Subdaily Precipitation Downscaling for Hydrology

Spatial Resolution Enhancement for Environmental Data
RSS Meeting – 24 October 2006

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A - Disaggregating output from Regional Climate Models for hydrological simulation: UKWIR methodology

- The scale problem
- The tools
- Some results

B - Disaggregating output from climate models for hydrological simulation: DEFRA project FD2113 methodology.

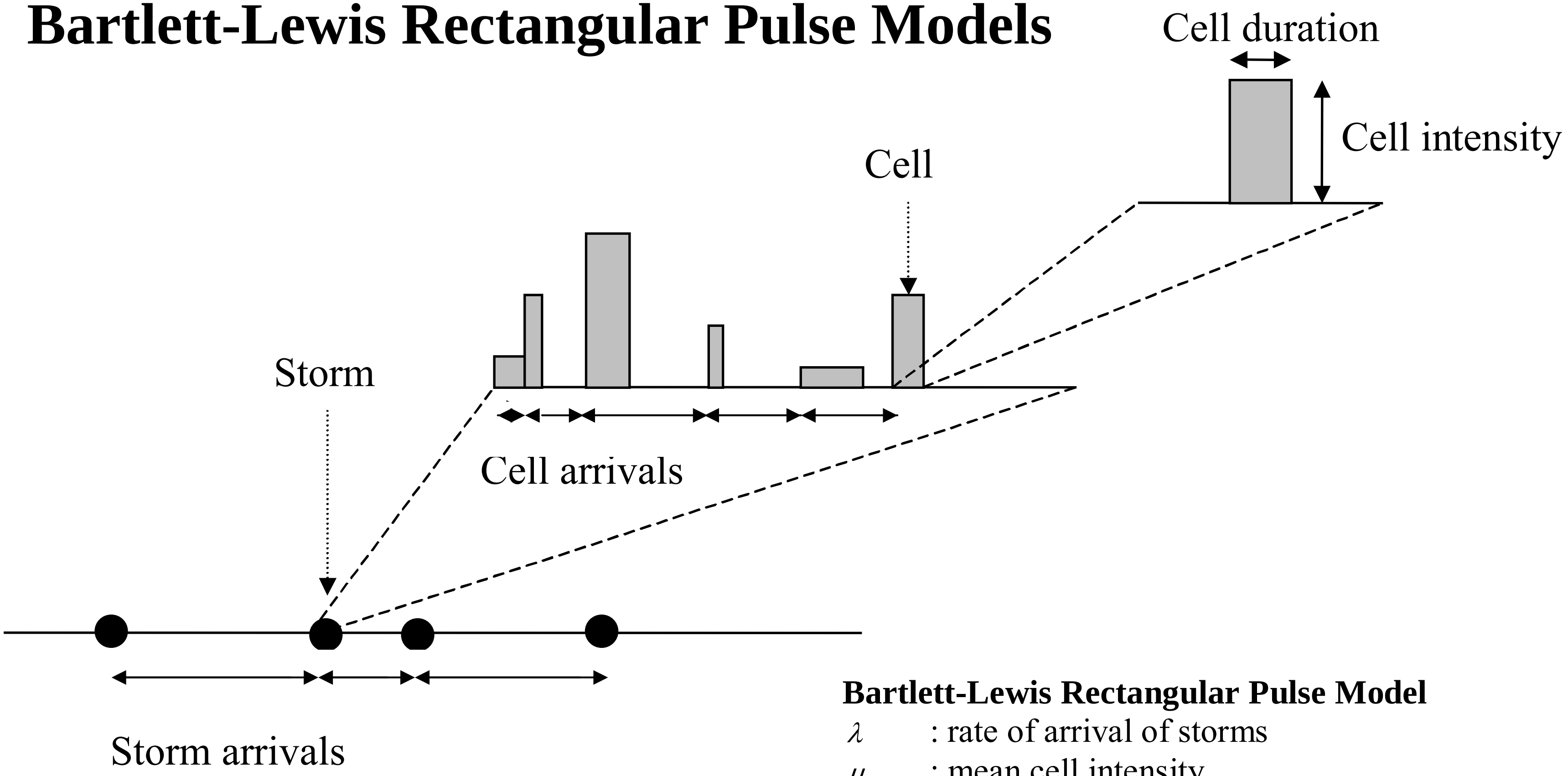
A.1 The problem

- The water industry wants to know to what extent the current assumptions which underpin its designs, would still be valid under a changed climate.
- Outputs from Regional Climate Models (RCM) are available at scales of 50x50km^2 (UKCIP02) and soon 25x25km^2 (UKCIPnext). General Circulation Models (GCM ~300x300km^2) could also be used.
- Rainfall models are available for the generation of long series of rainfall; by transforming these into streamflow series in natural or urban catchments, they provide estimates of extreme flow events (floods) under current climate conditions for design purposes.

How can the RCM outputs be used to update the parameterisation of the (single-site) rainfall models?

