INVESTIGATION OF IONOSPHERIC RESPONSE TO GEOMAGNETIC STORMS OVER A LOW LATITUDE STATION, ILE-IFE, NIGERIA.

Prof. Emmanuel Ariyibi
Earth and Space Physics Research Lab.
Department of Physics and Engineering Physics
Obafemi Awolowo University(OAU)
Ile – Ife
eariyibi@oauife.edu.ng , ariyibi32@gmail.com
+234(0)7014999210, (0)8051391004

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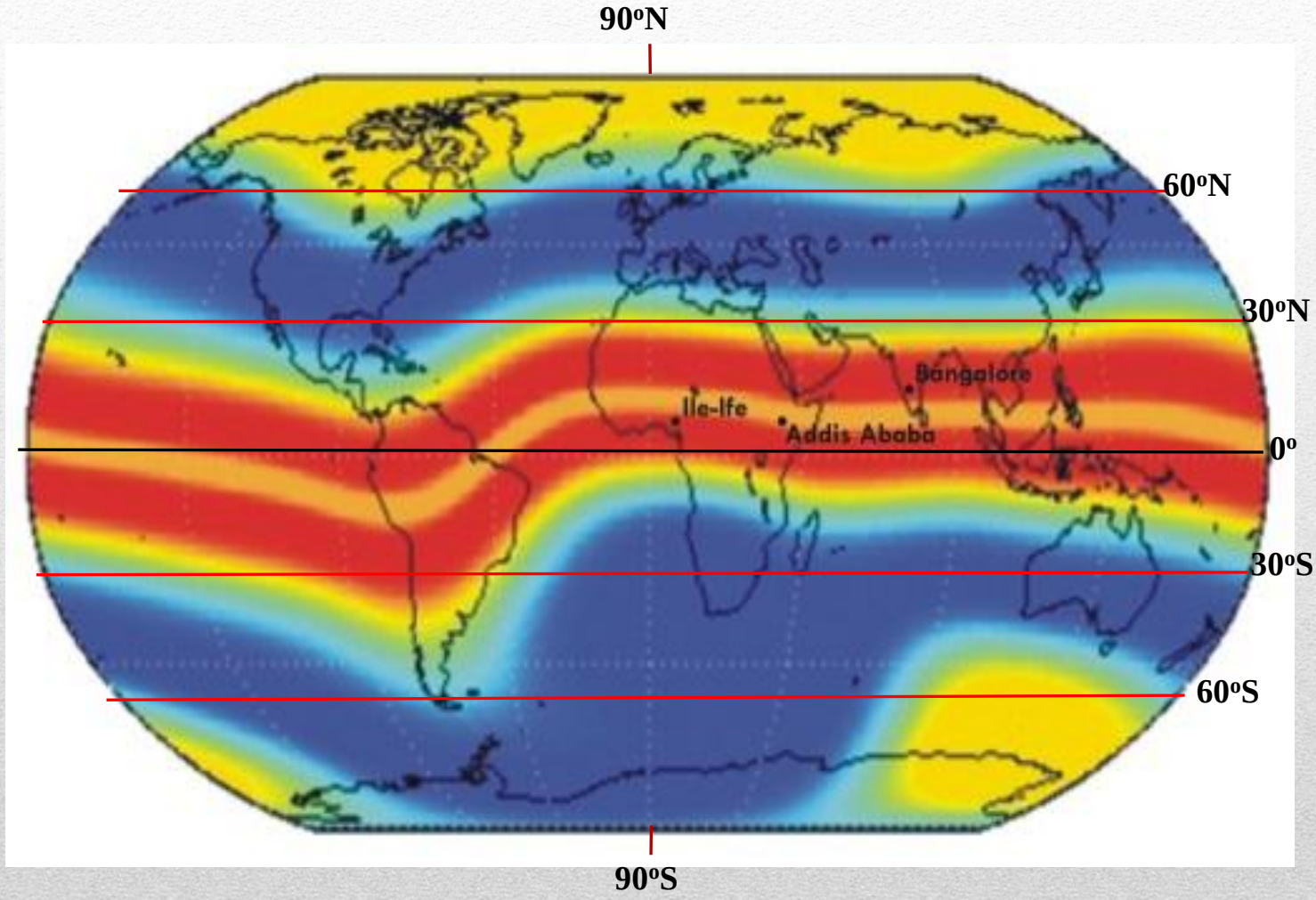
Introduction

It has become very important to investigate the ionospheric dynamics and disturbances during geomagnetic storms. This is majorly due to the significant role which the ionosphere plays in the transmission of radio signals from space borne satellites to ground based receivers. The ionosphere induces a time delay in transionospheric radio signals (Davies, 1990). The changes in the ionosphere that follow the geomagnetic storms could result in severe scintillations that disrupt radio communications and/ or cause large changes ionization that can over/ under estimate the ionospheric corrections required in some applications (Chandra and Rastogi, 2011). The primary causes of geomagnetic storms on the Earth are strong interplanetary electric fields associated with the passage of southward directed magnetic fields (Bz) past the Earth for a sufficiently long interval of time (Gonzalez et.al, 2002)

There are several studies on responses of low latitude ionosphere to magnetic storms events (Sobral et al., 1997; Sastri et al., 2000; Pincheira et al., 2002; Abdu 2001; Lobzin & Pavlov 2002a, 2002b; Pavlov, Fukao & Kawamura 2004; Lynn et al., 2004 and Lima et al., 2004; Dashora et al., 2009; de Siqueira et al., 2011; D'ujanga et al., 2013). A number of studies by Nigerian researchers have also been conducted on low latitudinal ionosphere responses during magnetic storm periods that have contributed to our understanding on this subject (Adeniyi, 1986; Olawepo & Adeniyi, 2012; Olawepo, 2013; Ariyibi et al., 2013a, Olatunbosun et al. (2022)

