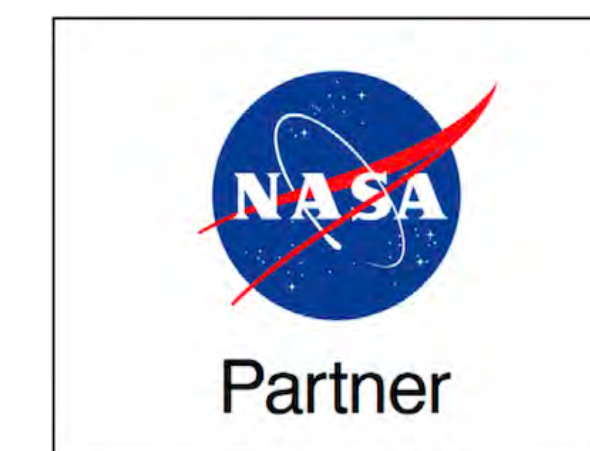# The Radio JOVE Project 2.0

C. Higgins (1), S. Fung (2), L. Garcia (3), J. Thieman (4), J. Sky (5), D. Typinski (6), R. Flagg (7), J. Brown (8), F. Reyes (9), J. Gass (10), L. Dodd (11), T. Ashcraft (12), W. Greenman (13), and S. Blair (14)

(1) Middle Tennessee State University, Murfreesboro, TN, (2) ITM Physics Lab/NASA GSFC, Greenbelt MD, (3) SGT/NASA GSFC, Greenbelt MD, (4) UMBC/NASA GSFC, Greenbelt MD, (5) Radio Sky Publishing, Louisville, KY, (6) AJ4CO Observatory, High Spring, FL, (7) RF Associates, Honolulu, HI, (8) Hawks Nest Radio Astronomy Observatory, Industry, PA, (9) Dept. of Astronomy, University of Florida, Gainesville, FL, (10) CNSP/NASA GSFC, Greenbelt, MD, (11) Georgia Amateur Radio Astronomy Observatory, Jasper, GA, (12) Heliotown Observatory, Lamy, NM, (13) LGM Radio Alachua, Alachua, FL, (14) Dalton State College, Dalton, GA.

NASA Partner

MIDDLE TENNESSEE STATE UNIVERSITY

Radio JOVE 2.0 Overview radiojove.gsfc.nasa.gov
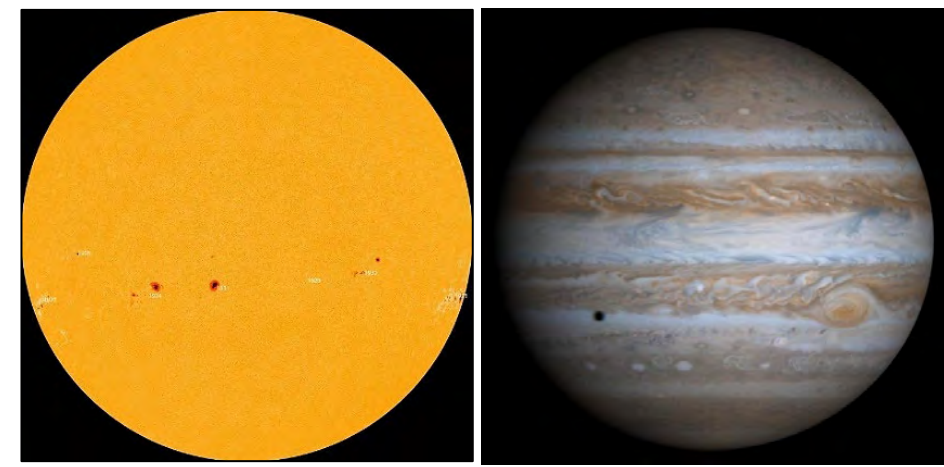
Radio JOVE 2.0: Citizen Science using a multi-frequency (16-24 MHz) radio telescope to observe Jupiter, the Sun, the Milky Way Galaxy, and Earth-based radio emissions.
[RJ 1.0 used single frequency 20 MHz equipment.]

Sun [SDO/HMI] and Jupiter [NASA/Cassini]

Radio JOVE 2.0 is an exciting NASA Partner citizen science project that allows participants to assemble and operate a multi-frequency radio astronomy telescope to gather and contribute quality data to support scientific studies. Participants may also interact with other radio observatories in real-time over the Internet.

