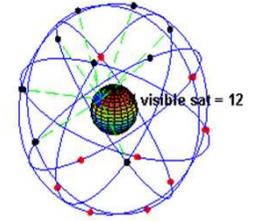


GNSS in Africa: Applications, Infrastructures, Research Implications & Prospects

*Babatunde Rabi,
Centre for Atmospheric Research,
National Space Research & Development Agency,
NASRDA, Anyigba, Nigeria
Email: tunderabiu2@gmail.com*

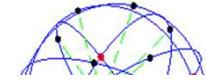


Outline



GNSS Challenges in Africa

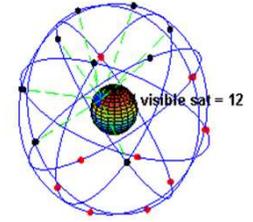
- About Africa
- Applications of GNSS in Africa
- Status quo
- AFREF and National Reference Frames
- AfricaArray
- IHY/ISWI
- ICTP-BC Joint Program on GNSS
- Prospects
- Conclusion.



Africa !



- A continent
- 54 individual nations
- Multi-lingual structure
- English, French, Portuguese, Arabic, Spanish
- ~ 30 billion km²
- ~ 850 million people
- ~14% World population

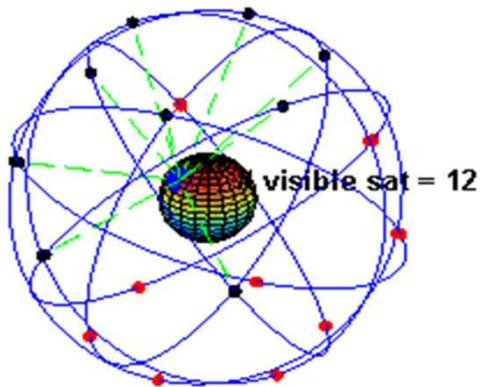


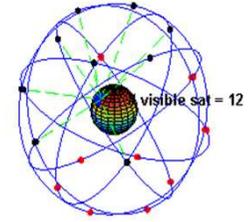
GNSS

Science

Technology

Applications





Science with GNSS

➤ Atmospheric & Geophysical research

- Characterization of ionosphere using TEC
- Space weather studies
- Scintillation studies
- Atmospheric delay
- TIDs
- Validation/improvement of existing atmospheric models
- Water vapour estimation
- Climate change studies
- Seismic studies

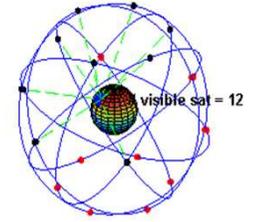
Output



- ✓ PhDs
- ✓ M.Sc
- ✓ Research publications

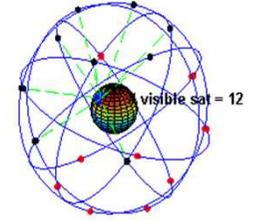


Social-Economic Applications



on increasing level

- 🌐 positioning services,
- 🌐 surveying & mapping,
- 🌐 Boundary mapping
- 🌐 food security,
- 🌐 disaster management,
- 🌐 air, land & sea navigation,
- 🌐 Land administration
- 🌐 emergency response
- 🌐 Wild life management

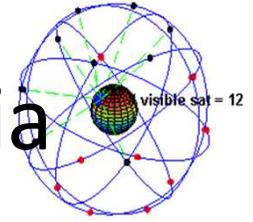


Impact of GNSS

- ✓ Military
- ✓ Aviation
- ✓ Education
- ✓ Economy
- ✓ Agriculture
- ✓ Minerals & oil exploration
- ✓ Disaster monitoring systems
- ✓ Land & maritime transportation
- ✓ Land surveying
- ✓ Health
- ✓ Revenue



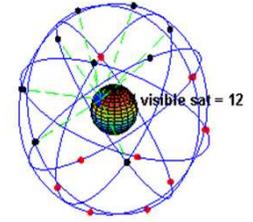
GIS & Land Administration in Nigeria



- A viable tool for promotion of Good Governance
- a system for land & property management, registration & taxation
- being used to increase revenue generation, planning & collection.
- Additional System features include data storage, information management, quick and easy data access, as well as retrieval of Statistical data and updated reports from the office & field.
- proved to be highly efficient and has greatly changed the landscape of town-planning services and land administration
- Uncovered some past corrupt practices
- removal of existing bottlenecks in the current land titling and registration procedures
- Abuja & Lagos (AGIS); being planned for entire nation

<http://www.punchng.com/news/land-reform-fg-picks-ondo-kano-for-pilot-scheme/March 12, 2012 Punch Newspaper>

<http://www.abujagis.com/index.html>



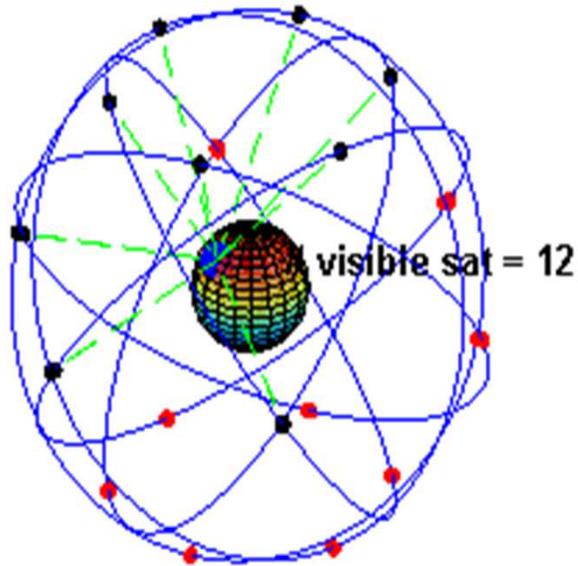
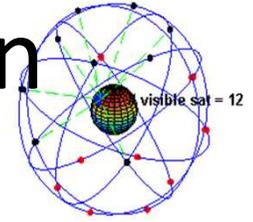
Defense/Military

- Signal transmission
- Robotics
- Space commands
- Navigation
- Drones





Applications of GNSS Technology in Africa



Wild life
conservation



1: Surveying



2: Road
transport



3: Aviation



4: Maritime
transport



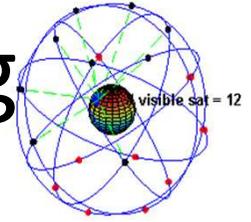
5: Environment
and agriculture



6: Civil
protection and
surveillance



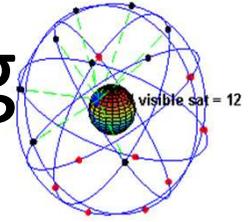
Latest Application: News Gathering



African Leadership Conf ALC Sp

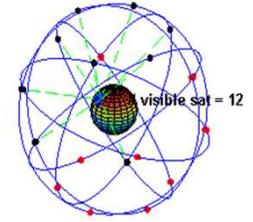


Latest Application: News Gathering

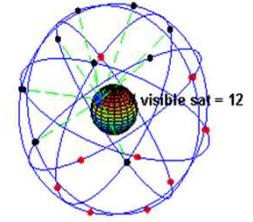




Other Applications in Nigeria

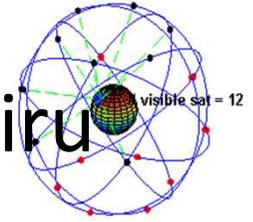


- Fadama rice plantation (Agriculture)
- control of meningitis disease
- desertification control and
- monitoring of encroachment of ocean along the coast
- Mapping of Bitumen deposit in SW Nigeria
- Climate change related studies



