TASK Page

- What is a PMSE - **Kimberlee / Jon**
  - When- summer, time of day
  - Where- polar mesosphere, D region
  - Why/cause
  - Noctilucent clouds
- Method - **Haixia**
  - Radar and code choice
    - EISCAT VHF Radar (224 MHz),
    - Manda
- Data
  - Electron density - **Johannes**
  - Power - **Johannes**
  - Reflectivity/Frequency Dependence - **Johannes**
  - Spectral Shape
- Discussion - **Hammad**
- Geomagnetic Connection? - **Vladimir**
- **Summary & Conclusion- Hammad**

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- 4-5: Kim
- 6-7: John
- 8: Kim
- 9-11: Haixia
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- 18-19: Johannes
- 20-23: Vladimir
- 24-end: Hammad

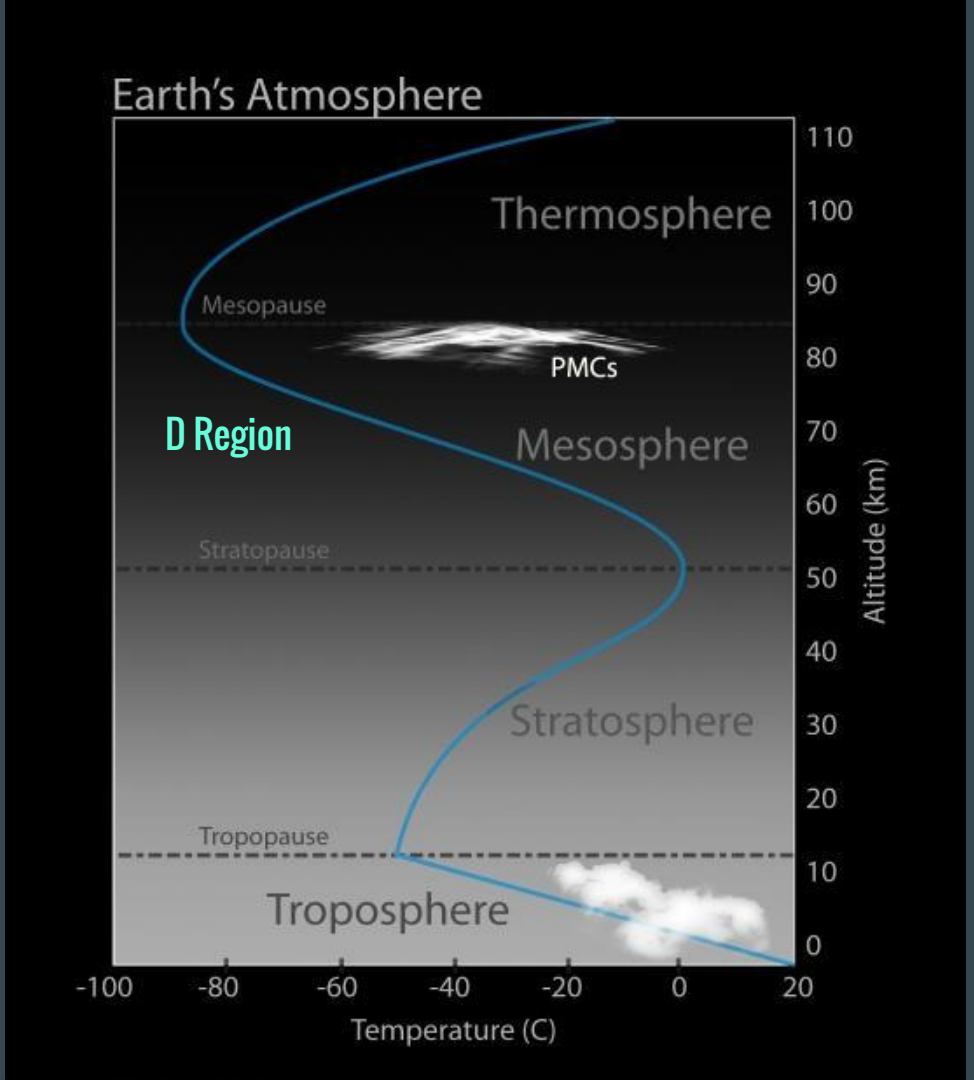
Observation of Polar Mesospheric Summer Echoes with EISCAT VHF Radar

Group 2: Haixia Lyu, Hammed Lawal, Johannes Norberg, Jon Pugmire, Kimberlee Dubé, Vladimir Belakhovsky

2016 Radar School
SGO, Sodankyla, Finland

D Region

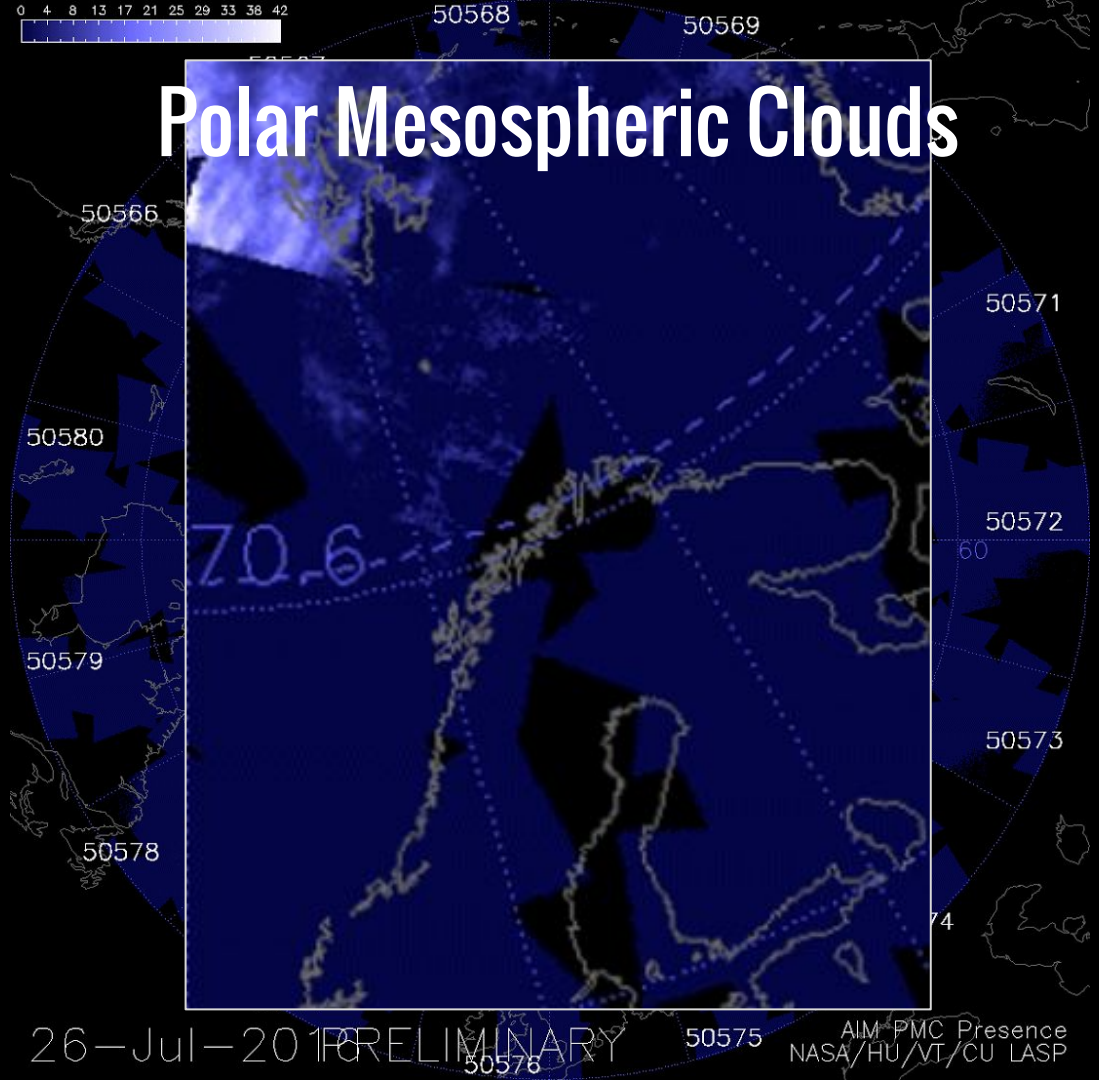
- Daytime
- Mesosphere is coldest layer
- Coldest in the summer



