RBR

Welcome, the RBR Webinar will begin shortly…

Welcome to the RBR technical webinar:

Profiling CTDs: RBR instruments in Argo floats, gliders/AUVs, and the Wirewalker

A few quick notes:

- This webinar will be recorded and posted on the RBR website
- Slides will be available on the website after the presentation
- You can use the chat section to ask questions at any time

Next week's webinar

Assessment of RBR*coda* T.ODO optode for profiling and long-term deployments

Greg Johnson

November 18, 2020

Learn more about how the RBR optical DO sensor has enabled improved oxygen measurement for vertical profiling and high-stability long-term moorings.

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rbr-global.com

Profiling CTDs: RBR instruments in Argo floats, gliders/AUVs, and Wirewalker

Greg Johnson, PhD
President, RBR

November 11, 2020

RBR Products

Loggers

OEM

Sensors

Systems

RBR

RBR*concerto*³ C.T.D

240 million readings, up to 32Hz sampling

750m, 2000m, and 6000m ratings

USB-C download

Twist Activation and Wi-Fi

Direction dependent sampling

Any AA

USB-C

WOCE accuracy

Sensor	Accuracy
Conductivity	±0.003 mS/cm
Temperature	±0.002°C
Depth	±0.05% FS

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One CTD – multiple platforms

RBR*argo*^{3} C.T.D

RBR*legato*^{3} C.T.D

Wirewalker with
RBR*concerto*^{3} C.T.D

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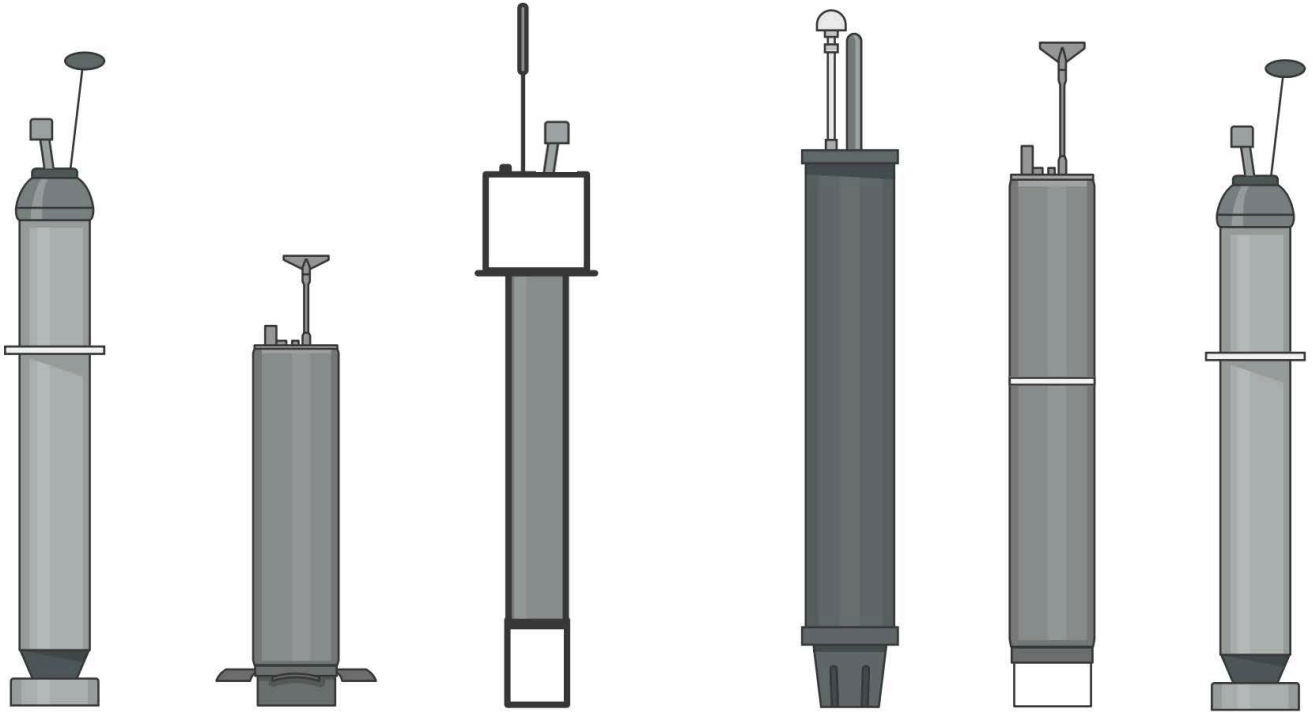
RBRargo^3 CTD



Teledyne APEX

MRV ALAMO

NKE ARVOR

MetOcean PABLO

MRV S2-A

NOTC COPEX

RBR

- Robust construction
- Low power electronics
- No pump needed
- High sensor stability
- Sensor integrations

https://www.pmel.noaa.gov/arctic-heat/sites/default/files/videos/ALAMO_slowmo_20160606.mp4

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RBRargo^3 CTD

Photos: Teledyne, NKE

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RBRargo³ CTD deep (4000dbar and 6000dbar)

62 cm

33 cm

Transverse configuration

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RBR*legato*^{3} CTD

Specifications

- Standard 7 inch by 2 inch bay
- 1000m depth rating
- 2Hz sample rate
  - 16Hz optional
  - 100ms response thermistor
- Natural flushing (no pump)
- 18mJ power at 1Hz (GPCTD 175mJ)
- Same CTD accuracy as SBE
- Custom radius to fit each glider

