

About the “Advanced Automatic QC (AQC) Argo Data” Dataset (Ver. 1.3)

1. Introduction

One of the major features of the Argo Programme is that profile data observed by Argo floats are available in real time. However, the real-time quality-control procedures implemented uniformly by the Argo Programme worldwide (hereafter referred to as rQC) are relatively simple, and the resulting data are not appropriate for research use. In contrast, the internationally standardized delayed-mode quality-control procedures provide data of sufficient accuracy for research, but even in the best case the data are not released for at least six months, making them unsuitable for applications such as near-real-time monitoring of ocean conditions.

JAMSTEC therefore applies advanced automatic quality control (AQC), which is more sophisticated than rQC, to Argo profile pressure, temperature, and salinity data, and publishes an Argo profile dataset containing the AQC results.

Questions arose regarding the contents of AQC ver. 1.2a data released in February 2018. These issues have been corrected, and the quality-control tests have also been slightly improved while retaining a level comparable to AQC ver. 1.2a. This document describes AQC ver. 1.3, including the source data and period used to create the dataset, the quality-control procedures, and the differences from AQC ver. 1.2a.

2. Changes from Ver. 1.2

The following changes were made.

(1) Change in the type of profiles subject to AQC

Because delayed-mode quality-controlled profile data takes time to become available, this dataset was originally intended to provide better-quality data with minimal delay by applying advanced automatic quality control to pressure, temperature, and salinity data released in real time.

However, the Argo Data Management Team has shifted to a policy of distributing better-quality data more rapidly and is asking national data centres to release simply adjusted data (“real-time data with adjusted values”. Within the Argo data-mode framework, this is the so-called “A-mode”) as early as possible. Consequently, A-mode data are increasingly being released at an early stage. In Ver. 1.2, AQC was limited to real-time data ([PRES]/[TEMP]/[PSAL]); this has been changed as follows.

- ① When A-mode data are available, [PRES_ADJUSTED]/[TEMP_ADJUSTED]/[PSAL_ADJUSTED] are used as the profiles subject to AQC.
- ② When A-mode data are not available and only R-mode data are available, [PRES]/[TEMP]/[PSAL] are used as the profiles subject to AQC.

The data mode of each profile can be checked in the profile header in the AQC dataset files (see Appendices A2 and A3).

(2) Change in the criteria for profiles subject to AQC

AQC ver. 1.2 required at least one observed level at which the pressure, temperature, and salinity data were not flagged as “bad.” The criteria have been

changed so that profiles in which only salinity is flagged as “bad” can also be used, as shown in the table below. The changed portions are underlined.

Ver. 1.2	Ver.1.3
1. The position QC flag [POSITION_QC] is 1 (good), 2 (probably good), or 8 (interpolated value). 2. The observation-date QC flag [JULD_QC] is 1 (good), 2 (probably good), or 8 (interpolated value). 3. At an observed level other than an unpumped CTD level, at least one of the three <u>rQC flags for pressure, temperature, and salinity [PRES_FLAG, TEMP_FLAG, PSAL_FLAG] is 1 (good), 2 (probably good), 3 (bad data that are potentially correctable), 5 (value changed), or 8 (interpolated value). In other words, a profile is excluded if all three rQC flags [PRES_FLAG, TEMP_FLAG, PSAL_FLAG] are 4 or 9 at every level.</u> 4. For a float that acquires observations on multiple pressure axes during its ascent from the target depth to the sea surface, the pressure axis with the deepest observed level is selected for AQC. If the deepest level is the same on multiple pressure axes, the axis having the largest number of levels at which all three rQC flags [PRES_FLAG, TEMP_FLAG, PSAL_FLAG] are 1 is selected for AQC.	1. The position QC flag [POSITION_QC] is 1 (good), 2 (probably good), or 8 (interpolated value). 2. The observation-date QC flag [JULD_QC] is 1 (good), 2 (probably good), or 8 (interpolated value). 3. At an observed level other than an unpumped CTD level, the pressure rQC flag [PRES_FLAG] is 1 (good), 2 (probably good), 3 (bad data that are <u>potentially correctable</u>), 5 (value changed), or 8 (interpolated value). 4. For a profile satisfying Conditions 1–3, at an observed level other than an unpumped CTD level where the pressure rQC flag [PRES_FLAG] is 1 (good), 2 (probably good), 3 (bad data that are potentially correctable), 5 (value changed), or 8 (interpolated value), at least one of the temperature and salinity rQC flags [TEMP_FLAG, PSAL_FLAG] is 1 (good), 2 (probably good), 3 (bad data that are potentially correctable), 5 (value changed), or 8 (interpolated value). A profile is excluded if both [TEMP_FLAG] and [PSAL_FLAG] are 4 or 9 at all levels. 5. For a float that acquires observations on multiple pressure axes during its ascent from the target depth to the sea surface, the pressure axis with the deepest observed level is selected for AQC. If the deepest level is the same on multiple pressure axes, the axis having the largest number of levels at which all three rQC flags [PRES_FLAG, TEMP_FLAG, PSAL_FLAG] are 1 is selected for AQC.

(3) Debugging of quality-control tests

(4) Improvements to quality-control tests

The following improvements were completed. See Appendix A5 for details.

- ① The World Ocean Atlas used in the “error check” was updated from the 2013 edition to the 2023 edition.

② The applicability criteria for each quality-control test were refined.

(5) Addition of processing for duplicate levels (identical pressure values)

When duplicate levels (identical pressure values) occur in a profile, the following data are written to the AQC data file.

