The ILRS solution

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The ILRS contribution to ITRF2005 is a time series of weekly station coordinates and daily Earth Orientation Parameters (X-pole, Y-pole and excess Length-Of-Day (LOD)) estimated over 7-day arcs aligned with the GPS weeks (Sunday to Saturday), starting from January 1993. Each weekly solution is obtained through the combination of weekly solutions submitted by the official ILRS Analysis Centers (ASI, DGFI, GFZ, JCET and NSGF). Both the individual and combined solutions have followed strict standards agreed upon within the ILRS Analysis Working Group to provide products of the highest possible quality.

Individual solutions

SLR observations on LAGEOS-1, LAGEOS-2, Etalon-1 and Etalon-2 are analysed to generate the individual EOP and positions solutions; the measurements are retrieved from the CDDIS and/or EDC archiving facilities. The observations are processed in intervals of 7 days to generate a loosely-constrained solution for station coordinates and EOPs. The EOPs include Xp,Yp and LOD, all computed as a daily average; daily UT parameters are also solved for, but they are of course considered as weakly-determined parameters by any satellite technique and are not included in the analysis product that is submitted to the combination centers. The station positions, with the midpoint of each 7-day interval as reference epoch, refer to the official station markers. Analysis contributors are free to follow their own computation model and/or analysis strategy, but a number of constraints must be followed for consistency:

1. The computation models follow the IERS 2003 Conventions as closely as possible.
2. The stations are included (positions estimated) in the weekly analysis if the number of observed LAGEOS-1 plus LAGEOS-2 ranges is greater than 10. Data weighting is applied according to the analyst's preference. However, the AWG has agreed to downweight “non-core” sites significantly.
3. The tropospheric correction is applied using the Marini-Murray formula, no modeling of atmospheric pressure loading and no estimation of tropo biases.
4. The center-of-mass correction for the station 7840 is 245 mm (instead of the standard 251)
5. Range biases are not modelled or estimated except for:
    - 1864 weekly range biases 1993.0 - 2006.0
    - 1868 weekly range biases 1993.0 - 2006.0
    - 1884 weekly range biases 1993.0 - 2006.0
    - 7210 weekly range biases 1993.0 - 2004.0
    - 7237 weekly range biases 1993.0 - 2006.0
    - 7810 weekly range bias for infrared data only
    - 7811 weekly range bias 1993.0 - 1994.0
    - 7835 weekly range bias 1993.0 - 1998.0
    - 7839 weekly range bias 1993.0 - end of September 1996
    - 8834 weekly range bias 1993.0 - 1997.0
6. The solutions are loosely constrained with an a priori standard deviation on station coordinates of 1 meter and the equivalent of at least 1 m for EOPs.

Further details on the individual AC analysis strategy can be found on the ILRS web page
http://ilrs.gsfc.nasa.gov/science_analysis/analysis_centers.html

Intra-technique combination

The combined solution was produced by the primary Combination Center, ASI/CGS, and named ILRSA. The main lines of the combination methodology rely on the direct combination of loose constrained solutions; this straightforward method (e.g. "*Methodology for global geodetic time series estimation: A new tool for geodynamics*", P. Davies and G. Blewitt, JGR, vol. 105, no. B5, pages 11083-11100, May 10, 2000) allows handling input solutions easily, with no inversion problems for the solution variance-covariance matrix and no need to know a priori values for the estimates. The reference frame is defined stochastically and is unknown; no relative rotation between the reference frames is estimated and removed. The ASI-CGS SW chain, based on these loose combination algorithms, has been implemented in a completely general case, to handle site coordinates, EOP, EOP rates.

The combination is performed along the lines of the iterative Weighted Least Square technique, in which each contributing solution (and related variance-covariance matrix) plays the role of an 'observation' whose residuals with respect to the combined solution must be minimized; each solution is stacked using its full covariance matrix rescaled by a factor. A scaling of the covariance matrix of the i-th solution is required because the relative weight of the contributing solutions may be incorrectly balanced. Imposing χ^2=1 for the combination residuals and requiring that each contribution to the total χ^2 is equally balanced, the relative scaling factors (σ_i) is estimated iteratively together with the combined solution. Being R_i the solution residuals (with respect to the combined product) and Σ_i the solution covariance matrix, the imposed conditions are:

$$R_1^T(\sigma_1\Sigma_1)^{-1}R_1 = \cdots = R_i^T(\sigma_i\Sigma_i)^{-1}R_i \quad \text{and} \quad \chi^2 = R_1^T\Sigma_1^{-1}R_1 + \cdots + R_i^T\Sigma_i^{-1}R_i = 1$$

The first guess for the combination is obtained with σ_i=1 for each solution. Tab.1 shows the mean value and its standard deviation, over the period 1993-2006, of the scale factors for each contributing agency.

