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Evaluation of Hydrologic Response Units by soil moisture simulations, in-situ observations and high resolution aerial photographs

Urooj Khan (1), Narendra Tuteja (2), and Ashish Sharma (1)

(1) School of Civil and Environmental Engineering, University of New South Wales (UNSW), Sydney, Australia (urooj.khan@student.unsw.edu.au), (2) Climate and Water Division, Bureau of Meteorology, Canberra, Australian Capital Territory, Australia

In last two decades, significant research has been carried out to find the minimum spatial resolution in watershed modeling which adequately represents the spatial heterogeneity of a watershed. Several methods have been developed to capture the spatial heterogeneity and to delineate Hydrologic Response Units (HRUs) in a watershed. Existing methods of HRUs delineation either lack topological connectivity across the units, or require artificial nodes to ensure connectivity between various spatial units. The topological connectivity is important in catchment hydrologic modeling which allows for transfer of fluxes from an upper HRU to the lower HRU and finally to the stream. The main aim of this research is to delineate contiguous topologically connected HRUs for large catchments and to check adequacy of the developed methodology.

To delineate topologically connected HRUs, the catchment is divided into four landforms. The thresholds for delineation of four landforms are derived from topographical and geomorphological attributes using a range of indices i.e. the area-aggregated slope relationship, the Compound Topographic Index, average local slope, the Multi Resolution Valley Bottom Flatness index and the surface curvature [Khan et al., 2009a; 2009b]. The catchment is also divided into sub-basins according to Strahler's stream order convention. The sub-basins delineated catchment is overlain with the delineated landforms and the common area is termed as HRUs.

The HRUs delineation method is investigated for the Maclaughlin, Delegate and Bombala catchment of the Snowy River, New South Wales, Australia. These catchments have high topographic relief. The HRUs delineation method is also applied to low topographic relief catchments i.e. Mandagery and Little river catchment located in Central West of New South Wales, Australia. The thresholds for delineation of four landforms in low topographic relief catchments are different to those from high topographic relief catchments but the HRUs delineation method is found suitable across all the catchments.

The adequacy of the HRUs delineation approach is ascertained by soil moisture movement modeling across multiple cross-sections of the Maclaughlin catchment. The soil moisture simulations using the HRUs delineation are compared with those using a single landform, and those enabling landscape representations at a pixel level. The results indicate that the HRUs basis simulations are very close to those on a pixel basis, whereas results from the single landform simulations are significantly different than HRUs and pixel basis simulations.

The HRUs delineation approach is validated against in-situ observations. Three sites in the Little river catchment on different geology and topography are surveyed. The thresholds for delineation of four landforms are found consistent with in-situ observations. The HRUs delineation work is further verified by using high resolution aerial photographs. Maclaughlin catchment (high topographic relief) and Little river catchment (low topographic relief) are selected for image analysis work. Although the image analysis is done with high resolution images and HRUs are delineated with a low resolution (25 x 25 m) Digital Elevation Model, results from both approaches are consistent.

The proposed methodology for delineating hydrologic response units is promising and has potential for developing numerically efficient hydrological models.

References

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