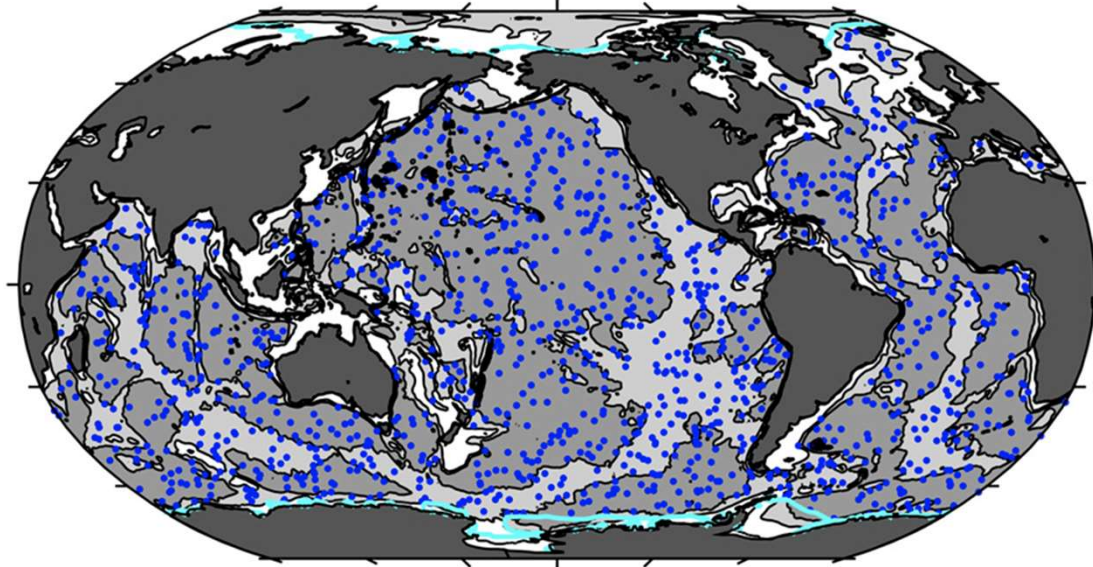# Three-head and two-head float analysis

- **Ifremer:** V. Thierry, M. Amice, X. André, C. Cabanes, D. Desbruyères, G. Le Provost,
- **IEO (Spain):** A. Gonzalez, P. Velez-Belchi
- **RBR (Canada):** M. Dever

Deep Argo array

- Deep Argo CTD instrument accuracy targets (Roemmich et al. 2019)
  - Salinity: ±0.002 g kg^{-1},
  - Temperature: ±0.001 °C
  - pressure : ±3 dbar

- Deep Argo accuracy targets are similar to the gold-standard GO-SHIP shipboard CTD measurements

- How far are we from those targets ?

Objectives

- Three sensors are currently available for Deep-Argo application

- The SBE61 sensor is subject to extended calibration, and is more expensive than the SBE41CP

- The RBR sensor is new on the market

| Initial accuracy	SBE41	SBE61	RBR
Pressure range	0 – 4000 dbar	0 – 6000 dbar	0 – 6000 dbar
Temperature	± 0.002 °C	± 0.001 °C	± 0.002 °C
Conductivity	± 0.003 mS/cm	± 0.002 mS/cm	± 0.003 mS/cm
Pressure	± 7 dbar	± 4.5 dbar	± 2 dbar

- **Intercompare pressure, temperature and conductivity sensors responses**

- **Evaluate the SBE41 sensor for Deep-Argo-4k application**

- **Evaluate the new RBR sensor**

- **Evaluate long-term drift of the sensors**

Deployments of two 3-head and two 2-head Deep-Arvor floats

Concerto RBR

SBE41

SBE61CP
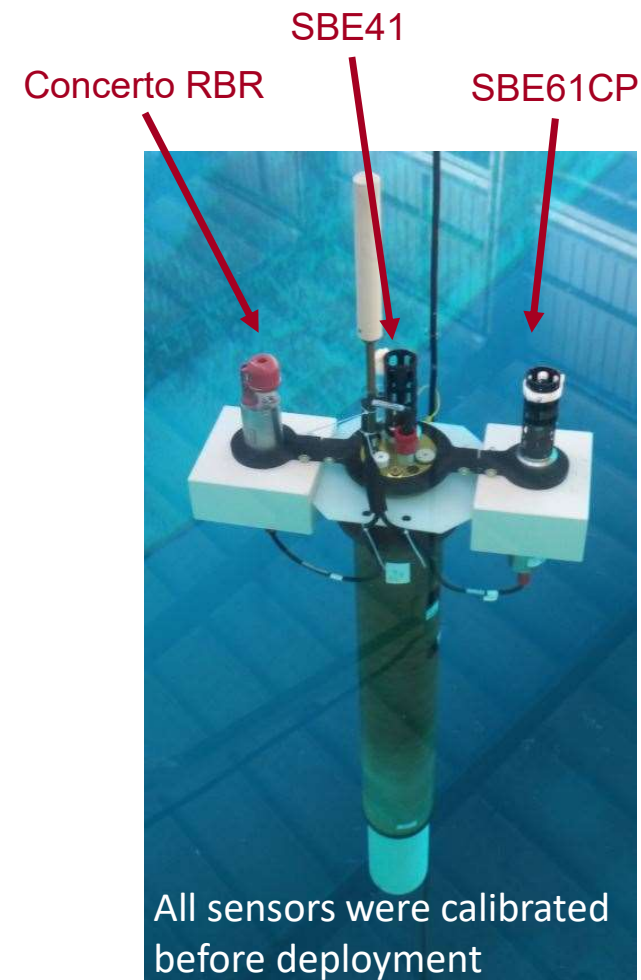
All sensors were calibrated before deployment

