

# Partitioning the impacts of spatial and climatological rainfall variability in urban drainage modelling - Supplementary Material

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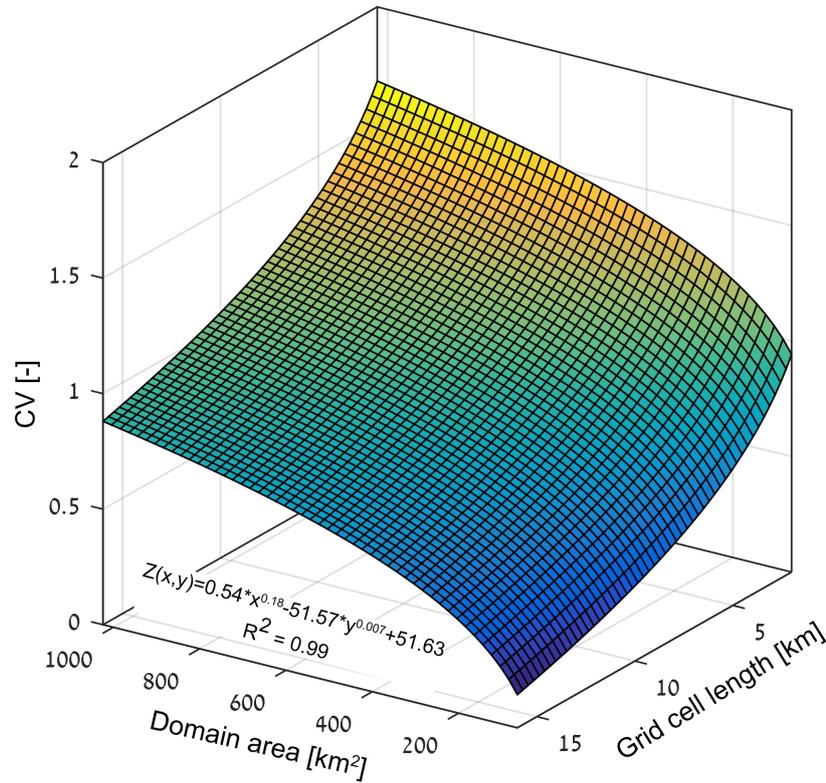
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## 1 STREAP Evaluation - Climate Variability

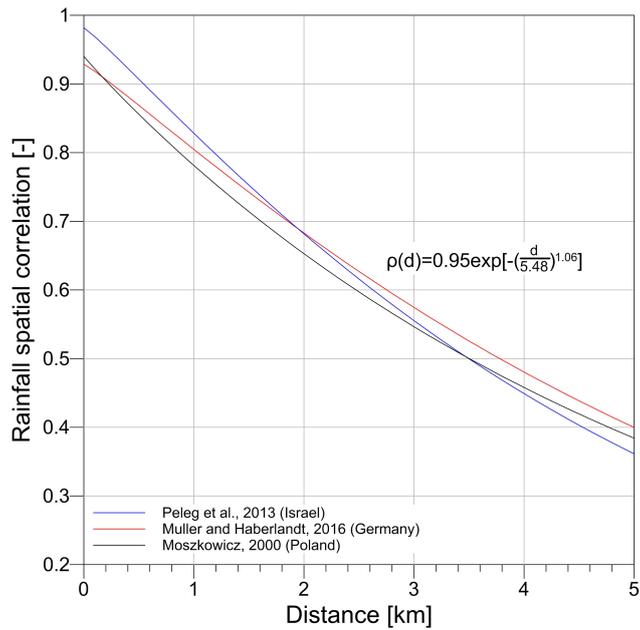
The ability of STREAP to reproduce the natural climate variability in relation to the annual maxima rainfall intensity is presented in Fig. S3. The mean and standard deviation of the observed annual maxima rainfall intensity are compared to the mean and standard deviation of annual maxima rainfall intensity that were generated for 30 realizations (each of 30 years) by STREAP. The observed point presented in Fig. S1 is located within the cloud of possible annual maxima rainfall statistics generated by STREAP. The "real" extent of the cloud is of course unknown, which hinders a direct validation of the results. STREAP results can be compared to other methods that are being used to estimate climate variability. One method is bootstrapping procedure (Efron, 1992) which was applied many times in the past to resample climate variability (e.g. Hänggi and Weingartner, 2011; Köplin et al., 2014; Peleg et al., 2016). Bootstrapping is based on the assumption that the 34-years of observed data are just one possible realization out of a larger population. Here, 1000 realizations of 30-years each are generated out of the original sample by re-sampling with replacement the annual maxima rainfall intensity, i.e. a specific annual maxima value from the sample can appear numerous times or never in each realization. Bootstrapping results yield a range of 64.7–82.2 for the annual maxima mean and a range of 10.8–20.5 for the annual maxima standard deviation. 3 out of the 30 realizations generated by STREAP fall out of this range. However, the bootstrapping technique is much more rigid than STREAP in its estimation, as it does not allow annual maxima to be higher or lower than the observed one.