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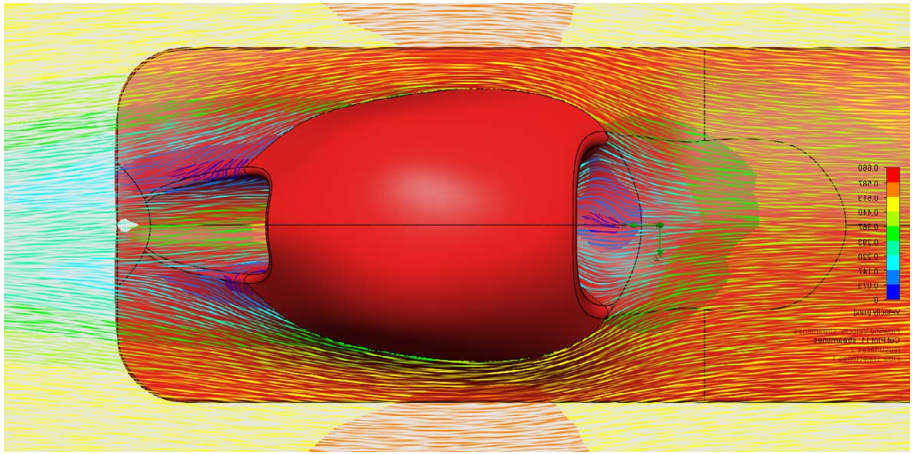
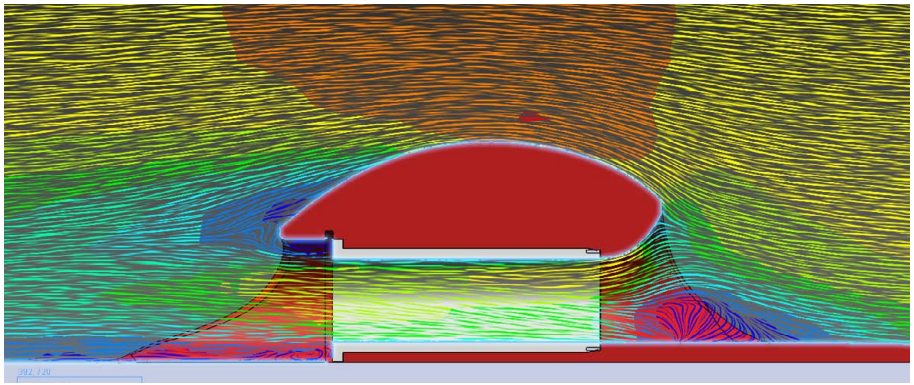
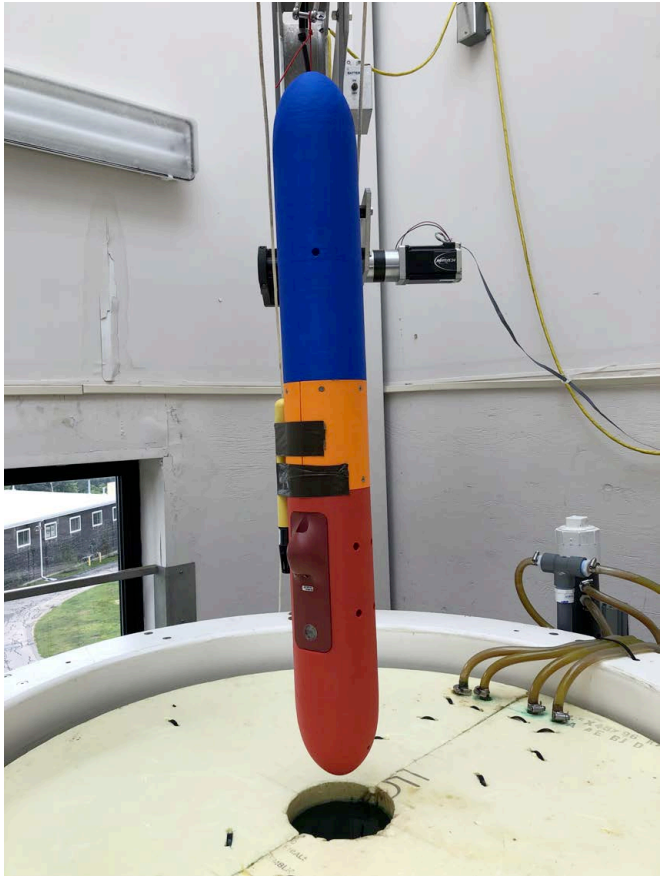
CFD Flow Analysis

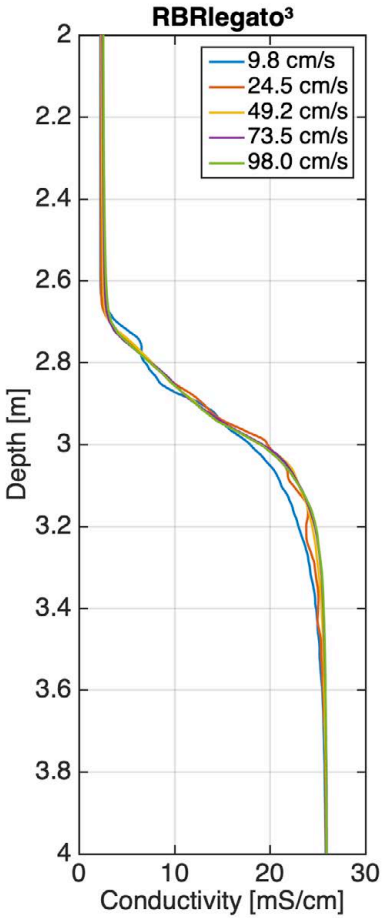
- No pump required
- Ensure natural flushing
- Reduce salinity spiking
- Reduce drag





RBR




RBRlegato³
9.8 cm/s
24.5 cm/s
49.2 cm/s
73.5 cm/s
98.0 cm/s
Depth [m]
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
0
10
20
30
Conductivity [mS/cm]

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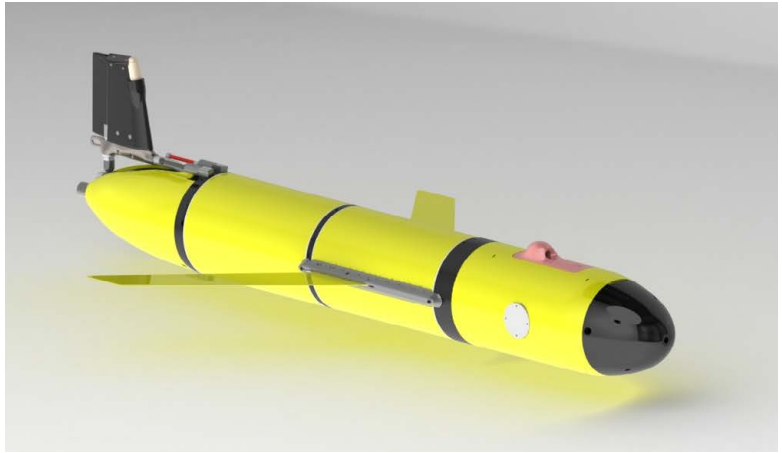
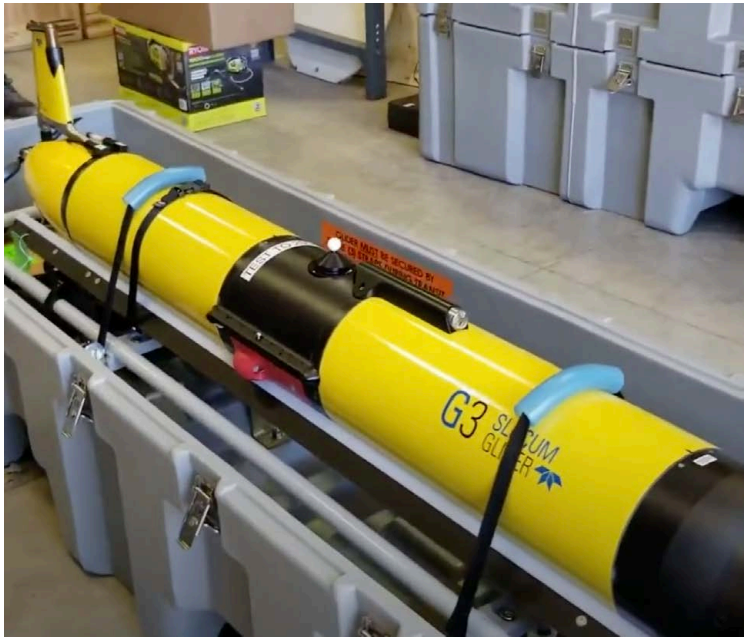
RBR*legato*^{3} CTD Teledyne Slocum





