

First Computations of Geodetic Reference Frame For Africa (AFREF)

**And Way Forward = Time Dependent Coordinates
Geodynamic Implications**



2026 GGOS – Africa Workshop - Nairobi

Building the Foundation for Geodetic Excellence in Africa

Elifuraha Saria
Ardhi University - Tanzania

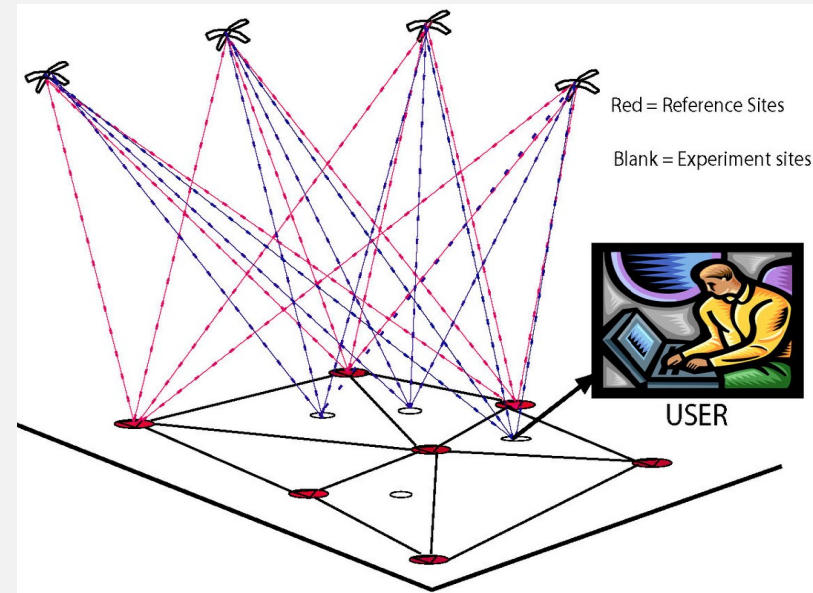
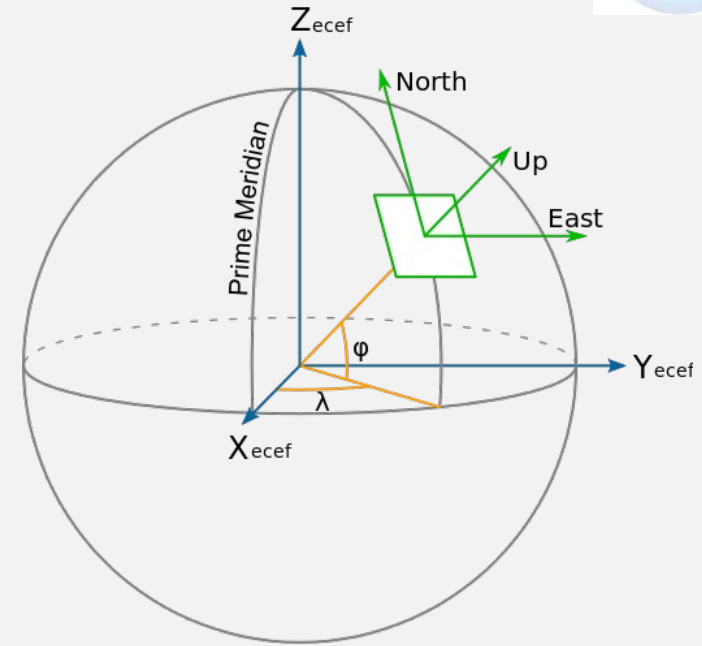


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Reference Frames: why and what are they?

- In practice: need to relate positions/velocities to an official standard frame, attached to the surface of the Earth.
- In theory: the “datum defect problem”, i.e. geodetic data – (observables/absolute quantities) not sufficient by themselves to calculate a position.
- A Reference Frame = set of sites, with a geodetic marker (passive or active), whose position and velocities are defined.
- A Reference Frame refers to – materializes – a “Reference System”

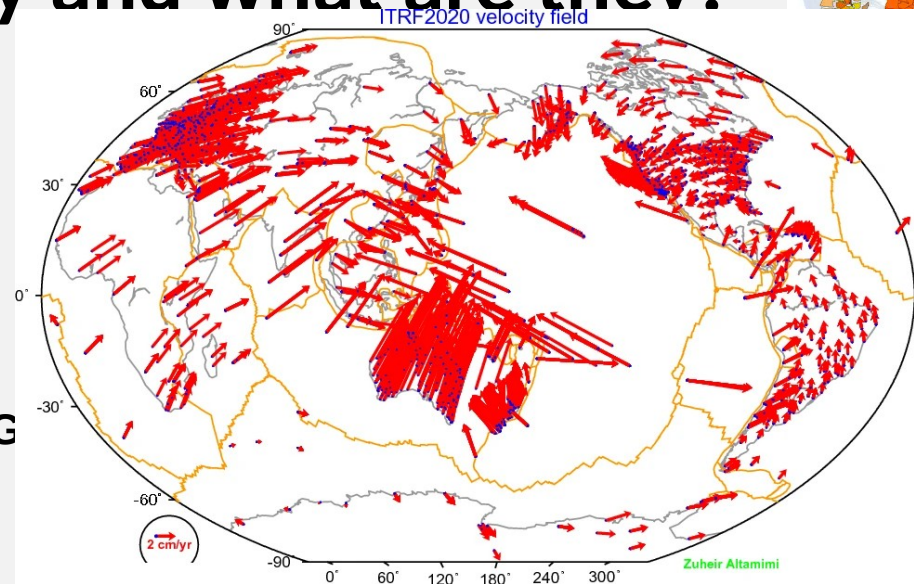


Reference Frames: why and what are they?

Global frames

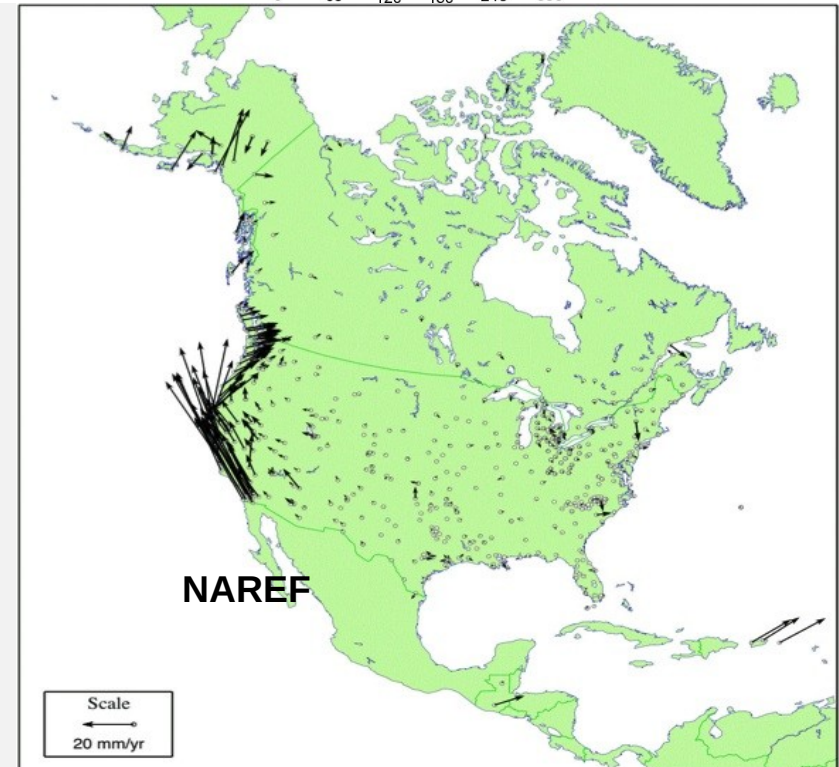
- BIT or BTS in 1984 – 1988
~ 4 realizations
- ITRF1988-2020 – ~ 12 realization (IUGG and IAU established)

Note: Techniques used GPS, DORIS, SLR and VLBI



Regional frames

- EUREF - Europe
- NAREF – N. America
- SIRGAS – S. America
- APREF – Asia and Pacific
- AFREF - Africa? - ??

