3.6.2.10 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 2004, three such reference series were generated: (1) SPACE2003, consisting of values and rates for polar motion and UT1 spanning September 28, 1976 to January 31, 2004 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) COMB2003, consisting of values and rates for polar motion and UT1 spanning January 20, 1962 to January 31, 2004 at daily intervals, was generated by additionally including the BIH optical astrometric measurements with the space-geodetic measurements used to generate SPACE2003; and (3) POLE2003, consisting of values and rates for just polar motion spanning January 20, 1900 to January 21, 2004 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 COMB2003. These reference series can be obtained by anonymous ftp to <ftp://euler.jpl.nasa.gov/keof/combinations/2003>. A report describing the generation of these series [Gross, 2004] 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 updating 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 2004 were largely concerned with updating the stochastic model used by the Kalman filter that describes the polar motion excitation process. The existing model for the x- and y-components of polar motion excitation includes an isotropic random walk with equal noise forcing both components and having a white noise power spectral density of 246.6 mas^2/day. In order for the filter to work properly, the stochastic model must be appropriate in the region of the excitation spectrum where the signal-to-noise ratio is near unity. Twenty years ago, when the stochastic model was first developed, the signal-to-noise ratio was near unity at periods of about 20 to 40 days. But with accurate GPS measurements of polar motion and polar motion rate now being routinely available at daily intervals, the polar motion excitation signal-to-noise ratio is currently near unity at a period of about 5 days. Increasing the white noise power spectral density by a factor of 3, to 739.2 mas^2/day, was found to give a better match to the observed polar motion excitation spectrum at a period of 5 days. This change to the stochastic model used by the Kalman filter to describe polar motion excitation will result in polar motion and polar motion excitation estimates that are not as smooth as before.

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References

Gross, R. S., Combinations of Earth orientation measurements: SPACE2003, COMB2003, and POLE2003, Jet Propulsion Laboratory Publ. 04-12, 28 pp., Pasadena, Calif., 2004.

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