Testing Processing Methodologies for the computation of AFREF solutions

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ABSTRACT

AFREF (African Reference Frame) is an effort carried out by the international community, in particular by the African countries, to establish a continental reference system that will serve as the basis of the future national reference networks based on the modern geodetic spatial techniques, in particular on GNSS (Global Navigation Satellite Systems) fiducial points.

We discuss here the approaches used to compute AFREF08. This solution intends to be a test case for the methodologies to be adopted for the computation of the first official solution for AFREF. AFREF08 is realized by simultaneously computing the accurate positions of an extended set of GNSS stations distributed by the entire African continent. The positions are referred to the latest realization of ITRS (International Terrestrial Reference System), ITRF2005, by aligning the continental solution into this global frame at a defined epoch (1st May 2008).

AFREF08 is fixed to a certain epoch in order to be the backbone system that will allow every country to realize its national system fully and directly consistent with the national realizations produced by the neighboring countries. To respect the dynamics due to the existence of several tectonic blocks, AFREF08 is fixed to the Nubia plate and the differential motions with respect to this block for stations located in different plates have been accurately modeled.

This first solution is being produced by combining two individual solutions produced using two different software packages. The issues rose during the data acquisition, data processing and solution combination processes will be thoroughly discussed by the involved partners at the AFREF project in order to establish the methodologies for the computation of the first official AFREF solution.

1. SURVEY OF CORS IN AFRICA

Figure 1 - Survey of known CORS in Africa and surrounding areas (104 sites), part of several networks, which could potentially be qualified for inclusion in the AFREF core network. They were fullfilling all or part of the established criteria:

-CORS with long term plan for future operations. Stations only occupied occasionally were not accepted.

-CORS with data that are publicly available. The data should be accessible through the AFREF and IGS data centres continuously and with a latency not greater than a few hours after file creation. However, it was admited stations with communication problems under the condition there will be an effort to solve such problems. It was also accepted stations without publicly available data under the condition that such station will provide open data in the future.

-CORS having good quality data. Considering the current situation (number of available stations), the selection of stations were not too strict.

CONTRIBUTORS

- IGS - International GNSS Service (many individual contributors)
- HartRAO - Hartebeesthoek Radio Astronomy Observatory
- TRIGNET - National Geodetic Network of South Africa
- EUREF - European Reference Frame
- NRIAG - National Research Institute Astronomy Geophysics (Egypt)
- RECTAS - Regional Centre for Training in Aerospace Surveys (Nigeria)
- NICRS - National Institute of Cartography and Remote Sensing (Algeria)
- SEGAL - Space & Earth Geodetic Analysis Lab (UBI/CGUL/DEOS)
- KISM/RCMRD - Kenya Institute of Surveying and Mapping / Regional Centre for Mapping of Resources for Development
- UNAVCO - University Consortium based on USA
- AMMA - African Monsoon Multidisciplinary Analyses
- GRN - Ghana Reference Network
- RAM - Regional Network of Madeira, Portugal

NOTE: However each station is here linked to only one network, many of them also belong to other networks since they were installed in the framework of international projects.

