Typification of Diagrams of the Vertical Distribution of the Current Velocity in the Gulf of Finland (Baltic Sea)

Natalia A. Sukhikh 1, 2, Valentin A. Rozhkov 2
1 Arctic & Antarctic Research Institute (AARI), St. Petersburg, Russia
2 Saint-Petersburg State University, St. Petersburg, Russia

ABSTRACT

In 2008-2012 near cape Shepelevsky in the Gulf of Finland of Baltic Sea the series of synchronous measurements of current velocities were executed by using ADCP (Acoustic Doppler Current Profiler). To summarize the results of analysis of the long-term current velocities instrumental measurements a method of diagram typification was proposed, based on their expansion on vector orthogonal basis, depending on vertical coordinate with time-dependent scalar coefficient. The method was applied for the first time for processing current velocities vertical structures and gives much fuller information about the process considering vector peculiarities as opposed to previously used methods, describing only velocity modulus change. The paper is based on the results of the diploma work defended by Ms. Natalia A. Sukhikh in the Saint-Petersburg State University in 2014.

KEY WORDS: Current velocity; vector EOFs; morphological classification.

INTRODUCTION

In recent years in different parts of the World's Ocean the significant amount of data on synchronous measurements of current velocity three-component vector $\mathbf{U}(z, t)$ was accumulated by using ADCP (Acoustic Doppler Current Profiler) instrument on a series of horizons $z_i$, $i = 1, n$. In this paper data from the Doppler profiler bottom mooring near cape Shepelevsky in the Gulf of Finland (Baltic Sea) was used. Before that there were no current and hydrological parameters measurements in that region, therefore utilized data set is unique. The method of statistical analysis of such multidimensional information was considered in publications (Klevantsov et al., 2012; Klevantsov et al., 2013). To summarize the results obtained from using the above mentioned analysis method, one should resort to current velocities vertical distribution diagram typification depending on hydrometeorological conditions changes (synoptical variability) and time of year (seasonal variability).

The research (Klevantsov et al., 2013) demonstrates that near cape Shepelevsky (Gulf of Finland, Baltic Sea) the current’s vertical structure is typically three-layered (surface layer, bottom layer and intermediate layer), vertical component of velocity vector is significant only in small-scale variability range (from several minutes to one hour), upon raw data smoothing (for each 60 minutes) synoptical variability reveals as both flow intensity and flow direction, seasonal variability of water body flow is significant.

Vector orthogonal functions for solution of classification problem were not previously applied. It was shown that the proposed approach gives convincing results to confirm the suggested hypothesis of three-layered flow (velocity increase in the surface layer, parameter stabilization in the intermediate layer, presence of small gradients in the bottom layer) in the studied area and find further application in vector hydrometeorological processes probabilistic modeling.

DATA USED

The information about sea currents velocity vector that was used in this paper was acquired by using the ADCP (Acoustic Doppler Current Profiler). The instrument was installed at a depth of 19.5 m. The measurements were taken once a minute, the size of profile cell was 1.5 m (11 measurement layers). An analysis of 27 time segments of 2010-2012 lasting 8-15 days each was introduced in this paper. Such segmentation helps examining data both in synoptical and seasonal variation range.

METHODS USED

For affine vectors and a system of random scalar processes the method of their vertical structure typification are well-established by the example of sea water temperature, salinity and density (Belkin, 1991; Bukhanovskiy et al., 2002; Hjelmervik and Hjelmervik, 2013). For Euclidean vectors $\mathbf{U}(z, t)$ the specificity is considered in this paper by the example of current velocity analysis using ADCP instrument in the Gulf of Finland (Baltic Sea) (fig. 1).

In this paper the following assumptions were adopted: