Observations Of The Ionosphere Using ISR

ISR Summer School 2018

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Outline

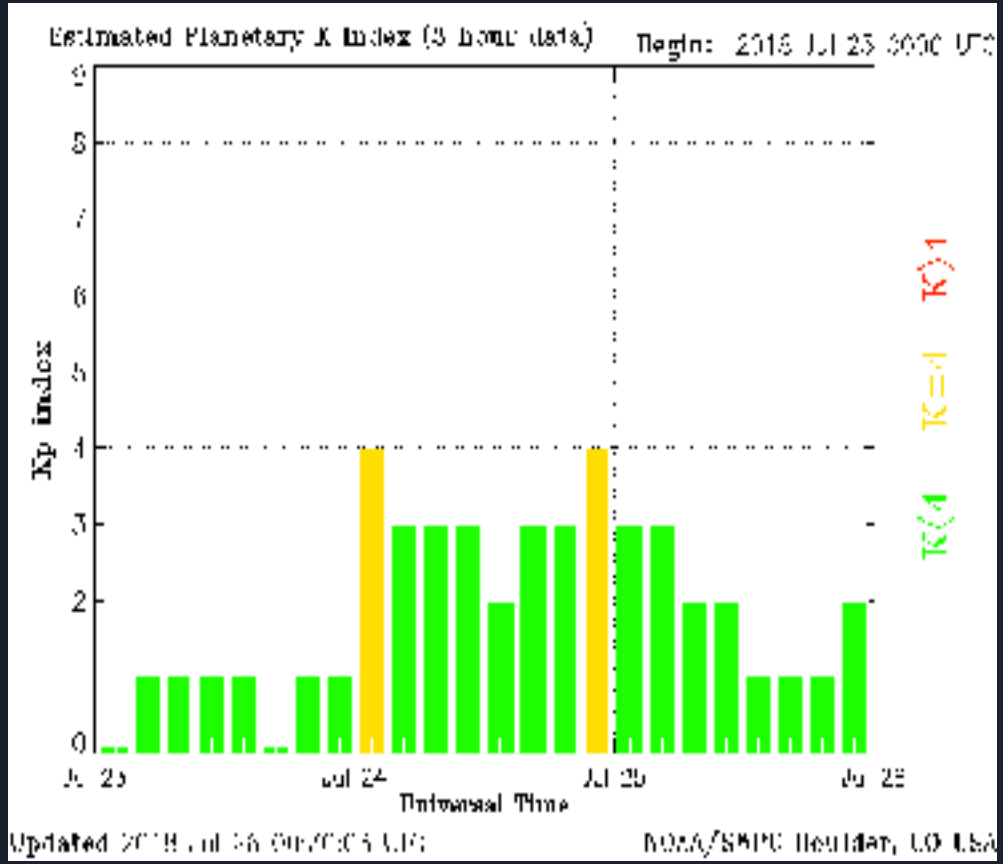
- Motivation
- Geomagnetic Indices
- Travelling Ionospheric Disturbances (TIDs)
- Experiment Data
- Comparisons to other data sets
- Conclusion and Discussion

Motivation

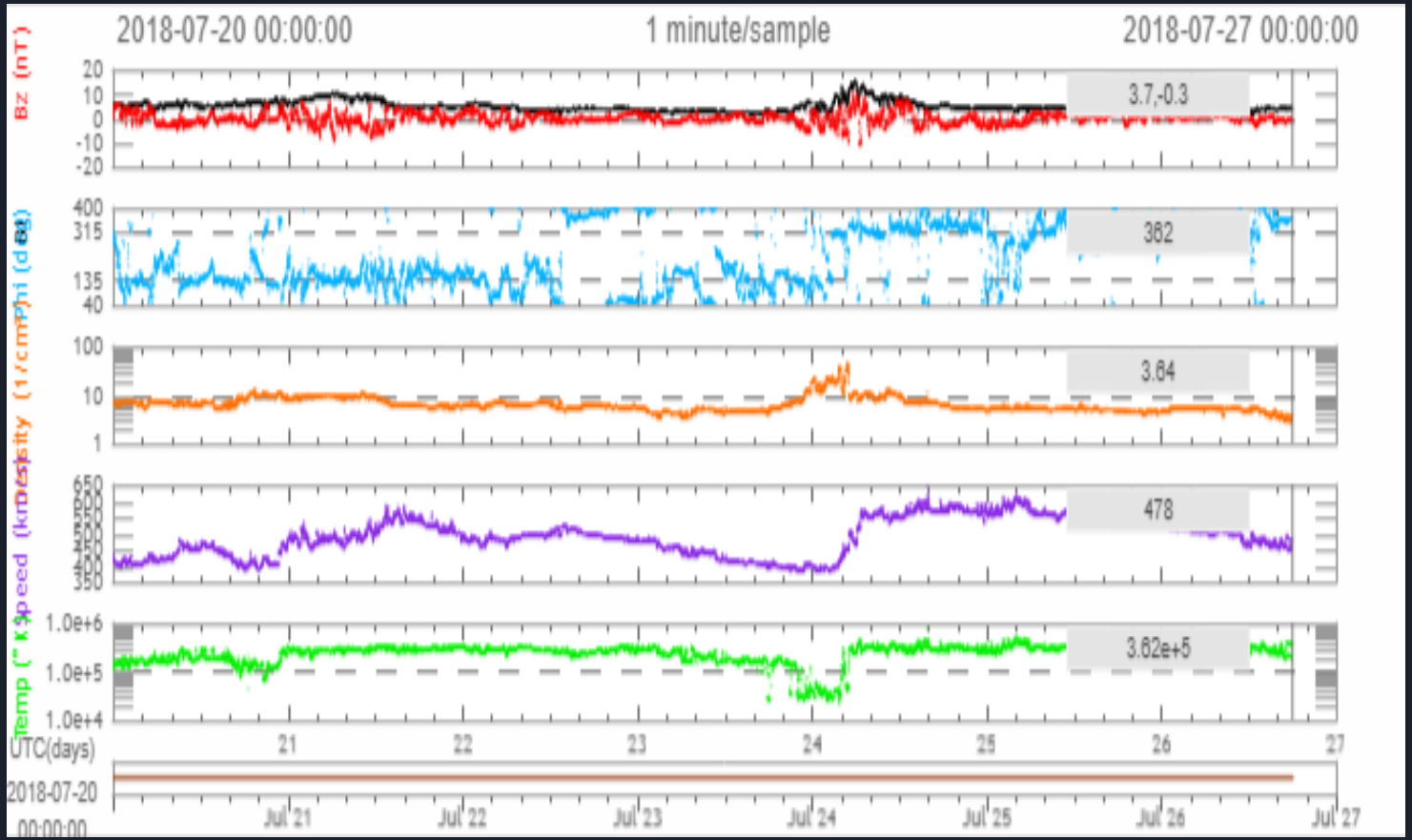
- Accessed the Millstone Hill Radar from 0400 -0600 UT to study dayside ionosphere in presence of minor geomagnetic storm
- Experiment Type B: Regional Vector + Topside
- Vertical profiles given by fully steerable MISA antenna (45 deg elevation)
- Also used the zenith antenna
- Experiment cycle time = ~18 minutes
    - Zenith: 3 minutes
    - MISA fixed positions: 3 minutes
- MISA : Mode Type B, pulse length: 0.00048s
- Zenith: Mode Type B , pulse length: 0.00048s

