Geostatistical Estimation of Water Quality Using River and Flow Covariance Models

Assessing water quality along rivers is vital for watershed management and to protect the public health. Monitoring water quality at every river mile is logistically impractical and prohibitively expensive. Geostatistical estimation offers a cost effective alternative that can be rapidly implemented to statistically model spatially dependent water quality parameters using the available monitoring data. Geostatistical modeling requires a covariance model to describe the variability and autocorrelation of the water quality along rivers. Three main classes of covariance models, namely the Euclidean, river, and flow-weighted covariance models, are commonly used in geostatistical water quality estimation.

In the first study we use a river covariance model to successfully characterize the space/time variability of chloride, an emerging contaminant, along rivers in Maryland. This method leads to a 24% reduction in mean square estimation error compared to the Euclidean method. In the next two studies we use the flow-weighted covariance for the estimation of fecal coliform (FC), and Dissolved Organic Carbon (DOC), respectively. Surprisingly, very few geostatistical water quality studies have successfully implemented the flow-weighted covariance model and improved estimation accuracy. To address this critical gap, we introduce the first implementation of a flow weighted covariance model that uses gradual flow, and we then use this model in a novel hybrid Euclidean/Gradual-flow covariance model to estimate FC in the Haw and Deep rivers in North Carolina, and DOC in three sub-basins in Maryland. Our novel hybrid Euclidean/Gradual-flow covariance model captures variability coming from both terrestrial sources and hydrological transport, and it leads to a 12% and 15% reduction in mean square error for FC and DOC, respectively, compared to the traditional Euclidean covariance. This novel hybrid covariance model is widely applicable to any other study area and to other water quality parameters.

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