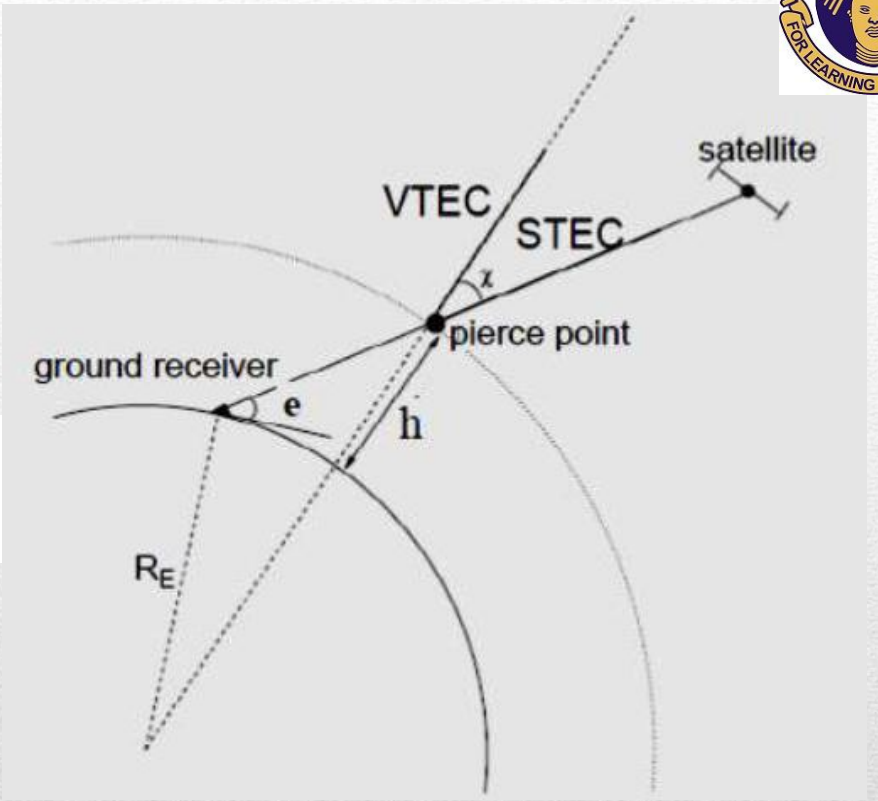

90ºN
60ºN
30ºN
Bangalore
Ile-Ife
Addis Ababa
0º
30ºS
60ºS
90ºS

Theoretical Basis

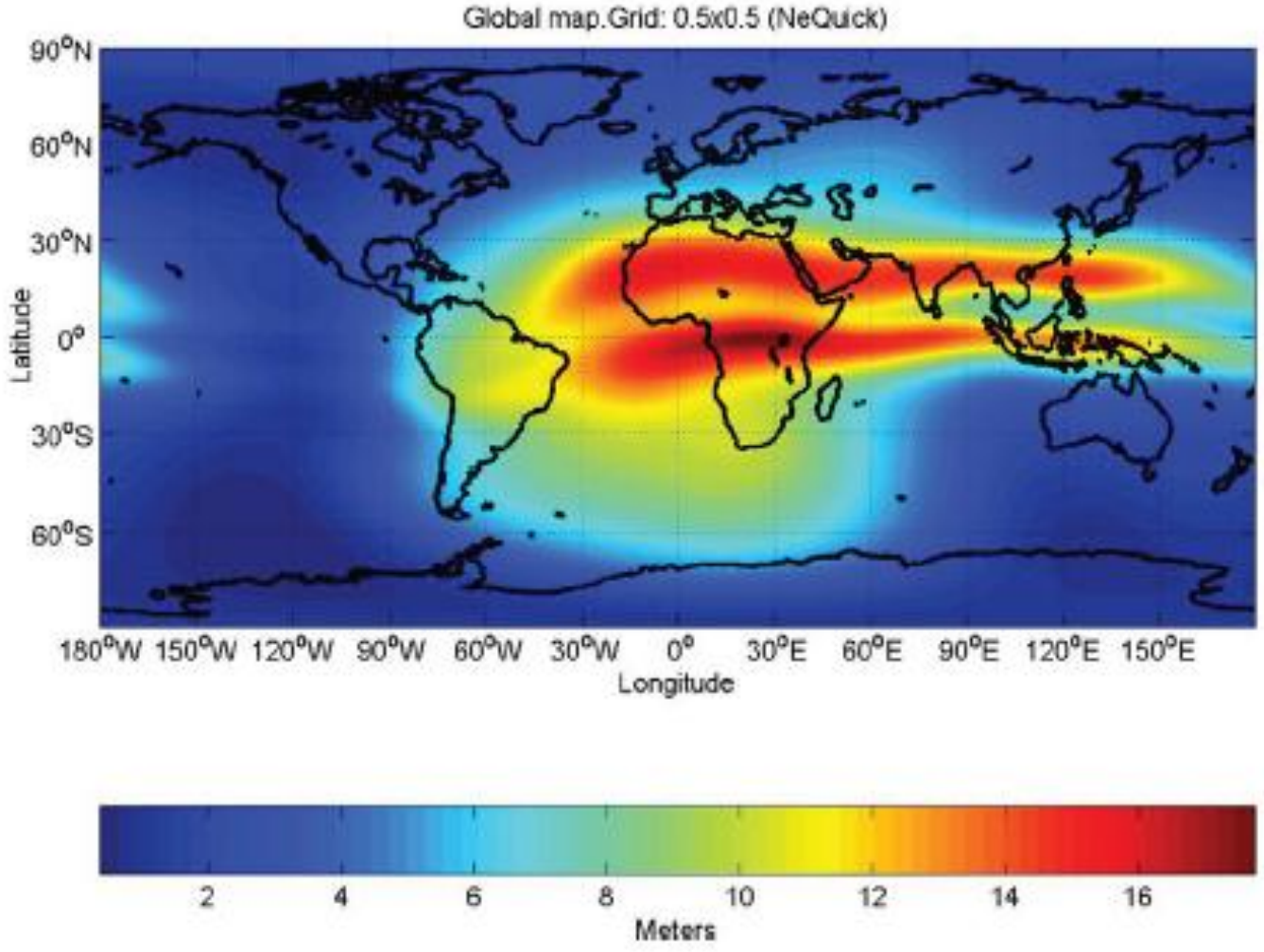
$$\mathrm{STEC} = \int_{\text{receiver}}^{\text{satellite}} N\,ds$$