- ① Write the record for which PRES_QC or PRES_ADJUSTED_QC is not 8 (the flag indicating an interpolated value).
- ② If duplicate records remain after excluding records with PRES_QC or PRES_ADJUSTED_QC = 8, write the record that appears first when proceeding from shallow to deep levels.

3. Reprocessing period

January 2016 through May 2026 (10 years and 5 months)

4. Important notes for use

As a result of the change in the criteria for profiles subject to AQC (Section 2. (2)), profiles for which either temperature or salinity is assigned a “bad” flag at all levels by Argo rQC may now be included in the AQC processing. In such cases, some AQC tests are not applicable. Consequently, the nine-digit profile AQC flag in each profile header of the AQC data files (AQC_Profile_Data_[yyyymm].[txt/nc]) may contain only “0” (pass) and “9” (not applicable), with no “1” (fail), even though the Argo real-time QC flag for a variable at individual levels is “bad.” Users are therefore strongly advised to check both the Argo real-time QC flag and the AQC flag for every variable at every level before using the data.

Example: P and T have Argo QC flag 1 (good data) at all levels, whereas S has Argo QC flag 4 (bad data) at all levels.

AO 5906096	256	20260518142340	13.569	-177.032	988	7111	000099900	Profile AQC flag Enlarged 000099900 [Test4] S: not applicable; T: applicable. T result is reflected. [Test9] S: not applicable; T: applicable T result is reflected. [Test6,7] not applicable because S is bad at all levels.
pres	pres_flag	temp	temp_flag	psal	psal_flag	aqc_flag		
4.15	1	27.76100	1	30.19200	4	0099999009		
5.85	1	27.76200	1	30.09100	4	0099999009		
7.85	1	27.76300	1	29.80500	4	0099999009		
9.85	1	27.76200	1	29.73300	4	0099999009		
11.85	1	27.76800	1	29.69600	4	0099999009		

A profile in which P, T, and S all pass AQC must satisfy both conditions below:

1. The profile AQC flag contains no '1' (fail); '9' (not applicable) is allowed.
2. At every level:
 (pres_flag=1,2, or 8) & (temp_flag=1,2, or 8) & (psal_flag=1,2, or 8)
 & (all level AQC flags except Test 5 are '0' [pass]).

The following sections describe AQC ver. 1.3. Items that have not been revised since AQC ver. 1.2a are marked “[No change from AQC ver. 1.2].”

5. AQC scope and processing frequency

(1) Observed variables subject to AQC

Measured pressure [PRES], temperature [TEMP], and salinity [PSAL] from Argo floats worldwide. [No change from AQC ver. 1.2]

* Text in square brackets gives the variable name in the profile NetCDF files distributed by the GDACs.

The data mode is A-mode or R-mode, as described below.

- ① When A-mode data are available, [PRES_ADJUSTED]/[TEMP_ADJUSTED]/[PSAL_ADJUSTED] are used as the profiles subject to AQC.
- ② When A-mode data are not available and only R-mode data are available, [PRES]/[TEMP]/[PSAL] are used as the profiles subject to AQC.

(2) Profiles subject to AQC

Profiles distributed by the Global Data Assembly Centres (hereafter GDACs) that satisfy all of the following conditions.

Profiles satisfying all of the following conditions are written to the AQC Data ver. 1.3 data files.

* Text in square brackets gives the variable name in the profile NetCDF files distributed by the GDACs.

- a. The position QC flag [POSITION_QC] is 1 (good), 2 (probably good), or 8 (interpolated value).
- b. The observation-date QC flag [JULD_QC] is 1 (good), 2 (probably good), or 8 (interpolated value).
- c. At an observed level other than an unpumped CTD level, the pressure rQC flag [PRES_FLAG] is 1 (good), 2 (probably good), 3 (bad data that are potentially correctable), 5 (value changed), or 8 (interpolated value).
- d. For a profile satisfying Conditions 1–3, at an observed level other than an unpumped CTD level where the pressure rQC flag [PRES_FLAG] is 1 (good), 2 (probably good), 3 (bad data that are potentially correctable), 5 (value changed), or 8 (interpolated value), at least one of the temperature and salinity rQC flags [TEMP_FLAG, PSAL_FLAG] is 1 (good), 2 (probably good), 3 (bad data that are potentially correctable), 5 (value changed), or 8 (interpolated value). A profile is excluded if both [TEMP_FLAG] and [PSAL_FLAG] are 4 or 9 at all levels.
- e. For a float that acquires observations on multiple pressure axes during its ascent from the target depth to the sea surface, the pressure axis with the deepest observed level is selected for AQC. If the deepest-observed level is the same on multiple pressure axes, the axis having the largest number of levels at which all three rQC flags [PRES_FLAG, TEMP_FLAG, PSAL_FLAG] are 1 is selected for AQC.

(3) QC processing frequency [No change from AQC ver. 1.2]

Once a month, all profile files during the preceding calendar month are downloaded from the GDACs and quality controlled before the AQC processing date (the 16th of each month). AQC is scheduled to be run in the middle of each month.

(4) Data period [No change from AQC ver. 1.2]

January 2001 through the preceding month (on or after the 16th of the current month) or through two months prior (before the 16th of the current month)

<Note>

The AQC version differs depending on the period.

V1.2: Data files from January 2001 to December 2012

V1.3: Data files from January 2016 onward.

6. Dataset contents [No change from AQC ver. 1.2]

The dataset contains the following two types of data files.

