Status Report on RBR CTDs for Argo floats

Breck Owens, WHOI

Susan Wijffels, WHOI

Mark Halverson, RBR

Jean-Michel Leconte, RBR

Greg Johnson, RBR

- Evolution of RBRargo CTD
- Stability from float deployed in Coral Sea
- Dynamic Response from ALAMO float in Tropical Atlantic
- Recommendation from Seattle Technical Workshop

Version 1:
RBR*argo* C.T.D, separate C and T sensors

- Conductivity cell is a sealed pressure vessel - ferrites remain at atmospheric pressure
- Thermistor sting mounted on float head.
- Conductivity Cell is not hydrodynamically smooth.
- Flushing rate proportional to profiling speed
- Long term deployments in the Coral Sea (S. Wijffels)
  - suggest excellent stability, but salty bias
  - significant density inversions due to entrainment, misaligned CT sensor pair

The Present: RBR*argo* C.T.D, combined CT cell
RBR*argo* C.T.D|deep

- RBR*argo* C.T.D has:
  1. Thermistor sting co-aligned with conductivity head
  2. Hydrodynamically smooth conductivity head
  3. Additional thermistor embedded inside conductivity cell
- Excellent dynamic response characteristics.
- RBR*argo* C.T.D|deep has an operating depth of 6000 m. It also has a low power, short time constant optode oxygen sensor. IFREMER has data from a GOSHIP section at 36°N in the Atlantic.
- Results for the double diffusive staircase structure in the Atlantic will be shown later.
- RBRargo C.T.D uses ~400 J for a 2000 m profile at 10cm/s, compared to 4.0 kJ for a SBE41CP.

RBRargo CTD delivery history

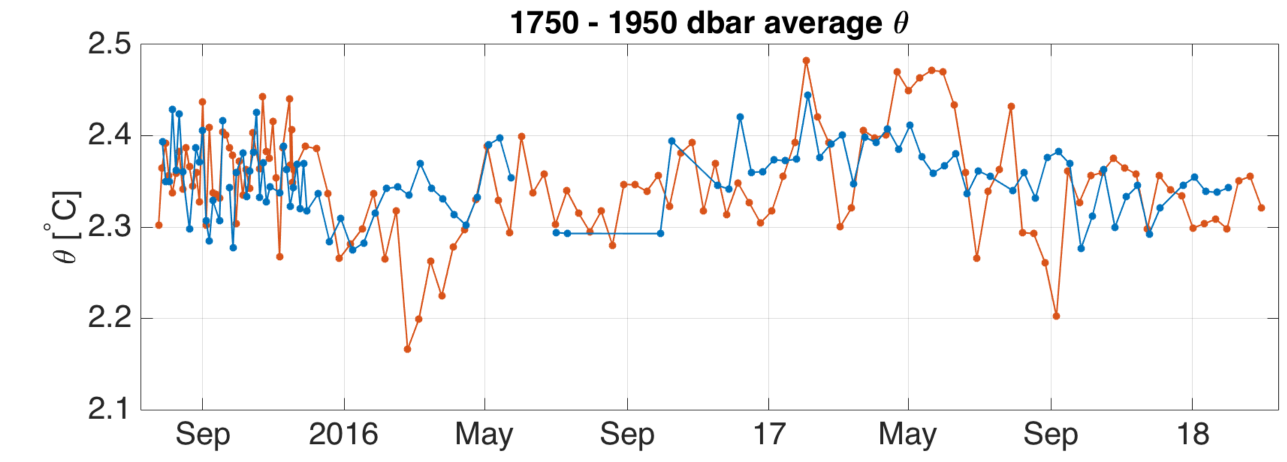
- TWR Apex: 7 T.D., 110 C.T.D.
    - 4 APEX NOC (2 x North Atlantic in Summer 2016, 2 x Indian Ocean)
    - 1 APEX to CSIRO (Coral Sea in 2015)
    - 1 APEX each to NOC/INCOIS/FMI/DFO (in assembly and/or calibration)
    - 1 APEX to UW (late 2017)
    - 1 APEX to Second Institute of Oceanography (late 2017)
    - 2 APEX to Argo JAMSTEC (late 2017)
    - 60 APEX RBR floats delivered to China
- Metocean: 281 T.D., 6 C.T.D.
    - 1 NAMI CTD to DFO (2016)
- MRV Systems (ALAMO floats)
    - 53 C.T.D., 78 T.D.

