Performance of the *RINKO* FT optical dissolved oxygen sensors attached to Argo floats

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Current meters

Compact loggers

Moored loggers with wiper

Parameters

- Conductivity
- Temperature
- Pressure
- **Dissolved oxygen**
- Currents
- Fluorescence
- Turbidity
- PAR
- pH, ORP

Profilers

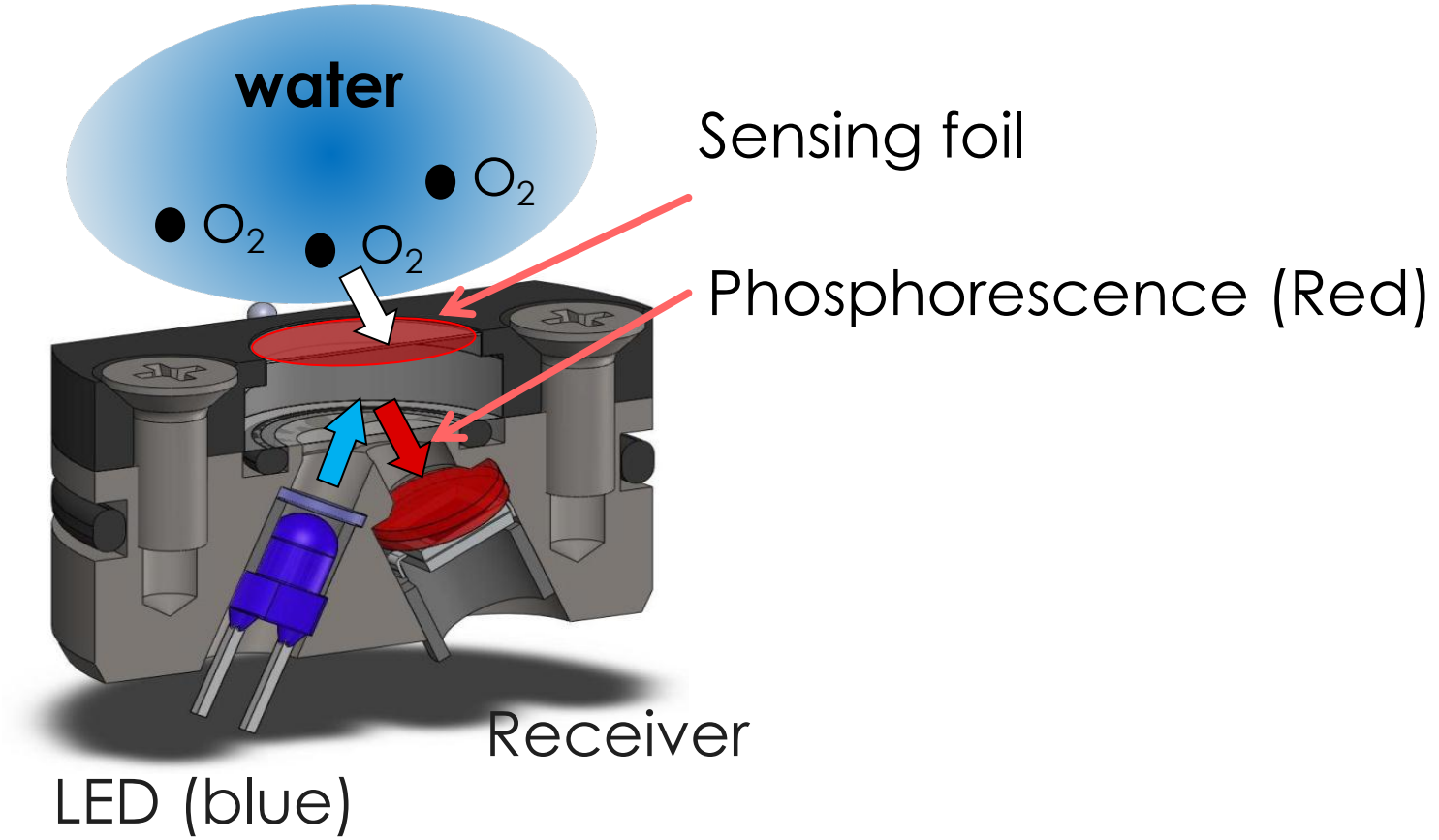
OEM sensors for integration

Loggers for deep sea

Dissolved oxygen: *RINKO*®

Measurement principle

- ***RINKO*** ® is an optical dissolved oxygen sensor



RINKO ® means phosphorescence in Japanese

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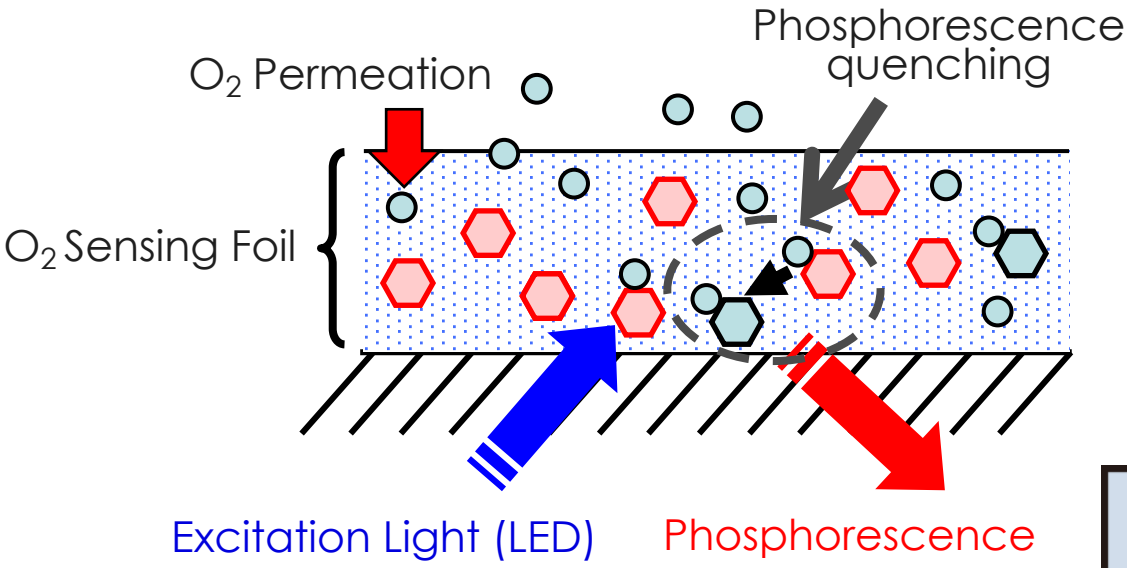
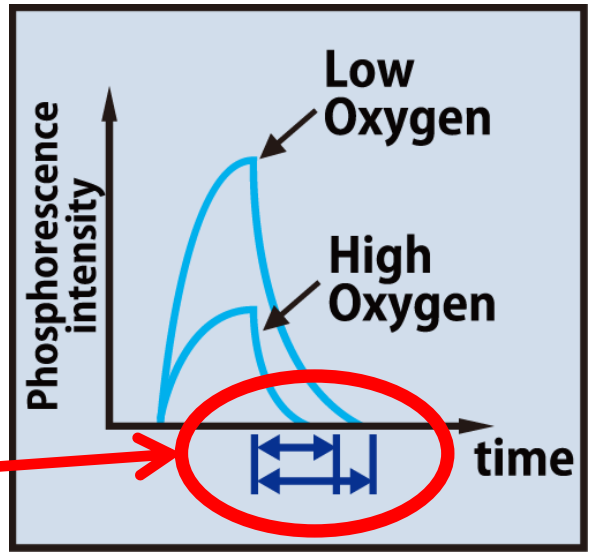
Measurement principle



Porphyrin (ground)

Porphyrin (excited)



Phosphorescence intensity is not stable

Phosphorescence life time (is what the sensor measures)

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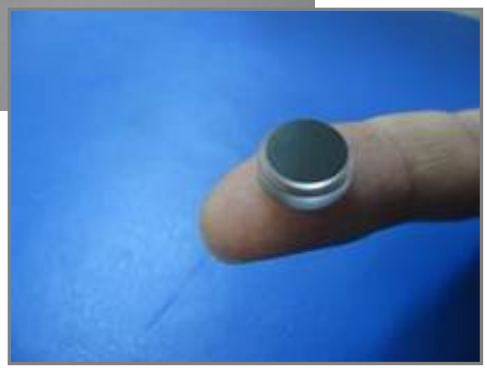
Development

We can provide various types of sensing foil



We are one of the few manufacturers in the world that provide both sensing foils and optical system technologies.

No. 165 for Argo floats

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RINKO® for Argo floats
(Development challenges)

- Maintain fast-response
- Long-term stability (small drift over time)
- High accuracy
- Small size, low power consumption

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RINKO FT (*RINKO*® for Argo floats)

- **Fast-response**
- Robust sensing foil with increased gas permeability

- **Long-term stability (small drift over time)**
- Controlled excitation light emission in order to avoid deterioration of the oxygen sensing foil

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RINKO FT (*RINKO*® for Argo floats)

- **High accuracy**
  - Modified Stern-Volmer equation is applied (Uchida et al., 2010).
  - Multipoint direct calibration

- **Small size, low power consumption**
  - φ30 x 146 mm,
  - 162g in water
  - Operation mode: less than 30 mA
    Sleep mode: less than 0.1 mA

