Interactive GPS/TEC Plotting

Quick Guide

The GPS/TEC Four Plot tool is a powerful feature which allows users to quickly generate maps of GPS TEC and SuperDARN data for easy comparison. New features are regularly being added to this tool and issues are addressed as they are identified. A few of these issues are identified at the end of this guide.

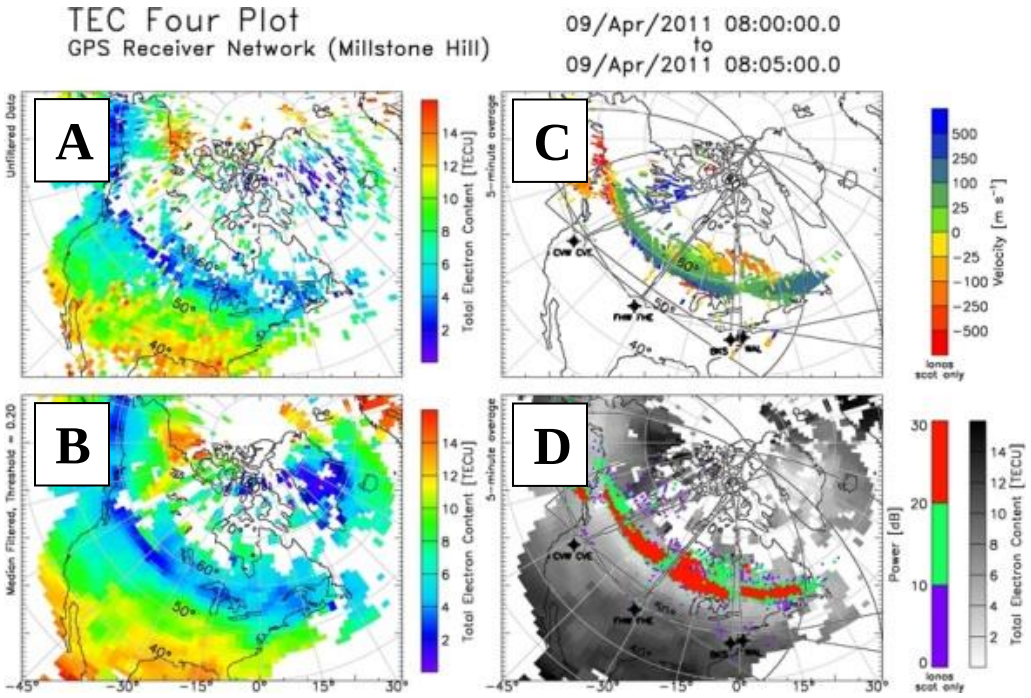

Figure 1. Output from the GPS/TEC Plotting - Four Plot page for a SAPS event

1. Four Plot

The Four Plot arrangement is designed to allow for quick comparisons between simultaneous GPS TEC and SuperDARN observations. Descriptions of each of the four panels seen in Figure 1 (above) are as follows:

- **A.** Upper Left – "Unfiltered" GPS TEC data as it is downloaded from Madrigal and plotted using a linear color scale. TEC measurements are given as five minute averages gridded into 1° by 1° geographic latitude and longitude bins.
- **B.** Lower Left – "Median Filtered" GPS TEC data plotted using a linear color scale. The user is able to define the size of the TEC latitude and longitude bins (see section 2).
- **C.** Upper Right – Either single scans or five minute averages of SuperDARN backscatter velocity measurements. For single scans, the actual scan time will be given along the upper left side of the panel. Linear and nonlinear color scales are available.
- **D.** Lower Right – SuperDARN backscatter power measurements overlaid on a grayscale map of median filtered TEC data. The size of the symbols is scaled according to power.

After generating one of these Four Plots, a link to that day's GPS/TEC data file on the Madrigal website at Millstone Hill can be found below the figure. If no data for the selected date is available, the user will receive an error message and a link to the available TEC data on Virginia Tech's servers will be provided (Figure 2).

