FROM 10-MIN RAIN-RATE TIME SERIES TO 1-MIN RAIN-RATE TIME SERIES IN SPINO D'ADDA

Emilio Matricciani

Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano,
Piazza L. da Vinci 32, 20133 Milano, Italy, Tel. +39-0223993639, Fax. 0223993413
e-mail: emilio.matricciani@polimi.it

The purpose of this paper is to develop a mathematical method to convert 10-min rain-rate time series into 1-min rain-rate time series, the latter to be subsequently used as input to the Synthetic Storm Technique (SST) for calculatin rain-attenuation time series [1]. The rationale for the need of such a method lies in the fact that now several Meteorological Services make available time series of quantity of water collected every 10 minutes, compared to the past when, at most, the quantity referred to 1 hour. To develop the method, we use a very large data bank (from 1993 to 2000, 10 years of practically all rain events occurred) of 1-min rain-rate time series collected in Spino d'Adda. We first convert them to 10-min rain-rate time series, to obtain the measured data bank allegedly provided by a Meteorological Service. From this latter data bank we develop the method that can generate 1-min rain-rate time series. First, we compare the converted 1-min rain-rate data bank to the original 1-min rain-rate data bank, by considering the two probability distributions. Afterwards, we input the two sets of rain-rate time series to the SST to generate rain attenuation time series at 20.7 GHz in a 35.5° slant path in Spino d'Adda. The two rain attenuation probability distributions obtained show no appreciable differences, so that the method can be used very reliably. In a future work we will extend the method worldwide.

Figure 1 shows an example of 1-min rain-rate time series converted into the corresponding 10-min rain-rate time series. The conversion conserves the quantity of water. By considering the full data bank of similar results, we have calculated: *i*) the conditional histograms of the 1-min rain rate within any 10-min intervals, for the following ranges of 10-min rain rate: 0-2, 2-4, 4-6, 4-6, 6-8, 8-10, 10-15, 15-20, 20-30, 30-40, > 40 mm/h; *ii*) the correlation coefficient between two successive 1-min rain-rate log-values within the 10-min interval, conditioned to the range of the 10-min rain rate. The marginal and joint distribution between two successive samples are all modelled as log-normal.

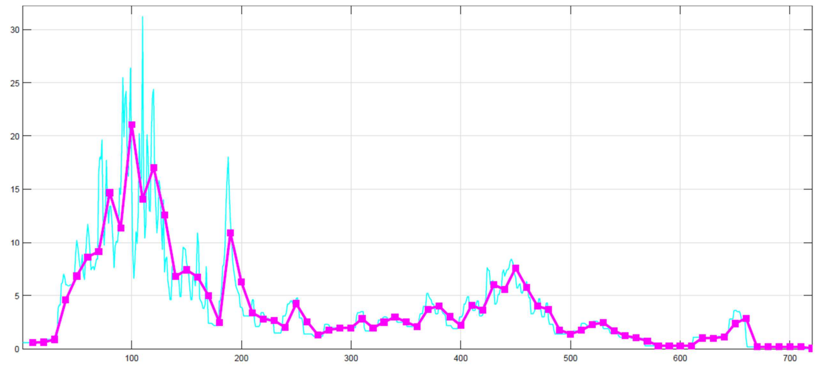


Figure 1: 1-min rain rate (mm/h) time series (cyan) and corresponding 10-min rain (mm/h) rate time series (magenta). Spino d'Adda, 20 October 2000, starts at 10:32.

The steps of the simulation are: 1) According to the first 10-min rain rate value, select the corresponding average value, standard deviation and correlation coefficient of the 1-min rain rate. 2) For sample 1 of the 1-min rain rate, extract a standard Gaussian random number and denormalize it to the corresponding 1-min rain rate according to step 1. 3) For samples 2 to 10, extract, for each sample, 1 standrd Gaussian random number as in step 2, but now denormalize it according to the conditional distribution of the bivariate log-normal distribution (all equation will be reported in the full paper). 4) Scale the 1-min rain-rate samples to maintain the same quantity of water of the original 10-min rain rate input sample. 5) Re-do the process by considering the next 10-min rain rate sample. The passage from the last sample (sample 10) of the previous 10-min interval to the first sample (sample 1) of the successive 10-min interval is statistically independent.

