Seven solar bursts, three JOVE stations

R.S.Flagg, August 2022

Seven solar bursts received simultaneously at three JOVE stations between 4/20/22 and 7/1/22 are compared in terms of peak amplitude.

THE STATIONS

ESCRadio - John Cox in Easley, South Carolina is using a 4 element, circularly polarized, terminated folded dipole (TFD) antenna.

MRO - Millhopper Radio Observatory - Francisco Reyes in Gainesville, Florida is using a custom 4 element, 20.1 MHz dipole polarimeter. Calibration changed by about 0.6 dB during the 3 month observation period – this is not reflected in the data values and plots.

HNRAO - Jim Brown in Industry Pennsylvania is using a standard linearly polarized JOVE dual dipole array.

Each station was operating a calibrated JOVE RJ1.1 receiver and recording burst intensities in terms of antenna temperature using the Radio SkyPipe stripchart program. A sample record (Fig 1) from HNRAO shows the burst at 1358 UTC on 6/25/22 followed by some smaller bursts.

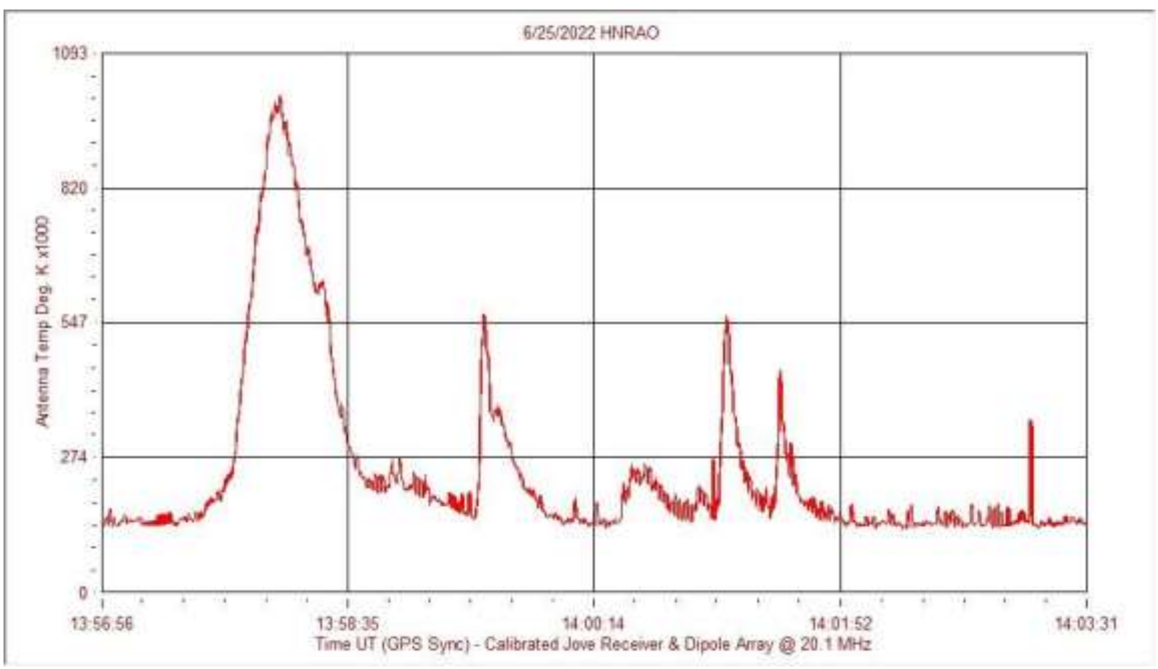

Fig 1 Solar bursts received using a calibrated RJ1.1 receiver and a linearly polarized JOVE dual dipole antenna.

Antenna temperature referenced to the antenna terminals is shown on the vertical axis. The background temperature in this record is estimated at 137 kilo Kelvin and the peak temperature of the burst plus the background is 1002 kK

DATA

Bursts were recorded at the dates and times shown below in Table 1. In addition, this table shows the background temperatures at each station, the background plus burst temperatures which are the actual burst peak readings, and the burst temperature alone (background + burst – background), all in kilo Kelvin.

