Linear patterns of soil saturated hydraulic conductivity in a tropical rainforest catchment, Panamá

Dustin Sammy Schinn, Lena Katharina Schmidt, Alexander Zimmermann and Helmut Elsenbeer

Introduction

Saturated hydraulic conductivity (Ks) is an important soil characteristic affecting overland flow generation, erosion processes, and water storage. In the tropical rainforest on **Barro Colorado Island, Panama**, high total annual rainfall and rainfall intensities serve as a basis for frequent saturation-excess **overland flow**. So far only geostatistical approaches were used to estimate spatial variability in Ks, which, however, are unsuitable to reveal spatial patterns resulting from linear structures such as **overland flow lines** (OFL). Thus we applied a purposive sampling strategy adapted to the presence of OFL in order to detect a potential pattern.

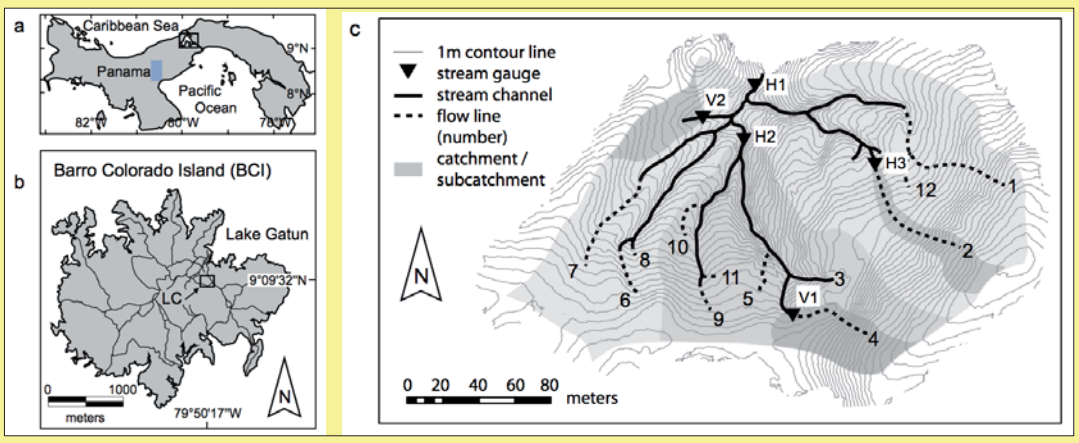

Fig. 1 (a) Location of Barro Colorado Island (BCI) in Panama and (b) of Lutzito catchment (LC) at BCI. (c) Numbered, dashed lines define sampled OFL in LC [1]

Study site

We studied Ks in Lutzito catchment on Barro Colorado Island (BCI), which is located in Gatún Lake in the Panama Canal Basin (fig. 1). This area is characterized by semi-deciduous secondary rainforest coupled with high rainfall intensities, high total annual rainfall reaching 2623 +/- 458 mm, and low Ks values. Seasonality is defined by a distinctive wet (May to mid-December) and dry season.[1]

Methods

Determination of Ks

Undisturbed soil samples were taken using a drop hammer method with core cylinders of 3.65 cm and 6 cm radius and length, respectively. After a saturation period of 48 hours, the flow rate was measured in the laboratory using the constant head method. Subsequently, Ks was calculated by Darcy´s Law.

Sampling design

Ks in and around OFLs was examined by comparing a total of 255 soil samples of the top 6 cm taken at 5 m intervals **within OFL**, **5 m** and **10 m** off OFL.

Data analysis

To compare the above mentioned 3 groups, a **Markov Chain Monte Carlo** (MCMC) approach for statistical inference was used by conducting a **Bayesian one-way ANOVA** (analysis of variance).[2,3] We coded the model in OpenBUGS[4] and used a conjugate prior based on knowledge gained by a pre-study[5]. Finally, posterior densities were compared in order to detect a potential link between the distance to OFL and Ks-values.

Results & Discussion

Kernel probability densities of the estimated posterior distributions are plotted in Fig.2 for comparison of the Ks means, on the supposition that mean Ks depends on the corresponding group. The posterior means of these distributions differ notably between OFL and the surroundings (log10-transformed values). This clearly shows a **strong link between the distance of a sampling point to an OFL and its Ks value**. This has not been found by other studies before, as it was impossible to capture this pattern using conventional geostatistical approaches. Our hypothesis to explain the decrease in Ks in OFL is the removal of the original topsoil which may be caused by erosive forces of overland flow.

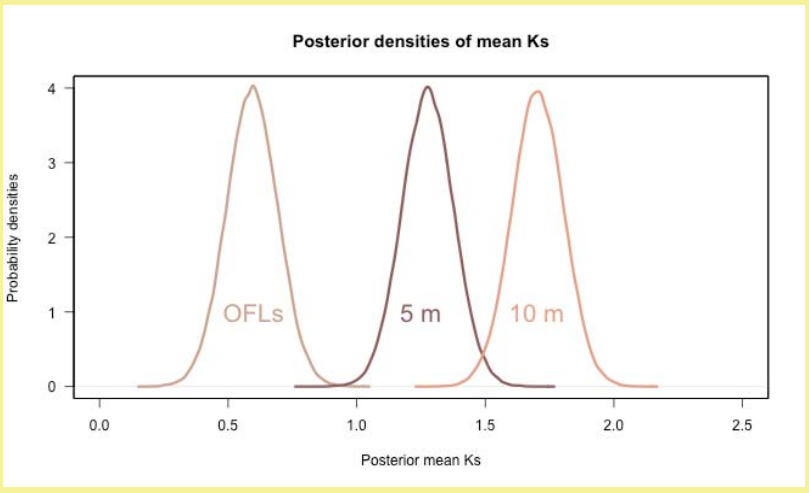

Fig.2 Posterior densities of mean Ks within as well as 5 m and 10 m apart of overland flow lines (OFLs).

References

1 Zimmermann, A., Francke, T., Elsenbeer, H., 2010. Forests and erosion: Views from a study on suspended sediment dynamics in an overland flowprone rainforest catchment. Submitted to Journal of Hydrology.
2 McCarthy, M.A., 2007. Bayesian Methods for Ecology. Cambridge University Press, New York.
3 Ntzoufras, I., 2009. Bayesian Modeling Using WinBUGS. John Wiley & Sons, Inc., Hoboken, New Jersey.
4 Lunn, D., Spiegelhalter, D., Thomas, A., Best, N., 2009. The BUGS project: Evolution, critique, and future directions, Statistics in Medicine 28:3049-3067.
5 Godow, S. and Plate, S., 2010. Spatial variation of saturated hydraulic conductivity in a tropical rainforest catchment. Not published.