

Session 9: GGOS & AFREF Analysis Centres: summary notes

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Moderator: Hussein Farah

Written from the Zoom transcript, cross-checked against the speakers' slides. 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. Talk order differed from the programme: André Nonguierma spoke last, without slides. The video starts about 1.5 minutes into Aletha de Witt's talk, and Patrick's closing comment (15:45) is not in the video.

Key points

- **GGOS-Africa wants a distributed network of African analysis nodes.**
 - They would build on high-performance computing that already exists, starting with the 13 African sites of South Africa's CHPC ecosystem.
 - They would serve AFREF, international products (e.g. the K-band VLBI celestial frame) and other domains.
 - The aim is eventually to be recognised as official IAG analysis centres.
- **The first AFREF computation (December 2012, about 50 stations, five analysis centres)** produced static coordinates tied to ITRF2008. With only two weeks of data, it gave no velocities.
- **A new, time-dependent AFREF solution is proposed for 2027–2028.**
 - It would use publicly available GNSS data from about 2010–2026.
 - Each analysis centre would produce daily loose solutions, combined (with CATREF at IGN or similar) and possibly with DORIS. Questions to settle include offsets, noise, and crustal deformation within Nubia.
- **AFREF analysis-centre criteria and categories** (global, global associate, national and other) were agreed in 2014 and 2017 but **the call for analysis centres has not yet gone out**. A technical meeting will be convened. NGI (South Africa) now hosts the data centre and is rebuilding the archive.
- **Capacity is the bottleneck**, not software. Too few younger analysts; equatorial ionosphere effects; the need for common metadata. Cloud computing and general-purpose HPC make the hardware question easier.

Talks

Aletha de Witt (online): GGOS Analysis Centres

(HartRAO / SARAo, South Africa; same slides as her GGOS Days talk that morning)

- One of GGOS-Africa's core functions is a **distributed analysis node network**: nationally hosted space-geodetic analysis nodes contributing to international data products, using existing astronomy and space-science computing.
- **For AFREF**: UN-GGIM: Africa needs analysis centres for hosting and analysing AFREF data. GGOS-Africa will work closely with UN-GGIM: Africa and the AFREF Working Group to avoid duplication.
- **African-led data to analyse**:
 - South Africa leads a **K-band (24 GHz) VLBI** programme. It contributes to the ICRF, has submitted data for the next ITRF, and has over 12 years of data collected monthly.
 - It could build capacity and produce publications through African nodes.
- **Infrastructure**: the CHPC computing ecosystem, built for astronomy, is deployed at **13 African sites**, and CHPC is looking for more users.
 - First step: assess what computing exists and which countries are interested.
 - Then roll out in phases (start with one country, learn, expand).
- **Multi-domain**: nodes could also serve Earth observation and astronomy, offering students a space where geodesy, astrometry and space science meet. Eventually they could become correlation centres for an African VLBI network. They should be designed for interconnection from the outset.
- **Discussion**:

- **Jack Radcliffe:** leverage the centralised national HPC and AI infrastructure many countries are building, buying into those schemes rather than buying compute.
- **De Witt:** agreed. Combining infrastructure also promotes collaboration.
- **Participant:** there is an HPC centre in Abidjan (Côte d'Ivoire) not shown on the map. **De Witt:** the CHPC sites are only a starting point; existing national infrastructure will be assessed too.

Muya Kamamia: AFREF Implementation and CORS (Muya CORS, Kenya)

(Director, Measurement Systems; Fellow, Institution of Surveyors of Kenya. The programme title “CORS System Analysis and Computations” was a misunderstanding, so he presented his own network.)

