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STRENGTHENING AFRICA'S GEODETIC INFRASTRUCTURE

ABSTRACT

Geodesy is the backbone of modern infrastructure, enabling climate resilience, disaster preparedness, precision agriculture, and smart cities. Despite its critical role, Africa's geodetic infrastructure remains underdeveloped and fragmented, limiting the continent's ability to fully support its own development and contribute to global geodesy. The accuracy and sustainability of global reference frames and Earth system monitoring depend on a well-distributed, fully integrated geodetic network—one in which Africa's participation is not optional, but essential. However, the region continues to face infrastructure deficits, data accessibility challenges, and policy gaps, which hinder long-term geodetic sustainability. Recognising the urgency of this issue, initiatives are underway to assess Africa's geodetic infrastructure, expand networks, and improve data accessibility. South Africa is leading efforts to bridge this gap, developing policy frameworks that prioritise geodesy as critical infrastructure, securing sustainable investment, and fostering international partnerships to modernise and expand geodetic networks and coordinate efforts across the continent. We provide an update on recent progress, ongoing initiatives, and plans to strengthen Africa's geodetic infrastructure, including work underway to assess the status of existing infrastructure across the continent. While challenges remain, continued collaboration, investment, and policy development are essential to ensuring that Africa becomes a fully integrated and indispensable part of the global geodesy community.

AFRICA'S ROLE IN GLOBAL GEODESY

- **Africa is vital to the ITRF, ICRF, and GGRF — but its geodetic infrastructure remains sparse (see Fig. 1: ITRF station map, Fig. 2: ICRF-3 station map)**
- **Africa has only one GGOS Fundamental Station — the SARAO/Hartebeesthoek site (South Africa) — the continent's sole site hosting all four space geodetic techniques and the only African contributor to geodetic VLBI (see Fig. 3)**
- **The Global Geodesy Supply Chain Needs Africa:**

Filling the Gaps:
→ Africa's vast landmass helps reduce spatial bias in global reference frame solutions
→ Contributes essential tectonic & atmospheric data (e.g., East African Rift, equatorial ionosphere)

Impact of Absence:
→ Sparse geodetic coverage leads to unmodelled errors in geodetic products
→ Satellite navigation, Earth observations, and disaster early-warning systems degrade globally

Conclusion:
→ Investing in African geodetic infrastructure is not optional…
→ It's a global imperative for accurate reference frames and Earth observation systems