Polar Mesospheric Summer Echoes

- Radar echoes found from 80-90 km altitude in the polar summer
- Where do they come from?
  - Ice particles form around aerosols
  - Electrons from D-region plasma charge the ice particles
  - Charged aerosol particles attract electrons, leading to coherent scatter
  - Turbulence from gravity waves moves the charged ice, leading to changes in the electron number density.

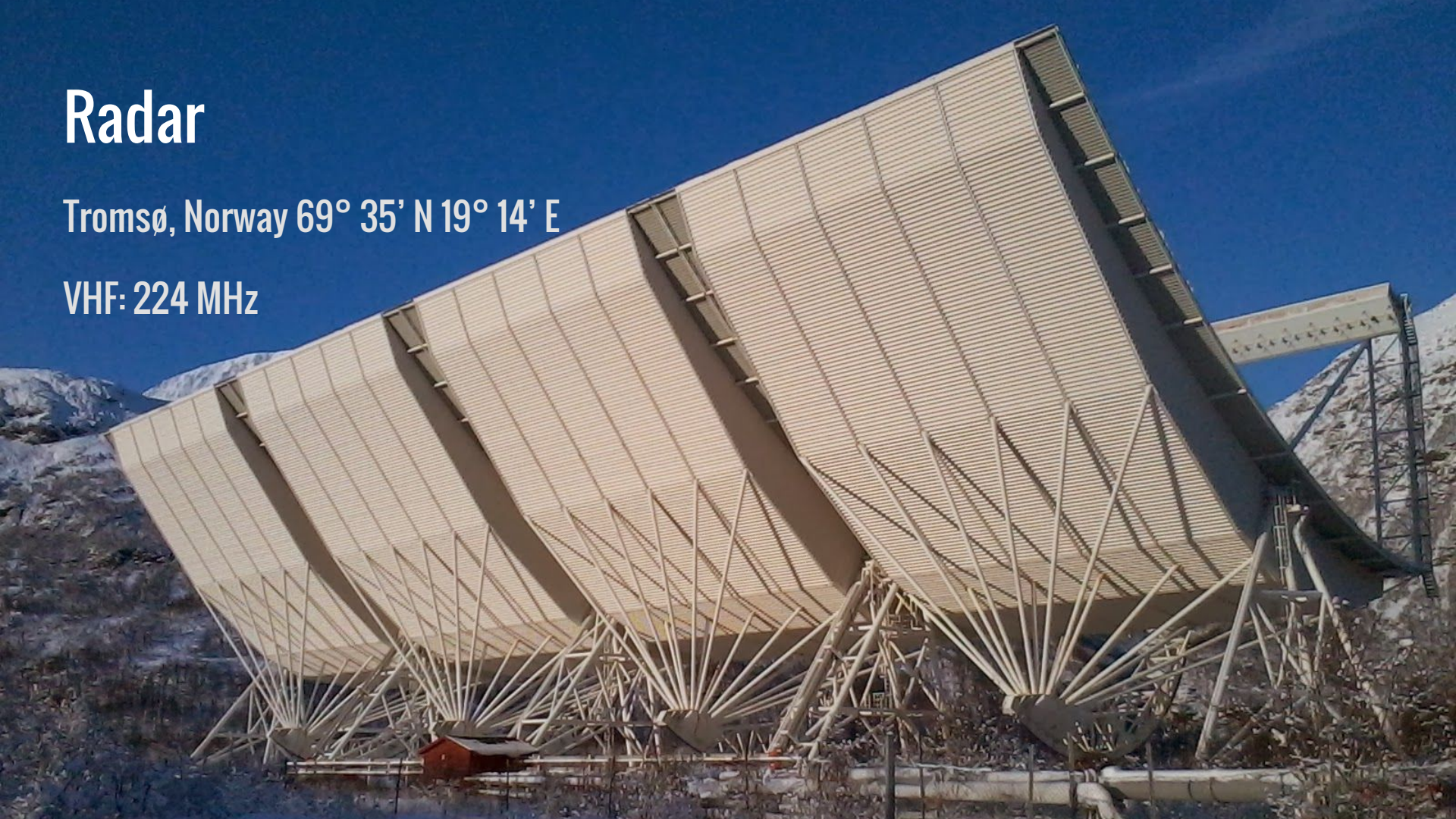
Noctilucent Clouds



Polar Mesospheric Clouds

CIPS AIM

What radar settings are needed to observe PMSE?



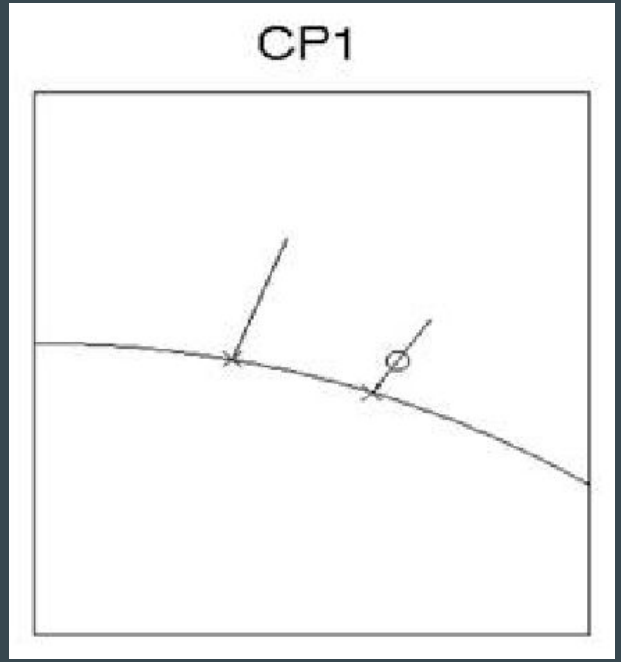
Radar

Tromsø, Norway 69° 35’ N 19° 14’ E

VHF: 224 MHz

Additional Radar Considerations

CP1



EISCAT Experiments, 2015

Additional Radar Considerations

CP1

Code: Manda

Table 3: EISCAT VHF radar standard experiments. The top three experiments have tri-static support.

