Laying the foundations for GGOS-Africa

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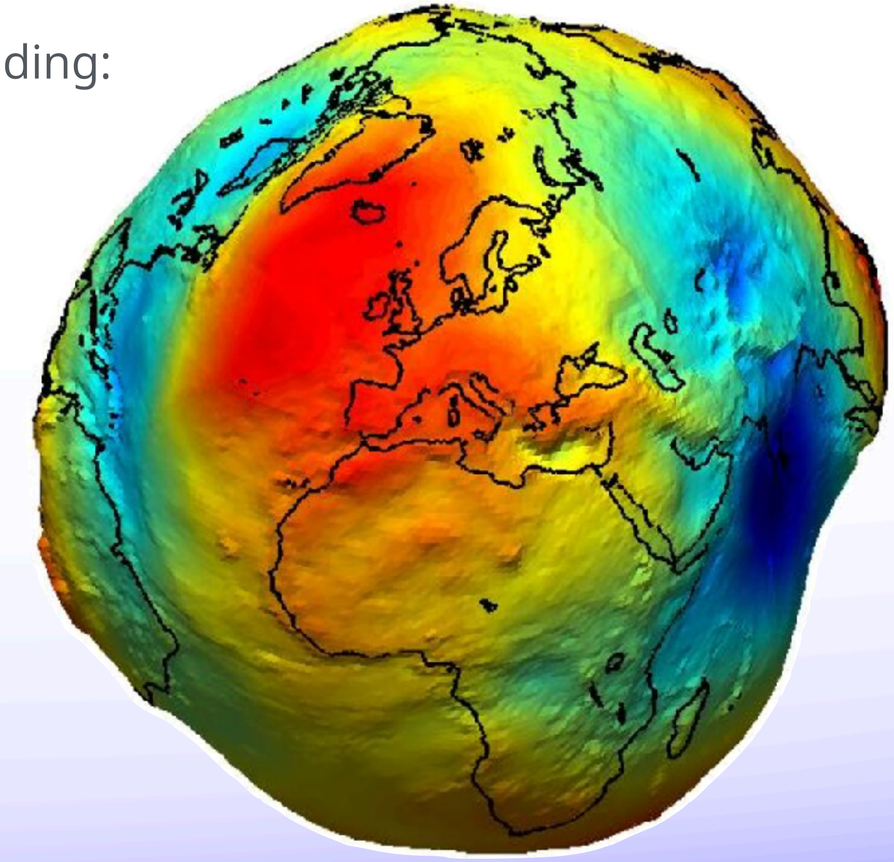
Geodesy & its hidden impact

GGOS-Africa
Global Geodetic Observing System - Africa

Geodesy studies the Earth's dynamic size, shape, and gravitational field, playing a crucial role in many scientific disciplines with **far-reaching societal impacts.**

Needed for anything needing geospatial information including:

- Agriculture
- Aviation And Drones
- Biodiversity, Ecosystems And Natural Capital
- Climate Services
- Consumer Solutions, Tourism And Health
- Earth System Science
- Emergency Management And Humanitarian Aid
- Energy And Raw Materials
- Environmental Monitoring
- Fisheries And Aquaculture
- Forestry
- Infrastructure
- Insurance And Finance
- Maritime And Inland Waterways
- Rail
- Road And Automotive
- Space & Astronomy
- Time Measurement And Synchronization
- Urban Development And Cultural Heritage



Earth's geoid as seen by GOCE

(Space) geodesy

VLBI

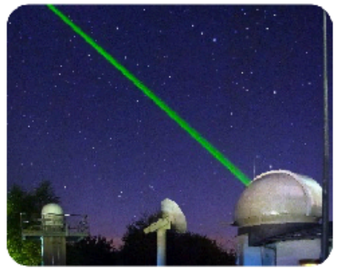
Very Long Baseline Interferometry

Earth rotation, station coordinates, quasar positions

GNSS

Global Navigation Satellite Systems
(GPS, GLONASS, Galileo, Beidou)

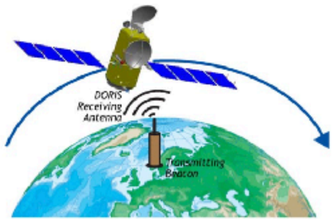
Station coordinates, Earth rotation, Geodynamics



SLR

Satellite Laser Ranging

Satellite orbits, station coordinates, Earth rotation, centre of mass of the Earth



DORIS

Doppler Orbitography and Radiopositioning Integrated by Satellite

Satellite orbits, Station coordinates, Earth rotation, gravity field

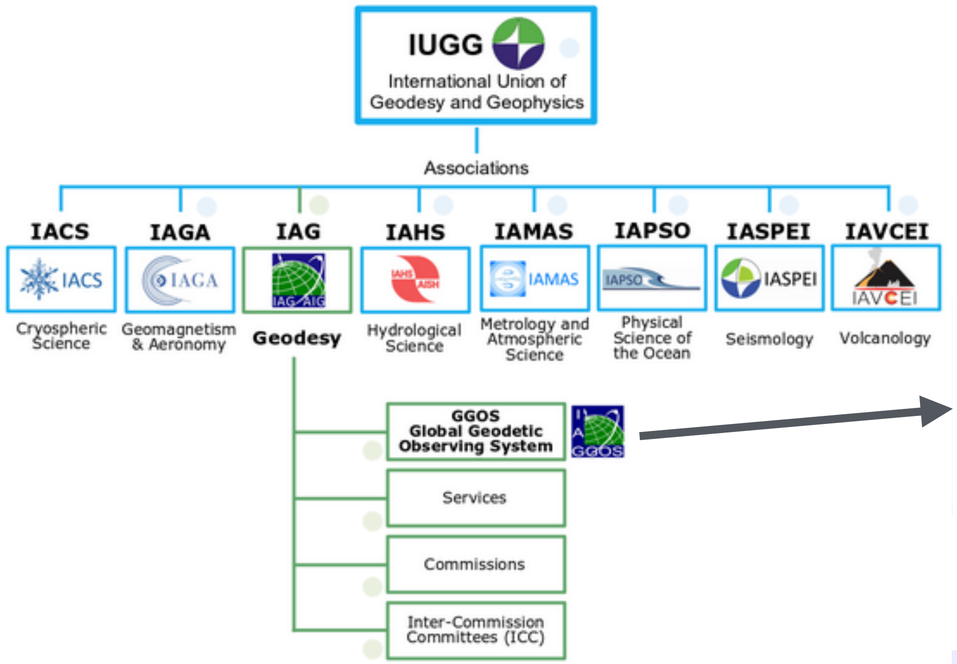
Parameter	VLBI	GNSS	DORIS	SLR
ICRF	■			
Nutation	■	▒		▒
Polar motion	■	■	■	■
UT1	■			
Length-of-day		■	■	■
Subdaily ERPs	■	■		
ERP oceantide amplitudes	■	■		
Coordinates/velocities	■	■	■	■
Geocentre		■	■	■
Gravitational field		■	■	■
Satellite orbits		■	■	■
LEO satellite orbits		■	■	■
Ionosphere	■	■	■	
Troposphere	■	■	■	
Time synchronisation	▒	■		▒

