SuperDARN MSTIDs and AIRS Gravity Waves in January 2016

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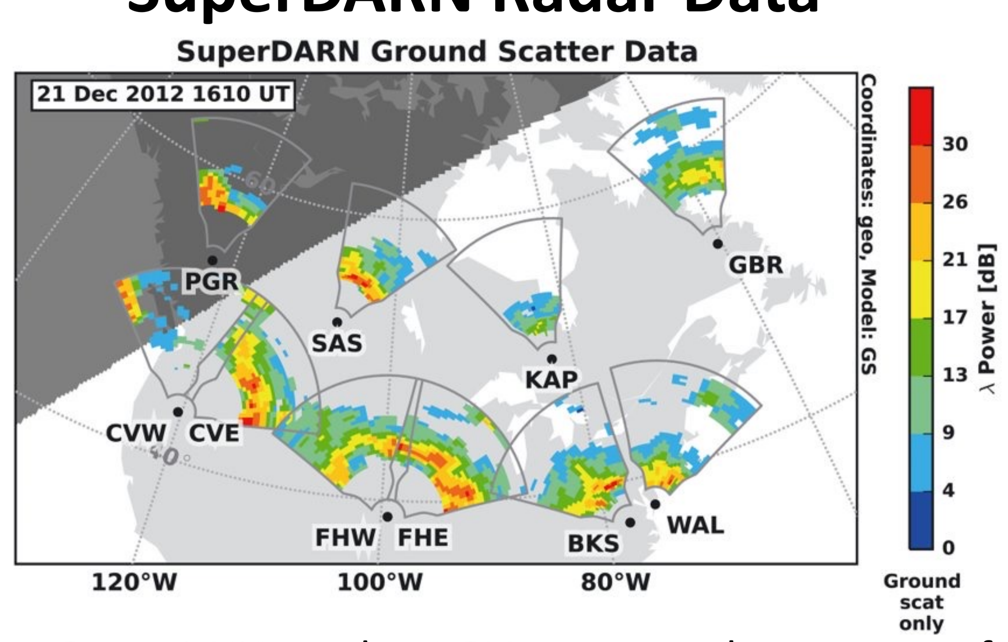
Introduction

Multiple Signal Classification (MUSIC) is a term used to describe theoretical and experimental techniques used to measure and determine parameters of various wavefronts arriving in a field of sensors. MUSIC was developed by *Schmidt (1986)* and first implemented for use in the Super Dual Auroral Radar Network by *Samson et al. (1990)* and *Bristow et al. (1994)*. The algorithm has been reimplemented by *Frissell et al. (2014, 2016)* to determine the presence of multiple, simultaneous medium-scale traveling ionospheric disturbances (MSTIDs) within the SuperDARN field of view. We present the MUSIC processing of SuperDARN observations over the North American continent for the period of 11-16 January 2016. A period of low MSTID activity is observed from 11-13 January followed by a period of elevated MSTID activity from 14-16 January. To explain these MSTID variations we analyze gravity wave (GW) observations from the Atmospheric Infrared Sounder (AIRS) and polar vortex behavior in MERRA-2. Higher order GWs are detected over the Atlantic from January 12-14 that may be the source of the MSTIDs on Jan 14-16. We show detailed analysis of MSTID activity from January 11-16 2016 with wavenumber plot comparisons and find possible connections between GWs and ionospheric perturbations.

SuperDARN Radar Data

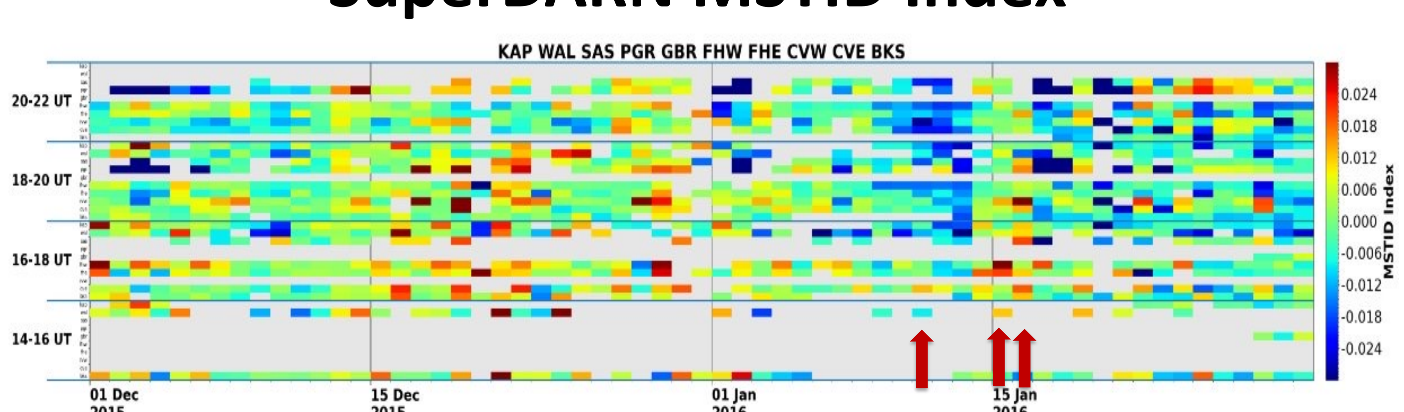
(1)



