Densification of the ITRF
through the weekly combination of regional and global GNSS solutions

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IAG Working Group
"Integration of Dense
Velocity Fields in the ITRF"

Introduction

The IAG WG "**Integration of Dense Velocity Fields in the ITRF**" (2011-2015) is the follow up of the IAG WG "**Regional Dense Velocity Fields**" [Bruyninx et al. 2012, in press]. The objective of the WG is to provide a **dense, unified and reliable velocity field** globally referenced in the **ITRF** (International Terrestrial Reference Frame) and useful for geodynamical and geophysical interpretations based on **regional GNSS-based velocity fields**.   The WG is embedded in IAG Sub-Commission 1.3 "Regional Reference Frames" where it coexists with the Regional Reference Frame Sub-Commissions **AFREF** (Africa), **APREF** (Asia & Pacific), **EUREF** (Europe), **NAREF** (North America), **SIRGAS** (Latin America & Caribbean). The IAG Regional Reference Frame sub-commissions are responsible to provide the GNSS-based weekly solutions for their region.

To obtain such velocity field, the WG will combine the weekly solutions and then stacked these weekly combined solutions in order to derive a cumulative position and velocity solution as well as residual position time series. This poster focus on the preliminary combinations of the individual weekly solutions to derive weekly combined solutions.

Data Set

	AC	Solution	Data span (year)	Data span (GPS week)	Antenna calibrations	# stations (raw)	# stations (selected)	# new stations wrt ITRF2008	Remarks
IGS	IGS	Global	1996.0-2011.3	834-1630	igs05	1030	719	187	
AFREF	AFR	Global	1996.0-2011.3	834-1630	igs08	197	163	103	preliminary solution
APREF	AUS	Global	2004.0-2011.3 (gap 2004.9-2006.0)	1254-1630 (gap 1300-1356)	igs08	492	308	82	still running
EUREF	EUR	Regional	1996.0-2011.3	834-1630	igs05 + indiv	290	254	134	
NAREF	GSB	Global	2000.0-2011.3	1043-1630	igs05	592	570	455	
	NGS	Global	2000.0-2011.3	1043-1630	igs05	2496	1360	1005	
SIRGAS	SIR	Regional	2000.0-2011.3	1043-1630	igs05	266	203	145	
Total			1996.0-2011.3	834-1630		3633	2380	1831	

Table1: List of the weekly solutions submitted to the WG.

Submitted Weekly solutions

Each solution submitted by regional sub-commissions (AFR, AUS, EUR, NGS, GSB, SIR) consists in:
– the weekly SINEXs (cleaned or with the list of the outliers),
– the cumulative solution and the associated residual time series,
– the position and velocity discontinuities that should be used for the cumulative solution,
– the station site logs if available,
Five of the seven solutions have a **global coverage**.
For the first time within this WG, a solution has been submitted for AFREF.

