GEM ULF Wave Challenge

- How well can long period ULF waves be represented in global models?

- Issues:
  - Accuracy of the Alfven continuum in models (cold plasma mass density; ionospheric sources; plasmaspheric effects)
  - Effect of continuum/Alfven speed profile on mode excitation and penetration in L?
  - Accuracy of mode structures generated in the magnetosphere ?
  - Accuracy of response to solar wind drivers ?
  - L, MLT and time response of driven wave fields ?
  - Persistence of ULF waves following excitation; energy loss processes including rate of Ohmic dissipation in the ionosphere ?

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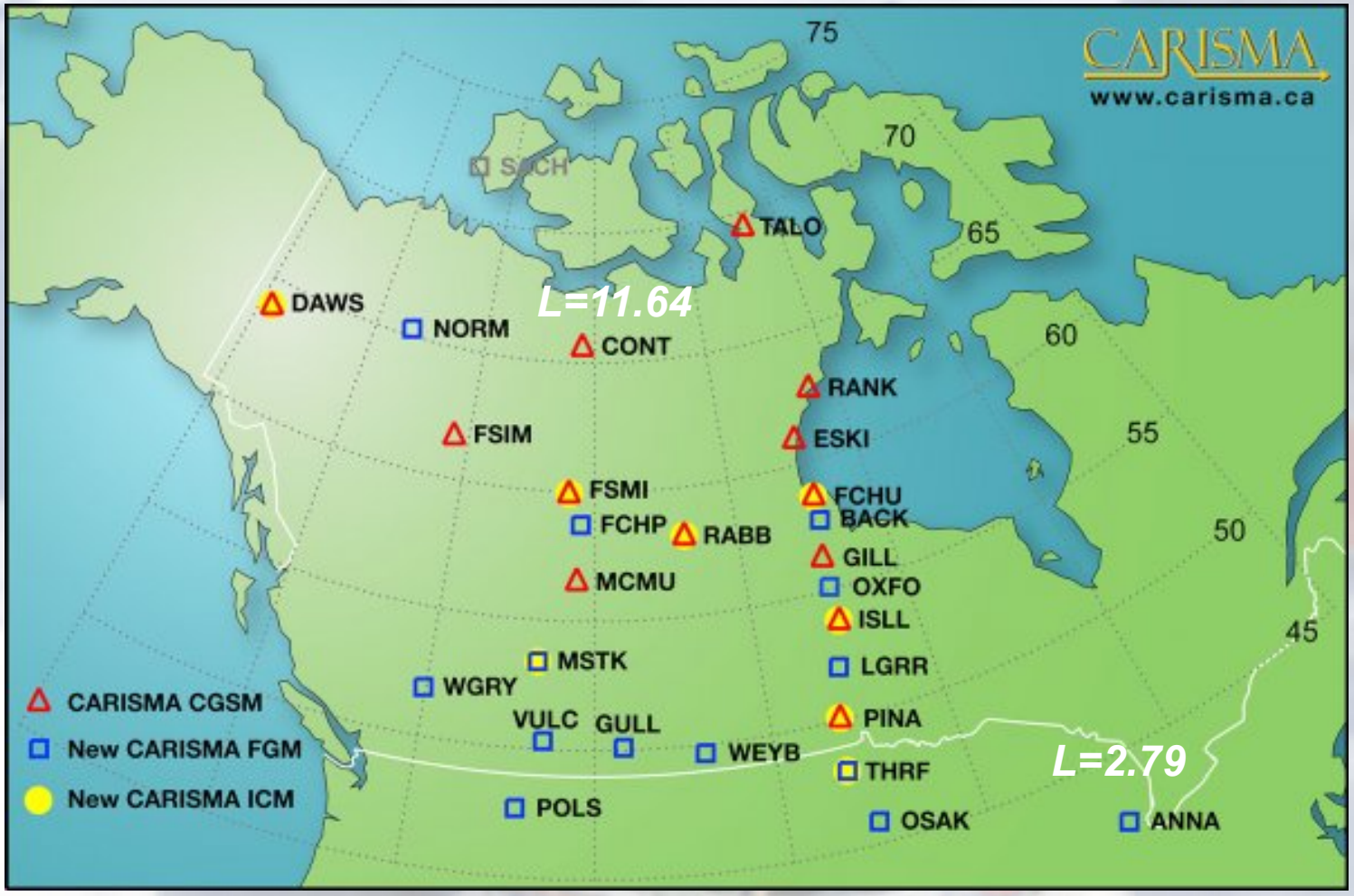
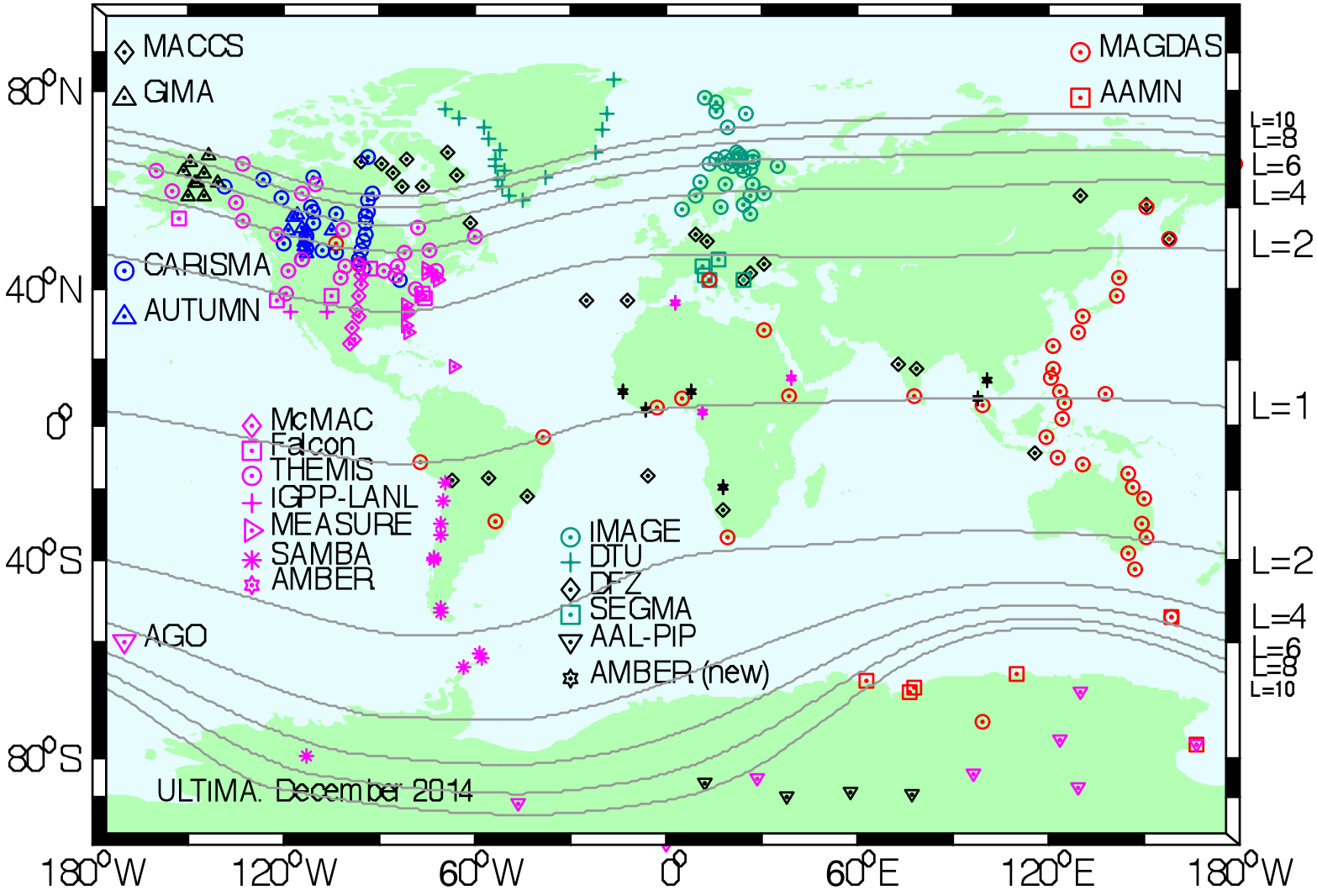


