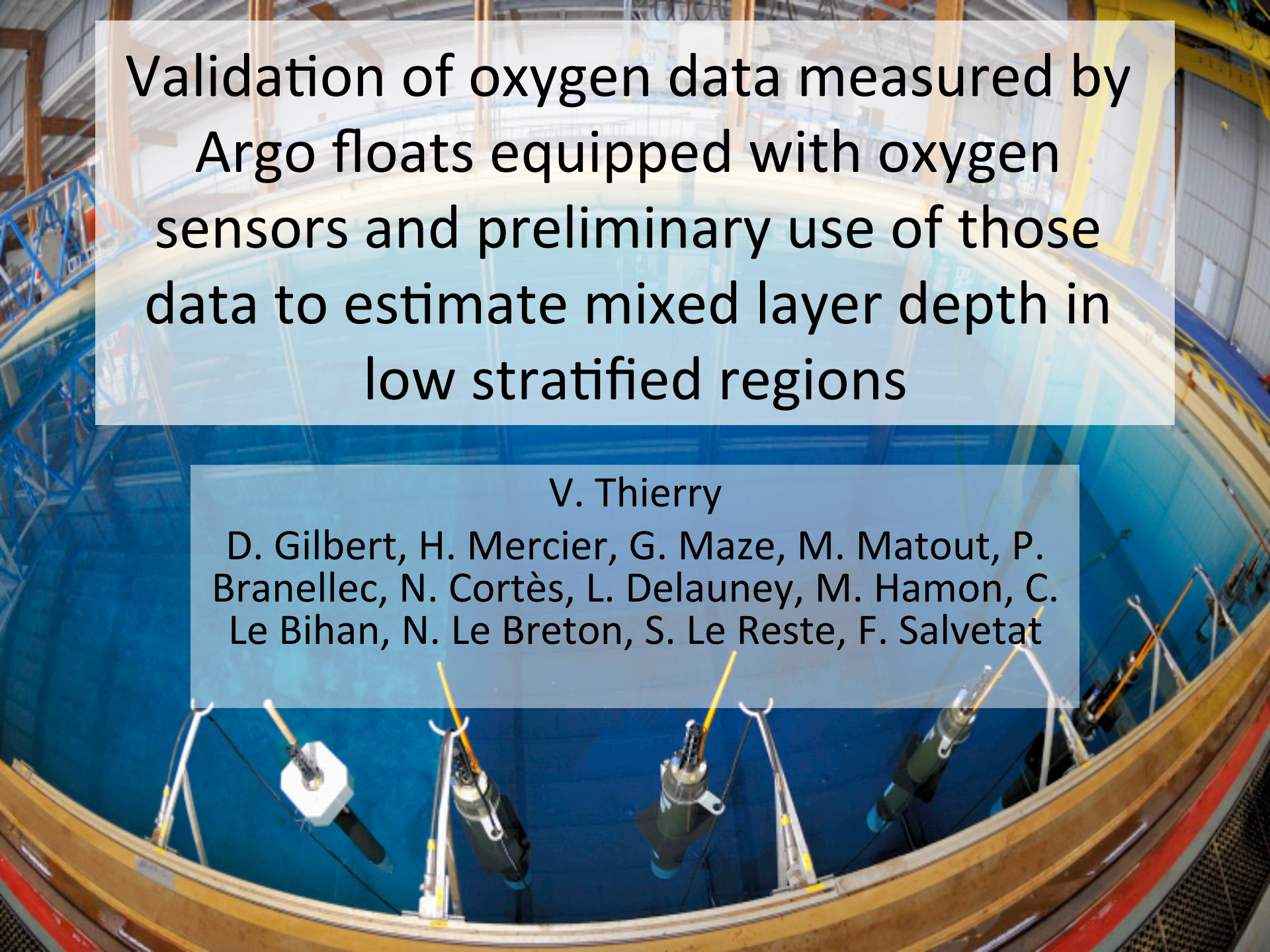
Validation of oxygen data measured by Argo floats equipped with oxygen sensors and preliminary use of those data to estimate mixed layer depth in low stratified regions

V. Thierry

D. Gilbert, H. Mercier, G. Maze, M. Matout, P. Branellec, N. Cortès, L. Delauney, M. Hamon, C. Le Bihan, N. Le Breton, S. Le Reste, F. Salvetat

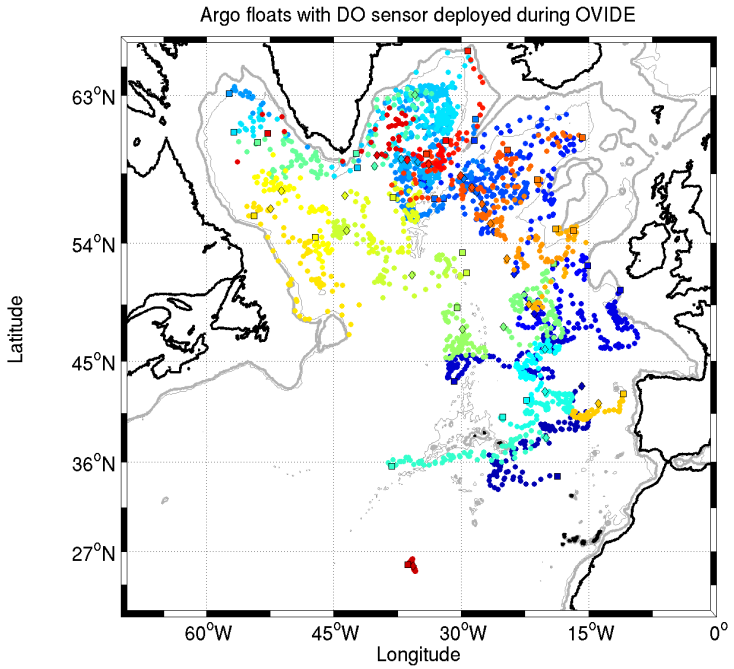


Plan

- **Where we are in terms of Oxygen validation** ?
  - Predeployment tests
  - O2 correction based on calibrated CTD-O2 cast
  - Comparison to WOA

- **Preliminary scientific use of those data**

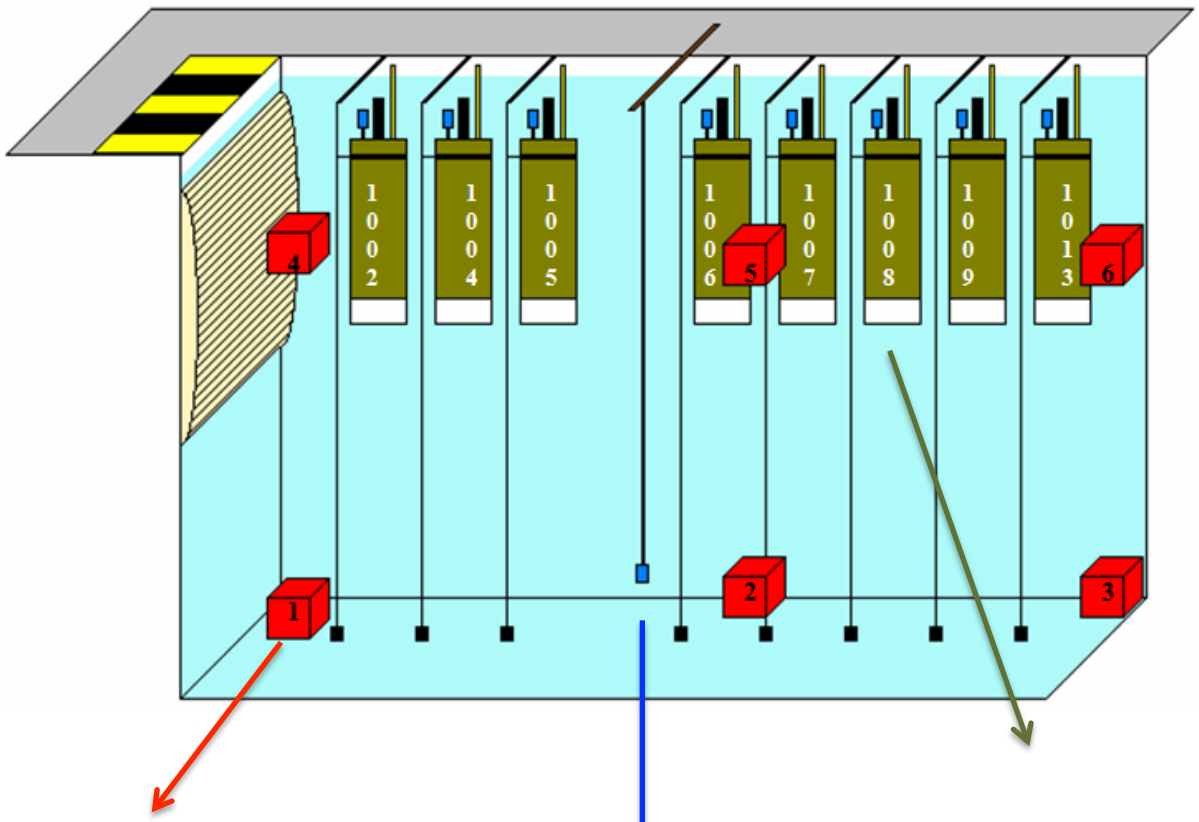
Deployments



A calibrated CTD-O2 cast is available for each deployment

- 2010 deployment
  - 13 PROVOR-DO
  - 3830 optodes
  - 20-coef based equation
  - No multipoint calibration
- 2011/2012 deployment
  - 12 PROVOR-DO +1 Deep-Arvor
  - 4330 optodes
  - 20-coef based equation
  - No multipoint calibration
- 2012 deployment
  - 10 PROVOR-DO
  - 4330 optodes
  - Stern-Volmer equation
  - Multipoint calibration