Selection of the stations

Stations selected:
– Number of observations > 104 weeks
– Data span > 3 years
– More than 60% of observations available within the data span
Young sites (~500 sites) especially in Africa, Asia & Pacific, Latin America & Caribbean solutions have been removed but will be available when a longer data span will be considered.
– In addition, "Bad stations" are also removed (visual check of the residual position time series).
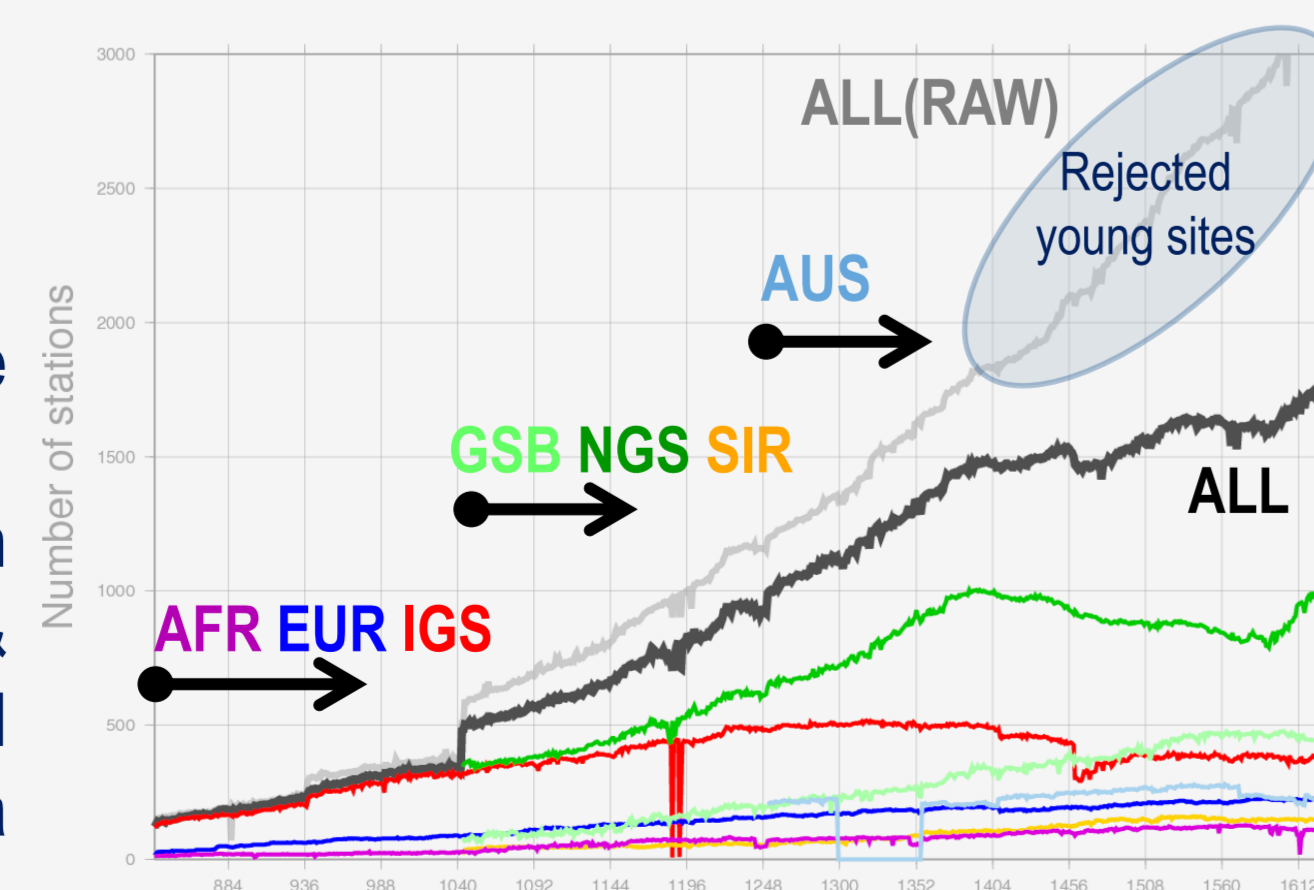

Figure 1: Number of stations in the weekly combined and individual solutions as a function of the GPS weeks.

Combination of the weekly solutions

Iterative Process

1) *Individual cumulative solutions:* Estimation of individual cumulative solutions (Pos., Vel. & time series) based on the individual weekly SINEXs using the information (discontinuities, outliers...) given by the regional sub-commissions.
2) *Weekly solution combination:* Combination of the weekly SINEXs.
3) *Cumulative solution of the combined SINEXs:* Estimation of a cumulative solution based on the combined weekly SINEXs using a harmonized set of discontinuities.
These 3 steps are carried out simultaneously and iteratively. This poster will focus on 2).

Figure 2: Map of the network. In red, ITRF2008 stations, in blue densification stations available in the combined SINEXs.

