NEON ALGORITHM THEORETICAL BASIS DOCUMENT (ATBD): TEMPERATURE AT SPECIFIC DEPTHS IN SURFACE WATER

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CHANGE RECORD

REVISION	DATE	ECO#	DESCRIPTION OF CHANGE
A	12/22/2017	ECO-05283	Initial Release
B	02/13/2020	ECO-06382	Update to temp chain lengths and thermistor locations to match ECO-06380

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1 DESCRIPTION

1.1 Description

Contained in this document are details concerning temperature at specific depths in surface water measurements made at NEON lake and river sites. Specifically, the processes necessary to convert "raw" sensor measurements into meaningful scientific units and their associated uncertainties are described. Temperature at specific depths will be continuously monitored by NEON at lake and river sites using a single sensor (PME T-Chain) with site specific geometries.

1.2 Purpose

This document details the algorithms used for creating NEON Level 1 data products for temperature at specific depths in surface water from Level 0 data, and ancillary data as defined in this document (such as calibration data) obtained via instrumental measurements made by the PME T-Chain. It includes a detailed discussion of measurement theory and implementation, appropriate theoretical background, data product provenance, quality assurance and control methods used, approximations and/or assumptions made, and a detailed exposition of uncertainty resulting in a cumulative reported uncertainty for this product.

1.3 Scope

The theoretical background and entire algorithmic process used to derive Level 1 data from Level 0 data for PME T-Chain is described in this document. The PME T-Chain employed is a single sensor with multiple digital temperature probes (3 to 10 sensors depending on water depth at the site), which is manufactured by Precision Measurement Engineering Inc.. This document does not provide computational implementation details, except for cases where these stem directly from algorithmic choices explained here.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

AD[01]	NEON.DOC.000001	NEON Observatory Design (NOD) Requirements
AD[02]	NEON.DOC.005003	NEON Scientific Data Products Catalog
AD[03]	NEON.DOC.002652	NEON Level 1, Level 2, and Level 3 Data Products Catalog
AD[04]	NEON.DOC.005005	NEON Level 0 Data Product Catalog
AD[05]	NEON.DOC.000782	ATBD QA/QC Data Consistency
AD[06]	NEON.DOC.011081	ATBD QA/QC Plausibility Tests
AD[07]	NEON.DOC.000783	ATBD De-spiking and time series analysis
AD[08]	NEON.DOC.000746	Evaluating Uncertainty (CVAL)
AD[09]	NEON.DOC.000785	TIS Level 1 Data Products Uncertainty Budget Estimation Plan
AD[10]	NEON.DOC.000751	CVAL Transfer of Standard Procedure
AD[11]	NEON.DOC.000927	NEON Calibration and Sensor Uncertainty Values [1]
AD[12]	NEON.DOC.001113	Quality Flags and Quality Metrics for TIS Data Products
AD[13]	NEON.DOC.005011	NEON Coordinate Systems Specification
AD[14]	NEON.DOC.004389	Temperature at specific depths in surface water ingest workbook
AD[15]	NEON.DOC.004390	Temperature at specific depths in surface water publication workbook
AD[16]	NEON.DOC.001152	Aquatic Sampling Strategy
AD[17]	NEON.DOC.003808	NEON Sensor Command, Control and Configuration (c3) Document: Buoy meteorological station and submerged sensor assembly
AD[18]	NEON.DOC.002651	NEON Data Product Numbering Convention

2.2 Reference Documents

RD[01]	NEON.DOC.000008	NEON Acronym List
RD[02]	NEON.DOC.000243	NEON Glossary of Terms

2.3 External References

External references contain information pertinent to this document, but are not NEON configuration-controlled. Examples include manuals, brochures, technical notes, and external websites.

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[1] Note that CI obtains calibration and sensor values directly from an XML file maintained and updated by CVAL in real time. This report is updated approximately quarterly such that there may be a log time between the XML and report updates.

