Arctic+ Salinity

Data User Manual

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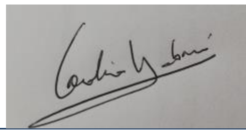
Author	Carolina Gabarro BEC		09/08/2019
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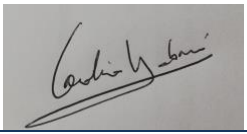
	Carolina Gabarro		09/08/2019
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Amendment Record Sheet

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March-2019 / v1r5	Deliver to ESA	New document
July 2019 / v2r6	NetCDF format reviewed Revision of consistency with RBD on the insitu dataset	Section 2.2
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Acronyms

AD	Applicable document
ADB	Actions database
AMOC	Atlantic Meridional Overturning Circulation
ATBD	Algorithm theoretical basis documents
BGEP	Beaufort Gyre Experiment Project
BODC	British Ocean Data Centre
BRO	Brochure
CliC	Climate and Cryosphere
CMEMS	Copernicus Marine Environment Monitoring Service
CTD	Conductivity Temperature Depth
DBCP	Data Buoy Cooperation Panel
DIR	Directory
DS	Dataset availability
DS-UM	Dataset user manual
DVP	Development and validation plan
EC RTD	European Commission Directorate General for Research and Innovation
EDS	Experimental dataset
EMI	Electromagnetic Interference
EO	Earth Observation
EOEP	Earth Observation Envelope Program
ESA	European Space Agency
FR	Final review
FWF	Freshwater fluxes
GCOS	Global Climate Observing System
GOSUD*	Global Ocean Surface Underway Data
IAR	Impact assessment report
IPP	Year of Polar Prediction
ITT	Invitation to tender
KO	Kick-off
MEOP	Marine Mammals Exploring the Oceans Pole to Pole
MR	Monthly report
MTR	Mid-term review
MV-TN	Modelling and validation technical note
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
OMG	Ocean Melting Greenland
OSNAP	Overturning in the Subpolar North Atlantic Program
PAR	Preliminary analysis report
PGICs	Peripheral glaciers and ice caps
PM	Progress meeting

PMP	Project management plan
RB	Requirements baseline
RD	Reference document
SAR	Synthetic Aperture Radar
SIAR	Scientific and impact assessment report
SMOS	Soil Moisture and Ocean Salinity
SoW	Statement of work
SR	Scientific roadmap
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
TDP	Technical data package
TDS	Training Data Set
TN	Technical note
TSG	Thermo-Salinograph
UDASH	Unified Database for Arctic and Subarctic Hydrography
VIR	Validation and intercomparison report
VOS	Voluntary Ocean Scheme
VR	Validation report
WCRP	World Climate Research Programme
WP	Work package
WS	Workshop minutes
WWRP	World Weather Research Programme

1 Introduction

1.1 Scope of this document

This document holds the Data User Manual (DUM) prepared by Arctic+ Salinity team, as part of the activities included in the [WP200] of the Proposal (Task 2 from SoW ref. EOP-SDR/SWO/084-17/DFP).

The objective of this document is to provide detailed description of the dataset and the related metadata.

1.2 Structure of the document

The DUM is structured as follows:

Section 1 is a brief introduction to all datasets and links to the different data sources
Section 2 presents a more detailed description of each dataset to be used within the Arctic+ Salinity project.
Section 3 presents the format of the dataset to be produced within the Artic+ Salinity project

2 Arctic+ Salinity Dataset

2.1 Satellite data

Three satellites have been designed and flown carrying an L-band radiometer, the instrument that permits to measure the SSS. The missions SMOS was launch by ESA in 2009 and SMAP was launch by NASA 2015.

The salinity data products which will be used in this project:

Global L3 SSS datasets

- Jet Propulsion Laboratory (JPL) produces global **SMAP** SSS product version 4.2 (smap.jpl.nasa.gov). JPL dataset is available via PODAAC website (Physical Oceanography Distributed Active Archive Center podaac.jpl.nasa.gov) [SMAP JPL 2019]. Maps can be downloaded from ftp://sealion.jpl.nasa.gov/pub/outgoing/smap/v4.2/L2B/
- Remote Sensing Systems (REMSS) currently produces version 3.0 of its global **SMAP** SSS product (www.remss.com). This dataset is available from the REMSS website. It is expected that they will distribute a new version of this product by summer 2019 [SMAP REMSS 2018]. Maps can be downloaded from ftp://ftp.remss.com/smap/SSS/V03.0/FINAL/L2C.

Specific Arctic SSS products

- BEC is currently distributing version v2.0 of its Debiased non-Bayesian Advanced product for Arctic through its distribution and visualization data service in http://bec.icm.csic.es/ocean-experimental-dataset-high-latitude-and-arcticsss/.
  This newly released BEC product is especially designed to target the Arctic region. The SMOS SSS product at high latitudes covers seven years (2011-2017). Maps can be downloaded from becftp.icm.csic.es. However, the currently distributed product contains some limitations and there is place for improvements on the algorithms, that could represent better quality SSS maps. The improved product (v3) is one of the objectives of this project and will be freely distributed on the webpage.

