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C-RAID Drifter Quality Control Manual

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RTQC tests definition
and
DMQC procedure

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0.9	November 2019	ALTRAN/PZR: initialization of the document.
0.99	February 2020	ALTRAN/PZR: incorporation Paul Poli comments and take into account the UNESCO document: Guide_to_drifting_data_buoys-1988.pdf. ALTRAN/PZR: solutions when applying QC to the first dataset (MeteoFrance).
0.999	August 2020	ALTRAN/PZR: modification of spike test, as it has been really applied in C-RAID. ALTRAN/PZR: definition of test19. ALTRAN/PZR: the test of comparison with ERA5 data is inserted in section 2 (Real time quality control). ALTRAN/PZR: incorporation of Application order of RTQC test.
0.9999	September 2020	ALTRAN/PZR: development of 3. Delayed mode quality control test. ALTRAN/PZR: revision of all the tests to introduce all the details about how the tests were really applied.
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1.2	09/05/2022	Capgemini Engineering/ PZR: Definition of ERA5 test for parameter “air temperature”.

1.3	09/12/2022	Capgemini Engineering/ PZR: Definition of RTQC TEST 44.

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Preface

This document is still in progress. As such, there are highlighted sections of text throughout that need to be addressed.

Yellow highlighting means this is a topic open to discussion - some things are known about this topic, but agreement needs to be reached.

Red highlighting means the issue needs a solution and nothing has been suggested yet.

Green highlighting is used for sections that have been modified since the previous version of the document.

The following temporary acronyms are also used:

- TBD: To Be Done or To Be Defined depending of the context.

1 Introduction

This document is the quality control manual for drifter data processed in the framework of the C-RAID project. It is derived from "Argo Quality Control Manual for CTD and Trajectory Data" ([RD1]). Specific information about the drifting buoy was also recovered from the "Guide to Drifting Data Buoys", UNESCO, 1988 ([RD2]).

The document describes two levels of quality control:

- Real Time Quality Control (RTQC) tests that perform a set of agreed automatic checks;
- Delayed-Mode Quality Control (DMQC) tests and procedures to be performed by an operator.

Drifters provide time-location parameters (see Reference Table 1), geophysical parameters (see Reference Table 2) and technical parameter (see Reference Table 3).

Note that C-RAID tests only concern time-location parameters and the following geophysical parameters: SST, ATMS.

2 Real-time quality control tests

2.1 Definition of tests

In this section we propose RTQC tests to apply automatically to drifter data.

2.1.1 Platform identification (TEST01)

Under the umbrella of the C-RAID project, we generate a unique identifier for each drifter mission (the mission of the drifter spans from its deployment date to its recovery (or loss) date).

The C-RAID identifier is defined as a 7 digits number: *TYYNNNN* where:

- *T*: refers to the drifter transmission type (1: for Argos, 2: for Iridium);
- *YY*: refers to the drifter deployment date (00: if deployed before 1979, deployed in year YY+1978 otherwise);
- *NNNN*: is a number designed so that the C-RAID identifier is unique.

The C-RAID identifier should fulfil:

- To have 7 digits;
- To have its first digit equal to 1 or 2;
- To have its second and third digits between 0 and (UTC year of the check – 1978);
- To be unique in the C-RAID database.

Action: if one or more of the four conditions fail, all the time-position, geophysical and technical parameters should be flagged as bad data (4).

2.1.2 Impossible date test (TEST02)

This test requires that the Julian Day (JULD) of drifter data be later than 1st January 1979 and earlier than the current date of the check (in UTC time).

- Julian day (1st January 1979) = 10592 <= JULD < UTC date of check

Action: if this test fail, all the time-position, geophysical and technical parameters should be flagged as bad data (4).

2.1.3 Impossible location test (TEST03)

This test requires that the observed latitude and longitude to be sensible.

- Latitude in range [−90 to 90]
- Longitude in range [−180 to 180[

Action: If either latitude or longitude fails this test, the position should be flagged as bad data (4).

2.1.4 Position on land test (TEST04 and TEST44)

This test requires that the observed latitude and longitude from a drifter be located in an ocean. Use can be made of any topography/bathymetry file that allows an automatic test to check if a position is located on land.
We suggest the use of the 15 arc-second intervals bathymetry GEBCO_2021 that is freely available and at https://www.gebco.net/data_and_products/gridded_bathymetry_data/.
The detailed description of the test implemented for C-RAID data is the following: For a given position, the elevations are retrieved from the bathymetry file (1, 2, 3 or 4 elevations depending on the drifter position on the GEBCO_2021 grid). The test fails if the average value of the retrieved elevations is ≥ 0.

