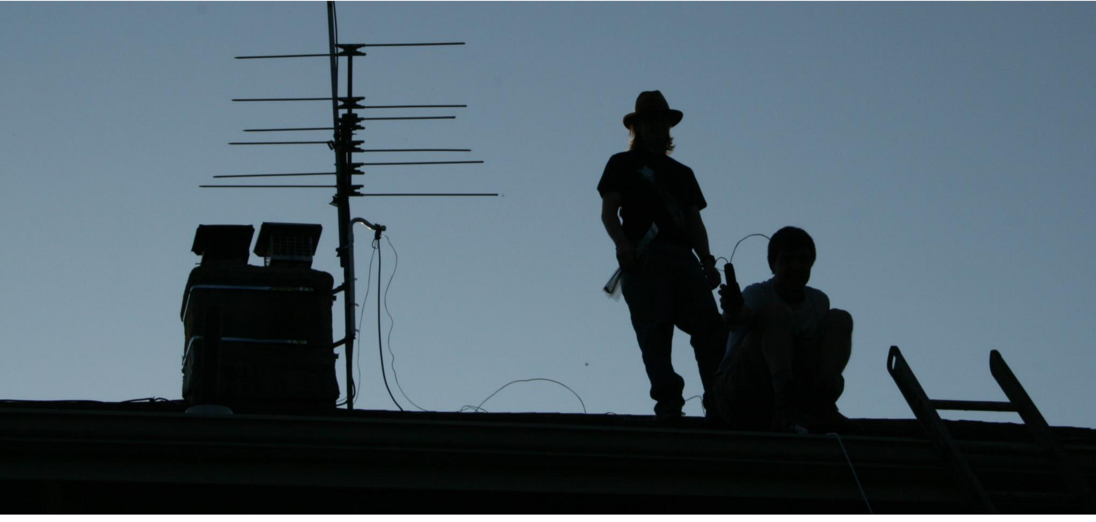

Observing Large Scale Traveling Ionospheric Disturbances using HamSCI Amateur Radio: Climatology with Connections to Geospace and Neutral Atmospheric Sources

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Abstract

Large Scale Traveling Ionospheric Disturbances (TIDs) are propagating variations in ionospheric electron densities that affect radio communications. LSTIDs create concavities in the ionospheric electron density profile that move horizontally with the LSTID and cause skip-distance focusing effects for high frequency (HF, 3-30 MHz) radio signals propagating through the ionosphere. This phenomena manifests as quasi-periodic variations in contact ranges in HF amateur radio communications recorded by automated monitoring systems such as RBN and WSPRNet. In this study, members of the Ham Radio Science Citizen Investigation (HamSCI) present a climatology of LSTID activity as well as using RBN and WSPRNet observations on the 1.8, 3.5, 7, 14, 21, and 28 MHz amateur radio bands from 2017. Results will be organized as a function observation frequency, longitudinal sector, season, and geomagnetic activity level. Connections to neutral atmospheric sources are also explored.