2.2 In situ dataset for validation

To date there is not an established Fiducial Reference Measurement (FRM) for satellite derived salinity product validation. The Arctic+ Salinity will detail as much as possible all the in situ observations used for the validation activities to be develop with this project. All the in situ observation listed in this section follow the standard of FRM to validate the Salinity measurement in the Arctic region. The FRM must comply with the following (http://www.frm4sts.org):

- Document evidence of its traceability
- Clear independence from the satellite retrieve measurement
- Supporting community agreeing with the protocols and managements practices

The limited number of in situ observations was foreseen by the Arctic+ team (see Technical Proposal, section 1.2.2). However, this project aims to gather all the available observations, including both historical datasets (i.e. already publicly dataset like Argo) and new dataset to be made available within the lifetime of the project, through established scientific networks between the Arctic+ team and other research groups external to the project (e.g. OSNAP and TERRIFIC projects).

The project website will contain brief description of the dataset included in this document. The website will be also directing future users to the data source. All in situ datasets used for this project (i.e. collocated within the satellite data) will be made available via FTP hosted by BEC.

Most in situ observations including Argo provide T and S profiles from surface down to depths of 1000 m or more. However, satellite are measuring the skin the of ocean, which in most cases might be comparable to in situ observations made down to 10 m [*Garcia-Eidell et al.*, 2017; *Boutin et al.*, 2018; *Olmedo et al.*, 2018]. Thus, the Arctic+ will gather all in situ observations from 0 down to 10 m only.

In section 3.2 from RBD document, we have described the different dataset to be used for the validation of the new generated Arctic SSS products. The links to the data can be found here. The Arctic+ in situ dataset (Table 1) will be mostly freely available and there are available from different data providers

Table 1 Arctic+ in situ Reference database (in alphabetical order of the provider name) to be used for the validation task [WP300]. Version of the Data can be Near Real Time mode (NR) or Delayed mode (DM) data. Notice some datasets might be found in different sources (*) and they will be used in case that data might be missing the main source.

Provider	system	Available temporal coverage	Version	Use of data in project and temporal coverage required	Source
ARGO	floats	2011 to 2017	DM	Validation	Coriolis
BGEP	BPR/CTD	2003-2018	DM	Validation	WHOI
CMEMS	CTD, TSG	2010-2018	DM	Validation	CMEMS
GOSUD*	CTD	2011 to 2017	DM	Validation	Ifremer
GOSUD*	TSG	2011 to 2017	DM	Validation	Ifremer
MEOP	CTD	2010-2018	DM	Validation	MEOP
NOAA	T, S	Regional Climatology 1990 to 2009	N/A	Validation	NODC
OMG	CTD		DM	Validation	OMG
OSNAP	CTD and floats	2014, 2016	DM	Validation	OSNAP
TARA	TSG	2013	DM	Validation	TARA
UDASH-PANGEA	CTD	2010-2015	N/A	Validation	PANGEA

UDASH/ PANGEA	TSG	2010-2015	N/A	Validation	PANGEA
VOS	TSG	1993-2019	DM	Validation	LEGOS

Table 2 Arctic+ in situ dataset websites providers in alphabetical order of the provider name

Link ID	Provider	Website
LK#01	ARGO	http://www.coriolis.eu.org/Observing-the-Ocean/ARGO
LK#02	BGEP	https://www.whoi.edu/page.do?pid=20756
LK#03	CMEMS	http://marine.copernicus.eu
LK#04	GOSUD	http://www.coriolis.eu.org/
LK#05	Ifremer	https://wwz.ifremer.fr/en/Research-Technology/Marine-data-portal
LK#06	MEOP	http://www.meop.net
LK#07	NOAA	https://www.nodc.noaa.gov/OC5/regional_climate/
LK#08	OMG	https://omg.jpl.nasa.gov/portal/browse/
LK#09	OSNAP	https://www.o-snap.org/observations/data/
LK#10	TARA	https://oceans.taraexpeditions.org/
LK#11	UDASH	https://doi.pangaea.de/10.1594/PANGAEA.872931

2.3 Model dataset (TOPAZ)

The TOPAZ4 reanalysis uses version 2.2.18 of HYCOM. In our implementation of HYCOM, the vertical coordinate is isopycnal in the stratified open ocean and z-coordinates in the unstratified surface mixed layer. Isopycnal layers permit high resolution in areas of strong density gradients and better conservation of tracers; and z-layers are well suited to the unstratified upper ocean. To realistically simulate the circulation in the Arctic region, an ocean model requires a particularly accurate representation of the dense overflow and the surface mixed layer to isolate the warm Atlantic inflow from the sea ice.