(1) Profile index file: AQC_Profile_Index_[yyyymm].txt

A list of profiles to which AQC has been applied. One file is provided for each month. See Appendix A1 for the format.

(2) Profile data file: AQC_Profile_Data_[yyyymm].<txt/nc>

All profile data acquired during a given calendar month are stored in a single file. Two formats are provided: text and NetCDF. The variables stored in the dataset are listed below. See Appendices A2 and A3 for detailed formats.

* Text in square brackets gives the variable name in the profile NetCDF files distributed by the GDACs.

* Items 2) a–f and 3) a–b are stored for each individual profile.

1) File header

a. Date on which global profile files were downloaded from the GDACs

b. Number of profiles stored in the file

2) Metadata for each profile

a. Data centre [DATA_CENTRE]

b. WMO number [PLATFORM_NUMBER]

c. Cycle number [CYCLE_NUMBER]

d. Observation date and time [JULD_LOCATION]

e. Position [LATITUDE, LONGITUDE]

f. Number of observed levels [N_LEVELS]

g. Profile flag

A four-digit number representing the following information for the profile data:

- a. Argo quality-control processing status
- b. Position QC flag
- c. Observation-date QC flag
- d. Observation-axis number
- * Some floats make observations on multiple pressure axes during their ascent from the target depth to the sea surface. This value identifies the axis of the profile data processed by AQC.

f. Profile AQC flag

A nine-digit code in which each digit represents the result of one of the nine AQC tests (see Section 4), using 0 (pass) or 1 (fail) (see Appendix A3.(1).8 for details).

For AQC Test 4.(4), if pressure is not subject to the check because every level has flag 4 or 9, the corresponding profile AQC flag digit is set to 9.

For AQC Tests 4.(4)–(9), if at least one observed level fails a test, the corresponding digit is set to 1, meaning “fail.”

3) Observed profile data and flags

- a. Pressure, temperature, and salinity, together with their respective rQC flags

[PRES, TEMP, PSAL, PRES_FLAG, TEMP_FLAG, PSAL_FLAG]

- b. AQC flag

A ten-digit code representing, for each observed level, the results of the six tests among the nine AQC tests that correspond to “4. Quality-control tests” (4)–(9). Each digit corresponds to the result of one AQC test in 4.(4)–(9). See Appendix A3.(3).7 for details.

(3) Notes on output

If an input profile contains duplicate observed levels (identical pressure values), the following record is written to the AQC dataset.

- (a) Write a record for which [PRES_FLAG] is not 8.
- (b) If records other than those with [PRES_FLAG] = 8 are still duplicated, write the record that appears first when proceeding from shallow to deep levels.

7. Quality-control tests

The following nine quality-control tests are applied.

For Tests (5)–(9), an observed level satisfying either of the following conditions is excluded from the check.

- i. An observed level with no pressure value [PRES]
- ii. An observed level for which the pressure rQC flag [PRES_FLAG] is 4 (bad data) or 9 (missing value)

	Quality-control tests	Specific quality-control procedure	Notes (including conditions excluded from the check)
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(1)	Position check	The check passes when all of the following conditions are met. 1. Latitude and longitude are neither a FillValue nor null. 2. The position differs from that of the preceding profile. 3. The speed calculated from the preceding profile position is less than 1 m s^{-1}.	Conditions 2 and 3 are not checked for Prof_No.1 of each float.
(2)	Number-of -levels check	The check passes when the target profile contains at least 10 levels with a pressure value whose rQC flag [PRES_FLAG] is neither 4 (bad data) nor 9 (missing value).	
(3)	Shallowest-level pressure check	The check passes when the pressure at the shallowest observed level is less than 17 dbar.	
(4)	Range check	Each variable passes when it satisfies the corresponding condition below. 1. Pressure: greater than 0 dbar and less than 2200 dbar. 2. Temperature: greater than -2.5° C and less than 35° C. 3. Salinity: greater than 29 psu or less than 41 psu.	a. For Item 1, pressure is excluded from the check at levels where the pressure rQC flag [PRES_FLAG] is 4 (bad data) or 9 (missing value). b. For Item 2, temperature is excluded from the check at levels with no temperature [TEMP] or with a temperature rQC flag [TEMP_FLAG] of 9 (missing value). c. For Item 3, salinity is excluded from the check at levels with no salinity [PSAL] or with a salinity rQC flag [PSAL_FLAG] of 9 (missing value). d. Levels with $P < 0$ are excluded from the check.
(5)	Stuck check	For a single profile, the check passes when, at pressures of 1000 dbar or deeper and where the pressure difference between adjacent observed levels is at least 10 bar, neither temperature nor salinity remains identical over a layer thickness of 300 dbar or more.	a. Levels at 1000 dbar or shallower are excluded from the check. b. At levels deeper than 1000 dbar, levels for which the pressure rQC flag [PRES_FLAG] is 4 (bad data) or 9 (missing value) are excluded from the check. c. When the pressure difference between vertically adjacent observed levels is less than 10 dbar, both levels are excluded from the check. d. Temperature is excluded from the check at levels with no temperature [TEMP] or with a temperature rQC flag [TEMP_FLAG] of 4 (bad data) or 9 (missing value). e. Salinity is excluded from the check at levels with no salinity [PSAL] or