ER[01]	RS232/RS485 T-CHAIN User's Manual

2.4 Acronyms

Acronym	Definition
AIS	Aquatic Instrument System
ATBD	Algorithm Theoretical Basis Document
CI	NEON Cyberinfrastructure
CVAL	NEON Calibration, Validation, and Audit Laboratory
DAS	Data Acquisition System
DP	Data Product
FDAS	Field Data Acquisition System
GRAPE	Grouped Remote Analog Peripheral Equipment
Hz	Hertz
L0	Level 0
L1	Level 1
QA/QC	Quality assurance and quality control

2.5 Variable Nomenclature

The symbols used to display the various inputs in the ATBD, e.g., calibration coefficients and uncertainty estimates, were chosen so that the equations can be easily interpreted by the reader. However, the symbols provided will not always reflect NEON's internal notation, which is relevant for CI's use, and or the notation that is used to present variables on NEON's data portal. Therefore a lookup table is provided in order to distinguish what symbols specific variables can be tied to in the following document.

Symbol	Internal Notation	Description
C_{T0}	CVALA0	Calibration coefficient for T-Chain sensor
C_{T1}	CVALA1	Calibration coefficient for T-Chain sensor
C_{T2}	CVALA2	Calibration coefficient for T-Chain sensor
$u_{A1,T}$	U_CVALA1	Combined, standard measurement uncertainty of the temperature measurement by T-Chain (celsius)
$u_{A3,T}$	U_CVALA3	Combined, standard calibration uncertainty of the temperature measured by the T-Chain sensor (celsius)

Table 1: List of PME T-Chain related L0 DPs that are transformed into L1 temperature at specific depths in surface water DPs in this ATBD.

fieldName	sampleFrequency	units	DPNumber
depth0WaterTemp	0.01667 Hz	celsius	NEON.DOM.SITE.DP0.20264.001.02887.HOR.VER.000
depth1WaterTemp	0.01667 Hz	celsius	NEON.DOM.SITE.DP0.20264.001.02888.HOR.VER.000
depth2WaterTemp	0.01667 Hz	celsius	NEON.DOM.SITE.DP0.20264.001.02889.HOR.VER.000
depth3WaterTemp	0.01667 Hz	celsius	NEON.DOM.SITE.DP0.20264.001.02890.HOR.VER.000
depth4WaterTemp	0.01667 Hz	celsius	NEON.DOM.SITE.DP0.20264.001.02891.HOR.VER.000
depth5WaterTemp	0.01667 Hz	celsius	NEON.DOM.SITE.DP0.20264.001.02892.HOR.VER.000
depth6WaterTemp	0.01667 Hz	celsius	NEON.DOM.SITE.DP0.20264.001.02893.HOR.VER.000
depth7WaterTemp	0.01667 Hz	celsius	NEON.DOM.SITE.DP0.20264.001.02894.HOR.VER.000
depth8WaterTemp	0.01667 Hz	celsius	NEON.DOM.SITE.DP0.20264.001.02895.HOR.VER.000
depth9WaterTemp	0.01667 Hz	celsius	NEON.DOM.SITE.DP0.20264.001.02896.HOR.VER.000
depth10WaterTemp	0.01667 Hz	celsius	NEON.DOM.SITE.DP0.20264.001.05516.HOR.VER.000

3 DATA PRODUCT DESCRIPTION

3.1 Variables Reported

The temperature at specific depths in surface water related L1 DPs provided by the algorithms documented in this ATBD are displayed in the accompanying file(s): Temperature at specific depths in surface water publication workbook (AD[14]).

3.2 Input Dependencies

3.3 Product Instances

One PME T-Chain will be deployed at each NEON lake or river site. T-Chain sensors will be suspended from buoys at lake and river sites. Data from each T-Chain will be sent to the Location Controller for ingest through wireless data transmission from a Campbell Scientific data logger located on the buoy (AD[17]).