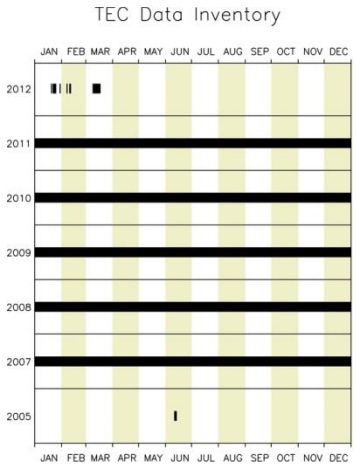

Figure 2. Sample TEC data inventory graph (no longer accurate)

2. Median Filtering

Due to the sparse GPS receiver coverage in some areas, a technique known as "median filtering" is sometimes applied to the TEC data after it has been downloaded from Madrigal. This process examines both spatially and temporally adjacent bins to determine whether enough real data values are present for a certain bin to be "turned on". If so, the median value from the adjacent cells is used; otherwise, that cell's value is set to zero. Here we describe the median filtering options available to the user on the GPS/TEC Plotting – Four Plot page in greater detail (Figure 3).

Figure 3. Median filtering options on the GPS/TEC Plotting – Four Plot page

- Lat/Lon Bin – The size (in degrees) of each of the new latitude and longitude bins.
- Start Lat – The lower latitude cutoff (in degrees) for the median filtering process. Moving this boundary poleward decreases computing time.
- Threshold – This percentage controls how strict of a threshold to impose on the median filtering routine. Higher thresholds (closer to one) will allow fewer grid cells to "turn on", while lower thresholds (closer to zero) will allow more grid cells to "turn on" (see Figure 4 below).

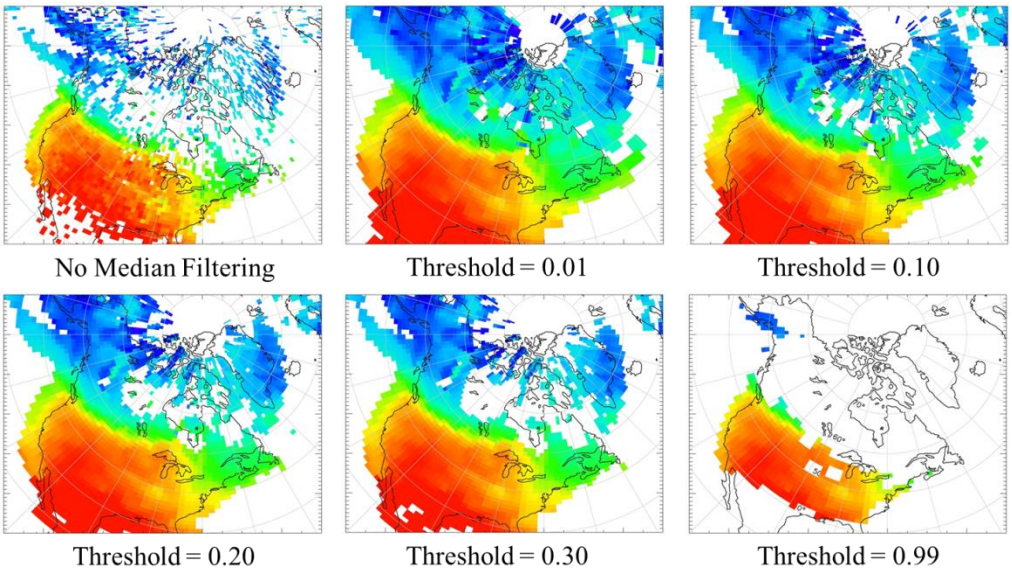

Figure 4. Examples of different median filtering threshold values and their comparison to the original GPS TEC data as downloaded from Madrigal

3. Miscellaneous Items

Known Issues:

1. Significant data gaps appear to be present for select files during 2007 that were downloaded from Madrigal. This issue has been communicated to Bill Rideout and he is re-processing all days with missing data. **This issue should be corrected as of February 24th, 2014.**
2. GPS TEC data for June 18th-25th 2011 is no longer available on the Madrigal experiment page; attempts to follow the link from the VT plotting page to the Madrigal page for these dates will result in an error. **This issue has been corrected as of July 19th, 2012.**
3. A bug was identified during a Feb. 2012 visit to MIT Haystack Observatory by Bill Rideout where default (final) TEC files were not always selected for download. **This issue has been corrected as of April 3rd, 2012.**
4. Formatting of the TEC Inventory page has been thrown off by addition of 2012 data; locations of data markers are still accurate. **This issue has been corrected as of April 2nd, 2012.**

Planned Updates:

1. Explanation of GPS Total Electron Content theory and interpretation.

This Quick Guide is still under construction and will provide more instruction on the use of the GPS/TEC plotting tools on the VT SuperDARN website in the future. Please contact Evan Thomas (egthomas@vt.edu) with any suggestions, requests, or questions.

