EDGES MEMO #047

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886

May 15, 2009

Telephone: 781-981-5407
Fax: 781-981-0590

To: EDGES Group
From: Alan E.E. Rogers
Subject: Further analysis of 2009 EDGES data from Boolardy

1] Average spectrum from days 33 thru 41

The rms from the average of all the data was 10 mK from 105 to 205 MHz with smoothing to 5 MHz resolution and removal of a 11 term polynomial. In order to reach this level spectral frequencies with a positive deviation of more than 4 times the rms were excluded and 30 second integrations with total power more than 40% over the average were excluded. Figure 1 shows the average spectrum in black with the excluded frequencies in blue. The fraction of the excluded frequencies (within the 105 to 205 MHz range) was 5% and the fraction of data excised was 30%. The theoretical noise estimate for this average spectrum is 10 mK using the parameters given in memo #46.

2] Comments on the RFI

The strongest RFI signals in addition to the Orbcomm 137-138 MHz were at the following frequencies:

Freq. MHz	Average signal (K)	Location
122.6	700	Meekatharra
125.2	200	Perth
127.3	3000	Meekatharra
131.55	2000	ACARS*
132.0	300	Geraldton†
133.8	2000	Mount Magnet

These are narrow band signals from Aircraft. However, I have not yet been able to be sure of the identity of the aeronautical ground stations assigned to these frequencies. They could be quite distant since the line of sight range for an aircraft at 30,000 ft is about 360 km and the ground station could be at twice that distance.

Figure 2 shows a "waterfall" plot for day 40. While the Orbcomm is fairly continuous the aeronautical signals are clearly less frequent at night especially after midnight. The FM signals are present at a low level (~100 mK) most of the time with short periods of simultaneous enhancement (~10 K) of all FM channels. It looks like the enhancements

* ACARS Aircraft Communication Addressing and Reporting System
† High level sector

are the result of reflections from aircraft since the frequency also decreases after midnight. The day to day variation of the low level continuous FM is most likely due to the changes in the tropospheric scatter and refraction. Since Boolardy is only 300 km from Geraldton any aircraft at 30,000 ft within the intersection of 360 km radius circles around Boolardy and Geraldton has line of site to the FM station and EDGES. If an aircraft is midway between Boolardy and Geraldton (i.e. 150 km) then one expects about 3K in 25 kHz for every m^2 of radar cross-section from a 100 kw EIRP FM station in Geraldton. The typical FM strength in 25 kHz at Boolardy into the EDGES antenna averaged over 9 days was as follows:

Freq. MHz	Strength K	City
93.7	3	P
94.5	8	P
94.9	25	G
96.1	3	P
96.5	30	G
96.9	10	P
97.7	10	P
98.1	40	G
98.9	30	G
99.3	3	P
99.7	40	G
101.3	60	G
P = Perth, G = Geraldton		

It is also noted that there are signals in the 144-148 MHz amateur band. In particular the signals at about 145.9 MHz maybe from the amateur radio satellite. In addition the Geraldton TV at 175 MHz may be detected in Figure 1. These signals are transient, as seen in figure 2. The average power over 9 days was about 30 K.

EDGES antenna Pattern

The EDGES antenna pattern is close to that of a horizontal dipole over a ground plane. Since the antenna site is on the ground the rejection of signals at 1 degree elevation is about 25 dB below the nominal 8 dBi zenith response. Details are in memo #4.

Thanks to Russ McWhirter and Joe Carter in helping identify aeronautical channels.

