Quality Checks and Validation Procedures for

Combination at velocity level at INGV

Roberto Devoti

Associated products

WP10-DDSS-014 Products.EPOS.Combined.Velocity

Introduction

This document describes the quality checks and validation procedures performed at the EPOS WP10 INGV analysis centre on the combination of the two EPOS velocity fields. The strategy for the combination at velocity level is briefly described for the understanding of the quality check and validation procedures.

Input files

WP10-DDSS-012 Products.EPOS.DDsolution.Velocity

WP10-DDSS-013 Products.EPOS.PPPsolution.Velocity

Quality checks of the input velocity fields

We firstly evaluated the quality of the input velocity fields. The DD and PPP solutions provided a similar number of velocities (572 for the DD solution and 537 for the PPP one) in the ITRF2008 reference frame. The mean horizontal and vertical uncertainties correspond to 0.31 and 0.66 mm/yr for the DD solution and to 0.32 and 0.69 mm/yr for the PPP solution (*Figure 1-left* and *Figure 1-centre*). Both the velocity solutions were computed using MIDAS software (Blewitt et al., 2016). The dispersion of the velocity differences reveals no detectable systematics and residuals lower than their mean uncertainties (*Figure 1-right*).

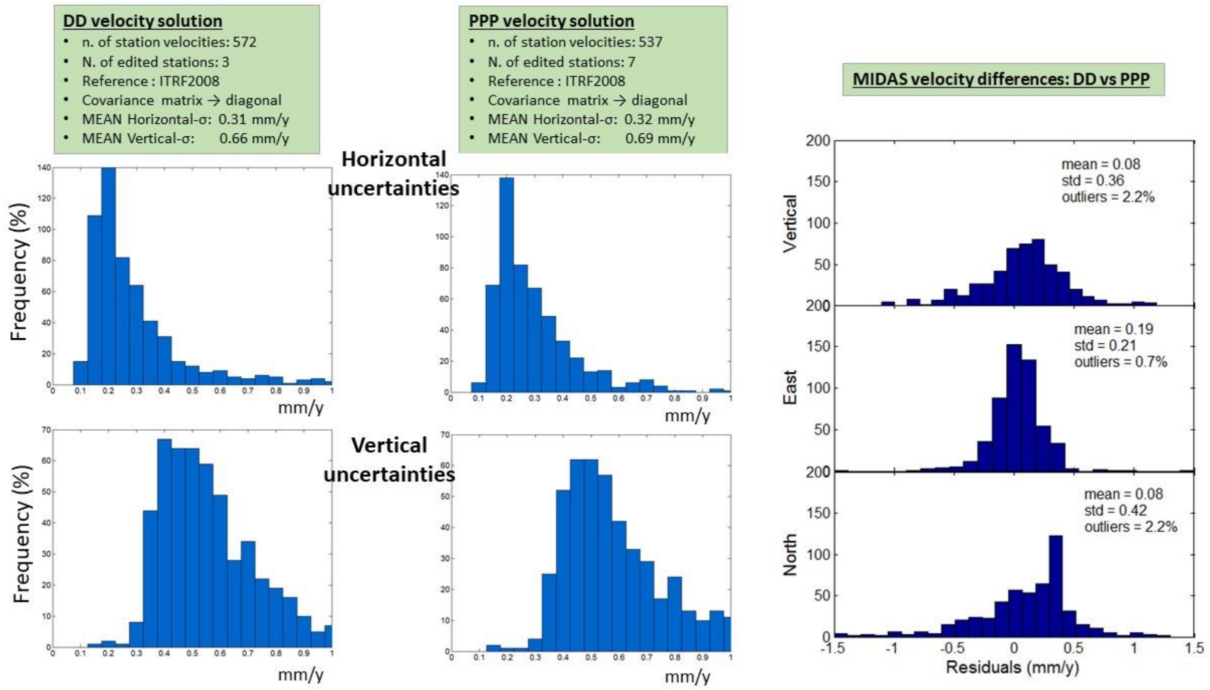

Figure 1: Distributions of horizontal and vertical uncertainties for both the DD and PPP velocity solutions (left and centre) and statistics on their differences

Analysis Strategy

The strategy foresees the combination of different velocity fields (no precise positions required) with a minimum of common fiducial stations (EUREF) that will define the reference system. Each input velocity field is considered as a stochastic sample of the true velocity field and the output combined velocity, as the best estimate of the true velocity field. In a small region approximation the input velocity fields can also be expressed into different reference frames (ITRF) because rigid rotations, translations and scale factor can be treated stochastically through a loosening transformation. The estimation problem is solved in a least squares scheme in which each velocity contributes to the estimation of a unique station velocity together with the loosened variance-covariance matrix. The final reference system can be established in the combination process by including the chosen ITRF velocities with their variance-covariance matrix that imposes the ITRF constraints to the combined solution.

