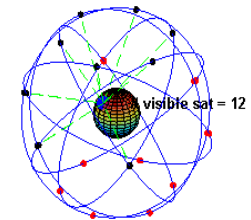


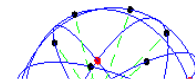
State of GNSS in Africa: Applications, Observational Infrastructures, Research Implications & Prospects

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



Outline

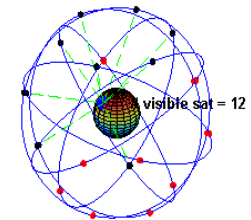
- ☐ About Africa
- ☐ Applications of GNSS in Africa
- ☐ Status quo
- ☐ GNSS infrastructure deployment
- ☐ Prospects
- ☐ Conclusion.



Africa !



- A continent
- 54 individual nations
- Multi-lingual structure
- English, French, Portuguese, Arabic, Spanish
- ~ 30 billion km²
- ~ 1.1 billion people
- ~14% World population

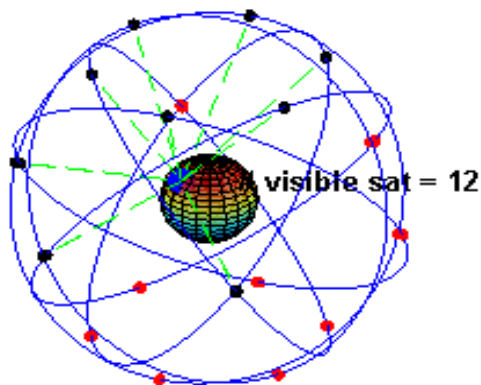


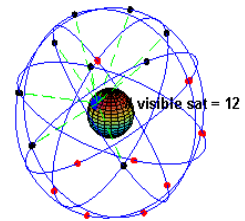
GNSS

Science

Technology

Applications





Science with GNSS

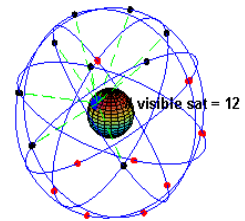
➤ Atmospheric & Geophysical research

- 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



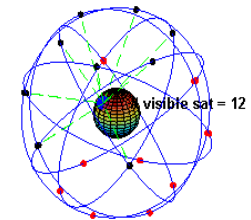
- ✓ PhDs
- ✓ M.Sc
- ✓ Research publications



Social-Economic Applications

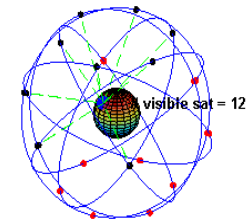
on increasing level

- 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



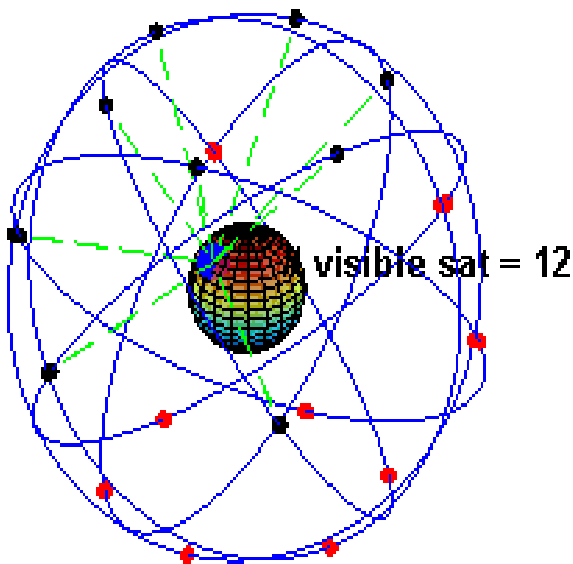
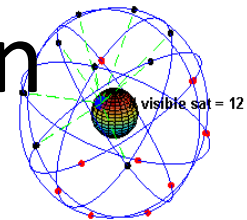
Defense/Military

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





Applications of GNSS Technology in Africa



**Wild life
conservation**



1: Surveying



**2: Road
transport**



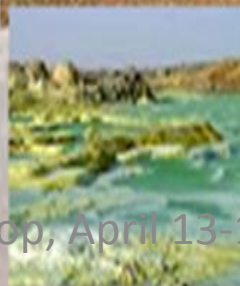
3: Aviation



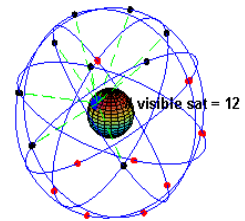
**4: Maritime
transport**



**5: Environment
and agriculture**



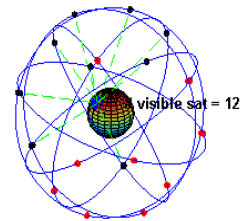
**6: Civil
protection and
surveillance**



