Long-term salinity stability of the RBRargo CTD: Assessment from in situ data on Argo floats

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rbr-global.com

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RBRargo - sensors

RBR has been building instruments since 1973.

- Introduced conductivity sensors in 2006.
- Conductivity measured with an *inductive* conductivity cell.
- Freely flushing (no pumps!)
- Measure to sea surface
- Very low power consumption
  - RBR*argo* CTD has 8 times lower power consumption than SBE41CP at 1 Hz
  - 18 mJ / sample at 1Hz

RBR builds OEM CTDs for Teledyne, MRV, and NKE*

* Special thanks to IFREMER, NKE, and EU funding to integrate the RBR CTD onto NKE floats

Argo and RBR

"While there have been many different designs of the hull and buoyancy engines on which sensors are deployed, Core Argo has depended almost exclusively on the SBE41 and SBE41CP CTDs by SeaBird Electronics (SBE). This has led to good consistency of data, and implementation of uniform procedures for data handling across the national programs, but exposes the program to the risk of single points of failure." Roemmich et al. (2019)

Roemmich et al. On the Future of Argo: A Global, Full-Depth, Multi-Disciplinary Array, Front. Mar. Sci., 02 August 2019, https://doi.org/10.3389/fmars.2019.00439

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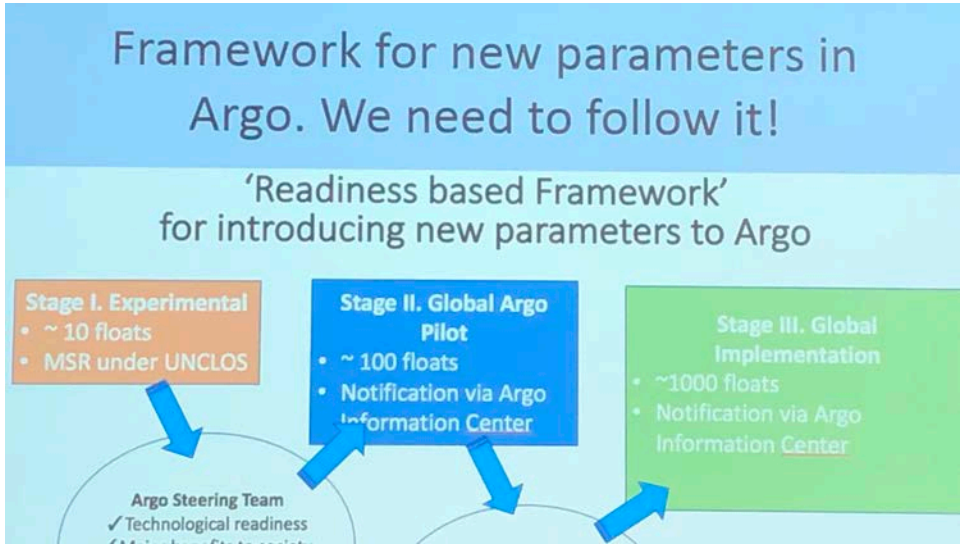
Argo and RBR

AST19 (2018): AST approved global pilot study with RBR sensors

ADMT and AST have approved the data from these sensors to appear in the GDAC data, marked with a flag QC=3



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RBR and Argo

Three requirements for sensor to be approved by Argo:

1. Dynamic performance
2. Static accuracy
3. Long-term stability

Outline

1. Analysis methods: Argo-viewer, climatology products
2. Results: Salinity stability
3. Discussion: Climatologies and reference data
4. Concluding remarks
5. Work in progress

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Data and methods

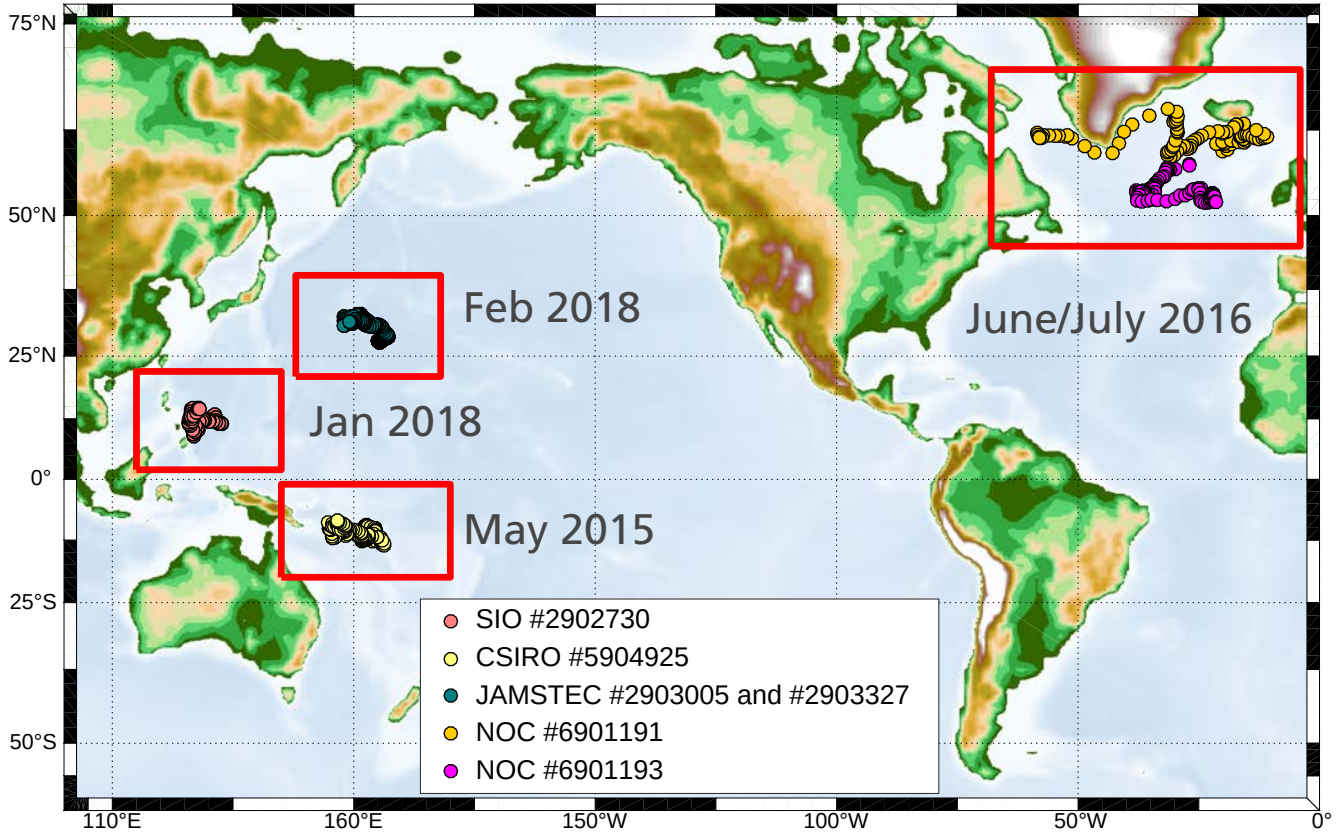
1. RBR CTD float data
2. Simplified Owens-Wong DMQC analysis
3. Climatology products
4. Argo-viewer