	ASI	DGFI	GFZ	JCET	NSGF
Mean	4.7	18.0	10.8	7.9	9.2
Std deviation	3.5	72.4	33.4	7.8	4.0

Tab. 1 - Mean scaling factors

In ILRSA a rigorous editing has been introduced: any estimated parameter in the incoming solutions being not site coordinates nor EOP (e.g. range bias, ...) has been rigorously pre-eliminated (cfr "Combination of solutions for geodetic and geodynamic applications....", E. Brockmann, PhD thesis, AIUB).

The same technique has been used to eliminate:

1. too weak sites (<10 NP) erroneously present in the contributing solutions
2. too weak site estimations in the contributing solutions, with uncertainties greater than 0.8m, in at least one component, after transformation to ITRF2000
3. too bad estimates in the contributing solutions, with discrepancy greater than 0.3m w.r.t. ITRF2000 in at least one coordinate for the set of Core Sites, 0.5m for the other sites (Arequipa excluded)
4. outliers with respect to combined solution following a 5σ criterion.

The list of core sites has been officially defined, within the Analysis Working Group, considering the quality and stability of the network sites.

The mean values of the 3-dimensional wrms of the site coordinate residuals w.r.t. the combined solution, obtained considering all the station of the network and the entire time span 1993-2006, are shown in Tab. 2.

	ASI	DGFI	GFZ	JCET	NSGF
3D wrms (mm)	9.4	20.7	11.4	9.7	16.9

Tab. 2 – 3D wrms w.r.t. ILRSA

The official ILRSA solution is routinely compared with the backup combined solution ILRSB that is produced by DGFI (the official ILRS backup combination center) following a completely different approach. The results show a good agreement between the two solutions. The two tables below briefly show this agreement in terms of:

1) mean of the 3D wrms of the site coordinates residuals w.r.t. ITRF2000 (see also Fig. 1)
2) mean differences of the translation and scale parameters w.r.t. ITRF2000 computed using the two time series ILRSA and ILRSB.

	ILRSA(mm)	ILRSB(mm)
All sites (mean)	21.5	26.0
Core sites (mean)	8.0	10.1

Tab. 3 – 3D wrms of the site coordinates residuals w.r.t. ITRF2000

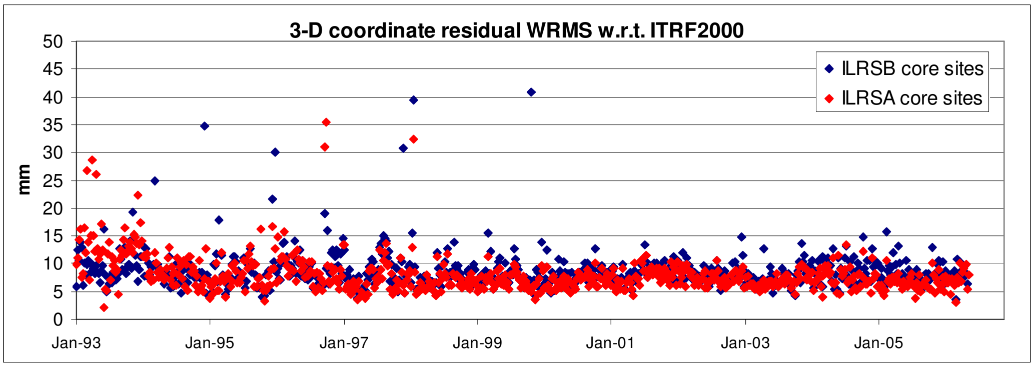

Fig. 1 – 3D wrms of the core site coordinates residuals w.r.t. ITRF2000

	TX(mm)	TY(mm)	TZ(mm)	SCALE(mm)
Weighted Mean	1.14±0.18	-0.24±0.18	-0.10±0.41	0.05±0.26
WRMS	3.14	2.27	4.03	3.13

Tab. 4 – Translation and scale (w.r.t. ITRF2000) differences between ILRSA and ILRSB

Further information can be found on the ILRS web pages
http://ilrs.gsfc.nasa.gov/science_analysis/analysis_products.html