Water Distribution and Climate change issues

Alejandro Chamorro, Msc.
University of Stuttgart, Germany
IWS

Institut für Wasserbau
Lehrstuhl für Hydrologie und Geohydrologie
Prof. Dr. rer. nat. Dr.-Ing. András Bárdossy
Pfaffenwaldring 61, 70569 Stuttgart, Deutschland

- **Liwa Project: Sustainable Water and Wastewater Management in Urban Growth Centres Coping with CLimate Change - Conceps for Lima Metropolitana (Perú)- Liwa**

- **Main task (IWS):**
  - **Simulation of the water and energy resources under changing climate**

- **General tasks:**
  - **Interpolation methods**
  - **Downscaling methods**

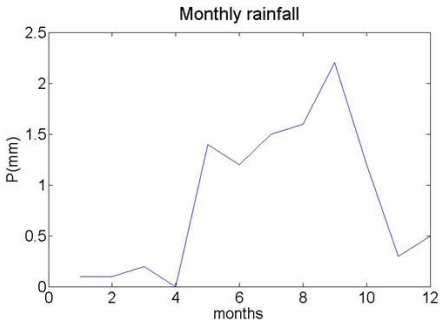


Fig 1a: Rainfall in Lima

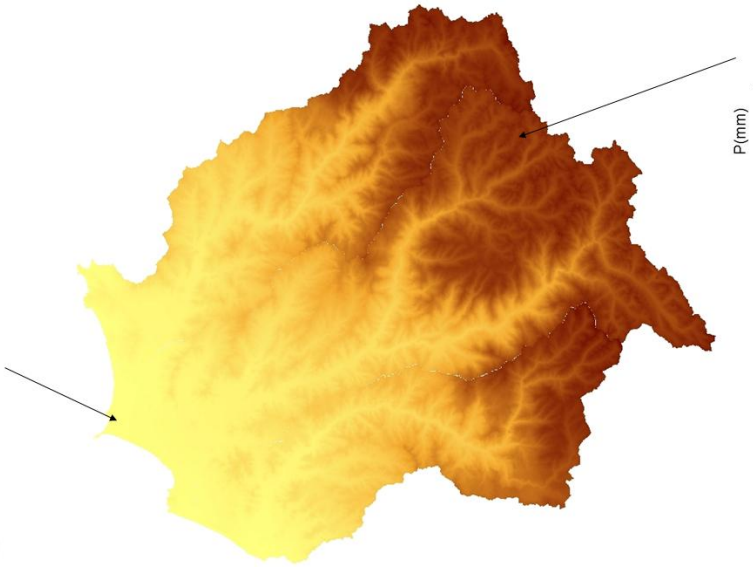


Fig 1b: 3 main catchments

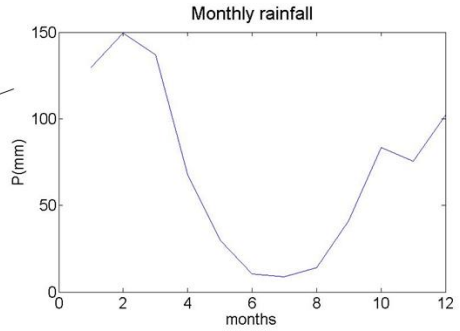
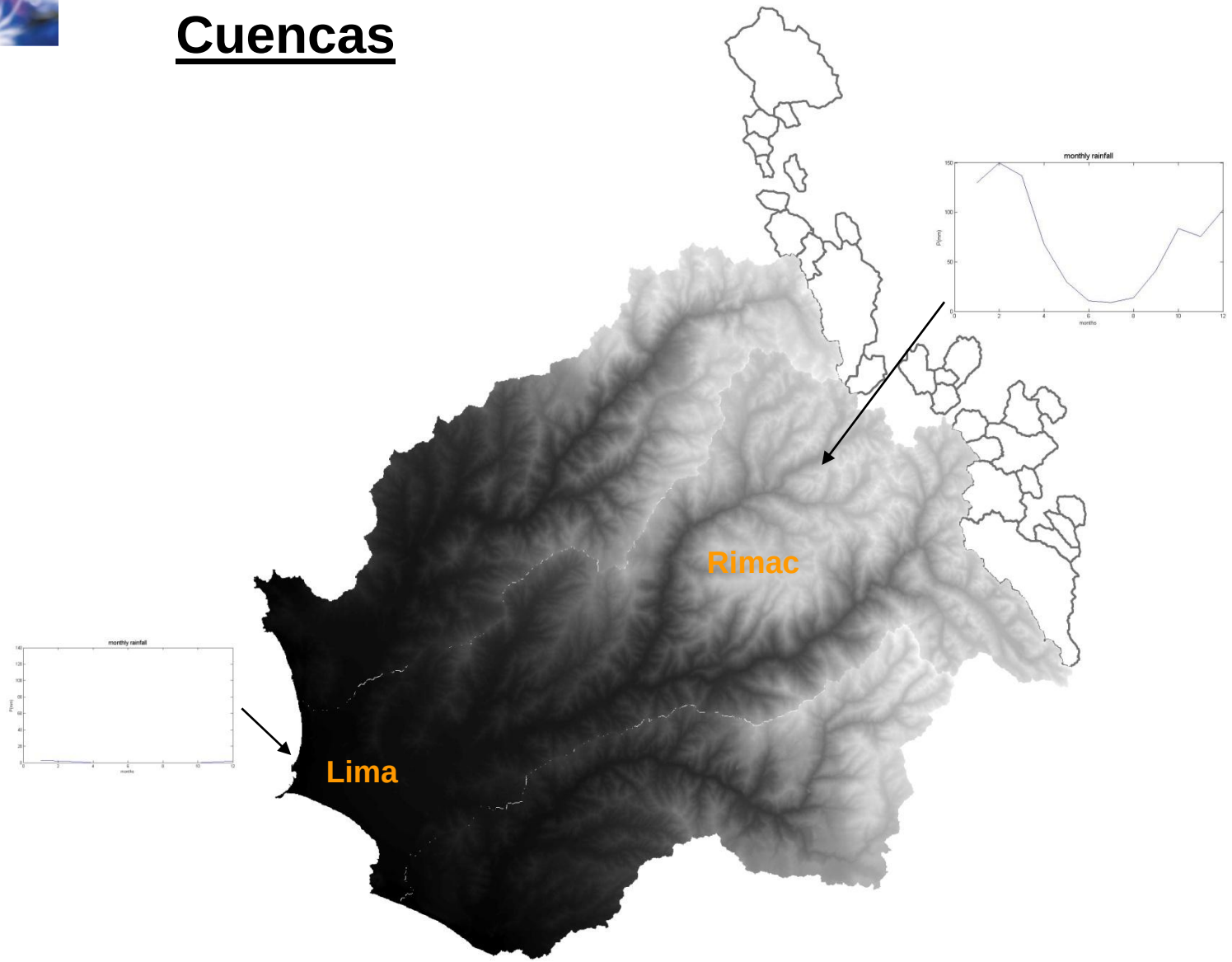