GSM & GPS

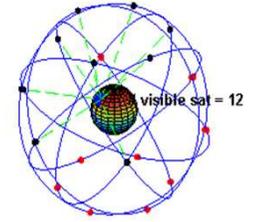
- GSM telecommunication systems are synchronized with GPS systems
- GSM users are now track-able – position and time
- Location identification
- Crime control and public safety



Phone call to Abu Qaqa gave Terrorist Kabiru Sokoto away

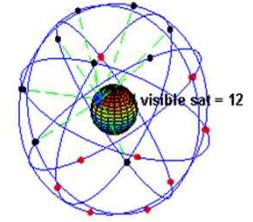
- The escapee Boko Haram's Christmas bomber, Kabiru Sokoto was re-arrested by the Nigerian Secret Police gave himself away when he called their spokesman, Abu Qaqa.
- Mallam Kabiru Sokoto not aware that the spokesman of the boko haram terror group, Abu Qaqa have been arrested, called Qaqa while he was in custody.
- The secret police with their improved **technology tracked him through GPS of his mobile down** to Mutum-Biu, in Gassol LGA Area of Taraba, where he was hiding inside a wardrobe
- Was re-arrested at about 4:00am on 10th February 2012

<http://www.naijaurban.com/phone-call-to-abu-qaqa-gave-kabiru-sokoto->



Ghana: Land Administration Project

- Ghana is adopting GNSS and GPS technology
- Govt of Ghana set out to implement Land Administration Project (LAP) by GPS based technology
- **LAP involves establishing an acceptable geodetic reference frame for Ghana.**
- A main objective for this was to recompute, adjust, and densify the existing national geodetic reference network
- The primary goal is to support surveying and national land information systems (LIS)



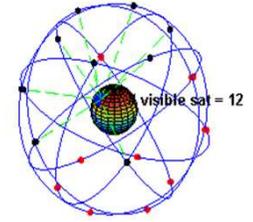
Ghana: Land Administration Project

- Ghana is adopting GNSS and GPS technology
- Govt of Ghana set out to implement Land Administration Project (LAP) by GPS based technology
- **LAP involves establishing an acceptable geodetic reference frame for Ghana.**
- A main objective for this was to recompute, adjust, and densify the existing national geodetic reference network
- The primary goal is to support surveying and national land information systems (LIS)

Any new news on LAP?



GNSS Receivers Densification Programmes in Africa



AFREF



National Reference Frames



IGS



IHY/ISWI

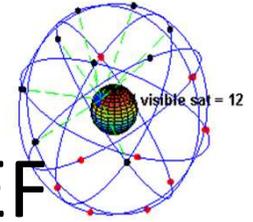


AfricaArray



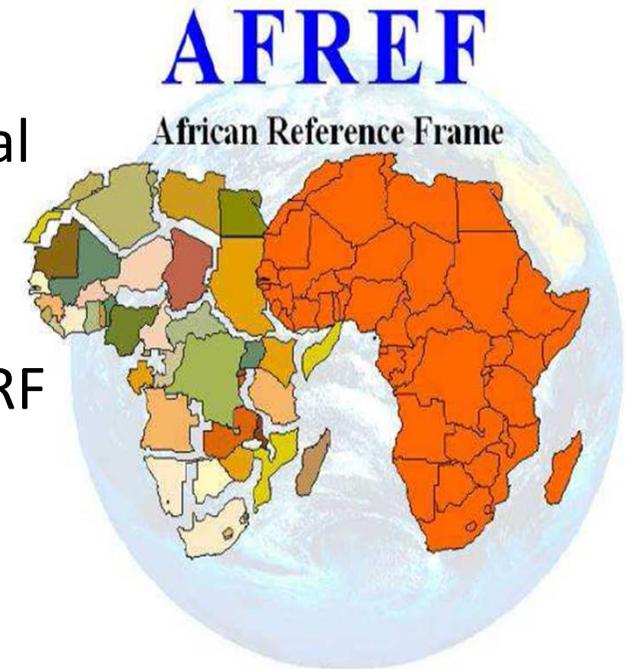
ICTP-BC joint GNSS program





The African Geodetic Reference Frame AFREF

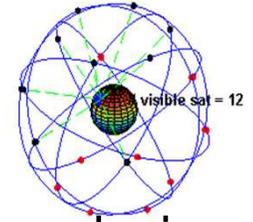
- ❑ a unified geodetic reference frame
- ❑ fundamental basis for the national & regional three-dimensional reference networks
- ❑ fully consistent and homogeneous with the International Terrestrial Reference Frame ITRF
- ❑ Densification of GNSS networks with its products in Africa
- ❑ Full implementation will include a unified vertical datum and support for efforts to establish a precise African geoid



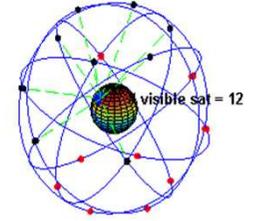
<http://geoinfo.uneca.org/afref/>



AFREF: African solution

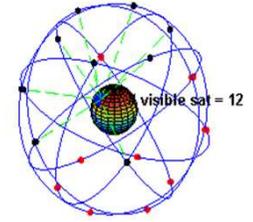


- ✓ each African country has its national geodetic reference system for producing maps and other geoinformation products - some countries even have more than one
- ✓ representation of cross-border features on maps cannot be done accurately
- ✓ For example, roads, watershed & ecosystem boundaries and wildlife reserves appear disconnected when national maps are joined together for regional planning and decision analysis
- ✓ Work on large infrastructure projects is normally undertaken in sections
- ✓ a uniform mapping surface is required to ensure that the sections join up
- ✓ To unify the reference systems, parameters of the best fitting surface for map projections need to be determined and used by all countries

