EMODNET PRELIMINARY HIGH-RESOLUTION TEMPERATURE AND SALINITY CLIMATOLOGIES FOR THE NORTHERN ADRIATIC SEA

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Abstract

The proposed study, conducted in the framework of EMODnet - Physics, presents a preliminary high resolution climatology of temperature and salinity for the Northern Adriatic Sea. The input data are co-located temperature and salinity profiles integrated from SeaDataCloud (Simoncelli *et al.*, 2020a and 2020b) and CORA5.2 (Szekely *et al.*, 2019) historical datasets. The analysis was performed with the DIVAnd software (Data-Interpolating Variational Analysis in n dimensions, Barth *et al.*, 2014) version 2.6.1.

Monthly and seasonal fields are calculated for the periods 1955-2016, 1955-1984 and 1985-2016, while seasonal fields are provided for 6 decades from 1955 to 2016. The climatological fields are computed on a regular grid of 3 km of horizontal resolution on 11 vertical layers.

The preliminary results show a significant impact of horizontal resolution on the detection of small scale patterns of temperature and salinity fields, but they also outline criticalities due to both spatial and temporal data gaps in particular along the Croatian coast and in the last decade.

Further developments will consider the integration of other datasets in order to reduce such gaps and to increase the resolution of the climatological products.

Keywords: Northern Adriatic Sea, high resolution climatologies, EMODnet, DIVAnd

1. Introduction

The Northern Adriatic Sea is an area of strong influence of river waters, a so-called ROFI (Region Of Freshwater Influence, Sanchez-Arcilla and Simpson, 2002), typically linked to the hydrological activity of the Po river and of the main river courses that flow into the same basin. Wind is the other main driver of the circulation, which also characterizes the spreading of the river plume within the basin (Kourafalou, 1999).

Preliminary temperature and salinity monthly and seasonal high resolution climatologies have been produced for the Northern Adriatic Sea within the framework of EMODnet – Physics. The climatological fields are provided on a regular grid with a horizontal resolution of 1/36° (3 km approximately) and 11 equally spaced layers (with a vertical resolution of 5m) from the surface down to 50 m depth. Deepest layers were not considered because the measurements are too scarce at depth and it makes it difficult to produce a robust climatology.

Temperature and salinity co-located profiles with Quality Flags (QF) 1 (good) and 2 (probably good) have been extracted for the Northern Adriatic Sea from a merged data collection for the climatologies generation.

The fine resolution in the horizontal should allow to detect the small scale patterns of temperature and salinity that appear in Spring and Summer seasons as a consequence of the increased baroclinic dynamics in the basin (Artegiani *et al.*, 1997b). The high vertical resolution should allow to better resolve the seasonal thermal cycle which characterizes the entire water column, as well as the seasonal stratification due to the fluctuations in freshwater discharge into the basin (Artegiani *et al.*, 1997a).

2. Methodology

2.1 Input data set

The source data set (hereafter SDC-CORA5.2) used for the production of the Northern Adriatic Sea climatologies derives from the integration of two different data sets: the SDC_MED_DATA_TS_V2 data set (Simoncelli *et al.*, 2020a), which has been obtained from the measurements contained within the SeaDataNet infrastructure and the CORA5.2 data set (Szekely *et al.*, 2019). Duplicate check has been performed, looking for 'quasi-perfect' duplicates within a coordinate interval of 0.0001deg (~11m) and a temporal interval of 0.0069 days (10 minutes). The SDC version of the duplicate data has been retained in the final dataset, meaning that only complementary CORA5.2 stations to SDC ones are displayed in the following statistics.

Data have undergone additional quality control (QC) through visual inspection using OceanDataView (described in details in Simoncelli *et al.*, 2020b), including range check, identification of outliers, stations falling on land and anomalous values flagged as good but visibly wrong. This additional QC was meant to guarantee the consistency among data coming from different sources that also went through different processing. Afterwards, the data have been interpolated on WOA18 (Boyer *et al.*, 2018) standard layers; extrapolation has been applied to observations with depth shallower than 1.5 m, which have been aggregated to the surface observations. In case of difference between the depth of an observation and the depth of the standard layer smaller than the 10% of the layer thickness, the observation has been assigned to the next standard layer.

The monthly and the annual temporal distribution of stations available in the SDC-CORA5.2 integrated data set over the time period 1955 – 2016 for the depth range 0 – 50 m is presented in Figure 1, along with the decadal spatial distribution. The data distributions show a surprisingly low number of data especially in the last decade, coinciding with the Argo data era. They are almost absent along the eastern coastal strip. Moreover, CORA5.2 provides very few additional data over the last two decades. Both considered data sources do not contain measurements later than 2016.

