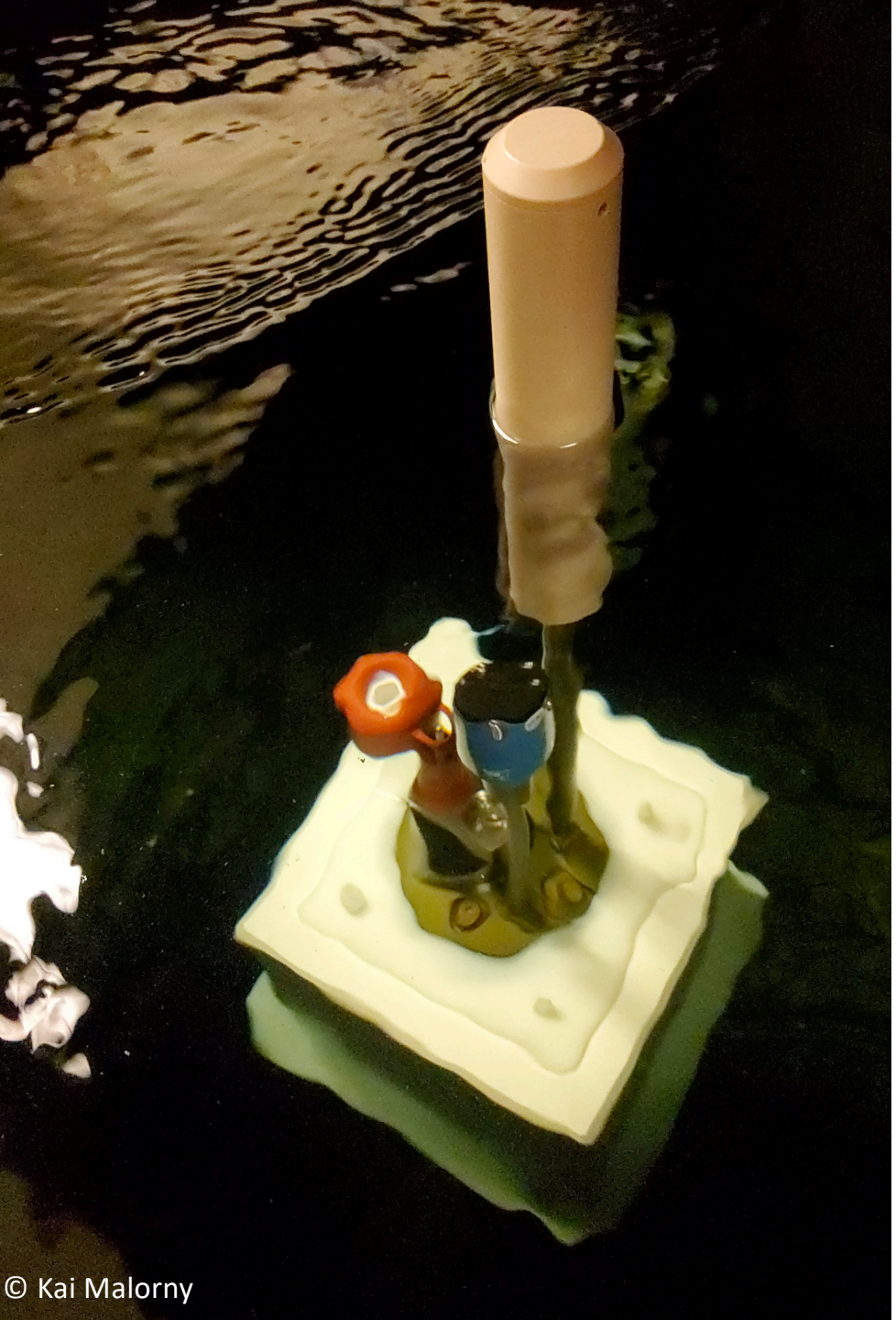


Field-based validation of dynamic corrections for the RBR*argo*³ CTD

Mathieu Dever
mathieu.dever@rbr-global.com

And the argo Data Task Team
Shigeki Hosoda, Greg Johnson, Brian A. King, Jean-Michel Leconte, Guillaume Maze, Travis Miles, Breck Owens, Clark Richards, Susan Wijffels, Esmee Van Wijk , Annie Wong, Liu Zenghong, and Nathalie Zilberman

December 3, 2020

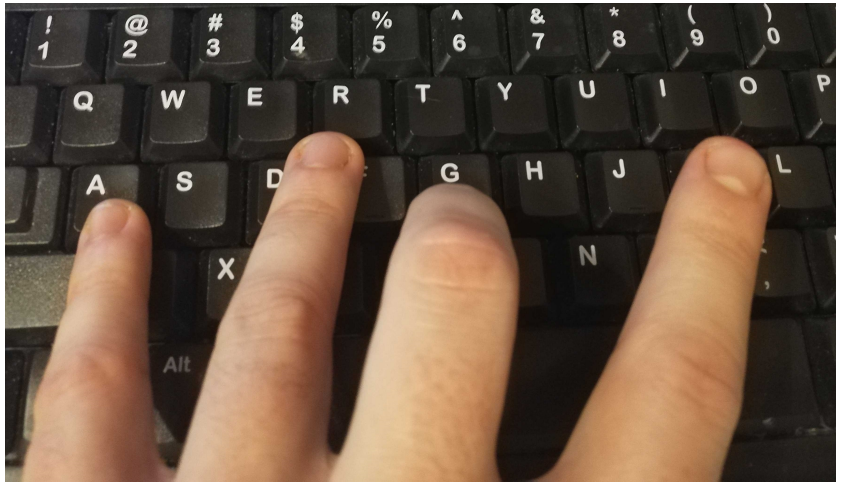
RBR

Floats deployed in 2020

WMO	Country	Region	Float Manufacturer	Buddy float	Reference cast	High-Res data
5905482	Australia	Southern Ocean	MRV	✓	x	x
5905483	Australia	Southern Ocean	MRV	✓	x	x
5906614	Australia	Southern Ocean	MRV	✓	x	x
5906615	Australia	Southern Ocean	MRV	✓	x	✓
5906616	Australia	Southern Ocean	MRV	✓	x	x
5906617	Australia	Southern Ocean	MRV	✓	x	✓
5906618	Australia	Southern Ocean	MRV	✓	x	✓
5906619	Australia	Southern Ocean	MRV	✓	x	x
5906298	USA	Subpolar Pacific	TWR-UW	x	x	x
5906383	USA	Equatorial Pacific	SIO	x	x	✓
5906299	USA	Subtropical Pacific	TWR-UW	-	-	-
N/A	USA	North Atlantic	TWR	x	x	✓

Access to RBR*argo*³ metadata

- Ongoing conversation with the RBR Argo Task Team and JCOMMOPS to establish best course of action.
  - Suggestions are welcome for useful additional fields
  - calibration date included in *calib_comment*
- Experienced the physical pain of manually typing each field for one sensor



- Metadata ASCII files are automatically generated and can be requested
  - Through e-mail: manually sent to user
  - Through a webservice : http://oem-lookup.rbr-global.com
    Currently working on getting authorization for public access without a key
- RBR-specific format and parser for now: should a uniform format/parser be agreed upon for all manufacturers?

oem-lookup.rbr-global.com/?

