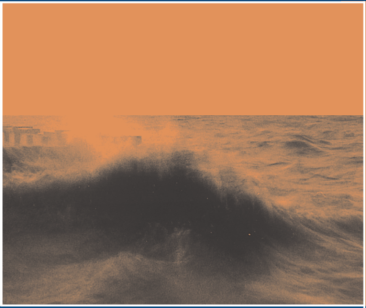
CLIMATE CHANGE IN THE LA PLATA BASIN



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Project
SGP II 057: ¨ Trends in the hydrological cycle of the Plata basin:
Raising awareness and new tools for water management ¨
of the INTER AMERICAN INSTITUTE ON GLOBAL CHANGE (IAI)

CHAPTER II

LA PLATA BASIN CLIMATOLOGY

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ABSTRACT

The hydrologic cycle of the La Plata basin is influenced by the South Atlantic High, which reaches greater intensity near the continent during winter. This system is responsible for the atmospheric moisture flow from the Atlantic Ocean over the coastal ridges of Brazil, and favors the southward flow in the central part of the continent. In this region, there is sometimes low level flow of water vapour from the Amazon region

The other regional atmospheric configurations of importance, the Bolivian High, the Chaco Low, the South Atlantic Convergence Zone, the Low Level Jet, the Meso Convective Systems and the Westerly Circulation, are succinctly described, along with their influences on weather and climate.

The general features of the precipitation field are described using modern data sets. There are two well defined rainfall regimes. One, north of the 20º, with summer rainfall, associated to the monsoon system, and a second with more uniform annual distribution to the south. The overall average of the basin is of 5.5 mm/day during the warm season and it is lower than 2 mm/day in June.

From north to south and from east to west, can be identified seven large climatic areas: the Monsoon Region in the Pantanal and in the north of the Upper Paraná basin, the Great Chaco, the east of Paraguay, the Planalto and the southern Rio Grande ridges, the Argentine Litoral, the eastern part of Uruguay and southern Rio Grande, and the southern and western edge of the La Plata basin. For each one of them, it is described the annual cycle of precipitation and temperature.

2.1. Introduction

The atmospheric circulation over the La Plata basin and bordering areas has a noticeable seasonality, which leads to a significant signal in the annual cycle of the determinant climatic elements of the hydrological cycle. The main centre of action on the atmospheric over the basin is the South Atlantic High semi permanent pressure system, with its subsiding and anticyclonic circulation. One of the main characteristics of this system is that it reaches greater intensity in Winter than in Summer (Prohaska 1976), contrary to what happens with most of the maritime subtropical anticyclonic systems in the planet. A branch of the associated circulation is responsible for the humidity advection over the coastal ridge mountains in Brazil (Marengo et al. 2004), where are located the sources of the most important tributaries of La Plata, with the exception of River Paraguay. It is also of first degree the system's displacement to the North and its penetration over the continent during winter so determining the dry season of all the tropical and subtropical regions of the basin.

In the low troposphere, the most important feature of circulation is that the predominant meridional component is from the North all year long, especially in winter *(Fig. 2.1)*. In the mid troposphere, the West Circulation dominates over most of the basin, since on one hand during Winter the Anticyclone is more to the North, and on the other it shifts to the South of 35ºS in Summer, but its wet border is more to the East over the ocean.

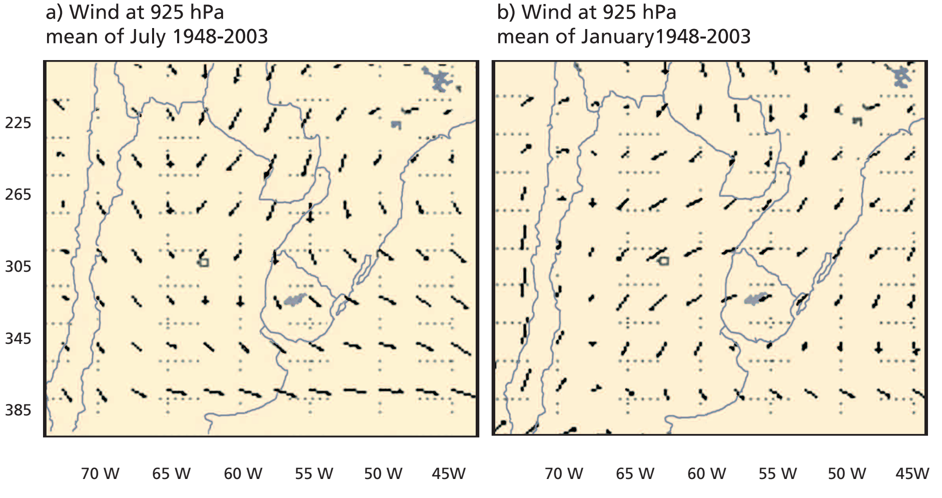

Fig. 2.1. *Predominant winds in the (a, b) low and (c,d) middle troposphere, for the central months of both warm and cold seasons.*

[NCAR/NCEP reanalysis (http://www.cdc.noaa.gov)].

Within the aforementioned seasonality, there is the Summer development of the low pressure system of Chaco, the intermittent termal-orographic depression of the Argentine Northwest, present all along the year but more intense during Summer, as well as the South Atlantic Convergence Zone (Kodama 1992), and the Bolivia High. The last is a circulation patter that appears in the high troposphere during the warm season. It establishes every year in September, together with the displacement of the nucleus of the tropical continental convection, from the North of South Amazon to the South. Its divergent flux at high levels is linked to abundant rainfall in the Highland (altiplano) itself and in the Northeast region of the La Plata basin, in the counterforts of River Paraguay (Lenters and Cook 1995). It is complemented over the tropical Atlantic by the called zonal wave of monsoon characteristics (Chen et al. 1999; Nogués-Paegle at al. 2002). The Bolivia High is a hot nucleus anticyclone, generated, among other causes by regional forcings: the radioactive heating in the Highlands, and the liberation of latent heat itself in the intense convection of the Amazon. This configuration, pertaining to the summer term, at the core of summer (January) is usually centred just at the West of the Titicaca Lake (Figueroa et al. 1995).

