PLUVIOMETRIC CHARACTERIZATION OF THE COCA RIVER BASIN BY USING A STOCHASTIC RAINFALL MODEL

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ABSTRACT

An adequate design of the hydraulic infrastructures, as well as, the prediction and simulation of a river basin require historical records with a greater temporal and spatial resolution. However, the lack of an extensive network of precipitation data, the short time scale data and the incomplete information provided by the available rainfall stations limit the analysis and design of complex hydraulic engineering systems. As a consequence, it is necessary to develop new quantitative tools in order to face this obstacle imposed by ungauged or poorly gauged basins. In this context, the use of a spatial-temporal rainfall model allows to simulate the historical behavior of the precipitation and at the same time, to obtain long-term synthetic series that preserve the extremal behaviour. This paper provides a characterization of the precipitation in the Coca river basin located in Ecuador by using RainSim V3, a robust and well tested stochastic rainfall model based on a spatial-temporal Neyman-Scott rectangular pulses process. A preliminary consistency analysis of the historical rainfall data available has been done in order to identify climatic regions with similar precipitation behavior patterns. Mean and maximum yearly and monthly fields of precipitation of high resolution spaced grids have been obtained through the use of interpolation techniques. According to the climatological similarity, long time series of daily temporal resolution of precipitation have been generated in order to evaluate the model skill in capturing the structure of daily observed precipitation. The results show a good performance of the model in reproducing very well the gross statistics, including the extreme values of rainfall at daily scale. The spatial pattern represented by the observed and simulated precipitation fields highlights the existence of two important regions characterized by different pluviometric comportment, with lower precipitation in the upper part of the basin and higher precipitation in the lower part of the basin.

1. Introduction

Flood design modelling in ungauged or poorly gauged basins requires long time series of discharge, based on the use of continuous rainfall-runoff models. However, this also involves the spatial and temporal characterization of local rainfall. Taking into account the lack of available information of precipitation, procedures for stochastic generation have been proposed (Cowpertwait, 1991), in order to reproduce the historical behaviour of the rainfall and to generate long time series that preserve the extremal behavior. Moreover, the influence of topographic configuration plays an important role in the pluviometry of a region, being necessary to identify homogeneous climatic regions.

2. Objectives

1. Characterize the regions with similar precipitation behavior patterns through the observed data analysis.
2. Generate long time series of daily precipitation (1000 years) by using a stochastic rainfall model.
3. Evaluate the capability of the model in reproducing the observed data and the extremal behavior.
4. Represent the spatial pattern of the observed and simulated rainfall series using interpolation techniques.

3. Methodology

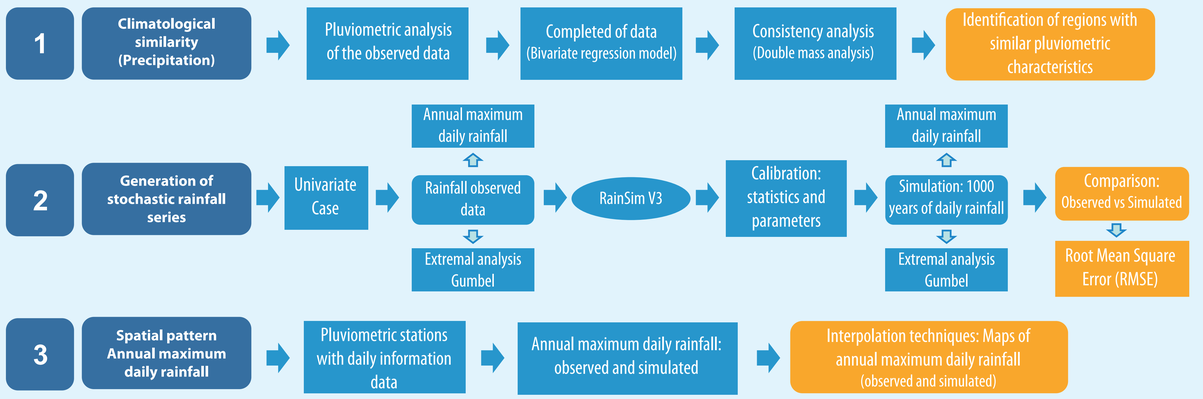


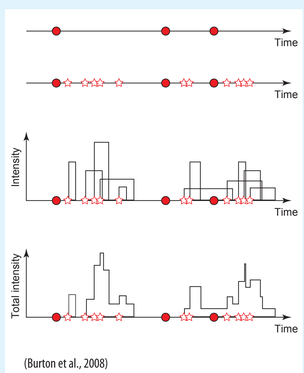
Figure 1. Methodological process

4. RainSim V3

Rainsim V3 uses the Neyman-Scott Rectangular Pulses (NSRP) model for the univariate case (Figure 2) and the Spatial Temporal Neyman-Scott Rectangular Pulses (STNSRP) model for the multivariate case.

The model operates in three modes of analysis:

1. Analysis: statistics at different aggregation level of time are obtained from the observed time series.
2. Calibration: a numerical optimization is used in order to identify a set of parameters of the model that match on average the observed statistics.
3. Simulation: long-term synthetic series of rainfall are generated based on the set of parameters.



