ITRF2000 Workshop Recommendations

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The ITRF2000 Workshop was held on 2-3 November 2000 at the Ecole Nationale des Sciences Gographiques (ENSG), a part of the Institut Gographique National (IGN), in Champs-sur-Marne, France. The meeting was organized by the Laboratoire de Recherche en Godsie (LAREG), which hosts the ITRF section for the International Earth Rotation Service. More than 35 researchers from most of the major ITRF contributors attended.

Following opening remarks by Michel Kasser, LAREG Director, and by Claude Boucher, head of the ITRF section, the first day of the workshop was devoted to presentations describing the various solutions which have been contributed to ITRF2000. Of the solutions which have removable constraints and are suitable for the global combination, the following numbers are available: 3 from VLBI, 7 from SLR, 1 from LLR, 6 from GPS global solutions, 2 from DORIS, and 1 from a multi-technique combination. In addition, another 6 GPS solutions are usable directly in the global combination for regional densifications. The remaining GPS densification solutions will be linked to the ITRF2000 in a second step.

The second half of the workshop dealt with reports based on a preliminary analysis of the ITRF2000 data sets. These reports described the characteristics and methodology of the preliminary combination, differences among the submitted solutions, differences compared to ITRF97, problem areas, uncertainties in the methods used by the analysts, an examination of the combination residuals, and questions of datum specification.

The final part of the workshop consisted of a discussion of a set of recommendations, based on the information presented earlier. Those recommendations should be available for presentation at the IERS Directing Board meeting in December 2000. They are summarized below:

- Relative weighting of solutions
  In a report by P. Sillard (IGN), the robustness of applying Helmert weighting to rescale the variance matrices of the submitted solutions was shown to be better when based on the the global combination than on combinations of solutions of the same technique only. It was agreed that the relative weightings should be based on the global combination.
- Editing and outlier detection
  An examination of the preliminary solution residuals shows a number of cases where an individual solution for some particular site differs from the combination by a relatively large amount. It was proposed that an editing criteria be applied to reject observed coordinates with residuals exceeding 4 times their re-scaled errors. All such rejections should be reported so that analysts are aware.

  In addition, any other data problems and significant residuals for local site ties should be reported in the final ITRF2000 report. It is particularly important that information about the local ties is fed back to the station managers.
- Datum: ITRF2000 origin
  It was agreed that the specification of the origin and its linear rate of change be defined by the weighted combination of all the SLR solutions (7).

- Datum: ITRF2000 scale

  It was agreed that the specification of the scale and its linear rate of change be defined by the weighted combination of the all the SLR and VLBI solutions (10).

  There was extended discussion of general relativistic time scales and the scale differences that result using either TDT/TT (terrestrial time) or TCG (geocentric time). G. Petit (BIPM) described the basis for the current IAU/IUGG recommendation to use TCG. However, for the ITRF, the time scale choice is purely a matter of convenience with the only observable consequence being a scale difference of 0.7 ppb. Errors due to adopting the TDT/TT framework enter at the 10^-17 level, about 7 orders of magnitude below the current geodetic capability but only 2 orders below current frequency standards. The TCG frame will be required in the near future by those working on frequency standards under development.

  Nonetheless, despite considerable and enduring confusion on this point, it does not appear that any space geodetic analysis group which contributes to ITRF uses TCG, nor are there any known users who do. Thus, the change made in ITRF94 (and the subsequent related realizations ITRF96 and ITRF97) to shift the global scale by applying an a posteriori rescaling of [1 + (0.6969... ppb)] has resulted in uniform inconsistency with the entire user community, including the IGS and its orbits. Since the effect is small (4.5 mm at the Earth's surface; 18 mm at GPS satellite altitude), this inconsistency has been nearly negligible. However, with ITRF2000 the time scale effect is significant at the level of a few formal sigmas for the global combination and should therefore be considered carefully.

  Based on this discussion, the majority view of the attendees was that ITRF2000 should revert to the conventions of ITRF realizations before ITRF94, consistent with TDT/TT time. All coordinate results should be distributed in this framework and clearly described as such. To satisfy any users needing an ITRF consistent with TCG time, as recommended by the IAU/IUGG, two alternatives were proposed: 1) provide the formulation needed to re-scale the ITRF2000 frame by [1 + (0.6969... ppb)]; or 2) provide a secondary set of coordinates with the re-scaling already applied but only if these are kept in a separate location with very carefully controlled user access.

  Note that a consequence of this change, together with the natural evolution of the contributed data, is that the shift in scale from ITRF97 to ITRF2000 will be about -2 ppb at epoch 2000.

- Datum: ITRF2000 orientation

  In keeping with previous ITRF realizations, it was agreed that the ITRF2000 will be aligned to match ITRF97 in orientation at the reference epoch 1997.0. In performing this alignment only those 64 sites which meet certain quality specifications as described by Z. Altamimi (IGN) will be used. This minimizes potential problems due to spurious site motions and other errors. The criteria for the selected sites (about 60 out of 385 total sites in ITRF2000) are:
  - continuously observed for at least 3 years
  - located away from plate boundaries and deformation zones
  - velocity uncertainty (in the combination) better than 3 mm/y
  - velocity residuals less than 3 mm/y for at least 3 different solutions.

- Datum: ITRF2000 orientation rate

  It could not be completely agreed at the workshop how best to specify the linear rates of change of the orientation angles. Generally, it is necessary to impose a condition to achieve no net rotation of the global frame with respect to the Earth's crust, as recommended by the IUGG. In the past this was done by minimizing differences with respect to the geological plate model NNR-NUVEL1A. However, deficiencies in this model have been noted in recent years. Other models are being developed which are based on empirical geodetic observations (e.g., APKIM by H. Drewes, DGFI), improved geological models, or combinations of data types.

It was agreed that members of the IERS Working Group on the ITRF Datum, particularly the sub-group on the rotational datum, would work during November 2000 to resolve this question and to develop a consensus on the best method to apply to ITRF2000, recognizing the need to finalize it by the beginning of 2001. The final recommendations should be available for presentation at the IERS Directing Board meeting in December 2000.

Regardless of which model is adopted as the rotation reference for the no-net-rotation condition, this minimal constraint should also be applied using only a suitable subset of sites selected for high quality. The sub-group will also evaluate whether the preliminary set of sites and selection criteria are optimal.

- Densification
  Some additional regional solutions are being sought or considered to inclusion in the final ITRF2000 realization. This is only feasible where data analysis have been performed but exporting of suitable SINEX files has not been done for particular reasons.
- User interface
  It is widely agreed that improved user education and interfaces with the IERS are needed. A complete descriptive report will be prepared for ITRF2000, as has been done with previous realizations. All input solutions and output product files will be made available via the new IERS data base system currently under development.
- IERS Conventions
  Improved interactions of the technique services and their analysis centers are needed with the IERS Conventions in order to ensure the highest level of consistency and understanding. Inputs should be sent to C. Boucher (IGN) for integration.