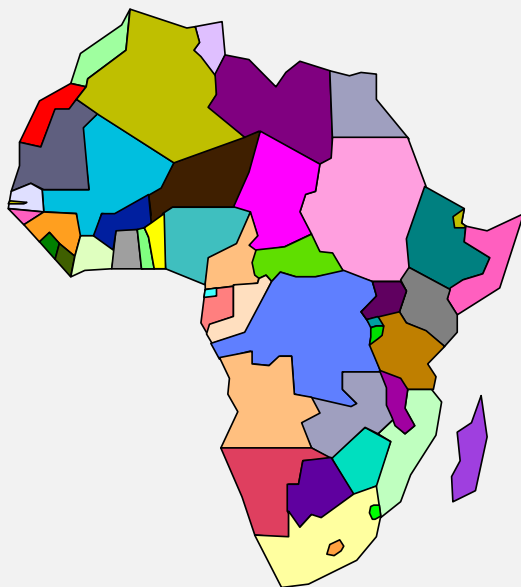




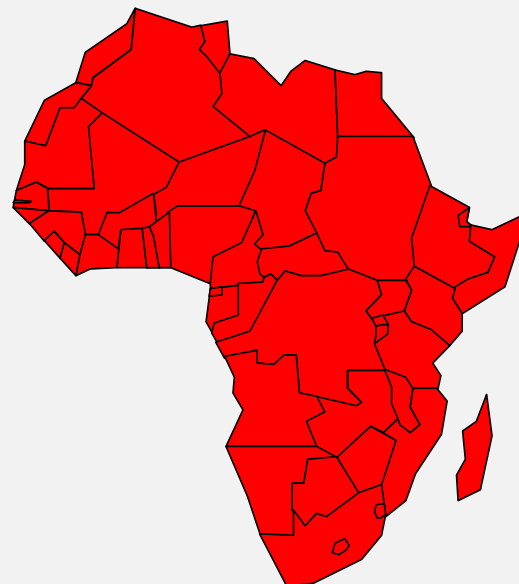
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AFREF AND ITS OBJECTIVE

Well Known



**GNSS
+
ITRF**



**Common
geodetic
RF for all
African
countries**

Appropriate Frame to describe Position+ Velocity of sites spanning Africa

- Use
- o Uniform mapping/engineering projects
 - o Resolve international boundary disputes
 - o Facilitate regional geophysical interpretation
 - o Add GPS sites for meteorological studies
 - o Orbital determination + ITRF = precise orbit + contribution to ITRF

First AFREF Computation – 2012 -2013



AFREF – STATIC COORDINATES

First AFREF Computation – 2012 - 2013

AFREF – STATIC COORDINATES

AFREF - Observed Various of activities in a number of countries – e.g. installing CORS and Change Their RF to ITRF:

AFREF – Established Operational Data Centre (ODC)

– www.afrefdata.org or [ftp.afrefdata.org](ftp://ftp.afrefdata.org) -

Host - The Chief Directorate: National Geospatial Information (CD: NGI) - RSA

Data centres include:

International GNSS Service (IGS Global Data Centres eg CDDIS)

Hartebeesthoek Radio Astronomy Observatory (South Africa)

National Geodetic Survey (USA)

TrigNet (South Africa)

UNAVCO (Africa Array)

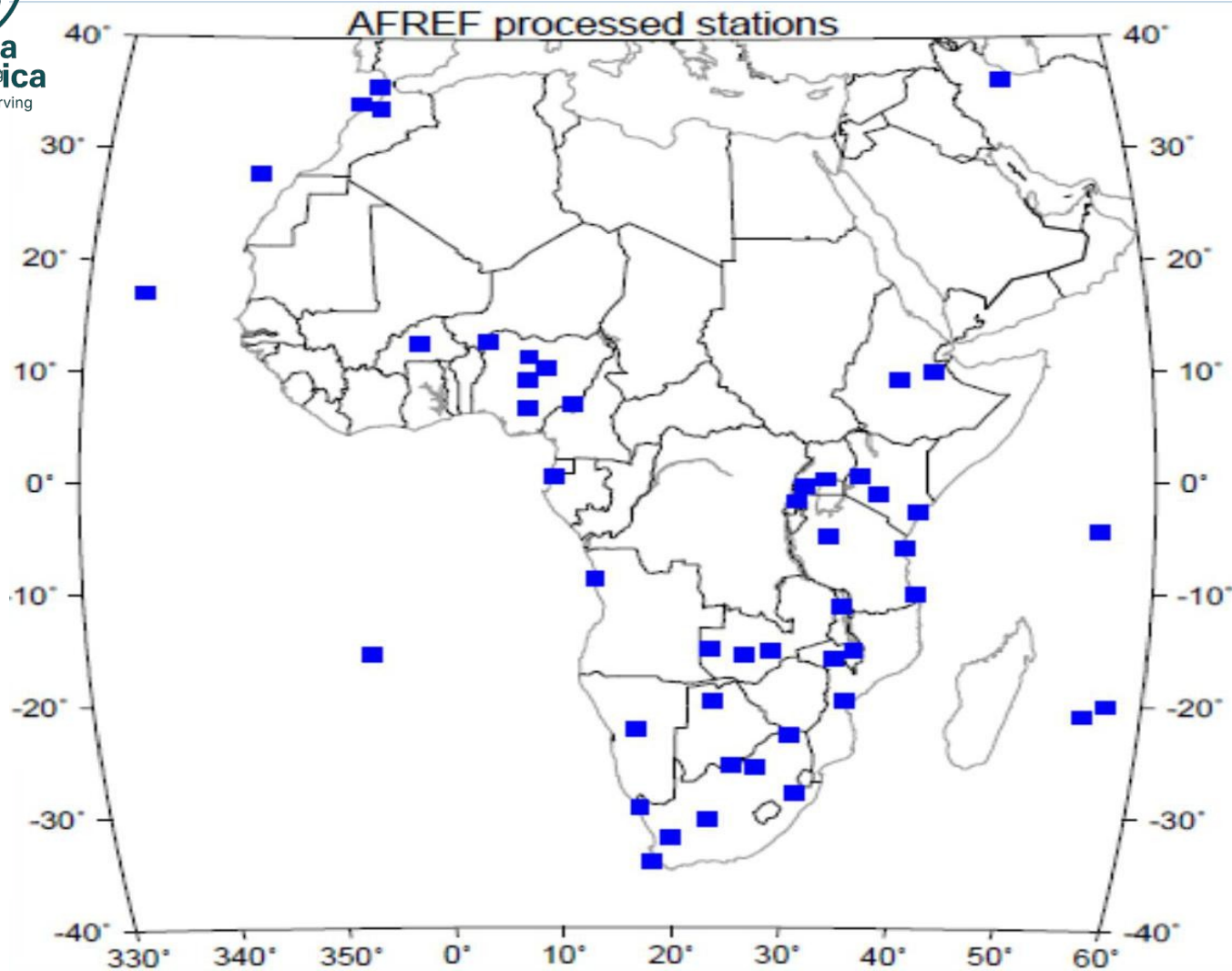
NIGNET (Nigeria)

SEGAL

Other are individual countries CORS and Scientific Research Contribution

Became – Base for AFREF sites processed

• AFREF sites processed



- Distribution of AFREF sites processed. Note gap from Angola through Congo, Sudan and across North Africa.

• **AFREF Data processed Period**

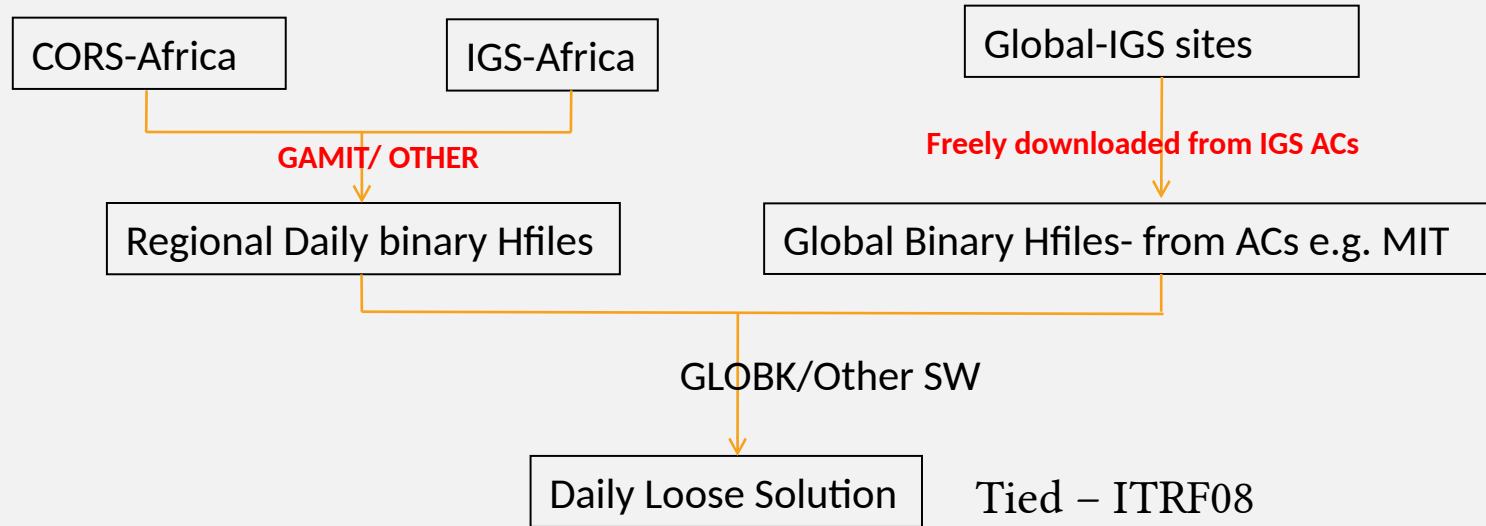
A two week period was identified during which data from approximately 50 stations was logged

-GPS Week 1717 (2nd Dec 2012) to Week 1718 15th Dec 2012

Five centers processed data from approximately 50 sites per day covering a two week period

- i. **HartRAO - South Africa**
- ii. **SEGAL (UBI/IDL) Mozambique - Portugal**
- iii. **Dir. Surveys & Mapping - Tanzania**
- iv. **Ardhi Univ - Tanzania**
- v. **CGG Toro – Nigeria**

Data Processing Strategies



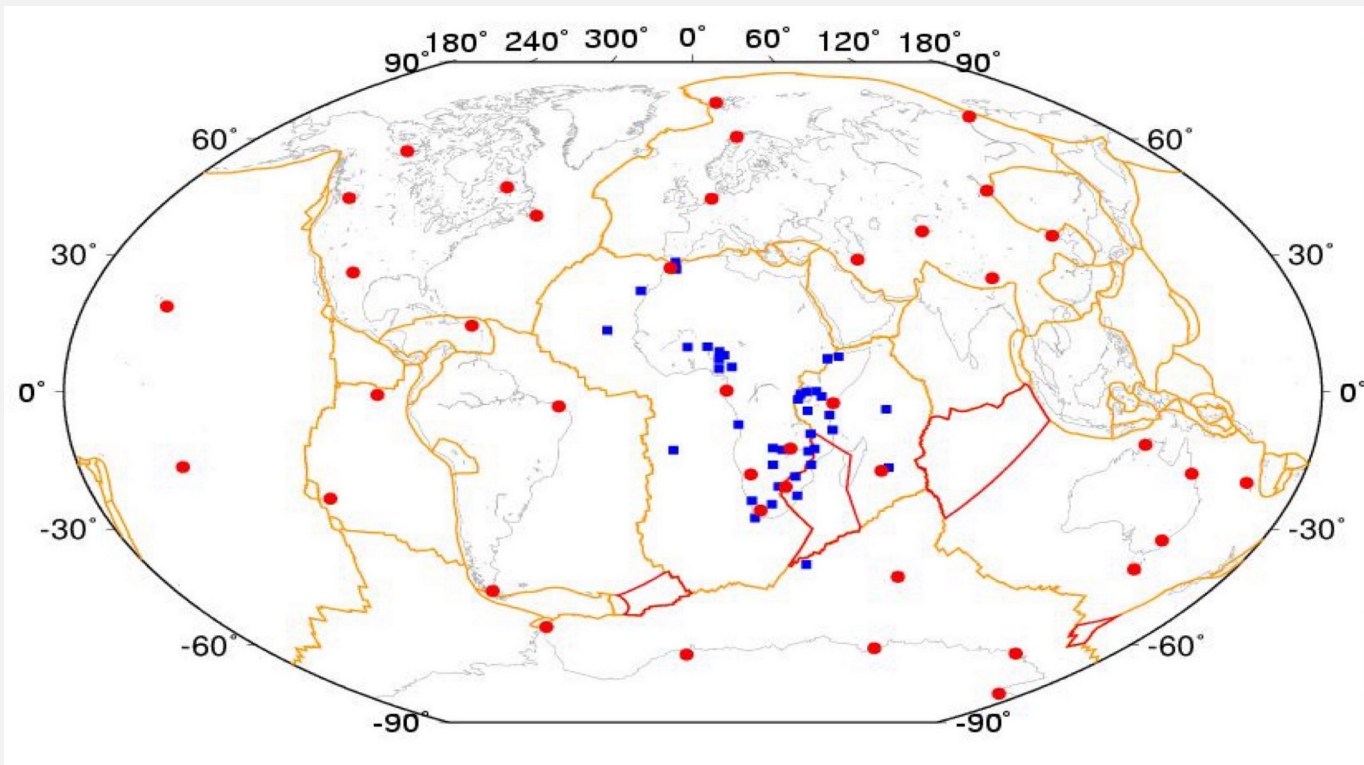
Processing Parameters

- 30 Sec Rinx Data
- Ephemerides - Final Orbit and Precise Navigation File
- EOP – IERS Files
- 0 Degree Elevation Mask
- Ocean Loading
- Troposphere – Dry part and Wet Part GMF
- Calibrated Antennas .atx
- etc

Data Processing Strategies

Processing Requirements

- Common Africa IGS site with 50 selected sites
- Global Loose Solution – From MIT
- Common Station Metadata file (Station Information)
- Results to be in SINEX loose format
- Combination done at IGN with CATREF Software



Final Combination and Solution – CATREF Software Combination and Analysis of Terrestrial Reference F ames) at IGN France - Prof. Zuheir Altamimi

What CATREF does

- **Frame Combination:** It rigorously stacks and combines individual space geodesy daily or weekly solution
- **Parameter Estimation:** It computes station positions, velocities, and Earth Orientation Parameters (EOP).
- **Helmert Transformations:** It applies similarity transformations to estimate translation vectors, scale factors, and rotation matrices across different solution epochs.
- **Deformation Modeling:** It incorporates post-seismic deformation (PSD) and seasonal (annual/semi-annual) signals into station time series.

