Daytime seasonal variation of Longitudinal structures of electron density and temperature measured with DEMETER satellite

Y. Kakinami[1], C. H. Lin[2], J. Y. Liu[3], M. Kamogawa[4], S. Watanabe[1], M. Parrot[5]

[1] Hokkaido Univ., Japan,

[2]National Cheng Kung Univ., Taiwan

[3]National Central Univ., Taiwan

[4]Tokyo Gakugei Univ., Japan, [5]LPCE/CNRS, France

Kakinami, et al. (2011) J. Geophys. Res., doi:10.1029/2010JA015632

11:15-11:30 12 Oct 2011, **the 2nd International DEMTER workshop**

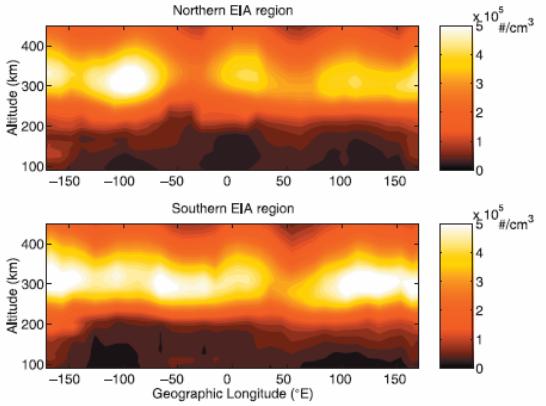
Content

- Introduction
  - Recent observations of wave-4 longitudinal structure
  - Motivation
- Longitudinal structure of Ne & Te observed by DEMETER
  - Focus on seasonal variation under low solar activity
- **Longitudinal structure of Ne & Te observed by Hinotori**
  - Focus on LT variation under high solar activity
- Summary

Introduction :observations of longitudinal structure

- Air glow[*Sagawa et al*., 2005; *Immel et al*., 2006]
- Equatorial electro jet [*England et al*., 2006]
- Total electron content [*Scherliess et al*., 2008]
- Plasma drift [*Kil et al*., 2007]
- Neutral wind at lower thermosphere [*Forbes et al*., 2003]
- Ne profile obtained by radio occultation [*Lin et al*., 2007]
- In-situ plasma observaton [*Liu & Watanabe* 2008]
- Neutral density [*Liu et al*., 2009]
- Ne in the top side ionosphere [Bankov et al., 2009]
- Etc…

Many observations have confirmed the wave-4 longitudinal structure



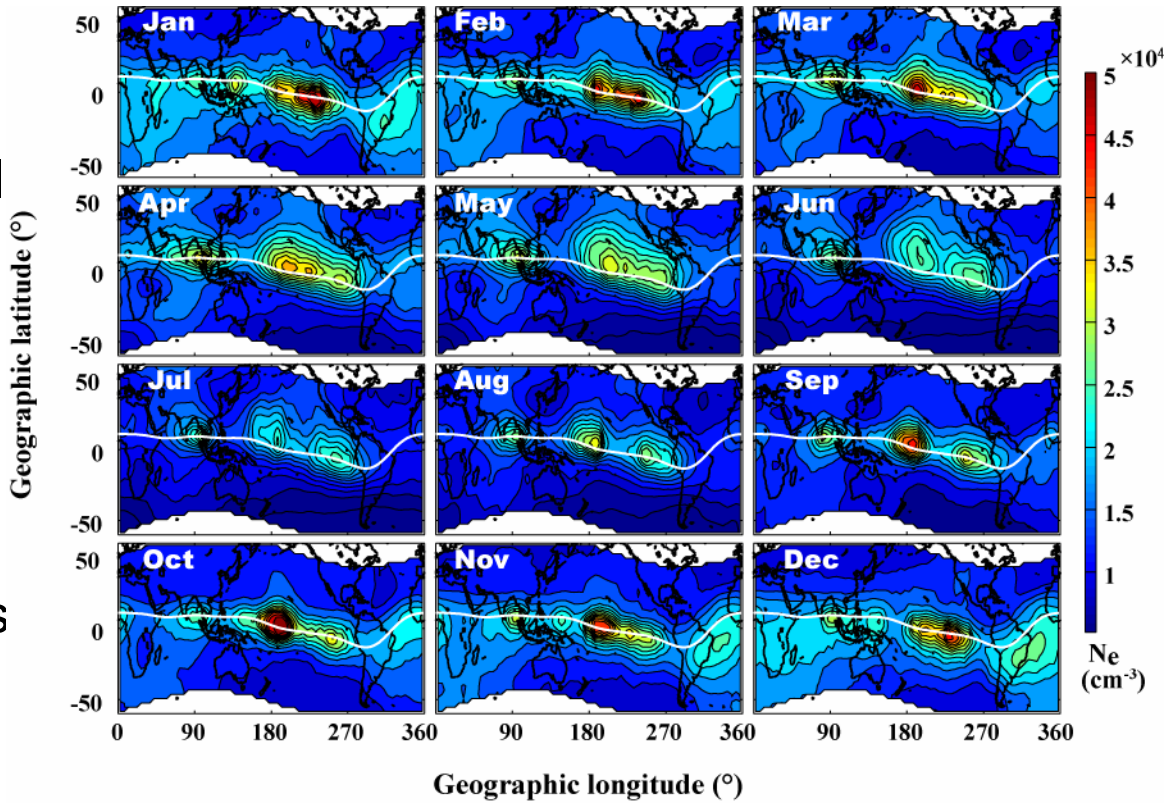
[*Lin et al*., 2007]