NOAA GLERL – Great Lakes Observing System

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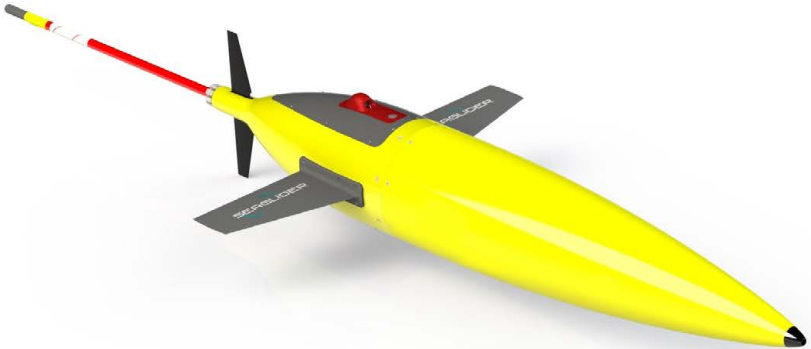
RBR*legato*^{3} CTD



APL-UW Seaglider

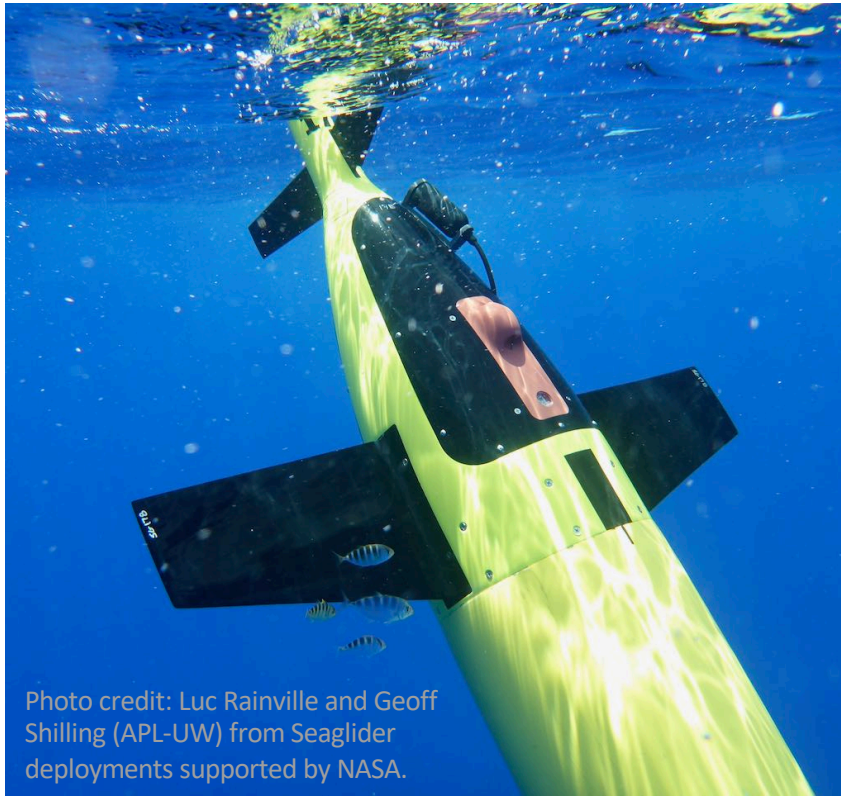
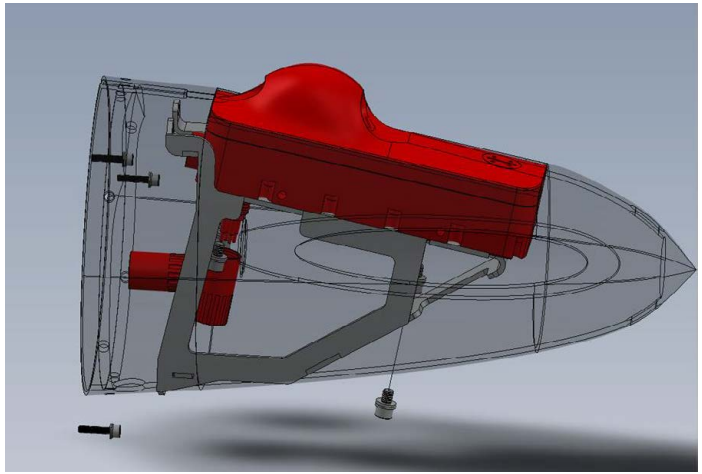
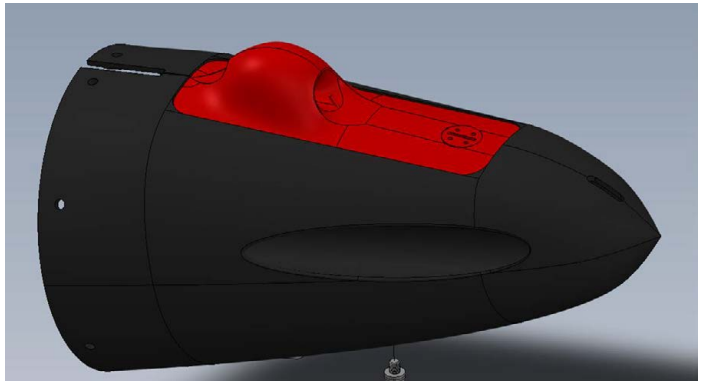


Photo credit: Luc Rainville and Geoff Shilling (APL-UW) from Seaglider deployments supported by NASA.