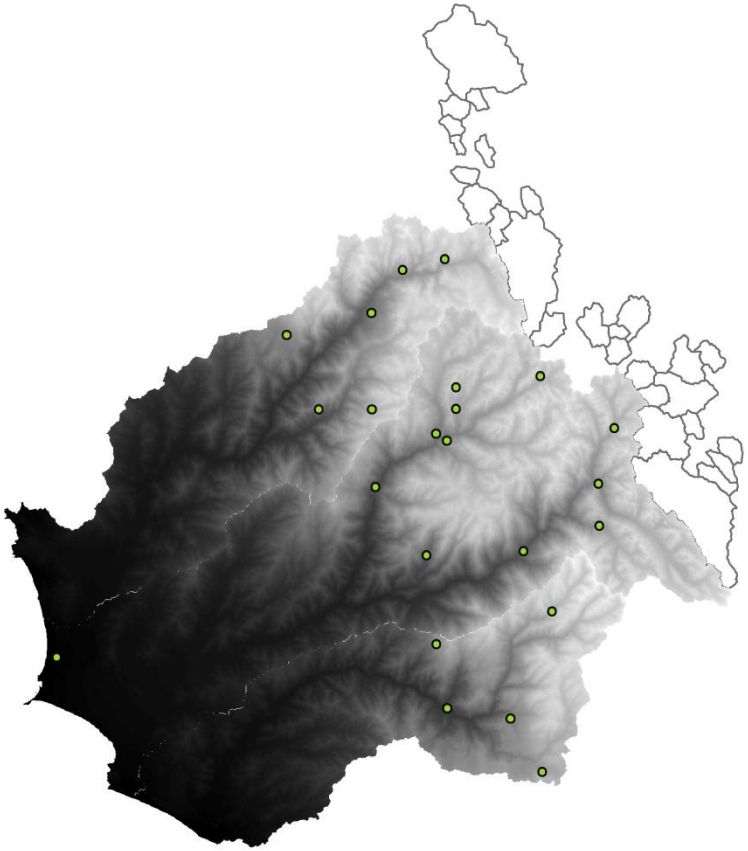
Fig 1c: Rainfall in the upper part of the andes

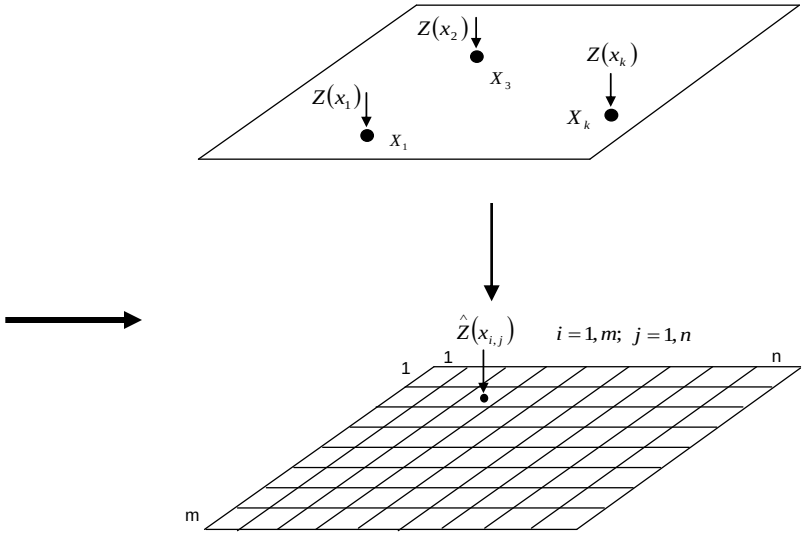
Fig 1: Comparacion de los patrones de Pp

Cuencas


monthly rainfall
months
monthly rainfall
months
Rimac
Lima

Estaciones





Interpolation

- **Kriging-Method**
  - i. Estimation error has zero mean
  - ii. The variance of the estimation error is minimum

- **i.**

$$e = \hat{Z}(x_0) - Z(x_0)$$

$$\hat{Z}(x_0) = \sum_{i=1}^{n} \lambda_i Z(x_i)$$

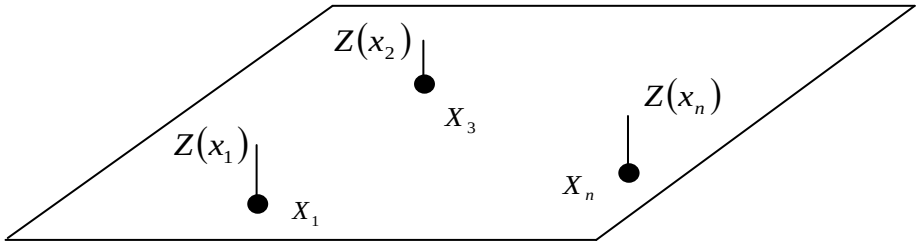


Abbildung 2: 2-d Schema

$$E\left(\hat{Z}(x_0) - Z(x_0)\right) = 0 \Rightarrow \sum_{i=1}^{n} \lambda_i = 1$$

- **ii.-**

$$Var\left(\overbrace{\hat{Z}(x_0) - Z(x_0)}^{e}\right) \rightarrow \min$$

$$Var\left(\hat{Z}(x_0) - Z(x_0)\right) = \sigma^2 + \sum_i \sum_j \lambda_i \lambda_j C_{ij} - 2\sum_i \lambda_i C_{i0}$$

Mit $C_{ij} : Cov\left(Z(x_i), Z(x_j)\right)$

$\min(Var) \Rightarrow Kriging\ \ System$

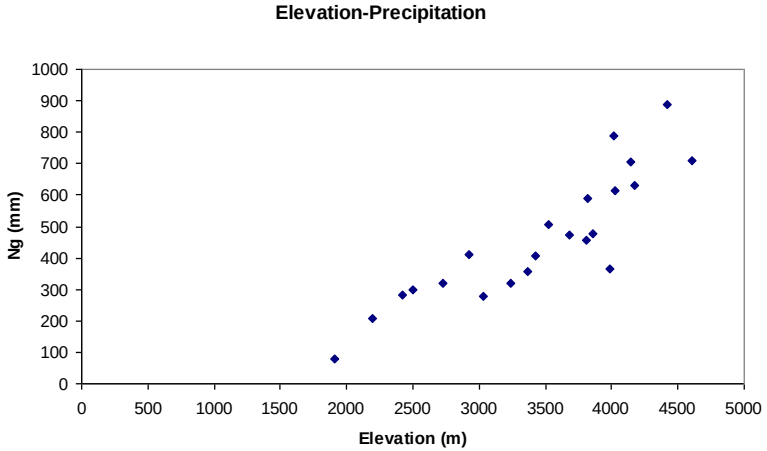
K-S

$$\begin{cases} \sum_{j=1}^{n} \lambda_j C_{ij} + \mu = C_{i0} & \forall\ i = 1,\ldots,n \\ \sum_{i=1}^{n} \lambda_i = 1 \end{cases}$$

Aditional knowledge:

$$E[Z(u)/Y(u)] = a + bY(u)$$

- **Ordinary kriging**
- **Drift kriging**
  - **Time period: 40 years**
  - **Elevation as a drift**
  - **Monthly rainfall as a drift**
  - **Smoothed data**



