Daily Solar Observations with the SRT

Introduction:

For 15 days in July 2002, the Small Radio Telescope (SRT) at Haystack Observatory was used to make daily measurements of the flux of the sun at a frequency of 1415.0 MHz. Several solar flares were detected during this period, some which correlated with x-ray flares and some which did not. The purpose of this project was to demonstrate the capabilities of the SRT as well as to demonstrate the kinds of solar science that can be performed with the SRT.

Observations:

The data were taken with the new digital receiver on the SRT at a frequency of 1415 MHz and a bandwidth of 500 kHz. The central channels of the spectrometer were averaged to obtain a total power measurement. The data were converted into an antenna temperature using the electronic noise calibration system on the SRT. The measurements were made in a continuous mode from about 13:00 UT to about 20:00 UT. Three pointing measurements were made at 14:30, 16:30 and 18:30 UT. The pointing is done by performing a 25-point grid measurement around the sun and fitting a 2-dimensional gaussian to the intensity.

During the same period as the SRT observations, another antenna was available at Haystack, which monitored the flux at 327 MHz. This antenna was part of the monitoring for RFI for the site for the Deuterium Array being built at Haystack. The antenna was a simple dipole-like system that has a wide-angle beam. This antenna, while it was pointed straight up, picked up strong reflected signals from the sun. The data from the SRT were compared to that from the 327 MHz receiver system in order to determine whether the features seen at 327 MHz during the day were from local interference sources or from the Sun. Some strong activity seen in the 327 MHz data is related to local thunderstorms.

The plots also include x-ray data from the GOES-8 satellite http://www.sec.noaa.gov) that are 1-minute averages in the 0.1-0.8 nm range.

The data were read into Microsoft Excel and averaged and plotted. The plots do not include calibrated SRT and 327 MHz data. The SRT data are raw antenna temperature numbers while the 327 MHz and the x-ray data have been arbitrarily scaled so that they fit on the same plot for comparison purposes. The slight discontinuities in the SRT intensities are caused by pointing drifts.

The Plots:
Day 184 - 07/03/02 - possible x-ray, SRT correlation at 20:30 UT
Day 187 - 07/06/02 - 327, SRT correlation
Day 188 - 07/07/02
Day 189 - 07/08/02
Day 190 - 07/09/02 - SRT event, no obvious x-ray correlation
Day 192 - 07/11/02 - SRT, x-ray correlation at ~14:45 UT
Day 193 - 07/12/02

Day 195 - 07/14/02 - intense x-ray activity, no obvious correlation
Day 196 - 07/15/02 - x-ray, SRT and 327 event
Day 197 - 07/16/02 - xray, SRT and 327 event
Day 198 - 07/17/02 - x-ray, SRT event
Day 199 - 07/18/02 - SRT, 327 event, possible correlation with weak x-ray event
Day 200 - 07/19/02 - 327, SRT event
Day 201 - 07/20/02
Day 202 - 07/21/02 - activity in 327 from thunderstorms

Interpretation:

Radio emission at meter-wavelength (m-λ) and decimeter-wavelength (dm-λ) from flares is quite different from emissions at centimeter and millimeter wavelengths. This has to do with the fact that at the shorter wavelengths the emission is caused by incoherent gyrosynchrotron radiation mechanisms while at the longer wavelengths the emission comes from coherent plasma radiation. The 1-3 GHz frequency range appears to lie at the transition between the two types of emission mechanisms. The shorter wavelength radio flares correlate well with the x-ray events while the longer wavelength events appear not to be well correlated. This lack of correlation also points to the different heights in the solar atmosphere at which the various events occur.

Solar flare emissions at X-ray wavelengths are sometimes accompanied by Coronal Mass Ejections (CMEs), which move away from the Sun at speeds exceeding 1000 km/s carrying strong magnetic fields and energetic particles. If Earth-directed, these CME events can couple significant amounts of energy into Earth's charged upper atmosphere and trigger geomagnetic storms. These storms have large impacts on atmospheric dynamics, and can also cause auroral displays, satellite outages, power grid disruptions, and GPS navigation errors. The SRT provides a tool for students to detect some of these solar flare events and to motivate their study of the Sun's effects on Earth's atmosphere.

References for further reading:

- “Radio Emission from Solar Flares", Bastian, Benz and Gary 1998, Annual Reviews of Astronomy and Astrophysics, vol. 36, p-131.
- "Solar Radiophysics: Studies of emission from the sun at metre wavelengths" ed. McLean & Labrum 1985, Cambridge University Press.
- "Storms from the Sun: The Emerging Science of Space Weather ," Carlowicz and Lopez 2002, Joseph Henry Press.
- “How to Cope with Space Weather", D. N. Baker, Science, v. 297, 1486, 2002.

Web sites for more solar data:
http://www.sec.noaa.gov/Data/solar.html
http://ovsa.ovro.caltech.edu/
http://solar.nro.nao.ac.jp/
http://www.sao.ru/~sun/latest.htm
http://www.spaceweather.com
http://web.haystack.mit.edu/pcr/precollegeindex.htm