IERS Workshop on Combination, GFZ Potsdam, 10 – 11 October 2005

Session 3

EOPs: Multi-year solutions, current analysis, weekly solutions, rapid products, and predictions

D. Gambis (1), W. Wooden (2) and J. Vondrák (3)

(1) *Observatoire de Paris, Paris, France*
(2) *U.S.Naval Observatory, Washington, USA*
(3) *Astronomical Institute, Prague, Czech Republic.*

The session addresses the different Earth Orientation Parameter (EOP) products that are currently computed and made available for various applications. These products include long-term and current analysis series as well as rapid series and predictions. Since the 1970s, these time series have been derived from the combination of individual astro-geodetic techniques, Very Long Baseline Interferometry (VLBI), Lunar Laser Ranging (LLR), Global Positioning System (GPS), Satellite Laser Ranging (SLR), and Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS). Previously, the time series were based on astrometric observations for many decades.

The ultimate objective of combination is to derive EOP time series taking advantage of the qualities of the various techniques after removing the instabilities and systematic behaviour of each individual technique. The resulting series must have the following characteristics: continuous, given at equidistant intervals without any gaps, homogeneous, stable at the various time scales with negligible systematic errors. Sometimes they are slightly smoothed to remove high-frequency noise.

Statistical analysis

In the process of combination, different critical steps should be considered. Formal errors are the internal values derived by each analysis centre. These errors may not be realistic and can be rescaled by an external procedure. In some combinations these errors are used to calculate weights for each of the input series. Each technique uses slightly different procedures and methods. As a consequence, these EOPs generally are not identical because they are estimated over different data intervals and may not be given at the same epochs. They can be given for specified epochs (e.g., 0:00 h, 12:00h) or for the mean of the considered interval. In order to refer to identical epochs, in particular for comparison, different approaches can be used for interpolation and smoothing, e.g., Vondrak's, Fourier, and spline algorithms. An alternative method uses a Kalman filter to produce a single time series. It requires accurate modelling of the errors for each of the techniques used in the combination but has the advantage of using no interpolation.

Current characteristics of EOP estimates, precision, accuracy

Precision is a measure of the agreement of various individual solutions with respect to combined solutions (e.g., EOP-PC, NEOS(USNO), and JPL). This agreement is 50 □as for polar motion, 4- 10 □s for Universal Time, and 60 □as for nutation offsets. Accuracy is a measure that reflects the real uncertainties of a solution taking into account the inconsistency and systematic errors of the EOP system with respect to the terrestrial and celestial frames. Minimizing these inconsistencies and systematic errors is more critical than improving precision. As expected, the uncertainty in accuracy is much larger than the uncertainty in precision. Currently, the accuracy of the EOPs is at the following levels: for polar motion (150-200 µas), for Universal Time (15-20 µs), and for nutation offsets (60 µas).

Predictions

Many real-time applications such as space navigation, orbit determination, time-keeping, or telescope pointing, require EOP prediction. Different approaches are used, based on whether short-, mid-, or long-term accuracies are needed. In short-term predictions, additional data such as GPS LOD from the International Global Navigation Satellite System Service (IGS), UTGPS from the U. S. Naval Observatory, and operational atmospheric angular momentum (AAM) analysis and forecast data from the National Center for Environmental Prediction (NCEP) are also used.

Checks and comparisons of the EOP combined solutions

Different approaches can be used to assess the quality of the EOP combined solutions: its internal consistency, differences with individual solutions, differences between series derived by the same centre using different routines, differences between independent solutions (EOP-PC, NEOS, and JPL) and possibly the use of external quantities like atmospheric and oceanic excitations. Here again, the interpolation scheme used to refer data to the same epoch can be very critical.

Consistency of IERS EOP series with ITRF and ICRF

Individual EOP series determined from the analyses of the various techniques present mutually systematic errors, generally limited to biases and drifts which can be attributed to the adoption of different references frames and models. The consistency between EOP and reference frames characterizes the « closure » when making the transformation between CRF and TRF via EOP.

The EOP combination processes make use of available EOP results to produce long term EOP series. Due to the separate computation of EOPs and TRF, it is not surprising that inconsistencies arise after several years. Understanding of the causes for the divergence over time between EOPs and the current realization of ITRF is a challenge. Two methods have been utilized: 1) traditional method at IERS EOP-PC using rotation angles between CRF and TRF and 2) direct comparisons of EOP long-term series (e.g., IVS Analysis Pilot Project, 2000; IERS EOP Alignment Campaign, 2002). A more satisfying method is now being used for the IERS Combination Pilot Project that includes a rigorous approach based on the simultaneous determination of EOPs and TRF.