SCALING THE FLOOD REGIME WITH THE SOIL HYDRAULIC PROPERTIES OF THE CATCHMENT

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INTRODUCTION

Changes in land use generate changes in the hydraulic properties of soil, mainly due to the variation of root depth, which depends on the vegetation type. Two parameters especially affected are the soil water content in the root zone (static storage Hu) and the saturated hydraulic conductivity (Ks).

We test the hydraulic properties of soil and Ks Hu present a scalable behavior to the flood regime

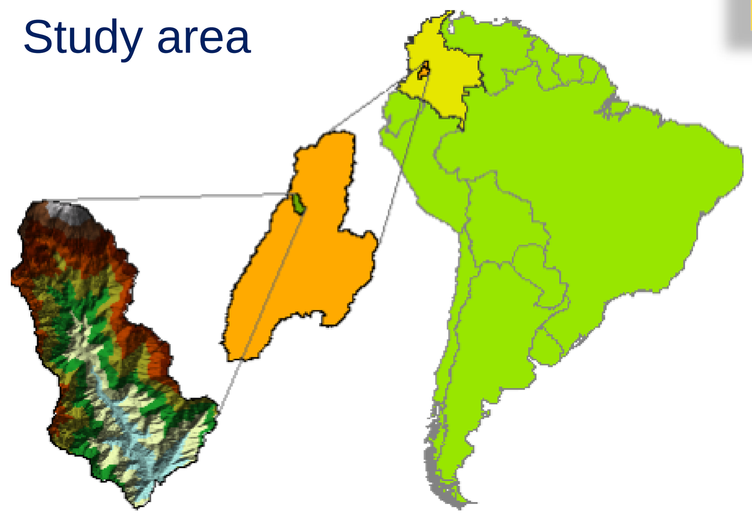
In order to characterize the flood regime, we use order moments and a GEV model

We simulated changes in the land cover of a watershed through hydrological modeling, in a case study with different land uses in order to have different samples corresponding to different periods of time.

To carry out frequency analyses of floods we relate changes in land use to the variation of the probability distribution function parameters.