The TOPAZ4 implementation of HYCOM uses: the tracer and continuity equation solved with the second order flux corrected transport [FCT2, Iskandarani et al., 2005; Zalesak, 1979]; the turbulent mixing submodel from the Goddard Institute for Space Studies [Canuto et al., 2002]; the vertical remapping for fixed and non-isopycnal coordinate layers with the Weighted Essentially Non-Oscillatory (WENO) piecewise parabolic scheme; the short wave radiation penetration with varying exponential decay depending on the Jerlov water type [Halliwell, 2004]; and biharmonic viscosity.

The model is coupled to a one thickness category sea ice model with elastic-viscous-plastic (EVP) rheology [Hunke and Dukowicz, 1997]; its thermodynamics are described in Drange et al. [1996] with a correction of heat fluxes for sub- grid scale ice thickness heterogeneities following Fichefet and Morales Maqueda [1997]. The sea ice strength is set to 27500 N/m^2 . The advection of ice concentration, ice thickness, snow depth, first year ice fraction and ice age is calculated using a 3rd order WENO scheme [Jiang and Shu, 1996], with a 2nd order Runge-Kutta time discretisation.

The model domain covers the North Atlantic and Arctic basins, with approximately 12-16 km grid spacing in the whole domain. This is eddy-permitting resolution for low and middle latitudes, but is too coarse to properly resolve all of the mesoscale variability in the Arctic, where the Rossby radius is as small as 1-2 km.

The minimum z-level thickness of the top layer is 3 m, while the maximum z-layer thickness is 450 m, to resolve the deep mixed layer in the Sub-Polar Gyre and Nordic Seas. The model bathymetry is interpolated from the General Bathymetric Chart of the Oceans database (GEBCO) at 1-minute resolution.

The model is initialized in 1973 using climatology that combines the World Atlas of 2005 [WOA05, Locarnini et al., 2006; Antonov et al., 2006] with version 3.0 of the Polar Science Center Hydrographic Climatology [PHC, Steele et al., 2001]. At the lateral boundaries, model fields are relaxed towards the same monthly climatology. The model includes an additional barotropic inflow through the Bering Strait, representing the inflow of Pacific water, with seasonal variations. The inflow varies seasonally as found in observations [Woodgate et al., 2005]: with a maximum in June (1.3 Sv), a minimum in January (0.4 Sv), and the mean transport is 0.8 Sv. [Ness et al., 2010]. This inflow is balanced by an outflow at the southern boundary of the domain in the Atlantic Ocean.

TOPAZ is forced at the ocean surface with fluxes derived from 6-hourly atmospheric fluxes from ERA-interim [Simmons et al., 2007] that has a resolution of 0.25◦. The atmospheric fields from ERA-interim include: precipitation, dew point temperature, total cloud cover, air temperature at 2 m, sea level pressure, wind speed at 10 m and long wave radiation at the sea surface. The incoming short wave radiation is computed every 3h from synoptic cloud fields, and the wind stress is derived from 10 m winds, estimated as in Large and Pond [1981]. The surface fluxes are forced with a bulk formula parameterization [Kara, 2000].

The value of river discharge is poorly known because the observation array for river flows is sparse. A monthly climatological discharge is estimated by applying the run-off estimates from ERA-interim to the Total Runoff Integrating Pathways [TRIP, Oki and Sud, 1998] over the 20-year reanalysis period (1989-2009). Rivers in HYCOM are treated as a negative salinity flux with an additional mass exchange. The remaining inaccuracies in the evaporation and run-off are constrained using relaxation towards climatology. However, relaxation can have a detrimental impact on some regions – particularly where strong fronts occur and/or they are misplaced (e.g., Gulf Stream). In such places the water mass distribution is bimodal, and the relaxation towards an average estimate reduces the sharpness of fronts. To avoid this problem, relaxation is only activated when the difference between the climatology and the model is less than 0.5 PSU (Mats Bentsen, BCCR, pers. comm.). Relaxation to climatological SSS will be removed in the SSS assimilation runs.

The model code is publicly available. It can be accessed from https://svn.nersc.no/repos/hycom . The TOPAZ4 reanalysis SSS, when compared to Arctic in situ observations shows correct accuracy except for low-salinity waters below 28 psu for which the SSS is overestimated. This will be exposed in more details in future Arctic+ Salinity deliverables.

After generating the initial ensemble the TOPAZ DA system is spun up during a period of 1 year, for the calendar year of 1990. In order to limit the impact from an abrupt start of DA, the observation error variance is at first purposely overestimated and gradually decreased to the realistic level over a period of one year, starting from a factor of 8 and reducing to 1 at the end of the year 1990 for an official start of the reanalysis in 1991. A summary of the maintenance performed during the reanalysis is provided in Table 1, although most of the changes listed there have had little influence on the SSS.

The assimilation cycle is weekly, similarly to the real-time system, but more observations are assimilated in delayed mode. The TOPAZ Reanalysis system changes are resumed in Table 3.