3.4 Temporal Resolution and Extent

Measurement of temperature will occur once per minute with each digital temperature sensor reporting data simultaneously. The data will initially be stored on a Campbell Scientific data logger and transferred to the Location Controller every 15 minutes via a wireless radio communication.

Table 2: List of PME T-Chain thermistor depths (TD) in meters (m) at each site.

SITE	TD_1	TD_2	TD_3	TD_4	TD_5	TD_6	TD_7	TD_8	TD_9	TD_{10}	TD_{11}
SUGG-L	0.05	0.30	0.55	0.80	1.05						
BARC-L	0.05	0.30	0.55	0.80	1.05	1.3	1.55	2.05	2.55	3.05	
CRAM-L	0.05	0.75	1.75	2.50	3.45	4.25	5.15	6.85	8.55	10.25	
TOOK-L	0.05	1.00	1.75	3.50	5.25	7.00	8.75	10.50	12.25	14.00	15.75
PRPO-L	0.05	0.30	0.55	0.80	1.05						
PRLA-L	0.05	0.30	0.55	0.80	1.05	1.30	1.55	1.80	2.05		
LIRO-L	0.05	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	
BLWA-R	0.05	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	5.00	
TOMB-R	0.05	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	5.00	
FLNT-R	0.05										

3.5 Spatial Resolution and Extent

A T-Chain will be attached at the top to the buoy at lake and river NEON sites, which will be deployed at a deep area of the main basin in lakes and at a deep area outside of the navigation channel in rivers. The number and spacing of temperature sensors on the T-Chain will depend on the depth of the lake or river (e.g., Table: 2). The top temperature sensor will be deployed at a depth of 0.05 m and shaded from direct radiation at all lake and river sites. The rest of the temperature sensors will be approximately equidistant along the length of the chain. The total length of the T-Chain will be such that it remains above the bottom of the water body under foreseeable conditions and the bottom of the T-Chain will be weighted to keep the chain oriented vertically.

4 SCIENTIFIC CONTEXT

Water chemistry and aquatic communities are highly dependent on water temperature. Temperature profiles indicate whether or not the lake or river is thermally stratified, where the body of water is separated into two or more layers based on temperature (Figure 1). Typically, in a thermally stratified system, the top layer of water is warmer (epilimnion) while the lower layer is colder (hypolimnion). The area separating the two layers is known as the thermocline. The thermocline occurs when the rate of decreasing temperature with increasing depth is greatest, where there is a change of >1 degree celsius per 1.0 m change in depth (USEPA 2012). Thermal stratification can dramatically change the water chemistry and biology of each layer. Frequent (1 per minute) and 30-minute averages will be useful for determining the physical stratification status of lakes and rivers through time.

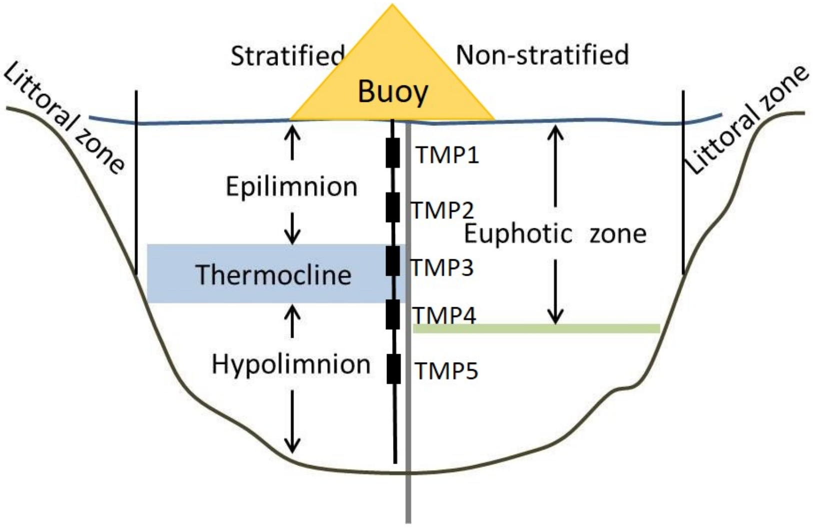

Figure 1: Diagram representing the zones in a thermally stratified and non-stratified lake