GSM & GNSS

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

GNSS Receivers Densification Programmes in Africa



AFREF



National Reference Frames



IGS



IHY/ISWI - SCINDA



AfricaArray

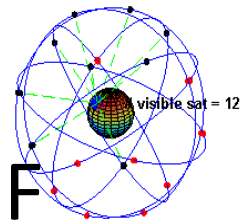


ICTP-BC joint GNSS program



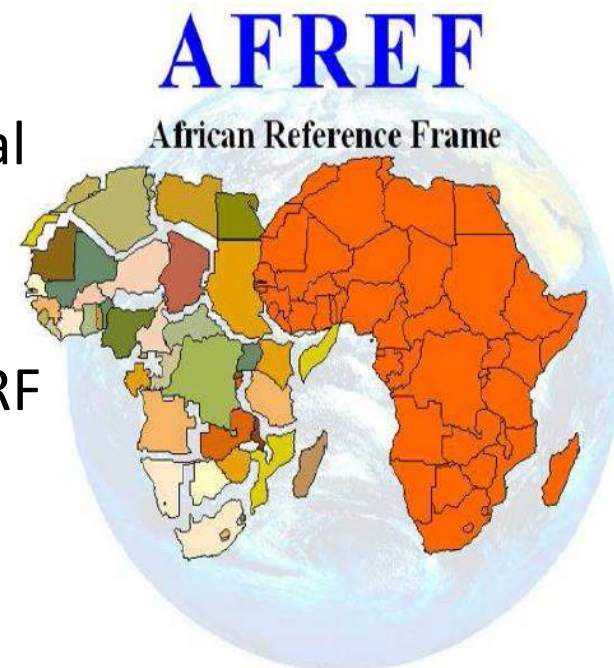
SWONON - SWONOA





The African Geodetic Reference Frame AFREF

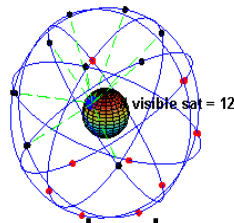
- ☐ a unified geodetic reference frame
- ☐ fundamental basis for the national & regional three-dimensional reference networks
- ☐ fully consistent and homogeneous with the International Terrestrial Reference Frame ITRF
- ☐ Densification of GNSS networks with its products in Africa
- ☐ Full implementation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



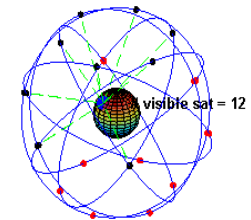
<http://geoinfo.uneca.org/afref/>



AFREF: African solution

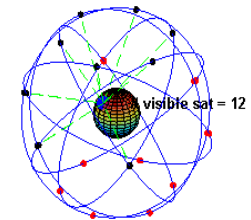


- ✓ each African country has its national geodetic reference system for producing maps and other geoinformation products - some countries even have more than one
- ✓ representation of cross-border features on maps cannot be done accurately
- ✓ For example, roads, watershed & ecosystem boundaries and 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

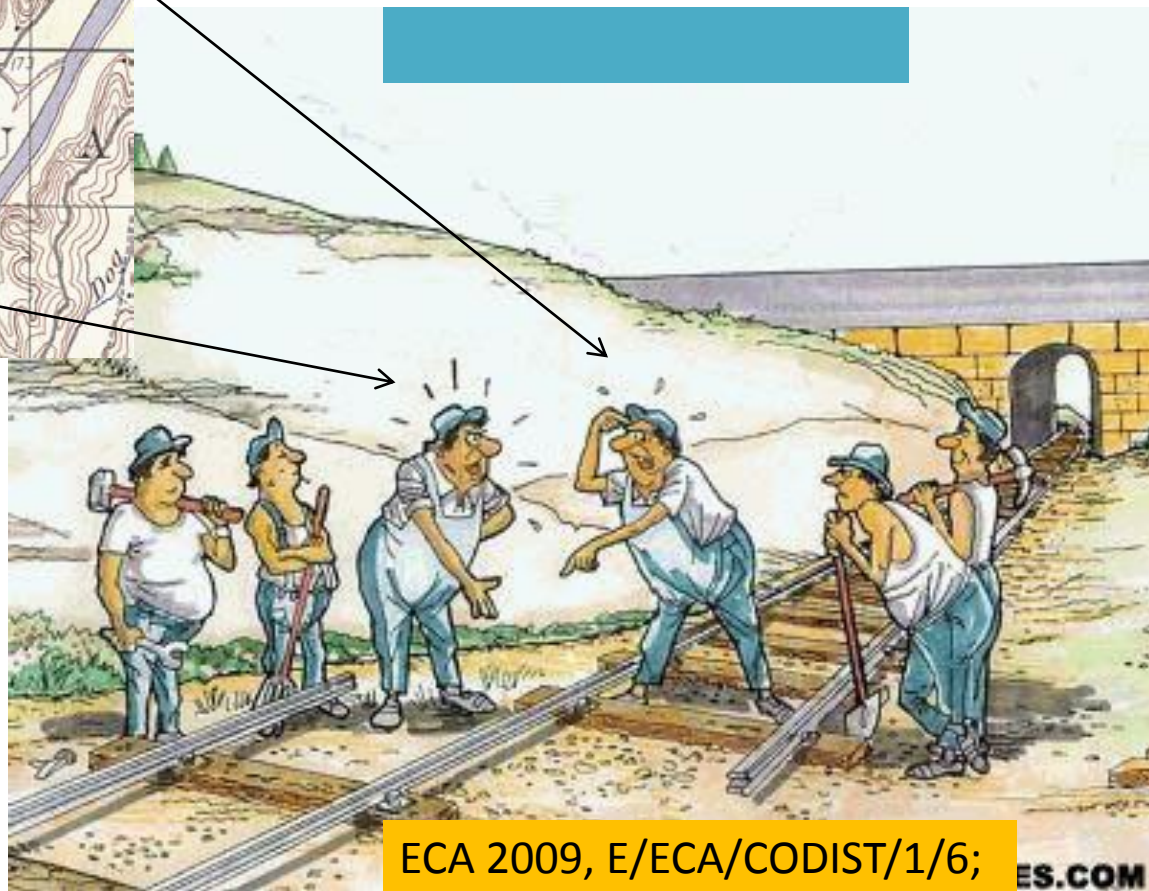
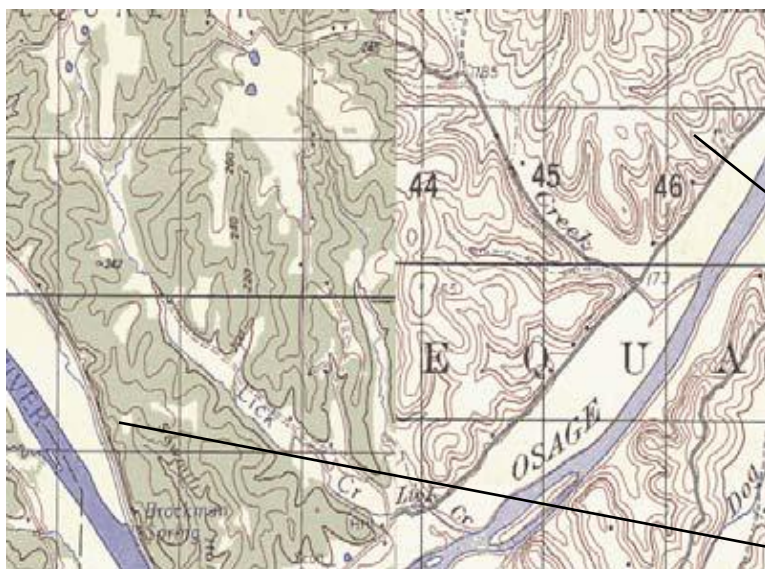


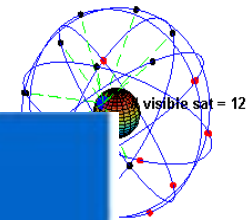
Consequences of using reference systems that are not consistent !