Combination of the Weekly Solutions

Each week, the available individual SINEXs are combined with CATREF Software [Altamimi et al. 2007]. Seven Helmert parameters are estimated to aligned the individual solutions to the IGS solution.
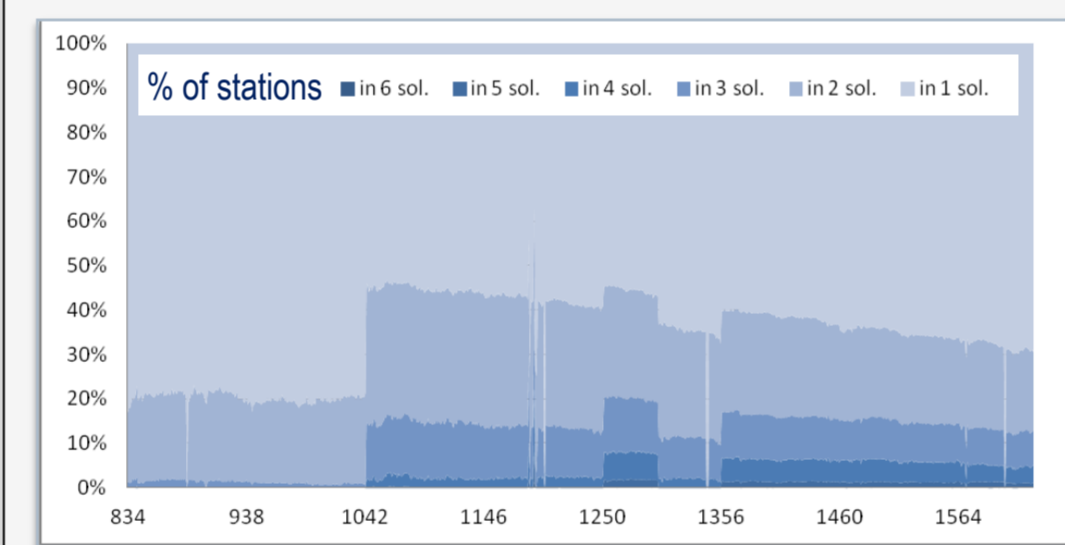

Figure 3: Percentage of stations available in 1, 2, 3, 4, 5 or 6 solutions as a function of the GPS weeks.
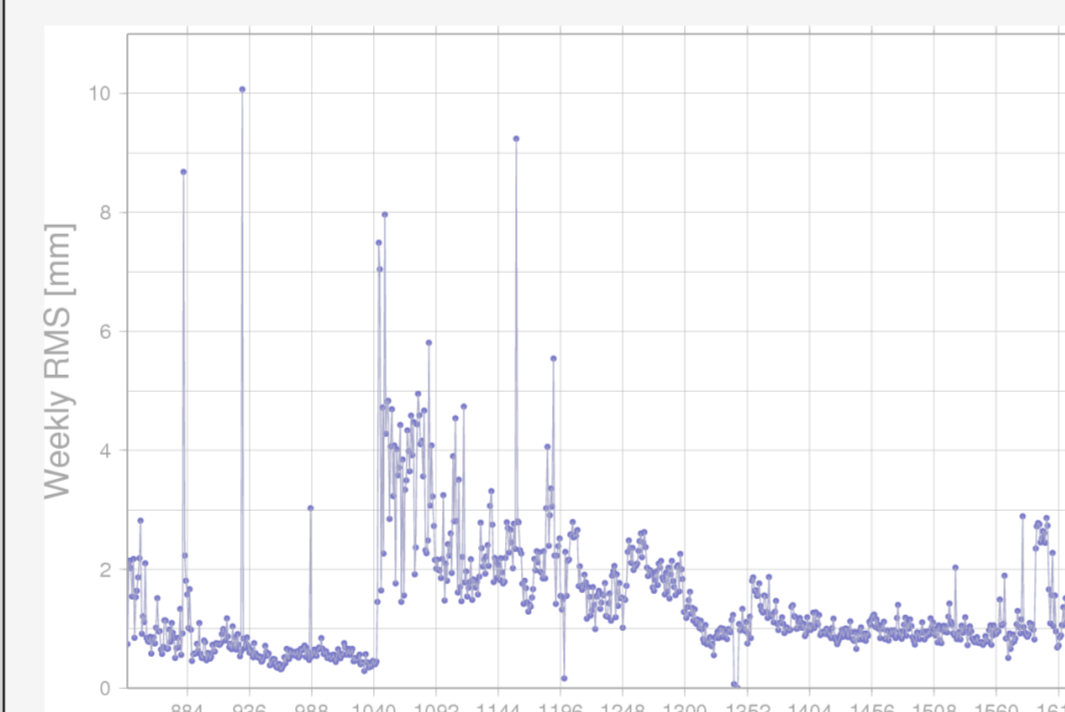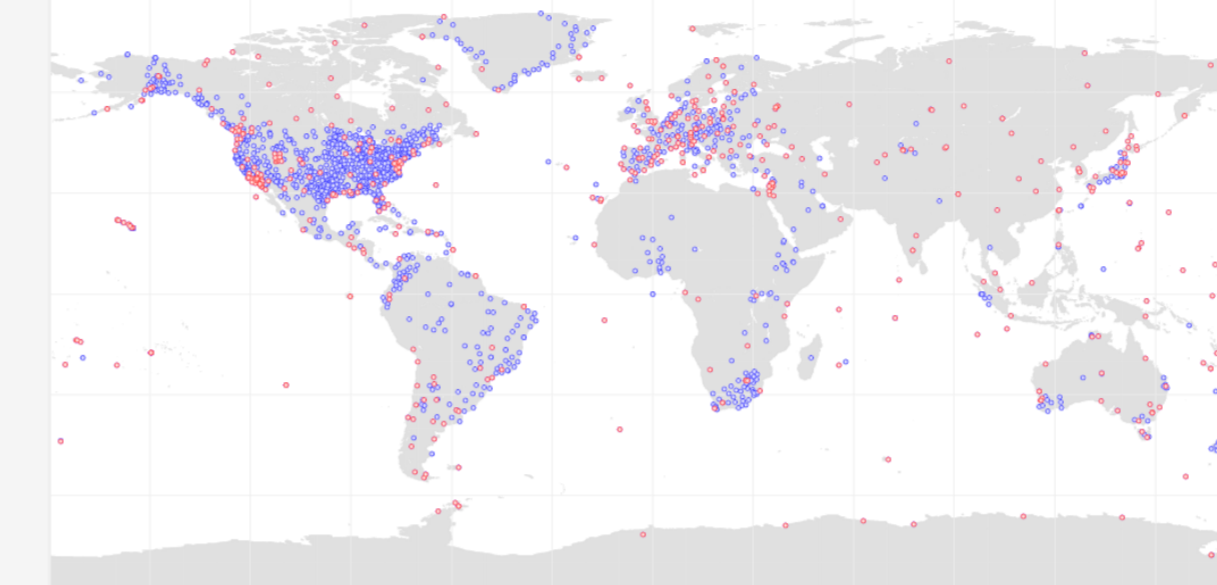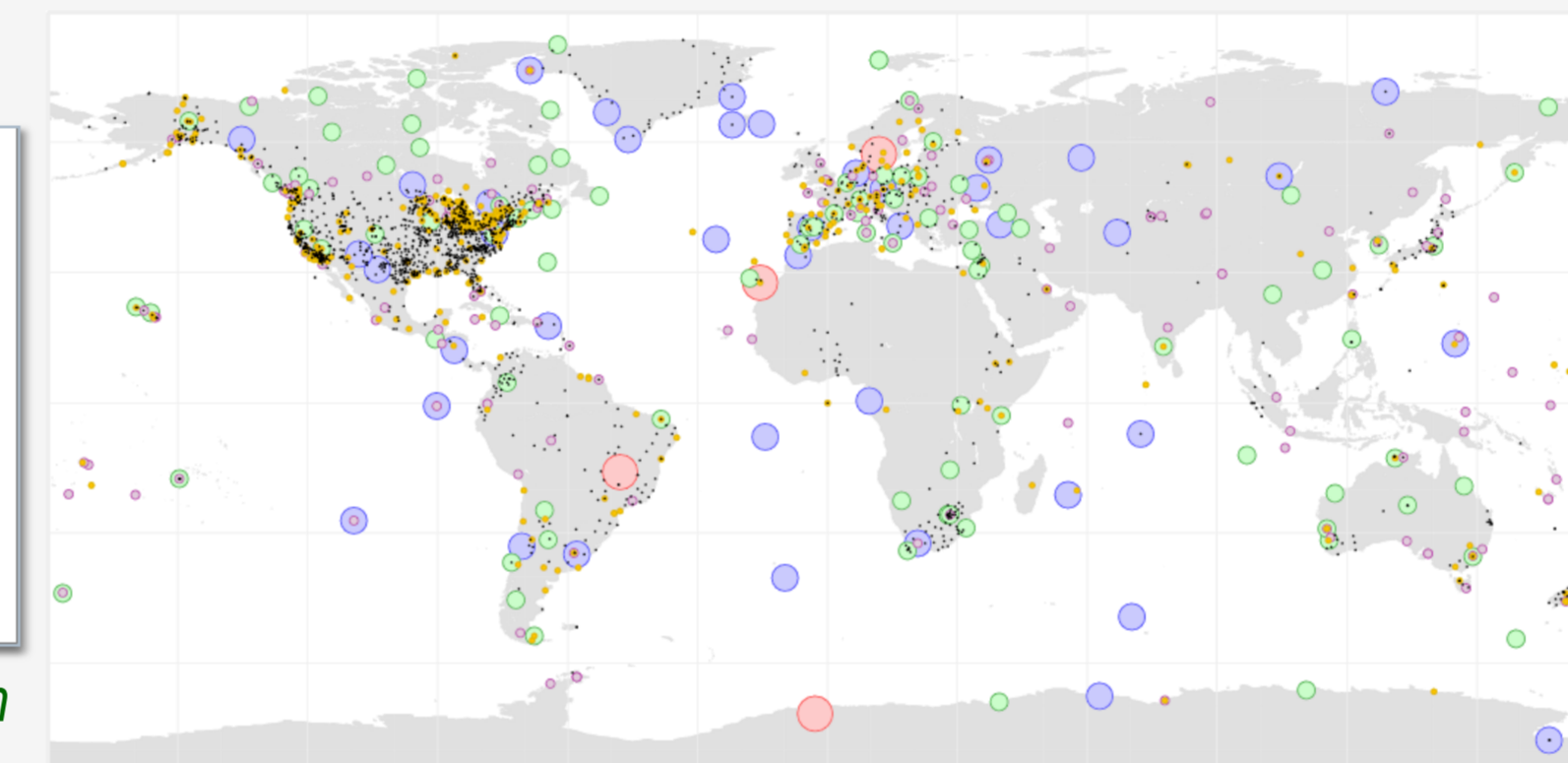

