

Longitudinal variations of mid-latitude trough structures

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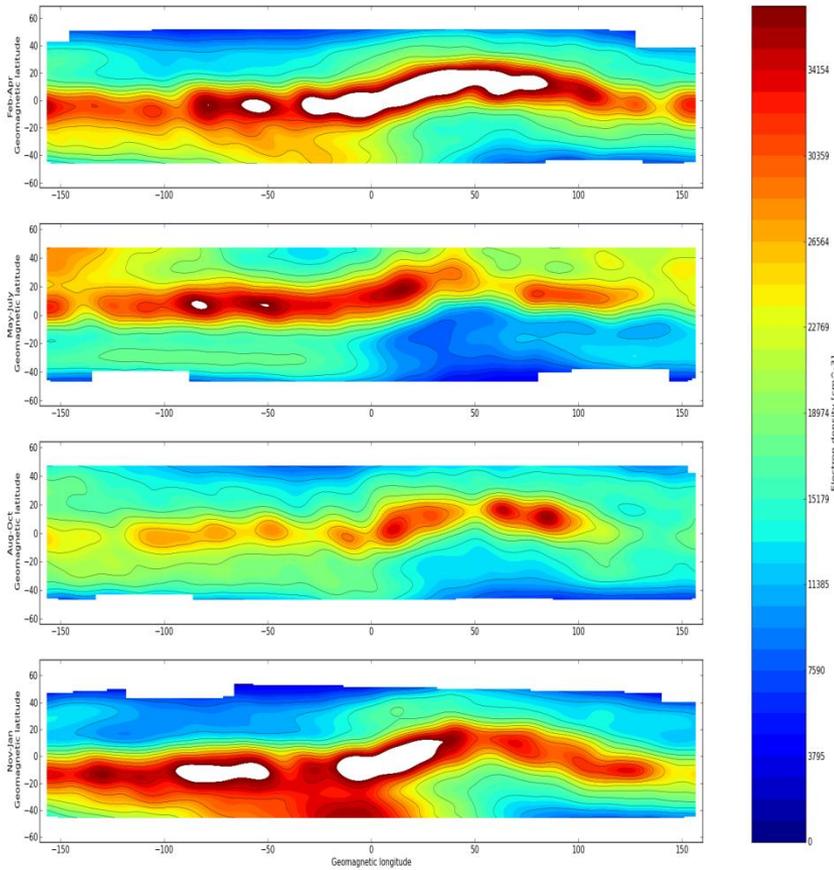
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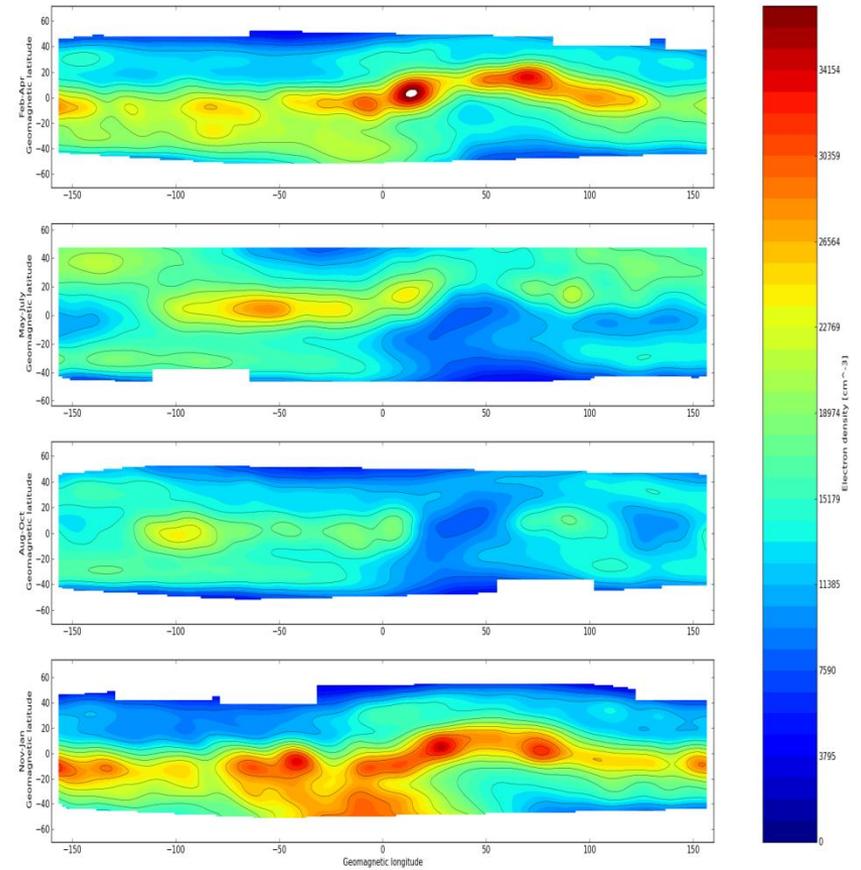
General characteristic of the main ionospheric trough

- Typical feature of the sub-auroral ionospheric F-region
- Area where significant depletion in electron concentration occurs
- Observed in the topside ionosphere is the near-Earth signature of the magnetospheric plasma pause
- Dependent on magnetospherically induced motions
- Mainly the night-time phenomenon
- Depend on the solar cycle, season, time of the day and many others
- Narrow in latitudes but extended in longitudes
- The trough structure moves to the lower latitudes with increasing geomagnetic activity and time interval from the local magnetic midnight