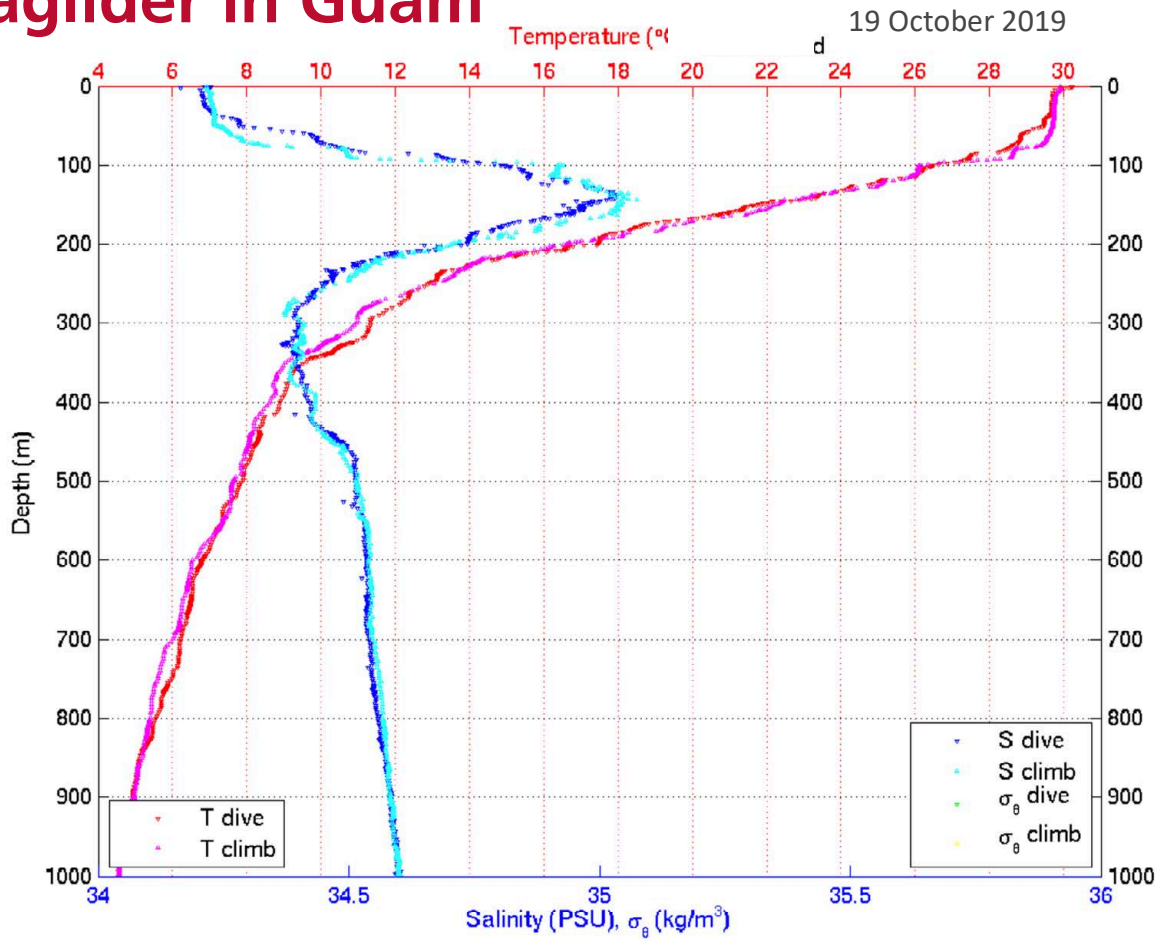
RBR*legato*^{3} CTD Alseamar SEAEXPLORER





UW-APL Seaglider in Guam

400 dives to 1000m



Data collected by Luc Rainville and Geoff Shilling (APL-UW) from Seaglider deployments supported by NASA http://iop.apl.washington.edu/seaglider/ (Seaglider 178)

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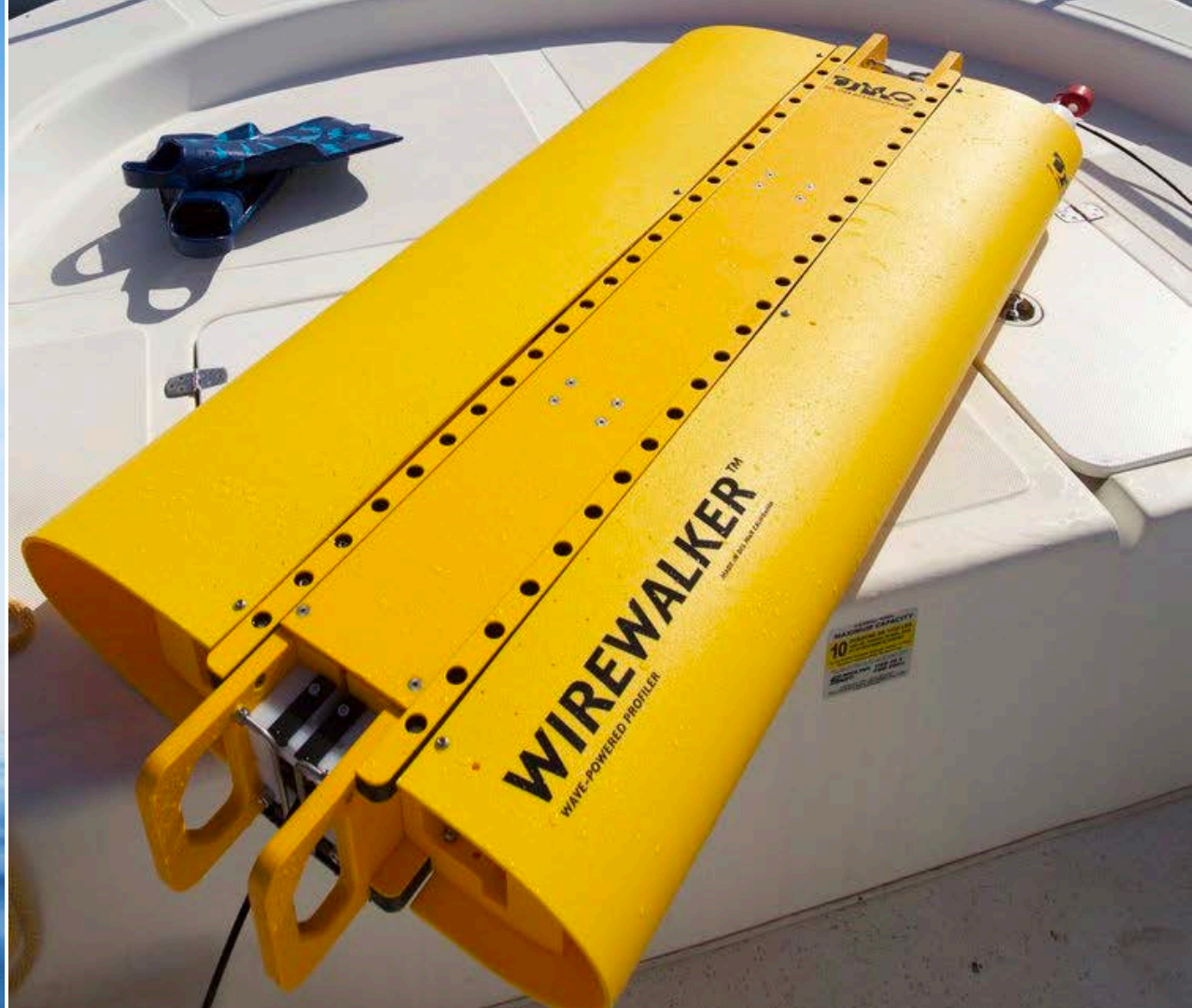
THE WIREWALKER

AN INTRODUCTION TO WAVE POWERED PROFILING

DEL MAR OCEANOGRAPHIC



Wirewalker
Buoyancy

RBRfermata
(Batteries)

CTD
*Facing Up

Surfacing the data

Inductive modem to get the data from WW to buoy

4800 baud

Transparent modem

Robust to intermittent drop-outs (damaged cable)