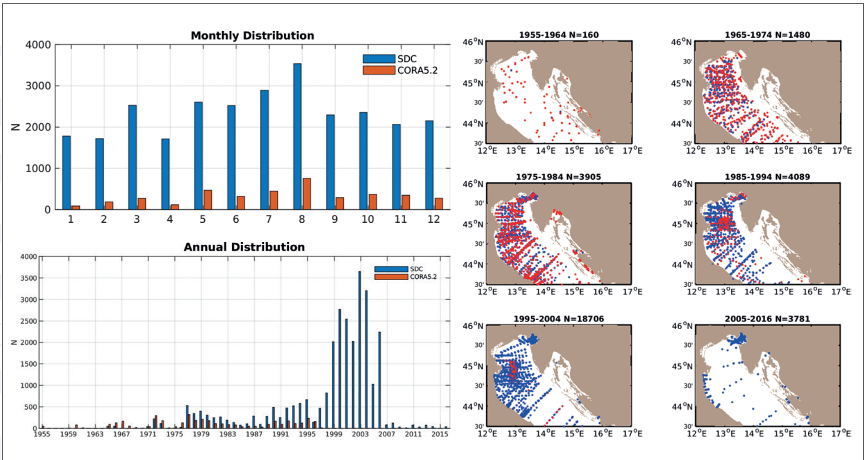

Fig. 1. Spatial and temporal distribution of stations in the SDC-CORA5.2 integrated dataset over the time period 1955-2016 for the depth range 0-50 m: (top-left panel) monthly distribution, (bottom-left panel) annual distribution and (right panel) decadal distribution. Blue indicates SDC stations and red denotes CORA5.2 ones.

2.2 DIVAnd implementation and settings

The Northern Adriatic Sea climatologies (NASC V1) have been produced using DIVAnd, version 2.6.1 (Barth *et al.*, 2014), which allows the interpolation of sparse observations onto regular grids by minimizing a cost function, for the area 11.50-16oE of longitude and 43.50-46.20oN of latitude.

The analysis topography (Figure 2) has been produced from the GEBCO_2019 Grid bathymetry (GEBCO Compilation Group, 2019), which has a 15 arc-second horizontal resolution. Some manual adjustments have been performed for the Croatian islands, due to the bathymetry interpolation onto a lower resolution computational grid.

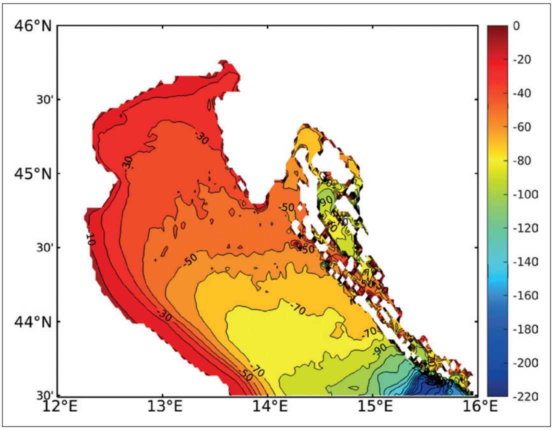

Fig. 2. GEBCO_2019 Grid bathymetry for the Northern Adriatic Sea interpolated onto the NASC computational grid.

The temporal resolution is both monthly and seasonal for the periods 1955 – 2016, 1955 – 1984, 1985 – 2016, while it is seasonal for the decades 1955 – 1964, 1965 – 1974, 1975 – 1984, 1985 – 1994, 1995 – 2004, 2005 - 2016. Winter is defined as January to March, Spring as April to June, Summer as July to September and Autumn as October to December.

A background field has been defined with a large horizontal correlation length (L) set equal to 2°, which represents the large scale spatial trend field. Salinity background is annual, while temperature background is monthly, computed considering a sliding three-month window. Three background fields with different time coverage have been used: 1955 – 2016, 1955 – 1984 and 1985 – 2016.

A tuning of horizontal correlation length *(L)* and error variance of the observations normalized by the error variance of the background field *(epsilon2)* parameters has been performed in order to find a reliable balance between the minimization of residuals and the smoothness of the climatological fields produced. The vertical correlation length has been set equal to 0, so that 2D interpolation for each layer of the grid is performed, being the 3D climatological fields produced by a combination of 2D slices. The DIVAnd settings for both the background fields and the analyses are summarized in Table I. The climatologies have been produced through an iterative process which computes the residuals first and then re-run the analysis excluding the observations with residuals larger than two standard deviations from the mean of the residuals population.

Table I. DIVAnd settings for temperature and salinity background fields and analyses: *L* is the horizontal correlation length.

	T BACKGROUND	T ANALYSIS	S BACKGROUND	S ANALYSIS
L [°]	2	0.5	2	0.5
epsilon2	12	1	12	1
Background	monthly	-	annual	-

3. Results

A consistency analysis has been performed to validate the first NASC results with respect to consolidated products for the considered domain: the first benchmark product is the SeaDataNet2 climatology (SDN2 V1.1, Simoncelli *et al.*, 2015); the second product is the SeaDataCloud climatology (SDC_MED_CLIM_TS_V2, hereafter shortened to SDC V2, Simoncelli *et al.*, 2020b). The different time coverage and the different settings of the three products (Table II) should be taken into account in the intercomparison.

