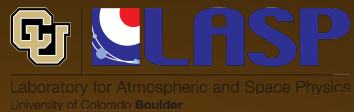


Plasma Wave Observations During Magnetic Storms with MMS



Student: Erin Radermacher (Kalamazoo College)
Mentors: Maria Usanova (LASP), Narges Ahmadi (LASP)

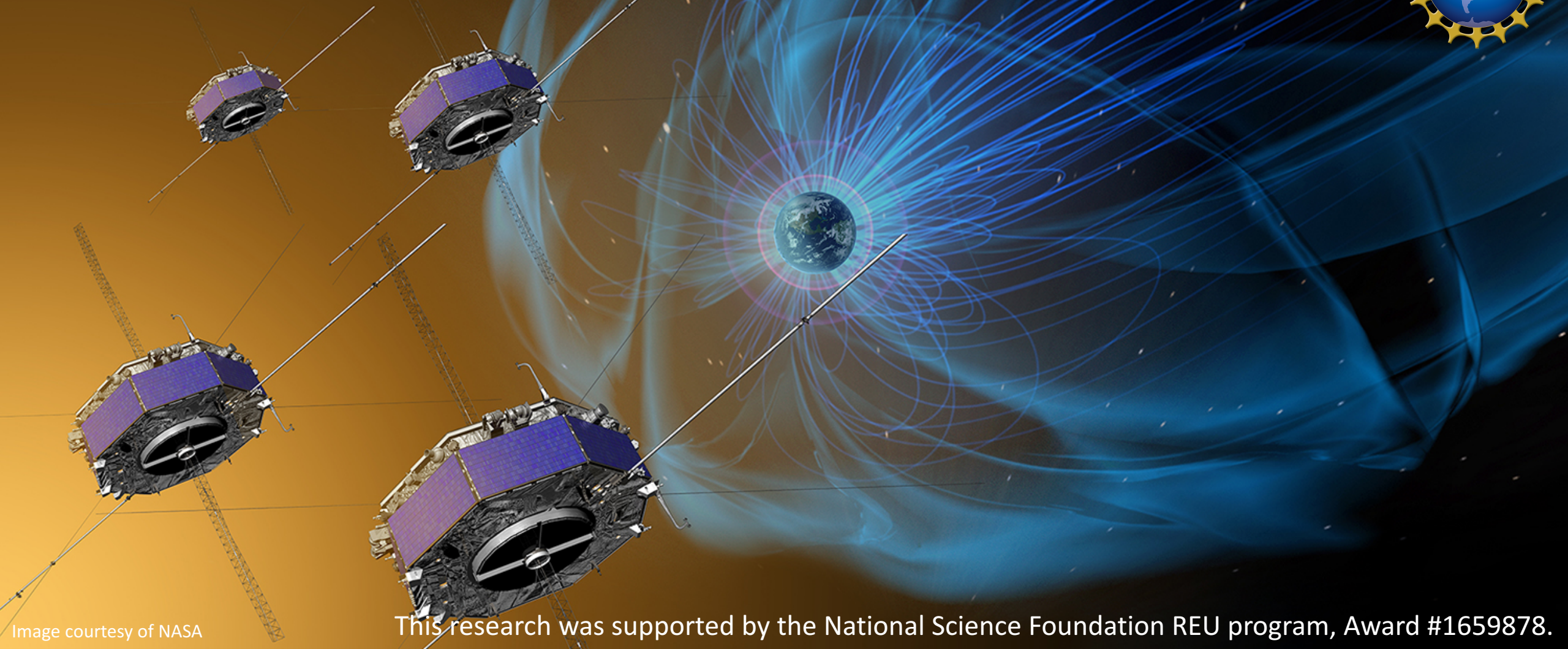


Image courtesy of NASA

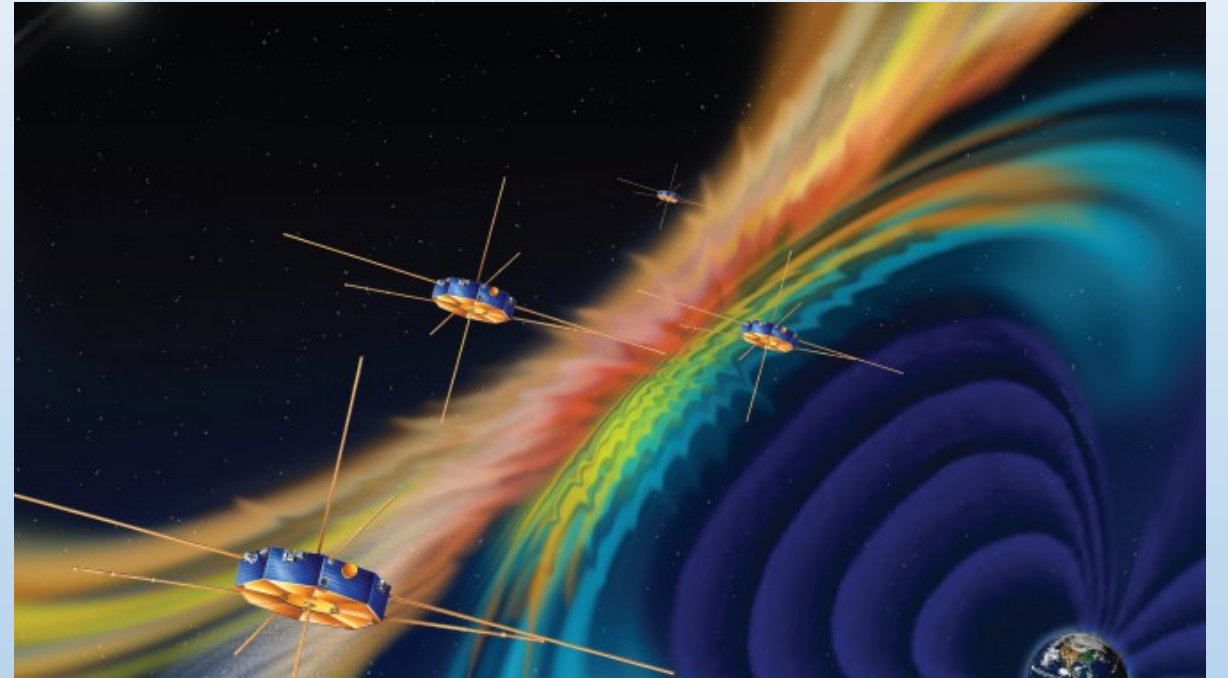
This research was supported by the National Science Foundation REU program, Award #1659878.

Why?

- Why look at these waves?
- Why look at the DST index?
- Why look at higher frequency waves?
- Why look at satellite location?

What is MMS?