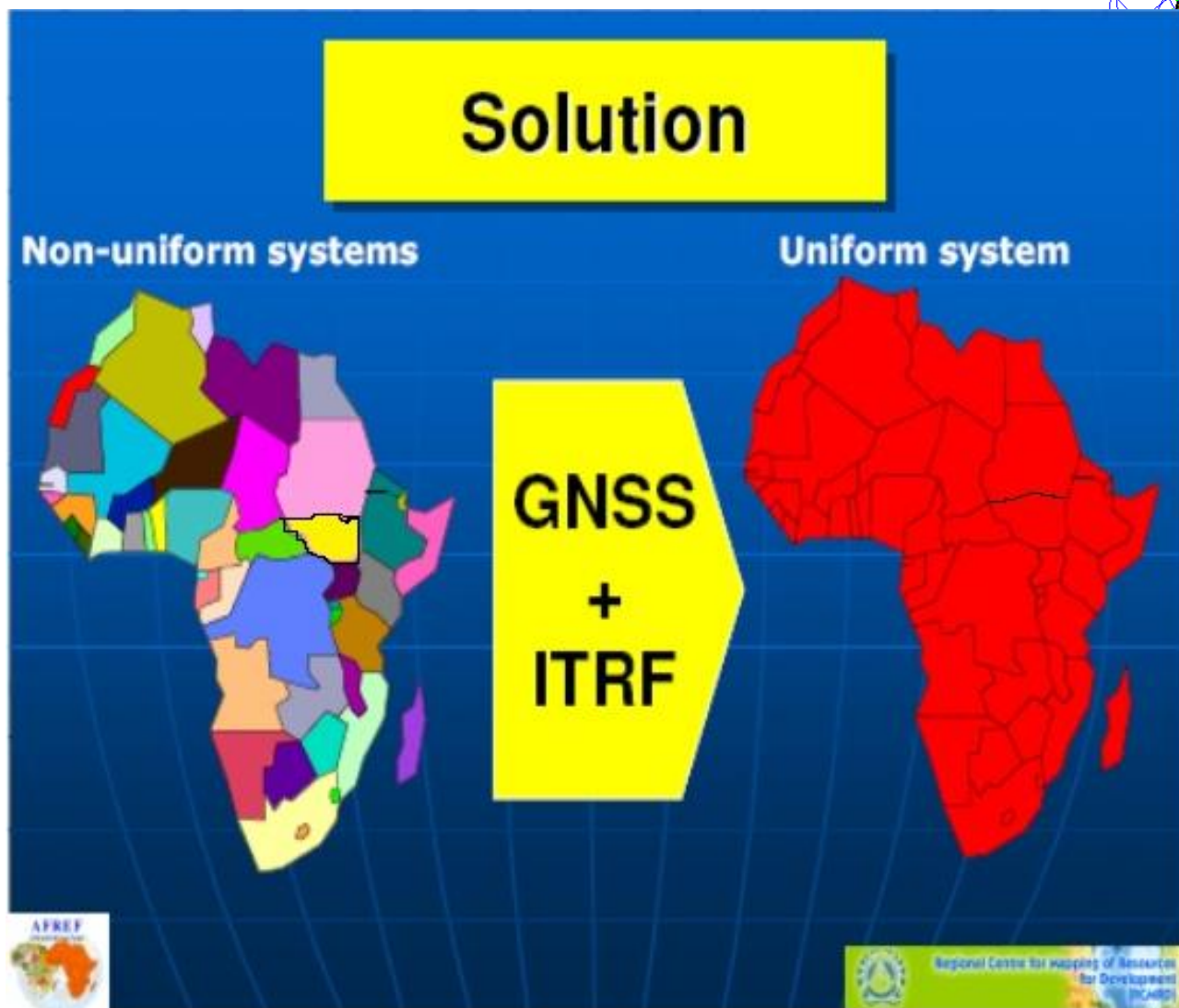
Products of incoherent maps - confusion



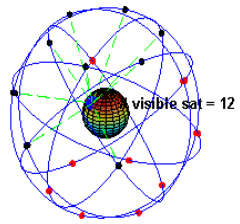


Reducing 54
Reference
frames to

1

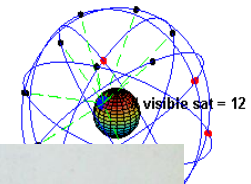


Combrinck (AFREF Presentation Berlin GNSS 2008)

