



Date: October 5, 2023
To: Argo users of Sea-Bird Scientific CDOMⁱ fluorometers
From: Sea-Bird Scientific
Subject: Reported bias in measurements from Sea-Bird Scientific CDOM fluorometers

Summary

This notification is to inform BGC Argo users that Sea-Bird Scientific (SBS) some CDOM fluorometers have been reported to measure biased values. This bias has been traced back to three distinct root causes:

1. Incorrect primary CDOM standard
2. In situ bias
3. Out-of-tolerance UV LED

The next sections outline how each root cause can manifest itself in the data and which sensors/models are affected. For each case, we summarize the actions SBS has completed or is undertaking to address the issue.

1. Incorrect Primary CDOM Standard

What will you see in the data?

CDOM concentration calculations from instrument readings are underreported by a constant factor for ECO and MCOMS CDOM fluorometers.

Root Cause: In a careful review of CDOM metrology, Sea-Bird Scientific found that the primary standard used to establish CDOM fluorometers' scaling to standardized units of ppb QSDE (quinine sulfate dihydrate equivalent) had been inaccurately prepared.

Sensors affected:

- ECO FLBBCDRT2K (ECO_FLBBCD) with S/N less than 8020
- ECO FLBBCDAP2 (ECO_FLBBCD_AP2) with S/N less than 6888
- MCOMS (MCOMS_FLBBCD) with S/N less than 0406

Actions:

SBS

- SBS has updated its primary CDOM standard. All SBS CDOM fluorometers with a calibration date of 13 January 2023 or later have the correct scale factor to retrieve CDOM fluorescence in QSDE ppb units.



- To reconcile BGC Argo CDOM retrievals with SBS CDOM fluorometers calibrated prior to 13 January 2023, SBS is currently developing specific correction factors with associated uncertainties to be applied to *all* CDOM data from impacted ECO and MCOMS fluorometers. SBS is anticipating a subsequent advisory with these correction factors to be sent out by the end of 2023.

Customer

- If you have any of the affected sensors that are not deployed, please contact SBS (support@seabird.com) for recalibration of the sensor.

Argo

- Until the corrections are made in all Argo GDAC databases, CDOM retrievals for sensor serial numbers prior to those listed above should be flagged with a quality control flag of '3' (*Probably bad data that are potentially adjustable*).

2. In Situ Bias

What will you see in the data?

Sea-Bird Scientific has observed that ECO CDOM fluorometer retrievals will vary by up to a factor of 6 for profiles in the same water mass. For example, in **Figure 1** below, CDOM profile data from six PROVOR III floats with ECO_FLBBCD sensors with nearly identical scale factors have CDOM retrievals that vary at depth from 0.3 to 2 ppb. (Note: CDOM data here has *not* been corrected for issue #1 above; rescaling all data a constant factor would still yield the same 6x range of offsets.)

Such offsets (including negative FDOM retrievals) were previously noted in BGC Argo data from the Irminger and Labrador Seasⁱⁱ.

Root Cause: In-situ changes in sensor dark counts after deployment *may* be the cause of this issue, but the root cause is still under investigation.

Sensors affected:

- ECO FLBBCD (ECO_FLBBCD, ECO_FLBBCD_AP2) fluorometers.

Actions:

SBS

- SBS is currently investigating whether a similar issue exists with the MCOMS CDOM fluorometer on Navis floats.
- SBS is working with the ocean optics community to develop a method to reconcile these ECO CDOM offsets such that contemporaneous and co-located deep profiles will yield values in QSDE ppb units that are globally comparable and regionally consistent. We will present our proposed correction methods to the BGC Argo community at upcoming AST & ADMT meetings.

