Quality Control of Argo Data Based on High Quality Climatological Dataset (HydroBase) I

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Abstract: By the Argo project, a large number of T-S profiles can be observed in the world ocean. However, it is very difficult to examine changes of the sensitivity of the sensors equipped at the Argo floats, because it is difficult to understand their condition in the sea. One of the most realistic methods for quality control of the Argo data is the comparison with the local climatology in the deep layer. JAMSTEC/FORSGC uses the climatological data set, HydroBase (Macdonald et al., 2001) for the quality control. We attempt to check the Argo data with higher quality based on the two advantages of HydroBase, its high quality climatological dataset and its excellent quality control method. We explain some of the quality control methods of the Argo data which have been developed.

Keywords: Argo project, Quality Control, HydroBase

1. Introduction

The Argo project, an international project launched in 2000, enables high-resolution and real-time observations of the surface and middle layers of the oceans (e.g., Mizuno, 2000). Argo floats carry out the observations, providing vertical profiles of temperature and salinity using the onboard pressure, temperature, and conductivity sensors as they resurface every 10 days from their parking depths (approximately 2000 m). Nearly 3,000 floats will be deployed in the global ocean in the Argo project, and approximately 100,000 temperature and salinity profiles will be observed annually.

Compared to observations using vessels, it is difficult to directly monitor the conditions of the onboard sensors of the Argo floats once they are deployed in the ocean. Also and it is extremely difficult to determine the cause of sensor deterioration during the drift of the floats in the ocean. Therefore, evaluating the quality of the data obtained by the Argo floats (Argo data) and, if possible, correcting the Argo data to obtain high-quality data is important for the project. Furthermore, it is necessary to perform such evaluation on a large amount of data within a limited period of time. Therefore, we can say that the success of the Argo project depends on the efficiency of the data quality control.

Needless to say, the optimal method of making quality evaluations of and corrections to Argo data would utilize data observed by vessels in the vicinity of the data point as standards. However, such a method could not be applied to all Argo data, and alternative methods must therefore be established. Generally, the temperature and salinity in deep layers are considered to be relatively stable. Therefore, the most practical method for making quality evaluations of and corrections to Argo data is to compare them for the deep layers to local climatology. Such a method has been adopted by some organizations. For example, at the University of Washington, Wong et al. (2001) is developing a correction method for salinity data using profile data from the World Ocean Database 1998. At the Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia, salinity data are corrected using the WOCE-CTD data obtained in the vicinity of floats (CSIRO, 2001).

As the standards for Argo data quality control, Argo team of JAMSTEC/FORSGC uses two climatological databases, the World Ocean Atlas 1998 (WOA98) and HydroBase (Macdonald et al., 2001). The former is the best-known climatological dataset. The latter is a dataset system consisting of historical profile data with independent quality control and related software for data processing. HydroBase is known not only for its high-quality dataset, but also for its data quality-control method designed to enhance the quality of the dataset. Here, we will report some quality control methods of Argo data in JAMSTEC/FORSGC, to which all system of HydroBase is applied such as high-grade climatological dataset and data quality-control methods.

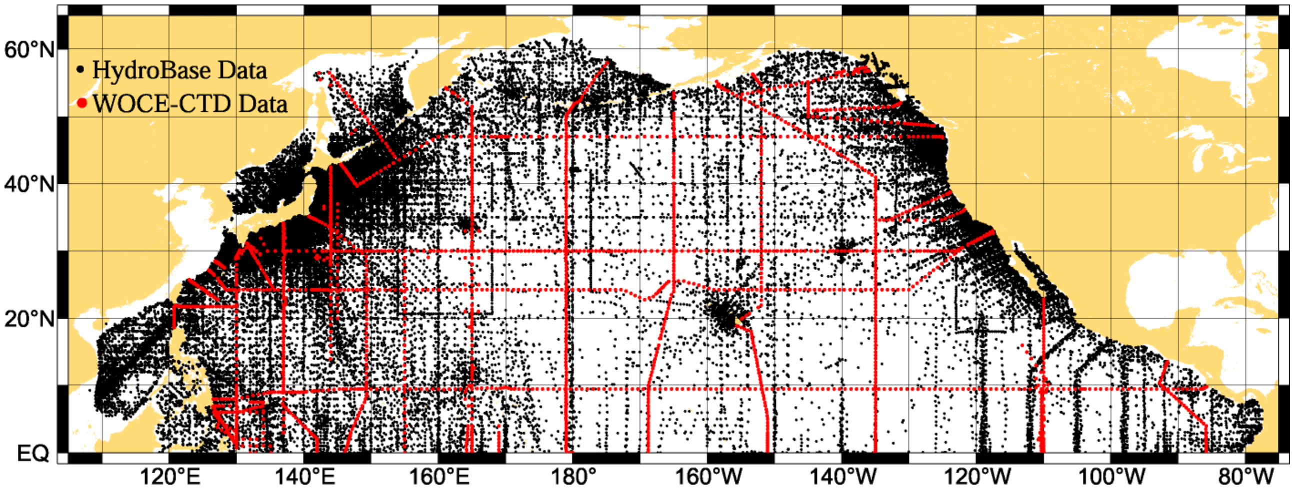

Figure 1: Horizontal distribution of the climatological data for quality control of Argo data in the North Pacific.

2. Climatological Dataset

For the quality control and correction of Argo data, the standard climatological dataset should be as large and high-grade as possible. Therefore, in addition to the quality-controlled data of HydroBase, we will use CTD data of the One-Time and Repeat Sections in WOCE/WHP program (hereafter WOCE-CTD dataset) as the climatological dataset for the quality control of Argo data in the North Pacific. They are the most recent data which were already published on April 2001, and their vertical intervals are normally 1 or 2 dbar.

2.1 HydroBase Data

Basically, all of the HydroBase data are adopted. However, anomalous data are included in some regions, so such data is removed manually (visually) to enhance the quality of dataset (regions of Marsden Square Number (MSN) 1013, 1213, 1215, 1313, 1314, 1315, 1414, 1415, 1416, 1515, 1516, and 7314). In addition, the quality control in the deep layer of the Sulu Sea is wrong (ignoring the locality of the water-mass structure), so the data for this region (MSN 1011, 1012, and 1112) is replaced by a new set created from raw data through quality control processing similar to that used by Macdonald et al. (2001). In the HydroBase, there is a region for which some data are missing (MSN 7312) and a region for which there is no quality-controlled data (MSN 1617). Thus, we conduct the quality control on the raw data for these regions, and they are added to the set.

2.2 WOCE-CTD Data

Only the WOCE-CTD data with quality flags of either “good” or “raw” is used. However, even among the “good” data, some should be anomalous considering the surrounding conditions, and such data are excluded through manual (visual) quality control.

As previously mentioned, the standard climatological dataset should be as large and high-grade possible for the quality control of Argo data. The WOCE-CTD data should fully satisfy these conditions. In addition, climatological dataset should sufficiently reflect the climatological conditions. The WOCE observations were conducted within a short period, and much of them consisted of snapshot observations that were only made once, so the WOCE-CTD dataset does not necessarily satisfy the last condition. The large amount of WOCE-CTD data, however, may distort the standards for Argo quality control because WOCE-CTD data can be strongly affected by the sea conditions at the time the observations, not the climatology. Therefore, to reduce such risks the WOCE-CTD data are given less weight by being sampled at 10-dbar intervals. In addition, data which seem to reflect climatologically rare conditions are excluded from the dataset with the HydroBase data used as a reference.

The numbers of stations of HydroBase and WOCE-CTD data in the climatological dataset for the quality control of Argo data are approximately 115,000 and 3,500, respectively. Their distributions are shown in Figure 1.

3. Climatological Standard for the Quality Control of Argo Data

Climatological standards for the quality control of Argo data are created from the climatological dataset described in section 2. The method used is similar to that for quality control of the compilation of HydroBase, and it is expected to maximize the advantages of HydroBase. The method is outlined below.