RBR*oem* and RBR*argo* Product Lookup

Lookup

By serial number | Argo Metadata

RBRargo serial number

203794

DAC authorization key

e3b0c44298fc1c149afbf4c8996fb92427ae41e4649b934ca495991b7852b855

Contact RBR at argo@rbr-global.com if you do not have your authorization key.

Lookup

cURL Request

```
curl "https://oem-lookup.rbr-global.com/api/v1/instruments/203794/argometadata"
```

Response

Status: success


```
{
  "CTD manufacturer name": "RBR",
  "CTD manufacturer model": "RBR_ARGO3",
  "Pressure sensor manufacturer": "RBR",
  "Pressure sensor model": "RBR_PRES_A",
  "CTD_TEMP SENSOR_MAKER": "RBR",
  "CTD_TEMP SENSOR_MODEL": "RBR_ARGO3",
  "CTD_TEMP SENSOR_SERIAL_NO": "203794",
  "TEMP PARAMETER_UNITS": "degC (ITS-90)",
  "TEMP PARAMETER_ACCURACY": "0.002 degC",
  "TEMP PARAMETER_RESOLUTION": "0.00005 degC",
  "TEMP PREDEPLOYMENT_CALIB_EQUATION": "Temperature = 1/(C0+C1*ln(1/VR-1)+C2*ln(1/VR-1)^2 +C3*ln(1/VR-1)^3)-273.15;",
  "TEMP PREDEPLOYMENT_CALIB_COEFFICIENT": "C0 = 3.514987E-3, C1 = -253.70164E-6, C2 = 2.4900985E-6, C3 = -71.258945E-9",
  "TEMP PREDEPLOYMENT_CALIB_COMMENT": "Calibration date: 2020-01-23",
  "CTD_CNDC SENSOR_MAKER": "RBR",
  "CTD_CNDC SENSOR_MODEL": "RBR_ARGO3",
  "CTD_CNDC SENSOR_SERIAL_NO": "203794",
  "PSAL PARAMETER_UNITS": "psu",
  "PSAL PARAMETER_ACCURACY": "0.003 psu",
  "PSAL PARAMETER_RESOLUTION": "0.001 psu",
  "PSAL PREDEPLOYMENT_CALIB_EQUATION": "Salinity = PSS-78 (Temperature, Ccorr, Hydrostatic Pressure); Ccorr = (Cmeas-X0*(Tcond-X5))/(1+ X1*(Tcond-X5)+X2*(Pcorr-X6)+X3*(Pcorr-X6)^2+X4*(Pcorr-X6)^3); Cmeas = C0+C1*VR;"
  "PSAL PREDEPLOYMENT_CALIB_COEFFICIENT": "C0 = 34.275584E-3, C1 = 156.18636, X0 = 877.56163E-6, X1 = -18.252294E-6, X2 = 1.8732E-6, X3 = -776.89E-12, X4 = 148.9E-15, X5 = 15.067707, X6 = 10",
  "PSAL PREDEPLOYMENT_CALIB_COMMENT": "Calibration date: 2020-02-05",
  "CTD_PRES SENSOR_MAKER": "RBR",
  "CTD_PRES SENSOR_MODEL": "RBR_PRES_A",
  "CTD_PRES SENSOR_SERIAL_NO": "203794",
  "PRES PARAMETER_UNITS": "dbar",
  "PRES PARAMETER_ACCURACY": "1 dbar",
  "PRES PARAMETER_RESOLUTION": "0.02 dbar",
  "PRES PREDEPLOYMENT_CALIB_EQUATION": "Pcorr = X0+(Pmeas-X0-X1*(Tpres-X5)-X2*(Tpres-X5)^2-X3*(Tpres-X5)^3)/(1+X4*(Tpres-X5)); Pmeas = C0+C1*VR+C2*VR^2+C3*VR^3;",
  "PRES PREDEPLOYMENT_CALIB_COEFFICIENT": "C0 = -52.06691, C1 = 4.2605093E3, C2 = -1.4404389, C3 = 4.9244876, X0 = 10.0203, X1 = 201.23374E-3, X2 = 272.2353E-6, X3 = -1.8363767E-6, X4 = 55.54845E-6, X5 = 23.2",
  "PRES PREDEPLOYMENT_CALIB_COMMENT": "Calibration date: 2020-01-29"
```

Static behavior analysis

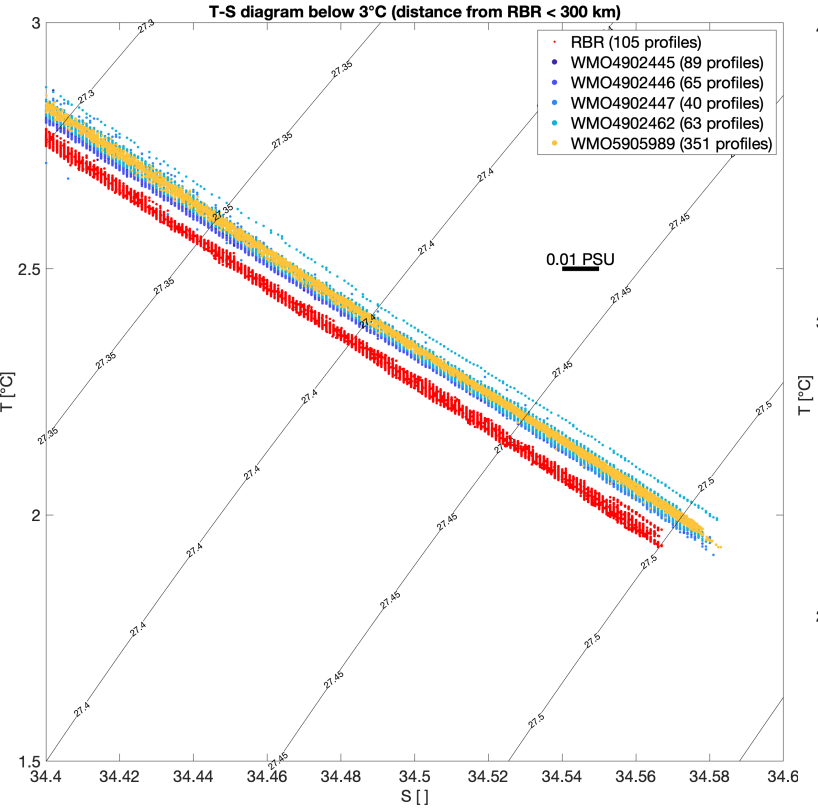
- ~~Static accuracy at low-pressure~~
- ~~Stability analysis[1]~~
- Pressure corrections on conductivity