Motivation

- Longitudinal structures of Te & Ne in the topside ionosphere have been reported by *Ren et al*. [2008]
  - However, …
    - Using 11 years integrated data of DMSP(800km)
    - Data were divided into 4 season
    - They concluded that Te variation is related to in-situ Ne variation
- Therefore, these results might be included solar activity variation
- Further, we confirm detail of seasonal variation of longitudinal structure of Ne & Te
- We found the evidence Te in the topside ionosphere does not necessary correlate with in-situ Ne

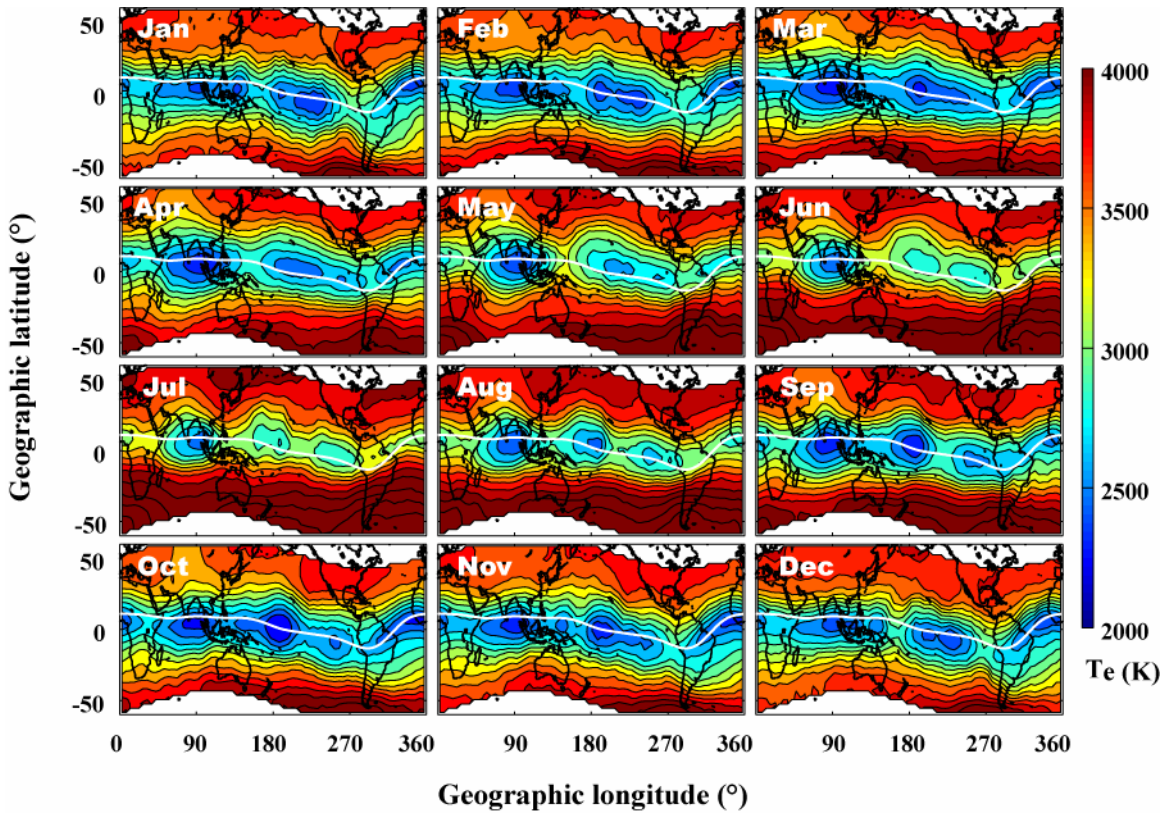
Seasonal variation observed by DEMETER ~ Ne

- Maximum Ne is high around magnetic equator in December sol. & low in June sol. due to seasonal variation of O/N_2
- Ne in summer hemisphere is higher than that in winter hemisphere due to neutral wind
- Longitudinal structure has seasonal variation
  - Wave-4: May-Oct.
  - Wave-3:Nov.-Apr



Seasonal variation observed by DEMETER ~ Te

- Te generally shows negative correlation of Te
- Minima of Te are high around magnetic equator during Jul.-Aug. & low during Oct.-May due to Ne variation
- However, it does not correspond exactly
- Longitudinal variation
  - Wave-4: Jul.-Sep.
  - Wave-3: Oct.-Jun.