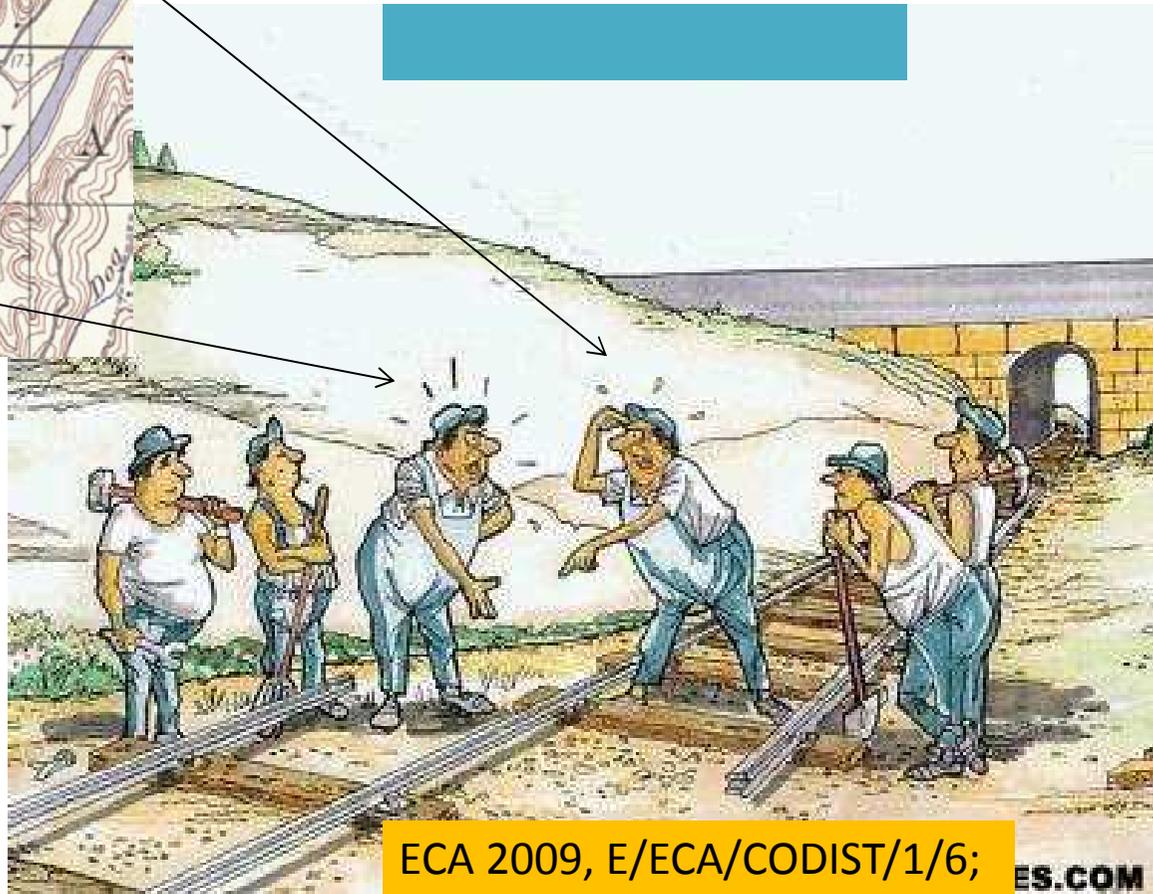


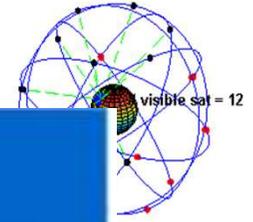
Consequences of using reference systems that are not consistent !



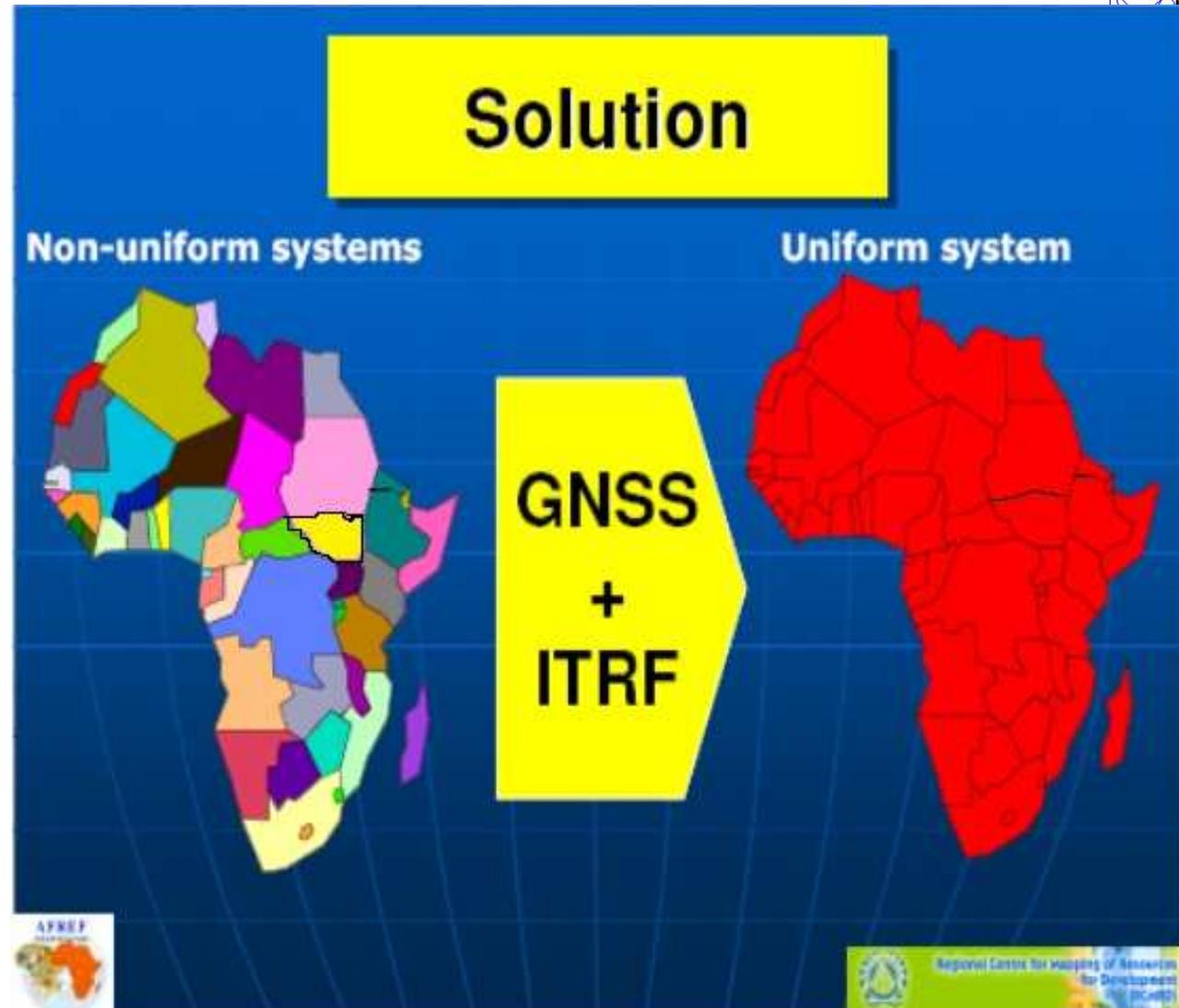


Products of incoherent maps - confusion





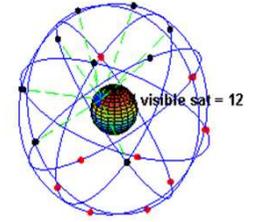
Reducing 54
Reference
frames to
1



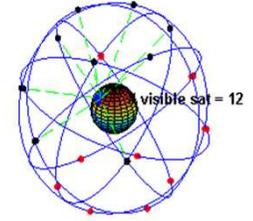
Combrinck (AFREF Presentation Berlin GNSS 2008)