[1]Nezlin et. al (2020) JTECH 10.1175/JTECH-D-20-0058.1

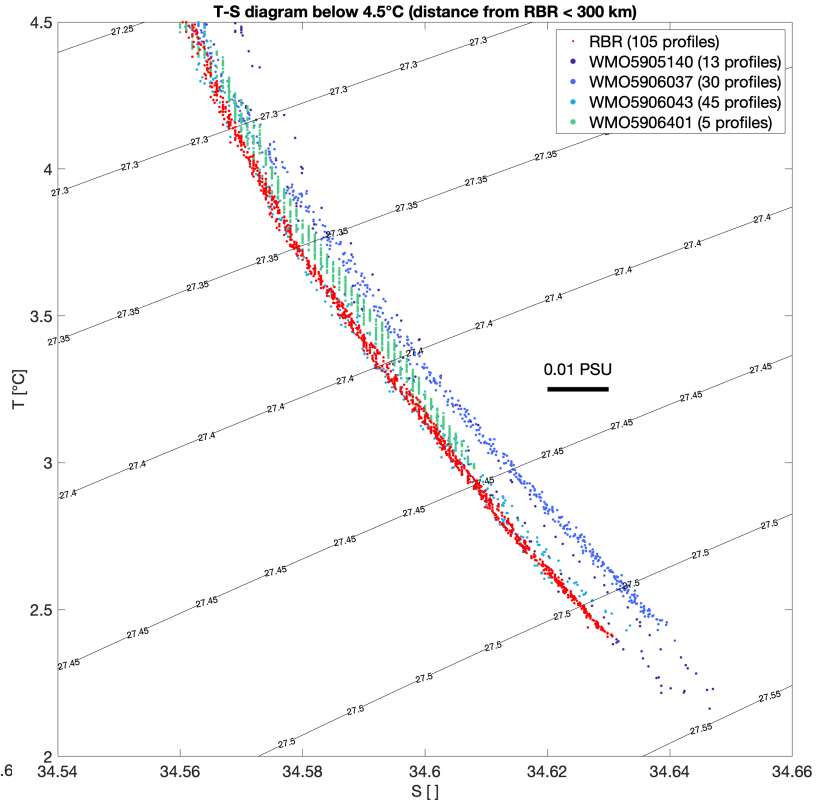
Field results: pressure correction

- Field data reveal unit-to-unit variability in pressure correction coefficients at 2,000 dbar O(0.01 PSU)

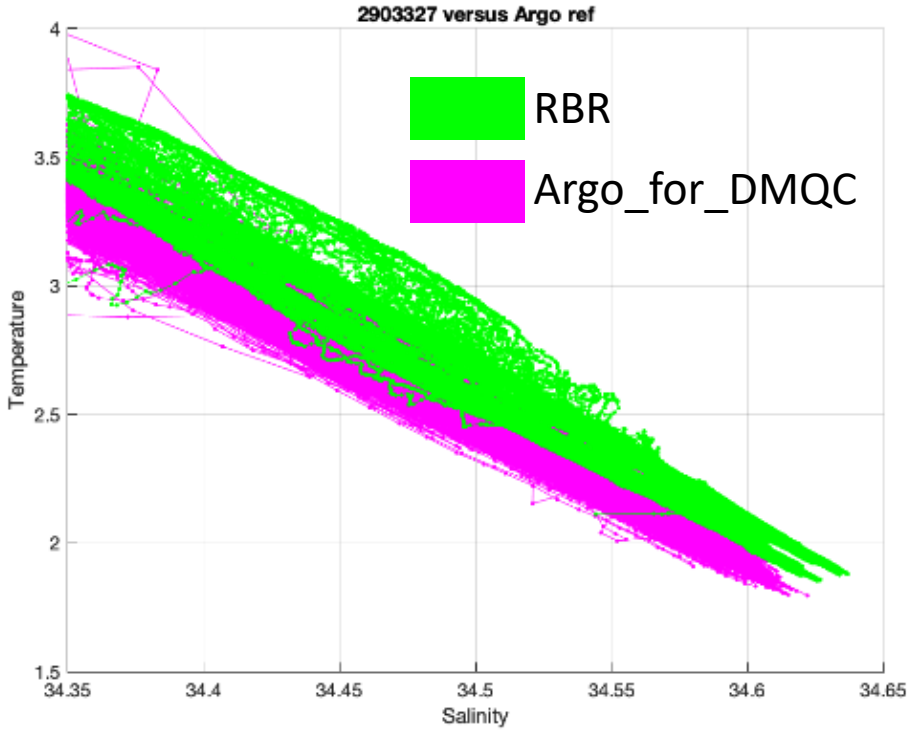
UW float (WMO5906298)



SCRIPPS float (WMO5906383)



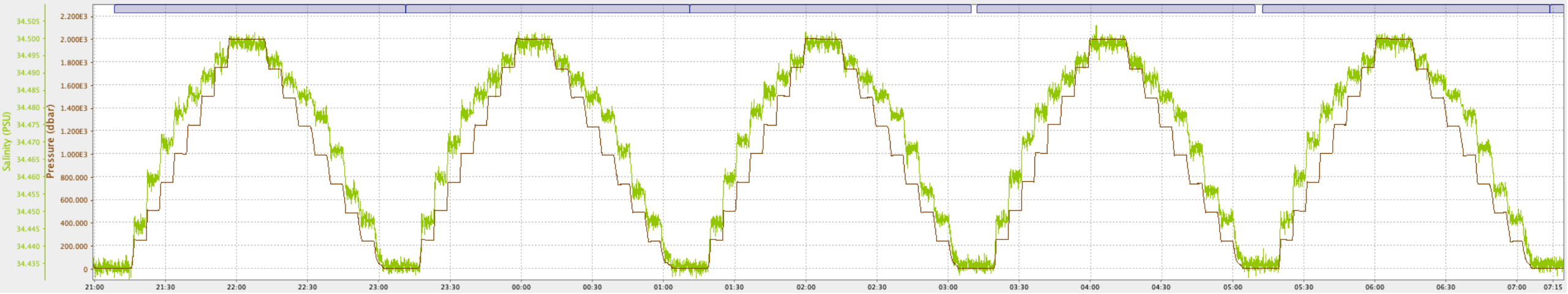
JAMSTEC float (WMO2903327)



Plot courtesy of Annie Wong

Lab results: pressure correction

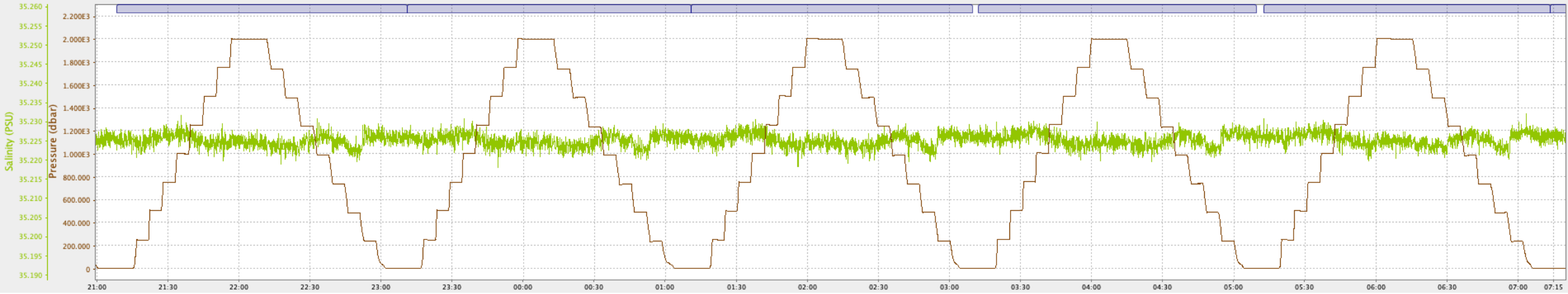
Raw pressure and salinity time series in pressure tank



