Flow Forecasting in large basins

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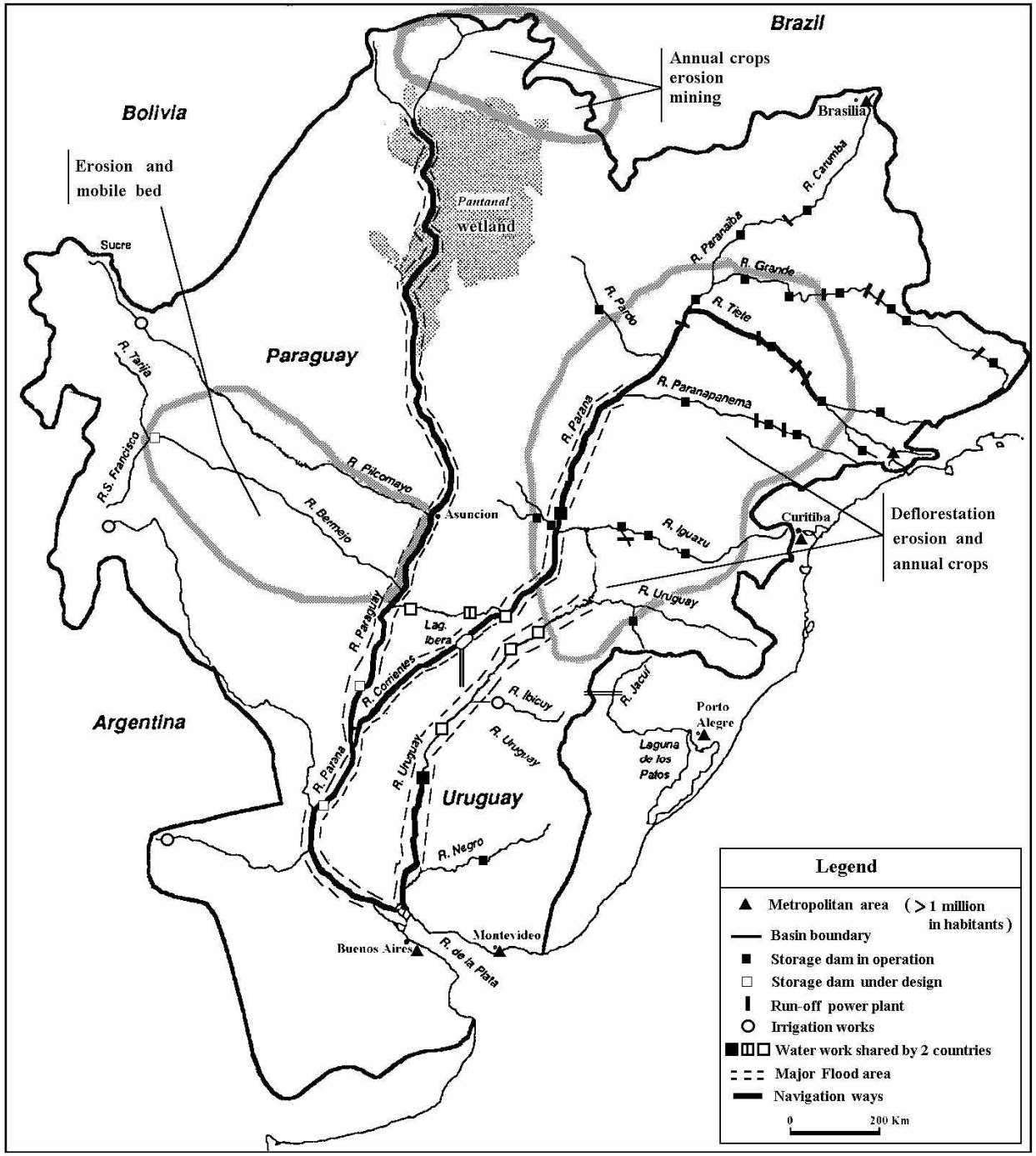
Outline

- Some challenges
- Modeling for water resources goals in some Brazilian Basins
- Long term forecasting in two basins and short tem forecasting in one basin

Some challenges

- Energy system in La Plata Basin
- Human and environment sustainability in Upper Paraguay Basin
- Agriculture sustainability in South of Brazil

LA PLATA BASIN



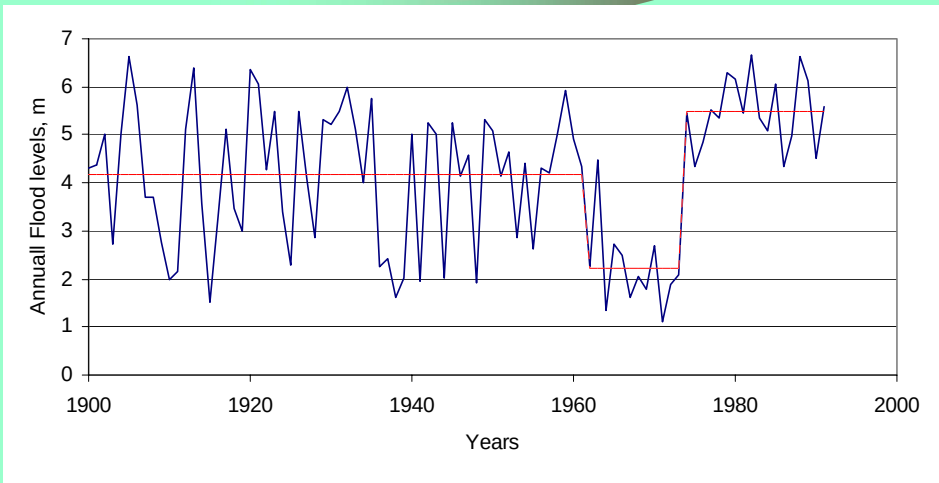
Paraná River and Brazilian Energy system

- Mean Flow increase after 70's in Paraná River and most of neighbors basins
- 60% of Brazilian energy is produced in the basin
- 90% of Brazilian energy production is based on hydropower ;
- Thermal plants has been constructed in order to support the lack of water or storage of the system
- The system is highly dependent of the next semester forecasting (mainly wet months)

River Section	Before 1970	1970-1990	Increase %
Parana River at Jupiá	5,852 (+)	6,969	19,1
R. Paranapanema at Rosana	1,057 (+)	1,545	46,2
R. Paraná at São José	6,900 (+)	8,520	23,3
R. Paraná at Guaira	8,620 (+)	11,560	34,1
R. Paraná r at Posadas	11,600(*)	14,255	22,9
R. Paraná at Corrientes	15,265	19,510	27,8

Climate and variability issues

- Change in the hydrology series trends and the impact of water uses and society
- Pantanal: Paraguay River : society impact
- Change of 2,5 m in the mean annual flood level in Pantanal; change in the mean flood areas from 17.000 km2 to 50.000km2



- A property flooded during 20% of the time in the 60's is now flooded 97% of the time

Basins in modeling

- Madeira River in Amazonas (PhD dissertation);
- Parnaiba River and Itaipu syb-catchment in Paraná River (National Operator System, ONS)
- Uruguay River Basin and

San Francisco River Basin (ANEEL)

Upper Paraguay (ANA, Water Agency)

Rio Grande (National Science Foundation, FINEP)

Total ~1,6 millions km^2

Forecasting in large basin

- Usually hydropower's are in large basins > 2000 km^2 and mainly > 10.000 km2
- Systems highly depend on long term climate variability
- Its complemented by thermal energy with higher cost
- Forecasting is the base for optimization of such system

Partners in the following studies

- Pedro Silva Dias

  University of São Paulo
- Gilvan Sampaio, Chou Chan and José Marengo

  CPTEC/INPE
- Project Funded by National Eletric Energy Agency (ANEEL)

Long – term (seasonal) flow forecasting: Uruguay River Basin

Models

flow statistics based on the historical flow series

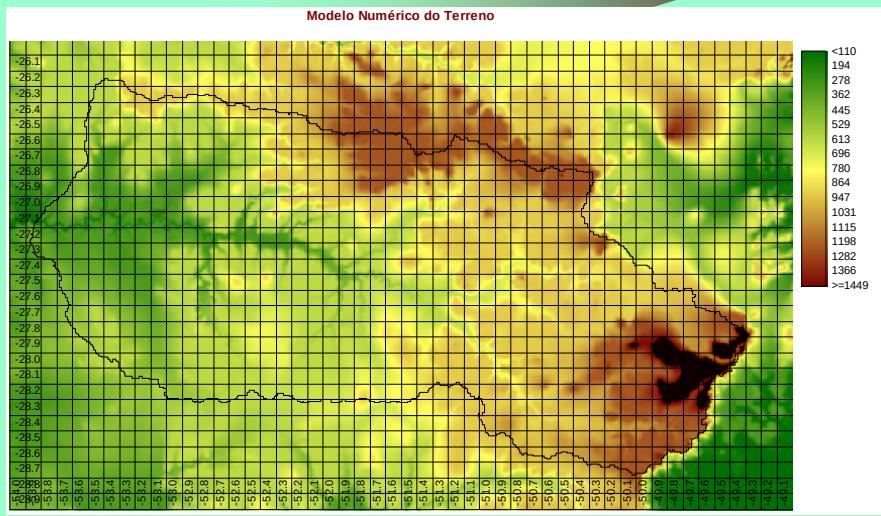
- Stochastic models;
- forecasting based on empirical relationship with Pacific and Atlantic temperature;
- climate model + hydrological model

Basin

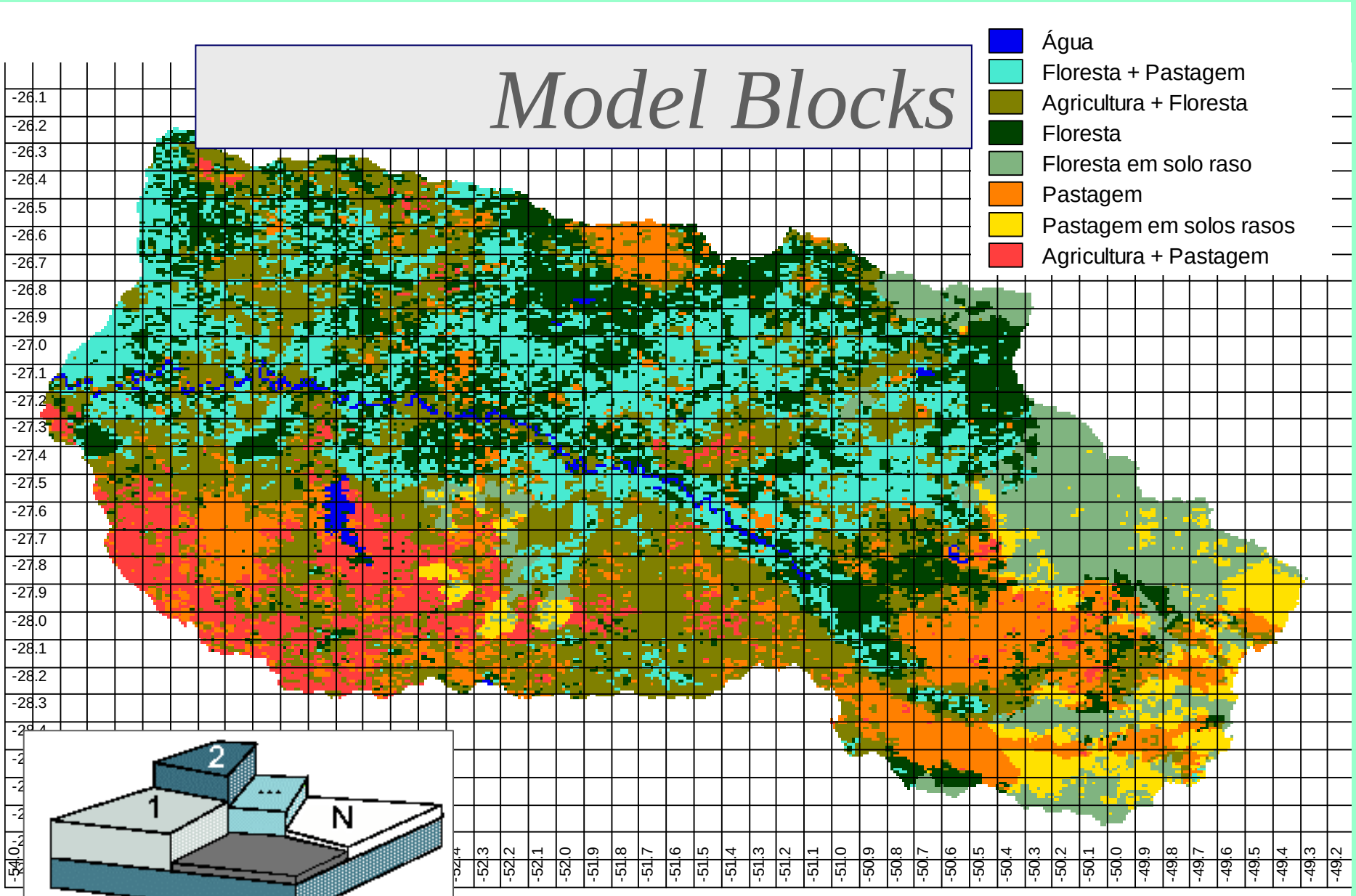
- area of ~75.000 km2
- The floods and drought could be in any month of the year;
- small time of concentration and low memory (small basin storage).

