Some results on rainfall modelling

Weather type analysis (Evinos river data)

Scaling model
Simulation/Forecasting } (Reno river data)

Presentation at the 5th meeting of the AFORISM project (Cork, Ireland)

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Topics of the presentation

A. Weather type analysis

1. Results
2. Conclusions

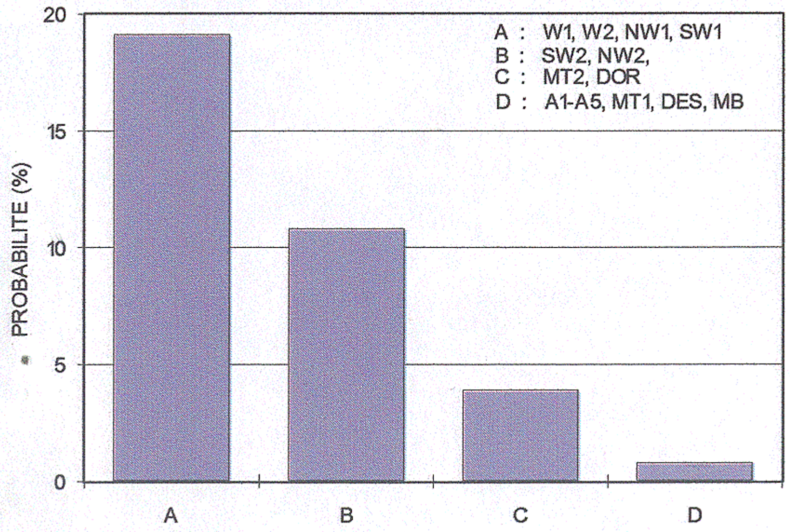
B. Reno river rainfall analysis

1. Data presentation
2. Exploratory analysis of rainfall data
3. Fitting of the scaling model to the historical data
4. Application of the model for conditional simulation
5. Conclusions