Electron density maps from DEMETER data
Kp index = 0-2, year 2005

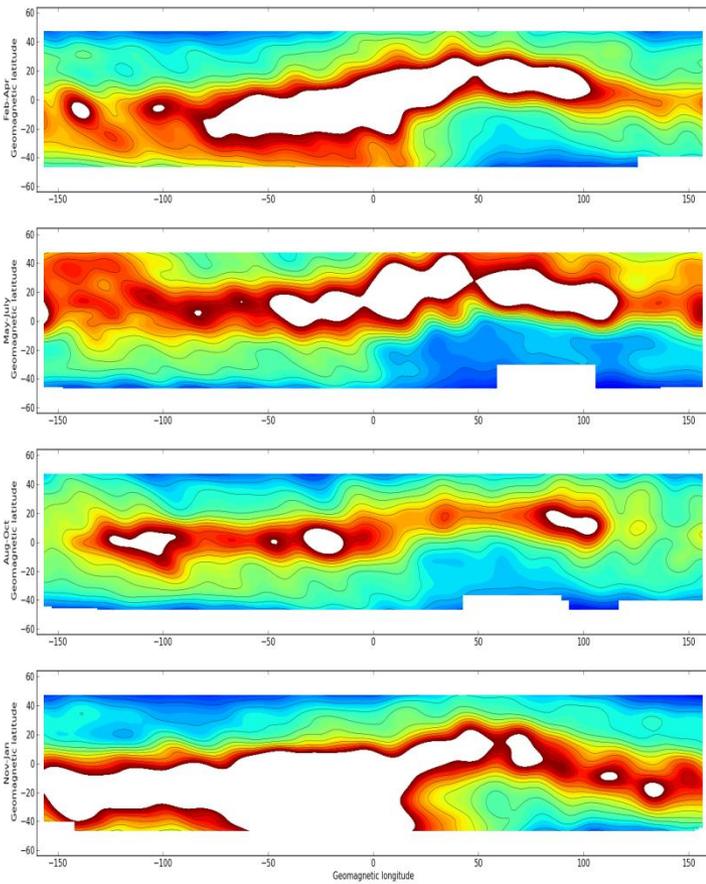


Electron density maps from DEMETER data
Kp index = 0-2, year 2007

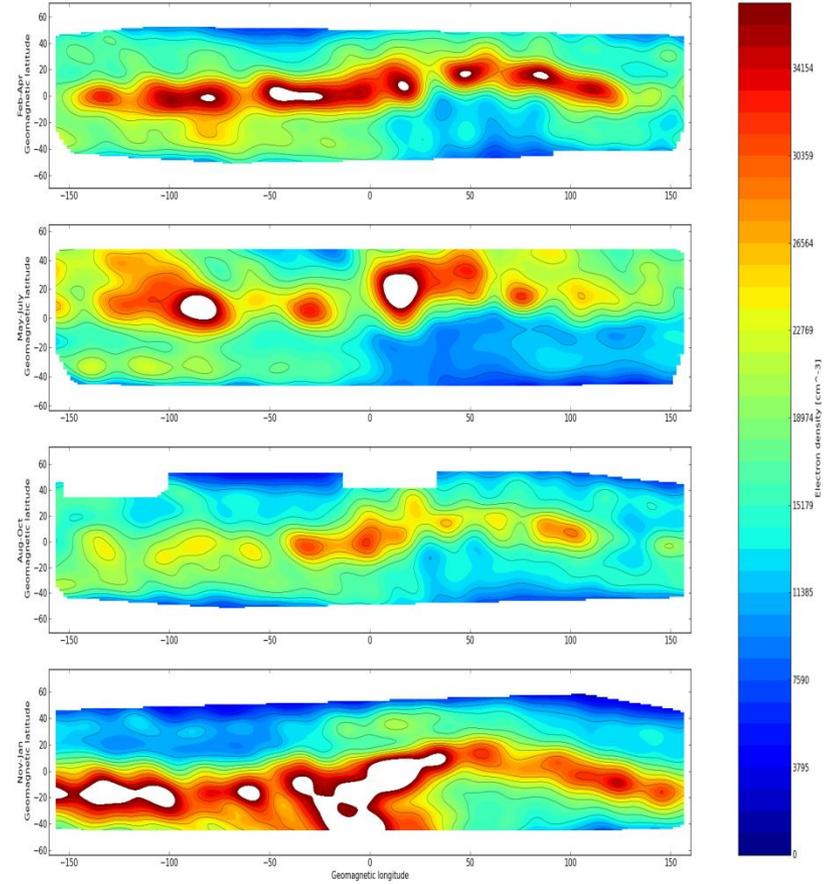


- DEMETER microsatellite operating from 2004 to 2010, orbit 710 km (660) and inclination of 98.3°. Onboard i.e. Langmuir probe (Ne, Te)
- Measurements from DEMETER are limited and for most orbits reaches maximally $\pm 65^\circ$ of geomagnetic latitude. Analysed can only be the equatorward edge of the midlatitude trough (minimum).
- Trough edge moves equatorward or poleward according to seasons

