NOTES AND CORRESPONDENCE

The Kinetic Energy of Large-Scale Atmospheric Motion in Wavenumber-Frequency Space: III. The Tropics

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ABSTRACT

The wavenumber-frequency spectra of the kinetic energy of the zonal and meridional components of the motion at 200- and 500-mb levels in the tropics show that there exists a band of wave activities which is oriented from a region of low wavenumbers and frequencies to a region of high wavenumbers and low frequencies. This orientation is distinctly different from what is found at higher latitudes where the band extends from a region of low wavenumbers and frequencies to a region of high wavenumbers and negative frequencies.

1. Introduction

In Part I (Kao and Wendell, 1970) and Part II (Kao *et al.*, 1970) of a series of papers, the wavenumber-frequency spectra of kinetic energy of large-scale atmospheric motion were analyzed at subtropical, temperate and high latitudes in the Northern and Southern Hemispheres. These studies were based on data which were limited to latitudes at and north of 20N, and at and south of 20S. In this paper, the wavenumber-frequency spectra of kinetic energy of large-scale atmospheric motion in the tropics at 10N, the equator, and 10S are analyzed.

2. Data and analysis

The horizontal velocities used in this analysis are derived from the 1967–68 National Meteorological Center (NMC) streamfunction analyses at the 200- and 500-mb levels. The streamfunction is constructed with the use of conventional, as well as aircraft and satellite, data. The wind velocities are calculated from streamfunction differences taken over 5° of latitude or longitude, centered about the desired location of the wind. The 5° latitude-longitude square is the basic grid employed in this analysis technique and is completely described in a discussion on the analysis scheme devised for computations within this area in a recent paper by Bedient *et al.* (1967). In these calculations, spring is the period March, April, May, 1968; summer is June, July, August, 1968; autumn is September, October, November, 1968; and winter is December 1967 and January, February, 1968. We realize that, because of uneven distribution of data, the tropical NMC analyses are not of even quality. Nevertheless, they are the best analyses that we have to date. Furthermore, for investigations of large-scale atmospheric motion, these analyses should be fairly good.

The method of analysis used in this study is the same as that used in the earlier investigations (Kao, 1968; Kao and Wendell, 1970; Kao *et al.*, 1970), i.e., Fourier analysis. The reasons for employing this method are two-fold: it provides a consistent analysis of the nonlinear interactions as shown in the first (Kao, 1968) of this series of papers; and the large-scale atmospheric motion is essentially periodic in nature.

3. Wavenumber-frequency spectra of the zonal and meridional components of velocity

The wavenumber-frequency spectra of the zonal and meridional components of the velocities at 10N, the