North American SuperDARN radar FOVs cover a large area of the continent. Incident wavefronts can be seen in the FOVs.

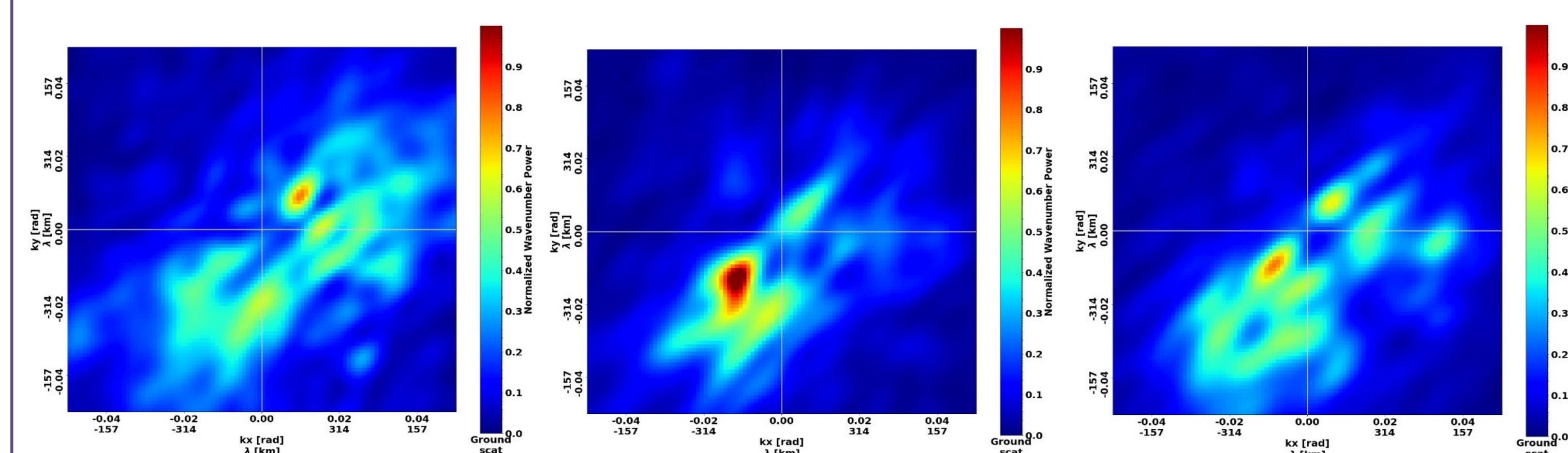
SuperDARN MSTID Index

(2)



