Climatology of Traveling Ionospheric Disturbances Observed by HamSCI Amateur Radio with Connections to Geospace and Neutral Atmospheric Sources

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Traveling Ionospheric Disturbances

- **TIDs are Quasi-periodic Variations of F Region Electron Density**
- **Medium Scale (MSTID)**
  - $T \approx 15 - 60$ min
  - $v_H \approx 100 - 250$ m/s
  - $\lambda_H \approx$ Several Hundred km (< 1000 km)
  - Often Meteorological Sources
- **Large Scale (LSTID)**
  - $\lambda_h > 1000$ km
  - $30 < T$ [min] <180
  - Often Auroral Electrojet Enhancement, Particle Precipitation
- **Often associated with Atmospheric Gravity Waves**

[*Francis*, 1975; *Hunsucker* 1982; Ogawa et al., 1967; *Ding* et al., 2012; *Frissell et al.*, 2014; 2016]

Data Sources

- **Ham Radio**
  - Reverse Beacon Network
  - Weak Signal Propagation Reporting Network (WSPRNet)
- **SuperDARN**
- **NASA OMNI Data**
- **MERRA-2**

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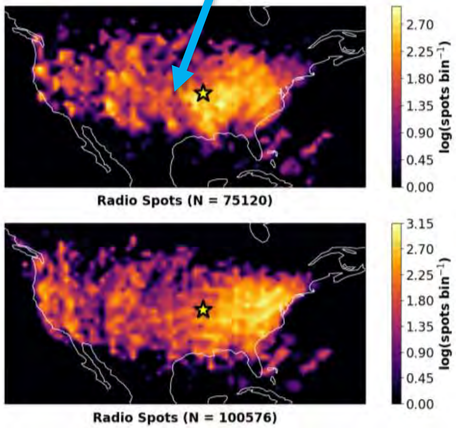
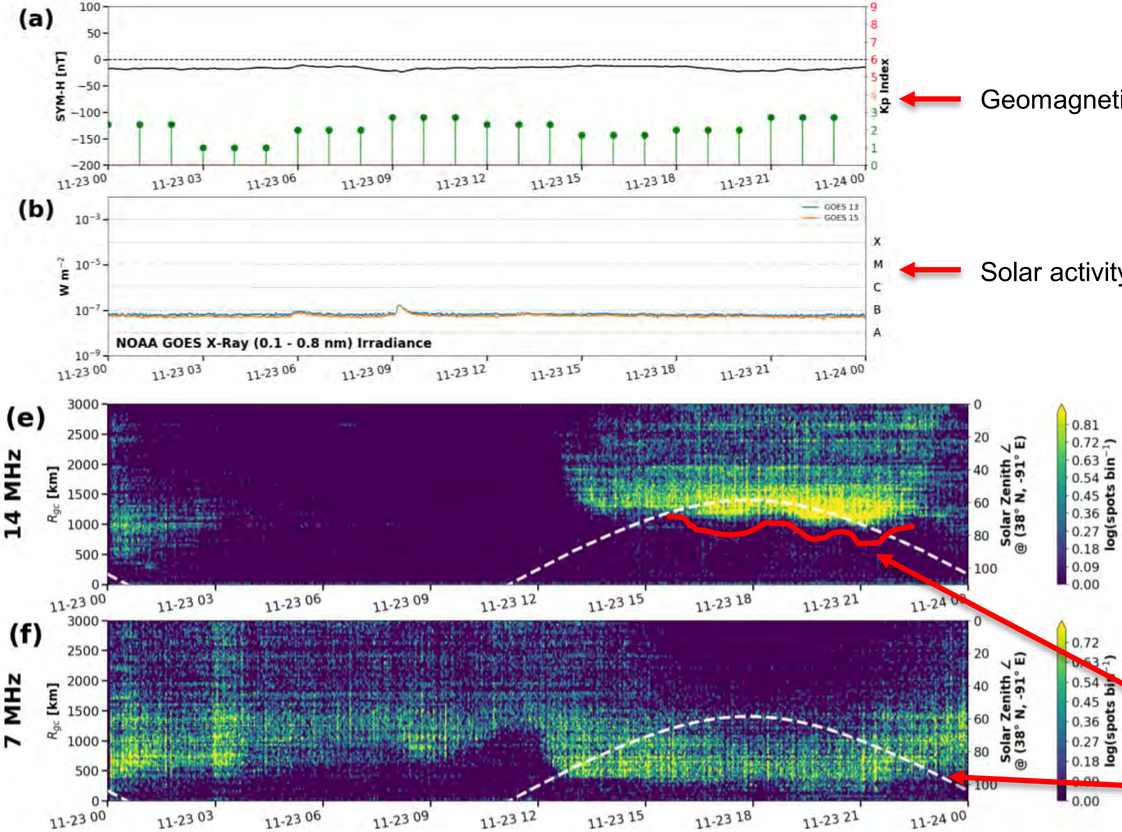
Ham Radio TIDs

23 Nov 2017-
24 Nov 2017
Ham Radio Networks
N Spots = 209145
RBN: 38%
WSPRNet: 62%

Date, number of spot data, and percentage of data source.

Location of the spot datums





Geomagnetic storm indices

Solar activity from GOES satellites

Ham radio spot data organized by propagation distance and time of day.

Quasi periodic wave TID structure.

