MEASUREMENT OF SALINITY AND TEMPERATURE PROFILES THROUGH THE SEA SURFACE ON ARGO FLOATS

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Abstract

Calibration of the surface salinity measurements made by the Aquarius satellite is a vital component of the mission. To accommodate the need for accurate surface measurements, Sea-Bird Electronics has developed a free-flushing conductivity cell with a companion thermometer, designed to sample through the sea surface on Argo profiling floats. This secondary sensor pair is calibrated against the main float CTD between 30 and 3 dbar. Here, we present surface profiles and calibration results from an Argo float equipped with surface salinity and temperature sensors, deployed in Spring of 2008. Results reveal diel temperature and salinity changes in the previously under-sampled surface skin, and provide evidence of rainfall. Depending on sea state, the new sensors are capable of measuring accurate surface temperature (± 0.002 deg C) and salinity (± 0.005 psu) as shallow as 0.2 dbar.

Introduction

With its extensive deployments throughout the world's oceans, the Argo float program provides an excellent platform for measuring near-surface salinities that can be used to validate the Aquariius synoptic surface-salinity snapshots. However, to prevent fouling of the pumped conductivity sensor by sea-surface oils, measurement of the temperature and salinity in the surface 3 dbar of the ocean is not normally implemented in Argo floats. Interest in collecting CTD data through the air-sea interface has provoked development and deployment of an add-on instrument for measurement of surface temperature and salinity (STS).

Methods

The STS sensor deployed on Argo floats operates independently of the primary CTD. Profiling through the sea surface exposes the secondary conductivity sensor to fouling that may cause drift in subsequent profiles.The accuracy of the secondary conductivity sensor is maintained by collecting data simultaneously from primary and secondary CTD sensors and calibrating the secondary conductivity sensor against the primary. Figure 1 shows the secondary temperature and conductivity sensor; Figure 2 shows a portion of a profile with overlapping primary and secondary sensors.

Figure 1: Argo STS float

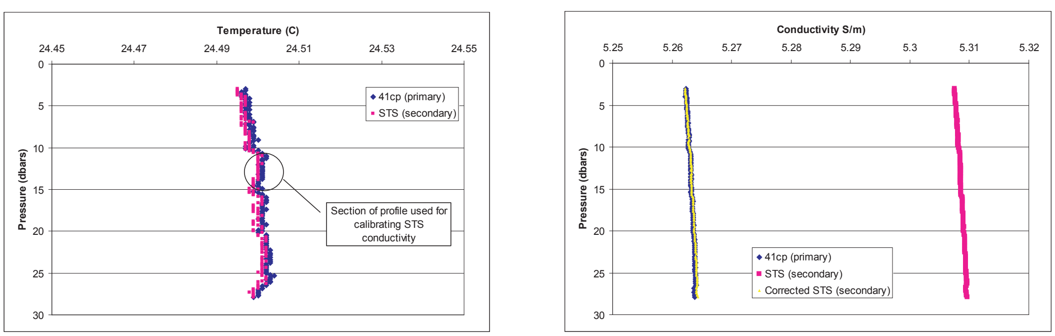


Figure 2: Overlapped sections of profile with section used for calibration circled

- Fouling events in Sea-Bird conductivity sensors manifest themselves as changes in sensitivity or calibration slope; they are corrected by using the ratio of the primary CTD conductivity to the STS conductivity.
- The highlighted region of the profile is used to calculate the correction ratio; it is chosen for low temperature and conductivity variability over enough data points to ensure residual temperature effects in the conductivity measurement are minimized.
- Figure 3 shows the correction ratios for all profiles collected to date from two Argo STS floats.

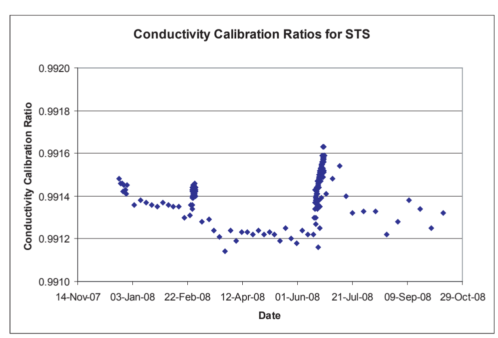


Figure 3: Conductivity correction ratios versus time

- Figures 4 and 5 present a comparison of 39055 primary and secondary temperature and salinity measurements.
  - STS temperature has been offset 0.00278 degrees C.
  - Each conductivity profile has been corrected by multiplication with a correction ratio calculated for that profile.
- The average difference between primary and secondary temperature measurements is 0.00025 degrees C, with a standard deviation of 0.0042.
- The average difference between primary and secondary salinity measurements is -0.0021 psu, with a standard deviation of 0.0053.

