RBR

RBRargo3 C.T.D, Field Service Bulletin Q1 2024 bis

Background

In January 2024, RBR discovered an inconsistency between salinity readings reported by an instrument while streaming and the salinity readings calculated by Ruskin with the downloaded data.

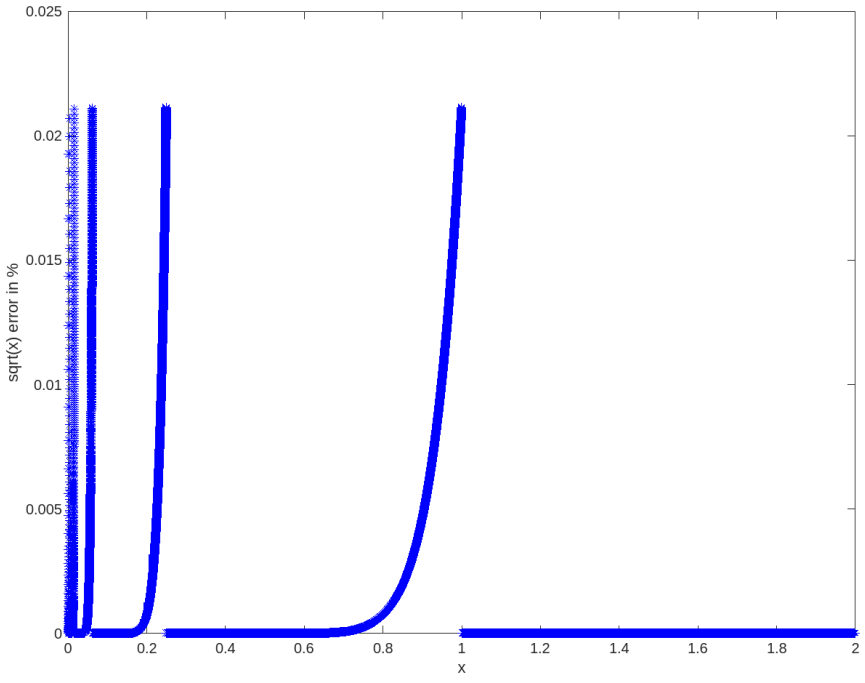
The root cause of the discrepancy between the onboard calculated and the Ruskin calculated salinity was quickly attributed to an approximation in the square root calculation onboard the instrument.

The maximum salinity discrepancy has been established to be less than 0.002, far from the Core Argo salinity accuracy requirements (+/- 0.010). This discrepancy only affects instruments streaming or being interfaced by a host controller, such as a float controller. The instruments' calibrations are unaffected. This does not affect salinity with dynamic correction.

Root cause investigation

Error in approximation of the square root function

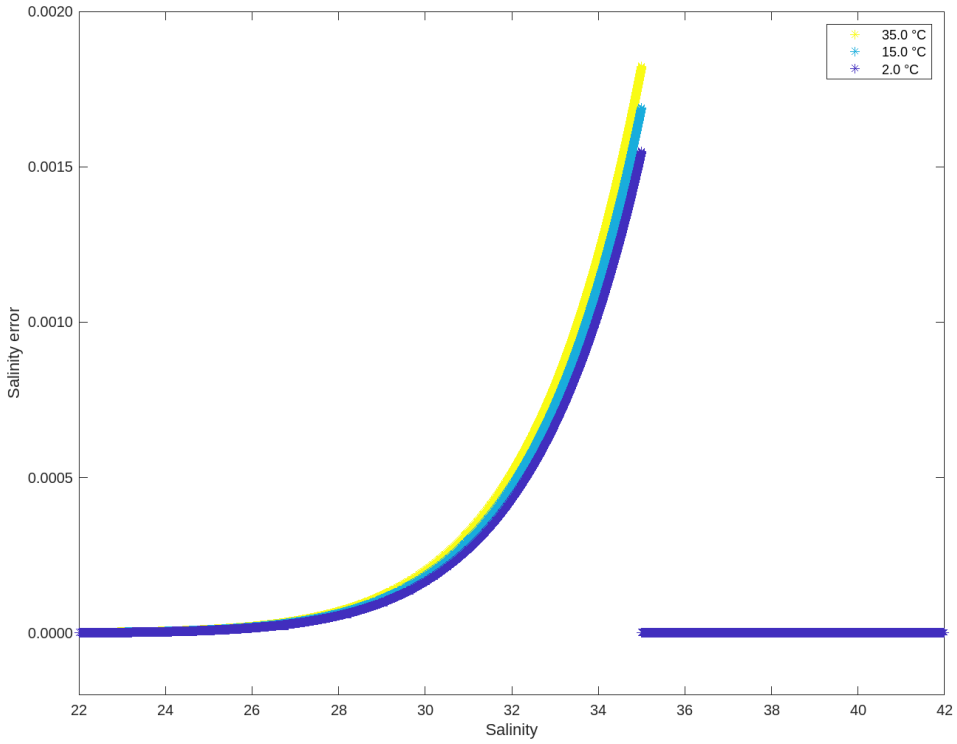
The root cause of the discrepancy was found in a square root C library that RBR has been using for the last ten years onboard instruments. At some particular values, the square root exhibits an error in its computation.



