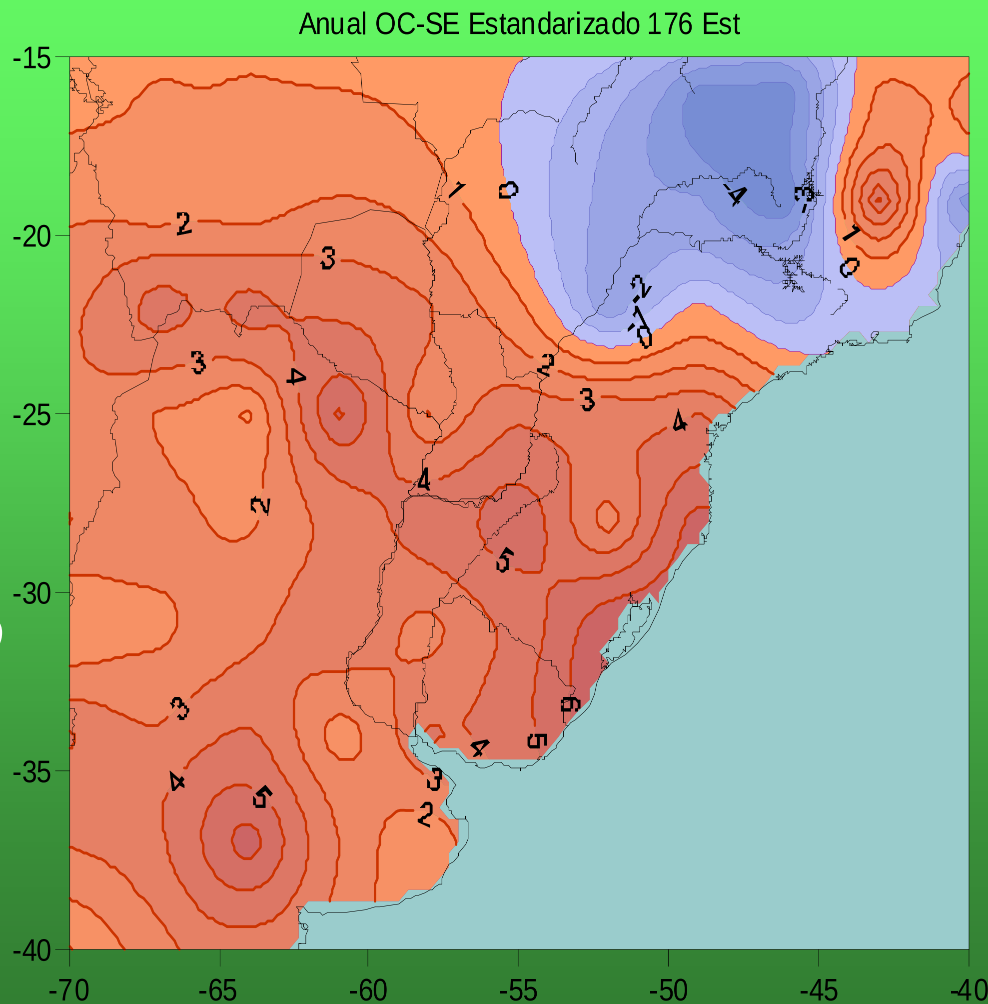
Atribuição das tendencias da Precipitaçao regional

