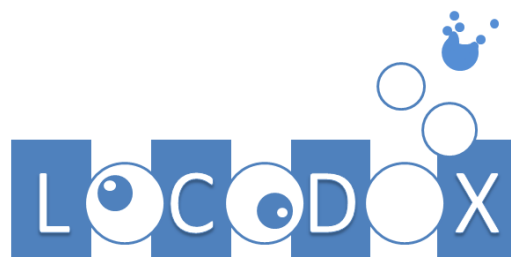

Delayed-mode quality control of dissolved oxygen concentration measured by ARGO floats in the North- Atlantic *with LOCODOX*

LOPS floats deployed in 2012

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This work is done as part of the AtlantOS project. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 633211.



Introduction

As part of the french Equipex NAOS and European H2020 AtlantOS projects, the LOPS is in charge of

- (1) Implementing and maintaining an array of Argo floats equipped with oxygen sensors in the North-Atlantic Ocean.
- (2) Performing the quality control of the oxygen data acquired by those floats
- (3) Transmitting the qualified data to the Coriolis data center

To achieve the last two objectives, the LOPS has developed a Matlab tool (LOCODOX) to correct Argo Oxygen data based on reference datasets.

The qualification procedure is done in different steps:

- When necessary, re-decode raw data transmitted by the floats in order to apply a non-zero "phasecoeff0" to them ;
- Correct the real-time Quality Control flag (QC) in order to put a QC=4 (bad data) to the outliers and "hooks" at the base of the profiles (generally over the first 50m of the ascending profile)
- When necessary, add an additional pressure correction on DOXY in the form $DOXY_{corrpres} = DOXY * (1 + coef * PRES / 1000)$;
- Apply the correction estimated by LOCODOX

This document summarizes the quality control performed on each floats and focusses on the LOCODOX corrections.

For each float, different corrections can be presented, in order to show how we reach the final/best correction for each of them. The chosen correction is presented at the beginning of each paragraph and the corresponding figures are framed in green.

As the figures are the same for each float, they are explained in detail for the first float only.

1. LOCODOX mainlines and configuration

LOCODOX relies on the Takeshita et al, 2013 and the Bittig and Kortzinger, 2015 correction methods. It is a MATLAB interactive tool which offers users to correct Argo NetCDF 3.1 oxygen data, and to provide data centers with corrected and well formatted delayed mode data.

Three correction methods are available:

- The WOA method uses the WOA09 climatology as reference;
- The REF method uses a reference *in-situ* profile coupled to a given float profile. Most of the time, the CTD profile done at the float deployment is coupled to the first ascending float profile;
- The INAIR method compares the in-air measurement of the oxygen sensor to atmospheric reference NCEP.

Here we are using only the REF method, because it gives the best results. We can choose between a correction using DOXY or PSAT. DOXY is directly measured by the float and PSAT is derived from pressure, temperature and salinity measured by the float. We generally apply the correction on PSAT, except when a too large number of salinity, temperature or pressure data have a QC=4 (PSAT is computed from the dissolved oxygen concentration but also from pressure, temperature and salinity). In that case, the correction is computed on DOXY instead of PSAT.

Furthermore, since the DOXY sensor may have a time drift, LOCODOX proposes the option to correct it before correcting the vertical profiles of DOXY. The shape of the drift is given by a function chosen by the user.

There are a lot of configuration settings in LOCODOX, here are the parameters used for all corrections:

- We are using the REF correction;
- We are not taking into account the pressure effect in the PSAT computation in LOCODOX, ie “*CONFIG.pressEff=0*”. Note that this is not related to the additional pressure compensation correction that might be applied on the DOXY data before using LOCODOX.
- LOCODOX uses the “*Delayed Mode*” fields for temperature, salinity and pressure in order to correct floats. For some floats, we use the real time field, but it will be specified in the document;
- Most of the time, we only use the data with QC values equal to 1 or 2. If it is not the case it is specified.
- The reference data unit used is micromole per kilogram, ie “*CONFIG.refUnit= 'mumol/kg'*”

2. Summary of correction

The table below gives the current status of each float (corrected and sent to Coriolis in green/ uncorrected in red) and gives the settings of the applied correction.

Float	Drift	Correction based on	Cycle/reference profile				Status	Cycles corrected	Sending date to Coriolis
			Cycle	Campaign	Station	Distance/time			
6901023	Yes, degree 1	DOXY	1	cat12	49	22km/1day	Inactive	1 to 212	22/11/18
6901027	Yes, degree 3	DOXY	1	cat12	63	14km/2days	Inactive	1 to 207	22/11/18
6901030	Yes, degree 1 with a slope of -0.007 (mumol/kg)/day	DOXY	1	cat12	78	2km/1day	Inactive	1 to 202	22/11/18

All cycles are corrected
 Need new DM correction
 Not corrected

Corrections

Float 6901023

Explanation

This first frame shows the drift computation.

A sensor drift should be more detectable at depth (below 1500m), where the profiles are more stable and independent from the seasonal variability. When the argo profiles are deep enough, the argo data are interpolated every 100m, from 1500 to 2000m, or to 6000m for deep floats. The WOA09 data are interpolated at the float position and on these same levels. Temporal evolution of oxygen concentration at deeper level than 1500 m measured by the float are displayed in blue and the corresponding WOA data in black.

The regression is computed between these two subsets, by comparing argo and WOA. The difference between the data measured by Argo float and its corresponding WOA data are plotted in green and the best adjustment equation is represented in red.

