PMD Analysis Center 2014 Annual Report

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Abstract Research activities carried out at the (PMD) IVS Analysis Center during 2014 are briefly highlighted, and future plans for 2015 projects are outlined in this report. The main topics tackled during 2014 concern so called space ties and consistency of Celestial and Terrestrial Reference Systems materializations. Comparisons with other geodetic techniques have been performed for parameter estimates related to tropospheric and ionospheric effects.

1 General Information and Staff

Milan University of Technology (Politecnico di Milano), Department of Civil and Environmental Engineering (DICA) [1] hosts and supports activities of the PMD (Politecnico di Milano DICA) Analysis Center. In particular the Geodesy and Geomatic research area of DICA supplies hardware equipment, software licenses and assistance, and the personnel necessary to manage it.

The following collaborators gave their contribution to the development of PMD activity during 2014:

- Vincenza Tornatore — team coordinator, responsible for AC projects and data analysis;
- Giovanna Venuti — GNSS troposphere parameter estimation;
- Cinzia Vajani — software maintenance;
- Daniele Passoni — data processing.

Politecnico di Milano, Department of Civil and Environmental Engineering (DICA), Geodesy and Geomatic area

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2 Current Status and Activities

Research topics investigated during 2014 mainly addressed problems related to reference frame stability and inter-technique comparisons of different parameters estimated using data from geodetic space techniques such as GNSS (Global Navigation and Satellite Systems), VLBI (Very Long Baseline Interferometry), and Doppler Orbitography and Radio Positioning Integrated by Satellite (DORIS). The activities can be summed up in the following main research lines:

1. space ties: post-processing of VLBI correlated data of GNSS observations
2. ICRF stability
3. estimate of atmospheric parameters using space geodetic techniques.

2.1 Data Processing of VLBI Observations of Satellites

A number of observing tests of GNSS satellites by the VLBI technique were performed with some VLBI stations able to receive GNSS frequencies during past years [12]. The efforts were dedicated to a deeper analysis of the correlation output to investigate possible indications to improve observations or correlation of the artificial satellite signals. For this analysis, software that is widespread in the radio astronomy community for processing natural radio source data was used. The software is the Astronomical Image Processing System (AIPS) developed and maintained by NRAO [2].

The data were stored in files of FITS-IDI (Flexible Image Transport System-Interferometry Data Interchange) [8] format with 0.5 s integration time. To calculate the delays and rates necessary for geodetic parameter estimation, first fringe-fitting [5], had to be applied. Here, as an example, we report on the analysis of one experiment which gave some useful information.

As the first step the amplitude and phases of the visibility fringes were plotted as they were collected in the FITS file (every 0.5 s) without any summation or averaging. Some insights of plots at two epochs, differing by only 0.5 s, showed that the phase often changed by about 160 deg. This big change of the phase during only 0.5 s, corresponding to a variation of about 10 cm in the correlator model, seems to be very high and requires some improvements of the model.

Fringe fitting was attempted with different integration times, but solutions became worse with increasing of integration time. The best solution was that with integration time equal to observation time, i.e. 0.5 s. The fringe fitting was done on a full first scan average of four minutes, beginning on channel BCHA 235 to ECHA 275, selecting only the strongest peaks. Then solutions were applied to all of the 512 channels. This result, obtained by taking correlation integration time equal to observing time interval, prevents the calculation of rates during the fringe fitting, because during 0.5 s integration time we have only one point in the plot of the phase with time. To make possible a good estimate of rates (the slope of phases with time) we should have in each integration time a good number of points (e.g. 20 points, one every eight degrees). This corresponds to a request of correlation, for the data of this example, not every 0.5 s but e.g. every 0.025 s (0.5/20). In this experiment only delays and phases could be corrected during fringe fitting; in Figure 1 DELAYS of antenna 2 with respect to antenna 1 are represented for each of the observed four IFs, and in Figure 2 PHASES are shown. Rates could be not determined on the basis of a single integration.

During inspection of the correlated data it was also noticed that the amplitude of the signals progressively decreases as long as the scan proceeds. One possible explanation could be that during the four minutes of observations, the satellite travels out of the antenna primary beam. In fact, because of the lack of proper antenna software (continuous tracking) it was possible to track the satellite only stepwise.

After this work, the following suggestions for satellite signal correlation and observation can be gathered to obtain better results:

- recorrelate each scan of four minutes with an integration time of 0.025 sec;
- make a Doppler tracking as good as possible;
- check the correlator model (10 cm is really a large number);
- use continuous tracking during observations.

2.2 ICRF Stability

Baselines, site coordinates, and CPO were estimated in ICRF1 and ICRF2 [7], using the software VieVS [4] and following the IERS (International Earth Rotation and Reference Systems Service) Recommendations [10] and the IVS (International VLBI Service for Geodesy and Astrometry) Conventions on VLBI data processing [9]. Time series of estimated parameters have been deeply analyzed, using standard Allan deviation methods, in tight collaboration with the VIE IVS Analysis Center (AC) and the PUL IVS AC. A thorough description of the analysis and discussion of the results have been submitted for publication.