2. SELECTION ISSUES

SOUTH AFRICA CASE

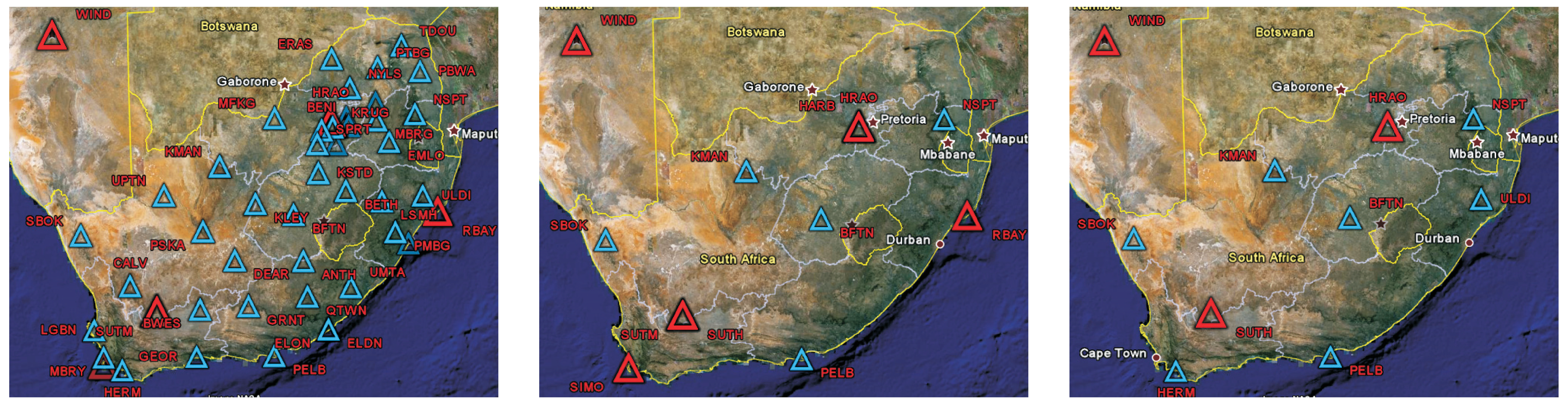


Figure 2 - (Left) A major goal for AFREF is to have baselines not exceeding 1000km. This is still not feasible at present. Many regions (cf. Figure 1) are still lacking stations. At opposite, some regions (e.g., South Africa) already have very dense networks of public CORS stations (41 stations are currently forming the TRIGNET network). Due to theoretical (good balance of network distribution) and practical (computational resources) constraints, only a subset of such networks must be selected to be part of the AFREF network...

(Center) A first iteration was done by selecting all IGS stations in South Africa and complement them with TRIGNET stations creating a uniform geographical distribution as good as possible over the entire region...

(Right) However, the IGS network has co-located sites at Hartebeesthoek(HRAO and HARB) and Sutherland (SUTH and SUTM). Only one station was considered at each site. Furthemore, RBAY was not available and SIMO shows stability problems. They were replaced by existing TRIGNET sites in the region.

