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First Results of the IVS Pilot Project "Time Series of Baseline Lengths"

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Abstract

Although earth orientation parameters have played a dominant role in recent years' VLBI activities, baseline length results have kept their importance from the very early days of geodetic VLBI. For various purposes the IVS has established a Pilot Project "Time series of baseline lengths" which is preparing procedures for making baseline length results fully qualified IVS products. In this paper, we describe the current stage of the development, first level analysis procedures and initial results.

1. Introduction and Motivation

Baseline lengths have been among the first types of VLBI results in the history of geodetic VLBI, e.g. [3] . Although earth orientation parameters (EOP) have been in the focus of analysts in recent years, baseline lengths have not lost their importance. In order to exploit the properties of baseline length results for the benefit of users but also for diagnosis purposes an IVS Pilot Project "Time series of baseline lenghts" has been established.

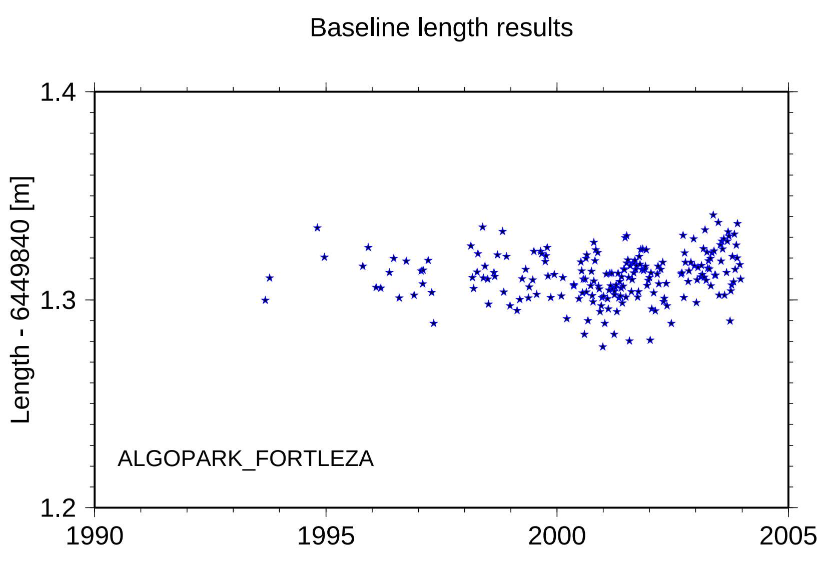

Figure 1. Baseline length results of a solution of a single IVS Analysis Center.

For the users baseline length time series as well as baseline lengths at epoch plus their time derivatives will have various applications. In the context of a global polyhedron, baseline length results are a much better indicator of scale and possibly scale evolution effects than station coordinates because the radial component is, off course, dependent on the station height.

Linking the VLBI results with and comparing them to those of other space geodetic techniques like GPS, DORIS and SLR are other applications where baseline length results can be used. Here also the pre-combination comparison of individual input series will be a main application.

Conceptually, VLBI baseline length results are invariant to translational and rotational changes in the reference frames. For this reason they are the ideal quantity for a detailed intercomparison of results generated by different analysis software packages. In addition, different analysis centers use different analysis strategies and models, e.g. for geophysical effects and most importantly for atmospheric refraction. Differences in the baseline length results can, therefore, be used for detailed analyses of possible deficiencies in models but also in analysis strategies. This is of particular importance to analysts who like to check the quality of their results and just submit time series for the purpose of comparison.

Finally, baseline length results will be well suited for an instant quality and plausibility check including warning mechanisms at primary level data analysis steps. For all these reasons, combination and comparison of baseline length results forms the ideal basis, independent of any reference frame issues.

2. Organisational Aspects

In preparation for making time series of baseline lengths an official IVS product, an IVS Pilot Project had to be set up requiring a few formal steps.

