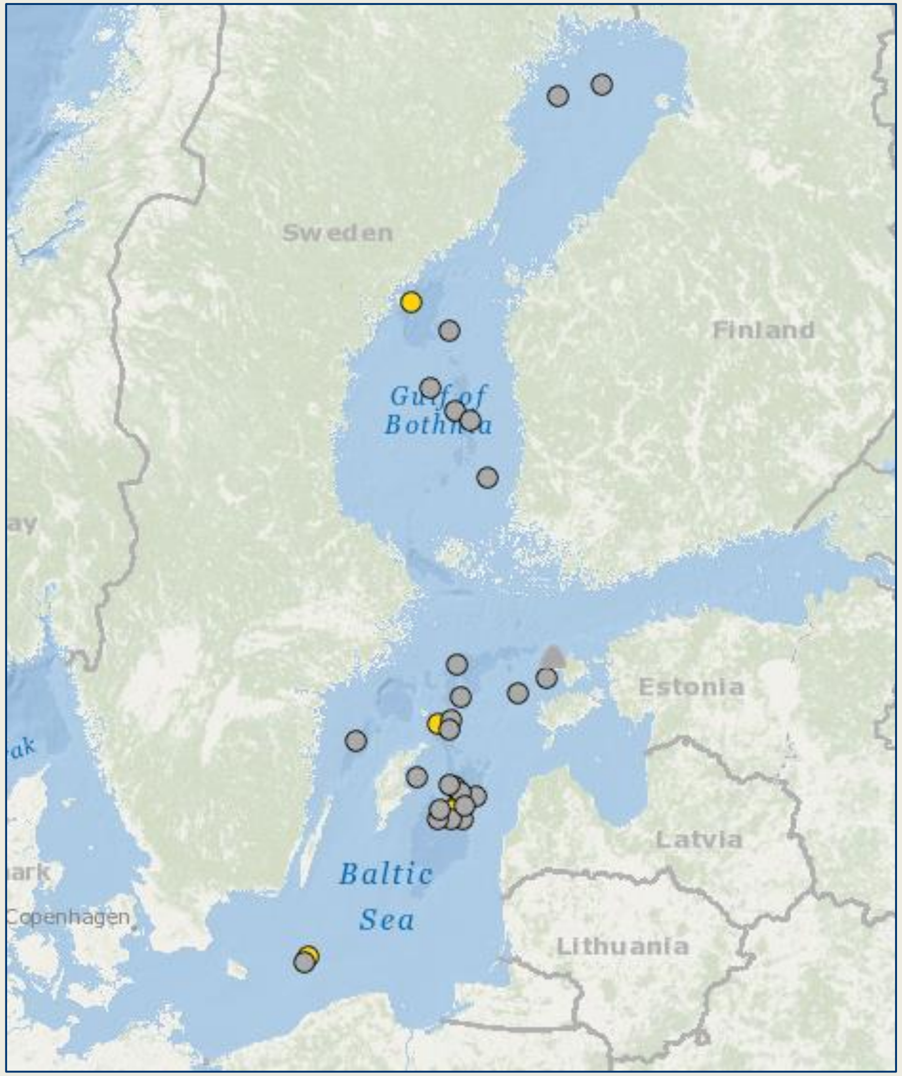
BGC-Argo adaptation needs for Baltic Sea DMQC: Oxygen, Nitrate, and Chlorophyll a

Henry Bittig, Catherine Schmechtig

(with some figures by Tany Maurer, Yui Takeshita)

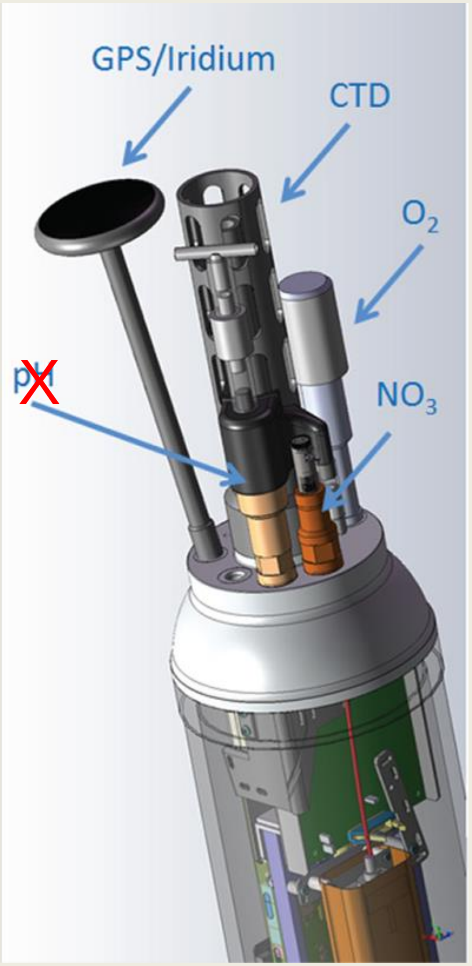
Float and sensors for BGC-Argo in the Baltic Sea