Electron density maps from DEMETER data
Kp index = 4-6, year 2005

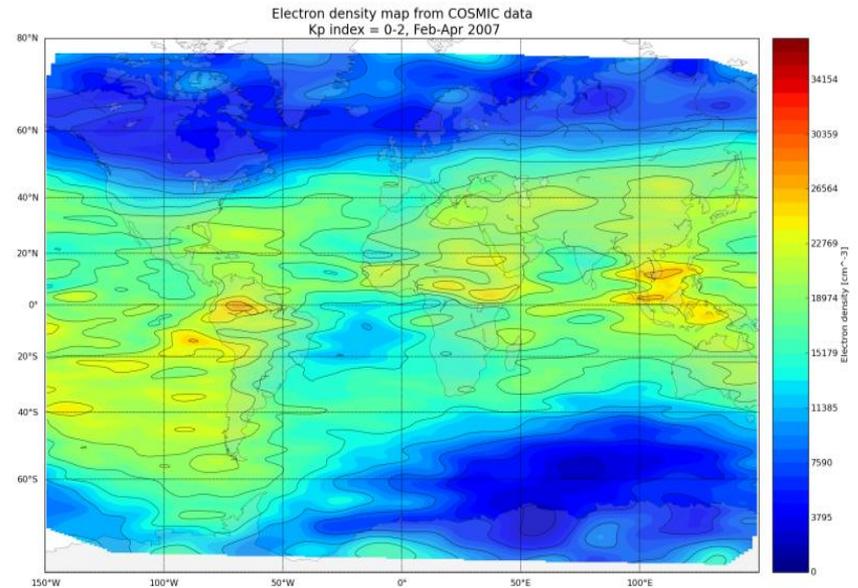


Electron density maps from DEMETER data
Kp index = 4-6, year 2007

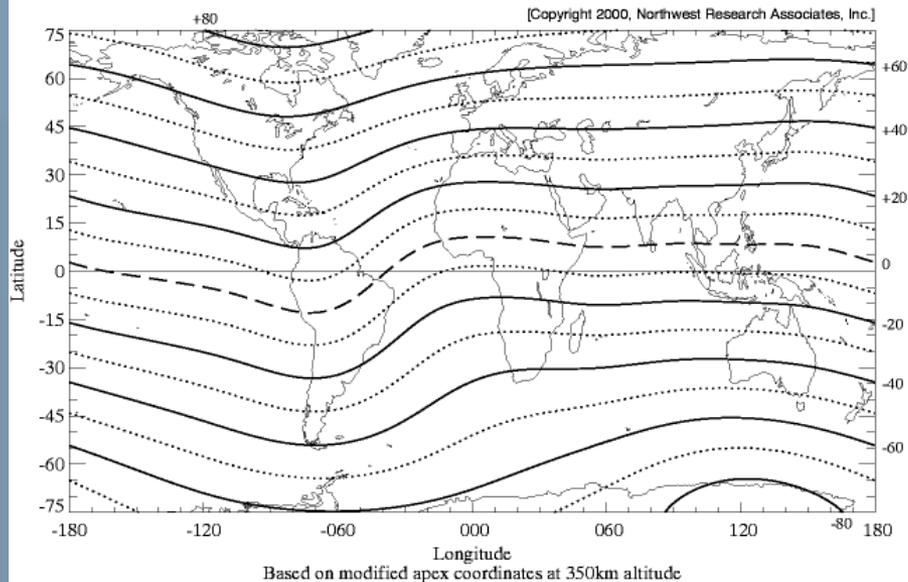


- With the higher geomatic conditions comes the higher electron densities
- Greater contrast between regions with high and low electron density

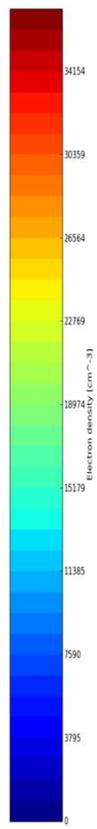
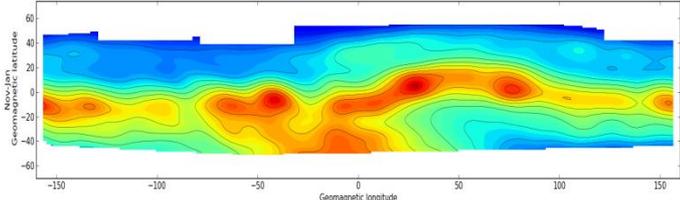
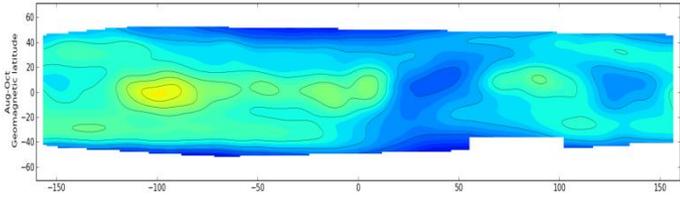
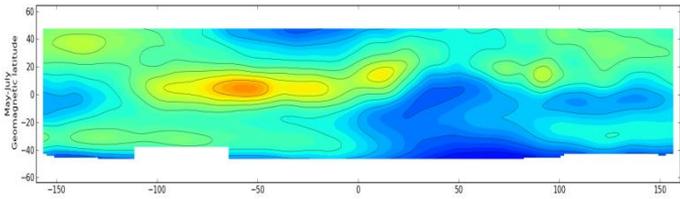
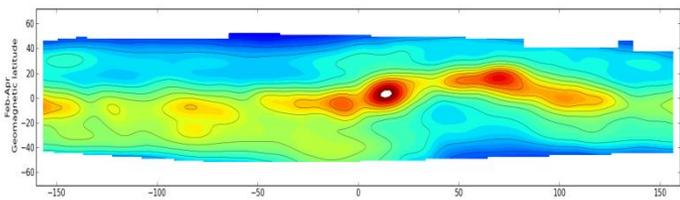
Electron density variations are strongly correlated with geomagnetic parallels geometry, thus it is evident that Earth's magnetic field plays crucial role in creating large scale structures e.g. mid-latitude trough



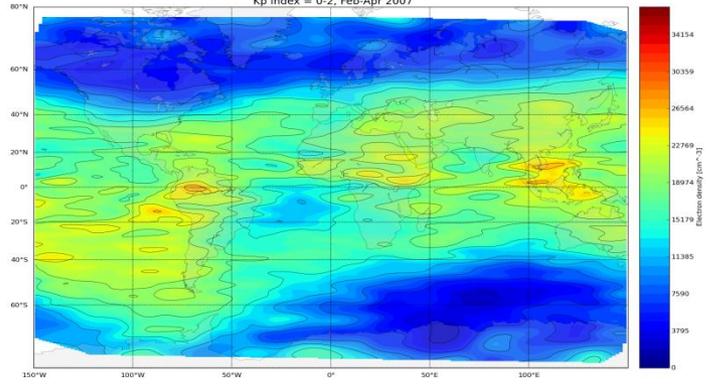
Geomagnetic (350km Apex) Latitudes



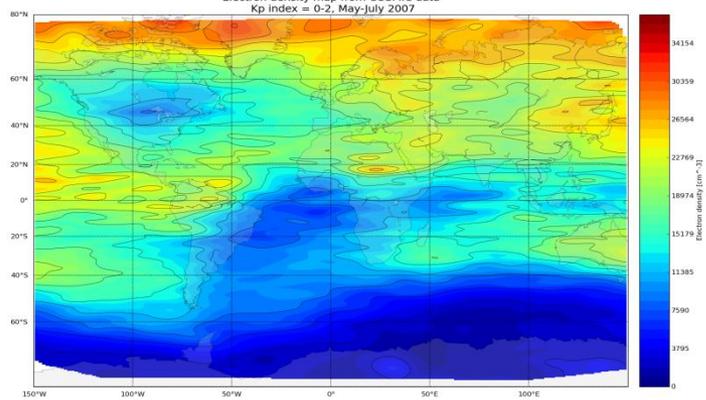
Electron density maps from DEMETER data
Kp index = 0-2, year 2007