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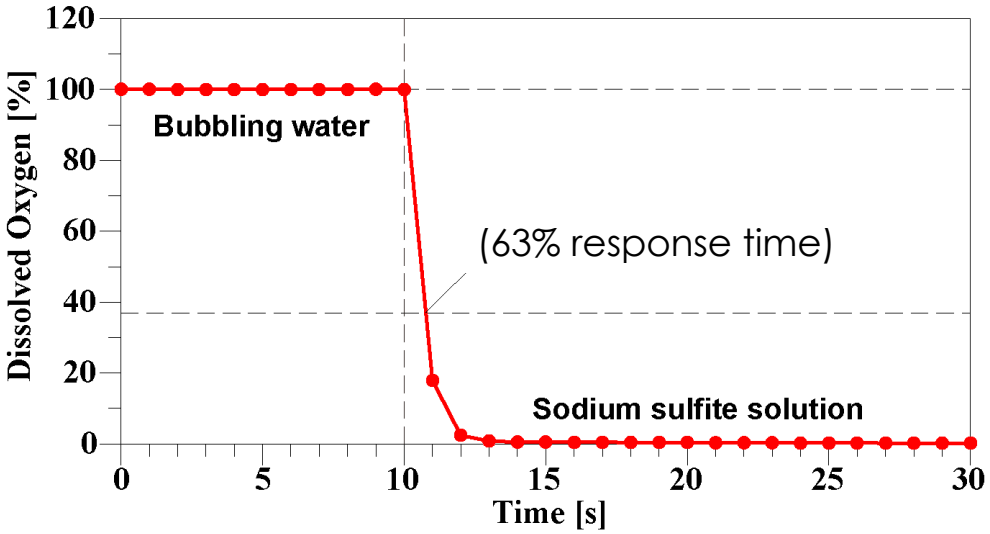
RINKO FT - Fast response

Fast response is essential to understand fine-scale DO variability.

A slow O_2 time response reduces fine-scale resolution and causes a lag between in situ and observed O_2 profiles (Bittig & Körtzinger, 2017).

RINKO FT response time(63% at 25℃): less than 1s in water



Time series of DO in water at 25 °C measured by *RINKO* FT.

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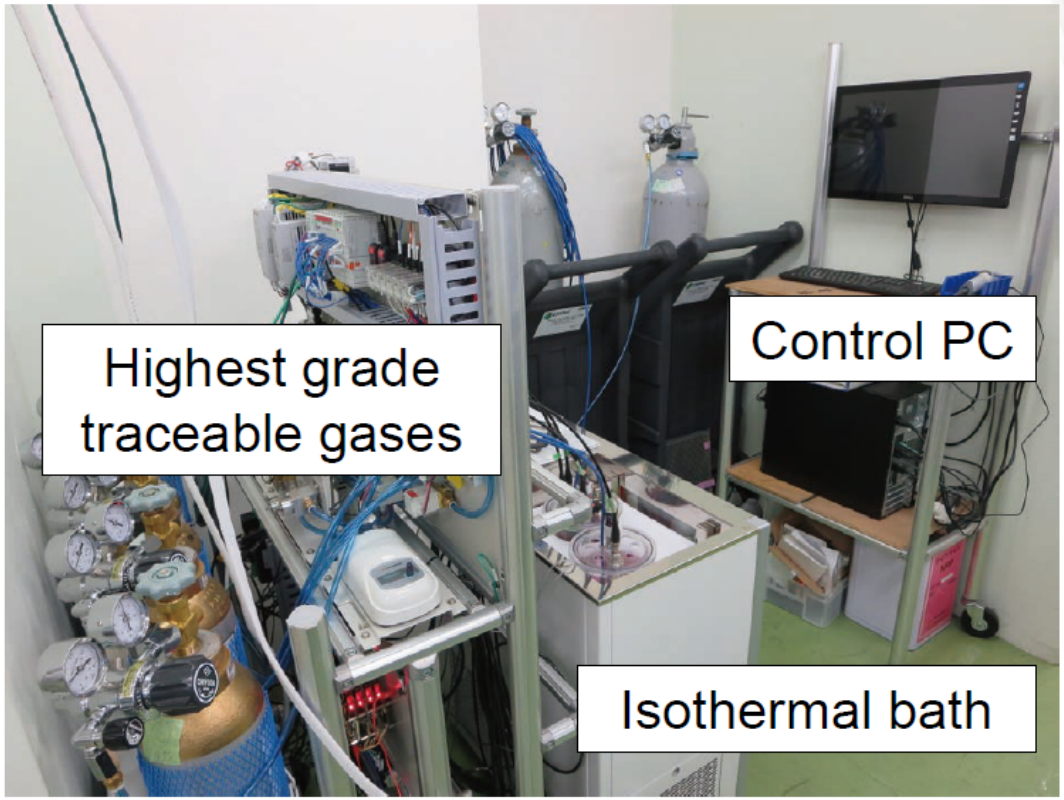
RINKO FT – High accuracy

RINKO FT accuracy: ± 2 % of measured value or ± 2.0 µmol L^{-1}



- 16-point calibration
- 4-point verification.