28 FGMs up to 8 samples/s and 8 ICMs (yellow) up to 100 samples/s spanning several hrs MLT and dL>10

Excellent opportunity for Van Allen Probe/other SC magnetic conjunctions,

Ultra Large Terrestrial International Magnetometer Array

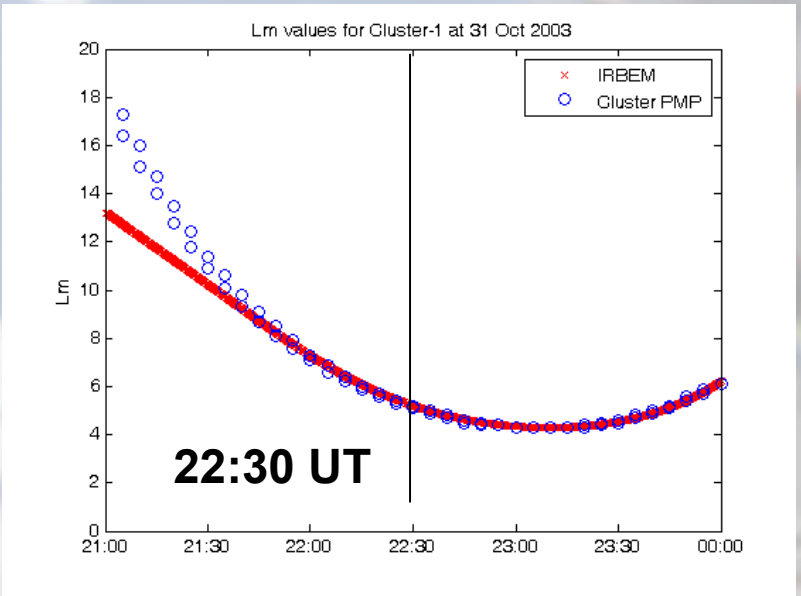


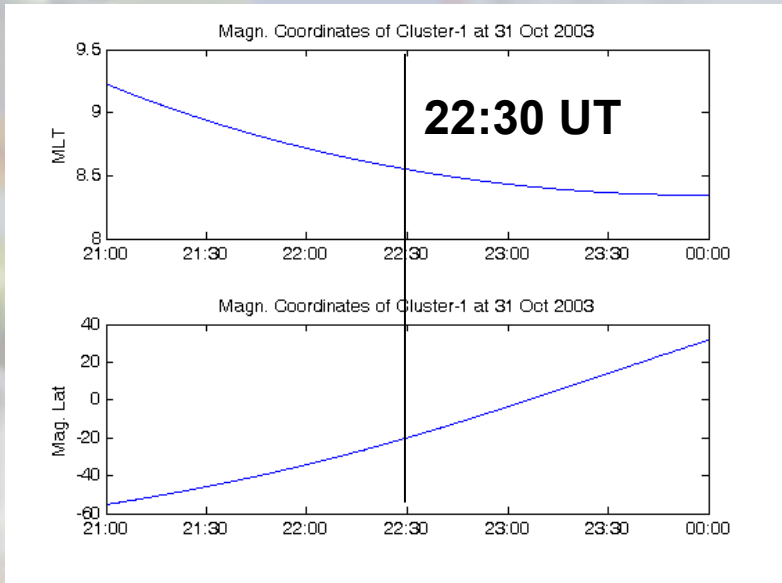
Courtesy of Peter Chi

Alfven Continuum

- Models such as LFM seem to do a good job of capturing the excitation of standing Alfven waves in the continuum (cf. Claudepierre et al.).
- What are the effects of non-uniform continuum – eg reflection and wave tunnelling at plasmapause – and how do models compare to observations?
- Critical for modelling and understanding penetration of Pc5 ULF power into the radiation belts.

1) Halloween: Cluster 31st October 2003 case – 21-24 UT.



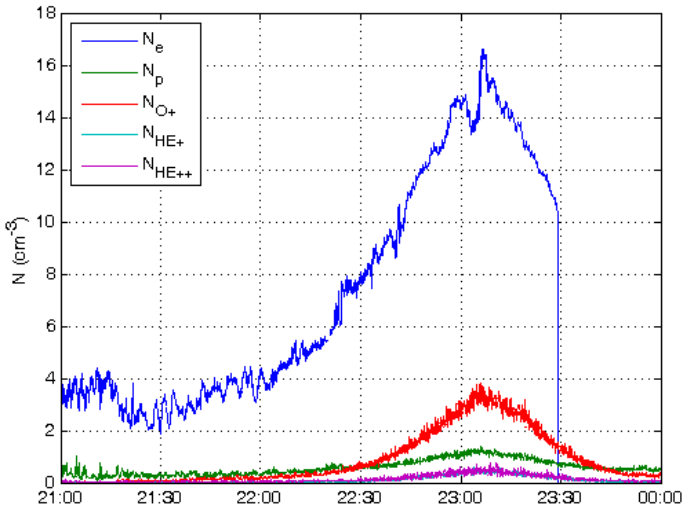


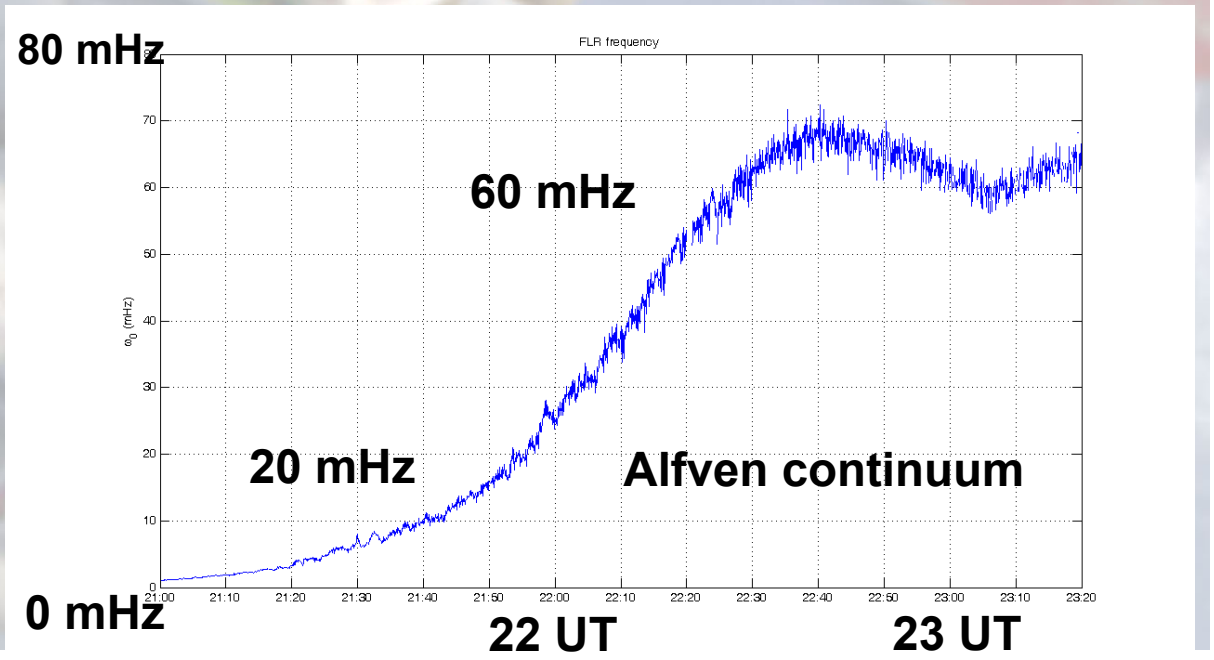
- Cluster equatorial perigee pass, L~5, 8-9 MLT. Conjunction with Alaska and western Canada.
- Based on paper - Balasis, Daglis, Mann et al., AG, submitted, 2015.
- Thanks especially to Constantinos Papadimitriou.
- Alfven continuum effects could be modelled in “test runs” or “full solar wind driven”.

