Antarctic SuperDARN Observations of Medium Scale Traveling Ionospheric Disturbances

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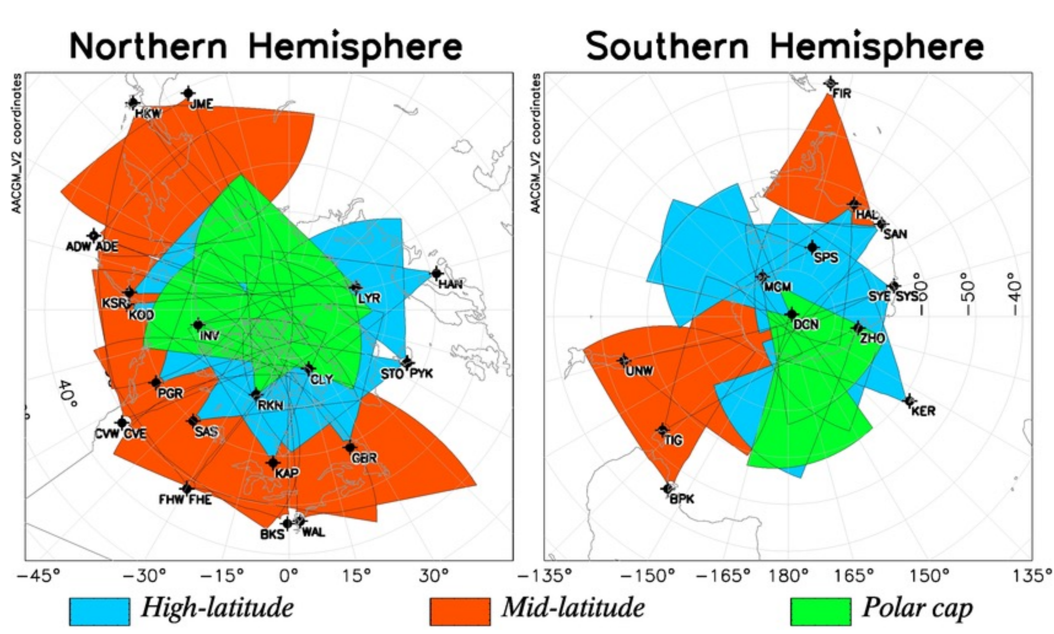
Introduction

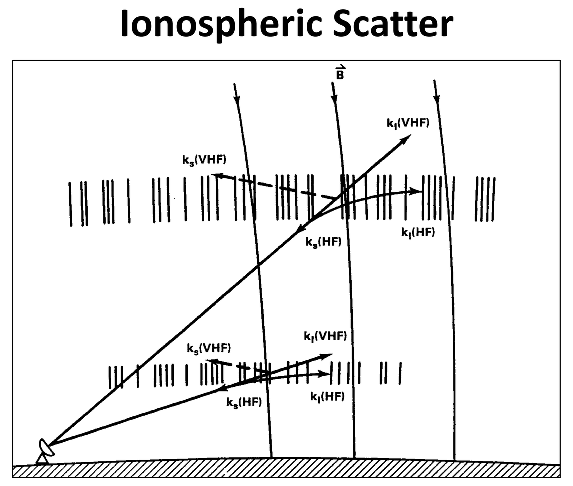
- Medium Scale Traveling Ionospheric Disturbances (MSTIDs) are quasi-periodic variations of the F-region ionosphere often associated with atmospheric gravity waves (AGWs) with periods of 15 to 60 minutes, horizontal velocities between 100 and 250 m/s, and horizontal wavelengths of a few hundred kilometers (Ogawa et al., 1987)
- Statistical studies of MSTIDs using Super Dual Auroral Radar Network (SuperDARN) radars in the Northern Hemisphere have shown strong correlation with Polar Vortex activity (Frissell et al., 2016), while a study of MSTIDs using the south hemisphere Falkland Islands SuperDARN radar showed populations of MSTIDs with signatures suggestive of both solar wind-magnetosphere coupling sources and lower neutral atmospheric winds sources (Grocott et al., 2013).
- The sources of the MSTIDs are still not well understood, and there are limited studies of MSTIDs using SuperDARN radars in the Southern Hemisphere.
- **We conducted a study looking for signatures of MSTID observations using the SuperDARN radar at McMurdo Station, but found that most McMurdo TID-like signatures are in fact due to Polar Cap Patches.**

