PMSE Experiment Using PFISR

Group Four(ier) ~ ISR School 2019

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Background

PMSE are strong radar echoes from the cold summer mesosphere at high latitudes (La Hoz et al., 2006)

It was first reported as: Mesospheric echoes

Seasonal variation

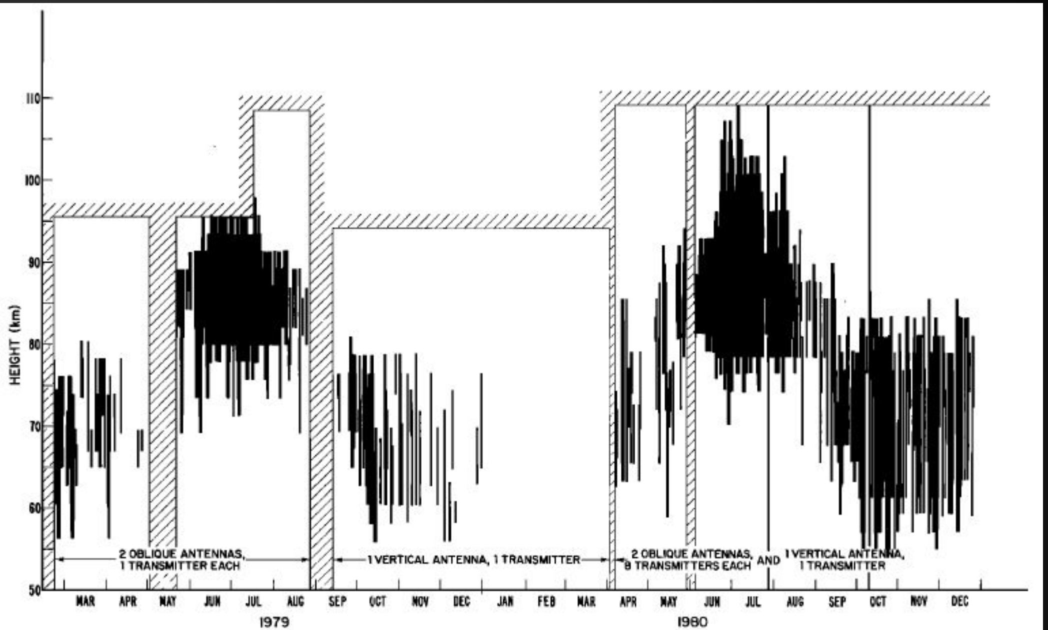


Fig. 1. Height of occurrence of mesospheric echoes on a daily basis from February 1979 to December 1980.

First report of PMSE
(Ecklun and Balsley, 1981)

h Summer

Stronger and higher in altitude (80 - 100 km)

Other seasons h

Motivation

Learn to correctly use the Poker Flat Incoherent Scatter Radar (PFISR) observations to further investigate the Ionospheric D-region plasma signatures related to polar mesospheric summer echoes (PMSE).

Identify PMSE in the data and their main characteristics.

Experiment Design

Where and when to observe PMSE?

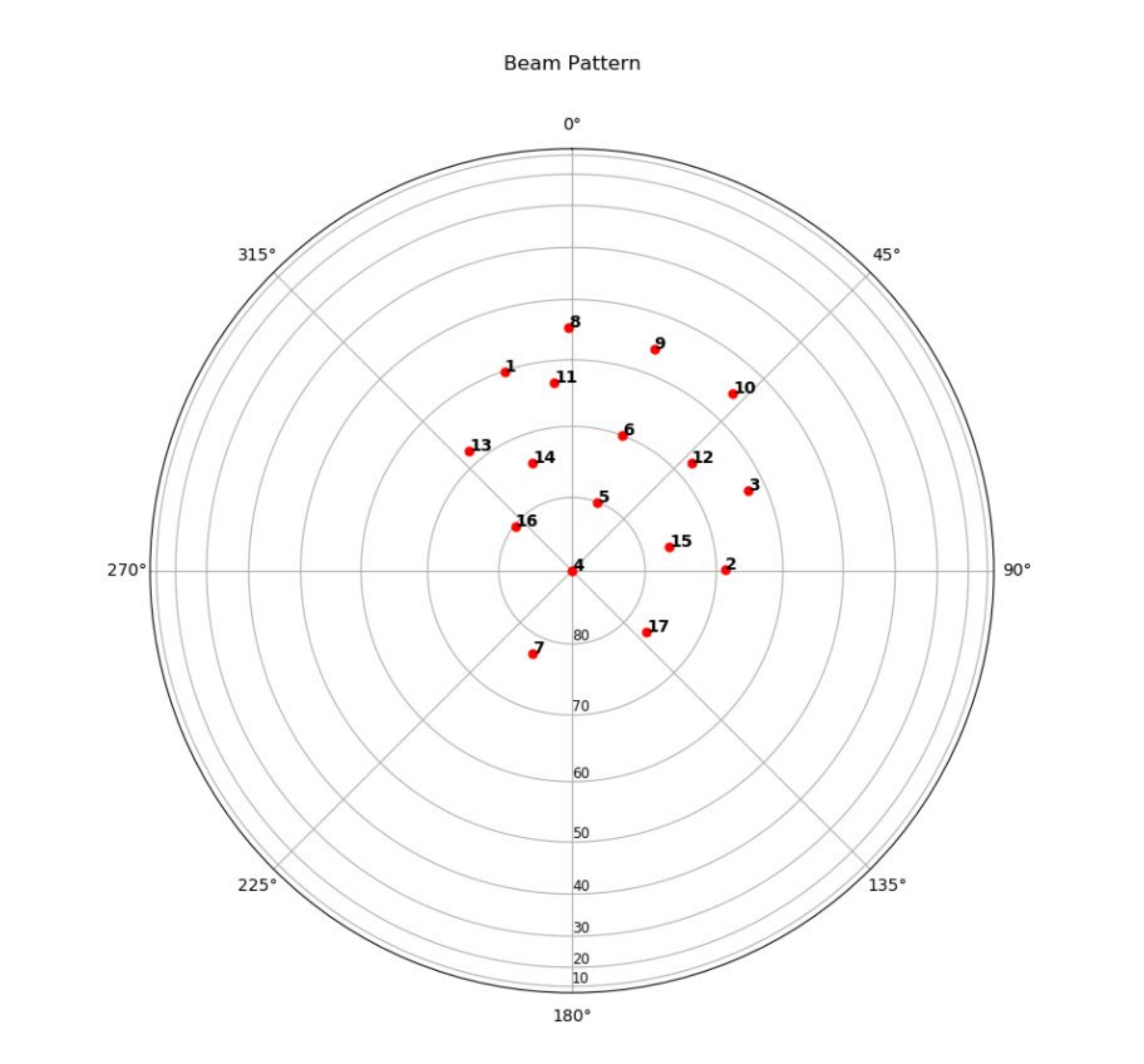
- Typically 80-90 km
- Spatially patchy
- Polar regions
- Occurs May through August