Active Argo floats with RBR CTDs

Year	Country	Region	Float Mfr	RBR CTD	Qty	Data on GDACs?
2015	Australia	Coral Sea	Teledyne	Previous design	1	X
2016	UK	North Atlantic	Teledyne	Previous design	2	X
2017	-	-	-	-		
2018	China	Subtropical West Pacific	Teledyne	Streamlined CT cell	1	✓
	Japan	Subtropical West Pacific	Teledyne	Streamlined CT cell	2	✓

ftp://ftp.ifremer.fr/ifremer/argo/dac/jma/2903005/
ftp://ftp.ifremer.fr/ifremer/argo/dac/jma/2903327/
ftp://ftp.ifremer.fr/ifremer/argo/dac/csio/2902730/

Photos: Teledyne Marine


75°N
50°N
25°N
0°
25°S
50°S
110°E
160°E
150°W
100°W
50°W
0°
Feb 2018
Jan 2018
May 2015
June/July 2016
SIO #2902730
CSIRO #5904925
JAMSTEC #2903005 and #2903327
NOC #6901191
NOC #6901193

Analysis of stability

Approach taken is to compare salinity on multiple isotherms to gridded climatological products (Wong et al., 2003)

- Isotherms chosen with OWC Matlab toolbox*
- Climatology products tested:
  - WOA-1° (last decade)
  - WOA-¼° (all)
  - MIMOC
  - CARS

- LSQ fit to salinity residuals with 1st order polynomial
  - → Linear drift rate estimate

Wong, A.P.S,G.C. Johnson, and W.B. Ownes (2003). Delayed-Mode Calibration of Autonomous CTD Profiling Float Salinity Data by ϑ–S Climatology, 20, *J. Atmos. Tech.*, https://doi.org/10.1175/1520-0426(2003)020<0308:DMCOAC>2.0.CO;2

*https://github.com/ArgoDMQC/matlab_owc

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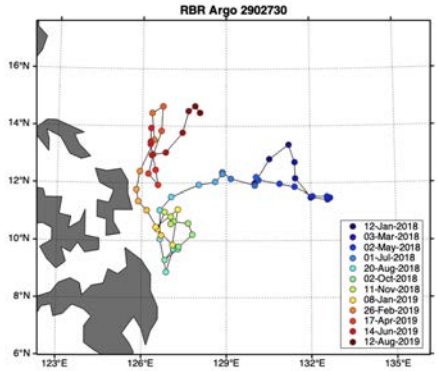
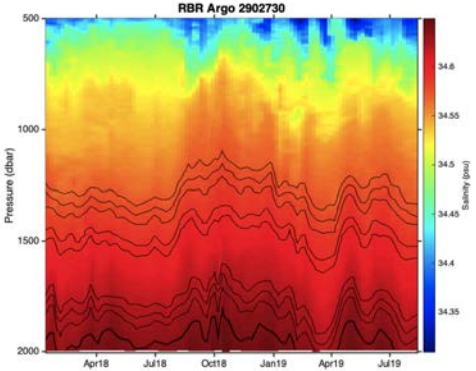
Analyzing Argo data with Argo-viewer

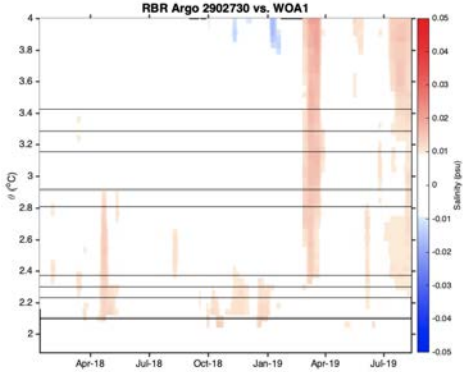
Load profiles from nc file

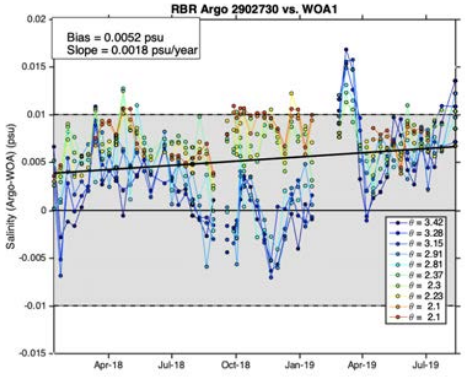


Select ten θ layers with minimum S variability



Calculate S anomalies against climatology





Calculate linear salinity drift averaged over 10 selected θ layers

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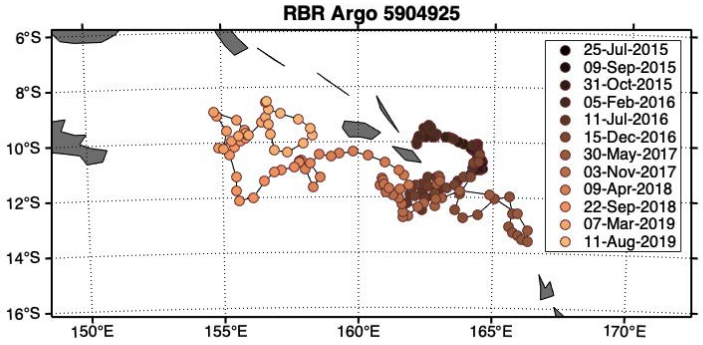
Results