Geomagnetic Indices

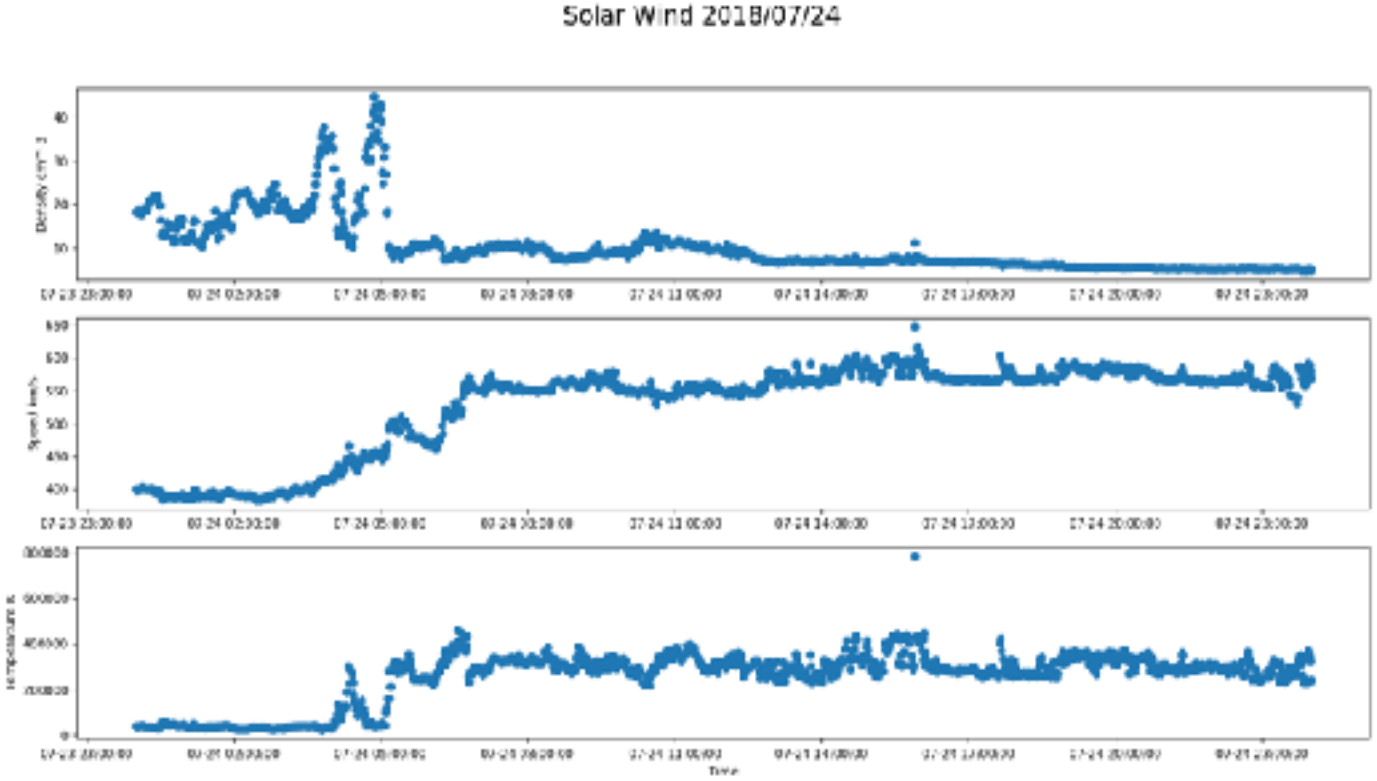
- Kp index of 4 indicates minor geomagnetic (G1) storm
- Solar wind and IMF data
  - Real-Time Solar Wind (RTSW) data from The NOAA/DSCOVR satellite.
  - Refers to data from any spacecraft located upwind of Earth, typically orbiting the L1 Lagrange point, that is being tracked by the Real-Time Solar Wind Network of tracking stations.



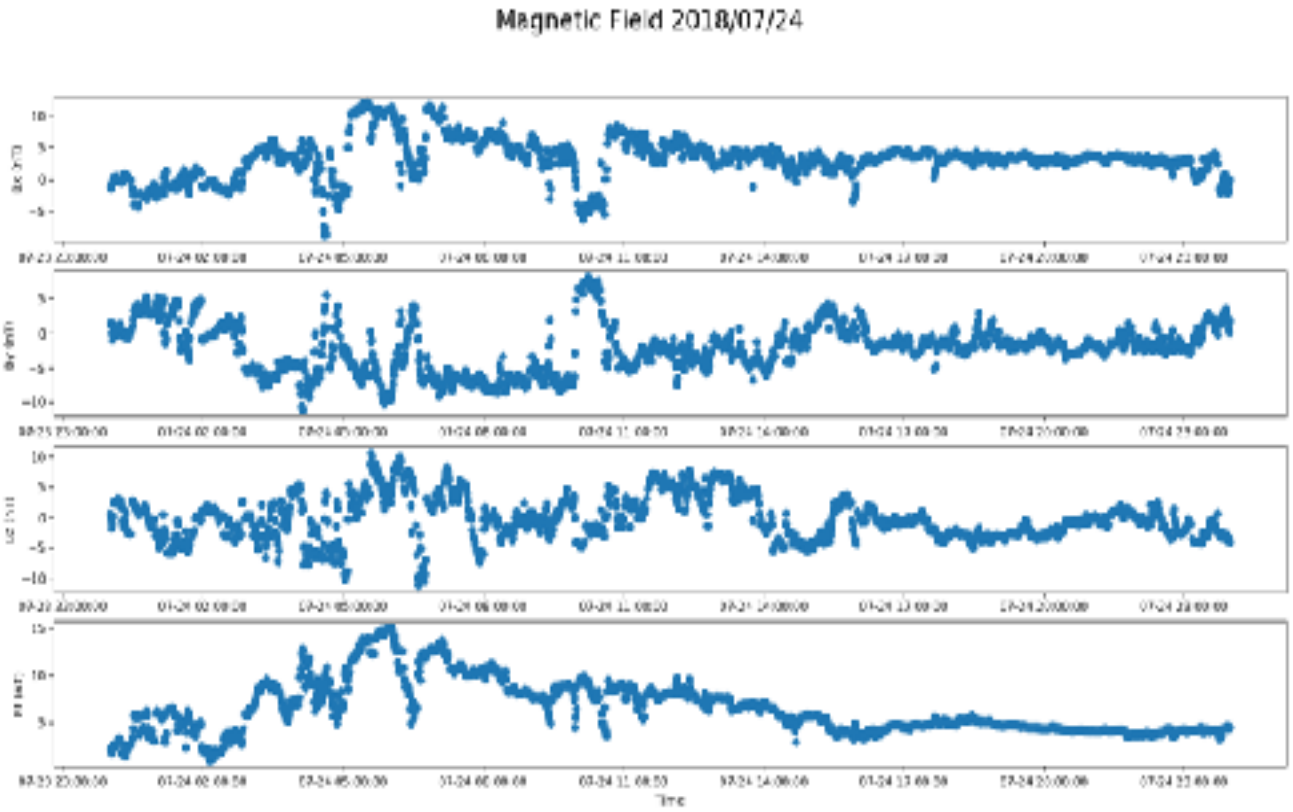
7 day Geomagnetic Indices 07/21-07/27



Solar Wind data for 2018/07/24



IMF data for 2018/07/24



Convection Maps

Travelling Ionospheric Distrubances (TIDs)

TIDs play a key role in the coupling of different ionospheric regions through momentum an energy transfer. The incoherent scatter (IS) method enables TIDs detection in such ionospheric parameters as electron density, ion and electron temperatures, and plasma velocity, thus providing critical information needed to examine different hypothesis about association of TIDs with their sources.

