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SHORT CONTRIBUTION

Southern hemisphere energetics: a reappraisal of some earlier estimates

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ABSTRACT

A climatology of the quasi-geostrophic available potential and kinetic energies of the southern hemisphere derived from 4 complete years of daily analyses is presented. The same energies, estimated from analyses based on the improved observation network operating during the Global Weather Experiment are also given and compared with the long-term statistics. Although the more recent results do differ in several respects from the earlier ones, the differences are generally small. The major inter-hemispheric differences noted in earlier reports are confirmed.

1. Introduction

Zonal and eddy components of the southern hemisphere's available potential and kinetic energies in the space domain (i.e. the zonal energies are those of the zonally averaged motion, and eddy energies, the difference between the zonal and total energies; for further discussion of this and other methods of partitioning the energies, see Oort (1964)) have been calculated for the lower troposphere using the International Geophysical Year (July 1957 to December 1958) data (Price, 1973) and the total atmospheric layer using data from May 1972 to April 1973 (Price, 1975). In an unpublished report by one of us (PGP) the same procedures were applied to 4 years of data to estimate the climatological values of the energies.

The first two studies compared the various energy terms with corresponding estimates for the northern hemisphere and several significant differences were noted. However, the southern hemisphere observational network upon which analyses for the above comparisons were based was sparse, relative to that of the northern hemisphere, possibly leading to inaccurate estimates of at least some of the components. For this reason, simplifications were made in the calculations, and no attempt was made to estimate the generation, dissipation, and exchange terms of the energy cycle. Studies by Van Loon (1980) and Oort (1978) suggest that calculations of the latter should await production of the final analyses from the Global Atmospheric Research Programme's First Global Experiment (the FGGE).

Nevertheless, the southern hemisphere operational observation system improved markedly during the year of the FGGE; in particular the drifting buoy system and the improved vertical temperature soundings available from TIROS-N should have resulted in considerably more accurate analyses over the southern hemisphere (see, for example, Guymer and Le Marshall, 1980). It therefore seems timely to compute the energetics in exactly the same way using the FGGE data set produced by the same analysis scheme to determine whether part or all of the differences between the two hemispheres could be attributed to the lower quality of the southern hemisphere data bases.

In this note, the method of calculation of the energetics is briefly described, the unpublished climatology is presented, the previously noted interhemispheric differences are re-examined, and the results of the FGGE-year calculations are compared with the long-term statistics.

2. Data and procedure

The equations used are identical to those given in Price (1975) and are not repeated here. The basic

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data consisted of grid point values, between 10S and 70S, of the fields of mean sea-level pressure, and geopotential heights at 500, 300 and 200 mb as archived by the Australian Bureau of Meteorology's operational numerical analysis programmes (see Gauntlett et al., 1972). Daily analyses from June 1, 1972 to May 31, 1976 were used to calculate the long-term climatologies and from December 1, 1978 to November 30, 1979 for the FGGE-year estimates. Data for those few isolated days which were not archived were assumed identical to those of the previous day. Daily contributions to the energy components were computed for each layer (1000–500 mb, 500–300 mb, and 300–200 mb) and then summed and extrapolated to estimate values for the total atmospheric layer.

The energy climatologies (averages and standard deviations of monthly means) derived from the 1972/76 data and the FGGE-year monthly means expressed as percentages of the long-term averages are given in Table 1.

In Fig. 1, both sets of southern hemisphere results are given, together with corresponding estimates for the northern hemisphere reported by Wiin-Nielsen (1967); the latter arranged so that seasons correspond.

3. Discussion

It is apparent from Fig. 1 that, as noted in the previous reports (Price 1973, 1975), the main differences between the two hemispheres are:

(a) the southern hemisphere energies exhibit less pronounced annual cycles;
(b) the proportion of each energy contained in its zonal component is greater in the southern hemisphere;
(c) kinetic energy makes a smaller contribution to the total energy in the southern hemisphere; and
(d) the total energy is greater in the southern hemisphere.