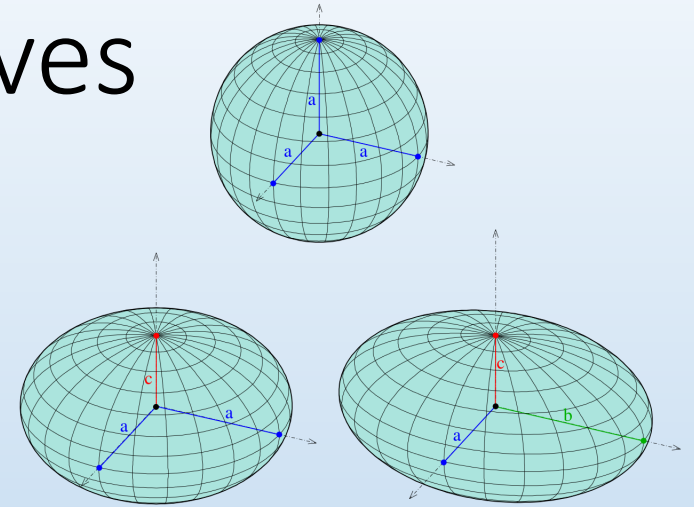
- MMS or Magnetospheric MultiScale Mission
- 4 Satellites, tetrahedral formation
- Original purpose: study magnetic reconnection
- My purpose: study plasma waves



Courtesy of NASA

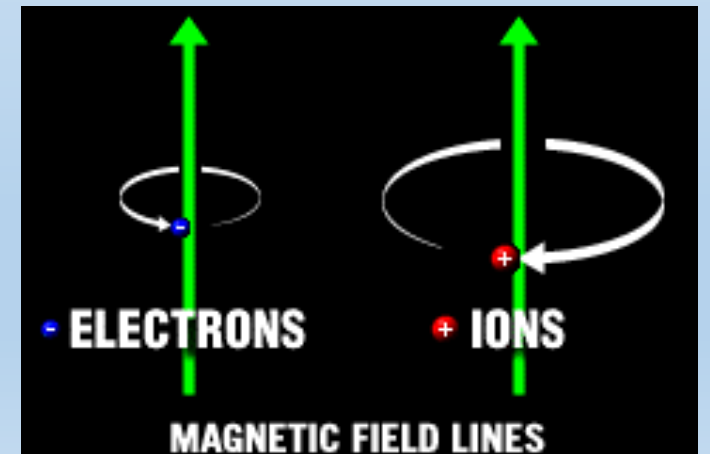
Electromagnetic Ion Cyclotron Waves

- Where do they come from?
 - Anisotropic (or asymmetric) velocity distribution
- How/Why?
 - There is an instability
 - There is a “release of energy” to create stability
- Cyclotron Motion
 - Lorentz Force
 - Electrons \sim kHz
 - Protons \sim 1-10 Hz
- Chorus waves = electron cyclotron waves



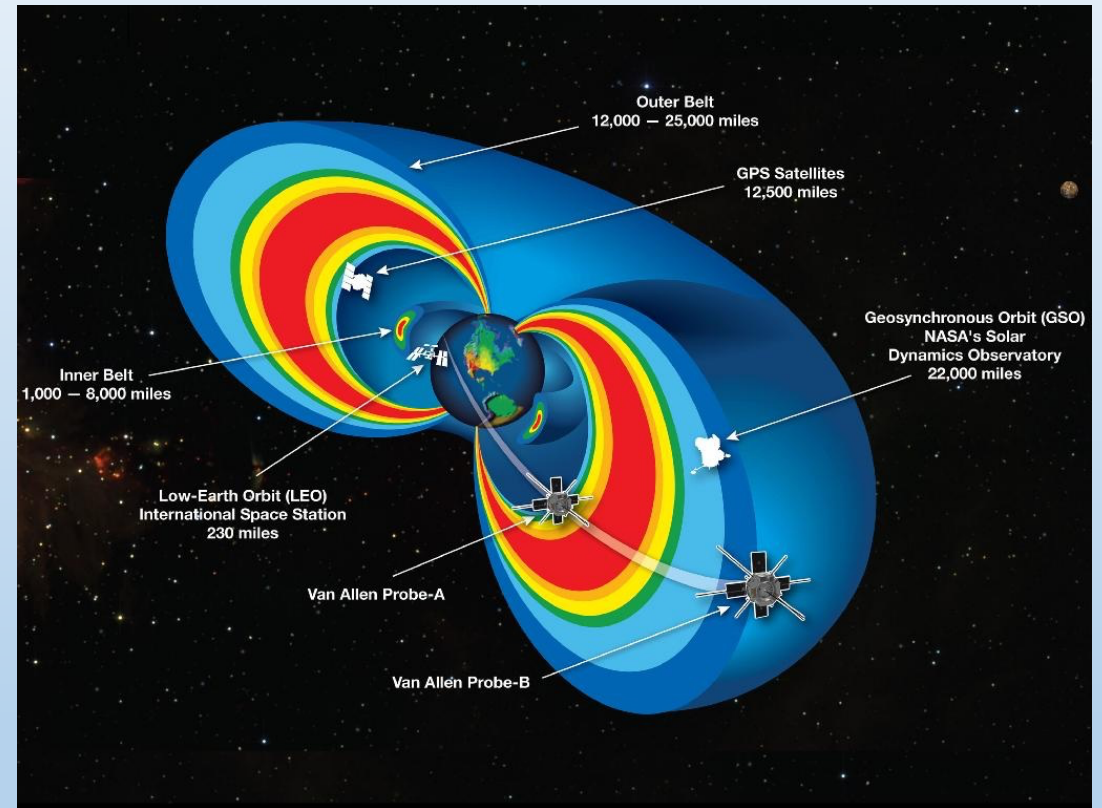
Retrieved from:

<https://commons.wikimedia.org/wiki/File:Ellipsoide.svg>



Why look at these waves?

- Ion cyclotron harmonic waves could produce a loss of energetic ions and electrons in the radiation belts due to wave particle interactions

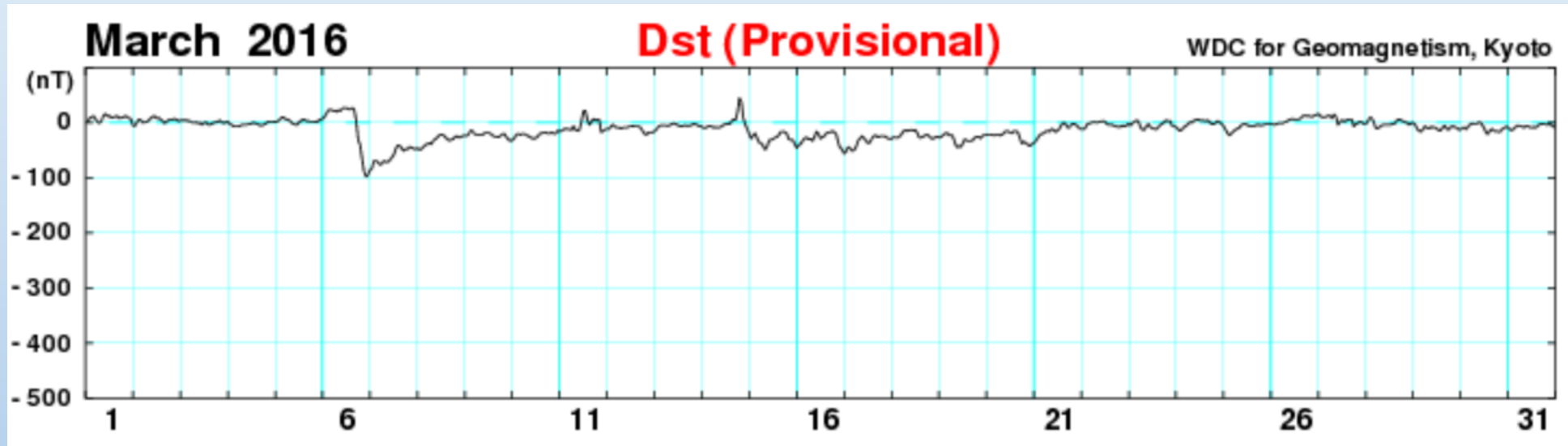


Retrieved from:

https://commons.wikimedia.org/wiki/File:Van_Allen_Radiation_Belt_Model_shown_with_2_VA_Probes.jpg

DST Index

- Disturbance Storm Time Index



Courtesy of WDC for Geomagnetism, Kyoto DST Index Service

- How did I use it?
 - Oxygen escapes Earth's magnetosphere during magnetic storms

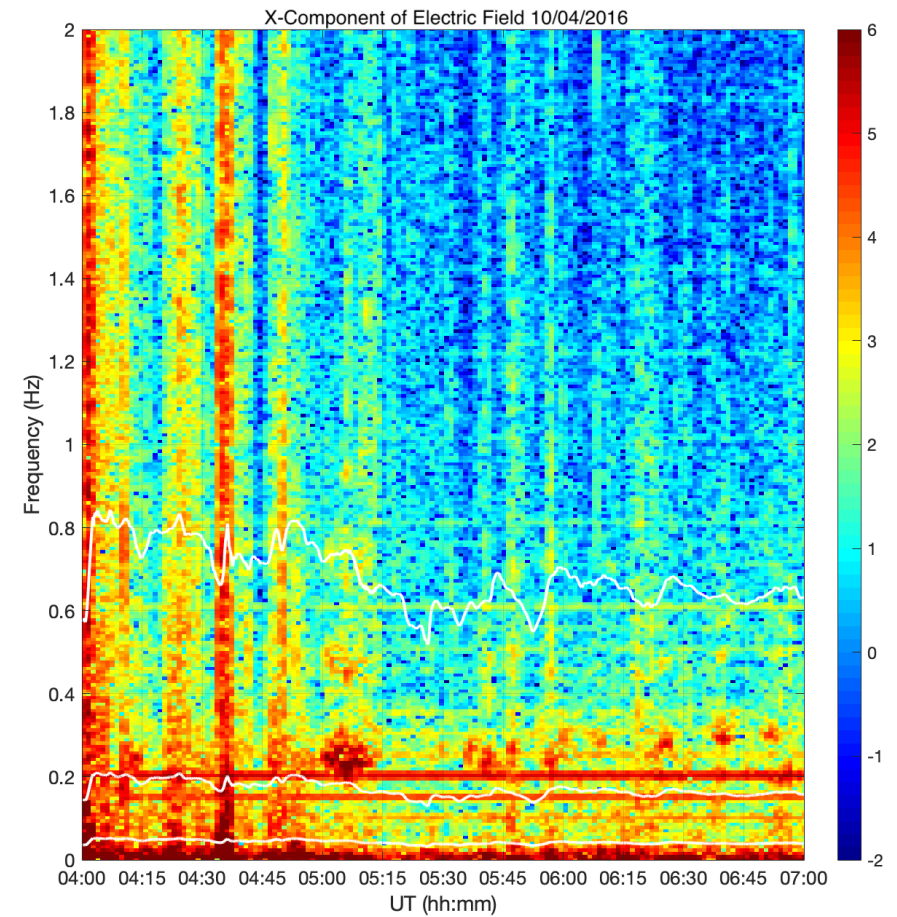
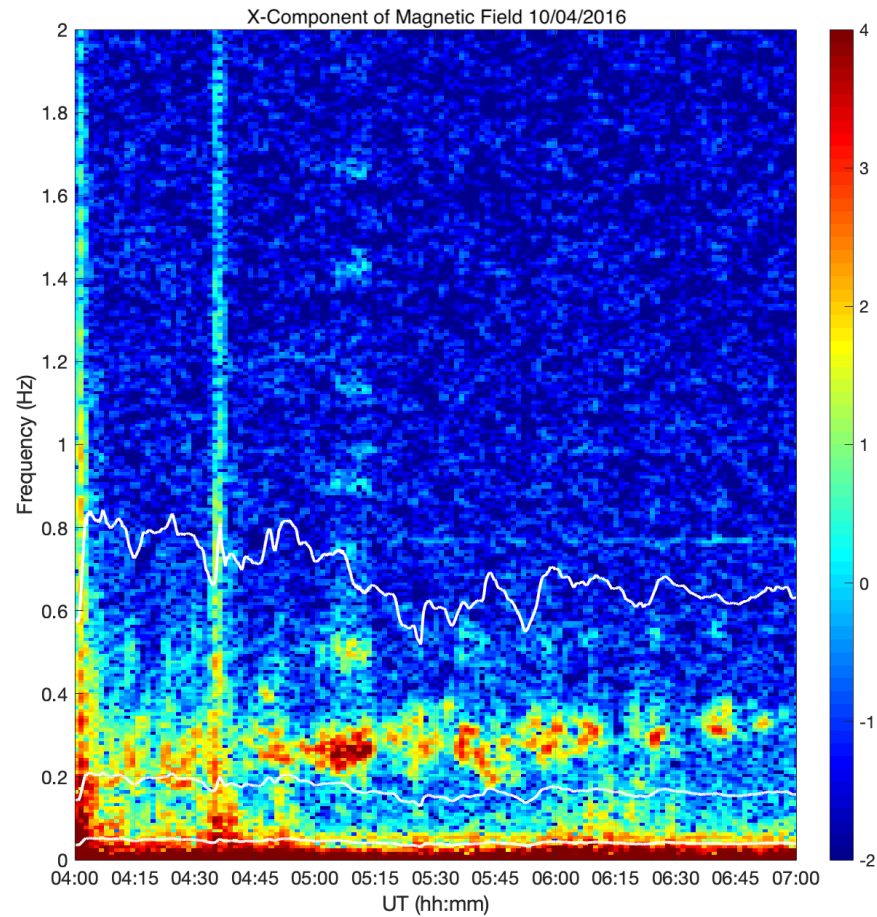
Why look at the DST index?

