

3.6.2.11 Jet Propulsion Laboratory (JPL)

Introduction

The uncertainty in our knowledge of the Earth's changing orientation in space is a major source of error in tracking and navigating interplanetary spacecraft. Because the Earth's orientation changes rapidly and unpredictably, measurements must be acquired frequently and processed rapidly in order to meet the near-real-time Earth orientation requirements of the interplanetary spacecraft navigation teams. These requirements are currently met at JPL by using the global positioning system (GPS) to provide daily determinations of polar motion and length-of-day within 24 hours of acquisition. Single baseline very long baseline interferometry (VLBI) measurements are taken twice-per-month by the Time and Earth Motion Precision Observations (TEMPO) project in order to provide the benchmark Universal Time (UT) measurements between which the GPS length-of-day measurements are integrated. The Kalman Earth Orientation Filter (KEOF) is then used to combine the GPS polar motion and length-of-day measurements with the TEMPO VLBI variation-of-latitude and UT0 measurements, along with other publicly available Earth orientation measurements including proxy measurements such as atmospheric angular momentum, in order to generate and deliver the required polar motion and UT1 Earth orientation parameters to the spacecraft navigation teams.

Data Products

Reference series of Earth orientation parameters are generated annually at JPL. During 2003, three such reference series were generated: (1) SPACE2002, consisting of values and rates for polar motion and UT1 spanning September 28, 1976 to January 11, 2003 at daily intervals, was generated by combining Earth orientation measurements taken by the space-geodetic techniques of lunar and satellite laser ranging (SLR), VLBI, and GPS; (2) COMB2002, consisting of values and rates for polar motion and UT1 spanning January 20, 1962 to January 11, 2003 at daily intervals, was generated by additionally including the BIH optical astrometric measurements with the space-geodetic measurements used to generate SPACE2002; and (3) POLE2002, consisting of values and rates for just polar motion spanning January 20, 1900 to December 22, 2002 at monthly intervals, was generated by additionally including the ILS optical astrometric measurements with the other optical astrometric and space-geodetic measurements used to generate COMB2002. These reference series can be obtained by anonymous ftp to <ftp://euler.jpl.nasa.gov/keof/combinations/2002>. A report describing the generation of these series [Gross, 2003] is also available at this site.

The near-real-time Earth orientation requirements of the interplanetary spacecraft navigation teams are met by twice-per-week up-

dating the annually generated reference series. The updated Earth orientation series are generated by additionally incorporating measurements that are rapidly available such as the GPS measurements from the JPL Analysis Center of the IGS and the atmospheric angular momentum measurements from NCEP that are used as proxy length-of-day measurements. In addition, short-term predictions of the EOPs are produced in order to provide the navigation teams with an uninterrupted series of Earth orientation parameters. The updated and predicted EOP series can be obtained by anonymous ftp to <ftp://euler.jpl.nasa.gov/keof/predictions>.

Research activities

Research activities during 2003 were largely concerned with using the three-corner-hat method to estimate the uncertainties in polar motion and length-of-day measurements taken by the space-geodetic techniques of SLR, VLBI, and GPS during 1997-2002 [Chin *et al.*, 2004]. In the three-corner-hat method the signal common to each series is eliminated by forming pair-wise differences between the series, thus requiring that the measurements be given at the same epoch. From the variances of the differenced series, the uncertainty of each series can be recovered when reasonable assumptions are made about the correlations between a subset of the series. Of the series studied, it is found that the IGS Final combined series has the smallest polar motion and length-of-day uncertainties. The results for the VLBI series are found to be unreliable due to the predominant amount of interpolation error present in the results that is caused by the need to interpolate the sparse, irregularly sampled VLBI measurements to the epochs of the other series. Better knowledge of the inherent uncertainties of individual space-geodetic series can lead to better combined series when the combinations are generated by techniques, such as the Kalman filter, that use measurement uncertainties as weights.

References

- Chin, T. M., R. S. Gross, and J. O. Dickey, Multi-reference evaluation of uncertainty in Earth orientation parameter measurements, *J. Geodesy*, submitted, 2004.
- Gross, R. S., Combinations of Earth orientation measurements: SPACE2002, COMB2002, and POLE2002, Jet Propulsion Laboratory Publ. 03-11, 28 pp., Pasadena, Calif., 2003.

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