3.1 Geographical Binning

The North Pacific is divided into numerous subregions considering the density of the observation and the spatial variations of water-mass structures. In the deep layers below 1000 m, the spatial variations in water-mass are not as large as in the surface layer. So relatively large grids (normally 10° x 10°) are used in the deep layers, with the bottom topography taken into consideration. In regions with few observations and large spatial variations in water-mass structure, the latter factor is given weight; so (relatively) finer grids are used.

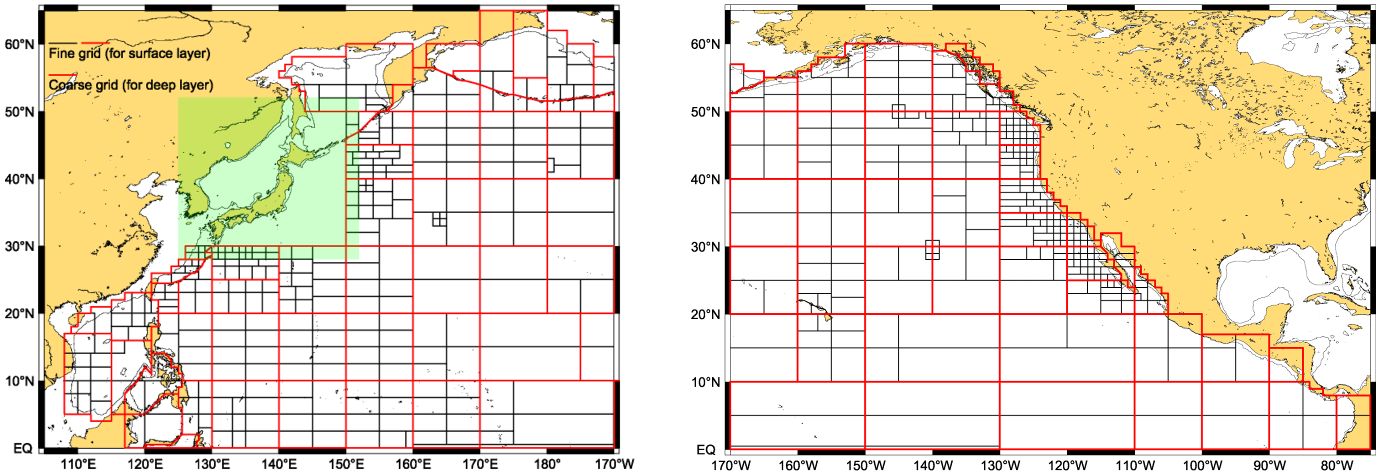

Figure 2: Horizontal geographical binning for quality control of Argo data in the North Pacific. The light-green-hatched area around Japan represents the area shown in Figure 3.

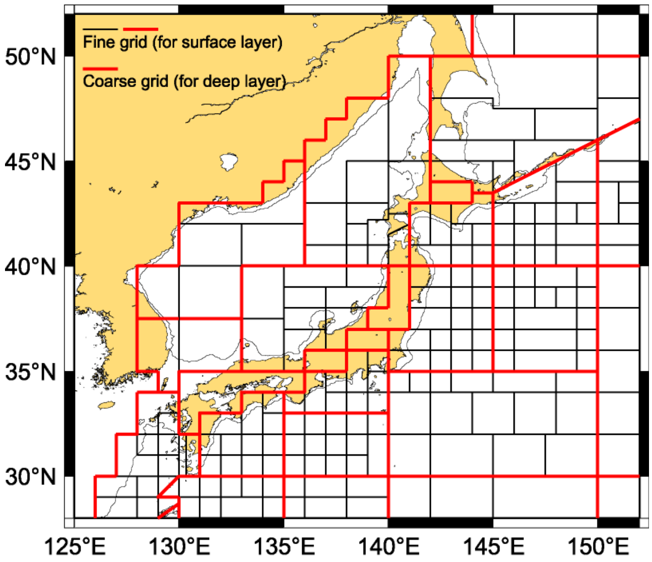

Figure 3: Same as Figure 2 but for the neighborhood of the Japan.

Figures 2 and 3 show the geographical binnings applied in the North Pacific and near Japan, respectively. Near Japan where dense observations are conducted (Figure 1), extremely fine grids (primarily 1° x 1°) are used. On the other hand, in the internal regions of the subtropical gyre and in the tropics, the grids are extremely large (maximum longitudal 20° x latitudal 5°) due to the sparse observation and small spatial variations in water-mass structure. The total numbers of ht subregions in the surface layer (above 1000 m) and the deep layer (below 1000 m) are approximately 800 and 100, respectively.

The geographical binnings are determined through trial and error, but the method used follows certain rules to facilitate the operation, management, and updating of the database for the quality control of Argo data. They are as follows:

- The basic unit of division (Geographical Unit) is a 1° x 1° grid. Exceptionally, both of the two regions which a 1° x 1° grid divides in by a straight line are also considered Geographical Unit.
- A subregion in the surface layer consists of either a single Geographical Unit or multiple connections of them.
- A subregion in the deep layer consists of either a single subregion for the surface layer or multiple connections of them.

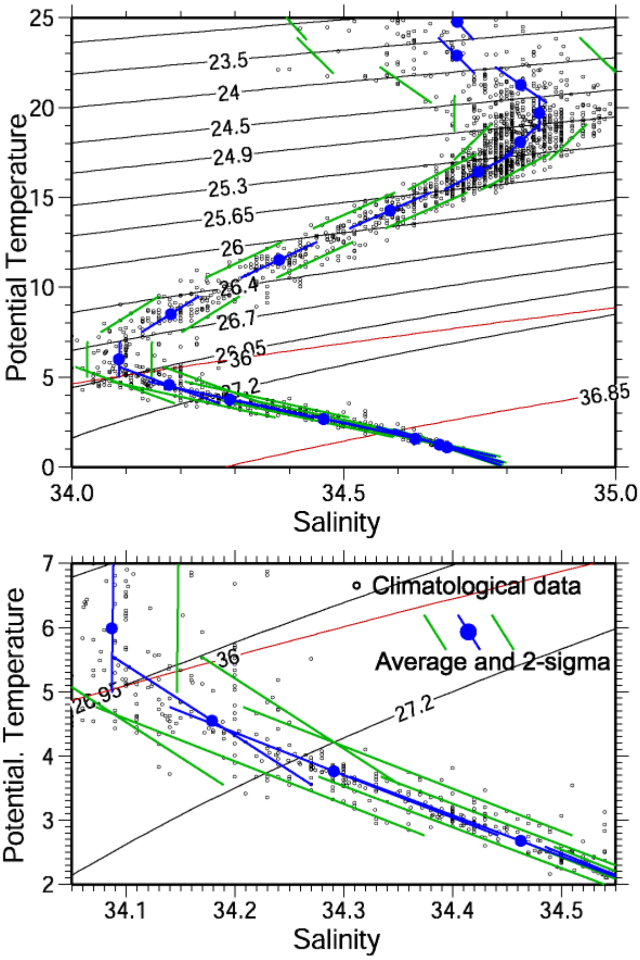

Figure 4: An example of the digitized T-S structure of the water-mass based on the climatological data.

