Development of HamSCI PSWS Ground Magnetometer and Data Visualization on the PSWS Central Website

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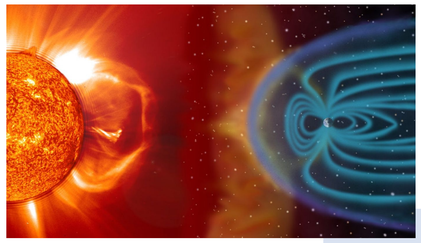
Introduction

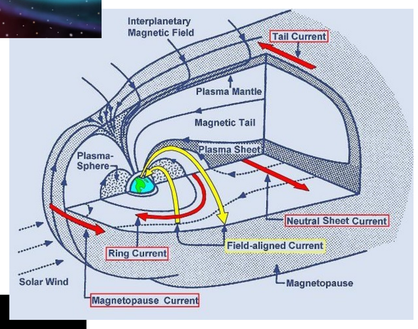
- As part of HamSCI Personal Space Weather Station (PSWS) project, magnetometers are designed to provide measurements of the geospace environment from the ground.
- Magnetometer data report magnetic field strength and direction and their temporal variations.
- PSWS Magnetometer data will be combined with high frequency (HF, 3-30 MHz) radio observations to monitor large-scale current systems and ionospheric disturbances.
- A densely-spaced magnetometer array, once established, will demonstrate their space weather monitoring capability to an unprecedented spatial extent.
- The primary goals are 1) to provide the general context of geomagnetic activity during the HF experiments; 2) to estimate ionospheric currents; 3) to measure ultra low frequency (ULF) waves; 4) to measure space weather-related disturbances (dB/dt).
- The magnetometer kit will be available for purchase at the TAPR store.
- Data from each location will be collected and stored in a central data archive in which users can view and download acquired data.

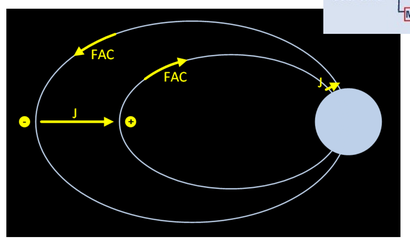
Magnetic Field Measurement on the Ground



(1) The Sun and the Earth are connected via magnetic fields.

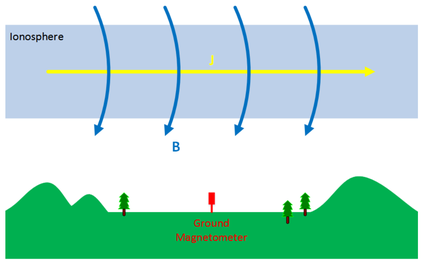
(2) The Sun-Earth connection creates complex current systems around the Earth.



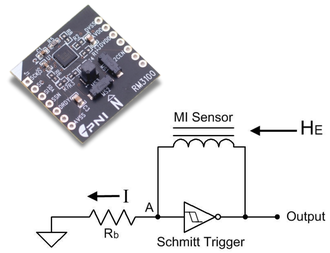


(3) Changes in currents and thus magnetic fields are projected onto the ionosphere.

(4) The processes in the ionosphere are often observed by magnetometers on the ground.



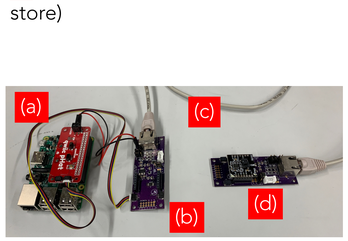
HamSCI PSWS Ground Magnetometer

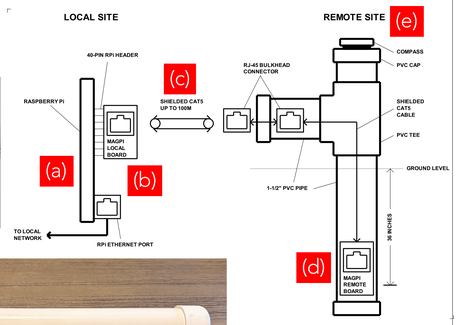


- PNI RM3100 magneto-inductive sensor (pnicorp.com)
- Low power, low mass, small size and large dynamic range (±1100 μT)
- Noise: ~20 nT
- High resolution: ~on the order of 10 nT
- Tri-axial measurements
- I2C and SPI interfaces
- $25 (sensor only)

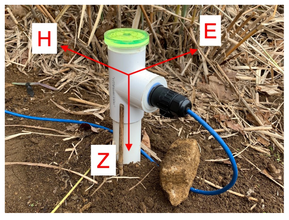
Magnetoinductive (MI) sensing technology: uses the principle of electromagnetic induction. An inductor develops a magnetic field when a current flows through it; alternatively, a current will flow through a circuit containing an inductor when the magnetic field through it changes.

