Connecting hillslope and riparian processes to arctic stream and river responses

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Connecting hillslope and riparian processes to river and stream temperature

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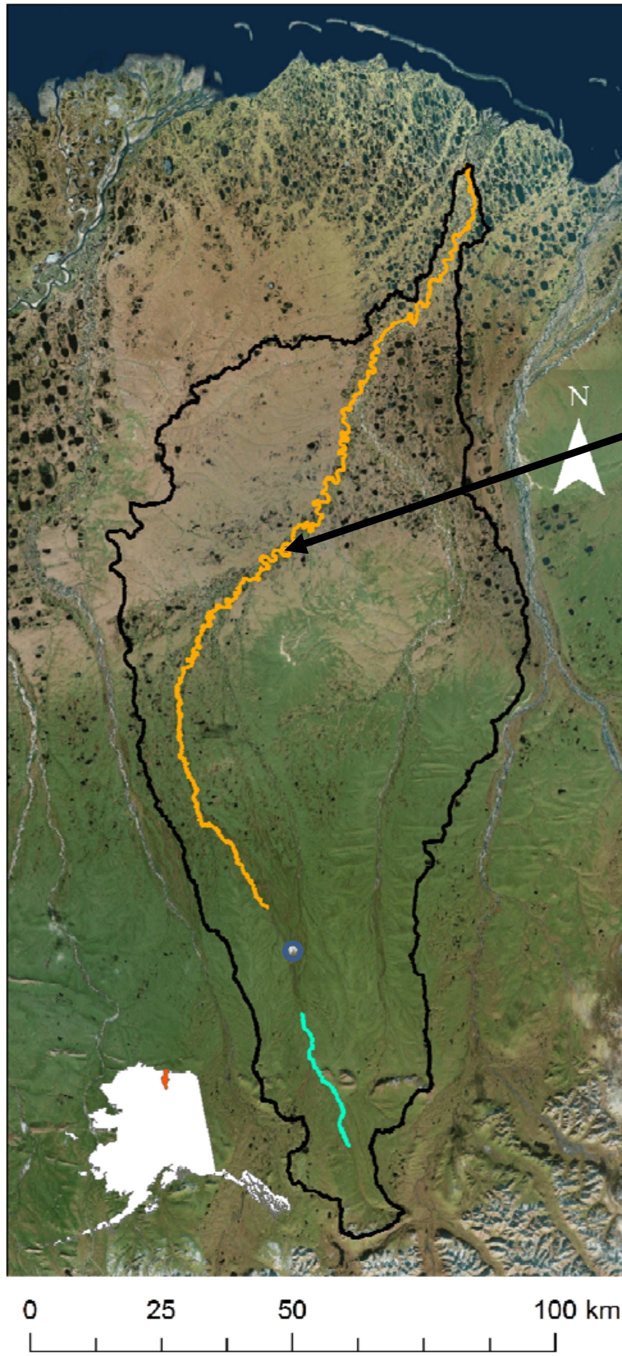
UPPER KUPARUK RIVER, ALASKA

FLOW



Arctic Ocean

Lower Modeling Reach

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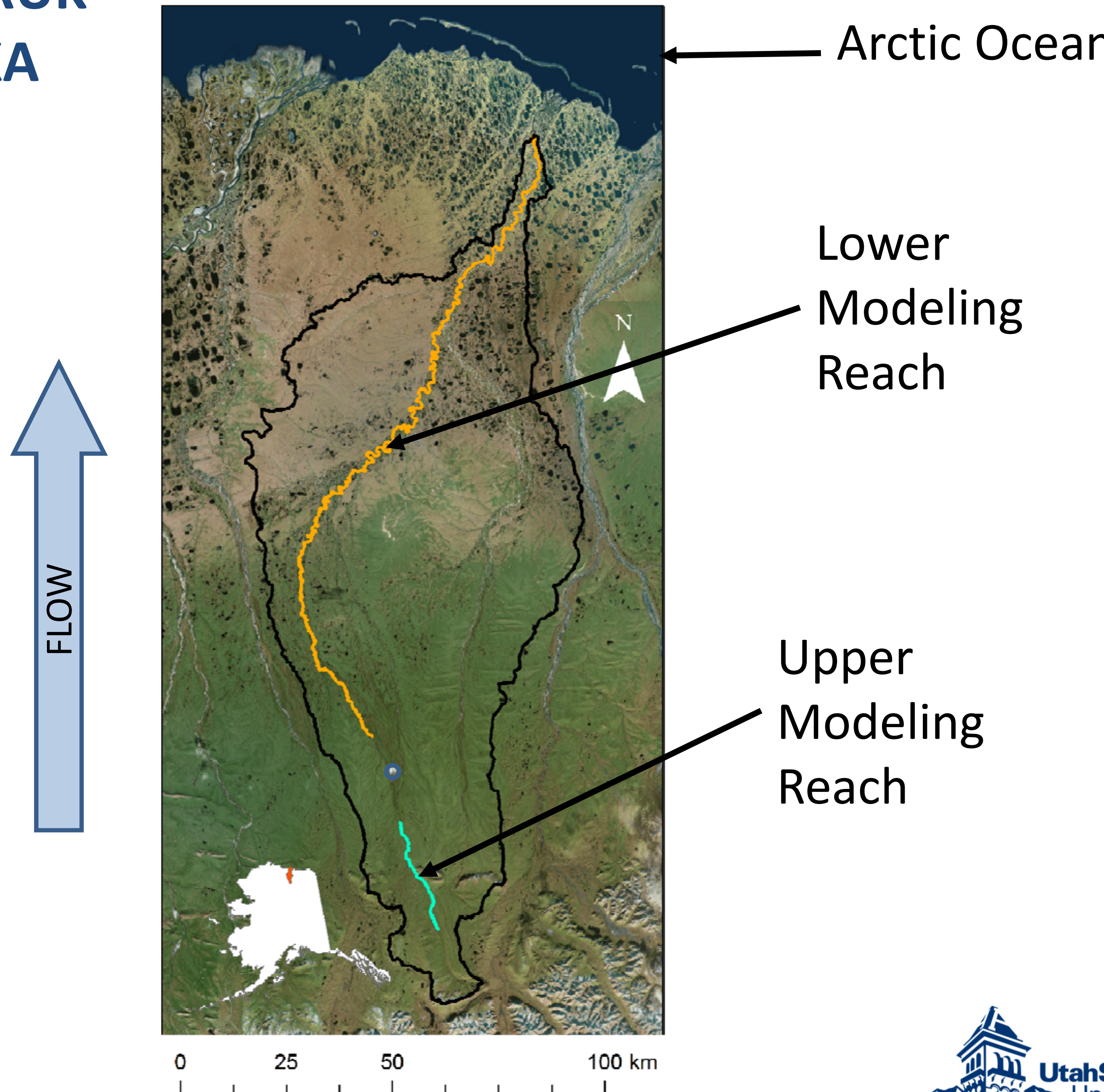
UPPER KUPARUK RIVER, ALASKA



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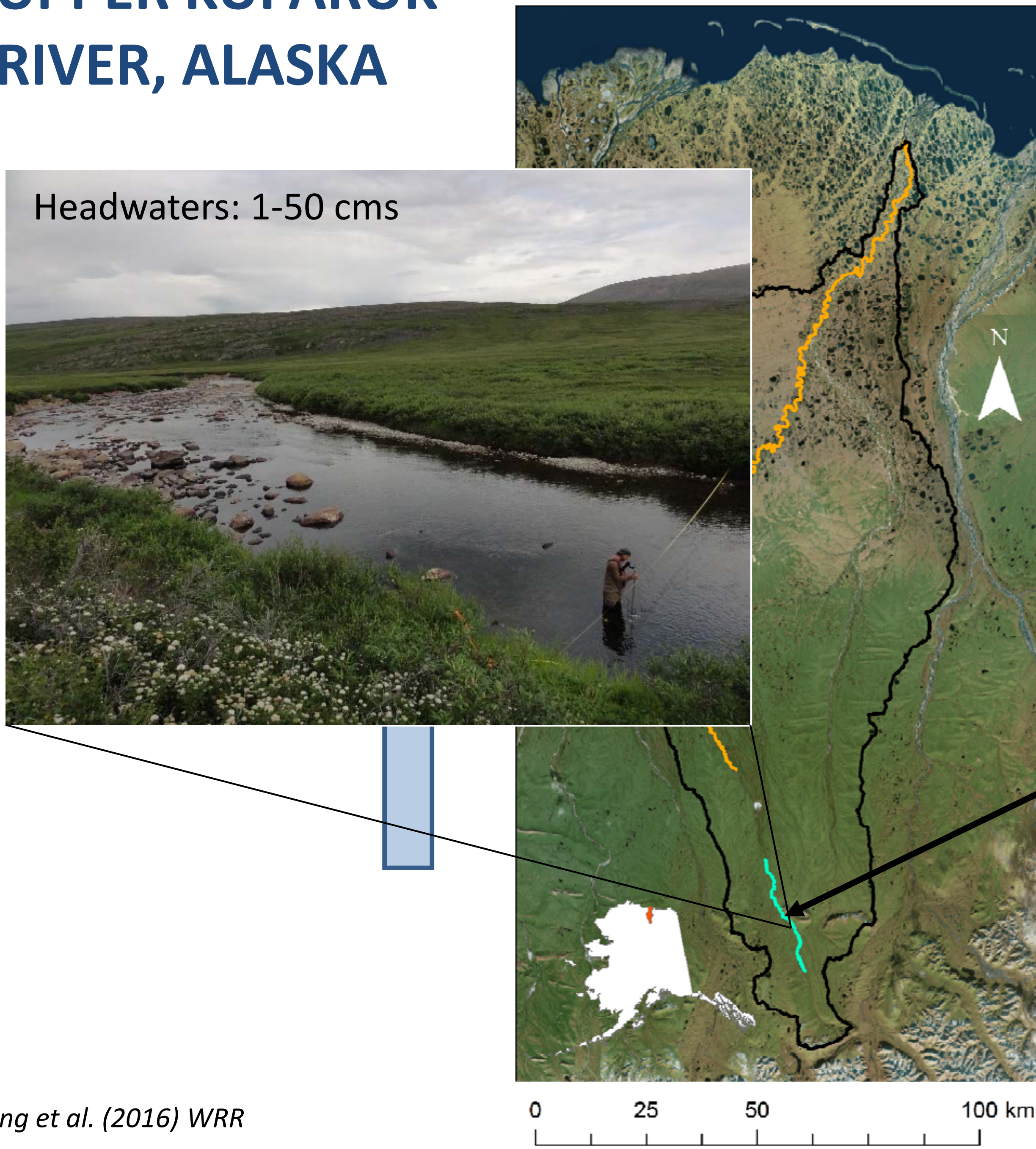
UPPER KUPARUK RIVER, ALASKA



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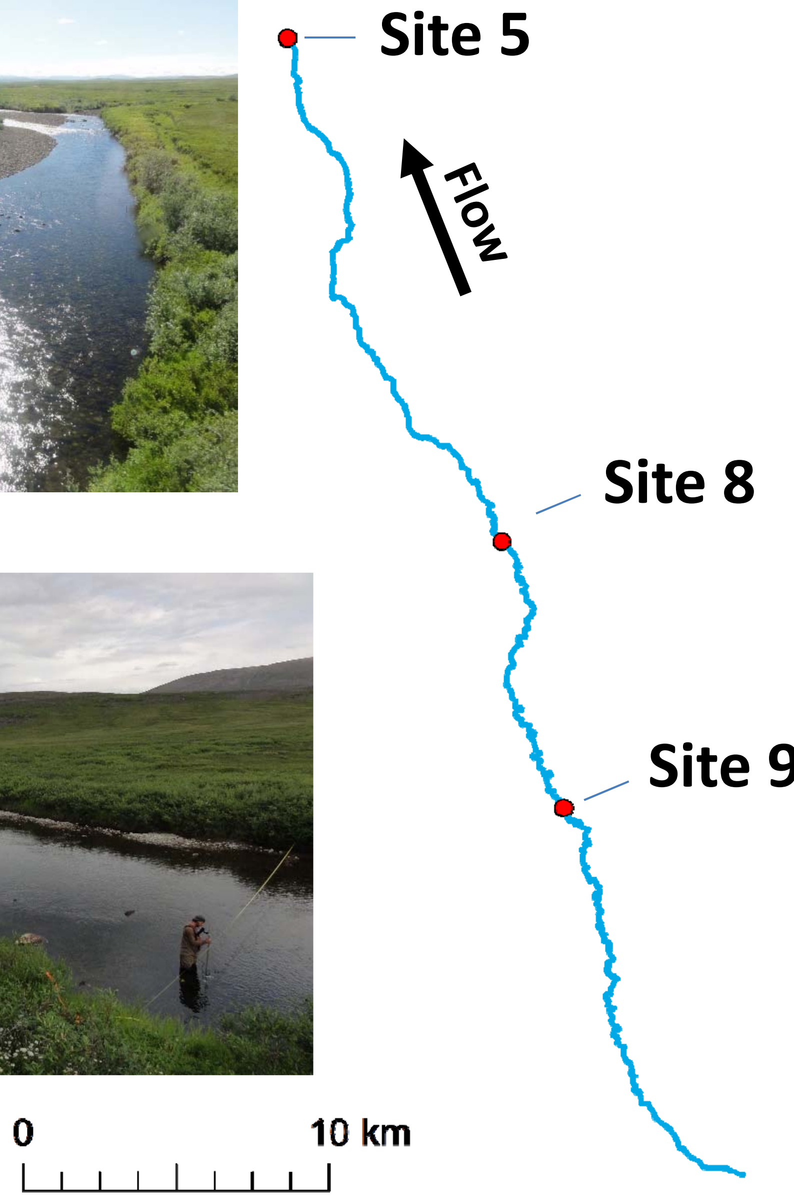
UPPER KUPARUK RIVER, ALASKA – DATA COLLECTION



2013 (Dry Year)
2014 (Wet Year)

- Discharge
- Temperature
- Specific Conductance
- Weather Data

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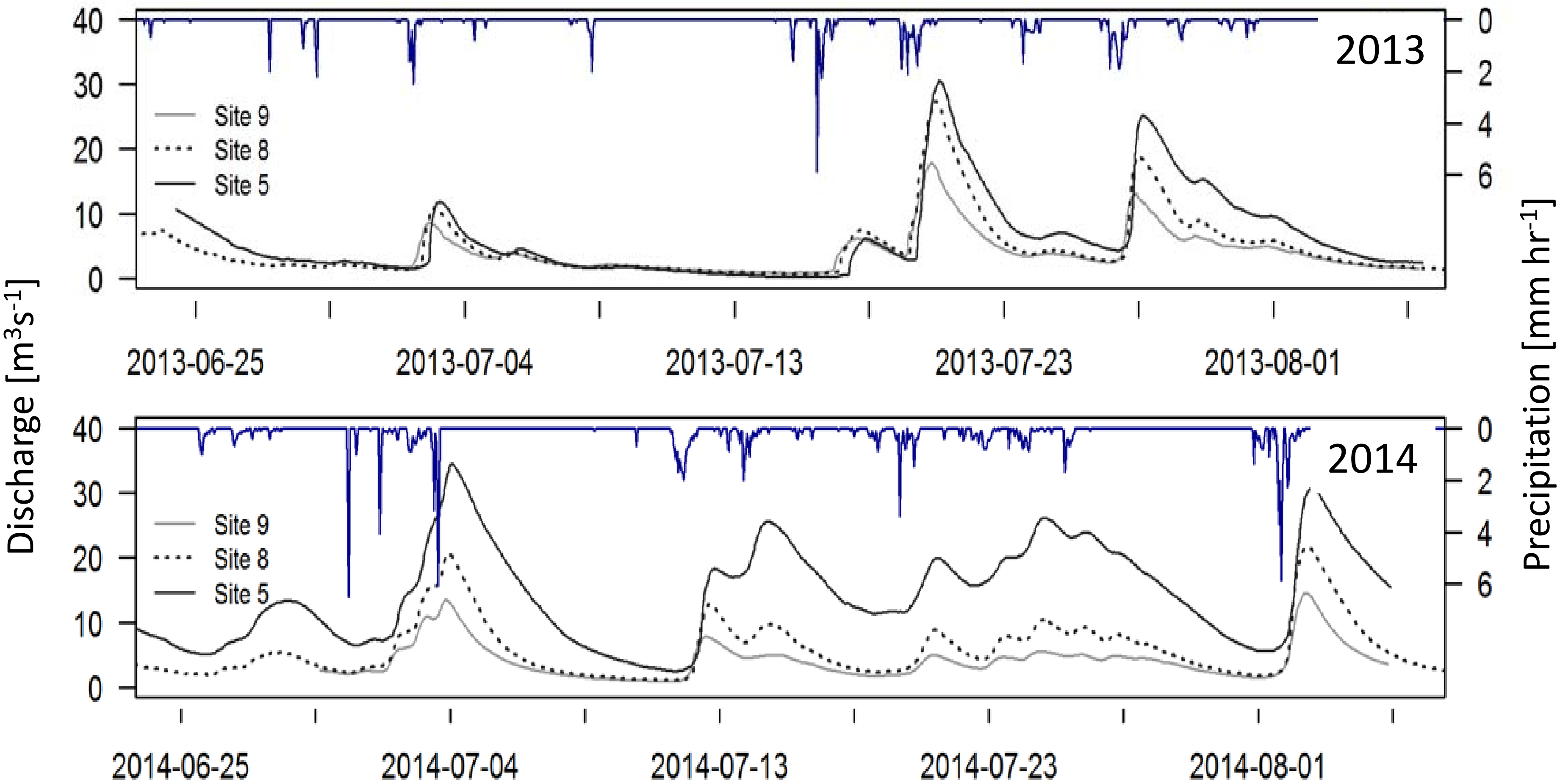
UPPER KUPARUK RIVER, ALASKA - DISCHARGE