Action: If the data cannot be located in an ocean, the position should be flagged as bad data

(4).

As explained later in section 3.1.1, once the DMQC on land test was carried out, the on land test (TEST04) should be deactivated.

TEST44 has been incorporate later, when we observed that TEST16 – Questionable Argos position test flagged QC = 3 positions clearly on land. Then, TEST44 applies TEST04 only on positions flagged QC = 3 by TEST16.

Action: If the data QC = 3 flagged by TEST16 is on land, the position should be flagged as bad data (QC = 4).

2.1.5 Impossible speed test *(to be implemented)*

Surface drift speeds can be generated given the positions and times of the drifter. In all cases we would not expect the surface drift speed to exceed 3 m s^{-1}. If it does, it means either the positions or times are bad data, or a drifter is mislabeled.

Action: For each point, the velocity is calculated in relation to the previous and after positions to the questioned position. If one or both estimated velocities exceed 3 m s^{-1}, the position, the time, or both, should be flagged as bad data (4).

2.1.6 Global range test (TEST06)

This test applies a large filter on geophysical parameters (see Reference Table 2) measured by the drifter. The ranges need to accommodate all of the expected extremes encountered in the oceans. The ranges are:

- ATMS in the range [901, 1060] hPa (taken from [RD2])
- AIR_TEMP in the range [-32, 42] °C (taken from [RD2]))
- SST in the range [−2.6, 40.0] °C
- PSAL in the range [2, 41.0] PSU
- WIND_INT in the range [0.0, 60.0] m s^{-1} (taken from [RD2])
- WIND_DIR in the range [0, 360] angular degree
- ATPT in the range [0, 99.9] hPa
- WAVE_HEIGHT in the range [0, 15.0] m (taken from [RD2])
- WAVE_DIRECTION in the range (TBD)
- WAVE_PERIOD in the range [1.95 26.0] s (taken from [RD2])
- Optics parameter in the range (TBD)

Action: If a value fails this test, it should be flagged as bad data (4). Note that only the parameter failing the test will be flagged as bad data.

2.1.7 Regional range test (TEST07)

This test applies to certain regions of the world where conditions can be further qualified. In this case, specific ranges for observations from the Mediterranean Sea and the Red Sea further restrict what are considered sensible values.

The Red Sea is defined by the region 10N, 40E; 20N, 50E; 30N, 30E; 10N, 40E.

The Mediterranean Sea is defined by the region 30N, 6W; 30N, 40E; 40N, 35E; 42N, 20E; 50N, 15E; 40N, 5W; 30N, 6W.

This test is implemented only for SST and PSAL data. The atmospheric parameters are not specific to regions.

Red Sea:

- SST in the range [21, 40.0] °C
- PSAL in the range [2, 41.0] PSU

Mediterranean Sea

- SST in the range [10, 40.0] °C

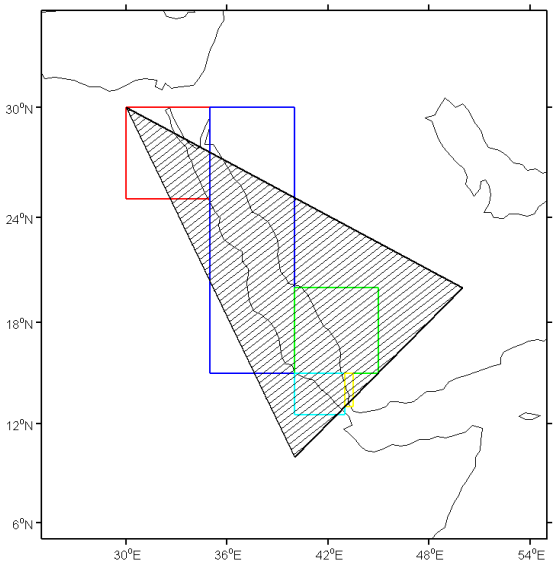
- PSAL in the range [2, 40.0] PSU

Action: If a value fails this test, it should be flagged as bad data (4). Note that only the parameter failing the test will be flagged as bad data.

