Contributions of UN IHY and ISWI to Africa: Scientific Results and Infrastructural Development

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outline

- Africa
- IGY
- UNBSSI
- Infrastructures
- Scientific results

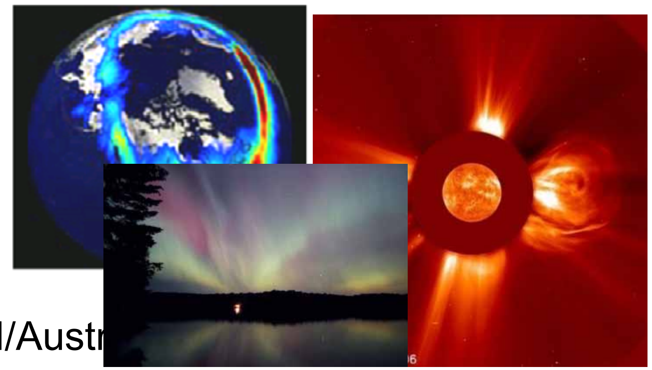
Africa !

- A continent
- 54 individual nations
- Multi-lingual structure
- English, French, Portuguese, Arabic, Spanish
- ~ 30 billion km^2
- ~ 850 million people
- ~14% of the World population

International Geophysical Year IGY

international multidisciplinary programme to study global phenomena of the Earth and geospace,

- Covered meteorology,
- geomagnetism,
- airflows, aurorae,
- ionospheric physics, solar activity, cosmic rays, glaciology, oceanography, seismology and gravimetry.



African involvement in IGY

- ignited during preparation for IGY in 1950s
- Scientists of African descent got involved in observational and theoretical studies
- Ionosondes, magnetometers and some other facilities were installed at certain locations in Africa to take measurements during the IGY
- Unfortunately those facilities used during the IGY have since packed up

Rabiu (2011).

UNBSSI in Africa

- UN Workshops on Basic Space Science (BSS) (1992-2006)
- International Heliophysical Year IHY (2007-2009)
- International Space Weather Initiative ISWI (2009-2012).

UN Workshops

- UN Workshops on Basic Space Science (BSS)
  - Lagos, Nigeria (1992)
  - Cairo, Egypt (1994) &
  - Reduit, Mauritus (2001).

- UN International Space Weather Initiative ISWI
  - Cairo, Egypt (2010) &
  - Abuja, Nigeria (2011).

African Regional Centres for Space Science & Tech Education ARCSSTE

- Francophone – Morocco
- Anglophone- Ile-Ife, Nigeria.
- Develop curriculum, capacity building & awareness
- Satellite Remote Sensing, Atmospheric sciences, Meteorology & Communication, and Geographic Information System (GIS)
- PG diploma in Atmospheric sciences, RS & GIS, & Sat Meteorology
- > 200 participants trained at Ile-Ife ARCSSTE-E

International Heliophysical Year 2007 (IHY, 2005-2009) & International Space Weather Initiative (ISWI, 2010-2012).

www.ihy2007.org

http://www.spaceweather-eg.org/iswi/

IHY/ISWI

- Initiated in 1990, the United Nations Basic Space Science Initiative (UNBSSI) has led to the establishment of planetariums, astronomical telescope facilities, and IHY/ISWI instrument arrays worldwide, particularly in developing countries
- ISWI is envisioned to continue the tradition of IHY in the worldwide deployment of space weather monitoring instrument arrays
- To date, ISWI contributes to the observation of space weather through 14 instrument arrays with close to 1000 operating instruments in 97 countries

www.ihy2007.org

http://www.spaceweather-eg.org/iswi/

IHY/ISWI Projects in Africa

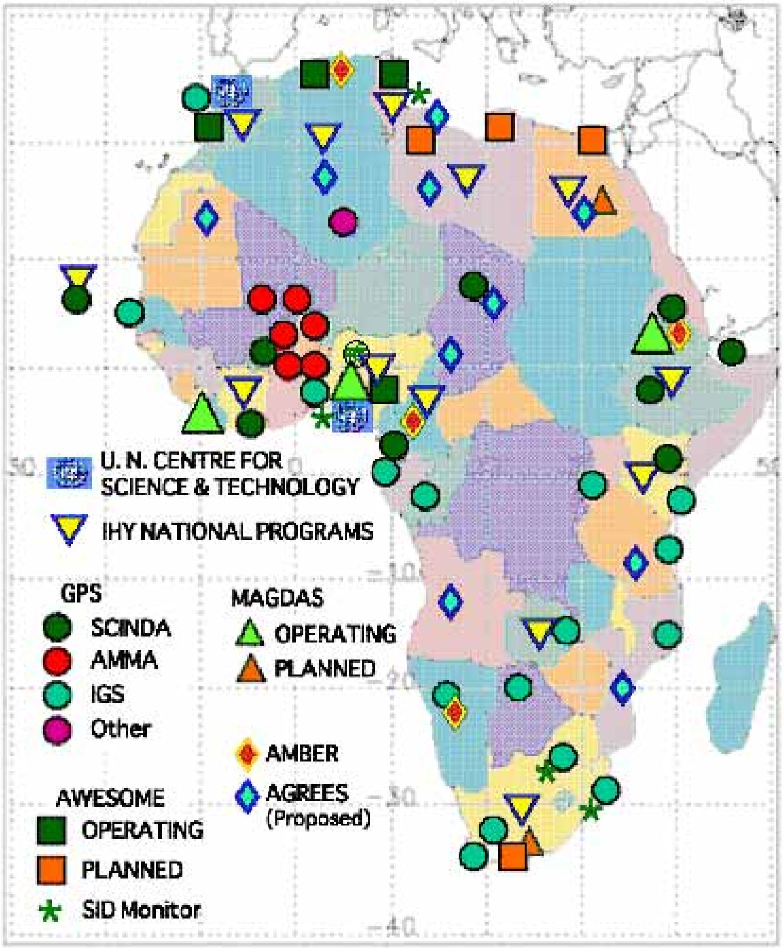
- MAGDAS / Magnetometers (Prof. K. Yumoto. SERC Japan)
  10 countries   13 units
- AWESOME / VLF radio (Prof. Umran Inan. Stanford University)
  Tunisia, Morocco, Algeria, Nigeria, Libya
- SCINDA /GPS (Prof. Keith Groves, AFRL)
  Cape Verde, Nigeria, Côte d’Ivoire, Ethiopia, Kenya
- ASTRONOMICAL TELESCOPES (NAOJ)
  Nigeria
- IPGP/ Magnetometers (CNRS)
  Mali, Côte d’Ivoire, Burkina Faso
- AMMA-IGRGEA/ GPS
  Benin, Burkina Faso, Ghana, Mali, Niger
- SID MONITOR (Deborah Scherer, Stanford University)
  Nigeria, Kenya, Ethiopia, DRC, South Africa, Zambia, Uganda
- AMBER (Moldwin, Yizengaw Endawoke, UCLA)
  Ethiopia, Cameroon, Sudan

IHY/ISWI facilities in Africa

- Over 17 magnetometers (MAGDAS and AMBER)
- more than 25 GPS receivers (SCINDA and others)
- well over 50 ionospheric RF sounders (Ionosonde, SID monitor and AWESOME)

Signatures of UN and IHY in Africa

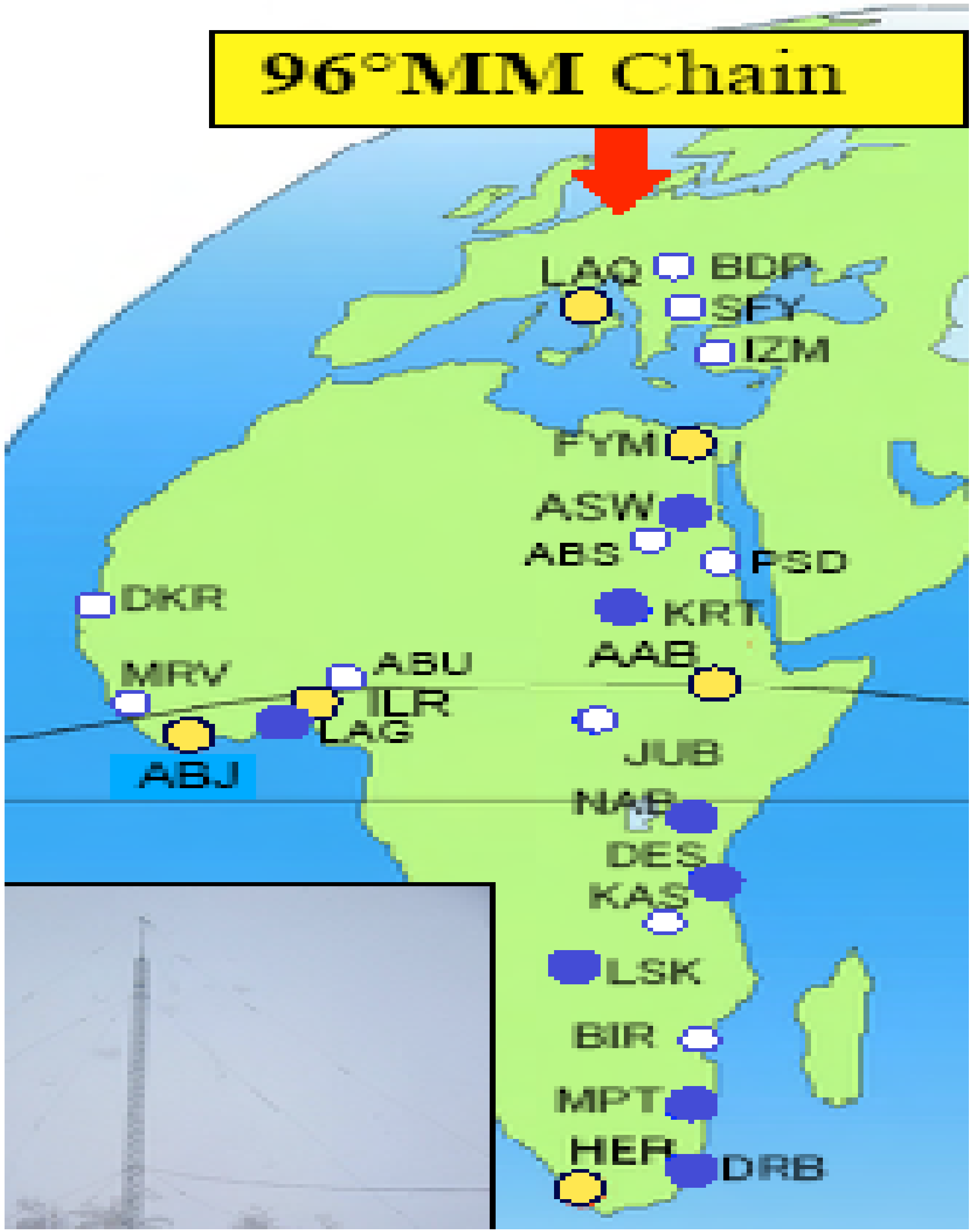
– strictly after Barbara Thompson 2007



Magnetic Data Acquisition System (MAGDAS) project

- Principal Investigator: Kiyohumi Yumoto (Space Environment Research Center, Kyushu University, Japan)
- The Magnetic Data Acquisition System (MAGDAS) is being deployed for space weather studies, viz:
  - ✓dynamics of geospace
  - ✓plasma changes during magnetic storms and auroral substorms,
  - ✓ the electro-magnetic response of the iono-magnetosphere to various solar wind changes and
  - ✓Behaviour of Equatorial electrojet