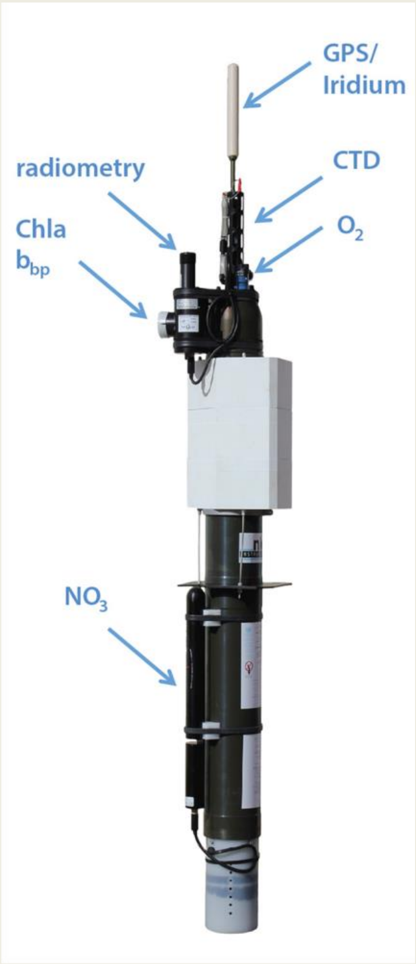
- Apex and Provor established in Baltic Sea; Navis untested
- Provor with largest buoyancy range (i.e. density range)
- O_2, Chla, bbp/turbidity, (hyperspectral) radiometry, NO_3^-, pCO_2 (and pH)
- pH sensor not suited for H_2S-containing waters !
- Most BGC data require core T and S data -> If you DMQC core profiles, check if you can salvage data on BGC floats

Float and sensors for BGC-Argo in the Baltic Sea

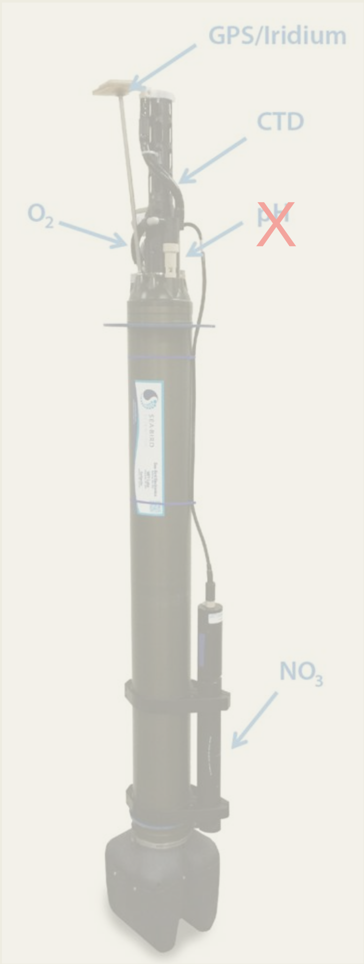
Apex



Provor



Navis



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Outline

- Optode background
- 1st-order corrections: SLOPE
  (~5–10 % improvement to accuracy)
  -> Correcting for optode storage drift
- 2nd -order corrections: SLOPE
  (~1 % improvement to accuracy)
  -> Correcting for optode in-situ drift
- Data Management process
- **Baltic Sea needs**
  (~0–10 % improvement to accuracy)
  -> OFFSET correction
  -> Time response correction

Oxygen Optode Paper/Review

"All you need to know about Oxygen Optodes"

- Sensor Sensing Fundamentals
- Environmental Factors (O_2, T, S, P, time, time)
- Field Aspects
- Data Processing
- Refs. to further Work

ORIGINAL RESEARCH ARTICLE
Front. Mar. Sci., 24 January 2018 | https://doi.org/10.3389/fmars.2017.00429

Check for updates

Oxygen Optode Sensors: Principle, Characterization, Calibration, and Application in the Ocean

Henry C. Bittig[1*], Arne Körtzinger[2,3], Craig Neill[4], Eikbert van Ooijen[4], Joshua N. Plant[5], Johannes Hahn[2], Kenneth S. Johnson[5], Bo Yang[6] and Steven R. Emerson[6]

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[3]Christian-Albrechts-Universität zu Kiel, Kiel, Germany
[4]CSIRO Oceans and Atmosphere, Hobart, Australia
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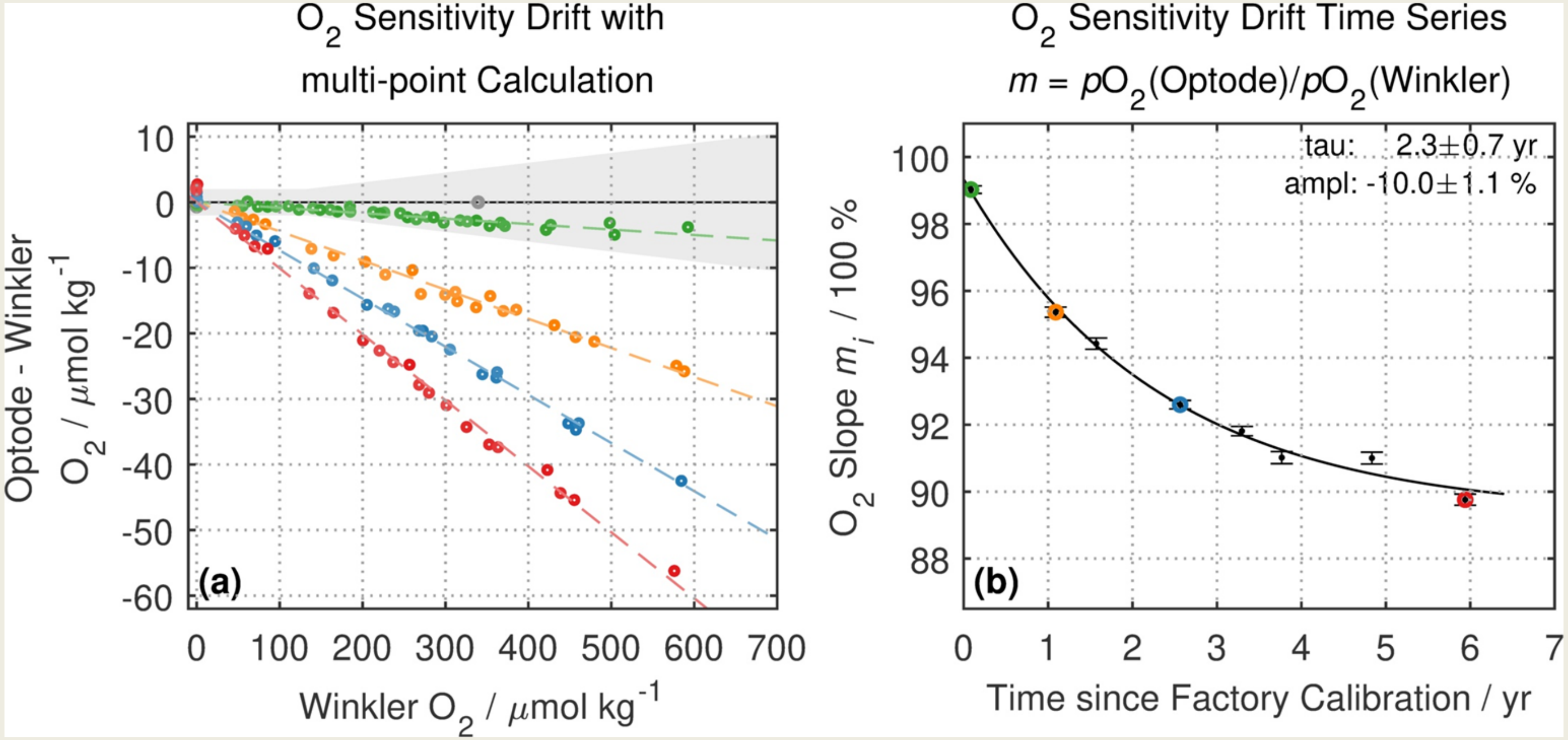
[6]School of Oceanography, University of Washington, Seattle, WA, United States

