Data Article

Sub-hourly water temperature data collected across the Nechako Watershed, 2019-2021

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A B S T R A C T

Water temperature is actively being monitored along the regulated Nechako River and some of its unregulated tributaries in northern British Columbia (BC) to determine how climate variability, climate change and flow regulation influence water temperatures. The Nechako Watershed, located mainly in the sub-boreal spruce biogeoclimatic zone, spans 47,200 km² in area [1]. The regional climate experiences a prominent seasonal cycle in air temperature and precipitation, with subfreezing temperatures and snow accumulating during winter. Waterways therefore experience extended near 0°C water/ice temperatures during the winter season. The accumulation of snow yields snowmelt-generated peaks in discharge during the spring freshet period in unregulated tributaries [2]. Regional studies on climate reveal recent warming trends that are anticipated to persist through the 21st century, with a projected mean air temperature increase of ~2°C by the 2050’s [3]. In response to warming air temperatures, regional water temperatures are also on the rise, with an average warming trend of 0.7°C from 1950 to 2015 [4]. Changing water temperatures are important in understanding ecological and environmental impacts on riverine systems, including aquatic species such as fish (e.g., sockeye salmon (*Oncorhynchus nerka*), rainbow trout (*Oncorhynchus mykiss*) and white sturgeon (*Acipenser transmontanus*), all endemic

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species to the Nechako Watershed), invertebrates, and microorganisms. Managing water temperatures during the fish spawning season is crucial as elevated temperatures induce stress and affect reproduction success [5].

Starting with a pilot project in summer of 2019, we expanded in situ monitoring of water temperature to 29 sites; however, for the purposes of this paper, only data from 24 sites are included (some sites have limited data samples or loggers could not be retrieved in the field). Currently, 25 sites are fully operational and collecting data, all deployed to sample and record data at 15-minute intervals starting at the top of the hour. Site data collection occurs at minimum once annually (typically during summer/early fall), along with site and logger maintenance. Field notes are taken to identify any potential issues with data collection, such as loggers dewatering during low flows, duration of logger removal for data collection, and any other environmental concerns that should later be considered during data analysis.

The assembled data are useful to build long-term time series of observed water temperatures within the Nechako Watershed and as a baseline for future projects. The data are also used to determine the effectiveness of the Summer Temperature Management Program at the Nechako Reservoir and Skins Lake Spillway [1]. Therefore, these data can be used in the future to better identify the optimal discharge from the reservoir to minimize ecological effects on the watershed.

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**Specifications Table**

| Subject | Hydrology and Water Quality |
|---------|-----------------------------|
| Specific subject area | Time series of sub-hourly water temperatures across the Nechako Watershed. |
| Type of data | CSV, Figure, Table |
| How the data were acquired | Data were acquired using water temperature loggers submerged in lakes, rivers and creeks to continuously record and collect water temperature data. |
| Data format | Raw, Analyzed, Filtered |
| Description of data collection | Temperature and date/time data were collected from 24 temperature loggers deployed throughout the Nechako Watershed between 2019 and 2021. Loggers were submerged on stream beds usually in or near the thalweg in creeks/rivers to minimize probability of loggers resurfacing during dry periods. In lakes, loggers were deployed in the epilimnion layer to a depth of about 1 to 2 m. All loggers were set to sample and record data at 15-minute intervals starting at the top of the hour [6,7,8]. |
| Data source location | • Institution: University of Northern British Columbia  
• City/Region: Nechako Watershed  
• Country: Canada  
• Latitude and longitude (and GPS coordinates, if possible) for collected samples/data: See Table 1 |
| Data accessibility | Repository name: Zenodo  
Data identification number: 10.5281/zenodo.6426024 |
| Direct URL to data | https://doi.org/10.5281/zenodo.6426024 |
| Related research article | None |
Value of the Data

- These data provide spatial and temporal water temperature values for select locations in the Nechako Watershed, including numerous tributaries and the main stem Nechako River.
- The data are beneficial to policy makers for the implementation of regulations to better manage water temperatures in response to rising air temperatures, especially during intense summer heat waves. The data also assist in developing strategies, such as the Summer Temperature Management Program, to alter the Skins Lake Spillway discharge to effectively reduce water temperatures during important ecological events such as sockeye salmon migration and spawning.
- These data can be reused to continuously expand existing water temperature time series to identify the effects of climate change in the watershed. The data can also be used to validate water temperature data collected by others in the area to build a higher level of confidence, and to calibrate/validate numerical models.

