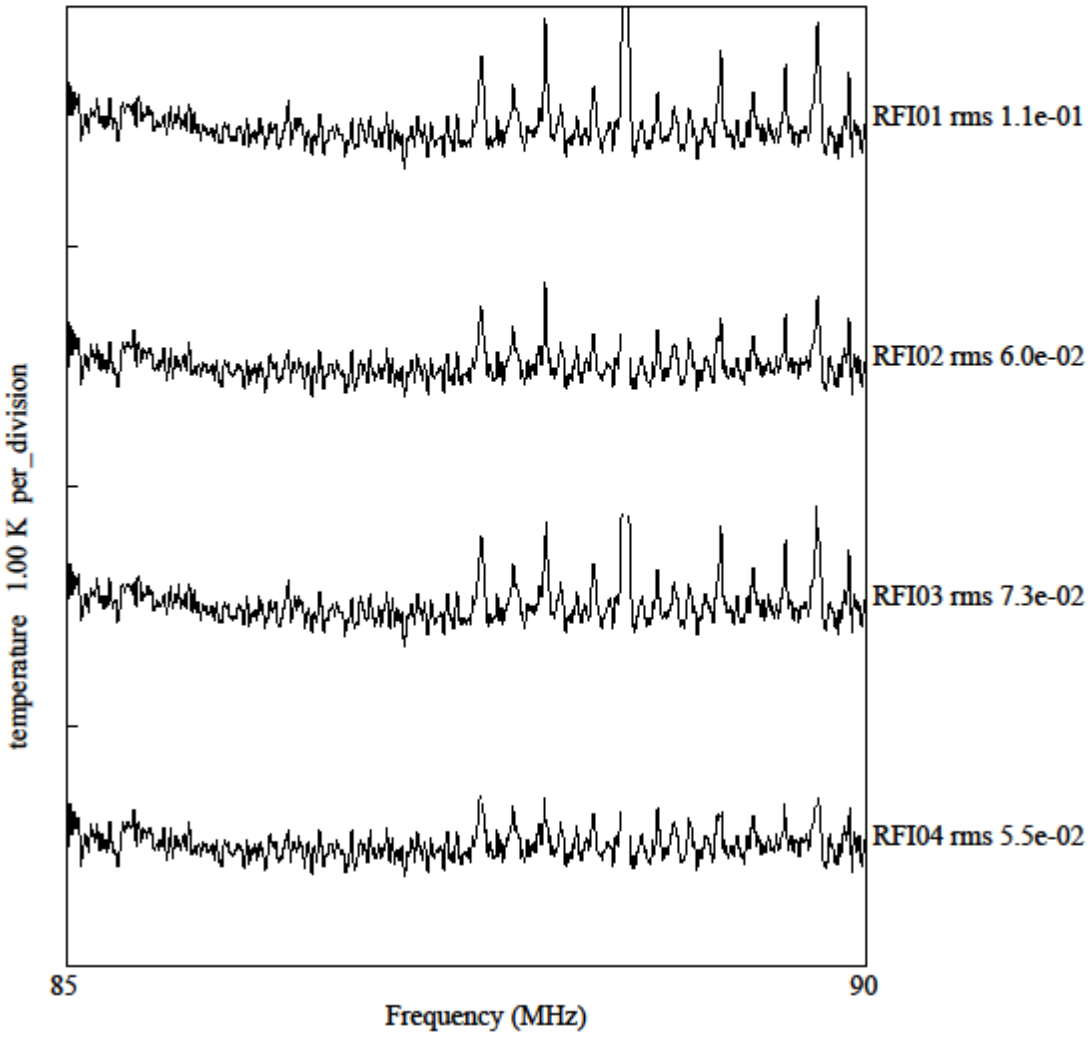

Figure 2. Zoomed view showing the relative sparseness of the FM band RFI.

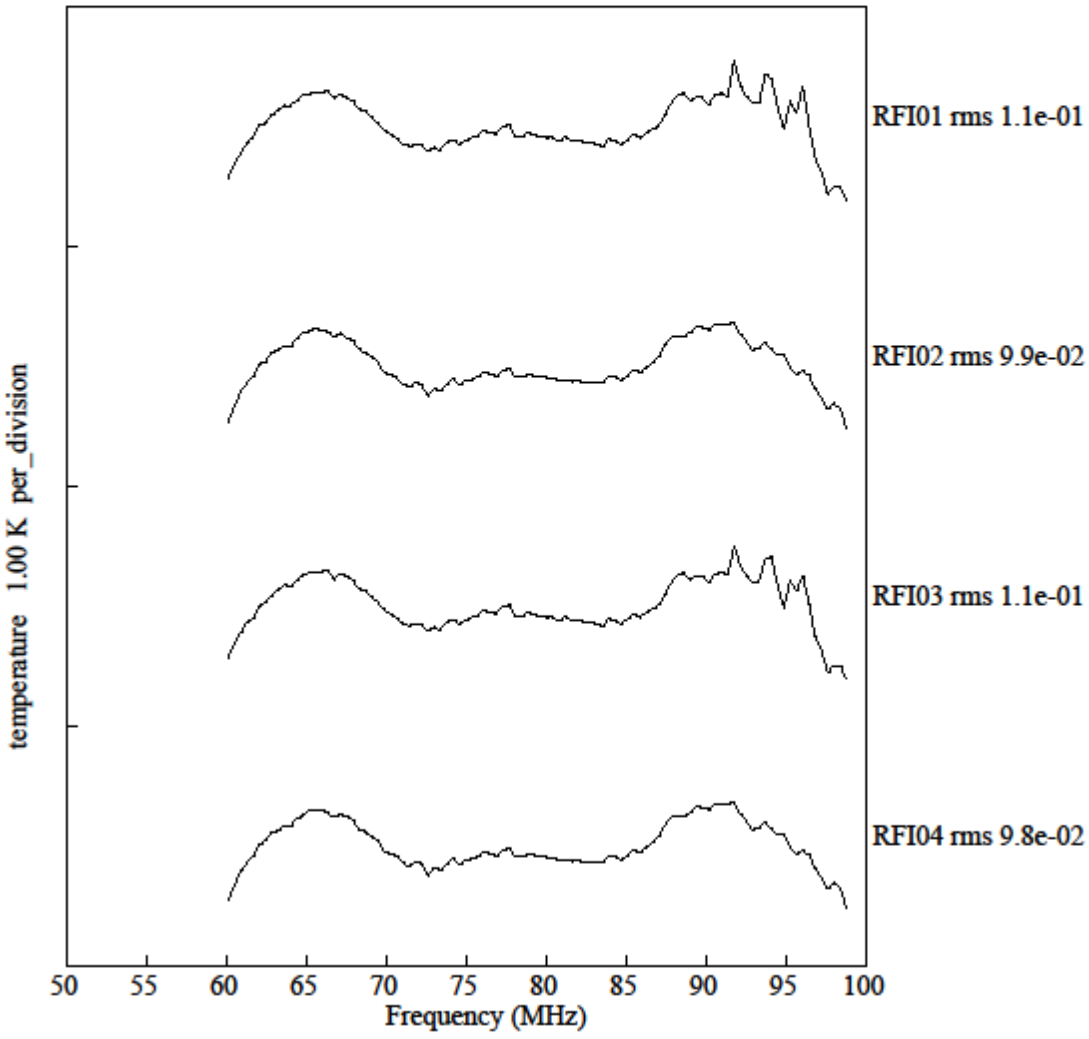

Figure 3. Residuals smoothed to 391 kHz resolution.