Copyright Ifremer

Deployments of two 3-head and two 2-head Deep-Arvor floats
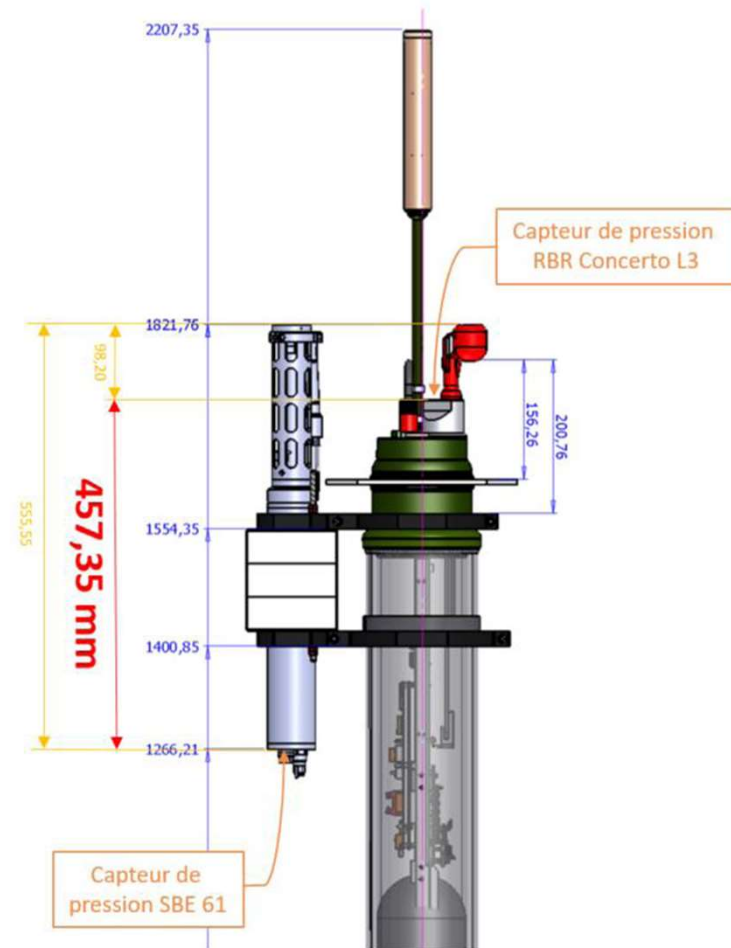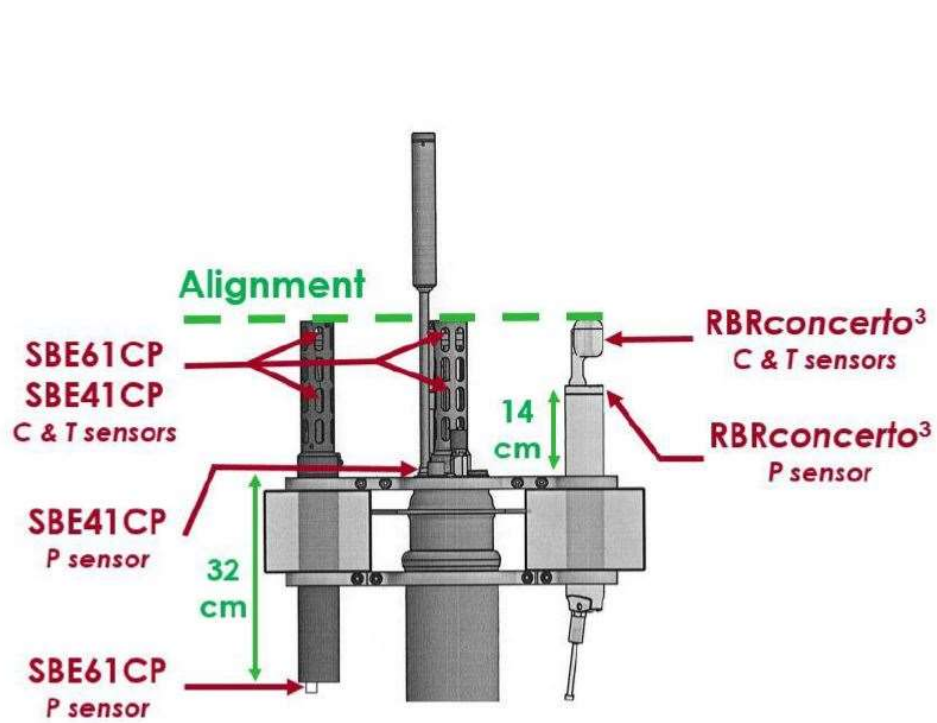
History of deployments and recoveries

	3-head NAOS	3-head EA-RISE	2-head EA-RISE FR001	2-head EA-RISE FR002
	Sensor calibration	Sensor calibration		
RAPROCAN cruise December 2020	Deployment	Deployment		
At sea	**35 cycles** Issue with SBE61 (SD card full) Recovered	14 cycles RBR sensor failure Recovered		
On shore	Waiting for new deployment (not yet scheduled)	New RBR Sensor SBE sensor recalibrated	Sensor calibration	Sensor calibration
RAPROCAN cruise March 2022		Redeployed	Deployment	Deployment
At sea		**21 cycles** Still active OK so far ;-)	**19 cycles** Communication issue with RRB sensor Recovered	**21 cycles** Still active (drifting in between Islands)
On shore			Investigation on going to understand failure	

