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Implementation of Argo Real Time Quality Controls by Coriolis

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Implementation of Argo Real Time Quality Controls by Coriolis

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History

Date (dd/mmm/yyyy)	Comment
09/Feb/2016	Creation of the document by Cecile, Jean-Philippe
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17/May/2019	Modification of pressure threshold determination for test #19

Reference Documents

Reference N°	Title	Link
#RD1	Argo Quality Control Manual for CTD and Trajectory Data	http://dx.doi.org/10.13155/33951
#RD2	Argo quality control manual for biogeochemical data	http://dx.doi.org/10.13155/40879
#RD3	Argo quality control manual for Dissolved Oxygen Concentration	http://dx.doi.org/10.13155/46542
#RD4	BGC Argo quality control manual for particles backscattering	TBD
#RD5	Bio-Argo quality control manual for Chlorophyll-A concentration	http://dx.doi.org/10.13155/35385
#RD6	BGC-Argo quality control manual for nitrate concentration	TBD

1. Introduction

This document describes how the Real Time Quality Control (RTQC) tests are implemented at the Coriolis data Centre.

These tests are defined in the Argo quality control manuals (#RD1 and #RD2). The present document provides a detailed description of their implementation in the Matlab processing chain that produces Argo V3.1 format NetCDF files.

This document describes the tests implemented in **profile RTQC version 4.1** and **trajectory RTQC version 2.5** of the Coriolis **Matlab decoder version '029a'** (http://doi.org/10.17882/45589).

The implemented tests are defined for the following parameters:

- PRES ,
- TEMP,
- PSAL,
- CNDC,
- DOXY,
- TEMP_DOXY,
- CHLA,
- BBP700,
- BBP532,
- PH_IN_SITU_TOTAL,
- NITRATE.

2. Implementation of Argo Real-time Quality Control test procedures on vertical profiles

2.1. Description of implemented tests

2.1.1. Test #1: Platform identification test

The Coriolis Matlab decoder cannot process a float without its WMO and associated PTT. Thus, nothing has been implemented for this test (it is always reported as successfully passed).

2.1.2. Test #2: Impossible date test

At Coriolis the JULD value is checked to be later than January 1st 1997 (JULD ≥ 17167) and earlier than the date of the check (in UTC time).

The JULD_LOCATION is also checked with the same criteria and contributes (with test #3, #4 and #5) to the final value of POSITION_QC.

2.1.3. Test #3: Impossible location test

At Coriolis the checked interval is [-90, 90] for latitudes and [-180, 180] for longitudes.

2.1.4. Test #4: Position on land test

At Coriolis we use the ETOPO2 file (ETOPO2v2g_i2_MSB.bin version).

The detailed description of the test is the following: For a given position, the elevations are retrieved from the bathymetry file (1, 2 or 4 elevations depending on the position location on the ETOPO2 grid). The test fails if the average value of the retrieved elevations is ≥ 0.

2.1.5. Test #5: Impossible speed test

At Coriolis, the profile position is defined according to DAC cookbook specifications (§2.2.2 of http://dx.doi.org/10.13155/29824), thus from a trajectory already checked by the JAMSTEC QC test. Consequently, this test is obsolete for Coriolis Argos floats and should be considered for Iridium floats only.

2.1.6. Test #6: Global range test

At Coriolis the checked intervals are:

- PRES ≥ -5 dbars,
- TEMP in the interval [-2.5, 40] °C,
- PSAL in the interval [2, 41] PSU,
- DOXY in the interval [−5, 600] micromoles/kg,
- TEMP_DOXY in the interval [-2.5, 40] °C,
- CHLA in the interval [−0.1, 50] mg/m^3,
- BBP700 in the interval [−0.000025, 0.1] m^{-1},
- BBP532 in the interval [−0.000005, 0.1] m^{-1},
- PH_IN_SITU_TOTAL in the interval [7.3, 8.5],
- NITRATE in the interval [-2, 50] micromoles/kg.