Hydrologic model

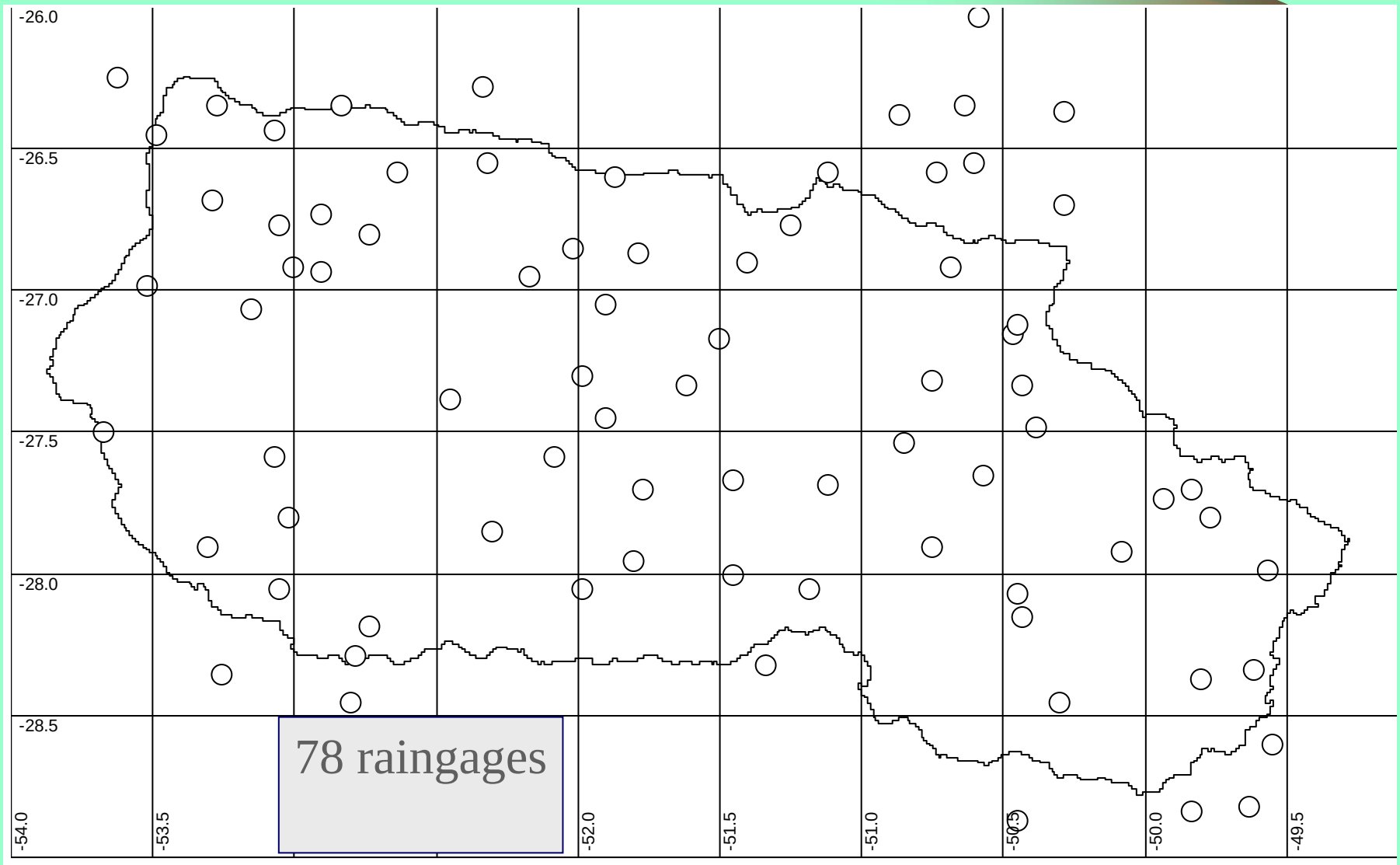
- Distributed model with grid of 0.1 x 0.1 deg.
- Model fitted through multi-objective optimization method



Model Blocks



Rainfall gages

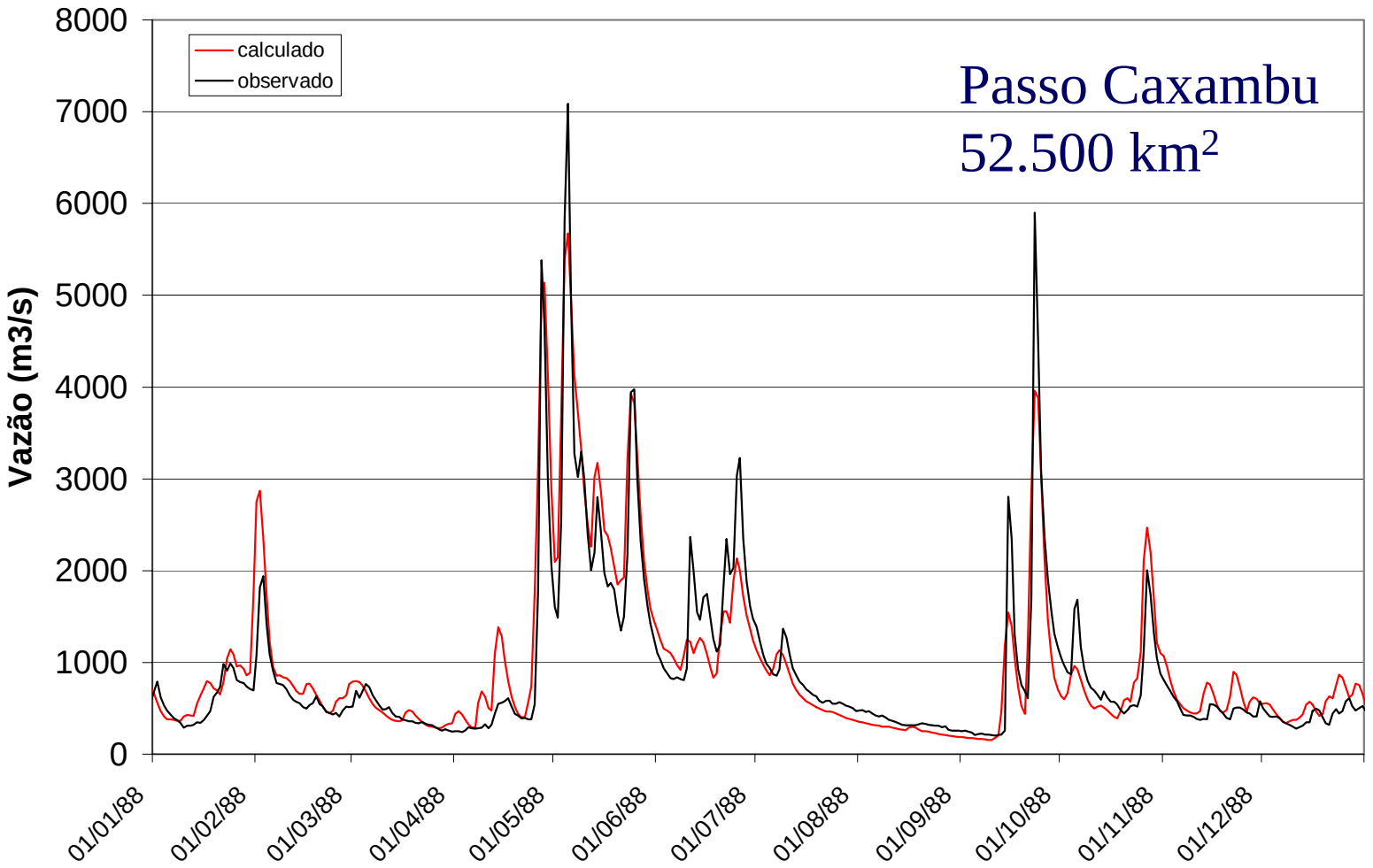


Fitting

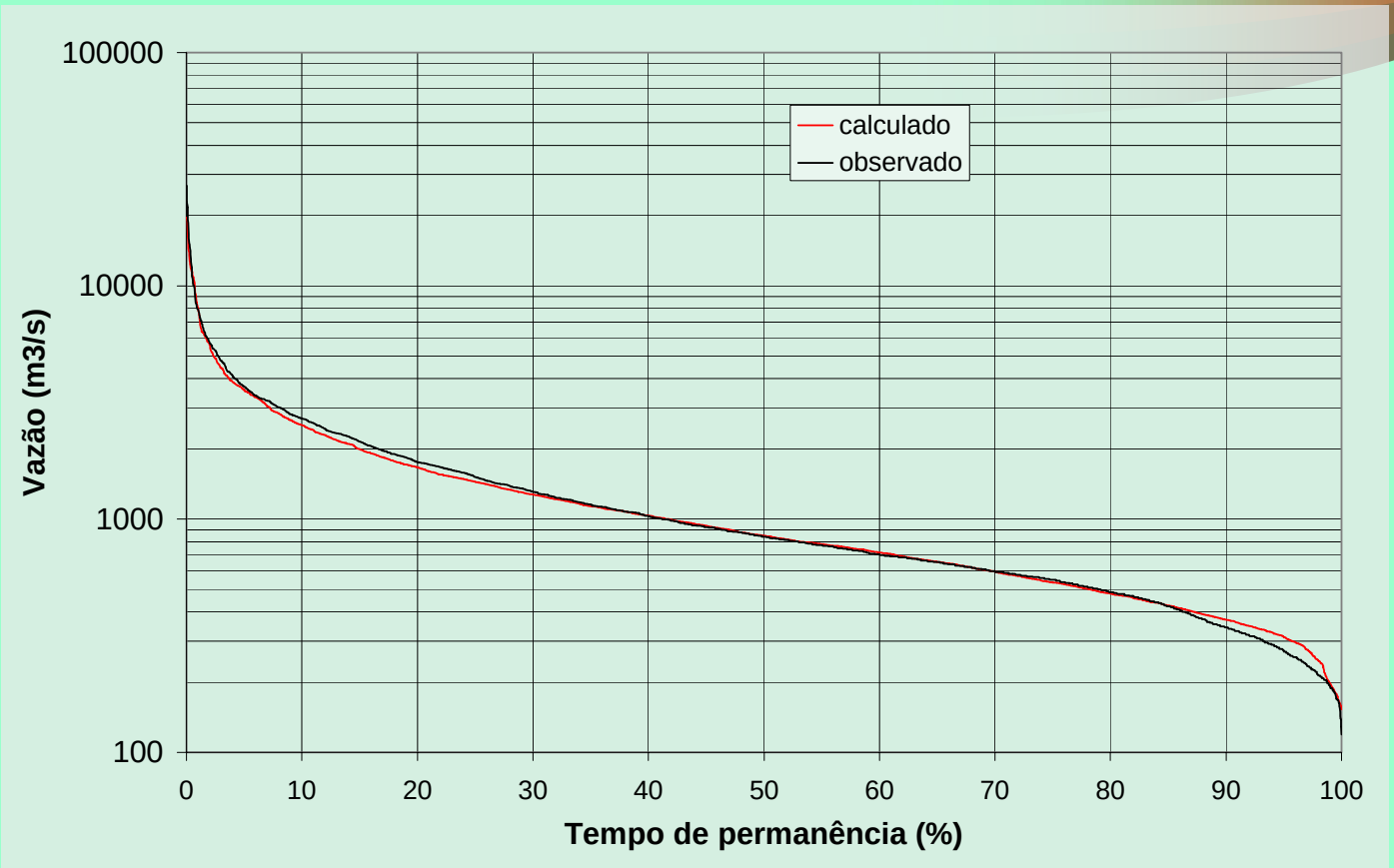
- To start, we used the same parameters from the neighboring basin
- 5 flow gages were used for fitting and 12 gages for verification
- the fitting was done on hydrographs and flow duration curves

