Mid & High Latitude Nighttime Ionospheric Dynamics

GROUP 5: Experiment A
Rapid Regional (07/18/2022 22-24 LT)

ISR Summer School 2022

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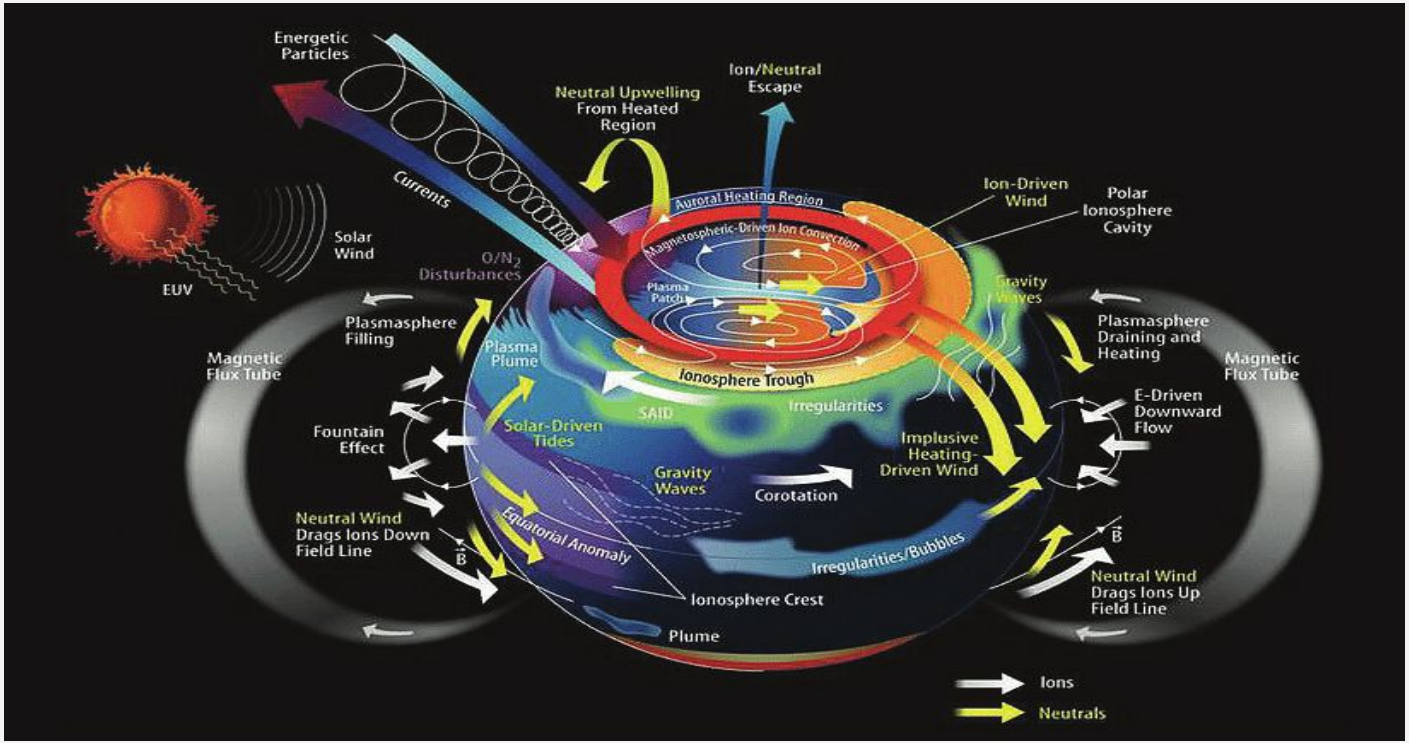
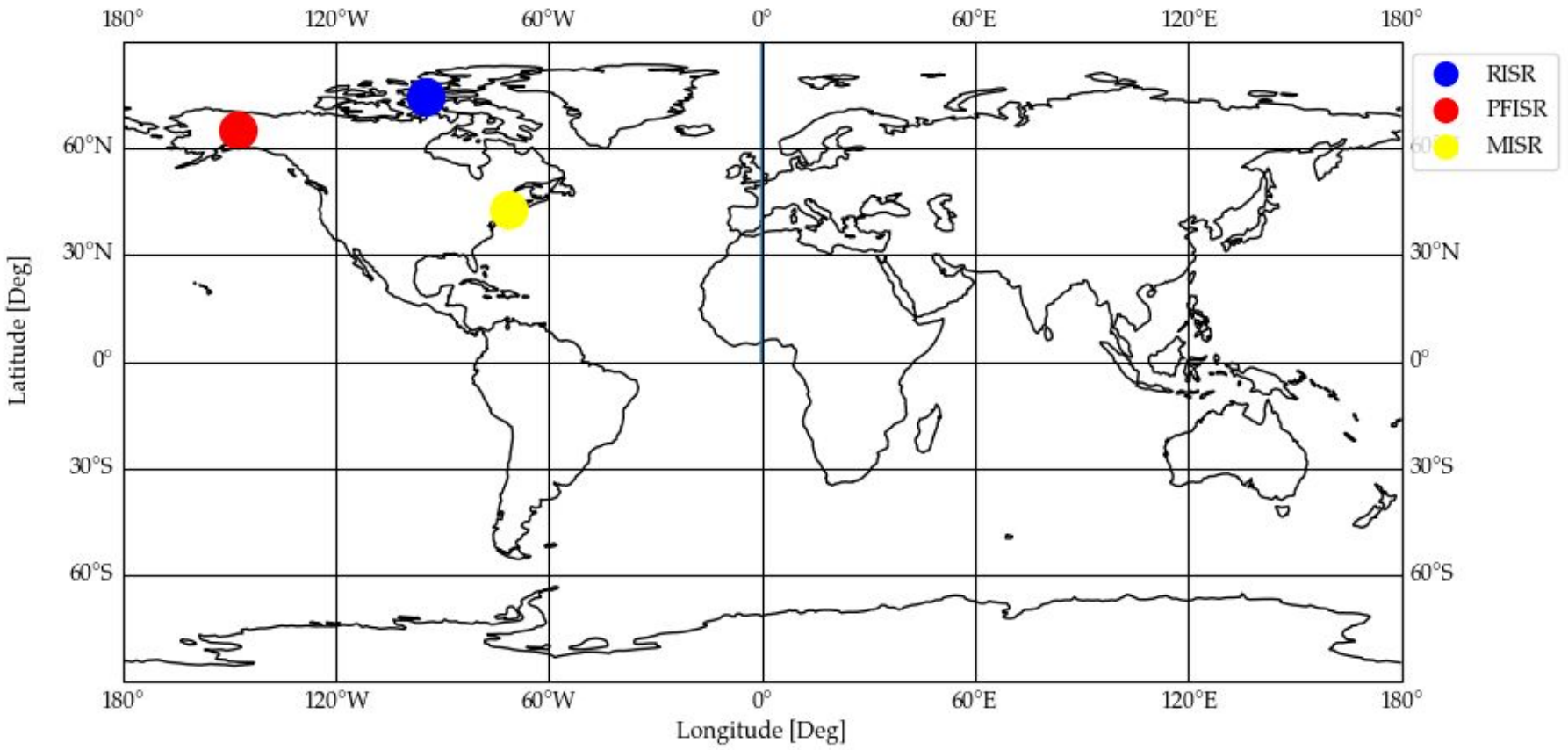
Experiment Objectives and Motivations