Name	Code length [bit]	Baud length [μs]	Sampling rate [μs]	Range span [km]	Time resolution [s]	Plasma line	Raw data
manda	61	2.4	1.2	19–209	4.8	-	Yes
beata	32	20	20	52–663	5.0	Yes	-
bella	30	45	45	63–1344	3.6	Yes	-
tau7	16	96	12	50–2001	5.0	-	-
arc_dlayer	64	2	2	60–139	5.0	-	-
tau1	16	72	24	104–2061	5.0	-	-

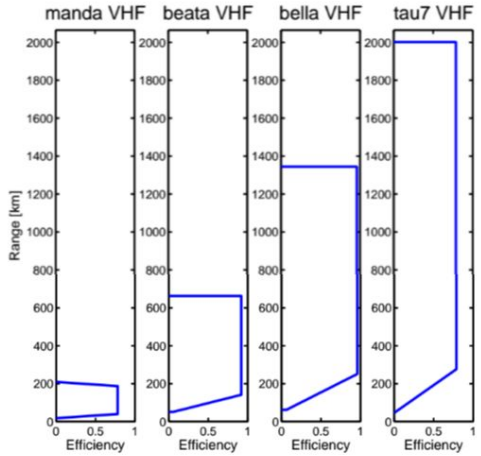


Figure 2: Overview of the ranges covered at the EISCAT VHF radar by the experiments used in the common programmes.