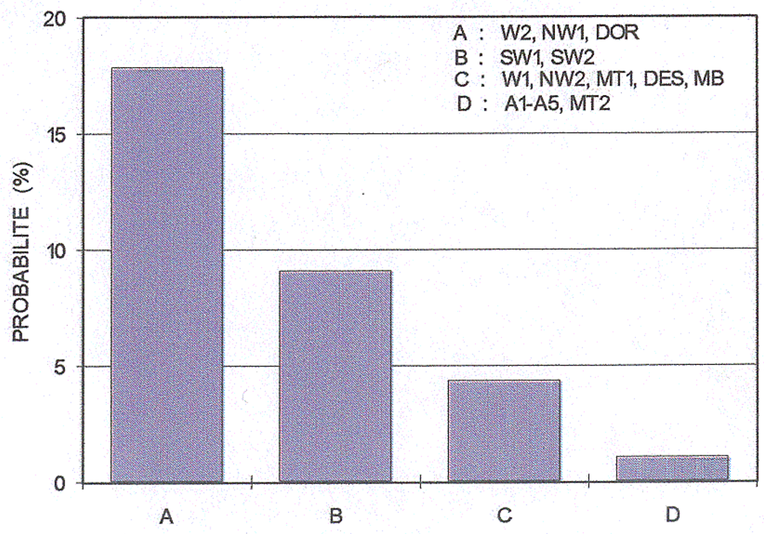
Weather type analysis

Probability of occurrence of intense rainfall events per weather type

Wet season

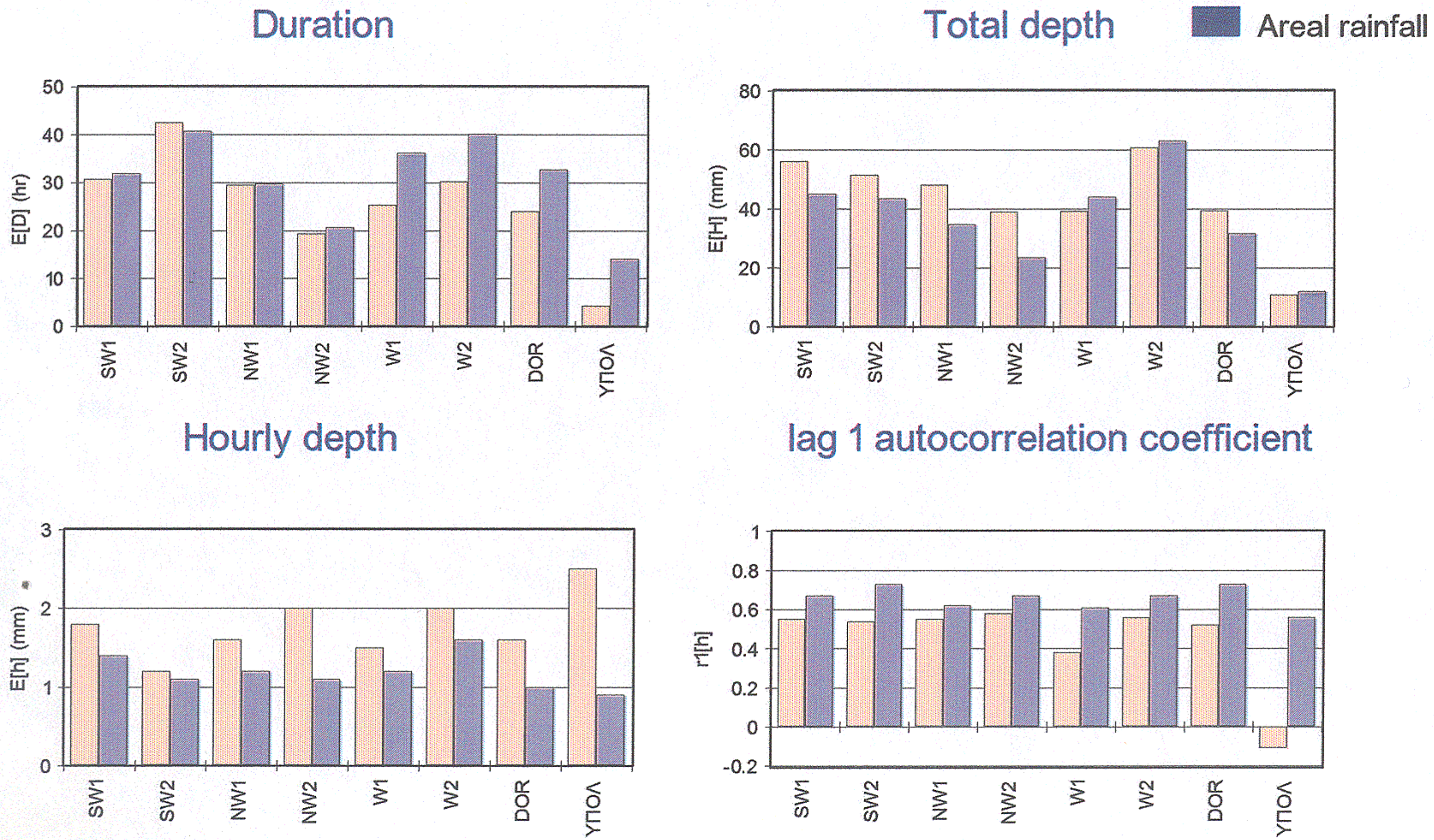


Dry season



Weather type analysis

Rainfall event characteristics (wet season)

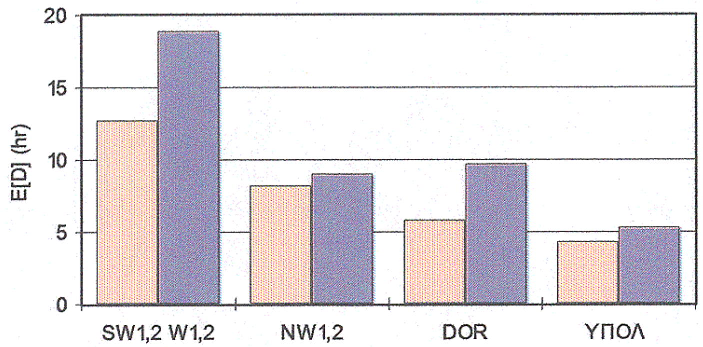


Weather type analysis

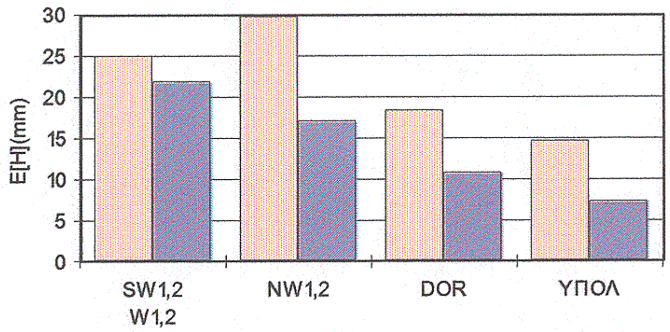
Rainfall event characteristics (dry season)