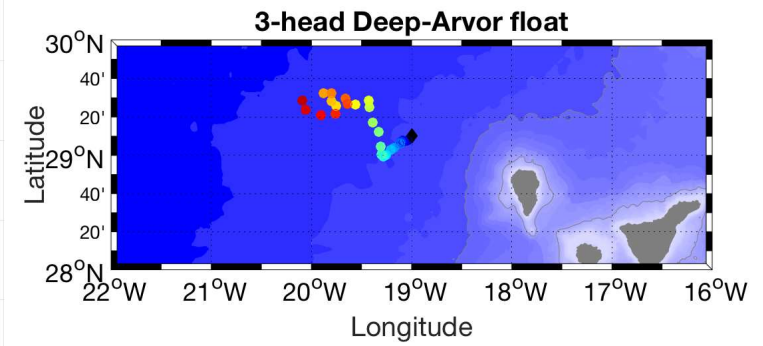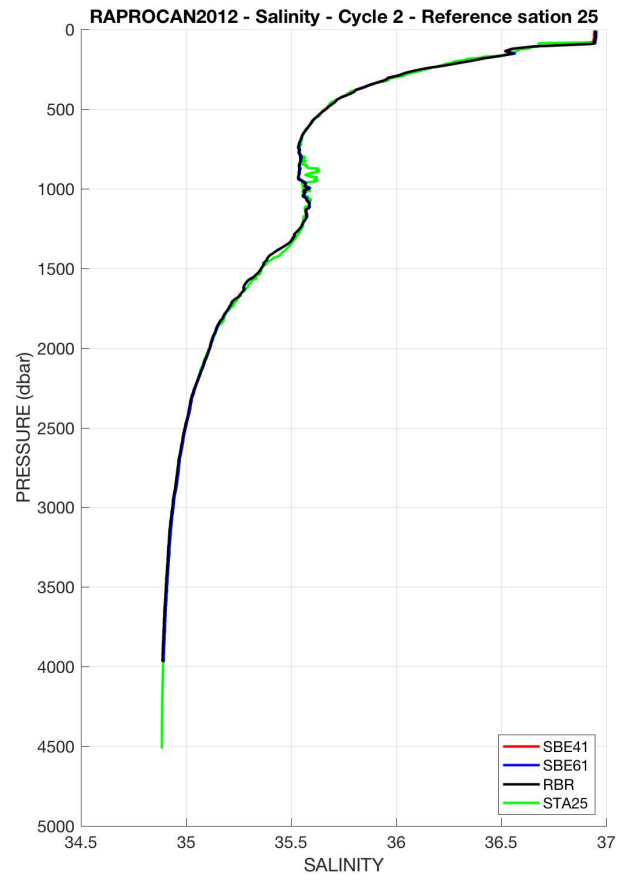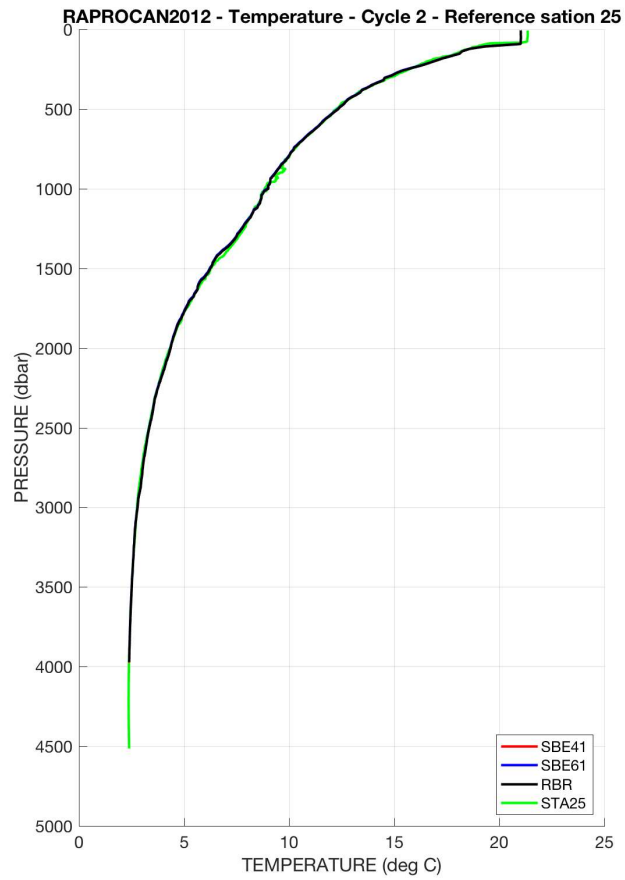# History of deployments and recoveries

December 2020
Deployment by IEO

2021
Recovery by R/V Thalassa

NAOS float
35 cycles realized

RAPROCAN2012 - Temperature - Cycle 2 - Reference sation 25

RAPROCAN2012 - Salinity - Cycle 2 - Reference sation 25

3-head Deep-Arvor float
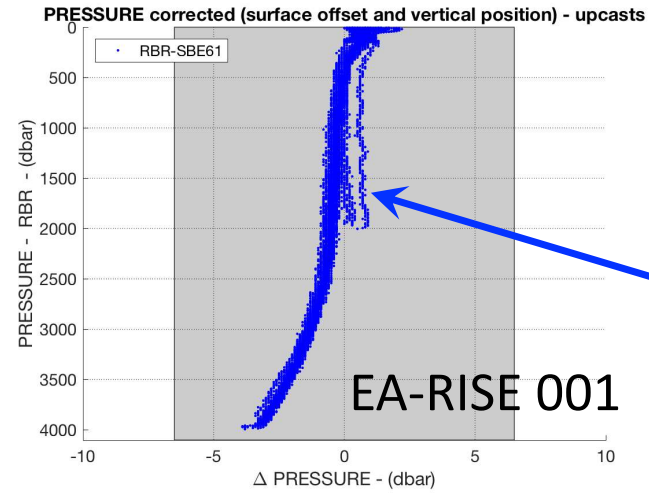
Sensors intercomparison

Unnamed: 0	Type de message	heure flotteur lors de la mesure	**** Echantillon CTD ****	Pression SBE41	Temperature SBE41	Salinite SBE41	Pression SBE61	Temperature SBE61	Salinite SBE61	Pression RBR	Temperature RBR	Salinite RBR	Temperature interne RBR	Complements
	254	121:49:07		3959,4	2,418	34,895	3956,4	2,418	34,897	0	0	0	0	
				3952,7	2,418	34,894	3949,9	2,418	34,896	3948,9	2,420	34,907	2,364	
				3946,2	2,419	34,894	3943,4	2,419	34,897	3942,3	2,421	34,908	2,496	
				3939,5	2,421	34,895	3936,7	2,421	34,897	3935,7	2,423	34,908	2,320	
	254	121:59:53		3933	2,422	34,895	3930,1	2,422	34,897	3929,1	2,424	34,908	2,496	
				3926,3	2,425	34,896	3923,5	2,425	34,897	3922,4	2,427	34,908	2,408	
				3919,7	2,426	34,896	3916,9	2,427	34,898	3915,8	2,429	34,909	2,408	
				3913,1	2,426	34,896	3910,2	2,426	34,898	3909,2	2,429	34,908	2,583	
	254	122:05:19		3906,6	2,427	34,896	3903,9	2,426	34,898	3902,7	2,428	34,909	2,496	