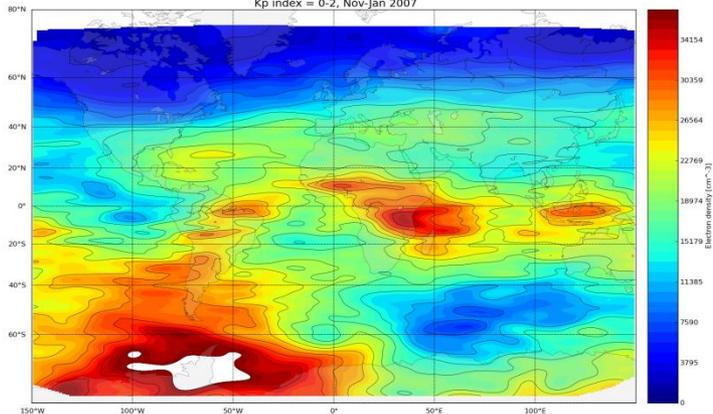
Electron density map from COSMIC data
Kp index = 0-2, Feb-Apr 2007



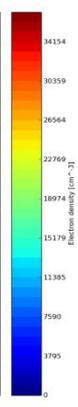
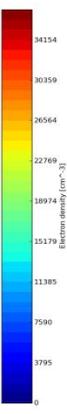
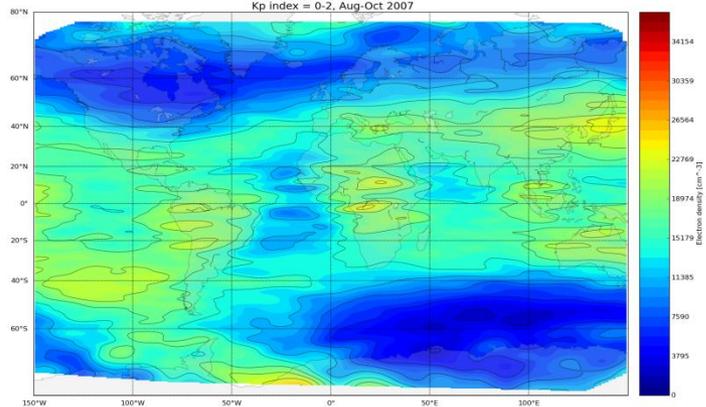
Electron density map from COSMIC data
Kp index = 0-2, May-July 2007



