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[2] Integers correspond to submitted versions.

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1. INTRODUCTION

This document is a report on the quality of existing float profiles in the Baltic (Figure 1) and propositions how to provide quality-controlled data in this shallow shelf sea. It has to be ensured that data processing for Argo floats in the Baltic is compliant with Argo rules and can make use the Argo Data System. Table 1 gives list of all 32 floats deployed in the Baltic to date and provides information on their deployment period. It also indicates if the float was recovered and the CTD was send in for recalibration.

Originally, Argo floats were devised to operate in waters deeper than 2000 m and provide measurements in the global ocean outside of marginal and shelf seas. The Finnish Meteorological Institute started deploying floats in the shallow brackish waters of the Baltic Sea since 2012 (see Table 1) as part of their monitoring program (Siiriä et al., 2018). They deployed floats in the different basins of the northern parts of Baltic Sea, usually for a year and then recovered and replaced with a new. The nominal observation cycle of these floats was usually a week in monitoring mode, but shorter intervals up to one day have occasionally been chosen for specific purposes. The satisfying experiences of the Finnish Meteorological Institute are summarized in (Siiriä et al., 2018) with the following statement : *'With proper piloting practices, Argo floats have demonstrated great value in monitoring and for research of shallow marginal seas, as they give regular and frequent data around the year, regardless of weather conditions. Operating the floats has matured to a level where we can state that Argo monitoring of the Baltic Sea is an operative reality'.*

In the framework of MOCCA additional 4 floats were deployed in this marginal sea (see Table 1). The Real-Time (RT) processing of the MOCCA floats is organised through Euro-Argo data centres, as described in the deliverable D4.2.3 Report on Real-Time processing of the MOCCA fleet. The real-time qc tests applied to the floats in the Baltic follow the regular set of 22 tests approved by the Argo data management. The same applies to the floats deployed by Finland and Poland. The DMQC of these MOCCA floats will be performed by delayed-mode operators of Euro-Argo MOCCA partners according to the area of deployment and taking into account their area of expertise. It is further described in the deliverable D4.1.1 Organization of Float Data Management among DAC and DM-operators.

The semi-enclosed, shallow, brackish Baltic Sea is a European marginal sea that suffers from serious environmental problems, mainly eutrophication. The environmental conditions of the Baltic Sea are monitored in international cooperation under the Baltic Sea Environment Protection Commissions Helsinki Commission (HELCOM) monitoring programs since 1979 (HELCOM, 2017). All the coastal countries of the Baltic Sea are members of HELCOM and provide data to the HELCOM data base. The HELCOM hydrography and chemistry monitoring dataset also includes all earlier observations in the Baltic since 1898. The data is freely available at International Council for the Exploration of the Sea ICES (*www.ices.dk*).

The Baltic Sea consists of a series of basins that are mostly separated by underwater sills. The limited connection to the North Sea through the narrow and shallow Danish straits has a great effect on the hydrography. At the surface excess precipitation and river run-off creates a low-salinity surface layer with a strong gradient to the more saline deeper waters. The halocline, usually located between 40 - 80 m depth, typically isolates the deep water from the upper layer that overturns seasonally. The deep-water masses in the southern and central Baltic and in the western Gulf of Finland renew only when large amounts of more saline- and oxygen-rich waters flow to the Baltic Sea from the North Sea known as Major Baltic Inflows (MBIs). The frequency of MBIs has been variable, but after the mid-1970s there have been few episodes.

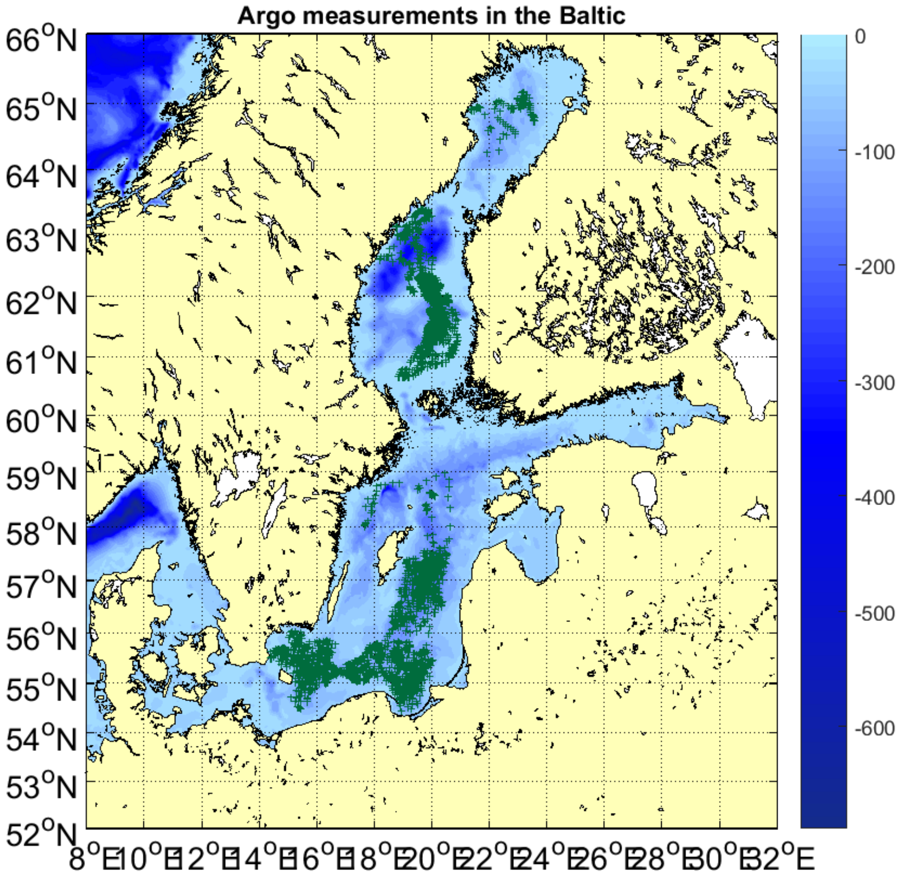

Figure 1: Historical and MOCCA float measurements in the Baltic.

WMO-number	Float serial. No	CTD serial no.	Float type	Country/ Programme	Deployment date	Date of last profile	Calib. of CTD after recovery
6901901	5397	3511	APEX	Argo Finland	17.05.2012	05.12.2012	y
6902013	5396	3503	APEX	Argo Finland	13.06.2013	02.10.2013	y
6902014	6711	4793	APEX	Argo Finland	14.08.2013	21.08.2014	y
6902017	5397	3511	APEX	Argo Finland	31.05.2014	24.10.2015	y
6902018	6710	5051	APEX	Argo Finland	31.05.2014	13.11.2014	y
6902019	7191	5699	APEX	Argo Finland	21.08.2014	05.08.2015	y
6902020	6711	4793	APEX	Argo Finland	05.08.2015	03.08.2016	y
6902021	6710	5051	APEX	Argo Finland	22.09.2015	13.05.2016	y
6902022	5396	3503	APEX	Argo Finland	13.05.2016	11.10.2016	y
6902023	5397	3511	APEX	Argo Finland	13.07.2016	25.01.2018	y
6902024	7191	5699	APEX	Argo Finland	03.08.2016	15.06.2017	y
6902036	7507	7248	APEX	Argo Poland	29.11.2016	01.02.2017	n
6902025	7958	8893	APEX	Argo Finland	09.05.2017	02.10.2018	y
6902026	7959	8894	APEX	Argo Finland	06.06.2017	02.06.2019	y
6902027	6711	4793	APEX	Argo Finland	15.06.2017	15.10.2018	y
6902028	6710	5051	APEX	Argo Finland	06.08.2017	04.09.2018	y
6902029	5396	3503	APEX	Argo Finland	06.08.2017	27.10.2017	y
3901940	AI2600-16FR083	8519	Arvor	MOCCA-EU	20.09.2017	04.10.2017	n
3901941	AI2600-16RF084	8498	Arvor	MOCCA-EU	21.09.2017	10.09.2019	y
3902100	7507	7248	APEX	Argo Poland	15.03.2017	07.01.2018	n
3902133	AI2600-16FR083	8519	Arvor	MOCCA-EU	03.11.2017	09.09.2019	n
6902030	5396	3503	APEX	Argo Finland	10.07.2018	04.03.2019	y
3902101	AI2632-17EU025	10114	Arvor	Argo Poland	06.02.2018	07.02.2020	n
3902104	AI2632-18EU005	4991	Arvor	Argo Poland	31.05.2018	10.09.2018	n
3902106	AI2632-18EU005	4991	Arvor	Argo Poland	11.09.2018	alive	-------------
3902134	AI2600-17EU010	10666	Arvor	MOCCA-EU	04.10.2018	11.01.2020	n
3902137	AI2600-17EU013	10073	Arvor	MOCCA-EU	09.11.2018	alive	-------------
6903696	AC0300-17FI001	10012	Arvorc	Argo Finland	30.09.2018	5.12.2018	n
6903697	7191	5699	APEX	Argo Finland	15.10.2018	18.08.2019	n
6903698	AI2600-18FI001	10946	Arvor	Argo Finland	30.05.2019	alive	-------------
6903699	8541	10306	APEX	Argo Finland	30.05.2019	alive	-------------
6903700	8543	10379	APEX	Argo Finland	01.06.2019	alive	-------------
6903701	8540	10305	APEX	Argo Finland	17.08.2019	alive	-------------

