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*Managing Water in the West*

# River Temperature Simulation under Climate Change

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# Acknowledgements


- Yong Lai
  - Model Development
- Jason Caldwell and Subhrendu Gangopadhyay
  - Climate Change Data Development
- Reclamation Science and Technology Office
  - Funding Support
- Reclamation Methow Field Office
  - Data collection support


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# Research Background

- Stream temperature is an important component of aquatic habitat throughout the year
- Tools needed to inform how climate change could alter the hydrologic runoff and water temperature inputs to stream and floodplain reaches utilized by endangered or threatened fish species
- A 2D model can show lateral changes across the river channel that may vary substantially in mixing zones or side channels important to fish
- Output from water temperature model can be linked with biological monitoring data

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# Numerical Model: SRH-2D

- 2D depth-averaged solution of the dynamic wave equations for flow hydraulics;
- An implicit solution scheme for solution robustness and efficiency;
- Unstructured or structured meshes with arbitrary mesh cell shapes may be used;
- Steady or unsteady flows;
- All flow regimes: subcritical, supercritical, or transcritical flows;

**See website for more info:**

**www.usbr.gov/pmts/sediment/model/srh2d**

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# Temperature Equation

$$\frac{\partial hT}{\partial t}+\frac{\partial hUT}{\partial x}+\frac{\partial hVT}{\partial y}=\frac{\partial}{\partial x}\left[\frac{h\nu_t}{\sigma_t}\frac{\partial T}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{h\nu_t}{\sigma_t}\frac{\partial T}{\partial y}\right]+\frac{\Phi_{net}}{c_w\rho_w}+\frac{q_{sp}}{A_{sp}}(T_{sp}-T)$$

$\Phi_{net}$ =net heat exchange between water column and its surroundings

$q_{sp}$ is the spring water flow rate [$m^3/s$] into the stream

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# Temperature Equation

$\Phi_{net}$ =net heat exchange between water column and its surroundings

$$\Phi_{net} = \Phi_{ns} + \Phi_{na} + \Phi_{bed} - \Phi_{br} - \Phi_{e} - \Phi_{c}$$