			with a salinity rQC flag [PSAL_FLAG] of 4 (bad data) or 9 (missing value).
(6)	Density-inversion check at levels deeper than 1000 dbar	At levels deeper than 1000 dbar, calculate the difference between the potential density at each level and that at the immediately shallower observed level. The check passes when the difference is less than -0.005 kg m^{-3}. Compare level n with level $n+1$, where $P(n) < P(n+1)$ and P is pressure, and assign the AQC result flag to level $n+1$. The check is performed in both directions: from shallow to deep levels and from deep to shallow levels.	a. Levels at 1000 dbar or shallower are excluded from the check. b. Levels with no temperature [TEMP] or no salinity [PSAL] are excluded from the check. c. Levels are excluded from the check when the temperature rQC flag [TEMP_FLAG] is 4 (bad data) or 9 (missing value), or when the salinity rQC flag [PSAL_FLAG] is 4 (bad data) or 9 (missing value).
(7)	Density-inversion check over all levels	For each level, calculate the difference between its potential density and that of the immediately shallower level. The check passes when the potential-density difference is less than -0.02 kg m^{-3}. Compare level n with level $n+1$, where $P(n) < P(n+1)$ and P is pressure, and assign the AQC result flag to level $n+1$. The check is performed from shallow to deep levels and from deep to shallow levels, i.e., in both directions.	a. Because the comparison is made with the immediately shallower level, the shallowest level is excluded from the check. b. Levels with no temperature [TEMP] or no salinity [PSAL] are excluded from the check. c. Levels are excluded from the check when the temperature rQC flag [TEMP_FLAG] is 4 (bad data) or 9 (missing value), or when the salinity rQC flag [PSAL_FLAG] is 4 (bad data) or 9 (missing value).
(8)	Observed-level spacing check	The check passes when the observed-level spacing satisfies all of the following conditions. 1. $0 \leq P \leq 300$ dbar: spacing less than 50 dbar 2. $300 \text{ dbar} < P \leq 1500$ dbar: spacing less than 110 dbar 3. $1500 \text{ dbar} < P \leq 2000$ dbar: spacing less than 250 dbar * These criteria follow the standard-level spacing used in the World Ocean Atlas.	a. Levels deeper than 2000 dbar are excluded from the check. b. Levels shallower than 0 dbar are excluded from the check. c. If the profile contains one or fewer observed levels whose pressure rQC flag [PRES_FLAG] is neither 4 (bad data) nor 9 (missing value), all levels are excluded from the check.
(9)	Error check	At every grid point and standard level (102 levels) in the annual mean World Ocean Atlas 2023 (hereafter WOA), the error for temperature and salinity is defined as the combination of	a. Levels deeper than 2000 dbar are excluded from the check. b. Temperature [TEMP] and salinity [PSAL] are excluded from the check at levels where pressure [PRES] is excluded from the “(4) Range check.”

		measurement error and natural-variability error, as follows. Temperature error: $T_e = [(0.005^\circ \text{ C})^2 + (\text{WOA temperature standard deviation})^2]^{1/2}$ Salinity error: $S_e = [(0.01 \text{ psu})^2 + (\text{WOA salinity standard deviation})^2]^{1/2}$ For the target profile, determine whether the temperature and salinity at the observed level nearest each WOA standard level and within ± 10 dbar of that level fall within $\pm 10T_e$ and $\pm 10S_e$, respectively, of the value at that level at the WOA grid point nearest the target Argo profile. The check is performed at all WOA standard levels shallower than or equal to 2000 m.	c. Temperature [TEMP] is excluded when it is not subject to the “(4) Range check.” d. Salinity [PSAL] is excluded when it is not subject to the “(4) Range check.” e. Temperature is excluded from the check at levels with no temperature [TEMP] or with a temperature rQC flag [TEMP_FLAG] of 4 (bad data) or 9 (missing value). f. Salinity is excluded from the check at levels with no salinity [PSAL] or with a salinity rQC flag [PSAL_FLAG] of 4 (bad data) or 9 (missing value). g. If no temperature profile is available at the WOA grid point nearest the target profile, or if fewer than 10 profiles were used to construct the temperature profile at that WOA grid point, temperature [TEMP] is excluded from the check at all levels of the target profile. h. If no salinity profile is available at the WOA grid point nearest the target profile, or if fewer than 10 profiles were used to construct the salinity profile at that WOA grid point, salinity [PSAL] is excluded from the check at all levels of the target profile.
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8. Use of the AQC ver. 1.3 dataset [No change from AQC ver. 1.2]

Use of the AQC ver. 1.3 dataset is generally unrestricted. When citing the dataset in a presentation, publication, or other product, users must clearly identify the source, for example by stating, “The AQC ver. 1.3 dataset published by JAMSTEC was used.” The AQC ver. 1.2 dataset must not be reproduced, redistributed, modified, used commercially, or otherwise used without permission.

9. About this document [No change from AQC ver. 1.2]

This document may be revised from time to time to correct deficiencies or incorporate new quality-control tests. Users should therefore check the document version.

References

Argo quality control manual v3.9 (<https://archimer.ifremer.fr/doc/00228/33951/>)

Appendices

- A1. Format of the dataset profile index file [No change from AQC ver. 1.2]
- A2. Format of the dataset profile data file (text format) [No change from AQC ver. 1.2]
- A3. Format of the dataset profile data file (NetCDF format) [No change from AQC ver. 1.2]
- A4. Code tables used in the dataset profile data files [No change from AQC ver. 1.2]
- A5. Comparison of AQC ver. 1.2 and ver. 1.3

A1. Format of the dataset profile index file

File name: AQC_Profile_Index_[yyyymm].txt

[Format]

Line 1 contains the following items, from left to right:

1. Date on which the profile NetCDF files were downloaded from the GDACs
2. Number of profiles contained in the file

Lines 2 and onward contain the following items, from left to right:

1. Data Centre
2. WMO number
3. Cycle number

A2. Format of the dataset profile data file (text format)

File name: AQC_Profile_Data_[yyyymm].txt

[Format]

Line 1 contains the following items, from left to right:

1. Date on which the profile NetCDF files were downloaded from the GDACs
2. Number of profiles stored in the file

Lines 2 and onward consist of two header lines ((1) and (2)) followed by profile data (3).

