ANALYSIS OF THE NIGHTTIME LOWER IONOSPHERE HEIGHT BEHAVIOR FOR EQUATORIAL, LOW AND MIDDLE LATITUDES

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1. INTRODUCTION

The lower ionosphere

It includes the D-region and the bottom part of the E-region (60km and 100km)

It can be study using ELF (Extremely Low Frequency: 3Hz-3kHz) and VLF (Very Low Frequency: 3kHz -30kHz) waves released during lightning discharges. Its cut-off (f_{cn}) frequency is related to the nighttime height of the lower ionosphere (h_N).

$$f_{cn}=nc/2h_N$$

n: cut-off frequency mode number
c: speed of the light in vacuum.

The relation between the nighttime lower ionosphere and the dynamics of Mesosphere-Lower Thermosphere (MLT) region has been studied using VLF narrowband signals. However, this technique is limited along the propagation path and its results represent an averaged observation along the path which can be somewhat smoothed.

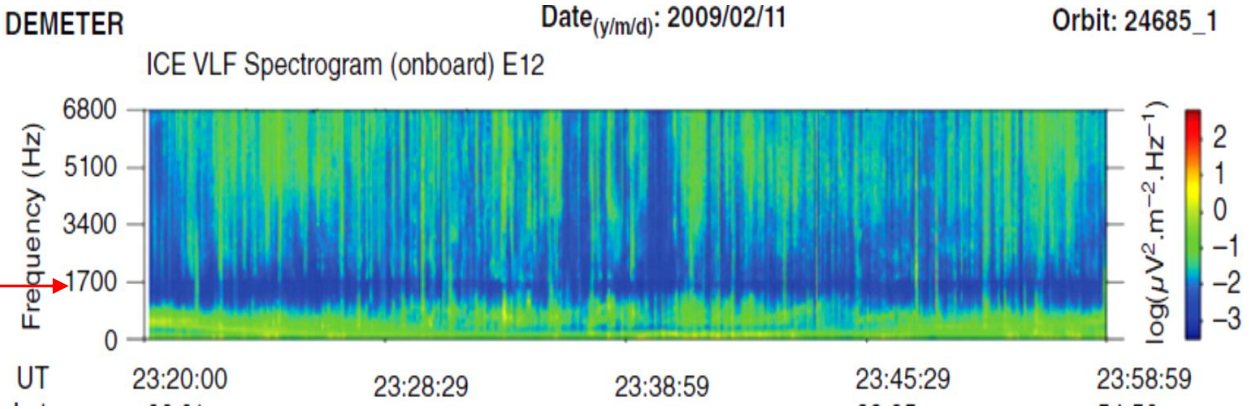
OBJETIVE: **Analyze the nighttime lower ionosphere height behavior and investigate its possible relation with the dynamics of MLT region.**

2. DATA AND METHODOLOGY

The Power Spectra Density (PSD) – ICE data in ELF/VLF band range (20 Hz - 20 kHz) survey mode from DEMETER (Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions) satellite has been analyzed since 2006 to 2009.

cut-off frequency (f_c) ~ 1.7 kHz

f_c is detected as a minimum of energy



Estimating the nighttime lower ionosphere height

1. Linearize each power spectra $S_{linear}[f] = 10^{S_{l1}[\mu V^2 m^{-2} Hz^{-1}]}$

S_{linear} is the linear spectrum
S_{l1} is the VLF power spectrum

2. Normalize by its mean power $S_{norm}[f] = \frac{S_{linear}[f]}{\overline{S_{linear}}}$

3. All the spectra that belongs to specific area is averaged as: $S_{region} = \frac{1}{N}\sum_{n=1}^{N} S_{norm,n}[f]$

The minimum of energy (f_c) is detected from S_{region}, then h_N is estimated as:

$f_{cn}=nc/2h_N$ n=1

2. DATA AND METHODOLOGY

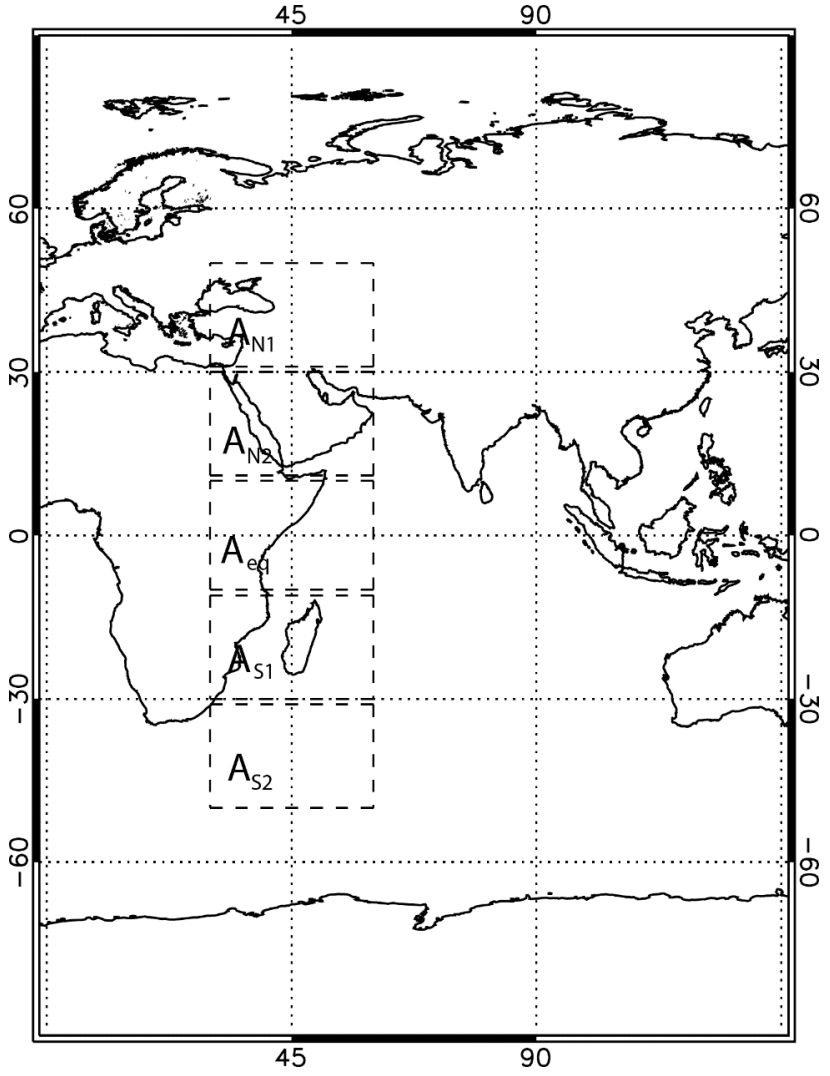
- In this study, we focus on the region located between:

  - Longitude : 30°E and 60°E
  - Latitude : 50°S to 50°N

- This region is in turn divided as follows:

  - Middle latitudes [±30°, ±50°] (A_{N1}, A_{S2})
  - Low latitudes [±10°, ±30°] (A_{N2}, A_{S1})
  - Equatorial latitudes [-10°, +10°] (A_{eq})