Participants
General Public & Radio Enthusiasts
High Schools – science classes or extracurricular projects
Colleges and Universities – science courses or laboratories
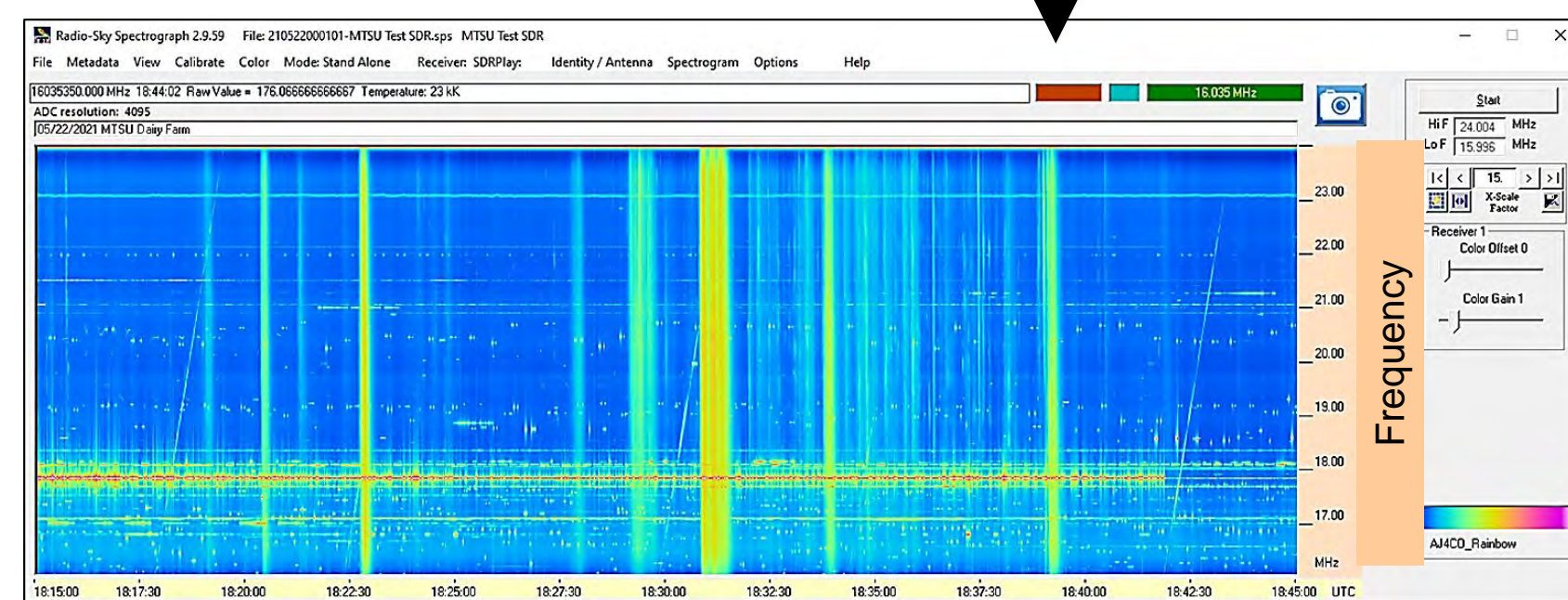**We are looking for amateurs to become citizen scientists**

