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Empirical Orthogonal Functions Analysis of Hydrophysical Characteristics in the Shira Lake in Southern Siberia

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Abstract : The method of empirical orthogonal functions is the method of data analysis with a complex spatial-temporal structure. This method allows us to decompose the data into a finite number of modes determined by empirically finding the eigenfunctions of data correlation matrix. The modes have different scales and can be associated with various physical processes. The empirical orthogonal function method has been widely used for the analysis of hydrophysical characteristics, for example, the analysis of sea surface temperatures in the Western North Atlantic, ocean surface currents in the North Carolina, the study of tropical wave disturbances etc. The method used in this study has been applied to the analysis of temperature and velocity measurements in saline Lake Shira (Southern Siberia, Russia). Shira is a shallow lake with the maximum depth of 25 m. The lake Shira can be considered as a closed water site because of it has one small river providing inflow and but it has no outflows. The main factor that causes the motion of fluid is variable wind flows. In summer the lake is strongly stratified by temperature and saline. Long-term measurements of the temperatures and currents were conducted at several points during summer 2014-2015. The temperature has been measured with an accuracy of 0.1 ºC. The data were analyzed using the empirical orthogonal function method in the real version. The first empirical eigenmode accounts for 70-80 % of the energy and can be interpreted as temperature distribution with a thermocline. A thermocline is a thermal layer where the temperature decreases rapidly from the mixed upper layer of the lake to much colder deep water. The higher order modes can be interpreted as oscillations induced by internal waves. The currents measurements were recorded using Acoustic Doppler Current Profilers 600 kHz and 1200 kHz. The data were analyzed using the empirical orthogonal function method in the complex version. The first empirical eigenmode accounts for about 40 % of the energy and corresponds to the Ekman spiral occurring in the case of a stationary homogeneous fluid. Other modes describe the effects associated with the stratification of fluids. The second and next empirical eigenmodes were associated with dynamical modes. These modes were obtained for a simplified model of inhomogeneous three-level fluid at a water site with a flat bottom.

Keywords : Ekman spiral, empirical orthogonal functions, data analysis, stratified fluid, thermocline
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