Oxygen Optodes need to be in-situ calibrated (cause: “storage drift”)

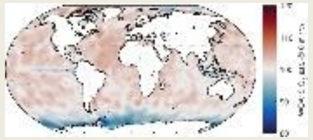
- Example: Optode calibrated multiple times, *same Data in both Panels*

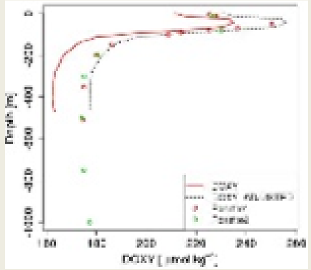


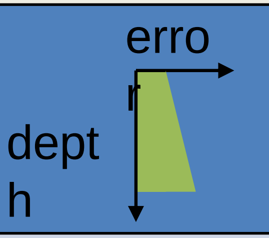
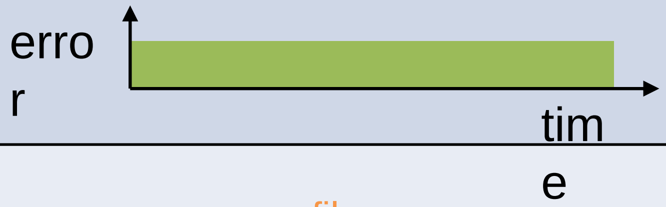
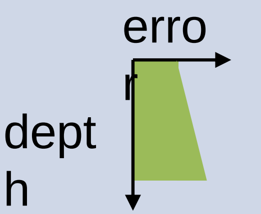
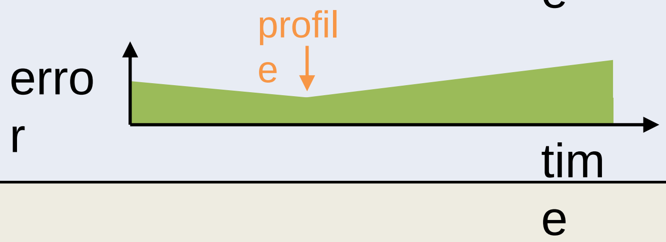
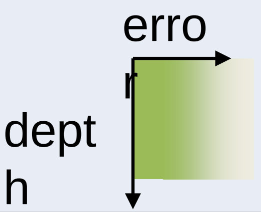
after Bittig et al. (2018). Data courtesy of Craig Neill (CSIRO O&A Hobart)

Oxygen Optodes need to be in-situ calibrated (cause: "storage drift")

- Significant gain in accuracy by **SLOPE** adjustment
- Accuracy depends on reference data accuracy and character

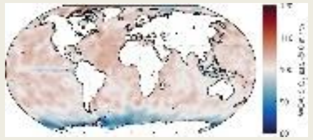


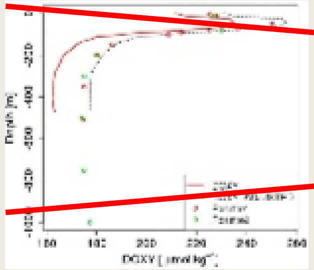


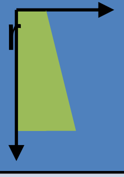
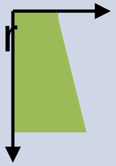
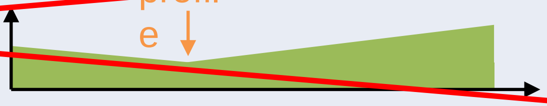
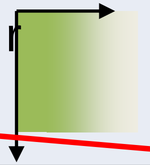
Direct in-air measurements (continuous)	~2 hPa		
Surface O_2 saturation climatology (continuous)	4–6 hPa		
Winkler-calibrated CTD-O_2 deployment profile (spot)	4–6 hPa		

Oxygen Optodes need to be in-situ calibrated (cause: “storage drift”)

- Significant gain in accuracy by **SLOPE** adjustment
- Continuous referencing allows for in-situ drift correction (= stable accuracy)





Direct in-air measurements (continuous)	~2 hPa		
Surface O_2 saturation climatology (continuous)	4–6 hPa		
~~Winkler-calibrated CTD O_2 deployment profile (spot)~~	~~4–6 hPa~~		

Data Management process ("Standard" case, outside of Baltic Sea...)

