Observation of PMSE with PFISR

2019 - ISR Summer School
Group 5

Thomas Coppeans[1], David Ecoffet[2,3], Kelby Gan[4], Leon Kocjancic[5], Johann Stamm[6], Tomi Teppo[7], Habtamu Wubie Tesfaw[8]

[1] University of Michigan, Ann Arbor, USA
[2] Institut de Recherche en Astrophysique et Planétologie (IRAP), Toulouse, France
[3] Office National d'Études et de Recherches Aérospatiales (ONERA), Toulouse, France
[4] University of California, Santa Cruz (UCSC), United States
[5] Cranfield University, Defence Academy of the United Kingdom
[6] Institute of physics and technology, University of Tromsø (UiT), Tromsø, Norway
[7] Sodankylä Geophysical Observatory, Sodankylä, Finland
[8] University of Oulu, Finland

August 17, 2019

Schedule

What is a PMSE ?

Definition of PMSE

- PMSE: Polar Mesosphere Summer Echoes
- Strong radar echoes from the summer mesopause region

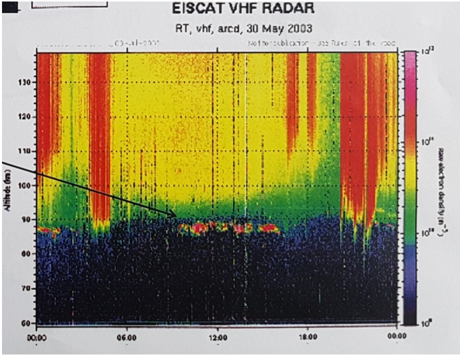

Figure: Example of a PMSE measured with EISCAT [Anita Aikio's exercise]

What is a PMSE ?

Definition of PMSE

- PMSE: Polar Mesosphere Summer Echoes
- Strong radar echoes from the summer mesopause region
- Closely related to the presence of ice particles (which form under the extreme conditions of the polar summer mesopause environment)
- Can last for several hours

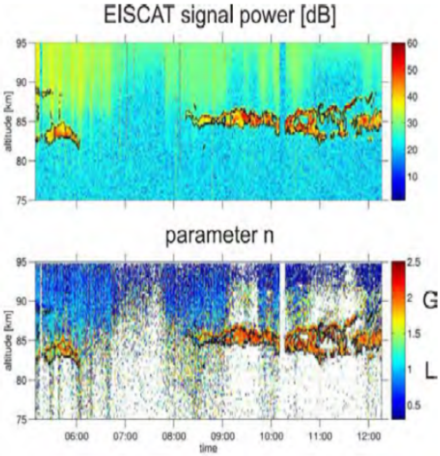

Figure: Example of a PMSE measured with EISCAT [Ian McCrea's presentation]

When / How can we observe them?

Detection

- Most likely to occur between May and early August at altitudes of 80 km to 100 km
- Observable at frequencies between 3 MHz to 1.3 GHz [M. Rapp and F.-J. Lubken, 2004]

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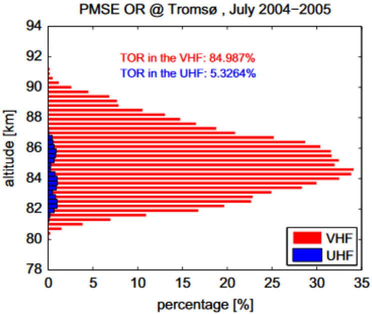


Figure: Comparison of PMSE occurrence rate at 930MHz (in blue) and 224MHz(in red) respectively derived from the EISCAT UHF and VHF observations in July 2004 and 2005 [Li et Rapp, 2010]

The Radar

PFISR : Poker Flat Advanced Modular Incoherent Scatter Radar

- Location 65° 7’12" N 147° 25’48" W
- Geomagnetic dip angle 77° 32’
- Frequency f = 449 MHz
- Wavelength λ = 0.6677 m
- Bragg wavelength $\lambda/2$ = 0.3338 m
- Antenna gain 43 dBi
- Full width half power antenna beamwidth 1°