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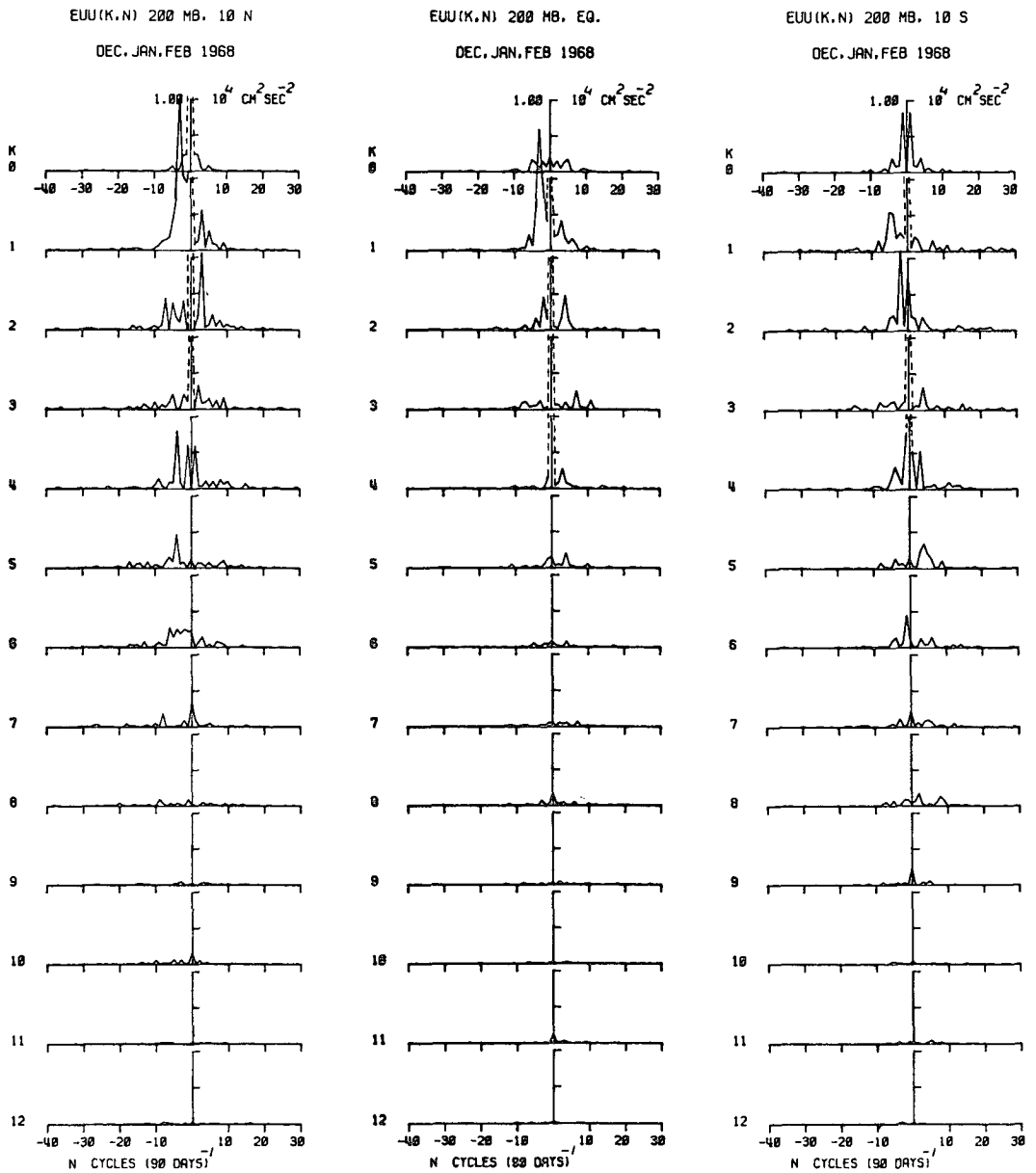

FIG. 1. Wavenumber-frequency spectra of the zonal component of velocity at 200 mb, winter 1968, for 10N, the equator, and 10S.

equator, and 10S at the 200- and 500-mb levels for the four seasons of 1968 have been computed. To eliminate repetition because of similarity of analyses between levels, only the power spectra of the velocities at the 200-mb level for the winter and summer seasons are presented in Figs. 1–4. In these figures, the vertical axis represents the spectral kinetic energy and the horizontal axis the frequency in units of cycles (90 days)$^{-1}$, the positive and negative frequencies being assigned to waves moving from east to west and from west to east, respectively; the wavenumbers are labeled on the left side of the figures.

It is seen from the figures that there exists a preferred spectral band in the power spectra of the zonal and meridional components of velocities at the various tropical latitudes, which indicates the wave-number-frequency domain of wave activities in the atmosphere. The spectral band is oriented almost vertically from a region of low wavenumbers and low frequencies to a region of high wavenumbers and low frequencies, with

