Sub-grid heterogeneity representation of soil parameters for distributed hydrological modelling

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INTRODUCTION

In the perspective of distributed hydrological modelling at catchment scale it is important to understand the scale at which heterogeneities are averaged and how much of the heterogeneity should be included in modelling units. If it is selected a coarse spatial resolution, the spatial variability effect may be lost and errors may occur due to omitting relevant information. However, if high spatial resolution is used, parameter identifiability is reduced. So, it is valuable the study of the spatial variability effect on the aggregation of hydrological processes. (Shrestha et al., 2006; Shrestha et al., 2007; Didszun y Uhlenbrook, 2008).

It was studied the spatial scale effect on the effective static storage capacity parameter H_u and effective saturated hydraulic conductivity parameter k_s at two supports. Those parameters are used by infiltration process conceptualization in the TETIS distributed hydrological model.

NUMERICAL EXPERIMENTS

It was performed stochastic simulations based on latin hypercube sampling and Cholesky factorization to generate random parameter fields at microscale support (sub-grid level, S1). We assumed stationarity in a wide sense for isotropic soils with lognormal distribution in parameters H_u and k_s and an exponential spatial dependence model for 18 correlation lengths (a = 2.5, 5, 10,… 50, 75, 100, 150, 250, 500, 2500 and 5000 m). Then, effective parameters were calculated at mesoscale support (S2) by solving the inverse problem for each realization of the different stochastic processes.

$$y = \frac{1}{x\sigma\sqrt{2\pi}} e^{\left[-\frac{(\ln x-\mu)^2}{2\sigma^2}\right]} \qquad [1]$$

$$\rho(h) = e^{\left(-\frac{3h}{a}\right)} \qquad [2]$$

Microscale Support (S1) [m²]	Mesoscale support (S2)		Number of Realizations
	Extension [m²]	Notation	
1 x 1	5 x 5	S2a	500
1 x 1	15 x 15	S2b	500
1 x 1	45 x 45	S2c	2500
1 x 1	100 x 100	S2d	5000