Table 1: An example of the digitized T-S structure of the water-mass based on the climatological data.

	sbin−u	sbin−l	Tmean	Smean	T/S	slope	y−cept	Std.D.	data #
1	18.00	22.00	28.606	34.574	T	−0.02643	35.330	0.1233	43
2	22.00	22.50	27.460	34.605	T	−0.01455	35.004	0.1588	89
3	22.50	23.00	26.084	34.611	T	−0.03859	35.618	0.1626	119
4	23.00	23.50	24.758	34.709	T	−0.03043	35.462	0.1534	94
5	23.50	24.00	22.891	34.708	T	−0.03346	35.474	0.1301	81
6	24.00	24.50	21.251	34.826	T	−0.04729	35.831	0.1062	123
7	24.50	24.90	19.685	34.860	T	0.00039	34.852	0.0778	278
8	24.90	25.30	18.078	34.825	T	0.03425	34.206	0.0437	612
9	25.30	25.65	16.423	34.748	T	0.06268	33.719	0.0336	634
10	25.65	26.00	14.263	34.586	T	0.07493	33.517	0.0332	351
11	26.00	26.40	11.525	34.381	T	0.07021	33.572	0.0326	360
12	26.40	26.70	8.507	34.182	T	0.05306	33.730	0.0371	331
13	26.70	26.95	5.987	34.087	T	0.00062	34.084	0.0298	311
14	26.95	27.20	4.551	34.179	T	−0.09135	34.595	0.0406	463
15	27.20	29.00	3.759	34.291	T	−0.15107	34.859	0.0339	138
16	36.00	36.85	2.674	34.463	T	−0.15681	34.882	0.0143	1939
17	36.85	38.00	1.582	34.632	T	−0.14752	34.866	0.0044	1905
18	45.00	45.87	1.227	34.676	T	−0.11702	34.820	0.0027	1404
19	45.87	48.00	1.084	34.690	T	−0.09867	34.797	0.0021	1524

The 1° x 1° grids used as the Geographical Unit will be sufficient as the minimum unit for defining the spatial variations in water-mass structure in the oceans. Furthermore, by dividing the 1° x 1° grids using straight lines, we can more precisely express the regions segmented by land and bottom topography, such as island arcs (and ridges) and peninsulas (discussed in a later section).

3.2 Digitization of Water-Mass Structure in Each Subregion

The means and standard deviations of temperature and salinity in each preset density bin (approximately 20 bins, though it differs by region) are calculated for each subregion. In the calculations, the number of observation data for each bin should be more than 30. When the number of data falls to below 30 in many density bins, the settings of the density bins and/or subregions are changed. However, as priority is given to reconstructing the spatial variations in the water-mass structure, some statistical values for pycnocline are calculated by the data less than 30.

By connecting the temperature and salinity averages in each density bin consecutively using linear lines, the averaged T-S profile can be obtained for each subregion. Also, the (salinity) variations of the T-S profile can be calculated from the standard deviations of temperature and salinity. As a result, the climatological average T-S profile and the range of its variations in the water-mass structure for each geographical binning can be obtained, and the spatial distribution of the water mass can be digitized (Figure 4 and Table 1).

3.3 Seasonal Variations in Water-Mass Structures

The water-mass structure in the surface layer will have seasonal variations due to such as summer heating and winter cooling. The maximum variations are seen at the sea surface, and the variations become smaller according to the depth, and below a certain depth the variations due to the seasonal change cannot be distinguished from those due to other reasons. Kobayashi et al. (2001) studied to what depth seasonal variations extend, but were unable to reach a clear

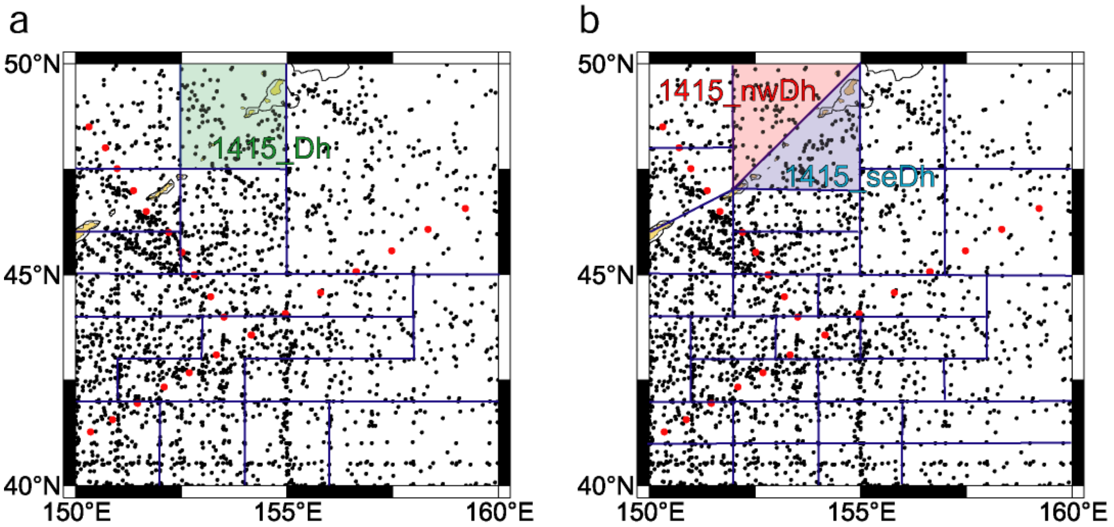

Figure 5: An example of the improvement of the geophysical binning in the region MSN 1415. (a) Macdonald et al. (personal communication) and (b) this study.

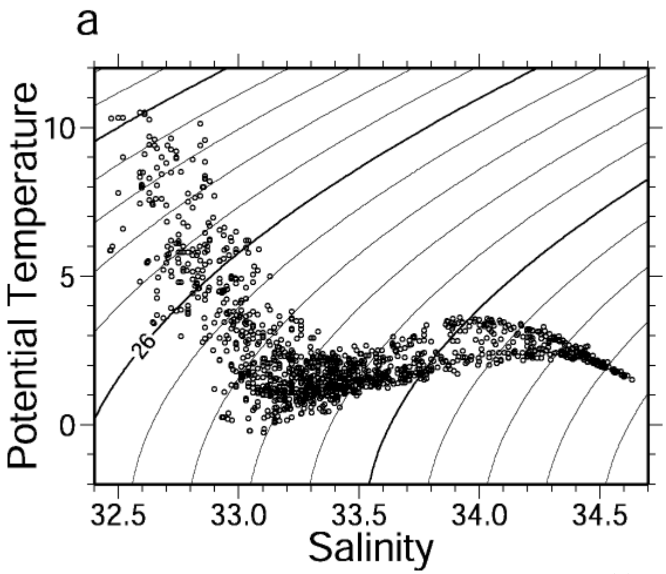

Figure 6: T-S diagram of the climatological data in (a) the area 1415_Dh and (b) the areas 1415_nwDh (red) and 1415_seDh (blue).

conclusion. Therefore, standards for quality control are prepared for the entire year and for each of the four seasons, winter (Jan.–Mar.), spring (Apr.–June), summer (July–Sep.), and autumn (Oct.–Dec.), to perform two-stage quality control.

However, the main purpose of quality control is to determine whether the obtained Argo data are climatologically valid. Therefore, high-grade quality control throughout the four seasons can be conducted in the only limited regions such as near Japan and North America where observations are densely conducted.

3.4 Advantages of the Quality Control Similar to HydroBase

As previously mentioned, the size of the region for calculating the climatological water-mass structure can be made dependent on the number of observations (to a certain extent). As a result, in regions where dense observations are carried out (in many cases, regions in which spatial variations in water-mass structure are large, such as in the frontal zones), quality control can be provided with an exceptionally high spatial resolution. This is one of the superiority of HydroBase in the quality control to the other datasets such as WOA98, which is made with the same (strong) spatial smoothing for all regions.

Furthermore, in many datasets such as WOA98, climatological water-mass structure is calculated by the isobathymetric averages. It was pointed out that such procedures generate unrealistic "average" water-masses resulting from the averaging of different density waters when the isopycnal surface is inclined (Macdonald et al., 2001). The HydroBase performs averaging on the isopycnal surface to avoid this problem. This is another of the most outstanding features of the quality-control method of HydroBase.

Creating a standard dataset for the quality control of Argo data, we use to the fullest extent the advantages of the HydroBase, such as high-grade climatological dataset and the superior quality-control methods. Thus, it is expected that the Argo-data quality-control system of JAMSTEC/FORSGC will be able to perform quality control with extremely high-grade.

In the following sections, the geographical binning actually used is explained in detail using two examples.