Pressure – Sensors intercomparison – Impact of short profiles
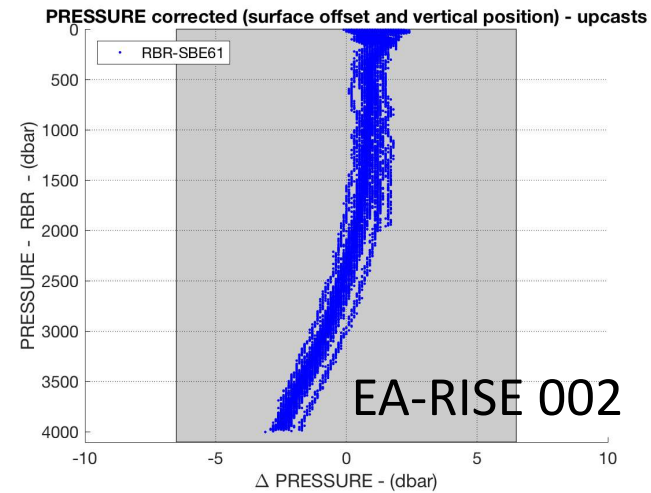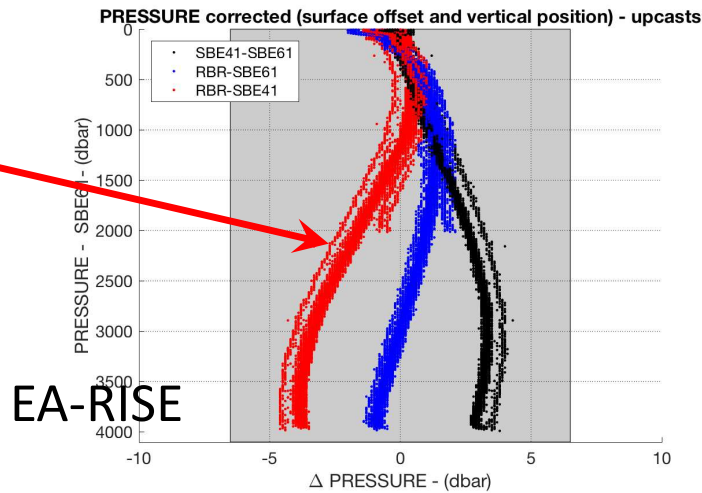
3-head
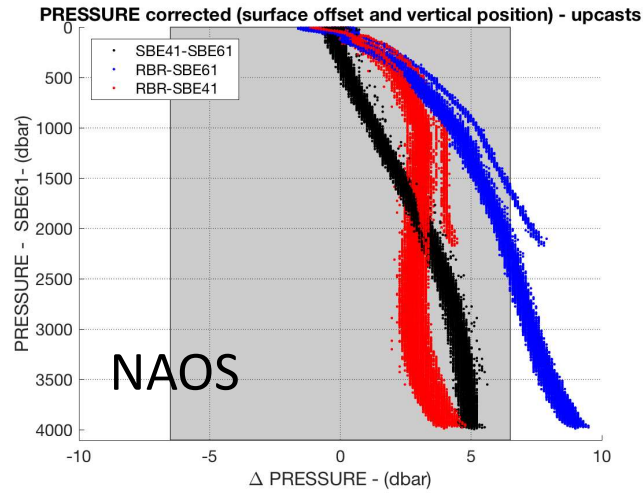
2-head

SBE41 - SBE61

RBR - SBE41

RBR - SBE61
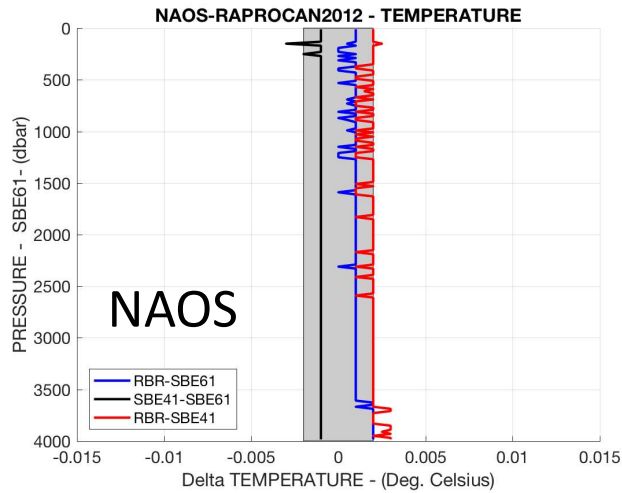

hysteresis

Need to correct surface pressure offset for the first cycle (SBE41)

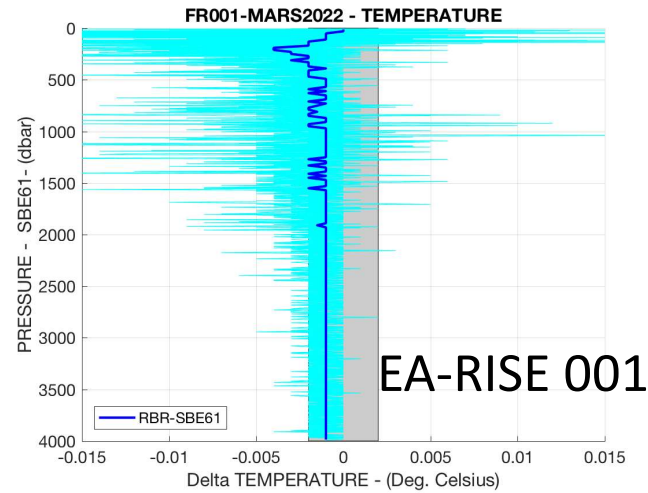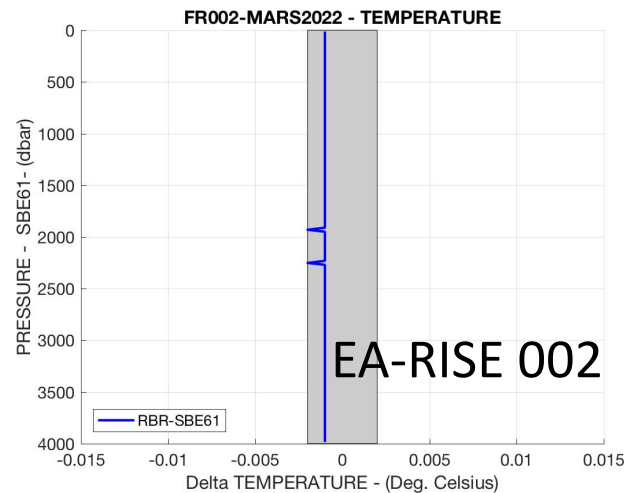# Temperature – Sensors intercomparison