The South Atlantic Convergence Zone (hereinafter referred to as SACZ), is also a summer configuration (October-March). It is a convective complex that extends to the Southeast from the main nucleus of the continent summer convection in the centre of Amazonia. Its mean and characteristic location is around 20ºS, continuing over the ocean up to latitudes close to 45ºS (Gusmão de Carvalho y Gandu 1996). This system has pulses in intensity and position related shifts (Barros et al. 2000; Barros et al. 2002). The SACZ shows periods (Nogués-Paegle and Mo 1997; Barros et al. 2002; Nogués-Paegle at al. 2002) similar in time scale to the West perturbations, but also has important variations within the season, causing the intensity of rainfall to fluctuate from North to South on the strip that occupies over the continent, most of which belongs to La Plata basin (Díaz et al 1998; Barros et al. 2002). Casarin and Kousky, back in 1986, determined that the drought events in the South region of Brazil are linked to a weakening of the SACZ at an interseasonal scale. Thus, it is possible to distinguish two SACZ leading position patterns, with different behaviours (Barros et al. 2002), which are related with anomalies in the rainfall at the South of its location. These patterns can be considered as extreme positions. In the first pattern the SACZ has a position that cuts the coastal line more to the North than 20ºS. It has a very intense convective activity and heavy rainfalls over the SACZ itself (Barros et al. 2002) and likely, due to a subsidence compensating phenomenon it is associated to negative anomalies in the precipitation on the South extreme of Brazil, South of Paraguay, Uruguay and Northeast of Argentina (Robertson y Mechoso 2002). In the second circulation pattern, the SACZ takes a more southerly position, with its intersection with the coast over the State of Sao Paulo. It has a weaker convection over the system, with smaller rainfalls than normal. Rainfall positive anomalies are then located in the same zone where in the other pattern appeared the negative ones.

Deeper inside the continent, over the slope extending from Chaco to Los Andes mountain range, there is a summer low pressure system: the Chaco Low. Due to its thermal nature, its development rarely involves levels higher than 700hPa, and therefore does not causing rainfall in a direct way. Toward the SW of its core, another system develops, intermittent, of thermal-orographic nature that appears as an appendix of the Chaco Low: The Argentine Northwest Summer Low (Lichtenstein 1980; Saulo at al. 2004). Its intensity is higher during summer. Its presence is related with the shift of the SACZ to the West of its usual position (Nogués-Paegle et al. 2002). Thus, its fluctuations in intensity and latitude provoke to its East intermissions in the humidity flux toward the central and southern region of the La Plata basin.

Another inherent characteristic of the central region of the basin is the development of the so called Mesoscale Convective Systems (MCS) (Velasco and Fritsch 1987). These systems are mostly nocturnal, organized in a kind of circular manner and have a minimum lifetime of 6 hours, which results noticeably greater that an isolated convection cell. MCSs are frequently found at leeward of the mountain systems (Figueiredo and Scolar 1996; Nieto Ferreira et al. 2003). During their lifecycle, they may have displacements of several hundred kilometres, in general with East component (Guedes et al. 1994). These Mesosytems are feed by intense humidity flows at low layers. From September to May, they are responsible of most of the rainfall in the whole basin.

In the Southern part of the basin, the circulation of the West with its baroclinic waves leaves its trace in the climate (Vera et al. 2002), with frontal and prefrontal rainfalls, and alternations of air masses from diverse origin. In winter, this circulation of mean latitudes usually penetrates sporadic and deeply toward the tropics, accompanied by intrusions of polar air, with the consequent and important plunges of the air temperature still in the most northern part of the basin (called *friagens* in Brazil).

The general thermal regime in the basin is asymmetric, with higher temperatures in spring than in autumn, except for the northeaster region of the high basin of the Paraná. Some districts of that region, and also the heights of the Southern Planalto (States of Santa Catarina, Paraná and Sao Paulo) are noticeably colder than the rest of the tropical and subtropical territory of the La Plata basin.

This is how diverse conditions both local *(geography, local annual cycle of solar radiation)*, as well as remote define the distribution of the climatic elements in the several regions that compose La Plata basin (Prohaska 1976). Its territorial extension so has different climate districts discriminated first by their rains regime and secondly by some characteristics of the thermal regime. Transitions also appear among those climatic regions and subregions, what in turn will be mentioned concisely. Then a general description of the space-temporal distribution of the precipitations of the whole basin at scale is introduced. Next, a description of the climatology of the big units is made. The causal atmospheric dynamics will be mentioned in this last description, although it is mentioned now the general predominance of winds with East component mainly from the Northeast. It is also important the already mentioned humidity flux at low levels from the Amazonia, bordering The Andes, which many times takes the characteristics of a low level jet in low layers (from now on, LLJ; see Verji 1981; Berbery and Collini 2000). The LLJ is present all over the year (Berbery and Barros 2002). Together with the SACZ constitute the determining elements of the basin's precipitation weather in combinations with the already mentioned South Atlantic High.

2.2. General regime of precipitation

2.2.1. Satellite estimates

For La Plata basin, a satellite estimated data set has been used for the period 1979-2000, in order to describe the space distribution of the precipitation *(Fig. 2.2a)*. The data set includes the called CMAP (Climate Prediction Centre - CPC - Merged Analysis of Precipitation) from the National Oceanic and Atmospheric Administration (NOAA) whose validity was discussed in Xie and Arkin (1997). The precipitation was estimated for a 2.5º x 2.5º latitude/longitude array, as a result of combining a group of satellite products with local observations, including the GPI (Infrared supported Index of Precipitation of the GOES satellite system), the OPI (The Outgoing Longwave Radiation based Index of Precipitation), and microwave based measurements. The used version of CMAP doesn't include the reanalyses of the NCEP-NCAR precipitation forecasts.