Experiment Design

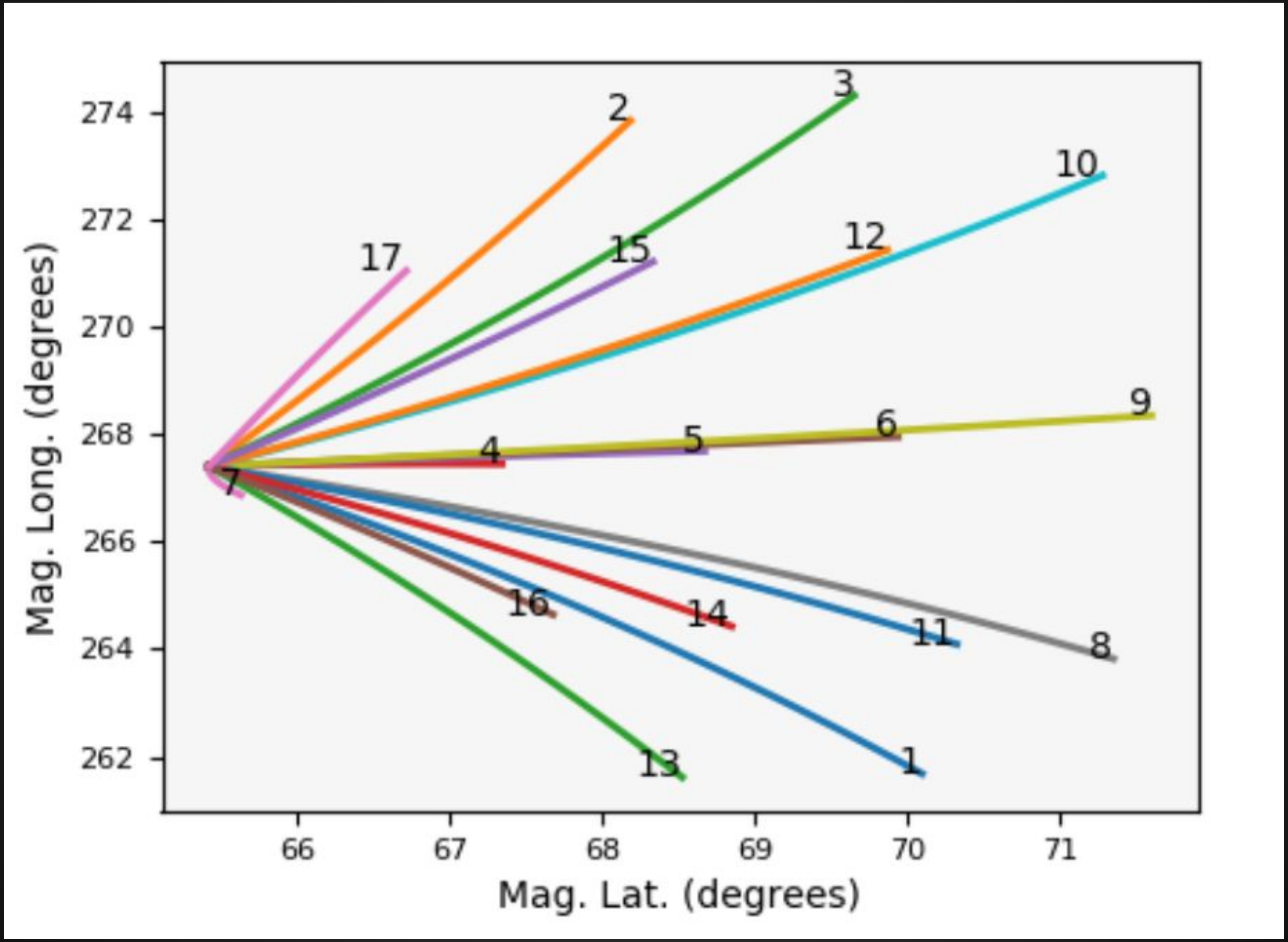
Existing AMISR experiment, MSWinds26

- 130 us, 13 baud Barker code, 10 us baud, 5 us sampling
- High range resolution in D and E regions
- Alternating codes and uncoded long pulses for higher altitudes
- 4 beams (typically)

Experiment Design



Experiment Design



Experiment Design

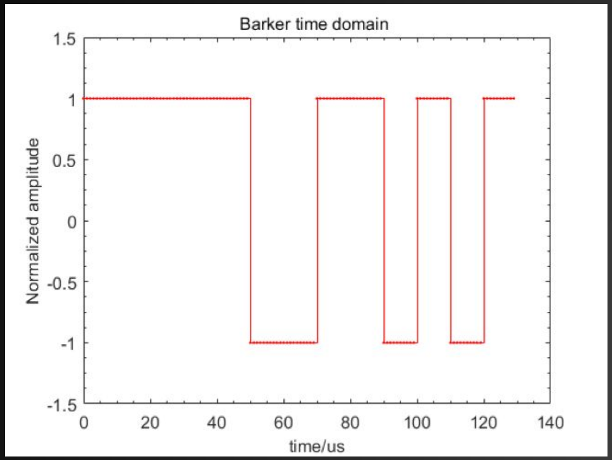
Experiment summary:

- AMISR MSWinds26 modified to use 17 beams
- 1200 to 1400 LT observation window

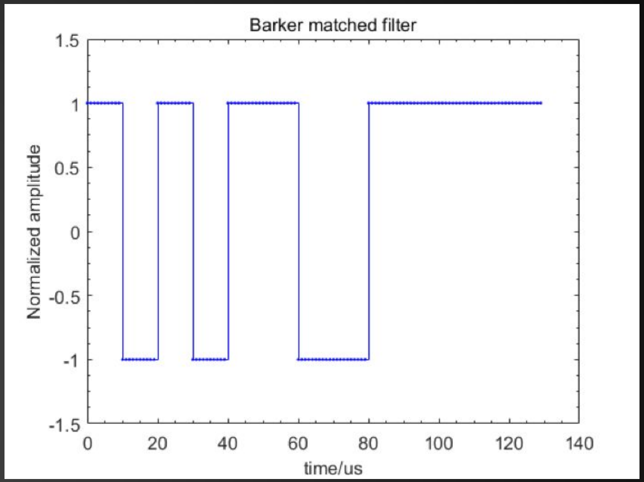
Operating in this mode:

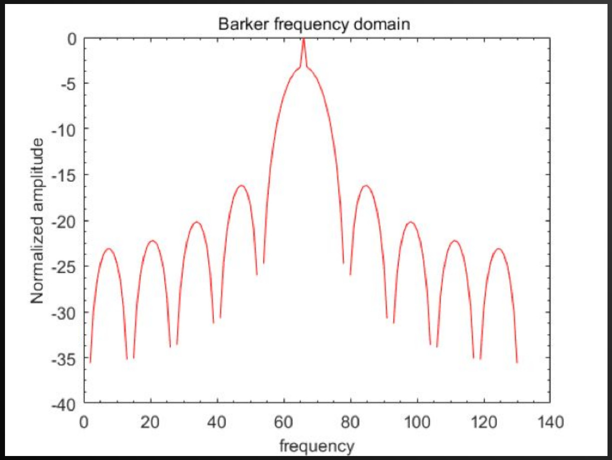
- Allows for high resolution in D and E regions
- Provides large spatial coverage
- Some E and F region measurements for context