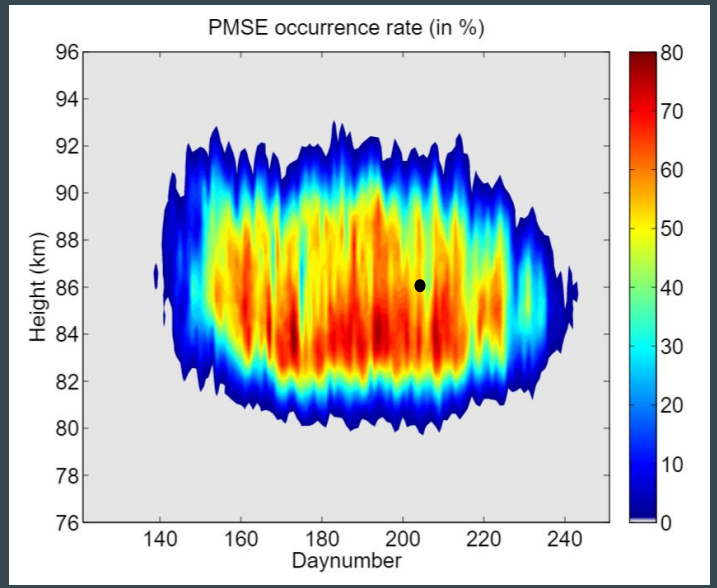
EISCAT Experiments, 2015

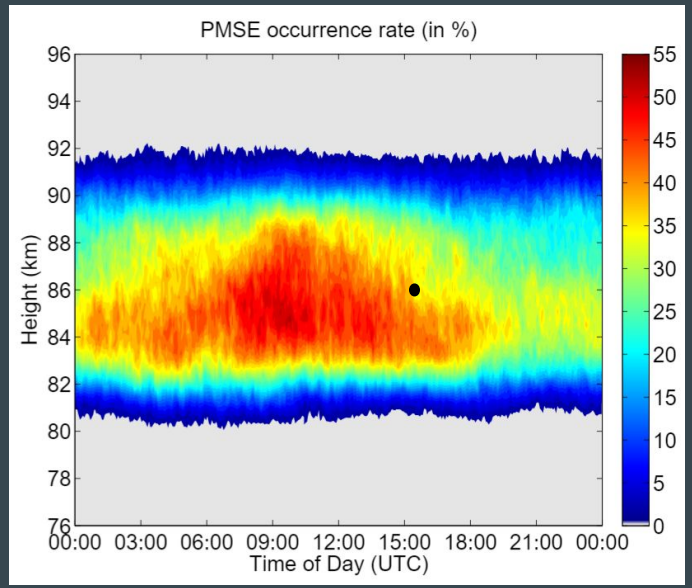
Additional Radar Considerations

CP1

Code: Manda

Time of experiment: 14:30-16:30

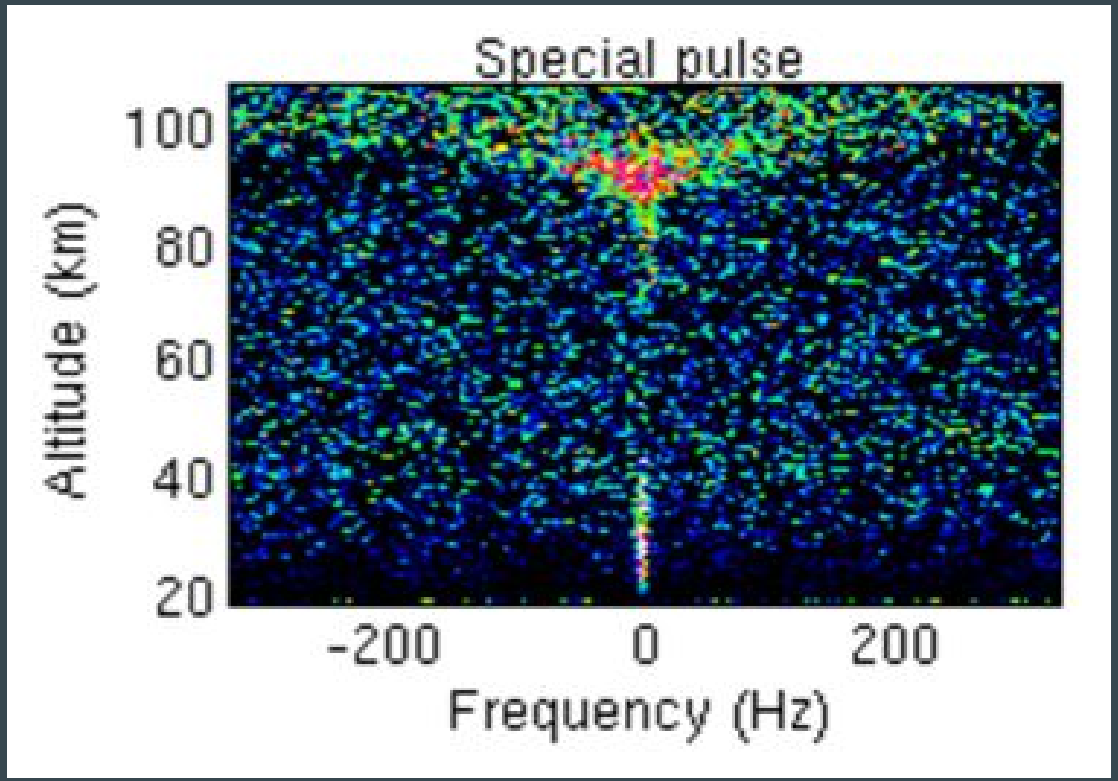




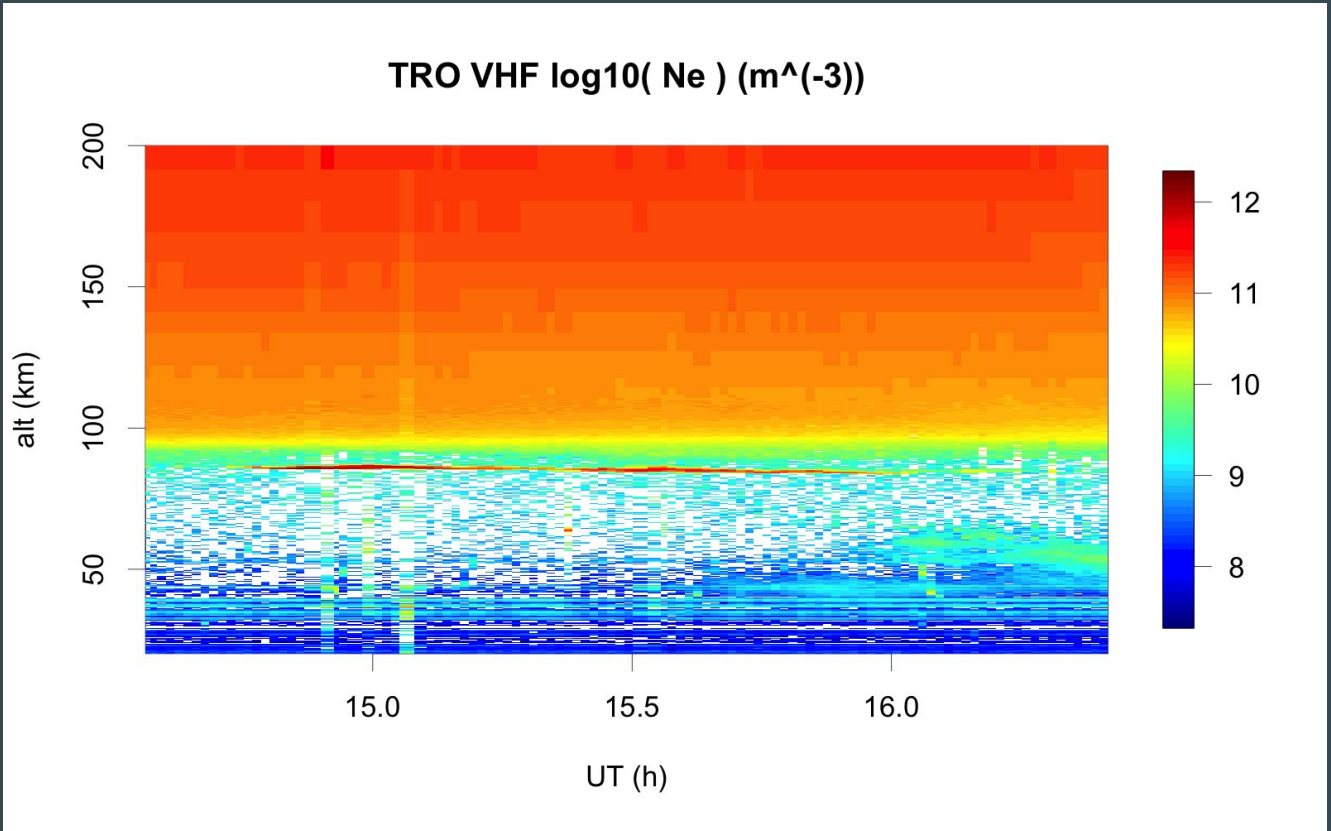