April 2003	Proposal to IVS Directing Board
July 2003	Acceptance by IVS Directing Board
August 2003	Call for Proposals to IVS Analysis Centers
October 15, 2003	Deadline for initial proposals

In the first round the following IVS Analysis Centers proposed to submit their baseline length results on a routine basis by 6 weeks after correlation of the respective session:

Agencia Spatiale Italiana, Matera (ASI)
Bundesamt für Kartographie und Geodäsie, Leipzig (BKG)
Deutsches Geodätisches Forschungsinstitut, München (DGFI)
Institute for Applied Astronomy, St. Petersburg (IAA)
Institut für Geodäsie und Geophysik, Wien (IGG)
NASA Goddard Space Flight Center, Greenbelt MD (GSFC)

For the submission of the results it was decided that the IVS Analysis Centers estimate station coordinates on a session by session basis from which baseline lengths with full covariance matrix can be inferred. Since the SINEX data format Version 2.0 (see http://alpha.fesg.tu-muenchen.de/iers) is now fully established for exchanges of space geodetic results it can be used without any further modifications.

The SINEX files which are submitted by the Analysis Centers only for the Pilot Project are being kept at separate directories of the IVS Data Centers. Currently, IVS Analysis Centers using the Calc/Solve analysis software package routinely generate SINEX files for the submission of their EOP results. In theses SINEX files station coordinate results are already embedded and no separate submission for the Pilot Project is required. For this reason also the SINEX files of the US Naval Observatory at Washington D.C. (USNO) can be used for the Pilot Project straight away.

In order to support the Pilot Project, an IVS Pilot Project Group was set up in the framework of the charter of the project. This group will discuss future steps and will guide the project from the pilot to the operational phase. Each Analysis Center has one delegate in the Pilot Project Group but any other person interested in the topic is welcome to join. The director of the IVS Coordinating Center is an ex-officio member of the Project Group.

3. Analysis Procedures

At present, initial baseline lengths and formal errors are computed from the station coordinates in the SINEX files of a single Analysis Center and are stored in a separate file for each baseline in a separate directory for each Analysis Center. Stations are identified by their DOMES number [1] and are subsequently converted into IVS names using the IVS conversion table (see http://gemini.gsfc.nasa.gov/solve_save/antenna.dat). For the coordinates themselves an initial outlier rejection filter is introduced identifying estimated station positions which differ by more than 0.5 m from the ITRF2000 position of date. Through this mechanism blunders in the generation of the files and very obvious outliers are eliminated at a very early stage.

Linear regressions by baseline and Analysis Center then offer a first impression of the quality of the submissions, providing an extra level of possible low pass filtering through weighted RMS (WRMS) criteria and outlier identification. In this step possible episodic motions of stations have to be taken into account in order to permit a correct piece-wise linear modeling of the baseline behaviour. Differences in baseline length of epoch (currently Jan. 1, 2000), baseline rate as well as WRMS give already a very good insight in the general agreement of the contributing Analysis Centers.

The combination of baseline lengths itself is currently being carried out on the basis of weighted averaging using the formal errors of the input series. Due to the fact that not all Analysis Centers have processed all sessions, combined baseline length results may have been computed using between one and all Analysis Centers. The implications of this deficit still have to be investigated.

In the current realization of the software, linear regressions of the combined time series and their statistical parameters are computed and can be compared with the ones of the individual input series. The residuals of the combined series as well as the residuals of the input series relative to the linear regression will give good insight into the advantages and disadvantages of the combination and various ways of combination. One of the most interesting parameters will be the scale between different analysis packages and Analysis Centers with its rate and possibly further signatures.

4. First Results

Owing to timing constraints, detailed investigations in the results and in the residuals have not been accomplished yet. However, the results of just a single baseline should be displayed as a first example here. Fig. 2 depicts the residuals of the input time series of three IVS Analysis Centers (BKG, GSFC, IAA) with respect to a combined time series. It can easily be seen that there are significant systematic offsets between the three series. In addition, the noise level gives some impression of the input series. Since the weighting scheme is not yet developed properly this initial result has to be considered as very preliminary. Nevertheless, this residual plot is a good indication of the potential of baseline length time series for various types of investigations.

