

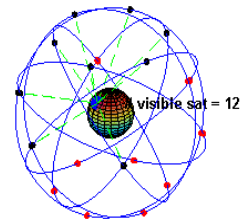
Space Weather Activities in Africa - prospects and challenges

Babatunde Rabi,

Centre for Atmospheric Research,
National Space Research & Development Agency,
Anyigba, Nigeria.

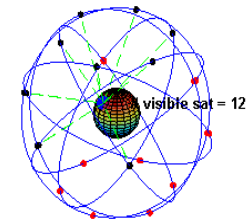
Email: tunderabiu@carnasrda.com, tunderabiu2@gmail.com

www.carnasrda.com



Outline

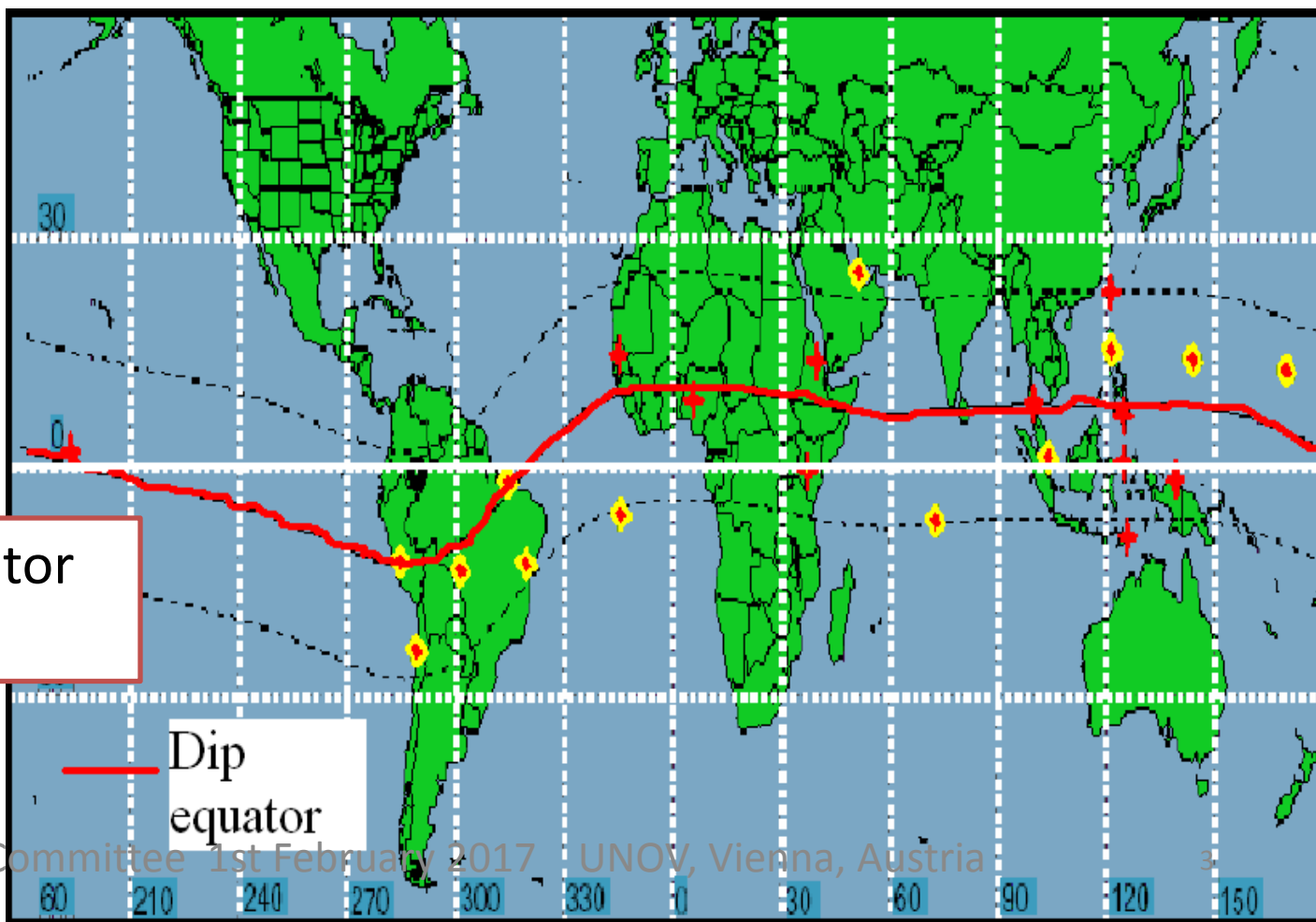
- Uniqueness of Africa in SW programs
- Participation of Africa in SW programs
- SW ground infrastructure densification programs
- National governments participation
- CAR contributions
- Summary



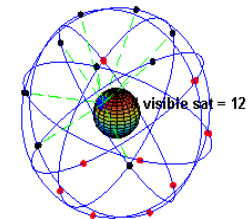
Uniqueness of SW over Africa

- Broad range of magnetic equator over land
- EIA width

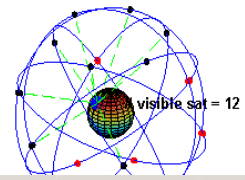
Atmospheric science



- geographic equator
- Large land mass



Space Weather Research Facilities in Africa

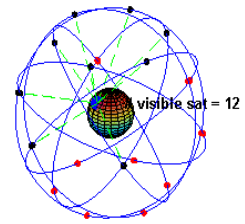


The African nations in Annals of IGY

pre-IGY years witnessed the establishment of new geophysical observatory sites all over the world

- Algeria
- Cameroon
- Egypt
- Ethiopia
- Ghana
- Nigeria
- Tunisia
- South Africa



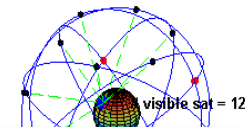


A break...

- Equipment – aged packed up
- After independence: Exodus of capable hands/brain drain
- Occasional campaigns come with hope



IHY/ISWI IN AFRICA



instruments

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

Capacity building

- ✓ Continental training of MSc and PhD student (more than 30)
- ✓ Short term visit to Overseas labs
- ✓ Series of Space Weather schools