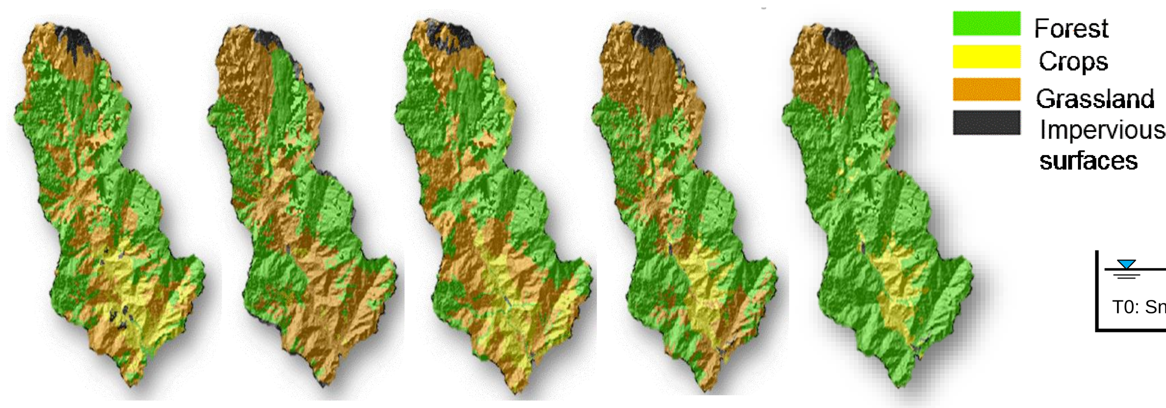
MATERIALS AND METHODS

Study area

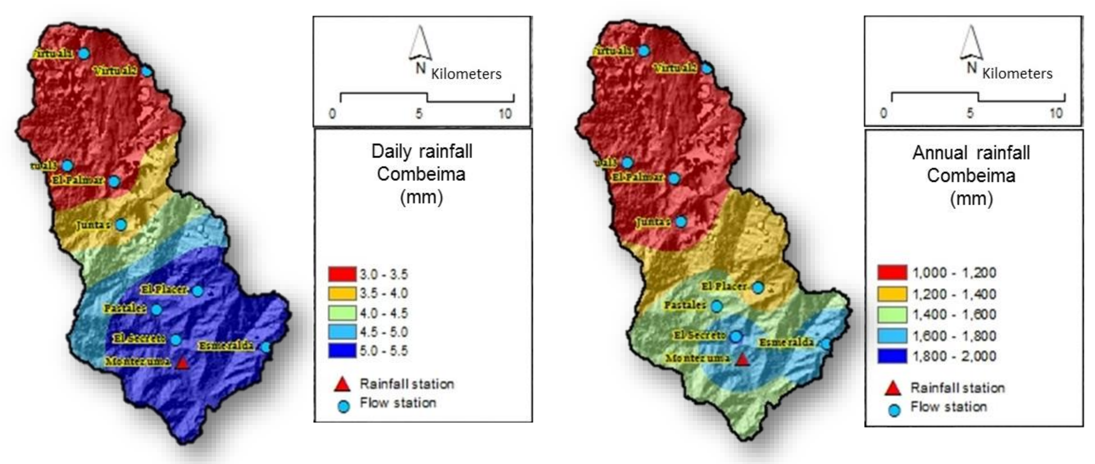


The study area is located in the Combeima River catchment in Colombia - South America

