Development of the Monitoring and Visualization Website for NOAA GNSS-RO Space Weather Products

Nishant Vellanki

Mentors: Xinjia Zhou, Xi Shao, Yong Chen

Objectives

1. **Enhance the existing NOAA STAR GNSSRO monitoring system**
   a. Build upon and enhance the monitoring system developed by previous summer interns
   b. Improve performance, usability, and data accessibility
   c. Extend existing tools to support new datasets and functionality :
1. **Expand GNSSRO monitoring from Neutral Atmosphere to Space Weather**
   b. Add GNSS space weather products to the existing monitoring system
   c. Develop new monitoring tools for Total Electron Content (TEC) and Electron Density Profiles (EDP)
   d. Integrate Space Weather products into the interactive Ground Tracker

Results 1: Existing System Enhancements

a. Improved drop-down menus and navigation across monitoring pages
b. Added a floating navigation bar and persistent permalinks
c. Developed separate menu structures for internal and external users
d. Improved statistics controls and preserved user settings across different views
e. Restored synchronization of highlighted plots across tabs and references
f. Consolidated duplicated menu controls and source code
g. Improved overall usability and consistency of the existing monitoring system
h. Added an introduction page for NOAA STAR PBLH product

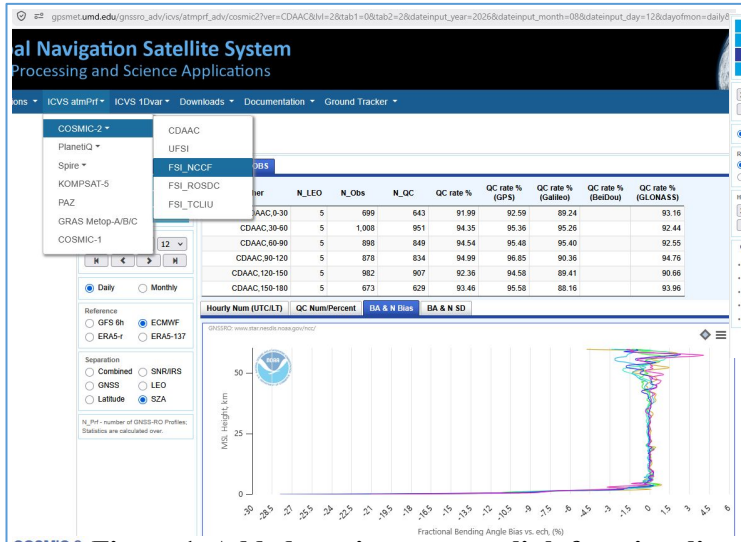


Figure 1. Added persistent permalink functionality

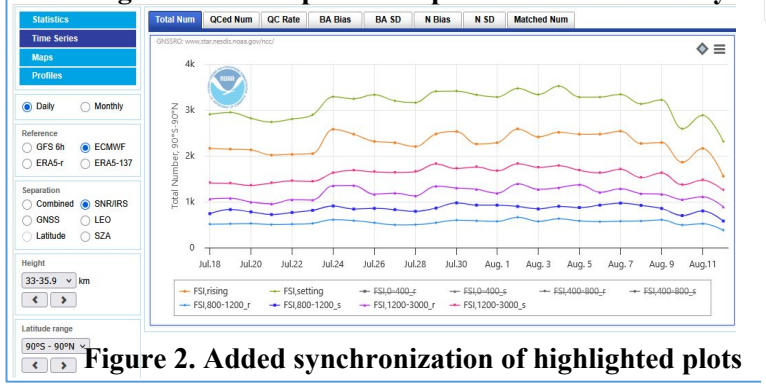


Figure 2. Added synchronization of highlighted plots

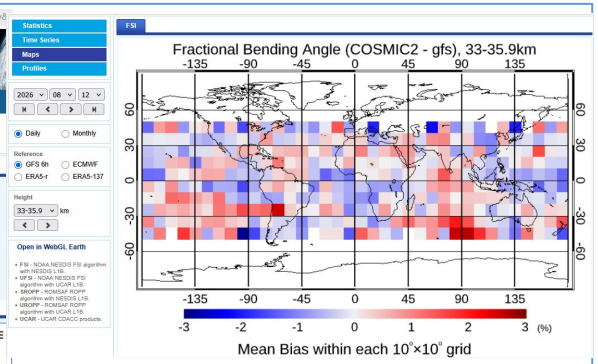


Figure 3. Improved the O−B map function

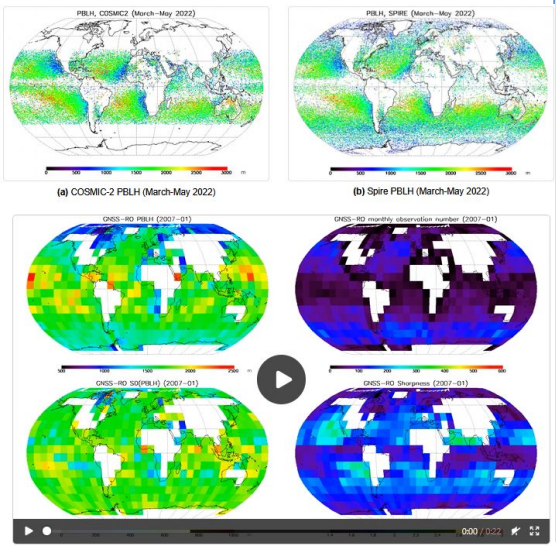


Figure 4. Added an introduction page for the NOAA STAR PBLH product

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Results 2: Expand the monitoring for Space Weather Products

Expansion the monitor and visualization web based tool to NOAA GNSS Space Weather Product,

1. **Extended Ground Tracker to Space Weather Products**
   a. Expanded the existing Neutral Atmosphere Ground Tracker to support ionospheric products
   b. Added Total Electron Content (TEC) observations and trajectories
   c. Added an interface for future Electron Density Profile (EDP) products
1. **Enhanced TEC Visualization**
   b. Added individual TEC profile display for each GNSS–LEO observation
   c. Added TEC color-coded trajectories on the global map
   d. Trajectory color now represents TEC variation along the GNSS–LEO observation instead of using a single color for the entire event
2. **Upgraded Cesium Visualization Framework**
   b. Migrated the Ground Tracker from Cesium Entity API to Primitive API
   c. Improved rendering performance and scalability for large numbers of trajectories
   d. Applied the new Primitive architecture across the Ground Tracker tools