- Oxygen escapes Earth's atmosphere during magnetic storms
- There could be elevated oxygen levels which could result in electromagnetic ion cyclotron waves at the oxygen gyrofrequency

Spectrogram and FFT(Fast Fourier Transform)

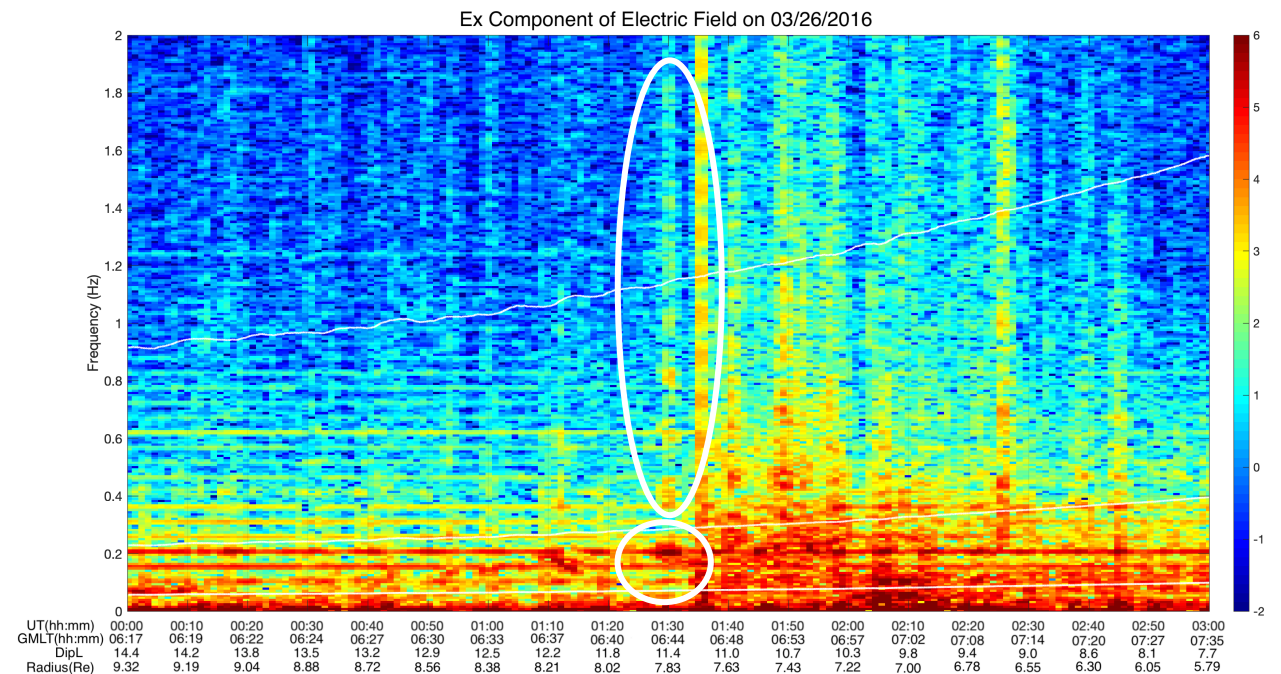
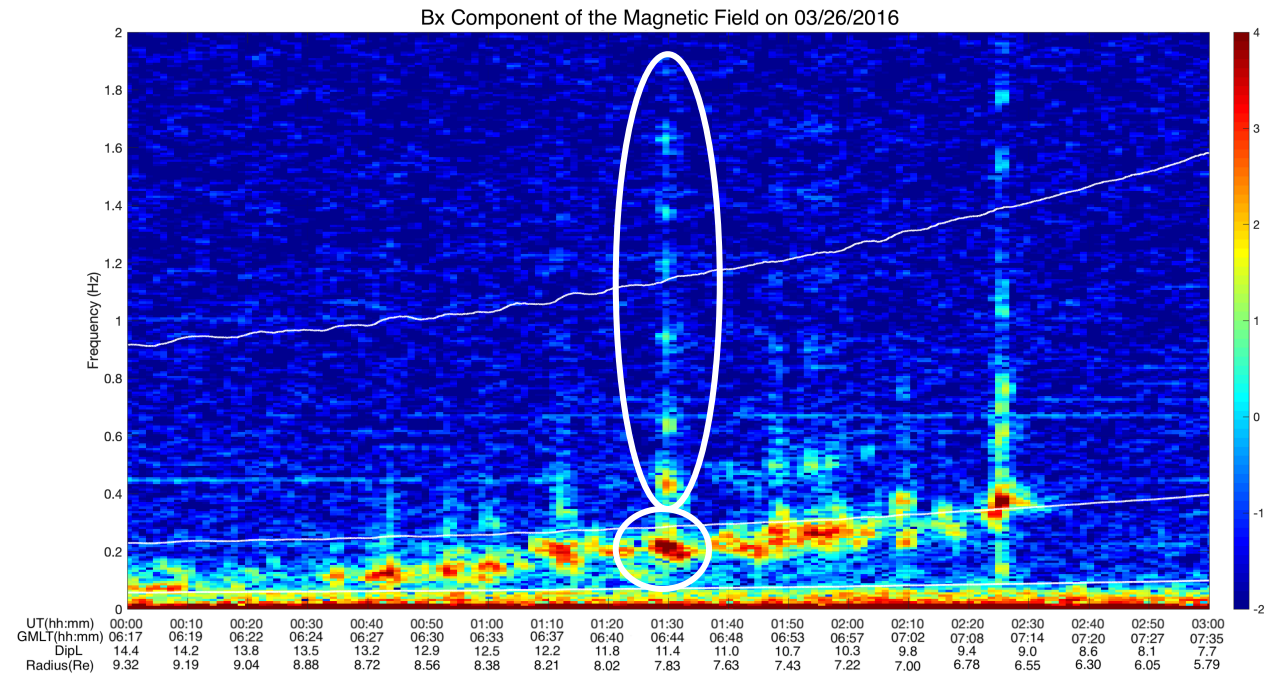
- Fourier transform
- How does the FFT differ from the Fourier transform?
- Spectrograms