Figure: P

FISR, Photo: Craig Heinselman, https://amisr.com/amisr

The Radar

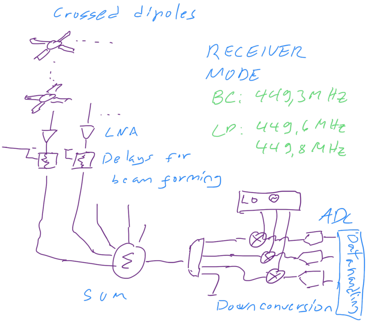


Figure: Receiving mode

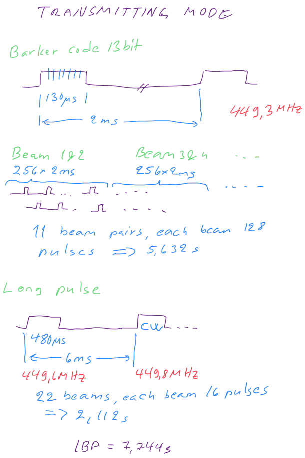


Figure: Transmitting mode

Experiment Geometry

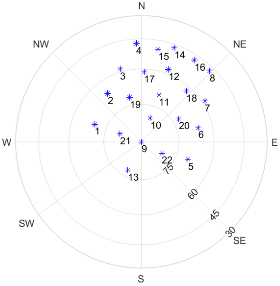


Figure: Elevation-Azimuth skymap of beams

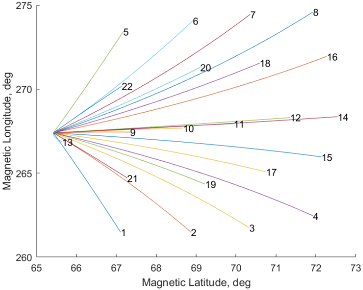


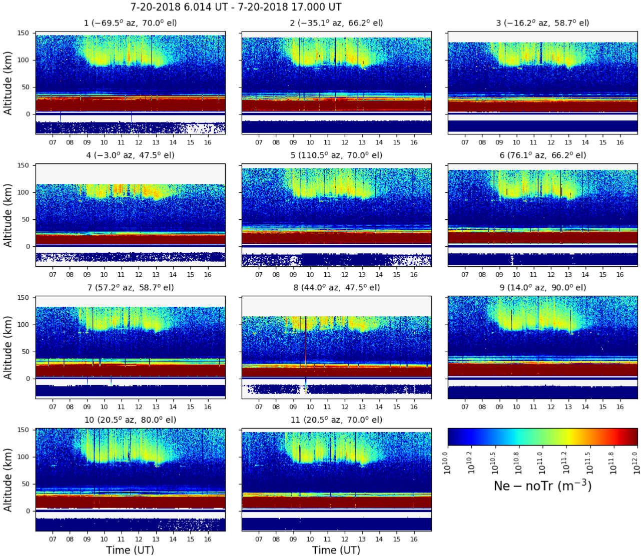
Figure: Beams on magnetic coordinate grid