Fitting Sample

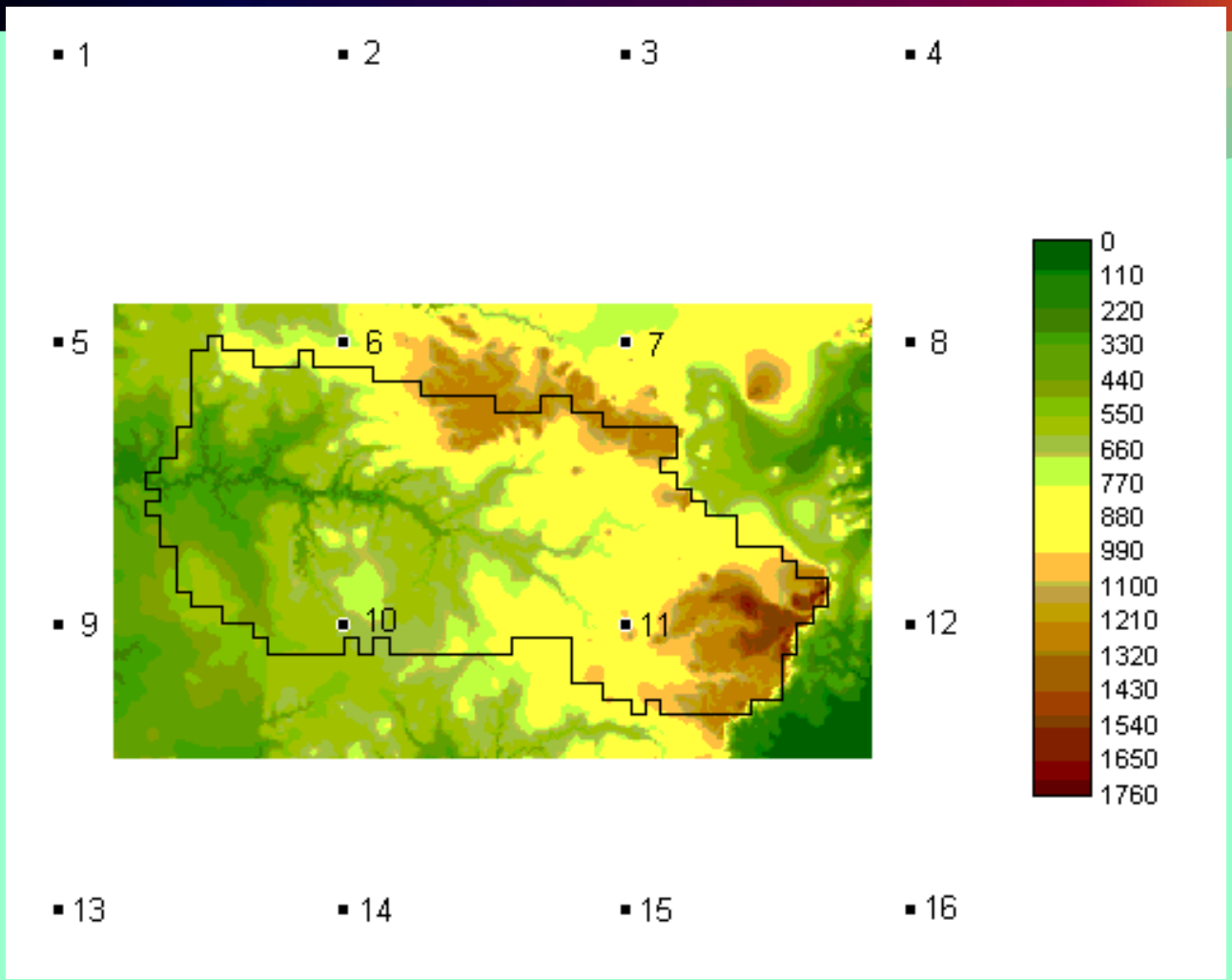
1988



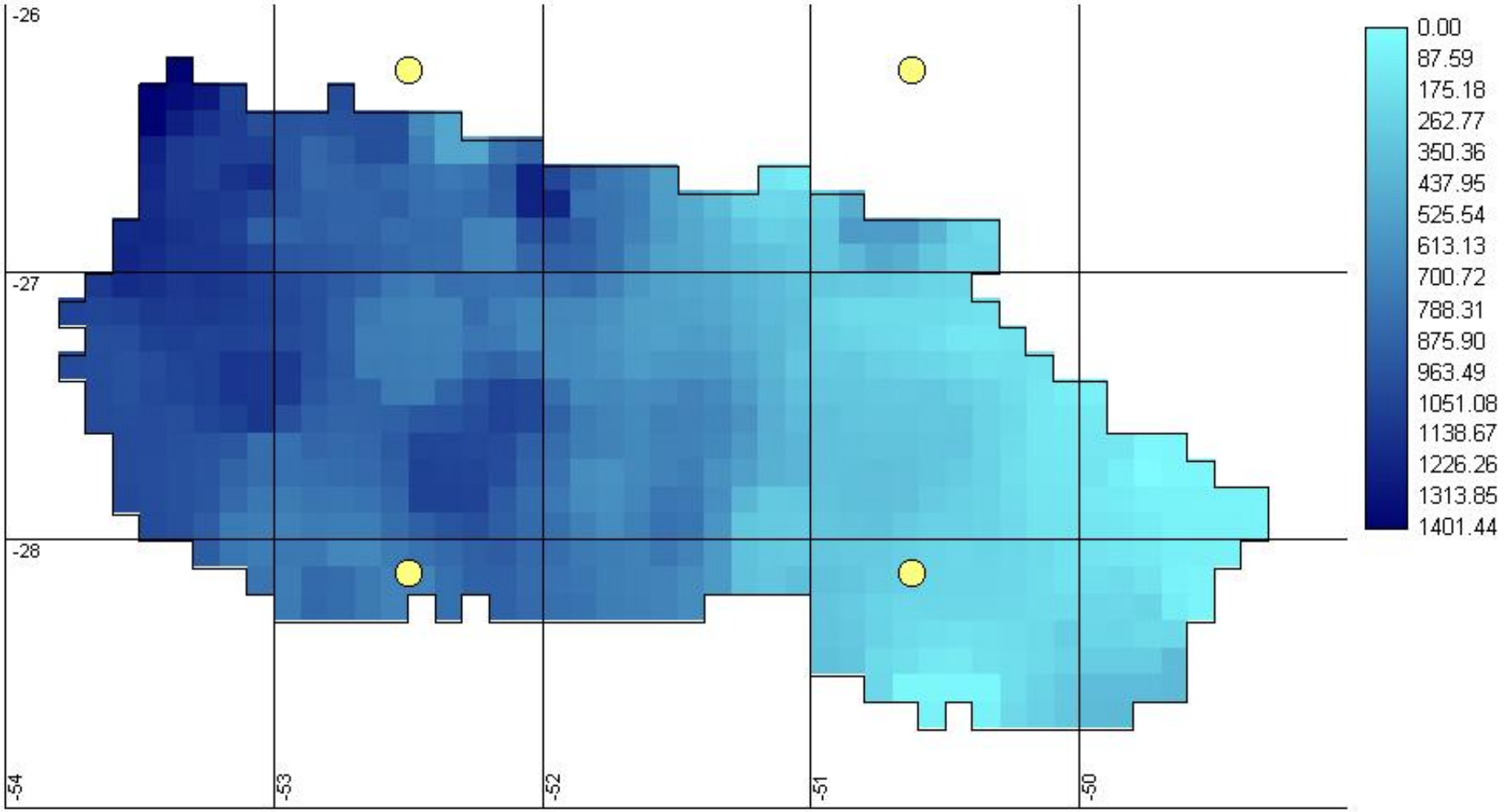
Fitting the flow duration curve



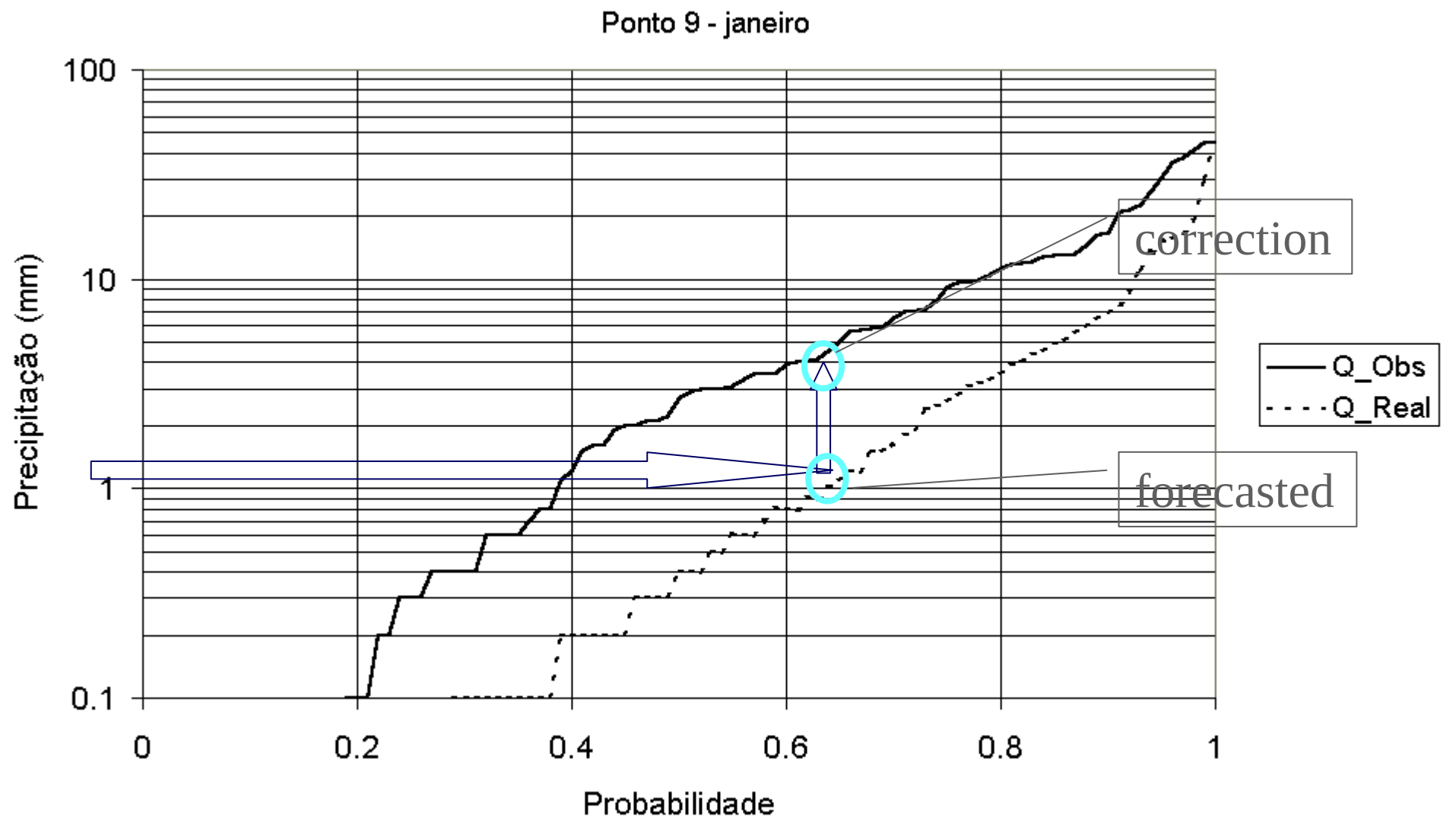
CPTEC Climate model grid



Bias Error of the rainfall forecast

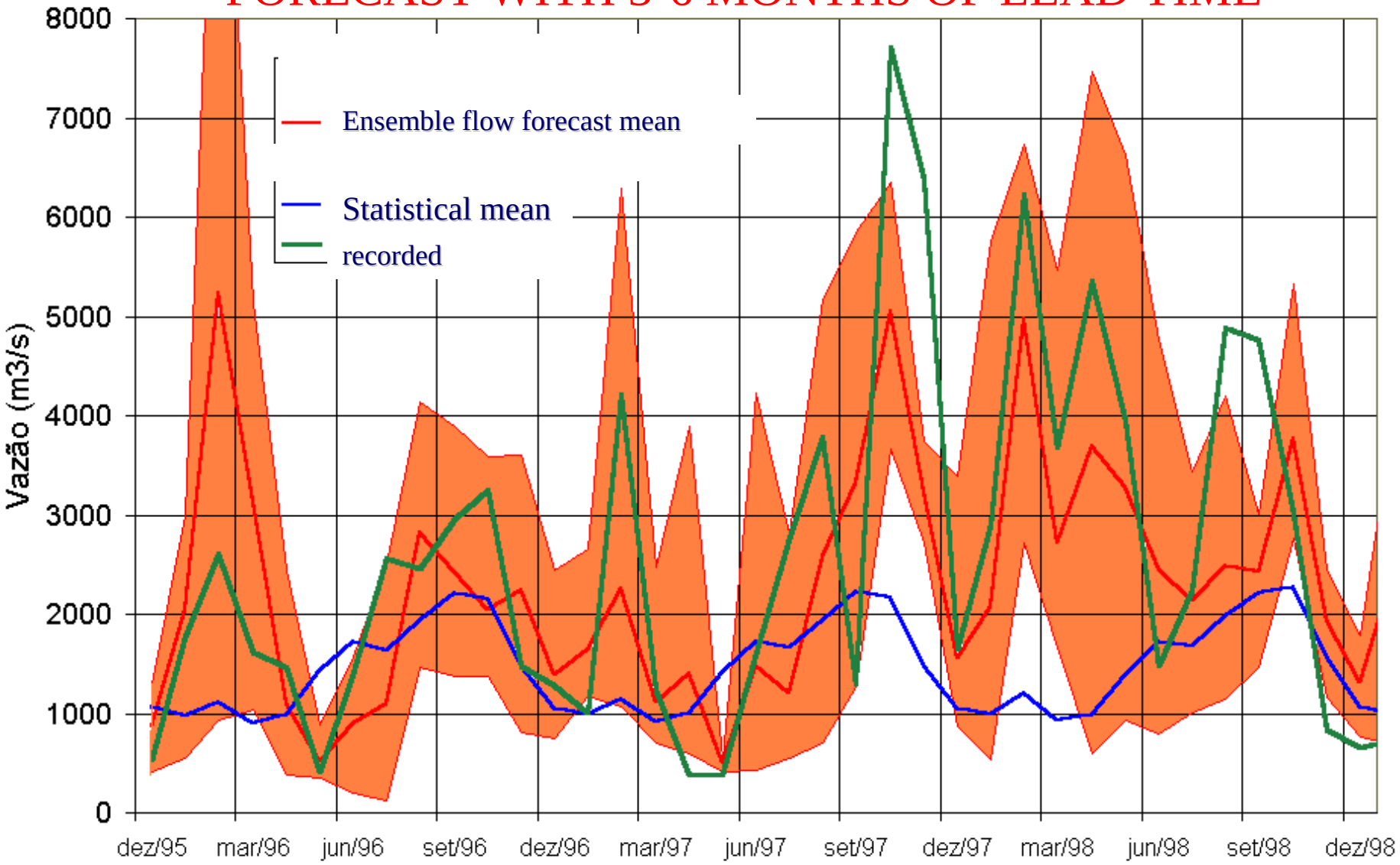


Statistical Correction :