- Step 0: Visual QC check
- Step 1: **SLOPE** estimation
- Step 2: Fill BD-file

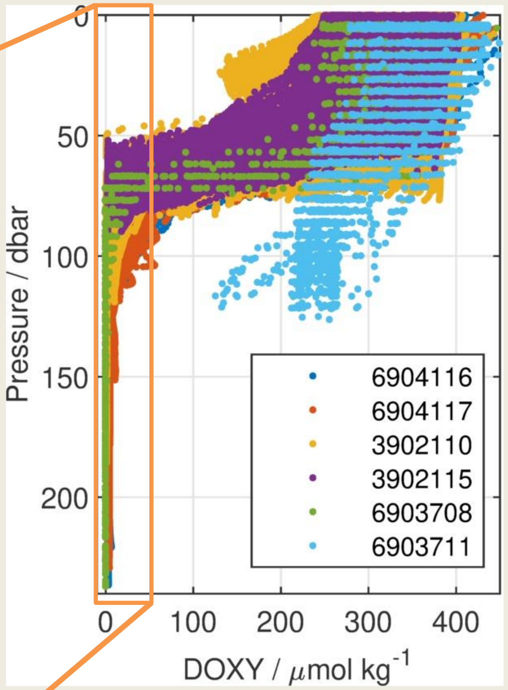
only accessible from continuous reference data

SCIENTIFIC_CALIB_EQUATION
PPOX_DOXY_ADJUSTED=
(**SLOPE***(1+DRIFT/100*(profile_date_juld –
launch_date_juld)/365)+INCLINE_T*TEMP)*(**PPOX_DOXY**+OFFSET
)

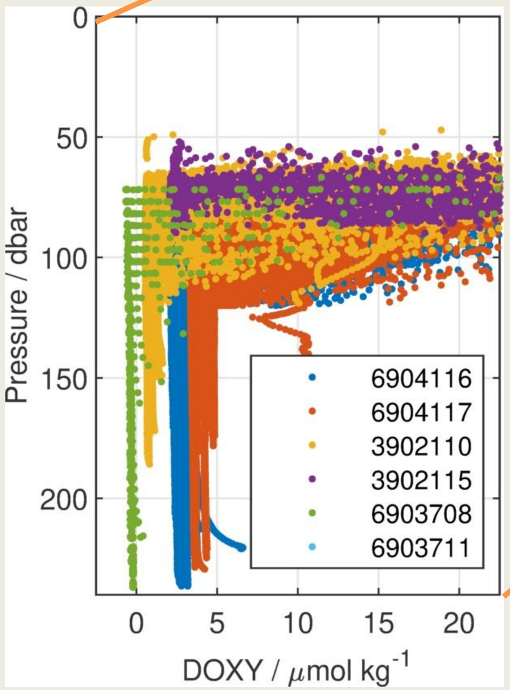
SCIENTIFIC_CALIB_COEFFICIENT
SLOPE = value of gain derived in DMQC assessment
OFFSET typically 0
INCLINE_T typically 0 (for well calibrated optodes)
DRIFT may or may not be required

Data Management process ("Baltic Sea" case...)

- Step 0: Visual QC check
- Step 1a: OFFSET estimation
- Step 1b: **SLOPE** estimation
- Step 2: Fill BD-file