Table 1: List of floats in the Baltic. The colour code in column CTD serial number is a visual help to identify reuse of specific CTDs after recalibration.

2. METHODOLOGY

Real Time (RT) processing of the data transmitted by the floats is carried out by DACs (Data Assembly Centres), which in case of the Baltic Sea is Coriolis. Automated procedures flag the gross errors in the data but some subtle errors may remain due to sensor drift and or offsets, position errors etc. and need treatment in delayed mode quality control. The automated real-time procedures are set-up with the background of statistical distributions of temperature and salinity in the global ocean and some specific range tests for certain areas. No specific rules have so far been included for the Baltic Sea. A final improvement of the data quality of the RT data is provided by the regular visual screening of the data through software like SCOOP.

A minimum of 1 year of float data is needed with the current DMQC software before the delayed mode processing (DMQC) can be performed. The DMQC of Argo floats follows guidelines provided by the Argo Data Management Team (ADMT), and is documented in the following manuals:

- Argo user's manual V3.2
  (*http://dx.doi.org/10.13155/29825*)
- Argo quality control manual for CTD and trajectory data, version 3.1
  (*http://dx.doi.org/10.13155/33951*)

In the global ocean the DMQC operator is tasked with comparing Argo data to other observations (climatology, altimetry, reference databases, deployment CTD, etc.) to determine data quality. Pressure, temperature and salinity data are extensively analysed in DMQC. Especially salinity data need careful examination since over time the conductivity sensor can experience instrumental drift that gives salinity measurements an artificial trend. In order to obtain robust determination of potential trends in the float conductivity data these comparisons are normally carried out in stable deep-water masses at depth larger than 1000-1500 m where water masses exhibit low spatial and temporal variability. By using deep climatological reference CTD data and objectively mapping these to float locations, a climatologically consistent salinity at the float locations can be obtained and corrections for the float data can be determined. Given the statistical approach for quality control the accuracy limit of quality assessed Argo data is expected to be 0.01 psu and reflects the natural variability background in most parts of the global ocean.

Because of the shallow water depth in the Baltic Sea the entire water column is influenced by seasonal variability and direct application of the Argo DMQC rules are not possible. For the Baltic Sea therefore new DMQC procedures have to be recommended and have to be endorsed at international level. The practice of the Argo Finland program to recover the floats after approximately one-year deployments is a good start for such procedures. For one it limits the potential drift of the conductivity sensor and the recalibration of the CTDs at Sea-Bird allows lab-based determination of drift. This should ultimately be superior to the in-situ comparisons as they are carried out in regular Argo DMQC work. The time span between the initial deployment of a float, its recovery and the recalibration of the CTD at SBE is in the order of 2 years and longer and thus is a limit for the availability of D-files. This is a longer time span than for floats in the global ocean where D-files should be provided a year after measurements.

Some floats however have not been recovered or some programs might not have means to recover floats. For these floats an assessment against the reference data in the Baltic has to be performed and levels of accuracy have to be defined. For the global ocean and the given natural variability and seasonal cycles the expectation on the accuracy limits is within 0.01 psu to allow use in monitoring and climate research applications. But given the huge range of salinity values in the shelf sea with values between 2-15 psu less rigorous standards for data accuracy levels of accuracy are needed in monitoring and scientific applications.

In the following sections we first show an examination of the Argo RT procedures in the Baltic. This analysis looked at the overall data quality of the float observations and checked the quality tests that have been failed and examines the performance of the flagging procedures in terms of false positives and negatives. The next section gives an overview of the reference data base in the Baltic and is followed by a set of rules which could be derived from the lab calibrations of floats. Finally, recommendations are given for floats which have not been recovered and need to be evaluated by in-situ comparisons.

2.1. Control of real time qc procedures

The 32 floats have delivered 6689 profiles until 22.04.2020 with 501.780 measurements of temperature (T), salinity (S) and pressure (P). More than 99.3% of the data have been flagged as good in real-time applying a set of tests to the primary profile as described in the Argo QC manual (see Table 2). Two more tests are performed on the near-surface data that some floats transmit in a secondary profile.

Application Order	Test Number (n)	Test Name
1	19	Deepest Pressure Test
2	1	Platform Identification
3	2	Impossible Date Test
4	3	Impossible Location Test
5	4	Position on Land Test
6	5	Impossible Speed Test
7	6	Global Range Test
8	7	Regional Range Test
9	8	Pressure Increasing Test
10	9	Spike Test
~~11~~	~~10~~	~~Top and Bottom Spike Test: obsolete~~
~~12~~	~~11~~	~~Gradient Test: obsolete~~
11	25	MEDD Test
12	12	Digit Rollover Test
13	13	Stuck Value Test
14	14	Density Inversion
15	15	Grey List
16	16	Gross salinity or temperature sensor drift
17	18	Frozen profile
18	17	Visual QC

Table 2: Real-time test from the Argo-QC manual

Most of the float data are qualified as good (QC 1) and only less than 1% is failing some of the real time tests given in Table 2. The measured data points have then received either a QC flag of 3 (probably bad) or 4 (bad). A QC of 3 was given to 2794 temperature data points and 2011 salinity data out of the 501780 data points in total in the vertical profiles. A QC of 4 was applied to 591 temperature data points, 1350 salinity data points and 72 pressure data.

Figure 2 gives an example of the data quality assessed in real time for a float with some data quality issues. Float 3901941 has delivered 382 cycles and more than 753 profiles since most of the cycles have measured both in ascending and descending mode. There are only few data in both temperature and salinity which have degraded in QC to either 3 or 4.

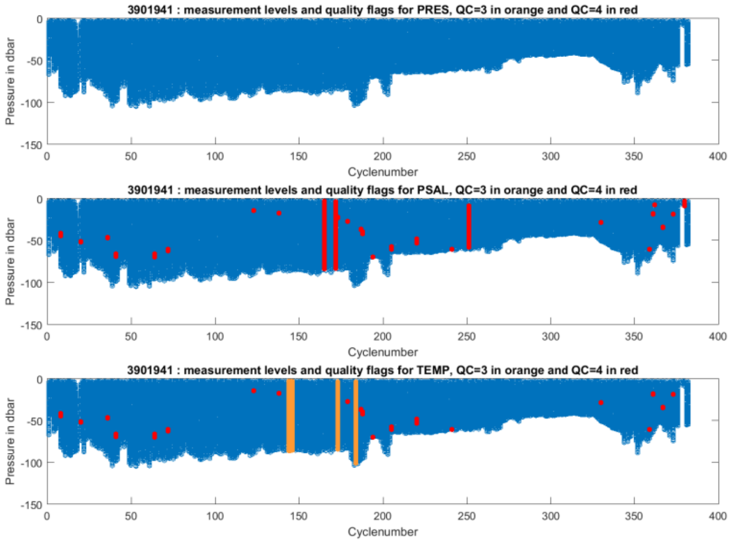

Figure 2: QC flags assigned in real time for float 3901941. The QC status is indicated by the color of the data points and blue indicates good data (QC=1), orange indicates probably bad data (QC=3) and red stands for bad data (QC=4).

