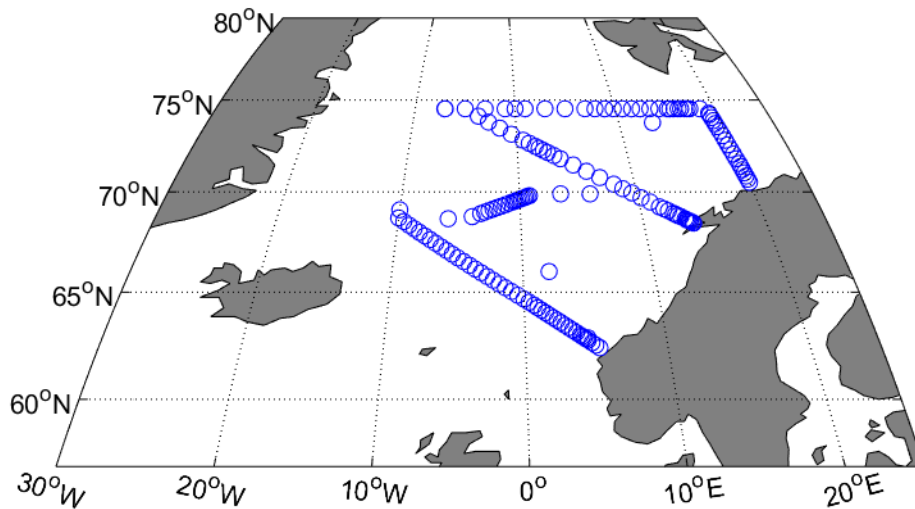


JOHAN HJORT JH2022207 – 58JH20220524

Report written by Siv K. Lauvset (NORCE Norwegian Research Centre, [siv.lauvset@norceresearch.no](mailto:siv.lauvset@norceresearch.no))

April 18, 2024



The map shows all stations on the cruise.

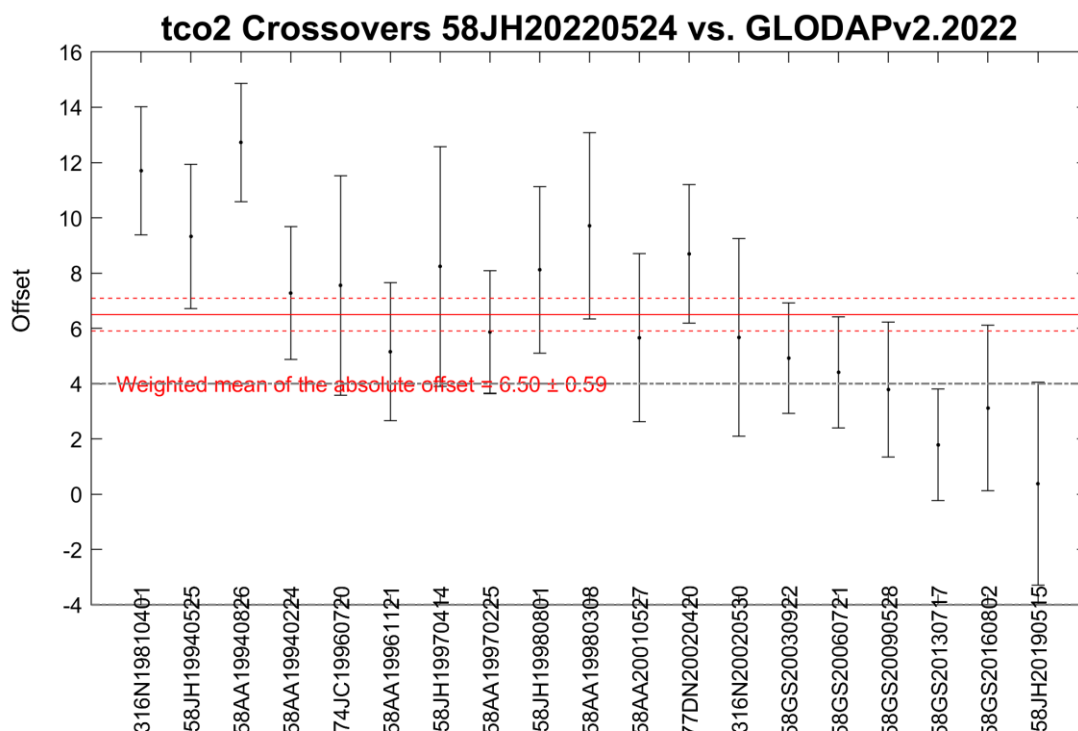
DIC and AT samples were taken in 250mL glass bottles following SOP (Dickson et al., 2007).

See metadata for details on analytical methods and instruments used.

