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СПЕКТРАЛЬНЫЕ ХАРАКТЕРИСТИКИ ВРЕМЕННЫХ РЯДОВ ТЕМПЕРАТУРЫ, ПОЛУЧЕННЫХ В ЮЖНОМ БАЙКАЛЕ

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SPECTRAL CHARACTERISTICS OF TEMPERATURE TIME SETS MEASURED IN THE SOUTH BAIKAL

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В докладе представлены результаты изучения температурных временных рядов, измеренных в южной части озера Байкал. Натурные наблюдения проводились в точке установки Байкальского нейтринного телескопа, в 3.5 км от берега в районе мыса Ивановский. Данные измерений получены термисторами, установленными вертикально на расстоянии 50–200 м друг от друга. Мы сопоставляем спектральные характеристики на различных глубинах для изучения процессов вертикального переноса энергии. На глубинах менее 100 м наиболее интенсивные возмущения наблюдались в летний период. Типичное время распространения энергии через приповерхностную зону было порядка месяца. Вследствие особенностей летней стратификации поверхностные возбуждения практически не достигают глубинных слоев. Вместе с тем энергия, непрерывно диссипируя, очень медленно распространяется сквозь толщу озера. С другой стороны, уже аккумулированная глубинными водами энергия достигает придонной зоны довольно быстро с типичными скоростями распространения порядка сотни метров в неделю. На больших глубинах заметные возмущения наблюдаются в периоды, близкие по времени к моментам весенней и осенней гомотермии. При этом осенняя динамика отличается значительно большей интенсивностью.

We examine spectra of temperature data obtained in the southern basin of Lake Baikal. The place of monitoring lies near Baikal Neutrino Telescope. The mooring is located at distance 3.5 km from the shore in the area of Cape Ivanovskii. The temperatures have been recorded from the thermistors installed on vertical line with separation 50–200 m. There may be more than one way to fit the problem of analysis of temperature data. We discuss those evidences that can be got from the consideration of spectral characteristics. Especially, the processes of vertical energy propagation lie with our scope. For depths lesser than 100 m the most intensity of excitations takes place in a summer season. A typical time of propagation of excitation energy through near-surface zone is about month. Due to the features of summer stratification the above influence do not penetrates into deep water. Rather perturbations energy is very slowly transferred from the surface layer to deep layers. On the other hand, if excitations of deep waters already accumulate significant energy then their penetration through deep zone up to near-bottom zone goes enough quickly. A typical time of propagation is about hundred of meters per week. In the deep layers the considerable intensities of excitations take place in those periods that are close to spring and autumn homothermy. During and after autumn homothermy the total energy of excitations is very larger than in period of spring homothermy.

Lake Baikal is the largest reservoir of high-quality fresh water. A unique flora and fauna have been evolved in the Lake during several millions of years. Processes of horizontal and vertical water exchanges are of great importance for preservation of Lake Baikal ecosystem [1]. They supply all layers of the 1640 m deep lake with oxygen, redistribute soluted and suspended matter and prevent accumulation of toxins. At the same time, it is also interesting to study hydrophysical processes in Lake Baikal from the physical point of view. Due to specific geographical, meteorological and other factors, very different phenomena are developed in the lake. Their space-time scales range from fraction of millimeters and seconds up to several hundreds of kilometers and several years. Nevertheless, the dynamic processes of different scales are often closely related. The temperature regime of the lake is a key factor that influences on physical as well chemical and biological phenomenon in water medium.

In the present work the spectral characteristics of temperature time series obtained in the southern basin of Lake Baikal are considered. The place of monitoring lies near Baikal Neutrino Telescope [2]. The position of measurement devices is located at distance 3.5 km from the coast line in the area of Cape Ivanovskii. The temperature series have been recorded from the thermistors distributed on vertical line with separation 50–200 m. The renewal rate of the deep water is very important for the well-being of ecosystem of the lake [1]. This rate is significantly depended on the temperature conditions of the lake. Especially, the processes of vertical propagation of excitations energy lie with our scope.