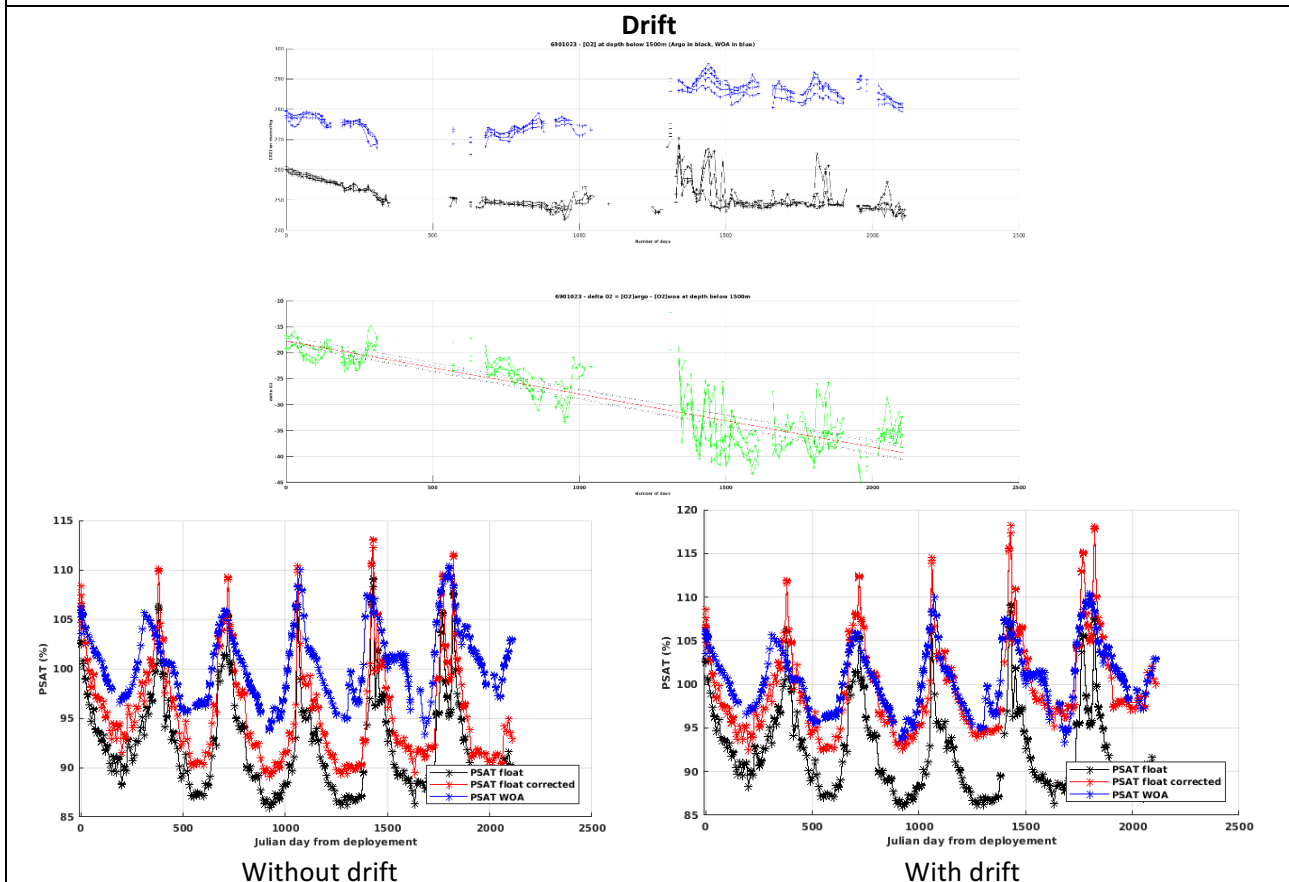
LOCODOX applies the drift compensation only with user approbation.

The relevance of the temporal drift compensation's application can be checked in the figures showing the surface time series of the percent of saturation (PSAT) (the two following figures). The surface time serie of the raw data is in black, that of the corrected data is in red and the WOA data are shown in blue. If the temporal drift correction is wrongly applied, then the corrected data (blue) diverge significantly from the WOA data (red), which indicates that the temporal drift correction has no sense. Note that PSAT values are expected to oscillate around 100%.

Comment

In the first figure we can see that the difference between the two datasets (in green) show a slope indicating a temporal drift. Moreover when we apply the drift, the data corrected (in blue) are closer to the WOA (in red) than when the drift is not applied.

Thus we chose here to apply the temporal drift defined by a first degree polynomial.



Explanation

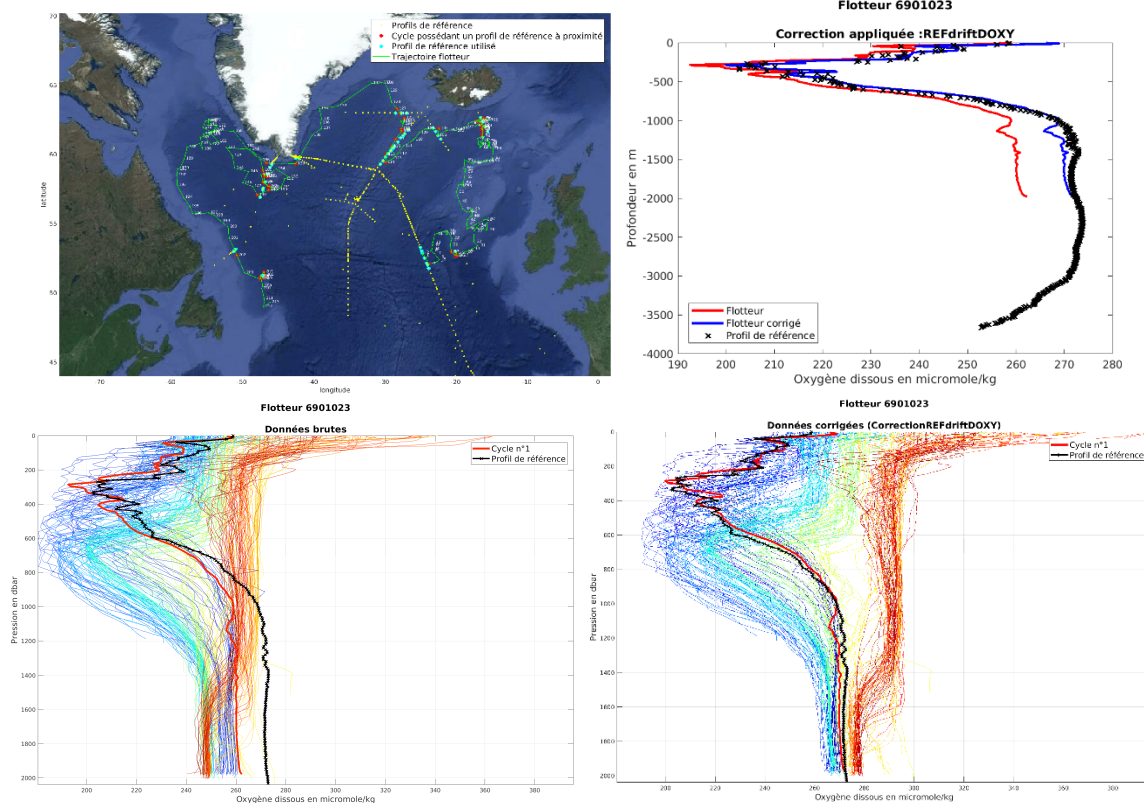
In the following frame, there are 6 figures showing the results of the correction :