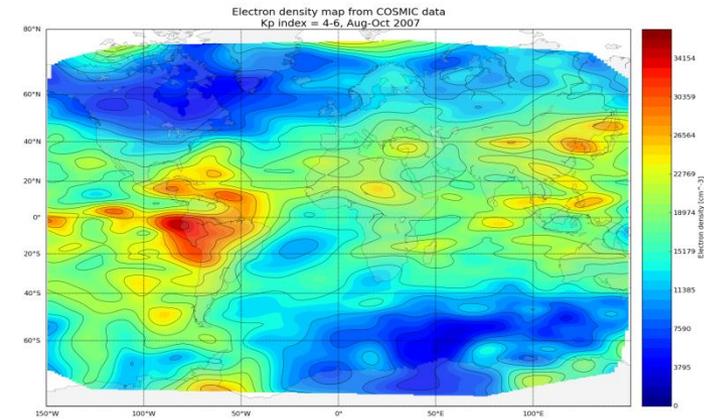
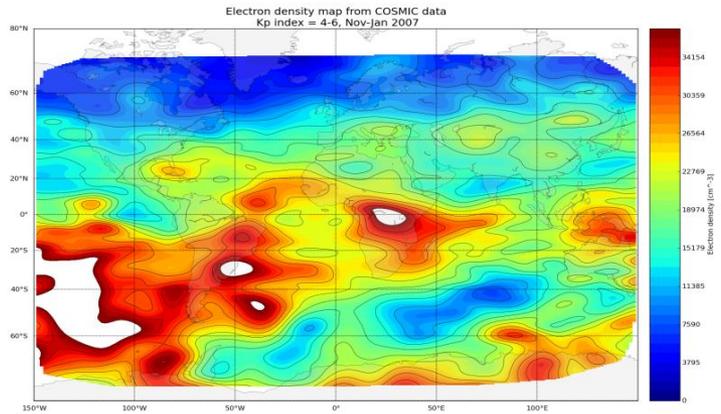
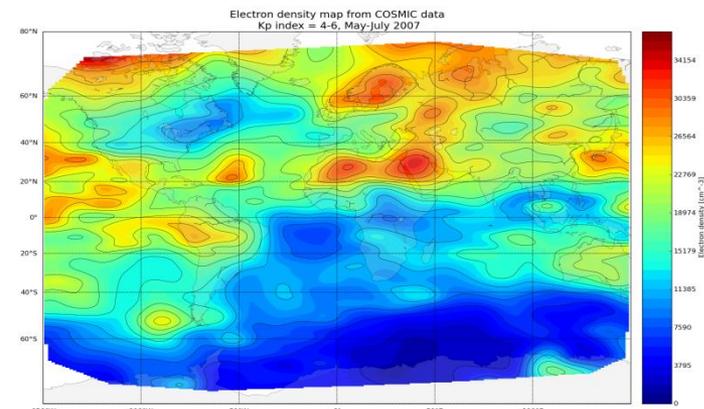
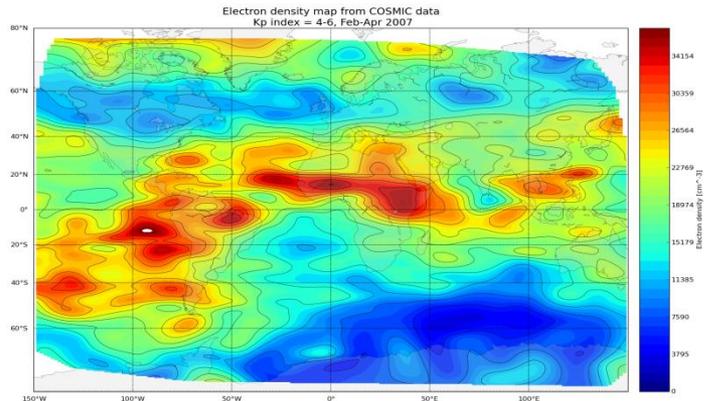
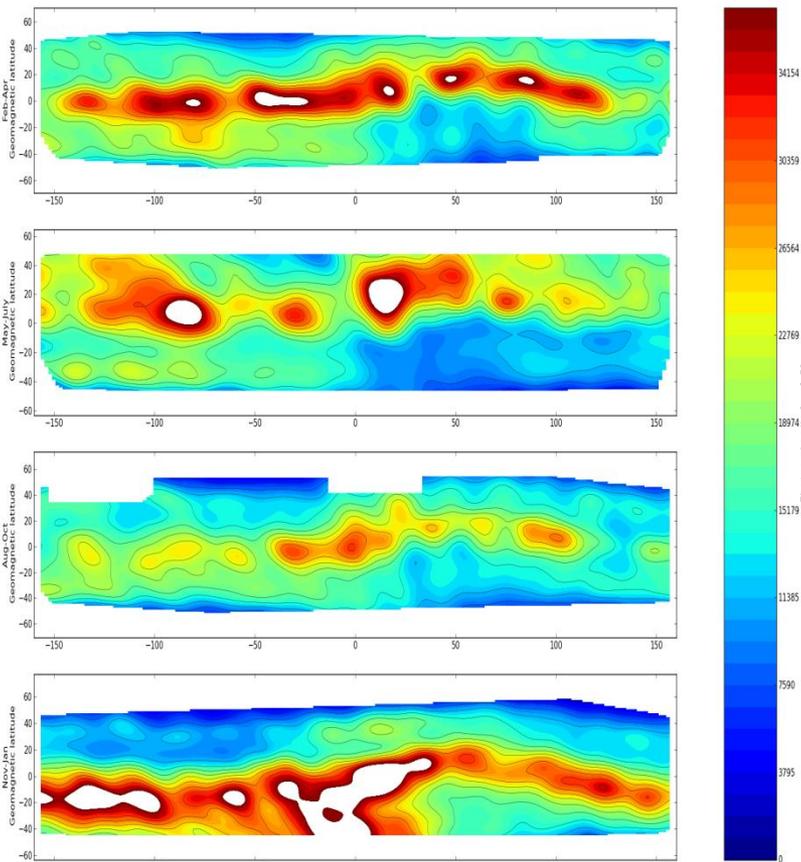
Electron density map from COSMIC data
Kp index = 0-2, Nov-Jan 2007



Electron density map from COSMIC data
Kp index = 0-2, Aug-Oct 2007



Electron density maps from DEMETER data
Kp index = 4-6, year 2007

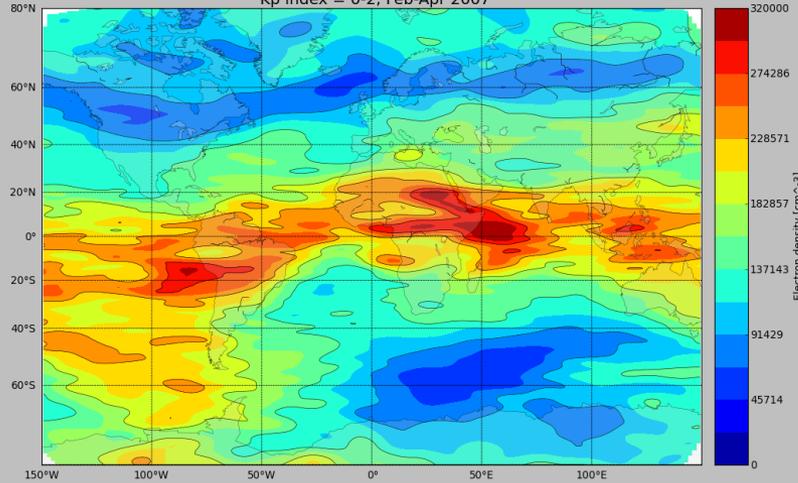


DEMETER and FORMOSAT-3/CSMIC data comparison

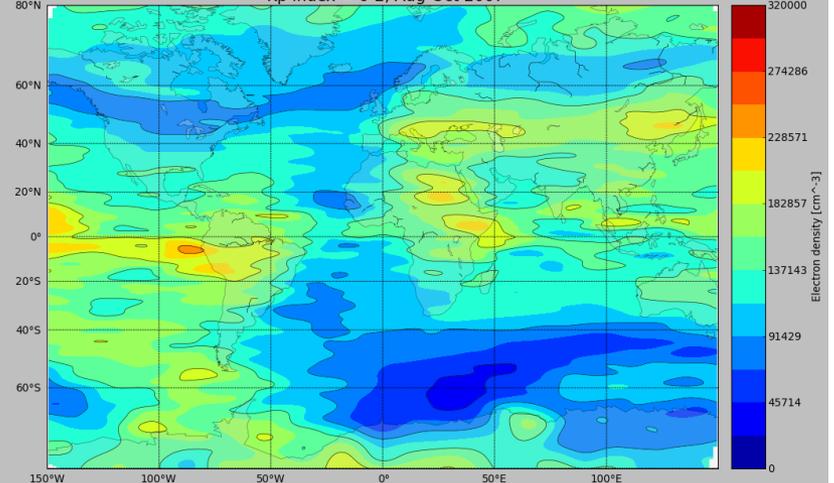
- From the COSMIC data we obtain comparable but expanded picture of midlatitude trough. Position of poleward edge
- Both datasets present similar behaviour of trough structure during fixed time periods and geomagnetic conditions
- Dependency on insolation clearly visible
- Narrower structures for higher geomagnetic activity