Strategy

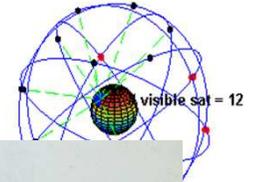


- Densification of GNSS CORS
- Central processing of data

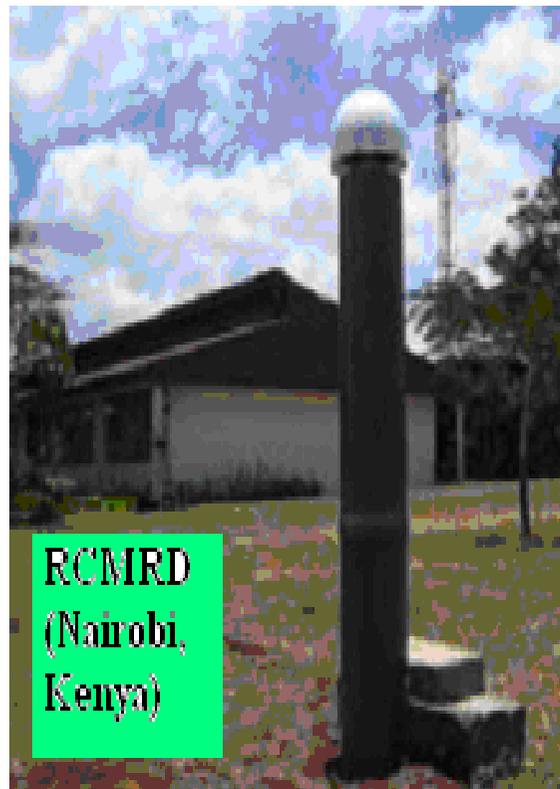


National Participation

- More than 5 countries have established a network of CORS
 - Ghana
 - Tanzania
 - South Africa
 - Nigeria
 - Egypt
 - (???)
- About 20 countries now have at least one CORS



Typical AFREF CORS



RCMRD
(Nairobi,
Kenya)



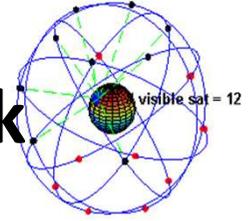
RECTAS
(Ile Ife,
Nigeria)



Recently installed
GPS antenna at
Sokoto, Northern
Nigeria, 6th Nov 2013



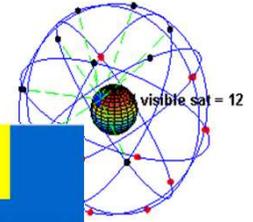
Benefits of Good national geodetic network



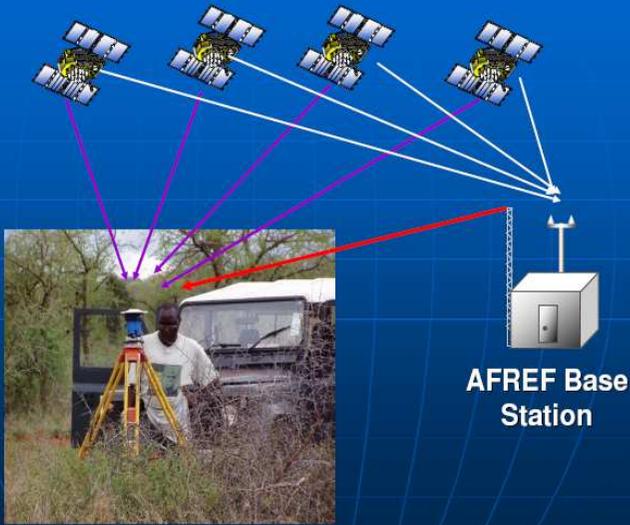
- ✓ Provides foundation for all geo-referencing activities.
- ✓ It is the base for coherent multipurpose Land Information System (cadastre) and its subsequent maintenance.
- ✓ positioning services,
- ✓ surveying & mapping,
- ✓ Community-Boundary mapping
- ✓ food security, disaster management,
- ✓ air, land & sea navigation,
- ✓ Effective land administration, registration & taxation
- ✓ emergency response, management of resources
- ✓ promotion of Good Governance
- ✓ revenue planning and collection.
- ✓ Checkmating corrupt practices



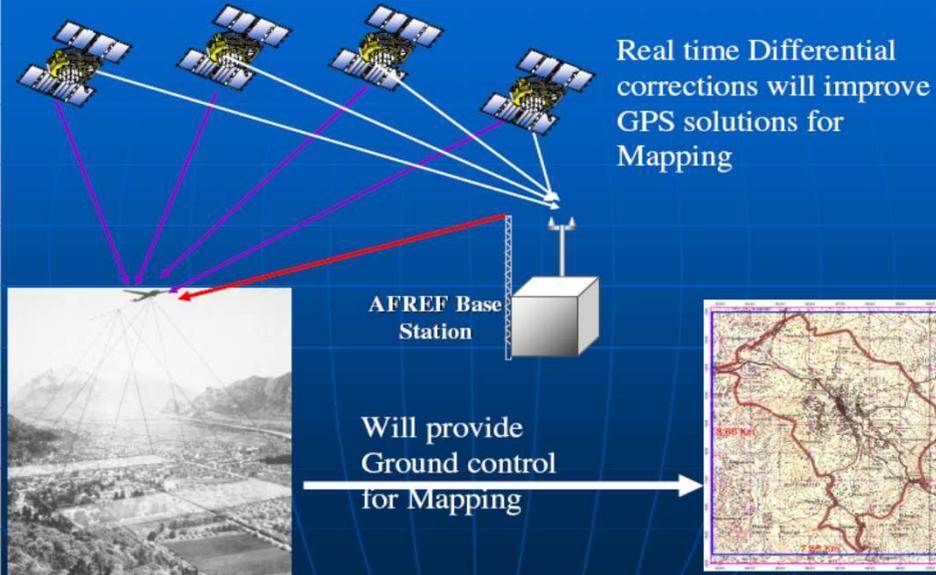
Capabilities of AFREF (Combrinck, 2008)



Applications in Land Surveys

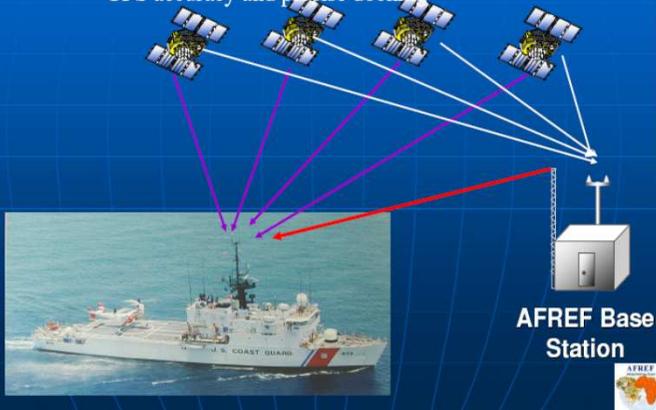


Applications in Mapping



Applications in Water Navigation

Real time Differential corrections will improve GPS accuracy and precise docking



Applications in Air Navigation

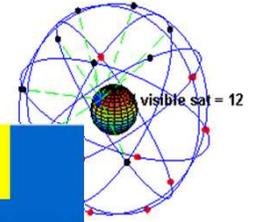
AFREF base stations(s) will provide coordinate corrections to planes for precise airport location and landing



