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Stream temperature data collection standards for Alaska: Minimum standards to generate data useful for regional-scale analyses

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ABSTRACT

Study focus: Statewide interest in thermal patterns and increasing data collection efforts provides Alaska's scientific and resource management communities an opportunity to meet broader regional-scale data needs. A basic set of stream temperature monitoring standards is needed for Alaskans to begin building robust datasets suitable for regional analyses. The goal of this project is to define minimum (base) standards for collecting freshwater temperature data in Alaska that must be met so that observations can support regional assessment of status and recent trends in freshwater temperatures and predictions of future patterns of change in these aquatic thermal regimes using downscaled climate projections.
New hydrological insights for the region: We defined 10 minimum data collection standards for continuous stream temperature data in Alaska. The standards cover data logger accuracy and range, data collection sampling frequency and duration, site selection, logger accuracy checks, data evaluation, file formats, metadata, and data sharing. We hope that the adoption of minimum standards will encourage rapid, but structured, growth in comparable stream temperature monitoring efforts in Alaska that will be used to understand current and future trends in thermal regimes.

1. Introduction

The availability of stream temperature data in the contiguous U.S. has enabled rapid advances in our understanding of stream temperature drivers, trends, and future projections. Analysis of historic stream temperature trends in the Western U.S. indicate that some aspects of the thermal regime are coherent across regional scales, such as increasing summer temperatures (Isaak et al., 2011), while other aspects of the thermal regime are responding in complex ways, such as daily minimums advancing more rapidly than maximums, but not for all streams, and no consistent changes to stream temperature variability (Arismendi et al., 2012, 2013). Projected increases in the annual maximum weekly water temperatures by

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2080 are on the order of 2–5°C for Washington State (Mantua et al., 2010). Future projections of increasing stream temperatures across regional river networks indicate decreases in suitable habitat and fragmentation of existing habitat for salmonids in the Western U.S. (Rieman et al., 2007; Isaak et al., 2010; Wenger et al., 2011; Ruesch et al., 2012; Jones et al., 2013). The identification of important drivers of stream temperatures allows for targeted management strategies that can increase resiliency in aquatic ecosystems, such as improving riparian vegetation to shade streams, restoring stream flows in summertime to decrease stream sensitivity, restoring fish passage to provide access to thermal refugia, and identifying sensitive areas for conservation (Rieman and Isaak, 2010; Isaak et al., 2010).

In Alaska, climate is changing more rapidly than in the contiguous U.S.; annual air temperatures have increased in Alaska by 1.7 °C (3°F) over the last 60 years while winter temperatures have increased by 3.3 °C (6°F, Chapin et al., 2014). In addition, dates of snowmelt and freeze-up have shifted so that the growing season is now 45% longer in Interior Alaska than it was at the beginning of the 20th century (Chapin et al., 2014). As Alaskans continue to feel the impacts of a changing climate, the need for resource managers to understand how these changes will alter aquatic systems and fisheries resources grows. Stream temperature data collection efforts have increased in recent years to begin to fill our gaps in knowledge about current thermal profiles. Several regional analyses have been conducted in an effort to differentiate the watershed characteristics driving differences in summertime stream temperatures across stream and river systems; important factors have included glacier cover (Kyle and Brabets, 2001; Fellman et al., 2014), elevation (Mauger, 2013; Lisi et al., 2013), wetlands (Mauger, 2013), and lakes (Lisi et al., 2013). Due to the limited spatial and temporal coverage of stream temperature data in Alaska, there is a lack of information describing historic trends or generation of future projections, especially as they relate to salmonids.

A recent effort to catalog historic and existing stream temperature data across Alaska found more than 150 continuous stream temperature sensors deployed across the state maintained by over 15 agencies. These agencies are likely using one of the many existing stream temperature data protocols specific to Alaska, such as the National Park Service (Shearer and Moore 2011 Sergeant et al., 2013), Cook Inletkeeper (Mauger, 2008), and the USGS in cooperation with U.S. Fish and Wildlife Service (Toohey et al., 2014). While these protocols provide excellent guidance regarding temperature monitoring, they are often focused on specific agency procedures and goals that are not applicable beyond their source entity. None of the aforementioned protocols direct the reader toward clear, minimum standards regarding sample frequency, sample duration, or data management. A basic set of stream temperature monitoring standards is still needed for Alaskans to begin building robust datasets suitable for regional analyses.

The goal of this project is to define minimum (base) standards for collecting freshwater temperature data in Alaska that must be met so that observations can support regional assessment of status and recent trends in freshwater temperatures and prediction of future patterns of change in these aquatic thermal regimes using downscaled climate projections. By identifying minimum data standards, our objective is to encourage rapid, but structured, growth in comparable stream temperature monitoring efforts in Alaska that will be used to understand current and future trends in thermal regimes. These trends can then inform strategies for maintaining ecosystem resilience.

2. Methods

We identified a sequence of steps essential to any stream temperature data collection project and within these steps, identified components where minimum standards should be established to ensure that data could be used in regional-scale analyses. The steps include selection of a data logger, data collection, data quality assurance and quality control, and data storage. We used a combination of empirical evidence, published research, and expert opinion in order to define each of the minimum standards. For each minimum standard, we have described the methodology along with a justification for the final standard.

3. Results

We defined ten minimum data collection standards to generate data useful for regional-scale analyses of stream thermal regimes. The standards cover data logger accuracy and range; sampling frequency and duration; data quality assurance steps including accuracy checks, site selection and data evaluation; and finally, metadata, data storage and sharing (Table 1). In some cases we have included recommendations beyond the minimum standards for the reader to consider. Guidance on how to implement these standards is provided in a separate report: Stream Temperature Data Collection Standards and Protocol for Alaska (Mauger et al., 2014).

3.1. Data logger

There are two minimum standards for data loggers: accuracy of ±0.25 °C and range from −4° to 37°C. The accuracy and range minimum standards are based on the best available technology for water temperature data loggers currently on the market. We set the minimum accuracy standard at ±0.25 °C as opposed to 0.2 °C to be clear that commonly used data loggers with accuracy specifications of 0.21 °C are appropriate. Examples of data loggers currently available that meet these specifications include TidbiT v2, HOBO Water Temp Pro v2 (Onset Computer Corporation), Levelogger Edge (Solinst Canada Ltd.) and YSI 6920 V2 sonde (YSI Incorporated). There are additional brands with less accuracy that should not be used (e.g.,