Performance of the RBRconcerto3 CTD on extended Antarctic deployment: mooring PIG_S

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1 Summary

Two companion CTDs, one Sea-Bird SBE37-SM and one RBR*concerto*^{3}, were deployed on a mooring in Pine Island Bay (Antarctica) over a one-year deployment in 2019/2020. This dataset provides the opportunity to assess the sensor performance for extended deployments in cold environments. Both CTDs present very similar performance, although a few features are noticed in the dataset: (1) the RBR*concerto*^{3} pressure signal suddenly shifted by about -0.5 dbar on January 12th, most likely following a collision with a drifting iceberg, (2) the SBE37 demonstrated a trend in monthly-average salinity that is most likely related to natural variability rather than sensor drift, and (3) the SBE37 suffered from larger salinity spiking than the RBR*concerto*^{3}, suggesting that conductivity and temperature might be misaligned and would benefit from correction in post-processing. On average, a difference of 0.0046 °C in temperature and 0.0055 mS/cm in conductivity is observed between the two CTDs. Based on both accuracy specifications, the total expected differences should be less than 0.0040 °C and 0.006 mS/cm. The slightly larger difference is attributed to stratification in the water column, which is in agreement with the fact that the RBR*concerto*^{3} was deployed deeper than the SBE37-SM (See Figure 2 in Webber et al., 2017).

2 Introduction

An RBR*concerto*³ was deployed by the British Antarctic Survey on a mooring located in Pine Island Bay (Antarctica) from March 2019 to February 2020 (Figure 1A). The RBR*concerto*³, like any RBR CTD, is equipped with an inductive conductivity cell that is self-flushing (Figure 1B). The absence of a pump makes the RBR*concerto*³ power-efficient and thus allows a higher sampling rate for a given deployment, if desirable. This specific RBR*concerto*³ (SN200269) is made with a titanium body rated to 2,000 m and was deployed at a depth of about 400 m, sampling at 5 min intervals. The SBE37-SM is an electrode-based, self-flushing, conductivity cell (i.e., unpumped). The temperature sensor is mounted beside the conductivity cell, under a metal guard. The mooring line consisted of 12 mm braid-on-braid polyester rope, guaranteeing that no external metallic objects were within the recommended 15 cm range of the RBR inductive conductivity cell.

In this report, we summarize the instrument performance of the RBR*concerto*³ relative to its "companion" SBE37-SM CTD. The long deployment period allows us to conduct an analysis on sensor drift in cold water conditions (<0°C). Note that all presented data in this report have not been adjusted for offsets and drift such as might be found by a post-deployment calibration.