Land Use / Cover Maps

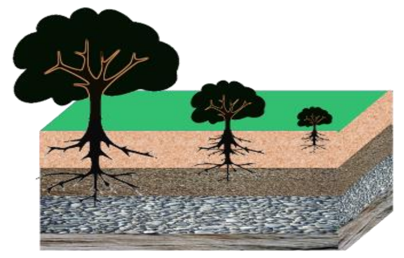


Rainfall Spatial variability



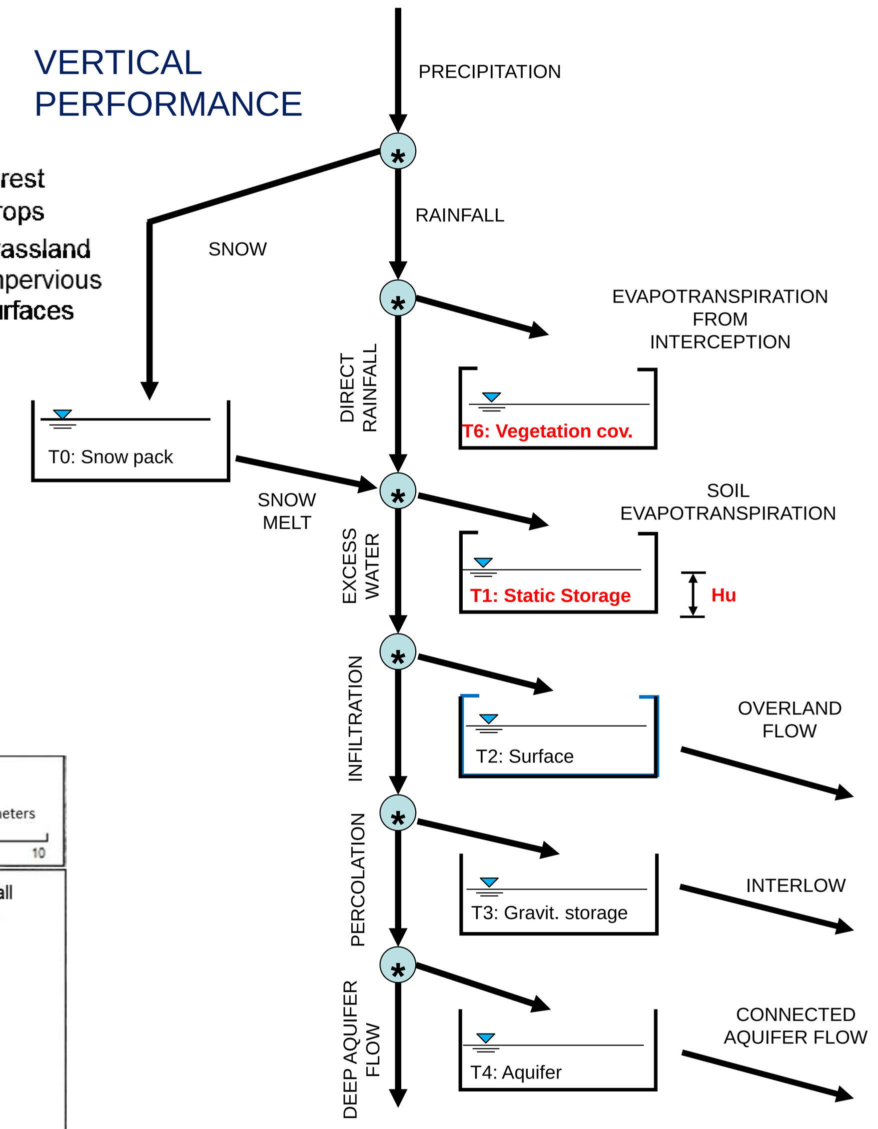
Soil data

- Soil hydraulic properties were estimated using pedotransfer functions (Schaap, 1999).
- Root depth was varied for each land use:



✓ Forest
✓ Grassland
✓ Crops
✓ Impervious surfaces

Distributed Hydrological Model TETIS



Francés F., Vélez I., Vélez J (2007)

Wide Sense Simple Scaling

Gupta & Waymire (1990) studied the behavior of the empirical moments of rain on the spatial scale to characterize the statistical structure of the rain and in this case applied to the soil hydraulic properties in a catchment.

$$Y_\lambda \overset{\text{def}}{=} \lambda^n Y_1$$

n is the scaling exponent and λ, is the scale (λ>0). If Y_λ has finite moments E[Y_λ^r] of order r, and the ramdom variables Y_λ^r and λY_1, follow the same probability distribution. It can be:

$$logE[Y_\lambda^r] = rnlog\lambda + logE[Y_1^r]$$

To examine the scaling properties of the statistical moments, linearity expresses as:

$$logmr(\lambda) = n_r log\lambda + a_r$$

With intercept α_r and slope n_r=r.n which is by linear regression for each r (Vascôva, 2001).

Flood Frequency Analysis

GEV Distribution

$$f(y) = \begin{cases} exp\left[-\left[1-k\dfrac{(y-\beta)}{\alpha}\right]^{1/k}\right] & k\neq 0 \\ exp\left[-exp\left[-\dfrac{(y-\beta)}{\alpha}\right]\right] & k=0 \end{cases}$$

$\beta+\alpha/k \le y < \infty$ for $k<0$
$-\infty < y < +\infty$ for $k=0$
$-\infty < y \le \beta+\infty/k$ for $k>0$
∞, β, k, parameters of scale, location and shape

