



# **Relationship between Rainfall and Electricity Spot Prices in the Southeast of Brazil**

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# Objectives

- ❑ Investigate the relationship between prices and precipitation in the SE region of Brazil.
- ❑ Create a forecasting model based on precipitation data.



# The data

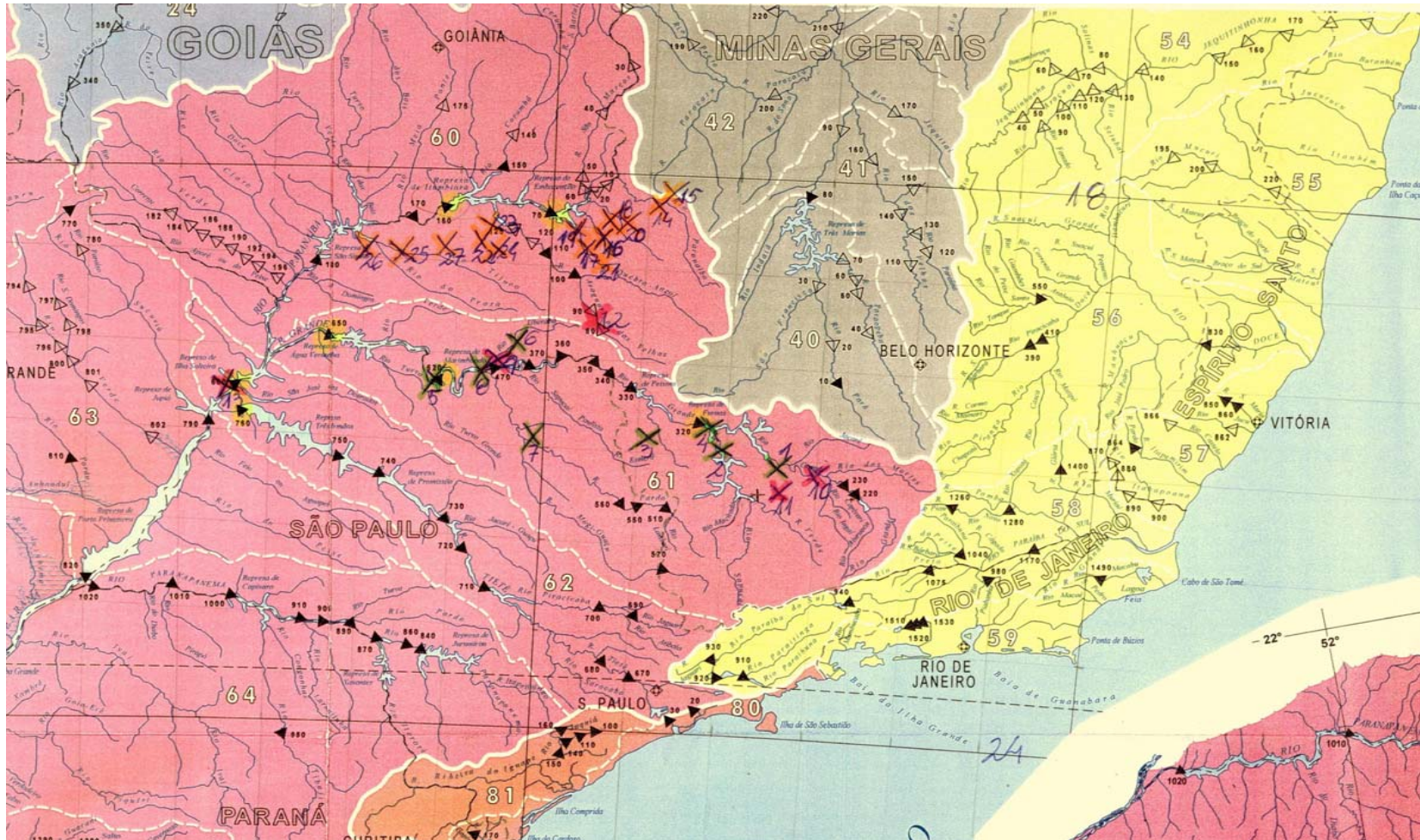
- ❑ **Monthly precipitation data on 28 measuring stations throughout the SE region of Brazil for the period between January 1995 and October 2001.**
  
- ❑ **Data Sources: Aneel (the regulatory agency for the electric sector in Brazil), Inmet (government sponsored climate institute) and Furnas (energy generator owned by the federal government).**
  
