National Aeronautics and Space Administration

Developing Citizen Science for GAVRT's Solar Patrol

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Program: FY21 R&TD Innovative Spontaneous Concepts

Objectives

Our objective is to develop easy-to-use comprehensive parameterizations and analysis to support citizen scientist program developed around GAVRT Solar Patrol.
Our goal is to use our analysis to demonstrate how citizen scientist can study the evolution of active regions above the sunspots using the GAVRT maps of the Sun as the basis to further expand their interest using solar data at other wavelengths (maps would be available from SDO, SOHO/LASCO, UV & X-ray) from ground and space missions

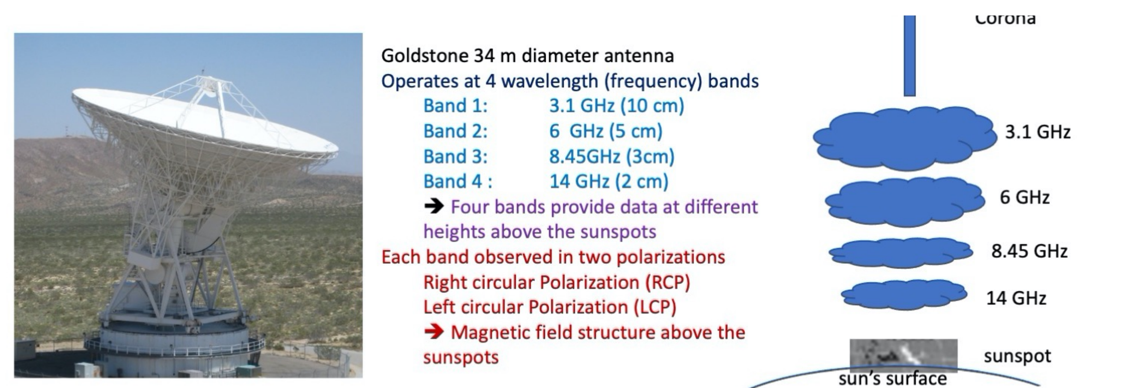


Fig. 1a

Fig. 1a GAVRT Solar Patrol centimeter wavelength radio maps of the Sun probe structure above the sunspots higher up in to the corona. a) GAVRT antenna; b) Solar Patrol parameters; c) schematic of emission above sunspots traced by GAVRT map frequencies.

Background

Goldstone Apple Valley Radio Telescope (GAVRT) operates a DSN 34-m antenna for science education under a unique partnership between JPL and Lewis Center for Educational Research (LCER).
GAVRT strives to inspire and enrich student learning through active contribution to professional science.
For over 20 years, GAVRT has provided opportunities for K-12 students and teachers to operate the telescope remotely taking science data.
In 2021, GAVRT Solar Patrol was developed using ROSES2020 Citizen Science seed funding, as a new opportunity to engage citizen scientists outside of K-12 .

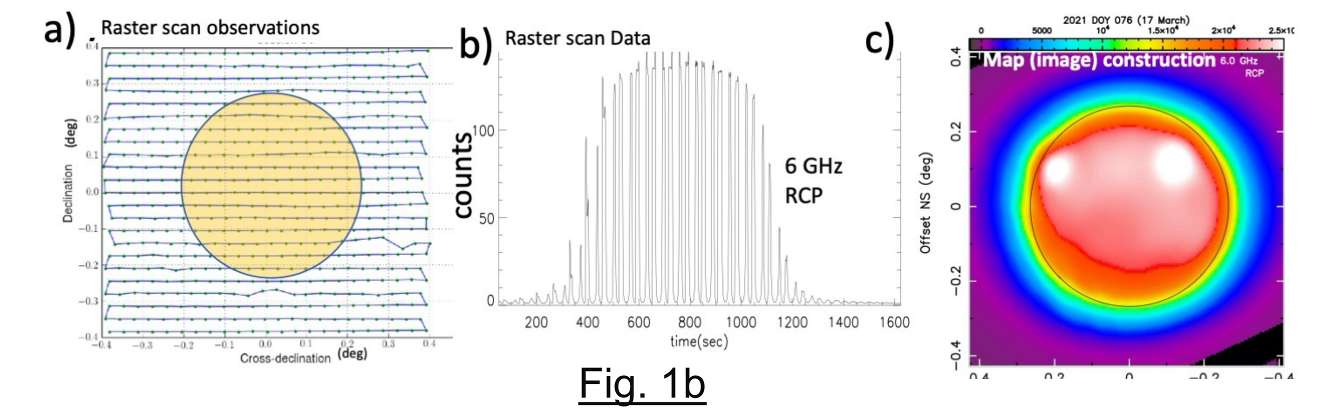


Fig. 1b

Fig. 1b GAVRT solar patrol as a great educational tool. Students control GAVRT antenna remotely to take scans across the Sun. a) & b) raster scans produce the raw data from the antenna as a time series. c) Example of the radio map produced using the mapping software developed under this RTD task to grid the time-data on to 2-D map grid. Note that one can now "see" image of the Sun at radio wavelengths which the eyes cannot see.

