3.6.2 Combination Research Centres

3.6.2.1 Agenzia Spaziale Italiana (ASI) - Centro di Geodesia Spaziale (CGS)

Introduction

The ASI Space Geodesy Center (CGS), located at Matera, is a Fundamental Geodetic Station, hosting three permanent Space Geodetic systems (SLR since 1983, VLBI since 1990, GPS since 1995) providing raw observation data, acquired, screened and archived continuously and then forwarded to the technique-dedicated organisations (ILRS, IVS, IGS). Moreover, a parallel, wide activity of data analysis has been developed in time, leading to the issue of several geodetic products, on a regular basis those submitted to the international geodetic organisations (ILRS, IVS, IGS, IERS), on request those solicited by scientific groups to perform joint research activities. The multi-technique feature of the Matera station has made the geodetic technique combination methods and applications a top priority objective of the data analysis activities performed at CGS, developed especially in the most recent years.

Combination research activity

In 2003, a predominant part of the combination research activity performed at CGS has been dedicated to the evaluation of the "loose" approach applied to the global solutions combination and to the development of related SW procedures.

Differently from the "fiducial" approach, based on the combination of solutions in the same reference frame, the "loose" approach foresees a combination of loose solutions without estimating and removing a relative rotation between their reference frames; constrained solutions can be preprocessed to remove a-priori constraints and then loosened by applying a *loosening transformation* [1]. The combination is performed along the lines of the iterative weighted least square technique; each solution is combined using its full covariance matrix rescaled by a factor, computed at each iteration, fulfilling the conditions that the normalized χ^2 of the combination be close to unity and each solution contribution to the total χ^2 be equally balanced.

The CGS SW procedures, based on the loose combination algorithms, have been implemented in the completely general case, to handle site coordinates, site velocities, EOP, EOP rates and including ITRF2000 local ties to connect site domes of different techniques.

To evaluate the method and the SW procedure, the "loose" combination approach has been applied, as a test case, to a subset (6 weeks) of multi-technique (DORIS, VLBI, SLR, GPS), multi-centre (INA, GSFC, ASI, IGN, DGFI, CODE) weekly solutions submitted to the CRC SINEX Combination Campaign, as presented in [2]; besides the operative advantage that the 'loose' approach is simpler than the fiducial approach, quality remarkable results have been

obtained (e.g. coordinate residuals (w.r.t. ITRF2000) of the combined weekly solutions about 4 mm WRMS; EOP X, Y residuals (w.r.t. C04) below 0.3 mas WRMS; UT1 residuals about 0.1 ms WRMS).

Combination products

In 2003, two main combination products have been defined and realized:

1. the intra-technique (SLR) weekly solution, in response to the Call-For-Proposal for the ILRS “Position+EOP” Pilot Project;
2. a Mediterranean, inter-technique velocity solution to lighten the critical tectonics of the area.

The CGS SLR combined solution has been issued since 2003, July, to participate to the ILRS POS+EOP Pilot Project section, aiming to select official ILRS centres to be in charge of producing combined SLR solution to be submitted to IERS.

The CGS solution is produced weekly by a fully automated procedure; the procedure strategy consists of three main steps:

- Pre-processing
- Combination
- Quality check and delivery

The procedure reads sequentially the available SINEX loose solution files participating to the Pilot Project, relevant to the 7-day period to be analysed and verifies their integrity and looseness level; the screened solutions are iteratively loose combined as sketched in the previous paragraph; data editing is performed: i.e. ‘weak’ sites (i.e. those with less than 10 normal points in the weekly arc) and/or solution parameters presenting too high uncertainties with respect predefined thresholds are eliminated. When the normalized χ^2 of the solution is almost unitary (i.e. less than 1.5 and more than 0.5), iterations stop and the combined product is transformed in the ITRF2000 frame, delivered to ILRS together with a “quick-look” report and archived at CGS too. Details on the procedure have been presented in [3].

The ASIMED solution is a multi-technique velocity solution for the Mediterranean area, produced at CGS twice a year and issued on <http://geodaf.mt.asi.it>: it is obtained by combining the CGS global solutions (VLBI, SLR), providing the stability and reliability of the global reference frame, with a regional, dense GPS solution. Each single technique solution has very different features: as far as the 2003 realization is concerned, the VLBI solution (1979 – 2001) is a minimal constrained velocity solution; the SLR solution (1984 – 2001) is a constrained velocity solution, while the GPS solution consists in a loose daily position time series continuously updated, starting from 1995.

The optimal creation of a velocity solution, combining position solutions, is another facet of the combination methods; its critical aspects are the correct use of all possible solutions information (e.g. the complete covariance matrix of each network position solution), system upgrades (e.g. GPS receiver replacement or modification), reference standard updates (e.g. ITRF updates, impacting on GPS orbits). The original SW developed at CGS implements algorithms taking into account the investigations performed on these aspects.

References

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