New Investigations and Contribution to Geodesy of the Italian GPS Fiducial Network at EUREF Analysis Center ASI/CGS

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Introduction

During the last year, at the Matera Space Geodesy Center (ASI/CGS) data analysis activities have been expanded both in the field of GPS and towards combination of different geodetic solutions.

The GPS activities increased: new permanent stations are managed and new investigations have been carried out, mainly in the atmospheric applications. Studies on the combination strategies of different solutions have been encouraged since coordinate and velocity solutions from three space geodesy techniques (GPS, VLBI and SLR) are performed at the fundamental station of Matera.

New stations and data-flow managing

The upgrade of the network has been achieved not only in terms of new stations, but also in terms of providing near real time observation, navigation and meteorological data.

During the last year, three new permanent GPS stations have been installed by ASI: Lampedusa, L'Aquila and Camerino (Fig.1). Moreover, ASI hosts data from three new Italian permanent stations, managed by local institutes, on the GeoDAF data bank: Novara, Prato, Reggio Calabria (Fig.1).

At present, observation and navigation data on hourly basis are available for Matera, Medicina, Cagliari and Torino, while meteorological hourly data are available only for Matera. Efforts are in progress at ASI/CGS in order to provide near real time data on hourly basis for the most of the Italian permanent GPS stations in the very next future and to promote all the activities related to such a product (studies on atmosphere, meteo forecast, production of rapid orbit, etc.).

New atmospheric products

The atmospheric activities cover the ionospheric and the tropospheric fields.

Ionospheric local map of Total Electron Content (TEC) are provided on daily basis using Matera GPS data. They are available since 17 May, 1999 on the GeoDAF with one day latency.

The "geometry free" combination of the carrier phase is modelled by an instrumental delay, depending on the receiver-satellite pair, and by a ionospheric delay, proportional to the TEC in the receiver-satellite direction. The method is completely general: it is possible to produce similar local maps to other sites of our network, on user request (FERMI et al.,1998).

Recently, studies on the troposphere using GPS signal for meteorological applications have been started at Matera Space Geodesy Center. In this framework, ASI/CGS jointed the MAGIC Project in 1999. It is a cooperative effort to improve weather prediction and climate models in the Western Mediterranean by deriving new measurements of atmospheric humidity from GPS network data (HAASE et al.,1999).

The ASI/CGS analysis is performed in order to provide tropospheric Total Zenith path Delay (ZTD) of a network of 20 European stations. On a daily basis, data acquired 15 days before are processed using the Precise Point Positioning

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approach (ZUMBERGE el al.,1997), fixing JPL precise orbits, satellite clocks and earth orientation parameters and estimating the total zenith path delay, together with station coordinates, clocks and phase ambiguities.

ASI/CGS cooperates with other national research institutes to promote the use of GPS derived tropospheric parameters for meteorological applications as well as for climate research. Comparisons among GPS estimated Precipitable Water Vapour (PWV) with ground-based microwave radiometer measurements and mesoscale model predictions (PACIONE et al., 2000) have been performed. Finally, the assimilation of GPS PWV into the MM5 nonhydrostatic modeling (DUDHIA, 1993) has been carried out.

Combinations of geodetic results

The most recent geodetic activities performed at ASI/CGS are oriented to the combination of solutions coming from different space geodesy techniques (BIANCO et al., 2000).

Matera is a fundamental geodetic station where SLR, VLBI and GPS are collocated. Regularly, global and regional solutions are produced at ASI/CGS for each one of these techniques. Taking advantage from this opportunity, an experiment of combination in terms of baseline velocity estimated by each technique has been made.

The SLR solution is a global solution based on the worldwide range observations to the LAGEOS I and LAGEOS II satellites from January 1984 to December 1998. The VLBI solution is based on nine year of data acquired from 1990 to 1998 within the EUROPE VLBI campaign. Two different GPS solutions contributed to the combined solution: one obtained with a *network fiducial* approach and another one based on *precise point positioning* approach. Both of them cover from January 1995 to January 1999 (DEVOTI et al., 2000a).

The first aim of this experiment was to develop a method for a correct comparison of homogeneous quantities coming from different techniques and, as consequence, to check the agreement of the obtained results.

In order to derive a unique velocity field from the results of the different techniques, each solution has been transformed in the ITRF97 reference frame, assumed as the reference model. The roto-translation parameters for each solution were estimated, in a least mean square sense, minimizing the velocity residuals. Then, the Eurasian plate motion has been removed at each site using the Eurasiatic Eulerian vector estimated from 21 sites, properly chosen to represent the Eurasia rigid plate. The obtained velocity residuals represent the site motion w.r.t. Eurasian considered as a fixed plate (Devoti et al., 2000b). These residuals are mutually differenced to derive the relative Cartesian motion between pair of sites and then projected into a local Length-Transverse-Up (LTU) reference frame.

The LTU local Cartesian reference frame is defined by assuming one station as the origin of the system and two orthonormal vectors, the Up pointing radially outwards, the length along the baseline connecting the sites and the Transverse is orthogonal to the previous ones (DEVOTI et al., 2000a).

