SuperDARN and EISCAT observations of SPEAR (Space Plasma Exploration by Active Radar) induced sporadic E-region heating at 78°N

L. J. Baddeley[1], I. Haggstrom[2]

1. UNIS, Longyearbyen, Norway 2. EISCAT Scientific Association, Kiruna, Sweden

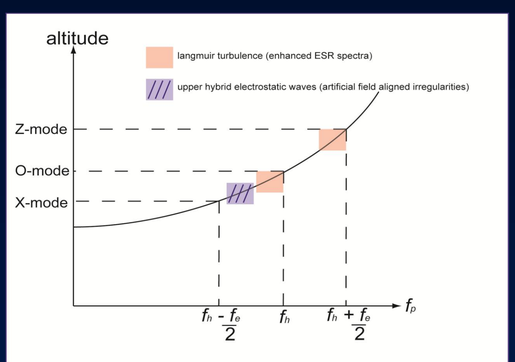
1. SPEAR

- Ionospheric heater located on Svalbard at 78.15°N, 16.05°E
- Co-located with EISCAT Svalbard Radar (ESR) and inside the FOV of CUTLASS radars
- Capable of transmitting between 4.45 - 5.82MHz. Typical Effective Radiated Power (ERP) = 16MW

2. Heater induced ionospheric effects

- Interaction mechanism depends upon ionospheric plasma density f(f_p), heater frequency, f_h
- Generation of field aligned irregularities occurs at upper hybrid height ///
- Enhanced langmuir turbulence at O and Z mode reflection height
- Condition for O to Z mode conversion:

$$f_h < f_0F_E < f_h + (f_e/2)$$



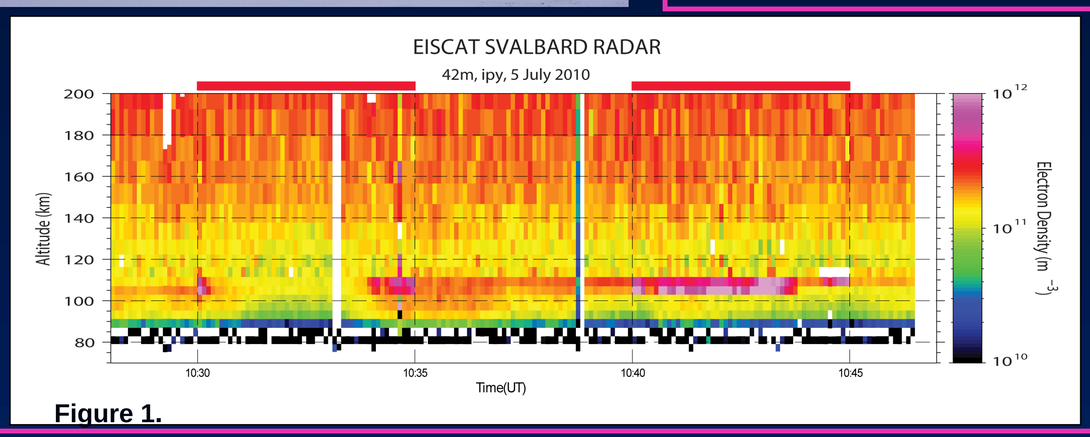
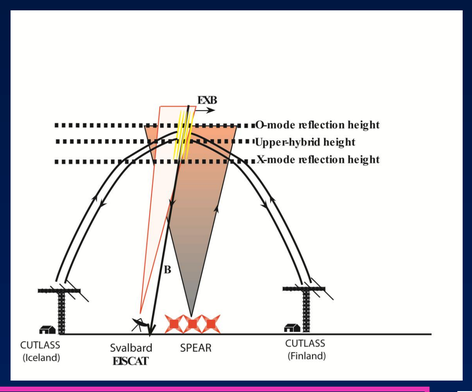


Figure 1.



3. Experimental Set Up

- SPEAR: O mode polarisation, f_h = 4.45MHz, Tx ON: 10:30-10:35 10:40-10:45
- ESR and SPEAR pointing Field Aligned (182.1° az., 81.6 ° el.)
- f_0F_E= 4.776MHz, f_0F_2~ 4.6 – 4.7MHz f_e~1.466MHz @110km

4. EISCAT Observations

- Naturally occurring sporadic E-layer observed as electron density enhancements in ESR data 10:27-10:47UT (figure 1)
- Plasma line enhancements at SPEAR heater frequency, f_h, during heater on period (10:30 – 10:35UT, 10:40 – 10:45UT) evident in E-region data (figure 2a and 2b)
- First observations of O- to Z-mode conversion resulting in simultaneous enhancements at bottom and top-side of a sporadic E-layer at 107.5 and 108.5km (figure 3)
- Reduction and disappearance of enhancements between 10:43:12 and 10:44:24 suggest disappearance of sporadic E-layer allowing propagation of heater beam into the F-region
- Plasma line enhancements at 10:44:24 at higher altitude (113km) are consistent with re-appearance of E-layer