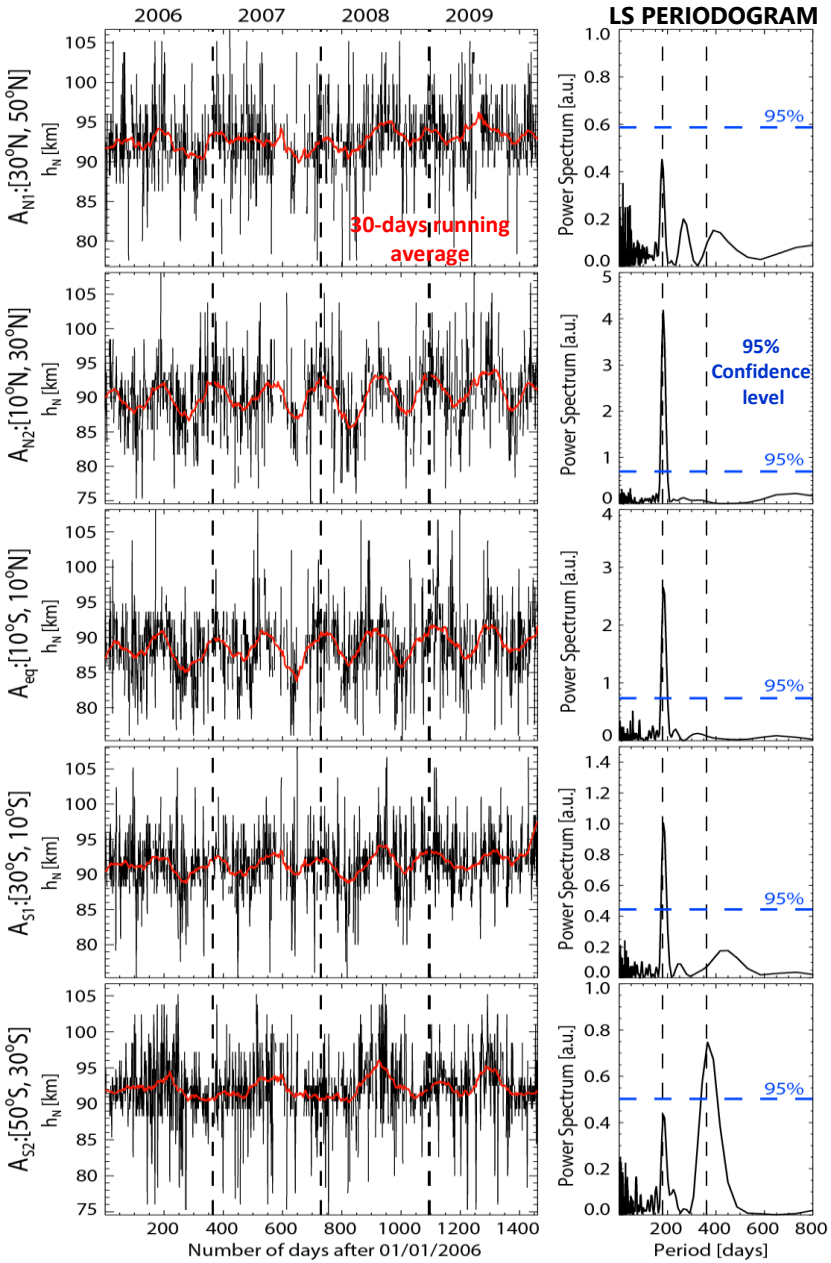
- For each box, daily nighttime ICE-VLF nighttime spectra is linearized and normalized to its mean. Finally, all the spectra which belong to the same region are daily averaged and then the local minimum is detected, hence f_c and h_N



3. RESULTS

3.1 Temporal variation of h_N

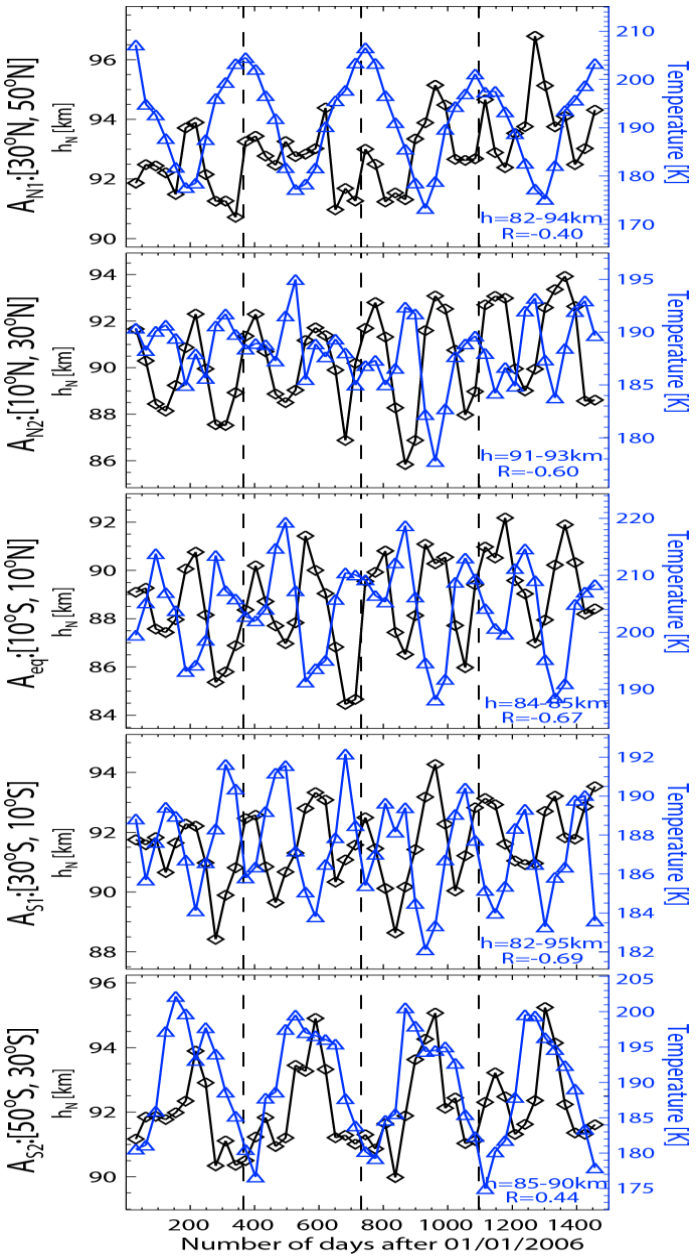
- h_N shows typical values for the nighttime lower ionosphere.
- h_N shows long-term timescales oscillations: semiannual (SAO) and annual oscillation (AO), confirmed by the Lomb-Scargle (LS) periodogram. Vertical black dashed lines illustrate periodicities at 180 and 365 days which correspond to the semiannual and annual oscillation, respectively.
- The SAO appears for equatorial, low and middle latitudes, being dominant for equatorial and low latitudes. For middle latitudes between A_{S2}[50°S, 30°S] the AO is dominant.