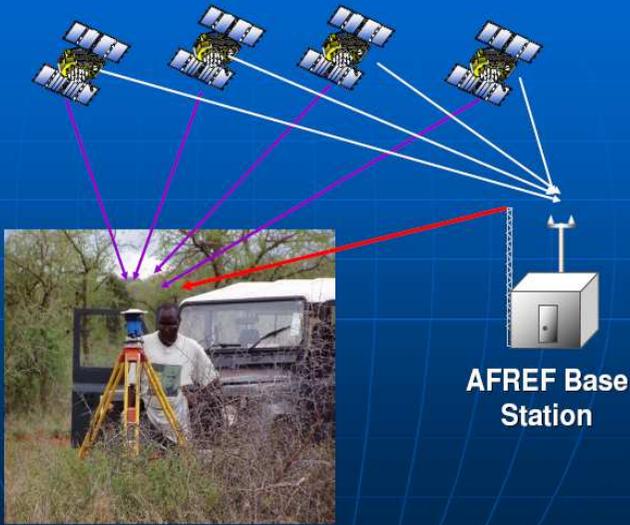
Combrinck, 2008



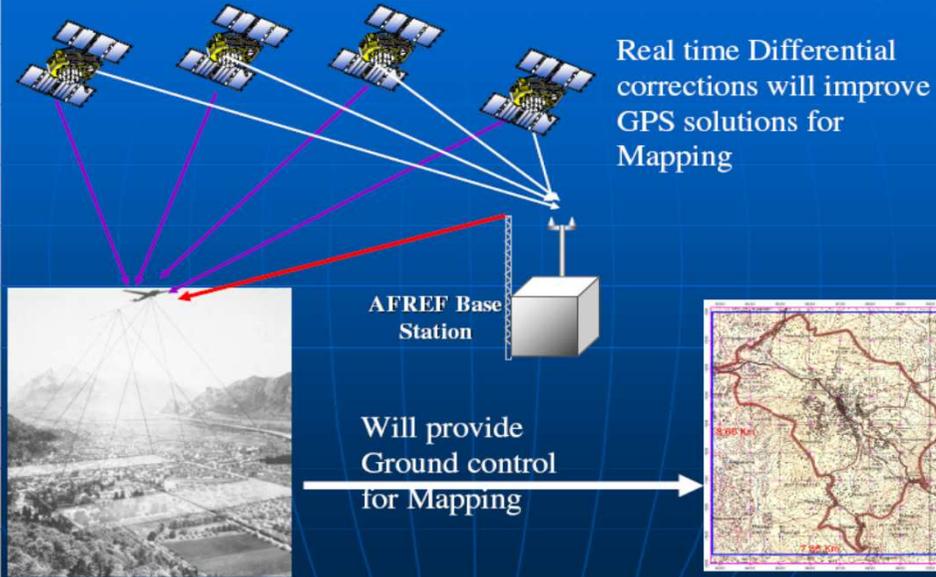
Capabilities of AFREF (Combrinck, 2008)



Applications in Land Surveys

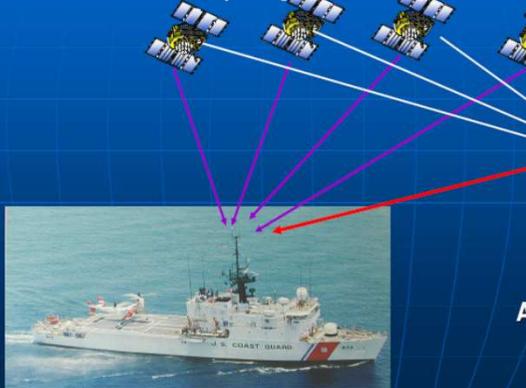


Applications in Mapping



Applications in Water Navigation

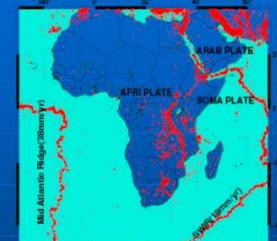
Real time Differential corrections will improve GPS accuracy and precise docking



Applications in Air Navigation

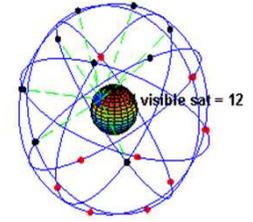


Applications in Crustal dynamics



GPS data from AFREF base stations will be used to continuously monitor earth crustal movements.

Combrinck, 2008, Berlin



NATIONAL REFERENCE FRAMES



NIGNET

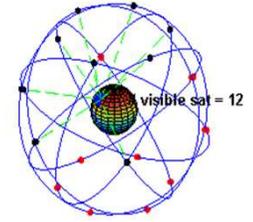
- **Top – OSGF station installed at OSGoF headquarters, Abuja**
- **Middle – UNILAG station installed at the campus of University of Lagos.**
- **Bottom Left –FUTY station installed at Federal University of Technology of Yola**
- **Bottom Right - location at Toro.**



(Jatau et al, 2010, Sydney, Australia)



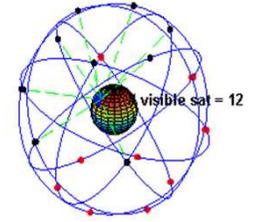
AfricaArray



- Launched in July 2004
- *AfricaArray* mission: To create new geoscientific research and training programmes and rebuild existing ones in Africa with Africans and for Africans
- While the long-term vision is to support training in many geoscience fields
- development of new geophysical training programmes and expanded support of existing ones
- promotion of geophysical research; and design and establishment of a network of geophysical observatories



AfricaArray: partners.



- *AfricaArray* grew out of a partnership of three organizations viz:
- University of the Witwatersrand (Johannesburg, South Africa)
- Council for Geoscience, formerly the South African Geological Survey (Pretoria, South Africa)
- Pennsylvania State University (University Park, PA, USA).