- DO reference standard from National Metrology Institute of Japan - NMIJ certified traceable gases with air saturation values of approx. 20%, 50%, 80% and 120%.

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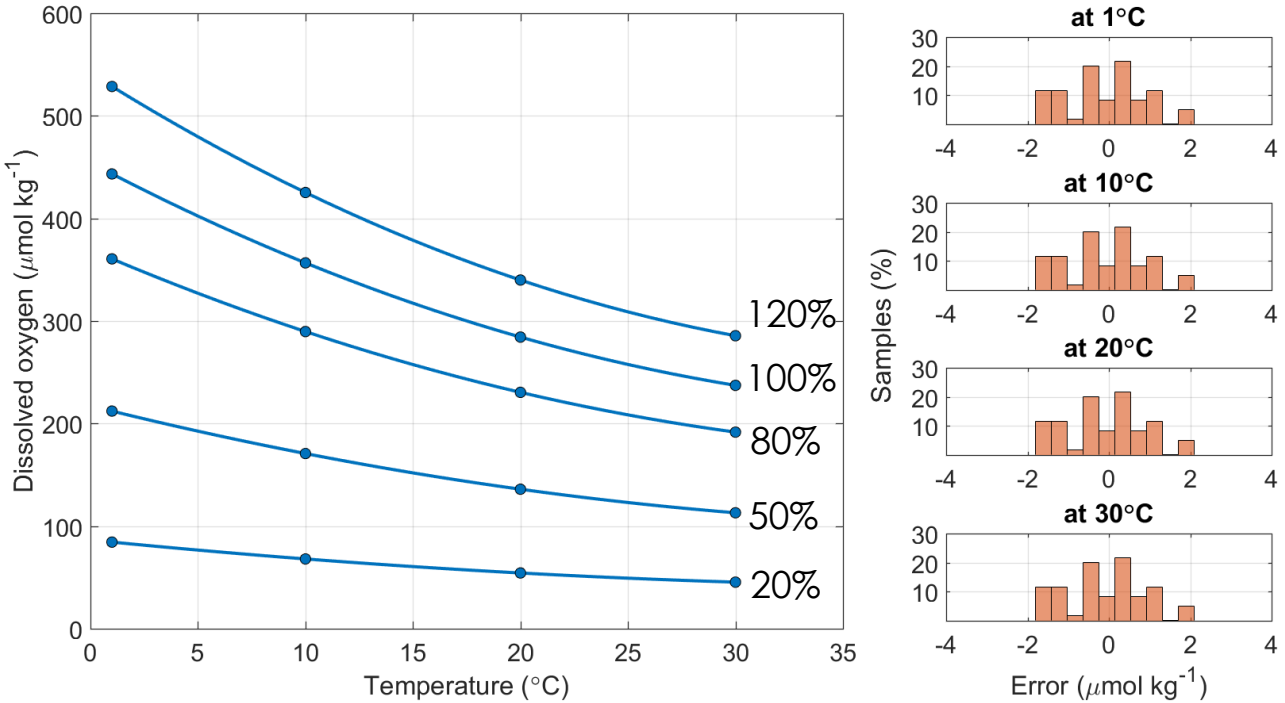
RINKO FT – High accuracy

RINKO FT accuracy: ± 2 % of measured value or ± 2.0 µmol L^{-1}



- More accurate
- It does not require a reference to be compared with, such as Winkler titration – minimizing systematic and experimental error).

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RINKO FT – High accuracy

- "Aging process" applied at factory to newly made DO sensing foil in order to overcome the initial drift.
- *RINKO* FT can be easily detached from the float for calibration just before deployment

User 2-point calibration

RINKO FT is designed to satisfy the required accuracy for a number of years without the need for recalibration.

In case of long-term storage: user calibration kit is available as an option, including a cable and a GUI software.

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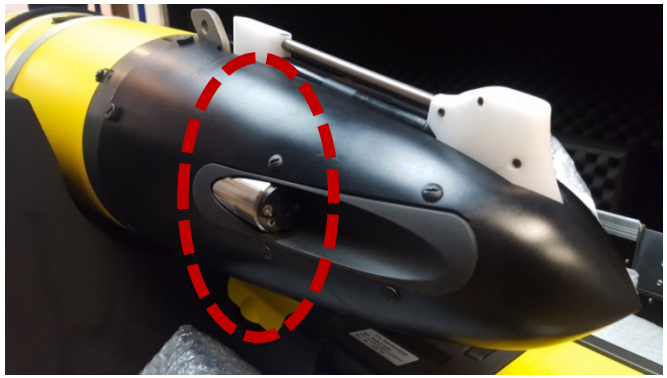
RINKO FT – Performance

We have integrated RINKO-FT on different platforms (floats and gliders).