- Observe mid/high-latitude ionospheric behavior and variability during nighttime
- Observe possible geomagnetic storm (Predicted to occur between 8:00 PM 18/07/2022 to 2:00AM LT 19/07/2022)
- Use observations to analyze and compare to possible changes in the electron density

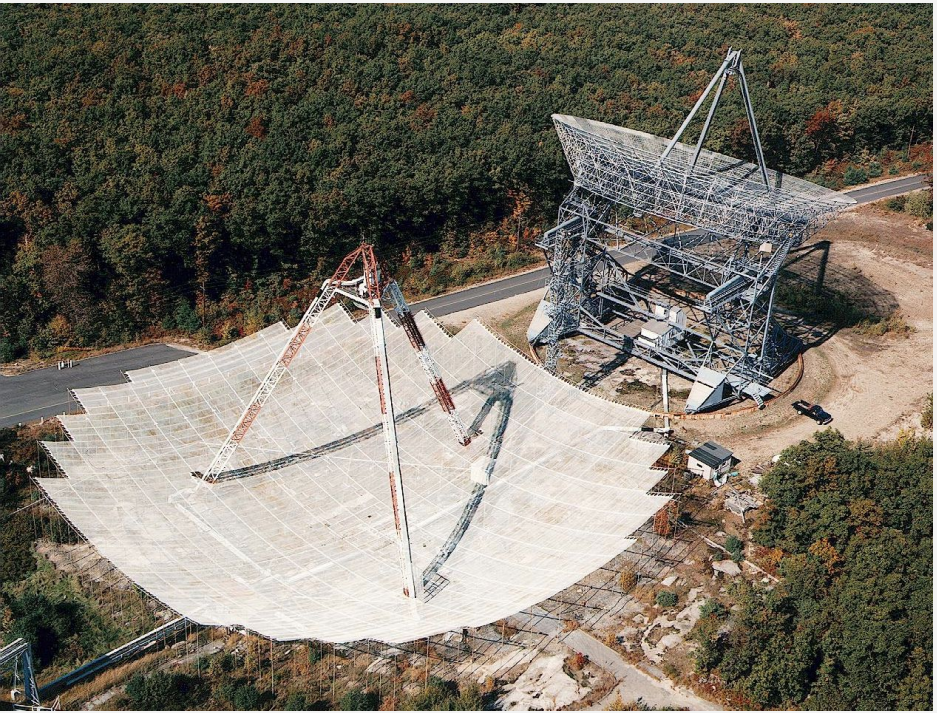


RADAR LOCATIONS



Experimental Setup (MISR)

MISR : Millstone Hill Incoherent Scatter Radar



Time: **10:00 PM to 12:00 AM LT** ***07/18/2022***

02:00 to 04:00 UT ***07/19/2022***

Characteristic : **Zenith, MISA**

Regional vectors: **[45 deg elevation, -44.98 deg azimuth]**

Wide field scans: **[6 deg elevation]**

Experiment cycle time = **~4 minutes**

- MISA fixed positions on either side of magnetic meridian
- E, F region

Experimental Setup (PFISR)

PFISR : Poker Flat Advanced Modular Incoherent Scatter Radar

Location: **65 7’12" N 147 25’48" W**

Geo-magnetic dip angle: **77 32’**

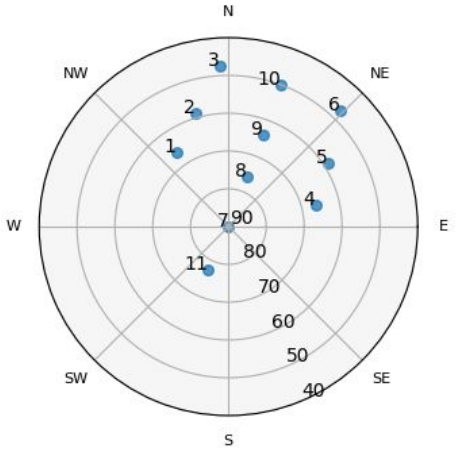
Frequency, f = **449 MHz**

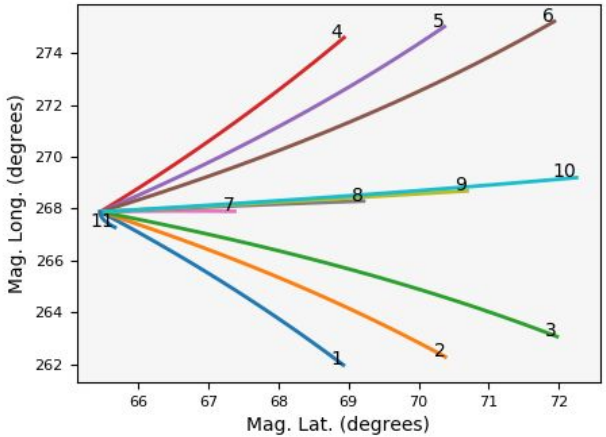
Wavelength = **0.6677 m**

Bragg wavelength/2: **0.3338 m**

Antenna gain: **43 dBi**

Full width half power antenna beamwidth: **1deg**





Experimental Setup (RISR)