We can group TIDs into two categories:

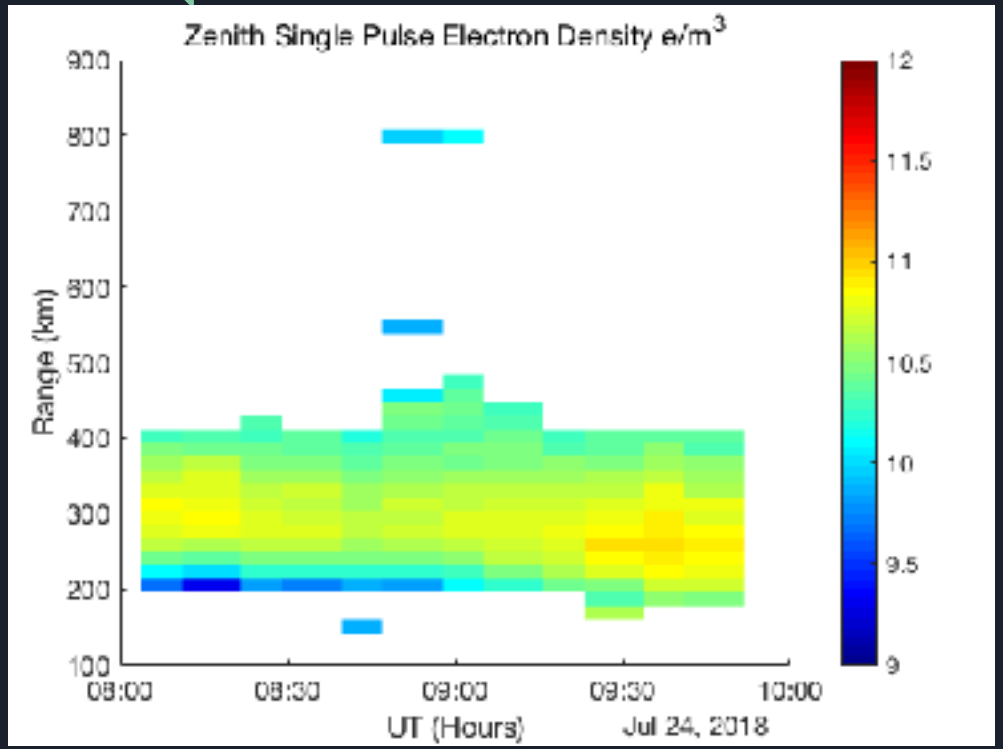
- Large-scale TIDs - horizontal wavelength of more than 1000 km, oscillation periods of 30 - 180 min and phase velocity of 200 - 1000 m/s
- Medium-scale TIDs - a horizontal wavelength of several hundred km, periods of oscillation of 15 - 80 min and a phase velocity of 50 - 250 m/s.

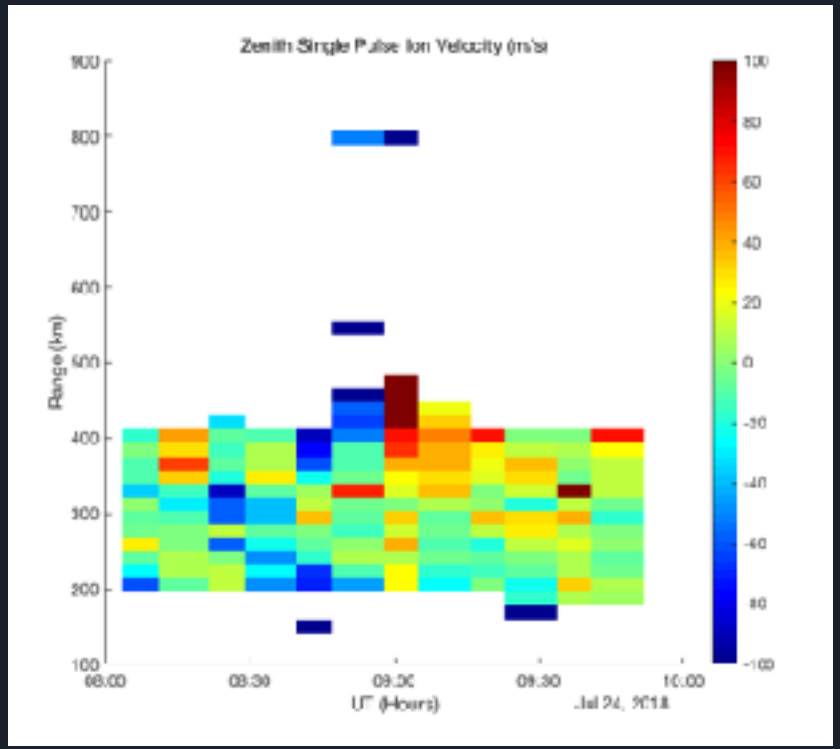
Solar Terminator as a Source

The sources of medium-scale TIDs are usually localized in the lower atmosphere and represent movements of weather fronts, thunderstorms, jet streams, earthquake, reaction to a solar eclipse or the passage of a solar terminator .

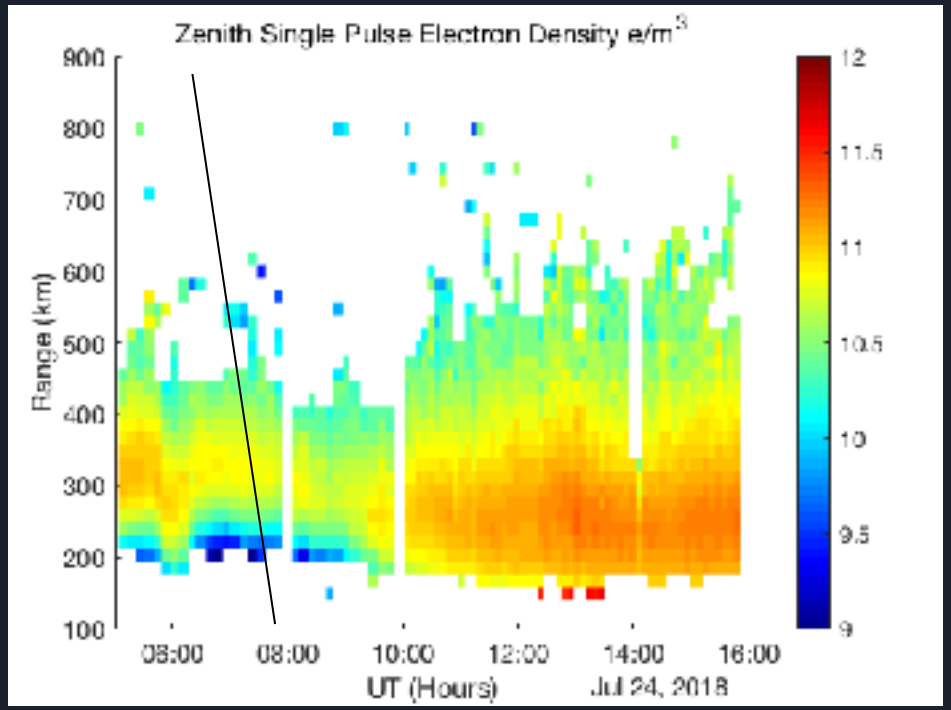
The solar terminator (ST) as a regular source of wave perturbations of the atmosphere, including the ionosphere and magnetosphere.