Table II. Summary of SDN2 V1.1, SDC V2 and NASC V1 products properties.

	SDN2 V1.1	SDC V2	NASC V1
Time coverage	1900-2013	1955-2018	1955-2016
Horizontal resolution	1/8°	1/8°	1/36°
Vertical resolution	33 iode levels	92 WOA levels	11 WOA levels
Interpolation tool	DIVA 4.6.9	DIVAnd 2.6.1	DIVAnd 2.6.1
Horizontal correlation length	2° analysis 10° background	2° analysis 5.5° background	0,5° analysis 2° background

As an example, January and May temperature and salinity climatological fields over the whole coverage period for the three products are presented in Figure 3, both at the surface and at 30 m depth.

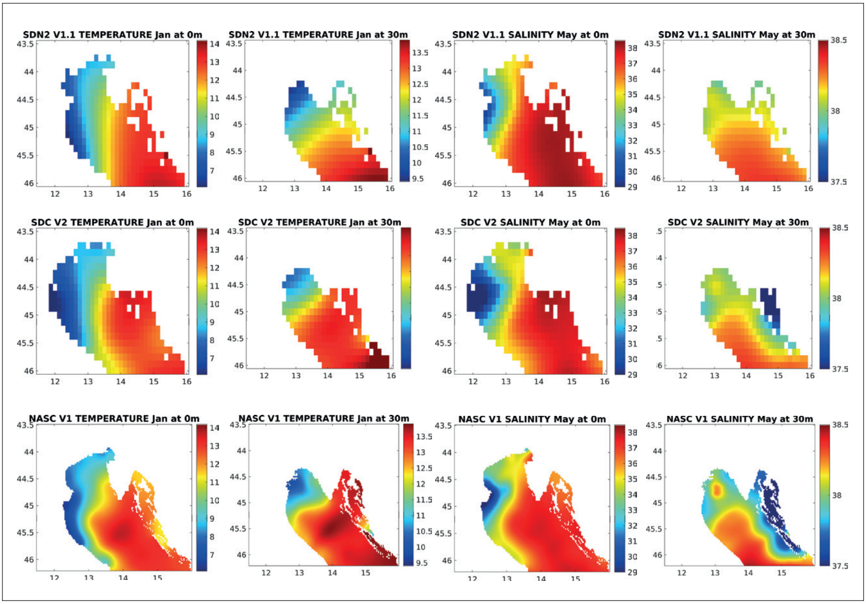

Fig. 3. 2D maps for temperature and salinity climatological fields:(top row) SDN2 V1.1, (middle row) SDC V2, (bottom row) NASC V1. Each column represents a different combination of month and depth, from left to right: January at the surface, January at 30 m, May at the surface, May at 30 m. The color palette varies per column.

The NASC shows a good agreement with the considered benchmark products for the sample climatological fields presented in Figure 3. The small scale structures become apparent due to the higher resolution of the NASC grid. Moreover, the Po river plume is better resolved showing a more realistic southward extension and a more realistic horizontal temperature and salinity gradient from the coast towards the interior of the basin. This is also due to the smaller horizontal correlation length used for DIVAnd setup with respect to the SDN2 V1.1 and SDC V2 products, whose target domain is the entire Mediterranean Sea basin.

4. Conclusions

Preliminary temperature and salinity monthly and seasonal high resolution climatologies have been produced for the Northern Adriatic Sea, starting from an integrated SDC-CORA5.2 data set. The NASC shows a good compliance with reference climatological products designed for the Mediterranean Sea, highlighting a more realistic topography and representation of small scale patterns, like the Po river plume, with respect to the lowest resolution climatological fields.

Nonetheless, some critical issues that decrease the reliability of the climatological product should be highlighted: the data gaps along the Croatian coast for the entire considered period, the very small number of available co-located profiles in the first decade (1955-1964), the rather small number and the uneven distribution of available observations for the last considered decade (2005-2016).

Additionally, it is important to outline the lack of measurements later than 2016.

In order to improve the quality of NASC product, additional data sources are needed and will be investigated to complement the delay mode SDC-CORA5.2 data set. The study also highlighted the critical importance of the ingestion and easy open accessibility of more existing coastal data as well as in the open and deepest sea.

More data will allow to increase the number of vertical levels and to extend the analysis at depths greater than 50 m, as well as to investigate the possibility to increase the horizontal resolution of the product. Finally, sensitivity tests with monthly salinity background will be performed to replace the annual background firstly adopted to mimic the DIVAnd setup of consolidated products which is more suitable for a ROFI region.

Acknowledgements

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