Note that, in the C-RAID implementation of this test, the regions are defined by rectangular areas.

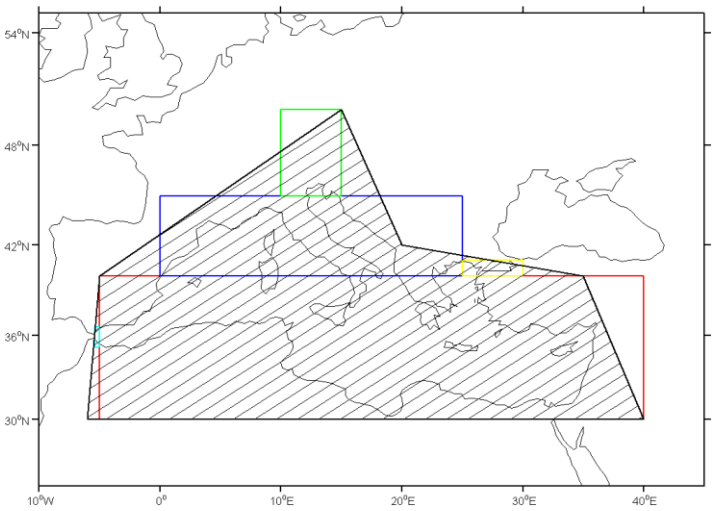
For the Red Sea Region, 5 rectangular areas:

- 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,
- .6N, 5.4W; 35.2N, 5W.



The borders are considered as part of the region.

2.1.8 Time-continuity test (TEST08)

This test was proposed following [RD2], it is applied to geophysical parameters, the test detects large differences between two consecutives data. The test algorithm depends on the time steps of two consecutives data.

$$Maxdelta = 0.58\ \sqrt{\Delta t}\ \sigma$$

where Maxdelta is the maximum allowable change between two consecutive measurements, Δt is the time difference in hours, and σ is a constant for each parameter:

- For ATMS: 21 hPa
- For SST: 8.6 °C
- For AIR_TEMP: 11 °C
- For WIND_INT: 25 m s^{-1}
- For WAVE_HEIGHT: 6 m
- For WAVE_PERIOD: 31 s
- For PSAL: 1 PSU.

Action: If a value fails this test, it should be flagged as bad data (4). Note that only the parameter failing the test should be flagged as bad data.

After numerous tests, we realized that about 90 % of data failing this test were good data, and when the data were wrong, they were flagged by other test. Consequently, we decided not to apply this test in the RT automatic process. However, at the beginning of C-RAID project, this test was active. Therefore, some indications about TEST08 can appear in the grey list. TEST08 was active for the first 638 drifters treated; they are drifters with three sensors that measured only SST.

2.1.9 Spike test (TEST09)

The difference between sequential measurements where one measurement is significantly different from adjacent ones is a spike.

For each parameter (PARAM) the spikes should be checked by comparison of the data at time$_i$ with the adjacent values (time $_{i-1}$ and time $_{i+1}$). The test is applied only if the time span between time $_{i-1}$ and time $_{i+1}$ is less than 12 hours. The value fails the test if both differences with the adjacent values exceed a threshold, which should be different for each parameter:

- Δ ATMS >= 8 hPa
- Δ SST >= 0.75 °C
- Δ AIR_TEMP >= 10°C
- Δ PSAL >= TBD
- Δ CNDC >= TBD

Action: If the value at time$_i$ fails this test, it should be flagged as bad data (4). Note that only the parameter failing the test should be flagged as bad data.

2.1.10 Digit rollover test (TEST10)

Only a number of bits are allowed to store the values of measured parameters by a drifter. This range is not always large enough to accommodate conditions that are encountered in the ocean. When the range is exceeded, stored values roll over to the lower end of the range. This rollover should be detected and compensated to continue the time series measured by the drifter. This test is used to make sure the rollover is properly detected.

- ATMS difference between adjacent positions > 50 hPa
- AIR_TEMP difference between adjacent positions > TBD
- WIND_INT difference between adjacent positions > TBD
- WIND_DIR difference between adjacent positions > TBD
- SST difference between adjacent positions > 15 °C
- PSAL difference between adjacent positions > 5 PSU
- WAVE_DIR difference between adjacent positions > TBD
- WAVE_HEIGHT difference between adjacent positions > TBD
- WAVE_PERIOD difference between adjacent positions > TBD

Action: Values that fail the test should be flagged as bad data (4). Note that only the parameter failing the test should be flagged as bad data.