Spectrograms and FFT

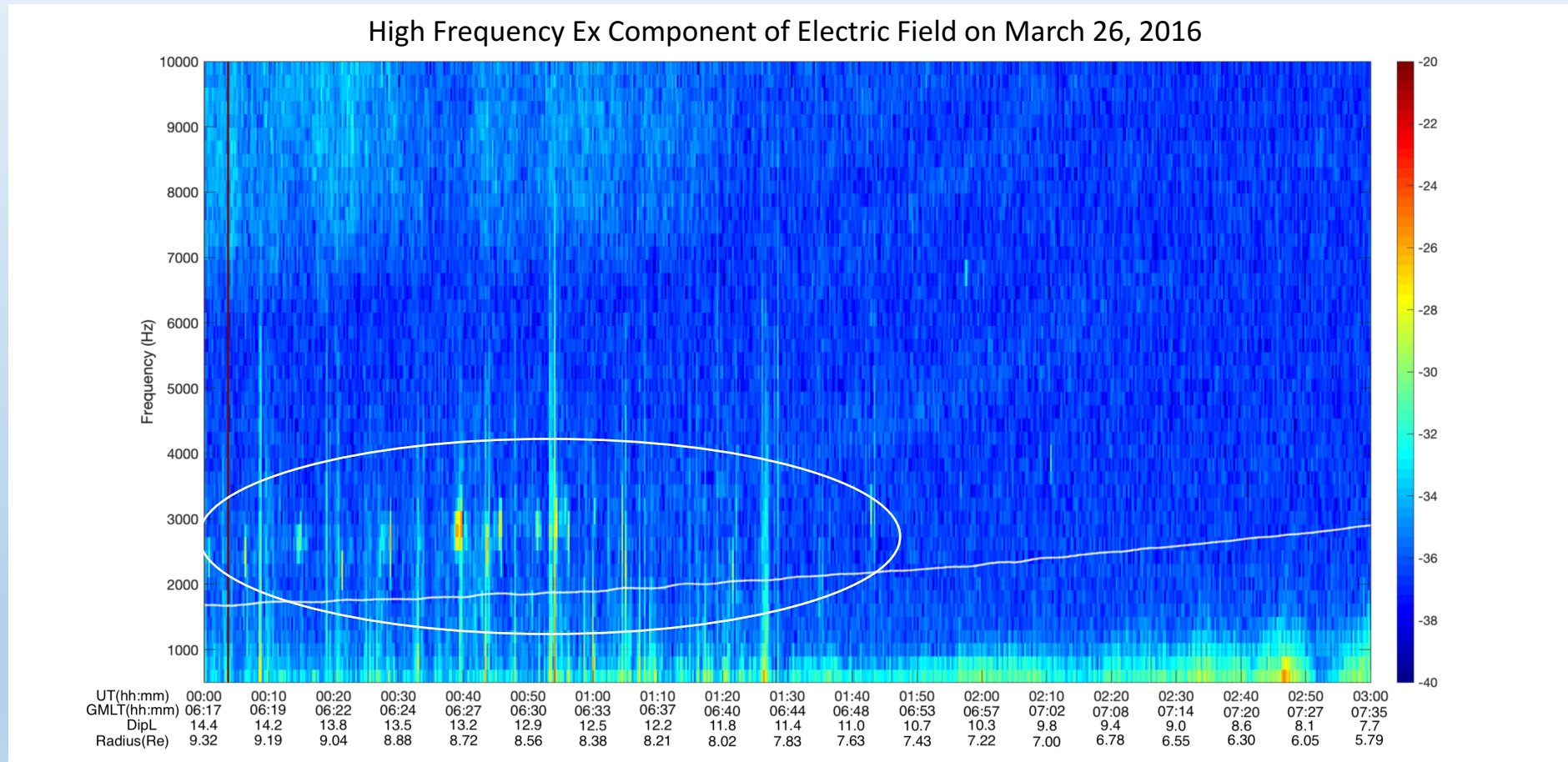


March 26, 2016

- 0:00-3:00 UT
- Harmonics
- Visible in Magnetic and Electric Field

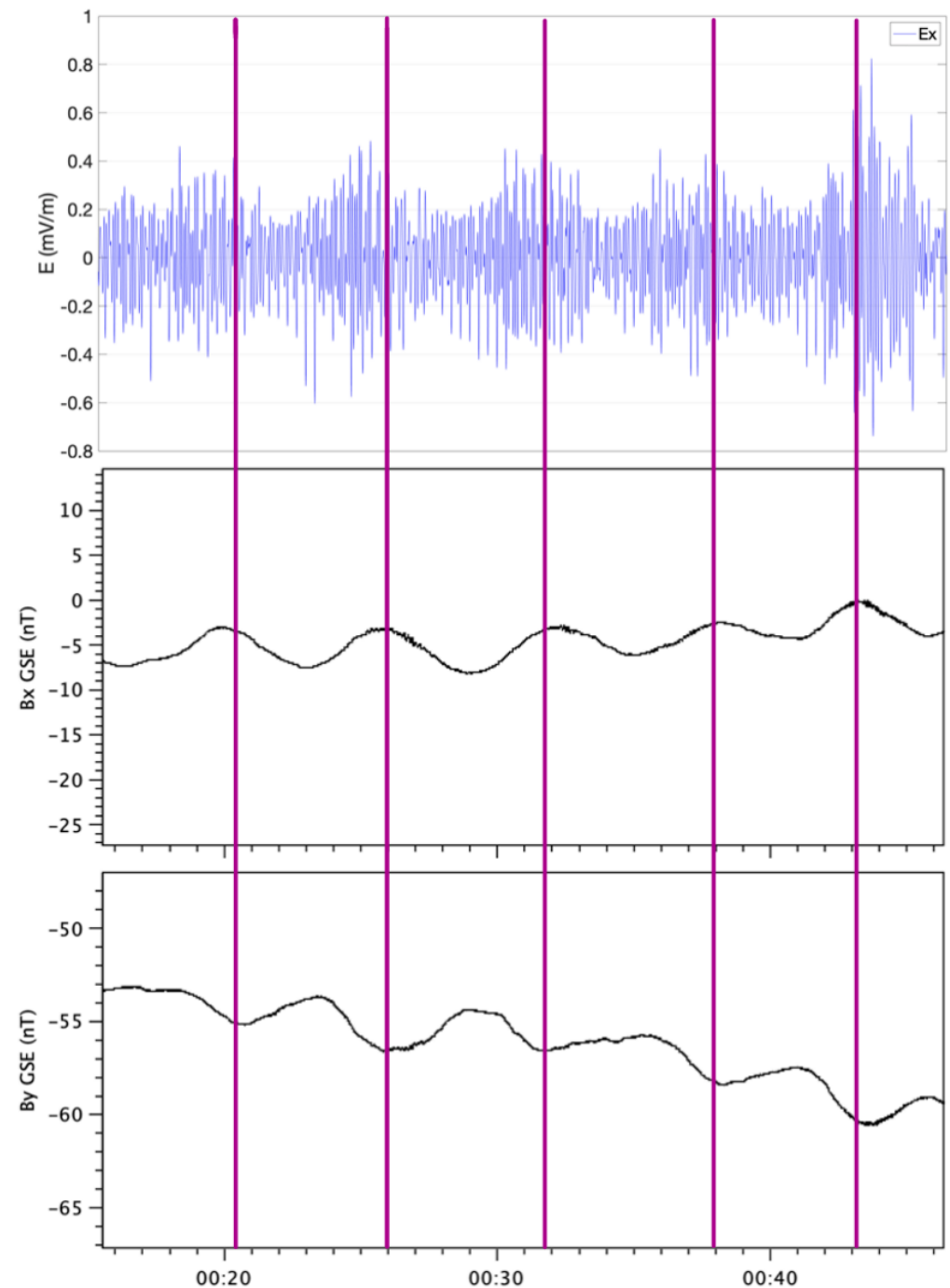


High Frequency Waves on March 26, 2016



Modulation of Waves

- March 26, 2016 from 00:16-00:46
- Why is this important?
 - It is indicative that there is a cross-frequency relationship at both ion and electron scales.