Summary

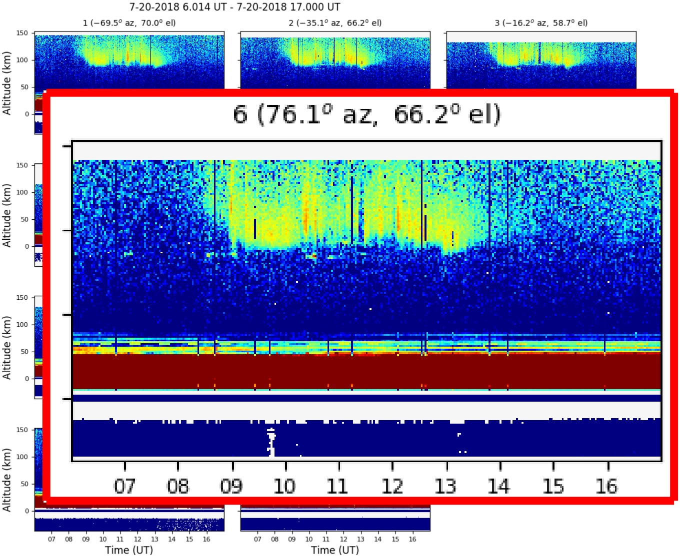
Objective

- Observe PMSEs with PFISR in Alaska
  - Time in Alaska AKST
    21:00 - 23:00 EEST = 18:00 - 20:00 UTC = 9:00 - 11:00 AKST = 7:00 - 9:00 MLT
  - Higher frequency than the EISCAT VHF radar , 449MHz
  - Barker code and long pulse coding
  - 22 beams, one zenith, one magnetic field line aligned 77.5°
- Compare our results with previous results observations using a similar mode