2.3 Estimation of Atmospheric Parameters using VLBI and GNSS Data

The Geodesy and Geomatics area of the DICA (Department of Civil and Environmental Engineering) is developing algorithms to process and analyze GNSS and VLBI data, not only for positioning purposes but also for estimation of tropospheric parameters, that today have an increasing interest for meteorological applications. More specifically these parameters are tropospheric and VTEC estimation parameters by GNSS and VLBI techniques carried out during 2014 for intertechnique comparisons and for real time modelling of troposphere parameters by national GNSS networks. We dispose in Italy a national GNSS network: Rete Dinamica Nazionale (RDN) and of several regional real time GNSS networks [3]; then three sites are colocated with GNSS and VLBI equipment [11]. Some tests have been performed in collaboration with the IVS KTU AC for the use of the Scientific GNSS software Bernese version 5.2 [6], to estimate atmospheric parameters.

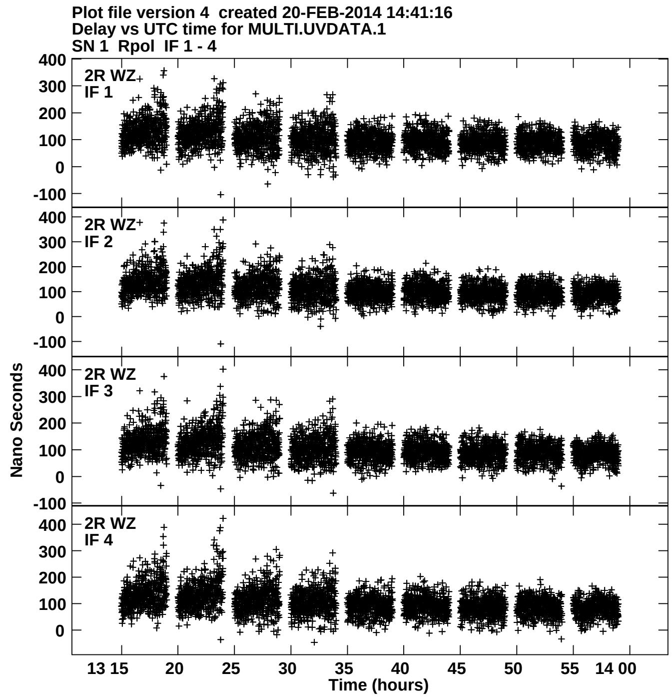

Fig. 1 Solutions from fringe fitting, delays of antenna 2 with respect to antenna 1.

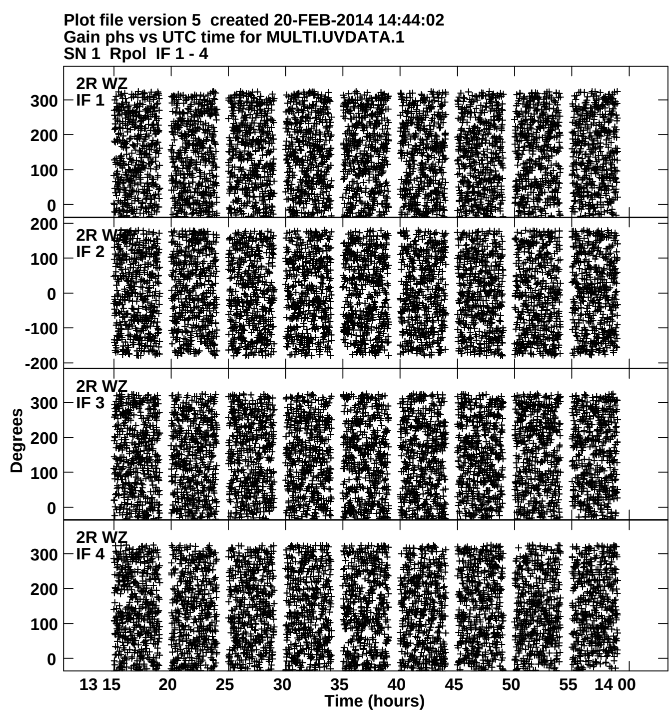

Fig. 2 Solutions from fringe fitting, phases of antenna 2 with respect to antenna 1.

3 Future Plans

The PMD Analysis Center plans to tackle the following topics during 2015: co-location on Earth and in Space for improved reference frames, investigation into dedicated algorithms for improvement of tropospheric parameter estimation and comparisons among atmospheric parameter estimates that come from the space geodetic techniques of VLBI and GNSS and that are particularly addressed to a not very broad region. Then in collaboration with IVS KTU AC an inter-technique comparison between VLBI and DORIS for a combination of TRF common parameters is being set up.

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