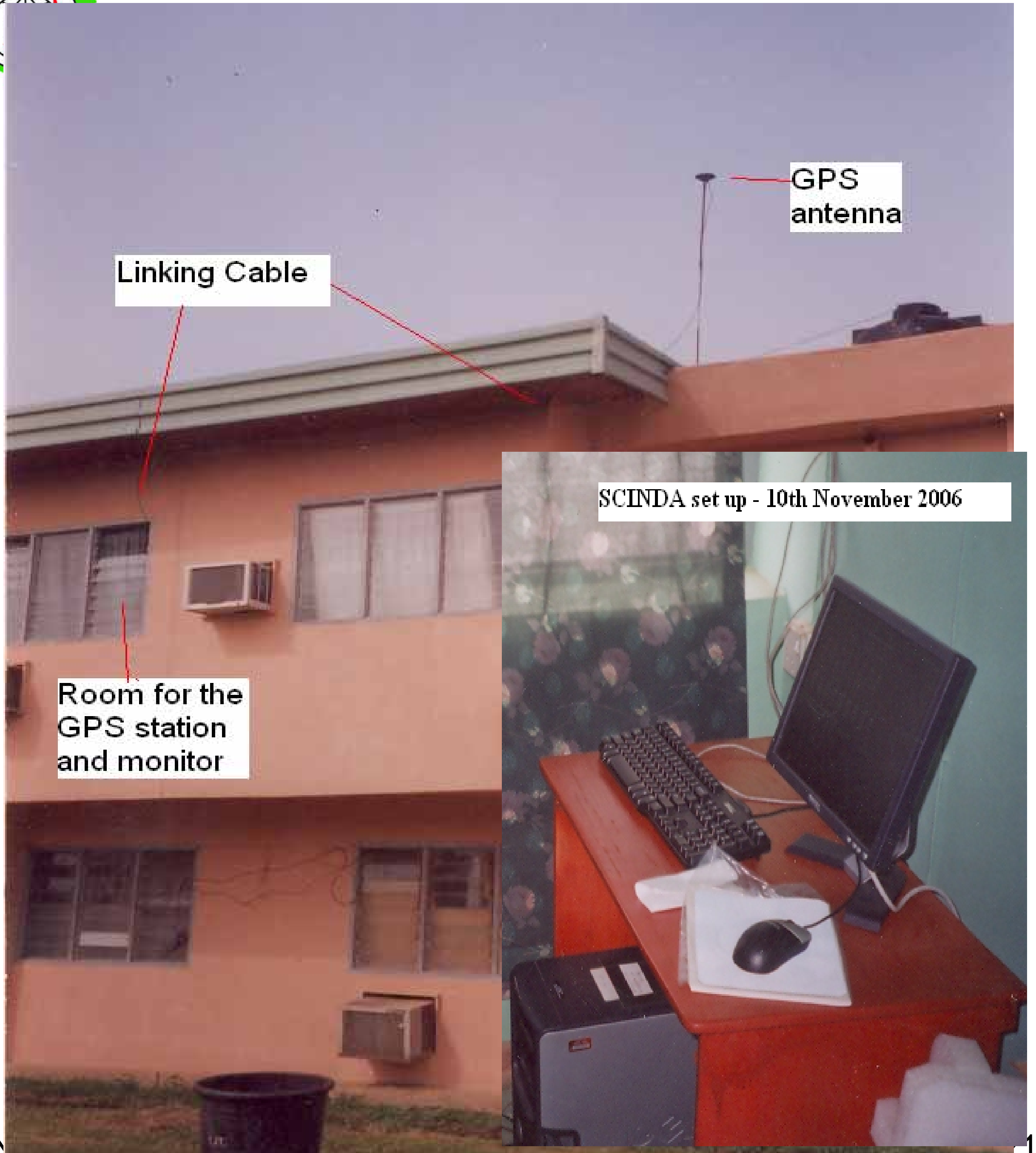
- Abidjan (Cote DIvore)
- Lagos (Nigeria)
- Ilorin (Nigeria)
- Fayoum (Egypt)
- Aswan (Egypt)
- Karthoum (Sudan)
- Addis Ababa (Ethiopia)
- Nairobi(Kenya)
- Dar Es Salam (Tanzania)
- Lusaka (Zambia)
- Maputo (Mozambique)
- Hermanus (RSA)
- Durban (RSA)
- Abuja (Nigeria)



MAGDAS at ILORIN, Nigeria. August 2006

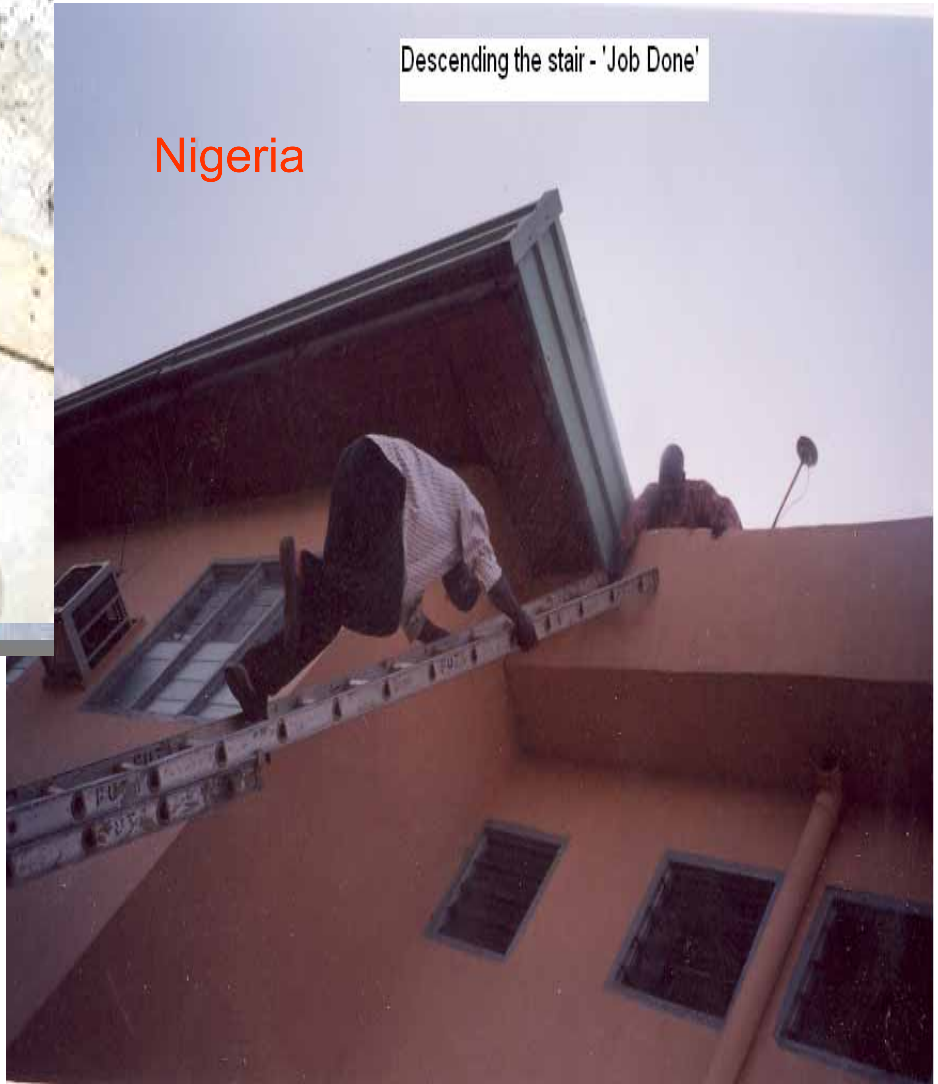
MAGDAS at Lusaka LSK

Geog Latitude	-15.25
Geog Longitude	28.16



Akure SCINDA GPS

10th Nov 2006



Climbing the stairs

AWESOME

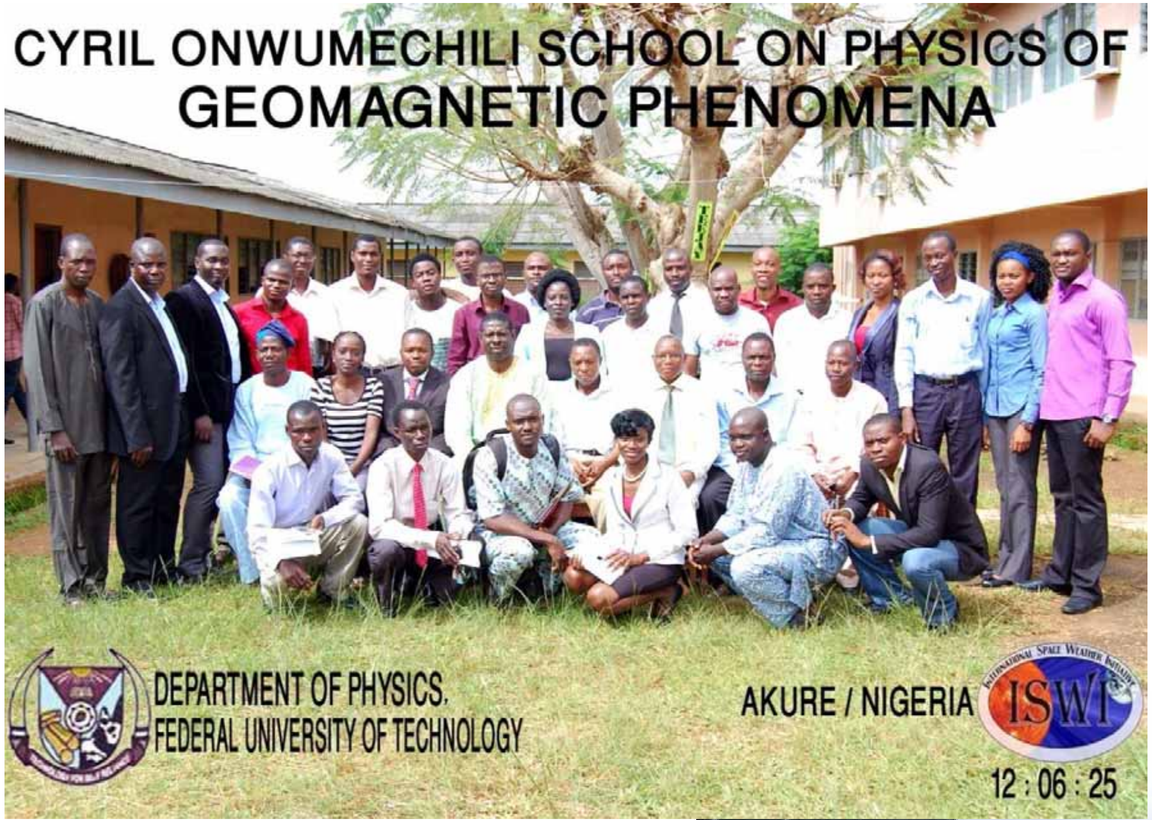
- ✓Installed May 2007
- ✓PhD students and some other students participated in the installation

SID MONITORS

- Congo
- Nigeria
- Egypt
- Tunisia
- Ethiopia
- Kenya
- RSA
- Zambia
- etc

Summer Schools

- 41 African graduate students & Postdocs
- From 14 African countries
- 15 Instructors