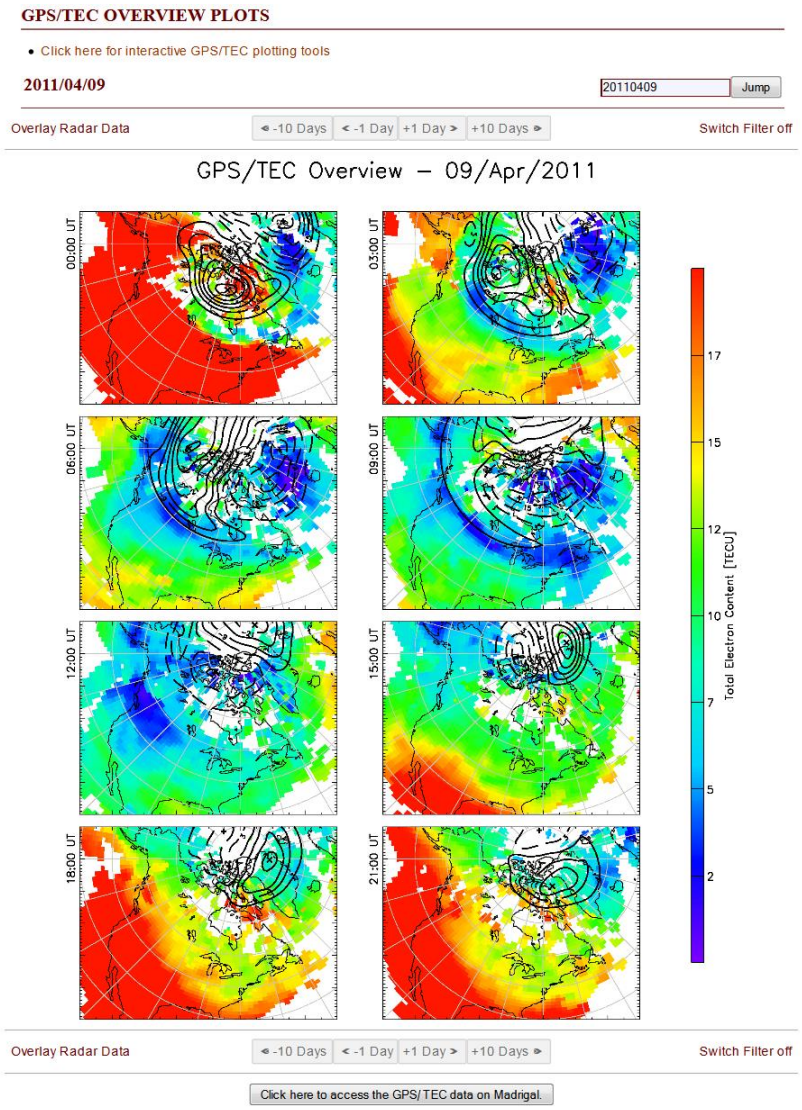

Figure 5. Now Available: A web tool allowing for quick overviews of GPS/TEC and SuperDARN data using pre-generated figures, located in the "GPS/TEC Plot Tools" section.

4. Credits

This effort grew from discussions between Evan Thomas and Anthea Coster at the 2010 AMISR Student Workshop hosted at MIT Haystack Observatory. It has been supported by the National Science Foundation under grants AGS-0946900, AGS-0838219, and ATM-0856093. Evan Thomas also acknowledges support provided by the Virginia Space Grant Consortium under a graduate research fellowship.

Last Updated:
August 17th, 2014
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