3-head

NAOS-RAPROCAN2012 - TEMPERATURE

NAOS

Legend: RBR-SBE61, SBE41-SBE61, RBR-SBE41

2-head

FR001-MARS2022 - TEMPERATURE

EA-RISE 001

Legend: RBR-SBE61

EARISE-MARS2022 - TEMPERATURE

EA-RISE

Legend: RBR-SBE61, SBE41-SBE61, RBR-SBE41

FR002-MARS2022 - TEMPERATURE

EA-RISE 002

Legend: RBR-SBE61

SBE41 - SBE61: within +/- 0.001°C

RBR - SBE41

RBR - SBE61: within +/- 0.002°C

Differences larger than 0.002°C in near surface layers on some floats
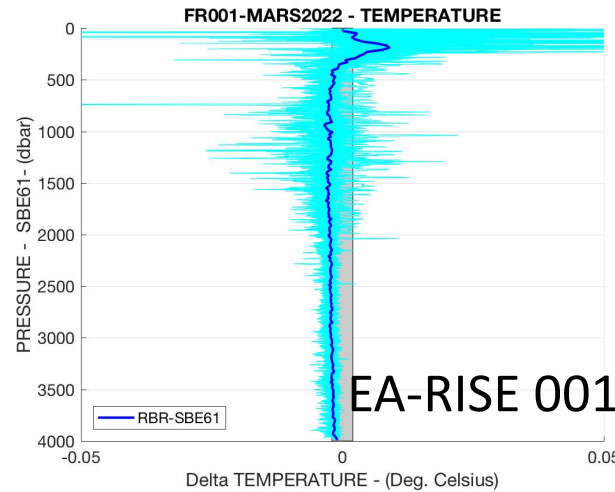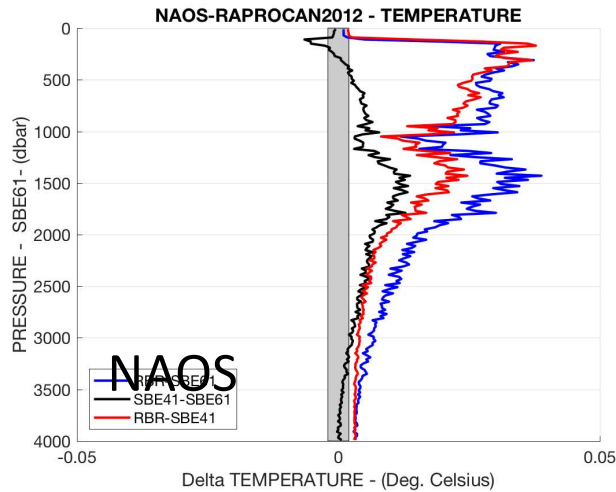
> - sensor on top colder
> - thermal inertia?
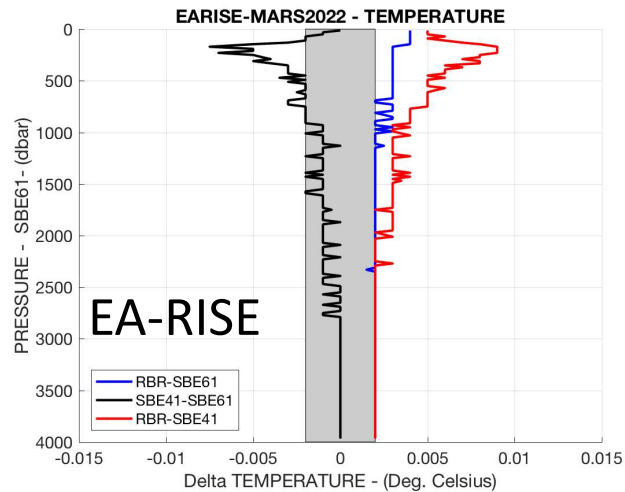
Temperature – Sensors intercomparison – Impact of pressure difference
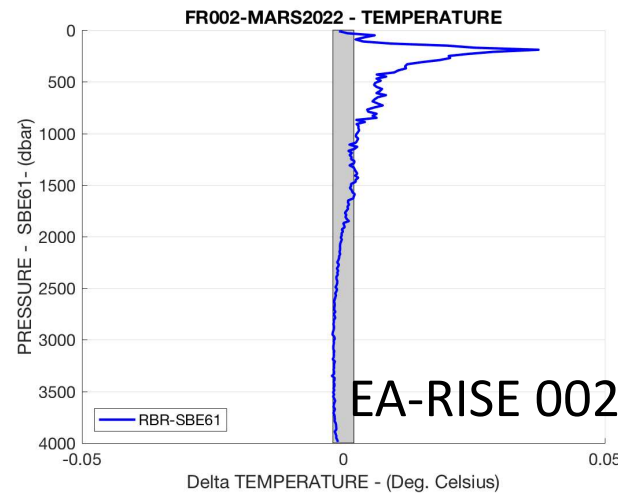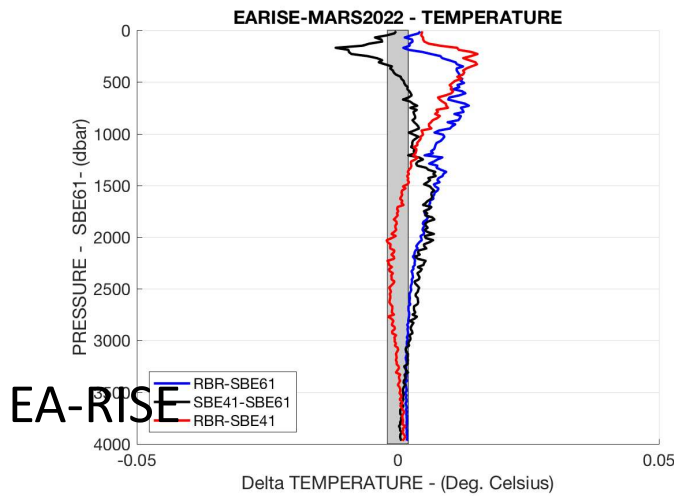
3-head
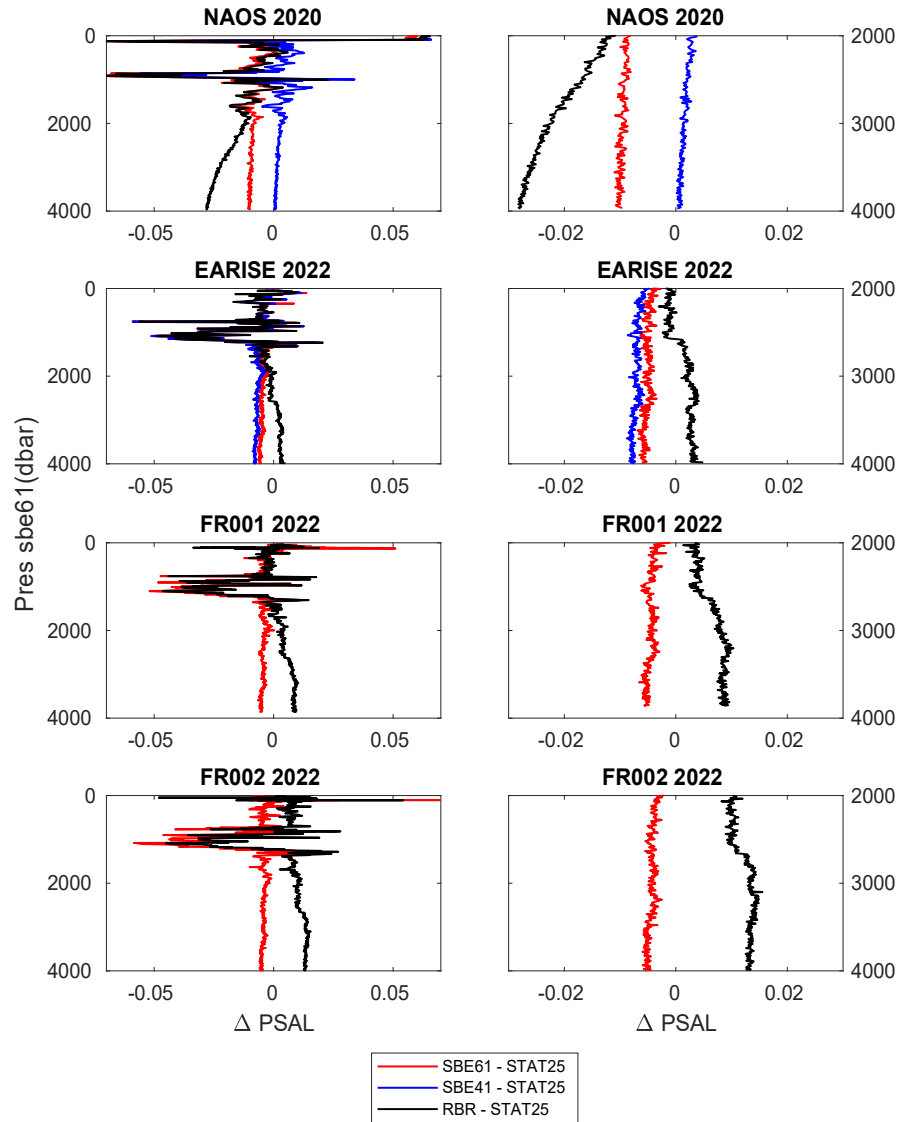

