Postmidnight ionospheric trough in summer and link to solar wind: how, when and why?

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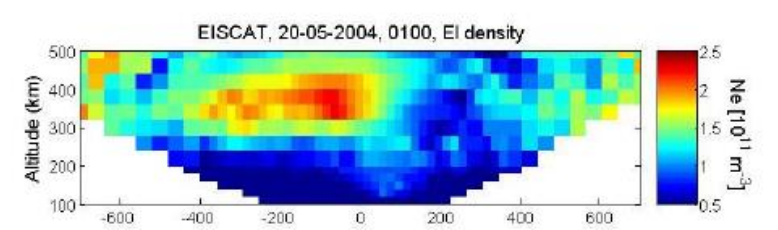
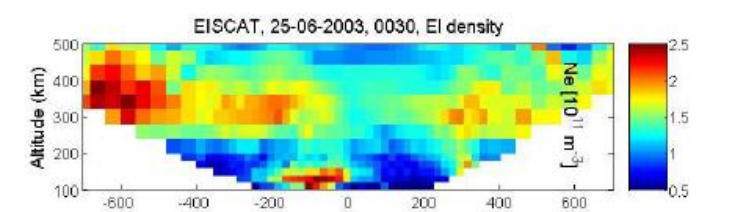
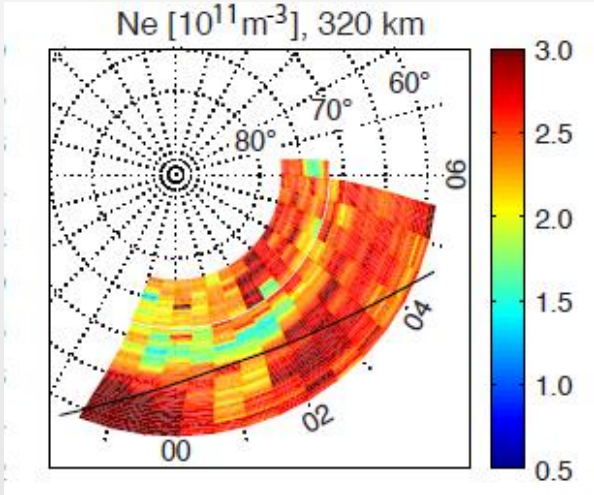
The F region trough

- a plasma density depletion observed at F region heights at geographic latitudes around 55–75 deg., longitudinally elongated, with widths in the latitudinal direction of 5-10 deg.







Trough occurrence and solar wind properties

CONVECTION PATTERN

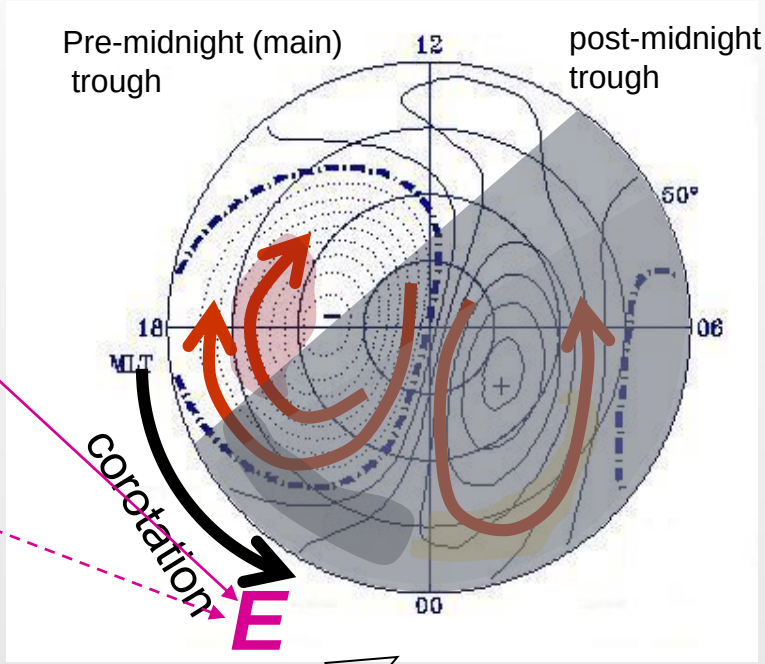
- stagnation regions: balance between westward convection flow and eastward corotation;
- horizontal transport of high density plasma in the vicinity of low density plasma;

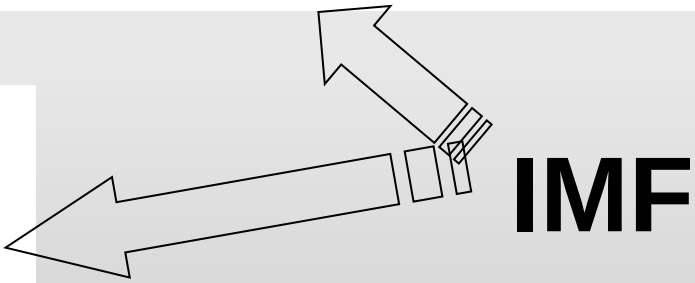
LOCAL PROCESSES

- field aligned plasma upflow (large horizontal winds, electron heating or rapid sub-auroral ion drifts)
-upwelling of the neutral atmosphere due to Joule heating, bringing more molecular ions (which recombine faster) in the F region

AURORAL PRECIPITATION

- poleward wall coincides with the equatorward boundary of precipitation

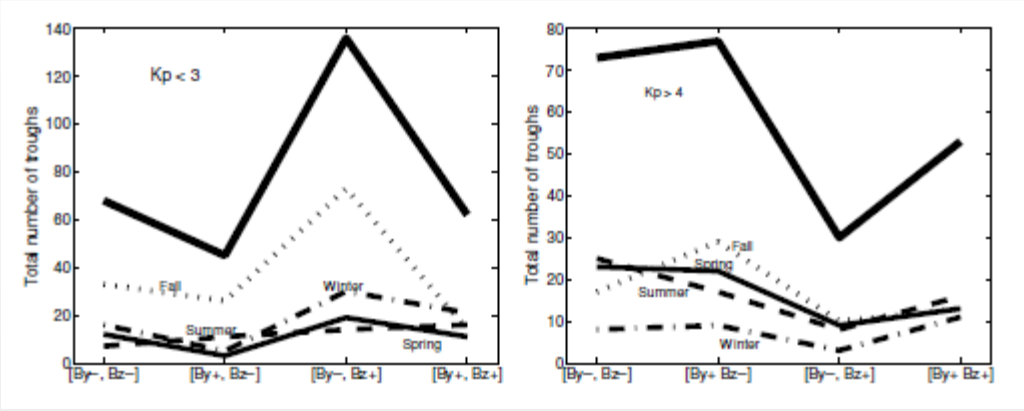




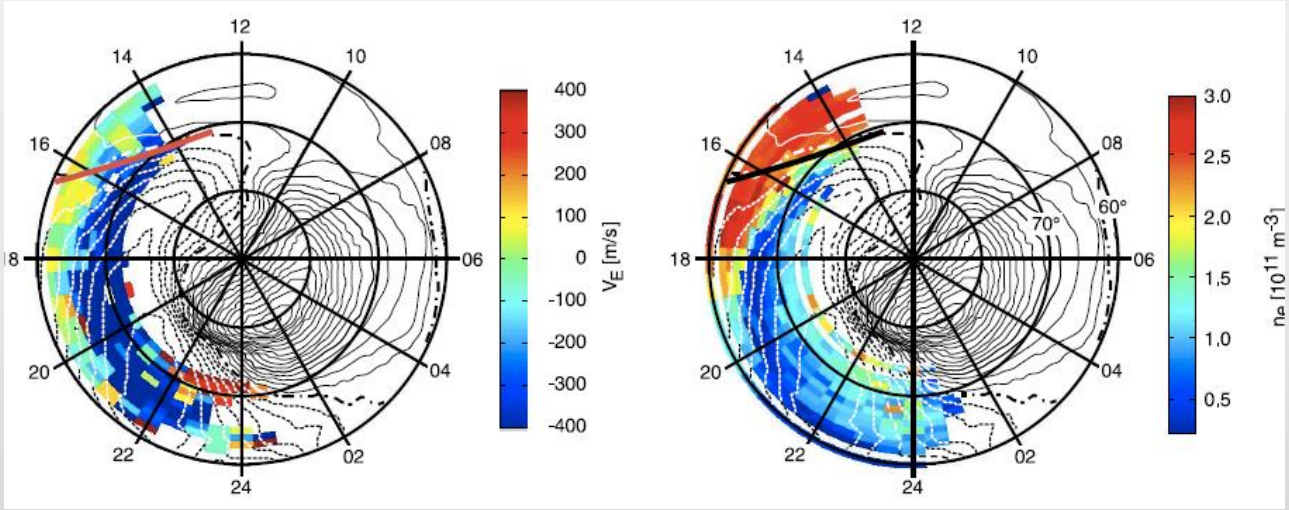
Pre-midnight trough

Number of troughs for various orientations of the IMF

- Dependence on Bz
- Dependence on By



Voiculescu et al (2006)