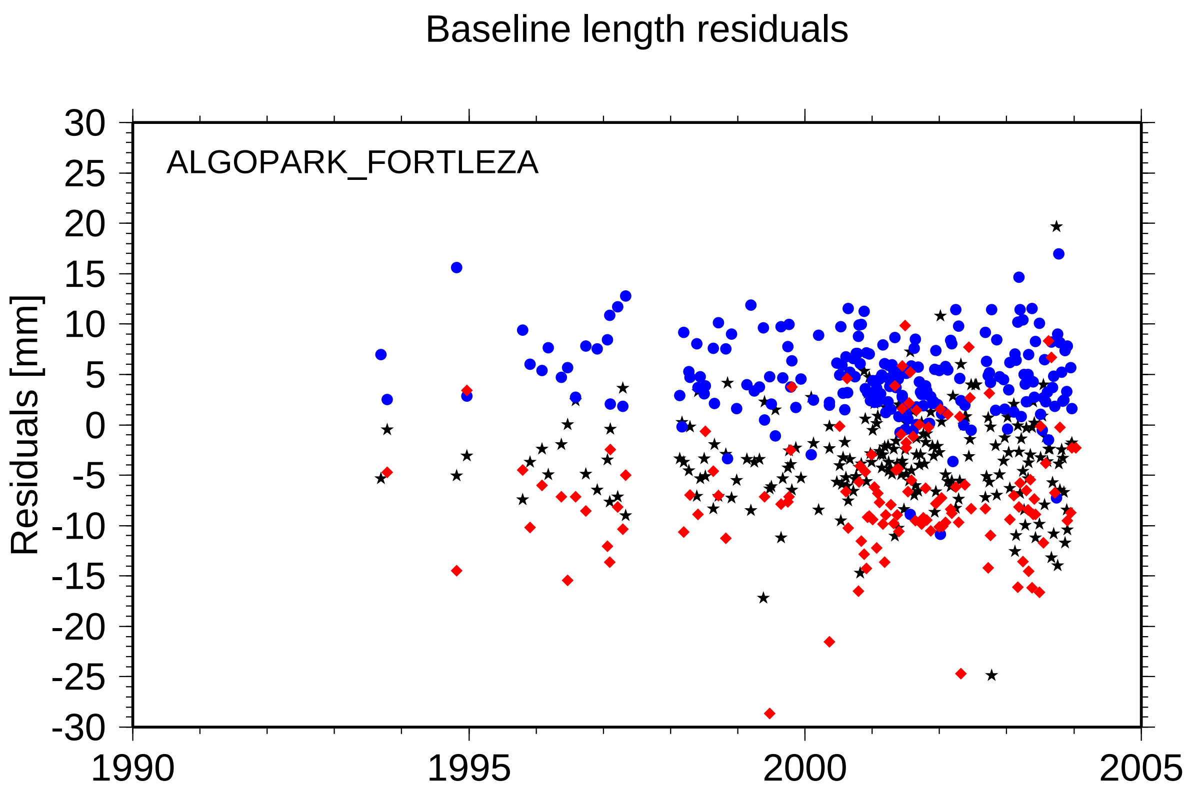

Figure 2. Baseline length residuals after combination. *asterisk* = BKG, *circle* = GSFC, *square* = IAA

5. Outlook

As a next step, correlations between Analysis Centers having processed the same VLBI observing session will be introduced shortly. Initial values for the correlation coefficients between Analysis Centers will be taken from [2] before correlation coefficients will be computed from the baseline length results themselves.

The combination process and its post-fit residuals will help to establish a correct relationship between the formal errors of the input series and will lead to scaling factors between them. After re-scaling the formal errors of the input series the combination will be done iteratively to end up with more realistic weights.

Using local tie information between the VLBI telescopes and other space techniques like GPS, SLR and DORIS will permit a detailed study of scaling differences and possible correlations between the time series at various time scales.

As soon as all basic computation mechanisms have been established a web page will be set up which will permit a button-based selection of baseline results together with ftp retrieval of raw data and residuals.

References

[1] Boucher C., Z. Altamimi, P. Sillard (1999): The 1997 International Terrestrial Reference Frame (ITRF97); IERS Technical Note 27, Observatoire de Paris

[2] Steinforth C., A. Nothnagel (2004); Considering a priori Correlations in the IVS combined EOP Series; Proceedings of the 3rd IVS General Meeting, Ottawa, Canada, Feb 9 - 11, 2004; this volume

[3] Hinteregger, H.F., I.I. Shapiro, D.S. Robertson, C.A. Knight, R.A. Ergas, A.R. Whitney, A.E.E. Rogers, J.M. Moran, T.A. Clark, B.F. Burke (1972): Precision Geodesy via Radio Interferometry; Science, Vol. 178, 396 - 398