Hardware and Software
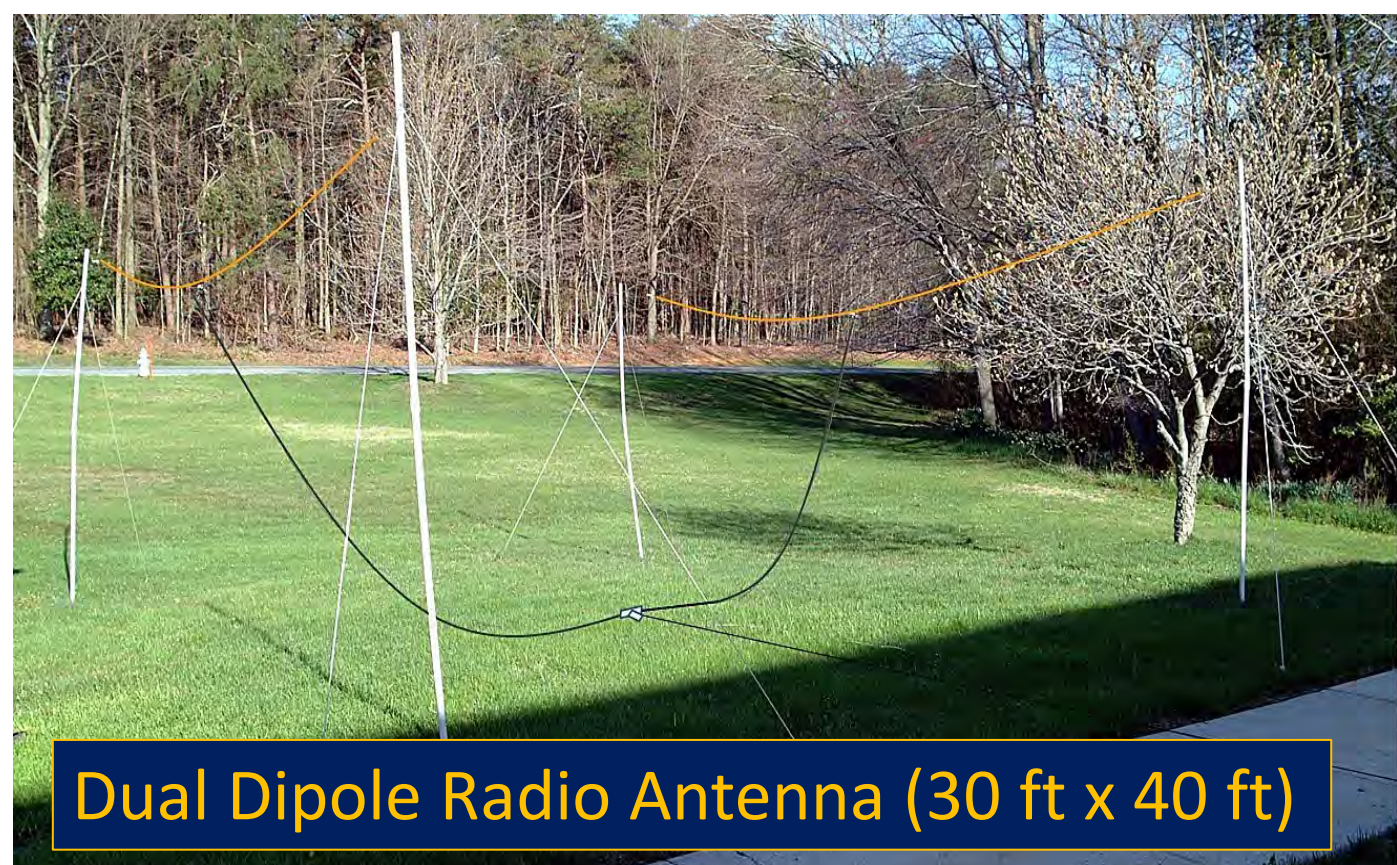
Dual Dipole Radio Antenna (30 ft x 40 ft)

SDRplay* RSP1A Radio Receiver

Radio-Sky Spectrograph Recording Software

Radio JOVE 2.0 Hardware: Dual Dipole antenna, SDRplay RSP1A receiver, and Radio-Sky Spectrograph (RSS) software. [Kit does not include antenna support structure]. *SDRplay (www.sdrplay.com) is a UK-based company that manufactures Software Defined Radio (SDR) radios. Radio-Sky Spectrograph software from radiosky.com.

Advanced Hardware

- 15-30 MHz Radio Spectrograph
- Wide band antennas and arrays
- Polarization Measurements
- Multi-Step Calibration

