Reply

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The main thesis of my paper (Kao, 1970) is to point out the similarity between the spectrum of temperature and that of kinetic energy of large-scale motions (Kao and Wendell, 1970) in the free atmosphere. To make a closer comparison, the spectra of temperature, $ETT(k)$, and kinetic energy, $EKK(k)$, at 500 mb, 1964, were computed; the computer outputs (versus circular wavenumber k) are shown in Figs. 1 and 2. It may be noted that similarities between the two spectra exist in the k^{-3} range as well as in the higher wavenumber range, and that in the latter the spectra are approximately proportional to k^{-5}.

If Saunders' hypothesis of the thermal wind effect is correct, the spectrum of the kinetic energy should be proportional to the product of k^2 and the spectrum of temperature. However, this does not agree with observation, since Figs. 1 and 2 show that the spectrum of kinetic energy is proportional to that of temperature. (The spectrum of temperature should be compared with that of kinetic energy instead of the meridional component of the wind as shown in Saunders' figures, since fluctuations of temperature are related to fluctuations of the total wind speed rather than to one component of the wind.)

The fact that similarities between temperature and kinetic energy spectra exist not only in the k^{-3} range, but also in the higher wavenumber k^{-5} range, indicates that fluctuations of temperature and kinetic energy can neither simply be interpreted by the thermal wind effect nor by two-dimensional turbulence. An analysis of the similarity relationship between temperature and kinetic energy spectra has recently been made by Charney (1971).

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Kao, S. K., 1970: The wavenumber-frequency spectra of temperature in the free atmosphere. *J. Atmos. Sci.*, **27**, 1000–1007.

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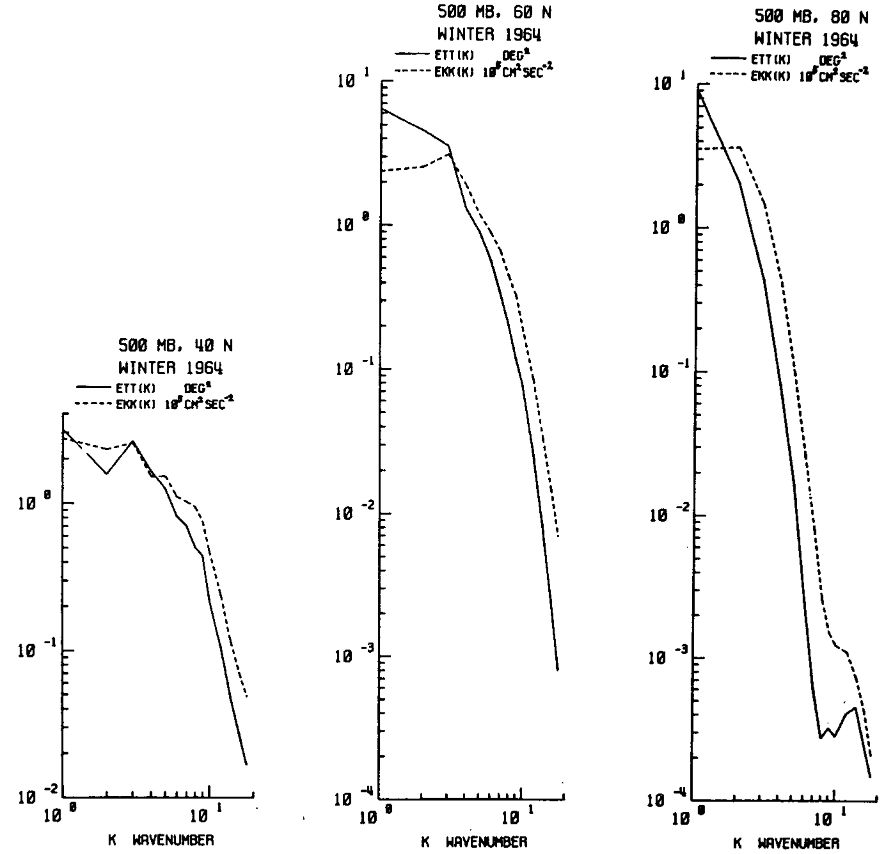

FIG. 1. Wavenumber spectra of temperature (solid curves) and kinetic energy (dashed curves) at 500 mb, at 40, 60 and 80N, summer 1964.