**Final Solution was Coordinates
of the selected 50 sites Tied to
ITRF2008.**

**Since only 14 days of Data No
velocity can be obtained**

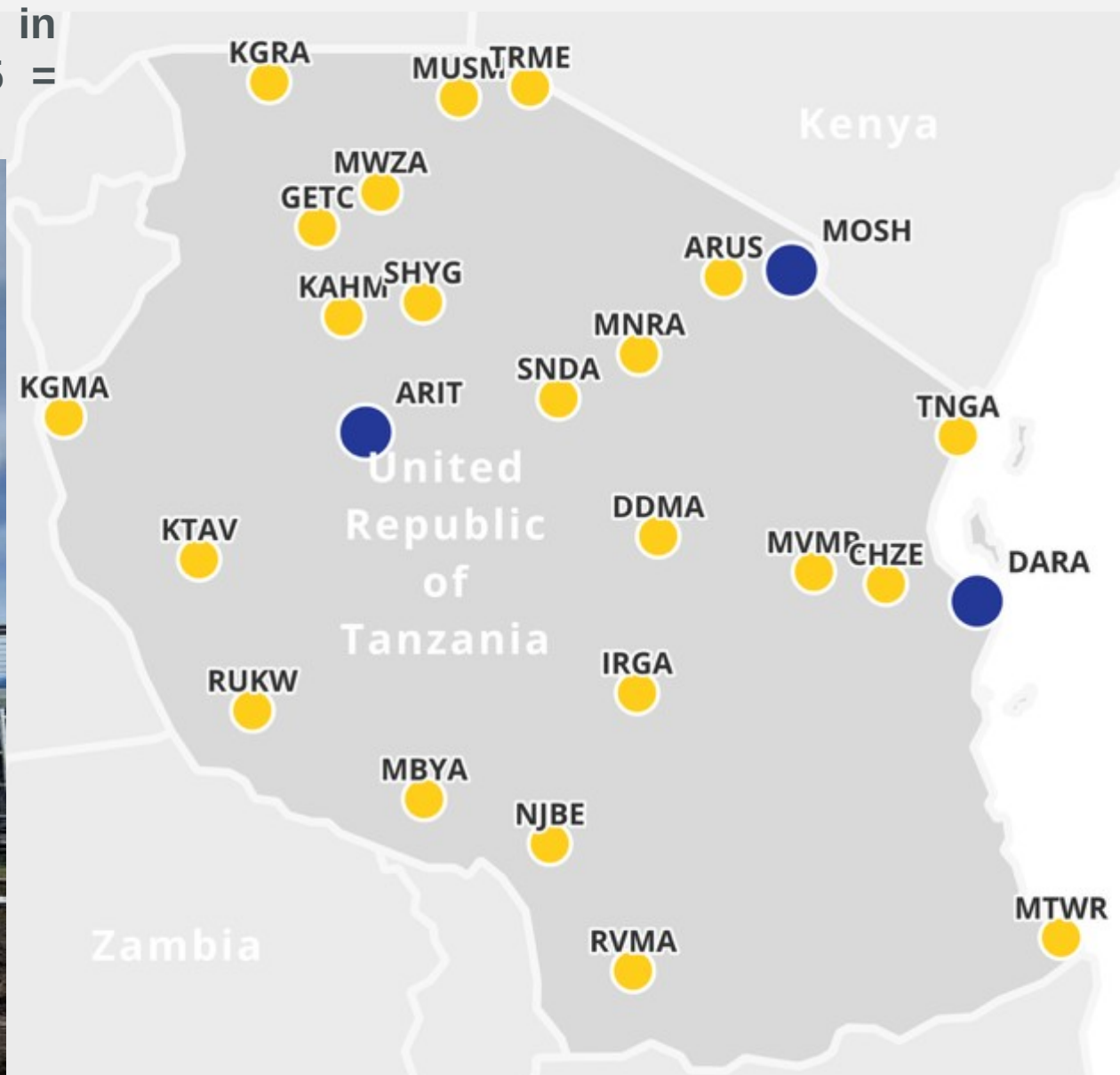
NEW / PROPOSED AFREF Solution 2027 -2028

What to Consider

- a) Available GNSS data in Africa – Publicly available from 2010 - 2026
- b) Computational Capacity and Processing Strategies– AFREF ACs
- c) Error Analysis – Noise Analysis, offsets (EQ files), and Internal Consistent Between AFREF ACs Solutions
- d) Crustal dynamics

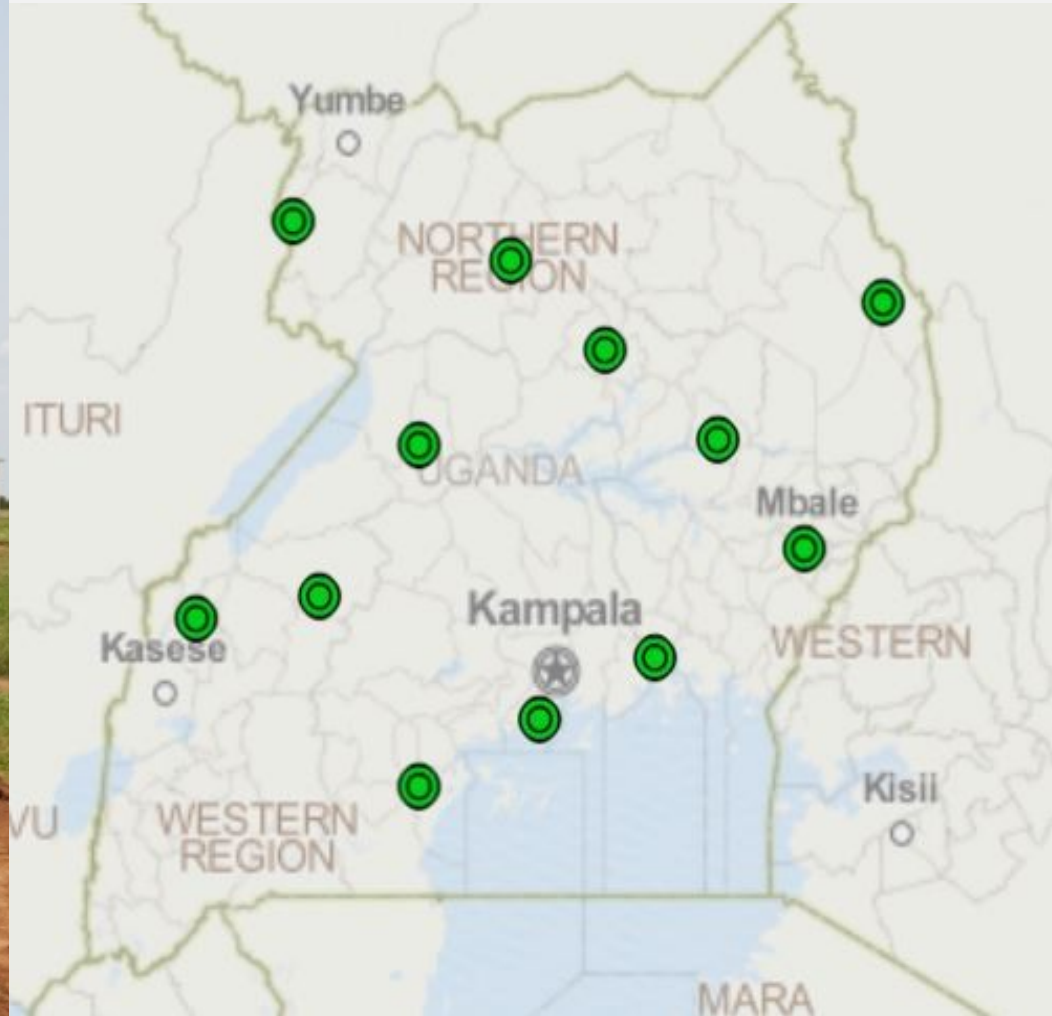
More Data in Tanzania

Additional 22 GNSS CORS in
Tanzania Installed in 2025 =
CONETA Project.