Salinity

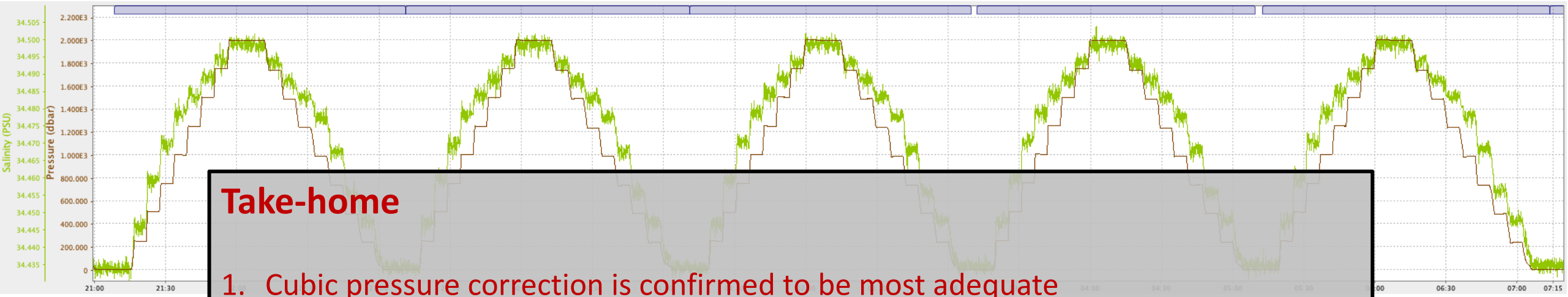
Pressure [dbar]

Corrected pressure and salinity time series in pressure tank



Lab results: pressure correction

Raw pressure and salinity time series in pressure tank

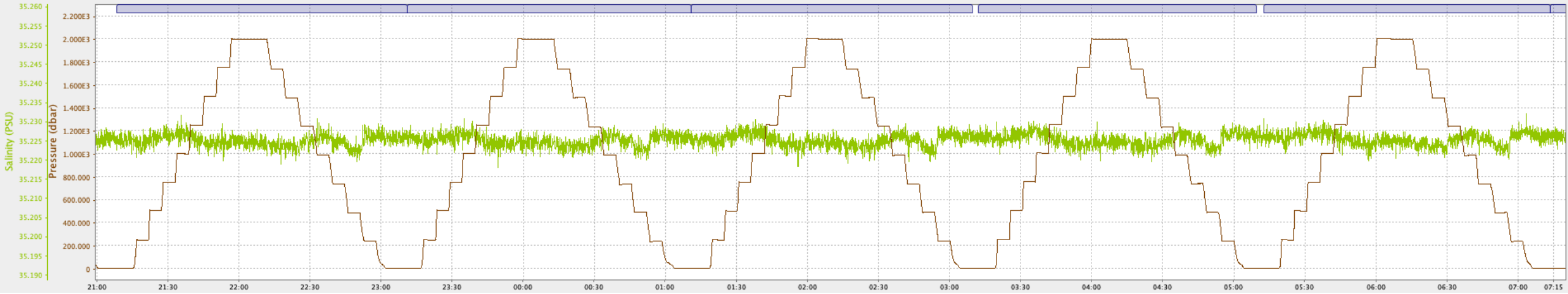


Salinity

Pressure [dbar]

Take-home

1. Cubic pressure correction is confirmed to be most adequate
2. Corrected salinity residuals are demonstrated to remain within +/- 0.003 mS/cm
3. All RBR*argo*^{3} will get customized pressure correction for highest accuracy at depth



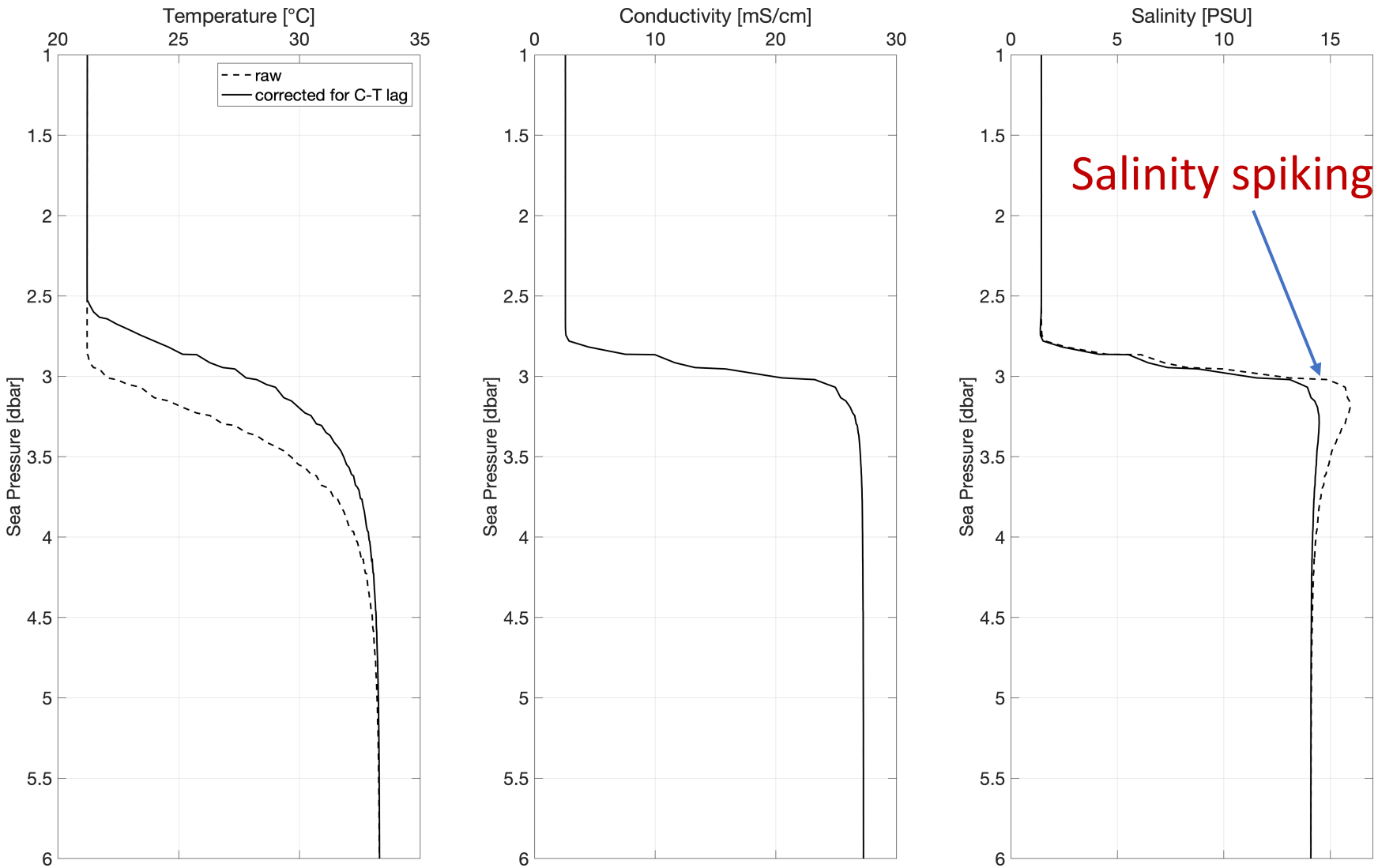
Dynamic behavior analysis

- Alignment of conductivity and temperature (C-T lag)
- Thermal mass corrections

Lab results: C-T lag

Validation from WHOI tank

Time lag of 0.35 s recommended to limit salinity spiking



See Schmitt et al. (2005)

