HIGH FREQUENCY VARIATIONS IN EARTH ROTATION

W. E. Carter, D.S. Robertson, and F.W. Fallon
National Geodetic Survey, Charting and Geodetic Services
National Ocean Service, NOAA
Rockville, Maryland 20852

ABSTRACT. The combined POLARIS-IRIS Earth orientation time series now span nearly a full cycle of the Chandler-annual beat period, beginning in late 1980. Since April 1985 there is also a nearly continuous coverage of UT1 at daily intervals. We have fit a simple model, consisting of circular 14-month and annual components and a linear drift to the polar motion series, then computed the "along-track" and "cross-track" residuals. Both sets of residuals display structure with amplitudes of tens of milliseconds of arc on time scales of months, but Fourier analysis reveals no significant peaks at shorter periods, including the 40-60 day period found in the UT1 time series.

During September, 1986, we introduced a new "quick-look" UT1 time series. The values are typically available within 7 days. The accuracy, which depends strongly on the accuracy of the X and Y pole coordinates used in the computations, ranged from 0.3 to 0.7 milliseconds during the first two weeks, but improved to about 0.1 milliseconds during the latter two weeks of the month. We plan to continue the quick-look UT1 series as a standard product of the IRIS Earth orientation monitoring service.

1. INTRODUCTION

The combined POLARIS [Carter et al., 1984] and IRIS [Carter et al., 1985] Earth orientation time series now span 6 years, beginning in September 1980. The series, particularly the X and Y polar motion values, are relatively sparse and of lower accuracy prior to January 1984, when the Wettzell Observatory became operational. Since then nearly complete 5-day interval series of corrections to the Wahr [1981] nutation values in obliquity and longitude, the X and Y components of polar motion, and UT1 are available. The estimated accuracies of individual values are 1 to 2 milliseconds of arc (mas) for the nutation and polar motion values, and 0.05 to 0.10 milliseconds for UT1 values. Since April 1985 there are also nearly continuous daily UT1 values accurate to 0.10 to 0.20 milliseconds. All of the Earth rotation values used in our analyses were derived directly

A. K. Babcock and G. A. Wilkins (eds.), The Earth's Rotation and Reference Frames for Geodesy and Geodynamics, 181–186.

from the POLARIS-IRIS observations at the National Geodetic Survey (NGS) using procedures described in Robertson and Carter [1982] and Robertson et al., [1986]. The only important deviations from the MERIT standards [Melbourne et al., 1983] in our computational procedures are the absence of ocean loading corrections to site positions and the corrections that we made to the standard nutation values.

2. HIGH FREQUENCY VARIATIONS IN POLAR MOTION

In Figure 1 we have plotted the observed positions of the pole since September 1980, along with a least-squares best fitting model consisting of circular 14 month and 12 month components, and a linear drift. As a test we fit a 6-month variation to the residuals, finding an amplitude of roughly 5 mas We decided that the small reduction in the RMS deviation of the residuals was not sufficient to cause us to use the more complex model in our current studies. The differences between the observed positions and the model are clearly not randomly scattered, but rather display systematic deviations over time scales of months.

In Figure 2 we have plotted the differences between the observed and computed positions of the pole as "along-track" and "cross-track" components, as well as the total discrepancy. The along-track residuals represent the discrepancy in phase, while the cross-track residuals represent the discrepancy in the radial component.

In Figure 3 we have plotted the frequency spectra of the cross-track and along-track residuals. In order to obtain these spectra correctly, we had to take into account the non-uniform spacing of the IRIS series. This spacing has the pattern of an initial one month of concentrated observations followed by seven months of sparser, irregular coverage; then 2.5 years of a seven-day schedule with occasional gaps, and finally nearly complete five-day coverage. The usual method of bridging gaps in a time series by interpolation so as to produce a uniformly-spaced series, was not used here because of the presence of quite large gaps and the absence of an underlying uniform spacing. Instead we used an approach (see, e.g., Swan, [1982]) which considers the observed series as the product of some 'true' series with a window function consisting of the actual observation times. The true transform can be obtained by deconvolving the window transform from the observed transform.