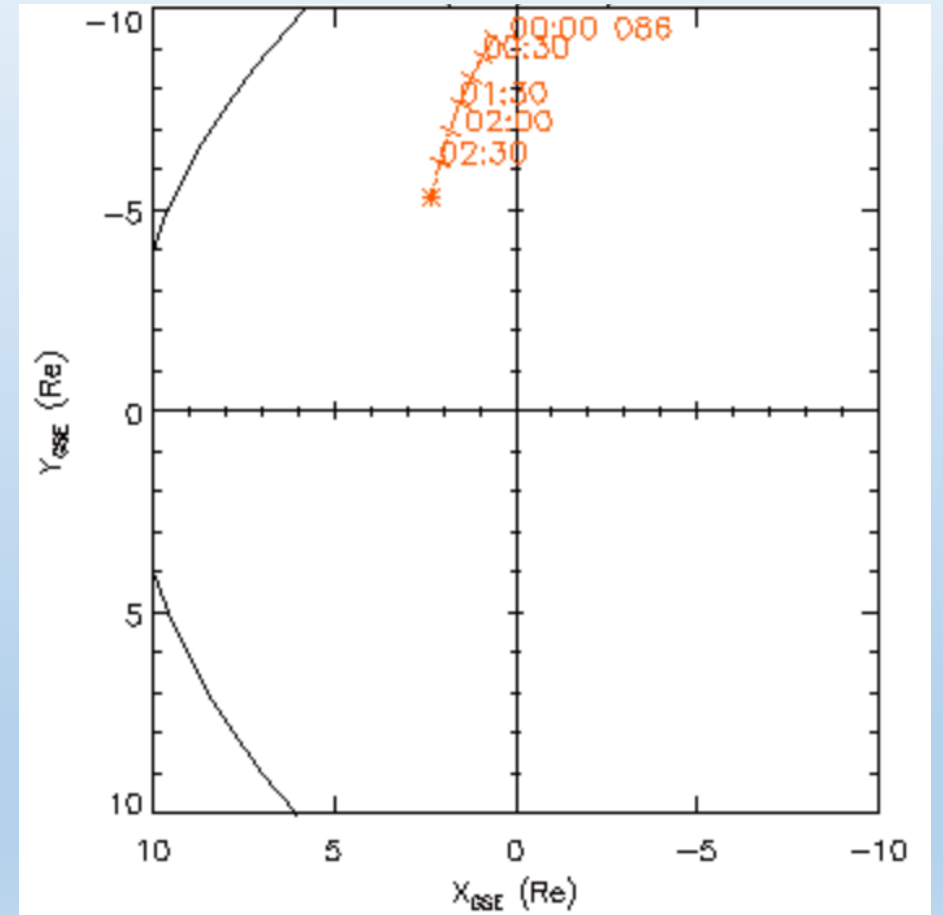


Why look at higher frequency waves?

- To see if there is a potential cross frequency relationship between waves at oxygen cyclotron frequency and electron cyclotron frequency

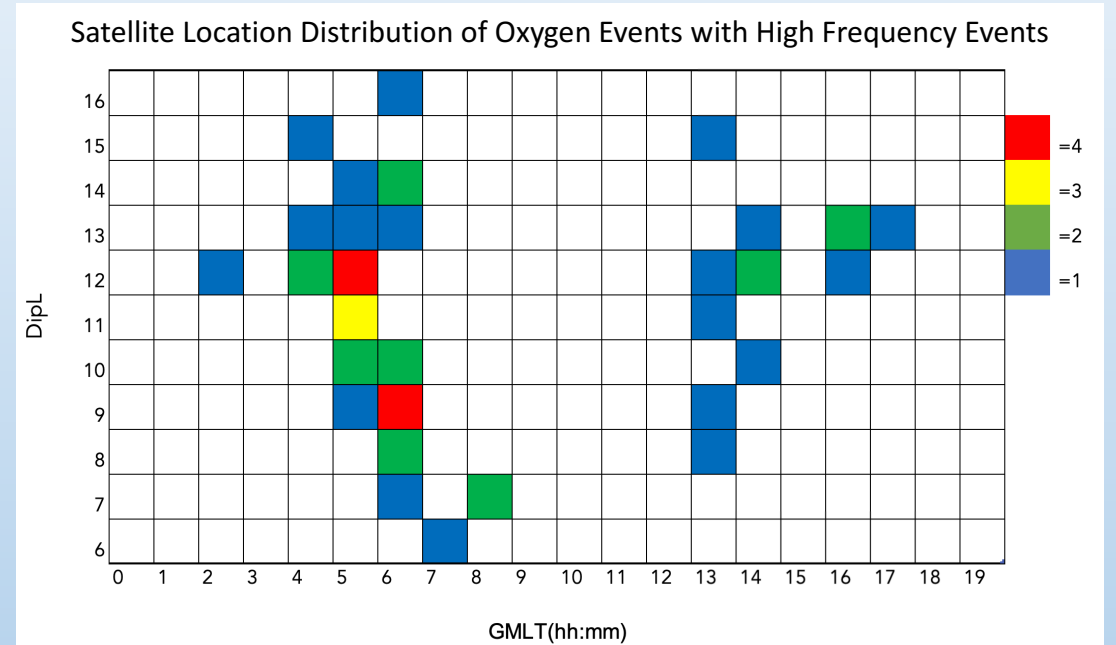
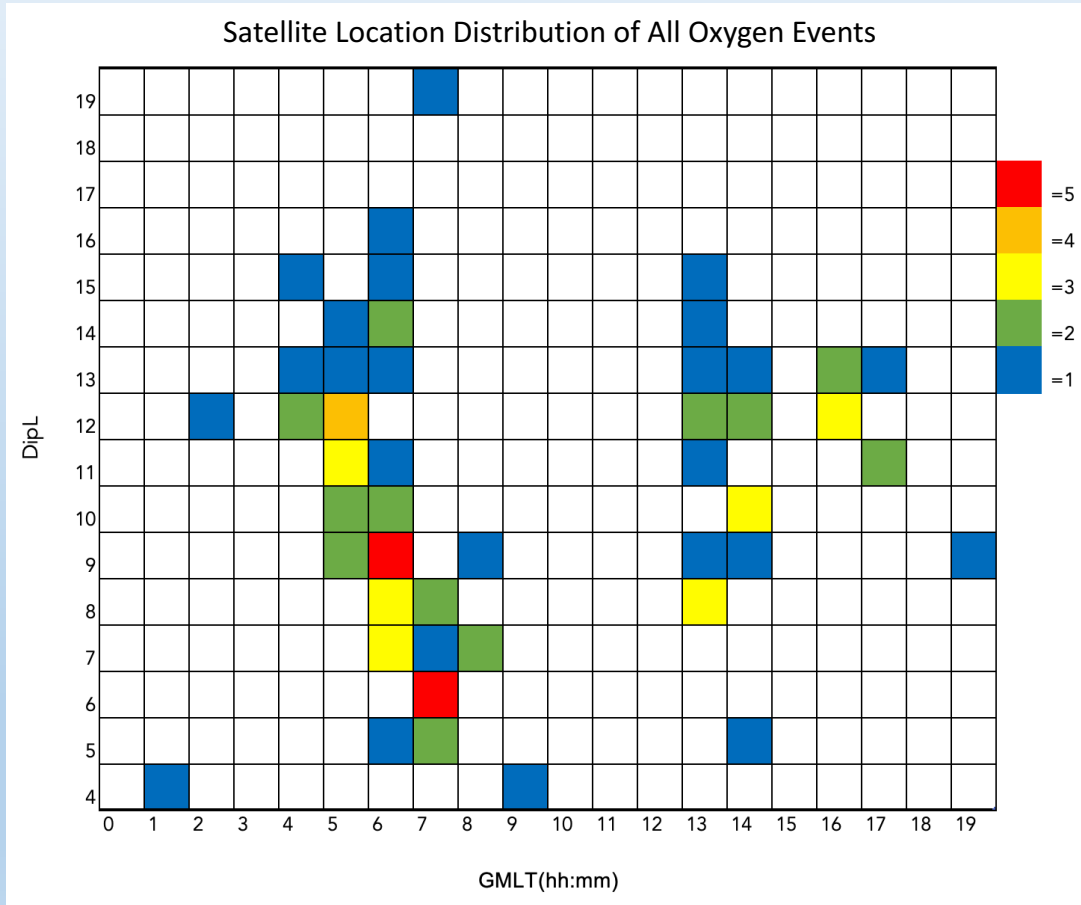
Satellite Location