APEX float from Teledyne Marine

S3A MRV floats



SEAEXPLORER Glider from Alseamar

Deep APEX float from Teledyne Marine

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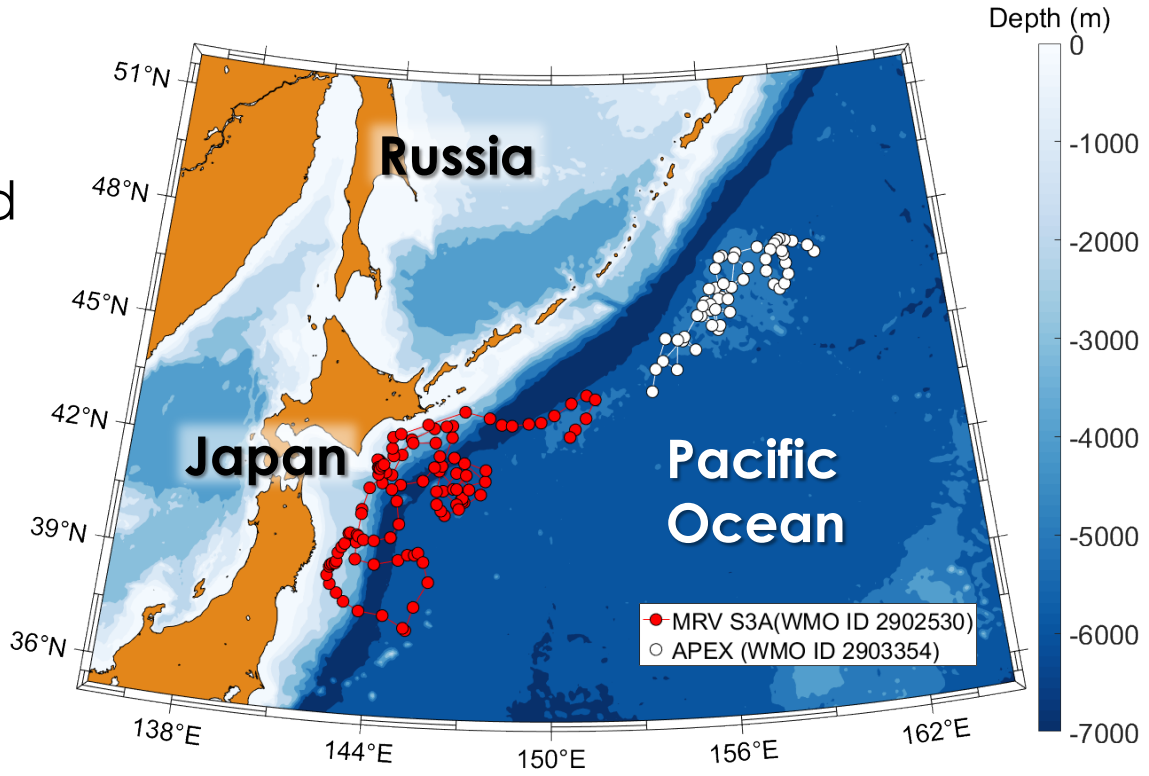
RINKO FT – Performance

- We analyzed data from BGC Argo floats equipped with *RINKO* FT
- Floats deployed by JAMSTEC



- This is a work in collaboration with **JAMSTEC**

(**J**apan **A**gency for **M**arine-Earth **S**cience and **Tec**hnology)

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RINKO FT – Performance

- NO adjustment applied to data labeled as **"realtime QC mode data"** made available by Argo's website.

- We analyzed DO profiles down to 2000 m depth.
  - 07/2014 to 01/2016 - MRV S3A(WMO ID2902530)
  - 07/2018 to 07/2019 - APEX (WMO ID2903354)

(still operational as July 2019)

