International Space Weather Initiative in Africa: Benefits, implications & some new scientific results

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Outline

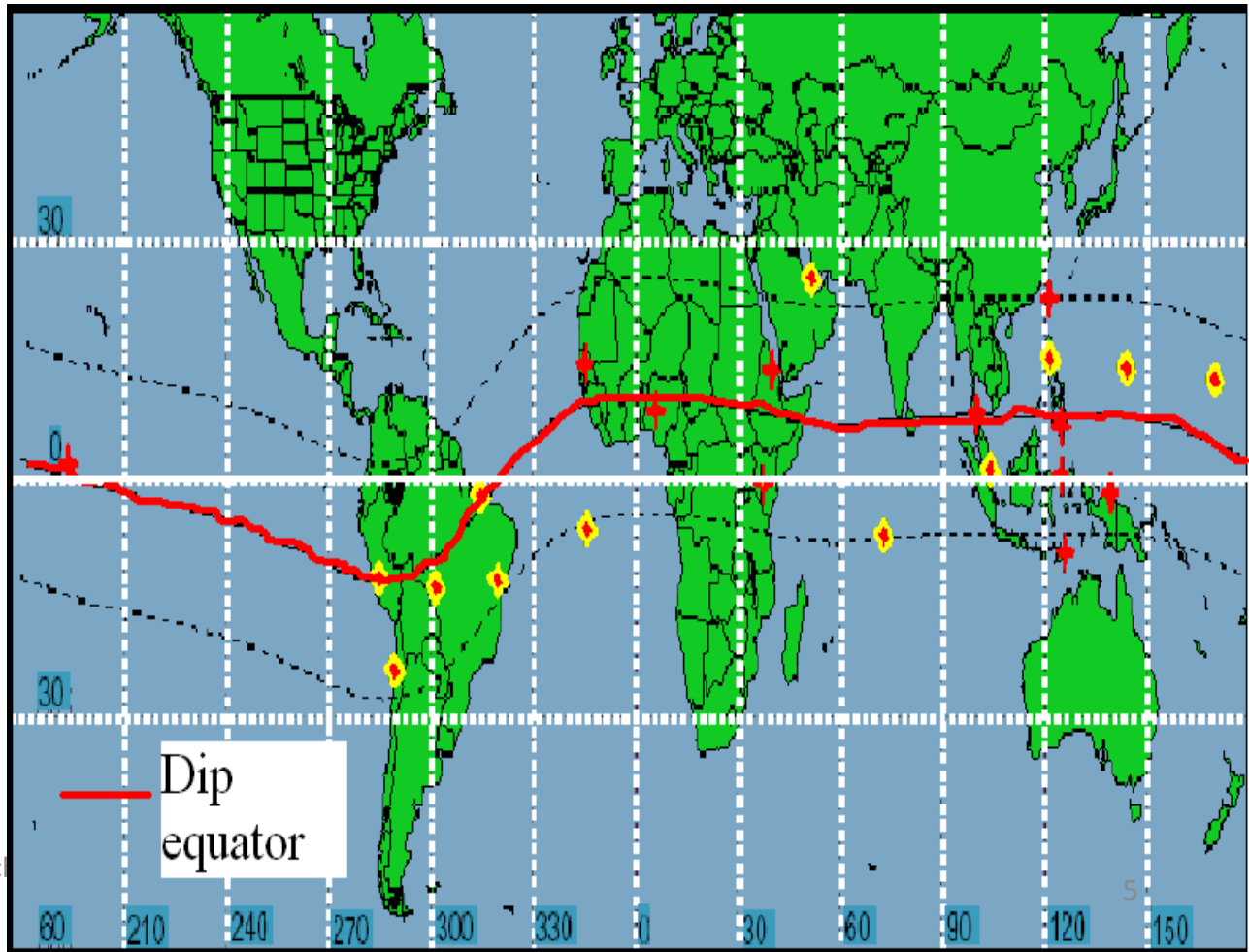
- Africa
- ISWI in Africa
- Output of ISWI
- Some Scientific Results
- Conclusions/Recommendations

Africa

- 54 sovereign nations
- 30.2 million km^2
- 1.1 billion population (2013)
- Less than 1/2 in ISWI

Uniqueness of SW over Africa

- Broad range of magnetic equator over land
- EIA width



ISWI IN AFRICA

instruments

- ✓ over 18 Magnetometers
- ✓ more than 15 GPS receivers
- ✓ More than 30 SIDs

Capacity building

- ✓ Continental training of MSc and PhD student (more than 30)
- ✓ Short term visit to ICSWSE
- ✓ Series of Space Weather schools
- ✓ ICSWSE – 2 PhD, 1 MSc

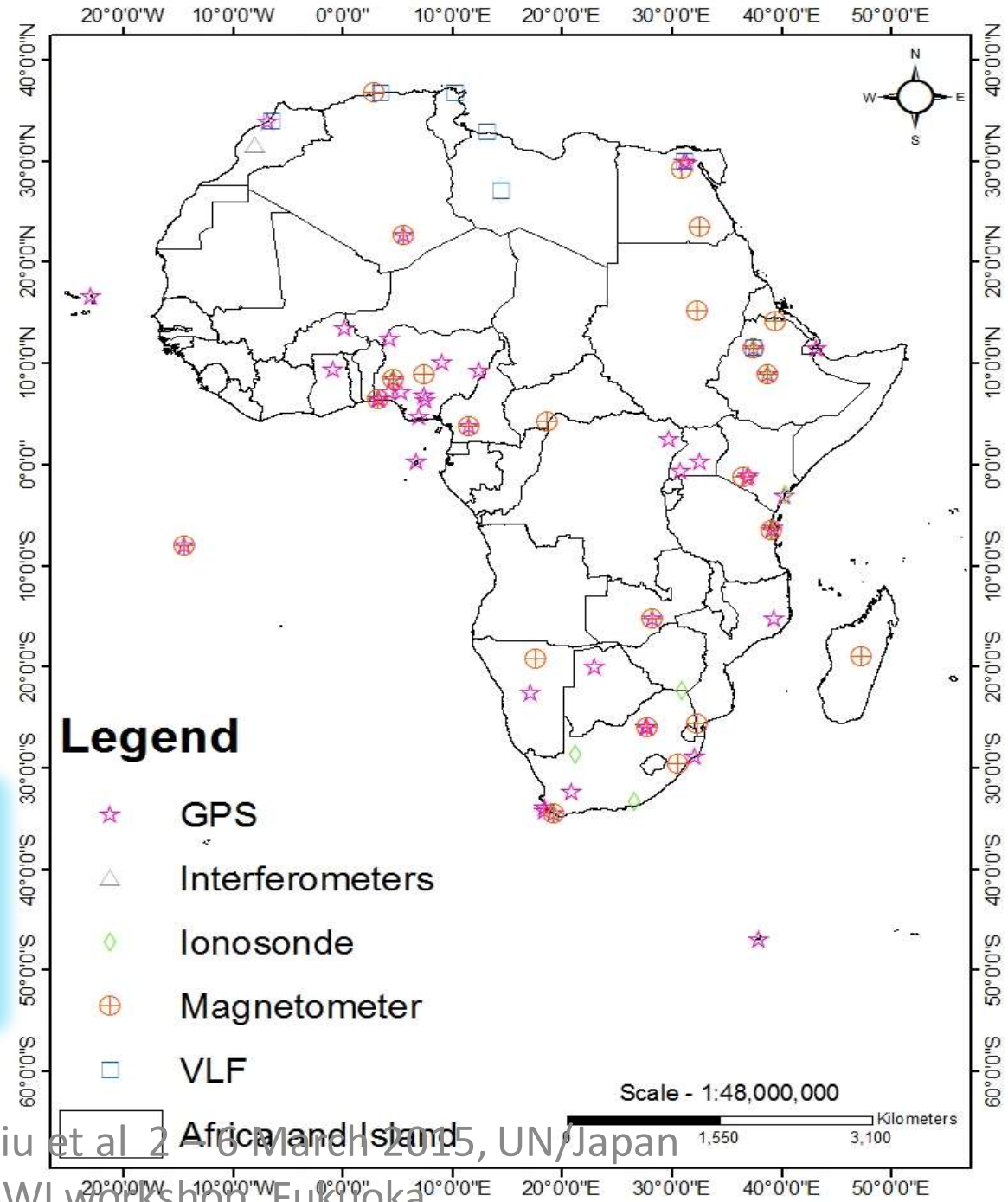
Workshops

- ✓ Egypt 2010
- ✓ Nigeria 2011

Status of Space Weather Research facilities

- ✓ ***54 sovereign nations***
- ✓ ***African Professors***
- ✓ ***Diligent students***
- ✓ ***Research facilities***

- Mostly foreign intervention
- National Participation



Workshop/Schools/Conferences

- African IHY Conference, Addis Ababa, Ethiopia 2007
- African IHY conference, Livinstone, Zambia, 2009
- IHY Regional School, Enugu, Nigeria November 2008
- ISWI School, Bahir Dar, Ethiopia2010
- MAGDAS School, Lagos, NigeriaAugust 2011
- UN/Nigeria Workshop on SW, Abuja, October2011
- UN/Egypt Workshop on SW, Helwan, Egypt 2010
- 2013 ISWI/SCOSTEP School On Space Sciences, Nairobi, Kenya 2013

Output

- M.Sc. And PhD. Degrees
- Instrument/Data Availability
- Research Publications in Journals
- Positive Catalyzation of National government participation in SW
- Inter/intra-national cooperation among scientists
- Brain drain control

AGS
African Geophysical Society

- Established Nov 2012, Addis Ababa, Ethiopia
- 1st conference June 2014, Abuja, Nigeria
- Participation from 7 African Countries, UK, India, & Japan
- **Prof. K. Yumoto - Fellow AGS, 2014**
- 2nd Conference, Nairobi 2015

African Geophysical Society

www.afgps.org

AGS is a dynamic, innovative, and interdisciplinary scientific association committed to the pursuit of understanding of Earth and Space for the benefits of mankind.