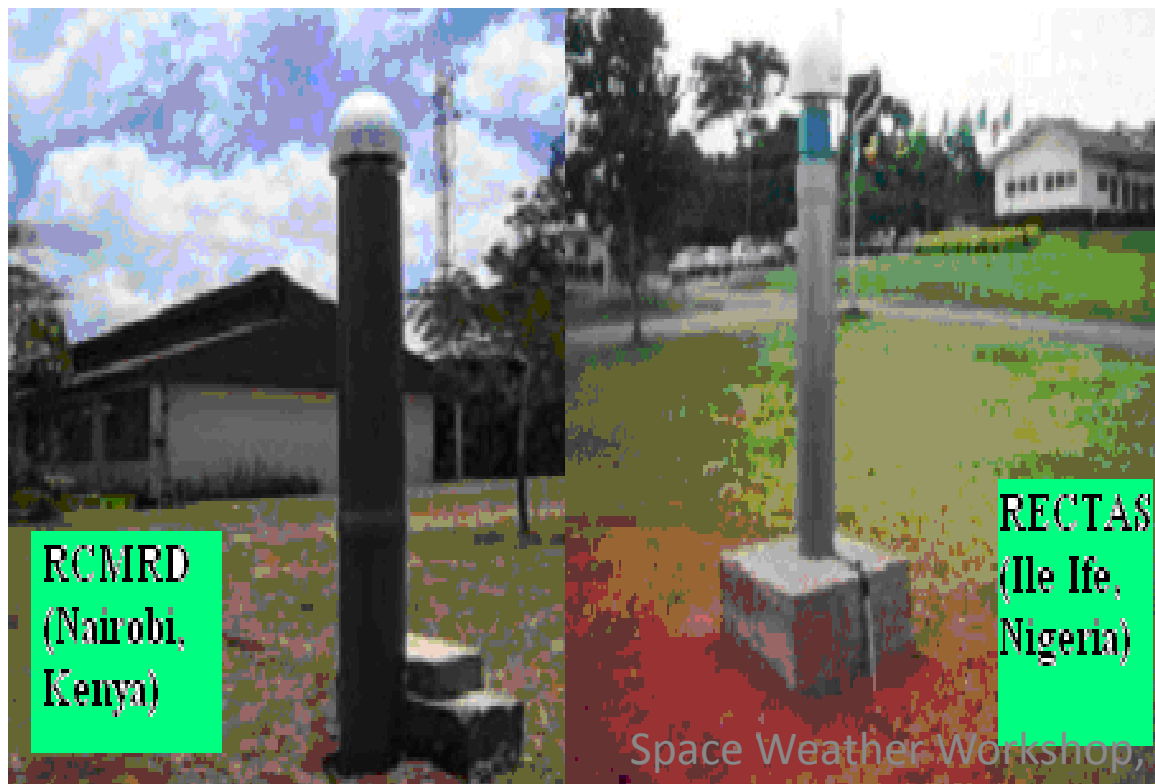


Strategy

- Densification of GNSS CORS
 - Many countries have established a network of CORS
- Central processing of data



Typical AFREF CORS



RCMRD
(Nairobi,
Kenya)

RECTAS
(Ile Ife,
Nigeria)

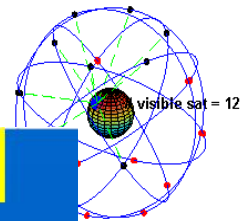
Space Weather Workshop,
April 13-17, 2015, Boulder
Colorado



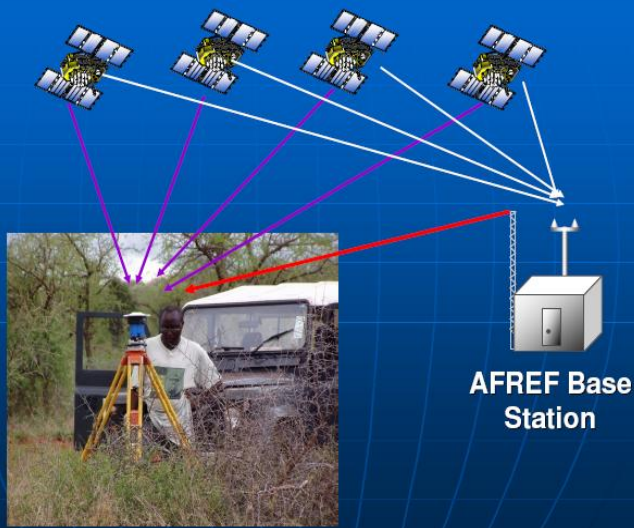
GPS antenna at Sokoto,
Northern Nigeria



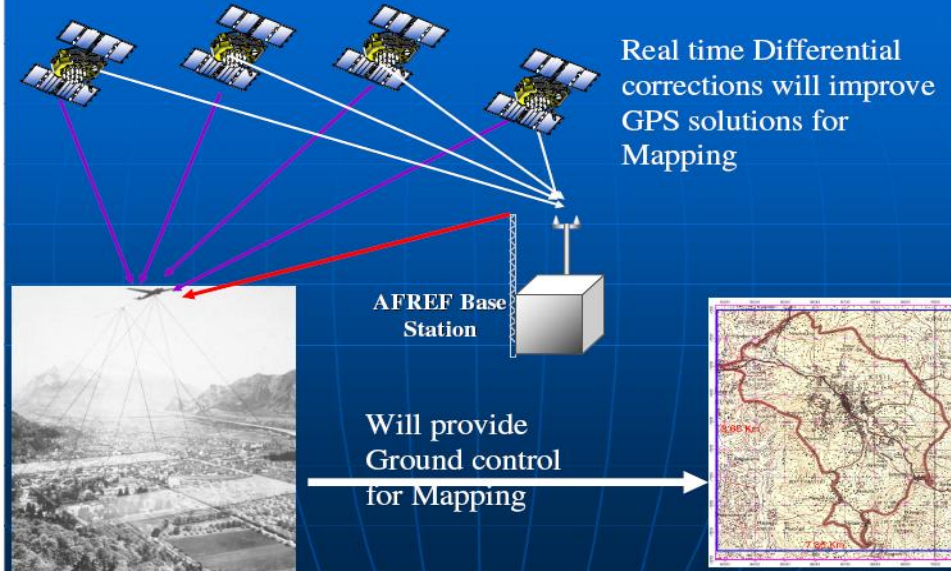
Capabilities of AFREF (Combrinck, 2008)