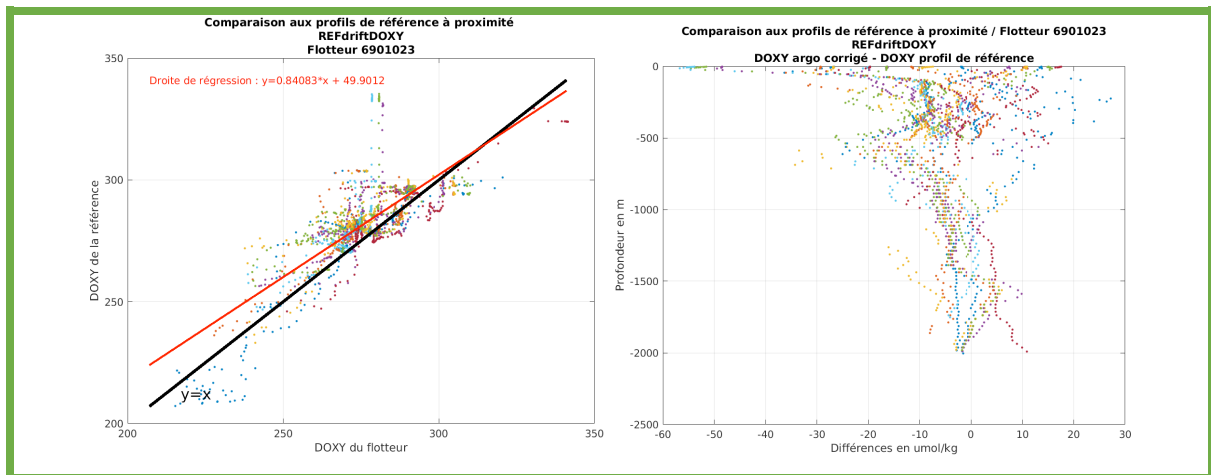
- First line
The left figure shows the trajectory of the argo float (in green) and the reference profiles in yellow. The highlighted points in cyan are reference profiles that are close in time (<2years) and in space (<50km of distance) from a profile of the argo float (highlighted in red). The figure on the right shows the reference profile used to correct the float data (in black), the raw Argo profile used to compute the correction by comparison to the reference profile in red and the same profile after correction in blue
- Second line
The figure on the left shows the raw oxygen data from the argo float with the reference profile in black and the cycle used to compute the correction in red. The figure on the right shows the float oxygen data after correction. The color of the profiles depend on their age: the oldest are in dark blue and the more recent in red.
- Third line
The third line shows the comparison between data from reference profiles (cyan points in the upper left panel) and the nearby argo float data (red dots in the upper left panel). In the figure on the left, the reference data are plotted as function of the float data. We expect here to obtain a regression line with an equation $y=x$. On the figure on the right, the differences between the argo cycles and the reference profiles are plotted as function of the depth. We expect here to find differences centered on zero.

Comment

In this case, we see that the reference profile is close to the argo cycle (first line, figure on the right). The last figure shows that the differences are a little spread but centered on 0.

Résultats





6901023 (Inactive)

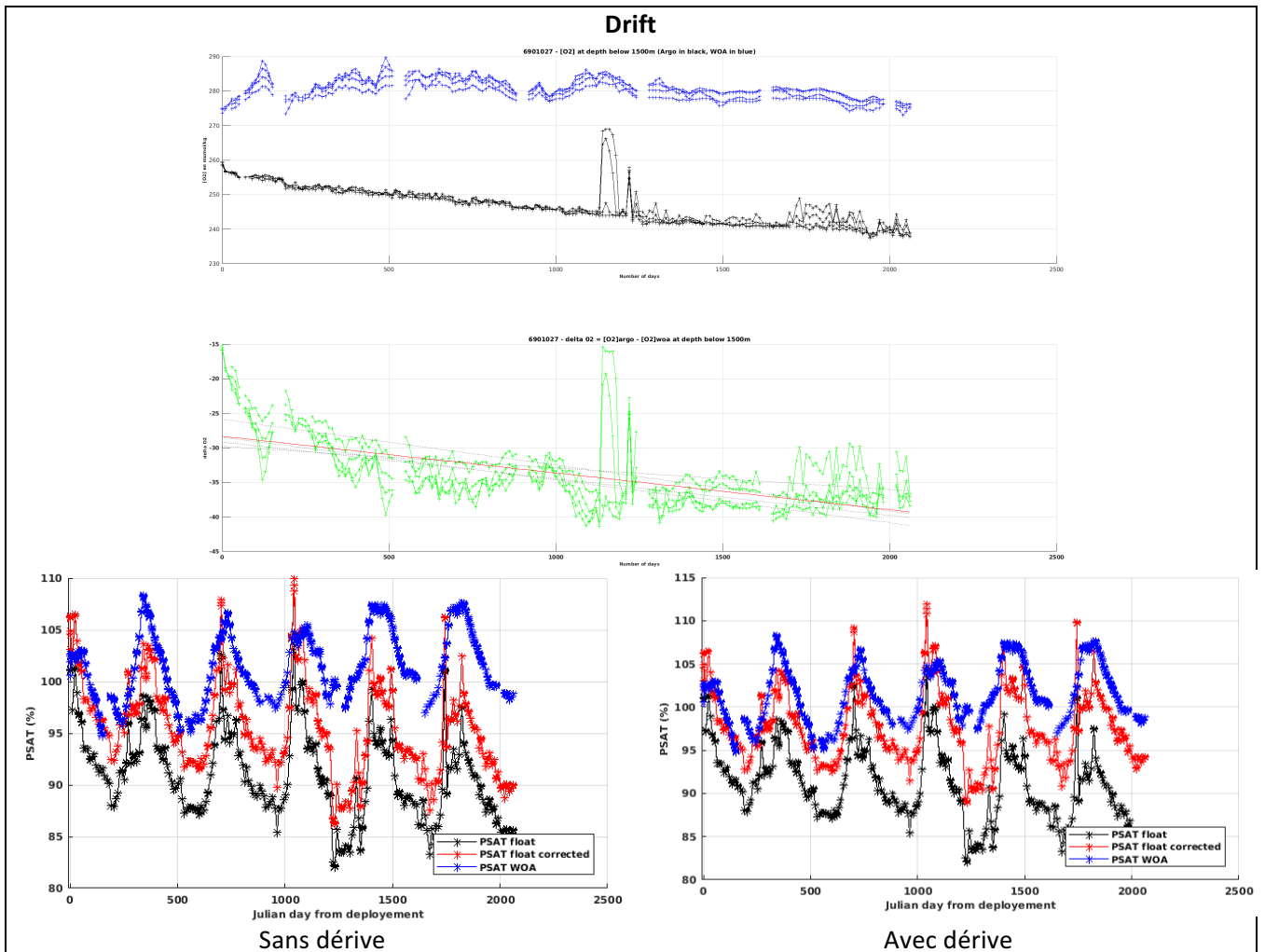
- Use of cycle 1 and cat12_49 reference (22km/1day)
- Drift correction (degree 1)
- Correction with DOXY because there are few differences with PSAT, and some salinity data are flag with bad QC.
- Relative error of 3%
- nc_check_file_format ok
- Cycles corrected : 1 to 212
- Data transmitted to Coriolis: 22/11/2018