#### DIC, PI onboard: Siv K. Lauvset and Are Olsen, post-processing: Siv K. Lauvset

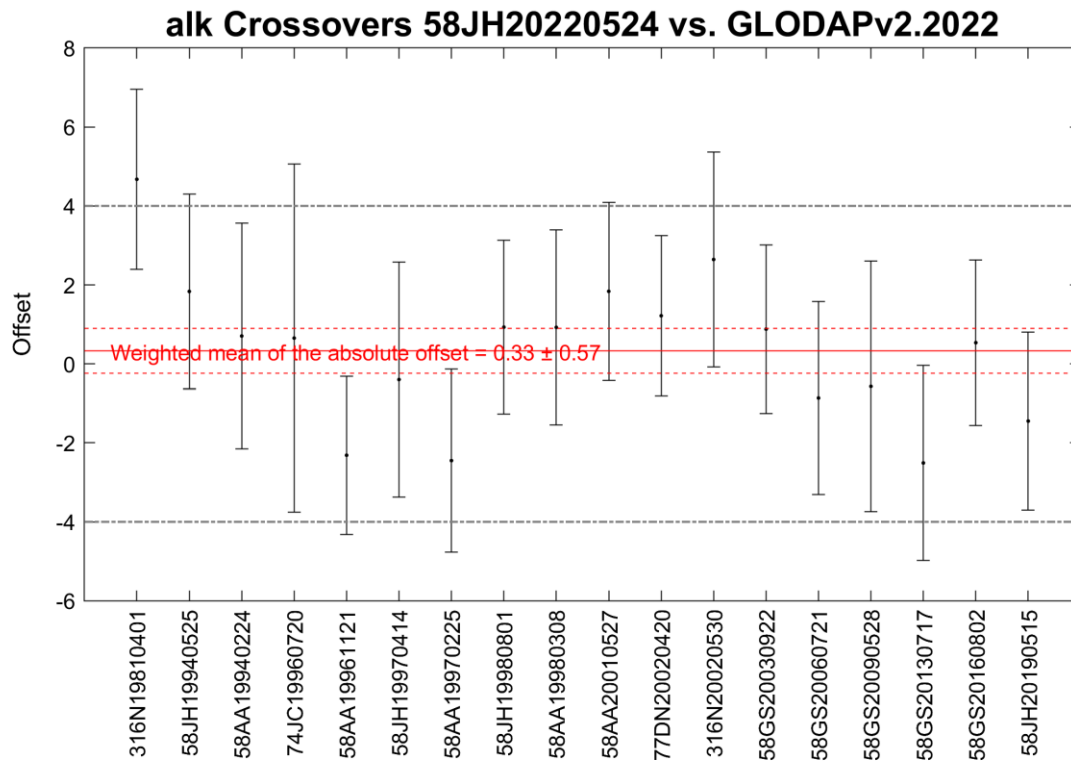
Overall good data. Below 1500dbar the data have the expected long-term trend compared to GLODAPv2.2022, but no bias compared to the most recent cruises in the data product.

Uncertainty in DIC data are estimated to  $\pm 1.0 \mu\text{mol kg}^{-1}$ , based on the standard deviation of CRM-analyses as well as precision on the test station (where all Niskin bottles were closed at the same pressure).



**AT, PI onboard: Tor de Lange and Jean Negrel, post-processing: Siv K. Lauvset**

Overall good data. Below 1500dbar these data compare very well with GLODAPv2.2022. Uncertainty in the AT data are estimated to  $\pm 3.5 \mu\text{mol kg}^{-1}$ , based on the standard deviation of CRM-analyses as well as precision on the test station (where all Niskin bottles were closed at the same pressure).