Point rainfall
Areal rainfall

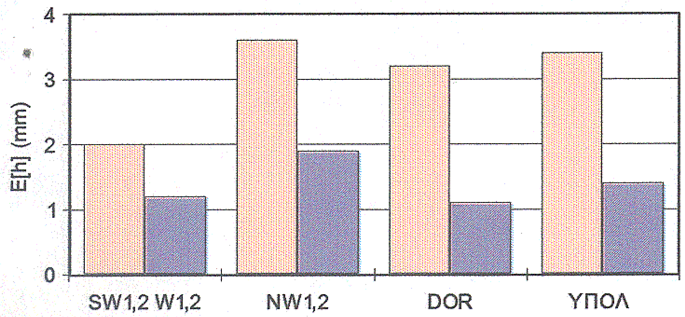
Duration



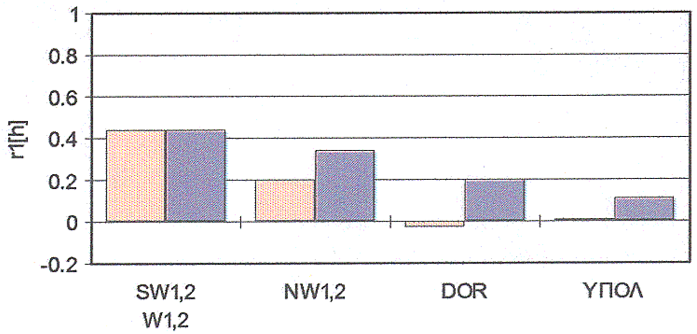
Total depth



Hourly depth



lag 1 autocorrelation coefficient



Weather type analysis

Analysis of variance

	Percentage of variance which is explained by weather types		Percentage of variance which is explained by duration (without reference to weather type)
	POINT RAINFALL	AREAL RAINFALL	AREAL RAINFALL
WET SEASON			
DURATION	7%	11%	
TOTAL DEPTH	3%	10%	47%
MEAN INTENSITY	7%	4%	6%
HOURLY DEPTH	1%	1%	1%
DRY SEASON			
DURATION	18%	28%	
TOTAL DEPTH	18%	22%	41%
MEAN INTENSITY	8%	9%	18%
HOURLY DEPTH	2%	2%	2%

Weather type analysis

Conclusion

1. Statistically significant differences in the probability of occurrence of intense rainfall events, between weather types.

2. Large variance in all rainfall event characteristics, for all weather types.

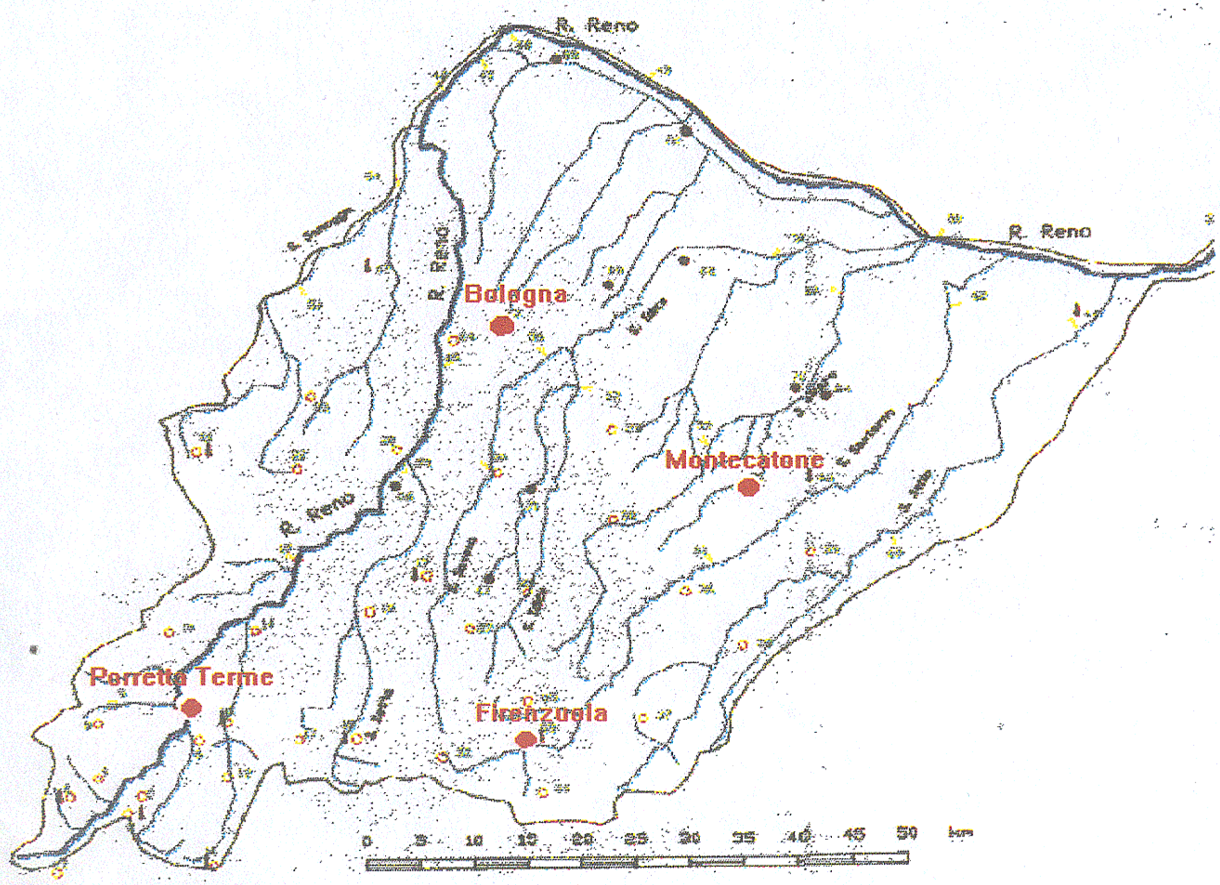
3. Significant differences in the stochastic structure and characteristics of the intense rainfall events, between dry and wet season.

4. No statistically significant differences in the rainfall event characteristics among the weather types of the wet season. Some significant differences among the weather types of the dry season.

Weather type analysis

5. A small percentage of the total variance of rainfall characteristics, could be explained by the concept of weather type. The double percentage can be explained merely by the duration of the event.
6. In modelling of intense rainfall, weather types are informative for the probability of occurrence (and duration). For the other rainfall event characteristics, the use of the scaling model with reference to duration is more effective.