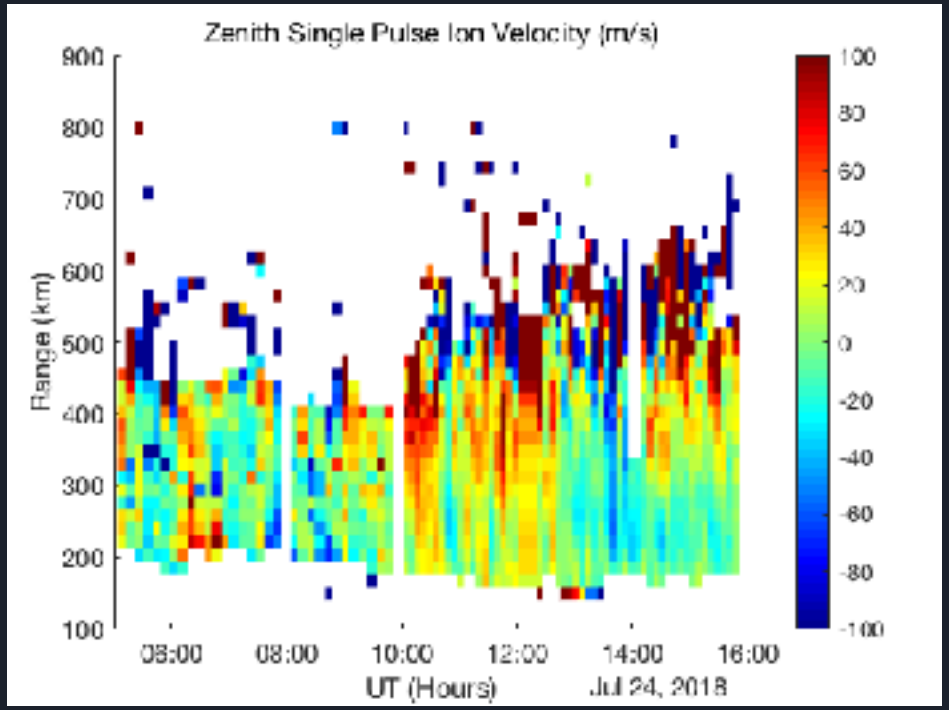
Group 1 Experiment Data



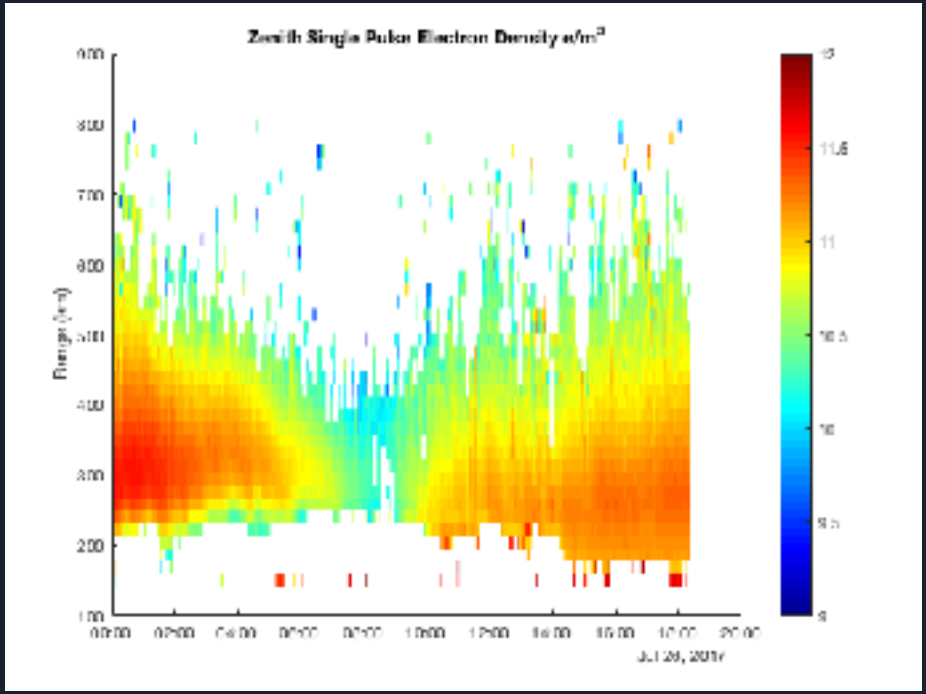


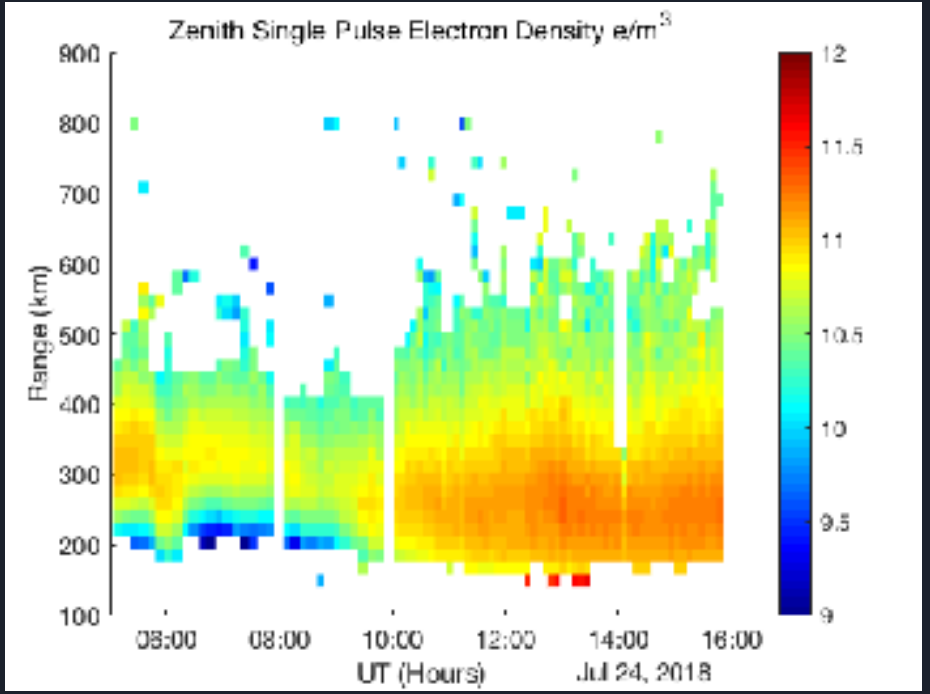
Electron Density and Ion Velocity



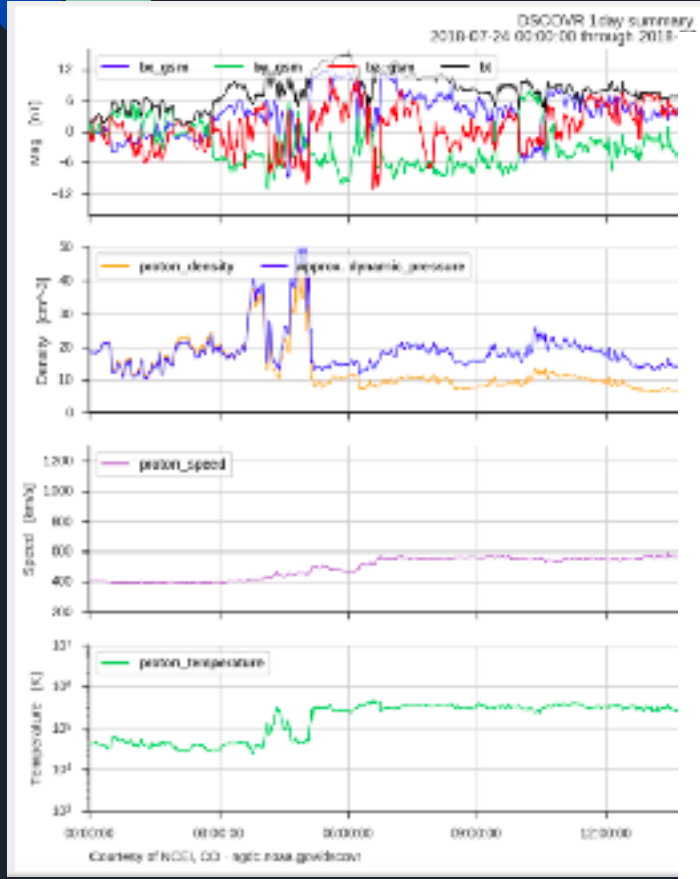


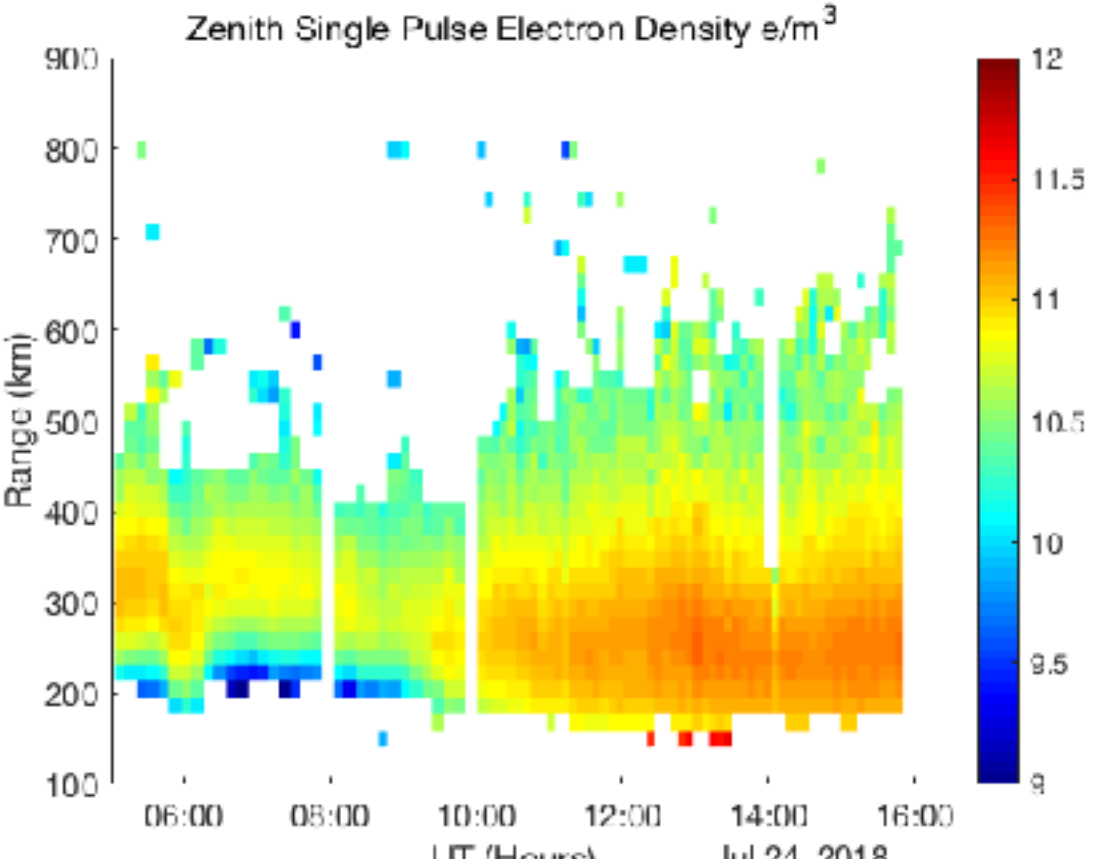
Temporal Comparison



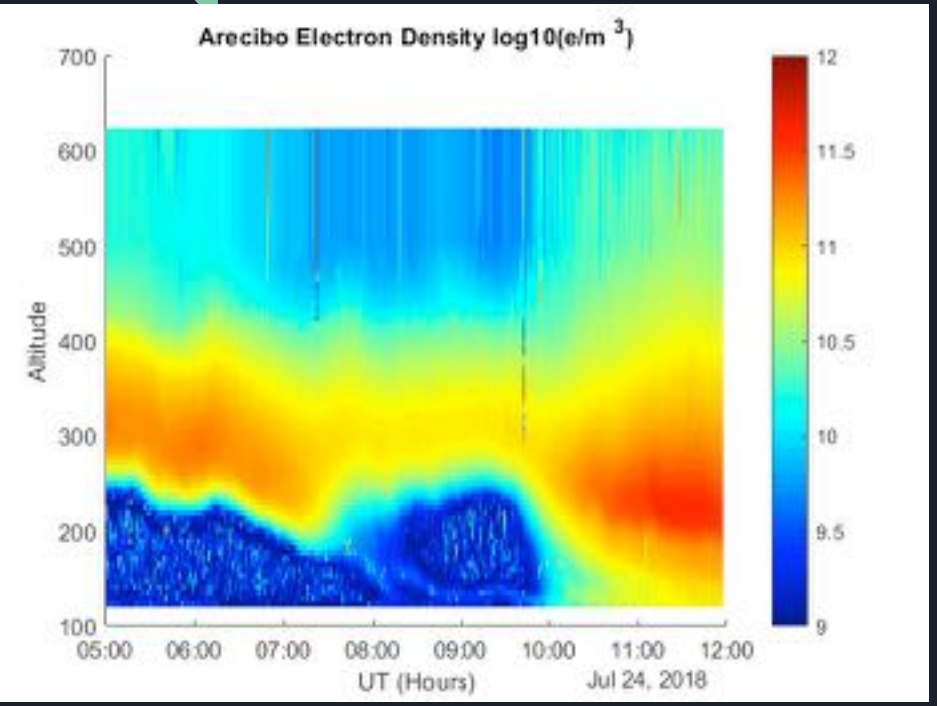