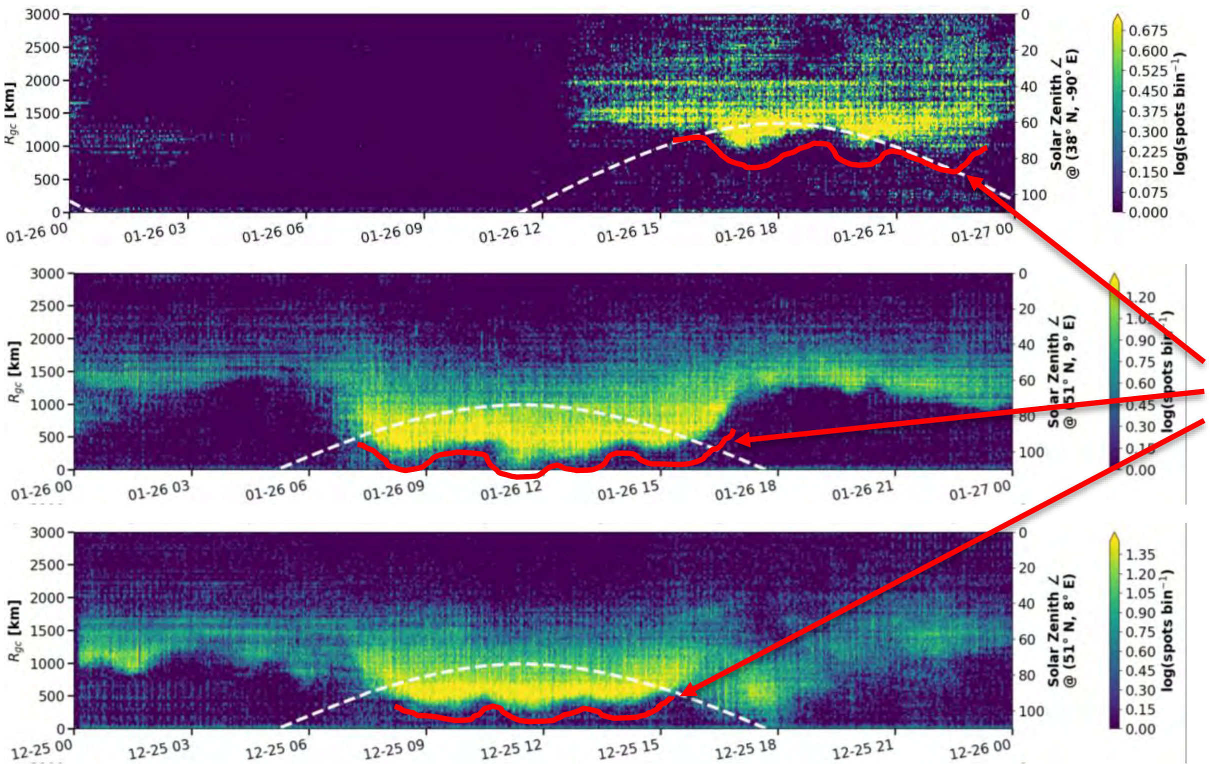
White dotted line: Solar Zenith.

TID Events

- 26 January 2017
- US
- 14 MHz

- 26 January 2017
- Europe
- 7 MHz

- 25 December 2017
- Europe
- 7 MHz



Well defined quasi periodic wave structures

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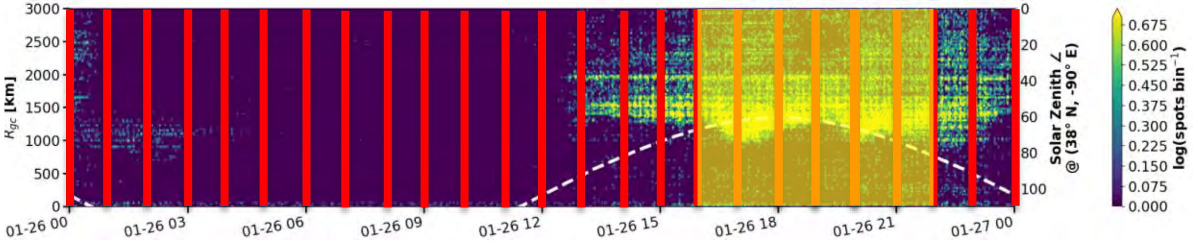
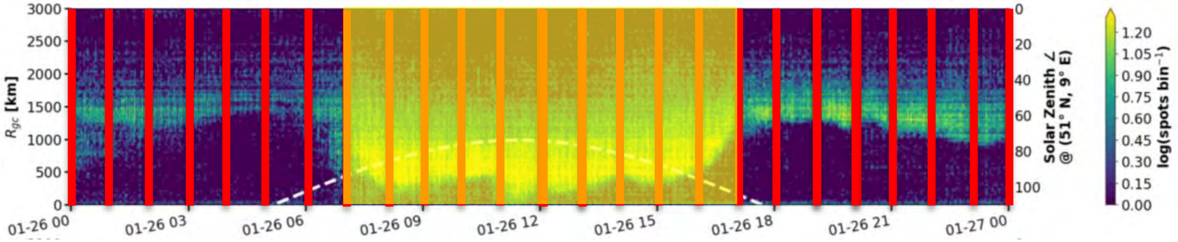
TID Events

- 26 January 2017
- US
- 14 MHz

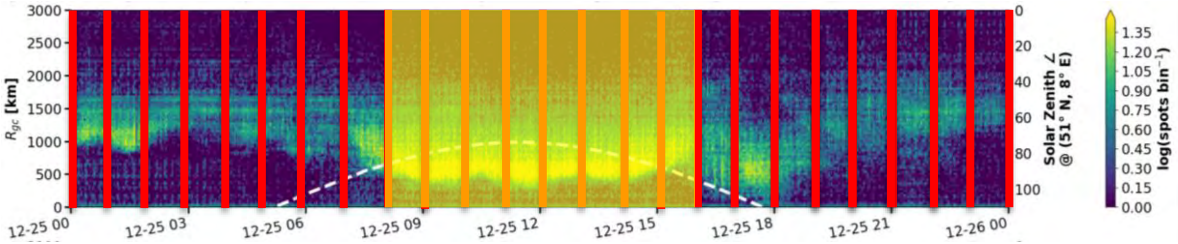


- 26 January 2017
- Europe
- 7 MHz



Highlighted yellow area: selected 1 hour time bins with noticeable potential TID activity.