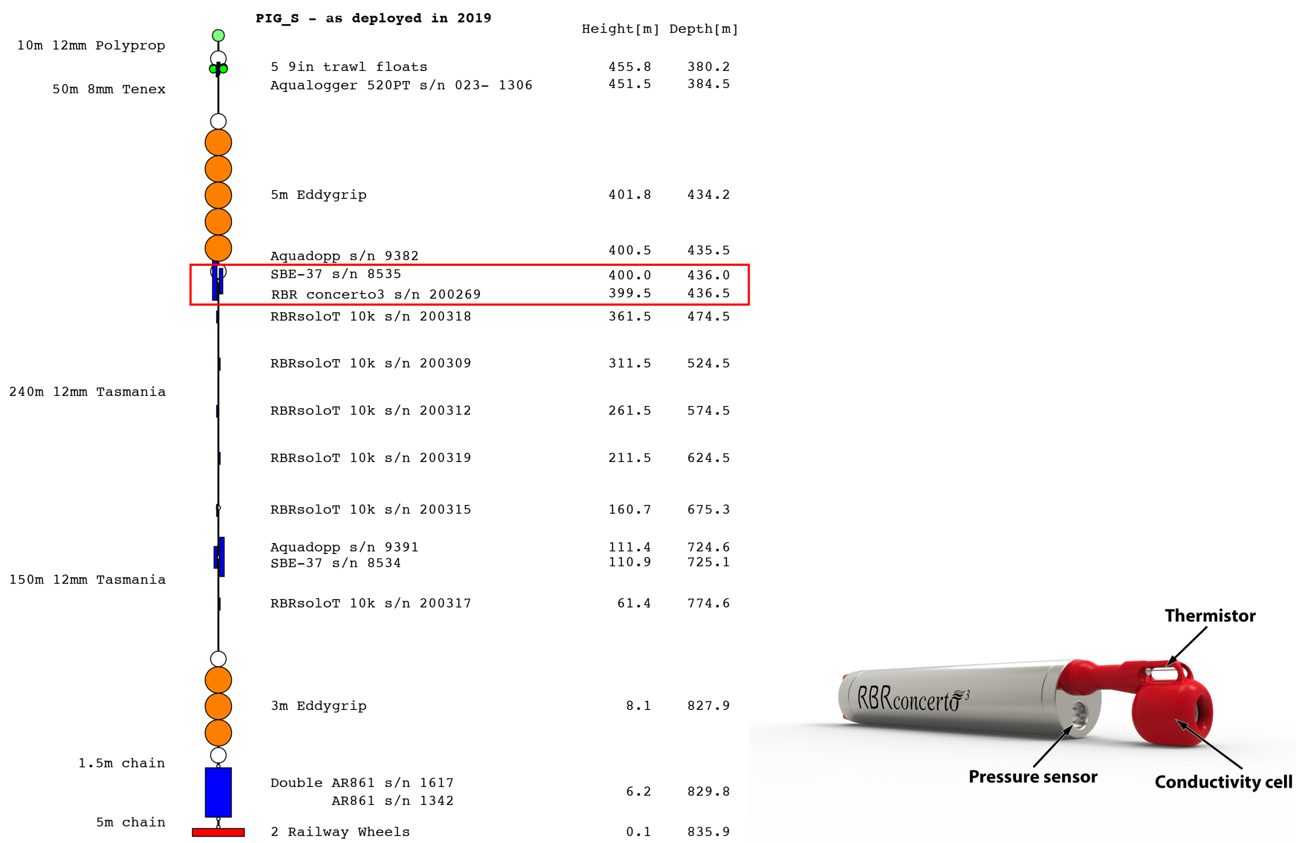

Fig. 1 Figure 1: [left] Mooring design for the PIG_S mooring located in Pine Island Bay, Antarctica. The instruments analyzed in this report are highlighted in the red box. [right] Rendering of the RBRconcerto3 deployed on the PIG_S mooring.

3 Measurement Performance

3.1 Pressure

The pressure signals measured by both the RBR*concerto*[3] and SBE37 are in good agreement. Pressure spikes are observed in both time series, although with slightly different amplitudes, and suggest that these spikes are not artifacts and represent real environmental conditions (Figure 2A). While spikes in the pressure signal are likely due to environmental conditions, spiking in the pressure difference between the two sensors is only due to a phase-lag between the RBR*concerto*[3] and SBE37 pressure measurements, as samples are asynchronous (Figure 2B). The pressure increases in March-May are likely caused by increased currents drawing down the upper instruments on the mooring. The subsequent spikes are caused by local icebergs from Pine Island Ice Shelf passing over the top of the mooring, depressing the upper instruments. These last for up to 3 hours, with most depressing the instruments by around 10-20 dbar. A stronger episode on 12 Jan 2020 lasted two hours, and depressed the upper instruments by over 150 dbar, to a depth of 554 dbar.

This collision resulted in a shift in the pressure difference between the two CTDs. The pressure difference between the two CTDs was 0.89 dbar (s.d. 0.01 dbar) until January 12th, when it decreased to 0.48 dbar (s.d. 0.01 dbar; Figure 2C). The average pressure recorded by the RBR*concerto*[3] for the 10 days prior to the event was 390.59 dbar, and shifted to 390.06 dbar for the 10 days following January 12. In the meantime, the SBE37 averaged pressure went from 389.59 to 389.69 dbar. This pressure jump is immediately preceded by a spike in pressure, but also temperature and salinity. This suggests that the pressure jump is likely triggered by a singular event (e.g., collision). Regardless, the pressure jump is smaller than the accuracy specifications of the sensor (+/- 1 dbar).