Fast enough to get 8Hz five channel data up

Jacketed mooring line

Hammerhead

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Topside

RBR*cervello* – the brains of the operations

Hands off operation – power and go

Internal storage

USB stick transfer for download

USB stick transfer for deployment changes

GSM when in range

Iridium when not

Debug port

Inductive test loop included

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```
curl --location --remote-name --remote-header-name --compressed
'http://data.rbr-global.com/rbr/download/080296?from=2016-09-
08&to=2016-09-09'
```

Data at home

RBR data hosting service

GSM or Iridium feeds

Cloud hosting (both in North America and China)

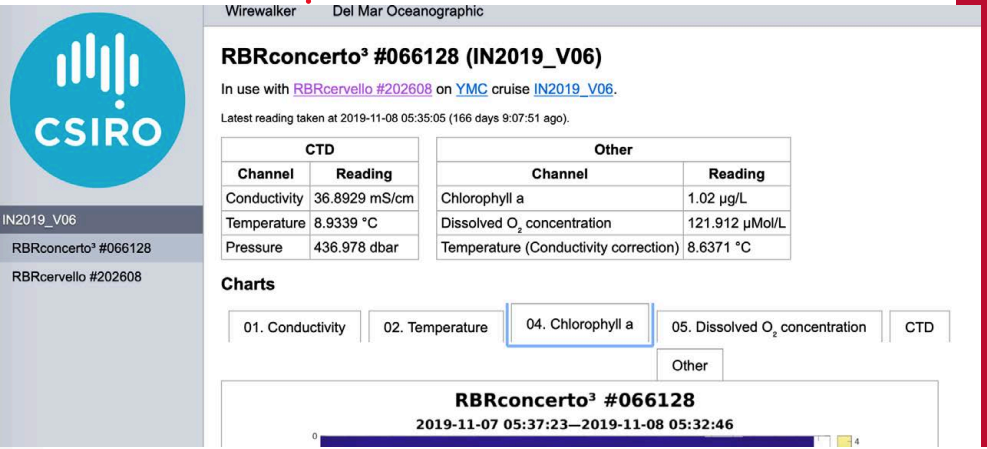
Simple daily charts

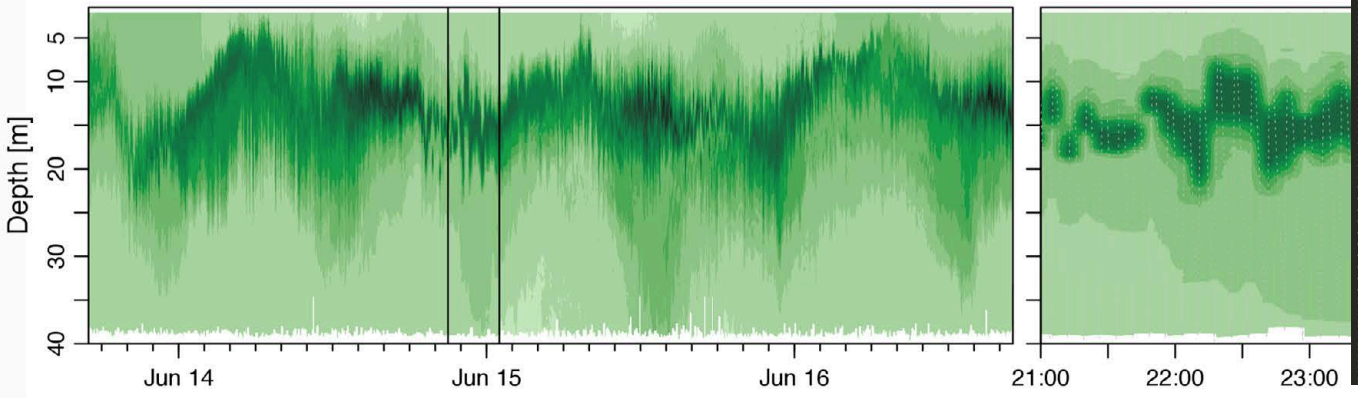
API to pull data

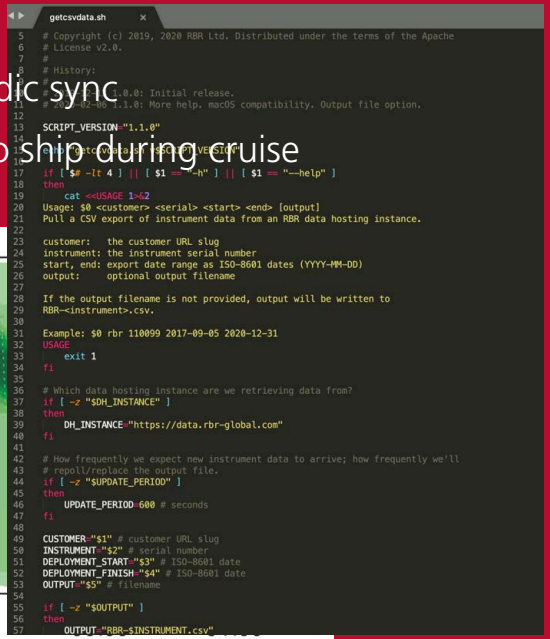
curl example

shell scripts for periodic sync

easy to get all data to ship during cruise







Sensor Integration

- Atmospheric temperature
- Optical DO
- Fluorescence
- Backscatter
- PAR
- Etc.

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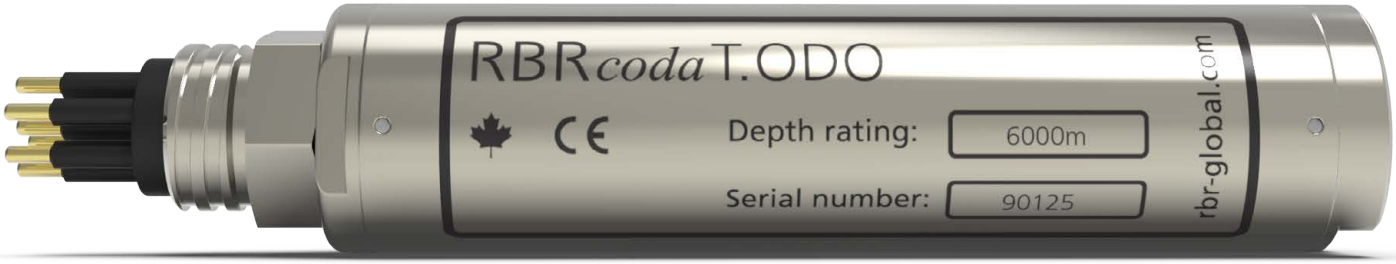

RBR*coda* T.ODO

Optical accuracy and stability similar to Aanderaa Optode

Standard accuracy of 8 µmol/l

