

Session 4: AFREF Infrastructure & Vertical Datum: summary notes

GGOS-Africa 2026 Workshop, Nairobi · Tuesday 6 October 2026 · 09:05–10:42 EAT

Moderator: Roelf Botha (per programme)

Written from the Zoom transcript, cross-checked against the speakers' slides where the transcript was unclear. Audience speakers' names are given only where they could be identified with reasonable confidence. Figures are as presented. Please check against the recording before quoting anyone.

Key points

- **The problem is no longer infrastructure but governance, data sharing and sustainability.** About 9 in 10 African countries now have CORS, but many do not share data, stations follow no common standard, and networks bought with project money go silent when the money ends.
- **AFREF is being relaunched.** The UN-GGIM: Africa Executive Working Group on AFREF was reinstated in 2024–25. A **second continental GNSS campaign** is planned before the end of 2026, and countries were asked to be ready to share data.
- **Côte d'Ivoire's "club good" model** pooled several World Bank programmes and agencies to grow from 1 to 20 CORS in five years (30 by end-2027), with about US\$5,000 per station per year for operation and maintenance.
- **RCMRD is building a continental CORS map** and asked every station owner to submit metadata. Martin Murimi proposed "five bridges" as candidate resolutions for Wednesday.
- **Heights need physical (gravity-based) datums.** South Africa's tide-gauge-based levelling datum differs from the global vertical reference (IHRF) by between –26.5 cm and +22 cm depending on the tide gauge.
- **Proposed way forward (Balé):** national agencies and scientific bodies work together; anchor AFREF in the AU Commission / African Space Agency for political backing and funding; align GGOS-Africa and UN-GGIM: Africa work plans to avoid duplication.

Talks

Fernand Balé: AFREF: Current Status and Way Forward

(BNETD, Côte d'Ivoire; co-chair UN-GGIM Subcommittee on Geodesy; chair UN-GGIM: Africa Working Group on AFREF)

- **What AFREF was built to deliver:** one continental frame consistent with ITRF; a station within 500 km of every user; open data access; and a vertical component ("we are still struggling on this"). "The vision has not aged. The delivery model has."
- **Already in place:**
 - Executive Working Group on AFREF under UN-GGIM: Africa (convened by Côte d'Ivoire, RCMRD secretariat), with updated terms of reference and five sub-regional seats.
 - AFREF Permanent Stations Guidelines, now followed by countries building new national networks.
 - AFREF Operational Data Centre hosted by NGI, South Africa.
 - Annual AFREF training at RCMRD in Nairobi; AFRIGIST, UN-GGCE and FIG now help with capacity development.
- **First station survey:** 116+ base stations identified, but only about 43 (slides; 33 said in the talk) broadcasting usable data. Donated stations (Trimble, Ordnance Survey) are in some cases still in offices and not installed.
- **2024 UN-GGIM survey:** only **11 of 54 countries** replied. 7 run a national CORS network; 5 of those 7 share data with the AFREF data and analysis centres; 2 operators say they cannot build or maintain stations on their own. Frames range from ITRF2000 to ITRF2014.
- **SIRGAS as a model:** more than 500 sites (about 67 in IGS), over 50 organisations, strong leadership, and governance that works alongside but is not embedded in UN-GGIM: Americas.
- **Four critical levers, none technical:** governance; data sharing; sharing products; and stronger analysis capability in Africa. "The greatest threat to AFREF is political, not technical." Countries must put in their own money; no one else will.

- **Côte d'Ivoire case study, the “club good”:**
 - The National Mapping Agency had zero government budget for this.
 - A pure public good gets no owner (stations go silent after projects); a market-only model only serves where it pays.
 - Instead, organisations that rely on geodetic services co-fund the network. Two World Bank programmes (rural land administration and urban resilience) each paid their share, after three years of negotiation.
 - Result: 1 CORS five years ago, **20 today, 30 by end-2027**; more than US\$4M invested; free for all users in Côte d'Ivoire.
- **Proposal for Africa:** UN-GGIM: Africa cannot receive money from member states, so countries modernise their own frames and share data. The AFREF working group speaks to governments (political mandate); GGOS-Africa speaks to the scientific and technical community. The overarching goal is an **annual AFREF solution**.
- Concern about young people choosing GIS or remote sensing over geodesy.