A linear fit is applied to the time series, excluding data collected after January 11, to quantify potential drift in the sensor. The linear trend in the pressure signal from the RBR*concerto*[3] is -1.89 dbar/yr (+/- 0.02 dbar/yr; see Table 1, which is virtually identical to the linear trend computed from the SBE37 pressure signal (-1.88 +/- 0.2 dbar/yr). This suggests that the linear trend in the data is most likely due to environmental conditions. No significant linear trend could be determined from the pressure residuals between the RBR*concerto*[3] and SBE37 (see Figure 2B and Table 1).

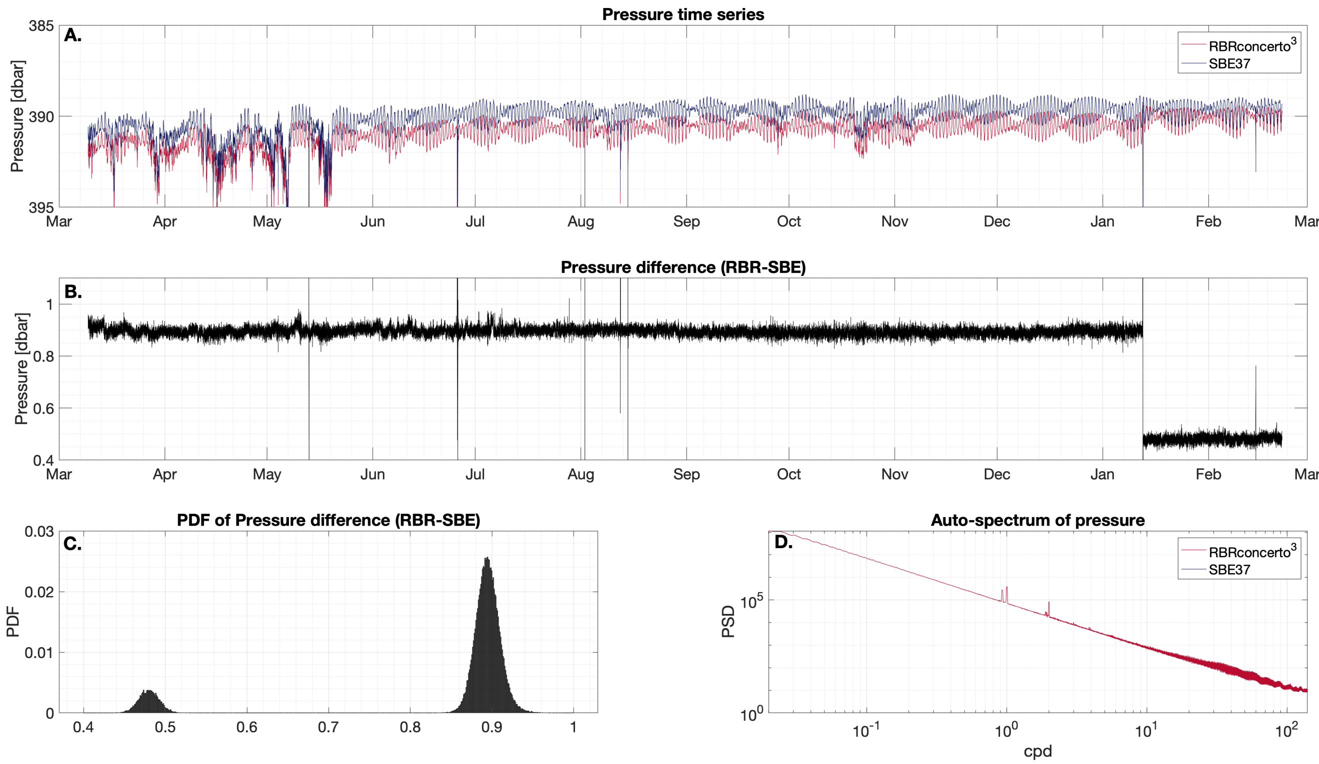

Fig. 2 Figure 2: [A] Time series of pressure from the RBRconcerto3 (red) and SBE37-SM (blue). [B] Pressure difference between the two CTDs. The instrument moved position on Jan 12, 2020. [C] Probability Distribution Function (PDF) of the pressure difference shows in [B]. [D] Power Spectral Density (PSD) computed on pressure measurements recorded before January 12th. Note that only one trace is visible as both curves are virtually identical.

