Multiple bidirectional EMIC waves observed by Cluster at middle magnetic latitudes in the dayside magnetosphere

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2013 GEM Workshop, Snowmass, CO, June 16-21, 2012

Abstract:

The generally believed source region for EMIC waves is around the magnetic equatorial plane (|MLAT|<11° [*Loto'aniu et al.*, 2005]). It is well accepted that the propagation of electromagnetic ion cyclotron (EMIC) waves are bidirectional near their source regions and unidirectional when away from these regions. Here we describe a series of EMIC waves in the Pc1 (0.2-5 Hz) frequency band above the local He^+ cyclotron frequency observed *in situ* by all four Cluster spacecraft on 9 April 2005 at mid-magnetic latitudes (MLAT=~33°-48°) with L=~10.7-11.5 on the dayside (MLT=10.3-10.4). A Poynting vector spectrum shows that the wave packets consist of multiple groups of packets propagating bidirectionally, rather than unidirectionally away from the equator, while the local plasma conditions indicate that the spacecraft are entering into an off-equator region sufficient for local wave excitation. This suggests that, while part of the observed waves are inside their source region, the others are either close enough to the source region, or mixed with the wave packets from multiple local source regions at different latitudes. It is also possible that the waves not in the source region are a mixture of newer wave packets (i.e., closer to the source region) with older ones reflected at a higher magnetic latitude from the source region or that the waves are still in a source region but linear theory is not accurate enough to predict this.

Motivation:

1. Study the properties of off-equator EMIC waves.
2. Investigate the effects of Shabansky orbits on off-equator EMIC wave generation [*Shabansky*, 1971].
3. Expand on the statistical study by *Loto'aniu et al.* [2005].
4. Expand the case study recently published by *Liu et al.* [2012].

Linear Theory:

Linear Theory states that for an EMIC wave to occur, the wave growth parameter, Σ_h, must be larger than the instability threshold, S_h [*Gary et al.*, 1994]. Where,

$$\Sigma_h = \left(\frac{T_\perp}{T_\parallel} - 1\right)\beta_{\parallel h}^{\alpha_h} \qquad S_h = \sigma_0 + \sigma_1 \ln\left(\frac{n_{hp}}{n_e}\right) + \sigma_2\left[\ln\left(\frac{n_{hp}}{n_e}\right)\right]^2$$

$$\alpha_h = a_0 - a_1 \ln\left(\frac{n_{hp}}{n_e}\right) - a_2\left[\ln\left(\frac{n_{hp}}{n_e}\right)\right]^2$$

with σ_0 = 0.429, σ_1 = 0.124, σ_2 = 0.0118 and α_0 = 0.409, α_1 = 0.0145, and α_2 = 0.00028 [*Blum et al.*, 2009].

Thus, by looking at Σ_h – S_h during the events, we are able to see whether the observed waves are in a predicted source region.

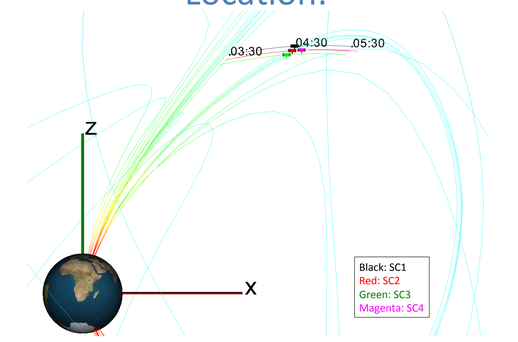
References:

Blum, L. W., *et al.* (2009), JGR, 114(A014396).
Gary, S. P., *et al.* (1994), JGR, 99(A02069).
Liu, Y. H., *et al.* (2012), GRL, 39(L17102).
Loto'aniu, T. M., *et al.* (2005), 110(A010816).
Shabansky V. P. (1971), 12(BF00165511).

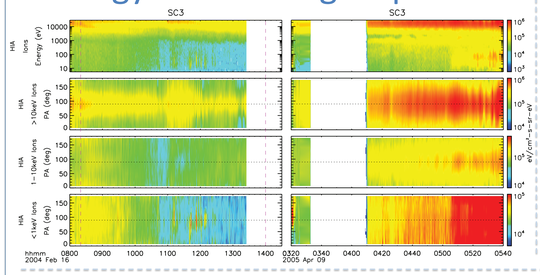
Acknowledgements:

Work at UNH was supported by NASA under grant numbers NNX11AO82G and NNX11AB65G. This work was also supported by RBSP-ECT funding provided by JHU/APL Contract No. 967399 under NASA's Prime Contract No. NAS5-01072.