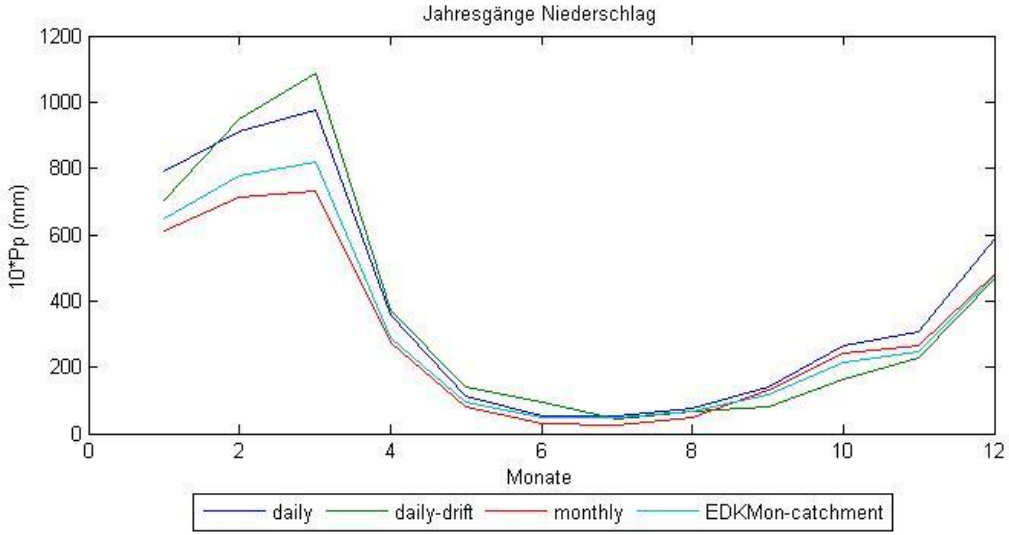
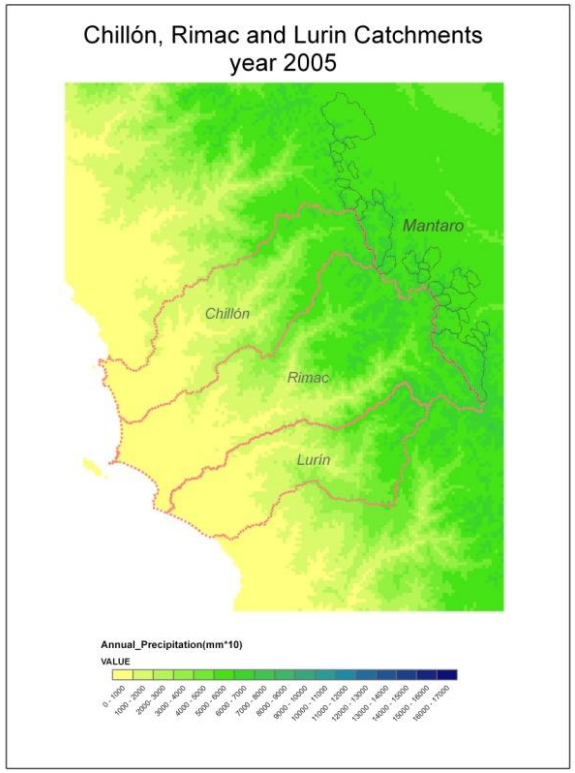


Fig 2: monthly average rainfall

Precipitacion anual regionalizada. Anos 2005-2006



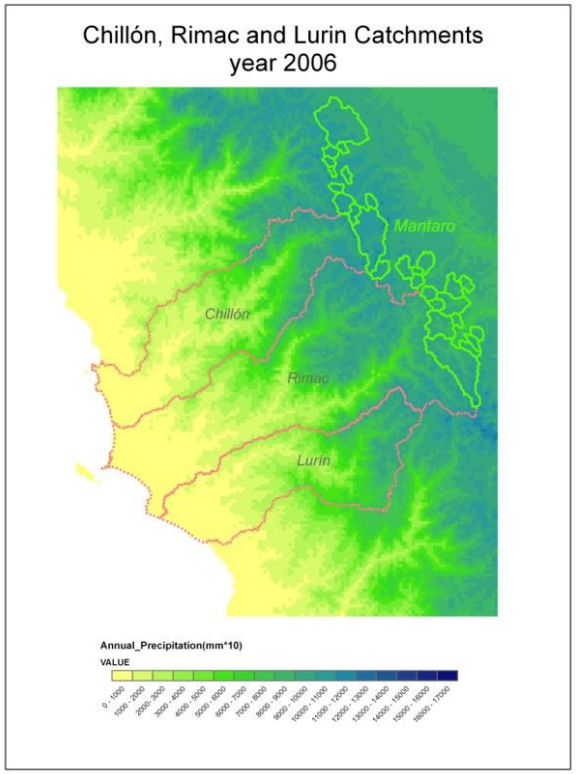


Fig 3: Cartas de precipitacion

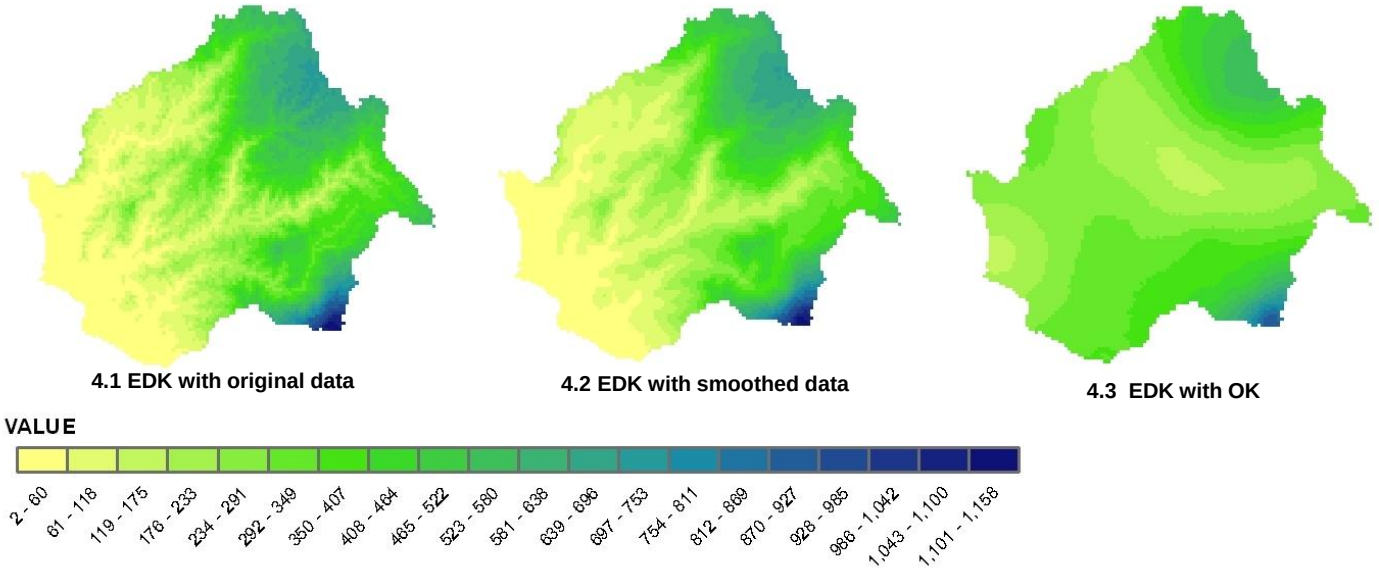


Fig 4: *comparacion de la interpolacion entre diferentes metodos*

Distribucion de la precipitacion en las 3 cuencas principales (Chillón, Rimac, Lurín) y subcuencas en Mantaro