Error propagated to the salinity calculation

The square root function is used onboard the instrument to compute the Practical Salinity Scale 1978 equation (PSS-78).

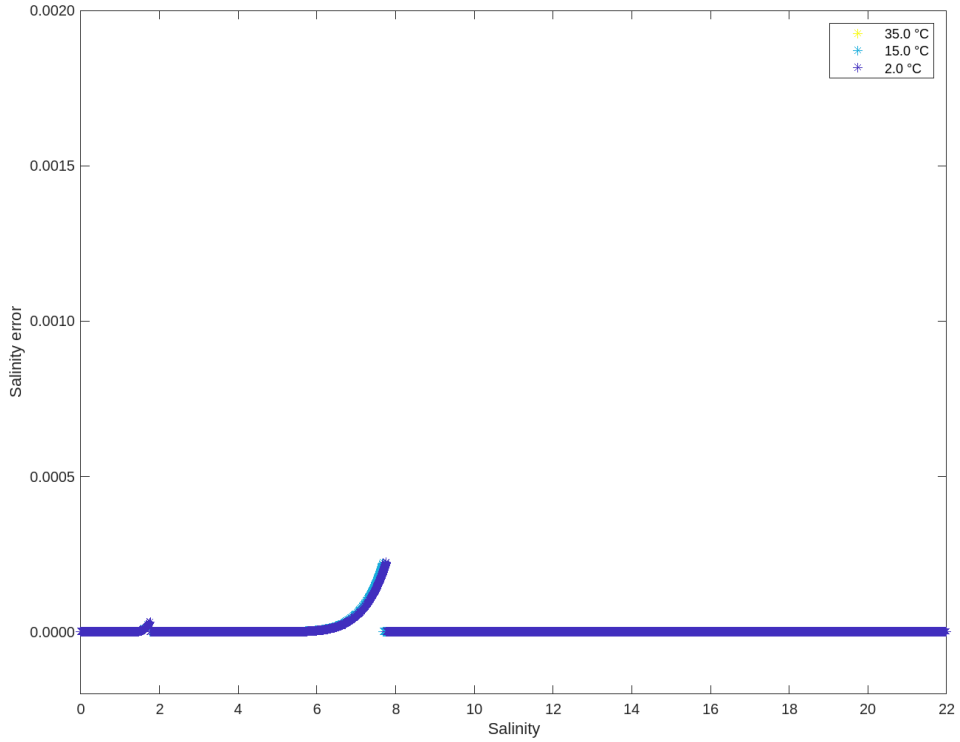
Simulations were run to estimate the maximum error induced by the square root approximation.



Given that the PSS-78 equation fundamentally derives salinity from the ratio of the sample conductivity at temperature to the conductivity of the standard seawater (S =35) at the same temperature, and because the square root approximation error is more significant on one side of unity, the propagated error in the PSS-78 equation is only on one side of salinity S= 35 in the range of salinities between 22 and 40. There is also a small dependence on temperature. No dependence on pressure was found.

Overall, the maximum error on the computed salinity was found to be around 0.0016 at 2.0°C and 0.0018 at 35°C.

At low salinities, as found in the Baltic Sea, the propagated error is less than 0.0003:



⚠ **This calculation error does not apply to the salinity with dynamic correction**. The square root function used for the salinity with dynamic correction has a different implementation and is not affected by this approximation error.

Postprocessing

It is possible to correct this error on shore if deemed necessary. A Python code snippet is shown below:

```
# Smeas salinity reported by the instrument
# Smeas_corrected salinity reported by the instrument corrected
Smeas_corrected=Smeas
correction=False
for idx, val in enumerate(Smeas):
    if correction == False:
        if val < 35.000:
            correction = True
    else:
        if val > 35.0018:
            correction = False
    if correction == True:
        error=(3.559e-10)*math.exp(0.4403*val)
        Smeas_corrected[idx]=val-error
```

Corrective and preventative actions

- RBR released a new firmware for RBR*argo*^{3} C.T.D to correct the original implementation of the square root in January 2024.
- RBR will assist the Argo community in every possible way to correct acquired data if deemed necessary.

Impact on the Argo program

RBR believes the impact on the Argo program is minimal. Simulation established the PSS-78's computational error to be less than 0.0019, worst case. This is well within the salinity accuracy specifications of the Core Argo program (+/- 0.010) and very close to the quantization level (0.001) used for salinity.

Continued RBR Support

RBR is committed to providing your company with the best product and service to help you achieve your goals. If you have any questions or concerns about the changes listed in this document, do not hesitate to contact us for help and information.

Revision Log

Rev	Revised by	Date	Description of Change
A	Jean-Michel Leconte	Mar 10, 2024	Initial release
B	Jean-Michel Leconte	Oct 20, 2025	Salinity with dynamic correction not affected