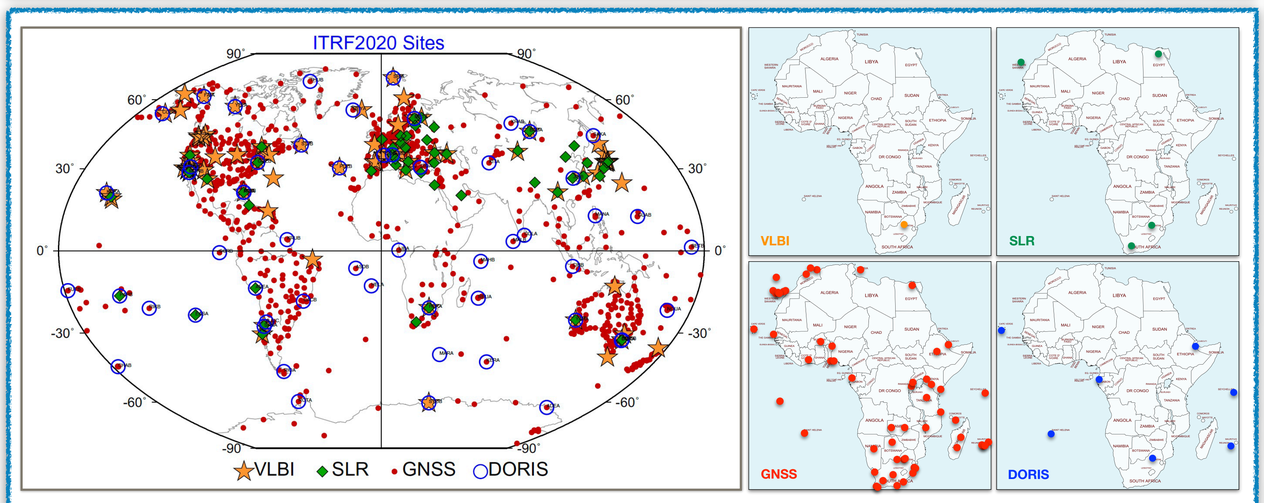


Figure 1. The global distribution of ITRF2020 sites (left), showing VLBI (orange stars), SLR (green diamonds), GNSS (red circles), and DORIS (blue circles). The imbalance and major infrastructure gaps are clear, particularly in Africa, which remains vastly underrepresented in the global network. The maps on the right show 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).

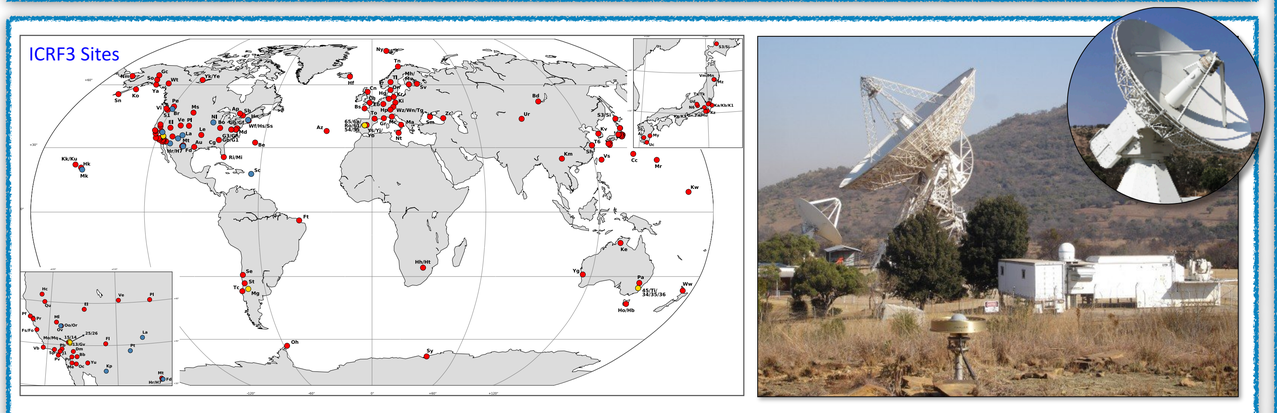


Figure 2. The 167 radio telescopes, located at 126 different sites worldwide, that participated in observations contributing to ICRF3 over the past 40 years (left). Only one telescope on the entire African continent contributed to the ICRF3: the SARAO/Hartebeesthoek site in South Africa (right). It joined the IVS in 1980 and has continuously contributed to both the ICRF and ITRF. It hosts all four space geodetic techniques (VLBI, GNSS, SLR, DORIS), and its new VGOS telescope began IVS operations in 2025. Credit: Charlot et al., 2020 (left) and SARAO (right).

GEODETIC INTEGRATION FOR AFRICA'S FUTURE

- **Many African countries have GNSS stations, but numerous are privately owned or poorly maintained, with little or no public data access. Several countries lack any CORS stations, and existing infrastructure is often fragmented, outdated, or underutilised**
- **A lack of national and regional repositories and data-sharing frameworks hampers national development, while inconsistent standards, no preservation of records of legacy systems, and limited technical capacity result in uneven data quality and poor system interoperability**
- **Most African countries use independent — and often multiple — geodetic reference frames based on different datums, creating a fragmented landscape that hinders regional integration. AFREF, launched by UNECA in 2000 to unify these, has stalled due to coordination and resource gaps. A UN-GGIM-Africa Geodesy Working Group was proposed in 2024 to revive AFREF efforts. The Working Group will formally constitute in November 2025.**
- **Africa Needs a Modern, Integrated Geodesy Supply Chain:**