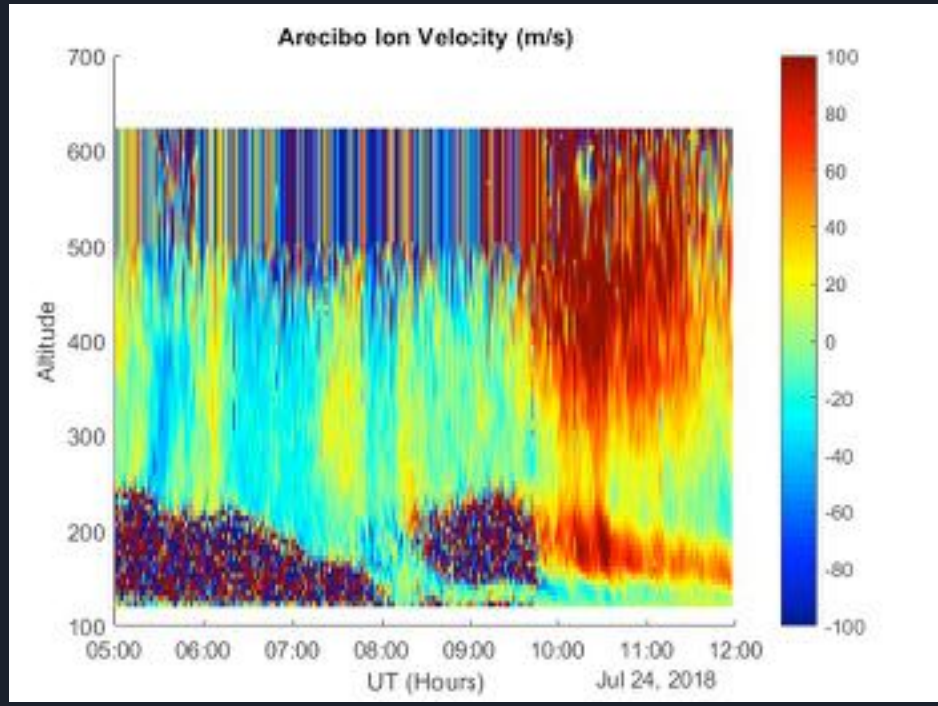
DSCOVR


DSCOVR 1 day summary
bt_gsm
bx_gsm
by_gsm
bz_gsm
bt
Mag [nT]
proton_density
Density [cm^-3]
proton_speed
Speed [km/s]
proton_temperature
Temperature [K]


Zenith Single Pulse Electron Density e/m^3
Range (km)
900
800
700
600
500
400
300
200
100
06:00
08:00
10:00
12:00
14:00
16:00
12
11.5
11
10.5
10
9.5
9