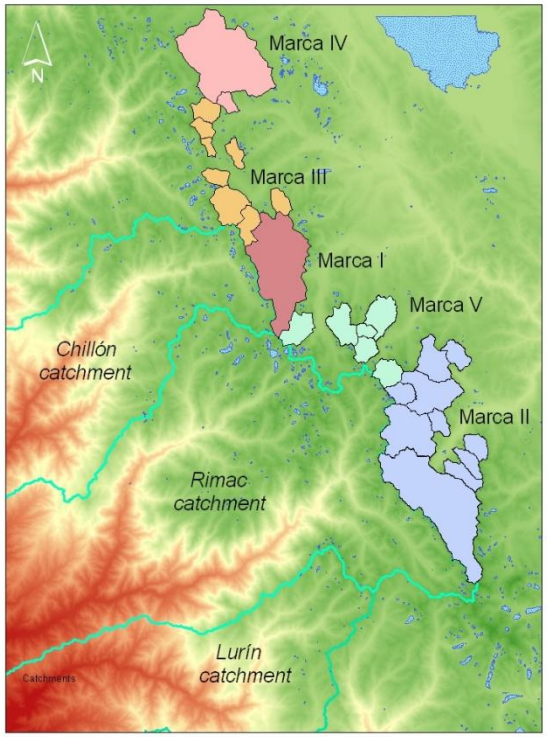


Figura 4: Cuencas y subcuencas

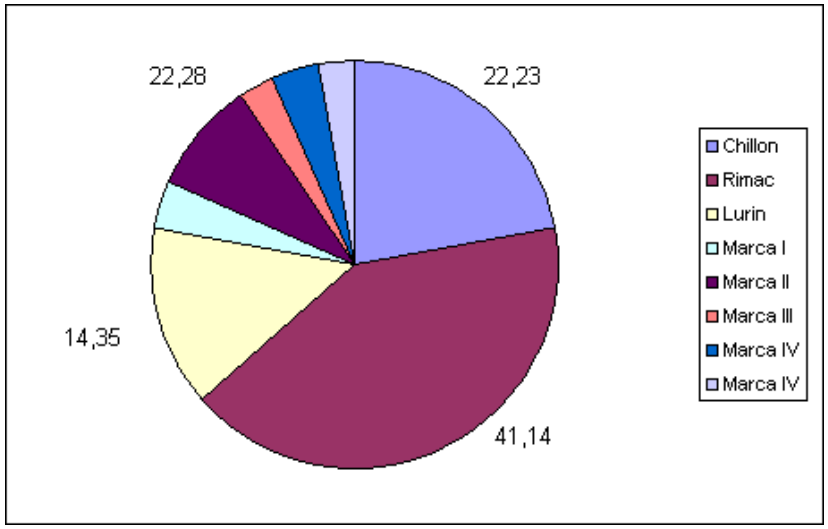


Figura 5: Distribucion de la precipitacion

- **Definicion de las cuencas**

Station	Höhe
Sheque	3150
Tamboraque	3000
Surco	1812
Chosica	850

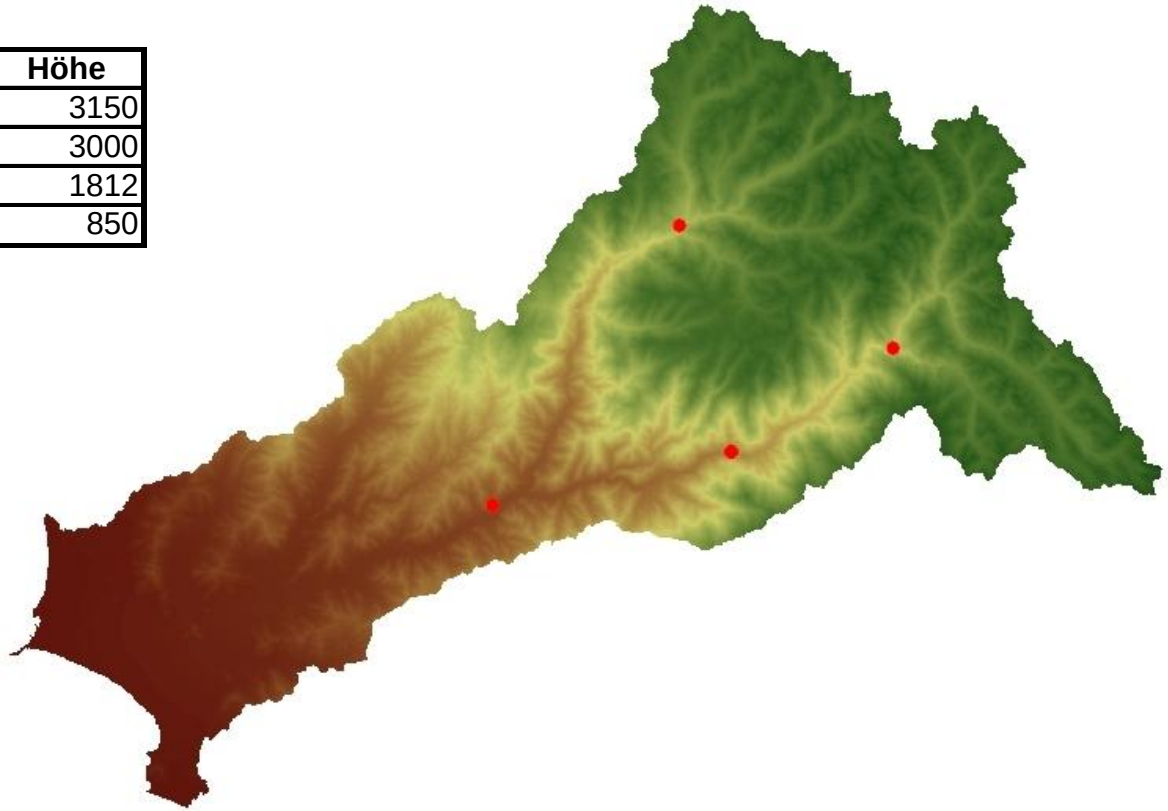


Fig 4:

Puntos de balance

- **Subcuencas**

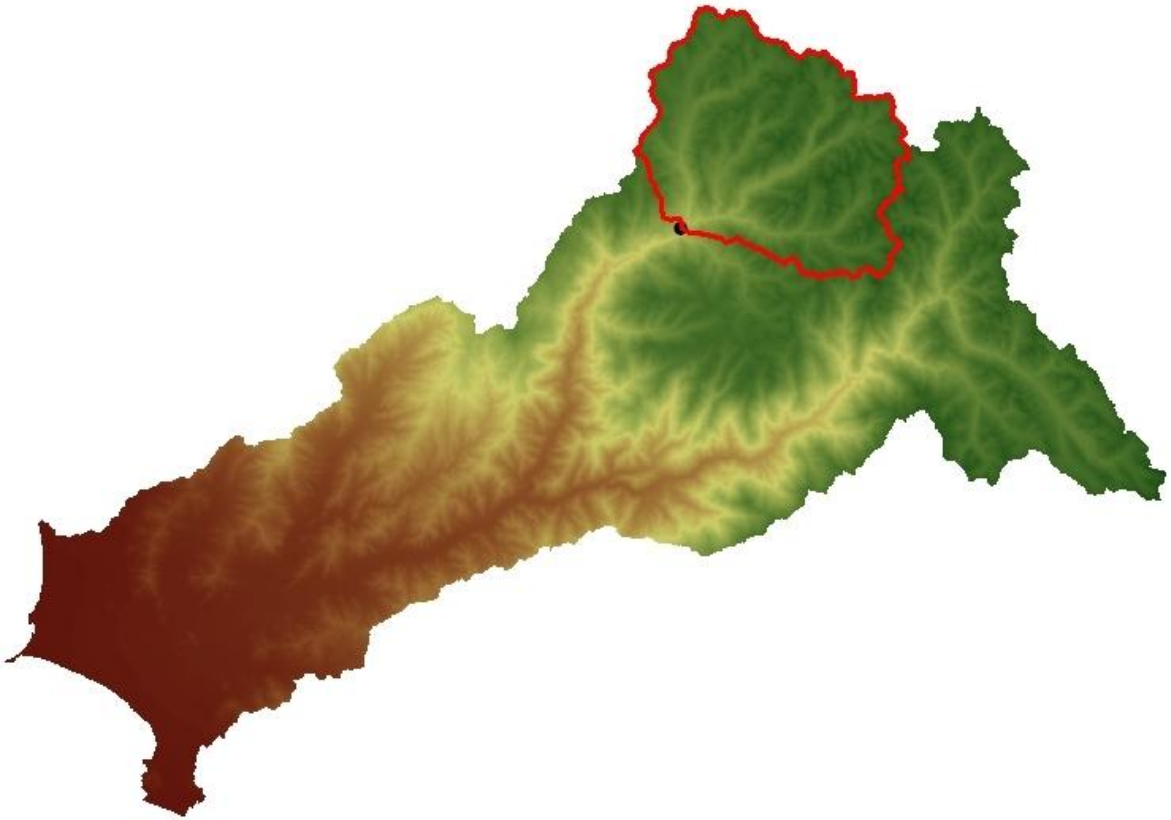


Fig. 5.1: Sheque

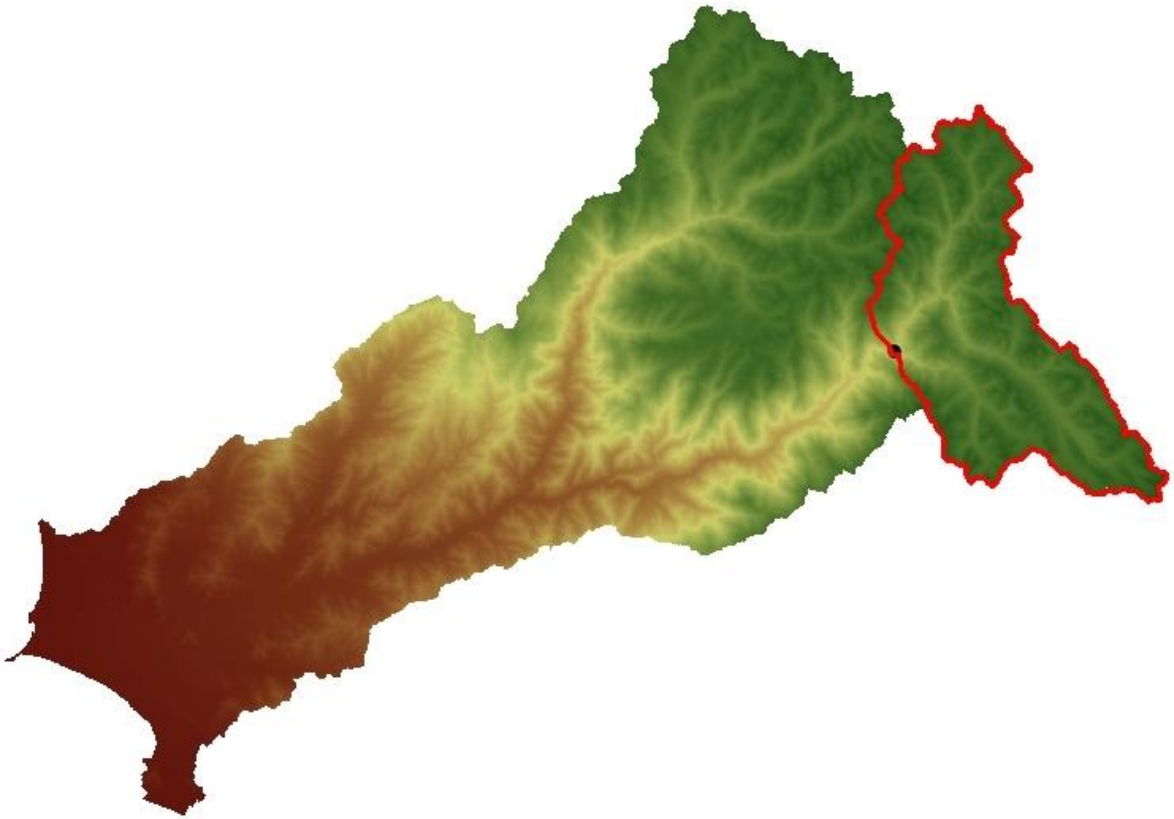


Fig. 5.2: Tamboraque

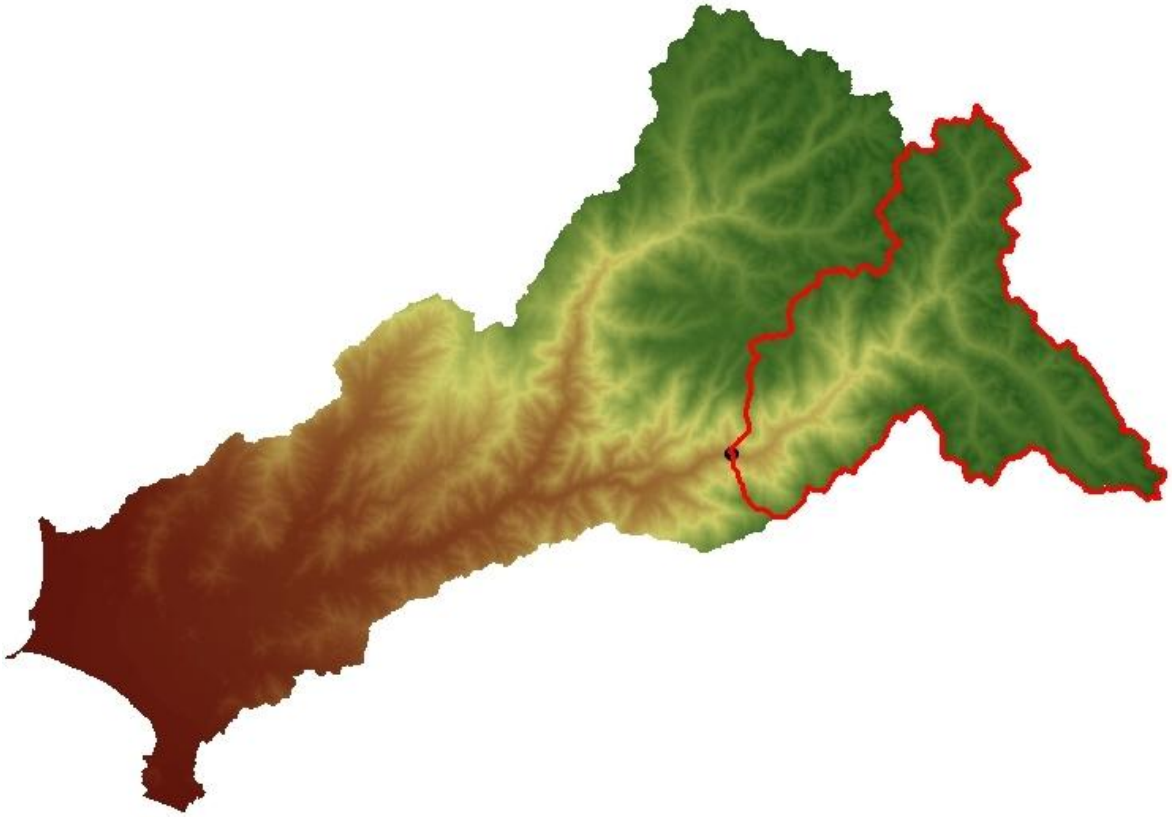


Fig. 5.3: Surco

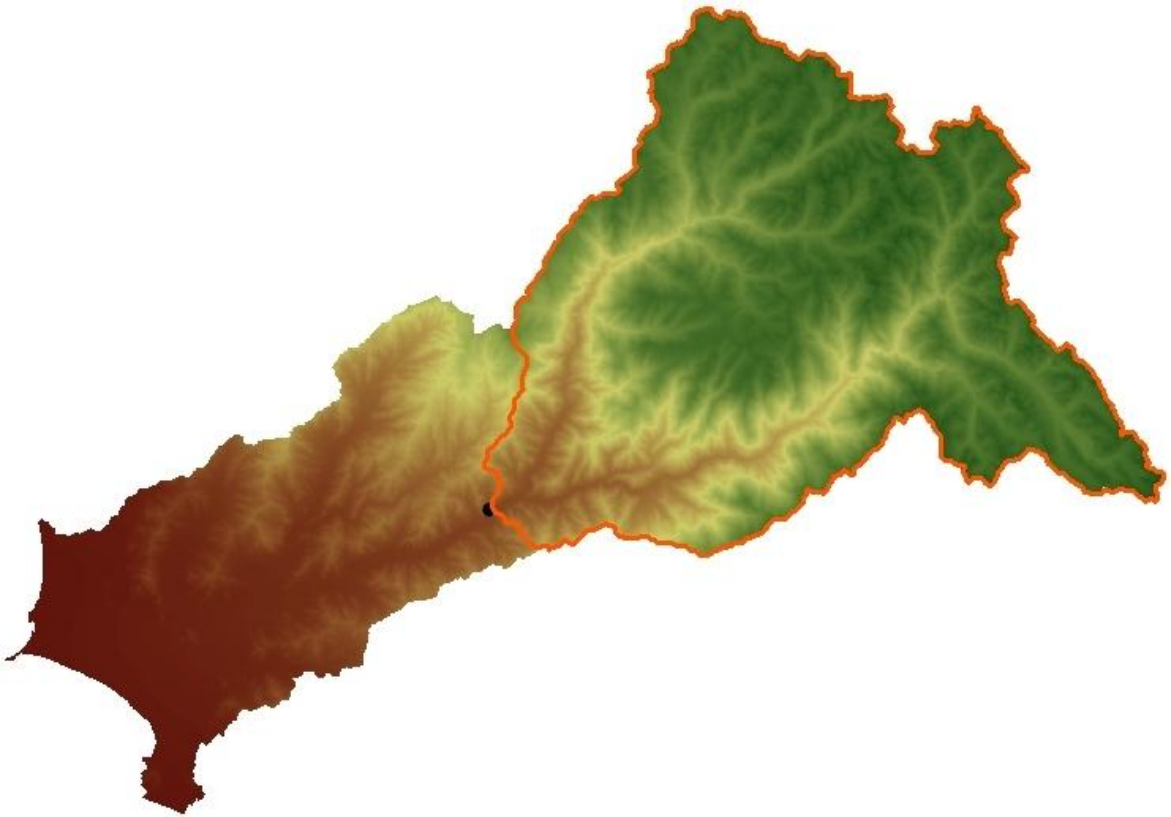


Fig. 5.4: Chosica

