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1. INTRODUCTION

This document describes the operational implementation of the MinMax method at the Coriolis Data Centre, the operational results and how it is used to help setting priorities for Delayed Mode Quality Control (DMQC) processing.

The MinMax method has been developed by OceanScope which is part of the R&D Coriolis team (submitted paper Gourrion et al., 2019). This method computes minimum and maximum values for the distribution of temperature and salinity profiles from surface to 2000 dbar by 20 dbar steps on equal surface areas of 110 km width (Figure 1). Thresholds are then smoothed over three neighbour ISEA cells. Datasets taken into account to compute these thresholds are Argo datasets, Sea-Mammals delayed mode datasets, CTD datasets. A special quality control is applied to detect outliers in the computed thresholds. The strength of this method is two-fold:

- This method takes into account the fact that the distribution of values is not Gaussian. The usual method used so far, namely the detection of outliers using the local average and a factor times the local standard deviation, is prone to have either a high rate of false detections on one side or miss good detections on the other side of the profiles distribution.
- This method also keeps the information of water masses that are present in the grid cell whereas the average melts this information.

The first part of this report explains the technical operational implementation in the Coriolis data centre. The second part presents the results obtained in operation in terms of performance and robustness. The third part presents the planned improvements.

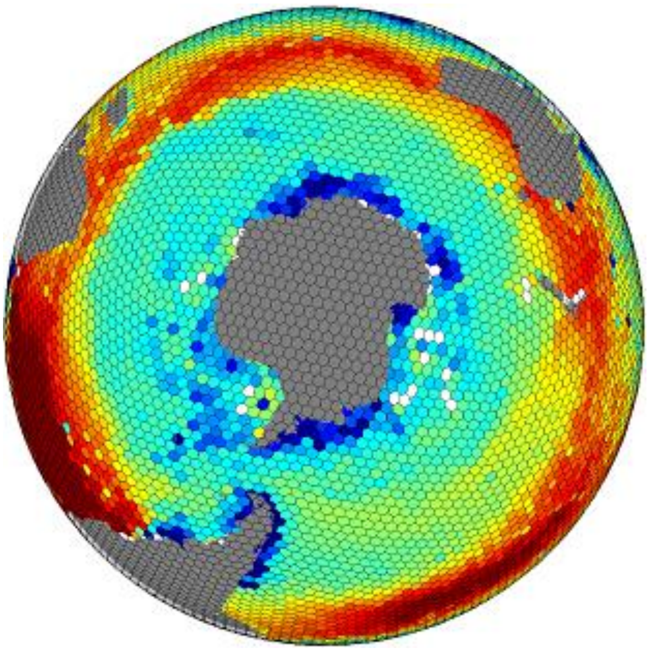

Figure 1: Illustration of the ISEA grid used to define MinMax thresholds
Each hexagon extent is one square degree. The color indicates the minimum threshold for salinity at surface.

2. TECHNICAL IMPLEMENTATION OF THE MINMAX METHOD

Before implementing the MinMax method at the operational Coriolis data centre, a first study was conducted by OceanScope together with the Ifremer Coriolis operator to determine a widening factor that would be a good trade-off between the number of good detections and the rate of false detections. Then operational tools have been developed to allow operational updates by the operator when relevant.

2.1. Widening factor

For the operator to be efficient in its visual inspection, it is important that the alerts raised by the system are more good alerts than bad alerts. In other words, the robustness must be good enough so that the operator will think of looking at what's bad in the profile rather than think in the first place that the thresholds are mostly too tight. To achieve this, a first study has been conducted to determine a widening factor for the thresholds.

The widening factor is applied as follows:

- Param_max_new = Param_mean + (1+P)*(Param_max – Param_mean)
- Param_min_new = Param_mean – (1+P)*(Param_mean – Param_min)

The study used the initial MinMax thresholds computed with datasets extending until 2015 and applied on three months data from July to September 2018. The study has been done on salinity profiles only. An operational widening factor of 40% was chosen based on Figure 2 curves. It seems a good compromise between a high decay in the number of false alerts with a small loss in the number of good alerts. The widening factor was chosen constant for the minimum and thresholds of salinity and temperature and for all the depth layers.