More Data in Uganda

GNSS CORS installed in Uganda in 2020 – PHASE I – 2024 – PHASE II Completed

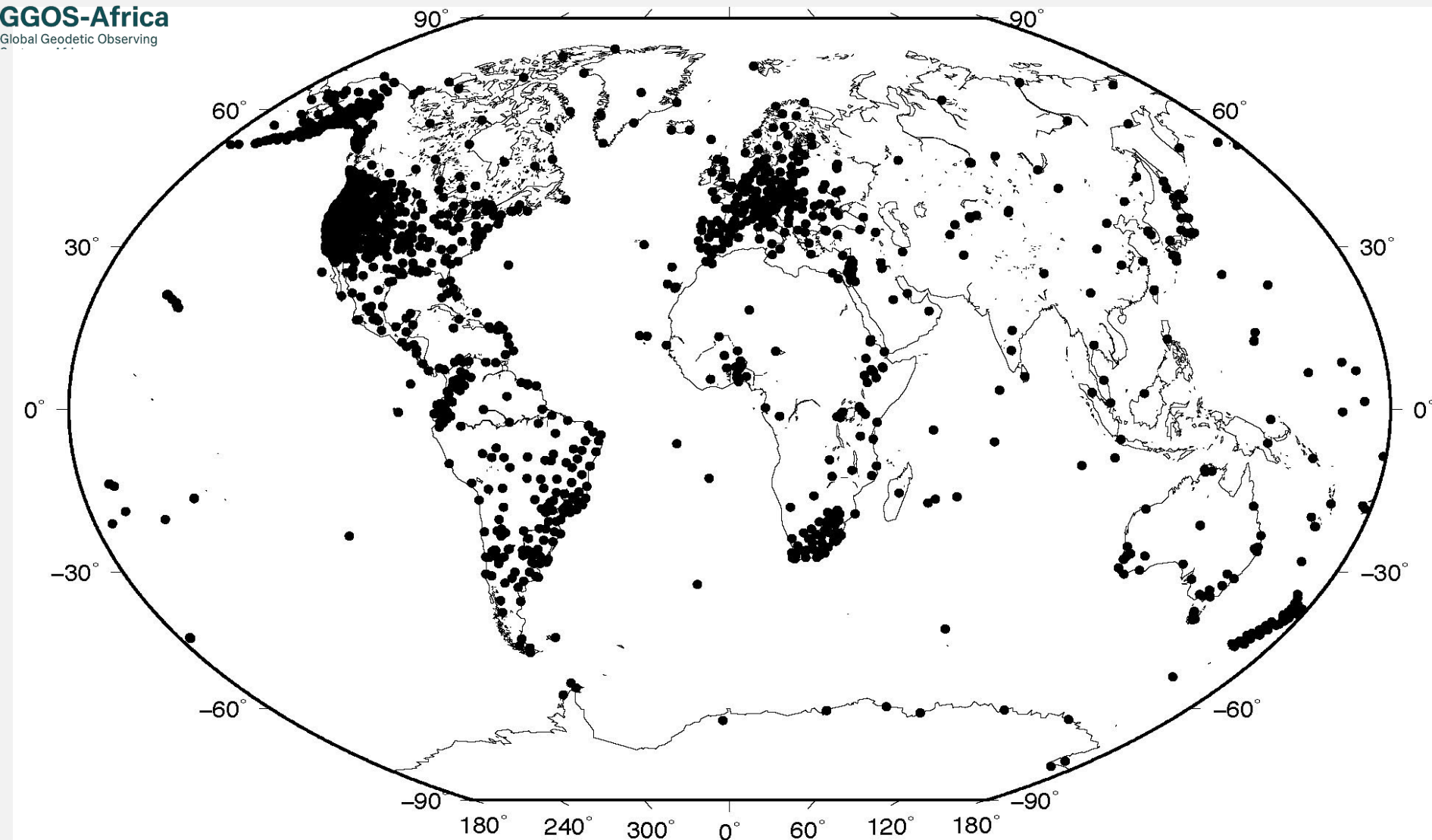


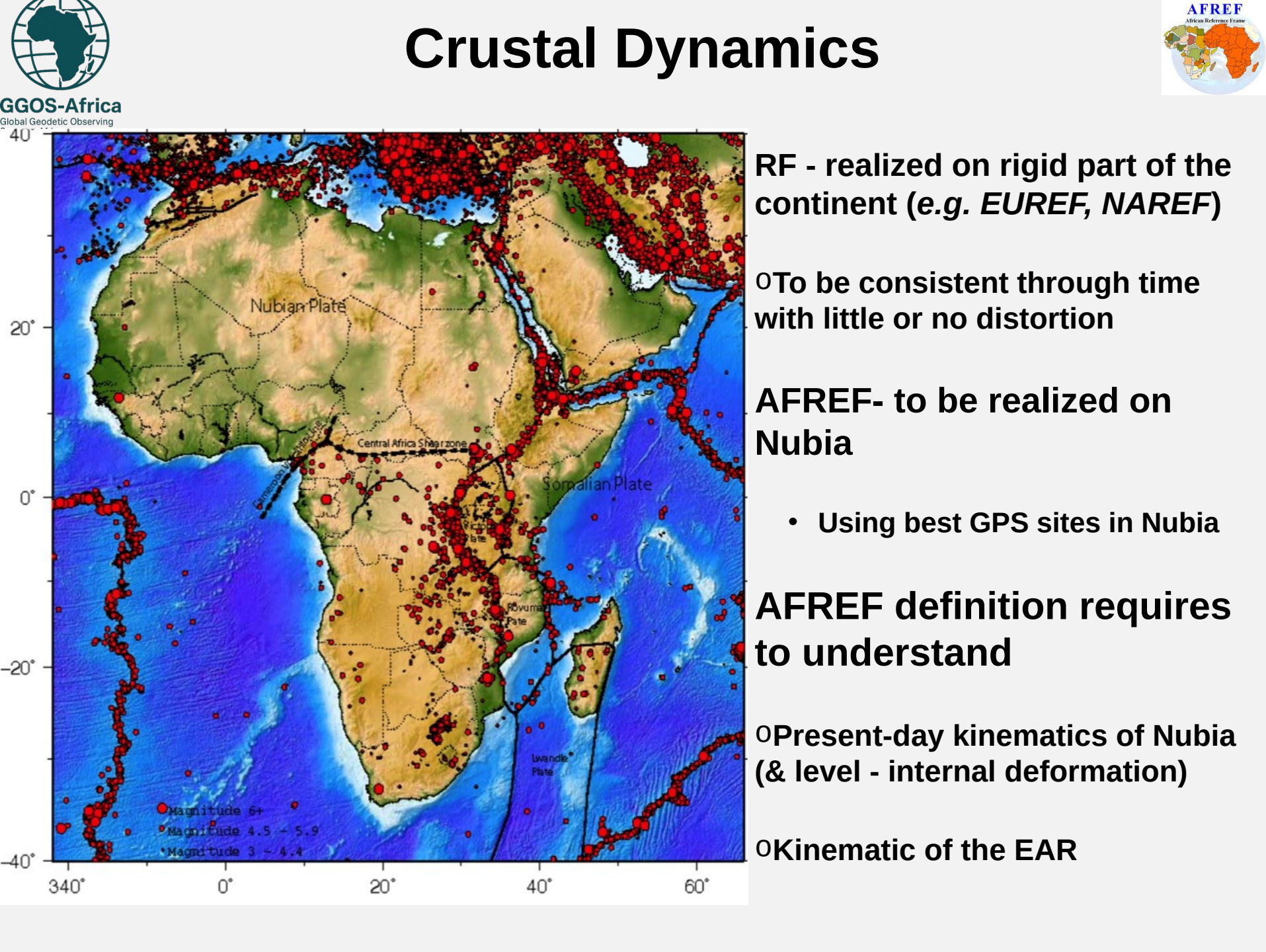
Courtesy – Bruno Kyamulesire



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Global CGPS coverage

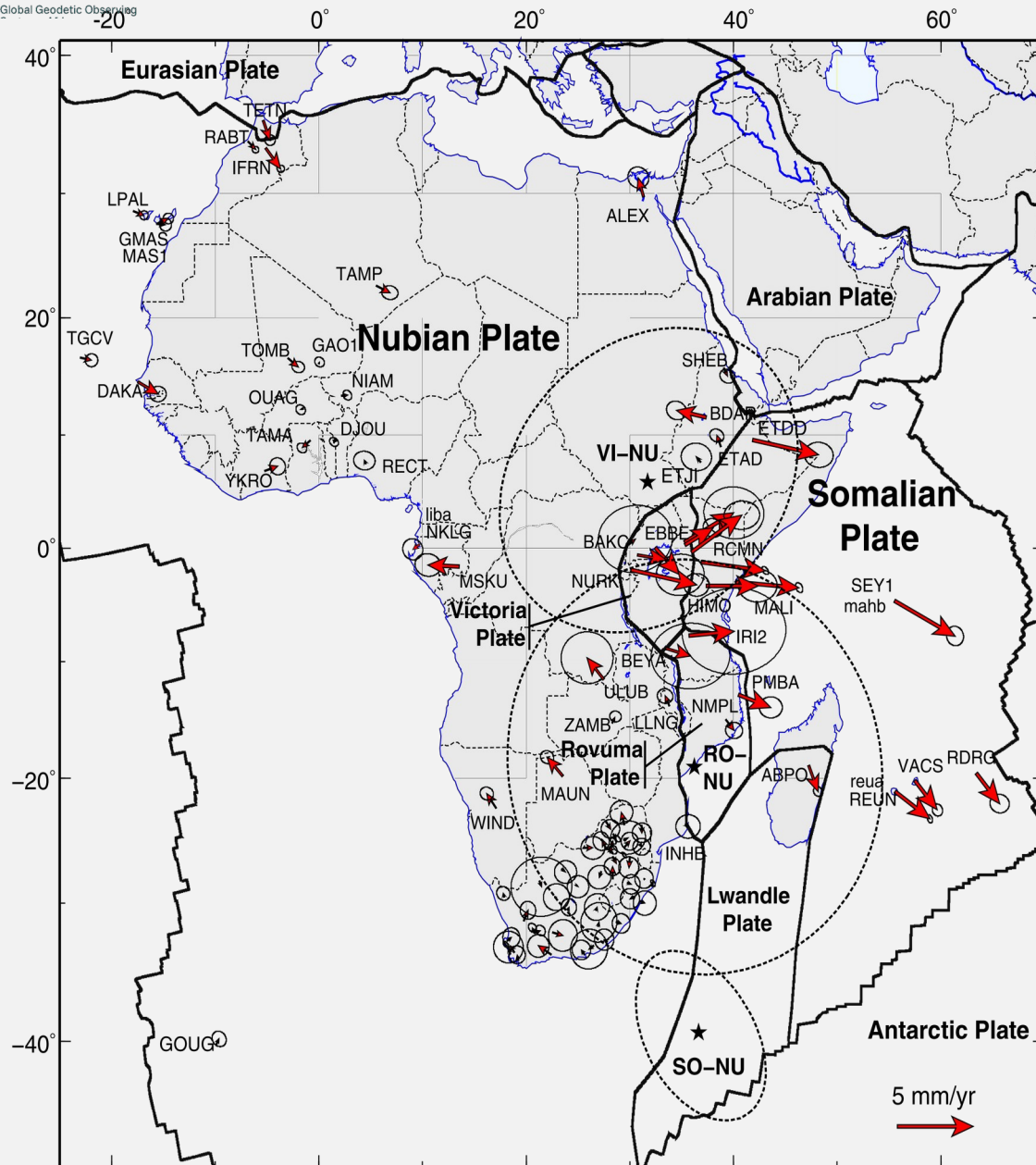






