Latitudinal Effect on Total Electron Content Variations

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***Abstract* – This work focuses on the latitudinal effect on the ionospheric parameters, in particular the Total Electron Content (TEC). Data of two IGS stations at Libreville, Gabon (9.6721°E, 0.3539°N), and at Ny-Alesund, Norway (11.8653°E, 78.9296°N) during February 2008 and July 2008 were analysed. It is found that hourly vertical TEC is higher at low latitude station than at high latitude station. TEC is also higher at Libreville in February 2008 than in July 2008 with the average difference of 5.908 TECU. However the difference between these months is less pronounced for Nya-Alesund with only 0.835 TECU difference. In addition, the diurnal variations of TEC are evident for both stations, especially for low latitude station. The findings show that TEC varies depending on the latitudes.**

***Index Terms* — Total Electron Content (TEC), ionospheric propagation, IGS network.**

I. INTRODUCTION

There are many factors that can affect the ionosphere's electron contents including the height above earth's surface, location, time of day, season, solar activity, and solar disturbances. The ionosphere can be categorised into three latitude regions; which are low, mid and high. The low latitude region is within about 20° to 30° of the magnetic equator. The high latitude region extends poleward from about 60° geomagnetic, and the mid latitude is between these two regions.

The high latitude ionosphere behaves differently from the low and middle latitude ionospheres since the geomagnetic field at high latitudes runs nearly vertical (as opposed to the horizontal magnetic field at low latitudes near to the magnetic equator) and connecting this area to the outer part of the magnetosphere, which is controlled by the solar wind. Therefore, it would be interesting to see the ionospheric variability (in particular, the Total Electron Content (TEC)) at both latitudes.

This work focuses on the latitudinal effect on the variations of TEC. Our area of interest is at a low latitude station at Libreville, Gabon (9.6721°E, 0.3539°N), and at a high latitude station at Ny-Alesund, Norway (11.8653°E, 78.9296°N).

II. DATA AND METHODOLOGY

Data from the International GNSS Service (IGS) network is utilized in this work, where data from two stations, Libreville, Gabon (IGS ID: nklg) and Ny-Alesund, Norway (nya1) are analysed. Each station represents low- and high-latitude region, respectively. The TEC is calculated by using the raw data obtained from both stations. The IGS network collects the raw data from the tracking stations and format them using a common standard data format, called Receiver Independent Exchange (RINEX). Then, the slant TEC (STEC) is calculated from the raw data. This is followed by the computing the vertical TEC (VTEC).

The conversion from STEC to VTEC can be achieved by assuming a thin-shell model and a horizontally uniform ionosphere [1]:

$$VTEC = STEC\cos(\chi) \qquad (1)$$

where $\cos(\chi)$ is the mapping function:

$$\cos(\chi) = \sqrt{1-\left(\frac{R_E}{R_E+h_{pp}}\cos(E)\right)^2} \qquad (2)$$

where χ is the satellite zenith angle at the sub-ionospheric pierce point, R_E is the radius of the earth, E is the satellite elevation angle, h_{pp} is the height of the sub-ionospheric point.

The calculated TEC has been corrected of the satellites and receiver biases, known as Differential Code Bias (DCB). If ignored, these biases may cause errors up to 9 TECU for satellite biases and more than 30 TECU for receiver biases [2]. These biases are then added to the TEC calculation to compensate for the delay between the satellite and the receiver.

In this preliminary work, data from both stations for February 2008 and July 2008 are analysed. This is during the minimum state of solar activity, where the daily sunspot number (SSN) in both months is below 10. Some data are unavailable in February 2008 for Libreville tracking station.

III. RESULTS AND ANALYSIS

Fig. 1 shows the hourly mean TEC for Libreville for both February 2008 and July 2008. It can be seen that the hourly TEC is higher in February than in July. The average difference between these two months is 5.908 TECU.

The hourly mean TEC for Ny-Alesund for both February and July 2008 is shown in Fig. 2. In comparison with Libreville station, the average difference between these months is only 0.835 TECU. Table I lists the minimum, maximum and average of these differences. While it is clear for Libreville that the hourly TEC is higher in February than in July, it is only few occurrences for Nya-Alesund where the TEC in February is higher than in July. In addition, the differences between the two months are small. It is expected for high latitude station during winter months to observe lower mean vertical TEC than summer and equinox months due to longer daytime. This was also found by Ref. [3] when observing the TEC changes at high latitude station at Resolute Bay (74.7° N, 265.1° E) between September 2008 and August 2009.