Approach and Results

We used the GAVRT Solar Patrol data collected during the +/-30 days window of PSP April 29 2021 perihelion (E #8) which includes highest solar activity with two active regions producing several flares.
We identified projects to engage citizen scientists to build on to studying solar activity in a wide range of topics including space weather.
We developed the mapping software converting the raster scan time series to 2-D map grid, interpolated using triangulation.
The maps are saved as *fits* images for future archival and data sharing purposes.

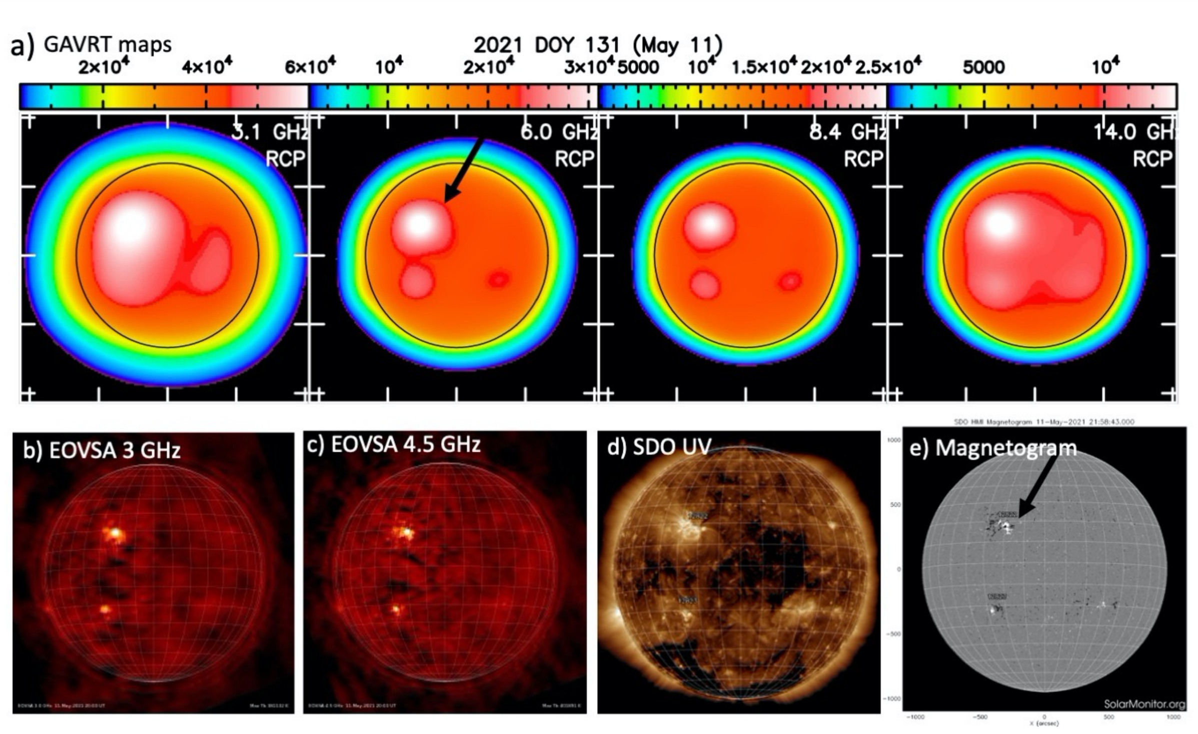


Figure.2 Example of the daily maps produced by GAVRT Solar Patrol. (a) GAVRT maps of the Sun at all 4 frequencies observed on May 11, 2021 during a Parker Solar Probe campaign. b) – e) examples of maps of the Sun at other wavelengths are shown for a comparative study with GAVRT data, as a potential topic for citizen scientist. The arrow marks the active region 12822 above the Sunspots.

