Royal Observatory of Belgium GNSS Research Group

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

J. Legrand, C. Bruyninx (WG Chair)**, J. Griffiths, M. Craymer, J. Dawson, A. Kenyeres, A. Santamaria Gomez, L. Sanchez, Z. Altamimi**

Contacts: J.Legrand@oma.be or C.Bruyninx@oma.be, Royal Observatory of Belgium, Av. Circulaire 3, Brussels, Belgium

IGS Workshop July 23 – 27, 2012 Olsztyn, Poland

Introduction

The IAG WG "**Integration of Dense Velocity Fields in the ITRF**" is the follow up of the IAG WG on "**Regional Dense Velocity Fields**" which was active from 2007 until 2011. 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 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 IAG Regional Reference Frame sub-commissions are responsible to provide the GNSS- based velocity field for their region to the WG.

IAG WG "Regional Dense Velocity Fields" 2007-2011

Period 2007-2009 "Inclusion of a maximum number of stations"

Submitted solutions:

Cumulative SINEX solutions (Regional solutions, velocity only and also campaigns)

Results:

Large **network effects** (several mm/yr!) due to discrepancies between velocity solutions:

- Inconsistent station naming and DOMES numbers
- Inconsistent handling of the discontinuity epochs
- Inconsistent modelling (historical and reprocessed solutions)

[Legrand et al. 2010, 2012, Bruyninx et al. In press] showed that:
- the regional solutions are affected by network effects which can exceed the noise level,
- the effects can be reduced when the agreement of the solutions is improved.

Perspectives after the first period:

Mitigate the network effects between regional densifications by:

- Improving the **agreement** between solutions
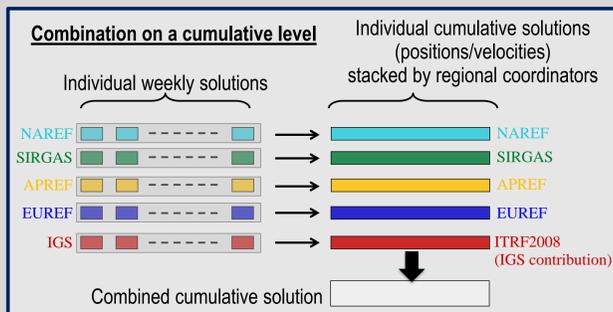- Encouraging **global** networks analysis

Combination on a cumulative level

Individual weekly solutions

Individual cumulative solutions (positions/velocities) stacked by regional coordinators

NAREF → NAREF
SIRGAS → SIRGAS
APREF → APREF
EUREF → EUREF
IGS → ITRF2008 (IGS contribution)

Combined cumulative solution

Figure 1: Combination of the individual cumulative solution on a cumulative level.

Period 2009-2011 "Reduction of network effects: Improvement of the agreement between solutions"

Submitted Solutions (Table 1):

- Regional coordinators appointed by the Regional Reference Frame Sub-Commissions
- **Reprocessed** cumulative solutions, restrained to "Core" networks
- Usage of the same **discontinuity** list, control over station naming + DOMES
- Access to **residual position time series!**
- **Feedback** and **iterations** with Regional Reference Frame Sub-Commissions

	Global Regional	Stations #	Stations ITRF	Stations New	Data span	Received
ITRF						
ITRF2008	Global	561	561	-	1997.0-2009.5	
Regional Reference Frame sub-commissions						
EUREF	Regional	283	128	155	1996.0-2011.3	05/2011
SIRGAS	Regional	183	57	126	2000.0-2010.5	04/2011
APREF	Global	265	188	77	2007.0-2012.2	03/2012
NAREF	Global	2032	309	1723	1997.0-2009.5	09/2011
Africa		No submission				
Antarctica		No submission				
Other submissions						
ULR	Global	317	260	57	1995.9-2008.9	02/2011

Table1: List of the solutions submitted to the WG.

Results:

Big improvements:
- Agreement on discontinuities
- Global networks: APREF, NAREF
- Better agreement wrt ITRF

But still some discrepancies
- Different time span (e.g. APREF)
- Different velocity constraints (SIRGAS)
- Different behaviour observed thanks to the residual position time series (Figures 3)!

Figure 2 shows the level of agreement of the different regional and global solutions wrt the ITRF2008. In green, the percentage of stations with velocity differences wrt ITRF2008:

- VN, VE < 1mm/yr
- Vup < 2mm/yr

June 2012
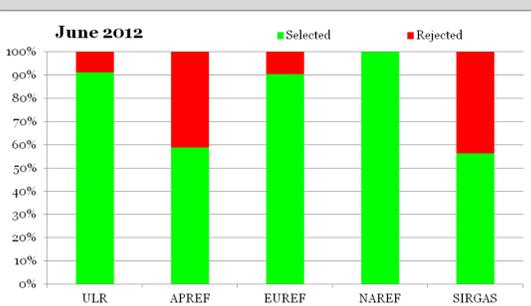Selected / Rejected
ULR APREF EUREF NAREF SIRGAS

Figure 2: Level of agreement of ULR, APREF, EUREF, NAREF and SIRGAS solutions wrt ITRF2008

More details about the WG "Regional Dense Velocity Fields" at http://www.epncb.oma.be/IAG

IAG WG "Integration of Dense Velocity Fields in the ITRF" 2011 – 2015

Period January – June 2012 "Test combination on a cumulative level"

First test combination: ITRF2008 with EUREF solution

Check of the disagreements and screening of the residual position time series

⇒ weaker estimations are rejected prior to combination:
- ITRF2008: 21 stations due to bad behaviour, lack of data (Figures 3)
- EUREF: 7 stations (mostly border stations)