F2 layer maximum density seasonal variations

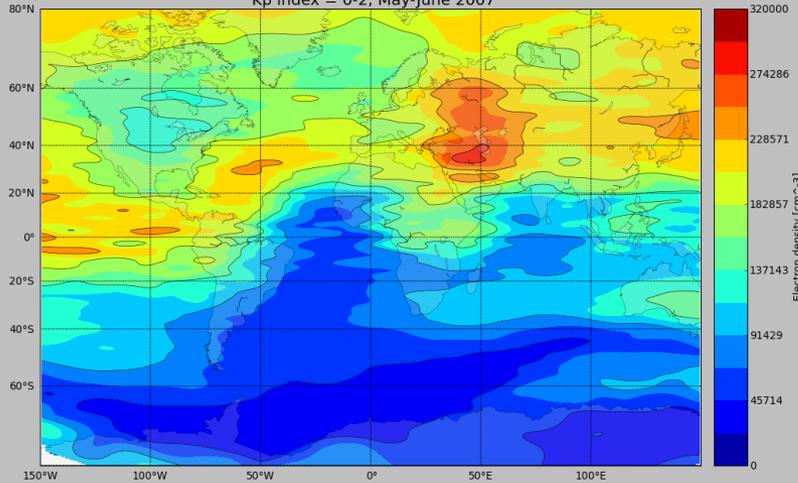
F2 layer maximum map from COSMIC data
Kp index = 0-2, Feb-Apr 2007



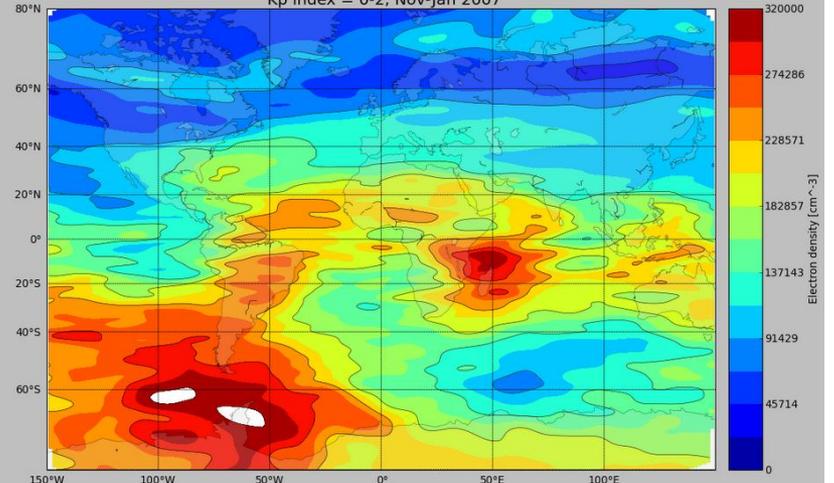
F2 layer maximum map from COSMIC data
Kp index = 0-2, Aug-Oct 2007



F2 layer maximum map from COSMIC data
Kp index = 0-2, May-June 2007

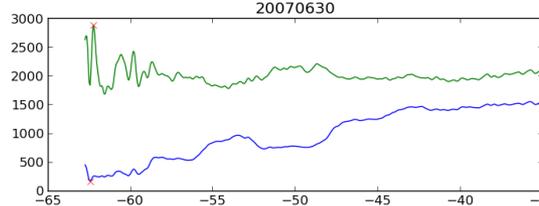
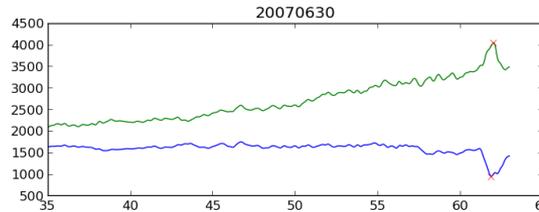
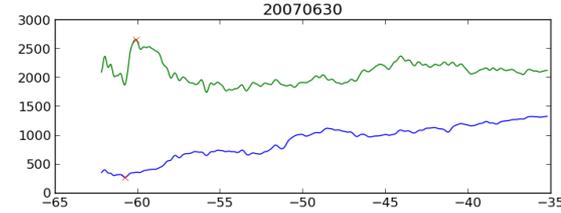
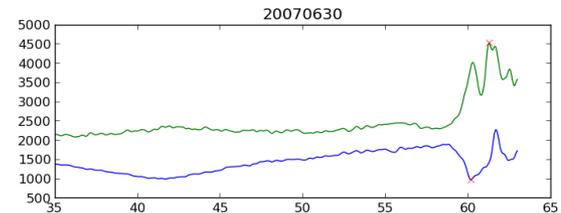
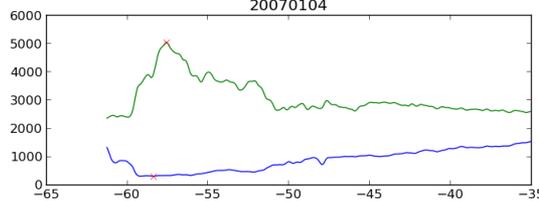
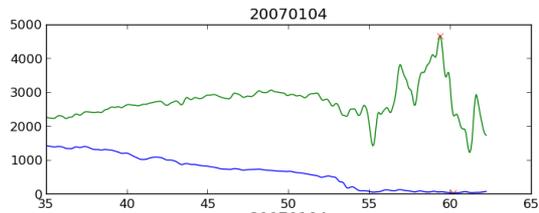
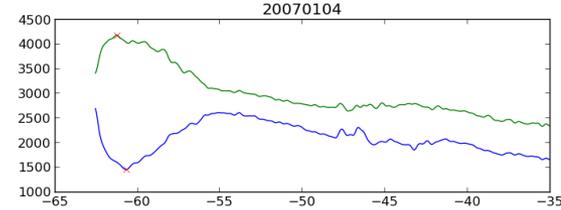
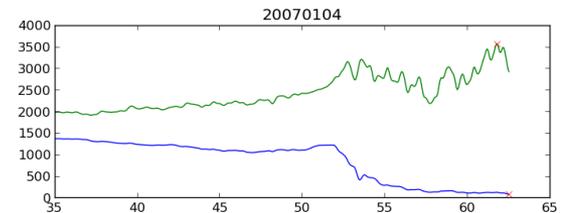
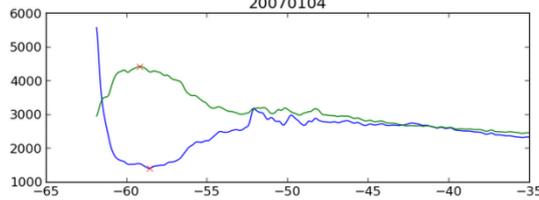
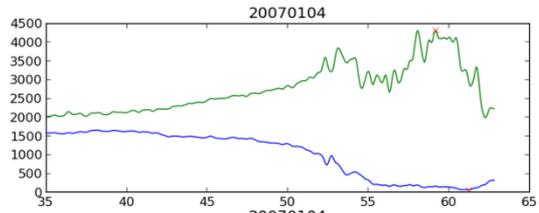