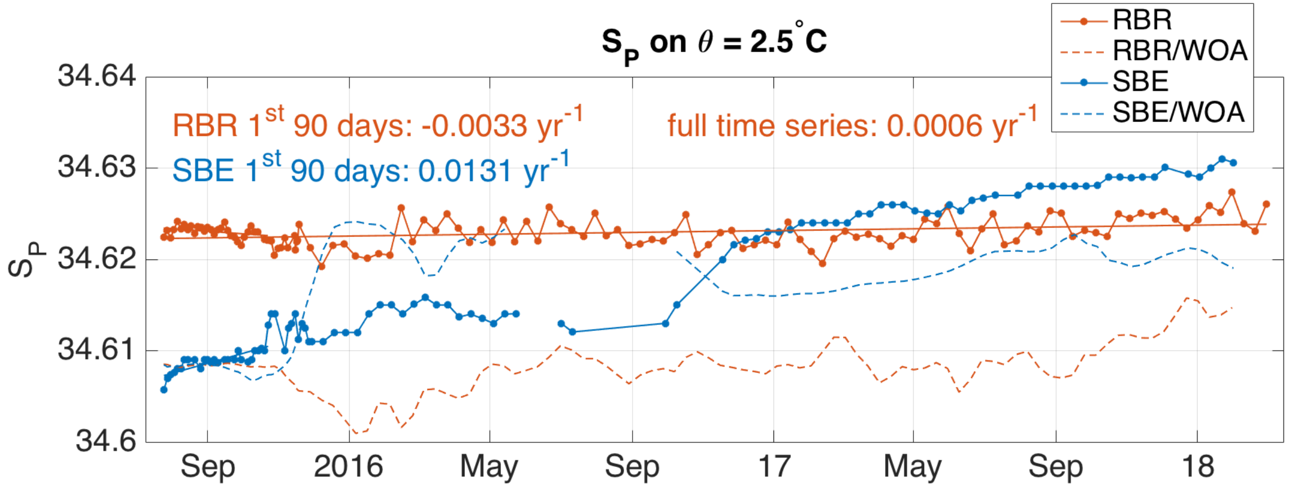
Only 3 *combined* CTDs are on operational Argo floats at present.

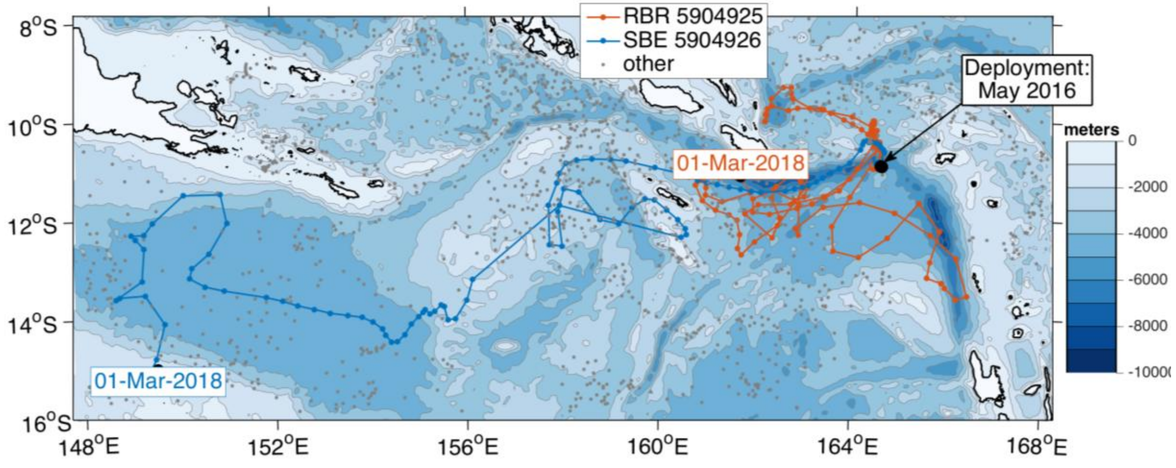
Issues seen at sea

- Variety of float failures (unrelated to sensors)
- One small batch of CTDs delivered to Teledyne Webb in May 2016
  - Issue with O-ring for mating to top-cap
  - Two floats leaked after first dive
  - All previous and subsequent batches have original design that doesn't have this failure mode
  - Investigation performed in Q4 2017 and a report was circulated to PIs.

