Assessing the Calibration Stability of Oxygen Sensor Data on Argo profiling floats using routine WOCE monitoring data from HOT

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INTRODUCTION

Scientific questions, such as the role of oceans on global warming and uptake of anthropogenic CO_2, can be addressed from quasi-Lagrangian profiling floats equipped with oxygen sensors. A key scientific objective of the Argo-Oxygen program is to determine seasonal and decadal time scale variability in sub-surface ocean oxygen storage and transport on a global scale (Gruber et al., 2007).

In order to meet the scientific goals of the Argo - Oxygen program, a target accuracy of 1 µmol/kg and a threshhold accuracy of 5 µmol/kg in Dissolved Oxygen (DO) measurements are required. The target response time of the sensor is 10 seconds, with a maximum threshhold of 30 seconds (Gruber et al., 2007).

Figure 1

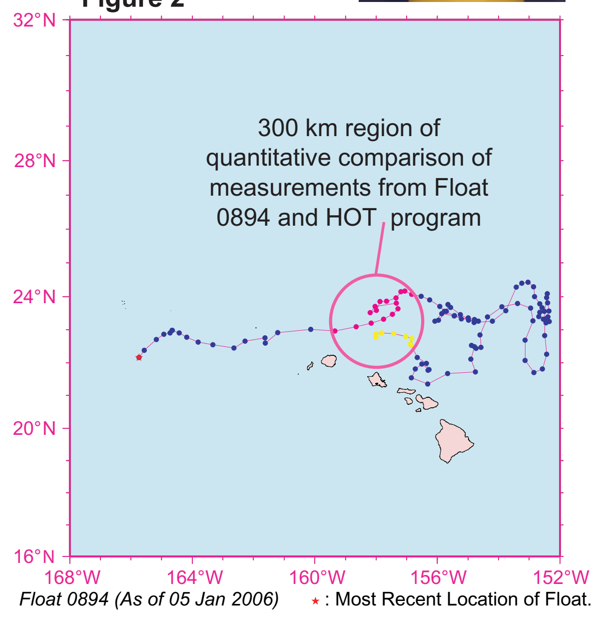
The SBE 43 was designed specifically for high accuracy profiling applications, and exhibits high initial calibration accuracy (2%) and fast response (4 seconds at 20 °C). 60% of profiling floats deployed with DO sensors use the SBE 43 sensor (Figure 1).

Argo floats are autonomously operational for 3-5 years and are typically not recovered, limiting evaluation of sensor calibration stability for the fleet.

Lagrangian APEX profiling float 0894, equipped with an SBE 43F DO sensor, was deployed at the Hawaii Ocean Time Series Study site (HOT-ALOHA) in 2002. Its drift trajectory returned the float to HOT 33 months later, offering two periods when the float was within 150 km of the HOT time series monitoring station.

Objective: To assess the long-term calibration capability of the SBE 43 DO sensor on Argo, data from float 0894 are evaluated against concurrent shipboard Winkler-titrated water samples at the HOT-ALOHA station when the float was within 150 km of HOT (Figure 2).

Figure 2



METHODS

Surface mixed-layer percent oxygen saturation data are analyzed for long-term trends using a least-squares regression.

Deep oxygen comparisons are conducted along constant potential density surfaces near 1000 and 1800 db. This removes DO variability caused by internal wave displacements at the different locations and times that separate the float from the shipboard work at HOT.

Meteorologic uniformity is assumed in surface oxygen saturation, within the 300 km comparison region.

The initial offset observed between HOT and float data is due to a calibration slope shift incurred prior to float deployment. Data were corrected for a single offset in trend analysis, but plotted with the offset for clarity.

Lines represent a least-squares fit to the data during periods when the float was within 150 km of HOT-ALOHA (circled data points in shaded regions at start and end of record).

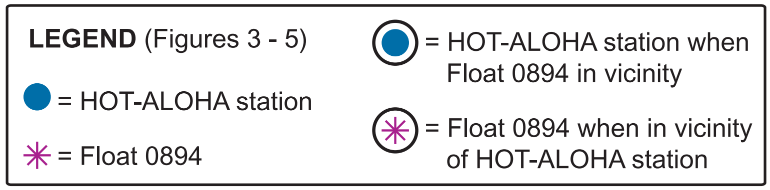
The degree of repeatability in the T-Oxygen relationship in deep water is assessed for float 0894 and float 0018, which had both an SBE 43 and an Optode®.