2.1.11 Stuck value test (TEST11)

This test should be applied to all geophysical parameters. It looks for all the values identical during a given time period. The test considers the measurement should be identical for at least 5 days and at least three measurements found in the former time interval.

Action: If this occurs, all the identical values should be flagged as bad data (4). Note that only the parameter failing the test should be flagged as bad data.

2.1.12 Grey list test (TEST12)

This test is implemented as a mechanism for real-time data assembly centers (DACs) to flag sensors that are potentially not working correctly. The grey list contains the following 7 items:

- Platform: C-RAID Id.
- Parameter: one of the parameters of the Reference Table 2, 'MISSION' or 'LOC'. If it is PARAMETER, only the PARAMETER should be flagged with the QC indicated in the grey list. If it is 'MISSION', all the parameters and locations should be flagged with the QC indicated in the grey list. If it is 'LOC', only the location data should be flagged with the QC indicated in the grey list.
- Start date: from that date (or, if empty, from drifter deployment date), all the values of the concerned parameter should be flagged with the QC indicated in the grey list.
- End date: until that date (or, if empty, the end of mission date (drifter recovery or loss)), all the values of the concerned parameter should be flagged with the QC indicated in the grey list.
- Quality Code: value of the flag to be applied.
- Comment: operator comment about the reason of this line in the grey list.
- DAC: data assembly center of this drifter

Example:

Drifter	Parameter	Start date	End date	Quality code	Comment	DAC
1260001	SST	20030925012230		3	Unstable sensor	IF

2.1.13 Argos Redundancy test (TEST13)

This test concerns only drifters with Argos transmission. It checks the possible corruption of the received message. Three different tests are possible depending on the drifter Argos format:

- Drifter with checksum in its Argos format:
  - If the checksum test fails and the decoded message has been received only once, all the parameters of the concerned message should be flag as potentially correctable data (3).
  - If the checksum does not fail and the decoded message has been received only once, all the parameters of the concerned message should be flag as probably good data (2).
- Drifter without checksum in its Argos format: if the decoded message has been received only once, all the parameters of the concerned message should be flag as probably good data (2).

2.1.14 Inside of mission test (TEST14)

Drifters may be reused, that is, recovered, reconditioned and deployed again some time later. Each new deployment of a drifter is considered as a new mission. A new C-RAID identifier is assigned to each drifter mission.

The C-RAID time series contains all the data received from a given Argos or Iridium identifier. However, only the data of the concerned C-RAID identifier mission is checked through the RTQC (and DMQC) tests.

Action: All type of data (time-position, geophysical and technical parameters) timely outside the C-RAID identifier mission interval should be flagged as bad data (4).

2.1.15 Questionable Argos position test (TEST16)

This test concerns drifters positioned by the Argos system. It identifies questionable Argos position data collected considering the drifter speed at the sea surface and Argos position errors. Details of the method can be found in Nakamura et al (2008), "Quality control method of Argo float position data" ([RD3]).

A brief description of the procedure is summarized here.

a) Collect all Argos positions transmitted by the drifter. The distance between two positions A and B is referred to as a segment. A segment is considered questionable if:
    a) the drifter speed along the segment exceeds 3 m s^{-1}, and
    b) the length of the segment is longer than the critical error length, defined as

$$1.0 \times \sqrt{Er_A^2 + Er_B^2}$$

    where Er_A^2 and Er_B^2 are the radii of position error of the Argos system (150m, 350m, and 1000m for Argos class 3, 2, and 1 respectively) at A and B respectively.

b) If a segment is not considered questionable, then both positions A and B are good.

c) If a segment is considered questionable, then:
    - if the Argos class at A and B are different, then the position with the less accurate Argos class is flagged as potentially correctable (3);
    - if the Argos class at A and B are the same, and there is one good position before and one good position after A and B (i.e. there are 4 positions for the check), then the position that gives the higher speed along the segment from the previous good position to the later good position is flagged as potentially correctable (3);
    - if the Argos class at A and B are the same, and there is one good position either before or after A and B (i.e. there are 3 positions for the check), then the position that gives the higher speed along the segment either from the previous good position or to the later good position is flagged as potentially correctable (3);
    - if the Argos class at A and B are the same, but there are no other good positions around A and B (i.e. there are 2 positions for the check), then both A and B are flagged as potentially correctable (3).