Zecha and Röttger, 2009

Results

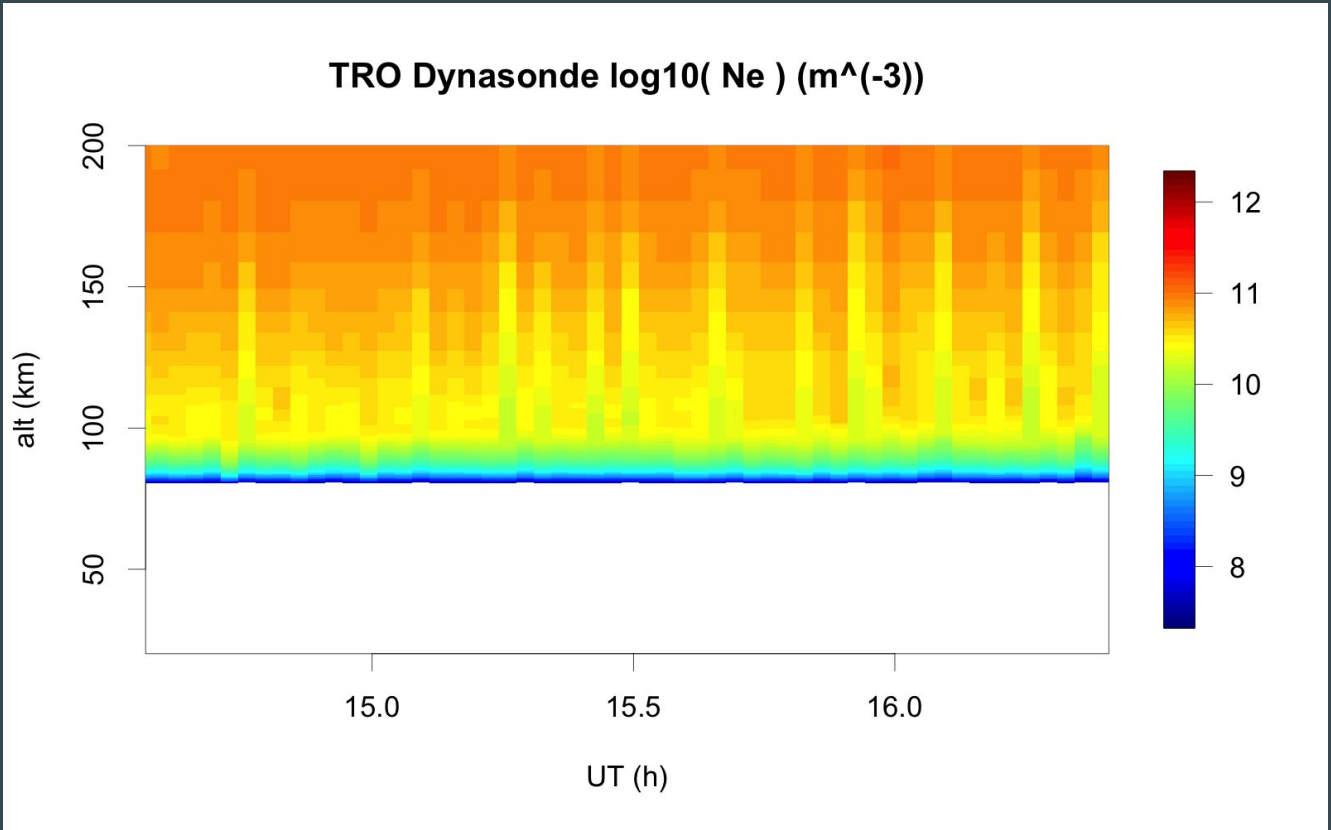
Power Spectrum



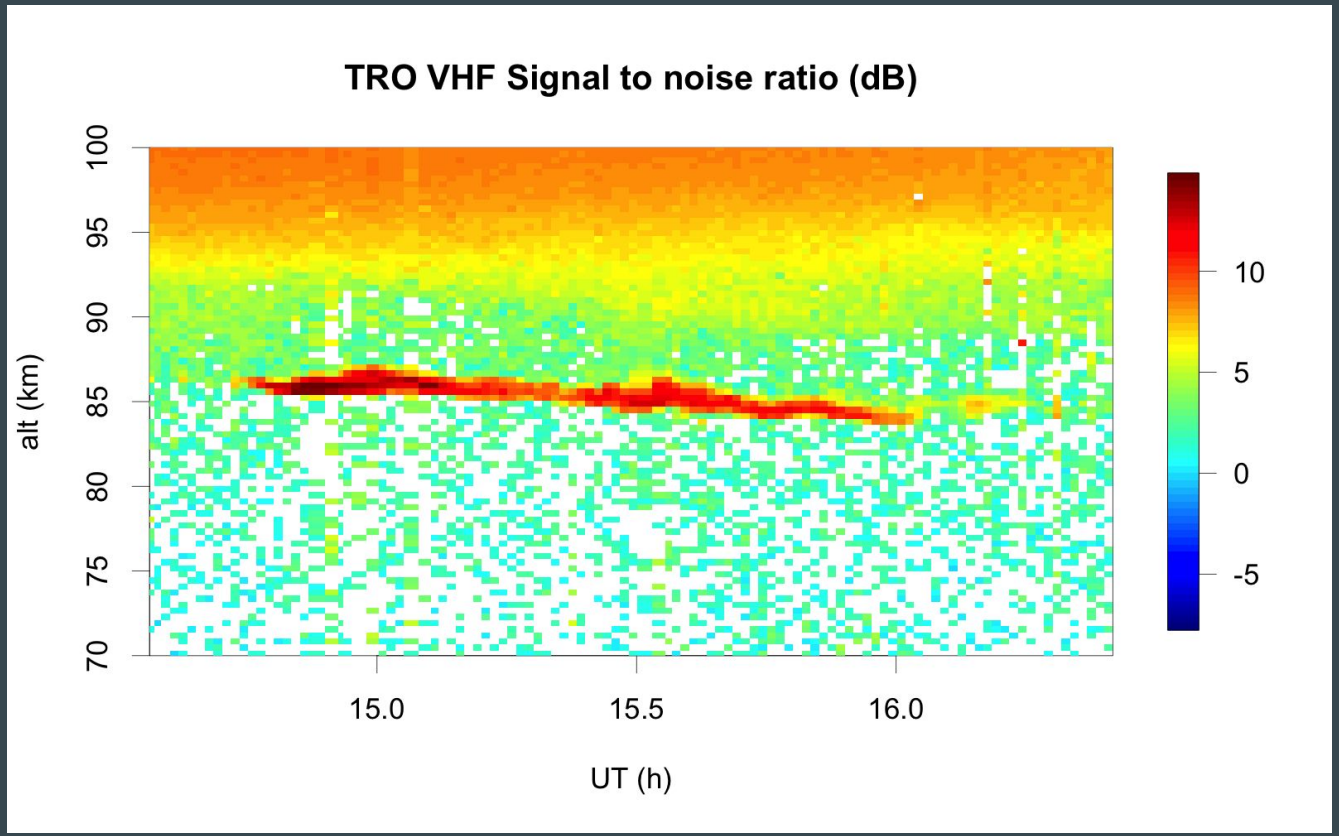
Electron density



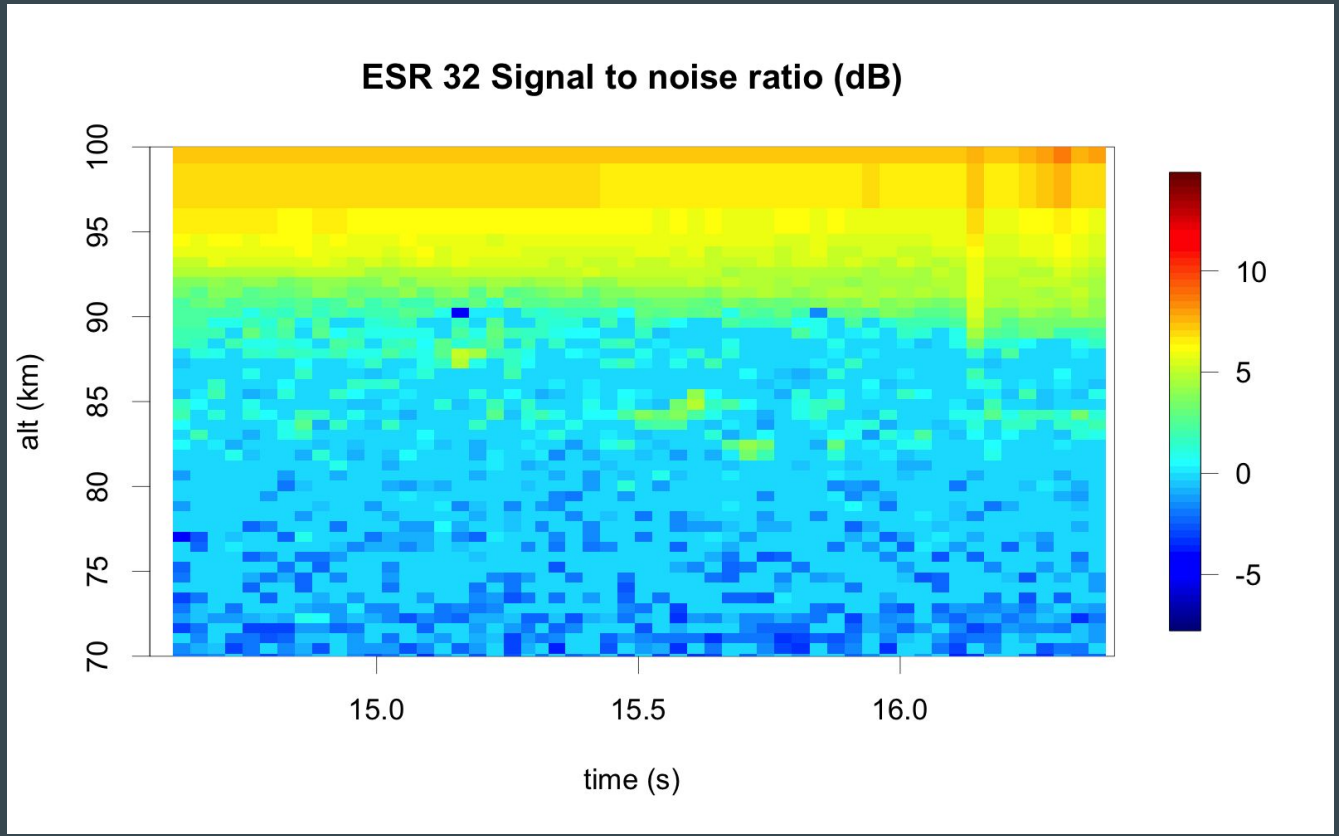
Ionosonde data



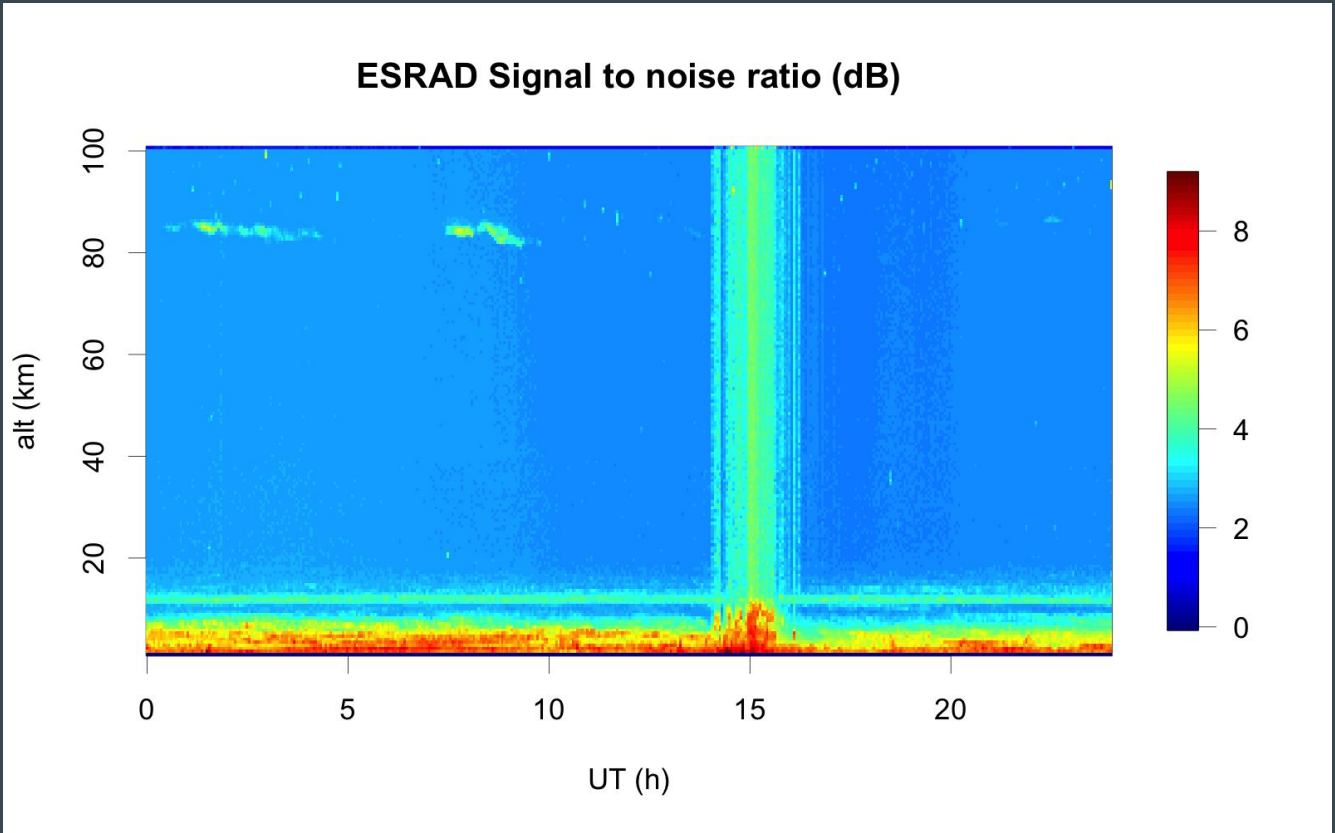
