

# Personal Space Weather Station

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# Introduction

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Space Weather is a common interest of hams, scientists, and engineers. By studying Space Weather, we aim to:

- Know the best frequencies for working DX
- Communicate better during emergencies
- Better understand ionospheric physics
- Improve navigation systems
- Protect satellite and power distribution systems from harmful disturbances

# Personal Terrestrial WX Station

- Multi-instrument
- Internet Connected
- Easy Set-Up
- Reasonable Cost



Ambient Weather WS-2902

<https://www.amazon.com/Ambient-Weather-WS-2902-Professional-Monitoring/dp/B01N5TEHLI/>

# Personal Terrestrial WX Station

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Can we build one for Space Weather?



Ambient Weather WS-2902

# What instruments?

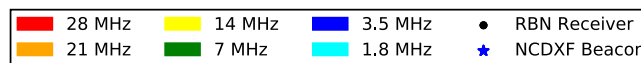
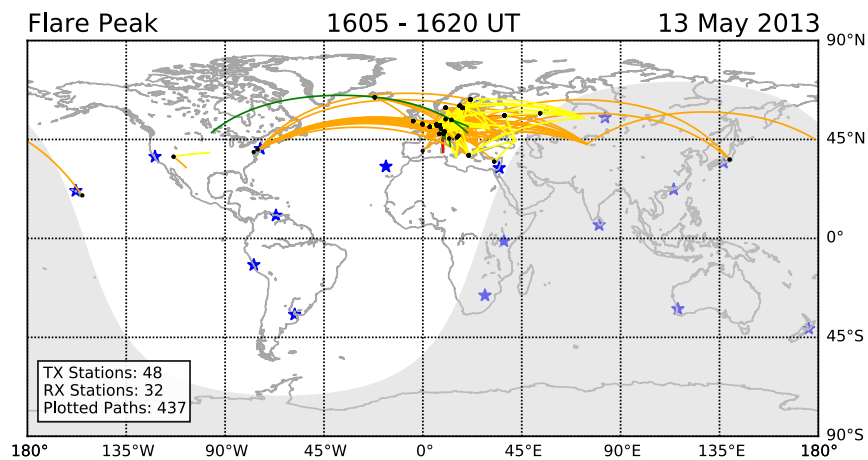
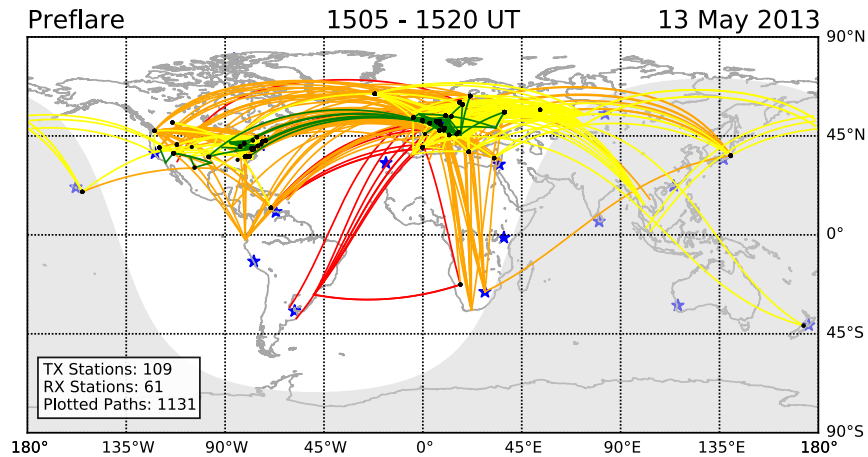
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- RBN/PSK Reporter/WSPR Receiver
- WWV/Standards Station Monitor
- Ground Magnetometer
- GPS TEC Receiver
- Lightning Detector
- Riometer
- Others?