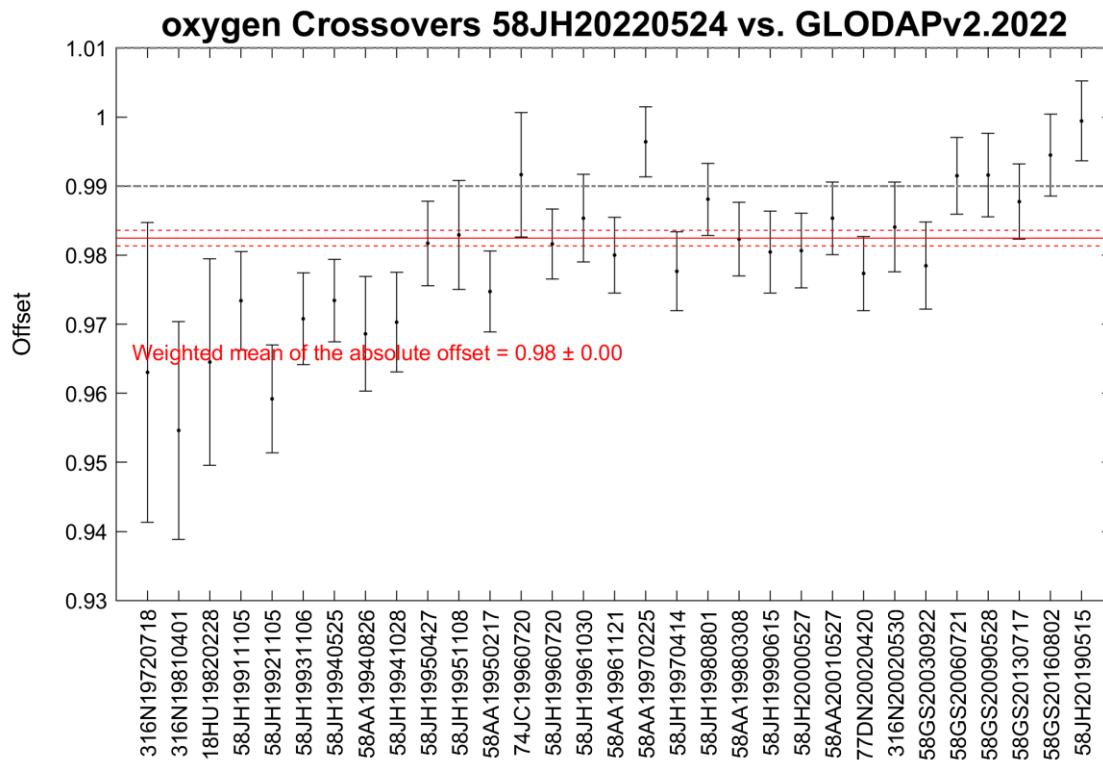


**Oxygen, PI onboard and post-processing (bottle samples): Linda Fonnes Lunde**

**CTD-data: Are Olsen**

Winkler oxygen in ml/l was converted to mmol/kg using the factor 44.661 and seawater density (calculated with CTD salinity). Winkler oxygen data exhibit the expected trend, but have no bias compared to the most recent cruises in GLODAPv2.2022.

On one station all niskins were closed at the same depth, and one sample for each niskin was taken for Winkler analysis. Using the standard deviation of these replicate samples, the uncertainty in the Winkler oxygen data is estimated to  $\pm 0.45 \mu\text{mol kg}^{-1}$ .

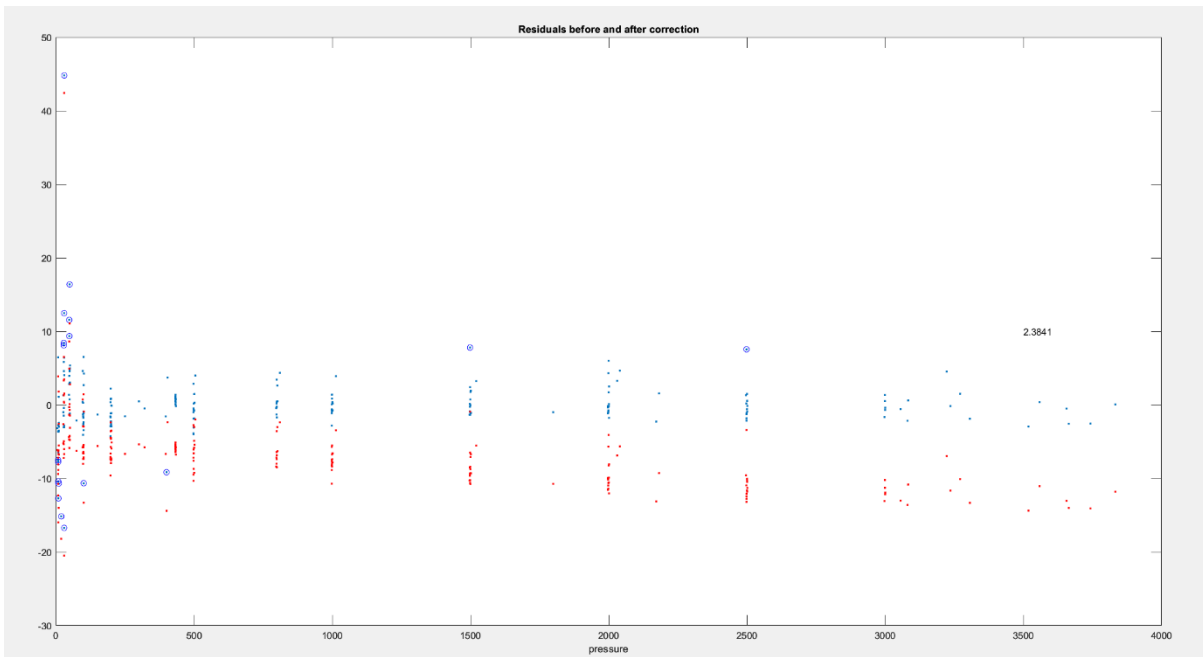


Winkler samples were collected at 18 stations. These were matched with the CTD downcast data and used to optimize the  $S_{oc}$ ,  $V_{off}$ ,  $E$  and  $\tau_{20}$  coefficients in the “Seabird oxygen calibration function” that links oxygen concentrations with the Voltage response of the oxygen sensor (Eq. 4 in Uchida et al., 2010). I used the downcast data to avoid issues with potential hysteresis and because the \*.btl files did not contain the Voltage sensor output – so the Seabird equation could not be applied. The CTDOXY data in the bottle file with corrected data are thus extracted from the CTD downcast files.