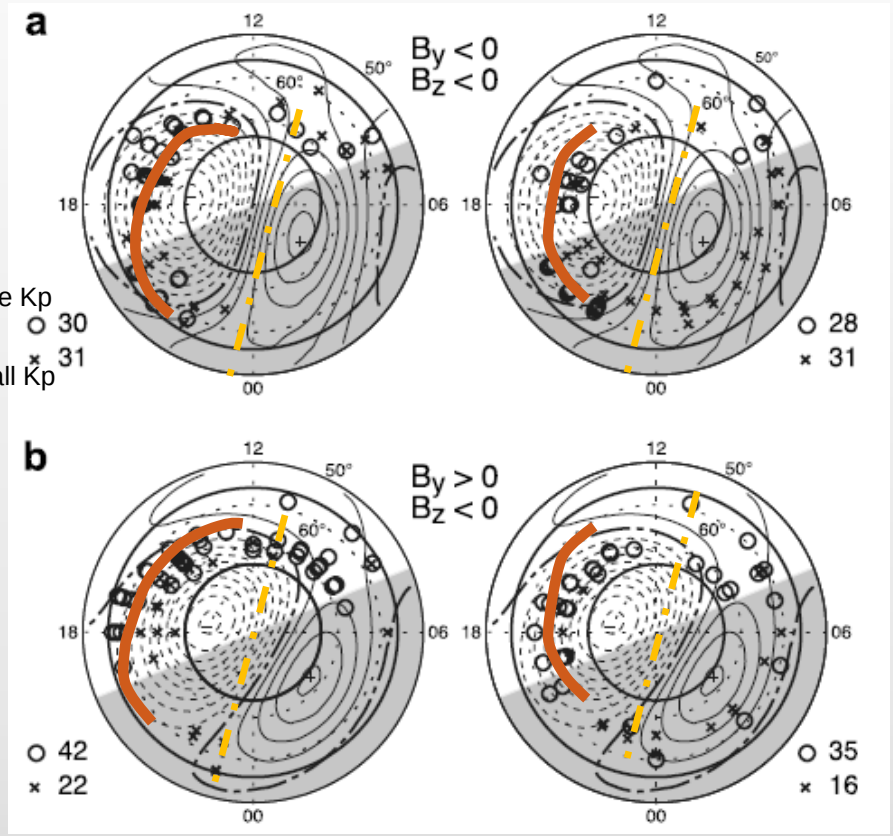
Zonal ion velocity

Electron density

stagnation

Voiculescu et al (2010)

Location of troughs for equatorward and poleward walls for various IMFs (Equinox)



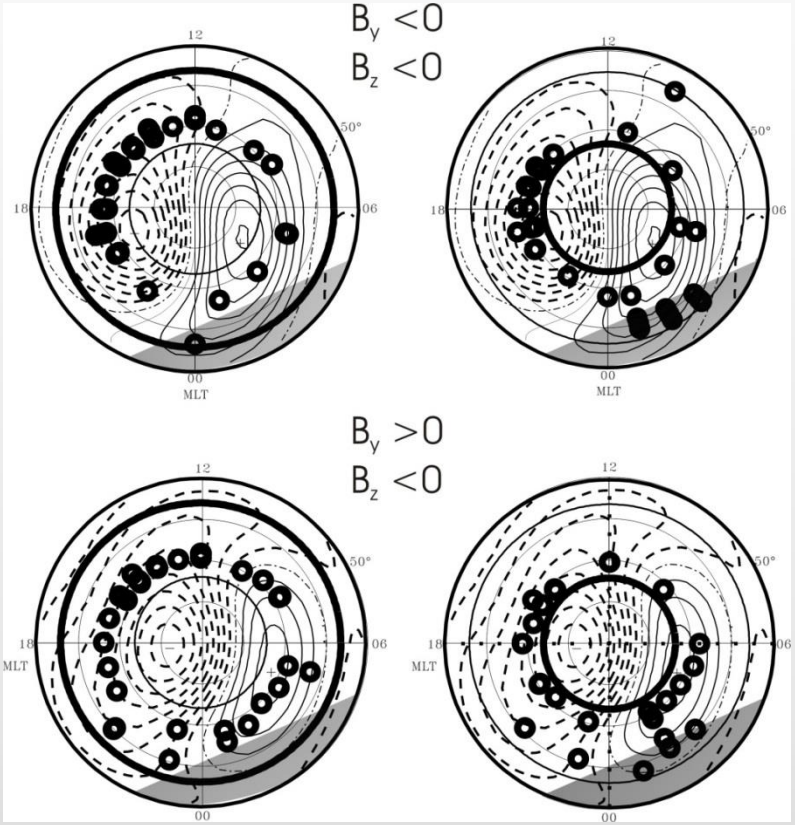
large Kp

small Kp

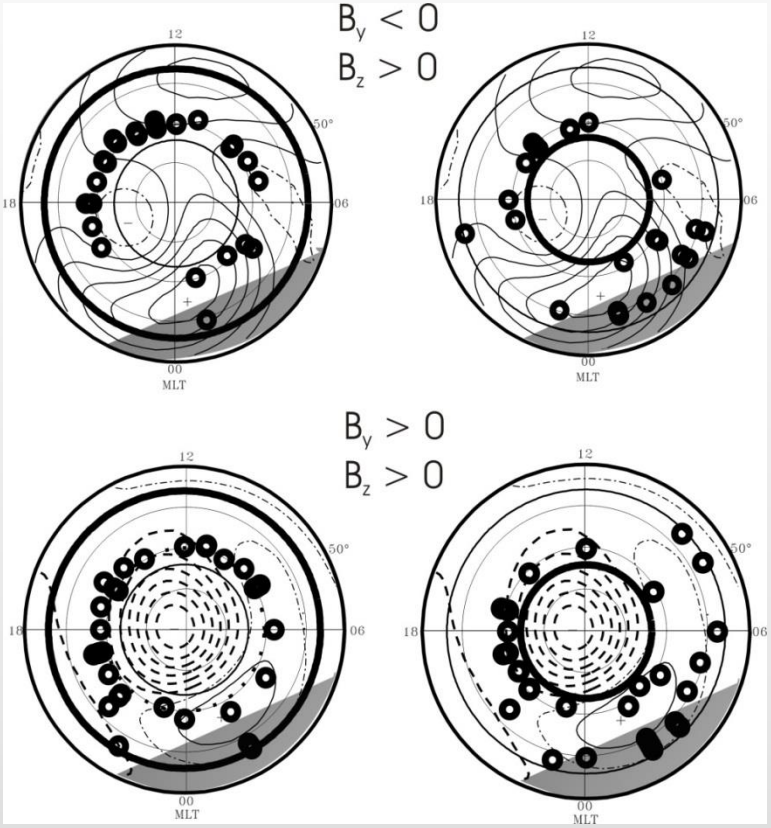
equatorward poleward equatorward poleward

Voiculescu and Nygren (2007)