24 - 30 June 2012,
Akure, Nigeria

Gains of IHY/ISWI in Africa

- Knowledge & technological transfer
- Positive collaboration
- Availability of Research facilities for internationally competitive research.
- Publication of scholarly articles
- Windows of postgraduate opportunities
- Control of brain drain
- Development of Research in Basic Space Science
- Capacity building
- Bridge between North & South
- strong intra–continental partnerships amongst African scientists

Observational Facilities available in Africa for Basic Space Science

S/N	City	Country	Instruments
1	Tamanrasset	Algeria	magnetometer Intermagnet, IGS-GPS,
2	Medea	Algeria	Magnetometer AMBER
3	Algiers	Algeria	VLF Receiver AWESOME
4	Maun	Botswana	GPS-IGS
5	Yaounde	Cameroon	Magnetometer AMBER, GPS-SCINDA
6	Sal island	Cape Verde,	GPS-SCINDA
7	Bangui RCI	Central African Republic	magnetometer Intermagnet
8	Djibouti NE Africa	Djibouti	GPS-SCINDA
9	Aswan	Egypt	Magnetometer MAGDAS
10	Fayum	Egypt	Magnetometer MAGDAS
11	Cairo	Egypt	VLF Receiver AWESOME, GPS
12	Helwan	Egypt	GPS-SCINDA, Coherent Ionospheric Doppler Radar
13	Addis Ababa	Ethiopia	Magnetometer MAGDAS, ionosonde, GPS-SCINDA, magnetometer Intermagnet
14	Bahir dar	Ethiopia	Magnetometer, ionosonde, GPS-SCINDA, VLF receiver AWESOME
15	Adigrat,	Ethiopia	Magnetometer AMBER

16	Tamale	Ghana	GPS-AMMA
17	Nairobi	Kenya	Magnetometer MAGDAS
18	San Marco	Kenya	ionosonde
19	Malindi	Kenya	GPS-IGS
20	Nairobi (J K Univ)	Kenya	GPS-SCINDA
21	Nairobi (Univ of Nairobi)	Kenya	GPS-SCINDA
22	Sebha	Libya	VLF Receiver AWESOME
23	Tripoli	Libya	VLF Receiver AWESOME
24	Rabat,	Libya	VLF Receiver AWESOME
25	Antananarivo	Madagascar	magnetometer Intermagnet
26	Marrakech	Morocco	Fabry-Perot interferometers FPI, GPS
27	Rabat	Morocco	GPS- IGS
28	Nampula	Mozambique	GPS-IGS
29	Maputo	Mozambique	Magnetometer MAGDAS
30	Tsumeb	Namibia	magnetometer Intermagnet
31	Windhoek	Namibia	GPS-IGS

32	Niamey	Niger	GPS-AMMA
33	Ile-Ife	Nigeria	GPS
34	Kebbi	Nigeria	GPS
35	Lagos	Nigeria	Magnetometer MADAS, GPS-SCINDA
36	Ilorin	Nigeria	Magnetometer MAGDAS, ionosonde, GPS
37	Abuja	Nigeria	Magnetometer MAGDAS AMBER
38	Lagos	Nigeria	GPS-SCINDA
39	Nsukka	Nigeria	GPS-SCINDA
40	Akure	Nigeria	GPS-SCINDA
41	Ilorin	Nigeria	GPS-SCINDA
42	Butare	Rwanda	GPS
43	Sao Tome Isl.	Sao Tome	GPS-IGS, GPS-SCINDA

44	Louisvale	South Africa	ionosonde
45	Madimbo	South Africa	ionosonde
46	Grahamstown	South Africa	ionosonde
47	Richards bay	South Africa	GPS- IGS
48	Sutherland	South Africa	GPS- IGS
49	Simonstown	South Africa	GPS- IGS
50	Pretoria	South Africa	GPS- IGS
51	Krugersdorp	South Africa	GPS- IGS
52	Southern Oce. Marion Island	South Africa	GPS- IGS
53	Hartebeesthoek	South Africa	magnetometer Intermagnet
54	Hermanus	South Africa	magnetometer Intermagnet, Magnetometer MAGDAS, GPS- IGS, GPS-SCINDA, ionosonde
55	Durban	South Africa	Magnetometer MAGDAS
56	Cape Town	South Africa	GPS-SCINDA
57	Khartoum	Sudan	Magnetometer MAGDAS
58	Dar Es Salaam	Tanzania	Magnetometer MAGDAS, GPS- IGS, ionosonde

59	Zanzibar	Tanzania	GPS-SCINDA
60	Tunis	Tunisia	VLF Receiver AWESOME
61	Kampala	Uganda	GPS-SCINDA
62	Mbarara	Uganda	GPS- IGS
63	Lusaka	Zambia	Magnetometer MAGDAS, GPS
64	Georgetown, Atlantic Ocean		GPS-SCINDA
65	Ascension Island, Atlantic Ocean		GPS-SCINDA , Magnetometer-INTERMAGNET

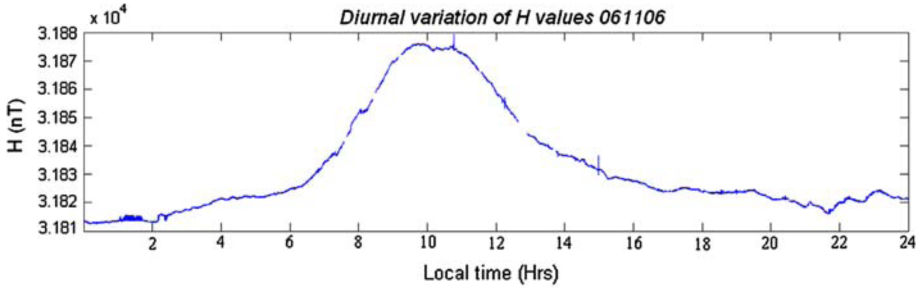
Some contributions

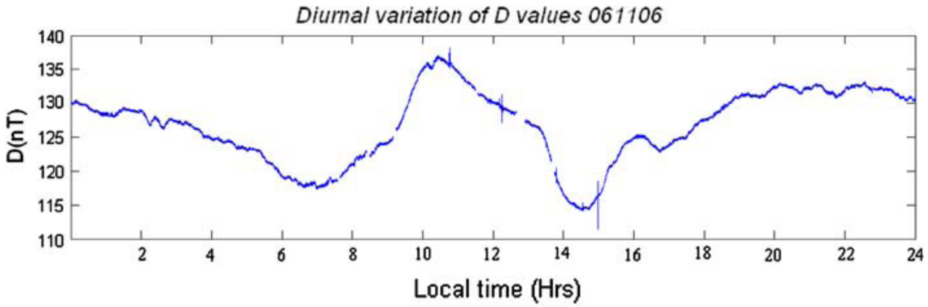
Earth Moon Planet (2009) 104:173–179
DOI 10.1007/s11038-008-9290-7

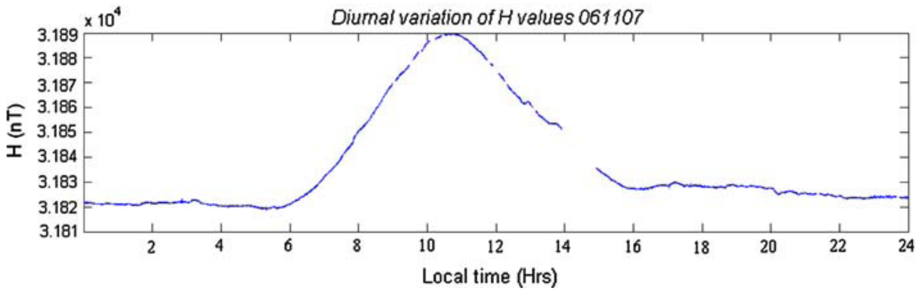
Preliminary Results from the Magnetic Field Measurements Using MAGDAS at Ilorin, Nigeria

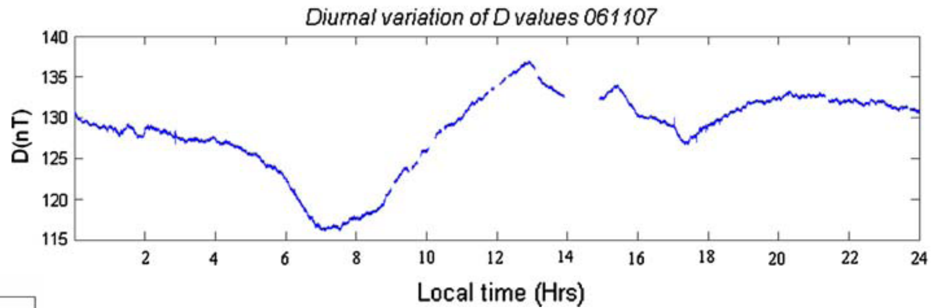
A. B. Rabiu · I. A. Adimula · K. Yumoto · J. O. Adeniyi ·
G. Maeda · MAGDAS/CPMN Project group

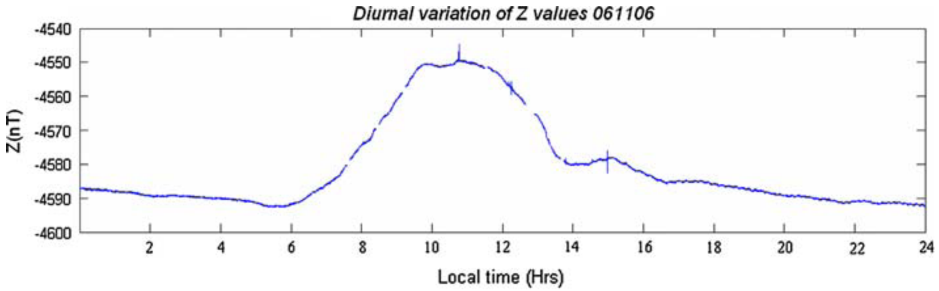
Diurnal variation of H D Z on 6 & 7 Nov 2006

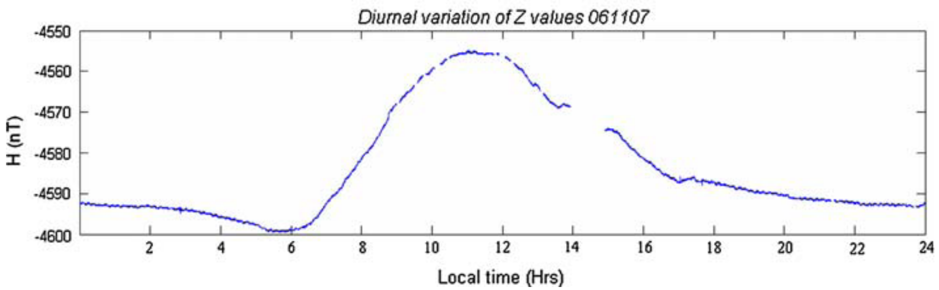












- Diurnal variations
- Day-to-day variability of ionospheric process etc
- Rabiu et al 2009

