第II部門 **A physically based hydrological model independent of DEM resolution effects: Scale Invariant TOPMODEL**

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INTRODUCTION

Higher resolution topographic information contained in topographic index of TOPMODEL is lost when DEMs with coarse grid resolution are used [1]. 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 TOPMODEL. To overcome this problem, scale laws that govern the relation in DEM grid resolution on geomorphometric parameters of topographic index of TOPMODEL have been analyzed. This research has developed a concept of resolution factor to account for the scale effect 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 scale effect on slopes. The method has been used to downscale the topographic index distribution. The method to downscale the topographic index distribution is then coupled with the TOPMODEL to develop Scale Invariant TOPMODEL.

METHODOLOGY

Effects of DEM resolution on topographic index of TOPMODEL is identified by analyzing the topographic index distribution at different DEM resolutions. To solve the problem of the dependency of topographic index on DEM resolution, we developed a method to downscale the topographic index distribution and coupled with TOPMODEL to develop Scale Invariant TOPMODEL

DEM resolution effect on topographic index

The topographic index of TOPMODEL is

$$I = \ln\left\{\frac{a}{(\tan\beta)}\right\} \qquad (1)$$

where a is the local up-slope catchment area per unit contour length and β is the slope angle of the ground surface. Topographic index represents the propensity of any point in a catchment to develop saturated conditions in TOPMODEL, saturation excess model. Points with the same value of the index will be predicted as having the same hydrological responses. However, in Fig. 1 distinct swift of topographic index density function towards the higher value is seen as the resolution of DEM changes from 50m-grid resolution DEM to 1000m-grid resolution DEM. This shows that TOPMODEL parameter values are dependent on DEM resolution. Thus to solve this DEM resolution effects we developed a method to downscale the topographic index distribution [2].

Resolution factor in topographic index

The smallest contributing area derived from a DEM resolution is a single grid of the DEM at that resolution. Area smaller than this grid resolution is completely lost as the larger sampling dimensions of the grids act as filter. But as we use finer resolution DEM, the smaller contributing area - that is the area of finer grid resolution is achieved. From this point of view resolution factor is introduced in topographic index as shown in equation (2).

$$TI = \ln\left\{\frac{C_i}{\left(W_i R_f \tan\beta_i\right)}\right\} \qquad (2)$$

where TI is topographic index. C_i is the upslope contributing area of the coarse resolution DEM and W_i is the unit contour length of coarse resolution DEM, i is a location in catchment. R_f is a resolution factor defined by equation (3).

$$R_f = \frac{Coarse\ \ DEM\ \ Resolution}{Target\ \ DEM\ \ Resolution} \qquad (3)$$

Fractal method for scaled steepest slope

Slope derived from coarse resolution DEM is underestimated. To scale the local slope, earlier research works in the fractal theory of topography and slope [3], [4] is followed and this research has developed a modified fractal method to scale steepest descent slope (S_{scaled}) given by equation (4).

$$S_{scaled} = \alpha_{steepest} d_{scaled}^{(1-D)} \qquad (4)$$

where d_{scaled} is the steepest slope distance of the target resolution DEM, $\alpha_{steepest}$ is the coefficient whose values are derived directly from the steepest slope of the available coarse resolution DEM and D is the fractal dimension.

Scale Invariant TOPMODEL

By combining equation (2) and equation (4), we developed the method to downscale topographic index shown by equation (5).

$$(TI)_{scaled} = \ln\left[\frac{C_i}{\{W_i R_f (\tan\beta_i)_F\}}\right] \qquad (5)$$

where, $(TI)_{scaled}$ is the scaled topographic index and $(\tan\beta_i)_F = S_{scaled}$ of equation (4) which is the scaled steepest slope by fractal method. The method to downscale the topographic index is combined with TOPMODEL to develop the Scale Invariant TOPMODEL.

RESULTS AND DISCUSSION

Results from Kamishiiba catchment (210 km^2) in Fig. 1 shows that the downscaled topographic index distribution from 1000m-grid resolution DEM is similar to topographic index distribution of 50m-grid resolution DEM.

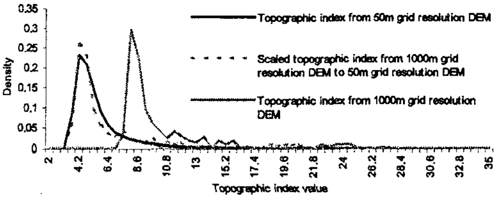

Fig. 1 Comparision of density function of topographic index from 50m grid resolution DEM, scaled topographic index from 1000m grid resolution DEM and topographic index from 1000m grid resolution DEM in Kamishiiba catchment (210 km^2).

The Scale Invariant TOPMODEL is applied to the Kamishiiba catchment (210 km^2). The physical significance of the Scale Invariant TOPMODEL is analyzed by deriving the effective parameter values of TOPMODEL from 50m-grid resolution DEM and applying the same parameters for 1000m-grid resolution DEM. Figure. 2 shows that the simulated runoff from Scale Invariant TOPMODEL applied at 1000m-grid resolution DEM, with the same effective parameter values derived from 50m-grid resolution DEM, has matched with the simulated runoff of 50m DEM resolution TOPMODEL. It is also shown that the simulated runoff from Scale Invariant TOPMODEL applied at 1000m-grid resolution DEM with the effective parameter values derived from 50m-grid resolution DEM has matched with the observed runoff with high efficiency. Figure. 2 shows the blunder in simulated result of 1000m DEM resolution TOPMODEL –without Scale Invariant TOPMODEL- with effective parameter values identified at 50m-grid resolution DEM.

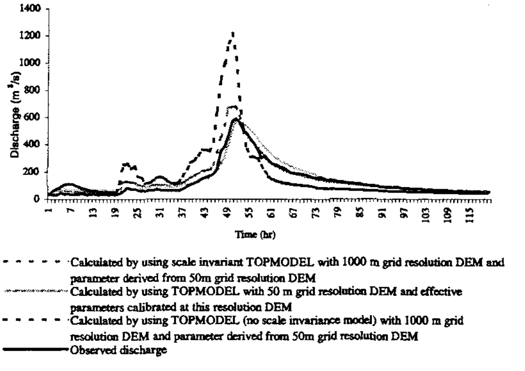

Fig. 2 Simulation results of TOPMODEL applied to Kamishiiba catchment (210 km^2) with and without scale invariant function for topographic index distribution.

CONCLUSION

The Scale Invariant TOPMODEL can reduce parameter 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.

REFERENCES

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