Comparison of vertical electron density profiles over Low latitude American, African and Asian longitudinal sectors from COSMIC measurements

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Abstract

This paper describes the variations of the vertical electron density profiles(EDP)and slant total electron content (STEC) values retrived from Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) measurement during March equinox of 2013, 2015 and 2019 over low latitudes of American, Asian and African longitudinal sectors. The result indicates that there was a drastic variations of EDP and STEC over the three sectors. The over all maximum EDP values were found in 22 March 2015 and the least was found in 22 March 2019 over all sectors. In 22 March 2015 the maximum EDP was found in American sector, in 22 March 2013 the maximum EDP was found over Asian sector and in 22 March 2019 the maximum value was found over African longitudinal sector. From this study it is probably possible to deduce that during high solar activity phase the low-latitude American sector ionospheric TEC get enhancement compared to the other sectors and during low solar activity the low latitude African sector TEC get enhancement relative to the other sectors.

Keywords: **Electron density profiles; Ionosphere (low latitude ionosphere), COSMIC**

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Back ground of the study

Since the beginning of radio occultation (RO) technique, the data obtained from Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) has provided immense occultation events for atmosphere and ionosphere research and these days, it is providing large data sets that can be used in numerical weather prediction and space weather predictions, Schreiner et al,.2020. It is known that GPS (Global Positioning System)/ GNSS (Global Navigation Satellite System) radio occultation (RO) based on a low Earth orbit (LEO) has been a powerful technique in ionosphere monitoring. It can provide the accurate electron density profiles (EDPs) in the ionosphere with high vertical resolution on a global scale from bending information of the RO signals (Kuo et al., 2004; Rocken et al., 2000; Schreiner et al., 1999).

It has been reported that at low latitude and equatorial region, COSMIC retrieved electron density may degraded performance because of significant ionospheric horizontal gradients, typically at lower altitudes(E and F1 regions), Yue et al., 2010a. But, this may probably be maneged by considering the mean of observed values of EDPs within spatial binning, which may account the horizontal gradients, for example with spatial resolution of $\mathbf{10^\circ \times 10^\circ}$($\boldsymbol{latitude \times longitude}$), and hence it can captured the optimal observed values. Thus, the main objective of this study is to investigate and compare the STEC and EDPs from COSMIC observations over low latitude American, Asian and African longitudinal sectors during March equinox of 2013, 2015 and 2019 by averaging the COSMIC observations over large spatial resolution.

Data and Method of Analysis

In order to make a comparison of electron density profiles(EDPs) over low latitude of American($\mathbf{-120^\circ}$E,$\mathbf{-45^\circ}$E), African ($\mathbf{-15^\circ}$E,$\mathbf{-55^\circ}$E) and Asian ($\mathbf{60^\circ}$E,$\mathbf{120^\circ}$E) longitudinal sectors, we have collected COSMIC RO data from the University Corporation for Atmospheric Research (UCAR) COSMIC Data Analysis and Archive Center (CDAAC) website: `https://cdaac-www.cosmic.ucar.edu/` for day of March equinox of 2013, 2015 and 2019. The collected data was procssed by writting MATLAB code which extract the desired longitudinal profiles and convert the NetCDF (Network Common Data Form) to readble form for plotting and analysis.
We have also used the average data within bin or spatial resolution of $\mathbf{10^\circ \times 10^\circ}$($\boldsymbol{latitude \times longitude}$), which mayreduce computational time and allow to capture horizontal variability of values) observational values in a day to produce daily(the temporal resolution is a day) global countor plot of electron density profiles and slant total electron contents between GPS satellite trasmitter and LEO satellite receiver. From COSMIC radio occultation, the bending angle values and the profiles of refractivity, temperature, pressure, and humidity can be obtained following Abel inversion and reasonable assumptions. The bending angle $\boldsymbol{\alpha}$, impact parameter **a** and the refractive index (n) can be related as

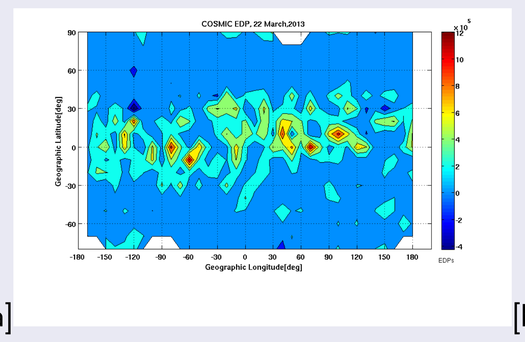
$$\boldsymbol{\alpha = a\left[\int_a^{XGPS} + \int_a^{XLEO}\right]\frac{dn/dx}{n(x)\sqrt{x^2-a^2}}dx} \quad (1)$$

where $\boldsymbol{x}$ is the refractional radius.