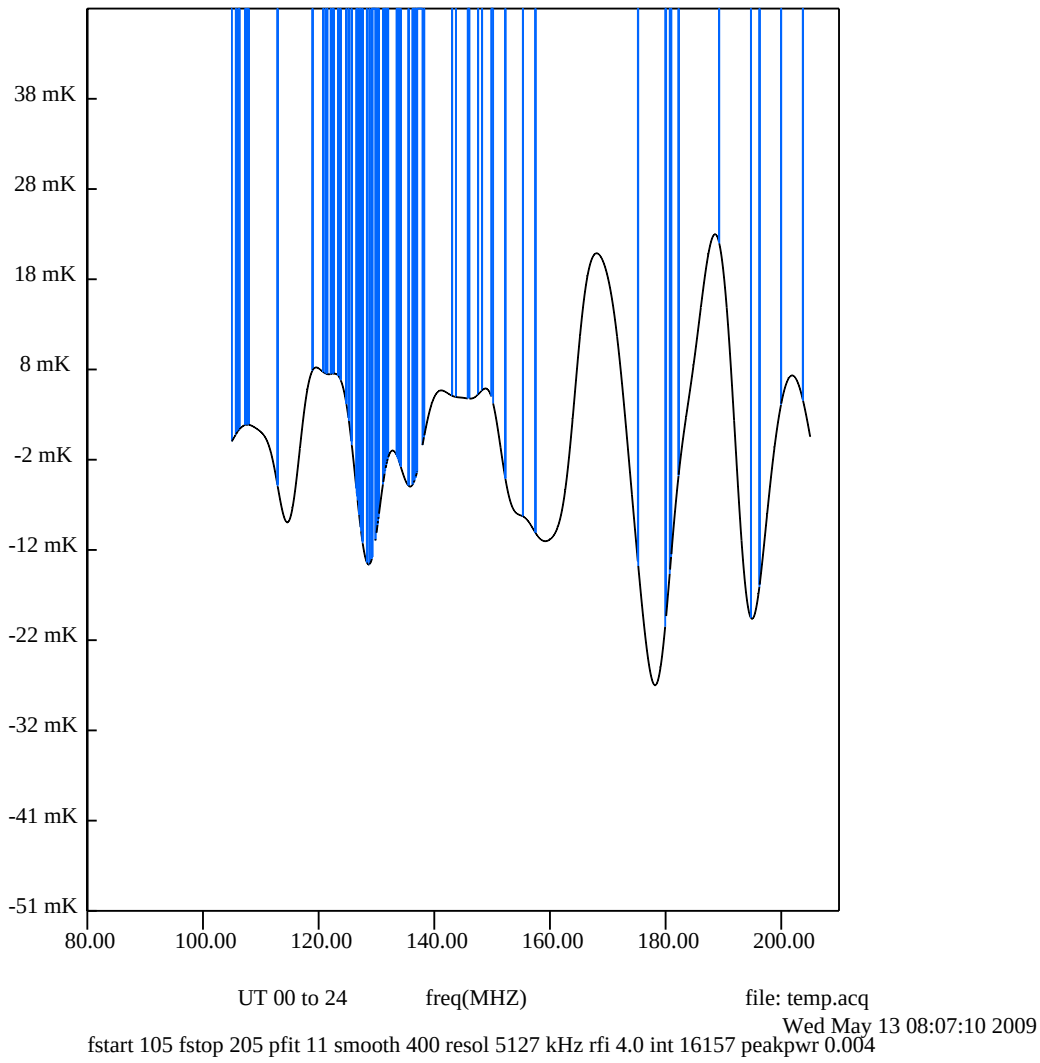

Figure 1. Spectrum from filtered average of days 33 through 41 in 2009. A 11 term polynomial has been removed from the spectrum. Blue lines indicate frequencies excluded due to RFI.

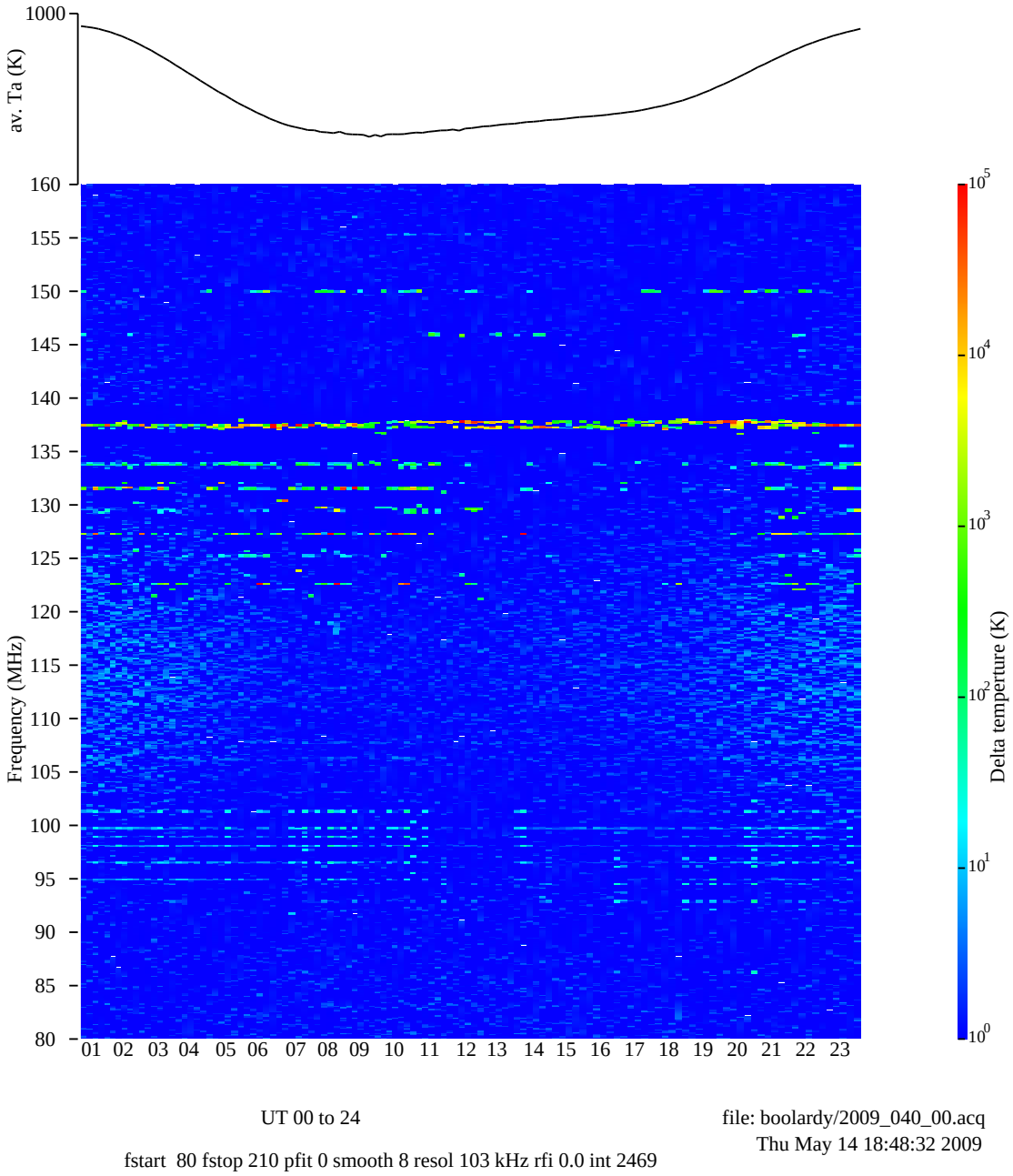

Figure 2. “Waterfall” plot for day 40. The variations in the FM signals are though to be the result of scattering from aircraft.