Test in Ifremer pool before deployment

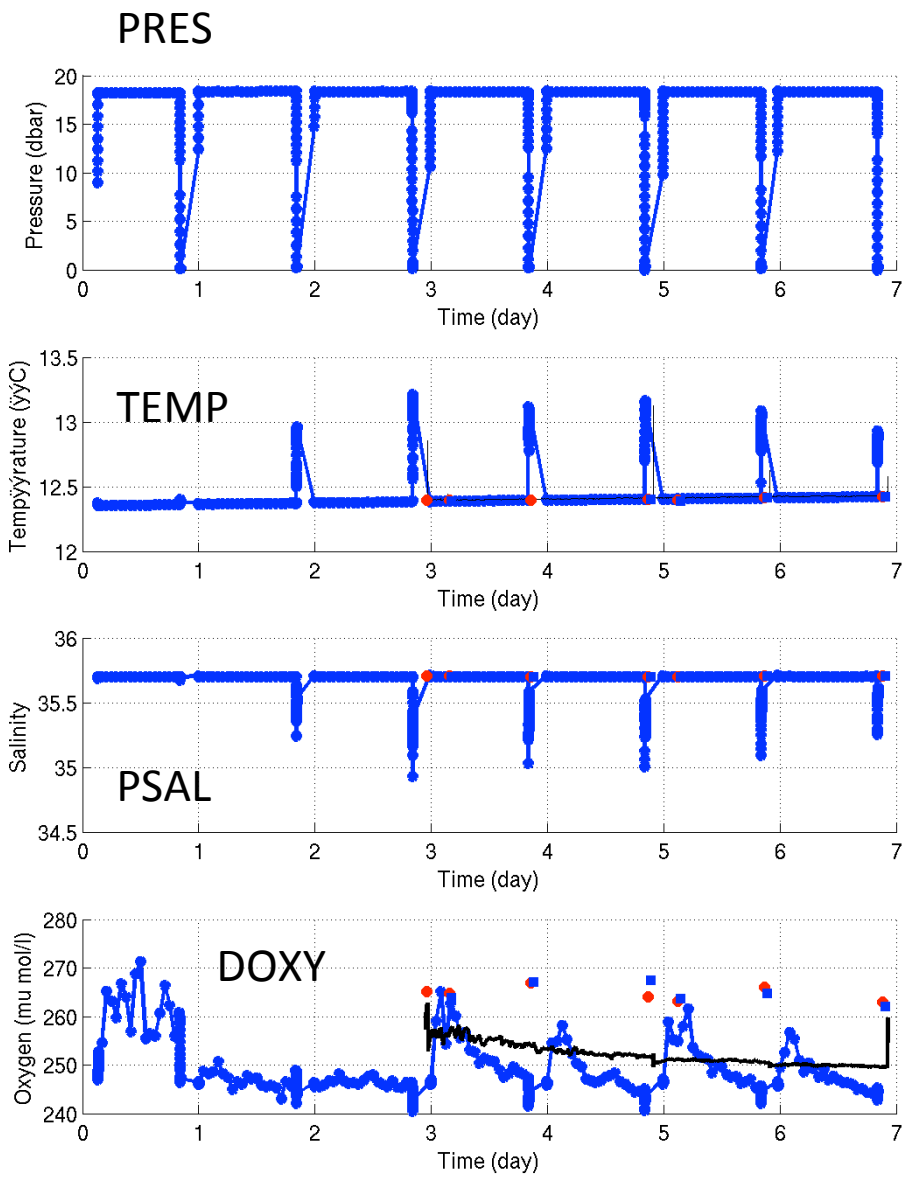


Bottle sampling and winkler titration

Free Optode

PROVOR floats with 4330 Aanderaa optode, multipoint calibrations performed

Example : PROVOR-DO 11002 and free optode



- Similar behavior of the other DO sensors
- Despite the calibration, all optodes underestimated oxygen concentration (between 11 and 24 mumol/L)

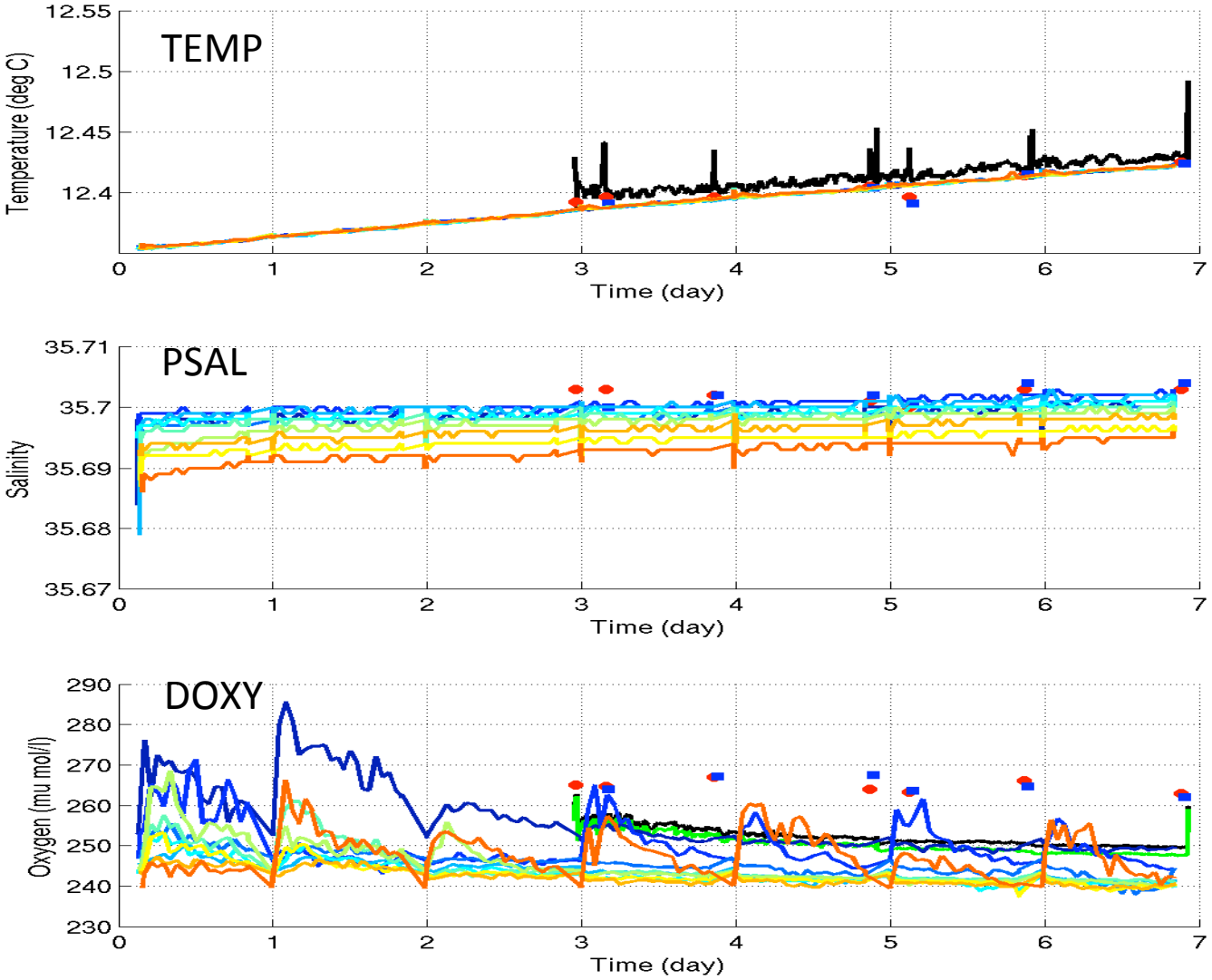
➔ Drift during storage ?

➔ Chlorine effect ?

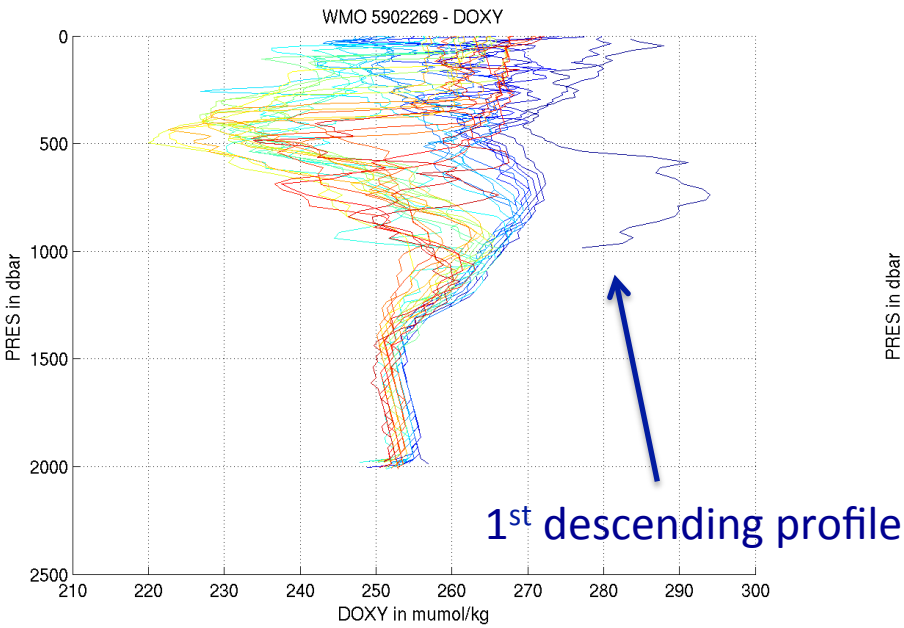
- Large (>20 mumol/L) unexplained fluctuations during « drift » at parking depth for the floats , still no clear explanation

➔ Outgassing of some plastic materials ?

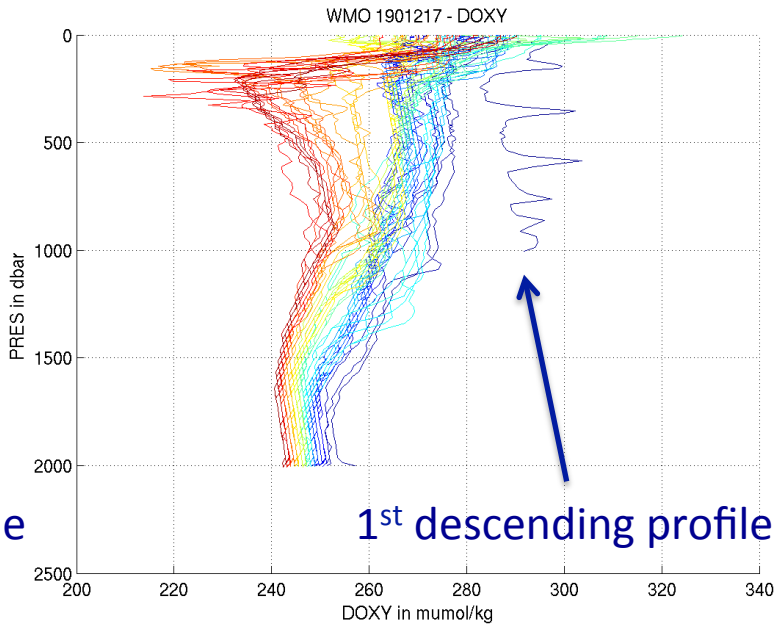
Results for all floats



Impact of storage ?