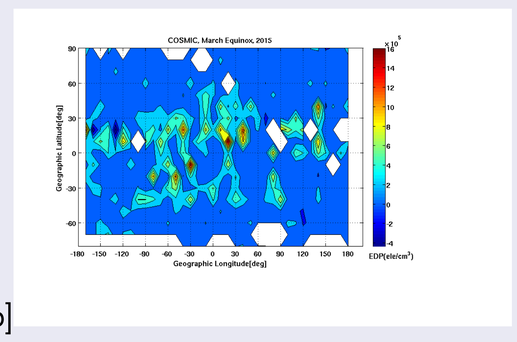
$$\textit{Total electron content(TEC) can be given by,}\boldsymbol{TEC = \frac{L_1 - L_2}{40.3 * 10^{16}}\left(\frac{f_1^2 f_2^2}{f_1^2 - f_2^2}\right), \Rightarrow TEC = 10^{-16}\int_{GPS}^{LEO} N_e ds, \Longleftrightarrow N_e(r0) = \frac{10^{16}}{\pi}\int_{r0}^{rLEO}\frac{dTEC/dr}{\sqrt{r^2 - r_0^2}}dr}$$

Results

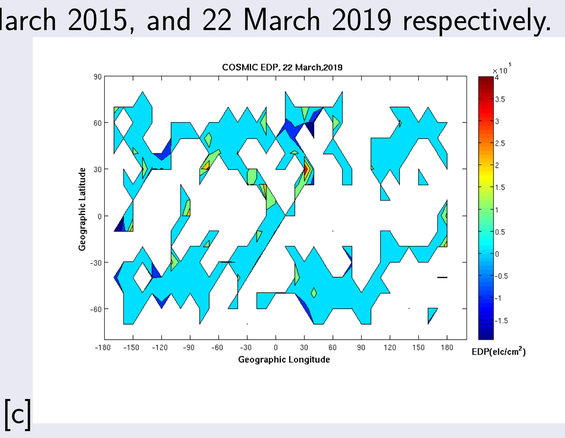
This paper shows EDPs during 22 March 2013, 22 March 2015 and 22 March 2019 from COSMIC measurements. This paper also shows that localized TEC enhancements in low latitude of American, Asian and African sector are observed during high solar activity of March equator of 2013, than that of March equator of 2015 and 22 March 2019(low solar activity). Figure **a**, **b** and **c** shows the daily countor plot of EDPs from COSMIC measurements in a year 22 March 2013, 22 March 2015, and 22 March 2019 respectively.



[a]



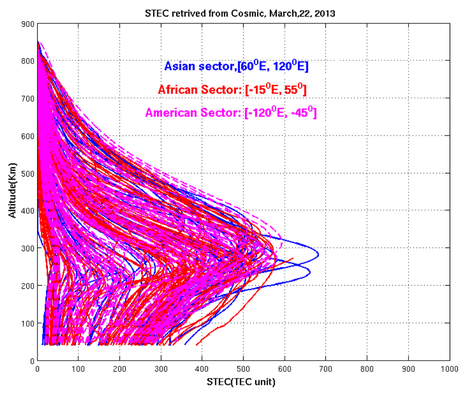
[b]



[c]

The results obtained in the current study agrees quite well with those of the other authors, for example Edemskiy et al., 2020.

- Ionospheric profiles during solar-maximum equinoxes of March 2015 was maximum over American sector. Ionospheric profiles during solar-maximum equinoxes of March 2015 was minimum over African sector.



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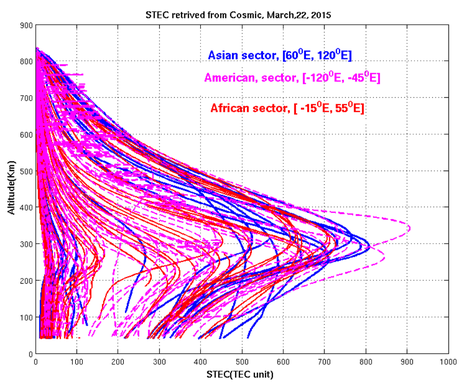

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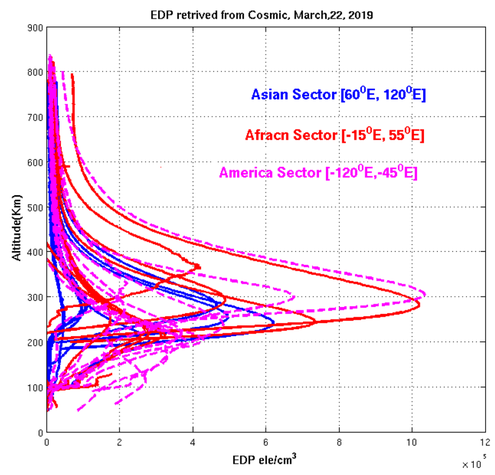

[f]

Conclusion

- The daily total electron concentration over low latitude American longitudinal sector is enhanced during equinox(March,22, 2015), than that of Asian and African longitudinal sector. However, during March equinox of March 2019, the value of EDPs are nearly the same over American sector and African sector, but smallest value observed over Asian sector.
- The maximum EDPs was observed over Asian low latitude longitudinal sector during March equinox of 2013, than that of American and African sectors.

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