- NASA's Satellites Situation Center System and Services
- March 26, 2016 from 0:00-3:00 UT
- Dayside



Courtesy of NASA's Satellites Situation Center System and Services

Satellite Location



Why look at satellite location?

- To guide our understanding of processes behind these waves

Summary

1. We surveyed low frequency MMS data from September 2015-April 2016 for electromagnetic ion cyclotron waves in the oxygen frequency band.
2. Used the DST index
3. We also surveyed high frequency electric field data for electromagnetic ion cyclotron waves in the electron frequency band.
4. We found that low frequency ion events modulate at the same frequency as chorus wave packets, suggesting a potential cross-frequency relationship.
5. These events appear to be preferential to the dayside of the magnetosphere.

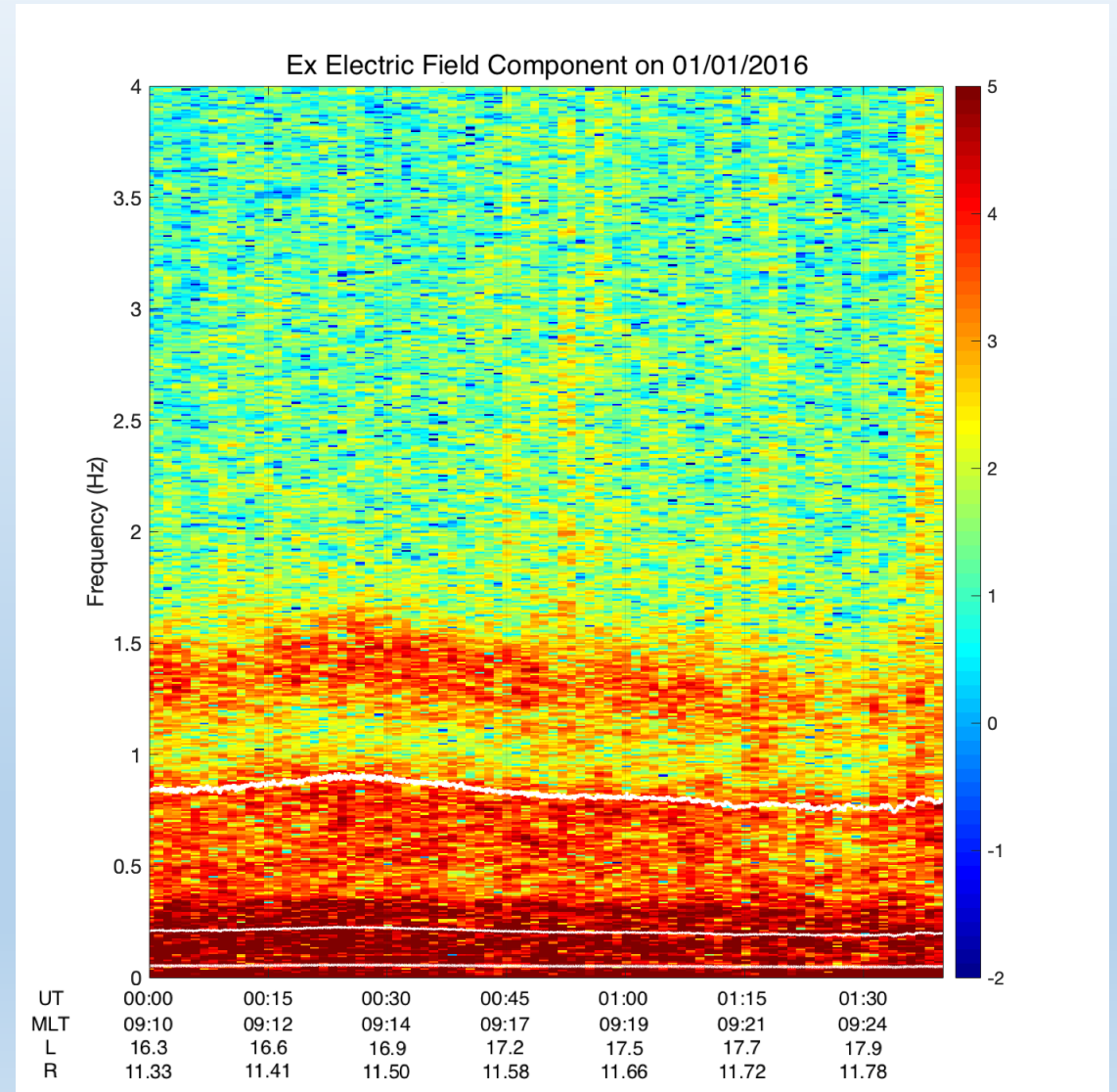
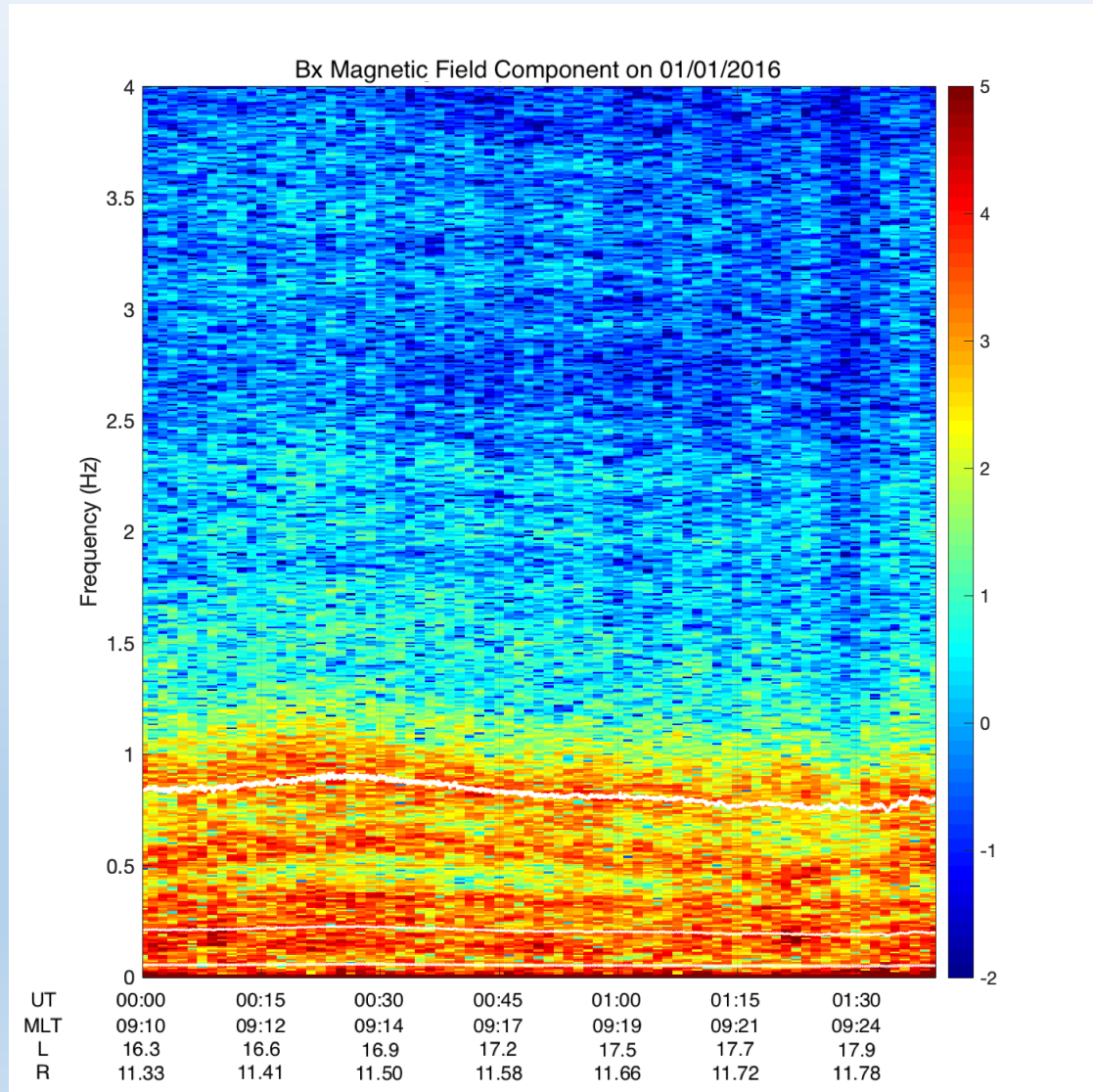
Why?