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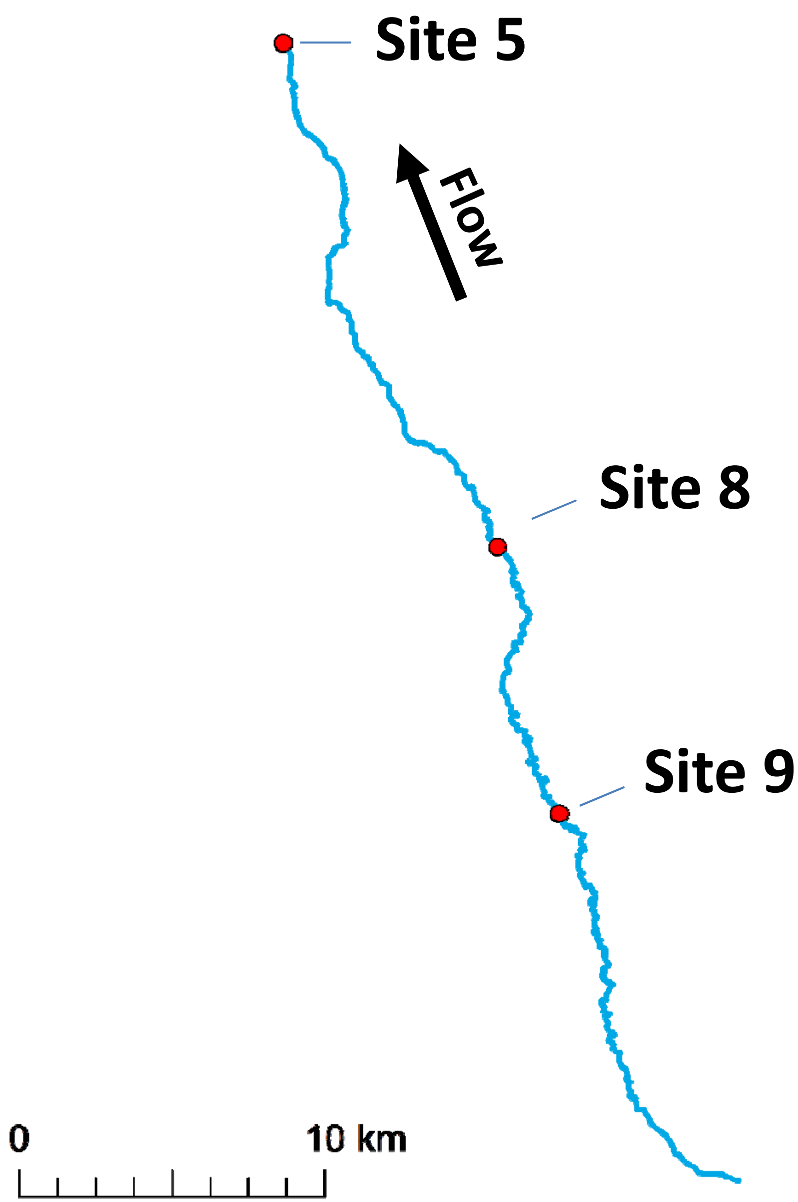
UPPER KUPARUK RIVER, ALASKA



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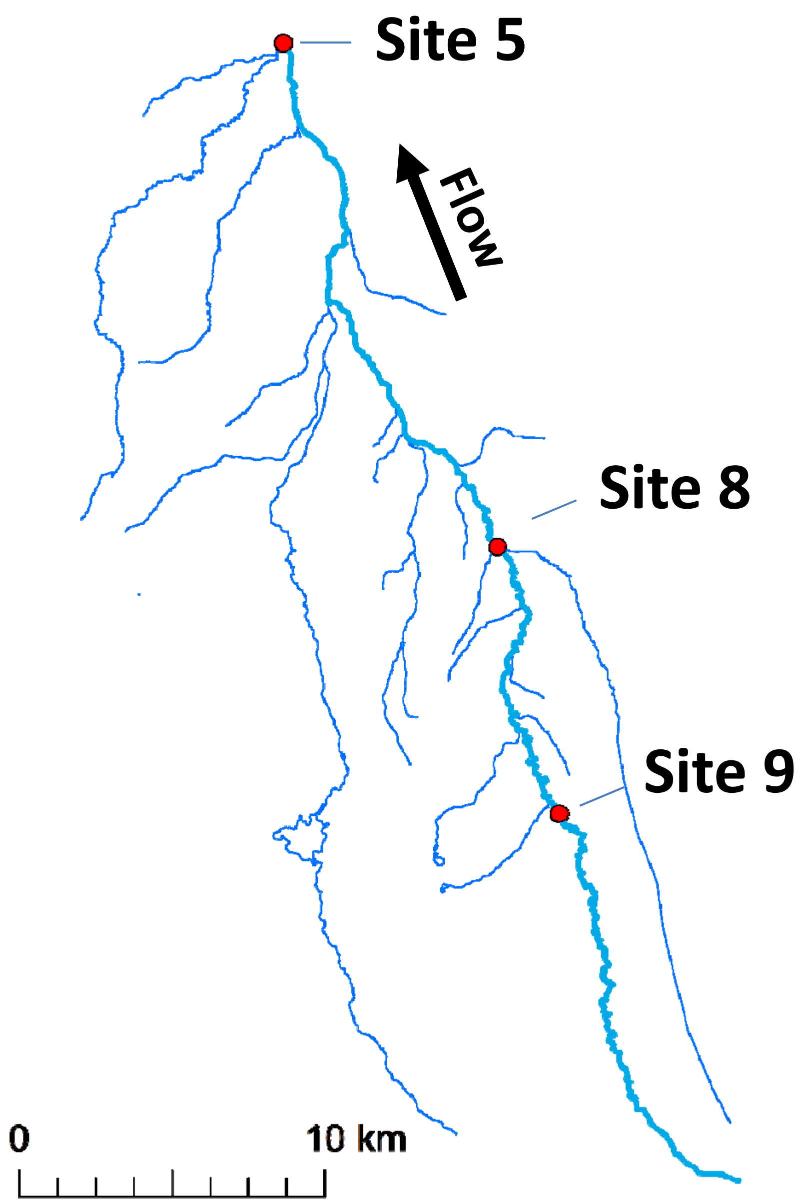
UPPER KUPARUK RIVER, ALASKA – LATERAL INFLOWS



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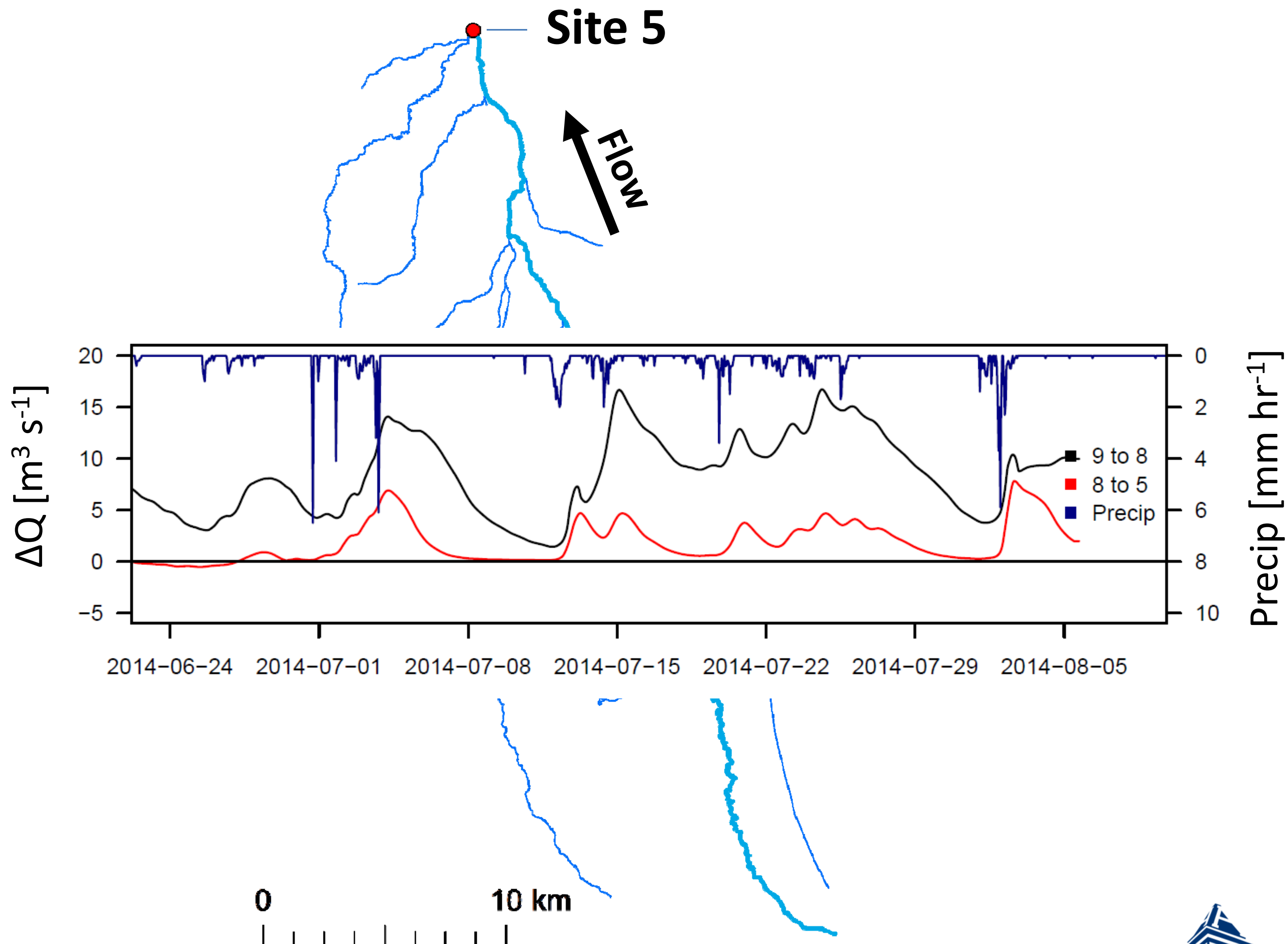
UPPER KUPARUK RIVER, ALASKA – LATERAL INFLOWS



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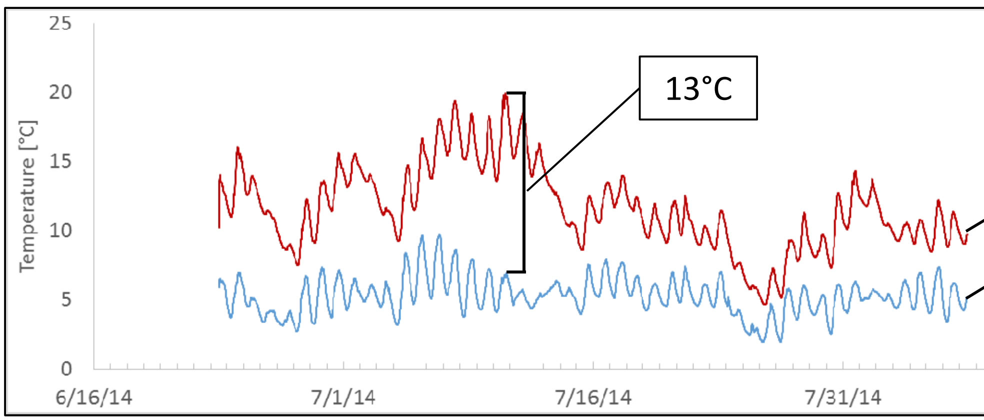
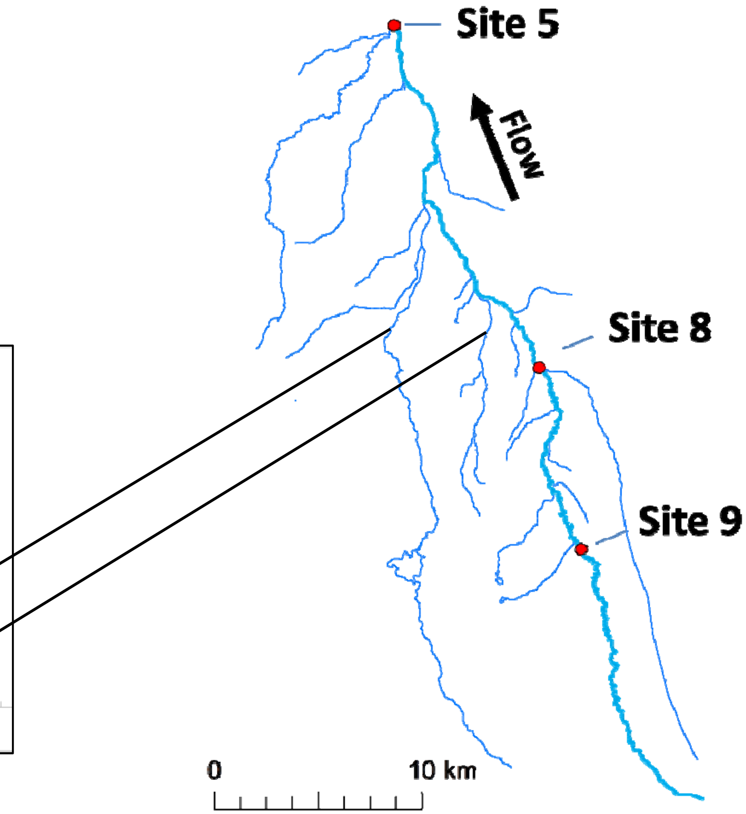
UPPER KUPARUK RIVER, ALASKA – LATERAL INFLOWS