Sustainable Development:
→ Geodesy underpins national mapping and land-use planning essential for African development
→ Supports early warning and reposes systems for drought, floods and other regional geo hazards
→ Strengthens climate adaptation, environmental monitoring, and sustainable natural resource use
→ Enables African-led research on geodynamics and climate across diverse ecological zones
→ Supports resilient infrastructure and spatial development in rapidly growing African cities

Economic Growth:
→ Africa is home to ~1.5 billion people with some of the world's fastest-growing economies
→ Geodetic underpins Africa's digital transformation and 4IR innovation across the continent
→ Essential for cross-border infrastructure and regional integration under the AU's Agenda 2063
→ Harmonised geospatial reference frames are essential for full implementation of the African Continental Free Trade Area (AfCFTA)

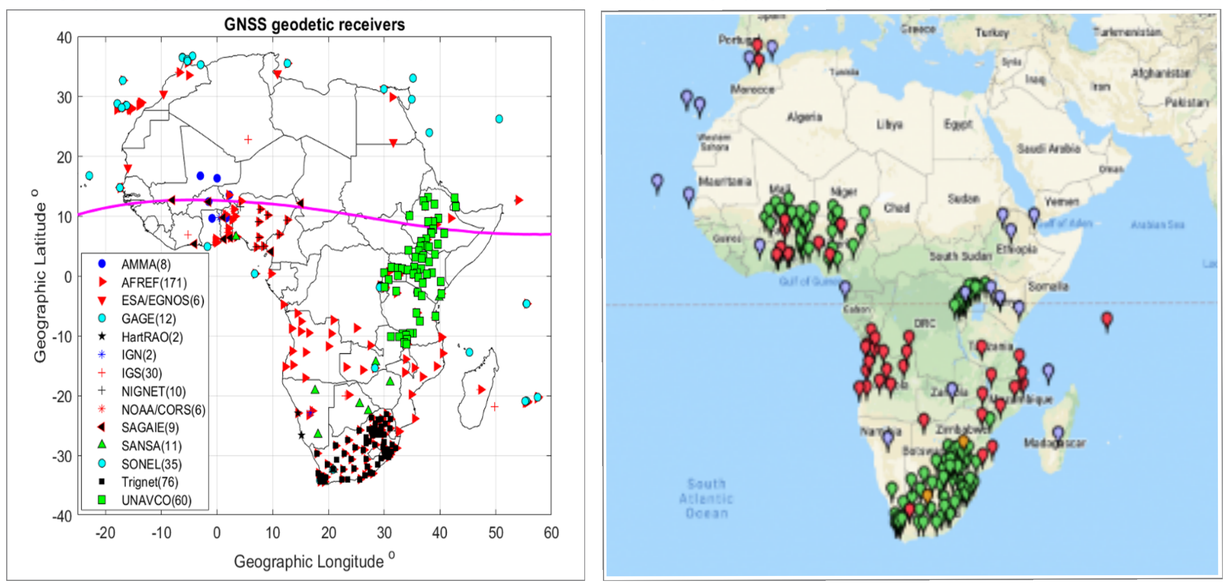
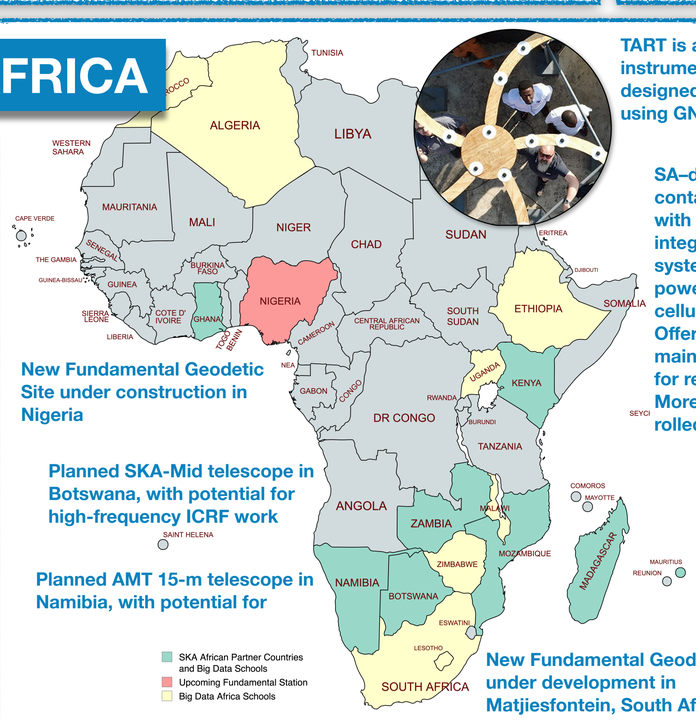