LETTER Earth Planets Space, 60, 785–790, 2008

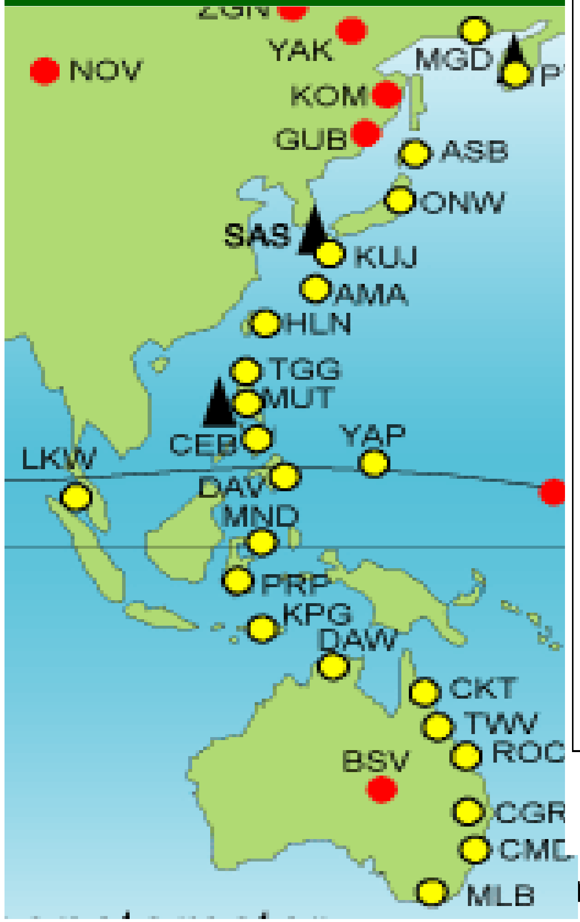
A new index to monitor temporal and long-term variations of the equatorial electrojet by MAGDAS/CPMN real-time data: *EE*-Index

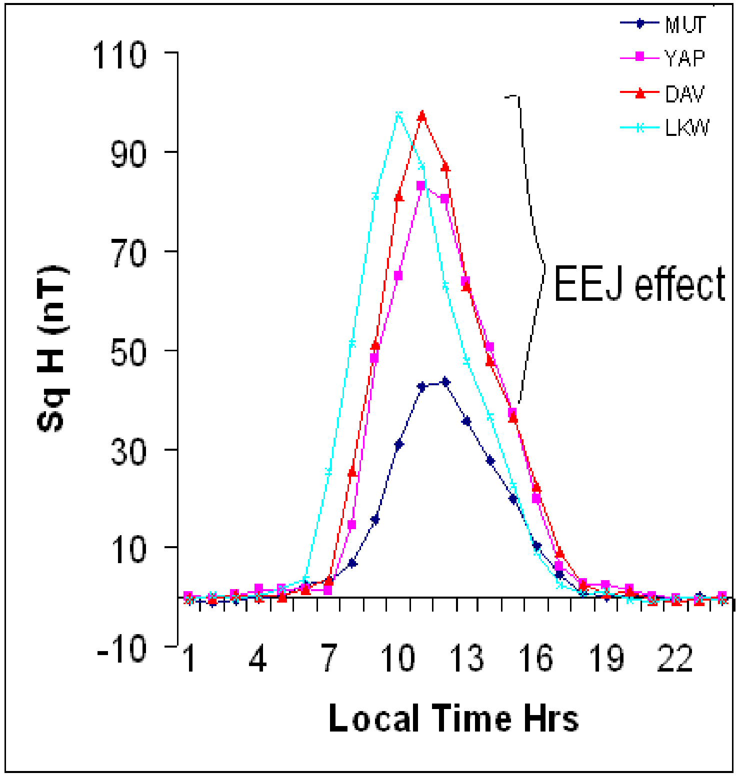
T. Uozumi[1], K. Yumoto[1], K. Kitamura[2], S. Abe[1], Y. Kakinami[1], M. Shinohara[1], A. Yoshikawa[1], H. Kawano[1], T. Ueno[3], T. Tokunaga[3], D. McNamara[4], J. K. Ishituka[5], S. L. G. Dutra[6], B. Damtie[7], V. Doumbia*[8], O. Obrou[8], A. B. Rabiu[9], I. A. Adimula[10], M. Othman[11], M. Fairos[11], R. E. S. Otadoy[12], and MAGDAS Group[1]

This index provides information that should clarify the situation of solar-geospace coupling and atmosphere-ionosphere coupling in the magnetic equatorial region

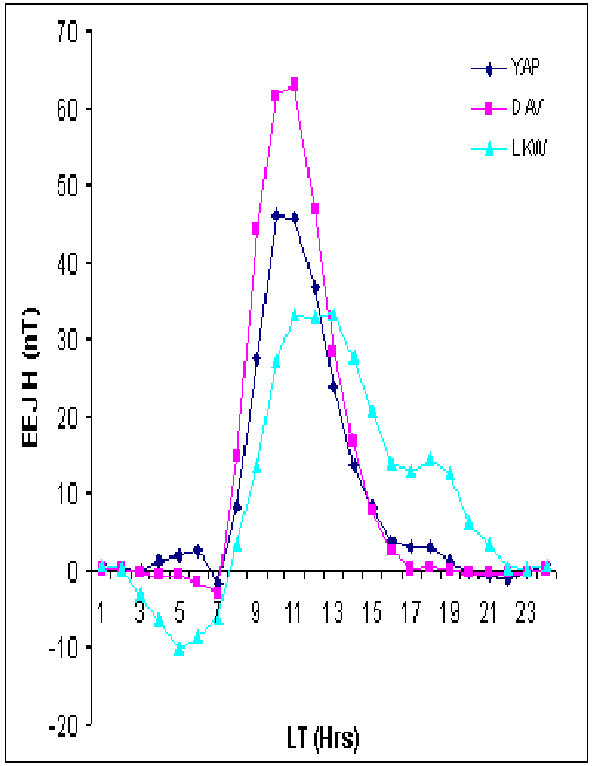
EQUATORIAL ELECTROJET PARAMETERS ALONG 210 MM USING A THICK CURENT SHELL FORMAT: PRELIMINARY RESULTS

Rabiu, A.B., Yumoto, Shiokawa and Fujimoto, A., 2009.



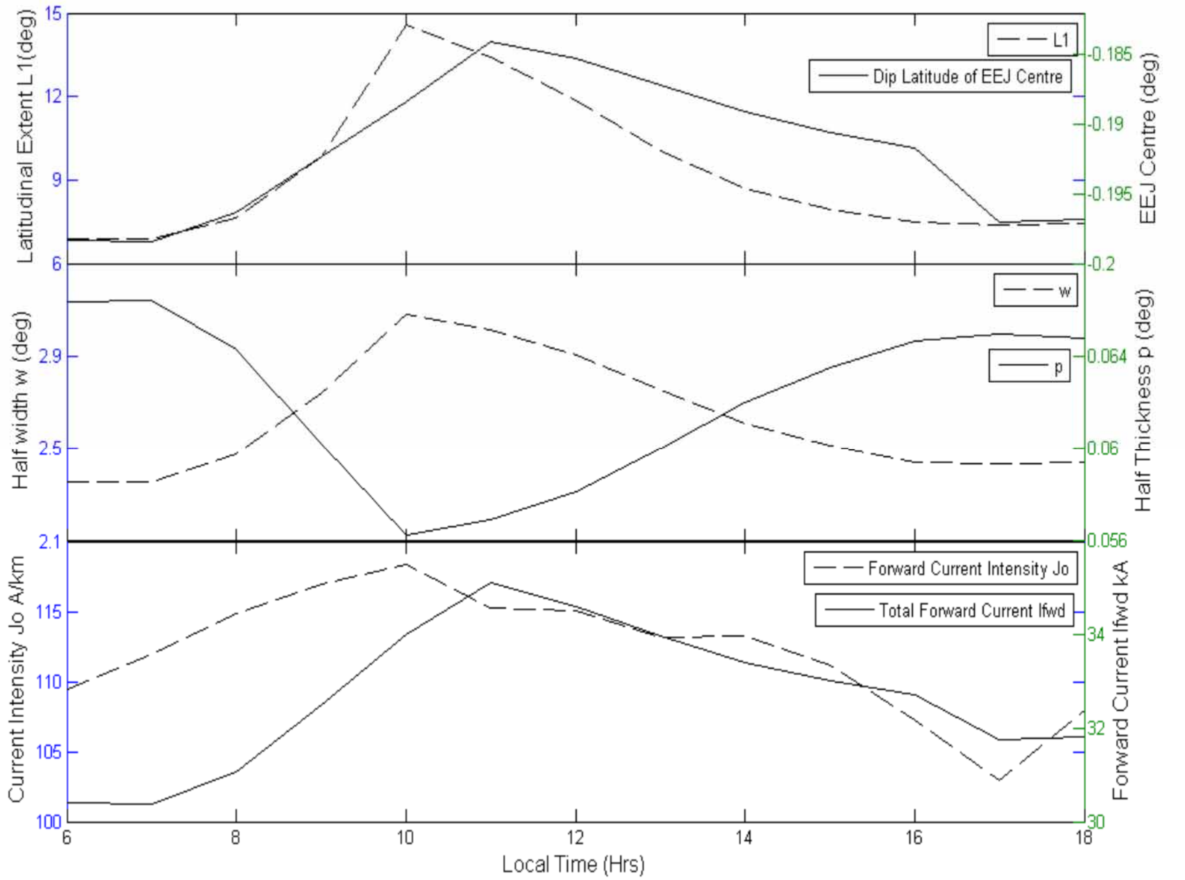


Sq variation in H on 2nd April 08 (Ap=1)



EEJ Strength at the statitions

interplay between the jet thickness, intensity and width was also observed in Indian sector by Rabiu & Nagarajan (2007), and attributed this to meridional winds.



Diurnal variations of the peak intensity of the forward current at its centre (bottom panel left axis), total forward current flowing between the current foci (bottom panel right axis), half of the latitudinal width or the focal distance from the current centre (middle panel right axis), half thickness of the peak current density (middle panel left axis), latitudinal extent of the current from its centre (top panel left axis), and dip latitude of the electrojet centre (top panel right axis). (Rabiu et al, 2009)

EEJ parameters along 210 MM during WHI

- peak intensity of the forward current at its centre 112.12 ± 4.33 A/km;
- peak intensity of the return current, 33.80 ± 6.82 A/km;
- ratio of the peak return to the peak forward current intensity 0.300 ± 0.052;
- total forward current flowing between the current foci 32.67 ± 1.54 kA;
- half of the latitudinal width or the focal distance from the current centre, 2.62 ± 0.25º;
- distance of the peak return current location from the current centre, 5.13 ± 0.32º;
- half thickness of the peak current density, 0.062 ± 0.004º;
- latitudinal extent of the current from its centre, 9.23 ± 2. 57º;
- dip latitude of the electrojet centre -0.19195 ± 0.005º.