From Fig. 1 it can be seen that during almost all months, the FGGE-year estimates of both eddy energies are significantly greater than the long-term averages. The zonal energies are marginally greater in most months, but significantly greater during the winter months. A similar increase in zonal characteristics during the southern hemisphere FGGE winter was also noted by Tucker and Physick (1979).

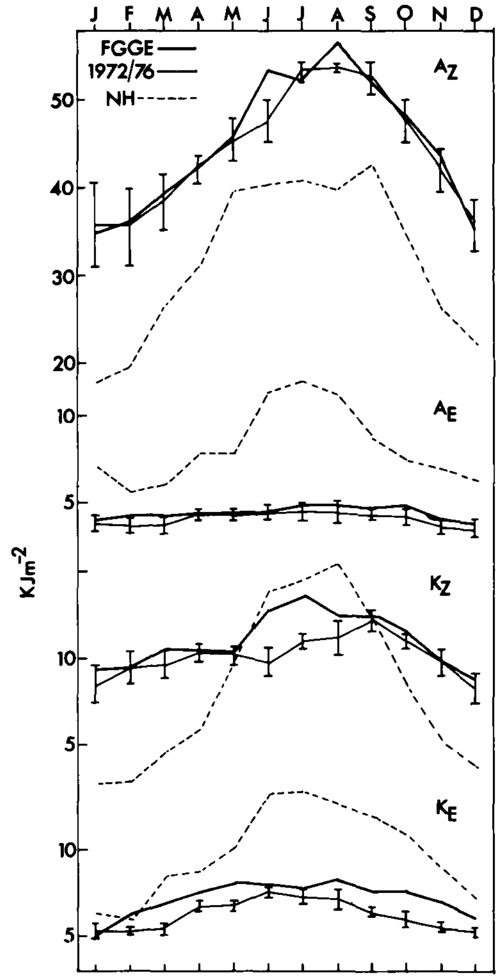

Fig. 1. Estimates of monthly means of A_Z, A_E, K_Z, K_E for the southern hemisphere for the FGGE-year, and for 1972/76 (with one standard deviation error bars) and for the northern hemisphere from Wiin-Nielsen (1967). Units: kJ m^{-2}.

The FGGE-year results do differ in some respects from the climatological values, but how much is due to the improved observational network and how much is the result of real interannual circulation variations is difficult to tell. It is possible that the pronounced increases in the zonal energies during some winter months reflect a real anomaly in these components for part of the FGGE-year. Whatever the causes of the observed differences, it should be noted that the differences between the two estimates of the southern hemisphere energetics are small compared to the

Table 1. *K_Z, K_E, A_Z, A_E for the southern hemisphere: (1) 1972–1976 monthly and annual averages, with standard deviations in brackets; (2) FGGE-year monthly and annual means expressed as percentages of the corresponding long-term averages. Units: kJ m^{-2}*

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
K_Z	(1)	854	945	972	1029	1006	977	1104	1123	1219	1110	979	833	1013
		(110)	(90)	(78)	(43)	(61)	(80)	(40)	(98)	(48)	(32)	(68)	(89)	(126)
	(2)	111	99	110	107	102	131	123	110	102	104	100	104	108
K_E	(1)	565	563	580	705	712	794	758	752	677	638	593	571	660
		(65)	(20)	(61)	(36)	(42)	(43)	(88)	(96)	(24)	(80)	(44)	(38)	(93)
	(2)	96	115	124	111	118	103	106	114	117	124	122	106	113
A_Z	(1)	3590	3584	3856	4228	4531	4764	5355	5377	5261	4760	4202	3577	4428
		(493)	(426)	(321)	(149)	(239)	(243)	(72)	(22)	(199)	(260)	(245)	(293)	(685)
	(2)	97	101	102	100	101	112	98	105	99	101	104	95	102
A_E	(1)	380	359	372	416	412	452	456	449	432	424	369	349	406
		(40)	(36)	(48)	(12)	(25)	(38)	(50)	(58)	(26)	(42)	(29)	(45)	(48)
	(2)	101	112	110	107	108	99	106	109	108	113	112	112	108

differences between the estimates for the two hemispheres. Thus, this study has provided no reason to believe that earlier conclusions about the interhemispheric differences in energy climatologies were simply the result of the poor observational network.

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