More often, all of the data transmitted from the float pass all the quality tests and none of the data points show degraded QC flags (Fig. 3).

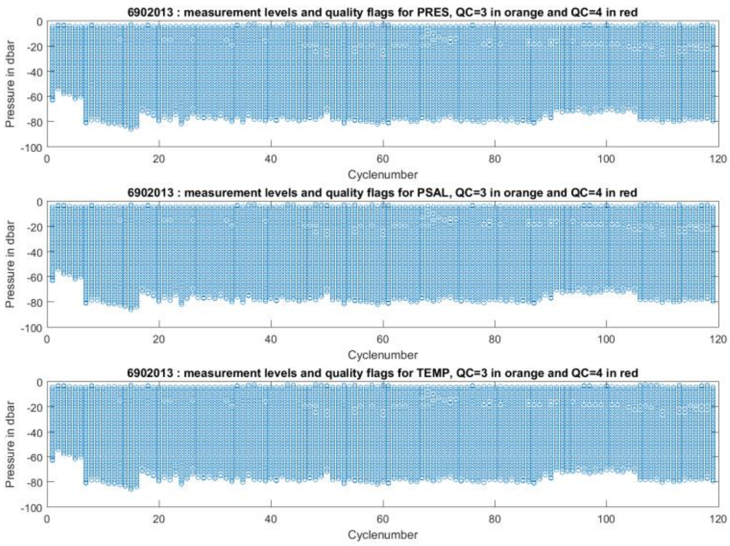

Figure 3: as Fig. 2 but for float 6902031.

Since the real-time tests were designed for the global ocean and have been tested for the hydrographic conditions in 2000 m deep profiles, the status of the real-time flagging in the Baltic must be checked for false positives and negatives. The search for false positives was conducted by looking at HISTORY_ACTION in the HISTORY section in the float data. It reports all actions performed on the float data and indicates failed QC-tests by QCF$. Information about these failed tests is then given in the corresponding entry in HISTORY_QCTEST. Here a hexadecimal number can be found which refers to a decimal code numbers in reference table 11 of the Argo_user_manual. In case that two or more of the tests fail, their numbers are added but can uniquely be reconstructed. In case of the example given in Fig. 2 the hexadecimal numbers for the failed test were given as 1000, 2000 and 4000, which translates to their decimal equivalents of 4096, 8192, and 16384. The look-up table 11 in the Argo_user_manual names them as digit-rollover test (test 12), stuck value test (test 13) and density inversion test (test 14). In the primary profiles 22 tests or test combinations showed up as failed (Table 3). They have looked at by visually examining the profiles which triggered the tests and some findings on these are given below. Additional to the real-time test described in the Argo manuals Coriolis performs comparisons of the individual float measurements with their ISAS product. This system operates at Coriolis Data Center to generate the weekly gridded product that is distributed by Coriolis (http://www.coriolis.eu.org/Science2/Global-Ocean/ISAS). If the float data disagree with weekly gridded product they are flagged.

QC-Test binary code	**QC test decimal**	**RT-test number**	**Number of occurence (profiles)**
3	3	ISAS objective analysis: Alert for high residuum in OA	3
4	4	Impossible Date test	2
5	5	ISAS objective analysis: spike or climatology alerts	26
6	6	ISAS objective analysis: Alert for medium residuum in OA	4
40	64	Global Range test	37
100	256	Pressure Increasing test	9
200	512	Spike test	4
800	2048	Gradient test	50
840	2112=2048+64	Gradient test Global Range test	4
1000	4096	Digit Rollover test	13
2000	8192	Stuck Value test	7
4000	16384	Density Inversion test	153
4040	16448=16384+64	Density Inversion test Global Range test	1
4200	16896=16384+512	Density Inversion test Spike test	1
4800	18432=16384+2048	Density Inversion test Gradient test	2
8000	32768	Grey List test	84
8100	33024=32768+256	Grey List test Pressure Increasing test	2
80000	524544	Deepest pressure test	2
80100	524544= 524288+256	Deepest pressure test Pressure Increasing test	1
88000	557056= 524288+32768	Deepest pressure test Grey List test	1
2000000	33554432	Internal test	2
2004000	33570816	Internal test	1

Table 3: List of failed tests in present real-time flagging of Baltic Floats. Only primary profiles have been considered.

Float 3901941 shown in Fig. 2 has triggered density inversion test, digit rollover test and stuck value test. Density inversion test is one of the most common reasons for a degradation in flags. An example is given in Fig.4.

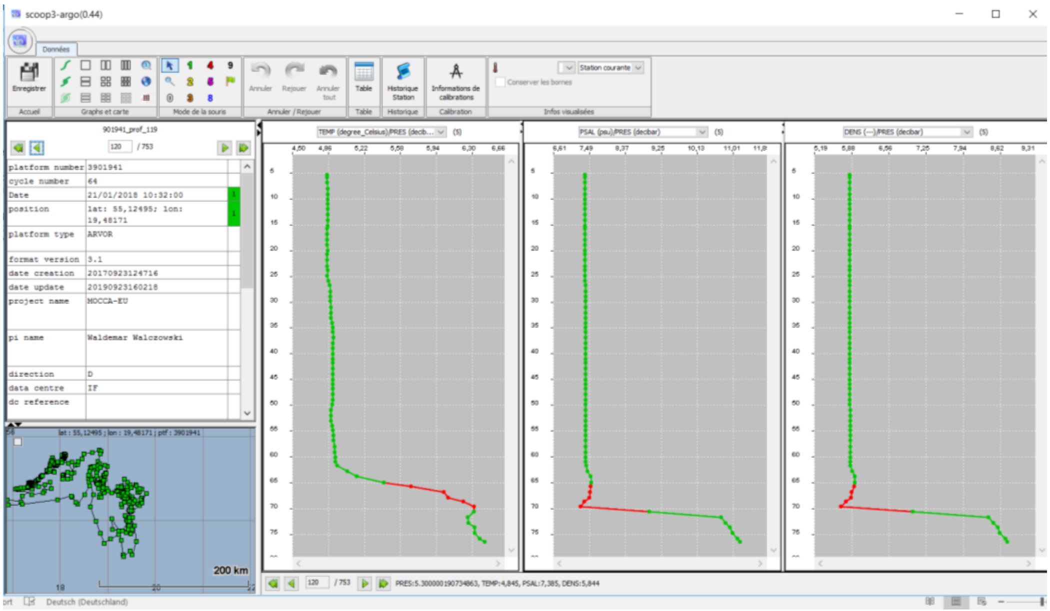

Figure 4: Visualisation with scoop of a profile which failed the density inversion test. Shown is cycle 64D (descending mode) from float 3901941.

The data points shown in red in Figure 4 are flagged as bad. Failed data points from the density inversion test most often occur at the base of the mixed layer where salinity shows a small fresh hook and density in that depth layer is therefore decreasing. In the real-time application of this test a threshold of 0.03 kg/m^{-3} is allowed before temperature and salinity data are flagged as bad. It needs to be decided if a larger threshold can be defined for the Baltic or if a thermal lag correction might help to reduce the salinity hook, which is mostly likely a result of slightly unadjusted temperatures in the conductivity cell. The occurrence of density inversions is slightly increased in the descending profiles were the float measures downward.

