NJIT New Jersey Institute of Technology

HamSCI

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

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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/

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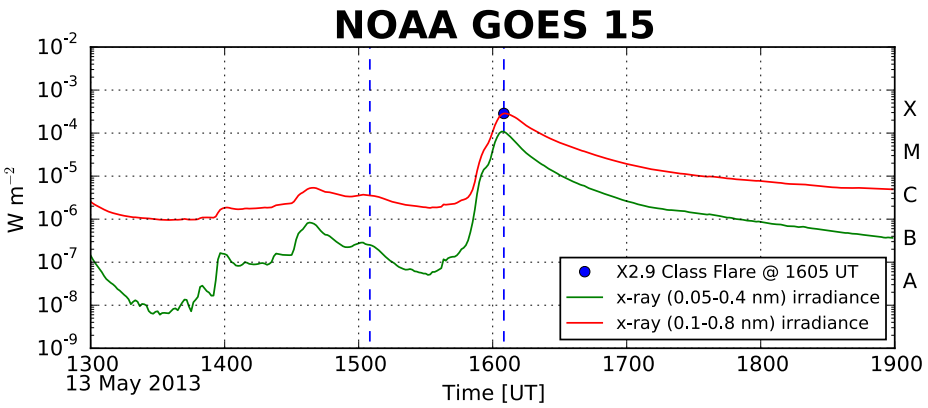
Ambient Weather WS-2902

Can we build one for Space Weather?

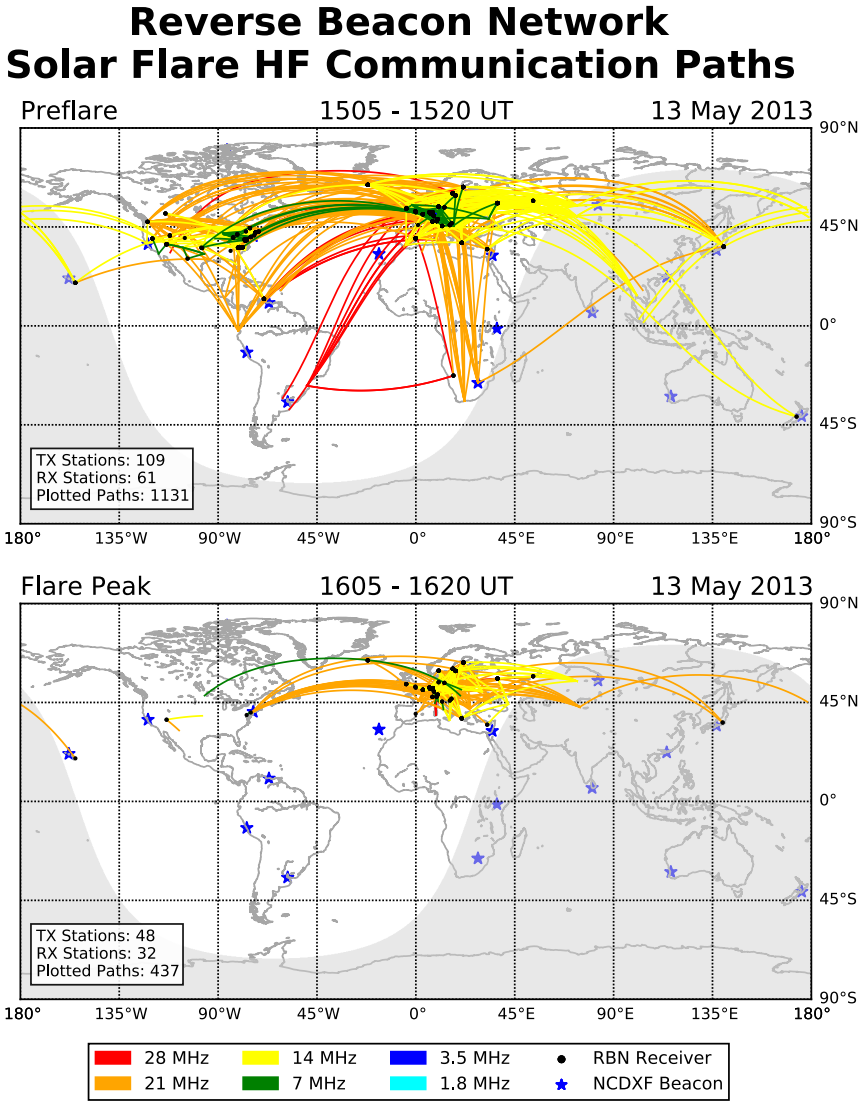
What instruments?