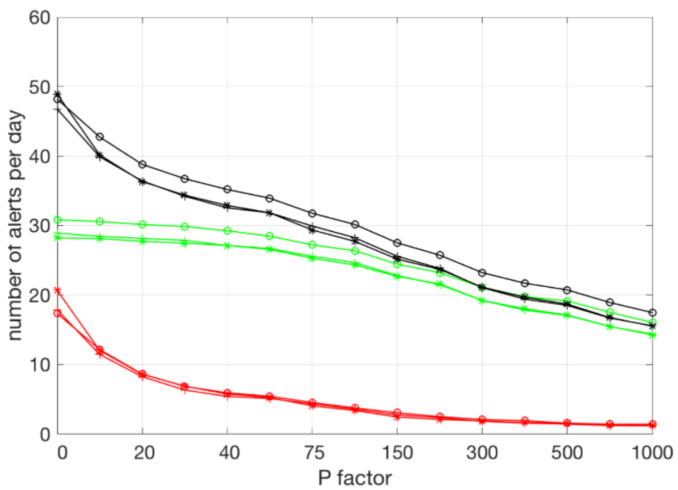

Figure 2: Numbers of Good and False alerts per day using the MinMax Method
Results extracted from the internal OceanScope report (J.Gourrion). The red curves are the number of false alerts per day function of the widening factor P for salinity profiles. The green curves are the number of good alerts and the black curves are the total amount of alerts. There are three curves of the same colour for each 3 months of the analysis.

2.2. Thresholds operational updates

For an operational operator, it is important to be able to update thresholds on the fly, especially in the real-time process where the flow is continuous and where profiles are submitted several time on the GDAC and go through the alert process each time (see workflow on *Figure 3*). The thresholds may be not suitable enough because the datasets used to compute the thresholds at one particular location were not statistically big/long enough to imprint all the possible variability (deeper thermocline or surface extrema for instance) but the operator will keep on seeing the alerts every time it is submitted.
To allow operational updates of the thresholds, a series of Matlab routines has been developed.

The main used routine has for inputs a given Argo profile file, an angle of extent (typically one degree) and a margin (typically 0.02/0.01 psu and 0.2 °C) with respect to the profile values. Some other routines can set manual values, or go back to original thresholds for one particular grid cell, etc. With these new tools, there is almost always an action to take on visual inspection of the profiles: either flag bad data or improve the thresholds.

The depth layer definition has also been a little bit changed to match operational observations: first layer was changed from 0-20 dbar to -5 to 20 decibar to account for pressure sensors uncertainties. The last layer was changed from 1980-2000 dbar to 1980-2020 dbar to account for profiles from the core mission that stabilized a little bit deeper than 2000 dbar.

2.3. MinMax in the dataflow

When Argo profiles are collected at each DAC, they first undergo automatic real-time quality control tests (RTQC auto). These tests are implemented on each DAC following the specification *Argo Quality Control Manual for CTD and Trajectory Data* (https://archimer.ifremer.fr/doc/00228/33951/). Then profile files are submitted to the GDAC. At this moment, they are ingested inside Coriolis database and the MinMax method is applied to them all DAC confounded provided that the date and location QC are good. The Argo profiles that raise a MinMax alert are not broadcast to the consumers of the Coriolis database exports until a visual quality control inspection frees them.