Date	4/20/22	4/30/22	6/25/22	6/26/22	6/27/22	6/30/22	7/1/22
Time UTC	1624	1343	1358	1829	1844	1818	1700
Event	1	2	3	4	5	6	7
ESC backgnd	108	100	144	135	246	130	125
MRO backgnd	300	285	75	113	137	100	94
HNRAO backgnd	288	237	137	183	288	180	126
ESC bgnd+burst	2341	5000	1227	650	3400	830	260
MRO bgnd+burst	3300	1900	500	375	3162	766	190
HNRAO bgnd+burst	2663	15352	1002	475	3031	1011	265
ESC burst	2233	4900	1083	515	3154	700	135
MRO burst	3000	1615	425	262	3025	666	96
HNRAO burst	2375	15115	865	292	2743	831	139

Table 1 Data from the three stations and seven solar bursts.

In Chart 1 we see background temperatures (galactic background + other radio frequency noise) for the 3 stations at the time of each burst. The events are labeled 1 thru 7 on the horizontal axis corresponding to the dates in Table 1.

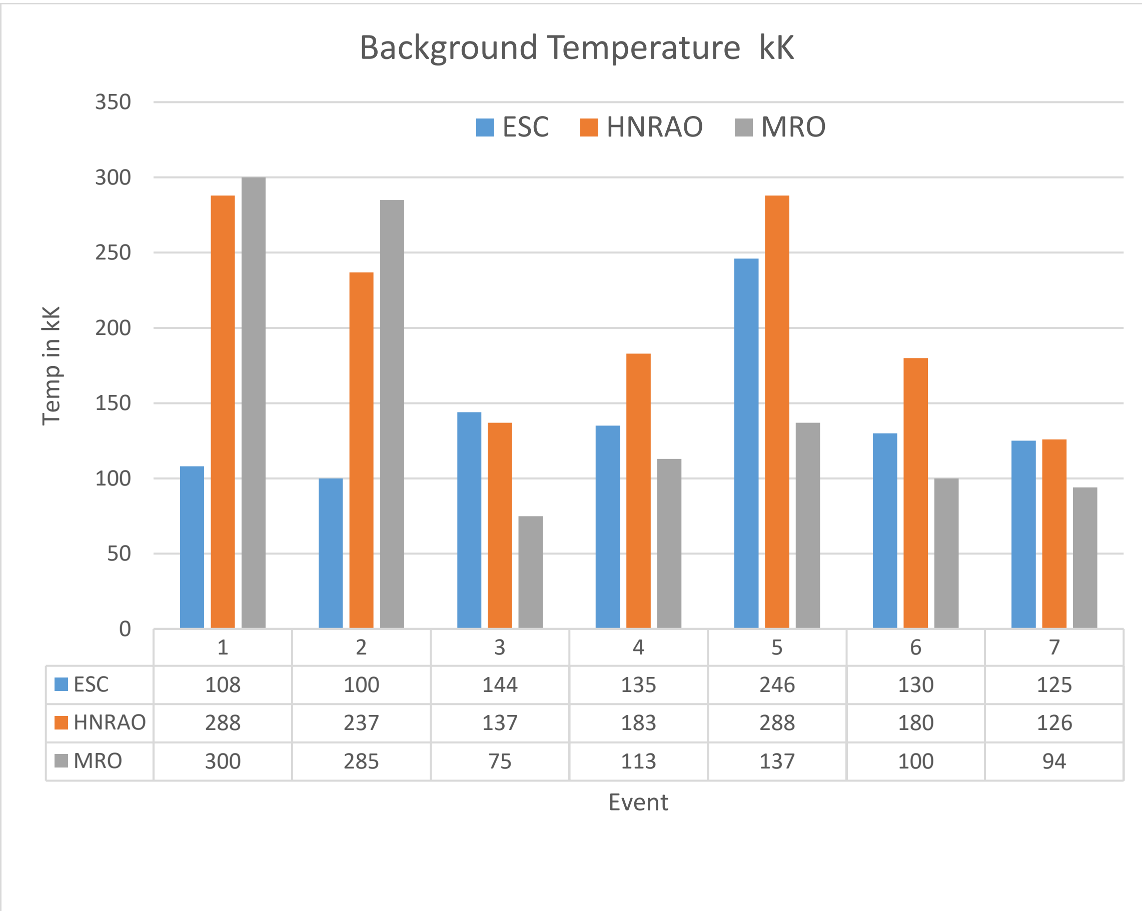

Chart 1. Background temperatures at each station vary considerably over the observing period with the MRO site showing both the lowest (event 3 on 6/25/22) and highest temperatures (event 1 on 4/20/22).

Station	Min Bkgnd Temp kK	Max Bkgnd Temp kK	Average Bkgnd Temp kK	Range dB
ESC	100	246	141	3.9
HNRAO	126	288	206	3.6
MRO	75	300	158	6

Table 2. Minimum, maximum, average, and background temperature range in dB.