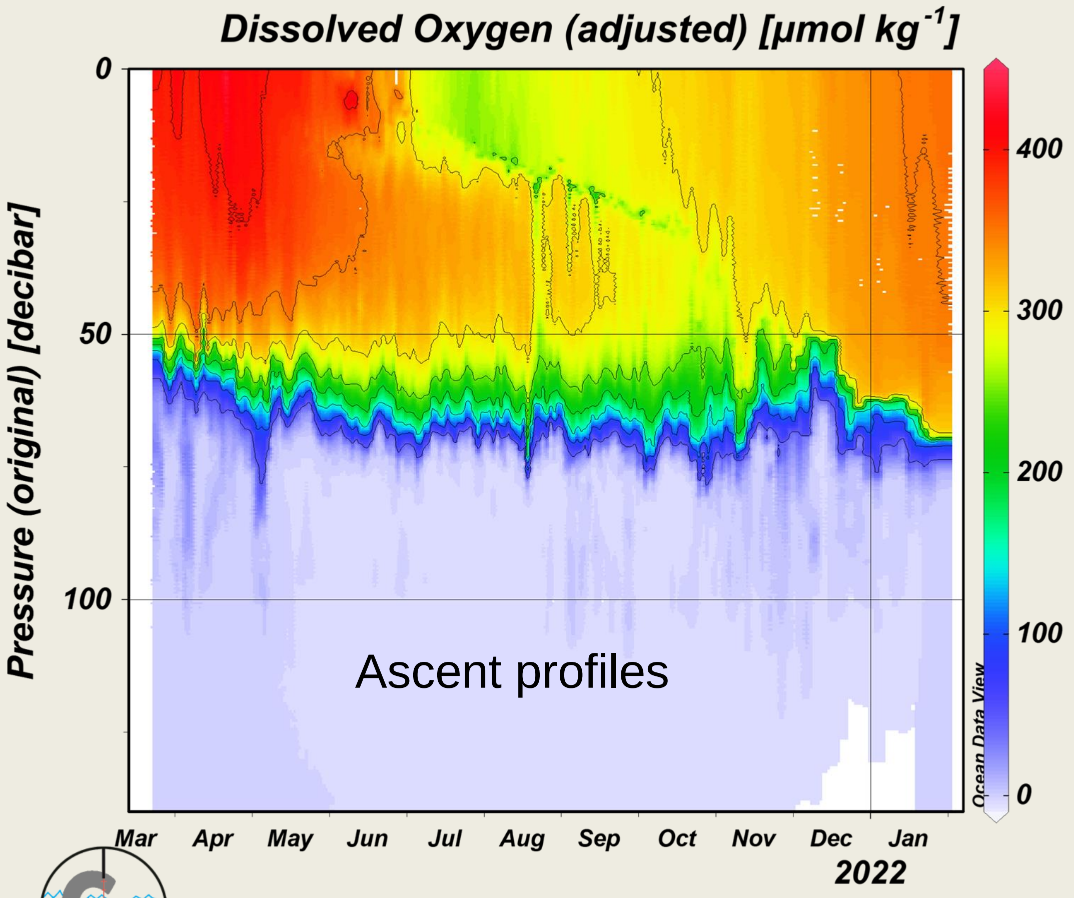
DOXY from some recent floats

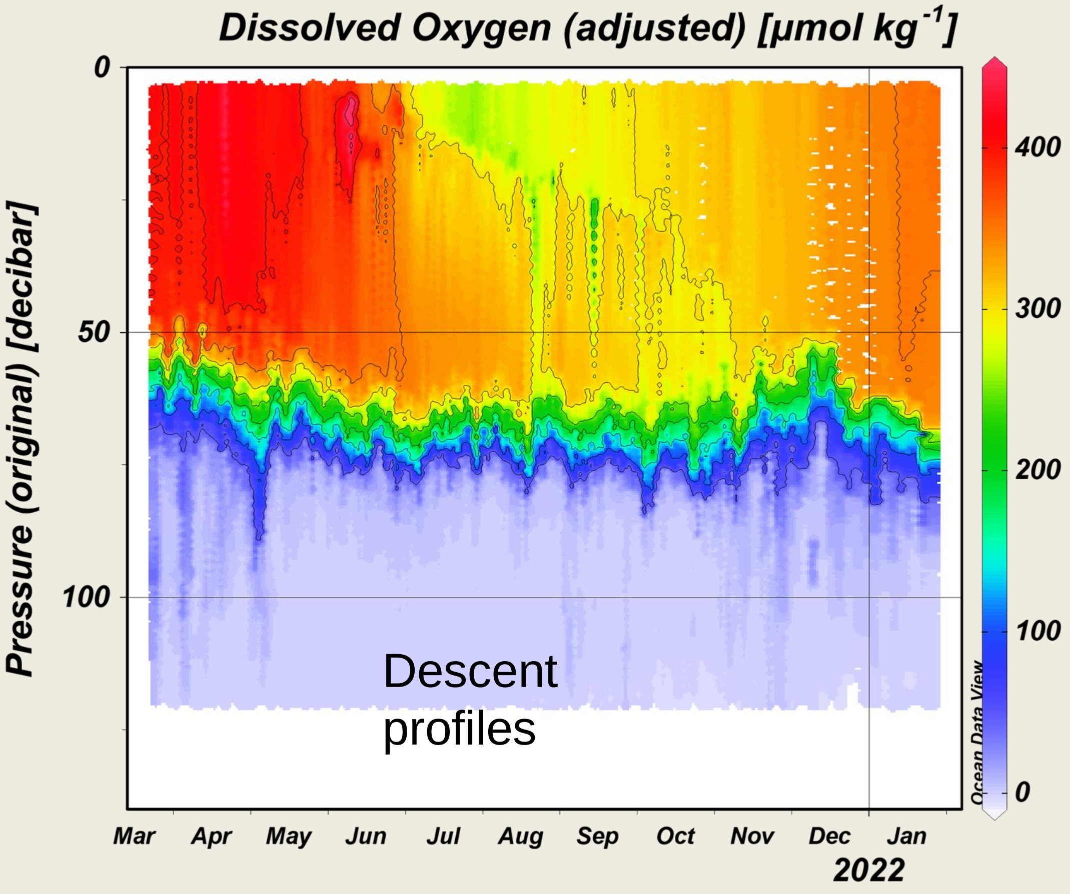


Zoom on low DOXY range:
Should be zero O_2 in H_2S-containing deep waters -> OFFSET correction needed

