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An overview of the Sardinia Radio Telescope geodetic potential at national and international levels

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Abstract.
Sardinia Radio Telescope (SRT) potentials in geodesy are mostly connected to VLBI techniques and they may have a remarkable impact on both national and international geodetic science. A development plan concerning geodetic technical instrumentation should be provided soon, so as to perform geodetic observations with the SRT in the near future. The SRT is being developed within a well-consolidated national environment of geodetic VLBI activities: Medicina and Noto observatories have been continuously participating in geodetic VLBI observations for almost two decades. Matera observatory, whose 20-m VLBI telescope is entirely devoted to geodetic VLBI, is one of the few fundamental geodetic Earth's observatories and is running VLBI experiments since 1990. At a national level, the SRT has the capability to establish a self-consistent Italian VLBI network: it would represent a unique facility in Europe. At an international level, the SRT should be made part of the geodetic International VLBI Network whose operations are supported and coordinated by the IVS (International VLBI Service for Geodesy and Astrometry). IVS promotes research and technological development in geodesy and astrometry, with important outcomes for the astronomical VLBI community, too. In the following sections, the contribution of the SRT to space geodesy, geophysics and related research fields will be outlined.

1. Introduction

The VLBI antennas of Medicina and Noto have been continuously performing geodetic observations since the very beginning of their activity, i.e. Italian geodetic VLBI data span a period of more than 15 years. Italian geodetic VLBI observations are completed by the dataset acquired by the VLBI antenna at Matera. This set of observations is the result of a strong international coordination and has a high scientific value for international and national geodetic research. In particular, Italy nowadays possesses the highest potential for geodetic VLBI research in Europe. It is also one of the nations worldwide that have been extensively developing VLBI instrumentation to a very high standard. In this framework, the SRT represents an important opportunity for completing a national VLBI network that has the capability of enhancing the level of geodetic research in Italy and in the Mediterranean

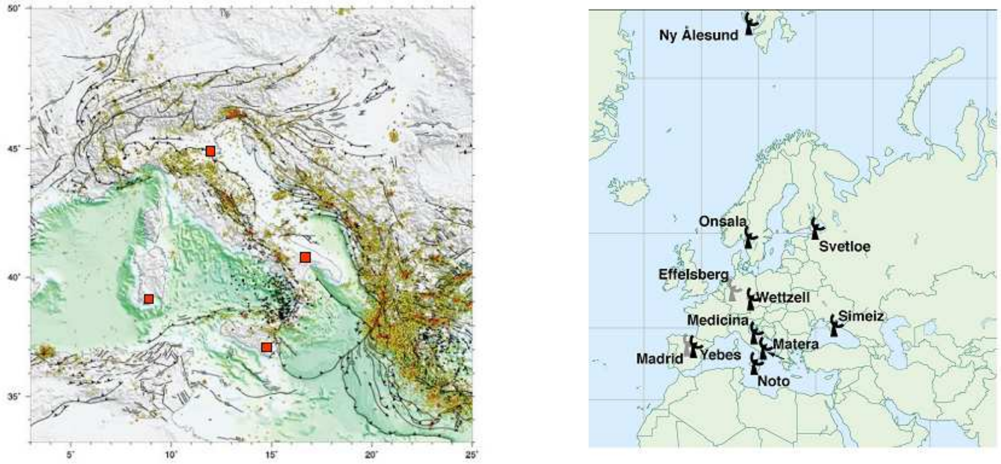

Fig. 1. Left: Location of Italian VLBI antennas (red squares) shown on a map containing the geodynamics, bathymetry (Gebco) and earthquakes (Neic) of the Mediterranean area. Courtesy of E. Serpelloni (INGV). Right: Map of the VLBI geodetic network

area. The complex geophysical environment that characterizes this area has to be interpreted and understood by merging a wide range of information. Geodetic observations and accurate geodetic results are a fundamental part of the information. In order to reach high accuracy and reduce the impact of systematic effects on geodetic results, observations of space geodetic techniques are often combined. An Italian geodetic VLBI network, established through the four Italian VLBI antennas, along with the capability of managing co-located instruments and tying together the different techniques, would allow a reliable combination of VLBI and GPS observations at a national level. This combination permits a deeper and more accurate investigation of important processes and allows one to infer their origins and their possible evolution. Italian VLBI can contribute to the study of e.g. crustal deformation in the Mediterranean region and related seismic hazard as well as tropospheric water vapour evolution. To a different extent, both these processes have an impact on social security and social development. A combination of Italian GPS and VLBI networks would also permit the definition of a precise national geodetic *datum* that can be used for scientific research and a wide range of technical and commercial applications.

2. Potentials: geodetic science

Several geophysical processes contribute to characterizing the evolution of the Mediterranean basin. A large number of earthquakes take place in the complex geodynamical structure of this area, linked to the motion of the different tectonic structures. The SRT is located in an area of small seismic activity and its location can be considered strategic when compared to the positions of the other Italian VLBI antennas. Figure 1 shows the location of the Italian VLBI antennas (red squares in left panel) with respect to main tectonic boundaries. Also shown is the European VLBI geodetic network (right panel). The SRT can be used to improve the long series of VLBI-derived crustal deformation records in the Mediterranean area (e.g. Haas et al. 2003), since it could be regarded as a stable regional reference point for computing VLBI-derived crustal motions.