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

RBN/PSKReporter/WSPRNet RX

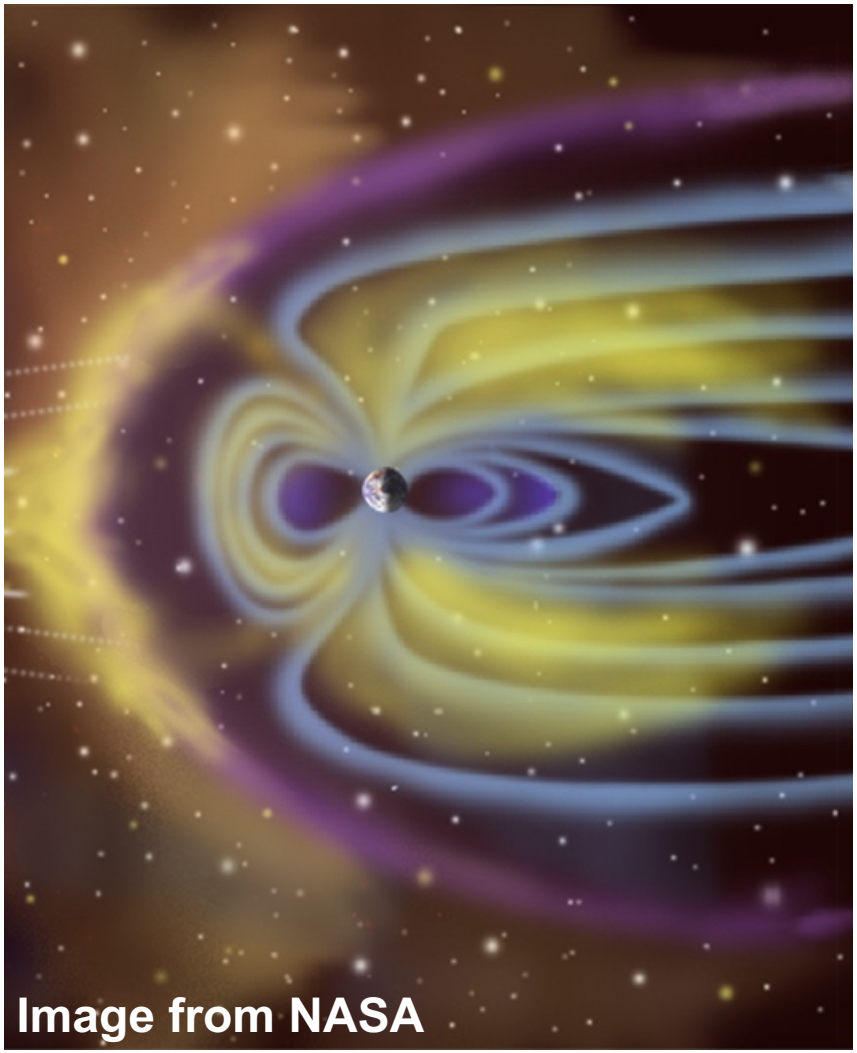


[*Frissell et al.*, 2014, *Space Weather*]