Ne & Te in the magnetic equator (|dip Lat.|<5)

- maximum of Ne are seen around 90, 190, 250 and 330 °E
  - 190°E : high during Aug.–Mar.
  - 330°E : low during Sep.–Apr. and almost disappears during May–Aug.
- the minima of Te are seen around 90, 190, 250, and 330°E.
  - 90°E: not always the lowest
  - 190°E: Feb.–Sep.
- Although the maximum of Ne at 190°E is larger than the other maxima of Ne during
- Te variation does not correspond to Ne exactly

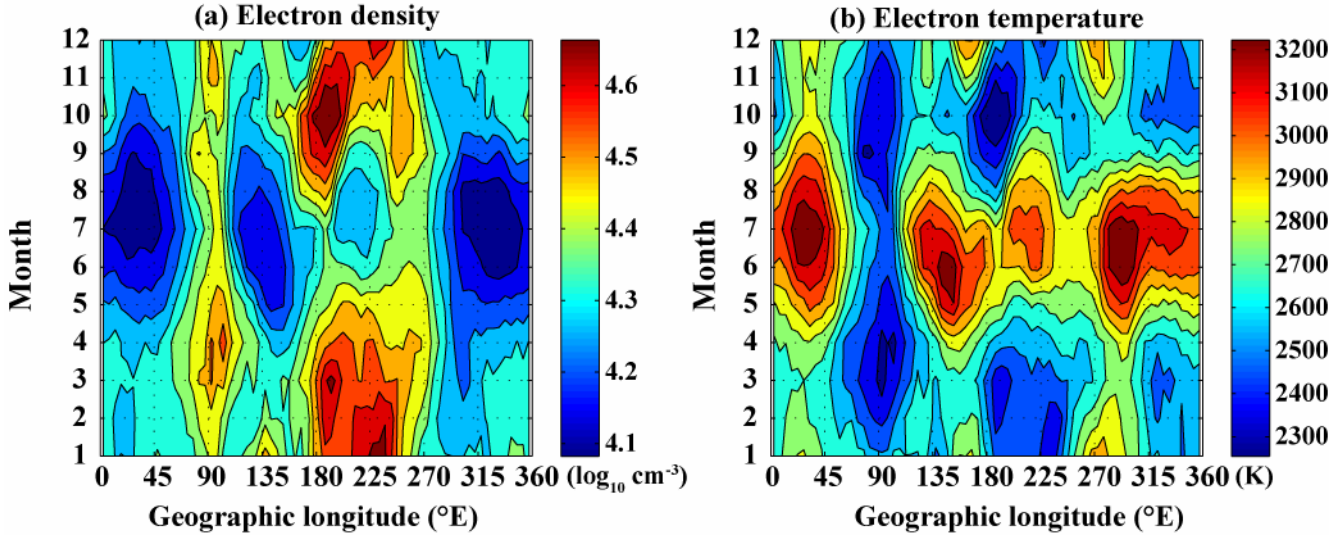
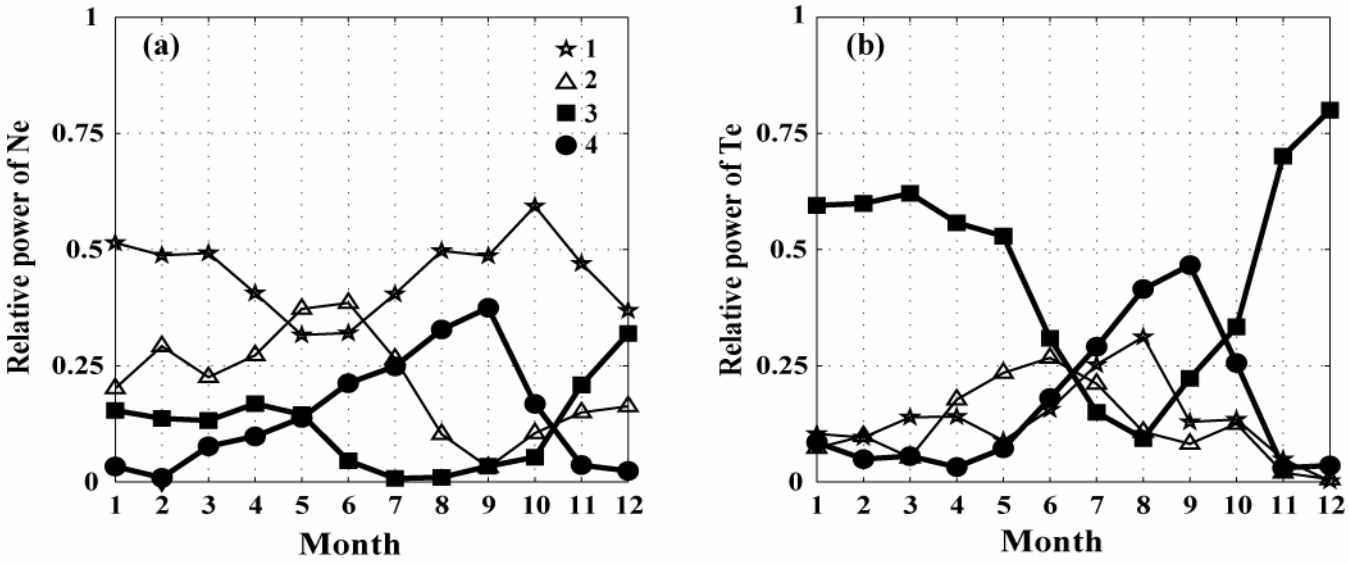