Float 6901027

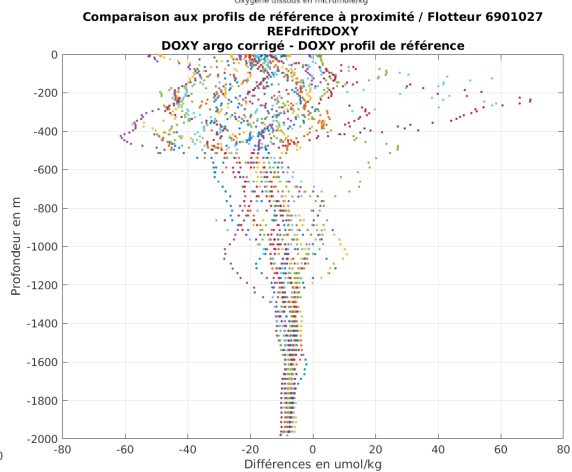
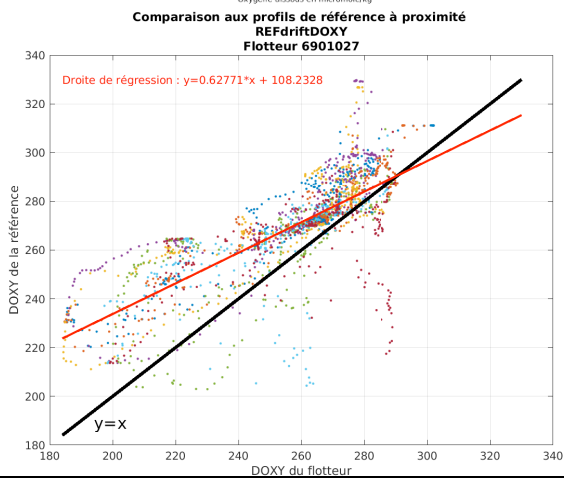
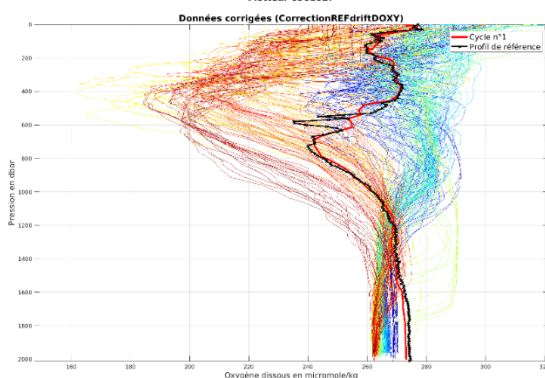
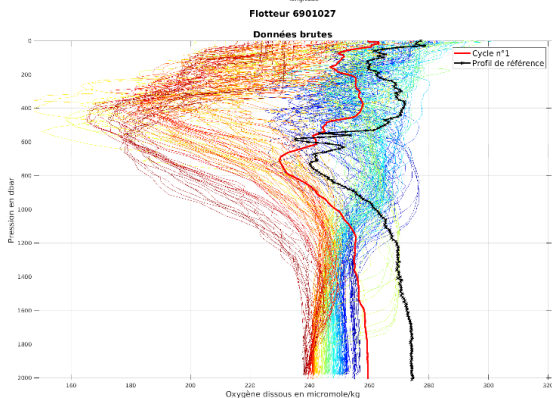
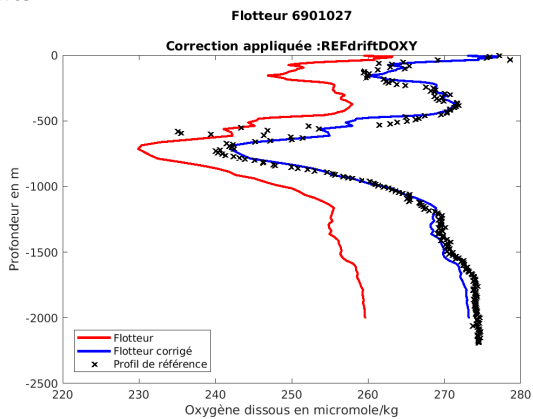
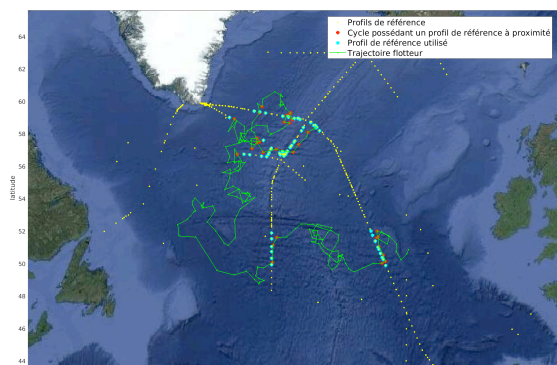
For this float different tests have been made. The chosen correction is framed in green.

1. First test: Drift of degree 1

Here we correct with a drift of degree 1. We can see that the curve do not fit well the data in the first figure. Moreover, we can see that even if the drift brings the corrected data and the WOA closer, there is still a space between the two datasets.