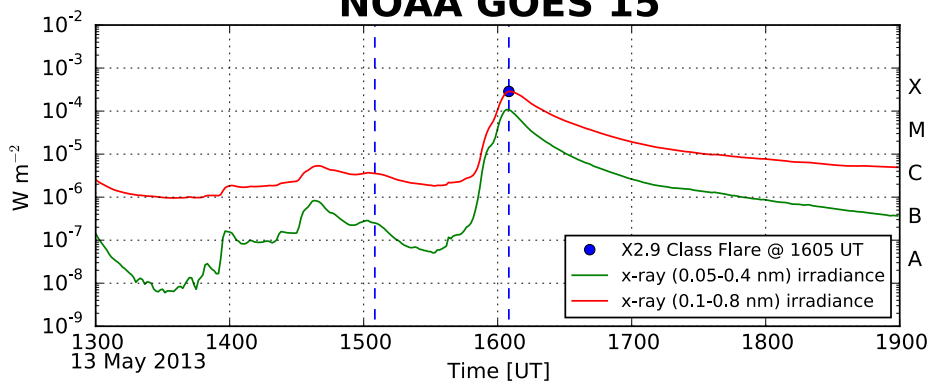
# RBN/PSKReporter/WSPRNet RX



## Reverse Beacon Network Solar Flare HF Communication Paths



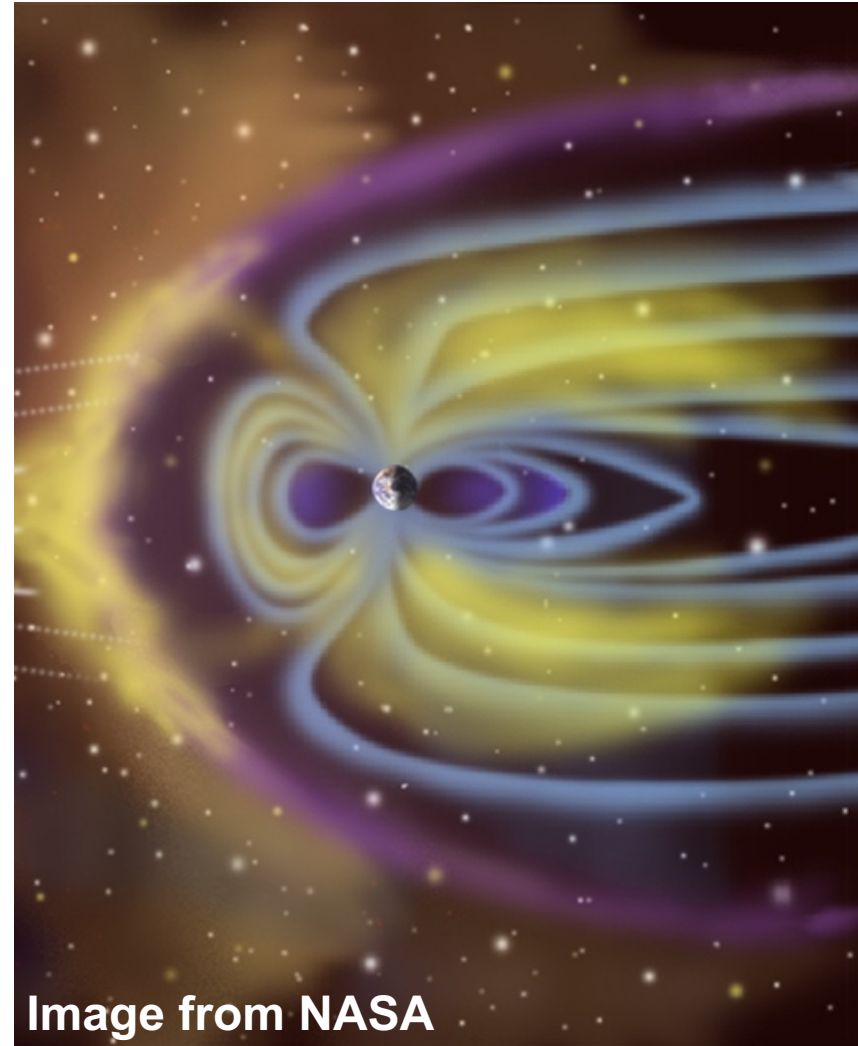
## NOAA GOES 15



[Frissell et al., 2014, Space Weather]

# Ground Magnetometer

- Detect Ionospheric & Space Currents
- Geomagnetic Storms
- Geomagnetic Substorms
- Kp and Ap are derived from GMAGs data.