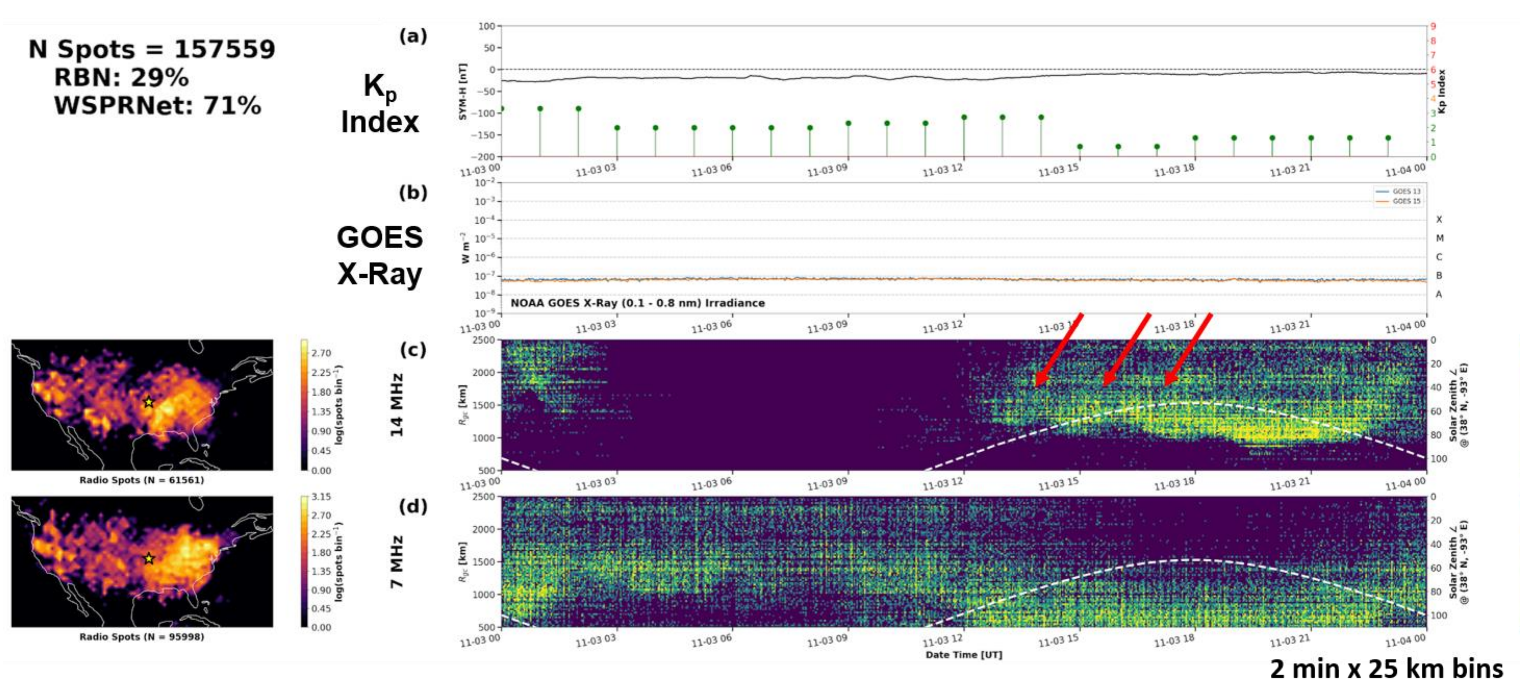
Introduction

In this study, we are searching for TID sources by analyzing observations from distributed passive radio receiver networks and amateur ham radio transmissions. We begin by comparing clear potential TID events observed by WSPRNet and RBN with observations of similiar TID events from the Super Dual Auroral Radar Network (SuperDARN), Global Navigation Satellite Systems (GNSS), and the Boulder Ionosonde. We determine TID parameters visually finding quasi-periodic variations in the minimum HF signal distance within WSPRNet and RBN ham radio observations. This is then applied to statistical study of TIDs observed by ham radio data from 1 January 2017 to 31 December 2017. Seasonal dependencies are identified in the observed TIDs.

Data and Methodology

WSPRNet and RBN are automated communication observation networks that are voluntarily operated by amateur radio operators that can monitor and log radio signals. Each datum ("spot") includes information on the transmitter, receiver, time, and frequency. Using data from these networks, two dimensional histograms were created that show:

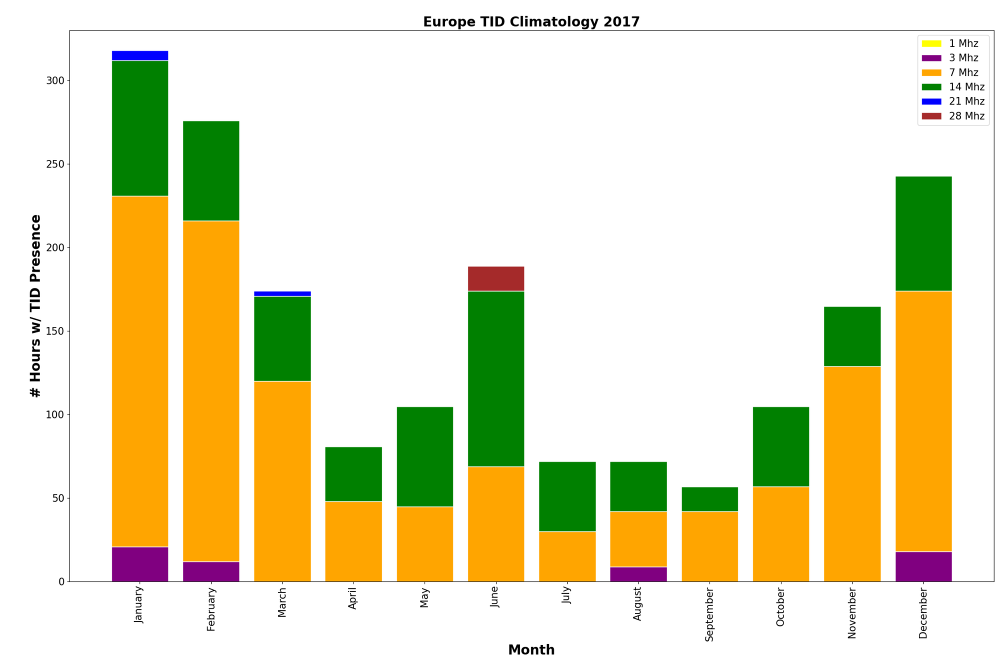
- Density of spots (from RBN and WSPRNet) per distance (between transmitter and receiver) over a 24 hour period.
- Geomagnetic activity from NASA MNIWeb (SYM-H and Kp Index) • Solar activity from GOES satellites.
- Maps of selected geographic location showing midpoint location of the spot data.

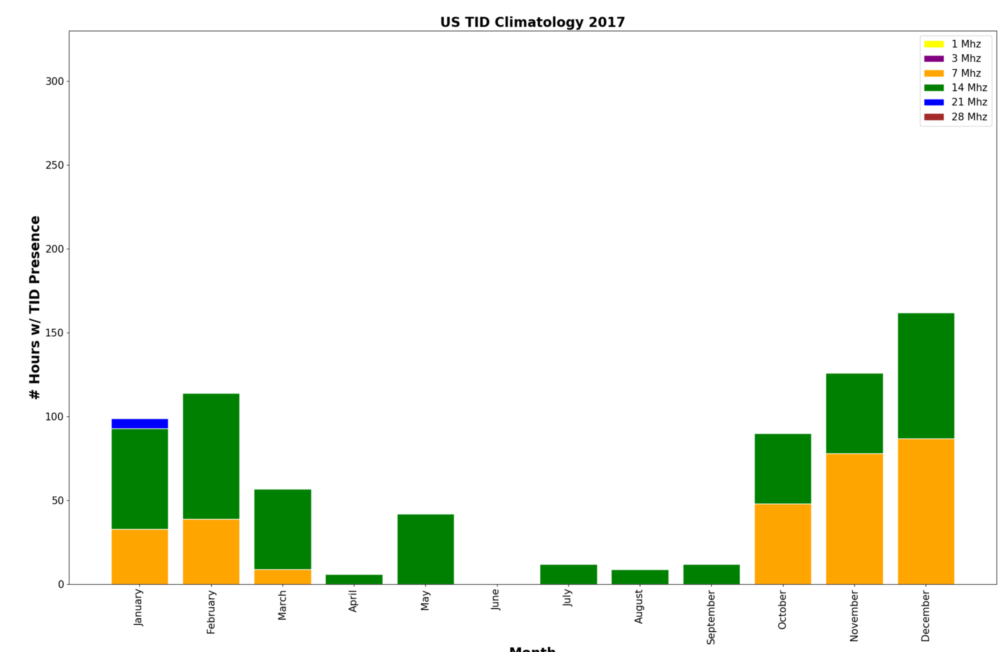


- As the ionosphere becomes perturbed by a passing TID, the amount of refraction an HF signal experiences changes which results in a perceived fading in HF propagation.

