Title: Application of new spatial statistical stream models for precise downscaling of climate change effects on temperatures in river networks

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Abstract: A warming climate will bring unprecedented changes to stream and river ecosystems, with temperature considerations being of utmost importance, given that most aquatic organisms are ectothermic. Previous broad-scale assessments of climate impacts to streams have been limited by inadequate availability of stream temperature data and often relied on imprecise surrogate air temperature-elevation relationships. Mechanistic models have sometimes been used to model stream thermal responses directly, but intensive parameterization limits the spatial scope of these applications. Modeling approaches are needed that address stream temperatures directly at the larger spatial scales commensurate with most conservation and restoration planning efforts. We applied new spatial statistical models that account for network topography (i.e., flow direction and volume) to an extensive, but non-random stream temperature database (n = 780) compiled across a 13 year period (1993–2006) for a large 2,500 km river network in central Idaho. Four predictors—radiation, elevation, air temperature, and stream flow—were used in the spatial model to represent important geomorphic and climatic effects on mean summer stream temperatures. The spatial models incorporated autocorrelation among sample sites to provide improved parameter estimates and predictive accuracy (R^2 = 0.93; RMSPE = 0.74°C) relative to traditional, non-spatial models (R^2 = 0.68; RMSPE = 1.53°C). A small bias between observed stream temperatures and those predicted by the spatial models amounted to 0.5°C at the extremes of the observed temperature range (5°C – 20°C) and caused over- (under-) predictions for the coldest (warmest) streams. This bias could have arisen from elevational gradients associated with influxes of cold, snowmelt groundwater or alterations in valley form due to past glacial activity. Better understanding regarding the importance of these and other factors that effect local variability in stream warming rates is needed to optimize future downscaling efforts. However, the application of new spatial models for streams provides a significant advance in our ability to translate climate change impacts to aquatic ecosystems. Moreover, the approach is widely scalable given the advent of GIS capabilities, increasing availability of stream temperature sensor networks, and flexibility to accommodate climatic forcing data from a variety of sources.