Preliminary Analysis of PSWS Magnetometer Data

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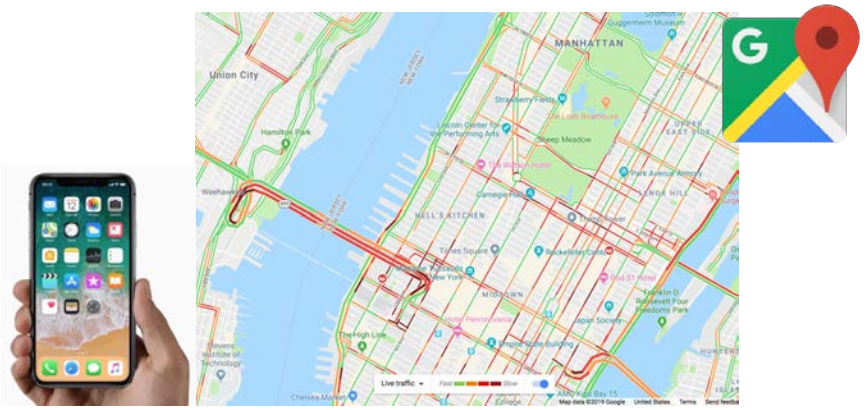
HamSCI PSWS Magnetometer Project Overview

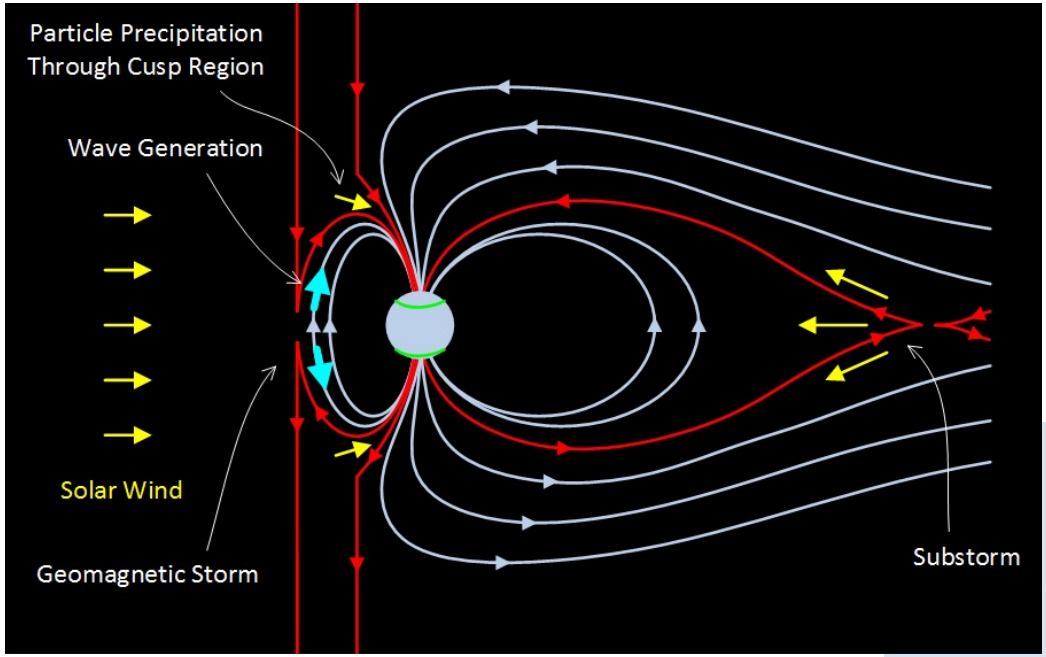
- A densely-spaced magnetic field sensor network
  - To provide quantitative and qualitative measurements of the geospace environment from the ground for both scientific and operational purposes at a cost that will allow for crowd-sourced data contributions.
  - To monitor large-scale current systems and ionospheric disturbances due to drivers from both space and the atmosphere in a more extensive spatial scale.