4.1 Theory of Measurement

The PME T-Chain is comprised of several matching digital temperature sensors (ER[01]). The T-Chain converts thermistor measurements to digital signals internally and is the only output option from the sensor. Obtaining raw analog signals are not possible from this sensor. Temperature is derived from the T-Chain, which uses a temperature dependent electrically resistive material coated in Inconel to maintain rapid response to changes in temperature. The sensor applies a fixed current within the circuit and monitors changes in voltage which are directly induced by the temperature dependence of the resistor. Empirically the voltage changes are correlated to water temperature values internally by the sensor prior to data output.

4.2 Theory of Algorithm

Surface water temperature at specific depths will be reported as the instantaneous 1-minute measurement and a 30-minute average. The instantaneous (0.01667 Hz) temperature will be determined accordingly to create additional L1 DPs:

$$T_{SW,i} = C_{T2} \cdot T_i^2 + C_{T1} \cdot T_i + C_{T0} \tag{1}$$

Where:

$T_{SW,i}$ = Surface water temperature (^{o}C)

C_{T2} = Calibration coefficient provided by CVAL ((^{o}C)$^{-1}$)

C_{T1} = Calibration coefficient provided by CVAL (unitless)

C_{T0} = Calibration coefficient provided by CVAL (^{o}C)

T_i = Individual (0.016667 Hz) temperature output from sensor (°C)

The instantaneous temperature measurements will be used to calculate the 30-minute average according to:

$$\overline{T_{30}} = \frac{1}{n}\sum_{i=x}^{n} T_{SW,i} \tag{2}$$

Where for each 30-minute averaging, n is the number of measurements in the averaging period and $T_{SW,i}$ is the surface water temperature calculated from the 1/60 Hz temperature measurement according to Equation 1 above during the 30-minute averaging period. For a 30-minute average, n = 30 if all points are included [0,30).

4.3 Special Considerations

Buoys will be deployed at 7 lake sites and 3 large river sites within NEON. These buoys are comprised of sensor sets which measure meteorological parameters over a water surface along with submerged sensors that measure physical and chemical parameters of the water body. Some of these sensors are unique to the buoy subsystem and others are shared with other NEON subsystems, such as the wadeable stream sensor sets. Due to power, space, and data storage constraints on the buoy, the configuration of sensors deployed on a buoy may be different than those in other parts of NEON. See AD[17] for more details about the configuration of all of the sensors deployed on the buoy.

5 ALGORITHM IMPLEMENTATION

Data flow for signal processing of the L1 DPs will be treated in the following order:

1. Calibration coefficients will be applied to instantaneous 1-minute surface water temperature (T_i) according to Equation 1.
2. QA/QC Plausibility tests will be applied to the T-Chain temperature data streams in accordance with AD[06]. The details are provided below.
3. Signal de-spiking will be applied to the T-Chain temperature data stream in accordance with AD[07].
4. Depth of the thermistors will be populated for 1-minute instantaneous measurements and 30-minute averages Table 2.
5. 30-minute averages will be calculated for surface water temperature at specific depths ($\overline{T_{30}}$), according to Equation 2.
6. Descriptive statistics, i.e. minimum, maximum, and variance, will be determined for 30-minute averages.
7. Quality metrics, quality flags, and the final quality flag will be produced for 30-minute averages according to AD[12].