A.2 The tools

- **Bartlett-Lewis Rectangular Pulse Models**



Bartlett-Lewis Rectangular Pulse Model

λ : rate of arrival of storms

μ_x : mean cell intensity

μ_{x^2} : mean of square of cell intensity

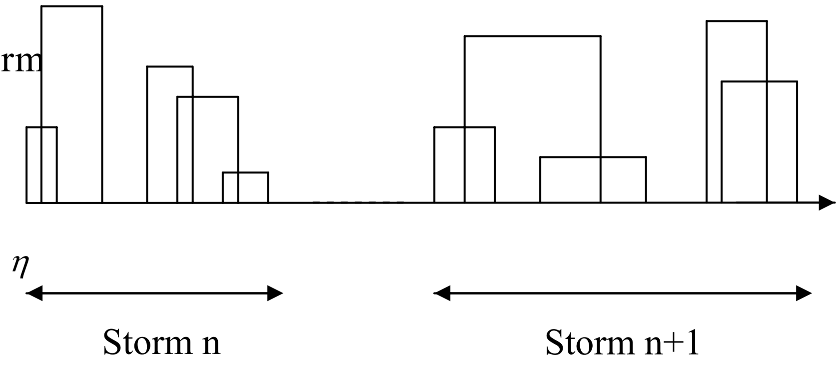
η : cell duration exponential parameter

β : rate of arrival of cells

γ : exponential parameter of duration of storm activity

Random Parameter Bartlett-Lewis Rectangular Pulse Model

The temporal structure of the storm is allowed to vary between storm

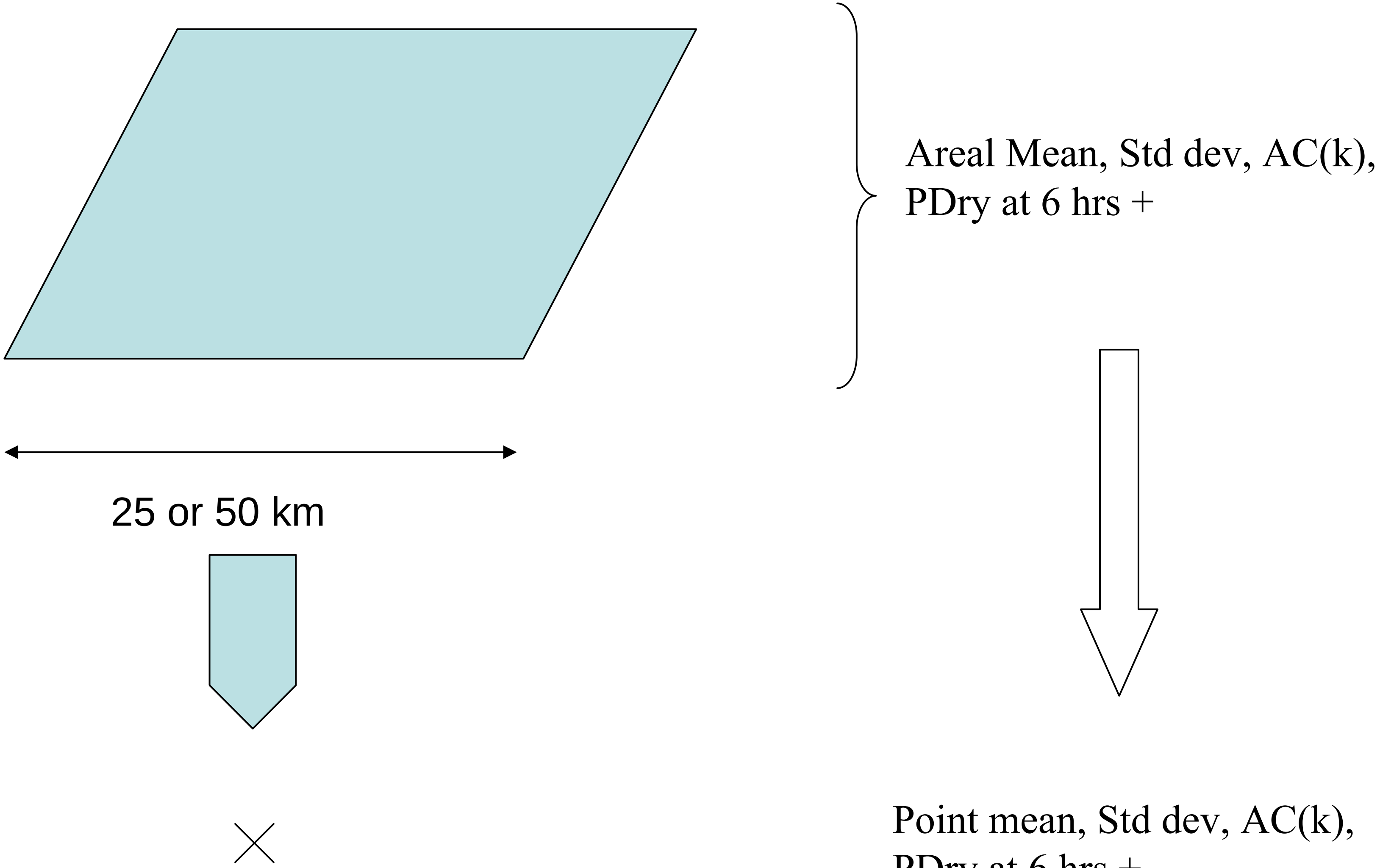


λ : rate of arrival of storms
μ_x : mean cell intensity
μ_{x^2} : mean of square of cell intensity
α, ν : gamma distribution parameters for cell duration parameter η
κ : cell arrival parameter $\kappa = \beta / \eta$
φ : duration of storm activity parameter $\varphi = \gamma / \eta$

The model is fitted by the Generalised Method of Moments: an objective function is formed by using statistics $\{Z_1, Z_2, \ldots\}$ of modelled rainfall at different time scales (e.g. mean, variance, proportions of dry periods, autocorrelations) and their corresponding estimates:

$$Min\left\{\sum_i \varpi_i \left(Z_i(\lambda, \mu_x, \mu_{x_2}, \alpha, \nu, \kappa, \varphi) - O_i\right)^2\right\}$$

- The BLRP model is calibrated with 6 hourly statistics scaled down from the RCM outputs. Scaling relationship is assumed to be unaltered by climate change