- 25 December 2017
- Europe
- 7 MHz



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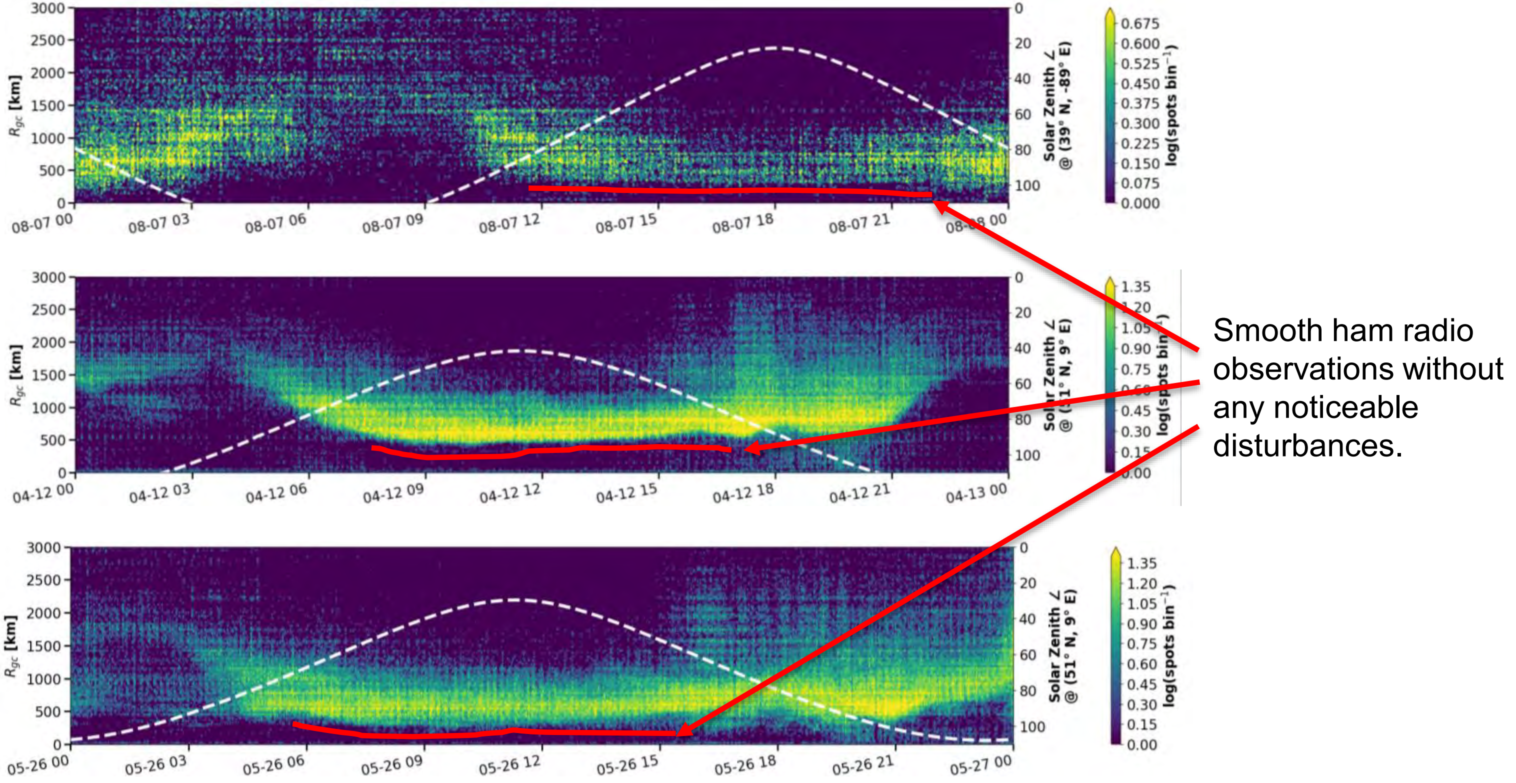
Quiet Events