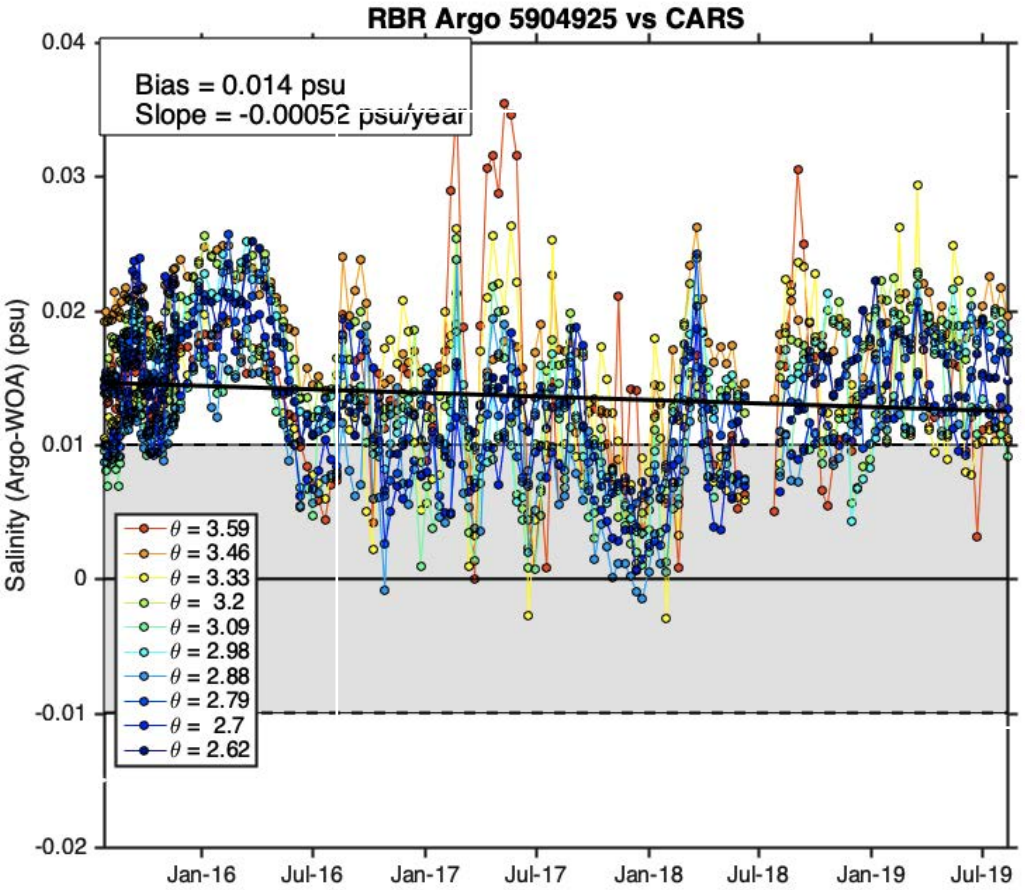
- Stability referenced to climatology
- Comparison to other Argo floats
- Choice of climatological product matters!

CSIRO float #5904925 in the Coral Sea

Deployed 4.5 years ago

- Bias = 0.014 psu
- Slope = -0.00052 psu/year





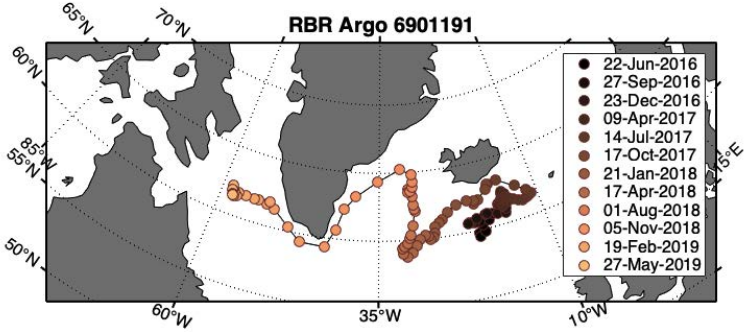
NOC float #6901191 in the North Atlantic