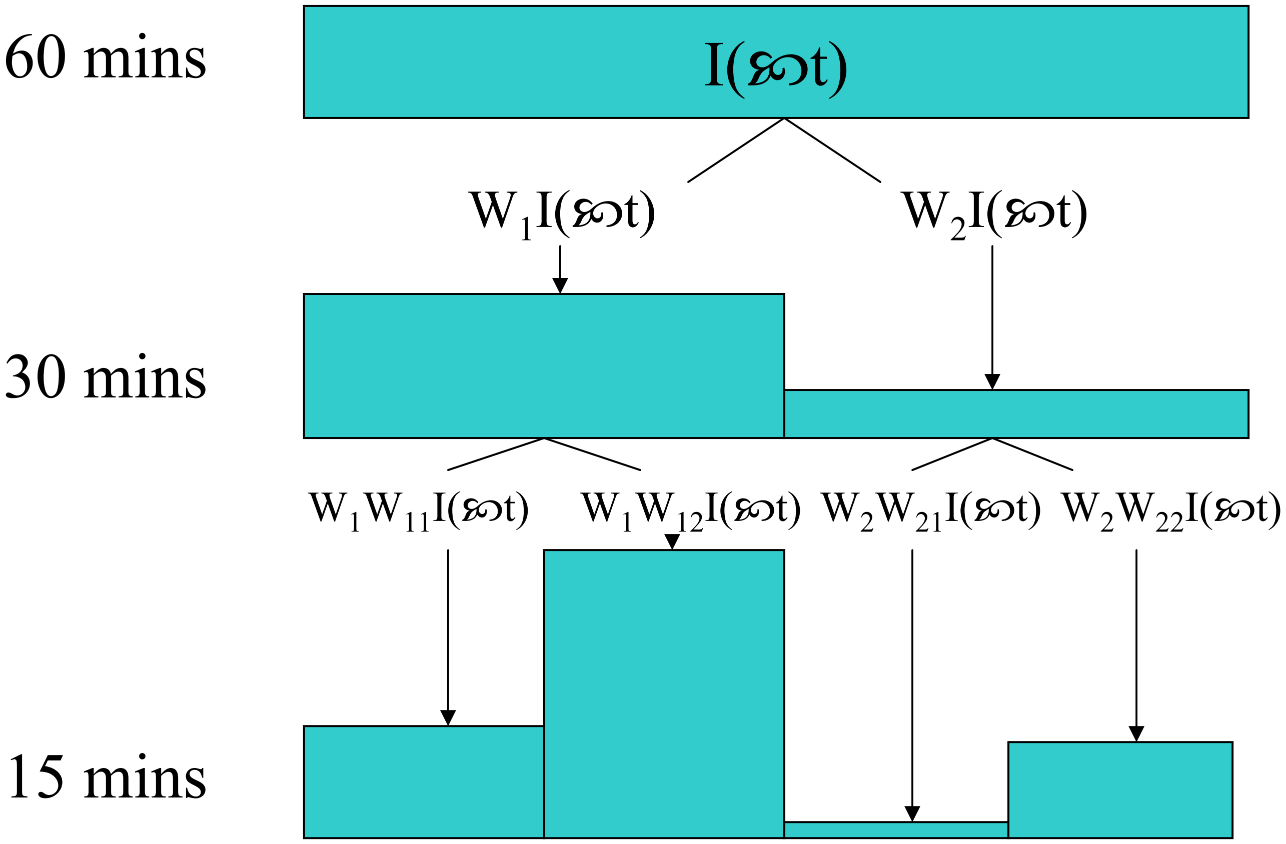


Areal Mean, Std dev, AC(k), PDry at 6 hrs +

25 or 50 km

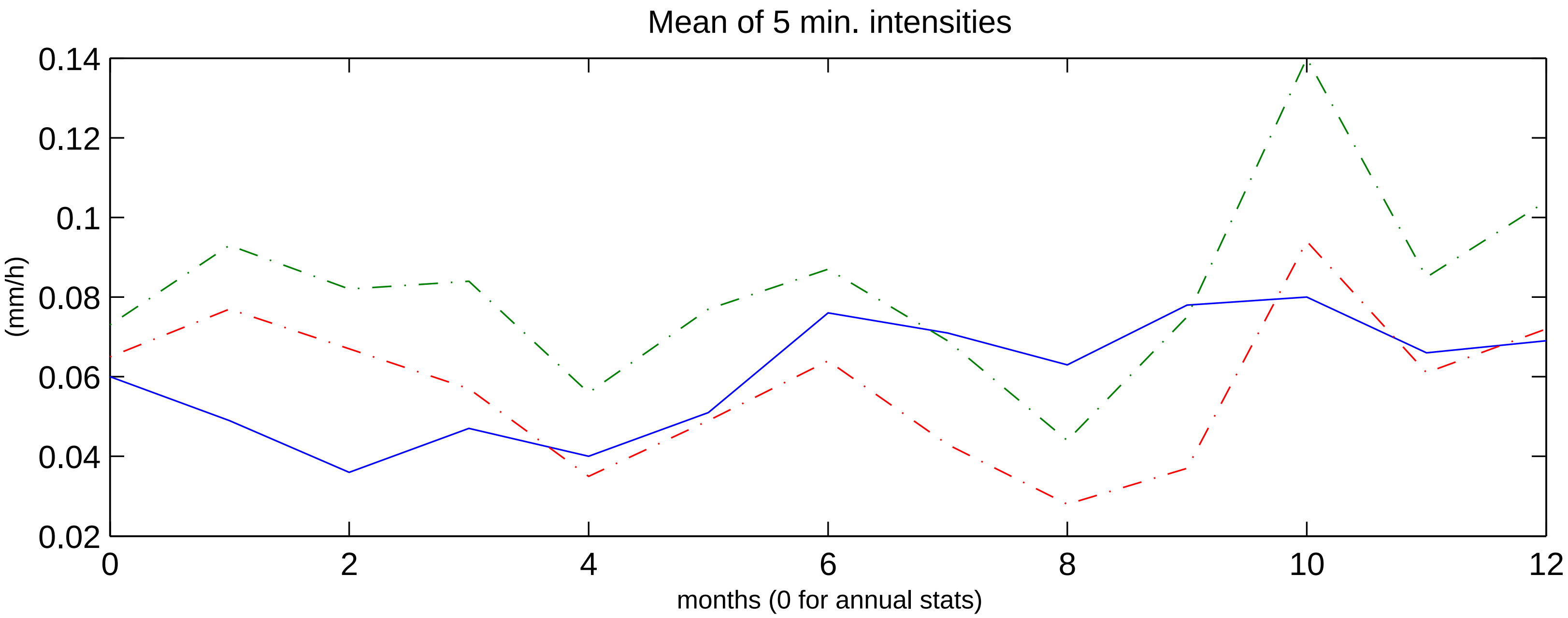
Point mean, Std dev, AC(k), PDry at 6 hrs +