Figure 4: Map of the network, in red stations in 6 solutions, in blue stations in 5 solutions, in green stations in 4 solutions, in purple stations in 3 solutions, in orange stations in 2 solutions and in black stations in 1 solution only.

First attempts to combine the weekly SINEXs lead to a quite good agreement between solutions: the weekly RMS of the combination stay is going from 6 mm to 2 mm (Fig. 5). Outliers larger than 10 cm have already been rejected, but refined rejection is still necessary.

Figure 5: Weekly RMS [in mm] as a function of the GPS weeks.

Tests realized / Experience Gained / Remaining Issues

Weighting of Weekly Solutions, Special Care to Regional Solution
– Several weighting schemes of the weekly covariance matrices have been tested but no conclusion has been reached yet.
– EUREF and SIRGAS solutions have a regional coverage. Covariance matrices for regional solutions are much more optimistic than global solutions. Usual covariance matrix rescaling with chi-square factor are not given sactifactory results so far.
– In regional solutions, the border stations are degraded compared to the other stations, but necessary to reduce the network effect [Legrand et al. 2012]. Border stations should be used but be deponderate to reduce their impact on the combined solution.

Metadata Check and Antenna Calibration
– To avoid the mix of antenna calibration model, preliminary combinations are stopped at week 1630 (igs05.atx to igs08.atx switch), nevertheless:
  – some solutions are using igs08.atx, while others are using igs05.atx (Table 1),
  – EUREF solution is using individual calibrations when available.
– Large systematic biases (few mm to several m) probably due to wrong antenna eccentricity and small systematic biases (few mm) between solutions have been observed. The latter seems to be linked to the different antenna calibration models. We will performed a systematic verification of the antenna installed at the station, wrt the antenna type and the antenna model used in the analysis.
  ⇒ If necessary, position offsets (igs05/igs08) will be applied if available [Rebischung et al. 2012,] or will be estimated to account for different calibration used.
  ⇒ Systematic meta-data verification will be done but for the same station, information contained in site logs can differs depending on the considered network! It is necessary to check site logs first?
– Harmonisation of discontinuities between solutions is necessary before the combination of the cumulative solution. Discontinuities will be cross checked with Antenna/Receiver changes, earthquakes…

Conclusion

The IAG WG "Integration of Dense Velocity Fields in the ITRF" aims at densifying the ITRF velocity field by combining weekly individual solutions to derive a cumulative (Pos., Vel. & time series) solution.

Remaining issues such as the stabilization of the regional (EUREF and SIRGAS) solutions and verification of the meta data and the antenna calibration model used.

The preliminary weekly combinations performed within the WG, contains 1830 additional stations compared to the ITRF2008 and includes 7 individual solutions. The agreement between the solutions is promising and leads to weekly RMS of about 4 mm.

References

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