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Towards IVS Analysis Conventions

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Abstract

One of the main goals of the IVS is to provide a supreme quality of the IVS products, such as EOP, TRF, CRF, etc. To achieve this, a comparison and combination of the products contributed by the IVS Analysis Centers is needed to understand and mitigate systematic errors of individual solutions and derive the final IVS combined product of the best quality. However, some inconsistencies in models and processing strategy used in various Analysis Centers still exist, which sometimes makes comparison and combination of their results more difficult than desirable. Moreover, this can lead to errors in the combined products, difficulties in geophysical interpretations, and inconsistency of the IVS products with other IERS techniques. So, IVS Analysis Conventions are definitely needed. In this paper some steps to establish such Conventions are proposed. They include standardization of some models used in analysis and other topics.

1. Introduction

One of the main goals of the IVS is to provide a supreme quality of the IVS products, such as EOP, TRF, CRF, etc. To achieve this, a comparison and combination of the products contributed by the IVS Analysis Centers (ACs) is needed to understand and mitigate systematic errors of individual solutions and derive the final IVS combined product of the best quality. However, some inconsistencies in models and processing strategy used at the IVS ACs still exist, which sometimes makes comparison and combination of their results more difficult then desirable. Moreover, this can lead to systematic errors in the combined IVS products, and inconsistency of the IVS products with other IERS techniques. So, IVS Analysis Conventions are definitely needed.

In this paper some steps to establish such Conventions are proposed. They include standardization of some models used in analysis and other topics. Evidently, the proposals made in this paper can be separated into three groups w.r.t. feasibility of realization:

1. No substantial change in analysis procedures or software update is needed.
2. No substantial change in analysis procedures is needed, but software update is required.
3. Change in analysis procedures is required. Evidently, this requires more detailed consideration in the IVS analysis community.

This paper is intended to continue a discussion on the standardization of analysis procedure at the IVS ACs started at the 4th IVS Analysis Workshop in April 2003, and understand where such a standardization is meaningful.

2. Database Version Numbering

The problem is that the correlator and analysis teams creating the databases often save the database version number after re-processing. There are many such examples of re-fringing, re-editing, adding new data or info, etc. when database name is not changed. This resulted in difficulties in automated update of institutional archives, and possible inconsistencies in results obtained in different AC using databases with different content.

Proposal: Change DB version number in case of ANY update.

Another issue related to the database numbering is a "final" version number. Mostly it is 4, but sometimes it is 3. As a consequence, one is not always sure which database is ready for scientific analysis.

Proposal: Establish a standard of the content of a database versions 1-4 (if it does not exist; I cannot find it, however).

3. EOP Format

There are three problems with the current EOP submissions.

1. Different ACs report EOP at different epochs—some use UTC as required by the IVS and IERS combination centers, some use TDB, which is inconsistency in epochs at the level of $TDB - UTC \approx 0.0007^d$, which is much greater than accuracy of reported EOP epochs ($0.00001 - -0.000001^d$).

Proposal: Use UTC for the EOP epochs in accordance with the IERS and IVS requirements.

2. At least two ACs (GSF and IAA) compute two kinds of EOP series obtained from the analysis of the 24h VLBI sessions. The first one contains sessions for which all five EOP are estimated, the second one contains only nutation estimates, mainly for sessions with poor geometry. Mixing these data in single file seems to be not convenient, and may be confusing.

Proposal: Include in the EOPS files only sessions for which all the EOP are estimated. Implement the third IVS EOP file type, in addition to EOPI and EOPS, which may be named as EOPN to with only meaningful nutation estimates.

3. Sometimes, during the analysis of the VLBI results, it is essential to know which stations participating in the session (and listed in the master file) were actually used for computation. There would be no problem in case of reporting the EOP results in the SINEX format, but with existing IERS/IVS EOP format, it is impossible to get such information if a participating station was excluded from the analysis.

Proposal: Include a station list in the EOP line, preferably in the last field for convenience of a processing.

We, at the IAA AC, include the station list in the master file format at the end of a EOP line (see *e.g.* the files iaao0307.eopi and iaao0307.eops in the IVS archive), and found this very convenient for some kind of analysis. Besides, we put the clock reference station in the beginning of the list, which also seems to be useful.

4. Station Positions and Eccentricities

It seems to be important to achieve agreement about handling station eccentricities and irregular changes in station positions in a uniform way to avoid possible confusions. It seems reasonable to use an eccentricity only for the stations whose observations are related to the geodetic mark or other point different of axes intersection. One well known example is TSUKUB32. In such a case, introducing a jump in the station position seems to be preferable to avoid an inconsistency with the ITRF.

