I.ITRF2008 input data

As for any ITRF solution, the ITRF2008 relies not only on space geodesy solutions (stations positions time series and EOPs), but also on local ties at co-location sites. In the following two sub-sections we describe the two sets of data used in the ITRF2008 construction.

I.1.   Space geodesy solutions

We recall that the ITRF input time series solutions are provided on a weekly basis by the International Association of Geodesy (IAG) International Services of satellite techniques: International GNSS Service (IGS), International Laser Ranging Service (ILRS), and International DORIS Service (IDS) and on a daily (VLBI session-wise) basis by the International VLBI Service (IVS). Each per-technique time series is already a combination of the individual Analysis Center (AC) solutions of that technique. A typical solution includes notably the positions of a network of stations, EOPs as well as the associated variance-covariance matrix. Table 1 summarizes the submitted solutions by the IAG services, specifying the time span, solution type and the constraints applied by the TCs as well as the estimated Earth Orientation Parameters (EOPs). The submitted VLBI solution involves more than 4000 session-wise SINEX[1] files spanning the entire VLBI observation history. The SLR solution covers also its full observation history, and comprises fortnightly SINEX files, with polar motion and Length of Day (LOD) estimated every three days between 1983.0 and 1993.0 and weekly SINEX files with daily polar motion and LOD estimates afterwards. The GPS submitted solution represents a large part of the first reprocessed solution by the IGS and covers the time period 1997.0 - 2009.5. Note that a very small portion of GLONASS observations were used by some IGS ACs that contributed to the reprocessing effort. For the first time the DORIS contribution is a combined time series involving seven ACs and covers its full observation history, using data from all available satellites with onboard DORIS receiver, except Jason-2. More detailed descriptions of the submitted solutions are available in the appendix of this technical note.

The ITRF2008 network comprises 934 stations located at 580 sites, with 463 sites in the northern hemisphere and 117 in the southern hemisphere. The ITRF2008 combination involves 84 co-location sites where two or more technique instruments were or are currently operating and for which local ties are available. Figure 1 illustrates the full ITRF2008 network where we superimposed the VLBI, SLR and DORIS sites co-located with GPS. In fact all the 84 co-location sites comprise permanent GPS stations, except two sites: Dionysos (Greece) were DORIS and an old mobile SLR were co-located, and Richmond (Virginia, USA) where VLBI, SLR and DORIS systems were co-located.

Table 1. Summary of Submitted Solutions to ITRF2008

TC	Data-Span	Solution Type	Constraints	EOPs
IVS	1980.0 - 2009.0	Normal Equation	None	Polar Motion, rate, UT1-UTC, LOD
ILRS	1983.0 - 2009.0	Variance-Covariance	Loose	Polar Motion, LOD
IGS	1997.0 - 2009.5	Variance-Covariance	Minimum	Polar Motion, rate, LOD
IDS	1993.0 - 2009.0	Variance-Covariance	Minimum	Polar Motion, rate, LOD

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[1]http://www.iers.org/IERS/EN/Organization/AnalysisCoordinator/SinexFormat/sinex_cont.html

I.2. Local ties in co-location sites

The local ties used in the ITRF2008 combination are provided in SINEX format with known measurement epochs, and 63% of them are available with full variance-covariance information. Most of the local ties used in the ITRF2005 combination are used here with some updates, e.g. Tahiti (GPS, SLR, DORIS), Tsukuba (GPS, VLBI), Herstmonceux (GPS, SLR), Medicina and Noto (GPS, VLBI), Greenbelt (GPS, VLBI, SLR, DORIS), Maui/ Haleakala (GPS, SLR), San Fernando (GPS, SLR), Onsala (GPS, VLBI). Most of the local tie SINEX files were provided by the national agencies operating co-location sites, and all the DORIS co-location sites were re-adjusted by the IGN survey department in order to generate full SINEX files, using the most recent surveys operated at these sites. All the local tie SINEX files used in the ITRF2008 combination are available at

`http://itrf.ign.fr/local_surveys.php`.

The local ties (mainly old ones) which are not available in SINEX format were converted into a complete set of positions for each site, provided in SINEX format. This has been achieved by solving for the following system of observation equations (I.1):

$$\begin{pmatrix} \Delta x_s^{i,j} \\ \Delta y_s^{i,j} \\ \Delta z_s^{i,j} \end{pmatrix} = \begin{pmatrix} x^j - x^i \\ y^j - y^i \\ z^j - z^i \end{pmatrix} \qquad (I.1)$$

Where $(\Delta x_s^{i,j}, \Delta y_s^{i,j}, \Delta z_s^{i,j})$ are the geocentric components of the tie vector linking two points i and j, of a given data set s. The standard deviations (SD) $(\sigma\Delta x_s^{i,j}, \sigma\Delta y_s^{i,j}, \sigma\Delta z_s^{i,j})$ for each local tie vector are used to compute a diagonal variance matrix. If these SD are not available, they are computed by :

$$\sigma_{computed} = \sqrt{\sigma_1^2 + \sigma_2^2} \qquad (I.2)$$

where,

$$\sigma_1 = 3\,\text{mm} \qquad \text{and} \qquad \sigma_2 = 10^{-6} \times \sqrt{(\Delta x_s^{i,j})^2 + (\Delta y_s^{i,j})^2 + (\Delta z_s^{i,j})^2}$$

The equation system (I.1) needs of course initial coordinates for one point per tie vector set s, which are taken from existing ITRF solutions with 1 meter as standard deviation.

Counting the number of co-locations between VLBI, SLR and DORIS, taken by pairs, we find 8 VLBI-SLR, 10 VLBI-DORIS and 10 SLR-DORIS. These are very poor numbers of co-locations to allow a reliable combination of these three techniques alone. Therefore, the GPS is playing a major role in the ITRF combination, by linking together the three other techniques. We count in total 137 tie vectors between GPS and the three other techniques: 44 for VLBI, 48 for SLR and 45 for DORIS. 15 additional ties were also used between old and current DORIS beacon reference points in DORIS-only sites.