THE USE OF GPS EARTH ORIENTATION DATA BY
THE INTERNATIONAL EARTH ROTATION SERVICE
SUB-BUREAU FOR RAPID SERVICE AND PREDICTIONS

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The International GPS Service provides polar motion data which have become
an important contribution to the operation of the International Earth Rotation
Service (IERS) Sub-bureau for Rapid Service and Predictions. Comparison with
other techniques shows that these data provide estimates of the position of the
rotational pole with an accuracy of approximately ± 0.5 milliseconds of arc.
This accuracy along with the fact that the daily data are available soon after
observation could make this source of data a valuable addition to the contribu-
tors to the IERS.

INTRODUCTION

Analyses of the orbits of the satellites of the Global Positioning System (GPS) by
participants in the International GPS Service (IGS) (Mueller and Beutler, 1992) have
provided daily observations of high-accuracy polar motion described by the pole
coordinates, x along the Greenwich meridian, and y along the meridian of ninety degrees
west. These data are used routinely by the IERS Sub-bureau for Rapid Service and
Prediction in its normal operations. The GPS data have also been analyzed by some
centers to produce estimates of UT1-UTC. Because of unresolved apparent systematic
error in these data, however, they are not being used operationally by the Sub-bureau.
Also, a longer series of GPS Earth orientation information is required to assess the value
of the data in maintaining a reference system over a long period of time. The purpose
of this paper is to provide an assessment of these observations and show how this
information is used currently.

The National Earth Orientation Service (NEOS) serves as the IERS Sub-bureau for Rapid
Service and Predictions. It is comprised of the U. S. Naval Observatory and the
National Ocean Services of the National Oceanic and Atmospheric Administration of the
United States. Each week NEOS publishes, in IERS Bulletin A, information for
approximately 350 users regarding the orientation of the Earth with respect to a celestial
reference frame. These data are near real-time estimates of the orientation of the Earth
as well as their predictions. This information is obtained from contributors who provide
data obtained from very long baseline radio interferometry, laser ranging to satellites and
the Moon, and now, from the analyses of GPS orbits.

SOURCES OF DATA

Daily estimates of pole positions have been provided by contributors to the IGS. These contributors include the Department of Energy, Mines, and Resources (EMR), the European Space Agency (ESOC), the GeoForschungsZentrum (GFZ), Jet Propulsion Laboratory (JPL), Scripps Institute of Oceanography, the University of Berne, and the University of Texas Center for Space Research. Estimates of UT1-UTC are contributed by EMR and the University of Berne.

ANALYSIS OF GPS DATA

The time series contributed by each of the institutions mentioned above were analyzed by comparing them with the National Earth Orientation Service (NEOS) combination series produced for the International Earth Rotation Service (IERS) Bulletin A. The data used to produce this series are derived from Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR). Figures 1 and 2 show plots of recent differences in polar motion after the removal of biases. Table 1 shows the statistical analysis of the polar motion data.

![Graph showing GPS data in x.](image)
Figure 2. GPS data in y.

Table 1. Comparison of GPS data with NEOS. Units are milliseconds of arc.

<table>
<thead>
<tr>
<th>Contributor</th>
<th>Data Span (MJD)</th>
<th>Points</th>
<th>Mean (NEOS-GPS) x</th>
<th>Mean (NEOS-GPS) y</th>
<th>Standard Deviation x</th>
<th>Standard Deviation y</th>
</tr>
</thead>
<tbody>
<tr>
<td>U. of Texas</td>
<td>48794.5-48880.5</td>
<td>76</td>
<td>-1.89</td>
<td>-3.11</td>
<td>0.82</td>
<td>0.63</td>
</tr>
<tr>
<td>Scripps</td>
<td>48780.5-49052.5</td>
<td>236</td>
<td>-1.56</td>
<td>-0.81</td>
<td>0.65</td>
<td>0.67</td>
</tr>
<tr>
<td>U. of Berne (ITRF90)</td>
<td>48792.5-48799.5</td>
<td>8</td>
<td>-0.89</td>
<td>1.21</td>
<td>1.52</td>
<td>1.88</td>
</tr>
<tr>
<td>U. of Berne (ITRF91)</td>
<td>48800.5-49056.5</td>
<td>257</td>
<td>-0.51</td>
<td>-0.19</td>
<td>0.95</td>
<td>0.89</td>
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<td>JPL</td>
<td>48794.5-49045.5</td>
<td>220</td>
<td>-0.79</td>
<td>0.01</td>
<td>0.82</td>
<td>0.74</td>
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<td>GFZ</td>
<td>48795.0-48925.5</td>
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<td>-2.33</td>
<td>-1.99</td>
<td>1.13</td>
<td>1.12</td>
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<td>ESOC</td>
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<td>259</td>
<td>-1.17</td>
<td>-0.89</td>
<td>1.42</td>
<td>1.85</td>
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<td>EMR</td>
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<td>-1.06</td>
<td>0.32</td>
<td>1.07</td>
<td>0.74</td>
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<td>GFZ (New Series)</td>
<td>48997.0-49059.5</td>
<td>63</td>
<td>1.89</td>
<td>-1.48</td>
<td>0.57</td>
<td>0.58</td>
</tr>
</tbody>
</table>

USE OF GPS DATA IN IERS BULLETIN A

The NEOS now makes use of GPS data contributed to the IERS in its combination series. This is done by smoothing the contributed data separately using algorithms similar to that used in the procedure to combine the VLBI, SLR and LLR data now (McCarthy and
Luzum, 1991). The smoothed fit is shown in Figures 1 and 2 as a thick solid line. Statistical weights are assigned to each of the contributors based on their past agreement with the NEOS combination series. Figures 3 and 4 show the agreement between the smoothed GPS estimates and those derived using data from other techniques for recent times.

Figure 3. x minus a linear fit.

Figure 4. y minus a linear fit.
ACCURACY

Comparison with the other techniques shows that the combined GPS series has an accuracy of ±0.55 msec of arc in x and ±0.48 msec of arc in y. Figures 1 and 2 show that serious systematic differences between the contributors remain which must be resolved to obtain further improvement.

CONTRIBUTION TO RAPID SERVICE AND PREDICTIONS

The contribution to the rapid service estimates of polar motion and prediction are shown graphically in Figure 5. The term "contribution" is estimated by taking into account the frequency with which the data are reported, the adopted a priori accuracy of each contributor, and the time delay between the epoch of the last available data point and the date of the weekly publication. It is a measure of the overall weight of the data in the weekly solution.

The contribution of the GPS data to the long-term maintenance of the reference frame remains unclear. A longer series of data is required to assess the value of the information in preserving a reference system over an extended period.

Figure 5. Contribution to rapid service and prediction.
REFERENCES
