# Distributed Sensor Array for Mid-Latitude Ionospheric Characterization


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## Background

This project studies the characteristics of Traveling Ionospheric Disturbances (TIDs) as they influence GPS signals. The data used in this study is obtained using CASES GPS receivers that measure scintillations in total electron content (TEC). These fluctuations can be used to calculate the characteristics of the ionospheric plasma within the TIDs, allowing for greater understanding of their composition and nature to allow for enhanced fortification of civilian and military systems against their effects.

On 10 October 2024, the aurora borealis was visible over West Point, NY following a geomagnetic storm (Pictured here). This sight affirmed the necessity for mid-latitude ionospheric research and the purpose behind installing sensors on West Point property for cadets to use in space weather research.

## Collaborating Work

This project is part of the work of a larger research group: COSMIC. We work closely with other cadet research teams doing similar work in ionospheric research. The collaborating projects are currently using ionospheric data collected at the Poker Flat Research Center in Fairbanks, AK, which this project aims to replace with on-site, mid-latitude data.

## Acknowledgements


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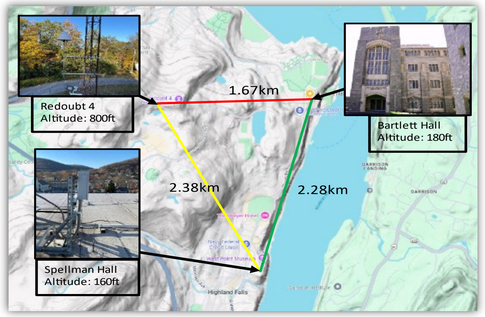
## Instrumentation

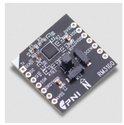



### Distributed Network

This is a map of West Point, NY, showing the installation locations for CASES receivers. These collect passive GPS data that derives TEC from pseudo-range measurements.

The baseline between receivers in 1.67k to 2.28km, and they range from 160ft to 800ft in altitude.

CASES GPS Receivers



Magnetometers


PHT Sensors

Electrometers



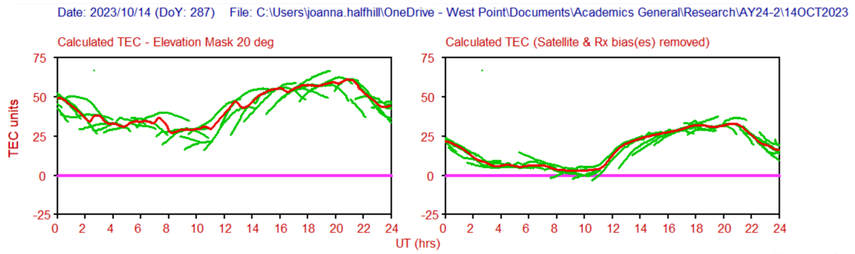
Seismometers



### Multi-sensor Network

A goal of this project is to incorporate multiple sensors into the network to provide data on magnetic fields, tropospheric weather, electric currents, and seismic activity. Such data would allow cadets to discern the probable origin of fluctuations and make more accurate characterizations.

## Data Processing




We extracted the raw pseudorange-derived slant total electron content (STEC) from our CASES receivers and converted it to vertical total electron content (VTEC) using GPS RINEX processing software that also removed satellite and receiver biases.

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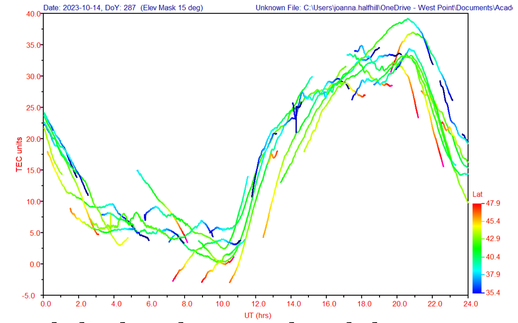
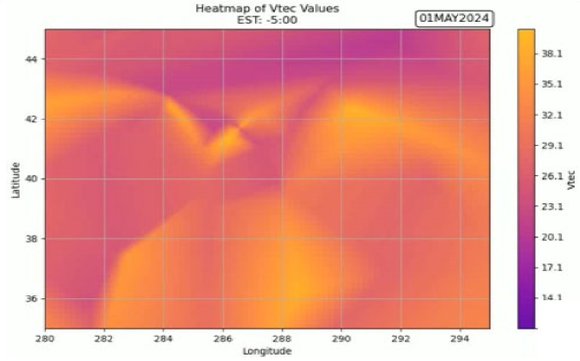
## Data Analysis




The graph displays the vertical total electron content above USMA during the October 14, 2023, annular solar eclipse with satellite and receiver biases removed. The colorbar represents the sub-ionospheric pierce point latitude in degrees at 350 km. Each line on the graph is data from a separate satellite that passed over the receiver that day.




The plot above shows a linearly interpolated VTEC heatmap of a normal day above West Point, NY. The current analytical focus of the project is using spatial maps like these to calculate TID movements and velocities to derive key characteristics like its scale and Fresnel frequency.

## Abbreviated References*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