## References

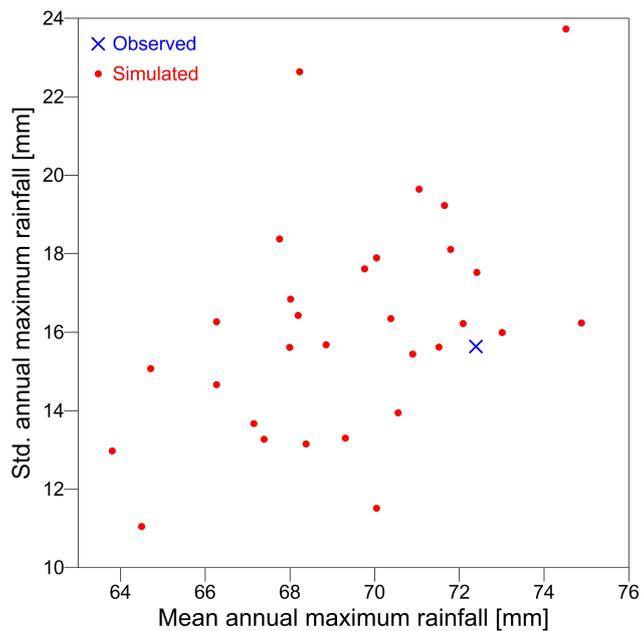
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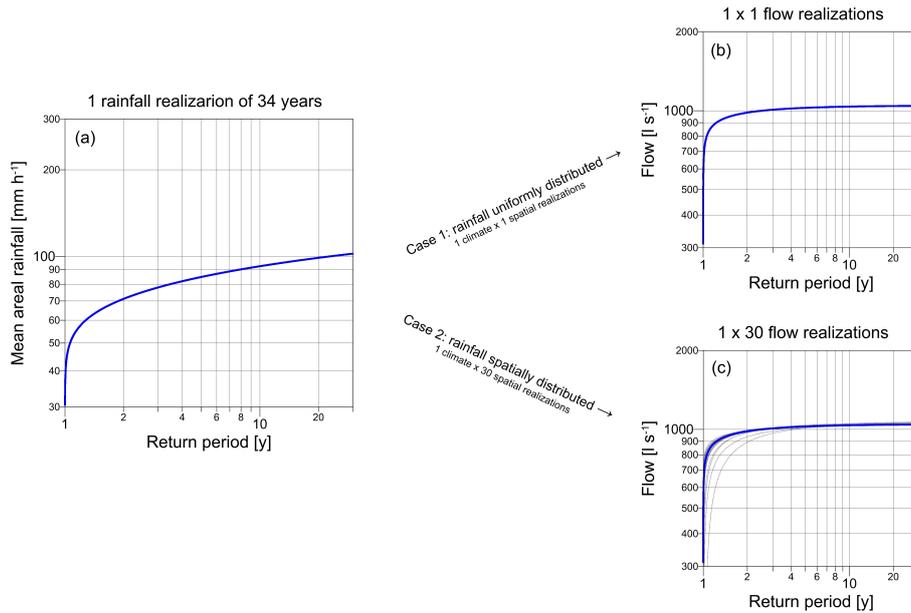
**Figure S1.** A surface representing the rainfall coefficient of variation (CV) for temporal resolution of 5 min as analyzed using MeteoSwiss weather radar system over the study area. X-axis refer to the domain area (64–1024 km<sup>2</sup>), Y-axis refer to the dimension of the rainfall grid cell (2–16 km) and Z-axis represent the rainfall CV. The surface was generated using a two-parameter power function that was fitted to the data [ $Z(X, Y) = 0.54X^{0.18} - 51.57Y^{0.007} + 51.63$ ] with a coefficient of determination of 0.99. For the case study, rainfall CV was extrapolated from the observed surface using the above function as follows:  $X = 2.25 \text{ km}^2$  (area of the case study for which rainfall was simulated),  $Y = 100 \text{ m}$  (simulate rainfall grid cell length) and  $Z = 1.5$  (simulated rainfall CV).



