The Effects of Pulsed Ionospheric Flows on EMIC Wave Behaviour

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Talking Points

- Continuous ULF Pulsations (Pc)
  - Frequency band 0.1-1.4 Hz (Pc1)
  - Observed on the ground between 56°-76°Mlat
- Pulsed Ionospheric Flows
  - Observed by han and pyk radars
- Ion Upwelling
  - Enhanced temperature and upward velocity

Key Observational Methods

- Finnish Pulsation Magnetometer Chain
- SUPERDARN
- EISCAT

Pc1-2 (0.1-5Hz) Pulsation phenomenology

- Magnetospheric generation is predominantly equatorial. (Loto'aniu et al. 2005)
- Generation has been associated with but is not necessarily bound to occur near the plasamapause. (Fraser and Nguyen 2000)
- "Normal", left-hand polarised, Alfvénic mode is fieldline guided.
- Conversion to non-guided modes can occur through:
  - Interaction with heavy ions.
  - Coupling to the conducting ionosphere.
- Ground observations are dependent on:
  - Magnitude of driving instability.
  - Propagation path.
  - Dissipation mechanism.

- Associated with:
  - Cusp region: Short lived unstructured Pc1 pulsations (Menk et al. 1992).
  - Reconnection events: anisotropic magnetosheath ions (Safargaleev et al. 2004).
  - Spectral width enhancements in artificially induced SUPERDARN backscatter coincident with Pc4 ULF wave activity (Wright et al. 2004).

ElectroMagnetic Ion Cyclotron (EMIC) Waves

- Wave growth occurs through wave-particle resonance.
- Pulsations occur in the Pc1-2 band (0.1-5 Hz).
- Instability driven by temperature anisotropy

Incident wave frequency, Doppler shifted in to the frame of the ion, must satisfy the resonance condition.

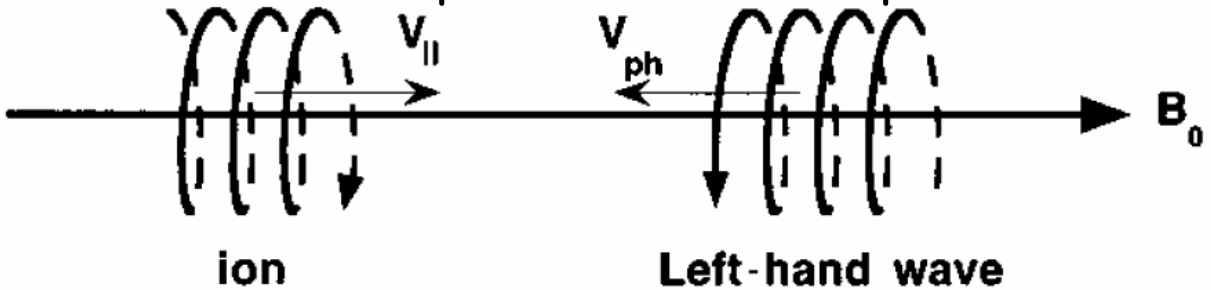
$$\omega - k.V = n\Omega$$

ω = wave frequency, k = wave vector
Ω = local gyrofrequency of the n^{th} harmonic order

$$T_{\perp} > T_{//}$$

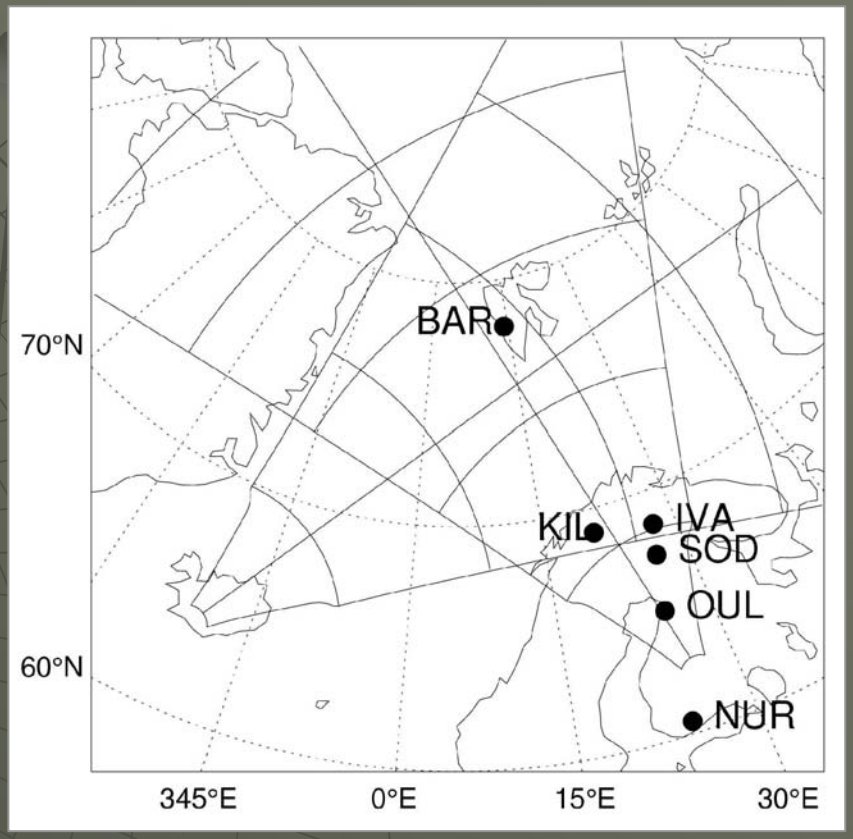
Perpendicular ion temperature must greatly exceed Parallel Temperature.