Climatology

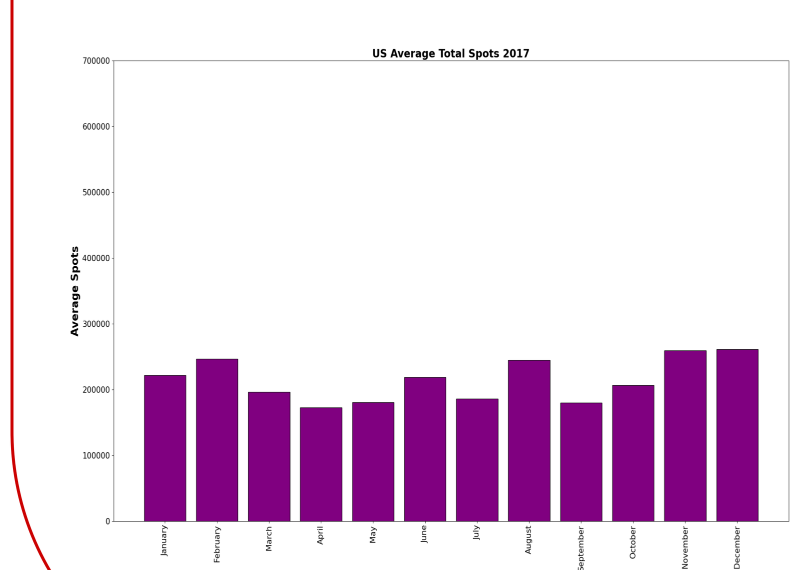
Daily ham radio WSPRNet and RBN plots were generated for the year 2017, for both Europe and the US, and were then searched manually for TID signatures.

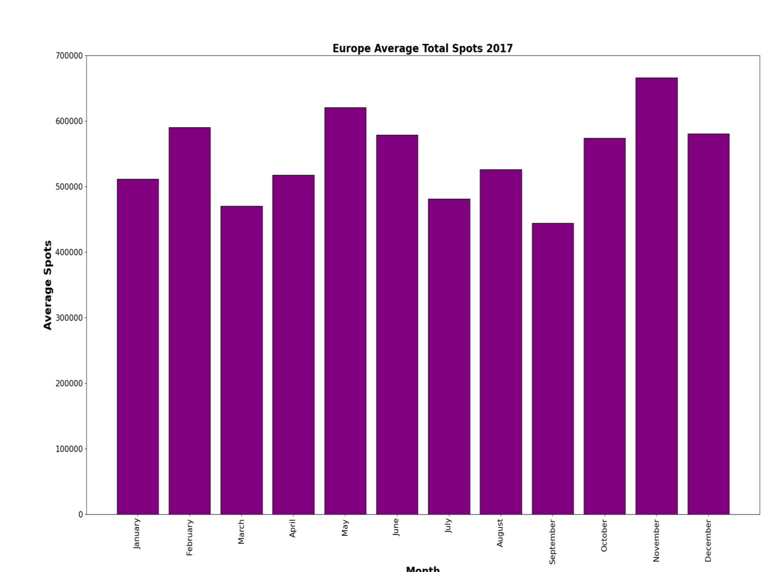




- TID activity was much more prominent in the late fall and early spring.
- Fewer observations were made in the summer months in general, except for June in Europe and May in the US.
- Results consistent with Frissell et al. (2014, 2016)