Martin Murimi: CORS in Africa: From Scattered Stations to a Continental Service

(RCMRD)

- **Opening story:** the 2024–25 Fentale–Dofen dyke in Ethiopia grew to about 50 km, with 300+ earthquakes (largest M5.9) and about 75,000 people evacuated. One IGS station (ADIS, Addis Ababa) moved about 20 mm west. “One station felt the continent pull apart”: what could a network have shown?
- **Not every CORS can carry a frame.** It needs a stable monument, a calibrated antenna (IGS ANTEX), continuous operation, a site log and a DOMES number. “A coordinate without an epoch is a coordinate that expires.”
- **One station, three jobs:** service (RTK for surveyors, machine guidance, drones), frame realisation, and science (deformation, ionosphere, water vapour).
- **Two decades:**
 - 2005: about 15 IGS stations in Africa. Today there are still only about 15 *active* ones.
 - 2013: the AFREF data centre tracked about 110 stations, but only about 49 delivered data.
 - 2019: 22 countries operating permanent GNSS stations.
 - 2026: about 9 in 10 countries have CORS.
- **Country snapshot:** South Africa TrigNet 70+; Uganda 40 government plus private networks; Nigeria 80+; Ghana 60+ (target 100); Kenya probably 60+ but undocumented; Rwanda expanding. Different funding models in each.
- **“We built the islands; five bridges are missing”:**
 1. *Coordination:* about 10 stations within 10–15 km in Nairobi, none in many rural areas. What return on investment would make the private sector go rural?
 2. *Open data:* most countries with CORS are not sharing. Even sharing station positions was hard; one country said it would need parliamentary approval.
 3. *Standards:* commercial stations often lack site logs or proper monuments.
 4. *Sustainability:* donated and project stations shut down once funding ends (e.g. a Kenyan county network).
 5. *A moving frame:* coordinates published without epochs, velocities or deformation models.
- **Benefits on the other side:** only about 10% of Africa’s rural land is registered (World Bank); precision agriculture; drones (Zipline: 2 million deliveries across five African countries); early warning; weather (water vapour); timing; the global GNSS market (about €260bn in 2023, about €580bn forecast for 2033).
- **RCMRD Africa CORS map:** a short survey asks owners for station position first, then receiver, antenna, monument, sampling rate and a photo. Ownership stays with the owner; the map is for coordination and research. Only 4 of RCMRD’s 20+ member states had responded. QR code and links were on the slides.
- **Five bridges, proposed as candidate resolutions for Wednesday:**
 1. Register every CORS: a continental inventory within six months, via RCMRD and GGOS-Africa.
 2. At least one station per country streaming to the AFREF data centre (and IGS where possible).
 3. Adopt common standards (IGS site guidelines, site logs, RINEX 3+, coordinates with epoch and velocity model).
 4. One national coordinator per country for government, private and academic networks, with periodic

- checks.
- 5. Invest in people.

Siphiwe Mphuthi: Vertical Datum Infrastructure in Africa: a South African perspective

(University of Cape Town)

- **Why heights matter:** drainage, flood risk, sewers, irrigation, road and rail gradients, under-keel clearance, sea-level monitoring.
- **The core problem:** GNSS gives ellipsoidal height h ; practical work needs physical heights tied to gravity. The geoid (orthometric heights) or quasigeoid (normal heights) links the two. Datasets must state which height type they use.
- **Concepts:** reference system (conventions) vs reference frame (its realisation) vs operational datum. Physical heights come from geopotential numbers, divided by actual mean gravity (orthometric) or normal gravity (normal heights).
- **Mean sea level is local.** Currents, winds, salinity and land motion mean a tide-gauge zero is not a globally consistent equipotential surface.
- **IHRS/IHRF** gives a global physical height system (conventional W_0). ITRF supplies the geometry, IHRS/IHRF the physical height. National datums should be traceable to both.
- **South Africa case study:**
 - The Land Levelling Datum (LLD) was set from four tide gauges in the early 1900s and carried inland by precise levelling. It uses spheroidal orthometric heights.
 - Estimated offsets of the LLD from the global vertical reference at the tide-gauge benchmarks: **Cape Town +6.0 cm, Port Elizabeth –20.3 cm, East London –26.5 cm, Durban +22.0 cm**. So the local datum is not one uniform surface.
 - Legacy levelling and trig networks sit alongside TrigNet and SAGEOID10. The task is to connect them, not discard the legacy.
- **What a reliable geoid model needs:** terrestrial, airborne, marine and satellite gravity; terrain corrections; GNSS/levelling control; tide-gauge interpretation; clear error reporting.
- **Practical checklist when using heights:** which height type and vertical datum; which horizontal frame and epoch; which geoid/quasigeoid model and version; which transformation; and a metadata trail.