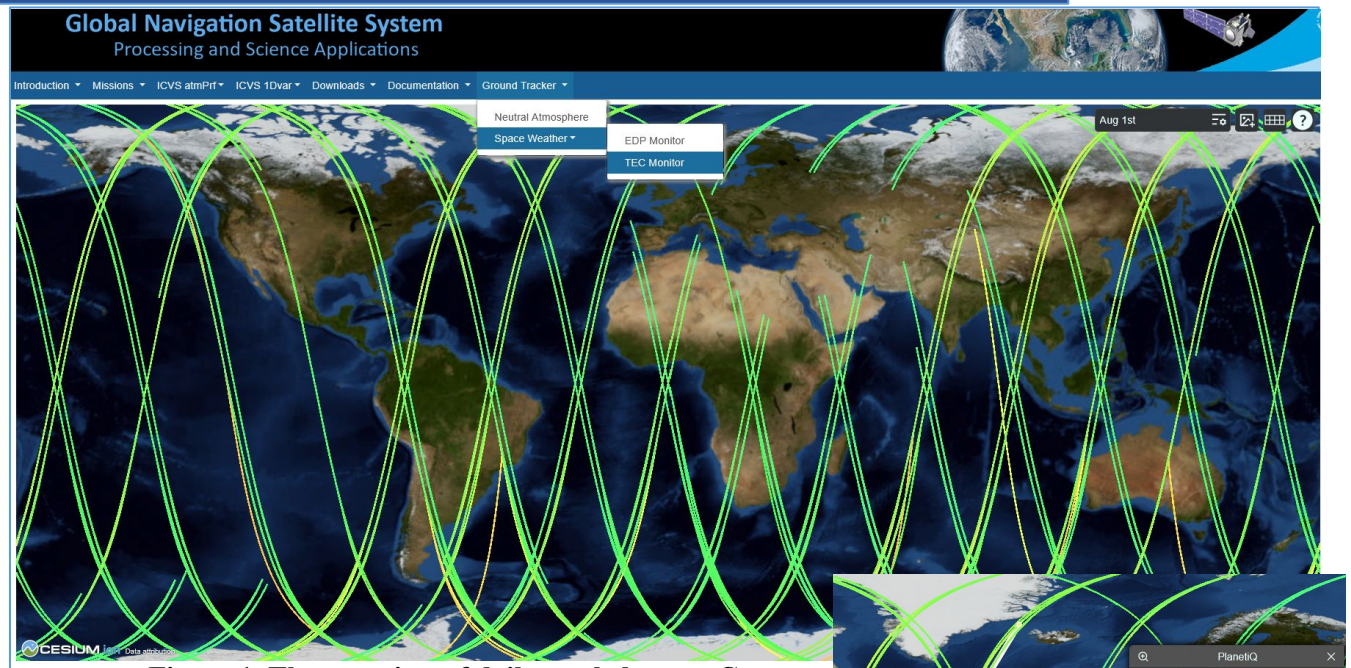


Figure 1. The overview of daily total electron Content

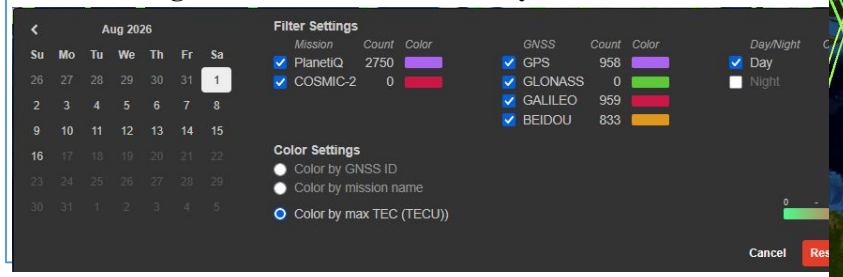


Figure 2. The filter control window

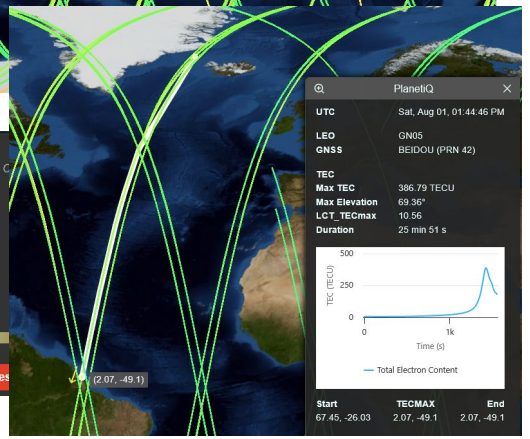


Figure 3. Individual TEC profile

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Future work and the Goals

Due to the late start of the internship this summer, several planned tasks are still in progress. Nishant has accepted an internship extension and will continue this work during the fall semester.

1. **TEC colored trajectories**
   a. Currently, only the MaxTEC value is displayed on the map.
   b. The goal is to color-code the entire trajectory based on TEC values.
   c. This requires a broader architectural change, including changes to how representative points are rendered and switching the Cesium object class.
2. **EDP (electron density profile) visualization.**
   a. Integrate and display the NOAA STAR EDP product in the Ground Tracker once the product becomes available.