3830 optode - June 2010 deployment



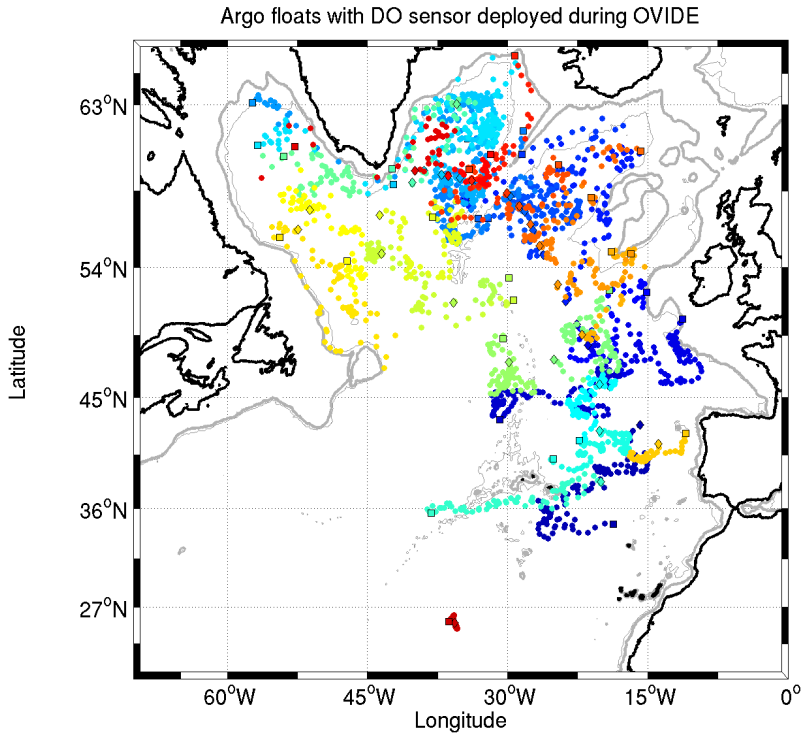
4330 optode - June 2011 deployment

It is highly recommended to store the optodes wet :

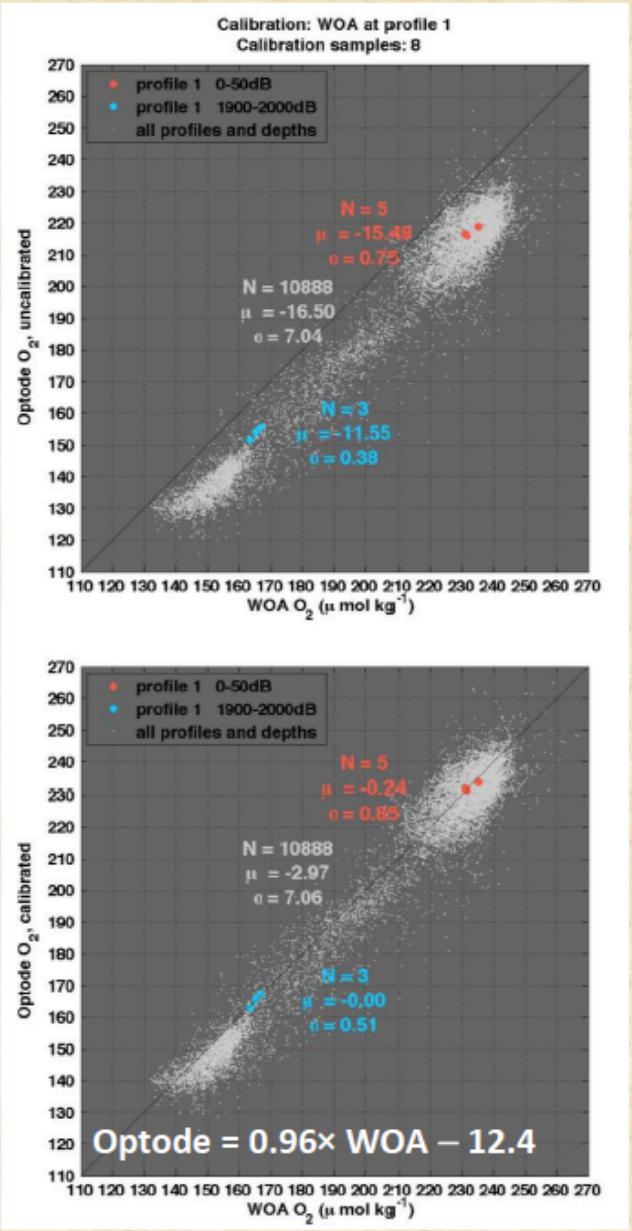
- Drift observed during 24 hours after storage in dry conditions
- The optode probably drift during storage anyway. How long a calibration is valid if the float is not deployed ?

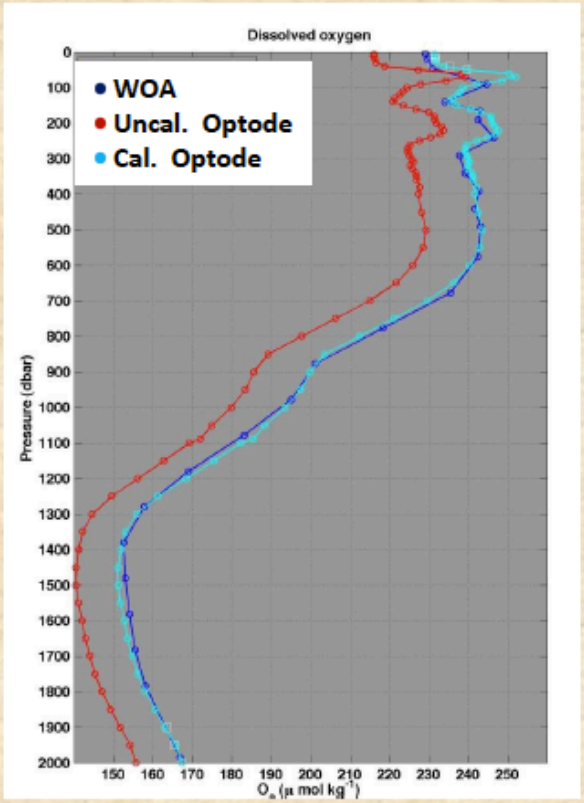
Post-deployment validation

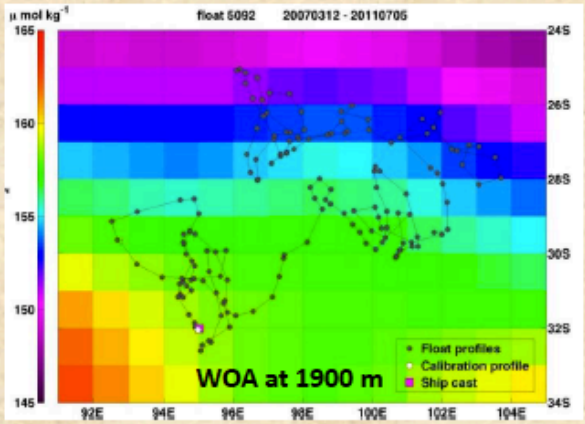
- Correction based on calibrated CTD-O2 cast acquired at float deployment
- Validation by comparison to climatological data
- Correction of the 25 PROVOR-DO floats deployed in 2010 and 2011 and of the Deep Arvor deployed in 2012



Post-deployment validation

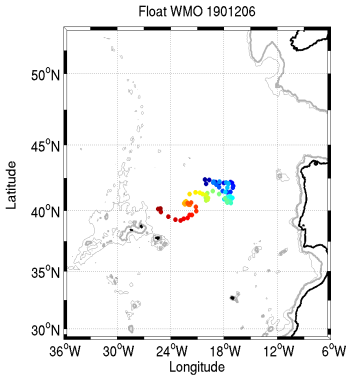






2-point calibration adjustment of O_2 data from UW float 5092 using WOA O_2 data in the eastern Indian Ocean

Courtesy S. Riser



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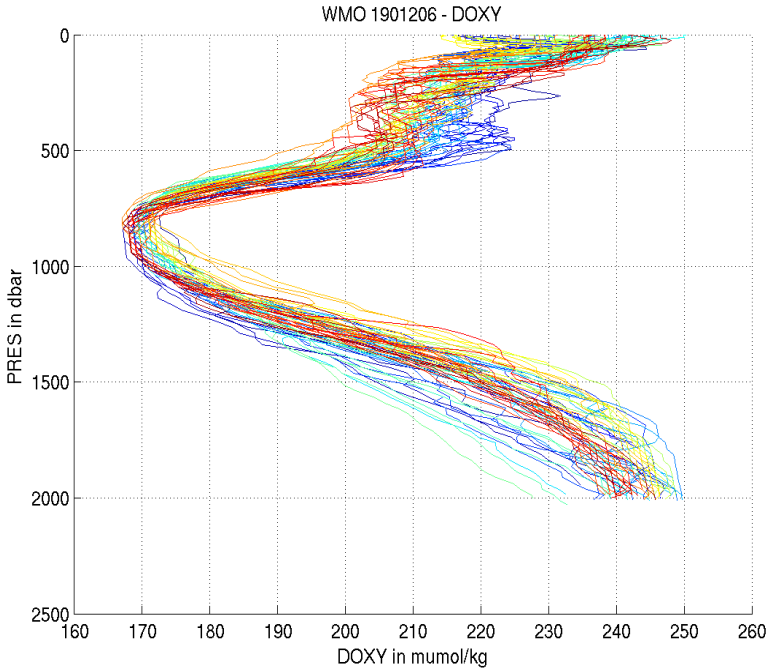
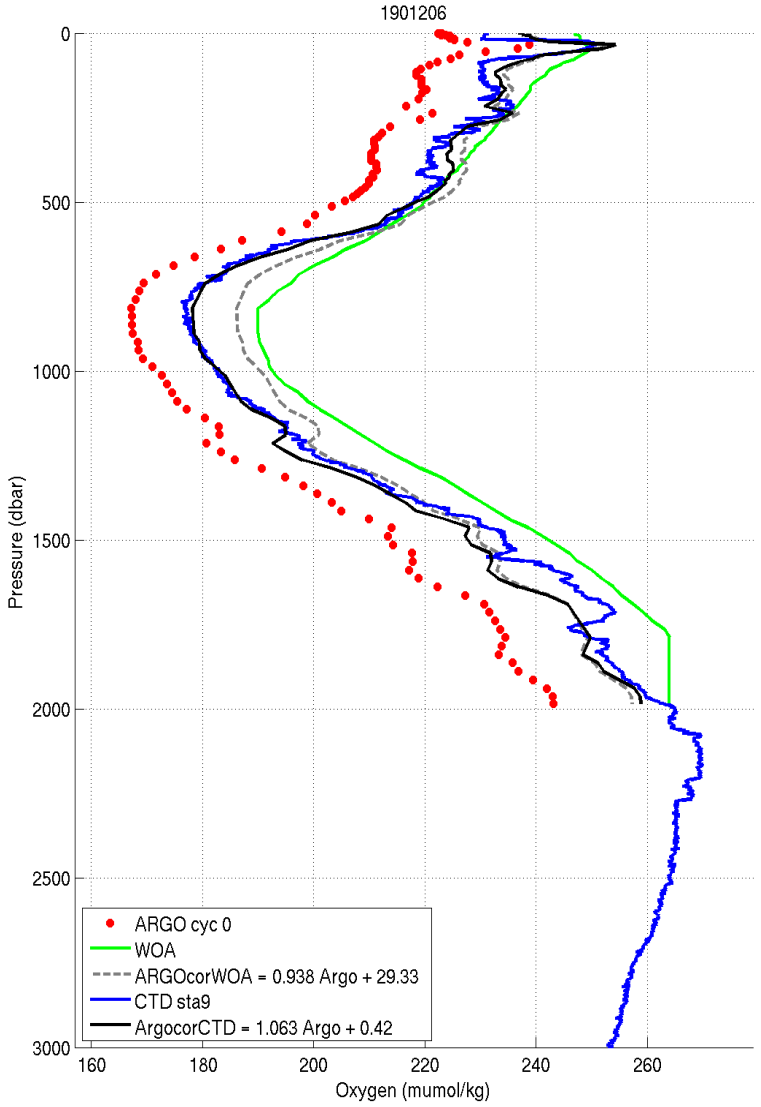
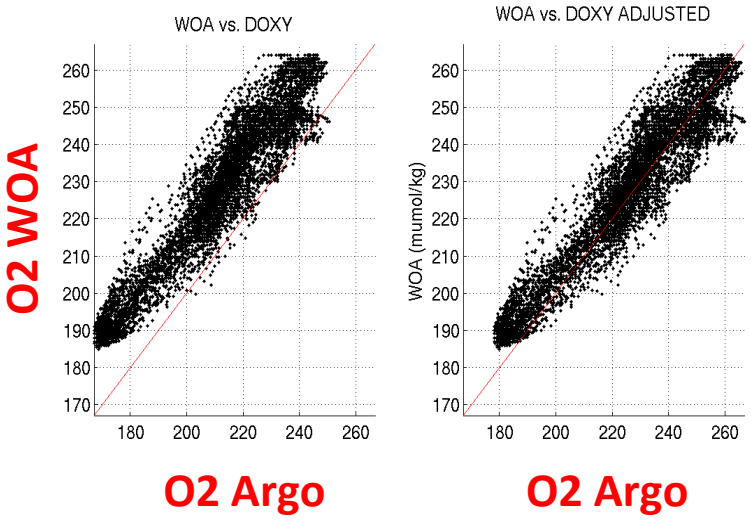