The combination process consists of two main steps (*Figure 2*): the stochastic model augmentation, in which rotations and scale uncertainties are increased, i.e. covariance loosening. The loosening constraints are in principle arbitrary and should be on the order of the expected systematic differences in order to allow the solutions to rotate and scale by the required amount. The resulting covariance matrix is termed as loosened covariance (Blewitt, 1998) and is associated to the corresponding (unchanged) velocity solution. The second step consists in the least squares estimation of the combined velocity field, where the observations are the velocity solutions with the associated loosened covariances together with an additional IGS velocity solution, used to establish the ITRF frame. The combination is iterated twice in order to estimate the corresponding solution weighting factors, balancing mutual weights according to each solution chi-squared (χ^2)

(Devoti et al., 2010). Finally, there is the possibility of forcing two or more velocities to be estimated together (velocities ties). This is achieved using the classical method of Lagrange multipliers (e.g. Arfken et al., 2013), where the least square problem is solved with the equality constraints.

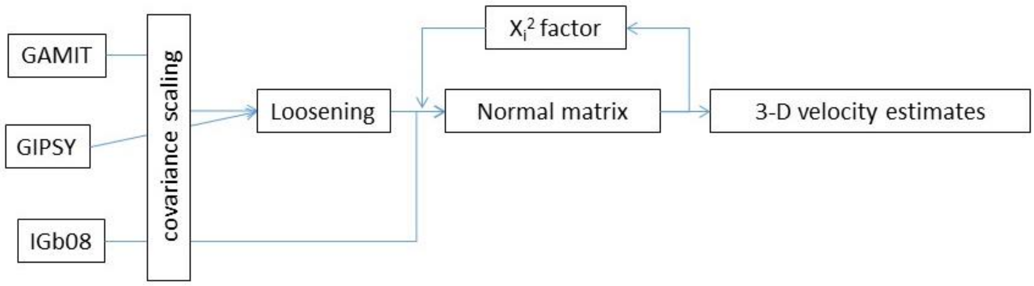

Figure 2: Flow-chart of the combination method

To recognize the station identity, we decide to adopt an *a-posteriori* approach based on the assignment of a unique label based on the station positions (i.e. geo-coding). In particular, we choose the *GHAM* code proposed by Agnew (2005) (*Figure 3*), to label each GPS station unambiguously. The *GHAM* code is composed of alternating letters and numbers, providing tags to geographic locations and defining addresses of equal-area cells with arbitrary precision. We choose a 12-character code that corresponds to a cell size of 1.9 m (square root of area), which is sufficiently small to identify a single GNSS antenna installation. This site recognition can be automated and alphabetically sorted codes group stations that would be nearby in space.