QA/QC Procedure:

1. Plausibility Tests - All plausibility tests will be determined for surface water temperature (AD[06]), including the valid calibration check. Test parameters will be provided by AQU and maintained in the CI data store. All plausibility tests will be applied to the sensor's L0 DP and an associated quality flags (QFs) will be generated for each test.
2. Signal De-spiking and Time Series Analysis - The time series de-spiking routine will be run according to AD[07]. Test parameters will be specified by AQU and maintained in the CI data store. Quality flags resulting from the de-spiking analysis will be applied according to AD[07].
3. Placeholder for Consistency Analysis (see section 7 for future implementation).
4. Quality Flags (QFs) and Quality Metrics (QMs) AD[12] - If a datum fails one of the following tests it will not be used to create a L1 DP: range, step, null and gap. QFs and QMs will be determined using the flags in Table 3. In addition, L1 DPs will have a QA/QC report and quality metrics associated with each flag listed in Table 3 as well as a final quality flag, as detailed in AD[12]. Ancillary information needed for the algorithm and other information maintained in the CI data store is shown in Table 4.

6 UNCERTAINTY

Uncertainty of measurement is inevitable; therefore, measurements should be accompanied by a statement of their uncertainty for completeness (JCGM 2008; Taylor 1997). To do so, it is imperative to identify all sources of measurement uncertainty related to the quantity being measured. Quantifying the uncertainty of AIS measurements will provide a measure of the reliability and applicability of individual measurements and AIS data products. This portion of the document serves to identify, evaluate, and quantify sources of uncertainty relating to individual, calibrated surface water temperature measurements as well as L1 mean surface water temperature DPs. It is a reflection of the information described in AD[11], and is explicitly described for the in-Situ T-Chain in the following sections.

Table 3: Flags associated with PME T-Chain measurements

Tests
Range
Step
Null
Gap
Valid Calibration
Signal Despiking
Alpha
Beta
Final Quality Flag

Table 4: Information maintained in the CI data store for PME T-Chain

Tests/Values	**CI Data Store Contents**
Range	Minimum and maximum values
Step	Threshold values
Null	Test limit
Gap	Test limit
Valid Calibration	CVAL sensor specific valid calibration date range
Signal Despiking	Time segments and threshold values
Calibration	CVAL sensor specific calibration coefficients
Uncertainty	AD[09]
Final Quality Flag	AD[12]

6.1 Uncertainty of temperature at specific depths in surface water measurements

Uncertainty of the PME T-Chain assembly is discussed in this section. The section is broken down into two topics. The first informs the sources of measurement uncertainty, i.e., those associated with individual temperature measurements. The second details uncertainties associated with temporally averaged data products. A diagram detailing the data flow and known sources of uncertainty are displayed in Figure 2.