HamSCI PSWS Magnetometer for Scientific Investigations

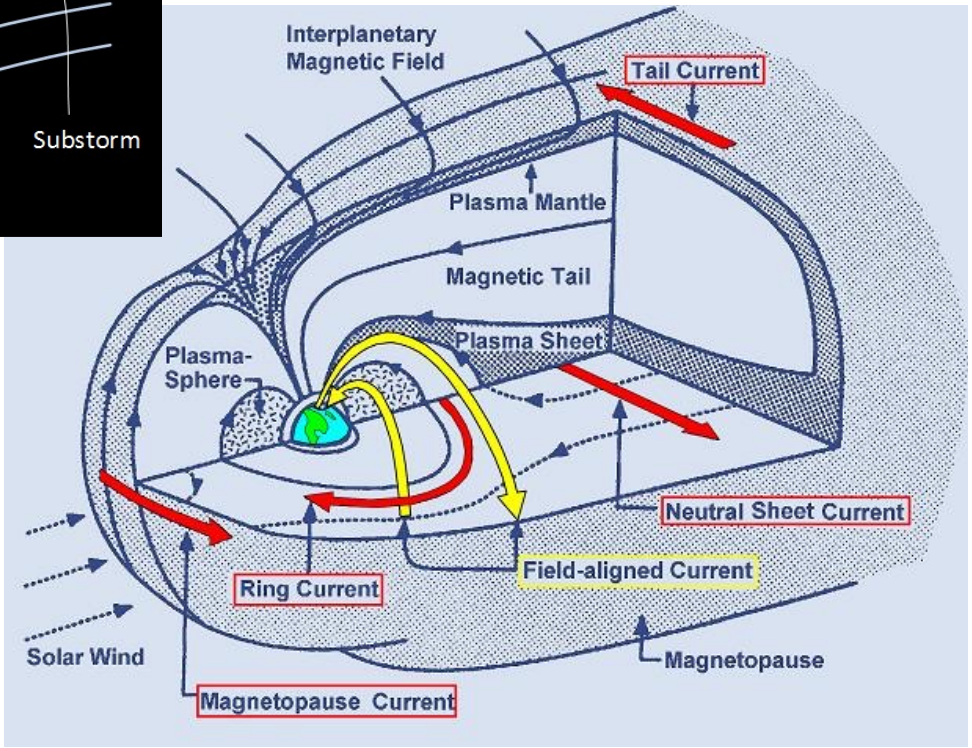
- Magnetic field resolution: ~6 nT @ 1 Hz
- Magnetic variometer operation: no absolute field measurement.
- Target spacing: ~ a few degrees LAT/LON.
- Target observations:
  - Large-scale current systems
  - Ultra low frequency (ULF) waves
  - Geomagnetically induced currents (GIC): dB/dt → important space weather issue.
- Crowd-sourced data contributions: closely-spaced multi-point measurements rather than sparse measurements using expensive systems (i.e. Google Map)



Solar Wind–Magnetosphere-Ionosphere (SW-M-I) Coupling



- Space weather is affected by a variety of the ***current systems*** in the magnetosphere and ionosphere due to the coupling between the Sun and the Earth.
- The currents are often observed by ***magnetometers*** in space and on the ground.