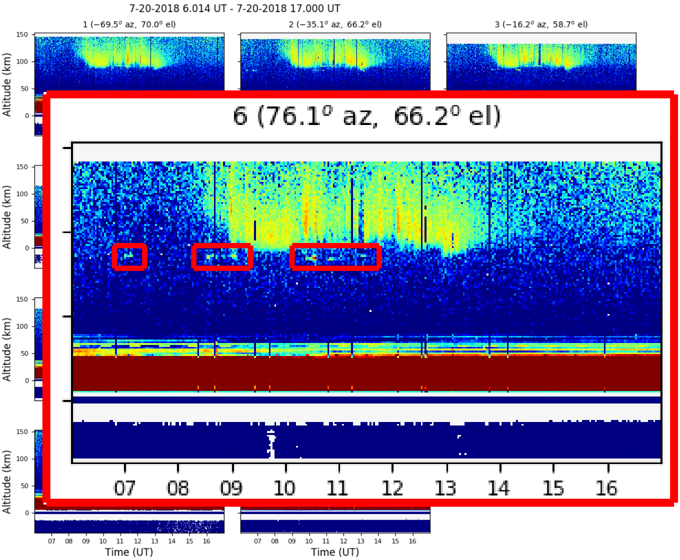
Observation of PMSE



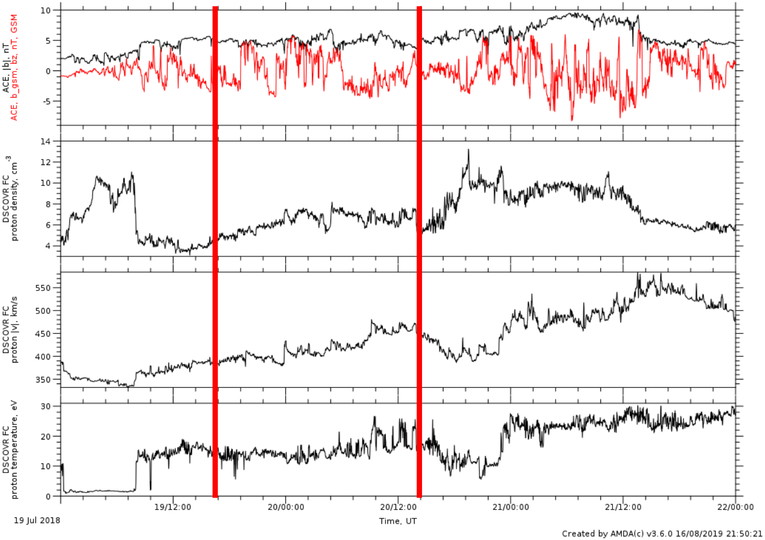
Observation of PMSE



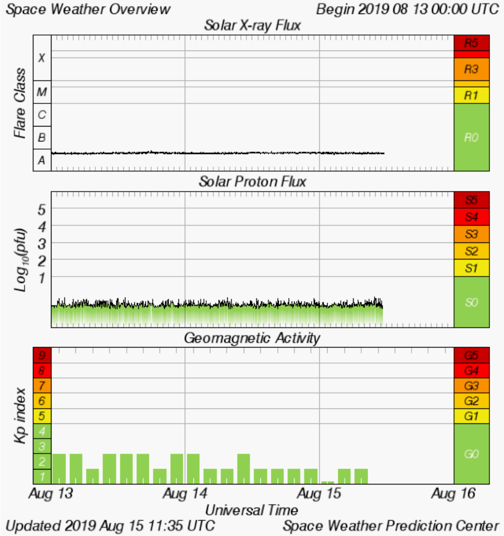
Observation of PMSE



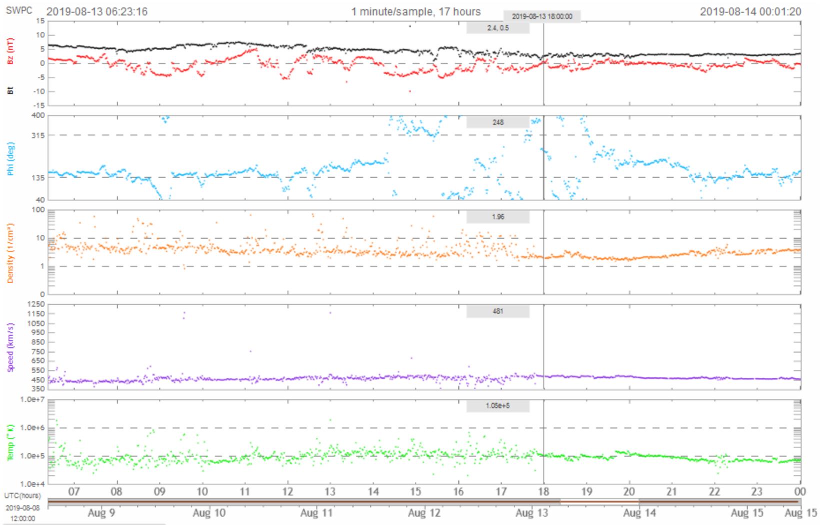
Solar Conditions of July 20th, 2018



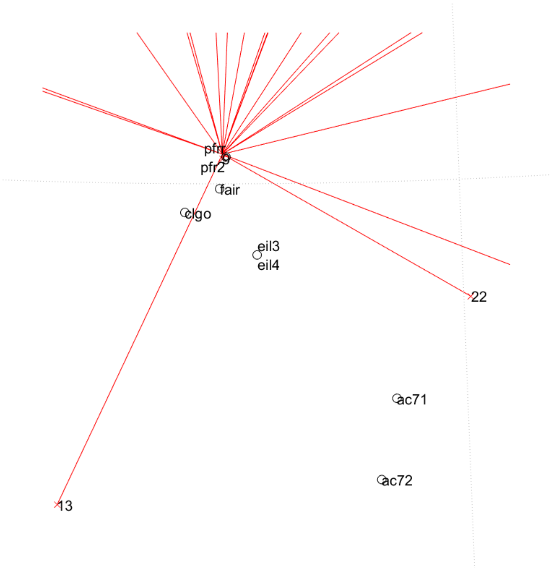
Solar Conditions of Tuesday



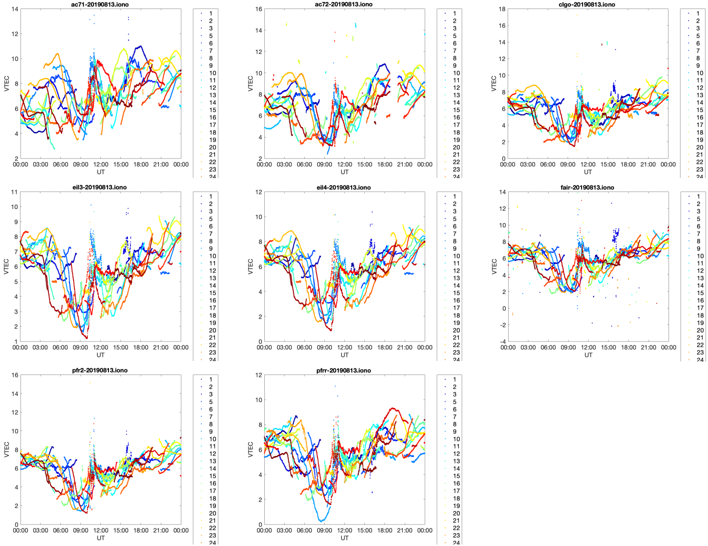