2-head

SBE41 - SBE61
RBR - SBE41
RBR - SBE61

Differences in pressure value significantly impact vertical temperature profiles in upper layers
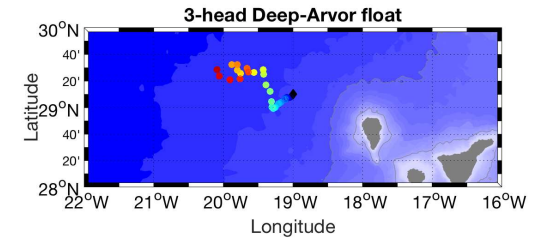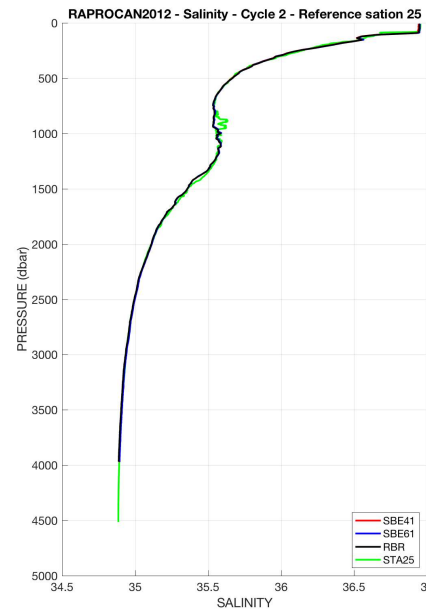
Salinity – Comparison to reference profile