Interactive discussion

- **Monuments and height systems (Ugandan participant).** Asked Murimi to collect monument types, not just positions. Asked Mphuthi how a country can tell which height system it is on when documentation is poor; in Uganda, two teams disagreed whether heights were orthometric or normal-orthometric.
 - **Mphuthi:** historical documentation is key. Very few countries use true orthometric heights because they need actual gravity. Most (perhaps 90–98%) use a variant (normal or normal-orthometric), commonly called “height above mean sea level”. South Africa has actual gravity on only one fundamental benchmark (Cape Town). Without legacy documents it is very hard to establish.
 - **Murimi:** the position-first request is a way to open the conversation; the full form asks for receiver, antenna, monument, sampling rate and a photo.
- **Who manages the Côte d’Ivoire network? (Emmanuel, participant).** **Balé:** the national agency coordinates and pays for maintenance and upgrades.
- **Communicating geodesy (Nigerian participant).** Use visual, practical examples for decision makers (e.g. Lagos subsidence research), rather than explaining gravity. Positions alone are only for mapping; AFREF needs observation data over time. **Standards do exist (IGS); the problem is that people don’t follow them.** National mapping agencies must take responsibility. Asked Balé how the Côte d’Ivoire model will be sustained beyond five years.
- **An African CORS registration platform (Elifuraha Saria, Tanzania).** There is no African form or platform to register CORS. Proposed that the AFREF data centre host (South Africa) build a website with standards and registration forms, and that a committee write to all mapping agencies. Project-funded geodynamic stations in Tanzania (e.g. AfricaArray) were installed with geological agencies, not mapping agencies, so nobody tracked them when funding ended; only the seismic part continued. Mapping agencies should lead.

- **Dr Odongo (Technical University of Kenya).** Can geoid–ellipsoid separations from GNSS/levelling be used to estimate gravity parameters? Noted Kenya’s mapping authority has no CORS, while Kenya Power has 16+ and private firms 30+, some within 2 km of each other.
 - **Mphuthi:** yes, the geoid–quasigeoid difference can be used as a one-dimensional transformation between reference surfaces.
 - **Murimi:** the data exist; the issue is getting owners to share. Responses from mapping agencies are slow.
- **Côte d’Ivoire costs (Balé).** About **US\$5,000 per station per year** paid to the operator, covering operation and maintenance, so the agency needs no data centre, analysis centre or operating staff of its own. A new business-model study next year: growing station numbers and rising software licence costs.
- **Prioritisation (André Nonguierma).** The question is no longer establishing networks but sustaining and institutionalising them as continental services. Asked how to prioritise the challenges into policy recommendations.
 - **Balé:** UN-GGIM’s committee of experts has mandated UN-GGCE and the Subcommittee on Geodesy to consult more broadly, so Africa has momentum. Three things: (1) national agencies working with scientific organisations (IAG, GGOS, IGS); (2) **anchor AFREF in the AU Commission and the African Space Agency** for political backing and funding, rather than voluntary contributions; (3) **align GGOS-Africa and UN-GGIM: Africa work plans** to avoid duplicated requests. Countries that already send data to NGI ignore repeat requests and so are missing from new maps (e.g. Nigeria, Côte d’Ivoire).

Session closed at 10:42 for the break.

Actions and follow-ups mentioned

- Countries to be ready to share data for the **second AFREF continental GNSS campaign** (before end-2026).
- Station owners to submit CORS metadata to the **RCMRD Africa CORS map** (QR code and links in Murimi’s slides; mmurimi@rcmrd.org).
- Murimi’s **five bridges** proposed as candidate resolutions for Wednesday.
- Proposal for an African CORS registration platform with common standards, possibly hosted with the AFREF data centre.
- Coordinate GGOS-Africa and UN-GGIM: Africa data requests and work plans to avoid duplication.