3. RESULTS

3.2 Study of the relation between h_N and the dynamics of the Mesosphere-Lower Thermosphere (MLT) region

- Atmospheric temperature data is obtained from SABER-TIMED satellite.
- h_N is compared with the nighttime mesospheric temperature (T_{mesf}) estimated for different ranges of altitudes between 80km and 100km, in order to find highest correlation. The correlation analysis was performed using monthly mean values from smoothed h_N and mesospheric temperature data.
- h_N shows mostly negative correlation with T_{mesf} with R ~ -0.7 for equatorial and low latitudes, while for middle-latitudes [±30, ±50] no significant correlation is observed.



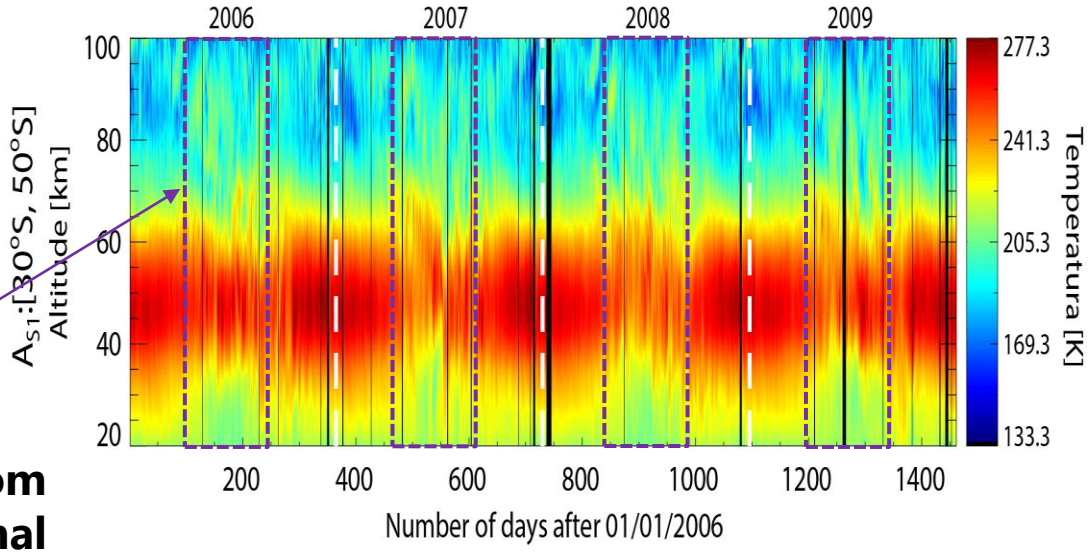
4. DISCUSSION

The global lightning activity shows SAO and AO in the tropics and mid- to high latitudes, respectively. However, it is more important over land areas than over oceans and moreover the oceanic lightning activity is fairly constant all over the year. Hence, the oscillations observed in h_N, even over oceanic regions, together with significant correlation with T_{mesf} might suggest a coupling between the nighttime lower ionosphere and the dynamics of the MLT parameters whose magnitudes and oscillations are drove mainly by dynamical processes such as winds, tides, planetary waves and gravity waves.

h_N and T_{mesf} doesn't show significant correlation

Temperature shows faster fluctuation during wintertime (May to August for Northern Hemisphere)