High accuracy marine temperature (0.002°C)

Power consumption is 20% of Aanderaa Optode

Depths up to 6000m

- |fast 1s response
- Standard 8s response

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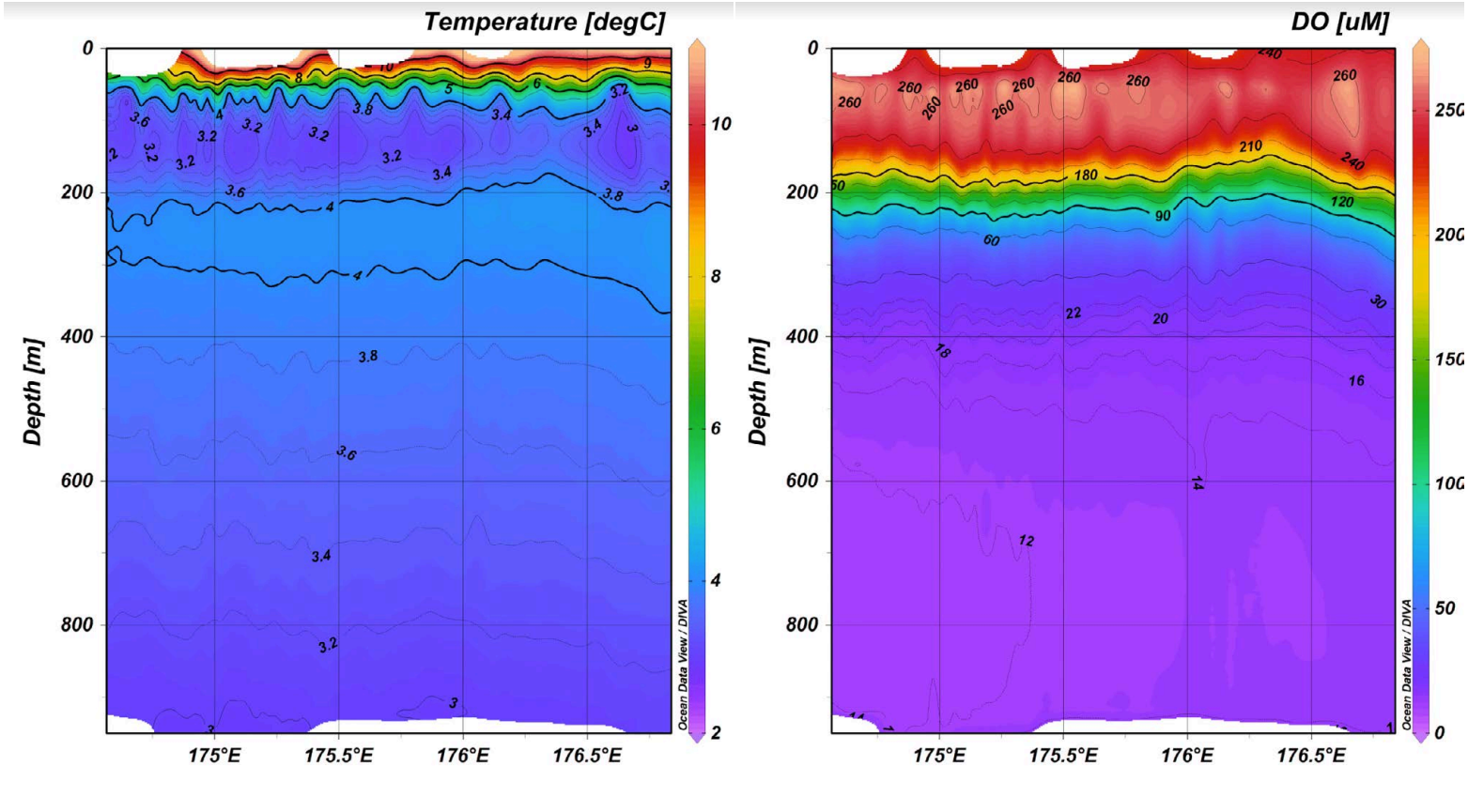
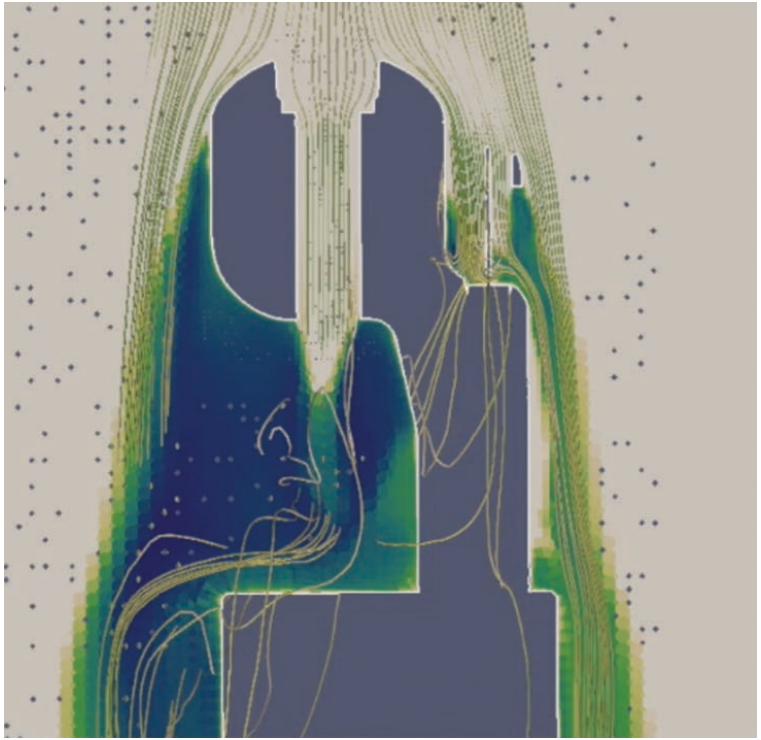
AMT Petrel Glider - China

北京蔚海明祥“海燕”水下滑翔机海测



Benefits of inductive cells

- Conductivity cell can be built with a low aspect ratio
- Cell flushes naturally
- No pump required
- Low power consumption
- Acoustically quiet
- Robust – can withstand very low temperatures
- Can measure accurate conductivity when cell is 10cm from air-sea interface
- "Contactless"
    - No metal electrodes
    - Not affected by surface oils



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Vulnerability of inductive cells

Proximity effects

Any material within close proximity of the conductivity cell changes the measured conductivity.

- Recommended to keep objects 15cm from cell
- High bias for conductive material (e.g., stainless steel guard)
- Low bias for non-conductive material (e.g., rope or insulated mooring line)
- Calibration can eliminate proximity effect
  - Instrument calibrated in the guard
  - Float heads calibrated with Iridium antenna and oxygen optode

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Primary causes of dynamic errors in CTD sensors