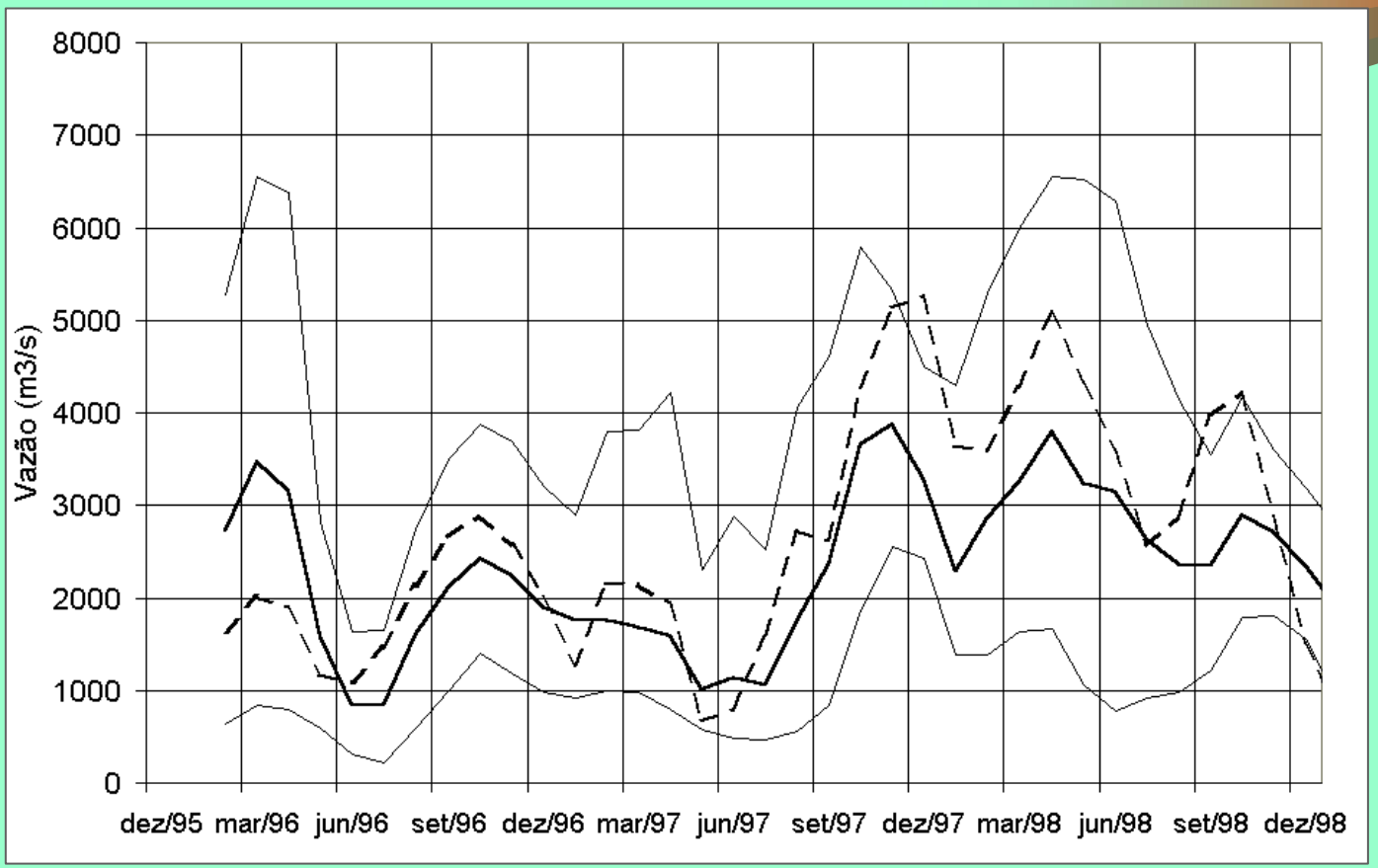


FITTING PERIOD

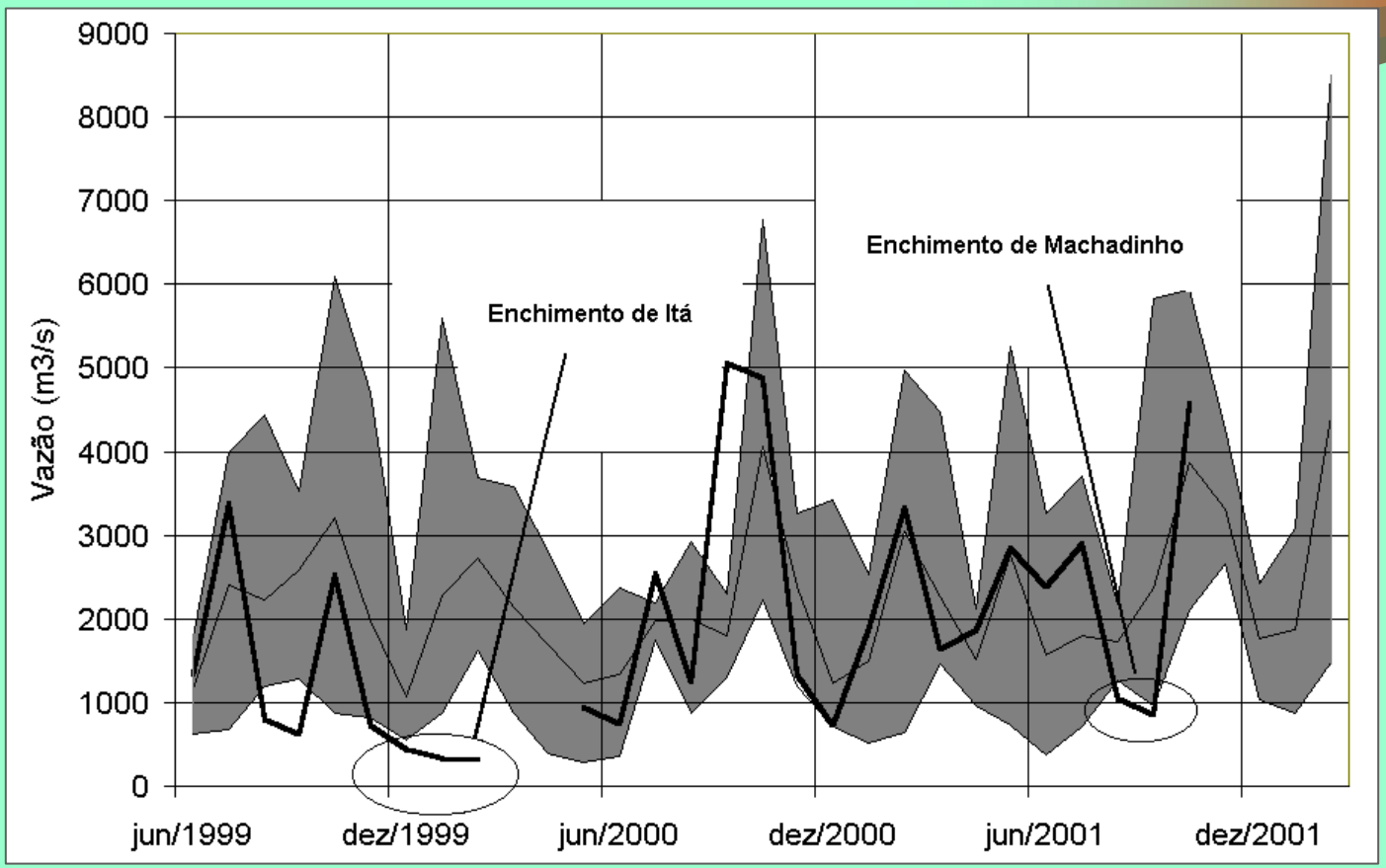
FORECAST WITH 3-6 MONTHS OF LEAD TIME



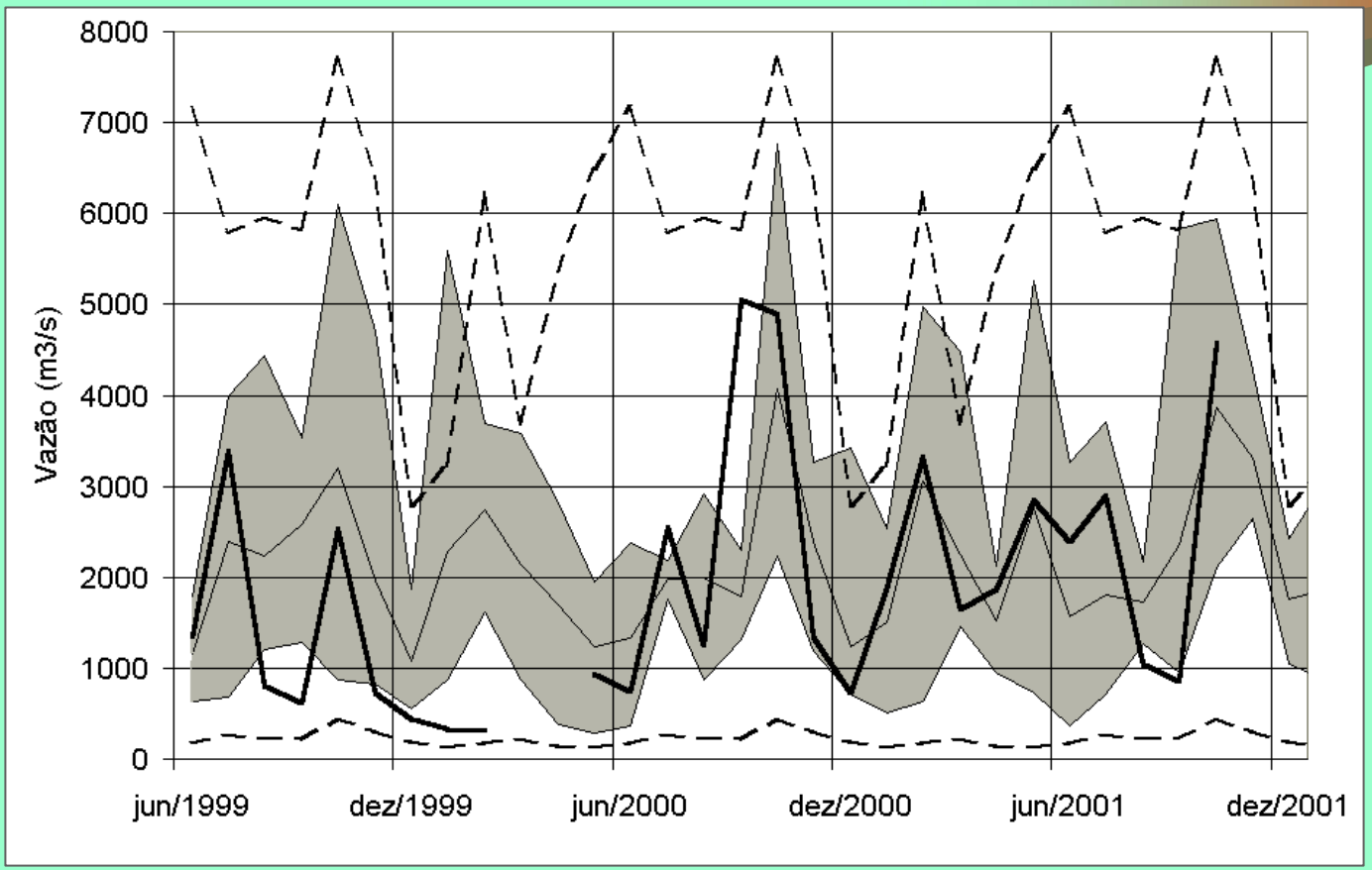
Mean of three month forecast



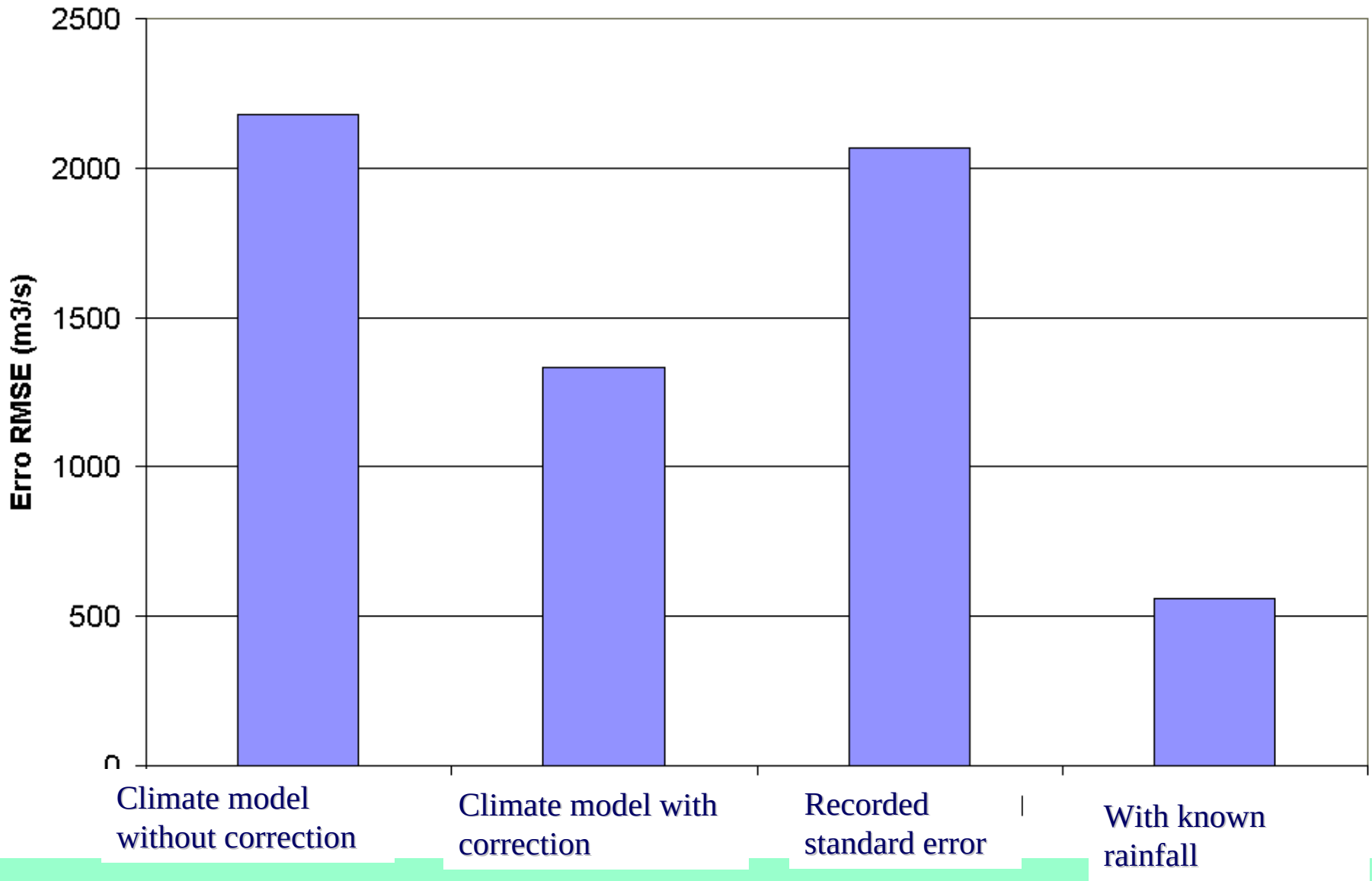
Forecasting 1999-2001



Reduction of the uncertainties

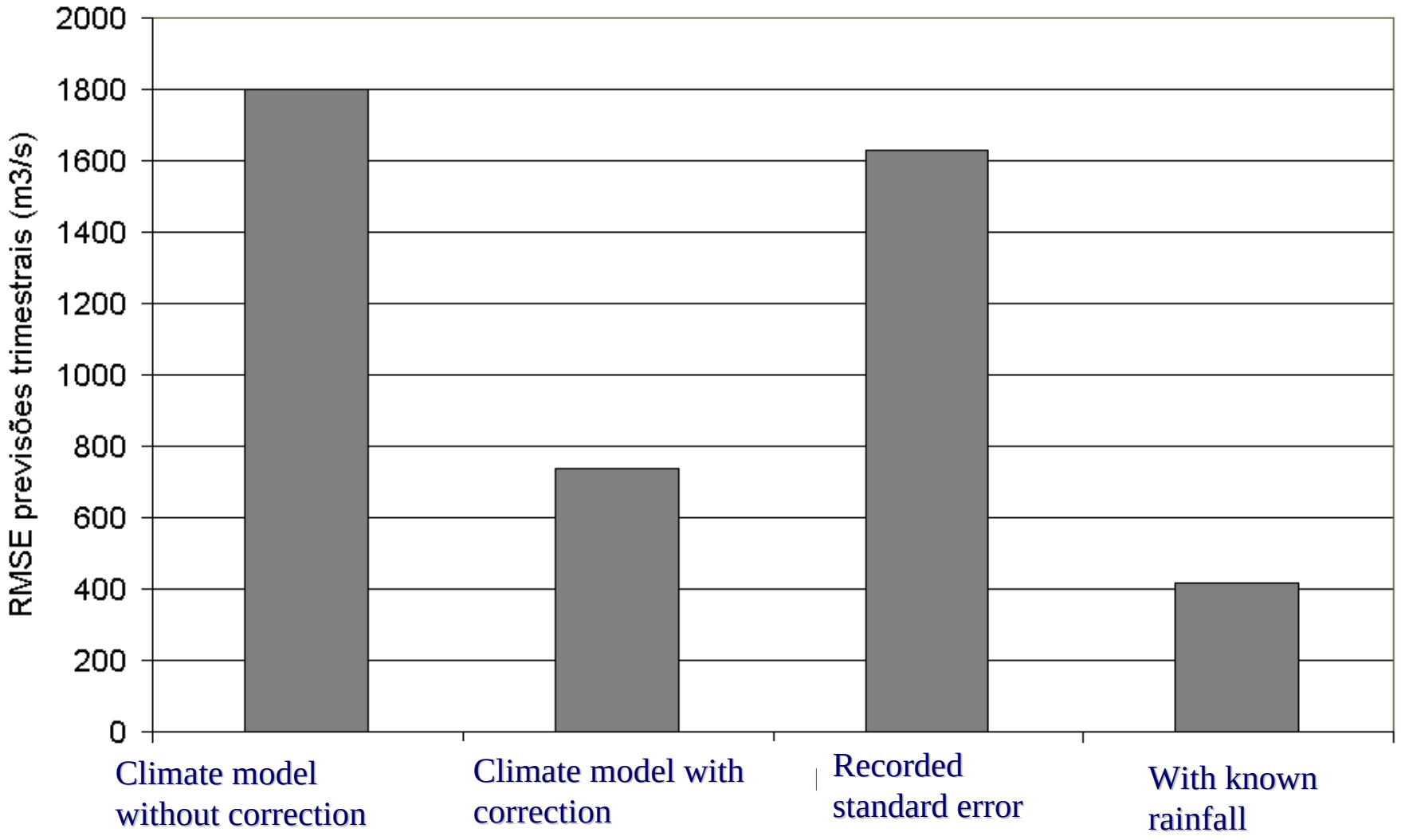


Standard error for monthly flow forecasts



Climate + hydrological model with rainfall correction decreased the error by 34%

Standard error for three months forecasts

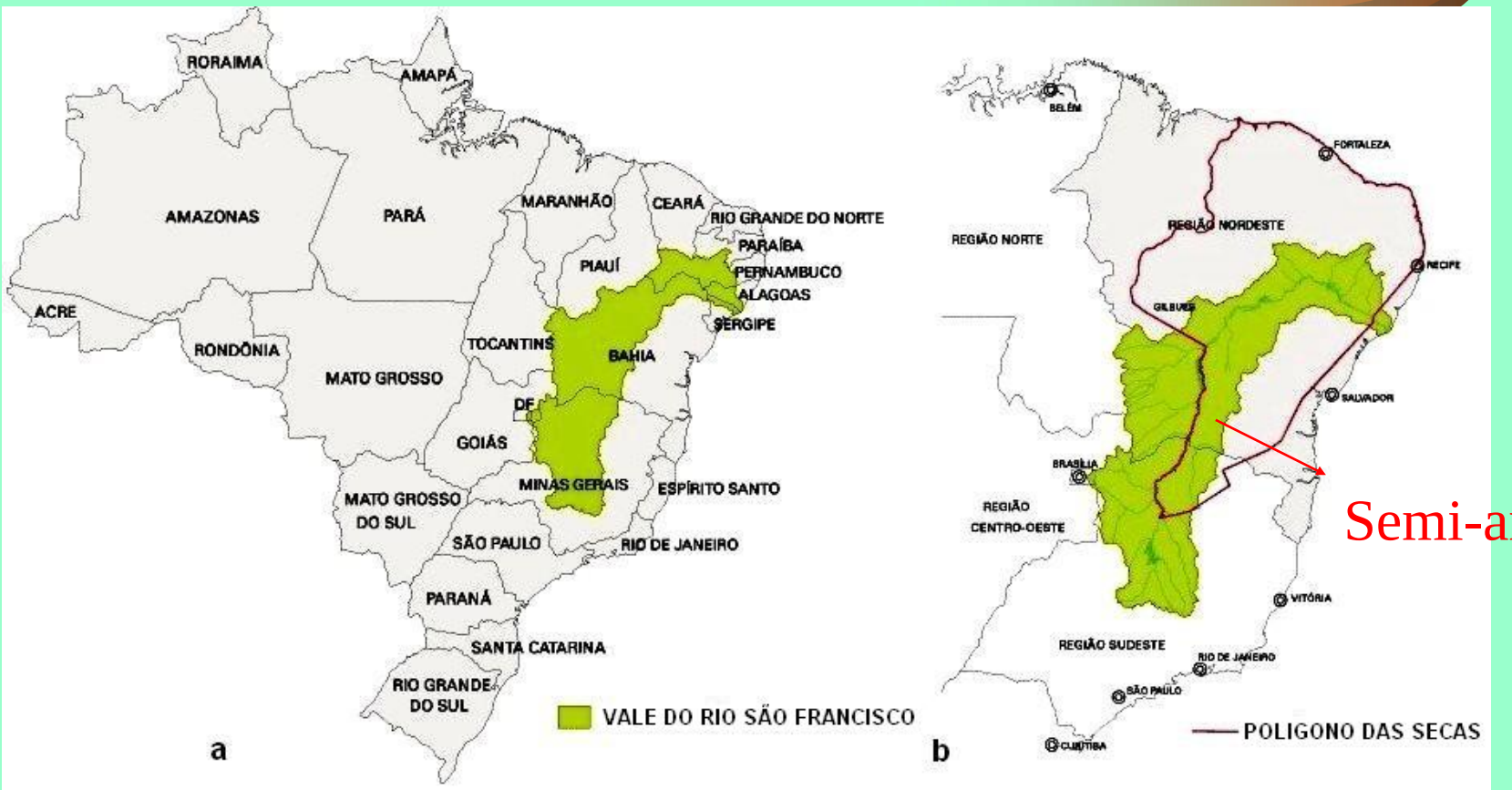


Climate + hydrological model with rainfall correction decreased the error by 54%

Comments

- For a few events the downscale climate model was evaluated, but it did not improve the forecasts ;
- we could not find any serial correlation on the residuals of the forecasts and recorded flow;
- Basin Characteristics and climate forecast for the region were the main factor of the positive results