The optimization was conducted iteratively removing outliers in each step until no more outliers were found.  $2.8 \times$  Standard deviation was used as the threshold for outliers. 18 such outliers were found, these are flagged 3 in my output file for bottle profiles. The optimization was conducted using the entire set of data, i.e., the coefficients were the same for all of the stations.

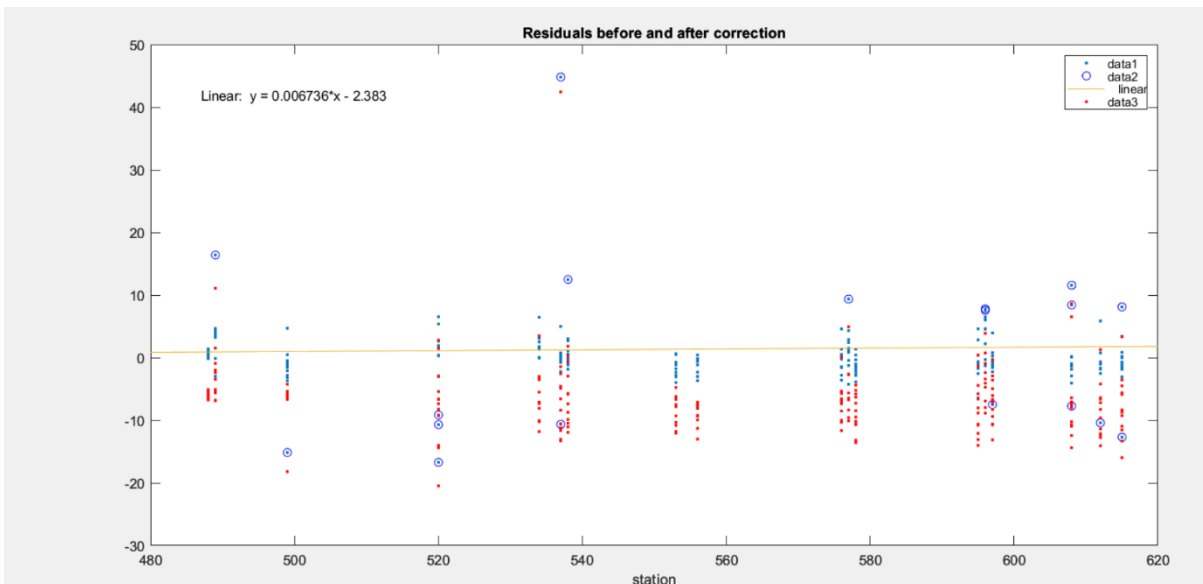
Also, note that instead of using actual  $dV/dt$  values, I set this to  $4 \times 10^{-4}$ , which is approximately the mean of actual  $dV/dt$  values. Using real  $dV/dt$  lead to very noisy downcast CTD Oxygen profiles in the end, while using a constant value made them much more smooth. Using a constant value did not otherwise affect the correction

The coefficient optimization took care of a pressure dependent offset in CTD oxygen (Fig. 2) and rmse between corrected CTD data and Winkler oxygen is  $2.3 \mu\text{mol/kg}$  (excluding the 18 outliers that were identified). This is a bit high, but acceptable.