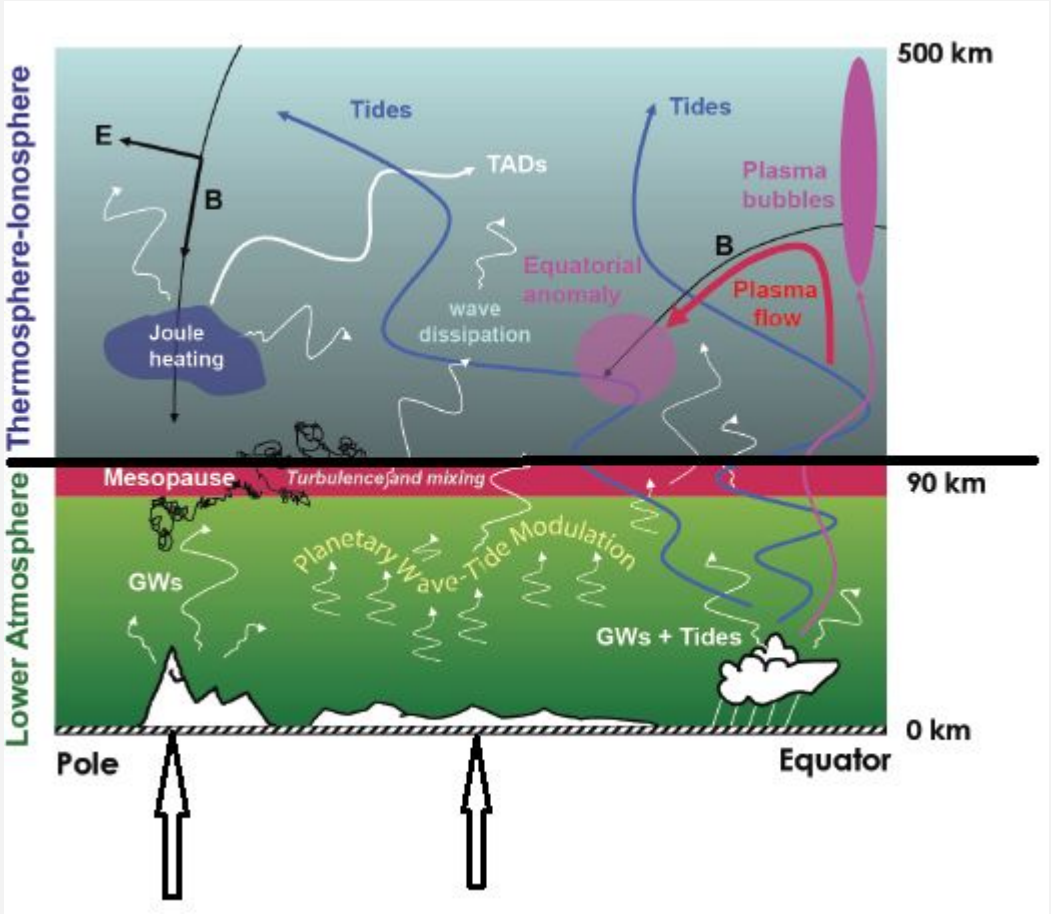
RISR : The Resolute Bay ISRs

Location **74.72955° N 94.90576° W, 145 m**

Frequency Band = **430-450MHz (Nominally operates ~442.5)**

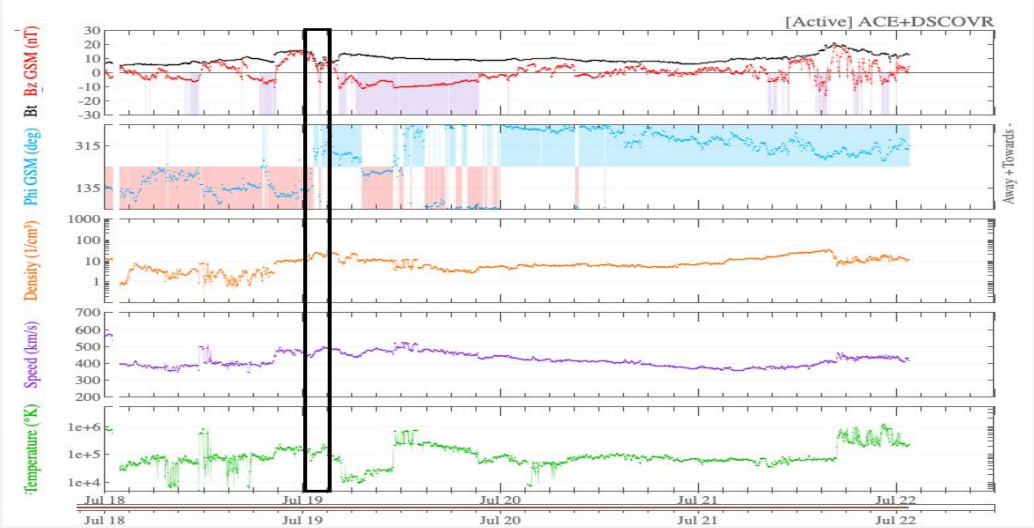
Antenna Boresight = **26° azimuth angle (E of N), 55° elevation**

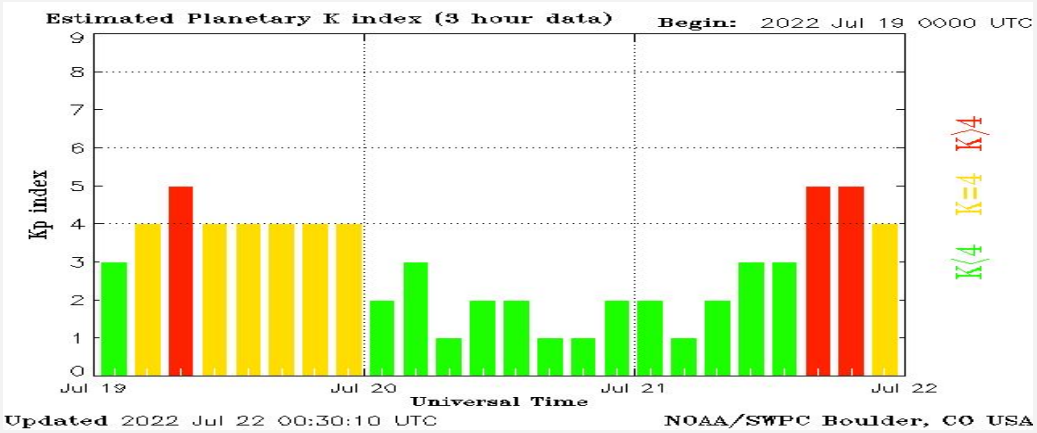
Mid & High Latitude Ionospheric Dynamics



- Location of ionospheric structures in the high latitude regions of study
- How plasma transport from high latitudes affects mid latitudes.
- The roles that magnetospheric background plays in the high latitude ionosphere.
- Mid-latitude zone is a buffer between low-latitude processes and high-latitude phenomena
- E-fields and neutral winds penetrate from high-latitudes, & equatorial plasma streams-in from events like EIA along B-field lines.
- Meridional components of the neutral wind exerts force on ionization. Geomagnetic field directs the motion of plasmas to ExB drift. Causing the lowering or raising of the altitude of F layer peak.

Results and Observations - *Space Weather Parameters*





WDC for Geomagnetism, Kyoto
Hourly Equatorial Dst Values (REAL-TIME)