- 07 August 2017
- US
- 7 MHz

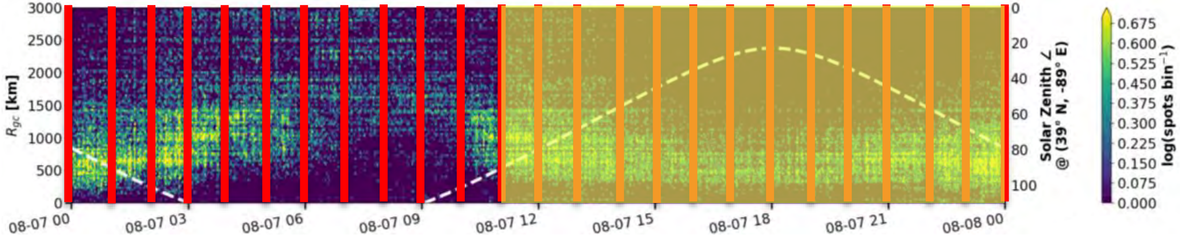
- 12 April 2017
- Europe
- 7 MHz

- 26 May 2017
- Europe
- 7 MHz

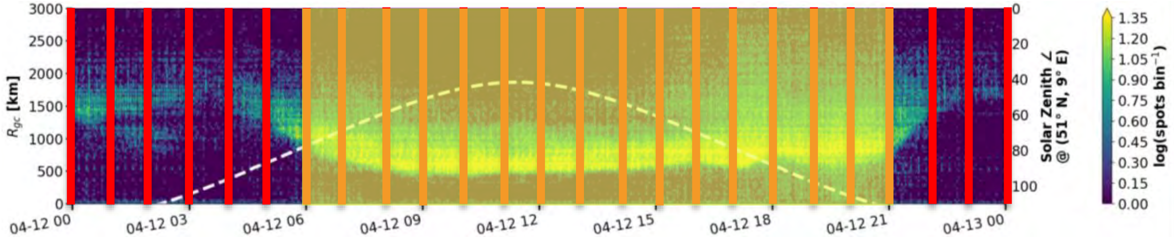


Quiet Events

- 07 August 2017
- US
- 7 MHz

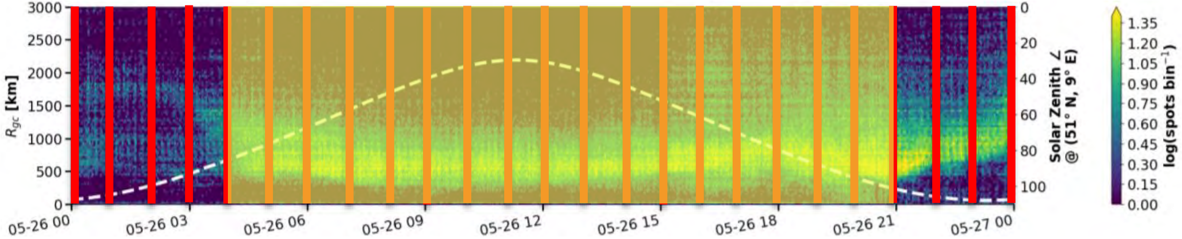


- 12 April 2017
- Europe
- 7 MHz



Highlighted yellow area: selected 1 hour time bins with noticeably smooth ham radio observations.

- 26 May 2017
- Europe
- 7 MHz



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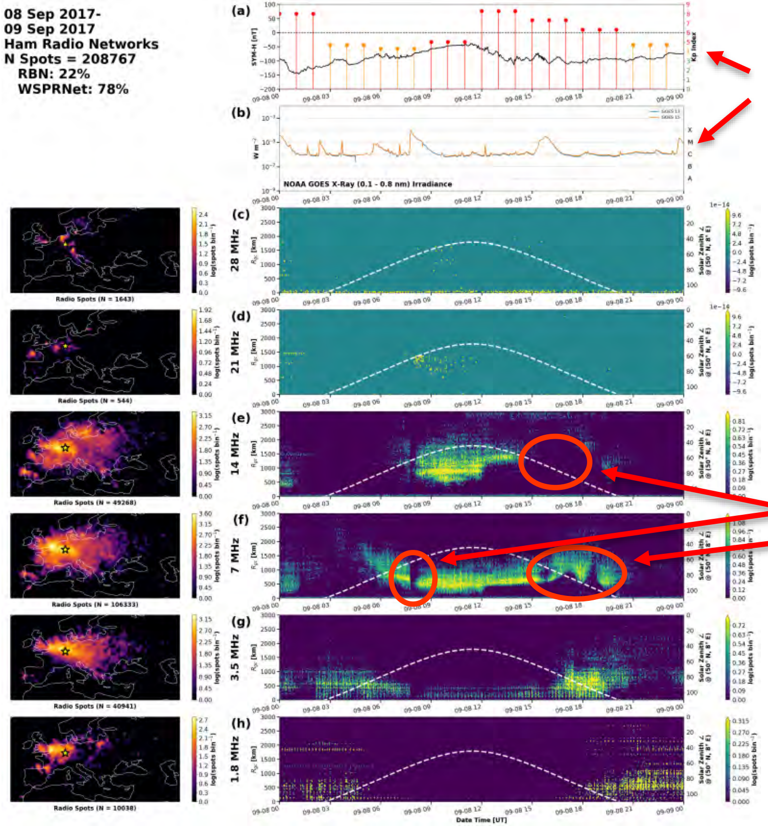
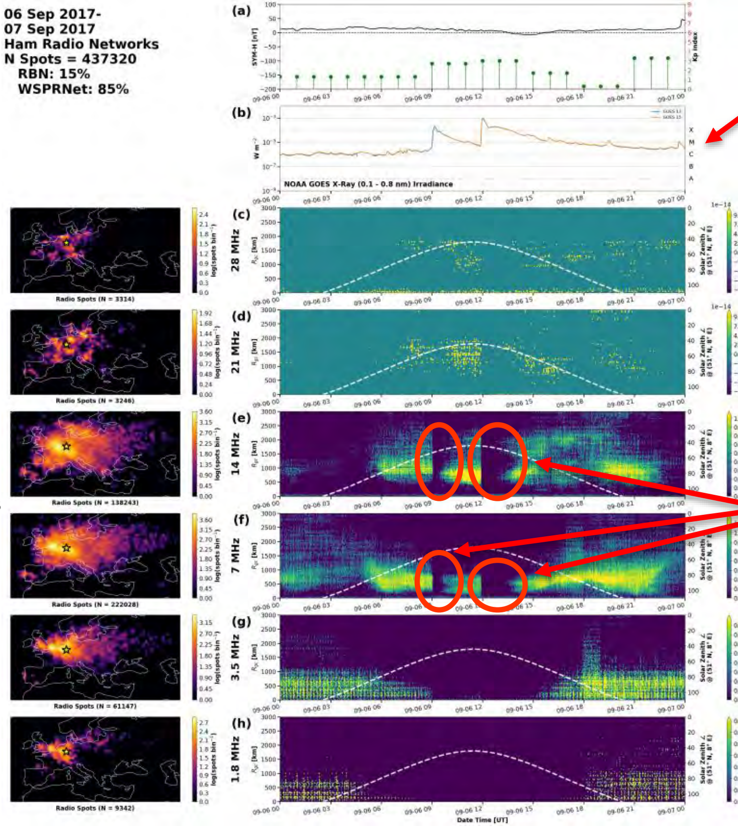
Examples of events not included