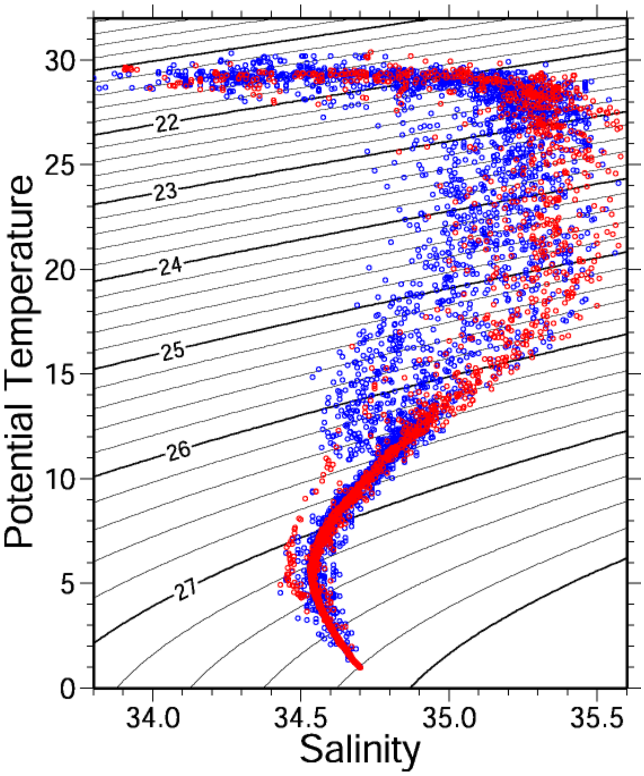

Figure 7: T-S diagram of the climatological data in the areas 0-0.5°N (red) and 0.5-2.5°N (blue) in the tropical region of 160-170 °E.

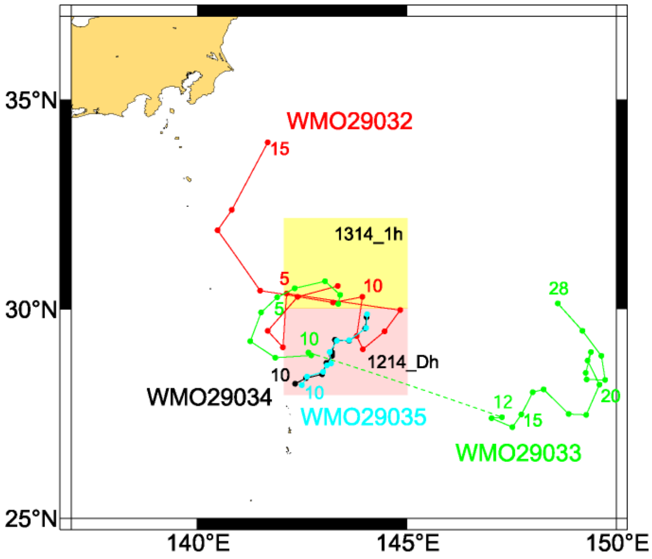

Figure 8: Horizontal distribution of the observations by the Argo floats (WMO 29032, 29033, 29034, and 29035). Note that the location of the profile number 11 of WMO29033 was not measured.

3.4.1 Regions Near Kuril Islands

It is well known that the water-mass structure changes largely between the Sea of Okhotsk and the subarctic Pacific (e.g., Ohtani, 1989). However, Macdonald et al. (personal communication) used the geographical binnings straddling the Kuril Islands (Figure 5a). Standard data containing two different water masses (Figure 6a) will cause the following problems that will reduce the grade of quality control:

- The standards will have wider criteria.
- The standards will reflect the bias in the spatial distribution of observations.

Generally, the regions with wider criteria are considered as the regions with large temporal/spatial variations; thus significant changes in observation data tend to be valid. It can lead to a reduction in the grade of quality control. When there are large differences in the number of observations in regions of different water-masses, the standard for quality control should be biased toward the region with more observations. In such a case, the quality control of data obtained in the region with fewer observations will be conducted using standards mainly based on the different water-mass and, as a result, normal data can be evaluated as "anomalous".

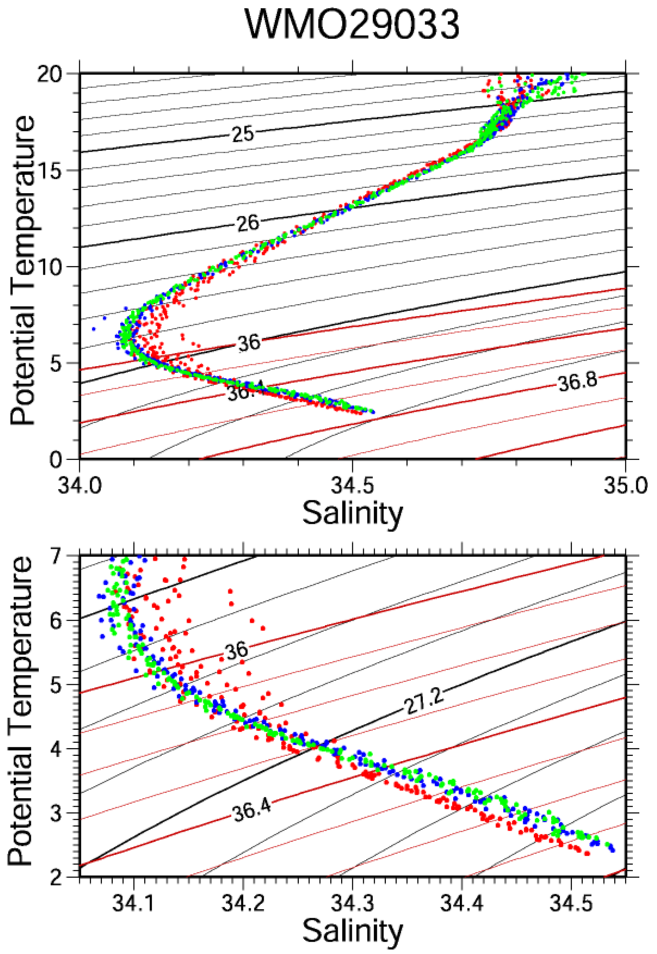

Figure 9: T-S diagram of the observed data by Argo float, WMO 29033. The red, blue, and green circles show the profiles of #1-10, #12-19, and #20-28, respectively.

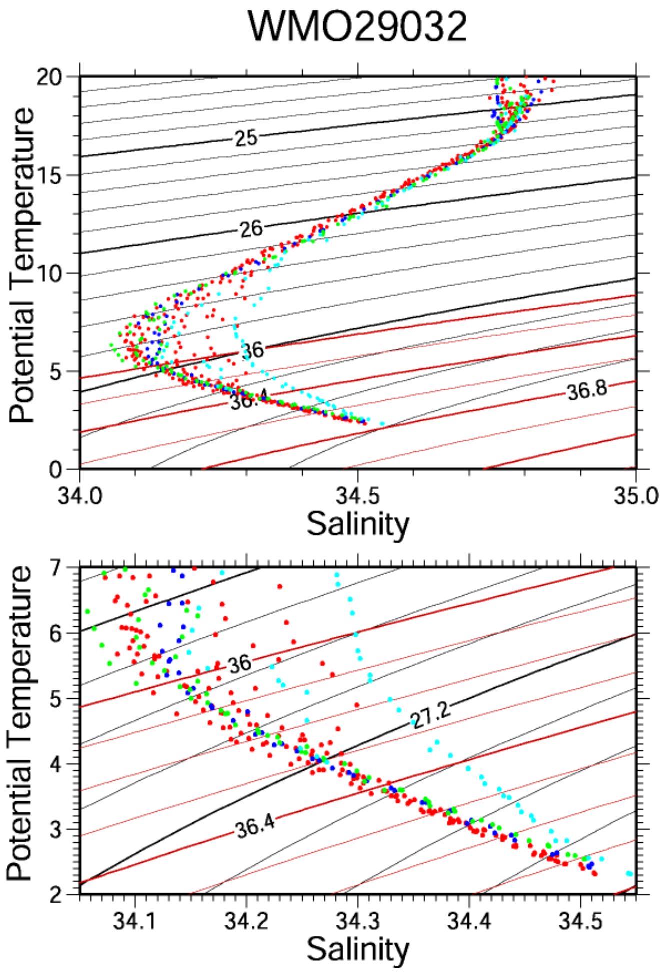

Figure 10: T-S diagram of the observed data by Argo float, WMO 29032. The red, blue, green, and light-blue circles show the profiles of #1-8, #9-10, #11-13, and #14-15, respectively.

