EDGES MEMO #230

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Subject: 3-position switch noise bias

Memos 18, 46, 174 and 176 discuss the 3-position switch. The noise bias due to the division by (P_{cal}-P_{load}) is briefly mentioned in memo 176. This bias is of no consequence as long as the calibration data and field data have the same noise in a single switch cycle. Future improvements made to lower the noise in a switch cycle will require that the same data acquisition processing (windowing number samples etc.) be used for calibration as used in the field.

The noise in (P_{cal}-P_{load}) is given by

$$\left(P_{cal} - P_{load}\right) = g\left(T_c + \left(n_2 - n_1\right)\left(T_L + T_R\right) + T_c n_2\right)$$

T_L = load temperature

T_c = cal temperature

T_R = receiver LNA temperature

and n_1 and n_2 the uncorrelated noise from the load and calibration cycle respectively. Expanding the division to 3-terms and taking the average gives the bias fraction as

$$\left[\left(T_L + T_c + T_R\right)^2 + \left(T_L + T_R\right)^2\right]^{1/2} T_c^{-1} \left(B\tau\right)^{1/2}$$

Where B = resolution bandwidth and τ is the integration time (from the number of samples) in each switch position.

The bias fraction is 8×10^{-2} for T_R=200, T_c=1000 and T_L=300 K.

The effect of the bias with incompatible processing is shown in Figure 1 by averaging 10 cycles of each 3-position state before the 3-position calculation to lower the bias by a factor of $10^{1/2}$.

Another test of the effect of incompatible processing was made by using the calibration results from averaged 3-position data to estimate the signature discussed in memo 220. The results given in Table 1 show the reduction in SNR and change of parameters with incompatible processing.

It is also pointed out that it is important that the backend contribution to the noise should be negligible and that it is better to add the out of band noise in the receiver to maintain the same conditions in the field as in calibration.

Center frequency MHz	SNR	Amplitude K	Width MHz
78.1	33	0.48	20
77.0	21	0.74	23

Table 1. Signature results for 4-poly terms removed for data from 2016_251 to 2017_017 using 60-99 MHz. Second entry is for "incompatible processing" of calibration data.

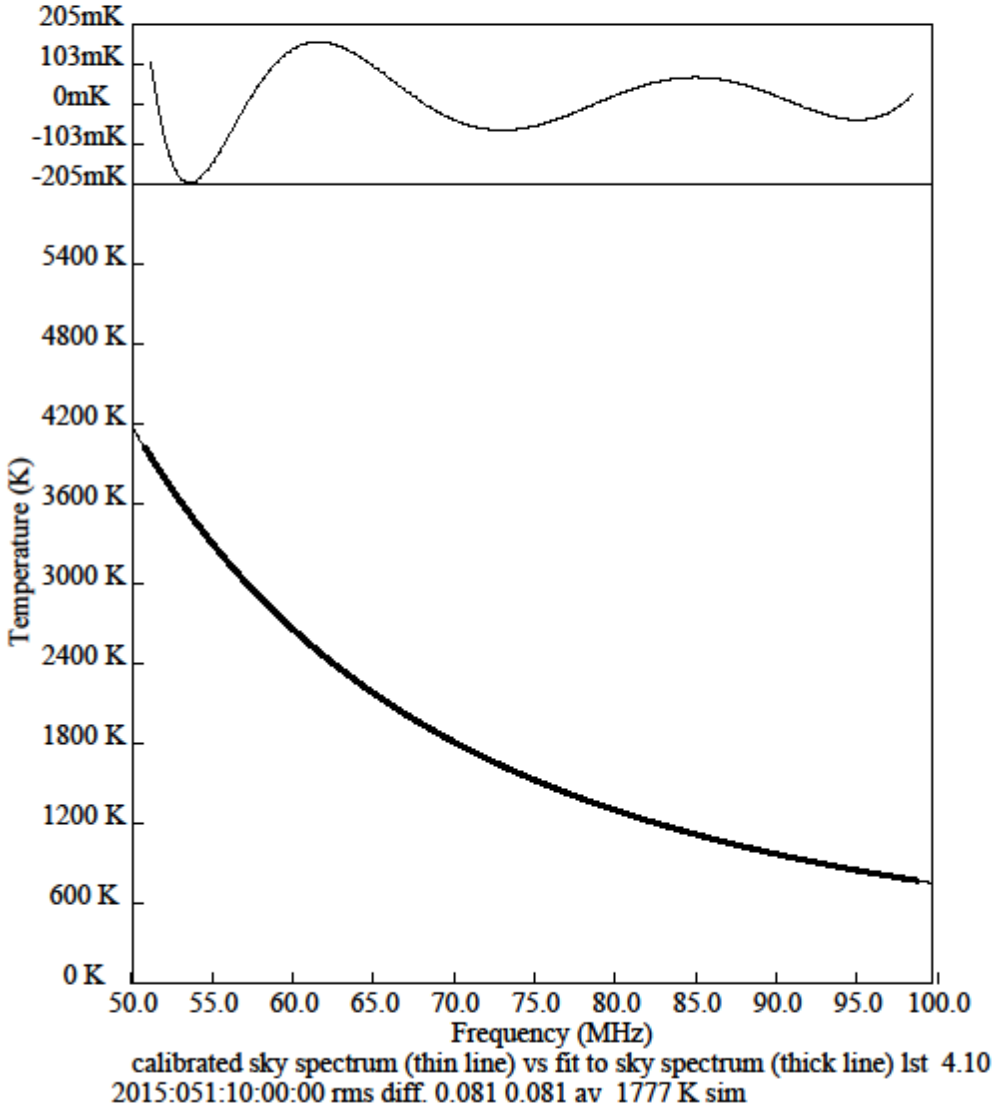

Figure 1. Structure of bias with 1 polynomial term removed for incompatible processing.