Barker code

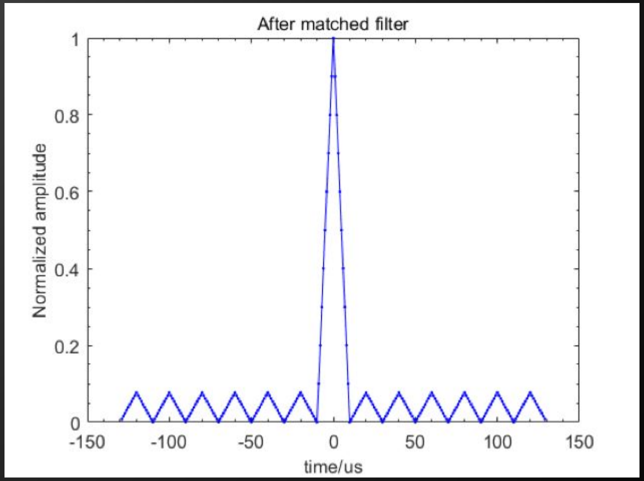


Pulse compression

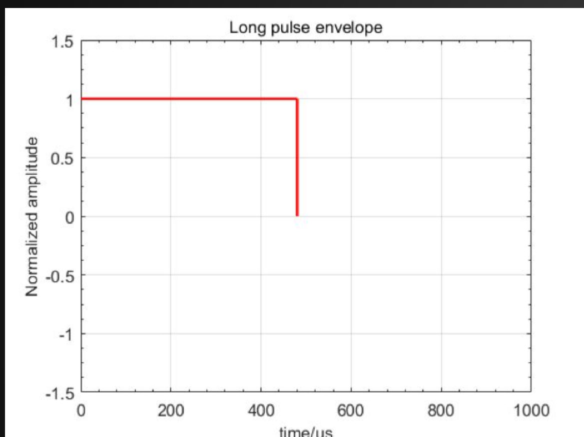




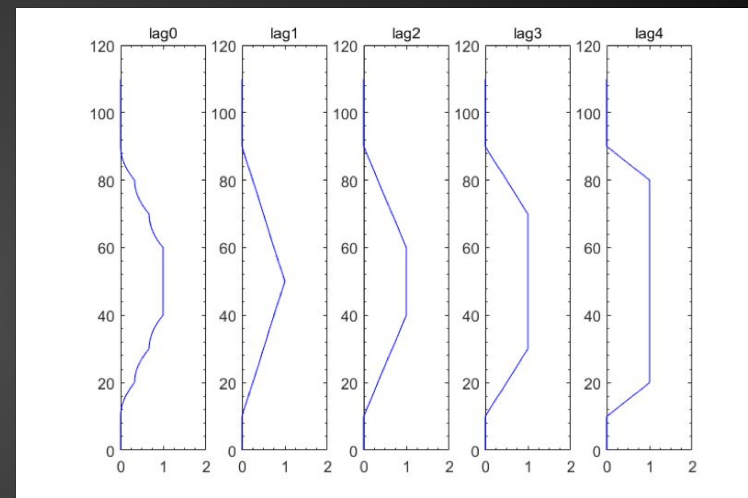
Good SNR!!



Long Pulse

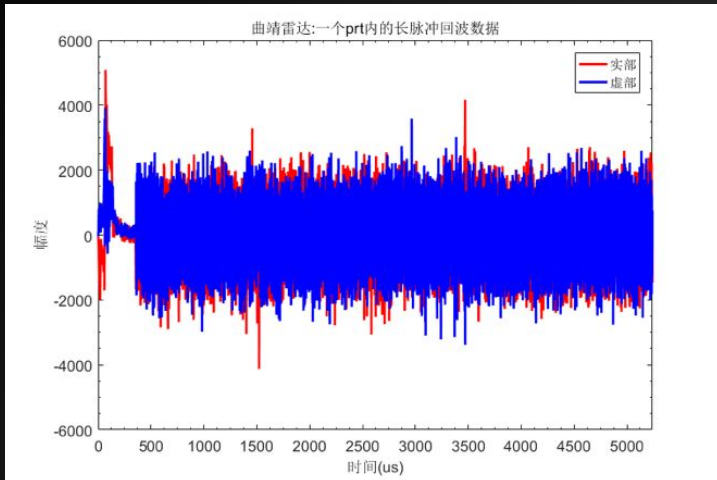


Range ambiguity function

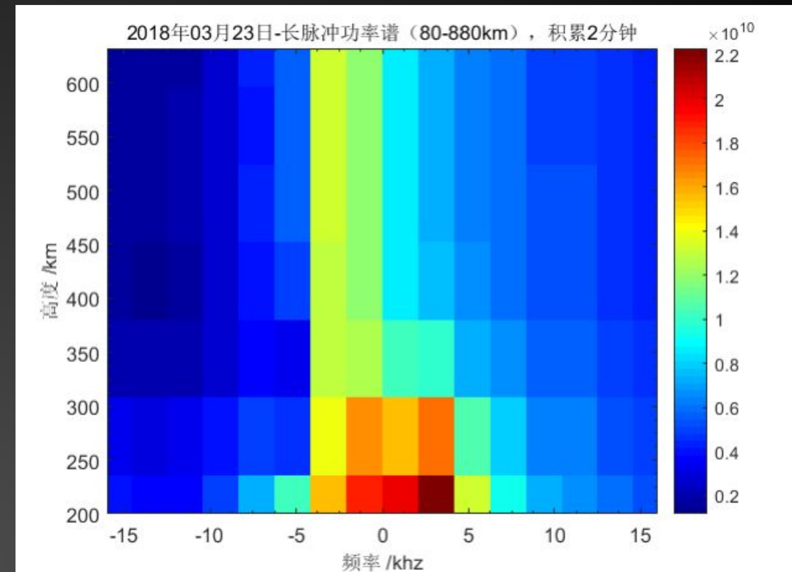


Removing ambiguity function from ACF

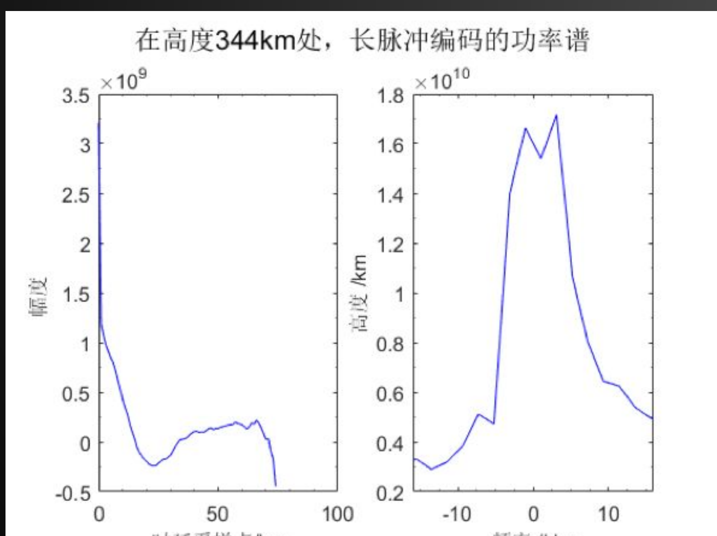
Ti.Te/Ti.Vi, ...