Paramters Maximum Likelihood Estimators

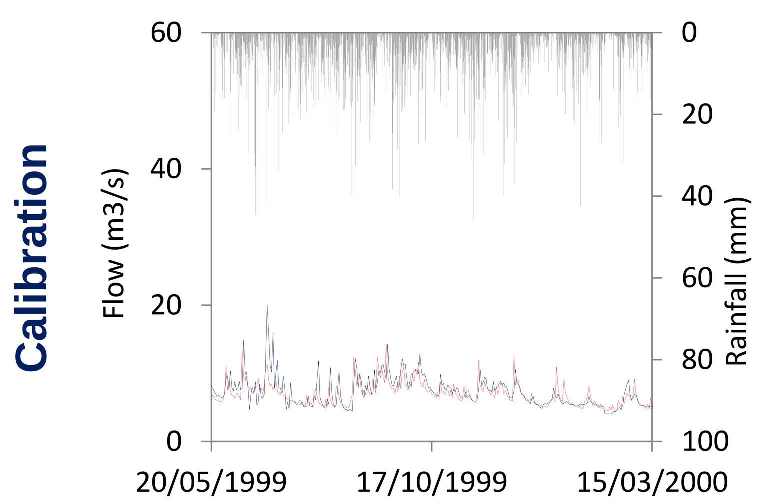
$$\frac{1}{\alpha}\sum_{i=1}^{S}\left[\frac{1-k-(y_i)^{1/k}}{y_i}\right] = 0$$

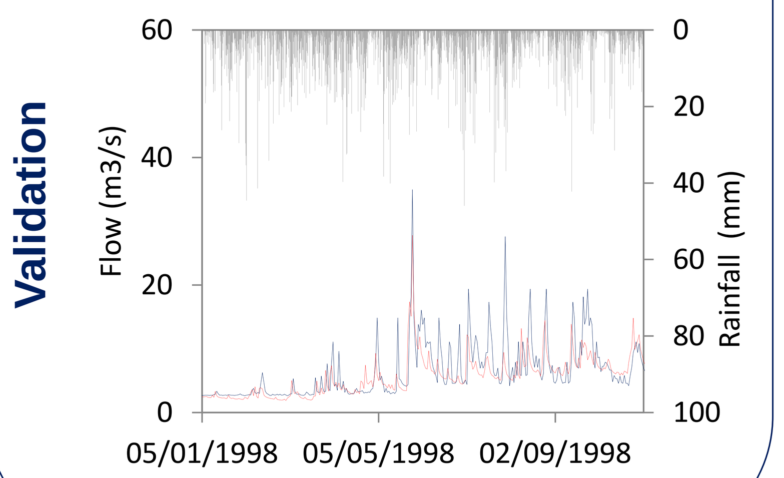
$$-\frac{S}{\alpha} + \frac{1}{\alpha}\sum_{i=1}^{S}\left[\frac{1-k-(y_i)^{1/k}}{y_i}\left(\frac{x_i-\beta}{\alpha}\right)\right] = 0$$

$$-\frac{1}{k^2}\sum_{i=1}^{S}\left\{ln(y_i)\left[1-k-(y_i)^{\frac{1}{k}}\right] + \frac{1-k-(y_i)^{\frac{1}{k}}}{y_i}k\left(\frac{x_{i-\beta}}{\alpha}\right)\right\} = 0$$