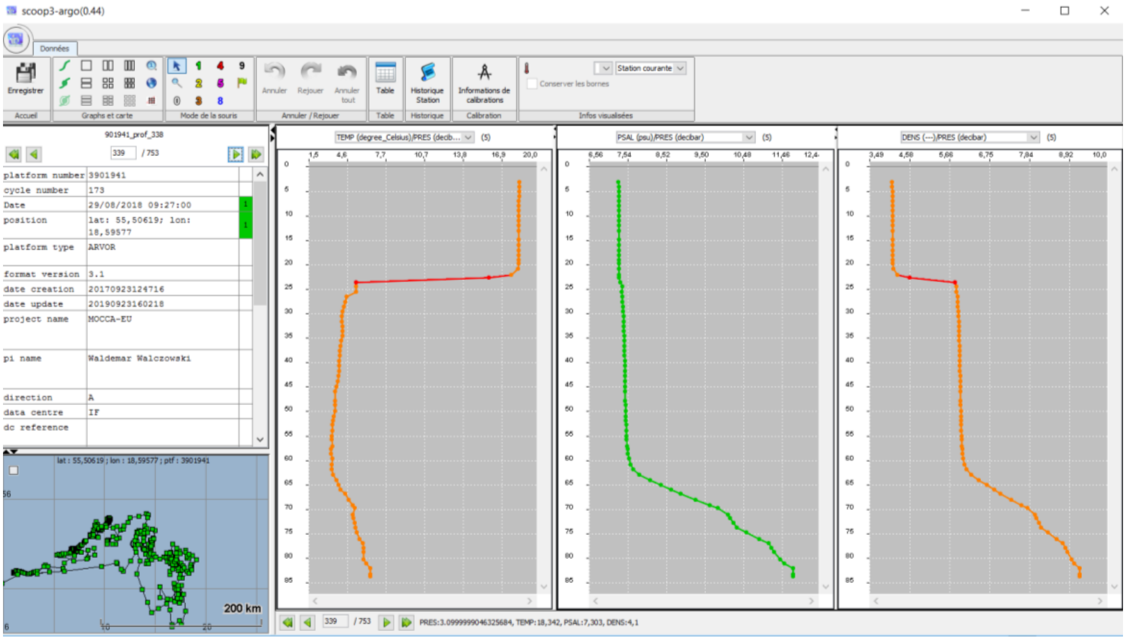

Figure 5: Visualisation with scoop of a profile which failed the digit rollover test. Shown is cycle 173A (ascending mode) from float 3901941.

Fig. 5 shows an example were the digit rollover test has triggered the flagging of the entire temperature profile as possibly bad (QC=3). The digit rollover test is a remainder from early Argo days when only a limited amount of bits were available for transmission in the Argos satellite system. The range of encountered temperature and salinity data however was not always large enough to accommodate them and when the range was exceeded stored values rolled over to the lower end of the range. To detect the rollover the test considers temperature differences between adjacent pressures > 10°C as a sign of rollover and salinity differences of >5 psu. This test is now longer necessary in modern floats with increased bandwidth for transmission. It was also never designed for strong, shallow thermo- and haloclines as encountered in the Baltic. It should definitely be disabled for the Baltic.

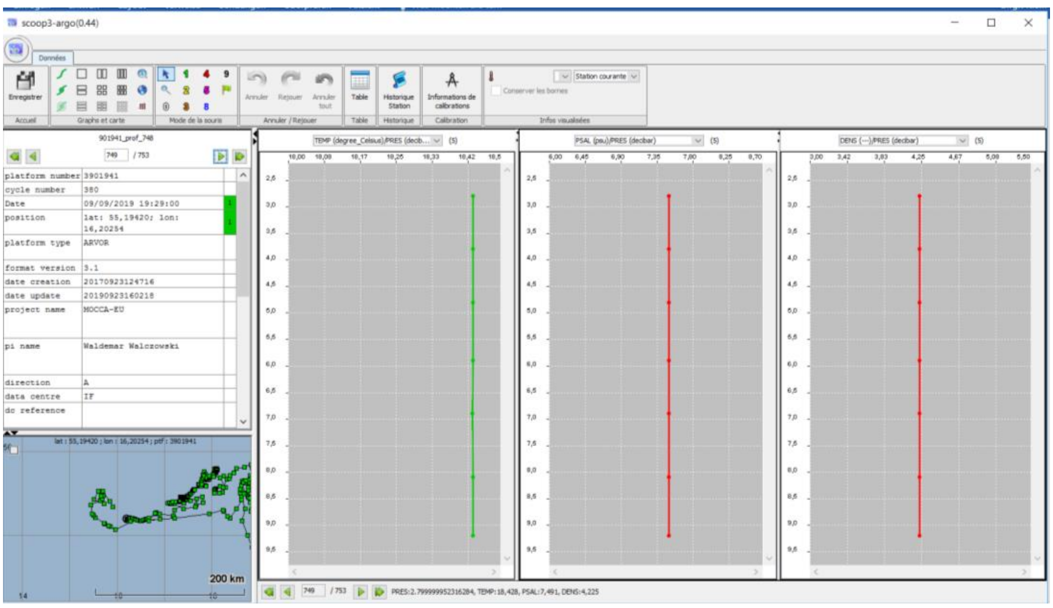

Figure 6: Visualisation with scoop of a profile which failed the stuck value test. Shown is cycle 380A from float 3901941.

The stuck value test looks for measurements of temperature and salinity in a profile being identical. In case of the profile shown in Fig. 6 it has caught on the salinity data in a very shallow profile which only covers the upper 10 m of the water column. In this partial profile, the mixed layer temperature and salinity are nearly homogeneous. All salinities are exactly the same and thus are flagged as bad, while temperatures at least show a 0.6 mK standard deviation and thus escaped a degradation in flagging. This test has to be modified in the Baltic to allow for deep winter mixing and partial profiles as shown in Fig. 6. Short profile length could also arise from the ice-avoidance algorithm and abortion of the ascent under ice conditions.

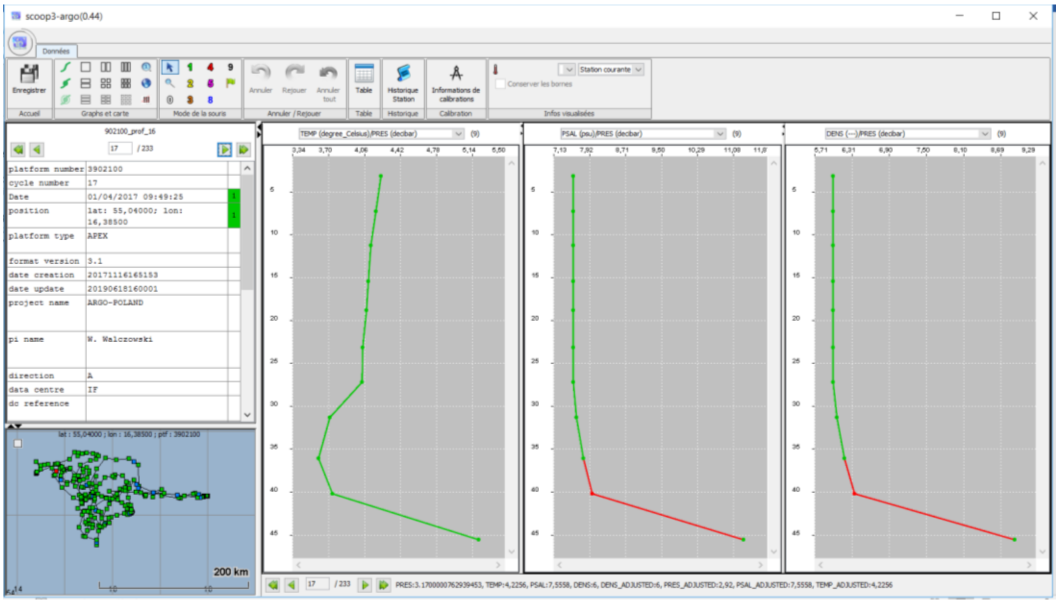

Figure 7: Example of a profile which failed the gradient test (float 3902100, cycle 17A).

The example shown in fig. 7 shows a triggering of the gradient test for the bottom layer of this profile. In the Baltic there can be strong gradients at the bottom because of the inflow of salty waters from the North Sea and the parameters of this test need to be set appropriately for the Baltic not to falsely flag these data.

The failed global range data points are associated to float 3902101 except for one profile (R6902026_099.nc), but only for the oxygen measurements associated with the primary profile which are not part of this report.

Some consideration should be given to the density inversion tests in cases of extended layers with unstable density profile. Figures 8, 9 and 10 give examples of the treatment of density inversions, which only seems to have flagged in part of a larger unstable layer. Here it needs to be checked how to improve and which parts of the layer can be kept.