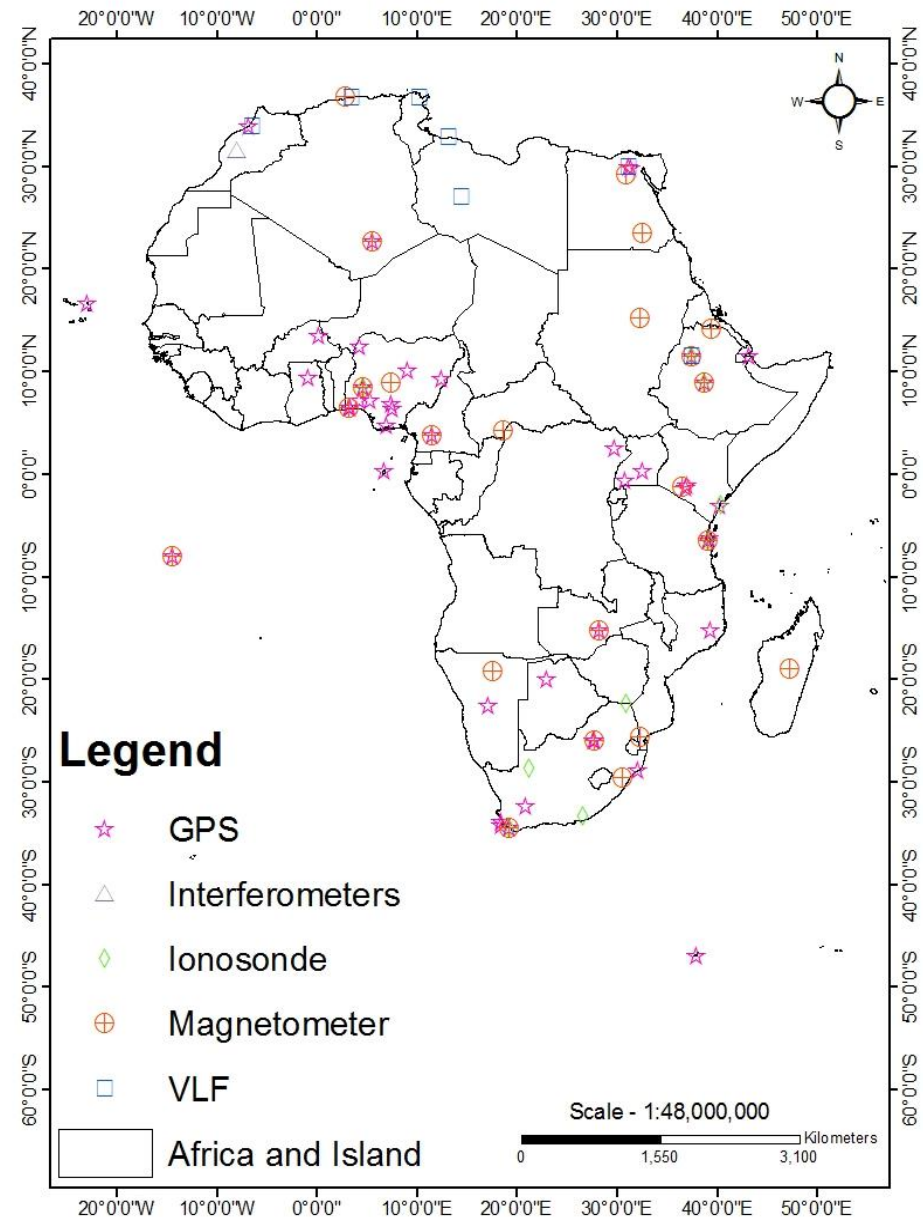
Workshops

- ✓ Egypt 2010
- ✓ Nigeria 2011



Facilities

- IHY/ISWI supported
 - MAGDAS magnetometers
 - SCINDA GPS
 - AMBER magnetometers
- ICTP/BC GPS, Ionosonde
- InterMAGNET magnetometers
- UNAVCO
- African Array
- AFREF Oriented GPS
 - NigNET GPS
 - TrigNET GPS

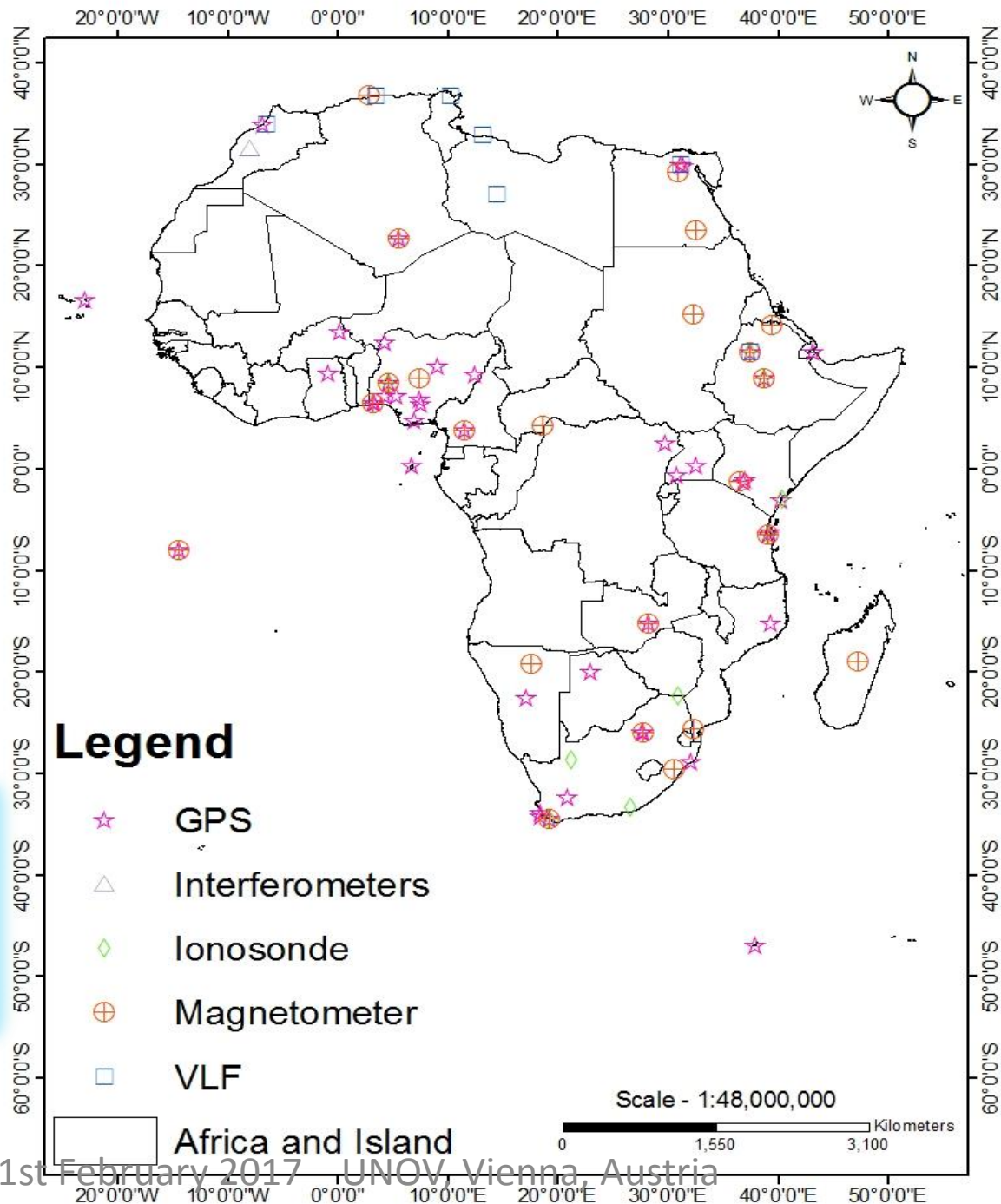




Status of Space Weather Research facilities

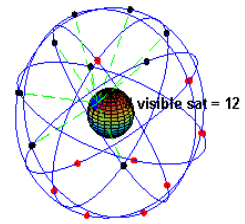
- ✓ **54 sovereign nations**
- ✓ **African Professors**
- ✓ **Diligent students**
- ✓ **Research facilities**