Temperature time constant

- Finite time for heat to diffuse through thermistor
- 1s (standard)
- 0.1s (fast)

Conductivity & temperature lag

- Small spatial separation causes sensors to encounter water parcel at different times
- 36mm distance from T to C (centre)

Recommended C-T lag correction for RBR*legato*^{3}

(standard thermistor)

$$lag = -0.90\ s$$

- Very weak dependence on fall-rate in the relevant range (< 0.02 s over 0.20 - 0. 35 m/s range)
- Uniform across platforms (Slocum, Seaglider, SeaExplorer)

Optimal lag is determined statistically by maximizing covariance between conductivity and temperature over short segments.
Barth et al. (1996), Ullman and Hebert (2014), Dever et al. (2020)

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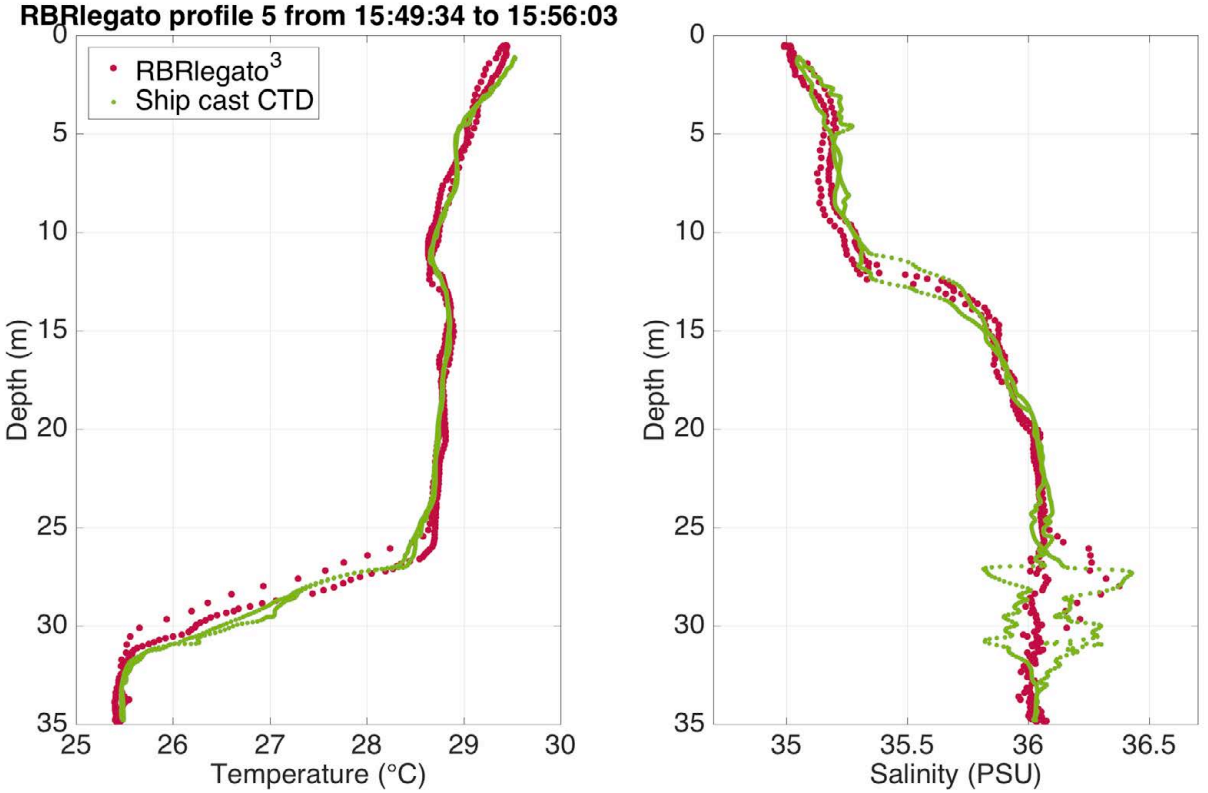
USF Ocean Data



Data Provided by University of South Florida, College of Marine Science

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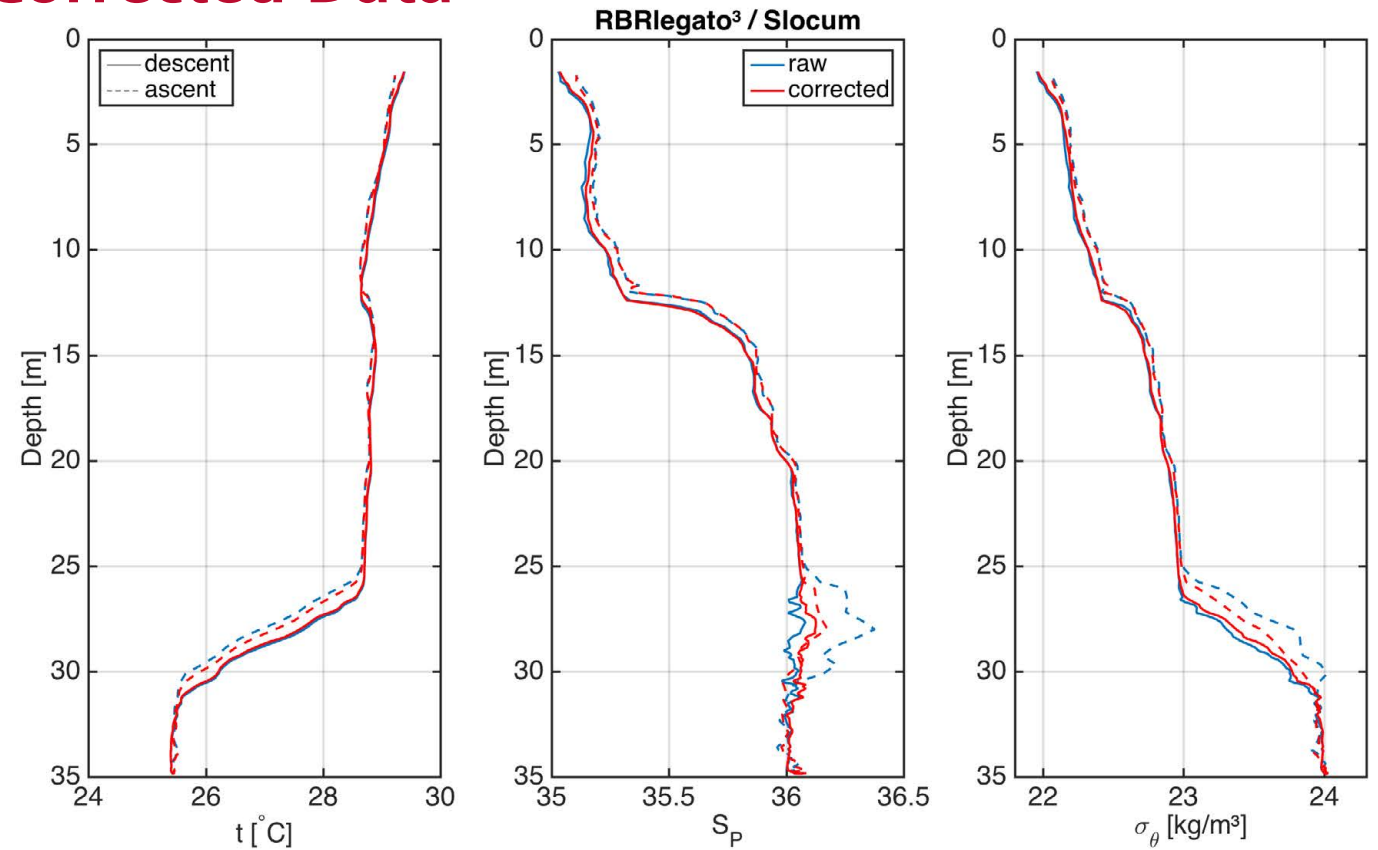
USF Corrected Data



Data Provided by University of South Florida, College of Marine Science

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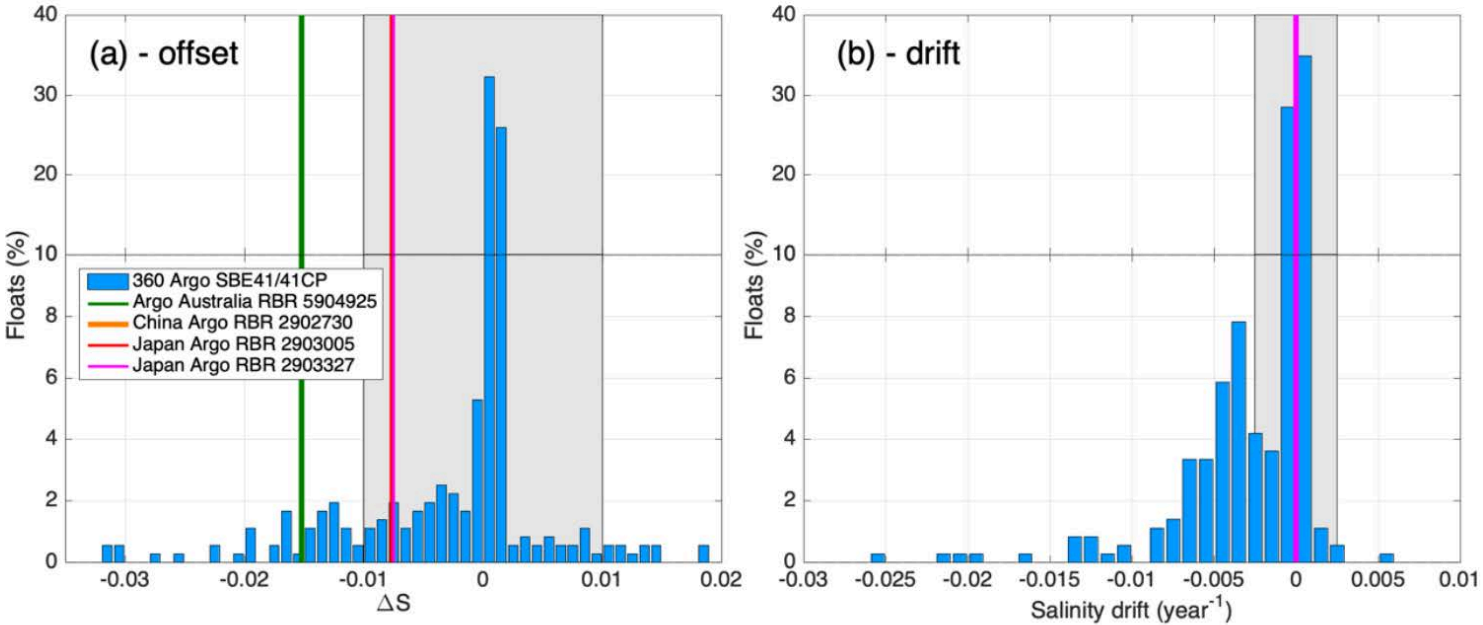
RBRargo³ bias and drift corrections compared to DM data from nearby floats