For the reasons specified above, we improve the geographical binnings to prepare respective standards for the regions of the Sea of Okhotsk and the subarctic Pacific (Figure 5b). In this way, the two water-masses can be clearly distinguished (Figure 6b) and the grade of the quality control will be enhanced.

3.4.2 Regions Near the Equator

As observations in the tropics are generally sparse, the geographical binnings are normally very large. However, the water-mass structures less dense than 26.7 σ_0 change drastically at 0.5°N (Figure 7). To represent this spatial variation, we use zonally narrow grids near the equator, even when the number of observations in each density bin becomes much smaller than 30.

4. Methods for Quality Control of Argo Data

Through the study in our group, the preliminary methods for quality control of Argo data are devised, and some of them will be briefly explained below. The distribution of Argo observations used in this report is shown in Figure 8.

4.1 Visual Check of the Drift of the T-S Profile Clusters

Figure 9 shows temporal changes of the T-S profiles obtained by float WMO29033. In the deep layers, the observed salinity values are approximately 0.02 psu higher after the 12th cycle compared to before that. During this period, this float could not resurface for nearly 3 months in the summertime due to a lack of float's buoyancy (Izawa et al., 2001), and it was considered to drift near the sea surface. This period is referred to as the "summer vacation" in our group, hereafter this term will be used in this report. The float observations before and after the "summer vacation" are located far apart (Figure 8), but the regional variations in the deep water-masses are extremely small based on climatological data. Therefore, this salinity drift is believed to be caused by the change in the sensitivity of the sensor onboard the float.

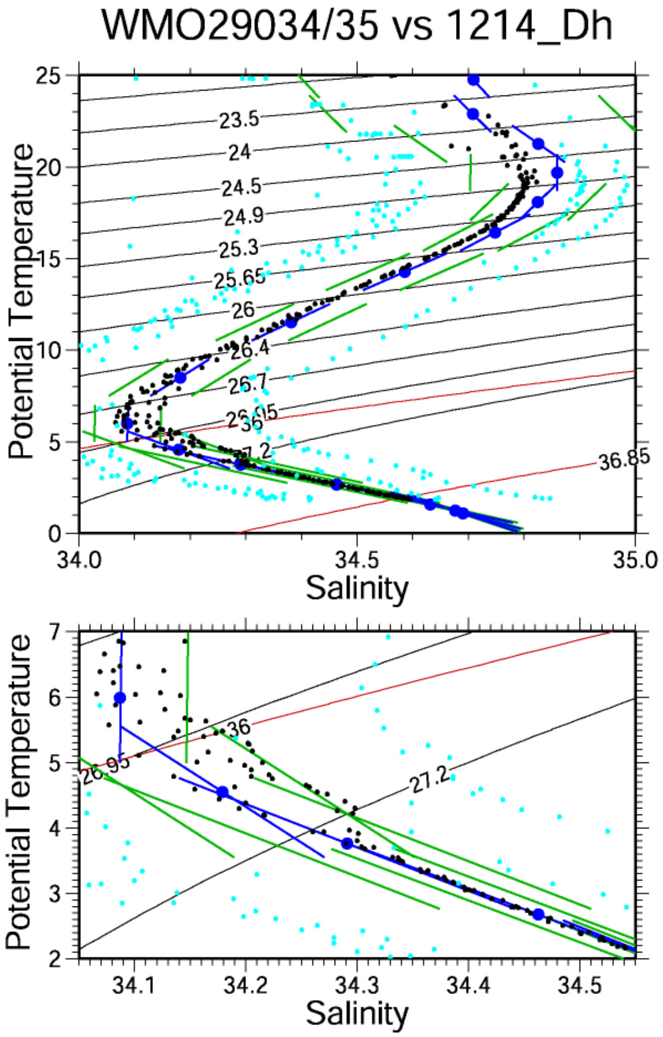

Figure 11: An example of quality control results by the method 4.2. The black and light-blue circles show the observations by WMO 29034 and 29035, respectively.

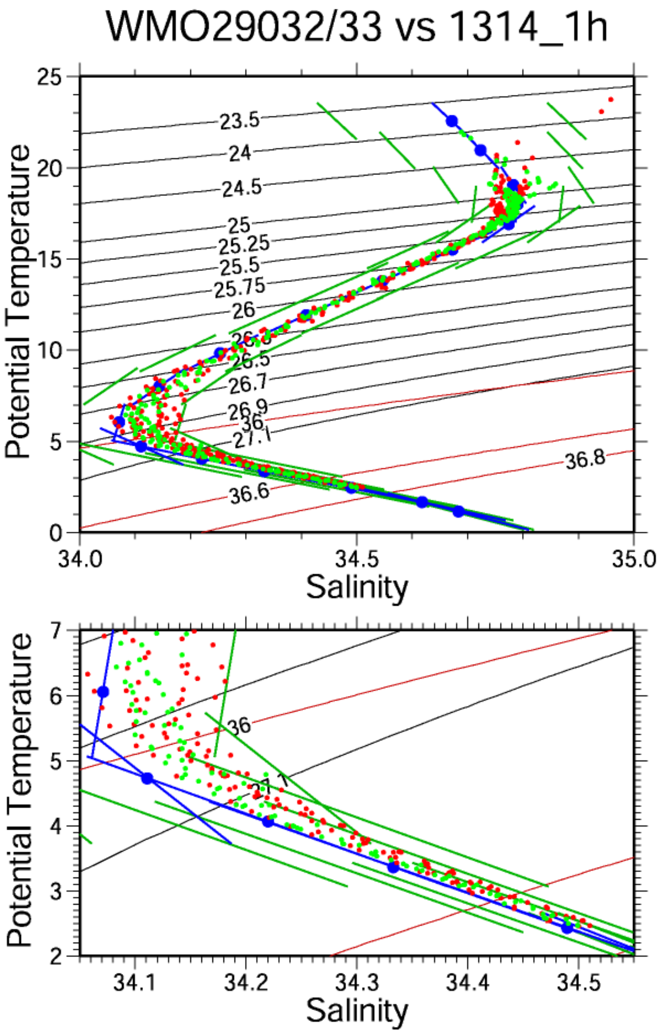

Figure 12: An example of quality control results by the method 4.2. The red and green circles show the observations by WMO 29032 and 29033, respectively.

Figure 10 shows another example of WMO29032 observations. The measured salinity values begin to gradually increase around the 9th cycle. After the 11th cycle, the salinity values are 0.02-0.03 psu higher than those measured immediately after deployment. This float stays in almost the same region before the 12th cycle (Figure 8), so this salinity drift is definitely attributed to the change in sensor sensitivity.

As is described above, we can detect the changes in sensor sensitivity onboard float through the visual check of the drifts of the T-S profile cluster obtained by the float. This method is extremely primitive and simple, and also data quality control can be provided with high grade considering that 0.02 psu salinity shift can be detected clearly. However, the entire process must be carried out manually, making it unsuitable for processing large amounts of data. Other problems are also involved, such that different results can be obtained due to the level of experience of the person processing the data.

4.2 Comparison With the Local Climatology

As is described in the section 3, we calculate the averaged T-S profile and its variability for each subregion, the local climatology, from the historical profile data. Comparing the Argo data with the local climatology, we can examine whether the data are climatologically valid or not.