$\Phi_{ns}$ = net solar radiation entering water surface

$\Phi_{na}$ = net atmospheric radiation entering water surface

$\Phi_{br}$ = heat loss by back radiation from stream

$\Phi_{e}$ = evaporative heat loss at water surface

$\Phi_{c}$ = conductive heat loss at water surface

$\Phi_{bed}$ = heat flux into stream at channel bed

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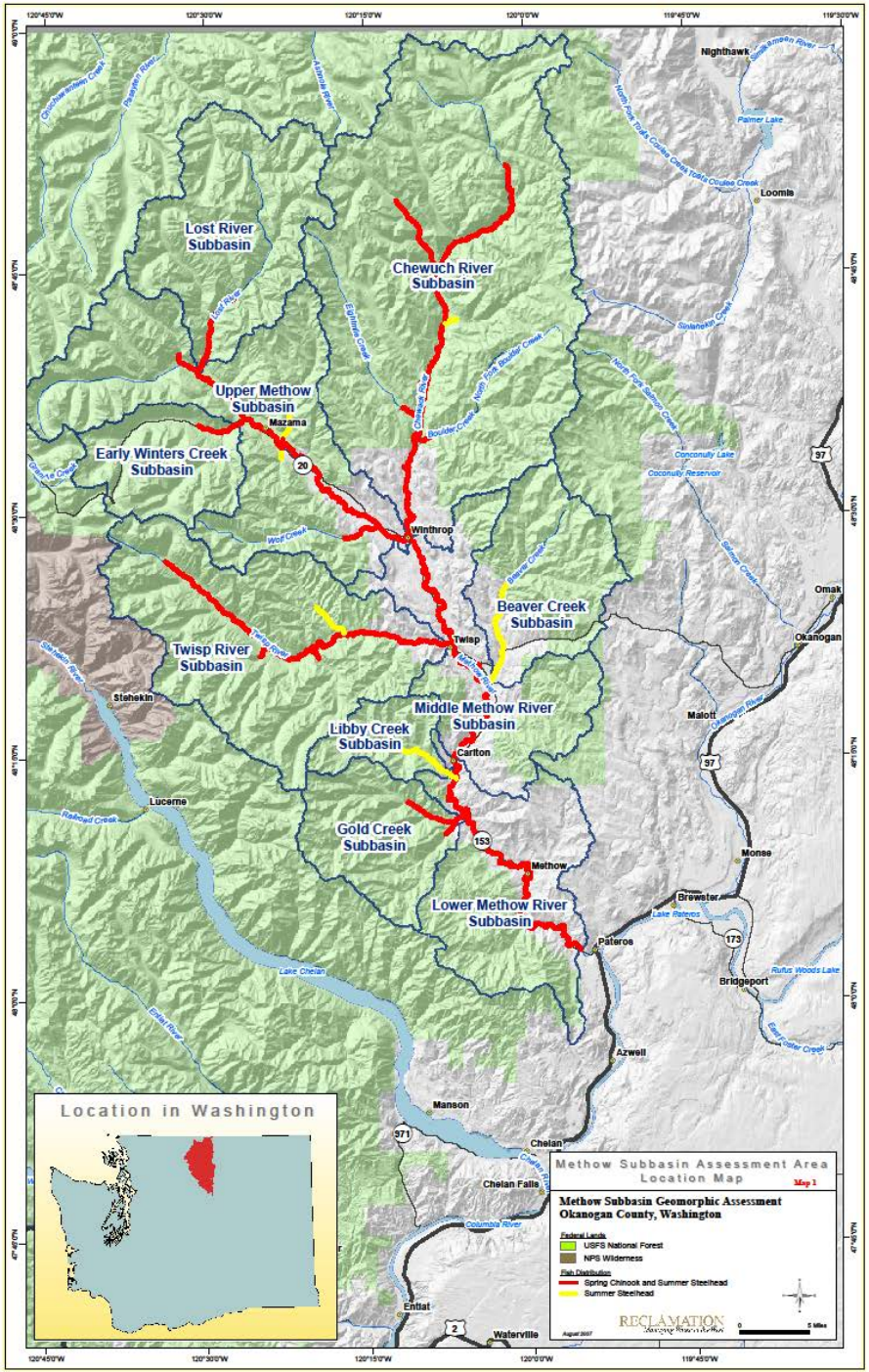


# Methow River Example

- Eastern Washington in Cascade Mountains
- Technical studies being done to assists with Chinook and Steelhead salmonid habitat restoration efforts (red and yellow outlines)

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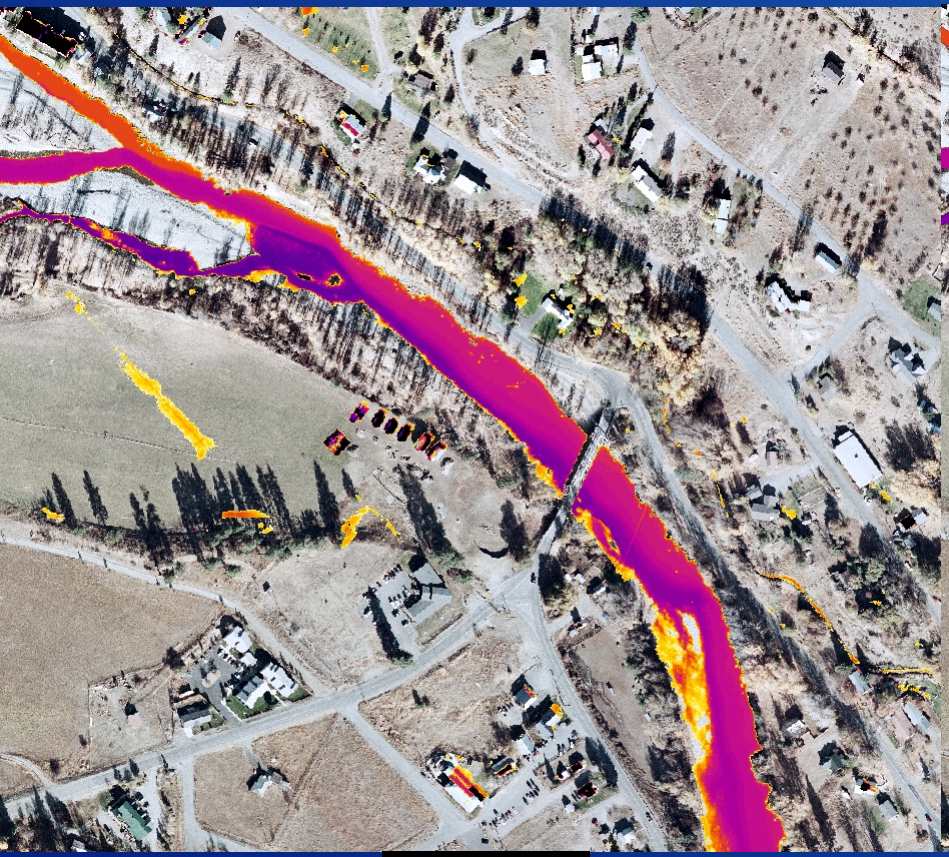
# Methow River Temperature Characteristics