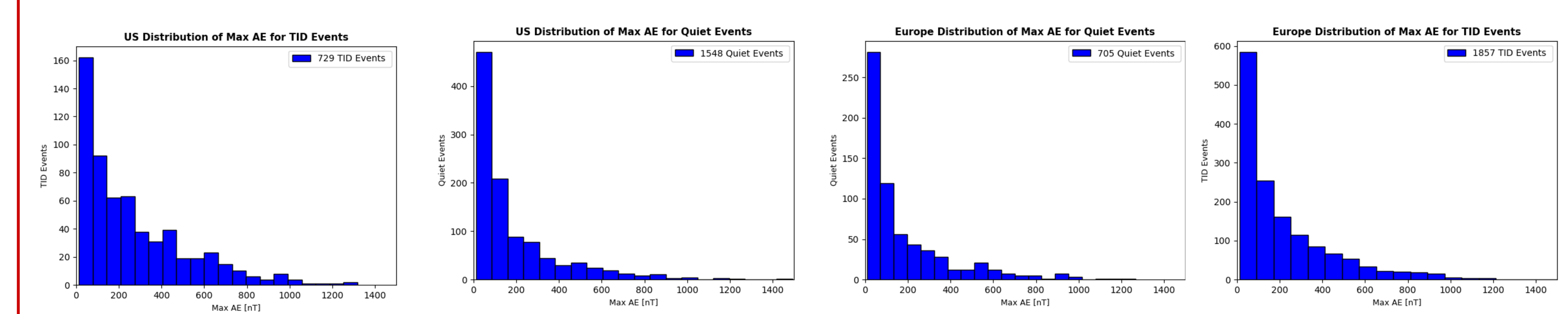
- Due to the nature of the data, it was especially important to rule out the possibility of lower spot densities resulting from diminished overall ham radio usage during different season. Average monthly spot numbers were calculated to determine if there was a pattern of varying ham radio usage over the course of the year.



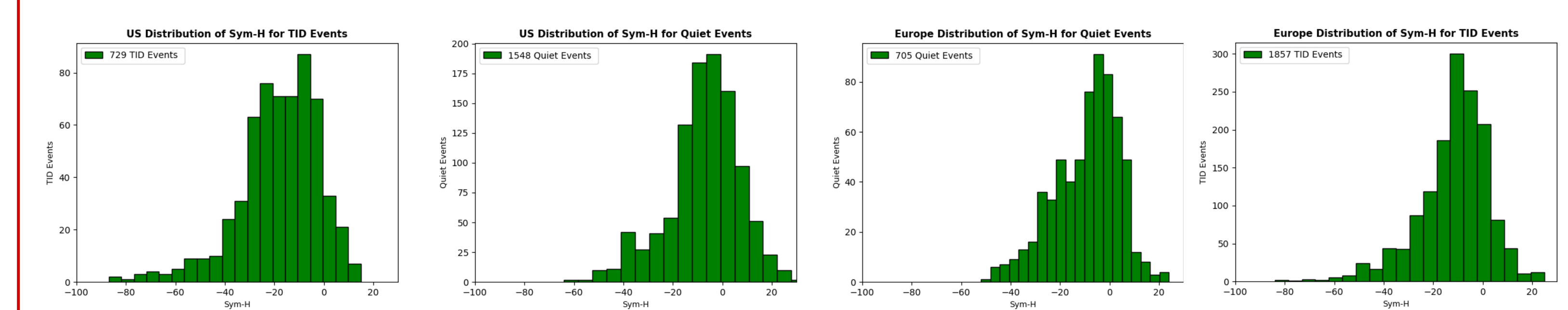


Geospace and Neutral Atmospheric Sources

Using the same data from the yearly distribution and NASA Omni data, we found the average hourly max AE and SYM-H values for each TID event. To contrast this, I also found the AE and SYM-H values for hours that were very clearly quiet. These results show slightly higher max AE values for TID events.



SYM-H values appear to be lower during potential TID events.



Summary and Conclusions

- RBN and WSPRNet can serve as a tool for monitoring LSTIDs day and night.
  - LSTIDs are detectable in RBN and WSPRNet observations when data is binned into 2D histograms with 2 min x 25 km bins over the United States and Europe.
  - LSTIDs affect available ham radio communication path lengths.
- Fewer night observation capabilities using 14 MHz.
- TID activity more prominent starting in late fall and ending in early spring.
- Ham radio traffic not noticeably influenced by season.
- Exact mechanism is uncertain, currently looking at auroral and geomagnetic sources. Initial observations show:
  - Slightly enhanced max AE [nT] for times with TID events.
  - Higher number of TID events falling around a SYM-H value of -20.

Future Work

- Develop Automated detection system for TID signatures within Ham radio data.

References and Acknowledgments

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