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Crustal Dynamics Saria et al., 2013

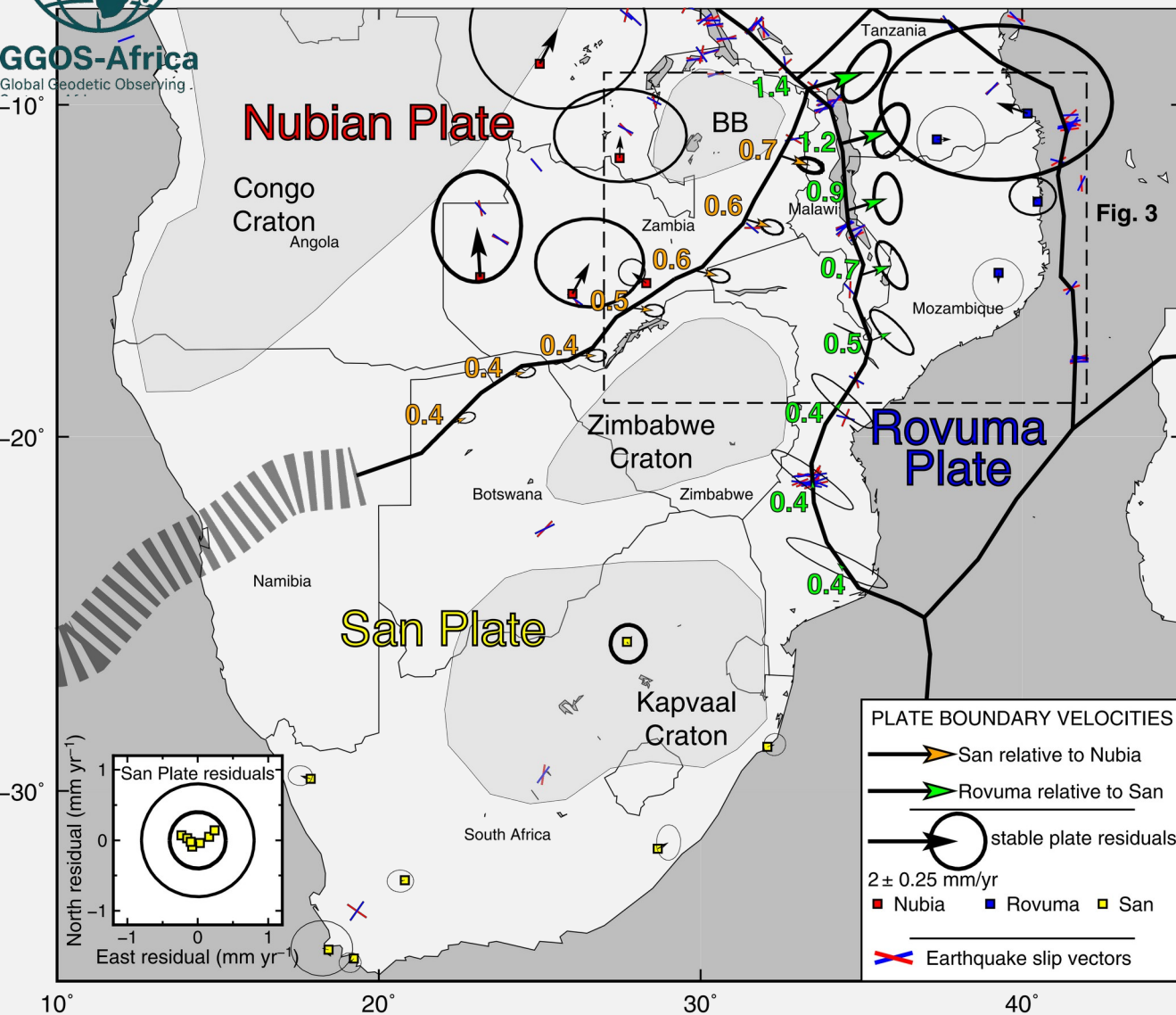


- Nubia Rigid at WRMS ~ 0.6 mm/yr
- Somalia and Nubia are well determined
- Rovuma and Victoria Well determined
- Lwandle poorly determined — Only when Other data are added



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Global Geodetic Observing System