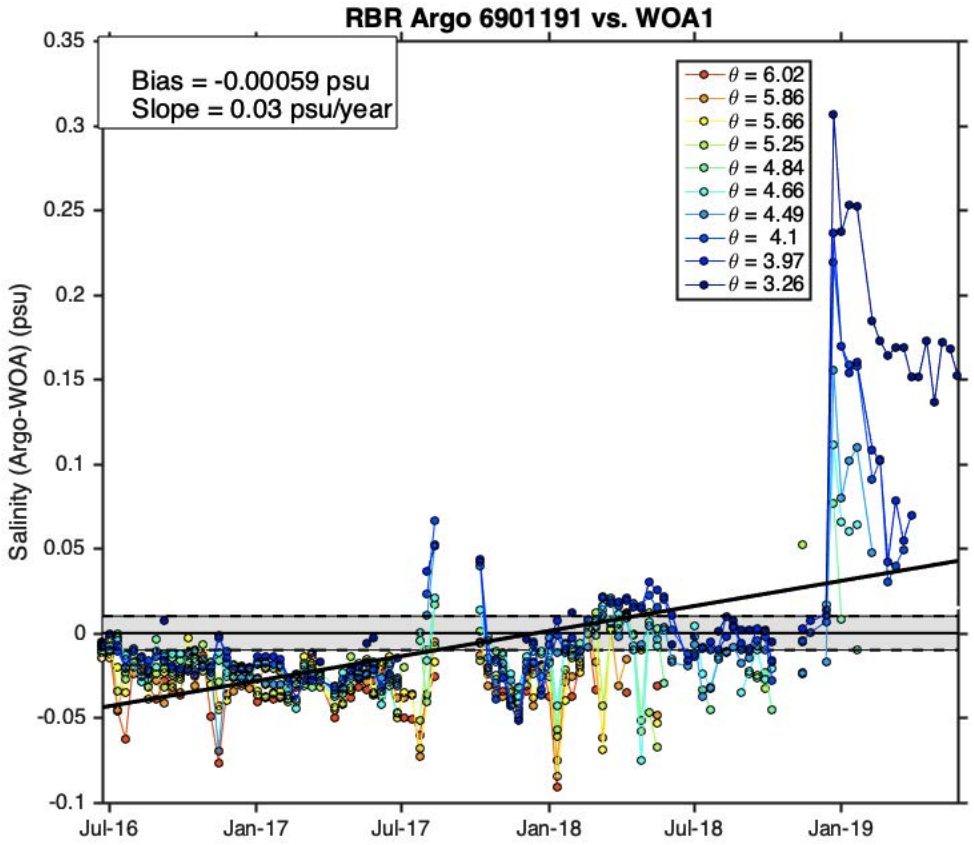
Deployed 3.2 years ago

- Bias = -0.00059 psu
- Slope = 0.03 psu/year*

Salinity deviates from climatology in the Greenland Current and Labrador Sea

→ No conclusion on drift can be drawn





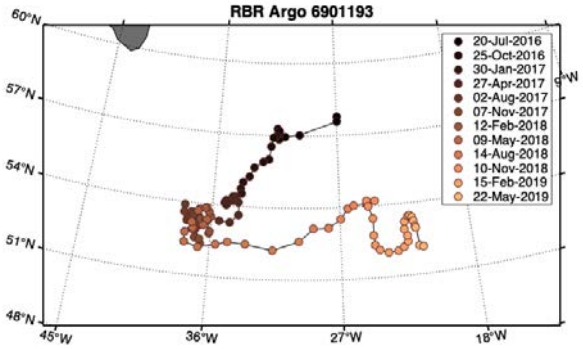
NOC float #6901193 in the North Atlantic

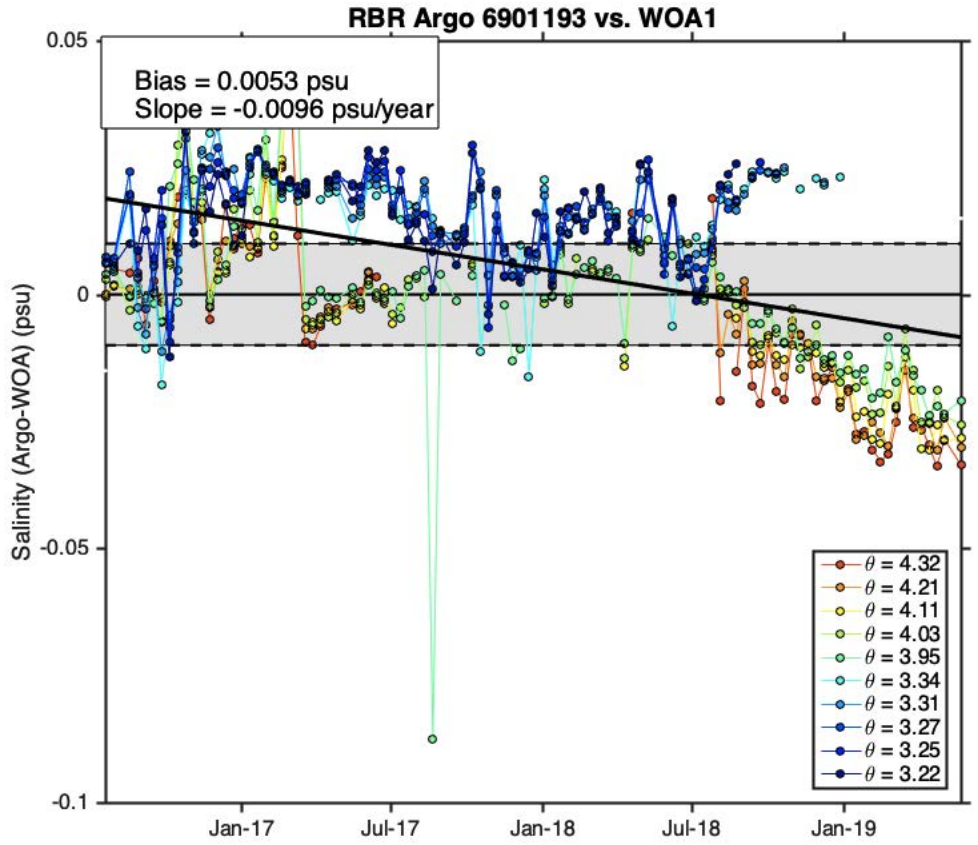
Deployed 3.2 years ago

- Bias = 0.0053 psu
- Slope = -0.0096 psu/year

North Atlantic climatology highly variable

→ Try Cabanes et al. (2016)?