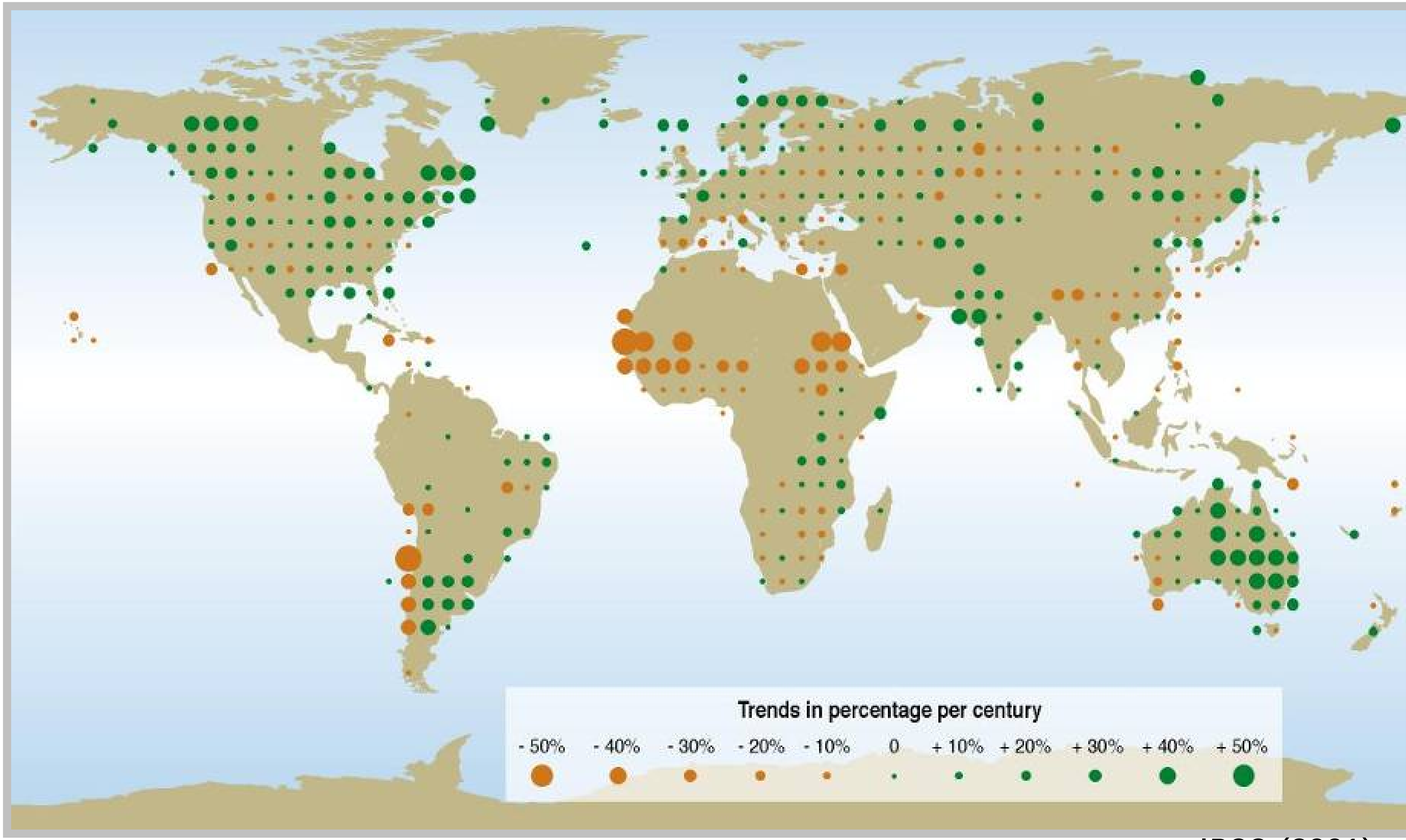
II Simpósio Internacional de Climatologia: Detecção e Atribuição de Causas para as Mudanças Climáticas na América do Sul

Sao Paulo,
2 de novembro 2007
Vicente Barros



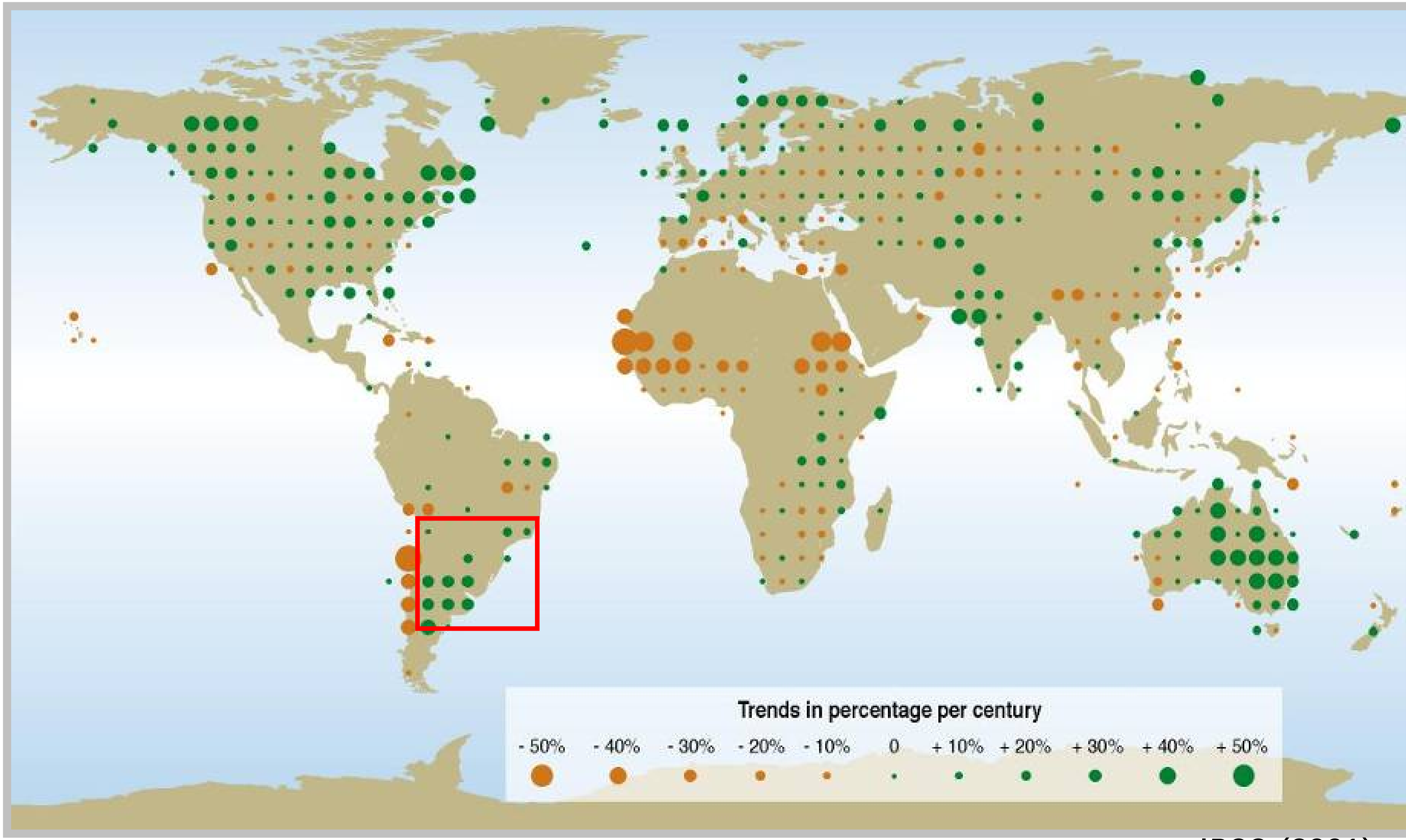
Mean annual precipitation trends (mm/year): 1960-2000

