Velocity field in the Mediterranean area from ASI-CGS GPS, SLR and VLBI solutions: the ASImed solution







EUREF Symposium 2011, Chisinau, 25 -28 May, 2011

Product description

The ASImed solution is a multi-technique crustal velocity field, covering mainly the Central Mediterranean area. It is derived from three independent space geodetic solutions (GPS, SLR and VLBI) delivered at ASI-CGS which are merged into a common reference frame.

The ASImed network includes the Italian ASI GPS Fiducial Network, many Italian permanent GPS sites, several EPN GPS sites and the European SLR and VLBI fundamental sites.

The ASImed solution is regularly issued at least once per year, using the most updated ASI-CGS GPS, SLR and VLBI solutions available.

Mono-technique solution features

	SLR Solution	VLBI Solution	GPS Solution
Data Set	2692450 NP LAGEOS 1-2 (January 1984- December 2010)	3680 sessions, (August 1979- December 2009)	daily RINEX files (July 1996 – November 2010)
Sites	126, world-wide	123(88), world-wide	102, (mainly in Italy)
Constraints	Estimated as loose-constrained network; globally roto-translated to ITRF2008	minimal constraints, no-net- translation and no-net-rotation (39 sites) on terrestrial reference frames (coordinates and velocities).	Loose constraints: 1 m apriori sigma on daily SSC
Reference	ITRF2008	ITRF2000	ITRF2005
Method	Site velocities and coordinates, 3- daily EOP (84-92) and daily EOP (93-08) & LOD, satellite dynamic parameters, monthly satellite biases have been estimated.	Site coordinates and velocities are solved for together with a set of constraint equations.	Each daily loose-constrained- solution is transformed into ITRF2005 frame. Site velocities and coordinates have been estimated merging the daily solutions
Software	NASA/GEODYNII – SOLVE	NASA/CALC – SOLVE	VMSI/MICROCOSM – SV

Mediterranean velocity field generation

- ASI-CGS SLR and VLBI global solutions, spanning more than 25 years, are available as SSC/SSV ITRF-constrained solutions
- The ASI-CGS GPS Network SSC daily solution time series is preliminarily compared to another independent ASI/CGS GPS solution computed by means of the SW GIPSY/OASIS under a PPP strategy to detect eventual anomalies in the coordinate time series and eliminate them
- The set of SSC parameters from the GPS Network daily solutions is merged into a SSC/SSV solution by a processing tool, developed at ASI-CGS, able to derive the SSV solution from the weighted linear fit of a set of ITRF-framed SSC solutions with the estimation/application of jumps when a change of the site configuration is known
- To avoid the effects from different realizations of the ITRF, each velocity solution, GPS, SLR, VLBI is loosened and then combined
- The Mediterranean portion of the final combined solution is rototraslated to ITRF2008

The combination approach

The ASI-CGS combination procedure is based on the direct combination of loose constrained solutions (*"Methodology for global geodetic time series estimation: A new tool for geodynamics"*, Davies and Blewitt, 2000).



Under these conditions, the reference frame biases cannot be estimated anymore and the Helmert transformation parameters could be treated stochastically:

- no inversion problems for the solution covariance matrix
- no need to know a priori values for the estimates
- no relative roto-translation between the reference frames is estimated

The iterative least square technique

The combination is performed along the lines of the iterative Weighted Least Square technique: each contributing solution plays the role of a 'pseudoobservation' whose residuals with respect to the combined solution must be minimized; each solution is stacked using its full covariance matrix rescaled by a factor by imposing

 $\chi^{2} = R_{1}^{T} C_{1}^{-1} R_{1} \dots + R_{i}^{T} C_{i}^{-1} R_{i} = 1$

 $R_{1}^{T}(f_{1}C_{1})^{-1}R_{1} = \dots = R_{i}^{T}(f_{i}C_{i})^{-1}R_{i}$

The first guess for the combination is obtained with $f_i=1$ for each solution. For each iteration, the contributing solutions are rototranslated to the combined solution and points exceeding a 3.5 σ criterion are edited.

Colocated sites

A key role in the combination procedure is played by the colocated sites, which allow a direct connection between the different technique solutions.