Echo signal in a IPP



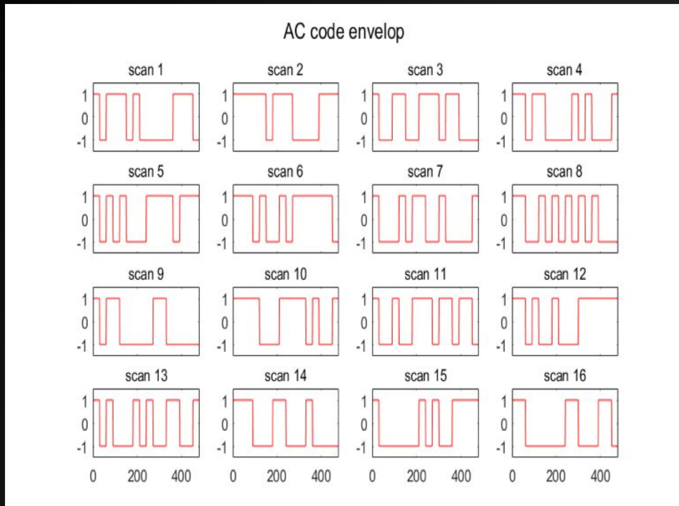
Power spectrum for all altitudes

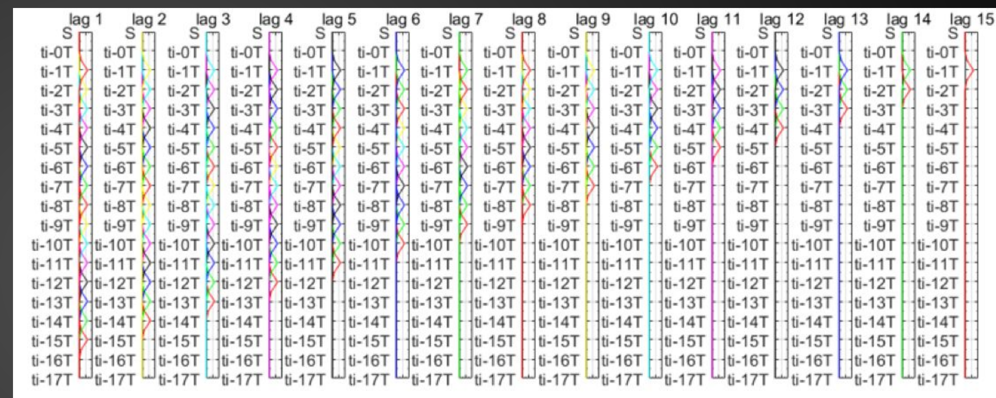


ACF and Power Spectrum at altitude

Echo power is strong

Range resolution is poor





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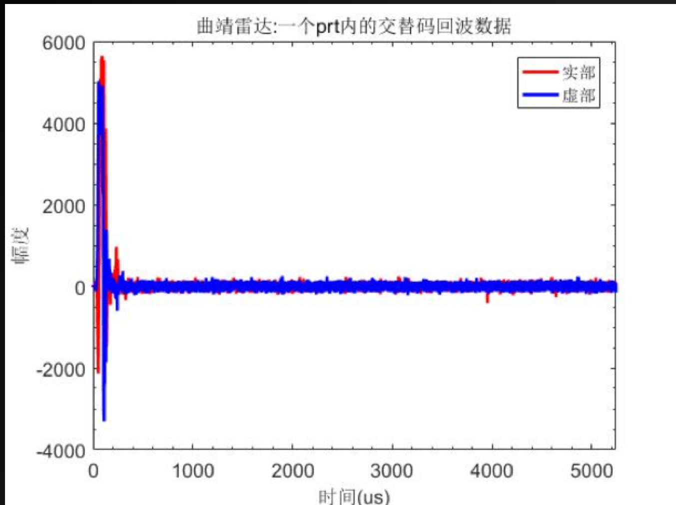
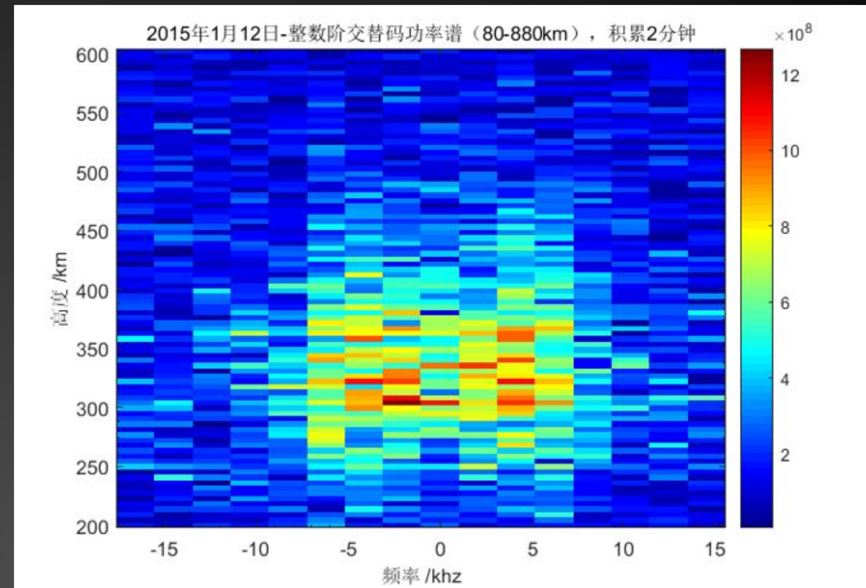
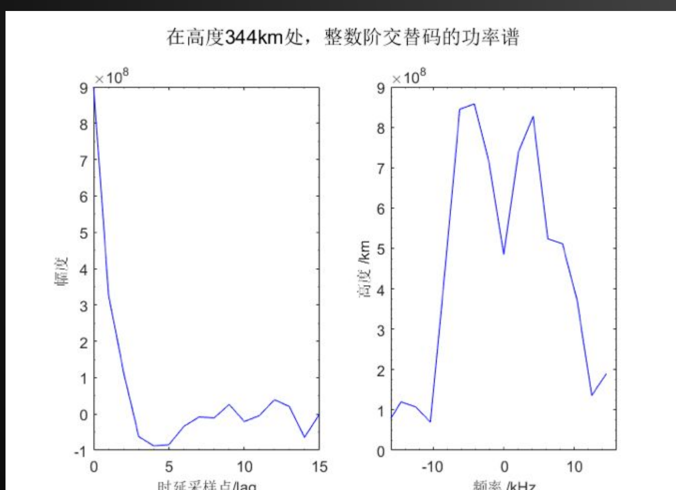


Echo signal in a IPP



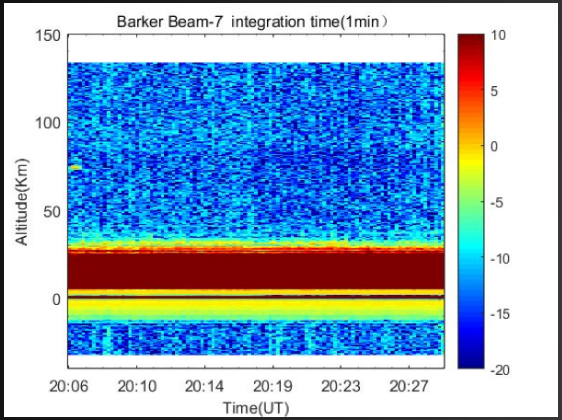
Power spectrum for all altitudes

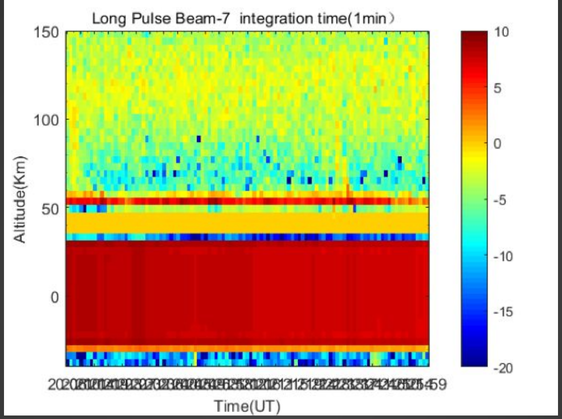


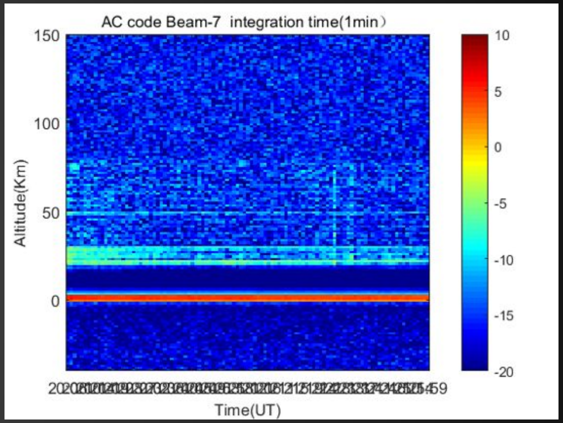
ACF and Power Spectrum at altitude

Echo power is very weak
Range resolution is the best ,which equals to baudlength!

SNR comparison







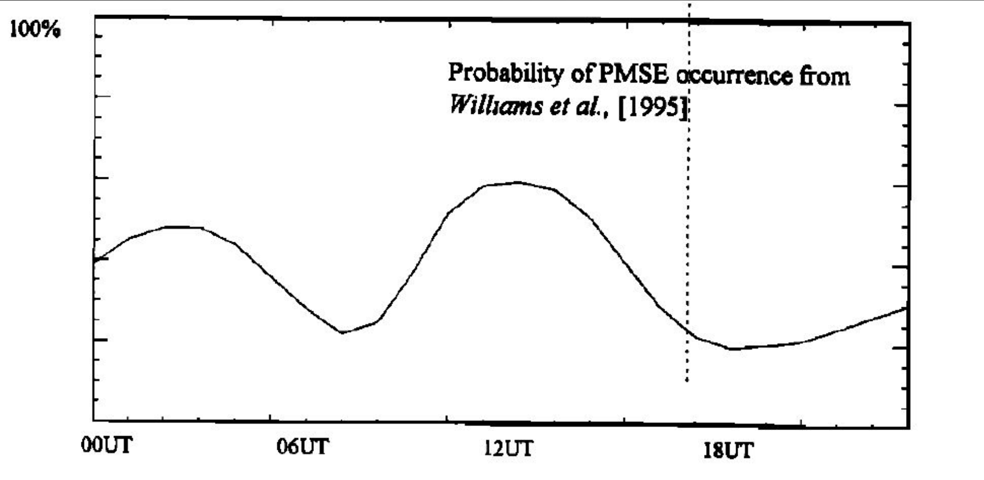
The Signal-to-Noise Ratio of Long Pulse is Maximum, so we can detect higher altitude with long pulse.