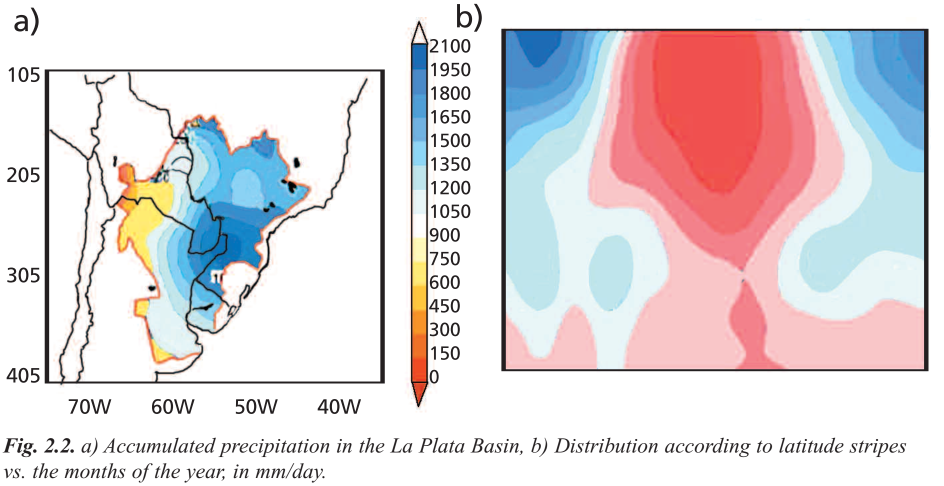

Fig. 2.2. *a) Accumulated precipitation in the La Plata Basin, b) Distribution according to latitude stripes vs. the months of the year, in mm/day.*

2.2.2. Annual and seasonal averages

At great scale, two well defined precipitation regimes are observed (e.g., Berbery and Barros 2002): the first one toward the North of the basin and the second over the central portion *(Fig. 2.2a)*. The transition between both regimes is clearly illustrated in *figure 2.2b*, which represents the annual cycle of precipitation averaged in bands of longitude between 60 and 50 W, as a function of latitude. The regime of Summer precipitation, associated to the South American monsoon system, can be observed up to the 20ºS *(Fig. 2.3b)*, while more to the South, the central portion of the basin can reach its maximum at different times of the year, what suggests that there is more than one acting mechanism, not only the monsoon forcing. Therefore, precipitation in the central and southern strips of the basin tends to be more evenly distributed during the whole year *(Fig. 2.3 a, d)*. Thus, during the

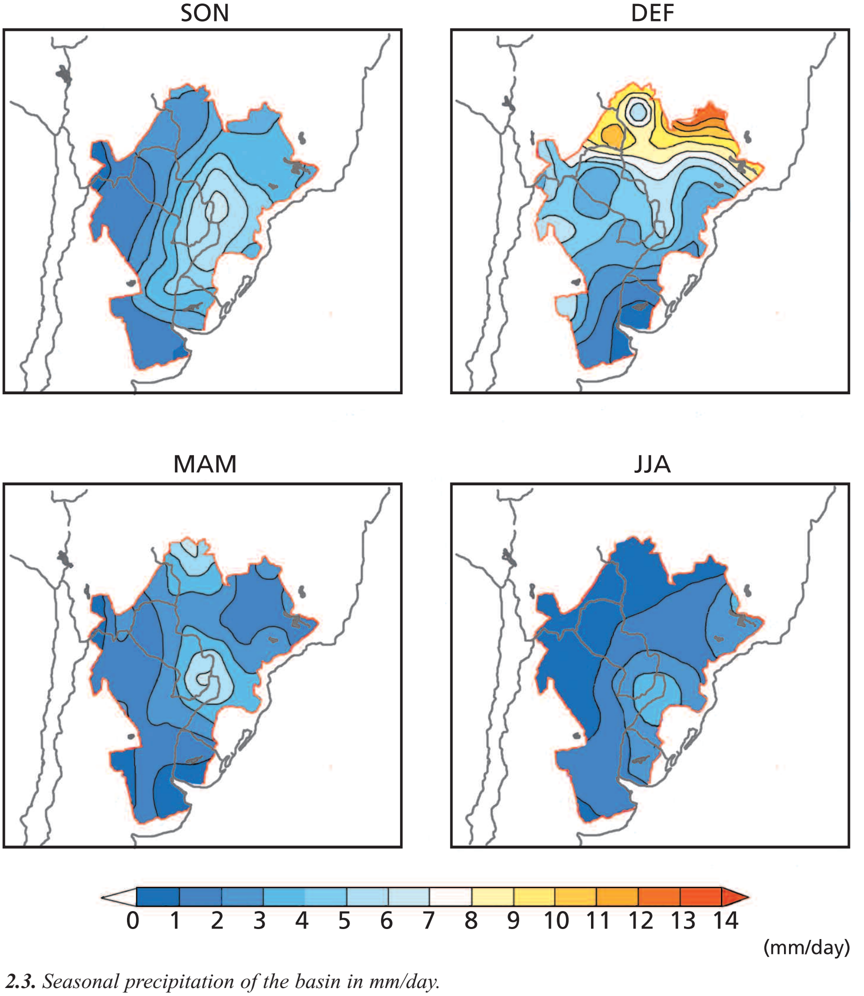

Fig. 2.3. *Seasonal precipitation of the basin in mm/day.*

warm season (October-April), in the central strip are frequent the Mesoscale Convective Systems (CCM), which account for a great deal of the precipitation (Velasco and Fritsch 1987; Laing and Fritch 2000). In the cold season (May-September), the most important contribution is imposed by the activity at synoptic scale of mean latitudes (Vera et al. 2002). Over the Southern end of the basin, this pre-eminence of the waves of the West circulation covers all of the year seasons except for summer.

2.2.3. Mean Annual Cycle

Figure 2.4 presents the annual cycle averaged over the total area of the La Plata basin. The precipitation of the order of 5.5 mm/day during the warm season is a clear indicator of the predominant monsoon region, where maximum close to 9 mm/day are reached, in the average of the region, *Fig. 2.4b*. This contrasts with what happens toward the central part of the basin *(Fig. 2.4c)* where a markedly irregular intra annual variation is noticed. This last chart suggests a larger volume by the end of summer, at the beginning of the autumn, and in spring (Sep-Oct).

