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Intensity-Duration-Frequency (IDF) rainfall curves, for data series and climate projection in African cities

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The intensity-duration-frequency curves are used in hydrology to express in a synthetic way, the link between the maximum rainfall height h and a generic duration d of a rainfall event, fixed a given return period T.

Generally, IDF curves can be characterized by a bi-parameter power law:

$h(d,T) = a(T)d^n$

where a(T), and n are the parameters that have to be estimated through a probabilistic approach.

An intensity-duration-frequency analysis starts by gathering time series record of different durations and extracting annual extremes for each duration. The annual extreme data are then fitted by a probability distribution.

The present study, carried out within the FP7-ENV-2010 CLUVA project (CLimate change and Urban Vulnerability in Africa), regards the evaluation of the IDF curves for five case studies: Addis Ababa (Ethiopia), Dar Es Salaam (Tanzania), Douala (Cameroon), Ouagadouogou (Burkina Faso) and Saint Louis (Senegal).

The probability distribution chosen to fit the annual extreme data is the classic Gumbel distribution.

However, for the case studies, only the maximum annual daily rainfall heights are available. Therefore, to define the IDF curves and the extreme values in a smaller time window (10', 30', 1h, 3h, 6h, 12h), it is required to develop disaggregation techniques of the collected data, in order to generate a synthetic sequence of rainfall, with statistical properties equal to the recorded data.

The daily rainfalls were disaggregated using two models:

- short-time intensity disaggregation model (10', 30', 1h);
- cascade-based disaggregation model (3h, 6h, 12h).

On the basis of disaggegation models and Gumbel distribution , the parameters of the IDF curves for the five test cities were evaluated.

In order to estimate the contingent influence of climate change on the IDF curves, the illustrated procedure has been applied to the climate (rainfall) simulations over the time period 2010-2050 provided by the CMCC (Centro Euro-Mediterraneo sui Cambiamenti Climatici). The climate projections used were performed following the IPCC (Intergovernmental Panel on Climate Change) 20C3M protocol for the 20^{th} Century, using the RCP4.5 and RCP8.5 radiative forcing scenarios and are characterized by vertical resolutions of 8 and 1 km.

In conclusion, the evaluation of the IDF curves allowed to frame the rainfall evolution of the five case studies, first considering only historical data, then taking in account the climate projections, in order to verify the changes in rainfall patterns. In particular, taking in account the climate projections, an increase of rainfall frequency can be highlighted, compared to a decrease of intensity.