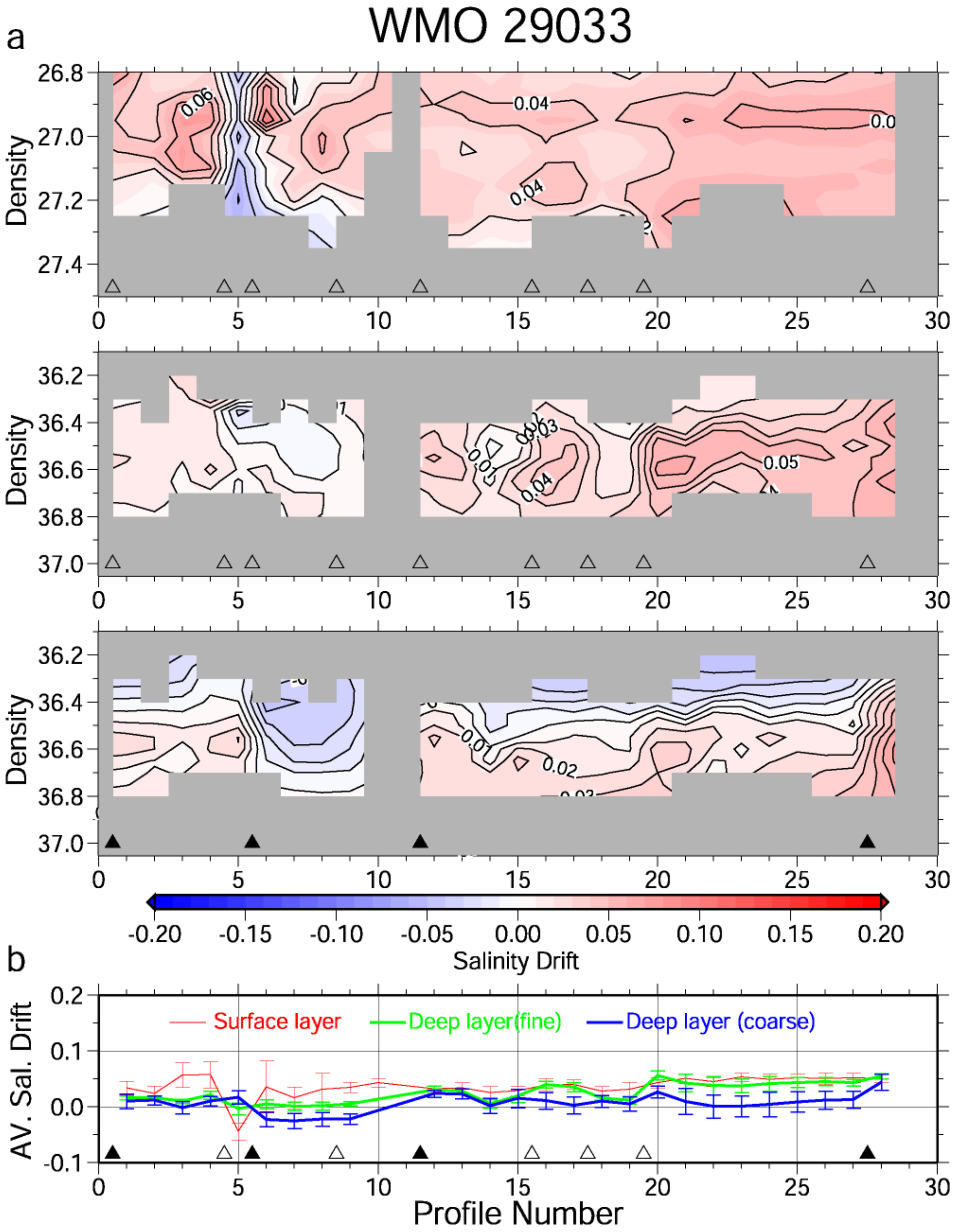

Figure 13: Results of quality control by the method 4.3 for WMO 29033. (a) Time series of salinity deviations from the local climatology in the layers above 1000 m (upper panel) and below 1000 m (fine/coarse geophysical binning: middle/lower panel), respectively, and (b) their averages and standard deviations. The open/filled triangles represent the change of the fine/coarse geophysical binning, respectively.

Figure 11 shows an example of a comparison made between data measured by floats WMO29034 and WMO29035 and the local climatology for the region 1214_Dh (see Figure 8). The envelope of green segments shows the 2σ criteria (σ is standard deviation) for the climatological variation in this region. The observed data should fall within the criteria with a probability of 95% when the climatological variations follow a normal distribution. Thus, if the Argo data is without this range, the data can be considered climatologically invalid. It can be seen that the data for WMO29035 fall completely outside this range. This float reported abnormal data probably due to malfunctions in its hardware, and the invalidity of the data can also be confirmed.

Figure 12 compares the observations for WMO29032 and 29033 to the local climatology for the region 1314_1h (see Figure 8). The data from WMO29032 include that for the after salinity drift, but they are also evaluated as "climatologically valid" data. The climatological variability (standard deviation) at 1,500 dbar is 0.017 psu in this region, so a salinity drift of 0.02 psu cannot be perceived.

This method is so simple that it is very easy to automate its quality control procedures. But it is only effective for data that is clearly invalid, and cannot be used to identify small shifts in salinity. In other words, data that are determined to be anomalous by this method have no need to make any quality control with higher grade. Thus, it will be most effective as the first step in quality control.

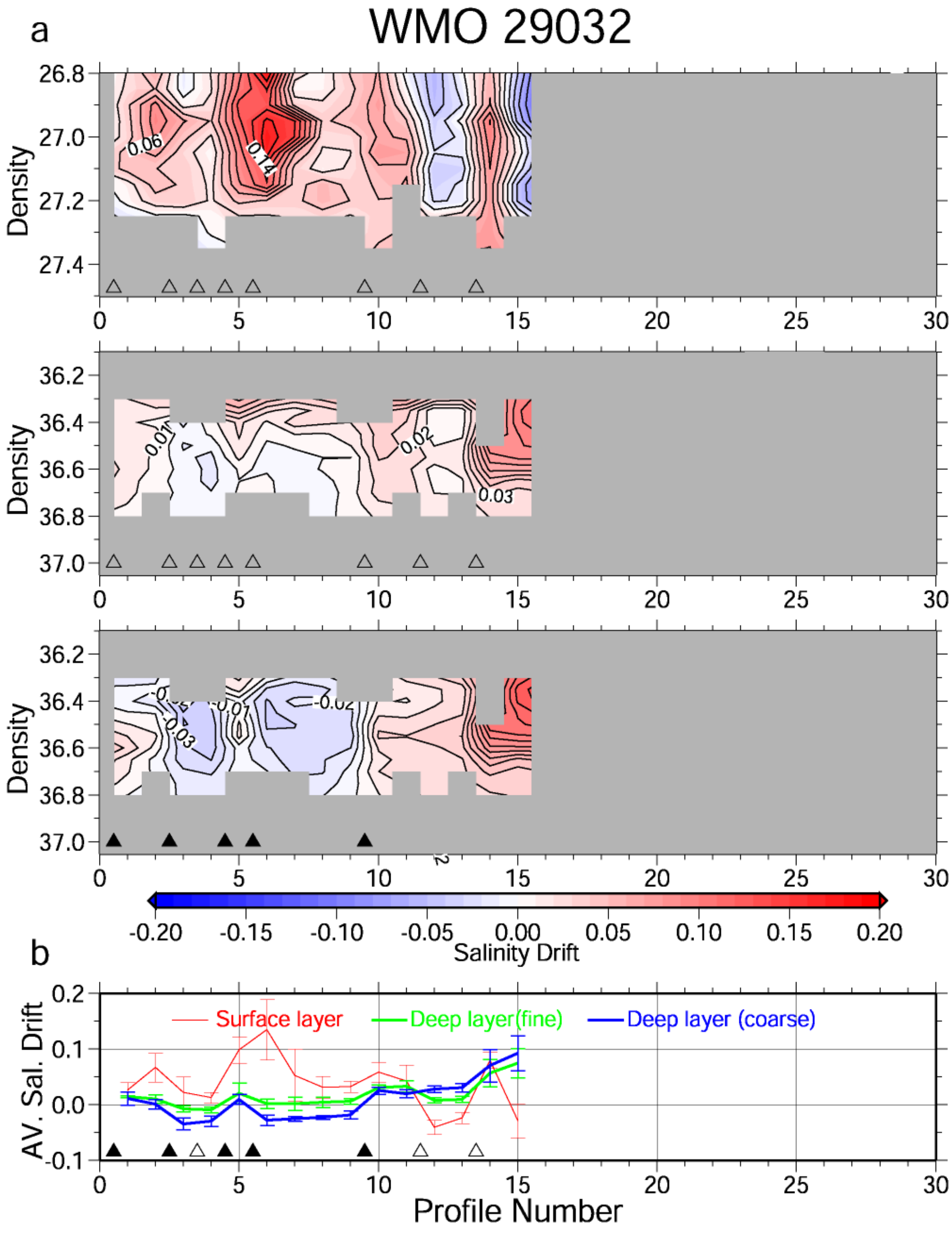

Figure 14: Same as Figure 13 but for WMO 29032.