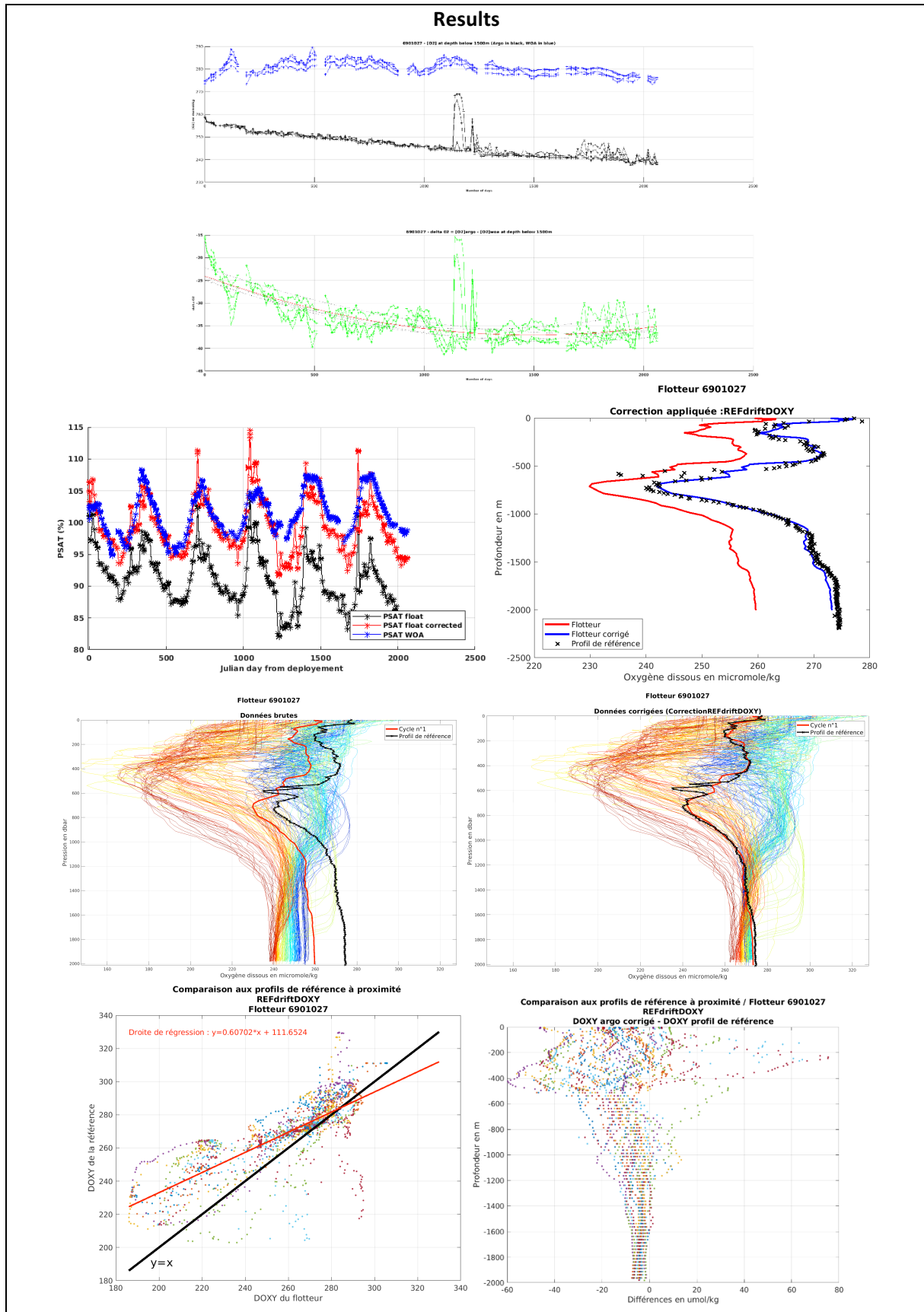


Results



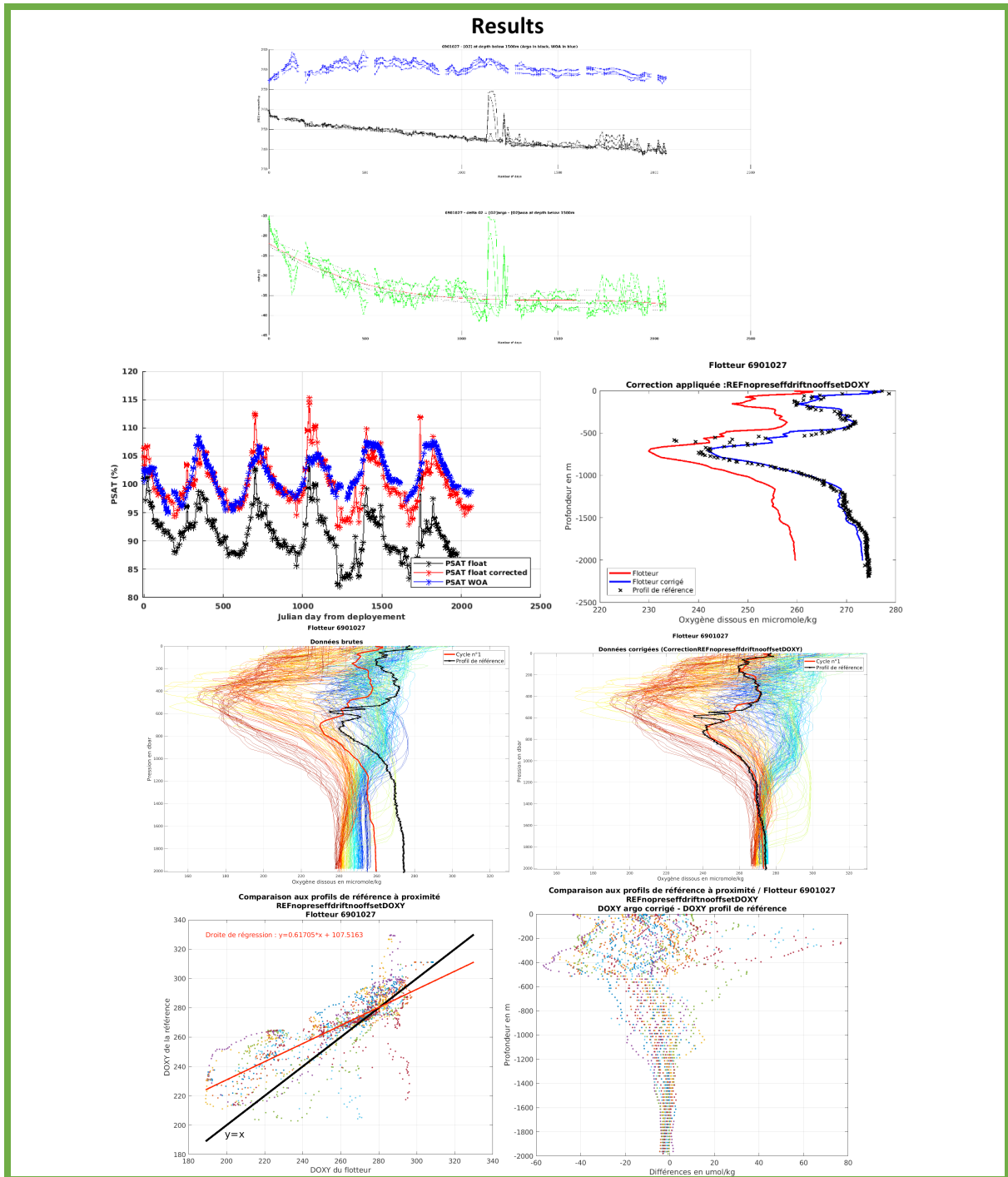
2. Second test: Drift of degree 2

Here we correct with a drift of degree 2. We can see that the drift curve fit better than the previous test, but it tends to go up at the end.



3. Third test : drift of degree 3

Here the curve is fitting very well the drift curve. It is the best solution we found. Moreover in the right figure of the last line, we can see that the differences are centered on 0, as we want.