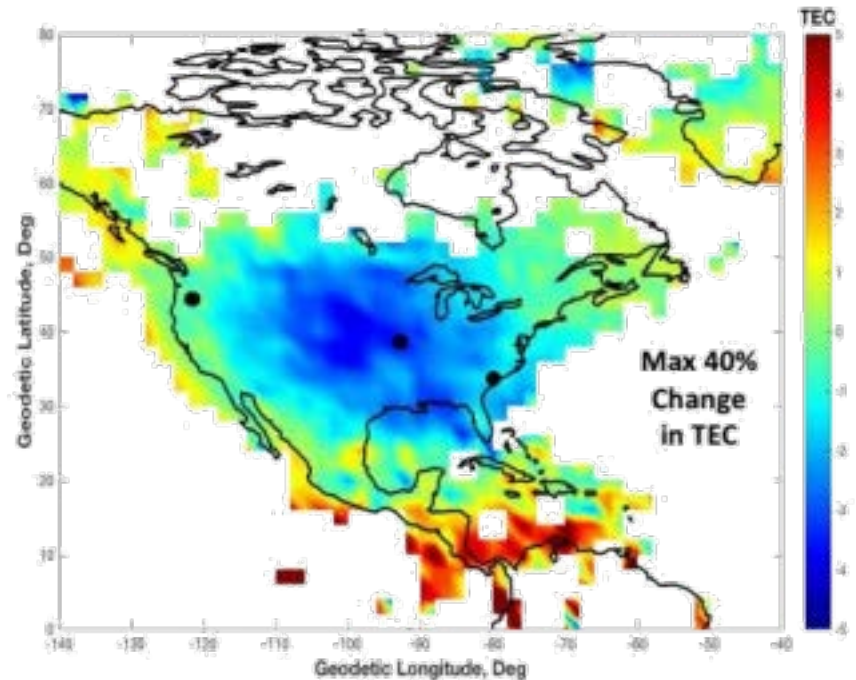


# GPS Total Electron Content

- Total Number of electrons between ground and GPS Satellite
- Measured by examining delay between two GPS Frequencies
- Traveling Ionospheric Disturbances
- Storm Effects
- Ionospheric Scintillations

## Solar Eclipse GNSS Vertical Total Electron Content 21 August 2017

Difference in TEC at 18:15 UT from start of solar eclipse at 16:45 UT



Support: NSF AGS-1242204, NASA NNX17AH71G



Courtesy of Anthea Coster



# Riometer

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- **Relative Ionospheric Opacity Meter**
- Directly measures absorption of cosmic rays
- Indirectly measures electron density, particle precipitation
- Typically passive instrument 30-50 MHz