Density and Alfven Continuum

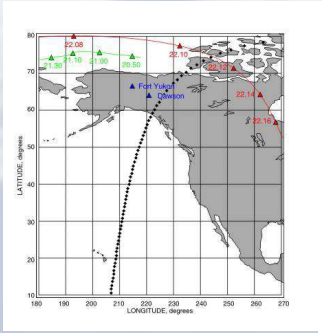
- Mass density – used CIS heavy ions and assumed quasi-neutrality with Ne (remaining assumed p+).
- Cut-off at SC potential density saturation.
- Nice measure of mass density profile at plasmapause – including effects of heavy ion torus.
- Magnetic field mapped to equator using dipole approximation.
- FLR toroidal eigenfrequency from Allan and Knox (1979) dipole field.
- Higher levels of sophistication in FLR eigenfrequency modelling of course possible.

What are effects of plasmapshere boundary layer on wave dynamics – around 22-22:30 UT ?





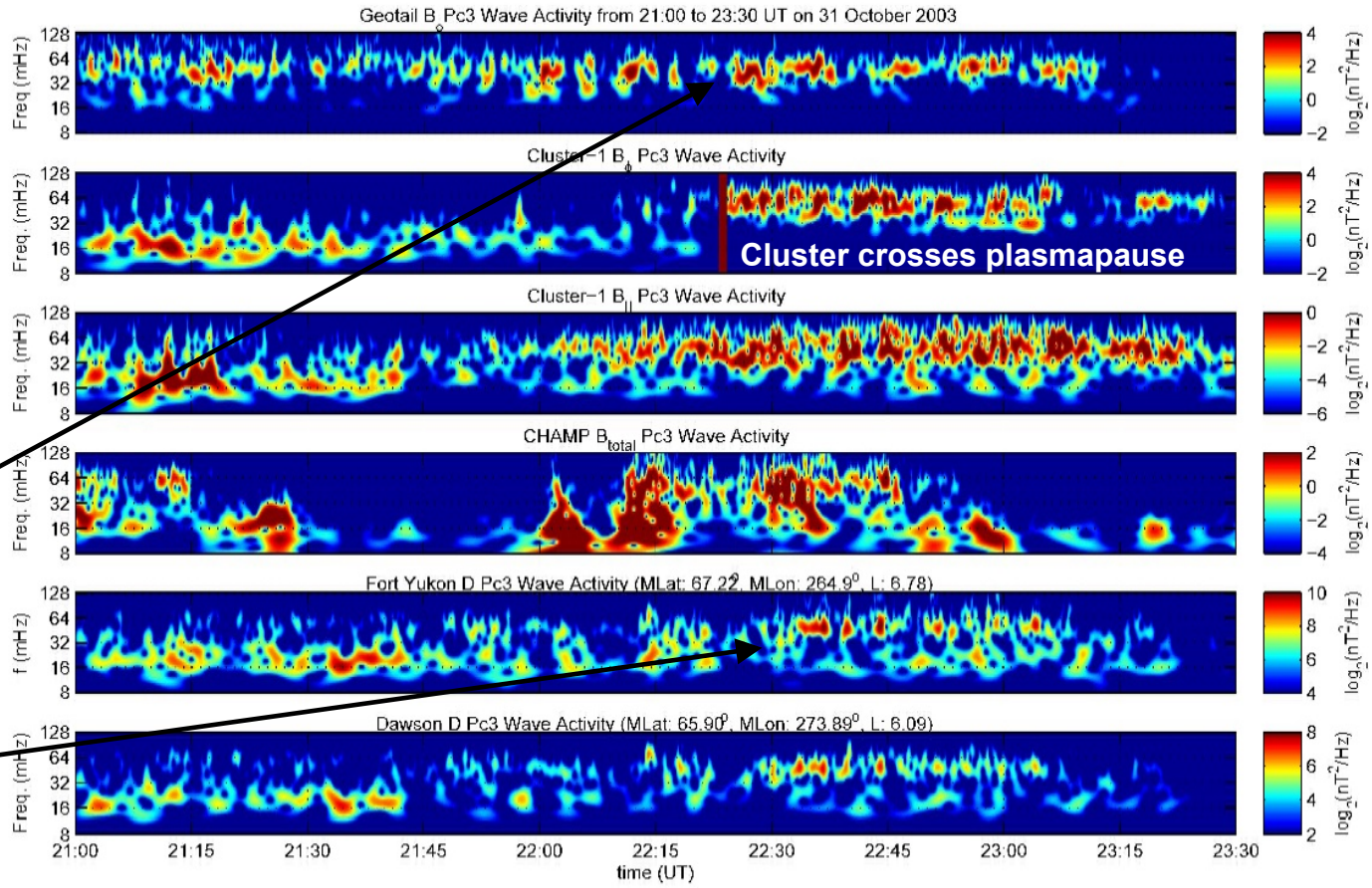
Pc5 excluded to outside plasmasphere but Pc3 enhanced inside: Model penetration?



Cluster (red) in southern hemisphere on perigee pass coming north.

Geotail in dawn sheath. Upstream Pc3 source?

GB data also show UT change in spectra. Why?