Demonstrating how citizen scientists trace the evolution of the active regions tracking any pre-, post- flare changes

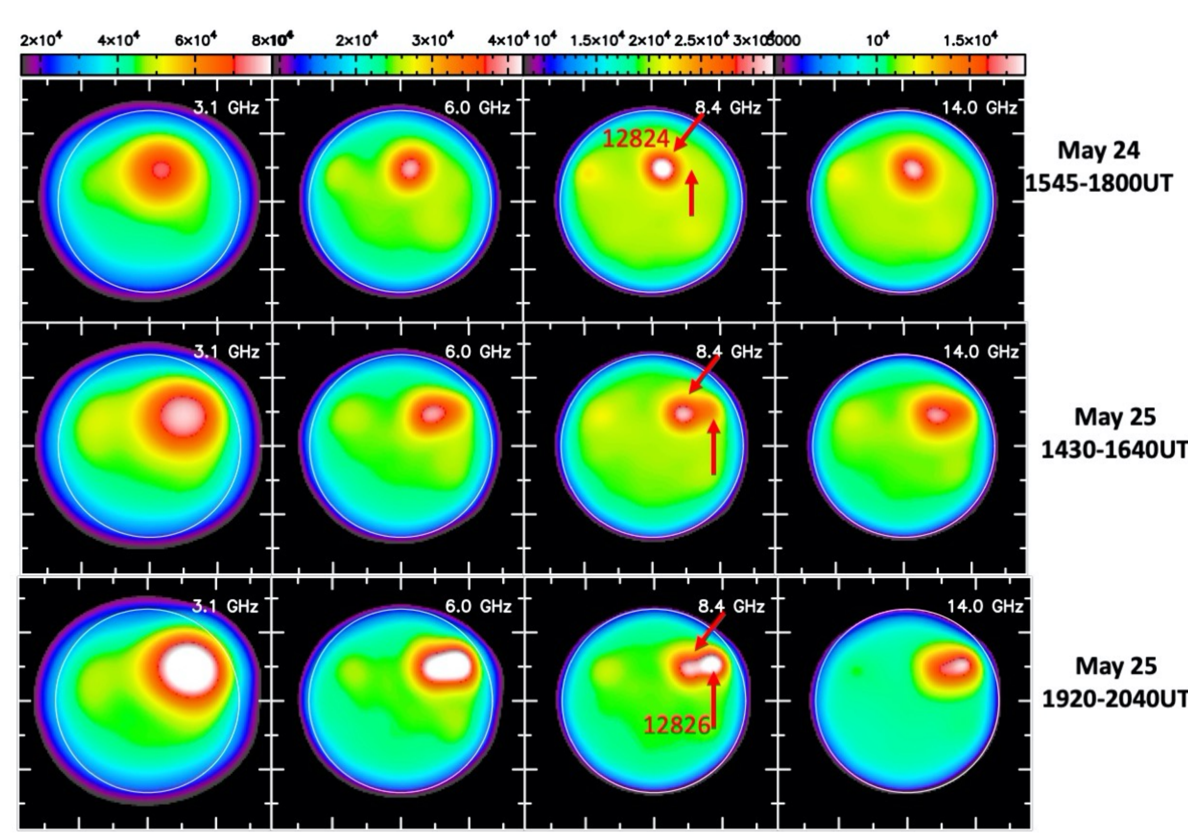
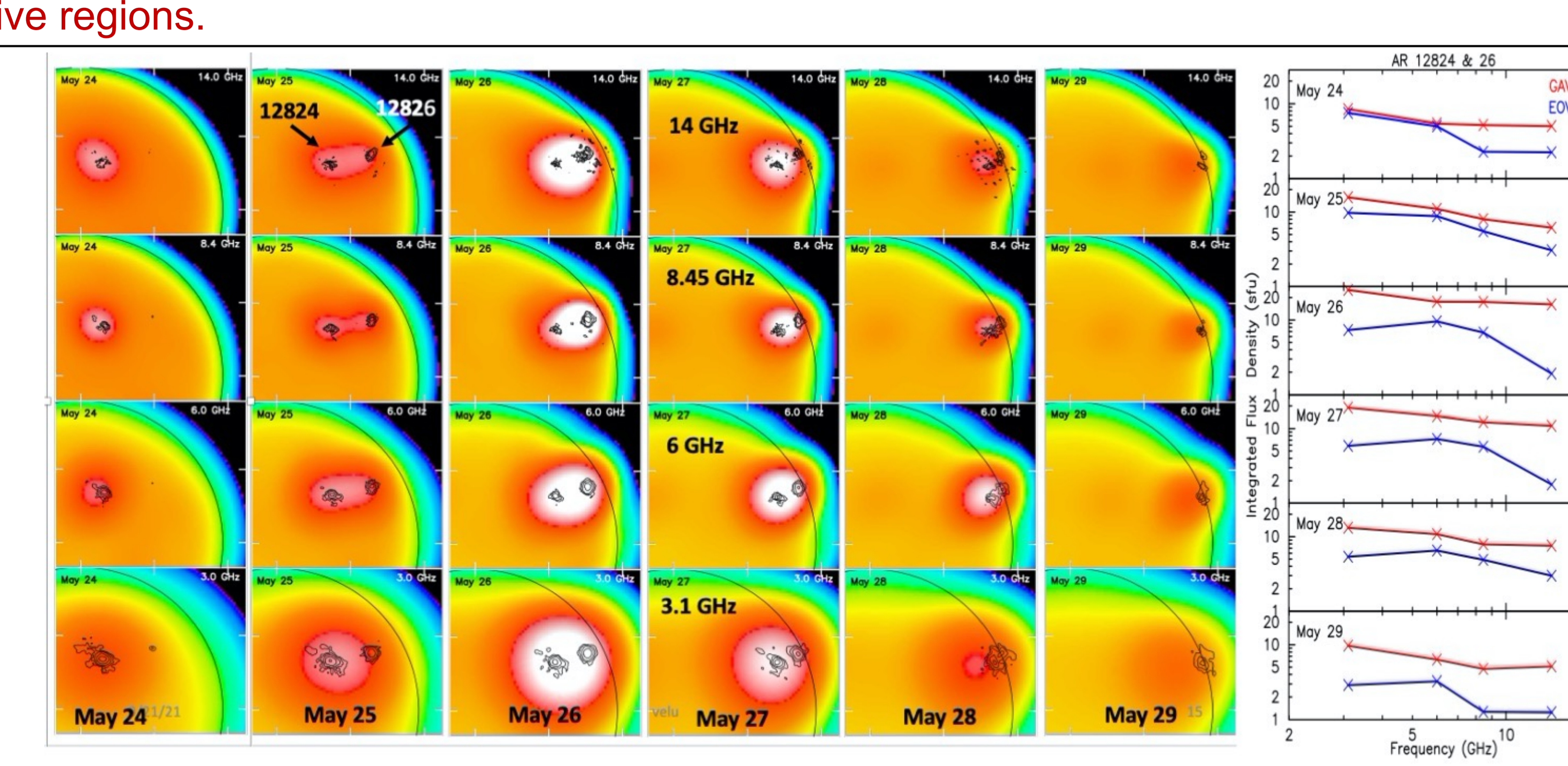