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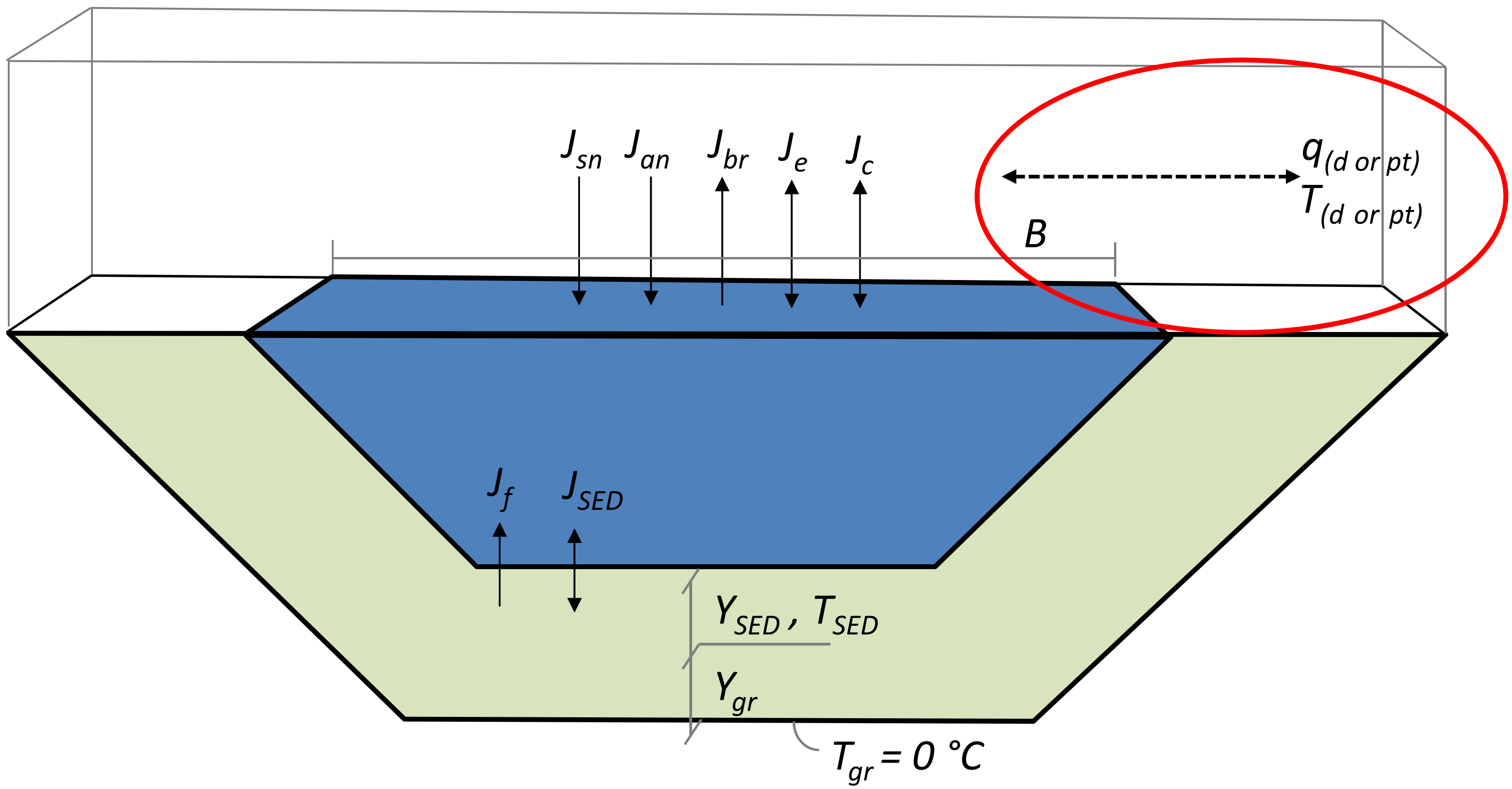
TEMPERATURE MODEL



$$\frac{\partial(A_c T)}{\partial t} = \frac{\partial(QT)}{\partial x} + q_d T_d + q_{pt} T_{pt} + \frac{B}{\rho C_P}\left(J_f + J_w + J_{SED}\right)$$

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$$\frac{\partial Q}{\partial x} + \alpha \beta Q^{\beta-1} \frac{\partial Q}{\partial t} = q$$

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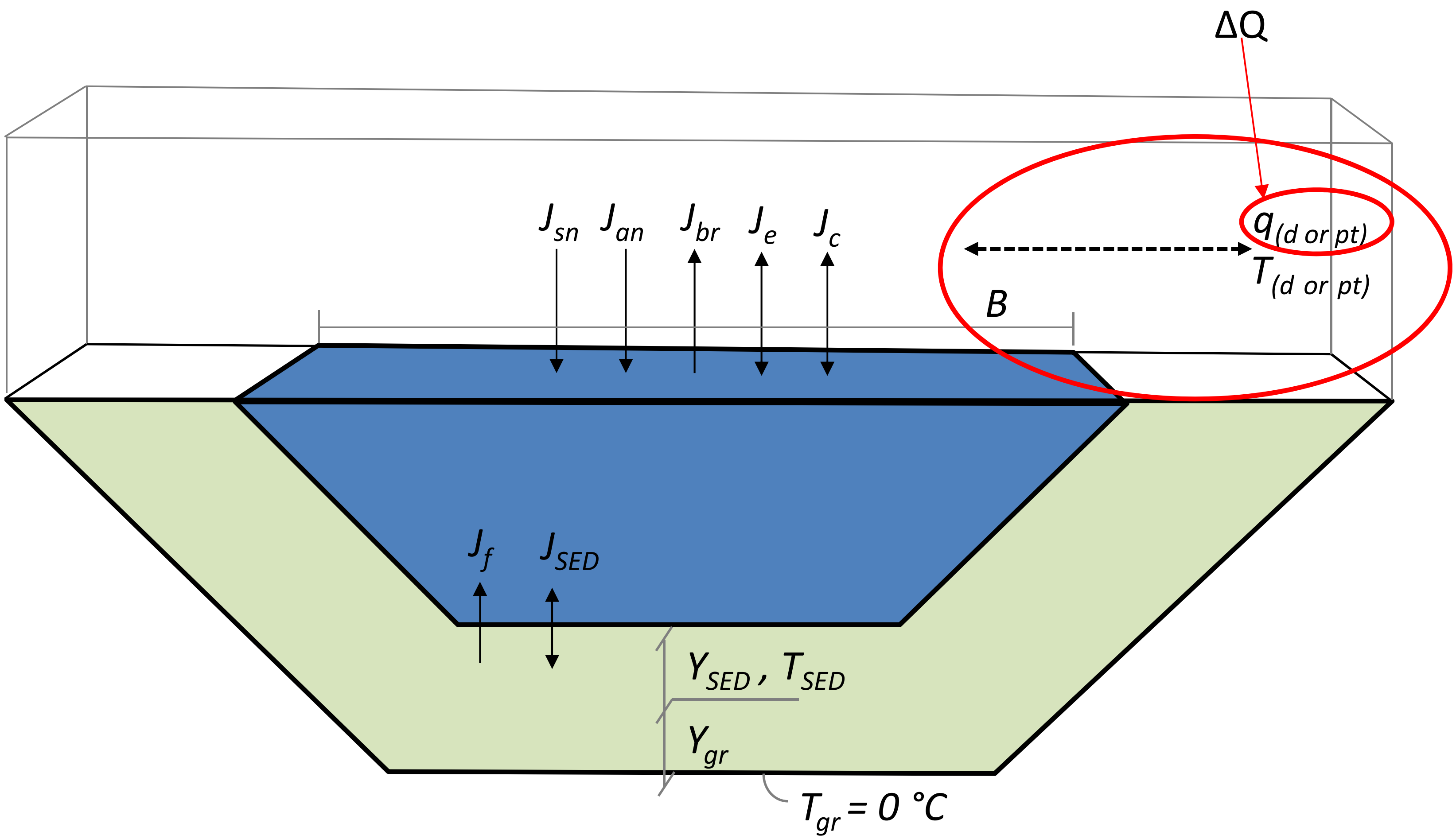
TEMPERATURE MODEL



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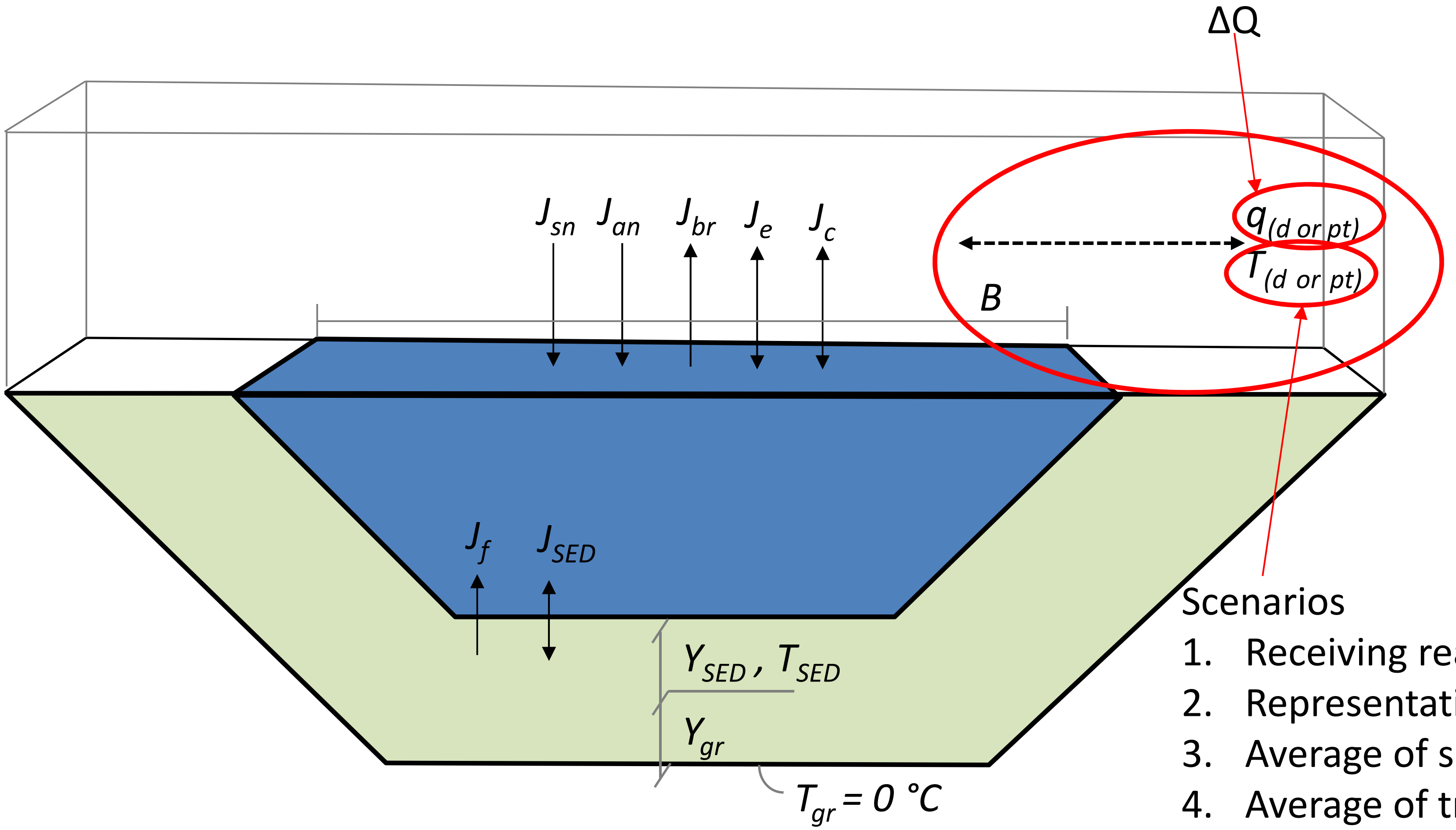
TEMPERATURE MODEL



Scenarios

1. Receiving reach
2. Representative tributary
3. Average of sub-reach
4. Average of tributary morphology

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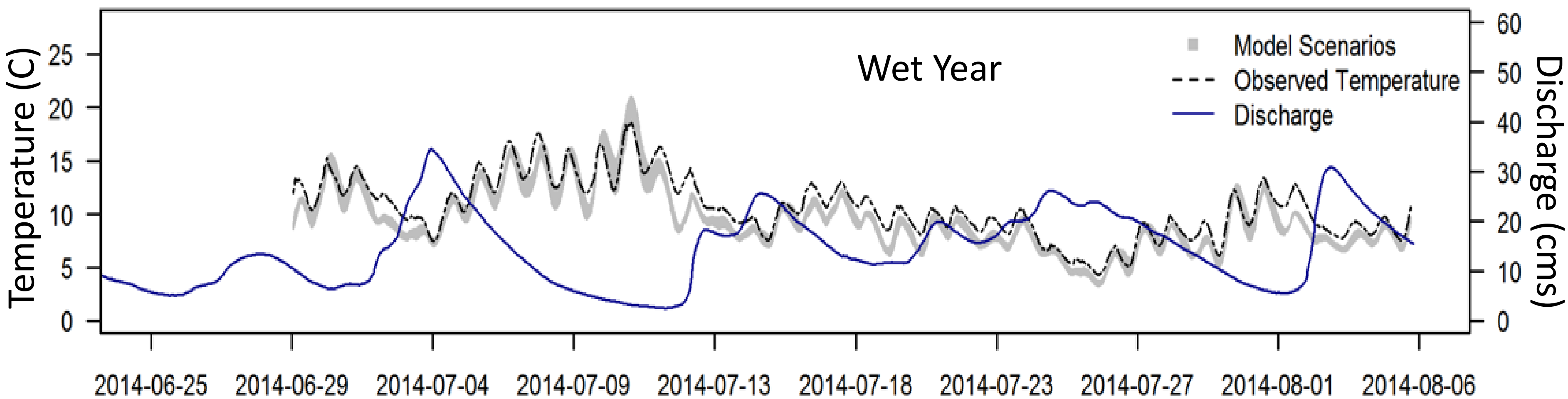
UPPER KUPARUK TEMPERATURE PREDICTIONS



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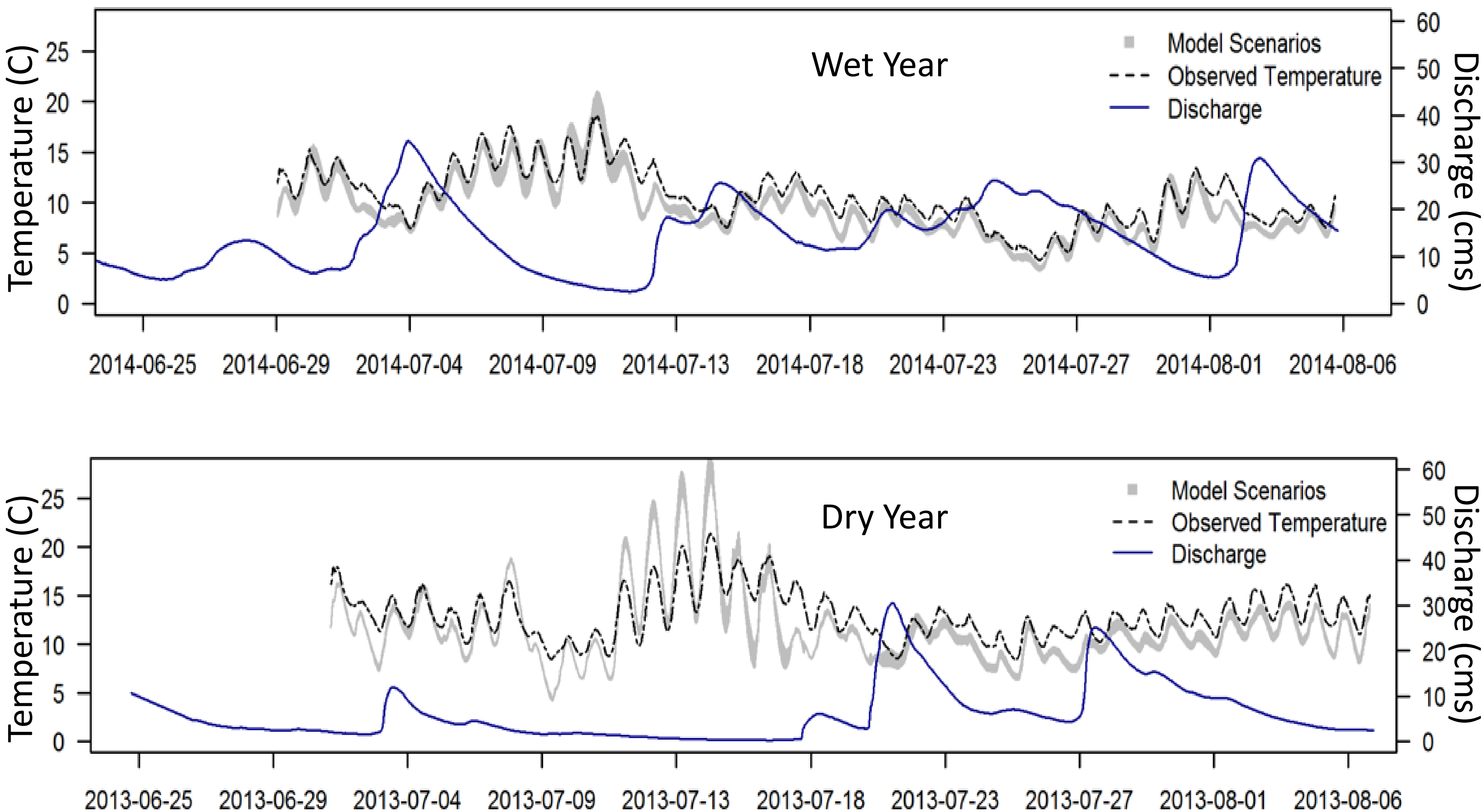
UPPER KUPARUK TEMPERATURE PREDICTIONS