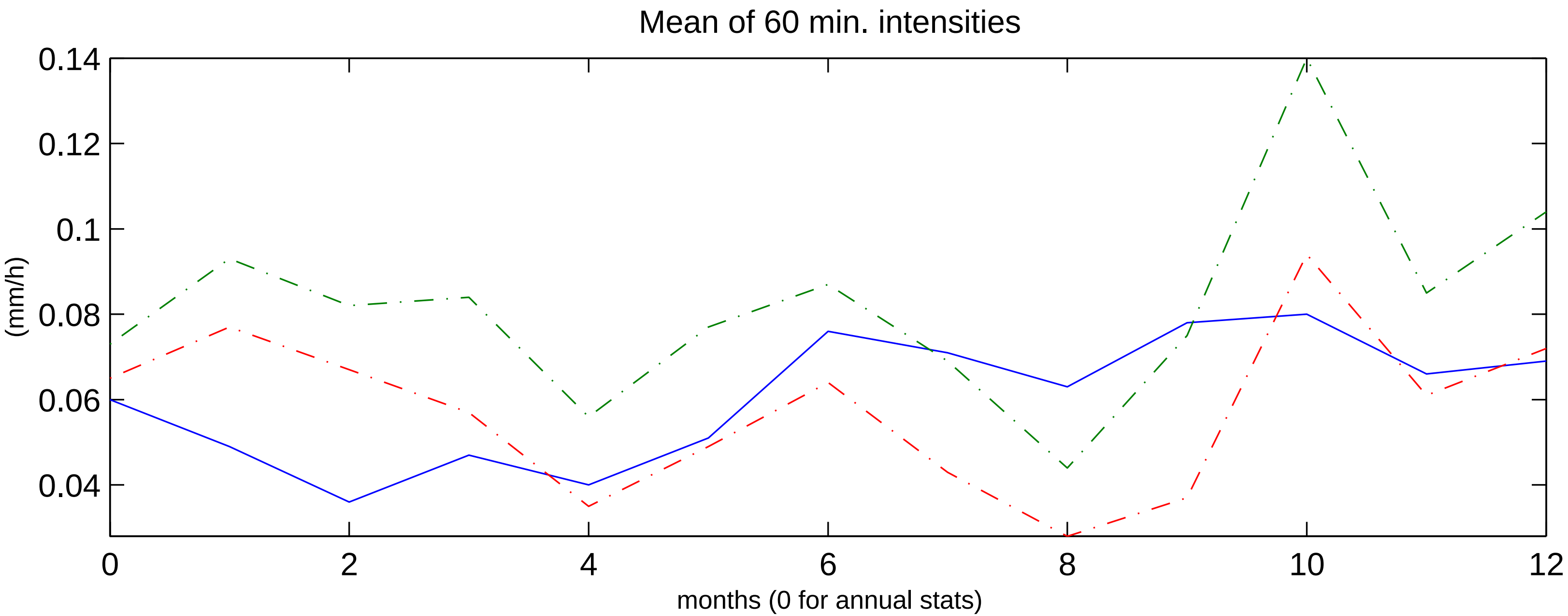
- A multifractal cascade is then used to take the hourly rainfall down to finer scales. This is achieved by successive multiplications by weights W which are i.i.d. & with E[W]=1 (distribution assumed unchanged under climate change). We choose: $W=A\beta^N$, where $N \sim \text{Poisson}(c)$.