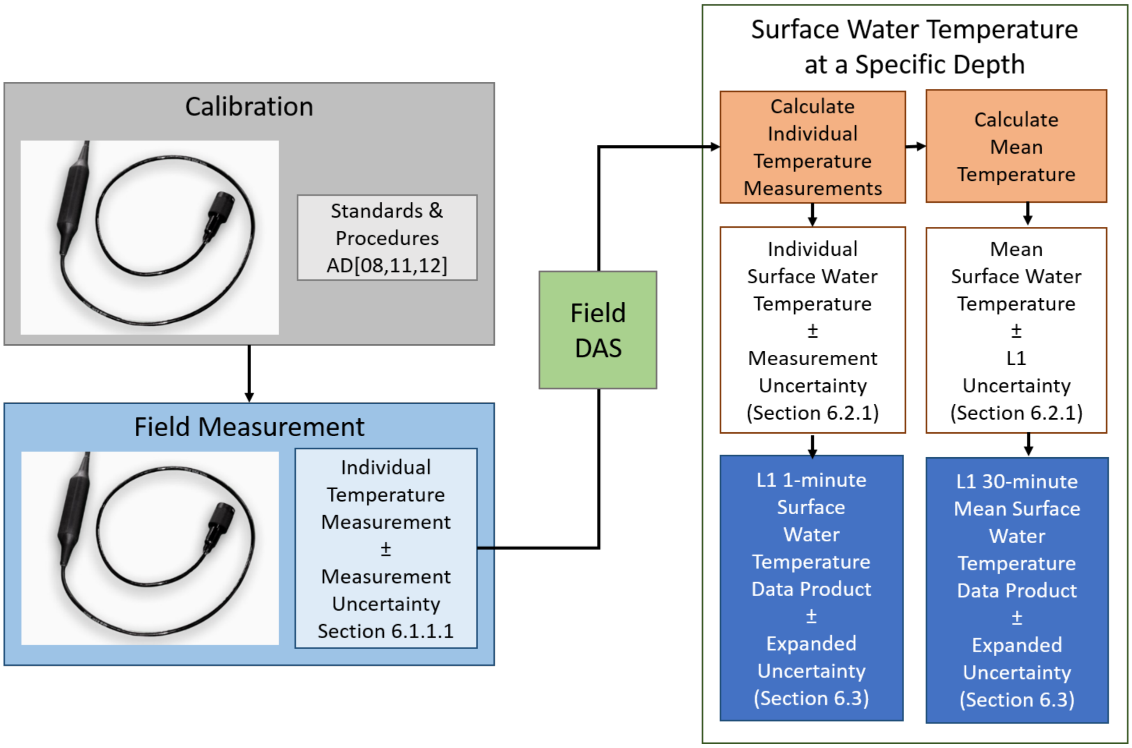

Figure 2: Data flow and associated uncertainties of individual measurements for temperature at specific depths in surface water and associated L1 DPs.

6.1.1 Measurement Uncertainty

The following subsections present the uncertainties associated with individual observations. It is important to note that the uncertainties presented in the following subsections are measurement uncertainties, that is, they reflect the uncertainty of an individual measurement. These uncertainties should not be confused with those presented in Section 6.1.2. We urge the reader to refer to AD[11] for further details concerning the discrepancies between quantification of measurement uncertainties and L1 uncertainties.

NEON calculates measurement uncertainties according to recommendations of the Joint Committee for Guides in Metrology (JCGM) 2008. In essence, if a measurand y is a function of n input quantities $x_i (i = 1, ..., n)$, i.e., $y = f(x_1, x_2, ..., x_n)$, the combined measurement uncertainty of y, assuming the inputs are independent, can be calculated as follows:

$$u_c(y) = \left(\sum_{i=1}^{N} \left(\frac{\partial f}{\partial x_i} \right)^2 u^2 \left(x_i \right) \right)^{\frac{1}{2}} \tag{3}$$

where

$\frac{\partial f}{\partial x_i}$ = partial derivative of y with respect to x_i

$u \left(x_i \right)$ = Combined uncertainty of x_i

Thus, the uncertainty of the measurand can be found be summing the input uncertainties in quadrature. For surface water temperature measurements, the sources of uncertainty are discussed below.

6.1.1.1 DAS

The In-Situ T-Chain sensors each have an internal Analog to Digital (A/D) converter and outputs data in digital form. Therefore, no data conversions occur within the DAS, and uncertainty introduced by the DAS can be considered negligible.

6.1.1.2 Calibration

Uncertainties associated with the calibration process of the T-Chain for surface water temperature at specific depth measurements will be provided by CVAL as individual standard combined uncertainty values. These uncertainties $u_{A1,T}$ (see Section 2.5) represent i) the repeatability and reproducibility of the sensor and the lab DAS and ii) uncertainty of the calibration procedures and coefficients including uncertainty in the standard (truth). Both are constant values that will be provided by CVAL, stored in the CI data store, and applied to all individual temperature measurements (that is, the uncertainty values do not vary with any specific sensor, DAS component, etc.). A detailed summary of the calibration procedures and corresponding uncertainty estimates can be found in AD[10] and AD[11].