Table 3 Changes in the TOPAZ Reanalysis system

	Date	**Change**	**Type**
1.	07.10.1992	Start of assimilation of altimetry data	Observation
2.	01.10.1993	Correction of wrong bias estimation for SST under ice	Assimilation
3.	14.01.1998	Start of assimilation of Argo profiles	Observation
4.	24.06.1998	Start of assimilation of OSTIA reanalysis, replacing Reynolds SST	Observation
5.	24.11.1999	Reduced variance of perturbations of air temperature to 2.25 K^2 Increased standard deviation of cloudiness and precipitation perturbations	Assimilation
6.	04.04.2001	Limit SST bias to 5 K Correction of defect in asynchronous assimilation Restoration of previous settings for perturbations of air temperature, cloudiness and precipitation	Assimilation
7.	26.09.2001	Limit SST bias to 10 K	Assimilation
8.	01.12.2001	Change of precipitation variance to $1 \cdot 10^{-12}$	Assimilation
9.	01.05.2006	Change of bias estimation routine from an inflation approach to an AR1 process	Assimilation
10.	01.01.2008	Start of assimilation of OSTIA NRT product, replacing OSTIA reanalysis Start of assimilation of AMSR-E, replacing OSI SAF (no repro)	Observation

11.	01.01.2009	Start of assimilation of OSI SAF (repro), replacing AMSR-E	Observation
12.	01.01.2010	Start of assimilation of OSI SAF (operational), replacing OSI SAF (repro)	Observation
13.	01.01.2011	Correction of a subsurface T/S bias in the central Arctic by relaxation, removal of the multiplicative inflation	Assimilation
14	05.02.2014	Correction of observation error of the OSTIA SST not accounted for in reanalysis.	Observation
15	01.01.2014	Assimilation of sea ice thickness from CS2SMOS in the winter month.	Assimilation

3 Format of the Dataset produced by the project

All the associated data, product, TOPAZ4 model and in-situ measures, will be distributed in netCDF-4 format following the CF conventions (at least v1.6). Compression will be applied for variables stored in netCDF files and time dimension will be defined as record dimension.

Grid mappings used will be described in the netCDF variables section specifying its name by means of grid_mapping_name attribute and map parameters and coordinates according to the grid mapping used.

As a general procedure the global attributes included in the produced netCDF files will be:

- title (brief description of the dataset)
- institution (where the data was produced)
- sources (list of the ancillary data files used)
- references (ATBD, algorithm…)
- Conventions (CF-version)
- product_version (the version of the product)
- date_created (the date in which the file has been created)
- creator_name / creator_url /creator_email
- project (the project name “Arctic+ salinity”)
- funding (“European Space Agency under contract 4000125590/18/I-BG”)
- license (conditions about data access and distribution)
- time_coverage_start (format “yyyymmddThhmmssZ”)
- time_coverage_end (format “yyyymmddThhmmssZ”)
- time_coverage_duration (ISO8601 compliant, for instance “P9D”)
- geospatial_lon_resolution (longitude resolution in degrees for regular lat-lon gridded data or km for EASE-Grid 2.0)
- geospatial_lat_resolution (latitude resolution in degrees for regular lat-lon gridded data or km for EASE-Grid 2.0)
- geospatial_lon_units (usually “degrees_east” for lat-lon gridded data or km for EASE-Grid)
- geospatial_lat_units (usually “degrees_north” for lat-lon gridded data)
- geospatial_lat_min / geospatial_lat_max (minimum and maximum value for latitude, range -90 to +90 degrees)
- geospatial_lon_min / geospatial_lon_max (minimum and maximum value for longitude, range -180 to +180 degrees)
- key_variables (comma separated list of primary variables)

3.1 Description of the regional SSS dataset

The adoption of a regional grid for the Arctic is essential to generate L3 and L4 products minimizing the possible interpolation effects (i.e. smoothing of the resulting signal or loss of representativeness among others). The adoption of the same grid in the complete processing chain from Level 1 to Level 4 will avoid such effects. The grid used will be WGS 84 / NSIDC EASE-Grid 2.0 North (CRS code 6931) at a 25-km resolution which introduces important improvements over the previous version [Brodzik et al., 2012, Brodzik et al., 2014, Brodzik et al., 2018]. This projection corresponds to a Lambert Azimuthal Equal Area (LAEA) using as ellipsoid the WGS84 and the projection centre (90^{o}N, 0^{o}E) does not define the centre of a cell but the intersection of the central four grid cells. The number of rows and columns are even (720x720 because the adopted resolution is 25km) and the grid is constructed from the projection origin establishing the centre of four cells at x,y ± 12.5 km and every 25 km from there (black squares in Figure 1).