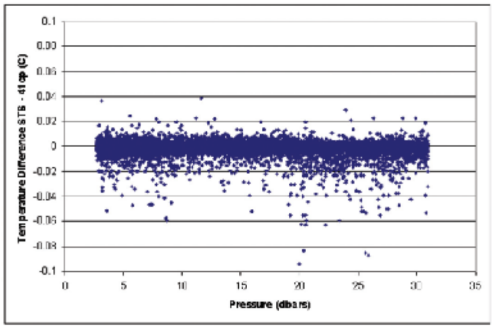


Figure 4: Temperature differences (degrees C), STS - 41cp

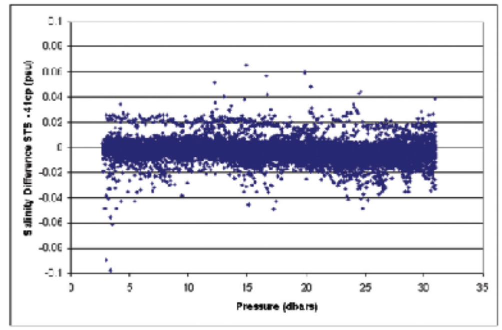


Figure 5: Salinity differences (psu), STS - 41cp

Results and Discussion

Figures 6 and 7 show an example of a time series of data collected by the STS sensor. Typically, the float ascends smoothly from 5 dbar to near the surface, its momentum allowing it to break through the surface before falling back to a depth of 0.1 to 0.3 dbar. The float remains at 0.1 - 0.3 dbar until an air bladder inflates, carrying the float through the surface while it continues to collect data for a short time.

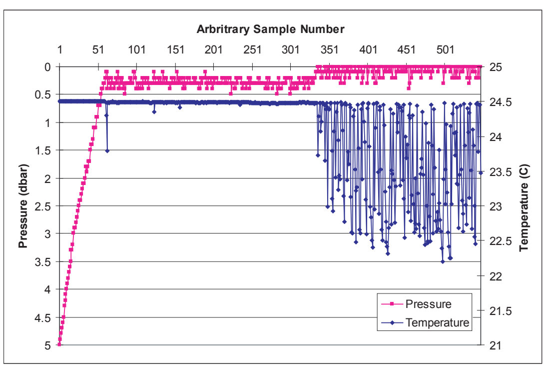


Figure 6: P & T time series, 3 dbar to surface

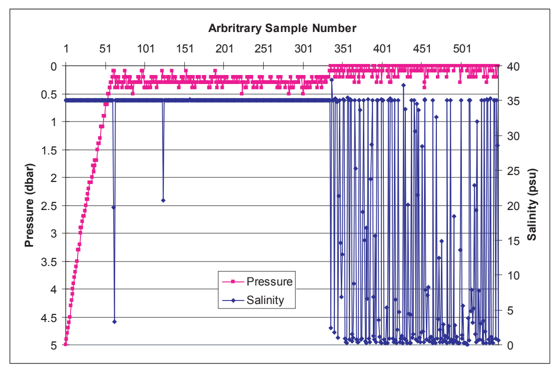
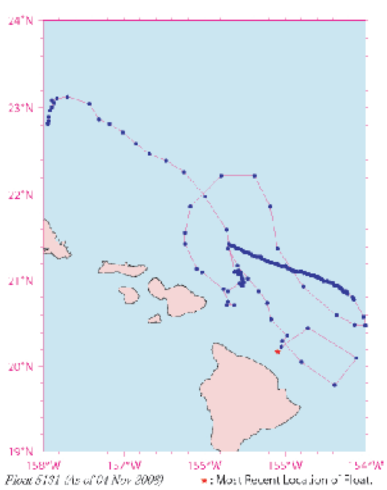


Figure 7: P & S time series, 5 dbar to surface

Float 5131 is deployed near the Hawaiian Islands; a drift trajectory is shown in Figure 8 and a time series of temperature and salinity for 0.2, 0.3, 0.4, and 0.5 db for 182 profiles is shown in Figure 9. Float 5131 executed multiple shallow profiles at a 2-hour interval over two periods, 38 profiles between February 22 and 25, 2008 and 82 profiles between June 17 and 29, 2008. Sea surface warming during the day and cooling at night is clearly evident.

Figure 8: Drift trajectory for 5131



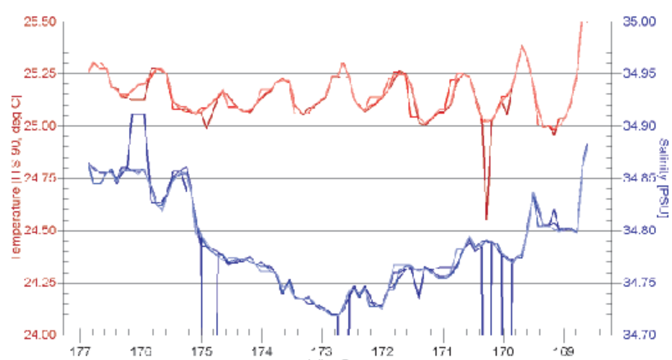


Figure 9: T & S time series at 0.2, 0.3, 0.4, and 0.5 dbar

Figures 10, 11, and 12 show a time series of temperature, salinity, and density profiles from 10 dbar to the surface. Each of the measurements is normalized by subtracting the 10 dbar value from the remaining data in the profile.