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AGS
African Geophysical Society
1st Annual Conference
of AGS 2 - 4 June 2014

Ionospheric research in Africa

- The ALCANTARA Survey provided very interesting results about ionospheric research by African scientists working in the continent
- growing number of papers published in peer-review journals

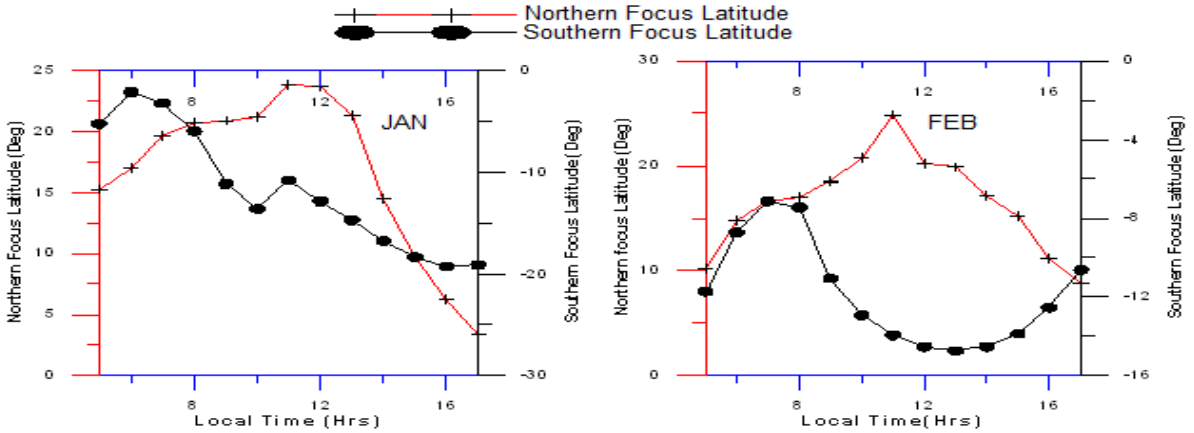
Country	Total n° of papers	1st author from the country	2008	2009	2010	2011	2012
UGANDA	2	1	0	0	0	0	2
SOUTH AFRICA	63	41	9	20	13	8	13
NIGERIA	56	45	9	8	12	9	18
KENYA	4	3	0	0	0	0	4
ETHIOPIA	6	4	0	0	2	1	3
EGYPT	16	14	1	2	4	4	5
COTE D'IVOIRE	9	6	1	2	1	2	3
BOTSWANA	1	0	0	1	0	0	0
ALGERIA	9	8	0	2	5	0	2
BURKINA-FASO	8	8	0	2	0	2	4
TOTAL	*174*	*130*	*20*	*37*	*37*	*26*	*54*

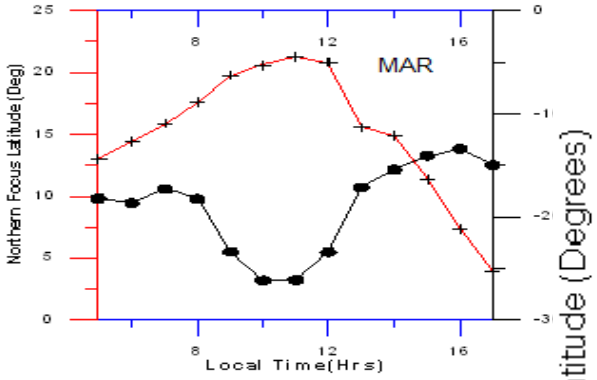
Table 14 Ionospheric research papers published by African scientists working in Africa

Radicella, et al 2014

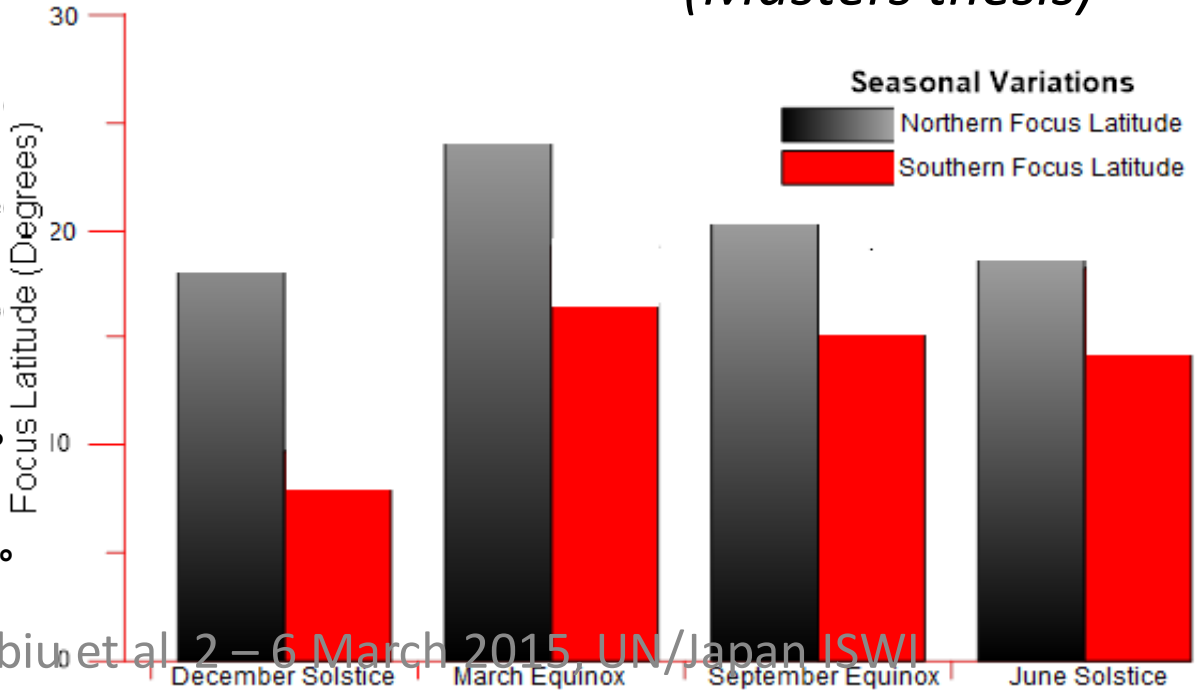
Some Results

Sq Studies



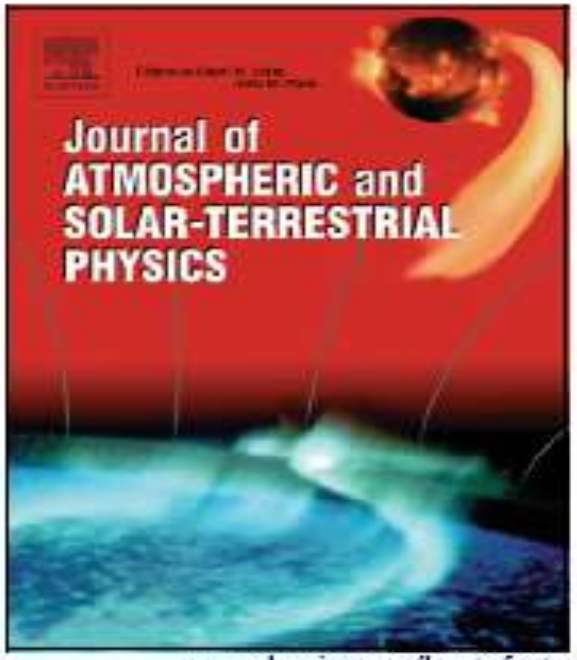


Variability of Sq Foci along Euro-African Sector in 2009 - Owolabi (2014) *(Masters thesis)*



The northern focus = 33.16 ± 2.1° larger mean
the southern focus = -15.63 ± 1.4° over the year.