DOXY_ADJUSTED = 0.938 DOXY + 29.3



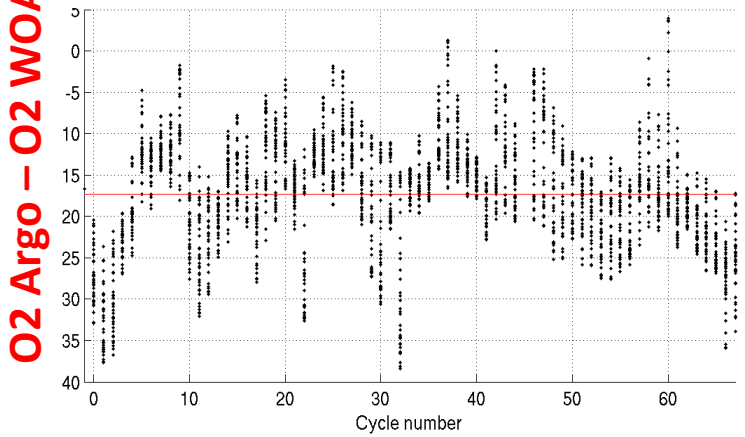
Comparison to WOA

Before correction **After correction**



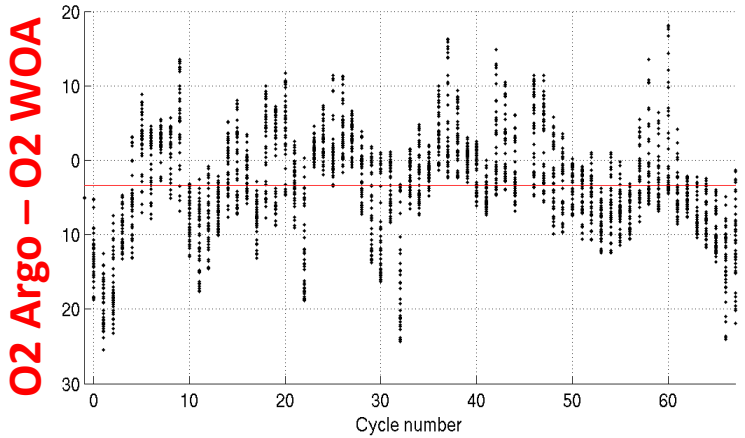
1901206

Before correction



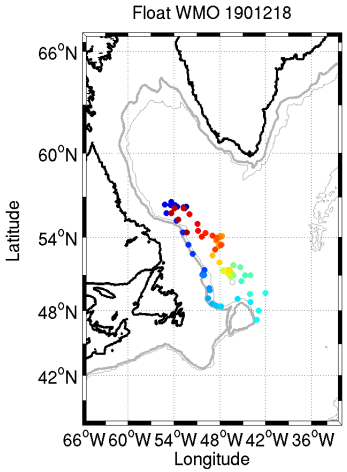
-17.3 mumol/kg

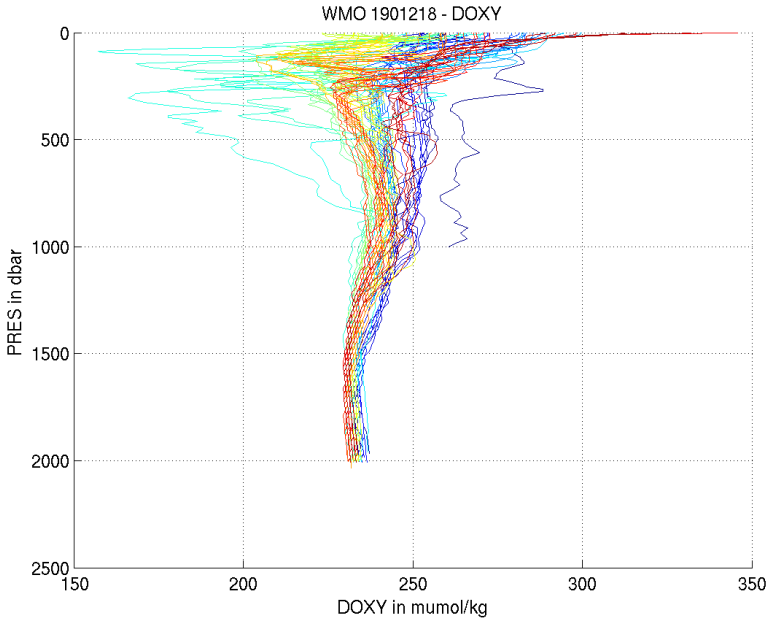
After correction

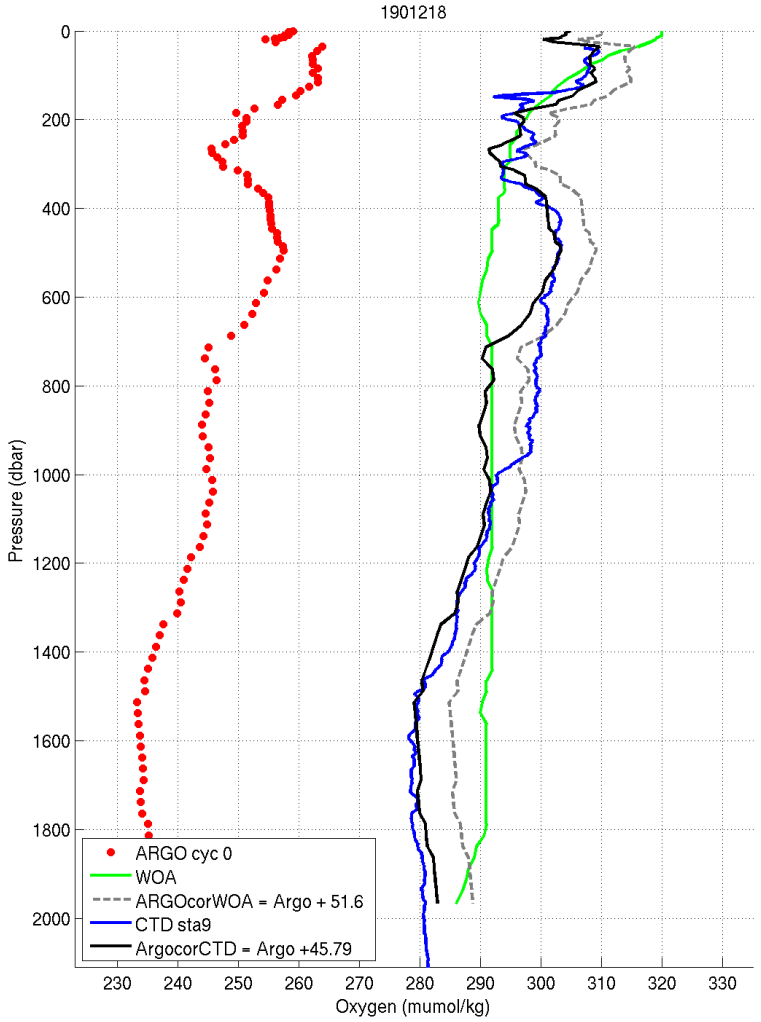


-3.3 mumol/kg

1901218