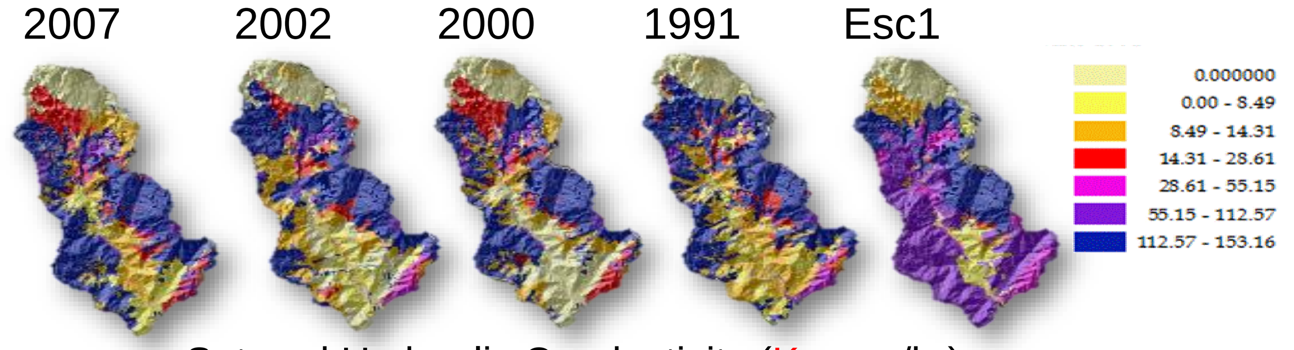
MAIN RESULTS

Distributed Hydrological Model

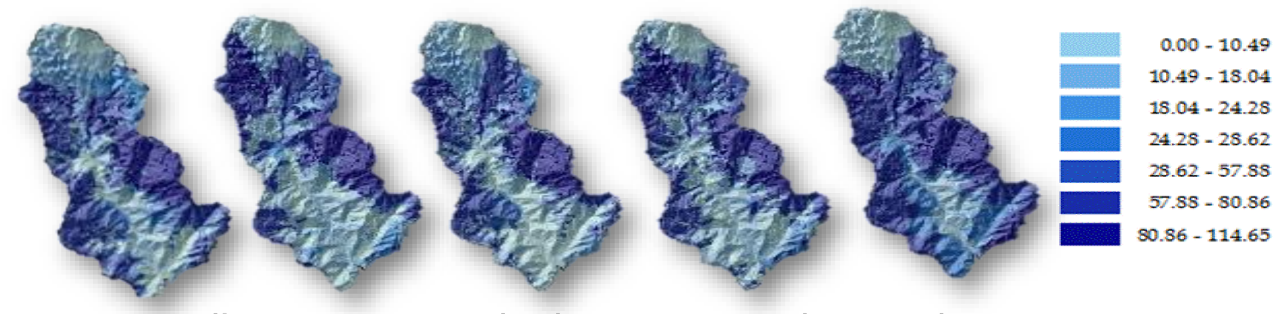




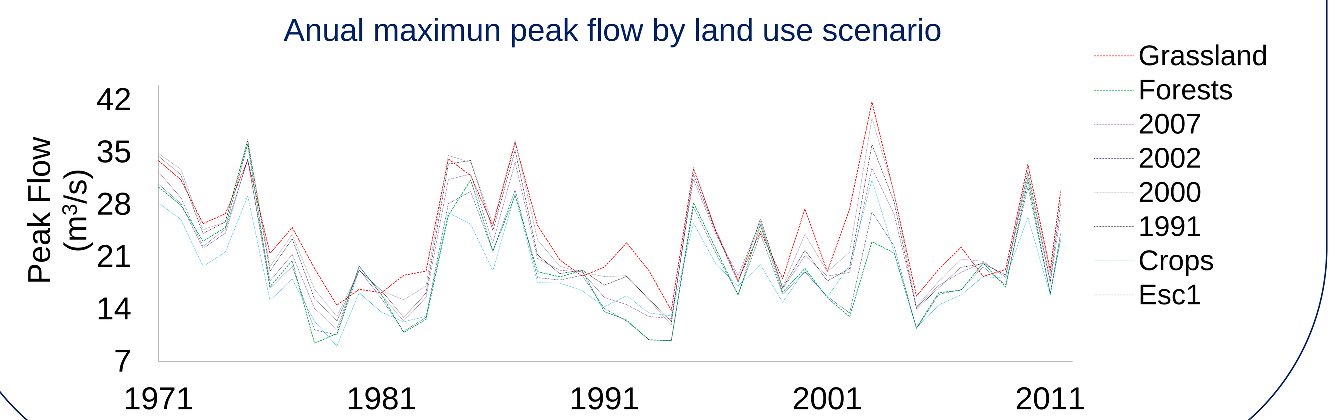
Simulation scenario Change land use / cover