$$(\mathrm{VTEC}) = \mathrm{STEC} \times \mathrm{Cos}\left[\arcsin\left(\frac{R_e \cos z}{R_e + h_{max}}\right)\right]$$

$$S_4 = \frac{\sqrt{\langle I^2 \rangle - \langle I \rangle^2}}{\langle I \rangle}$$



The NovAtel GSV 4004B GPS SCINDA receiver which is specifically configured to measure amplitude and phase scintillations from the L1 frequency GPS signal, and the ionospheric TEC from the L1 and L2 frequency GPS signals was used in this experiment. It recorded the TEC and S4 index at Ile-Ife, Nigeria



A simulation of disturbed ionosphere around noon time GMT, showing ionosphere scintillation due to incoming solar energy;. Credit ESA

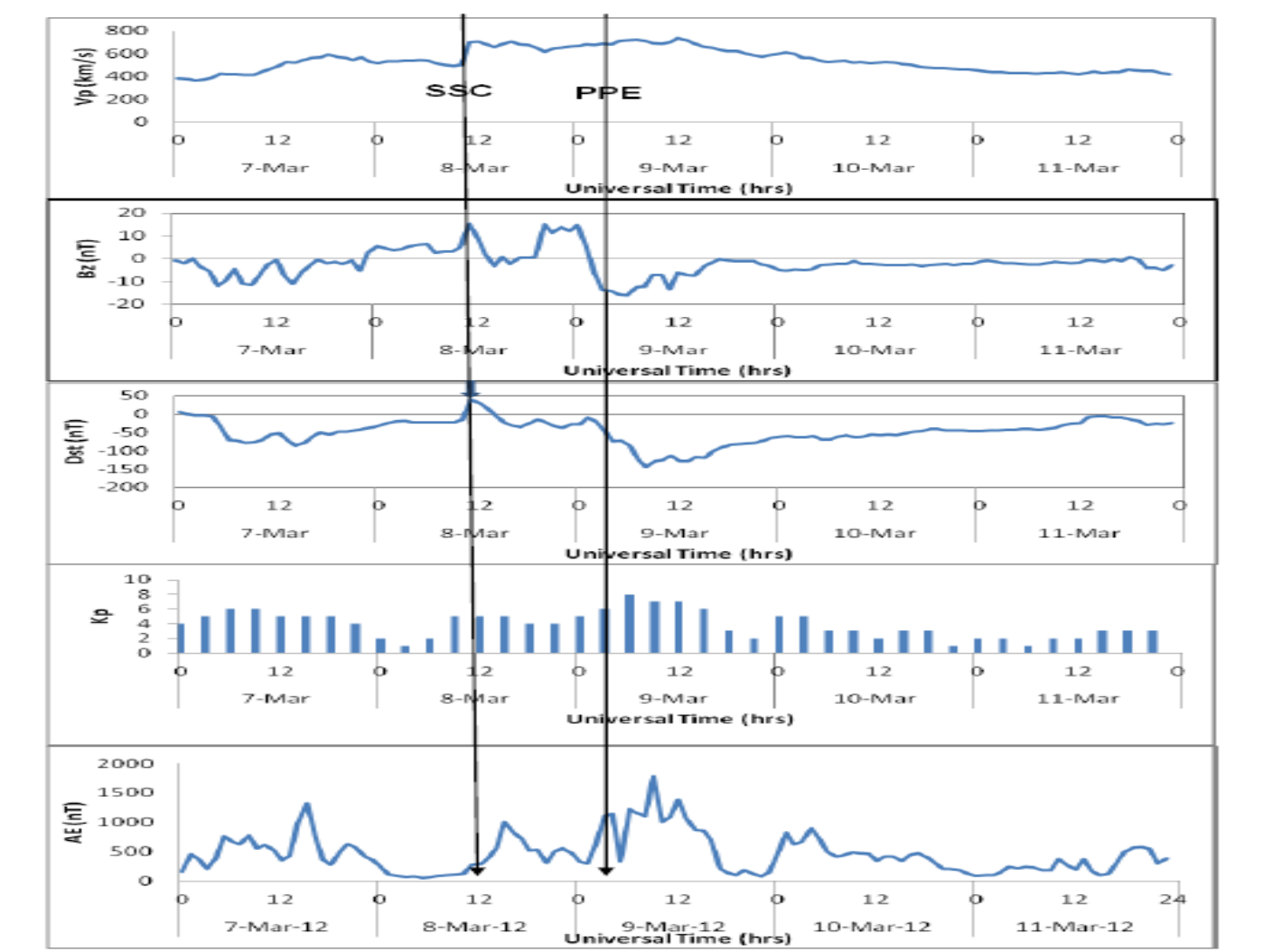
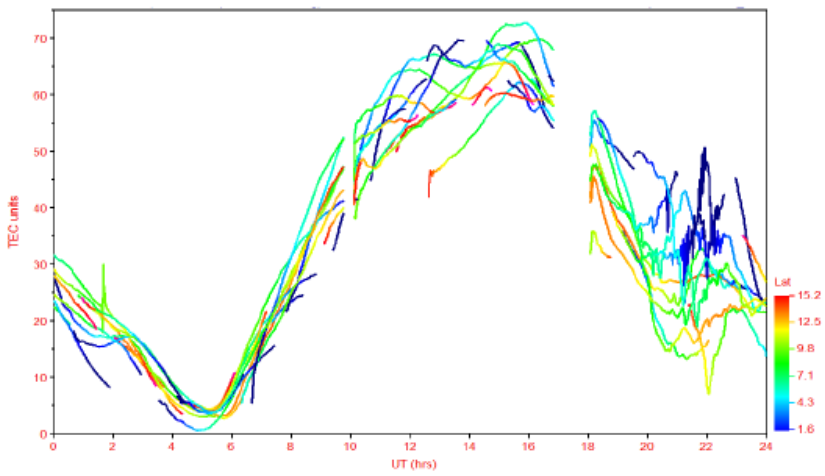