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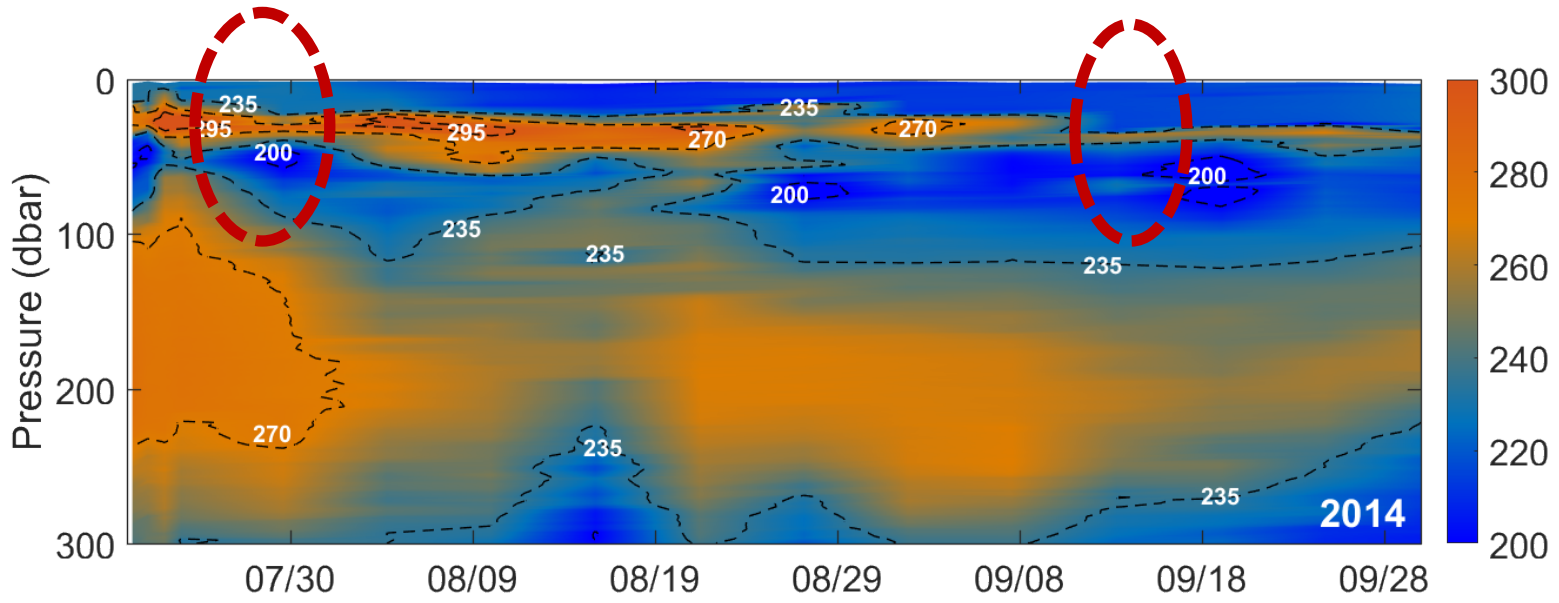
RINKO FT – Performance

- DO minimum or maximum thin layers, as well as sharp gradients can be identified by the *RINKO* FT



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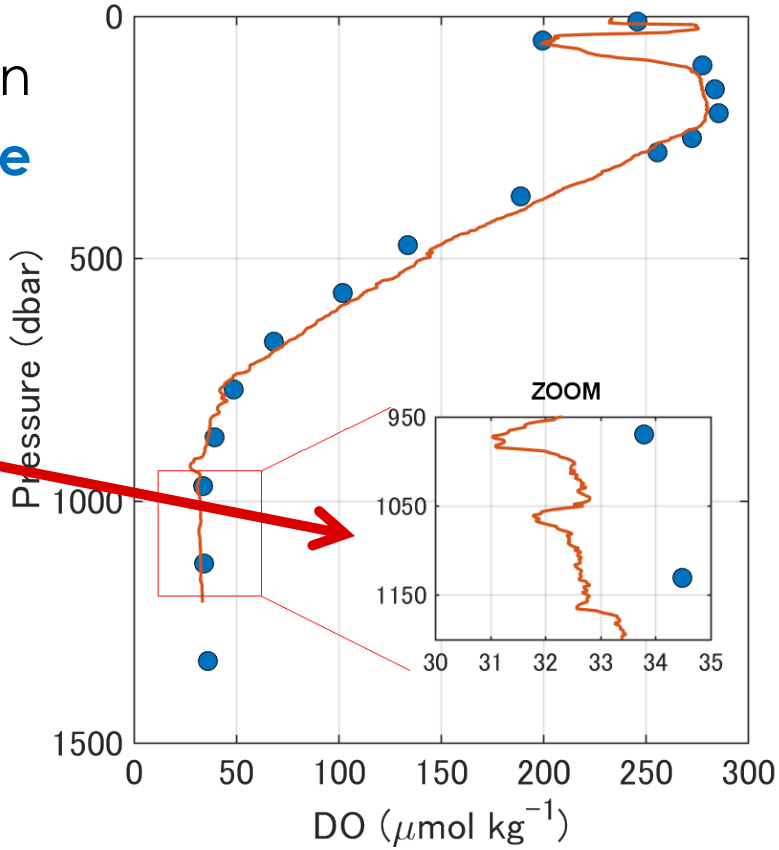
RINKO FT – Performance

