PAN-EUROPEAN INFRASTRUCTURE FOR OCEAN & MARINE DATA MANAGEMENT

Regional Climatologies

WP10 THIRD YEAR REPORT – DELIVERABLE D10.3

Project Acronym : SeaDataNet II
Project Full Title : SeaDataNet II: Pan-European infrastructure for ocean and marine data management
Grant Agreement Number : 283607

Deliverable number	Short Title
D10.3	Regional Climatologies
Long title	
First Release of Regional Climatologies	
Short description	
This document describes the temperature and salinity climatologies computed from the first version of the SeaDataNet aggregated data set. The climatologies are computed for the 6 sea basins: Mediterranean Sea, Black Sea, Arctic Sea, Baltic Sea, North Sea and North Atlantic Ocean.	
Author	Working group
S. Simoncelli, C. Coatanoan, V. Myroshnychenko, H. Sagen, Ö. Bäck, S. Scory, A. Grandi, A. Barth, M. Fichaut	WP10

History

Version	Authors	Date	Comments
1.0	S. Simoncelli	18/03/2015	Creation
1.1	C. Coatanoan, V. Myroshnychenko, H. Sagen, Ö. Bäck, S. Scory	03/04/2015	Regional reports
1.2	M. Fichaut	28/04/2015	Edits
1.3	S. Simoncelli, M. Fichaut	29/04/2015	Edits

Table of contents

1. INTRODUCTION 9
2. Mediterranean Sea Climatology 11
  2.1. Methodology 11
  2.2. Temperature Maps 12
  2.3. Salinity Maps 14
  2.4. Climatology validation 16
3. Black Sea Climatology 22
  3.1. Methodology 22
  3.2. Temperature Maps 24
  3.3. Salinity Maps 28
  3.4. Climatology validation 30
4. Arctic Sea Climatology 34
  4.1. Methodology 34
  4.2. Temperature Maps 34
  4.3. Salinity Maps 36
  4.4. Climatology validation 37
5. Baltic Sea Climatology 38
  5.1. Methodology 38
  5.2. Temperature Maps 39
  5.3. Salinity Maps 41
  5.4. Climatology validation 42
6. North Sea Climatology 44
  6.1. Methodology 44
  6.2. Temperature Maps 46
    6.2.1. Note on the datasets 46
    6.2.2. Winter 49
    6.2.3. Spring 49
    6.2.4. Summer 50
    6.2.5. Fall 51
    6.2.6. Seasonal climatologies at depth=100m 51
  6.3. Salinity Maps 52
    6.3.1. Winter 52

6.3.2. Spring 53
6.3.3. Summer 54
6.3.4. Fall 55
6.3.5. Seasonal climatologies at depth=100m 55
6.4. Climatology validation 56
6.4.1. Temperature 56
6.4.2. Salinity 57
7. North Atlantic Ocean Climatology 59
7.1. Methodology 59
7.2. Temperature Maps 61
7.3. Salinity Maps 63
7.4. Climatology validation 64
7.4.1. Comparison done with the world ocean atlas climatology (WOA2013) 64
7.4.2. Comparison with ISAS method (LPO, Ifremer) 65
7.4.3. Comparison with Coriolis maps (ISAS method, Ifremer): 66
8. Conclusions and Future Work 67
References 67

List of Figures

Figure 1 Finite elements grid used for the Mediterranean Sea climatology computation. 11
Figure 2 Surface temperature climatology computed in (a) January; (b) April; (c) July; (d) October. 13
Figure 3 Temperature climatology at 50m: (a) January; (b) April; (c) July; (d) October. 13
Figure 4 Temperature climatology at 250m: (a) January; (b) April; (c) July; (d) October. 14
Figure 5 Seasonal salinity climatology at the surface: (a) January-February-March; (b) April-May-June; (c) July-August-September; (d) October-November-December. 15
Figure 6 Seasonal salinity climatology at 50m: (a) January-February-March; (b) April-May-June; (c) July-August-September; (d) October-November-December. 15
Figure 7 Seasonal salinity climatology at 250m: (a) January-February-March; (b) April-May-June; (c) July-August-September; (d) October-November-December. 16
Figure 8 Seasonal salinity climatology at 500m: (a) January-February-March; (b) April-May-June; (c) July-August-September; (d) October-November-December. 16
Figure 9 Temperature maps at the surface: (top left) WOA13 January; (bottom left) SDN January; (top right) WOA13 April; (bottom right) SDN April. 17
Figure 10 Temperature maps at the surface: (top left) WOA13 July; (bottom left) SDN July; (top right) WOA13 October; (bottom right) SDN October. 18
Figure 11 Basin monthly averages of BIAS and RMSE computed between temperature SDN climatology and WOA13. 18
Figure 12 Temperature hovmoller plots: (a) BIAS; (b) RMSE; (c) correlation coefficient 19
Figure 13 Salinity maps at the surface: (top left) WOA13 winter; (bottom left) SDN winter; (top right) WOA13 spring; (bottom right) SDN Spring. 20
Figure 14 Salinity maps at the surface: (top left) WOA13 summer; (bottom left) SDN summer; (top right) WOA13 autumn; (bottom right) SDN autumn. 20
Figure 15 Basin seasonal averages of BIAS and RMSE computed between salinity SDN climatology and WOA13. 21
Figure 16 Black Sea domain. 22
Figure 17 The schematic diagram for the main features of the upper layer circulation derived from synthesis of past hydrographic studies prior to 1990 (from Korotaev et al. 2003, reproduced from its original given by Oguz et al. [1993]). 23
Figure 18 Monthly surface Temperature (automatic scaling is applied to highlight spatial features). 25
Figure 19 Temperature in July (automatic scaling is applied to highlight spatial features). 26
Figure 20 Temperature Relative Error in July. 27
Figure 21 Annual Temperature 27
Figure 22 Monthly surface Salinity (automatic scaling is applied to highlight spatial features). 28
Figure 23 Salinity in July (automatic scaling is applied to highlight spatial features). 29
Figure 24 Annual Salinity. 29
Figure 25 Temperature fields (top row) and Temperature difference fields (bottom row), surface, August. 32
Figure 26 Salinity fields (top row) and Salinity difference fields (bottom row), surface, August. 33
Figure 27 - Arctic Sea domain and data distribution map at the surface. 34
Figure 28 Temperature at surface level in December all years masked with 50% 35
Figure 29 Temperature at surface level in March all years masked with 50% 35
Figure 30 Temperature at surface level in August all years masked with 50% 36
Figure 31 Salinity at surface level in December all years masked with 50% 36
Figure 32 Salinity at surface level in March all years masked with 50% 37
Figure 33 Salinity at surface level in August all years masked with 50% 37
Figure 34 Baltic Sea domain and data distribution map at the surface. 38
Figure 35 Surface temperature maps without error masking: January, April, July and October. 39
Figure 36 Surface temperature maps masked where relative error is higher than 30%: January, April, July and October. 40
Figure 37 January Temperature maps at 20m, 50m and 100m, masked where relative error is higher than 30%. 40

Figure 38 July Temperature maps at 20m, 50m and 100m masked where relative error is higher than 30%. 40
Figure 39 Surface salinity maps without error masking: January, April, July and October. 41
Figure 40 Surface salinity maps masked where relative error is higher than 30%: January, April, July and October. 41
Figure 41 July Salinity maps at 20m, 50m and 100m masked where relative error is higher than 30%.............. 41
Figure 42 January temperature maps masked where relative error is higher than 30%: (a) old surface temperature; (b) new surface temperature; (c) old temperature 30m; (d) new temperature 30m. 42
Figure 43 January salinity maps masked where relative error is higher than 30%: (a) old surface temperature; (b) new surface temperature; (c) old temperature 30m; (d) new temperature 30m. 43
Figure 44 Location of stations in the TS data collections for the North Sea for the period 1900-2013: (a) freely accessible data; (b) restricted dataset. 44
Figure 45 Example of data distribution (temperature in summer) in the upper layer, showing the computational domain boundaries (not projected). 44
Figure 46 Examples of DIVA computational grid at (a) depth= 0m and (b) depth = 100 m. 45
Figure 47 Data density maps of the historical dataset: (a) focus on 1988, (b) focus on 1989. 47
Figure 48 Zoom on one of the locations with a very density of measurements during the period of the North Sea Project. 48
Figure 49 Snapshot of SST climatology around the heavily sampled locations. 48
Figure 50 Climatological maps of SST for the winter season computed over the period 1900–2013. Above: (a) December, (b) January; below: (c) February, (d) December-February (framed). Color scales vary. 49
Figure 51 Climatological maps of SST for the spring season computed over the period 1900–2013. Above: (a) March, (b) April; below: (c) May, (d) March-May (framed). Color scales vary. 50
Figure 52 Climatological maps of SST for the summer season computed over the period 1900–2013. Above: (a) June, (b) July; below: (c) August, (d) June-August (framed). Color scales vary. 50
Figure 53 Climatological maps of SST for the fall season computed over the period 1900–2013. Above: (a) September, (b) October; below: (c) November, (d) September-October (framed). Color scales vary........ 51
Figure 54 Seasonal climatological maps of temperature at depth = 100m computed over the period 1900–2013. Above: (a) winter, (b) spring; below: (c) summer, (d) fall. Color scales vary. 52
Figure 55 Climatological maps of sea surface salinity for the winter season computed over the period 1900–2013. Above: (a) December, (b) January; below: (c) February, (d) December-February (framed). Color scales vary. 52
Figure 56 Climatological maps of sea surface salinity for the spring season computed over the period 1900–2013. Above: (a) March, (b) April; below: (c) May, (d) March-May (framed). Color scales vary.......................... 53
Figure 57 Climatological maps of sea surface salinity for the summer season computed over the period 1900–2013. Above: (a) June, (b) July; below: (c) August, (d) June-August (framed). Color scales vary. 54
Figure 58 Climatological maps of sea surface salinity for the fall season computed over the period 1900–2013. Above: (a) September, (b) October; below: (c) November, (d) September-October (framed). Color scales vary. 55
Figure 59 Seasonal climatological maps of salinity at depth = 100m computed over the period 1900–2013. Above: (a) winter, (b) spring; below: (c) summer, (d) fall. Color scales vary. 56
Figure 60 Comparison of climatological maps of sea surface temperature using SDNv1 (left) and WOD2013 (right). From the top: winter, spring, summer and fall. Color scales vary. 57
Figure 61 Comparison of climatological maps of sea surface salinity using SDNv1 (left) and WOD2013 (right). From the top: winter, spring, summer and fall. Color scales vary. 58
Figure 62 Domain definition and mask (green line) for the North Atlantic Ocean 59
Figure 63 Error fields for Temperature and Salinity, July, surface (level 10033) and 1000m (level 10015). 60
Figure 64 Distribution of data for temperature measurements during autumn. 61
Figure 65 Temperature measurements location for the time period 1900-2012. Distribution in terms of stations count. 61
Figure 66 Temperature fields in January and July, at the surface (level 10033) and at 1000m depth (level 10015) 62
Figure 67 Surface currents of the Atlantic Ocean. SAF: Subantarctic Front, Antilles (AC) Currents and the Caribbean Counter current (CCC), AF: Azores Front (*From Tomczak, Matthias & J Stuart Godfrey: Regional Oceanography: an Introduction 2nd edition (2003))* 62

Figure 68 Salinity measurements location for the time period 1900-2012. Distribution in terms of stations count. 63
Figure 69 Salinity fields in January and July, at the surface (level 10033) and at 1000m depth (level 10015) 64
Figure 70 January mean temperature and salinity at the surface and at 1000m depth (WOA2013) 65
Figure 71 Temperature and Salinity anomalies for near surface seasonal cycles (2002 for temperature and 2012 for salinity 66
Figure 72 Salinity map from Coriolis website. 66

List of Tables

Table 1 – Common specifications from Table 1 of SeaDataNet 1 Harmonization and Quality report. 9
Table 2 - Geographical boundaries definition of the European marginal seas (from Table 2 SDN1 HQ report) .. 10
Table 3 - param.par input file lists the parameter setting used for analysis and reference field computation for the Mediterranean Sea climatology. 11
Table 4 - driver input file lists the parameter setting used for analysis and reference field computation for the Mediterranean Sea climatology. 12
Table 5 - param.par and driver input files parameters setting for the Black Sea climatology computation. 24
Table 6 - Characteristics of climatic products. 30
Table 7 - Comparison of SeaDataNet 2 and WOA 2013 annual fields.. 31
Table 8 - Comparison of SeaDataNet 2, WOA 2013 and SeaDataNet 1 monthly fields 32
Table 9 - param.par input file with the settings for the Baltic Sea climatology computation. 38
Table 10 - Reference levels considered for the climatology computation in the North Sea. 45
Table 11 - param.par input file with the settings for the North Sea climatology computation 46
Table 12 - driver input file with the settings for the North Sea climatology computation 46
Table 13 - DIVA parameters used for the North Atlantic climatology computation. 59

1. INTRODUCTION

Common specifications for gridded fields have been defined during the first year of WP10 activity and it is described in deliverable D10.1:

"Common specifications for gridded fields have been chosen considering both SDN1 outcome and SDN2-MyO2 Joint Meeting outcome. WP10 activity will produce temperature and salinity monthly climatologies for all the regional seas on the IODE standard vertical levels. Vertical resolution could be higher in some shallow regions. The horizontal grid resolution will be at least equal to SDN1 climatology and it will be refined where data density would allow it. All temperature and salinity fields will have the corresponding error field.

In order to produce good quality climatologies the collections of observations could be integrated with SDN restricted data but also with external data sources.

The first priority of T and S climatology production is to show and synthesize the SDN database content, to implement new common QC analysis in synergy with MyOcean INS TAC based on the new computed climatologies, last but not least, to deliver good quality products to the external users for both data analysis and modelling purposes."

During RC Meeting in September the 2nd 2014 it was indicated as a reference for climatology the following SDN1 HQ (Harmonization and Quality) report: "SDN Harmonization and Quality Assurance Assessment Regional Climatological Data" released on 21 June 2010.
http://gnoo.bo.ingv.it/export/guest/MarinaTonani/SDNJRAsHarmRep2010.pdf

OBSERVATIONS to be used for climatology computation belong from regional aggregated data sets restricted, unrestricted and external sources for the period: 1900-2012.

Parameters, space/time scales and vertical levels are specified in Table 1, while geographical boundaries of regional basin on which climatologies have been computed are listed in Table 2.

Even if the required time scale should be monthly, due to poor data coverage in some region, some climatologies are going to be presented at seasonal scale.

Table 1 – Common specifications from Table 1 of SeaDataNet 1 Harmonization and Quality report.

	in situ parameter	time	space	level
		(1)	(2)	(3)
(a)	**S**	mo	r/m	IODE
(a)	**T**	mo	r/m	IODE

(1) Required time scales: monthly
(2) Required space scales: regional (r) / model (m) compatible
(3) Required vertical levels: IODE list

Table 2 - Geographical boundaries definition of the European marginal seas (from Table 2 SDN1 HQ report)

Basin	Longitude	Latitude
Med Sea	9.25W-36.5°E	30-46°N
Black Sea	27-42°E	40.5N-47.5N
Arctic Sea	40W-65°E	65N-82°N
Baltic Sea	9-31°E	53-66°N.
North Sea	4W-9°E	48.5-62°N
North Atlantic	-80°W + 8°E	10-65°N

2. Mediterranean Sea Climatology

2.1. Methodology

- Domain definition: The Mediterranean climatology is defined between 9.25◦W-36.5°E of longitude and 30-46°N of latitude. Figure 1 shows the computational grid generated from DIVA according to the input bathymetry and the correlation length applied.

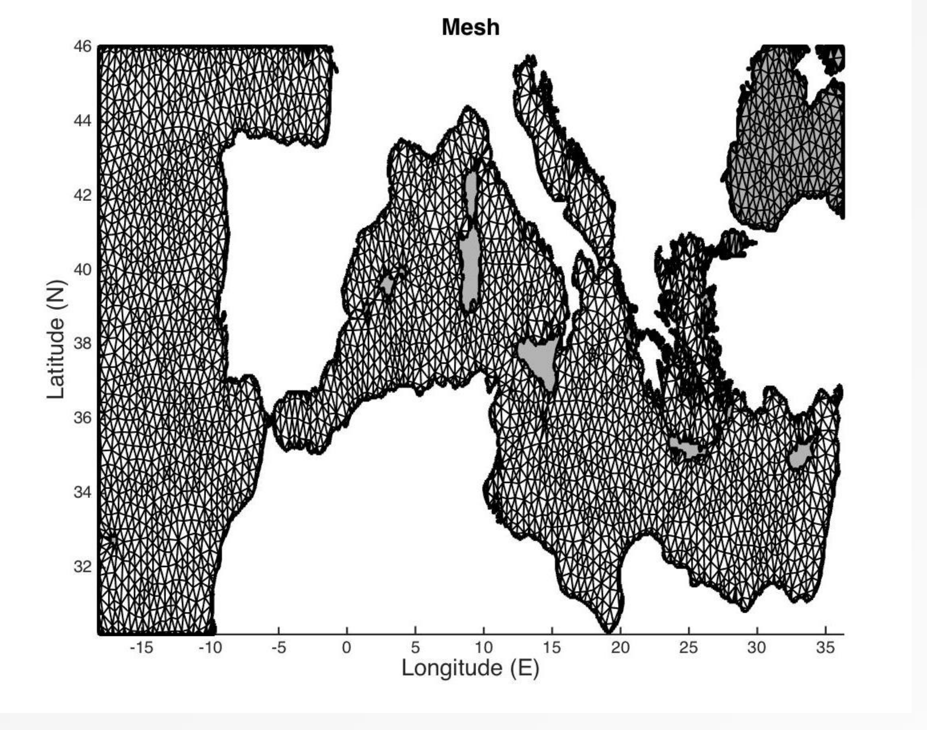


Figure 1 Finite elements grid used for the Mediterranean Sea climatology computation.

- Time-space resolution: horizontal resolution is 1/8x1/8 of a degree on 33 IODE standard levels [5500 5000 4500 4000 3500 3000 2500 2000 1750 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 250 200 150 125 100 75 50 30 20 10 0];
- DIVA (4.6.9 version) settings, considered for both analysis and reference field computation, are listed in Table 3 and Table 4. Table 3 contains the param.par file input parameters and Table 4 contains the driver file input specifications.

Table 3 - param.par input file lists the parameter setting used for analysis and reference field computation for the Mediterranean Sea climatology.

Parameter	AN	REF
Lc correlation length	2	2
Icoord change	1	1
ispec	11	11
ireg	1	0
xori	-9.25	-9.25
yori	30	30
dx	0.125	0.125
dy	0.125	0.125
nx	367	367

ny	129	129
valex	-9999.0	-9999.0
snr	0.5	0.5
varbak	0.6	0.6

Table 4 - driver input file lists the parameter setting used for analysis and reference field computation for the Mediterranean Sea climatology.

Parameter	AN	REF
Data extraction	0	0
boundary lines and coastlines generation:	0	0
cleaning data on mesh:	4	4
minimal number of data in a layer	-1	-1
Parameters estimation and vertical filtering	0	0
Minimal L	1.4	1.4
Maximal L	10	10
Minimal SN	0.1	0.1
Maximal SN	50	50
Analysis and reference field:	1	2
lowerlevel number	1	1
upperlevel number	33	33
4D netCDF files generation:	1	1
gnuplot plots	0	0
Data detrending	0	0

- Description of the tuning of DIVA
- Background field choice: annual semi-normed analysis for salinity and 3 months semi-normed analysis for temperature centered on the analysis months.
- Error Maps

2.2. Temperature Maps

Monthly temperature maps have been computed. Figure 2 shows surface temperature climatology for selected months. We show these months to represent the seasonal cycle of the thermal field. There are remarkable differences between Western and Eastern basins. The Western basin presents smaller values than the Eastern basin. This is related to the modification of the Atlantic Water that changes its characteristics during the circulation into the entire basin. Moreover is apparent the ‘meridional’ gradient, that located the warmest waters along the southernmost regions. Temperature climatology ranges at the surface between 6°C (Northern Adriatic Sea) and 28.5°C (Eastern Levantine Basin).

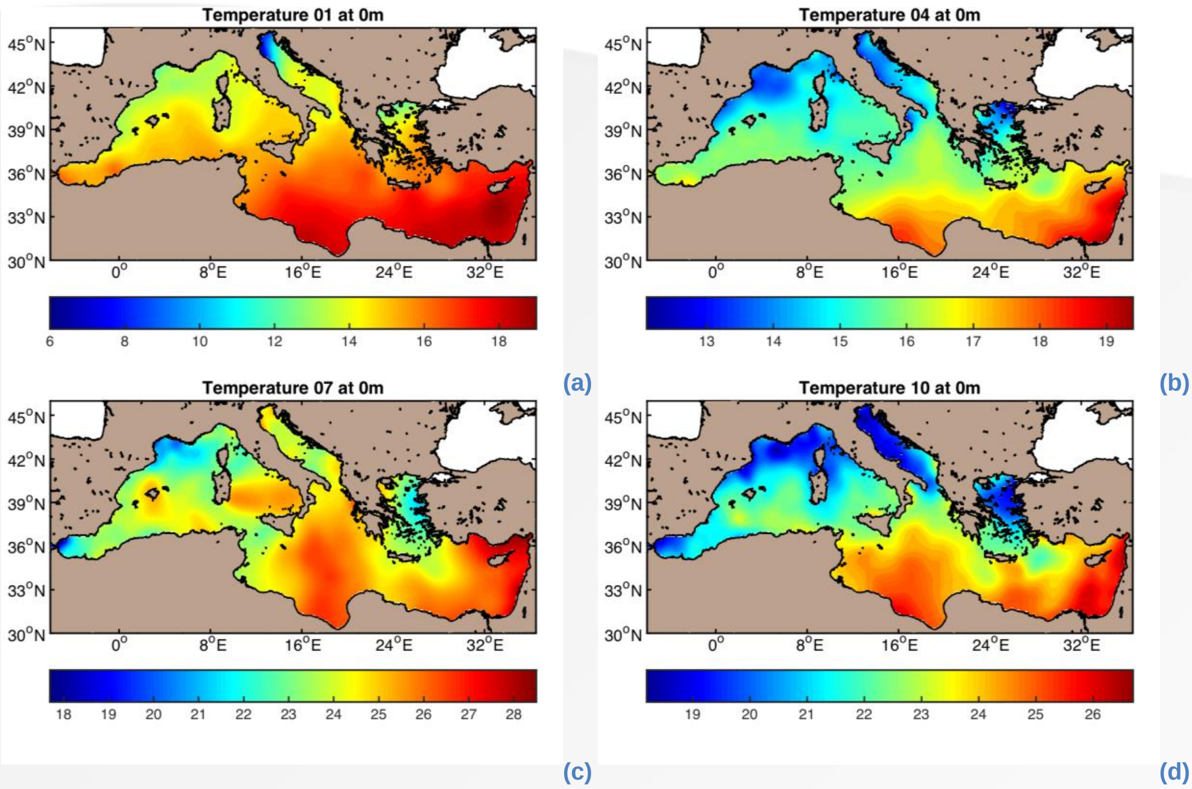


Figure 2 Surface temperature climatology computed in (a) January; (b) April; (c) July; (d) October.

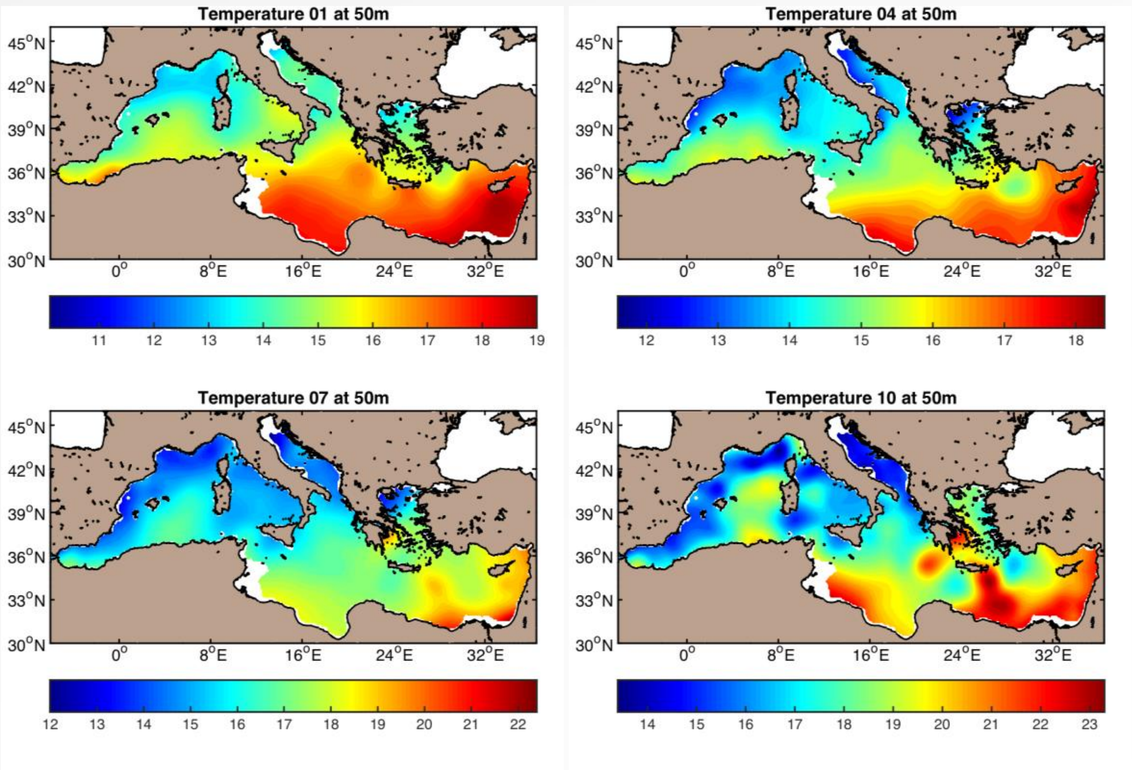


Figure 3 Temperature climatology at 50m: (a) January; (b) April; (c) July; (d) October.

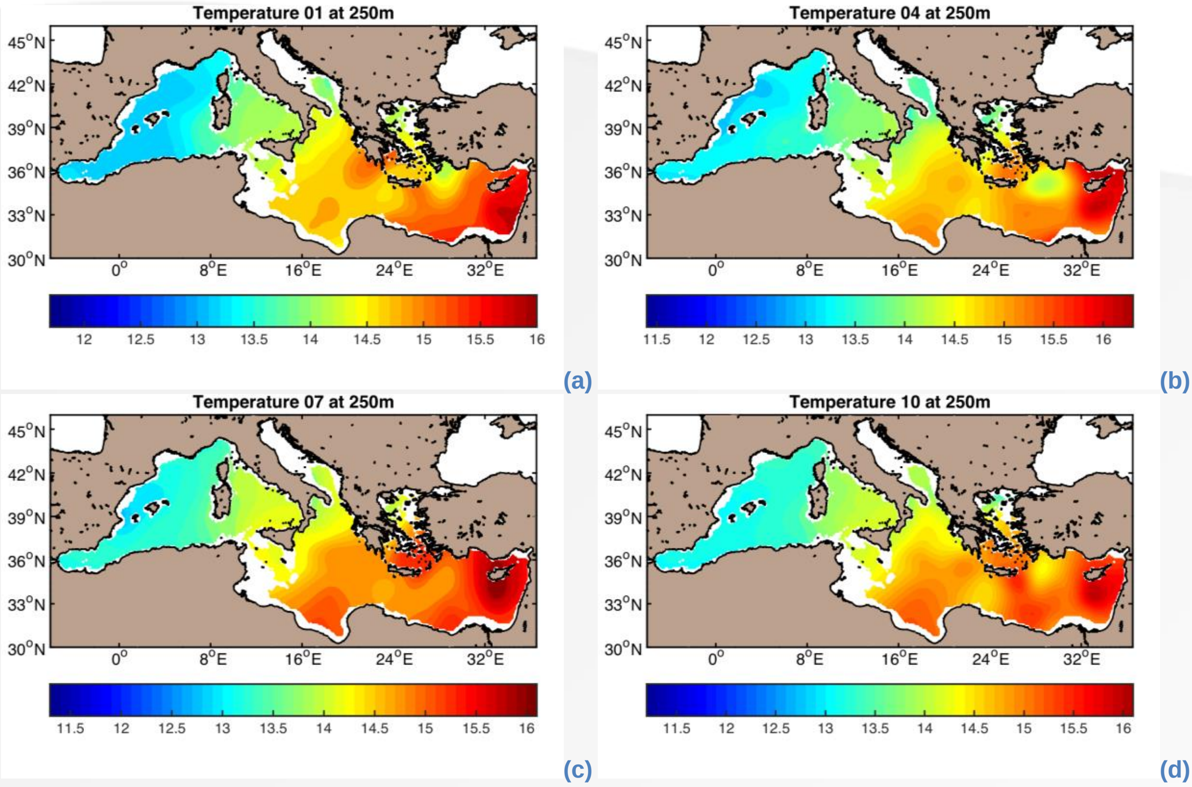
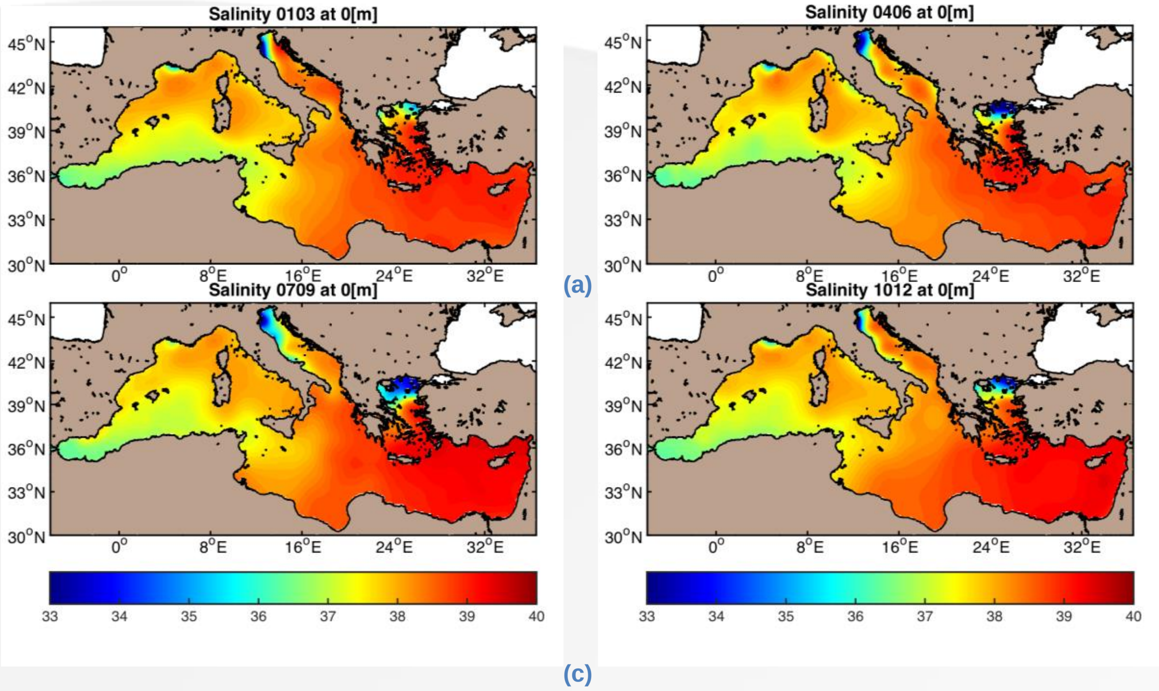


Figure 4 Temperature climatology at 250m: (a) January; (b) April; (c) July; (d) October.