Figure1: Shows the interplanetary geomagnetic Condition for the Period 7-11 March, 2012

a



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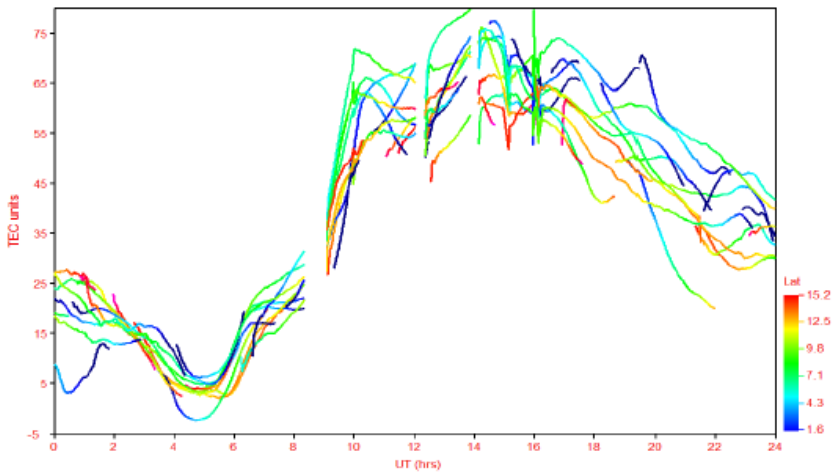


c

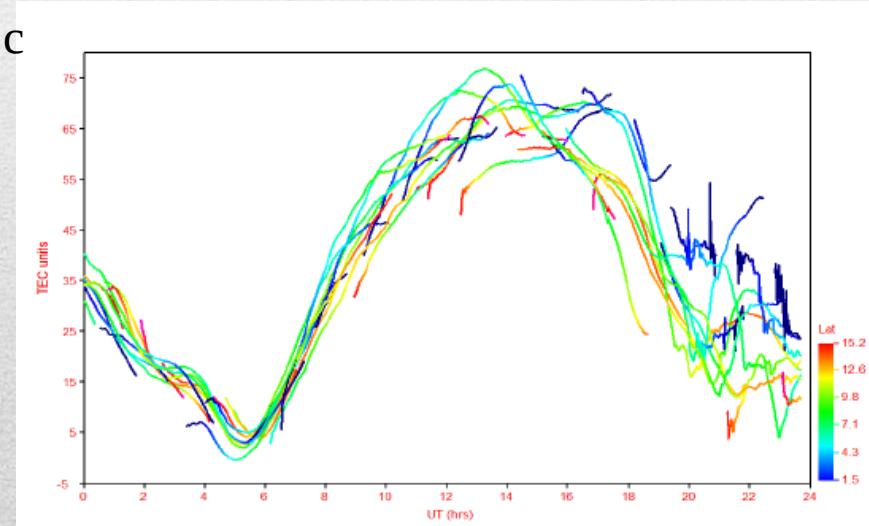


Figure 2 a, 2b, and 2c Showthe VTEC plots for available PRNs on 8,9, and10 March,2012 respectively