- *RINKO* FT reveals fine scale DO distribution that cannot be obtained by slow response sensors or water sampling

- *RINKO* FT DO concentration agreed well with Winkler (**blue circles**)

ΔDO < 2 μmol kg^{-1}



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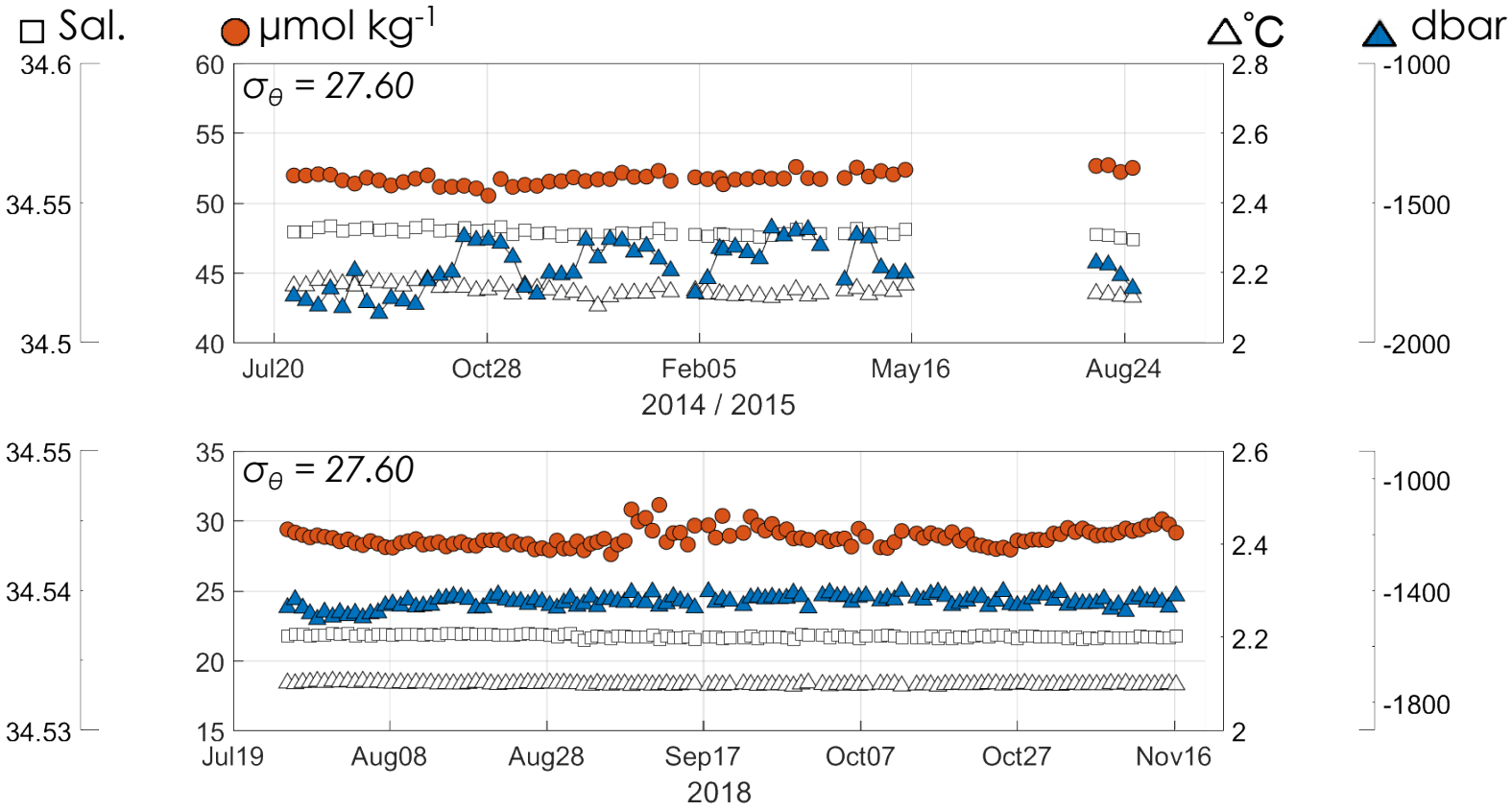
RINKO FT – Long-term stability

No remarkable drift

- 2014: less than **1 µmol kg^{-1}**
- 2018: less than **2 µmol kg^{-1}**



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RINKO FT – Conclusions and next steps

- **High accuracy**: *RINKO* FT agrees well with values obtained from Winkler
  (difference is below 2 µmol kg^{-1})
- **Fast response:** allowed for fine scale DO gradient observations
- **Small drift:** DO varied within 1 µmol kg^{-1} after several pressure cycles.

Pressure-induced effect:
RINKO® sensing foils did not present noticeable time-dependent pressure-induced effect at 1000 m (parking depth).