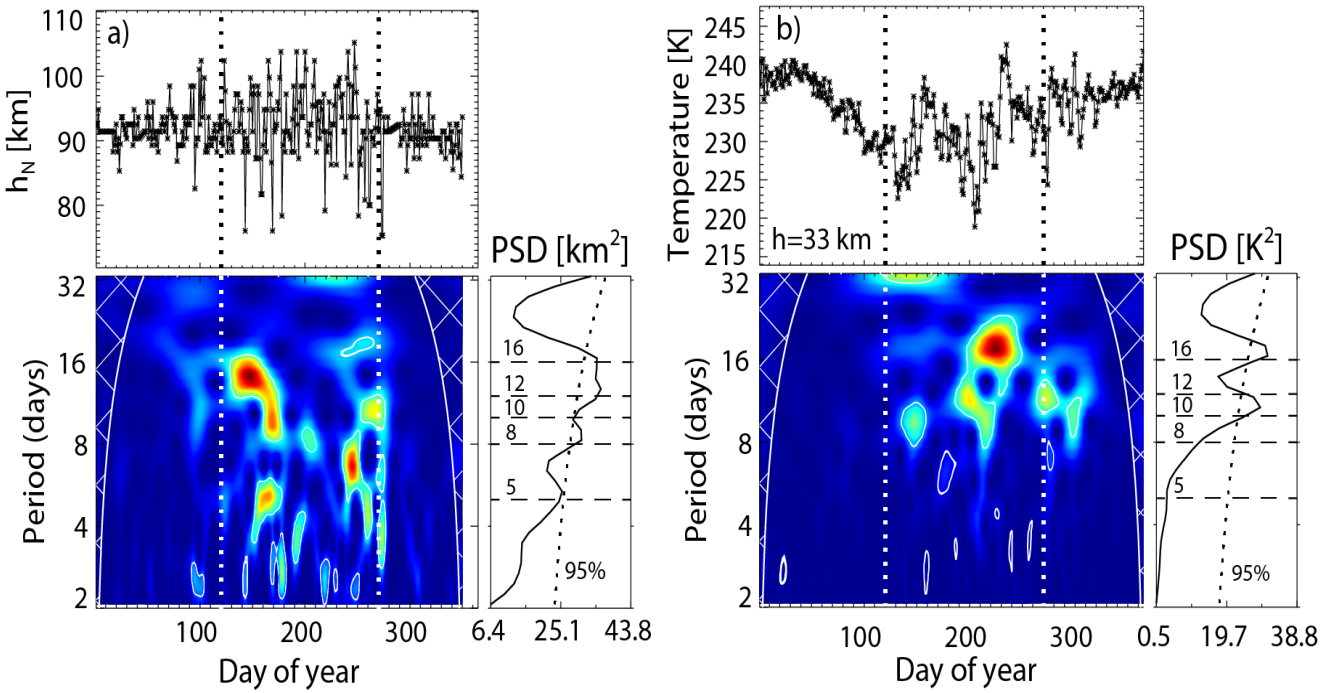
Planetary waves (PWs) from bellow might disturb the seasonal dependence resulting in low correlation.



VARIATIONS OF THE TEMPERATURE FOR [30°E, 60°E], [30°S, 50°S] FROM 2006 TO 2009.

4. DISCUSSSION

Wavelet analysis for h_N at middle-latitudes [30ºS, 50ºS] and Stratosphere temperature at h= 33 km.



- h_N fluctuates mostly with periods around 8, 10, 12 and 16 days
- Stratospheric temperature fluctuates with periods around 10, 12 y 16 days

Similar periodic components in both parameters during wintertime. It reinforces the evidence for the coupling between the lower ionosphere and the stratosphere.

5. CONCLUSIONS

- Semiannual an Annual Oscillations are observed in h_N, being SAO dominant for equatorial, low and middle latitudes except for the region at mid-latitude between [50°S, 30°S] where the AO becomes dominant. It might evidence a coupling between the nighttime lower ionosphere and the dynamics of the MLT region.

- It is proposed that atmospheric forcing from bellow at middle latitudes might disturb the seasonal behavior of the nighttime lower ionosphere, resulting thus low correlation between h_N and mesospheric parameters. This result suggests a close relation between the nighttime lower ionosphere and the dynamics of the lower-lying of the atmosphere which appears to be strong during local wintertime when high upward propagating planetary wave activity is commonly observed.

- Long-term observations of atmospheric waves disturbing the lower ionosphere are still necessary in order to characterize the coupling between different layers of the atmosphere.

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THANKS
for your attention!!

Questions?
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