Fig.8

Wave number of Ne & Te in the magnetic equator

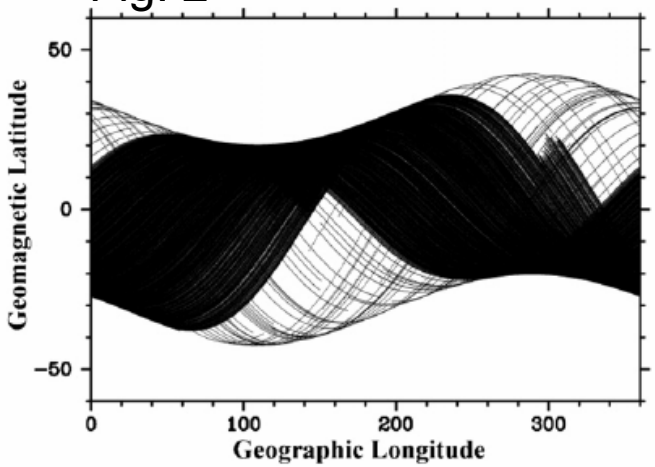
- Ne
  - Since one or two peaks are more pronounced than other small peak, wave-1 or -2 are always pronounced
  - Wave-3: Nov.-Apr., wave-4: May-Oct.
- Te
  - Wave-3: Oct.-Jun., wave-4: Jul.-Sep.



HINOTORI

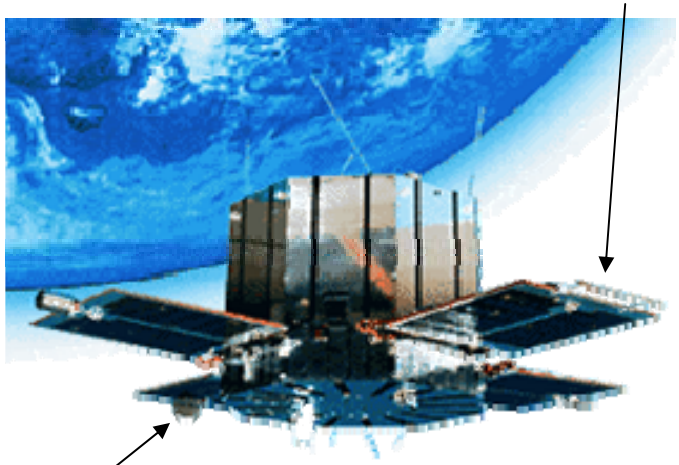
- Japanese satellite
- 23 Feb.1981-14 June 1982
- Solar activity :maximum and medium
- Latitude: -32~32°
- Height: 576~644 km
- Electron Density (Ne) & Temperature (Te)
- All LT range

Fig. 2



[*Kakinami et al*., 2008]

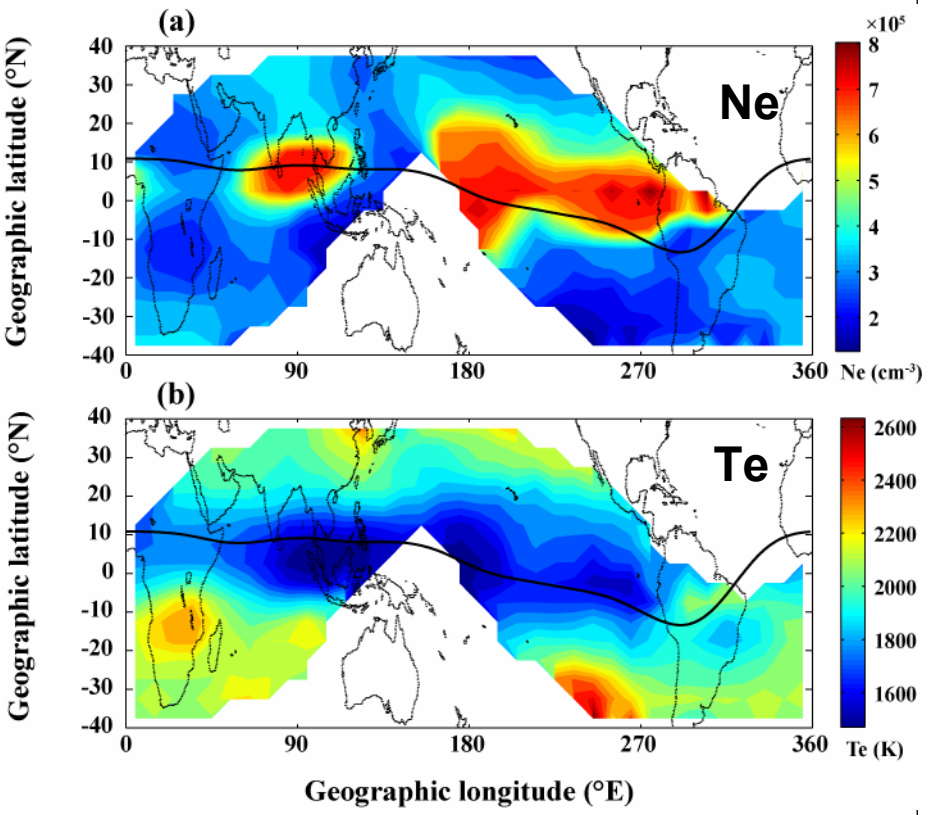
Impedance Probe [*Oya, et al*., 1986]