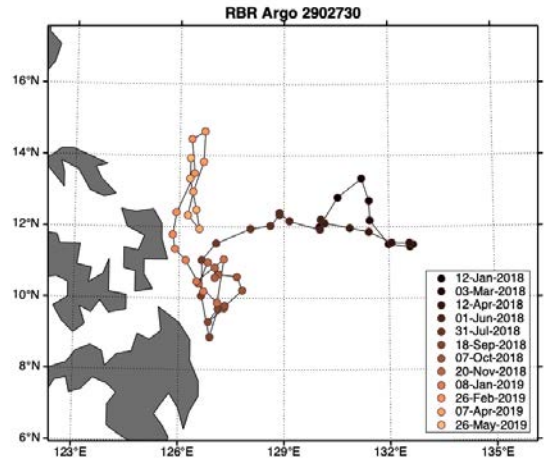


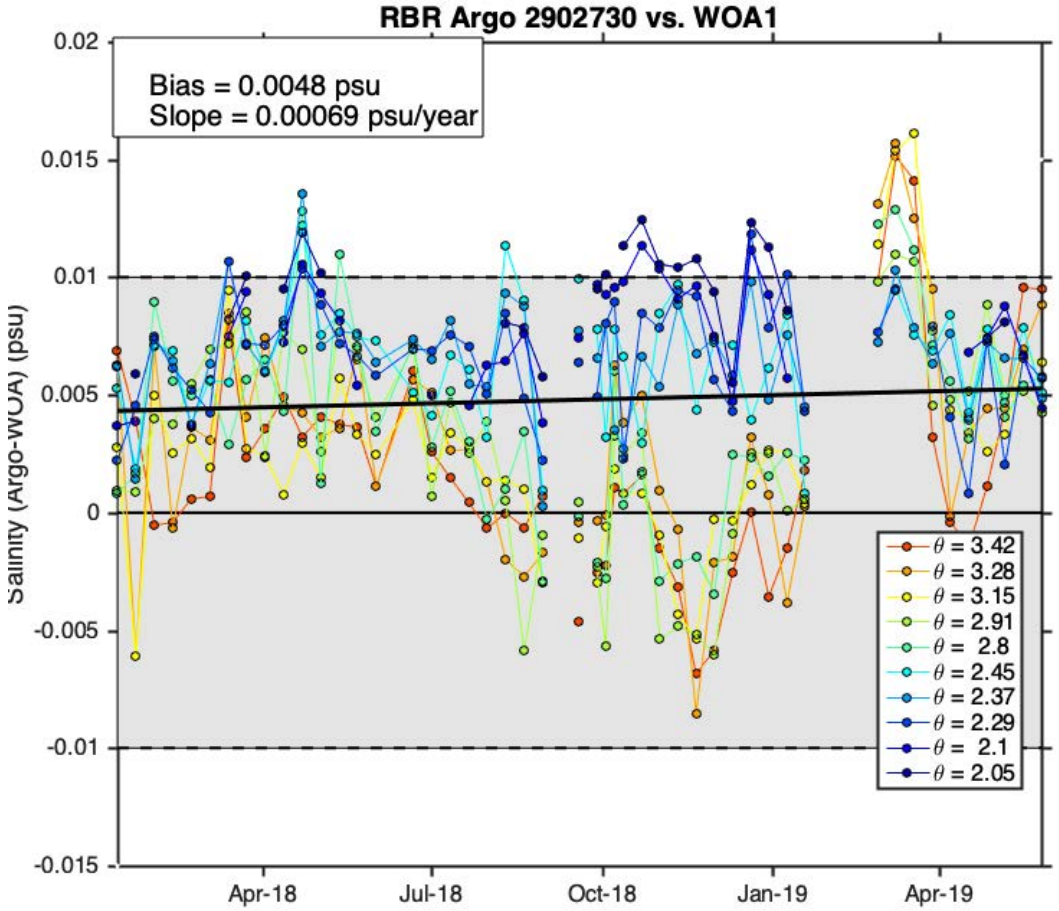


CSIO float #2902730 in the Philippine Sea

Deployed 1.8 years ago

- Bias = 0.0052 psu
- Slope = 0.0018 psu/year

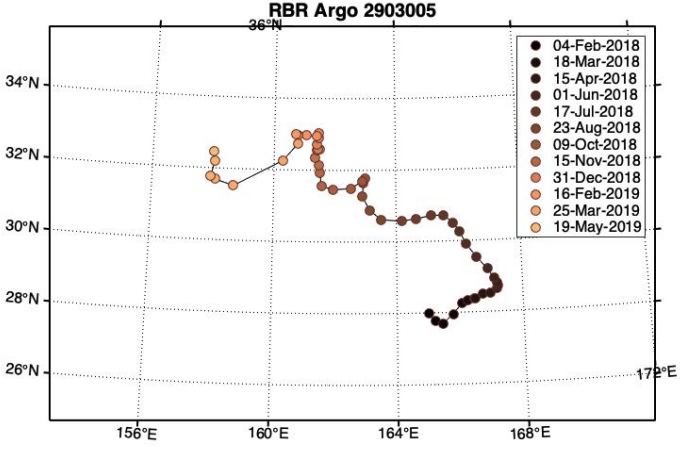


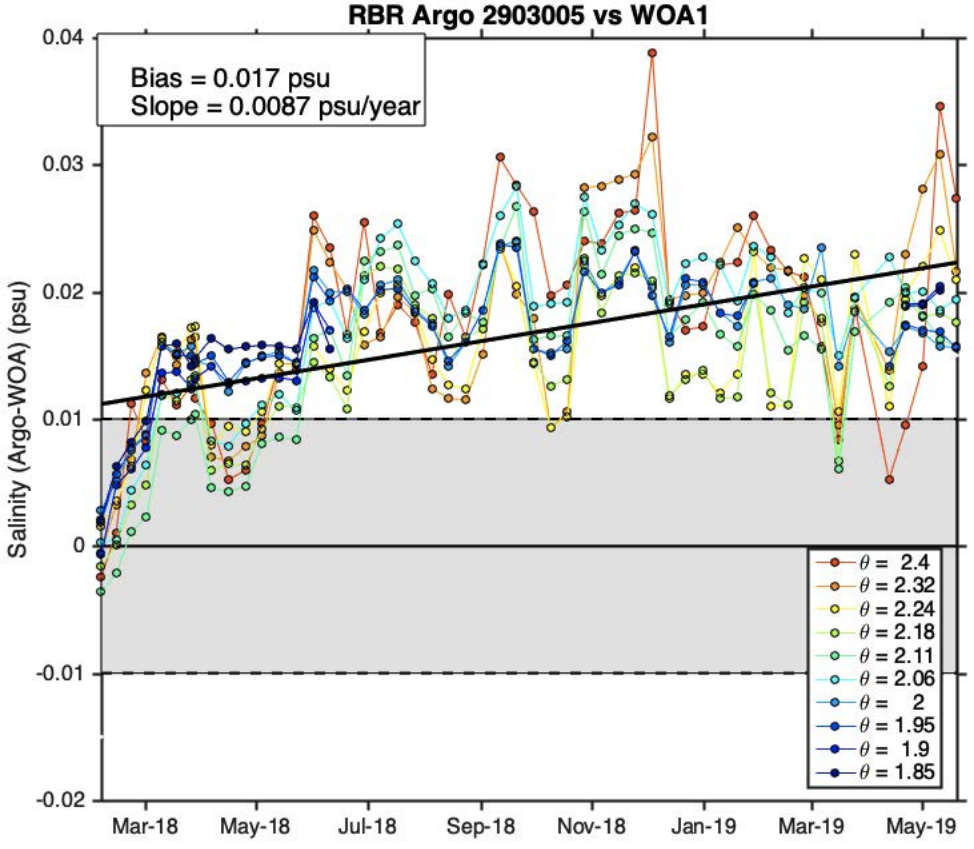


JAMSTEC float #2903005 in the Northwest Pacific

Deployed 1.8 years ago

- Bias = 0.016 psu
- Slope = 0.0025 psu/year

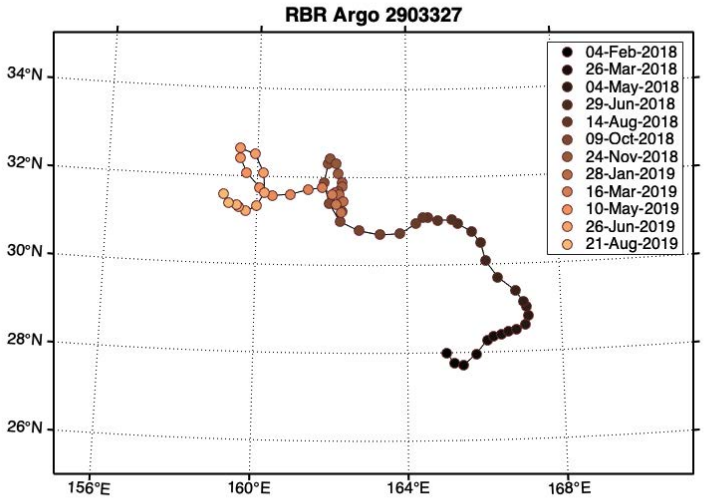