Table 1. Support and size of the spatial domain

RESULTS

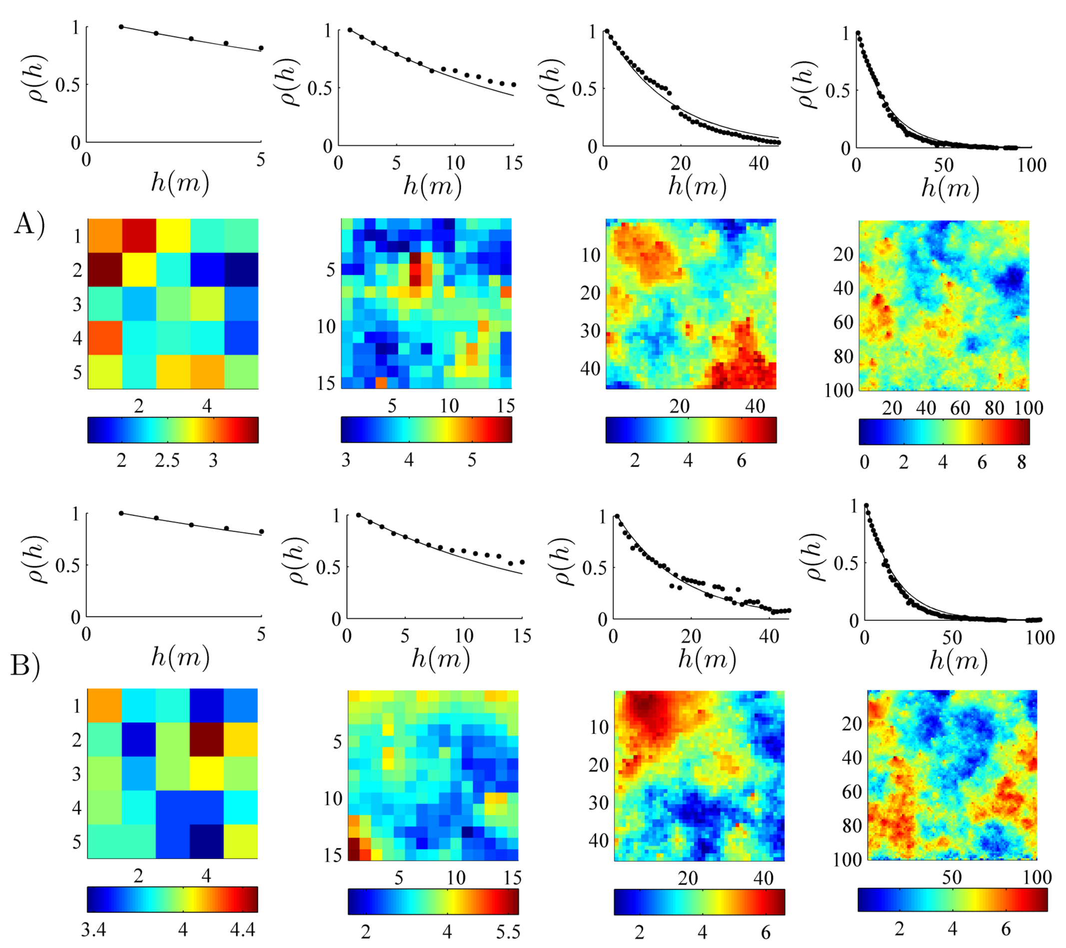

Figure 1. A realization of four random fields with support 1 m and extension of 5,15,45 and 100 m. A) ln(H_u). B) ln(k_s).

If effective parameters H_u and k_s are scaled from support S1 to a greater support (S2). The values of the scaled parameters depend on the input variables and spatial variability of H_u[S1] and k_s[S1]:

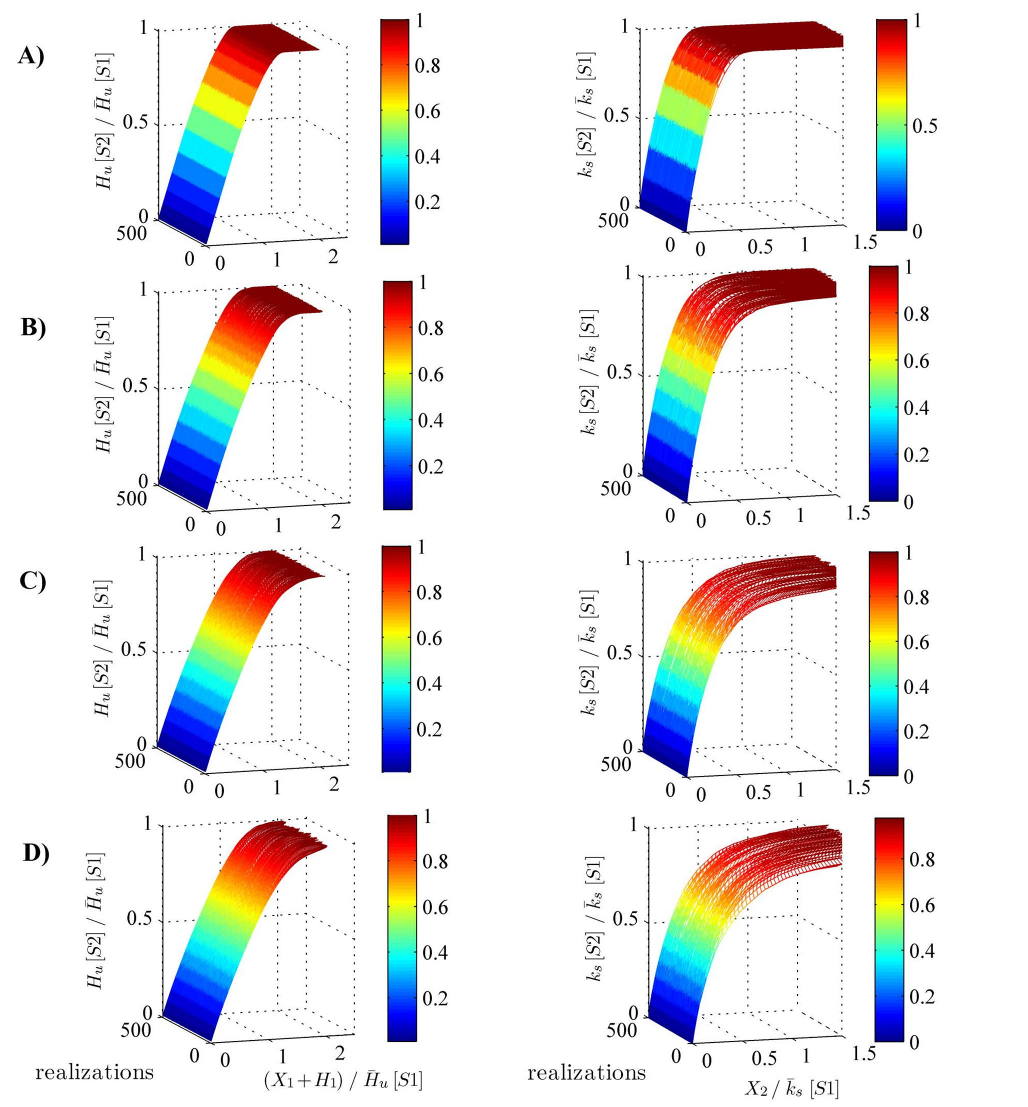

Figure 2. Effective Parameter as a function of state variables for 500 realizations (correlation length = 100 m, CV=2). A) S2a. B) S2b. C) S2c. D) S2d.

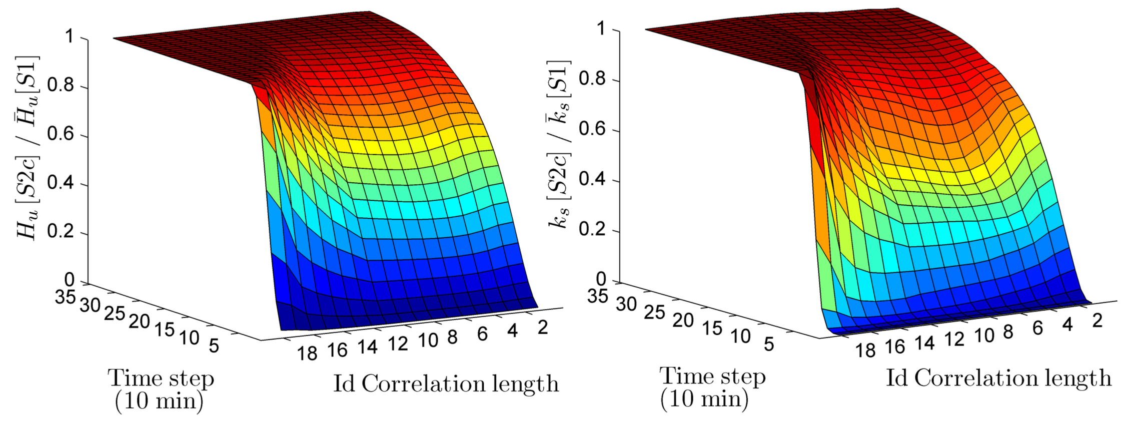

Figure 3. Effective parameter values at support S2c for 18 correlation lengths (a = 2.5, 5, 10,… 50, 75, 100, 150, 250, 500, 2500 and 5000 m). Left (H_u), Right (k_s).

