On the relationships between low-frequency variations of Earth's rotation and equatorial atmospheric angular momentum

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Abstract

This work mainly concerns low-frequency variations of atmospheric angular momentum (AAM), emphasizing the role of the equatorial region and its relationships with the length of day (LOD) variations, whose observed time series $LOD(t)$ indicate an accelerating Earth's rotation over the last several decades. We apply bivariate and trivariate empirical mode decomposition (EMD) methods to extract coherent nonstationary signals from the monthly time series of $LOD(t)$ and the two components of AAM, i.e., the pressure term $M\Omega$ and the motion term $M\mathrm{r}$. It is found that, over the global domain, a decreasing trend of $LOD(t)$ during the last five decades correlates with an increasing trend in $M\Omega$. In contrast, the trend in $M\mathrm{r}$ is negligibly small. However, there is a significantly positive trend in $M\mathrm{r}$ of the equatorial lower troposphere (from 1000 to 700 hPa), which is logically consistent with the larger transfer of westward momentum due to the acceleration of the Earth. Spatio-temporal variations of $M\mathrm{r}$ suggest a redistribution of $M\mathrm{r}$ anomalies across the globe at interannual to multidecadal time scales. On the other hand, the long-term positive trend in $M\Omega$ is most likely attributed to a global increase in surface pressure from the mid-1970s until about 1990, which seems to have been profoundly affected dynamically by the atmosphere and ocean systems over the equatorial belt for a prolonged duration. Low-frequency variation of $LOD(t)$ is also found to have a high correlation with Atlantic Meridional Oscillation (AMO) index. Overall, our results suggest that long-term changes in Earth's rotation rate are at least partially attributable to the low-frequency variations of the atmosphere and ocean in the tropics and vice versa.

Keywords: atmospheric angular momentum, Earth's rotation, length of day, multidecadal climate variability, nonstationary time series

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