Author's Accepted Manuscript



www.elsevier.com/locate/jastp

Climatology of the inter-hemispheric field-aligned currents system over the nigeria ionosphere

O.S. Bolaji, A.B. Rabiu, E.O. Oyeyemi, K. Yumoto

PII: S1364-6826(12)00184-8
DOI: http://dx.doi.org/10.1016/j.jastp.2012.07.008
Reference: ATP3656

To appear in: *Journal of Atmospheric and Solar-Terrestrial Physics*

Received date: 19 March 2012
Revised date: 23 June 2012
Accepted date: 27 July 2012

Cite this article as: O.S. Bolaji, A.B. Rabiu, E.O. Oyeyemi and K. Yumoto, Climatology of the inter-hemispheric field-aligned currents system over the nigeria ionosphere, *Journal of Atmospheric and Solar-Terrestrial Physics*, http://dx.doi.org/10.1016/j.jastp.2012.07.008

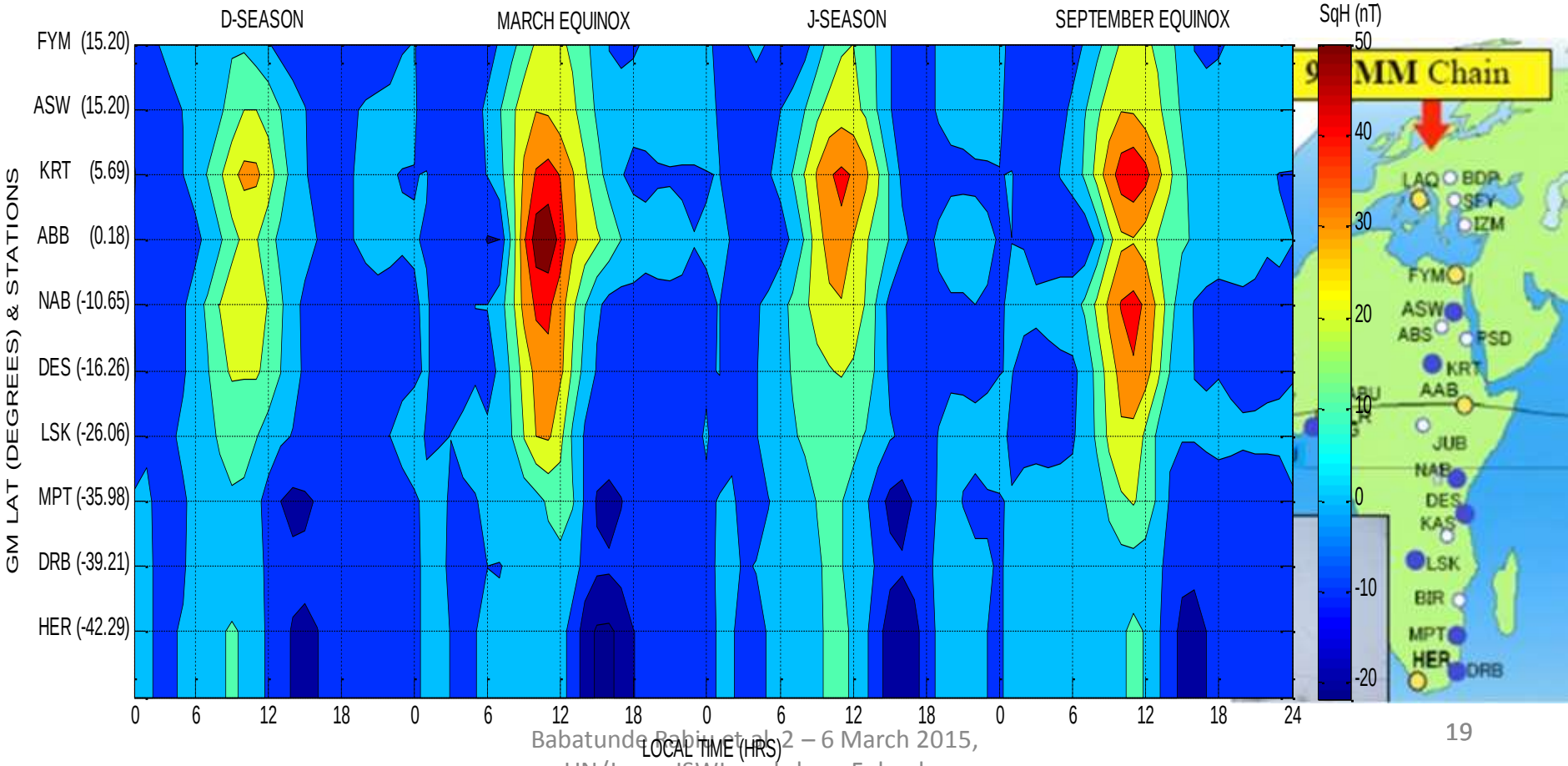
IHFACs Climatology

- The IHFACs magnetic field variation flow in opposite direction of the winter northern-hemisphere.
- Dusk-side IHFACs was confirmed & are weakly northbound in all the seasons.
- Diurnal, monthly mean and seasonal variations of IHFACs exist and exhibit downward & upward inter-hemispheric field-aligned sheet current that appears as a pair at all local times.
- IHFACs exhibit longitudinal variability

Seasonal variation of Sq(H) along the African latitudes

- Sq (H) is greater in all seasons in the neighbourhood of dip equator
- Obviously due to EEJ effect
- Max effect at Autumn (Sept) Equinox

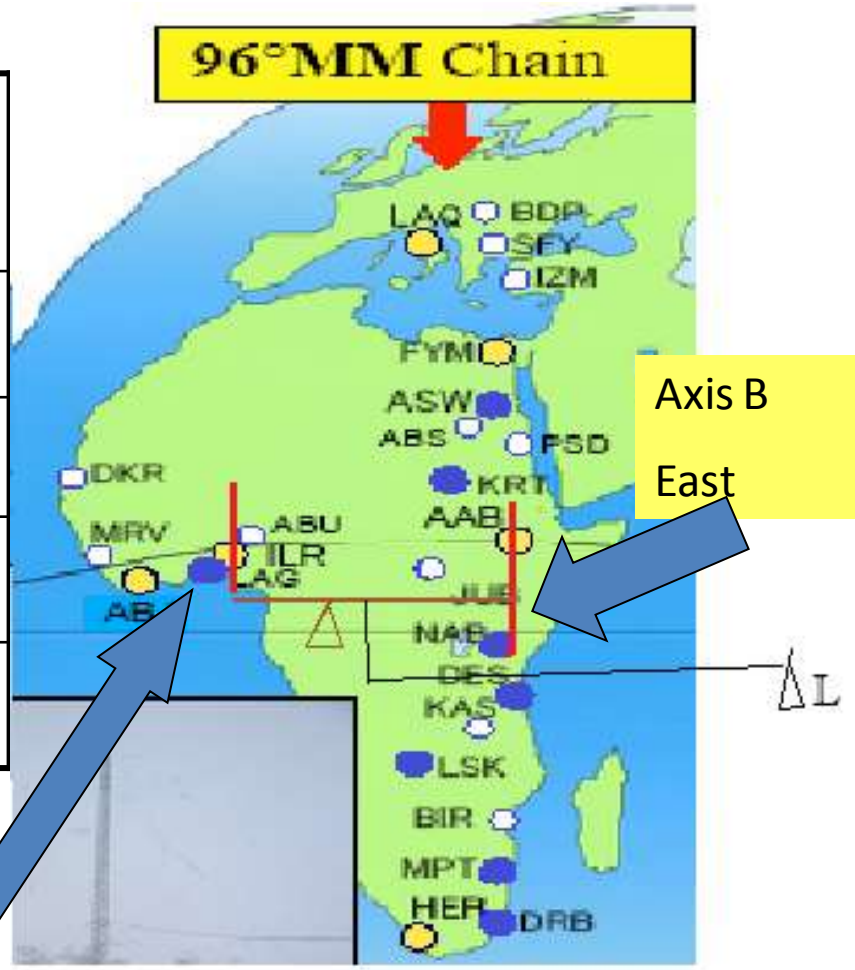
Bolaji et al 2015 ..