- Mostly foreign intervention
- National Participation

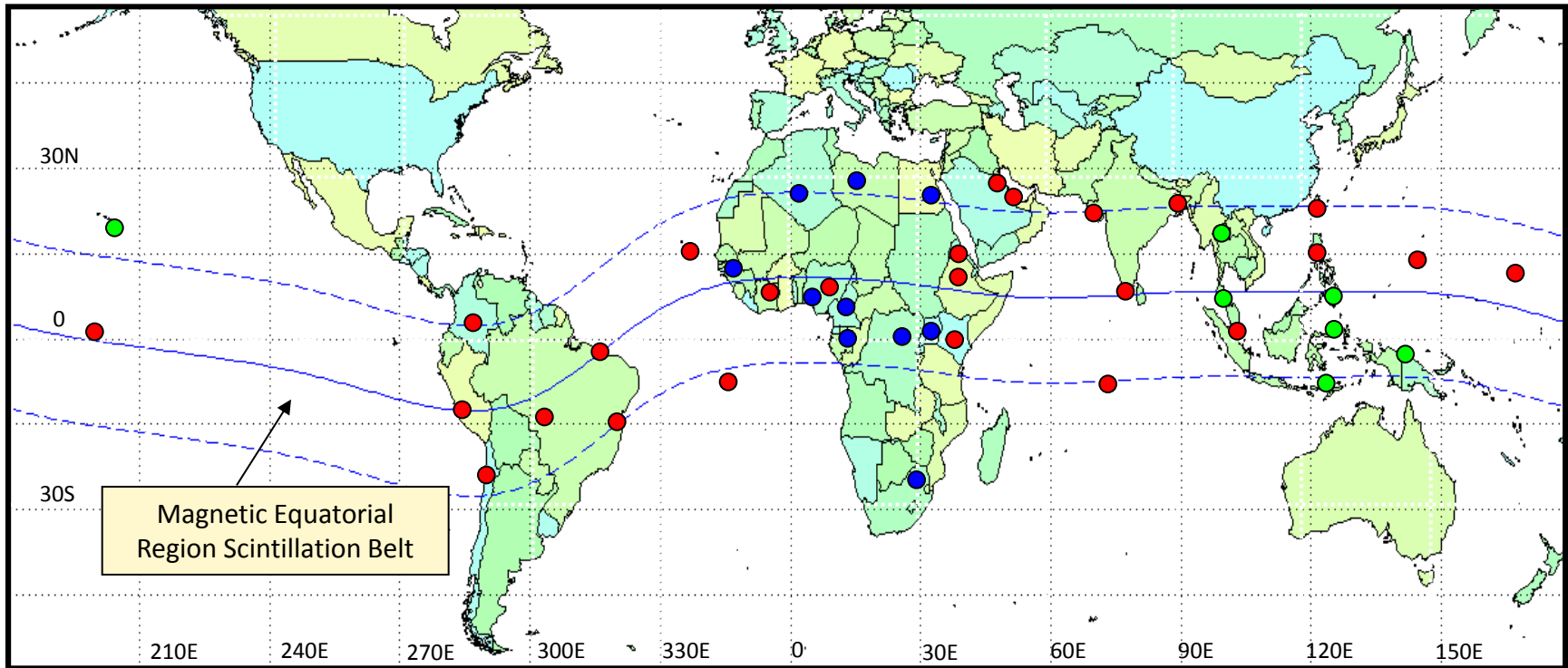




SCINDA Ground Stations



- Broad range of magnetic equator over land
- EIA width



[Groves, 2010]

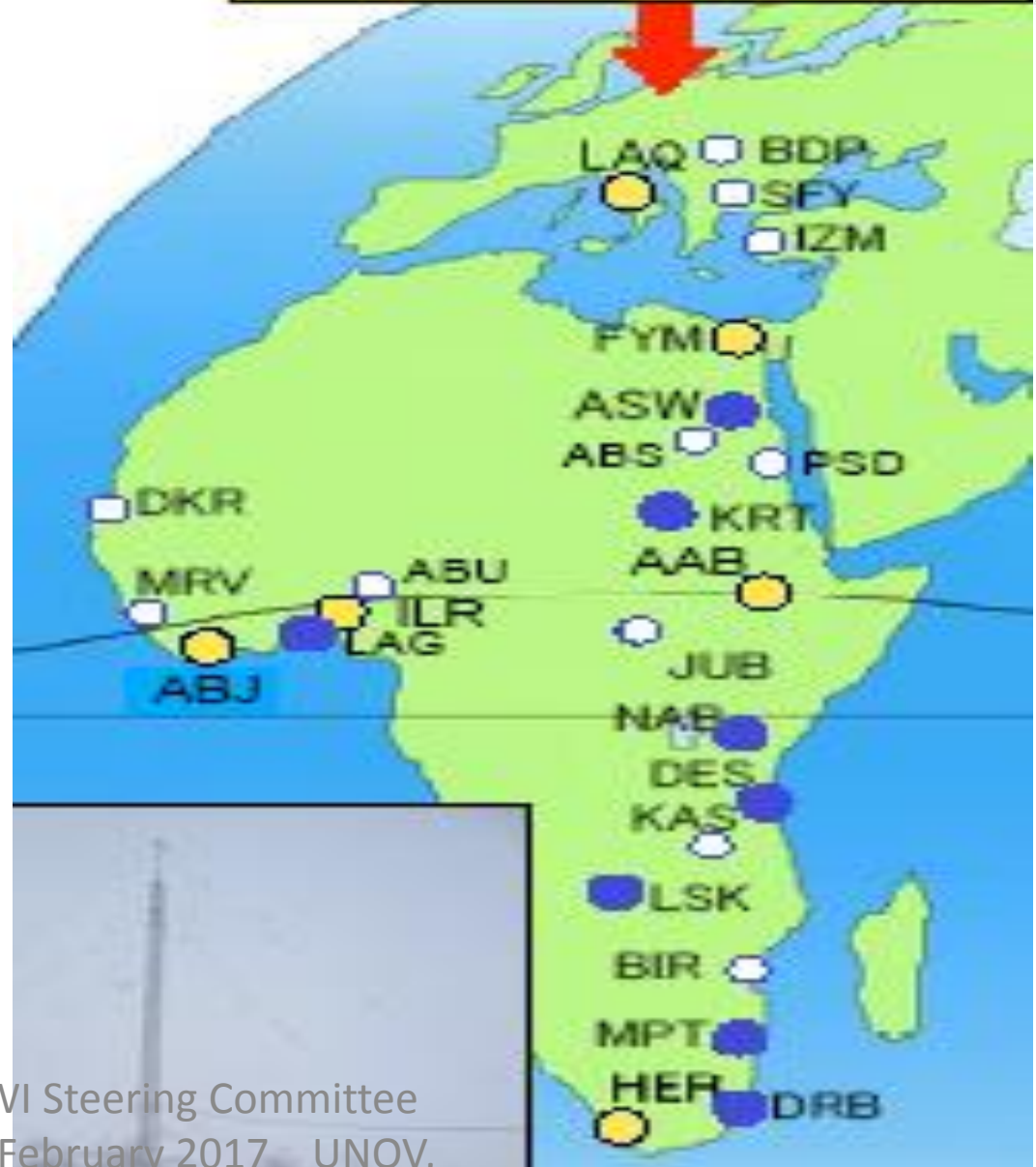
- Existing Sites
- UN IHY Sites
- Other/collaboration