3.2 Temperature

The temperature signal measured by both the RBR*concerto*^{3} and SBE37 agree very well (r = 0.97, p<<0.01; see Figure 3A). Spikes in temperature can be observed in the time series, but are co-occuring in both the RBR*concerto*^{3} and SBE37 observations, suggesting a natural cause to the spiking. Just like for the pressure signal, the spiking observed in the temperature differences between the two CTDs is mostly due to a phase difference in the measurements (Figure 3B). The distribution of temperature difference has an average of 0.004 °C, and a standard deviation of 0.007 °C (Figure 3C).

A statistically identical linear trend can be detected in both temperature time series of +0.31 °C/yr (+/- 0.004 °C/yr); see Table 1). This trend is mostly due to natural variability: in fact, the temperature difference between both CTDs drift away from one another at a rate of -0.0020 °C/yr (+/- 0.0003 °C/yr). Whether or not this drift in the temperature difference is due to natural variability or instrument drift cannot be established, although the estimated drift rate is within the specs of the instruments (0.0020 °C/yr for both RBR*concerto*^{3} and SBE37).

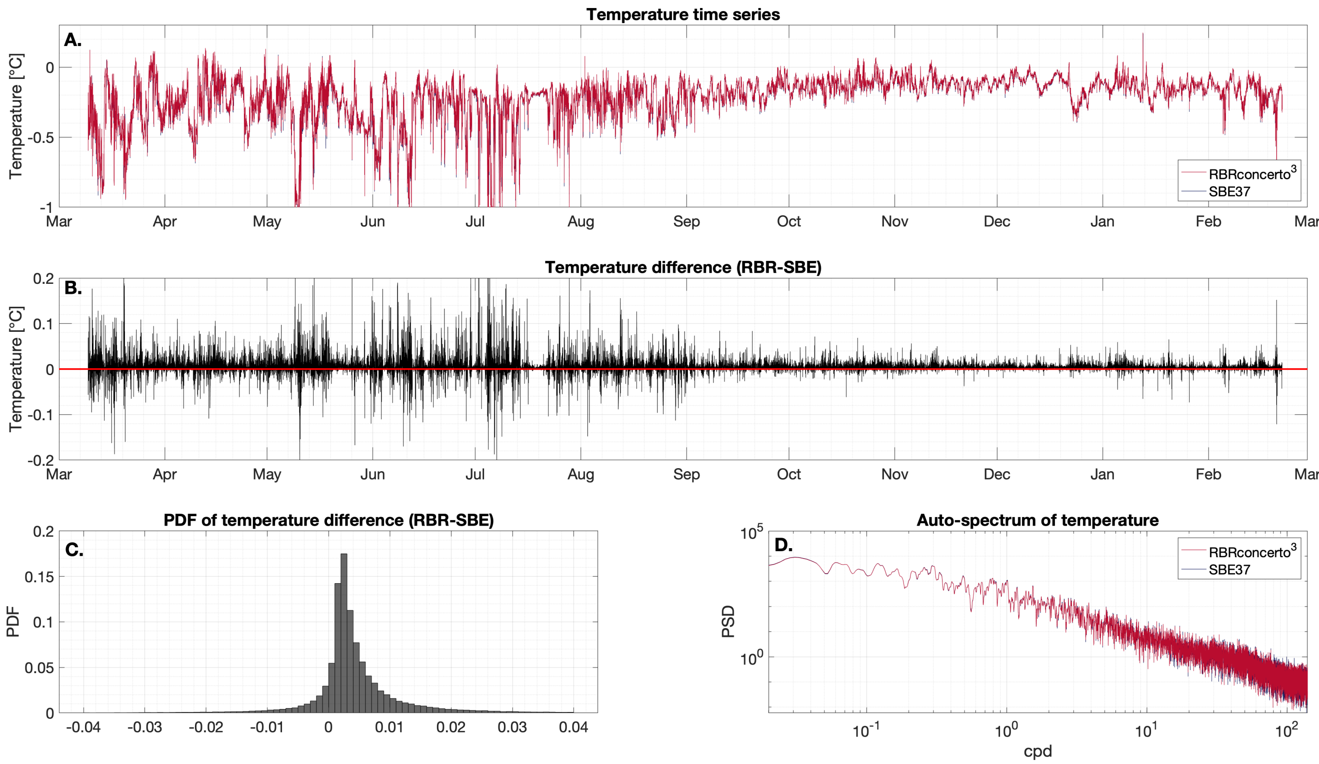

Fig. 3 Figure 3: Same as in Figure 2, but for temperature.

3.3 Salinity

Both salinity time series correlate well (r = 0.89, p<<0.01; see Figure 4A). The lowest correlation coefficient compared to temperature is likely a result of the larger salinity spiking observed in the SBE37 time series, although some spiking is also visible in the RBR*concerto*^{3} measurements. The largest salinity spiking for the SBE37 is mostly observed over the period from June to August 2019, when both temperature and conductivity are also showing elevated spiking. However, the temperature and conductivity spiking observed over this period is consistent between the SBE37 and the RBR*concerto*^{3}. This suggests that the higher salinity spiking visible in the SBE37 time series compared to the RBR*concerto*^{3} might potentially be caused by a misalignment of the temperature and conductivity channels. The fact that this salinity spiking is more prominent when temperature quickly varies corroborates this hypothesis.