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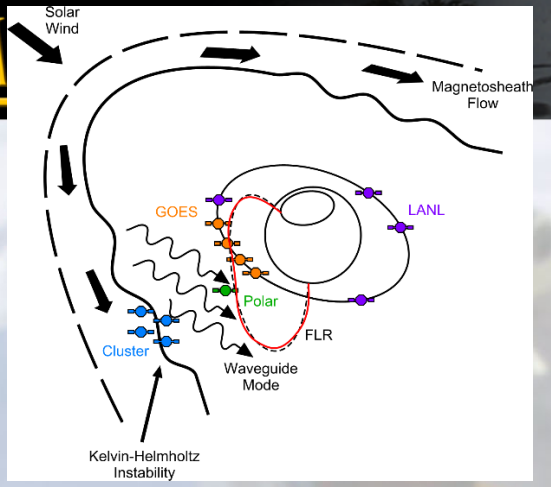
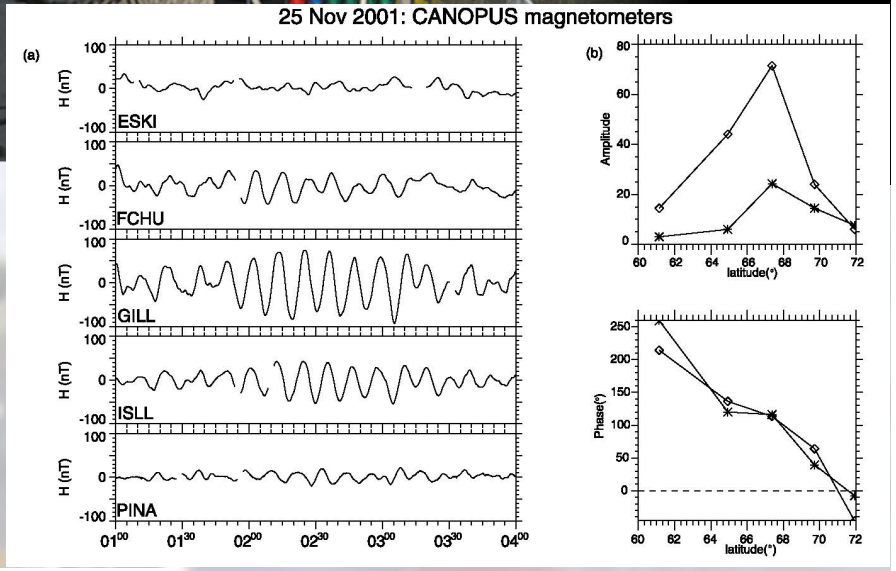
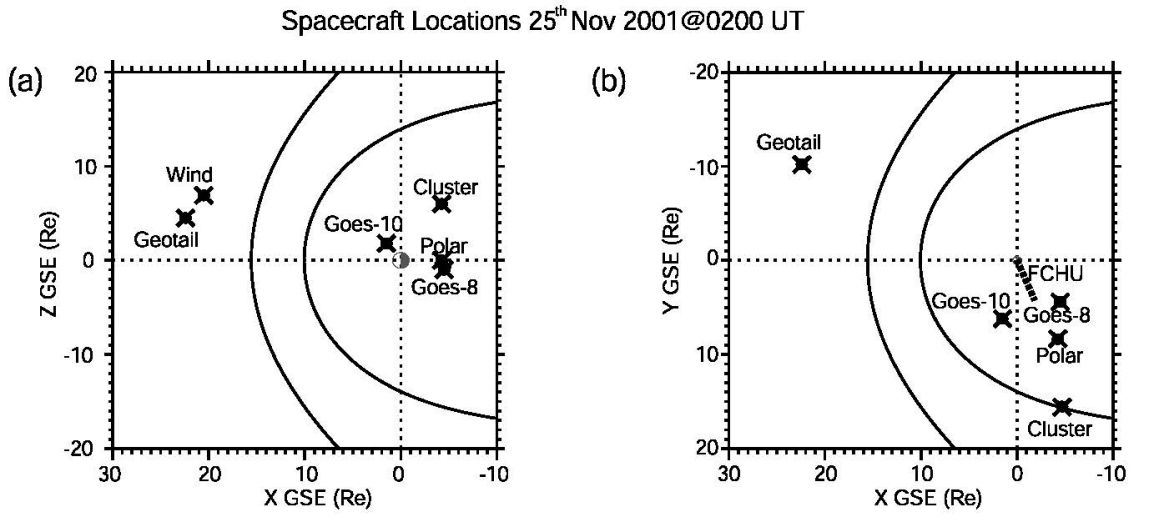
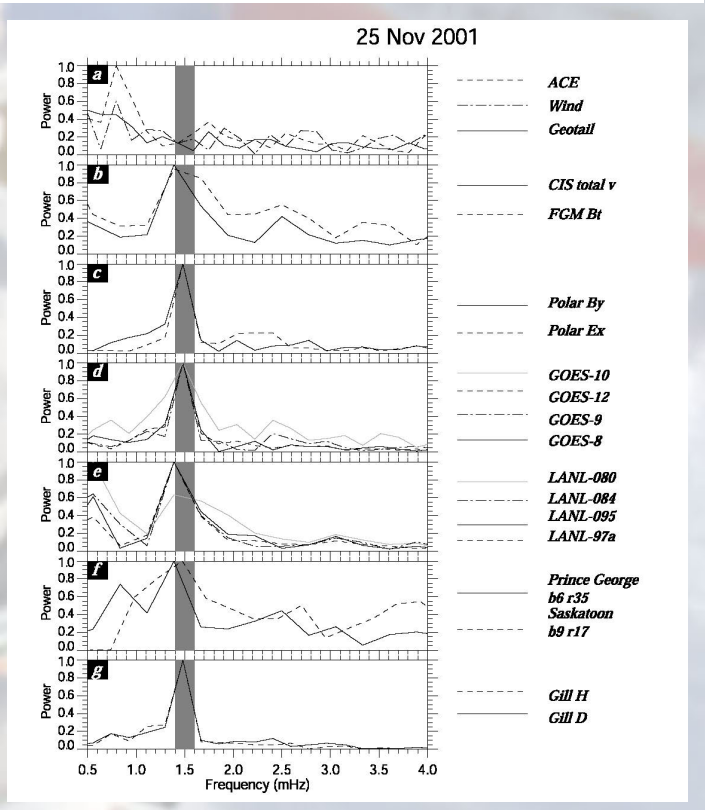
2) Rae et al., JGR, 2005









- Multiple SC event – including clear GB and Polar SC E- and B-fields.
- Nice global MHD test case?