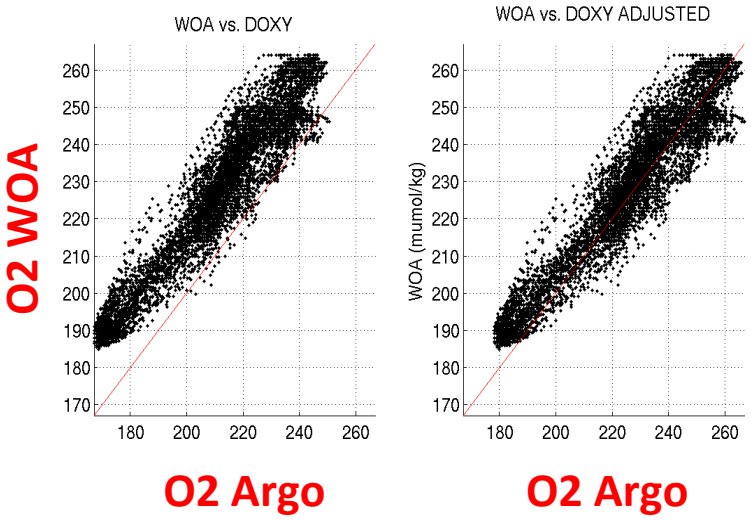


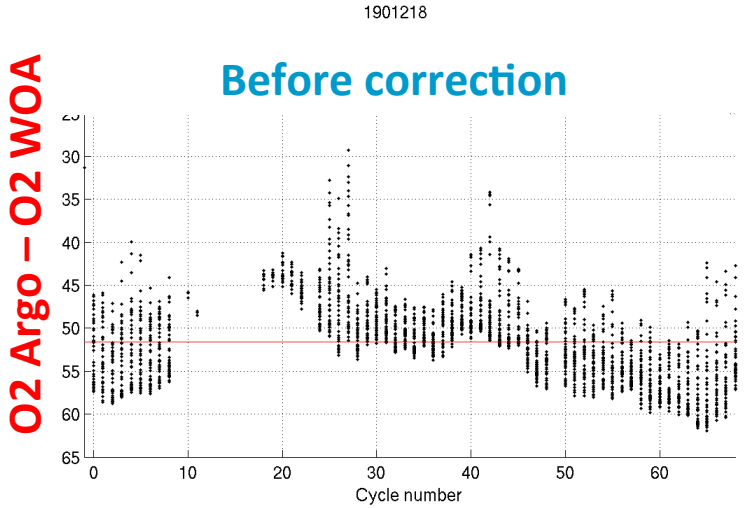


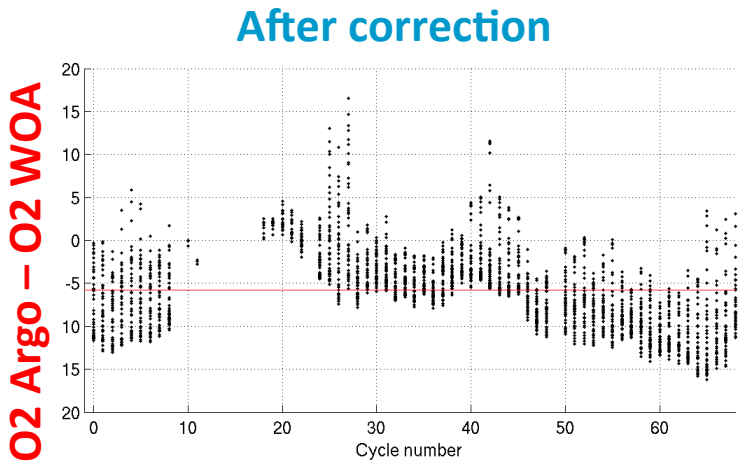
DOXY_ADJUSTED = DOXY + 45.8

Comparison to WOA

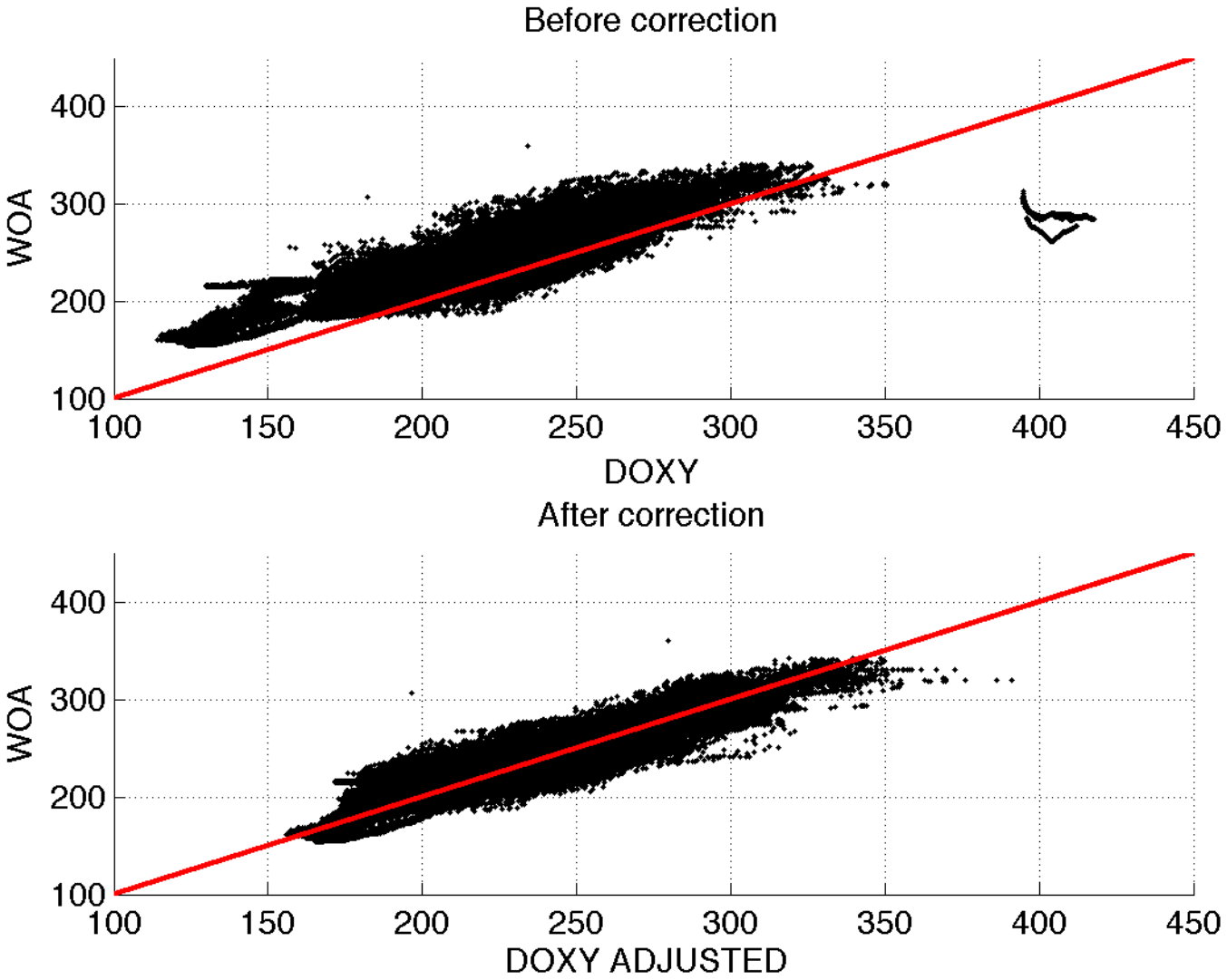
Before correction **After correction**



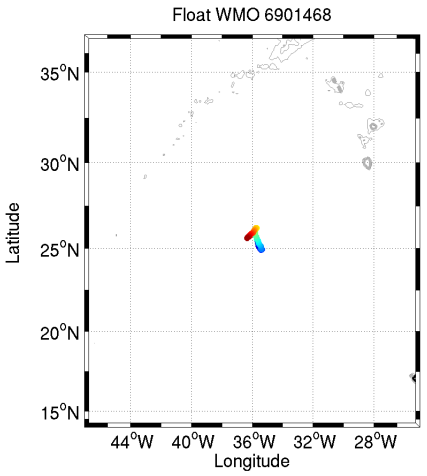


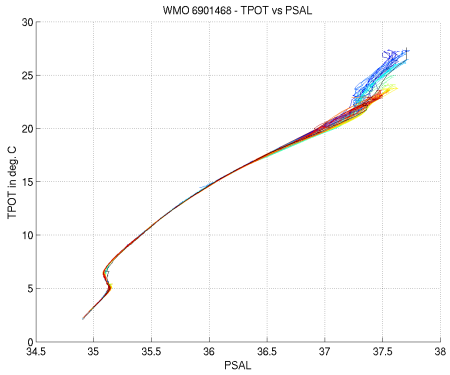


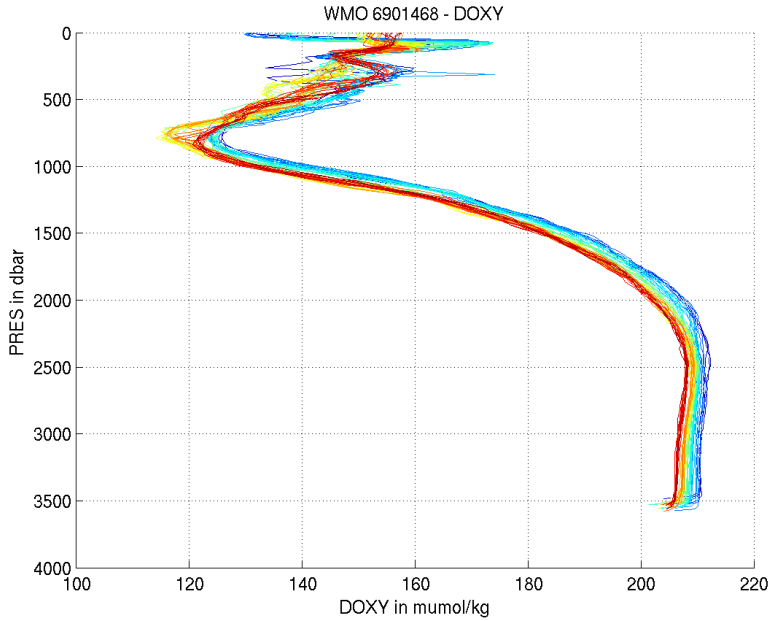
Comparison to WOA when considering the 26 floats