Raw data
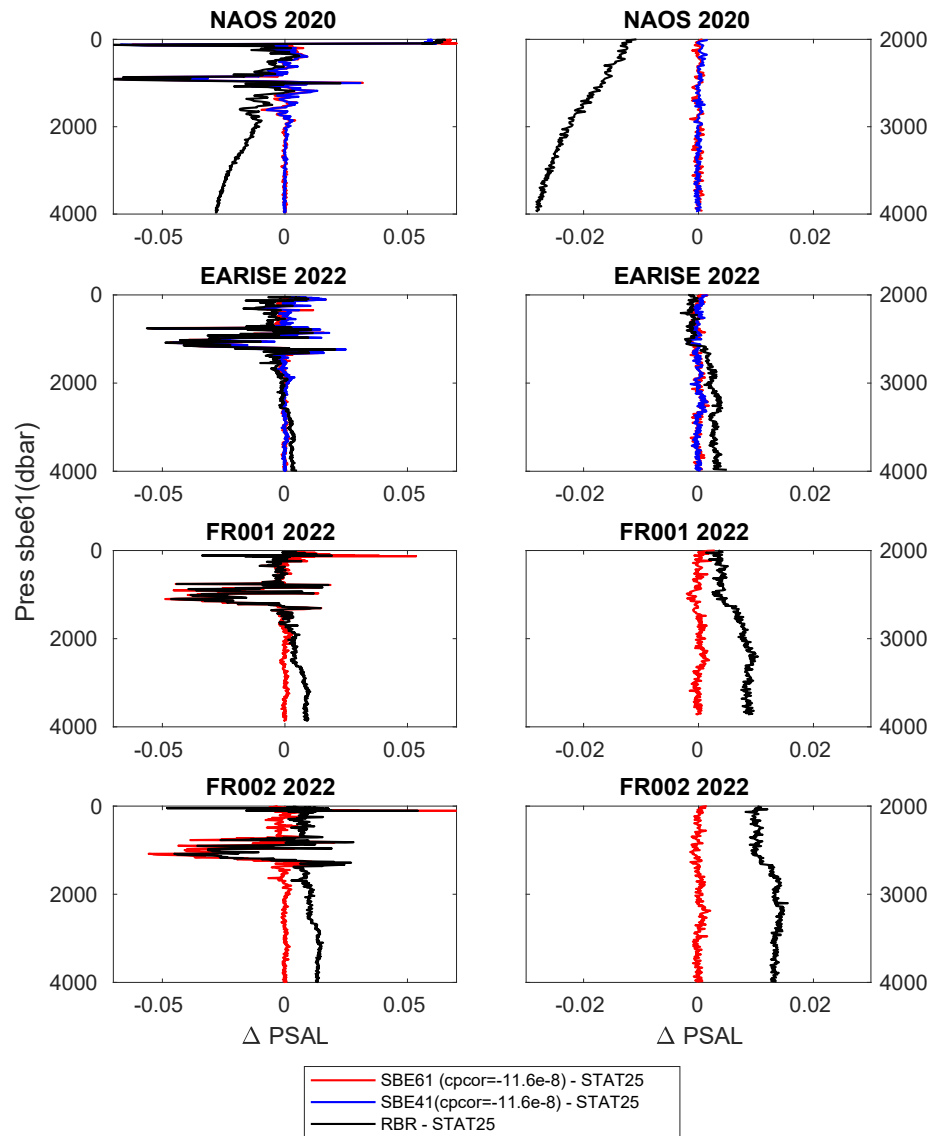

Salinity difference between float sensors and reference CTD cast

Salinity difference between float sensors and reference CTD cast

Salinity – Comparison to reference profile

Seabird sensors
- post-deployment correction of pressure dependancy using standard Cpcor value (=-11.6 e^{-8})
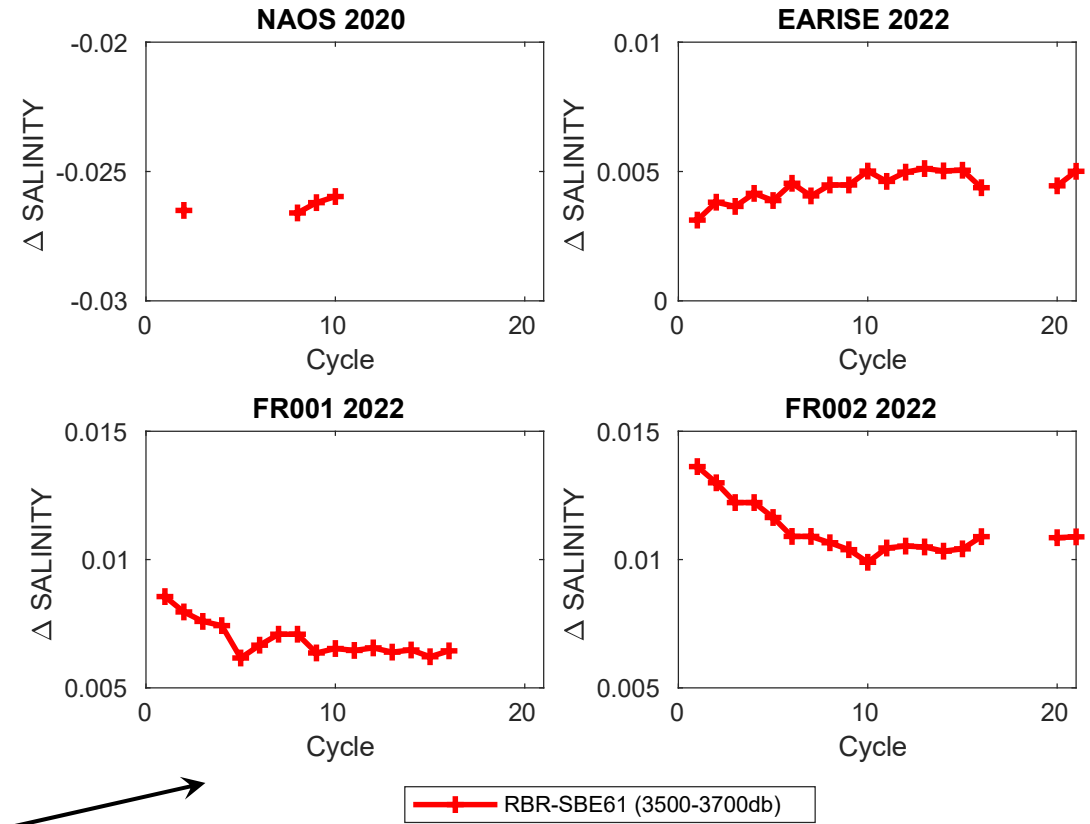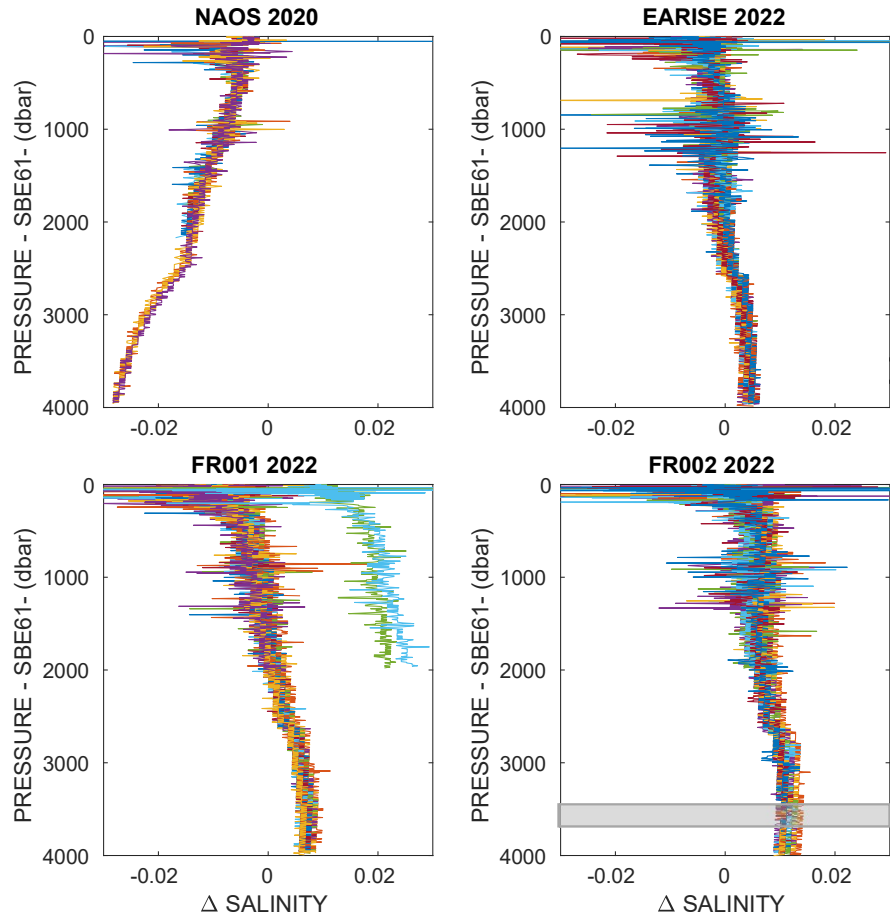- Offset correction by comparison to reference profile