The resulting frequency spectra show no clear signals at higher frequencies. Specifically, there is no signal detectable near 50 days, such as occurs in the UT1 series. The high-frequency spectrum is consistent with a random-walk ('brown noise') process.

3. QUICK LOOK UT1 VALUES

The delay between conducting IRIS observations and distributing the Earth orientation values has been dominated by two components, i.e. the time required for intercontinental transport of data tapes to the correlator, and time lost waiting in line at the correlator. We have given highest priority to observing the Earth orientation as frequently and as accurately

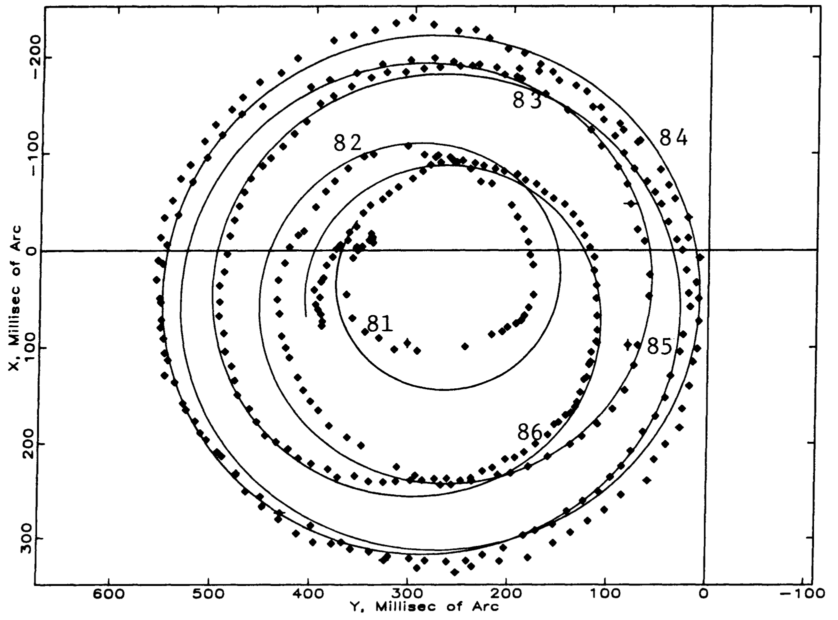

Figure 1. Positions of the pole plotted along with the track of the pole calculated from the simple two-component model described in the text.

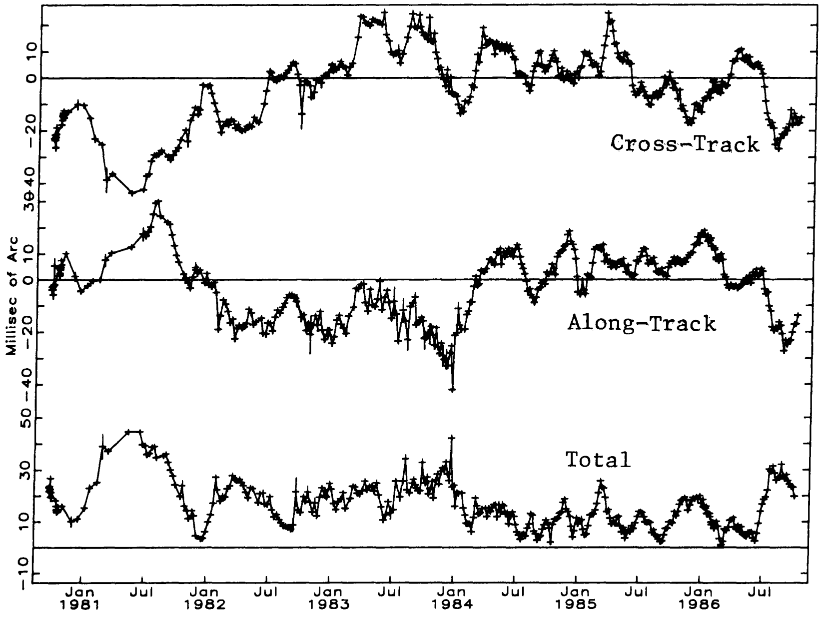

Figure 2. Cross-track, Along-track, and total differences between the observed polar motion and the model referred to in figure 1.

https://doi.org/10.1017/S0074180900119461 Published online by Cambridge University Press