Applications in Land Surveys

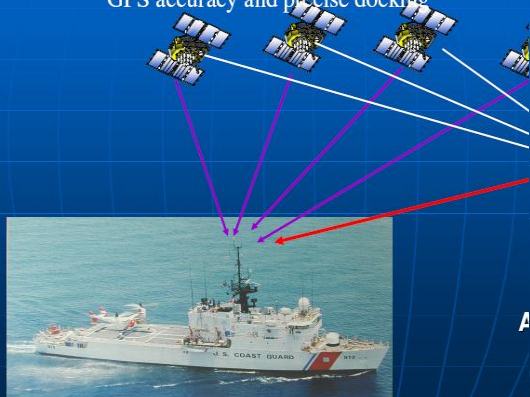


Applications in Mapping



Applications in Water Navigation

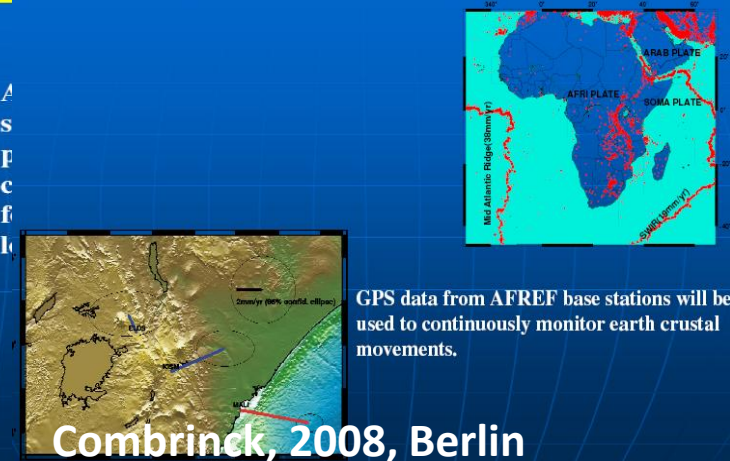
Real time Differential corrections will improve GPS accuracy and precise docking

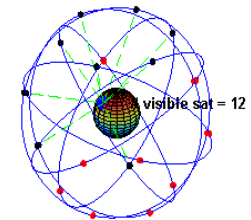


Applications in Air Navigation

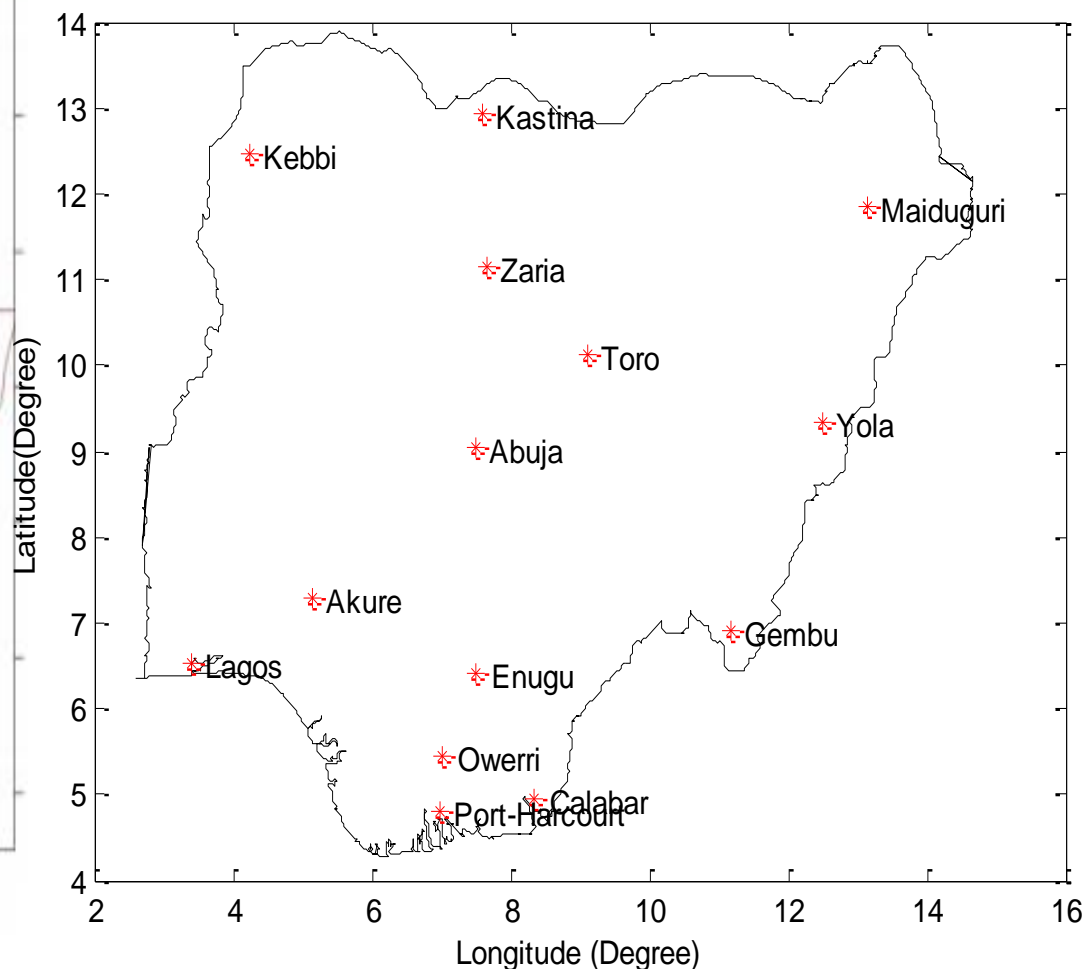
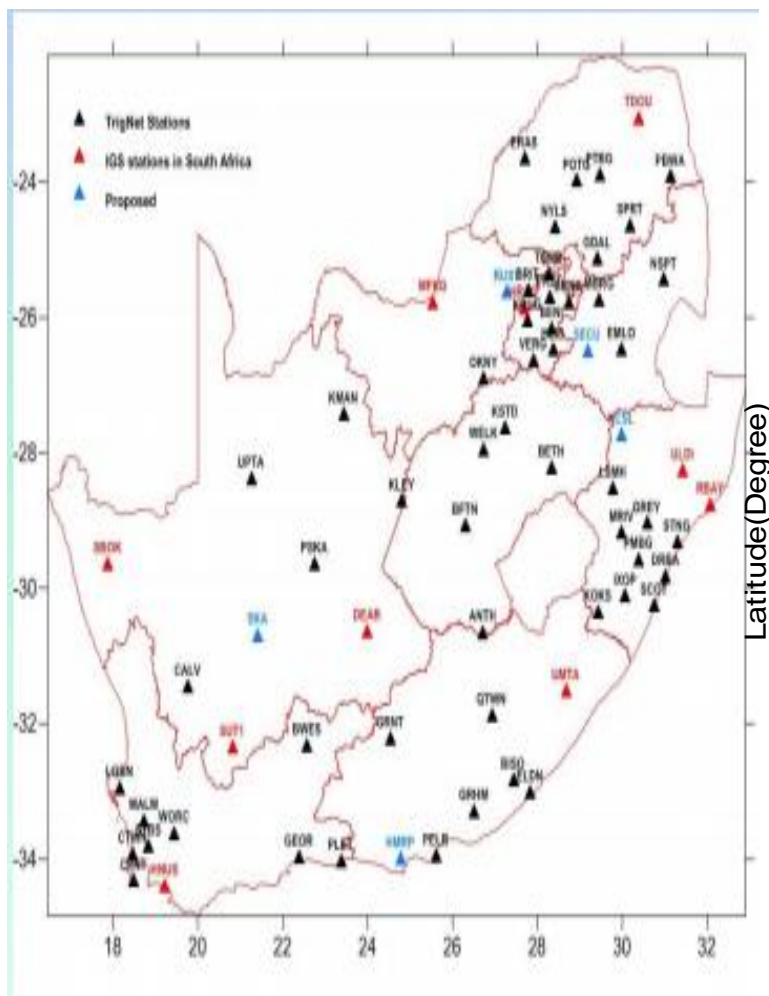