JULY 2022

unit=nT

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	2	5	10	9	7	7	5	3	4	3	10	14	16	15	14	16	21	20	23	20	14	10	8	12
2	10	-6	-22	-16	-16	-31	-45	-52	-48	-50	-53	-51	-50	-46	-43	-41	-36	-35	-33	-31	-30	-26	-21	-14
3	-7	1	5	7	7	7	9	11	20	24	24	22	19	23	19	18	23	19	17	9	3	3	14	18
4	17	19	18	17	7	-10	-4	-7	1	-5	-10	-8	-8	-5	-5	-2	-12	-25	-30	-29	-28	-24	-26	-22
5	-15	-12	-12	-13	-10	-9	-11	-12	-10	-10	-10	-9	-8	-5	-5	-6	-5	-6	-4	2	8	11	11	11
6	10	11	14	18	21	22	18	17	14	9	12	14	15	15	13	13	12	8	8	9	9	10	10	11
7	13	16	17	18	18	16	14	26	27	29	36	44	32	8	-20	-36	-41	-52	-62	-71	-76	-77	-82	-77
8	-71	-64	-66	-57	-40	-37	-30	-27	-17	-19	-20	-31	-34	-34	-34	-37	-36	-31	-25	-24	-17	-13	-15	-14
9	-13	-15	-15	-16	-15	-15	-15	-12	-8	-7	-2	1	2	0	-5	-12	-15	-14	-14	-16	-17	-15	-14	-12
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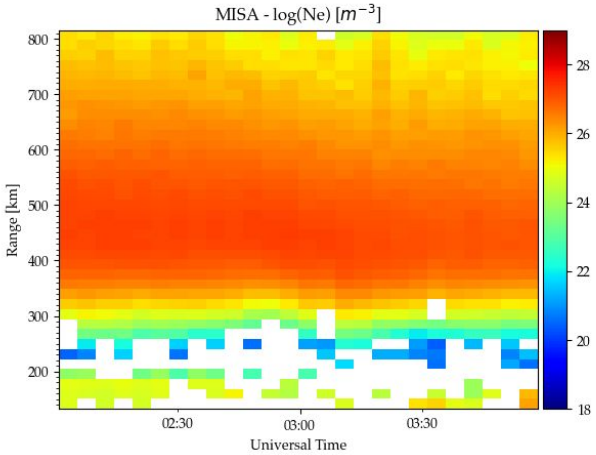
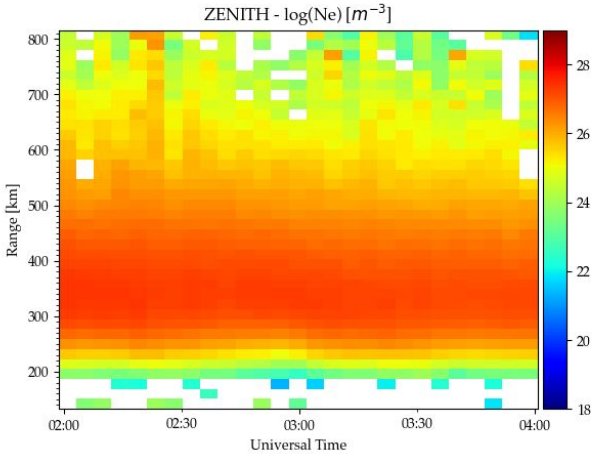
17	-5	1	4	5	3	-1	-7	-7	-3	0	1	0	0	1	2	3	4	3	3	3	1	1	1	4
18	8	11	16	16	16	11	3	-1	3	4	3	3	-5	-3	2	5	7	6	5	4	-7	-14	-14	-2
19	9	16	30	25	31	19	4	-5	-18	-19	-30	-40	-50	-53	-53	-56	-59	-62	-61	-57	-61	-59	-49	-40
20	-33	-27	-28	-24	-20	-16	-15	-14	-12	-9	-6	-6	-6	-5	-6	-8	-6	-6	-10	-10	-9	-6	-3	0

- Bz turn southward at 01:55 UT
- Kp index was approximately 3
- Solar wind speed increased to around 500 km/s
- Dst index was above 10 nT

The southward IMF Bz leads to negative incursion of *Dst* index when the solar wind speed exceeds 600 km/s. Kyung-Eun Choi et al., (2017)

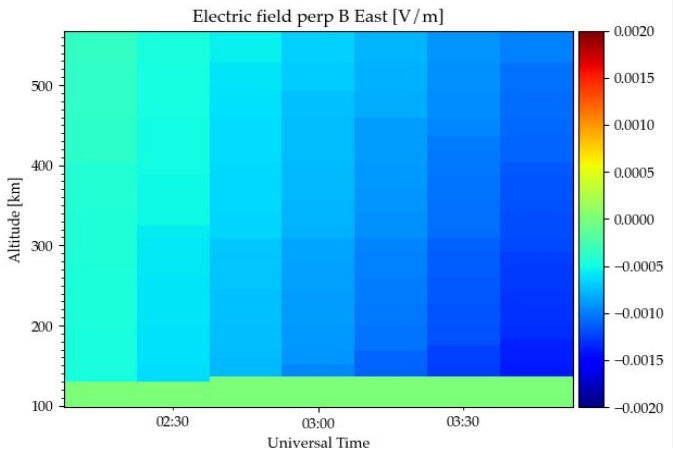
Results and Observations - *Nighttime Electron Densities*

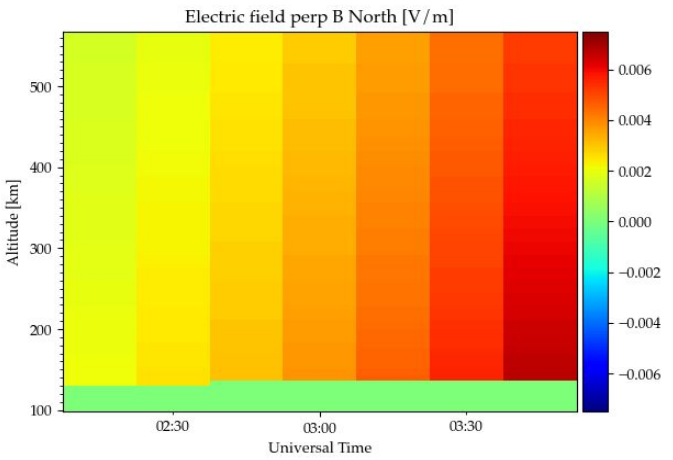




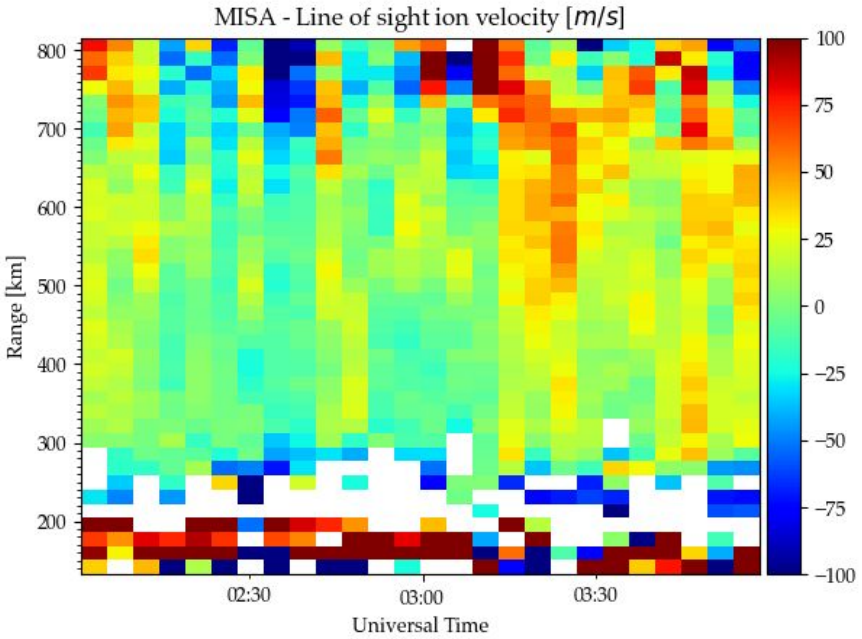
- ➔ Electron density increased upto the F layer peak, resulting in increase in nighttime F layer height.
- ➔ East/North electric field was decreasing/increasing spatially and temporally.