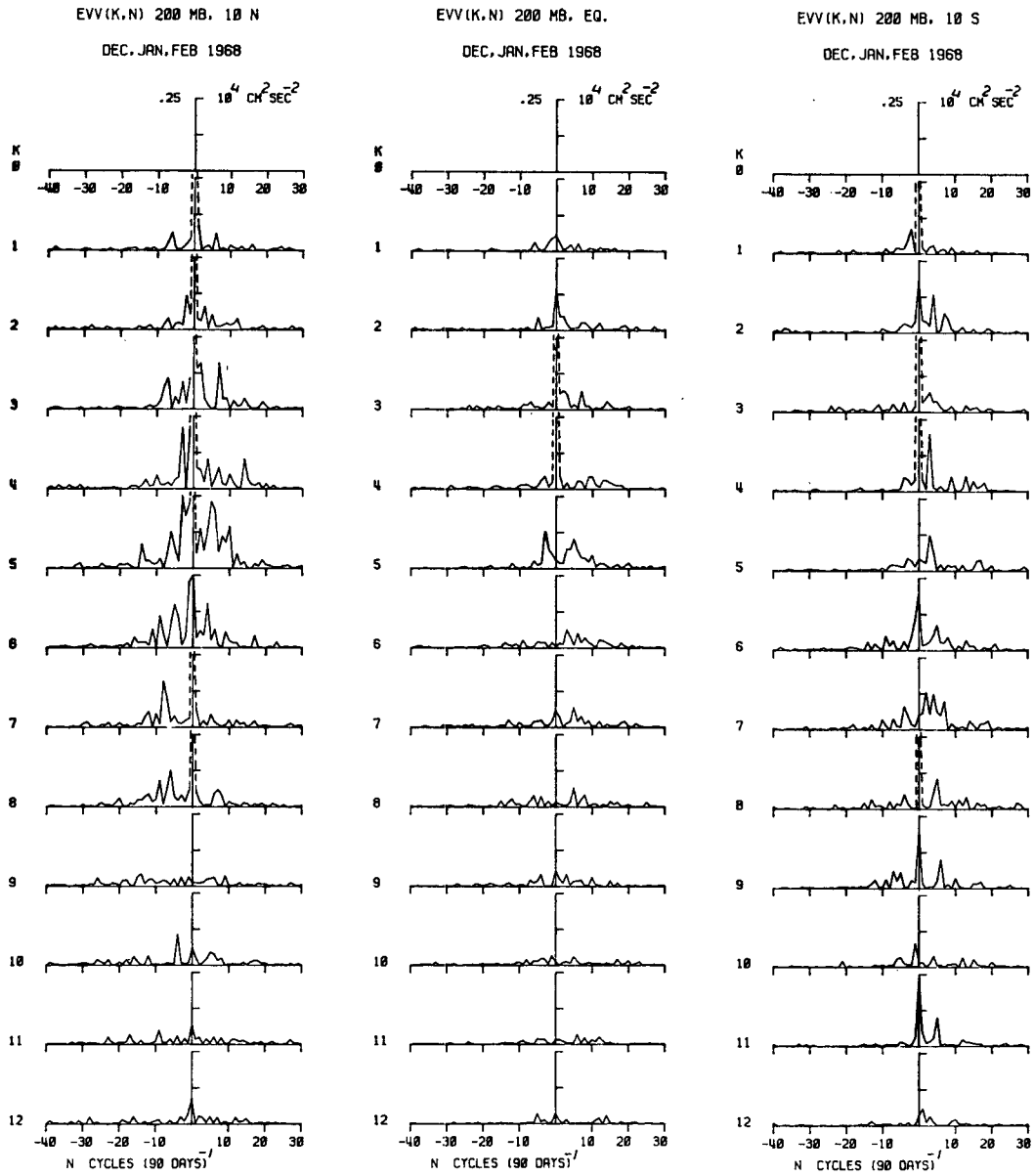

FIG. 2. Wavenumber-frequency spectra of the meridional component of velocity at 200 mb, winter 1968, for 10N, the equator, and 10S.

the wavenumber-frequency spectra of the zonal component of velocity showing a tendency toward the longest wavelengths. This orientation, however, is distinctly different from what is found at higher latitudes, as at the higher latitudes the band extends from a region of low wavenumbers and frequencies to a region of high wavenumbers and negative frequencies (see Parts I and II).

The spectra also show that more waves move toward the west than toward the east, which is distinctly shown in the spectra of the meridional component of the motion. Figs. 2 and 4 show that wave activity is more intense at 10S in the summer, but at 10N in the winter. In the tropics, wave intensity of the zonal component is generally greater than that of the meridional component.