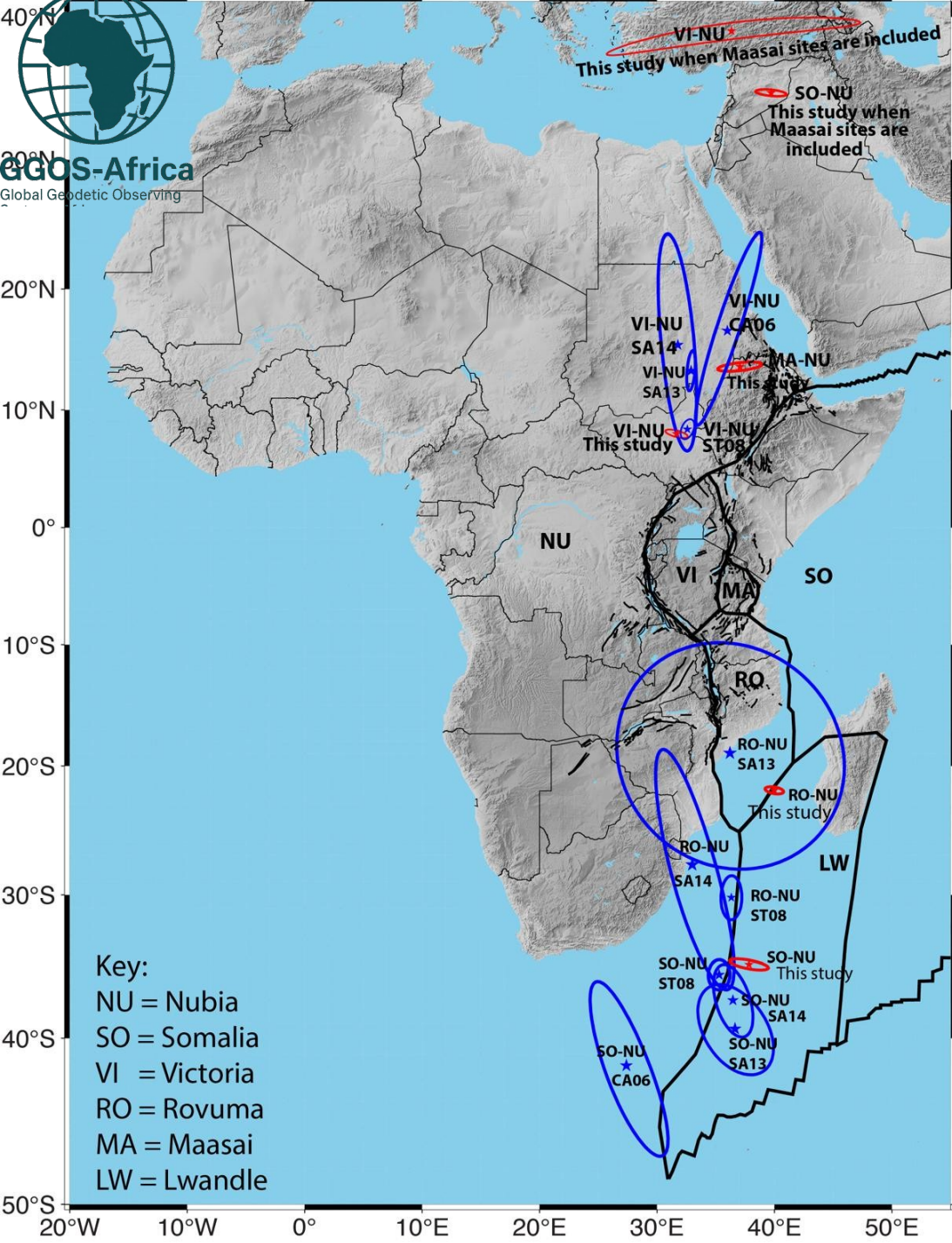
Crustal Dynamics



AFREF to be Realized on Nubia. However “San” microplate - Distinct from Nubia, with deformation of 0.4–0.7 mm/yr

Wedmore et al., 2021

Saria et al., 2013 – Nubia rigidity ~0.6mm/yr



As data are increasing

New geological Plate
Discovery

AFREF definition requires
to understand

○ Present-day kinematics of Nubia
(& level - internal deformation)

○ Kinematic of the EAR



Suggestion for New Processing Strategy

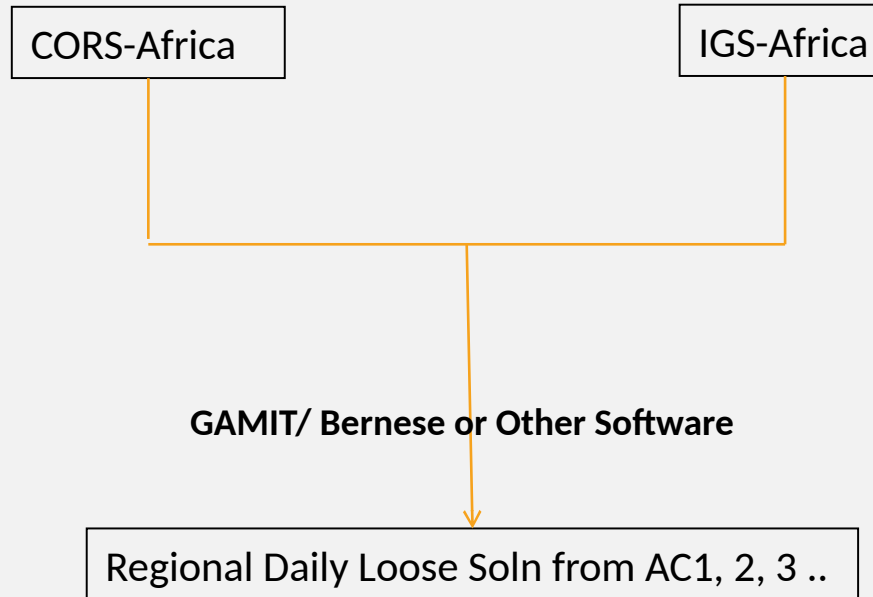
New AFREF Solution



New AFREF Solution - Data Processing Strategy



Solution for African ACs



Processing Parameters

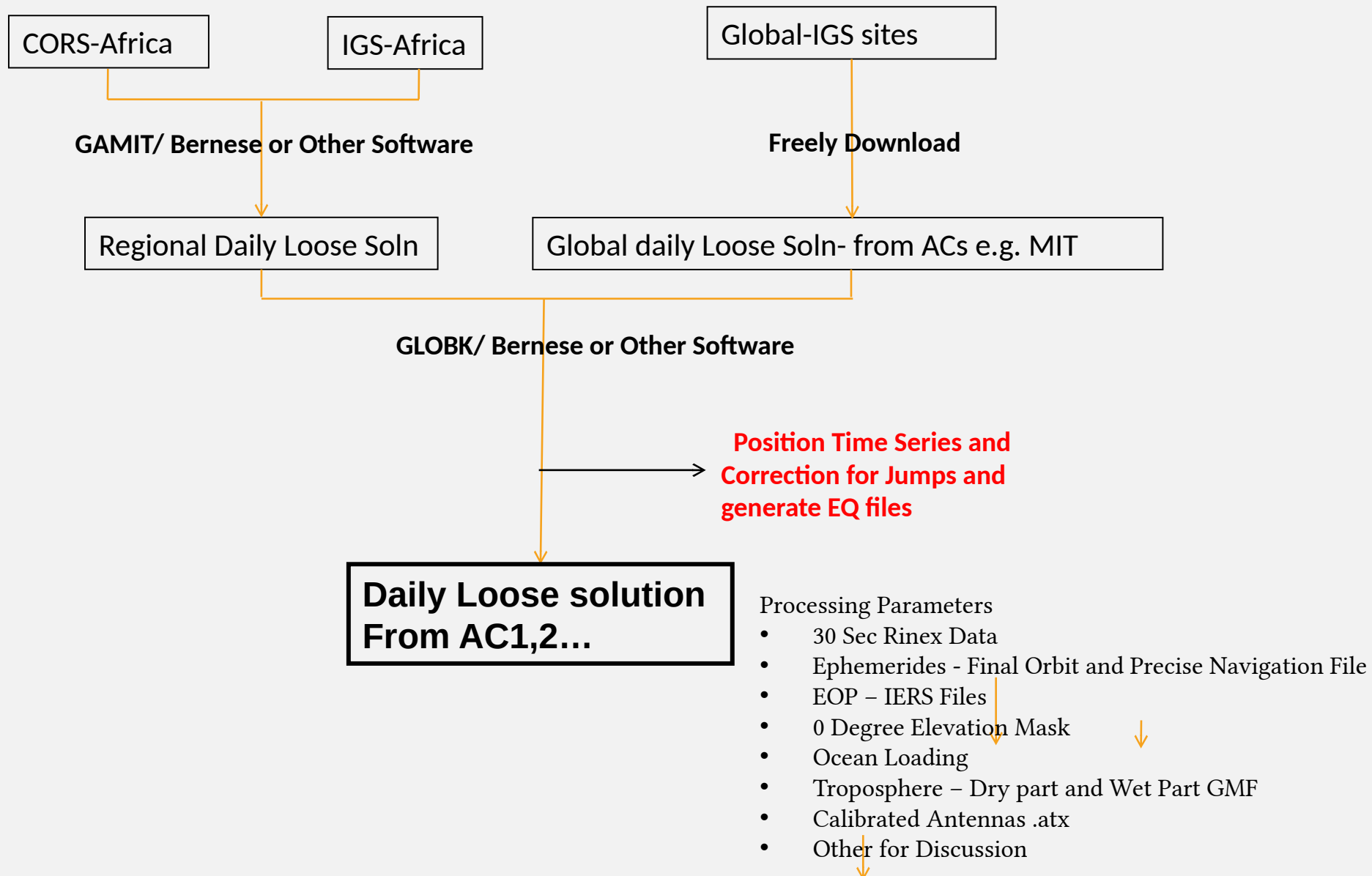
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- Other for Discussion