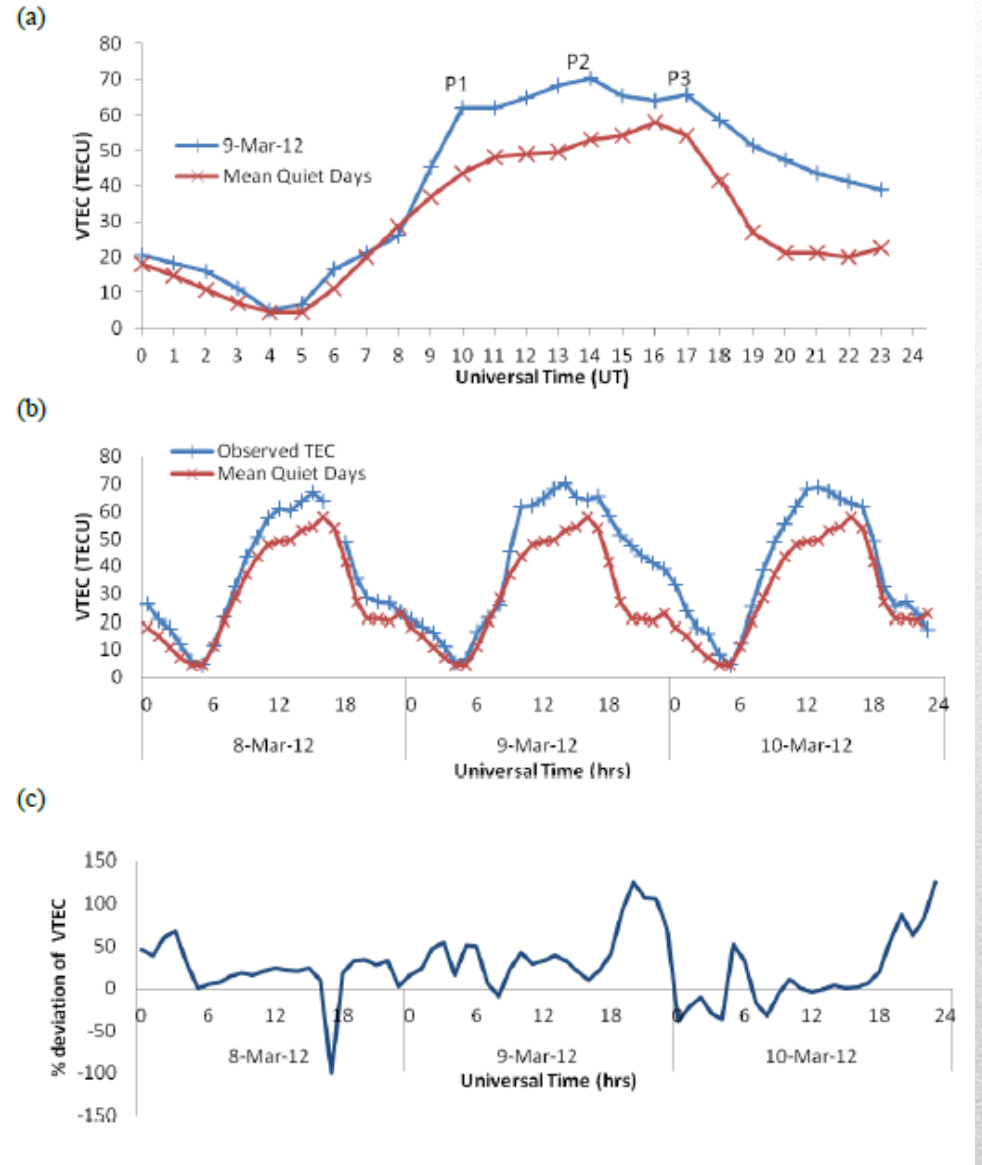


Figure 3: VTEC observation from Ile –Ife :

a)Mean VTEC for 9 March, 2012 (blue cross) compared with the Average of Quiet Days VTEC (red stars)

b) Mean VTEC for 8 - 10 March, 2012 (blue cross) compared with the Average of Quiet Days VTEC(red stars)

