Changing water temperature in New England: impact of climate change and implications for fish habitat

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Questions: How do regional scale water temperatures respond to projected changes in climate?

What implications do these water temperature changes have on fish habitat?

Rationale: Water temperature is a major ecosystem variable
- -that influences water quality and biotic conditions in river systems
- -has implications for suitable habitat for fish and other aquatic species
- -impacts algal blooms and primary productivity in lakes, rivers and reservoirs

Management of aquatic resources in riverine environment experiencing alteration due to climate change

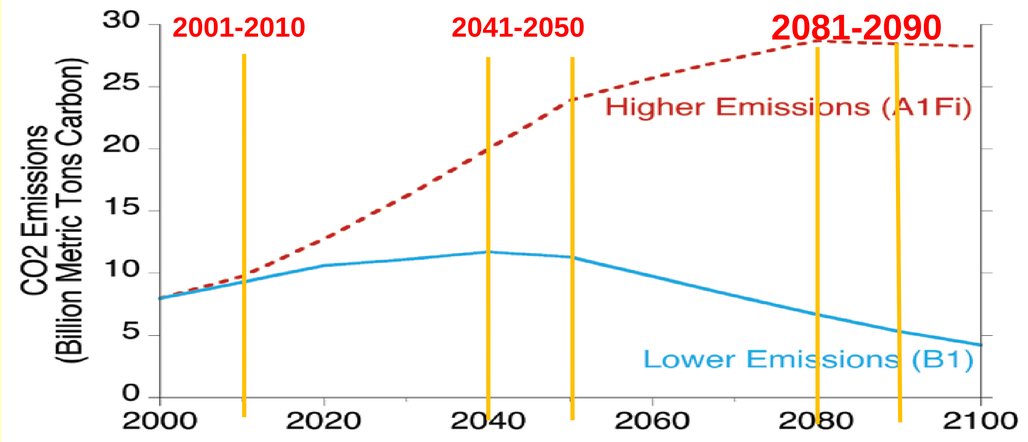
Goal: Utilize a daily time step river network model to determine the sensitivity of water temperature under projected climate change at regional scale and to assess the quantity of unsuitable thermal habitat for cold, cool, and warm water fish species for contemporary and extreme (i.e. drought) climate conditions

Data and Climate Scenarios:

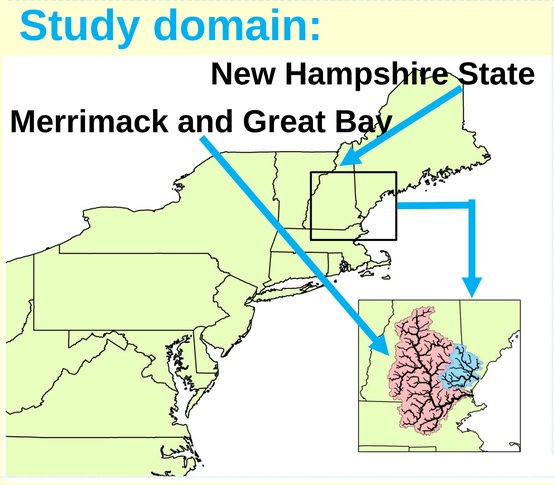
Model forcing for contemporary climate: total daily precipitation; average daily air temperature, solar radiation / cloud cover, and wind speed; current land use

Source: NASA's Global Modeling and Assimilation Office (Modern Era-Retrospective analysis for Research and Applications or (MERRA)

Scenarios	Climate data (CMIP3), IPCC 2007:AR4	Time period
Validation	MERRA	2001-2010
High (A1Fi) Low (b1)	gfdl_2_1	2041-2050 & 2081-2090



Study domain:



River Network Model:

Water temperature models in the Framework for Aquatic Modeling in the Earth System (FrAMES)
(Wollheim *et al* 2008a, 2008b, Stewart *et al* 2011)

- **spatially distributed, gridded river network model**
- **utilizes the Water Balance Model (WBM) and**
- **Water Transport Model (WTM)**

(Vorosmarty *et al* 1998, Wisser *et al* 2010)

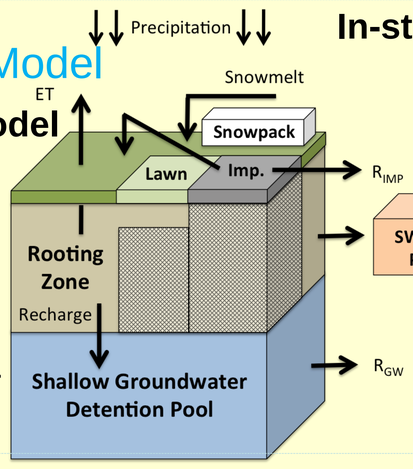
Simulate river flows, water temperature (Stewart et al. 2013) and biogeochemical dynamics in the Northeast US at a spatial resolution of 3 min