4.3 Long-Term Trend of Salinity Deviations From the Local Climatology

The sensitivity changes of the sensors onboard Argo floats affect all measurements regardless of float location, and all of the data will drift toward either higher or lower salinities. Thus, it should be possible to detect salinity drift on the float measurements by examining the long-term trend of salinity deviations from the local climatological T-S profiles.

Figure 13a shows a time series of salinity deviation from the local climatology for WMO29033. Large changes at several points are caused by the changes of referential T-S profiles due to the movement of the float crossing the subregion boundaries. Therefore, these shifts are apparent ones. Before the equipped sensor suffers some damages (to the 10th cycle), the deviations are relatively small (nearly 0) in the deep layers. In contrast, after the 12th cycle, the deviations continuously show values approximately 0.02-0.05 psu higher than the local climatology for the fine grids. The results for the coarse grids have the trend similar to those for the fine grids, however, the changes in the vertical direction are also large; denser layers shift to relatively higher salinity, while less dense layers shift to relatively lower salinity. To examine the overall features of the salinity drift, the averages and standard deviations of the salinity deviations in the surface and the deep layer are shown in Figure 13b. Prior to "summer vacation", the deviations in the deep layer are almost 0 even though they do show significant values due to some temporary variations in the ocean. In contrast, after changes occur in the sensor sensitivity, the values continue to be positive and do not return to 0. This contrast suggests the occurring the salinity drifts of the floats measurements during the

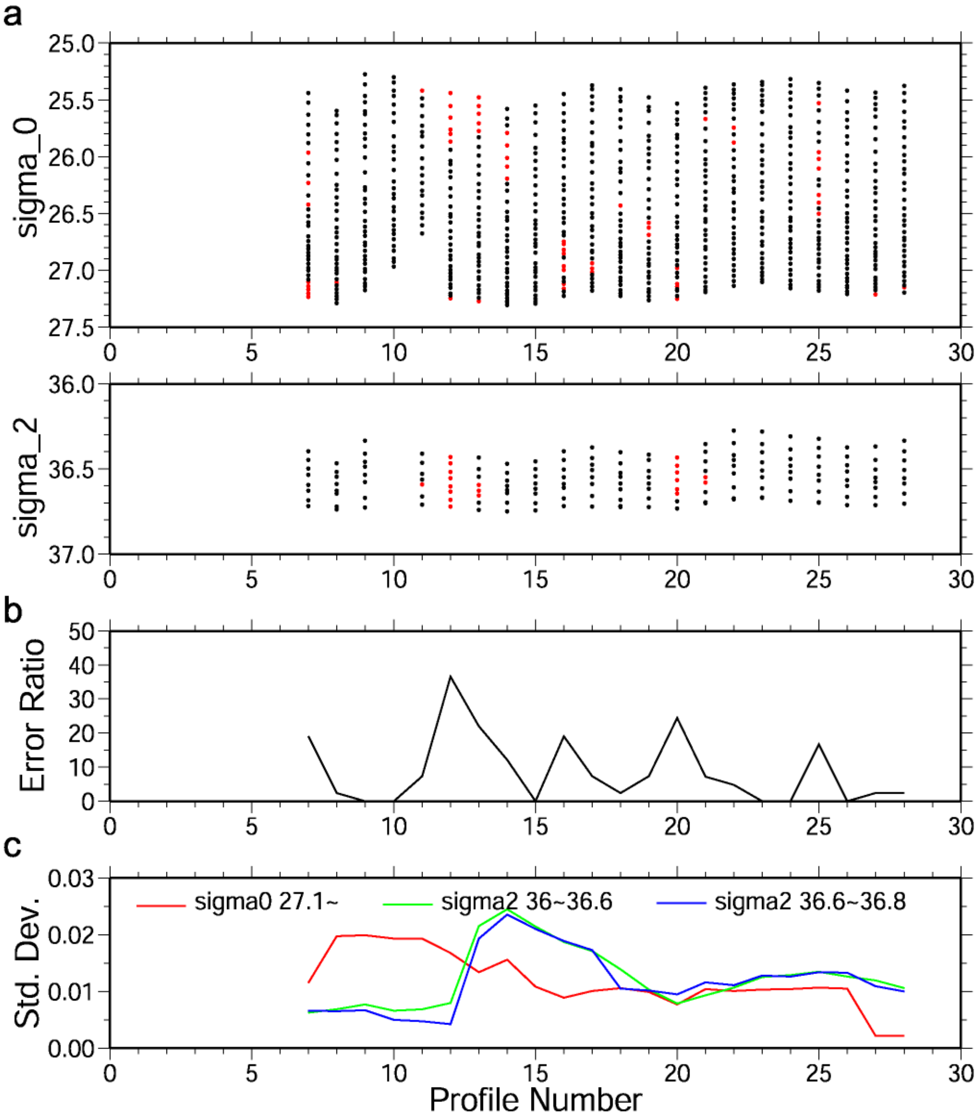

Figure 15: Results of quality control by the method 4.4 for WMO 29033. (a) Time series of expected (black) and unexpected (red) data above 1000 m (upper panel) and below 1000 m (lower panel), (b) the ratio of the unexpected data, and (c) standard deviations of salinity used for the check, respectively.

"summer vacation" and it is particularly evident with using the fine geographical binning. Values of the salinity deviations are generally about 0.02-0.03 psu during the 12-19th observation cycles, and nearly 0.05 psu after 20th cycle. Thus, we can conclude that a drift of 0.02-0.03 psu to higher salinities occurs during the "summer vacation" and that another deterioration up to 0.05 psu is suggested to occur around 20th cycle.

Figure 14 shows another example for WMO29032. As in the previous example, large variations due to the change of the references are prominent in the surface layer, and temporary high-salinity waters are also observed at 6th cycle. In contrast, the salinity deviations in the deep layer are relatively stable. It can be seen that the values shift to higher salinity after the 10th cycle for both the fine and the coarse grids. This is also evident in the change in average values; before the 10th cycle, the values return to 0 even after large shifts are seen. But after the 10th cycle, the values keep positive and do not return to 0. This result is nearly the same as that for method 4.1, proving that this method is effective in detecting salinity drift.

Using the fine geographical binning as the climatological reference, the salinity deviations are relatively sensitive to changes in sensor sensitivity, but the frequent switching between references due to the float movements can make the signs less perceivable. On the other hand in the case for the coarse grids, the salinity deviations tend to show vertically opposite values, probably due to the less perspective of the climatological standards, especially at edges of the grids. Thus, the results for the coarse grids normally show averages nearer to 0 and the larger variability than those for the fine grids. However, the values for the coarse grids are more stable because they are less affected by the movement of the floats. Thus, using the coarse grids has an advantage for observing long-term trends.