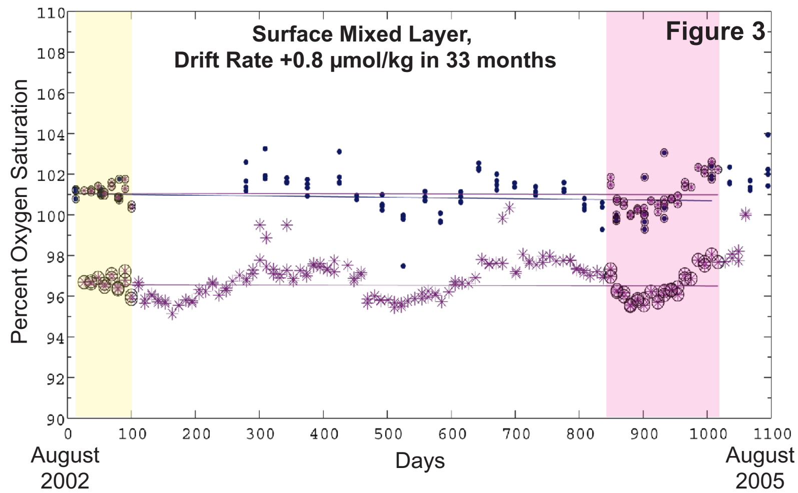
RESULTS

Percent Oxygen Saturation Comparisons in Near-Surface Ocean (Figure 3)

- Both HOT and Argo data track the seasonal surface minimum in observed oxygen saturation during winter (January and February).
- Argo data along the drift track indicate the large spatial uniformity of the seasonal saturation trends.

Upshot: Difference in the linear trends in oxygen measured by HOT versus the float is approximately 0.3% over 33 months, or 1 µmol/kg over the 2.75-year deployment.

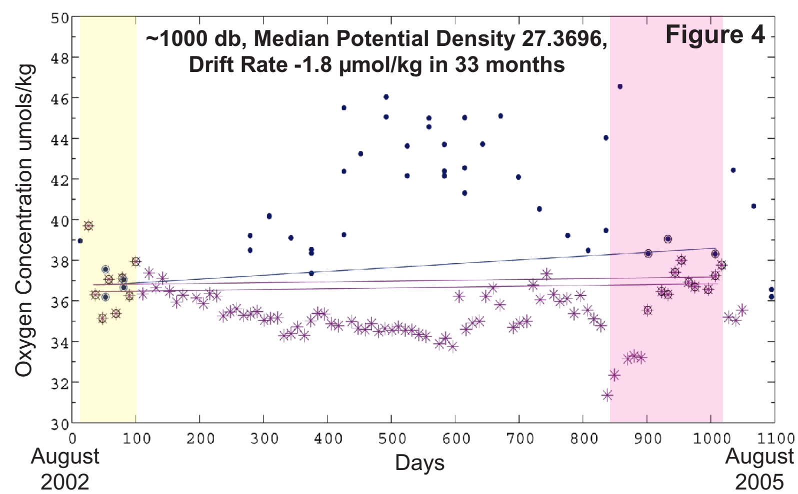


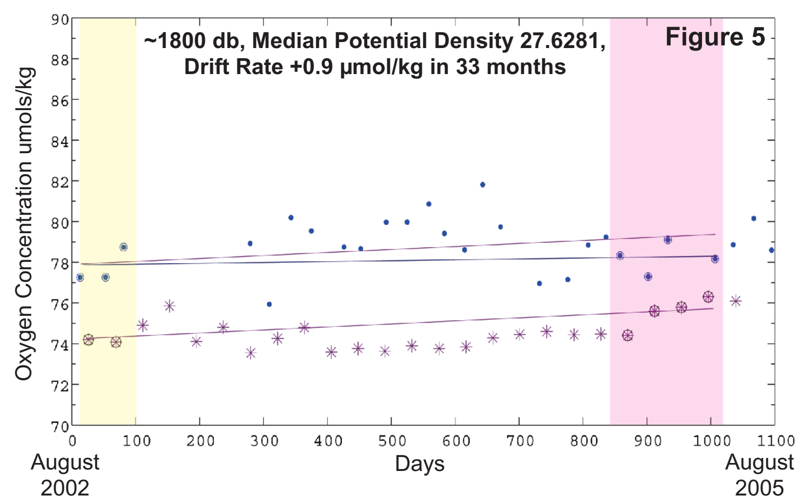


Oxygen Concentration on Deep Density Surfaces (Figures 4 and 5)

- Analyzing along deep density surfaces reveals a 10 µmol/kg range in Eulerian HOT oxygen values near 1000 db.
- Lagrangian float data exhibit a smaller range of 4-6 µmol/kg, because the float was closely tracking a specific water mass.
- When the float is furthest east of HOT, a zonal gradient in oxygen of ~1 µmol/kg per 100 km is observed along the 1000 db median density surface, and ~0.5 µmol/kg per 100 km is revealed on the 1800 db surface.