Solar Conditions of Tuesday



TEC



TEC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eil4-20190813.iono
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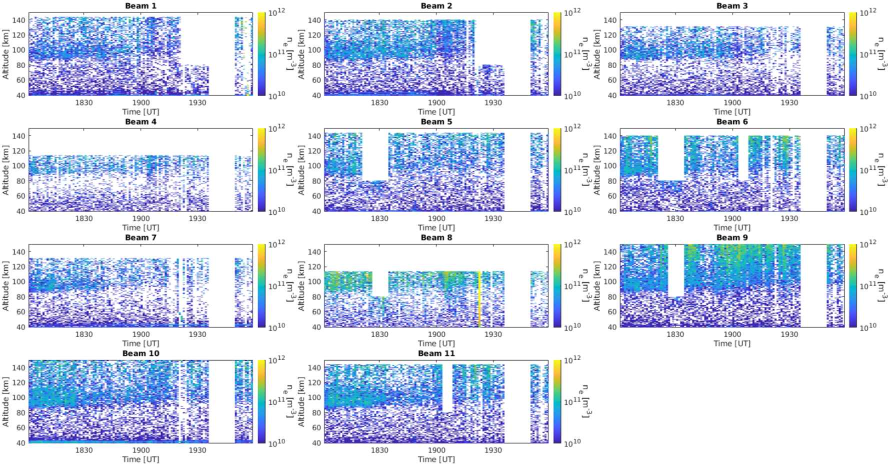
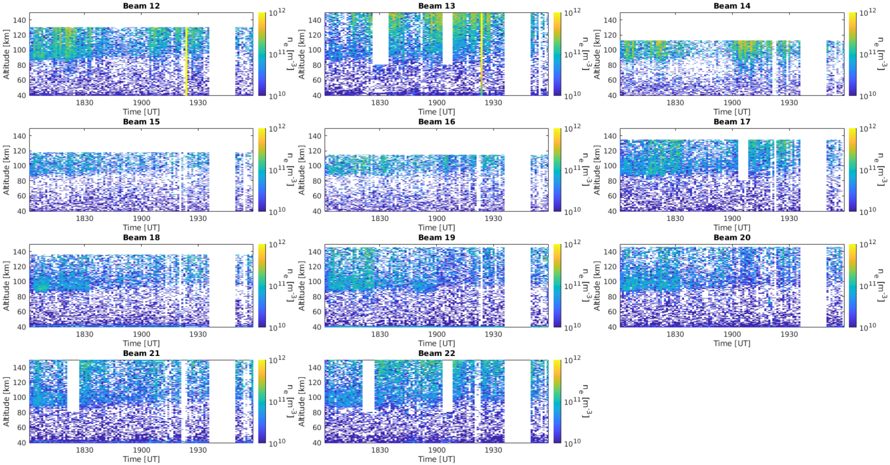
pfr2-20190813.iono
pfrr-20190813.iono
VTEC
UT
00:00 03:00 06:00 09:00 12:00 15:00 18:00 21:00 00:00
1 2 3 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