1. Data Description

The data described contain date/time stamps and corresponding temperature data recorded by water temperature loggers. Due to daylight savings, all data have been adjusted to UTC to accurately develop a time series and to have ubiquitous, comparable temperature data between sites throughout the watershed. A total of 25 sites (Fig. 1) are currently being monitored throughout the Nechako Watershed, with data being available for 24 of the sites (Table 1).

All water temperature times series are available through Zenodo (https://doi.org/10.5281/zenodo.6426024) in addition to a map of the study area and detailed metadata including coordinates, elevation, period of record and site visits in a “read me” text file. Data are provided in comma-delimited format (.csv) with one file for each site covering the period of record. Each file name identifies the site location. The first column contains the date/time (UTC) in the format MM/DD/YEAR HH:MI. The second column contains the corresponding water temperature in °C to two decimals. The third column contains a recommended flag for data quality, with “P” representing a “pass”, “F” denoting a “fail”, and “B” denoting “backwater conditions” with the likely presence of ice and below freezing temperatures.

2. Experimental Design, Materials and Methods

Water temperature data were obtained from 24 sites within the Nechako Watershed, including major tributaries draining into the main stem Nechako River and several locations along the Nechako River itself, down to its confluence to the Fraser River (Fig. 1 and Table 1). These sites were chosen from the headwaters through to the confluence of the Nechako and Fraser rivers to build an understanding of how water temperatures fluctuate across the watershed. Deployment locations were selected with consideration to the proximity of current or former Water Survey of Canada hydrometric gauges. This was effectively done to help calibrate, compare, and increase the confidence of these loggers and their collected data. Accessibility was also considered for site deployment to facilitate data retrieval at any time of year, if required.

Data are acquired using Onset HOBO Pendant® MX2201 Water Temperature Data Loggers [9] and Onset HOBO 64K Pendant® Temperature/Alarm (Waterproof) Data Loggers [10]. The MX2201 Data Loggers operate on firmware version 140.59 and maintain an operating accuracy of ±0.5°C and a resolution of 0.04°C, while the 64K Pendant Data Loggers operate on firmware 1.17 and have an operating accuracy of ±0.53°C and a resolution of 0.14°C. Both logger types support a typical operating range of -20°C to 50°C in water/ice. Data sampling and recording rate is set to 15 minute time intervals, starting at the top of the hour. Data are collected at minimum once a year from these loggers and routine maintenance is carried out to ensure their continued efficiency, such as regular battery changes and clearing logger memory after downloading data.
Fig. 1. Locations of all 25 active water temperature loggers in the Nechako Watershed. Consult Table 1 for site identification codes.

For their deployment, data loggers are secured inside a PVC housing containing numerous openings to allow water to flow freely within the housing (Fig. 2). This system is securely fastened to a cinder block with a hose clamp through two holes drilled in the cinder block. Plastic coated metal wire is hooked into the cinder block and PVC housing, which is then connected to a sturdy structure (trees, boulders, sturdy rebar) on shore for easy retrieval (Fig. 2). This system
Table 1
Currently active water temperature sites in the Nechako Watershed.