- ❑ **Stations were chosen with 2 major concerns:**
  - Proximity to large reservoirs**
  - Availability – whenever possible, public data sources were chosen (Aneel and Inmet)**

# Location of Measuring Stations



Estação	Latitude	Longitude	Fornecedor	Número
Boa Esperança	21:08S	45:57W	Furnas	1
Carmo	20:95S	46:15W	Furnas	2
Guapé	20:75S	45:92W	Furnas	3
Usina de Furnas	20:68S	46:28W	Furnas	4
Usina de Marimbondo	20:28S	49:18W	Furnas	5
Conceição das Alagoas	19:90S	48:39W	Furnas	6
Fazenda Bela Vista	20:90S	48:03W	Furnas	7
Usina Porto Colômbia	20:12S	48:57W	Furnas	8
Frutal	20:02S	48:56W	Inmet	9
Lavras	21:14S	45:00W	Inmet	10
Machado	21:40S	45:55W	Inmet	11
Uberaba	19:45S	47:56W	Inmet	12
Três Lagoas	20:47S	51:38W	Inmet	13
Rocinha	18:37S	46:92W	Hidroweb	14
Lagamar	18:18S	46:80W	Hidroweb	15
Monte Carmelo	18:72S	47:52W	Hidroweb	16
Estrela do Sul	18:73S	47:69W	Hidroweb	17
Abadia dos Dourados	18:49S	47:40W	Hidroweb	18
Cascalho Rico	18:58S	47:87W	Hidroweb	19
Coromandel	18:47S	47:19W	Hidroweb	20
Iraí de Minas	18:98S	47:46W	Hidroweb	21
Fazenda Cachoeira	18:70S	48:78W	Hidroweb	22
Tupaciguara	18:60S	48:69W	Hidroweb	23
Xapetuba	18:86S	48:58W	Hidroweb	24
Ituiutaba	18:94S	49:46W	Hidroweb	25
Ipiacu	18:69S	49:94W	Hidroweb	26
Avantiguara	18:77S	49:07W	Hidroweb	27

# Location of Measuring Stations



# Correlations – Log(Price) and rainfall



	LOG CMO SOUTHEAST
LOG CMO SOUTHEAST	100.00 %
Zc: B Esperança	-0.02 %
Zc: Carmo	-1.64 %
Zc: Guapé	-6.39 %
Zc: Us. Furnas	-7.83 %
Zc: Conc. das Alagoas	-4.41 %
Zc: Fz. Bela Vista	-6.38 %
Zc: Us. Marimbondo	1.00 %
Zc: Usina Porto Colombia	-6.83 %
Zc: Frutal	-12.79 %
Zc: Lavras	-1.78 %
Zc: Machado	-4.60 %
Zc: Uberaba	0.10 %
Zc: TLagoas	-4.79 %
Zc: Rocinha	-8.26 %
Zc: Lagamar	-5.52 %
Zc: Monte Carmelo	6.66 %
Zc: Estrela do Sul	4.10 %
Zc: Abadia dos Dourados	-3.63 %
Zc: Cascalho Rico	2.18 %
Zc: Coromandel	-7.58 %
Zc: Iraíde Minas	4.64 %
Zc: Fazenda Cachoeira	-4.11 %
Zc: Tupaciguara	-4.96 %
Zc: Xapetuba	-8.76 %
Zc: Ituiutaba	-3.35 %
Zc: Ipiaçu	-2.99 %
Zc: Avantiuara	-3.47 %



# Model Considerations

- ❑ Let  $t$  denote the current time period, so that  $t - 1$  and  $t - 2$  refer to the previous month and two months ago
  
- ❑ We'll fit a model with the following structure:
- ❑ **Dependent Variable:  $\log(\text{Price}(t))$**
- ❑ **Explanatory Variables**
  - ❑  $\log(\text{Price}(t-1))$
  - ❑ ***Standardized* Precipitation** at different measuring points at times  $t$ ,  $t - 1$  and  $t - 2$



# Model Considerations

- ❑ **Why use standardized rainfall?**
  - ❑ **To keep all variables on “equal footing”;**
  - ❑ **What should really matter is whether or not it rained a lot, but not the actual amount of rain;**
  - ❑ **Thus, we standardize all precipitation values (to have mean zero and std. deviation one) before using them in any model.**