TEC

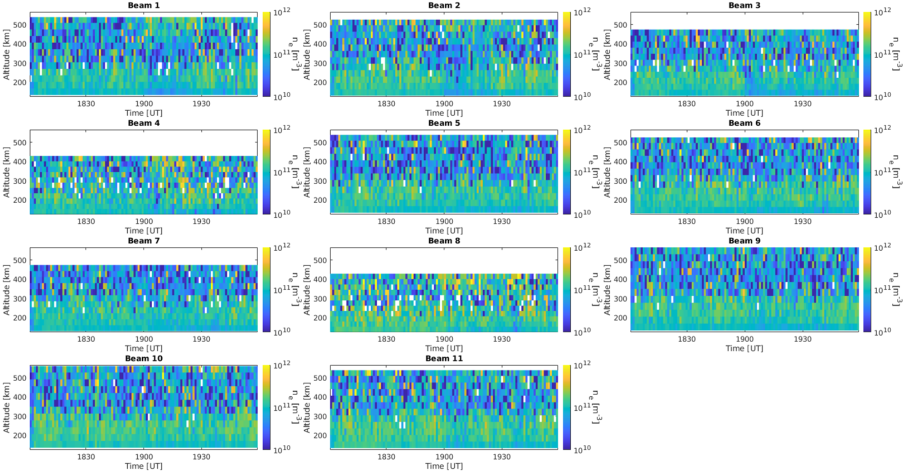
Electron Density - E-layer (1)



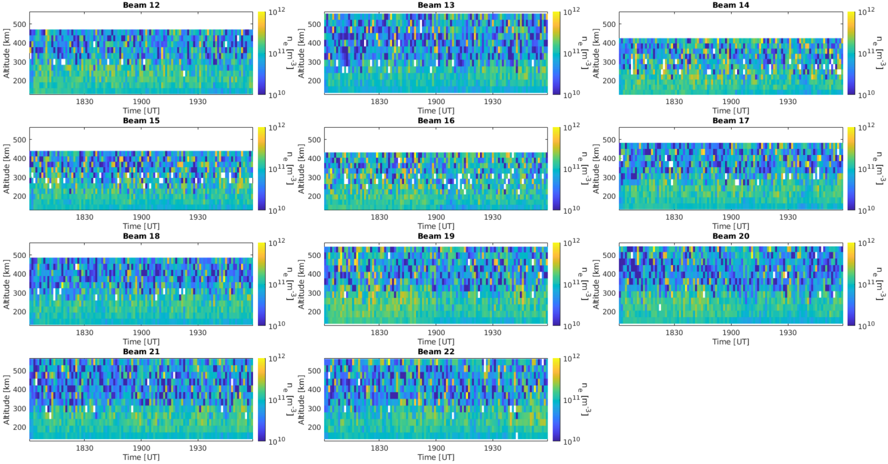
Electron Density - E-layer (2)



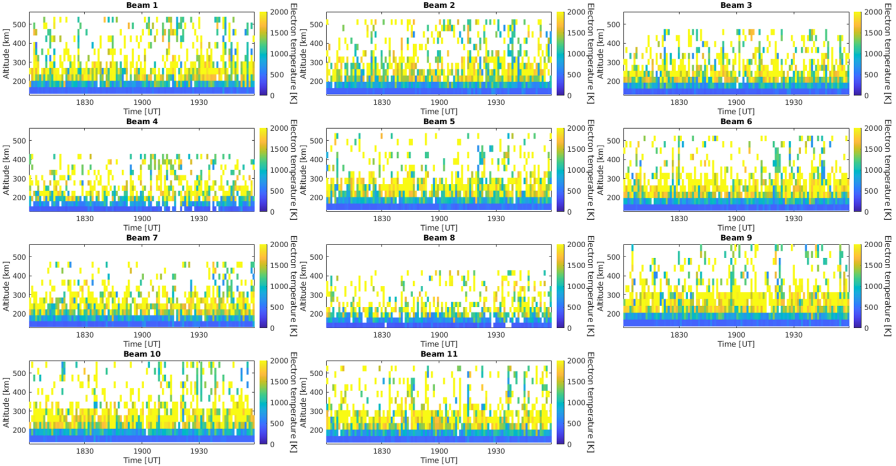
Electron Density - F-layer (1)