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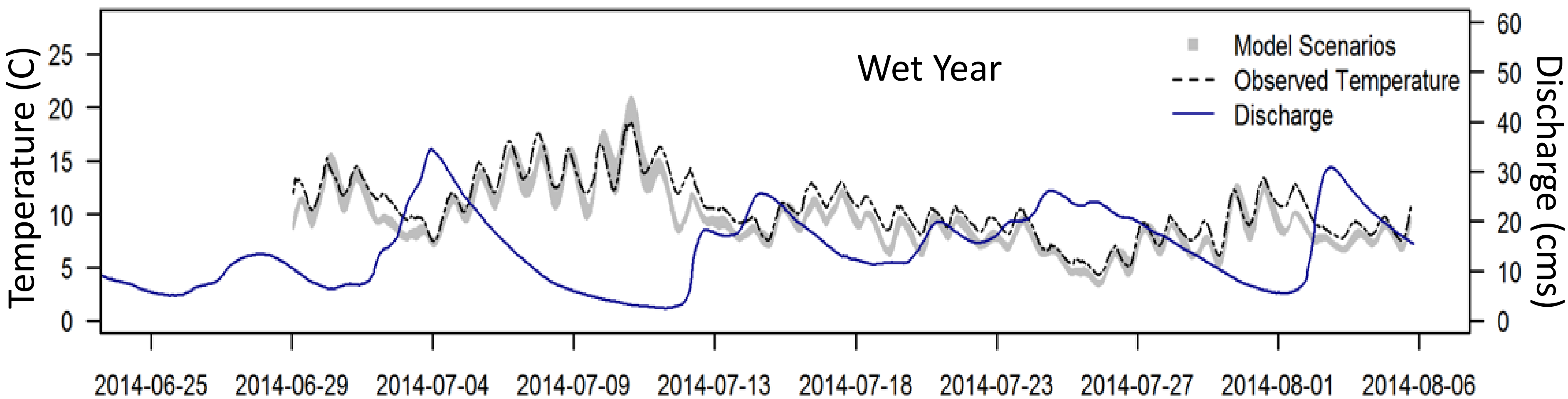
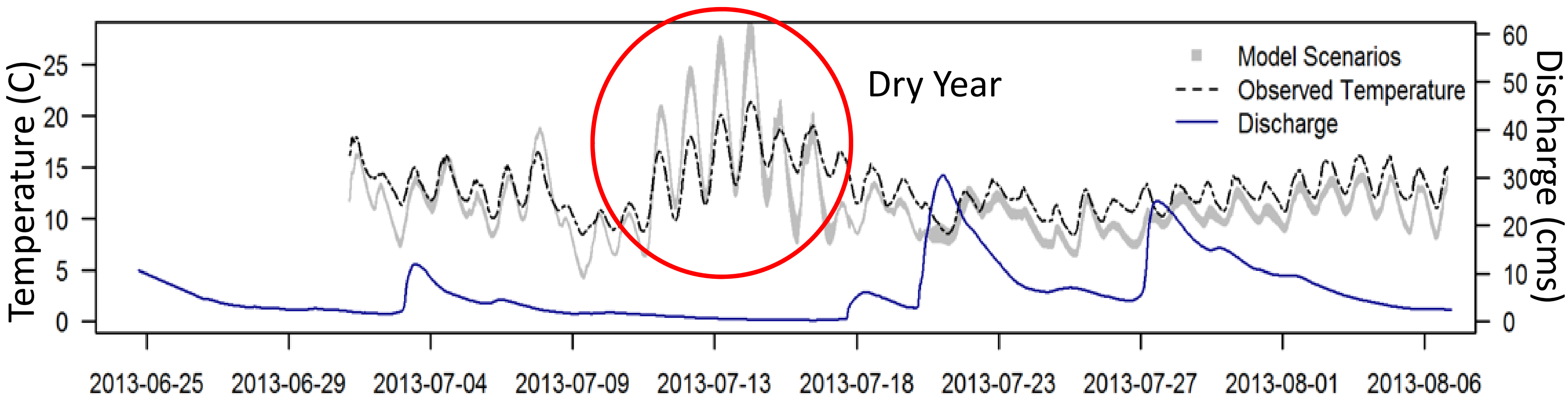
UPPER KUPARUK TEMPERATURE PREDICTIONS





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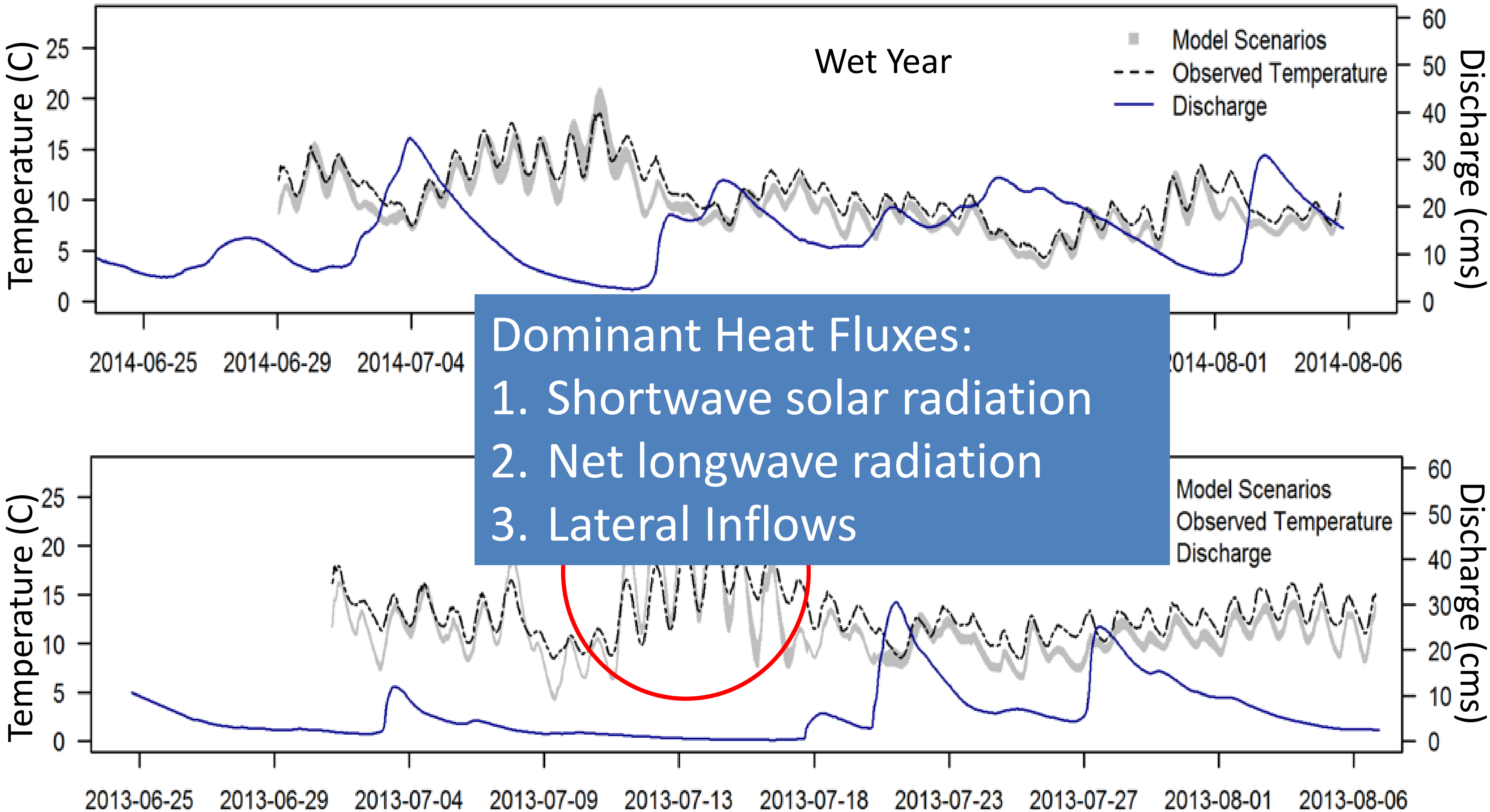
UPPER KUPARUK TEMPERATURE PREDICTIONS



Dominant Heat Fluxes:

1. Shortwave solar radiation
2. Net longwave radiation
3. Lateral Inflows

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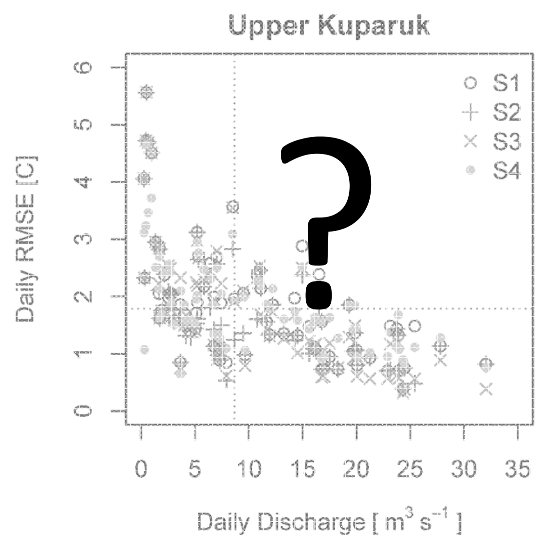
LOW FLOW PREDICTIONS

- Correct surface areas?
- Correct volumes (lateral inflows/losses)?
- Other processes?



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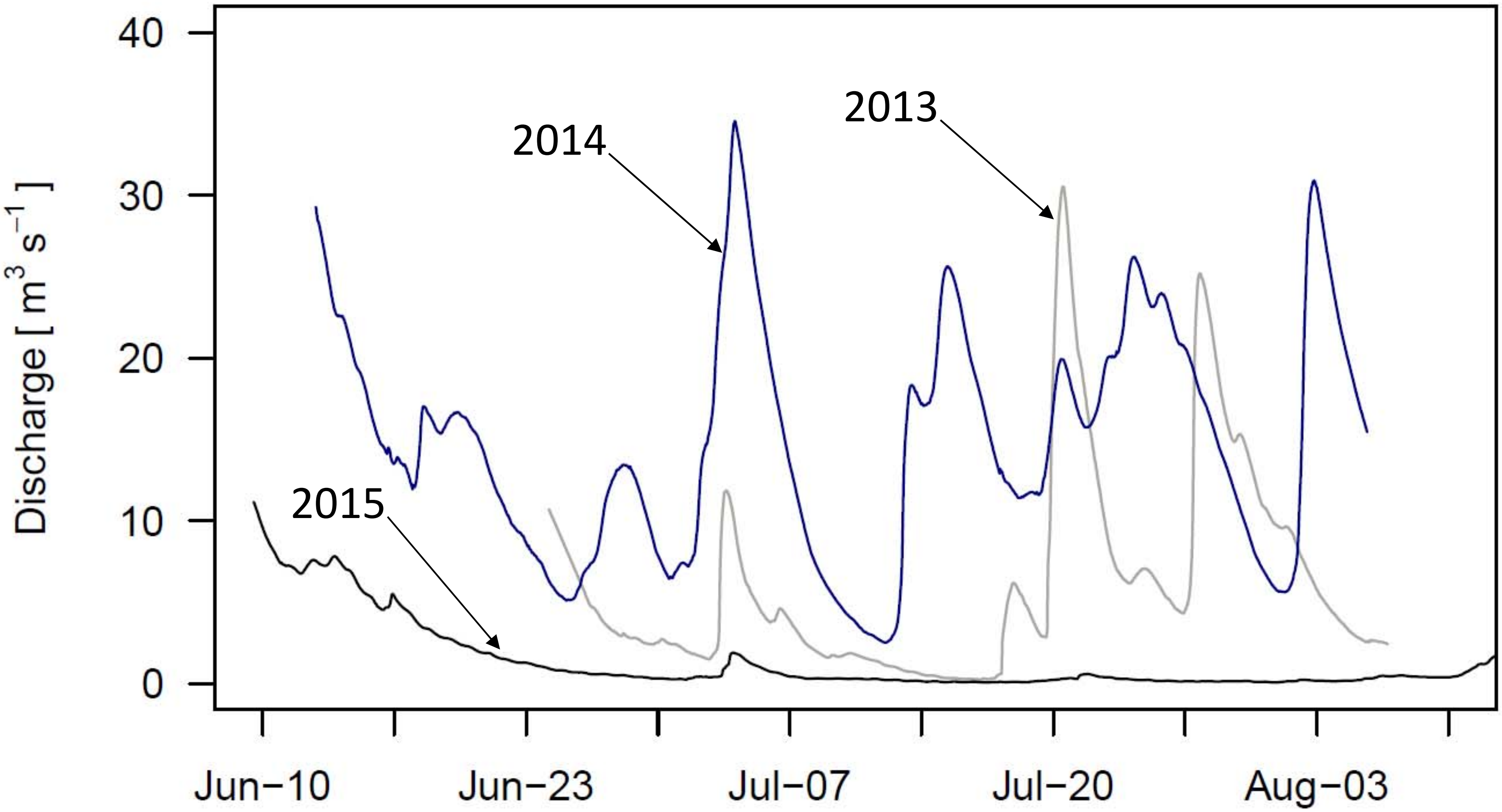
UPPER KUPARUK RIVER, ALASKA - SITE 5 DISCHARGE



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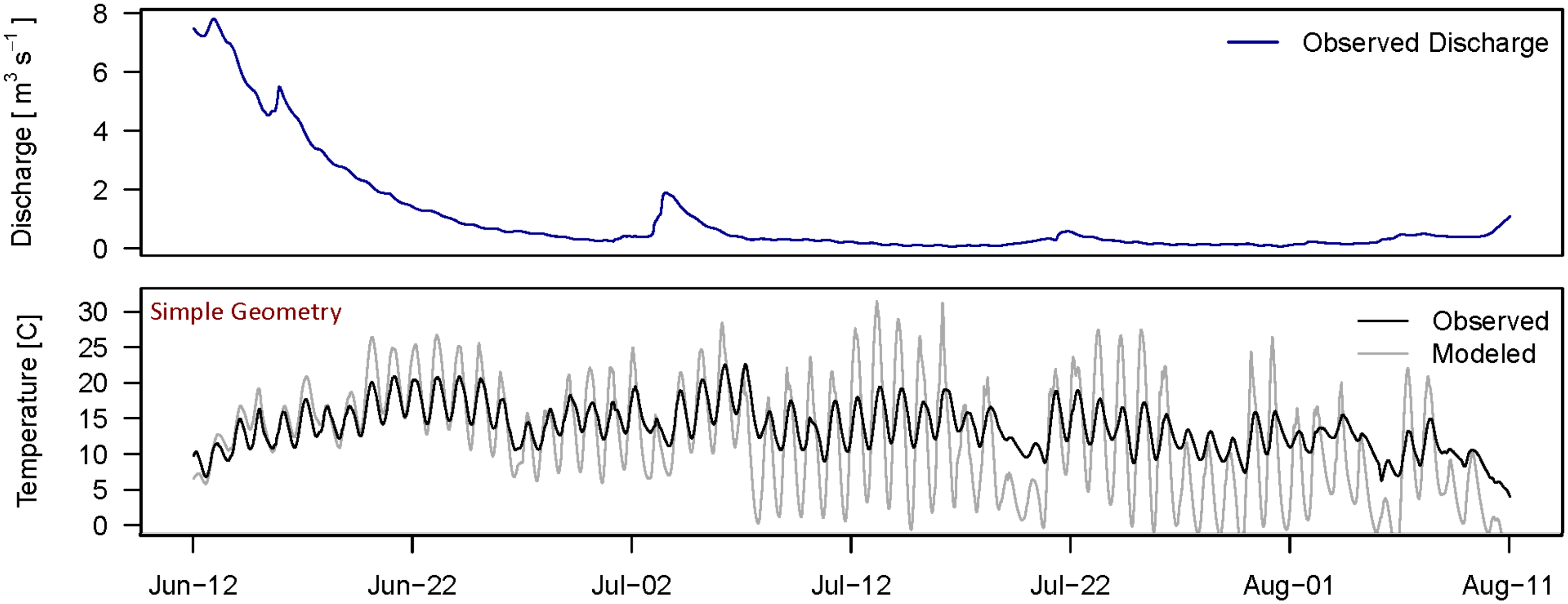
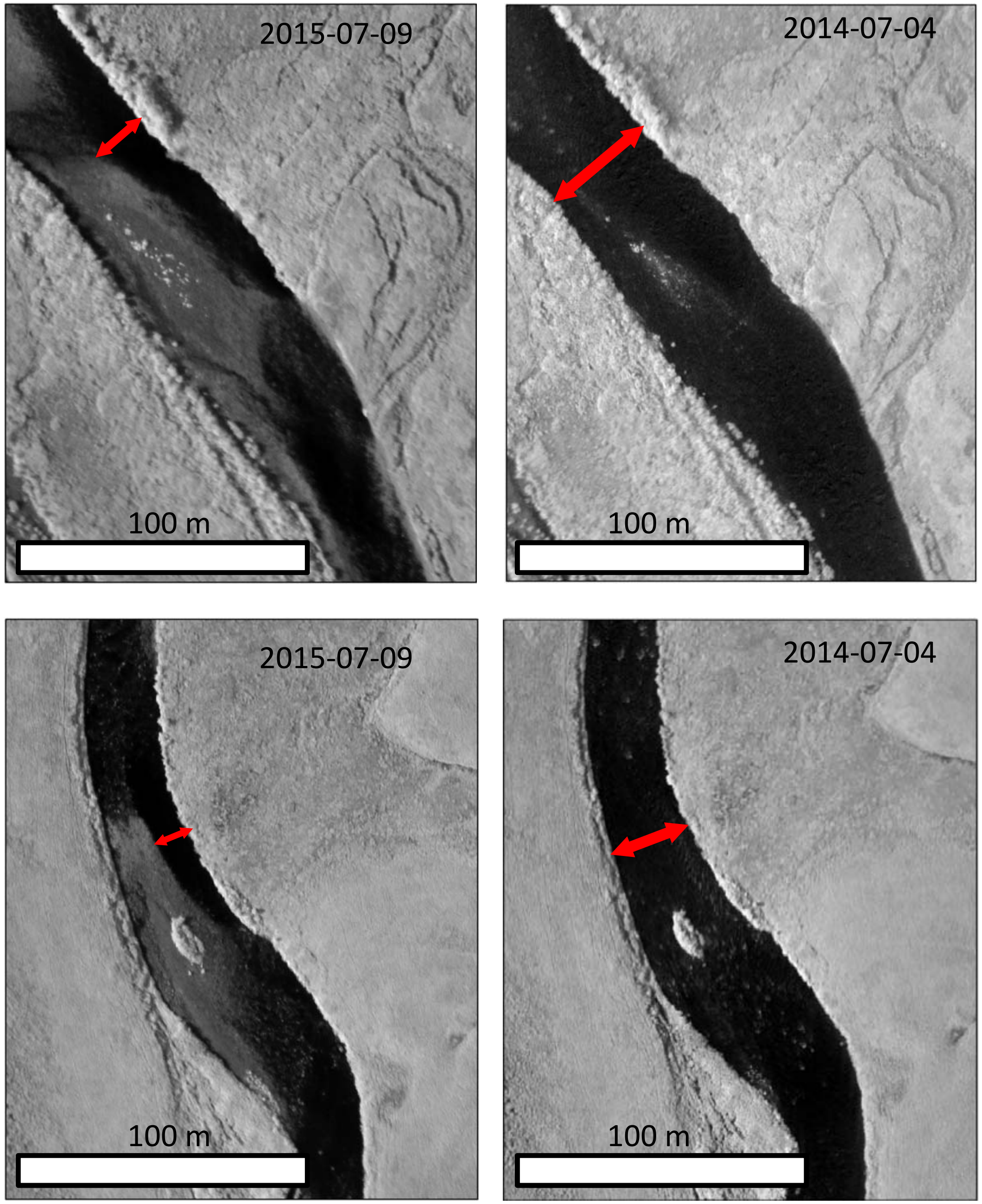
2015 PRELIMINARY LOW FLOW MODELING



