Black Sea Temperature and Salinity climatologies computed with DIVAnd tool

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General description

The Black Sea (including Sea of Azov) Temperature (T) and Salinity (S) gridded climatologies for the period 1955 – 2017 were created in the framework of the SeaDataCloud (SDC) project from in situ observations extracted from 3 major sources: 1) SeaDataNet infrastructure, 2) World Ocean Database (Boyer et al., 2018), and 3) COriolis Ocean Dataset for Reanalysis (Szekely et al., 2016). Computing was performed with DIVAnd (Data-Interpolating Variational Analysis - n-dimensional) (Barth et al., 2014) on the following grid: geographical extent 27.5 - 41.875°E, 40.875 - 47.25°N; horizontal resolution: 1/8°; vertical resolution: 67 depth levels from 0 to 2000 m - same as in World Ocean Atlas (WOA, 2018).

The data product SDC_BLS_CLIM_TS_V1 (https://doi.org/10.12770/ad2d0efc-7191-4949-8092-796397106290) is published at the SeaDataNet web site along with the Product Information Document (https://doi.org/10.13155/61812). The product contains:

- monthly T and S fields for the periods 1955 – 2017, 1955 – 1994, and 1995 – 2017;
- seasonal fields for 6 decades starting from 1955 and for the same 3 periods as monthly.

Observational data

The input dataset for the computation of the Black Sea T and S climatological fields was integrated from two internal SDC datasets and two external datasets:

1. SDC Temperature and Salinity Historical Data Collection for the Black Sea (Version 1) – product SDC_BLS_DATA_TS_V1 (Myroshnychenko et al., 2018).
2. SDC Restricted Temperature and Salinity Historical Data Collection for the Black Sea.
3. Data extracted from the World Ocean Database 2018 - WOD18.
4. Data extracted from the COriolis Ocean Dataset for Reanalysis - CORA 5.1.

The quality controlled (QC-ed) SDC datasets were taken as primary. Data integration was performed through the following steps: excluding internal duplicates; identifying and excluding overlapping data; applying additional QC to non-overlapping data from external datasets; merging non-overlapping data; excluding climatically non-relevant data, i.e. those acquired in river estuaries or in adjacent lakes (called “limans” in Black Sea region).

Table 1: Content of the input dataset

	SDC_BLS_DATA_TS_V1	SDC restricted	WOD18	CORA 5.1	Total
# of stations	130466	10285	48227	57847	246825
	53%	4%	20%	23%	

CORA dataset mainly supplied the underway data. They are distributed irregularly in time and space and further were heavily subsampled in order to eliminate “trajectories effect” from climatic fields.

Methodology

Computation was done with DIVAnd tool implemented in the Julia programming language with a Jupyter notebook interface. DIVAnd allows the interpolation of observations onto orthogonal grids in an arbitrary high dimensional space by minimizing a cost function. The fields produced with DIVAnd are the results of 3D (or 4D if time is considered) interpolation and this is the innovation and also the main difference of SDC T-S climatologies from similar products (e.g. WOA), where 3D fields are combined from 2D slices.

Table 2: DIVAnd settings

DIVA parameter	Background field		Climatology	
	T	S	T	S
Horizontal correlation length (km)	200	200	150	150
Vertical correlation length [m]	depth dependent for 67 levels			
epsilon2	0.5	0.1	0.3	0.1
epsilon2 adjustment	With weights of the observations			

In the first iteration, the residuals obtained with DIVAnd for global (1955 – 2017) monthly fields were analysed against Three-Sigma criteria, the outliers were discarded, the second iteration was run to obtain the final fields.

Results

The Black Sea T and S climatological fields well represent Black Sea oceanographic and circulation features (Oguz et al., 1993) as well as their seasonal variability. For example, the inflow of rivers fresh water and its propagation is well visible in surface salinity field all over the year but mostly in spring months, while the Black Sea Rim Current, Batumi eddy, Bosporus plume are more pronounced in 70-130m layer (Figure **1**).

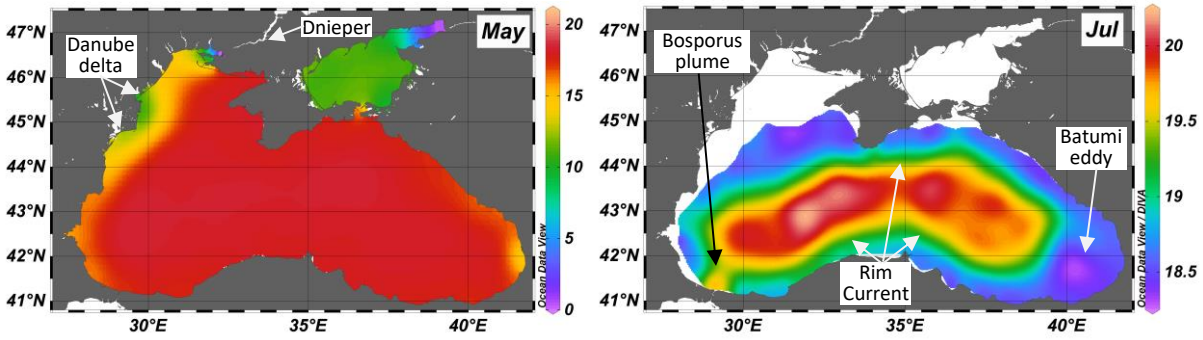

Figure 1: (left panel) Surface Salinity and (right panel) Salinity at 70 m (DIVAnd analysis for 1955-2017)

Despite overall good quality of the climatological fields there are known issues such as: anomalies in some decadal fields – mainly due to scarcity of data; anomalies in upper layer (DIVAnd issue that later was resolved in new version of the software); violation of vertical stability in some T-S profiles that are combined from separately calculated fields.

A consistency analysis was performed against WOA18 climatological fields (objectively analysed means) available at a 1/4° resolution. Most of the differences between the two products are observed in the upper 300 m layer. The WOA18 maps are smoother and do not capture some important Black Sea features (e.g. Batumi eddy, Bosporus plume), while SDC maps, even noisy, are more realistic.

Conclusions

The SDC Black Sea Temperature and Salinity climatologies are computed from the most complete dataset combining in-situ data from the tree major data sources – SeaDataNet, WOD, and CORA. Performing real 3-d interpolation with DIVAnd allowed us to obtain realistic climatological fields however with some known issues, which will be addressed in next release of the product.

References

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