Regular geodetic observations with the SRT would also have a positive influence on radioastronomy and its applications. A precise determination of the telescope's reference point coordinates is crucial for performing signal correlation. Geodetic observations allow a quick and accurate measure and an easy monitoring of telescope's position.

Geodetic analysis can be further refined through the combination of observations performed by independent space geodetic techniques: technique-dependent systematic effects can be monitored and reduced (Ray 2000) and e.g. more accurate stations' positions and motions can be estimated. In order to do so, co-location of space geodetic instruments has to be ensured, managed and maintained at each co-location site. This is the case for Medicina, Noto and Matera observatories, where continuous observations performed by the IGS (International GPS Service) GPS permanent stations match a regularly performed schedule of geodetic VLBI observations. In such co-location sites, local ties are mandatory. Local ties aim at estimating eccentricity vectors. These latter locate the Reference Points (RPs) of the co-located instruments, thus providing an external link between solutions obtained by independent space geodetic techniques. Space geodetic solutions are eventually combined through SINEX (Solution INdependent EXchange format) files. Therefore, eccentricity vectors must also be provided in SINEX format and they are key elements in the combination process of space geodetic solutions (Rothacher 2000). In particular, accurate eccentricity vectors must be provided for all co-location sites (Altamimi 2005). VLBI technique is fundamental for computing combined products and for realizing ITRF (International Terrestrial Reference Frame; Altamimi et al. 2002). Under this perspective the Italian VLBI observatories greatly contribute to the realization of the global frame. The well-established cooperation between the Istituto di Radioastronomia and DISTART-University of Bologna has led to the optimization of a complete method for eccentricity vector estimates and SINEX generation (Sarti et al. 2004). The VLBI-GPS co-locations established at Medicina and Noto observatories were used as tests. A co-location between VLBI and GPS instruments has to be realized for the SRT, too. The know-how on local ties developed within INAF will ensure meeting the required international standards on local tie computation and SINEX generation (Sarti & Angermann 2005). Local ties would also ensure regular monitoring of SRT site stability, enhancing SRT performances and the international multidisciplinary scientific relevance of the site.

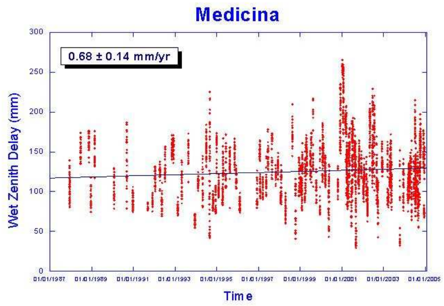

Fig. 2. Wet Zenith Delay estimated at the Medicina station.

VLBI is an efficient tool for sensing the atmosphere. VLBI-derived troposphere water vapour content has been compared with analogous contents derived by other techniques (radiosonde, GPS; e.g. Niell et al. 2001). Geodetic VLBI is nowadays used for determining long time-series of atmosphere water vapour content (Negusini & Tomasi 2004). Figure 2 shows Wet Zenith Delay estimated at the Medicina station using all geodetic observations performed at the observatory. VLBI-derived water vapour time-series are an interesting source of information for climate change studies and global warming processes. Geodetic SRT observations, possibly combined with a co-located GPS, can contribute by monitoring the water vapour evolution in the Mediterranean area and by providing more information to be used to infer the future climate evolution.

3. Potentials: technical applications

Beside international geodetic research, the SRT and the other Italian VLBI antennas can uniquely contribute to the definition and realization of a national geodetic *datum*. Again, co-locations with GPS instruments are essential. The computation of the IGM95 national geodetic *datum* (Istituto Geografico Militare, 1996 realization) was connected to ETRS89 (European Terrestrial Reference System as defined at epoch 1989.0) through a set of coordinates representing the positions of nine Italian GPS sites within the GPS-derived EUREF89 (EUropean REference Frame, ref. epoch 1989.0). This connection involved all three GPS instruments that are observing at Italian VLBI sites. The most recent realization of ETRS89 is ETRF2000 (European Terrestrial Reference Frame, 1989.0); the best framing of IGM95 into ETRF2000 can be ensured by taking full advantage of national EUREF co-location sites. This is the case for the Italian VLBI observatories. Therefore, accurate local ties and combination of observations represent the added value toward a definition of a national *datum*. SRT and the other three national VLBI observatories would eventually represent the backbone of a national combined VLBI-GPS geodetic network. Integration of VLBI and GPS observations for several geodetic applications has been successfully realized e.g. in Japan (Imakiiere et al. 2004). Finally, the long time-series of geodetic observations along with the technical and scientific infrastructures that are located at the Italian VLBI observatories must be considered as important tools for planning and developing technical and commercial services for external users. A description of the applications that can potentially be developed and offered to final users (e.g. SME, public offices and institutions, private survey agencies) may be found in Sarti & Vittuari (2004).

4. Conclusions

The SRT does not only represent a powerful tool for astrophysics; it also represents an important opportunity of development for Italian and international geodetic VLBI. The SRT can considerably support geodetic research and it is a potentially important step toward the creation of the Italian VLBI network and toward its integration with other space geodetic techniques. This integration can contribute significantly to the understanding of several geophysical processes that are nowadays taking place in the Mediterranean area. SRT should therefore be equipped with all necessary technical tools for performing high-quality geodetic observations. The destiny of Italian geodetic VLBI is strictly related to INAF future policy. INAF should seize the opportunities deriving from the management of three VLBI telescopes, supporting their use and application to the greatest extent.

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