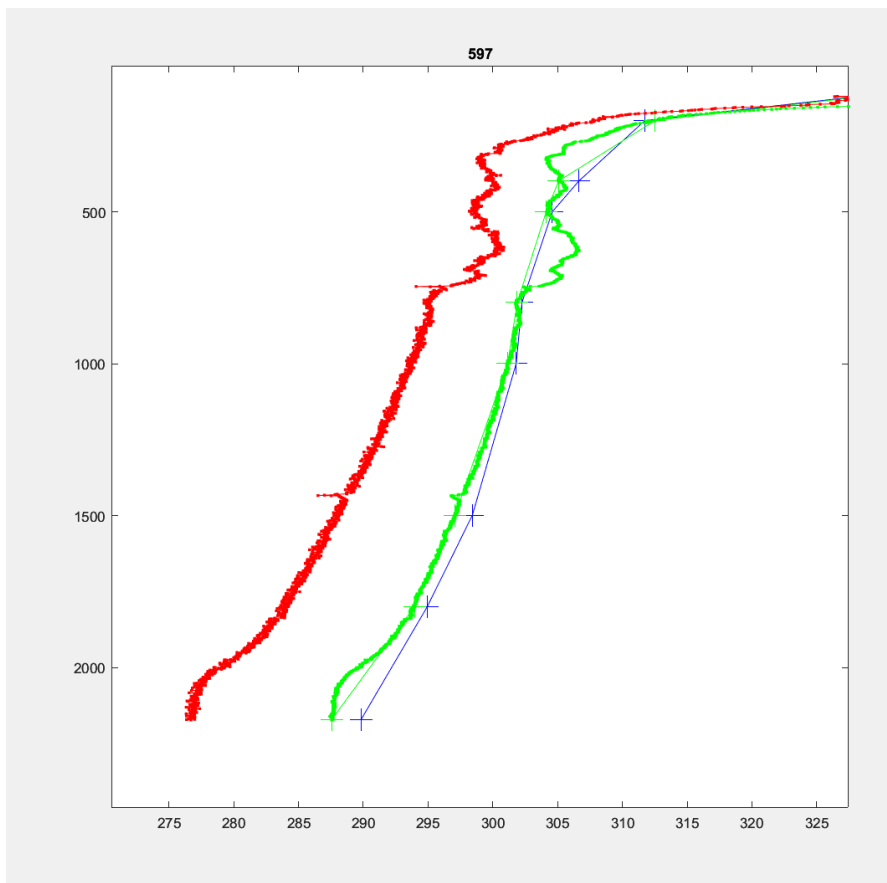
Difference between uncorrected (red) and corrected CTD (blue) and Winkler oxygen – with pressure. The encircled datapoints are the outliers. The number is the rmse between the corrected CTD data and Winkler data- excluding the outliers. In  $\mu\text{mol/kg}$

A slight station number dependency in the CTD -Winkler oxygen difference was also evident in the uncorrected data, but this vanished almost entirely after the correction – even if the coefficients were optimized using data from all stations at once. I believe that the station dependence reflect that the stations towards the end of the cruise were typically deeper than those at the start.



Difference between uncorrected (red) and corrected CTD (blue) and Winkler oxygen, vs station number. The encircled datapoints are the outliers. The line shows the fit to the corrected CTD residuals. In  $\mu\text{mol/kg}$

The optimized coefficients were also applied on on the CTD downcast files. Here, there are a few issues. (i) The uncorrected oxygen data are very noisy. The corrected profiles are more smooth – a consequence of using a constant  $dV/dt$  – but there is still some high frequency noise. (ii) Spikes also occur, so some despiking should be conducted before these data are used for any serious purpose.

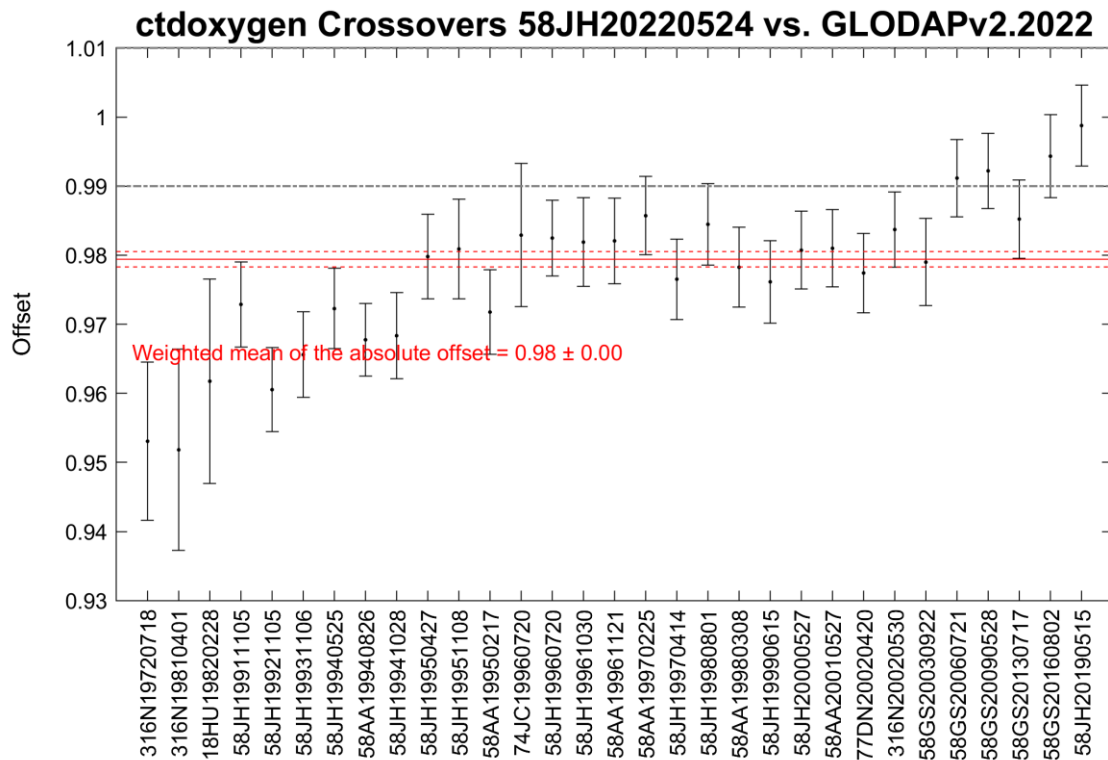


Oxygen ( $\mu\text{mol/kg}$ ) vs pressure (dbar) at station 597. Red: uncorrected CTD downcast oxygen data. Green line: corrected CTD downcast data. Green + symbols connected by straightlines: Corrected CTD data at bottle sampling depths- these are the CTDOXY data in the bottle sampling exchange files. Blue plusses connected with straight lines, winkler oxygen results.