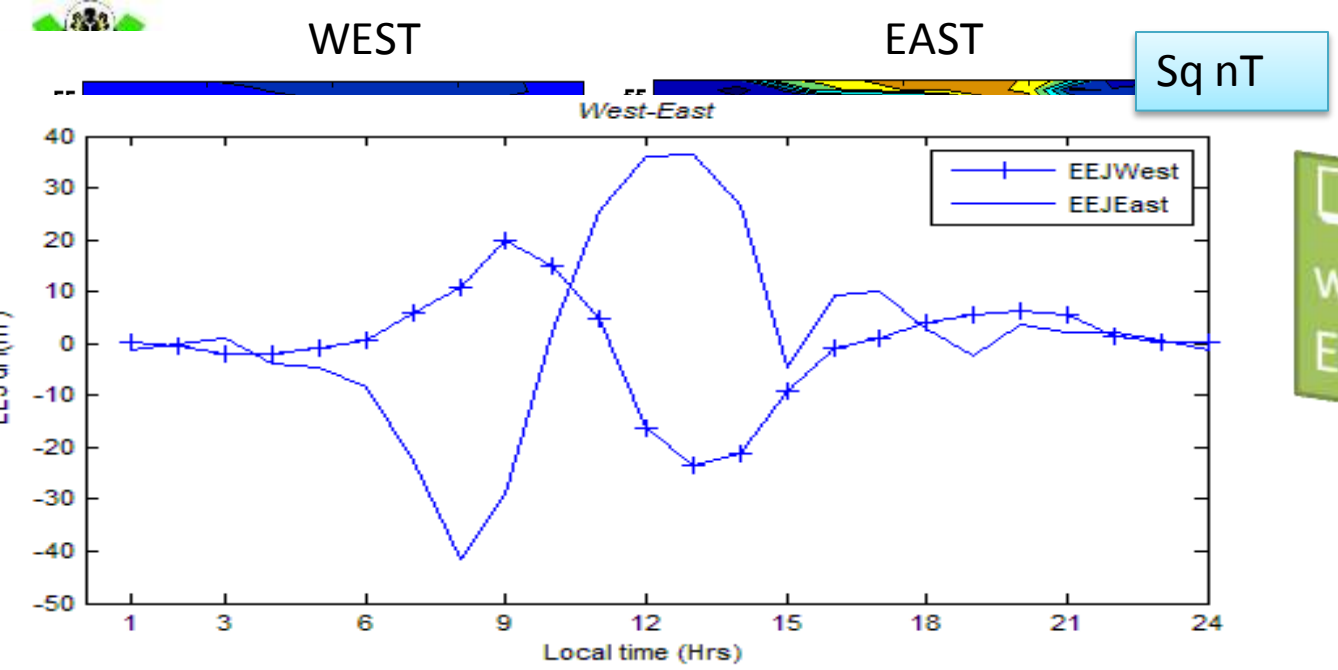
EEJ in Africa

Coordinates of the Stations

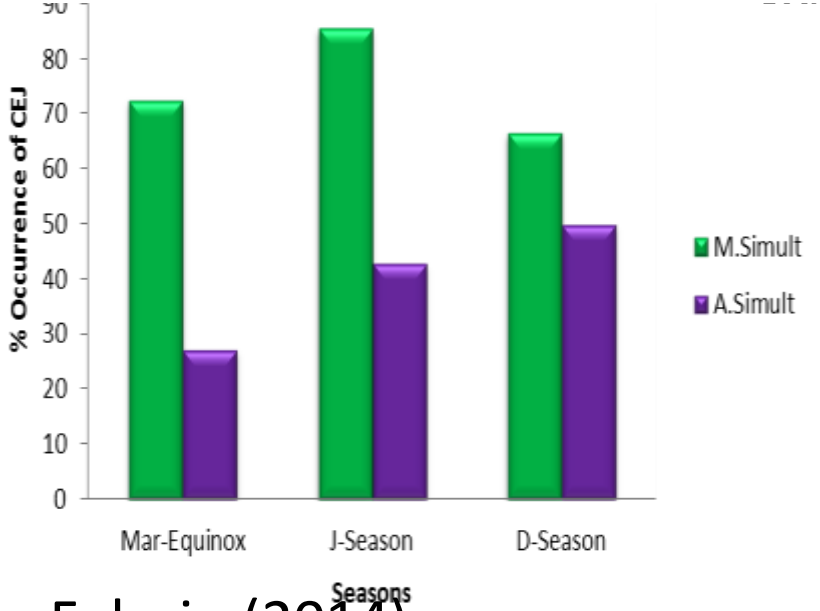
OBS	GMLat°	GLong ° E	GLat°
ILR	-1.82	4.67	8.50°N
LAG		3.43	3.42°N
AAB	0.18	38.77	9.04°N
NAB		36.80	1.16°S



Separation of axes, Δ L = 33.735° = 3744.585 km



❑ Western EEJ appears weaker than Eastern EEJ!

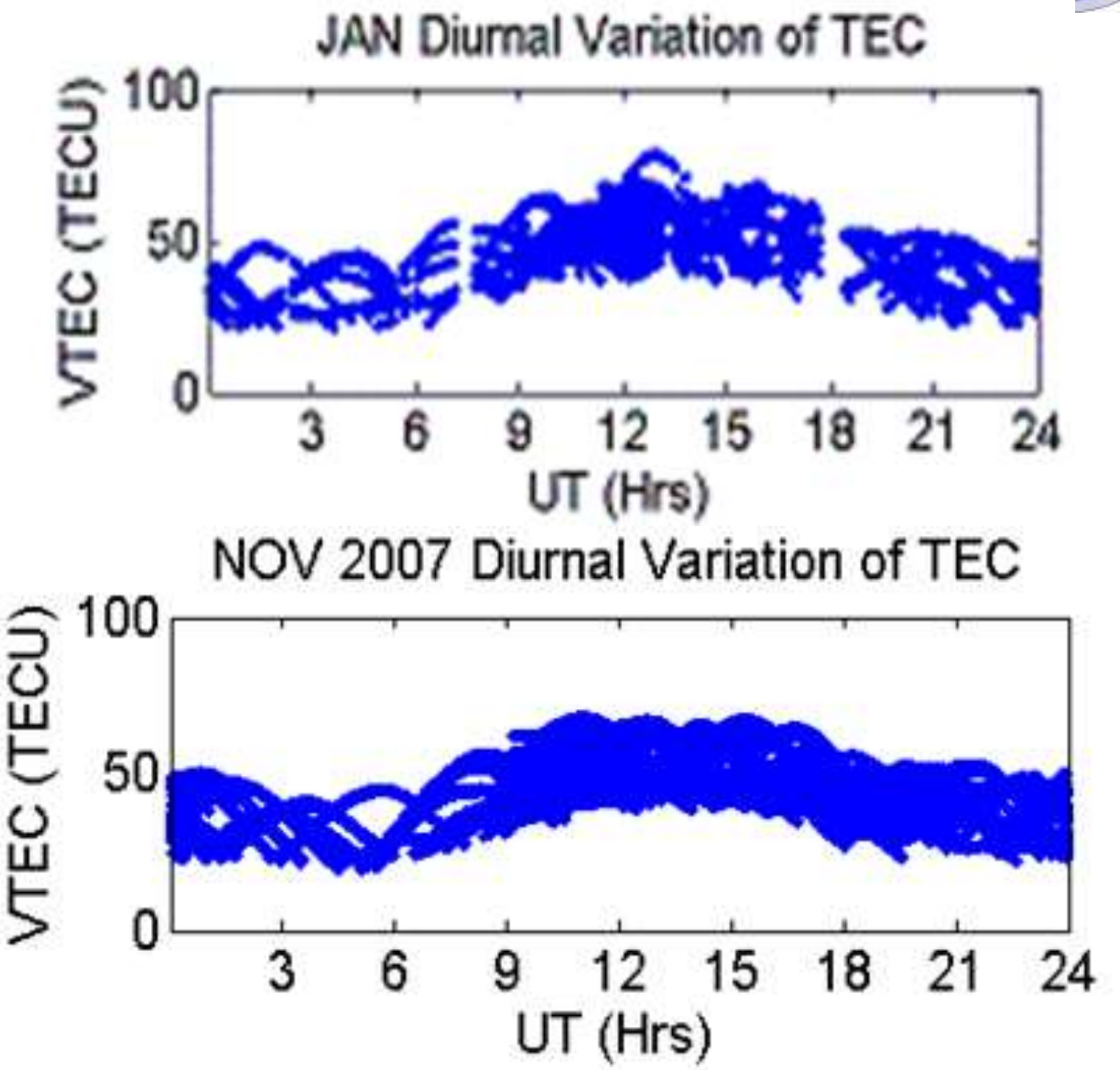


- occurrence of morning CEJ is much prevalent along the E/A longitude (90%) than the W/A (80.9%)
- evening CEJ is dominant along the W/A longitude (82.9%) than the E/A longitude (50%)

Folarin (2014) *(Masters thesis)*

TEC STUDIES

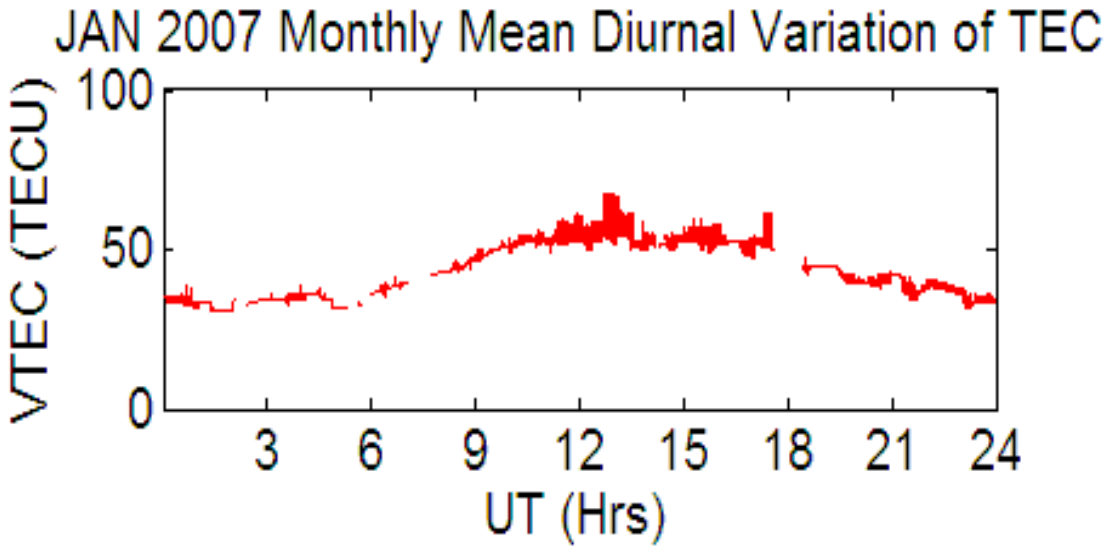
Mass plots of the Diurnal Variation of VTEC as observed from the data from all the visible PRN over Akure