Exploratory analysis of Reno river rainfall data



Exploratory analysis of Reno river rainfall data

Stations

Bologna oss. sez. idrogr., Firenzuola, Montecatone, Porretta Terme

Selection of rainfall events

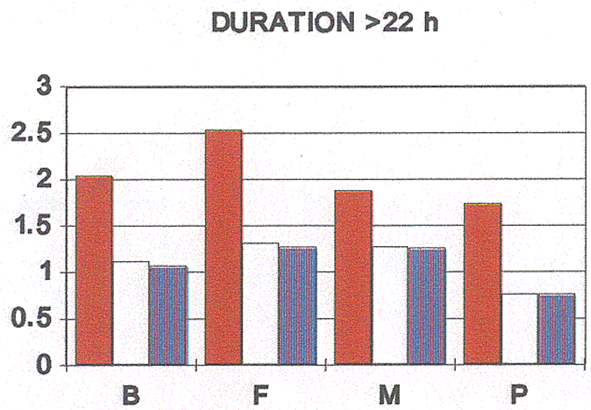
Separation time	6h
Hourly depth	≥ 1 mm

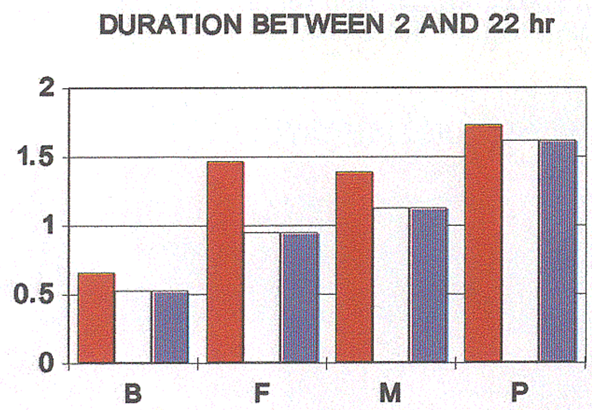
Data set

Total number of events	149
At wet season (Oct - May)	99
At dry season (Jun - Sep)	50

Exploratory analysis of Reno river rainfall data

Comparison of the variance of residuals computed by different models (wet season)





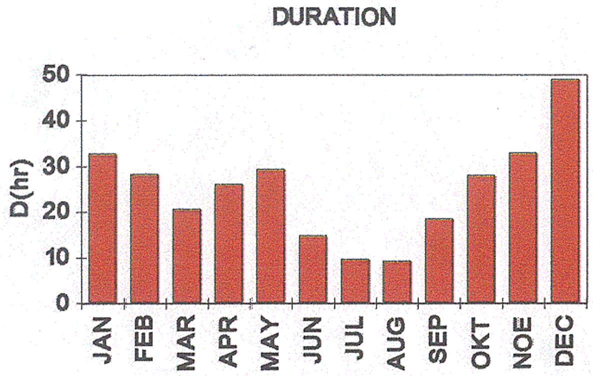
: Total variance of the hourly depth Y_t (no model)

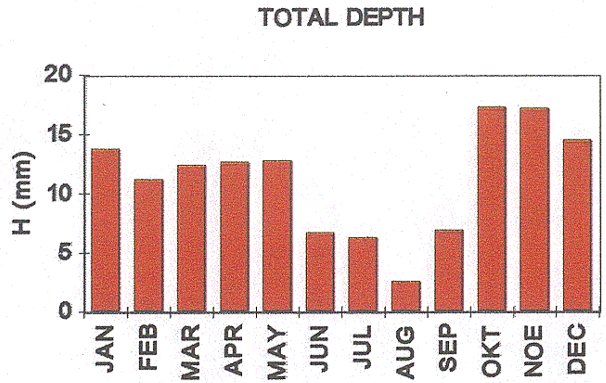
: Variance of the residual W of the model $Y_t = aY_{t-1} + W_t$

: Variance of the residual W of the model $Y_t = aX_t + bY_{t-1} + cX_{t-1} + W_t$

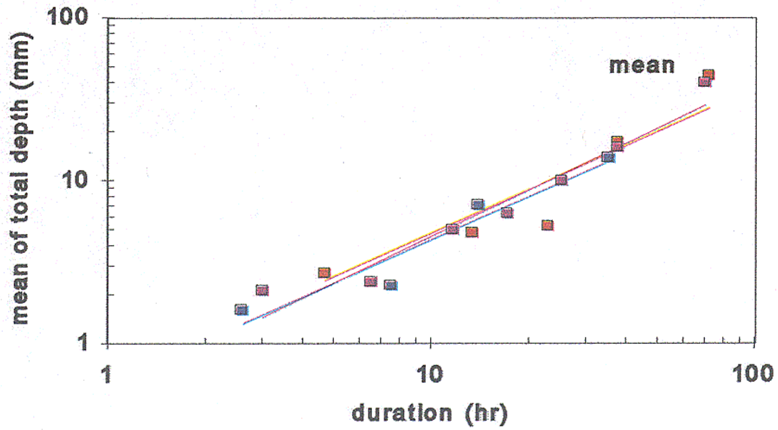
Exploratory analysis of Reno river rainfall data