Temperature fields at 50m (Figure 3) and 250m (Figure 4) presents the same large scale West-East and North-South gradients.

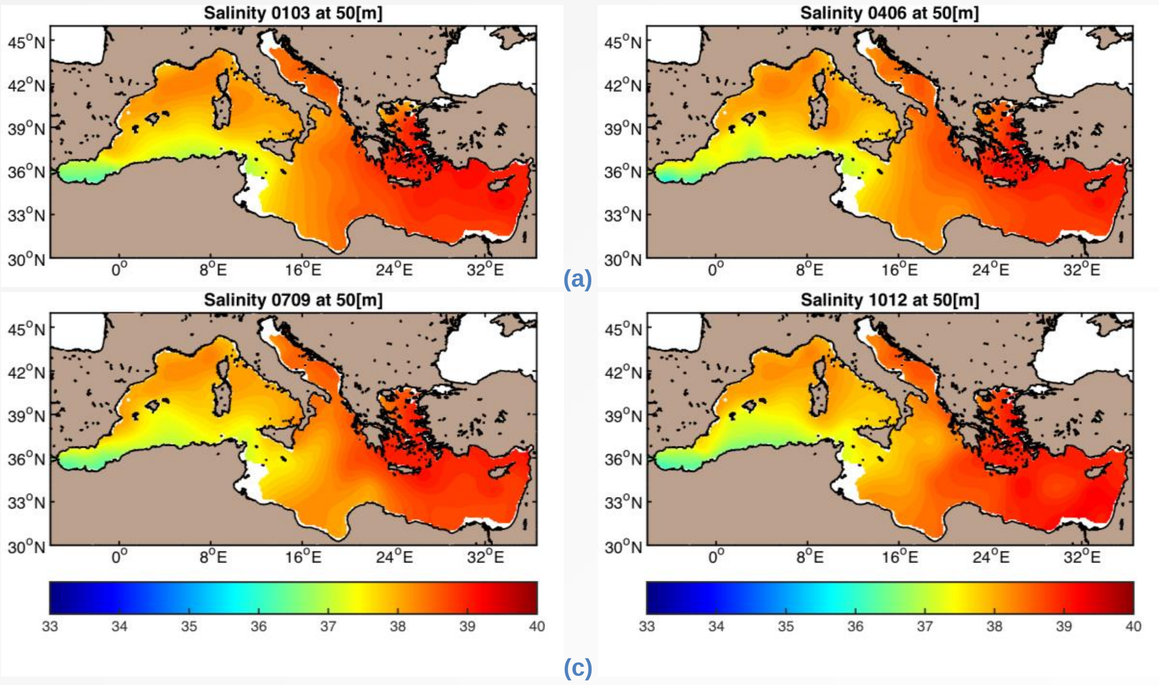
2.3. Salinity Maps

Seasonal Salinity maps are presented in Figure 5, Figure 6, Figure 7 and Figure 8. The lowest salinity values can be noticed in the Northern Adriatic Sea, influenced by the Po river outflow, and in the Northern Aegean, influenced by the Dardanelles inflow. The fresher Atlantic water characterizes the Western basin salinity, flowing along the Algerian coast and entering the eastern basin through the Sicily Straight.



(a) (b) (c) (d)

Figure 5 Seasonal salinity climatology at the surface: (a) January-February-March; (b) April-May-June; (c) July-August-September; (d) October-November-December.



(a) (b) (c) (d)

Figure 6 Seasonal salinity climatology at 50m: (a) January-February-March; (b) April-May-June; (c) July-August-September; (d) October-November-December.

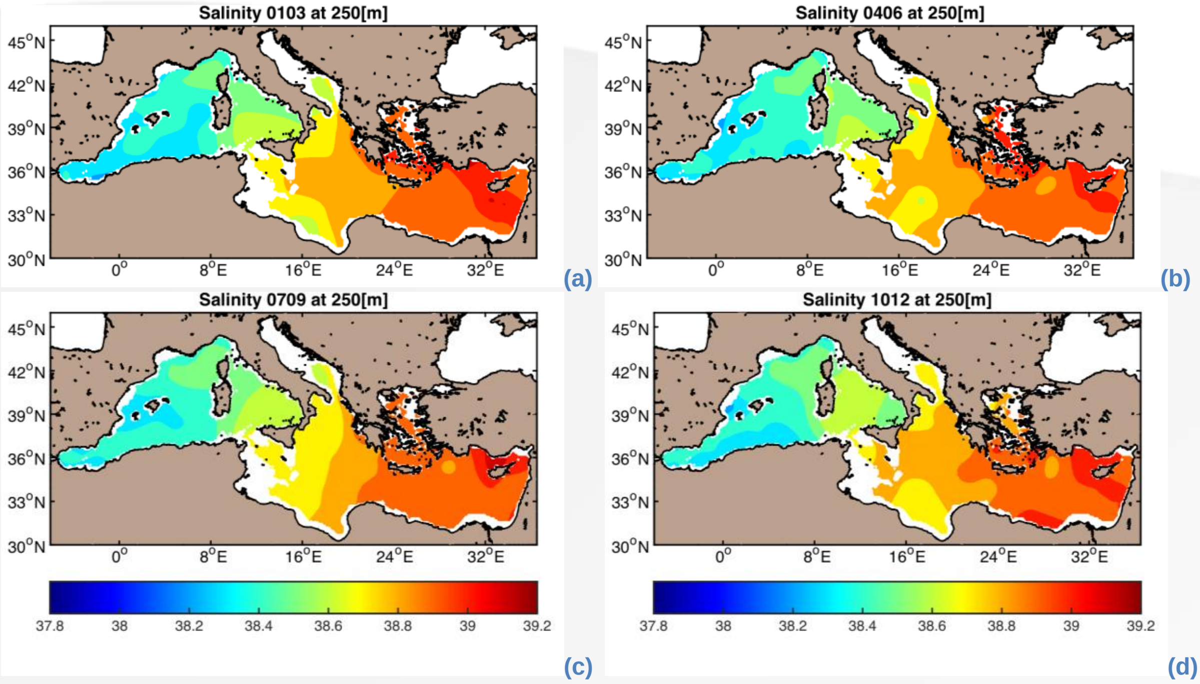


Figure 7 Seasonal salinity climatology at 250m: (a) January-February-March; (b) April-May-June; (c) July-August-September; (d) October-November-December.

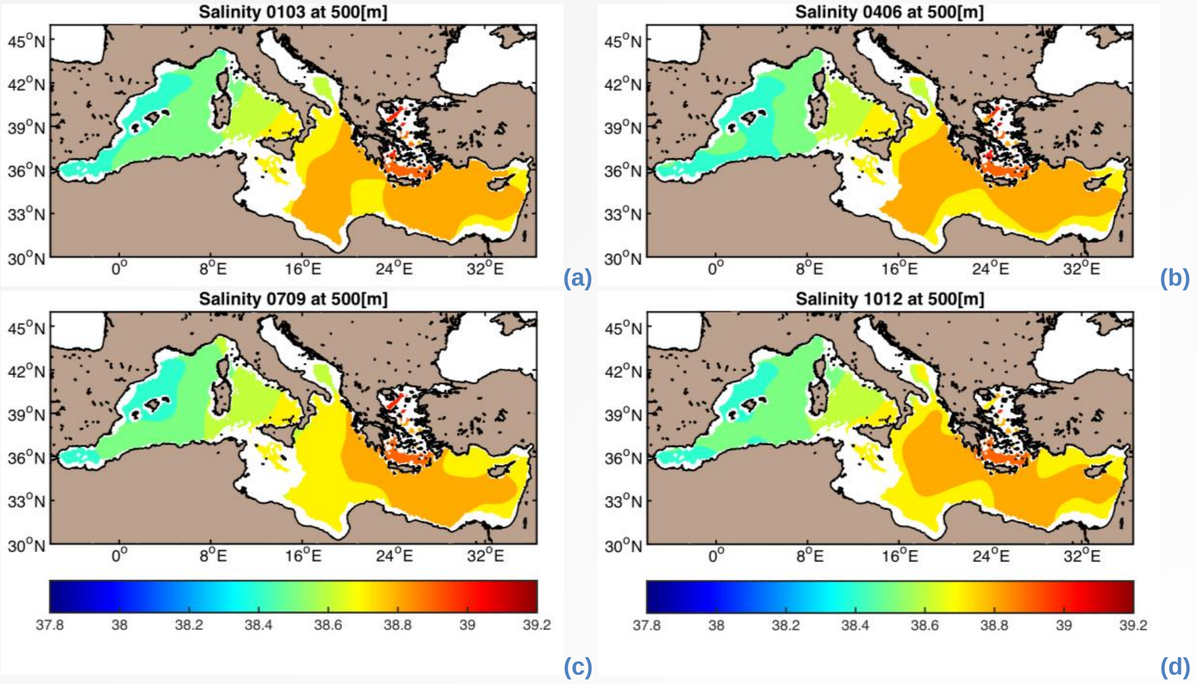


Figure 8 Seasonal salinity climatology at 500m: (a) January-February-March; (b) April-May-June; (c) July-August-September; (d) October-November-December.

2.4. Climatology validation

The Mediterranean Sea climatology has been validated considering the WOA13 temperature (Locarnini et al. 2013) and salinity (Zweng et al. 2013) climatologies as a reference. WOA13 climatology has been defined over 57 vertical levels from the surface up to 1500m, thus we had to sub-sample them in order to select the IODE levels considered from SDN climatology computation. We first checked the consistency between SDN and WOA13 by visual inspection. Figure 9 and Figure 10 present temperature maps from WOA13 (top) and their corresponding SDN field (bottom). We then used statistical indexes like BIAS and RMSE to quantify the differences between SDN and WOA13 fields. Figure 11 presents monthly basin averages between temperature fields. Temperature BIAS (SDN minus WOA13) ranges between 0.04°C in February to 0.17°C in November indicating that SDN is always warmer than WOA13. RMSE ranges between 0.18°C in February and 0.3°C in October-November months. Both indexes increases in fall months. Figure 12 shows the monthly evolution of BIAS, RMSE and correlation along the water column. Both BIAS and RMSE present maximum values between the first 5 vertical levels between September and December. Further investigations are needed to understand the cause of those discrepancies. The total BIAS is of 0.09°C and total RMSE is 0.24°C.

Figure 13 and Figure 14 display the comparison of seasonal salinity maps at the surface between WOA13 (top) and the corresponding SDN fields (bottom). Figure 15 shows the seasonal BIAS and RMSE indexes. Salinity BIAS is negative, indicating that WOA13 is slightly saltier than SDN climatology, and its mean value is -0.01psu. Salinity RMSE ranges between 0.07 and 0.08psu. Maximum differences are located in the first layers.

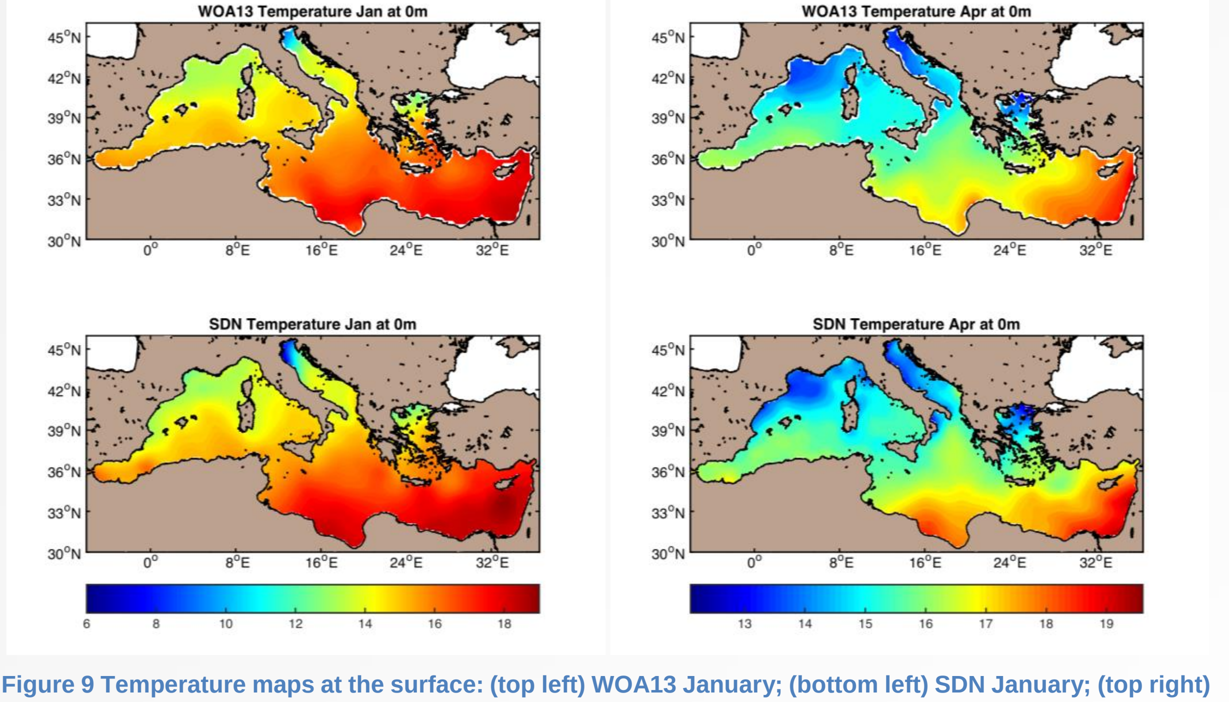


Figure 9 Temperature maps at the surface: (top left) WOA13 January; (bottom left) SDN January; (top right) WOA13 April; (bottom right) SDN April.

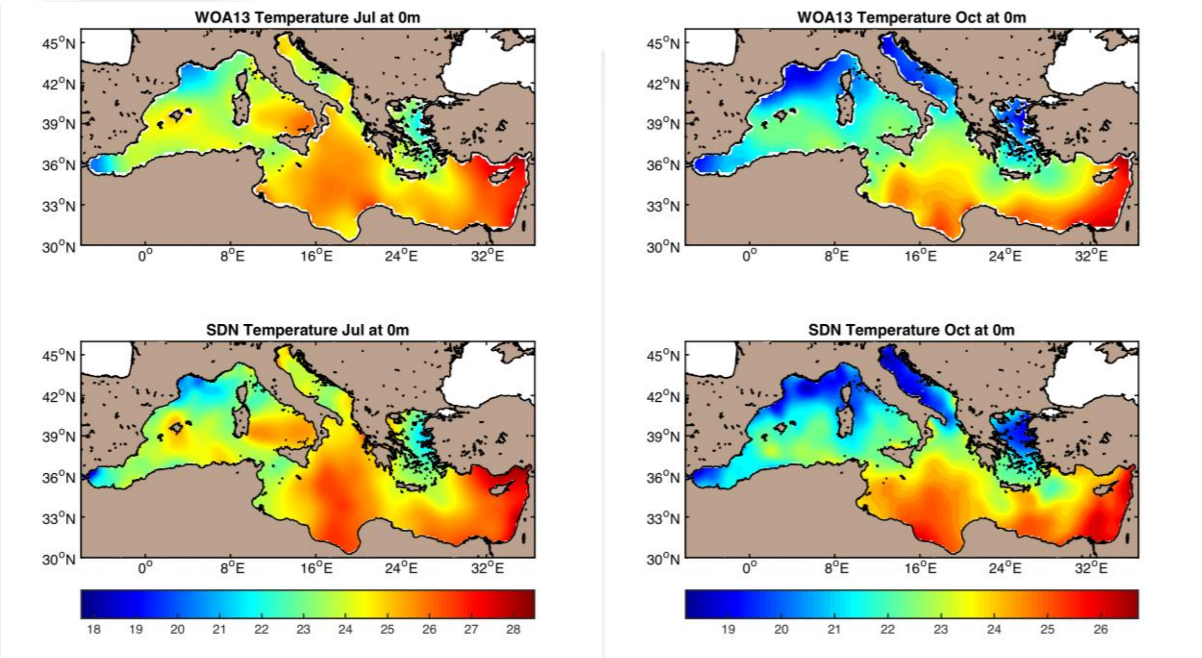


Figure 10 Temperature maps at the surface: (top left) WOA13 July; (bottom left) SDN July; (top right) WOA13 October; (bottom right) SDN October.

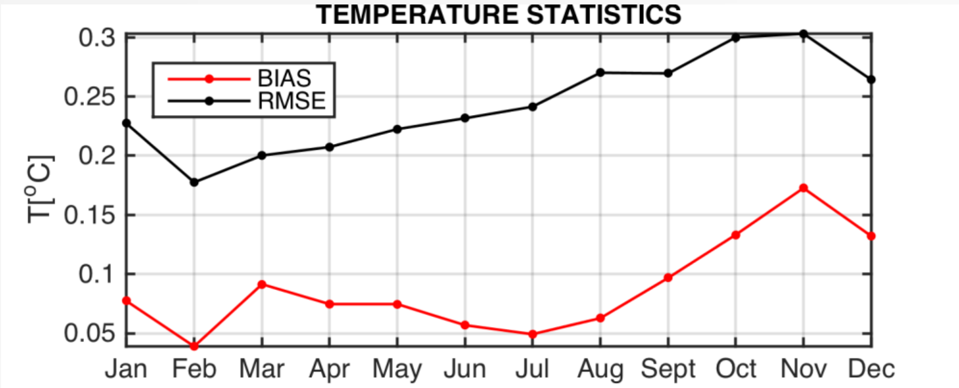
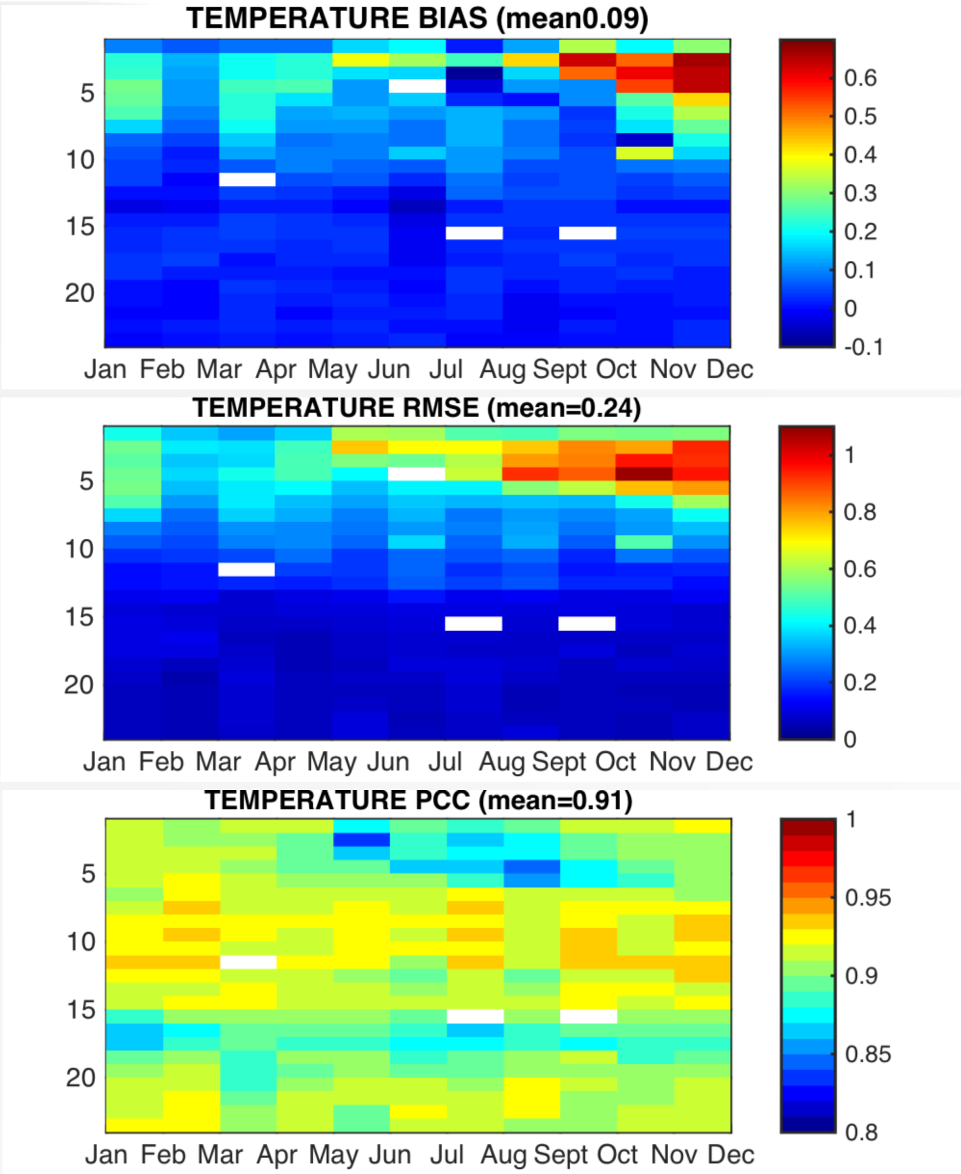


Figure 11 Basin monthly averages of BIAS and RMSE computed between temperature SDN climatology and WOA13.



(a)
(b)
(c)

Figure 12 Temperature hovmoller plots: (a) BIAS; (b) RMSE; (c) correlation coefficient

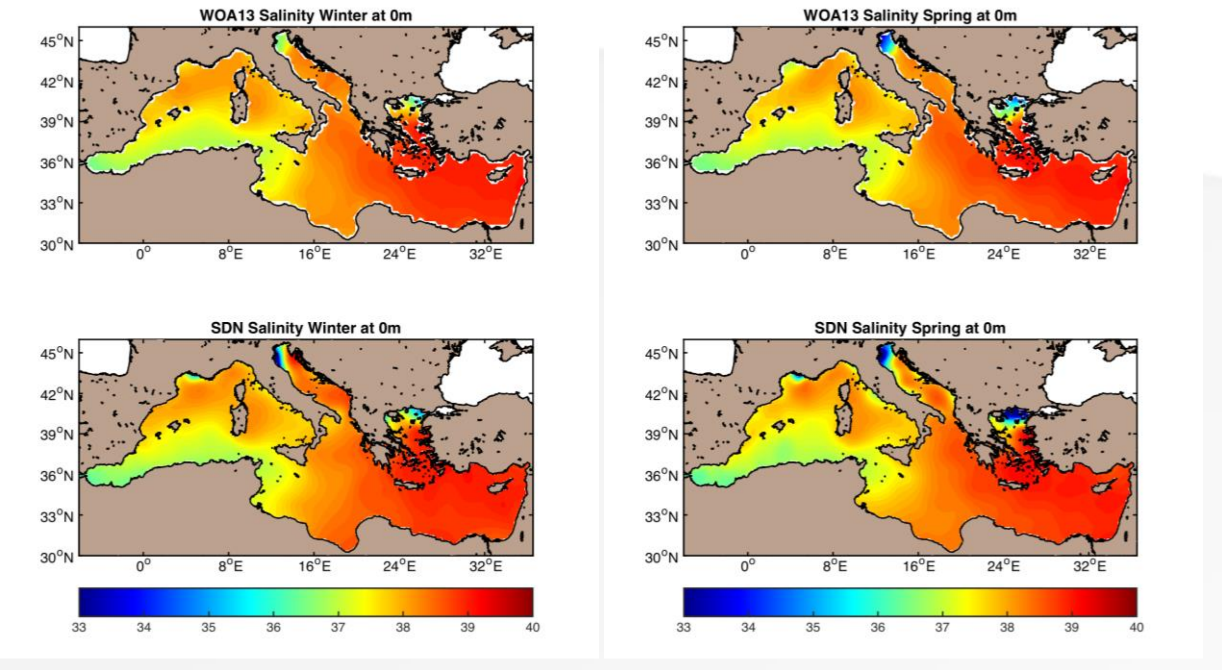


Figure 13 Salinity maps at the surface: (top left) WOA13 winter; (bottom left) SDN winter; (top right) WOA13 spring; (bottom right) SDN Spring.

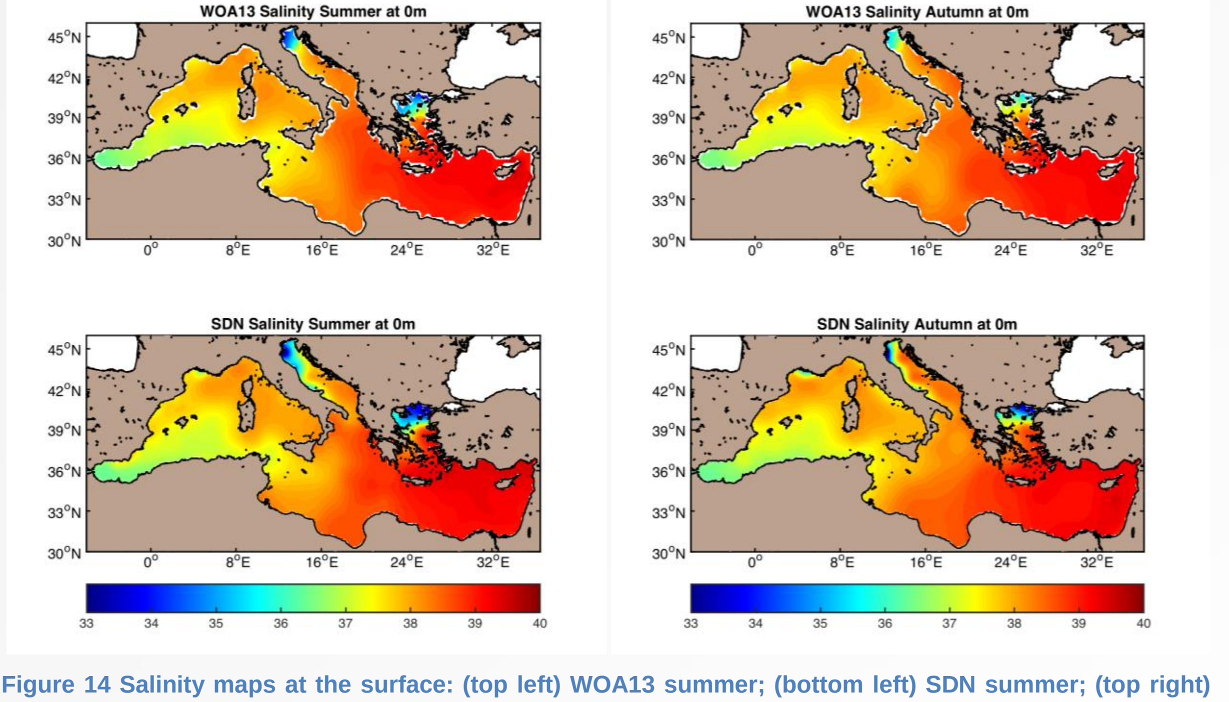


Figure 14 Salinity maps at the surface: (top left) WOA13 summer; (bottom left) SDN summer; (top right) WOA13 autumn; (bottom right) SDN autumn.

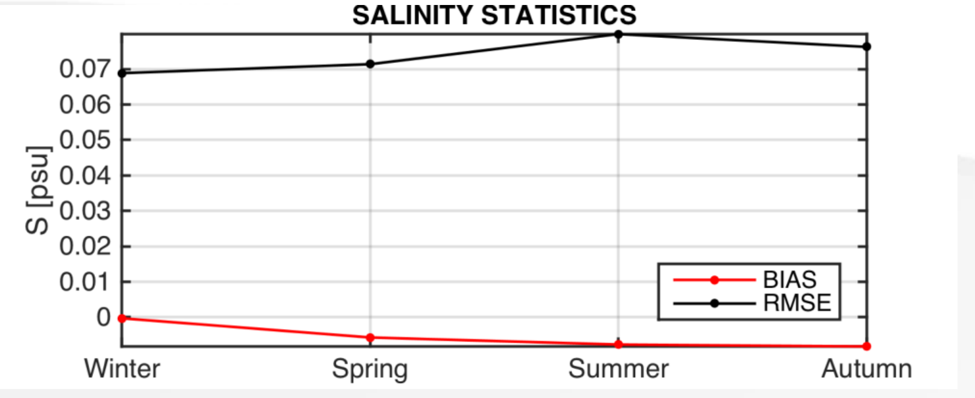


Figure 15 Basin seasonal averages of BIAS and RMSE computed between salinity SDN climatology and WOA13.