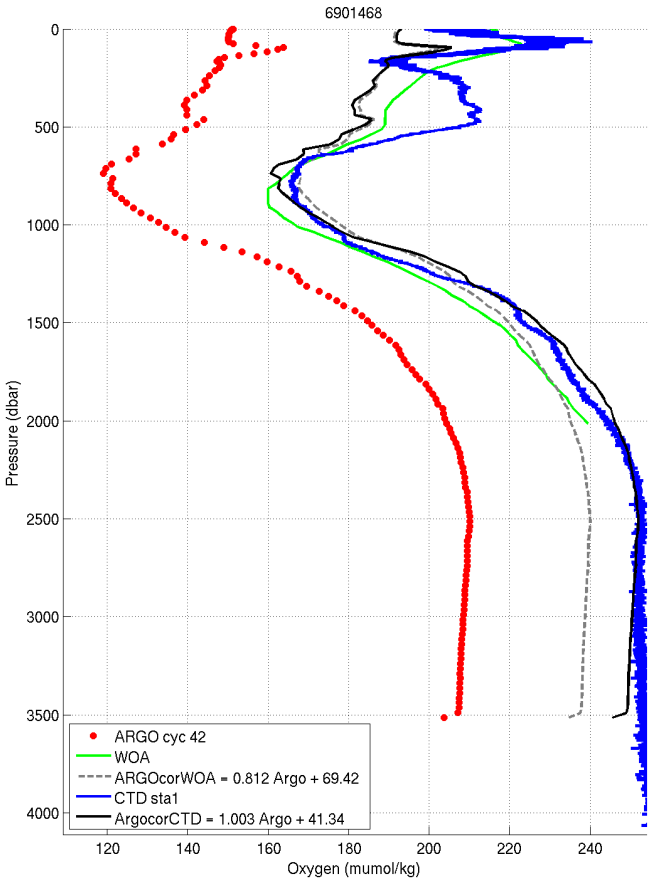


Deep-Arvor 6901468





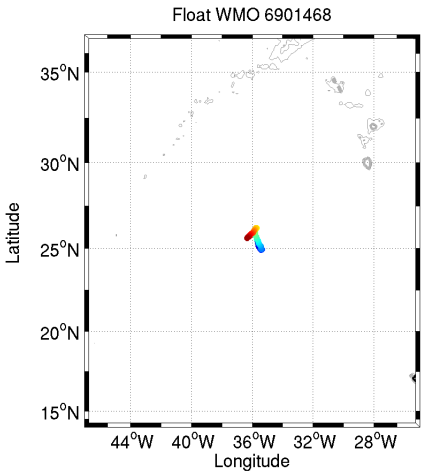


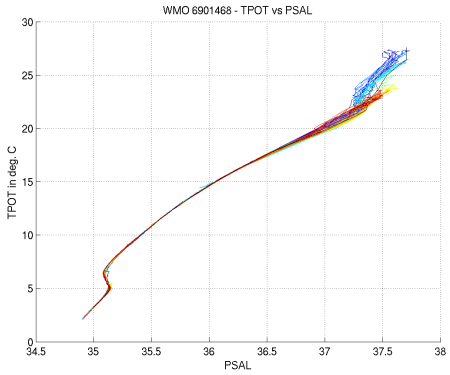


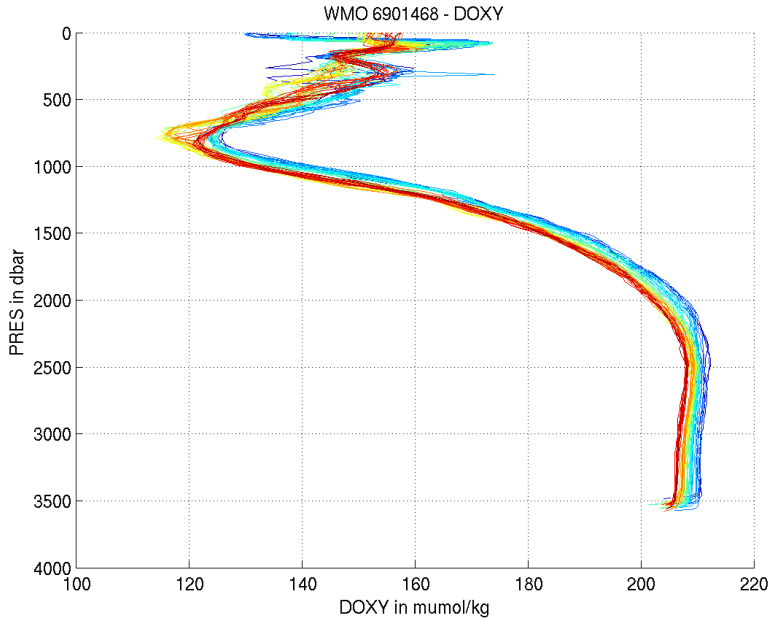
DOXY_ADJUSTED = 1.003*DOXY + 41.3

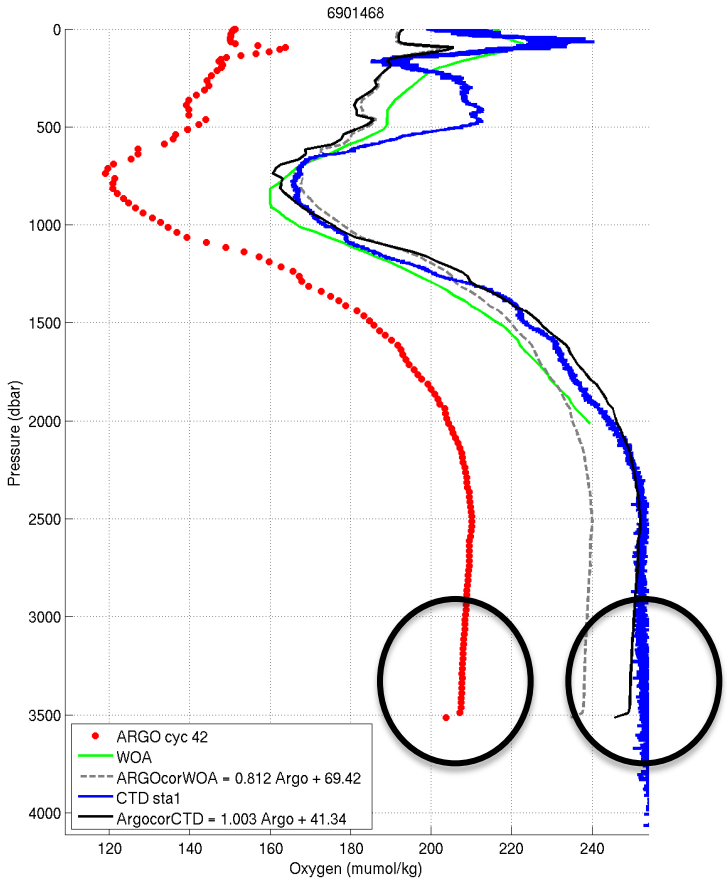
➔See poster on this float

Deep-Arvor 6901468





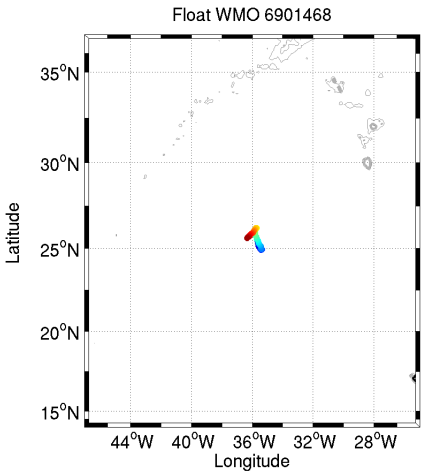


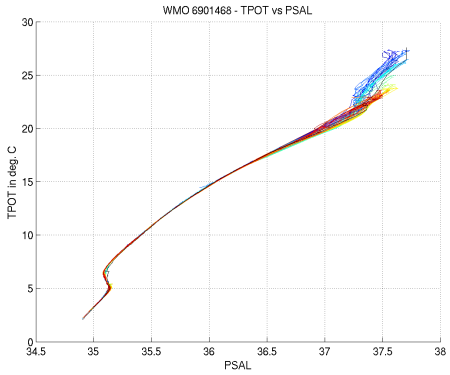


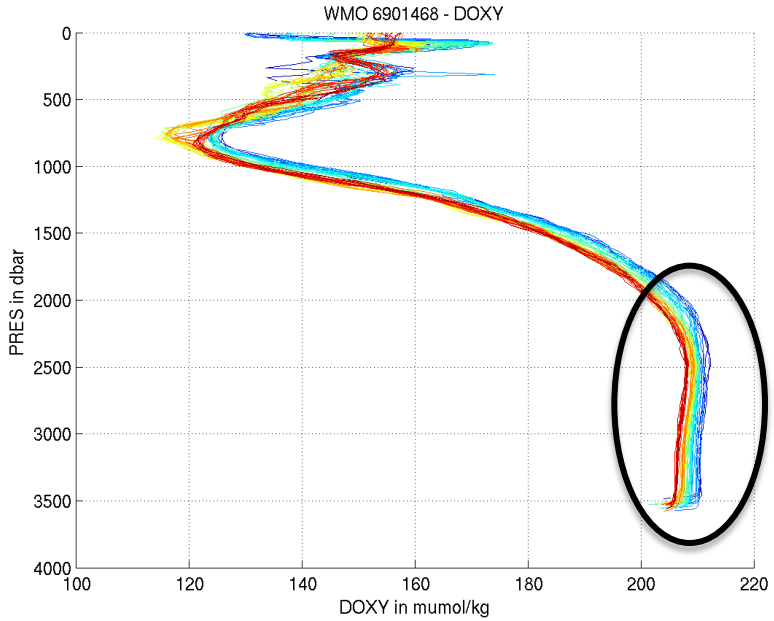
DOXY_ADJUSTED = 1.003*DOXY + 41.3

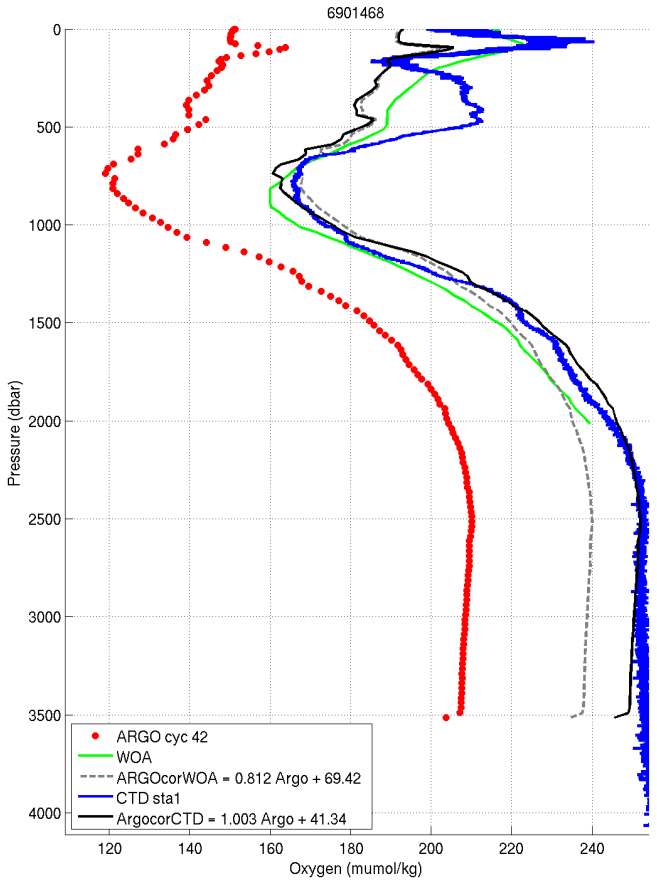
➔See poster on this float

Deep-Arvor 6901468





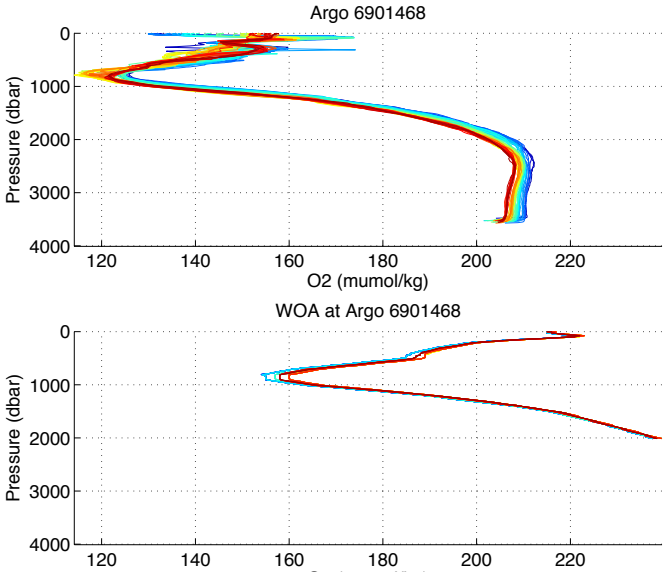


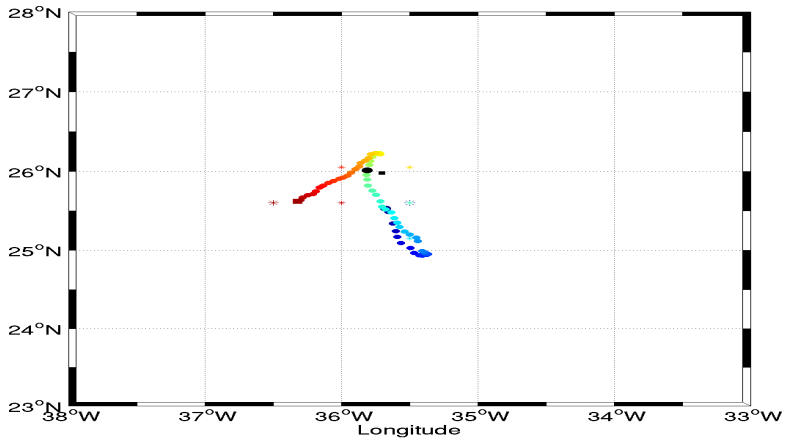


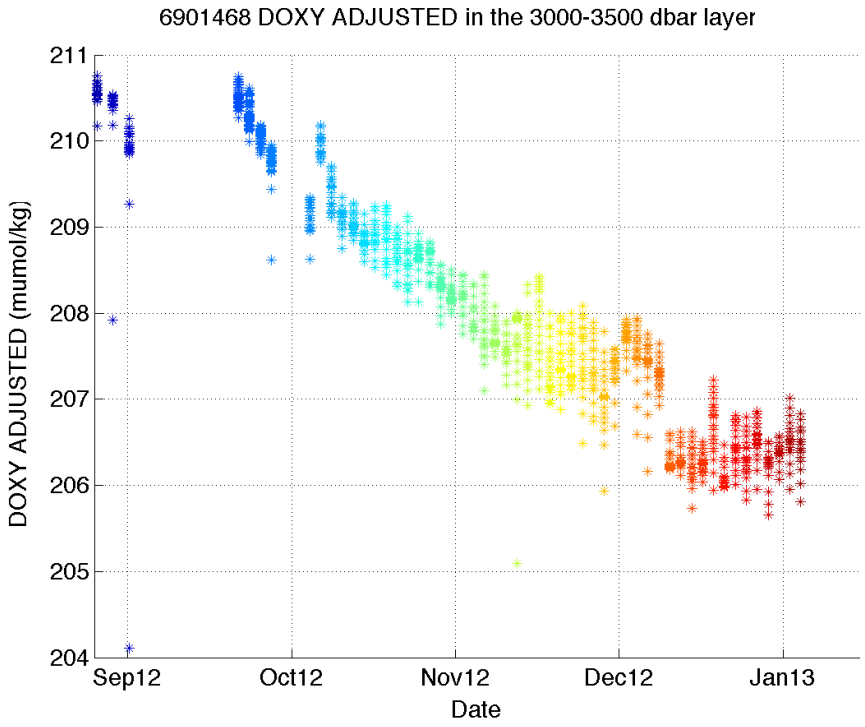
DOXY_ADJUSTED = 1.003*DOXY + 41.3

➔See poster on this float

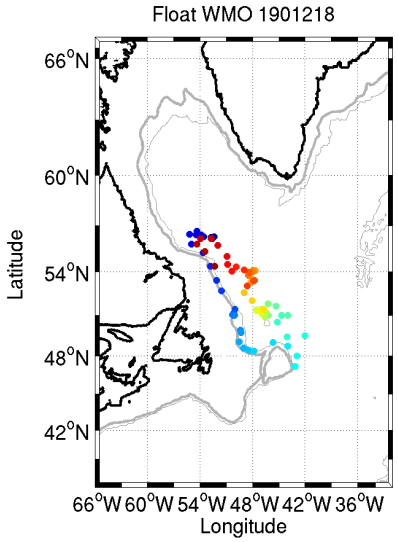
Do the Aanderaa optodes drift in water ?

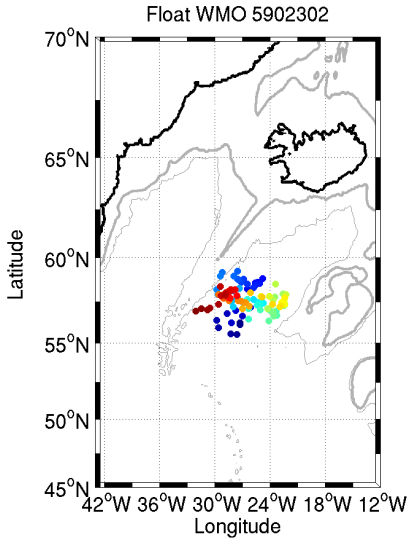


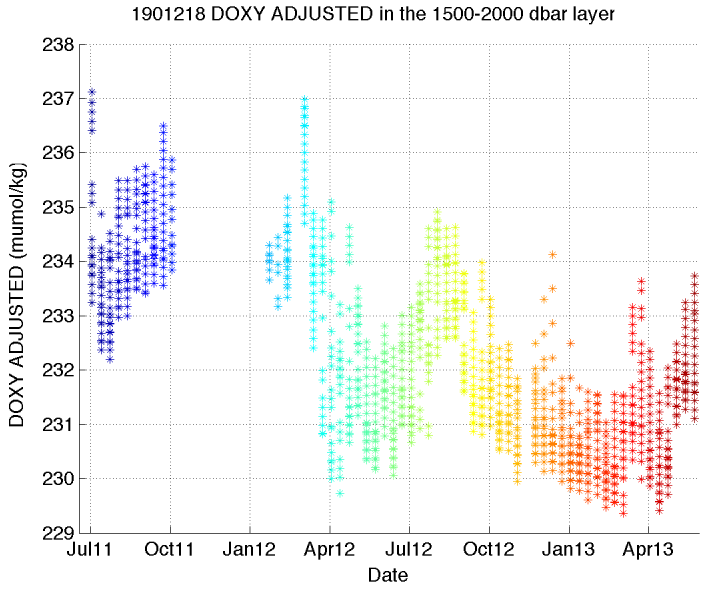


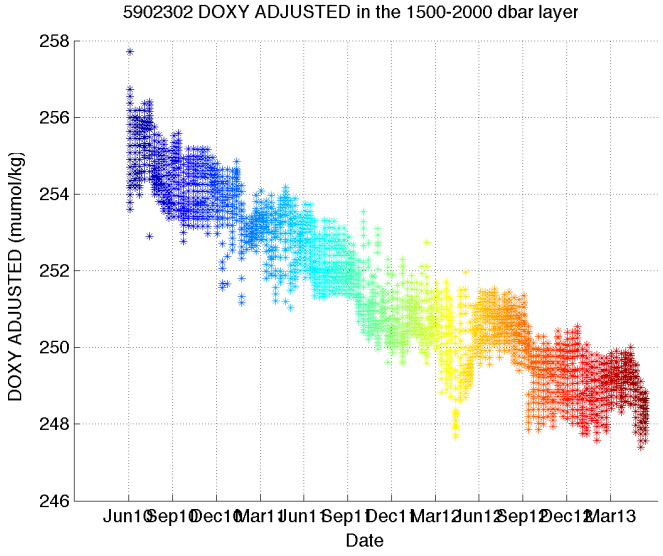


Do the Aanderaa optodes drift in water ?









Estimating Mixed Layer Depth from oxygen data ?