Abidjan (Cote D'Ivoire)

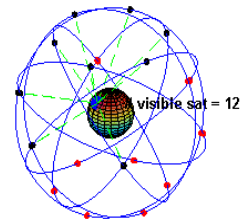
- ▶ Lagos (Nigeria)
- ▶ Ilorin (Nigeria)
- ▶ Fayoum (Egypt)
- ▶ Aswan (Egypt)
- ▶ Karthoum (Sudan)
- ▶ Addis Ababa (Ethiopia)
- ▶ Nairobi (Kenya)
- ▶ Dar Es Salam (Tanzania)
- ▶ Lusaka (Zambia)
- ▶ Maputo (Mozambique)
- ▶ Hermanus (RSA)
- ▶ Durban (RSA)
- ▶ Abuja (Nigeria)

96°MM Chain



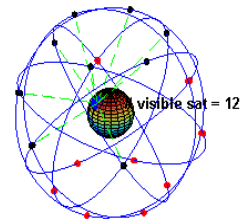
ISWI Steering Committee
1st February 2017 UNOV,

Vienna, Austria



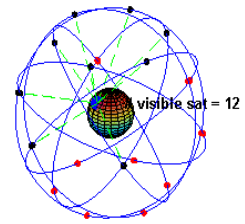
SW facilities in Africa

- ❑ 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)
- ❑ FPI
- ❑ Optical Imager



International Intervention in Capacity building

- Short term Space Weather schools organized in Africa
 - IHY, ISWI, SCOSTEP, MAGDAS, National Schools
- Short term exchange program
- ICTP
- BC
- Nagoya University
- Kyushu University
- SCOSTEP SVS



Output

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





Ionospheric research in Africa



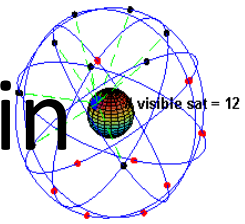
- The ALCANTARA Survey provided very interesting results about ionospheric research by scientists in the continent

| 2008 | 2009 | 2010 | 2011 | 2012 |
|------|------|------|------|------|
| 20 | 37 | 37 | 26 | 54 |

| Country | Total n° of papers | 1 st author from the country | 2008 | 2009 | 2010 | 2011 | 2012 |
|---------------|--------------------|---|-----------|-----------|-----------|-----------|-----------|
| | | | UGANDA | 2 | 1 | 0 | 0 |
| SOUTH AFRICA | 63 | 41 | 9 | 20 | 13 | 8 | 13 |
| NIGERIA | 56 | 45 | 9 | 8 | 12 | 9 | 18 |
| KENYA | 4 | 2 | 0 | 0 | 0 | 0 | 4 |
| | | | | | 2 | 1 | 3 |
| | | | | | 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 |

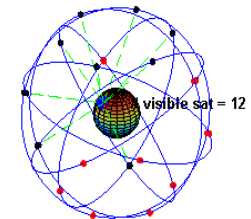
Table 14 Ionospheric research papers published by African scientists working in Africa

Radicella, et al 2014

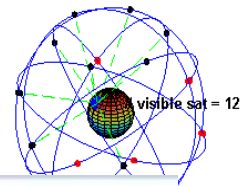


Studies in Space Weather Science in Higher Institutions

- | | | |
|---|---|---|
| <ul style="list-style-type: none">• Nigeria• South Africa• Egypt• Cote D'Ivoire• Ethiopia | <ul style="list-style-type: none">• Kenya• Zambia• Uganda• Burkina Faso• Algeria• Morocco• DR Congo | <ul style="list-style-type: none">• Ghana• Tanzania• Cameroon• Niger |
|---|---|---|