- It is important because ion cyclotron harmonic waves are believed to produce a loss of energetic ions and electrons in the radiation belts due to wave particle interactions.
- Understanding under what conditions these waves occur could be important to understanding the loss of energetic particles in the radiation belts as well as magnetospheric dynamics.

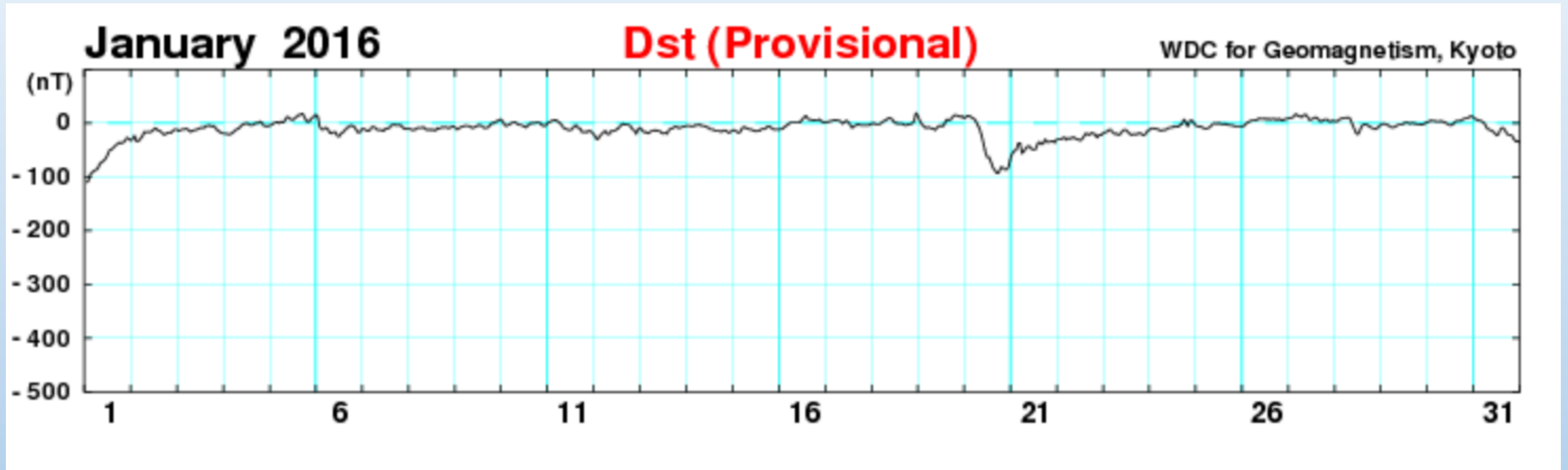
Future Work

- Check more dates
- Check solar wind dynamic pressure and other conditions during the events
- Also continue what's on my next slide...

Unstructured Waves at Ion Cyclotron Frequencies



Unstructured Waves at Ion Cyclotron Frequencies



Courtesy of WDC for Geomagnetism, Kyoto DST Index Service

Thank you! Questions?

References

- Usanova, M.E., Ahmadi, N., Malaspina, D.M., Ergun, R.E., Trattner, K.J., Reece, Q., Leonard, T., Fuselier, S.A., Torbert, R.B., Russell, C.T., Burch, J.L. (2018). MMS Observations of Harmonic Electromagnetic Ion Cyclotron Waves. *Geophysical Research Letters*, 45, 8764-8772. <https://doi.org/10.1029/2018GL079006>
- Usanova, M. E., Malaspina, D. M., Jaynes, A. N., Bruder, R. J., Mann, I. R., Wygant, J. R., & Ergun, R. E. (2016). Van Allen Probes observations of oxygen cyclotron harmonic waves in the inner magnetosphere. *Geophysical Research Letters*, 43, 8827-8834 <https://doi.org/10.1002/2016GL070233>