- Mixed layer are important region because it directly interacts with the atmosphere and determine the ventilation of the ocean interior
- MLD estimates remain an issue, especially in low stratified area, and various method exists (difference-based criteria, gradient-based criteria, split and merge method, …)
- The density difference criterion (de Boyer Montegut 2004) is widely used because it is rather simple.
  - In the North-Atlantic : $\sigma(z_{mld}) - \sigma(surf) > 0.01$ kg/m^3

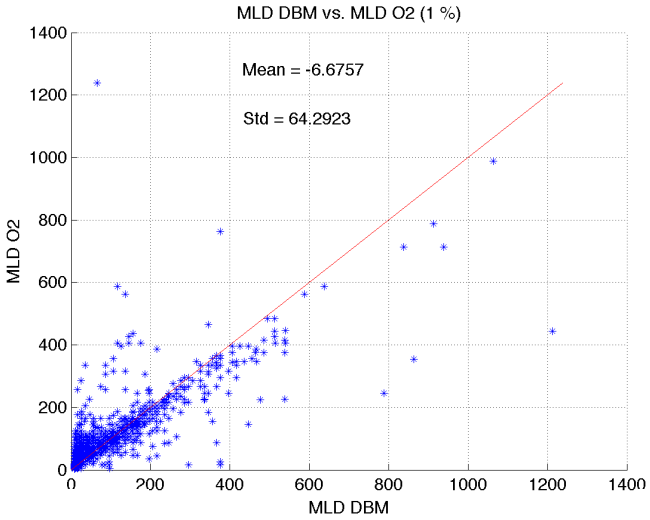
- Can oxygen data be used to estimate mixed layer depth, especially in low stratified region ?
- MLD O2 estimates based on relative differences compared to a reference surface value Castro-Morales and Kaiser (2012)

$$O2(surf) - O2(z_{mld}) > O2(surf) * xx\%$$

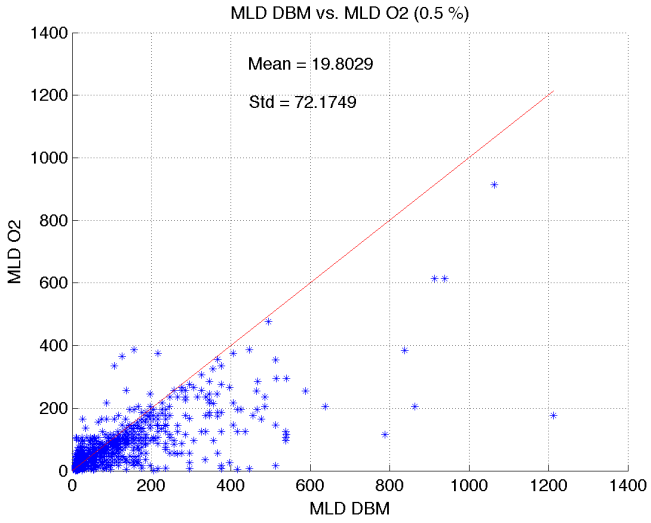
- Three values will be tested on the corrected O2 profiles (1867 profiles) and compared to the MLD estimated from the density difference criterion
  - 0.5 (Castro-Morales and Kaiser,2012; near Antarctic)
  - 1
  - 2