Significant geomagnetic storm and solar activity

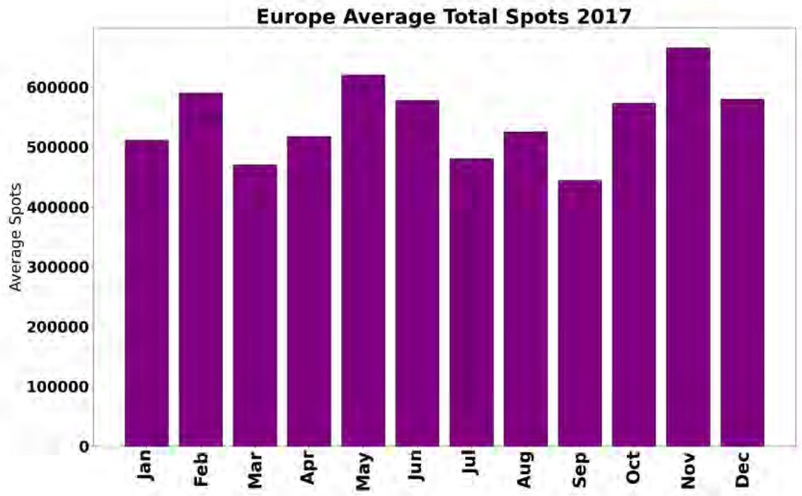
Radio blackouts and disturbances likely caused by the geomagnetic storm and solar activity.

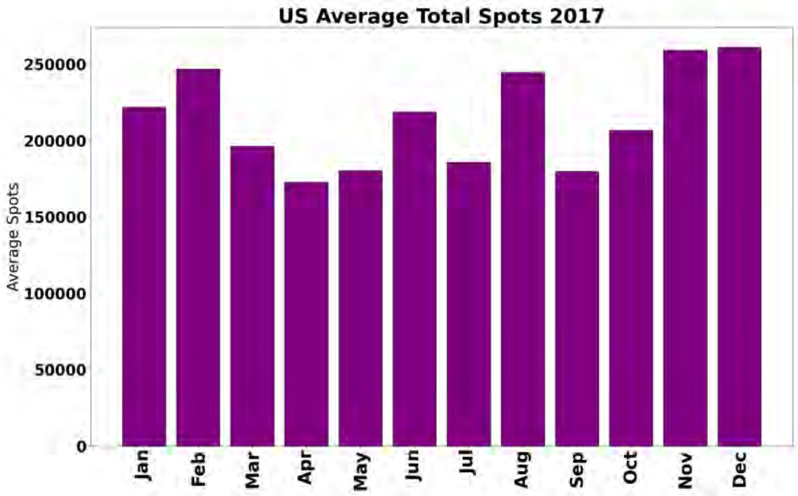


Significant solar activity (solar flares)

Radio blackouts and disturbances likely caused by solar flares.

Total Spot Activity





Daily average number of total spots in Europe and the US for the year 2017.

- Relative consistency in the number of spots.
- No noticeable decrease in ham radio activity in the summer months.