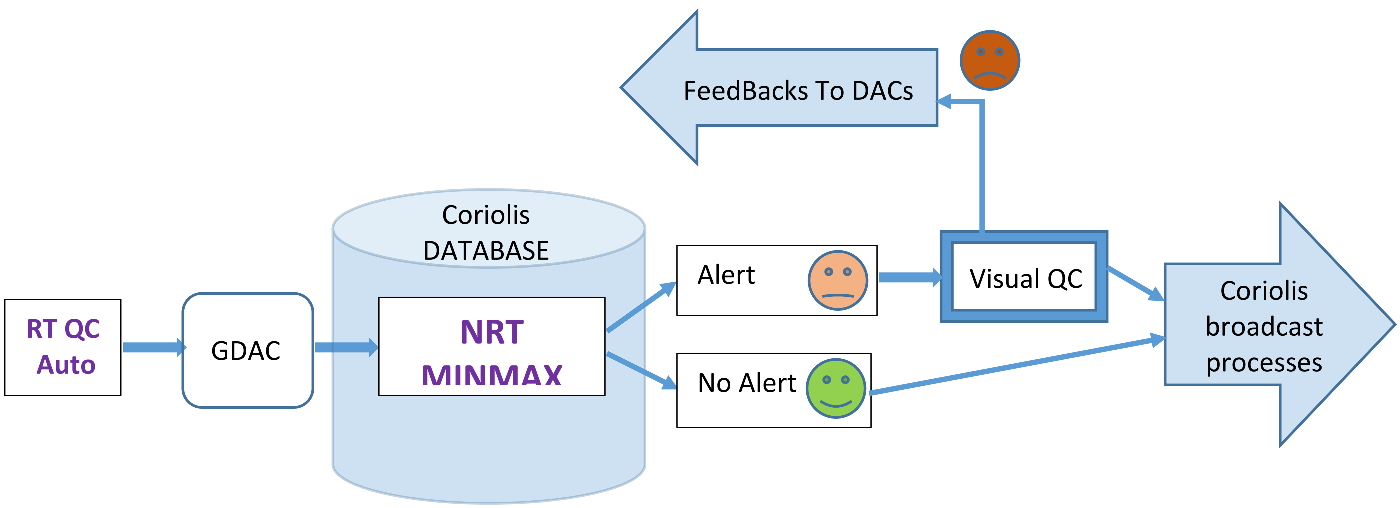

Figure 3: MinMax Method in the operational dataflow

3. OPERATIONAL RESULTS

3.1. Robustness and performance

To assess the efficiency of the method operationally, there are several possible diagnostics. We chose to compute operational robustness rate and a performance rate.

1. The robustness rate is computed as the number of profiles in alert with a change of QC after visualisation divided by the total number of profiles in alert.

Thanks to the widening factor and the operational updates, the MinMax method achieves a good rate of operational robustness: 85% of good alerts. This means that each time the alerts are visualized, 85% of the profiles have a change in the quality control code (QC) for one or more of their measures.

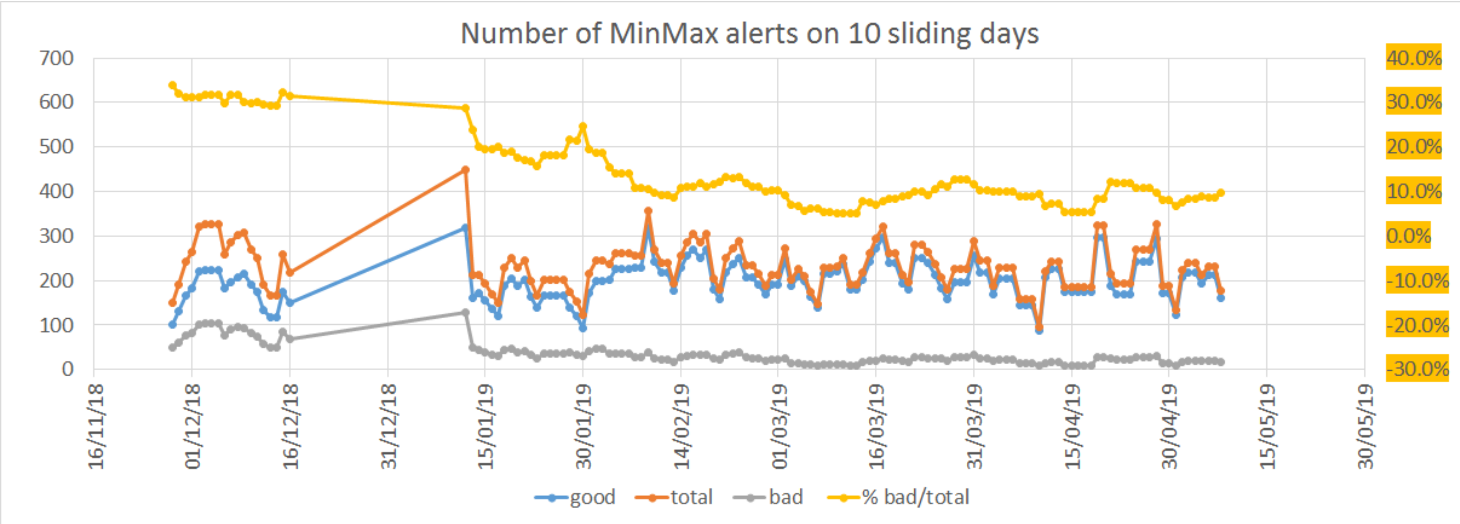

Figure 4: Operational Robustness of the MinMax method
All curves are smoothed on ten sliding days. The yellow curve is the percentage of false alert with its corresponding y-axis on the right. The red curve is the total number of alerts with the values on the left axis. The blue (resp. grey) curve is the number of good (resp. false) alerts with the values on the left axis.