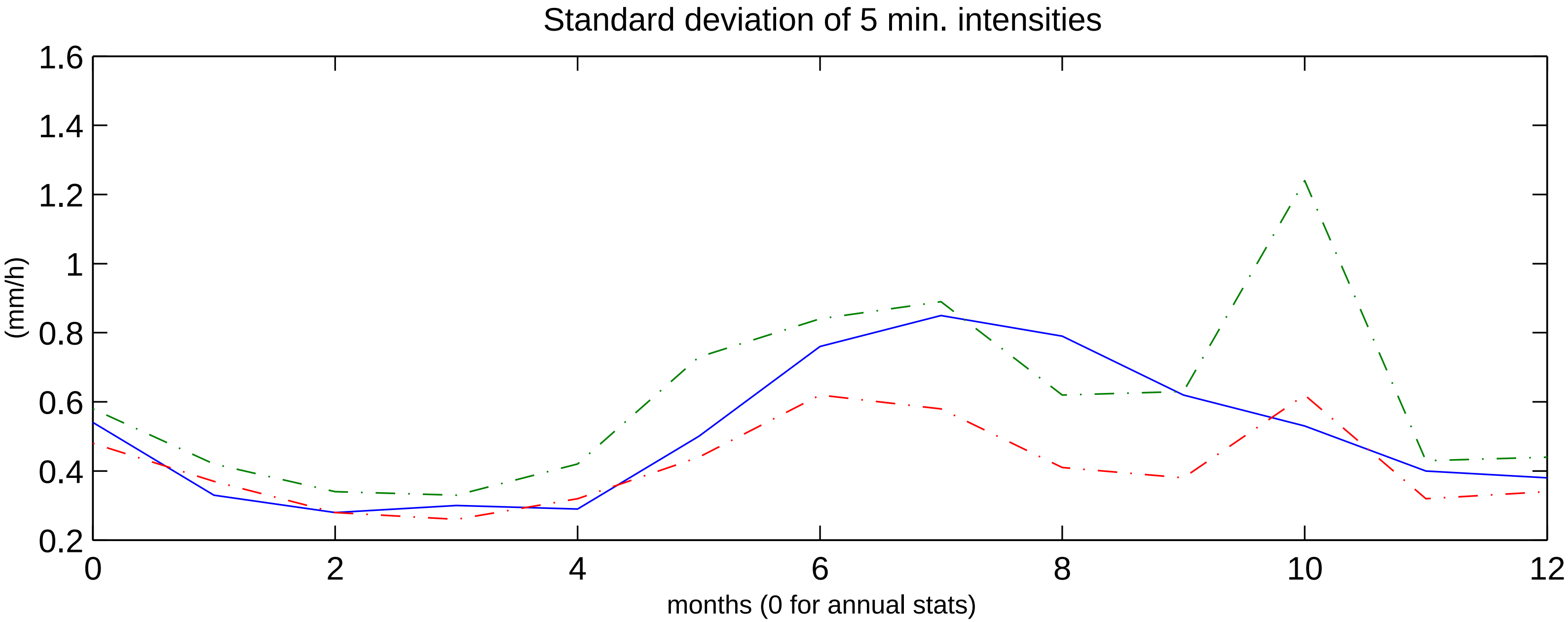


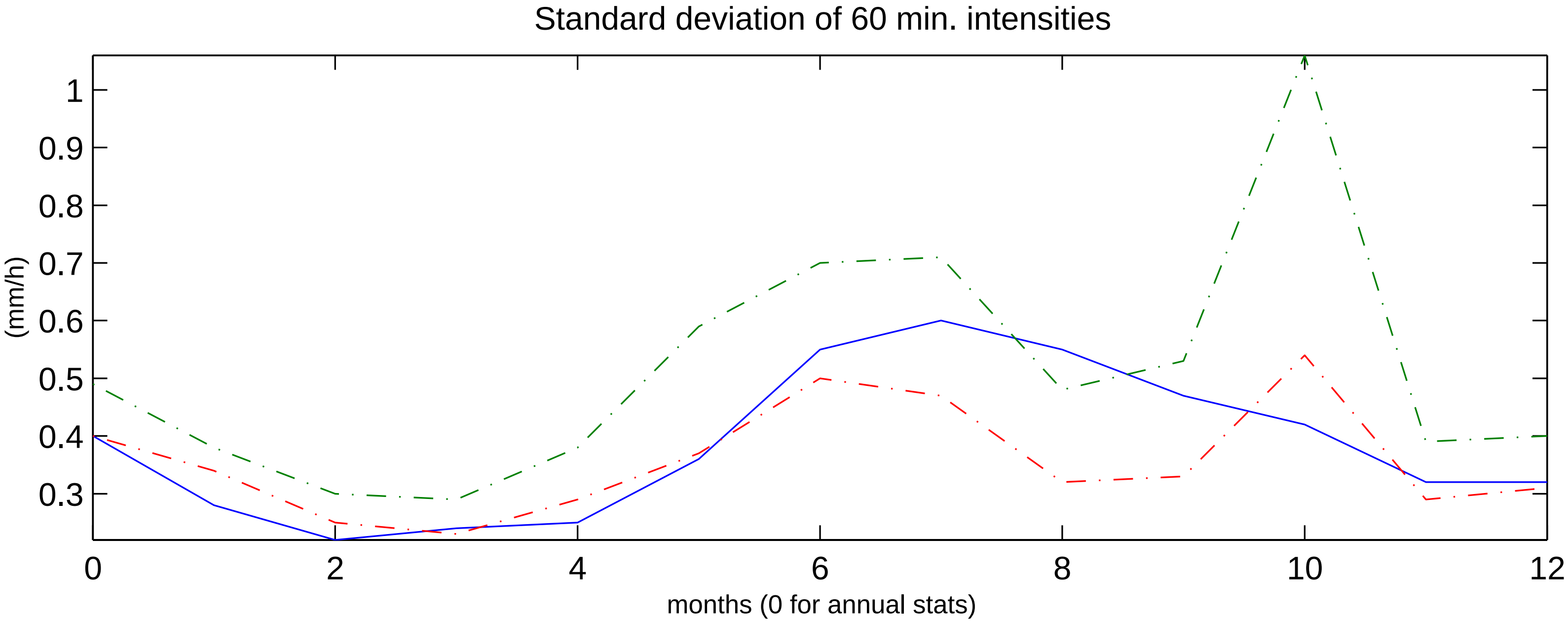
... and so on ...