3. Black Sea Climatology

3.1. Methodology

- Domain definition

  The Black Sea is a semi-enclosed sea connected to the Mediterranean Sea by the narrow Turkish straits system consisting of Bosporus and Dardanelles. The Black Sea domain with boundaries 40.5N – 47.5N, 27E – 42E includes also the adjacent shallow Sea of Azov at the NE, which is connected to the Black sea via Kerch strait (Figure 16).

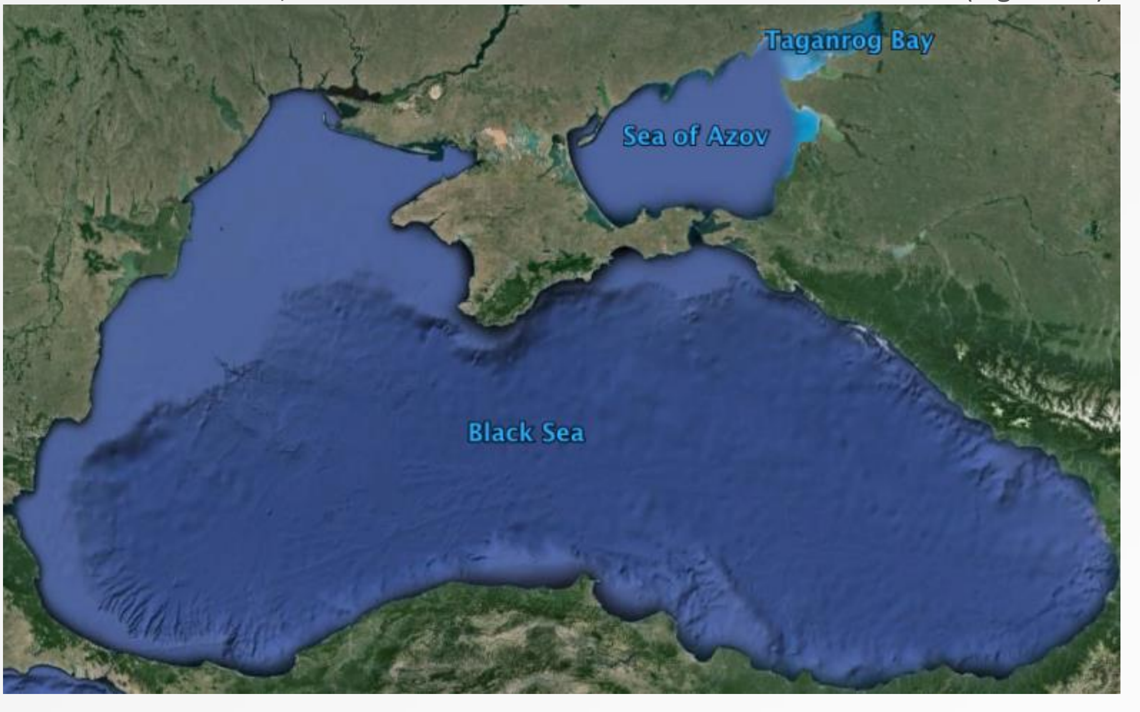


Figure 16 Black Sea domain.

The bottom topography of the Black Sea is bowl-shaped with average depth 2000m in the central part. In the most of the basin the shelf does not exceed 10-15 km width except the NW part.

The most remarkable circulation feature is the cyclonic meandering Rim Current, the interior of which is formed either by one elongated cell covering the entire basin or by two separate cyclonic cells occupying the western and eastern halves of the basin (C. Hogan, 2013. Black Sea. http://www.eoearth.org/view/article/150694). The periphery of Rim Current is characterized by appearance of eddy processes, some of which are more pronounced and persistent (e.g. Batumi Eddy) as presented in Figure 17.

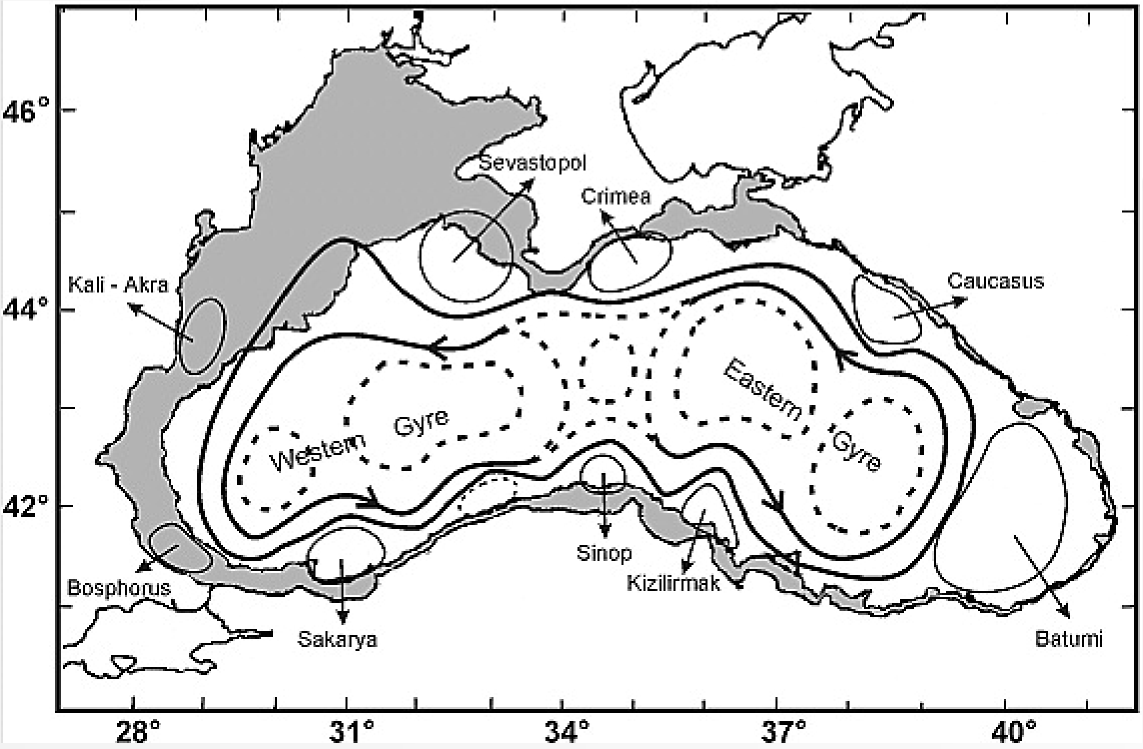


Figure 17 The schematic diagram for the main features of the upper layer circulation derived from synthesis of past hydrographic studies prior to 1990 (from Korotaev et al. 2003, reproduced from its original given by Oguz et al. [1993]).

- Time-space resolution

  The Black Sea climatologies were produced from the first release of the Black Sea Aggregated Dataset containing Temperature and Salinity data from ~104,400 stations for period 1900 - 2013.

  Considering the data coverage presented in the Deliverable 10.2 monthly climatologies of Temperature and Salinity were calculated for depth levels 0, 10, 20, 30, 50, 75, 100, 150, 200, 250 m and annual climatologies for depth levels 300,400, 500, 600, 800, 1000, 1200, 1500, 2000 m.

  The horizontal resolution of the produced climatological grids is 0.1 degrees.

- DIVA settings are listed in Table 5.

Table 5 - param.par and driver input files parameters setting for the Black Sea climatology computation.

param.par		driver	
Lc: correlation length	1.5	Data extraction:	1
icoordchange	2	boundary lines and coastlines generation:	1
ispec	11	cleaning data on mesh:	0
ireg	2	minimal number of data in a layer	0
xori	27	Parameters estimation and vertical filtering:	0
yori	40.5	Minimal L	0.5
dx	0.1	Maximal L	2
dy	0.1	Minimal SN	0.1
nx	151	Maximal SN	5
ny	71	Analysis and reference field:	1
valex	-99	lowerlevel number	1
snr	0.5	upperlevel number	10
varbak	1	4D netCDF files generation:	11
		gnuplot plots	0
		Data detrending	0

Accepted quality flags: 1 (good) and 2 (probably good) according to SeaDataNet scheme.

- Description of the tuning of DIVA
  The updated Black Sea topography was produced from the GEBCO08 dataset. Special attention was paid to masking numerous firths (limans) and river estuaries in Northern part in order to eliminate possible DIVA-produced artefacts.
  The values for minimal and maximal correlation length were taken from literature.
- Background field choice
  The ireg parameter was set to 2 meaning that the linear regression of the data (plane) is subtracted.
- Error Maps
  Relative error maps were produced.

3.2. Temperature Maps

Figure 18 shows monthly surface temperature climatologies: winter sea surface temperatures vary from 0 C° (or even from small negative values) in the NW part to 10 C° in South while summer temperatures reach 29 C°.

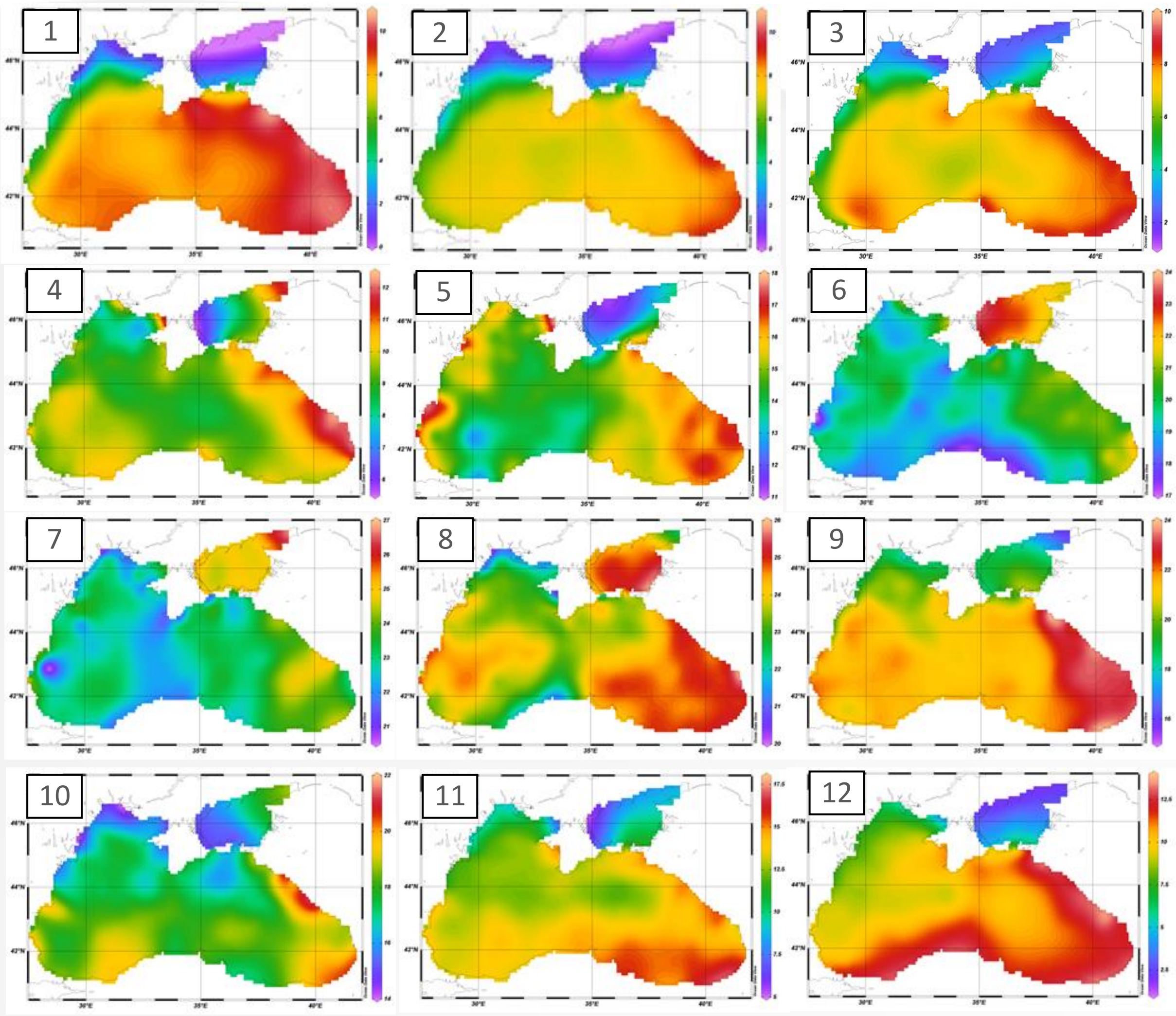
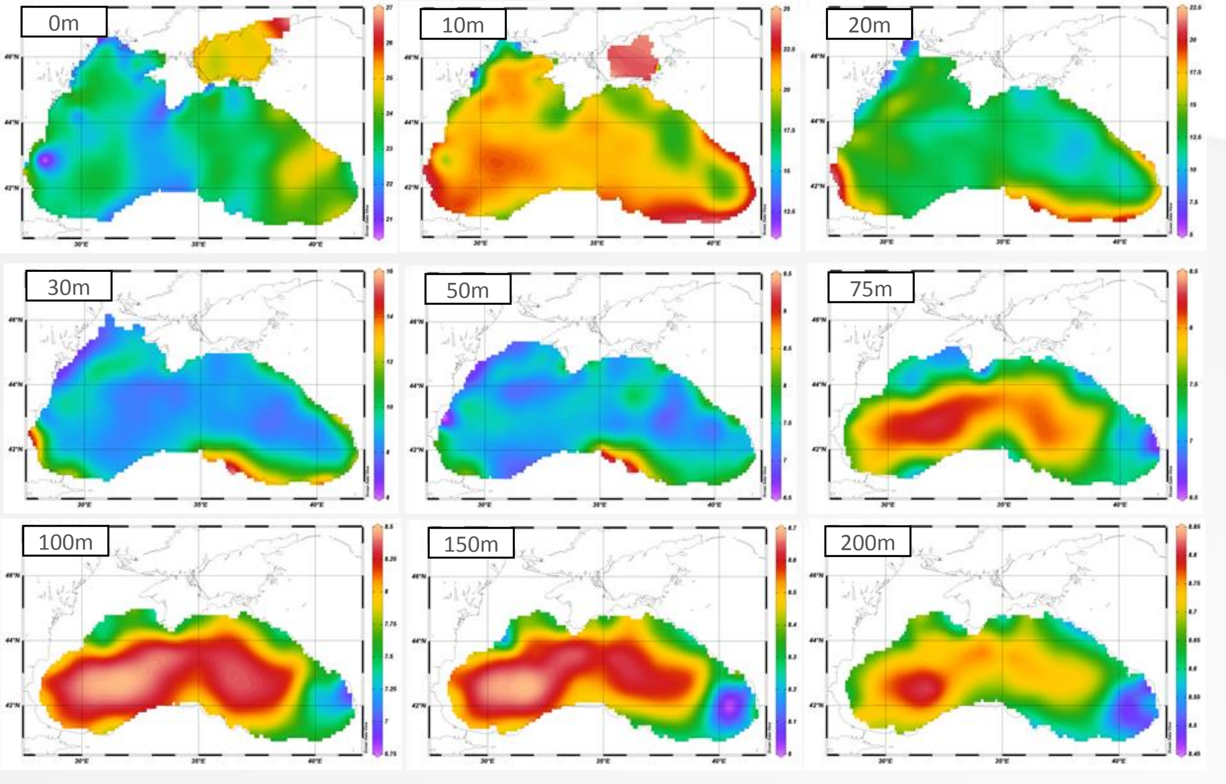


Figure 18 Monthly surface Temperature (automatic scaling is applied to highlight spatial features).

The surface Temperature field looks patchy in some months. It can be explained by effect of transitional processes, e.g. in April and in October, however anomalies visible on May, June and July maps rather are evidence of problems with underlying data. For example, the cold spot on July map at Bulgarian coast to a great extent caused by data from one cruise where relatively low temperature was observed (it should be noted that the data within the cruise appear to be consistent!).

One of important characteristics of Black Sea is the Cold Intermediate Layer (CIL), which depth and thickness varies depending on location, season and hydrodynamics. The CIL is usually observed at depth 40-70m, which is observed in climatic Temperature fields.

Figure 19 Temperature in July (automatic scaling is applied to highlight spatial features).



The main Black Sea circulation feature – Rim Current - is also well noticeable in Temperature climatic fields particularly at depth levels below 75m, as in Figure 19 showing July climatology at different depth levels (i.e. below mixed layer and CIL).

The relative error (Figure 20) for most of fields does not exceed 0.1 (10%) meaning that Temperature climatologies were calculated with sufficient amount observation data. The exception is the Sea of Azov, where relative error is rather high compared to Black Sea exceeding 0.5 in winter season. However the Temperature fields in winter months look reasonable therefore no masking was applied.

Figure 21 presents annual Temperature maps. Below 300m temperature gradually increases from 8.75 C° to 9.1 C°. The relative error does not exceed 0.1 except two locations at SE at depth 1000m and 1200m (not shown).

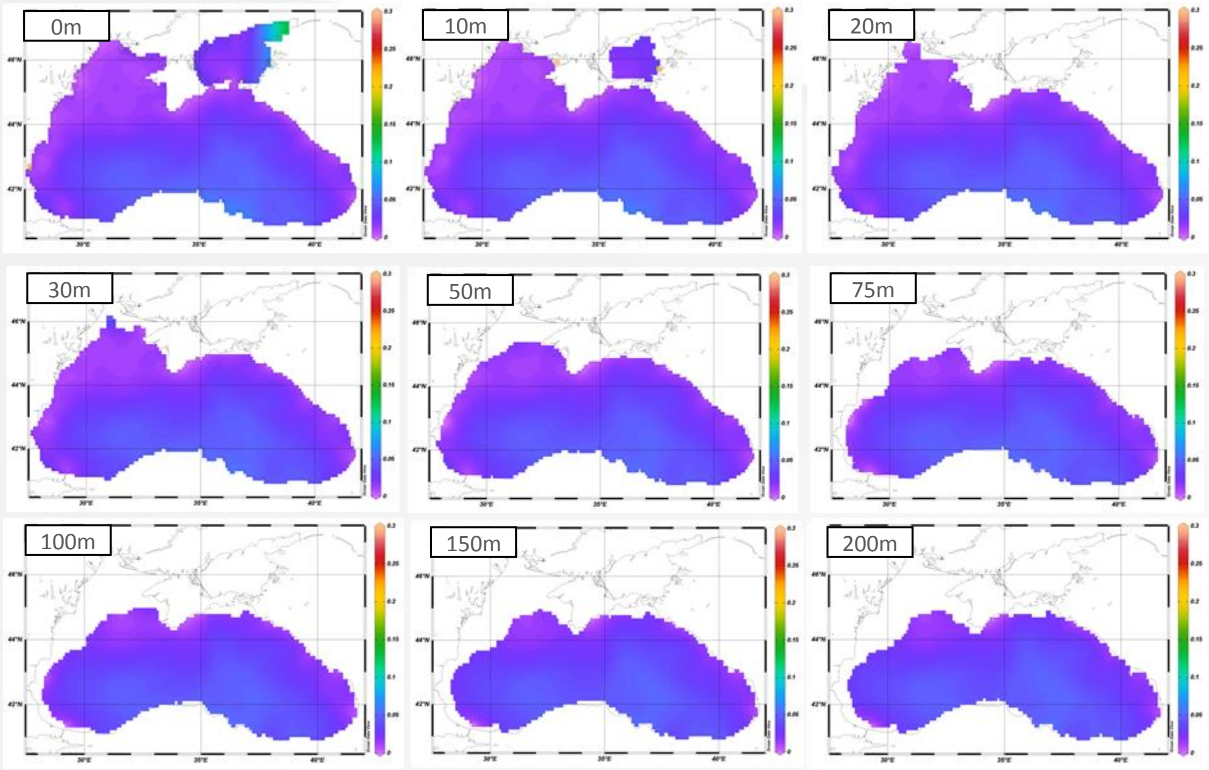


Figure 20 Temperature Relative Error in July.

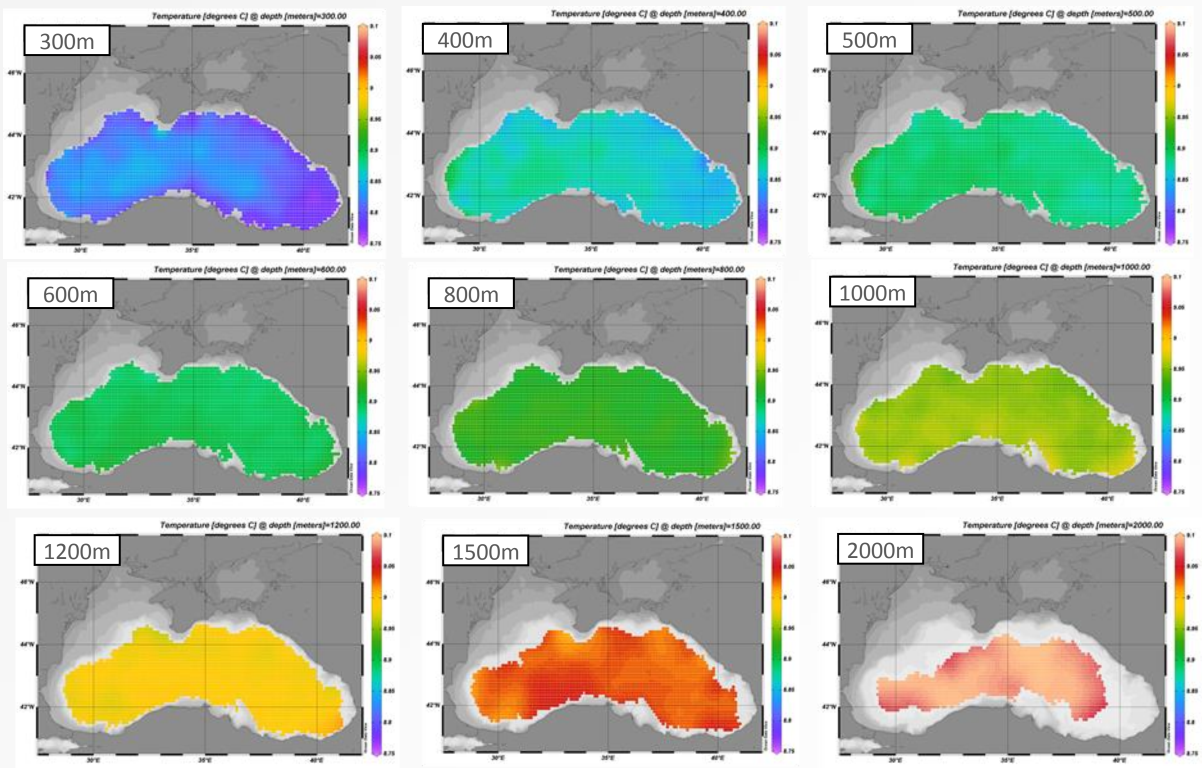


Figure 21 Annual Temperature

3.3. Salinity Maps

Salinity in Black Sea varies from 18 at surface to 22 at depth below 500 m. The shallow NW part of the Black Sea receives most of the river fresh water inflow, and salinity here goes down to 11 and less. The light low salinity surface waters of river origin overlay the dense saline waters of Mediterranean origin inflowing through the Turkish straits system. This two-layer feature is observed all over the basin. Due to stratification, the vertical circulation is very weak. Inter-annual variability of salinity at the surface is presented in Figure 22.
Similar to Temperature, the Salinity relative error for most of fields does not exceed 0.1 (10%) with exception of the Sea of Azov (not shown).
The main Black Sea circulation feature – Rim Current - is well noticeable at different depths in Salinity climatology as well, as displayed in Figure 23 for July.
Annual Salinity below 300m gradually increases from 21.5 C° to 22.4 C° (Figure 24).

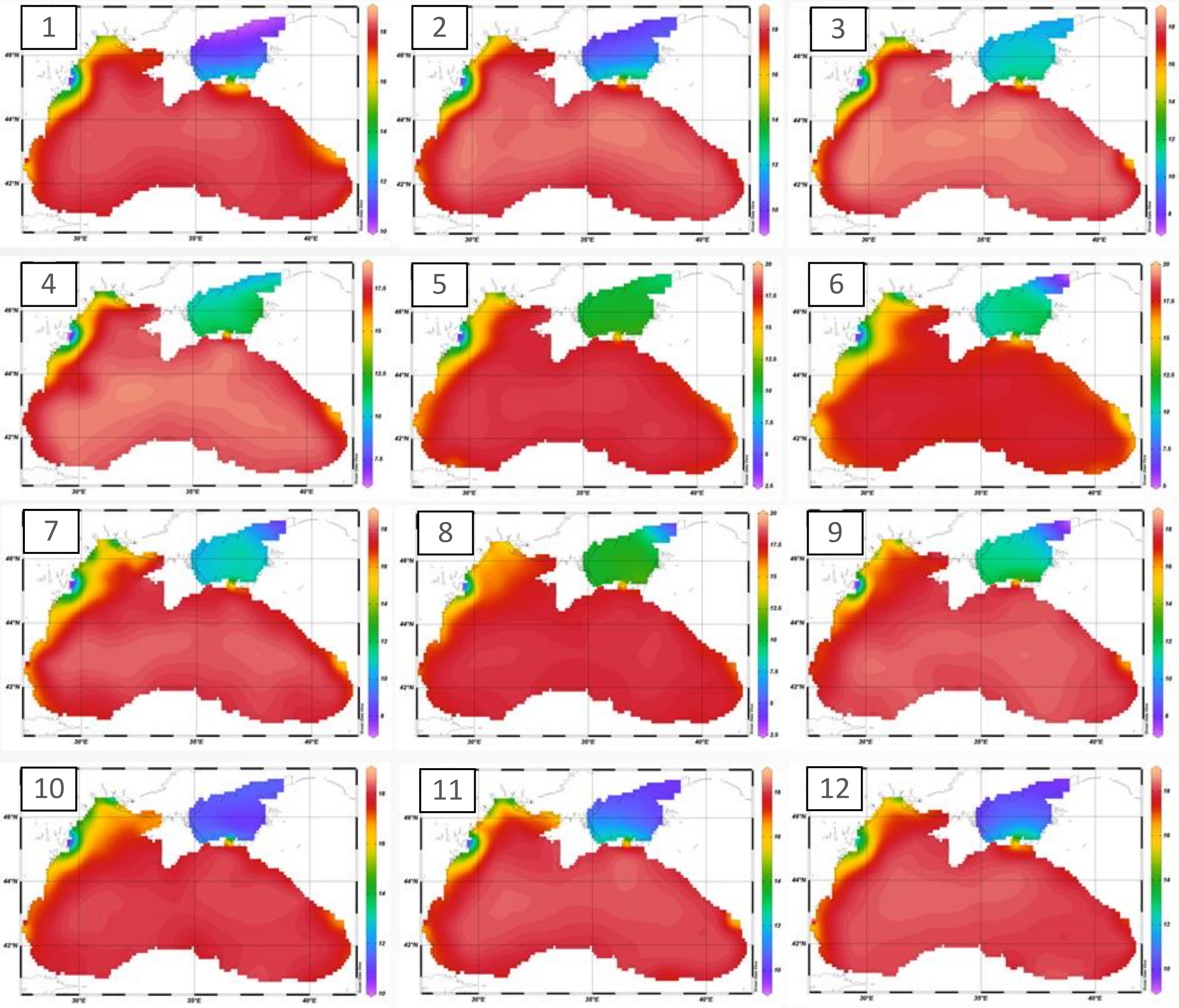


Figure 22 Monthly surface Salinity (automatic scaling is applied to highlight spatial features).