-Nitrogen (Wollheim *et al.* 2008; Stewart et al. 2011); **-Chloride** (*Zuidema et al*. in preparation)

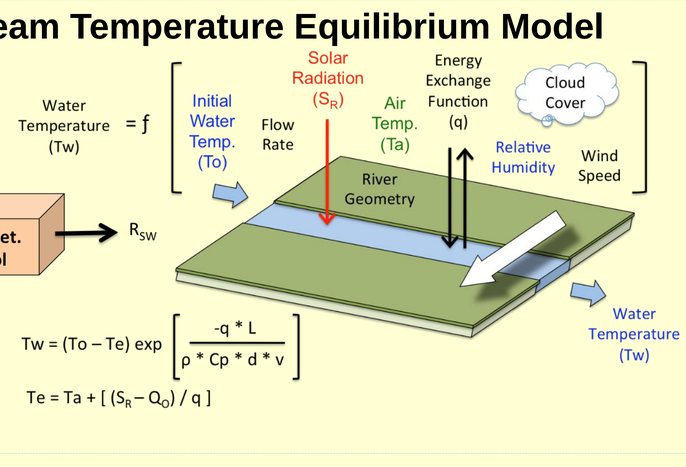
-DOC (Wollheim *et al.* in preparation)

WBM and WT Model

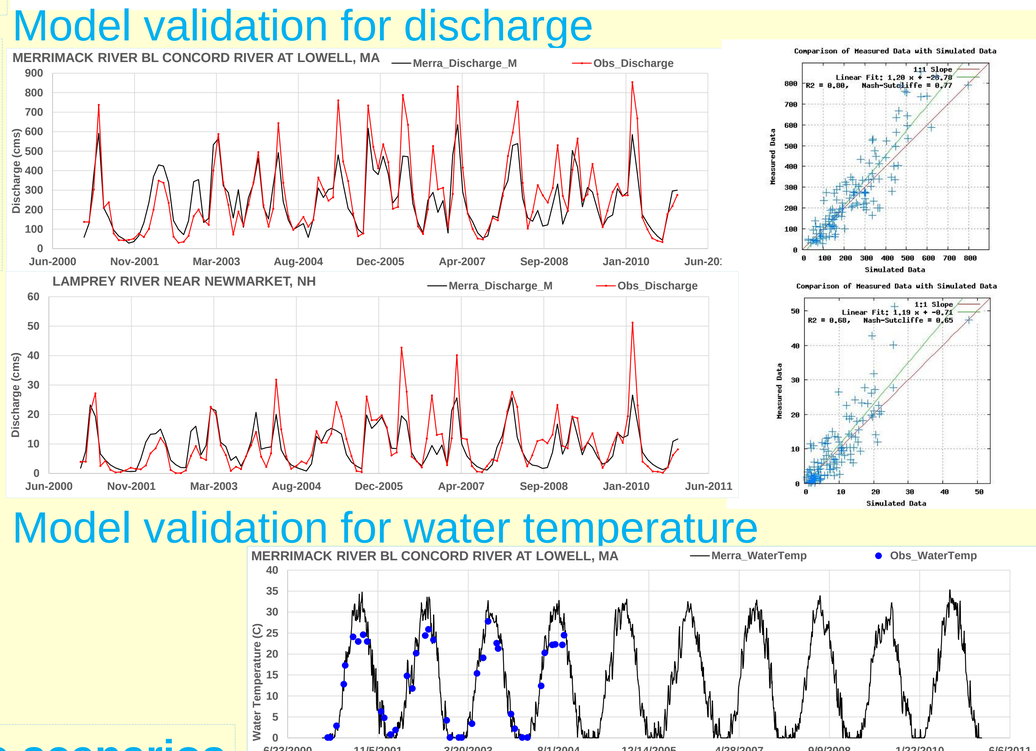
Water Balance Model
- ✓Air temperature
- ✓Precipitation
- ✓Wind speed
- ✓Could cover
- ✓Topography
- ✓Impervious cover