Very strong O_2 gradient -> Time response causes noticeable lag

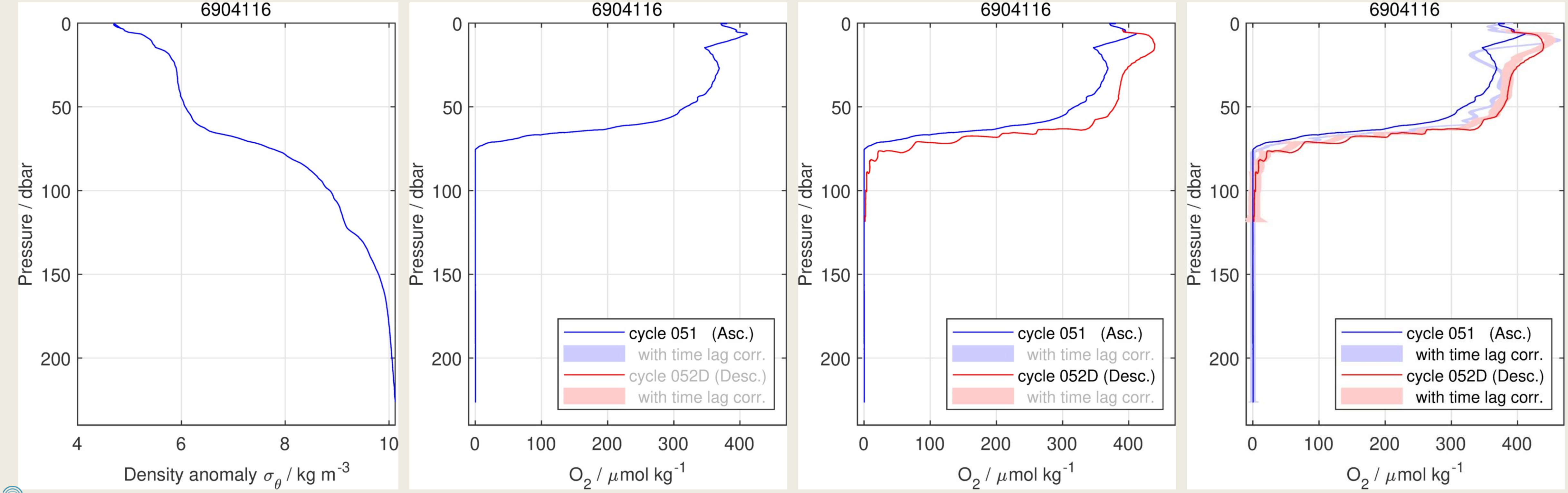
Example 6904116





Very strong O_2 gradient -> Time response causes noticeable lag

- Ascending vs. Descending profiles: Provides lower / upper bounds.
- Measurement times for each sample needed for good time response correction!



Data Management process (“Baltic Sea” case...)

- Step 0: Visual QC check
- Step 1a: OFFSET estimation *(0–10 µmol/kg improvement to accuracy)*
- Step 1b: SLOPE estimation *(5–10 % improvement to accuracy)*
- Step 1c: Time response correction *(0–10 % improvement to accuracy)*
- Step 2: Fill BD-file

Required for Baltic Sea
DOXY DMQC

Data Management process (“Baltic Sea” case...)

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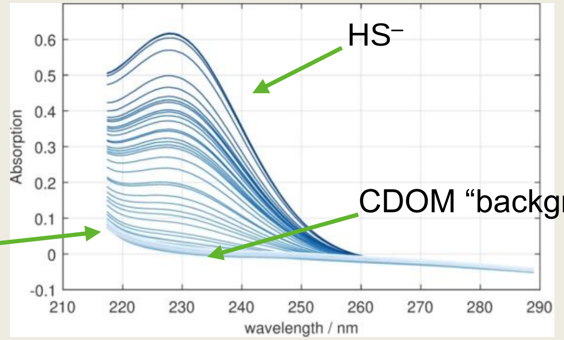
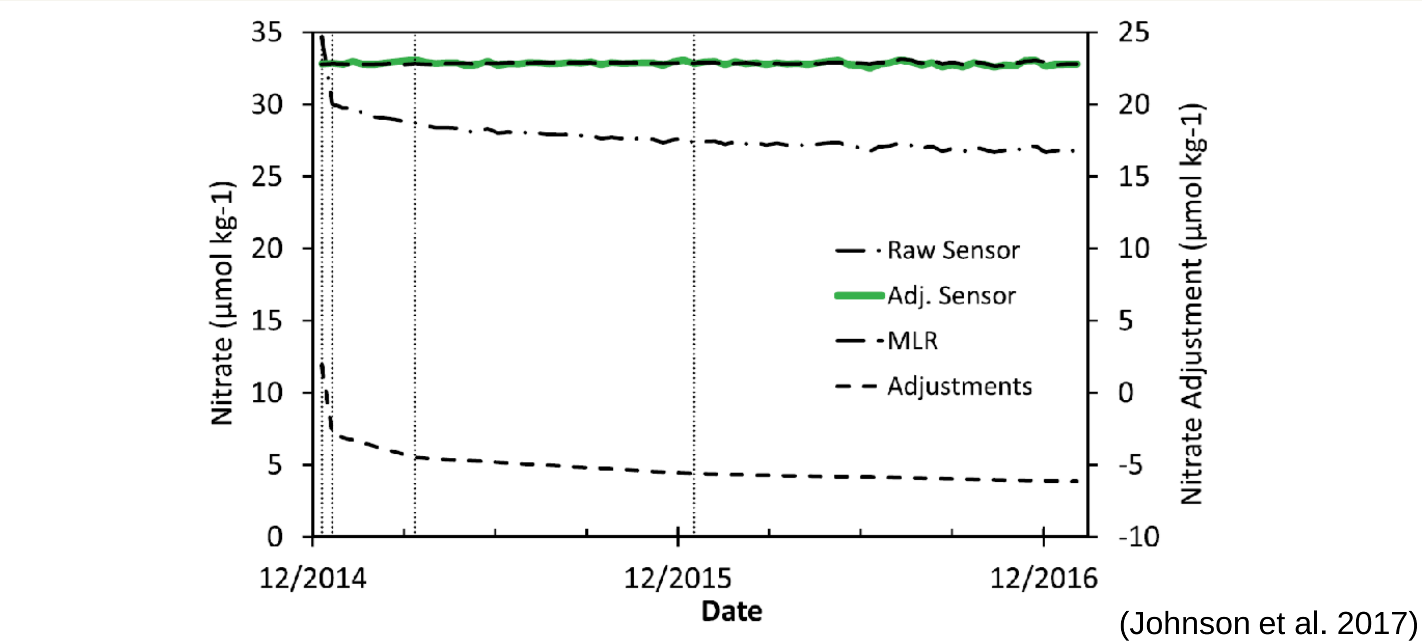
- Step 1: OFFSET estimation
- Step 2: Fill BD file

Standard: Take deep “stable” water mass for reference





(Johnson et al. 2017)

Figure 5. Nitrate sensor data at 1500 m depth for float 5904469/9096 and the predicted (MLR) nitrate concentrations. Dashed line shows the adjustments that are applied to the raw sensor data. Vertical dotted lines are locations of four nodes where changes in the adjustment parameters in Table 5 are applied.

Data Management process (“Baltic Sea” case...)