The averaged salinity correction (a) bias and (b) linear drift rate

4 floats with RBR*argo* CTDs

360 Argo floats with SBE41 CTDs

Nezlin, N. P et al. (2020) JTECH (*10.1175/JTECH-D-20-0058.1*)

Dynamic corrections RBR*argo*^{3}

Conductivity – Temperature alignment (C-T lag)

Standard (τ ~ 1 s)

$lag = -0.35\ s$

Fast (τ ~ 100 ms)

$lag = -0.046\ s$

Thermal mass corrections

1.Heat transfer between water and cell characterized by **two time constants**

2. **τ_{60}** uses the marine temperature (T_{marine}) and the internal cell temperature (T_{ctcell})

3. **τ_8** uses the Morison's (1994) application of the Lueck and Picklo (1990) model

τ_{60}:

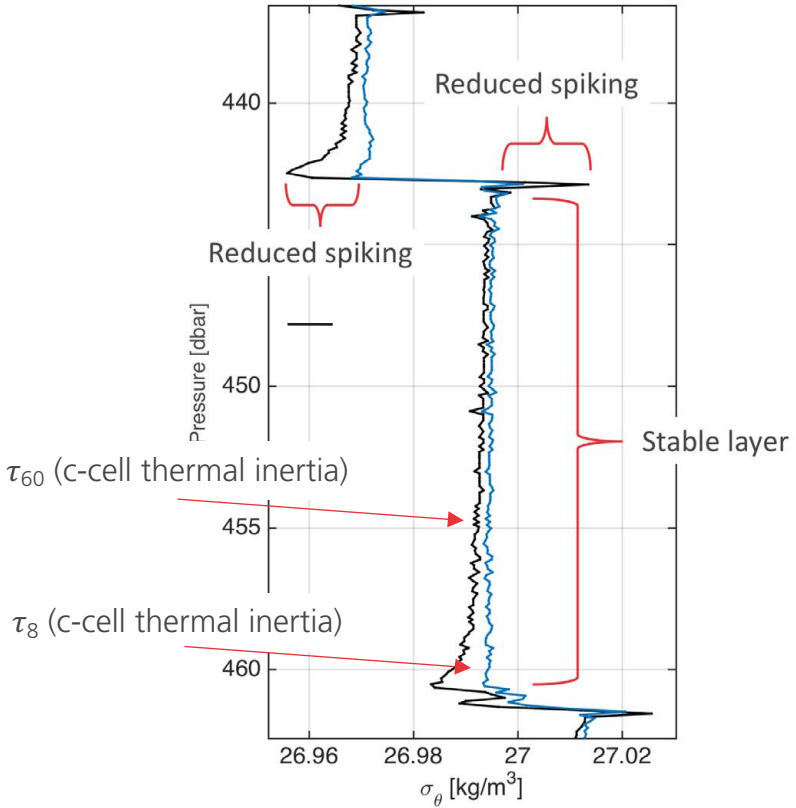
$$C_{\tau 60}(n) = \frac{C_{meas}}{1 + 2.4\times10^{-4}[T_{ctcell}(n) - Tmarine(n)]}$$

τ_8:

$$T_T(n) = -bT_T(n-1) + a[T(n) - T(n-1)]$$

using α = 0.08 and τ = 8 s

1 Hz sampling rate; 10 cm/s profiling rate



Caribbean Sea, MRV/RBRargo ALAMO #9139

Summary

- RBR CTDs available on a wide variety of platforms
- Core CTD technology with vehicle-specific customizations have yielded great results
- Low power, high accuracy
- Responsiveness to end users

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Thank You!

Contact Us

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