Variation of mean duration and depth per month



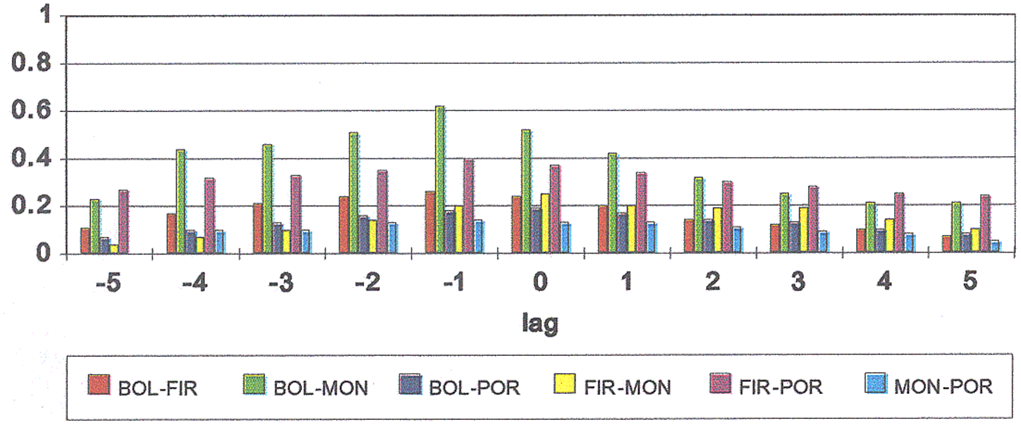


Total rainfall depth (wet and dry season)

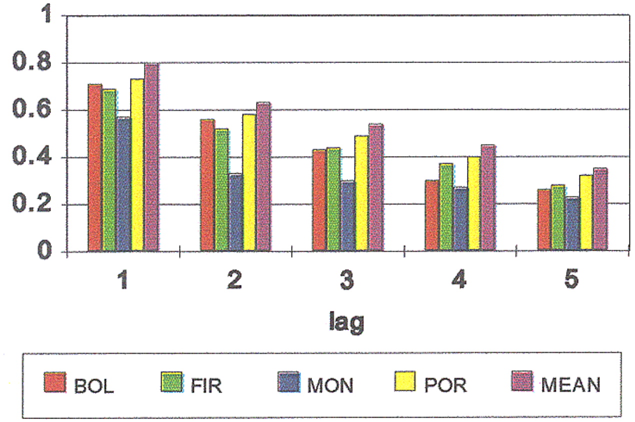


Exploratory analysis of Reno river rainfall data

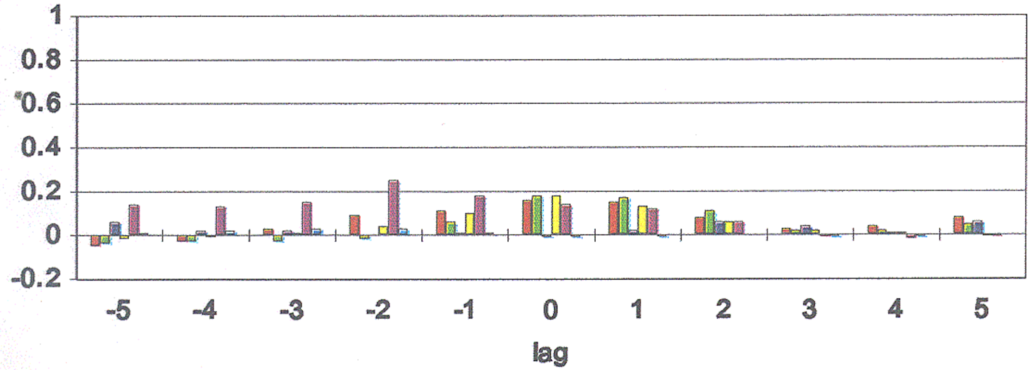
CROSS CORRELATION (WET SEASON))



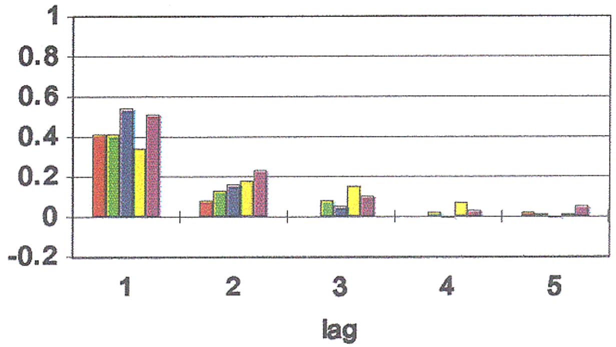
AUTOCORRELATION (WET SEASON)



CROSS CORELLATION (DRY SEASON)

