Assessment of Differences in Watershed Physical Characteristics Between Gaged and Ungaged Portions of the Great Lakes Basin

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Introduction

Methods for predicting streamflow in basins with limited or non-existent streamflow records typically invoke the concept of regionalization, whereby knowledge pertaining to gaged catchments is transferred to ungaged catchments (Vogel 1988). Regionalization approaches relying on watershed physical characteristics are calibrated model parameters or hydrologic signatures have been important contributions to what Würgler and Moiniet (2011) call a “sweepstakes” of approaches toward understanding watershed behavior in ungaged catchments. However, differences in watershed physical characteristics between gaged and ungaged catchments constitute a common obstacle for any regionalization approach. For example, predictions from approaches based on spatial proximity may be of limited value or reliability if there are substantially different climates, soils, land cover, or topographic settings in the gaged and ungaged areas. Additionally, regression models between gaged watershed physical characteristics and their hydroclimatic response may not be valid across ungaged basins. The distribution of gaged catchments’ characteristics do not adequately represent those of ungaged catchments. Understanding the degree of spatial homogeneity among such characteristics is therefore essential for selecting an appropriate regionalization scheme.

The straits gage network in the Great Lakes basin, with its many coastal regions, exhibits a clear string of coastal areas that are largely ungaged, while inland areas are predominantly gaged. This hypothesis that existing data may not be appropriate for predicting flow in ungaged basins is further confirmed by the importance of coastal areas to the Great Lakes system, both economically and ecologically. Given the importance of these areas to the Great Lakes system, understanding the degree of similarity between gaged and ungaged portions of the Great Lakes basin is critical.

Approach and Data

Differences in watershed physical characteristics between gaged and ungaged areas of the Great Lakes basin were examined at three spatial scales with data from the 2010-2011 U.S. National Water-Quality Assessment Program (NWQAP). These data include information on basin area, drainage area, mean annual precipitation, mean annual temperature, stream density, percent slope, and percent forest. Data from the NWQAP provide a unique opportunity to examine the degree of similarity in watershed physical characteristics between gaged and ungaged portions of the Great Lakes basin.

Using the @viper@ package in R, violin plots (Hartigan & Nelson 1985) were created to display the range and distribution of variables for each class of watershed physical characteristics. Violin plots present both the quartiles and density slope of a variable’s distribution.

To assess gaged-ungaged differences at a smaller scale we compared the Goode-Ord (G-O) statistic for each of the HUC-12 sub-areas. G-O is frequently used spatial statistics to show how “hot” or “cold” a location is. In this case, we compare the spatial distributions of high and low values of an individual characteristic. For each characteristic, a z-score map was created to examine differences in the gaged and ungaged portions of each zone.

The distribution of gaged catchments’ characteristics do not adequately represent those of ungaged catchments. Understanding the degree of spatial homogeneity among such characteristics is therefore essential for selecting an appropriate regionalization scheme.

Conclusions

Understanding the degree of physical similarity between gaged and ungaged catchments is an important step toward predicting flow in ungaged areas. In this study, differences in watershed physical characteristics between gaged and ungaged portions of the Great Lakes basin were examined at multiple spatial scales. These differences begin to appear at the individual lake basin scale and become more pronounced (and complex at smaller scales). The results illustrate how localized spatial heterogeneity of watershed physical characteristics may be significant between gaged and ungaged portions of a sub-basin, thereby complicating or potentially invalidating regionalization approaches based on spatial proximity. This study focused on the Great Lakes basin, but the spatial analysis and conditional base areas readily applicable to other coastal environments, e.g., with gage string basins, or multi-scale commonalities for large basins.

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References


Figure 4c provides an exemplary case of a watershed physical characteristic spanning both gaged and ungaged areas and represents a typical spatial scale for analysis based on LBRM delineations. Each zone contains at least 50 HUC12 units. Understanding the degree of spatial homogeneity among such characteristics is therefore essential for selecting an appropriate regionalization scheme.

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