2. The performance rate was computed as an estimation of a relative performance: how much "best" the new system is compared to other methods. The absolute performance would be computed as the number of raised alerts on the total number of bad data but this would mean the knowledge of the exact number of bad data which is hard to know on such an amount of data.

Two other methods were compared: the CLS blacklist and the ISAS alerts.

- The CLS blacklist are the feedbacks from the data broadcast and used in the Mercator models. They apply their own tests and make feedbacks when alerts are raised. We used to have between 5 and 10 of these alerts each day. Since the MinMax method is used operationally, these alerts have almost disappeared for Argo profiles.
- The ISAS (Gaillard et al. 2016) alert is the historical system of alerts that was used. It is based upon an Optimal Interpolation algorithm. In terms of alerts, it performs a little better but is

less robust than the MinMax. The study of comparative number of alerts shows that almost all alerts raised by ISAS system were also trapped by the
MinMax method. There remains some small outliers, estimated as less than 0.5 profiles per day based on a 45 days comparative study done in late 2019.

3.2. Main types of failure detection: visual inspection classification

To improve the overall quality of the system, a thorough logbook has been kept and during a year, all detected bad data have been classified.

The main types of detected failure are:

- Conductivity sensor drifts: 50 % , see *Figure 5*
- Spikes: 30%
- Transient dirt : 5 % , see *Figure 6* (The transient dirt comes from dirt (either biofoul or mineral or whatever) travelling through the water pipe, changing the space between the conductivity plates and thus disturbing the conductivity measure*)*
- Wrecked profiles : 5 %
- Weird temperature or salinity profiles : 5 %

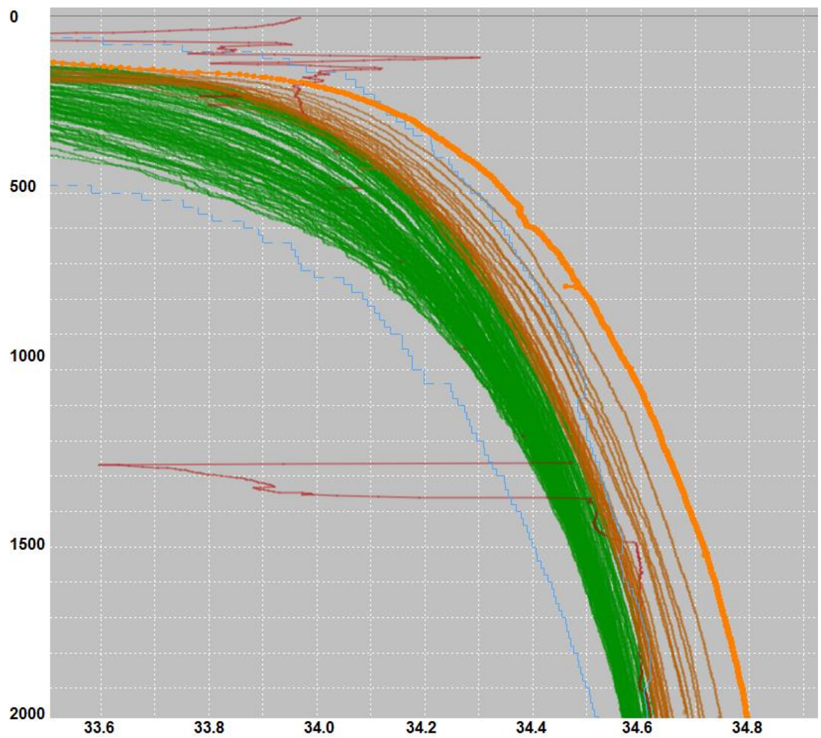

Figure 5: Example of a drift suspicion detection using the MinMax method
MinMax thresholds are the blue curves. All salinity profiles are from float 4902312. The QC1 green profiles are estimated good profiles, then orange QC3 (correctable in DM or doubtful) is set when the drift is suspected. The bold orange profiles is the last cycle of the series (cycle 125). Red QC4 measurements are transient dirt.