Thanks to the rejection of bad estimations, the combined velocity field is improved compared to both EPN and ITRF2008.
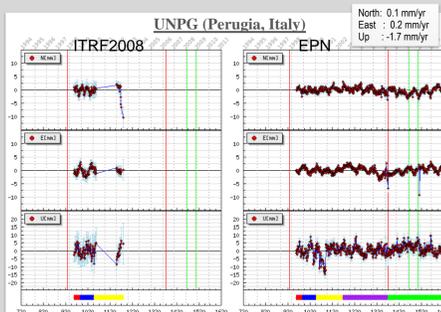
BZRG (Bolzano, Italy) North: 0.5 mm/yr East : 0.1 mm/yr Up : -0.7 mm/yr
ITRF2008 / EPN

UNPG (Perugia, Italy) North: 0.1 mm/yr East : 0.2 mm/yr Up : -1.7 mm/yr
ITRF2008 / EPN

VARS (Vardoe, Norway) North: -1.2 mm/yr East : -2.2 mm/yr Up : 1.6 mm/yr
ITRF2008 / EPN

Figure 3: Residual position time series obtained by the ITRF2008 on the left and the EUREF solution on the right.
a) BZRG, Bolzano Italy,
*b) UNPG Perugia, Italy*
c) VARS, Vardoe, Norway
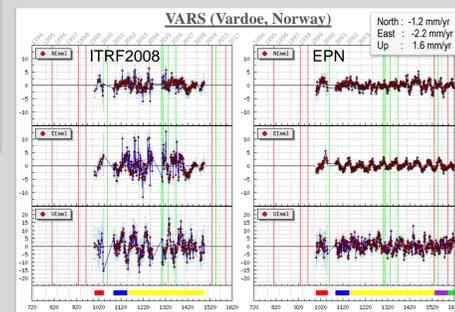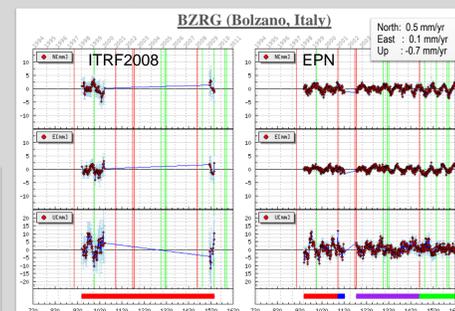
ITRF2008 and EUREF solutions have not been degraded: the 3D velocity RMS between the combined solution and ITRF2008 < 0.1 mm/yr and EUREF < 0.2 mm/yr.

This approach was successful for the EUREF solution thanks to:
- an **extremely good agreement** between both solutions
- a **large number of common stations** which allows to remove stations showing a disagreement

But, this is not applicable to the other solutions submitted to the WG:
- SIRGAS: disagreements wrt ITRF2008 due to different velocity constraints handling and different time span and too few common stations to rejected the estimations
- APREF: disagreements mainly due to different time span wrt ITRF2008

Since June 2012 "Quit cumulative level and move to weekly level"

The combination on a weekly level which was ruled out at the beginning of the WG because it was too restrictive and too time consuming is finally the only option which will allow to derive a satisfactory velocity field.
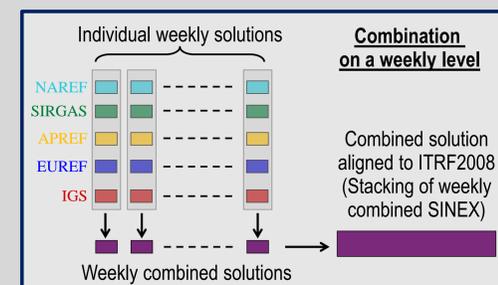
This will avoid the problems due to different ways of handling velocity constraints and due to different data span in the submitted solutions.

Individual weekly solutions

Combination on a weekly level

NAREF
SIRGAS
APREF
EUREF
IGS

Combined solution aligned to ITRF2008 (Stacking of weekly combined SINEX)

Weekly combined solutions

Figure 4: Combination of the individual solutions on a weekly level.

This new approach will allow to **mitigate network effects**, to have a full control over the **discontinuities** and the **velocity constraints**, to manage the different **data span** and to derive **residual position time series** in addition to the velocity field.

Conclusions

The IAG WG "Regional Dense Velocity Fields" and its follow up "Integration of Dense Velocity Fields in the ITRF" aims at densifying the ITRF velocity field. The WGs stalled on several, time consuming, issues mainly linked to meta data management. Nevertheless, since the beginning, the action of the WG have been reward by some great improvements in the agreement of the regional solution wrt the ITRF2008.

Despite the efforts within the WG, the cumulative approach turns out to be "**not enough**" in order to obtain a satisfactory combined GNSS velocity field and we moved to a **weekly approach** in June 2012.

References

Bruyninx C. et al., A Dense Global Velocity Field based on GNSS Observations: Preliminary Results (2012) International Association of Geodesy Symposia 136, Geodesy for Planet Earth, pp. 19-26, doi:10.1007/978-3-642-20338-1_3.

Bruyninx C. et al., IAG WG SC1.3 on Regional Dense Velocity Fields: First Results and Steps Ahead, "Reference Frames for Applications in Geosciences 2010", IAG Symposia Series, in press

Legrand J. et.al. (2010) Impact of regional reference frame definition on geodynamic interpretations, Journal of Geodynamics, Volume 49, Issues 3-4, pp. 116-122, doi: 10.1016/j.jog.2009.10.002.

Legrand J. et.al. (2012) Comparison of Regional and Global GNSS Positions, Velocities and Residual Time Series, International Association of Geodesy Symposia 136, Geodesy for Planet Earth, pp. 95-104, doi:10.1007/978-3-642-20338-1_12.