SITUATION OF IGS NETWORK

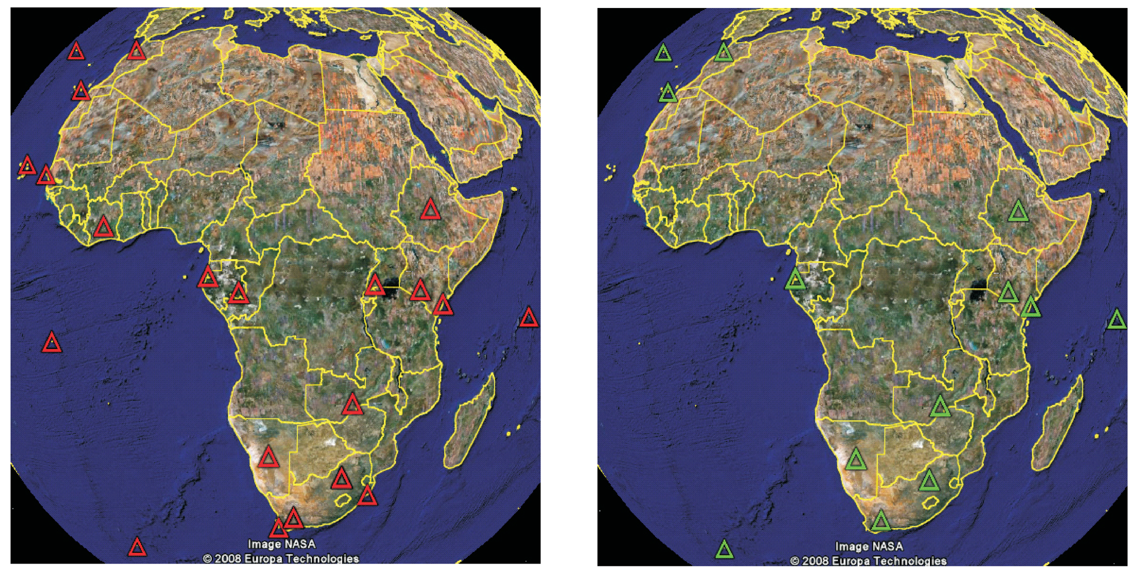


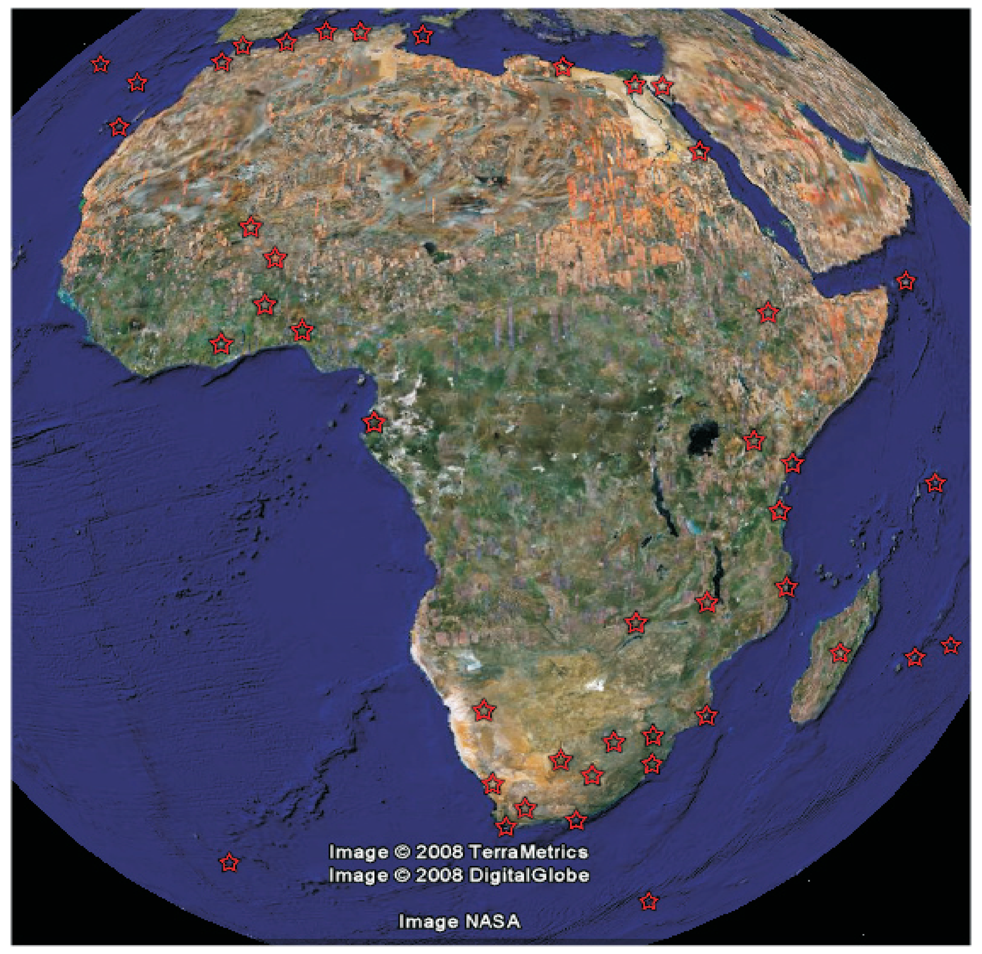
Figure 3 - (Left) Distribution of the CORS IGS network in the African continent; (Right) IGS Stations included in the computation of the AFREF08 solution.

Out of 21 individual stations that are officially part of the IGS network in the African continent, only 13 sites could be selected. Eight stations were not operational during the period of interest. The situation is more critical on West Africa where all three stations integrated in the IGS network (Cape Verde, Senegal and Côte d'Ivoire) are not operating for a long period of time.

3. SELECTED AFREF08 SITES

Figure 4 - Current distribution of the sites selected for the computation of the AFREF08 solution. The distribution is far from optimal with large parts of Africa (in particular on Central Africa and Sahara regions) still lacking stations. However, an improvement over the recent years is clearly evident with some clusters having already a sufficient good number of stations (e.g., South Africa, Mediterranean region).

Particular efforts should be carried out not only to densify the present CORS distribution but also to guarantee that the existing CORS network will continue to operate in the future. This is necessary in order to ensure the utility of AFREF08 (and any future solution) by having a sufficient number of core stations that can therefore support the densification of the network of reliable reference stations at regional and national levels.