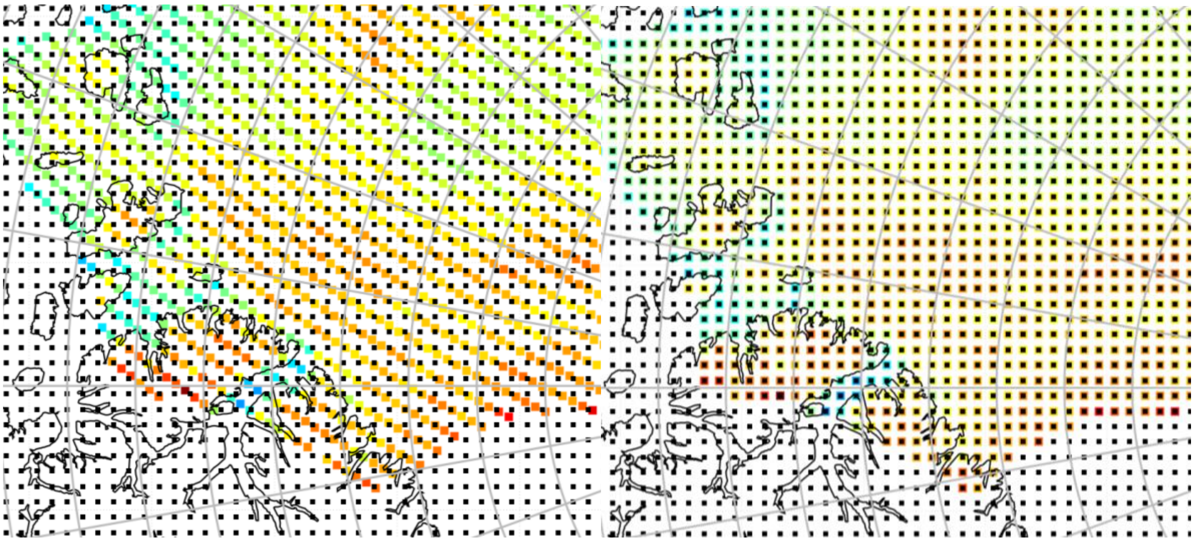

Figure 1 Brightness temperature in the range 50-300 K obtained for a single snapshot at 2018-08-26 07:28:54 UTC processed using a LAEA with origin in the centre of the orbit and reprojected to the EASE-Grid 2.0 North (left) and the same snapshot natively processed in the EASE-Grid 2.0 North (right).Black dots indicate the EASE-Grid 2.0 North grid cells centre. The region corresponds to Queen Elizabeth Islands located in the northwest of Greenland.

When SSS values are retrieved from L1 orbits centred in different longitudes, they cannot be projected over the centre of the grid cells of a regional projection (figure 1 left). In such cases it is necessary to use an interpolation method to create L3 maps. Adopting the EASE-Grid 2.0 North in the early stages of the processing chain, SSS can be obtained in this regional projection making interpolation unnecessary (Figure 1 right).

The spatial coverage of the final Arctic+ dataset will be from 50˚N to 90˚N. This range of latitudes includes regions such North Sea, Hudson Bay or Bering Sea (figure 2). Due to the SMOS orbital parameters no data above 84.6^{o}N in latitude can be retrieved. The Arctic+ SSS product will be created daily covering periods of 9 days.