# Lightning Detector

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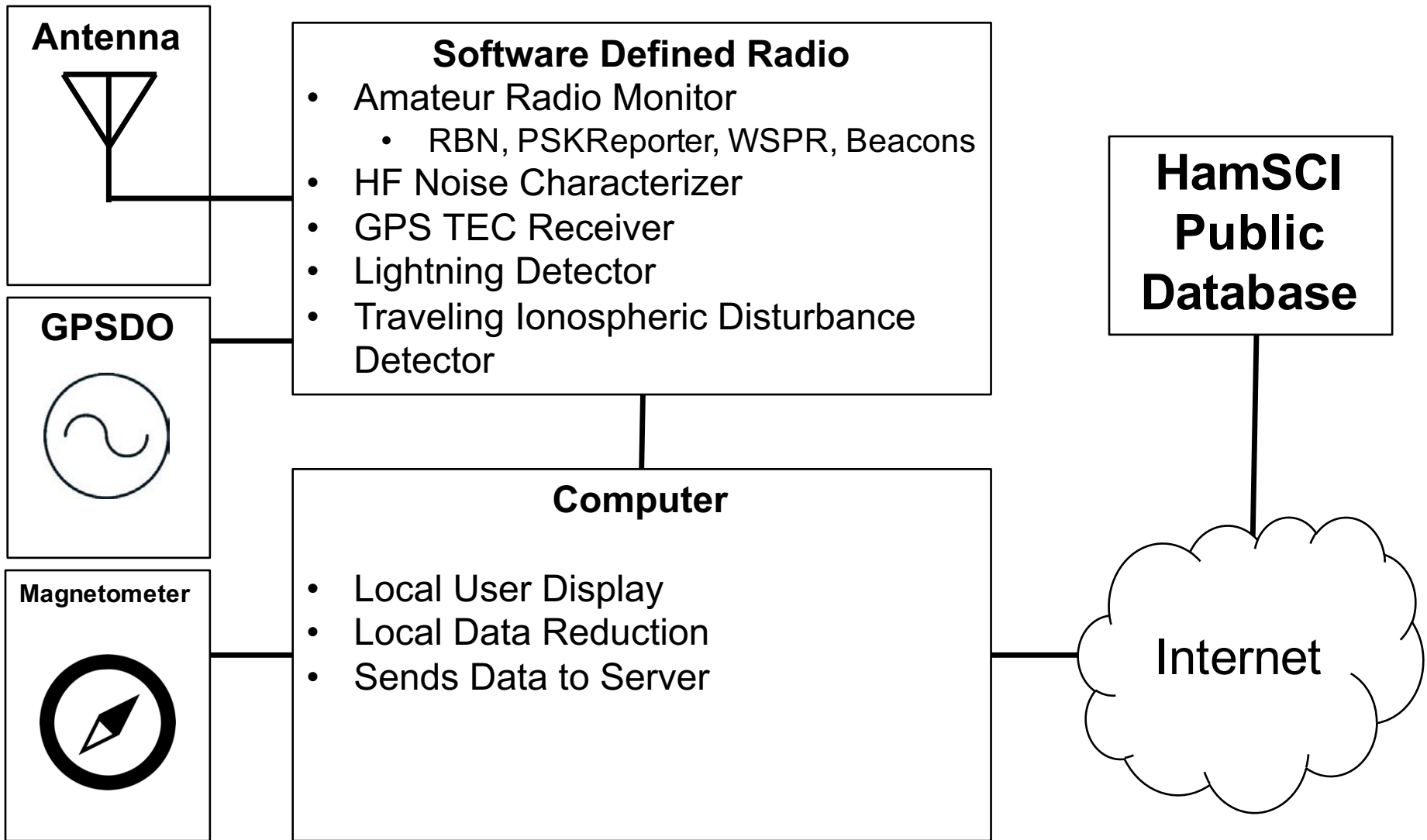
- Signatures from LF to VHF/UHF
- On HF, lightning noise can propagate long distances and disrupt communications



Photo: Jessie Eastland

([https://en.wikipedia.org/wiki/File:Desert\\_Electric.jpg](https://en.wikipedia.org/wiki/File:Desert_Electric.jpg))