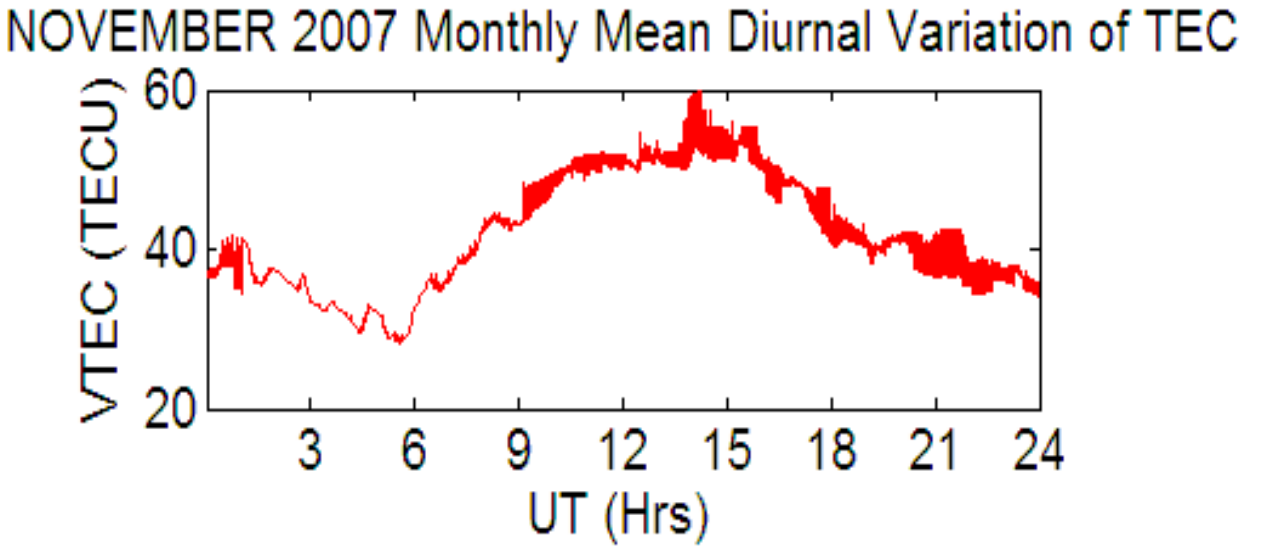


Diurnal Variation of VTEC over Akure

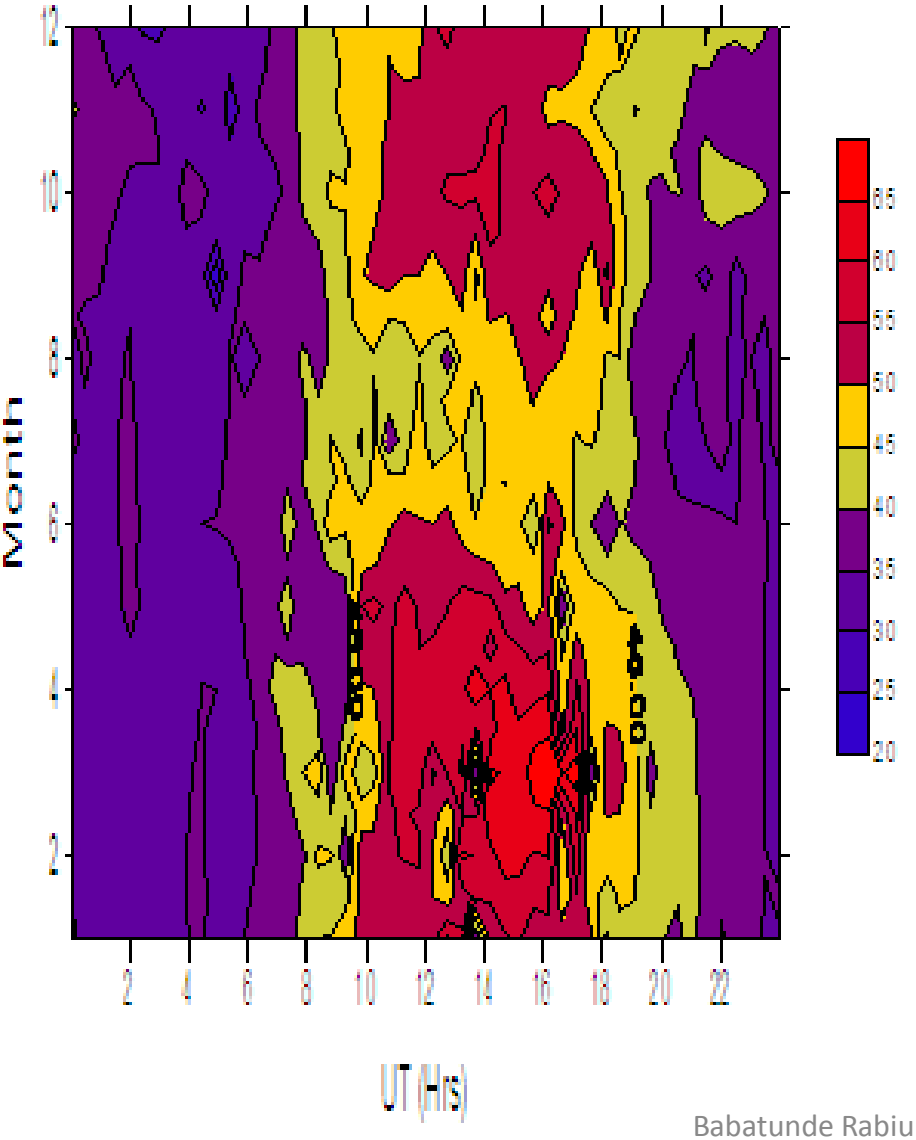
✓pre-dawn minimum for a short period of time followed by steep early morning increase.

✓TEC reaches maximum value between 1300UT (1400LT) & 1400UT (1500LT)