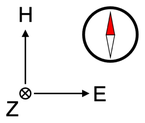
The PSWS magnetometer (MagPi) system consists of 5 basic components:
(a) Local computer (Raspberry Pi) (user-supplied)
(b) Local MagPi PC board
(c) Shielded CAT5 interconnecting cable (user-supplied)
(d) Remote MagPi PC board
(e) Burial components (user-supplied, will be available for purchase at the TAPR store)





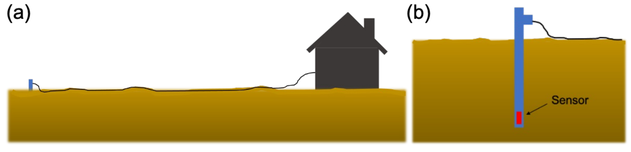
- MagPi samples data at a 1 Hz sample rate (per axis).
- Preliminary test shows that it measures field variations with a ~6 nT resolution.





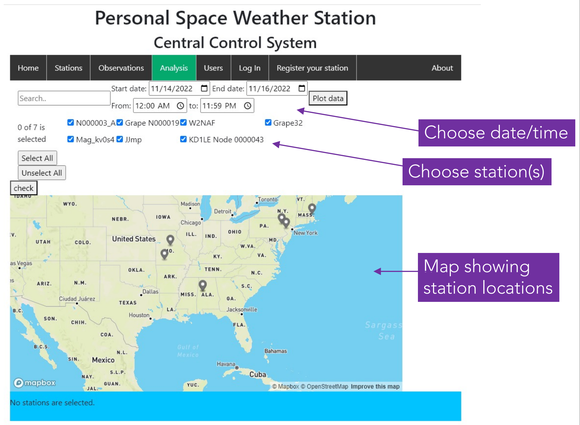
- Sensor burial kit installed on the ground and sensor orientation ("HEZ" system).
- For temperature stability, it is recommended that the sensor is buried under the ground.

The sensor module must be located away from metal objects and magnetic fields.

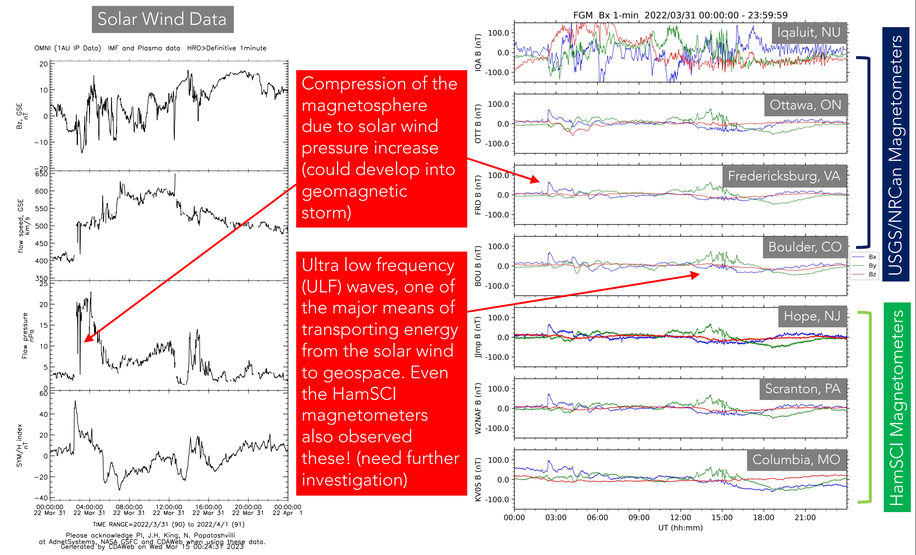


GUI for Data Visualization

- Magnetometer data from each location will be collected and stored in a central data archive.
- Development of a graphic user interface (GUI) is underway: Users can view and download acquired data.
- The central data archive will combine magnetometer data and radio receiver data to monitor space weather in a broader context.



Example Data



- The example data (both from the professional and HamSCI magnetometers) show ionospheric responses to magnetospheric dynamics shown in solar wind data (obtained by spacecraft).
- Data are background-removed.
- The HamSCI magnetometer data are moving-averaged (60 sec).

Conclusion

- Data from a low-cost, magneto-inductive type magnetometer for the HamSCI PSWS project are presented and compared with a professional, science-grade magnetometer nearby.
- The HamSCI magnetometers successfully observed space weather-related phenomena, demonstrating that the its performance is very adequate for scientific investigations.
- Once established, the proposed closely-spaced magnetometer network will provide quantitative and qualitative measurements of the geospace environment from the ground for both scientific and operational purposes at a cost that will allow for crowd-sourced data contributions.

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