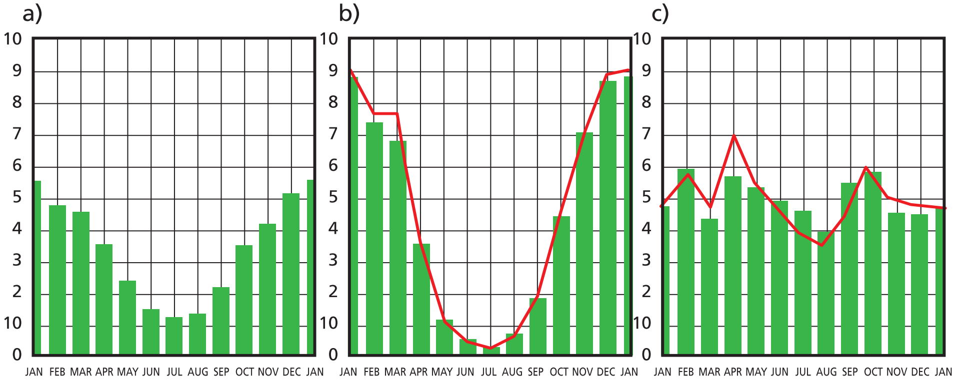

Fig. 2.4. *a) Average precipitation of the whole La Plata Basin in mm/day, b) Average of the Monsoon region, bars: CMAP analysis (see text) in mm/day, and lines: observations, c) bars: average in mm/day (CMAP) in Misiones, representative of the central region and lines: observations.*

The reliability of the "CMAP" data set has been examined comparing them with a new data set of observed precipitation interpolated in a regular 0.5 x 0.5 º of latitude-longitude mesh (Willmott and Matsuura 2001). The annual cycle for two representative points of the main precipitation regimes in the basin *(Fig. 2.4b and 2.4c)* shows that in both of them the estimate is close and shares the same yearly cycle. However, it is to notice that the CMAP estimate underestimates the precipitation during the warm season, probably due to its low resolution that cannot solve the convective precipitation appropriately. It also has a slight overestimation during the cold season.

2.3. Regions

2.3.1. Region of the monsoon regime (Upper Paraguay and High Upper Paraná basins)

This is a region of great contrast in the precipitation regime with a marked minimum in winter and an abundant maximum in summer, when the superficial heating together with the vapour advection from the North favours the convection. The difference with the Asian monsoon classic regime is that the longitude of the dry season is slightly shorter, because of this, for similar annual totals, in La Plata "monsoon" region, the rainfall is distributed over more months, lacking both the spectacular summer picks and extremely low humidity at low layers during winter, like in most of the Asian Monsoon. Nevertheless, they are similar in the seasonality type and the dynamic causes of the rain regime: alternation of the anticyclonic presence and subsiding high-pressure in winter, with low pressures during summer, which is because of the thermal contrast of the Tropical Continent with the adjacent Atlantic. Thus, Zhou and Lau (1998) affirm that when removing the mean annual fluxes the same characteristics as in the Asian Monsoon appear and so they reach the conclusion that there is monsoon-like regime in South America. Inside La Plata basin region, it can be distinguished: *a)* the superior basin of River Paraguay in the western territory, including the Pantanal, *b)* the High Paraná valley, separated from the previous region by the Maracayú ridges, together with the region of the Central Planalto, and the corresponding ridge mountains on the East that separate the basin from the coast. In all of them, there is a predominance of winds from the North to Northeast sector, while in summer, in the upper troposphere, the presence of the Bolivian High affects the West of this tropical region and even more the South. The advection of humidity coming from the Amazon basin is an important source for the precipitation. Although this aspect is present the whole year, the winter subsidence almost causes a ceasing of the rain from May to August. The interannual variability is relatively small, although, like as it will be seen later, an important ENSO signal exists, what is extensive to the subtropical regions of the La Plata basin (Barros et al. 2000; Barros et al. 2002).

a. Paraguay River upper basin: El Pantanal region

By way of example, Corumbá is mentioned, right in the core of El Pantanal, where the precipitation maximum takes place in December, with annual totals superior to 1300 mm. On the counterfort of the slope more to the West, the annual precipitation is even larger. Extensive records of the region are shown to be more profuse in autumn than in spring, although in the last years this situation is reverting. The LLJ presence is the main source of humidity.

b. Upper and septentrional basins of the Upper Paraná.

The influence of the trade winds is notorious, in spite of being to leeward of the coastal mountains. Thus, the rain period extends a little longer than in the basin of the Paraguay River and in the ridges the annual precipitation is higher. Cuiabá, representative locality of the area, presents maximum precipitation in January, and annual totals superior to 1400 mm being the precipitations more abundant in spring than in autumn. It is remarkable that in spite of the fact those heights over 1300 m separate this sub basin from the coast, the advection of humidity is present not only from the Amazon North, but also from the Atlantic.

In the most oriental heights of the Planalto night temperatures near to 0ºC can be registered, as well as in the middle of the Alto Paraná basin valley, upstream of Itaipú. (Bela Vista, see *figure 2.5c*, and in light green in *figure 2.5a*). The charts correspond to points taken from the IRI interactive map. The source of the chart data is the University of East Anglia, its Monthly Climatology in grid points of 0.5º x 0.5º, available in:
http://iridl.ldeo.columbia.edu/maproom/.Regional/.S_America/.Climatologies/Select_a_Point.html

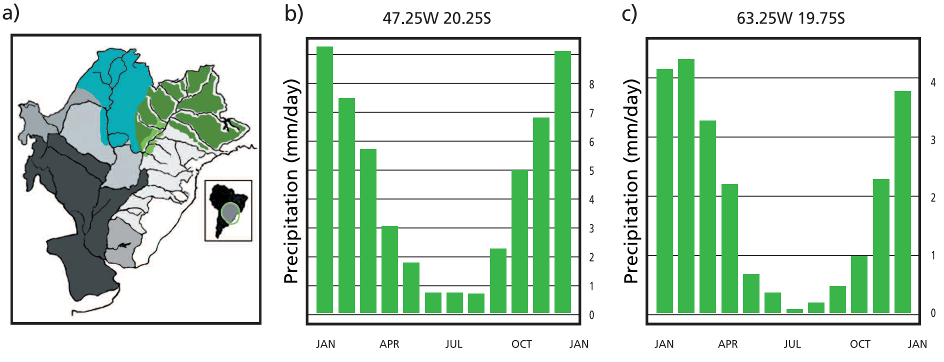

Fig. 2.5. *Monsoon climate regions. a) Location, b) Precipitation (mm/day, of a representative location in El Pantanal. c) Precipitation (mm/day) of a representative place of the upper basin of the High Paraná.*