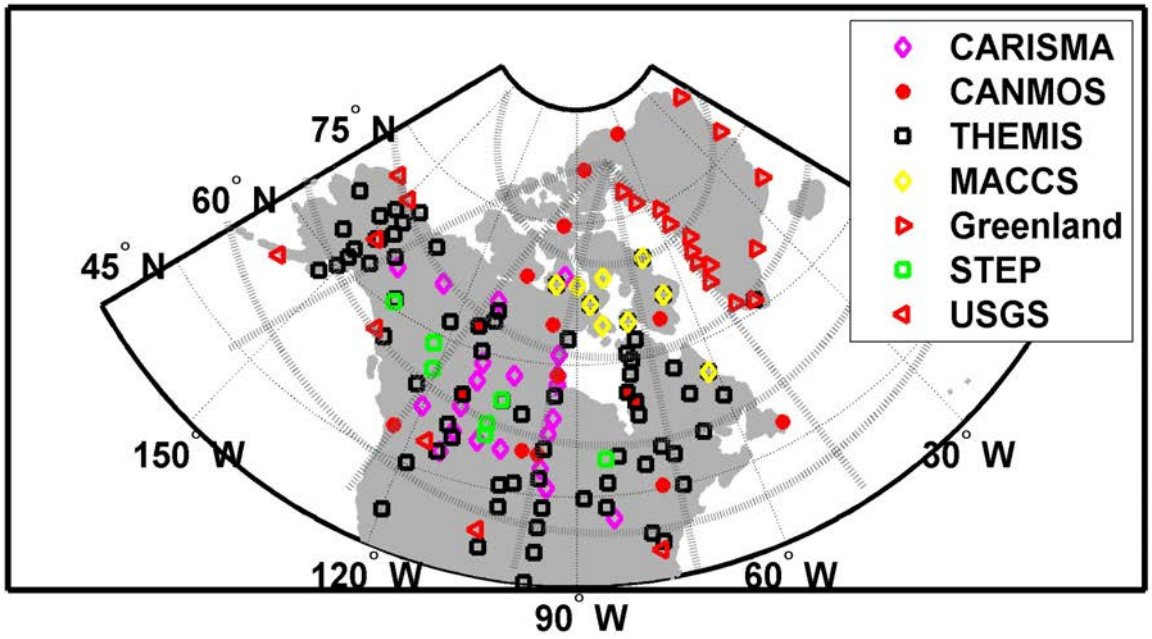


- The Sun and the Earth are connected via magnetic fields.
- The Sun-Earth connection creates a unique geomagnetic field structure: The **Earth's Magnetosphere.**
- The outflow of the solar wind from the sun's atmosphere and its interaction with the earth's magnetic environment and human technologies ("space weather").

Science Example: Ionospheric Currents

- *Ionospheric current systems* derived from ground-based magnetometer data [e.g., Amm and Viljanen, 1999; Weygand et al., 2011].
