Applications of Spatial Statistical Network Models to Stream Data

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Streams and rivers host a significant portion of Earth's biodiversity and provide important ecosystem services for human populations. Accurate information regarding the status and trends of stream resources is vital for their effective conservation and management. Most statistical techniques applied to data measured on stream networks were developed for terrestrial applications and are not optimized for streams. A new class of spatial statistical network model (SSNM), based on valid covariance structures for stream networks, can be used with many common types of stream survey data (e.g., water chemistries, habitat conditions, biological attributes) to develop accurate information at river network scales. The SSNMs account for spatial autocorrelation (i.e., non-independence) among measurements, which allows their application to databases with non-random measurement locations. Large amounts of stream survey data exist in many areas where spatial statistical analyses could be used to develop novel insights, improve predictions at unsampled sites, and aid in the design of efficient monitoring strategies at relatively low cost. SSNMs require larger sample sizes than non-spatial models (n > 50 or 100 observations) and are computationally demanding (both for data preprocessing and estimation) but provide significant advantages for many stream applications. Here, we demonstrate the use of SSNMs with datasets relevant to common water quality research and management questions. Free software for implementing the spatial models has been developed that enables custom applications with many stream databases. More information and example datasets are available at the SSN/STARS website (http://www.fs.fed.us/rm/boise/AWAE/projects/SpatialStreamNetworks.shtml) and the Spatial Stream Networks (SSN) package for R is also available from the CRAN website (http://cran.r-project.org/web/packages/SSN/index.html).