Stability of First Generation RBRargo CTD







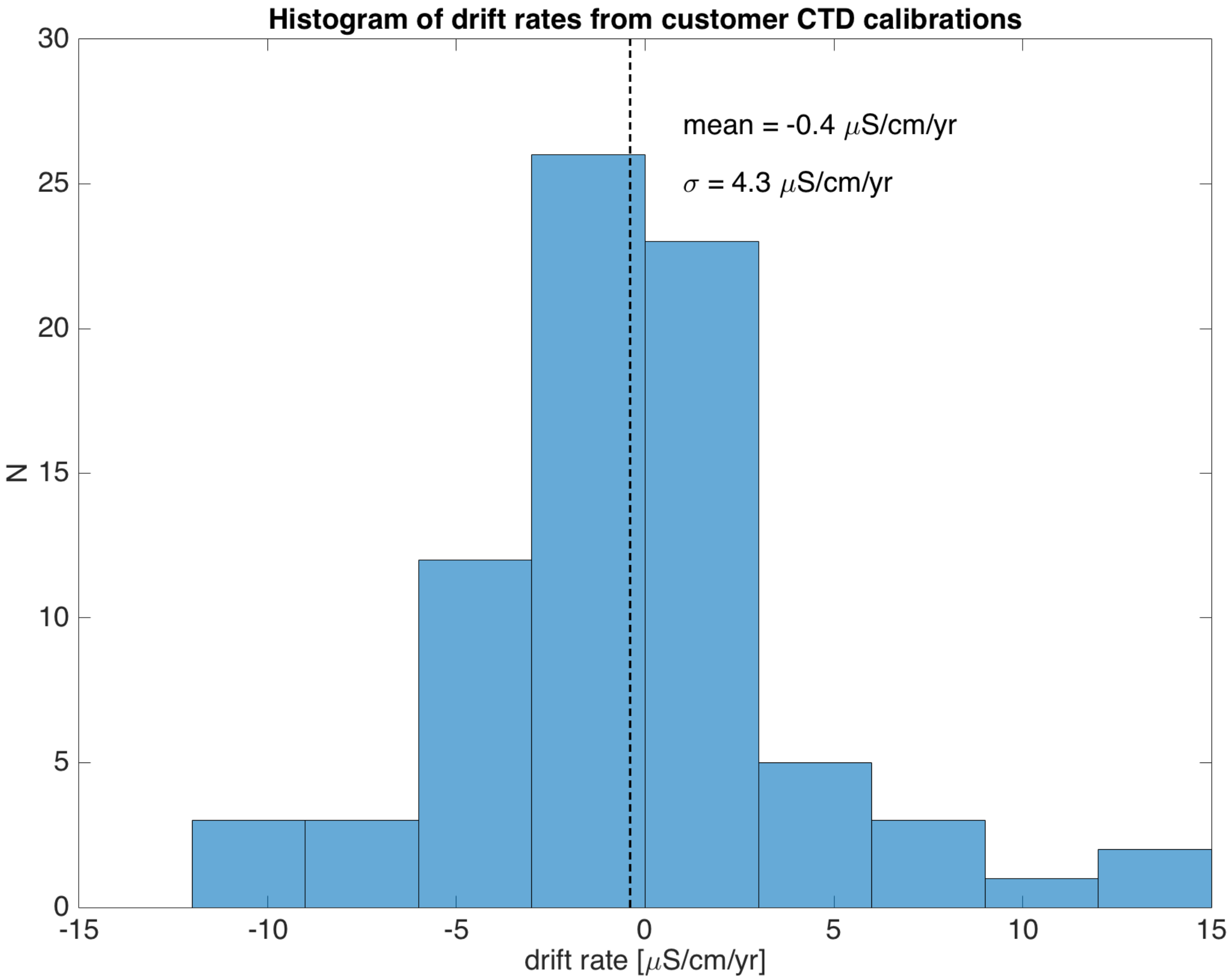
Drift over the first three months when RBR and SBE floats were less than 200km apart:

- RBR salinity: -0.0033 yr^{-1}
- SBE salinity: 0.0131 yr^{-1}

Full time series:

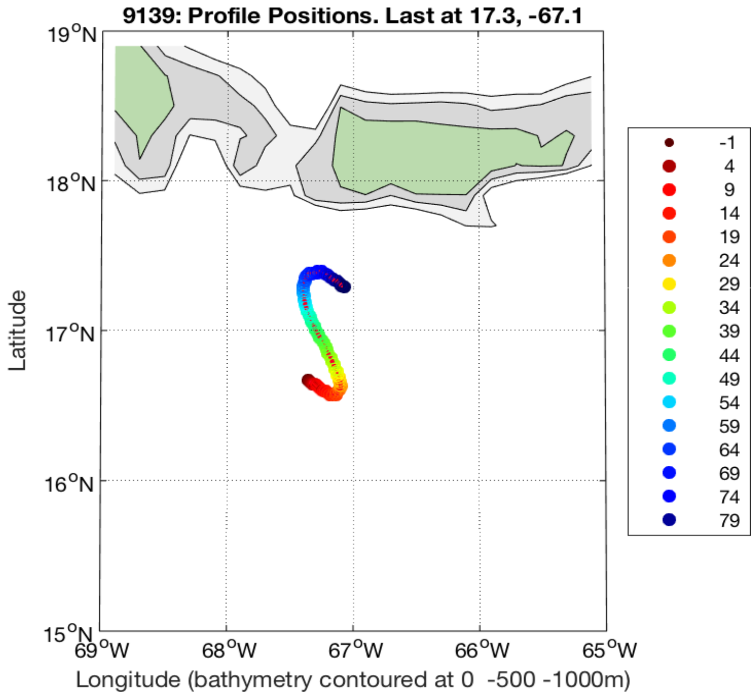
- RBR salinity: 0.0006 yr^{-1} average drift
- SBE salinity: N/A (sig. T/S water mass change)

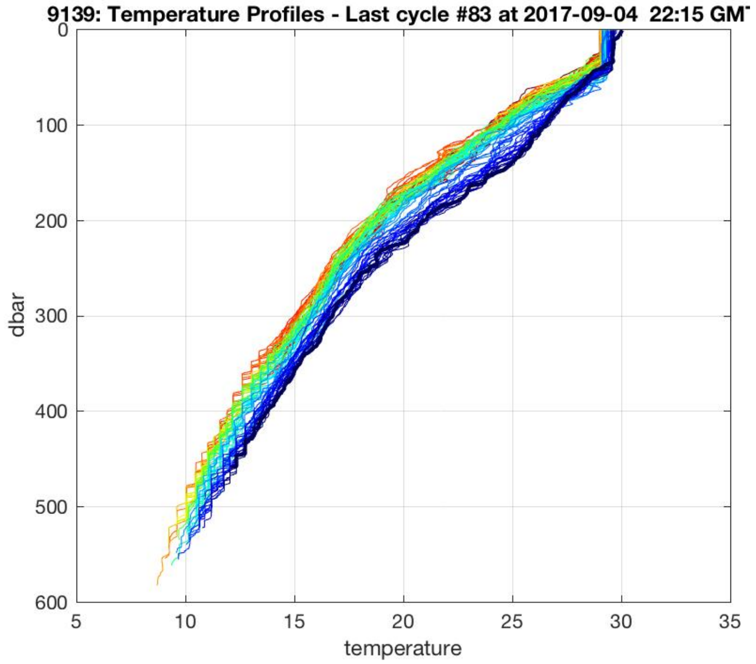
Long-term stability from calibration of customer units
Unknown handling between calibrations!