(1) Header line 1 contains the following items, from left to right:

1. Data-centre code (see Table 1 for the meaning of each code)
2. WMO number
3. Cycle number
4. Observation date and time (UTC) (yyyymmddhhmmss)
5. Latitude (90°S to 90°N)
6. Longitude (-180° to 180°)
7. Number of observed levels
8. Profile flag (four digits)

A flag representing the observation-axis number and the QC flags for the observation date/time and position. The meaning of each digit is as follows.

[Meaning of each digit of the profile flag] * The first digit is the rightmost digit.

Fourth digit: Argo quality-control processing-status code (see Table 3 in Appendix A4)

Third digit: Position QC flag (see Table 2 in Appendix A4 for flag meanings)

Second digit: Observation-date QC flag (see Table 2 in Appendix A4 for flag meanings)

First digit: Observation-axis number

* Some floats make observations on multiple pressure axes during their ascent from the target depth to the sea surface. This value identifies the axis of the profile data processed by AQC.

9. Profile AQC flag

A nine-digit code representing the results of the nine AQC tests (see “4. Quality-control tests”). Each digit represents the result of one AQC test. The correspondence between digits of the profile AQC flag and the AQC tests is shown below. For the meaning of each digit in

the profile AQC flag, see Table 4 in Appendix A4.

Note 1: For AQC Tests 4.(4)–(9), if at least one observed level fails a test, the corresponding digit of the profile AQC flag is set to 1, meaning “fail.”

Note 2: For AQC Tests 4.(4)–(9), if all observed levels are excluded from a test, the corresponding digit of the profile AQC flag is set to 9, meaning “not applicable.”

Note 3: For AQC Tests 4.(4)–(9), if no observed level fails but levels that pass and levels excluded from the check are both present, the corresponding digit of the profile AQC flag is set to 0, meaning “pass.”

[AQC test represented by each digit of the profile AQC flag] * The first digit is the rightmost digit.

Ninth digit: Position-check result (4.(1))

Eighth digit: Number-of-levels check result (4.(2))

Seventh digit: Shallowest-level pressure check result (4.(3))

Sixth digit: Range-check result (4.(4))

Fifth digit: Stuck-check result (4.(5))

Fourth digit: Density-inversion check result at levels deeper than 1000 dbar (4.(6))

Third digit: Density-inversion check result (4.(7))

Second digit: Observed-level spacing check result (4.(8))

First digit: Error-check result (4.(9))

Examples of profile AQC flags and their meanings are given below.

Example 1: 001000000

The seventh digit from the right is 1. This means that only the shallowest-level pressure check failed.

Example 2: 100000001

The first and ninth digits from the right are 1. This means that the position check (4.(1)) failed and that the error check (4.(9)) failed at one or more observed levels.

Example 3: 000909000

The fourth and sixth digits from the right are 9. This means that the stuck check (4.(5)) and the density-inversion check at levels deeper than 1000 dbar (4.(6)) are not applicable; in other words, the deepest level is shallower than or equal to 1000 dbar.

(2) Header line 2

pres pres_flag temp temp_flag psal psal_flag aqc_flag

(3) Profile data contain the following items, from left to right:

1. Pressure
2. Pressure flag (see Table 2 in Appendix A4 for flag meanings)
3. Temperature
4. Temperature flag (see Table 2 in Appendix A4 for flag meanings)
5. Salinity
6. Salinity flag (see Table 2 in Appendix A4 for flag meanings)
7. AQC flag

A ten-digit code representing, for each level, the results of the six tests among the nine AQC tests that correspond to “4. Quality-control tests” (4)–(9). Each digit represents the result of one AQC test in 4.(4)–(9). The meaning of the AQC test represented by each digit is given below. See Table 4 in Appendix A4 for the meaning of each digit value.

[AQC test represented by each digit of the AQC flag] * The first digit is the rightmost digit.

Tenth digit: Pressure range-check result (4.(4).1)

Ninth digit: Temperature range-check result (4.(4).2)

Eighth digit: Salinity range-check result (4.(4).3)

Seventh digit: Temperature stuck check result (4.(5))

Sixth digit: Salinity stuck check result (4.(5))

Fifth digit: Density-inversion check at levels deeper than 1000 dbar result (4.(6))

Fourth digit: Density-inversion check result (4.(7))

Third digit: Observed-level spacing check result (4.(8))

Second digit: Temperature error-check result (4.(9))

First digit: Salinity error-check result (4.(9))

Note: For Items 1–6, the processing level of the stored values differs according to the data mode ((1).8, fourth digit: Argo quality-control processing-status code).

