Proceedings of 8 ICSHMO, Foz do Iguaçu, Brazil, April 24-28, 2006, INPE, p. 835-840.

RUN OFF PROPERTIES OF EXTREME DISCHARGES ON PARANA AND URUGUAY RIVERS.

Walter Vargas
Department of Sciences of the Atmosphere and the Oceans, School of Exact and Natural Sciences, UBA, CONICET
vargas@at.fcen.uba.ar
Susana Bischoff
Department of Sciences of the Atmosphere and the Oceans, School of Exact and Natural Sciences, UBA
bischoff@at.fcen.uba.ar

Abstract

Climate variability in different spatial scales is a study area which has reached interest in application, especially during de last years. River discharges can be considered as a robust integrator of the properties of the basin; under these premises the goal of this work is to analyze flows from the Paraná and Uruguay rivers in several gauge stations and study the behavior of positive and negative anomalies and their extremes. The variable to be analyzed was defined as the number of anomalies with the same sign per year. Results show that the structures are different for both rivers, which implies a different stochastic process. Identical representativeness was found between the anomaly series in each river. The risk estimation of extremes in both rivers indicates that it is possible to establish a decision model. The series of annual number of anomalies presented a climatic jump 1970's in both rivers.

1. Introduction

The climate variability at different spatial scales is an area of study that has gained interest mainly during the last years. One of ways to measure the climate variability is from the runoff data since these can be considered as a sound integrator of the properties of the drainage basin. (Rickey et al (1989), Conway and Hulme (1993)).
The objective of this work is to analyze the streamflow series of Paraná and Uruguay rivers in several gauging stations for each river and study the behavior of the monthly negative and positive anomalies, and their extreme values in order to find out transference functions of both rainfall and discharge. Another objective is to estimate the homogeneity and representatives of the measurements over one river itself and over both rivers jointly and assess the joint risks in extreme situations. A more general goal of the work line is to diagnose extreme minimum and maximum streamflows. As a pilot example of the potential relation between the functions of peak flows and precipitation, in Vargas, Bischoff (2000) it was analyzed the compatibility of the models that adjust the properties of the monthly rainfall and streamflows. In some other way, even though it is not unknown that one or two gauging stations do not necessarily represent what happens in the basins since there is some anisotropy, the potential relationship with some precipitation reference stations is estimated.
In prior studies it was demonstrated that the number of monthly precipitation anomalies per year can be adjusted to a Binomial distribution, which does not apply to streamflow-related anomalies.

2. Data

The information used corresponds to mean monthly flows, measures in four gauging stations at the Paraná river and four at Uruguay river. The utilized station with its respective locations and information records are shown in table 1.
Data were provided by Water Resources (Hydrological statistics). Monthly precipitation data were also used in one station of the basin mentioned in Table 2

Gauge station	River	Start year	End year	Latitud	Longitud
Santo Tomé	Uruguay	1908	1998	-28.50	-56.01
Monte Caseros	Uruguay	1908	1989	-30.25	-57.63
Paso de los Libres	Uruguay	1908	1988	-30.72	-57.07
Concordia	Uruguay	1898	1998	-31.30	-58.01
Posadas	Paraná	1901	1990	-27.37	-55.97
Itatí	Paraná	1911	2000	-27.28	-58.24
Corrientes	Paraná	1904	2000	-27.45	-58.82
Túnel	Paraná	1904	1994	-31.70	-50.51

Table 1: Gauging stations of Uruguay and Paraná rivers.

Estación	Año Inicio	Año Fin	Latitud	Longitud
Posadas				

Table 2: Posadas precipitation station.

3. Methodologies and data management

For both flow and precipitation were calculated the monthly anomalies in terms of the monthly mean of the whole available record . Thus, most part of the influence of the yearly wave was eliminated. The lacking months were written off the series.

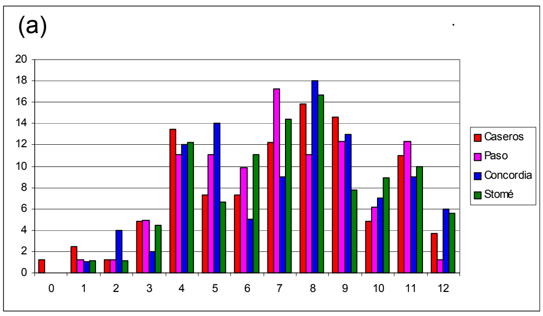
Positive and negative anomalies, defined as extreme maximum and minimum value, were those which were over the seventh and below the third decile respectively.

The quantity of anomalies of the same sign per year was defined as a variable to be analyzed.

4. Results and conclusions

4.1. *Frequency of anomalies per year*

For each one of the gauging stations the number of positive and negative anomalies per year (independently) was calculated. Figure 1 shows the frequency in percentages of the negative anomalies and Figure 2 shows the positive anomalies for (a) Uruguay river and (b) Paraná river



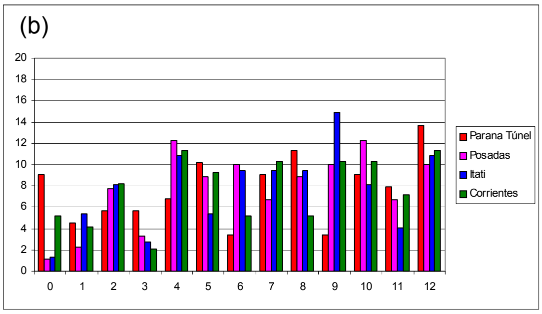
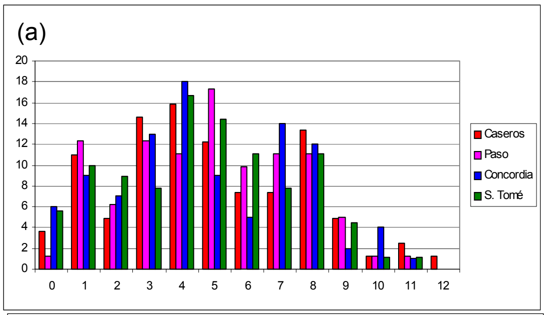


Figure 1: Frequency in percentage of the negative yearly anomalies in the River Uruguay (a) and River Paraná (b)



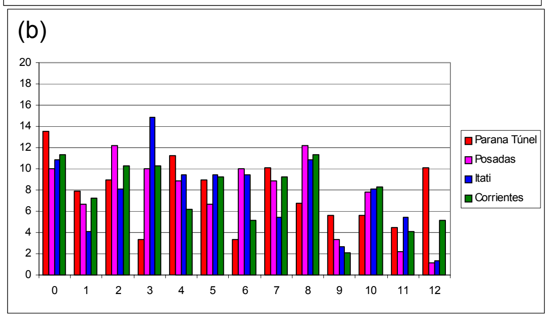


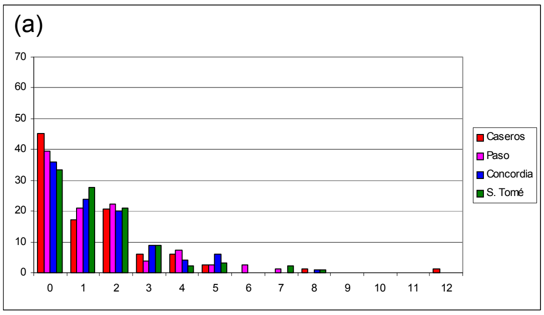
Figure 2: Frequency in percentage of the positive yearly anomalies in the Uruguay river (a) and Paraná river (b)

As from results shown in figures 1 and 2 it can be stated that at a starting point the gauging stations selected for each river have similar statistical structures in terms of the occurrence of both, positive and negative anomalies, in their own courses. One exception is the Túnel gauging station on the Paraná river. For positive as well as for negative anomalies we can see that for the Uruguay river the structure is of a very distinctive main maximum and two secondary maximums. At Paraná river the structure gets less defined, but yet two or three peaks with a similar percentage of frequencies can be noticed. This implies different stochastic processes for the flow series of each river. On the other hand, it is clear that the asymmetry of the distributions depends on the sign of the anomalies. It can be observed smaller frequencies for low values of the variable in the negative anomalies and the other way around for the positive anomalies for both rivers.

Regarding the monthly precipitation anomalies, the distribution has one only maximum and perfectly fits to a binomial distribution. In terms of the flows, the presence of more than one maximum does not allow for them to adjust to this model.

4.2. *Extreme anomalies*

It is worth to ask, considering the work line, if these structures stand for the extreme anomalies defined in Vargas, Bischoff (2000). In figures 3 and 4 are shown the histograms of the extreme negative and positive anomalies in the Uruguay river (a) and in the Paraná river (b), respectively.



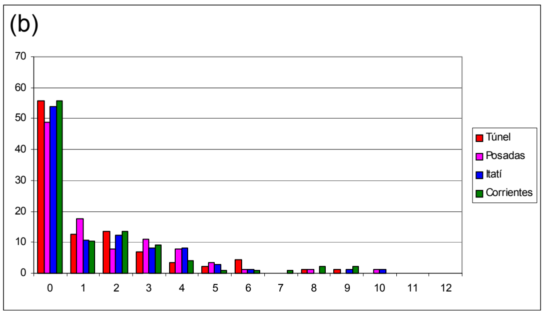


Figure 3: Frequency in percentage of negative extreme anomalies per year in the Uruguay River (a) and the Parana River (b).

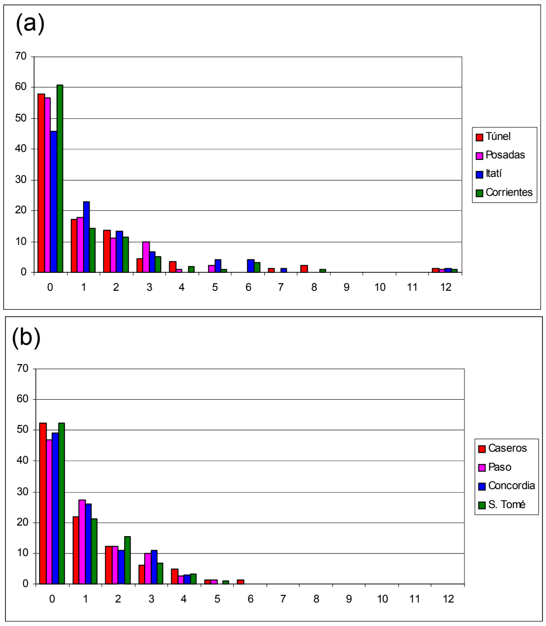


Figure 4: Frequency in percentage of positive extreme anomalies per year in the Uruguay River (a) and the Parana River (b).

It can be observed on the basis of these figures that the model that fits the extreme anomalies changes significantly regarding the one of the general anomalies. In this last case both flow series show an empirical distribution of the decreasing exponential type. However, some differences are seen:

Upon comparison of the models for both rivers, we can see that the drop of the frequencies of zero month per year, for any sign of anomaly, at an anomalous month per year for the gauge stations on the Uruguay river, is smoother than for the Paraná river. The decrease of the frequency per year is slower in the Uruguay River that in the Paraná river.

In physical terms this would indicate that the Paraná river has a greater inertia to produce greater number of anomalous months along the year than the Uruguay river.

Up to here it was possible to be observed that the extreme anomalies in the different water gauge stations behave coherently in terms of annual frequencies. This implies that any gauge station can represent the streamflow regime on the river.

4.3. *Analysis of the partial spatial coherence*

In order to complete the verification of the homogeneity of the structures of the anomalies of each river and to consider the spatial and temporal coherence, the correlations between the series of anomalies of monthly streamflows were calculated. Tables 2 and 3 respectively show cross correlations for the complete series of anomalies between the gauge stations in the river Uruguay river and the Paraná river.

	S. Tomé	Caseros	Paso	Concordia
S. Tomé	**1.00**	**0.91**	**0.95**	**0.89**
Caseros	**0.91**	**1.00**	**0.98**	**0.98**
Paso	**0.95**	**0.98**	**1.00**	**0.97**
Concordia	**0.89**	**0.98**	**0.97**	**1.00**

Table 2: Cross correlations of the series of anomalies between water gauge stations of the Uruguay river. The colored values are significant at 5%.

	Posadas	Itati	Corrientes	Túnel
Posadas	**1.00**	**0.83**	**0.93**	**0.75**
Itati	**0.83**	**1.00**	**0.84**	**0.79**
Corrientes	**0.93**	**0.84**	**1.00**	**0.89**
Túnel	**0.75**	**0.79**	**0.89**	**1.00**

Table 3: Cross correlations of the series of anomalies between water gauge stations of the Paraná river. The colored values are significant at 5%.

It is possible to observe that in spite of being all the significant correlations, these are greater for the river Uruguay. In other terms, this would imply a greater homogeneity in the streamflow of this river. This can be due to the greater importance of the tributaries and water drainage in the Parana river than in the Uruguay.

We can say as from these results, that in principle any of the series of gauging stations represents satisfactorily the behavior of the anomalies in the whole river basin.

4.4. *Joint risk of the extreme anomalies*

For the estimation of joint risk of anomalies of extreme volumes necessary for decision models on operation, modification and construction concerning water resources- it was considered the joint probability of low water occurrence and monthly excesses for a variable number of stations in each one of the rivers.

Tables 4 and 5 show the frequency in percentage of the relation between minimum and maximum streamflow in both rivers respectively. The relation is calculated for 0 to 4 stations in each one of the rivers.

Minimum streamflow events:

PARANÁ \ URUGUAY	0	1	2	3	4
0		**9.7**	**3.0**	**4.0**	**12.0**
1	**10.4**	**0.3**	**0.3**	**1.0**	**3.0**
2	**9.0**	**0.7**	**0.7**	**1.3**	**1.0**
3	**9.4**	**1.7**	**0.3**	**0.3**	**4.3**
4	**15.4**	**1.3**	**1.0**	**1.0**	**8.7**

299 casos

Table 4: Minimum streamflow frequency in percentage for 0 to 4 water gauge stations in both rivers.

Maximum streamflow events:

PARANÁ \ URUGUAY	0	1	2	3	4
0		**6.9**	**4.0**	**8.4**	**12.9**
1	**13.9**	**1.5**	**1.5**	**2.0**	**2.5**
2	**6.4**	**0.0**	**0.5**	**1.0**	**4.5**
3	**11.4**	**2.0**	**1.0**	**2.5**	**7.4**
4	**5.9**	**1.0**	**0.0**	**1.0**	**2.0**

202 casos

Table 5: Maximum streamflow frequency in percentage for 0 to 4 water gauge stations in both rivers.

For minimum streamflows, the simultaneous occurrence in both rivers is not more probable than the joint maximum streamflow .
In the case of the maximum streamflows the probability of having the same condition in river Parana river and minimum streamflows in the Uruguay river diminishes substantially.

4.5. *Temporal variability of the annual frequencies of positive anomalies*

Among the most important variabilities operated in these river basins can be distinguish those of low frequency in the series of volumes and precipitation or their anomalies in the form presented in this work.

In figures 5, 6 and 7, which show the annual variation of quantity of streamflow monthly positive anomalies per year in the Uruguay river, Paraná river and of the annual precipitation in the station Posadas respectively. The located climatic jump around 1970 (more clearly defined in the river Paraná) and in the rainfall anomalies at the Posadas station can be seen. This causes that in many cases the estimation of the trends in these long series provide as a result an increase of streamflows and precipitation in this region.

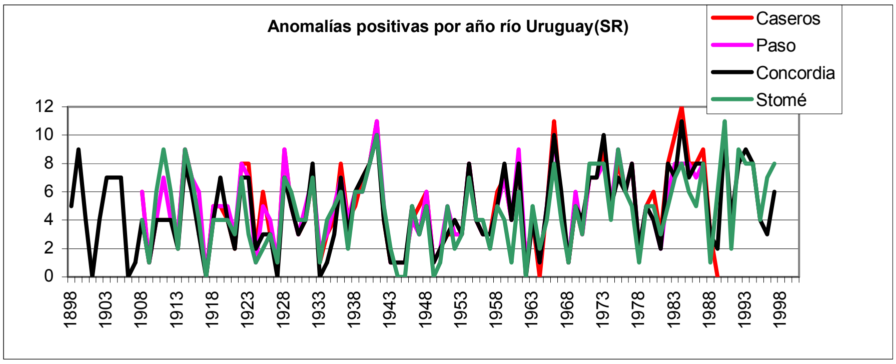


Figure 5: Interannual variability of the positive anomalies frequency, Uruguay river.

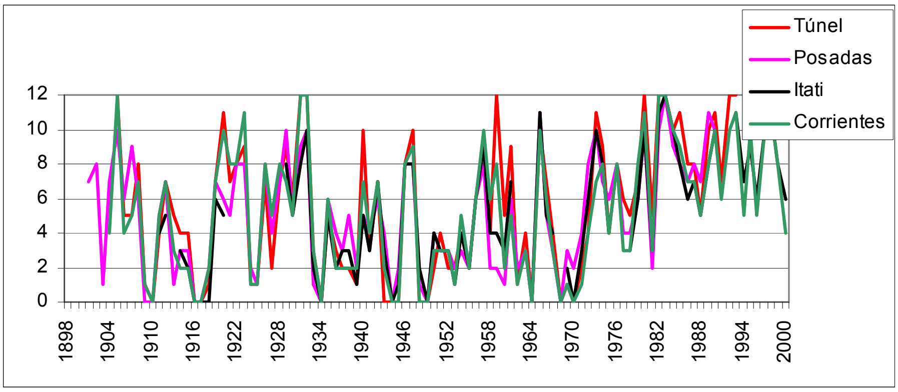


Figure 6: Interannual variability of the positive anomalies frequency, Paraná river.

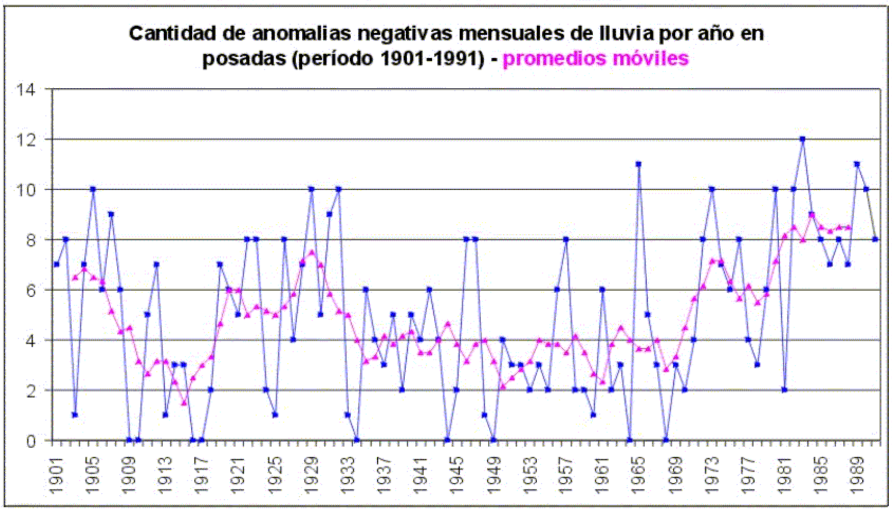


Figure 7: Interannual variability of the positive anomalies frequency, Posadas station.

5. *Conclusions*

It is shown that the water gauge stations of the River Uruguay and Parana are coherent in the behavior in their own course, still in properties of the extremes as it is analyzed in this work. Therefore a model of synthesis of samples and/or series of volumes can be representative of the river basin using the information of a single station. An exception to this could be the Túnel gauging station on the River Paraná. The structure of the properties of the studied anomalies of any sign shows us different regimes in both rivers. In addition, the asymmetry in the distributions indicates that the number of positive and negative anomalies per year present frequencies inverted in the low values (1 to 3 months) and in the high values (10 to 12 months). However, when the studied properties refer to extreme anomalies both rivers present the same type of distribution (decreasing exponential) that on the other hand is identical to spell anomaly distribution (not shown here). This implies that for the extreme anomalies both rivers have the same regime interpreting it based on climatic processes, their scale in this case would be greater than the size of each river basin or would include them altogether.

Yet, the simultaneity of minimum streamflow and/or maximum shows that they are capable to happen in a river basin and not in the other, which confirms that the dominant processes in both river basins do not always have the same scale. From the point of view of the low frequencies both rivers show in this property a jump in the by the 1970s, fact that is also confirmed by what happens in the precipitation in a station that would represent aspects of both river basins.

Special thanks:
The making of this work was funded by projects X095 and X234 of the University of Buenos Aires and the Project PICT 26094/2004.

Bibliography:

Rickey, J. E.;C. Nobre and C. Deser (1989): Amazon river discharge and climate variability: 1903-1985. Science, 246, 101-103.

Conway D. And Hulme M. (1993): Recent fluctuations in precipitation and runoff over the Nile subbasins and their impact on main Nile discharge. Climatic Change, 25, 127-151.

Sneyers,R. 1975: Sur l' analyse statistique des series d' observations. Technical note N 143, OMM, pag 87-100

Walter Vargas- Susana Bischoff (2000). Comparison between the statistical structures of rainfalls and volumes of the Uruguay river basin, XICongreso Brasileiro de Meteorologia. October 2000 Rio de Janeiro.