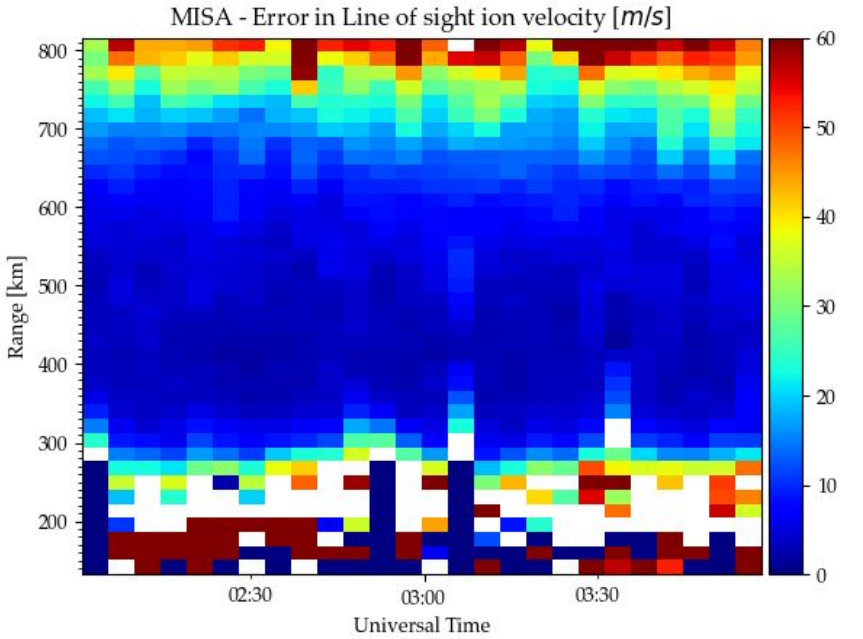
- ❑ At the nightside of the solar terminator, the Earth's ionosphere crosses into the dark side of the Earth.
- ❑ The E region conductivity decays as the E layer disappears causing the enhancement of the Northward electric field.
- ❑ The increase in Northward electric field creates a corresponding enhanced eastward electric field and upward drift of plasma.