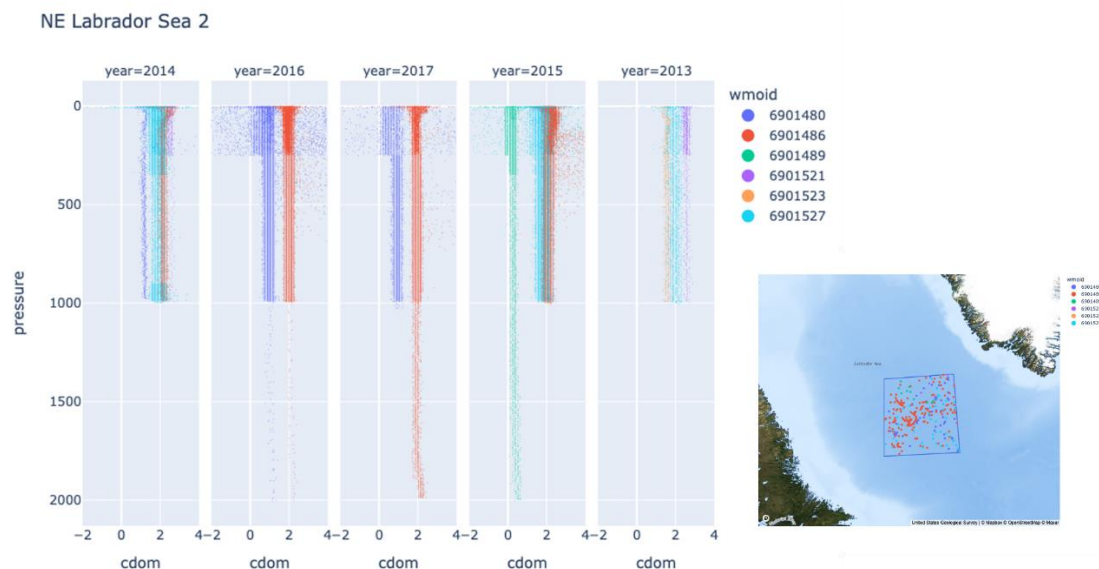


Figure 1. ECO CDOM profiles in the Labrador Sea show profile offsets among ECO FLBBCD fluorometers.

Customer

- No actions until correction methods are finalized.

3. Out-of-Tolerance UV LED in some ECO CDOM Fluorometers

What will you see in the data?

CDOM retrievals from some floats deployed in 2022-2023 were found to have reduced sensitivity. See **Figure 2** showing 2022-2023 CDOM profiles from PROVOR V JUMBO floats 4903634, 6904240, and 6904241 showing very little dynamic range compared to 2017 CDOM profiles from ECO CDOM fluorometers on PROVOR III floats 6901480 and 6901486 in the same region.

Root Cause: Upon investigation, Sea-Bird Scientific determined it received one lot of 370 nm UV LEDs that contained UV LEDs with the spectral and power characteristics outside of the manufacturer's tolerances for that part. ECO CDOM fluorometers built with LEDs from these lot(s) may contain out-of-tolerance LEDs. **CDOM is irretrievable from CDOM fluorometers built with out-of-tolerance UV LEDs.**

Sensors affected:

- ECO FLBBCD (ECO_FLBBCD, ECO_FLBBCD_AP2); affected S/N range TBD

The list of floats identified so far to have an ECO CDOM fluorometer with an out-of-tolerance UV LED are:



WMO ID	ECO S/N
6904240	7155
6904241	7208
4903634	7156
1902578	7204
5906970	7211
3902471	7342 ⁱⁱⁱ
2903783	7209
1902593	7001
4903657	7207

Actions:
SBS

- We are presently investigating the serial numbers of ECO FLBBCDs affected and will issue a subsequent advisory with the serial number range for this issue.
- We have instituted inspection of CDOM UV LEDs to ensure that spectral and power characteristics are within design tolerances.
- Sea-Bird is examining all BGC Argo CDOM profile data for deployments with ECO sensors built between 2021 and 2023 to identify any additional floats have been deployed with bad UV LEDs.

Customer

- If you have an undeployed an ECO FLBBCD sensor calibrated in 2022, please contact us at (support@seabird.com) so we can confirm if the UV LED is out-of-tolerance.

Argo

- Irretrievable CDOM data should be flagged with a quality control flag of '4' (bad data).