Credit: UN-GGCE

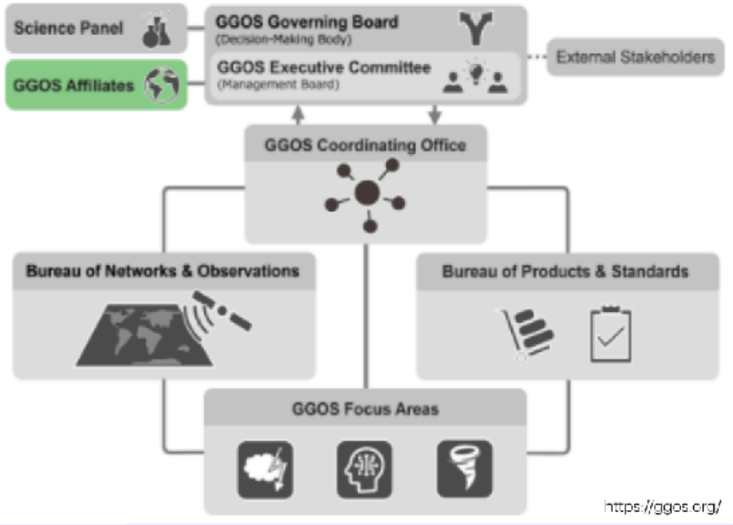
GGOS-Africa
Global Geodetic Observing System - Africa

Global Geodetic Observing System (GGOS)

GGOS is the organisation responsible for the advancement of geodesy. **GGOS Core Sites** co-locate the major observation techniques.



GGOS structure



A **GGOS Affiliate** is a national or regional organisation that coordinates geodetic activities in that country or region.

Milestones:

- 1998 - Birth of GGOS
- 2017 - Establish Affiliate GGOS-Japan
- 2021 - Establish Affiliate GGOS D-A-CH
- 2024 - Establish Affiliate GGOS IberAtlantic
- 2025 - GGOS-Africa(?)

Do we need a GGOS-Africa?

The global and regional situation in Africa

GGOS-Africa
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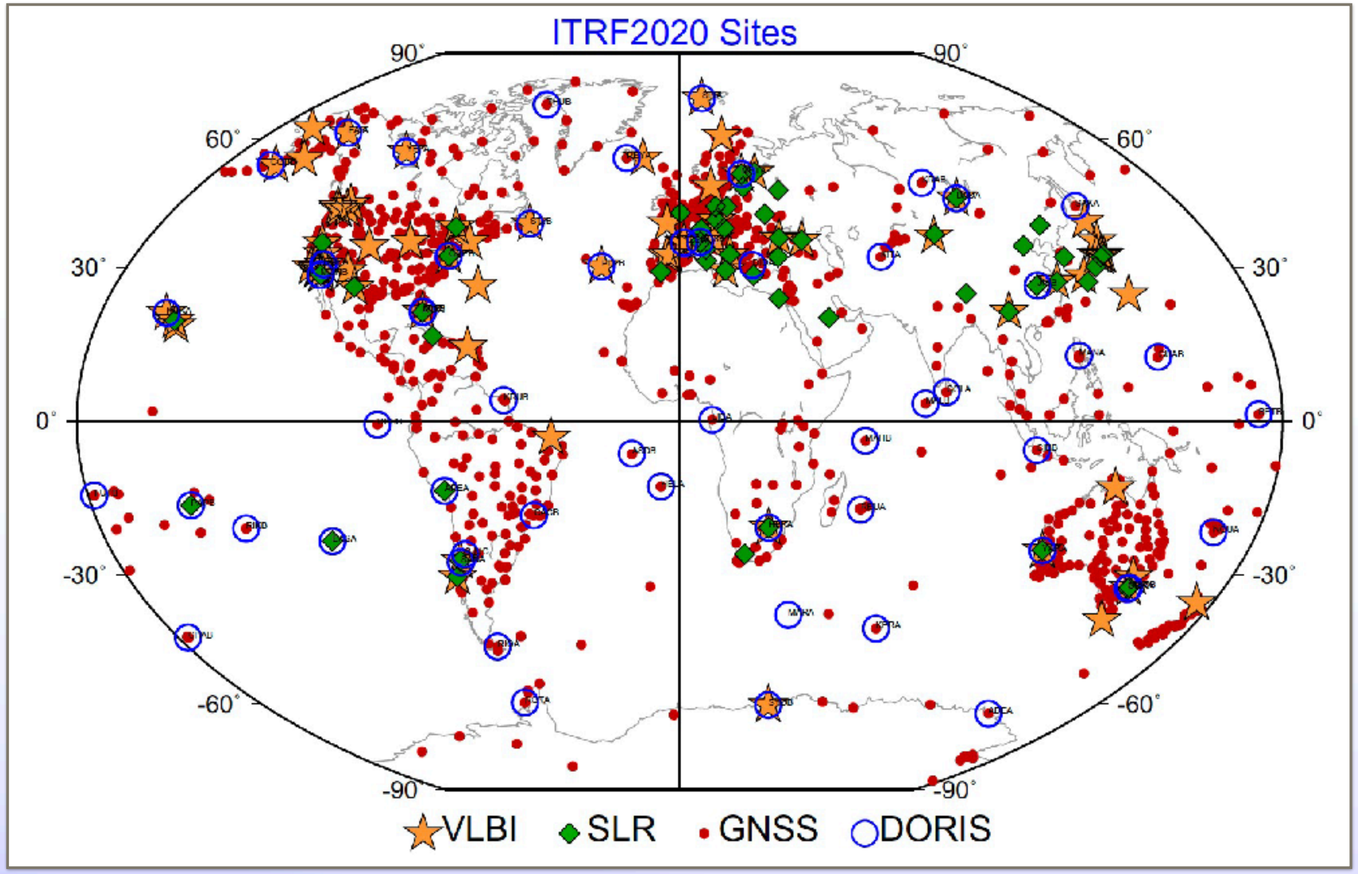
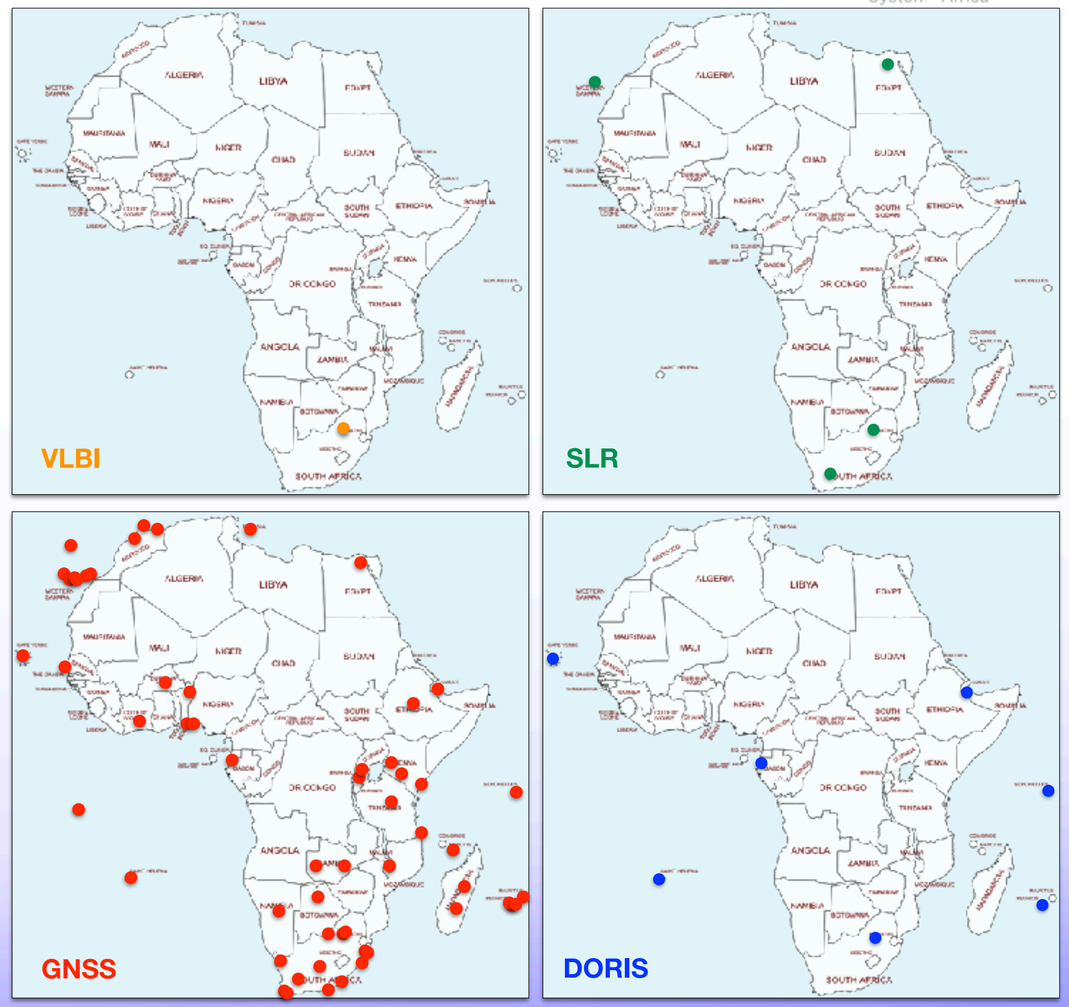