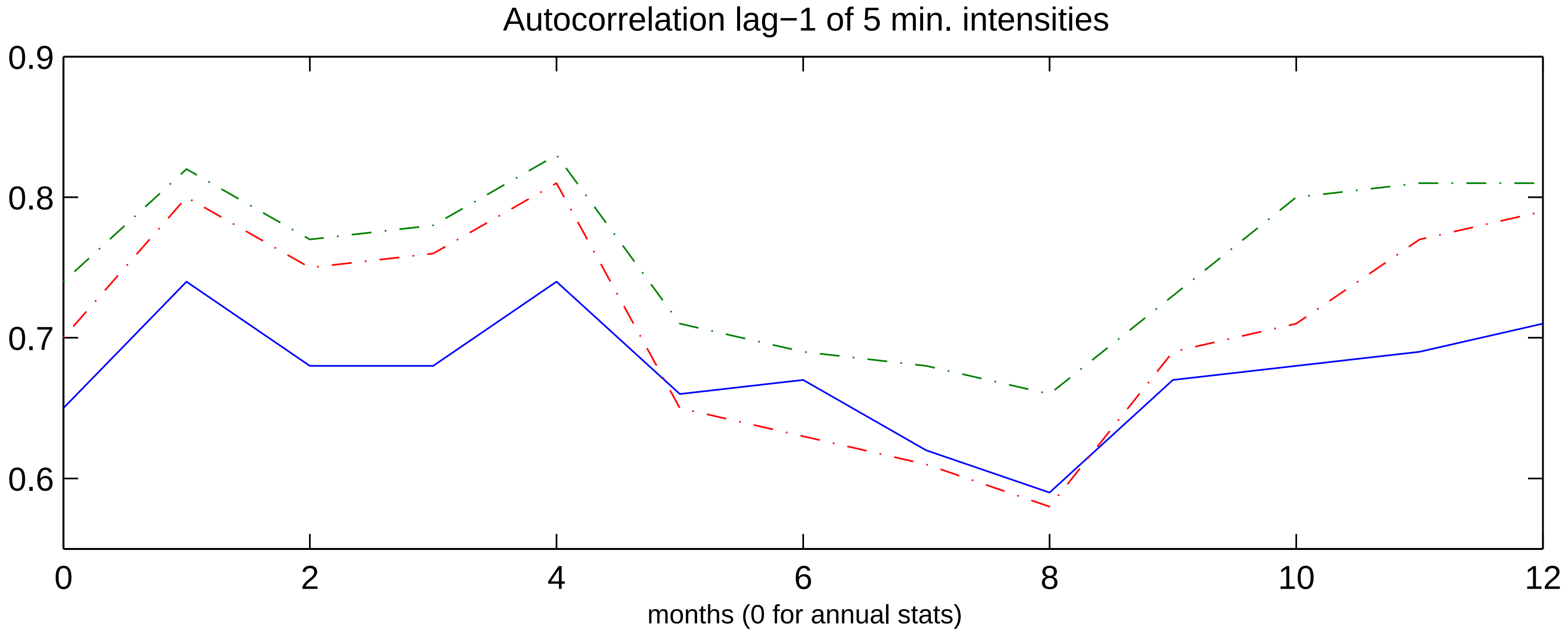
A.3 Some results


Mean of 5 min. intensities

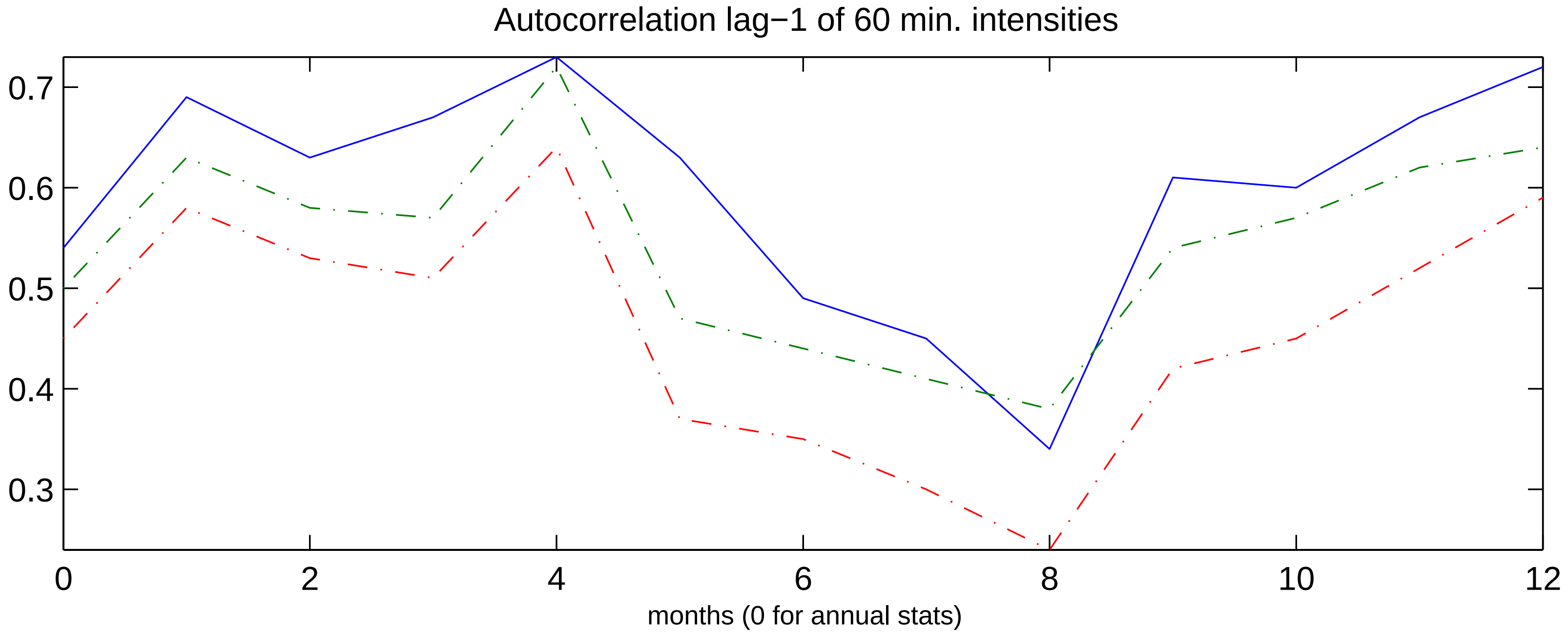

Mean of 60 min. intensities


Standard deviation of 5 min. intensities
(mm/h)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
months (0 for annual stats)