Data mode	(1) 8. Value of the fourth digit	Variable in the AQC_Profile_Data file	Corresponding variable name in the Argo data file
R	9	(3) 1. Pressure, 3. Temperature, 5. Salinity	[PRES/TEMP/PSAL]_Adjusted
		(3) 2. Pressure flag, 4. Temperature flag, 6. Salinity flag	[PRES/TEMP/PSAL]_Adjusted_QC
A	7	(3) 1. Pressure, 3. Temperature, 5. Salinity	[PRES/TEMP/PSAL]
		(3) 2. Pressure flag, 4. Temperature flag, 6. Salinity flag	[PRES/TEMP/PSAL]_QC

A3. Format of the dataset profile data file (NetCDF format)

File name: AQC_Profile_Data_[yyyymm].nc

[Header information] * Blue text describes the variable names.

```
netcdf AQC_Profile_Data_200101 {
    dimensions:
        N_LEVELS = nnn ; // Maximum number of observed levels among the profiles contained in AQC_Profile_Data_[yyyy][mm].nc
        N_PROF = 111 ; // Number of profiles contained in AQC_Profile_Data_[yyyy][mm].nc
        STRING16 = 16 ;
        STRING8 = 8;
        STRING4 = 4;
        STRING2 = 2;
        STRING_N_LEVEL10 = 15290;
    variables:
        char DATE_DOWNLOAD(STRING16) ; // Date on which the profile NetCDF files were downloaded from the GDACs
            DATE_DOWNLOAD:long_name = "Date when profile netcdf files was downloaded from GDAC for AQC" ;
        char PLATFORM_NUMBER(N_PROF, STRING8) ; // WMO number
            PLATFORM_NUMBER:name = "WMO_NO" ;
        int CYCLE_NO(N_PROF) ; // Cycle number
            CYCLE_NO:name = "CYCLE_NO" ;
        char TIME(N_PROF,STRING16) ; // Observation date and time (UTC)
            DATE:name = "DATE" ;
            DATE:units = "YYYYMMDDHHMISS(UTC)" ;
        float LONGITUDE(N_PROF) ; // Longitude (-180° to 180°E)
            LONGITUDE:name = "LONGITUDE" ;
            LONGITUDE:units = "degrees_east" ;
        float LATITUDE(N_PROF) ; // Latitude (-90° to 90°N)
```

```

    LATITUDE:name = "LATITUDE" ;
    LATITUDE:units = "degrees_north" ;
char DATA_CENTRE(N_PROF, STRING2); // Data centre (see Table 1 in Appendix A4 for code meanings)
    DATA_CENTRE:name="Data Centre" ;
    DATA_CENTRE:_FillValue=" " ;
char PROFILE_FLAG(N_PROF, STRING4); // Profile flag (see Appendix A2.(1).8)
    PROFILE_FLAG:name="PROFILE_FLAG";
    PROFILE_FLAG:long_name="Data mode (R, A, or D), QC flags for position and observation date, and Number of
    profiles contained in the file" ;
char PROF_AQC_FLAG(N_PROF, STRING16); // Profile AQC flag (see Appendix A2.(1).9)
    PROF_AQC_FLAG:name= "PROF_AQC_FLAG ";
int LAYER_NUMBER(N_PROF); // Number of levels in each profile
    LAYER_NUMBER:name="LAYER_NUMBER";
    LAYER_NUMBER:long_name = "Number of the observed layers" ;
float PRES(N_PROF, N_LEVELS) ; // Pressure
    PRES:name = "PRES" ;
    PRES:long_name = "Pressure." ;
    PRES:units = "decibar" ;
    PRES:_FillValue = 9999.9f ;
char PRES_FLAG(N_PROF, N_LEVELS) ; // Pressure flag (see Table 2 in Appendix A4 for flag meanings)
    PRES_FLAG:name = "PRES_FLAG" ;
    PRES_FLAG:long_name = "Pressure QC Flag." ;
    PRES_FLAG:_FillValue = " " ;
float TEMP(N_PROF, N_LEVELS) ; // Temperature
    TEMP:name = "TEMP" ;
    TEMP:long_name = "Temperature.(ITS90)" ;
    TEMP:units = "degree_Celsius" ;

```

```

        TEMP:_FillValue = 99.999f ;
char TEMP_FLAG(N_PROF, N_LEVELS) ; // Temperature flag (see Table 2 in Appendix A4 for flag meanings)
        TEMP_FLAG:name = "TEMP_FLAG" ;
        TEMP_FLAG:long_name = "Temperature QC Flag." ;
        TEMP_FLAG:_FillValue = " " ;
float PSAL(N_PROF, N_LEVELS) ; // Salinity
        PSAL:name = "PSAL" ;
        PSAL:long_name = "Salinity.(PSS-78)" ;
        PSAL:units = "psu" ;
        PSAL:_FillValue = 99.999f ;
char PSAL_FLAG(N_PROF, N_LEVELS) ; // Salinity flag (see Table 2 in Appendix A4 for flag meanings)
        PSAL_FLAG:name = "PSAL_FLAG" ;
        PSAL_FLAG:long_name = "Salinity QC Flag." ;
        PSAL_FLAG:_FillValue = " " ;
char AQC_FLAG(N_PROF,STRING_N_LEVEL10) ; // AQC flag (see Appendix A2.(3).7)
        AQC_FLAG:name="AQC_FLAG";
        AQC_FLAG:long_name="AQC Flag.";
        AQC_FLAG:_FillValue=" ";

// global attributes:
        :title = "AQC [yyyymm]" ;
        :institution = " JAMSTEC/RCGC/Ocean Circulation Research Group";
        :source = "Argo float";
        :history = " yyyy-mm-dd creation" ;
        :references = "http://www.jamstec.go.jp/ARGO/argo_web/AQC/index_e.html";
        :comment = "free text";
        :conventions = "CF-1.6" ;

```

Note: As in Appendix A2, the processing level of the values stored in PRES, PRES_FLAG, TEMP, TEMP_FLAG, PSAL, and PSAL_FLAG differs according to the data mode ((1).8, fourth digit: Argo quality-control processing-status code).

