An empirical relation between the angular momentum content of the hemispheres and the flux across the equator

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The existence of a seasonal flow of atmospheric angular momentum across the equator was postulated by Widger (1949) and first verified by Tucker (1965). Since then, much information has accumulated regarding atmospheric angular momentum content and its transport between the hemispheres. It is now established that there is a large annual oscillation in the angular momentum content of the two hemispheres, the winter hemisphere having by far the greater momentum. Concomitantly, there is a net transport of relative angular momentum across the equator, always in the direction of the hemisphere having the lower momentum content. Most of this transport is accomplished by standing and transient eddies in the upper troposphere (Kidson & Newell, 1969; Kidson et. al., 1969).

This note is to call attention to a rather striking correlation between the variations in observed relative angular momentum content of the two hemispheres and the angular momentum flux across the equator. Not only does the angular momentum consistently flow toward the hemisphere with the lower momentum content, but quantitatively the flux seems to be in direct proportion to the interhemispheric angular momentum difference.

Table 1 shows the total westerly relative angular momentum content, M, of the Northern and Southern Hemispheres and the northward flux of relative angular momentum, F, across the equator, by seasons. The values for hemispheric angular momentum content are taken from Kidson & Newell (1969). These were calculated from zonal wind distributions compiled by other authors and represent averages over the four midseason months. The values for equatorial flux are taken from Newton (1971). These figures represent his best average, obtained by a synthesis of the work of many authors, and are seasonal means.

In Fig. 1 the equatorial flux F is plotted against the interhemispheric angular momentum difference M(SH)–M(NH) for the four seasons. The straight line is drawn as a best fit to the points. The equation of the line is

$$F = a[M(\mathrm{SH})-M(\mathrm{NH})]$$

where $a = 1.2 \times 10^{-7}\ \mathrm{sec}^{-1}$. Although it is difficult to estimate the uncertainty which should be assigned to the values of F and M, it is probably safe to say that the equatorial flux is directly proportional to the interhemispheric angular momentum difference, within the accuracy of our knowledge.

The physical basis for such a correlation is not obvious. It is tempting to interpret this result as simply momentum flow down a gradient. However, the "gradient" in this case should be the rate of change of relative angular momentum with latitude *at the equator*, and not the gross interhemispheric difference. In the literature, the equatorial flux has always been attributed to the strong *source* of angular momentum in the trade-wind belt close by on the winter-hemisphere side of the equator (Widger, 1949; Tucker, 1965; Kidson et al., 1969). If there is any causal connection between

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the equatorial flux and the state of the atmosphere at higher latitudes (where most of the relative angular momentum is located), it must be rather obscure, involving the complex interrelationships among all parts of the global atmosphere.

Nonetheless, it is difficult to believe that the excellent fit of the data points in Fig. 1 to a linear relationship is mere coincidence. Of course it must be admitted that the numbers used in this analysis are constantly subject to revision; moreover the comparison of monthly means (of angular momentum) with seasonal means (of flux) is not wholly legitimate. It may be that when more detailed and precise information becomes available, the data will no longer suggest this linear relationship. But if this empirical relationship is indeed valid, it might be very instructive to seek a theoretical basis for it.

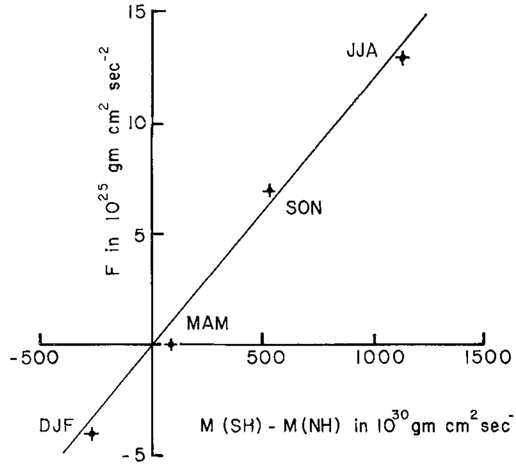

Fig. 1. Northward flow of relative angular momentum F across the equator, as a function of the interhemispheric angular momentum difference M(SH)–M(NH).

Table 1. *Relative westerly angular momentum content M of North and South Hemispheres (in 10^{30} g cm^2 sec^{-1}) and northward flux of relative angular momentum across the equator (in 10^{25} g cm^2 sec^{-2})*

	M(NH)	M(SH)	M(SH)–M(NH)	Flux
DJF	1 115	845	−270	−4
MAM	879	968	89	0
JJA	73	1 205	1 132	13
SON	545	1 077	532	7

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