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Comparison of different climate change scenario effects in rainfall pattern in the city of Lima.

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Project description

LiWa project, „Sustainable Water and Wasterwater Management in Urban Growth Centres Coping with Climate Change – Conceps for Lima Metropolitana (Perú)-„ is a megacity project which involves several disciplines. Among them, are economy, hydrologie, wastewater and education, and also some institutions and universities in Germany as well as in Perú, like the universities of Stuttgart, Leipzig, Ostfalia, and Universidad Nacional de Ingenieria. Concerning university of Stuttgart, one of the tasks, among others, is to perform an hydrological modelling considering climate change. Modelling groundwater and hydropower sistems which are directly related with Lima are also involved.

Water distribution

Rainfall distribution plays a very important role in Lima and the catchments connected to the city. Lima is located at the coast, and the main catchment, Rimac, extend from the city to the top of the Andes, covering a distance of approximately 150 km and a high different of approximately 5000 m. The distribution of the precipitation in this whole area is very inhomogeneous, varying form a few millimetres per year at the coast to round 900 millimetres per year on the Andes. In figure 3, a comparison between this two regions can be seen.

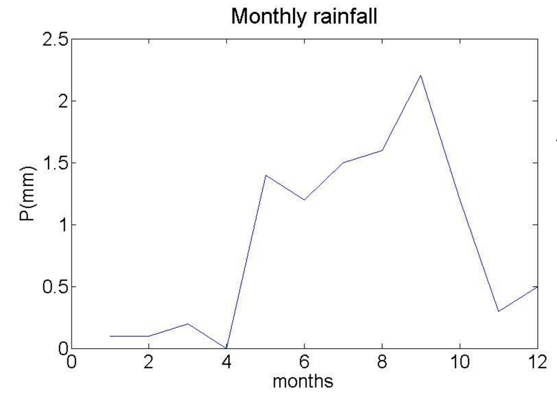


Fig 1a: Rainfall in Lima

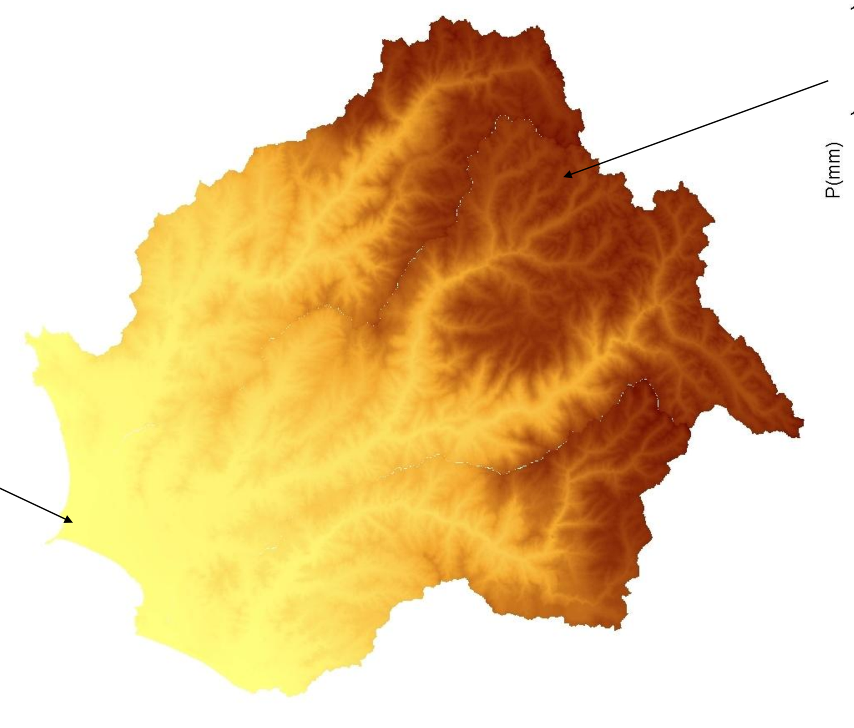


Fig 1b: 3 main catchments

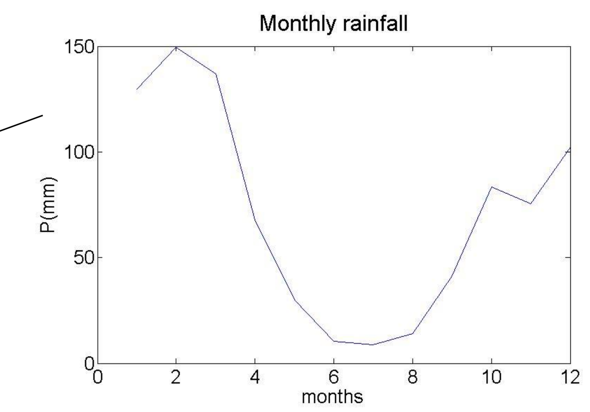


Fig 1c: Rainfall in the upper part of the andes

Interpolation

