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Atmospheric frequency spectra of short period fluctuations

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Accumulation of good quality data after the International Geophysical Year (1957-58) allows us to analyze statistical properties of meteorology in terms of wavenumber and/or frequency spectra. It is well known that in the free atmosphere, wavenumber (frequency) spectral shape is roughly proportional to a power of the wavenumber (frequency) (e.g. VanZandt 1982, Ecklund et al. 1985). This means that the spectra have a constant slope in the log-log plot. Recently, frequency spectra of surface meteorological parameters over a wide frequency range of 2 hours to 20 years in Japan and at Syowa Station in the Antarctic were examined. It was shown that frequency spectra have two different slopes with a transition frequency of several days (Sato and Hirasawa 2007; Tsuchiya et al. submitted). The spectral shape clearly varies as a function of latitude. Frequency spectra of the short period fluctuations of the surface pressure were examined using simulations with a global nonhydrostatic model (Nonhydrostatic Icosahedral Atmospheric Model, NICAM: Satoh et al. 2008). It was clear that spectral slopes are steeper than 3 at latitudes higher than about 30 degrees and are gentle at lower latitudes. In comparison with two simulations for different seasons, it was shown that the region with the gentle slope is extended into the summer hemisphere by about 10 degrees.

In this study, we analyzed frequency spectra with hourly data from simulations over 3 years by a gravity wave resolving Atmospheric Global Circulation Model (Watanabe et al. 2008). Spectral slopes of the sea level pressure fluctuations in the high frequency range (from $(2\ \text{days})^{-1}$ to $(6\ \text{hours})^{-1}$) is similar to these of NICAM data in terms of the latitudinal variation and seasonal dependence. The shape of the frequency spectra of the geopotential height, temperature, and wind speed fluctuations in the troposphere resemble those at the surface. The spectra in the stratosphere and mesosphere tend to have a constant slope, which is about 5/3, at frequencies higher than the inertial frequency, except for the temperature and wind speed spectra in the tropics and polar regions in the lower stratosphere.

Keywords: universal spectrum, mesosphere, stratosphere, troposphere