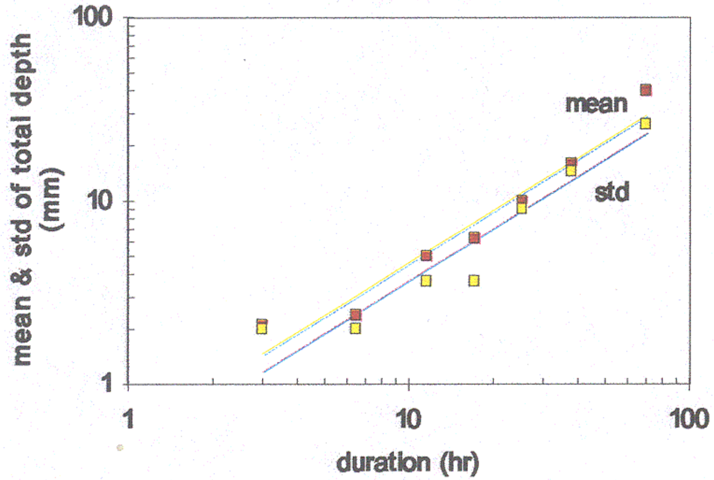


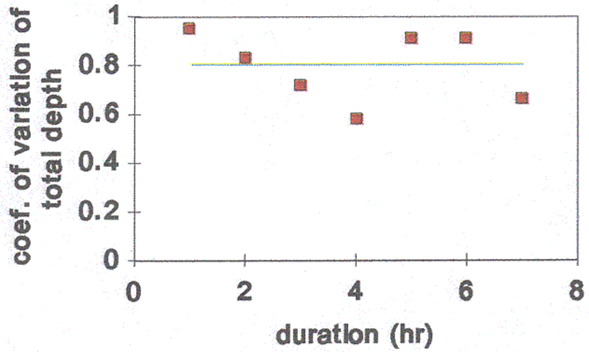
AUTOCORRELATION (DRY SEASON)



Fitting of the scaling model

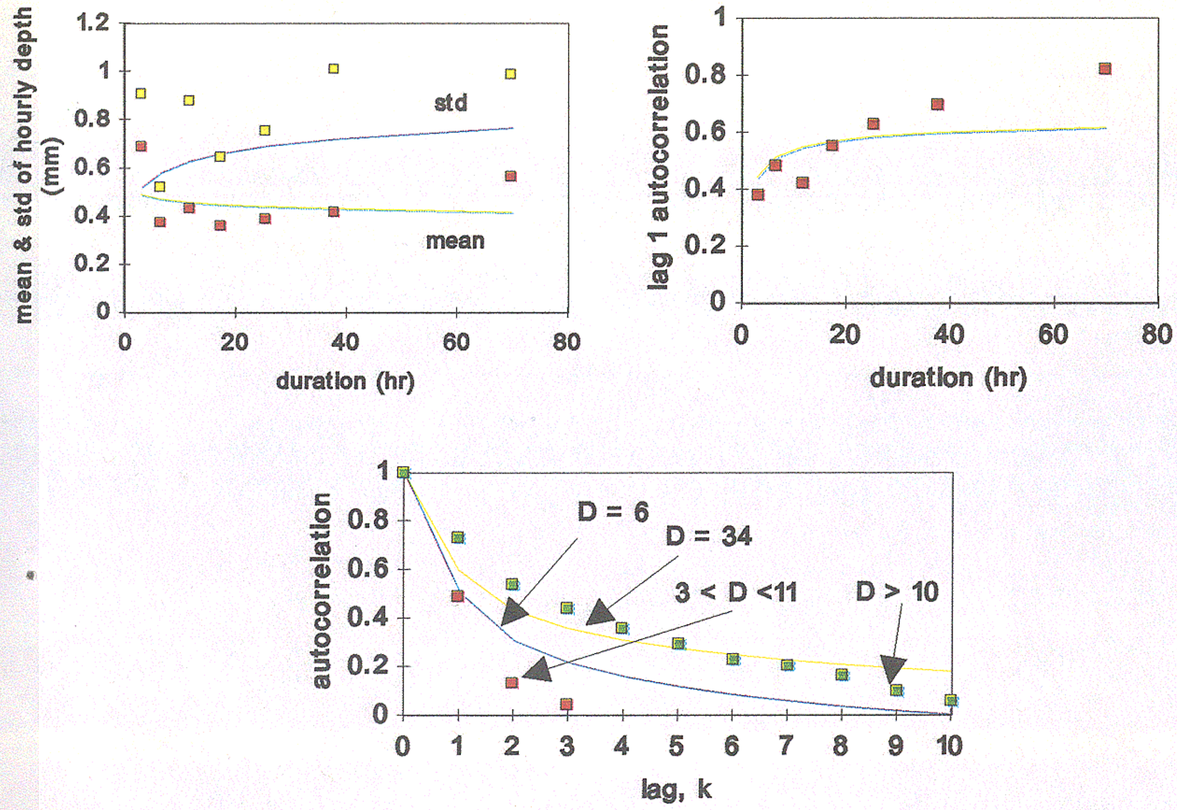
Total rainfall depth





Fitting of the scaling model

Hourly rainfall depth



Application of the model for simulation

Link to the rainfall model

Inputs to the simulation model: $E[\boldsymbol{X}]$, $Cov[\boldsymbol{X},\boldsymbol{X}]$, $\mu_3[\boldsymbol{X}]$

Link to the the past of the simulated hydrograph

At time step k: $(X_1 = x_1, X_2 = x_2, \ldots, X_k = x_k) + (D > K)$

Generation steps

1. Generation of total duration D (from the conditional distribution)
2. Generation of sequential hourly depths X_j for $j = k + 1, \ldots, D$.