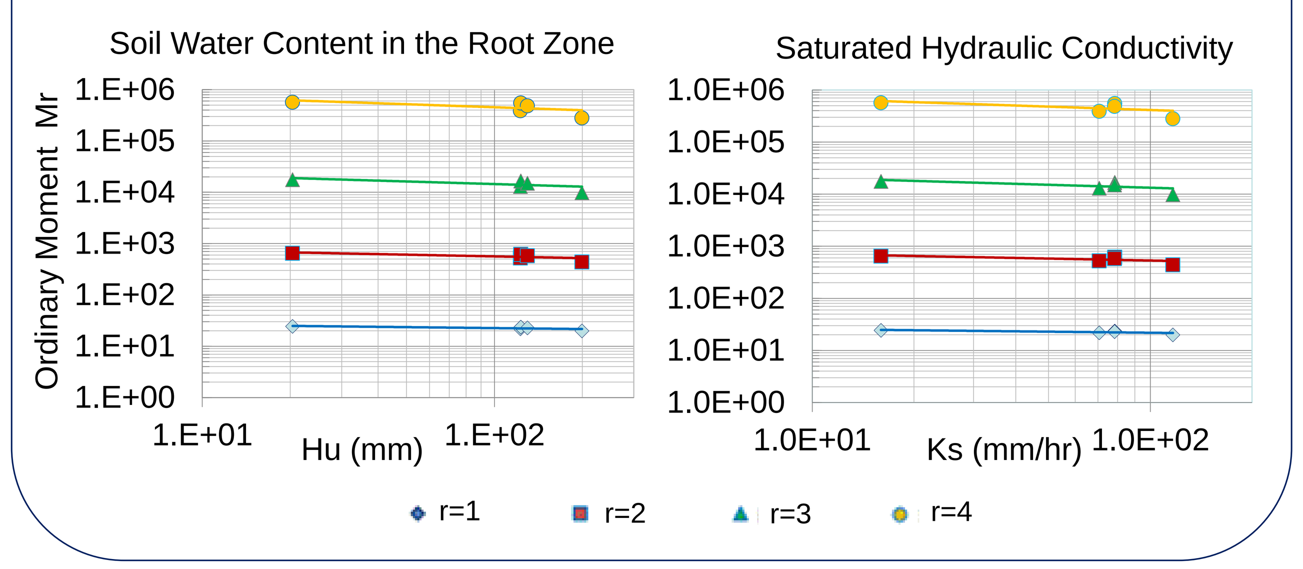
Satured Hydraulic Conductivity (Ks mm/hr)



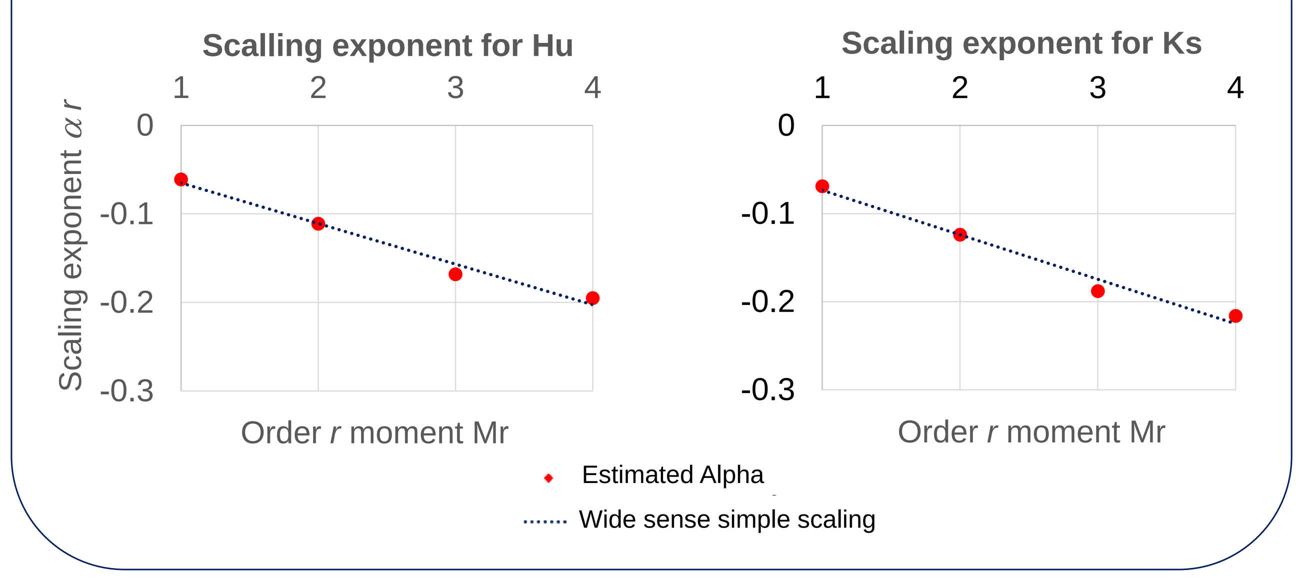
Soil water content int he root zone (Hu mm)