Data mode	(1) 8. Value of the fourth digit	Variable in the AQC_Profile_Data file	Corresponding variable name in the Argo data file
R	9	PRES, TEMP, PSAL	[PRES/TEMP/PSAL]_Adjusted
		PRES_FLAG, TEMP_FLAG, PSAL_FLAG	[PRES/TEMP/PSAL]_Adjusted_QC
A	7	PRES, TEMP, PSAL	[PRES/TEMP/PSAL]
		PRES_FLAG, TEMP_FLAG, PSAL_FLAG	[PRES/TEMP/PSAL]_QC

A4. Code tables used in the dataset profile data files

Table 1. Data-centre codes (same as Reference Table 4 in the Argo User's Manual)

Code	Data-centre name and country
AO	AOML, USA
BO	BODC, United Kingdom
CI	Institute of Ocean Sciences, Canada
CS	CSIRO, Australia
GE	BSH, Germany
GT	GTS: used for data coming from WMO GTS network
HZ	CSIO, China Second Institute of Oceanography
IF	Ifremer, France
IN	INCOIS, India
JA	JMA, Japan
JM	JAMSTEC, Japan
KM	KMA, Korea
KO	KORDI or KIOST, Korea
ME	MEDS, Canada
NA	NOVA, USA
NM	NMDIS, China
PM	PMEL, USA
RU	Russia
SI	SIO, Scripps, USA
SP	Spain
UW	University of Washington, USA
VL	Far Eastern Region Hydrometeorological Research Institute of Vladicostock, Russia
WH	Woods Hole Oceanographic Institution, USA

Table 2. QC flags (same as Reference Table 2 in the Argo User's Manual)

Flag	Meaning
0	No QC was performed
1	Good data
2	Probably good data
3	Bad data that are potentially correctable
4	Bad data
5	Value changed
8	Interpolated value
9	Missing value

Table 3. Argo quality-control processing-status codes

Code	Meaning
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9	real time data
8	delayed mode data
7	real time data with adjusted values

Table 4. Codes for the profile AQC flag and the AQC flag at each level

Code	Meaning
0	Pass
1	Fail
2	Not applicable

A5. Comparison of AQC ver. 1.2 and ver. 1.3

Differences between the two versions are underlined.

Ver. 1.2	Ver.1.3
2. (2) Profiles subject to AQC 3. At an observed level other than an unpumped CTD level, at least one of the three rQC flags for pressure, temperature, and salinity [PRES_FLAG, TEMP_FLAG, PSAL_FLAG] is <u>1 (good), 2 (probably good), 3 (bad data that are potentially correctable), 5 (value changed), or 8 (interpolated value)</u>. In other words, a profile is excluded if all three rQC flags [PRES_FLAG, TEMP_FLAG, PSAL_FLAG] are 4 or 9 at every level.	2. (2) Profiles subject to AQC 3. At an observed level other than an unpumped CTD level, the pressure rQC flag [PRES_FLAG] is <u>1 (good), 2 (probably good), 3 (bad data that are potentially correctable), 5 (value changed), or 8 (interpolated value)</u>.
-	2. (2) Profiles subject to AQC 4. For a profile satisfying Conditions 1–3, at an observed level other than an unpumped CTD level where the pressure rQC flag [PRES_FLAG] is <u>1 (good), 2 (probably good), 3 (bad data that are potentially correctable), 5 (value changed), or 8 (interpolated value)</u>, at least one of the temperature and salinity rQC flags [TEMP_FLAG, PSAL_FLAG] is <u>1 (good), 2 (probably good), 3 (bad data that are potentially correctable), 5 (value changed), or 8 (interpolated value)</u>. A profile is excluded if both [TEMP_FLAG] and [PSAL_FLAG] are 4 or 9 at all levels.
	2. (2) Profiles subject to AQC 6. For duplicate observed levels (identical pressure values), the following record is <u>written to the AQC dataset.</u> (a) <u>Write a record for which [PRES_FLAG] is not 8.</u> (b) <u>If records other than those with [PRES_FLAG] = 8 are still duplicated, write the record that appears first when proceeding from shallow to deep levels.</u>
Ver. 1.2	Ver.1.3