Examined cases

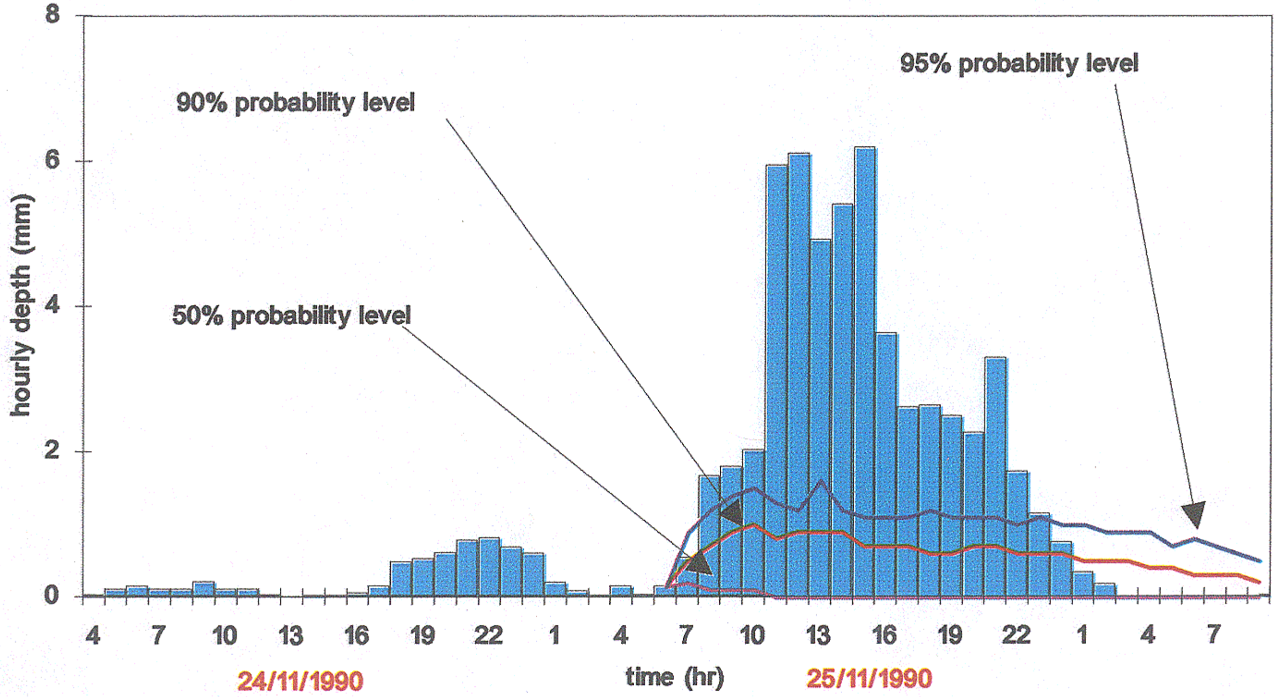
1. Condition for duration: $D > k$.
2. Adaptive simulation (one hour forecasting). At each time step it is assumed that the list of known hourly depths is updated. Duration as in case 1.
3. Estimations of the total duration and depth are assumed, i.e. $D_l \le D \le D_h$ and $Z_l \le Z \le Z_h$

