Angular momentum of the atmosphere
Variations of atmospheric relative angular momentum and length of day

**FIGURE 11.2.** Time series of daily values of the relative westerly angular momentum $M_r$ of the global atmosphere between 1000 and 100 mb based on NMC analyses in units of $10^{26}$ kg m$^2$ s$^{-1}$ (heavy solid line; scale on right) and values of the length of day (LOD) in units of $10^{-3}$ s (thin solid line; scale on left) for the years 1976–1988. The daily LOD data are based on an optimal combination of observing techniques prior to April 1985 with approximately 5-day effective resolution and on VLBI (very long baseline interferometry) observations with approximately daily resolution from April 1985 (based on data from Rosen et al., 1990, updated by Salstein).

---

**Fig. 1** Peixoto and Oort, Fig 11.2
Mean zonal wind (m/s) in latitude-height plane

Fig. 2
NCEP reanalysis: imbalance in the angular momentum budget

Torques
T(M): mountain
T(F): frictional
T(G): gravity-wave

Figure 2. The actual angular momentum (solid line) versus the predicted angular momentum with $T = T_M + T_F$ (dashed line) and $T = T_M + T_F + T_G$ (dash-dotted line) from January 16 to May 31, 1988.

Fig. 3 Huang, JGR, 1999; Fig 2
FIGURE 11.7. Zonal-mean cross sections of the northward flux of momentum by all motions (a), transient eddies (b), stationary eddies (c), and mean meridional circulations (d) in m^2 s^-2 for annual-mean conditions (from Oort and Peixoto, 1983).

Fig. 4 Peixoto and Oort, Fig 11.7
Northward flux of momentum ($m^2 s^{-2}$)

Total

Transient

Stationary

Mean

**FIGURE 11.8.** Meridional profiles of the vertical- and zonal-mean northward transport of momentum by all motions (a), transient eddies (b), stationary eddies (c), and mean meridional circulations (d) in units of $m^2 s^{-2}$ for annual, DJF, and JJA mean conditions [to convert to angular momentum transport units of $10^{18}$ kg m$^2$ s$^{-1}$ multiply values by $2\pi R^2 \cos^2 \phi (p_0/g) = 2.56 \cos^2 \phi$, where $2\pi R \cos \phi =$ length of latitude circle, $R \cos \phi =$ distance to rotation axis, and $p_0/g =$ mass per unit area $\approx 10^4$ kg m$^{-2}$; from Oort and Peixoto, 1983].
Mean surface torques on the atmosphere $(10^{18} \text{ kg m}^2 \text{ s}^{-2})$
Schematic of dynamic angular momentum transports and surface torques

Fig. 7  Figure credit: MIT OCW
Cospectrum of $v$ and $T$ at 300hPa, 47N, DJFM

Fig. 8  Randel and Held, JAS, 1991: fig 1
Fig. 1. Zonal wavenumber–frequency covariance spectra of $\bar{v} \bar{T}$ at 300 mb, 47°N during DJFM. The spectral bandwidth (BW) associated with the Gaussian spectral window (2) is also shown. Spectral density contour interval is 0.01 K m s$^{-1}$ · Δω$^{-1}$, with Δω the unit frequency interval of $(2\pi/120$ days). (b) Zonal wavenumber phase speed covariance spectra calculated from (a) via (3). Contour interval is 0.02 K m s$^{-1}$ · Δc$^{-1}$, with Δc the unit phase speed interval of 1.0 m s$^{-1}$. Shaded regions denote wavenumber–phase speed combinations which are unresolved at this latitude (as discussed in text).
Cospectrum of $u$ and $v$ in phase speed at 300hPa

Fig. 10 Randel and Held, JAS, 1991

Fig. 6. Contours of 300 mb transient eddy momentum flux versus latitude and phase speed for DJFM (left) and JJAS (right). Contour interval is $0.50 \text{ m}^2 \text{s}^{-2} \cdot \Delta c^{-1}$, with zero contours omitted. Heavy lines in each panel denote seasonal average zonal mean zonal wind, and shading denotes plus and minus one daily standard deviation.
Fig. 6. Contours of 300 mb transient eddy momentum flux versus latitude and phase speed for DJFM (left) and JJAS (right). Contour interval is 0.50 m²·s⁻²·Δc⁻¹, with zero contours omitted. Heavy lines in each panel denote seasonal average zonal mean zonal wind, and shading denotes plus and minus one daily standard deviation.

Cospectrum of \( u \) and \( v \) in phase speed at 300hPa (JJAS)

Fig. 11 Randel and Held, JAS, 1991
EP flux and divergence - winter, transient

Fig. 12

(Reproduced in Edmon et al, 1980)
Transformed Eulerian mean (TEM) circulation ($10^9$ kg s$^{-1}$)

Fig. 13

ERA40 1980-2001
Transformed Eulerian mean (TEM) circulation ($10^9$ kg s$^{-1}$)

Fig. 13
Transformed Eulerian mean circulation \((10^9 \text{ kg s}^{-1})\)

Dry isentropic circulation interpolated to sigma coordinates \((10^9 \text{ kg s}^{-1})\)

Fig. 14

ERA40 1980-2001