MLD estimated from a relative O2 difference compared to a reference surface value

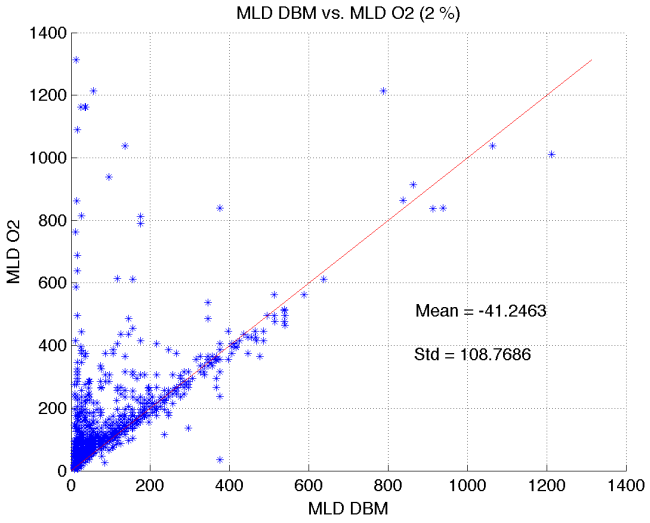
Criteria= 1%

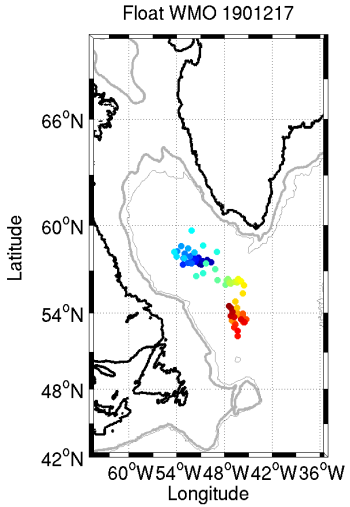


Criteria= 0.5%



Criteria= 2%

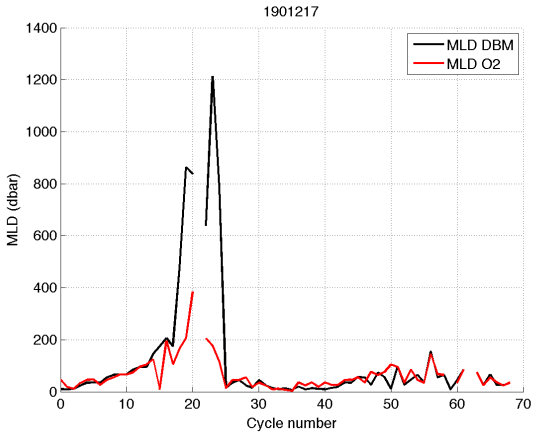




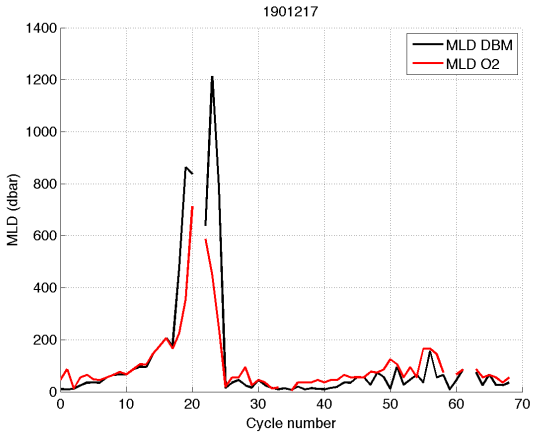
MLD comparison

Density difference criterion: 0.01 kg/m3
O2 relative difference criterion = 0.5%, 1% or 2%

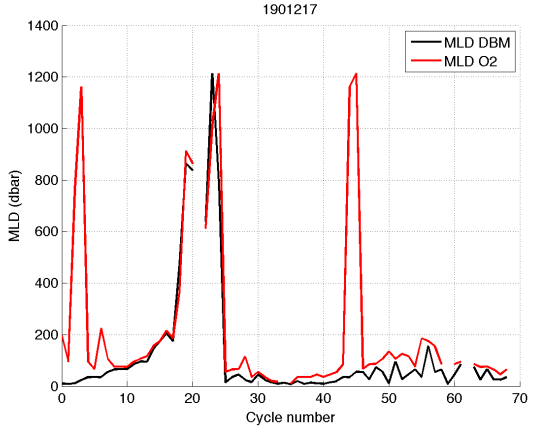
0.5% criterion



1% criterion

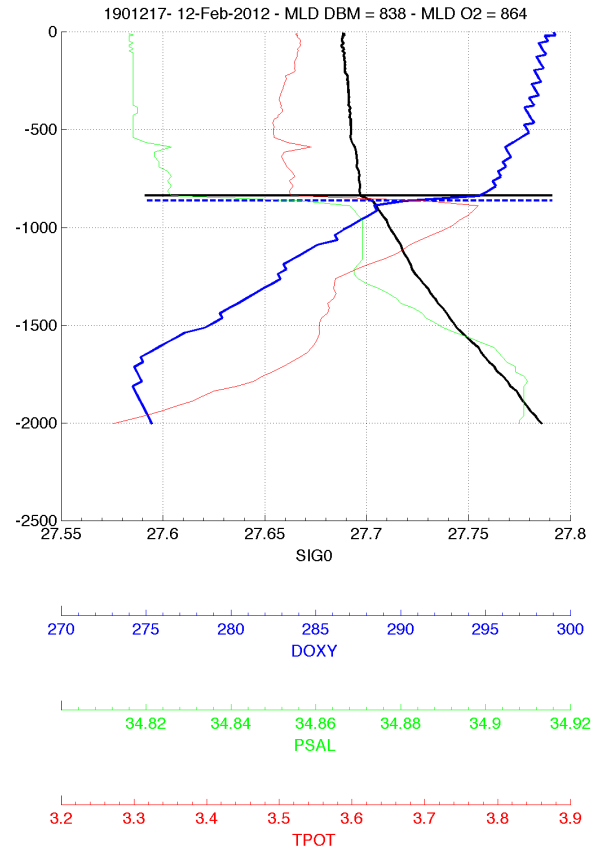


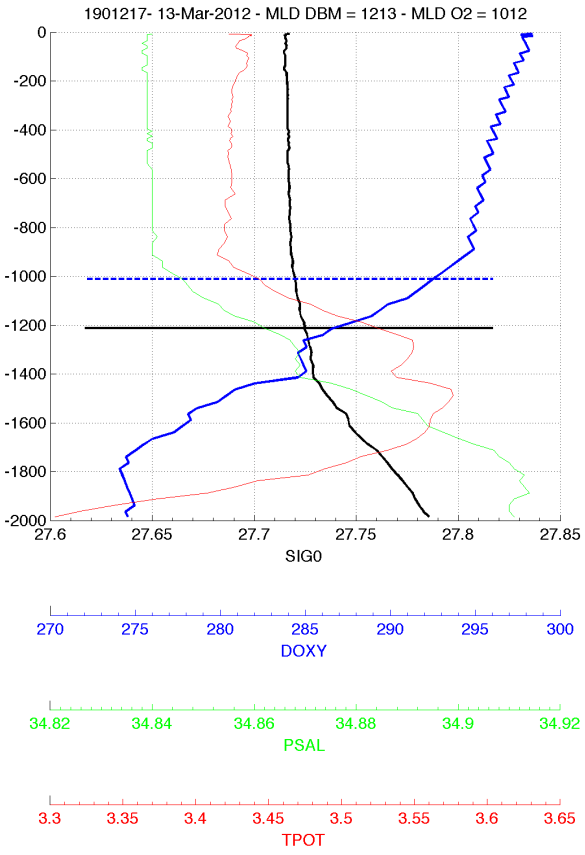
2% criterion

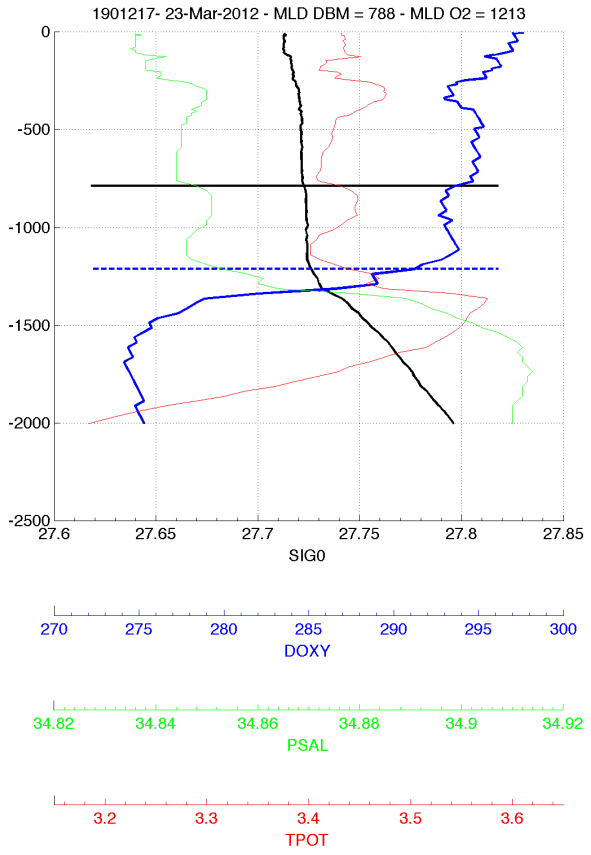


MLD comparison

Density difference criterion: 0.01 kg/m3
O2 relative difference criterion = 2%







Conclusion

- **Oxygen validation results/perspectives**
  - Calibrated CTD-O2 cast acquired at float deployment are mandatory for correcting the data because Aanderaa optodes always underestimate the oxygen concentration and tests in pool not reliable
  - Corrections of 25 PROVOR-DO floats were transmitted to Coriolis (DOXY_ADJUSTED=a*DOXY+b). Data are already available (Deep Arvor corrections soon available) ➔Need to complete the validation for the 2012 deployment and to compare corrections with/without a multipoint calibration performed before deployment
  - Evidence of sensor drift while in water ➔Further investigations required
- **MLD estimated from O2 concentration relative difference** (Castro-Morales and Kaiser, 2012)
  - Good agreement with a density difference method (0.01) when using a criteria of 1%, 2% criterion might be better for deep mixed layer (>500 db)
  - Further investigations required to assess the use of those data to define MLD in low stratified area


Thank you