2.3.2. Great Chaco Region

Although the Tropic of Capricorn is included in this region *(Fig. 2.6a)*, from the climatic point of view it is a subtropical area whose nucleus embraces approximately from the 19°S to 25ºS and from the 64º to the 58º and 60ºW. Approximately along this meridian, a quick transition between the humid subtropical regions and the dry ones takes place. In these last ones, located to the West, most of the precipitation concentrates in 3 to 5 months of the summer period, beginning in spring, while the maximum of precipitation is usually in December. It is the warmest region in the basin, with summer daily maximum temperatures frequently over

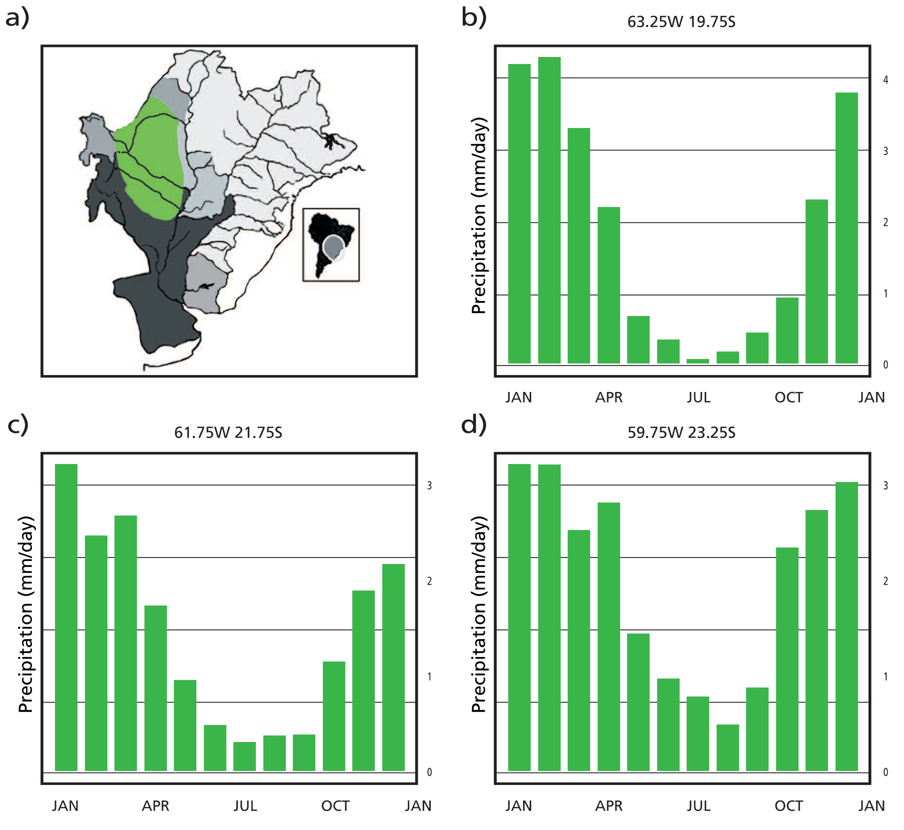

Fig. 2.6. *The Chaco region. a) Approximated location. Rainfall regime at: b) the Boreal Chaco, c) at ~62ºW and d) at ~60ºW, Example of the east-west gradient of precipitation in the La Plata Basin.*

45ºC. In spite of the important flow of humidity at low layers, which somehow continues during the winter, during this season rains are null or almost null because of the presence of a continuous subsidence over the region, when the tropospheric circulation of the West, reaches the Chaco region. The humidity drops from more than 20 g/kg in summer to less than 14 g/kg in winter. However, cloudiness continues to be important by this time of the year, close to 40% in the average (Prohaska 1976). In Chaco, the rainy season usually begins in September and ends in March-April, being the flux in low layers from Amazonia, the only effective source of humidity.

The slopes of the Chaco toward the Andes maintain all a semi-arid character, except in the Aconquija Mountains where it rains more than in the plains with the same spatial pattern than in the northern and western borders of the Pantanal. With this exception, the precipitation gradient goes from less than 300 mm in the West end to close to 1000 mm in the East, always maintaining the great concentration of the period of rains in summer, though.

2.3.3. Region centred at the East of Paraguay

This humid subtropical region, maintains an annual mean precipitation between 1500 and 1900 mm, according to the locations. Precipitation minimums occur in winter, although less marked than in the Chaco, with a transition toward the Southeast with a more constant-like annual regime. The Mesoscale Convective Systems are directly responsible for the abundance of precipitation during the extensive summer period (September-April). Notice *(Fig. 2-7b d)* the maximum during Spring-beginning of the summer.

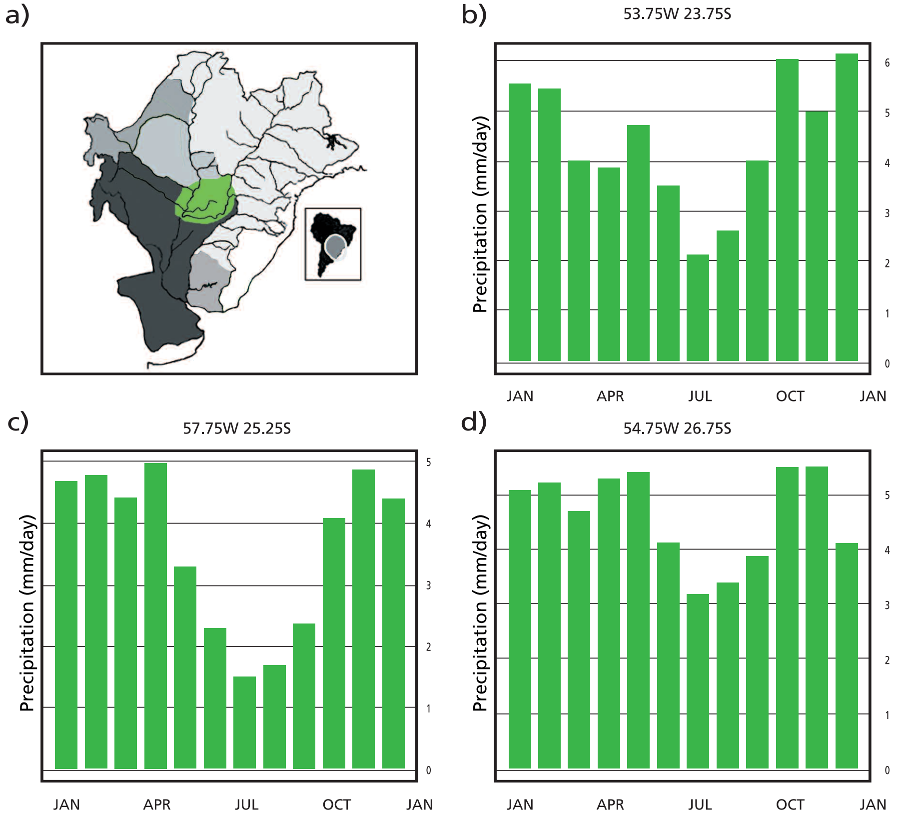

Fig. 2.7. *Central region. a) Location. Rainfall regime at: b) at the northern part of the region, c) close to the confluence of Pilcomayo and Paraguay rivers, d) in the southeast of the region.*