Signal to noise ratio



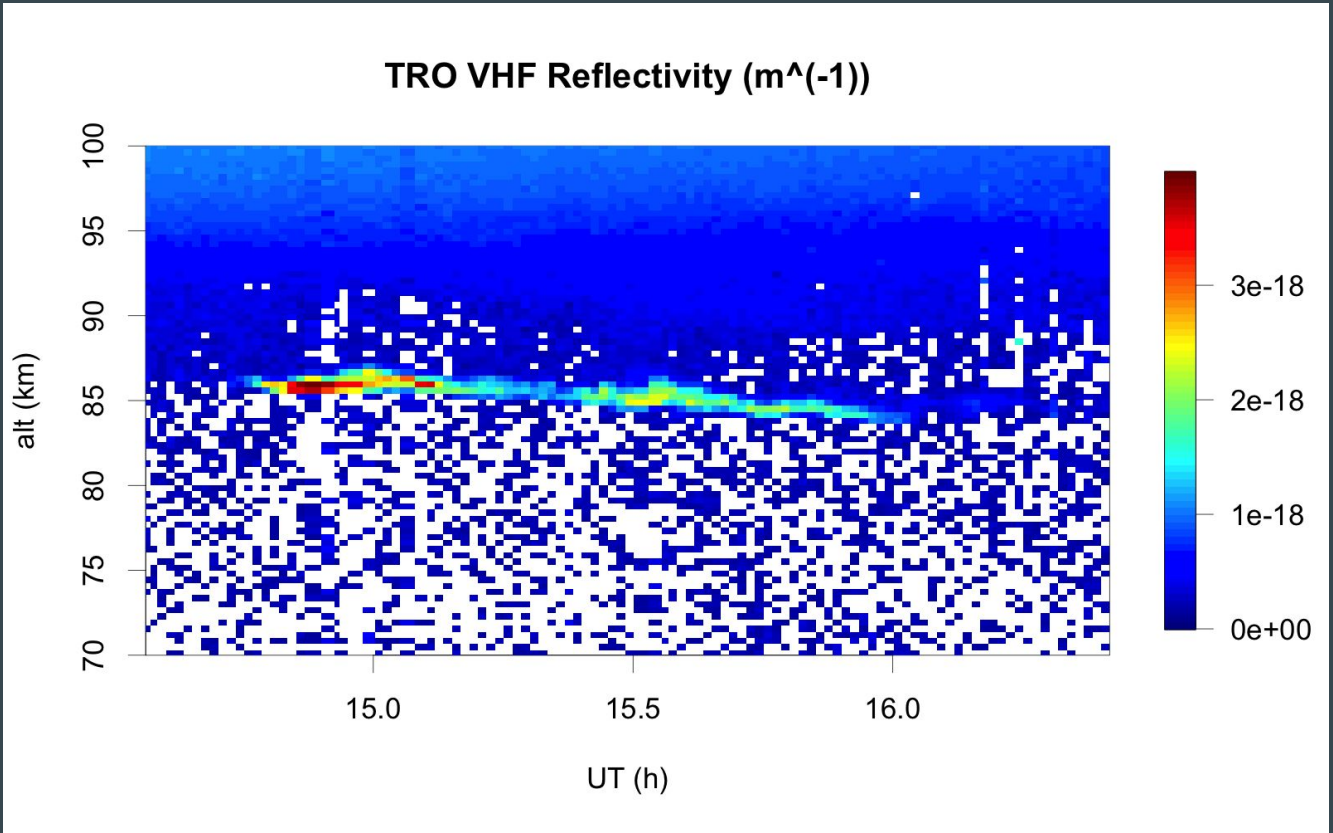
Signal to noise ratio Svalbard



Esrange MST Radar (52 MHz)



Reflectivity



Reflectivity

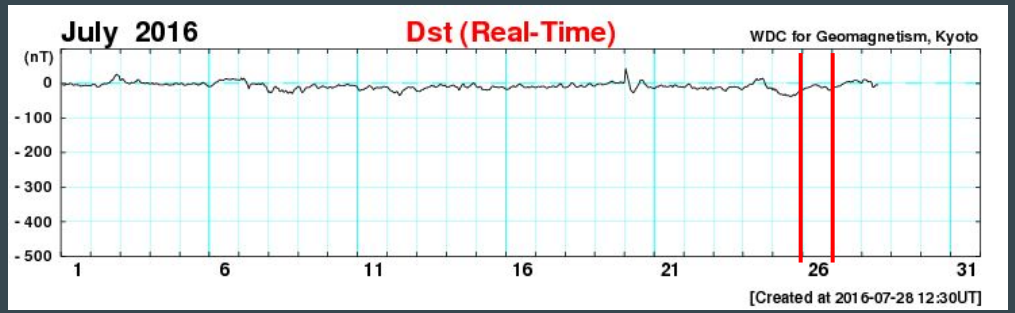
Table 1. PMSE studies at different frequencies.