| Water Temperature Logger Site Name | Site Code | Latitude | Longitude | Elevation (m) | Data Period (m/d/y) |
|------------------------------------|-----------|----------|-----------|---------------|---------------------|
| Chedakuz Creek above Nechako Reservoir | CNR | 53° 19’ 17.4” N | 124° 44’ 35.3” W | 923 | 8/13/2020 - 7/30/2021 |
| Chelsatta Lake above Sather Creek | CSC | 53° 44’ 52.8” N | 125° 27’ 16.7” W | 786 | 7/31/2020 - 9/2/2021 |
| Chiilako River above Nechako River | CNE | 53° 46’ 54.2” N | 122° 59’ 20.8” W | 618 | 7/9/2020 - 7/26/2021 |
| Chiilako River below Tatuk Lake | CTL | 53° 30’ 55.9” N | 123° 59’ 17.8” W | 838 | 8/13/2020 - 8/19/2021 |
| Endako River above Stellako River | ESR | 54° 04’ 52.0” N | 125° 00’ 13.7” W | 672 | 11/12/2020 - 6/27/2021 |
| Kasalka Creek above Tahtsa Lake | KTL | 53° 38’ 49.6” N | 127° 08’ 28.2” W | 861 | No data yet |
| Kazhek Creek above Middle River | KMR | 54° 53’ 20.6” N | 125° 10’ 01.4” W | 722 | 7/17/2020 - 6/29/2021 |
| Kuzkwa River below Tezzeron Lake | KTE | 54° 47’ 50.1” N | 124° 41’ 34.0” W | 754 | 7/16/2020 - 6/29/2021 |
| Laventie Creek above Tahtsa Lake | LTL | 53° 39’ 20.0” N | 127° 32’ 17.7” W | 861 | 7/30/2020 - 8/12/2021 |
| Middle River above Trembleur Lake | MTL | 54° 52’ 45.4” N | 125° 08’ 32.4” W | 716 | 7/17/2020 - 6/29/2021 |
| Nadina River above Francois Lake | NFL | 53° 58’ 1.0” N | 126° 51’ 50.7” W | 844 | 7/30/2020 - 10/5/2021 |
| Nechako River above Cluculz Creek | NCC | 53° 59’ 03.1” N | 123° 37’ 54.1” W | 632 | 7/13/2019 - 7/13/2021 |
| Nechako River at Miworth | NMI | 53° 57’ 23.0” N | 122° 55’ 43.7” W | 579 | 7/9/2020 - 9/30/2021 |
| Nechako River off Dellwood Road | NDR | 53° 59’ 8.4” N | 123° 49’ 39.0” W | 638 | 7/13/2019 - 7/13/2021 |
| Necoslie River above Stuart Lake | NSL | 54° 24’ 35.0” N | 124° 14’ 07.2” W | 686 | 7/17/2020 - 6/28/2021 |
| Otter Creek below Finger Lake | OFL | 53° 33’ 10.1” N | 124° 17’ 20.2” W | 927 | 6/3/2020 - 9/25/2021 |
| Pinchi Creek above Stuart Lake | PSL | 54° 34’ 36.3” N | 124° 29’ 32.3” W | 703 | 7/16/2020 - 6/28/2021 |
| Rhine Creek above Sweeney Creek | RSC | 53° 41’ 56.8” N | 127° 16’ 24.2” W | 902 | 8/24/2020 - 10/29/2021 |
| Skins Lake Spillway | SLS | 53° 46’ 29.7” N | 125° 59’ 30.1” W | 839 | 8/12/2019 - 9/4/2020 |
| Stellako River above Fraser Lake | SFL | 54° 04’ 55.8” N | 125° 00’ 19.1” W | 680 | 11/12/2020 - 8/23/2021 |
| Stuart River above Nechako River | SNR | 54° 09’ 54.5” N | 123° 37’ 43.3” W | 670 | 7/8/2020 - 6/8/2021 |
| Tachie River above Stuart Lake | TSL | 54° 42’ 12.0” N | 124° 47’ 50.0” W | 685 | 7/16/2020 - 6/29/2021 |
| Tsilcoh River above Pinchi Lake | TPL | 54° 36’ 39.0” N | 124° 14’ 46.7” W | 733 | 7/17/2020 - 6/28/2021 |
| Whitesail Creek above Tahtsa Lake | WTL | 53° 41’ 43.7” N | 126° 59’ 07.4” W | 866 | 7/30/2020 - 8/12/2021 |
| Whiting Creek | WHC | 53° 43’ 7.3” N | 127° 07’ 43.0” W | 988 | 9/18/2021 - 10/29/2021 |

is then deployed in deep sections of a water body, such as the thalweg or deep portion of a lake, typically at a depth of 1-2 m on deployment in rivers/creeks/lakes.