Figure 4. Caught in the act. Example of an appearance of a new active region detected in GAVRT Solar Patrol on May 25 2021. Note no emission is seen at this location on May 24 and only faint emission seen on May 25 maps at 14:30 -16:40 UT. However, in the maps at 19:20 -20:40 UT the brightest emission is seen at this location (AR 12826) and it remained the strongest feature for several days after.

Demonstrating GAVRT maps as an excellent resource to study the day to day evolution of active regions and sunspots.
We derive the key parameters of active region: flux density. peak brightness and angular size, all extracted from the maps and are related to the magnetic field, temperature and density in the corona in the gyroresonance framework.
Expressing these key parameters as frequency spectra for each AR on a daily basis is an efficient way to quantify the energetics and evolution of active regions.

Figure 4. GAVRT Solar Patrol monitoring active regions over 6 consecutive days May 24 -29, 2021. In the image panels GAVRT brightness is shown by color bar and EOVSA interferometer map brightness by the contours. The image panels are arranged by date (left to right) and by frequency (top to bottom). The flux density spectra are shown in the right panel. The integrated flux densities of a region containing both active region 12824 & 26 were extracted from the GAVRT and EOVSA maps. Note that the missing flux in EOVSA interferometer maps.



Merging GAVRT and EOVSA map data as a way to overcome the limitations of (i) low resolution in GAVRT map, and (ii) missing short spacings in the EOVSA map .
Use the integrated flux density spectra for the two regions as a way forward to interpreting the results in the gyroresonance frame work

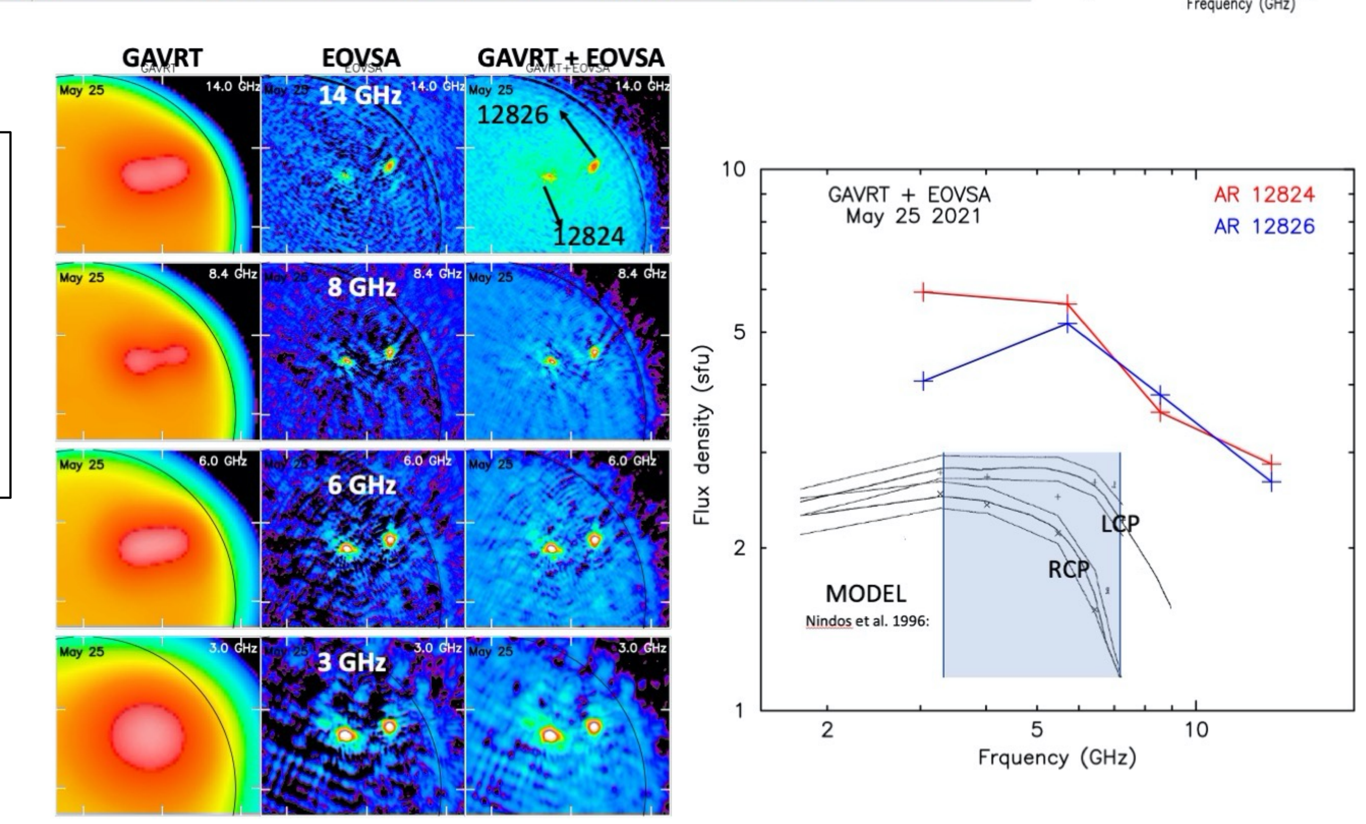


Figure 5. Example of merging GAVRT and EOVSA map data for May 25 2021. Image panels are arranged left to right GAVRT, EOVSA and merged maps and top to bottom frequency bands. The integrated flux density spectra for the two active regions (marked by arrows) is shown on the right. The inset shows a set of model flux density spectra in L and R polarizations, computed from MSFC magnetic field extrapolations. The GAVRT/EOVSA frequency range is highlighted by shaded area.

Significance/Benefits to JPL and NASA

Under this RTD effort we have demonstrated the vast potential for doing good science with GAVRT Solar Patrol data and new opportunities for citizen scientists.
This effort shows promise of Citizen scientists, including but not limited to K-12 students, can become engaged in GAVRT Solar Patrol by taking data, image construction & analysis and using it, as a gateway to NASA's Heliophysics missions.
Demonstration of such observations and analysis, as presented here, will strengthen future science/citizen science proposal with a specific aim of ensuring a more robust science (for peer review publication) with the "citizen science" or educational data.
It will benefit the GAVRT Solar Patrol team to propose citizen science efforts as part of proposals for ROSES funding opportunities on current or future NASA missions.

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