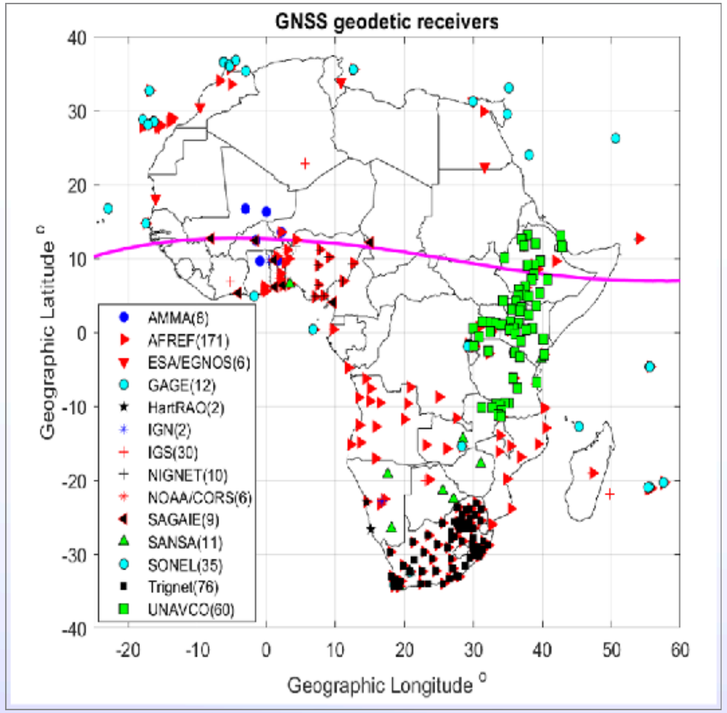
The distribution of VLBI, SLR, GNSS, and DORIS stations in Africa that contributed to ITRF2020–u2023. Credit: Altamimi et al., 2020 (left) and https://itrf.ign.fr/ (right).

Do we need a GGOS-Africa?

Disparity between global and regional infrastructure & core stations

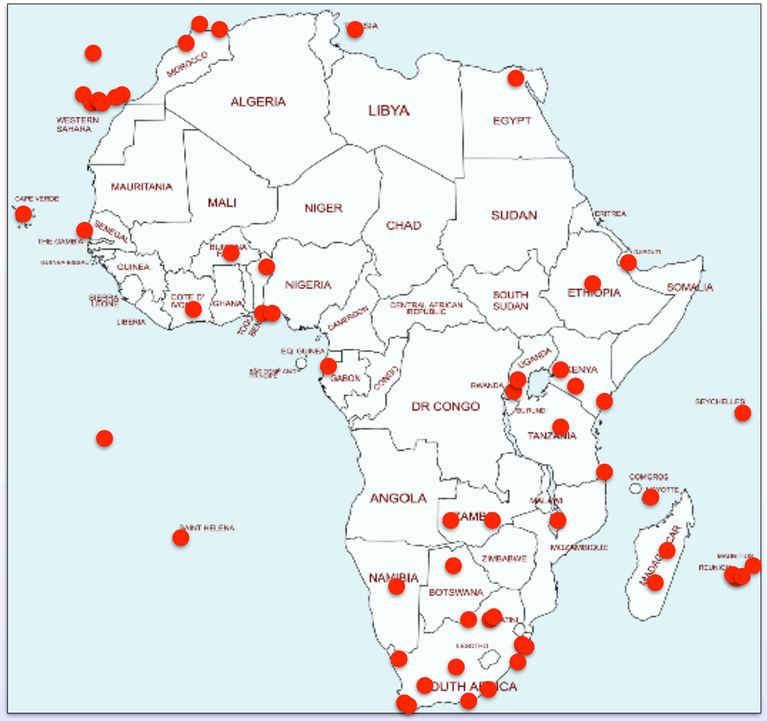
GGOS-Africa
Global Geodetic Observing System - Africa