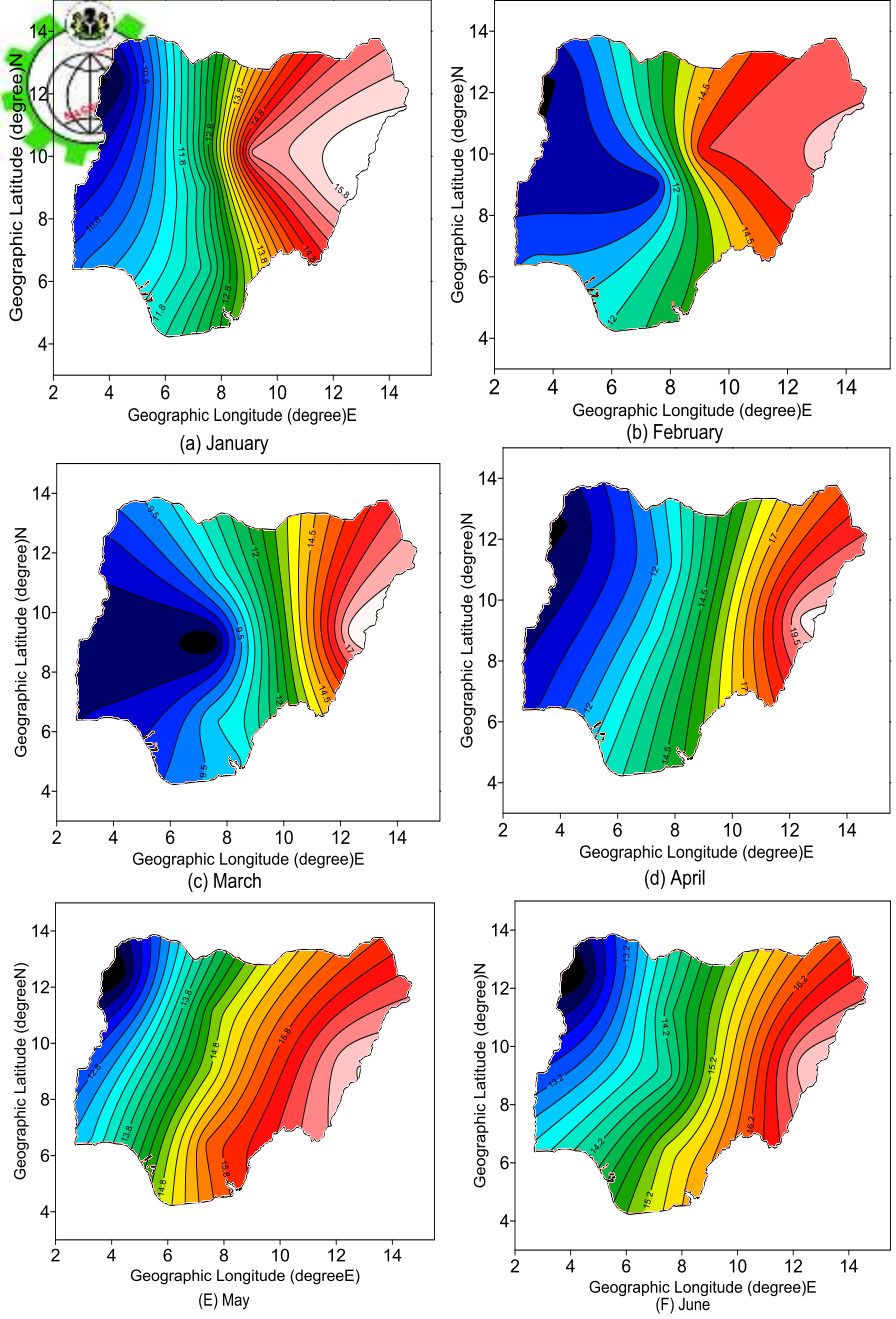


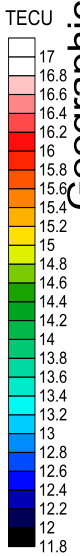
Annual VTEC variation at Akure, Nigeria

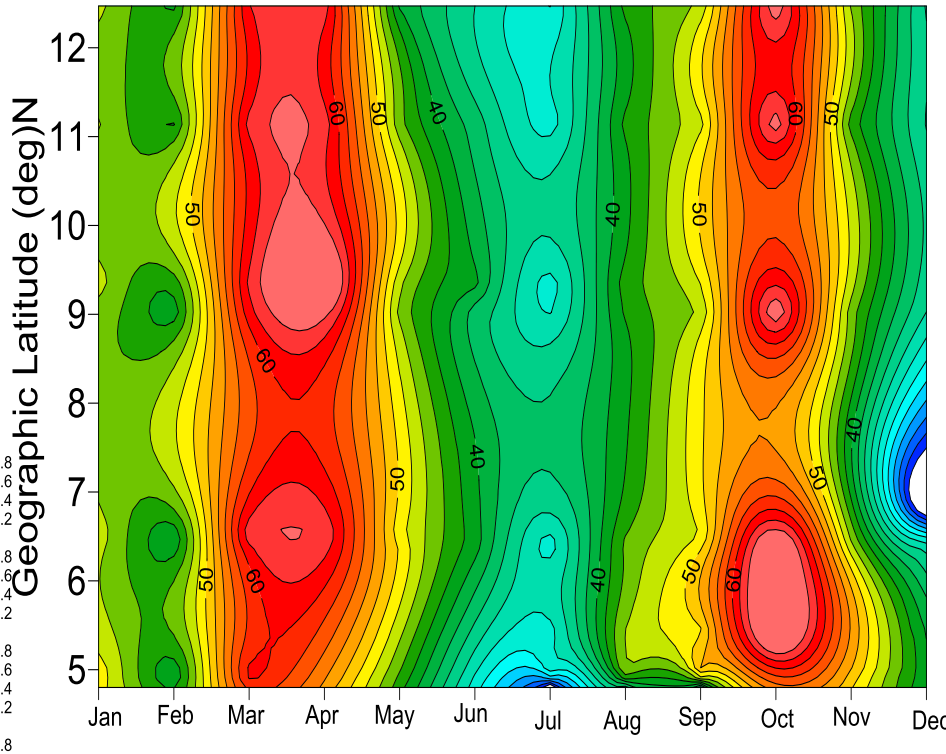


- **pre-dawn minimum for a short period of time followed by steep early morning increase.**
- **Attain maximum between 14.00UT and 16.00UT.**
- **maximizes during Equinox months, minimizes during winter months**
- **The semiannual variation of TEC is asymmetry with maximum in spring Equinox**