Low Flow High Flow



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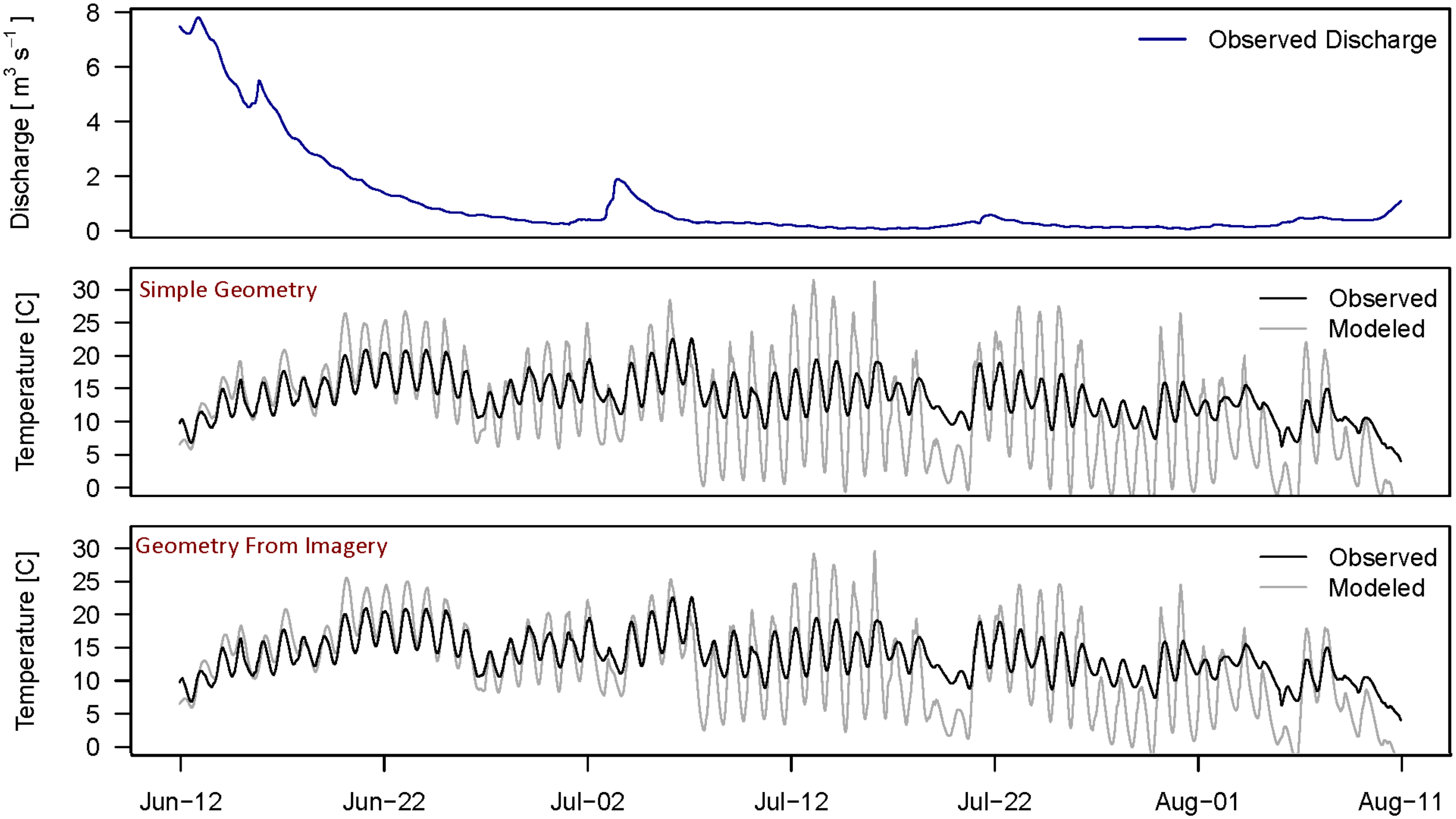
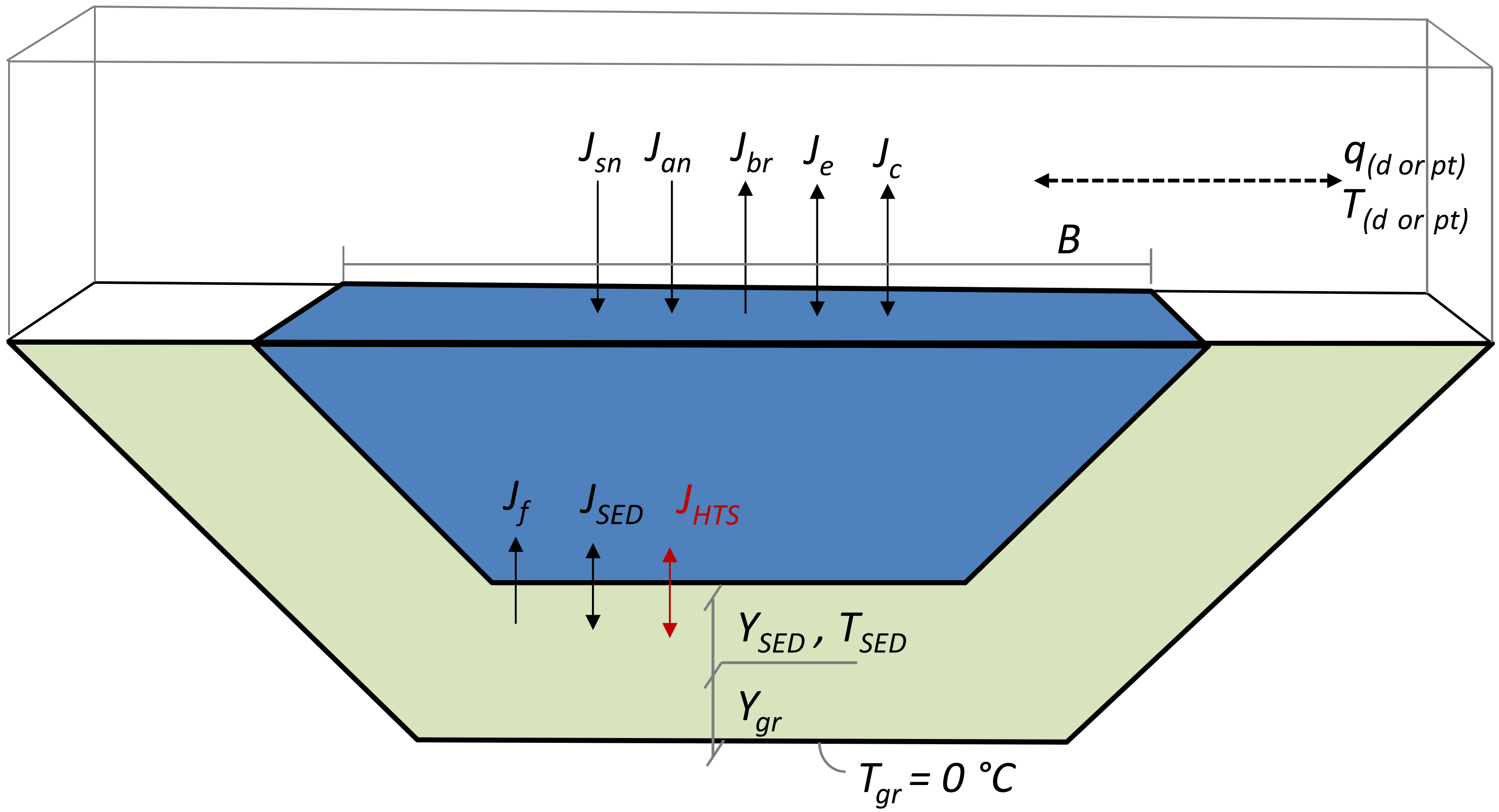
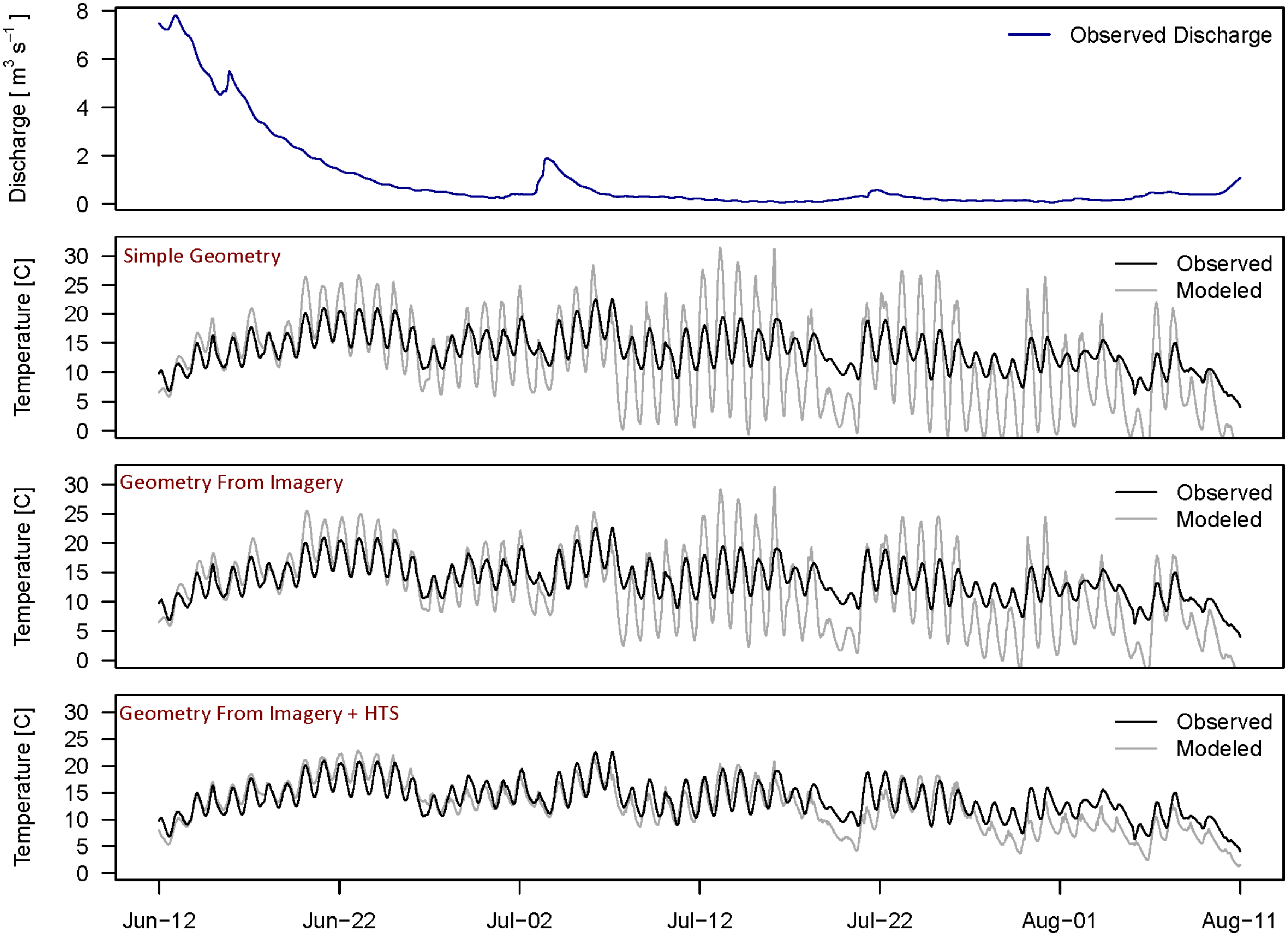
2015 PRELIMINARY LOW FLOW MODELING



REVISED TEMPERATURE MODEL: HYPORHEIC TRANSIENT STORAGE



2015 PRELIMINARY LOW FLOW MODELING



KUPARUK RIVER CONCLUSIONS

Higher Order Rivers:

- Wet conditions - Lateral inflows play an important role in understanding instream temperatures during higher flows.
- Dry conditions – Hyporheic exchange becomes an important heat sink and buffers instream temperatures.

Do these trends hold for other lower order watersheds in this area?