6.1.1.3 Combined Measurement Uncertainty

Because the only known quantifiable uncertainties are those provided by CVAL, the combined uncertainty of temperature is simply equal to the standard uncertainty values provided by CVAL (See Section 2.5).

$$u_c(y) = u_{A1,T} \tag{4}$$

where

$u_{A1,T}$ = Combined, standard measurement uncertainty of the temperature measurement

6.1.2 Uncertainty of the L1 Mean Data Products

The following subsections discuss uncertainties associated with temporally averaged, i.e., L1 mean data products. As stated previously, it is important to note the differences between the measurement uncertainties presented in Section 6.1.1 and the uncertainties presented in the following subsections. The uncertainties presented in the following subsections reflect the uncertainty of a time-averaged mean value, that is, they reflect the uncertainty of a distribution of measurements collected under non-controlled conditions (i.e., those found in the field), as well as any uncertainties in the form of Truth and Trueness related to the accuracy of the field assembly.

6.1.2.1 Repeatability (Natural Variation)

To quantify the uncertainty attributable to random effects, the distribution of the individual measurements is used. Specifically, the estimated standard error of the mean (natural variation) is computed. This value reflects the repeatability of measurements for a specified time period:

$$u_{NAT}(\overline{T_{SW}}) = \sqrt{\frac{\sigma^2}{n}} \tag{5}$$

where

$u_{NAT}(\overline{T_{SW}})$ = standard error of the mean (natural variation)

σ = experimental standard deviation of individual observations for a defined time period

n = number of observations made during the defined period

6.1.2.2 Calibration

The calibration uncertainty for a L1 mean DP is similar to that described in Section 6.1.1.1. However, the uncertainties provided by CVAL (see Section 2.4) do not account for i) individual sensor repeatability, or ii) the variation of sensors' responses over a population (reproducibility). These components estimate the uncertainties due to the accuracy of the instrumentation in the form of Truth and Trueness, a quantity that is not captured by the standard error of the mean. Both values are constant values that will be provided by CVAL and stored in the CI data store. Please refer to AD[10] for further justification regarding evaluation and quantification of this combined uncertainty.

6.1.2.3 Combined Uncertainty

The combined uncertainty for L1 temperature at specific depths in surface water are computed by summing the uncertainties from Section 6.1.2.1 and the CVAL provided uncertainties in quadrature:

$$u_c(\overline{T_{SW}}) = \left[u^2_{NAT}(\overline{T_{SW}}) + u^2_{A3,T}\right]^{\frac{1}{2}} \tag{6}$$

6.2 Expanded Uncertainty

We assume the measurement variability is normally distributed (Gaussian). The combined uncertainty represents plus or minus one standard deviation or a confidence interval of 68%. This confidence level is below the industry standard and is therefore expanded to a 95% confidence interval. This is typically calculated by multiplying the combined uncertainty, $u_{c,r}(y)$, by a coverage factor, k_p.

$$U_p = k_p u_{c,r}(y) \tag{7}$$

We can conservatively estimate the expanded uncertainty at a 95% confidence level to be two times the combined uncertainty.

$$U_{Expanded} = 2 \times u_c \tag{8}$$

This expansion is to be applied to all combined uncertainties for the L1 DP described herein.

6.3 Communicated Precision

The accuracy of the temperature chain sensor is +/- 0.010 Celsius. As such, the communicated precision of L1 temperature at specific depths data will be 0.01 Celsius.

Table 5: Uncertainty budget for individual measurements. Shaded rows denate the order of uncertainty propagation (from lightest to darkest).

Source of Measurement Uncertainty	**Measurement Uncertainty Component $u(x_i)$**	**Measurement Uncertainty Value**	$\frac{\partial f}{\partial x_i}$	$u_{x_i}(Y) \equiv \lvert\frac{\partial f}{\partial x_i}\rvert u(x_i)$
Temperature	$u_{A1,T}$	AD[11]	n/a	n/a

Table 6: Uncertainty budget for L1 mean DPs. Shaded rows denate the order of uncertainty propagation (from lightest to darkest).