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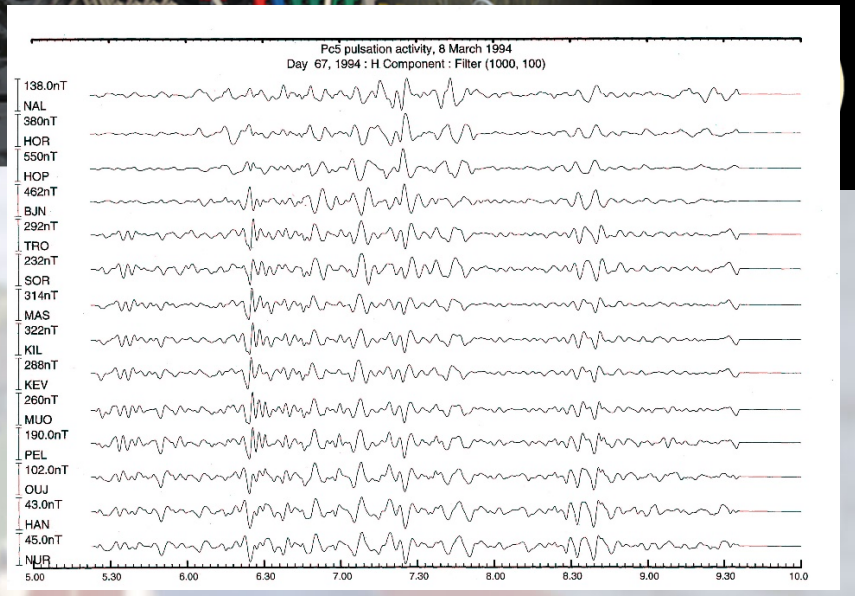
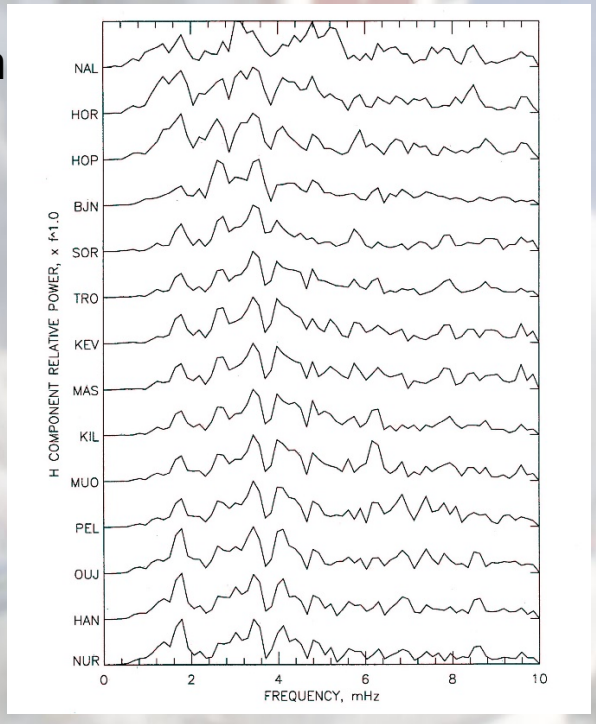
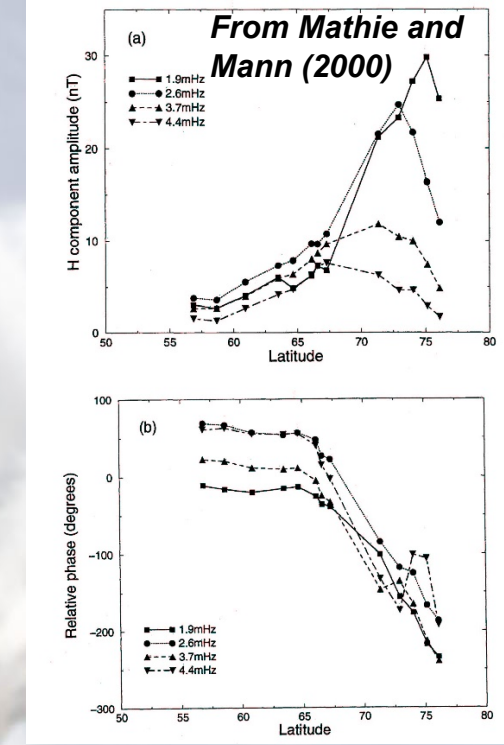
3) Multiple Waveguide Harmonic Driven Discrete FLRs in Global MHD.