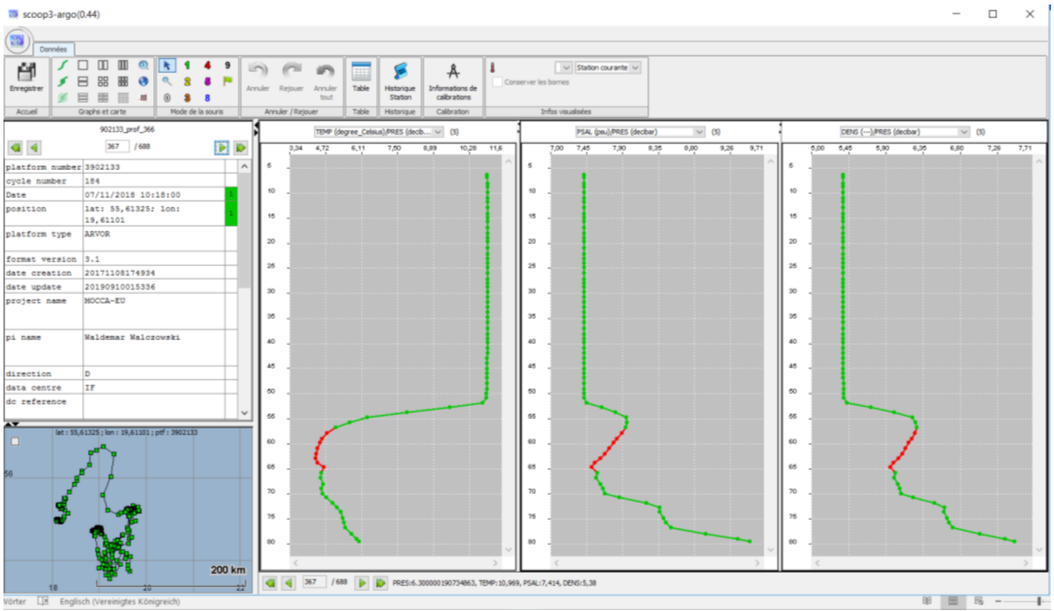

Figure 8: Example of an extended unstable density range. Shown is cycle 184D from float 3902133.

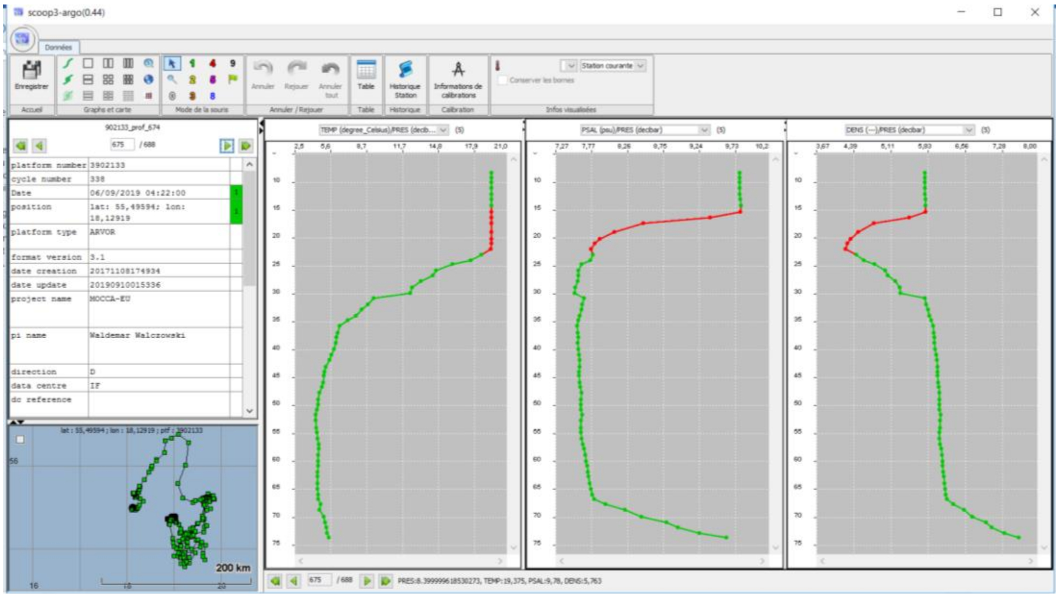

Figure 9: Example of a partially flagged density instability in combination with large surface salinities. Shown is cycle 338D from float 3902133.

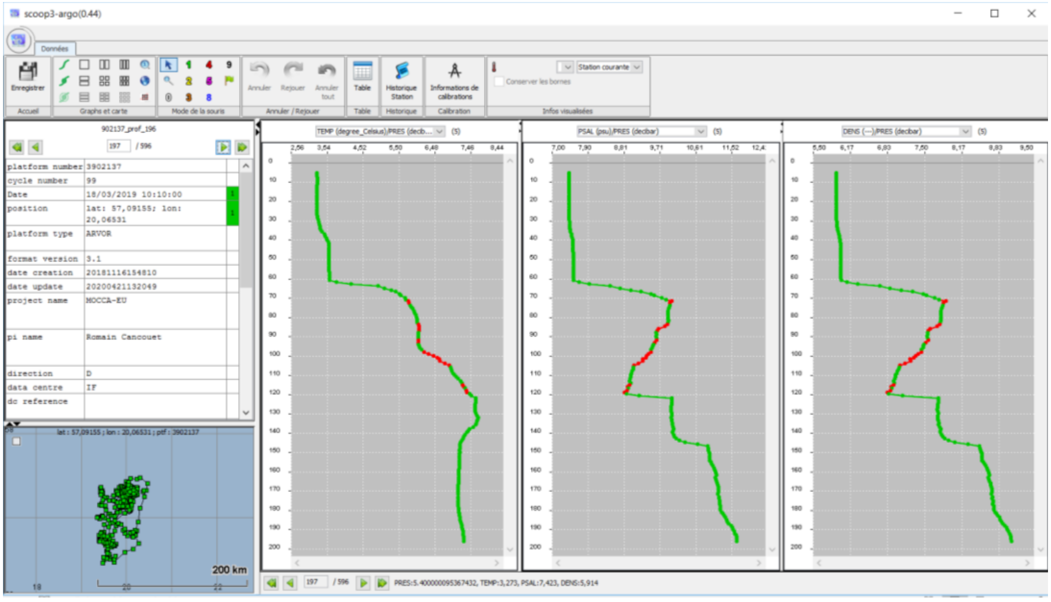

Figure 10: Example of intermittently flagged density instability. Shown is cycle 99D from float 3902137.

The remaining unidentified errors in the data (false negatives) were looked at by running the SCOOP software on all 6689 profiles delivered from the 32 floats. This software is commonly used by real-time and delayed-mode operators to visually inspect the float data and manually change flags, since some pathologies in the float are impossible to catch by automated procedures. Here we have used the tool to look for suspicious patterns in the vertical profile which might be flagged automatically with adapted or new tests. But it has to be kept in mind that data quality in the Baltic is really good and so far, less than 1% of the data have been flagged in real-time. A manual visualisation of the profiles might be a feasible approach to treat this. It mainly concerns some spikiness in temperature data and high surface salinities, which might be caught by a regional range test.

Fig. 11 shows an example of the interlayering in temperature below the mixed layer. It does not lead to unstable density stratification and has not exceed gradient thresholds. The local experts probably have to determine visually if such behaviour needs corrections or it needs to be investigated if adjustments to the gradient test can do that automatically. It might need area specific tests since some areas in the Baltic are more highly variable than others. Specifically, the sill areas showing such dynamics and even density inversions and differ from the quieter deeper basins.