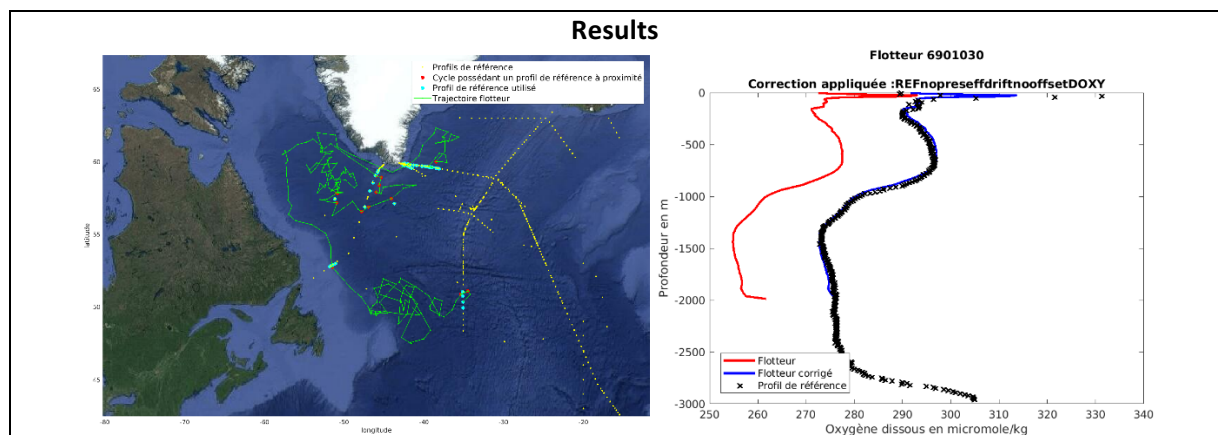
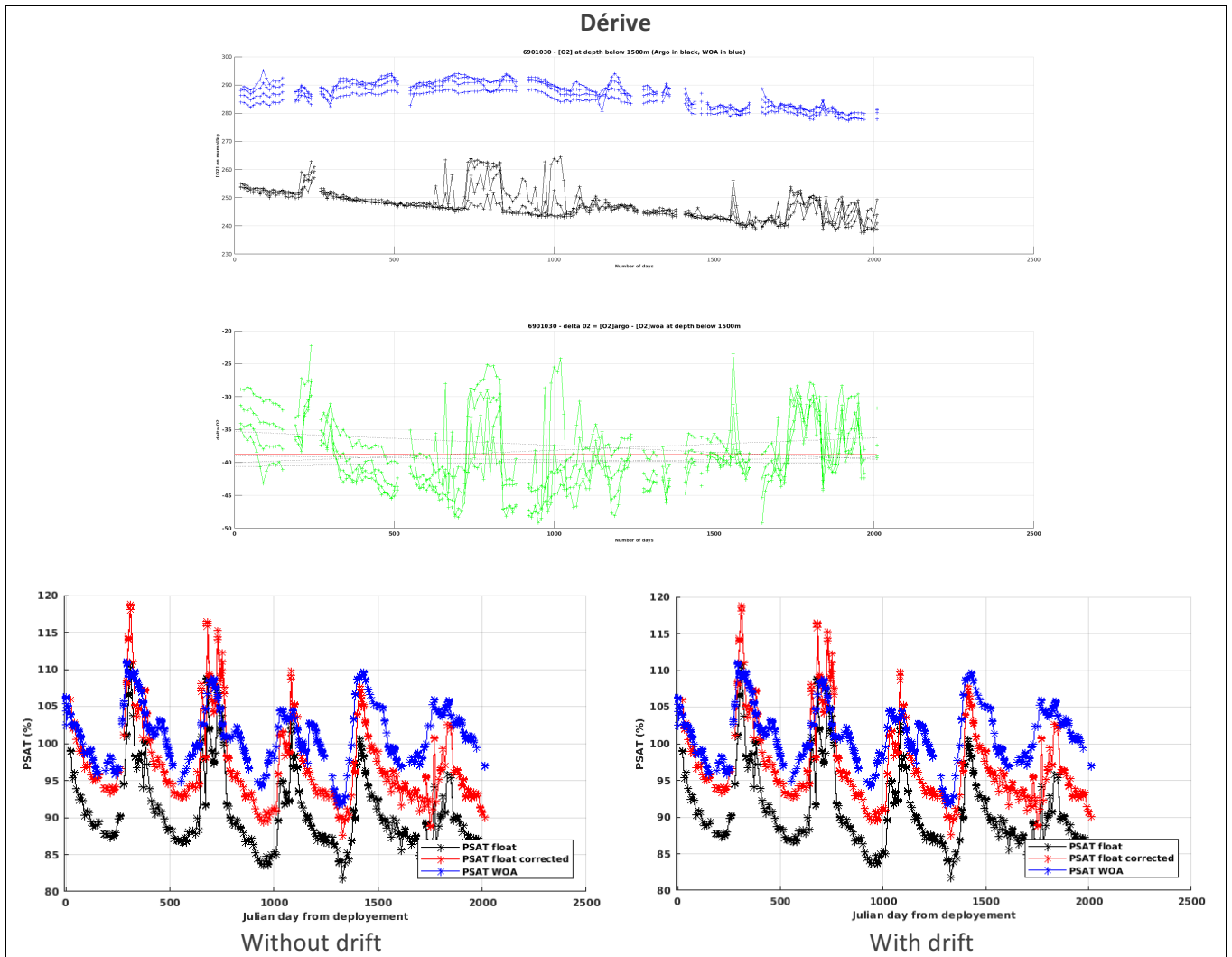
6901027 (inactive)

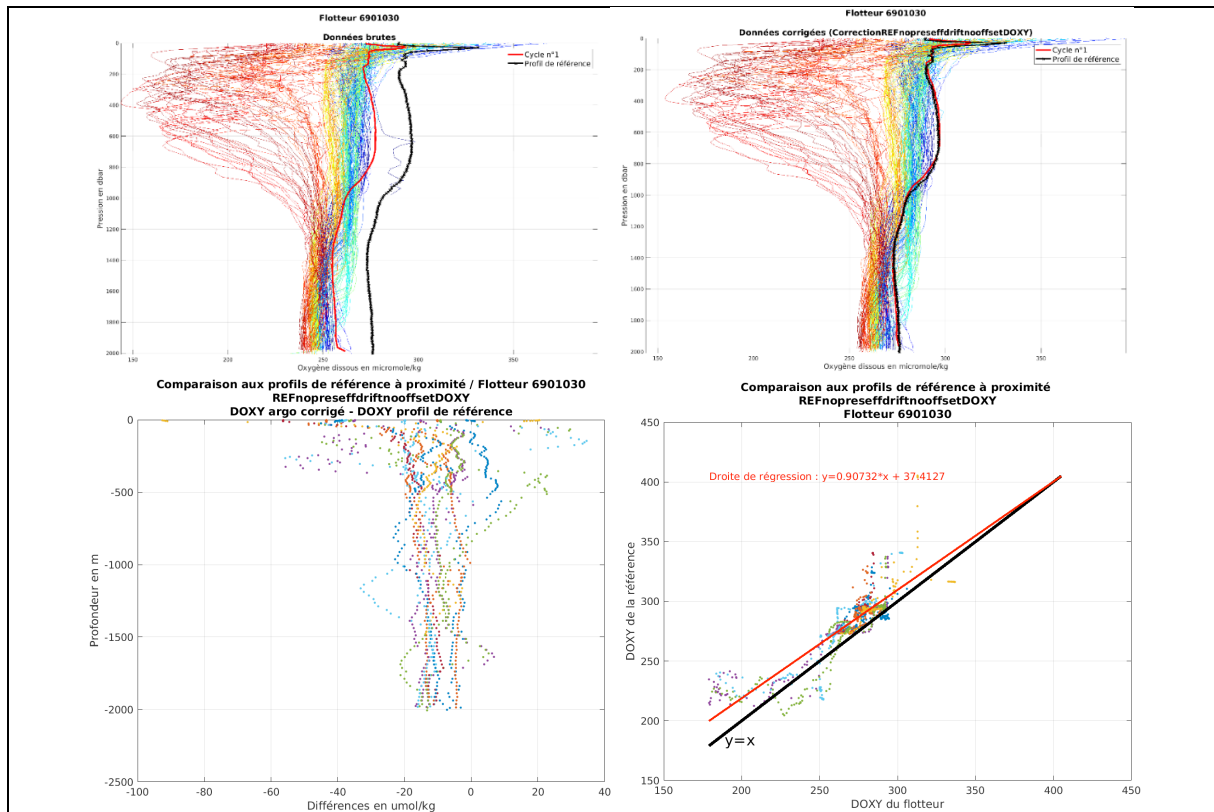
- Use of cycle 1 and cat12_63 reference (14km/2days)
- Drift correction (degree 3)
- Correction with DOXY because there are few differences with PSAT, and some salinity data are flag with bad QC
- Relative error of 3%
- nc_check_file_format ok
- Cycles corrected : 1 à 207
- Data transmitted to Coriolis: 22/11/2018

Float 6901030

1. First test : drift of degree 1, correction based on DOXY because first cycle of PSAL entirely flagged at QC=4, correction made with cycle 1 and cat 12_78 reference