(Uchida, H. et al. 2018 – poster pres. at 6th Argo Science Workshop, Tokyo, Japan) —article under preparation

Next steps:
RINKO-FT performance in the deep ocean (using Deep Argo floats and laboratory experiments).
- analyzing pressure-induced effects and its correction.

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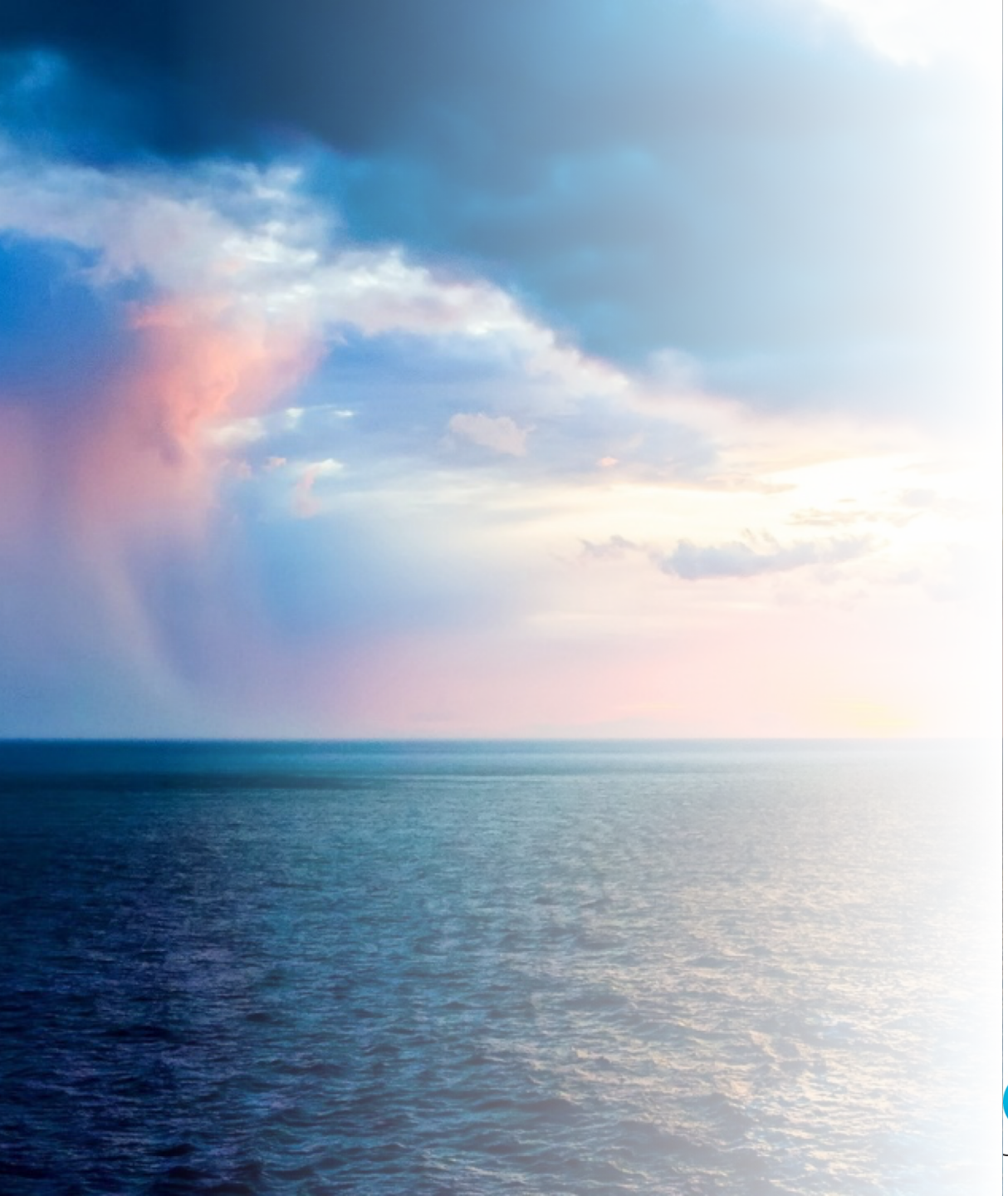

Thank you

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	RINKO FT	A	S
Response time (63%)	**< 1 s**	**< 8 s**	**< 6 s**
Initial accuracy	±2 µmol L^{-1} or ±2 %	±2.5 µmol L^{-1} or ± 1.5 %	±3 µmol kg^{-1} or ±2 %
Resolution	< 0.1 µmol L^{-1}	< 1 µmol L^{-1}	0.2 µmol kg^{-1}
Sampling speed	1 Hz	1 Hz	1 Hz
Depth rating	2000 m/6700 m	6000 m	7000 m

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