- **CORS components:** reference receivers (geodetic antenna, multi-frequency receiver, power, internet); the network control centre (servers and software such as Leica Spider, Trimble TPP, Topcon, ComNav, CHC); and users' rovers.
 - Products: RINEX, DGPS and RTK corrections (single-base or network VRS/FKP), and post-processing.
 - Single-base RTK fixes are now possible beyond about 70 km with four constellations.
- **Siting:** clear sky, no interference, secure, stable rooftops; reliable 24/7 internet and power (backups). “Take it where it's needed.”
- **Challenges in the region:**
 - Funding: national networks have mostly relied on donors (“we need to fund ourselves”; PPPs).
 - Internet and power interruptions and non-payment.
 - **Maintenance:** budgets and procurement are too slow for repairs and upgrades.
- **Muya CORS:**
 - About 30 stations across Kenya, concentrated where users are, plus stations shared with a partner across the Uganda border. Purely solar powered.
 - Chinese receivers and ComNav software, tracking all constellations.
 - Coordinates are in **ITRF2020** (reference epoch 1 April 2026, day 091), computed with online PPP (Canada's CSRS-PPP, cross-checked with OPUS).
 - Users register and buy time-based subscriptions; static data can be downloaded for a small fee; rovers are available for hire.

Elifuraha Saria: First Computations of AFREF and Way Forward: Time-Dependent Coordinates

(Ardhi University, Tanzania)

- **Why reference frames:** observables alone cannot fix positions (the datum defect). A reference frame is a set of marked sites with defined positions and velocities.
 - ITRF has about 12 realisations since 1988.
 - A global no-net-rotation frame hides regional geodynamics, so regional frames (EUREF, NAREF, SIRGAS, APREF) hold the stable plate interior fixed.
- **First AFREF computation (2012–2013):**
 - Two weeks of data (GPS weeks 1717–1718, 2–15 December 2012) from about 50 stations. Sources: CDDIS, HartRAO, NGS, TrigNet, UNAVCO/AfricaArray, NIGNET and SEGAL (Portugal, for Lusophone countries). There was a gap from Angola through Congo and Sudan and across North Africa.
 - **Five analysis centres:** HartRAO; SEGAL (Mozambique/Portugal); the Tanzanian Directorate of Surveys and Mapping; Ardhi University; CGG Toro (Nigeria).
 - Common strategy: 30 s data, final orbits, IERS EOPs, 0° elevation mask, ocean loading, calibrated antennas. Each centre processed African CORS plus the African IGS sites. A common station-information file was used. The output was loose SINEX solutions (from GAMIT, Bernese or GIPSY).
 - These were combined at IGN with **CATREF** (Zuheir Altamimi) using IGS core sites.
 - **Result:** static coordinates for about 50 sites in ITRF2008, with no velocities from 14 days.
- **Proposed new AFREF solution (2027–2028):**
 - All publicly available GNSS from about 2010 to 2026, including new networks (e.g. 22 CORS installed in Tanzania in 2025 under CONETA, and Uganda's 40).
 - Each African analysis centre produces daily loose solutions, either regional or combined with the global loose solution (e.g. from MIT).

- Then: time series, jump correction and earthquake/offset files, noise analysis, and checks of internal consistency between centres (agreement within a few centimetres for loose solutions).
- Combine into a long-term position-and-velocity solution in ITRF. Optionally add DORIS weekly solutions, linked by local ties.
- **Crustal dynamics:** AFREF is to be anchored on Nubia (rigid to about 0.6 mm/yr; Saria et al. 2013). But Wedmore et al. (2021) found a distinct “San” block deforming at 0.4–0.7 mm/yr, and more blocks may emerge as data grow. AFREF must account for the kinematics of Nubia and the rift.
- **Governance suggestions (slide):** “Who is AFREF?” It should be like EUREF or SIRGAS, with a management and technical committee, standards, application forms, possibly a main domain hosted by UNECA, and RCMRD and AFRIGIST involved.

André Nonguierma: AFREF Analysis Centres

(UNECA / UN-GGIM: Africa; no slides)

- Meetings in **2014 (Tunis)** and **2017 (Addis Ababa)** agreed on analysis centres beyond the original five, including a prospective centre in Ethiopia.
- The revamped AFREF project sets **criteria** and categories: global network analysis centres, global associate centres, and national network centres.
- He acknowledged that little progress has been made, but good work is happening behind the scenes. The next step is to **reconvene the experts** to resolve pending issues.
- ECA recommits to producing clear guidelines on who can be an AFREF analysis centre. “Africa for Africa”, while using what partners and the global community already do.