Source of Measurement Uncertainty	**Measurement Uncertainty Component $u(x_i)$**	**Measurement Uncertainty Value**	$\frac{\partial f}{\partial x_i}$	$u_{x_i}(Y) \equiv \lvert\frac{\partial f}{\partial x_i}\rvert u(x_i)$
Temperature	$u_c(\overline{T}_{SW})$	Equation 6	n/a	n/a
Calibration	$u_{A3,T}$	AD[11]	n/a	n/a
Natural Variation	$u_{NAT}(\overline{T}_{SW})$		n/a	n/a

6.4 Uncertainty Budget

The uncertainty budget is a visual aid detailing i) quantifiable sources of uncertainty, ii) means by which they are derived, and iii) the order of their propagation. Uncertainty values denoted in this budget are either derived within this document or are provided by other NEON teams (e.g., CVAL), and stored in the CI data store (Tables 5 & 6).

Table 7: Linking L0 data streams (terms) to L1 thermistor depth attributes. Assume ”NEON.DOM.SITE” and ”HOR” are identical within each row

L0 term	L0 data product	L1 data product
depth0WaterTemp	DP0.20264.001.02887.HOR.VER.000	DP1.20264.001.03375.HOR.501.001
depth1WaterTemp	DP0.20264.001.02888.HOR.VER.000	DP1.20264.001.03375.HOR.502.001
depth2WaterTemp	DP0.20264.001.02889.HOR.VER.000	DP1.20264.001.03375.HOR.503.001
depth3WaterTemp	DP0.20264.001.02890.HOR.VER.000	DP1.20264.001.03375.HOR.504.001
depth4WaterTemp	DP0.20264.001.02891.HOR.VER.000	DP1.20264.001.03375.HOR.505.001
depth5WaterTemp	DP0.20264.001.02892.HOR.VER.000	DP1.20264.001.03375.HOR.506.001
depth6WaterTemp	DP0.20264.001.02893.HOR.VER.000	DP1.20264.001.03375.HOR.507.001
depth7WaterTemp	DP0.20264.001.02894.HOR.VER.000	DP1.20264.001.03375.HOR.508.001
depth8WaterTemp	DP0.20264.001.02895.HOR.VER.000	DP1.20264.001.03375.HOR.509.001
depth9WaterTemp	DP0.20264.001.02896.HOR.VER.000	DP1.20264.001.03375.HOR.510.001
depth9WaterTemp	DP0.20264.001.05516.HOR.VER.000	DP1.20264.001.03375.HOR.511.001

7 Publication of Named Location Attributes

Since the temperature chain is installed at one “named location” and it is one “data generating device (DGD)”, the actual depth of the thermistors will need to be stored as attributes of the named location rather than as the location of the named location. Each thermistor depth is an individual property of the named location of the thermistor string. On publication the appropriate location will be populated in the publication table based on the “VER” component of the data product number (Table 7).

8 FUTURE PLANS AND MODIFICATIONS

Future system flags may be incorporated into the data stream and included in the QA/QC summary DP ($Qsum_{1min}$) that summarizes any flagged data that went into the computation of the L1 DP. There is a plan to add in a final quality flag and associated alpha and beta quality metrics to the 1-minute data table in the future.

It is planned that a QA/QC flag for data consistency will be applied according to a developed consistency analysis (AD[06]) and a pass/fail flag will be generated to reflect this activity. Temperature measurements from each thermistor along the T-Chain at a given NEON aquatic site will have the time series data compared against the measurements at other thermistor depths along the same chain. If a difference between the measurements is less than the defined limits, provided by AQU and maintained in the CI data store, then the sensor will have passed the consistency analysis. Alternatively, a difference outside the defined limits will result in a failed test, and will be flagged as such. L1 DPs that fail the consistency analysis will continue to be reported, but will have an associated failed flag that will be include in the QA/QC summary.

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