Daily rainfall data are available in 22 points (stations) distributed in the 3 main catchments (fig.1b). Interpolation was performed considering a spatial resolution of 1x1 km, and the interpolation method used was External drift kriging (EDK). To this respect, EDK was applied to the available digital elevation model (DEM) on the one hand, and on the other hand to the smoothed DEM. The time scale considered is 1day. Despite the observed rainfall pattern (Fig.1) and the extension of the area, Ordinary Kriging (OK) was also applied in order to see the effect of the non fulfillment of the basic assumptions of the method on the interpolation. Comparison of the three cases are shown in figure 2 which shows the monthly rainfall (multiplied by 10) of january 1991. Fig 2a represent EDK with original data. Fig 2b represent EDK with smoothed data and fig 2c represent OK.

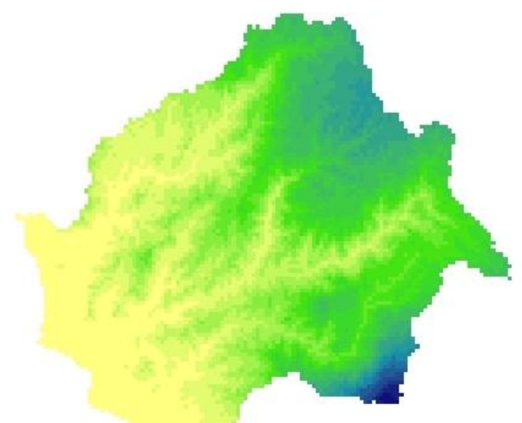


Fig 2a: EDK with original data

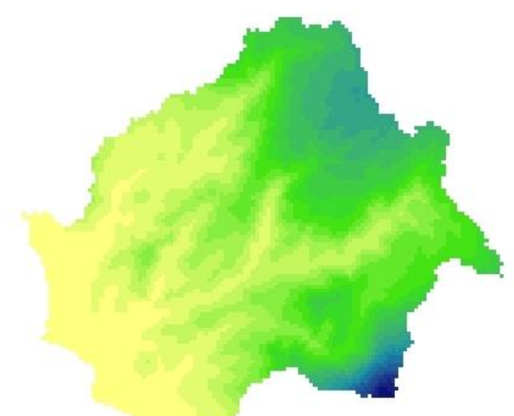


Fig 2b: EDK with smoothed data

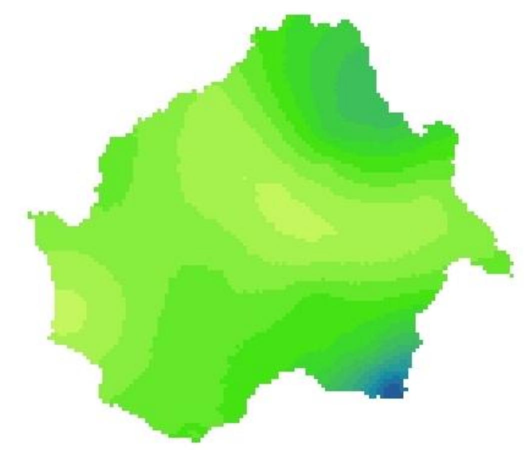
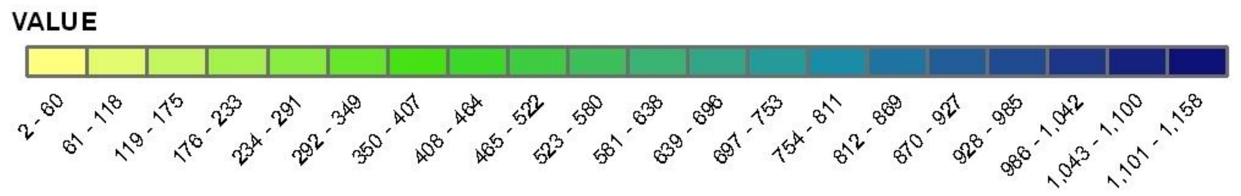


Fig 2c: Ordinary Kriging



Future Assesment

From a pure deterministic point of view, the rainfall seems to behave as an strange attractor. This means, that in general the error in the assesment of one variable (for instance rainfall) with this behaviour can grow in an exponential manner. From a pure stochastic point of view, it is not possible to predict with certainty the future behaviour of the variable. This fact obliges us to look for an alternative way to express the development of our variable of interest, by means of the definition of diferent scenarios and analysis of diferent deterministic models. In this context, different Global Climate Models (GCM) results were analyzed, considering different scenarios.