São Francisco



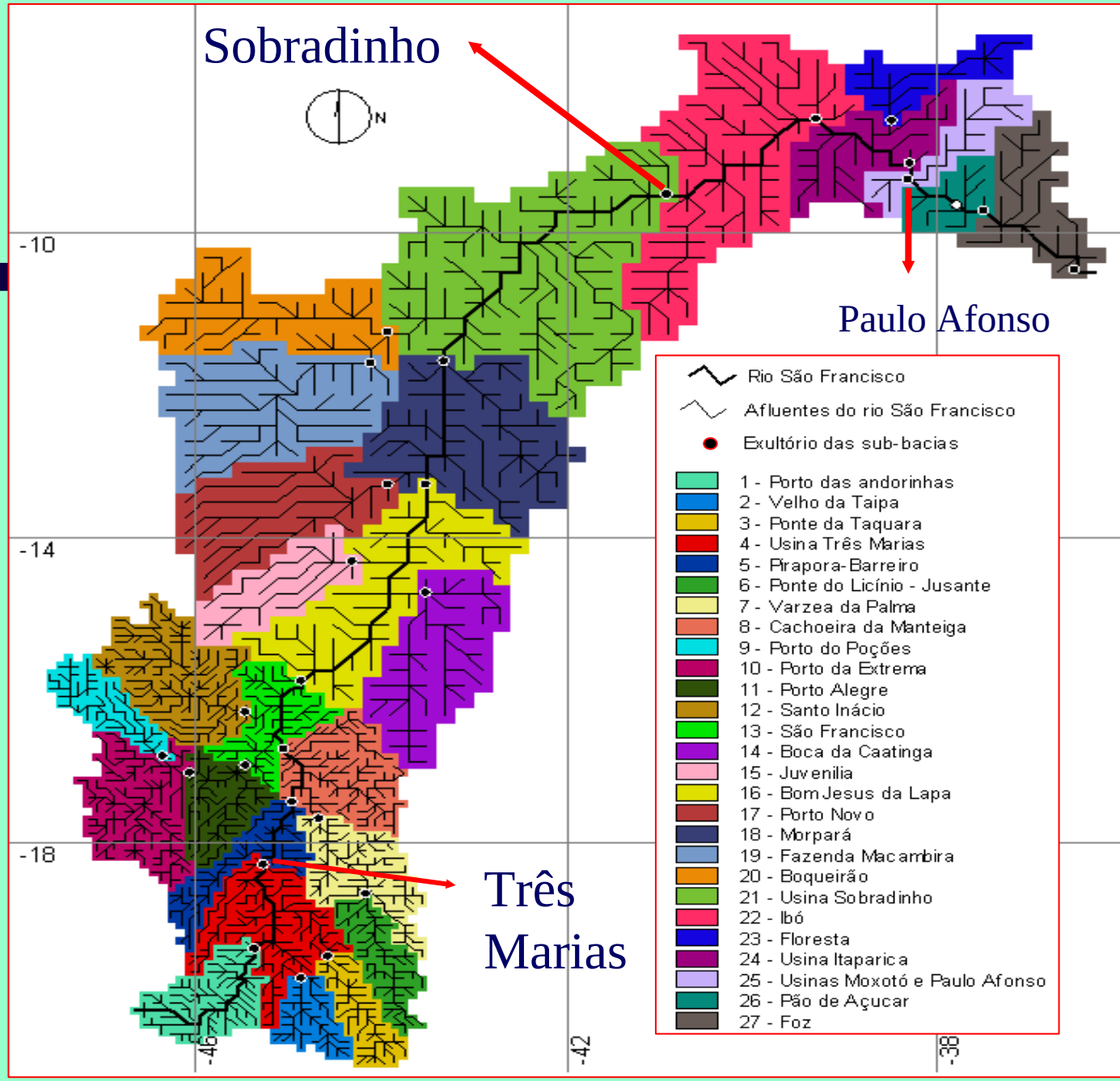
Semi-arid

Area: 640,000 km^2

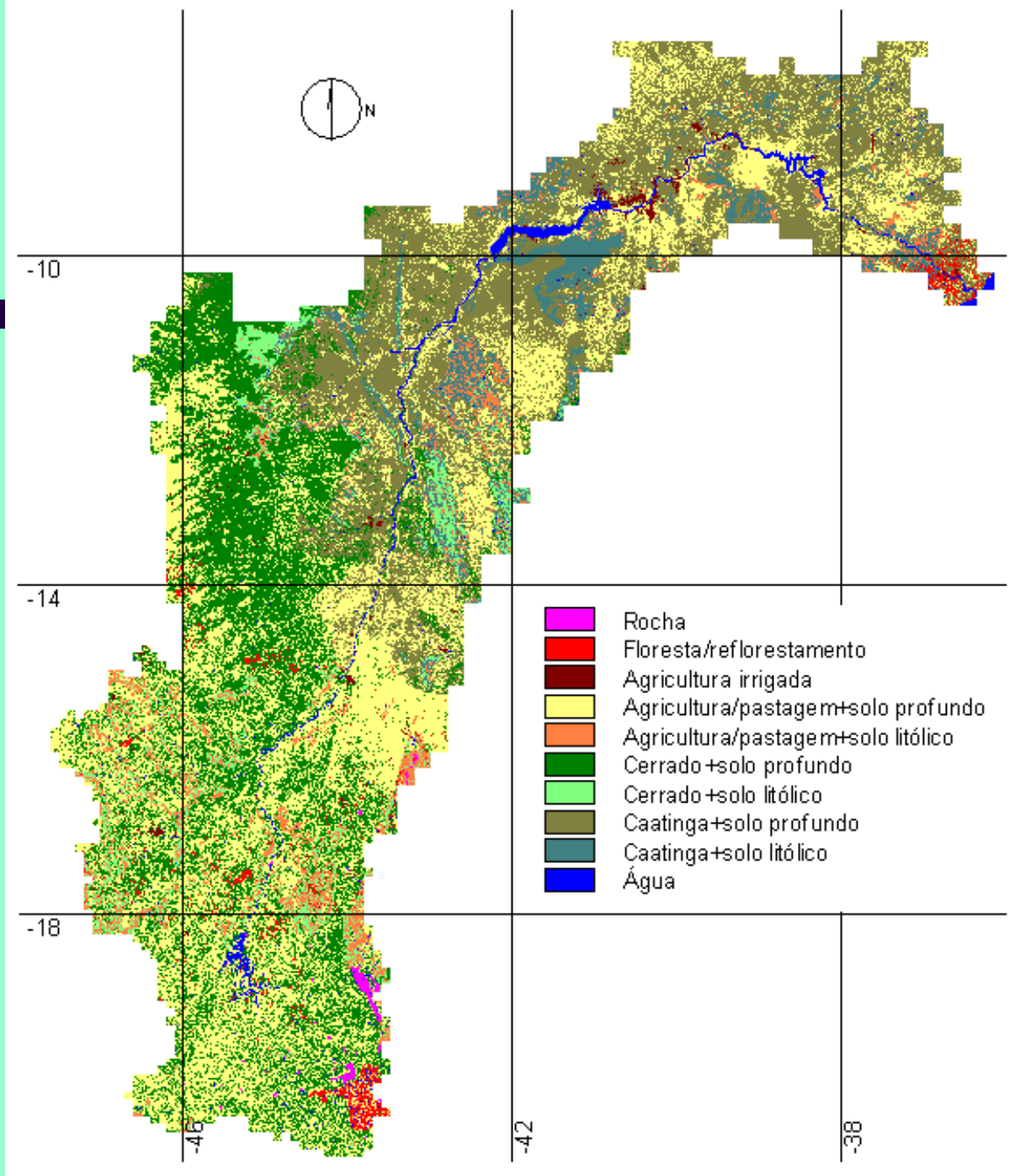
Characteristics

- hydropower: main source of energy of Northeast of the country;
- Great hydrologic and climate change along the basin: upstream basin supply most of downstream flow;
- In the semi-arid it is lowest social-economic development of the country.