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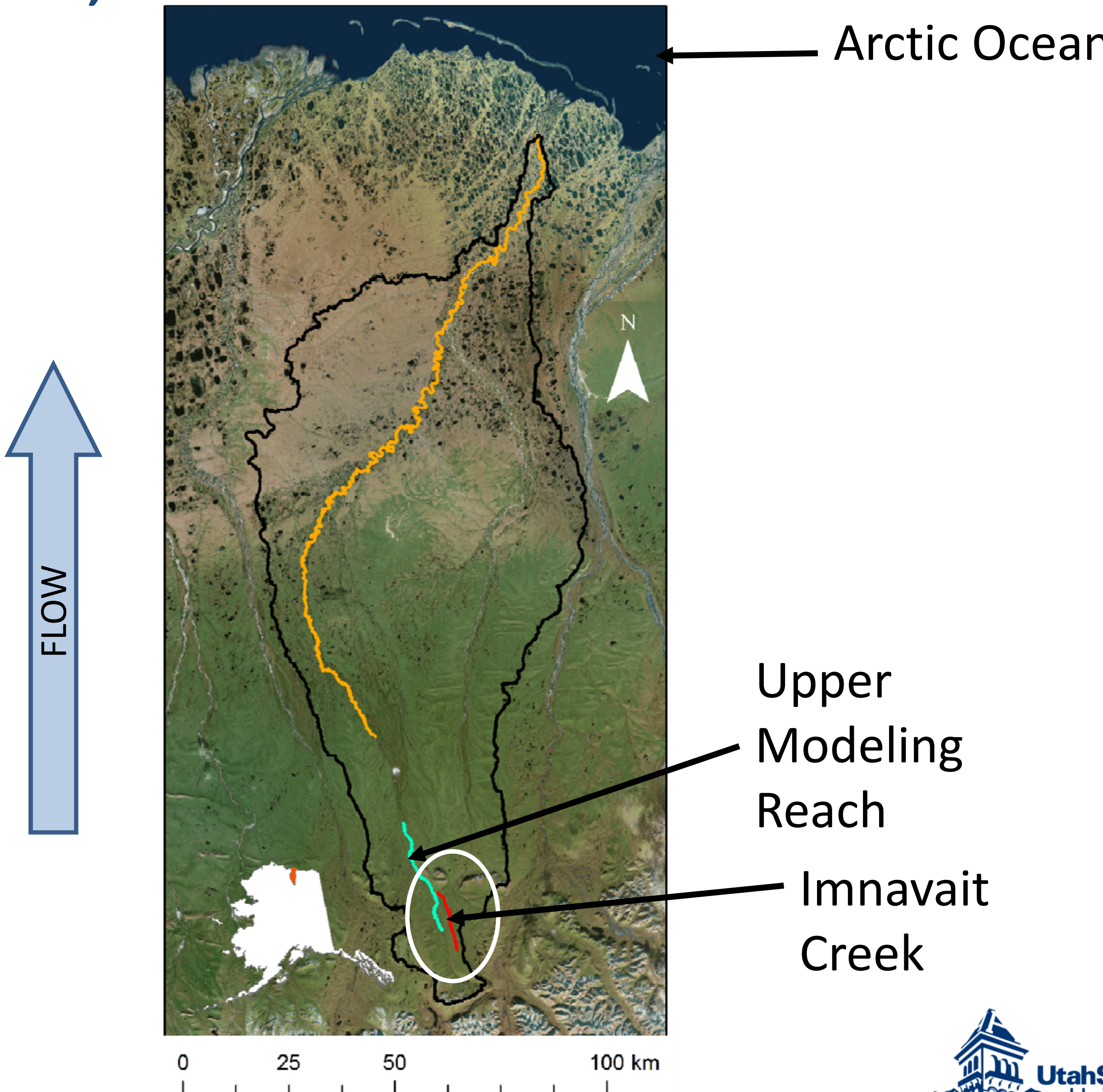
IMNAVAIT CREEK, ALASKA



IMNAVAIT CREEK, ALASKA

- Beaded, peat lined
- Flowrate – ~0-1 m^3/s

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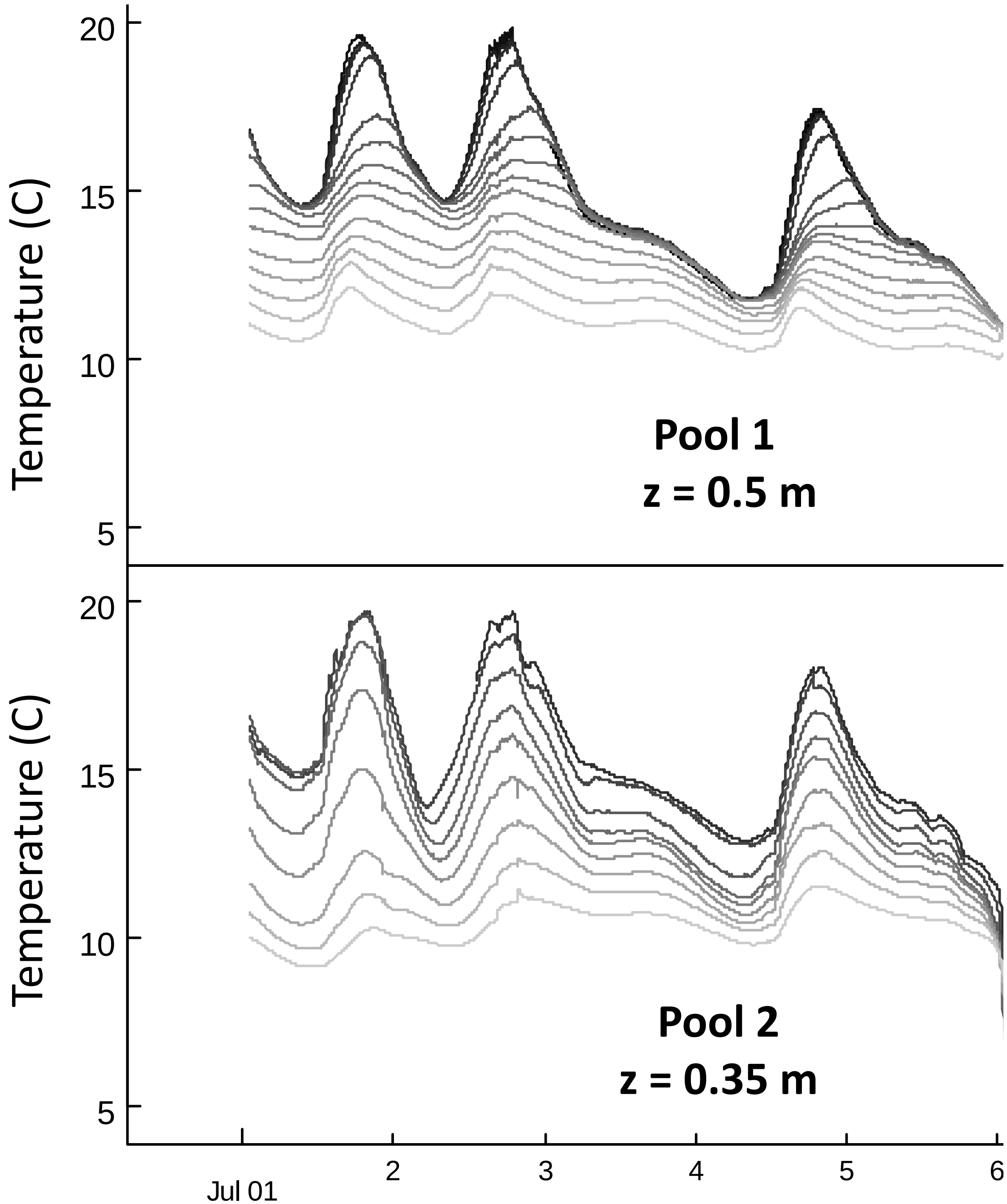
IMNAVAIT CREEK, AK – DRY CONDITIONS



Merck, M. and B.T. Neilson 2012, Hydrological Processes
Merck, M., B.T. Neilson, R.M. Cory, G.W. Kling, 2012, Hydrological Processes

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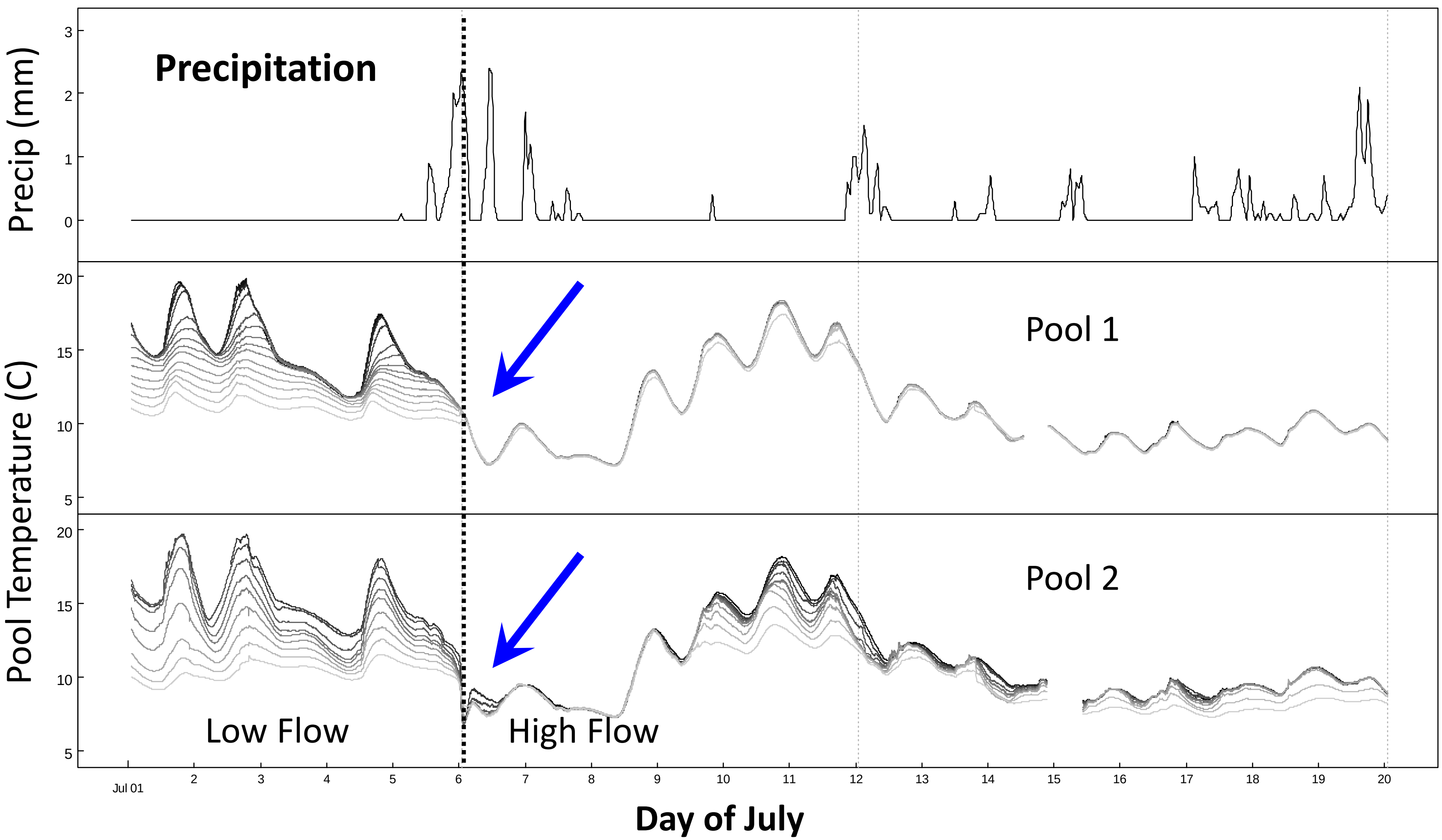
IMNAVAIT CREEK, ALASKA – WET CONDITIONS



Merck, M. and B.T. Neilson 2012, Hydrological Processes
Merck, M., B.T. Neilson, R.M. Cory, G.W. Kling, 2012, Hydrological Processes

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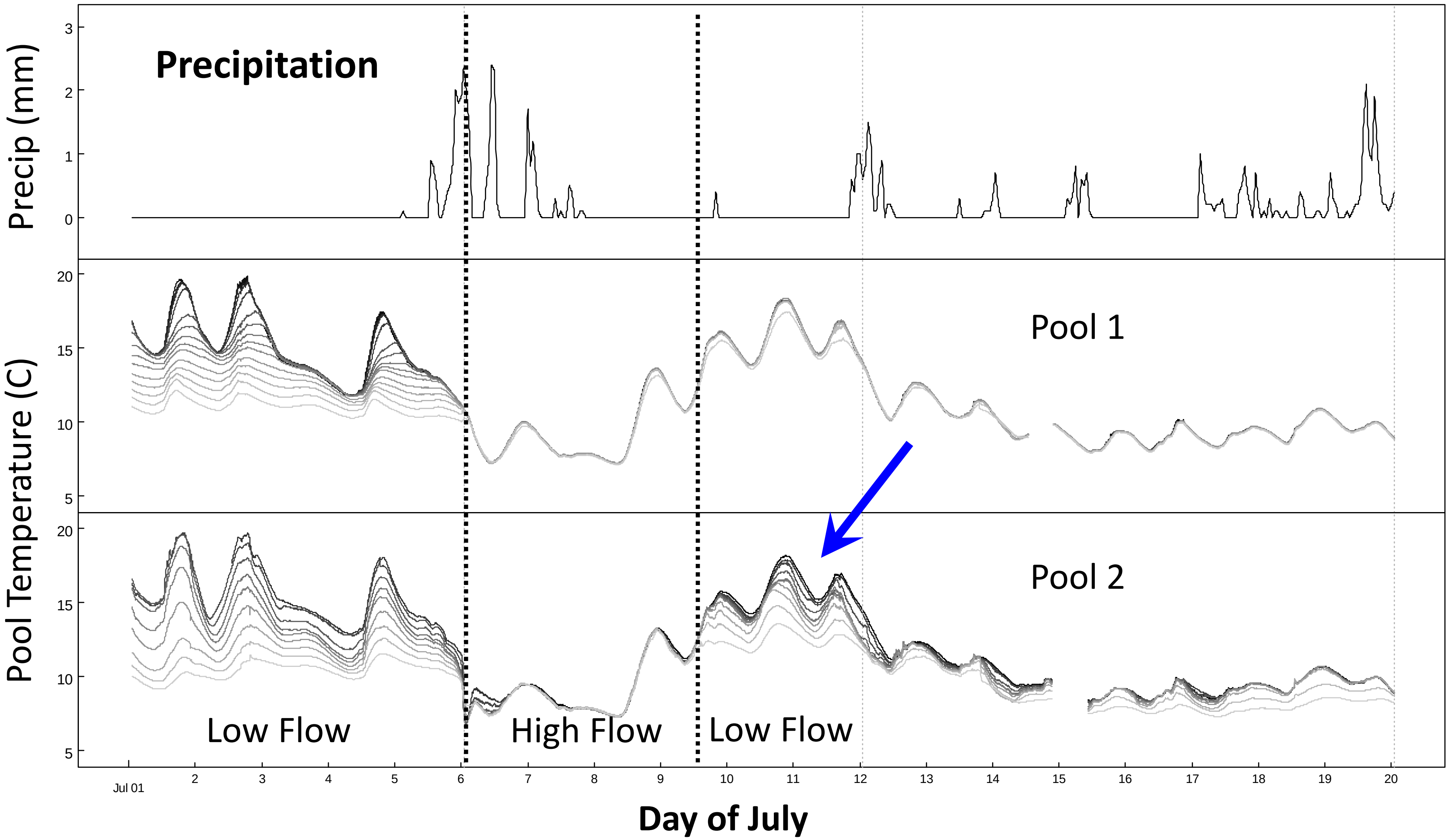
IMNAVAIT CREEK, ALASKA – WET AND DRY CONDITIONS



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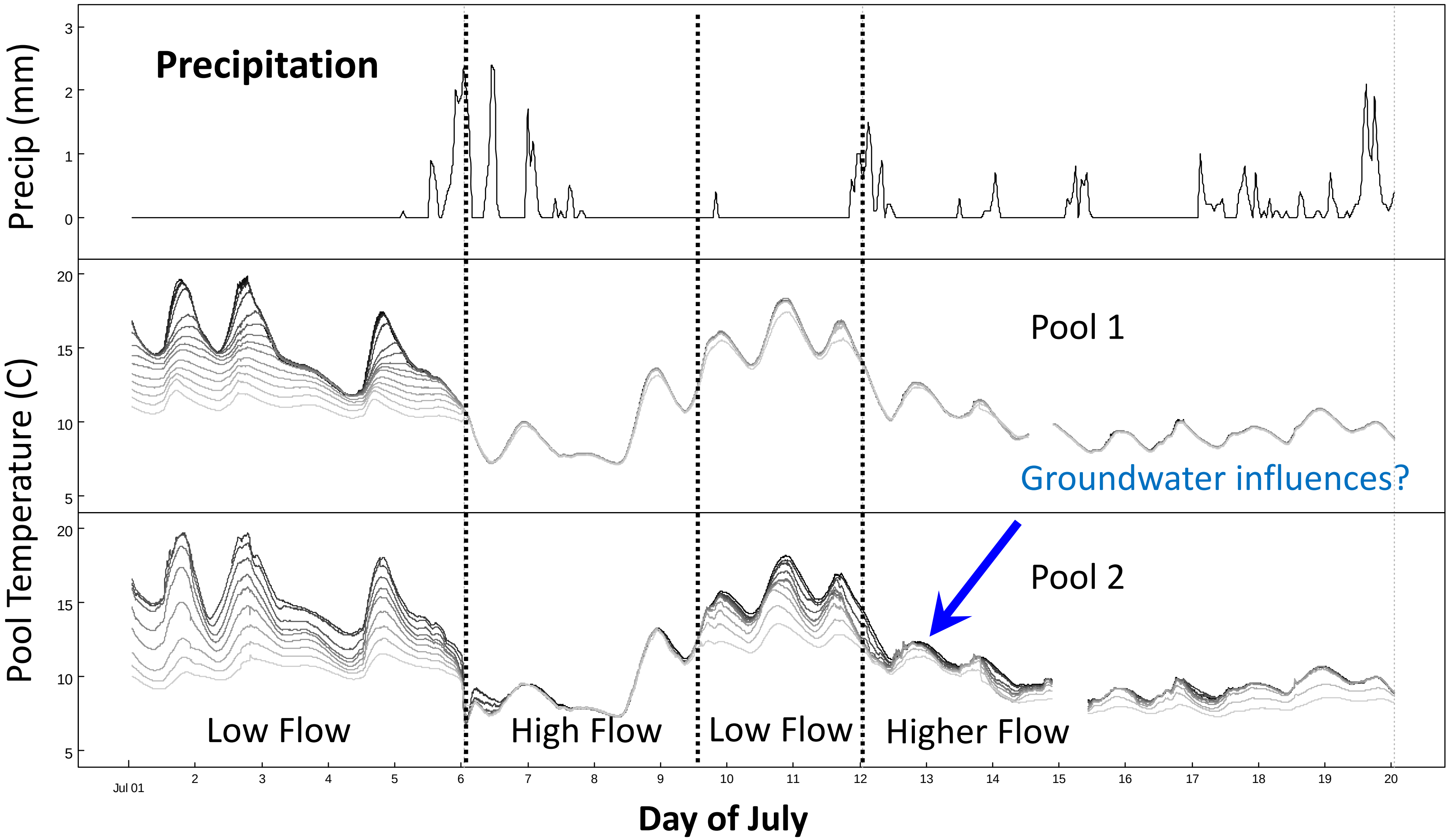
IMNAVAIT CREEK, ALASKA – WET AND DRY CONDITIONS



