QUALITY CONTROL OF ARGO SURFACE TRAJECTORY DATA CONSIDERING POSITION ERRORS FIXED BY ARGOS SYSTEM

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Argo has another goal that global velocity fields on sea surface and in subsurface layers are estimated from float drifting. We introduce a method for quality-control (QC) of the float positions based on float speed along its path considering positioning errors determined by Argos satellites. The method identifies one of two temporal-continuous positions questionable if the float must move by faster than 3 m/sec on the segment. In case that the distance between the positions is less than the error range determined by their Argos positioning errors, both positions are acceptable exceptionally. The method gives fairly reasonable QC results which are comparable with those by visual inspection of experts and several % of float positions are identified questionable in average. We believe the method is appropriate as the standard of Argo position QC.

1. INTRODUCTION

Argo has another goal to estimate velocity fields on the sea surface and at float parking depths from float trajectories. Some scientific researches with the velocity estimated from float movements have been done (e.g., [1], [2], [3], and [4]) and some atlases of the velocity fields are available now (e.g., YoMaHa, [5], [6]) and will be prepared near future (ANDRO, [7]). However, there are not so much as studies using Argo temperature and salinity profiles. One of the reasons for it may be that Argo trajectory data (including float positions) are not so familiar as the Argo profile data. The most reason is, probably, that Argo trajectory data are no user-friendly: some of float positions in the trajectory data look “questionable”, but they are not identified with a sort of “quality flags.” Since no method for quality control (QC) of the float trajectory (position) data has been determined by Argo until now ([8]). Here, we introduce a QC method for float positions and it identifies suspicious ones based on float movements along the trajectories considering nominal errors of Argos positioning system.

2. QC PROCEDURE FOR FLOAT POSITIONS

This QC method identifies “questionable” positions based on float speed along trajectory which is fixed by Argos satellites. Until no suspicious positions are found, the following processes of 1) - 3) are applied repeatedly after the identified “questionable” positions are removed.

1) Estimate a speed on a segment which is composed by two temporal-continuous float positions, A and B.
2) One position of the segment (A or B), at least, is identified “questionable” when the following two criteria are satisfied:
    - Float speed on the segment exceeds 3 m/sec.
    - Distance between the positions A and B is longer than the critical error range determined by Argos positioning errors as follows:

$$\textit{Critical error range} = 1.0 \times \sqrt{Er_A^2 + Er_B^2}\,. \qquad (1)$$

Here, Er_A and Er_B are the nominal errors of Argos positioning system at the float positions A and B, respectively. The nominal error for Argos class of 3, 2, and 1 is 150, 350, and 1000 m, respectively ([9]).

Next, the questionable position is identified among the positions A and B as follows:

3a) The position fixed less accurately is identified questionable based on Argos flag.
Accuracy of Argos class:
more accurate $\leftarrow$ 3, 2, 1, 0, A, B $\rightarrow$ less accurate

Here, the position with Argos class 0 means that its nominal error radius is “grater than 1000 m”, and Argos class A (B) means that the float position is fixed by 3 (2) messages received per satellite pass and its accuracy is not officially determined. Note that the positions with Argos class 3, 2, 1, and 0 are determined by 4 or more messages and are more accurate than those with class A and B ([9]).

3b) When both positions have the same Argos class, the position is determined to be suspicious which demands the float to have moved faster on the new paths which are newly set with temporally-forth/back positions as follows:
    - In case that both of temporally-back and -forth positions (+1 and -1) of the segment can be used for the check, set the paths via position A and via B (yellow and cyan path in Fig. 1a).
    - In case that only one temporally-back or -forth

position is available (i.e., the questionable segment includes the first/last position of the cycle), set the paths terminated at A and at B (yellow and cyan path in Fig. 1b).

- If no additional position is available for the check (i.e., the float cycle is composed of only two positions), both positions are flagged "questionable" exceptionally. Since we can not determine which position is worse than the other.

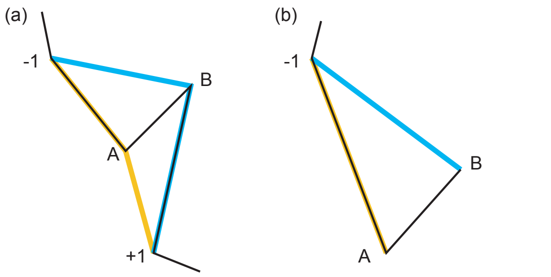

Figure 1. Schematics of identification of the position to be flagged (a) in case both of the temporal-back/forth positions (signed by -1 and +1) of the "questionable" segment (AB) are available additionally and (b) in case only either of them (-1, the previous or next) is.

An execution program of the QC method was prepared from http://www.jamstec.go.jp/ARGORC/ (Page of "Tools and Links") so as that the method should be tried widely. The execution program inputs Argo trajectory netCDF data directly and then outputs QC flags of float positions by text file. Parameters (e.g., the maximum float speed, nominal errors of Argos positioning system) are changeable. The execution program also outputs a kml file, by which the QC results are shown on "Google Earth" easily.

3. RESULTS

Fig. 2 shows some results of position QC obtained by the method. Fig. 2a is results for a float deployed in the subarctic North Pacific (77th cycle of World Meteorological Organization (WMO) 2900055). The first position of this cycle was fixed on 12:03:00, 22 July 2003 (Argos class 1) and then the float drifted north-eastward generally. The red line represents the float trajectory connecting the positions which passed the QC scheme. The float drifted sometimes zigzag: however, its movement seems reasonable considering positioning error radii fixed by Argos system. A float position (on 00:08:14, 23 July 2003) is identified "questionable", shown as the red star, in the cycle. It seems too away from the temporal-neighbourhoods.