Europe TID Climatology

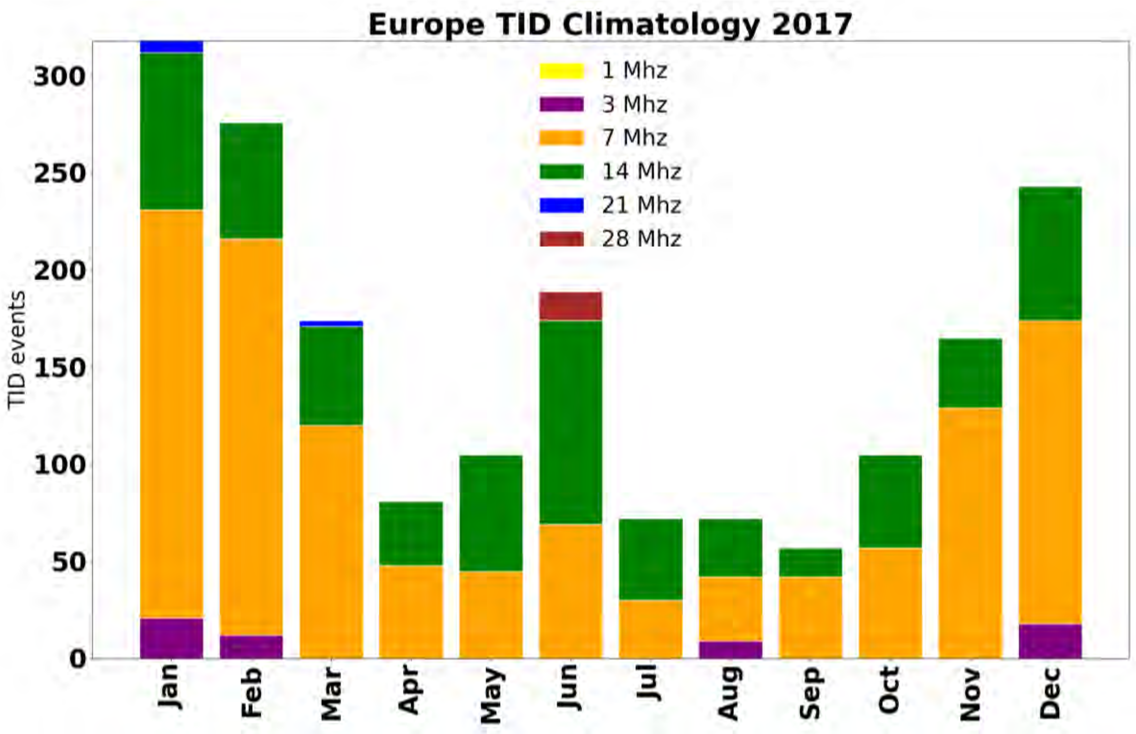


Figure showing the total number of hours with TID activity by month observed within daily ham radio observation plots.

TID event = 1 hour with observable TID signature

US TID Climatology

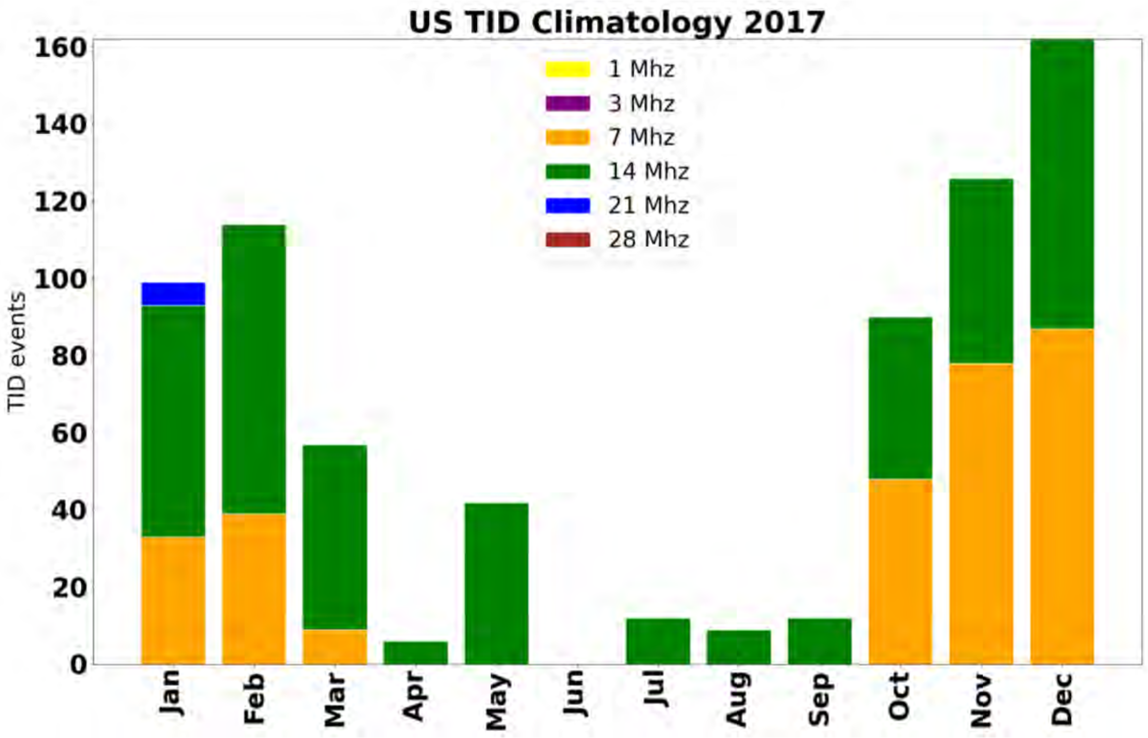
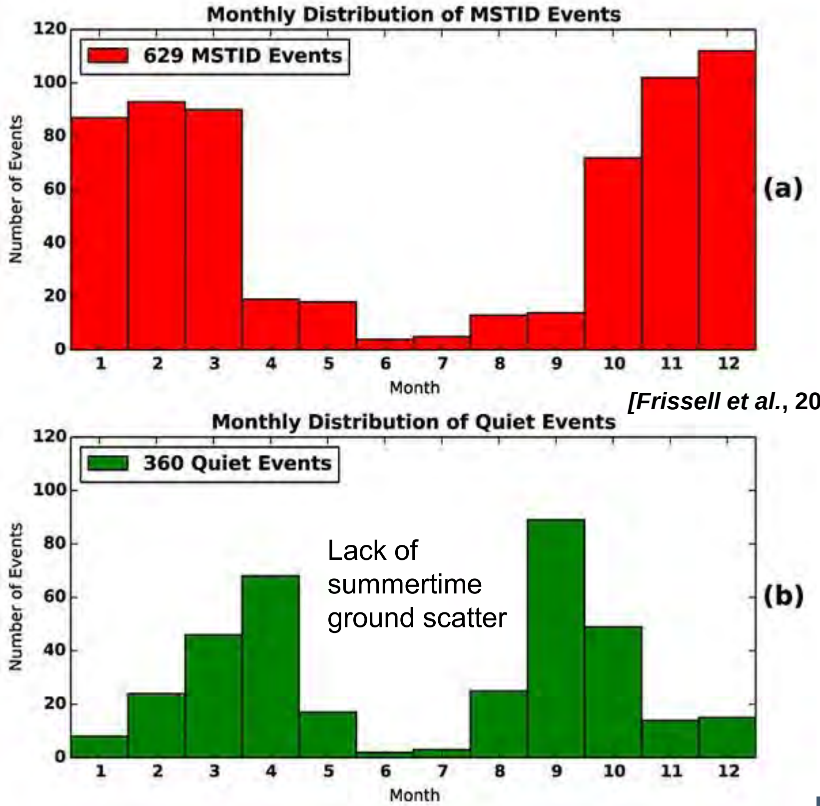