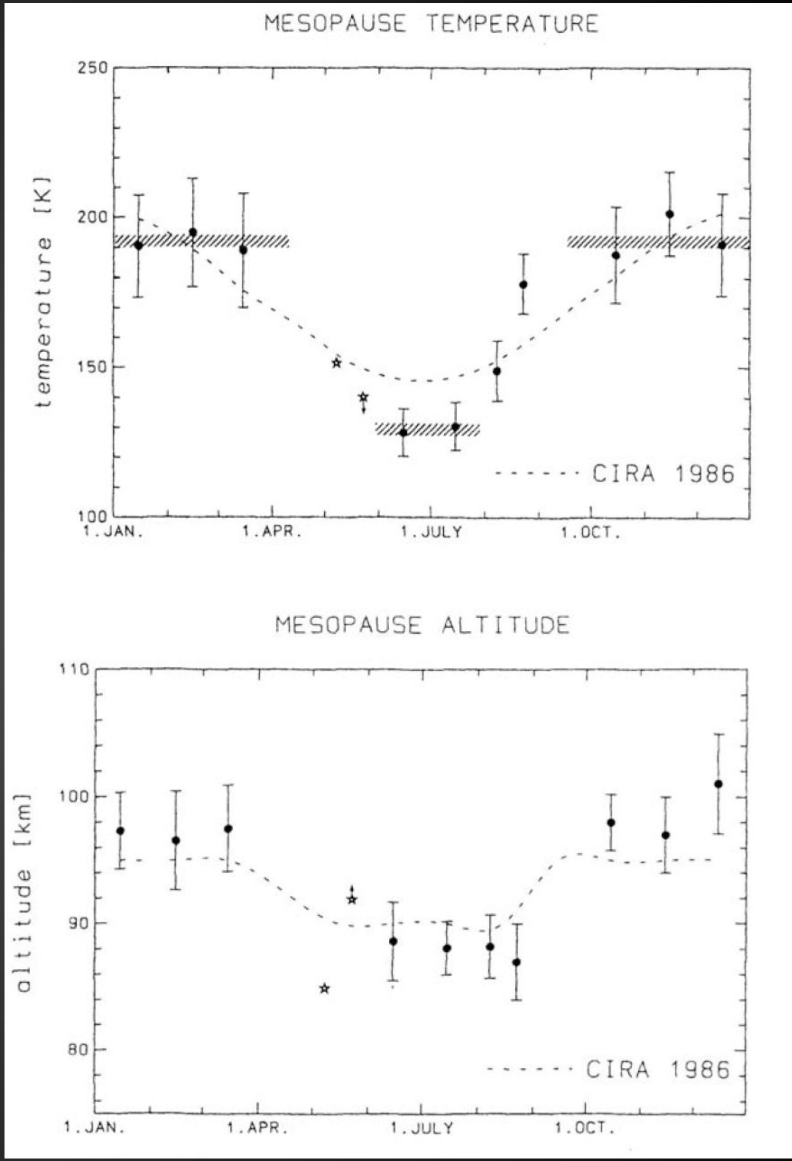
But We need to see strong echoes with good resolution at low altitude, so we need to choose Barker code

Conditions

- Annual Cycle
  - May - August.
  - Peak in July.
- Diurnal Cycle
  - Peak at 12UT and 2UT.
- Cold temperatures

(Williams et al, 1995)
(Lübken and von Zahn, 1991)





Conditions

- Water vapour
  - Less ppmv requires lower temperature as in early May.
  - 82 ~90 km altitude range shrinks as season progresses.

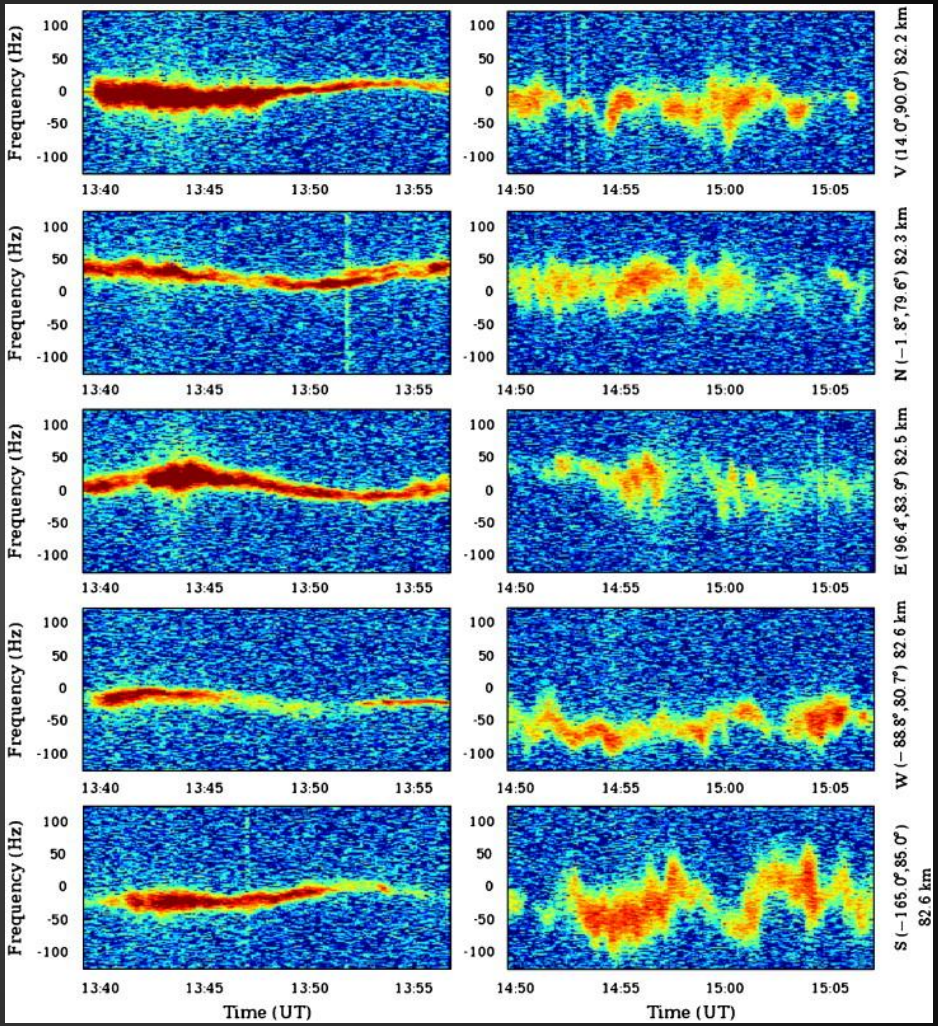
$$\log_{10} P_{sat} = 12.537 - \frac{2663.5}{T}$$

Marti and Manersberger (1993):

- Dust Particles (Lie-Svedsen et al, 2003)
  - (1) low temperatures and water vapor availability allow the ice particles to grow
  - (2) charge aerosol number density is comparable to the local plasma density
  - (3) aerosol's low mobility "implies that small-scale structures in their distribution can persist for a long time without being smeared out by diffusion.

