USING WATER TEMPERATURES TO UNDERSTAND GROUNDWATER/SURFACE-WATER INTERACTIONS IN SOUTHWEST MONTANA

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• The Nature Conservancy
• Montana DNRC
• Montana FWP
• Water and Environmental Technologies (WET)
Managing Groundwater and Surface Water as a Single Resource

- “Conjunctive” management
- Need to know
  - Where streams are gaining
  - Where streams are losing
  - How much water is moving

Methods

- Flow Measurements
- Hydraulic Gradient
- Temperature
Flow Measurements (reach scale)
Measure all inflow and diversions
Get direction and magnitude of flow from one measurement
Relatively high uncertainty (>~5%)

\[ s = \sqrt{(\pm a^2) + (\pm b^2) + \ldots + (\pm n^2)} \]

Example with 10% error:
\( Q_{up} = 50 \pm 5.0 \) cfs
\( Q_{down} = 45 \pm 4.5 \) cfs
\( \Delta Q = 5 \pm 6.7 \) cfs
Gain of 1.7 cfs to loss of 11.7 cfs
Measuring Gradients (point scale)

Clear indication of direction of flow

No information on magnitude

Figures from Winter et al., 1998
Temperature from Caldwell and Eddy-Miller, 2013

Gaining Stream (not to scale)
Temperature

Boulder River – Qualitative Point Measurements

Gaining

Losing

Bobst and others, 2016 (OFR 682)
Temperature

Jefferson River (2014) – Qualitative Reach Measurements

Gaining
Temperature

Long Creek (August 2016) – Qualitative Distributed Values
Thermal Imaging Using a Drone (WET)
Use absolute values with caution

20 m Moving Minimums

Distance Downstream (m)

Temperature (°C)

Distance Downstream (m)
Temperature

All temperature measurements up to here have been Qualitative. It is possible to be Quantitative.
Temperature

Long Creek – Flux Stations – Point Measurements

Quantitative
Install in Seasonally Inundated Areas
Calculate 1D flux, and vertical hydraulic conductivity ($K_z$)
Temperature

East River – near Crested Butte, CO (RMBL/CUSHI)
Use material type and observations to calculate flux

Specific Discharge, \( q = -0.3 \text{ m/d} \)
Overall RMS = 0.15
Summary

• Temperature Data
  • Are relatively cheap and easy to collect
    • They may be collected already
  • Provide another perspective on Groundwater/Surface-Water Interactions
  • May be point, reach, or distributed values
  • May be used qualitatively or quantitatively

• Limited since temperature is non-conservative, and at the surface it is controlled by many factors.