Location of troughs for equatorward and poleward walls for various IMFs (SUMMER)



equatorward poleward



equatorward poleward

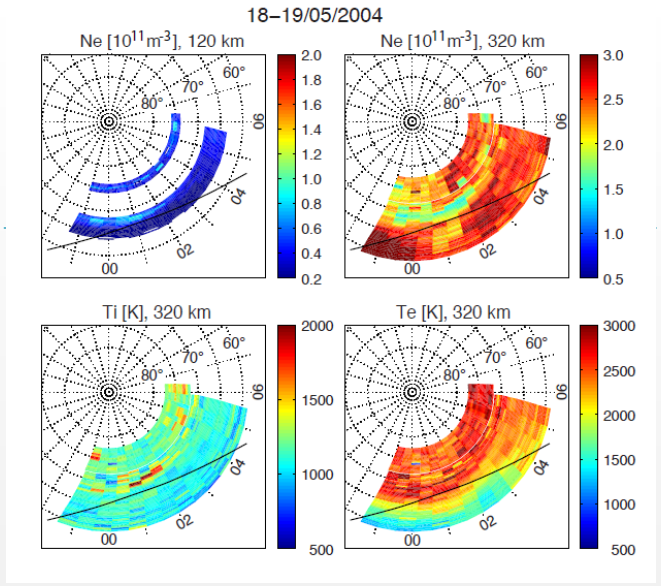
Post-midnight trough, sunlit
EISCAT – mainland and ESR

- EISCAT CP3 meridional scans
- Criteria of data selection:

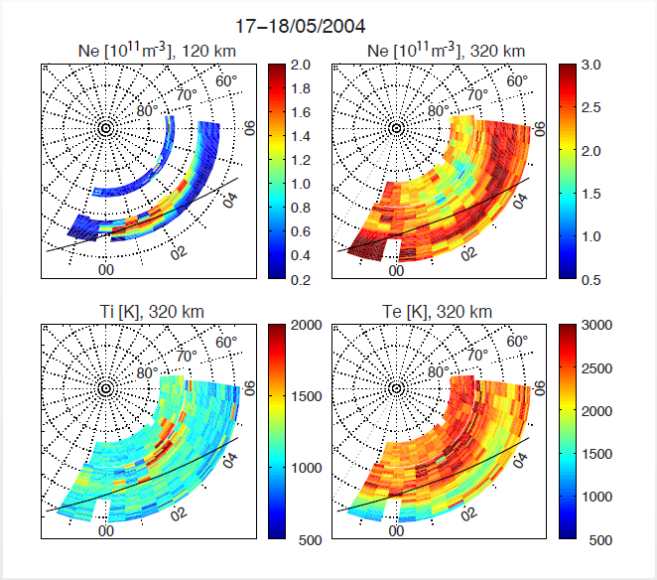
1) May - August (when the postmidnight sector is mainly sunlit);
2) the trough is observed during minimum 3 consecutive scans between 21.00 UT and 03.00 UT (corresponding to 23.30 MLT - 5.30 MLT).

- Ionospheric parameters: electron density, beam aligned ion velocity, ion temperature and electron temperature.