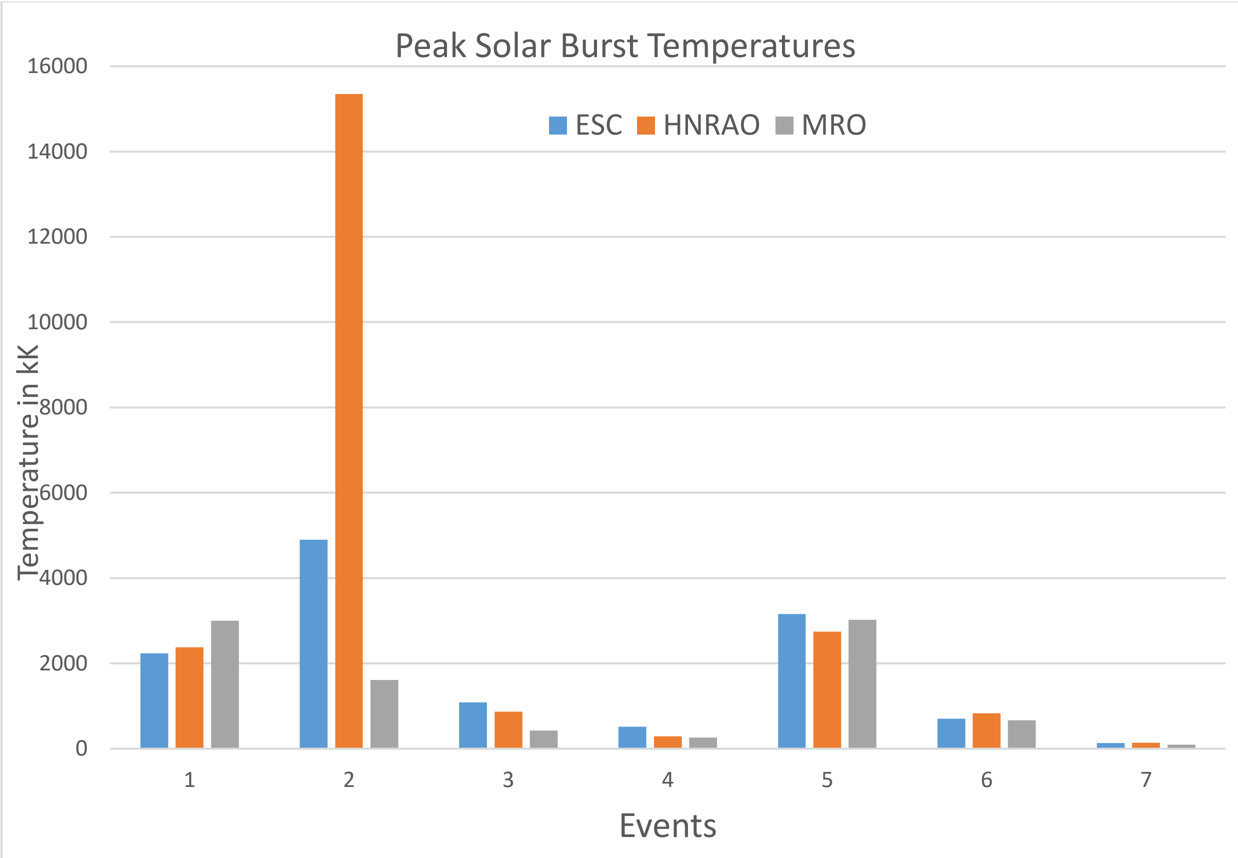

Chart 2. Peak burst temperatures are seen for the 7 solar bursts at the 3 observing stations.

With the exception of event 2 (4/30/22) most stations reported fairly similar burst peak amplitudes on each of the observing days as seen in the right hand column of Table 3 which shows the range [10 LOG (max/min)] in readings between the three stations in decibels for each event.

Event	Date	ESC kK	HNRAO kK	MRO kK	Average kK	Range dB
1	4/20/22	2233	2375	3000	2536	1.3
2	4/30/22	4900	15115	1615	7210	9.7
3	6/25/22	1083	865	425	791	4
4	6/26/22	515	292	262	356	2.9
5	6/27/22	3154	2743	3025	2974	0.6
6	6/30/22	700	831	666	732	1
7	7/1/22	135	139	96	123	1.6

Table 3 Peak burst temperatures for the 3 stations and 7 events along with the average temp for each event and the range in dB between the min and max temperature.

Event 2 is quite interesting as it appears that the burst as received at HNRAO was 9.7 dB stronger than at MRO and 4.9 dB stronger than at ESC. This is in marked contrast to other bursts which are much closer in amplitude at all 3 stations. Could this be due to a localized ionospheric focusing effect?

DISCUSSION

Recall that all three stations are viewing the sun with different antennas (and hence different antenna gains in the direction of the sun). Even though the HNRAO signal was stronger than other stations for event 2, that station was using a linearly polarized Jove dual dipole while the other stations were using 4 element arrays. The ESC station was using a TFD which has about 5.5 dB of inefficiency loss while MRO was using a 4 dipole array with coaxial hybrids to generate circular polarization. Note that a higher gain antenna not aimed at the sun could have less gain in the direction of the sun than the 2 element JOVE dipole