Data filtering and analysis were performed using RStudio version 3.6.1 by initially plotting all of the sites (date/time vs. water temperature) to visually analyse for errors or gaps in the data. Statistical analyses (subsequent temperature difference, rolling mean, rolling standard deviation, etc.) were applied to identify erroneous data and time spans when loggers were retrieved for maintenance and data download. Flags (“P” = Pass, “B” = Icing, “F” = Fail) were added onto every data point based on the statistical criteria (Table 2) to allow for easy filtering of erroneous or uncertain data for further analysis. Data values were assigned a fail flag when the recorded
temperature changed more than \(\pm 0.8^\circ C\) from the previous or following data point, had a rolling mean value difference greater than or equal to \(\pm 1.5^\circ C\), a rolling standard deviation greater than or equal to \(\pm 2^\circ C\), or a temperature greater than or equal to 30\(^\circ C\) (Table 2). These statistical tests were developed based on literature recommendations [6,7,8] and criteria values were chosen based on visual data analysis. Icing (B) flags were applied to any data below 0\(^\circ C\). Loggers have surfaced in the past following dry periods/low flows or following ice melt, resulting in data uncertainty as it can be difficult to pinpoint when the logger surfaced. In this case, visual data analysis was done to identify when loggers may have surfaced, and those data were then either flagged for uncertainty (F) when dewatering was obvious from the data or noted in the associated “read me” file. Data points that did not obtain an “F” or “B” flag are considered reliable data, and where assigned a “P” flag.

To create a complete time series for each site, missing date/time stamps were filled in to avoid temporal gaps in the data and were assigned an ‘NA’ value for their temperature. Flags were assigned given our knowledge of site events and potential disturbances, as well as the selected statistical analysis and criteria. However, these flags are subjective and identify many erroneous data, but may also flag good data and miss other erroneous data points. Judgement and caution should therefore be applied when analyzing these data and the flagging is only meant to provide recommendations on data quality.

![Image of PVC pipe system with an Onset HOBO Pendant® MX2201 Water Temperature data logger secured to the cap. Right: Standard logger PVC pipe system housed and secured to a cinder block, attached to a rebar stake.](image)

**Fig. 2.**

**Table 2** Statistical formulas used to flag erroneous water temperature data.

| Statistical Analysis          | Formula\(^a\)                                                                 | Flanging Criteria |
|-------------------------------|-------------------------------------------------------------------------------|-------------------|
| Lagging Temperature Change    | \(TC_{lag} = |T1 - T2|\)                                                                 | F if \(\geq 0.8^\circ C\) |
| Leading Temperature Change    | \(TC_{lead} = |T2 - T3|\)                                                                 | F if \(\geq 0.8^\circ C\) |
| Rolling Mean Right            | \(MR6 = |T6 - \left(\frac{T1+T2+\ldots+T5}{5}\right)|\)                           | F if \(\geq 1.5^\circ C\) |
| Rolling Mean Left             | \(ML6 = |T6 - \left(\frac{T7+T8+\ldots+T11}{5}\right)|\)                           | F if \(\geq 1.5^\circ C\) |
| Rolling Standard Deviation Right | \(SDR3 = \sqrt{\frac{\sum (T_i - (T1+T2+T3))^2}{3}}\)                   | F if \(\geq 2^\circ C\) |
| Rolling Standard Deviation Left | \(SDL3 = \sqrt{\frac{\sum (T_i - (T4+T5+T6))^2}{5}}\)                   | F if \(\geq 2^\circ C\) |

\(^a\) Abbreviations are as follows: TC – temperature change, MR – mean right, ML – mean left, SDR – standard deviation right, SDL – standard deviation left.
Ethics Statements

The authors declare there are no ethical issues with the data presented or methods used.

CRediT Author Statement

Derek Gilbert: Formal Analysis, Investigation, Data curation, Writing – original draft; Jeremy Morris: Conceptualization, Methodology, Resources, Investigation, Data curation; Anna Kaveney: Investigation, Data curation; Stephen Déry: Project administration, Funding acquisition, Supervision, Visualization, Writing – review & editing, Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Sub-hourly water temperature data collected by UNBC’s northern hydrometeorology group (NHG) across the Nechako Watershed, 2019–2021 (Original data) (Zenodo).

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