- Provides context for All Sky Images, Ionospheric Radars, MI coupling, and Riometers.
- Magnetometer coverage has changed significantly over the years.
  - Number of stations in the lower 48 states is now about ~10 down from about 24.
  - Number of stations in Eastern Canada has increased.
- In order to meets the requirements of the Space Weather Action Plan the number of stations in the lower 48 needs to increase to diagnose the possible dB/dt spikes.

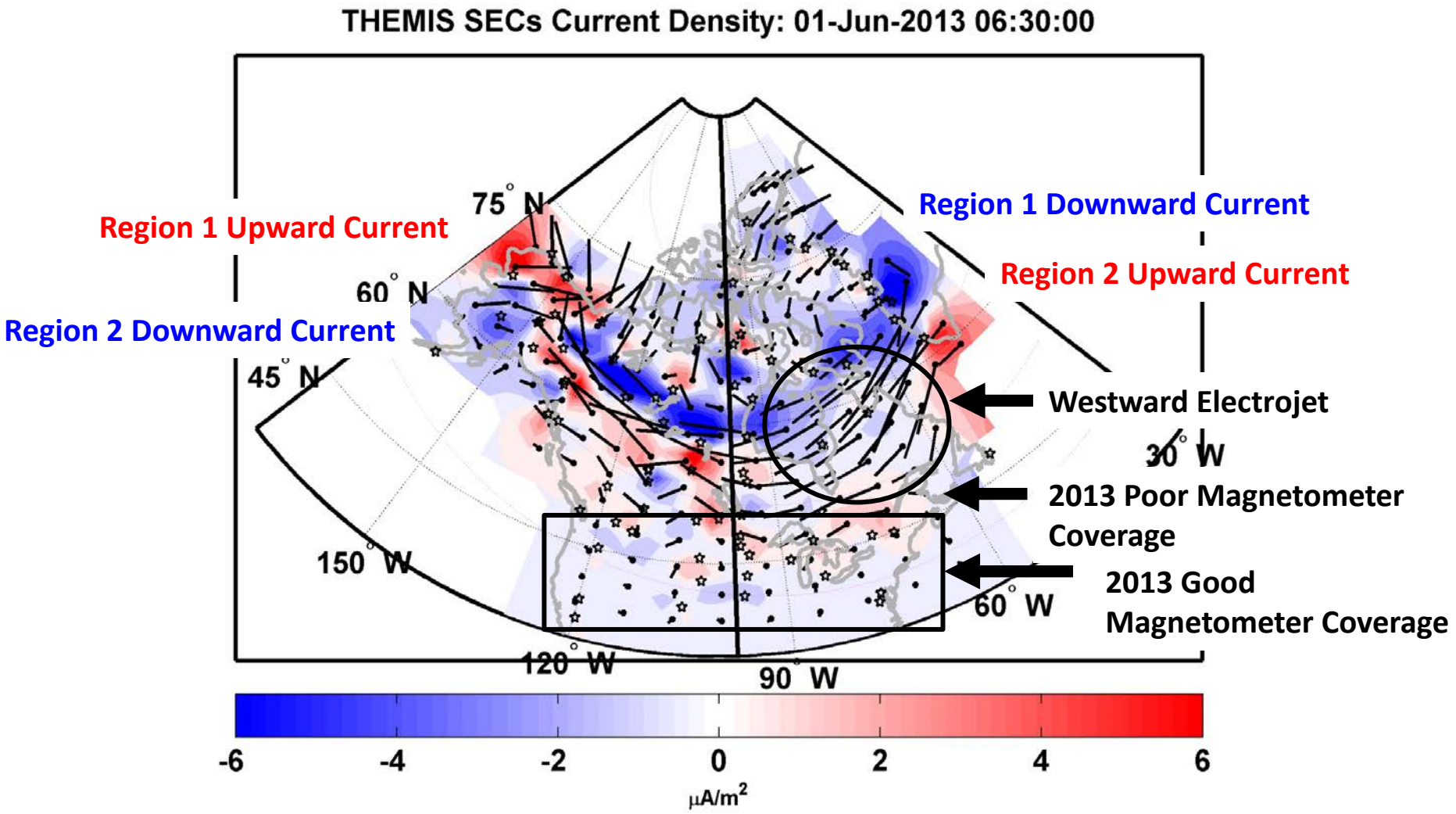
CARISMA, CANMOS, GIMA, Greenland, MACCS, McMAC, THEMIS, STEP, USGS