Electron temperature Probe [*Hirao and Oyama*, 1970]

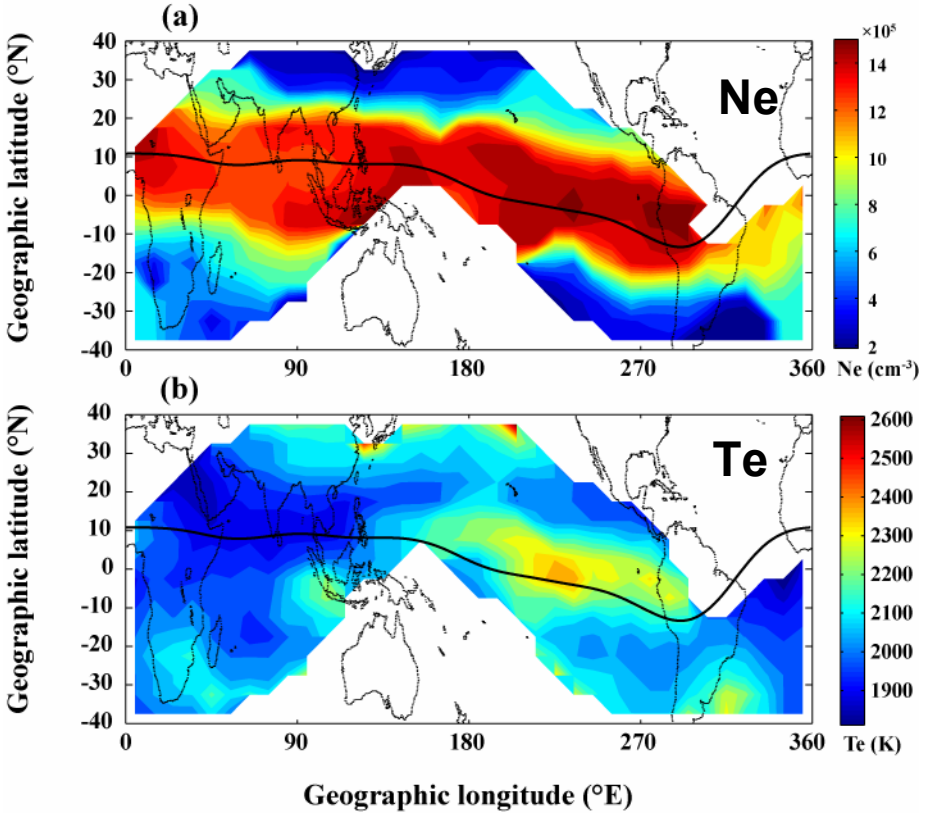
LT variation observed by HINOTORI (1)

- Median during July-October under Kp<4
- LT=0900-1100
- Wave-4 like structure can be seen
- Near the magnetic equator, correlation between Ne & Te is negative



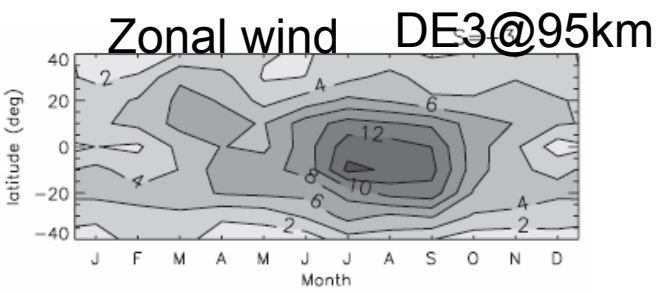
HINOTORI ~LT variation observed by HINOTORI(2)

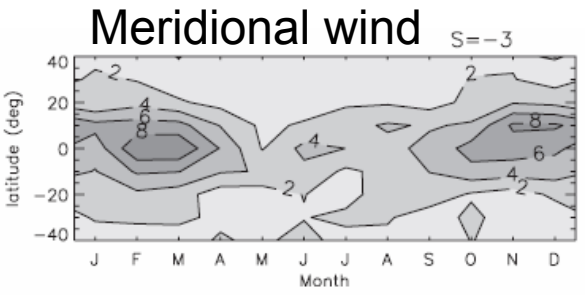
- The same condition of Fig. 4 but different LT
- LT=1300-1500
- 4 maxima of Ne are seen
- Peak Ne are shifted to eastward
  - Basic feature of nonmigrating tide of wave number 4 (DE3)
- In the magnetic equator, correlation between Ne & Te is positvie