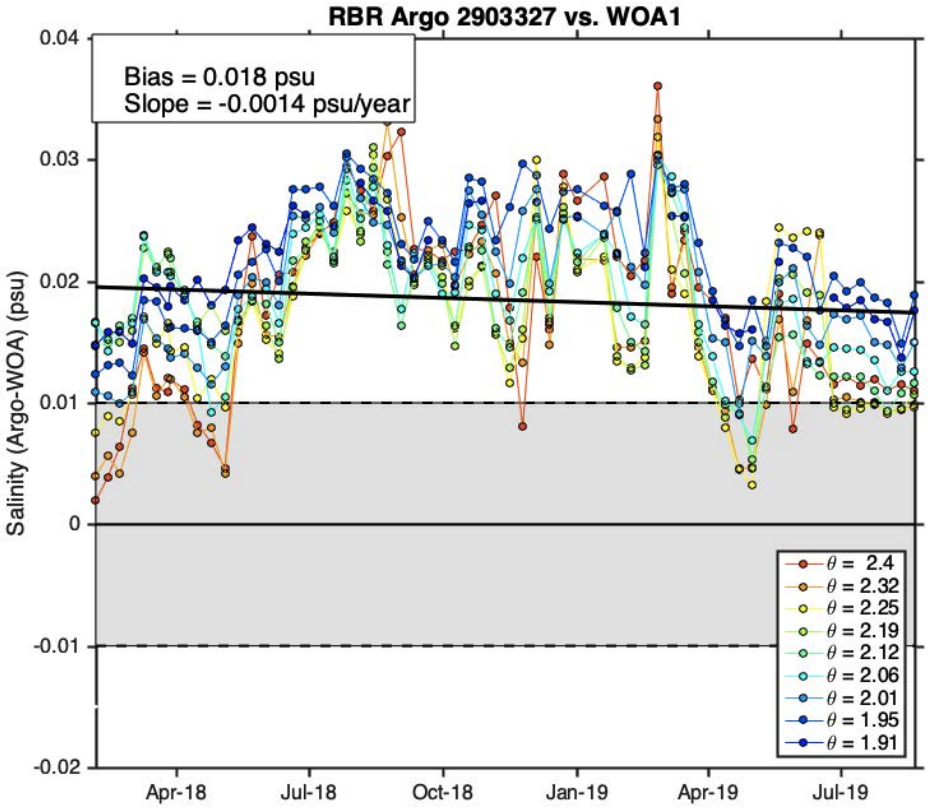


JAMSTEC float #2903327 in the Northwest Pacific

Deployed 1.8 years ago

- Bias = 0.018 psu
- Slope = -0.0014 psu/year

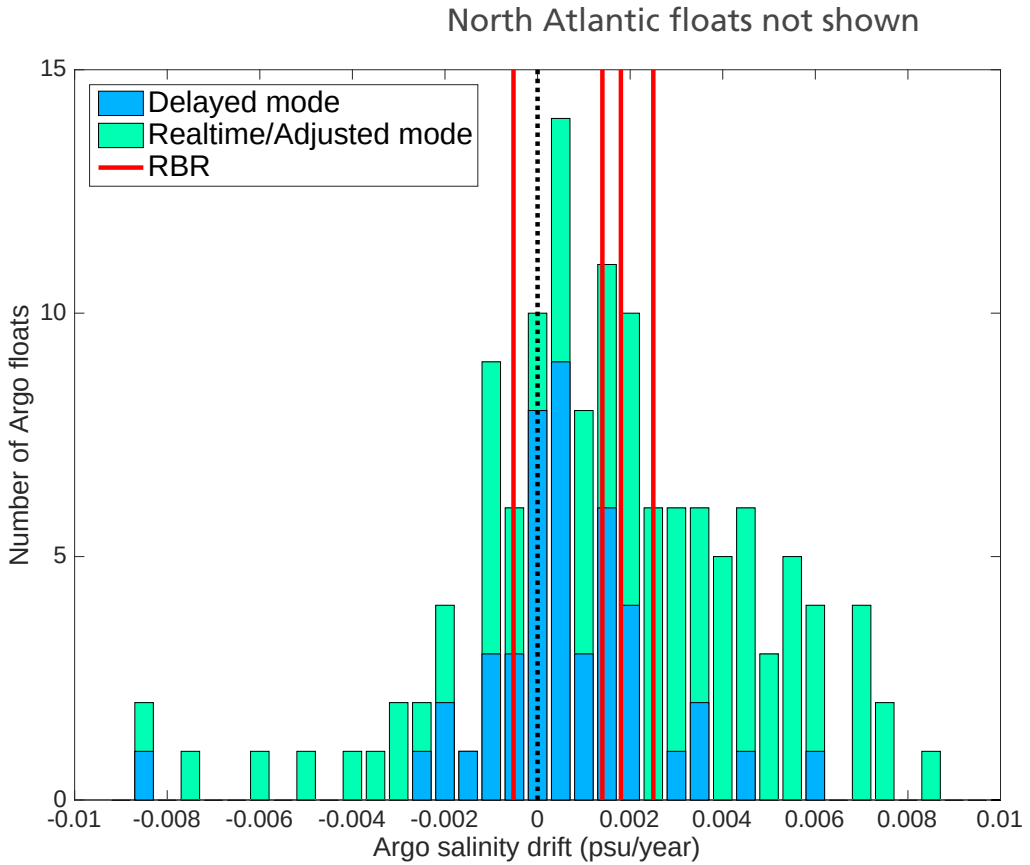




Salinity drift of RBR Argo CTDs is lower than others

Salinity drift

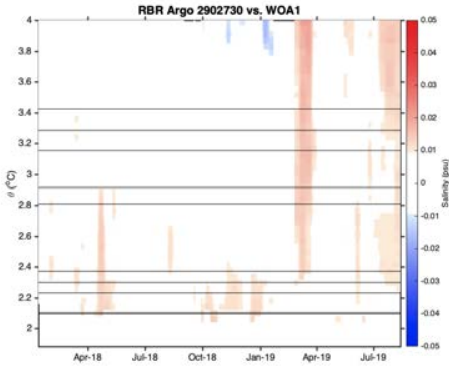
Other Argo floats were selected within 1000km from the location of RBR Argo floats during the periods starting 1 year before each RBR CTD Argo float.