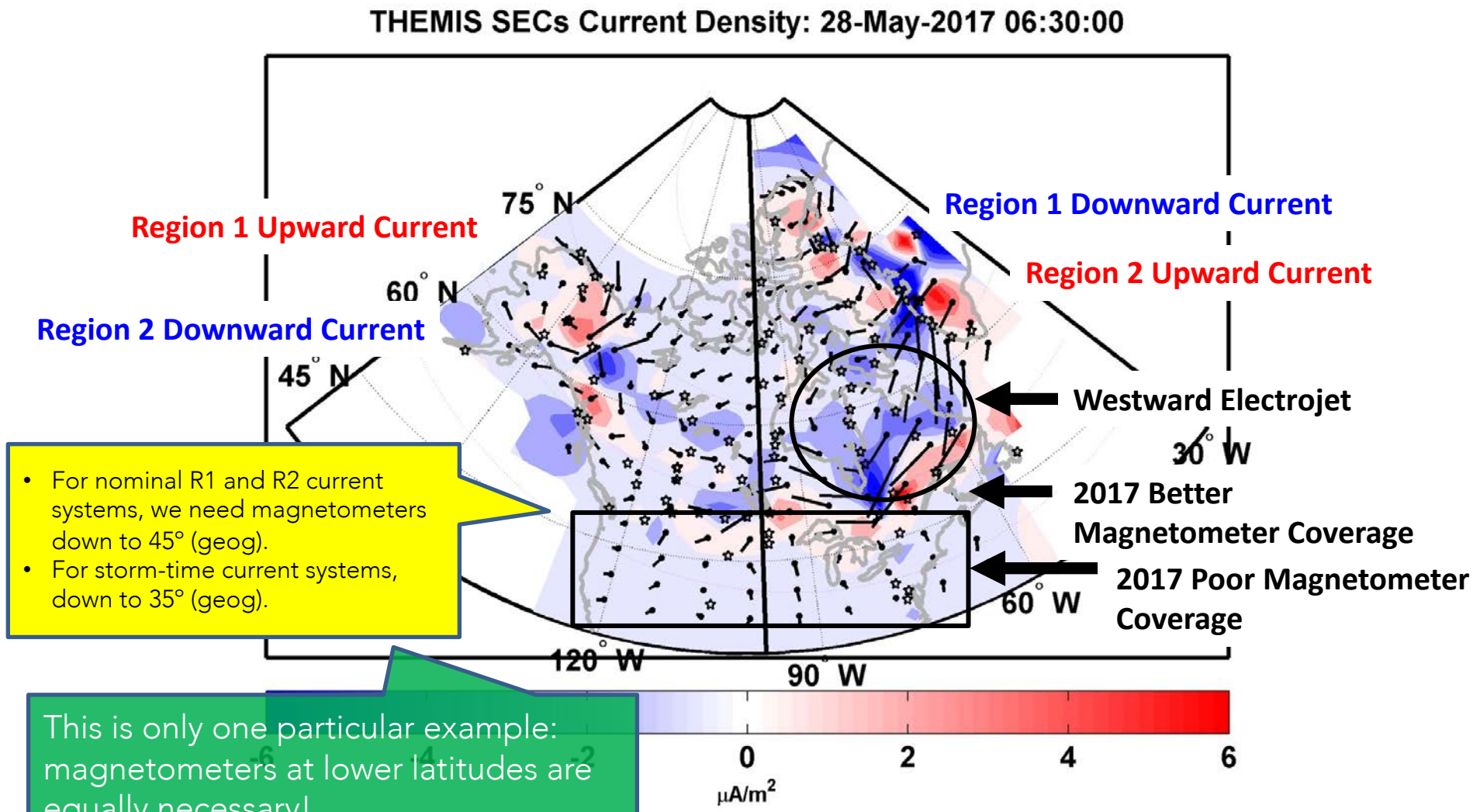
Ionospheric currents are estimated using Ampere's Law.

