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DEVELOPMENT OF SCALE INVARIANT PHYSICALLY BASED HYDROLOGICAL MODEL: SCALE INVARIANT TOPMODEL

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Higher frequency topographic information contained in topographic index of TOPMODEL is lost as the larger sampling dimensions of the grids in a coarse resolution act as filter. Thus topographic index is scale dependent which leads identified parameter values to be dependent on DEM resolution. This makes difficult to use model parameter values identified with different resolution model. Moreover, a model may be physically based in theory but not consistent with observations. This results primarily from the mismatch in scales between the scale of observable state variables and the scale of application.

To overcome this problem, scale laws that govern the relation in digital elevation data resolution on geomorphometric parameters of topographic index of TOPMODEL have been analyzed. This research has developed concept of resolution factor to account for the effect of scale in up-slope contributing area per unit contour length in topographic index and a fractal method for scaled steepest slope as an approach to account for the effect of scale on slopes, which are combined to develop scale invariant model of topographic index distribution. The method successfully derived topographic index distribution of fine resolution DEM by using only coarse resolution DEM. The scale invariance model is applied to Kamishiiba catchment (210 km^2) and is shown that the down scaled topographic index distribution is similar to a target topographic index distribution.

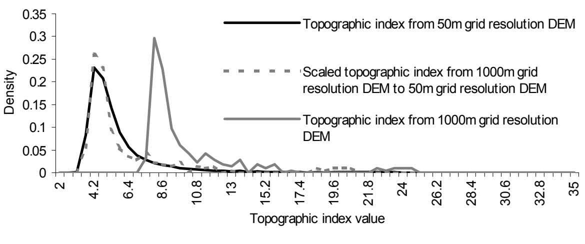

Fig. 1 Comparision of density function of topographic index from 50m grid resolution DEM, scaled topographic index from 1000m grid resolution DEM and topographic index from 1000m grid resolution DEM in Kamishiiba catchment (210 km^2).

The scale invariance model of topographic index distribution is then coupled with the TOPMODEL to develop scale invariant physically based hydrological model. The physical significance of the scale invariant TOPMODEL is analyzed by deriving the effective parametric values of TOPMODEL with fine scale DEM (50m grid resolution) of Kamishiiba catchment and applying the same parameters for coarse scale DEM (1000m grid resolution) of Kamishiiba catchment. It is shown that the simulated runoff from scale invariant TOPMODEL applied at 1000m grid resolution DEM of Kamishiiba catchment, with the same set of effective parametric values derived from 50m grid resolution DEM, has matched with the simulated runoff of TOPMODEL at 50m grid resolution DEM and the observed runoff for different rainfall events of Kamishiiba catchment with high efficiency. The scale invariant model can reduce parametric uncertainty and can be used to acquire subgrid scale parameterization that can avoid blunder in predicting ungauged basins where only coarse resolution DEM is available. It is hoped that the findings of this research seeks its applicability as a tool to a wider range of boundary as per the scale problems in hydrology and solution approach is concerned.

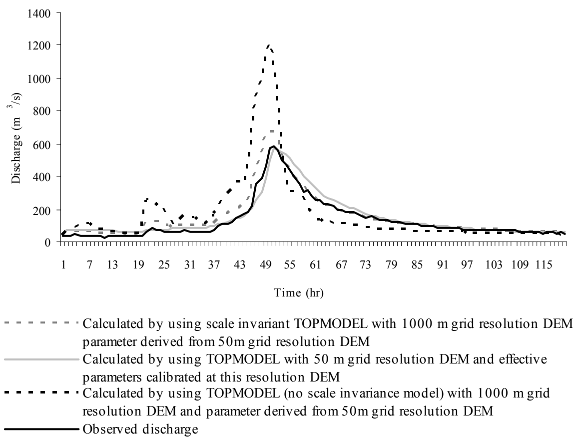

Fig. 2 Simulation results of TOPMODEL applied to Kamishiiba catchment (210 km^2)with and without the use of scale invariant model for topographic index distribution.