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STUDY OF EXTREME EVENTS ON COLOMBIA USING A REGIONAL CLIMATE MODEL

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Abstract: In this contribution, an approach to the underlying regional climate dynamics from the regional climate model REMO on the Colombian Caribbean catchment are presented. The dynamics is examined in terms of annual cycle and spatial properties of extremes values distribution. A prior model validation is made by evaluating climatological values of the variables temperature and precipitation. The validation also considers the spatial distribution of statistics which are relevant to the extreme event analysis. For each grid cell data excesses are fitted to Generalized Pareto Distribution with the Maximum Likelihood method.

keywords: Climate dynamics, Regional Climate Model, REMO model, Colombia climate, extreme events.

1. INTRODUCTION

Colombia has a high vulnerability to climate changes by natural and anthropogenic factors. Therefore, it becomes necessary to study climate in order to scientifically validate the possible impact on different regions of the country, and to propose possible adaptation and mitigation initiatives. The study area includes the Colombian Caribbean catchment that covers the most colombian complex orography dominated by the Northern Andes Mountains and is the region with most economical development in the country. Previous efforts to characterize the climate on Colombia can be found in [1]As an improvement to current knoweledge about the present-days regional climate dynamics, we introduce the use of the MPI regional model REMO. This model has shown a significant improvement in the reproduction of the climate in South America compared to reanalysis data [2]. We take advantage of the potential of the Regional Climate Models (RCMs) to provide detail information on mean conditions and extrems. In this way, we obtain the extremal properties in REMO data set and find the optimal distribution function of outliers and the corresponding threshold.

2. DATA AND METHODOLOGY

The model data used correspond to the regional climate model REMO [3] over South America for the period 1960-2000 with boundary condtions from the ERA40 reanalysis and spatial resolution of $0.5° \times 0.5°$. The study is focused on the Colombian Caribbean catchment area (Fig. 1). The data analyzed are temperature and precipitation as relevant fields involved in the hydrological cycle and climatic change. For

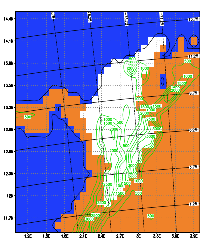

Figure 1 – Study area in white. REMO resolution is in the back, REMO orography in contour green. Real coordinates are show with emphasis in the study area and the reanalyses resolution.

comparison, we also analized the monthly mean fields from the ECMWF-ERA40 [4] and NCEP-NCAR [5] reanalyses, with spatial resolution of $2.5° \times 2.5°$. The observational data are from the annual cycle of temperature and precipitation on eighteen stations distributed uniformly in the region during 1982 to 1998, reported in [6]. The validation of REMO is made for the seasonal cycle of precipitation and temperature, which identifies the performance of model in reproducing regional climate characteristics. To address the study of extreme events, we adopted the methodology proposed by [7]. In this methodology, the peaks over time-varying threshold are used to make inference about extreme behavior in order to account for the seasonality of data and the long term trend, this also allows skip bias. The excesses set Z are fitting by the Maximum Likelihood method to the Generalized Pareto Distribution Function (GPDF): $Pr(Z \leq z) = 1 - (1 - \frac{\xi z}{\sigma})^{1/\xi}$, with shape parameter ξ and positive scale parameter σ. The spatial distribution of adjusted parameters of single grid-cell suggests regions within the study area with similar dynamic characteristics. This is used as a criterion to introduce a smooth spatial covariate model that additionally allows the introduction of the influence of phenomena such as El Niño-Southern Oscillation.

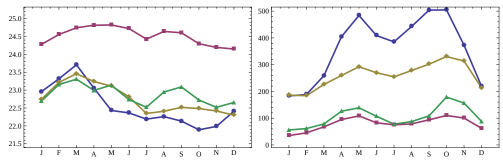

Figure 2 – Mean seasonal cycle for temperatura (left) and precipitation (right) from REMO (blue), ERA40 (fuchsia) and Observations (green), during 1982-1998.

Table 1 – Annual regional mean temperature T in °C and precipitation PP in mm/month computed from REMO, ERA40, NCEPNCAR (NN) and observations (OBS). Mean bias are presented in percentages with respect to the observations.

	REMO		ERA40		NN		OBS
	mean	bias	mean	bias	mean	bias	
T	22.5	2	24.5	7	22.7	1	22.8
PP	362.9	254	79.5	23	259.0	161	105.3

3. RESULTS

General annual features for region are entered in Table 1. The mean seasonal cycle for temperature and precipitation is showed in Figure 2. Roughly speaking, the model reproduces the constant annual trend of temperature with bias below 1°C (corresponding to 2%) with respect to observational values and on months november to april, REMO introduces a improvement about the annual cycle with respect to ERA40 data. For precipitation, although the model reproduces correctly the bimodal regime for the annual cycle shown in observational data, the regional rainfall is higher that the observations. The Figure 3 is an illustration of maps of spatial distribution of the GPDF parameters for temperature, similar maps are obtained for the precipitation. The scale parameter allows us to differentiate regions within the study area displaying different extremes dynamics since the spatial distribution is similar to median of excess and gives us information about the variability of extremes. The shape parameter is related with the thickness of distribution tail of the excess and the bound of distribution. Shape parameters below zero indicate that the excess distribution has an upper bound [7]. For the temperature, regions within the study area with higher scale parameter are found in the Andes section with more variability in contrast with northern lowlands with lower scale parameter and less variability. About the shape parameter, just the 0.69% of grid points are minor zero, as a consequence, the distributions of excess are bounded, the regional characteristic on study area is distributions of excess unbounded. About precipitation, similar regional characteristics are found but the percentage of grids points with upper bound distributions significantly increases regarding to the temperature case.

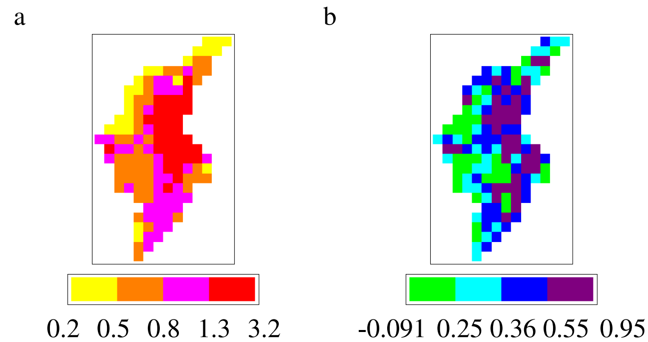

Figure 3 – Spatial distributions of GPDF parameters for REMO temperature (°C) during 1960-2000. Excess over 90^{th} quantile. a. Scale parameter, b. Shape parameter.

4. SUMMARY AND CONCLUSIONS

In spite of the improvement in regional climate, REMO large overestimates the precipitation probably due to a bad representation of the mean flow with the complex orography ([2]), nevertheless, it is more accurate describing the regional temperature. The extreme analysis, not only makes possible to classify areas within the region with different underlying dynamics but also to calculate return periods to anticipate climate change and ENSO. It is very important to carry out studies like present one to characterize the regional climate in this area, since the complex terrain is a determining factor in the evolution of the local climate.

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