2.1.16 Spike two points test (TEST19)

This test is applied to identify questionable high frequency variability in the time series of geophysical parameters.

For each parameter the spike two points should be checked by comparison of the data at time$_i$ with the adjacent values (time $_{i-2}$ and time $_{i+2}$). The test is applied only if the time span between time $_{i-2}$ and time $_{i+2}$ is less than 12 hours. In order to trigger the test, the value to be exceeded should be different for each parameter:

- Δ ATMS >=8 hPa
- Δ SST >= 0.75 °C
- Δ AIR_TEMP >= 10°C
- Δ PSAL >= TBD
- Δ CNDC >= TBD

Action: If the value at time$_i$ fails this test, it should be flagged as correctable data (3). Note that only the parameter failing the test should be flagged.

2.2 Test application order

The RTQC tests on drifter data are applied in the order described in the following table.

Note that each test is only applied to good data (QC = 1) and probably good data (QC = 2). The <PARAM>_QC_FAILED indicates the test number that first set each value its final QC.

Table 1. Order in which the quality control tests are applied

Order	Test number	Test name
1	1	Platform identification test
2	14	Inside of mission test
3	13	Argos redundancy test
4	2	Impossible date test
5	3	Impossible Location test
6	16	Questionable Argos position test
7	44	Position on land QC = 3 flagged by TEST16
8	6	Global range test
9	7	Regional range test
10	9	Spike test
11	19	Spike two points test
	8	~~Time-continuity test~~ (UNUSED)
12	10	Digit rollover test
13	11	Stuck value test

	4	~~on land test~~
14	12	Grey list test

3 Delayed-mode quality control tests

This section proposes procedure and additional tests performed, in delayed–mode, to evaluate the values of the different parameters and the QCs given during the RTQC process.

On the one hand, the very fine resolution bathymetry used (GEBCO 2020), in occasion, is not enough to provide the exact depth at the position of the drifter. On the other hand, the natural processes in both the ocean and the atmosphere can result in values of geophysical parameters that are real but flagged automatically by the RTQC tests. The automatic RTQC are revised during the DMQC process by the visualization, by an operator, of all the data and their QC assigned during the RTQC process.

During the DMQC process, originally set QCs can be modified from good data to bad data for erroneous measurements that have been "missed" by RTQC tests but also from bad data to good data for erroneously flagged measurements.

The flags given during the DMQC steps revoke the flags given by specific RTQC tests as indicated in the following sections. Once the different steps of DMQC finished, the RTQC tests are ran again with the corresponding revoked RTQC test inactive, or with the new test order indicated in the DMQC test. Note that all the decision taken in the DMQC tests are indicated in the grey list, which is the last test to run during the RTQC procedure. Consequently, the operator decisions can be reproduced in a further run of the RTQC procedure.
For QC traceability, we indicate in the C-RAID drifter grey list each modification of QC values performed during this phase.

3.1 Delayed-mode procedure

The delayed-mode procedure, used to check the C-RAID drifters is defined by the following 4 steps:

3.1.1 Delayed-mode on land test)

The RTQC on land test can fail when the drifter is in shallow waters, e.g. near an island, over a bank, inside an atoll, when the drifter was really in the ocean. We propose a DMQC on land test as follow.

The trajectories of drifters failing the RTQC on land test are generated in KML format. An operator visualizes the trajectory of the drifters using Google Earth in order to verify whether the drifter was on land (bathymetry >= 0 m).

Actions: drifter positions on land should be flagged as bad data (4). This test affect to all the parameters (time-position, geophysical and technical), therefore, MISSION should be indicated as parameter in the grey list. Once the DMQC on land test was carried out, the RTQC procedure should be ran again with the RTQC on land test (TEST04) deactivated.

Drifter positions inside an atoll, on the beach affected by the tide, or blocked in the glass, should be also indicated in the grey list. In this case, the QC should be 1 or 2 as determined by the delayed-mode operator. Some examples in the following table:

Drifter	Parameter	Start date	End date	Quality code	Comment	DAC
1250020	MISSION	20030925012230		4	On land	IF
1280684	MISSION	20060912123546	20060930005623	2	Drifter inside atoll	IF

3.1.2 Recover data before and after the dates indicated in the initial metadata file

The deployment and end mission dates indicated in the initial metadata file are subject to human or automatic actions, a priori, not verified. In C-Raid project, these dates are verified as follow. The whole satellite messages received from the drifter Argos emitter are decoded. All the positions and sensors data contained in each satellite message are visualized and confronted with the deployment and end mission dates indicated in the initial metadata file. If the operator considers the drifter was naturally drifting in the ocean before the initial deployment data or after the initial end mission date, these data initially out of mission, are subject to the RTQC tests.

