Adaptation for tropical regions of a Statistical Downscaling technique

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Introduction

The knowledge of the evolution of the climate in next decades is essential for carrying out mitigation and adaptation policies to ensure the best optimization of the resources.

Nowadays the General Circulation Models (GCMs) are the only available tool for simulating future climate, and although they are able to accurately simulate the atmospheric circulation, for local simulations it is not enough. That’s why the statistical downscaling techniques try to adapt the output of these GCMs to the local level.

Working locally is vital as climate changes do not affect in the same way to each location, even if these are just a few miles away.

In the example of the figure we see how two stations only 30 km separated are expected to experience very different maximum temperature increases.

The objective of this project was to adapt a statistical downscaling methodology, with excellent results over the Iberian Peninsula, to the region of Nicaragua for the subsequent generation of future climate scenarios.

Data and study area

- The study was conducted on Nicaragua (lat 0-30° N; lon 101-109° W). It has been used data from 17 and 19 meteorological stations in Nicaraguan territory with temperature and precipitation data, respectively. These stations go through a prior study to ensure both the validity of the data and its length (2000 days with daily data), which are required for conducting a successful regionalization.

- The used reanalysis database is generated by the National Centre American Prediction (NCEP; http://www.esrl.noaa.gov). Spatial resolution: 2.5° x 2.5°; temporal: six-hourly; time period: 1951-2008.

- The General Circulation Models used are:
- ECHAMS (German). Spatial: 1.8° x 1.8°; temporal: daily data
- BCM2 (Norwegian). Spatial: 2.8° x 2.8°; temporal: daily data
- CNCM3 (French). Spatial: 2.79° x 2.79°; temporal: daily data

The control scenarios 20C3M and the emission scenarios A1B, A2 and B1 have been used for every model.

Methodology

The methodology of regionalization developed by the FIC is a regionalization technique based on statistical techniques that attempt to establish empirical relationships between fields of low-resolution variables (predictors) and high-resolution variables (predictands) on surface (temperature and precipitation).

The FIC method is an analog method in two steps.

- First step: for a “X” problem day, those “n-days” whose atmospheric configurations are more similar to the problem day are selected from a reanalysis database.

- Second step: to establish the relationships between predictors and predictands. This process works in different ways depending on the variable to be simulated. For temperature it is set to a multiple linear regression between potential predictors and predictands (e, those fields that can influence the temperature) to the “n-days” selected in step 1. The regression obtained is applied to the “X” problem day to get the value of the predictand.

For precipitation, it is made a weighted average of the values of the predictands associated to the atmospheric configurations of the “n-days” selected in step 1.

Selection of Predictors

The choice of appropriate predictors in the study area adds value to the performance of the used methodology.

In studies on the Iberian Peninsula it has been found that the best predictors are the geopotential fields at levels of 500, 850 and 1000 hPa. These fields are not necessarily the best for Nicaragua. This study has shown that for Nicaragua the fields that show the better results are the zonal and the meridional wind at the levels of 1000, 700 and 200 hPa.

Based on the above idea, the FIC methodology has used wind fields in the step 1 where the analogue days are selected. In the second step of the methodology for temperature, not only have been used as potential predictors the thicknesses between levels of Z500-Z850 and Z500-Z1000 (as it was done for the Iberian Peninsula) but also introduced as a potential predictor the relative humidity at 850 hPa.

There is an improvement when the wind fields are used as predictors, especially in the case of precipitation.

Verification of the Methodology

The verification process is used to study the ability of the methodology to simulate the climate locally. This process involves the comparison from the results to regionalize the data of the NCEP reanalysis against the observations from the own Nicaraguan stations.

The obtained results are quite good for temperature and precipitation. In both cases they reflect the variability of the variable in a very satisfactory way. In the case of precipitation is observed how the methodology is able to show the differences between the dry and wet tropical seasons. In addition, the results show how the method simulates the Canclini (midsummer drought) in a good way. The maximum temperature peak during the month of April is well reflected by the methodology.

Future climate scenarios

Once the methodology has been successfully validated and verified, future climate scenarios are generated using the outputs provided by different GCMs. In this study we have worked with three models (ECHAMS, CNCM3 and BCM2) and three future climate scenarios (A1B, A2 and B1). As an example of these studies, the results obtained for the model ECHAMS and the A1B emission scenario (considered as the intermediate stage) are shown.

Conclusions

- The adaptation of the methodology for each study area by choosing the most appropriate predictors is a key point for obtaining the best results. The use of wind fields instead of the geopotential fields can capture not only the synoptic situation affecting Nicaragua but also the phenomena that lead to forced convection.

- The results of verification and validation for Nicaragua are quite robust. These results are better for temperature than for precipitation so the results obtained for the latter variable should be treated with caution.

- The quality of the verification results obtained with the FIC methodology in the study region allow to state that this methodology can be used in both tropical and middle latitudes.

References


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