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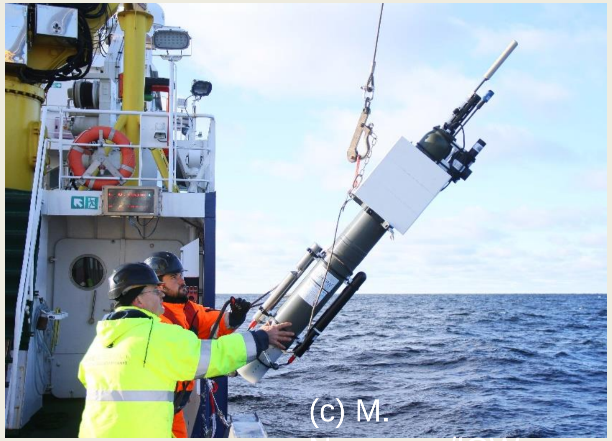
Standard: Take deep “stable” water mass for reference

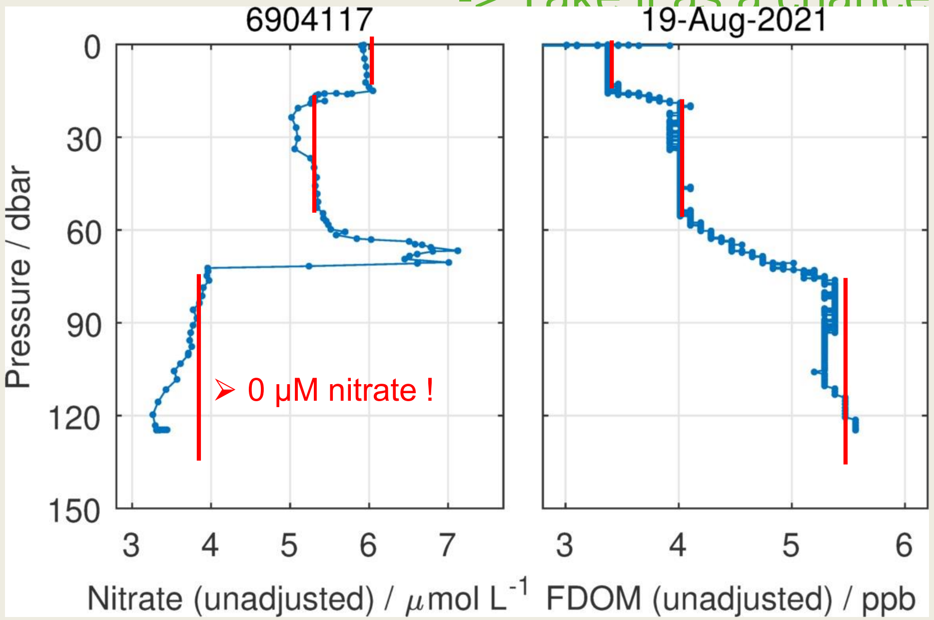
Baltic Sea requires adapted DMQC methods (Bittig, unpubl.):

No deep “stable” water mass + interference from high CDOM load

-> Take it as a chance !



(c) M. Naumann/IOW



- Surface + winter water have 0 µM nitrate in summer (e.g., August)
- H_2S zone has 0 µM nitrate

➢ Permanent / seasonal zero-nitrate occurrence

➢Use FDOM signal for zero-nitrate correction !