NAOS RBR sensor: pressure dependancy + drift due to design issue

Other RBR sensors
- new design
- Pre-deployment calibration to take into account pressure dependancy
    - Pressure signal remains
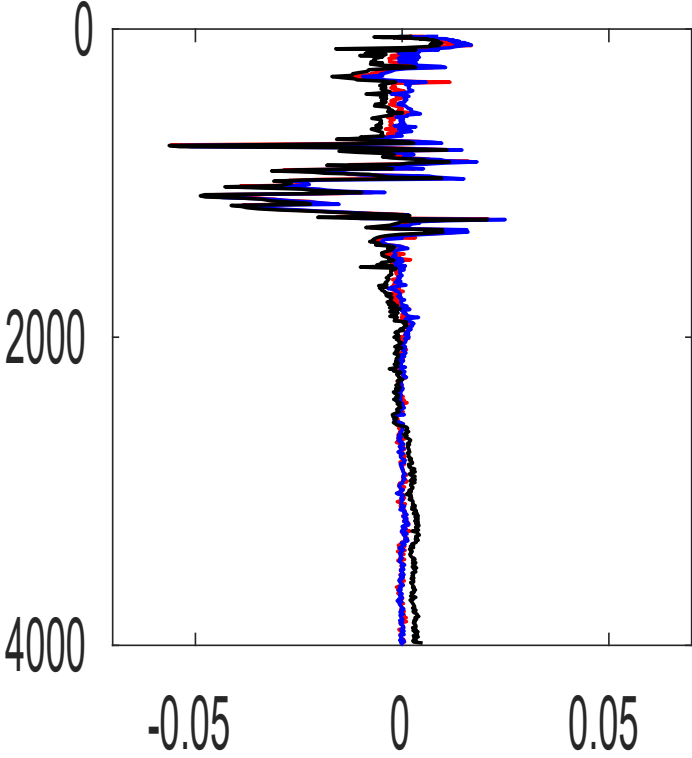   - Offset not corrected

Salinity – Sensors intercomparison

Salinity : RBR -SBE61

Salinity – Sensors intercomparison – Impact of pressure and temperature

EARISE 2022

Legend (left plot):
- SBE61 (cpcor=-11.6e-8) - STAT25
- SBE41(cpcor=-11.6e-8) - STAT25
- RBR - STAT25

EARISE 2022

Difference between SBE41 and SBE61 after correction
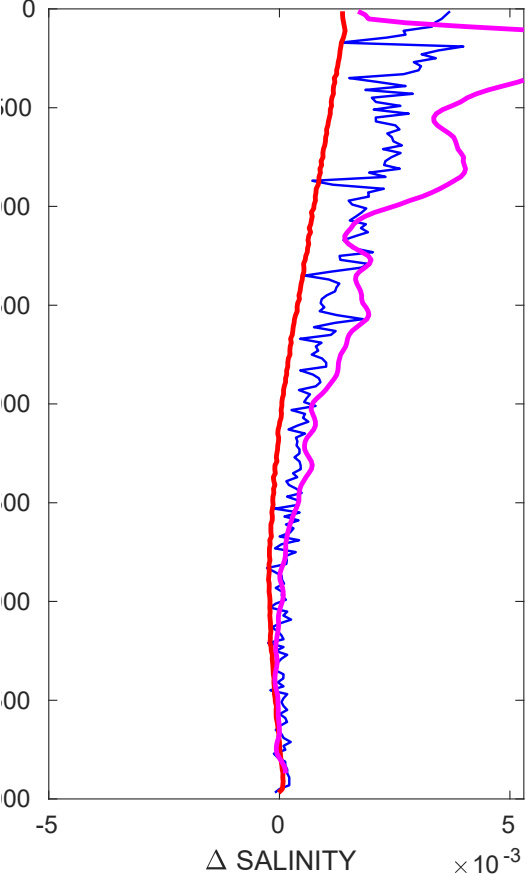
Legend (right plot):
- SBE41-SBE61
- SBE41 -SBE41 (with PRES SBE61)
- SBE41- SBE41(with PRES and TEMP SBE61)

Δ SALINITY × 10⁻³

- Pressure is one of the limiting factor for reaching Argo accuracy target

- Temperature sensors ok. Is there a thermal inertia issue?

- Seabird salinity data needs to be corrected (pressure response, offset), after correction data OK in the deep layers

- Deep-RBR sensor still needs to be improved for Deep-Argo application

- Long-term evolution of the sensors still need to be investigated

	Aanderaa 4330
	Rinko AROD-FT
	RBR coda ODO
	Seabird – SBE83 (< 2 000 m)

▮ Sur Deep-Arvor (4 000 m)

▮ Choix Aanderaa - Rinko
- Ne pas se disperser

▮ Ce qui prend du temps
- Métrologie
- Interactions fournisseurs
- Connaissance du capteur (fonctionnement général, temps de réponse, filtrages internes, etc.)
- Analyse, qualité de la donnée

▮ Fin de qualification : fin 2022
  Déploiement en 2023
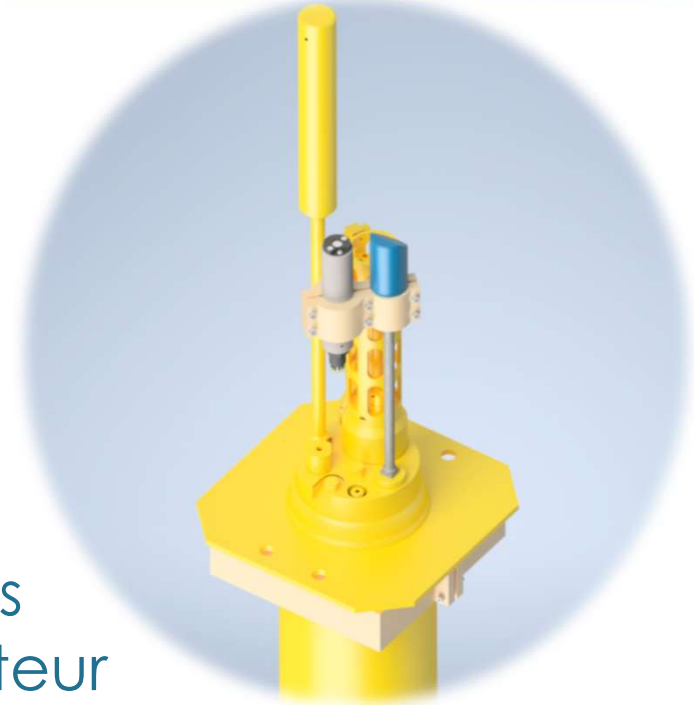
Intercomparison exercices are very powerful tools

- Better understanding of the sensor behavior
- Help track any systematic error to improve the overall accuracy of the data
- Provide independant evaluation of the sensors
- Help emergence of new sensor manufacturer (RBR vs Seabird)

But

- Time and budget consuming
- Need expertise (integration, behavior, analysis, etc) on all the sensors
- Difficulty to determine what is the best sensor
- Sensors evolve with time and we are not always aware of the changes
    - some conclusions are no longer valid after deployment
    - need to redo the intercomparison (eg new pressure SBE61 pressure sensor; new O2 sensor)
- What is our part vs manufacturer part ?

Some comments

- Need more than one float to conclude (at least 3) and even more because of sensor or float issues
- Need independant « reference sensor »
- Need upstream analysis (pressure tank, metrology)?