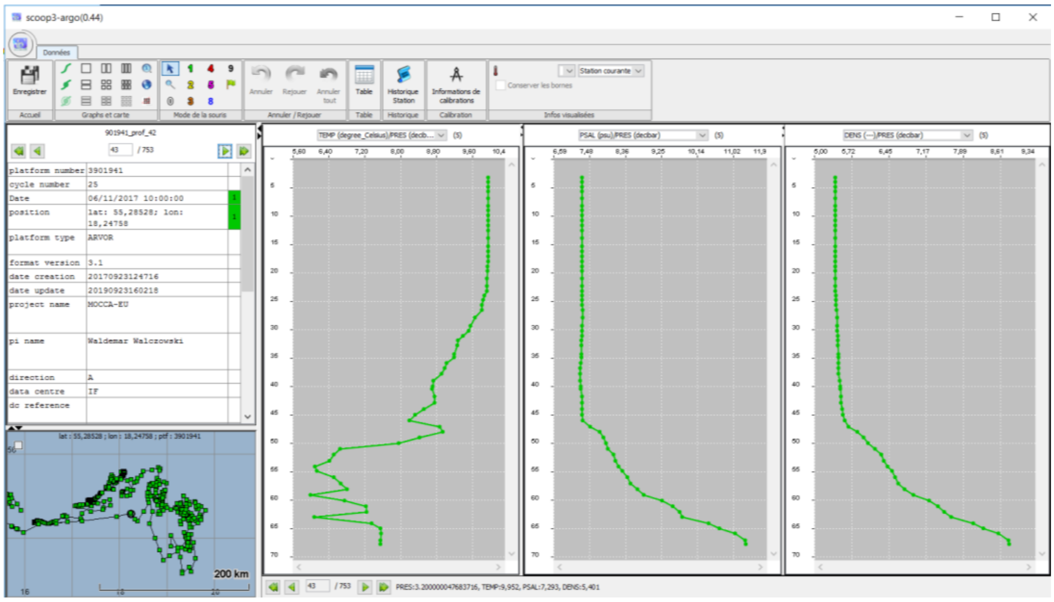

Figure 11: Example of a spiky temperature profile. Shown is cycle 25A from float 3901941.

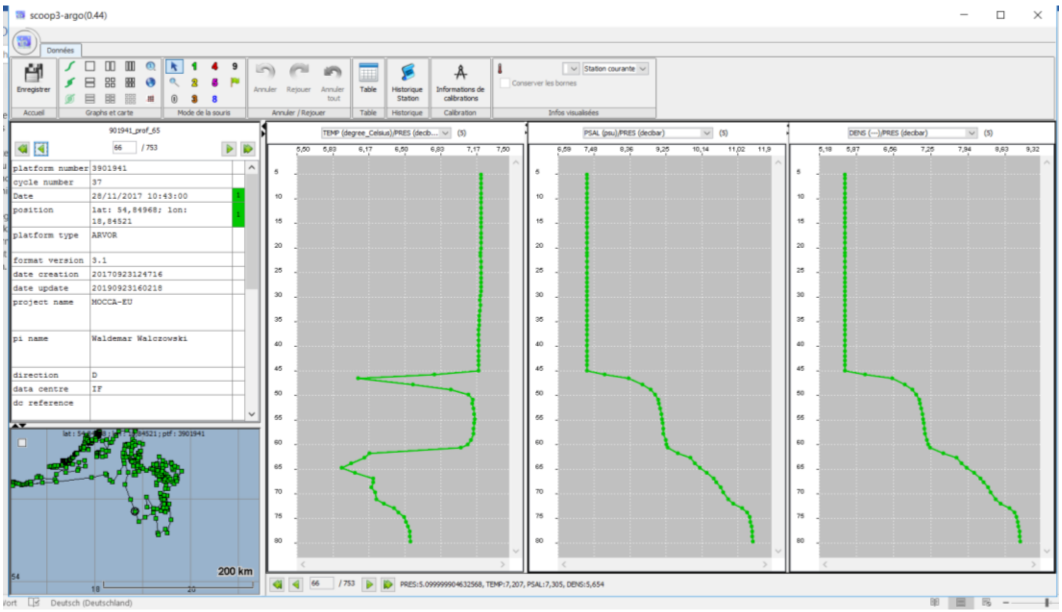

Figure 12: Example of a spiky temperature profile. Shown is cycle 37D from float 3901941.

The example shown in fig. 12 is similar to fig. 11 but more singular and pronounced.

The last example in this section (Fig. 13) concerns some faulty salinity measurements which show up with high surface salinities. In this example from the northern Baltic surface salinities as high as 9.24 psu are reported by the float and have passed the real-time tests with a qc of '1'. These are quite unreasonable salinities for the fresh mixed layers in the area and could be flagged by a regional range test in the surface layer which sets the threshold to ~ 7.5 psu. The appropriate values have to be determined yet and it has also to be tested if these work for the entire Baltic. Most likely reason for these errors is the clogging of the sensor (Fig. 14), which causes the deeper water values show on the surface. In some instances, it has been observed that the sensor clears before reaching the surface, causing faulty values in the mid-profile, but no detectable errors in surface values. Detection of such errors will require further considerations on appropriate automatic tests.

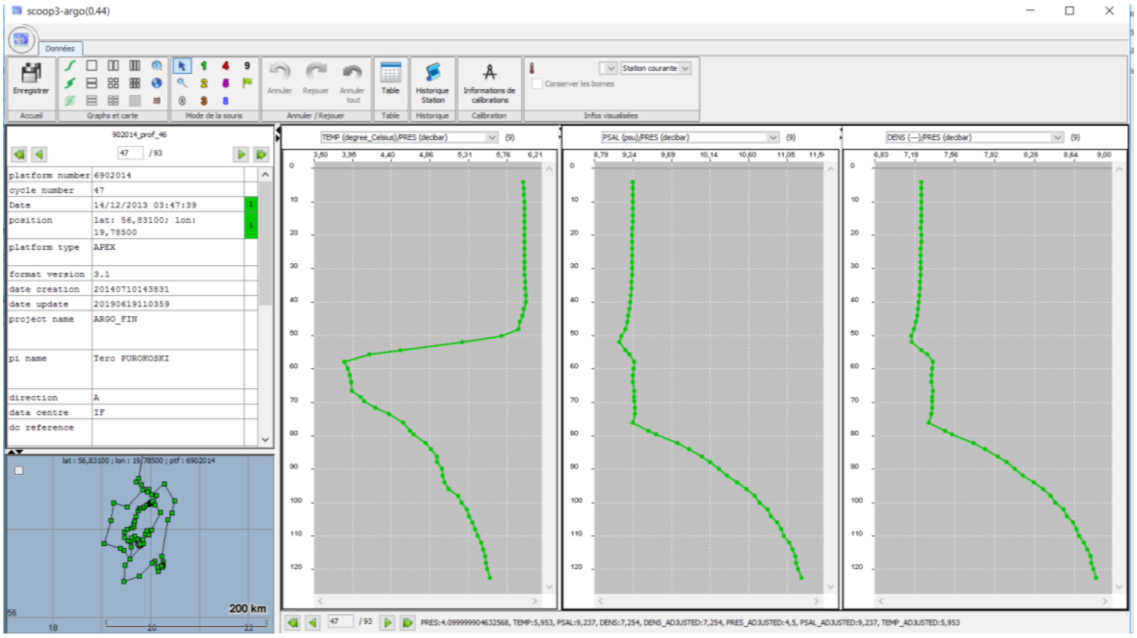

Figure 13: Example of suspiciously high surface salinities in float 6902014 cycle 47A.

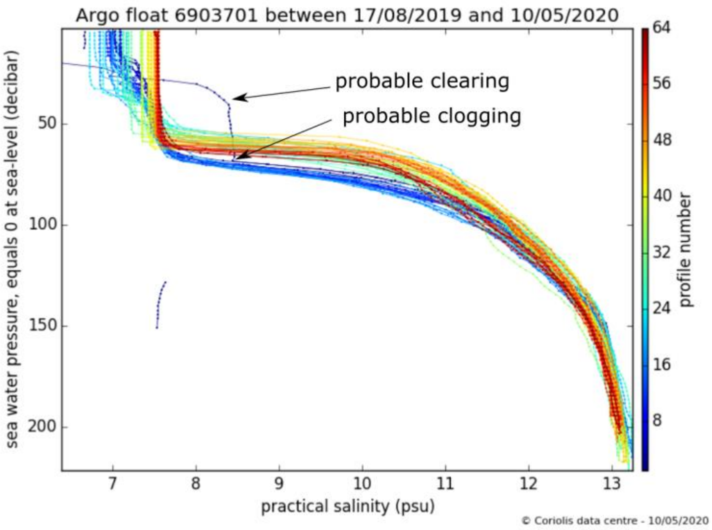

Figure 14 : Example of a probable error caused by sensors clogging and clearing during the profile. For comparison other profiles from the same float (6903701) are indicated.

