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Hydrology and Earth System Sciences Discussions

Interactive comment on "Explicitation of an important scale dependence in TOPMODEL using a dimensionless topographic index" *by* A. Ducharne

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Answers to Prof. M.J. Kirkby

First of all, the author wishes to thank Prof. Kirkby for his insightful comments (below in italic), which will be useful to improve the manuscript.

The title could usefully be shortened and made into better English by removing the first two words.

I totally agree that the title is perfectible, and I rather propose the following one: "Re-

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Interactive Discussion

Discussion Paper

ducing scale dependence in TOPMODEL using a dimensionless topographic index", which better points out the main interest of the dimensionless topographic index (TI).

The first part of the ms is a straightforward review of TopModel, and adds little to existing published material. The second part discusses the scale dependence of the topographic index with respect to DEM resolution, and the knock-on effects to calibrated transmissivity. This is more valuable, but could be made still more useful if the sources of the dependence were fully pursued. To do this it would be sensible to look at the distribution of a/tanB values within a given catchment, to ask how the larger estimates of the average (or log average) come about when coarser resolution is used.

This approach of the question has been followed many times, always showing the same main effects, that I tried to summarize in Table 2. But based on the formal analysis of section 3, Table 2 introduces a new effect, the "numerical" effect which results from the fact that the pixel length, C, is implicitly present in the specific area per unit contour length, a. Excluding C from the TI (Eq. 18) has the double advantage of making the resulting TI dimensionless and the numerical effect explicit. An important result is then that this numerical effect largely dominates the sensitivity of the mean TI to DEM resolution in real world case studies (section 5), what sheds a new light upon the widely shared assumption according to which the dependence of the TI on DEM resolution mostly results from changes in terrain information.

The methods used for calibrating T or K are not explicit. I assume that the different a/tanB estimates link directly to the larger T or K, but more detail might clarify this point.

You are perfectly right and the following precisions will be added at the end of section 4.2, using the additional Table A: "In the 6 case-studies, TOPMODEL was calibrated for each of the different tested DEM resolutions, to optimize the fit between predicted and observed discharge. The goodness-of-fit criterion was the Nash and Sutcliffe (1970) efficiency, except in the Réal Collobrier where it was the correlation coefficient between

Catchment	Calibration method				Calibration results			
	Period	Time step (h)	DEM resolution range (m)	NCP	K_0 range (m/h)	$1/\nu$ range (m)	SRmax range (mm)	Efficiency range
Sleepers-W3	1 year	24	30-90	2	**0.018-0.034**	**3.3-3.6**	NA	0.88-0.89
Réal Collobrier	3 months	1	60-480	1	**35-700**	58.8	22	0.96*
Maurets	11 storms of 10 to 24 days	0.5	20-120	3	**82-1402**	**38.5-40**	**19-21**	0.83
Bore Khola	1 month	0.5	20-500	3	**18-198**	**14-19.2**	**3.6-5.8**	0.72-0.74
Haute-Mentue	28 days with 2 storms	1h?	25-150	2	**27-118**	**22.8-29.2**	20	0.79-0.82
Kamishiiba	1 storm of 120 h	NA	50-1000	1	**86-2858**	14.3	10	0.96

* Correlation coefficient

Table A. Summary of the calibration method and results in the 6 selected case studies (see Table 3). The goodness-of-fit criterion is the Nash and Sutcliffe (1970) efficiency, except in the Réal Collobrier where it is the correlation coefficient between the simulated and observed discharge. In each case, bold figures indicate the parameters that were calibrated to compensate for the DEM resolution changes. NCP = Number of calibrated parameters, NA = Not Available.

the simulated and observed discharge. This calibration always addressed the surface saturated hydraulic conductivity K_0, but was not systematic for the other parameters, namely ν, the decay factor of K_0 with depth, and the water capacity SRmax of the interception and root zone storage, which controls the recharge term in TOPMODEL (Table A). Important common features of the 6 calibration exercises are that similar goodness-of-fit were achieved for all DEM resolutions, and that K_0 was always the most effective parameter to compensate the DEM resolution changes, as shown by the small variation ranges, if any, of ν and SRmax in Table A." In addition, to facilitate the comparison of the different case studies, Table 5 will be changed to only show $T_0 = K_0/\nu$ instead of a mix of T_0 (which depends on K_0 and ν) and K_0 (which does not depend on ν).

The paper is currently rather slight, with no evidence of analysis of DEM data by the author for this ms, but could form the nucleus of an interesting discussion.

It is true that I am not a geomorphologist, and I did not work on the influence of DEM resolution on the TI distribution from a geomorphologist's perspective. The DEM effect I am introducing, that I called the Âń numerical Âż effect in the paper, does not stem from geomorphology but from mathematics. This analysis is straightforward, it does not change the heart of TOPMODEL since it proceeds from a simple rearrangement of the equations, and one may even say it is completely trivial.

Yet, trivial here does not mean unimportant, as revealed by the results discussed in section 5, showing that this numerical effect largely dominates the sensitivity of the mean TI to DEM resolution. This result has important consequences regarding TOPMODEL, in particular regarding the interplay between DEM resolution and transmissivity, that leads to recalibrate T_0 to keep a good fit between predicted and observed discharge when DEM resolution changes (section 4). Introducing the dimensionless TI makes the outflow from the saturated zone depend on T_0/C, which is defined as the transmissivity at saturation per unit contour length. This new variable is shown to depend much less on DEM resolution than does T_0 (Table 5), what is directly related to the fact that the dimensionless TI varies less with DEM resolution than the classical TI. This result reduces the need to recalibrate TOPMODEL when DEM resolution changes and altogether offers an interesting rescaling framework for this model.

Note also that these conclusions are supported by verification in 6 different catchments, what adds value to what could be found from the detailed analysis of one single catchment. I really think that there is much to find in an extensive statistical analysis of the question, as attempted by Wolock and McCabe (2000) for instance.

Cited references

Nash, J. E. and Sutcliffe, J. V.: River flow forecasting through conceptual models. 1. A discussion of principles, J. Hydrol., 10, 282-290, 1970.

Wolock, D. and McCabe, G.: Differences in topographic characteristics computed from 100- and 1000-meter resolution digital elevation model data, Hydrol. Process., 14, 987–1002, 2000.

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