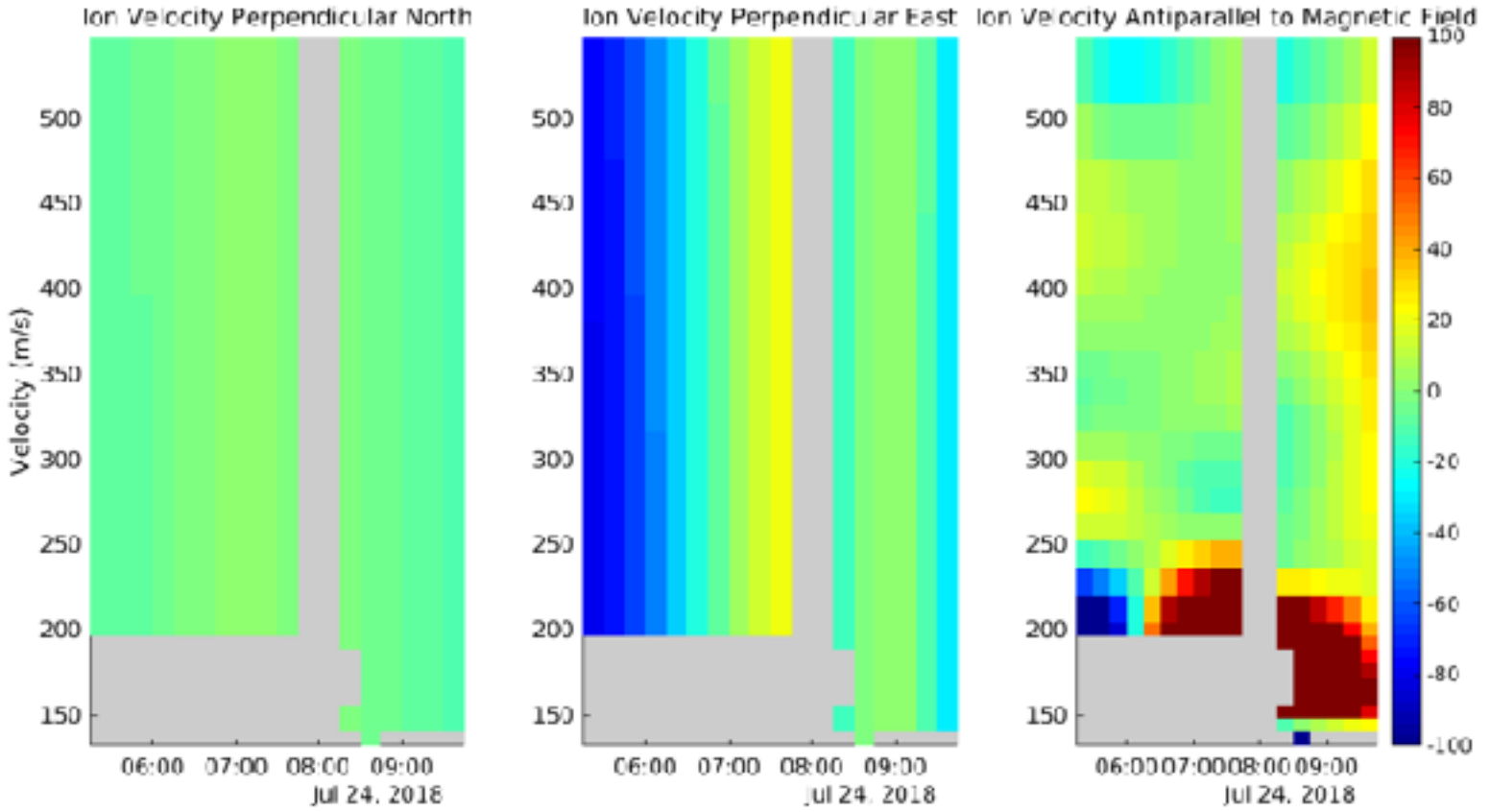
Arecibo Comparison



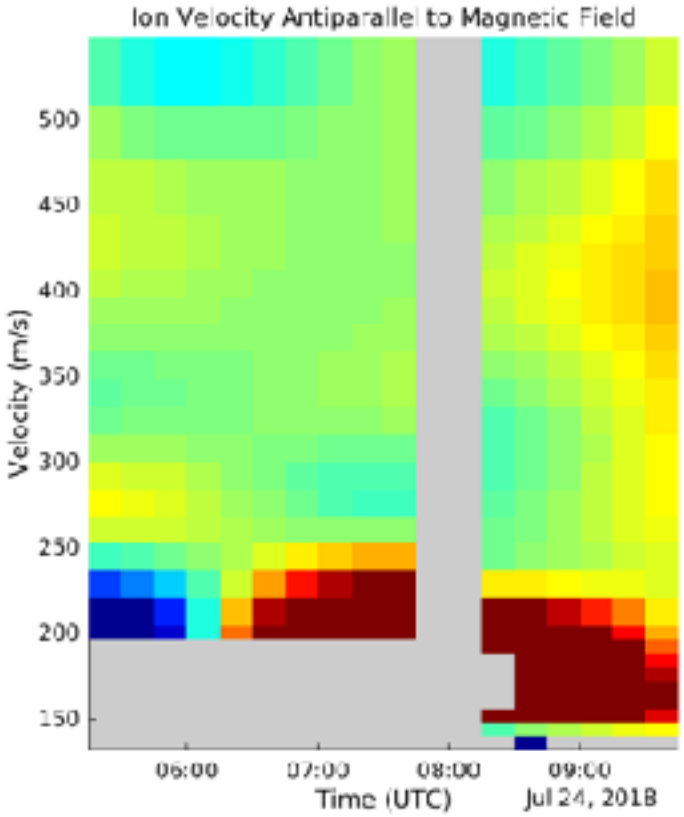