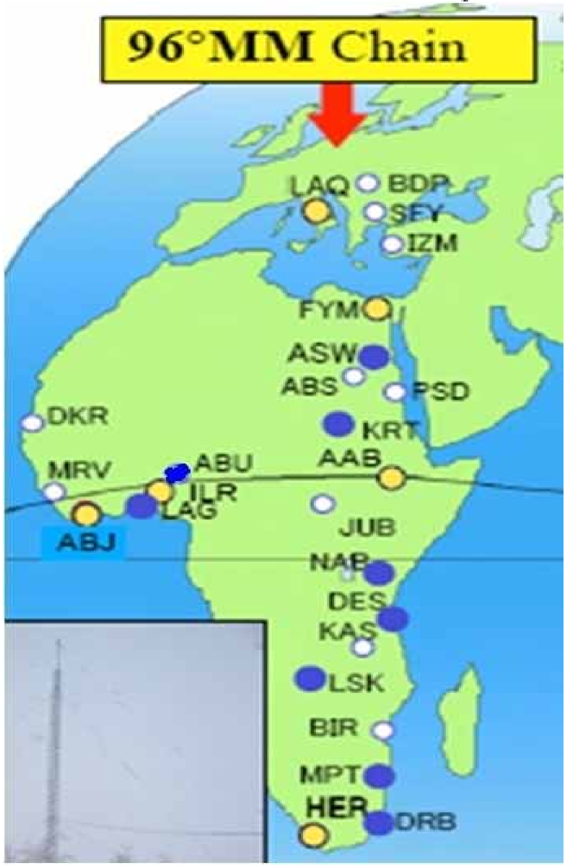
Comparison of EEJ at 210 MM with Indian and Brazil sectors

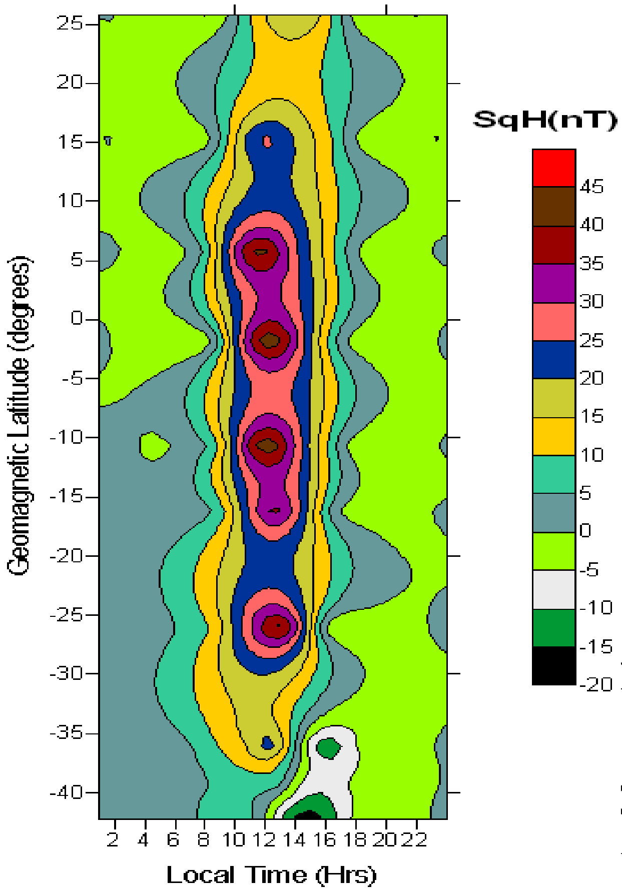
	Jo	Jm	Jm/Jo	Ifwd	Dip latitude of EEJ center
210 MM	112.1264	-33.7956	-0.29997	32.67	-0.192
Indian Sector	66.23	-16.53	-0.251	21.1	-0.187
Brazil	148	43.7	-0.29	67	-0.189

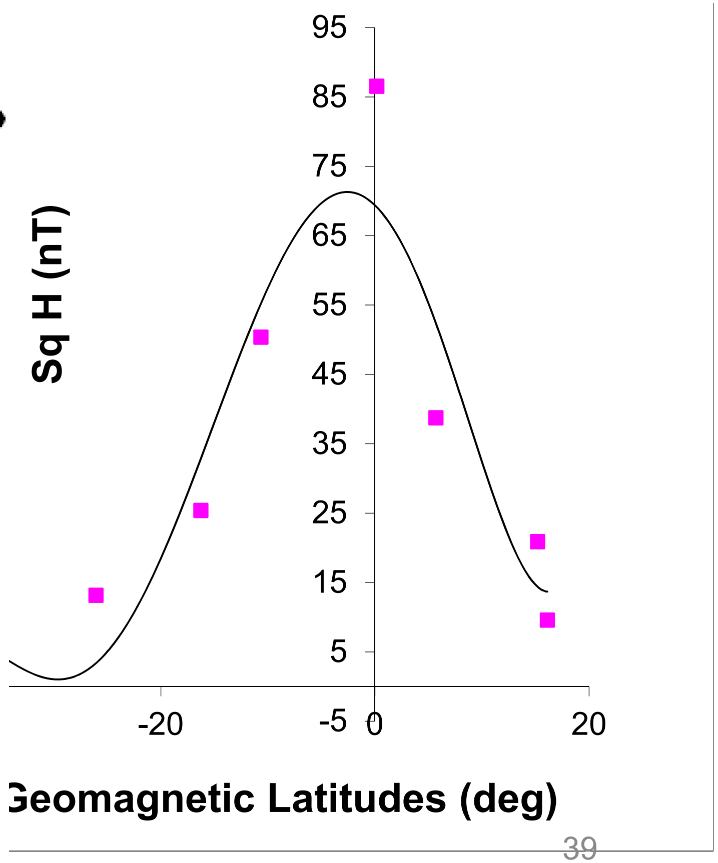
Sun and Geosphere, 2011; 6(2): 63 - 66 ISSN 1819-0839

Ionosphere over Africa: Results from Geomagnetic Field Measurements During International Heliophysical Year IHY

A.B. Rabiu[1,2], K.Yumoto[3], E.O. Falayi[2,4], O.R.Bello[2], MAGDAS/CPMN Group[3]







Seasonal variation of Sq(H) along the 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

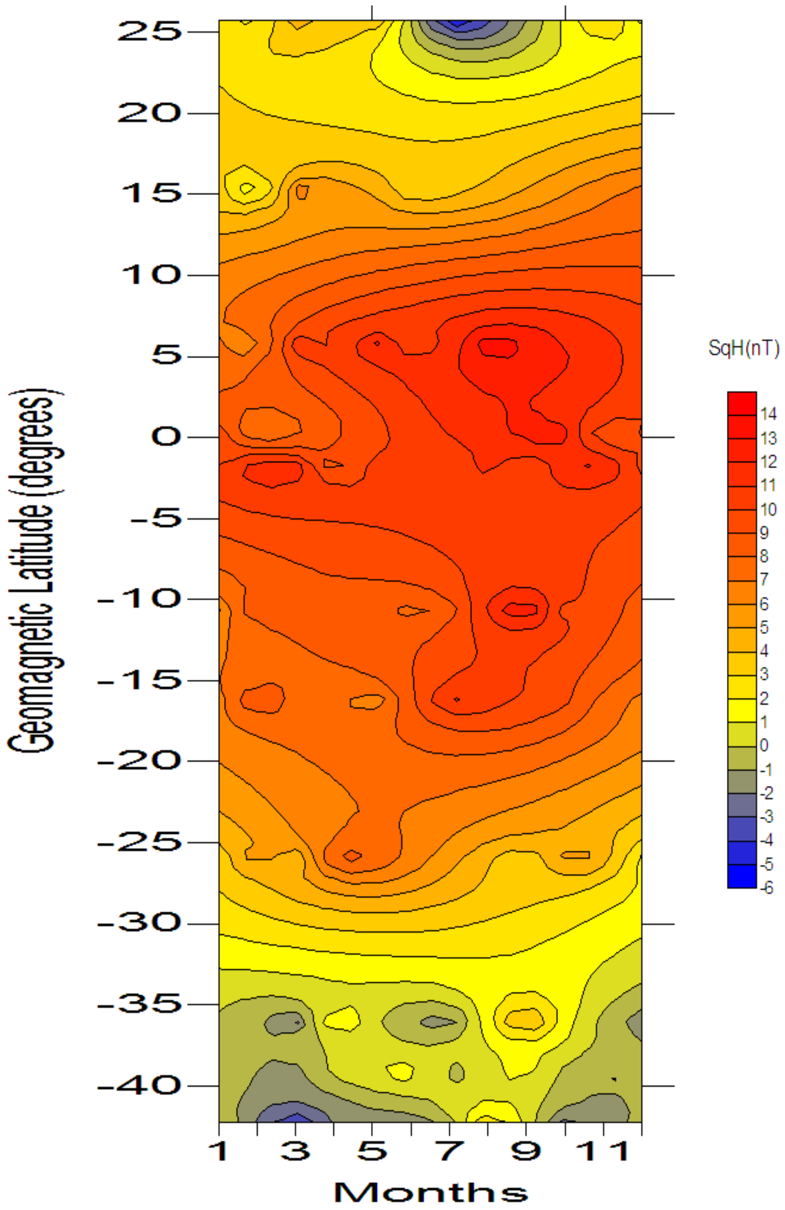
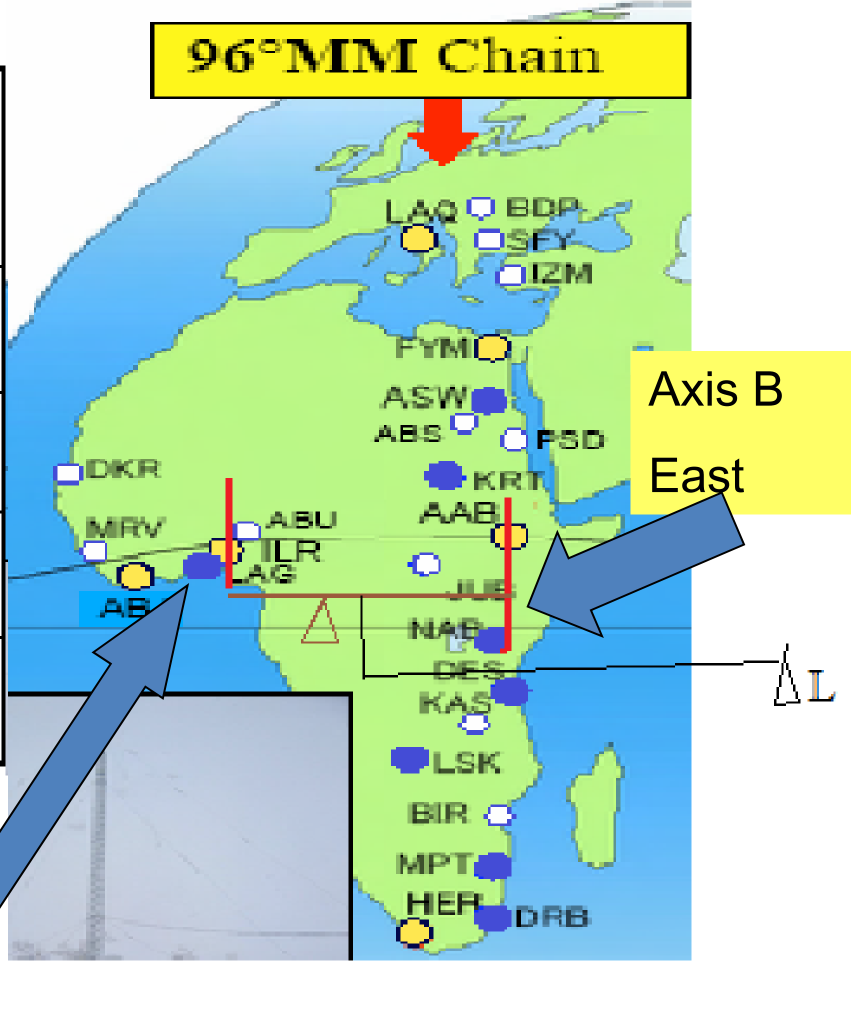