2025 DArgo

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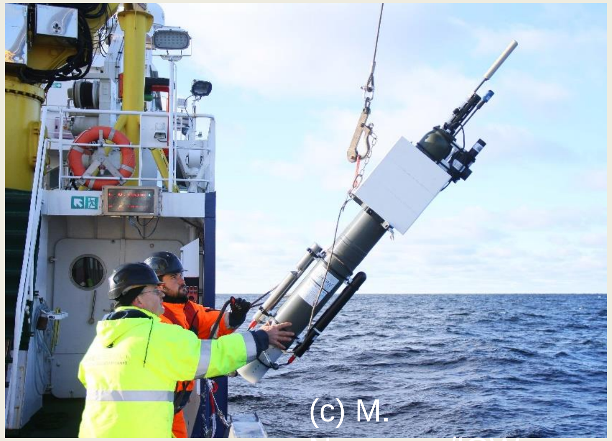
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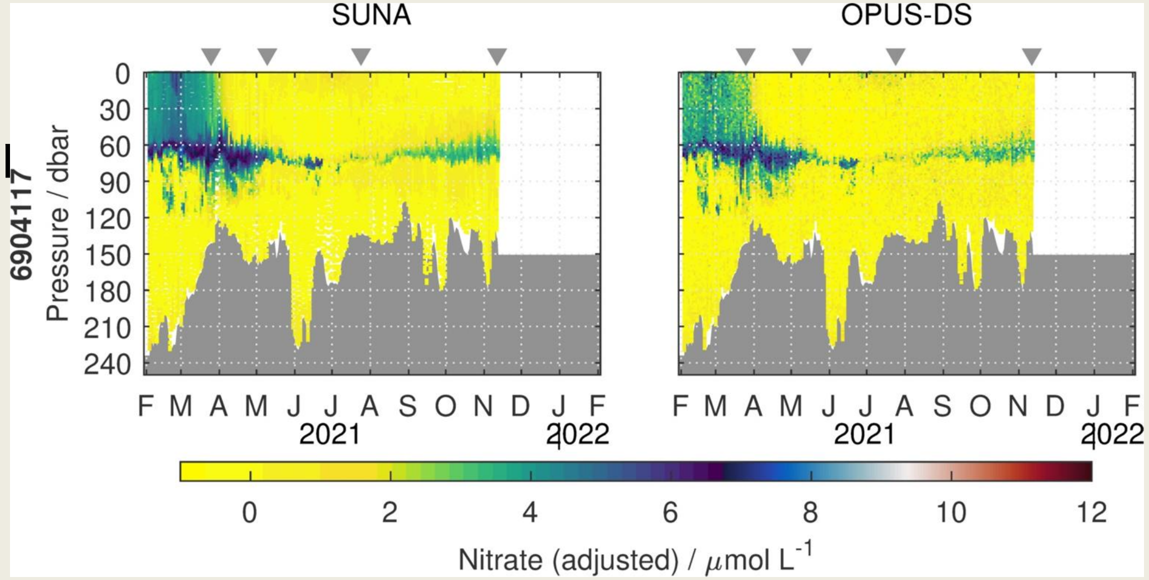
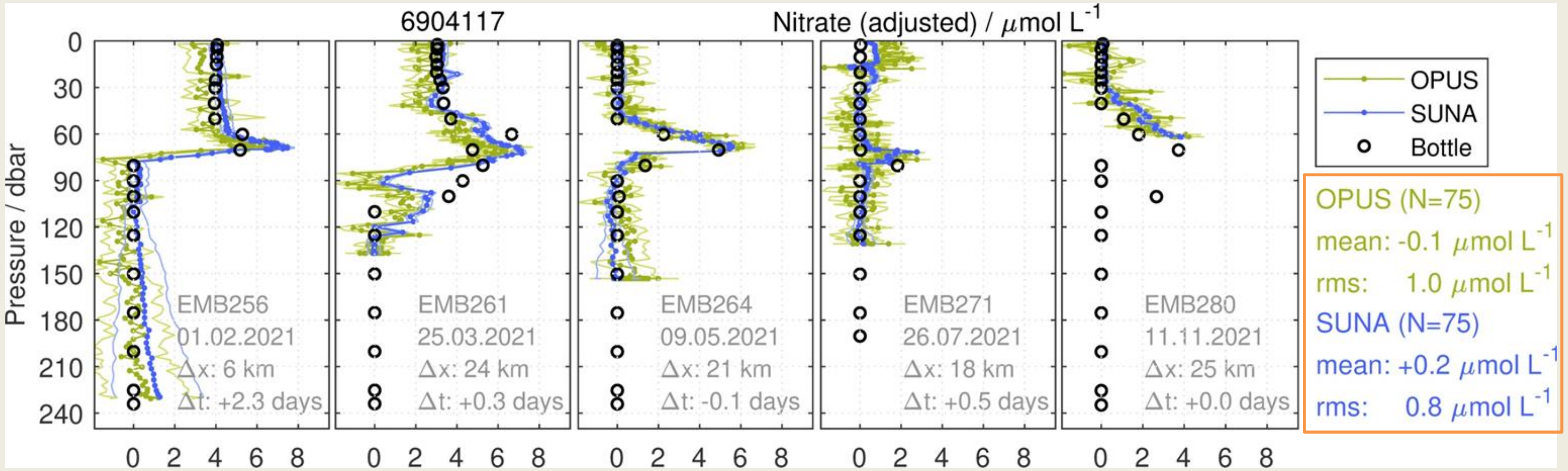


Correction possible also in the Baltic!

Good match with nearby ship bottle samples.

OPUS and SUNA equally good.



Float and sensors for BGC-Argo in the Baltic Sea

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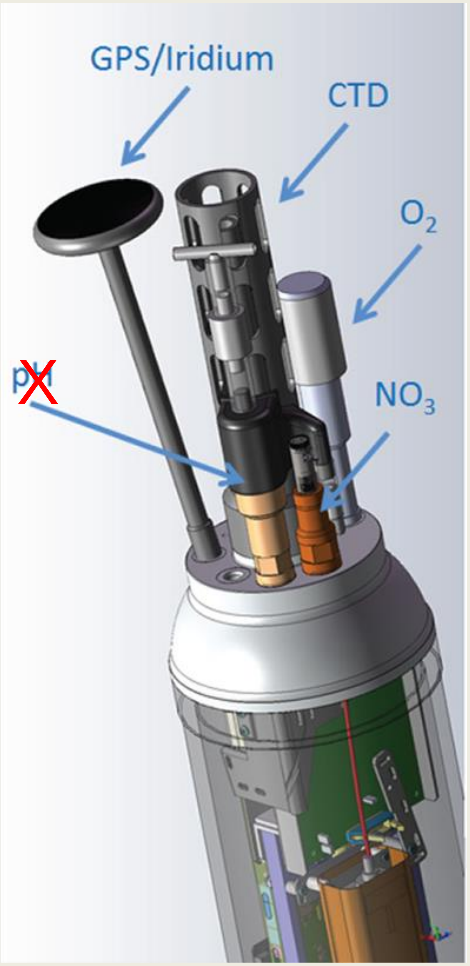
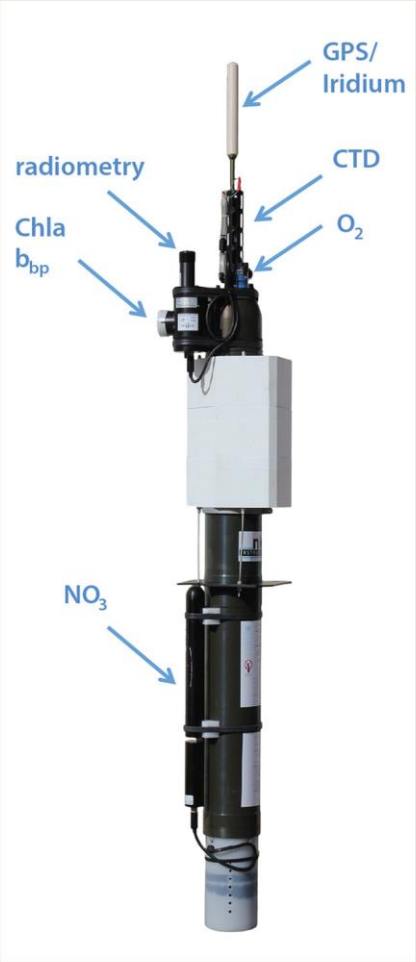


Provor



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