We shall analyze those conclusions that can be obtained from the consideration of spectral characteristics. Let $T(\omega, h)$ denote Fourier-transform of time series of temperature at fixed depth h. Then the spectral density is defined as $S(\omega, h)=|T(\omega, h)|2$. Some approaches to estimation of space-time scales of dynamical processes demand that a concrete model of water displacement should be used [5]. We will utilize other approach in which the integral of spectral density is considered. Namely, let us introduce the quantity

$$J(t,h) = \int S(\omega,h)d\omega ,$$

where moment t is a center of sampling window. Indeed, in connection with the features of obtained data we cannot use any two- or three-dimensional models. On other hand, the integral of spectral density may be accepted as the marker of total energy of excitations in the concrete moment of time. The integral of spectral density $J(t,h)$ is really approximated by Cauchy sum. The lower and upper limits of summation are chosen for the following two reasons. First, a contribution of season evolution of temperature profile must be excluded. Second, the upper limit is bounded by the installed rate of response of thermistors. The dependences $J(t,h)$ on time for several depths in 2000 year are plotted on Figure. In the near-surface zone typical values of integral of spectral density is considerably larger than typical values in deep layers. In order to clarify the changes of $J(t,h)$ for large depths we use relative units along the ordinate. In other years we have observe analogous dependences.

We have comparatively examined the calculated values of $J(t,h)$. As a result, the following conclusions have been made. For depths lesser 100 m the most intensity of water perturbations takes place in the summer season. Apparently, this fact is a direct manifestation of power wind stress. As it is well known, strong storms in Lake Baikal often occur during August-September. A typical time of propagation of excitations energy through near-surface zone is about month. However, due to the features of summer stratification the above influence do not penetrates into deep water. Rather, perturbations energy is very slowly transported from the surface layer to deep layers.

In addition, if excitations of deep waters already accumulate considerable energy then their penetration through deep zone up to near-bottom zone occurs enough rapidly. A typical time of propagation is about week per hundred of meters. Of course, in the deep layers the considerable intensities of excitations take place in those periods that are close to the spring homothermy and the autumn homothermy. It should be emphasized that during and after the autumn homothermy the total energy of excitations is very larger than in period of spring homothermy. This peculiarity is well shown on Fig. 1. Apparently, this is a manifestation of the following well-known fact. That is, in deep temperate lakes only the surface water exhibits dimictic behavior [5]. On the contrary, the bottom waters are often monomictic. The obtained dependences $J(t,h)$ on time and depth do not contradict this remarkable peculiarity.

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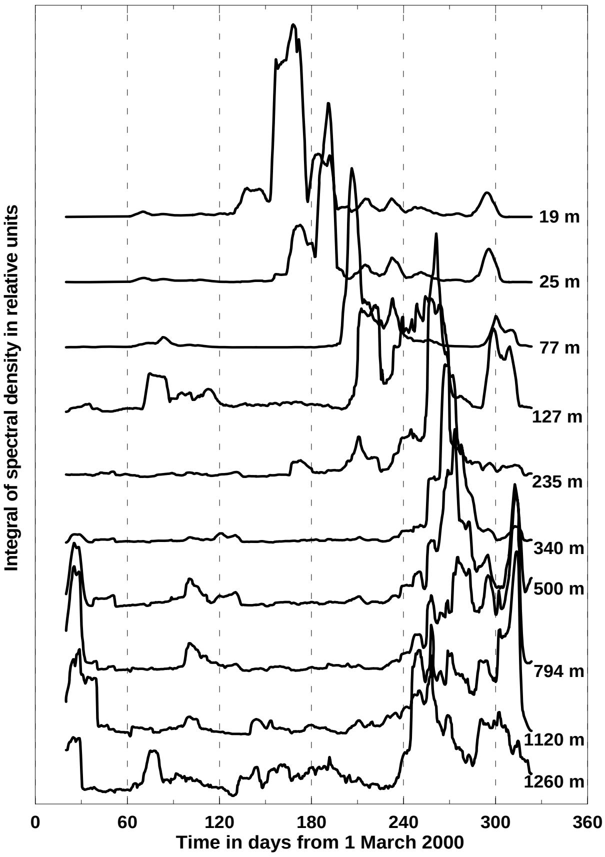

The calculated values of integral of spectral density versus time for several depths.

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