A Terminated Folded Dipole (TFD) Square Array

Project Goals

- Inspire amateurs to become citizen scientists
- Increase science literacy and understanding of the scientific process
- Provide a hands-on experience in radio astronomy
- Expand a network of radio telescopes for advance projects
- Enable access to online observatories and real data
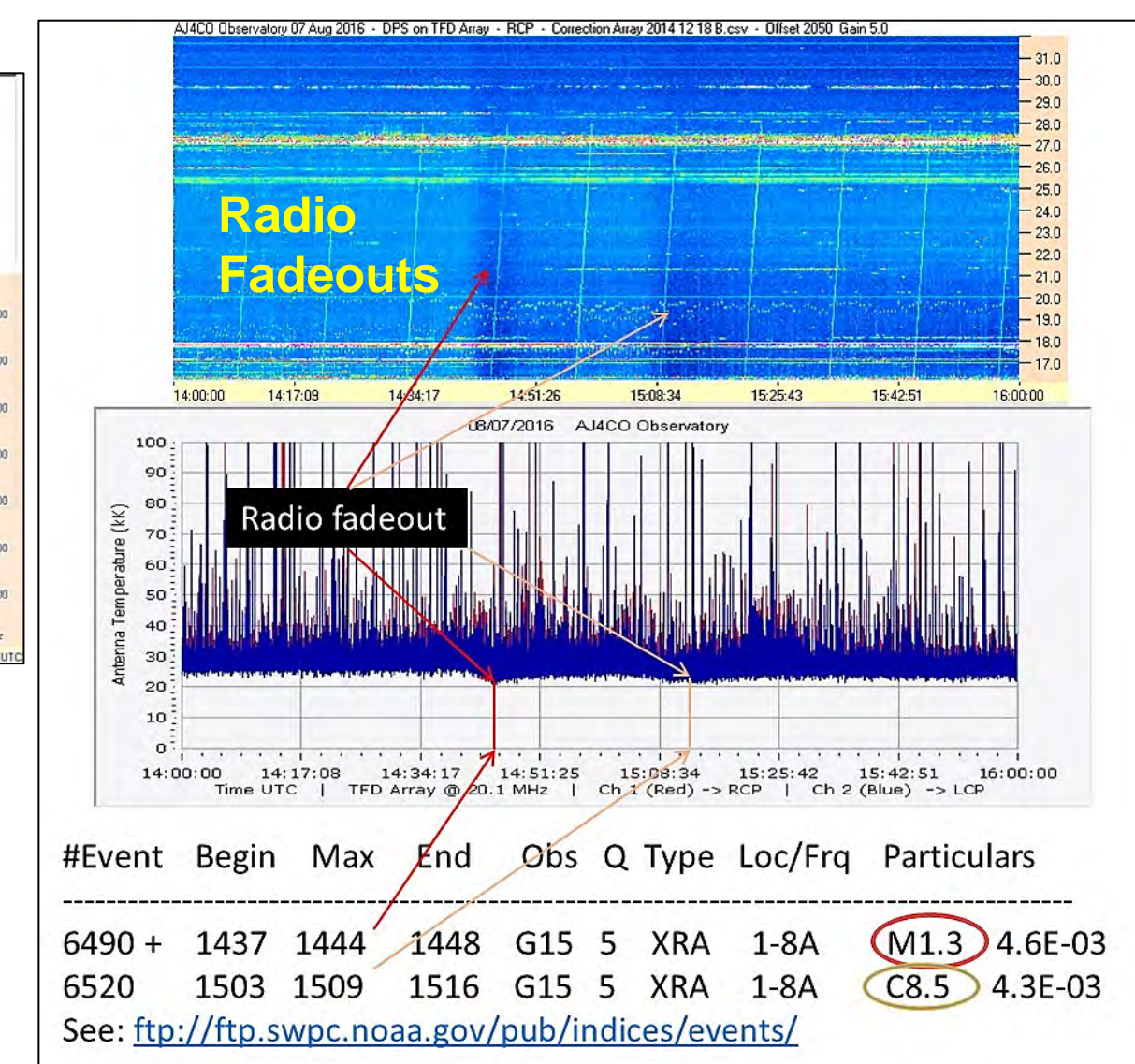- Facilitate the exchange of data and ideas among participants