Applications in Crustal dynamics





Densification of National networks



South African TRIGNET (60 GPS CORS)

Nigerian NIGNET 14 GPS CORS



NIGNET

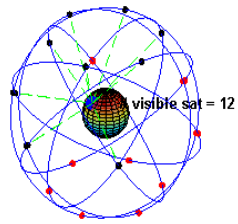
- **Top – OSGF station installed at OSGoF headquarters, Abuja**
- **Middle – UNILAG station installed at the campus of University of Lagos.**
- **Bottom Left –FUTY station installed at Federal University of Technology of Yola**
- **Bottom Right - location at Toro.**



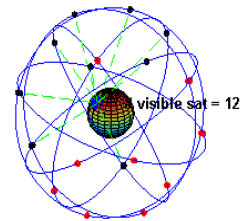
(Jatau et al, 2010, Sydney, Australia)



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).

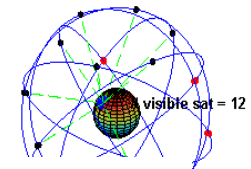


Council for Geoscience

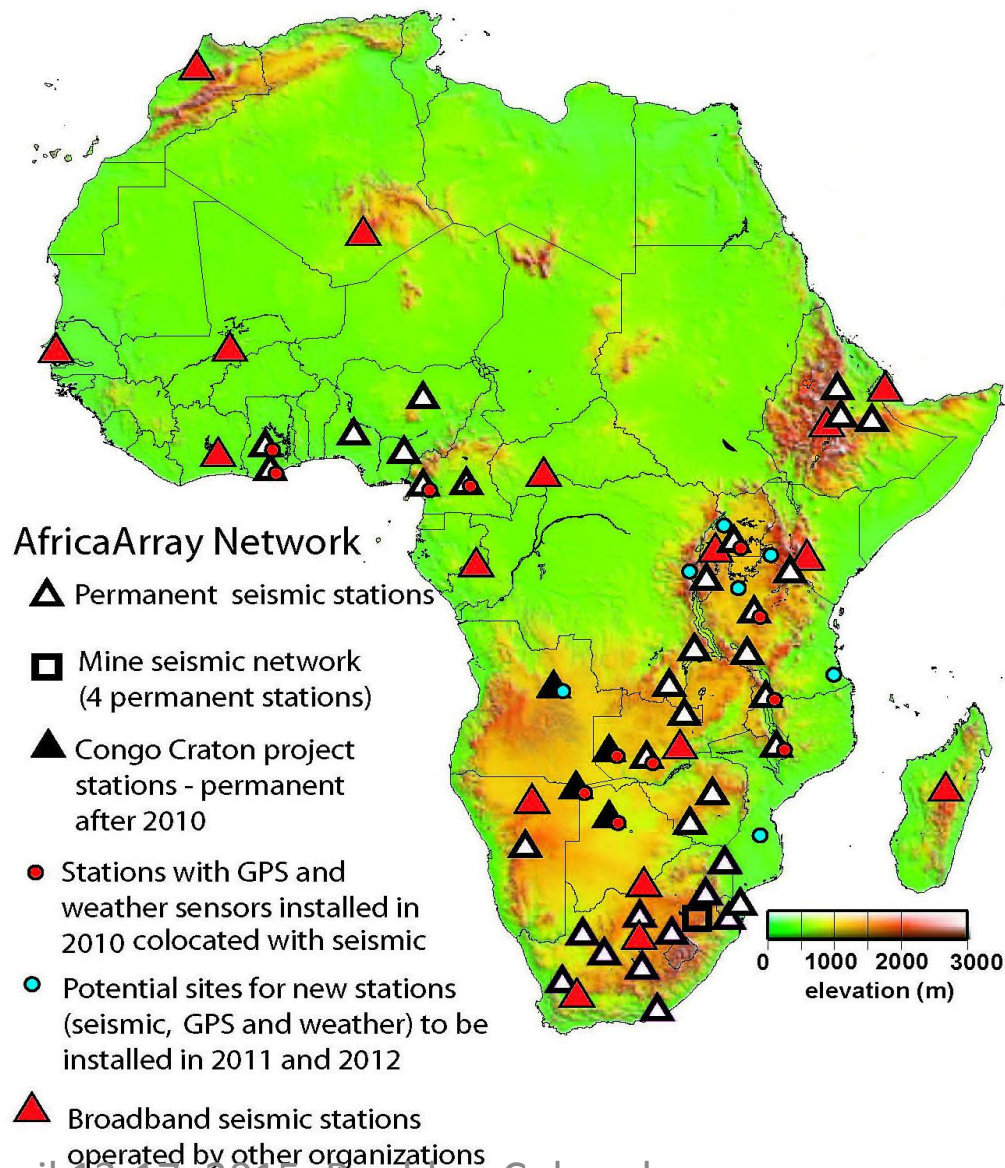
<http://www.africaarray.psu.edu>

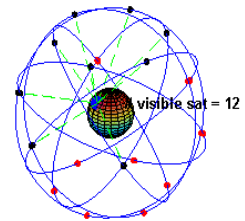


AfricaArray stations



- 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

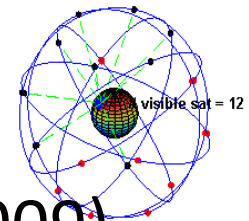




ICTP-BC GNSS in Africa

- 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 -).