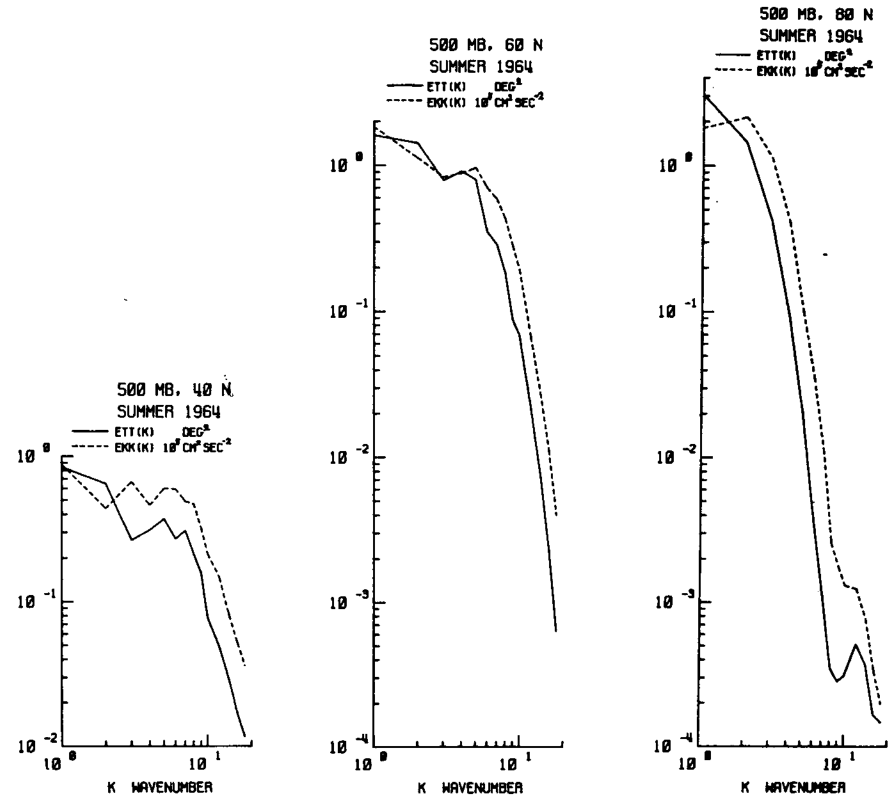

FIG. 2. Same as Fig. 1 except for winter 1964.

APPENDIX

TABLE 1. Spectral values of kinetic energy, $E_{KK}(k)$, and temperature, $E_{TT}(k)$, at 500 mb, summer 1964.

	$E_{KK}(k)$ (10^4 cm^2 sec^{-2})			$E_{TT}(k)$ (°K)^2		
k	20N	40N	60N	20N	40N	60N
1	2.6286	8.7556	18.2247	1.1612	0.8391	1.5950
2	1.6953	4.3824	11.1733	0.2401	0.6470	1.4124
3	2.4008	6.6656	8.3190	0.0820	0.2653	0.7873
4	1.9216	4.6175	8.8358	0.0808	0.3120	0.9091
5	1.3760	6.0060	9.6297	0.0595	0.3716	0.7931
6	1.7397	5.9515	6.9636	0.0635	0.2711	0.3487
7	1.6190	4.9025	5.8675	0.0699	0.3088	0.2863
8	1.5420	4.7299	4.2894	0.0506	0.2143	0.1828
9	1.1976	3.2162	2.7950	0.0377	0.1562	0.0869
10	1.1268	2.1266	1.9271	0.0499	0.0771	0.0694
11	1.0618	2.0325	0.9743	0.0215	0.0623	0.0337
12	0.9737	1.3721	0.6496	0.0208	0.0420	0.0214
13	1.0952	1.0476	0.3905	0.0234	0.0395	0.0127
14	0.7222	0.7603	0.2690	0.0197	0.0272	0.0069
15	0.8222	0.6509	0.1758	0.0371	0.0214	0.0038
16	0.7796	0.4910	0.1043	0.0245	0.0173	0.0022
17	0.5849	0.4299	0.0626	0.0138	0.0118	0.0011
18	0.4486	0.3552	0.0371	0.0084	0.0135	0.0005
19	0.5163	0.2952	0.0241	0.0081	0.0076	0.0004
20	0.4467	0.2541	0.0163	0.0067	0.0056	0.0002

TABLE 2. Spectral values of kinetic energy, $E_{KK}(k)$, and temperature, $E_{TT}(k)$, at 500 mb, winter 1964.

	$E_{KK}(k)$ (10^4 cm^2 sec^{-2})			$E_{TT}(k)$ (°K)^2		
k	20N	40N	60N	20N	40N	60N
1	7.1108	27.3823	23.8403	0.7645	3.1356	6.4085
2	3.4487	23.1410	25.6606	1.1430	1.5726	4.5764
3	5.4278	25.5093	31.4415	0.3337	2.6322	3.5758
4	3.5008	15.1989	19.2100	0.2895	1.6476	1.3166
5	4.1603	15.2834	11.9190	0.2320	1.2547	0.8992
6	3.5917	11.0682	8.9048	0.1559	0.8157	0.5743
7	3.1262	10.2056	6.6637	0.1201	0.7008	0.3357
8	2.2147	9.4393	4.4576	0.0614	0.5049	0.2024
9	1.3231	7.5167	3.2883	0.0477	0.4412	0.1202
10	1.2582	4.7598	1.9733	0.0340	0.2183	0.0803
11	1.1131	3.1773	1.2279	0.0367	0.1406	0.0414
12	0.8261	2.4357	0.8577	0.0232	0.1102	0.0243
13	0.8717	1.3273	0.4789	0.0170	0.0523	0.0151
14	0.7828	1.2389	0.3190	0.0157	0.0505	0.0063
15	0.6953	0.7536	0.2338	0.0182	0.0357	0.0044
16	0.6394	0.7358	0.1387	0.0120	0.0243	0.0021
17	0.5072	0.5648	0.0939	0.0095	0.0228	0.0015
18	0.4974	0.4819	0.0716	0.0075	0.0168	0.0006
19	0.3704	0.4267	0.0435	0.0070	0.0107	0.0004
20	0.3698	0.2828	0.0273	0.0048	0.0073	0.0002