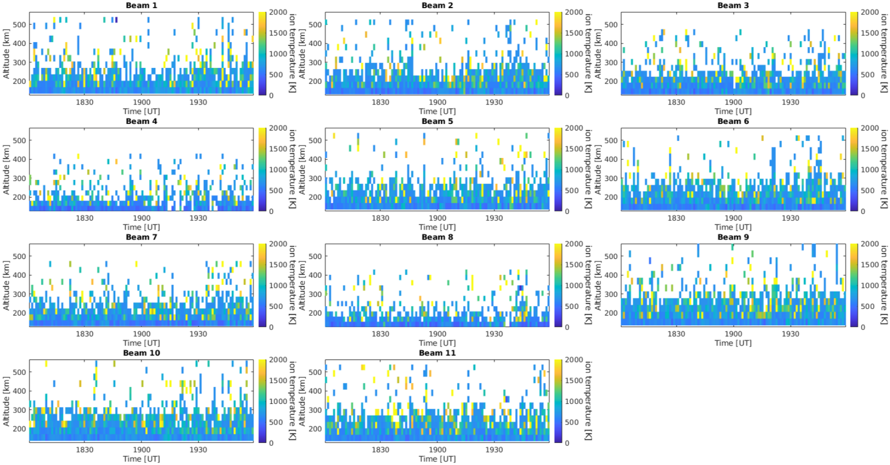
Electron Density - F-layer (2)