In order to make meaningful measurements of burst amplitudes (from the Sun or Jupiter) it will be necessary to understand the antenna patterns and to correct antenna temperature measurements by knowing the antenna losses and the gain in the direction of the target at the time of reception.

For many solar bursts a single dipole should be sufficient and EZNEC modeling could produce the desired antenna gain vs angle information. A dual dipole array could also be modeled for various beam steering angles.

Antenna modeling for 4 element polarimeters with beam steering is more complex and might require actual measurements, possibly using a drone.

The simplest starting point to minimize antenna beaming corrections might be to measure burst amplitudes in the summer in the northern hemisphere when the Sun is close to overhead using either a single dipole of a dual dipole steered to the zenith. Burst amplitudes can be measured using a calibrated JOVE receiver or an SDRPlay RSP1A receiver in conjunction with SDRUno software which provides accurate signal strength measurements at the antenna terminal in terms of dBm.

CONCLUSIONS

Background temperatures at the three stations varied between 3.6 and 6 dB during the study period, most likely due to changing local RFI conditions.

Peak burst temperatures agreed within a range of 0.6 to 4 dB with the exception of HNRAO data showing a burst peak 9.7 dB stronger than MRO for the burst on 4/30/22.

In order to obtain scientifically useful measurements of burst amplitudes it will be necessary to factor in antenna gains in the direction of the target for each station. Knowing the RA and DEC of the target and the coordinates of the station and the antenna beaming pattern this correction term could be written into SkyPipe as a modification to the antenna temperature scaling – yielding a “sky side” temperature which could be easily converted to flux density.