F2 layer maximum map from COSMIC data
Kp index = 0-2, Nov-Jan 2007

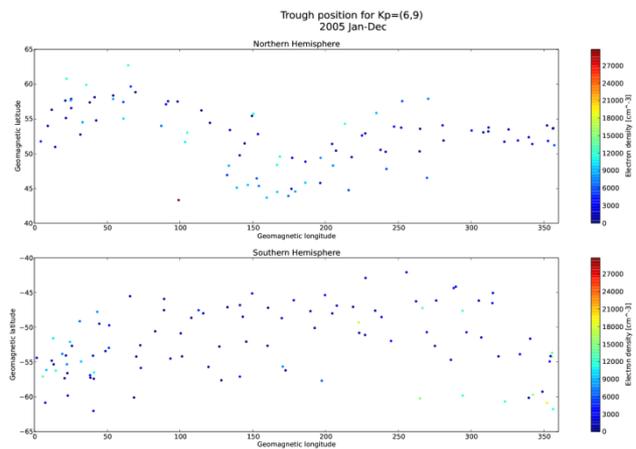
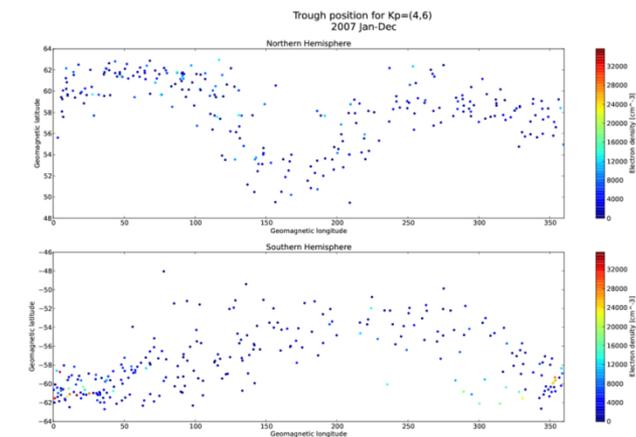
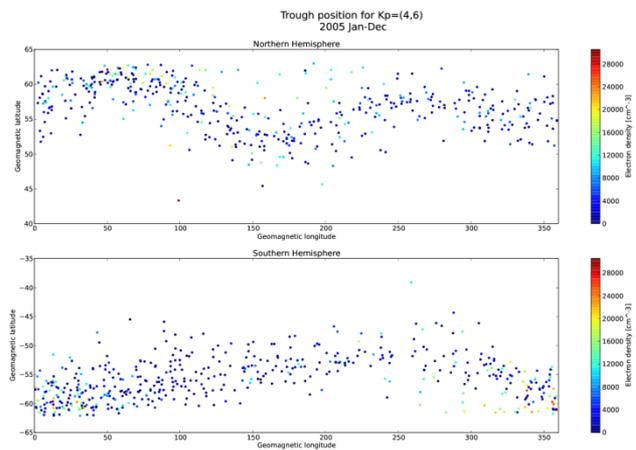
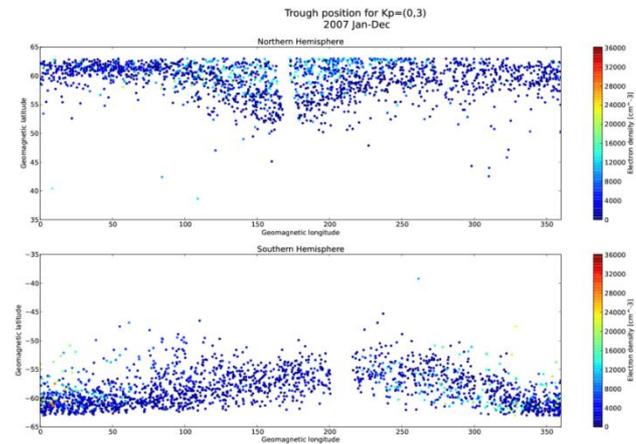
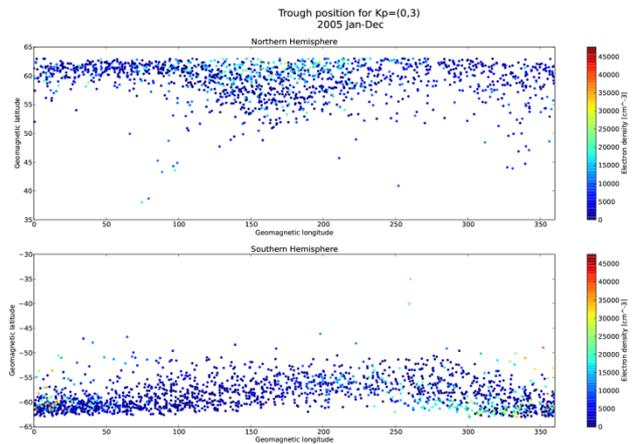