Figure : Seasonal Variation of SqH (nT)

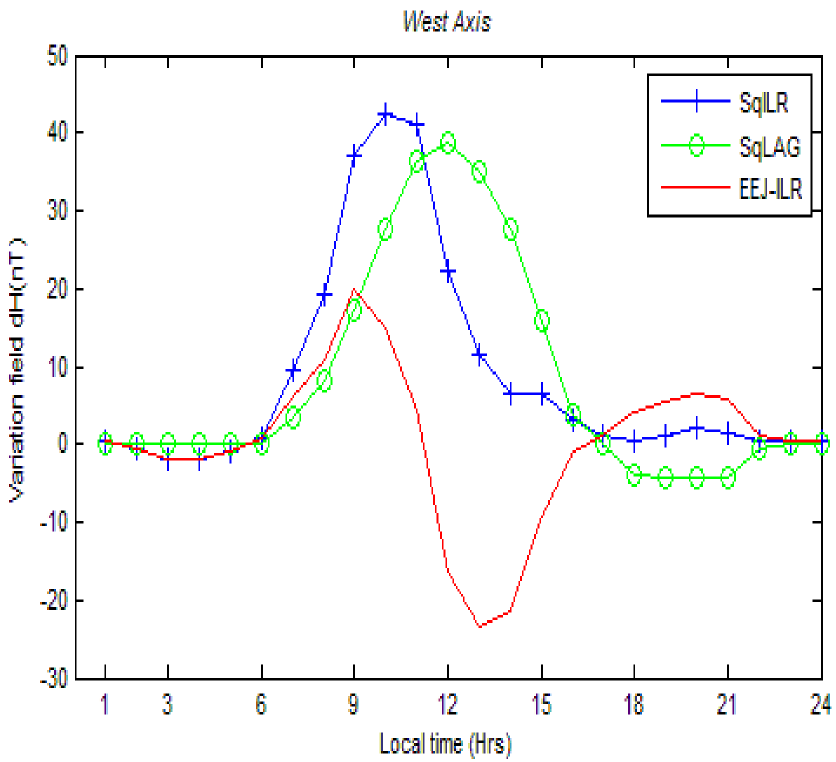
EEJ in Africa

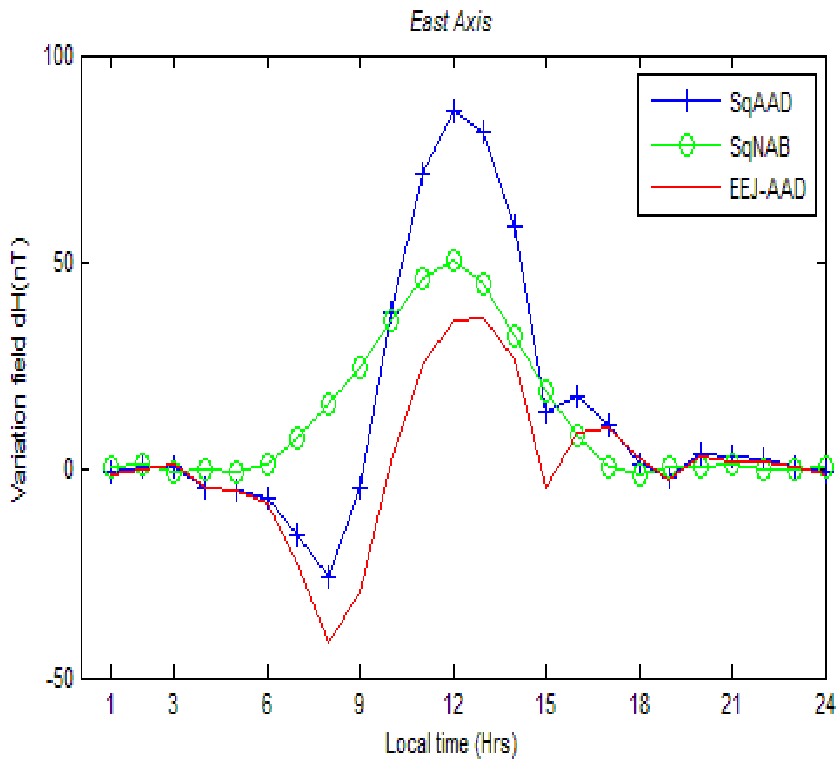
Coordinates of the Stations

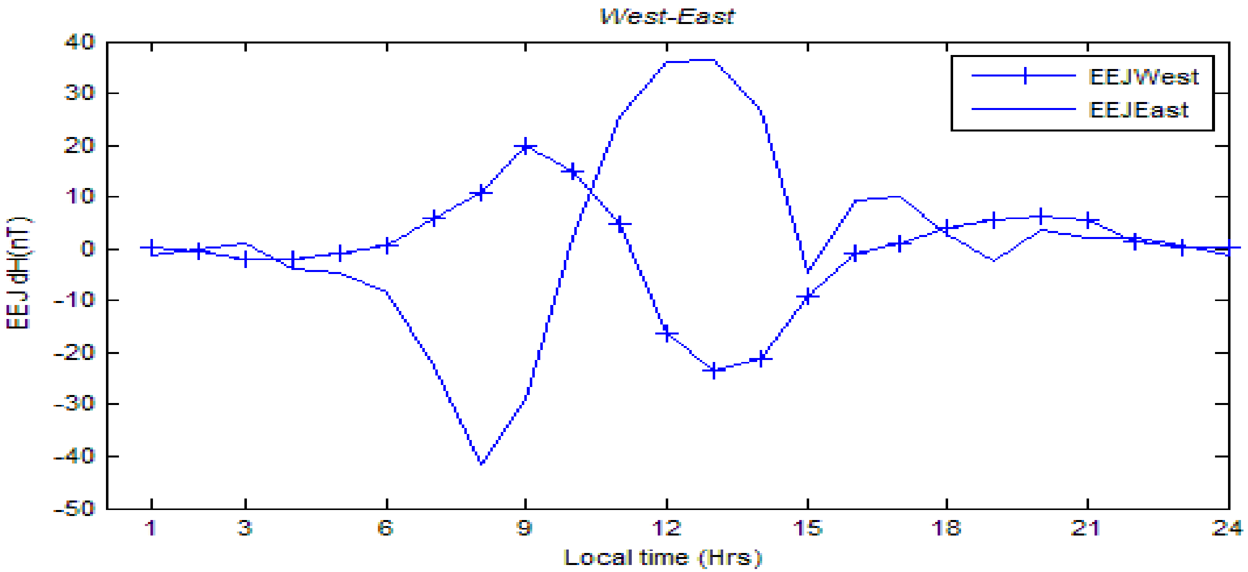
OBS	GMLat°	GLong ° E	GLat°
ILR	-1.82	4.67	8.50°N
LAG		3.43	3.42°N
AAB	0.18	38.77	9.04°N
NAB		36.80	1.16°S



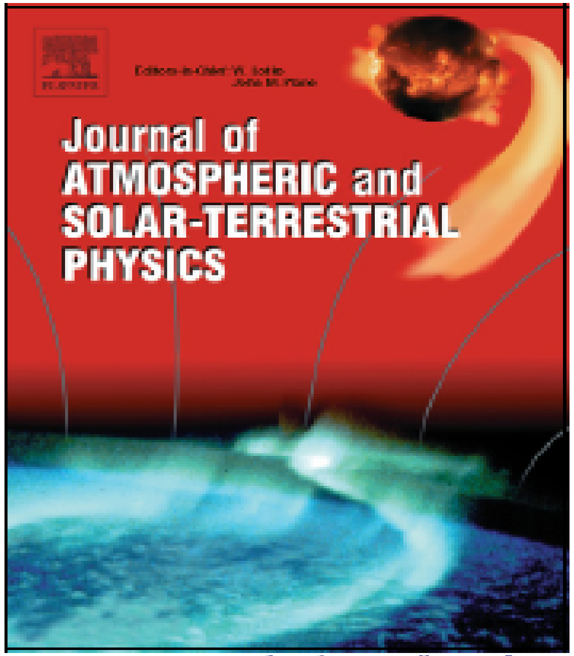
Separation of axes, Δ L = 33.735° = 3744.585 km







- Western EEJ appears weaker than Eastern EEJ!
- It is as if there is a process of re-injection of energy as Jet flows eastward



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

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

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Reference: ATP3656

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Author's Accepted Manuscript

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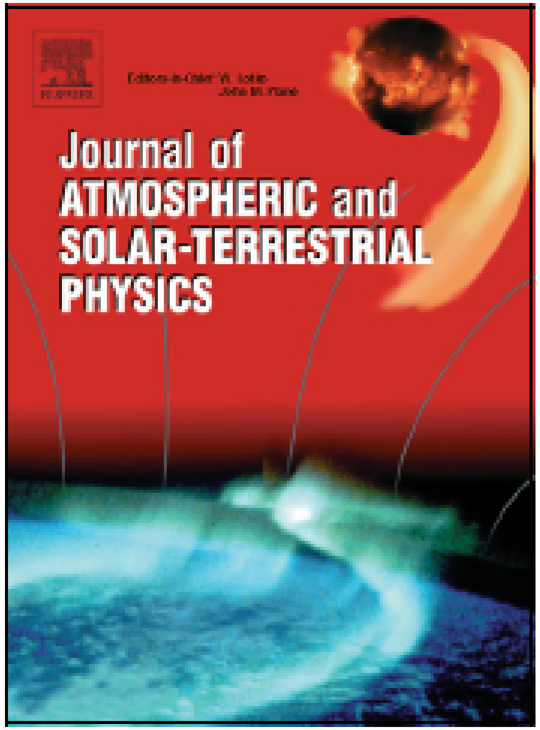