After corrections the CTD oxygen data have the same trend and bias compared to GLODAPv2.2022 as Winkler oxygen.

#### References:

Uchida, H., Johnson, G. C., McTaggart, K. E., 2010, CTD Oxygen Sensor Calibration Procedures, in Hood et al. (eds): The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines, IOCCP Report No 14, ICPO Publication Series No 134. Available at : [https://www.go-ship.org/Manual/Uchida\\_CTDO2proc.pdf](https://www.go-ship.org/Manual/Uchida_CTDO2proc.pdf)



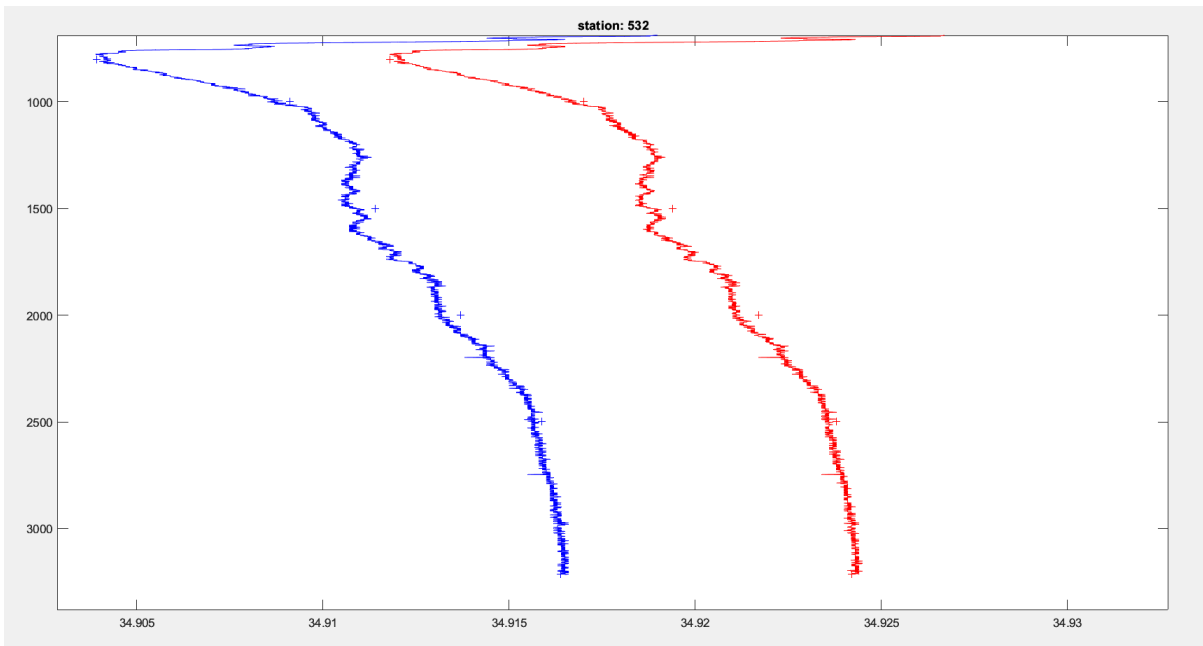
**Salinity, PI: Are Olsen (CTD data)**

For salinity, bottle samples were taken at the deepest level at each station and analyzed at IMR after the cruise. They found that a correction of -0.006 mS/cm needed to be applied on the CTD data. IMR themselves have applied this on the downcast CTD data and recalculated CTD salinity.