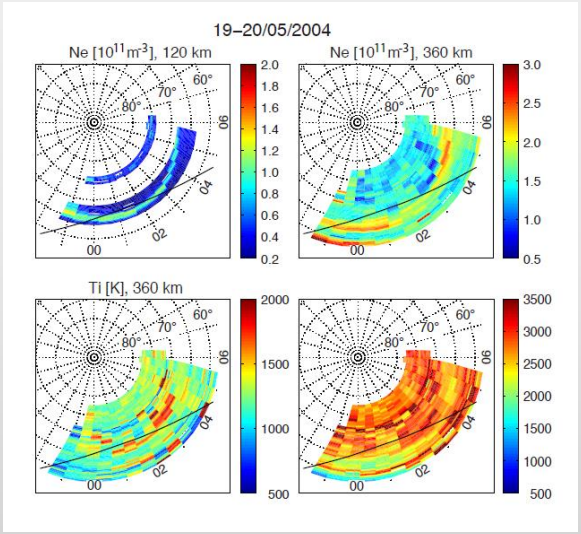
Troughs



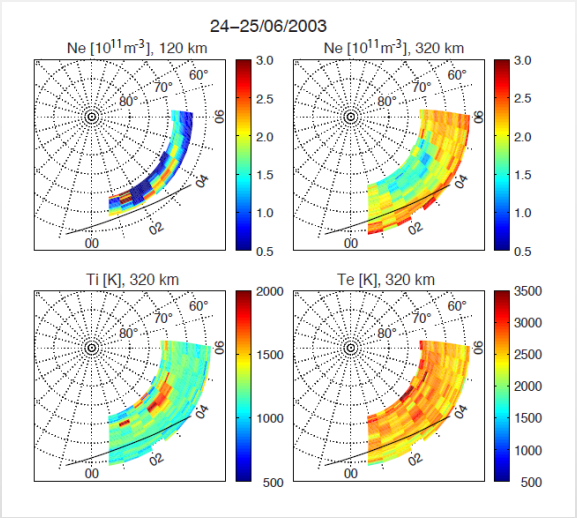
Trough B



Trough A



Trough C and L

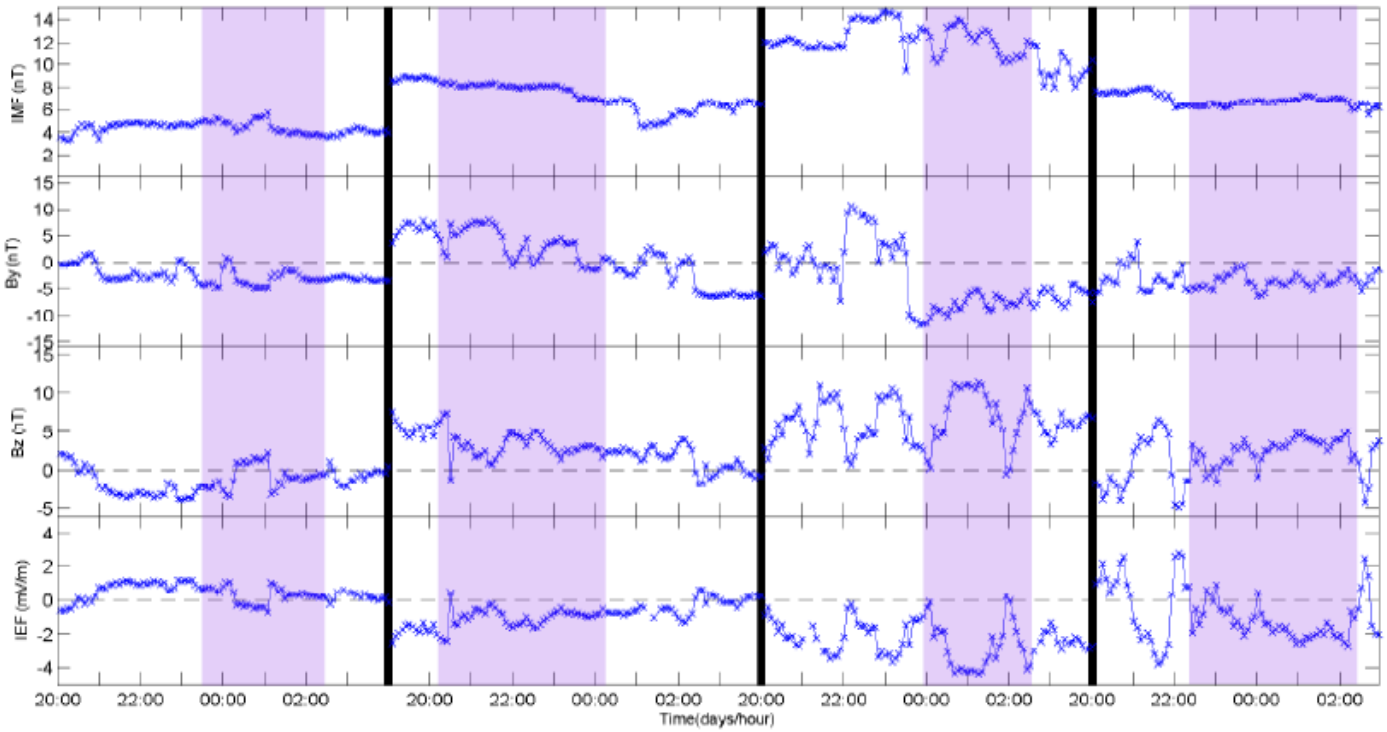


Trough D

Geomagnetic/IMF conditions

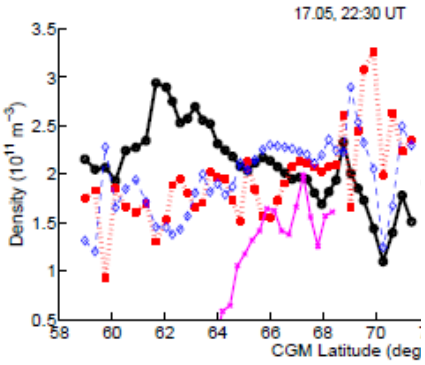
- Kp: 1-2, quiet time

TrA: 17-18/05 TrB: 18-19/05 TrC: 19-20/05 TrD: 24-25/06

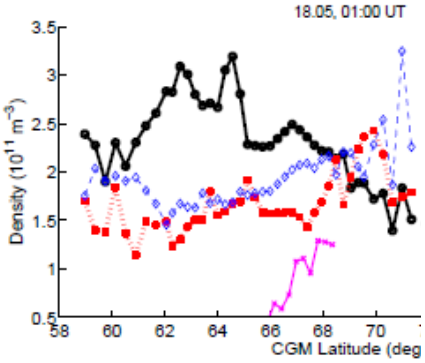


Rectangles: troughs

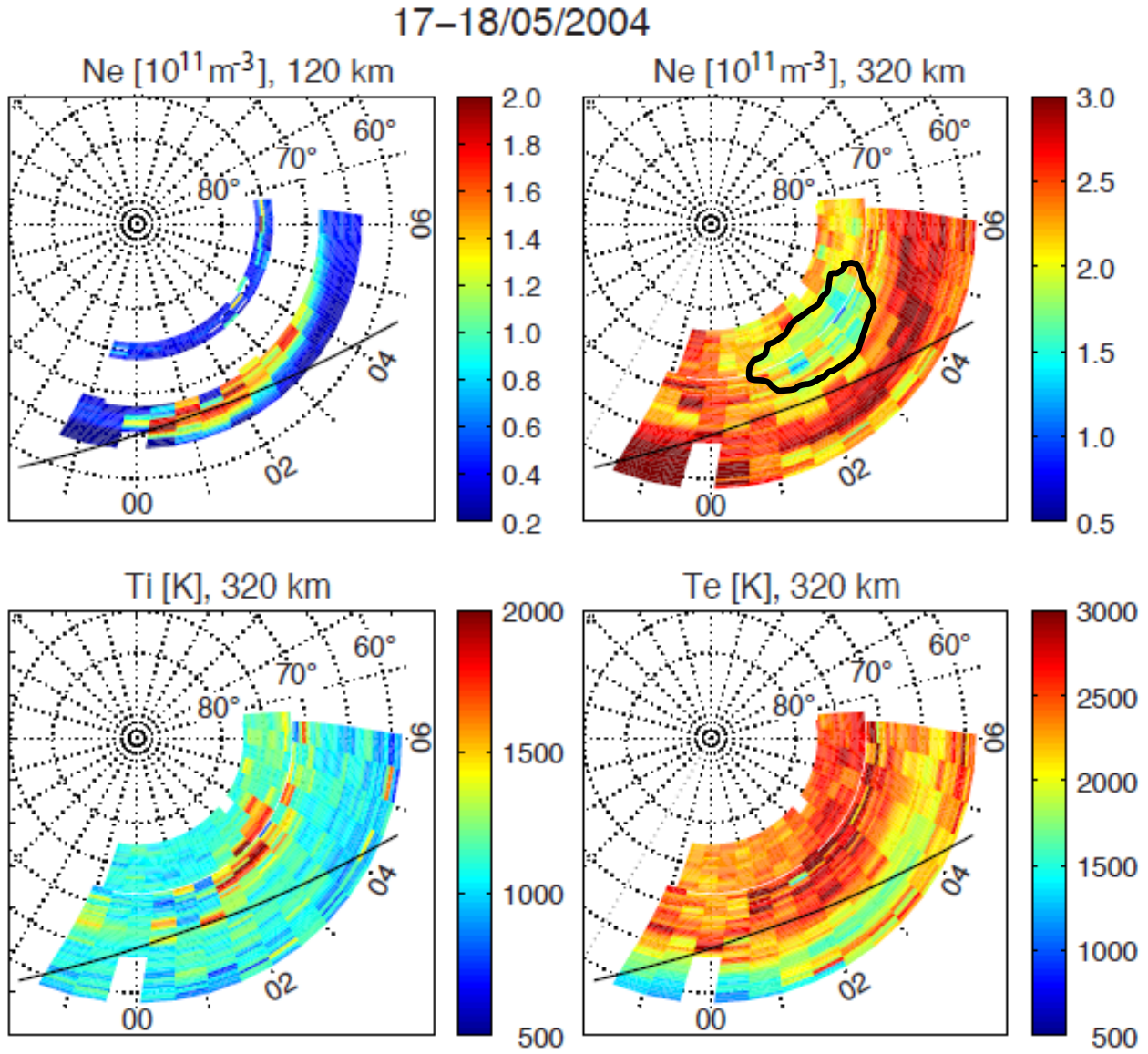
Trough A (



(a) 01:

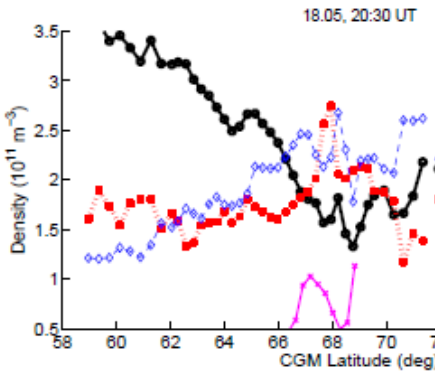


(c) 03:

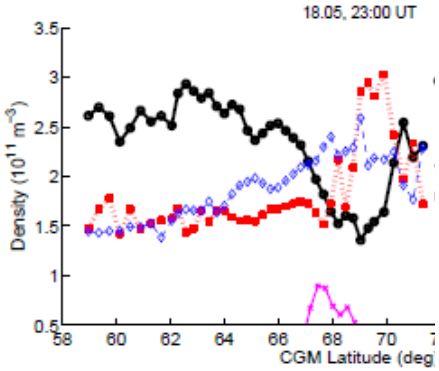


Horizontal variation of ion

Trough B (

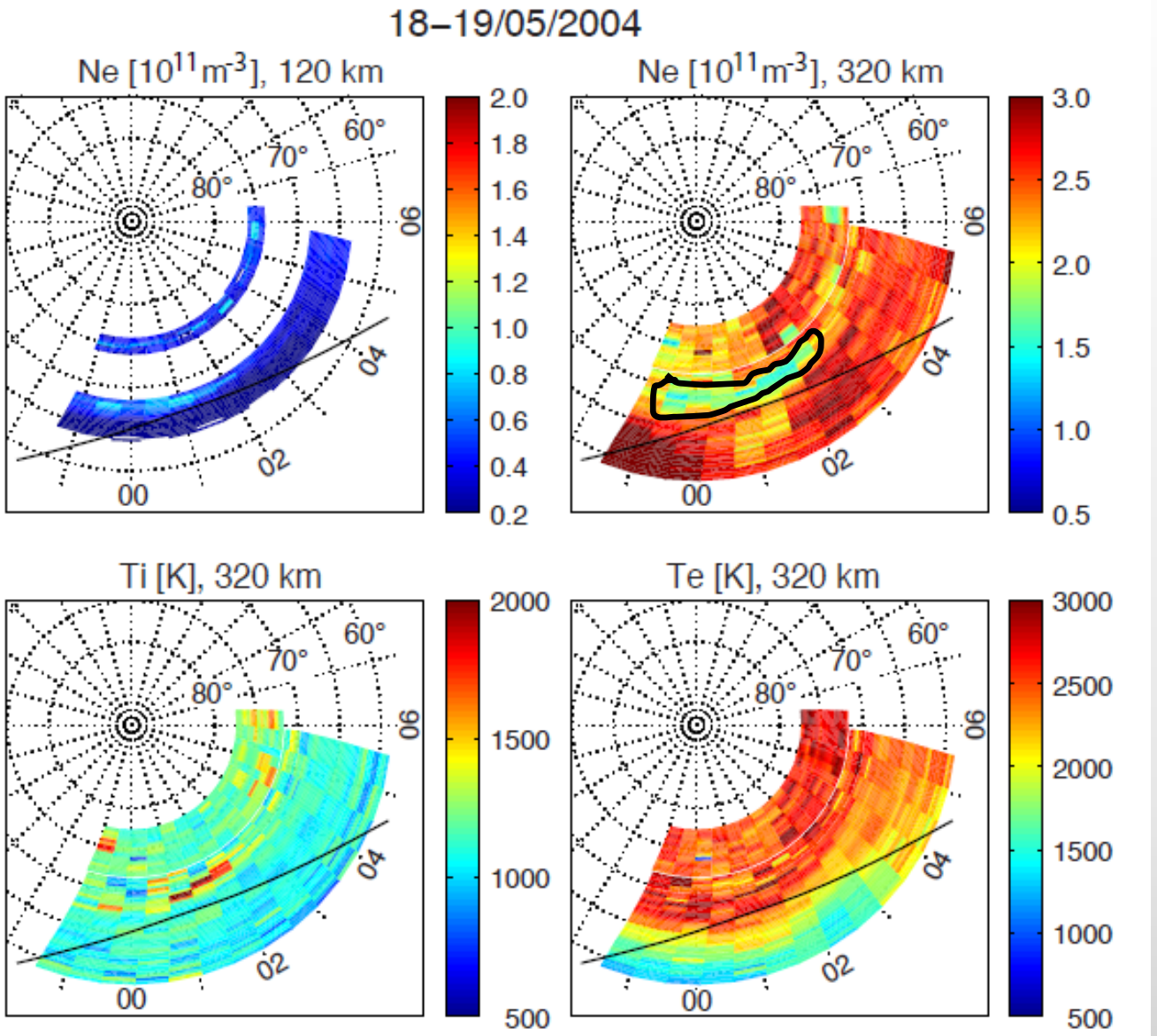


(a) 23:

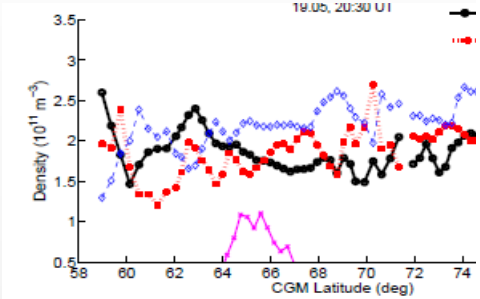


(c) 01:

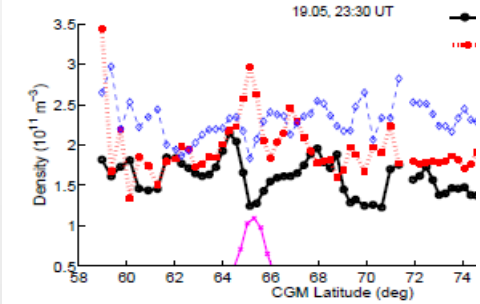
Horizontal variation of ionc



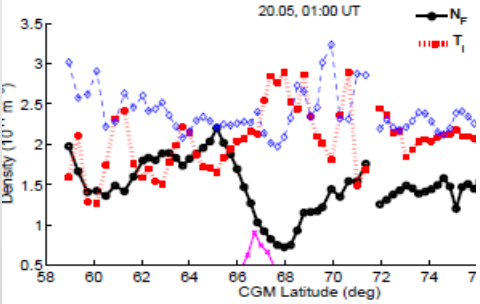
Troughs C and L (19-20/05/2014)