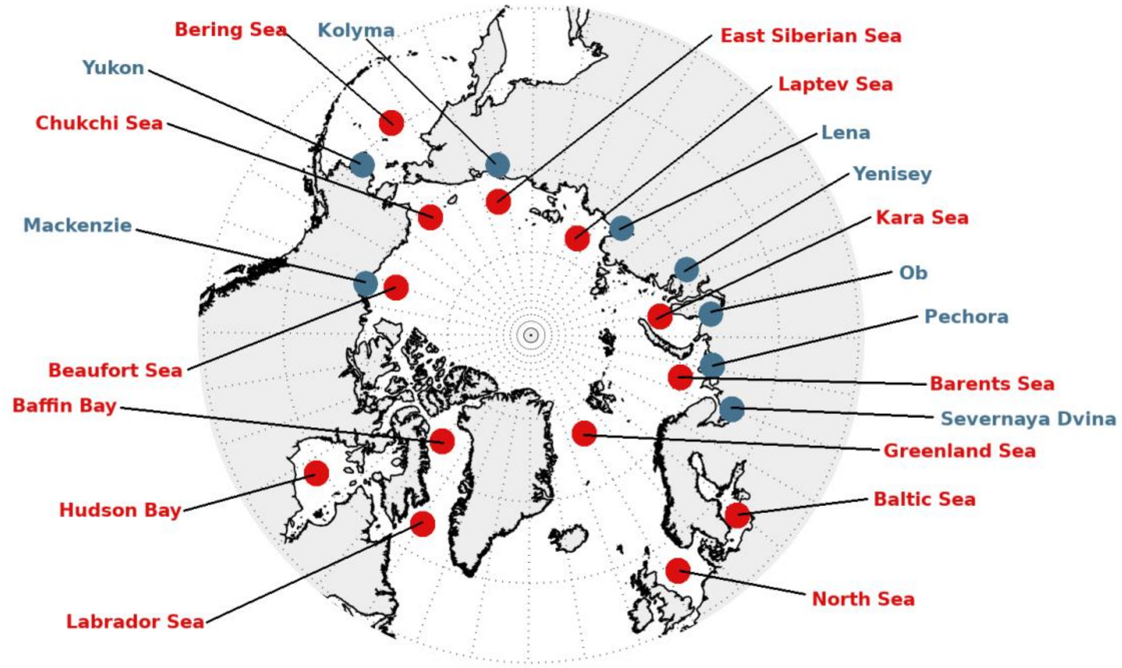

Figure 2 General view of the region covered by the Arctic+ dataset. Main seas and bays are indicated in red whereas blue dots and names indicate main river mouths

Example of a netCDF file containing Arctic L3 (SMOS) and L4 (fused SMOS and SMAP) product is described below:

```
dimensions:
   y = 720 ;
   x = 720 ;
   time = UNLIMITED ; // (1 currently)
variables:
   int time(time) ;
       time:standard_name = “time” ;
       time:long_name = “time” ;
       time:units = “seconds since 1970-1-1 00:00:00” ;
       time:time = “t” ;
       time:coordinate_defines = “center” ;
       time:_CoordinateAxisType = “Time” ;
       time:calendar = “gregorian” ;
   float y(y) ;
       y:standard_name = “projection_y_coordinate” ;
       y:long_name = “y coordinate of projection” ;
       y:units = “km” ;
       y:coordinate_defines = “center” ;
       y:_CoordinateAxisType = “GeoY” ;
   float x(x) ;
       x:standard_name = “projection_x_coordinate” ;
       x:long_name = “x coordinate of projection” ;
       x:units = “km” ;
       x:coordinate_defines = “center” ;
       x:_CoordinateAxisType = “GeoX” ;
   float latitude(y, x) ;
       latitude:standard_name = “latitude” ;
```

```
      latitude:long_name = "Latitude" ;
      latitude:units = "degrees_north" ;
      latitude:valid_min = 50.f ;
      latitude:valid_max = 90.f ;
   float longitude(y, x) ;
      longitude:standard_name = "longitude" ;
      longitude:units = "degrees_east" ;
      longitude:long_name = "Longitude" ;
      longitude:valid_min = -180.f ;
      longitude:valid_max = 180.f ;
   int crs ;
      crs:grid_mapping_name = "lambert_azimuthal_equal_area" ;
      crs:longitude_of_projection_origin = 0.f ;
      crs:latitude_of_projection_origin = 90.f ;
      crs:false_easting = 0.f ;
      crs:false_northing = 0.f ;
      crs:proj4tex = "+proj=laea +lat_0=90.000000 +lon_0=0.000000
+x_0=0.000000 +y_0=0.000000 +ellps=WGS84 +datum=WGS84 +units=m
+no_defs" ;
      crs:datum = "WGS84" ;
      crs:scale_factor_at_projection_origin = 25000.f ;
      crs:_CoordinateTransformType = "Projection" ;
      crs:_CoordinateAxisTypes = "GeoX GeoY" ;
   float sss(time, y, x) ;
      sss:missing_value = -999.f ;
      sss:_FillValue = -999.f ;
      sss:standard_name = "sea_surface_salinity" ;
      sss:long_name = "Sea Surface Salinity" ;
      sss:valid_min = 0.f ;
      sss:valid_max = 50.f ;
      sss:grid_mapping = "crs" ;
      sss:coordinates = "time latitude longitude" ;
      sss:units = "1" ;
      sss:description = "Sea Surface Salinity [psu]" ;
   float sss_error(time, y, x) ;
      sss_error:missing_value = -999.f ;
      sss_error:_FillValue = -999.f ;
      sss_error:standard_name = "sea_surface_salinity_uncertainty" ;
      sss_error:long_name = "Sea Surface Salinity uncertainty" ;
      sss_error:valid_min = 0.f ;
      sss_error:valid_max = 10.f ;
      sss_error:grid_mapping = "crs" ;
      sss_error:coordinates = "time latitude longitude" ;
      sss_error:units = "1" ;
      sss_error:description = "Sea Surface Salinity uncertainty [psu]"
  ;
   float sss_anomaly(time, y, x) ;
      sss_anomaly:missing_value = -999.f ;
      sss_anomaly:_FillValue = -999.f ;
      sss_anomaly:standard_name = "sea_surface_salinity_anomaly" ;
      sss_anomaly:long_name = "Sea Surface Salinity anomaly" ;
      sss_anomaly:valid_min = -50.f ;
      sss_anomaly:valid_max = 50.f ;
      sss_anomaly:grid_mapping = "crs" ;
```

```
sss_anomaly:coordinates = "time latitude longitude" ;
sss_anomaly:units = "1" ;
sss_anomaly:description = "Sea Surface Salinity anomaly [psu]" ;
```