# Model 1

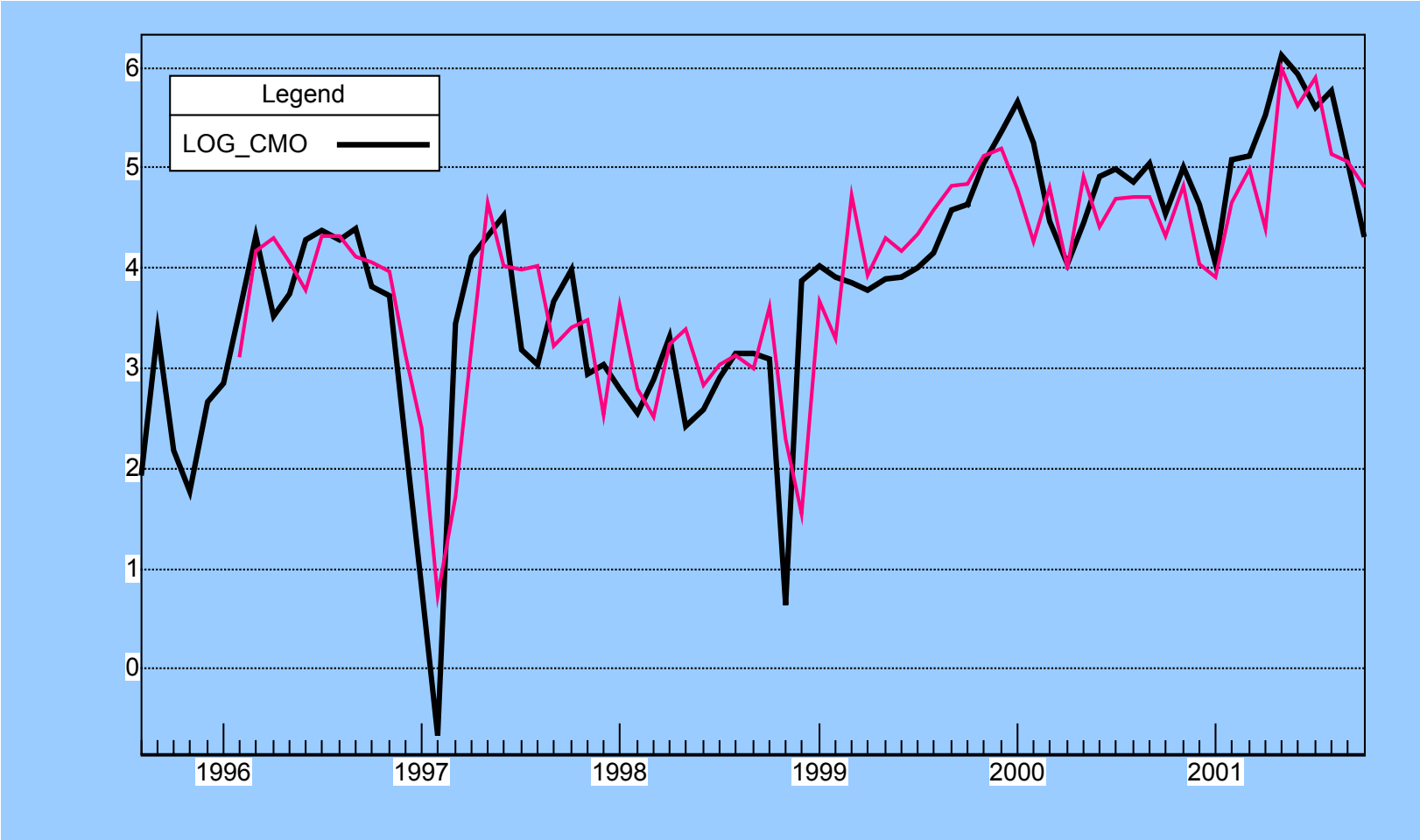
## □ Structure and Coefficients

□ Constant	0.8233
□ Log Price (t-1)	0.7852
□ Xapetuba (t-2)	0.5265
□ Uberaba (t-1)	-0.5613