The difference in salinity between the two CTDs therefore also presents spiking, due to both a slight temporal misalignment between the two times series (as mentioned for pressure and temperature), and to the larger salinity spiking observed in the SBE37 time series (Figure 4B). The distribution of salinity difference is bi-modal, with a mostly negative salinity difference over the first half of the time series, and a dominantly positive difference over the second half of the time series. A short return to negative salinity difference for a short period in Dec-Jan can also be observed. This could be caused by episodic fouling of the conductivity cells in either instrument, with the conductive cell of the SBE37 arguably being more susceptible to fouling, as the inductive RBR cell samples a larger volume of water and is less sensitive to direct deposits on the cell surface.

Time series were monthly averaged to investigate a potential drift in salinity measurements. Monthly-average salinity as measured by the \concerto present a linear trend of -0.025 g/kg/yr (+/- 0.055 g/kg/yr), while monthly-average salinity recorded by the SBE37 experienced a linear drift of -0.045 g/kg/yr (+/- 0.051 g/kg/yr; see Table 1). As a result, the difference in monthly salinities between the two CTDs shows a trend of 0.020 g/kg/yr (+/- 0.012 g/kg/yr). The order of magnitude of the salinity drifts are within natural variability and could very well be due to either or both variability at seasonal and inter-annual timescales (Webber et al., 2017).

The auto-spectra of salinity confirms the higher noise level observed in the time series of SBE37 measurements (Figure 4D). The noise levels of pressure (Figure 2D), temperature (Figure 3D), and conductivity supports the hypothesis that temperature and conductivity might be slightly misaligned on the SBE37.