SuperDARN

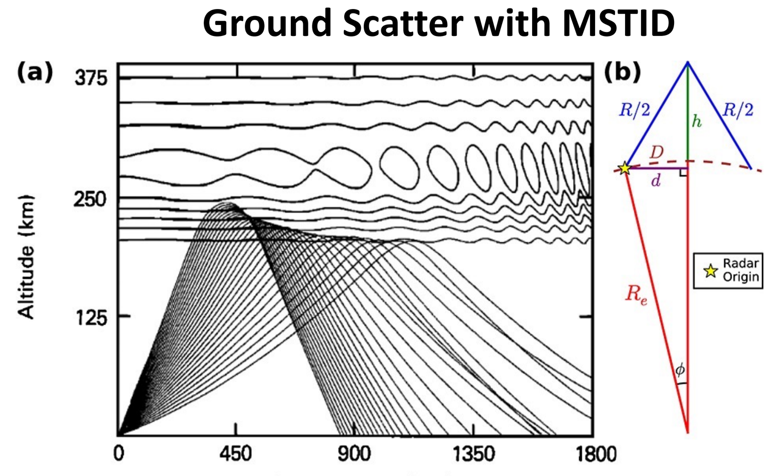
- SuperDARN is a network of high frequency (HF) radars located in both the Northern and Southern hemisphere for studying both mid- and high-latitude ionospheric dynamics (Nishitani et al., 2019; Greenwald et al., 1995).



- SuperDARN backscatter is classified as ionospheric (e.g. half-hop) and ground (e.g. single-hop) scatter.
- SuperDARN MSTIDs are typically seen in ground scatter due to the focusing and de-focusing of rays by the MSTID.
- Ionospheric scatter is presented using the slant range, while ground scatter is mapped to the ionospheric reflection point using the formula $D \approx R_e \sin^{-1}\left[\frac{\sqrt{R^2/(4-h^2)}}{R_e}\right]$ (Bristow et al., 1994).



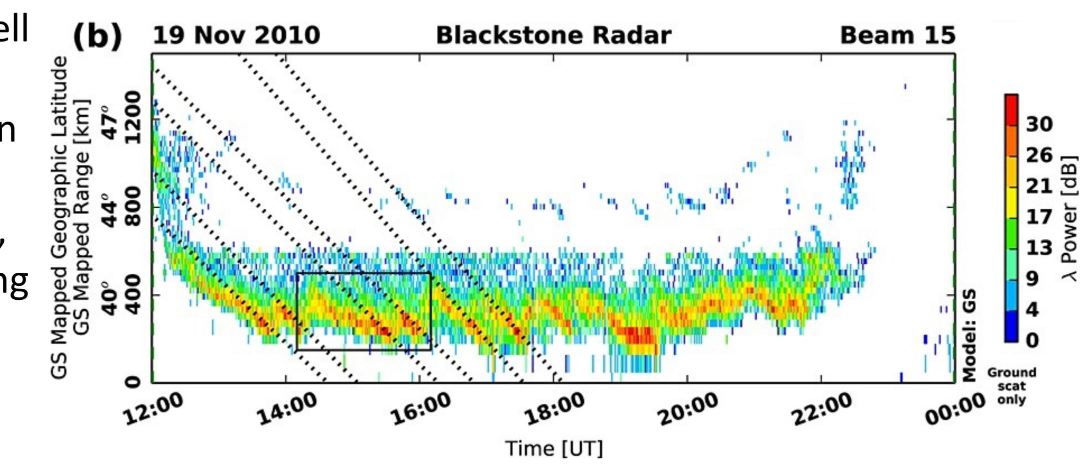
From Greenwald et al. (1995)



From Samson et al. (1990) and Frissell et al. (2014)

MSTID Signatures

- MSTID signatures can be observed in ground scatter power range-time-parameter (RTP) plots along single beams of the SuperDARN radars.
- In this figure from Frissell et al. (2014), MSTIDs with a period of ~32 min can be see moving towards the Blackstone, Virginia (BKS) radar along Beam 15 with a line-of-sight (LOS) velocity of ~88 m/s.