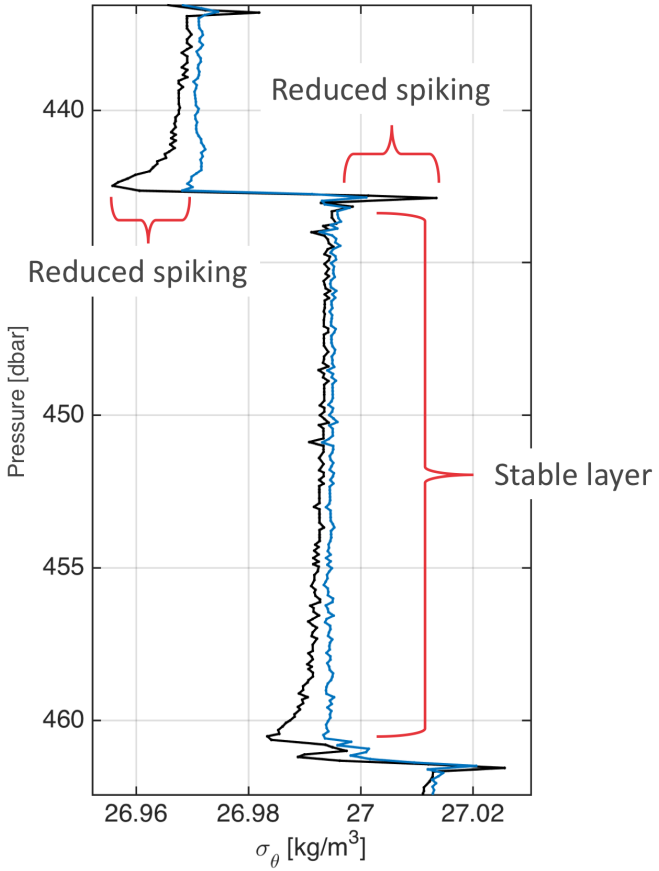
Field results: C-T lag

Validation from floats

Time lag of 0.35 s recommended to limit salinity spiking

ALAMO float #9139

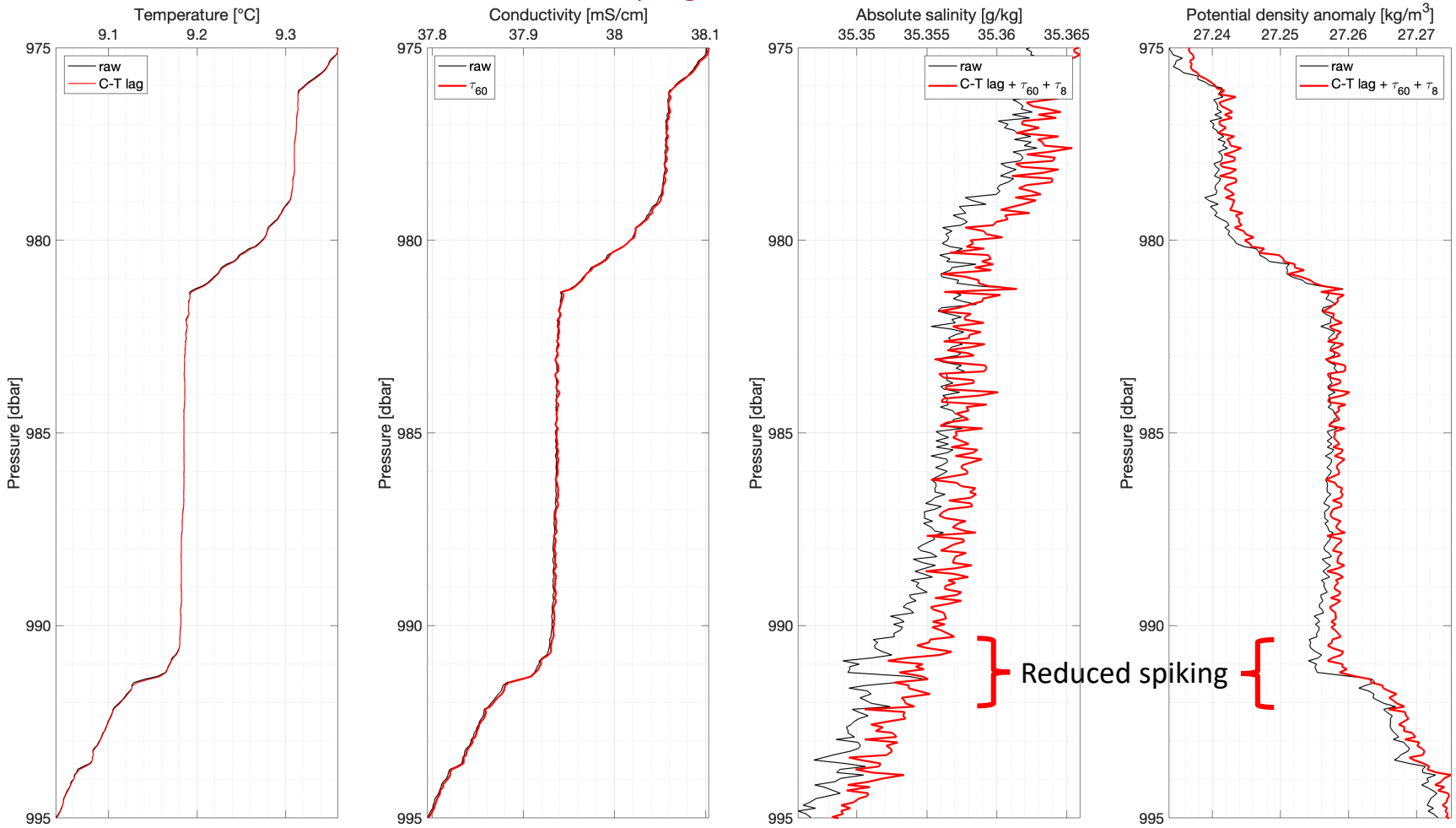
1 Hz sampling rate; 10 cm/s profiling rate



See report by Halverson et al. (2020)