2.2. Reference data base in the Baltic

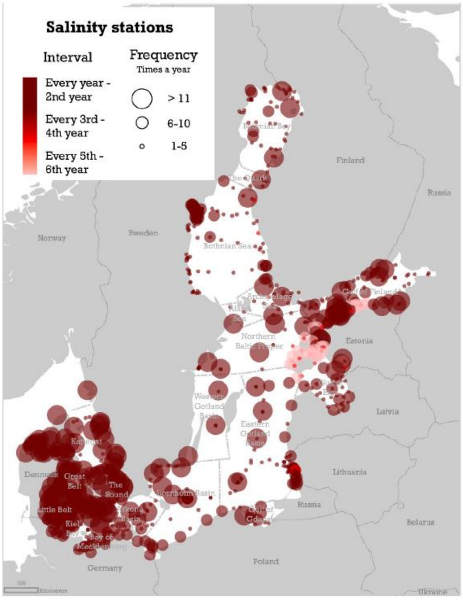

Figure 15: Coverage of salinity measurements in the Baltic within the HELCOM monitoring plan. The size of the circles indicates the measurement frequency within a year and the color the repletion interval (source Helcom MORE report, 2013).

The environmental conditions of the Baltic Sea are monitored in international cooperation under the Baltic Sea Environment Protection Commissions Helsinki Commission (HELCOM) monitoring programs since 1979 (HELCOM, 2017). All the coastal countries of the Baltic Sea are members of HELCOM and provide data to the HELCOM data base, which is freely available at International Council for the Exploration of the Sea ICES (*www.ices.dk*). A total of almost 800 stations are regularly monitored and provide reference data for salinity. Observation station BY15 in the Gotland Deep (57.32N 20.05 E) is one of the most visited monitoring stations in the Baltic Sea Proper, and it is a benchmark of the state of the Baltic Sea.

Therefore, files from this data base are readily available to establish the reference data set for Argo. They will be converted into the regular Argo reference data set format and can then be used in the OWC software. Additional visual inspection of the CTD data will be performed in the Euro-Argo RISE project.

2.3. DMQC workflow for recovered floats

In case that the float is recovered and returned to Sea-Bird potential drift of the floats conductivity sensor can be directly looked at from the calibration sheets provided by Sea-Bird. But there is one caveat, SBE states that the drift given is at 3.0 S/m and most of the conductivity values in the Baltic are below 1.0 S/m. The selected calibration range of Sea-Bird reflects the case that most of the customers operate in higher salinities and using calibration baths with lower conductivity would require extra baths and using different IAPSO seawater salinity standards thus making the process more complex, expensive and time consuming. However, based on the experience of the monitoring groups in the Baltic with their shipboard CTDs the achieved accuracy has always been very good, no matter how low the actual sea water conductivity values have been.

The conductivity drift is being assumed to be linear and therefore the drift line is interpolated to 0 at 0 S/m. As can be seen on Figs. 15 and 16 the conductivity drift is larger at higher conductivity values the drift given at 3.0 S/m is greater than drift at 1.5 S/m, which is about the highest conductivity value encountered in Baltic floats. So, these drift rates should be considered as an upper bound and true drift rates are considered to quite a lot smaller than the drift/month in salinity at 3.0 S/m given by post cruise calibration of the SBE.

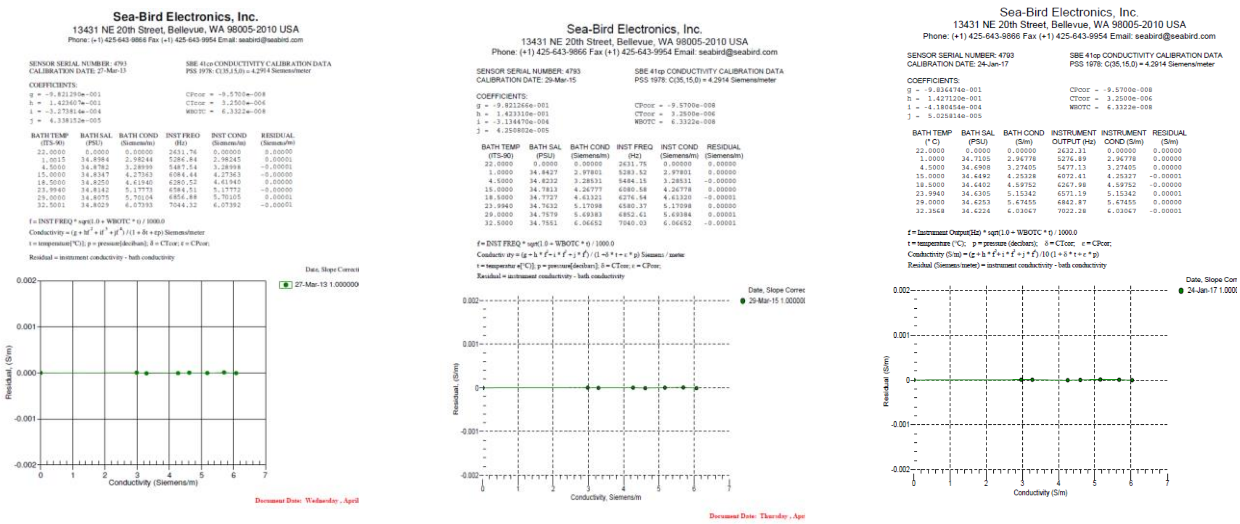

Figure 16: Calibration sheets for SBE SN 4793, used on floats 6902014 (deployed 2013), 6902020 (deployed 2015) and 6902027 (deployed in 2017).

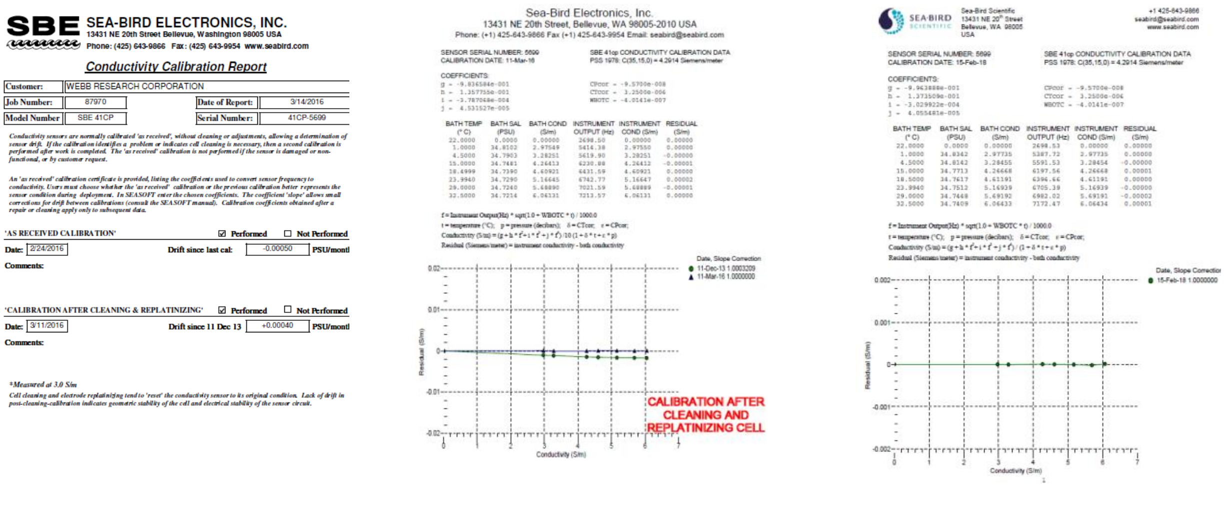

Figure 17: Calibration sheets for SBE SN 5699, used on floats 6902016 (deployed 2014), 6902024 (deployed 2016) and 6903697 (deployed in 2018). The left panel gives one of the original SBE reports with drift calculation which is no longer provided. The middle panel relates to the first recalibration and shows pre- and post-slopes in conductivity. The right panel is showing last recalibration in March 2018.