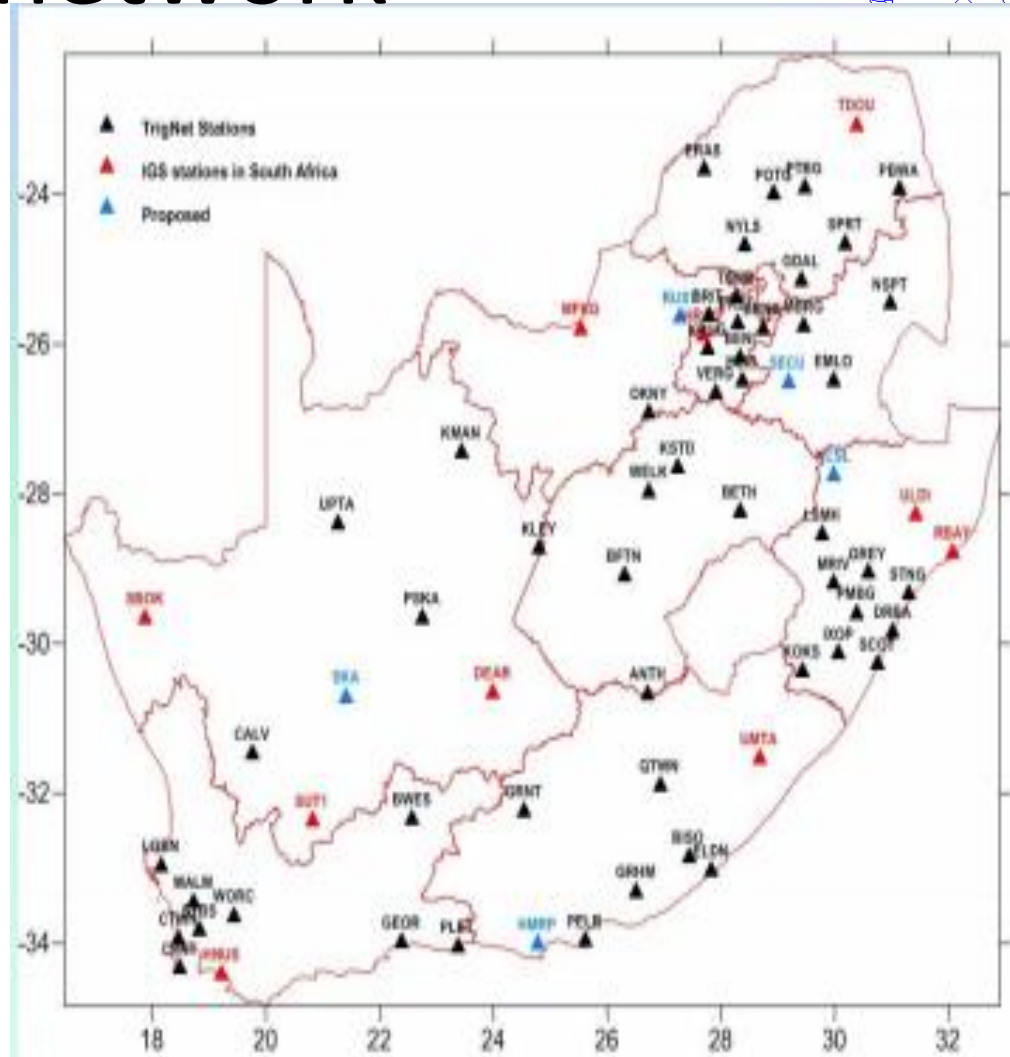


SOME NATIONAL GOVERNMENTS ARE BEGINNING TO PARTICIPATE IN INSTRUMENT DENSIFICATION



RSA: TrigNet network

- 67 base stations,
- maximum inter-station spacing distance of 300 km
- The data is streamed, via dedicated leased lines, to the National Geospatial Information NGI office in Cape Town
- where it is processed and made available, free of charge, to national & international users.

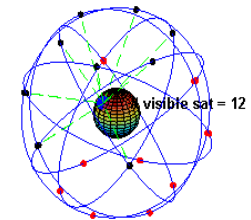


<http://www.trignet.co.za/>

[Rubinov et al, 2012]



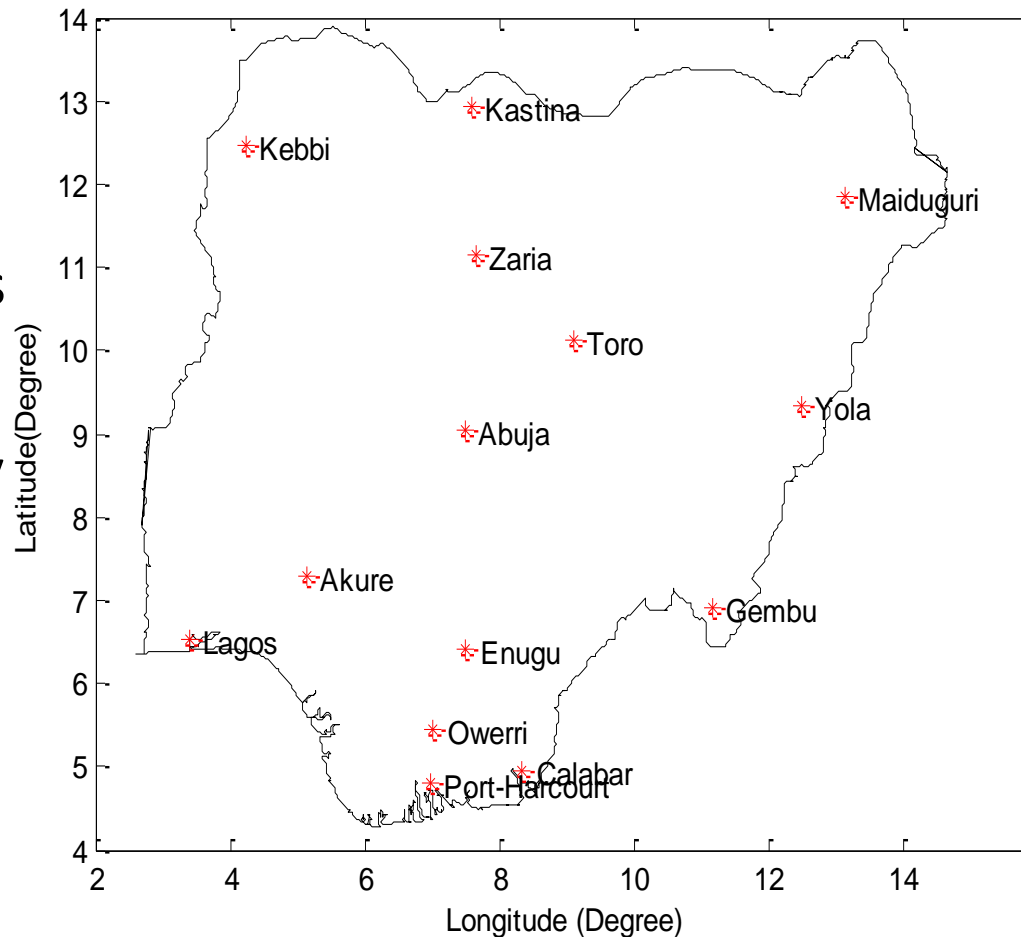
NIGERIA: NIGNET



- Primarily meant for land mapping and surveying
- RINEX files were accessed and 1st used for ionospheric studies by **Rabiu et al., (2014)**
- It's a project fully supported by the Office of Surveyor General of the Federal Government of Nigeria (OSGoF)
- 14 CORS

<http://server.nignet.net/data/>

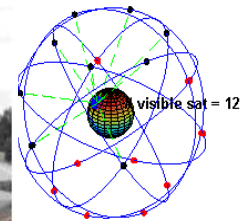
(Jatau et al, 2010)





NIGNET

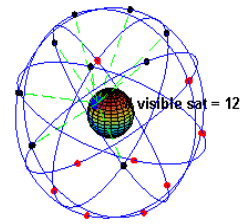
- **Top – OSGF station installed at OSGoF headquarters, Abuja**
- **Middle – UNILAG station installed at the campus of University of Lagos.**
- **Bottom Left –FUTY station installed at Federal University of Technology of Yola**
- **Bottom Right - location at Toro.**