F2 layer maximum density seasonal variations

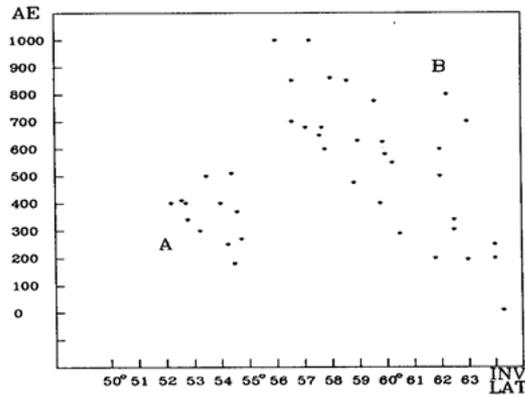
- The Northern hemisphere trough position varies with seasonal changes. It shows that insolation plays an important role in plasma density variations. Midlatitude trough occurs between 40-150°W for equinoxes, almost disappears for local summer, and expands eastward during local winter.
- Similar variations are observed in the Southern hemisphere. During equinoxes midlatitude trough locates between 0-100° E. In local winter it is longitudinally extended and covers almost entire geomagnetic parallel. During local summer it is hardly visible and effect intensifies presence of so called Weddell Sea Anomaly.
- It is worth to notice that trough in the Southern hemisphere appears more visible and larger structure than northern one



- Trough minimum is correlated with local electron temperature maximum

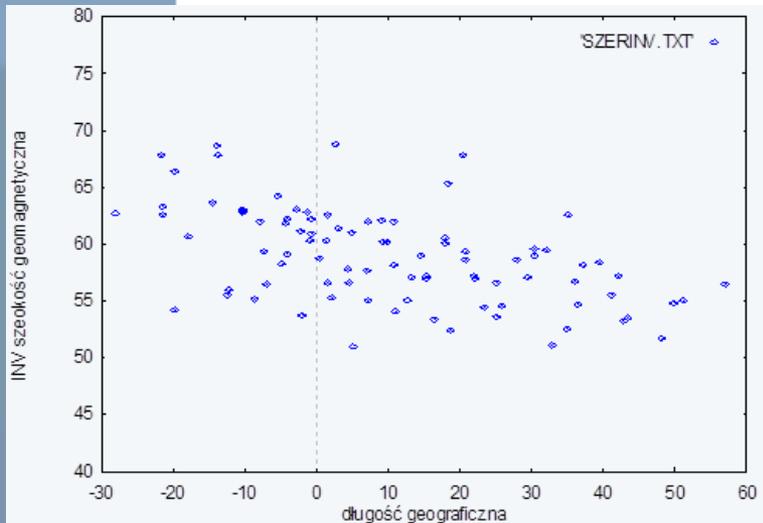


- Mid-latitude trough minimum moves equatorward with increasing geomagnetic activity
- About 5° equatorward during the higher geomagnetic activity (*Muldrew [1965], Wang [1998]*)

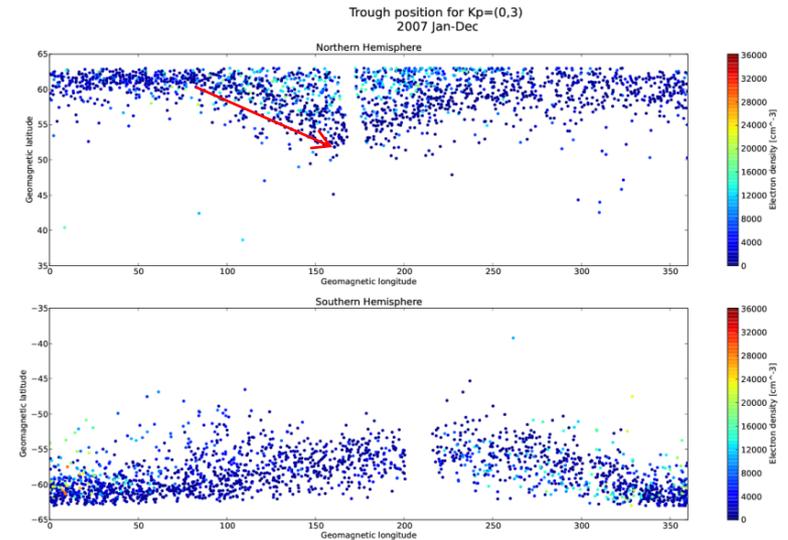


IK -19 , 1978-1981, - 500-980-km .
Trough minimum position (inv lat) vs. AE index

Magion-3 , 1991- 1992, 3000-400 km
Trough min position (inv lat) vs. long



- Trough minimum position occurs at lower latitudes with longitudes in sector from -30,60 for Northern hemisphere. Then back again to the previous position.



Summary

- Longitudinal variations of position of mid-latitude trough are strongly correlated with seasonal changes and insolation.
- Typical latitudinal location of mid-latitude trough minimum is about $\pm 62^\circ$, but during the higher geomagnetic activity it moves equatorward.
- Annual changes of insolation causes the lack of readily visible trough structures in the Northern hemisphere during the local summer, the same situation can be observed in the Southern hemisphere.
- Observations show that the midlatitude trough tends to shift equatorward for some longitudes in both hemispheres
- The Southern hemisphere trough structure appears as deeper and better visible even during the local summer

Thank You