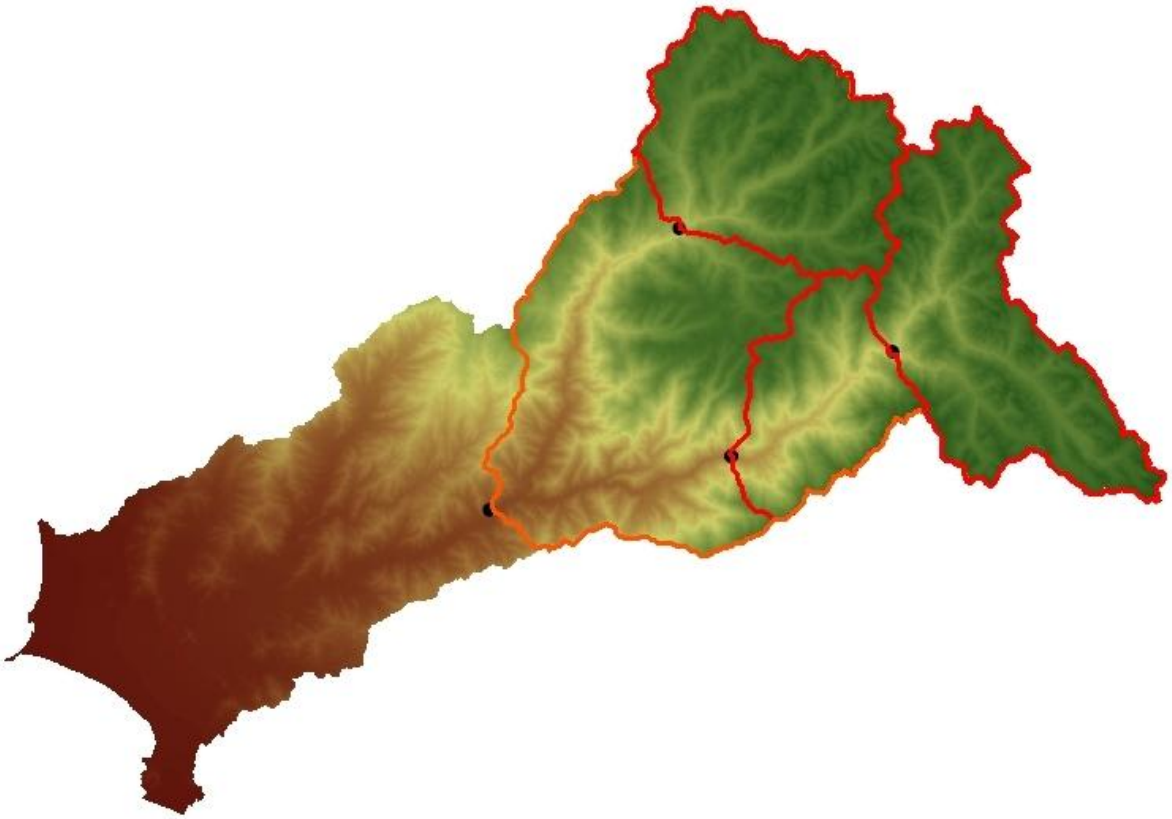


Fig. 5.5: Subcuencas

Pronostico futuro: Downscaling

- **Monthly GCM precipitation distributions**
  - Control time period
  - Scenario runs 2010-2050
- **Interpolated sub catchment precipitation and temperature**
- **Diferent scenarios**

