A Measurement of Precipitation Static Intensity

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Introduction:

Precipitation static has been observed many times at HNRAO. See [Precipitation Static, Brown (HNRAO, 2011).pdf]. posted on the SUG web site. On the morning of August 10, 2018, a local rain storm occurred making it possible to measure the equivalent antenna temperature during one of these events.

Experiment:

Before the rain storm and using the TFD array with the beam steered toward 35 degrees south, the galactic background temperature at 20.1 MHz was measured as 60.7 kK. This is the temperature at the "Sky side" of the TFD antenna, which takes into account internal losses of 4.3 dB in the array itself (Figure 1).

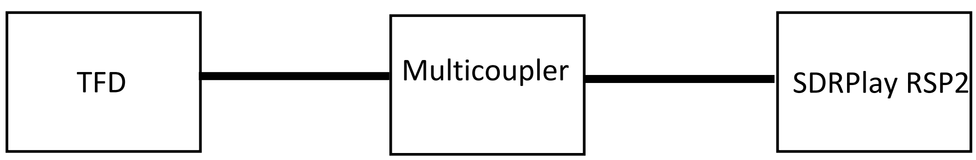

Figure1. System diagram as connected for the measurement of antenna temperature

Approximately an hour later, precipitation static was observed during a heavy rain storm at the observatory. Radio Sky Spectrograph (2.8.50) displays showing conditions before and during the precipitation static event are seen in Figures 2A and 2B.

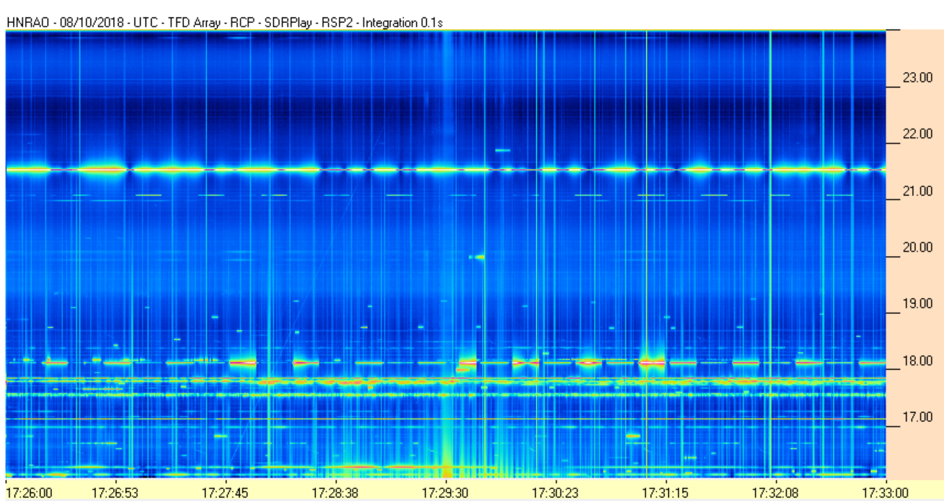

Figure 2A. August 10, 2018 spectrogram showing conditions before the precipitation event

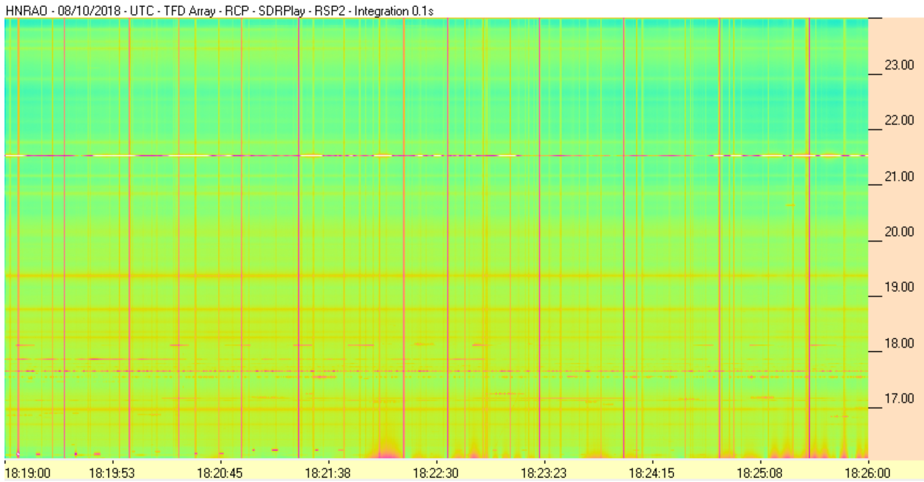

Figure 2B. August 10, 2018 spectrogram showing conditions during the precipitation static event

A seven minute segment of the galactic background (1726-1733 UT) was selected as representative of the noise intensity prior to the precipitation event. Similarly, a seven minute segment (1819-1826 UT) was selected as representative of the noise intensity during the precipitation event.