3. (2) 2) 8. Profile AQC flag A nine-digit code in which each digit represents the result of one of the nine AQC tests (see Section 4), using 0 (pass) or 1 (fail) (see Appendix A3.(1).8 for details). For AQC Tests 4.(4)–(9), if at least one observed level fails a test, the corresponding digit is set to 1, meaning “fail.”	3. (2) 2) 8. Profile AQC flag A nine-digit code in which each digit represents the result of one of the nine AQC tests (see Section 4), using 0 (pass) or 1 (fail) (see Appendix A3.(1).8 for details). <u>For AQC Test 4.(4), if pressure is not subject to the check because every level has flag 4 or 9, the corresponding profile AQC flag digit is set to 9.</u> For AQC Tests 4.(4)–(9), if at least one observed level fails a test, the corresponding digit is set to 1, meaning “fail.”
4. (2) Number-of-levels check — Specific quality-control procedure <u>The check passes when the target profile contains at least 10 observed levels with a pressure value.</u>	4. (2) Number-of- levels check — Specific quality-control procedure <u>The check passes when the target profile contains at least 10 observed levels with a pressure value whose rQC flag [PRES_FLAG] is neither 4 (bad data) nor 9 (missing value).</u>
4. (4) Range check — Notes (including conditions excluded from the check) a. <u>For Item 1, pressure is excluded from the check at levels with no pressure value [PRES], or where the pressure rQC flag [PRES_FLAG] is 4 (bad data) or 9 (missing value).</u> b. For Item 2, temperature is excluded from the check at levels with no temperature value [TEMP], or where the temperature rQC flag [TEMP_FLAG] is 4 (bad data) or 9 (missing value). c. For Item 3, salinity is excluded from the check at levels with no salinity value [PSAL], or where the salinity rQC flag [PSAL_FLAG] is 4 (bad data) or 9 (missing value).	4. (4) Range check — Notes (including conditions excluded from the check) a. For Item 1, pressure is excluded from the check at levels where the pressure rQC flag [PRES_FLAG] is 4 (bad data) or 9 (missing value). b. For Item 2, temperature is excluded from the check at levels with no temperature [TEMP], or where the temperature rQC flag [TEMP_FLAG] is 4 (bad data) or 9 (missing value). c. For Item 3, salinity is excluded from the check at levels with no salinity [PSAL], or where the salinity rQC flag [PSAL_FLAG] is 4 (bad data) or 9 (missing value). <u>d. Levels with $P < 0$ are excluded from the check.</u>
Ver. 1.2	Ver.1.3
4. (8) Observed-level spacing check — Notes (including conditions excluded from the check) Levels deeper than 2000 dbar are excluded from the check.	4. (8) Observed-level spacing check — Notes (including conditions excluded from the check) a. Levels deeper than 2000 dbar are excluded from the check.

	b. Levels shallower than 0 dbar are excluded from the check. c. If the profile contains one or fewer observed levels whose pressure rQC flag [PRES_FLAG] is neither 4 (bad data) nor 9 (missing value), all levels are excluded from the check.
4. (9) Error check — Specific quality-control procedure <u>At every grid point and standard level (102 levels) in the annual mean World Ocean Atlas 2013 (hereafter WOA), the error for temperature and salinity is defined as the combination of measurement error and natural-variability error, as follows.</u> Temperature error: $T_e = [(0.005^\circ \text{ C})^2 + (\text{WOA temperature standard deviation})^2]^{1/2}$ Salinity error: $S_e = [(0.01 \text{ psu})^2 + (\text{WOA salinity standard deviation})^2]^{1/2}$ <u>For the target profile, determine whether the temperature and salinity at the observed level nearest each WOA standard level and within ± 10 dbar of that level fall within $\pm 10T_e$ and $\pm 10S_e$, respectively, of the value at that level at the WOA grid point nearest the target Argo profile. The check is performed at all WOA standard levels shallower than or equal to 1950 m.</u>	4. (9) Error check — Specific quality-control procedure <u>At every grid point and standard level (102 levels) in the annual mean World Ocean Atlas 2023 (hereafter WOA), the error for temperature and salinity is defined as the combination of measurement error and natural-variability error, as follows.</u> Temperature error: $T_e = [(0.005^\circ \text{ C})^2 + (\text{WOA temperature standard deviation})^2]^{1/2}$ Salinity error: $S_e = [(0.01 \text{ psu})^2 + (\text{WOA salinity standard deviation})^2]^{1/2}$ <u>For the target profile, determine whether the temperature and salinity at the observed level nearest each WOA standard level and within ± 10 dbar of that level fall within $\pm 10T_e$ and $\pm 10S_e$, respectively, of the value at that level at the WOA grid point nearest the target Argo profile. The check is performed at all WOA standard levels shallower than or equal to 2000 m.</u>
4. (9) Error check — Notes (including conditions excluded from the check) a. Levels deeper than 1950 dbar are excluded from the check. b. Temperature is excluded from the check at levels with no temperature value [TEMP], or where the temperature rQC flag [TEMP_FLAG] is 4 (bad data) or 9 (missing value). c. Salinity is excluded from the check at levels with no salinity value [PSAL], or where the salinity rQC flag [PSAL_FLAG] is 4 (bad data) or 9 (missing value).	4. (9) Error check — Notes (including conditions excluded from the check) a. Levels deeper than 2000 dbar are excluded from the check. b. Temperature [TEMP] and salinity [PSAL] are excluded from the check at levels where pressure [PRES] is excluded from the “(4) Range check.” c. Temperature [TEMP] is excluded when it is not subject to the “(4) Range check.” d. Salinity [PSAL] is excluded when it is not subject to the “(4) Range check.” e. Temperature is excluded from the check at levels with no temperature [TEMP] or with a temperature rQC flag [TEMP_FLAG] of 4 (bad data) or 9 (missing value). f. Salinity is excluded from the check at levels with no salinity [PSAL] or with a salinity rQC flag [PSAL_FLAG] of 4 (bad data) or 9 (missing value). g. If no temperature profile is available at the WOA grid point nearest the target profile, or if fewer than 10 profiles were used to construct the temperature profile at that

	<u>WOA grid point, temperature [TEMP] is excluded from the check at all levels of the target profile.</u> <u>h. If no salinity profile is available at the WOA grid point nearest the target profile, or if fewer than 10 profiles were used to construct the salinity profile at that WOA grid point, salinity [PSAL] is excluded from the check at all levels of the target profile.</u>
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