Known GNSS receivers in Africa



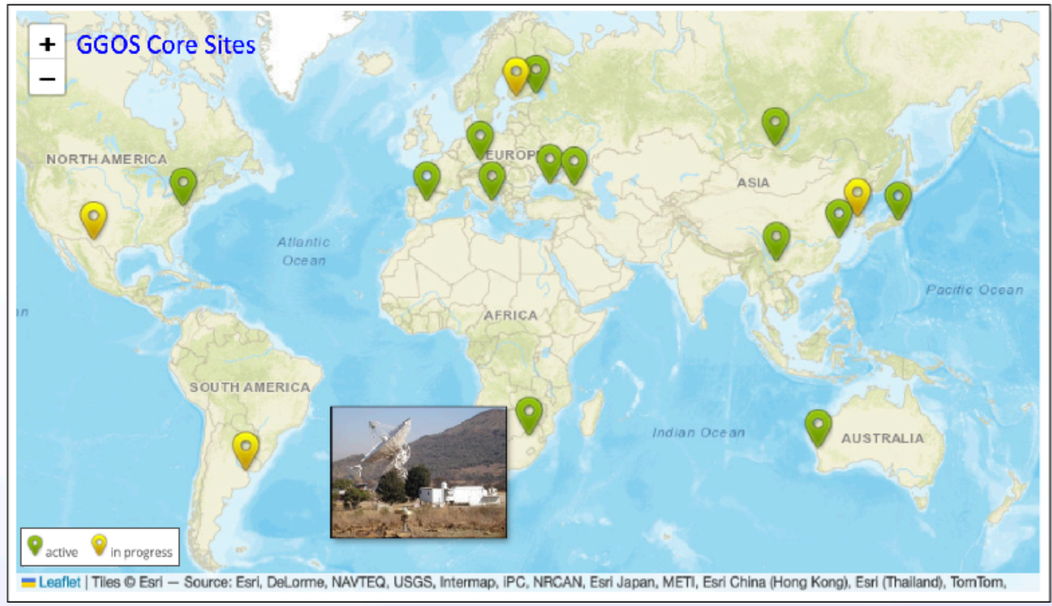
Distribution of known GNSS geodetic and reference receivers in and around Africa. Some receivers/networks are privately owned and data is not freely available. NOAA/ CORS and NIGNET were shut down 2017 and 2020. Credit: Baki et al., 2023 .

GNSS receivers contributing to GGOS



Credit: https://itrf.ign.fr/

GGOS core-sites (have all 4 techniques co-located)



Credit: GGOS

The GGOS-Africa project

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Global Geodetic Observing System - Africa

- UK Research and Innovation (UKRI) & Science and Technologies Facilities Council (STFC) provided 2-yr seed funding (~270k GBP) through the Africa-UK physics partnership collaborative research projects fund to start building the foundations of GGOS-Africa.
- Project from 02/2025–02/2027 and is a collaboration of the following institutes:

The University of Manchester

TECHNICAL UNIVERSITY OF KENYA
Education and Training for the Real World

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

SCIENCE, TECHNOLOGY & INNOVATION - SECRETARIAT
REPUBLIC OF UGANDA

United Nations
Global Geodetic
Centre of Excellence

National Research Foundation
SARAO
South African Radio Astronomy Observatory

GHANA SPACE
SCIENCE & TECHNOLOGY
INSTITUTE

Science and
Technology
Facilities Council

Our vision and goals

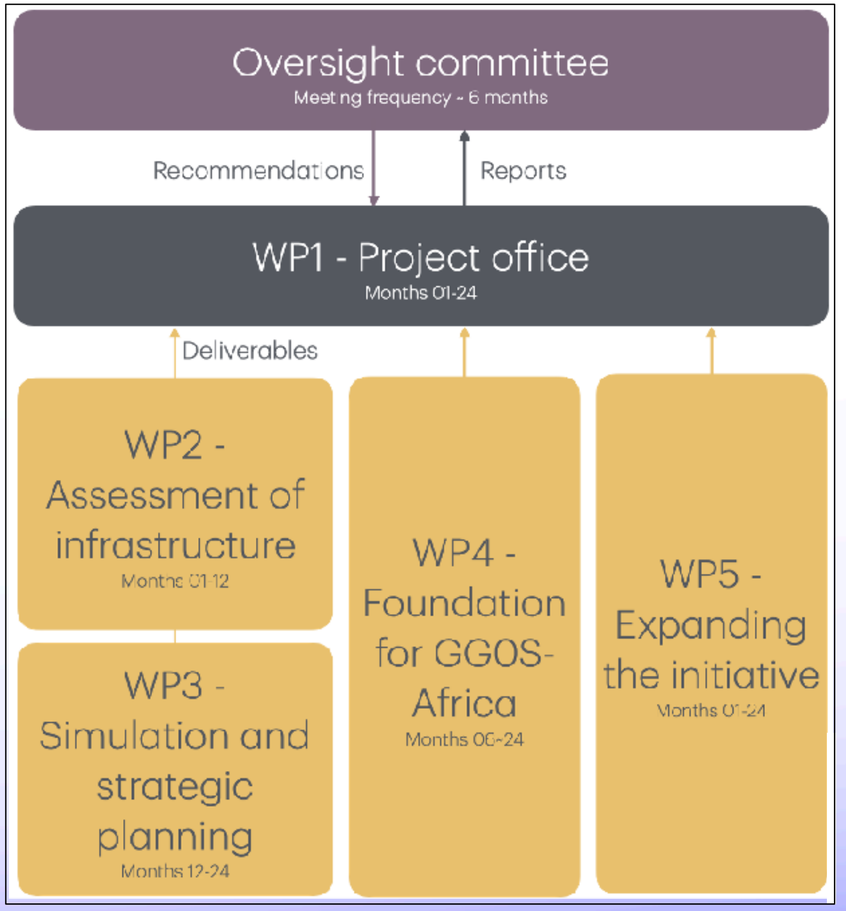
Our vision:

We intend to establish GGOS-Africa and support both new and existing geodetic initiatives throughout Africa, thereby promoting developments at global, regional, and national levels.

***Not a replacement** for ongoing initiatives (e.g., AFREF) but instead a forum to network, unify and create common goals in advancing geodetic initiatives across the continent.

Our goals:

1. Assessing Africa's geodetic infrastructure and resources.
2. Developing strategic infrastructure plans using simulations.
3. Training early-career African geodesists through workshops and collaborations.
4. Establishing GGOS-Africa to help coordinate geodetic activities.
5. Raising awareness among policymakers about the role of geodesy in sustainable development.