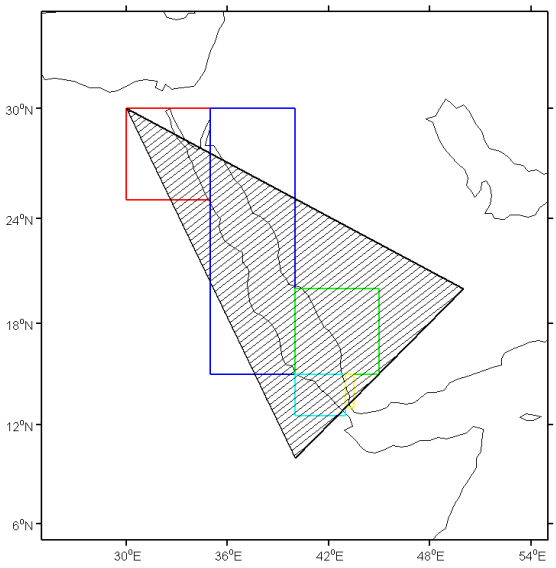
Values that fail this test are flagged ‘4’ except for BBP700 and BBP532 which are flagged ‘3’.

2.1.7. Test #7: Regional range test

At Coriolis the regions are defined by rectangular areas.

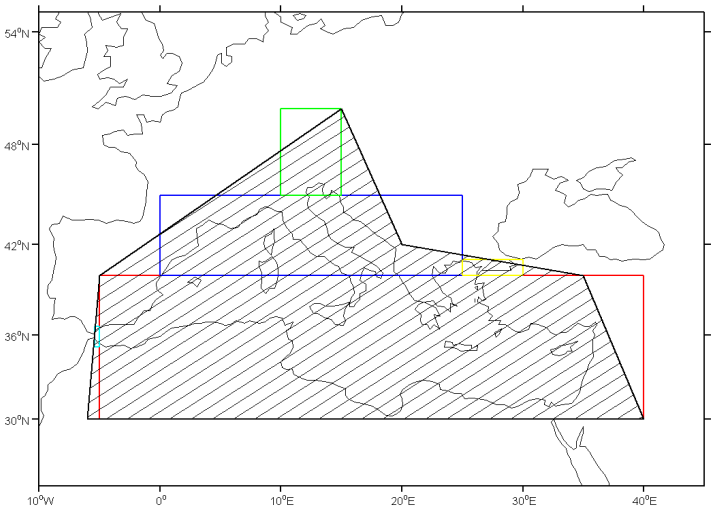
For the Red Sea Region, 5 rectangular areas:

- 30N, 30E ; 25N, 35E,
- 30N, 35E ; 15N, 40E,
- 20N, 40E ; 15N, 45E,
- 15N, 40E ; 12.55N, 43E,
- 15N, 43E ; 13N, 43.5E.



For the Mediterranean Sea region, 5 rectangular areas:

- 40N, 5W ; 30N, 40E,
- 45N, 0; 40N, 25E,
- 50N, 10E; 45N, 15E,
- 41N, 25E; 40N, 30E,
- 36.6N, 5.4W; 35.2N, 5W.



The borders are considered as part of the region.

The checked intervals are:

- TEMP and TEMP_DOXY in the interval [21.7, 40] °C in the Red Sea and [10, 40] °C in the Mediterranean Sea,
- PSAL in the interval [2, 41] PSU in the Red Sea and [2, 40] PSU in the Mediterranean Sea.

2.1.8. Test #8: Pressure increasing test

Some BGC floats have the ability to transmit 'raw' sampled data, i.e. direct sensor output without any averaging or decimation of the measurements. Some parts of these 'raw' sampled profiles will probably be flagged as bad by this test (at the beginning and end parts of the profile).

As shown in the table below, the flagged data depend on the implementation (if we start the check from shallow values, from deep values or from the middle of the profile).