- Mathie et al., JGR, 1999; GRL,1999; Mathie and Mann, 2000. Studies of multiple waveguide modes as seen on the ground. ***Can MHD models reproduce more than 1 radial waveguide harmonic?***

- Mathie and Mann (2000) suggested common azimuthal phase speed as diagnostic of SW driven waveguide-FLRs***. Is this seen for fast Vsw cases?***







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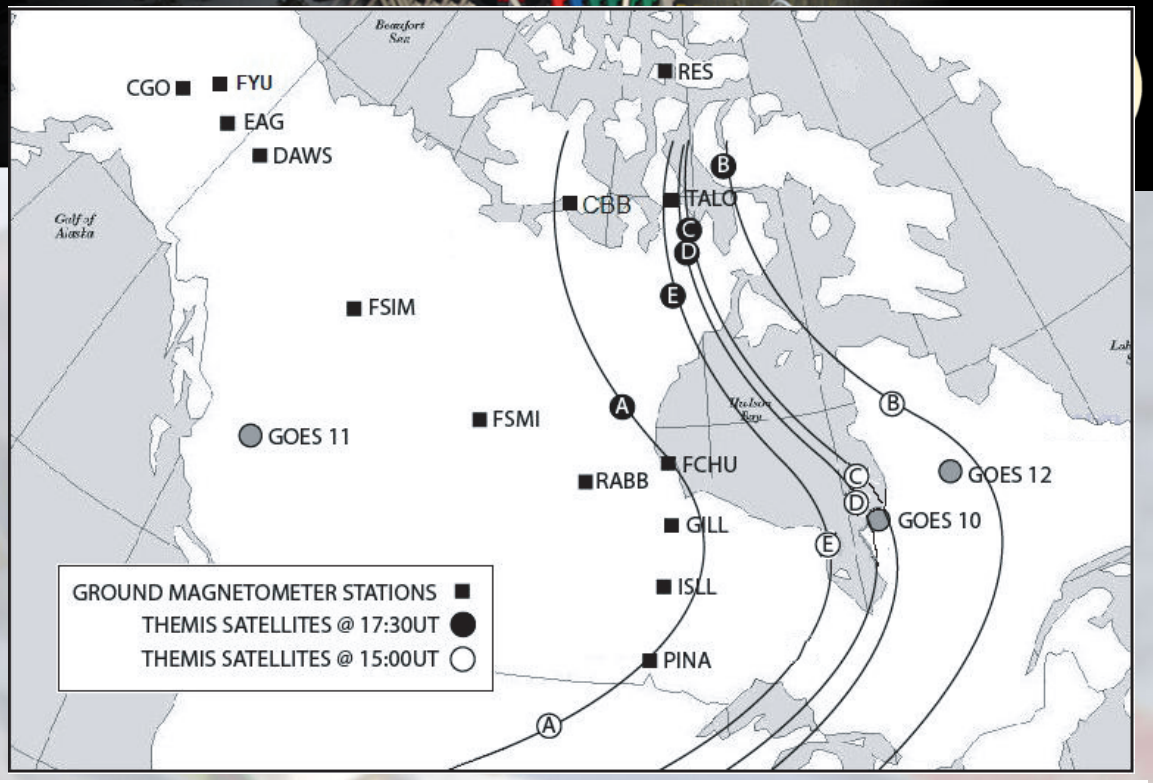
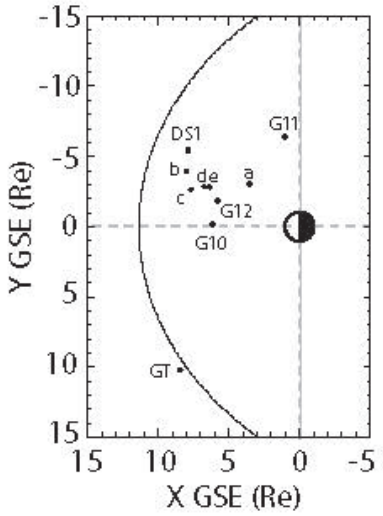
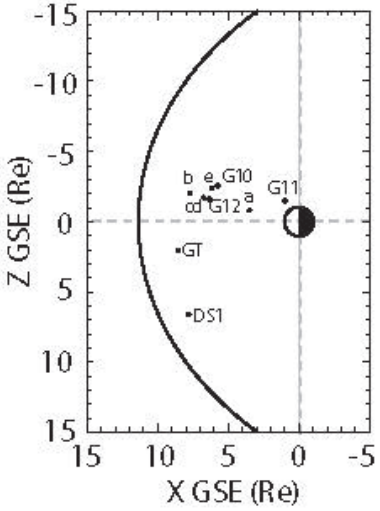
4) Multiple THEMIS satellite and Geotail observations of Flank Waveguide mode (?)

- (Manuscript in preparation) Multiple THEMIS satellite study of waveguide modes on the flank, with CARISMA coverage magnetically conjugate below.







a = THEMIS A
b = THEMIS B
c = THEMIS C
d = THEMIS D
e = THEMIS E
G10 = GOES 10
G11 = GOES 11
G12 = GOES 12
DS1 = Doublestar 1
GT = GEOTAIL