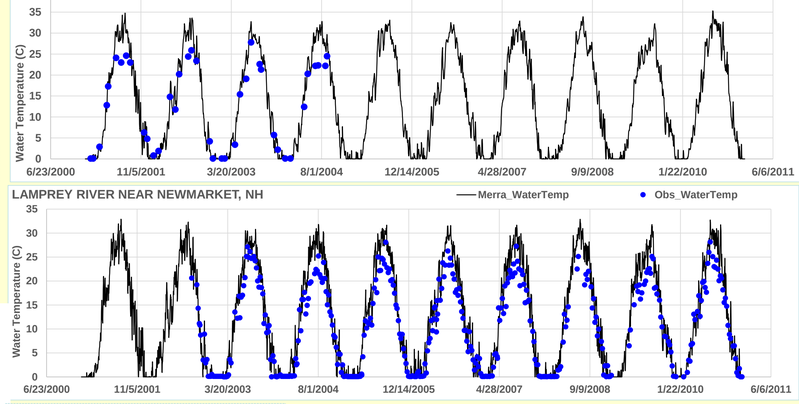
In-stream Temperature Equilibrium Model



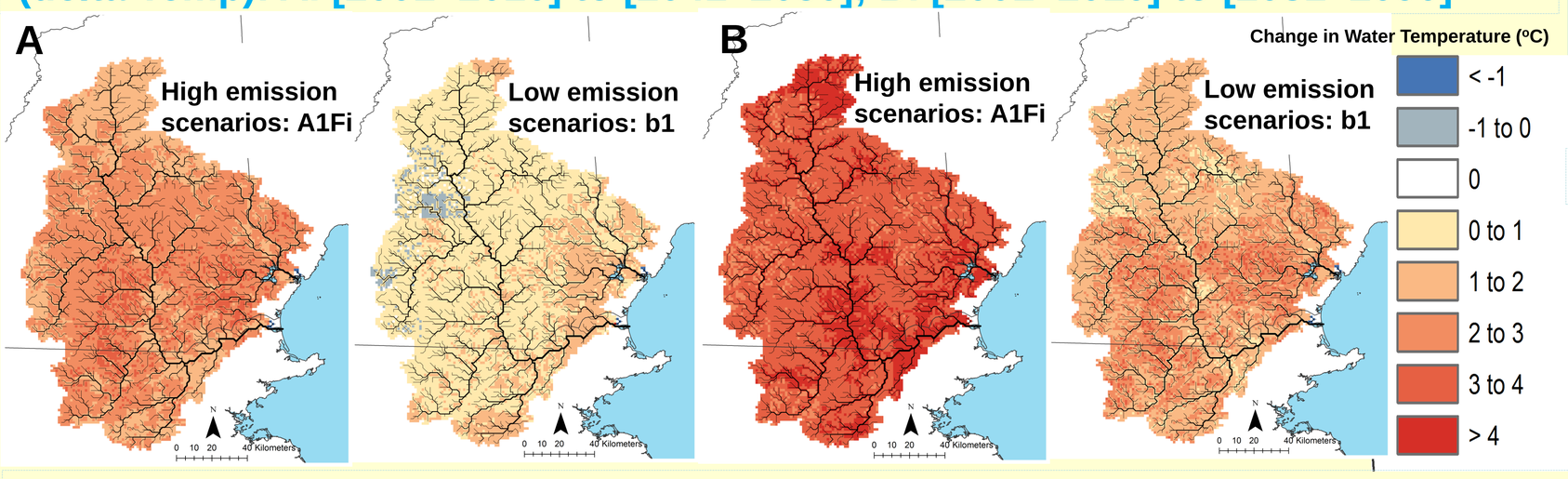
Model validation for discharge



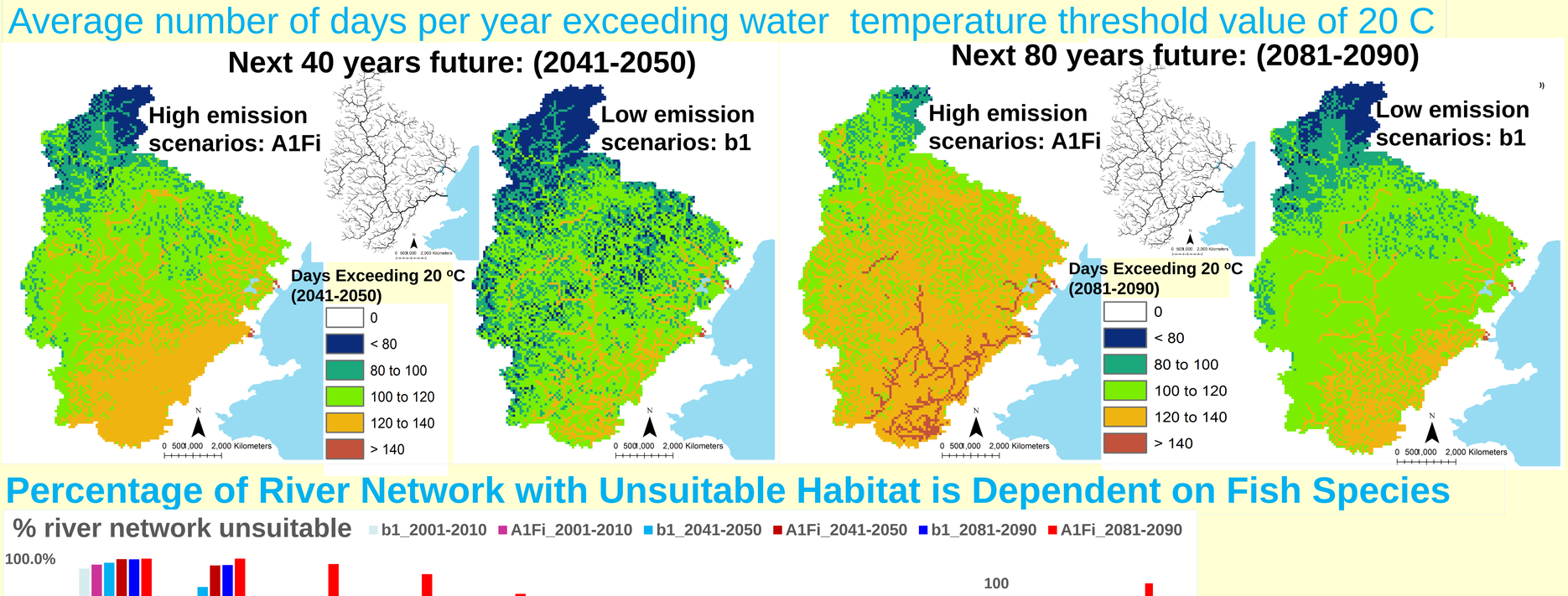
Model validation for water temperature



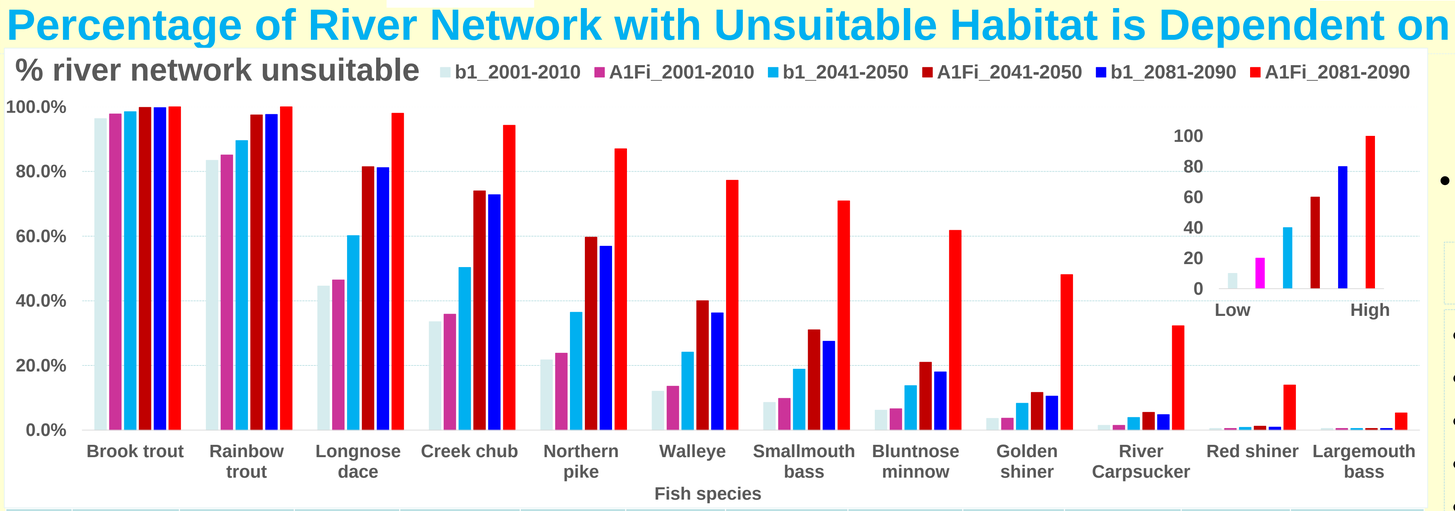
Increase in average summer water temperature under various climate scenarios (delta Temp): A. [2001–2010] to [2041–2050]; B. [2001–2010] to [2081–2090]



Average number of days per year exceeding water temperature threshold value of 20 C



Percentage of River Network with Unsuitable Habitat is Dependent on Fish Species



*	22.4	24	26.5	27.1	28	29	29.5	30.1	30.9	32.1	34	35.5

*Average maximum weekly tolerance (^{0}C), Ref: Stewart et al. (2013), Environmental Research Letters.

Conclusions

- **Projected emissions directly influence water temperature in 21st century**

  -Impacts are greatest in large rivers due to warming of water temperatures along river flow paths

  -Lower emissions delay the magnitude of impact

- **Low Emissions are more protective of fish habitat in the White Mountains, a critical recreational destination, through the 21st century**

- **Under projected thermal regimes, cold water fish (i.e. brook trout) are most strongly affected**

While, warm water fish (i.e. large mouth bass) aren't expected to be impacted

- **Increase in water temperature promote exotic invasion**

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