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- By Author
- By Title

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Effect of land use-based surface roughness on hydrologic model output

Alfred J. Kalyanapu, Steven J. Burian, Timothy N. McPherson

Abstract

The Manning's roughness coefficient (n) is commonly used to represent surface roughness in lumped and distributed hydrologic models. Model parameter sensitivity studies identify runoff response to be sensitive to Manning's n changes. For large watersheds, modelers typically use land use / land cover datasets to assign Manning's n values based on the use or cover class (e.g., residential, impervious). Although this approach is expected to introduce errors to the simulation results, studies have not adequately assessed the

occurrence or magnitude because of the challenge of producing an accurate Manning's n map to compare to a map produced by the land use / land cover approach. This paper presents a watershed scale assessment of the hydrologic model error incurred by use of land use / land cover datasets to estimate Manning's n. A digital dataset of Manning's n is generated by manual inspection of aerial photos for a 23 km2 watershed. Manning's n is also estimated using the land use classes in the National Land Cover Dataset (NLCD). Up to 50% difference in the magnitude and variation in spatial distribution of Manning's n values is found in more than 90 % of the study area. The differences did not translate into significantly altered runoff responses (hydrograph magnitude: 9 % to 22 % relative peak discharge difference and shape: 2 % to 18 % relative time to peak difference) from 3 storm events at the watershed outlet for a lumped model (SWMM) and a distributed model. However, these differences are significant (up to 75 % relative peak discharge difference and up to 300 % relative time to peak difference) at the subcatchment levels and showed increasing trend in deviation of the hydrograph peaks with increased Manning's n deviation. The results of this study suggest that the use of NLCD-defined Manning's n values is acceptable for medium to large watersheds.

Keywords

land use-based; surface roughness; hydrologic model; coefficient; Manning; parameter sensitivity; watershed; runoff responses

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