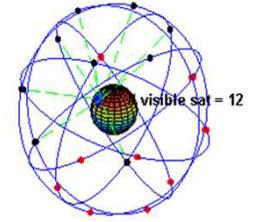


Council for Geoscience

<http://www.africaarray.psu.edu>



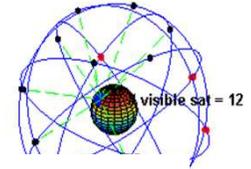
AfricaArray: Operations



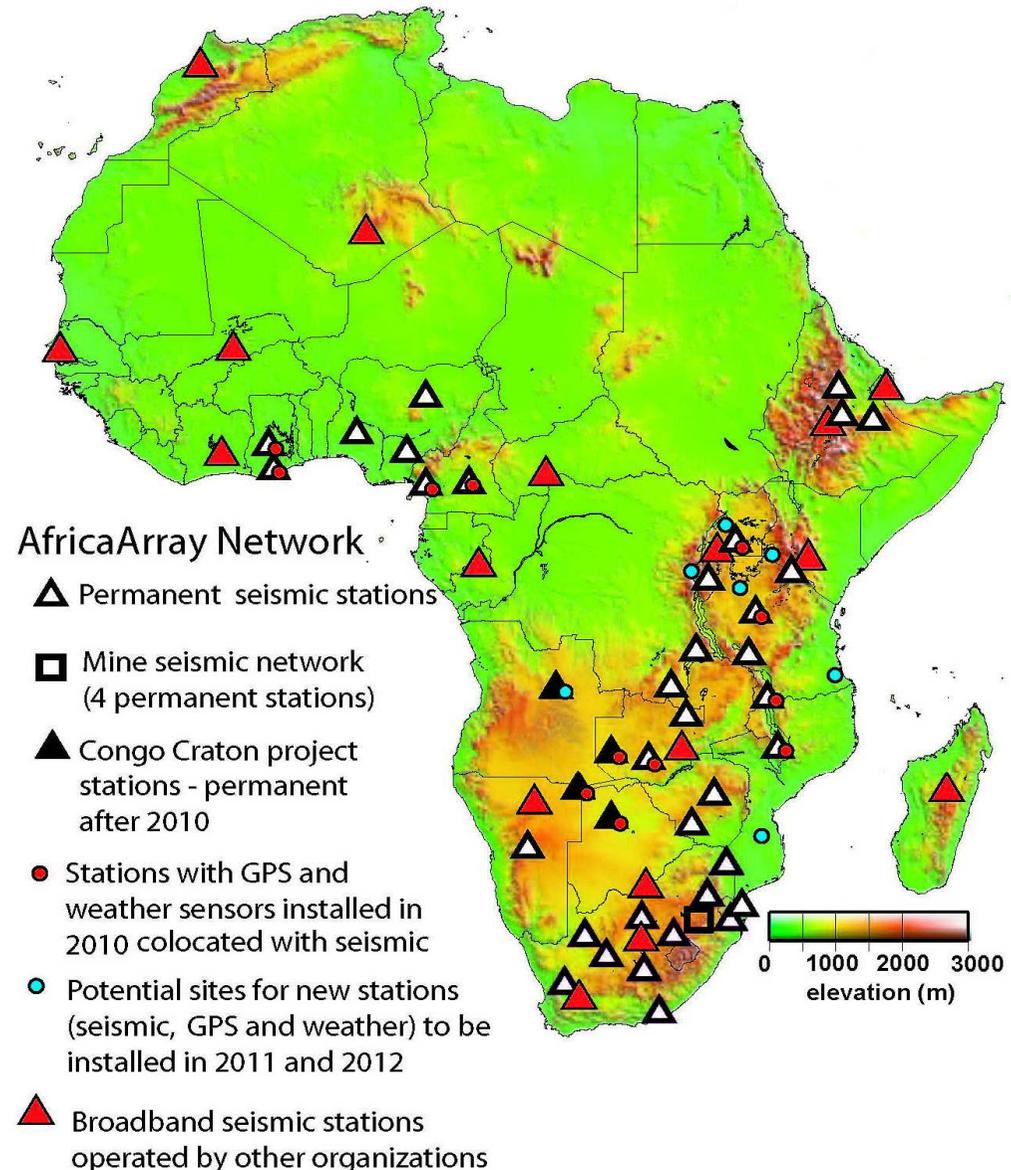
- A network of shared scientific observatories across Africa linked through common instrumentation, data access, and operation
- Data from the observatories provide the underpinning for much of the science supported by *AfricaArray*. Some of the observatories are permanent, while others are installed and operated on a temporary basis
- The first phase of *AfricaArray* (2005-2007) established a network of 20 to 30 permanent observatories spanning much of southern and eastern Africa
- the second phase of *AfricaArray* (2008-2010), the network of permanent observatories was expanded into other parts of Africa,

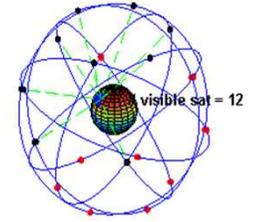


AfricaArray stations



- starting in August, 2010, many of the observatories are being equipped with GPS receivers and automated weather stations.
- data are archived at the UNAVCO Data Management Facility

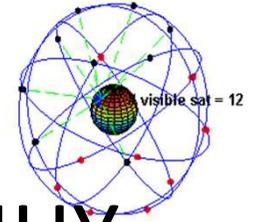




ICTP-BC GNSS in Africa

- Partnership between Boston College, USA and Abdus Salam ICTP, Trieste, Italy.
- Series of annual Workshops since 2009
- Deployment of GPS stations in Africa
- Over 300 African scientists have been trained at ICTP
- Leading experts in GNSS teach at the annual workshops
- A training model





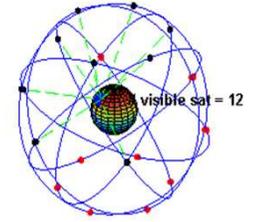
International Heliophysical Year 2007 (IHY,
2005-2009)
&
International Space Weather Initiative
(ISWI, 2010 -).



www.ihy2007.org



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

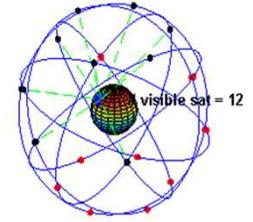


IHY/ISWI

- 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

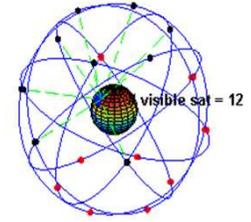
www.ihy2007.org

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



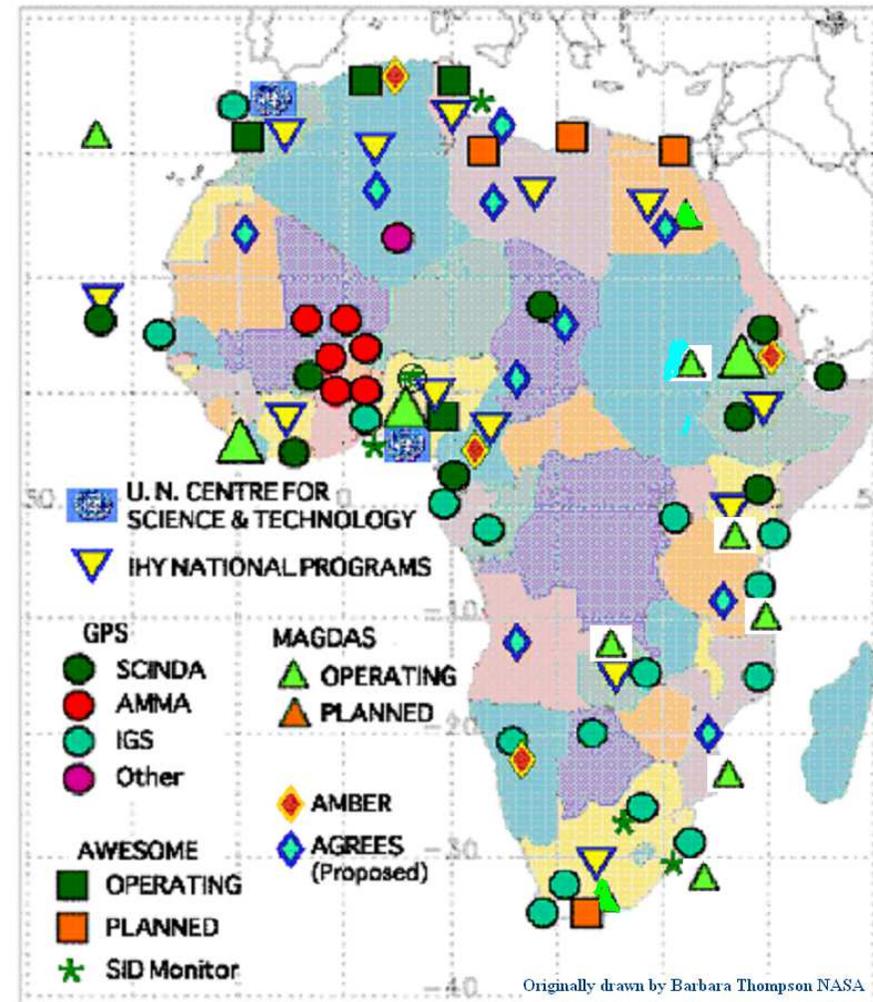
IHY/ISWI ANCHORS

- United Nations office for Outer Space Affairs UNOOSA, Vienna, Austria
- International Committee on Global Navigation Satellite Systems (ICG)
- NASA



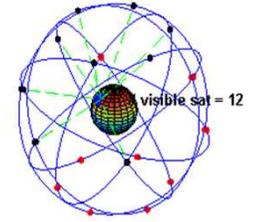
IHY/ISWI

- increase of stations that can serve as CORS in Africa in recent time
- IHY/ISWI activity has increased the potential CORS in Africa by more than 20

