EDGES MEMO #172

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September 14, 2015

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To: EDGES Group

From: Alan E.E. Rogers
Subject: Comparison of two methods for "Galaxy" calibration

The 2 Galaxy calibration methods are

1] "Difference" method (see memos 48, 55, 145)

$$S = (G_d / G_u)(a/(a-1))$$

Where G_d = spectrum when Galaxy is "down"

G_u = spectrum when Galaxy is "up"

$a = (G_u / G_d)$ at 150 MHz

2] "Ratio" method (see memo 171)

$$S = uf^{-2.5}(G_d / G_u)(a/a-1)$$

Where $u = G_u$ at 150 MHz

f = frequency/150

Both methods are "normalized" by *a* so that the strength of the EoR signature present in G_u and G_d is preserved in S.

Two 5 term fitting functions are tested:

a) "Physical"

$$f^{-2.5},\ f^{-2.5}\ln(f),\ f^{-2.5}\left[\ln(f)\right]^2,\ f^{-4.5},\ f^{-2}$$

Which represent scale, spectral index, curvature in spectral index, ionosphere absorption and ionosphere emission.

b) "Polynomial"

The following test function was used to simulate data

$G = af^{b}(1 - cf^{-2}) + df^{-2}$

Where a = 300K for G_d and 900K for G_u

$$b = 2.52 + 0.2\ln(f) + 0.1(\ln(f))^2 \ \mathit{for}\ G_d$$

$$= 2.48 - 0.2\ln(f) + 0.2(\ln(f))^2 \ \mathit{for}\ G_u$$

c = 0.02 for G_d and 0.01 for G_u

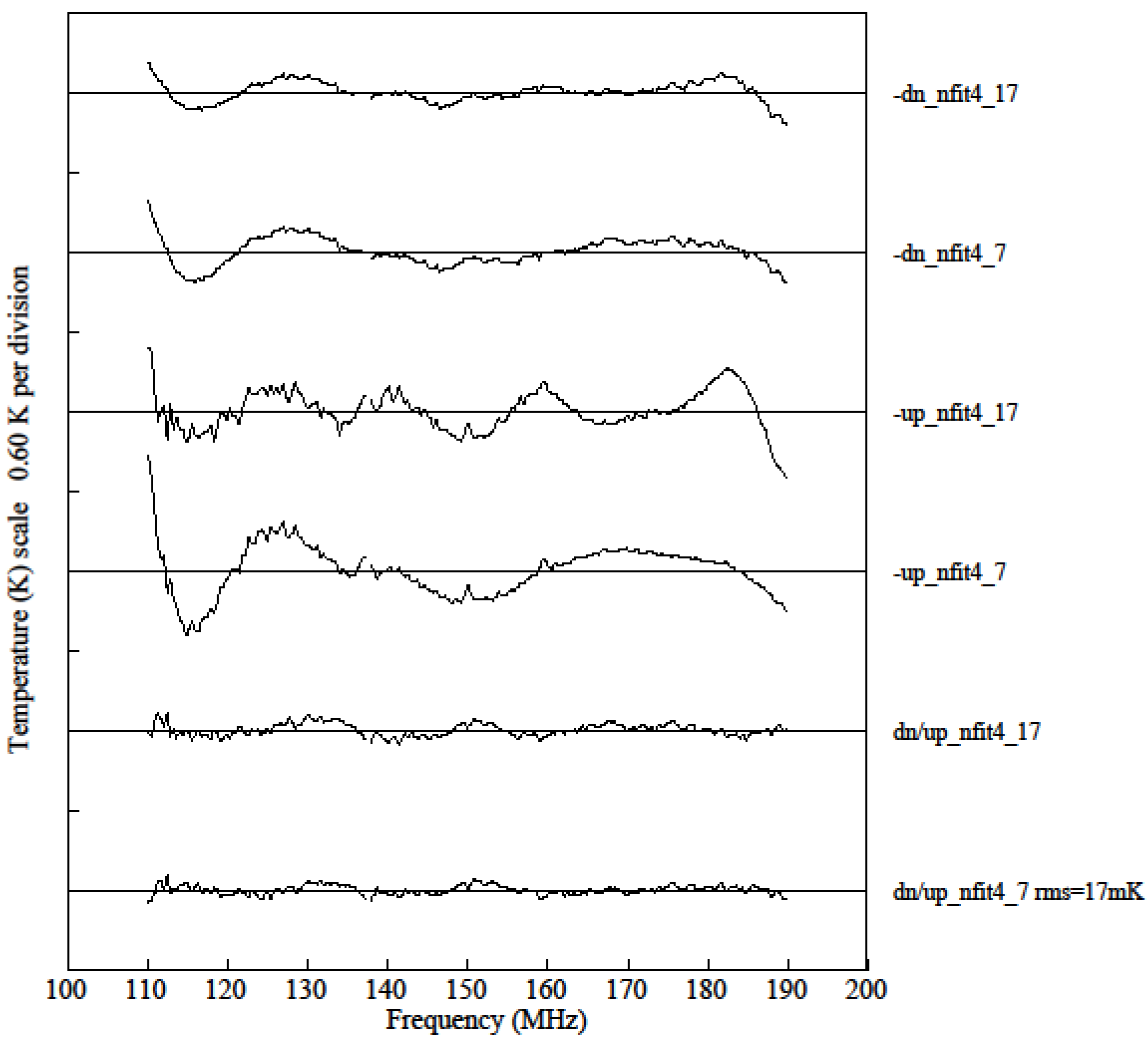
d = 10 for G_d and 20 for G_u

	Ratio	Difference	Std. deviation	
Fit	Rms (mK)	Rms (mK)	20 MHz	40 MHz
Physical	0.4	6.0	0.5	1.0
Poly	76	25	0.5	1.0

The table above gives the rms residuals for a 5 term fit from 100-200 MHz and the square root of covariance for 6 term fit for the 5 parameters plus an EoR Gaussian of 20 and 40 MHz half power full width. In summary the simulations show that fitting with physical parameters is better than fitting with a polynomial.

The 5 physical functions are able to handle a departure of spectral index from the nominal values of -2.5, a slope in the spectral index ("gamma") and a curvature in spectral index. The choice of the difference or the ratio method appears to be somewhat dependent on the data set being analyzed.

Figure 1 shows from top to bottom the "Galaxy down" spectra, the "Galaxy up" spectra and the difference spectra from the blade antenna from 2015-204 through 2015-237 with 5 physical terms removed. These results are shown for 2 cases of smoothing of the antenna S11. In the first case a 17 term Fourier series was used and in the second case a 7 term polynomial was used. With the added smoothing of the S11 the difference method yielded a lower rms than the ratio method used in memo 171.



Temperature (K) scale 0.60 K per division
-dn_nfit4_17
-dn_nfit4_7
-up_nfit4_17
-up_nfit4_7
dn/up_nfit4_17
dn/up_nfit4_7 rms=17mK
100
110
120
130
140
150
160
170
180
190
200
Frequency (MHz)

Figure 1.