□  $R^2 = 67\%$

□  $MAPE = 21.2\%$

# Model 1 Fit (in sample)



# Why include these measuring stations?

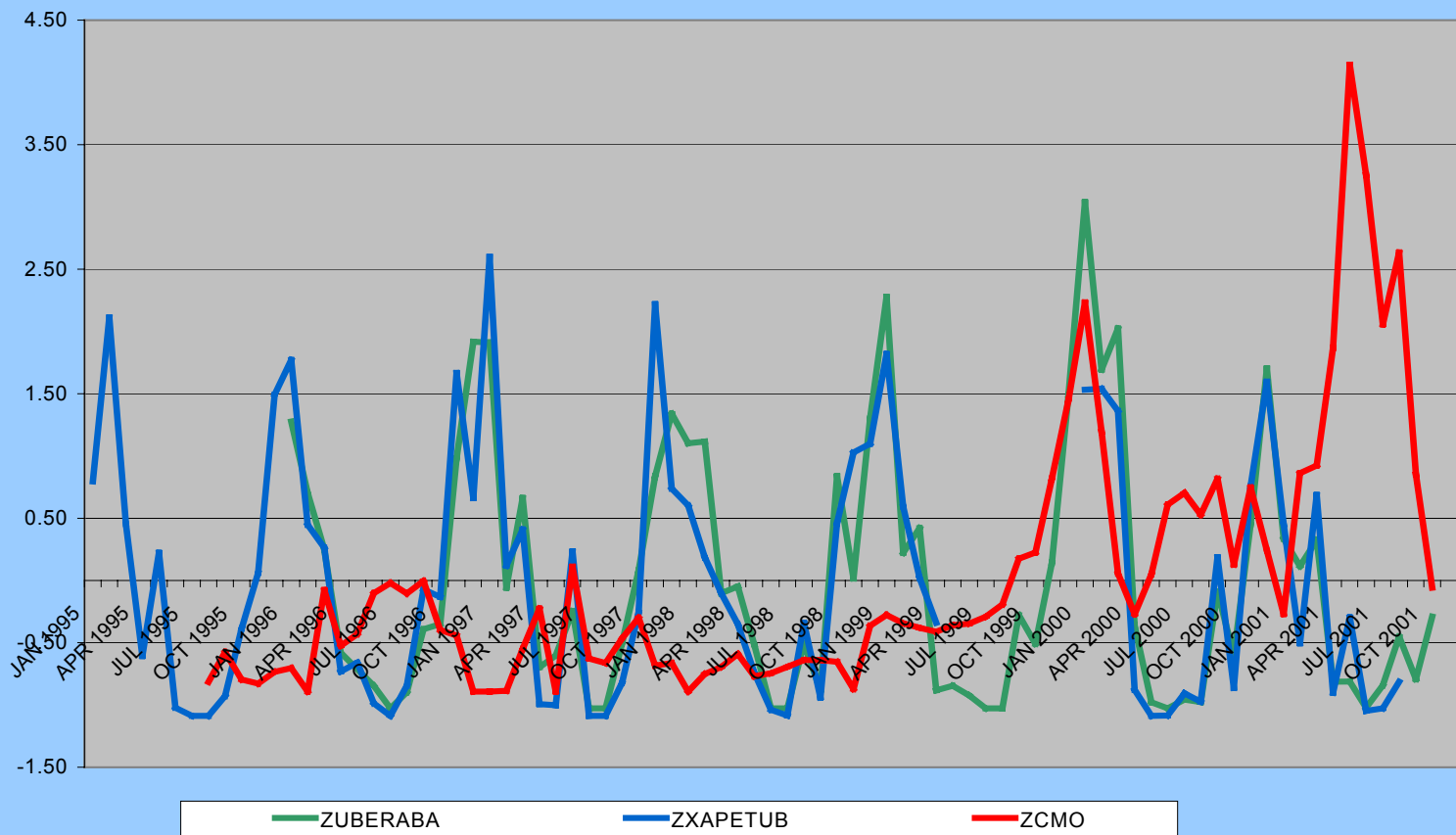


- ❑ **Some dramatic rainfalls!**
- ❑ **On the next graph we present the standardized rainfalls for Xapetuba and Uberaba stations – note some values above 3 standard deviations during the wet season (December to March).**

# Standardized Rainfalls



CMO, Uberaba and Xapetuba - Standardized Variables





# Conclusions

- ❑ **Can precipitation provide information about spot electricity prices in Southeast Brazil? YES!**
- ❑ **The proposed model has a very simple structure and can be used in forecasting BUT... Most of its the explanatory power comes from the AR component (previous month price).**
- ❑ **However, the proposed model can serve as a first guess when trying to forecast next month's spot price, since currently electricity prices in Brazil are generated by a complex optimization model, that requires several hours to run in a top quality PC.**



## Further Steps

- ❑ **Cluster similar measuring stations, to try to combine their informations.**
- ❑ **The question that remains is: will the clusters have better predictive ability than individual stations?**