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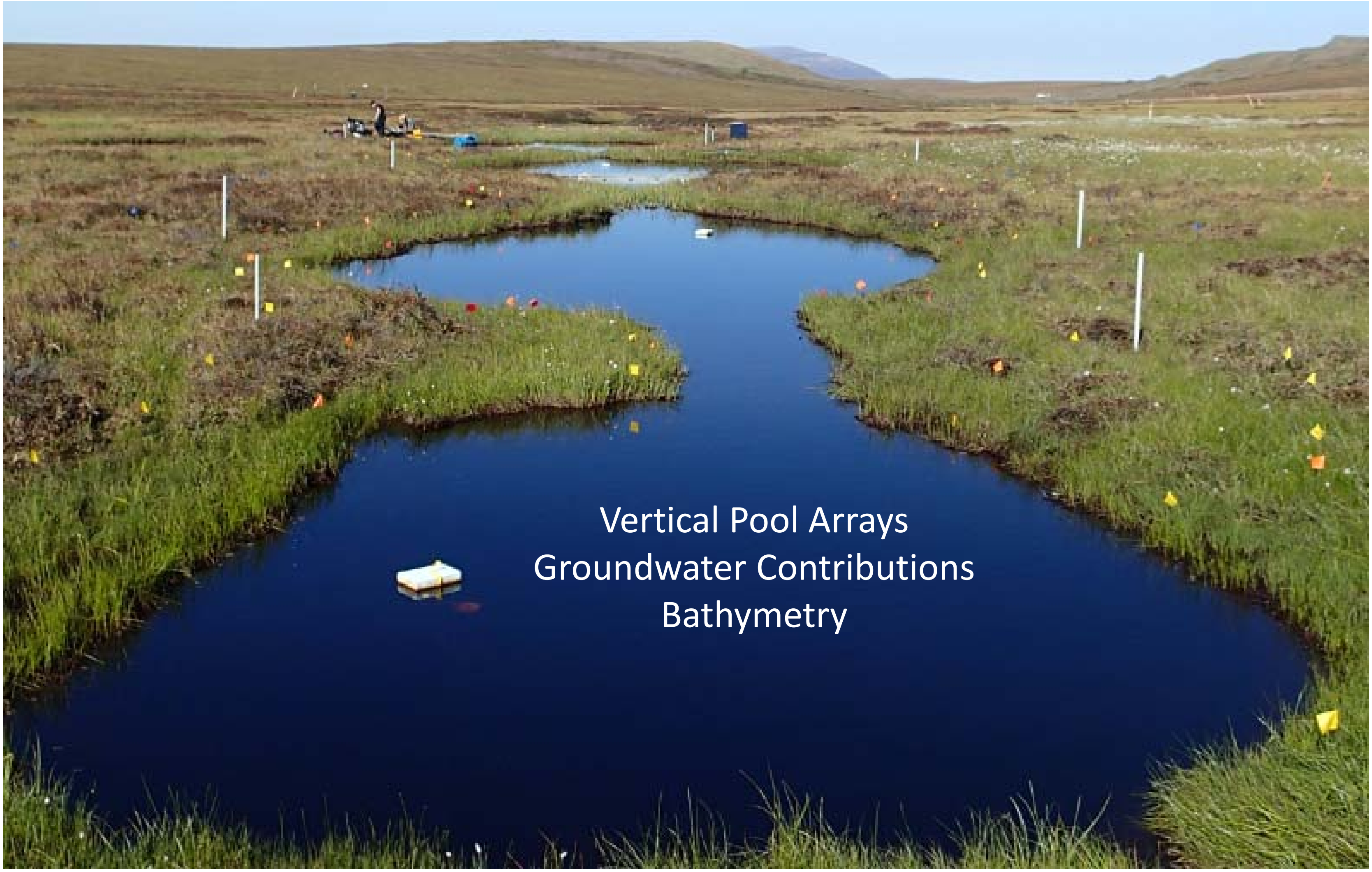
IMNAVAIT CREEK, ALASKA



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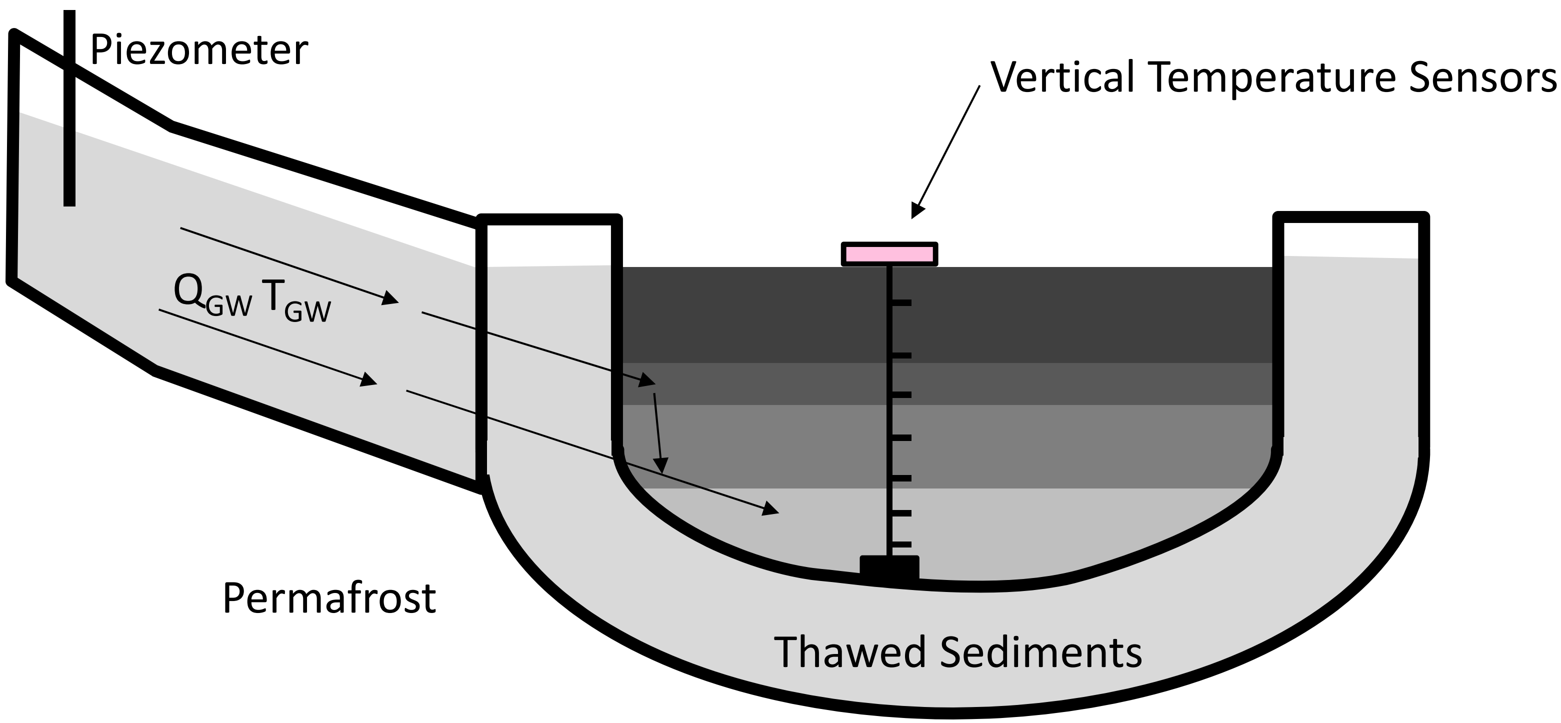
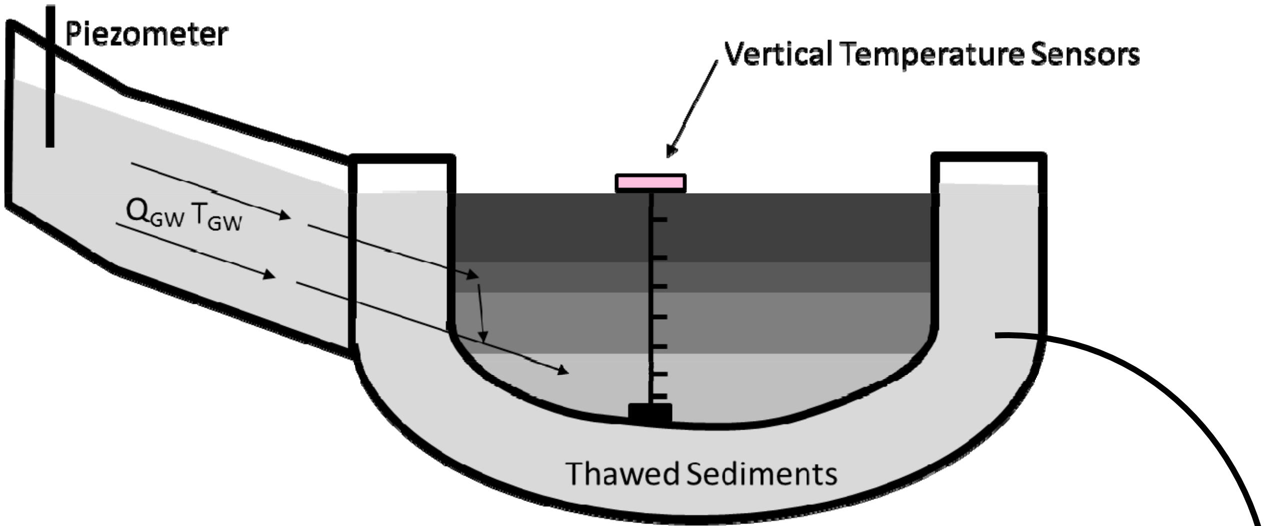
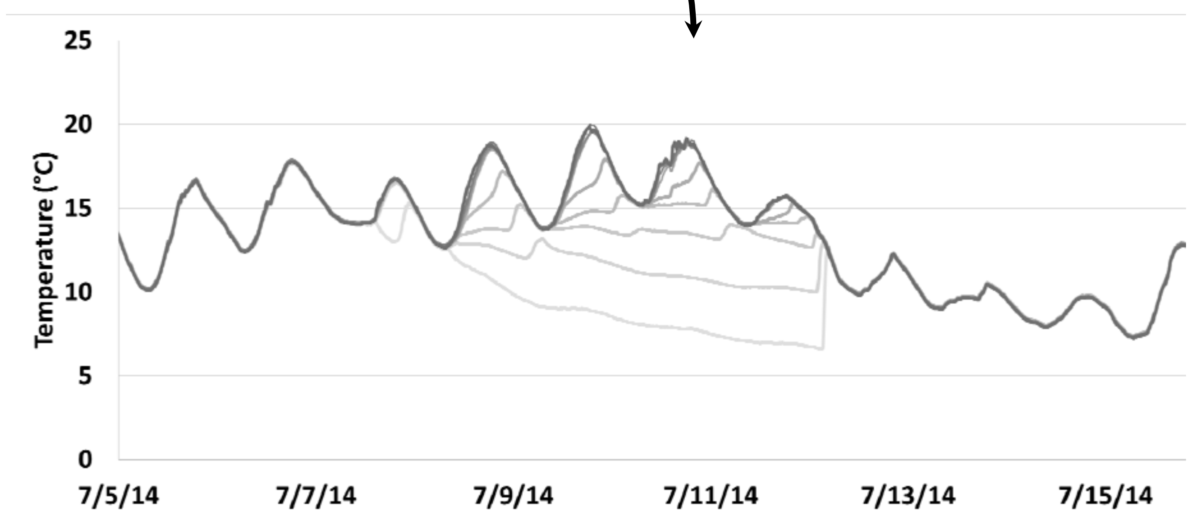
IMNAVAIT CREEK, ALASKA







Groundwater inflows account for 85% of the cooling in the bottom layers

THE ROLE OF GROUNDWATER/SURFACE WATER EXCHANGES ON INSTREAM TEMPERATURES

Higher Order Rivers:

- Wet conditions - Lateral inflows play an important role in understanding instream temperatures during higher flows.
- Dry conditions – Hyporheic exchange becomes an important heat sink and buffers instream temperatures.

Lower Order Beaded Streams:

- Wet conditions – Lateral inflows from very shallow, high hydraulic conductivity layers increase stream discharge, mix pools, and result in colder instream temperatures on average.
- Dry conditions – Lateral inflows from "deeper" groundwater are cold and play a role in thermally stratifying water columns.

Future hydrologic responses and the associated groundwater/surface water interactions are key to understanding the potential influences of climate change on instream temperatures.