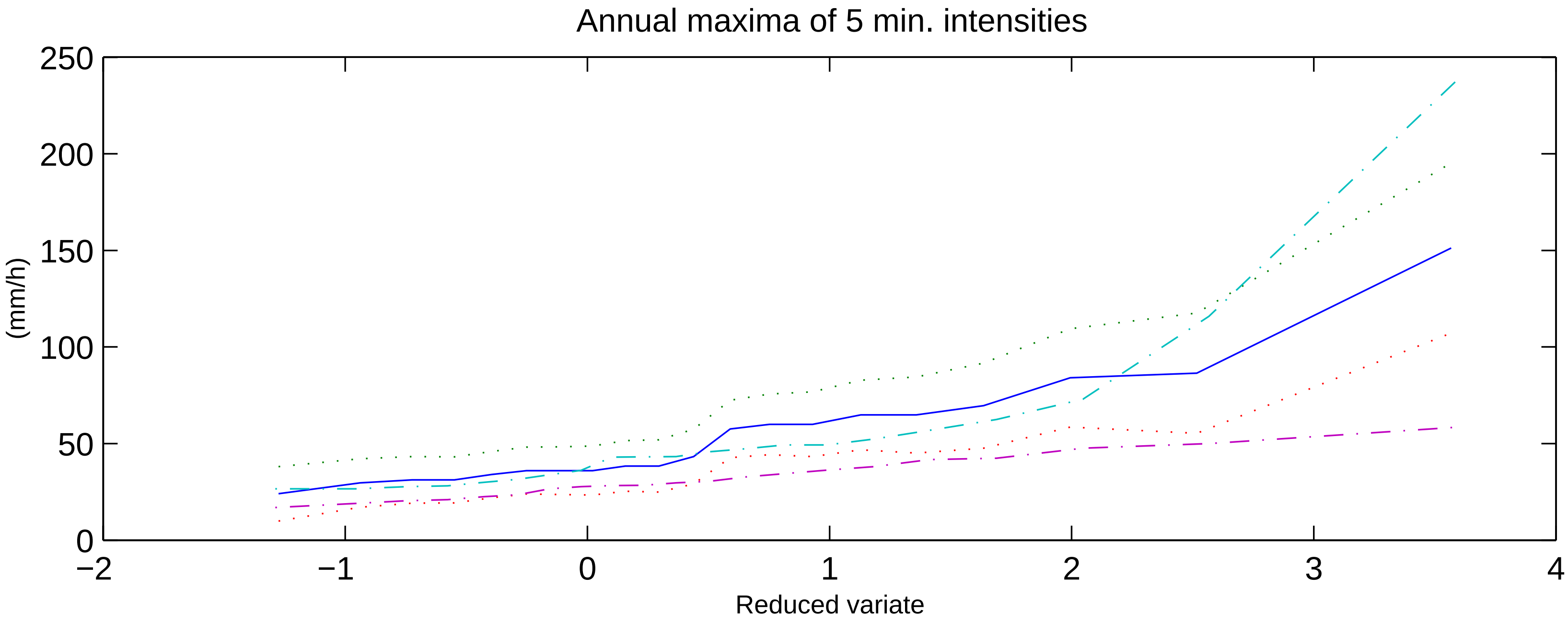

Standard deviation of 60 min. intensities
(mm/h)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
2
4
6
8
10
12
months (0 for annual stats)