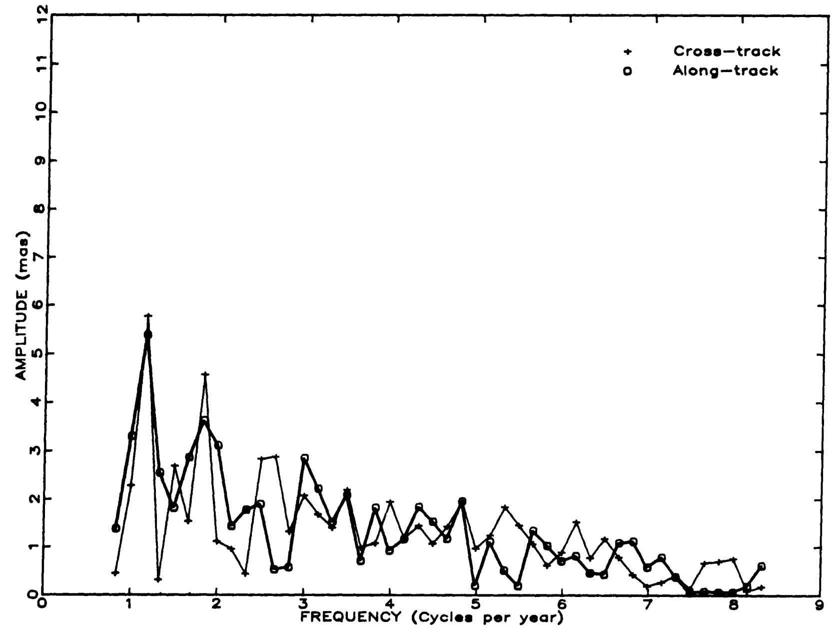

Figure 3. Frequency spectra for cross-track and along-track residuals plotted in figure 2.

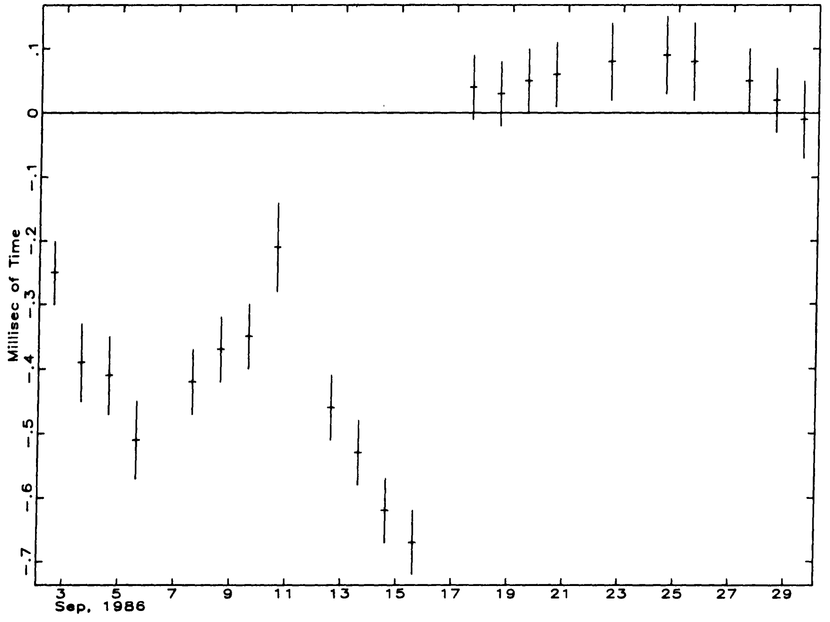

Figure 4. The differences between the IRIS quick-look and final UT1 values.

https://doi.org/10.1017/S0074180900119461 Published online by Cambridge University Press

as possible at the expense of moderate delays of about one month, in the availability of the results. In August 1986, the Washington D.C. correlator, jointly developed by NGS, the National Aeronautics and Space Administration, the U.S. Naval Observatory, and the Naval Research Laboratories reached operational status [Whitney, 1988]. The primary purpose of the new correlator is to process geodetic VLBI observations, with the highest priority being afforded the POLARIS-IRIS observations. As a result it is now feasible to process completely an IRIS daily observation within 4 to 8 hours after receipt of the tapes at the correlator. The cost of transporting the Wettzell tape constrains the minimum total delay to several days. During our first month, the quick-look values were typically available within 7 days.