Ground Magnetometer

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



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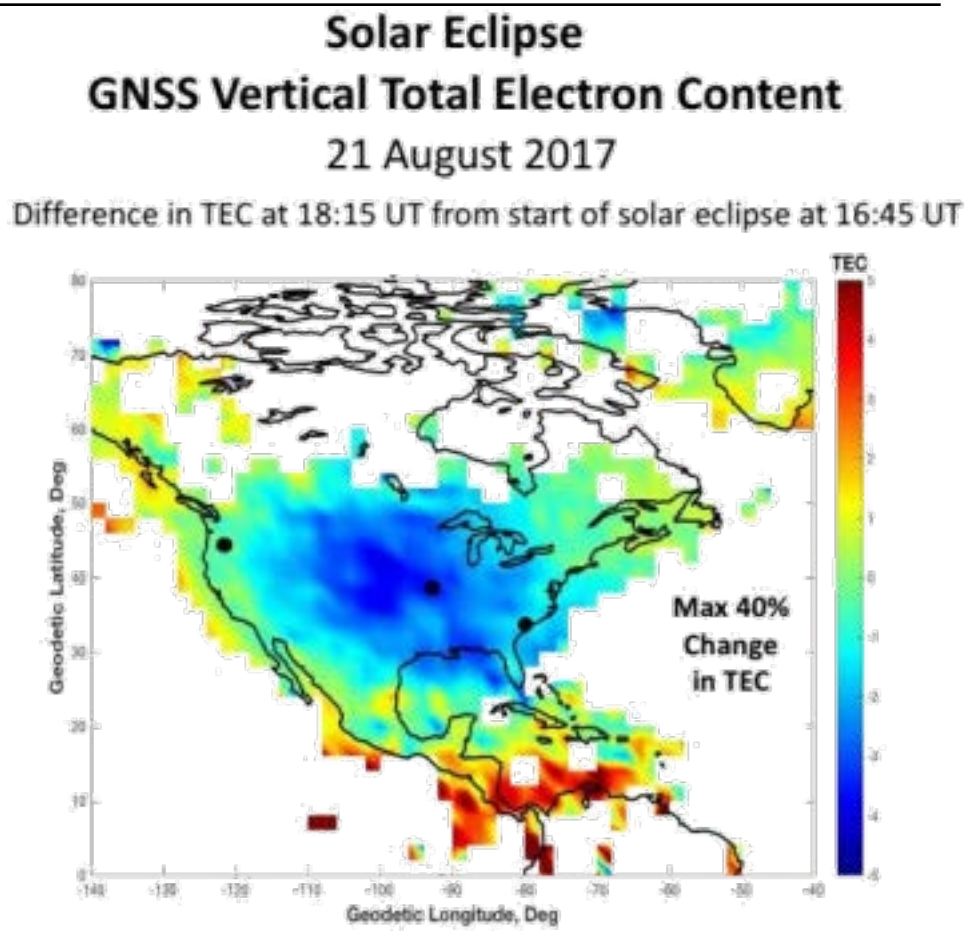
GPS Total Electron Content

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



Support: NSF AGS-1242204, NASA NNX17AH71G

Courtesy of Anthea Coster

Riometer

- **R**elative **I**onopheric **O**pacity **M**eter
- Directly measures absorption of cosmic rays
- Indirectly measures electron density, particle precipitation
- Typically passive instrument 30-50 MHz

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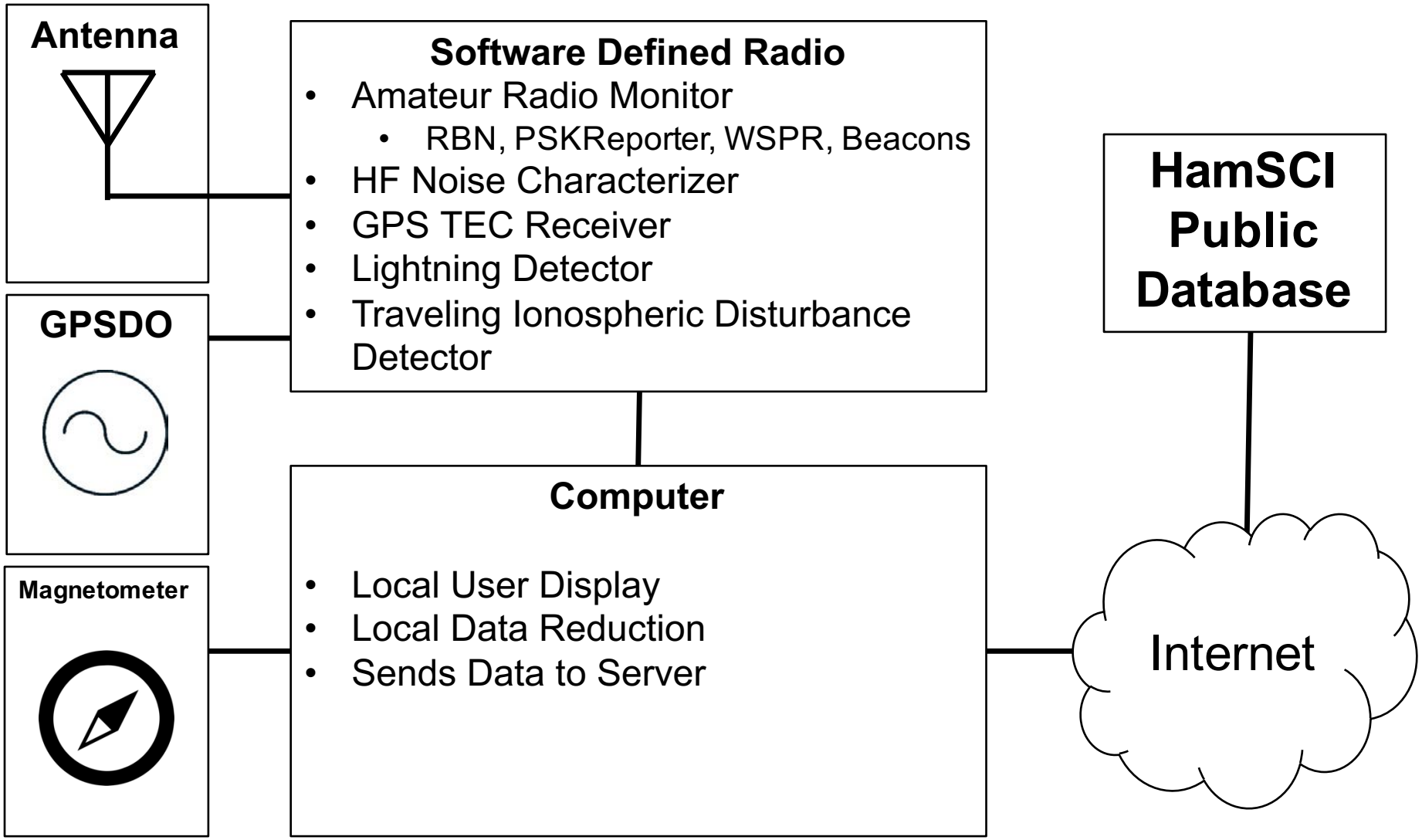
Lightning Detector