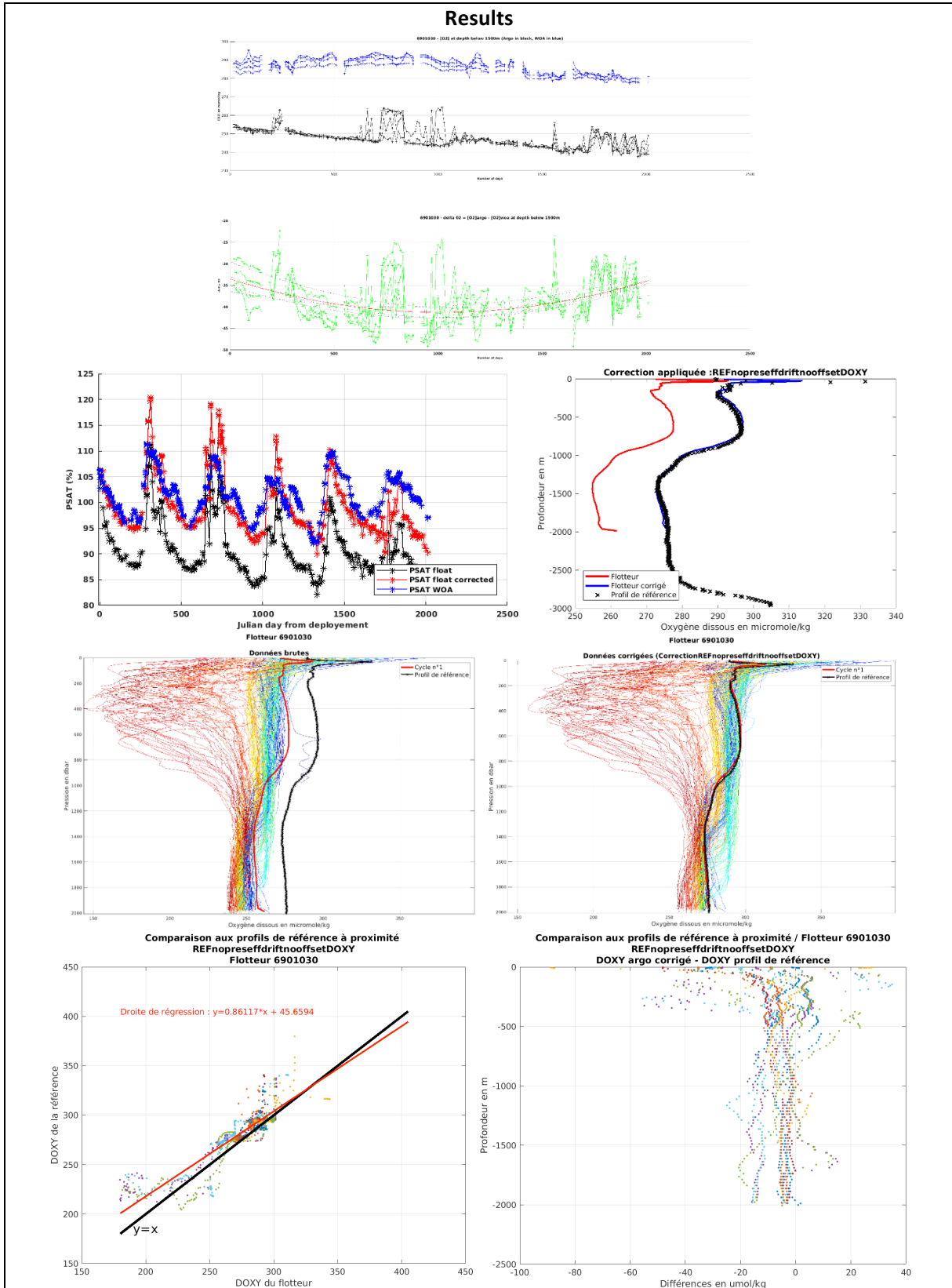
The drift of degree 1 doesn't fit the curve. The drift seems here to be almost constant.



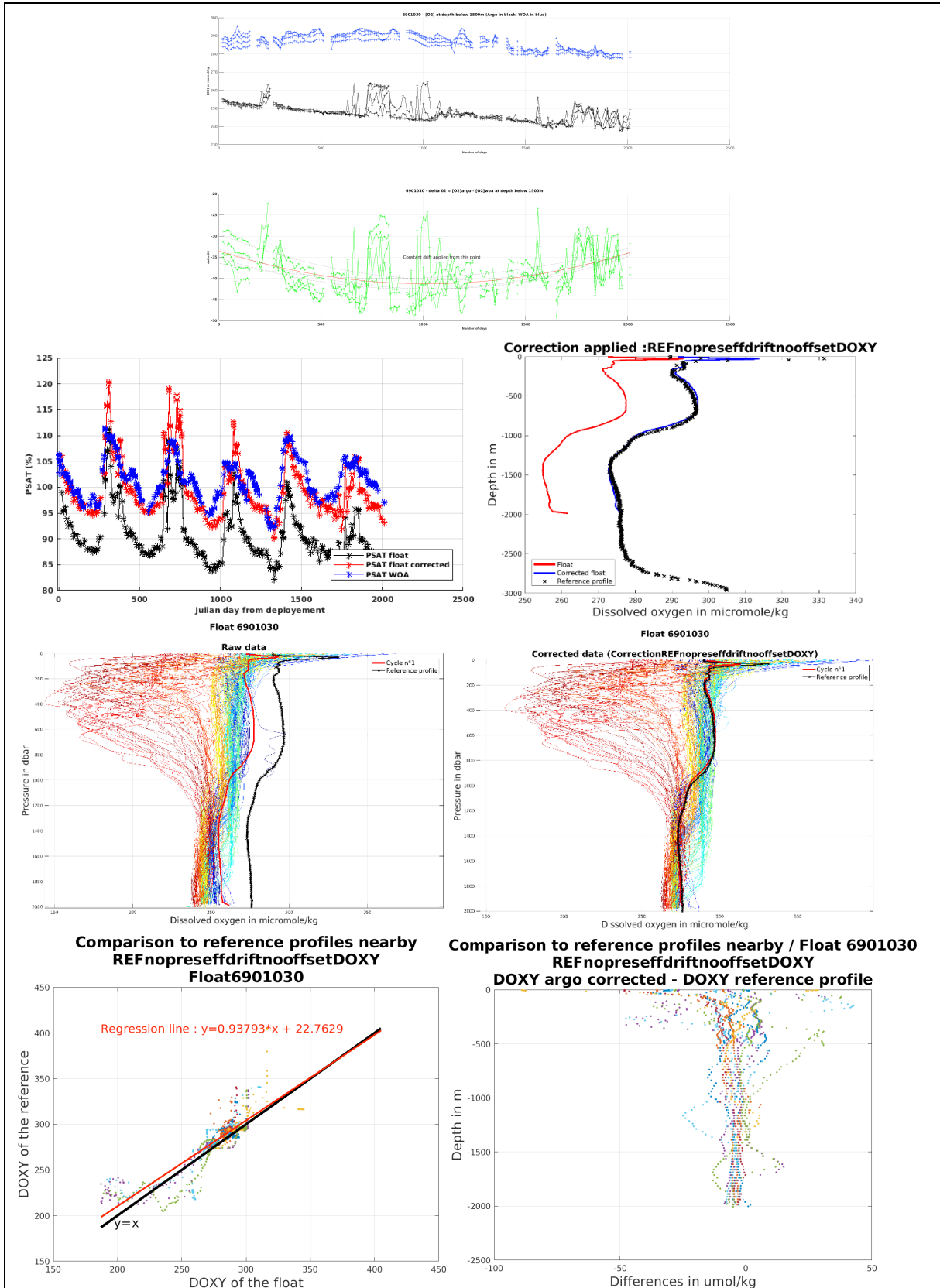


2. Second test : drift of degree 2, correction based on DOXY because first cycle of PSAL entirely flagged at QC=4, correction made with cycle 1 and cat 12_78 reference

Here the drift seems better at the beginning. But at the end, we can see that the corrected data and the WOA are far from one another.