As we pointed out in Robertson et al., [1985], the accuracy of the daily UT1 values depend strongly on the accuracy of the X and Y pole coordinates used in reducing the observations, approximately according to the relationship $e(UT1) = -0.03\,e(X) + 0.05\,e(Y)$, where $e(UT1)$ is the error in milliseconds of time and $e(X)$ and $e(Y)$ are the respective errors in X and Y in milliseconds of arc.

In Figure 4 we have plotted the differences between the quick-look UT1 values and the final values obtained after the final IRIS X and Y values became available. The marked difference in the accuracy achieved during the first two weeks as compared to the latter two weeks shows dramatically the degradation of the results caused by using poor values of X and Y. A reliable source of accurate X and Y values is required if the quick-look UT1 values are to be accurate to the 0.1 millisecond level. When the ongoing upgrading of the IRIS stations to higher density tape recorders is completed, currently scheduled for early 1987, it should become practical to reduce the delay in processing the IRIS 5-day series to 7 to 10 days, making sufficiently accurate pole coordinates routinely available.

4. CONCLUDING REMARKS

Six years of operations have established the high reliability and accuracy of the VLBI Earth orientation time series. The combined effects of the new Washington correlator and the upgrading of the tape recorders currently in progress will soon make it relatively straight forward to reduce the processing delay to the order of 7 to 10 days. Further reductions in the delay are technologically feasible, but will be costly. If the necessary resources are to be obtained the user community will have to state clearly the applications and benefits to be derived from more rapid turn around.

5. REFERENCES

Carter, W.E., D.S. Robertson, J.E. Pettey, B.D. Tapley, B.E. Schutz, R.J. Eanes and Miao Lufeng, 1984, Science, 224, 957-961.

Carter, W.E., D.S. Robertson and J.R. Mackay, 1985, J. Geophys. Res., 90, no. B6, 4577-4587.

Melbourne, W., R. Anderle, M. Feissel, R. King, D. McCarthy, D. Smith, B. Tapley, and R. Vicente, 1983, U.S. Naval Observatory Circular No. 167, Washington, D.C.
Robertson, D.S. and W.E. Carter, 1982, in High Precision Earth Rotation and Earth-Moon Dynamics, O. Calame, ed., D. Reidel Co., Dordrecht, Holland, 97-122.
Robertson, D.S., W.E. Carter, J.A. Campbell, and H. Schuh, 1985, Nature, 316, 424-427.
Robertson, D.S., F.W. Fallon and W.E. Carter, 1986, Astron. J., 91, (6), 1456-1462.
Swan, P.R., 1982, Astron. J., 87, (11), 1608-1615.
Wahr, J.M., 1981a, Geophys. J. R. Astron. Soc., 64, 677-704.
Whitney, A.R., 1988, this volume.

DISCUSSION

Eubanks: A comment: One higher frequency deterministic variation in the polar motion is, of course, the semi-annual variation with an amplitude, based on my work, on the order of 10 milliarcseconds. A question: When you fit to the annual and Chandler periods in the polar motion, is the fit only to the prograde component of circular motion?

Reply by Carter: I believe that the way it is presently coded, in that case, yes.

Dickey: You mentioned that polar motion values introduce error in your daily measurement. Why not give UT0, which is less sensitive to these problems?

Reply by Robertson: The effect of pole position error on the intensive UT1 determinations involves correlations with the determinations of the VLBI station clock parameters. It is more complicated than just the UT0–UT1 correction.

Tapley: Could you comment on how the polar motion solution is determined to support your rapid UT1 determinations?

Reply by Carter: We use the latest SLR values, remove offsets from VLBI series, and fit annual and 14–month circular terms to the most recent 2 year interval. We are also testing the CORE quick–look values obtained from the USNO.

Débarbat: Have you studied the influence of the approximation made for each component of the simple model used, over the rather long period analysed ('81–'86), on the results?

Reply by Carter: No. We have determined, by least squares, the best fitting circular annual and 14–month components over the full span of data.