4. METHODOLOGY

PROCESSING STRATEGIES

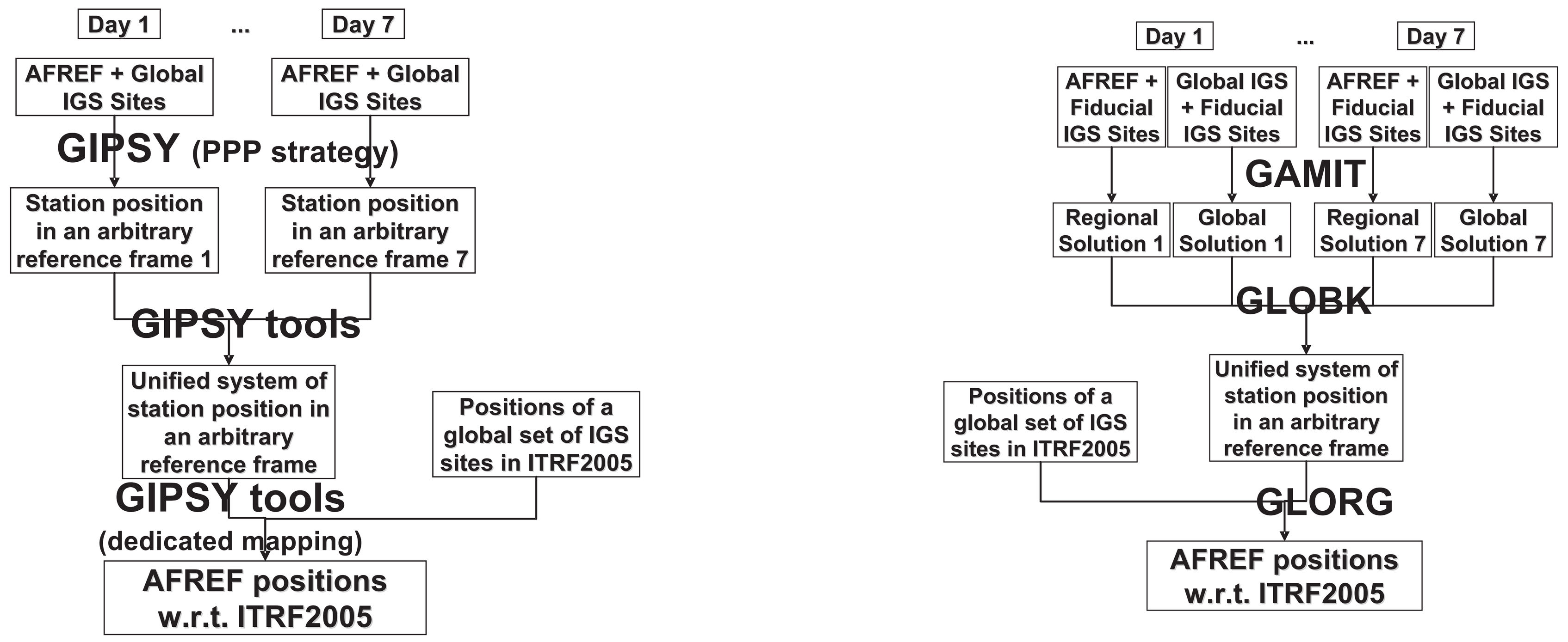


Figure 5 - Scheme of the data processing in order to obtain the AFREF08 solution using GIPSY (Left) and GAMIT (Right).

The final solution for AFREF08 will be estimated by combining two different solutions computed using at least two different software packages. Currently, this is already ensured by the commitment of RCMRD/IDL and HartRAO to produce individual solutions using GIPSY and GAMIT processing software packages, respectively. The computation of these two independent solutions will guarantee that possible biases due to particular methodologies or models used by the two organisations and/or by the software packages can be detected and corrected. It is also advisable that in the future, additional organisations can provide more individual solutions using also other software packages (e.g., BERNESE). However, for the first AFREF solution, the two available solutions will provide the necessary redundancy.

The final product provided by each group will be a set of coordinate positions with respect to ITRF2005 for the AFREF stations included in the AFREF08 solution. This set of positions will be computed by combining daily solutions into a unique combined (weekly) solution. There are two main reasons to perform this step:

-The estimated combined position using several days is more reliable than a single daily estimate (during a week it is assumed that the change of the site position due to tectonic motions is negligible), since daily outliers can be identified and removed during the combination phase.

-The daily repeatabilities provide a more realistic quantification of the (combined) position solution uncertainty than the value derived from the daily solution formal uncertainties (which are too optimistic).

The combination of the solutions (submitted using SINEX files) will be carried out now by using GIPSY tools. However, it is planned to use the CATREF software in the future. Ideally, both solutions must be very similar and the weighted average position would be sufficient to obtain the final position for each site. However, due to the different approaches used, in particular for the mapping phase, some small systematic differences can exist between both solutions. Any significant differences between the solutions will be identified and analysed. If necessary, the recomputation of the solutions will be performed in order to solve any software-related bias.