Figure showing the total number of hours with TID activity by month observed within daily ham radio observation plots.

TID event = 1 hour with observable TID signature

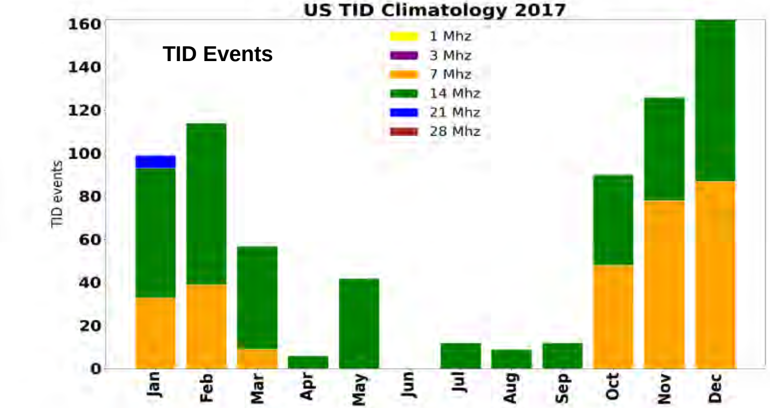
SuperDARN Climatology Comparison

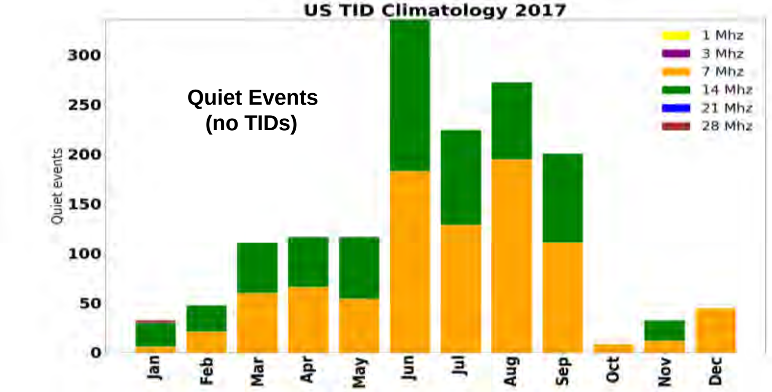
SuperDARN



[Frissell et al., 2014]