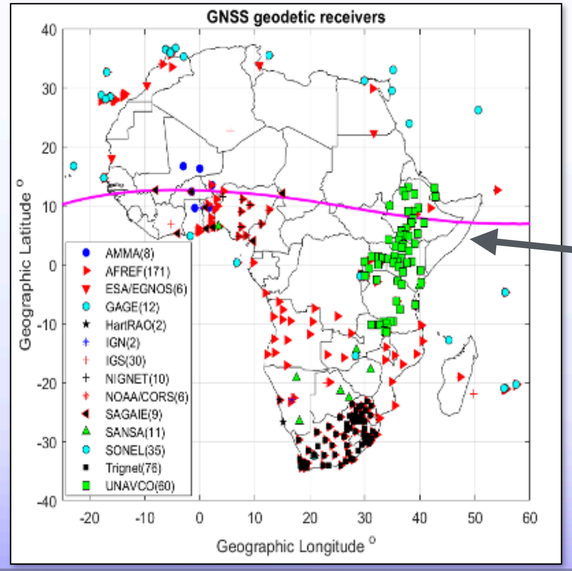
More information at the project website: https://www.jb.man.ac.uk/GGOS-Africa/

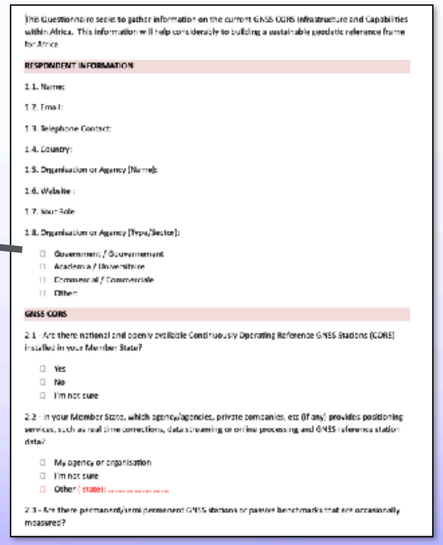
Infrastructure assessment and planning

- **Infrastructure and capacity assessment:** Detailed inventory of existing geodetic and computational infrastructure and operational status, and country-level geospatial reference systems and capacity (surveys and site visits, UN-GGCE Factbooks, UN:GGIM-Africa/AFREF).
- **Simulation models and geospatial analysis:** Analyse current infrastructure gaps and predict the impact of and best locations for new geodetic infrastructure.
- **Strategic infrastructure development plan:** Outlines recommended locations for new infrastructure and identifies priorities for infrastructure enhancement and human capital development.

WP2 - Assessment of infrastructure
Months 01-12

WP3 - Simulation and strategic planning
Months 12-24




This Questionnaire seeks to gather information on the current GNSS CORS infrastructure and capabilities within Africa. This information will help considerably in building a sustainable geodetic reference frame for Africa

RESPONDENT INFORMATION

1.1. Name:

1.2. Email:

1.3. Telephone Contact:

1.4. Country:

1.5. Organisation or Agency (Name):

1.6. Website :

1.7. Your Role:

1.8. Organisation or Agency (Type/Sector):

- Government / Government
- Academia / University
- Commercial / Commercial
- Other:

GNSS CORS

2.1. Are there national and openly available Continuously Operating Reference GNSS Stations (CORS) installed in your Member State?

- Yes
- No
- I'm not sure

2.2. In your Member State, which agency/agencies, private companies, etc (if any) provides positioning services, such as real-time corrections, data streaming or online processing and GNSS reference station data?

- My agency or organisation
- I'm not sure
- Other (state):

2.3 - Are there permanent/semi-permanent GNSS stations or passive benchmarks that are occasionally measured?