Step 5 simplifies the simulation but it does introduce high frequency noise, as also does, although reduced, the simulation within the 10 samples in any 10-min interval. To reduce this noise, the generated 1-min rain-rate times series is filtered with a low-pass Butterworth filter of order 10, and its values are again scaled to conserve the original quantity of water of the corresponding 10-min interval. The optimal cut-off frequency of the filter is 1/3 min^{-1}.

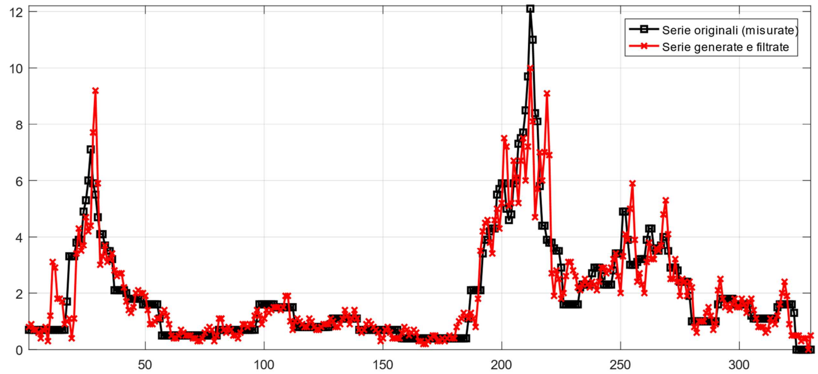
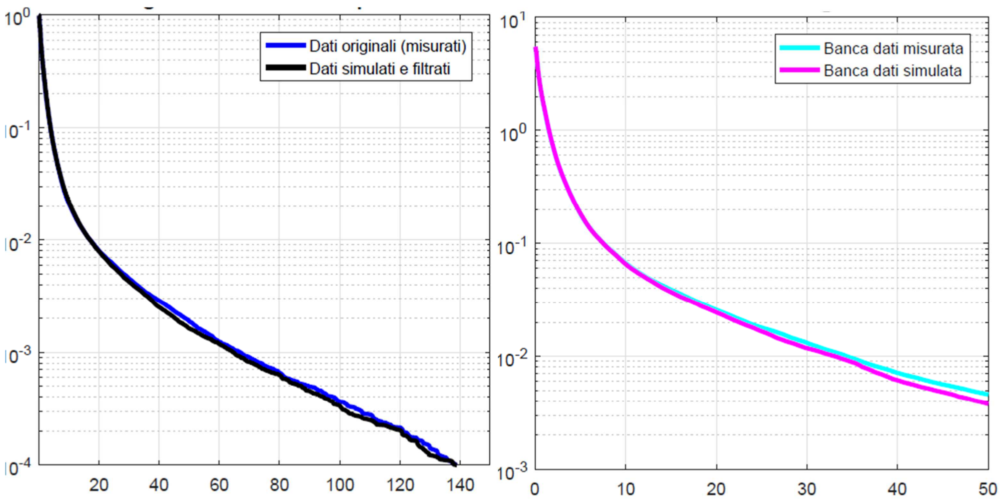


Figure 2: Black line: original 1-min rain rate (mm/h) time series; red line: generated final 1-min rain-rate (mm/h) time series.

Figure 3a shows the two 1-min rain-rate conditional probability distributions. We see no appreciable differences between the two. Finally 2b shows the annual rain-attenuation probability distributions obtained with the original and with the generated 1-min rain-rate data bank, both obtained with the SST. There are no appreciable differences.



(a) Rain rate (mm/h) (b) Rain Attenuation (dB)

Figure 3: (a) Conditional probability distribution of original (blue) and simulated (black) 1-min rain rate in Spino d'Adda, 1993-2000. (b) Annual probability distributions of rain attenuation in a 35.5° slant path: SST simulated with the original 1-min rain rate data bank (magenta); SST simulated with the estimated 1-min rain rate data bank (cyan).

References

[1]. E. Matricciani, Physical-mathematical model of the dynamics of rain attenuation based on rain rate time series and two layer vertical structure of precipitation, *Radio Science*, 1996, 31, 281-295.