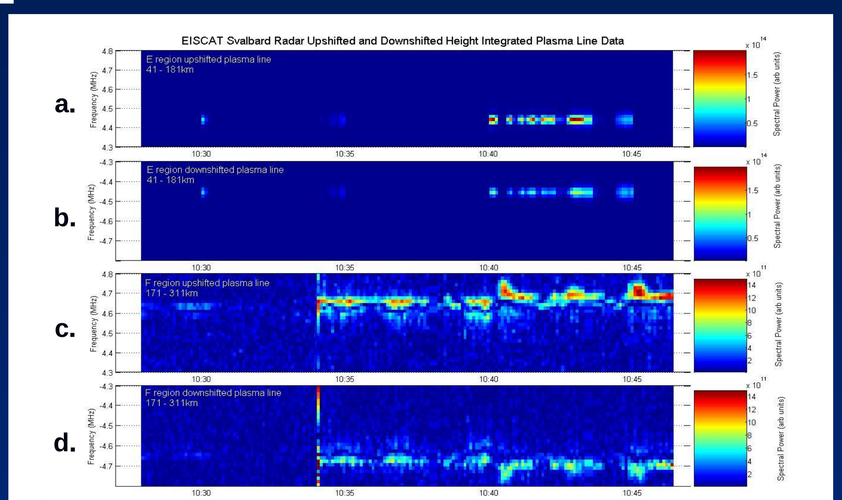


Figure 2.

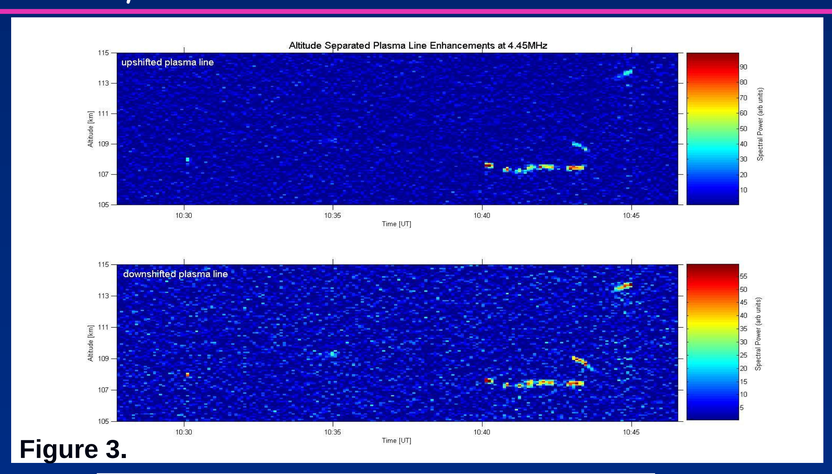


Figure 3.

5. SuperDARN Observations

- Backscatter observed using Hankasalmi radar at SPEAR latitude (78.15°N) during ESR observations of sporadic E-layer (figure 4 and 5)
- Additional backscatter patch observed at 10:43:18UT which coincides with disappearance of sporadic E-layer plasma line enhancements (figure 6)
- Disappearance of sporadic E-layer at 10:43UT allows SPEAR beam to propagate to F-region where artificial field aligned irregularities (AFAIs) are generated at F-region upper hybrid height
- Return of E-region results in absorption of heater beam at lower altitudes, quenching AFAI generation

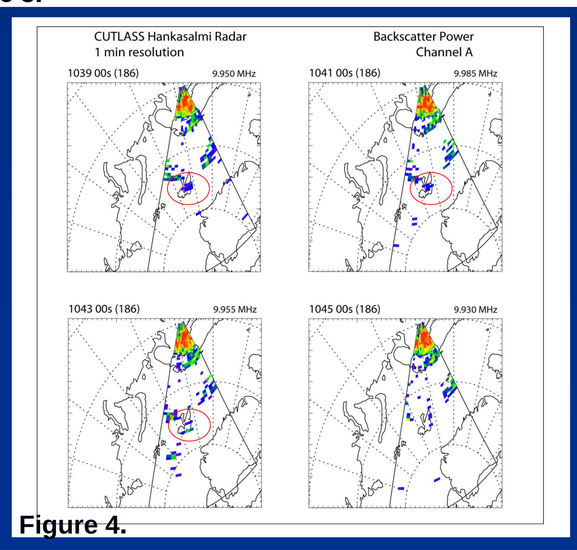


Figure 4.