C) Hourly deviation of VTEC before and after the storm in %

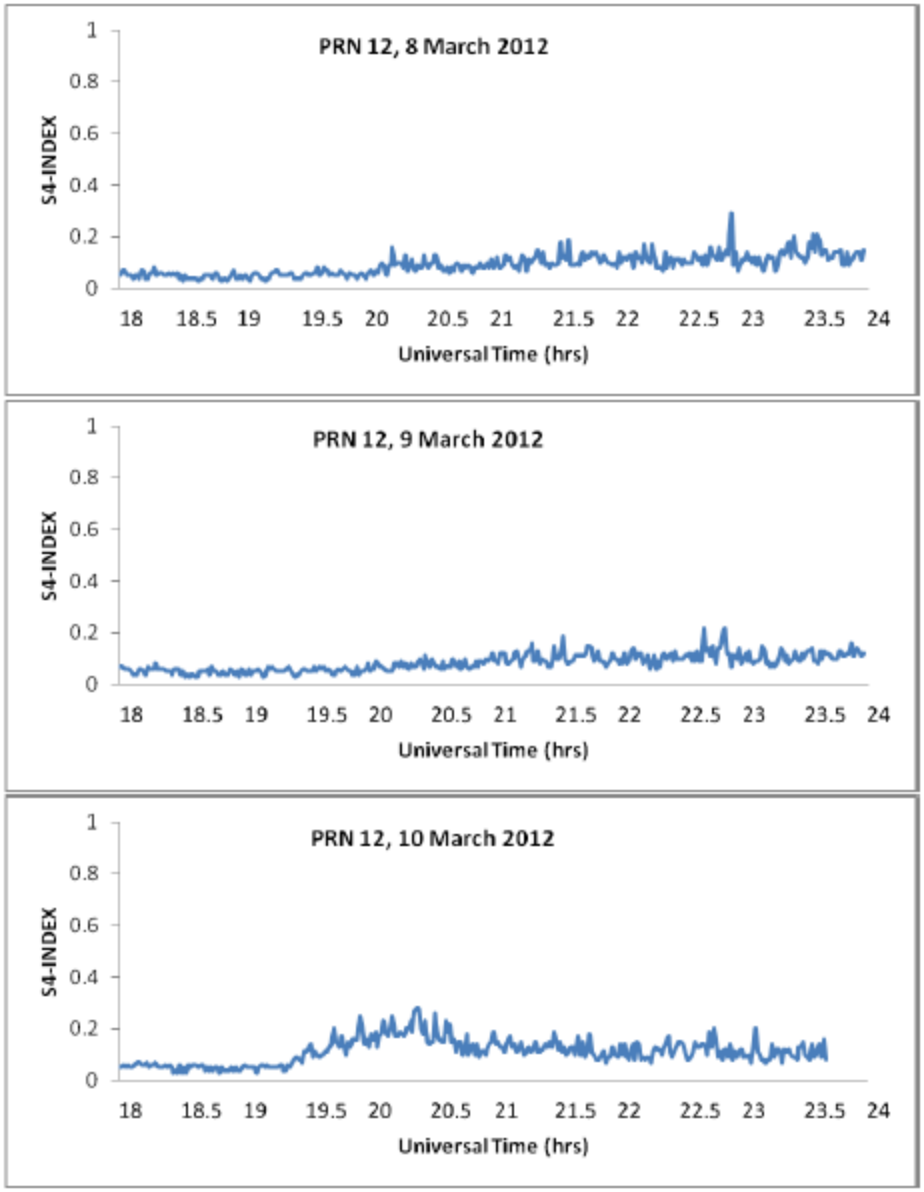


Figure 4 : The Variation of s4 index from 8 -10, March 2012 for PRN 12

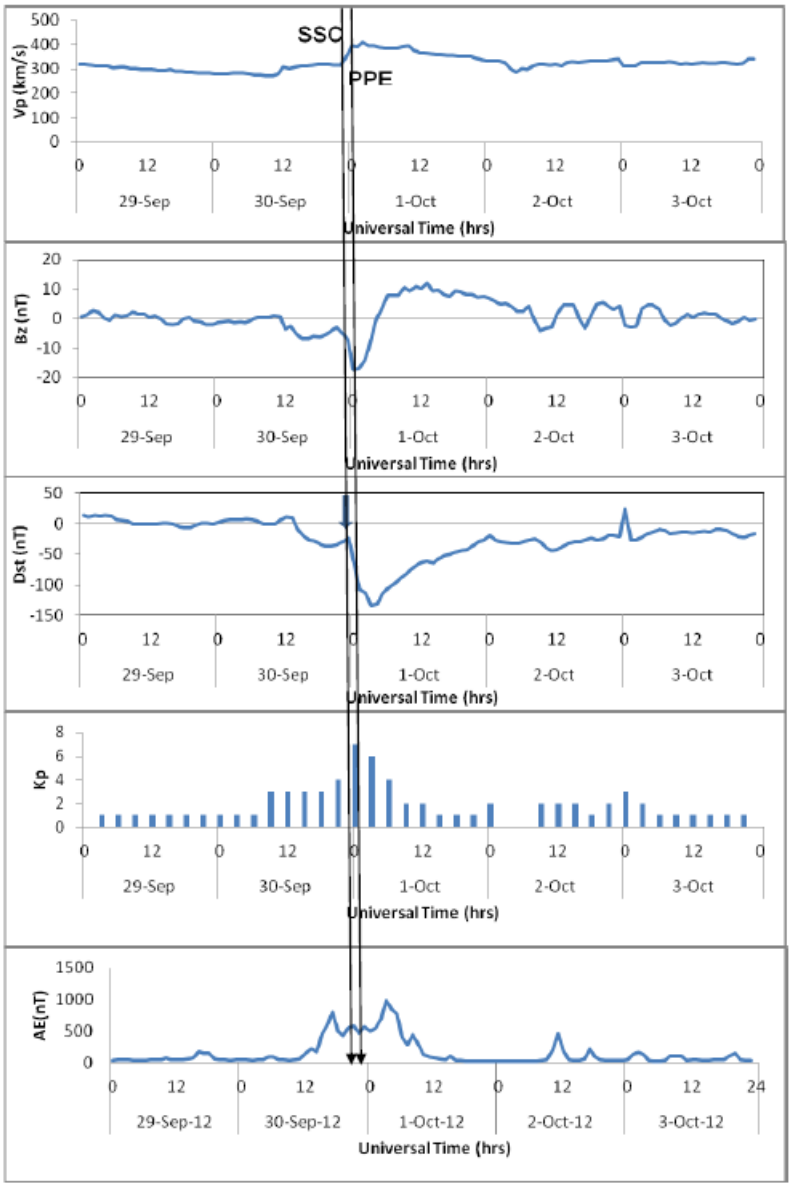
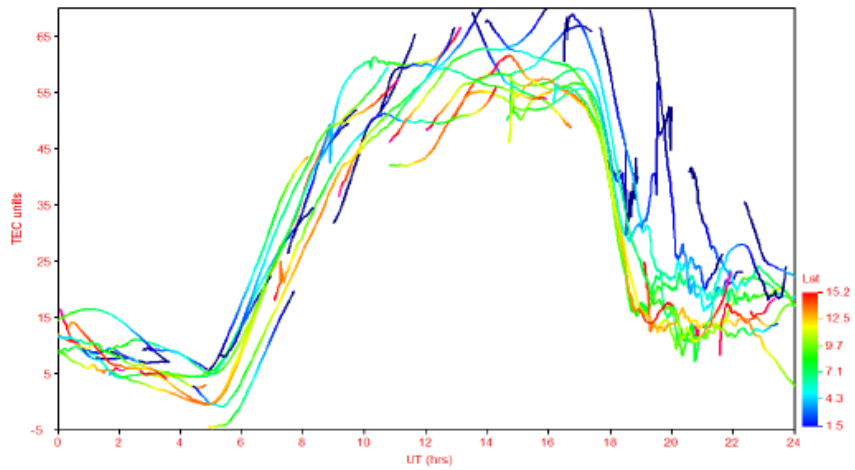


Figure 5 : Interplanetary and geomagnetic Observations for 29Sept. – 3 Oct., 2012. The Arrow on Dst is indicating the SSC

a



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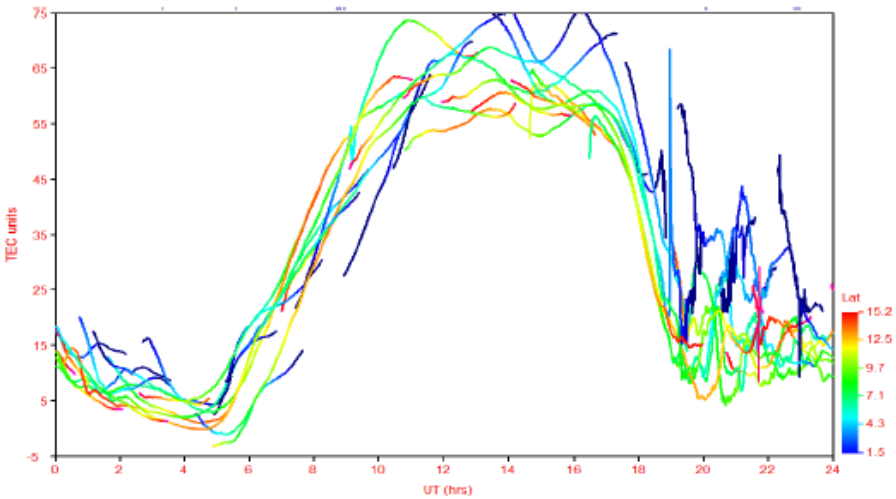