Simulated hyetographs

1000 simulated hyetographs for each event

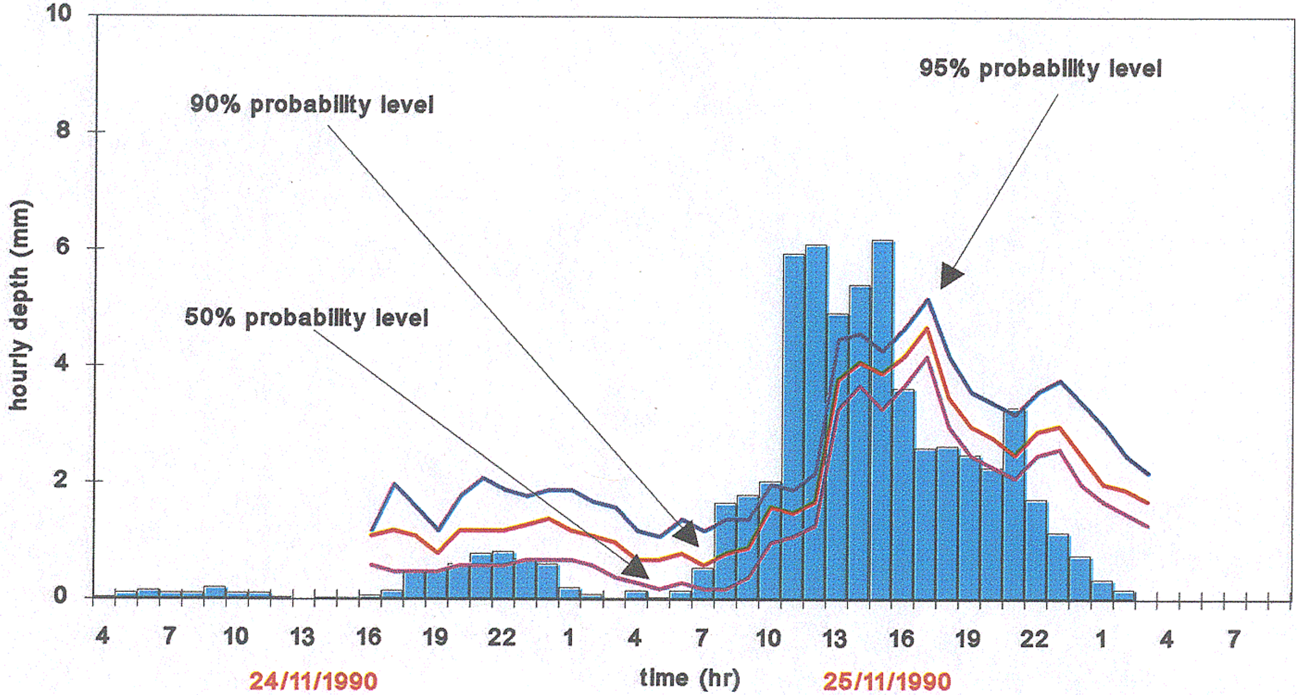
Application of the model for simulation

Case 1 Total duration (D) > current duration (k)



Application of the model for simulation

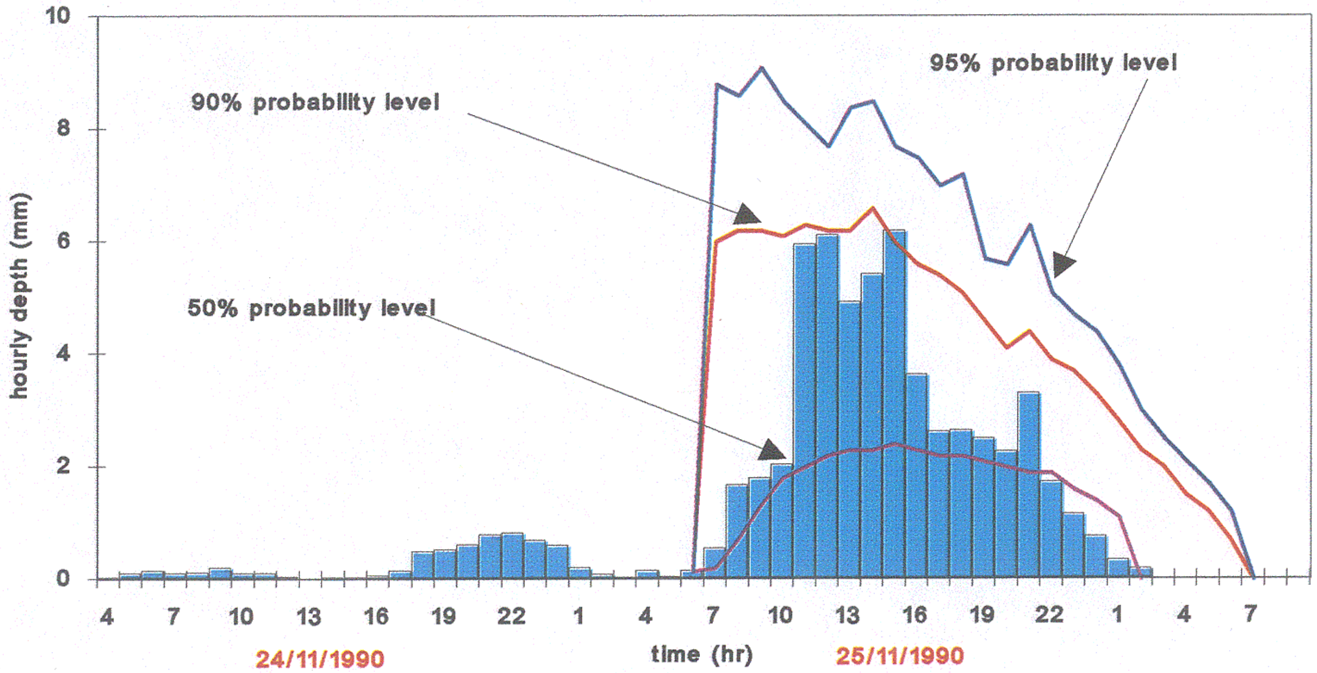
Case 2 Adaptive simulation



Application of the model for simulation

Case 3 $D_l \leq D \leq D_h$ where $|D_{l,h} - D| = 0.1*D$

$Z_l \leq Z \leq Z_h$ where $|Z_{l,h} - Z| = 0.2*Z$



Conclusion

1. It is impractical to convey information of neighbouring stations to decrease the variance of hourly depth in stochastic simulation of rainfall.

2. Consequently, for a lumped rainfall-runoff model, it is more convenient to build a lumped (areal) stochastic rainfall model, not a multivariate one.

3. The scaling model is suitable for the Reno river data and can be fitted to all data regardless of season (wet or dry).

4. The use of the scaling model for stochastic simulation of rainfall can give sufficient forecast if the total duration and depth of the event are estimated approximately by another (meteorological) model.