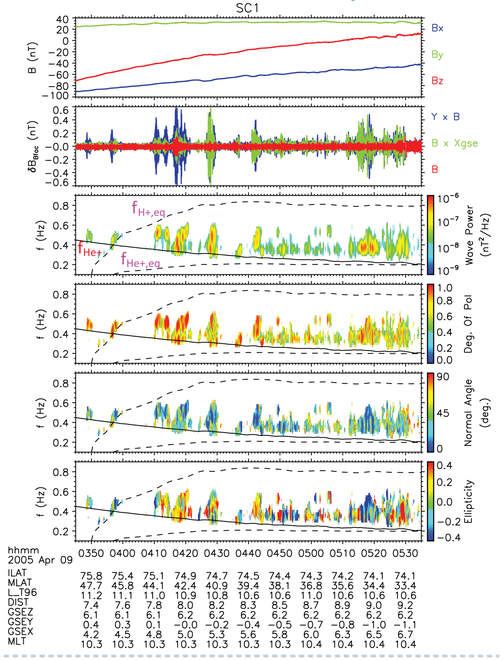
Location:



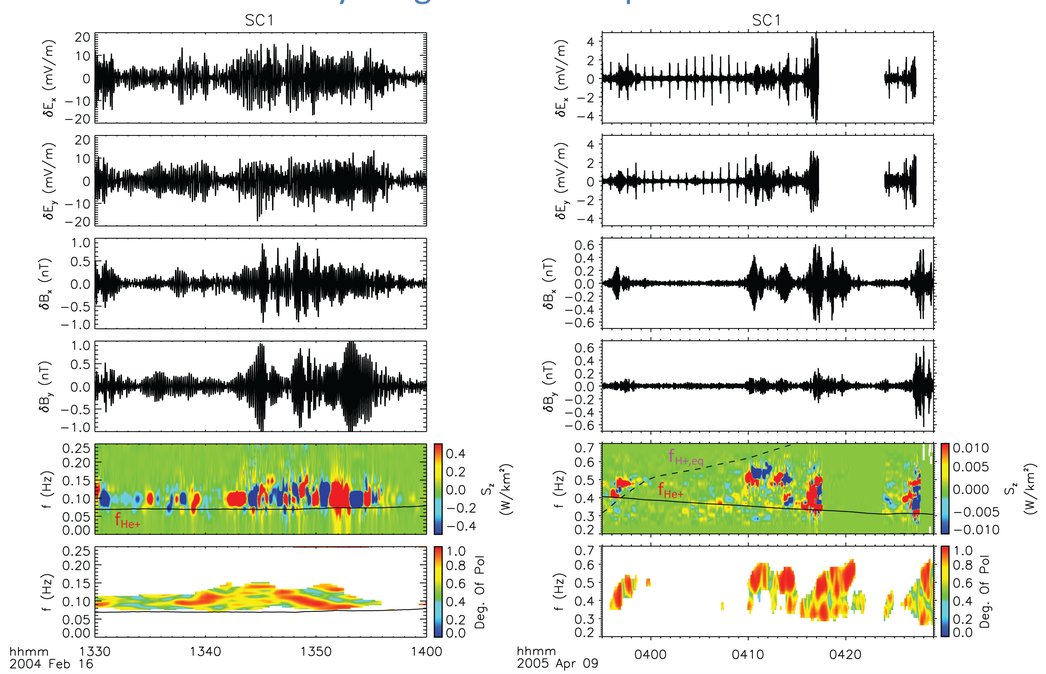
Energy & Pitch Angle Spectra:



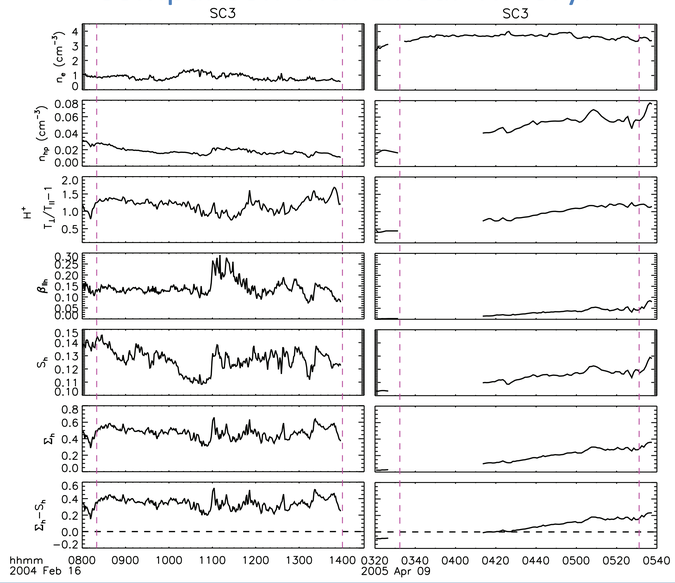
Polarization Analysis:



Poynting Vector Comparison:



Comparison with Linear Theory:



Summary & Discussion:

	14 Feb 2004	9 Apr 2005
Location:	MLAT = ~20-13 L= ~13 MLT=~13	MLAT= ~33-48 L= ~11 MLT= ~10
Ion pitch angles:	Anisotropic	Anisotropic
Linear Theory Consistency:	Satisfied for entire duration of wave observations	Becomes satisfied half way through wave observations, although there is a data gap in the first half

This suggests that the 2004 event is observed inside of the EMIC wave source region. However, for the 2005 event, only the second half of wave observations satisfy linear theory. To explain the bidirectional propagation observed in the first half, we propose four possibilities:

1) The observed waves are still close enough to the source region.
2) The wave observations are taking place between two source regions.
3) The waves are being reflected at higher latitude.
4) The waves are also in a source region, but linear theory is not accurate enough to show this.