TWR Engineering float #9139

1 Hz sampling rate



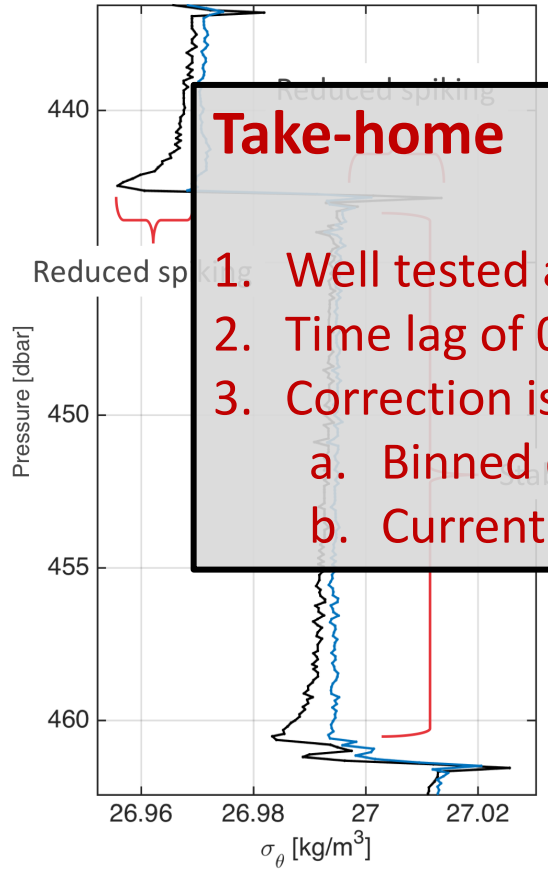
Field results: C-T lag

Validation from floats

Time lag of 0.35 s recommended to limit salinity spiking

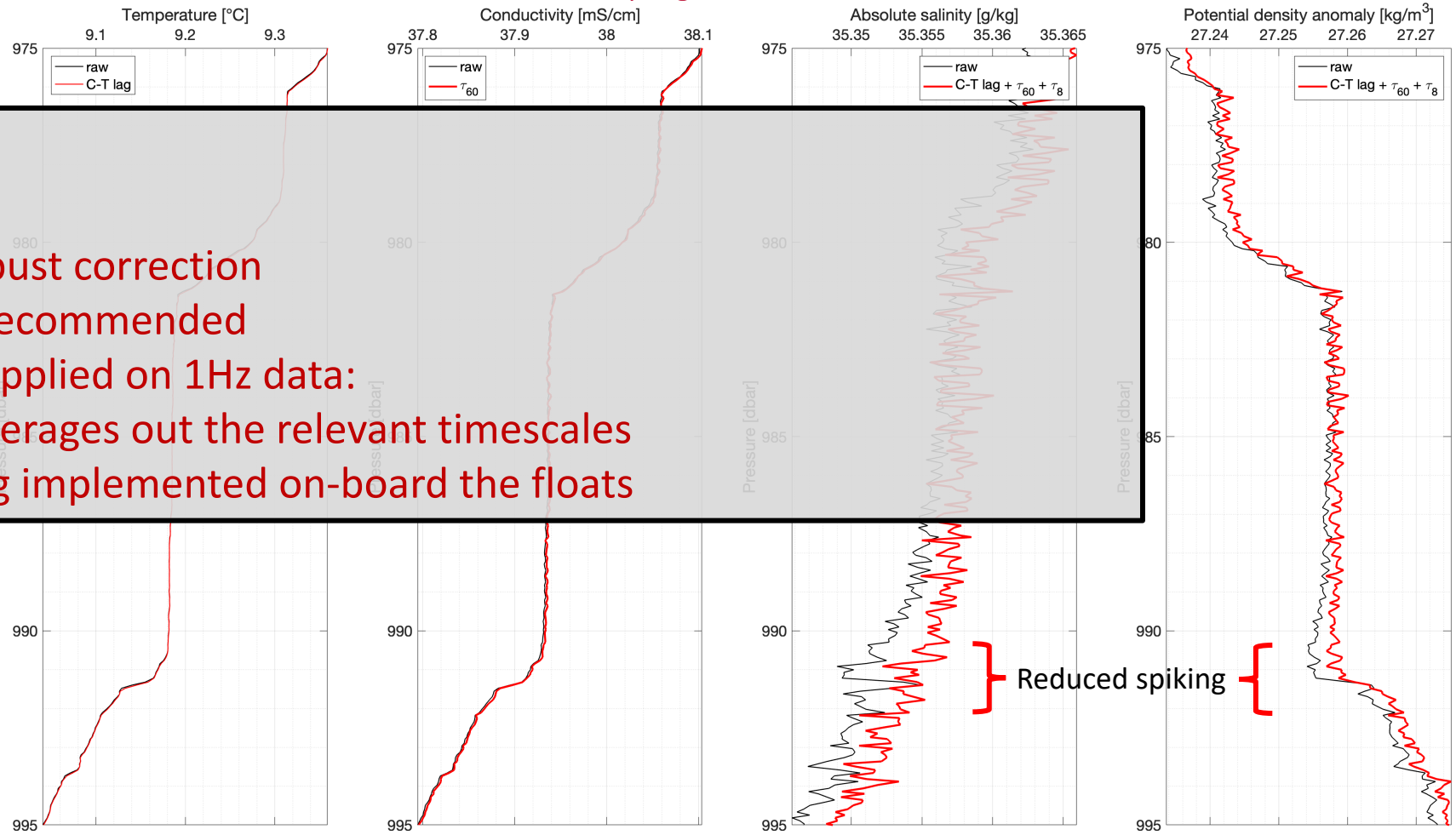
ALAMO float #9139

1 Hz sampling rate; 10 cm/s profiling rate



TWR Engineering float #9139

1 Hz sampling rate

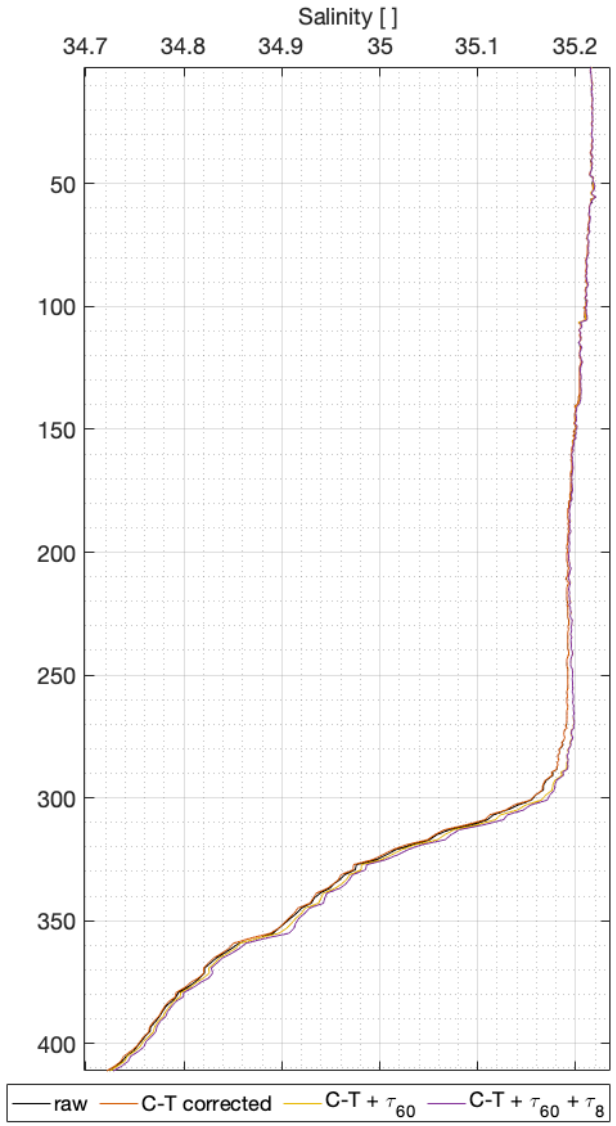


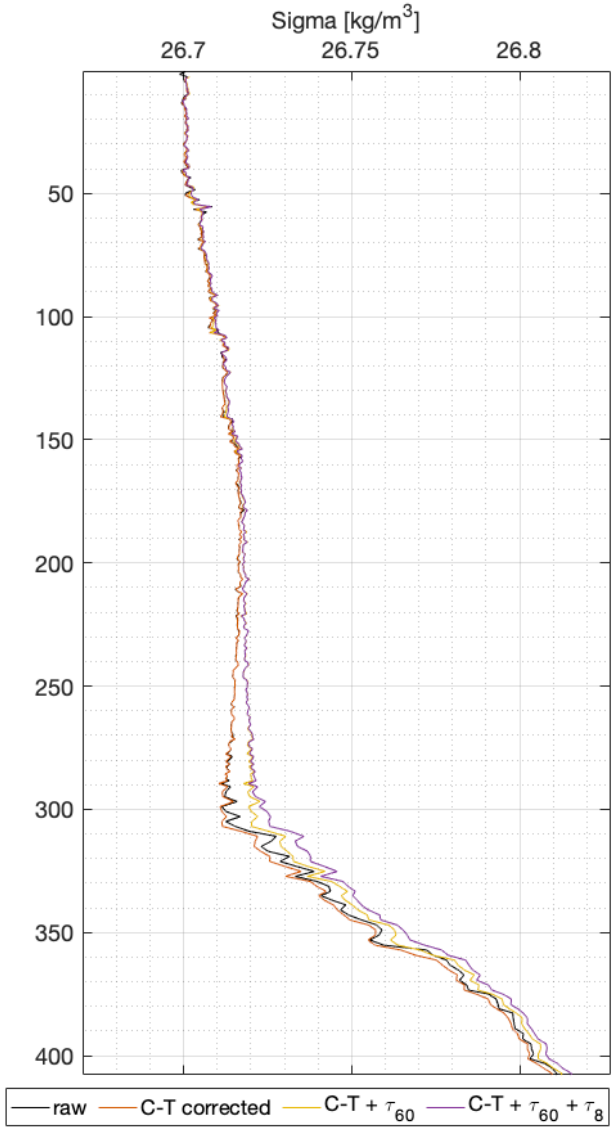
Take-home