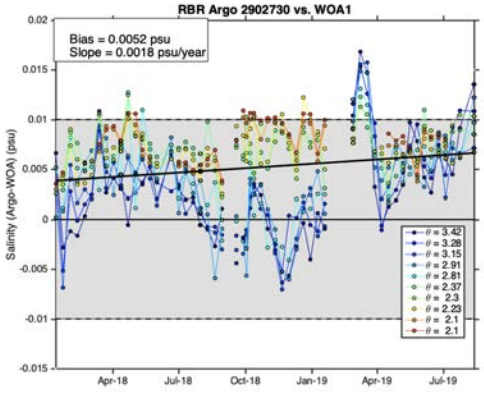
Discussion

The results of drift assessment depend on climatology

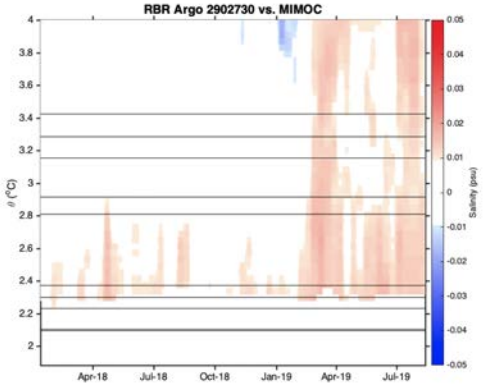
World Ocean Atlas



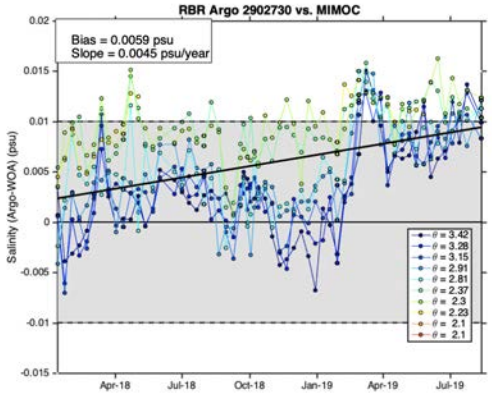
0.0018/year



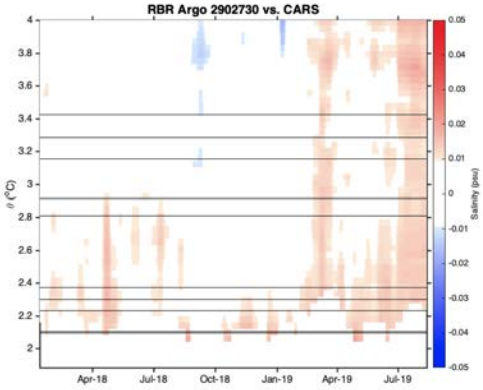
MIMOC



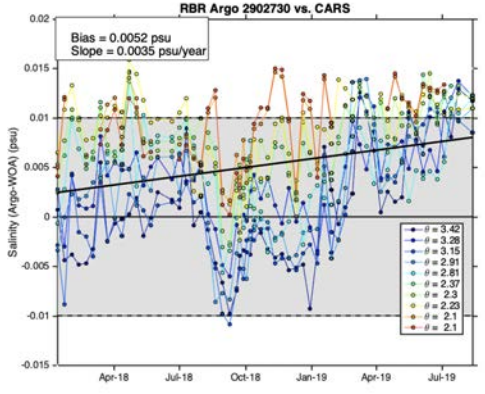
0.0045/year



CARS



0.0035/year



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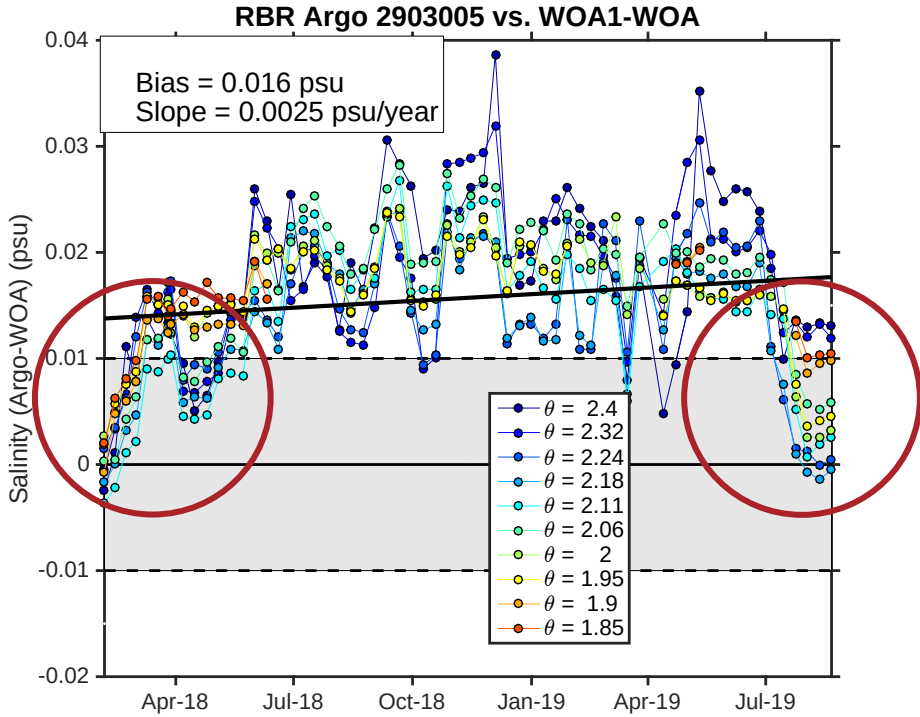
Return to the JAMSTEC floats