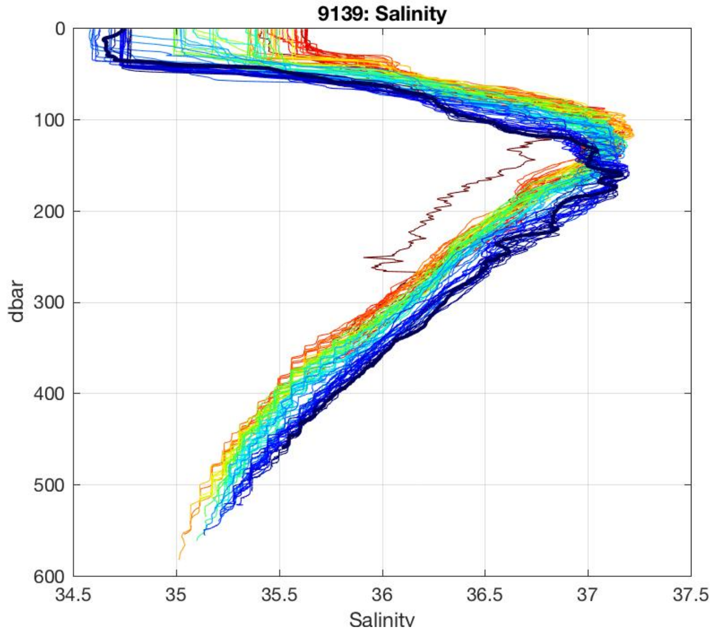


Mean drift of all cals:
-0.4 uS/cm/yr
(~-0.0004 psu/yr)