Normal Ion Cyclotron Resonance involves a left hand polarised electromagnetic wave coupling with a temperature-anisotropic ion



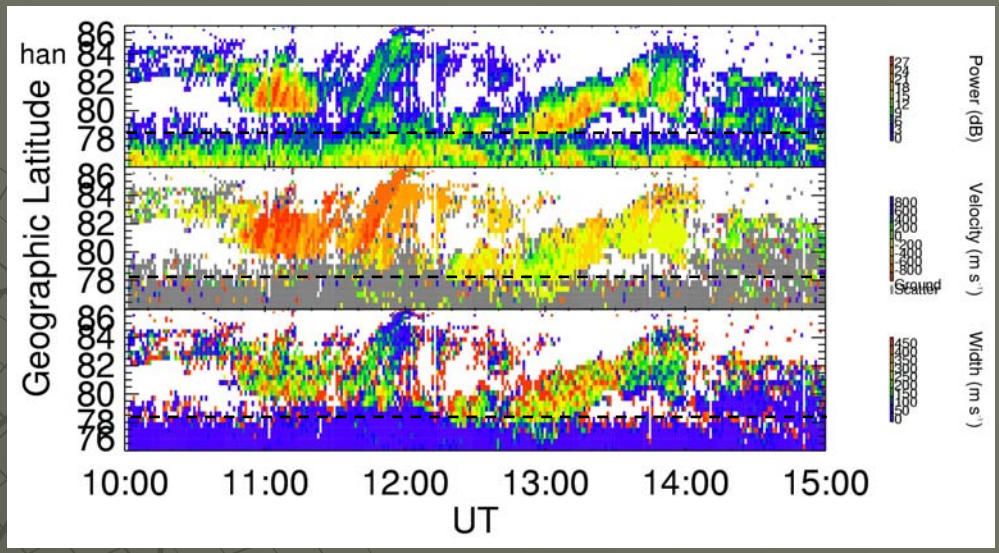
Finnish Pulsation Magnetometer Chain

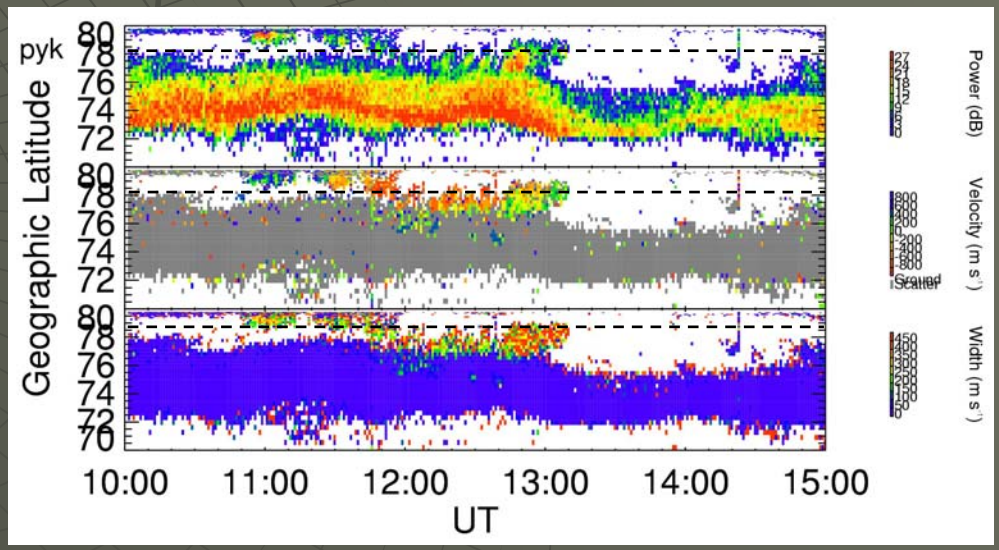
- Lowest Latitude station at Nurmijärvi, Finland.
- Highest latitude Station Located in Barentsburg, Svalbard.
  - ~40km from the ESR.
  - In the field of view of CUTLASS.
- Triaxial induction coil magnetometers (H,D,Z).
- 40Hz sample rate.
- Optimised response at 1 Hz.



Pulsed Ionospheric Flows

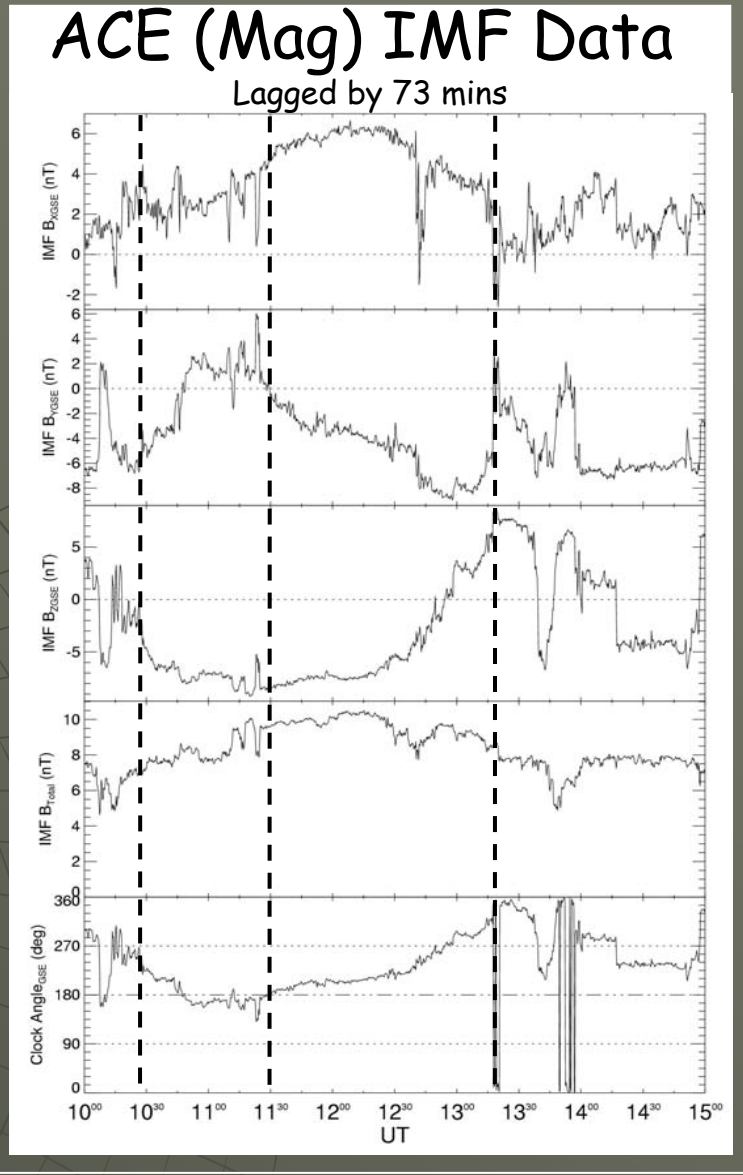
- September 25th 2005.
- At ~10.40 Pulsed Ionospheric Flows (PIFs) are observed in Hankasalmi Radar
- A short time later PIFs/PMRAFs observed in Pykkvibaer Radar.
- Flows persist for ~2.5 hours.