New AFREF Solution - Data Processing Strategy



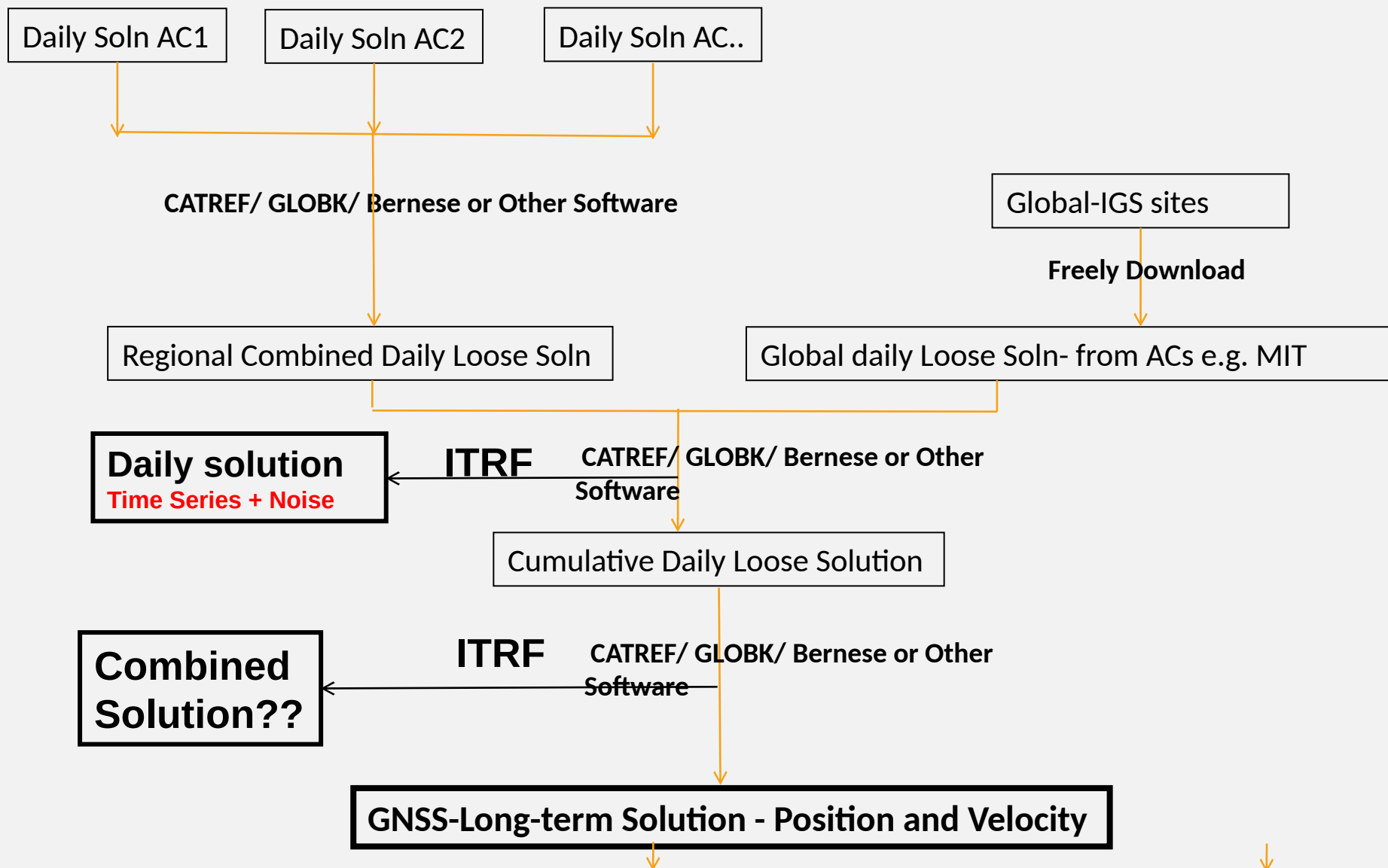
Solution for African ACs



FINAL AFREF Solution – GNSS Only

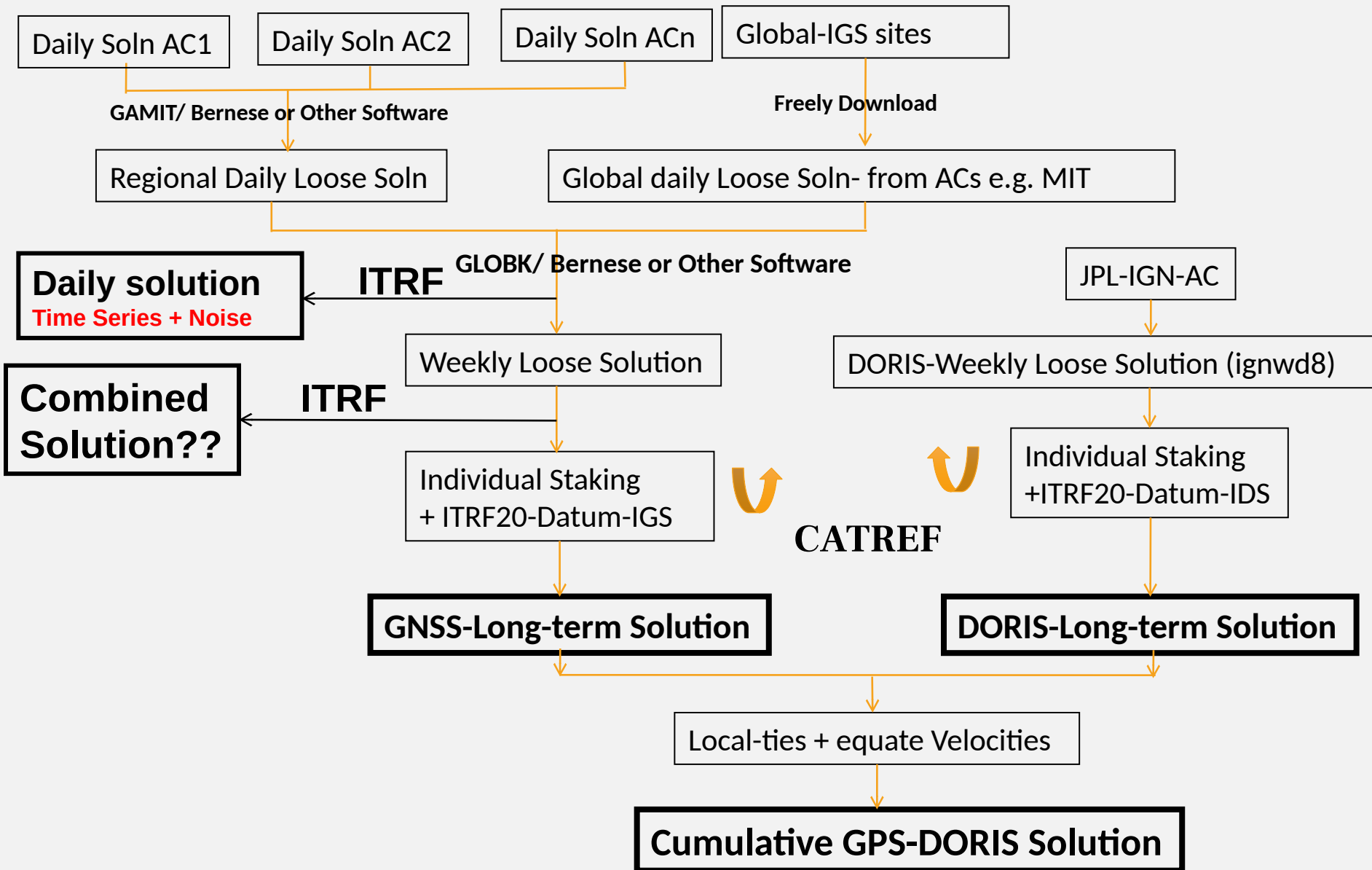


Agreed years of GNSS ONLY e.g. 2010 – 2026??



FINAL AFREF Solution – GNSS + DORIS

Agreed years of GNSS only? Or GNSS and DORIS e.g. 2010 – 2026??



Conclusion

- Scientific Co-operation and data sharing between African Countries other has been of benefit to AFREF
- GNSS Processing Capability - Capacity Building has increased
- Increased IGS and CORS instrumentation in African countries will benefit New AFREF solution
- AFREF Solution will benefit AFREF Tectonic Model



Recommendation for AFREF

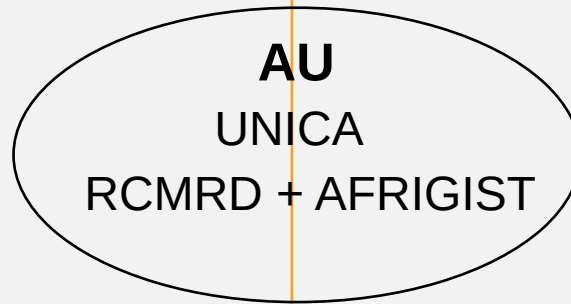


Who Is AFREF? – Need to be Like EUREF - SIRGAS

Suggestion If
Possible

AFREF – Main Domain

→ May be Hosted by
UNECA???



AFREF Management and Technical Committee



Africa Mapping Agency – Directors