IHY/ISWI ANCHORS

- ✓ United Nations office for Outer Space Affairs UNOOSA, Vienna, Austria
- ✓ NASA



www.ihy2007.org



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



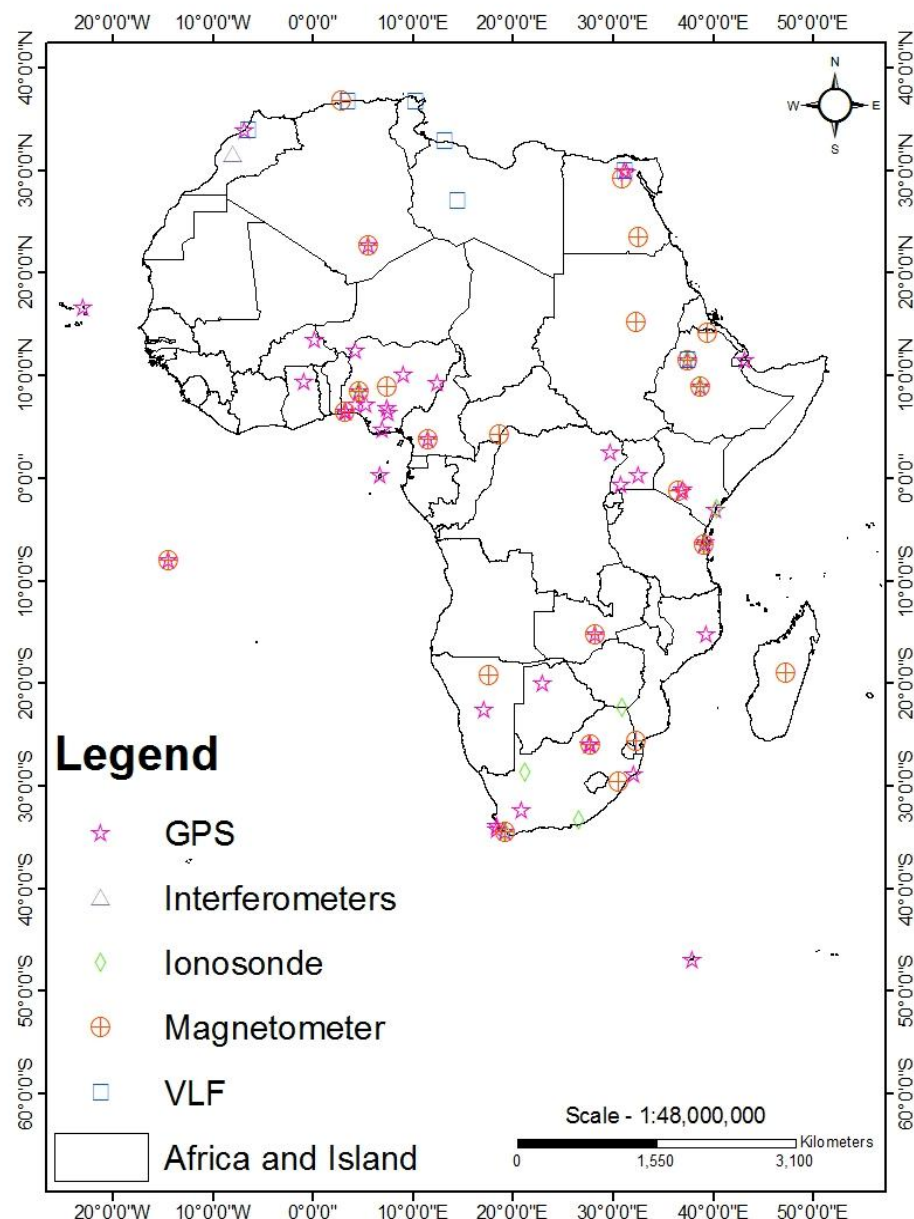
IHY/ISWI

increase in # of
stations that can serve
as CORS in Africa in
recent time

SCintillation Network Decision Aid (SCINDA)