Caution: FDOM sensors use an UV LED light source. **Do not look directly at a UV LED when it is on. It can damage the eyes. Wear polycarbonate UV-resistant safety glasses to protect the eyes when a UV LED is on.**

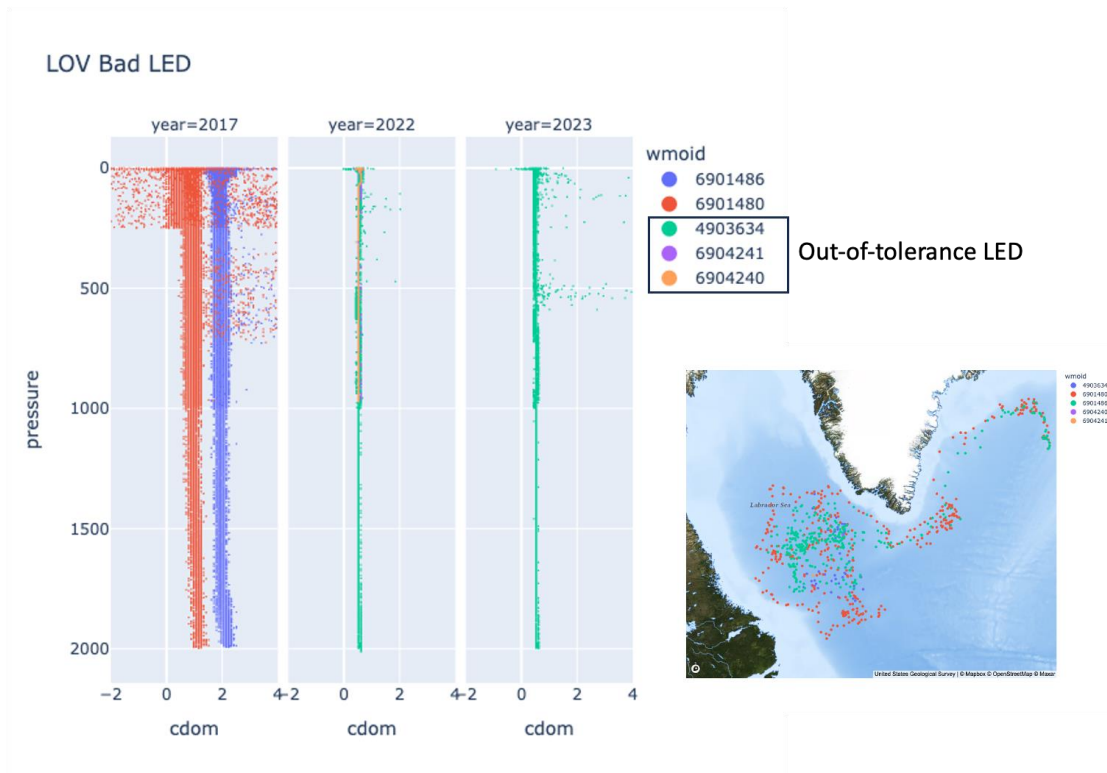


Figure 2. PROVOR III floats (left: 6901480, 6901486) with ECO FLBBCD (good UV LEDs) compared to recently deployed PROVOR V JUMBO floats (center, right: 4903634, 6904240, 6904241) with ECO FLBBCD (bad UV LEDs)

ⁱ Note that we have used the historical term CDOM (colored dissolved organic material), while the more accurate term is fDOM (fluorescent dissolved organic material), which itself is a subset of CDOM.

ⁱⁱ Hendry, K. R., Briggs, N., Henson, S., Opher, J., Brearley, J. A., Meredith, M. P., ... & Meire, L. (2021). Tracing glacial meltwater from the Greenland Ice Sheet to the ocean using gliders. *Journal of Geophysical Research: Oceans*, 126(8), e2021JC017274 <https://doi.org/10.1029/2021JC017274>

ⁱⁱⁱ Argo Sensor Serial Number metadata appears be incorrect for WMOID 3902471