In this work the following multi-technique sites appear: Matera (SLR, VLBI, GPS) Wettzell (SLR, VLBI, GPS) Medicina (VLBI, GPS) Noto (VLBI, GPS) Cagliari (SLR, GPS) San Fernando (SLR, GPS) Lampedusa (SLR, GPS)



Pillars of the combination

In practice, a careful choice of the co-located sites to be assumed as 'pillars' in the combination procedure has to be performed: the loose combination is able to absorb small global roto-translations among mono-technique velocity solutions, but site-dependent velocity discrepancies, due to eventual technique-based systematics, must be monitored before the inter-technique combination takes place, in order to avoid misleading results.

Thus, the co-located sites chosen for the present ASImed combination are Matera, Medicina, Noto, Wettzell. Cagliari, San Fernando and Lampedusa are kept separate even if co-located.

ASIMed: Mediterranean coverage

The geographic coverage is quite dense: >100 sites, the majority of those being in Italy. The GPS network is the principal actor, providing alone the whole coverage.

SLR and VLBI have been giving a picture of the area since 80's and 90's.

Many Mediterranean sites have been occupied by SLR mobile stations during the WEGENER-MEDLAS campaigns. Even if the occupations were sporadic and short, they gave the first experimental evidence of characteristic tectonic motion features, as in the Aegeum.



SLR & VLBI Mediterranean solution



GPS network: spatial and temporal coverage The GPS data coverage is not uniform: GPS sites are continuously added to the network, turning out in different levels of velocity estimated accuracy. The accuracy improvement becomes a critical factor when the expected eurasiatic residual motion is of the order of a few mm/y as in the Italian region.



Velocity sigma

The velocity formal uncertainty is influenced by the combination strategy. The final combined solution has a formal uncertainty level more realistic than that of the GPS solution.



Velocity residuals computation

The combined SSV solution is rototranslated to ITRF2008 by using the following sites: MATE, UPAD, VILL, WTZR, CAGL, MEDI, SFER, GENO, NOT1, VENE, LAMP, 7840, 7836, 7810, 7835, 7811, 1884, 7805, 1565, 7332, 7333 (GPS acronym used for colocated sites)

An Eulerian pole of the rigid block motion for the central Europe has been computed using a set of stable European ITRF2008 sites.

The plots shown in the following slides show the residual velocities with respect to the modeled Central Europe motion. As expected, Central Europe does not show any significant deformation with respect to the computed pole. **Eastern Mediterranean** The Aegean area shows the largest residual motions w.r.t. Eurasian plate, in agreement with geological model which predict an ongoing spreading of the Aegean sea over the African plate.



The SLR sites in this area have been occupied by temporary campaigns in the past years (sporadic 1-2 months occupations in 1985-1995).

GPS permanent sites have collected a significant data history whose analysis results agree with the motion derived from SLR-only sites.

Western Mediterranean

Residual motions w.r.t. Eurasian plate seem generally really small in the Iberian Peninsula. The residuals show a small rigid clockwise rotation, probably due to the reference Eulerian pole which has been derived from Central European sites only.



Northern Italian peninsula

The combined velocity field does not show significant residual motion w.r.t. Eurasian plate along the Alps chain. Small residual motions arise along the Northern Apennines and on the nearby Po valley.



Central Italian peninsula

The Central part of Italy shows different velocity pattern discriminated by the Apennines axis: westwards residuals in the Tirrenian area, north-eastwards residuals in the Adriatic area



Southern Italian peninsula

Southern Italy shows the largest residual motions w.r.t. Eurasian plate in the Italian peninsula. CAGL, on the Sardinian block, confirms its stability. Sicily and Lampedusa show a residual motion close to African one. MATE, on the Apulian platform, shows a motion with different direction w.r.t. the African one.



Younger stations of the Southern Apennines show residual motions different among them, both for value and direction. This could be due to local complexity, hence further observations are needed.

Strain-Rate Analysis

- The residual velocity field is used to perform a strain-rate analysis over the Italian peninsula. The obtained deformation field has been compared w.r.t. historical database of seismic data recorded in Italy.
- We find a good agreement between geodetic and seismic deformation, both in terms of velocity and direction.



Acknowledgements

Thanks to:

International Laser Ranging Service (ILRS), International VLBI Service (IVS), International GNSS Service (IGS), EUREF Permanent Network, all the Italian data providers for the availability of data.