ROLE OF TECTONICS

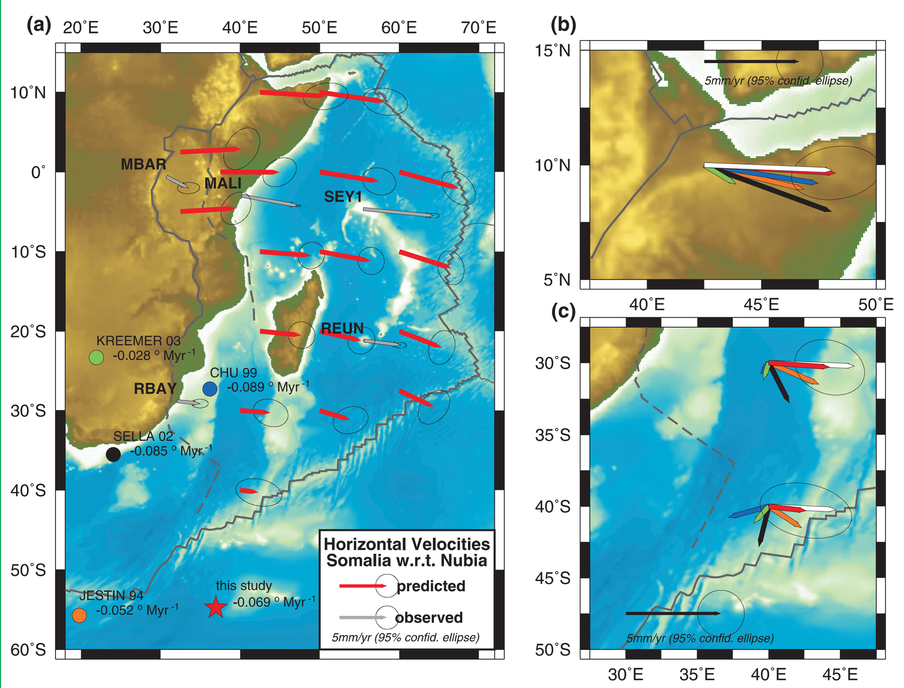


Figure 6 - Relative predicted motions of Somalia plate with respect to Nubia.

The AFREF08 solution will not only be formed by a set of coordinate positions. In fact, it is necessary to consider internal relative motions due to the tectonic structure of the African continent. Africa is split in two major plates plus a few more tectonic blocks where continuous internal deformation exist causing differential motion between stations located on the different blocks. The problem is more acute in Eastern Africa, where the Nubian (west) and Somalian (east) tectonic blocks are moving apart at a rate of 6-7mm/yr.

AFREF08 will be a static set of station positions that will be used as the backbone of the continental reference frame by realizing the polyhedron of stations that will allow the various National Survey Agencies to further densify the AFREF network. Consequently, the positions of the AFREF stations cannot vary in time in order to maintain the consistency among the different densification computations (which will be carried out in different epochs). However, the relative positions of stations located in different tectonic blocks physically vary in time. This must be considered when such stations are used as reference stations for static reference frames at different epochs.

Nubia will be considered as the reference plate for AFREF08. This implies that AFREF08 will be stationary with respect to the Nubian plate. All AFREF08 stations located in Nubia will have no motion associated. However, for the stations located in the other blocks, in particular in Somalia, relative motions have to be computed in order that these stations can be used as reference stations in the future.

Only angular velocities for the Somalia plate will be provided together with the AFREF08 solution, although some authors are postulating the existence of more plates. However, the angular velocity estimations for such plates are not yet sufficiently accurate to use them for reference frame purposes.

5. AFREF08 SUMMARY

Reference Epoch: 1st May 2008
Number of used days: 14 (1 week + 1 week for comparison tests)
Number of Individual Solutions: 2
Number of Stations: 45
Number of Tectonic Plates Modeled: 2
Evaluation: 18-19 June 2008 - AFREF Steering Committee Meeting, Johannesburg

International GNSS Service - Analysis Center Workshop 2008
2-6 June, Miami Beach, Florida, USA

This work is being carried out with the support of the KINEMA (PTDC/CTE-GIN/82681/2006) project, funded by Fundação para a Ciência e Tecnologia (FCT), Portugal.