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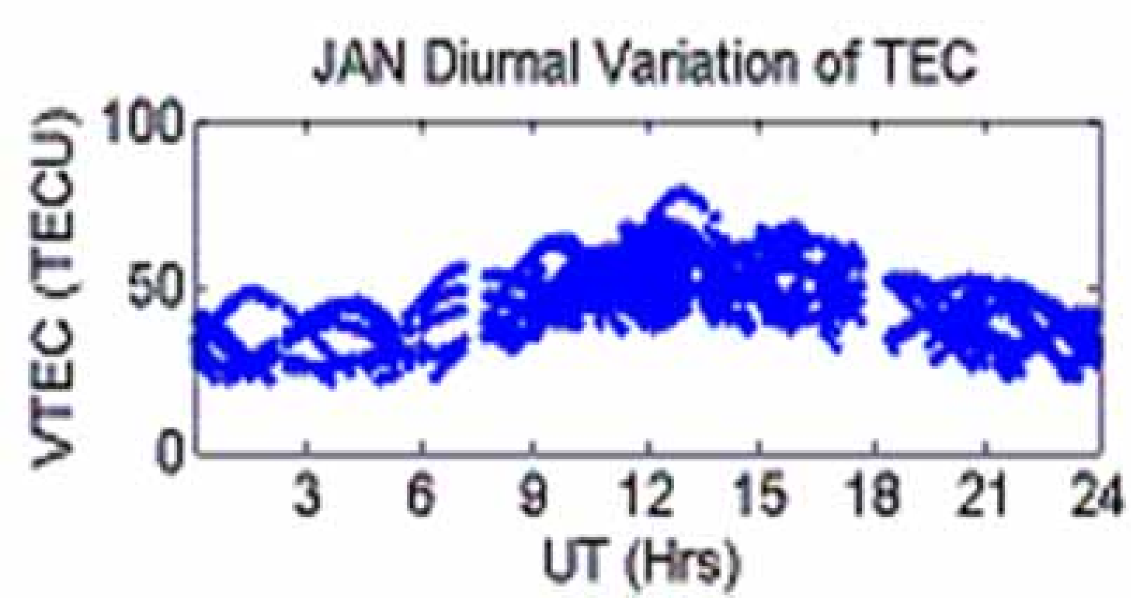
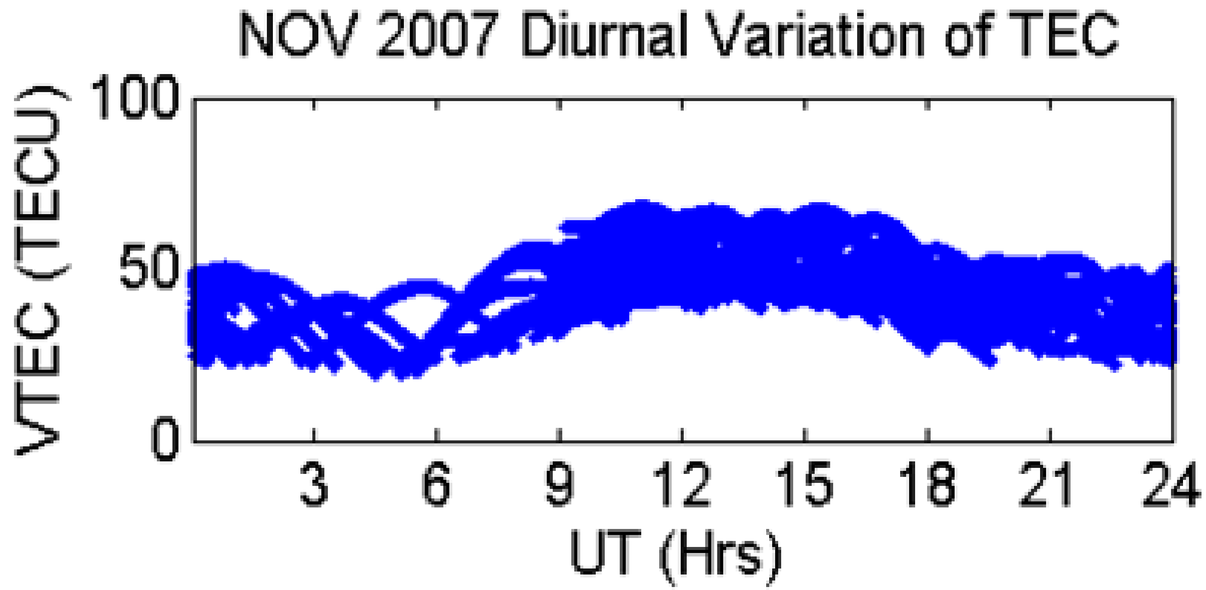
IHFACs Climatology

- 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

TEC STUDIES

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

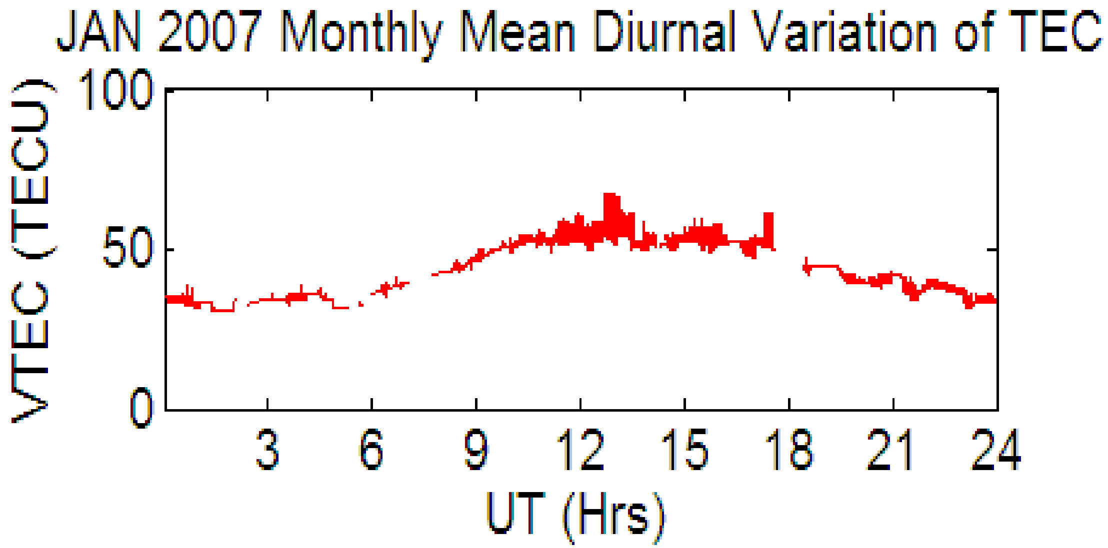


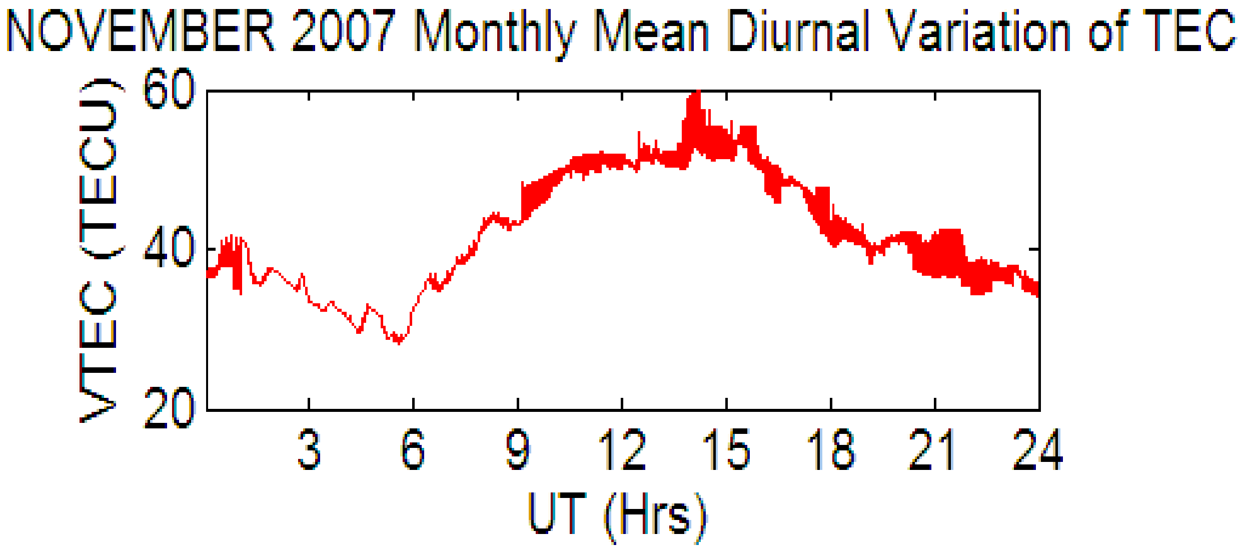


Diurnal Variation of VTEC over Akure

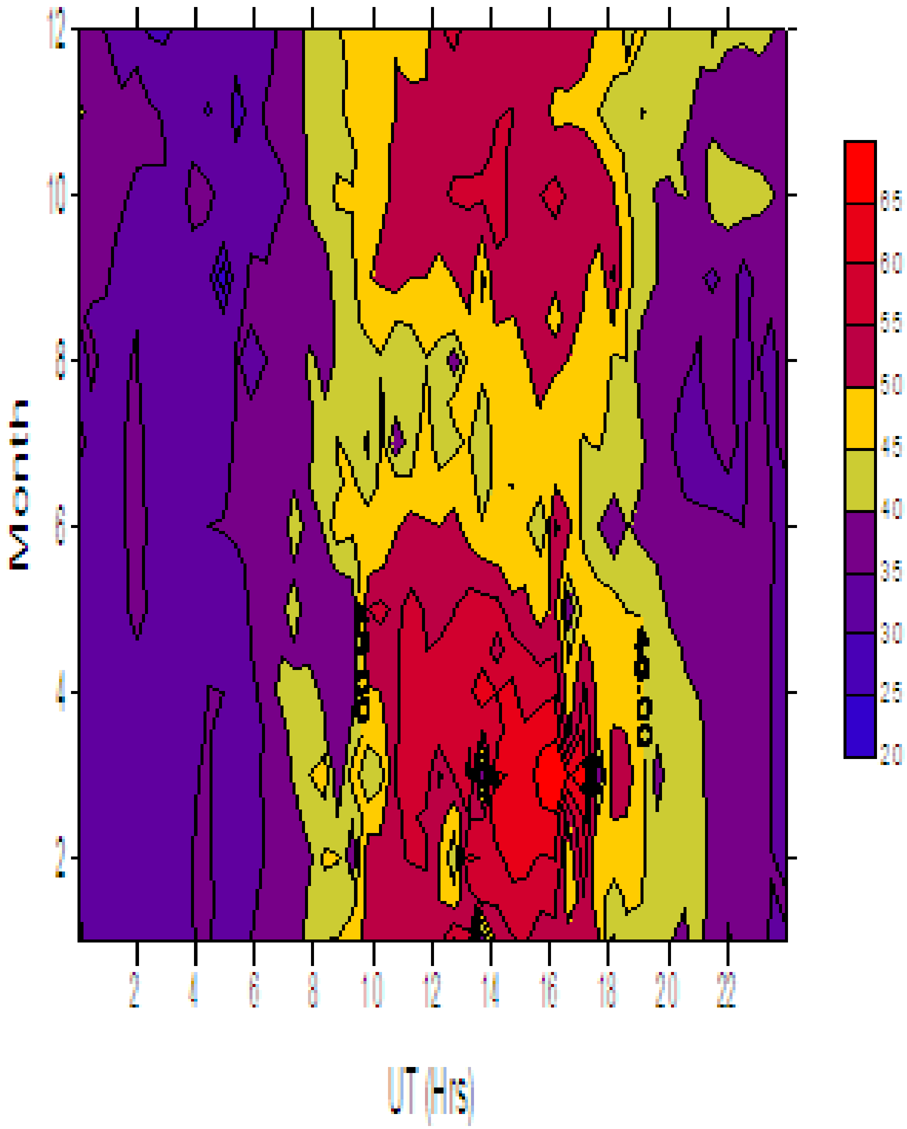
✓pre-dawn minimum for a short period of time followed by steep early morning increase.