Three catchments, Chillón, Rimac and Lurín are directly connected to the city of Lima. The total area of these three catchments is approximately 7250 km2, much smaller than the resolution of the GCM's. To transform one spatial scale into another (GCM resolution into catchment resolution), downscaling approach was performed. The first method adopted was Quantile-Quantile downscaling, which is based on the cumulative distribution functions of the control period and the observed data. In this manner, a density function was fit to the time series. If S is the set of selected points (GCM outcomes), for each Xs in S the pars (*Xs,Pcntl(Xs)*) and (*Xf,Pobs(Xf)*) are searched, so that

$$Pcntl(Xs) = Pobs(Xf)$$

where

Pcntl(x): cumulative distribution function of the control period

Pobs(x): cumulative distribution function of the observed data.

Xf: the assessed future value.

For the case of precipitation, a parametric approach was considered and the Weibull distribution was fitted (Eq. 1). In the case of temperature, both parametric and non parametric approaches were analyzed. For the non parametric approach, the density function (Eq. 2) was calculated by means of the Gauss kernel function (Eq. 3):

$$f(x;\lambda,k) = \frac{k}{\lambda}\left(\frac{x}{\lambda}\right)^{k-1} e^{-(x/\lambda)^{k}} \qquad \text{(Eq. 1)}$$

$$f(x) = \frac{1}{n}\sum_{i=1}^{n} K(x - x_i) \qquad \text{(Eq. 2)}$$

$$K_G(x) = \frac{1}{\sqrt{2\pi d}} e^{-\frac{x^2}{2d^2}} \qquad \text{(Eq. 3)}$$

With *λ* scale parameter and *k* shape parameter (Eq.1).

Downscaling results for the models Echam5 and Hadley and for the scenarios A2, A1B and B1 can be seen in figure 4. The variables analyzed is rainfall. The period conidered is 2011-2050

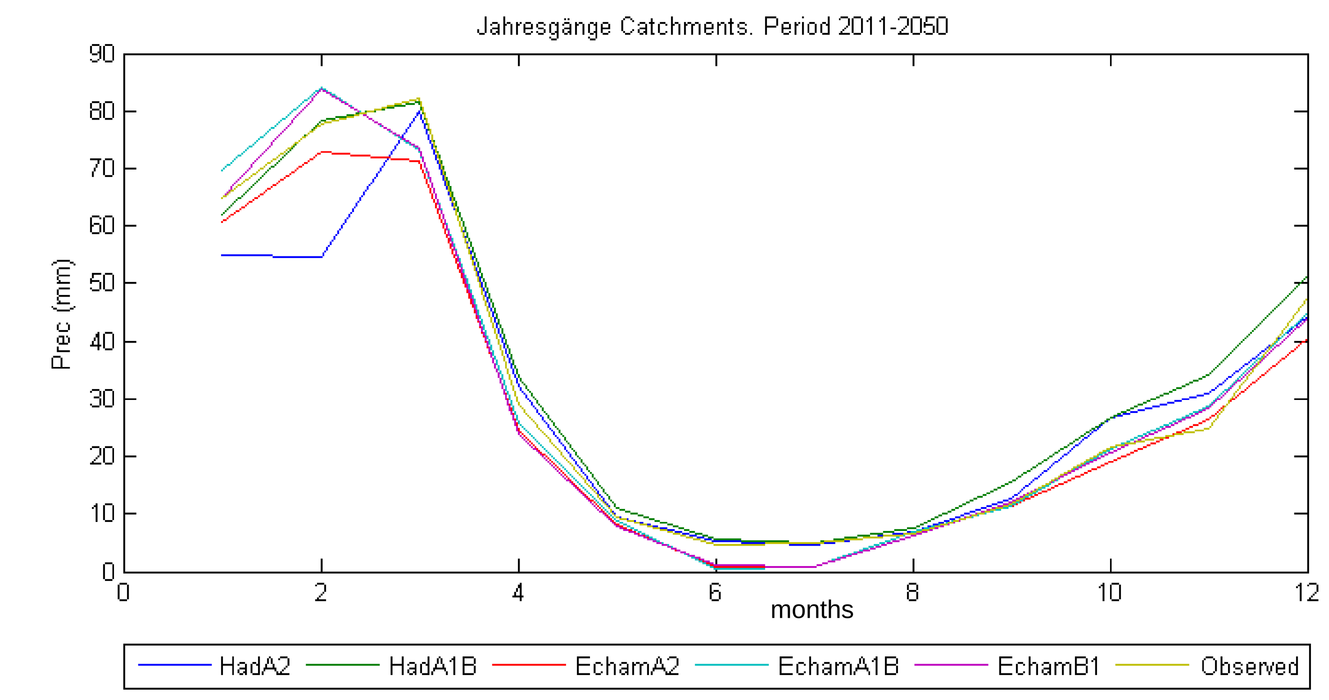


Figure 4: Downscaling results. Annual cycle for the three catchments (fig.1b)

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