3. **Performance and real-time visualization**
   a. Improve the performance of the Ground Tracker and TEC Monitor..
   b. Replace static NOAA STAR NCC TEC plots with interactive, dynamically updated real-time visualizations
4. **Cross-link atmospheric products**
   a. Cross-link the space weather products with the neutral-atmosphere products to provide integrated access and visualization.

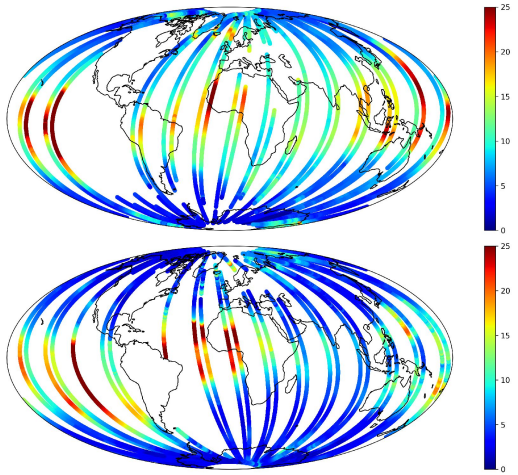


Figure 1. TEC products generated manually for papers and presentations. The new TEC Monitor will provide interactive, real-time visualization.



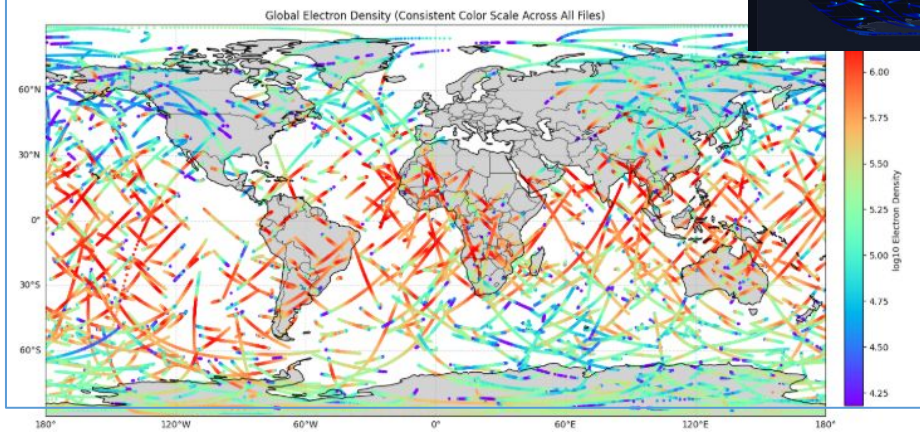


Figure 3. Design plan for the EDP Monitoring tool. Similar to the TEC product and soon to be implemented.

Figure 2. Current static visualization of the EDP product on the NOAA NESDIS NCC website. https://ncc.nesdis.noaa.gov/gnssro/PlanetIQ-TEC.php

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