Action: if the delay-mode operator considers (thanks to RTQC test results) that the “recovered” data is part of the drifter mission, the deployment date and/or the end mission date are modified and saved in the C-Raid drifter metadata file. This change affect the following run of the RTQC procedure, particularly, the inside mission test (TEST14), however, it neither revoke any other test nor change the test order.

Furthermore, this test allows identifying drifters whose trajectory has been modified by human actions. For example, drifter recovered by a boat or vessel, brought (or not) to port, and re-deployed later. In this case, a second mission should be created, indicating a new end mission date for the first mission, and new deployment and end mission dates for the second mission, and providing a new C-RAID identifier for the second mission.

3.1.3 ERA5 comparison (TEST15)

ERA5 is a product of reanalysis produce by the European Centre for Medium-Range Weather Forecasts (ECMWF). It provides hourly estimates of a large number of atmospheric, land and oceanic climate variables. The data cover the Earth on a 30km grid. For details of ERA5 and data access visit https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5. Because ERA5 is a product of reanalysis, quality-assured data are available within 3 months of real time. Consequently, this test is not directly in the RTQC procedure. However, when dealing with historical data, as in C-RAID, this test should be directly applied in the quality control.

3.1.3.1 Definition of the test

This test concerns SST, ATMS and AIR_TEMP data. The data measured by the drifter are automatically compared to ERA5 data. The difference between the ERA5 data and the drifter data are expected to be smaller than 5 °C, 20 hPa and 15°C, for SST, ATMS and AIR_TEMP, respectively.

Action: if the data fail this test, the SST_QC, ATMS_QC, AIR_TEMP_QC, should be 4.

3.1.3.2 New test application order

Once the ERA5 data are available, the ERA5 test take part of the quality control. All the RTQC tests should be run again with the following order:

Table 2. Order in which the quality control tests are applied once the ERA5 data are recovered.

Order	Test number	Test name
1	1	Platform identification test
2	14	Inside of mission test
3	13	Argos redundancy test
4	2	Impossible date test
5	3	Impossible Location test
6	16	Questionable Argos position test
7	6	Global range test
8	7	Regional range test
9	9	Spike test
10	19	Spike two points test
-	8	~~Time-continuity test~~ (UNUSED)
11	10	Digit rollover test
12	11	Stuck value test
13	**15**	**ERA5 comparison test**
-	4	~~RTQC on land test~~
14	12	Grey list test

3.1.3.3 Retrieve ERA5 data at drifter positions

The drifter positions are first evaluated by running a “light” version of RTQC tests. The “light” version concerns the following tests in the indicated order:

1- inside of mission test (TEST14);
2- impossible date test (TEST02);
3- impossible location test (TEST03);
4- questionable Argos position test (TEST16).

Only the drifter positions that do not fail the tests are retained for co-localization with ERA5 data.

Note that in drifters transmitting in Argos, there are two type of information: location and sensor. The sensor information only provides the time-stamp when the measurements were collected, the position of each measurement should be inferred by time-position linear interpolation of the location information. In order to retrieve the ERA5 data, first, the "light" version of RTQC is run to the drifter locations. Second, the locations that do not fail the tests are used to interpolate the measurement positions. Finally, the interpolated positions are considered to do the co-localization with ERA5 data.

The ERA5 data (SST and ATMS) are spatially interpolated to the measurement positions, using the ERA5 time step the nearest to the measurement time. The Python function "interp" of "xarray package" (http://xarray.pydata.org/en/stable/generated/xarray.Dataset.interp.html) was used for the 2D – linear interpolation. If only 2 or 3 positions around the drifter positions are in the ocean, the meridional and/or zonal gradient of the available data are used to interpolate the parameter to the drifter position.