Proposal: Use eccentricity for "M" DOMES only, for other events/jumps use change in coordinates and, when necessary, velocity (*e.g.* for GILCREEK after the earthquake).

5. Models

It seems evident that all AC should submit their results to the combination centers using the same geophysical models. If this is not the case, inevitably systematic differences between the solutions obtained in different ACs will (and do) exist which is difficult to account for during comparison and combination. Evidently, models used for VLBI data analysis should be consistent with other space geodesy techniques to avoid systematic differences between them, which may (and do) give rise to errors of the final IVS and IERS products.

Recently, Goddard and Vienna teams accomplished a hard and important work on computation and distribution of data related to modelling atmospheric loading and mapping function. The provided files are convenient enough for easy implementing of these models in an analysis software, and all ACs should be encouraged to do that as soon as possible (although, strictly speaking, after an approval of the IVS Analysis Coordinator; in particular one of two computed mapping functions should be recommended).

Moreover, it seems reasonable to have a single procedure and data files (to eliminate the computational efforts, simplify file downloading and implementation in analysis software) for computation and distribution of all atmosphere related models (loading, mapping function, gradients, ..., something else?), if feasible.

However, some models still need to be standardized. Ocean loading, hydrology, antenna deformations, rotational deformations of the Earth, etc., influence mainly on the estimates of station coordinates. Using different models of the daily and subdaily EOP variations leads to an inconsistency in the nutation series.

Let us consider some examples of inconsistencies in used models and possible consequences for scientific analysis. Also let us keep in mind that modern geodetic analysis does try to achieve an mm level of accuracy.

1. Using numerical atmospheric loading and mapping function models using direct processing of numerical weather data proves its benefit. As a result, we may expect that more and more centers will compute those models for space geodesy data processing. However, it would be useful for proper interpretation of results to compare the results computed at the various centers. For instance, a brief comparison of the three atmospheric loading models computed at the GSFC, OSO and JPL shows disagreement in both height and horizontal components at a level of several millimeters for individual epochs and up to 1 mm in the amplitude of seasonal components. Even larger effects can be seen when using different values of the reference pressure and/or topography models

2. A preliminary results of the just started IVS Pilot Project on baseline length show the systematic differences between individual solutions at a level of several millimeters [1]. It can be easily seen that that may result from inconsistencies (which really exist) in ACs' processing strategy. Most evident of those are the following.

- Different handling (or ignoring) of the antenna thermal deformation, including using different reference temperatures, may lead to biases and seasonal terms at a level of 2-3 mm [2].

- Using different mapping functions leads to scale differences of about several tenths ppb, *i.e.* about 0.2–0.4 mm/Mm in the baseline length [3].
- Using different relativistic models (*e.g.* IERS 1992 and 2003) leads to the scale difference in the baseline length $L_G \approx$ 0.7 ppb, *i.e.* 0.7 mm/Mm.
- Using different models for polar tide, more precisely different model for mean pole (zero values vs. IERS recommended actual mean pole coordinates) leads to the difference in the baseline length more than 15 mm for recent epochs and baselines located in different hemispheres.

Evidently, proper comparison, combination and interpretation of the baseline length series at a millimeter level of accuracy is impossible without a correction of individual series for the differences in the individual ACs' models.

Proposal: All models used for the VLBI analysis should be considered, and ways for their standardization should be discussed.

Evidently, this topic is difficult to agree. Moreover, improvement of the models is an natural task for all ACs. Nevertheless, it seems to be necessary to find a way to combine ACs' interests with the IVS ones. A possible strategy is to use the same conventional models for submission of the results to the IVS and IERS, and use extended/improved models for other scientific investigations. Here we consider the TRF and CRF realization as a part of model.

In any case, a special investigation of the impact of differences in the models used in the ACs on the final result seems to be extremely important (many results of such studies are known, but many points yet have to be clarified).

6. Conclusion

Of course, not all topics related to the subject of this paper are considered here. As mentioned above, this is only an attempt to activate a discussion. However, it seems extremely important to solve the problems raised here, in the first place related to the unification of models and/or careful investigation of their impact on the IVS and IERS products. Results of such investigations can be then used to mitigate the systematic errors in combined products, especially taking into account that nowadays they prevail in the differences between the solutions obtained in different ACs.

Probably the problems of developing IVS Analysis Conventions should be considered in the framework of the IVS WG 3 on VLBI2010, and/or a special IVS Pilot Project should be initiated.

References

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