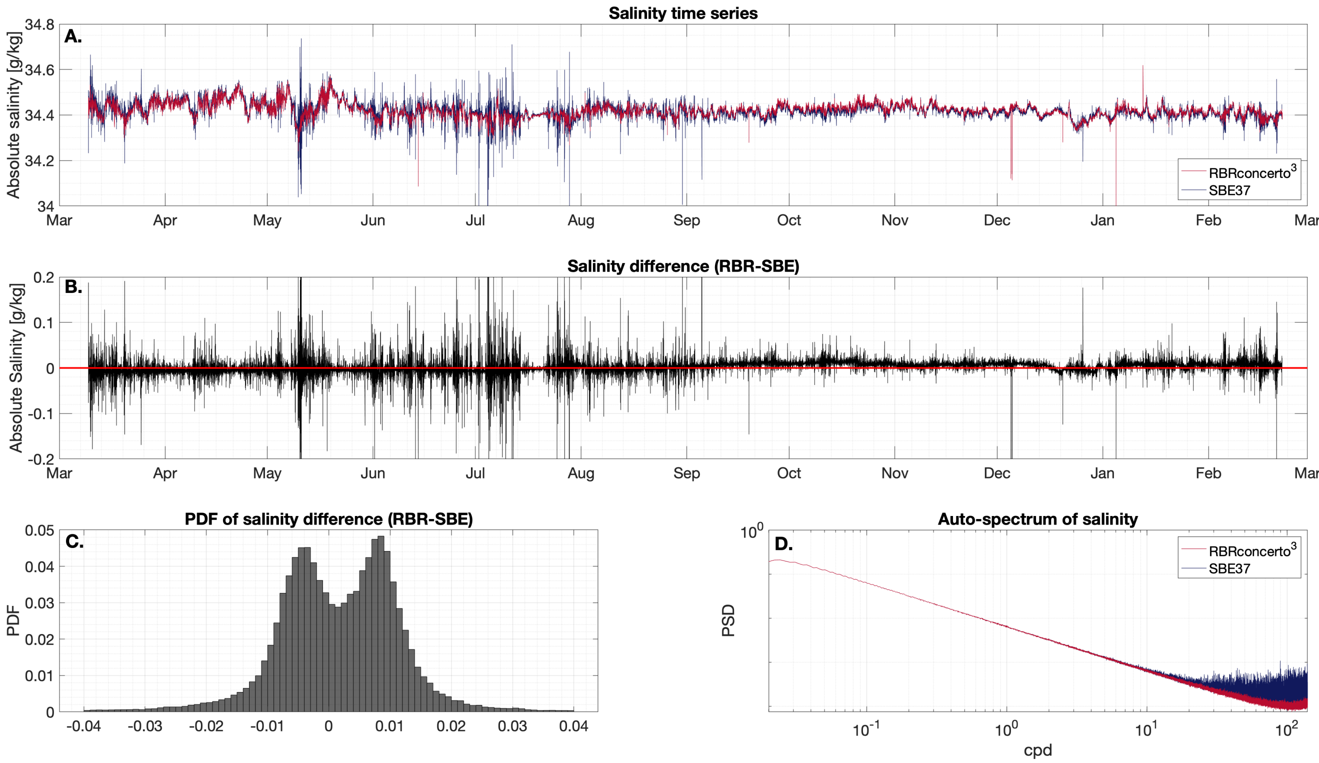

Fig. 4 Figure 3: Same as in Figure 2, but for salinity.

Table 1: Summary of measurement drift computed from a linear fit through the monthly averaged data from March 2019 to December 2019. January to March 2020 is ignored in the linear regression to avoid contaminating the signal with the significant pressure change observed on Jan 12, 2020.

			SBE37-SM		RBR-SBE	
	trend	S.E.	trend	S.E.	trend	S.E.
Pressure [dbar/yr]	-1.89	± 0.02	-1.88	± 0.02	no trend	NA
Temperature [°C/yr]	+0.310	± 0.004	+0.312	± 0.004	-0.0020	± -0.0003
Salinity [g/kg/yr]	-0.0262	± 0.0008	-0.0447	± 0.0009	0.0185	± 0.0004

4 References

Webber, B., Heywood, K., Stevens, D. *et al.* Mechanisms driving variability in the ocean forcing of Pine Island Glacier. *Nat Commun* **8,** 14507 (2017). https://doi.org/10.1038/ncomms14507

5 Revision History

Date	Revision	Description
July 8, 2020	A	Initial document