Example Observations

Terrestrial propagation

Solar bursts

Calibration

Jupiter bursts

Radar Sweepers
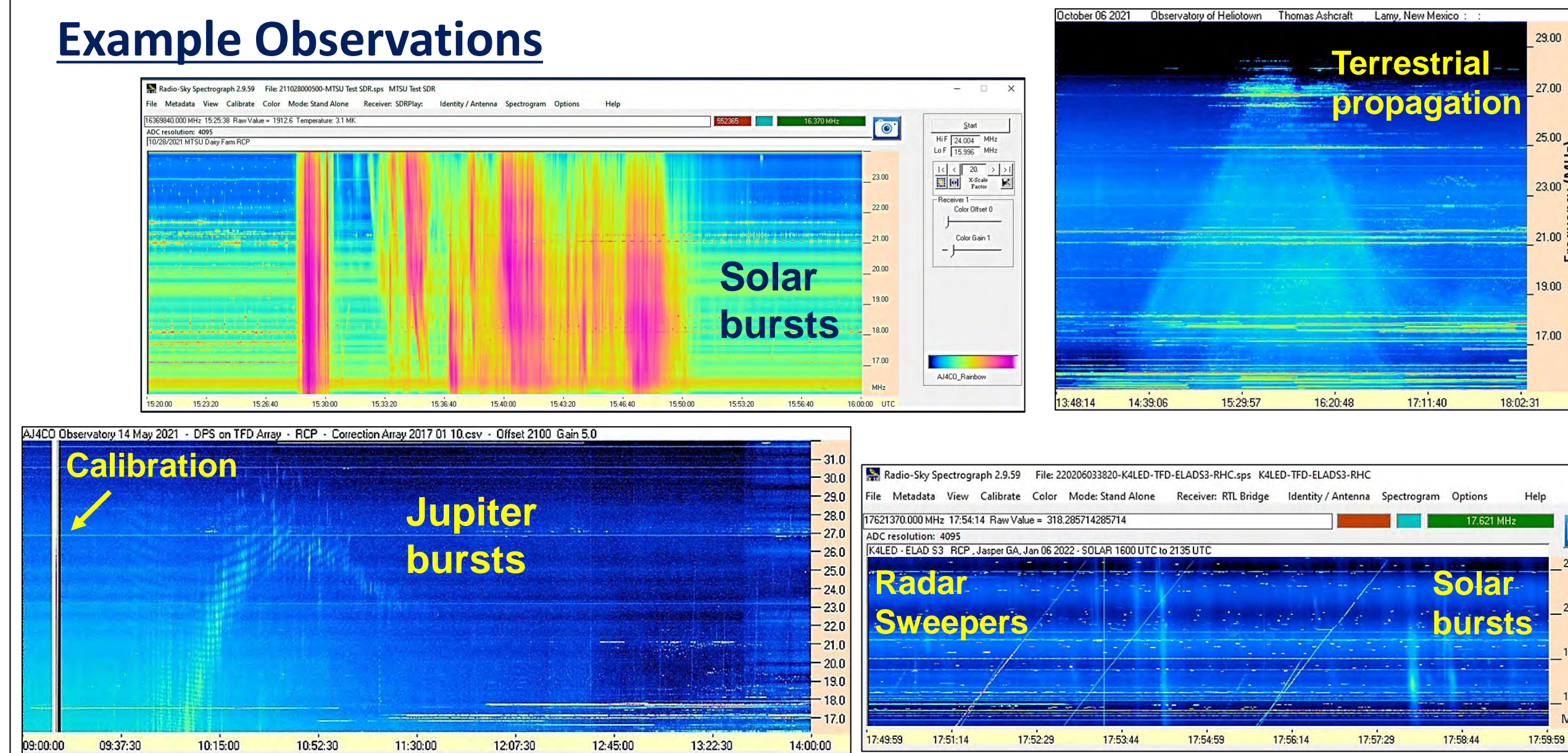
Solar bursts

Example Radio JOVE frequency-time spectrograms of terrestrial, solar, and Jupiter radio bursts seen by different observers. Terrestrial "TP" propagation from lightning (T. Ashcraft), solar bursts (C. Higgins), Jupiter Io-B event (D. Typinski), and solar bursts and terrestrial radar sweepers (L. Dodd).

Solar bursts

Radio Fadeouts
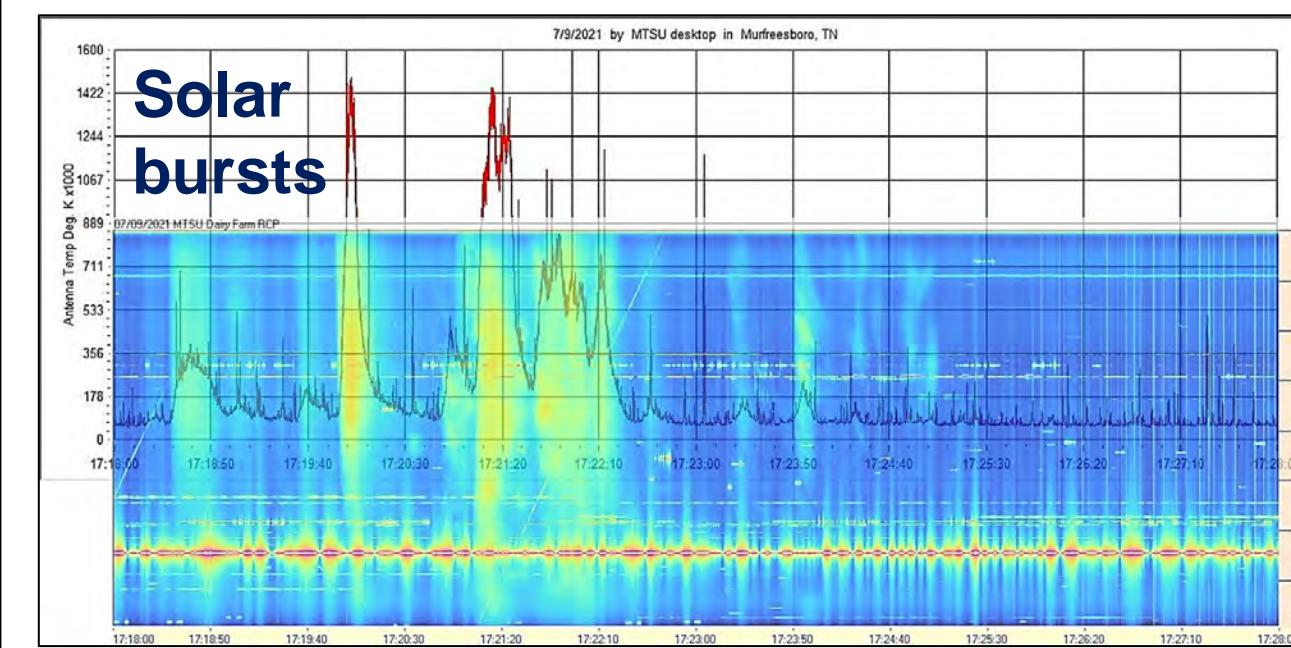
Radio fadeout

Solar bursts on a calibrated 20 MHz chart overlayed onto a Radio JOVE 2.0 frequency-time spectrogram (C. Higgins), and radio fadeout ionosphere disturbances associated with M- and C-class solar flares (D. Typinski).

