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Detection of the climatic signals propagated across Nolso-Flugga line by means of objective and cluster analysis

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Oceanographic measurements started in 1896 along sections in the Faroe- Shetland Strait (FSS) represent one of the longest instrumental time series in the World Ocean. The sections position is of great importance for monitoring of exchanges between North Atlantic and the Nordic Seas and ocean climate change detection. Presence of waters masses with different origin, complicated circulation in the strait, strong vertical and horizontal gradient zones, mesoscale rings and meanders and seasonal transformations hamper identification of the long-term variability of oceanographic variables. Therefore identifying of long-term variability requires separation of spatial and temporal variability. We have developed an algorithm based on joint use of both objective and cluster analysis of the oceanographic fields along a section. The methodology was applied to the Nolso-Flugga line (NFL), one of the standard sections in the FSS with most complete temporal coverage. Initial dataset for NFL was collected from all available data sources including AARI surveys and comprises of total 543 surveys of the section for 1896- 2006. Both station number and their position is not uniform for each individual survey therefore coordinates of the fixed (most frequently occupied) stations were defined by cluster analysis. Eleven fixed stations were identified with coordinates derived from the centers of isolated clusters. Two-dimensional interpolation grid net for objective analysis was established by adding grids between fixed stations with depth dependent vertical resolution ranged from 5 to 50m. Kriging

algorithm was used to compute objectively analyzed (OA) fields for each collected section with different properties of variogram above and below 400m assuming two layer model of water mass vertical structure. Sequence of the OA fields can be used for variables and their anomalies composite analysis. Subsequent cluster analysis of the OA fields allows water mass structure definition for individual or for mean fields. Two kinds of time series contraction inside distinguished water types is possible - for each individual section and for mean fields. In first case an averaging inside a water mass core was performed by taking into account spatial migration of the core. In second case only mean fields classification is needed but with additional fields of variables standard deviations. Mean parameters represent water types structure while standard deviations introduce temporal component of variability for the selected period. Both characteristic are essential for a water mass definition. We present time series constructed from mean fields with four classification parameters - temperature, salinity and their standard deviations. Seasonal and interannual variations of temperature and salinity are discussed. Most remarkable event is that the strong warming and salinity increase in the surface and subsurface layer during the late 1960s- early 1970s were more pronounced than early warming event of the 1930s-1940s. It can be attributed to the increased advection of the AW through FSS and reduction in air-sea exchange. It is supported by Torshavn' and OWS 'Mike' surface air temperature time series. Since 2000, upper layer conditions in the FSS are characterized by strong temperature and salinity increase similar to the 1960s event. Because of temperature dominant contribution on density the strong negative density anomaly was formed and propagated to the Arctic with substantial affect on vertical exchange and ecosystems in the Nordic Seas. The developed methodology of climate signals detection can be used for any sequence of repeated standard sections.