

### 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 (AAM), 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 2007, three such reference series were generated: (1) SPACE2006, consisting of values and rates for polar motion and UT1 spanning September 28, 1976 to February 10, 2007 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) COMB2006, consisting of values and rates for polar motion and UT1 spanning January 20, 1962 to February 10, 2007 at daily intervals, was generated by additionally including the BIH optical astrometric measurements with the space-geodetic measurements used to generate SPACE2006; and (3) POLE2006, consisting of values and rates for just polar motion spanning January 20, 1900 to January 21, 2007 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 COMB2006. These three reference series can be obtained by anonymous ftp to <ftp://euler.jpl.nasa.gov/keof/combinations/2006>. A report describing the generation of these series [Gross, 2007] is also available at this site.

The near-real-time Earth orientation requirements of the interplanetary spacecraft navigation teams are met by once-per-day updat-

ing 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 AAM measurements from the National Centers for Environmental Prediction (NCEP) that are used as proxy length-of-day measurements. In addition, short-term predictions of the EOPs are produced. 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 2007 were largely concerned with both evaluating alternate sources of AAM forecasts and with evaluating the potential impact of oceanic angular momentum (OAM) forecasts on UT1 predictions [Gross et al., 2008]. Predictions of UT1 are improved when dynamical model-based forecasts of the axial component of AAM are used as proxy length-of-day (LOD) forecasts. For example, JPL's predictions are improved by nearly a factor of 2 when AAM forecast data from NCEP are used. Given the importance of AAM forecasts on the accuracy of UT1 predictions, other sources of AAM forecasts should be sought. So the angular momentum of the forecasted wind fields from the European Centre for Medium-Range Weather Forecasts (ECMWF) was evaluated as a potential alternate source of AAM forecasts.

JPL's Kalman Earth Orientation Filter was run 73 times during 19 March 2004 to 22 July 2004 to predict polar motion and UT1. These runs were reprocessed using AAM forecasts from ECMWF instead of from NCEP. Since the angular momentum of only the 5-day wind forecasts from NCEP are used at JPL to predict UT1, only the 5-day wind forecasts from ECMWF were used during the reprocessing. It was found that if no AAM forecasts are used to predict UT1, the error in the predictions grows rapidly, becoming 33.7 cm after just 7 days. But when AAM forecasts are used, the error is dramatically reduced, becoming only 19.2 cm after 7 days with the NCEP forecasts, and 20.1 cm with the ECMWF forecasts. Thus, during this time period, AAM forecasts produced by ECMWF have nearly the same impact on UT1 predictions as those produced by NCEP.

To assess the potential impact of OAM forecasts on UT1 predictions, an OAM series was added to the AAM forecasts and the predictions regenerated. Since actual OAM forecasts are not currently available, analyses from the ECCO/JPL data assimilating ocean model kf066b were treated as if they were forecasts. Adding OAM to AAM forecasts was found to improve the accuracy of the UT1 predictions only slightly, reducing the error of the 7-day prediction from 19.2 cm to 17.9 cm when added to the NCEP AAM forecasts, and from 20.1 cm to 19.4 cm when added to the ECMWF forecasts.

**Acknowledgments**

The work described in this paper was performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

**References**

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