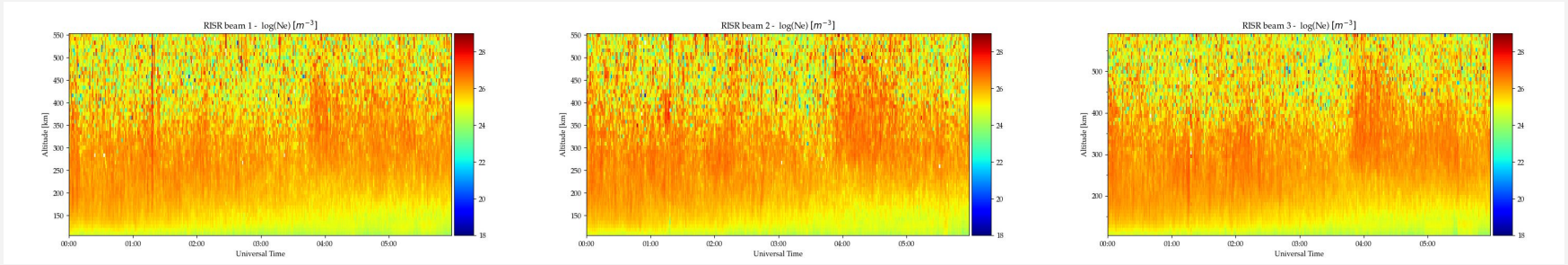


Results and Observations - *Ion behaviour*

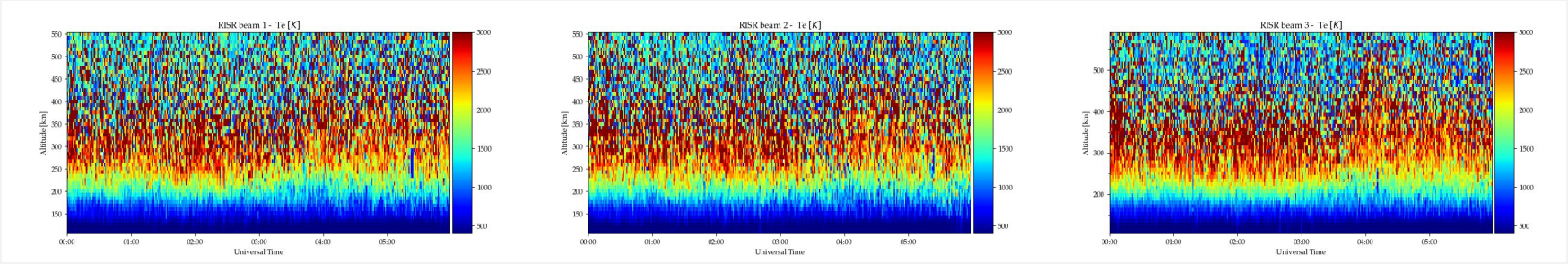


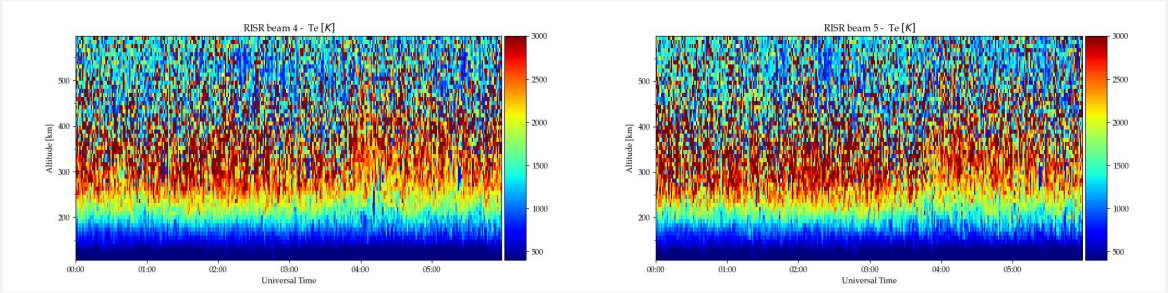


Results and Observations - *Nighttime Electron Densities for RISR*

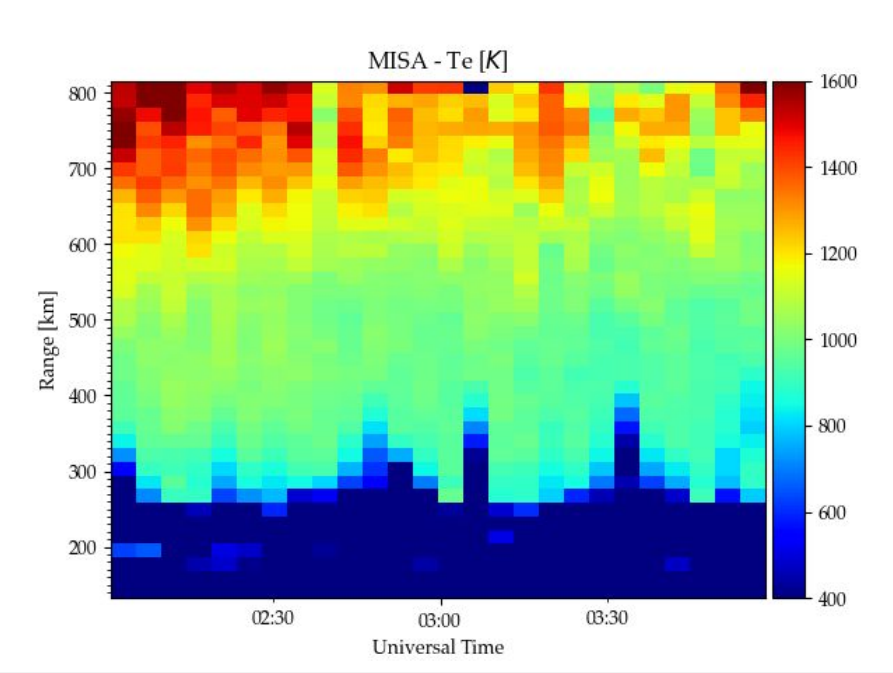


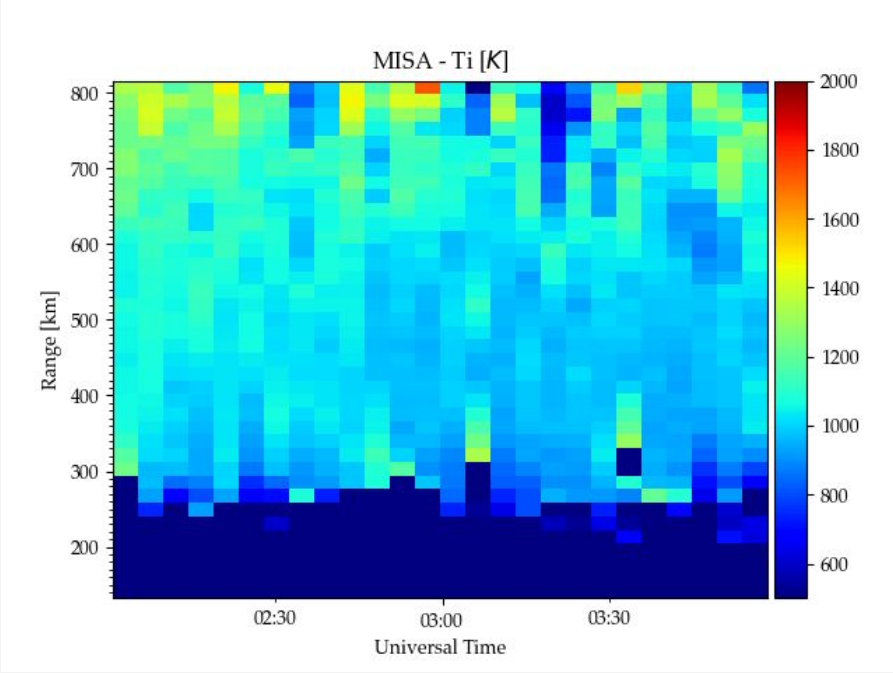
Results and Observations - *Nighttime Electron Temperatures for RISR*



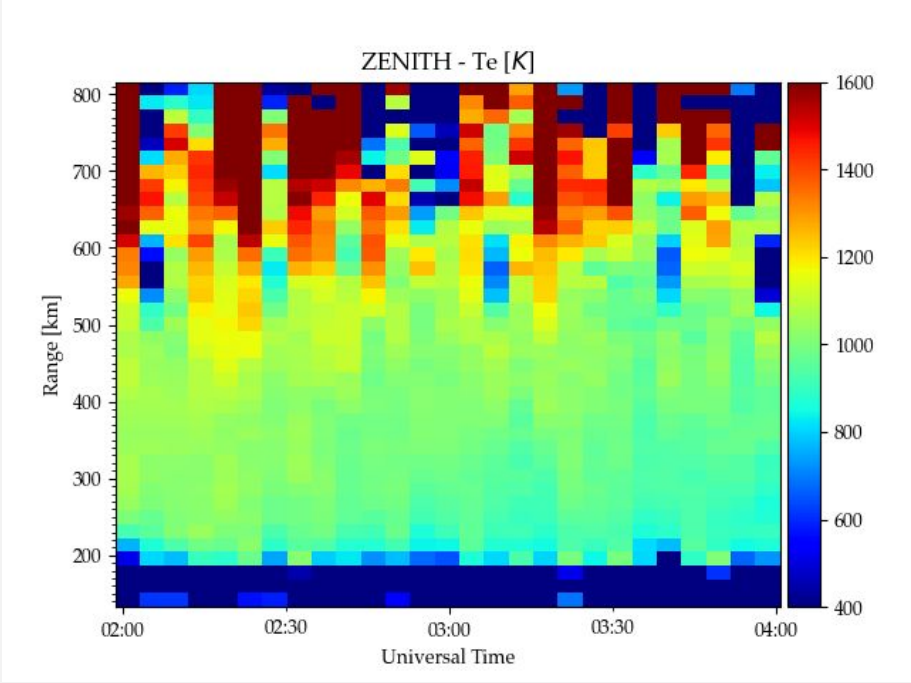


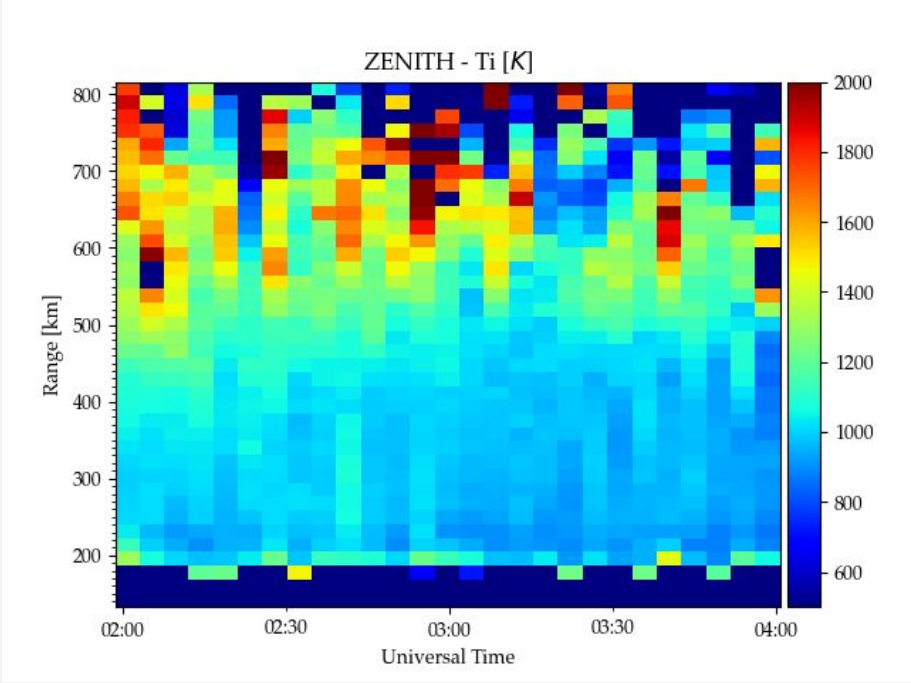
Results and Observations - *Te & Ti variation*



