LONG-TERM CHANGES IN DEEP ADRIATIC WATER MASSES OBTAINED BY SELF-ORGANISING MAP ANALYSIS

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Abstract

A novel approach in detecting and determining water mass changes is documented in the paper, based on a Self-Organising Maps (SOM) method. We used the method to extract and classify long-term variability (1957-2009) of temperature, salinity, dissolved oxygen and nutrients at a single station in the deep South Adriatic Pit. The extracted vertical profile patterns and their variability are associated with the known Adriatic water masses. We also tested the capacity of the method to recognize the masses by changing the dimensions of SOM nodes and by varying the number of input parameters.

Keywords: Adriatic Sea, Deep Waters, Time Series

Adriatic water masses are known to play an important role in ventilation of deep layers of the Eastern Mediterranean, and the South Adriatic Pit (SAP) is recognized as a place where most of the deep waters are formed [1] inside of a cyclonic gyre. The formation can be enhanced or modified by other masses [2]: (i) very cold North Adriatic Dense Water, which is turbulently sinking along the western SAP perimeter, and filling the deepest layers of the pit, and (ii) saline Levantine Intermediate Water (LIW) which is coming into the Adriatic through the Otranto Strait and preconditioning the generation of the Adriatic water masses. There are several studies describing a long-term variability and interplay between the Adriatic water masses [2, 3]. This paper will document the use of a state-of-the-art method for extraction of patterns from time series, the Self-Organising Maps (SOM) method, and its application to the long-term series of thermohaline and chemical parameters in the South Adriatic. We analysed the series of temperature (T), salinity (S), dissolved oxygen (DO), ortophosphate (HPO_4^{2-}) and total inorganic nitrogen (TIN) concentrations measured at the D1200 station (42°13'N, 17°42'E) located in the nortern SAP in the 1957-2009 period. These series have been quality checked for bad values, offsets and spikes, normalized by standard deviation and mean value of each parameter, and introduced to SOM.

SOM is an artificial neural network based on unsupervised learning [4]. It consists of a nonlinear cluster analysis mapping of high-dimensional input data onto a two-dimensional output space. The gaps in the input data are treated by the method, allowing SOM to effectively extract patterns from large data sets. Thus, the SOM method has been widely used in various fields of studies ranging from economics to sciences, including oceanography [5]. In this analysis we used 2x3 SOM arrays, which allows for the detailed extraction of the characteristic water profiles, but we also tested the sensitivity of the method by applying 2x2 and 3x3 SOM arrays to the data. Sensitivity to the input variables has been tested as well, by introducing different groups of parameters to SOM (all, without TIN, without HPO_4^{2-}, without DO, without nutrients, only T and S) and assessing the variations of characteristic patterns and Best Matching Unit (BMU) evolution in time. BMU is the number of the SOM solution that can be identified according to the minimum Euclidian distance between certain input data field and all SOM solutions.

Figure 1 plots the profiles of 2x3 SOM BMUs for all parameters. The profiles adequately resemble the Adriatic water masses. The resemblance is the most obvious for the salinity BMU profiles. For example, BMU1 can be associated to a strong LIW inflow to the Adriatic, as it is characterised by very high salinity, low DO and high nutrients in the intermediate layer. The generation of the Adriatic Deep Water (ADW) may be seen in BMU2 and BMU4, as these patterns are characterised by vertical homogeneity between 200 and 600 m. Temporal evolution of the BMU in time (not shown) depicts the variations of water masses in the area. For example, BMU1 is appearing around 1970, 1980, late 1980s and mid 2000s, when LIW intrusions have been detected [2]. However, some additional changes in BMU patterns and their temporal evolution are obtained when restricting the input variables to T, S and DO, and especially when using only T and S in the analyses.

The results highlight the advantageousness of the SOM for water mass assessment, as objective classification may be made for an area. Therefore, the method may be used for objective classification of the overall Adriatic masses, and may introduce new insights in our knowledge of existing water mass definitions, especially when including chemical parameters in such an analysis.

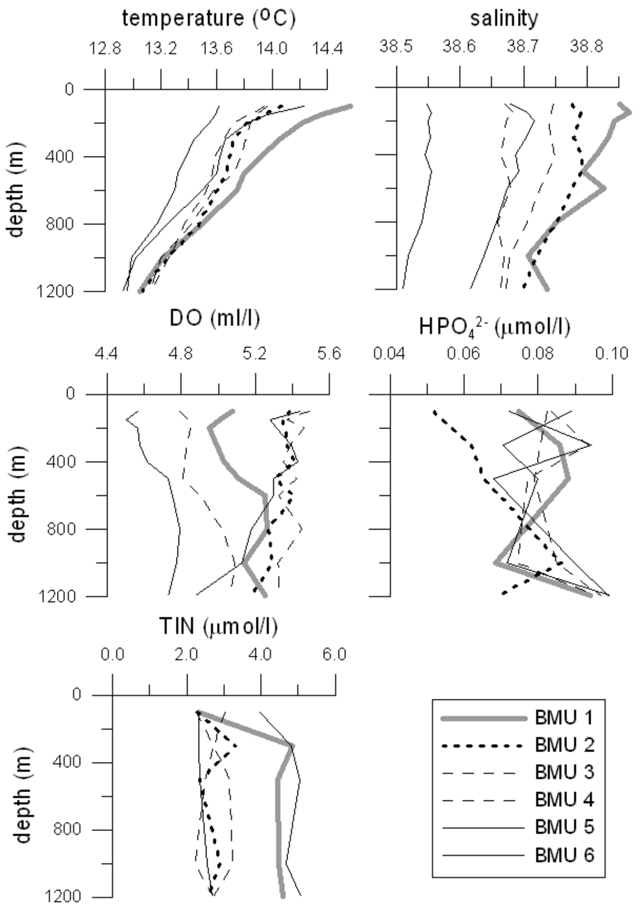

Fig. 1. Characteristic profiles (BMU1 to BMU6) of termohaline and chemical parameters as extracted by the 2x3 SOM from the data collected at D1200 station between 1957 and 2009.

References

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