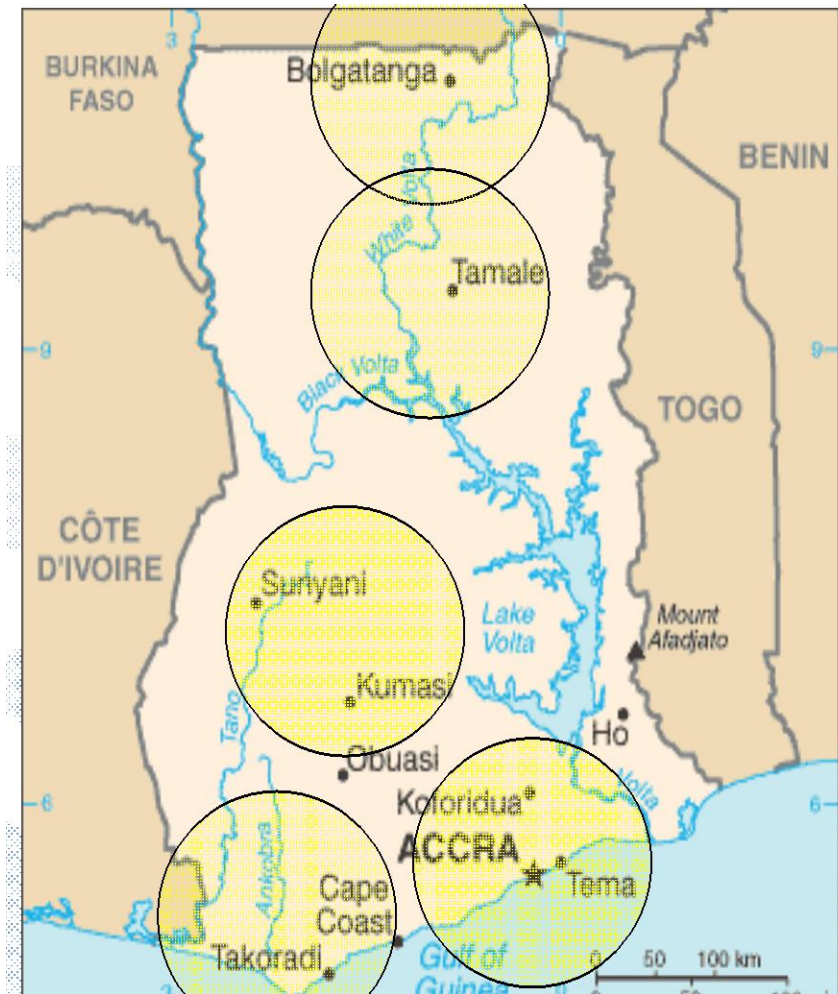
(Jatau et al, 2010, Sydney, Australia)



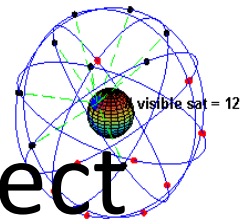
Ghana: Land Administration Project LAP



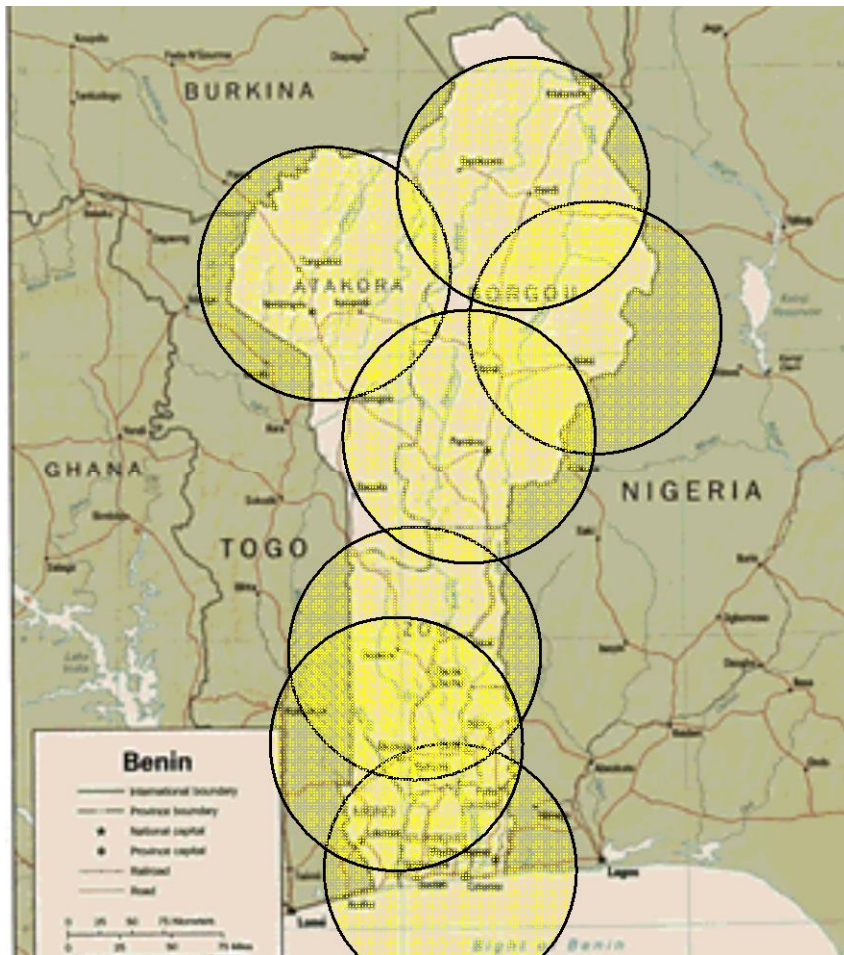
- Ghana is adopting GNSS & GPS technology
- Land Administration Project (LAP) is by GPS based technology
- **LAP involves establishing an acceptable geodetic reference frame for Ghana.**
- main objective: recompute, adjust, and densify the existing national geodetic reference network



primary goal: to support surveying & national land information systems (LIS)



Benin Republic: Access to Land Project

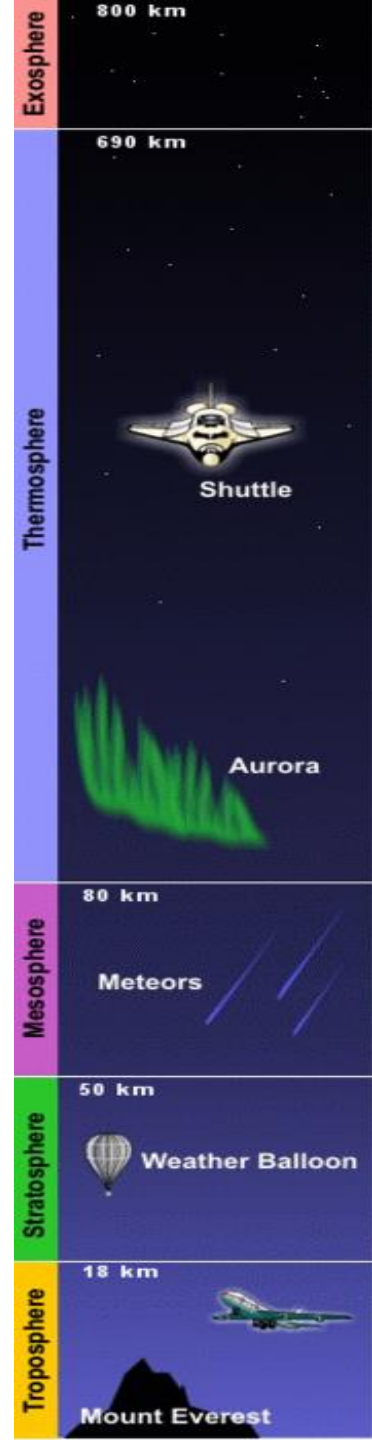


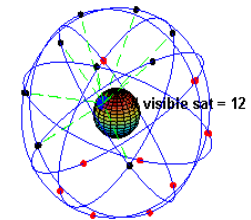
- Post processing of the survey data into National Grid using the CORS data centrally stored in Cotonou
- 100 km coverage using regional survey offices
- 100% national coverage



Centre for Atmospheric Research

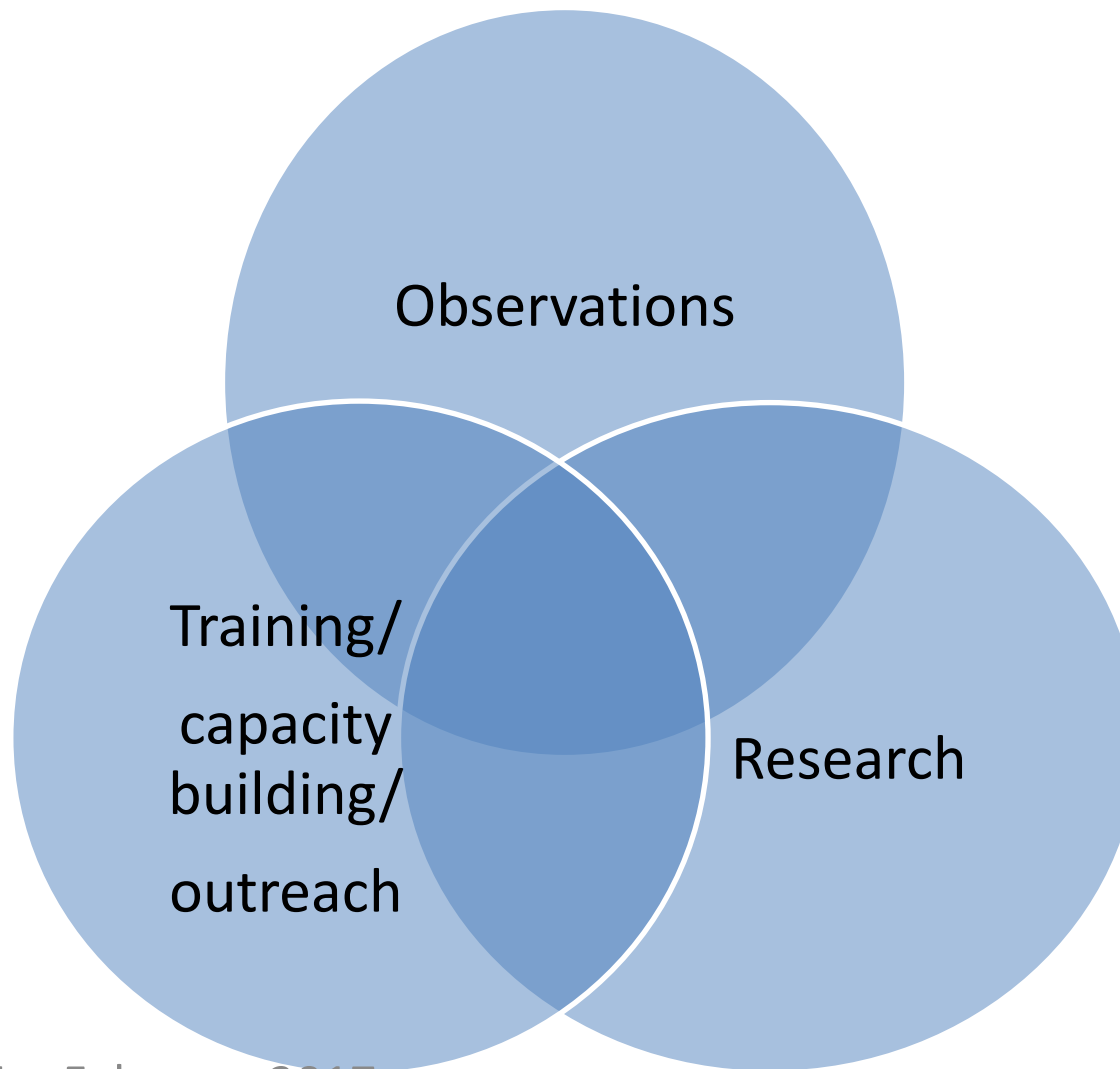
- Established January 2013
- Located at Anyigba, Kogi State, Central Nigeria
- To promote **capacity development in relevant atmospheric sciences** as a way of **facilitating international competitiveness** in research being conducted by atmospheric scientists; and
- To disseminate atmospheric data and products to users towards socio-economic development of the Nation





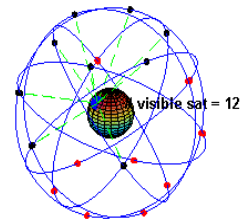
Operations

CAR is
envisioned to
operate in 3
modes



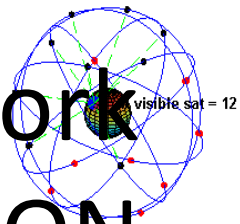


Research Projects of CAR



- ① Space Weather Observation Network over Nigeria-
SWONON
✓ Space Weather Observation Network over Africa- SWONOA
- ② Tropospheric Data Acquisition Network – TRODAN
- ③ Atmospheric Chemistry and Environment Research –
ACER
- ④ Microgravity and Human Space Technology - MHST
- ⑤ Atmospheric Research Software and Instrumentation
Development - ARSID

Space Weather Observation Network over Nigeria- SWONON

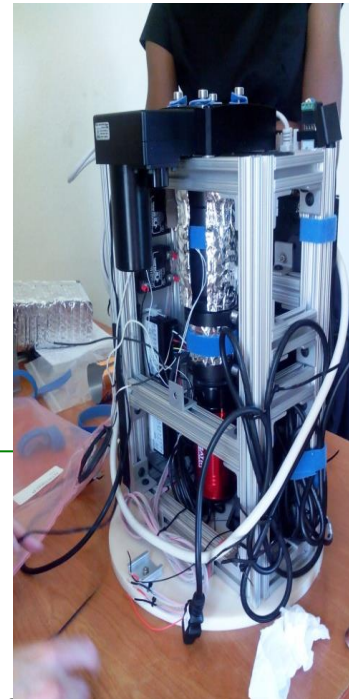


26

- Monitoring space environment including satellite altitudes
- Maintenance of existing stations
- Networking of existing stations
- 1 Station per state
- Data generation
- Secondary products

- Magnetometer
- GPS SW monitor
- Digisonde
- FPI
- All Sky Optical imager

Equipment



2017 / UNOV,

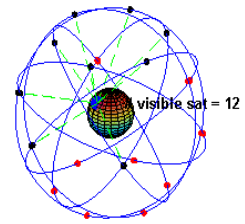
Vien. Austria



5-8 November 2013;
Sokoto

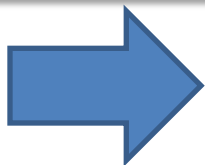


Space Weather Observation Network over Nigeria- SWONON



- to monitor and nowcast space weather over Nigeria
- To develop in-country expertise for implementation, operations, processing and analyses of space weather processes.