Relationship of l_2/a with the concept of REA (Wood et al. 1988):

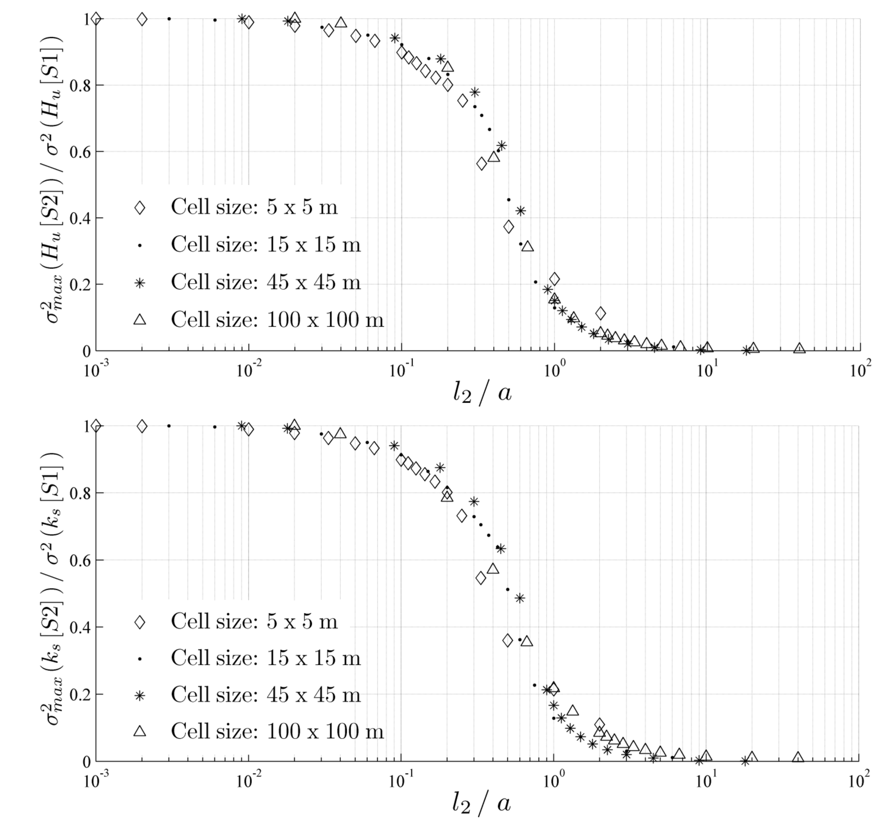

Figure 4. Variance of effective parameter related to cell size and correlation length ratio.

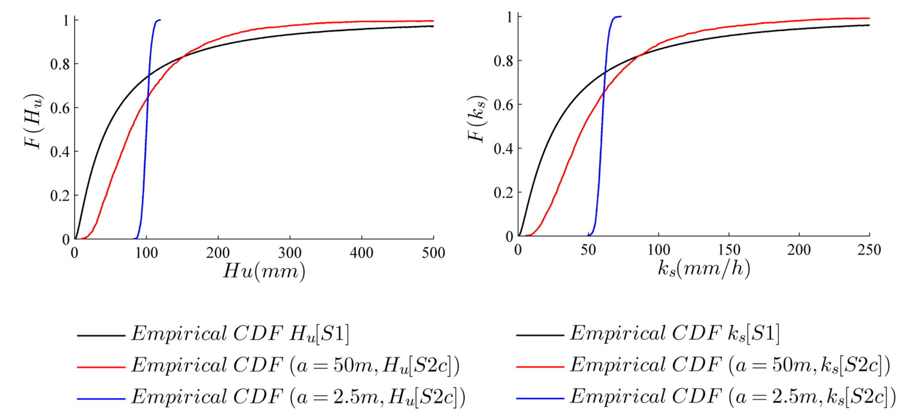

Figure 5. Empirical CDFs of effective parameters at supports S1 and S2c.

CONCLUSIONS

The statistical structure of a set of random parameter fields influences the determination of a cell size that describes the characteristics of a representative elementary area, and that REA size depends mainly on the correlation length, which can vary spatially.

In a particular case, REA size would therefore be dominated not only by hydrological attributes, but would also be influenced by the statistical characteristics of the attributes.

The ratio between spatial cell discretization and spatial correlation length is an important factor in the transfer of uncertainty between scales. The uncertainty in estimating the effective parameters could be reduced if the relationship between cell size and correlation length of the parameters at the sub-cell level is included in the criteria for establishing optimum cell size in the context of distributed hydrological modelling.

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