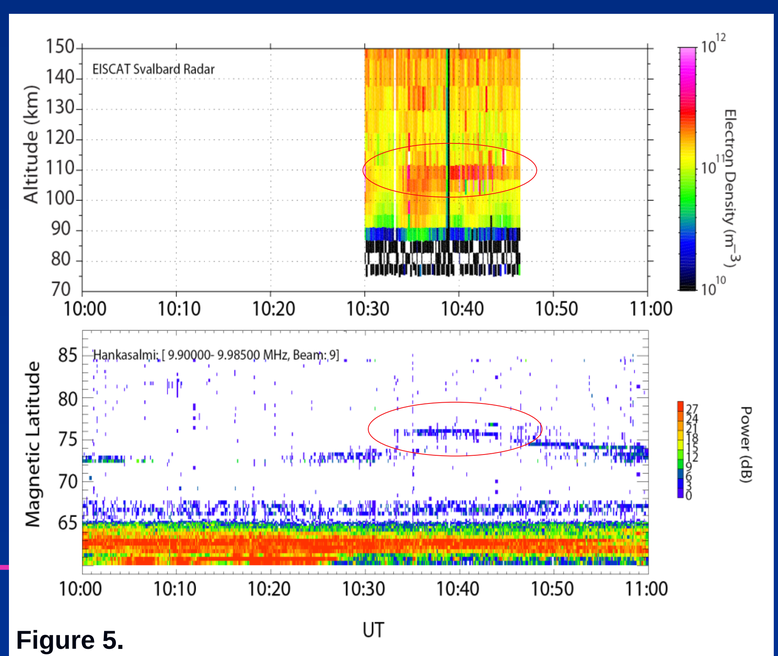


Figure 5.

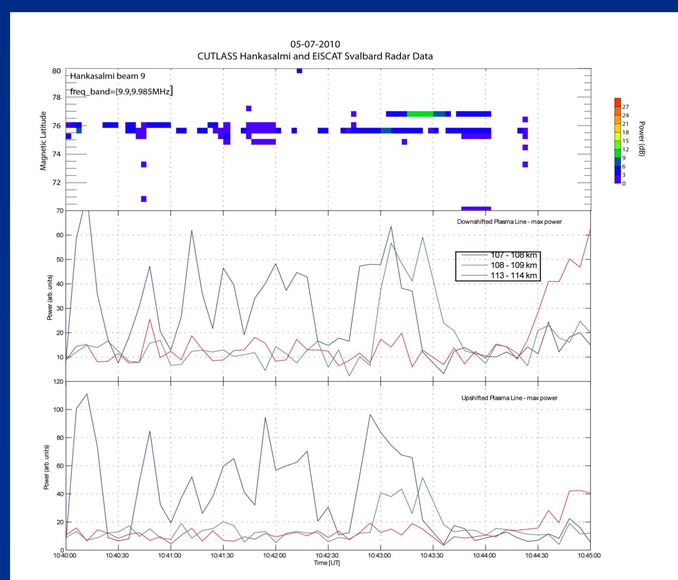


Figure 6.

6. Altitude of backscatter?

-Z-mode enhancements observed outside Sptize angle -requires presence of FAI (Mishin et al. 2001)

<u>F-region irregularities observed</u> (most likely due to propagation path)

- SPEAR ERP~16MW (AFAIs possibly generated in E-region but not observed)
- AFAIs appear at higher latitude than naturally occurring FAIs (SPEAR heater region often ~10 range gates (cf. Vickers poster fig 5.))

<u>E-region irregularities observed</u> (provide evidence for scattering of Z-mode outside Spitze angle)

- AFAIs appear in F-region – interpreted as backscatter from higher latitudes
- Lack of observed FAIs at 10:44:06 supports theory that Z-mode enhancements require FAI for scattering outside Spitz angle

7. Conclusions

- First evidence of O to Z mode conversion of SPEAR beam resulting in simultaneous enhanced langmuir turbulence at top and bottomside of a naturally occurring sporadic E-layer
- Density depletion results in propagation of heater beam to F-region
- Generation of artificial field aligned irregularities (AFAIs), observed by CUTLASS Hankasalmi radar.
- Further work to be undertaken regarding altitude of observed AFAIs

References:

- Mishin, E., T. Hagfors, and B. Isham (2001), A generation mechanism for topside enhanced incoherent backscatter during high frequency modification experiments in Tromsø, *Geophys. Res. Lett.*, 28, 479 – 482, doi:10.1029/2000GL000122