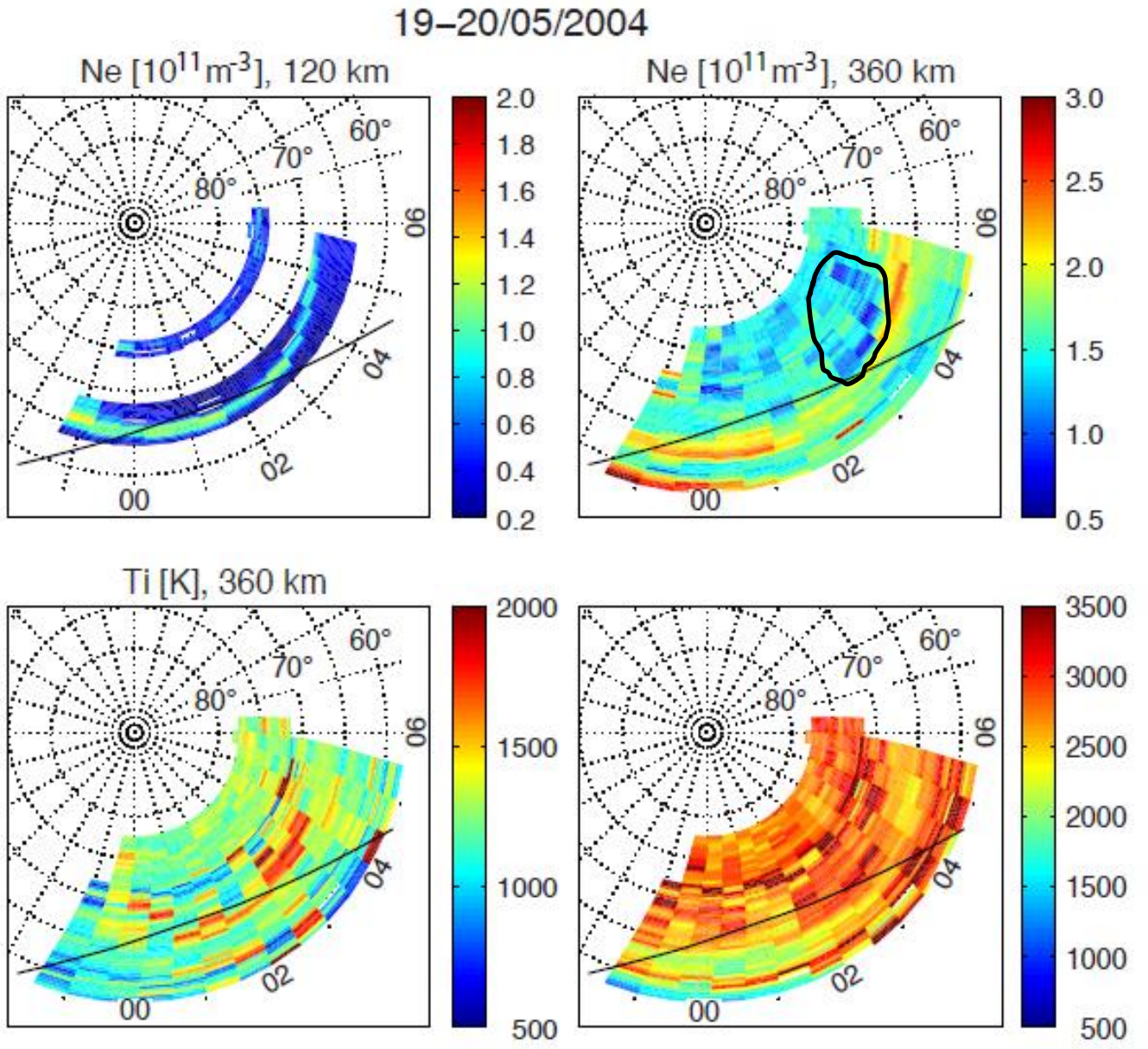
(a) 23:10 MI



(c) 02:10 MI

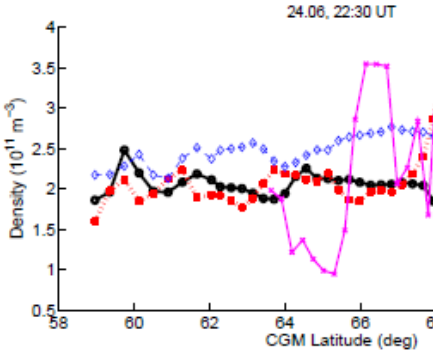


(e) 03:40 MLT

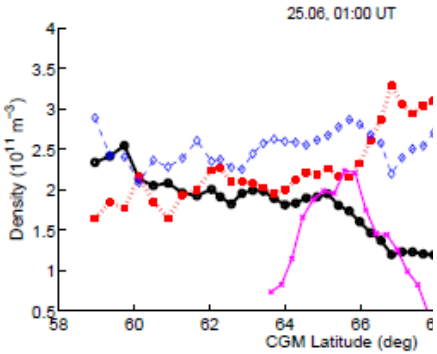


Horizontal variation of ic

Trough D



(a) 00:40



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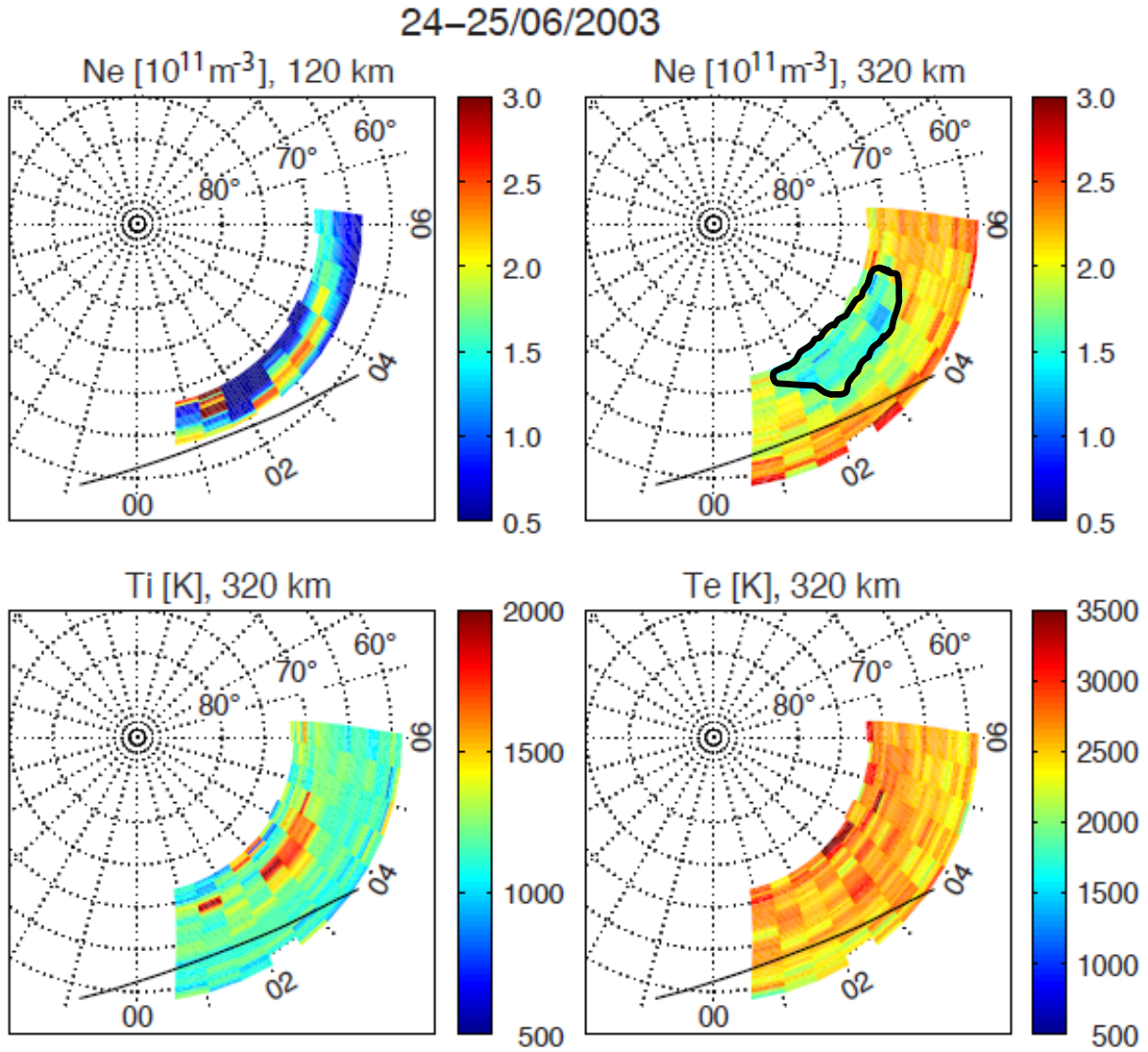


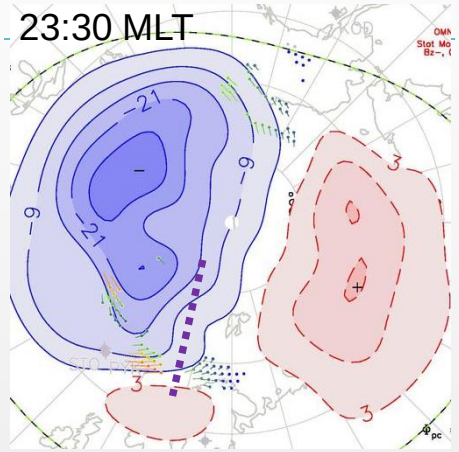
Horizontal variation of ionc

Common features (high-lat)

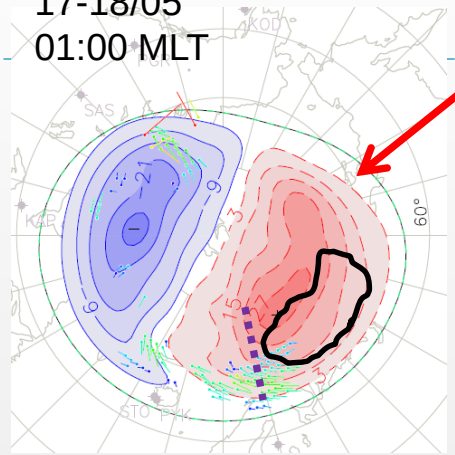
- sunlit, around 70 deg, between approximately 02:00 and 04:00 MLT;
- not very deep, walls generally shallow;
- the equatorward side coincides with plasma density increases in the E region, precipitation might contribute to the formation of the trough;
- the ion temperature is high where the maximum depletion occurs;
- small increases in the electron temperature are observed in the trough;
- *For one event, trough B, the above listed characteristics are less evident: the trough is observed for a longer time and earlier than the other troughs, between 23.00-03.00 MLT, it is narrow and better defined, the increase of ionisation in the low E region is smaller than for the other events, the ion temperature is elevated only locally.*
- *Event L:, completely different: high Te, no change in Ti, narrow*

Trough A (17-18/05/2004)