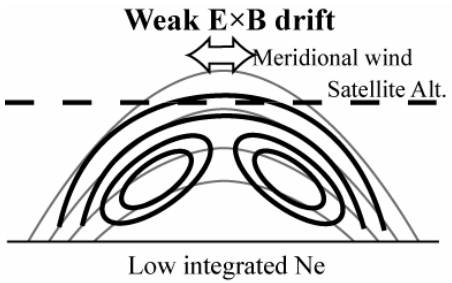
Discussion

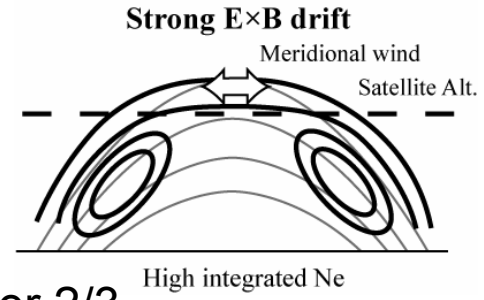
- Seasonal variation of wave-3/-4 structure of Ne &Te is similar to DE2/DE3 zonal wind at dynamo region
- However, seasonal variations of Ne & Te show discrepancy
- Cause of Ne variation
  - Electric field which produces the fountain effect is modulated by zonal wind [*Jin et al*., 2008]
  - Ne in the topside is also affected by meridional wind in the topside ionosphere [*Watanabe & Oyama*, 1996]
- Cause of Te variation
  - Heat conduction is dominant in the top side ionosphere
  - Te is correlated with integrated Ne along the magnetic field line below the satellite height in the topside [Kakinami et al., 2011 submitted to JGR]
  - Therefore, lower ionosphere condition might reflect Te in the topside ionosphere
- Meridional wind might produce the discrepancy





[*Forbes et al.*, 2003]





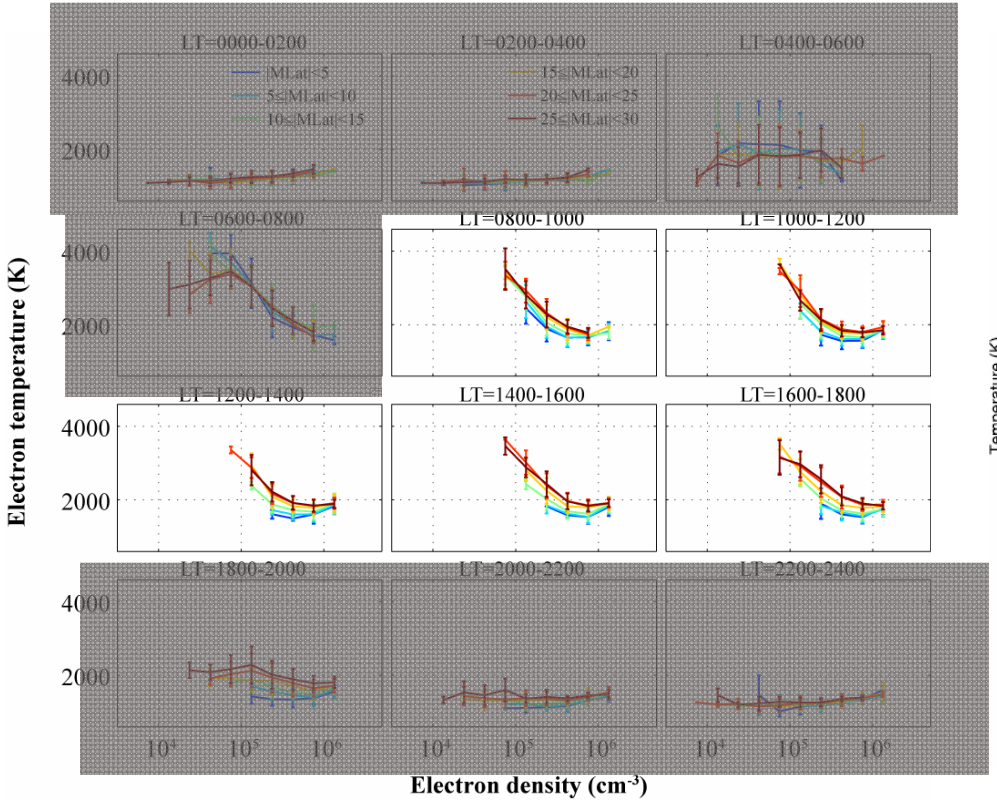
DE2/3: eastward propagating diurnal tide with wave number 2/3