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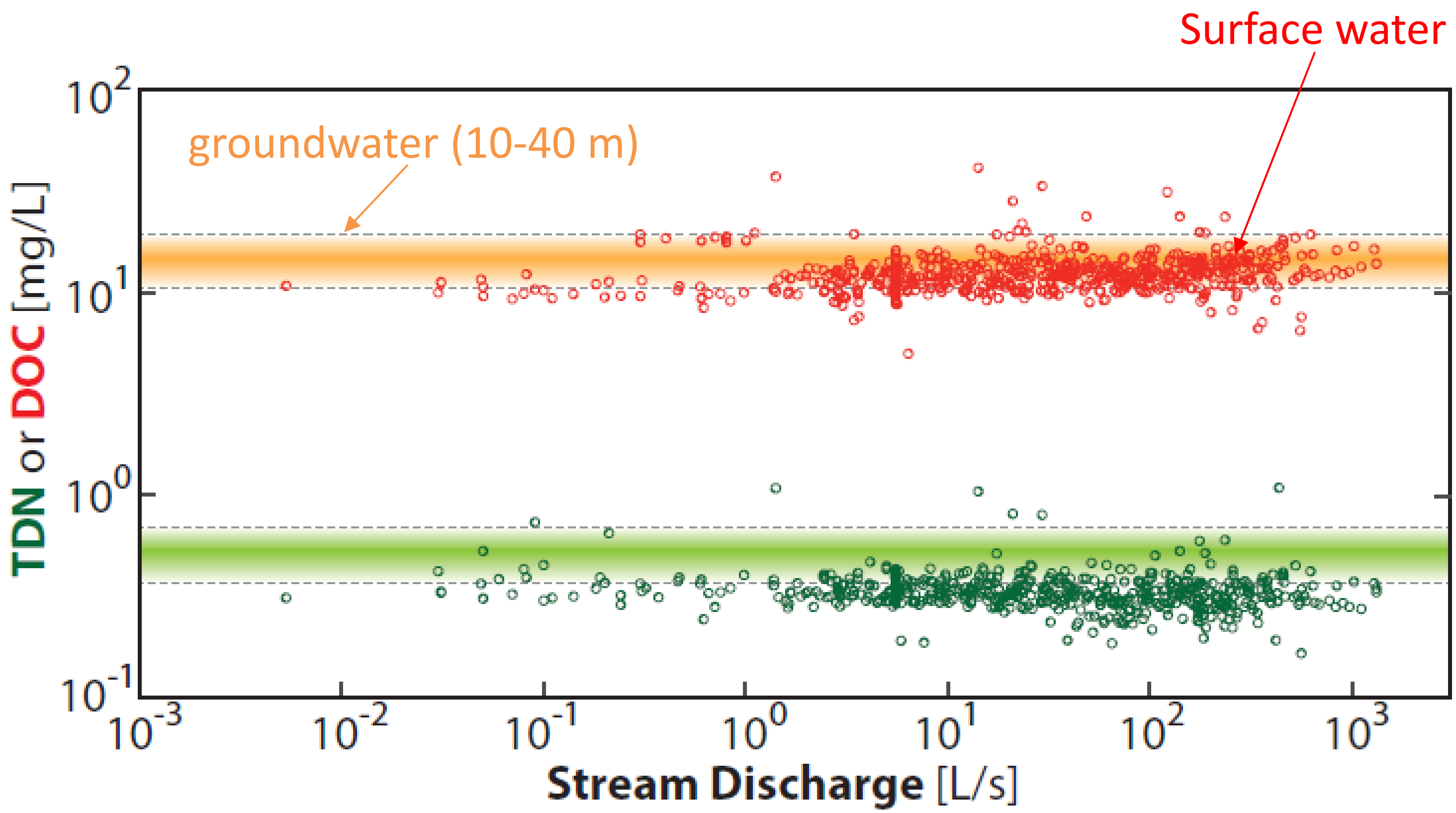
Connecting hillslope and riparian processes to river and stream DOC

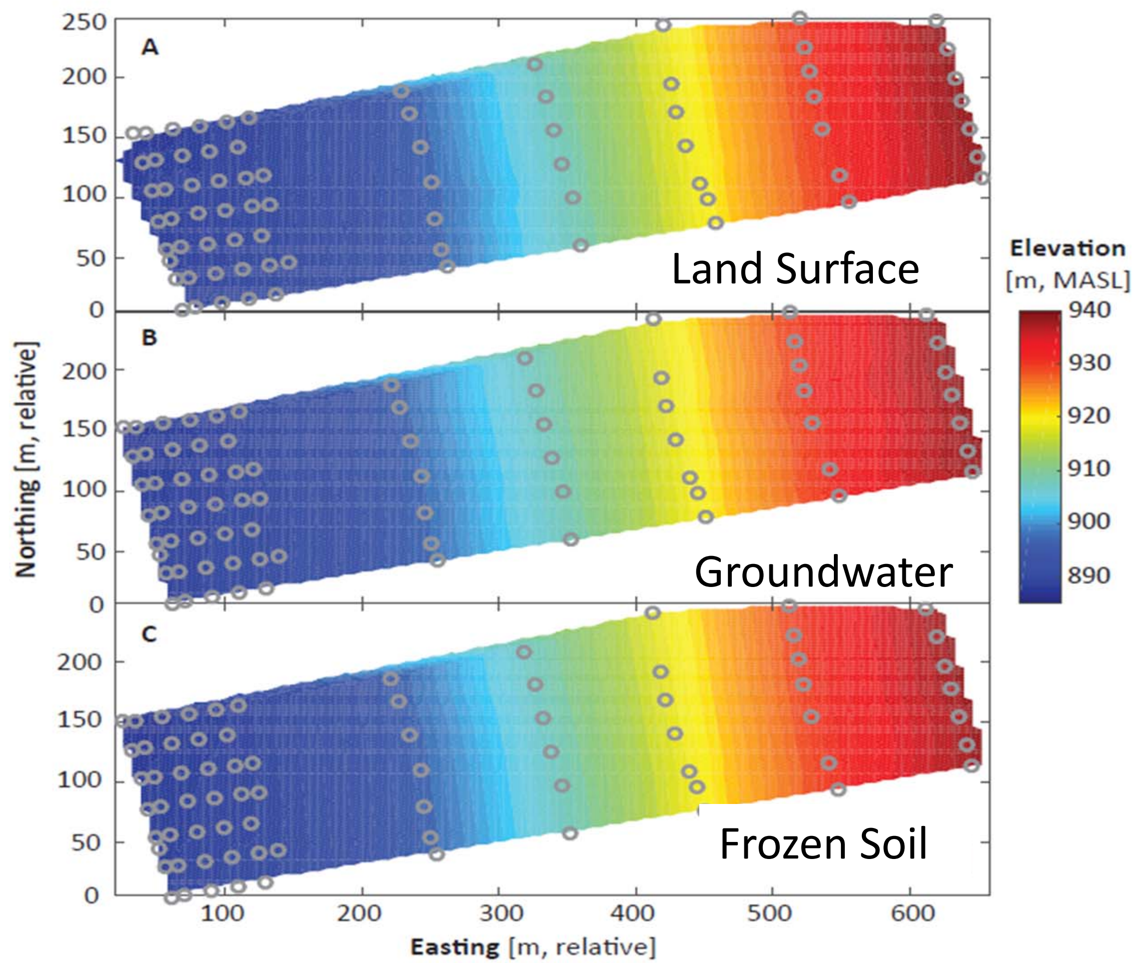
Imnavait Creek (1993-2011)



Why are there relatively constant DOC concentrations over a large range of Q?

Vertically Integrated Modeling

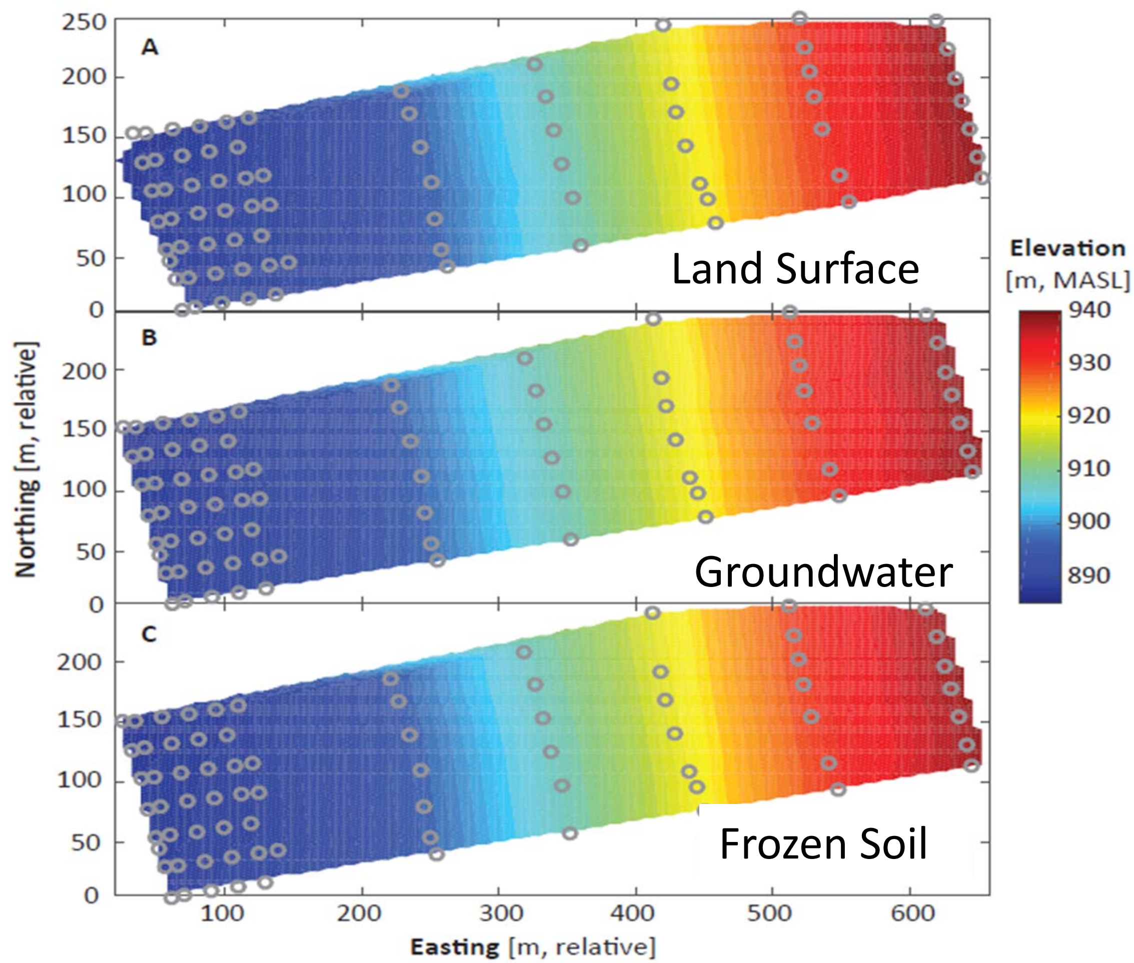
- Macro-topography controls groundwater flow under partially saturated conditions



Vertically Integrated Modeling

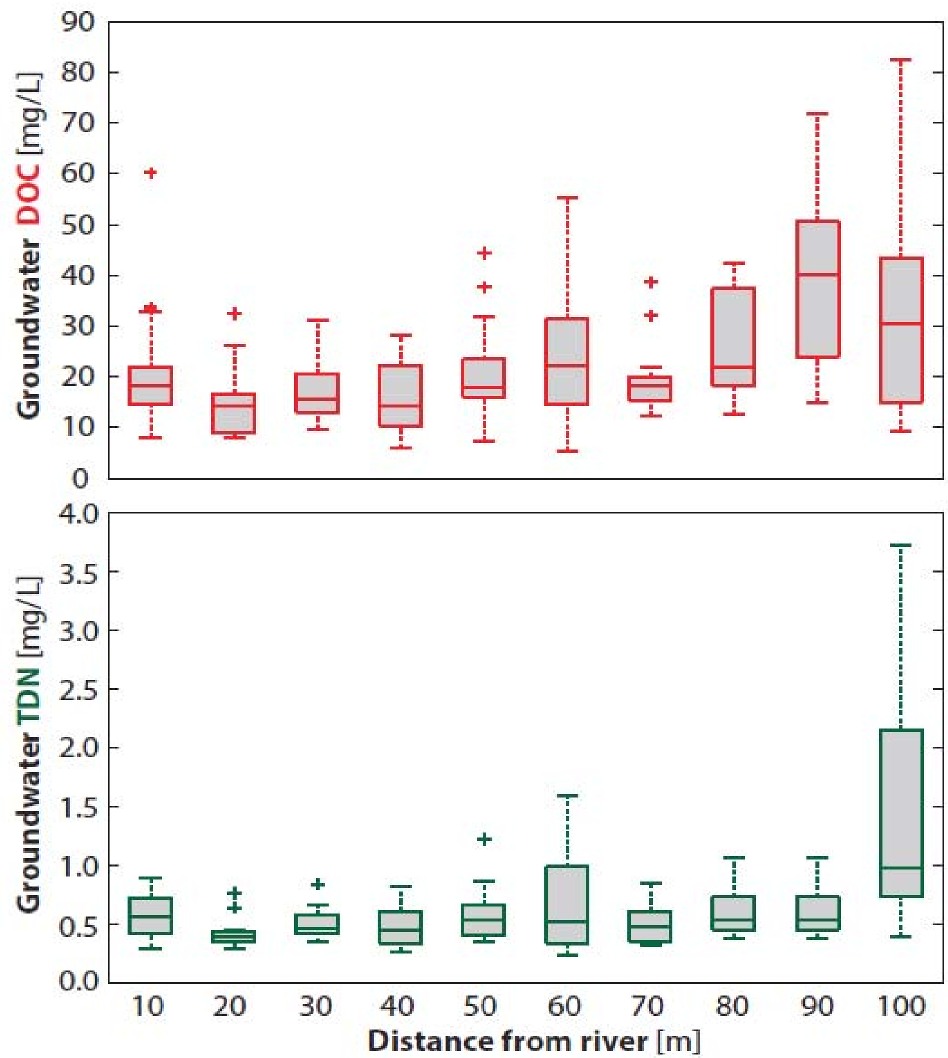
- Macro-topography controls groundwater flow under partially saturated conditions

- Groundwater modeling estimates match
  - baseflow measurements
  - groundwater inflow estimates based on measurements

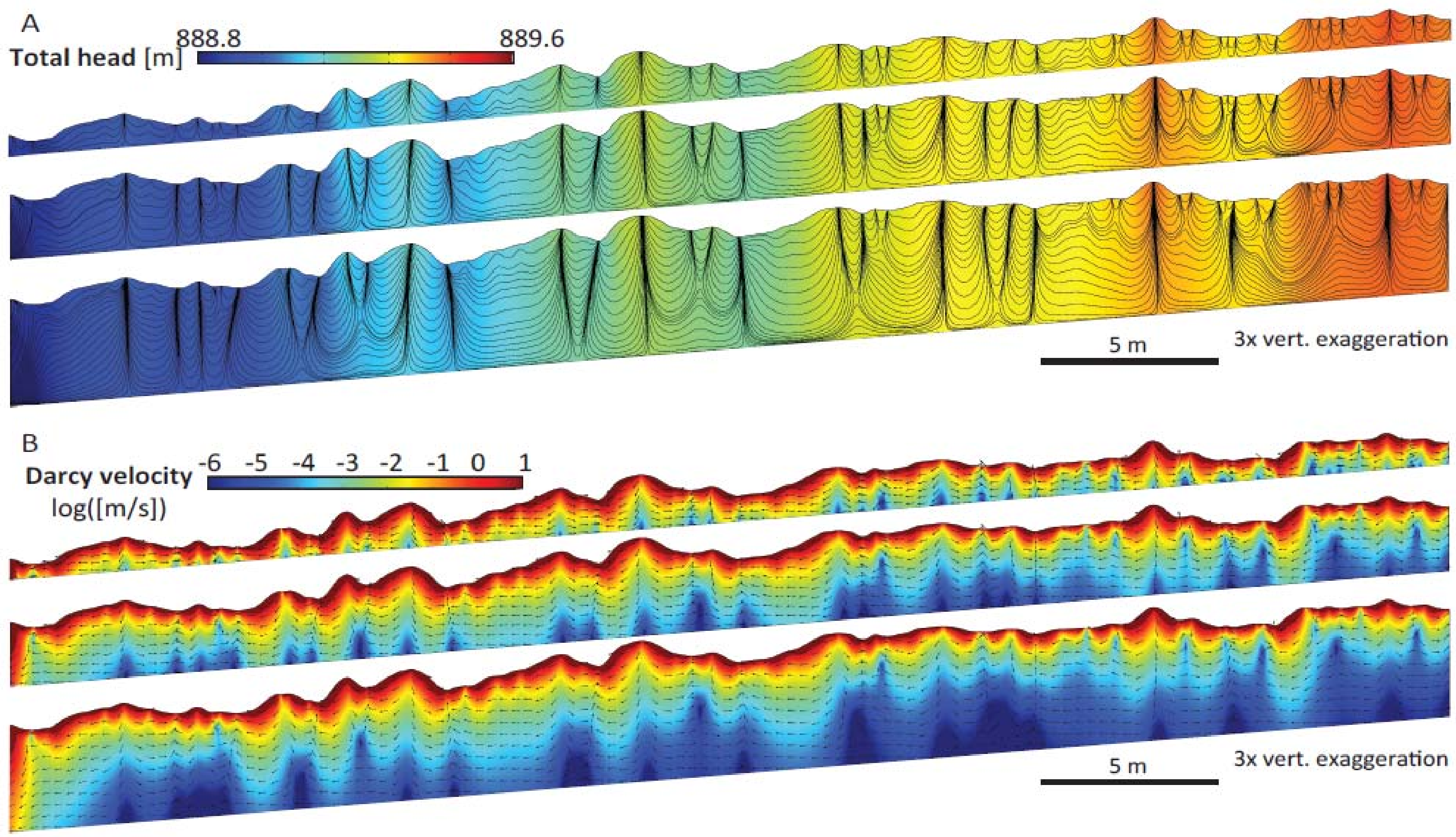


Vertically Integrated Modeling

- Macro-topography controls groundwater flow under partially saturated conditions
- Groundwater modeling estimates match
  - baseflow measurements
  - groundwater inflow estimates based on measurements
- DOC and TDN loads require groundwater contributions from entire riparian zone



Vertically Explicit Modeling



Conclusions

DOC and DON contributions in streams/rivers–

- baseflow groundwater contributions
- flushing from rising water tables
- influence of groundwater through surface-subsurface exchanges across the land surface

Future Research Needs

- Hydrologic responses in a changing climate

- Role of groundwater on surface water systems in a changing climate

- Links between changing hydrology, chemistry, and ecological responses within surface waters

Future hydrologic responses and the associated groundwater/surface water interactions are key to understanding the potential influences of climate change on surface water.

QUESTIONS?

Funding:

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- Utah Water Research Laboratory, Utah State University

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