PRES	QC (start shallow)	QC (start deep)	QC (start middle)
0	1	1	1
1	1	4	4
2	1	4	4
1	4	1	1
2	4	4	4
3	1	4	4
4	1	4	4
3	4	4	4
2	4	1	1
3	4	4	4
3	4	1	1
4	4	1	1
5	1	1	1
6	1	4	4
7	1	4	4
8	1	4	4
9	1	4	4
10	1	4	4
9	4	4	4
8	4	4	4
7	4	4	4
6	4	1	1
7	4	1	1
8	4	1	1
9	4	1	1
10	4	1	1

11	1	1	1
12	1	1	1
13	1	1	1
14	1	1	1
15	1	1	1
…	…	…	…
1995	1	1	1
1996	1	1	1
1997	1	4	1
1998	1	4	1
1999	1	4	1
2000	1	4	1
2001	1	4	1
2002	1	4	1
2002	4	4	4
2001	4	4	4
2000	4	4	4
2000	4	4	4
1999	4	4	4
1998	4	4	4
1997	4	1	4

At Coriolis:

- For near-surface profiles, we start from the deepest measurement of the profile and check increasing pressures,
- For other profiles, we start from the middle of the profile and check increasing pressures to deep measurements and decreasing pressures to shallow measurements.

2.1.9. Test #9: Spike test

This test is implemented for TEMP, PSAL, DOXY, DOXY, TEMP_DOXY, CHLA, PH_IN_SITU_TOTAL and NITRATE according to Argo quality control manuals (#RD1 and #RD2).

It is not implemented yet for BBP700 and BBP532 (Catherine SCHMECHTIG's decision).

2.1.10. Test #10: Top and bottom spike test: obsolete

2.1.11. Test #11: Gradient test

This test is implemented for TEMP, PSAL, DOXY and TEMP_DOXY according to Argo quality control manuals (#RD1 and #RD2).

2.1.12. Test #12: Digit rollover test

The test provides thresholds to detect a jump between two adjacent measurements of a parameter. It then specifies that the values that failed the test should be flagged as bad data. However, when a jump is detected, we cannot be sure in real time which part of the profile has rollover values

At Coriolis, when a jump is detected in a measured parameter (with the specified criteria) the 'jumped values' are flagged '4' and all the remaining values of the profile for this parameter are flagged '3'.

This test is implemented for TEMP, PSAL and TEMP_DOXY.

2.1.13. Test #13: Stuck value test

This test is implemented for TEMP, PSAL and TEMP_DOXY according to Argo quality control manuals (#RD1 and #RD2).

2.1.14. Test #14: Density inversion

This test has been implemented thanks to Cécile Cabanes's additional Matlab implementation example provided in Annex A of the present document.

2.1.15. Test #15: Grey list test

This test is implemented according to Argo quality control manuals (#RD1 and #RD2).

2.1.16. Test #16: Gross salinity or temperature sensor drift

In the Coriolis implementation of this test we search the previous good profile within the multi-profile file (thus from primary sampled profiles only) and within the profiles of the same direction as the checked profile.

This test is implemented for TEMP, PSAL and TEMP_DOXY.

However, this test is designed for floats that always profile from the same pressure and not for:

- Argos floats with multi-mission,
- Iridium floats with a mission that can be modified at sea.

Consequently, we finally decided to not apply this test in Coriolis RTQC.

2.1.17. Test #17: Visual QC

This test is performed by Coriolis operators.

2.1.18. Test #18: Frozen profile test

This test is implemented for TEMP, PSAL and TEMP_DOXY.

However, this test is designed for floats with constant cycle duration of ~10 days and not for:

- Argos float versions with different programmed cycle durations,
- Iridium floats with a mission that can be modified at sea.

Consequently, we finally decided to not apply this test in Coriolis RTQC.

2.1.19. Test #19: Deepest pressure test

Remember that this test will flag '4' the measurements sampled deeper than a pressure threshold (when PRES > PRESSURE_THRESHOLD).

In #RD1, it is specified that PRESSURE_THRESHOLD should be "CONFIG_ProfilePressure_dbar plus 10%". However, since floats usually have difficulties to precisely stabilize at shallow profile pressure depths, this PRESSURE_THIRESHOLD is not suitable for shallow profile pressure configuration values.

Consequently, at Coriolis, we decided to use the specified fixed coefficient of 10% only when CONFIG_ProfilePressure_dbar is greatest than 1000 dbar and to use a variable coefficient for shallow CONFIG_ProfilePressure_dbar values.