1. Well tested and robust correction
2. Time lag of 0.35 s recommended
3. Correction is best applied on 1Hz data:
   a. Binned data averages out the relevant timescales
   b. Currently being implemented on-board the floats

See report by Halverson et al. (2020)

Field results: Dynamic corrections on binned data





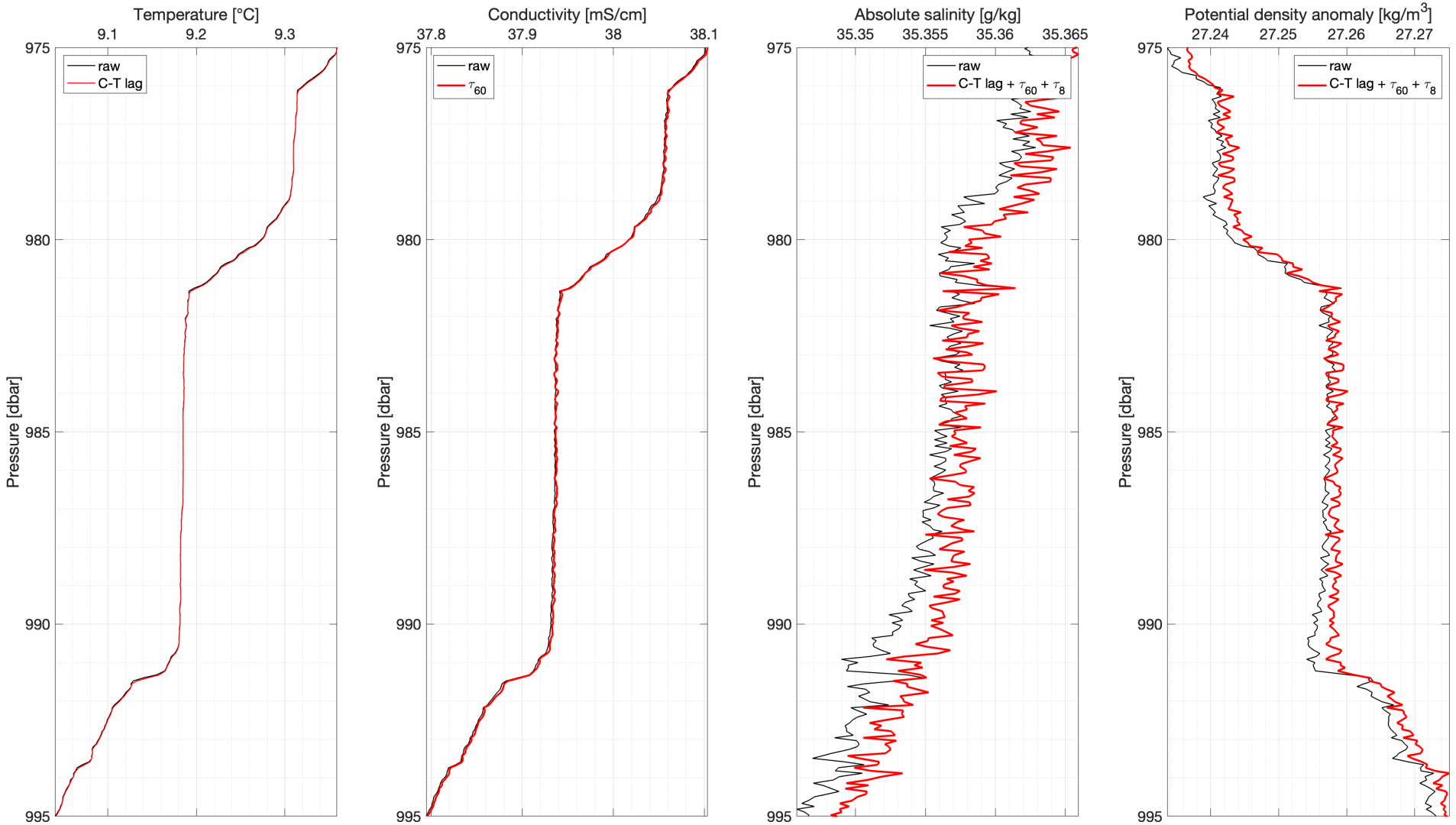
WMO5906618 (CSIRO float 11157) sampled through favorable conditions (Profiles 2, 4, and 19)