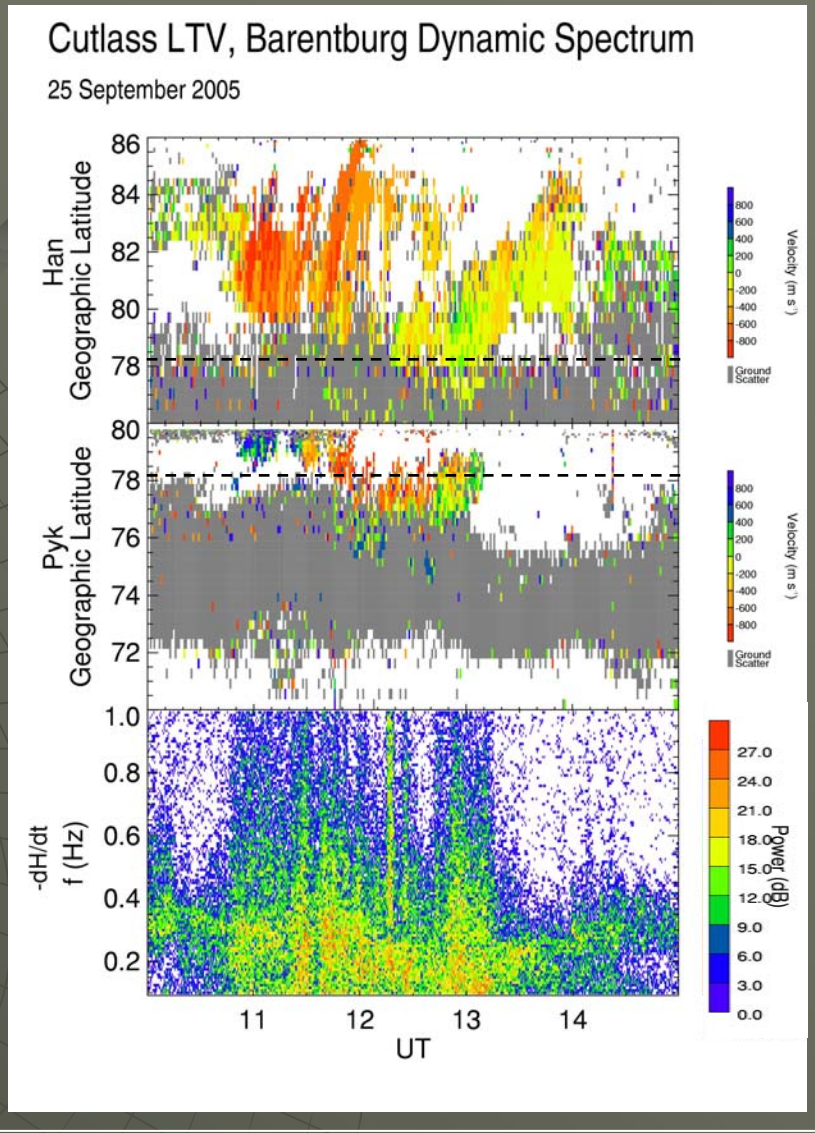
IMF Conditions

- ~10.30 B_z becomes strongly negative and remains so for the remainder of the interval.
- ~11.30 B_y negative at UT
- ~13.30 quiescent conditions return



Simultaneous PIF-Pc1 Observation

- Pc 1-2 pulsations of frequency 0.1-0.2 Hz occur simultaneously.
- Pulsations contain a distinct band limited substructure.
- Pulsations are not limited to observed PIF interval.



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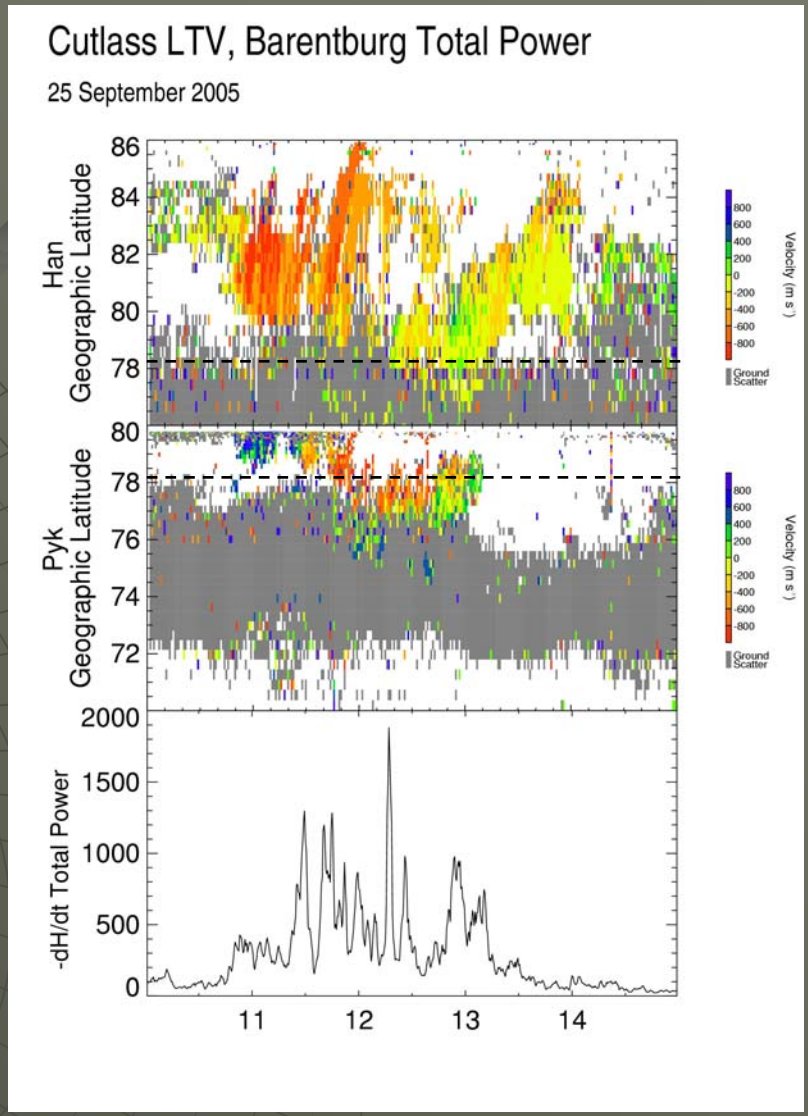