- Temperature profiles that move to the left show cooling, profiles that trend right show warming.
- Salinity profiles trending left indicate freshening, to the right more salty.
- The density profiles move to the left as they shallow, indicating a stable water column.

The temperature profiles show warming occurring throughout the day. Salinity profiles show salinity variation, the water column becoming saltier as it warms, precipitation occurring in the afternoon evident as freshening in the top 10 dbar during the first two of the three day-night cycles shown. The sigma-t profiles confirm that the temperature and salinity measurements exhibit no large density inversions.

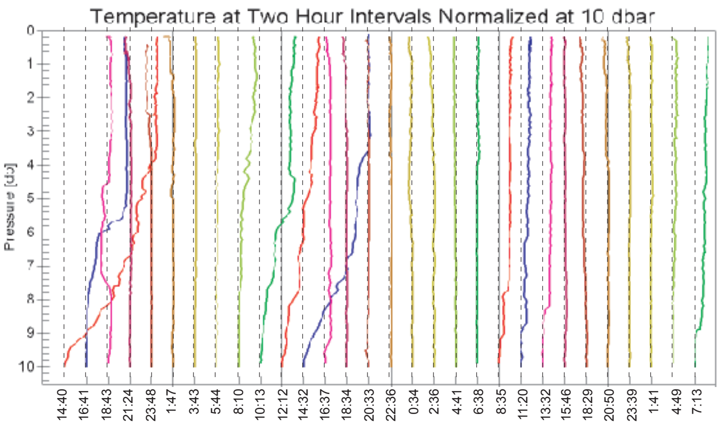


Figure 10: Temperature profiles taken at 2-hour intervals. Each profile normalized to its temperature at 10 db.

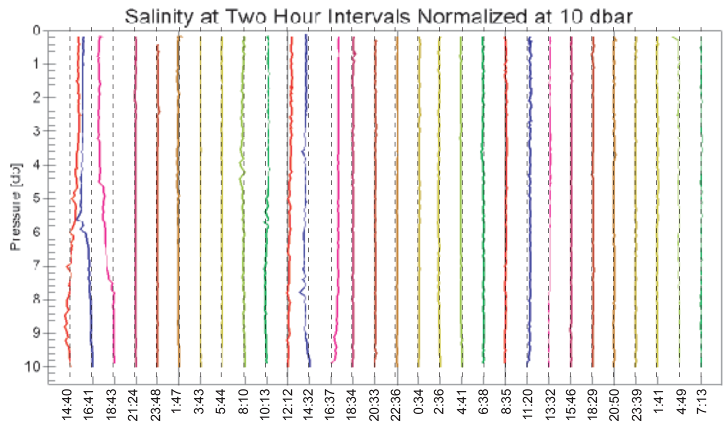


Figure 11: Salinity profiles taken at 2-hour intervals. Each profile normalized to its salinity at 10 db.

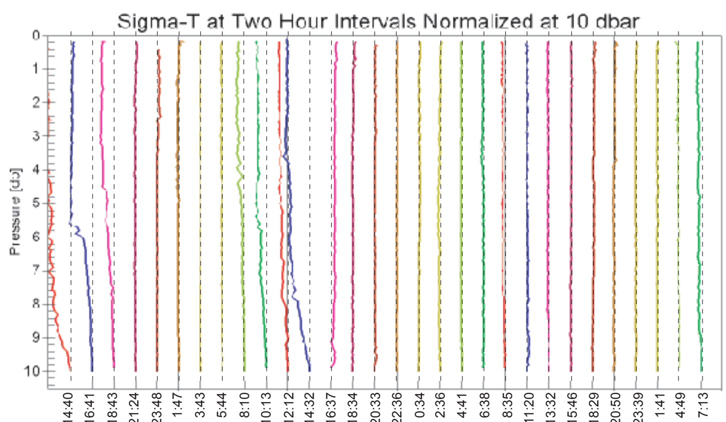


Figure 12: Sigma-T profiles taken at 2-hour intervals. Each profile normalized to its Sigma-T value at 10 dbar.

Conclusions

These results from an initial deployment of an STS-equipped Argo float show that sea surface temperature and salinity measurements can be accurately made to within 0.2 dbar of the air-sea interface. An intense 2-hour interval profiling time series reveals distinct day-time warming and night-time cooling, as well as freshening of salinity profiles presumably caused by precipitation. The 2-hour profiling exercise shows that comparisons of Argo STS data with Aquarius must be coordinated in time to meet the Aquarius accuracy goals. *In-situ* calibration results for the STS sensor indicate that the agreement of the primary CTD temperature and salinity measurements are 0.0003 ± 0.004 degrees C and -0.002 ± 0.005 psu. This level of accuracy is achievable without removing dynamic measurement errors with data processing. The STS sensor has remained stable over the course of 182 profiles.