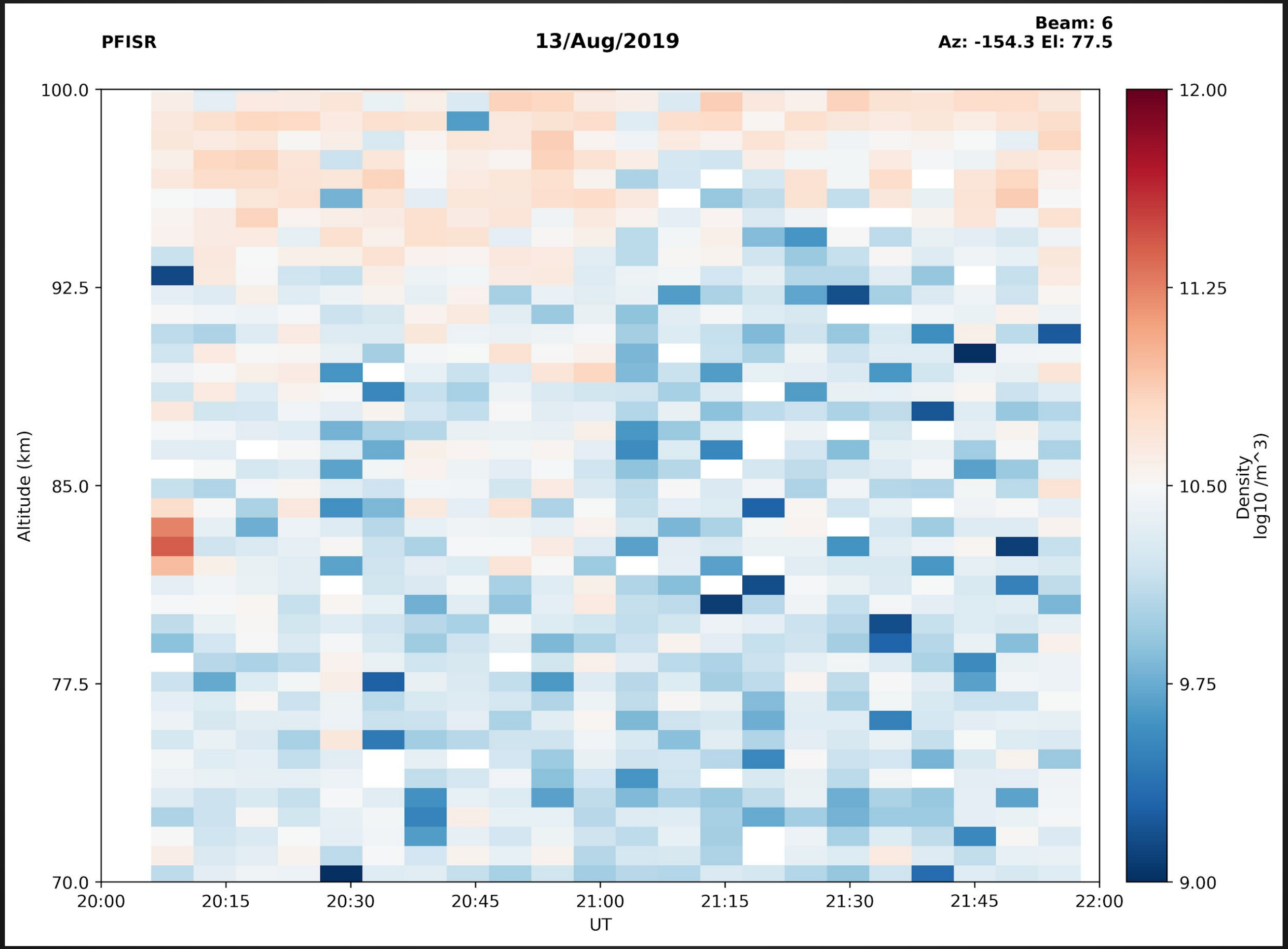
How PMSE looks to PFISR

- Altitude range 80 ~90 km
- Frequency Spectra
  - Narrow doppler.
  - Strong response.