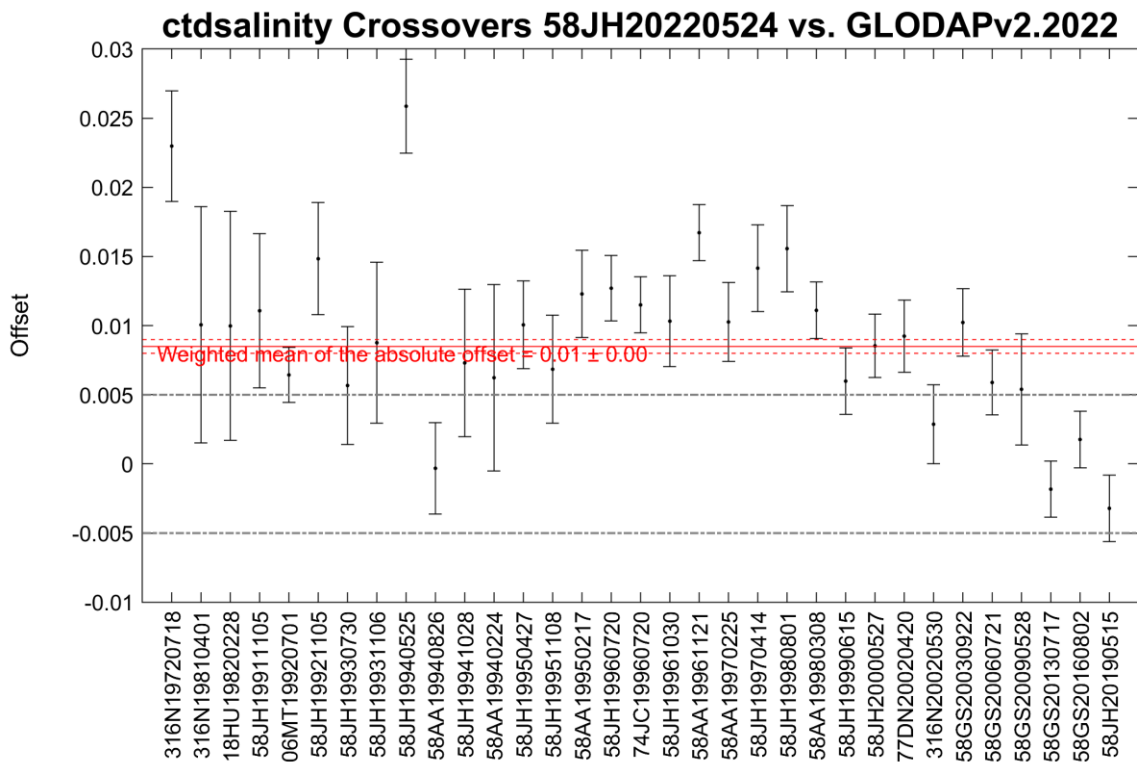
For CTDSAL in the bottle files, I applied the same correction on the conductivity in the \*.btl files and calculated CTDSAL using the sw\_salt function in the seawater matlab package. This is based on Fofonoff and Millard and gives salinity in PSS 78.

The thus corrected CTDSAL data was close to those in the CTD downcast files – in particular at the deepest level, but I did note that both uncorrected and corrected CTDSAL is a bit lower than uncorrected and corrected CTD data up to ca 1000. I am not sure what this indicates, but it is impossible to deal with since we only have bottle salinity at the deepest sampling depth. In any case, this difference is less than 1/1000, so smaller than the accuracy.

I also noted quite a bit of high frequency noise in the CTD downcast salinity. It is at the 1/10000 level. I have informed IMR about this issue. There is also quite a few spikes in some of the CTD downcast salinities. See figure below to get a sense of the magnitude of these issues.



CTD salinity data from beneath ~900 dbar at station 532, as an example of some of the issues noted in the text. Corrected data in blue and uncorrected in red. The plus symbols are from \*.btl files.



**Nutrients, PI onboard: NA, analysis and post-processing: Linda Fonnes Lunde**

Nutrient samples were taken by people from the Institute of Marine Research (IMR) onboard, and subsequently analyzed in their lab by Linda Fonnes Lunde. Units were converted from  $\mu\text{mol/L}$  to  $\mu\text{mol/kg}$  using density calculated from CTD salinity (since bottle salinities are not available on all bottles, and also appear biased).