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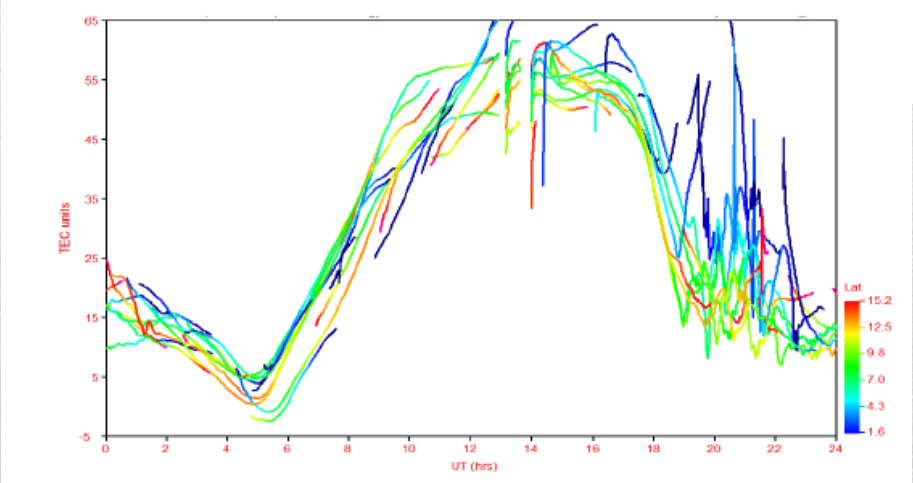

Figure 6 a, 6b, and 6c Show the VTEC plots for available PRNs on 30 Sept., ,1 Oct., and 2 Oct. 2012 respectively

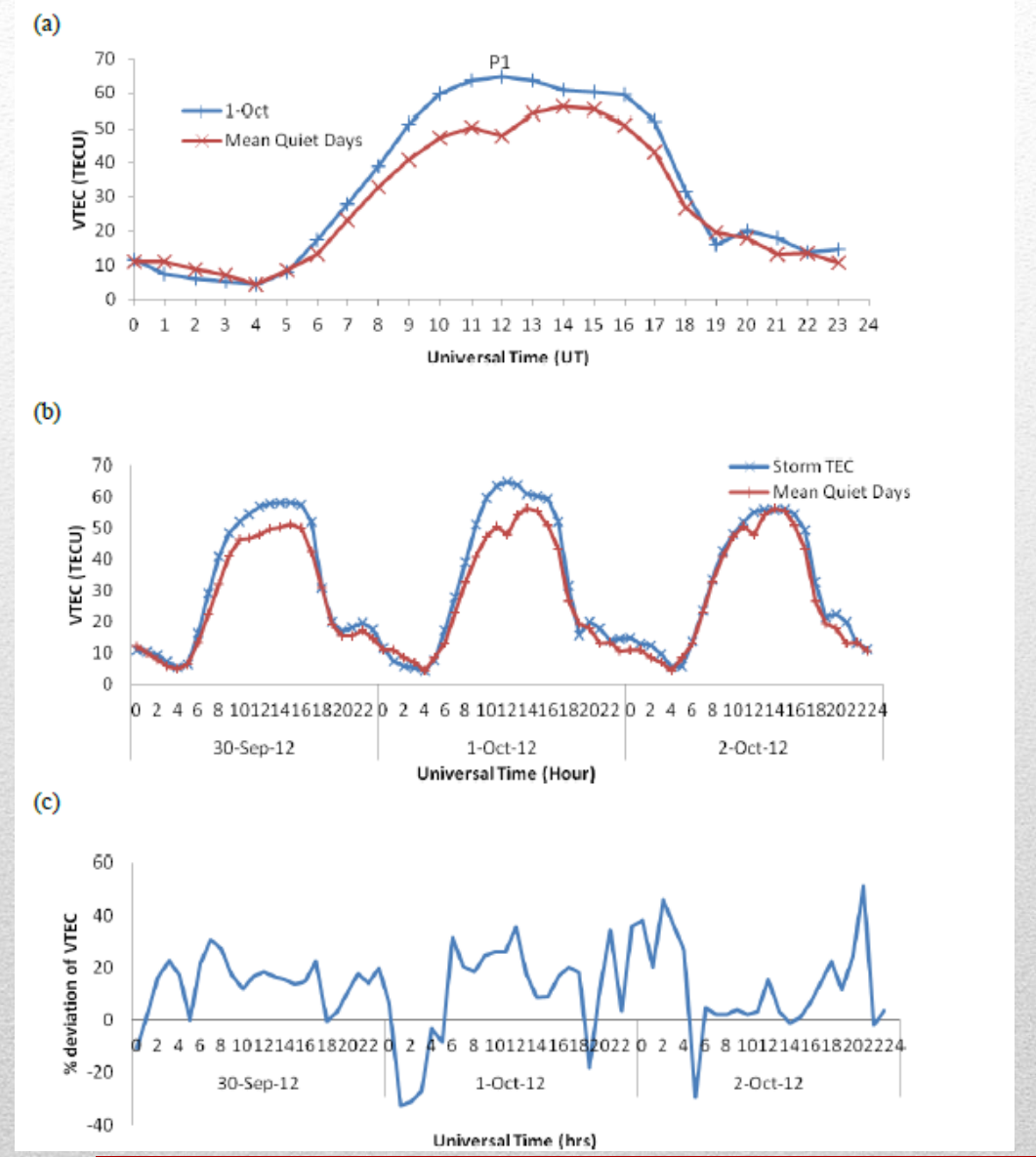

Figure 7: VTEC observation from Ile –Ife :

a)Mean VTEC for 1 Oct., 2012 (blue cross) compared with the Average of Quiet Days VTEC (red stars)

b) Mean VTEC for 30Sept., 2012 (blue cross) compared with the Average of Quiet Days VTEC(red stars)