Basin discretization and sub-basins

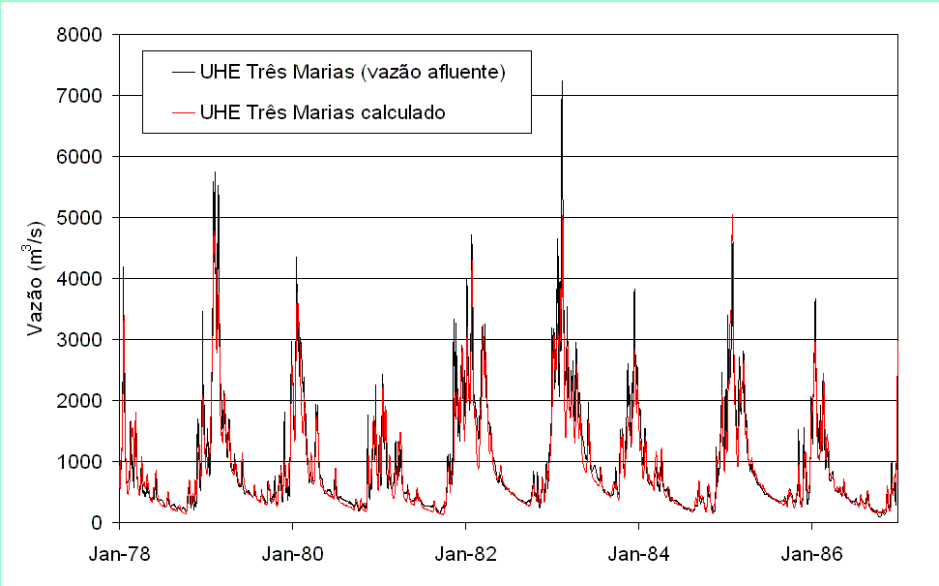


Basin Characteristics

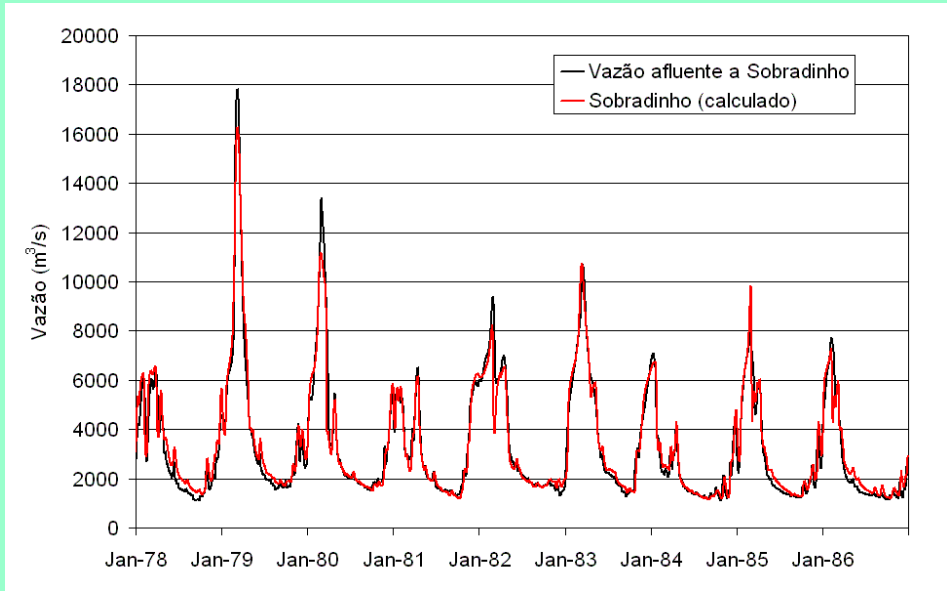


Fitting the hydrologic model

Três Marias: Upstream dam at wet region

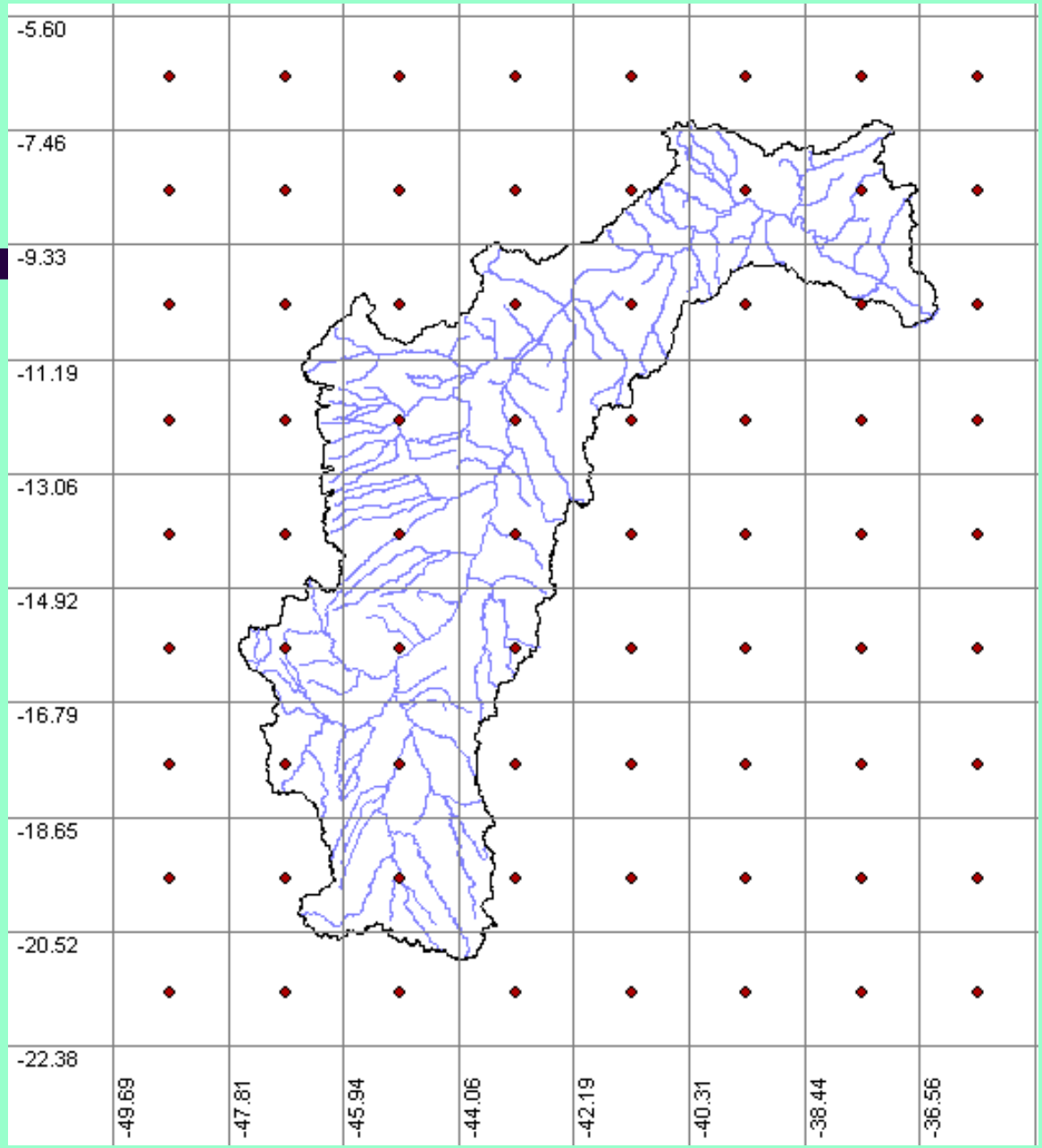


Sobradinho



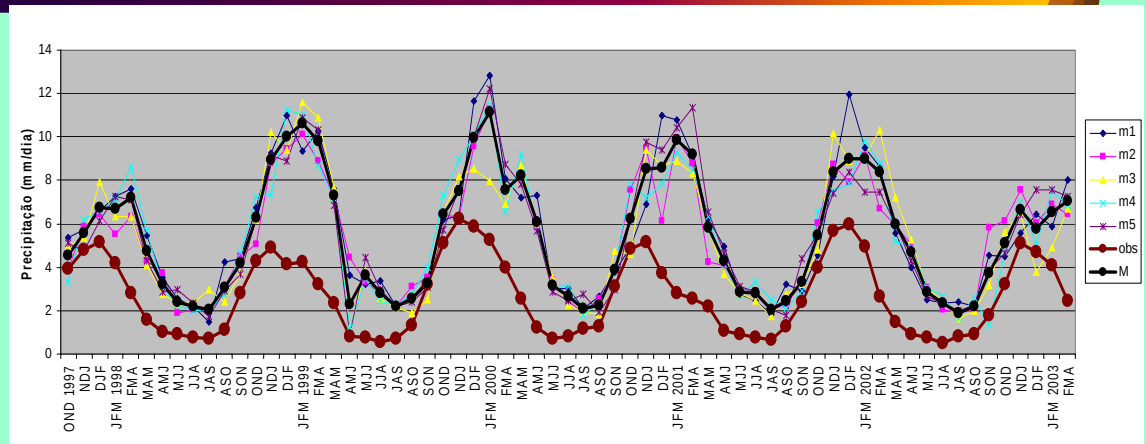
GCM Grid

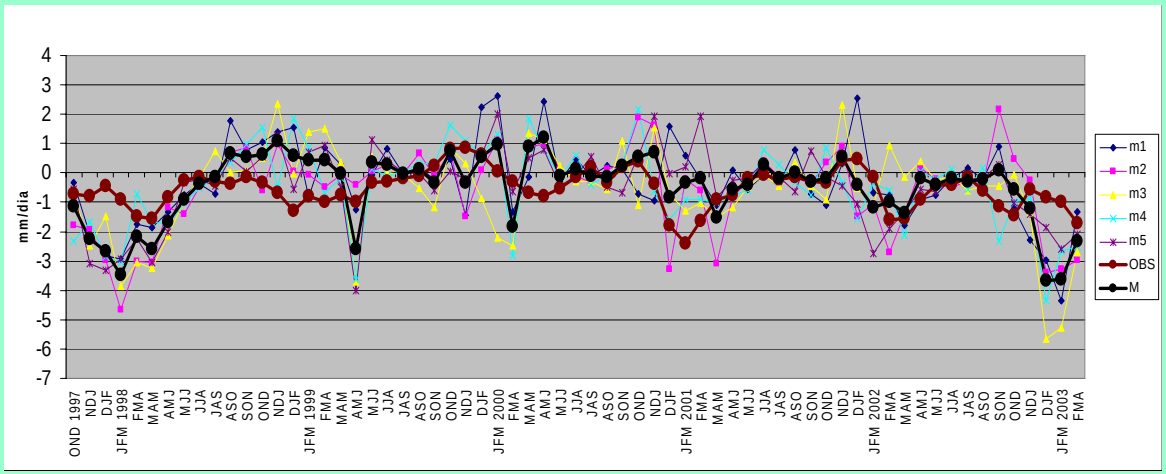
- Model CPTEC/COLA;
- 200km grid



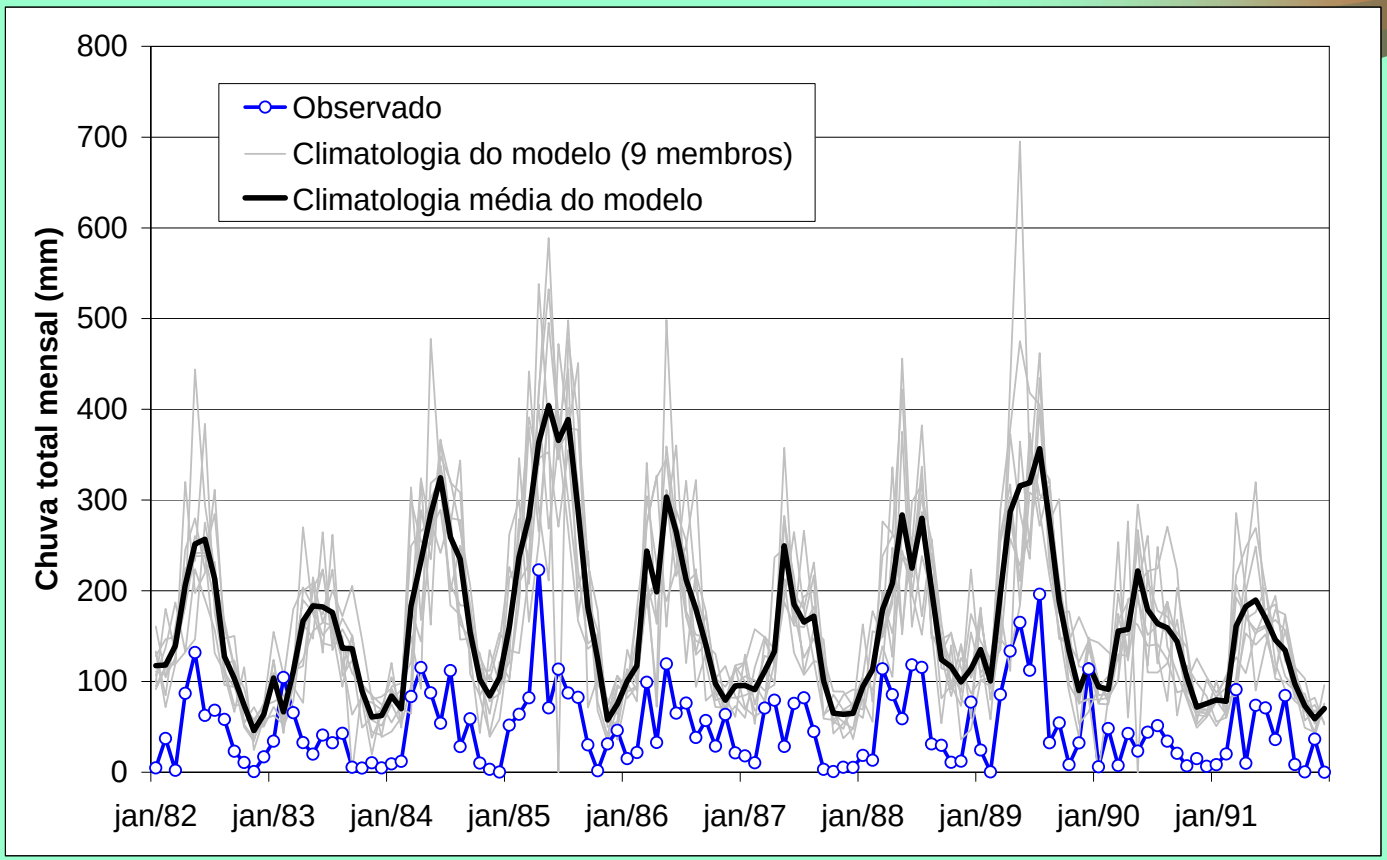
Long Rainfall Forecast

- The model underestimate the regional rainfall in absolute values;
- It is not bad in relative values