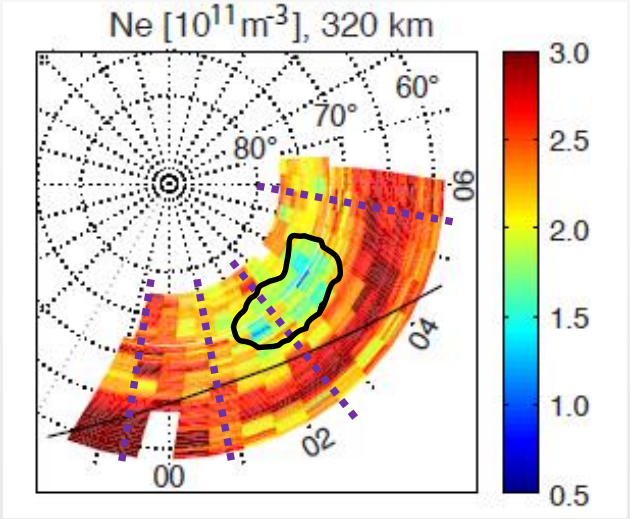
17-18/05
23:30 MLT



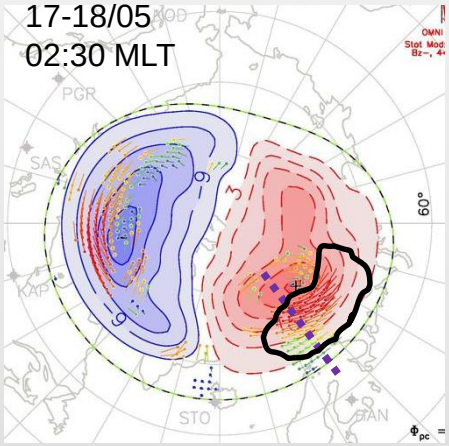
17-18/05
01:00 MLT



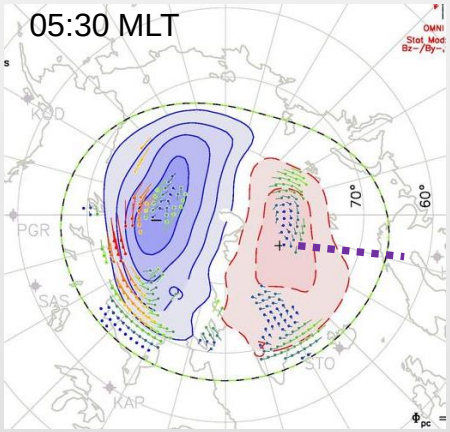
SuperDARN potential lines/model and measured velocities



17-18/05
02:30 MLT

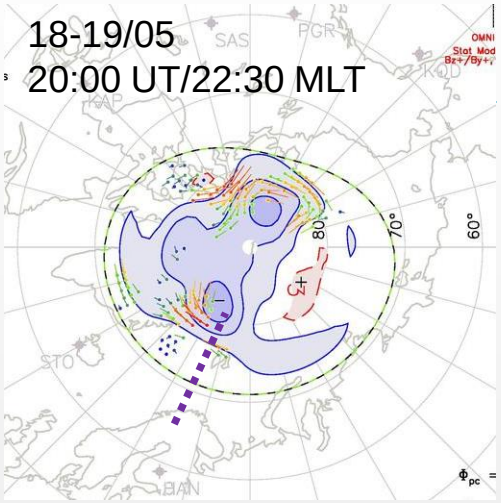


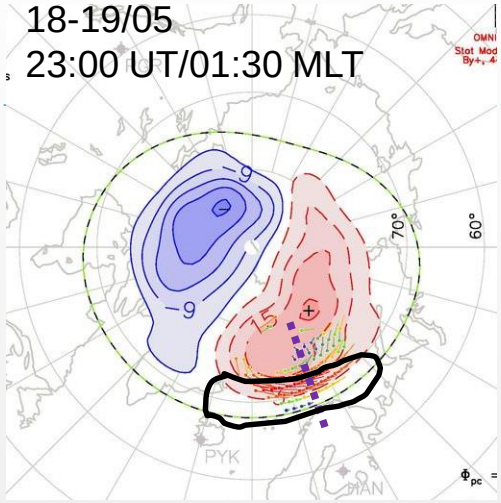
17-18/05
05:30 MLT

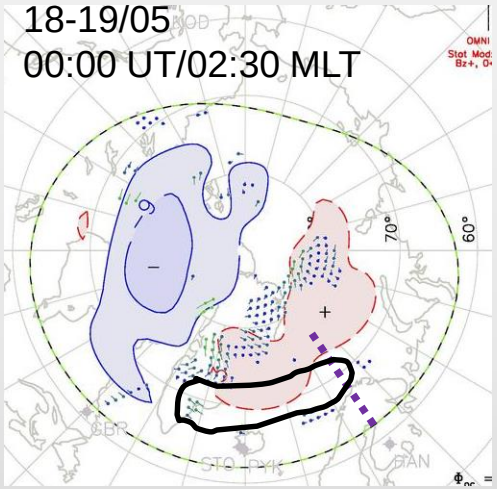


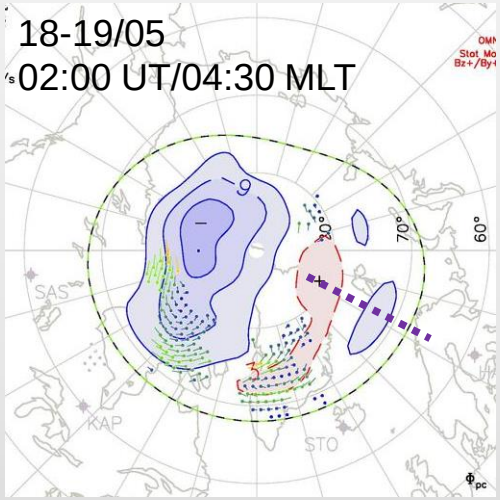
Trough – increased velocities, frictional heating
Trough moves towards higher latitudes; filling up due to increase solar irradiation

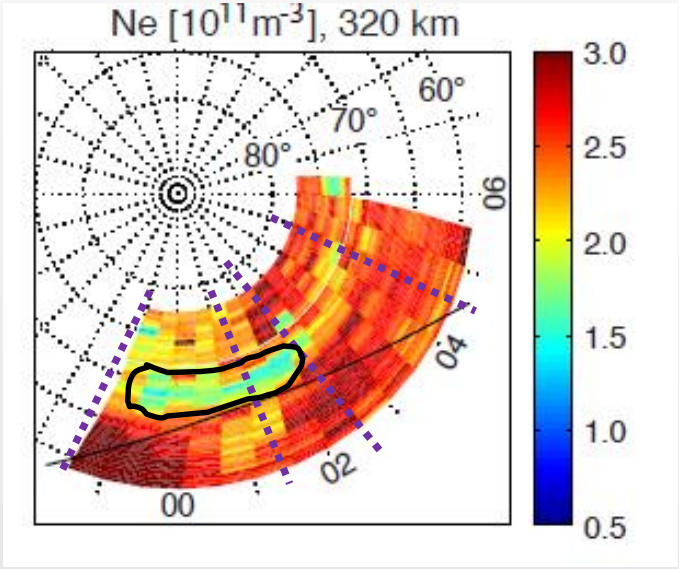
Trough B (18-19/05/2004)