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{encl}}$$

Science Example: Ionospheric Currents During 2013/06/01 Storm



Science Example: Ionospheric Currents During 2017/05/28 Storm



- For nominal R1 and R2 current systems, we need magnetometers down to 45° (geog).
- For storm-time current systems, down to 35° (geog).

This is only one particular example: magnetometers at lower latitudes are equally necessary!

Preliminary Data Analysis

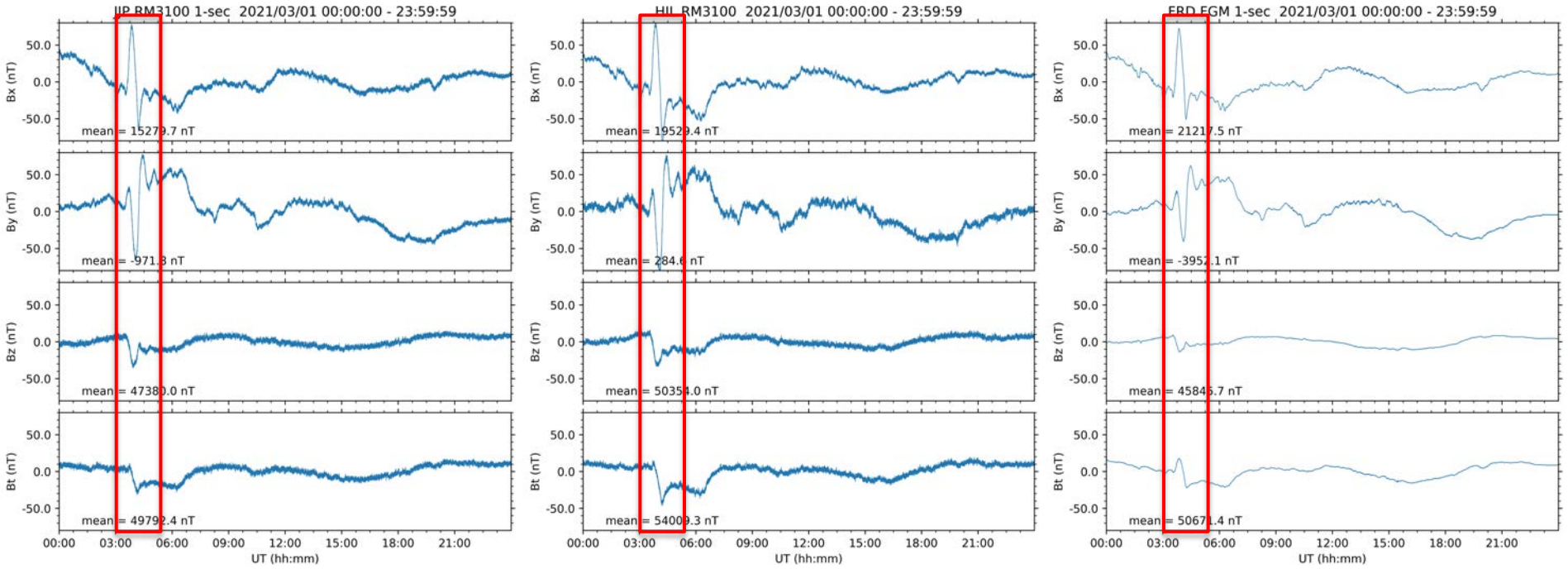
- Presented here are data acquired by HamSCI magnetometers (magneto-inductive type, Model RM3100) from Jan to Feb, 2021 at two test sites.