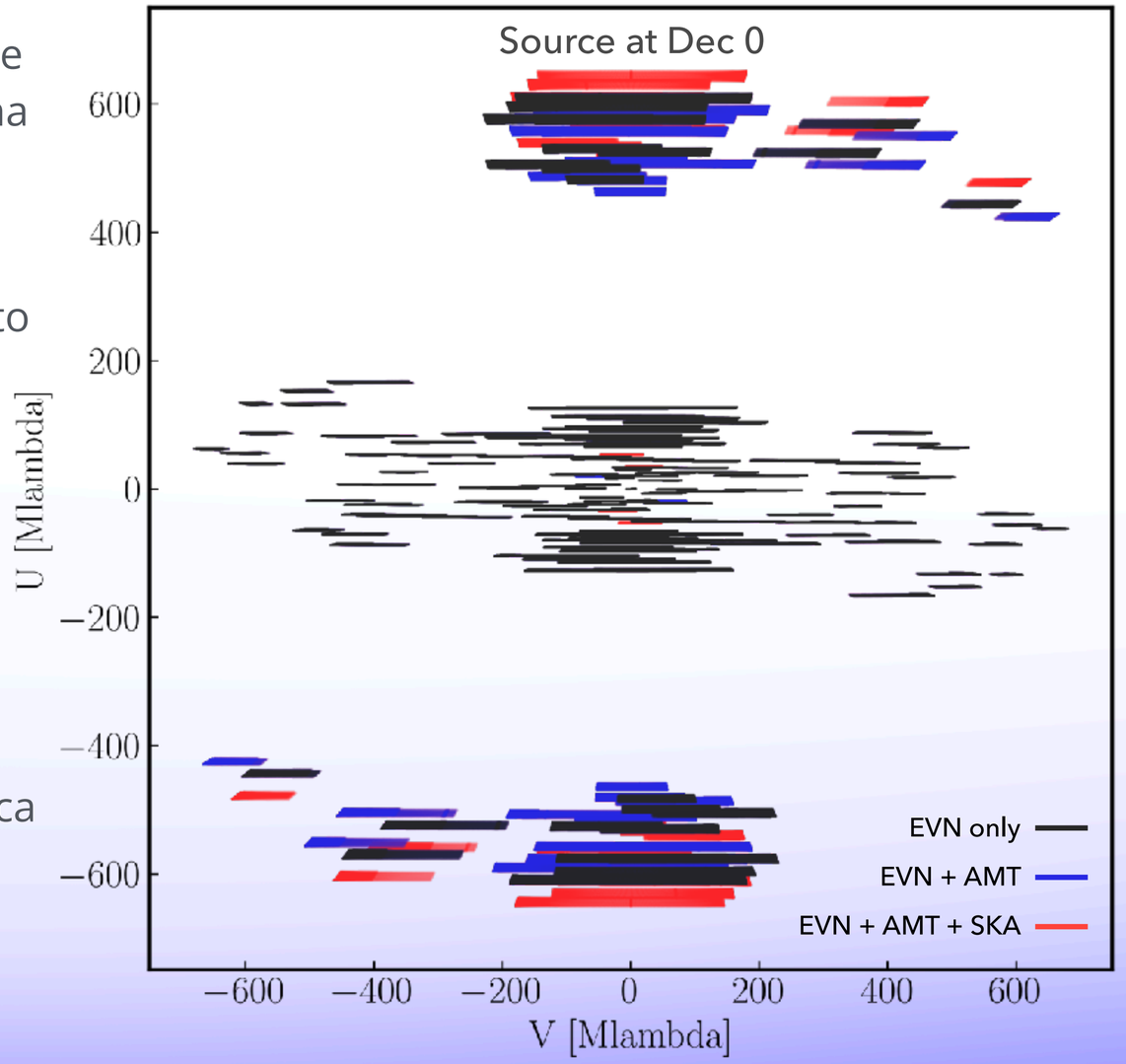
Remote GeoStations

Simulations & infrastructure development

VLBI networks and synergies with astronomy

- Very Long Baseline Interferometry techniques are used to look at extreme astrophysical phenomena **and** determine Earth Orientation parameters, universal time (UT1) & plate tectonics.
- Geodetic measurements are used in astronomy to allow for, e.g., a) precise coordinates of astronomical objects (e.g., via determining the ICRF, b) geometric delays for interferometric correlators, c) Ionospheric & tropospheric calibration corrections.
- Leverage existing expertise in astronomy to be used in geodesy! Understand ideal location for location of VLBI instrument for both fields in Africa
- Another possible avenue to funding parts of the African VLBI Network — **talks already ongoing with SKAO**

Example simulation of AMT @ 22GHz



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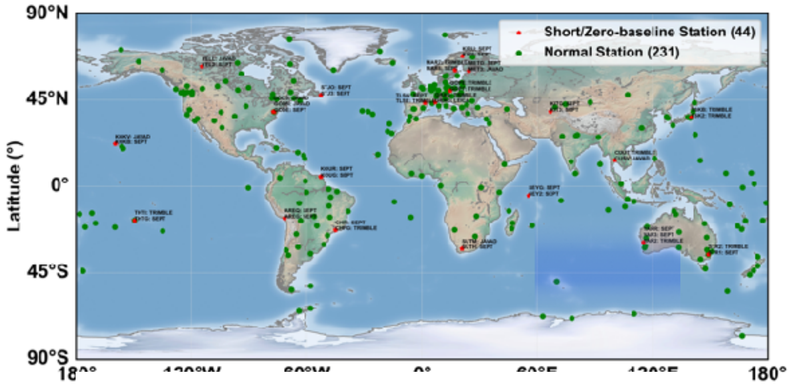
Simulations & infrastructure development

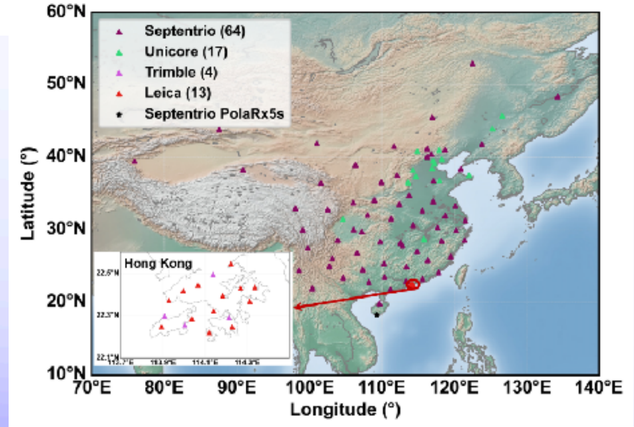
GNSS networks

Zhouyu Zhang

- Incoming PhD student at U. Manchester, who is an expert in GNSS modelling and ionospheric research
- Example: Global ionospheric perturbation (ROTI) and Activity level (AL) maps