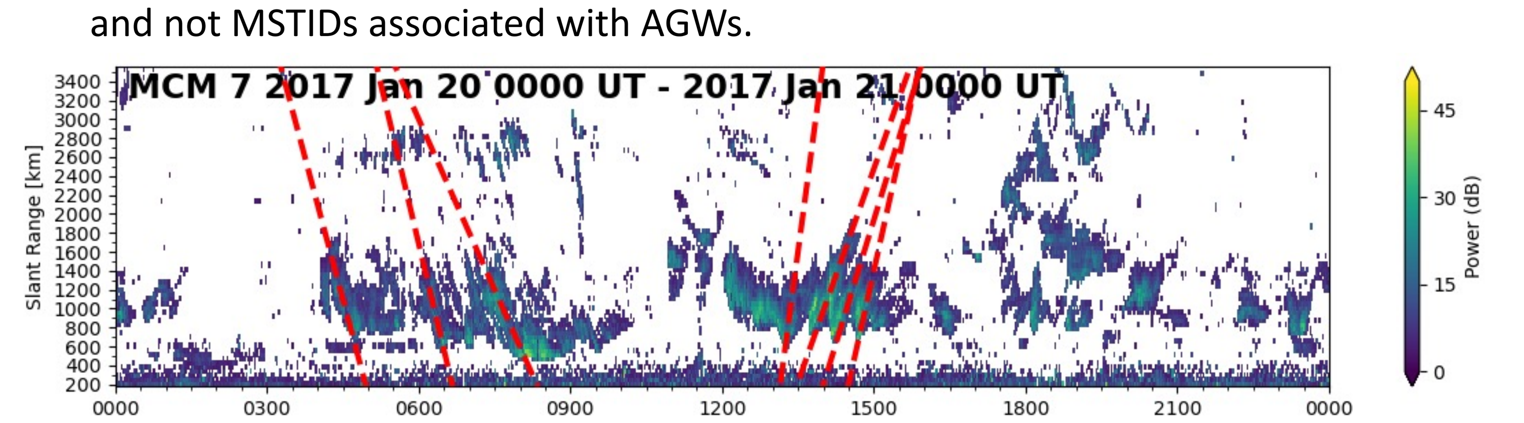
McMurdo Station Observations

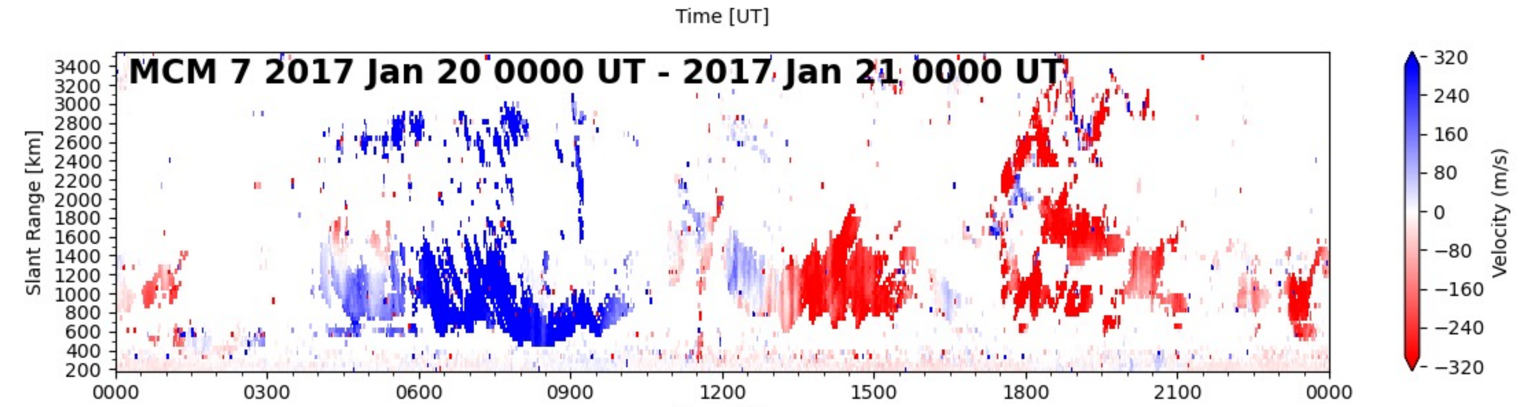
- To start looking for MSTIDs in Antarctica, we examined power and velocity RTP plots along Beam 7 of the McMurdo (MCM) station SuperDARN radar for every day in 2017.
- We learned that compared to BKS, MCM observes very little ground scatter. This is due to the fact that the MCM field-of-view (FOV) is primarily over ice, which provides less backscatter than the ground.

2017 Ground Scatter Statistics

Radar	N Ground Scatter	N All Scatter	% Ground Scatter
BKS	7.8 x 10^7	10.9 x 10^7	71.6%
MCM	7.2 x 10^6	58.5 x 10^6	12%

- Although significant ground scatter was not observed, we did observe signatures in the ionospheric scatter that looked similar to MSTIDs.
- More careful analysis, however, suggest that these are polar cap patch signatures and not MSTIDs associated with AGWs.





- The figure above is representative of the polar cap patches observed with MCM.
- The change of the direction from towards the radar (before 1200 UT) to away from the radar (after 1200 UT) as the radar rotates under the polar cap along with the high disturbance velocities are consistent with polar cap patch signatures (e.g., Bristow et al., 2011).
- Out of the 13 days that we examined the average velocity of the polar cap patches was 562 m/s and the STD is 358 m/s.

Summary

- We investigated a year's worth of McMurdo Station SuperDARN (MCM) Observations from 2017 searching for atmospheric gravity wave (AGW)-associated medium scale traveling ionospheric disturbances (MSTIDs).
- MCM observes very little ground scatter due to its FOV looking out over the Ice.
- TID-like signatures were observed in the ionospheric scatter.
- Analysis of the TID-like signatures revealed high velocities and a change of direction consistent with a radar rotating under features moving in the anti-sunward direction.
- These signatures are more consistent with polar cap patches (PCPs) than AGW-associated MSTIDs.

Future Work

- Our goal is to characterize AGW-associated MSTIDs from the Antarctic continent, therefore we will search other SuperDARN radars for MSTID signatures.
- Future searches will be focused on radars with high ground scatter percentages.
- Once Antarctic MSTID activity is characterized, it will be compared with the Northern Hemisphere MSTID activity to search for hemispheric asymmetries in an effort to better understand MSTID sources.

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