Example Event 1: Geomagnetic Storm on March 1, 2021

HamSCI Magnetometer
Jeffer Observatory, Hope, NJ

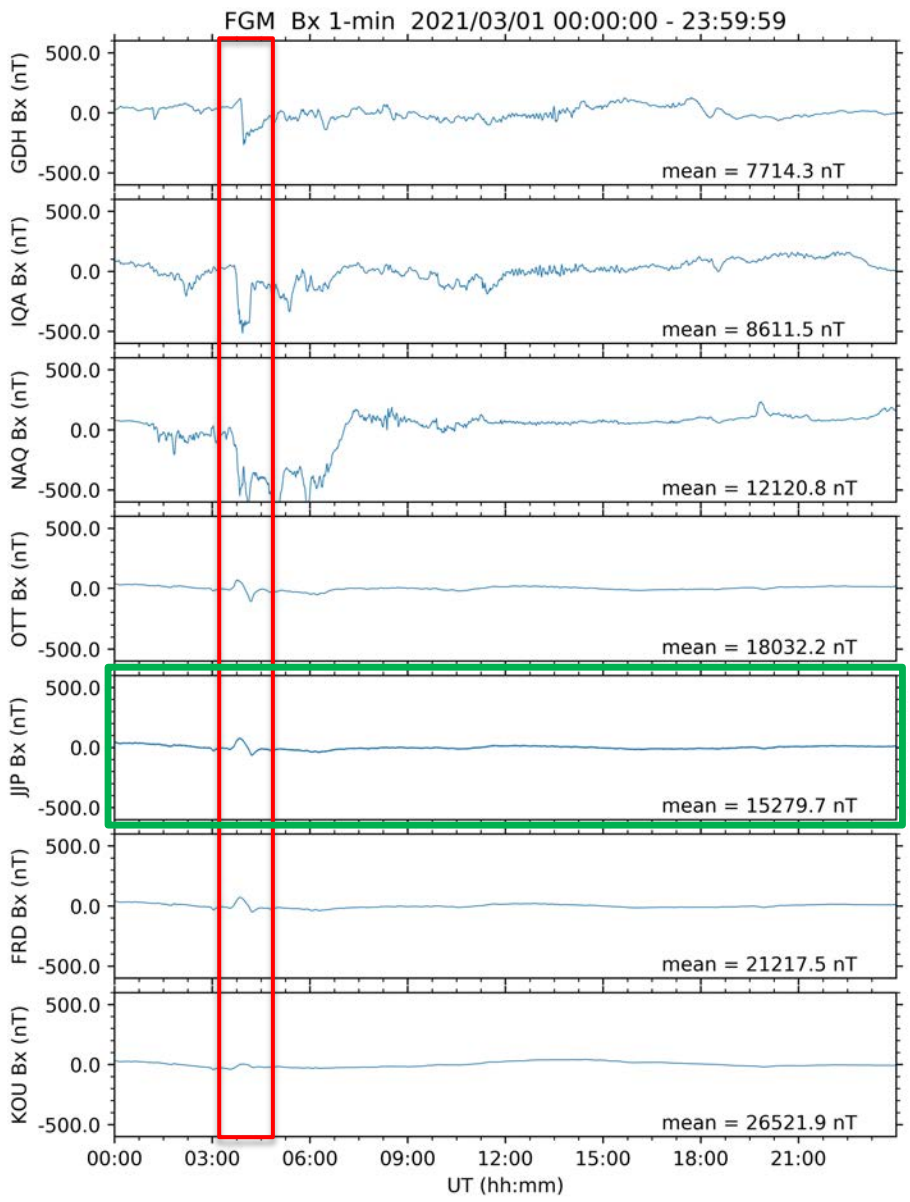
HamSCI Magnetometer
Hillsdale, NY

USGS Magnetometer
Fredericksburg, VA

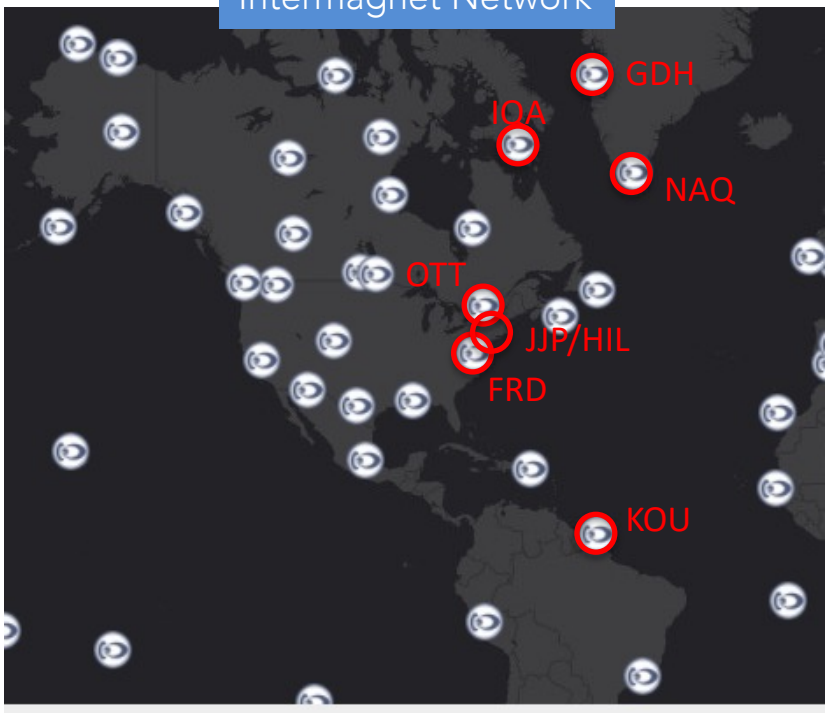


- Bipolar structures (~4 UT) associated with a geomagnetic storm (Kp =5).
- > 100 nT changes at mid latitudes.