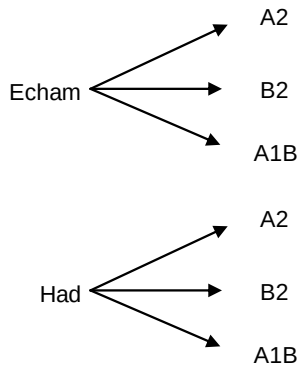
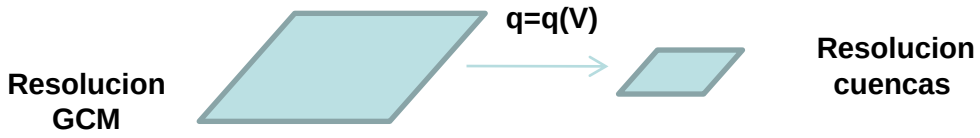


***Fig5*: models and scenarios**

Downscaling



Downscaling

Diferentes metodos
Transformacion Quantile-Quantile
- Ajuste de distribution para precipitacion y temperatura:
  Parametrico y no parametrico

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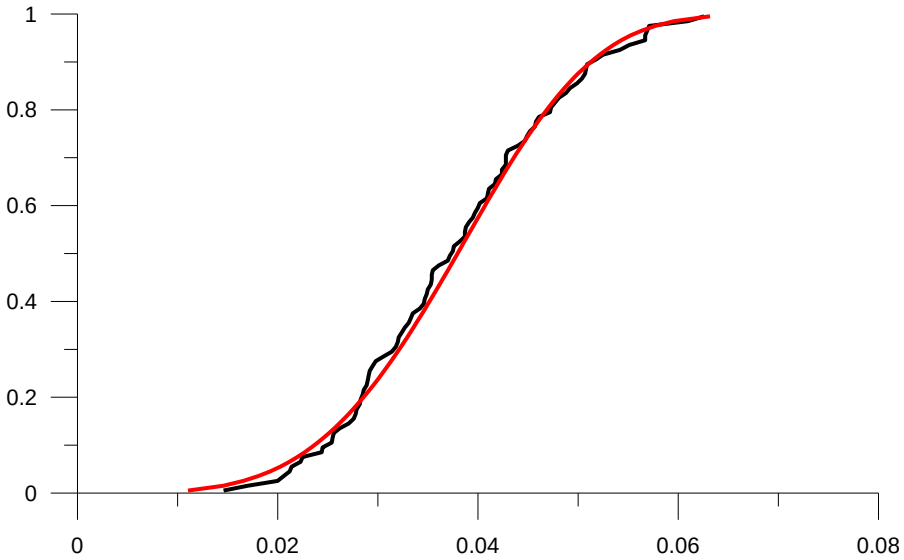


Ajuste (October)

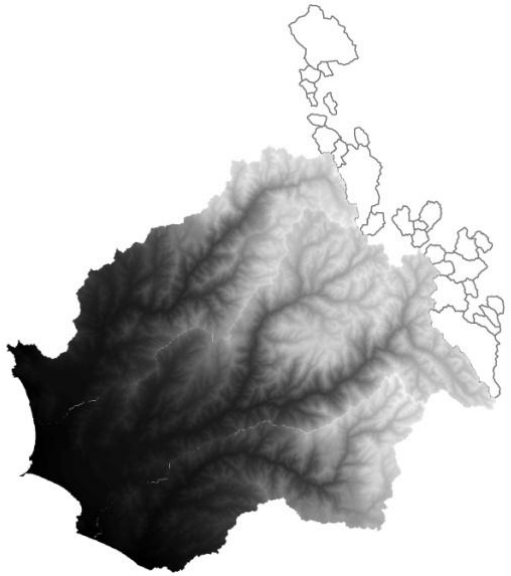
Used distributions

- **Precipitation: Weibull fit for each month**
  - **GCM control run**
  - **Interpolated areal precipitation**
- **12 weibull fit using maximum Likelihood**

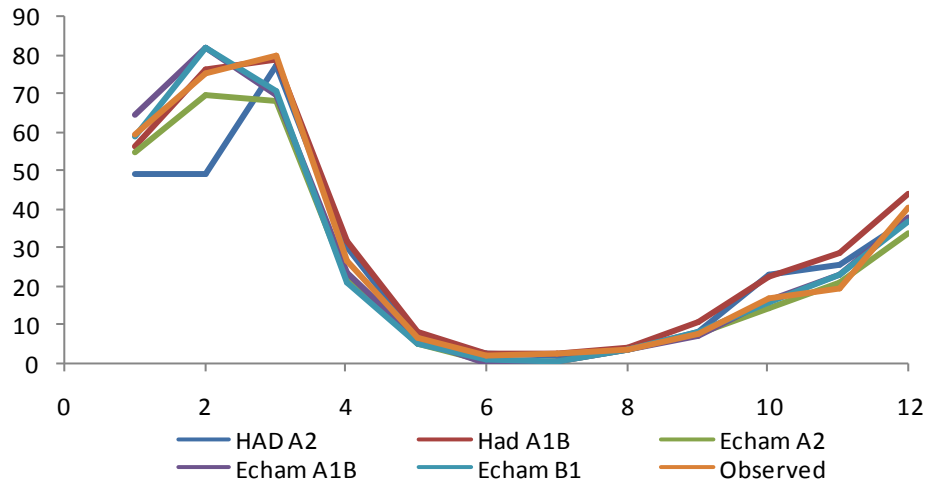
- **Temperature: Parametric and non parametric aproach**
  - **Normal distribution**
  - **Kernel function**