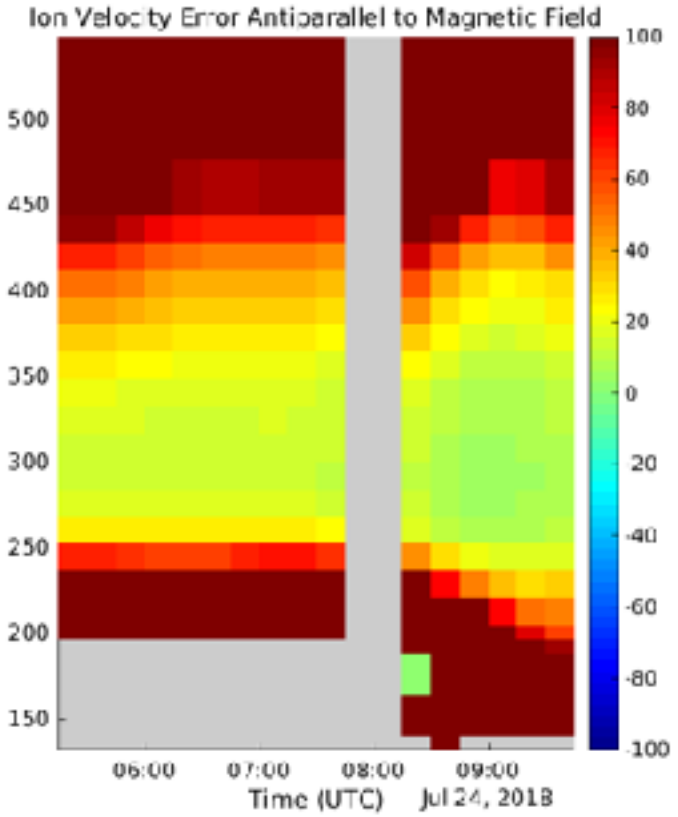
Regional Ion Velocity

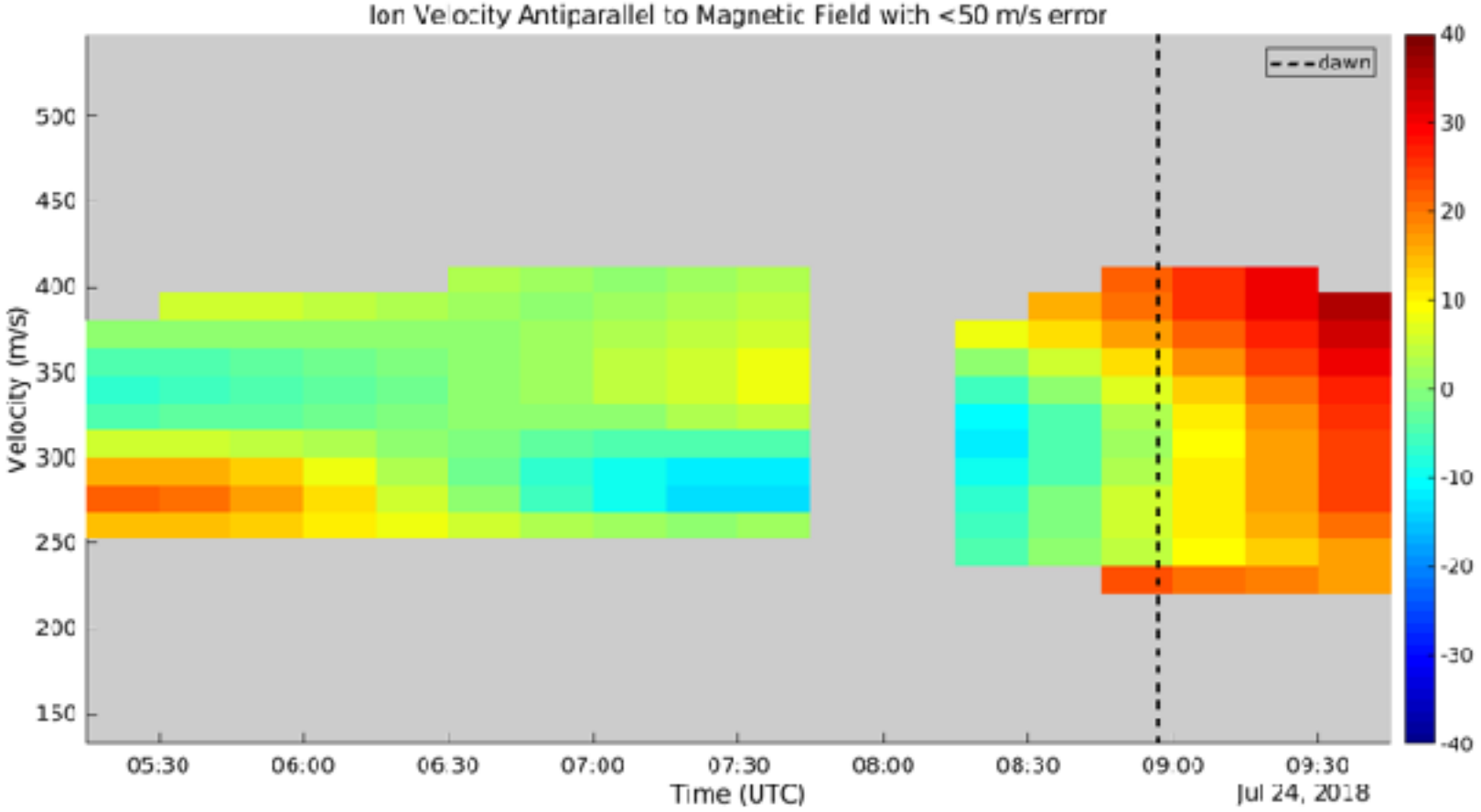
So what else we got?



