INTRODUCTION

In recent years, it has been well established that the (axial) angular momentum of the atmosphere and that of the solid earth are closely related on a variety of time scales. On the subseasonal scale, for example, 30-50 day atmospheric fluctuations are strongly mirrored in the rotation of the earth (Langley et al., 1981). On seasonal scales, annual and semiannual cycles in the momentum of the atmosphere are matched by those of the earth (Rosen and Salstein, 1985). At interannual time scales, features such as the El Niño-Southern Oscillation (ENSO) and the stratospheric quasi-biennial oscillation have been shown to be related to the earth's rotation rate (Rosen et al., 1984; Chao, 1989). However, on the very shortest and longest time scales the atmospheric and geodetic momentum series appear to diverge, even when measured by the most recent techniques. The purpose of this note is to outline the character of the disagreement at these two time scales. A fuller discussion, including details of our analysis methods, appears in Rosen et al. (1990).

DATA SETS

Conservation of angular momentum by the earth-atmosphere system implies that changes in the momentum of the atmosphere are proportional to those in l.o.d., the length of day (Rosen and Salstein, 1983). To study the discrepancies at high frequencies, we used a time series of intensive l.o.d. values derived by VLBI, very long baseline interferometry (Robertson et al., 1985). These VLBI values, with tidal terms removed, are based on once-daily measurements of earth rotation and have been routinely produced since 2 April 1985. To supplement the intensive VLBI values for earlier years, we obtained l.o.d. values produced by Kalman filtering observations from a combination of techniques (Morabito et al., 1988). In this way, data since January 1976 were used to create a 12.5 year set for examining low frequencies.

Values of atmospheric angular momentum are calculated from wind and surface pressure fields produced at the major meteorological centers as part of their weather forecasting operations. To do so, raw data taken by a heterogeneous network of observing instruments are melded with each other and with fields of variables generated by an earlier forecast.
This assimilation procedure produces analysis fields of the state of the atmosphere for a certain synoptic hour. In another step, the analysis fields are modified to make them compatible with the weather forecasting model. This modification, or "initialization", is performed so that the resulting fields, when used as the initial conditions for the forecast model, do not create imbalances in forecasted fields. The cycle is then continued when these forecasted fields are combined with values from the next observing time, usually 6 hours later. (See Figure 1 in Salstein and Rosen, 1985.)

The main global analyses used here are those from the U.S. National Meteorological Center (NMC) because they date back to 1976. The angular momentum of the atmosphere about the polar axis relative to an earth-fixed frame, based on \([u]\), the zonal mean zonal wind, is given as

\[
W(p_U) = \frac{2\pi a^3}{g} \int_{1000 \text{ mb}}^{p_U} \int_{\pi/2}^{-\pi/2} [u] \cos^2 \phi \, d\phi \, dp
\]

where \(a\) is the mean radius of the earth, \(g\) the acceleration due to gravity, \(\phi\) latitude, \(p\) pressure which ranges from 1000 mb near the bottom of the atmosphere to \(p_U\) at some upper level. Changes in the axial momentum arising from surface pressure variability are typically less important than those from the winds (Barnes et al., 1983), and so will not be considered in the momentum budget here. With this approximation, then, the proportionality between l.o.d., in units of seconds, and \(\Delta W\), in units of \(\text{kg m}^2\text{s}^{-1}\), is given by

\[
\Delta \text{l.o.d.} = 1.68 \times 10^{-29} \Delta W
\]

Global analyses produced by the European Centre for Medium Range Weather Forecasts (ECMWF) have been available since 1981 and are used to compare with those from NMC.

HIGH FREQUENCY DISCREPANCIES

A coherency analysis relating \(W(50)\), atmospheric momentum up to the 50 mb level, from NMC with the intensive l.o.d. values for the period 2 April 1985 through 30 June 1988 was performed for time scales from about 2 to 150 days. This analysis, shown in Fig. 1, reveals that the two series are significantly related on time scales greater than about 15 days. At the frequencies for which they are coherent, no significant phase lead or lags between the series exist. This result moves the correspondence between l.o.d. and atmospheric momentum from the 40-day limit found by Eubanks et al. (1985) to higher frequencies. An analysis of the spectrum for the two series (Fig. 2) shows energy density at the highest frequencies that are significantly higher for \(\Delta \text{l.o.d.}\) than for \(W\) at periods shorter than about 8 days.