WATER TEMPERATURE MONITORING

DISTRIBUTED FIBRE OPTIC

PACIFIC SALMON FOUNDATION

Fibre optic distributed temperature sensing (FO-DTS) in streams uses a fibre optic cable to collect continuous water temperature profiles over long distances (kilometers). Laser pulses sent through the cable produce backscattered light whose properties change with temperature, allowing precise temperatures to be calculated along the entire length at 25 cm (or greater) intervals, simultaneously. A single cable reveals temperature variations along an entire stream reach in near real time, which cannot be captured by traditional point sensors. The data can be used to identify groundwater inflows and mixing zones.

SUMMARY OF METHOD

There are five main steps involved with temperature monitoring using DTS:

1. **Site selection and planning:** Select stream reach based on study objectives and a secure and dry location nearby to store sensors and power sources(s). Design the system layout (single or double-ended), cable type and length, spatial resolution (e.g., 0.25-2.0 m between measurements), temporal resolution (e.g., minutes, hours), and power supply requirements (batteries, solar, or wired).

2. **Preparation:** Prepare the cable on a reel for deployment. Cut to the required length and use fusion splicer to install connectors and waterproof housings, which provide strain relief and protect against damage and signal loss.

3. **Installation:** Set up calibration baths, power supply, and DTS sensor. Deploy the cable along the streambed or banks, and secure to ensure stable positioning. Installation of independent temperature sensors at the middle/end of cable is recommended.

4. **Monitoring/Maintenance:** Collect coordinates of cable course (e.g., RTK survey) and monitor power supply (e.g., change batteries). Ensure calibration baths maintain steady but different temperatures.

5. **Data processing:** Download raw data signals (Stokes/Anti-Stokes intensities, calibration bath temperatures) and process the data to calculate temperatures along the cable. Apply quality control measures (e.g., remove observations affected by de-watering or solar related overheating; uncertainty analysis).

Photo credit: Leia Fougere

IMPORTANT CONSIDERATIONS

The method is complex and requires extensive training with hardware (e.g., fibre optic cable and connectors, fusion splicer) and software (e.g., Python or MATLAB). Accuracy can range from ±0.01–0.5°C. The resolution of the data is dictated by the equipment, and the calibration process defines the precision.

Calibration baths that are set at steady but different temperatures are a core component of DTS data collection, using bubblers, ice, and/or aquarium heaters to ensure consistent water temperature. Coolers are often used with best practice assuming ≥10 m of cable in each bath.

Type and size of power supply is critical to operating the DTS, as clean and sufficient power is required to run the DTS sensor and other components for the duration of the study (24 hrs a day).

Cable selection is important and has many considerations, such as study objectives, site conditions, and physical practicalities (weight of cable). Cable length should include study reach, length for calibration baths and independent temperature sensor(s), length to reach DTS sensor, and length for other considerations, such as cable repair. Minimize bends or tension in the cable, as it affects signal quality.

STREAM CHARACTERISTICS

- Safe access for installation may be impeded by deep water and/or muddy streambed
- May be problematic for streams with high-energy flow and/or frequent channel changes (unstable bed)
- May require periodic cleaning of sediment and/or algae build-up around cable
- Risk of shearing cable with ice

MEASUREMENT CHARACTERISTICS

- Automated data acquisition
- Point measurement within the cross-section
- Distributed measurement along stream network
- High temporal resolution; data frequency set during logger programming
- Accuracy and data storage are product specific and vary with system design and field setup

SITE ACCESSIBILITY FACTORS

- Most setups unsuitable for remote foot access; can be scaled down for remote deployment
- Can avoid entering stream during high flow
- Initial set up involves medium-sized equipment (e.g., 25 kg cable roll, solar panels, batteries)
- Ongoing monitoring involves small equipment (e.g., field laptop, temperature loggers)

SCALE OF EFFORT: INITIAL SET UP

Equipment cost: low-moderate (rental of DTS instrumentation) or high (purchase)
Field time: high; >2 days
Field expertise: high; see Considerations

SCALE OF EFFORT: ONGOING MONITORING

Equipment cost: low
Field time: moderate; 1 day/week
Field expertise: high; see Considerations
Analysis time: moderate or high; varies with amount and quality of data
Analysis expertise: high; see Considerations

PRODUCTS TO CONSIDER

Silixa XT-DTS

ADDITIONAL RESOURCES

Briggs et al., 2012
CTEMPS, n.d.
Selker et al., 2006
Tyler et al., 2009