This coefficient is linearly determined so that its value is 10% when CONFIG_ProfilePressure_dbar = 1000 dbar and 150% when CONFIG_ProfilePressure_dbar = 10 dbar.

The following table provides corresponding PRESSURE_THRESHOLD values.

CONFIG_ProfilePressure_dbar	Coefficient (%)	PRESSURE_THRESHOLD
10	150.00	25.00
20	148.59	49.72
30	147.17	74.15
40	145.76	98.30
50	144.34	122.17
60	142.93	145.76
70	141.52	169.06
80	140.10	192.08
90	138.69	214.82
100	137.27	237.27
150	130.20	345.30
200	123.13	446.26
250	116.06	540.15
300	108.99	626.97
350	101.92	706.72
400	94.85	779.39
450	87.78	845.00
500	80.71	903.54
550	73.64	955.00
600	66.57	999.39
650	59.49	1036.72
700	52.42	1066.97
750	45.35	1090.15
800	38.28	1106.26
850	31.21	1115.30
900	24.14	1117.27

950	17.07	1112.17
1000	10.00	1100.00

When PRES ≤ PRESSURE_THRESHOLD, this test will flag all profile parameters as good data. This is not acceptable for parameters that have no RTQC test already defined.

Consequently, at Coriolis, we decide to apply this test to parameters that already have at least one (other) RTQC test defined; their associated 'intermediate' parameters are also flagged according to Argo quality control manuals (#RD1 and #RD2).

2.1.20. Test #57: DOXY specific test

These tests are implemented according to the dedicated Argo quality control manual (#RD3).

2.1.21. Test #58: CDOM specific test

No test specific to CDOM parameter is implemented yet.

2.1.22. Test #59: NITRATE specific test

These tests are implemented according to the dedicated Argo quality control manual (#RD6).

2.1.23. Test #60: PAR specific test

No test specific to PAR parameter is implemented yet.

2.1.24. Test #61: IRRADIANCE specific test

No test specific to IRRADIANCE parameter is implemented yet.

2.1.25. Test #62: BBP specific test

No test specific to BBP parameter is implemented yet.

The "bad offset test" will be implemented as soon as the dedicated Argo quality control manual (#RD4) is available.

2.1.26. Test #63: CHLA specific test

These tests are implemented according to the dedicated Argo quality control manual (#RD5).

2.2. Tests application order on vertical profiles

At Coriolis, Argo real-time QC tests on vertical profiles are applied in the order described in the following table.

Order	Test number	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	11	Gradient test
12	12	Digit rollover test
13	13	Stuck value test
14	14	Density inversion test
15	15	Grey list test
not used	16	Gross salinity or temperature sensor drift test
not used	18	Frozen profile test
16	23	Real-time Quality Control flag scheme for float data deeper than 2000 dbar
-	24 to 56	Not used
17	57	DOXY specific test
not defined yet	58	CDOM specific test
18	59	NITRATE specific test
not defined yet	60	PAR specific test
not defined yet	61	IRRADIANCE specific test
19	62	BBP specific tests
20	63	CHLA specific tests

3. Implementation of Argo Real-time Quality Control test procedures on near-surface data of vertical profiles

3.1. Description of implemented tests

All tests, listed in § 2.1 are implemented and applied on near-surface data of vertical profiles. Note that for "Test #8: Pressure increasing test", the starting point is the deepest measurement and the check is performed on increasing pressures.

Two additional specific tests have been implemented for near-surface data of vertical profiles.

3.1.1. Test #21: Near-surface unpumped CTD salinity test

This test is implemented for PSAL and DOXY according to Argo quality control manuals (#RD1 and #RD2).

3.1.2. Test #22: Near-surface mixed air/water test

This test is implemented for TEMP and TEMP_DOXY according to Argo quality control manuals (#RD1 and #RD2).

3.2. Tests application order on near-surface data of vertical profiles

At Coriolis, Argo real-time QC tests on near-surface data of vertical profiles are applied in the order described in the following table.