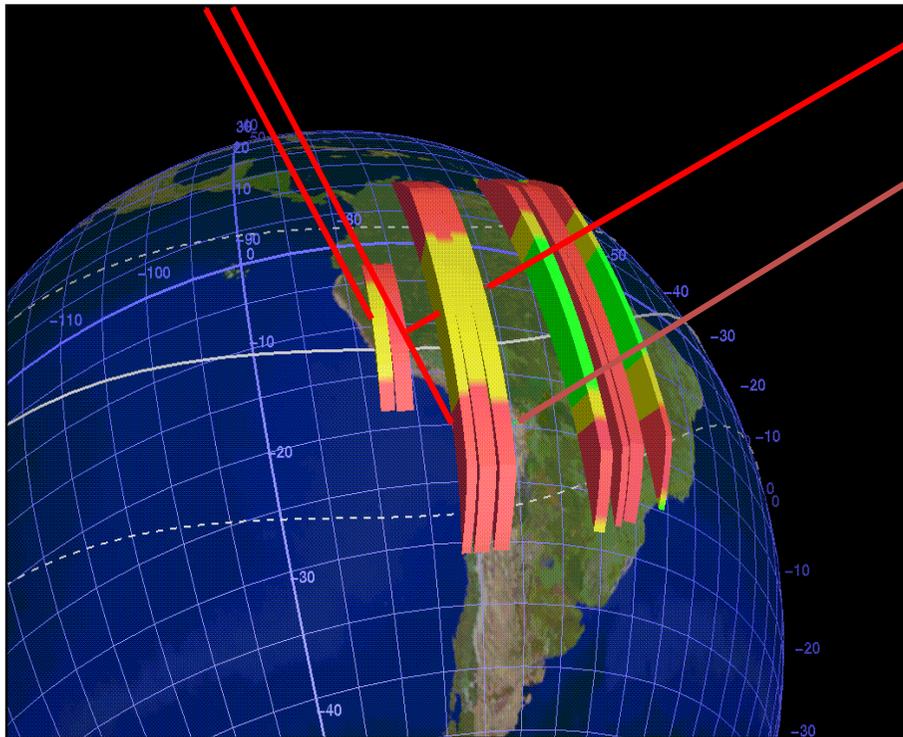




SCINTILLATION NETWORK DECISION AID (SCINDA)



A regional nowcasting system to support research and users of space-based communication and navigation systems

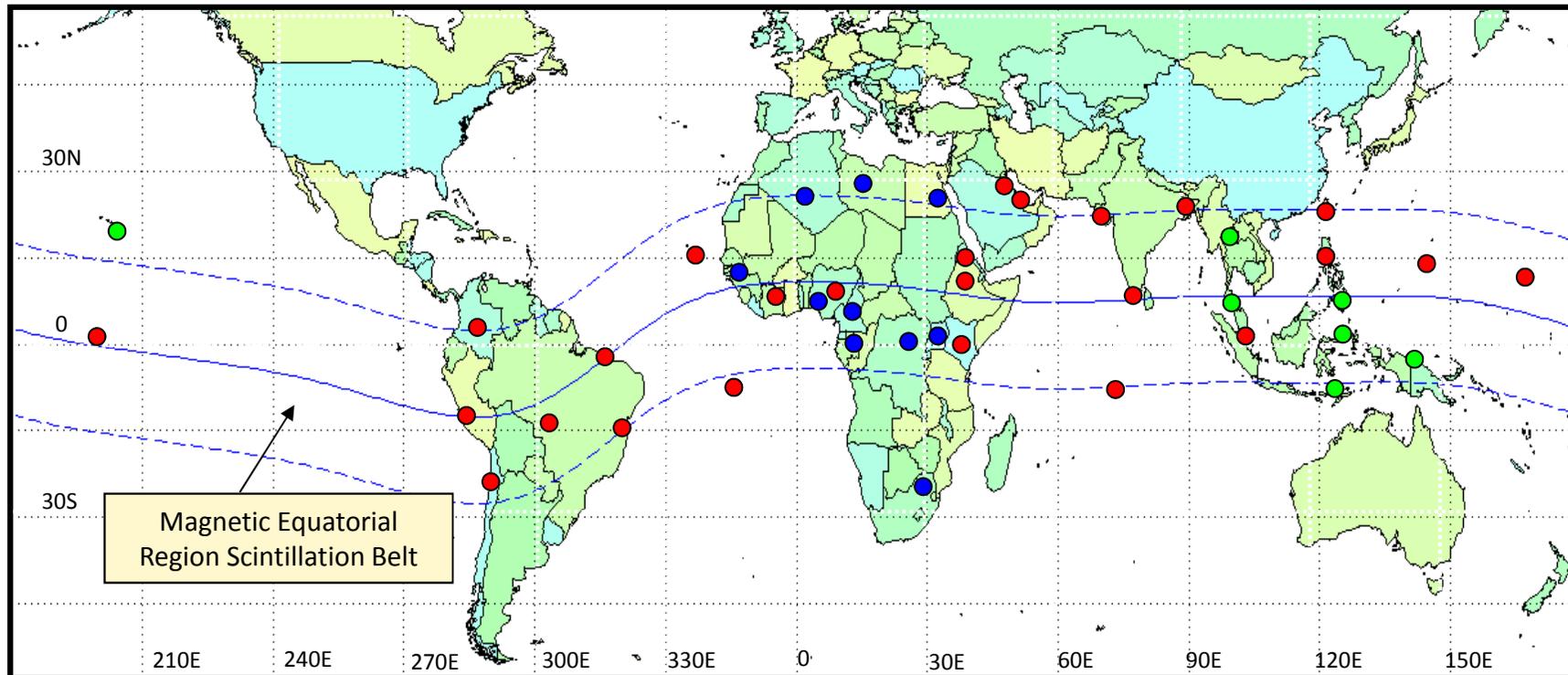
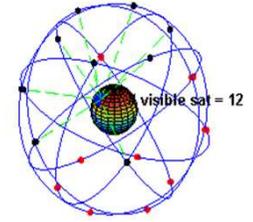


Real-time to 2-Hr Forecasts

- Ground-based sensor network
 - Passive UHF / L-band /GPS scintillation receivers
 - Measures scintillation intensity, eastward drift velocity, and TEC
 - Automated real-time data retrieval via internet
- Data supports research and space weather users
 - Understand on-set, evolution and dynamics of large-scale ionospheric disturbances
 - Empirical model provides simplified visualizations of scintillation regions in real-time