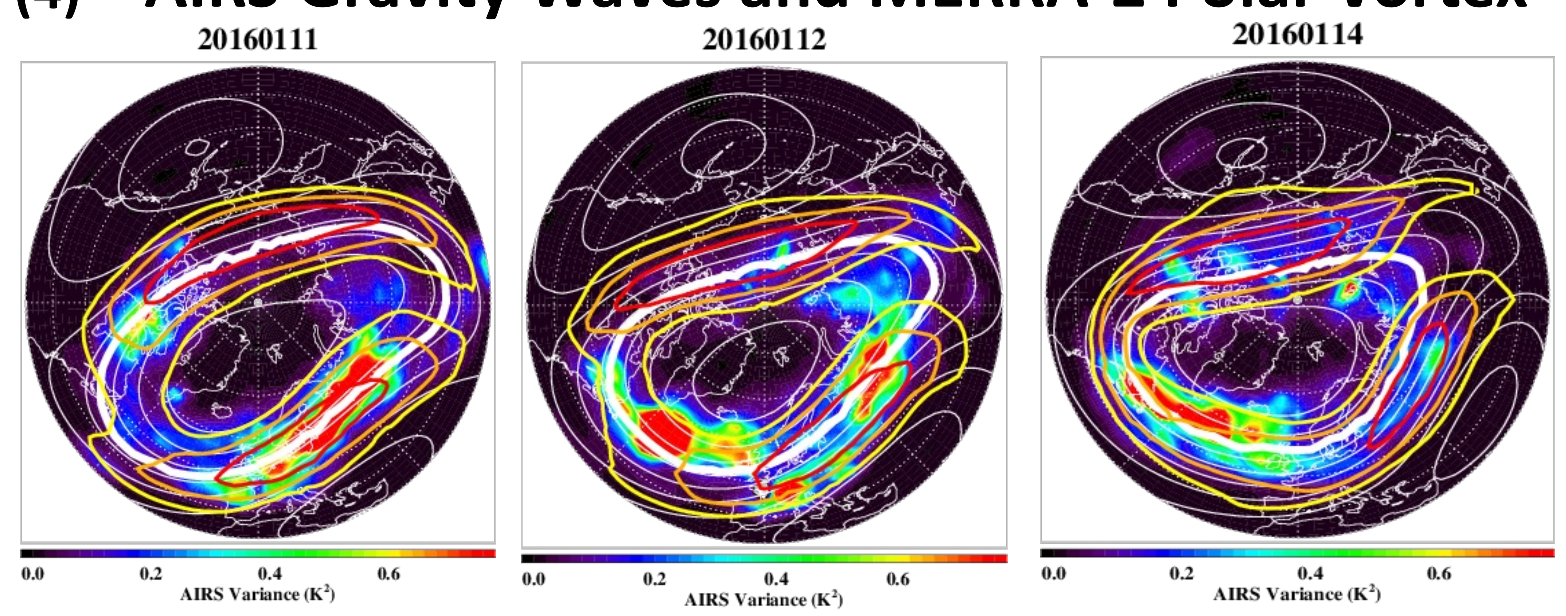
MSTID Index over the 2015-16 winter. (Indicator 1) on 11 Jan. shows the beginning of an MSTID quiet period until 14 Jan. when high MSTID activity begins. (Indicator 2) This activity lasts for three days until returning to relatively quiet conditions observed around 17 Jan. (Indicator 3) The sharp onset of increased TIDs in this period of days indicates an abrupt start of a TID generation due to the GW activity beginning days before.

(3) SuperDARN MSTID Analysis Fort Hays East January 11th, 15th, and 16th

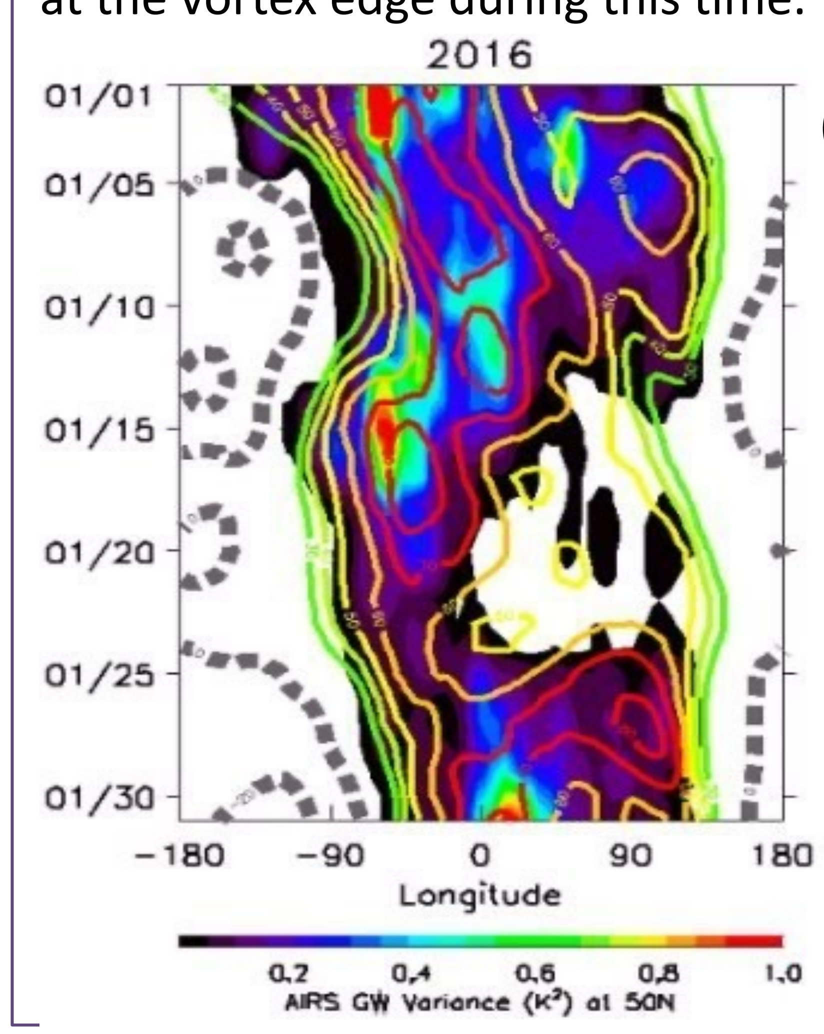


Low MSTID activity occurs on 11 Jan. On 15 and 16 Jan., MSTID propagation directions and wavelengths are displayed. The direction of propagation of observed signals is primarily southwestward.