Order	Test number	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	21	Near-surface unpumped CTD salinity test
8	22	Near-surface mixed air/water test
9	6	Global range test
10	7	Regional range test
11	8	Pressure increasing test
12	9	Spike test
13	11	Gradient test
14	12	Digit rollover test
not used	13	Stuck value test
not used	14	Density inversion test
15	15	Grey list test
not used	16	Gross salinity or temperature sensor drift test
not used	18	Frozen profile test
not used	23	Real-time Quality Control flag scheme for float data deeper than 2000 dbar
-	24 to 56	Not used
16	57	DOXY specific test
not defined yet	58	CDOM specific test
17	59	NITRATE specific test
not defined yet	60	PAR specific test
not defined yet	61	IRRADIANCE specific test

18	62	BBP specific tests
19	63	CHLA specific tests

4. Implementation of Argo Real-time Quality Control test procedures on trajectories

4.1. Description of implemented tests

4.1.1. Test #1: Platform identification test

See § 2.1.1.

4.1.2. Test #2: Impossible date test

At Coriolis the JULD value is checked to be later than January 1st 1997 (JULD ≥ 17167) and earlier than the date of the check (in UTC time).

4.1.3. Test #3: Impossible location test

See §2.1.3.

4.1.4. Test #4: Position on land test

See §2.1.4.

4.1.5. Test #5: Impossible speed test

This test is not implemented at Coriolis; it has been replaced by test #20: Questionable Argos position test.

4.1.6. Test #6: Global range test

See §2.1.6.

4.1.7. Test #7: Regional range test

See §2.1.7.

4.1.8. Test #15: Grey list test

This test is implemented according to Argo quality control manuals (#RD1 and #RD2).

4.1.9. Test #20: Questionable Argos position test

This test has been implemented according to Annex H of http://dx.doi.org/10.13155/29824.

4.1.10. Test #57: DOXY specific test

These tests are implemented according to the dedicated Argo quality control manual (#RD3).

4.1.11. Test #58: CDOM specific test

No test specific to CDOM parameter is implemented yet.

4.1.12. Test #59: NITRATE specific test

The specified test is relevant for vertical profiles only.

4.1.13. Test #60: PAR specific test

No test specific to PAR parameter is implemented yet.

4.1.14. Test #61: IRRADIANCE specific test

No test specific to IRRADIANCE parameter is implemented yet.

4.1.15. Test #62: BBP specific test

See §2.1.25.

4.1.16. Test #63: CHLA specific test

The specified test is relevant for vertical profiles only.

4.2. Tests application order on trajectories

At Coriolis, Argo real-time QC tests on trajectories are applied in the order described in the following table.

Order	Test number	Test name
1	1	Platform identification
2	2	Impossible date test
3	3	Impossible location test
4	4	Position on land test
5	20	Questionable Argos position test
6	6	Global range test
7	7	Regional range test
8	15	Grey list test
9	57	DOXY specific test
not defined yet	58	CDOM specific test
no relevant for trajectories	59	NITRATE specific test
not defined yet	60	PAR specific test
not defined yet	61	IRRADIANCE specific test
10	62	BBP specific tests
no relevant for trajectories	63	CHLA specific tests

4.3. Profile measurements reported in trajectories

The following profile measurements are duplicated in the trajectories:

- The deepest measurement of the descending and ascending profiles (duplicated and stored with MC 203 and MC 503 respectively),
- The measurements of the dated levels of the profiles (duplicated, with their JULD, and stored with MC 190 (for descending profiles) or MC 590 (for ascending profiles).

These profile measurements are duplicated with their QCs set by RTQC tests on vertical profiles.

5. Implementation of Argo Real-time Quality Control test procedures on in-air data of trajectories

Some Coriolis floats are able to sample in-air measurements which are stored in the trajectories with MC 1090.

5.1. Description of implemented tests

All tests, listed in § 4.1 are implemented and applied on in-air data of trajectories.

Two additional specific tests have been implemented for in-air data of trajectories.

5.1.1. Test #21: Near-surface unpumped CTD salinity test

See §3.1.1.