Summary

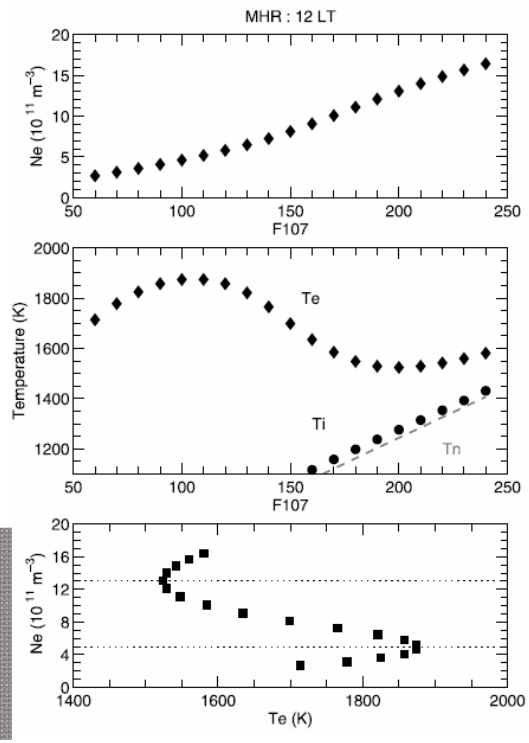
- Longitudinal structure (wave-3/-4) are seen during both low and high solar activity
- Wave-3/-4 of both Ne & Te are seen when zonal component of DE2/DE3 is enhanced
- One of 4 or 3 Ne peaks are pronounced
  - Only Strong fountain effect which can reach the satellite height can be detected
- Discrepancy between Ne & Te
  - Ne：May-Oct. (wave-4) ：Nov.-Apr. (wave-3)
  - Te：Jul.-Sep. (wave-4)：Oct.-Jun. (wave-3)
  - Maximum of Ne often appear around 190 deg.
  - Minimum of Te often appear around 90 deg.
  - Therefore, cause of longitudinal structure is different between Ne & Te
- In the topside ionosphere, correlation between Ne & Te is not always negative
  - The correlation is positive when Ne is significantly high
- Ne easily affected by meridional wind
- Therefore, Te is a better indicator for nonmigrating tidal effect at topside ionosphere than the Ne.

Discussion (2)

- Positive correlation between Ne & Te
  - No significant seasonal variation
  - Magnetic latitude dependency