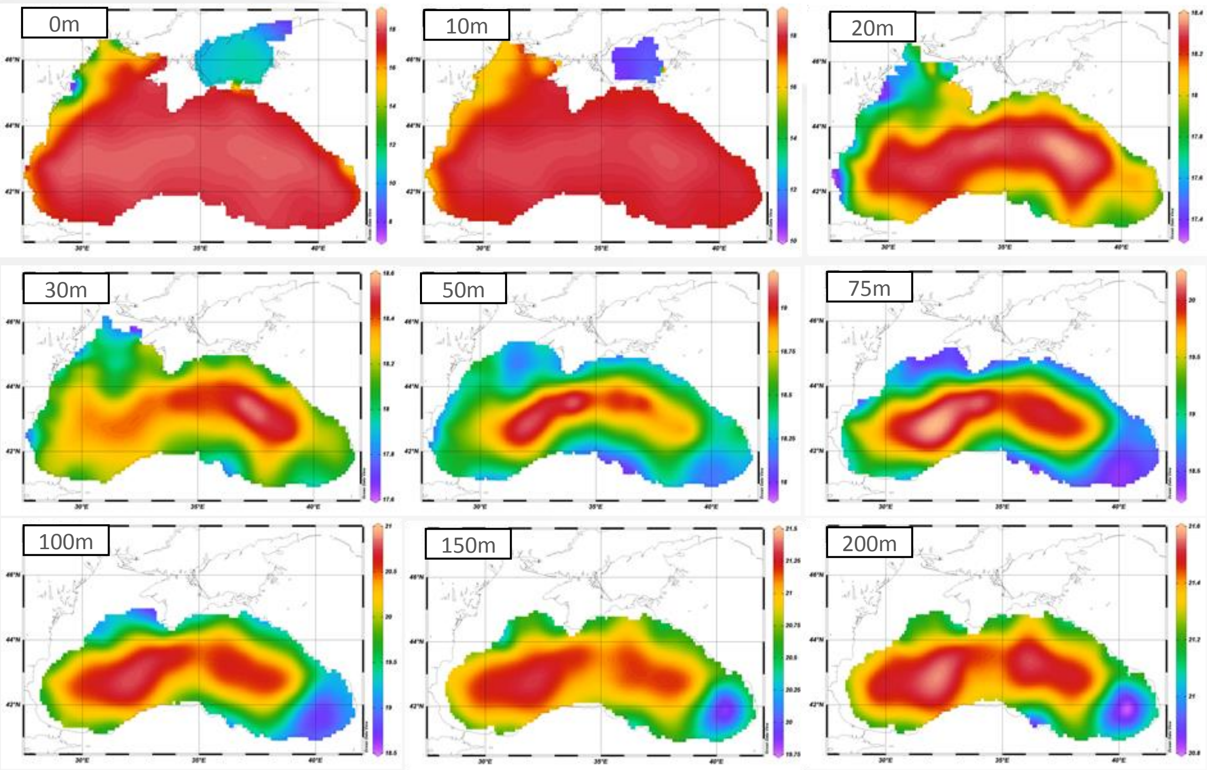


Figure 23 Salinity in July (automatic scaling is applied to highlight spatial features).

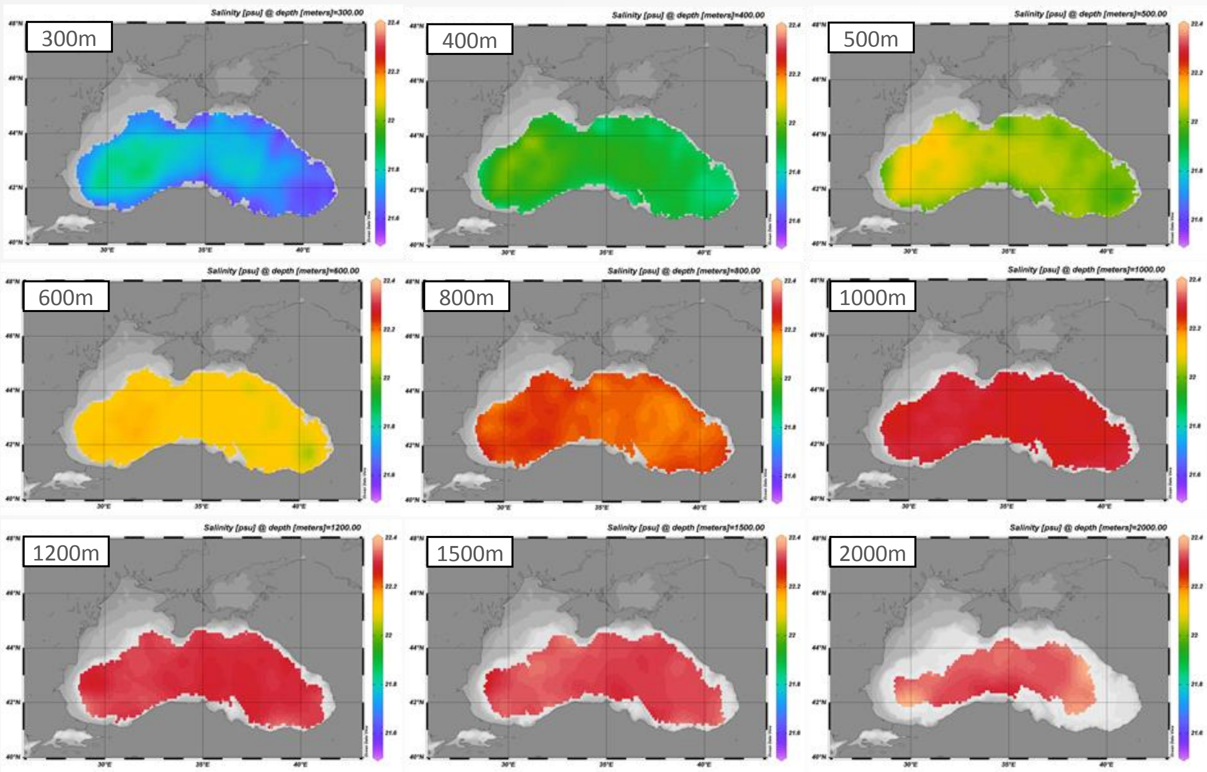


Figure 24 Annual Salinity.

3.4. Climatology validation

The main characteristics of the existing Black Sea climatologies are presented in Table 6 .

Table 6 - Characteristics of climatic products.

Name of product	Year of issue	Underlying data	Horizontal Resolution	Vertical Levels	Available Climatologies	URL	Comment
MEDATLAS	2002	~51,000 stations (1890-1998)	0.25°x0.25° (~40x40km)	28	Temperature: Monthly (0-300m) Seasonal (400-800m) Annual (>800m) Salinity: Seasonal (0 - 800m) Annual (> 800m)	http://www.ifremer.fr/medar/	
WORLD OCEAN ATLAS 2013 (WOA13): Black Sea domain	2013	~36,000 (1955-2012)	0.25°x0.25° (~40x40km)	67	Monthly (0-1500m) Seasonal Annual	https://www.nodc.noaa.gov/OC5/woa13/	Climatological mean as average of decadal time spans since 1955.
WOA CLIMATIC ATLAS OF THE SEA OF AZOV 2008	2008	34,517 marine stations (1891-2006),	10x10 km	3 (0, 5, and 10m)	Monthly	https://www.nodc.noaa.gov/OC5/AZOV2008/HTML/main_menu.html	
SeaDataNet 1 products: Black Sea Climatic Maps	2008	~158,000 stations (1890 - 2007)	20'x30'	19	Monthly (0-300m) Annual (> 300m)	http://www.ims.metu.edu.tr/SeaDataNet/	
SeaDataNet 2 products: Black Sea Climatologies	2015	~104,400 stations (1900-2013)	0.1°x0.1°	19	Monthly (0-250m) Annual (>250m)		

The main advantage of the current product is better resolution and better underlying data coverage compared to most of other products. There are two exceptions from this statement:

1. The WOA CLIMATIC ATLAS OF THE SEA OF AZOV 2008 has comparable resolution and better underlying data coverage however only foe Sea of Azov geographical scope;
2. The SeaDataNet 1 product was produced on the base of Oceanographic Data Bank for the Black Sea of the MHI NASU, Sevastopol, however the declared number of 158,000 stations seems to be unreal when is goes about Temperature and Salinity, particularly considering that most of the available data from Black Sea countries is already included in the SeaDataNet CDI and hence included in the current Black Sea Aggregated Dataset, which contain 104,400 stations including restricted data.

The preliminary validation of Black Sea Climatology was provided against WOA 2013 and SeaDataNet 1 product. Visual comparison of maps demonstrates very good correspondence between different products particularly at deeper depth levels, though due to lower resolution WOA 2013 maps look more smoothed and contain less small scale features.
The average difference between SeaDataNet 2 and WOA annual Temperature fields at WOA grid is 0.02 C° at depth 300 m and 0.01 C° on deeper depth levels up to bottom, while maximum deviation does not exceed 0.07 C° (Table 7). The average difference between annual Salinity fields ranges from 0.03 PSU at 300 m to 0.01 PSU at 2000 m, while maximum deviation does not exceed 0.12 PSU. Such good correspondence confirms expectations considering very low variability of parameters at depth below 300 m.

Table 7 - Comparison of SeaDataNet 2 and WOA 2013 annual fields

Depth	Temperature		Salinity	
	AvDev	MaxDev	AvDev	MaxDev
300	0.02	0.06	0.03	0.10
400	0.01	0.07	0.03	0.12
500	0.01	0.05	0.03	0.10
600	0.00	0.02	0.01	0.06
800	0.00	0.02	0.01	0.03
1000	0.01	0.02	0.01	0.04
1200	0.00	0.02	0.01	0.04
1500	0.01	0.02	0.01	0.08
2000	0.01	0.07	0.02	0.07

However, comparison of average and maximums deviation for upper layers revealed rather large differences between products (Table 8). The average deviation of Temperature is going up to 0.67 C° at certain depth levels with maximum deviation reaching 6-7 C°. The Salinity field is more conservative: average deviation from WOA product ranges from 0.05 to 0.22 except the surface where it reaches 0.35 PSU, while average deviation from SeaDataNet 1 product ranges from 0.05 to 0.16 PSU. However maximum deviation can reach as much as 5-6 PSU at surface.

Table 8 - Comparison of SeaDataNet 2, WOA 2013 and SeaDataNet 1 monthly fields

	WOA13				SDN1			
	Temperature		Salinity		Temperature		Salinity	
Depth	AvDev	MaxDev	AvDev	MaxDev	AvDev	MaxDev	AvDev	MaxDev
0	0.55	5.45	0.35	4.79	0.37	3.46	0.15	6.12
10	0.65	4.99	0.22	4.14	0.40	4.49	0.08	1.20
20	0.67	5.72	0.08	1.12	0.64	7.31	0.06	0.71
50	0.31	3.12	0.12	0.59	0.25	3.70	0.08	0.48
75	0.19	1.23	0.21	0.94	0.14	1.83	0.13	0.92
100	0.15	1.15	0.21	1.03	0.10	0.70	0.16	0.79
150	0.10	0.69	0.14	0.85	0.05	0.44	0.11	0.98
200	0.09	0.79	0.08	0.67	0.03	0.26	0.07	0.58
250	0.09	0.83	0.05	0.37	0.02	0.17	0.05	0.34

Detailed analysis of Temperature differences at surface for August is presented in Figure 25. The SeaDataNet2 map looks patchy compared to two other products: this could be caused improper choice of DIVA parameters such as correlation length, background field. However it should be noted that SeaDataNet2 contains some features which are less pronounced or missing on other maps. For example, the upwelling at Western Anatolian coast observed in July and August is present in SeaDataNet2 map, but it is less pronounced and practically absent at WOA 2013 map. Maximum temperature deviations are observed as well in other areas along coasts.

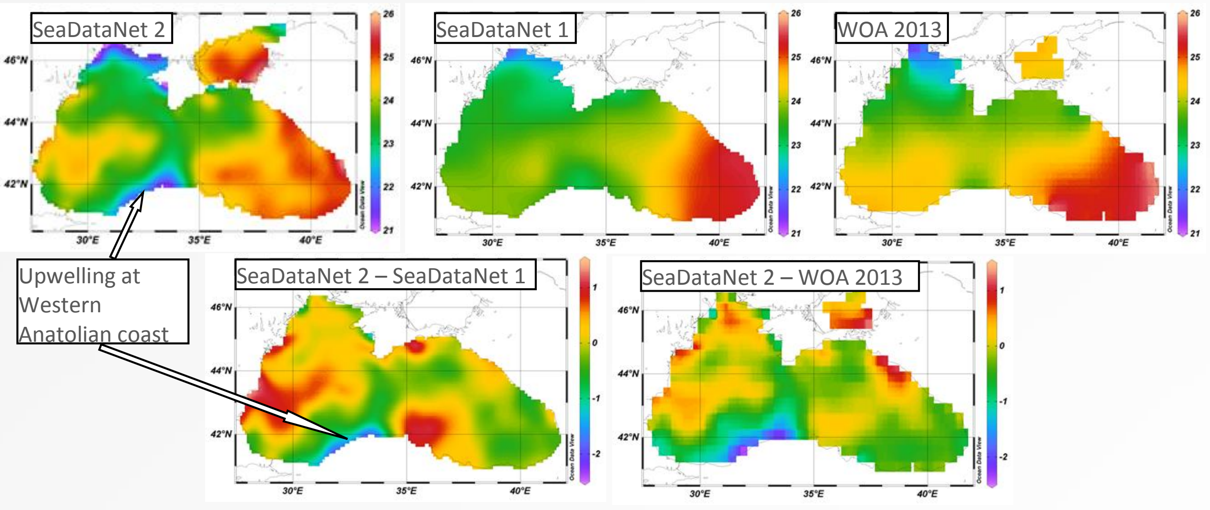


Figure 25 Temperature fields (top row) and Temperature difference fields (bottom row), surface, August.

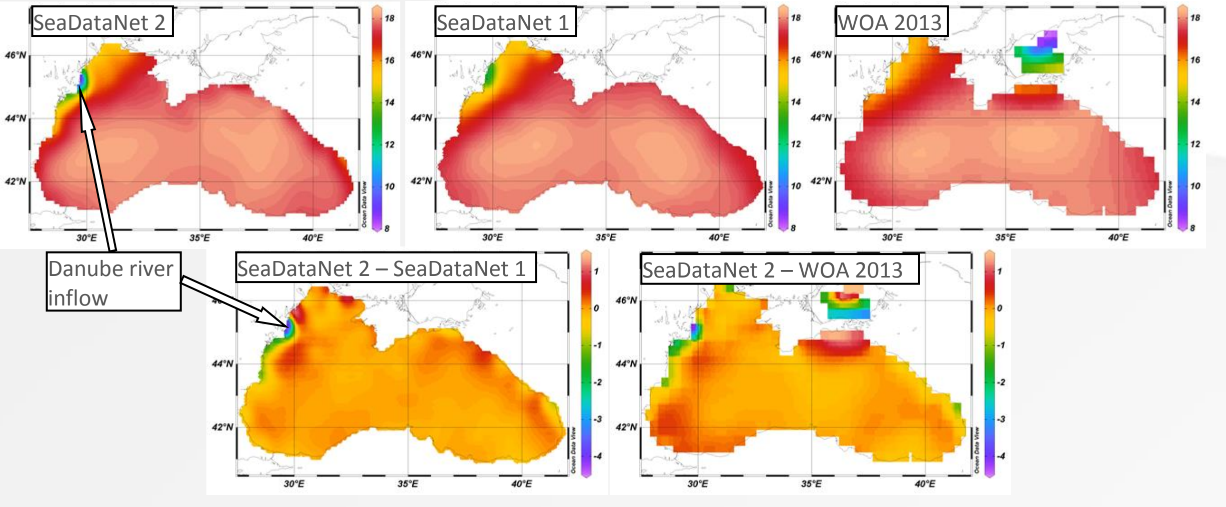


Figure 26 Salinity fields (top row) and Salinity difference fields (bottom row), surface, August.

The comparison of Salinity fields at surface in August is presented in Figure 26. The maps from different products have many similarities. The main differences in Salinity are observed in areas of river inflow. The largest such area – Danube inflow - is situated in the N-W part of the Black Sea. Analysis of data in that area confirmed presence of low salinity waters very close to coast, however on DIVA maps low salinity waters propagate far away from shore. The reason for this could be improper choice of correlation length for salinity field in coastal area.

Short conclusion is as follows:

- The produced climatic maps pretty well represent the main Black Sea features such as Rim Current, Western and Eastern Gyre, Batumi Eddy as well as river inflow and upwelling areas.
- Further improvement of quality of monthly fields is required considering presence of anomalies on some monthly maps and found differences with other climatologies. The work on improvement should include both analysis of found problems in order to reveal and eliminate erroneous data and tuning of DIVA parameters for obtaining more stable and reliable result.

4. Arctic Sea Climatology

4.1. Methodology

- Domain definition
  - The geographic domain used is 40W to 65E and 65N to 82N

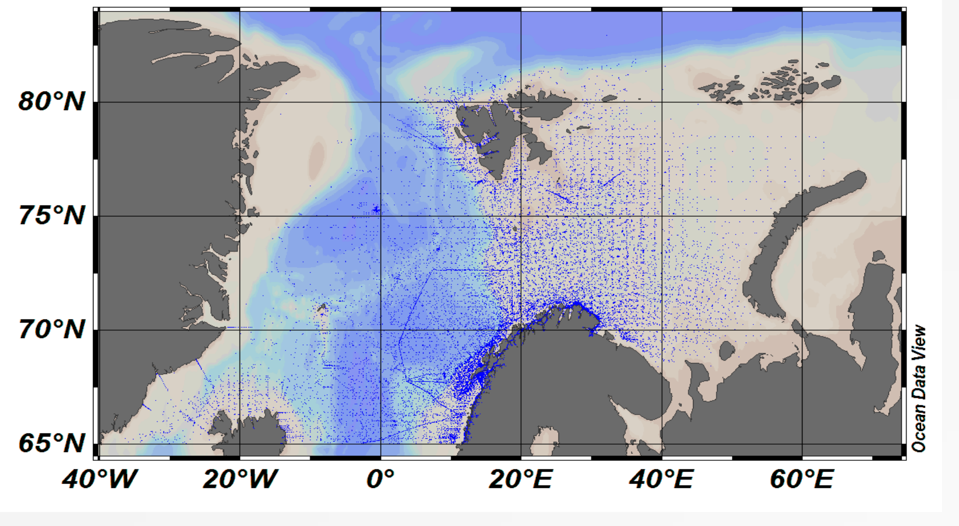


Figure 27 - Arctic Sea domain and data distribution map at the surface.

- Time-space resolution
  - The time period used is 1900 to 2013 giving monthly values
- DIVA settings (table with the parameters)
  - param.par xori -**40** yori **65**; dx **0.2** dy **0.1**; nx **526** ny **171**
  - contour.depth 3000,2500,2000,1750,1500,1400,1300,1200,1100, 1000,900,800,700,600,500,400,300,250,200,150,125,100,75,50,30,20,10,0
  - Quality flags **0 1 5**
- Description of the tuning of DIVA
  - No specific tuning
- Background field choice
  - No reference field
- Error Maps
  - 30% and 50%

4.2. Temperature Maps

Warmer water transported northwards following the main currents.

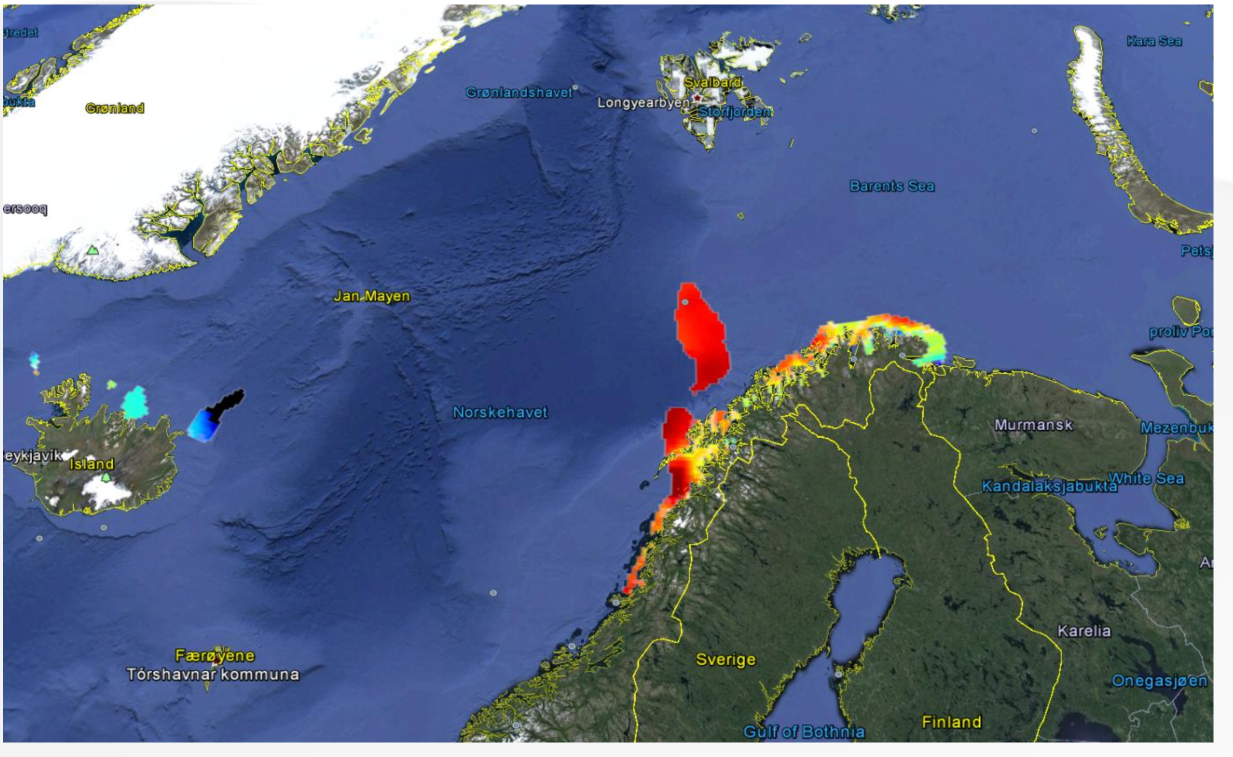


Figure 28 Temperature at surface level in December all years masked with 50%

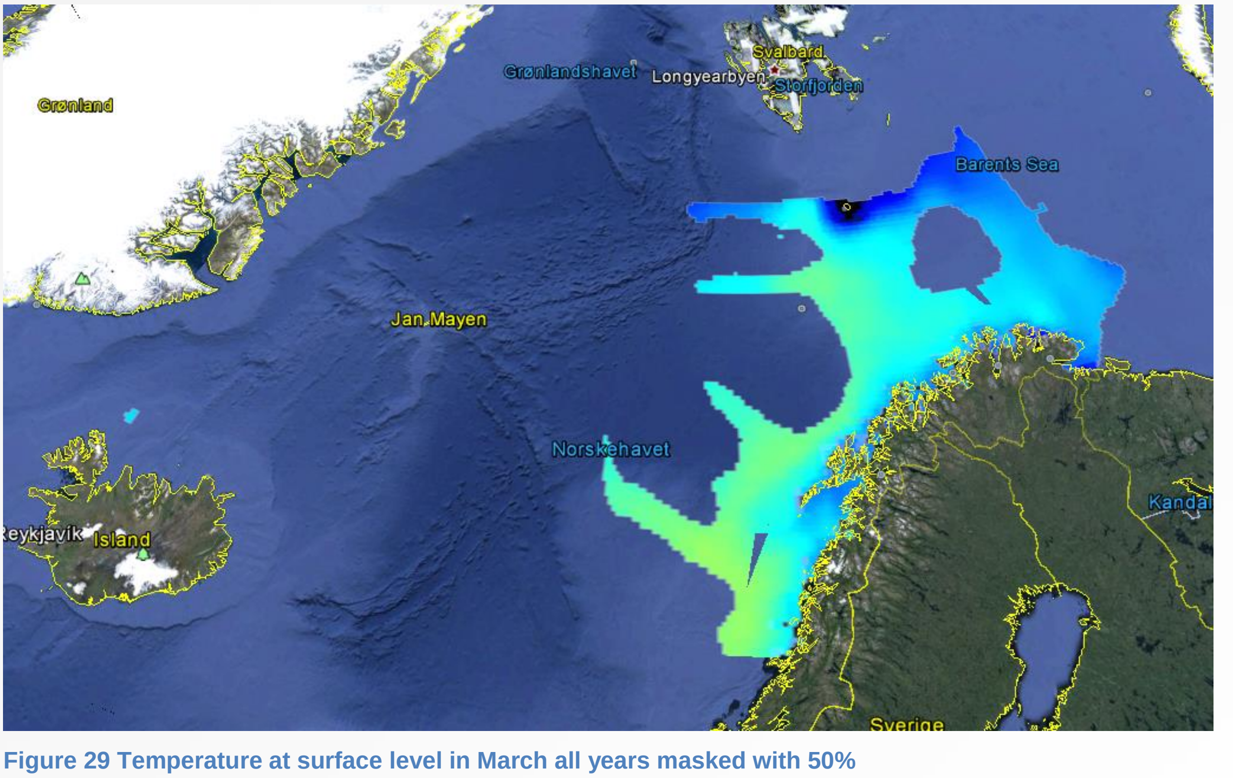


Figure 29 Temperature at surface level in March all years masked with 50%

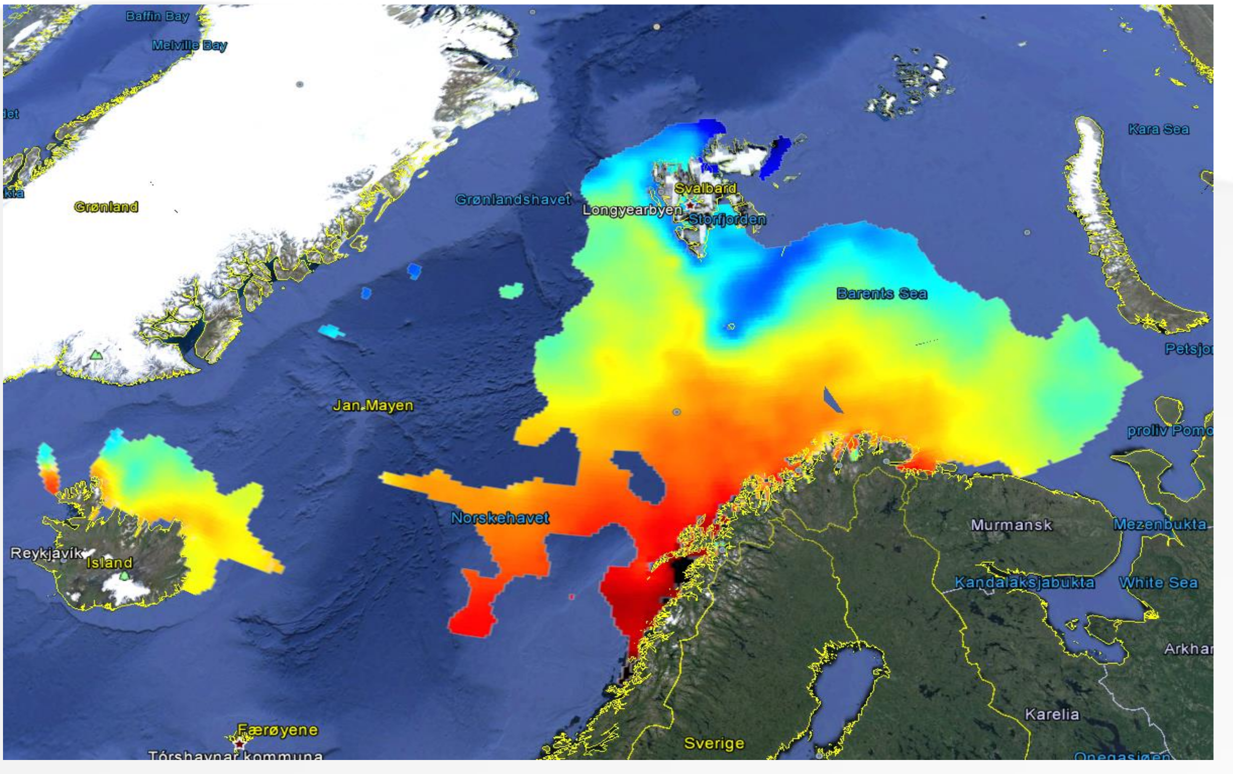


Figure 30 Temperature at surface level in August all years masked with 50%

4.3. Salinity Maps

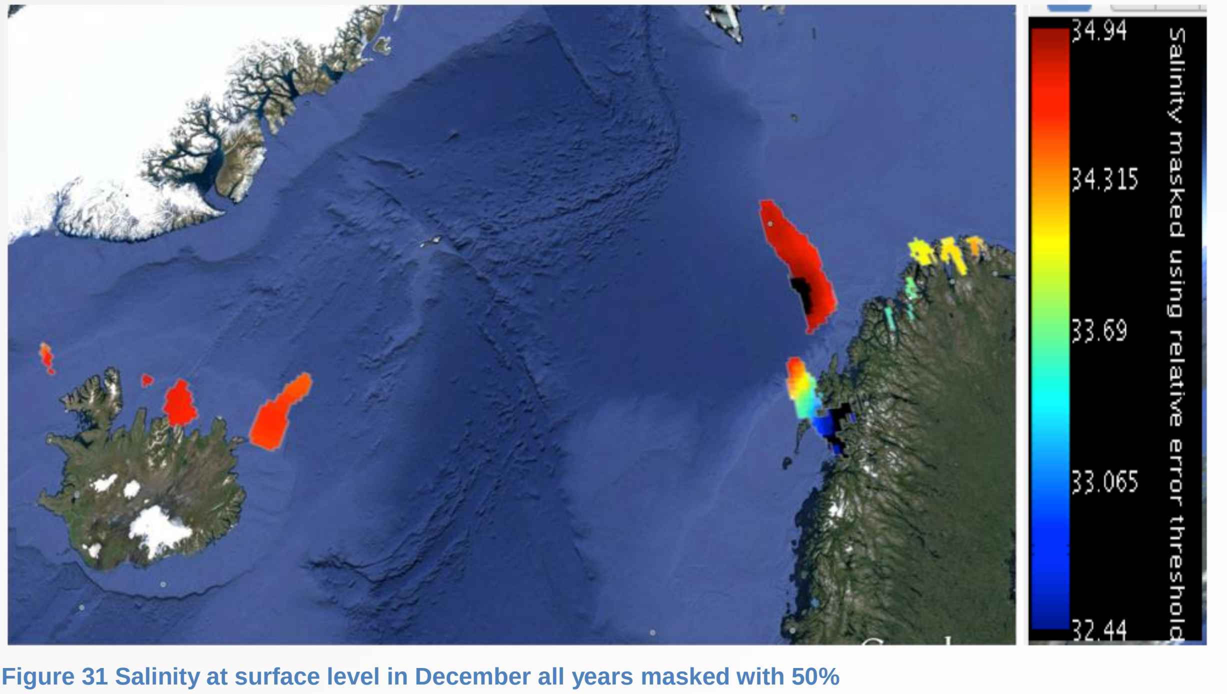
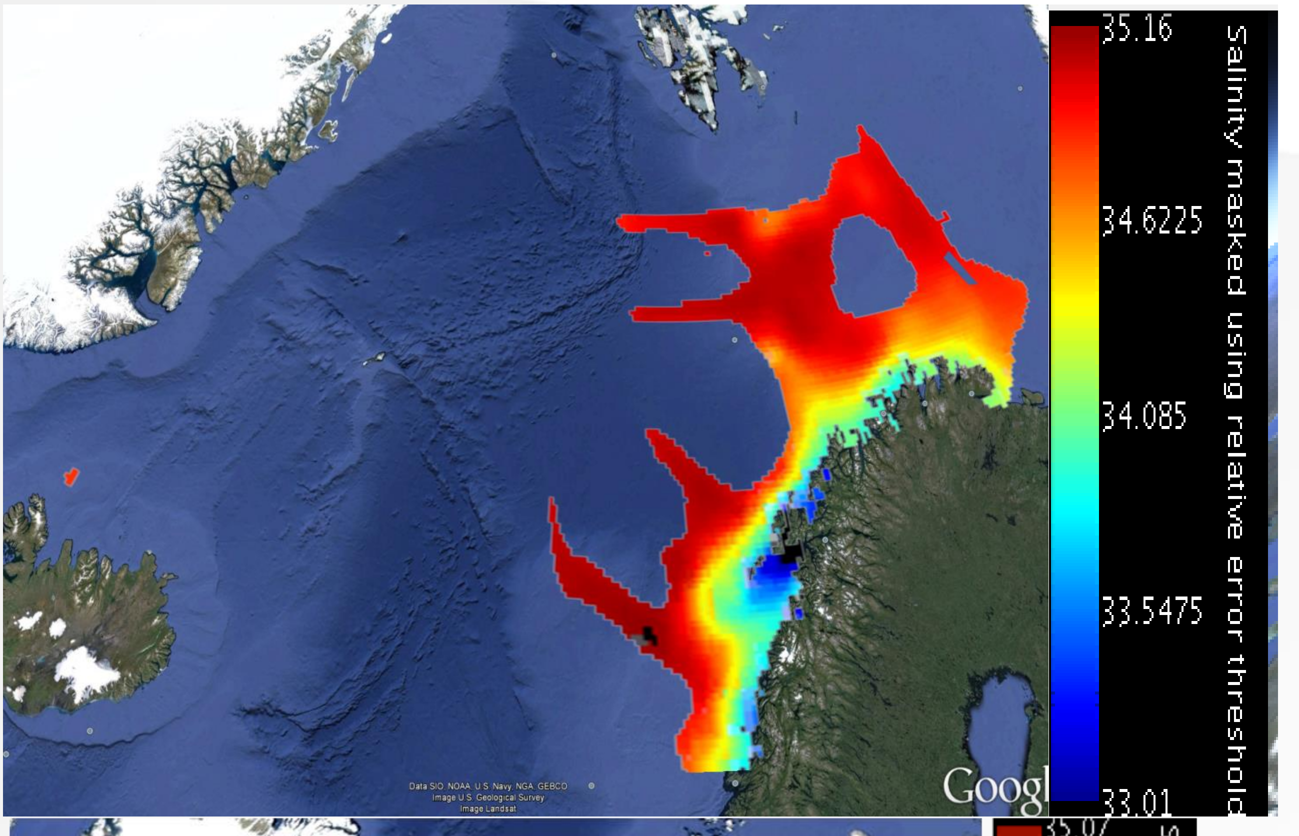