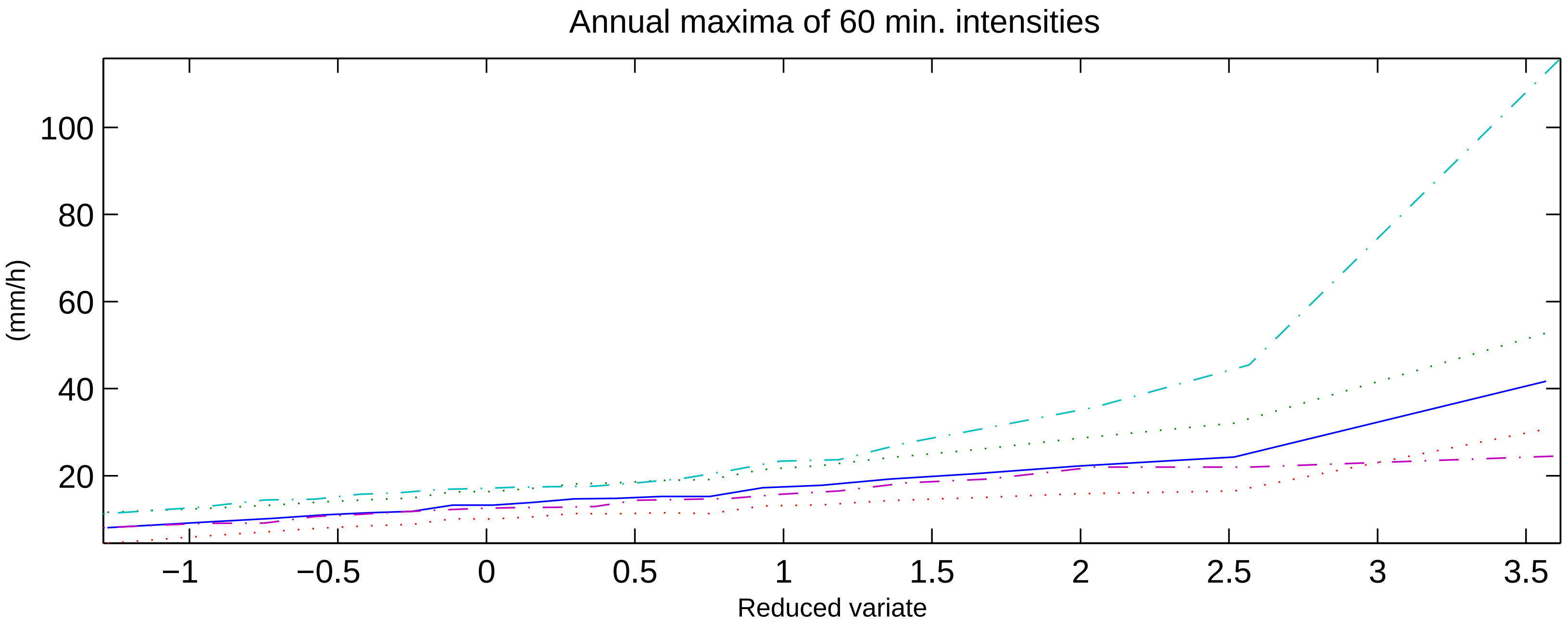


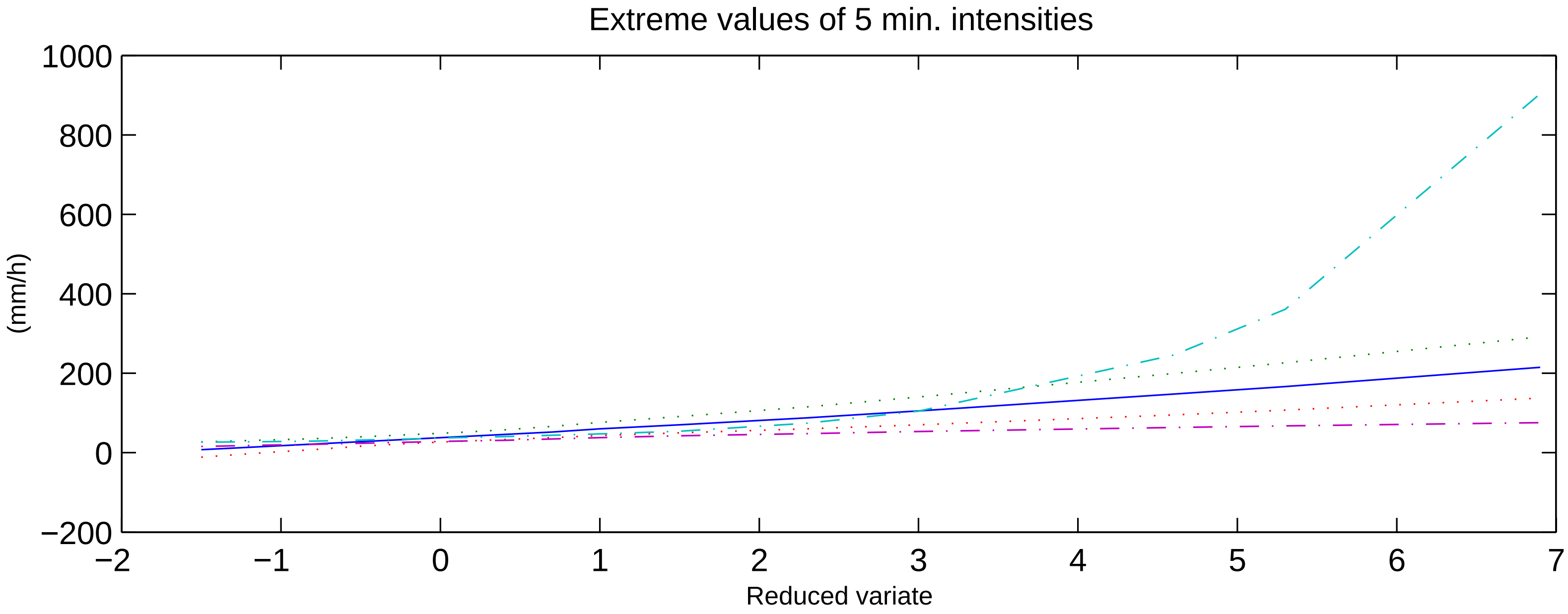
Autocorrelation lag−1 of 5 min. intensities



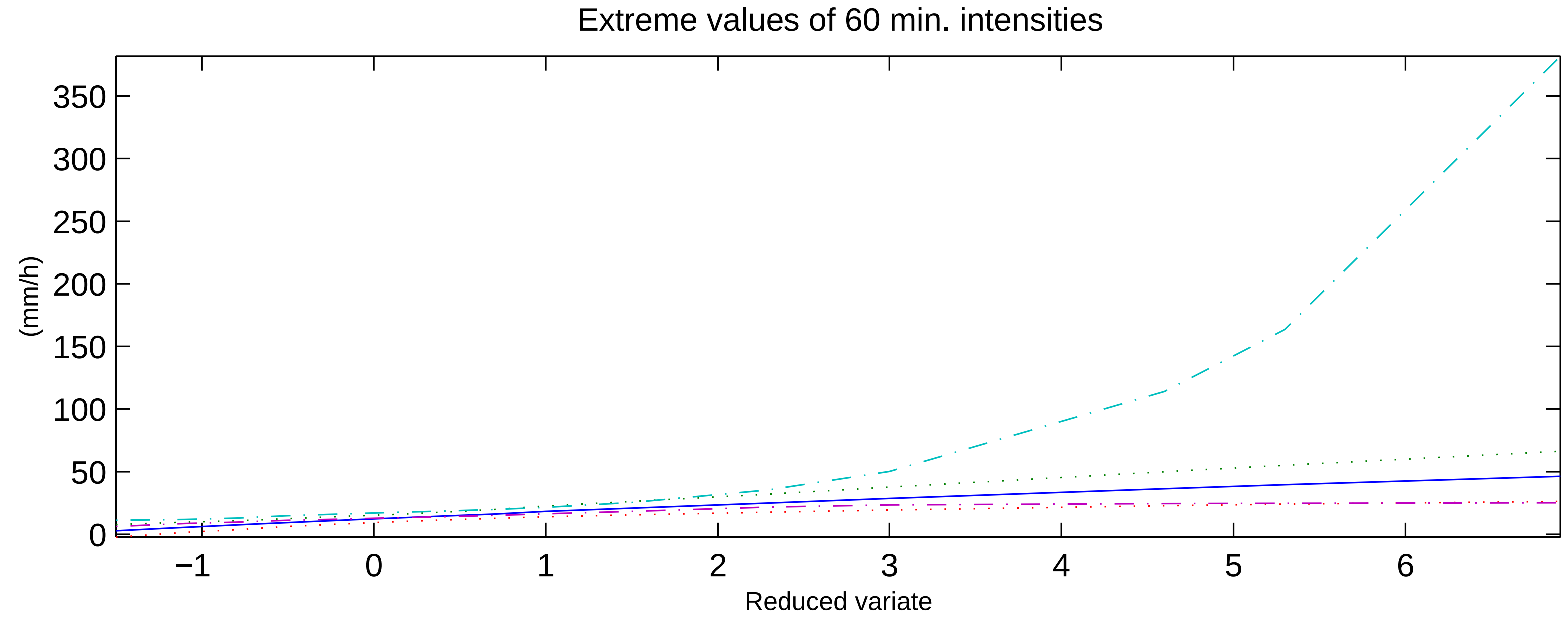
Autocorrelation lag−1 of 60 min. intensities


Annual maxima of 5 min. intensities
(mm/h)
250
200
150
100
50
0
−2
−1
0
1
2
3
4
Reduced variate


Annual maxima of 60 min. intensities
(mm/h)
100
80
60
40
20
−1
−0.5
0
0.5
1
1.5
2
2.5
3
3.5
Reduced variate



Extreme values of 5 min. intensities



Extreme values of 60 min. intensities