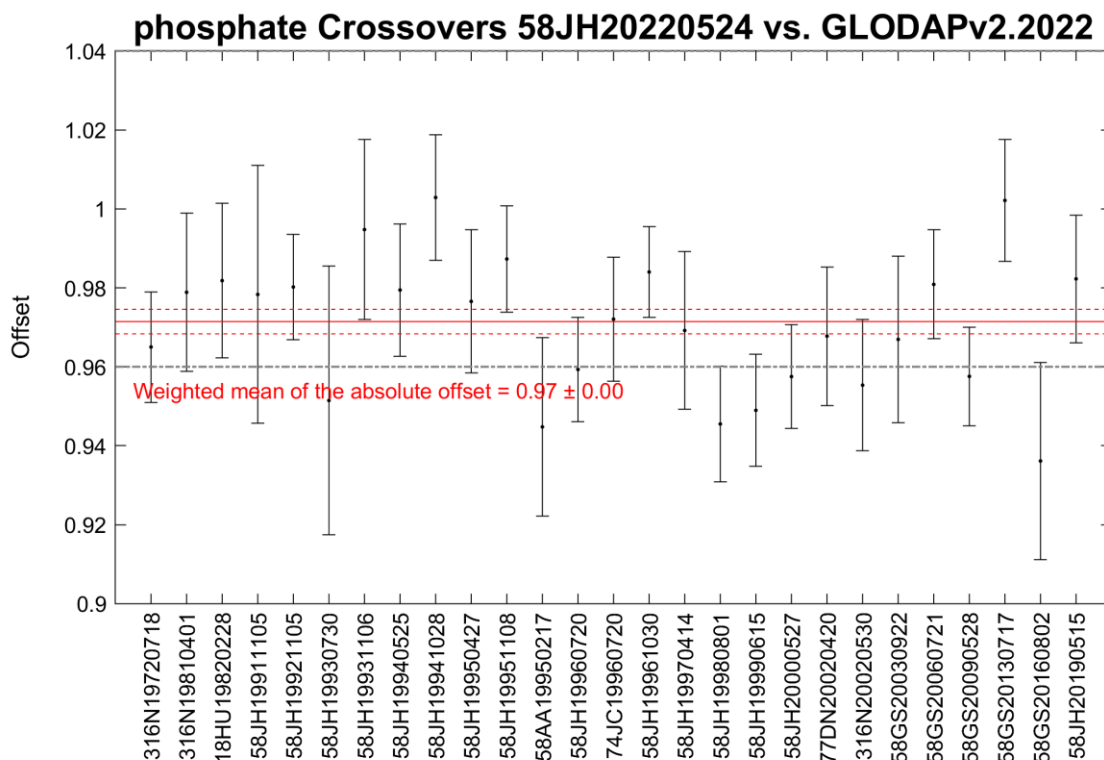
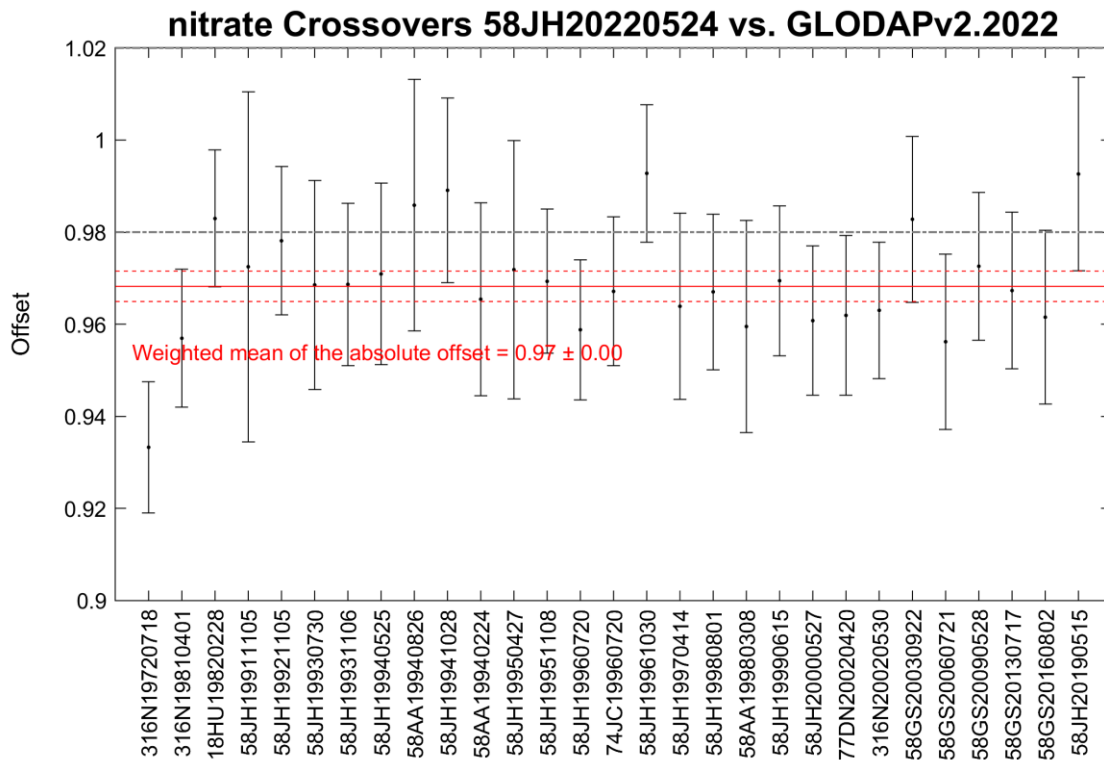
Nitrate, phosphate, and silicate were all compared with data in GLODAPv2.2022.

Nitrate appears to be biased slightly low (~3%). Note that nitrate in this case is NO<sub>2</sub>+NO<sub>3</sub>, even though the two are separated in the datafile.

Phosphate is somewhat noisy, but within the ±4% adjustment limit.

Silicate exhibits the expected temporal trend and has no bias with the most recent cruise in GLODAPv2.2022.

Stated uncertainty (in the metadata) for all nutrients is the detection limit of the method(s) used. No other uncertainty estimate exists.



### silicate Crossovers 58JH20220524 vs. GLODAPv2.2022