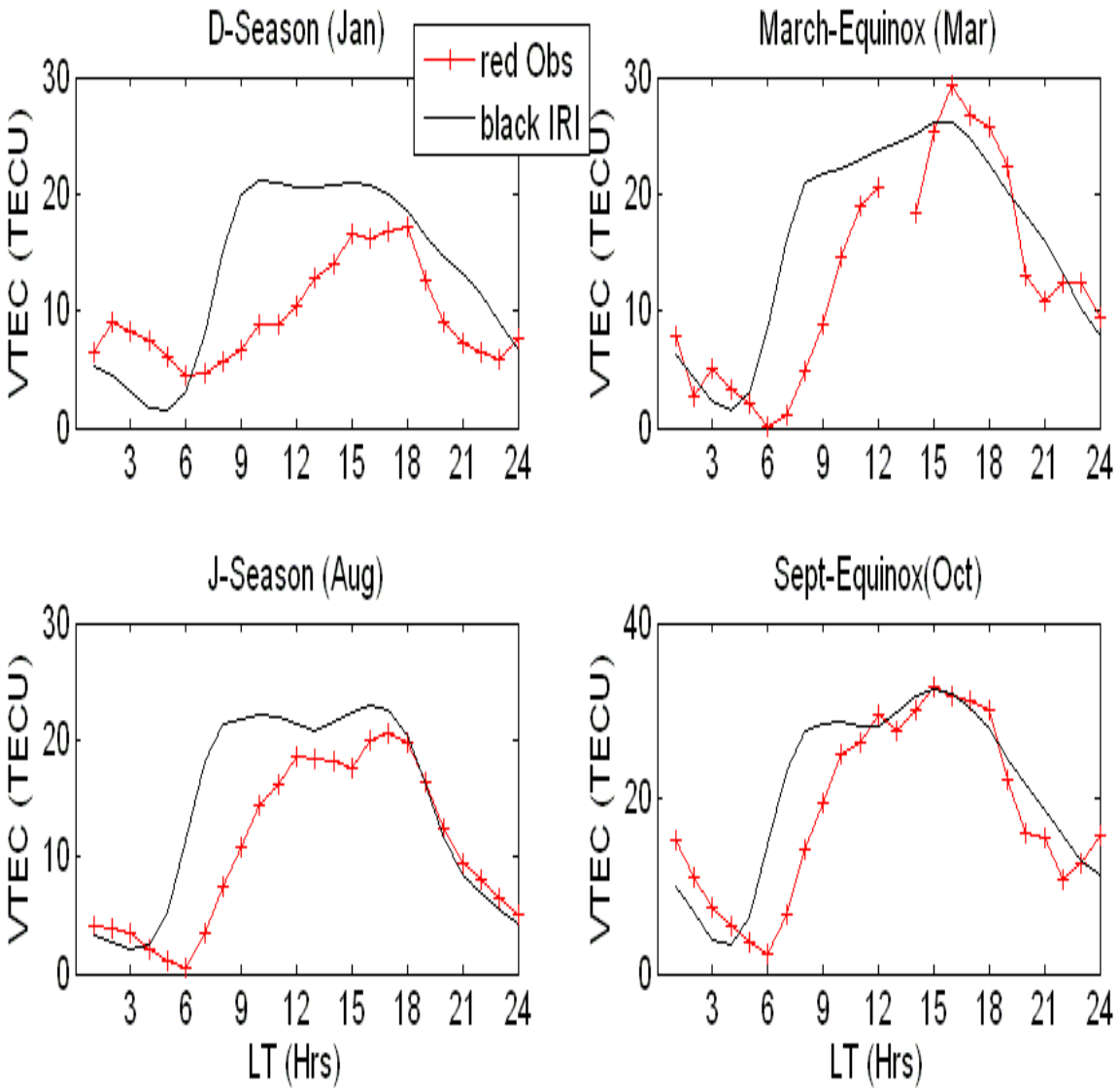
Rabiu et al 2011





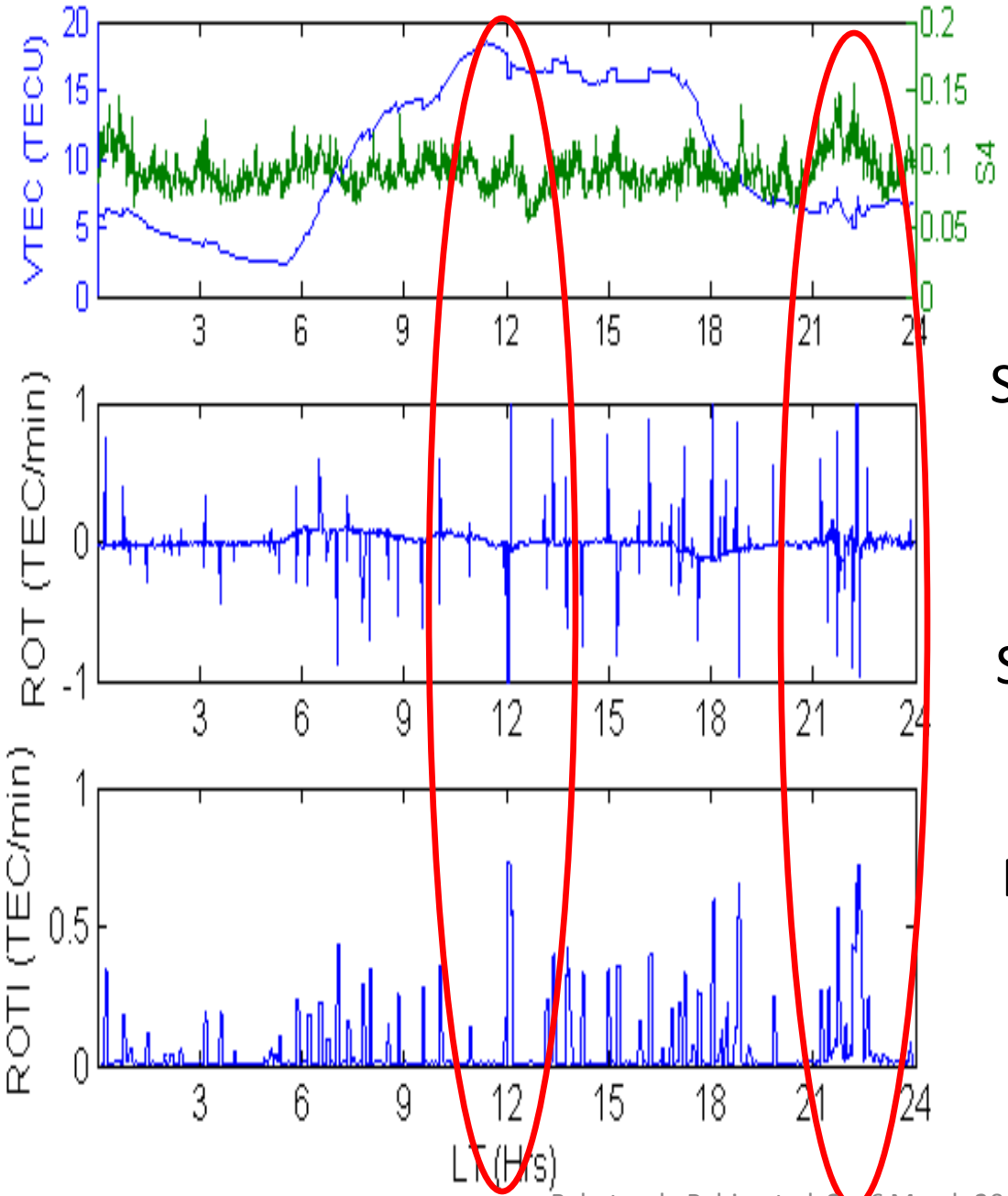


Eyelade (2014)
(Masters thesis)



IRI & Observed TEC @ Akure 2010

IRI Under- & over- estimate the values of TEC at different times in all the seasons considered.

