3.6.2.9 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 2006, three such reference series were generated: (1) SPACE2005, consisting of values and rates for polar motion and UT1 spanning September 28, 1976 to January 7, 2006 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) COMB2005, consisting of values and rates for polar motion and UT1 spanning January 20, 1962 to January 7, 2006 at daily intervals, was generated by additionally including the BIH optical astrometric measurements with the space-geodetic measurements used to generate SPACE2005; and (3) POLE2005, consisting of values and rates for just polar motion spanning January 20, 1900 to December 21, 2005 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 COMB2005. These reference series can be obtained by anonymous ftp to <ftp://euler.jpl.nasa.gov/keof/combinations/2005>. A report describing the generation of these series [Gross, 2006] 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 2006 were largely concerned with assessing the ITRF2005 Earth orientation series by comparing it to other EOP measurements and to global geophysical fluid models. Unlike previous realizations of the terrestrial reference frame, the ITRF2005 realization was constructed by simultaneously combining time series of station positions and Earth orientation parameters. So, besides site positions and velocities, the set of ITRF2005 products also includes a series of combined Earth orientation parameters. The ITRF2005 Earth orientation series was assessed by comparing it with other combined EOP series and with models of surface geophysical fluids. Ideally, assessments of EOP series should be done with independent data. However, since all available combined EOP series, including the ITRF2005, IERS C 04, and SPACE2005 series, are constructed from the same basic set of SLR, VLBI, and GPS measurements, they are not completely independent of each other. But because Earth orientation variations on subdaily to interannual time scales are known to be predominantly caused by atmospheric, oceanic, and hydrospheric effects, and because models of these effects are independent of Earth orientation measurements, it may be possible to use models of global geophysical fluids to independently assess the ITRF2005 Earth orientation series. This possibility was explored by comparing the ITRF2005, IGS Final combined GPS, and SPACE2005 polar motion excitation series to daily averaged atmospheric angular momentum from the NCEP/NCAR reanalysis project, daily averaged oceanic angular momentum from the ECCO/JPL data assimilating ocean model, and monthly averaged hydrospheric angular momentum from the Land Dynamics (LaD) model. In addition, mass conservation of the global geophysical fluids was imposed when using them to assess the EOP series.

The correlation with the sum of the global geophysical fluid models was found to be the same for all three observed polar motion excitation series with the correlation coefficients for the (x, y)-components being (0.81, 0.90). In addition, the same variance of (66%, 80%) of each of the three observed series was explained by the

models. So, all three observed polar motion excitation series were found to agree equally well with the sum of the global geophysical fluid models. All that could be concluded about the accuracy of the new ITRF2005 combined polar motion excitation series was that it is at least as accurate as the SPACE2005 and IGS Final combined GPS series.

Acknowledgments

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Reference

Gross, R. S., Combinations of Earth orientation measurements: SPACE2005, COMB2005, and POLE2005, Jet Propulsion Laboratory Publ. 06-3, 26 pp., Pasadena, Calif., 2006.

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