Figure 31 Salinity at surface level in December all years masked with 50%

Figure 32 Salinity at surface level in March all years masked with 50%



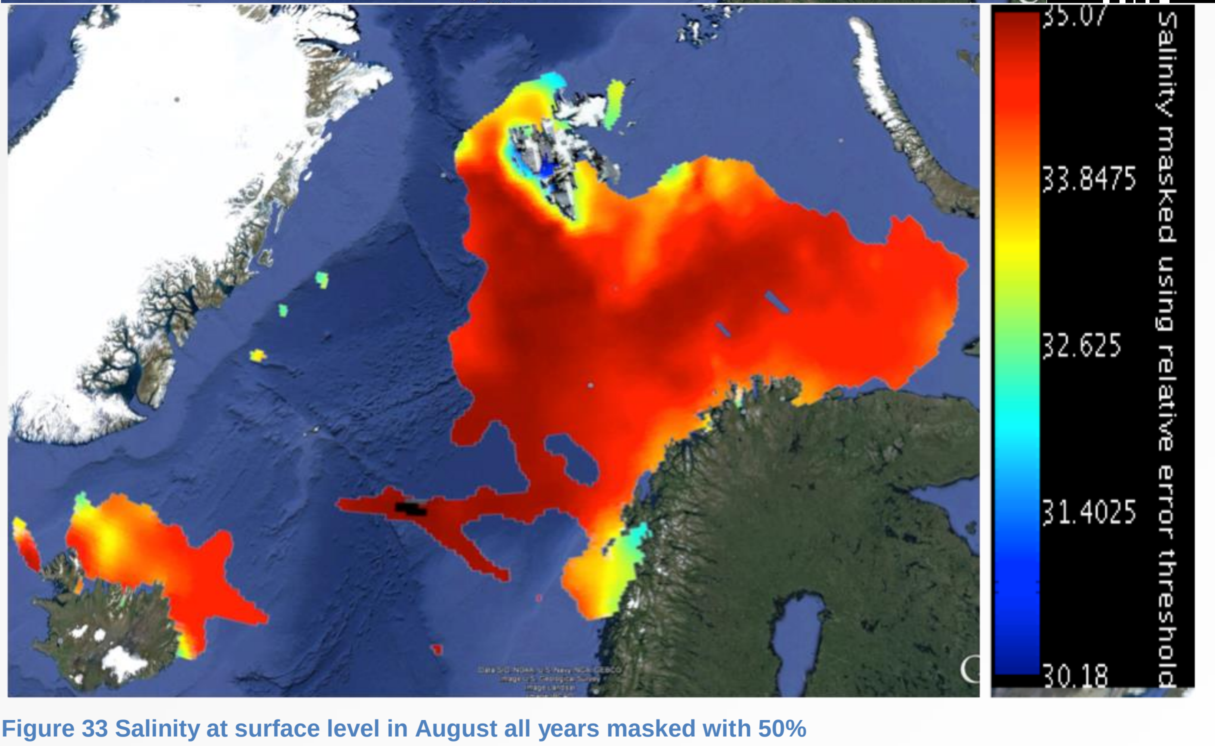


Figure 33 Salinity at surface level in August all years masked with 50%

4.4. Climatology validation

No validation performed at this stage due to small amounts of data in the Arctic dataset.

5. Baltic Sea Climatology

5.1. Methodology

Diva 4.6.9 was used to create climatologies.

- Domain definition
  The Baltic Sea including Kattegat and parts of Skagerrak. Bounding Box: 9°E - 31°E, 53°N – 66°N.
  Excluding areas outside the region (included in the North Sea/Atlantic/Arctic Sea region):
  9°E - 14°E, 62°N - 66°N
  9°E - 9.4°E, 54°N - 55°N
  9°E - 10°E, 53°N - 54°N

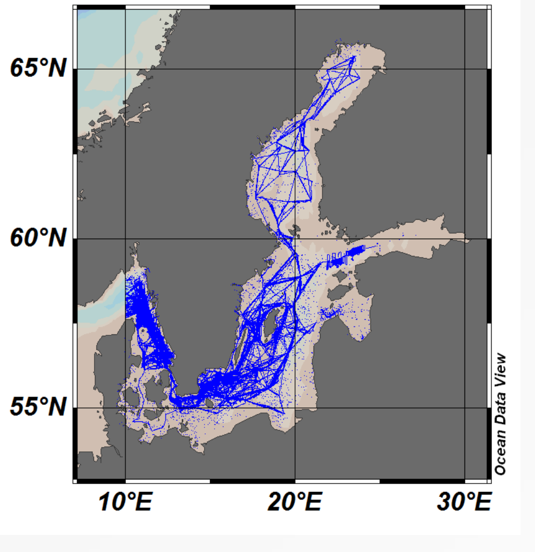


Figure 34 Baltic Sea domain and data distribution map at the surface.

- Time-space resolution
  Monthly Climatologies have been produced with data from 1900 – 2012. Output grids have resolution 200x200 cells, with the cell size in degrees: 0.11° in longitude, 0.065° in latitude.
  Depths: 300, 275*, 250, 225, 200, 175, 150, 125, 100, 90*, 80, 70, 60, 50, 40, 30, 20, 15, 10, 5, 0 (Helcom Combine standard depths, except some extra marked with star (*). Depth 0m is also often written as 1m, it's a surface value and treated the same way).
- DIVA settings are listed in Table 9.

Table 9 - param.par input file with the settings for the Baltic Sea climatology computation.

Lc	0.7
icoordchange	1
Ispec	111
ireg	0
xori	9

yori	53
dx	0.11
dy	0.065
nx	200
ny	200
valex	-9999.0
snr	1.0
varbak	1.0

- Description of the tuning of DIVA
  We have tuned the correlation length, Lc, and signal-to-noise ratio, snr. The correlation length has been a balance to get a low enough value and not get too high errors that will mask away too much. Used values are: Lc = 0.7, snr = 1.0
- Background field choice
  Four seasonal climatologies have been created and used as background fields. Seasons defined as month: 12-02, 03-05, 06-08 and 09-11, corresponding to winter, spring, summer and autumn.
- Error Maps
  Clever poor man's error in DIVA has been used to calculate a relative error. This will be used to mask the climatologies where the error exceeds a set value.

5.2. Temperature Maps

Generally colder waters in the northern Part of the Baltic Sea during all months. With hints of warm or cold water from river runoff depending on season.
Temperature is increasing with depth during winter, and decreasing with depth during summer in the upper water column.
Temperature varies a lot during the year in the surface layer, but is quite stable below the halocline (~60m) during the whole year.

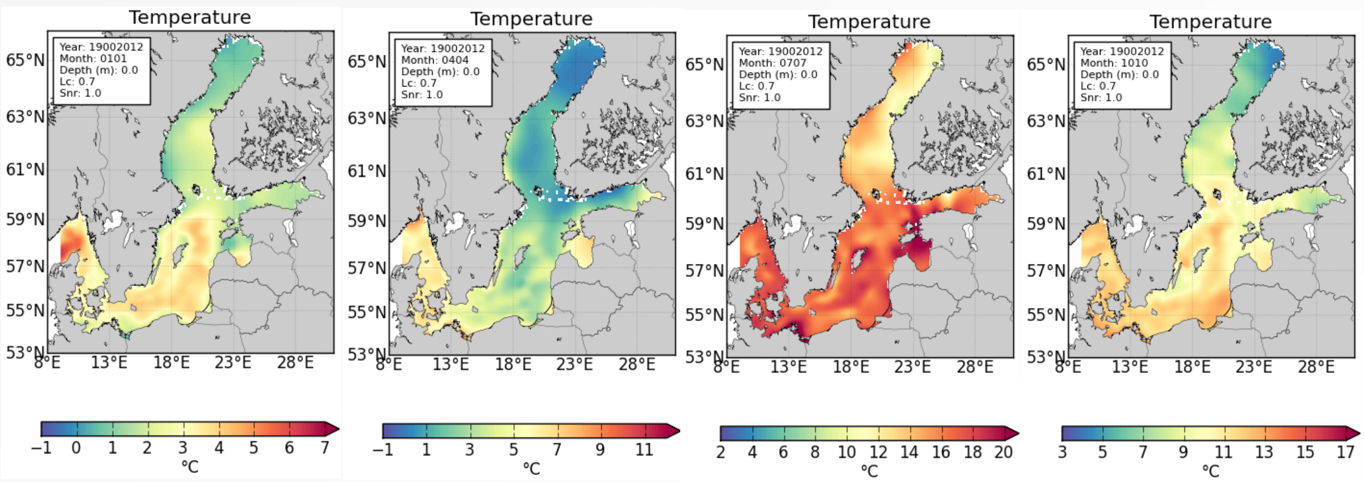


Figure 35 Surface temperature maps without error masking: January, April, July and October.

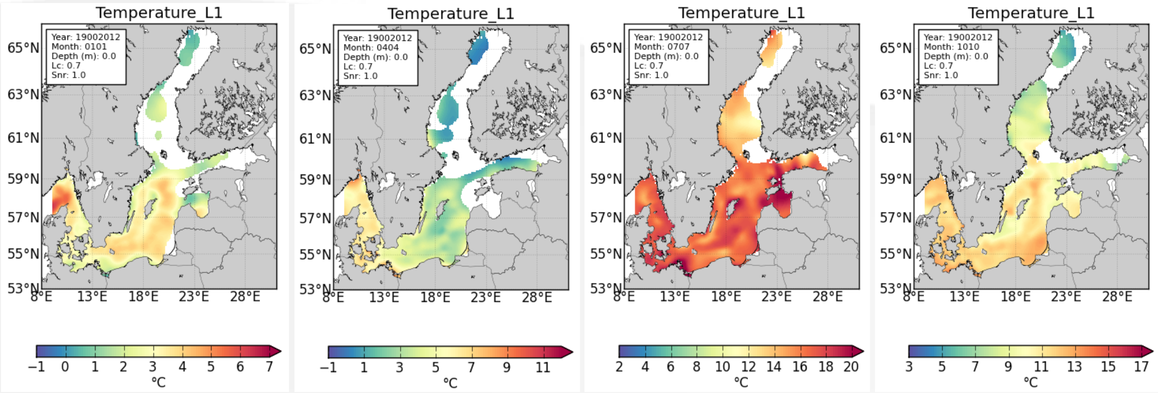


Figure 36 Surface temperature maps masked where relative error is higher than 30%: January, April, July and October.

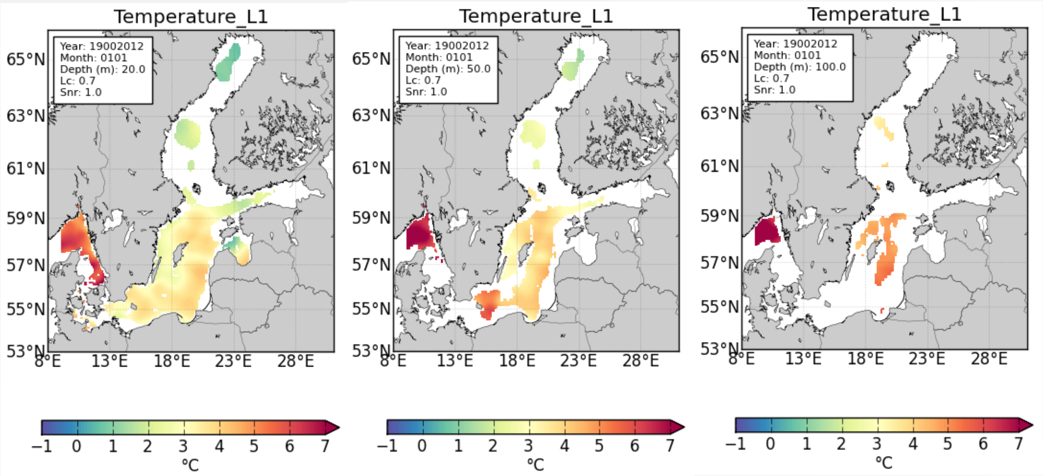


Figure 37 January Temperature maps at 20m, 50m and 100m, masked where relative error is higher than 30%.

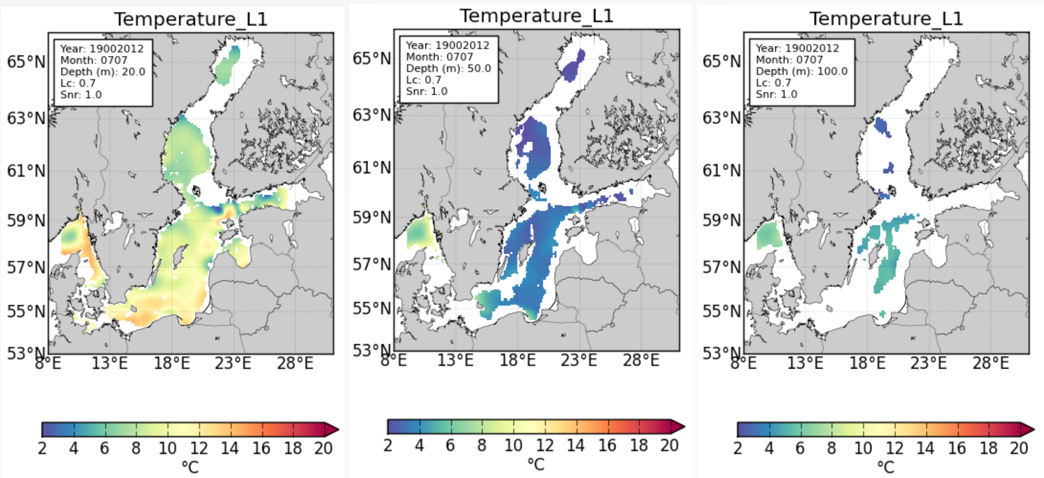


Figure 38 July Temperature maps at 20m, 50m and 100m masked where relative error is higher than 30%.

5.3. Salinity Maps

Very clear gradient with low saline waters in the northern part of the Baltic Sea to high saline waters in the Skagerrak. Salinity is very conservative during the year, only showing small variations due to fresh water from rivers.

Salinity is increasing with depth, most visible in the Baltic Proper when comparing above and below the halocline that usually is found at ~60m.

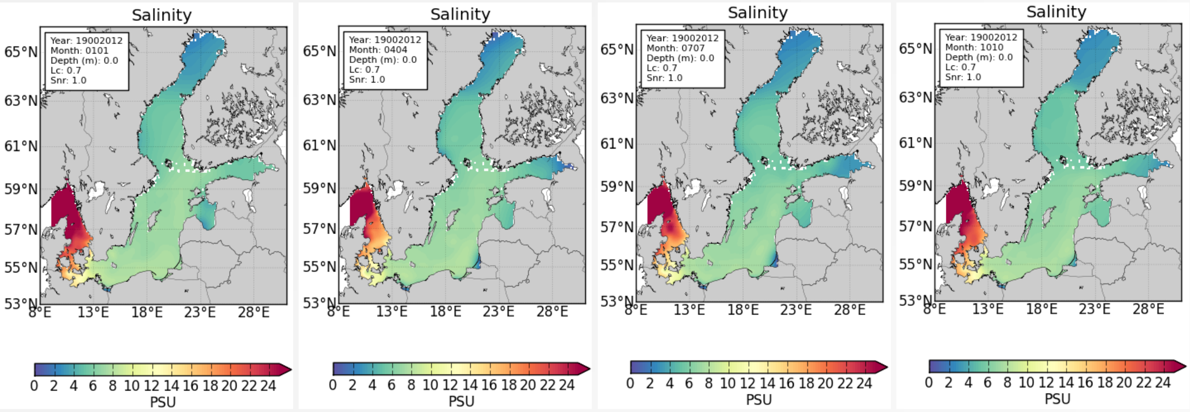


Figure 39 Surface salinity maps without error masking: January, April, July and October.

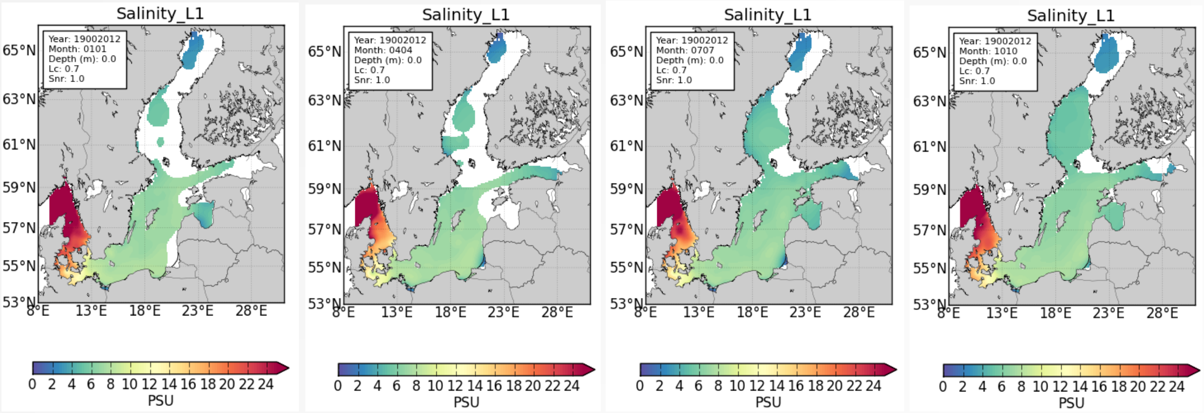


Figure 40 Surface salinity maps masked where relative error is higher than 30%: January, April, July and October.

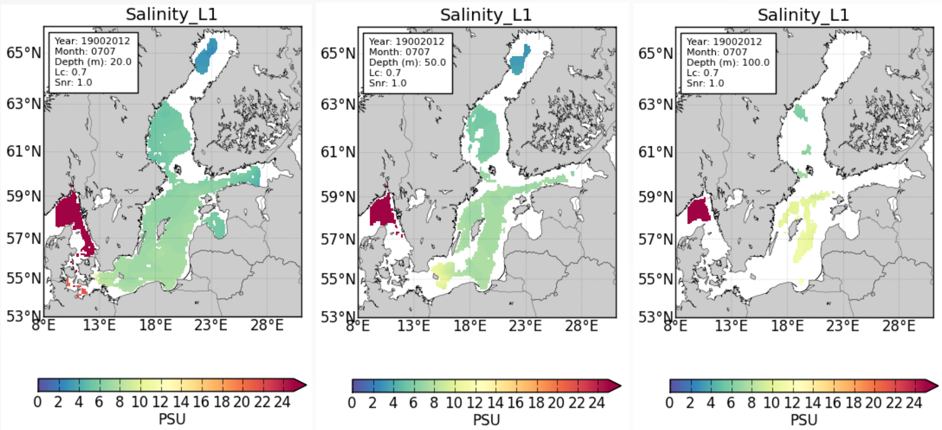


Figure 41 July Salinity maps at 20m, 50m and 100m masked where relative error is higher than 30%.

5.4. Climatology validation

Comparison with previous SeaDataNet climatologies (the ones currently available at the portal).

Very similar results compared to the old climatologies. Differs in how much is masked away when using the relative error field because the old climatologies probably used another error estimation routine, which underestimates the error. For the old salinity plots, the data field have been masked where relative error > 5% instead of 30%, the reason for this is unknown. Further evaluation against World Ocean Atlas 2013, WOA13, will probably be made before the project ends.

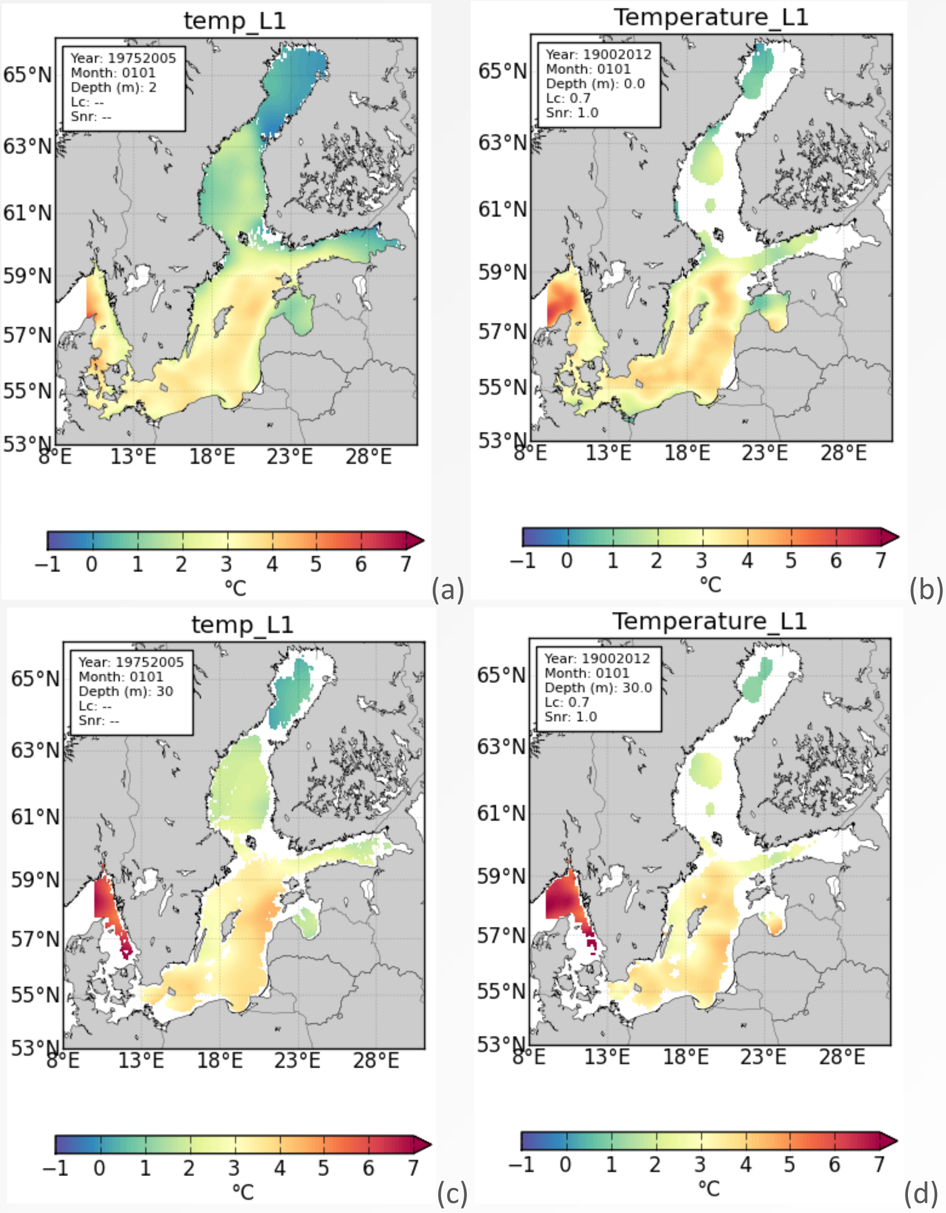


Figure 42 January temperature maps masked where relative error is higher than 30%: (a) old surface temperature; (b) new surface temperature; (c) old temperature 30m; (d) new temperature 30m.

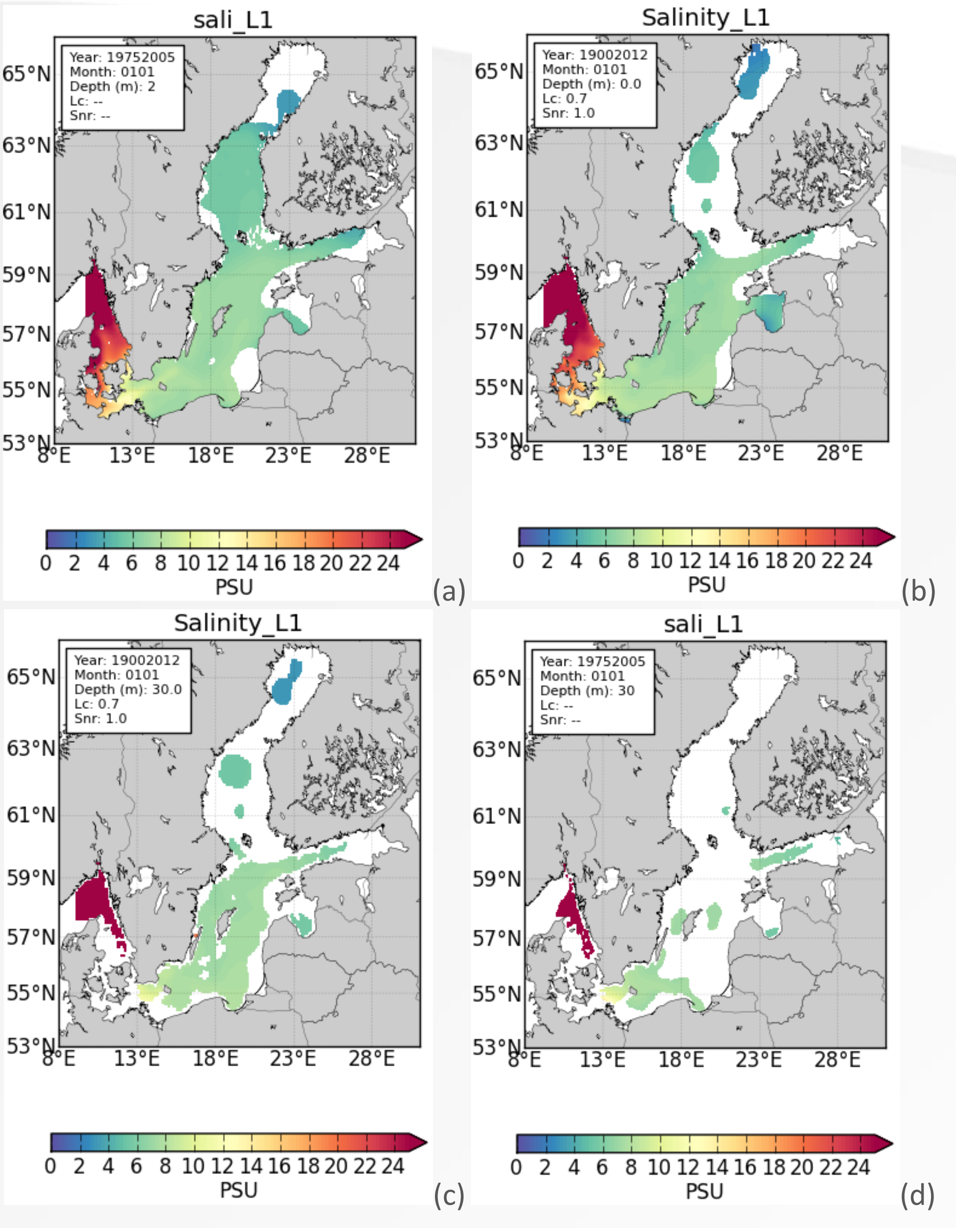


Figure 43 January salinity maps masked where relative error is higher than 30%: (a) old surface temperature; (b) new surface temperature; (c) old temperature 30m; (d) new temperature 30m.