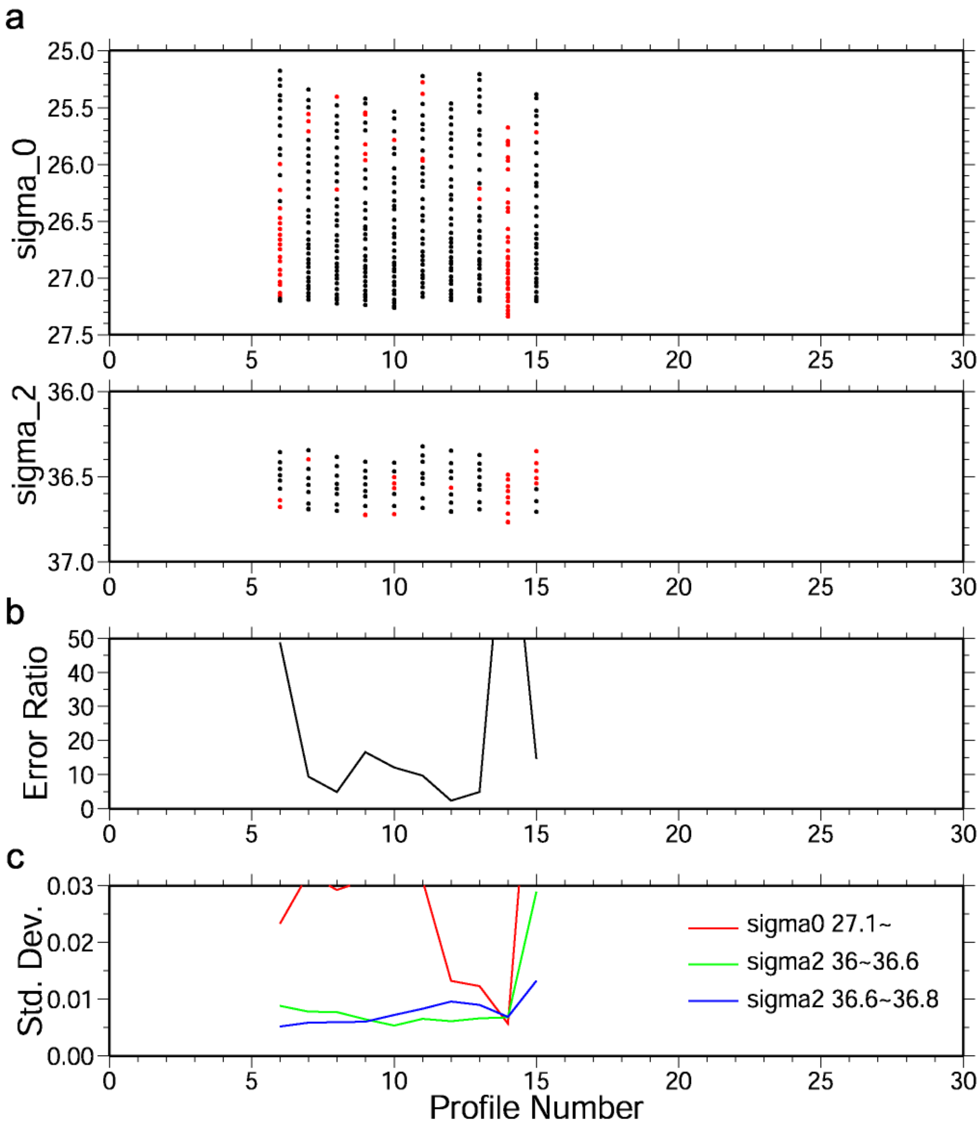

Figure 16: Same as Figure 15 but for WMO 29032.

In the surface layer the salinity deviations from the local climatology show extremely large temporal variations, and cannot be used independently to detect salinity drifts measured by Argo floats. In other words, when the obtained profiles are limited to depths shallower than 1000 m, it is very difficult to detect salinity drift using this method.

4.4 Statistical Check Based on the Stability of Float Measurements

As is shown in Figures 9 and 10, the results of observation by Argo floats are concentrated at the same T-S profile. Therefore, an Argo float will be suspected of occurring salinity drift if its measurements are derived from the T-S profile which is expected by the several observations just before. The expected T-S profiles as references can be calculated in a manner similar to that used to calculate the climatological profiles. If the newly measurements fall outside the expected variation range of the averaged T-S profile (criterion of $\pm 2\sigma$ is used here), it is concluded that the new data are statistically different from the past ones for some reasons including a possibility of sensor deterioration.

Figure 15 shows the results for WMO29033 statistically checking the newly data with the past 6 observation cycles (period of approximately 3 months). Before the "summer vacation", the data outside the criterion are less than 10% of the total. However, at the 12th observation more than 30% is rejected, particularly in the deep layer. Therefore, it can be concluded that a shift in sensor sensitivity occurred during this period. The time series of the criteria (the standard deviations) show relatively stable values of approximately 0.006 psu in the deep layer before the "summer vacation". But after the 13th observation, they suddenly increase up to approximately 0.02 psu. This also indicates that the data for the 12th cycle are totally different from that for before the 12th cycle. The less strict criteria after the 13th cycle suddenly reduce the amount of rejected data. This feature concludes that the signals of salinity drift never accumulate in this method.

In the 20th observation cycle, more than 20% data are rejected and most of them are obtained in the deep layer. This seems another signal of salinity drift, which is less clear than that in the 12th cycle. This result is almost the same as the results in section 4.3.

Figure 16 shows the results for WMO29032 checking new measurements by the past 5 cycles. Using the quality-control method specified in 4.1 and 4.3, it is determined that salinity drift began in the 9th or 10th cycle. However, It seems very difficult to detect it by this methods alone, because its signal is rather weak in both the 9th and 10th cycles; the ratio of the rejected data is 20% or less and the criterion for the deep layer keep the values less than 0.01 pus, which are almost the same order to those for other cycles. It is noted that relatively much of the deep data are rejected in the 10th cycle (Figure 16a), it is considered an only indication of the salinity drift.

As is shown for WMO29032, it will be difficult to detect the salinity drift by this method when they go forward gradually. Also this method is sensitive to the values themselves measured by the floats. Therefore, the results are affected not only by the salinity drift due to the sensor deterioration but also by the change in water-mass structure observed due to the float movements (for example, data for the 6th and 14th cycles of WMO29032). Therefore, it will not be effective that this method is applied to regions with large spatial or temporal variations in water-mass structure, such as around the frontal regions.

4.5 Design of the Quality Control Procedures

Details on the 4 methods of quality control are described above. All methods involve both advantages and shortcomings, and no single method is superior. In principle, methods 4.2-4.4 can be automated, but the actual criteria for the data evaluation are not determined yet, so currently quality control must be performed manually. At the present stage, the procedures of the quality control which will be expected to be the most efficient are as follows.

1. Eliminate climatologically abnormal data with the method 4.2.
2. Examine whether the salinity drifts occur in the float measurements with the method 4.3 and 4.4. Then, detect signals of the salinity drifts.
3. Evaluate the validity of them with method 4.1 and make a final decision.

5. Plans for the Future

JAMSTEC/FORSGC have operated about 20 Argo floats as of the end of July 2001, and most of them were deployed only a half-year before. So we must confess that we do not have much experience of Argo float operation to construct a quality-control system for Argo data. Therefore, we will evaluate and revise the methods outlined in this report by handling problems that arise in the future on a case-by-case basis.

Also, quality-control system will be improved to enable the fast processing of large amounts of Argo data automatically. Needless to say, new methods of quality control will also be developed and evaluated.

Most of the profile data in HydroBase (Macdonald et al., 2001) are relatively old, so the quality control standards are calculated based on the low-grade observations before 1970s. Therefore, revisions must also be made to the climatological data itself for high-grade quality control.

Thus far, the quality-control database for Argo data using HydroBase is complete for the North Pacific region. Work is presently underway to extend the database to include the Indian Ocean and the South Pacific, in step with JAMSTEC/FORSGC's Argo float deployment plan.

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