In case of distribute a version of the product in a regular latitude-longitude grid (WGS 84 -- WGS84 - World Geodetic System 1984) dimensions and coordinate variables will be changed as follow:

```
dimensions:
      lon = 1440 ;
      lat = 180 ; // only values of latitudes higher than 50°N will be
   considered
      time = UNLIMITED ; // (1 currently)
variables:
   float lat(lat) ;
      lat:standard_name = "latitude" ;
      lat:long_name = "Latitude" ;
      lat:units = "degrees_north" ;
      lat:axis = "Y" ;
       float lon(lon) ;
      lon:standard_name = "longitude" ;
      lon:long_name = "Longitude" ;
      lon:units = "degrees_east" ;
      lon:axis = "X" ;
       int time(time) ;
      time:standard_name = "time" ;
      time:long_name = "Time" ;
      time:units = "seconds since 1970-1-1 00:00:00" ;
      time:time = "T" ;
      time:calendar = "gregorian" ;
       int crs ;
      crs:grid_mapping_name = "latitude_longitude" ;
      crs:longitude_of_prime_meridian = 0.f ;
      crs:semi_major_axis = 6378137.f ;
      crs:inverse_flattening = 298.2572f ;
      crs:datum = "WGS84" ;
      crs:proj4tex = "+proj=latlong +ellps=WGS84"
```

The file naming will follow the following fixed convention in order to simplify access to the users:

<processing_centre>-<processing_level>-<data_type>-<area>-<period>-<resolution>-v<version>.nc
for instance

```
BEC-L3-SSS-ARCTIC-__25k-20120201_20120210-v3.0.nc
BEC-L4-SSS-ARCTIC-0.25d-20120201_20120210-v3.0.nc
```

3.2 Description of the Collection in-situ data

In-situ data which has been identified in the RBD are collected in the WP200. In-situ data collocated with the satellite measurements will be distributed to facilitate the validation of the Arctic+ SSS products.

The match-up files provided in NetCDF format will contain the collocated SSS for a given satellite/in situ product pair and also auxiliary geophysical parameters such as temperature, as well as, distance to coast, time lag between measurements, etc. The in situ measurements are the drivers of the file, which means that there are as much pairs as in situ measurements, even though several in situ measurements fall in the same satellite cell grid. Match-up files will have the same temporal coverage as their corresponding satellite product. In the case of in situ measurements provided by moorings, profilers or CTD only the uppermost measurement has been included (considering only measurements in the mixed layer depth). The format of the data files delivered under this project is the same defined in PI-MEP.

Match-up files will have the same temporal coverage as their corresponding satellite product. So, the match-up file will contain the in situ data of 9 days.

The in situ based observations have been grouped as punctual measurements (group 1) and continuous measurements (group 2).

3.2.1 Group 1

- ARGO profilers data (& CORA)
- Moored buoy data
- CTD measurements from oceanographic ships

3.2.2 Group 2

- Thermo-Salinograph (TSG) data installed on Voluntary Observing Ships & Research Vessels
- Surface Drifters
- Equipped marine mammals (MEOP)
- Dedicated Campaign data

The format of the files will be slightly different for the different group sensors and will be distributed through the BEC secure FTP service becftp.icm.csic.es available through port 27500. This ftp server will be available before June 2019.

File Name convention given to the Match up files is the following:

ESA_ITT+Arctic-<processing_level>-<area>-<insitu_sensor_type>-<date_ini>-<date_end>-v<product_version>.nc

<insitu_sensor_type> can be ARGO, MOOR, CTD_, MAM_, TSG_, DRIF

for instance:
ESA_ITT+Arctic-L3-ARCTIC-ARGO-20120201_20120210-v1.0.nc (for L3 products)
ESA_ITT+Arctic-L4-ARCTIC-ARGO-20120201_20120210-v1.0.nc (for L4 products)

