ON THE MODULATION OF DIURNAL MODES OF METEOROLOGICAL VARIABLES BY LOW-FREQUENCY PROCESSES

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The year and diurnal modes with frequencies Ω and ω_d respectively are the main natural periodic processes of meteorological quantities variability. Apart of them there are the modes of year cycle and synoptic periods in the power spectra of meteorological variables, and the considerable part of energy falls on periods between 10 and 50 days [1]. The research of interaction between diurnal modes and low-frequency variability is the object of the paper. The study is based on the spectral analysis applied to long time series of pressure, air temperature, wind speed components, absolutely humidity and cloudiness in the surface atmosphere layer. All time series are the surface measurements. The continuance of time series is about 44 year with 3 hour time step. Data on three stations of European Russia in middle latitudes were analyzed.

Researching of the fine structure of meteorological energetic spectra showed the existence of as diurnal period and its harmonics (12 and 8 hours). As it can be seen in Fig. 1 each of them including diurnal period has a few lateral maximums. On X-axis there are the harmonics numbers i shifted on I and related with frequency as $(i+I)/$. T is the continuance of the time set. I is equal 16000 for diurnal mode, 32000 for 12-hour mode and 48000 for 8-hour mode.

The frequency distance between central and lateral maximums is multiple the difference Ω - ω_d. For instance the first lateral maximums for diurnal mode fall on the periods 24.034 and 23.966 hours exactly. This is the point to the amplitude modulation of diurnal period in meteorological variables by their year cycle. The splitting of spectral lines of meteorological parameters varies for different meteorological parameters and their harmonics. The asymmetry in splitting of spectral lines can be seen, especially in pressure spectra. As a rule a left lateral maximum related with less frequency is more then right one.

The interaction can be described by multiplicative model which generates as averaged time series and its spectrum:

$$X(t) = (1+M\cos(\Omega t+\varphi)\ \{(1+m_1\cos\omega_d t)^2\ (1+m_2\sin\omega_d t)\sin\omega_d t\}.$$

Here $X(t)$ is the time series, t is the time, Ω и ω_d are yearly and diurnal frequencies, M, m_1, m_2 are modulation coefficients, φ is the phase; M, φ, m_1, m_2 are constants. Their approximate estimates were obtained from data sets. The accounting of half-yearly and other harmonics of year cycle in this formula would produce the multiple lateral maximums in the spectra.

The spectral analysis of temperature diurnal amplitude indicates that besides year modes there are other low-frequency components in the band of periods about 10-40 days. They are much less than year modes. However, some consistent patterns of interaction of diurnal cycle and low-frequency components can be seen in Fig.2 and Fig.3 where the power spectrum of temperature diurnal amplitude and the spectrum of coherency between diurnal temperature amplitude and original temperature set are given.