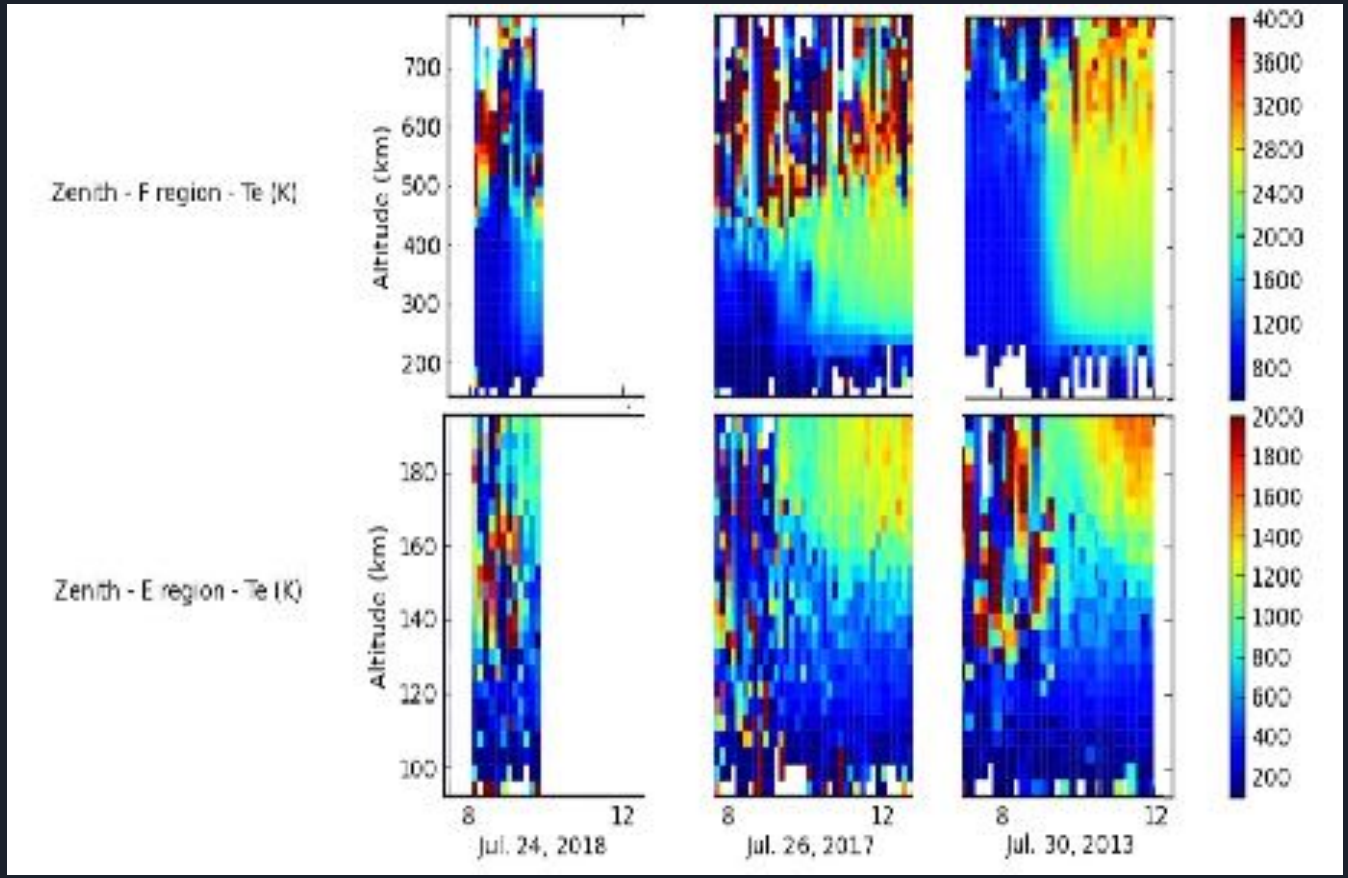
Error bars ruin everything



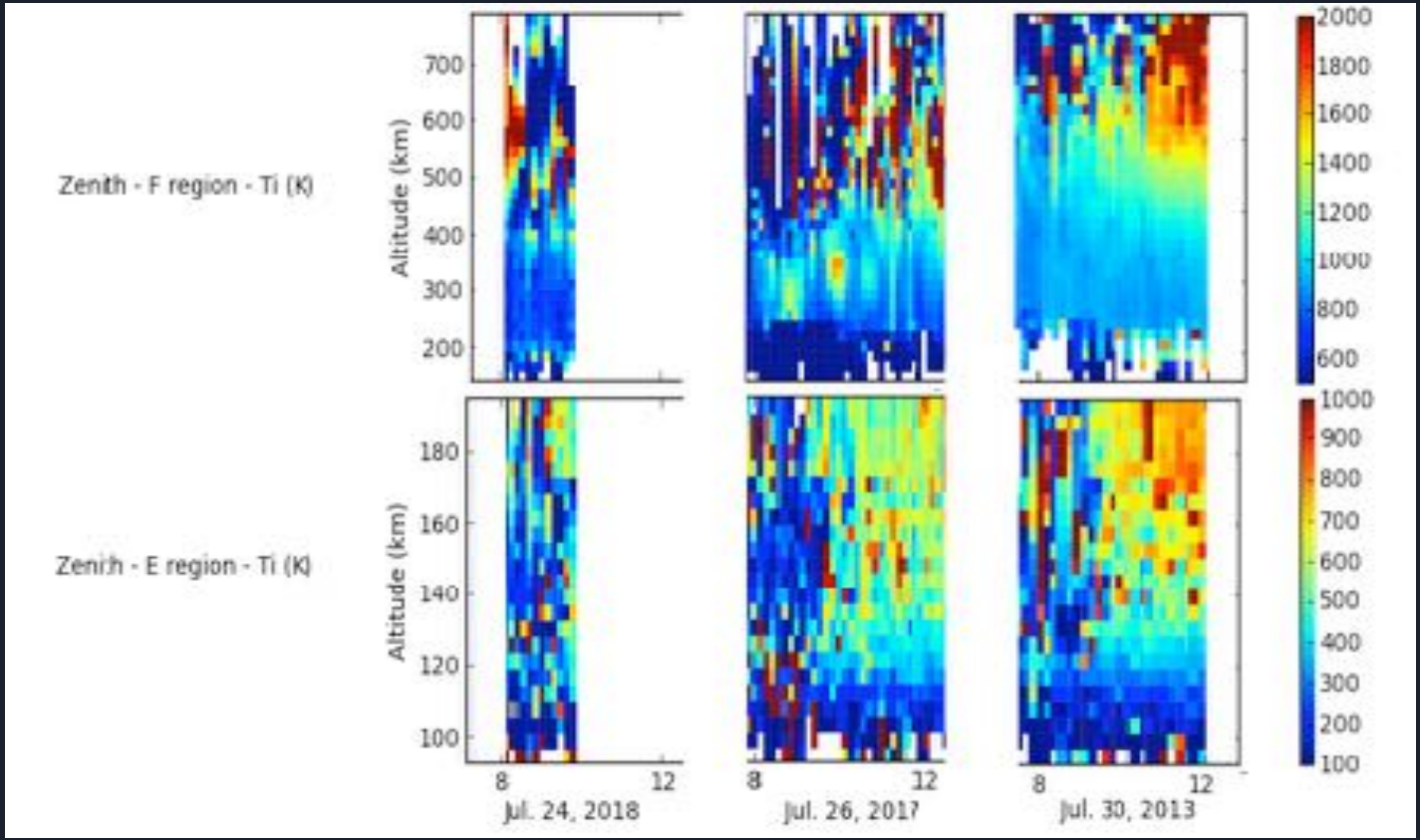



Ion Velocity Antiparallel to Magnetic Field with <50 m/s error
dawn
Velocity (m/s)
500
450
400
350
300
250
200
150
40
30
20
10
0
-10
-20
-30
-40
05:30
06:00
06:30
07:00
07:30
08:00
08:30
09:00
09:30
Time (UTC)
Jul 24, 2018

Te Comparisons



Ti Comparisons



Conclusions

- The application of the IS method gives opportunity to receive extensive information about parameters of wave processes in the ionospheric plasma.
- Our observations were carried out at the phase of the decline of solar activity

  $F_{10.7}$ = 67, Kp = 4 (active), Dst = -15 to 13 nT.

- Also our experiment were conducted during the passage of morning solar terminator, and such natural disturbances make changes in atmospheric parameters such as energy, temperature, pressure, and electron density at a given altitude and contribute to the generation and amplification of AGW / TIDs.
- We conducted a comparative analysis of the state of the ionosphere parameters with the previous year and with measurements from another station.