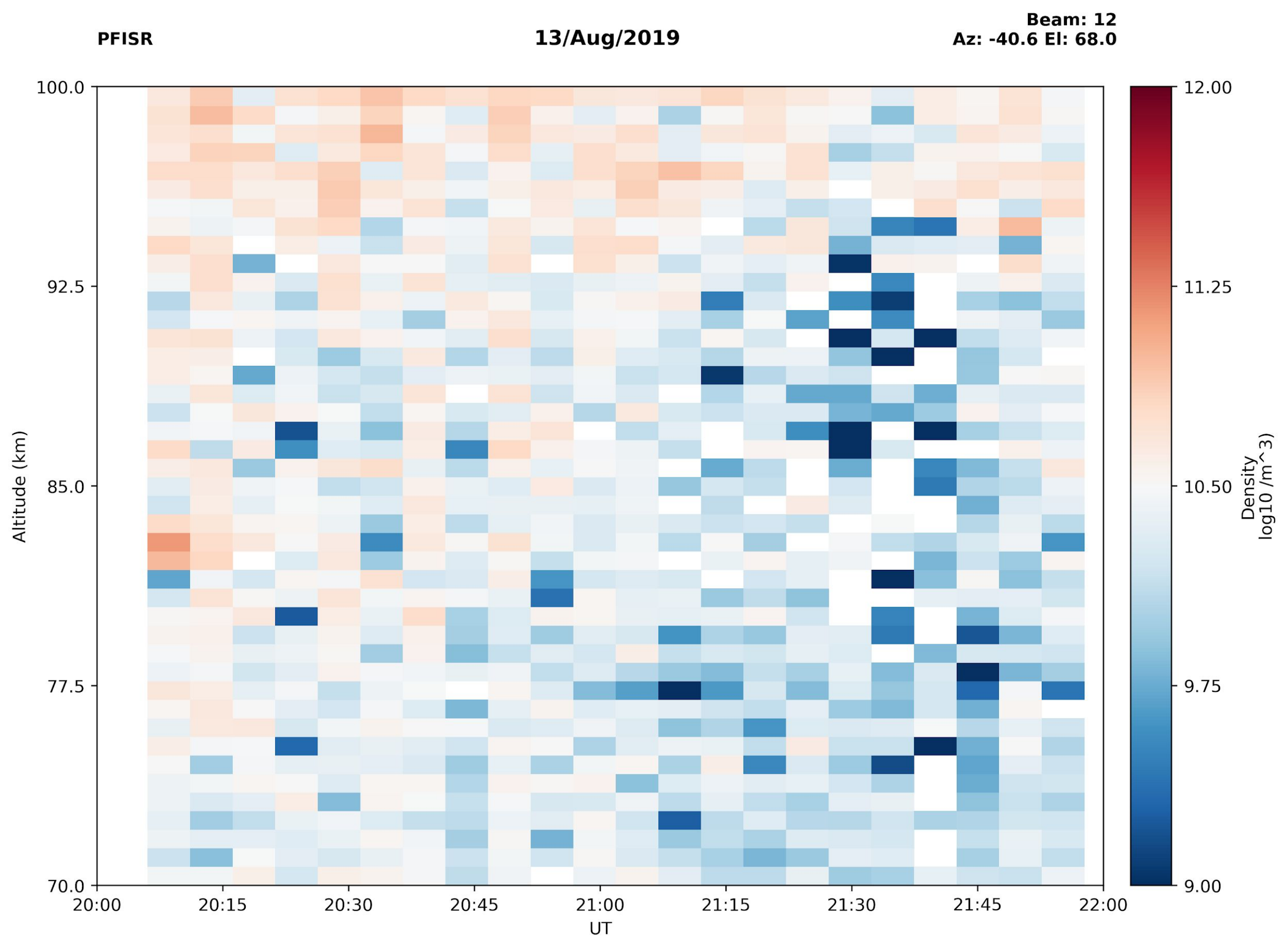
Nicolls et al, 2009

Results



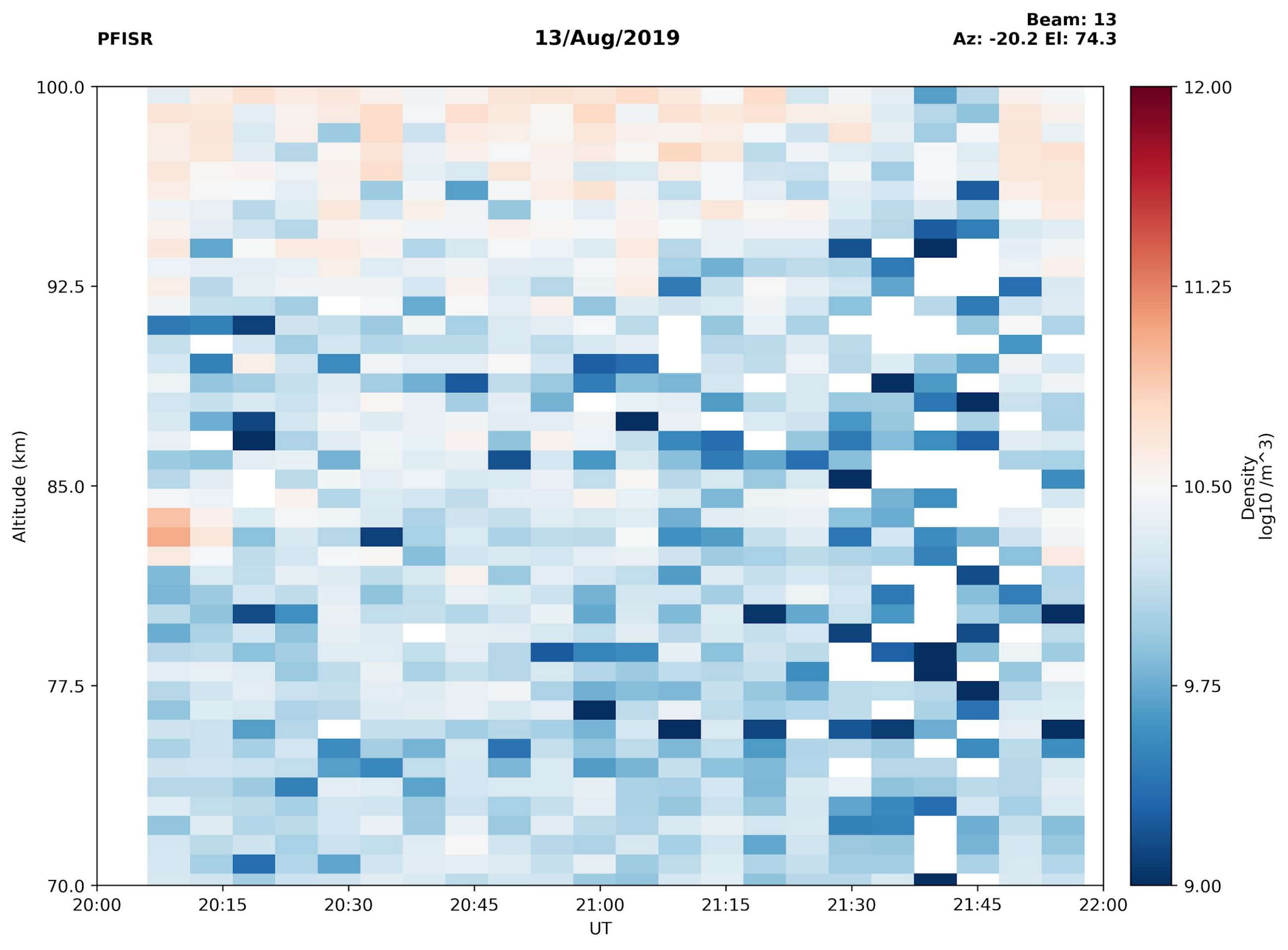
PFISR
13/Aug/2019
Beam: 6
Az: -154.3 El: 77.5
Altitude (km)
100.0
92.5
85.0
77.5
70.0
20:00
20:15
20:30
20:45
21:00
21:15
21:30
21:45
22:00
UT
12.00
11.25
10.50
9.75
9.00
Density
log10 /m^3)

Results



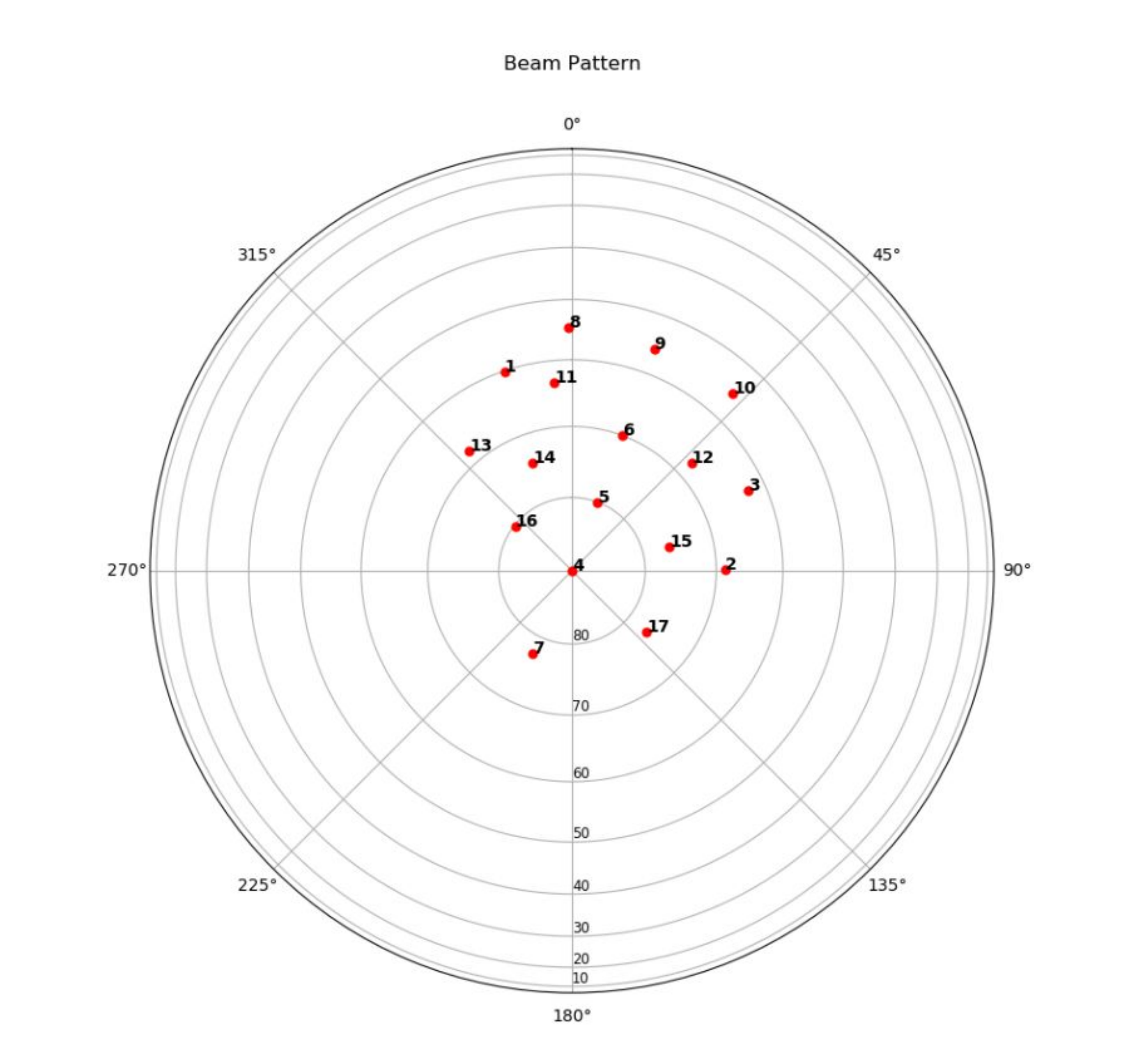
PFISR
13/Aug/2019
Beam: 12
Az: -40.6 El: 68.0
100.0
92.5
85.0
77.5
70.0
Altitude (km)
20:00
20:15
20:30
20:45
21:00
21:15
21:30
21:45
22:00
UT
12.00
11.25
10.50
9.75
9.00
Density
log10 /m^3)