3.1.3.4 ERA5 comparison analysis

The drifter data may have been assimilated in the ERA5 reanalysis, so the QC given by this test is not guaranteed to provide independent information. In addition, the drifter may have encountered situations not properly represented by the reanalysis. Consequently, this QC is expected to help identify, respectively, situations when sensors malfunctioned for a large period (before further investigations can be made), and situations where the reanalysis (inherently limited in resolution and realism) may have missed interesting events.

Action: the delayed-mode operator can re-flag as "good" reasonable SST or ATMS data that have been flagged as "bad" by the ERA5 comparison test. Likewise, thanks to data flagged by ERA5 comparison test, the operator can identify period of malfunction sensor and flag all the data of the period as "bad" data. In both cases, the drifter Id, date or dates, the new QC, and a comment should be indicated in the grey list.

3.1.4 Grey list completion

Data are usually flagged as bad data (4) in the grey list. In the case of drifters, data flagged as bad data by the RTQC test can be re-flagged as good data (1), probably good data (2) or correctible data (3), following the criteria of the delayed-mode operator.

During the delayed-mode quality control the DM-operator visualize the time series of geophysical parameters and the trajectory of each drifter. The QC given during the RT process can be modify by the DM-operator following her/his scientific criteria. The grey list should be fed with the new information resulting from the DM tests carried out by the DM-operators. With such a grey list content, each new application of the entire processing steps (decoding, RTQC and DMQC tests) will result an identical set of QCs.

Examples of lines in the grey list in the following table:

Drifter	Parameter	Start date	End date	Quality code	Comment	DAC
1280679	SST	20101025003123	20101101012030	1	Wrong QC given by ERA5 test	IF

1280661	ATMS	20010320230631	20010320230631	4	Spike not detected	IF
1280641	SST	20060524130002	20060524130002	1	Wrong QC given by test10	IF
1260687	ATMS	20050222035600	20050228012352	4	Sensor malfunctioning detected with ERA5 test	IF
1270108	MISSION	20061002150850		4	On land	IF
1270606	MISSION	20060105164903	20060323005349	2	blocked close to an island coast	IF

4 Reference tables

4.1. Reference table 1: description of time-position parameters

Code	long name	standard name	unit	valid_min	valid_max
JULD	Julian day (UTC) of each measurement relative to REFERENCE_DATE_TIME		days since 1950-01-01 00:00:00 UTC		
LATITUDE	Latitude		decimal degree		
LONGITUDE	Longitude		decimal degree		

4.2 Reference table 2: description of geophysical parameters

Code	long name	standard name	unit	valid_ min	valid_ max
ATMS	Air pressure	air_pressure	hPa		
ATMS_COUNT	Air pressure		count		
SST	Sea surface temperature	sea_surface_temperature	degree_Celsius		
SST_COUNT	Sea surface temperature		count		
PSAL	Salinity				
CNDC	Conductivity				
AIR_TEMP	Air temperature		°C		
WIND_DIR	Wind direction		degree		
WIND_INT	Wind intensity		m s^{-1}		
WAVE_DIR	Wave direction		degree		
WAVE_HEIGHT	Wave height		m		
WAVE_PERIOD	Wave period		seconds		
ATPT	Air pressure tendency		hPa		
ATPT_COUNT	Air pressure tendency		count		

4.3 Reference table 3: description of technical parameters

Code	long name	standard name	unit	valid_ min	valid_ max
BATTERY	Battery voltage		Volts		
BATTERY_COUNT	Battery voltage		count		
DROGUE	Drogue detection sensor				
DROGUE_COUNT	Drogue detection sensor		count		
MSG_REDUNDANCY	Redundancy of received message		count		
TTFF	Time of first GPs fix		seconds		
SBTD	Iridium SBD transmission duration				
SBTR	Number of Iridium SBD transmission Retries				
HULL_INTERNAL_HUMIDITY	Hull internal humidity				
HULL_INTERNAL_PRESSURE	Hull internal pressure				
CEP_RAD	CEP radius		km		

5 Reference documents

Reference N°	Title	Link
#RD1	Argo Quality Control Manual for CTD and Trajectory Data.	http://dx.doi.org/10.13155/33951
#RD2	Guide to Drifting Data Buoys, UNESCO, 1988.	https://www.oceandocs.org/handle/1834/2734
#RD3	Quality control method of Argo float position data, JAMSTEC Report of Research and Development, Volume 7, March 2008, 11– 18.	http://www.jamstec.go.jp/ARGORC/tools/JAM_RandD07_02.pdf