The DMQC operator in the Baltic needs access to the calibration coefficients, which should at best be part of the regular Argo Data Stream and should have been included in the META information for the floats. It could be discussed if the original calibration sheets should be stored at a central accessible directory within the Argo data management stream to allow for checks of coefficients entered in the meta files or additional information on the sheets. Please note that on Fig. 15 the original calibration is not shown, but only the change from the first to the second calibration with a computation of the drift rate by Sea-Bird. The listed value of +0.0004 per month since December 2013 would result only in a salinity change of <0.005 during the one-year measurement period from 2014-2015 (see Tab.1) and this is within the expected accuracy for the global Argo fleet. This threshold could be defined at an even larger value for the higher range of salinity variability in the Baltic. It needs to be defined for the DM-operators to make a decision if to correct or not.

In order to get the slope for the drift, which now that Sea-Bird no longer directly provides it, one needs to follow instructions provided in their application note 31: "Correcting for Conductivity Drift Based on Pre- and Post-Cruise Laboratory Calibrations" (see Appendix 1). It recommends use of the SeaSoft Software to determine the drift:

To correct conductivity data taken between pre- and post-cruise calibrations:

islope = 1.0 + (b / n) [(1 / postslope) - 1.0]

where

islope = interpolated slope; this is the value to enter in the configuration (.con or .xmlcon) file
b = number of days between pre-cruise calibration and the cast to be corrected
n = number of days between pre- and post-cruise calibrations
postslope = slope from calibration sheet as calculated above (see *Appendix I: Example Conductivity Calibration Sheet*)

In the configuration (.con or .xmlcon) file, use the **pre-cruise calibration coefficients** and use **islope** for the value of slope.*

Figure 18: snapshot from Sea-Bird Appnote 31 on how to correct drift between pre- and post-cruise calibrations.

So far, the monitoring program with Argo Floats in Finland has shown no need for major data corrections after the recalibrations (see for example Fig. 16) and is less the 0.01 threshold set as Argo goal for salinity accuracy. A routine to calculate the drift between corrections from the Sea-Bird calibrations sheets need to be created in matlab to integrate this step into the regular DM-work. The SCIENTIFIC_CALIB fields that need to be filled need appropriate text to indicate this source of information. Error estimates for the salinity corrections need to be determined as well. In the global oceans these errors are determined from the mapping errors in the reference data selection and are at minimum set to 0.01.

2.4. DMQC workflow for floats without recalibration

In case that the floats have not been recovered, their data quality has to be determined by comparison to existing reference data from the HELCOM reference data base. Similar procedures than used in the OWC program should be carried out and suitable reference data within a search radius should be selected for comparison. Some of these floats have stayed with one sub-basin and make selection of reference data easier. Other floats such as MOCCA float 3902134 have sampled a larger area (Fig. 18) and therefore show a wide range of salinities in both the mixed layer and at depth (Fig.19). With a Salinity range of >1.5 psu at surface and still ~1 psu a depth, the more subtle long-term drift in a fouling conductivity cell will be a challenge to detect, but the short missions periods of 1-2 years compared to 4 years and more in the open ocean should limit the drift signal.

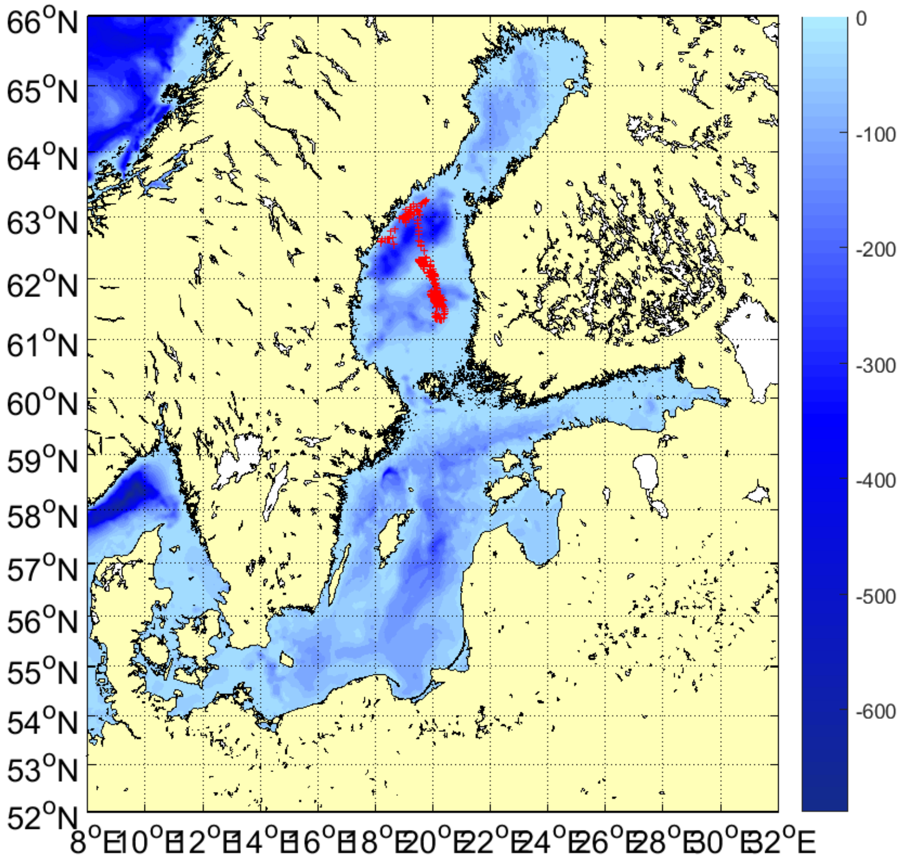

Figure 19: Drift track of MOCCA float 3902134.

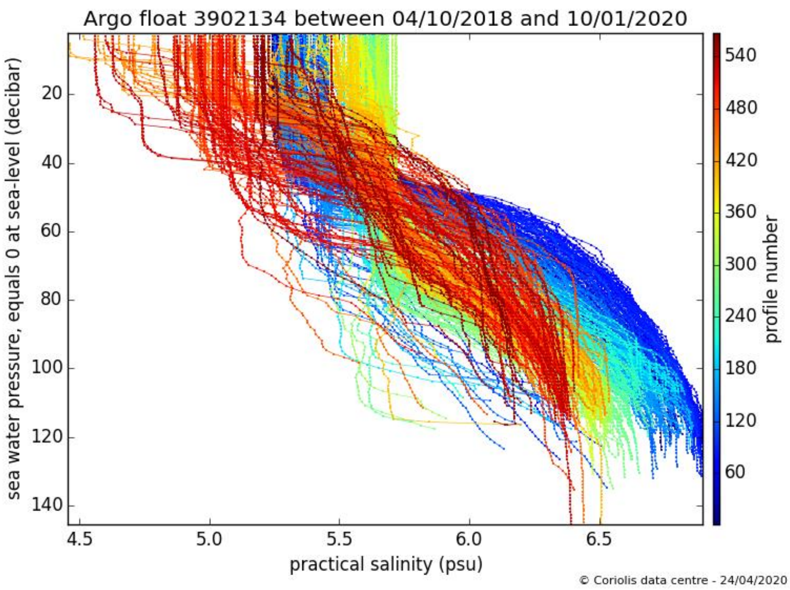

Figure 20: Vertical profiles of salinity from MOCCA float 3902134. The color code on the salinity profiles indicates the profile number. The float has measured cycles in ascending and descending mode.

3. SUMMARY

Argo floats have demonstrated great value in monitoring and for research of the Baltic, as they give regular and frequent data around the year, regardless of weather conditions. Operating the floats has matured to a level where monitoring of the Baltic Sea is an operative reality.

The majority of the data transmitted by the floats is of high quality and only less than 1% of the data is flagged with the regular real-timed procedures. However, some false positive and negative alarms have been identified and suggestions are made what changes to the real-time system are needed. Additional tests which need to be constructed and tested have been named and this work will be carried out in WP2 in Euro-Argo RISE.

The delayed mode quality control of the floats can rely on an excellent reference data set, which is routinely collected and updated in the HELCOM process. It is a current practise to recover floats in the Baltic and that provides laboratory-based drift determination. The calculation of the drift and appropriate thresholds for corrections have to be incorporated into the Argo data stream. This will be achieved in WP2 of Euro-Argo RISE. For floats without recovery cross checks to the reference data and min/max bounds will also be devised in the Euro-Argo RISE.