Results

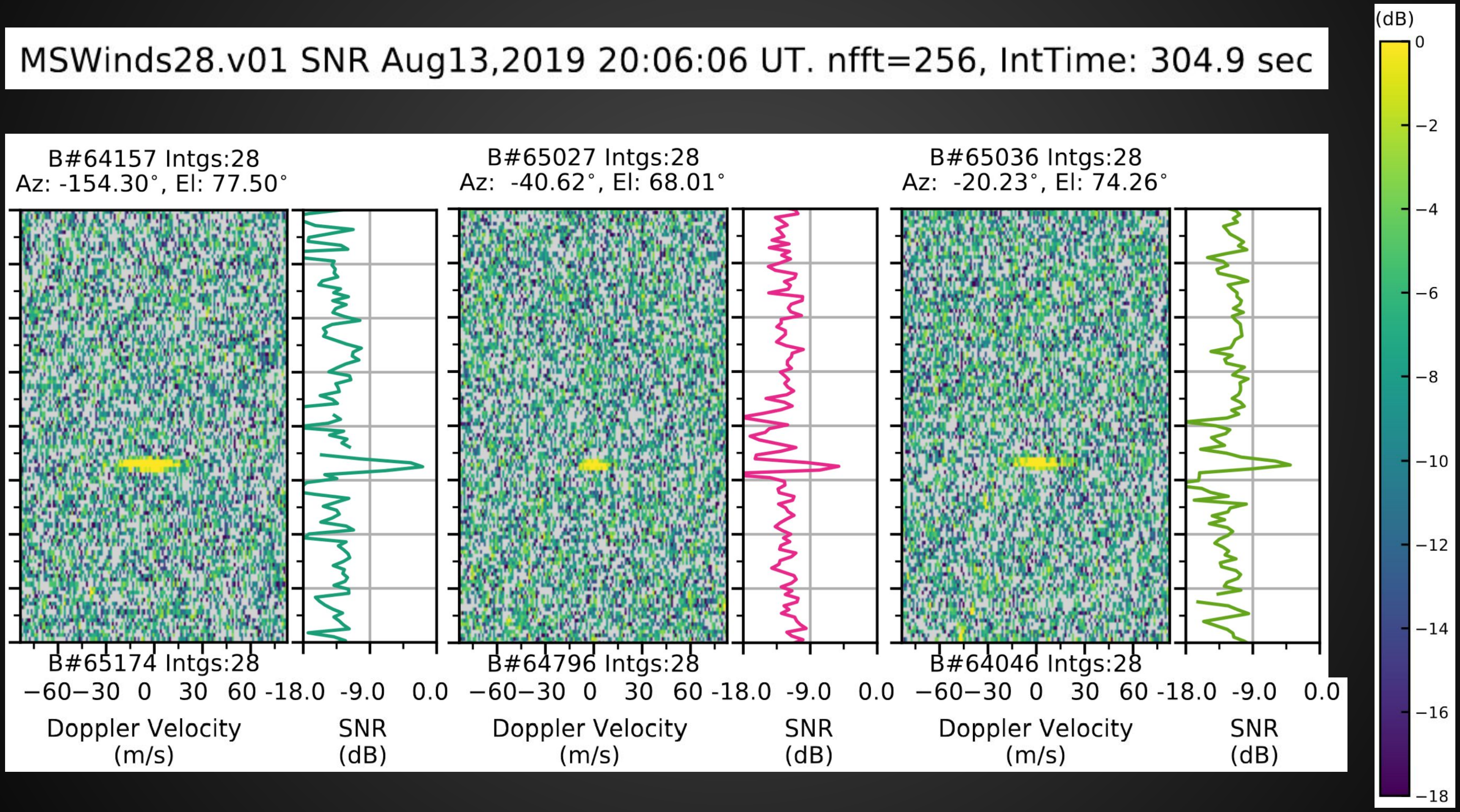


PFISR
13/Aug/2019
Beam: 13
Az: -20.2 El: 74.3
Altitude (km)
100.0
92.5
85.0
77.5
70.0
20:00
20:15
20:30
20:45
21:00
21:15
21:30
21:45
22:00
UT
Density
log10 /m^3)
12.00
11.25
10.50
9.75
9.00

Experiment Design

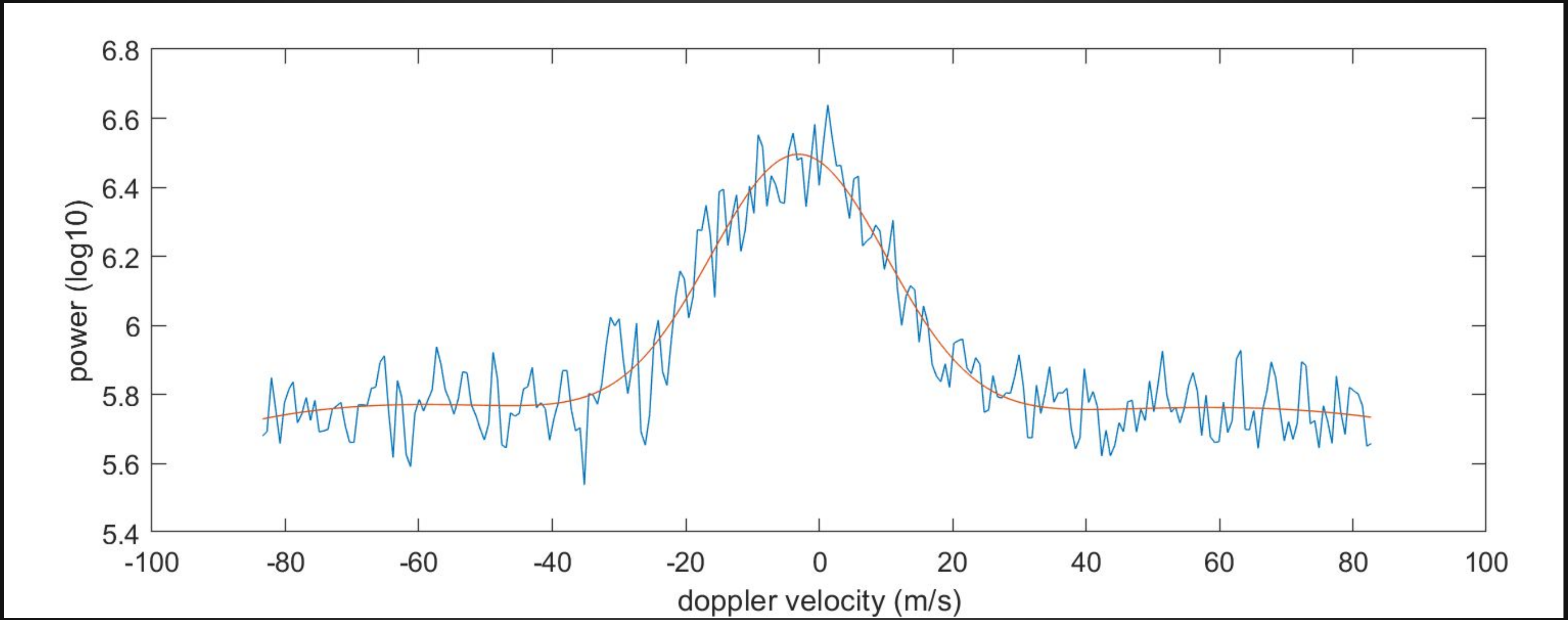


Results



MSWinds28.v01 SNR Aug13,2019 20:06:06 UT. nfft=256, IntTime: 304.9 sec
B#64157 Intgs:28
Az: -154.30°, El: 77.50°
B#65027 Intgs:28
Az: -40.62°, El: 68.01°
B#65036 Intgs:28
Az: -20.23°, El: 74.26°
B#65174 Intgs:28
B#64796 Intgs:28
B#64046 Intgs:28
−60 −30 0 30 60
-18.0 -9.0 0.0
Doppler Velocity (m/s)
SNR (dB)
(dB)
0 −2 −4 −6 −8 −10 −12 −14 −16 −18

Results



Beam 6 PDS at ~84 km (range)

Conclusion

We used PFISR to study Polar Mesospheric Summer Echoes

To observe the PMSEs, we used 17 beams and chose a time slot near 12:00 LT

PMSEs are found in high latitude regions during the summer in the mesosphere

To observe a PMSE, there must be water vapor, dust particles, and ice aerosols

We observed a PMSE around 20:00 UT at an altitude of about 80 km

The particularly strong season for PMSEs is coming to an end