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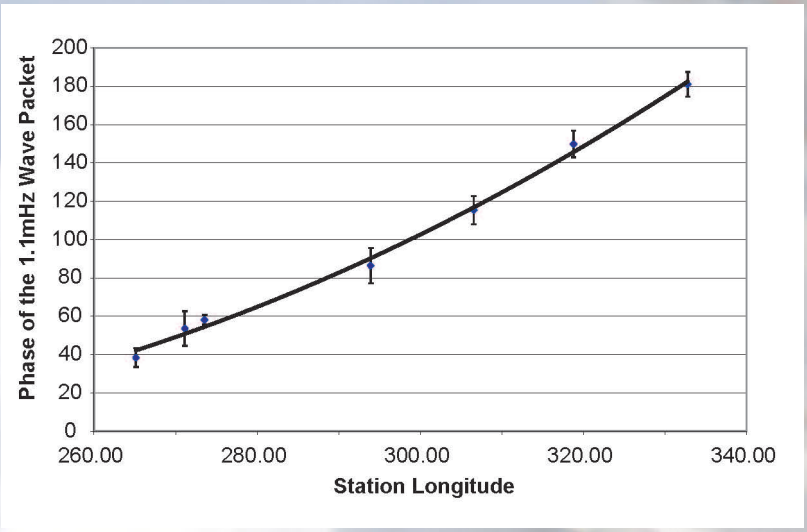
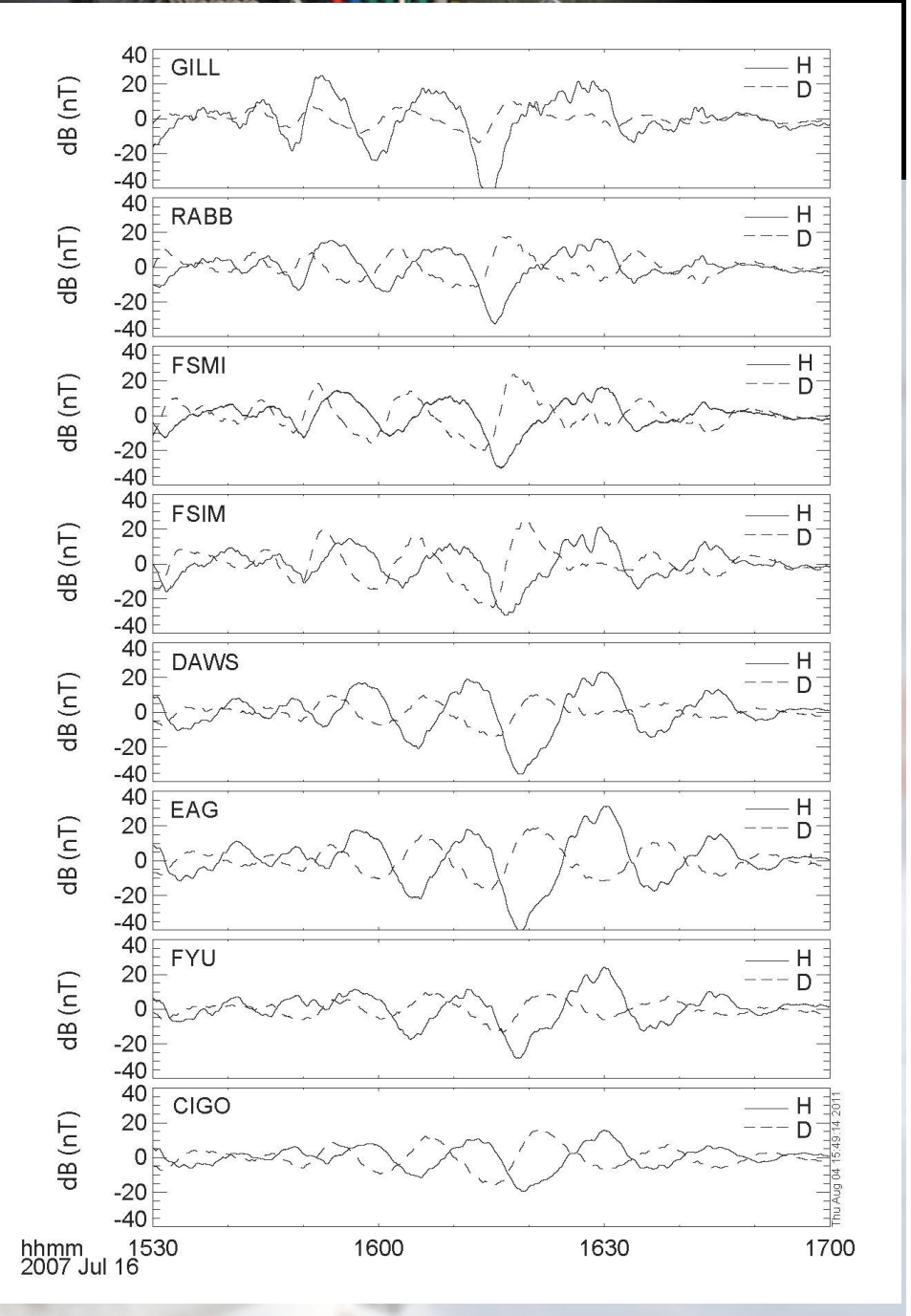
- Geotail sees magnetopause oscillations at same frequency as ULF waves.

- Clear propagation and phase characteristics seen on ground and in the THEMIS spacecraft wavepackets.



- ***FLRs in the auroral zone seem absent. Possible FLR response confined to very high L close to last closed field line and MP. Why?***



5) Find examples of “simple” drivers such as single solar wind impulse in Van Allen Probes era.

- Suggest we select some dayside apogee Van Allen Probe events in the 18 UT time interval in response to solar wind impulses.
- For such UT the CARISMA array and GOES satellites provide coverage on continent scale with which to examine response to ``simple`` solar wind dynamic pressure pulses.
- Events to be selected…..
- And then modelling comparisons with global MHD….