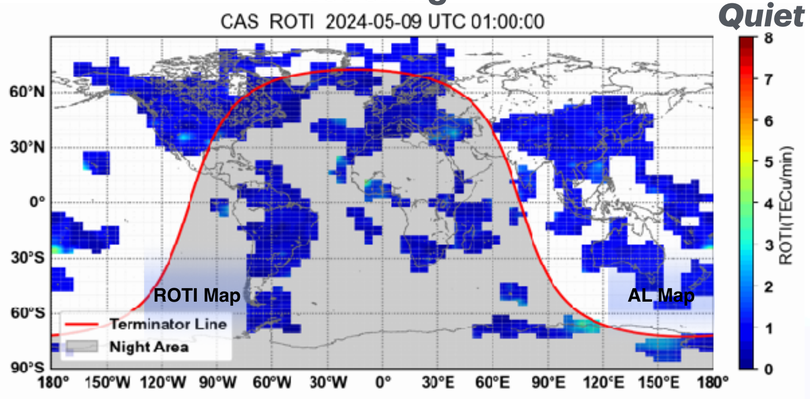
Station distribution

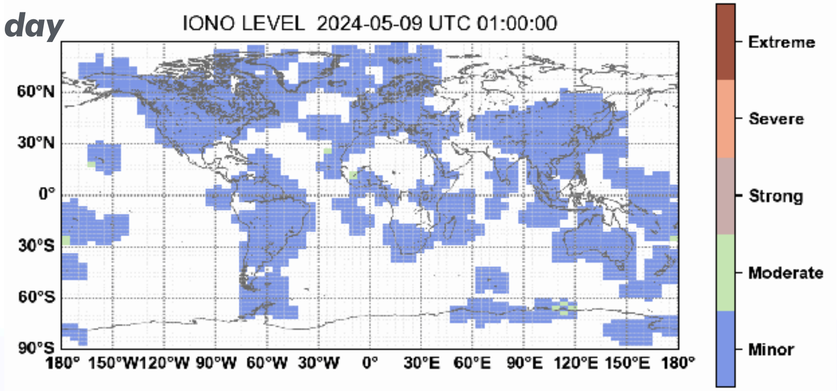




Modelling

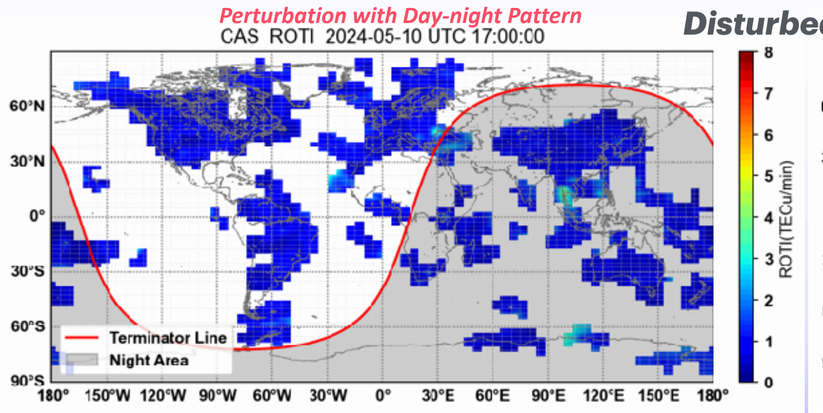
Quiet day

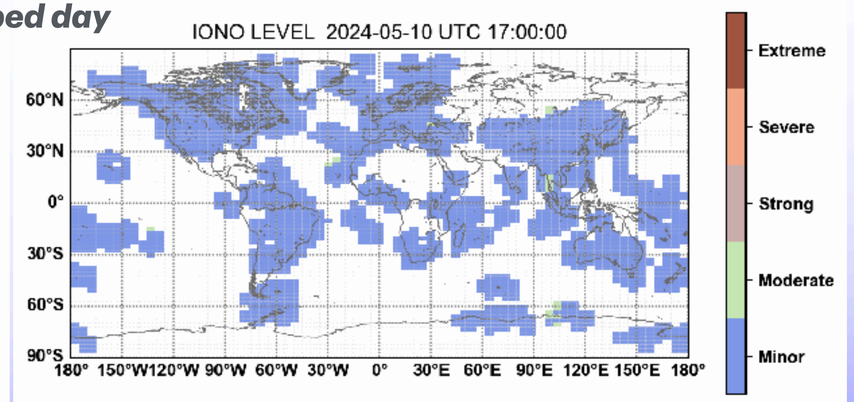




Perturbation with Day-night Pattern

Disturbed day





Slide credit: Z. Zhang

Note: The real-time products are pre-operating in the websites: iono.bdsmart.cn and igs.bdsmart.cn

Simulations & infrastructure development

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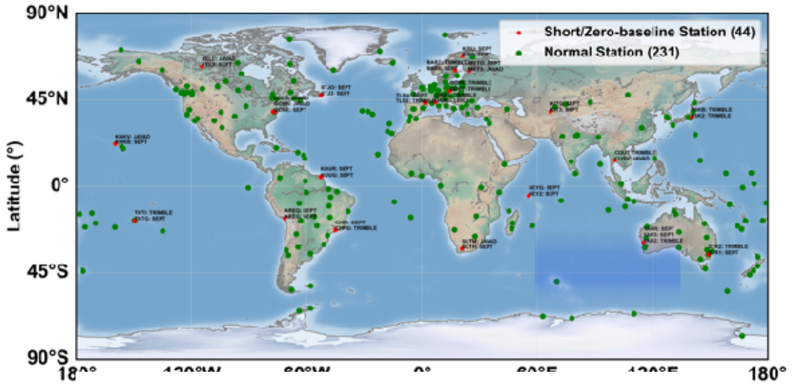

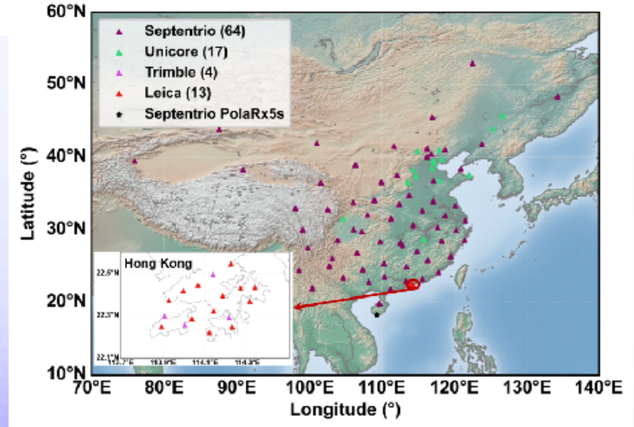

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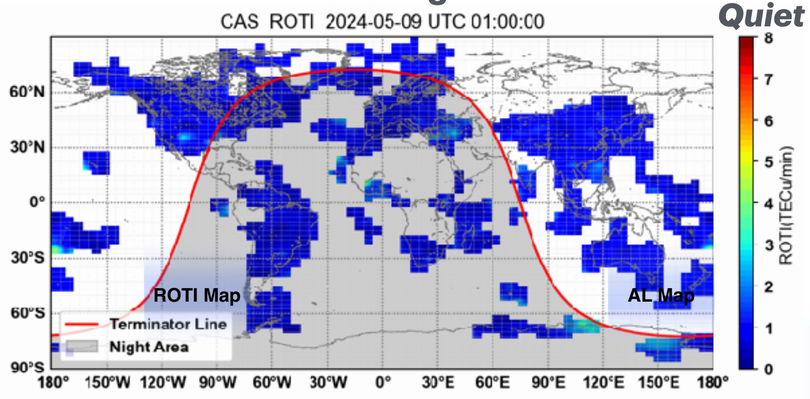

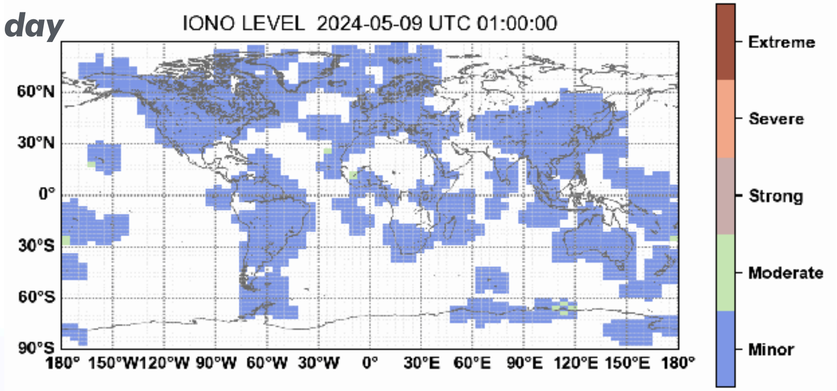

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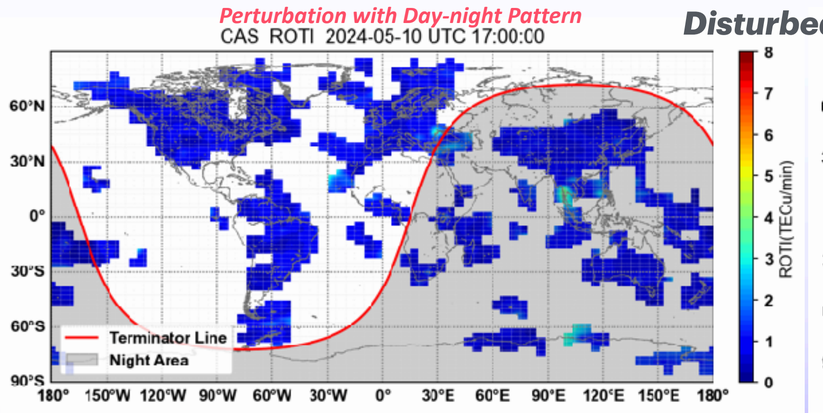