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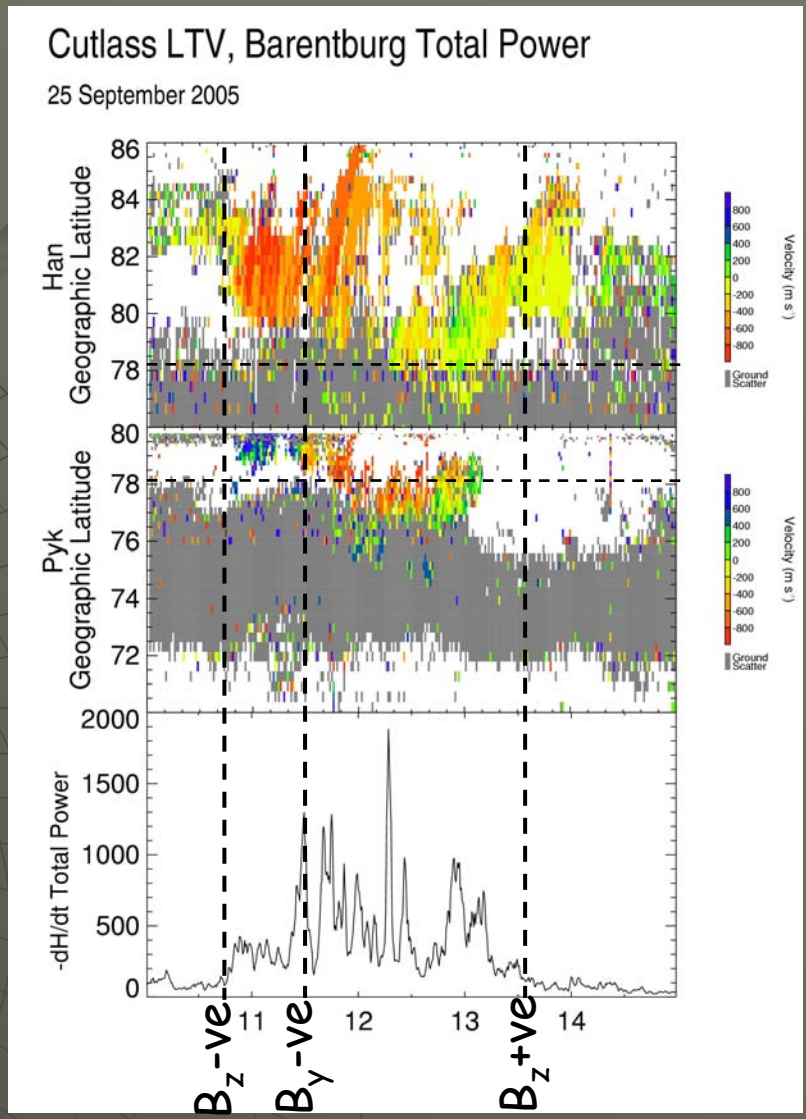
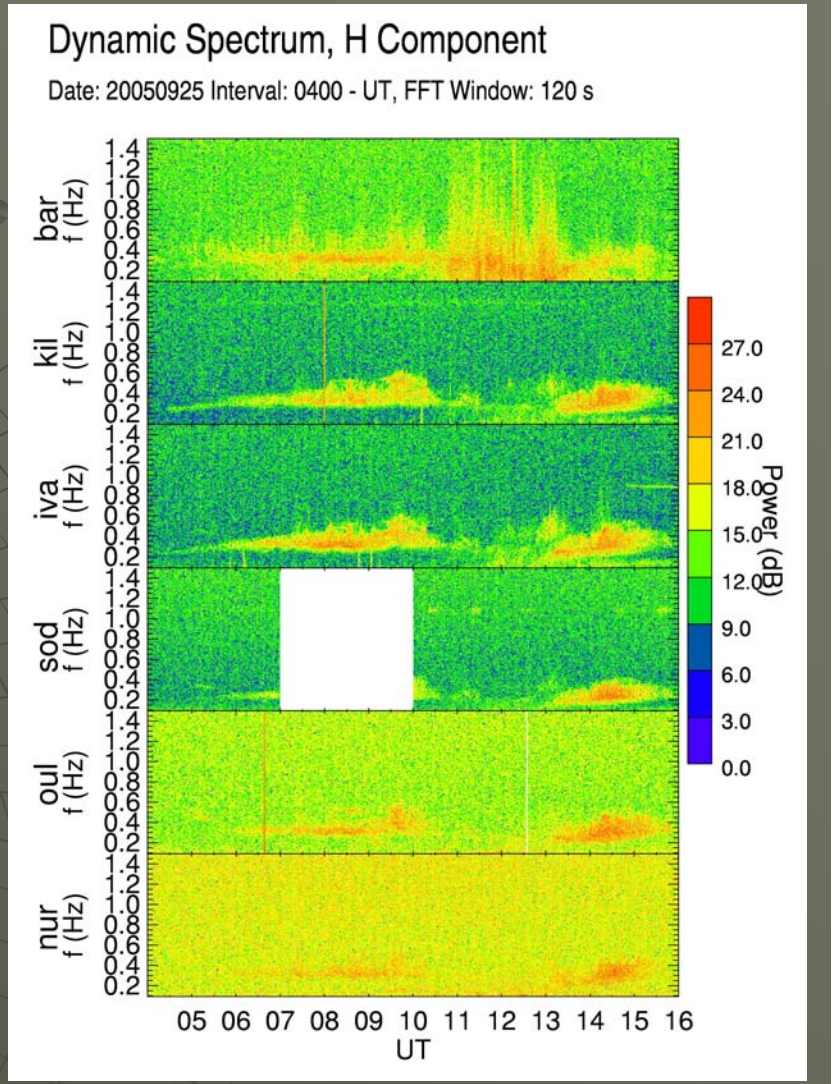