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References

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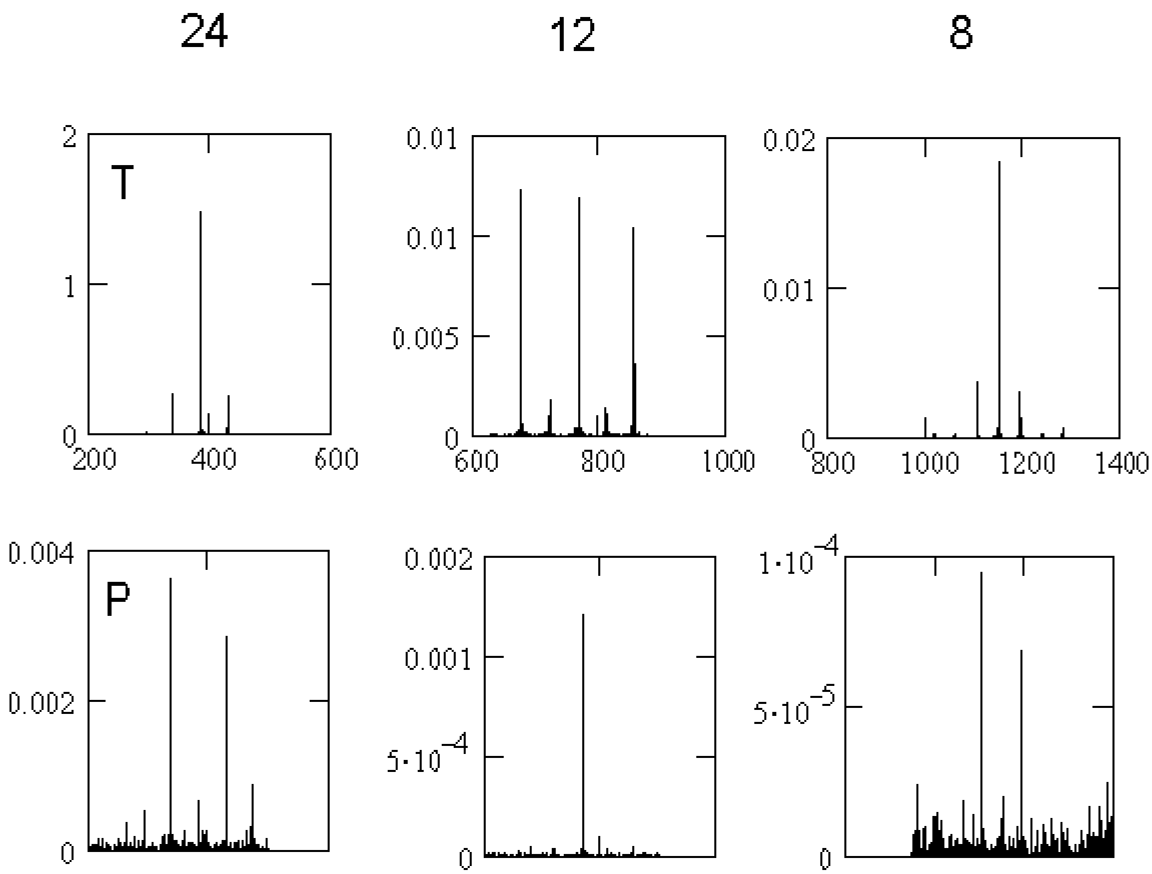

Fig.1. The power spectra for temperature (upper set) and pressure (lower set) for Moscow station. The modes 24, 12 and 8 hours are presented.

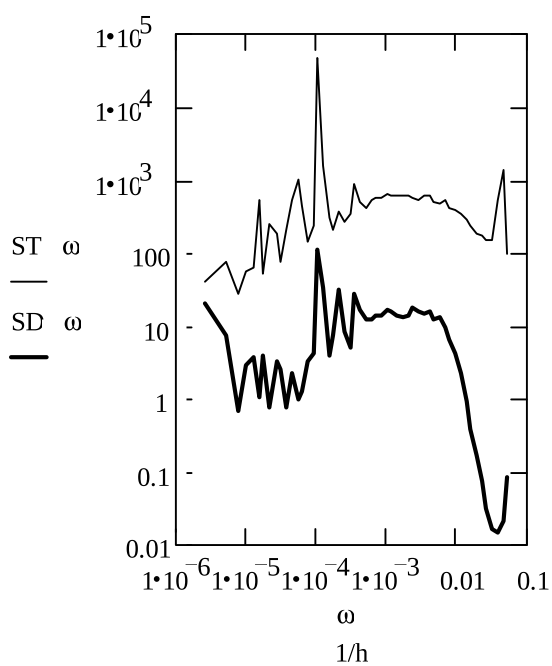

Fig.2. The power spectrum of original temperature time set (*ST*) and its diurnal amplitude (*SD*) for Moscow station.

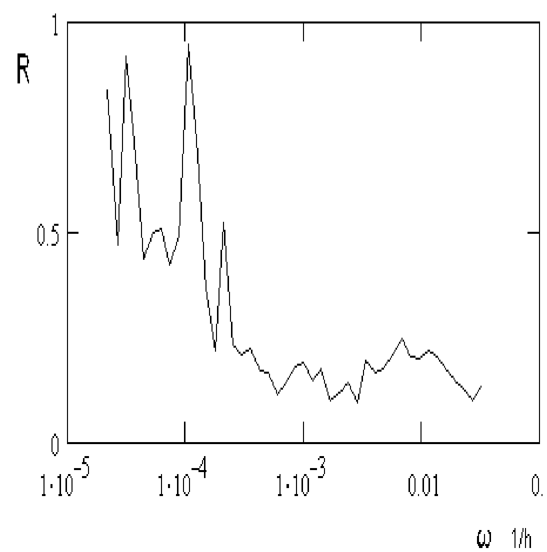

Fig.3. The spectrum of coherency between diurnal temperature amplitude and original temperature time set averaged on 3 stations.