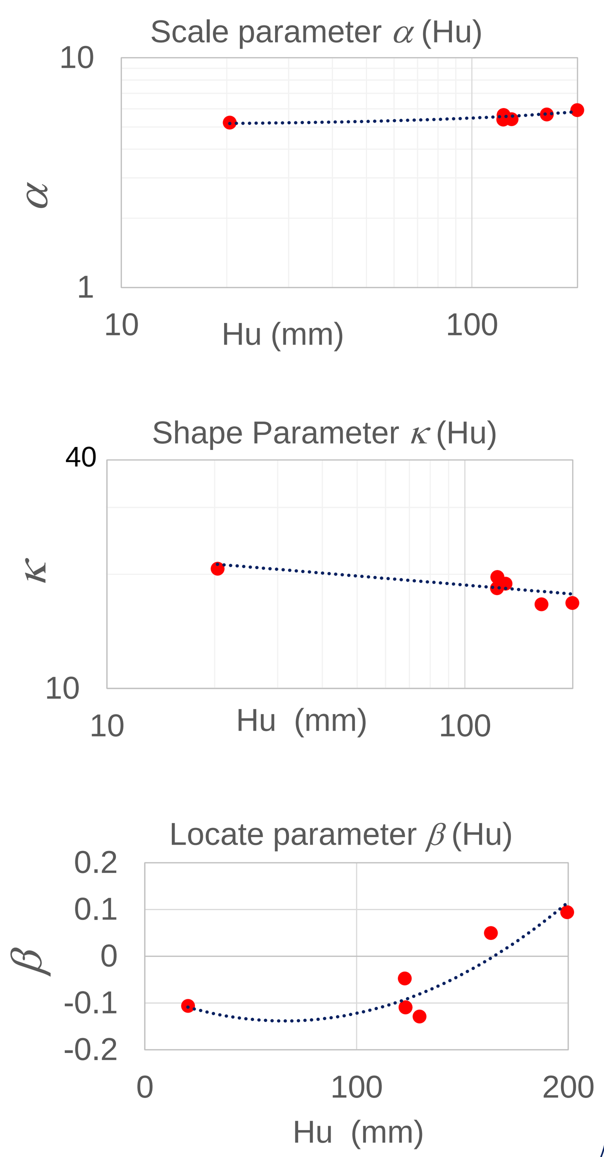
Testing Scaling Behavior of Soil Hydraulic Properties



Scaling exponents r for different moment orders



GEV Parameters Behavior



CONCLUSIONS

- TETIS results show that changes in land use/cover affect the flood regime
- Grassland increases the flood quantiles, meanwhile forest covers show a decrease of peak flow
- flood regime presents a scaling behavior in relation with the soil hydraulic properties (static storage and saturated hydraulic conductivity)
- Scaling with soil hydraulic properties allows adjustment of the parameters of the GEV distribution
- So, the proposed methodology allows to evaluate the effect of changes in land use on flood regime by power equations.

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