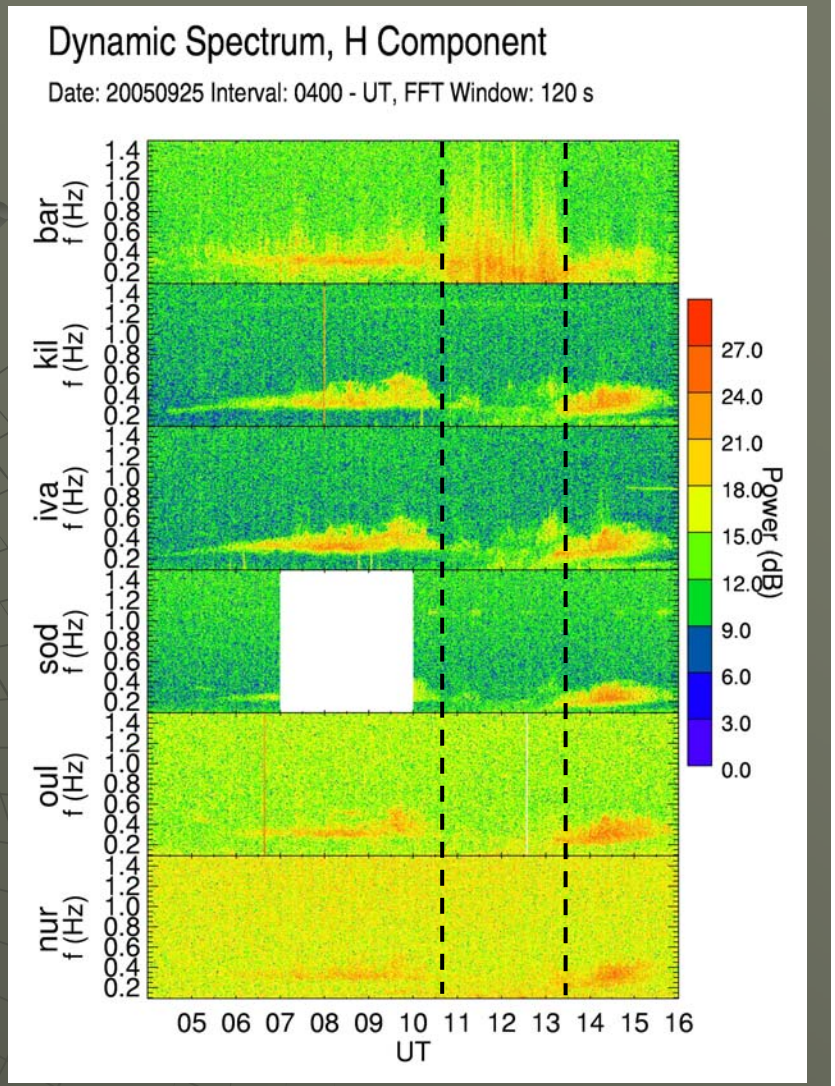
Cross Latitude Pulsations

- Full latitudinal range of the Finnish Pulsation Magnetometer Chain
- Activity outside PIF interval appears to have source region at much lower latitude.
- Significant drop in activity in lower latitude stations during the period of poleward flows.



Cross Latitude Pulsations

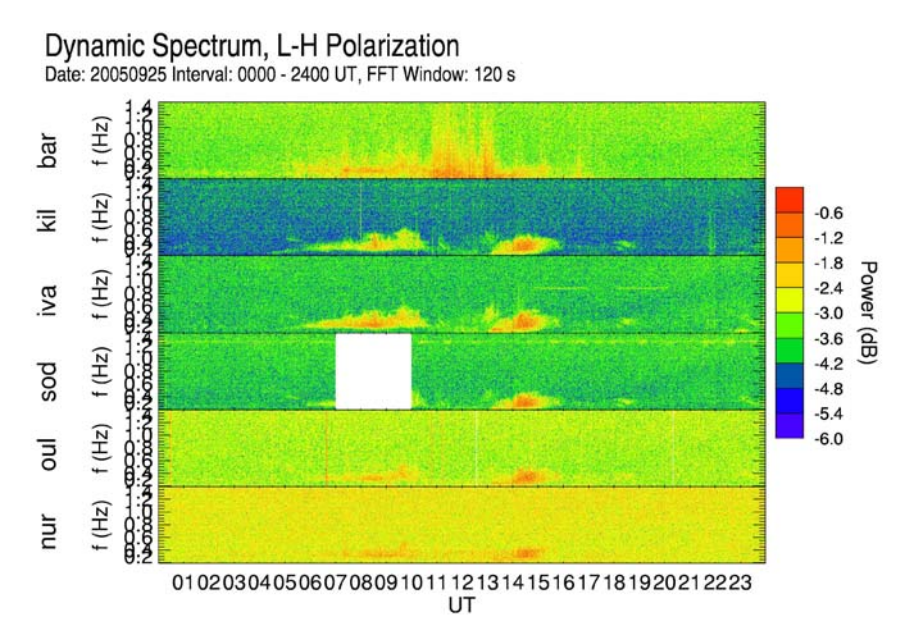
- Full latitudinal range of the FPMC
- Activity outside PIF interval appears to have source region at much lower latitude.
- Significant drop in activity in lower latitude stations during the period of poleward flows.
- Central frequency of return from drop out is marginally lower