(Burton et al., 2008)

Figure 2. Schematic representation of NSRP

PARAMETERS

λ^{-1} : Mean waiting time between adjacent storm origins (h)
β^{-1} : Mean waiting time for raincell origins after storm origin (h)
η^{-1} : Mean duration of raincell (h)
ν : Mean number of raincells per storm (-)
ξ-1: Mean intensity of raincell (mm/h)

5. Case of study

The study was conducted in the Coca river basin located at the northeast of Ecuador. **Figure 3** shows the Coca river basin location and the pluviometric information used in the study.

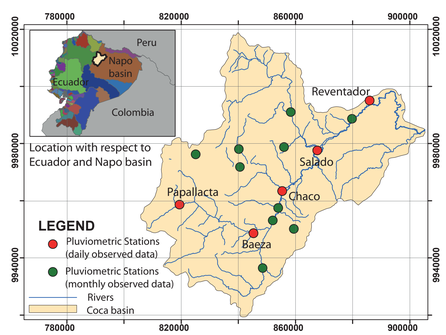


Figure 3. Coca basin

6. Results

Figure 4 shows the consistency analysis of the historical rainfall data. Three climatic regions with similar precipitation behavior pattern have been identified in accordance with elevation.

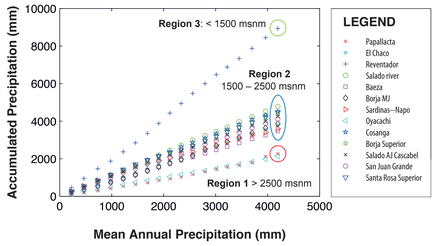


Figure 4. Tendency of precipitation

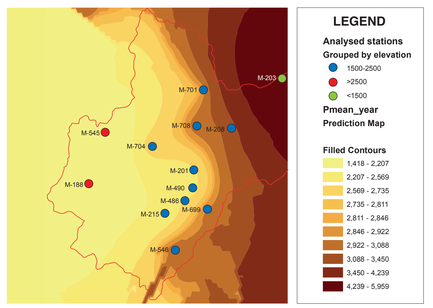


Figure 5. Observed mean annual rainfall in the Coca basin in accordance with the identified climatic regions

Statistics	Period (h)	Weight				
		Papallacta	Baeza	Chaco	Salado	Reventador
Mean	24	6	6	6	6	6
var	24	1	1	1	1	1
corr	48	6	6	6	6	6
pdry1.0	24	7	7	7	7.5	7.5
skew	24	3.5	2.5	3	3.5	2

Figure 6. Selected statistics and weights used for fitting the model

Figure 7 shows the distribution of the annual maximum daily rainfall on a Gumbel paper (univariate case). Results highlight a good performance of the model in reproducing the extreme values of rainfall at daily scale.

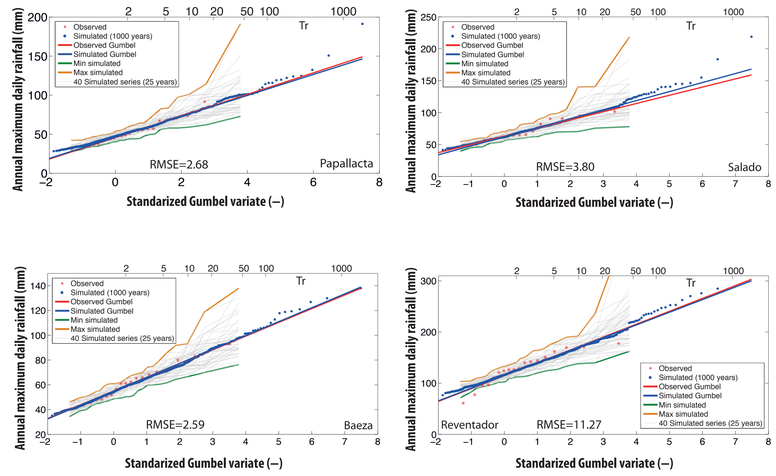


Figure 7. Comparison of observed and simulated annual maximum daily rainfall distribution in Papallacta, Salado, Baeza and Reventador stations.

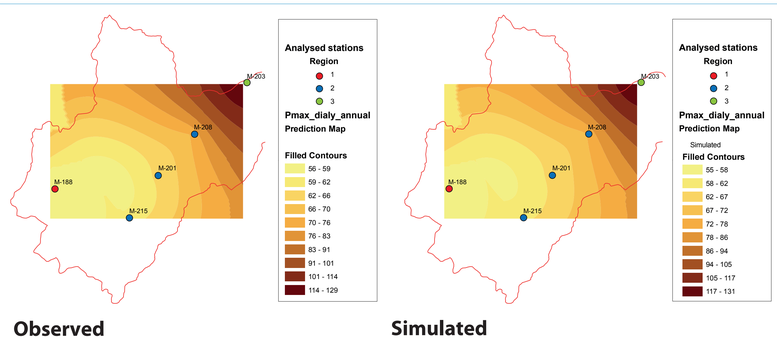


Figure 8. Spatial pattern of the observed and simulated annual maximum daily rainfall

7. Conclusions

1. Three homogeneous regions of precipitation have been identified in accordance with the influence of topographic configuration.
2. The stochastic rainfall model presents a good performance in reproducing the gross statistics and extreme values of rainfall at Papallacta, Baeza, Chaco, Salado and Reventador stations.
3. Observed and simulated spatial pattern of annual maximum daily rainfall highlight the existence of two different comportment, with higher precipitation in lower elevations and lower precipitation in higher elevations.

8. References

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Coperwait PSP, 1991. Further developments of the Neyman-Scott clustered point process for modelling rainfall, Water Resources Research, 27: 1431-1438.

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