(4) AIRS Gravity Waves and MERRA-2 Polar Vortex



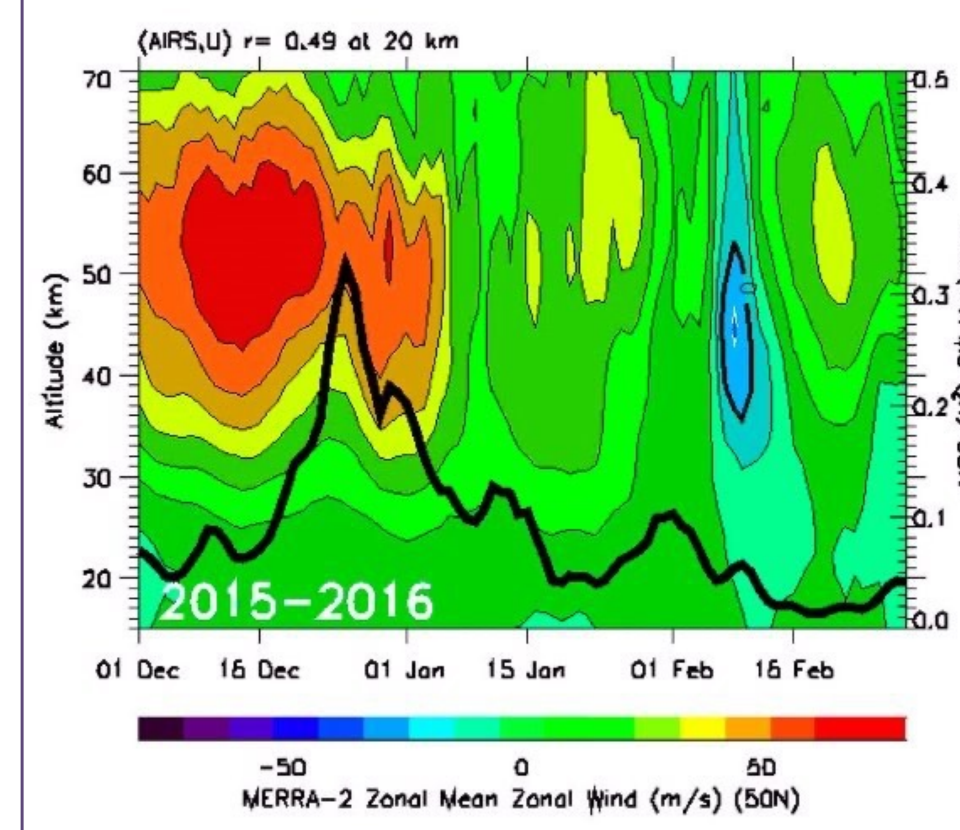
AIRS GW variance shows region of high wave activity moving westward from Europe on the 11th to the Atlantic on the 14th. Colored contour lines show wind speeds and the bold white contour is the edge of the polar vortex. *Vadas et al. (2024)* demonstrate GWs are generated by fast winds at the vortex edge during this time.



(5) AIRS Gravity Waves and MERRA-2 Winds

- GW variance (color fill) and MERRA-2 wind speed (color contours) as a function of longitude and time during January 2016.
- We focus on the GW hotspot on 15 Jan. near -50° longitude.
- GWs originating from this location may be the cause of the increase in observed TID index.
- The duration of high GW activity is comparable to the duration of MSTID enhancement.

(6) MERRA-2 Winds & AIRS Gravity Waves



- MERRA-2 zonal mean winds (colors) as a function of altitude and time during DJF 2015-2016. AIRS GW variance is the thick black contour. The winds and the GWs are both moderate during January 11-16.
- A small peak in GW variance occurs around 13 Jan. This may be the source of MSTID enhancement during the case study shown here.

Conclusions

- The observed period of low MSTID activity on Jan 11-13 followed by a period of higher MSTID activity on Jan 14-16 is attributed to atmospheric GW activity generated by the polar vortex.
- Ionospheric perturbations appear correlated to GW activity below.
- There is a delay between the observation of high GW activity and elevated MSTID observations of 2-6 (originally 3-5) days.

Future Work

Compute lagged correlations between SuperDARN MSTIDs and AIRS GW activity to study GW coupling to MSTIDs.

References

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[6] Vadas et al. (2024). **https://doi.org/10.1029/2024JA033040**

Acknowledgements

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