Dynamic Response: ALAMO float in Staircase Structure

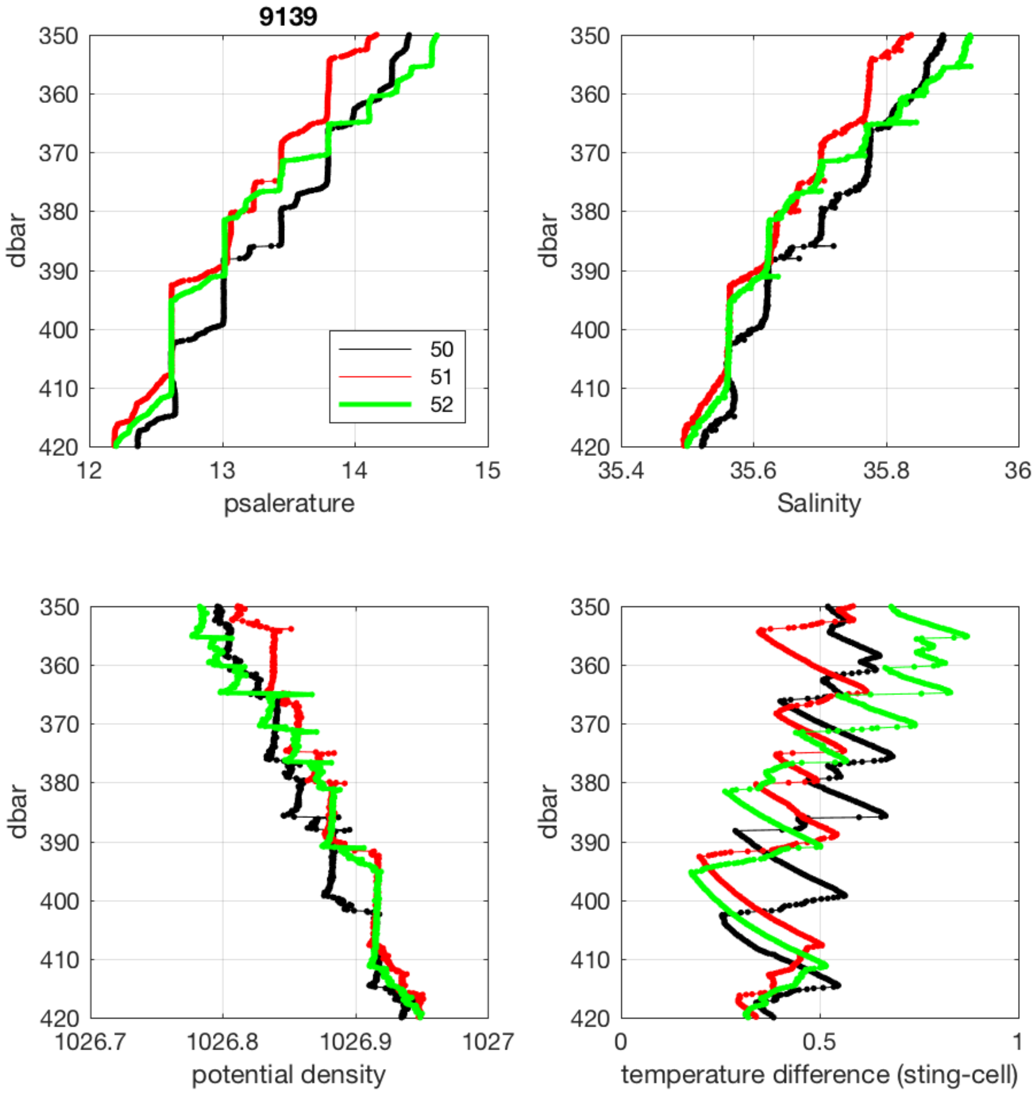


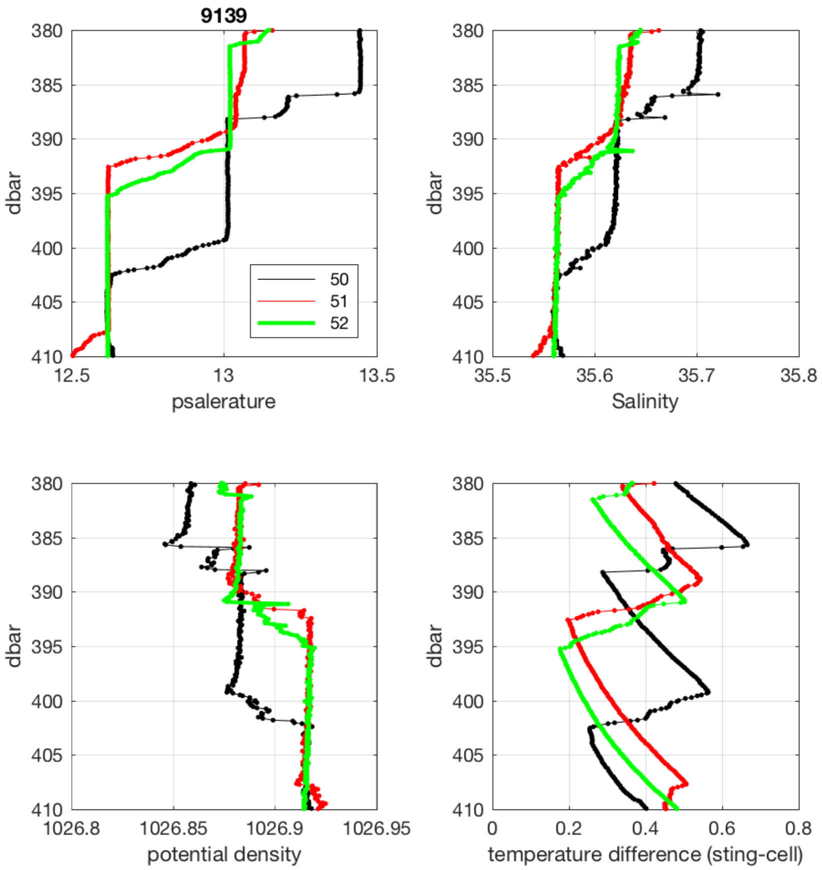




For full set of plots for this float see:
http://argo.whoi.edu/alamo/9139/index.html