6. North Sea Climatology

6.1. Methodology

The domain covered by the data sets extends from –4° W to 9°E and from 48.5°N to 62°N, as shown in Figure 44.

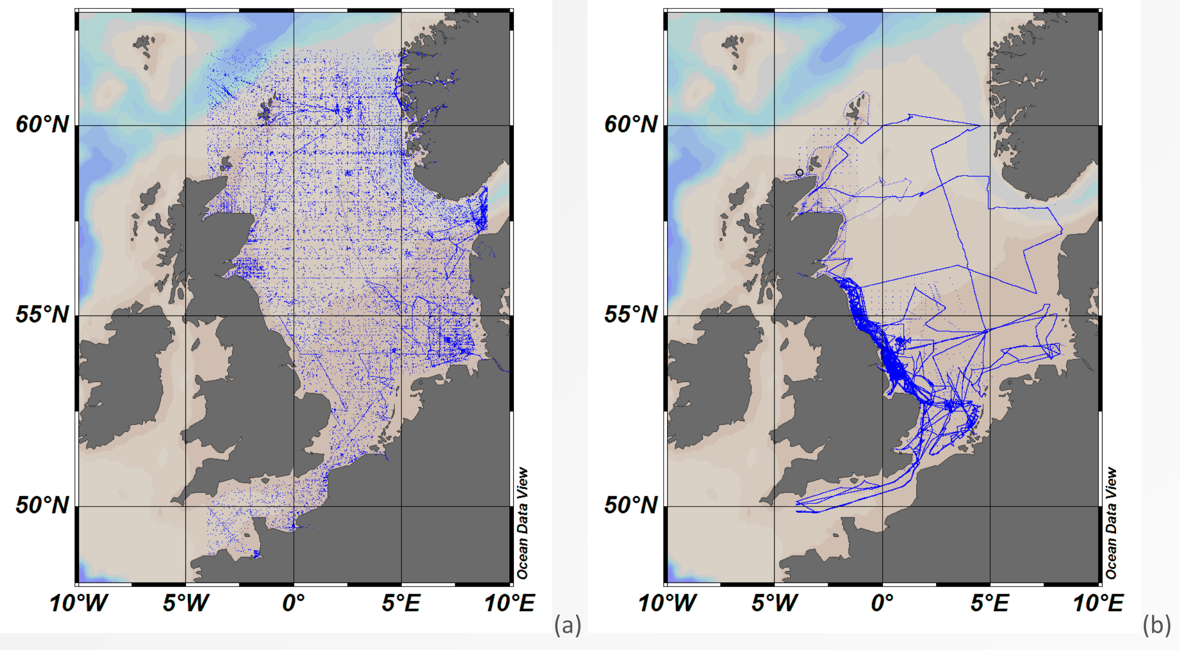


Figure 44 Location of stations in the TS data collections for the North Sea for the period 1900-2013: (a) freely accessible data; (b) restricted dataset.

In this first version of the North Sea climatologies however, the bathymetry used corresponds to the official limits of the North Sea, as defined by the International Hydrographic Bureau (1953), see Figure 45. This will be adapted in the next release.

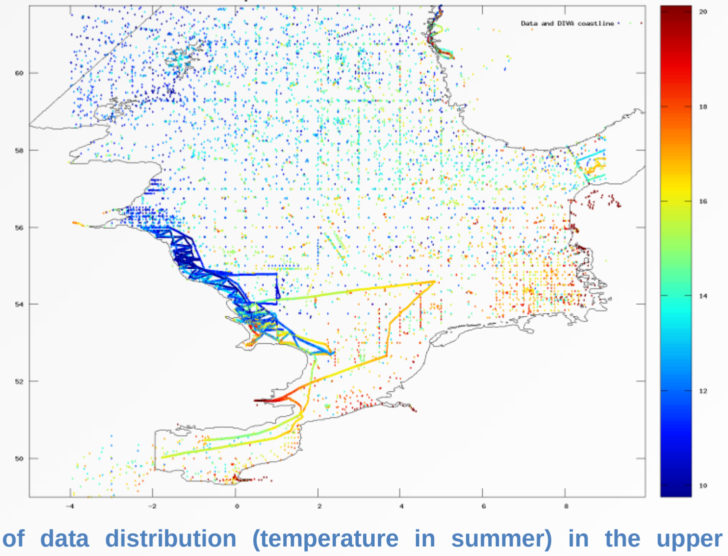
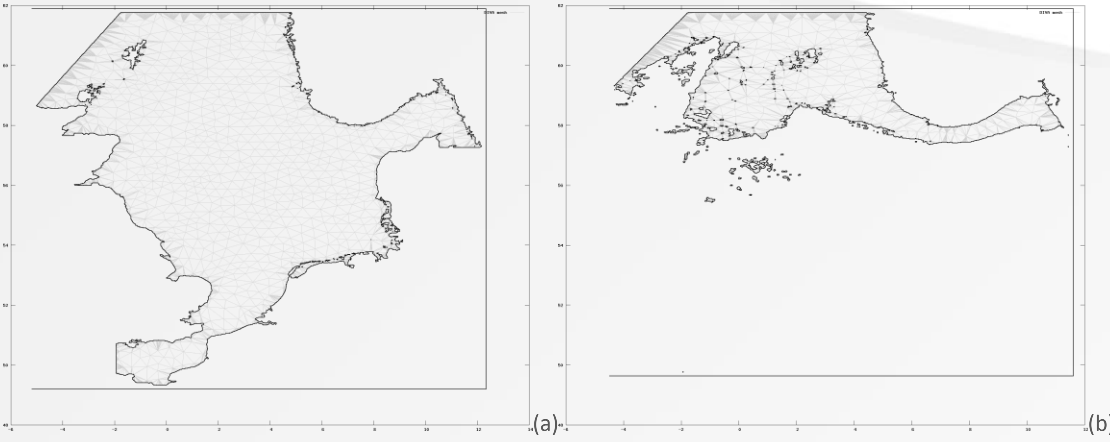


Figure 45 Example of data distribution (temperature in summer) in the upper layer, showing the computational domain boundaries (not projected).

The bathymetry, based on GEBCO "One minute grid" (2008) was generated using $\Delta\varphi = \Delta\lambda = 0.05°$, resulting in very detailed meshes along the boundaries:



(a) (b)

Figure 46 Examples of DIVA computational grid at (a) depth= 0m and (b) depth = 100 m.

The data used are those of the aggregated datasets (V1.1), both the open access data set and the restricted data set have been used.
Fourteen depth levels, listed in Table 10 were considered.

Table 10 - Reference levels considered for the climatology computation in the North Sea.

#	Standard depth (m)
14	0
13	10
12	20
11	30
10	50
9	75
8	100
7	125
6	150
5	200
4	250
3	300
2	400
1	500

DIVA settings are given below in

Table 11 and Table 12

Table 11 - param.par input file with the settings for the North Sea climatology computation

Parameter	AN
Lc correlation length	1.5
icoordchange	2
ispec	11
ireg	2
xori	-5
yori	49
dx	0.05
dy	0.05
nx	300
ny	256
valex	-9999.0
snr	0.5
varbak	1

Table 12 - driver input file with the settings for the North Sea climatology computation

Parameter	
Data extraction	-1
boundary lines and coastlines generation:	0
cleaning data on mesh:	0
minimal number of data in a layer	-1
Parameters estimation and vertical filtering	0
Minimal L	1.4
Maximal L	10
Minimal SN	0.1
Maximal SN	50
Analysis and reference field:	1
Lower level number	1
Upperl evel number	14
4D netCDF files generation:	0
gnuplot plots	1
Data detrending	0

At this stage, no specific tuning of the DIVA parameters took place.

6.2. Temperature Maps

6.2.1. Note on the datasets

The datasets are strongly influenced by the huge measurement effort that took place during the so-called “North Sea project”, between August 1988 and October 1990, as recalled on Figure 47.

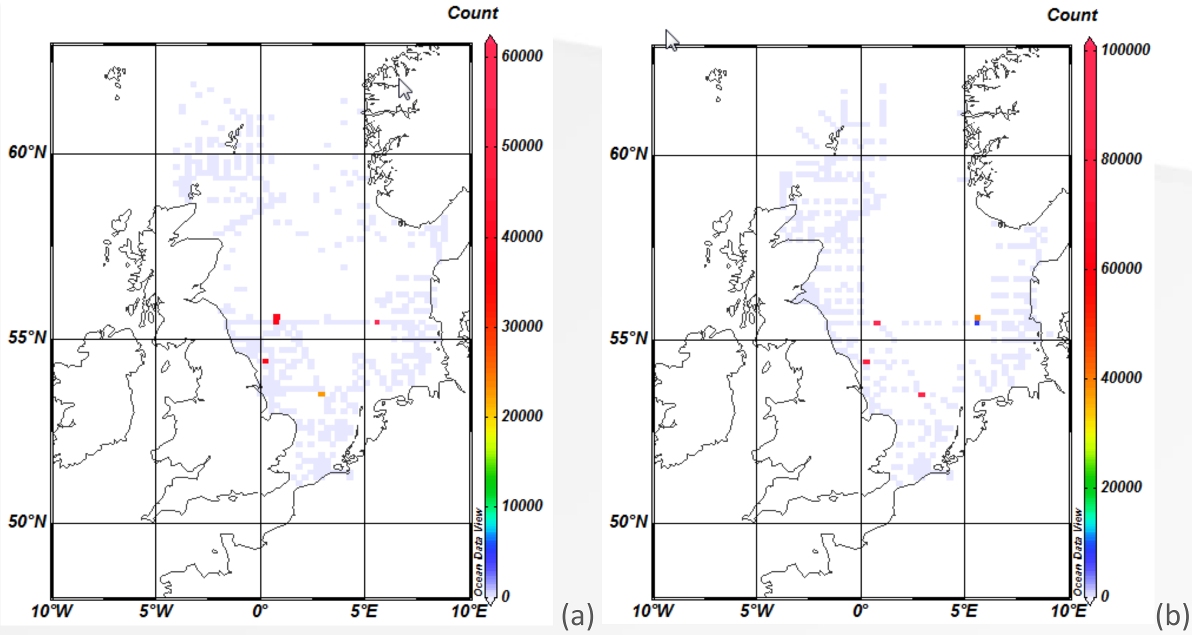


Figure 47 Data density maps of the historical dataset: (a) focus on 1988, (b) focus on 1989.

As shown on Figure 47, some stations where heavily sampled. Zooming in (Figure 48) shows close but distinct sampling locations (moorings?). Despite the use of “reasonable” correlation lengths in DIVA, these time series induced numerical artefacts (Figure 49). Discussions are ongoing on how to handle this. Possible options are:

1. Remove these data,
2. Assign a common location to these clusters,
3. Use a weighting function in DIVA to smooth the influence of these data.

In this release of the climatologies, these data have been removed from the dataset used for the computation.

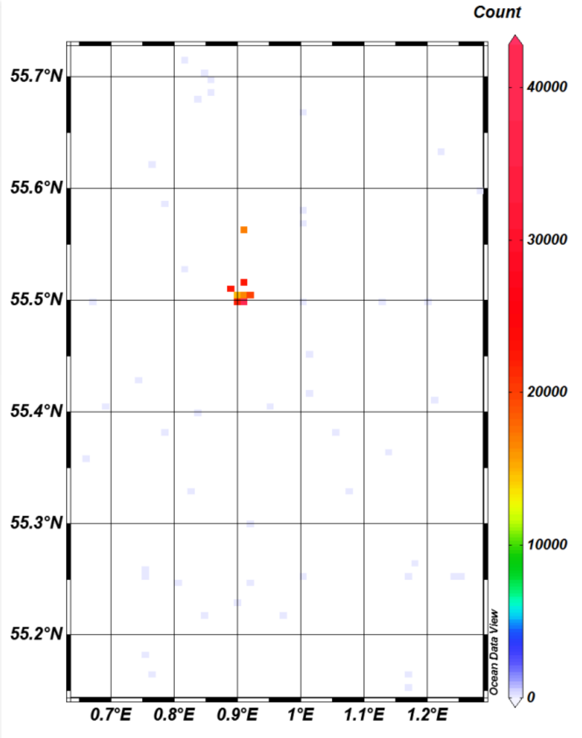


Figure 48 Zoom on one of the locations with a very density of measurements during the period of the North Sea Project.

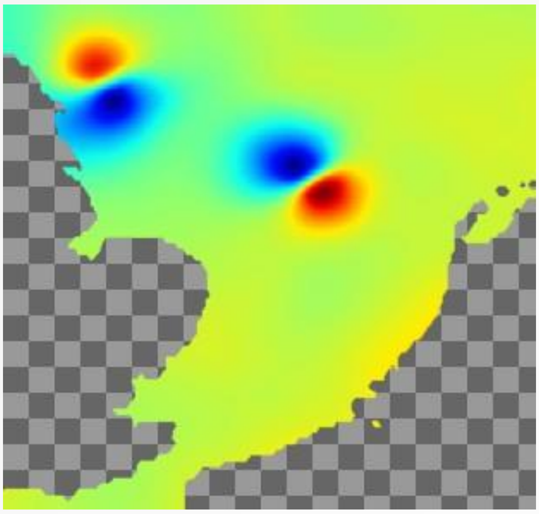


Figure 49 Snapshot of SST climatology around the heavily sampled locations.

6.2.2. Winter

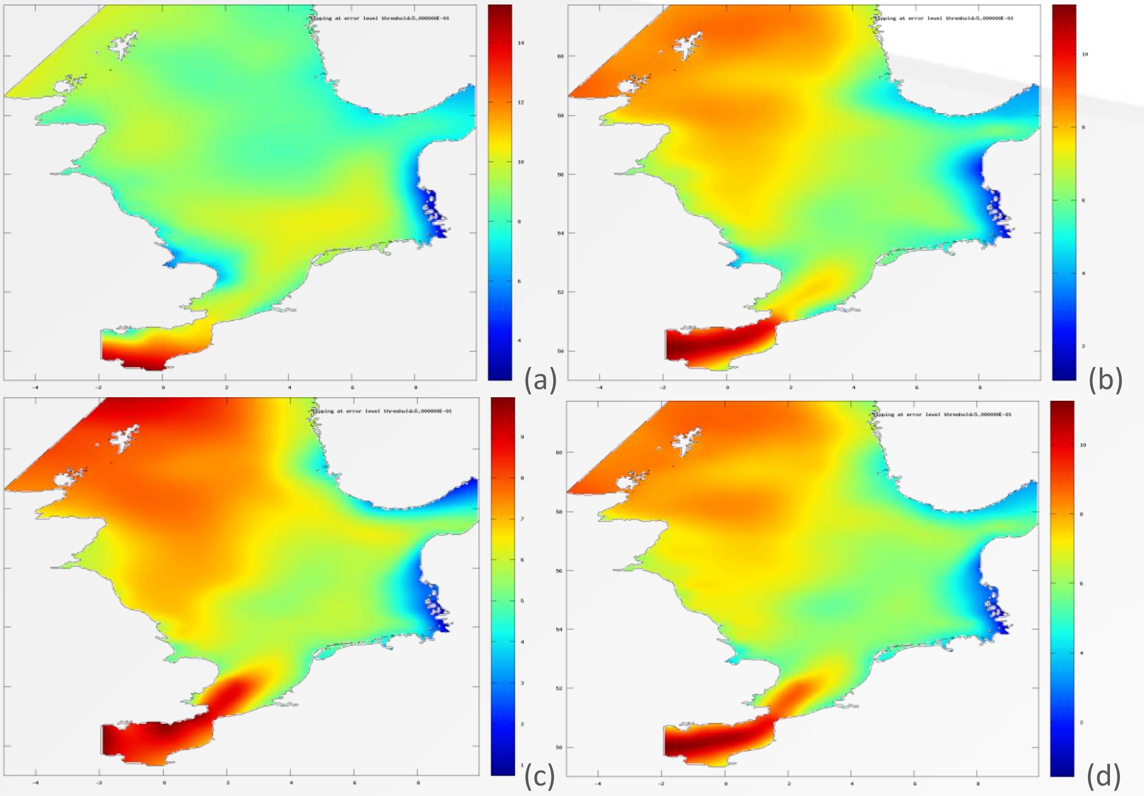
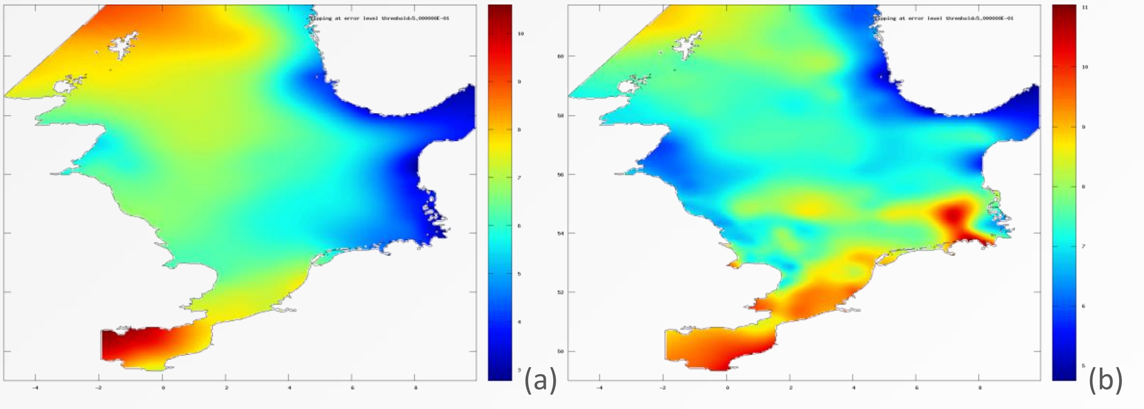


Figure 50 Climatological maps of SST for the winter season computed over the period 1900–2013. Above: (a) December, (b) January; below: (c) February, (d) December-February (framed). Color scales vary.

6.2.3. Spring



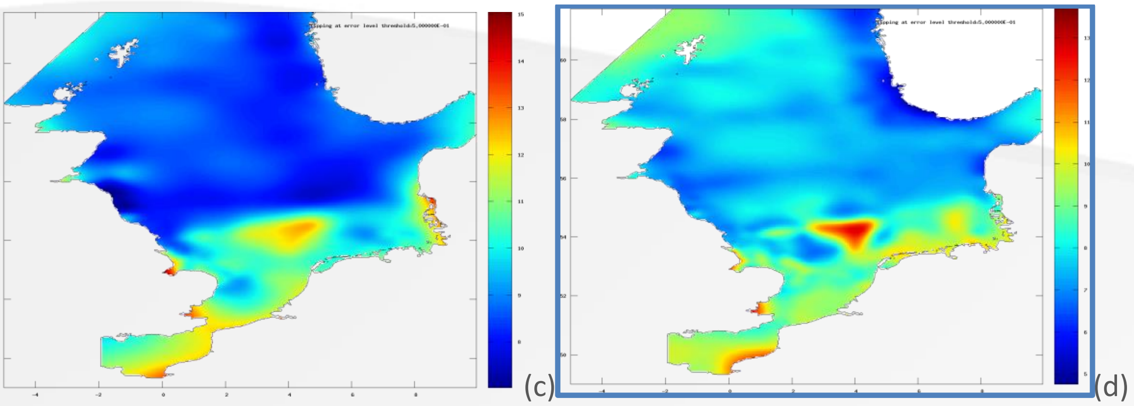


Figure 51 Climatological maps of SST for the spring season computed over the period 1900–2013. Above: (a) March, (b) April; below: (c) May, (d) March-May (framed). Color scales vary.

6.2.4. Summer

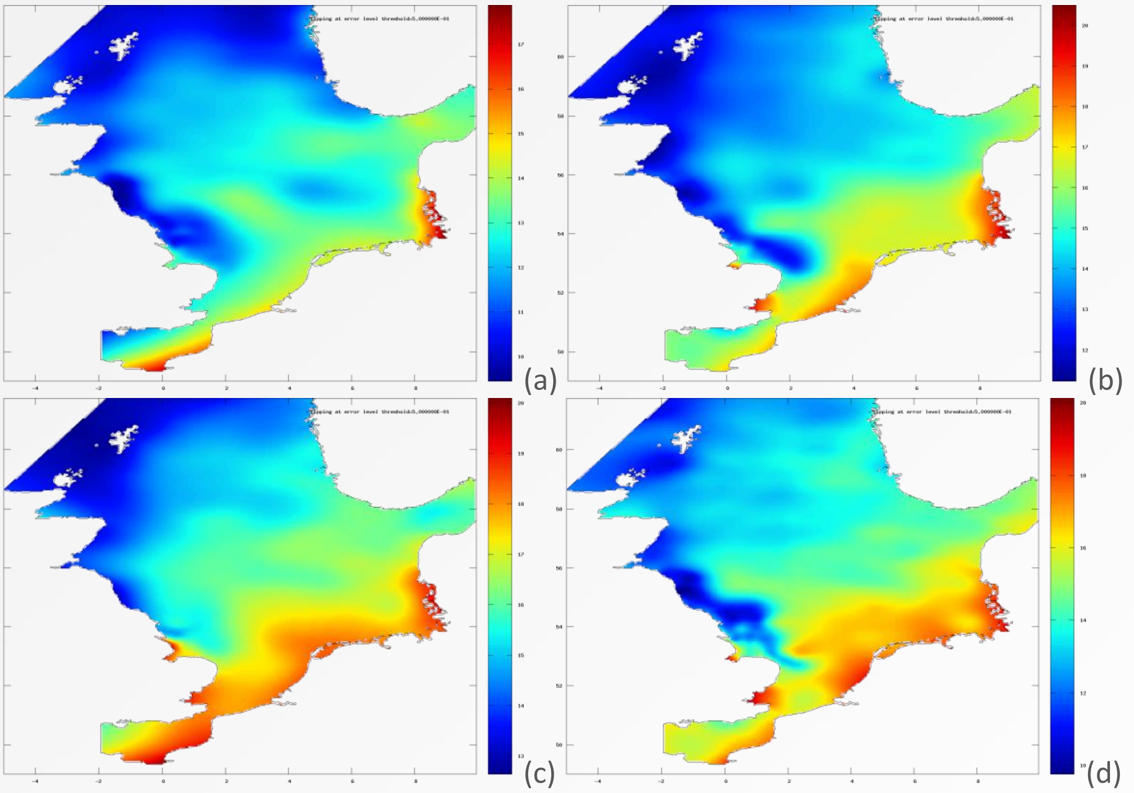


Figure 52 Climatological maps of SST for the summer season computed over the period 1900–2013. Above: (a) June, (b) July; below: (c) August, (d) June-August (framed). Color scales vary.

6.2.5. Fall

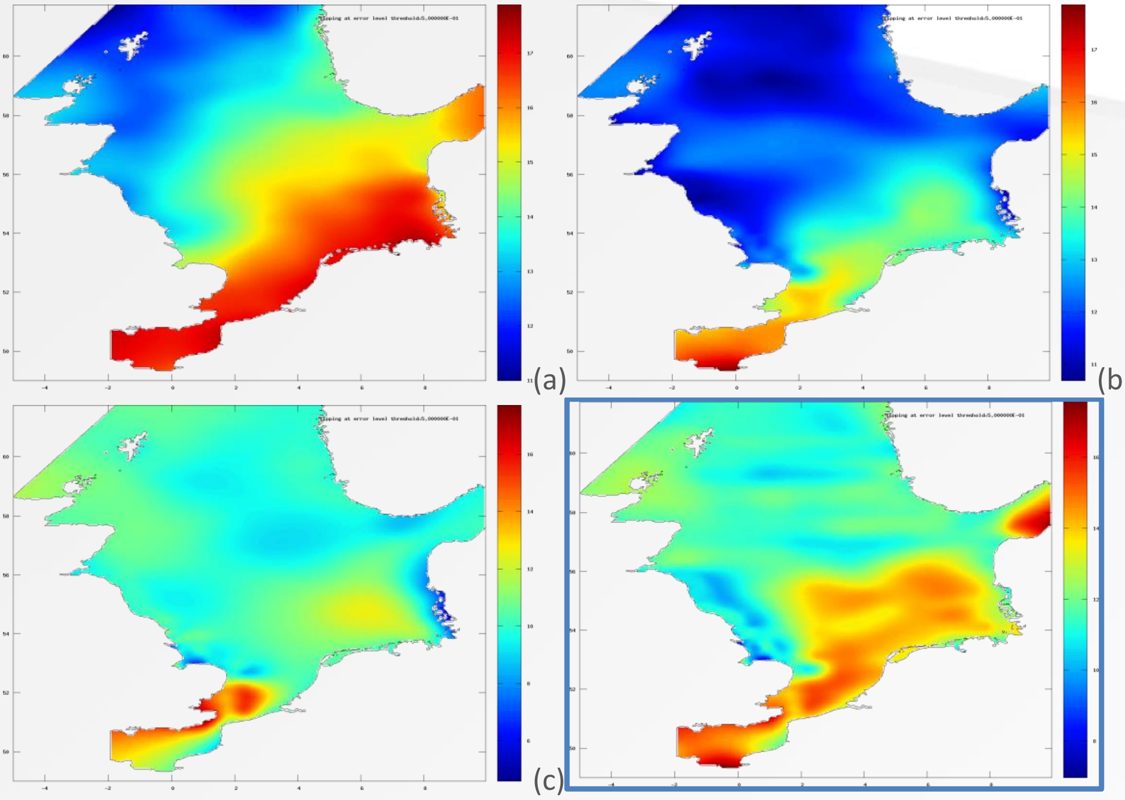
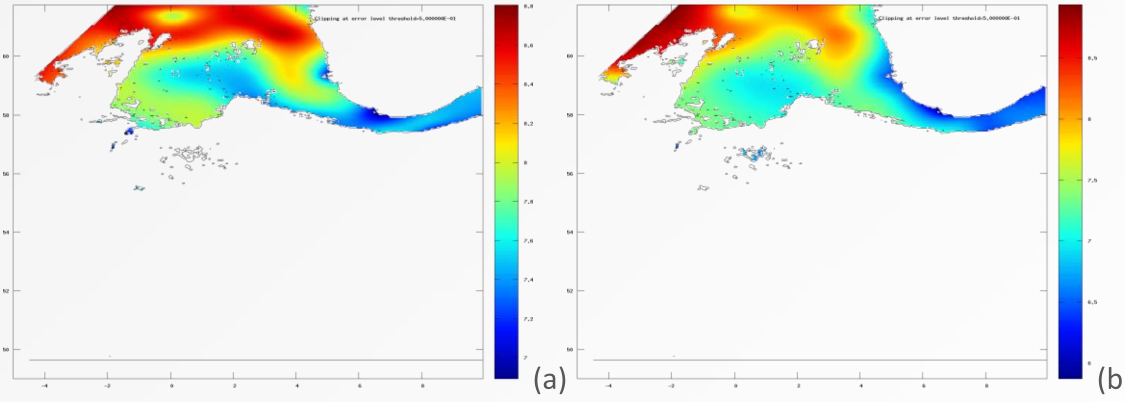


Figure 53 Climatological maps of SST for the fall season computed over the period 1900–2013. Above: (a) September, (b) October; below: (c) November, (d) September-October (framed). Color scales vary.

6.2.6. Seasonal climatologies at depth=100m



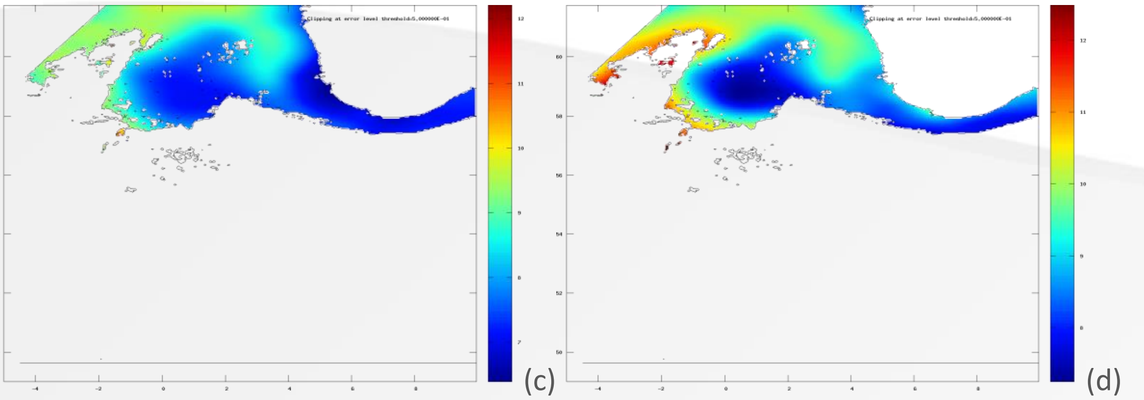


Figure 54 Seasonal climatological maps of temperature at depth = 100m computed over the period 1900–2013. Above: (a) winter, (b) spring; below: (c) summer, (d) fall. Color scales vary.