Example Event 1: Geomagnetic Storm on March 1, 2021

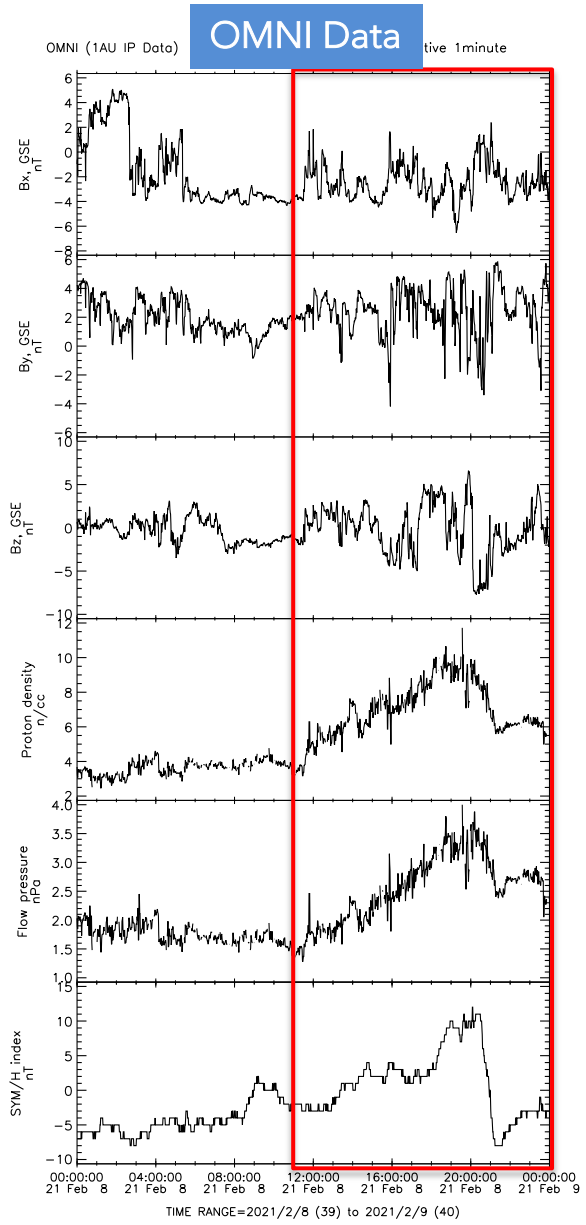


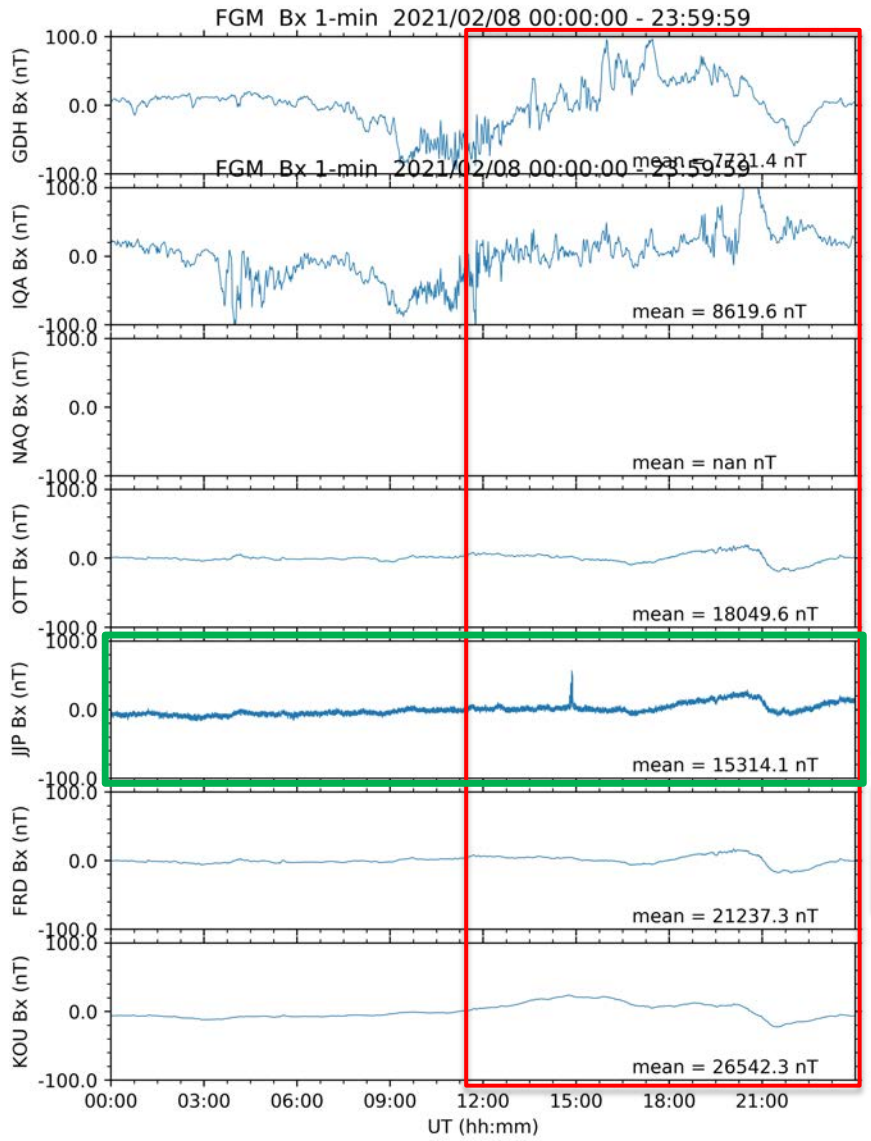
Lat.



HamSCI Magnetometer

Example Event 2: Magnetospheric Compression/Ring Currents





The magnetometers observed the compression of the magnetosphere and the enhancement of ring currents.

HamSCI Magnetometer

Summary

- A low-cost, magneto-inductive type magnetometer for the HamSCI PSWS project has been tested at two locations in Jan-Feb, 2021.
- The HamSCI magnetometers successfully observed space weather-related phenomena along with many other science-grade magnetometers.
- The test operations demonstrated that the its performance is very adequate for space weather sciences.
- 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.

Thank you!