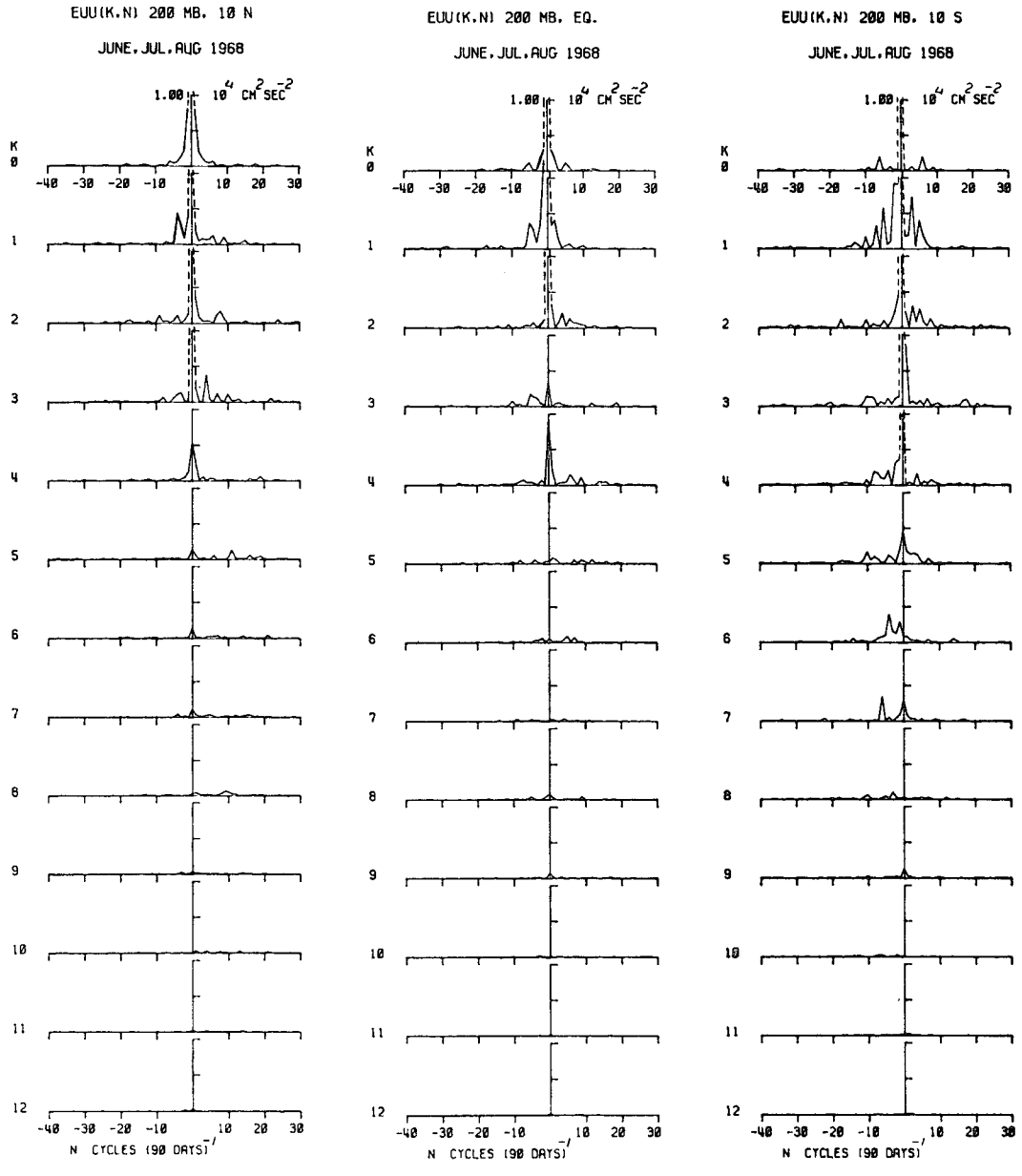

FIG. 3. Wavenumber-frequency spectra of the zonal component of velocity at 200 mb, summer 1968, for 10N, the equator, and 10S.

The distribution of the wavenumber-frequency spectra of the zonal and meridional components of the velocity in the tropics at the 500-mb level is similar to that at the 200-mb level, except that the intensity of wave activities is approximately 30% of that at 200 mb.

The wavenumber and frequency spectra of the kinetic energy of the zonal and meridional components of the motion in the tropics have also been computed. The characteristics of these spectra will be reported elsewhere.