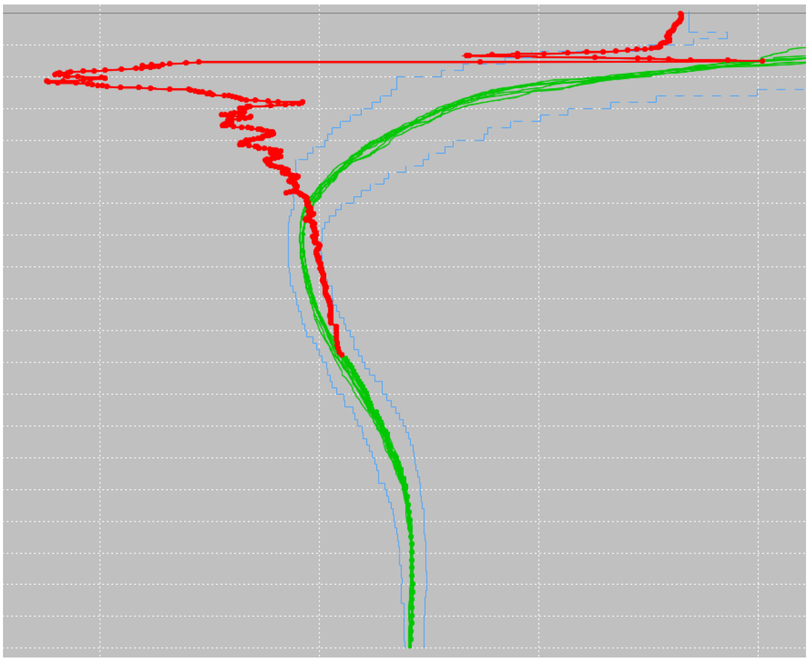

Figure 6: Example of a transient dirt suspicion detection using the MinMax method
All salinity profiles are from float 5905986. The red QC4 part of the cycle 52 is a failure due to transient dirt.

The percentage are really an indication that can change when the automatic real-time quality control tests are improved (New spike test from Early 2020, or new entries in the Grey list for wrecked/drifting sensors) or when a new failure is observed in series (such as surface spikes for a series of Indian floats beginning in Early 2019 for instance).

3.3. Drift suspicion list

The biggest margin for improvement on the workload of the real-time operator is to work on the conductivity sensor drifts. When a drift is established, it can be down-qualified directly in the RTQC process by updating the grey list. Those updates are under the responsibility of each DAC/PI.
A log of the Argo floats suspected to drift from real-time visualisation is filled in and feedbacks are sent to DACs through the monthly Anomaly Argo report. There is still some room to improve technically this feedback channel (For instance, recently, the traditional Excel spreadsheet has been changed for a table entry in the Coriolis database, which eases cross tracks). We have some returns from some PI or DAC which tell us that this new feedback is useful to the community.

4. PLANNED IMPROVEMENTS

The focus for the first sets of MinMax thresholds was set on the main world basins. Thus they are well designed on the Indian, Atlantic, Pacific and Antarctic main areas.

Given the efficiency of the method in terms of robustness, performance and early drift suspicion detection, it seems now important to have a finer coverage of the method in marginal areas such as the Mediterranean Sea, the Nordic seas, the Black Sea, the Amen Gulf, the Mexico Gulf or the Caribbean Sea and others that I don't mention.

A second study was set by OceanScope to improve the MinMax method and the new thresholds includes several improvements:

- includes datasets until end of 2018
- removes a 1800 dbar bathymetry limit (and thus improves Nordic Seas and Mediterranean Coverage)
- better qualifies marginal Seas
- computes an optimized widening factor P depending on parameters (salinity or temperature), threshold side (min or max) and depth

At the time this report is written, this new sets of thresholds have been delivered by OceanScope and are under the process of being validated for operational purpose before being set in operation in the Coriolis dataflow.

5. REFERENCES

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