$$f_h(x) = \frac{1}{n}\sum_{i=1}^{n} K_h(x - x_i)$$

$$K_h(x) = \frac{1}{\sqrt{2\pi}h} e^{-\frac{x^2}{2h^2}}$$



Chillon



Rimac

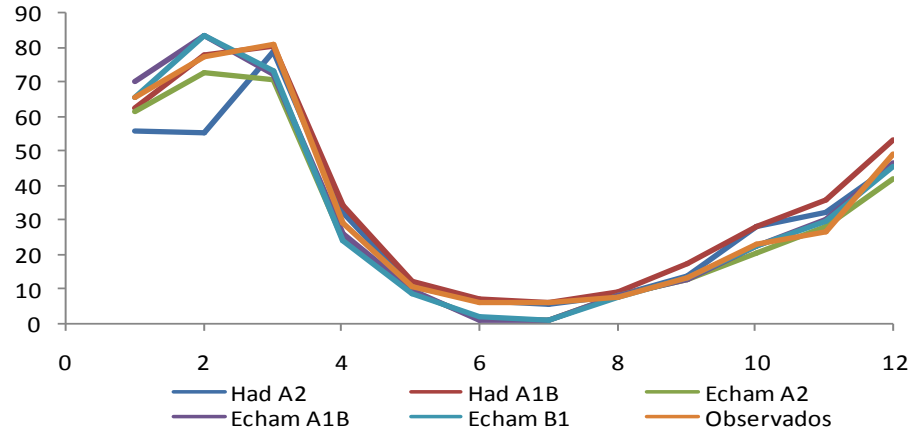
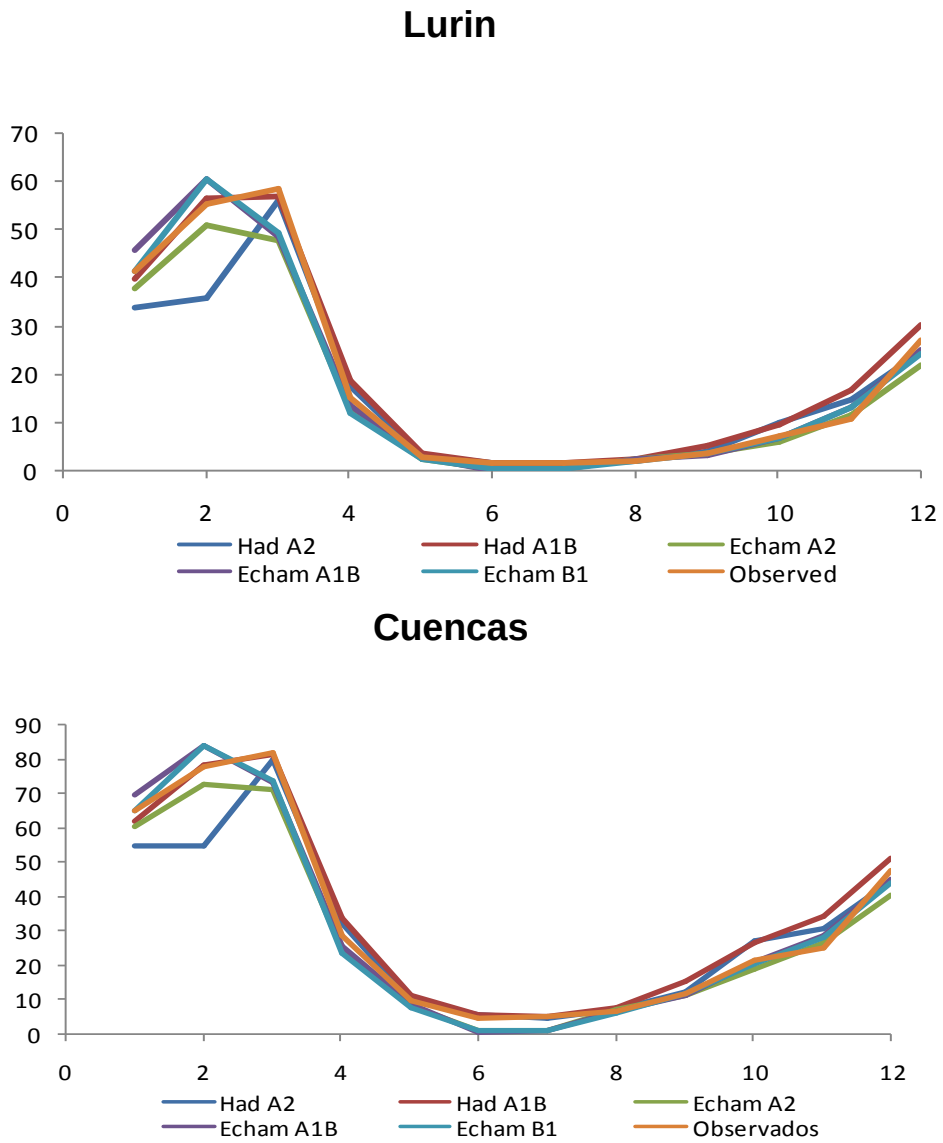


Fig 8: Resultados Downscaling. Promedio mensual de precipitacion



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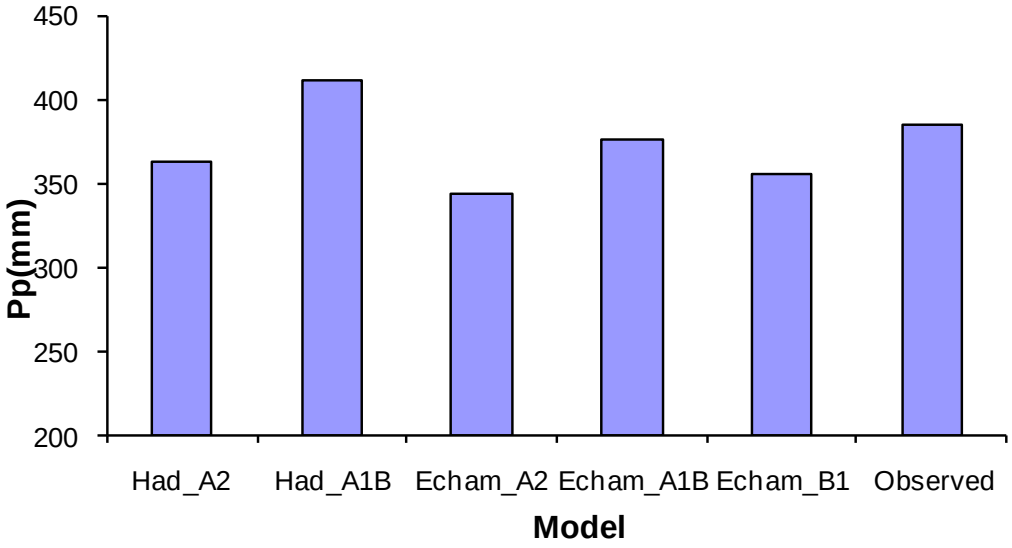

Cuencas principales. Promedio anual de precipitacion

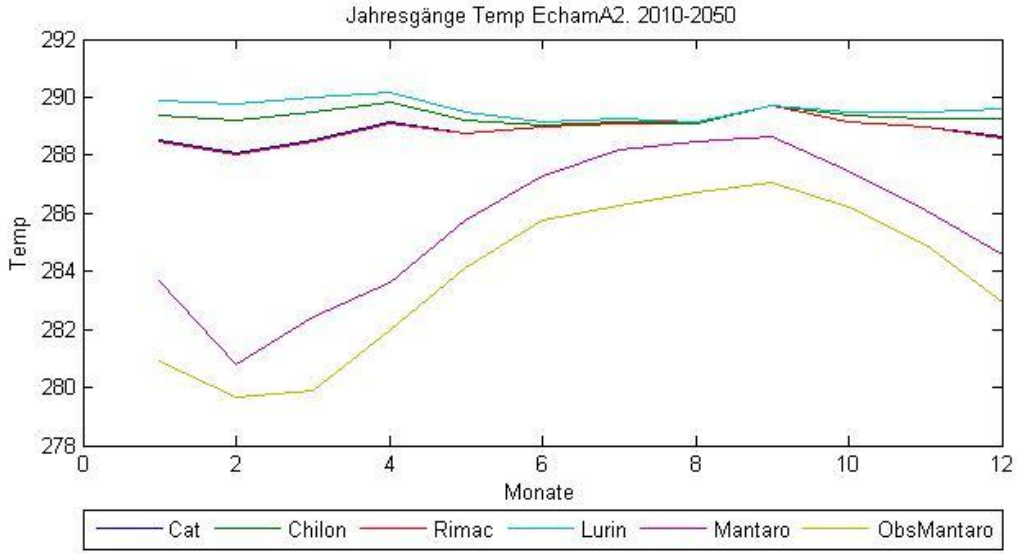

Fig 7: Resultado Downscaling para Echam A2, periodo 2010-2050

Trabajo actual

- Analisis de diferentes metodos de interpolacion

- downscaling basedo en patrones de circulacion y fuzzy rule systems.

- Modelamiento Hidrologico.

Gracias