The residuals baseline velocity vectors in the L and T directions, of each solution, are then combined in a weighted average (Tab.1).

It must be considered that the average value has been obtained at each baseline depending on the technique available at the sites involved in the baseline. So, each result may based on a number of solutions ranging from one to four.

Preliminary results of the combination

We tried a geodynamic interpretation of the geodetic results in the Italian region. We have chosen five sites in this area, focussing our attention on those relevant from a geophysical point of view (Fig.2).

For our convenience, the area has been studied forming three triangles among the chosen sites: Matera-Padova-Wettzell, Cagliari-Matera-Padova and Cagliari-Matera-Noto. The relative motion of the baseline involved in the first and second triangles will help us to understand relative motion between the Eurasian and Adriatic plates, while the third one, the interaction between the Eurasian and African plates.

Matera and Padova stations show a residual motion with respect to Wettzell and Cagliari stations (Fig. 3 and 4), on the order of a few mm/yr. Since those motions, as viewed from Wettzell and Cagliari, are consistent between each other, we can consider Wettzell and Cagliari representative of the Eurasian plate.

Assuming that Matera and Padova belong to the Adriatic plate, their motions are compatible with a migration of the Adriatic plate towards NNE with respect to Eurasia.

Moreover, since Matera is moving faster than Padova, by an amount of about 2 mm/yr, we can suppose a counterclockwise component for the Adriatic plate. Summing the vectors Padova-Wettzell and Wettzell-Matera, Padova-Cagliari and Cagliari-Matera, we obtain the same result as the direct measurement of the Padova-Matera vector, at one sigma level (Fig. 5).

The motion of Noto site seems to be in agreement with African one at the site (MULLER and KAHLE, 1993) (Fig.6).

The baseline Matera-Noto shows an extensive relative motion between Africa and Eurasia in this area (Fig.7). It could be in agreement with an ongoing spreading of the Calabrian arc.

Conclusions

During the last year, several new activities have been started at ASI/CGS analysis center. Together with the historical activities of continuous GPS analysis for EUREF contributions, in terms of weekly coordinates of a wide network covering the South part of West Europe and the consolidated production of ionospheric maps over the Italian region, at present we are successfully working in the field of GPS derived tropospheric parameters for meteorological applications, jointing national and international project, and in the field of combination of space geodesy solutions from different techniques (DEVOTI et al., 2000b) as the very challenging activity. Contemporary, our national GPS permanent network is continuously spreading and data on sub-daily basis are planned to be provide for the most of the network in the very next future.

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Tab.1: The combined weighted average values of the baseline velocity vectors

Baseline	L Comp. (mm/yr)	T Comp. (mm/yr)
Cagliari-Mate	1.7 ± 0.4	-4.6 ± 0.3
Cagliari-Noto	-4.2 ± 0.4	-3.1± 0.4
Matera-Noto	0.8 ± 0.3	2.3 ± 0.3
Matera-Wettzell	-3.8 ± 0.2	-2.1 ± 0.3
Cagliari-Wettzell	0.3 ± 0.4	-0.7 ± 0.4
Cagliari-Padova	3.0 ± 0.4	-0.8 ± 0.5
Matera-Padova	-0.9 ± 0.4	-1.3 ± 0.4
Noto-Padova	-2.4 ± 0.4	2.0 ± 0.5
Padova-Wettzell	-2.6 ± 0.4	-0.2± 0.5

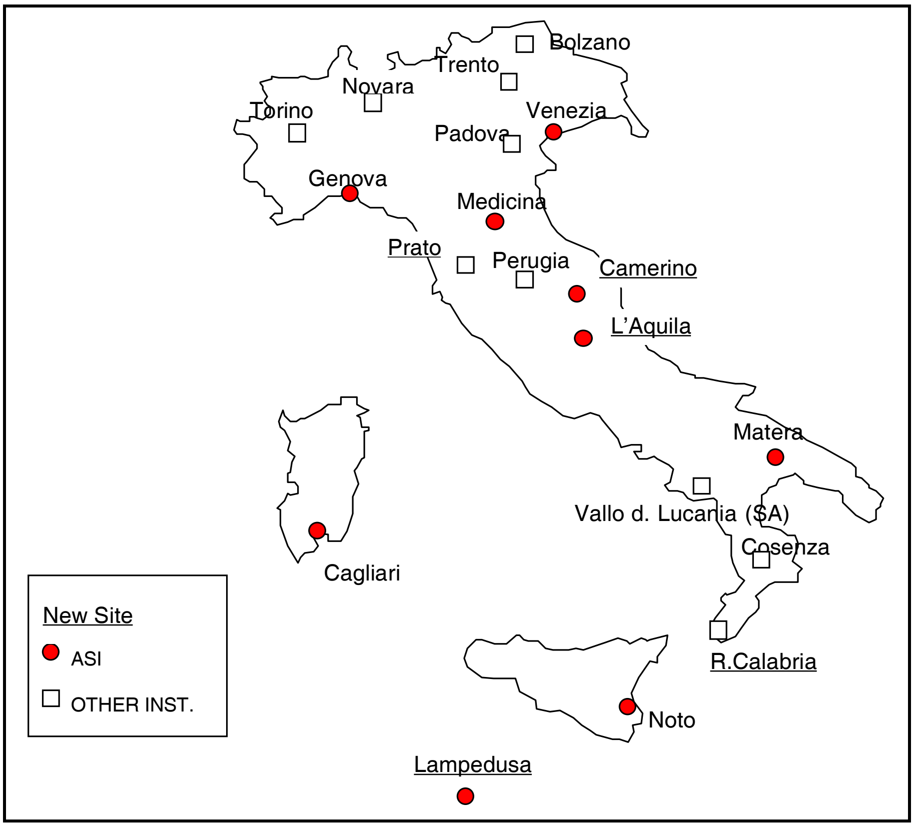

Fig..1: The whole Italian GPS Fiducial Network

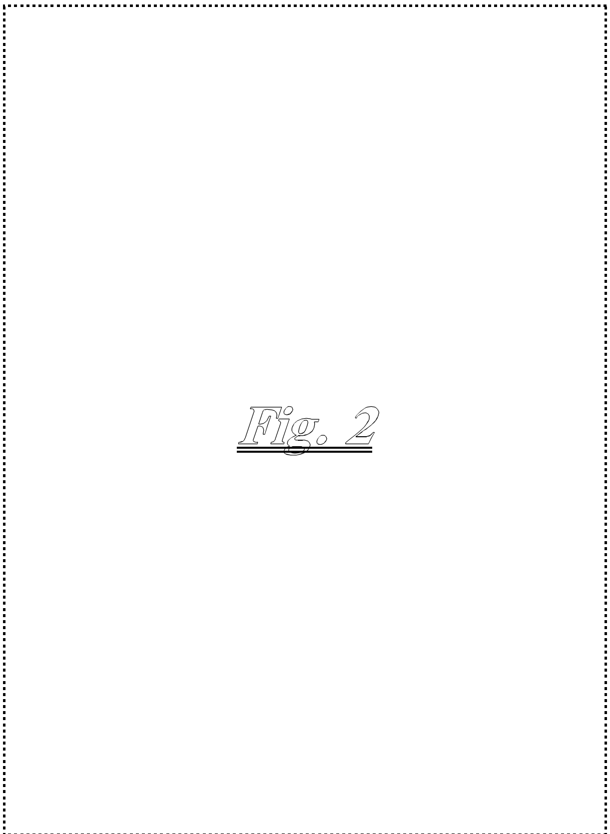

Fig. 2: Sites chosen for geodynamical interpretation of the area

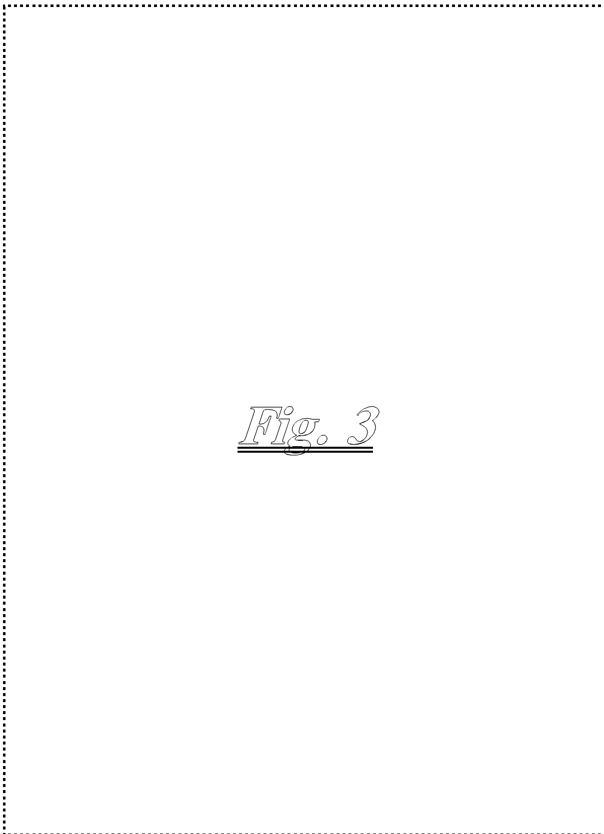

Fig.3:The triangle Matera-Padova-Wettzell: Padova-Wettzell and Matera-Wettzell vectors

Fig. 4

Fig. 4: The triangle Cagliari-Matera-Padova: Cagliari-Padova and Cagliari-Matera vectors

Fig. 5

Fig. 5: Matera – Padova vector

Fig. 6

Fig. 6: The triangle Cagliari-Matera-Noto: Cagliari-Matera and Cagliari-Noto vectors

Fig. 7

Fig. 7: Matera – Noto vector