Hinotori@600km
each line indicate magnetic latitude region

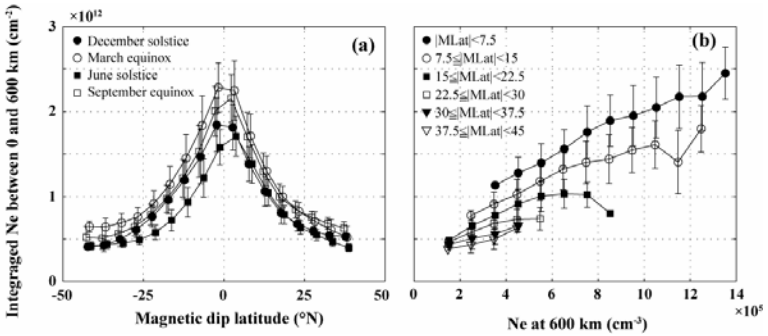


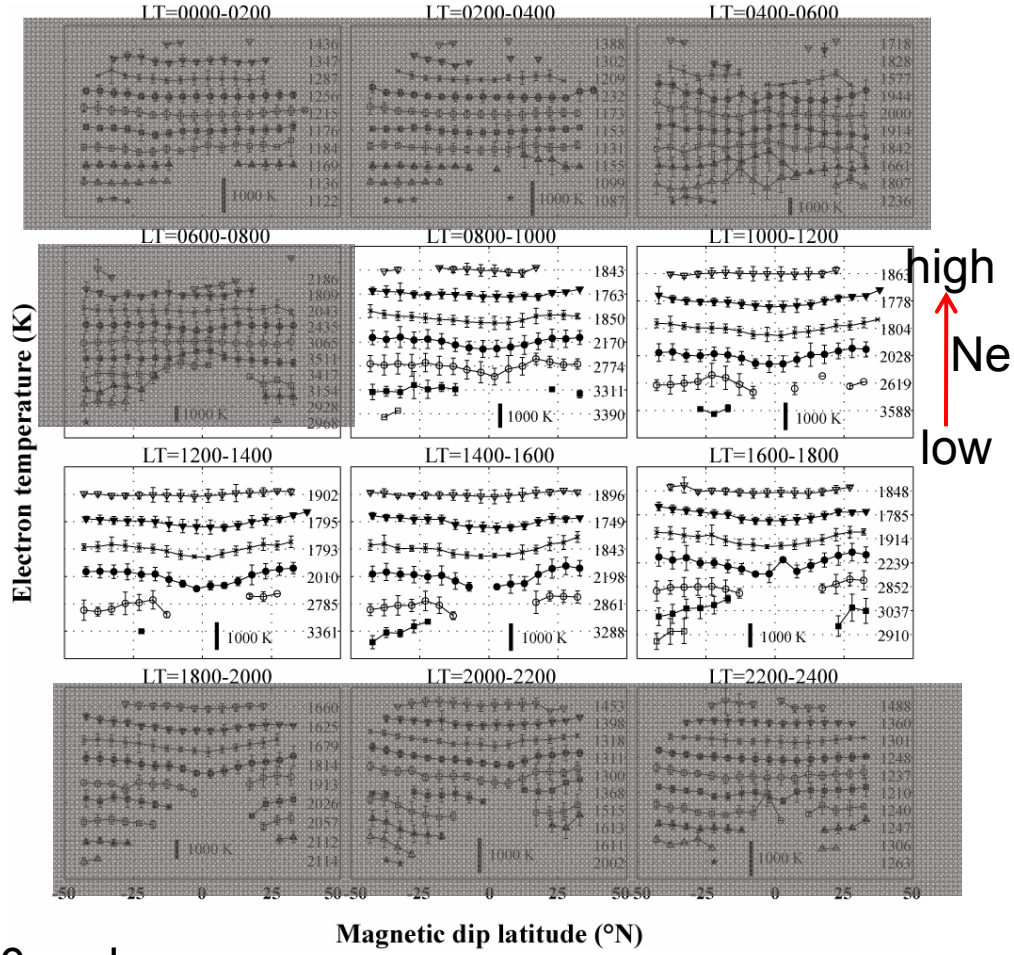
Simulation@F2 peak

[Lei et al., 2007]

Discussion (3)

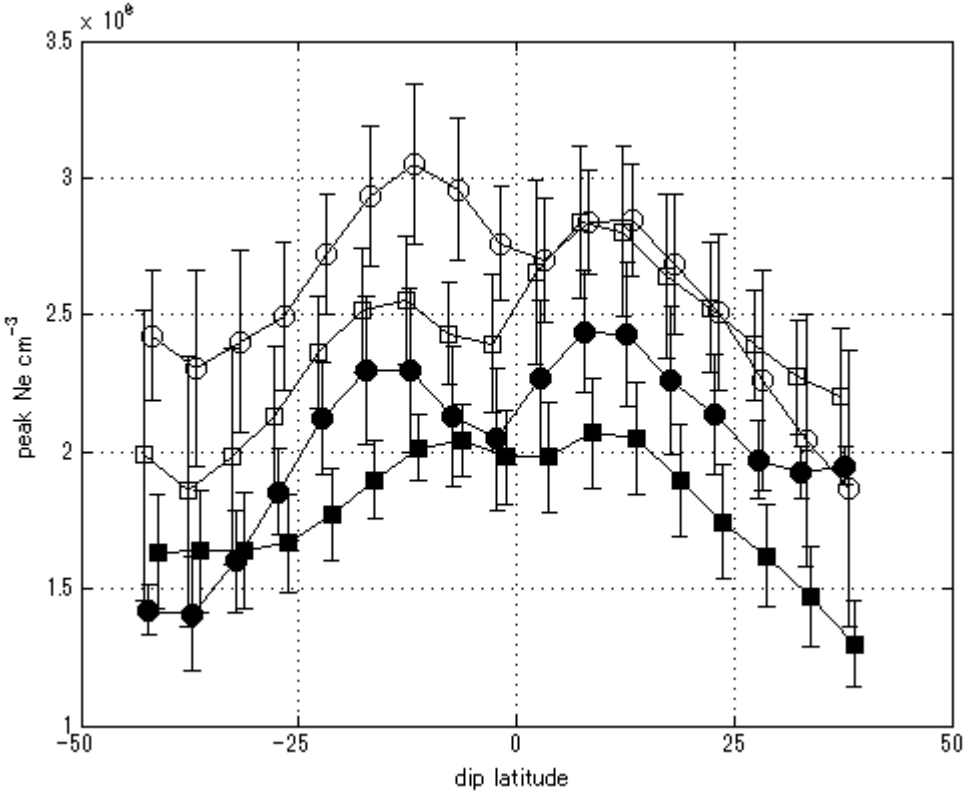
- Each symbol indicate same Ne region
- Te decreases with increasing magnetic Lat. during daytime when Ne is the same region
  - Te does not fully depend on in-situ Ne rather integrated Ne





Integrated Ne along field line between 0 and 600 km below the satellite height

Discussion (2)



●December solstice, ○March equinox
■June solstice, □September equinox

DEMETER

Fig. 3

- French satellite
- Detection of Electro-Magnetic Emissions Tran from Earthquake Regions
- January 2004
- Solar activity: low
- Magnetic field, Electric field (DC to 3.25MHz), Te & ion temperature (Ti), Ne & ion density (Ni), ion velocity, electron spectrum (> 30 KeV)
- Inclination: 98°, sun-synchronous (1030, 2230 LT)
- Altitude: ~710 km, 660 km after December 2005
- In this study, data in 2006 & 2007 are used