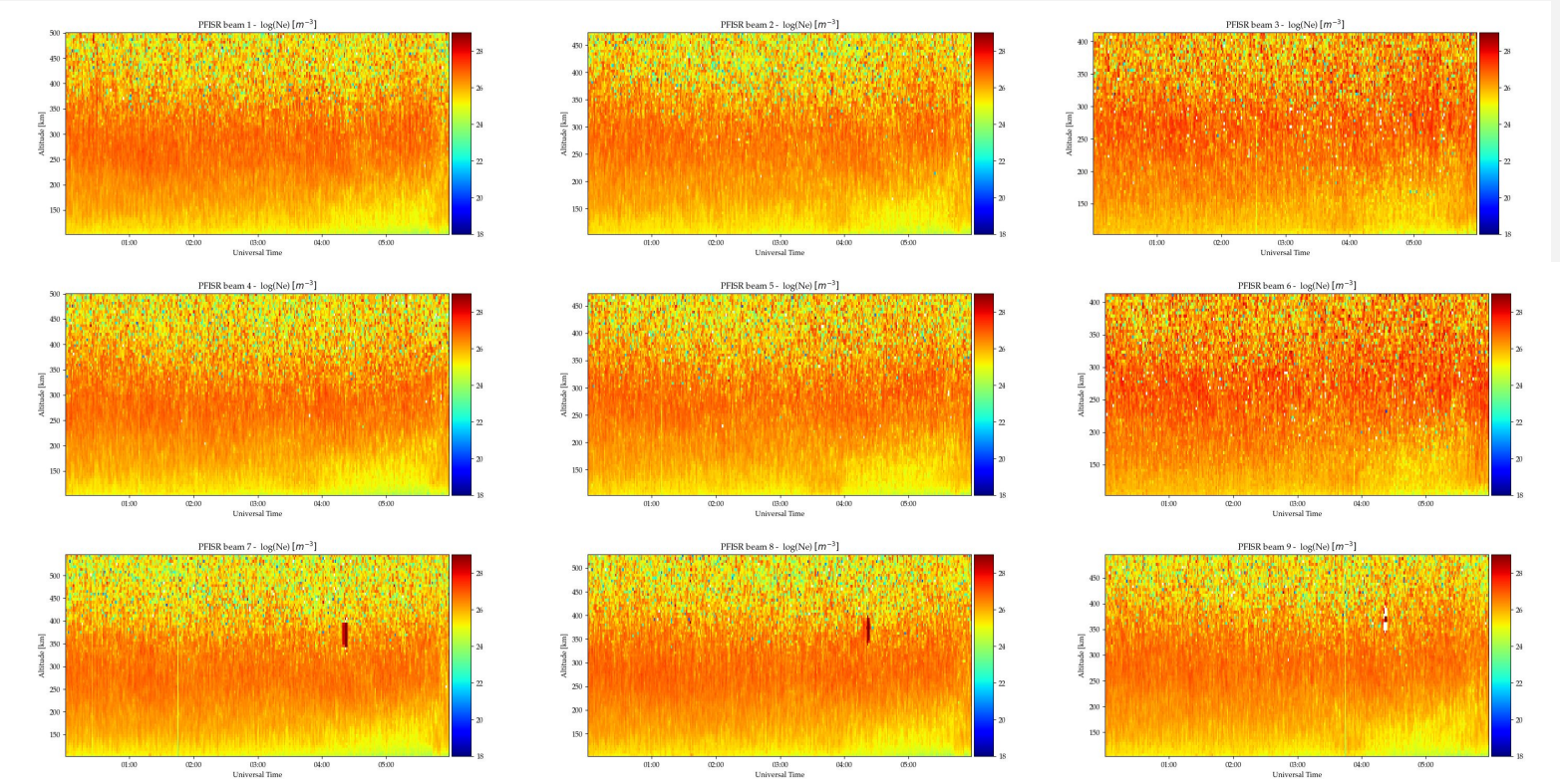


Results and Observations - *Te & Ti variation*

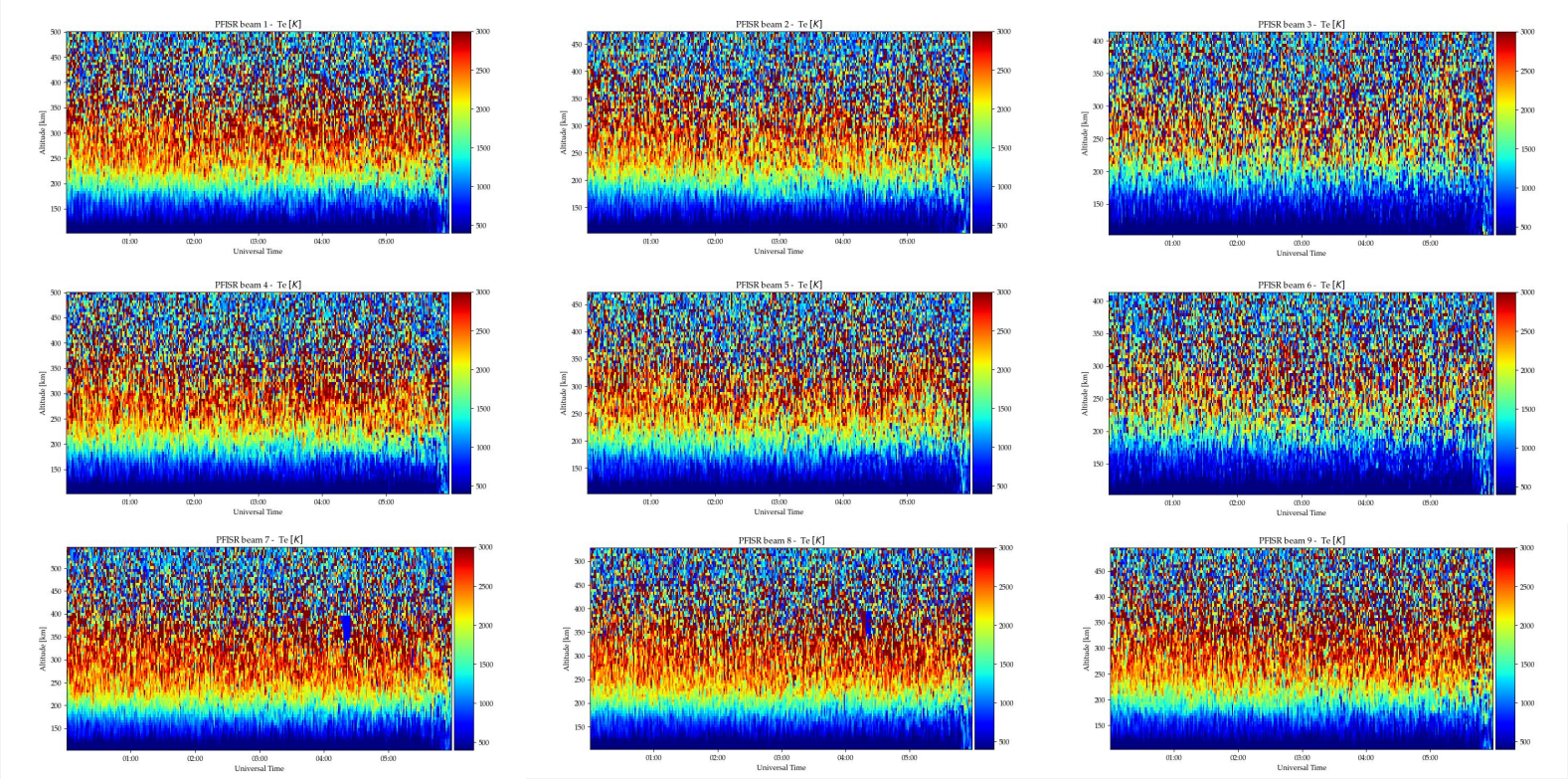




Results and Observations - *Nighttime Electron Densities for PFISR*



Results and Observations - *Nighttime Electron Temperatures for PFISR*



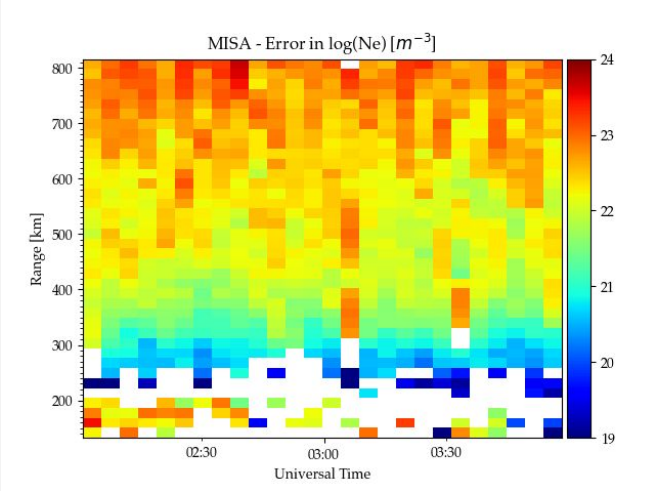
Conclusions

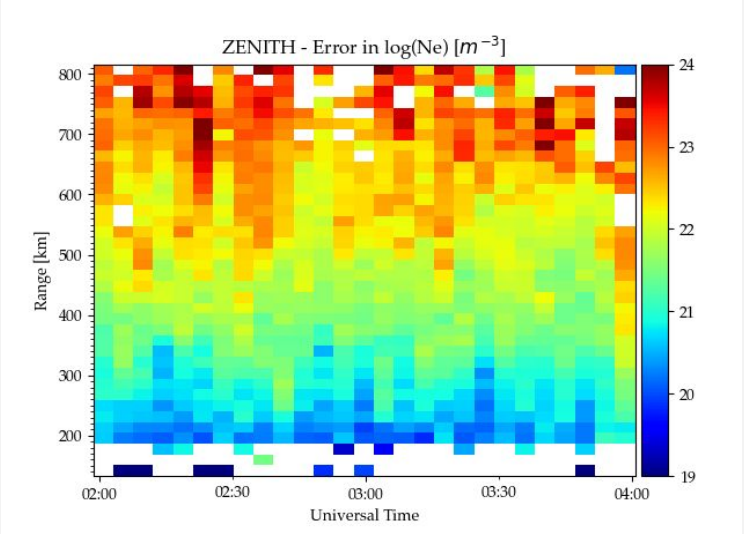
- Moderate geomagnetic conditions
- Electron density peak disagreed with decrease in E-field enhancement - winds??)
- Doppler velocity plots demonstrated plasma drift both away and toward the radar, which may relate to spikes in electron density
- Small peak in Te and decrease in Ti right before peaks in electron density

Suggestions for Future Work

- Integrate neutral winds/HWM for comparison with electron density
- Make a comparison with stormtime conditions

Thank You!


MISA - Error in log(Ne) [m^{-3}]