- 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)

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

- 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
- Magnetometer: British Geological Survey
  - 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)

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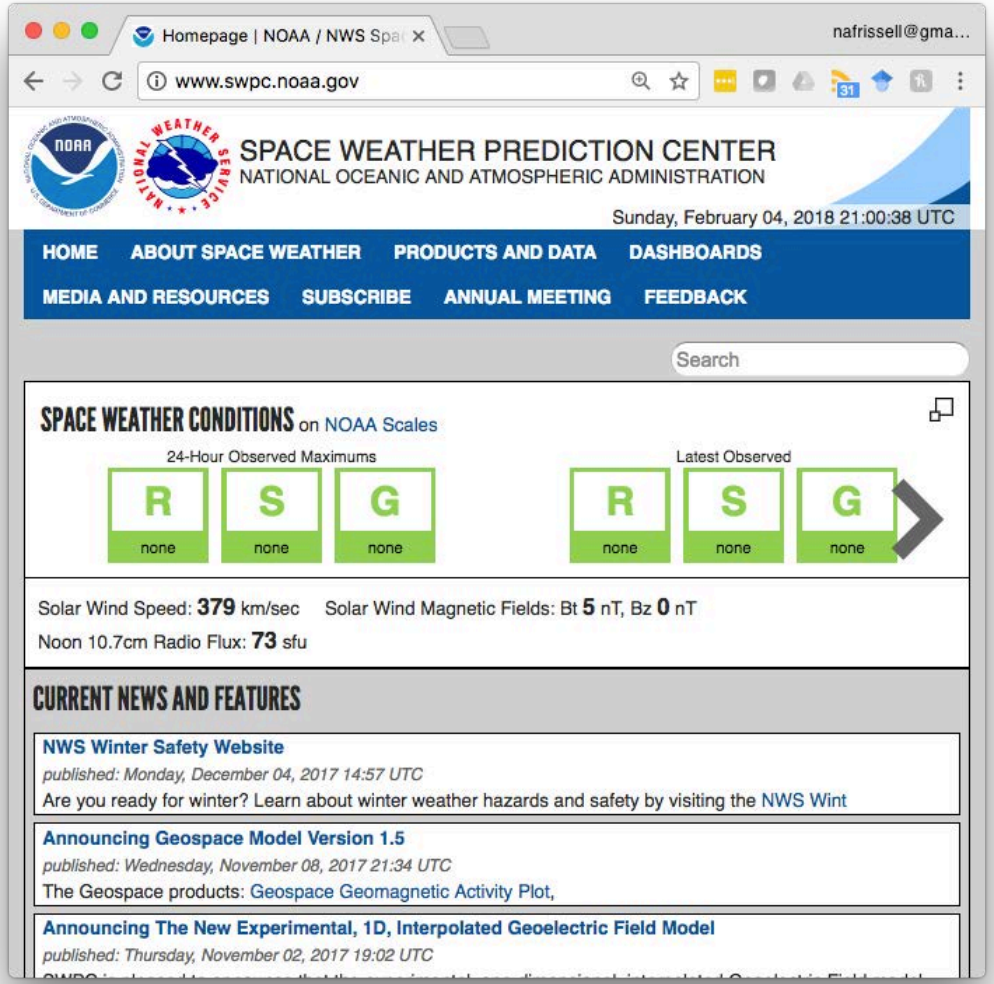
NOAA Space Weather Prediction Center

- 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.

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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!

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