#Event	Begin	Max	End	Obs	Q	Type	Loc/Frq		Particulars
6490 +	1437	1444	1448	G15	5	XRA	1-8A	M1.3	4.6E-03
6520	1503	1509	1516	G15	5	XRA	1-8A	C8.5	4.3E-03

See: ftp://ftp.swpc.noaa.gov/pub/indices/events/

Data Archive

- **radiojove.org**
- Contains more than 6000 Jupiter and solar observations (files, images, sound files, spectrograph data)
- Collaboration with the Virtual Wave Observatory (heliophysics wave data) at vwo.gsfc.nasa.gov
- Calibrated spectral data archived at the Planetary Data System Plasma Node (https://pds-ppi.igpp.ucla.edu)
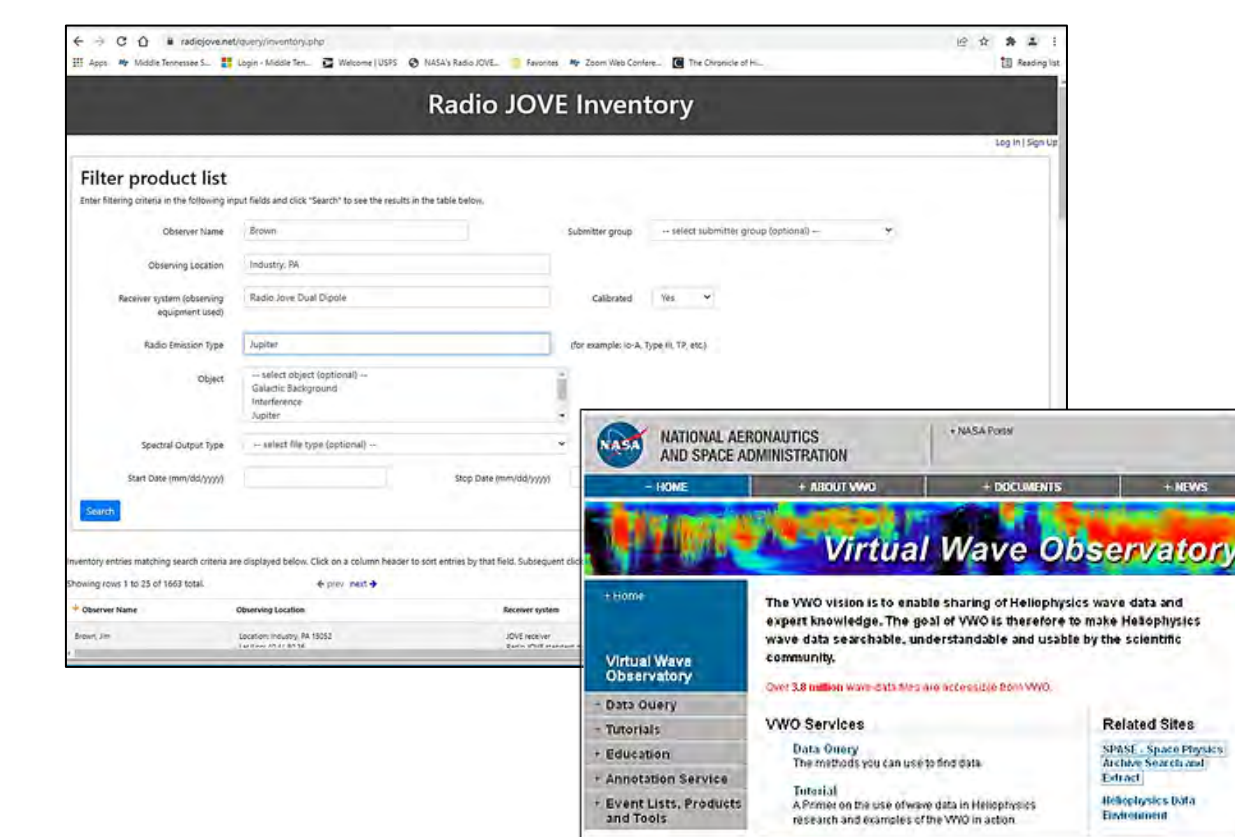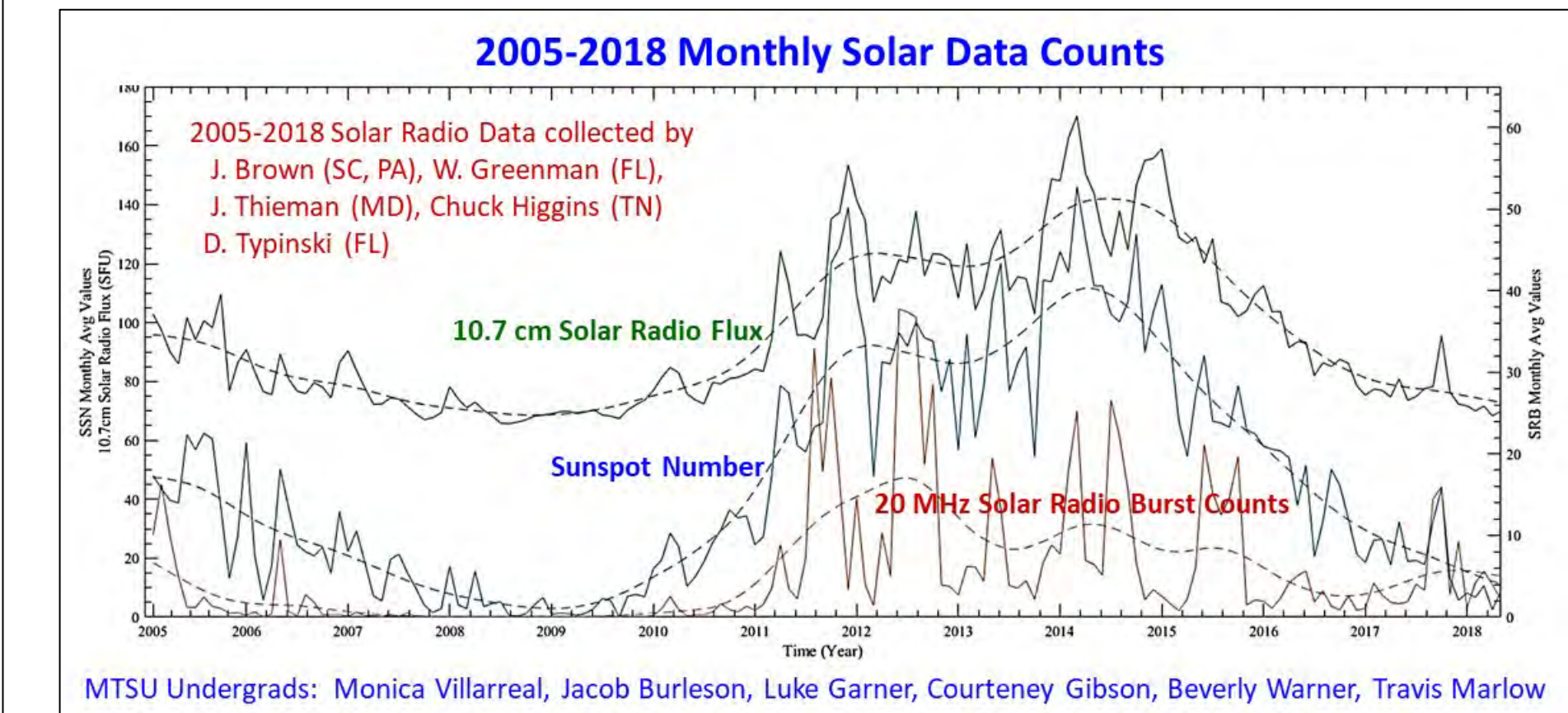
The Radio Jove Data Archive [radiojove.org] coordinates with the Virtual Wave Observatory [vwo.gsfc.nasa.gov]