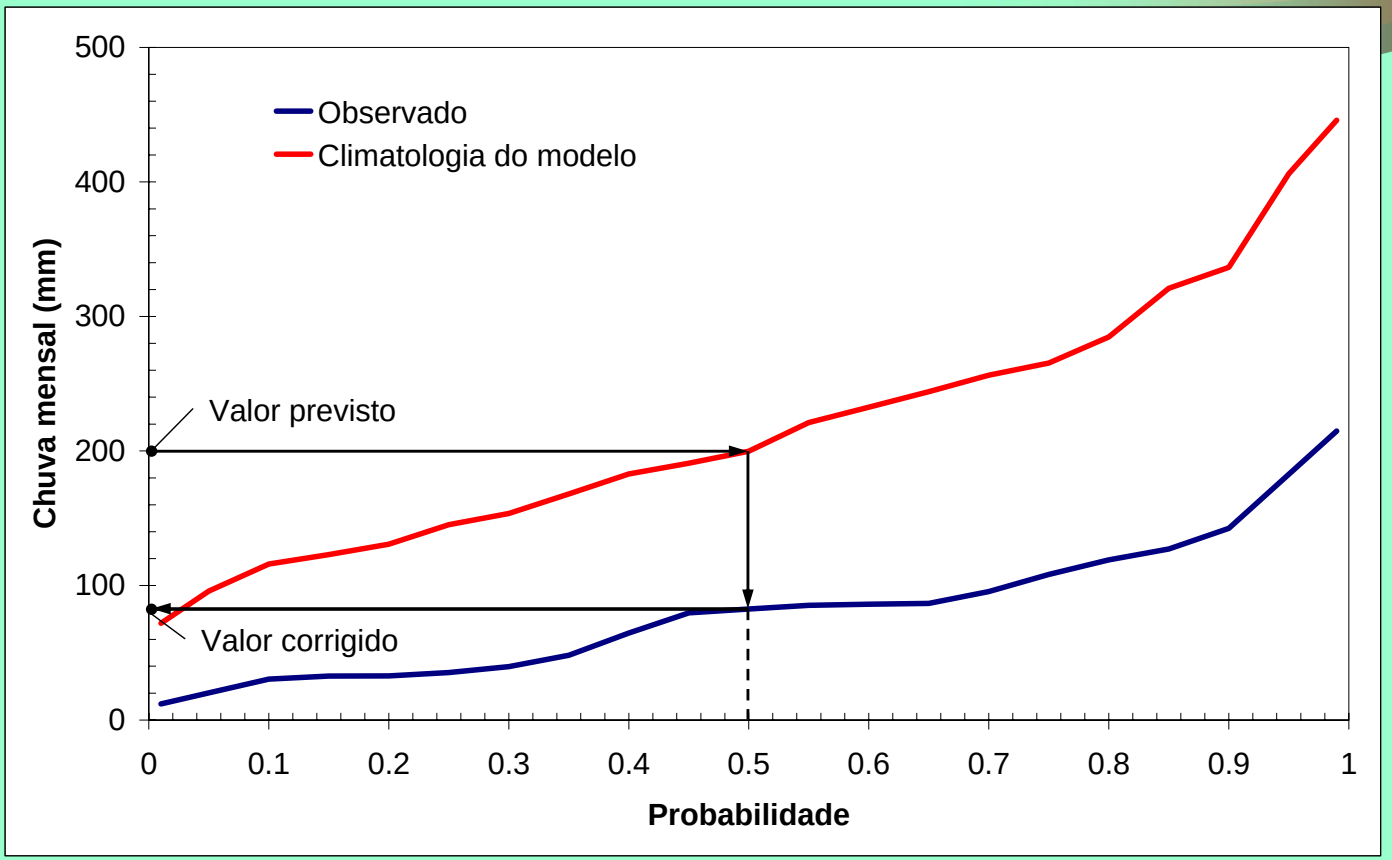




Evaluation of 9 years in a specific area

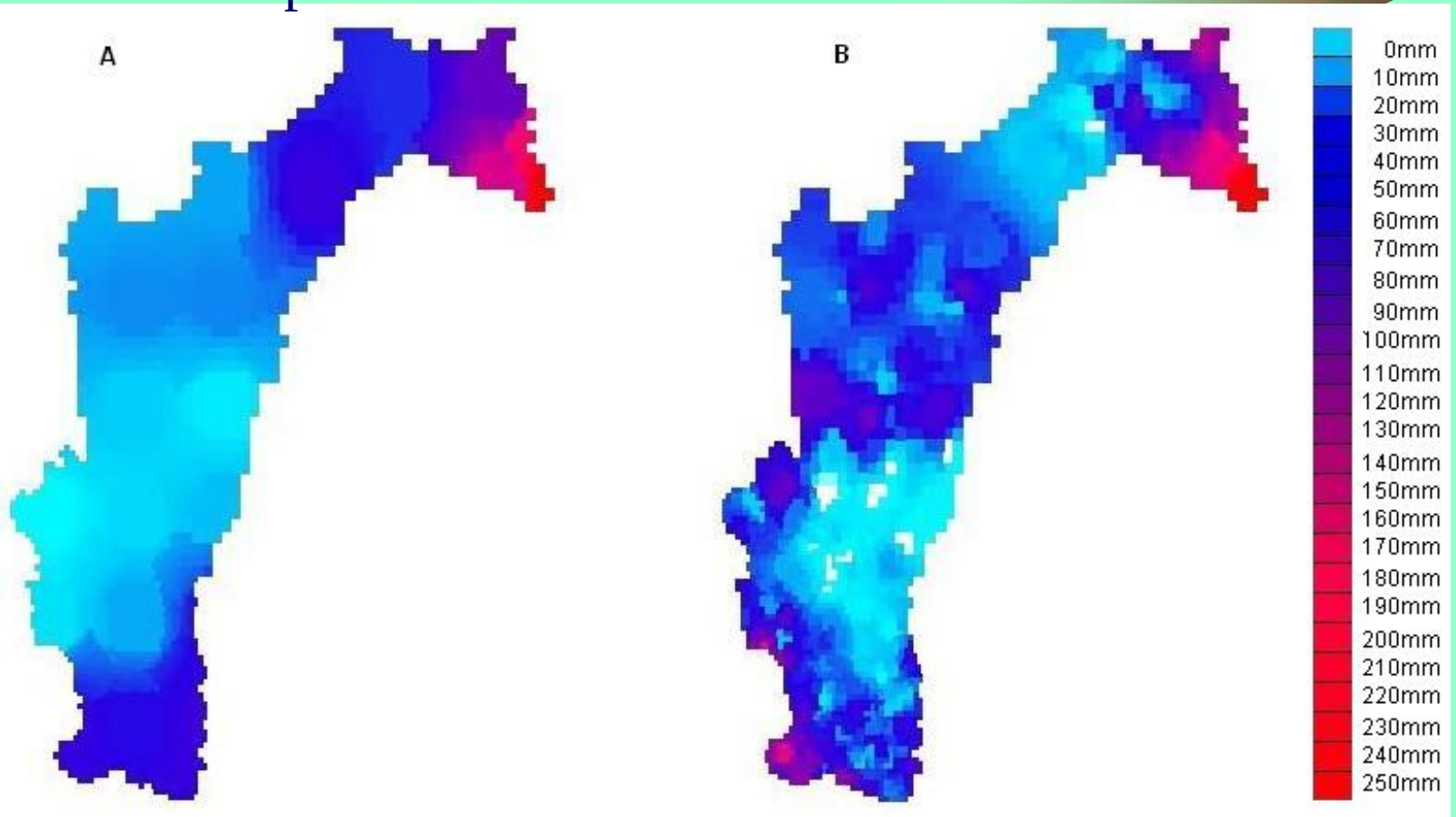


Statistic correction



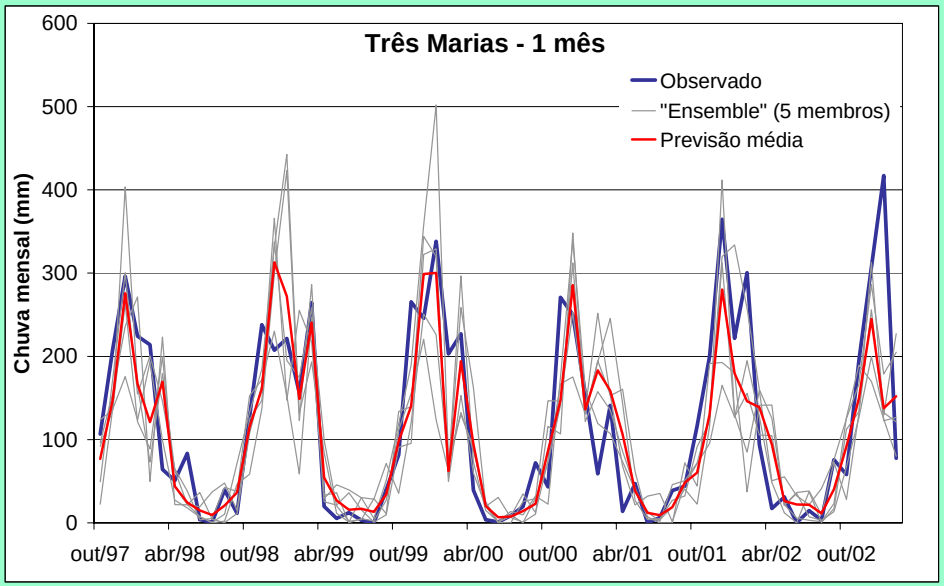
Rainfall forecast and recorded after correction

Sample of a month

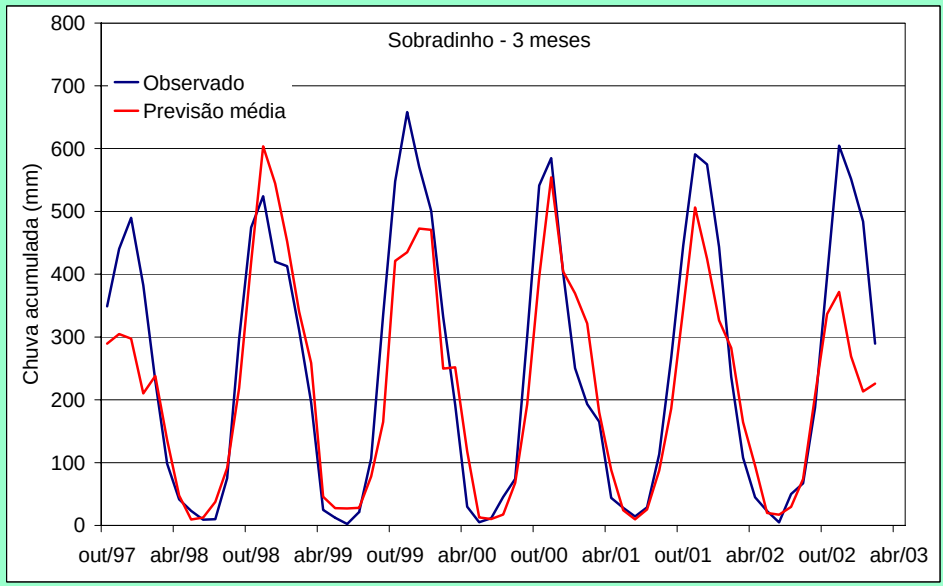


Rainfall forecast for the sub-basins

Três Marias – lead time: 1 month

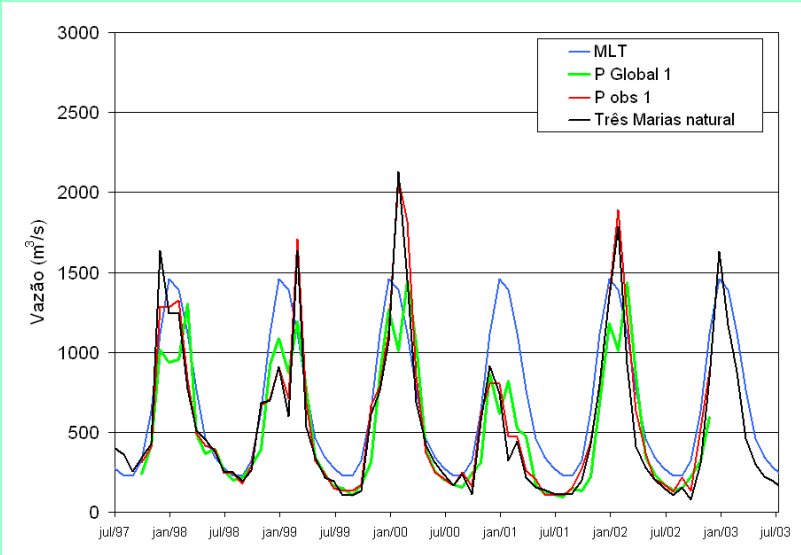


Sobradinho lead time 3 months

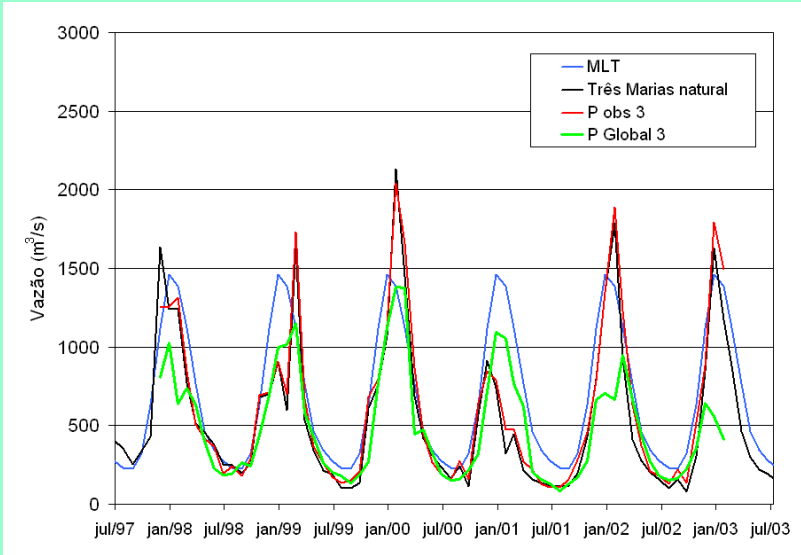


Flow forecast – Três Marias –

1 month



2 months



Models Comparison: TRÊS MARIAS

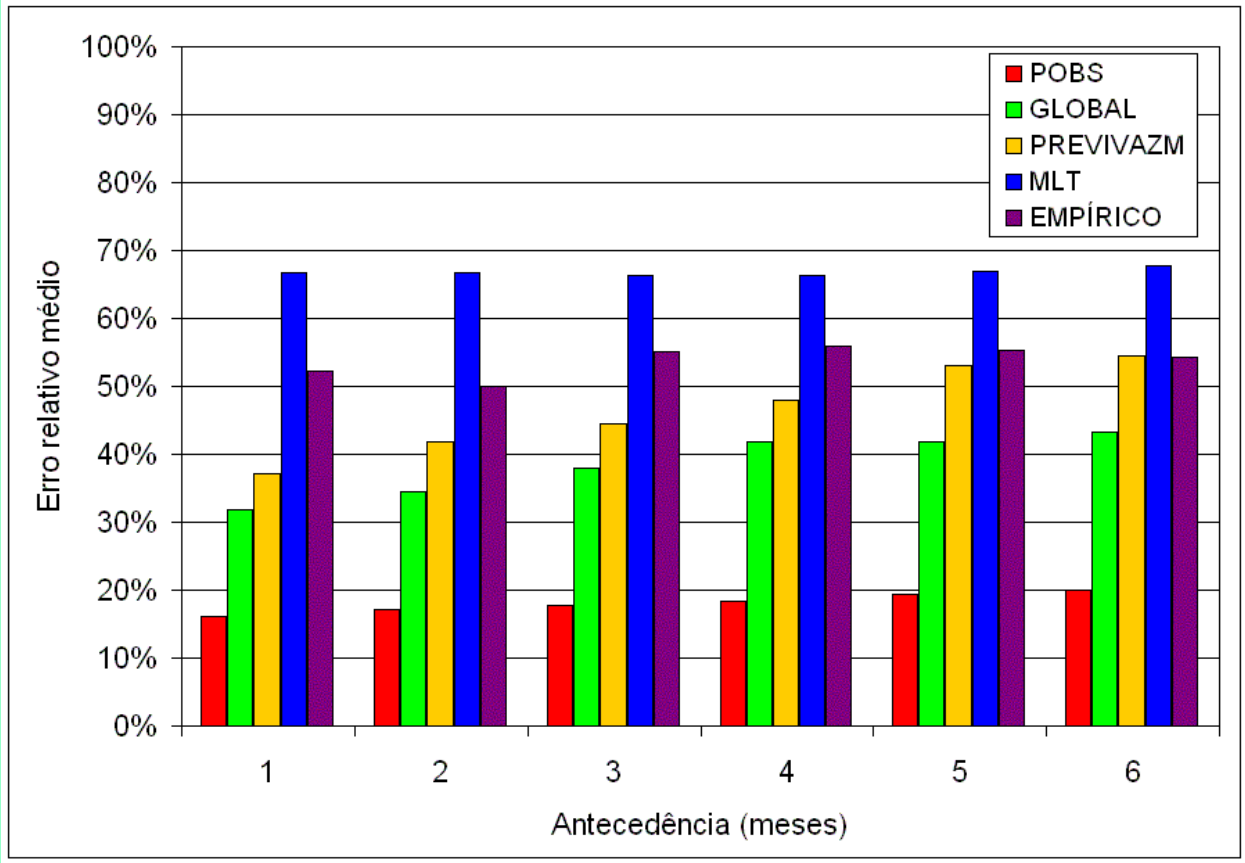
RED: Hydrologic model and record rainfall

GREEN: Climatic + hydrologic model

YELLOW: stochastic model used by Eletric System;

BLUE: persistence

PURPLE: Empírico based on TSM



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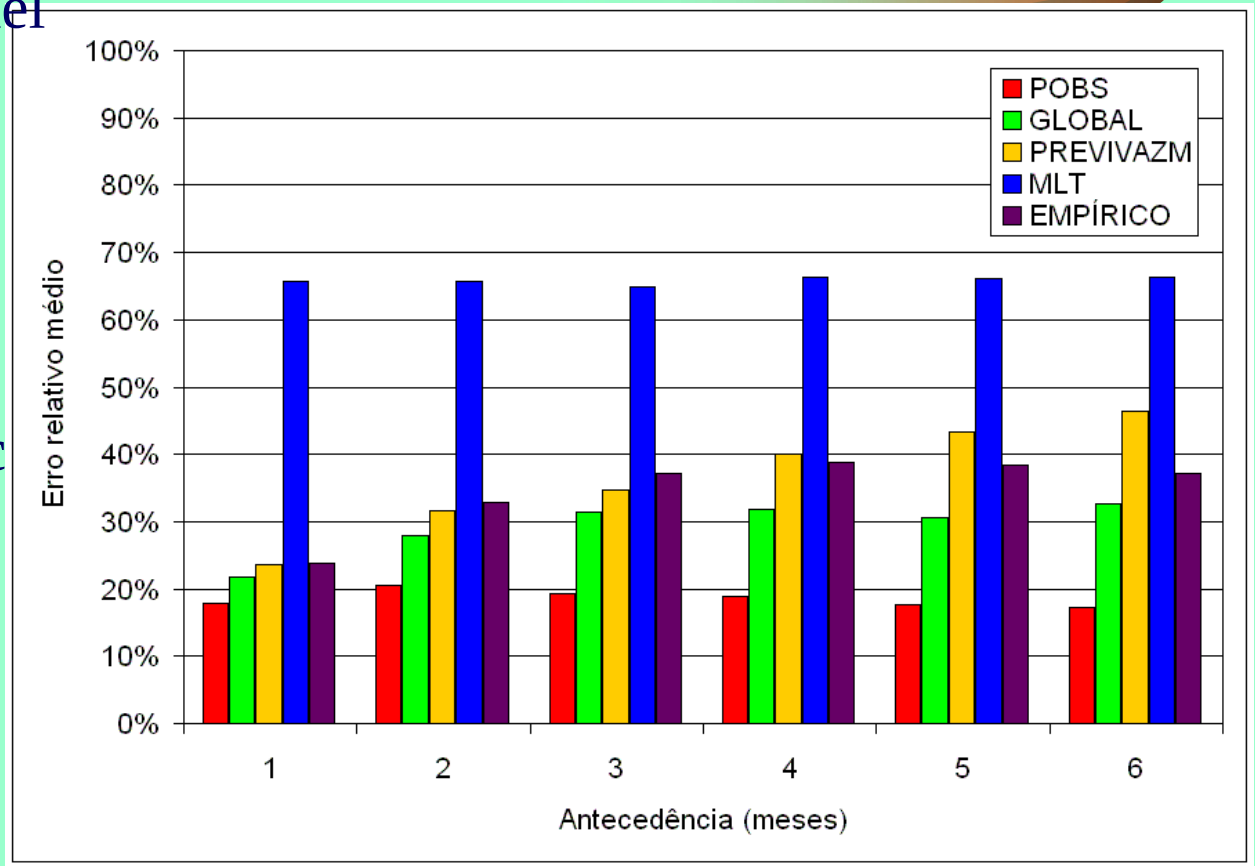
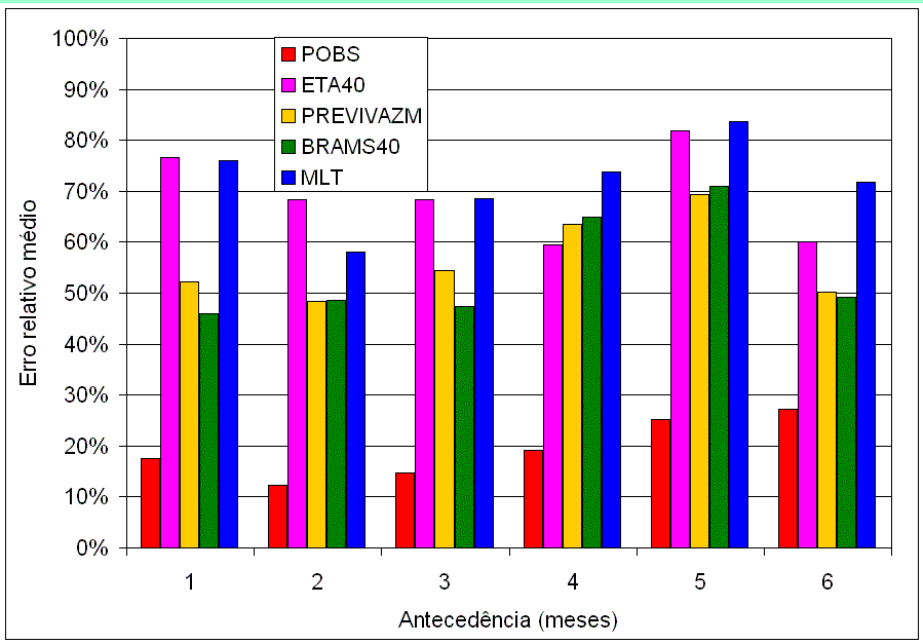
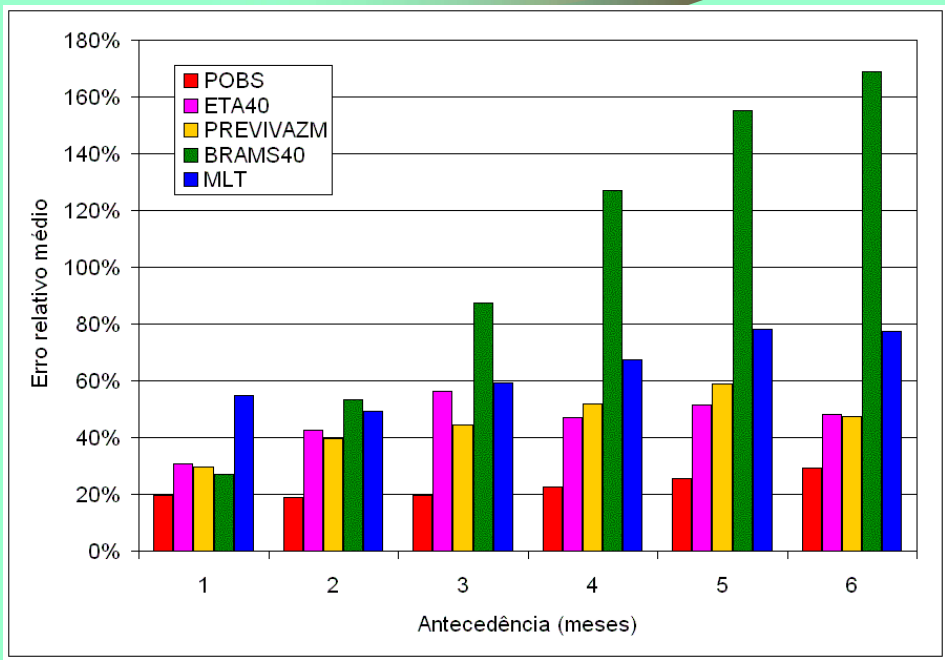