Range [km]
800
700
600
500
400
300
200
02:30
03:00
03:30
Universal Time
24
23
22
21
20
19


ZENITH - Error in log(Ne) [m^{-3}]
Range [km]
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700
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02:00
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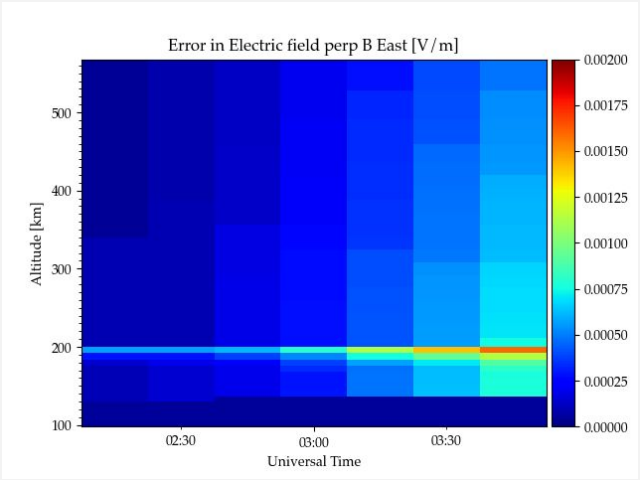
03:00
03:30
04:00
Universal Time
24
23
22
21
20
19


Error in Electric field perp B East [V/m]
Altitude [km]
500
400
300
200
100
02:30
03:00
03:30
Universal Time
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0.00100
0.00075
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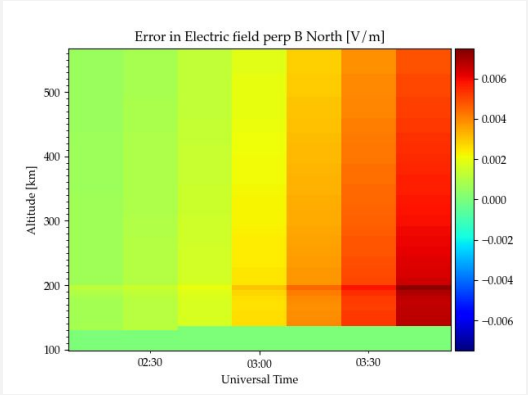
0.00025
0.00000


Error in Electric field perp B North [V/m]
Altitude [km]
500
400
300
200
100
02:30
03:00
03:30
Universal Time
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0.002
0.000
−0.002
−0.004
−0.006