Number of density inversions in the profile

Profile	Raw	C-T + τ_{60} + τ_8
2	111	35
4	60	9
19	81	63

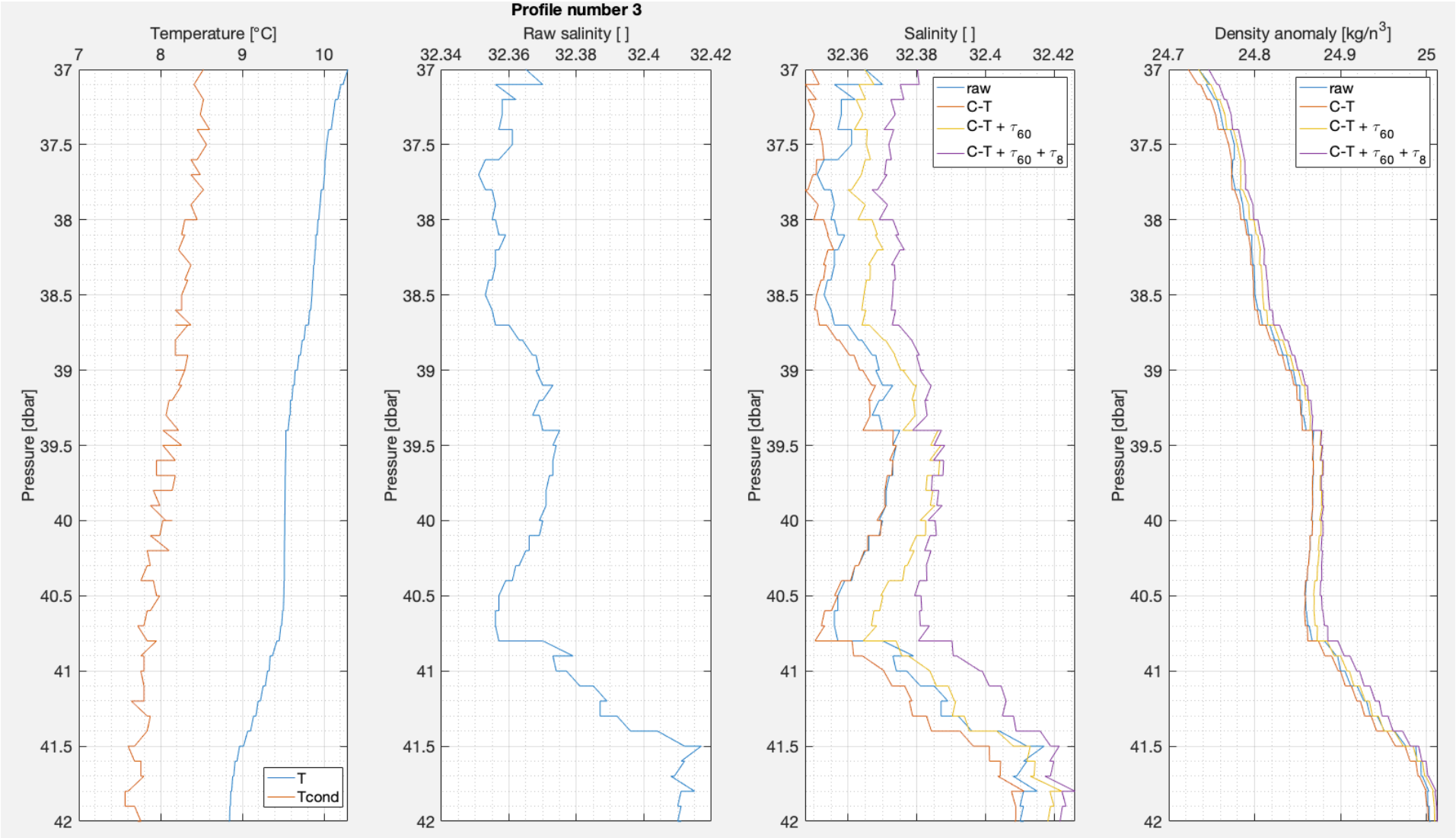
Field results: Dynamic corrections on High-Res data

TWR engineering float (float 7395) sampled at 1Hz for a few profiles.



Field results: Dynamic corrections on High-Res data

WMO5906298 (UW float 18726) sampled at 1Hz for a short pressure range

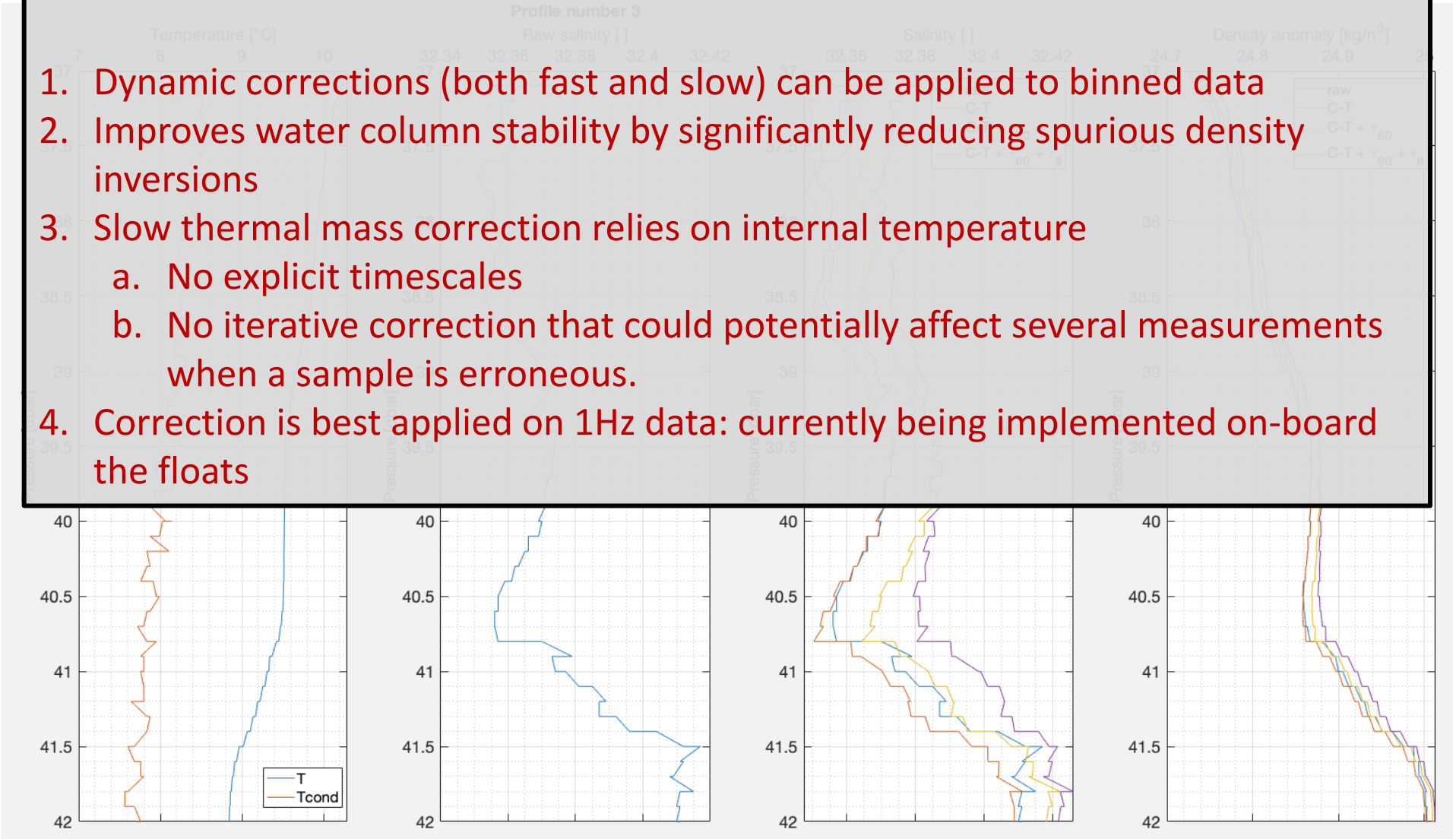


Field results: Dynamic corrections on High-Res data

WMO5906208 (UW float 18726) sampled at 1Hz for a short pressure range

Take-home

1. Dynamic corrections (both fast and slow) can be applied to binned data
2. Improves water column stability by significantly reducing spurious density inversions
3. Slow thermal mass correction relies on internal temperature
   a. No explicit timescales
   b. No iterative correction that could potentially affect several measurements when a sample is erroneous.
4. Correction is best applied on 1Hz data: currently being implemented on-board the floats



Field results: Dynamic corrections on High-Res data

WMO5906208 (UW float 18726) sampled at 1Hz for a short pressure range

Take-home

1. Dynamic corrections (both fast and slow) can be applied to binned data
2. Improves water column stability by significantly reducing spurious density inversions
3. Slow thermal mass correction relies on internal temperature
   a. No explicit timescales
   b. No iterative correction that could potentially affect several measurements when a sample is erroneous.
4. Correction is best applied on 1Hz data: currently being implemented on-board the floats

Ignoring technical and budgetary limitations, valuable information on CTD performance is provided when sampling at 1Hz. It is sometimes more helpful than a buddy float, or a ship-based deployment CTD cast