The files will have the following format:

```
dimensions:
      nmeas = 200 ; // number of the  in-situ measurements
variables:
float latitude_insitu(nmeas) ;
            latitude_insitu:standard_name = "latitude" ;
```

```
            latitude_insitu:long_name = "Latitude of the in-situ
measurement" ;
            latitude_insitu:units = "degrees_north" ;
            latitude_insitu:axis = "Y" ;
      float longitude_insitu(nmeas) ;
            longitude_insitu:standard_name = "longitude" ;
            longitude_insitu:long_name = "Longitude of the in-situ
measurement" ;
            longitude_insitu:units = "degrees_east" ;
            longitude_ insitu:axis = "X" ;
int date_insitu(nmeas) ;
            date_insitu:standard_name = "time" ;
            date_insitu:long_name = "Time" ;
            date_insitu:units = "seconds since 1970-1-1 00:00:00" ;
            date_insitu:time = "T" ;
            date_insitu:calendar = "gregorian" ;
float sss_insitu(nmeas) ;
            sss_insitu:missing_value = -999.f ;
            sss_insitu:_FillValue = -999.f ;
            sss_insitu:standard_name = "sea_surface_salinity" ;
            sss_insitu:long_name = "In-situ Sea Surface Salinity" ;
            sss_insitu:valid_min = 0.f ;
            sss_insitu:valid_max = 50.f ;
            sss_insitu:units = "1" ;
            sss_insitu:description = "Sea Surface Salinity [psu]" ;
      float latitude_satellite(nmeas) ;
            latitude_satellite:standard_name = "latitude" ;
            latitude_satellite:long_name = "Satellite product latitude
at the in-situ location" ;
            latitude_satelliteinsitu:units = "degrees_north" ;
            latitude_satelliteinsitu:axis = "Y" ;
      float longitude_satellite(nmeas) ;
            longitude_satelliteinsitu:standard_name = "longitude" ;
            longitude_satelliteinsitu:long_name = "Satellite product
longitude at in-situ location" ;
            longitude_satellite:units = "degrees_east" ;
            longitude_satelliteinsitu:axis = "X" ;
      float sss_satellite(nmeas) ;
```

```
            sss_satellite:missing_value = -999.f ;
            sss_satellite:_FillValue = -999.f ;
            sss_satellite:standard_name = "sea_surface_salinity" ;
sss_satellite:long_name = "Satellite SSS at in-situ location"
            sss_insitu:valid_min = 0.f ;
            sss_insitu:valid_max = 50.f ;
            sss_satellite:units = "1" ;
            sss_satellite:
      float sst_insitu(nmeas) ;
            sst_insitu:long_name = "In-situ Sea Surface Temperature" ;
            sst_insitu:units = "degree Celsius" ;
            sst_insitu:standard_name = "sea_water_temperature" ;
            sst_insitu:_FillValue = -999.f ;
      float coast_distance(nmeas) ;
            coast_distance:long_name = "Distance to coasts at Argo float
location" ;
            coast_distance:units = "km" ;
            coast_distance:_FillValue = -999.f ;
float depth_insitu(nmeas) ;
            depth_insitu:long_name = "Depth" ;
            depth_insitu:units = "m" ;
            depth_insitu:standard_name = "sea_water_depth" ;
            depth_insitu:_FillValue = -999.f ;
float time_lags(nmeas) ;
            time_lags:long_name = "Temporal lag between in-situ time and
            satellite SSS product central time" ;
            time_lags:units = "days" ;
            time_lags:_FillValue = -999.f ;
float spatial_lags(nmeas) ;
            spatial_lags:long_name = "Spatial lag between in-situ
            location and satellite SSS product pixel center" ;
            spatial_lags:units = "km" ;
            spatial_lags:_FillValue = -999.f ;
float sss_gradient_insitu(nmeas) ; //this field is for in situ of
group 1
            sss_gradient_insitu:long_name = "Sea Surface Salinity g
            radient" ;
            sss_gradient_insitu:standard_name =
            "sea_water_salinity_gradient" ;
```

```
            sss_gradient_insitu:_FillValue = -999.f ;
            sss_gradient_insitu:units = "m-1" ;
float sst_gradient_insitu(nmeas) ; //this field is for in situ of
group 1
            sst_gradient_insitu:long_name = "Sea Surface Temperature
            gradient" ;
            sst_gradient_insitu:standard_name =
            "sea_water_temperature_gradient" ;
            sst_gradient_insitu:_FillValue = -999.f ;
            sst_gradient_insitu:units = "Kkm-1" ;
```

3.3 Description of the regional TOPAZ4 model data

The TOPAZ reanalysis system (described in details in Section 2.3) assimilates available satellite and in situ observations available on the period 1991-2017. It will be updated twice a year by NERSC and it is distributed by Copernicus (CMEMS) as product identification ARCTIC_REANALYSIS_PHYS_002_003. The 3-dimensional fields are provided as monthly averages while the surface fields (including SSS) are given on a daily basis. The TOPAZ4 product is currently distributed in a Polar Stereographic North coordinate reference system with a resolution of 12.5 km (projection information included in the NetCDF metadata attributes).

The v3 of the BEC Arctic SSS data (Section 3.1) will be assimilated (in every weekly cycle) in TOPAZ4. In addition, the new version of the reanalysis of TOPAZ4 (after the assimilation of SSS data) will be distributed in the same temporal resolution, spatial resolution and coordinate reference system as the regional SSS dataset.

TOPAZ includes variables involving the dynamics and geophysics of the Arctic such sea water and sea ice velocity, sea ice thickness and its concentration, snow thickness, mixed layer thickness, sea surface height, sea water salinity or sea water temperature among others. The vertical coverage is divided into 12 levels covering the range from -3000 meters to 0 metres. The distributed dataset will include the following variables at surface level:

- sea water salinity
- sea water temperature
- sea ice area fraction
- mixed layer thickness

The netCDF structure will be identical to the SSS dataset, except for the definition of the variables, as the described in section 3.1

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