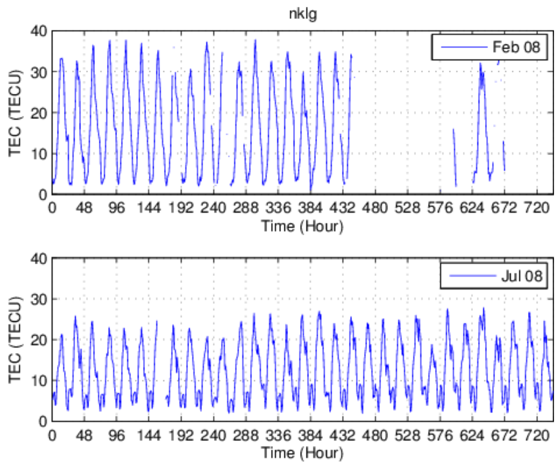

Fig. 1. Hourly mean VTEC for Libreville in (a) February 2008, and (b) July 2008.

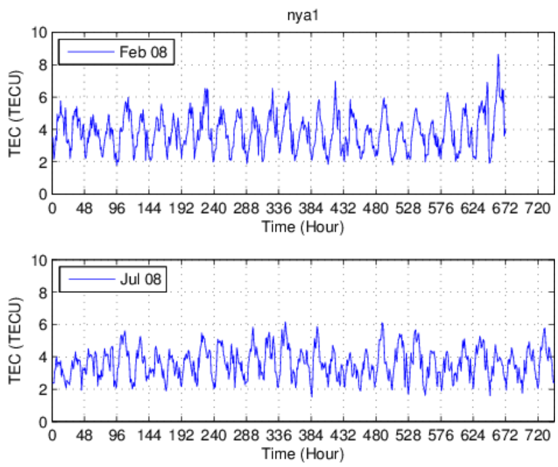

Fig. 2. Hourly mean VTEC for Ny-Alesund in (a) February 2008, and (b) July 2008.

TABLE I
DIFFERENCES OF TEC BETWEEN LIBREVILLE AND NYA-ALESUND

Station	TEC (TECU)		
	Min	Max	Average
Libreville	0.002	21.233	5.908
Nya-Alesund	0.001	4.847	0.835

The diurnal variations are also evident in Fig. 3 where the TEC is maximum during local noon (both stations are 1 hour ahead of UT). This is more pronounced for Libreville than in Nya-Alesund, where for the latter the TEC is low but still shows diurnal variations.

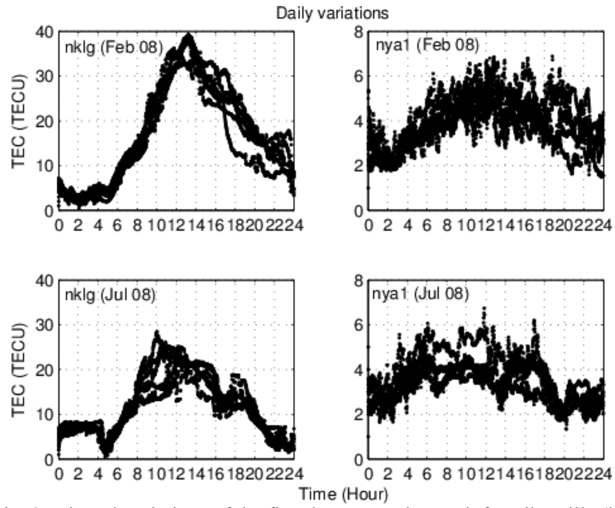

Fig. 3. Diurnal variations of the five days on each month for Libreville (left), and Nya-Alesund (right)

IV. CONCLUDING REMARKS

This preliminary work highlights the TEC variations during minimum solar activity at low and high latitude stations. It is found that hourly TEC is higher at low latitude station than at high latitude station. TEC is also higher in February 2008 than in July 2008 with the average difference of 5.908 TECU. However the difference between these months is less pronounced for Nya-Alesund with only 0.835 TECU difference. In addition, the diurnal variations of TEC are evident for both stations, especially for low latitude station. This preliminary work will be continued for longer period of observations.

ACKNOWLEDGMENT

The author acknowledges IGS for providing the GPS data on the website. This work is funded by the Ministry of Education Malaysia under FRGS/1/2013/STWN06/ UTHM/02/1.

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