Upshot: Linear trends in DO indicate insignificant float-DO sensor drift of less than 2 µmol/kg during the 33 months of float operation, corroborating the more intensive comparisons from the surface mixed layer.





Deep T-S and T-Oxygen Curves (Figures 6 and 7)

A secondary assessment offers a means for evaluating stability of oxygen sensors on floats over time, when coincident water samples are unavailable.

- Composite of T-S and T-DO curves from all 112 profiles on float 0894 exhibit tight oxygen repeatability at the 2.5 °C isotherm, until the sensor stopped operating.
- Strong signals in the surface and photic zones are observed.
- High calibration stability is evident below 1000 db, where the water mass T-S is stable.
- A similar deep water stability curve is shown for float 0018 in the North Atlantic, which was co-equipped with an Optode® (Figure 7).

Figure 6

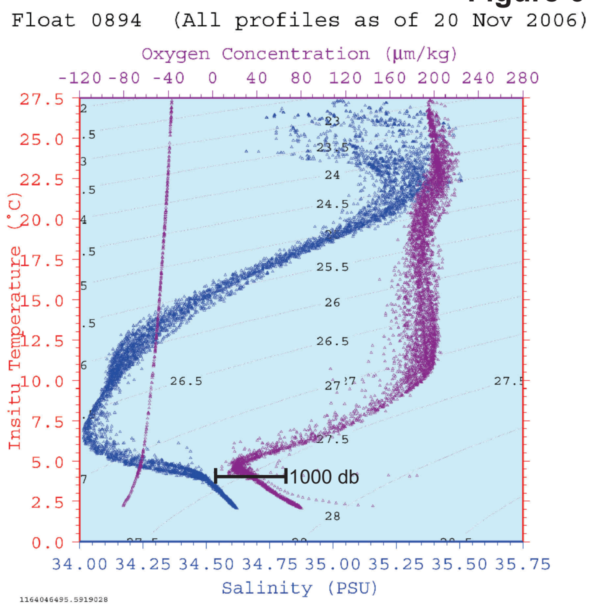
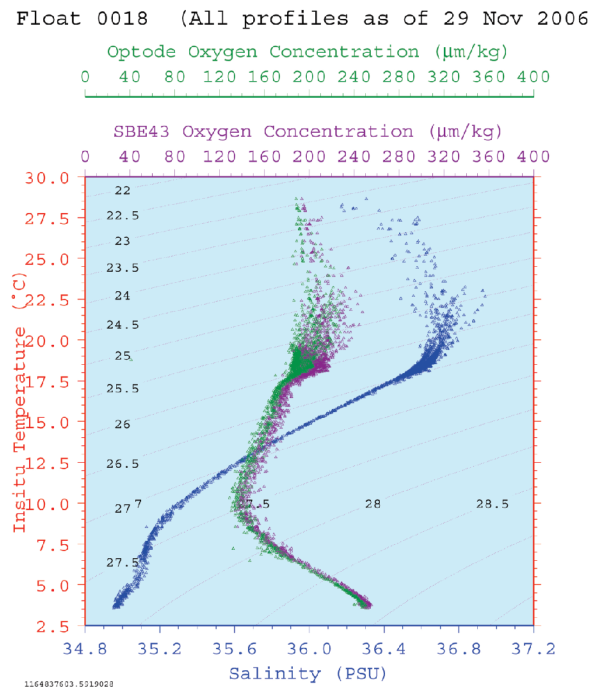


Figure 7



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Upshot: The width of the oxygen variability on density bounds the drift by presuming no natural oxygen variation, though real oxygen variations do occur, as implied by Figures 4 and 5.

CONCLUSIONS

- Comparative analysis between Argo profiling float data and HOT-ALOHA WOCE data indicates an SBE 43 calibration shift of less than 1 μmol/kg per year.
- The tight repeatability of oxygen on deep density surfaces. corroborate the low calibration drift rates directly assessed in the surface mixed layer. Any natural oxygen variability on deep density surfaces further bounds the calibration drift rate.
- The low calibration drift rate is an upper bound on electrochemical drift in the SBE 43 Clark design.

References: Gruber, N., S.C. Doney, S.T. Emerson, D. Gilbert, T. Kobayashi, A.Körtzinger, G. C. Johnson, K.S. Johnson, S.C. Riser, O.Ulloa, 2007. The Argo-Oxygen Program: A white paper to promote the addition of oxygen sensors to the international Argo Float Program, Version 5-1, Prepared for distribution to the Argo Steering Committee, February 14, 2007.

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