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



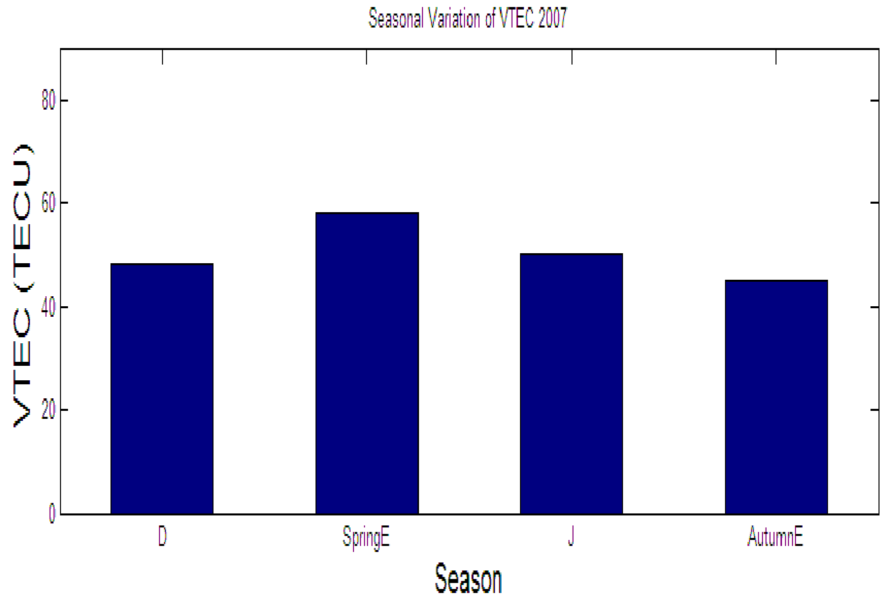


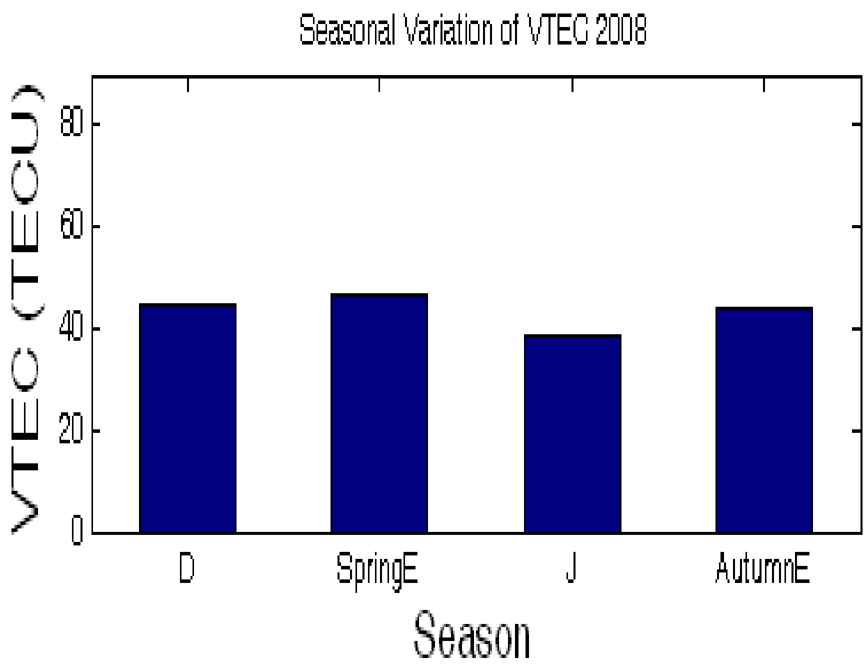
Annual VTEC variation at Akure, Nigeria



- **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





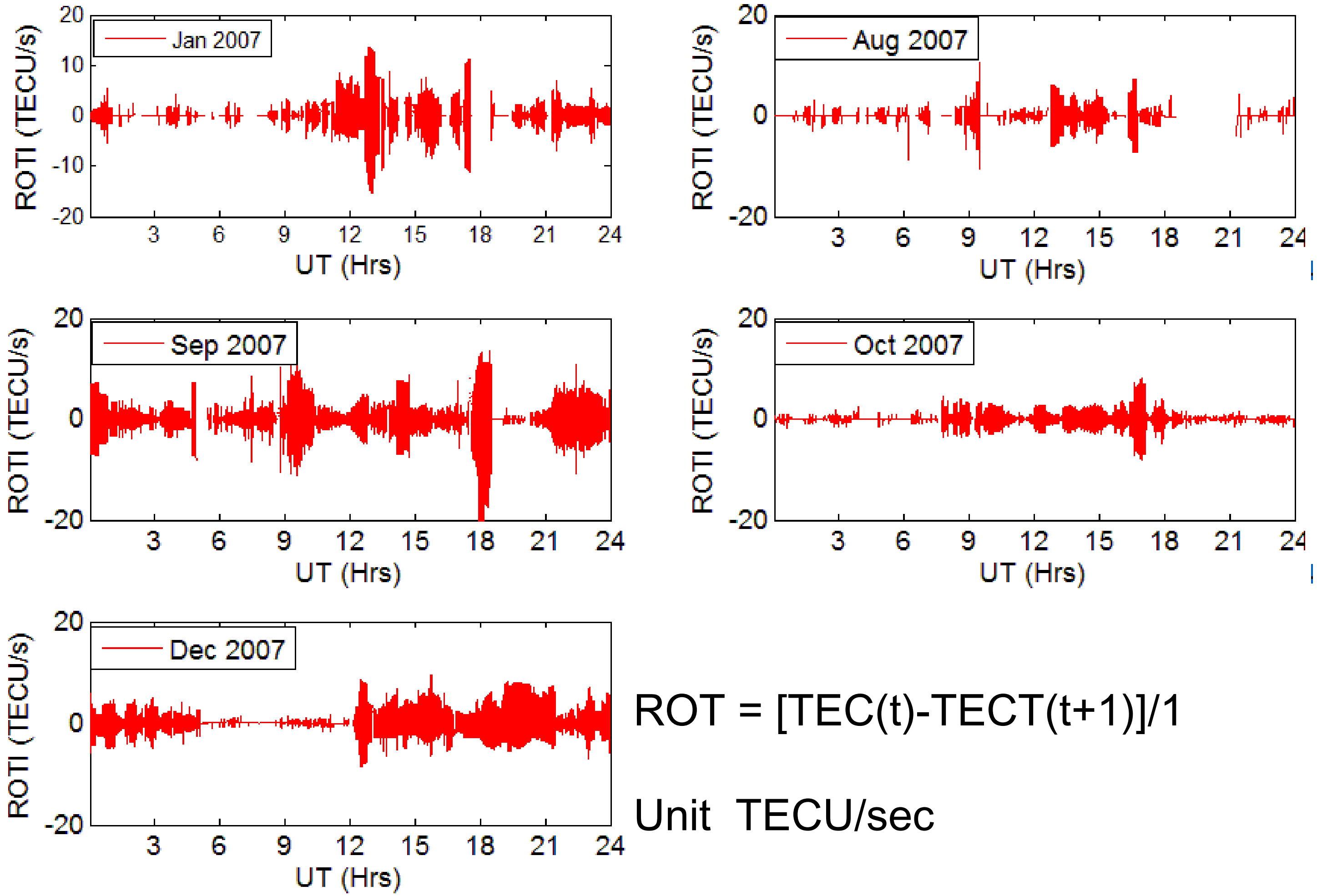
Seasonal variation of TEC

- **The semiannual variation of TEC is asymmetry with maximum in spring Equinox.**

ROT

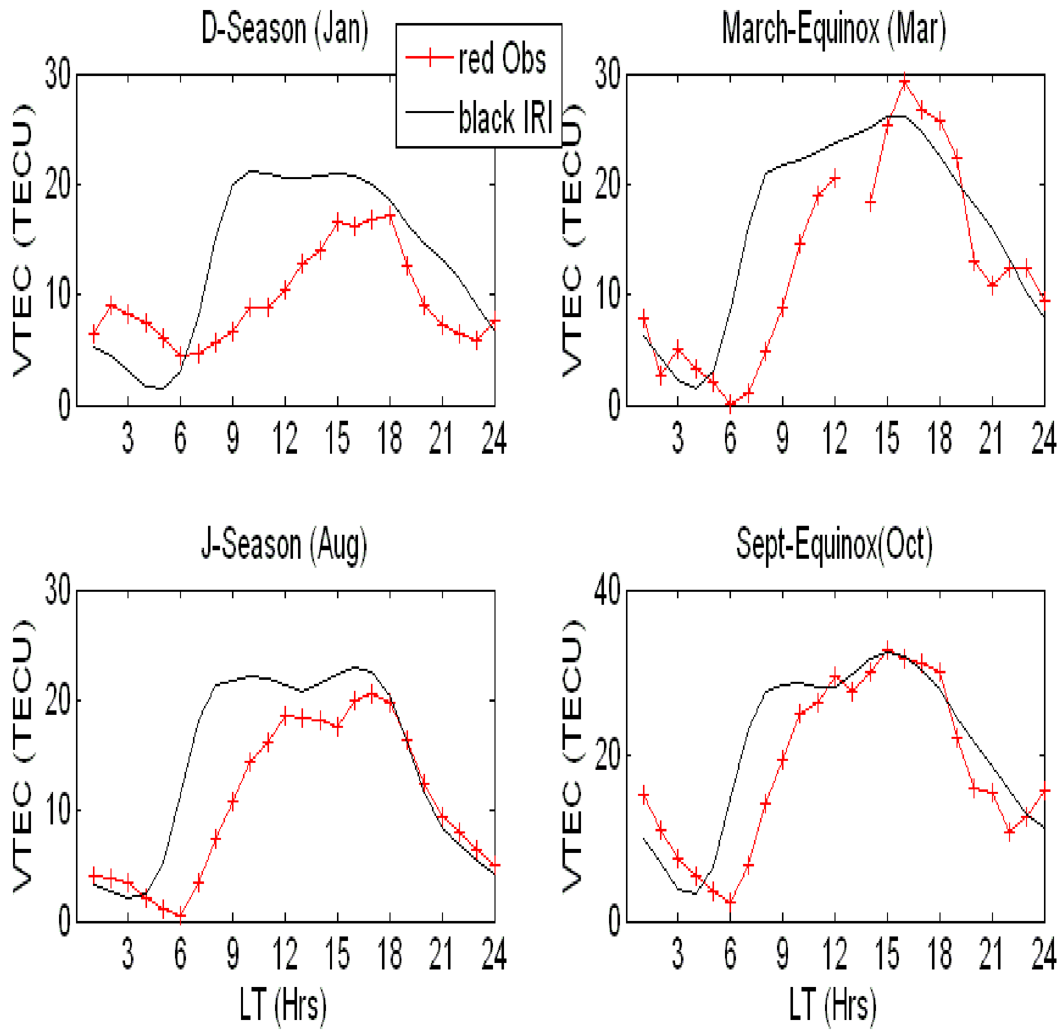
✓More TEC Fluctuations in daytime.

✓Seems to lack seasonal dependent



ROT = [TEC(t)-TECT(t+1)]/1

Unit TECU/sec



IRI & Observed TEC @ Akure 2010

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

Conclusions

- The main support for BSS in Africa has been foreign intervention in terms of observational facilities/equipment grants and fellowships (study/travels).
- We highlighted the contributions of UN BSSI (1992-2006), International Heliophysical Year IHY (2007-2009) and International Space Weather Initiative ISWI (2009-2012) to Africa

Conclusions

- Over 17 magnetometers (MAGDAS and AMBER), more than 25 GPS receivers (SCINDA and others), and well over 50 ionospheric RF sounders (Ionosonde, SID monitor and AWESOME) are now operational in Africa

- Some scientific results have been presented

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Thank You