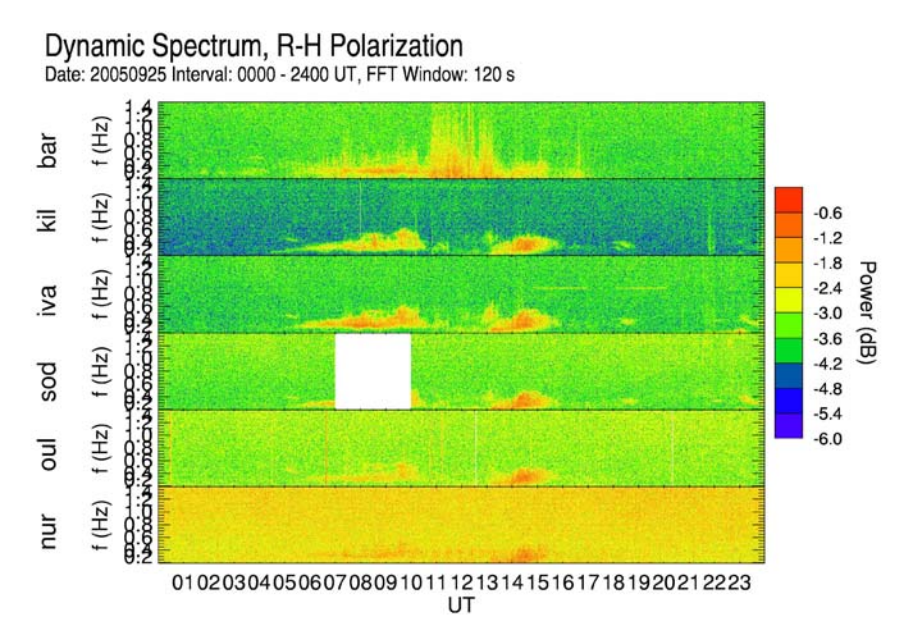


Polarisation Features

- Significant right hand polarisation power.
- Right hand polarisation shows greater horizontal propagation from lower latitude source

- Possible explanations
  - Mode conversion via heavy ion coupling