Figure 3. Distribution of known GNSS geodetic and reference receivers in and around Africa (left). Some receivers/networks are privately owned and data is not freely available. NOAA/CORS and NIGNET were shut down 2017 and 2020. GNSS data from "AFREF" CORS (right) is archived at the AFREF Operational Data Centre (AODC), http://www.afrefdata.org, hosted by the National Geospatial Information (NGI), South Africa. Credit: Baki et al., 2023 (left) and NGI (right).

GROWING CAPACITY IN AFRICA

Ongoing infrastructure and human capacity building for astronomy in the SKA African partner countries;

- Ghana 32-m radio telescope conversion (GRAO)
- Planned SKA-Mid telescope for Botswana (BIUST/MPIfR/SARAO)
- These new and planned radio telescopes provide the potential for an African VLBI Network (SARAO/ARAP)
- Co-location of geodesy infrastructure
- Deployment of high performance compute infrastructure and training (e.g. NICIS/CHPC)
- Big Data Africa School (BDAS) in SKA partner and other African countries
- Deployment of training instruments for astronomy and geodesy (e.g. the Transient Array Telescope—TART)
- Astronomy and geodesy undergraduate training workshops and post-graduate funding (e.g. DARA)



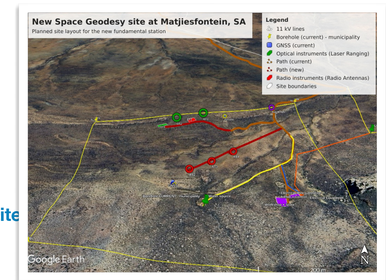
New Fundamental Geodetic Site under construction in Nigeria

Planned SKA-Mid telescope in Botswana, with potential for high-frequency ICRF work

Planned AMT 15-m telescope in Namibia, with potential for

TART is a low-cost, scalable radio astronomy training instrument deployed in the SKA African partner countries, designed to teach the principles of radio interferometry using GNSS-type antennas

SA–developed, self-contained GeoStations with GNSS and integrated weather systems. Fully solar powered, equipped with cellular communication. Offer robust, low-maintenance solution for remote deployment. More than 14 stations rolled out in SADC.



New Fundamental Geodetic Site under development in Matjiesfontein, South Africa

Policy frameworks and seed funding are in place to launch GGOS Africa — enabling coordination, and strategic expansion of geodetic capacity across the continent

At 10th meeting of UN-GGIM-Africa, it was resolved to reinstate a Regional Committee in Geodesy to co-ordinate the implementation of the AFREF project at the continental level and to undertake an inventory of already established CORS in every country

UN-GGCE Capacity Development Workshop for Africa, May 2025, Nairobi, Kenya. In the process of compiling Geodesy Fact-books for each country

Africa-UK Geodesy partnership
UKRI/STFC seed funding secured to launch GGOS Africa and to assess geodetic infrastructure, compute platforms, and human capacity across Africa, to enable coordinated gap analysis, regional planning, and network expansion

GEODESY COORDINATION & CAPACITY BUILDING

Towards a structured repository of geodetic infrastructure, technical capacity, and geodetic reference systems across Africa