Personal Space Weather Station

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Introduction

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

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Can we build one for Space Weather?
What instruments?

- RBN/PSKReporter/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

Preflare 1505 - 1520 UT 13 May 2013

Flare Peak 1605 - 1620 UT 13 May 2013

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.

Image from NASA
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

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Courtesy of Anthea Coster
Riometer

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

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

Photo: Jessie Eastland
Personal Space Weather Station

- Antenna
- GPSDO
- Magnetometer

Software Defined Radio
- Amateur Radio Monitor
  - RBN, PSKReporter, WSPR, Beacons
- HF Noise Characterizer
- GPS TEC Receiver
- Lightning Detector
- Traveling Ionospheric Disturbance Detector

Computer
- Local User Display
- Local Data Reduction
- Sends Data to Server

HamSCI Public Database

Internet

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http://hamsci.org

NJIT
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

- Red Pitaya
  - [https://www.redpitaya.com/](https://www.redpitaya.com/)

- Raspberry Pi

- Antenna: DXEngineering ARAV3
  - [https://www.dxengineering.com/parts/dxe-arav3-1p](https://www.dxengineering.com/parts/dxe-arav3-1p)

- GPS Disciplined Oscillator:

- 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

• 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

• 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

• 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.

http://www.swpc.noaa.gov
Questions

• 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

• 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!