5.1.2. Test #22: Near-surface mixed air/water test

See §3.1.2.

5.2. Tests application order on in-air data of trajectories

At Coriolis, Argo real-time QC tests on in-air data of trajectories are applied in the order described in the following table.

Order	Test number	Test name
1	1	Platform identification
2	2	Impossible date test
3	3	Impossible location test
4	4	Position on land test
5	20	Questionable Argos position test
6	6	Global range test
7	7	Regional range test
8	15	Grey list test
9	21	Near-surface unpumped CTD salinity test
10	22	Near-surface mixed air/water test
11	57	DOXY specific test
not defined yet	58	CDOM specific test
not defined yet	59	NITRATE specific test
not defined yet	60	PAR specific test
not defined yet	61	IRRADIANCE specific test
12	62	BBP specific tests
no relevant for trajectories	63	CHLA specific tests

6. Passed/failed test traceability

Passed and failed test number lists are reported in the profile and trajectory files through the HISTORY_QCTEST variable.

At Coriolis:

- Tests # 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 19, 20, 21, 22 and 23 are reported in the C files (i.e. tests # 57, 59, 62 and 63 are not),
- Tests # 1, 2, 3, 4, 5, 6, 7, 9, 11, 12, 13, 15, 19, 20, 21, 22, 23, 57, 59, 62 and 63 are reported in the B files (i.e. tests # 8 and 14 are not).

7. Annex A: Example of Matlab implementation of the density inversion test

```
% [delta_upbot,delta_botup,is_inv_dens] = test_density14(P,T,S,threshold)
% INPUT:
% P(1,nlevel) pression (dB)
% T(1,nlevel) T in situ (°C)
% S(1,nlevel) S in situ (PSU)
% treshold : treshold used for detecting density inversion (0.03kg/m3)
% OUTPUT:
% delta_upbot (1,nlevel) : top to bottom test :  if delta_upbot >= 0.03kg/m3 flag 4 of the
level i
% delta_botup (1,nlevel) : bottom to top test:  if delta_botup <= -0.03kg/m3 flag of the level
i
% is_inv_dens (1,nlevel) : is_inv_dens=1 if level i should be flagued as bad (flag 4) ; ==0
otherwise

% You will need The ITS-90 version of the CSIRO SEAWATER library, which you can obtain from
% http://www.cmar.csiro.au/datacentre/ext_docs/seawater.htm.  Version 3.3   22-Sep-2010
%

function [delta_upbot,delta_botup,is_inv_dens] = test_density14(P,T,S,treshold)

if size(P,1)> 1
P=P';
end
if size(T,1)> 1
T=T';
end
if size(S,1)> 1
S=S';
end


%%
% From top to bottom :  two consecutive levels, i and i+1, are checked (Pi < Pi+1 )
%%
Pref = (P(1:end-1)+P(2:end))/2;


% rho_i(Pi, Ti, Si, Pref): potential density referenced to the mid-point Pref

rhop_i = sw_pden(S(1:end-1),T(1:end-1),P(1:end-1),Pref);

% rho_ip1(Pi+1, Ti+1, Si+1, Pref): potential density referenced to the mid-point Pref

rhop_ip1 = sw_pden(S(2:end),T(2:end),P(2:end),Pref);

delta_upbot = [rhop_i-rhop_ip1, NaN];


%%
% From bottom to top:  two consecutive levels, i and i+1, are checked (Pi > Pi+1 )
%%
Pref = (P(2:end)+P(1:end-1))/2;


% rho_i(Pi, Ti, Si, Pref): potential density referenced to the mid-point Pref

rhop_i = sw_pden(S(2:end),T(2:end),P(2:end),Pref);

% rho_ip1(Pi+1, Ti+1, Si+1, Pref): potential density referenced to the mid-point Pref

rhop_ip1 = sw_pden(S(1:end-1),T(1:end-1),P(1:end-1),Pref);

delta_botup = [NaN, rhop_i-rhop_ip1];


% test if there is density inversion with the 0.03kgm-3 criterion

is_inv_dens = delta_upbot>=treshold | delta_botup<=-treshold;
```