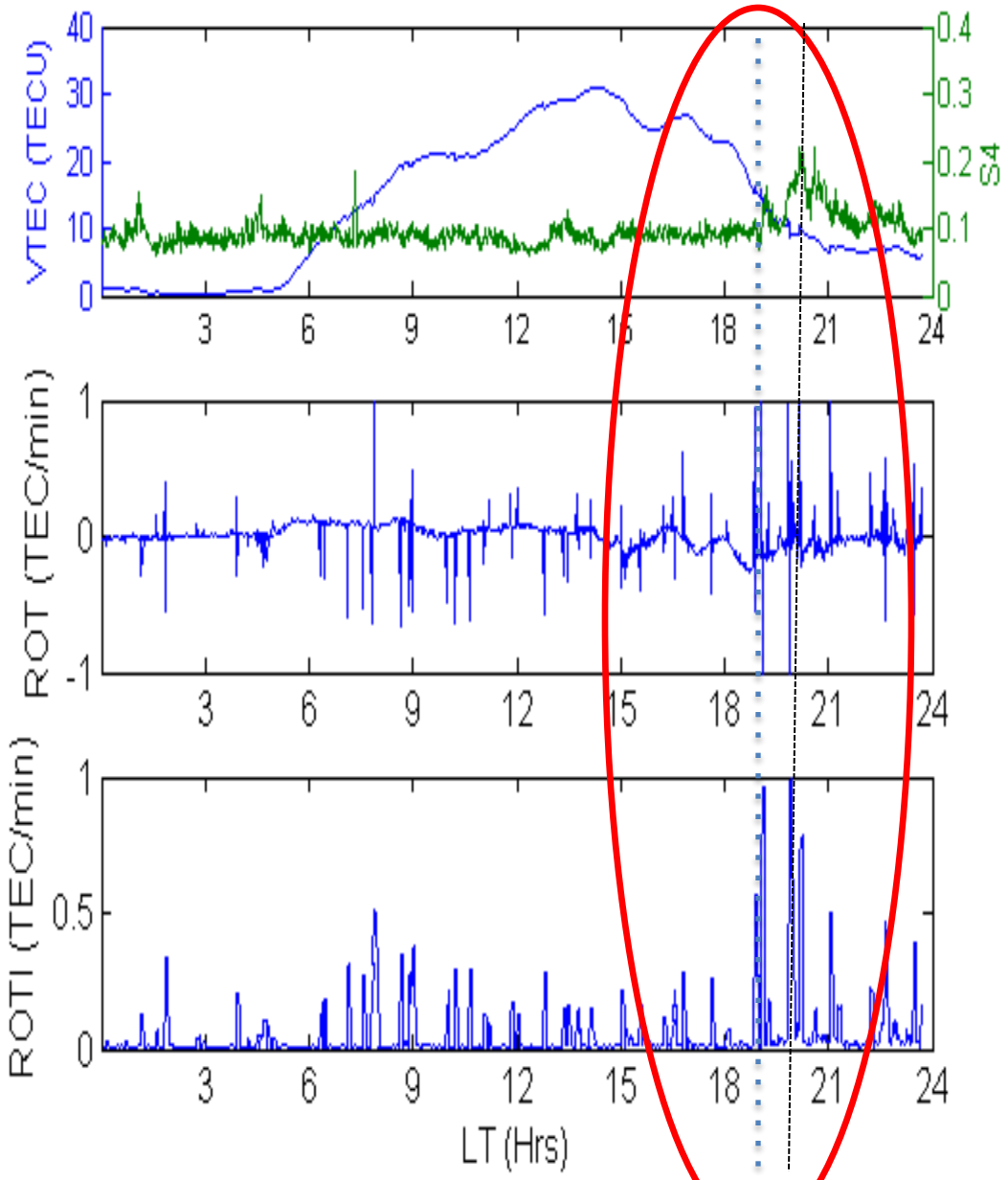


VTEC, S4, ROT & ROTI, 17th Jan 2010 Ap = 1

S4, ROT and ROTI gives information on the dimension of irregularities

S4 is sensitive to scale < the Fresnel scale

ROTI>0.5 corresponds to scale lengths of few km



VTEC, S4, ROT & ROTI,

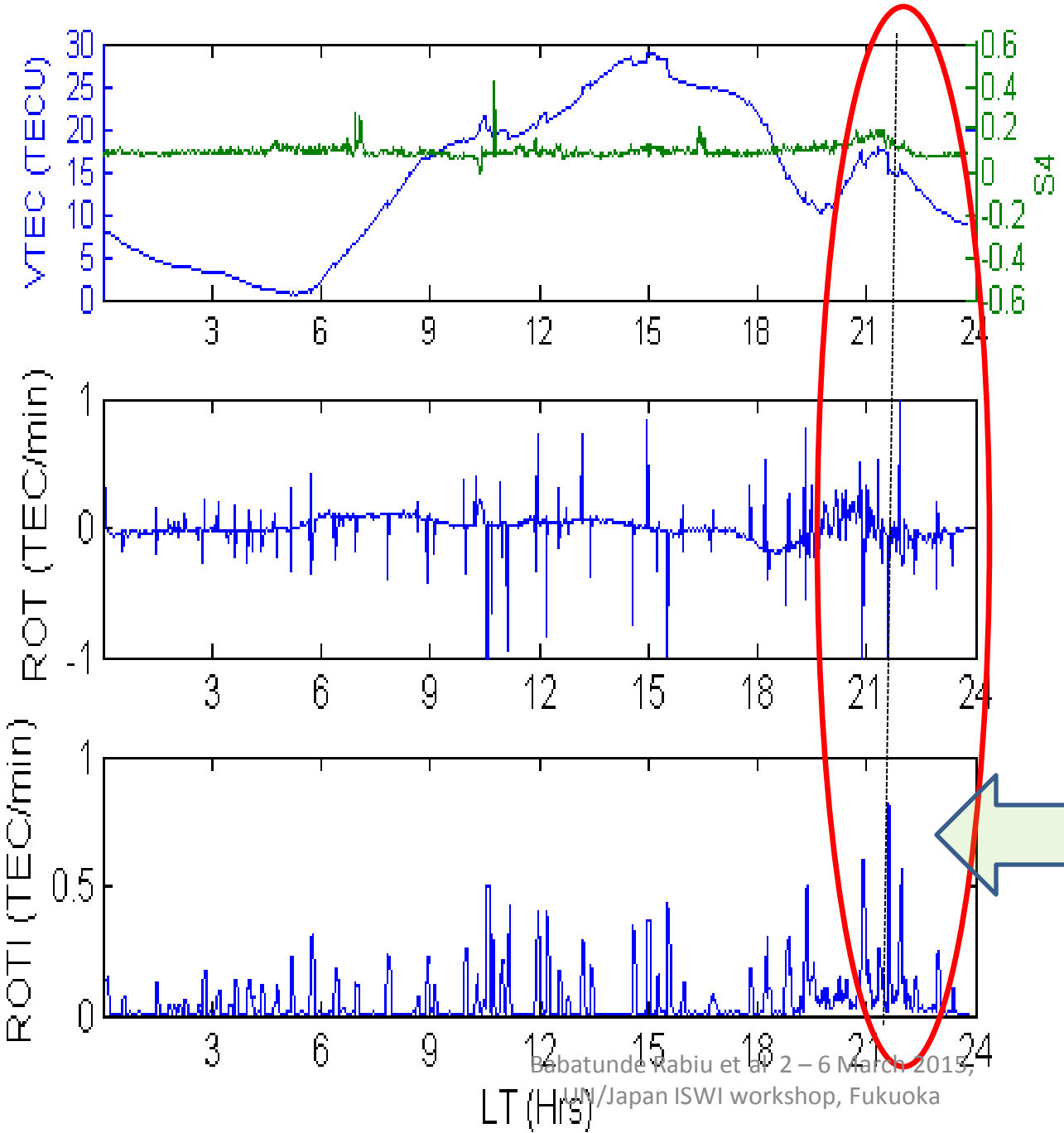
27th August 2010

Ap= 14

ROTI : standard deviation of ROT at 5 mins interval

VTEC, S4, ROT & ROTI, 3rd March 2010

Ap = 8



ROTI gave a more pronounced representation of TEC fluctuation than S4

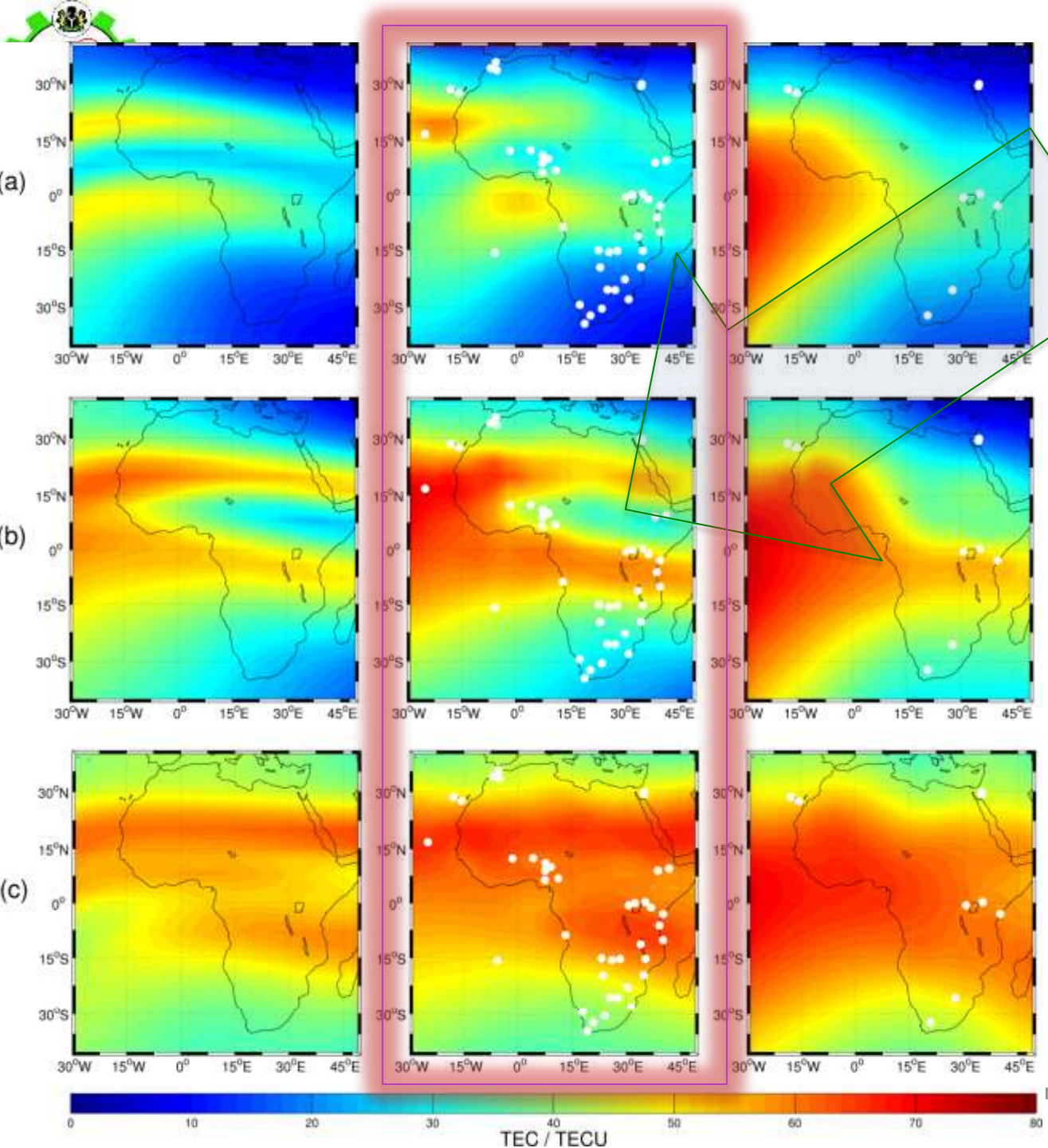
Equivalent ranges of TEC & Dst at Akure, Nigeria. April 1-15, 2010

Activity Level	Dst (nT)	Mean TEC (TECU)
Low	Dst > -20	16.713
Medium	-20 > Dst > -50	16.851
High	-50 > Dst > -100	20.138

TEC increases with increasing magnetic activity.

Measured TEC could serve as proxy for monitoring ionospheric responses to magnetic activity

Rabiu & Abdulrahim (2012): PAPER ID: IAC-12, D5,3,6,x12869, IAF, Naples, Italy



The IRI simulations in the left column, the reconstructions based on all the available data in the middle column and the reconstructions based on just the IGS data in the right column. The first row, (a), is for 22:00 UT on 2 December 2012. The second row, (b), is for 17:00 UT on 3 December 2012. The third row, (c), is for 12:00 UT on 7 December 2012. The GPS receiver sites used to make each set of reconstructions are shown in white.

Chartier et al, 2014

Conclusions/Recommendation

- ISWI has a being a productive venture in Africa in terms of
  - Human Capacity development
  - Observational facilities / infrastructural development
  - Data availability
- Ground observations over Africa is fundamental to the understanding of global Space Weather and its monitoring
- African Geophysical Society and other research networks in the region are potential allies in the maintenance of existing ground stations

Conclusions/Recommendation

- Space weather is observed to be very dynamic over Africa.
- The Sq foci at the two hemispheres over the European/African meridian were found to show a great transient variability on diurnal-, monthly-, and seasonal- scales; with unequal contributions for each hemisphere
- The northern focus has larger mean variations with numerical value $33.16 \pm 2.1°$ while the southern focus has $-15.63 \pm 1.4°$
- occurrence of morning CEJ is much prevalent in East Africa longitude (90%) than the West Africa (80.9%), while the evening CEJ is dominant along the West African longitude (82.9%) than the East African longitude (50%)

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35

Conclusions/Recommendation

- TEC maximizes during the equinox months; lowest in solstice months
- In Nigeria, at 07:00 LT (sunrise) TEC decreases westwards across all the latitudes
- TEC decreases eastward across all latitudes as a result of reduction in the ionization at the east due to the relative position of the sun as the sun begin to set at 17:00 LT.
- TEC could serve as proxy for monitoring ionospheric responses to SW

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36

THANK YOU

Acknowledgements

- UNOOSA
- ISWI Secretariat
- ICSWSE - MAGDAS
- BC – SCINDA GPS
- CALLISTO
- NIGNET
- ICSWSE – sponsored my participation in this meeting