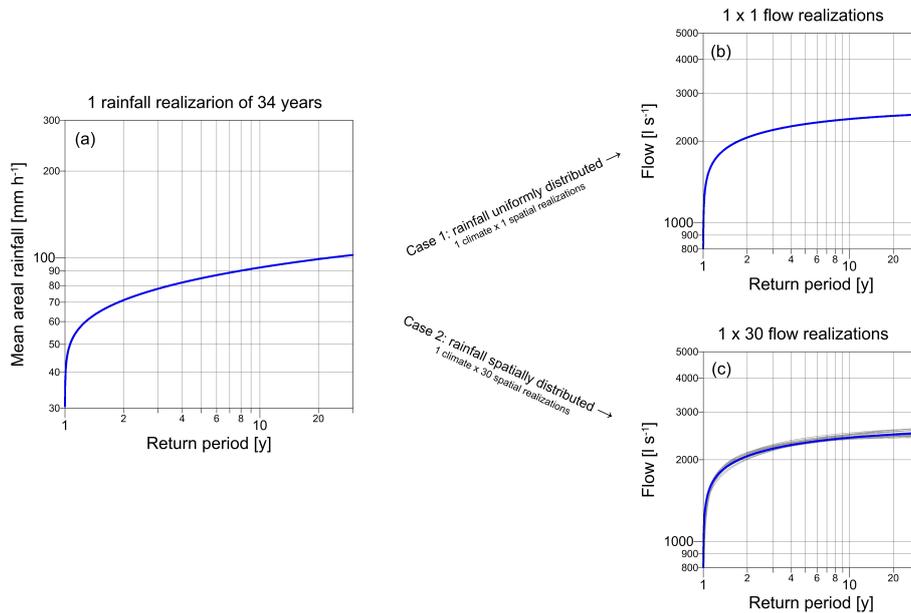
**Figure S2.** . Small-scale spatial correlation structure for 5-min temporal resolution as was recorded using dense rain-gauge networks in Germany, Poland and Israel. The average correlation structure of the three (expressed by the three-parameter exponential function given in the figure) was used in this study.



**Figure S3.** Example of STREAP ability to reproduce the climate variability in relation to the annual maxima rainfall intensity. The mean and standard deviation of the observed annual maxima rainfall intensity for the years 1981–2014, as recorded by Lucerne rain–gauge, is presented (blue x symbol). Red dots represent the same, but for 30 realizations of 30 years each reproduce by STREAP.



**Figure S4.** Rainfall and flow results for cases 1 and 2. In the left panel, the IDF curve computed for the mean areal rainfall over the catchment is presented. In the right panels, FDF curves for location A are presented. Gray lines represent the FDF curves computed for the different spatial simulations and blue line represents the FDF curve computed for the uniform rainfall simulation.



**Figure S5.** Same as Fig. S4, but for location C.