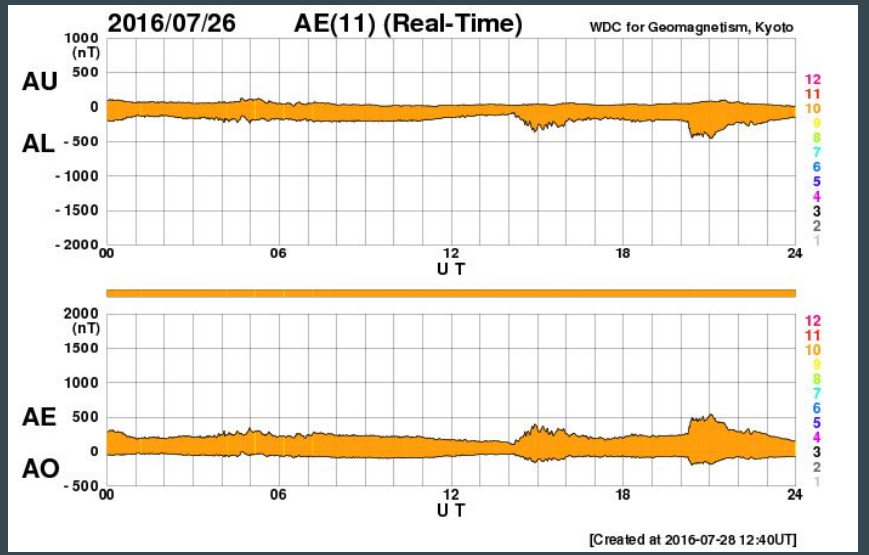
Frequency (Bragg scale) [MHz (m)]	Location	Reference	Reflectivity [m^{-1}]
2.78 (53.9)	Tromsø, (69° N)	Bremer et al. (1996b)	
8–9 (18.8)	Vasil'surk, Russia (56° N)	Karashtin et al. (1997)	
3.3, 4.9, 7.6	Gakona, Alaska, (62° N)	Kelley et al. (2002)	
9, 11, 13. 15	Hankasalmi, Finnland, (62° N)	Ogawa et al. (2003)	
49.6 (3.0)	Tromsø, (69° N)	Röttger et al. (1990)	$2.0 \cdot 10^{-12}$
50.0 (3.0)	Poker Flat (65° N)	Ecklund and Balsley (1981)	
		Kelley and Ulwick (1988)	$9.0 \cdot 10^{-15}$
51.5 (2.9)	Resolut Bay (75° N)	Huaman et al. (2001)	
53.5 (2.8)	Andøya, (69° N)	Inhester et al. (1990)	$4.0 \cdot 10^{-12}$
53.5 (2.8)	Svalbard, (78° N)	Röttger (2001)	$2.2 \cdot 10^{-14}$
224 (0.67)	Tromsø, (69° N)	Hoppe et al. (1988)	$1.5 \cdot 10^{-16}$
		Röttger et al. (1988)	
		Hocking and Röttger (1997)	$1.3 \cdot 10^{-15}$
500 (0.3)	Svalbard, (78° N)	Röttger (2001)	$5.3 \cdot 10^{-19}$
933 (0.16)	Tromsø, (69° N)	Röttger et al. (1990)	$1.2 \cdot 10^{-18}$
1290 (0.12)	Sondrestrom, (67° N)	Cho and Kelley (1992)	

Rapp, M. and Lübken, F.-J., 2004

Geomagnetic Activity and PMSE

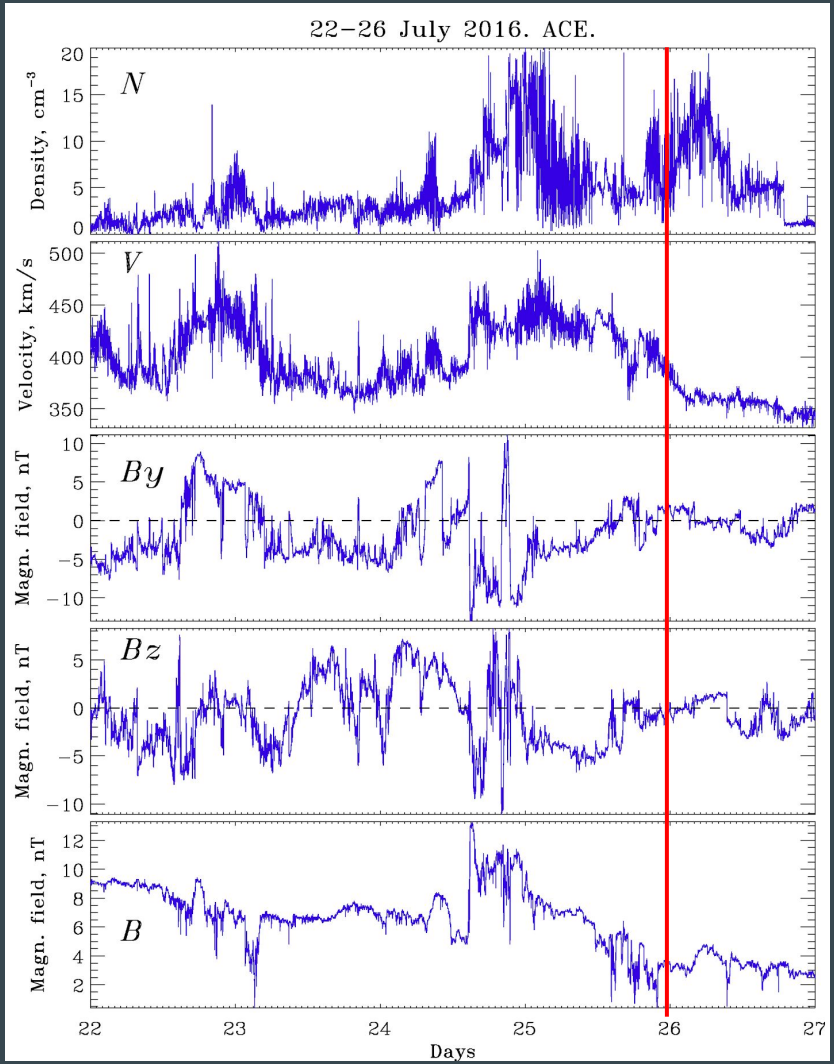
Does geomagnetic activity influence the occurrence of PMSEs?





No geomagnetic storms (Dst=-15, -5 nT) or substorms (AE < 500 nT) were observed during this day

25 day decrease of Dst. Small CIR storm?



