Rolling Deck to Repository (R2R)

Best Practices for Underway Transmissometers

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The R2R team envisioned starting near-real time (NRT) quality evaluation of underway parameters from flow-water systems

Determined that present data acquisition methods are not sufficiently standardized and metadata too inconsistent/hard to locate to facilitate NRT evaluation QC

Recommendations from R2R Advisory:

- Identify flow-water parameters in physical units desired by science
- R2R to work with operators [of underway systems] to establish procedures required to derive and distribute parameters in physical units to meet user requirements
- R2R to work with operators to further document flow-water instrumentation
Established in 2018

Started with underway transmissometers (all C-Star type in UNOLS)

Drafted best practices that include
  - Data to record and provide to users
  - Basic C-Star Calculations
  - Metadata to document devices
  - Cleaning and in-situ calibration
  - Installation
  - Storage between cruises

Seabird C-Star Transmissometers
(source: datasheet_cstar.pdf)
Data to Record

- What do science users want?
  - **Signal voltage (Vsig) or raw counts**
    - contingent upon device configuration
  - Used by science to calculate
    - Transmittance Ratio (Tr)
    - Beam Attenuation (c)

Calculated beam-c from an underway transmissometer for a cruise off the Oregon coast.
C-Star Calculations

Transmittance Ratio (Tr) =

\[ \frac{V_{\text{sig}} - V_{\text{darkS}}}{V_{\text{ref}} - V_{\text{d}}} \times \frac{V_{\text{air}} - V_{\text{d}}}{V_{\text{airS}} - V_{\text{darkS}}} \]

- $V_{\text{sig}}$ = recorded signal from instrument (in volts or counts)
- $V_{\text{darkS}}$ = dark (closed path) value from the Ship in-situ calibration
- $V_{\text{ref}}$ = clean water signal measured during Factory calibration
- $V_{\text{d}}$ = dark (closed path) value from the Factory calibration
- $V_{\text{air}}$ = air (open path, no water) value from the Factory calibration
- $V_{\text{airS}}$ = air (open path, no water) value from the Ship in-situ calibration
Beam Attenuation (c) = \(-1/z \times \ln(Tr)\)

- \(Tr\) = Transmittance Ratio
- \(z\) = instrument path length in meters (0.10 or 0.25)

- \(Tr\) typically reported in % rather than decimal
- \(Tr\) entered as a decimal to calculate \(c\) in units of \(m^{-1}\)
The following need to be provided to properly calculate transmittance ratio and beam attenuation from the signal voltage:

- **Reference voltage (Vref)** - From factory sensor calibration
- **Dark voltage (Vd)** - From factory sensor calibration
- **Open-air voltage (Vair)** - From factory sensor calibration
- **Dark voltage (VdarkS) and Open-air voltage (VairS)**
  - From routine shipboard in-situ cleaning and calibration
- **Beam path length (z in meters)**
Also useful to properly quality evaluate or apply observations to scientific activities are:

- **Wavelength of light used:** e.g., 650nm (red), 530nm (green), 470nm (blue), 715nm (infrared)
- **Instrument number (serial number from manufacturer)** - Traces the individual device to essential metadata
- **Technician name** - Who did the ship in-situ calibration?
- **A technician/engineering log** - Noting problems, cleanings, repairs, etc.
Calibration Recommendations

• **In-situ** $V_{\text{darkS}}$ and $V_{\text{airS}}$
  • Before and after each cruise
  • Or weekly as needed for science

• $V_{\text{airS}}$ and $V_{\text{darkS}}$ in-situ calibration and optics cleaning should occur whenever a device is installed/swapped

• **Factory Calibration**
  • Yearly as a minimum
  • This resets Vref
  • Operator should routinely provide factory calibration sheet with dataset
Cleaning Recommendations

• Cleaning optics
  • Before each cruise, prior to in-situ calibration for cruise
  • Or weekly as needed for science or environmental conditions
  • If dockside for more than 1 week, the optics should be cleaned and left dry until the next cruise

• Cleaning tubing
  • After each cruise, or for long duration cruises, every two weeks
  • Or as soon as biofouling is suspected
  • Never bleach sensors, bypass when ”pickling” underway system
Cleaning & In-situ Calibration Methods

• Best practice document provides
  • A list of recommended cleaning supplies
  • Step-by-step instructions for
    • optics cleaning
    • cleaning flow tubing
    • in-situ sensor calibration to determine $V_{\text{airS}}$ and $V_{\text{darkS}}$

• A second set of tubing helps with both turnaround and ensuring tubing has ample cleaning time prior to installation
Installation Recommendations

- Install a debubbler upstream of the transmissometer to reduce bubbles in the system.
- The flow-tube offered by SeaBird is recommended in conjunction with black tubing to decrease biofouling.
- Water should flow from bottom to top

Diagram of science sea-water system on R/V Armstrong
Storage Recommendations

- Conduct a fresh-water flush of the entire underway system to remove any seawater.
- Drain the system of all water.
- Follow the Cleaning Procedures as outlined.
- Re-assemble the system, clean and dry.
Summary

• Working group created draft Best Practices document for Underway Transmissometers

• Seeking input from RVTEC
  • Send feedback to srsmith@fsu.edu by 30 November 2019

• Once revised:
  • Encourage adoption of practices on U.S. research vessels
  • Document will be submitted to International Ocean Data Exchange best practices repository (https://www.oceanbestpractices.org/).
Thanks to the working group members, R2R Advisory Panel, and reviewers of the draft document.
Trouble with the Bubble & a good example of when a little bit of everything goes right and wrong...

**Good data, a few bubbles but fine, steady, reasonable total (0.12-0.4) and filtered (0.05-0.1 values)**

**Bad data, bubble city, noisy, unreasonable total (any value >1) values; filtered values not unreasonable but bubbles are still apparent spikes=bubble trouble**

**Good data, a few bubbles but fine, steady, reasonable total (~0.2); filtered values non-existent meaning issues with the filter, in this case no filter on the hour every hour**