Although there are frequent invasions of polar air during winter in the region, it is common the occurrence of winters without frosts, except for the districts with important topography. A characteristic of this region is the low cloudiness at the end of the winter (August), what brings along a rapid thermal recovery at the beginning of the spring. (González and Barros 1998).

2.3.4. Region of the meridional Planalto and the Rio Grande Ridges

This is a region with precipitations during the whole year. It is one of the territories of the La Plata basin under the direct influences of the South Atlantic Convergence Area, which determine the summer and contiguous months' rain regime. In Winter, it is frequent the passage of perturbations from the West circulation, which added to important fluxes of humidity in low layers, from the Northwest on one hand, and from the Northeast on the other, causes precipitations to be considerable also in Winter The dynamics of the SACZ produces the greatest intraseasonal and interannual variability in this region. It is a transition regime, from the typically tropical one with maximums in summer, more to the North, to one of maximums in winter in the southern part of Rio Grande do Sul and in Southeast of Uruguay. The annual means are higher than 2000 mm. Although the region is at relatively low latitudes, the height of the region makes temperatures to be considerably low, with frequent occurrence of frosts in winter, with the exception of the coast, where the radiative effects are less important than the advective ones. The high over sea level makes that in winter, during some polar air intrusions, the precipitations in some subregions of Southern Planalto to be in form of snow, especially in high places of the State of Santa Catarina, but also in Paraná and Rio Grande do Sul.

For the mentioned mixed regime, the annual cycle of precipitation ends up showing three picks: (Grimm et al. 1998) one at the beginning of Spring, other in the middle of Summer and another in Autumn *(Fig. 2.8b)*, being the August-September-October quarter the one with more precipitation *(Fig. 2.8c, d)*, in the sub region of the eastern tributaries of the Uruguay River.

2.3.5. Region of the Argentine Litoral and bordering areas

The Argentine Mesopotamia is the place of the transition place between the predominance of the zonal flux more to the South, and the prevalence of the meridional flux from the North, which, although still predominant, alternates with the West flow.

The maximum of precipitation is in the intermediate seasons, with a main minimum in winter and other, barely insinuated, in summer. In this season, the Mesoscale Convective Systems alternate with some front passages and produce most of the precipitation. In winter, the circulation of the West is noticeable with its well defined front systems and presence of the jet flow in the upper troposphere and low level flows from the North and the East. The main maximum of rainfall is in autumn. Together with the pampas region more to the South, the Uruguayan territory and the south of Rio Grande do Sul, this region is scenario of frequent but dispersed severe phenomena, especially not during winter: hail, intense winds caused

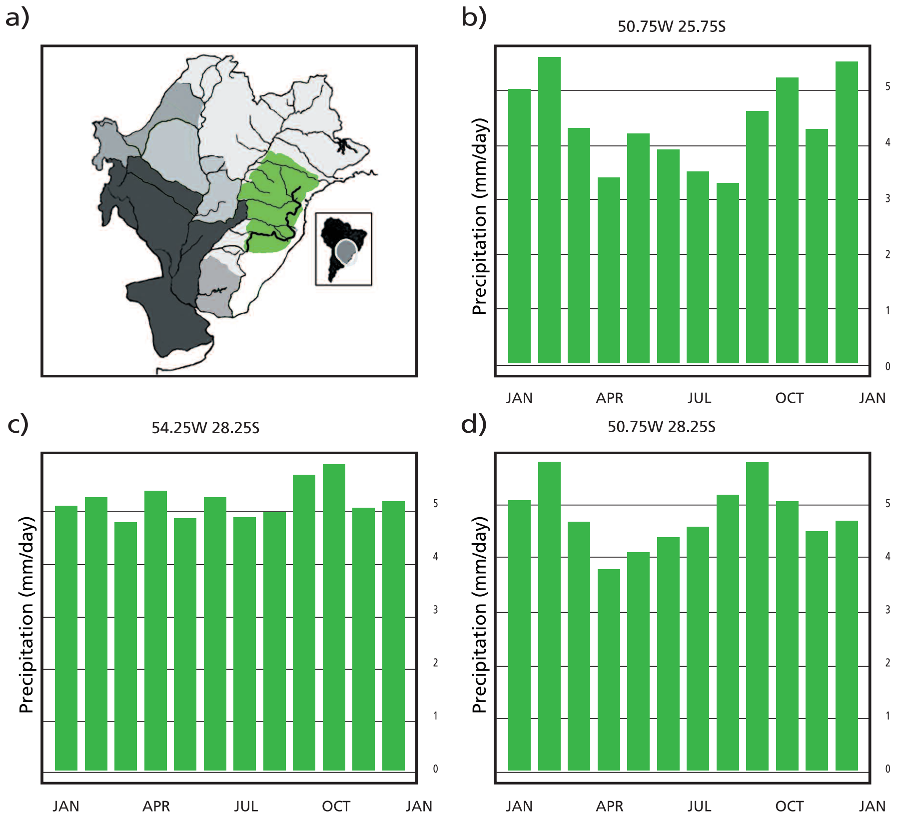

Fig. 2.8. *Southern Planalto a) Location. Rainfall regime at: b) central-eastern region (River Iguazú basin) c) at the west d) at the south of the Planalto, where a shift of the spring maximum can be noticed by the end of winter.*

by descending currents from cumulonimbus, tornados, in general as by-products of the activity of Mesoscale Convective Systems. There is a great interannual and intraseasonal variability and the annual isohyets have a noticeable North-South orientation, slanted toward the Southwest in the most southern region. The general orientation is indicative of the transition regime, between the Great Chaco minimums (<900 mm) and the Southern Planalto maximums (>1400 mm).