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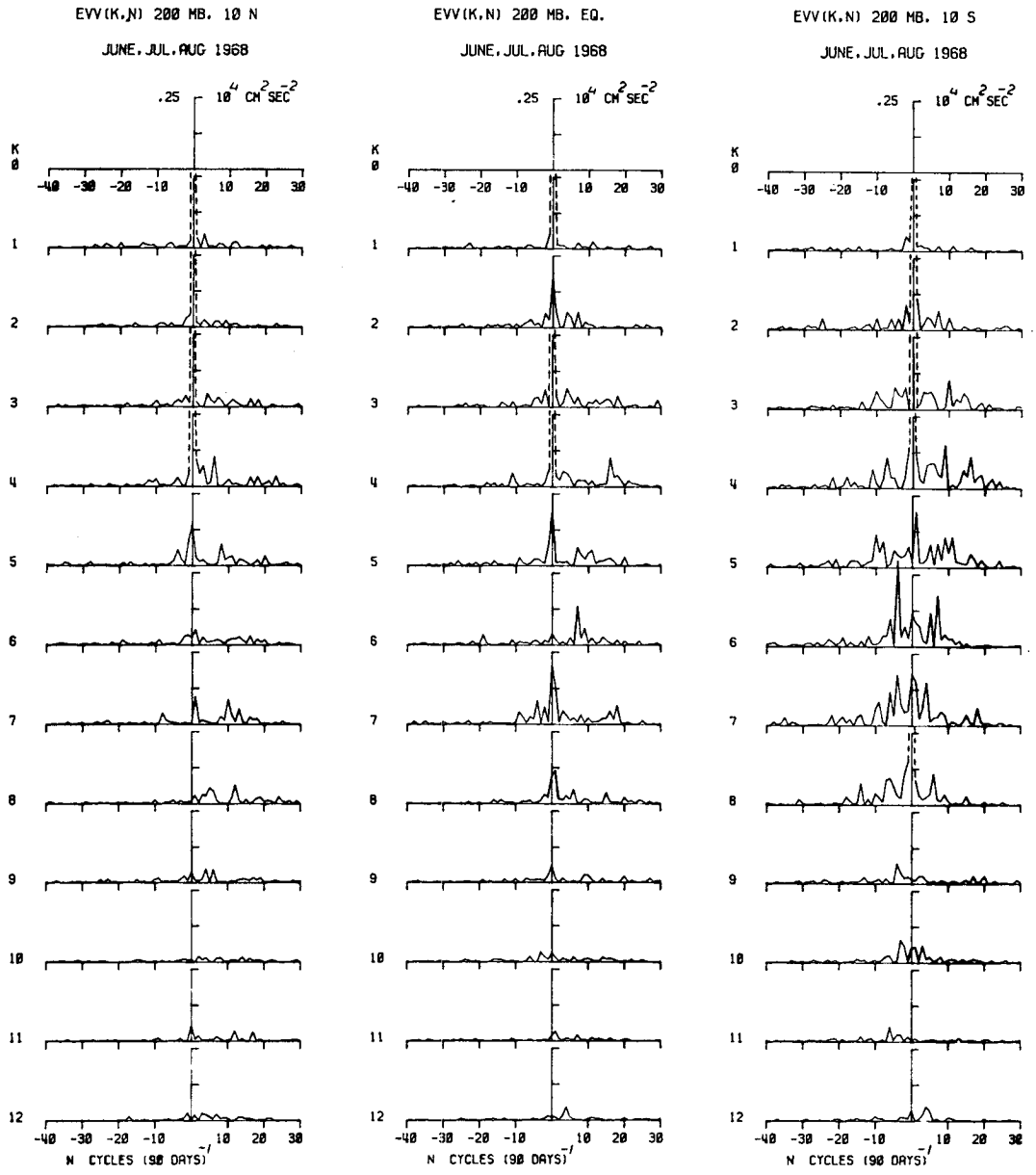

FIG. 4. Wavenumber-frequency spectra of the meridional component of velocity at 200 mb, summer 1968, for 10N, the equator, and 10S.

REFERENCES

Bedient, H., W. Collins and G. Dent, 1967: An observational tropical analysis system. *Mon. Wea. Rev.*, **95**, 942–949.

Kao, S. K., 1968: Governing equations and spectra for atmospheric motion and transports in frequency-wavenumber space. *J. Atmos. Sci.*, **25**, 32–38.

——, and L. L. Wendell, 1970: The kinetic energy of the large-scale atmospheric motion in wavenumber-frequency space: I. Northern hemisphere. *J. Atmos. Sci.*, **27**, 359–375.

——, R. L. Jenne and J. F. Sagendorf, 1970: The kinetic energy of the large-scale atmospheric motion in wavenumber-frequency space: II. Southern Hemisphere. *J. Atmos. Sci.*, **27**, 1008–1020.