Network of ground-based space observatories (facilities include magnetometers, digisondes, ionospheric GNSS monitors, optical imagers)



SWONOA

ISWI Steering Committee 1st February

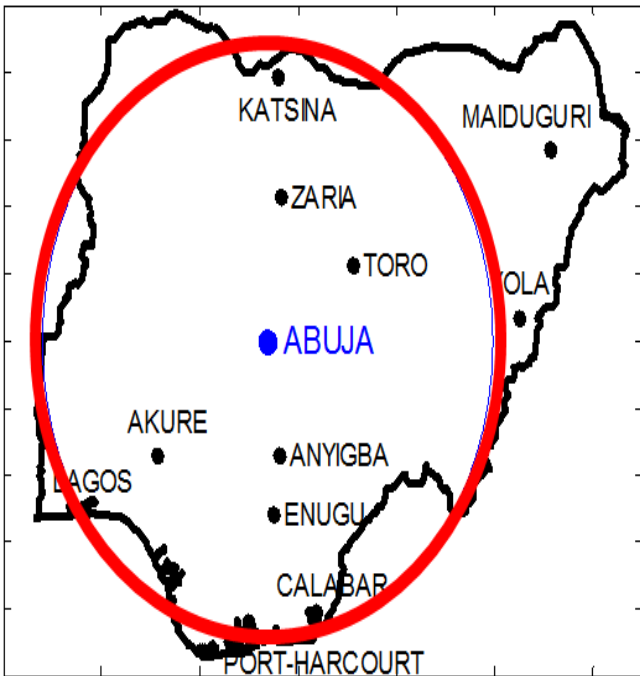




Space Environment Research Lab, Abuja

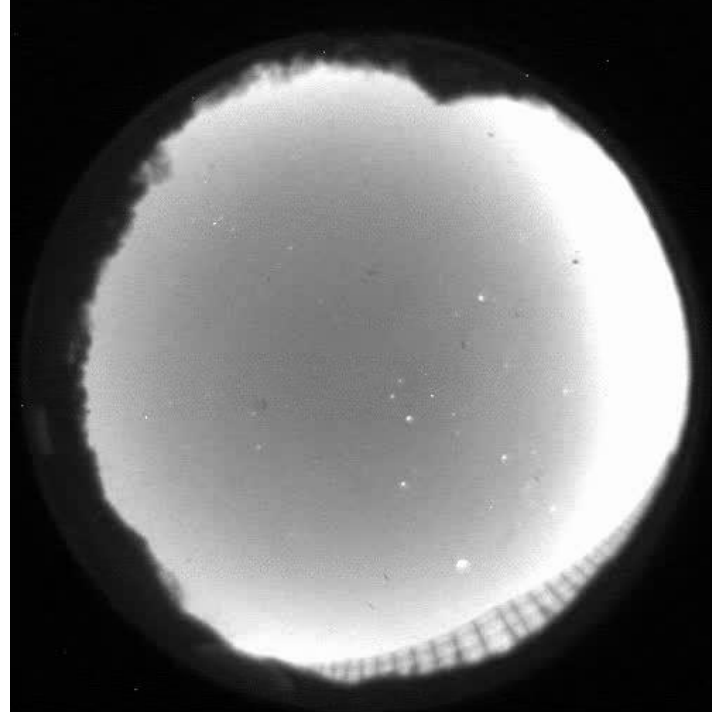
- June 2015
- Partnership with ISEE, Nagoya University, Japan
- FPI, Magnetometers (2), GNSS Space Weather Monitor



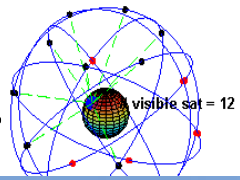


Abuja, Nigeria

June 21, 2015



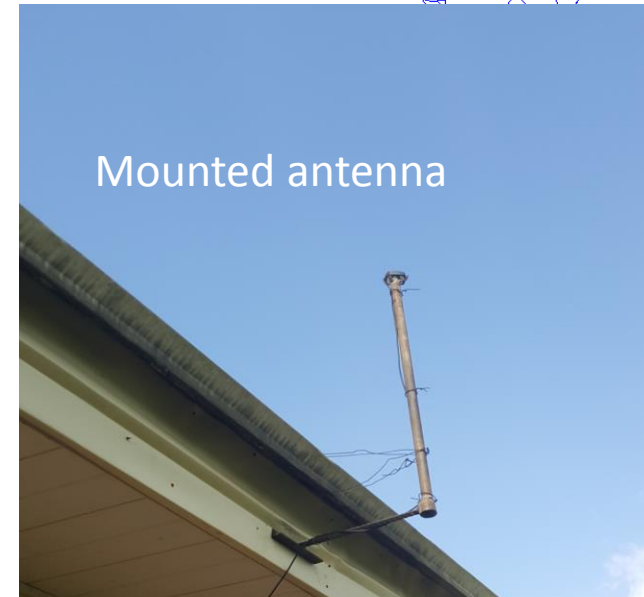
captures the space environment up to 500 km over a radial distance of up to 400 km and gives information about travelling ionospheric disturbances, gravity waves and plasma bubbles among other ionospheric phenomena



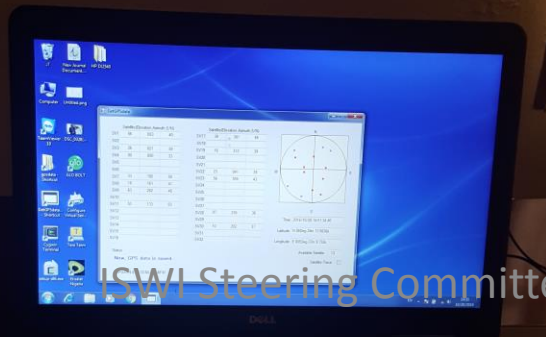
- Located at the University of Benin

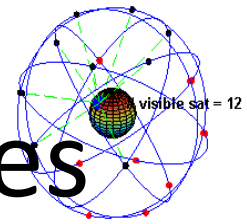
Activity began on 1st September 2016

- 1st equipment Scintillation monitor
- installed in SEERL 20 October 2016



Mounted antenna

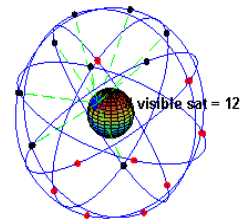




CAR Space Research Laboratories

- Abuja, Benin, Kano
- Scintillation monitor
- Magnetometer installed January 2017 at Lokoja
- Planned GPS CORS installation in cooperation with NIGNET at Benin



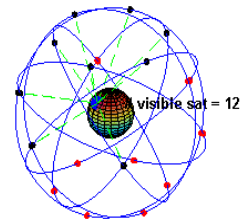


Challenges

- institution, not an individual, should be in charge of equipment deployed to Africa
- Intra-continental cooperation becomes necessary for effective coordination of SW infrastructure in Africa
- International community should promote organisation of schools/workshops meant for Africa within Africa

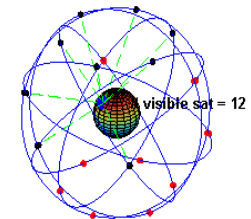


Summary



- Intensified complimentary efforts at densifying the ground infrastructures for monitoring space weather
- ISWI has positive impact in Africa
- Promotion of intra-continental cooperation becomes necessary for effective coordination of SW infrastructure in Africa





Thank You