6.3. Salinity Maps

Describe briefly the main features

6.3.1. Winter

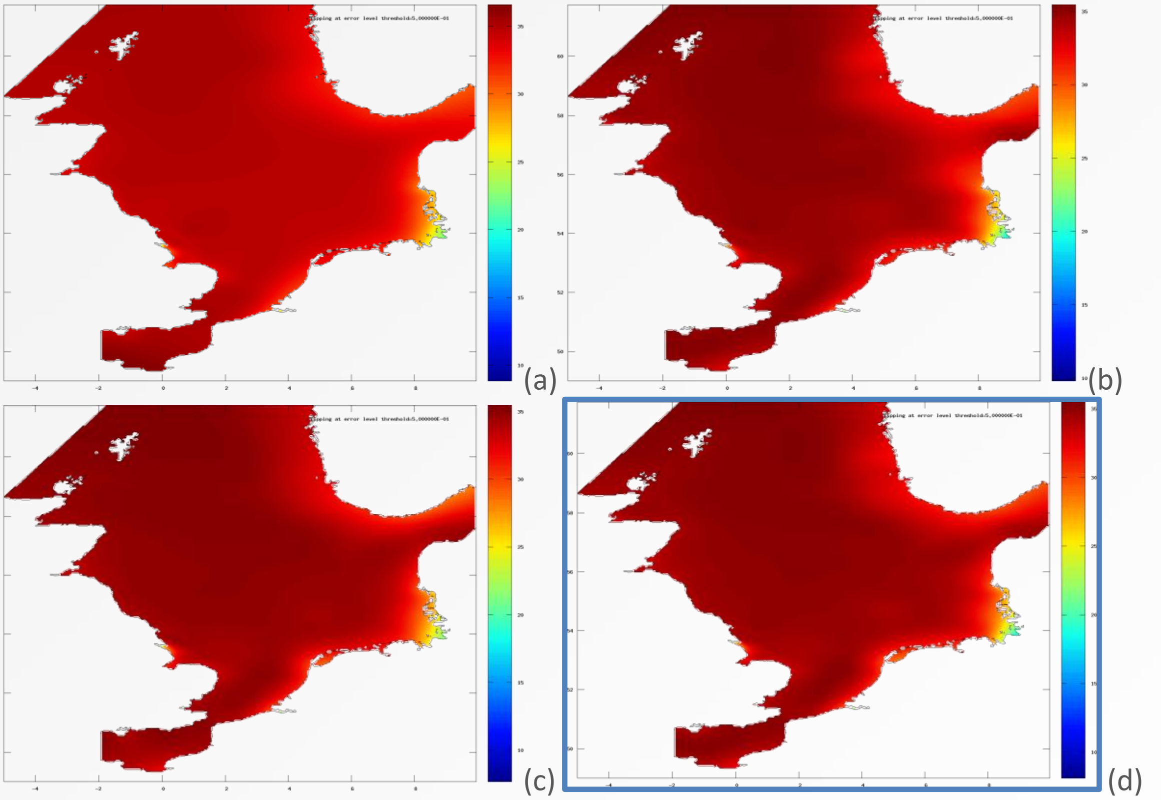


Figure 55 Climatological maps of sea surface salinity for the winter season computed over the period 1900–2013. Above: (a) December, (b) January; below: (c) February, (d) December-February (framed). Color scales vary.

6.3.2. Spring

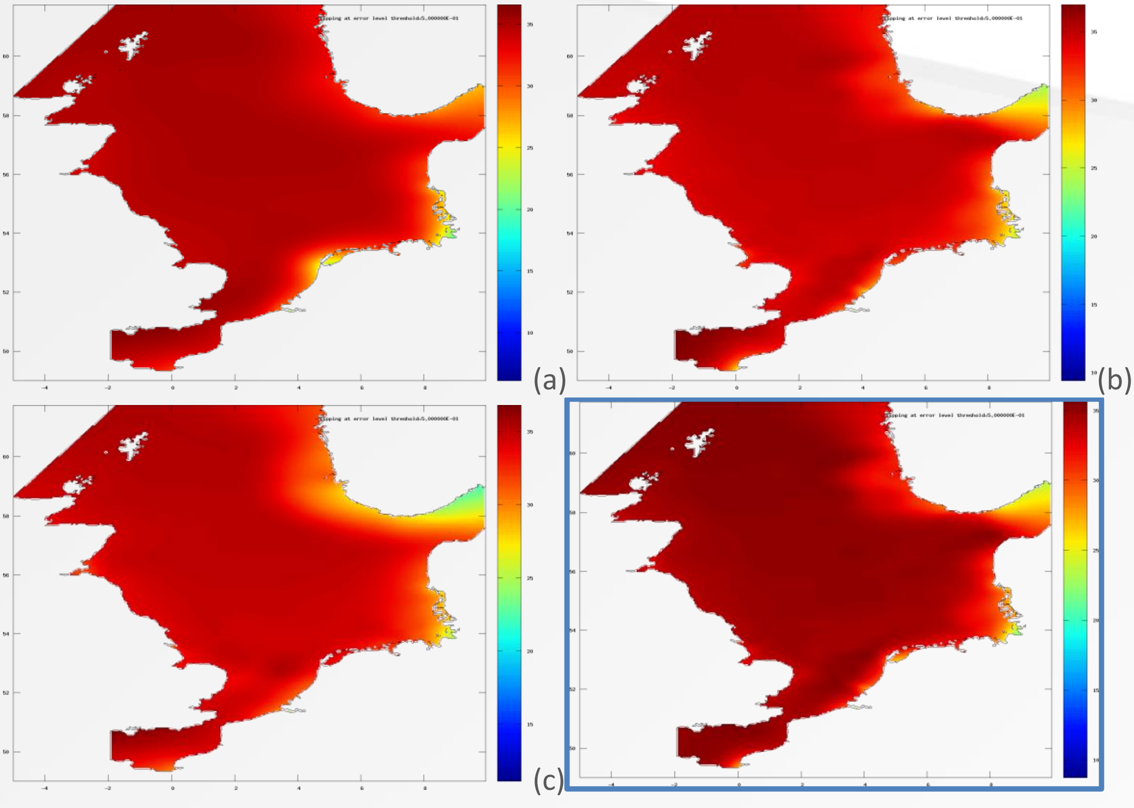


Figure 56 Climatological maps of sea surface salinity for the spring season computed over the period 1900–2013. Above: (a) March, (b) April; below: (c) May, (d) March-May (framed). Color scales vary.

6.3.3. Summer

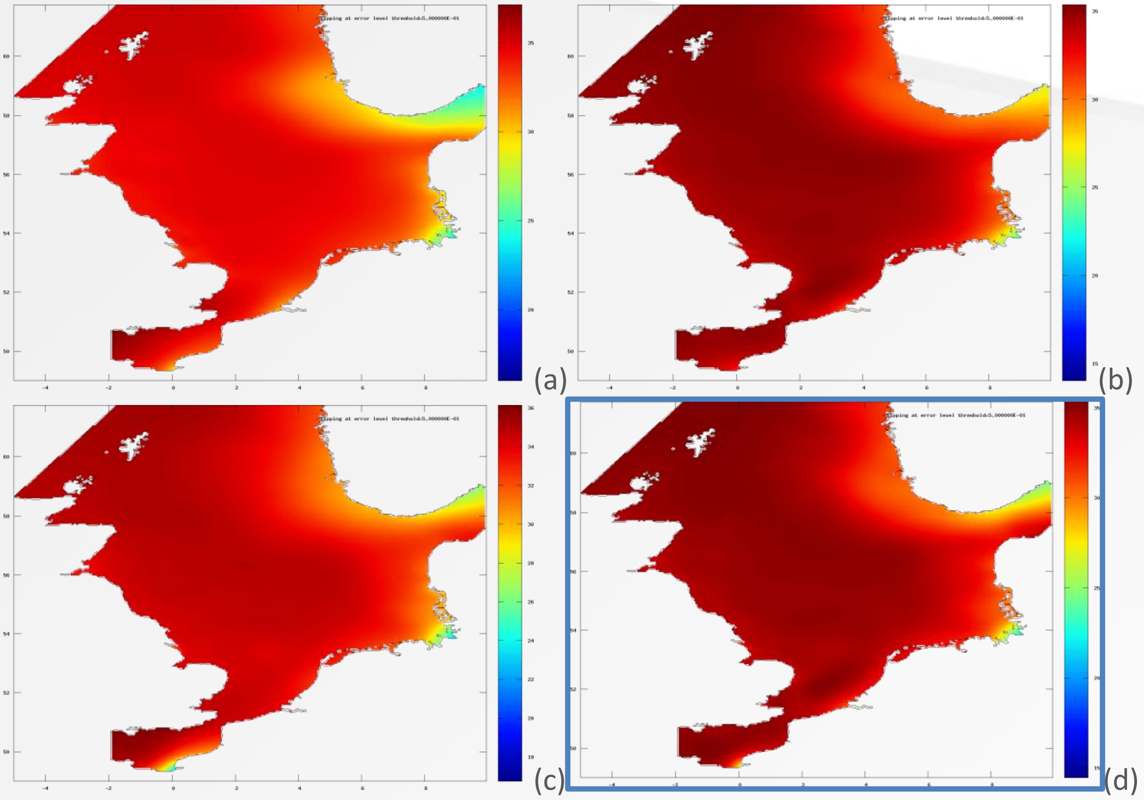


Figure 57 Climatological maps of sea surface salinity for the summer season computed over the period 1900–2013. Above: (a) June, (b) July; below: (c) August, (d) June-August (framed). Color scales vary.

6.3.4. Fall

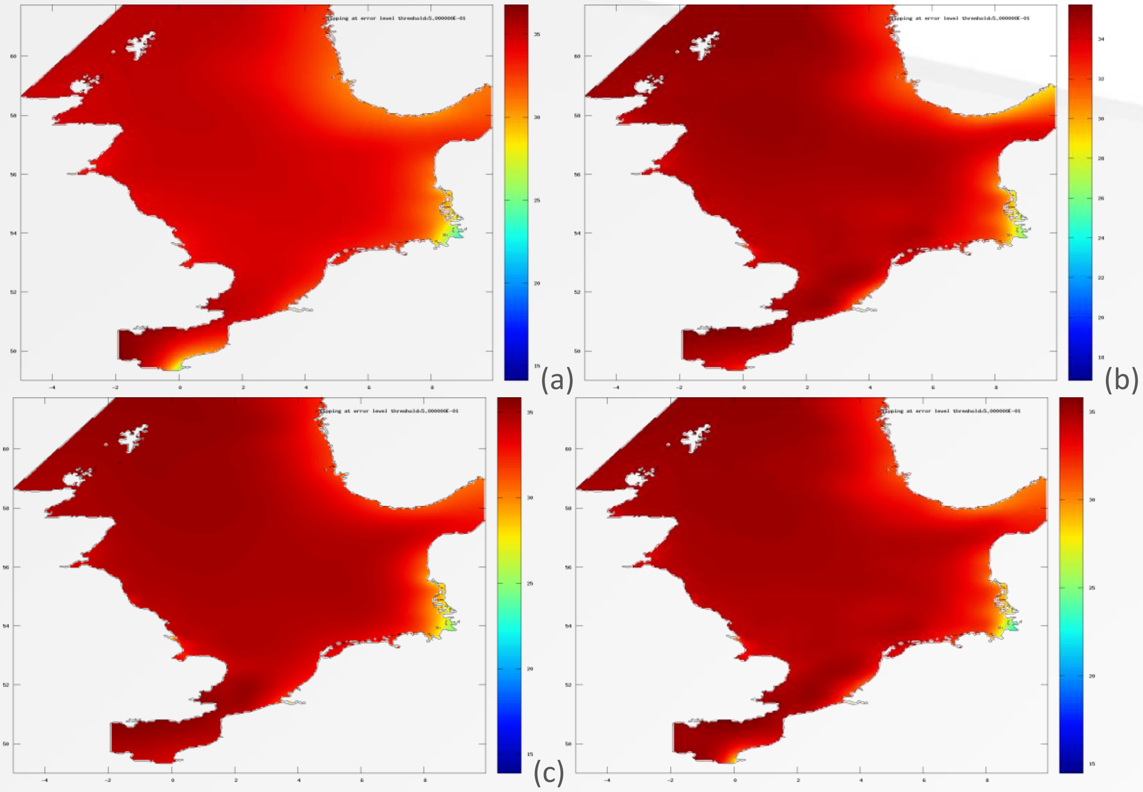
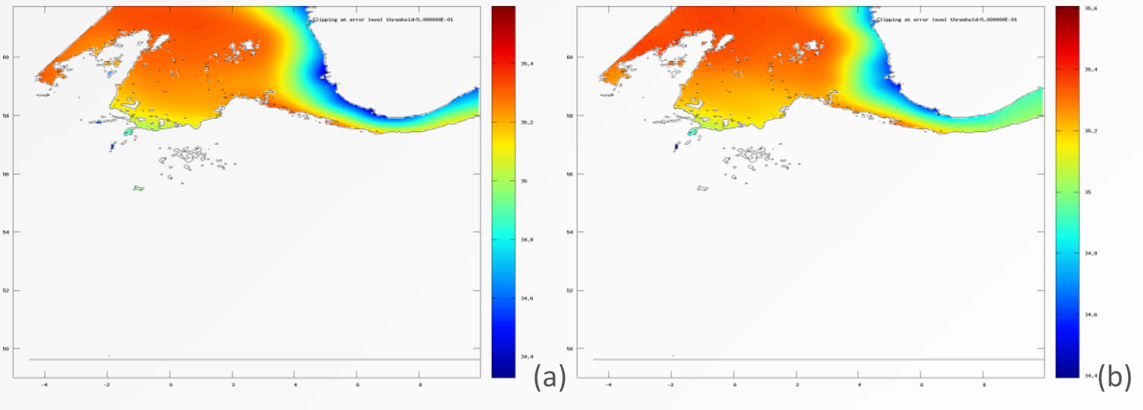


Figure 58 Climatological maps of sea surface salinity for the fall season computed over the period 1900–2013. Above: (a) September, (b) October; below: (c) November, (d) September-October (framed). Color scales vary.

6.3.5. Seasonal climatologies at depth=100m



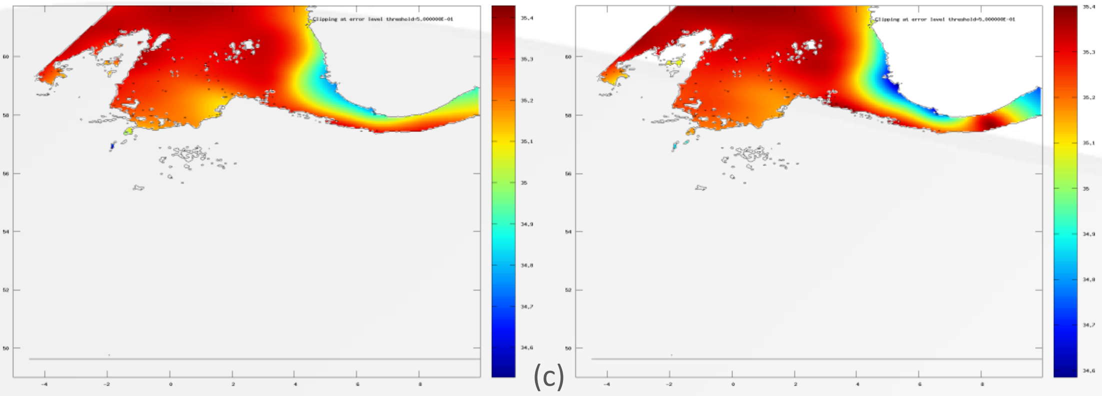
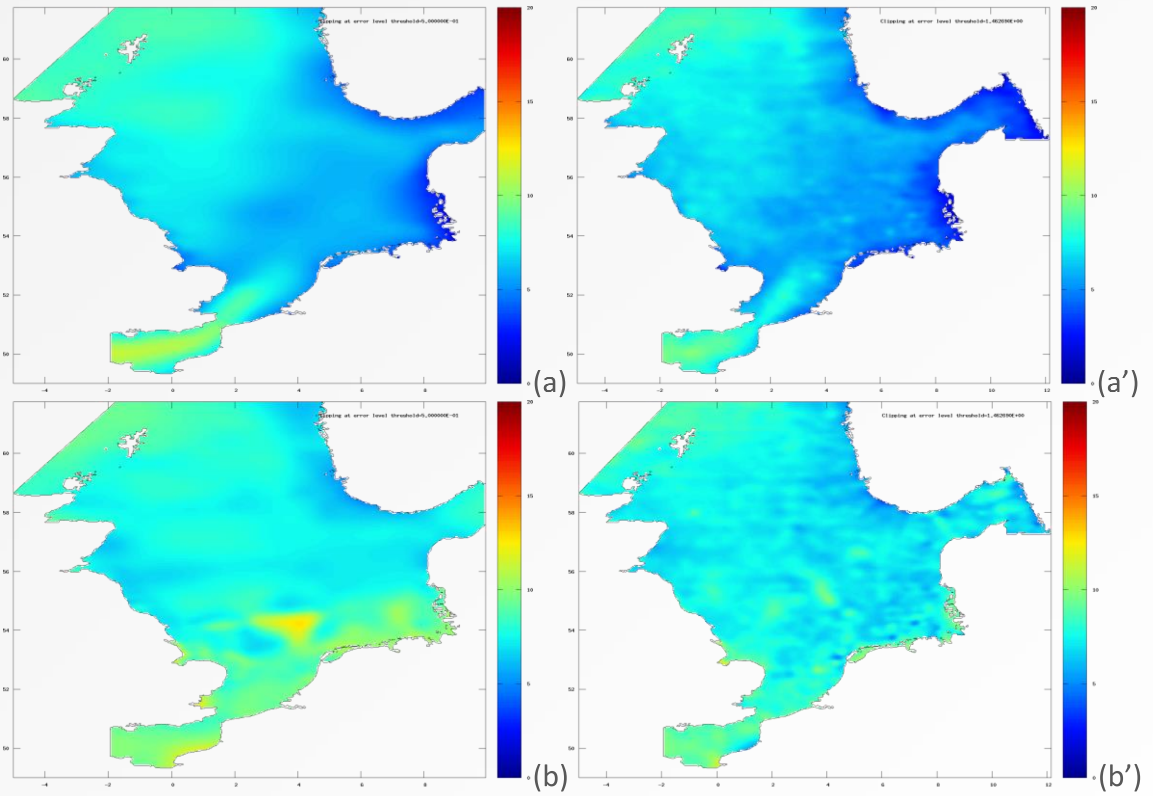


Figure 59 Seasonal climatological maps of salinity at depth = 100m computed over the period 1900–2013. Above: (a) winter, (b) spring; below: (c) summer, (d) fall. Color scales vary.

6.4. Climatology validation

At this stage, no quantitative validation took place. The figures hereafter are meant to give a subjective assessment of the quality of the SeaDataNet aggregated datasets (hereafter SDNv1) by comparing seasonal climatologies with those resulting from the analysis of data extracted from the Word Ocean Database 2013 (hereafter WOD2013).

6.4.1. Temperature



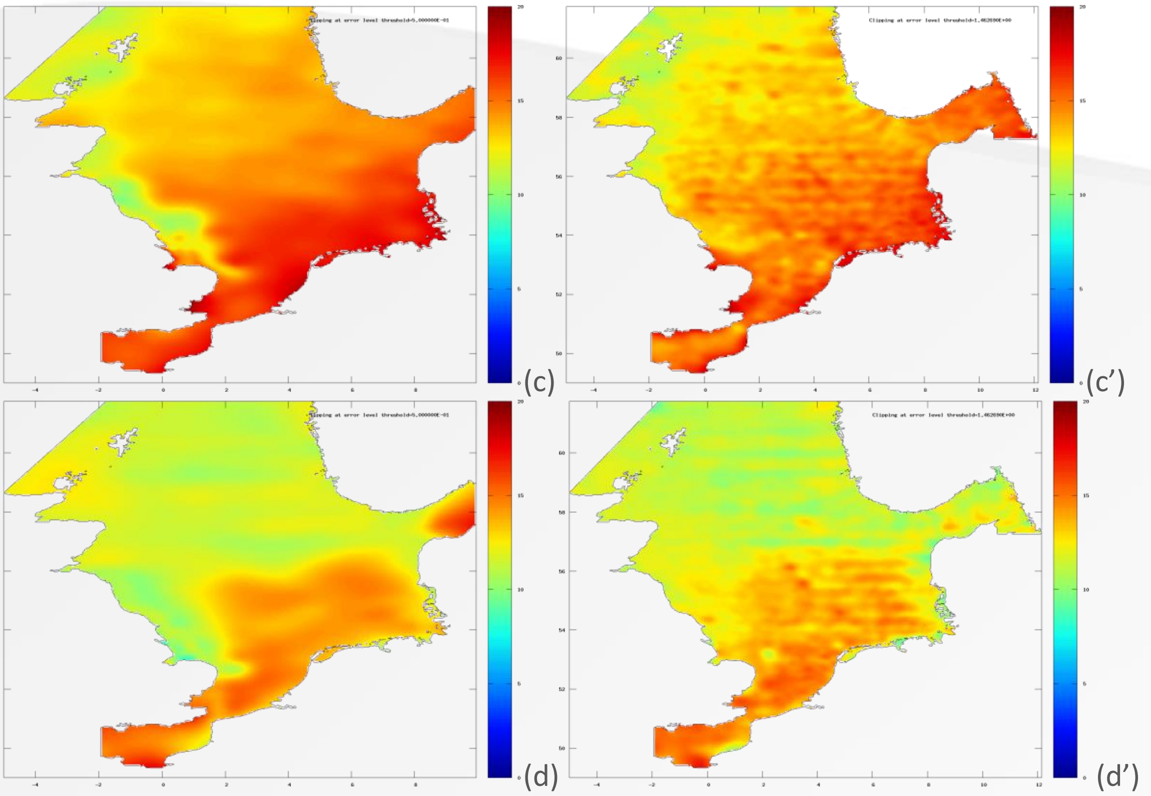
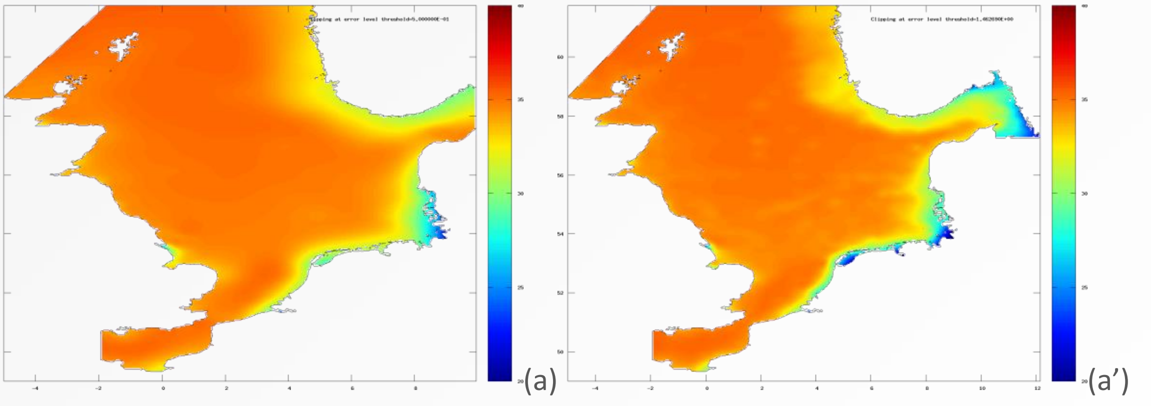


Figure 60 Comparison of climatological maps of sea surface temperature using SDNv1 (left) and WOD2013 (right). From the top: winter, spring, summer and fall. Color scales vary.

The sea surface temperature climatologies computed with SDNv1 exhibit much more smoother fields than with WOD2013. Major features that are distinguishable in WOD2013 results are also present in SDNv1 but some new features appear, like the "hot spot" off the Dutch coast during spring. The influence of the data collected during the "North Sea project" (1988-1989) is clearly visible in the SDNv1 results, *e.g.* the generally colder SST along the eastern coast of Great-Britain.

6.4.2. Salinity



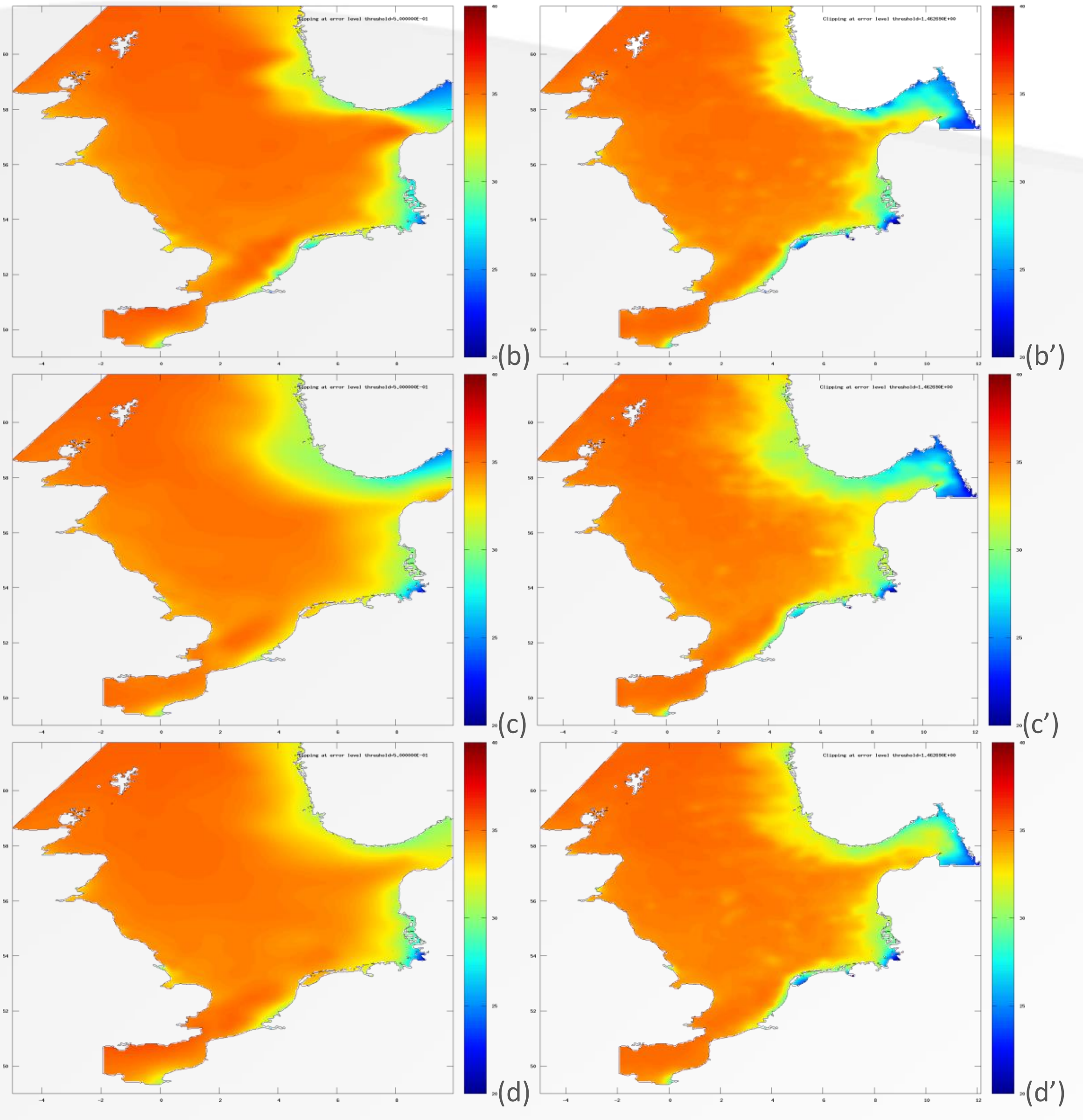


Figure 61 Comparison of climatological maps of sea surface salinity using SDNv1 (left) and WOD2013 (right). From the top: winter, spring, summer and fall. Color scales vary.

Like for temperature the sea surface salinity climatologies computed with SDNv1 exhibit much more smoother fields than with WOD2013. Major features that are distinguishable in WOD2013 results are also present in SDNv1 but some new features appear, like the “hot spot” off the Dutch coast during spring. The influence of the data collected during the “North Sea project” (1988-1989) is clearly visible in the SDNv1 results, *e.g.* the generally colder SST along the eastern coast of Great-Britain.

7. North Atlantic Ocean Climatology

7.1. Methodology

- Domain definition
  The studied area is the North Atlantic Ocean, starting at 10°N up to the boundary of the Artic sea (65°N). A mask has been defined (Figure 7.1) to not take into account North Sea, Artic sea, Mediterranean sea.

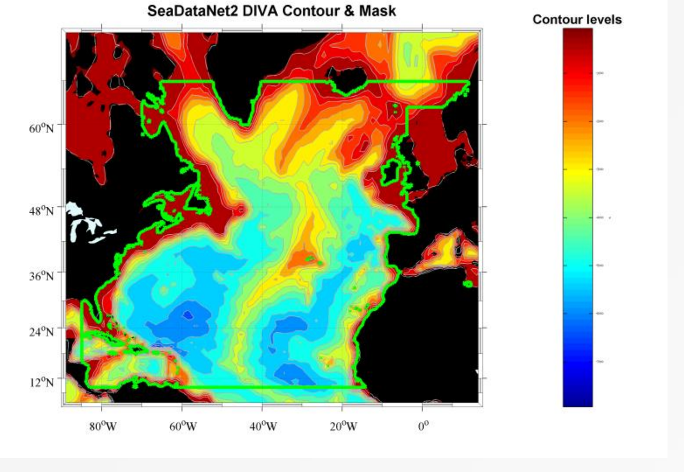


Figure 62 Domain definition and mask (green line) for the North Atlantic Ocean

- Time-space resolution
  The analysis was run for the period 1900-2012 (a run has been done for 1990-2012 without differences). A first run was done on the monthly scale and another one on the seasonal scale (winter: 1202, spring: 0305, summer: 0608, autumn: 0911). A decadal analysis has been also processed.
- DIVA settings (Table 13) – version diva 4.6.8

Table 13 - DIVA parameters used for the North Atlantic climatology computation.

