The hydrological processes in the Rio de la Plata basin

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The Rio de la Plata basin (La Plata basin) in South America comprises the Paraná, Paraguay and Uruguay rivers. It covers about 3.6 H 10^6 km^2 and spreads over five countries, where about 50% of their combined population lives. Approximately 46% of the basin's surface is in Brazil, 30% in Argentina, 13% in Paraguay, 7% in Bolivia, and 4% in Uruguay. The basin is important in different ways for the regional economies; about 70% of the total GNP of the five countries combined is produced within the basin. Firstly, harvests and livestock are among the region's most important resources. Secondly, the rivers are natural waterways and ground transportation has greatly increased in recent years due to the integration of regional economies. Thirdly, several hydroelectric plants provide energy to the region, and, in fact, 92% of the energy produced by Brazil depends on hydroelectric resources. Finally, the rivers of the basin are the water resource for one of the most densely populated regions of South America.

The VAMOS implementation plan for the Monsoon Experiment in South America (MESA) has a particular interest in the water cycle and regional water resources. Within MESA, the study of the South American Low-level Jet (LLJ) seeks to understand its role in moisture transports and associated hydrological processes (Mechoso 2000). In a second stage, MESA will target the climatology and hydrology of the La Plata basin.

This note discusses basic features of the La Plata river discharge, and contrast them with those of the Mississippi River. Such a comparison is of interest in view of the intense research that has been devoted to the latter; both basins are about the same size and it is expected that the experience gained in studies of the Mississippi's hydrologic cycle could greatly help to better understand La Plata's. The same reasoning motivates the American Low-level Jets (ALLS) project, since the two basins have an important inflow of moisture from the tropics/subtropics through poleward LLJs east of a mountain barrier (the Rockies for the Mississippi River basin and the Andes for the La Plata basin). On the other hand, it is also important to identify differences that will require special research. For instance, despite the overall similarities, the Great Plains LLJ has marked differences with its South American counterpart, both in structure and seasonal cycle (see, e.g., Noguϑs-Paegle and Mo 1997; Berbery and Collini 2000). Further details are discussed in Noguϑs-Paegle and Berbery (2000). Concerning river discharge, it is crucial to investigate the main contributors to its seasonal cycle and variability.

The Mississippi River discharge (Figure 1a) has a well defined seasonal cycle with a maximum of about 25,000 $m^3\ s^{-1}$ during spring (March-April-May); this maximum is the result of snow melting in the northern parts of the basin, with an additional contribution by springtime precipitation associated with convective activity that develops over the Great Plains. The minimum river discharge (of about 8,000 $m^3\ s^{-1}$) occurs towards the end of the boreal summer and autumn, when the contribution from ice melting has decreased significantly. An additional factor for the reduced river discharge may be the result of the development of the North American monsoon system: when precipitation over northwestern Mexico increases (usually at the beginning of July) that over the Great Plains decreases (Douglas and Englehart 1996; Higgins et al. 1997; Barlow et al. 1998).

The La Plata River discharge (the combined discharge of the Paraná/Paraguay and Uruguay rivers) presented in Fig. 1b is fairly uniform around the year, with typical values of about 20,000 $m^3\ s^{-1}$. There is a slight discharge increase from February to July (late austral summer and autumn). However, the analysis of the discharge for each of the subbasins (Fig. 1c) shows that in fact the Paraná and Uruguay rivers each have well defined seasonal cycles, but that their peaks are out of phase: the Paraná river has a maximum in late austral summer while the Uruguay river has largest discharge (although of smaller magnitude) between June and November.

Figure 2 presents the mean seasonal cycle of river discharge and the historical maximum and minimum for each month (based on monthly time series during 1932-1998 for the Mississippi River and 1904 –1993 for the La Plata River). The potential for flooding of the Mississippi basin (Fig. 2a) as revealed from these historical maxima is during the first half of the year, concurrent with the mean maximum of the annual cycle. On the other hand, Fig. 2b shows that flooding in the La Plata basin may occur at any time of the year, with largest values during austral winter. [Although not shown here winter maxima tend to be associated with El NiZo episodes, as those during 1982/1983 and 1997/1998.] The Uruguay River discharge, while usually small in comparison to the Paran< river, can in some cases achieve values that are as high as the Paraná mean discharge.

The main aspects of the river discharge are summarized in Table 1: The La Plata River has a large mean annual discharge (larger than the Mississippi River), and its potential for flooding is present at any time of the year (with a maximum in winter). Moreover, floods can cover large areas due to the flat terrain that characterizes the region. These remarkable features strongly suggest the need for more detailed studies of the La Plata basin. Indeed, the new challenge ahead is to increase our understanding of the regional climate and hydrology, in order to develop the capability to perform seasonal to interannual forecasts that include the water resources.

References

Barlow, M., S. Nigam, and E. H. Berbery, 1998: Evolution of the North American Monsoon System. *J. Climate*, **11**, 2238-2257.

Berbery, E. H., and E. A. Collini, 2000: Springtime precipitation and water vapor flux over southeastern South America. *Mon. Wea. Rev*., **128**, 1328-1346.

Douglas, A. V., and P. J. Englehart, 1996: Variability of the summer monsoon in Mexico and relationships with drought in the United States. *Proceedings of the 21 Annual Climate Diagnostics Workshop*. Huntsville, Alabama, October 28 - Nov 4, 1996.

Higgins, R. W., Y. Yao, E. S. Yarosh, J. E. Janowiak, and K. C. Mo, 1997: Influence of the Great Plains low-level jet on summertime precipitation and moisture transport over the central United States. *J. Climate*, **10**, 481-507.

Mechoso, C. R., 2000: Introduction to VAMOS. *Exchanges*, No 16.

Noguϑs-Paegle. J., and K.-C. Mo, 1997: Alternating wet and dry conditions over South America during summer. *Mon. Wea. Rev.*, **125**, 279-291.

Noguϑs-Paegle. J. , and E. H. Berbery, 2000: Low-level Jets over the Americas. *Exchanges*, No 16.

Table 1

	Mississippi River	**La Plata River**
Area	3.1 H10^6 km^2	3.6 H10^6 km^2
Mean annual discharge	17,100 m^3 sec^{-1}	21,400 m^3 sec^{-1}
Maximum river discharge/ Time of year	27,200 m^3 sec^{-1} April	23,970 m^3 sec^{-1} June (and several other months)
Minimum river discharge/ Time of year	8,350 m^3 sec^{-1} September	18,350 m^3 sec^{-1} September
Historical Maximum/ Timing	55,000 m^3 sec^{-1} Spring	72,000 m^3 sec^{-1} Winter