What causes the anomalous salinity measurements at the beginning and end of the time series?

- Sensor issue or local T/S anomaly?
  - Anomaly at beginning thought to be T/S anomaly
  - Anomaly depends on climatology
- Future work: Run the full OWC analysis with the standard databases used by the DMQC operators at the DACs.



Conclusions

Agency	Float WMO	Time in water (years)	Linear drift estimate (psu/year)
CSIRO	5904925	4.5	-0.0005
NOC	6901191	3.2	N/A
NOC	6901193	3.2	N/A
CSIO	2902730	1.8	0.0018
JAMSTEC	2903005	1.8	0.0025
JAMSTEC	2903327	1.8	-0.0014

- Results are promising, but we need more floats in the water
- What should be done about with respect to how the climatology product impacts the assessment?

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Work in progress

- get Argo-Viewer ready for public release
- Run ”Full” OWC method
  - Roemmich-Gilson Argo Climatology
  - Coriolis DMQC_Argo database
- Try Cabanes method for North Atlantic floats
- Publish results!
- Dynamic corrections in firmware by December 2019

Acknowledgments

- CSIRO
- Ifremer
- JAMSTEC
- CSIO
- NOC
- UW/PMEL
- DFO

Thank You

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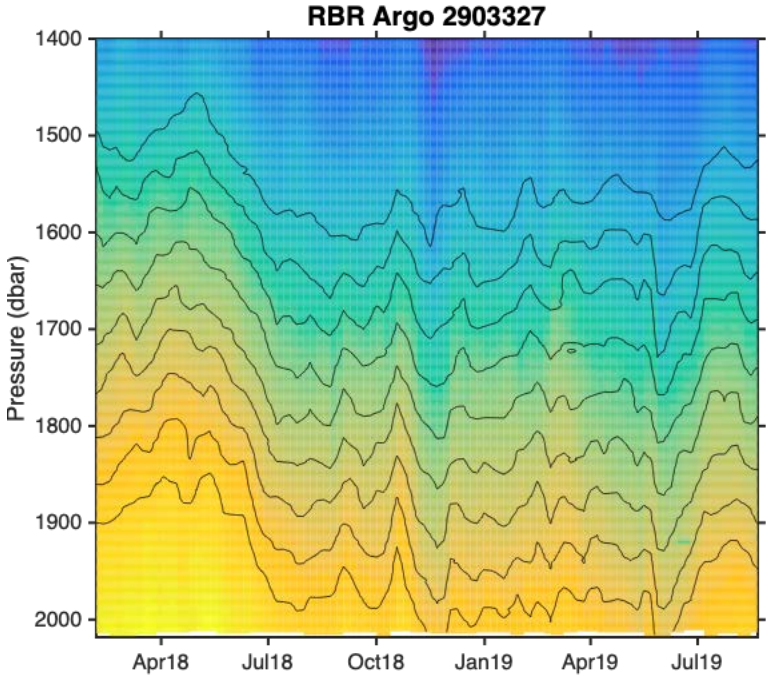
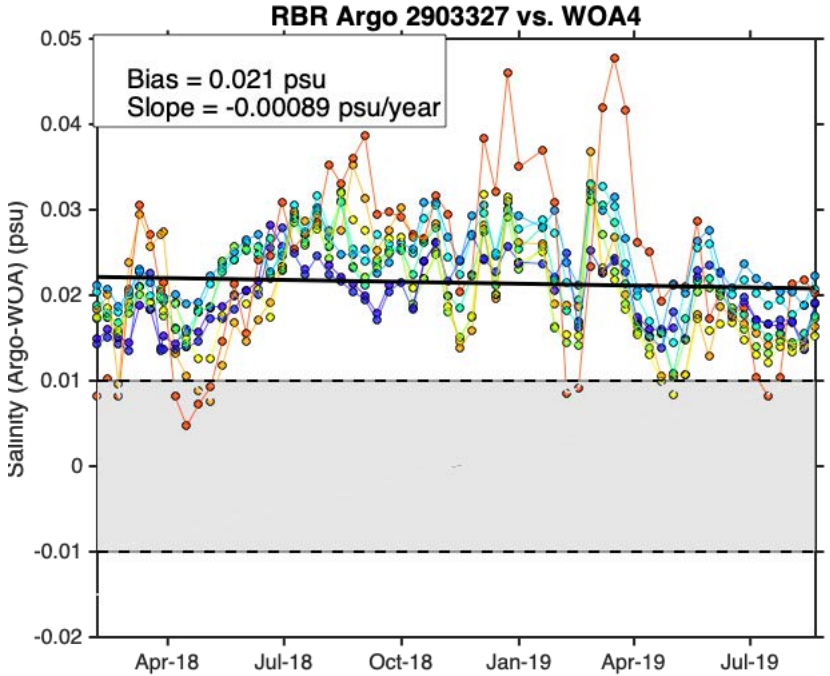

RBR Argo 2903327
Pressure (dbar)
1400
1500
1600
1700
1800
1900
2000
Apr18
Jul18
Oct18
Jan19
Apr19
Jul19


RBR Argo 2903327 vs. WOA4
Bias = 0.021 psu
Slope = -0.00089 psu/year
Salinity (Argo-WOA) (psu)
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
Apr-18
Jul-18
Oct-18
Jan-19
Apr-19
Jul-19

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