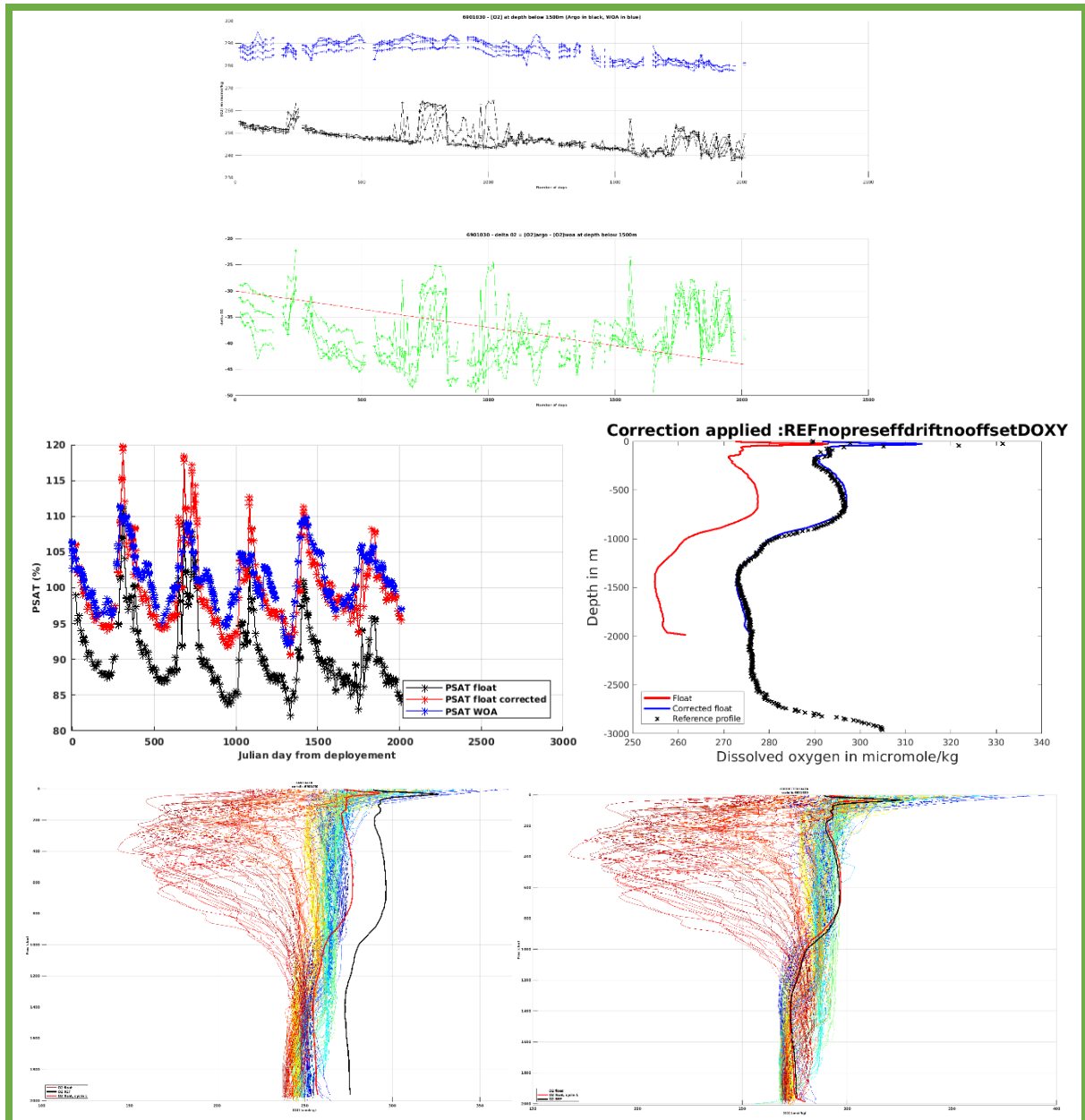


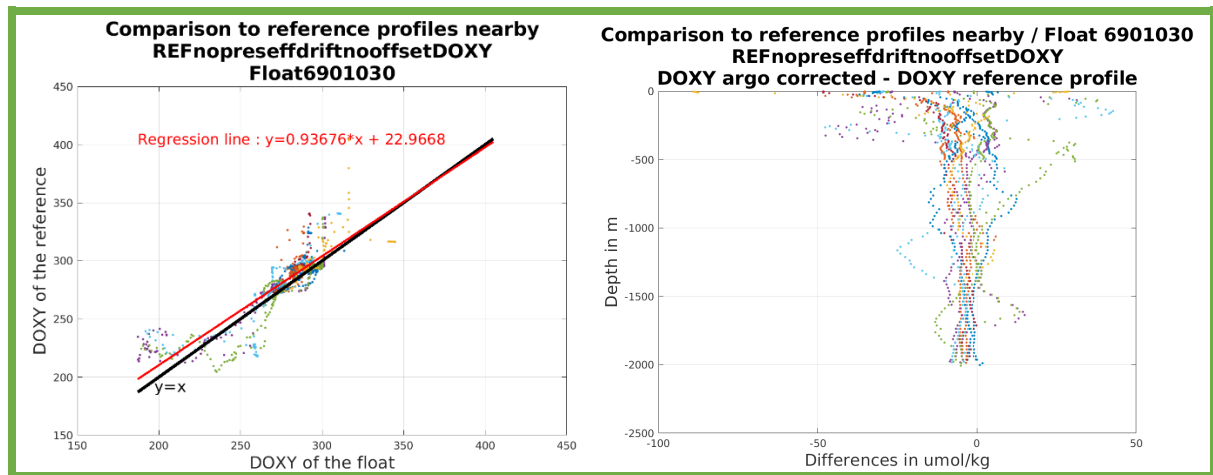
3. Third test : drift of degree 2, stopping at day=900 (ie constant drift applied from d=900) , correction based on DOXY because first cycle of PSAL entirely flagged at QC=4, correction made with cycle 1 and cat 12_78 reference



4. Fourth test : drift of degree 1 with the equation $y = -0.007 * x$, correction based on DOXY because first cycle of PSAL entirely flagged at QC=4, correction made with cycle 1 and cat 12_78 reference

When we compared the previous correction with other floats nearby, the data of this float were shifted from the others. Thus, we choose to apply this particular drift with the coefficient equal to -0.007. With this correction PSAT float and PSAT WOA are very close.





6901030 (inactive)

- Use of cycle 1 and cat12_78 reference (2km/1days)
- Drift correction (degree 1 with coeff = -0.007)
- Correction with DOXY because there are few differences with PSAT, and some salinity data are flag with bad QC
- Relative error of 3%
- nc_check_file_format ok
- Cycles corrected : 1 à 202
- Data transmitted to Coriolis: 22/11/2018