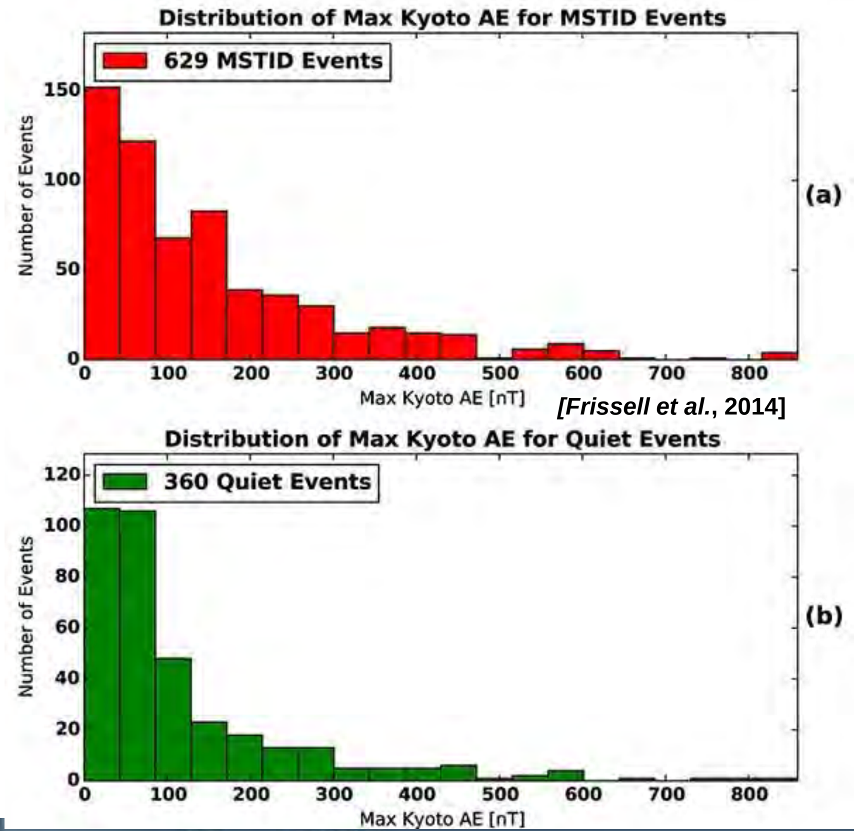
Amateur Ham Radio



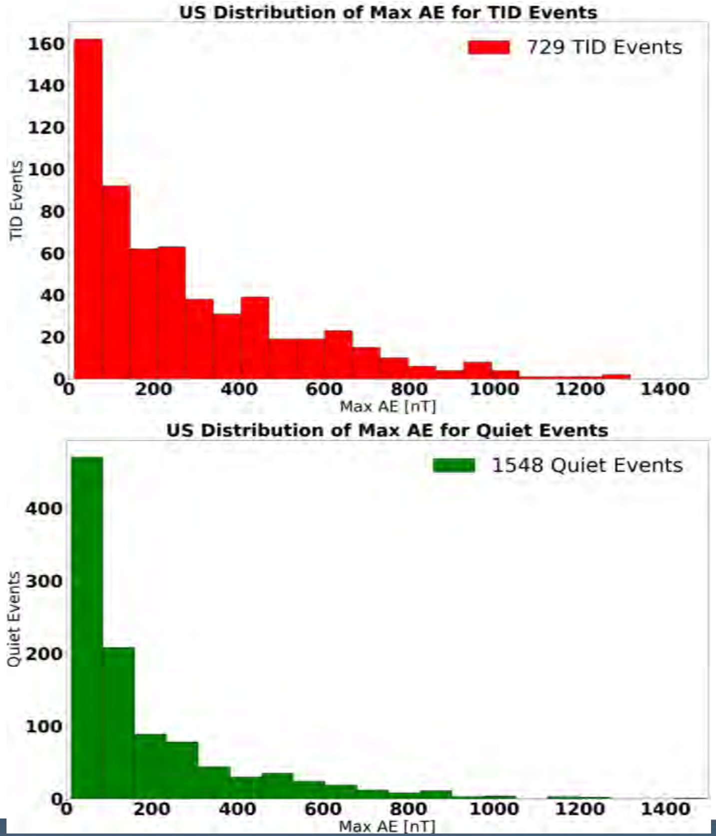


SuperDARN Max AE Comparison

SuperDARN



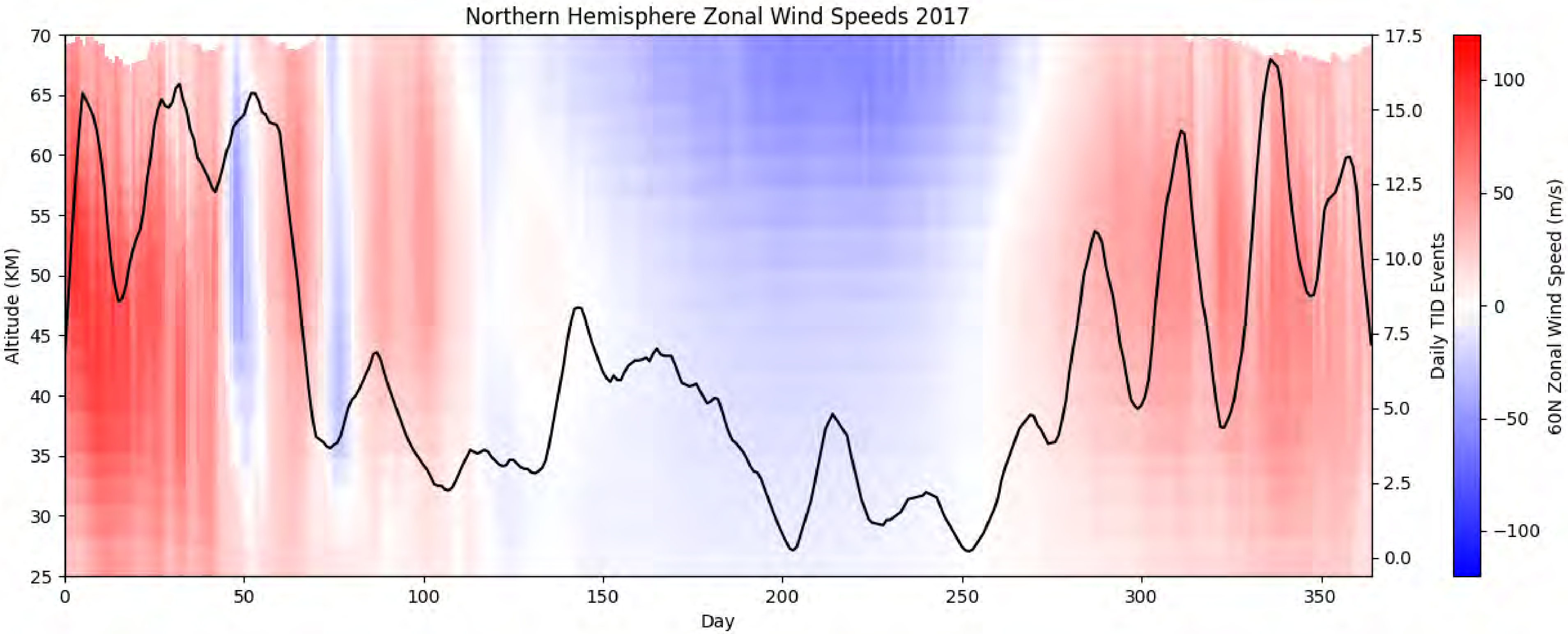
Amateur Ham Radio



Enhanced Max AE values for TID events

Lower Max AE values for quiet events

MERRA-2 60N Zonal Wind Speed Data



Conclusions and Future Work

- 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.
  - Large wind shifts appear to coincide with noticeable drops in TID activity.
  - Little to no TID activity when the 60N zonal winds are predominantly eastward.
- Develop Automated detection system for TID signatures within Ham radio data.

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Acknowledgments

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