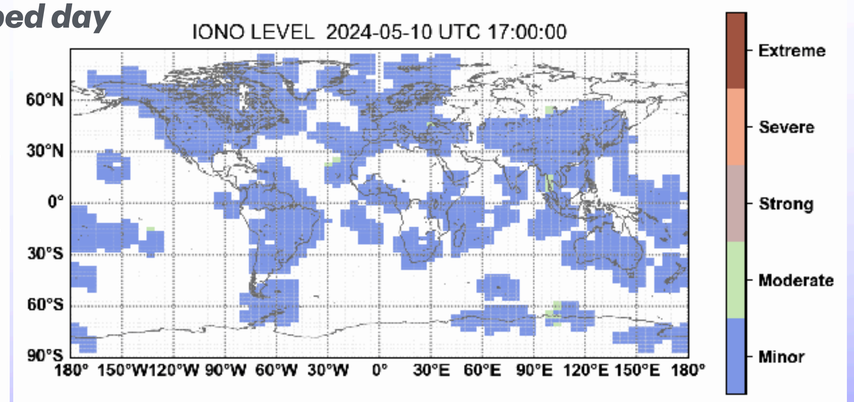

Slide credit: Z. Zhang

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Founding GGOS-Africa

WP4 - Foundation for GGOS-Africa
Months 00-24

Strategic Purpose of GGOS Africa:

- Reminder: We aim to establish GGOS Africa as a continental coordination platform, promoting development at national, regional, and global levels.
- GGOS Africa is not a replacement for established institutes, committees, and projects

Phased Development Approach:

- Allows countries that are ready to engage immediately
- Enables gradual inclusion of others as capacity develops
- Promotes equitable growth and regional balance

(possible) Governance Structure:

- Secretariat: Located in South Africa
- Membership: Open to all AU member states.
  National representatives + observer participation for institutions
- Steering Committee (SC): Responsible for ToR, strategy oversight
  2 representatives per African region (North, East, South, West, Central)
  Plus established committees/projects in Africa (e.g. AFREF, UN-GGIM: Africa, RCMRD, AFRIGIST)
- Expanded Steering Committee (ESC): Broader consultation body for alignment and consensus
  1 representative per African country — up to 55 members (aligned with AU structure)

Tentative Regions: UN Geoscheme
AFREF slightly different

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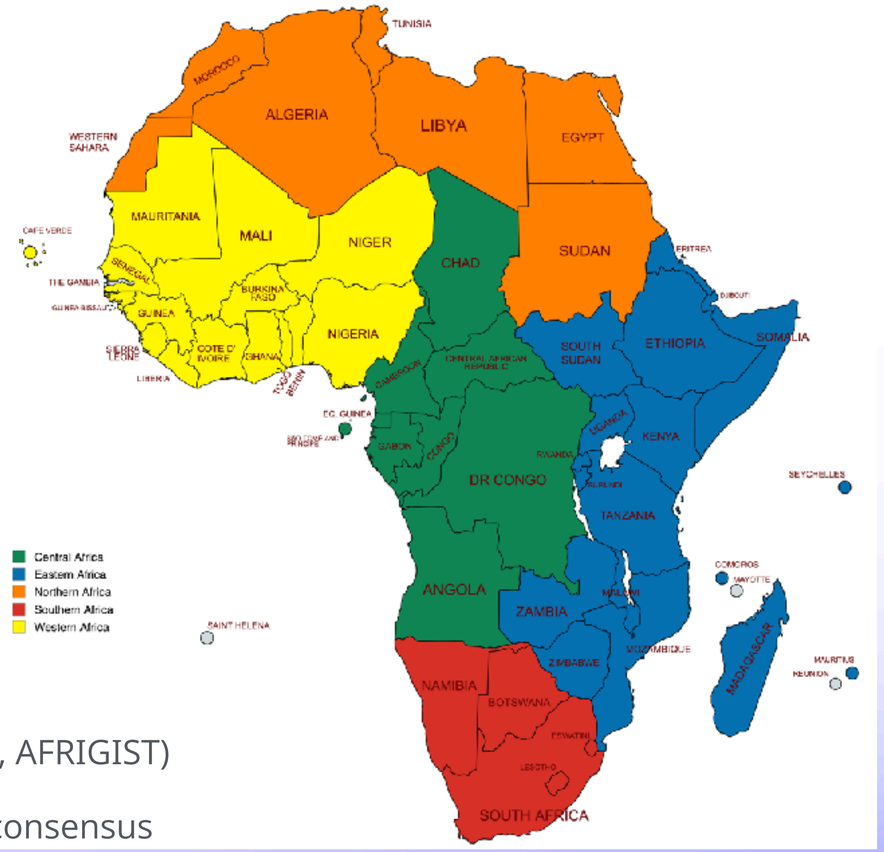
Global Geodetic Observing System - Africa



Slide credit: A. de Witt

After 2027?

- A key effort of this project is to **ensure the sustainability of the initiative after funding ends** (work package 5)
- This will be achieved through:
  - Exploring opportunities for expanding the initiative to cover more regions and aspects of geodesy. This would include applying for new funding opportunities (e.g., Horizon Europe / Africa Initiative III)
  - Build an operational plan to enhance African geodesists' and computational experts' skills, and knowledge and ensure the effective management and use of geodetic infrastructure.
  - Raise awareness of the importance of geodesy in sustainable development and promote the project's findings to a broad audience.
  - Develop plans for human capital development (HCD) programmes that would enhance the skills and knowledge of African geodesists and computational experts to ensure the effective management and use of geodetic infrastructure — leverage in-house experience from astro HCD programmes (e.g., SARAO, NASSP, DARA).

An invite to the African Rift Valley

As part of the GGOS-Africa seed funding, we are putting together a workshop to bring together geodesists across Africa in **Q2 2026.**

Expect first announcement soon!

GGOS-Africa
Global Geodetic Observing System - Africa

Summary

- The Africa-GGOS project has been founded to accelerate the improvement of geodetic infrastructure, capabilities and human capital across the African continent.
- To achieve this, work has begun on the following initiatives:
  - An understanding of the current gaps in geodetic infrastructure across the continten
  - Founding of the official GGOS-Africa affiliate organisation.
  - Close collaboration and input from all stakeholders from government to academia, and institutions across Africa, such as AFREF, RCMRD etc. and international institutions such as the UN and GGOS/IAG/IUGG.
  - Sustained, stable funding to continue GGOS-Africa.

If you wish to join the initiative, feel free to contact jack.radcliffe [at] manchester.ac.uk