Staircase structure seen in raw data

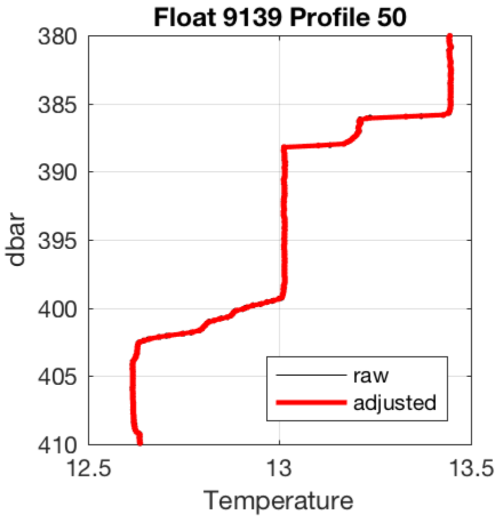


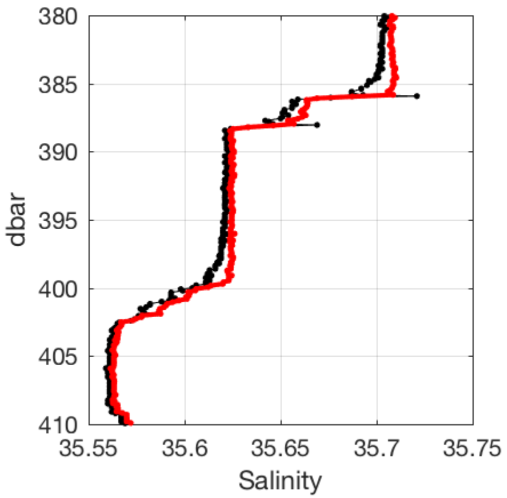


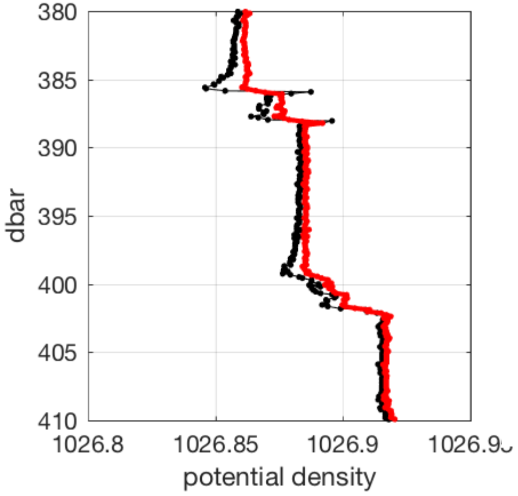
Note:

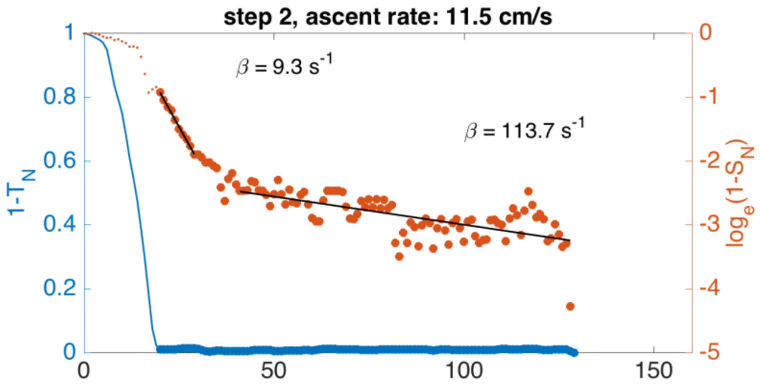
- density inversion at bottom of steps
- Long time constant for difference between internal and sting temperature

Post-processing estimates of thermal mass









Two issues to address

1. Non-verticality of mixed layer (~ 10 m scale)
2. Behavior at step transition (~ 2 m scale)

Processing addresses each issue

1. Sensor temperature correction (sting T vs cell T) thermal dependence of ferrite permiability
2. Thermal mass by the Lueck & Picklo (1990)

Different timescales for two correction steps

1. Sensor correction has ~2 min time constant laboratory calibrations used for corrections
2. Thermal inertia has ~8 sec time constant in situ calibrations and double-diffusive tank calibrations

Conductivity thermal mass correction applied here uses the same form as L&P, which has an amplitude and e-folding time scale. Here:

$\alpha = 0.08$

$\beta = 0.125\ s^{-1}$ ($\boldsymbol{\tau} = 8$ s)

RBR developments in progress

- Optional thermal (type I and type II) correction *inside* the instrument
- Flexible post-processing at time of instrument data download to float controller
  - Bin sizes
  - Regime boundaries
  - Alpha/beta(tau) for L&P
  - Lead/lag application
  - Mean, median, standard deviation, count per bin
  - Partial transfer by channel, time, depth ranges

Recommendation from Seattle Technical Workshop

- RBRargo CTD has met the criteria that it is ready to be deployed in a pilot study (See presentation on what is an Argo Float).
- This pilot study should involve deploying tens of floats in different oceanographic regimes to make sure that they perform well globally.
- The AST needs to approve this proposed pilot study and recruit float providing institutions to carry it out.

- Past ship based comparisons have been very useful. RBR offers additional collaboration - CSIRO, IFREMER, GO-SHIP, analysis aids.