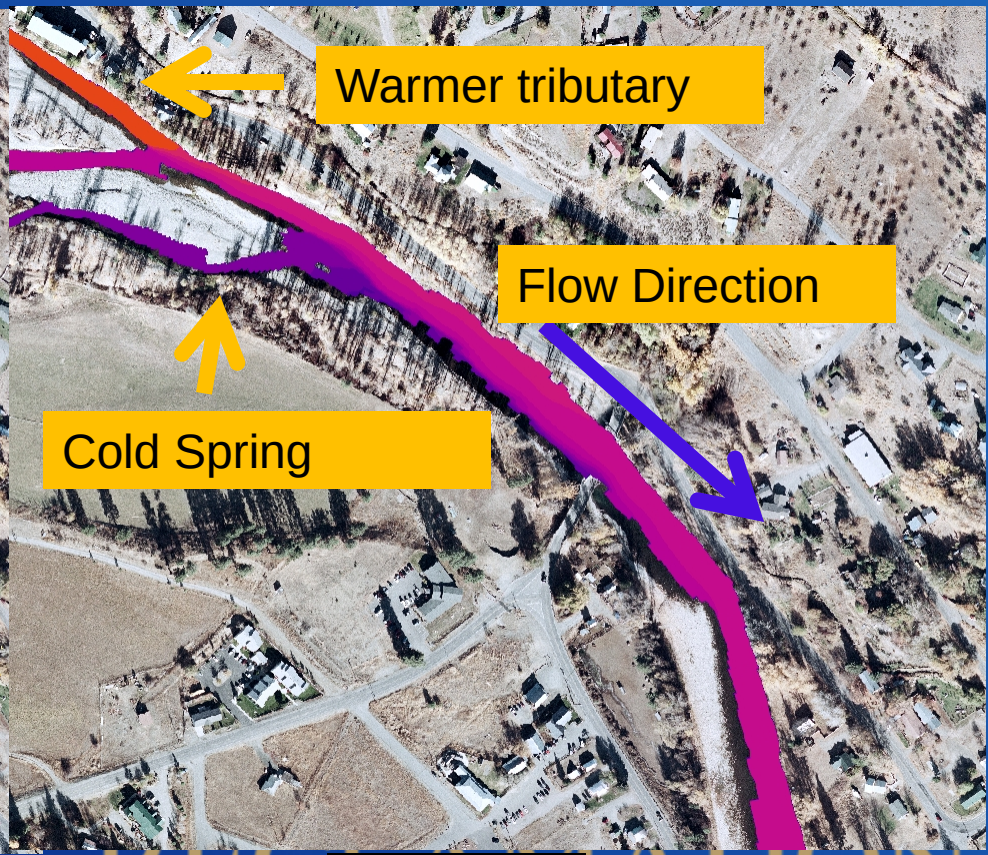
- Well mixed with steep slope and fairly shallow depth;
- Temperature difference in the vertical direction is within 0.2 degree;
- Warmer Chewuch River entering on the river left;
- Colder water springs entering on the river right;
- Thermal infrared images were recorded for surface temperature during a three day flight from August 24 to August 26 2009.
- Two gage stations in study reach: USGS 12448500 Methow at Winthrop and USGS 12448000 Chewuch at Winthrop.
- Temperature loggers in the study reach.

# Field Measurements versus Predicted

| | Flow Rate (cfs) | Temperature (ºC) |
|---|---|---|
| **Chewuch** | 89 | 17.3 |
| **Methow** | 146 | 15.4 |
| **Spring Creek** | 21 | 13.6 |
| **Point Source** | 20 | 13.6 |



Field




Modeled

# Future Research Steps

- Reach sensitivity analysis to weather parameters
  - Solar radiation
  - Atmospheric radiation
- Heat losses
  - Water surface: reflection, evaporation, conduction
  - Bed: conduction
- Climate change
  - Water temperature
  - Air temperature
  - Discharge

Weather Station in New Brunswick (http://www.dfo-mpo.gc.ca/science/publications/article/2010/01-11-10-eng.html)

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