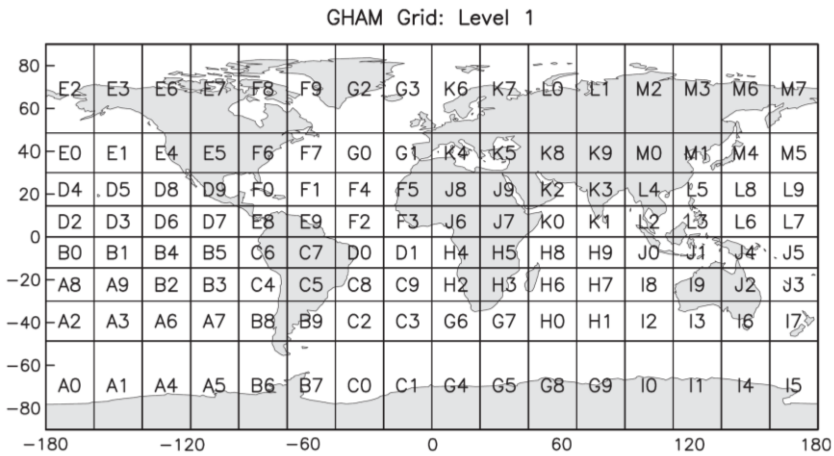

Figure 3: Cell-size distribution from an example of 2-char code

Quality check and Validation of the Combination at the velocity level

To estimate the quality of the combination of the velocity fields, we calculated the dispersion of the residuals between each velocity solution and the Combined (COMBI) velocity solution. The mean values of the residuals in both cases (*Figure 4-left* and *Figure 4-right*) are very close to zero and their standard deviations are comparable to the uncertainties of each single solution. The percentage of outliers is also low (< 0.8%), thus suggesting the absence of significant discrepancies between the two solutions. At the IGb08 stations velocities, a comparison was also performed between the COMBI velocity solution and IGb08 one. In this last case, the mean values correspond to 0.03, -0.02 and 0.10 mm/yr for the North, East and Vertical components, respectively, whereas the standard deviation amount up to 0.31, 0.30 and 0.32 mm/yr for the North, East and Vertical components, respectively. In *Figure 5*, a spatial comparison between the COMBI, DD and PPP solutions are also shown for regions characterized by different tectonic regimes.

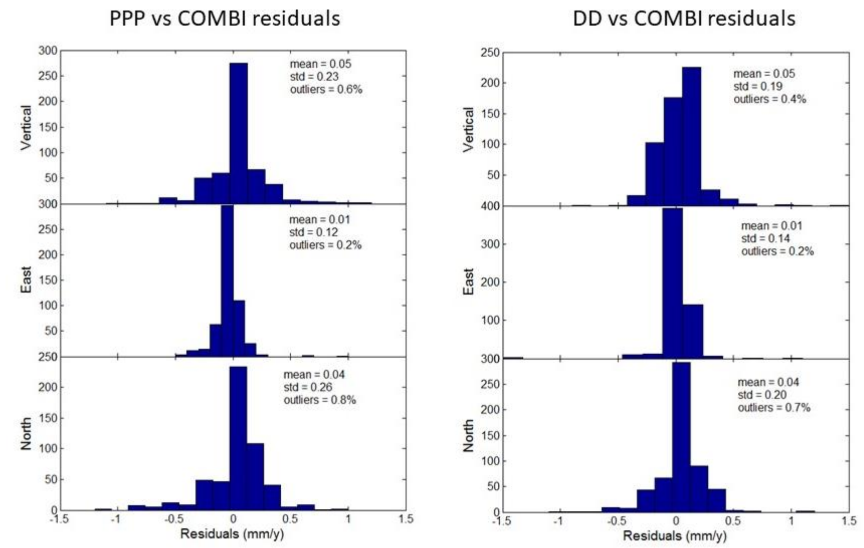

Figure 4: Residuals between COMBI and each single velocity solution

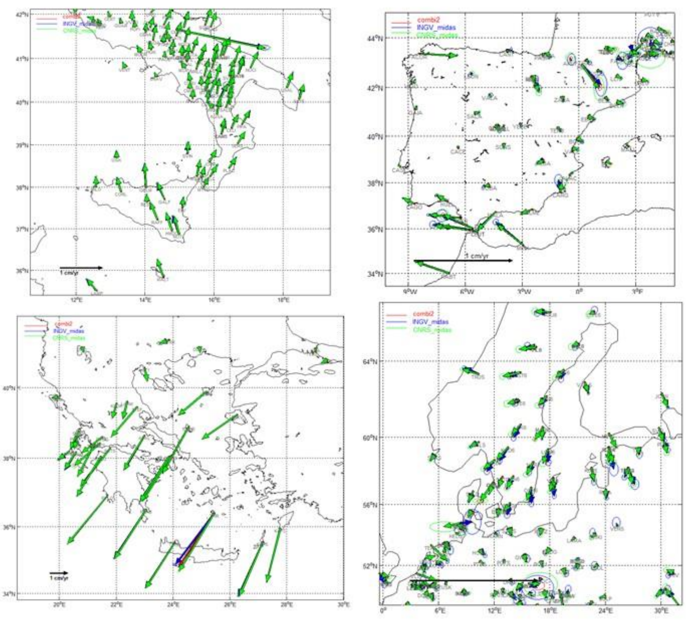

Figure 5: Spatial comparisons between COMBI (red vectors), DD (green vectors) and PPP (blue vectors) velocity solutions in both slowly and quickly deforming regions

References

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