  - Mode conversion through conducting ionosphere coupling
  - Anomalous cyclotron resonance





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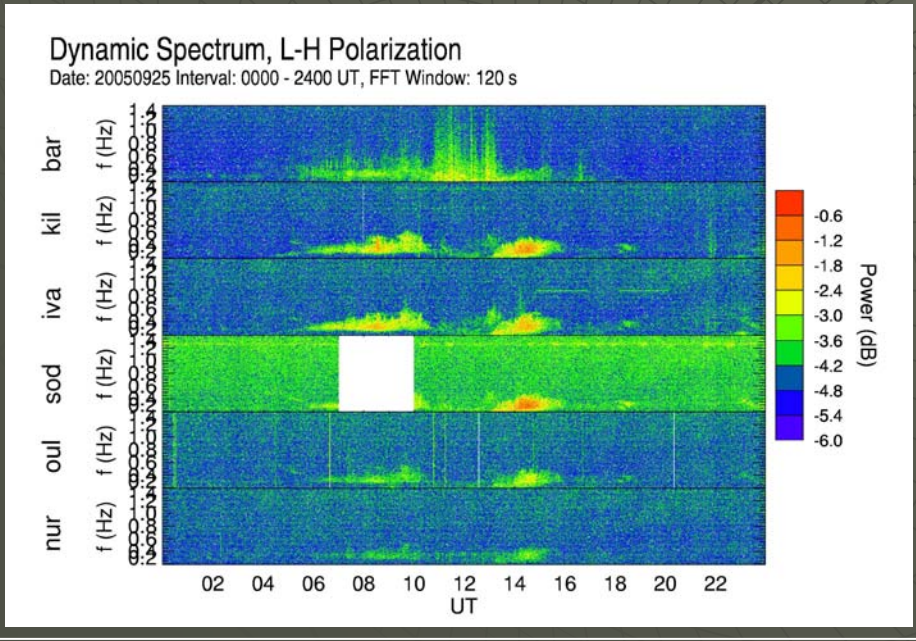
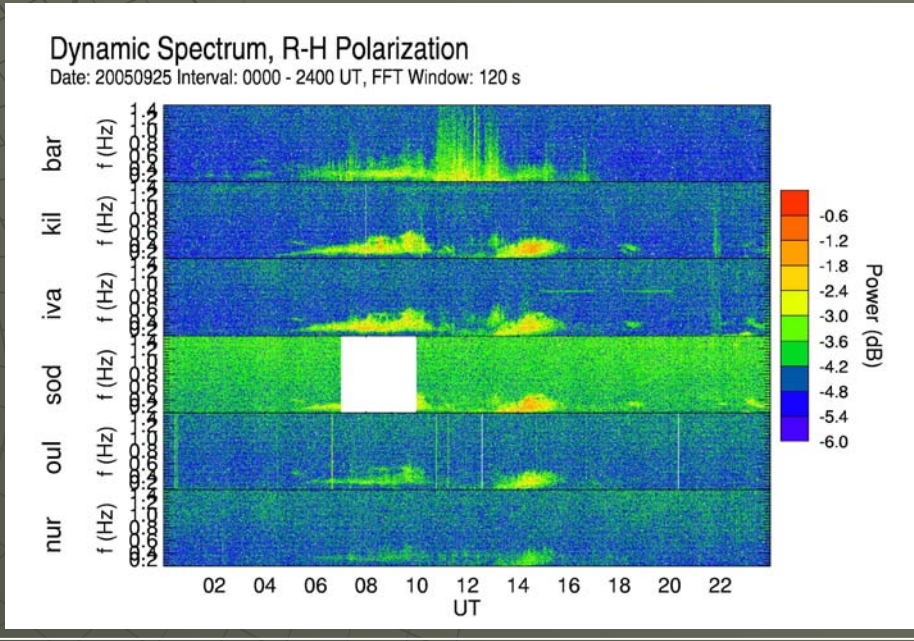
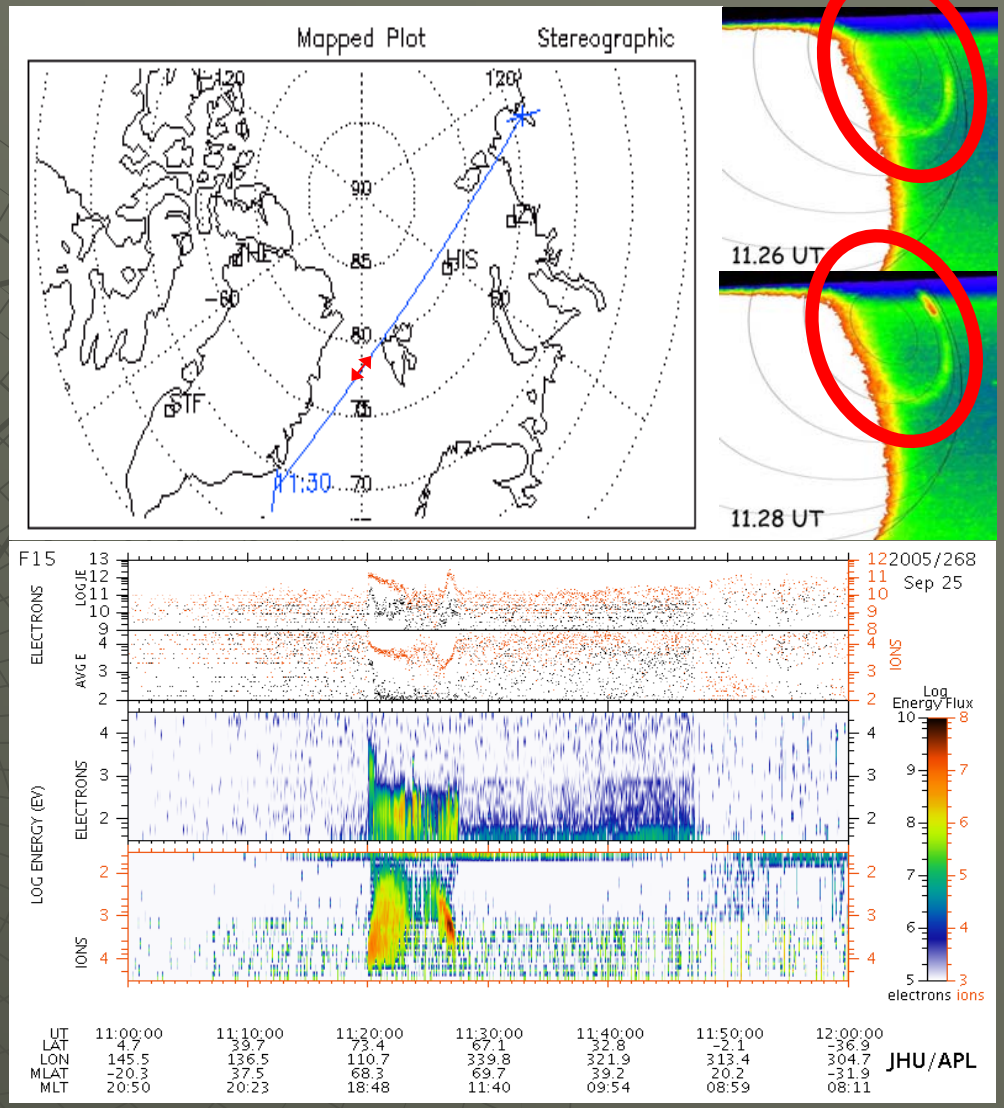