2.3.6. Eastern Uruguay and South of Rio Grande do Sul

It is a transition region, with a very high variability both intra and interseasonal, and fluctuating monthly rainfall, although in general the intermediate seasons are those with more rain. The annual mean is in the order of 1600 mm in the North and of 1200 mm in the South.

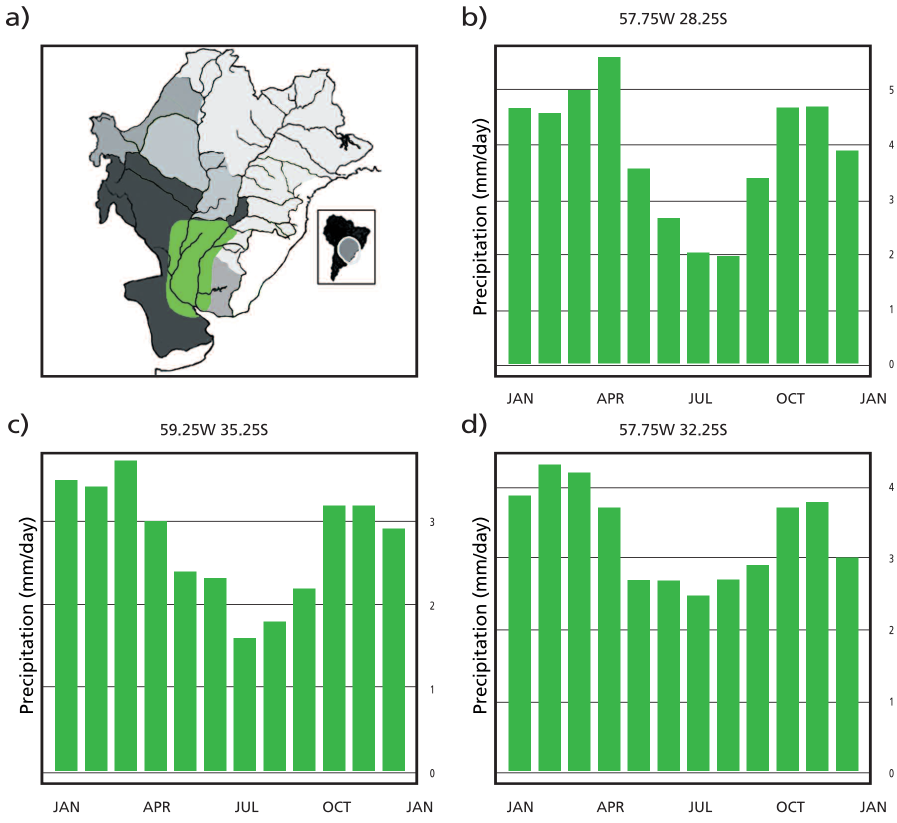

FIG. 2.9. *Littoral Region a) Location. Rainfall regime at characteristic sites: b) Center-North c) South region d) Eastern Region.*

Here the influence of the circulation of the West is especially important in winter. In this season, the cyclogenesis over either Uruguayan or the Argentine Mesopotamia has a maximum in frequency (Gan and Rao 1991; Vigliarolo 1998). The further displacement toward the Southeast of these recently generated low pressures centres causes a maximum of precipitation by the end of winter, on the southeaster border of the continent, practically entirely outside La Plata basin.

Spite of the relative proximity to the Atlantic Ocean, the region presents features of continental climate as in Winter there is frequent frosts, while in Summer, the daily maximum temperatures usually exceed the 36ºC (except near the coast), especially during the second half of December and January.

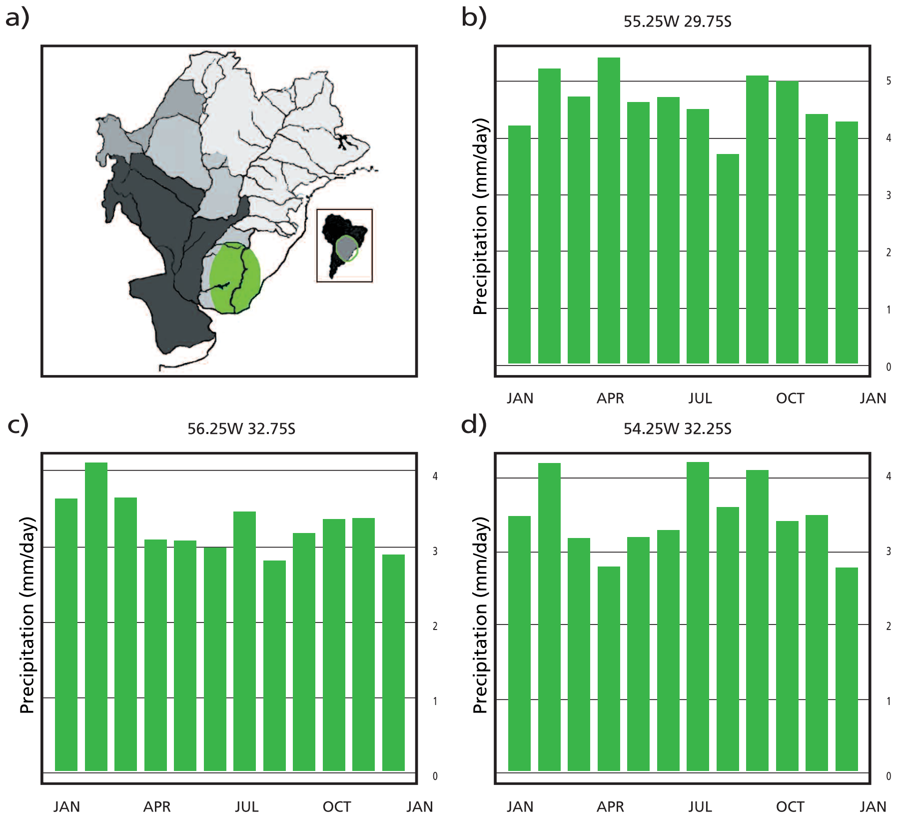

Fig. 2.10. *Eastern Uruguay and South of Brazil. a) Location. Rainfall regime at characteristic sites: b) and c) in the middle of the transition zone d) at the Southeast, region of winter maximum.*

2.3.7. West and South borders

It embraces the whole western and southern fringe of the La Plata basin in Argentine territory, from the 25ºS to the Ridge Mountains of Aconquija *(Fig. 2.11a)*. Except for the oriental bands of the ridge mountains, where the precipitation is considerable (*Fig. 2.11c*, Hoffman, 1982), it has similar characteristic to the Chaco climate, with maximums at the beginning of autumn. The rest is a flat region, with scarce precipitation and mainly very little runoff, contributes very little to La Plata flow.