Lc: correlation length	6.84083557	
snr: signal to noise ratio	1.06429684	
varbak	5.41515350	
Parameters estimation and vertical filtering:	-30	Estimation and vertical filtering of SN ratio and Lc using data mean distance as a minimum for Lc
xori	-80	dx 0.20 – nx 460
yori	10	dy 0.20 – ny 275
vertical levels	33 levels	5500, 5000, 4500, 4000, 3500, 3000, 2500, 2000, 1750, 1500, 1400, 1300, 1200, 1100, 1000, 900, 800, 700, 600, 500, 400, 300, 250, 200, 150, 125, 100, 75, 50, 30, 20, 10, 0

- Description of the tuning of DIVA
  Several runs have been processed taking into account:

a) boundary lines and coastlines generation : using contours and velocity or only contours.
b) some changes have been made on the correlation length and signal to noise ration

For the next version, an updated mask will remove the Caribbean seas and Labrador Sea, and a new area will be defined to focus on the North East Atlantic area where data are the most aggregated.

- Background field choice
  Null for the first run – Mean for the second one
- Error Maps
  Clever poor mans error has been used.

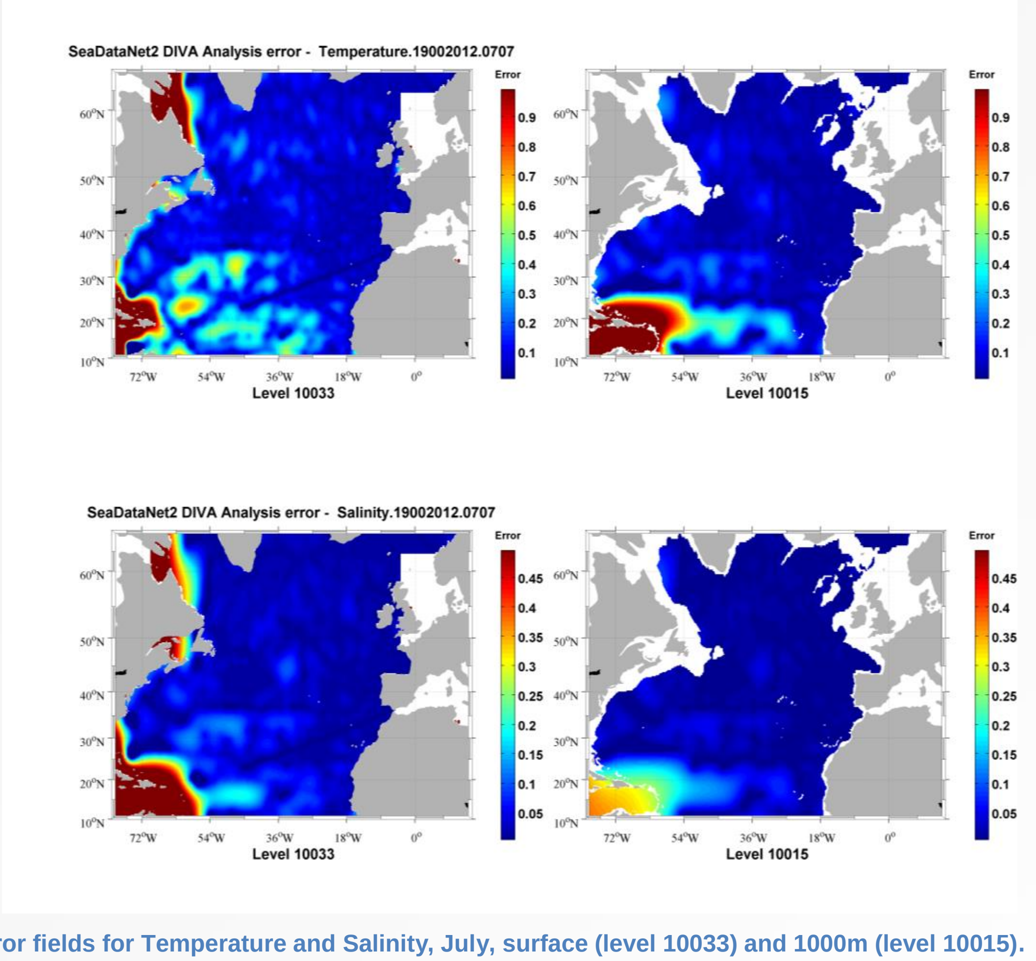


Figure 63 Error fields for Temperature and Salinity, July, surface (level 10033) and 1000m (level 10015).

The highest values are observed in areas where data are scattered (mainly in southwest close to the Caribbean seas) (Figure 7.2). Some bad data are still in the dataset (figure 7.3) and have to be removed for the next runs.

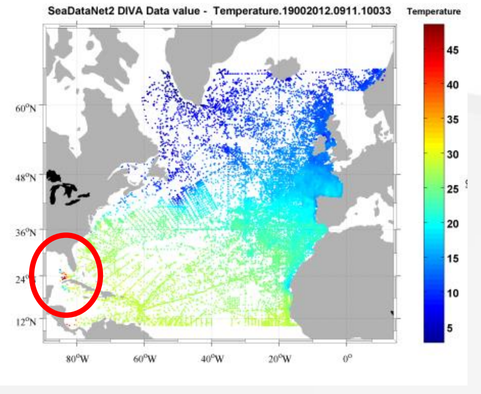


Figure 64 Distribution of data for temperature measurements during autumn.

7.2. Temperature Maps

The temperature measurements are represented by 928391 stations on the figure 7.4 for the time period 1900-2012. The dataset is more important in the northeast part of the Atlantic Ocean, especially in the Bay of Biscay and along the European coasts.

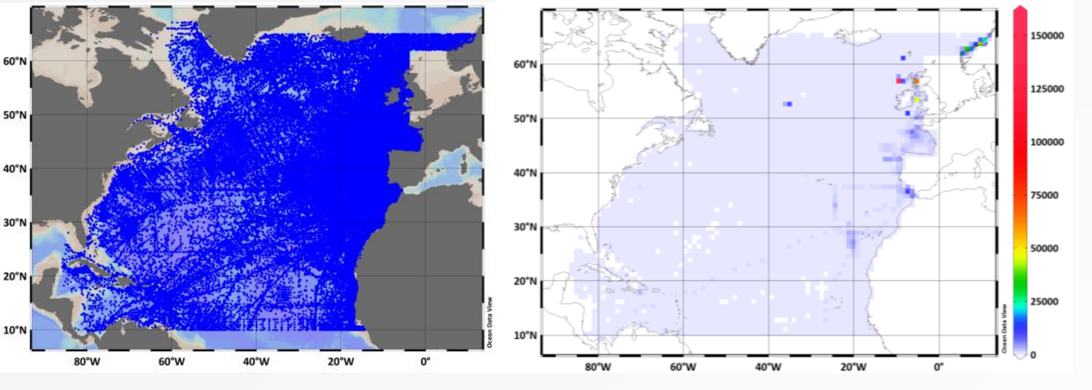


Figure 65 Temperature measurements location for the time period 1900-2012. Distribution in terms of stations count.

The distribution of the temperature fields is shown on the following maps (Figure 7.5). Two levels have been chosen to focus on the surface distribution (level 10033) and on the level 1000m (level 10015 on which circulation of the Med Sea can be observed in the Atlantic Ocean).

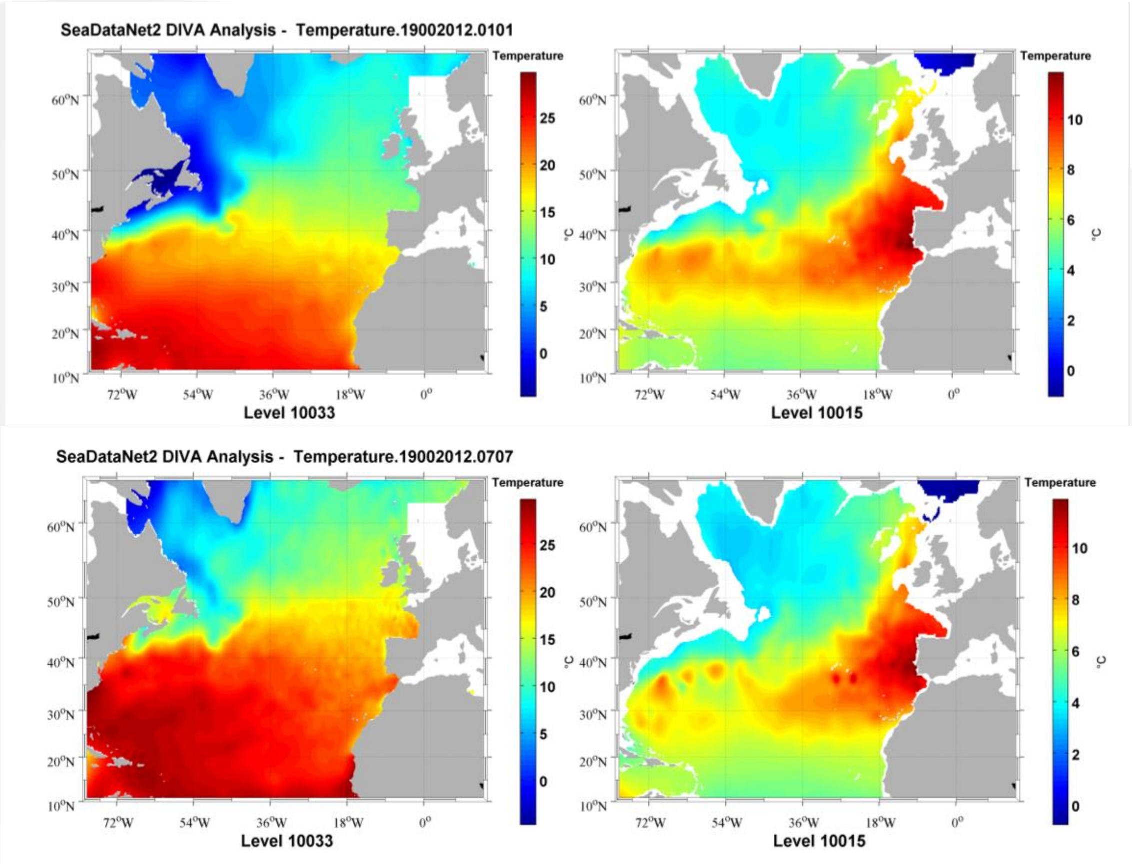


Figure 66 Temperature fields in January and July, at the surface (level 10033) and at 1000m depth (level 10015)

The comparison between the two months January and July shows differences on the temperature distribution. Warmer surface currents and cold north Atlantic Deep Water (NADW) can be easily identified. The thermohaline circulation heats the North Atlantic and Northern Europe. It extends right up to the Greenland and Norwegian Seas, pushing back the winter sea ice margin (Figure 66).

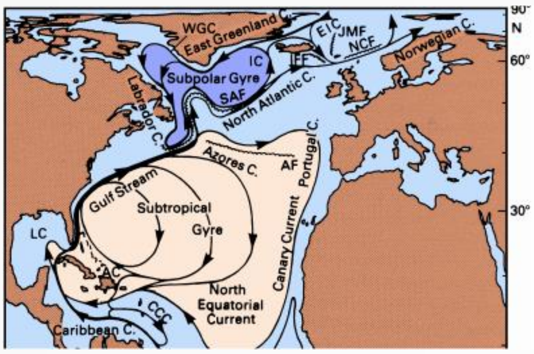


Figure 67 Surface currents of the Atlantic Ocean. SAF: Subantarctic Front, Antilles (AC) Currents and the Caribbean Counter current (CCC), AF: Azores Front (*From Tomczak, Matthias & J Stuart Godfrey: Regional Oceanography: an Introduction 2nd edition (2003)*)

On the temperature distribution maps at level 10033, the surface currents can be identified according to Figure 67, with variations according to the season. The Gulf Stream is represented by a band of warm water.

7.3. Salinity Maps

The salinity measurements are represented by 320458 stations on the Figure 68 for the time period 1900-2012. The dataset is more important in the northeast part of the Atlantic Ocean, especially in the Bay of Biscay, along the European coasts and close to the North African coasts.

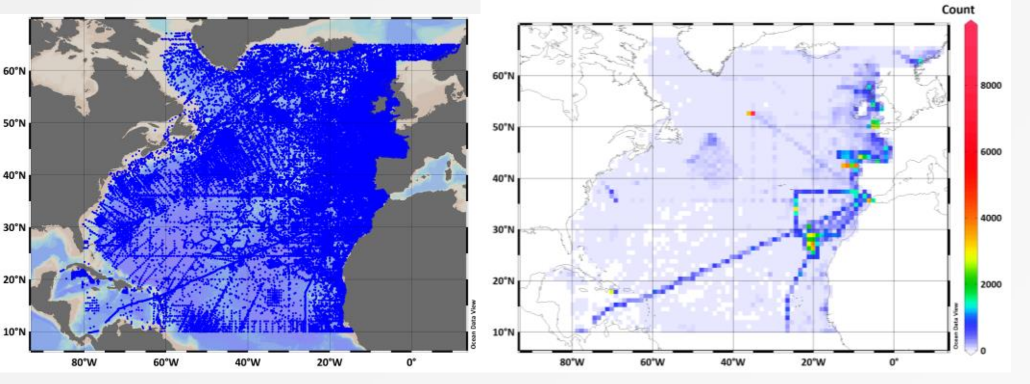


Figure 68 Salinity measurements location for the time period 1900-2012. Distribution in terms of stations count.

The distribution of the salinity fields is shown on the following maps. Two levels have been chosen to focus on the surface distribution (level 10033) and on the level 1000m (level 10015 on which circulation of the Med Sea can be observed in the Atlantic Ocean with a salinity maximum).

At the west part of the Mid-Atlantic Ridge, on the American continental slope, minor subsurface salinity minima (S < 34.95), originating from the Labrador Sea Water core, is observed. These minima are traces of south flowing LSW in the upper parts of the NADW water mass (Figure 69).

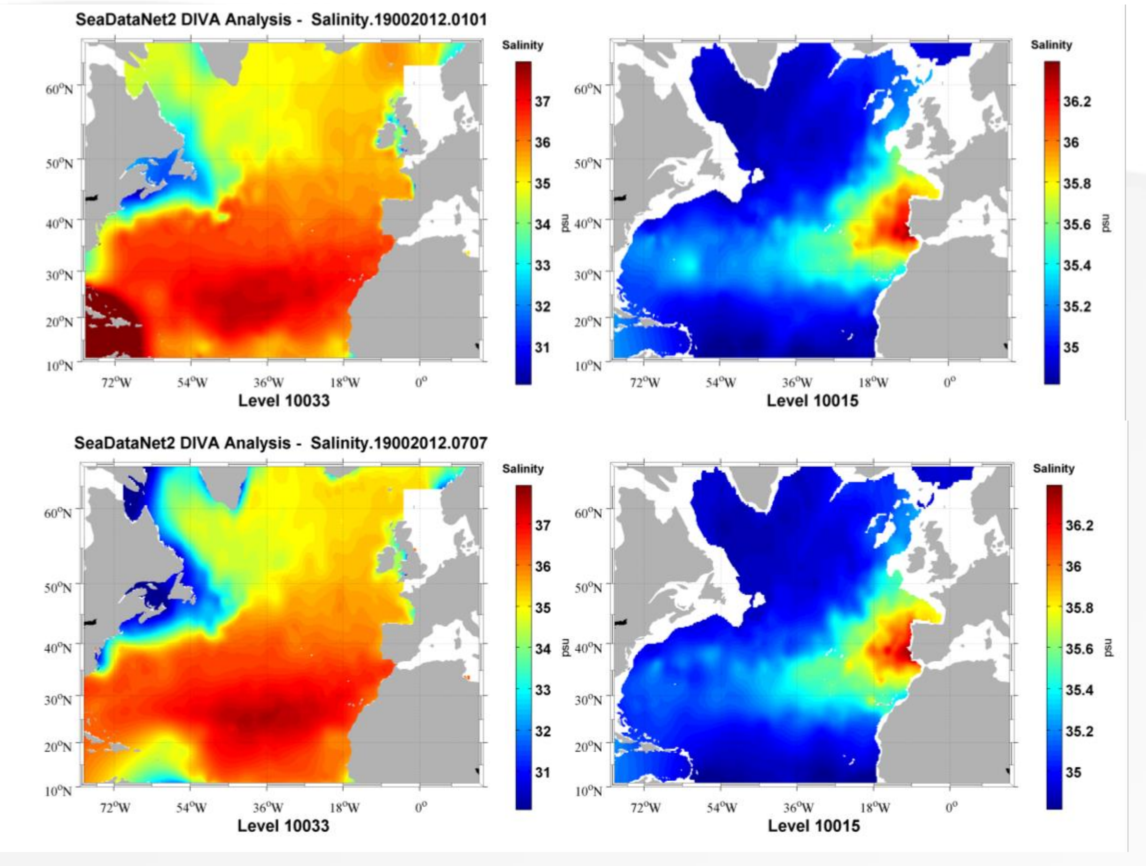


Figure 69 Salinity fields in January and July, at the surface (level 10033) and at 1000m depth (level 10015)

The decrease of salinity in the North Atlantic Ocean, is concentrated in the west and linked with advection by the East and West Greenland Currents and the Labrador Current.
A salinity and temperature maximum are observed at 1000 m depth near the upper distribution limit of NADW, this is the sign of the Mediterranean Water which is carried northward along the Portuguese shelf and mixes into the subtropical gyre circulation.

7.4. Climatology validation

Comparison with several sources for validation of the climatology can be done.

7.4.1. Comparison done with the world ocean atlas climatology (WOA2013)

Maps (Figure 70) are available on the website from a request (zoom on the studied area), data fields are also provided and will be used for the more detailed comparison to focus on the specific areas with a better resolution. Anomalies will be calculated between both climatologies.

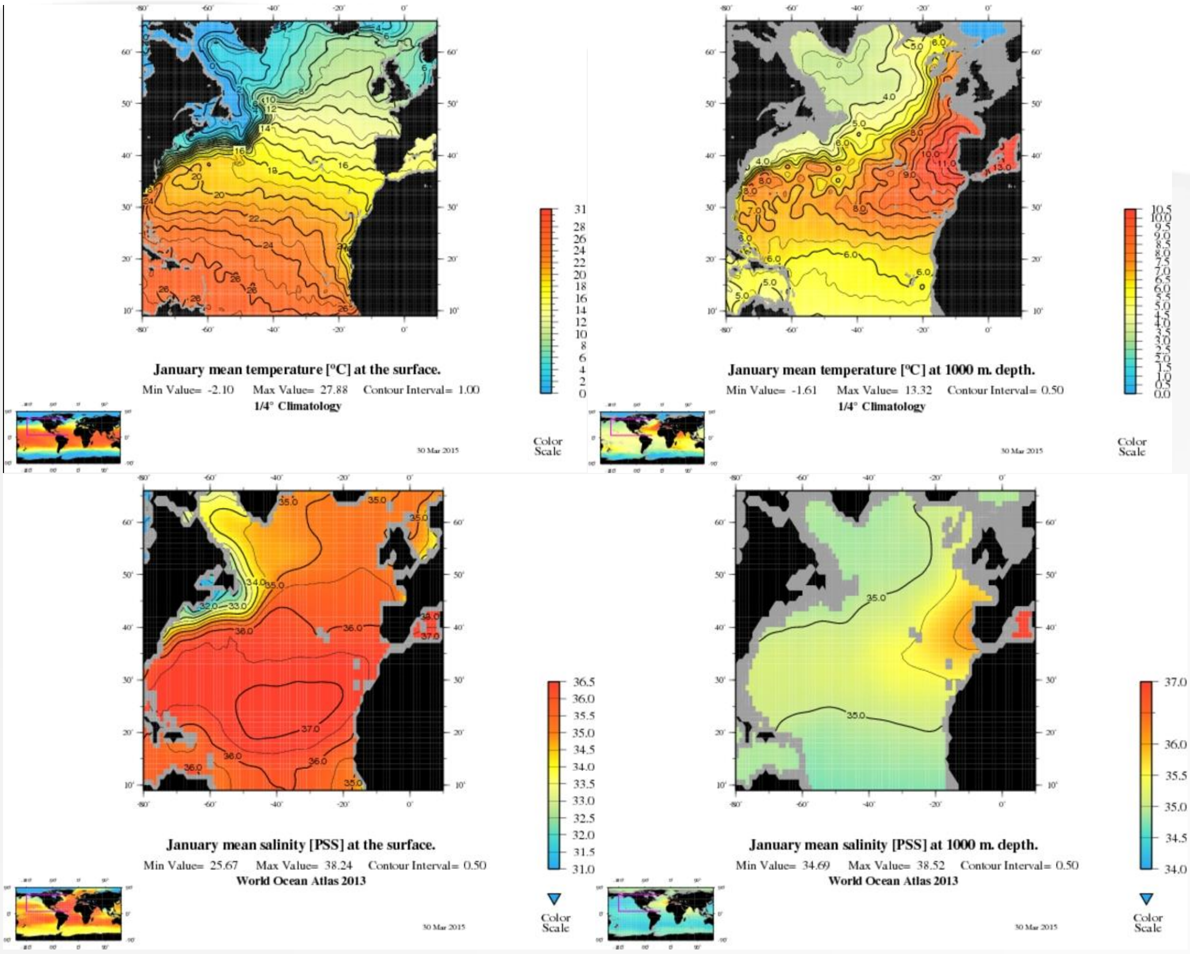


Figure 70 January mean temperature and salinity at the surface and at 1000m depth (WOA2013)

7.4.2. Comparison with ISAS method (LPO, Ifremer)

Temperature and salinity anomalies maps are available for near surface seasonal cycles, and annual mean conditions (near surface and deep layers) (Figure 71).

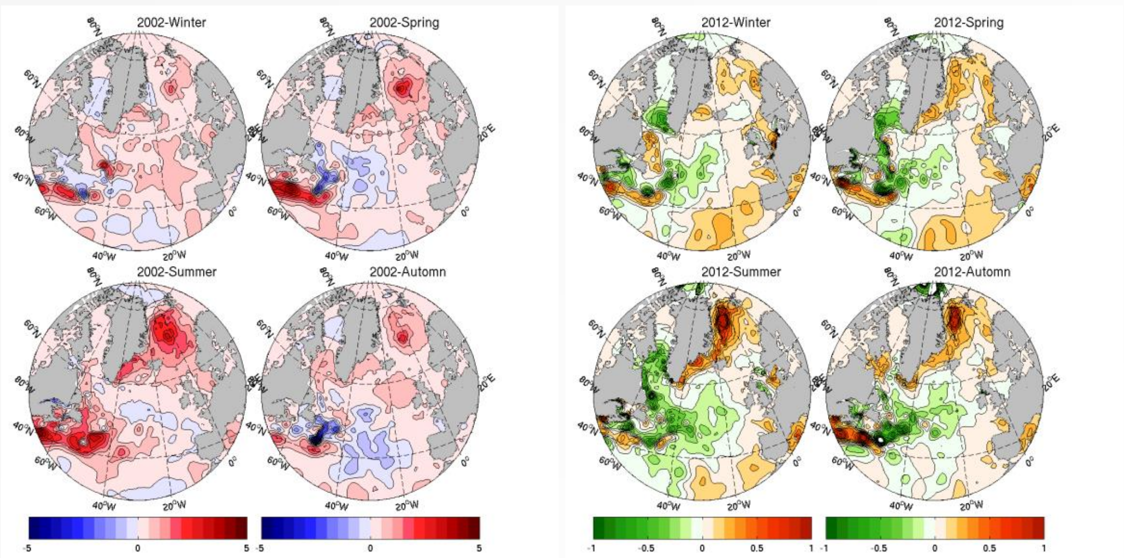


Figure 71 Temperature and Salinity anomalies for near surface seasonal cycles (2002 for temperature and 2012 for salinity

7.4.3. Comparison with Coriolis maps (ISAS method, Ifremer):

Maps of temperature and salinity grilled fields are available on the Coriolis website (as Figure 72) to have a quick overview of the analysis. Data can be downloaded from the MyOcean website.

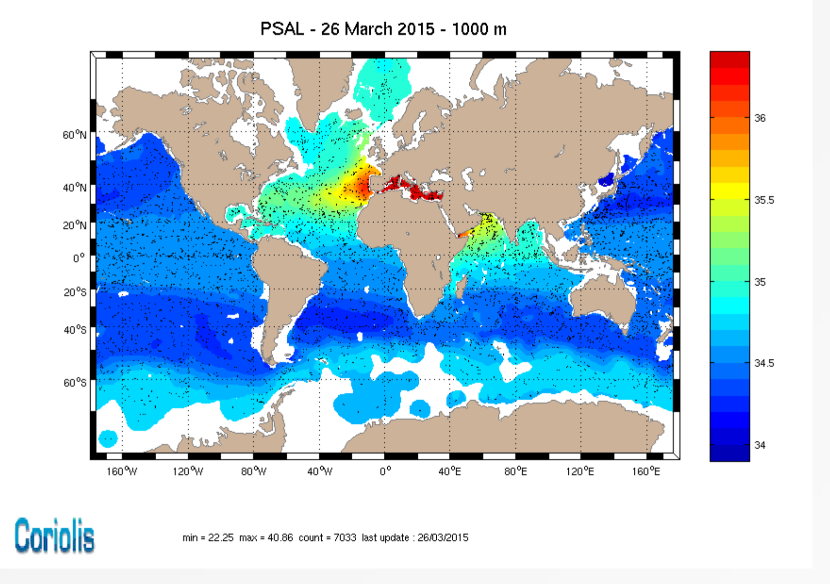


Figure 72 Salinity map from Coriolis website.

8. Conclusions and Future Work

All RCs worked on the climatologies and presented their results at the Product Meeting held in Athens last 8th of April, 2015. Product leaders decided to keep working on climatologies in order to improve the quality of the final products. They decided to switch all to the final 4.6.9 version of DIVA and to continue on the tuning of DIVA parameters like correlation length and signal to noise ratio. An harmonization effort will be done on the reference field and the error fields computation. Reference field will be obtained through semi-normed analysis, while the error field will be defined as the "clever poor men's error field" (ispec=111). Also season definition and error masking definition (30% threshold) will be considered in the upcoming versions. A common validation approach has been established, which takes into consideration the WOA13 as reference. A netCDF file per parameter will contain all the seasons/months, which it is easier to handle by the users.
A shared publication on SDN2 products has been planned to describe both historical data collections ad climatologies:
S. Simoncelli, C. Coatanoan, Ö. Bäck, H. Sagen, S. Scory, V. Myroshnychenko, D. Shaap, R. Schlitzer, S. Iona, M. Fichaut, A. Barth, S. Watelet …? "SeaDataNet Temperature and Salinity historical data collections and climatologies for the european marginal seas"
The proposed Journal were: Data Science Journal or Earth System Science Data.
Specific publications on regional climatologies are very welcome too (Med Sea, Black Sea, N. Atlantic).

Other points to be addressed:

- outlier elimination to be tested
- duplicate check: are stored in the input data directory with the file extension _bkp
- how to handle data concentration in some period/region at high frequency→ weighting function
- stability analysis
- Include in the product metadata the DIVA settings both in the netCDF and the xml output
- Product documentation with a user prospective → regional contribution to D10.3 and D10.4 should go as side doc in the catalogue
- product documentation will be linked into the SEXTANT catalogue

References

Korotaev, G., T. Oguz, A. Nikiforov, *and* C. Koblinsky *(*2003*),* Seasonal, interannual, and mesoscale variability of the Black Sea upper layer circulation derived from altimeter data*,* J. Geophys. Res.*,* 108*, 3122, doi:*10.1029/2002JC001508*,* C4*.*

Locarnini, R. A., A. V. Mishonov, J. I. Antonov, T. P. Boyer, H. E. Garcia, O. K. Baranova, M. M. Zweng, C. R. Paver, J. R. Reagan, D. R. Johnson, M. Hamilton, and D. Seidov, 2013. World Ocean

Atlas 2013, Volume 1: Temperature. S. Levitus, Ed., A. Mishonov Technical Ed.; NOAA Atlas NESDIS 73, 40 pp.

S. Simoncelli, C. Coatanoan, Ö. Bäck, H. Sagen, S. Scory, D. Tezcan, D. M.A. Schaap, R. Schlitzer, S. Iona, M. Fichaut, M.Tonani. "TEMPERATURE AND SALINITY HISTORICAL DATA COLLECTIONS FOR THE EUROPEAN MARGINAL SEAS: AGGREGATION AND QUALITY ASSESSMENT PROCEDURES". IMDIS Conference 2013, Lucca, Italy. http://imdis2013.seadatanet.org/content/download/73084/949811/file/S1P05_IMDIS2013_SDN2_Products_Simoncelli.pdf

Zweng, M.M, J.R. Reagan, J.I. Antonov, R.A. Locarnini, A.V. Mishonov, T.P. Boyer, H.E. Garcia, O.K. Baranova, D.R. Johnson, D.Seidov, M.M. Biddle, 2013. World Ocean Atlas 2013, Volume 2: Salinity. S. Levitus, Ed., A. Mishonov Technical Ed.; NOAA Atlas NESDIS 74, 39 pp.