In Fig. 2b, most of positioning error circles overlapped each other. The float may have moved north-eastward slowly in the cycle and 2 positions are failed by the QC check. Fig. 2c is a result that many positions are failed by the QC method. In this float-cycle 19 positions were fixed totally by Argos system and 5 of them were identified questionable. The 8th and 9th position in the cycle (on 2:38:17 and 4:08:51, 16 December 2002) was very far away from the other succeeding (7th and 10th) position considering the time fixed, which shows they are erroneous positions clearly.

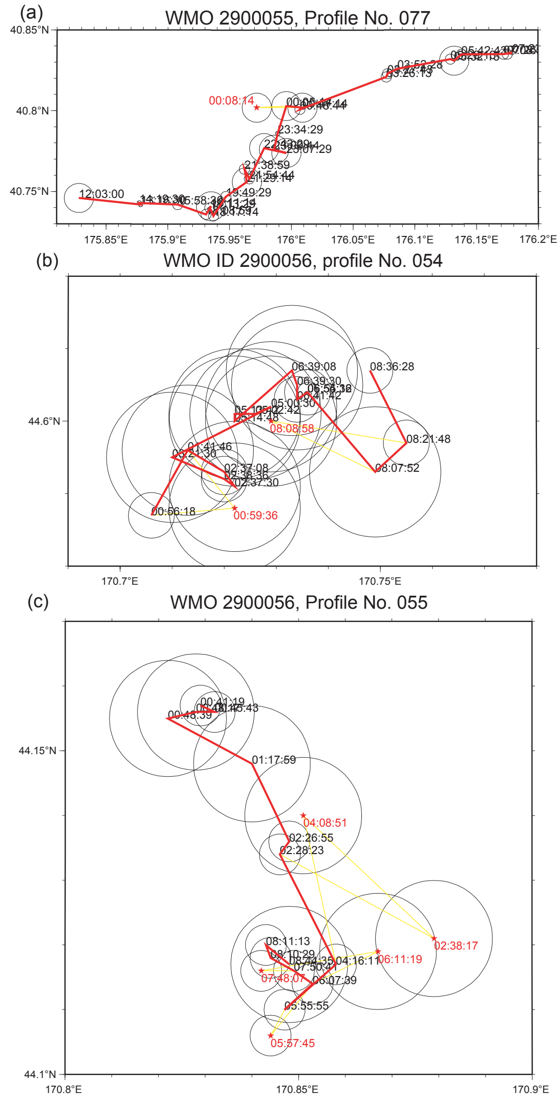

Figure 2. Results of position QC for (a) the 77th cycle of WMO 2900055, (b) the 54th cycle, and (c) the 55th cycle of WMO 2900056. The red line represents float drifting connecting the positions through the QC method and red stars shows identified questionable positions. The time when the position is fixed by Argos positioning system is also shown. Circles mean radii of nominal Argos positioning error (1000m, 350m, and 150m for Argos class 1, 2, and 3, respectively).

Table 1 shows the ratios of questionable positions identified for 28 Argo floats selected randomly. In average the QC method identifies several % of positions to be questionable, but the ratio varies largely (from <1 % to more than 10%) by float. The differences among Data Assembly Centers (DACs) are mainly caused by those of trajectory data managements, e.g., whether positions with less accurate Argos classes (0, A, B) are included in Argo trajectory data or not.

WMO ID	DAC	Ratio
4900369	AOML	1.10%
4900598	AOML	4.20%
6900091	AOML	1.80%
1900097	BODC	4.60%
1900288	BODC	1.20%
1900453	BODC	1.60%
2900194	BODC	6.00%
6900082	BODC	9.10%
6900083	BODC	9.80%
6900193	BODC	7.30%
53553	CSIRO	0.70%
2900425	ifremer	4.90%
3900137	ifremer	1.40%
3900195	ifremer	3.10%
6900139	ifremer	10.50%
6900279	ifremer	1.70%
7900097	ifremer	2.20%
2900342	INCOIS	13.00%
2900343	INCOIS	12.10%
2900354	INCOIS	10.60%
2900463	INCOIS	8.40%
2900055	JMA	5.98%
2900287	JMA	5.50%
2900460	JMA	4.19%
2900312	KMA	2.80%
4900101	MEDS	5.60%
4900414	MEDS	3.90%
4900517	MEDS	1.20%

Table 1. Ratio of questionable positions by Argo float.

4. DISCUSSIONS

We introduced an automatic QC method for float positions based on speed along float trajectory considering Argos positioning errors. The method yields fairly reasonable QC results which are comparable with those by visual inspection of experts. We supposed that the method be appropriate as a standard of Argo position QC.

We also suppose the QC method is a preliminary QC of Argo float positions and that a more sophisticated inter- and extra-polating scheme, or a "delayed-mode QC for Argo trajectory" (e.g., [10], [11], [12]) be applied succeedingly. Estimation of actual movements of a float is important. Furthermore, the locations where the float arrives at and departs from the sea surface, which will allow us to estimate velocities in subsurface layers more accurately from float trajectories, are very sensitive to "questionable" positions in the dataset to be used for extrapolation.

5. REFERENCES

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