Solar wind and IMF parameters

ACE spacecraft

- -V < 500 km/s
- - Increase of Np of the solar wind at 26 July 2016, > 10 cm^3 .
- It may cause compression of the magnetosphere on the dayside and increase the level of precipitating particles into the ionosphere.
- Bz-component of the IMF has a short excursion to the southward direction

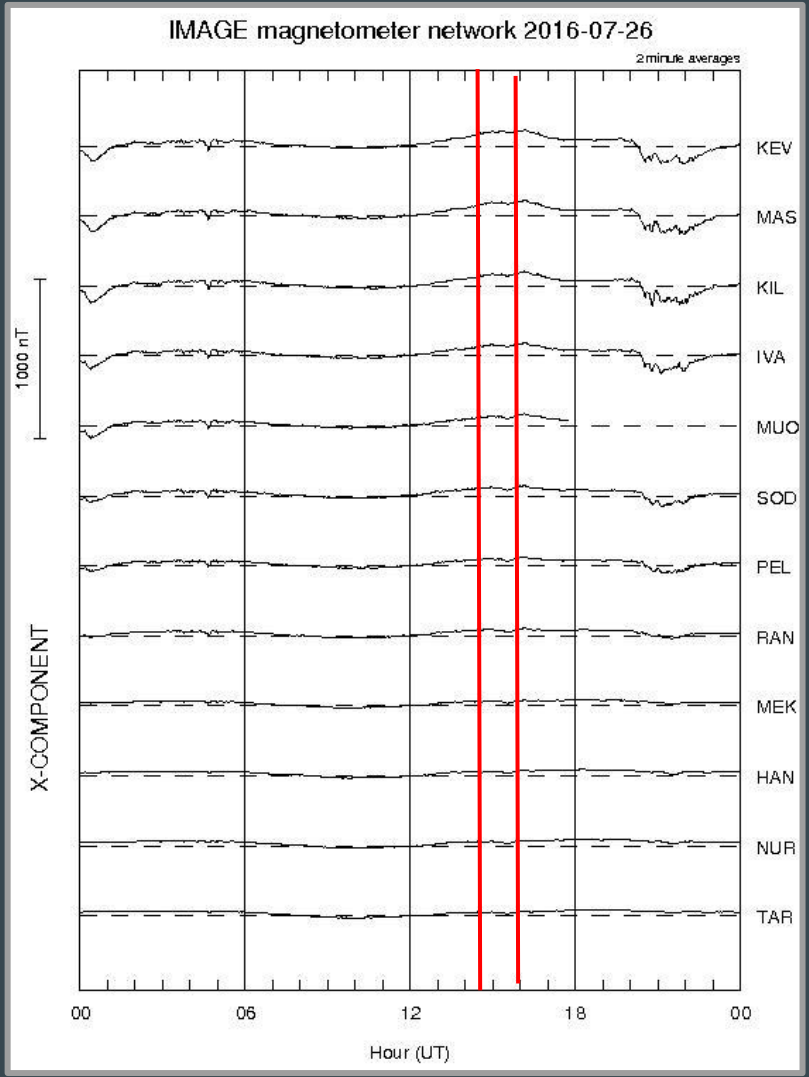
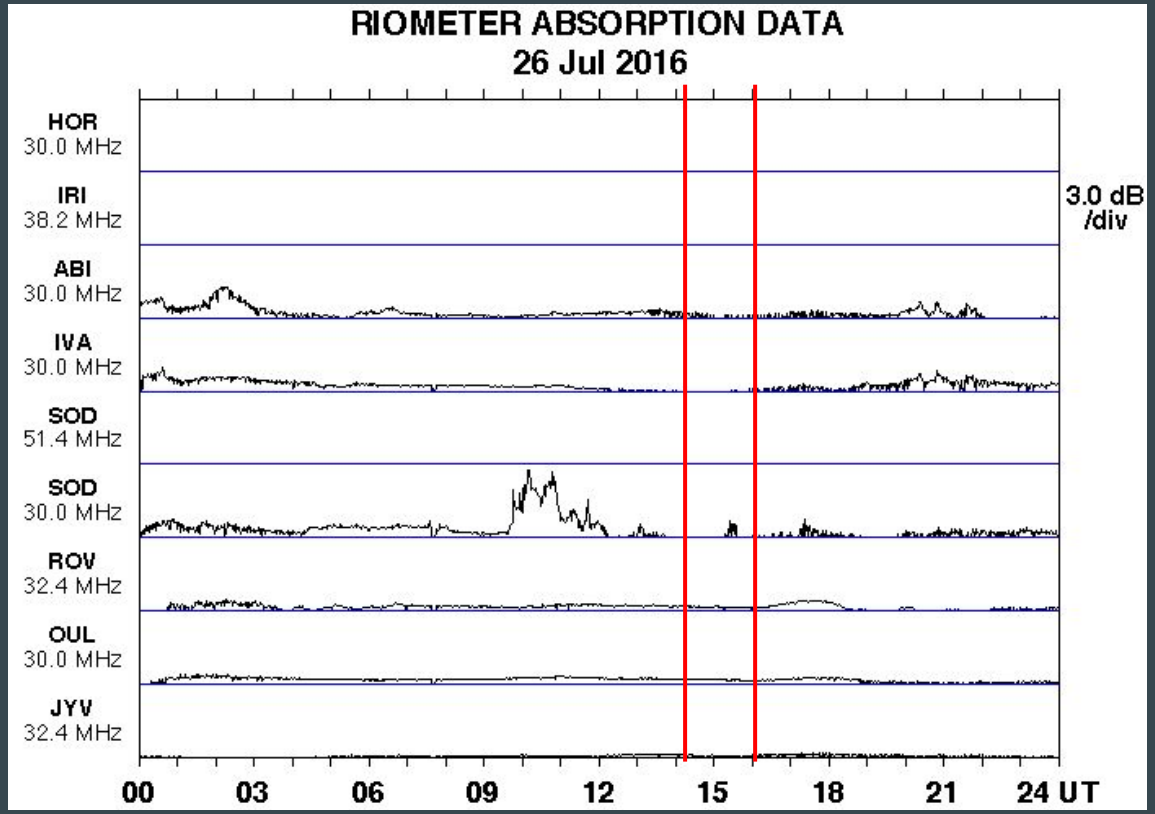


IMAGE magnetometers (mainland)

- X-component
- No strong geomagnetic disturbances was observed during our experiment

Cosmic noise absorption (CNA)



No strong energetic electron precipitation (30 keV) was registered in the D layer of the ionosphere by the riometers in Scandinavia

No IRIS riometer data in Kilpisjarvi

PMSE occur during the low level of geomagnetic activity and low level of the electron precipitation into the D region of the high latitude ionosphere

But this question needs more statistical analyses.

Summary

- We carried out an investigation of Polar Mesosphere Summer Echoes (PMSE) on 26/07/2016 between 14:30 - 16:30 UT using an EISCAT VHF Radar (224 MHz)
- Manda pulse code mode
- We have analysed and interpreted our data with data from other instruments
- PMSE were seen between 82 - 87 km altitude with peak value around 14:50 UT
- The reflectivity value observed appears to be in the same range with the values from previous studies, e.g Rottger et al, 1988, 1990, 2001
- PMSE were observed during low level of geomagnetic activity, also the level of the charged particles precipitation at the D region of the ionosphere was observed to be low
- Our science goal of observing PMSE was achieved even though we have 30% chances.

Future studies & Conclusion

- Long term studies of PMSE using large data sets from other Incoherent Scatter Radars including PFISR, UHF and MST radars
- Does the occurrence of PMSE depends on Solar Activity?
- Do PMSE have a hemispheric dependence (Northern or Southern)?

Kiitos!