# Personal Space Weather Station



# Some possible hardware...

## Antenna

*DXE ARAV3*



## GPSDO

*Leo Bodnar*



## Magnetometer

*British Geological Survey*



## Software Defined Radio

*Red Pitaya*



## Computer

*Raspberry Pi*



**HamSCI  
Public  
Database**

**Internet**

# Web Links / Sources

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- Red Pitaya
  - <https://www.redpitaya.com/>
- Raspberry Pi
  - <https://www.raspberrypi.org/>
- Antenna: DXEngineering ARAV3
  - <https://www.dxengineering.com/parts/dxe-arav3-1p>
- GPS Disciplined Oscillator:
  - [http://www.leobodnar.com/shop/index.php?main\\_page=product\\_info&products\\_id=234](http://www.leobodnar.com/shop/index.php?main_page=product_info&products_id=234)
- Magnetometer: British Geological Survey
  - [http://www.geomag.bgs.ac.uk/education/raspberry\\_pi\\_magnetometer.html](http://www.geomag.bgs.ac.uk/education/raspberry_pi_magnetometer.html)

# Target Specifications

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- Useful to ham radio, space science, and space weather communities.
- \$100 to \$500 price range
- Modular Instrument Design
  - Easy ability to add or remove instruments, especially in software architecture
- Small footprint
- Nice User Interface/Local Display
- Standard format to send data back to a central repository
- Open community-driven design

# Putting it Together

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- This is a problem of integration... most of the technology we want to use already exists. It is just not put together in a unified package and costs too much separately.
- Meet bi-annually
  - HamSCI Workshop in February
  - TAPR-DCC in September
  - At each meeting, set goals for next meeting.
  - Aim to have a prototype within a year.

# Project Management

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- HamSCI
  - Overall project management
  - Data collection and scientific analysis
- Amateur Radio Community
  - Hardware and Software Engineering
- Divide Project into Teams
  - Each team has designated leader(s)
  - Define Engineering Teams
    - Software engineering
    - RF/SDR
    - Magnetometer
    - Etc.
  - Designate a science PI for each instrument (like a satellite mission)



# NOAA Space Weather Prediction Center

- Makes space weather predictions and nowcasts.
  - Radio Blackouts
  - Solar Radiation Storms
  - Geomagnetic Storms
- Uses global-scale data for predictions
- Does not actually monitor HF comms.

The screenshot shows the NOAA Space Weather Prediction Center website. The page header includes the NOAA logo, the National Weather Service logo, and the text "SPACE WEATHER PREDICTION CENTER NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION". The date and time are "Sunday, February 04, 2018 21:00:38 UTC". The navigation menu includes "HOME", "ABOUT SPACE WEATHER", "PRODUCTS AND DATA", "DASHBOARDS", "MEDIA AND RESOURCES", "SUBSCRIBE", "ANNUAL MEETING", and "FEEDBACK". A search bar is located below the navigation menu. The main content area is titled "SPACE WEATHER CONDITIONS on NOAA Scales" and displays "24-Hour Observed Maximums" and "Latest Observed" conditions. Both sets of conditions are represented by three green boxes labeled "R", "S", and "G", each with "none" underneath. Below this, the current solar wind speed is "379 km/sec" and the solar wind magnetic fields are "Bt 5 nT, Bz 0 nT". The noon 10.7cm radio flux is "73 sfu". The "CURRENT NEWS AND FEATURES" section includes three news items: "NWS Winter Safety Website" (published Monday, December 04, 2017 14:57 UTC), "Announcing Geospace Model Version 1.5" (published Wednesday, November 08, 2017 21:34 UTC), and "Announcing The New Experimental, 1D, Interpolated Geoelectric Field Model" (published Thursday, November 02, 2017 19:02 UTC).

<http://www.swpc.noaa.gov>

# Questions

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- How do we know if the predictions came true?
- Did HF radio comms really drop out as predicted?
- Are these global model predictions good enough? Or, do we need to make predictions on a smaller scale?

*A network of Personal Space Weather Stations may help answer these questions.*

# Summary

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- We aim to make a Personal Space Weather Station in the \$100-\$500 range that is of interest to the ham radio, space science, and space weather communities.
- This project will aim to provide verification measurements to predictions of HF communications, for example, those made by NOAA SWPC.
- Development will be a collaborative effort of the amateur radio and professional science communities, coordinated by HamSCI.

# Thank you!

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