Interactive discussion

- **Bruno Kyamulesire.**
 - What qualifies a team as an analysis centre, and where is capacity building? The same senior names appear on all the papers, and younger people lack Bernese or GAMIT skills.
 - IGS data gaps are large in the 2010–2026 period, especially in geomagnetic storms. Start with a signal-to-noise assessment of candidate stations.
 - Dual frequency is not enough near the equator: higher-order (second- and third-order) ionospheric terms must be considered.
- **Patrick (South Africa).** What is a “loose” solution? Bernese (v5.4) in South Africa forms baseline-by-baseline solutions; do other packages differ? South Africa offered in 2015 to be an analysis centre, but no call came. Agree how centres are set up and train everyone to the same level.
- **Participant (Cameroon).** CATREF came from Altamimi, who is retiring. Is there collaboration with IGN to keep access to combination software?
- **Joseph Dodo.** What are the criteria for a GGOS analysis centre (versus AFREF)? Can a centre be both?
- **Participant.** Why 30 s data when 1 s receivers are now common? Are there provisional results from the first computation (“something is better than nothing”)?
- **Saria’s responses:**
 - **Loose solution:** a network solution with full covariance, not yet anchored to ITRF. This is standard across the high-end packages.
 - **Ionosphere:** handled by the ionosphere-free combination. A student’s study found higher-order effects at the millimetre-to-centimetre level, mainly very near the equator.
 - **Training:** he has trained people in South Africa and Madagascar (with UNAVCO funding) and through Ardhi’s master’s programme. But students, for example about ten Kenyans, chose GIS and remote sensing over geodesy.
 - **Qualification:** anyone with the capacity can be an analysis centre, and can partner with an experienced centre to learn. GAMIT and CATREF are “not hard”.
 - **Altamimi** is still active (producing ITRF2020 updates) and trained Saria on CATREF.
 - **AFREF as the technical arm:** AFREF should provide the technical support that GGOS and UN-GGIM: Africa draw on.
 - **30 s** is sufficient; 1 s adds little for frame computation.
 - **Provisional results** will be communicated.

- **Farah:** “You say it is easy; it is easy for you.” It took him months in France and years in the US.
- **Jack Radcliffe.** AFREF analysis centres compute and move on. A GGOS-type centre should also be a **repository**. He suggested an **African Geodetic Analysis Centre** doing AFREF, VLBI reduction, ICRF and ITRF work on one general-purpose HPC: the most “bang for your buck”, given that HPC needs people to maintain it.
- **Dodo.** In 2012 analysis centres had to use Bernese, GAMIT or GIPSY. The same senior people are still the ones doing it because there is no funding to bring younger trained people to meetings.
- **Participant (Malawi).** Centres should develop their own software, since processing parameters differ between packages.
 - **Radcliffe:** with cloud computing you configure the machine to fit any software; general-purpose compute is enough.
 - **Saria:** the packages are platforms whose parameters you set. With agreed parameters, results should match; outliers are dropped in the combination.
- **Has the call for analysis centres gone out? (Farah).** Not yet. A technical meeting will be convened. NGI now hosts the AFREF data centre and is encouraging countries to contribute.
- **Participant.** The first AFREF coordinates exist but the geodetic community seems unaware of them. They should be published from a central place (ECA, GGOS-Africa).
- **Patrick (NGI / AFREF data centre).** Little data comes directly from African countries. The archive is being rebuilt by pulling from UNAVCO/EarthScope and CDDIS. A push-to-FTP mechanism is being developed so each country can send data to NGI.

Session closed at 15:46 for tea.

Actions and follow-ups mentioned

- Assess existing HPC in Africa (CHPC’s 13 sites plus others, e.g. Abidjan) and national interest in hosting analysis nodes; roll out in phases.
- UN-GGIM: Africa / AFREF WG to convene a technical meeting and issue the **call for AFREF analysis centres** with clear criteria.
- Plan the 2027–2028 time-dependent AFREF solution: agree data span, processing parameters, metadata and combination centre.
- Publish the first AFREF (2012) coordinates from a central place.
- NGI to roll out the push-to-FTP mechanism for national data submission to the AFREF data centre.