The experiment strategy was to obtain an average temperature during each 7 minute interval and then determine the ratio of those two temperatures.

To obtain that average, values the 7-minute data files were exported to Excel using the RSS "Export to CSV File" utility.

The CSV file is an array of date, time, and RSS raw data values for each channel of the spectrogram. The raw data for each channel falls in the range of 0 to 4096 as represented by the count of the 12 bit data stream from the SDRPlay spectrograph, after processing by Nathan Towne's SDRPlay2RSS software. A sample of the CSV files with the data channel at 20.156 MHz is seen below in Figure 3.

Date	Time	20.156 MHz
8/10/2018	26:00.0	525
8/10/2018	26:00.1	537
8/10/2018	26:00.2	520
8/10/2018	26:00.3	517
8/10/2018	26:00.4	515
8/10/2018	26:00.5	526
8/10/2018	26:00.6	517
8/10/2018	26:00.7	531
8/10/2018	26:00.8	529

Date	Time	20.156 MHz
8/10/2018	19:00.0	1141
8/10/2018	19:00.1	1145
8/10/2018	19:00.2	1124
8/10/2018	19:00.3	1136
8/10/2018	19:00.4	1123
8/10/2018	19:00.5	1141
8/10/2018	19:00.6	1138
8/10/2018	19:00.7	1140
8/10/2018	19:00.8	1130

Figure 3. Galactic background data on the left, precipitation static plus GB on the right.

The 7-minute data files each contained 4,203 data points. An average value of 528 (σ =77) was obtained for the galactic background prior to the event and the average during the precipitation static was 1203 (σ = 117).

The next step (Figure 4) involved connecting the noise source and attenuator to the multicoupler and adjusting the manual step attenuator so that the input temperatures to the multicoupler matched the RSS averages both prior to, and during the precipitation event. The temperature of the HP461 was 75 MK. The attenuation value of 38.76 dB matched the GB level at the input to the multicoupler. The attenuation value of 27.29 dB matched the level of the GB plus the precipitation static. These attenuation values equated to temperatures at the multicoupler input of 9.98 kK and 140 kK. The precipitation static plus GB to GB ratio was 14.02. Expressed in dB, this is 10*LOG ((140+9.98)/9.98) = 11.5dB.

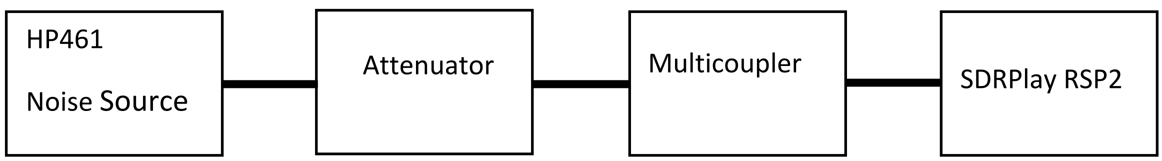

Figure 4. – 75MK HP-461 noise source connected to the multicoupler input thru the recently calibrated manual step attenuator.

The temperatures measured at the input to the multicoupler can be referenced back to the “sky side” of the TFD array. The cable losses between the multicoupler and the TFD feedpoint are 3.54 dB. Losses in the array itself at 20.1 MHz account for an additional 4.3 dB, giving a total loss of 7.84 dB.

dB loss expressed as a ratio = 10^ (total system loss dB/10)
= 10^ (0.784) = 6 (ratio)

Temperatures at the “sky side” of the TFD are therefore 6 times the temperatures at the multicoupler input.

The sky side GB temperature was 60.7 kK while the precipitation static plus GB temperature was 840 kK.

Where did the extra noise come from?

In an issue of the Quarterly Journal of The Royal Meteorological Society in 1955, L.G. Smith describes the process by which they measured the electric charge of raindrops. Smith, L. G. (1955), The electric charge of raindrops. Q.J.R. Meteorol. Soc., 81: 23-47. doi:10.1002/qj.49708134705.

He speaks of the experiment as, “The electric charge is measured by electrostatic induction on a metal cylinder as the drop falls through. The size of the smaller drops is determined from the time of fall between two such cylinders…”.

Conclusion:

Precipitation static may be caused by electrically charged raindrops striking the antenna elements. However, there are reports from some observers about hearing precipitation static from nearby rain storms, when the storm was not overhead and no raindrops were actually striking the antenna.