Downscale models: ETA and BRAMS

Três Marias



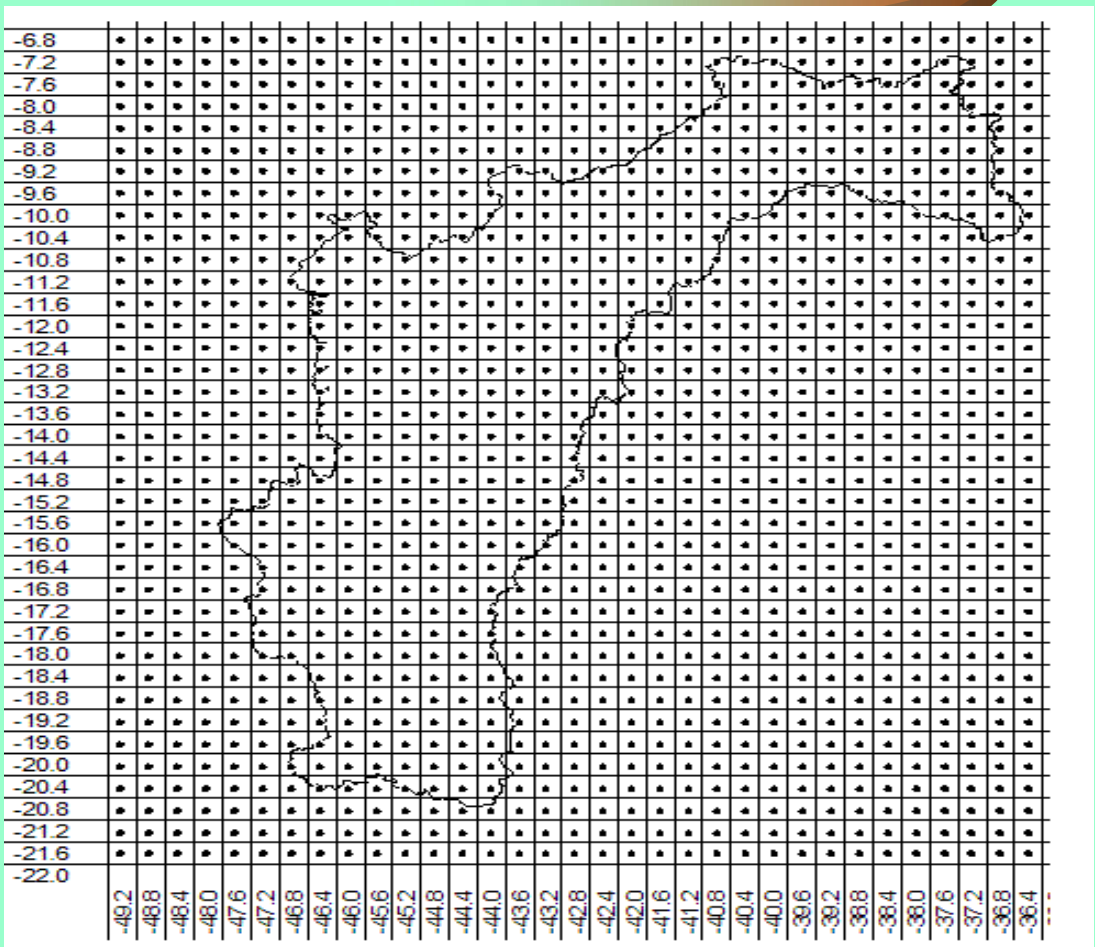
Sobradinho



Part of the total series: wet periods

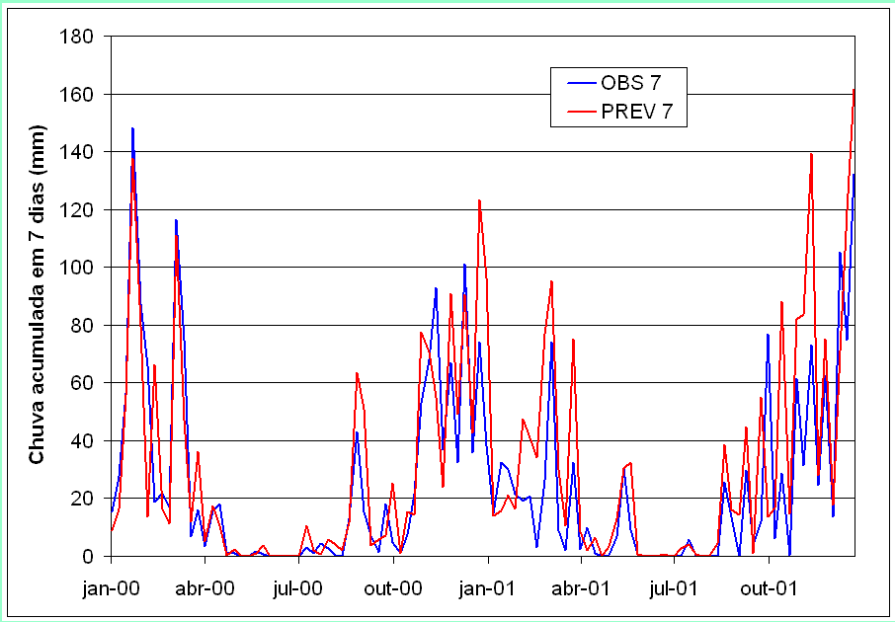
Short term Forecast in São Francisco

- ETA 40 + Hydrologic Model
- Lead time : two until four weeks



Rainfall forecasted lead of 1 week

Três Marias



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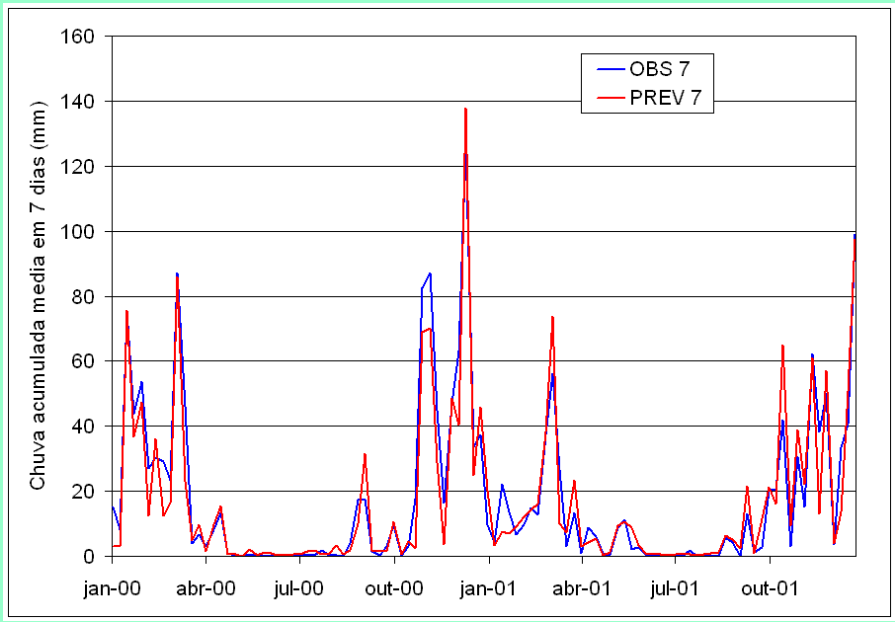
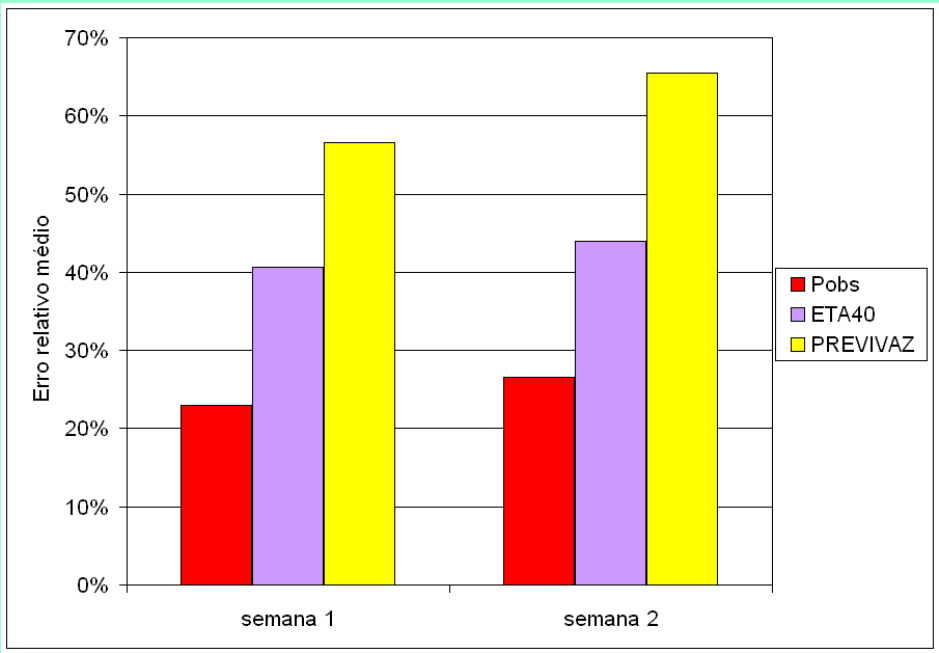


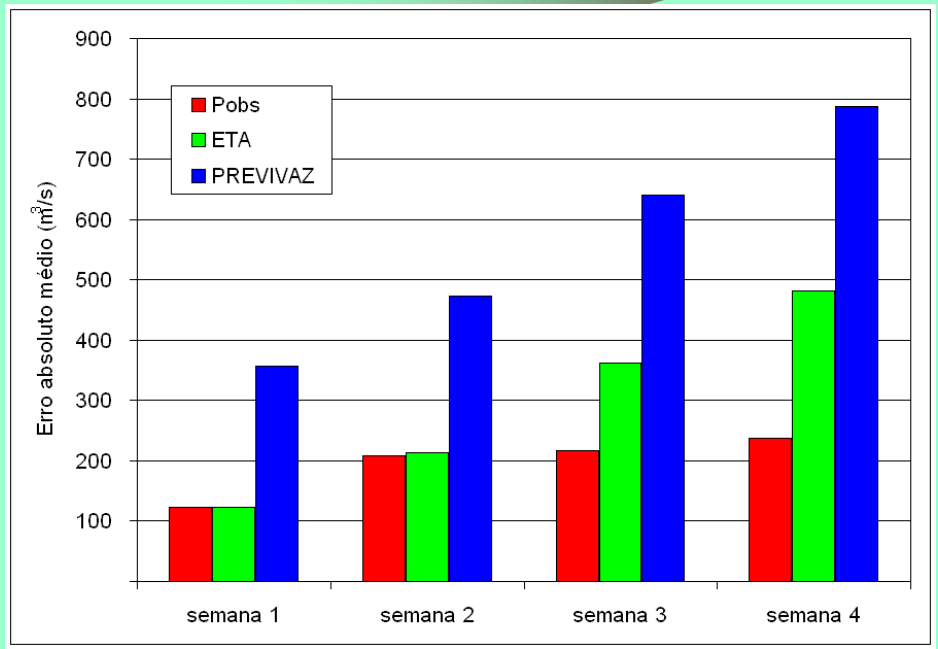
Accumulated values

Forecast errors

TRÊS MARIAS



SOBRADINHO



Conclusions

- In Uruguay River Basin we first learned that was possible to have to improve the existing long term forecasting, but we could not simulated the downscale and there were not updating in the hydrologic model;
- In São Francisco was possible to use de downscale, its result were good for rainfall (without correction) but could not improve the flow forecasting.
- Climate predictions on Southeast of the country is bad
- Short Term forecast showed good results.

Future Goals

- Rio Grande project - Improve the forecasting from downscale
- Operational implementation for short – term forecast in São Francisco and Rio Grande
- Use other climate models
- La Plata Basin modeling - GEF