Citizen Science Projects

- Use RJ 1.0 and 2.0 equipment to make calibrated observations (Jupiter, Sun, Galaxy)
- Observing campaigns (solar eclipses, Jupiter events)
- Galactic background Quiet Day Curve (QDC)
- Ionosphere radio wave propagation and space weather
- Monthly solar burst counts
- Jupiter radio emission probability maps

Probability of Jupiter Radio Emissions
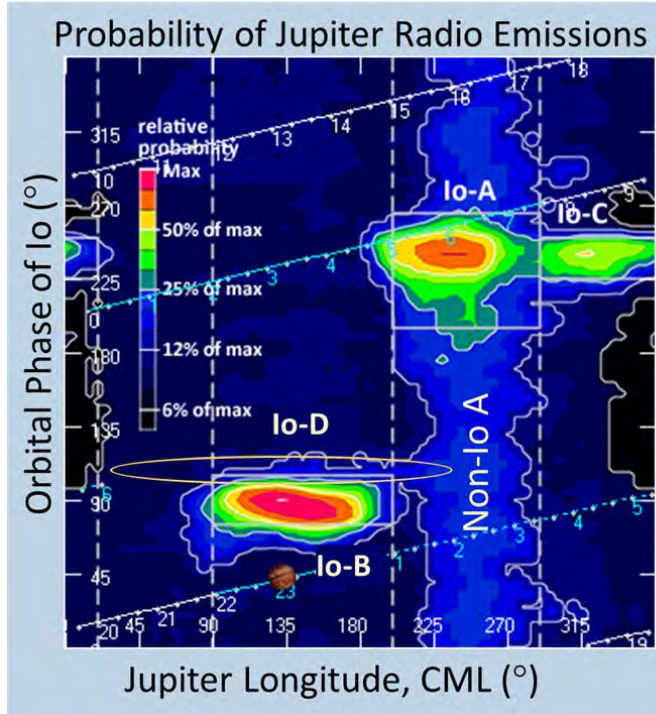
Jupiter radio emission occurrence probability plotted as Io orbital phase vs. Jupiter longitude (CML). [J. Sky, radiosky.com].

2005-2018 Monthly Solar Data Counts

2005-2018 Solar Radio Data collected by J. Brown (SC, PA), W. Greenman (FL), J. Thieman (MD), Chuck Higgins (TN), D. Typinski (FL)

10.7 cm Solar Radio Flux
Sunspot Number
20 MHz Solar Radio Burst Counts

MTSU Undergrads: Monica Villarreal, Jacob Burleson, Luke Garner, Courteney Gibson, Beverly Warner, Travis Marlow

2005 – 2018 Monthly Solar Radio Burst Counts (SRB) at 20 MHz correlate well with the visible Sunspot Number (SSN) and the 10.7 cm (2800 MHz) Radio Flux data.

Radio JOVE 2.0 Summary
Join Radio JOVE 2.0: https://radiojove.gsfc.nasa.gov/joinin.php
Join Our Email Listserv on Groups.io: https://groups.io/g/radio-jove
Assemble and Operate a Radio Spectrograph Telescope
Citizen Science: the Sun, Jupiter, the Galaxy, and the Terrestrial Ionosphere
Help Us Expand the Radio JOVE Observing Network

Radio JOVE 2.0 Kit Purchases

- Complete kit (receiver, software, unbuilt antenna): $195.00* + shipping
- Prebuilt Complete kit (receiver, software, professionally built antenna): $364.00* + shipping
- Orders: http://radiojove.org/kit/order_form.html
*Antenna support materials could be $75.00 extra.
*Prices subject to change.

Radio JOVE 2.0 Hardware: SDRplay RSP1A, cables, Antenna Kit, assembly manuals, and Radio-Sky Spectrograph (RSS) software.

Radio JOVE 1.0 Participants, Hardware, and Software are Supported

- Due to lack of parts, we retired the 20 MHz Receiver (no longer available)
- Radio-Skypipe Software (free and Pro versions available)
- Dual Dipole Antenna (available)
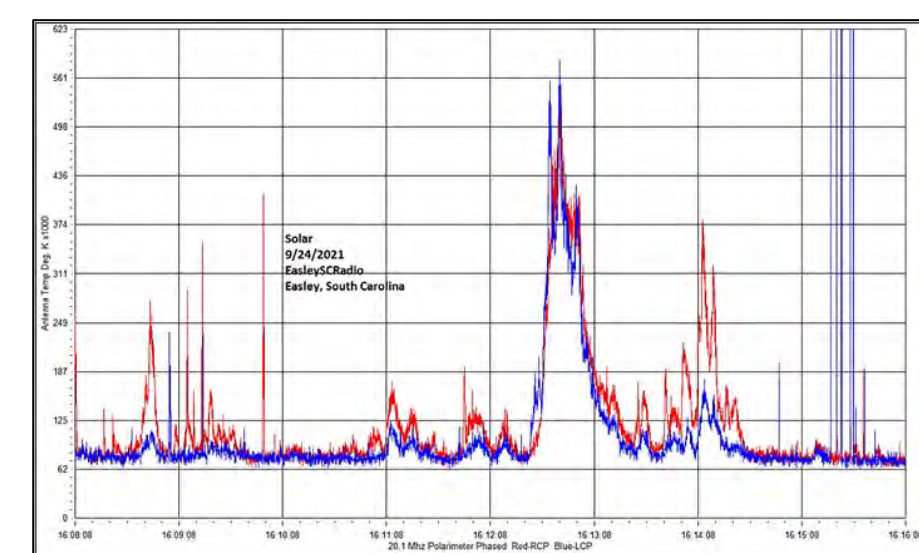
The original Radio JOVE 1.0 system: The RJ1.1 20 MHz Receiver, a dual dipole antenna, and Radio-Skypipe software. The Radio-SkyPipe intensity-time graph of multiple solar bursts using a JOVE receiver (J. Cox). Software from radiosky.com.