C) Hourly deviation of VTEC before and after the storm in %

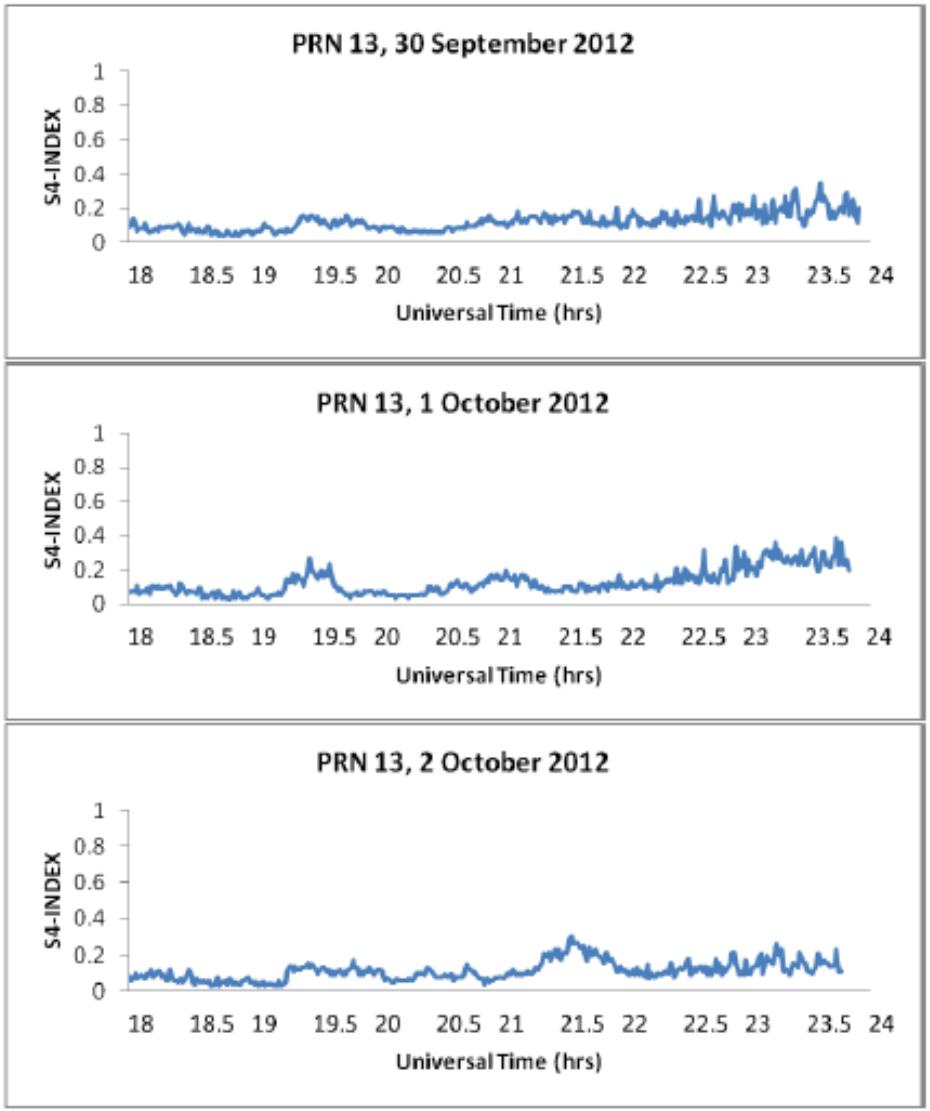

Figure 8 : The Variation of s4 index for 30 Sept., 1 Oct., and 2 Oct., 2012 for PRN 13

Conclusion

The magnitude, duration and orientation of the IMF-Bz played an important role in the dynamics and electrodynamics associated with these geomagnetic storms

The storm of 9 March 2012 might not have significantly impacted S4, that of 1 October 2012 may have had impact on the scintillation activity on this day

The change of ionospheric range delay, which is directly proportional to change of TEC during geomagnetic storms, is a potential limitation in precise positioning using radio waves from GPS, hence studies like these are important for Satellite Based Navigation System, especially at Low-Latitude stations

The regional TEC model for better understanding and prediction over the equatorial and low latitudes of the African region.

Previous work from our Lab

PhD Thesis supervision

i) Owolabi T.P. (2018) A study of ionospheric conditions during intense and super geomagnetic storm events at low – and mid-latitude regions. Reg. No. SCP 13/14/R/0195 (Now in Canada)

ii) Olatunbosun, L . G. (2016). A Study of Ionospheric Conditions During Intense Geomagnetic Storms at Low – Latitude Stations. Reg.No.: SCP12/13/H/0123

MSc Thesis Supervision

i) Jimoh O.E. (2014). Investigation of Ionospheric response to geomagnetic storms over a low –latitude station in Ile –Ife, Nigeria. Reg.No: SCP11/12/H/0114. (China for PhD)

ii) Akintufede E.I.(2015). The study of Total Electron content (TEC) variations during different geomagnetic activities in Ile – Ife, Nigeria. Reg. No.: SCP11/12/H/0068.

iii) Babinisi A.B. (2016). Investigation of solar radiation flux and the ionospheric response during different geomagnetic activities at low – latitude station in Ile -Ife, NigeriaReg.No.SCP12/13/H/1154.

iv) Olabode A. O.(2014). An investigation of ionospheric conditions during the main phase of geomagnetic storm events as measured from GPS observations at Ile – Ife, Nigeria. Reg.No.: SCP10/11/H/1224. (Germany for PhD)

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Thank you