To the South of 32ºS, the circulation of the West prevails, although the polar front during the summer, usually locates more to the South (around Bahía Blanca). Thus, in this season, it is frequent the convective prefrontal activity in the tropical air, which in addition to intense short lasting precipitations, usually bring along, severe phenomena (descending winds, tornados, hail). The intensity of the frontal perturbations depends on the intensity and position of the polar jet in winter, and of the sub-

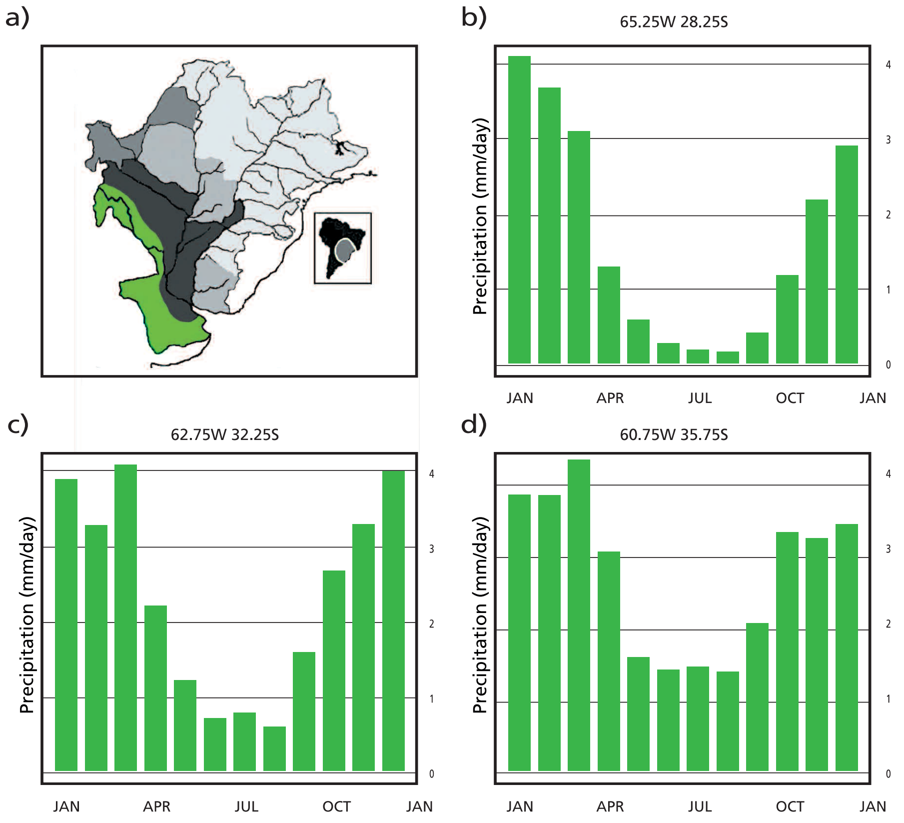

__Fig. 2.11.__ Western and southern border of the La Plata basin. Rainfall regime at characteristic sites: b) eastern border of the Aconguija Mountain range c) southwestern corner, d) south border.

tropical jet in summer. Their effectiveness in terms of the occurrence, character and intensity of the rainfalls, will depend in turn on the position and intensity of both the Argentine Northwest Low and the one of the Chaco, which modulate the advection of humidity from the North. During winter, the frosts are a recurrent phenomenon, although it rarely snows. The rainfall minimum appears in winter. There is a gradient of annual isohyets toward the Southwest, registering an average of around 1100 mm in the coast of La Plata River, and less than 800 in the Southeast end.

In this chapter it has been described the main characteristics of the Climate in La Plata basin. The regional features of the La Plata basin climate are summarized in the *table 2.1*.The whole region is subject both to long period fluctuations as well as trends in climate that will be addressed in chapter 5.

Table 2.1. Summary of the principal climatic characteristics per region

Region	Main causes of the climatic regime	Characteristics	
		Precipitation	Thermal Regime
Monsoon a) Pantanal b) High Paraná	a) Monsoon, Bolivia High b) Monsoon, ZCAS	Summer maximum and Winter minimum, both marked	Low seasonal variation
Chaco	Monsoon, LLJ, MCS, position of the ANW Low, position of the Jet.	Maximum in Summer, often void in Winter	Very hot in Summer
East of Paraguay and surrounding areas	LLJ, MCS, ZCAS, frontal activity in Winter.	Maximum in Summer, minimum in Winter	Very hot in Summer
Meridional Planalto and Rio Grande ridges	ZCAS, MCS, Frontal activity (indirectly LLJ)	Abundant the whole year. Variable between months	Hot in Summer. Relatively cold Winter in high regions.
Argentine Littoral and surrounding areas	LLJ, MCS, frontal activity, position of the ANW Low, (indirectly ZCAS)	Maximum in intermediate seasons, with a marked minimum in Winter	Hot in Summer, Winter with frosts
Oriental Uruguay and South of Río Grande do Sul	Frontal activity, MCS, (indirectly ZCAS and LLJ)	Maximum in intermediate seasons, abundant in Summer except for the extreme South	Hot in Winter, Winter with frosts
West Borders and South of La Plata basin a) To the North of 32ºS b) To the South of 32ºS	a) Position of the currents in jet and of the Chaco and ANW Lows b) Frontal activity, position of the currents in jet and of the ANW Low	a) scarce, greater in Summer b) less scarce, although minor than in the East and North, more distributed throughout the year, Winter minimum	a) Similar to Chaco b) Several days with frosts almost every winter

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