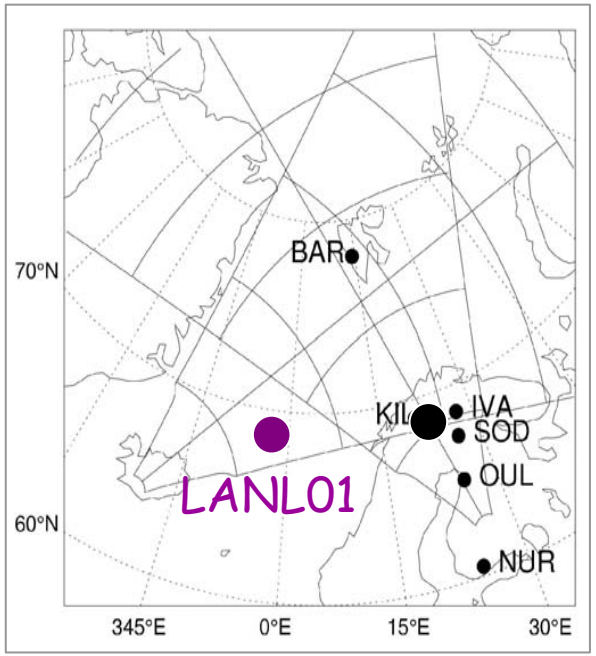
DMSP Cusp Signature

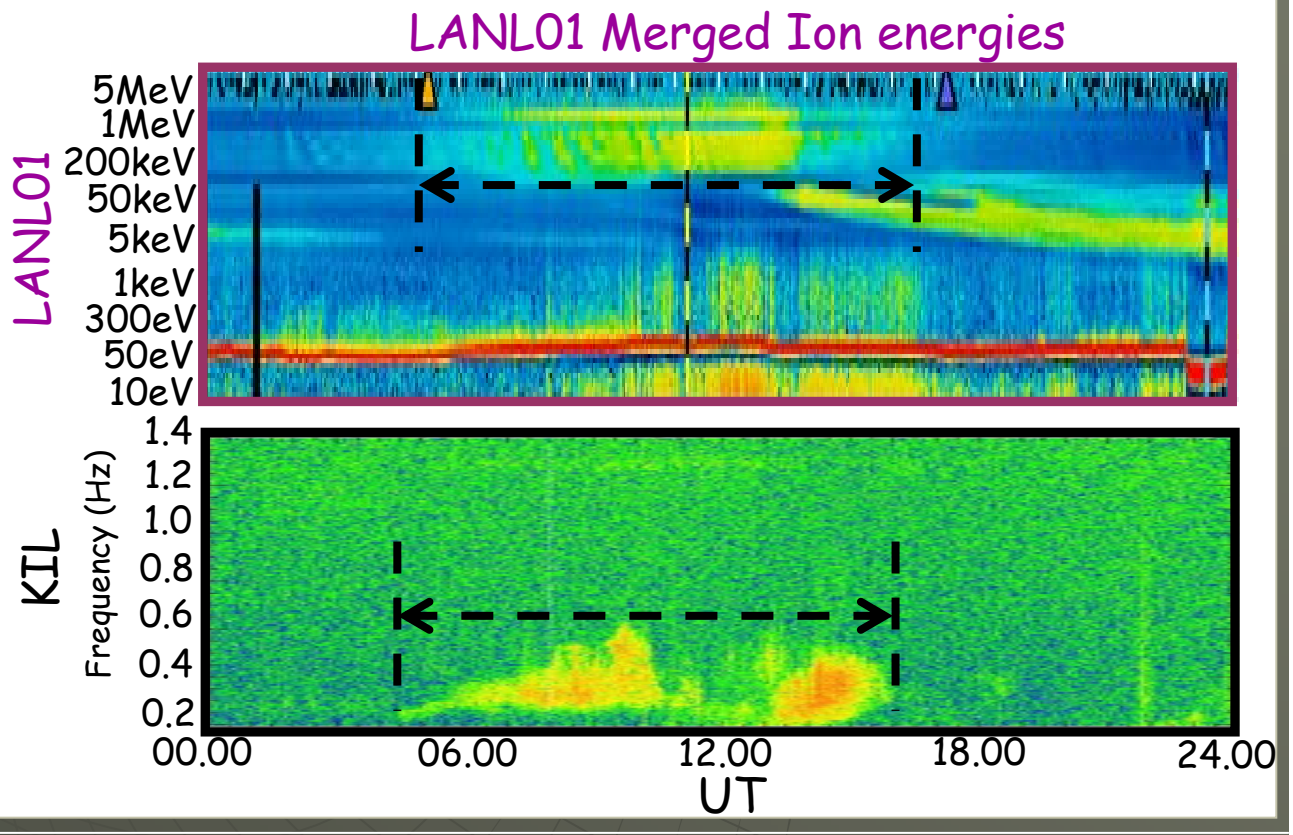
- DMSP F15 conjunct at ~11:26
- Dispersed ion cusp signature at 11:26:30-11:27:20
- Indicates that Barentsburg is close to the northward edge of the cusp proper
- IMAGE (WIC) - substorm aurora at ~11.28 UT



Drifting Energetic Ion Population

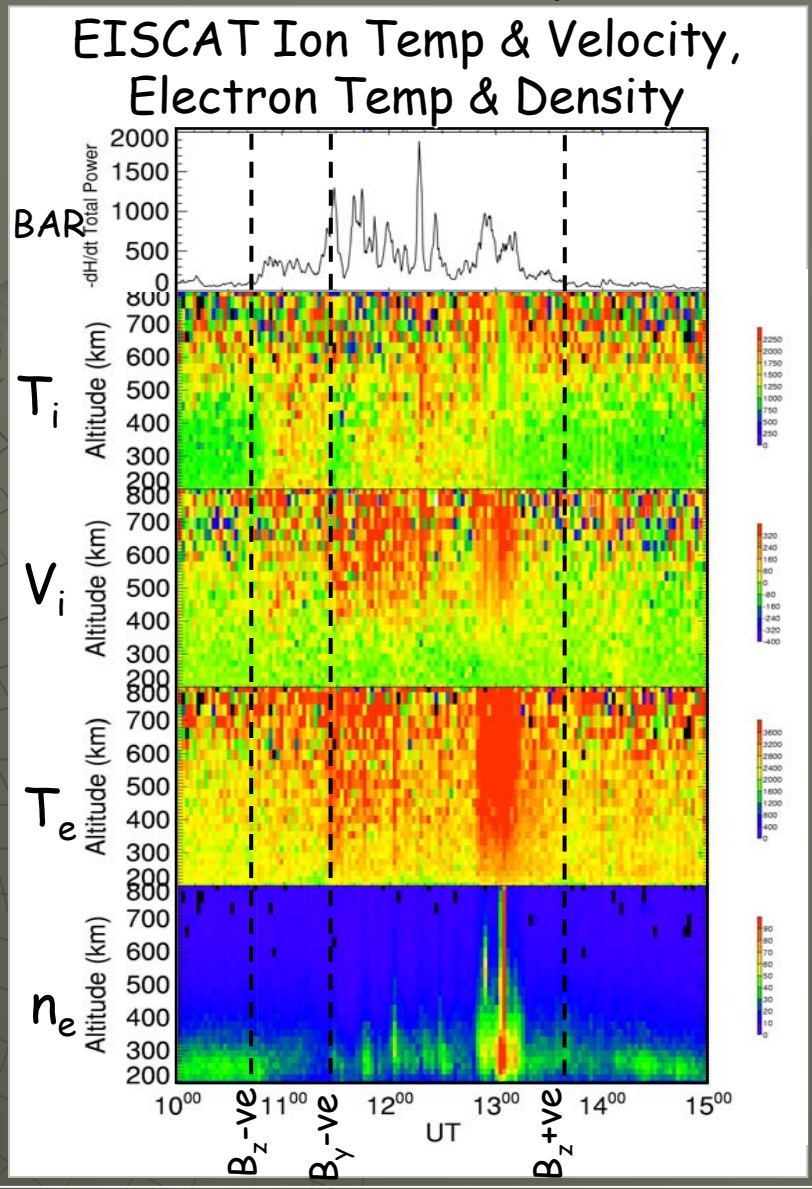
- Drifting ions of energy > 50keV
- Coincident and quasi-continuous during the period of Pc1 pulsation





ESR Ion Temperature Enhancements

- 42m field aligned dish.
- Steffe, common program.
- Ion temperature enhancements.
- Ion upwelling throughout interval.
- Steps in velocity corresponding to B_z –ve and B_y –ve intervals.
- Upward ion flow is consistent with normal cyclotron resonance observed on the ground



Further Work

- Analysis of pulsation substructure.
- Determination of ion temperature anisotropy and interaction with neutrals in the reconnection region.
- Consideration of heavy ion contribution to polarisation characteristics
- Quantify the change in conditions that lead to the curtailing of low latitude wave growth.

Summary

- Presented an interval of Pc1-2 activity over a wide range of latitudes.
- Suggested that the particle population responsible for EMIC wave growth during distinct intervals within the event originated from independent sources.
- Suggested that the Pc1-2 activity is associated with Pulsed Ionospheric flows of reasonably enhanced spectral width.
- Shown that upward ion flow in the region northward of the dayside reconnection site is associated with downward travelling EMIC waves.