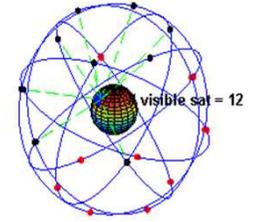
SCINDA Ground Stations



● Existing Sites

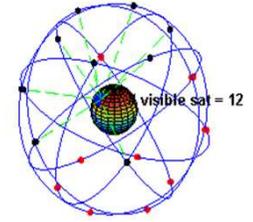
● UN IHY Sites

● Other/collaboration



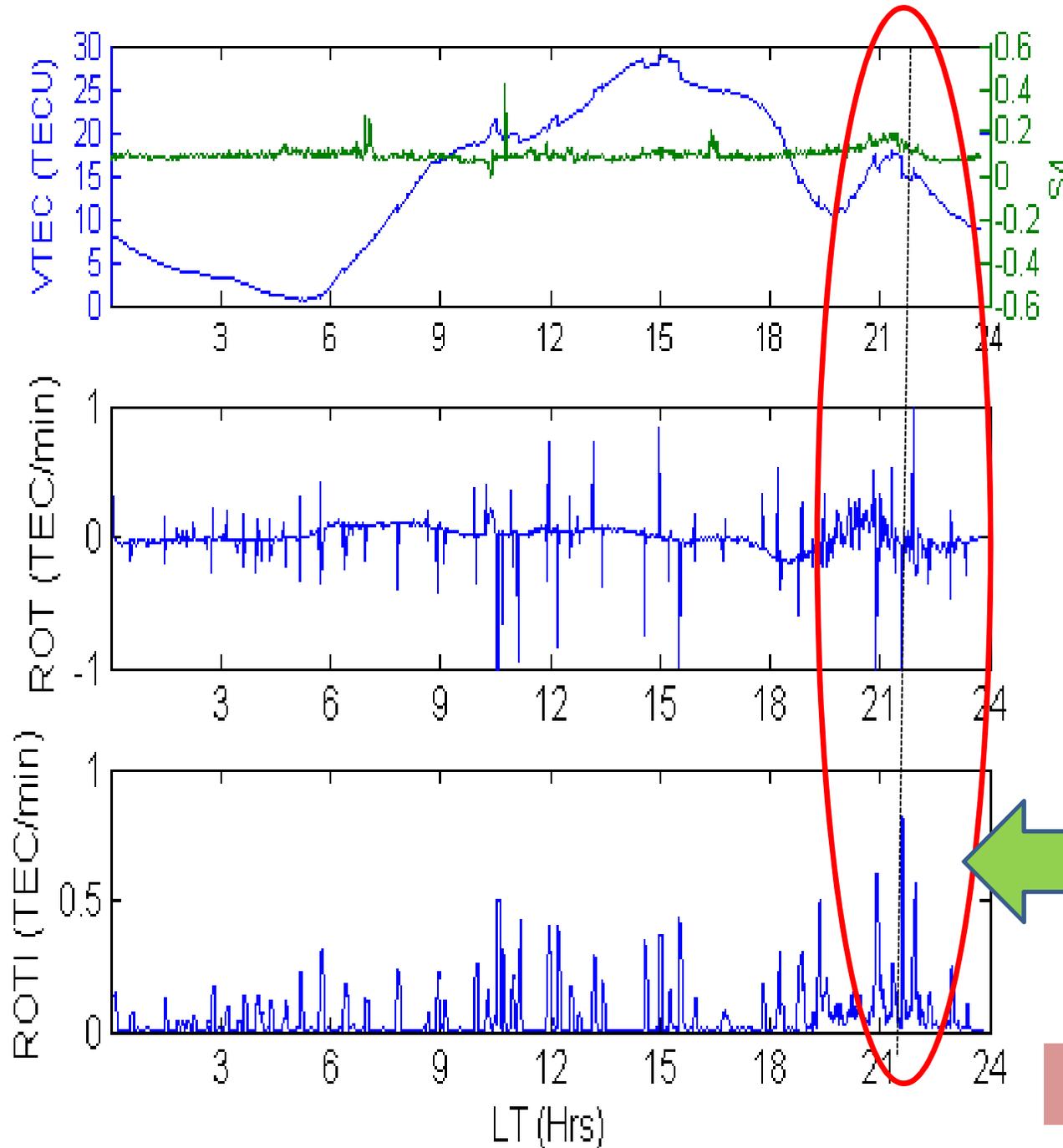
SCINDA facility at Akure, Nigeria





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

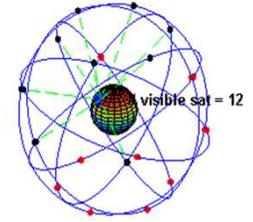
$A_p = 8$



ROTI gave a more pronounced representation of TEC fluctuation than S4

Rabiu et al (2012)

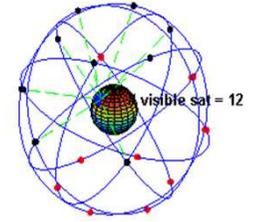
U, Aso, Ghana



Capabilities of GNSS products

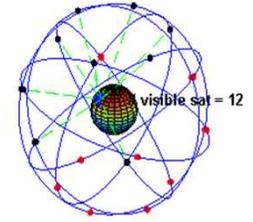
- producing **good governance**
- **inhibits corruption**
- **create job opportunities**
- **advance wealth creation**
- **promote quality of living**
- Secured society/public safety
- Control emigration, **engaging active minds**
- provide platform for **sustainable manpower** and **economic development**





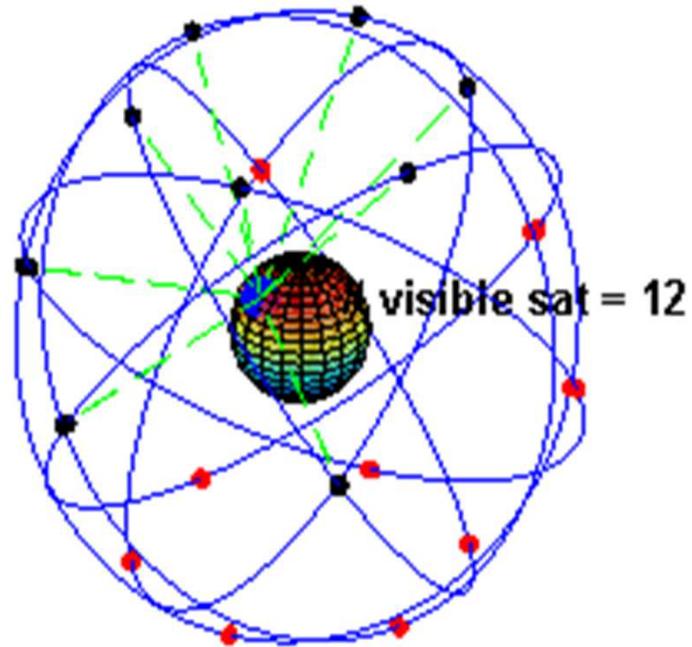
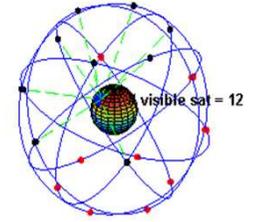
Recommendations

- Intensify complimentary efforts at densifying the GNSS ground infrastructures
- Development of Pre-requisite physical infrastructures for GNSS facilities
 - Internet connectivity
 - Power

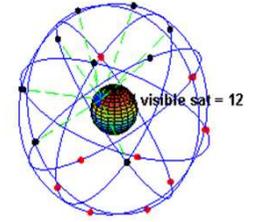


Summary

- GNSS is being used for ionospheric and space weather research in Africa
- Socio-economic application of GNSS is increasing in Africa
- International GNSS programs with impact in Africa include those of:
 - ✓ AFREF
 - ✓ National Reference Frames
 - ✓ IGS
 - ✓ IHY/ISWI
 - ✓ AfricaArray
 - ✓ ICTP-BC joint GNSS program
- GNSS has enormous capability to provide platform for **sustainable manpower** and **socio-economic development**
- GNSS is still being under-explored in developing Africa!**



Thank You



Acknowledgements

- UNOOSA
- NASRDA
- LOC, ALC 2013