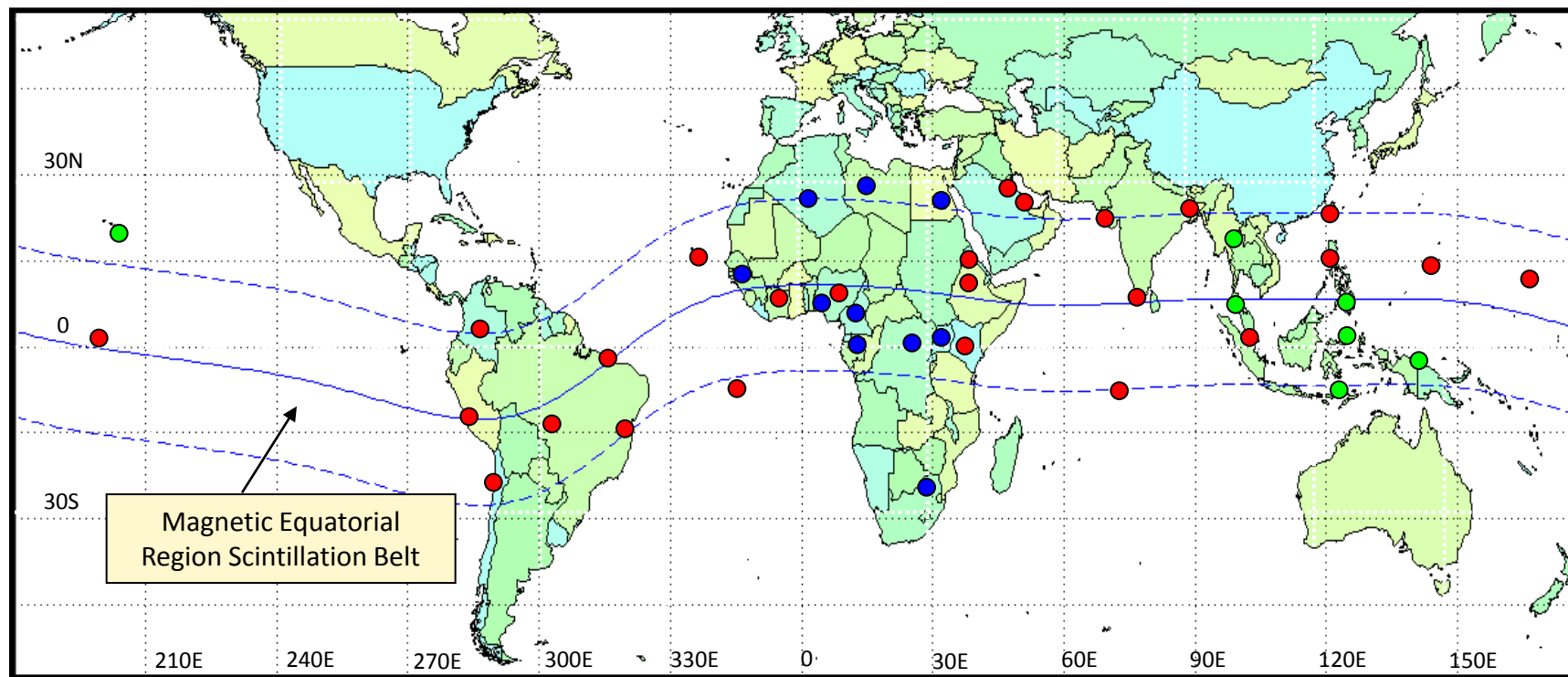
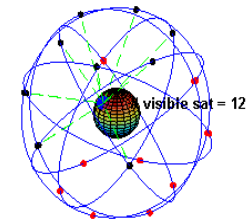
-US Air Force Research
Lab Project
– PI Keith Groves,

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





SCINDA Ground Stations



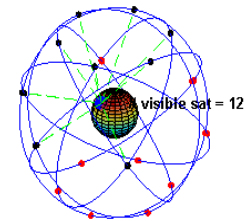
● Existing Sites

● UN IGY Sites

● Other/collaboration

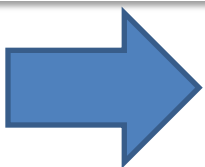


Space Weather Observation Network over Nigeria- SWONON



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

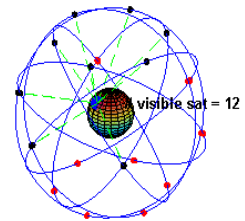
Network of ground-based space observatories (facilities include magnetometers, digisondes, ionospheric GNSS monitors, optical imagers)



SWONOA

Babatunde Rabiou 7th April 2015, NCAR Boul





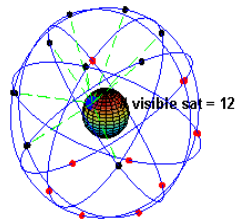
Capabilities of GNSS products

- 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**

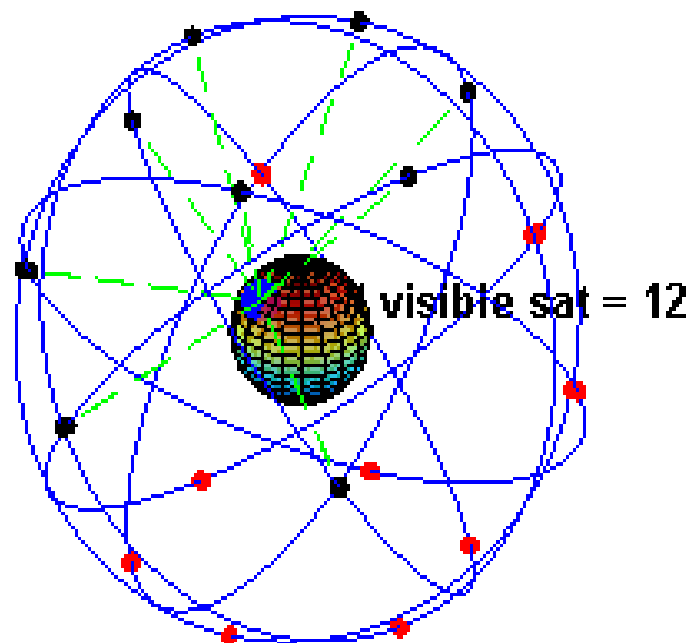
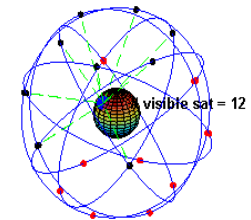




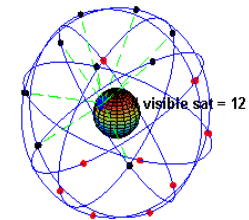
Summary



- ☐ Intensify complimentary efforts at densifying the GNSS ground infrastructures
- ☐ International GNSS programs has impact in Africa
- ☐ GNSS is being used for ionospheric and space weather research in Africa
- ☐ African stations **produces data for SW services**
- ☐ Socio-economic application of GNSS is increasing in Africa
- ☐ 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

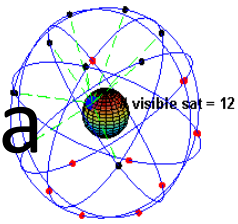


Acknowledgements

- ☐ UNOOSA
- ☐ NASA
- ☐ US Air Force
- ☐ BC
- ☐ NCAR



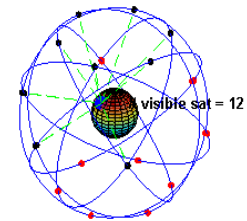
GIS & Land Administration in Nigeria



- 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
- Most states including Abuja & Lagos

<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>



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)