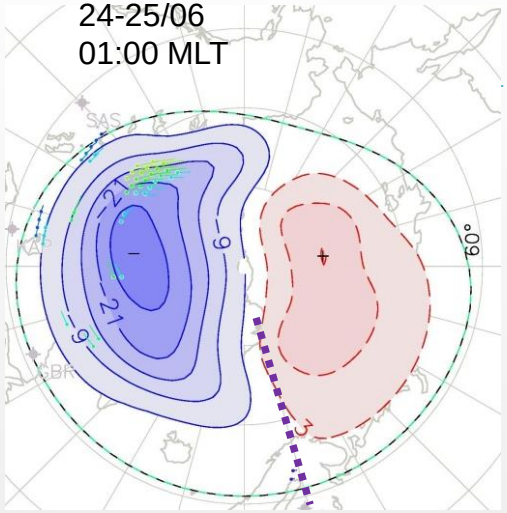


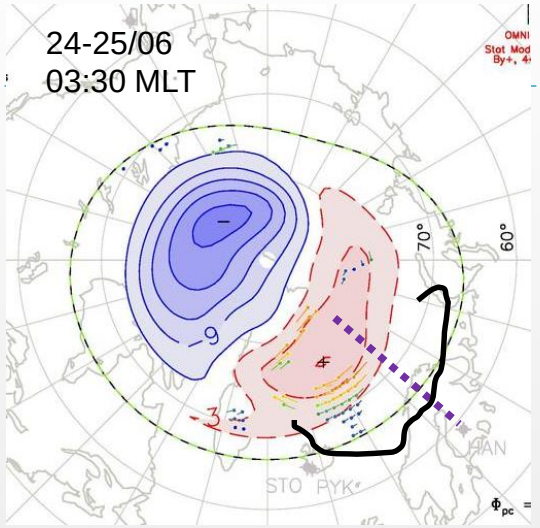


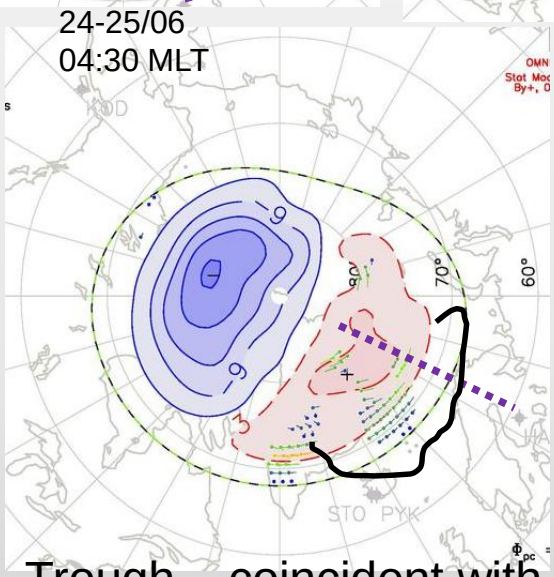


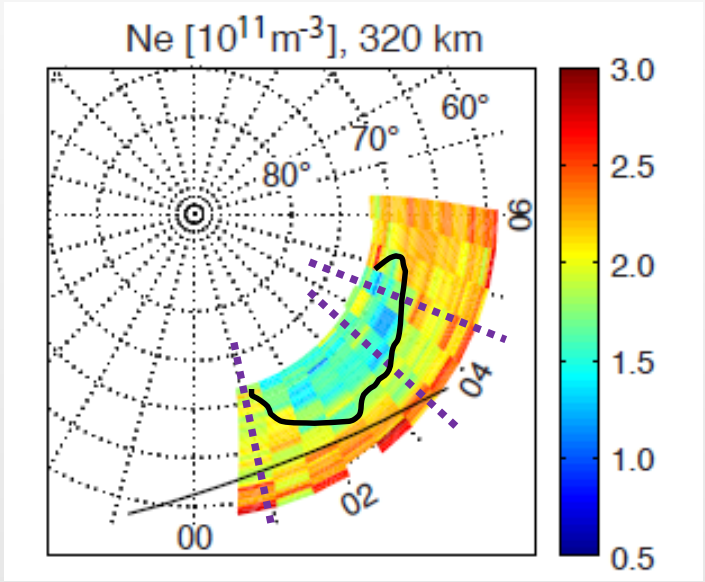
Multi-cell convection – modified form/time of the trough;
trough observed mainly during two-cell convection
Plasma transportation – modifies the F region

Trough D (24-25/06/2003)



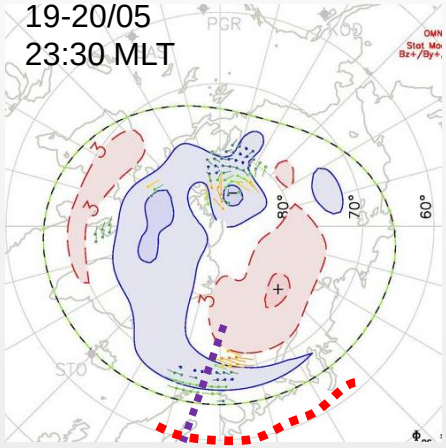


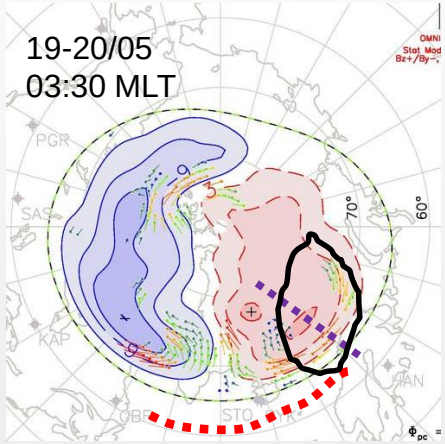


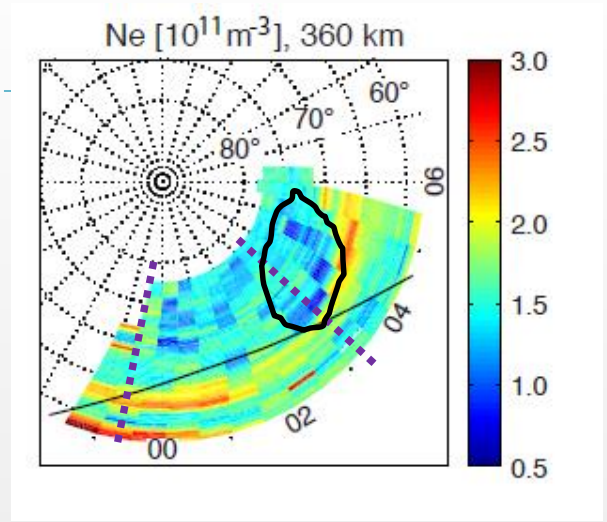


Trough – coincident with large zonal ion velocities

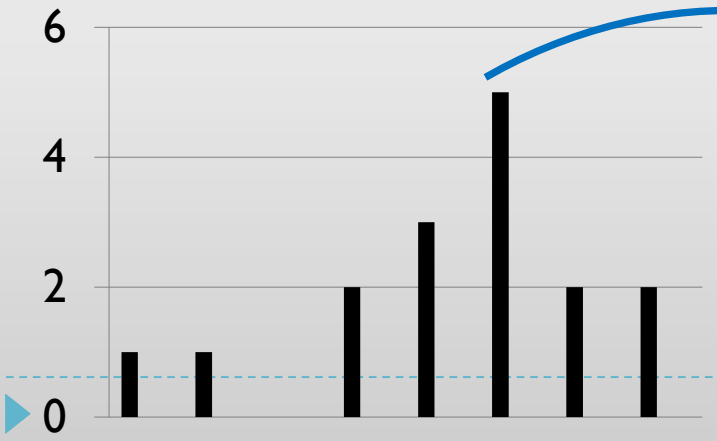
Troughs C and L (19-20/05/2004)

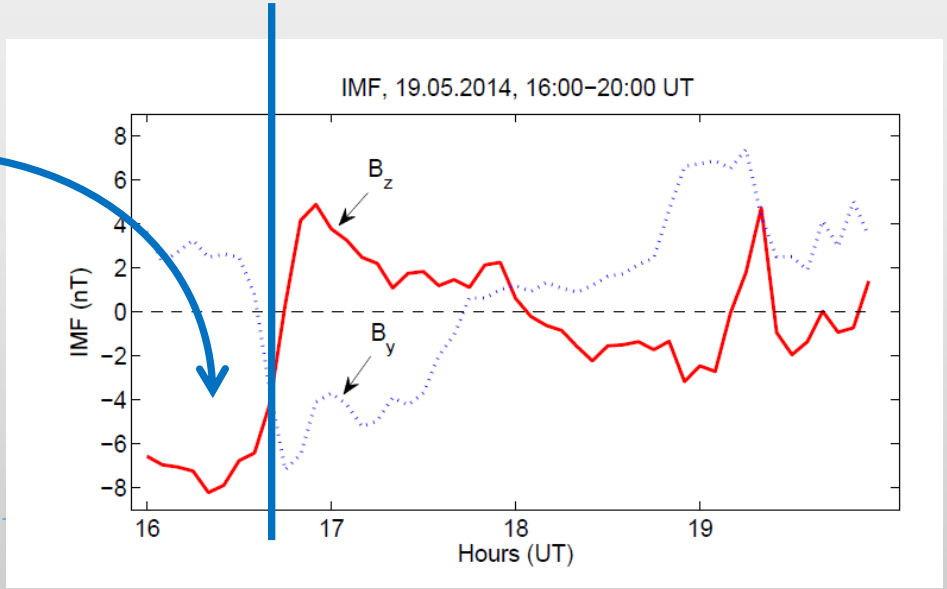






overshielding; subauroral ion drift?





CONCLUSIONS

- **Post midnight, high latitude troughs in summer** (sunlit plasma) formation (rare): frictional heating – high zonal ion velocities – convection pattern – magnetospheric electric field – **IMF orientation, both Bz and By**

- **Post midnight, mid latitude troughs in summer** (large zenith) formation:

Subauroral ion drift – ? (magnetospheric current, electric, thermoelectric, overshielding) – **IMF short-term variability**