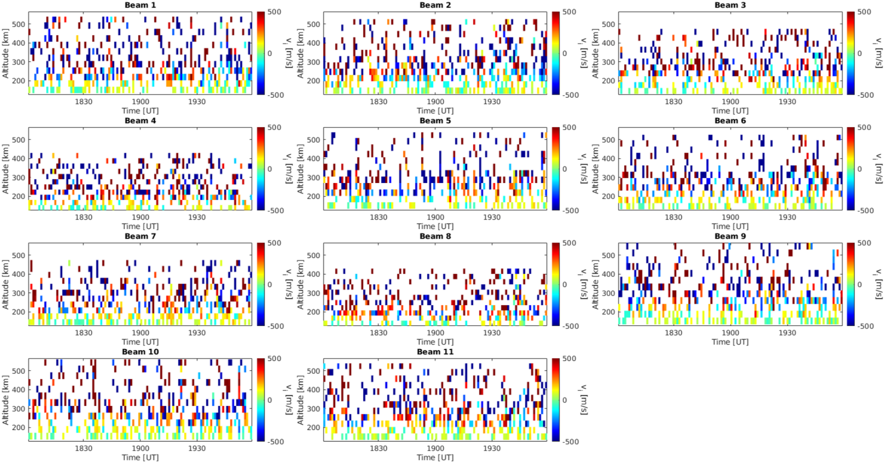
Electron Temperature



Ion temperature

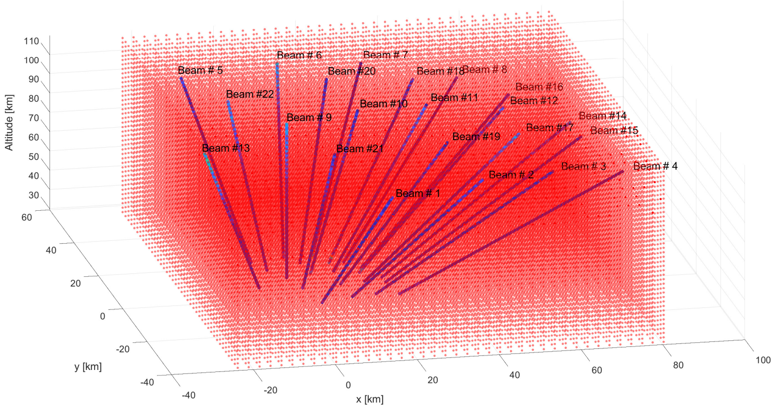


Results of Ion Velocity



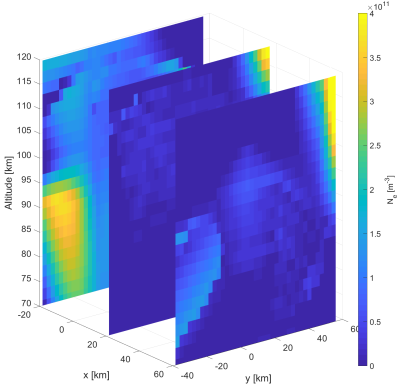
Volumetric Representation

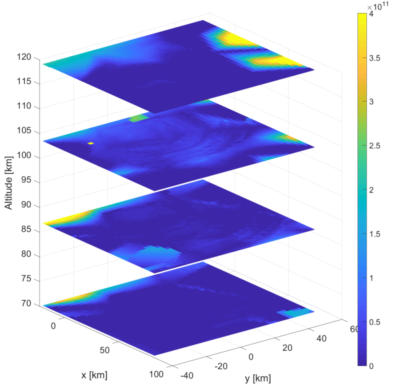
- Volumetric representation of electron density N_e was performed where 22 beams were interpolated on a Cartesian grid with 40x40x40 data points.
- Data of E and D region was used between 40 km and 120 km of altitude that was acquired with Barker codes.



Volumetric Slicing

Volumetric slices at 19:01 UTC 13 Aug 2019 between altitudes 70 km and 120 km taken with `ThemisD1.v01` mode. Linear interpolaiton between datapoints was used.
Datafile: `20190813.002_bc_5min-fitcal.h5`

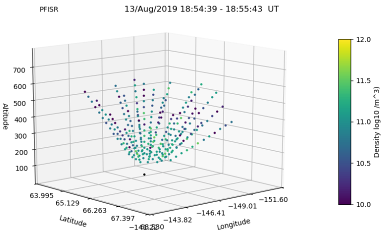




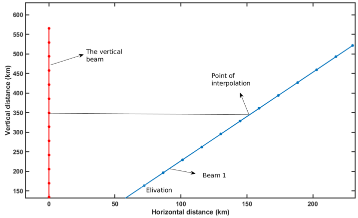
Altitude Search

Altitude scan of D and E layer in 1 km steps. Natural neighbour interpolation was used, which is based on Voronoi tessellation and produces smoother transitioning.

Altitude-Latitude-Time Variation of Electron density



(a) Visualising the radiating beams of the radar



(b) Determining interpolating points

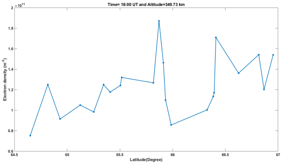


Figure: Latitudinal variation of electron density at 349.73 km at 18:00 UT

Altitude-Latitude-Time Variation of Electron density

Conclusion

- We probed the D, E and F region of ionosphere with an advanced experimental set up of PFISR. However, we did not observe any PMSE structure.
- The electron density obtained from the lower ionospheric regions was relatively noisy.
- Using extra ground and space based instruments, we showed that the geomagnetic condition of the ionosphere on 2019/08/13 was relatively quit.
- In addition to the radar data, the data obtained from these ground and space based instruments help us to verify that there was no favourable extreme condition for the formation of PMSE.
- We demonstrate that the advanced set up of PFISR radar can be used to obtain the altitude, latitude and time variation of plasma parameters of the ionosphere.