Annual precipitation trends 1900-2000



IPCC (2001)

Annual precipitation trends 1900-2000



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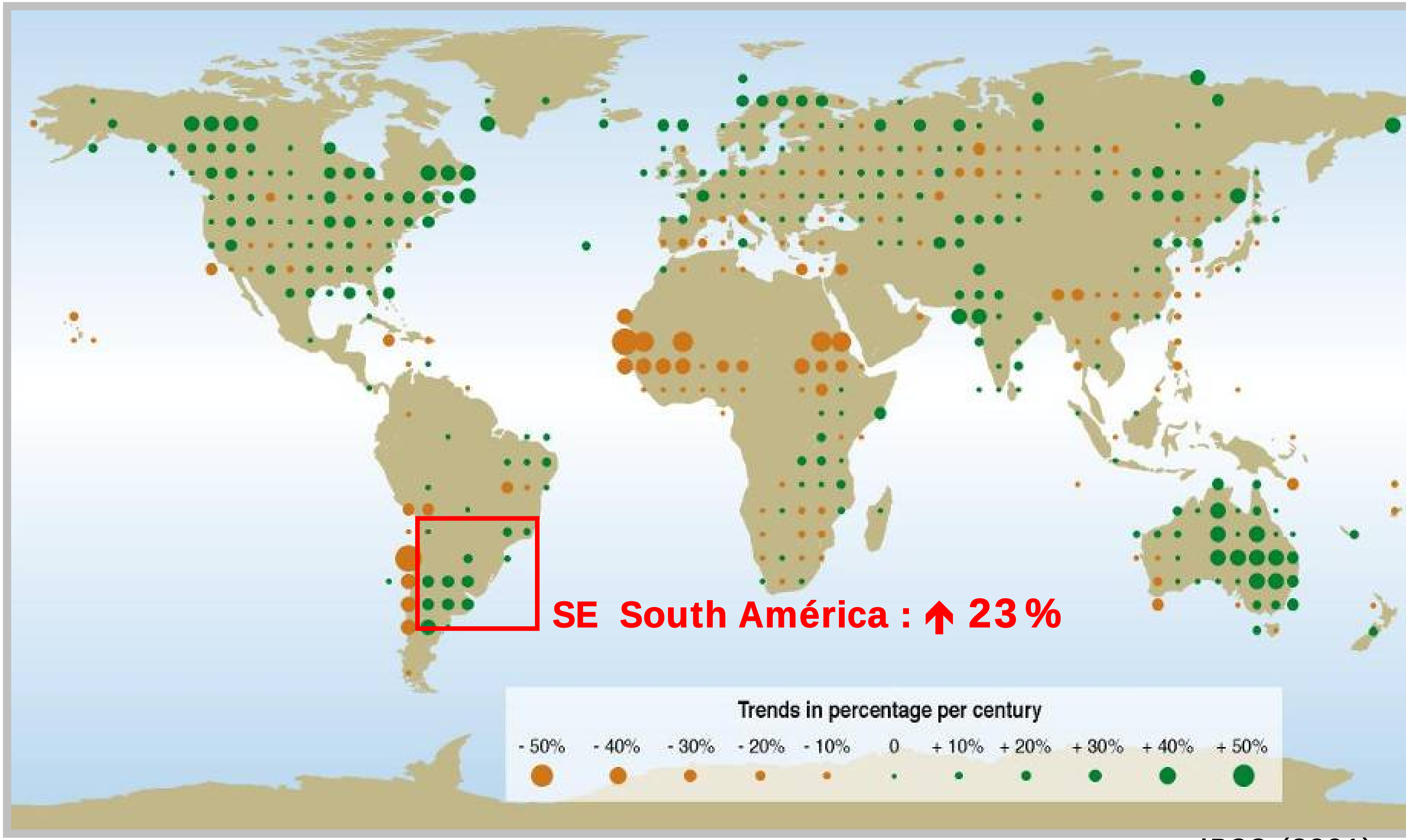

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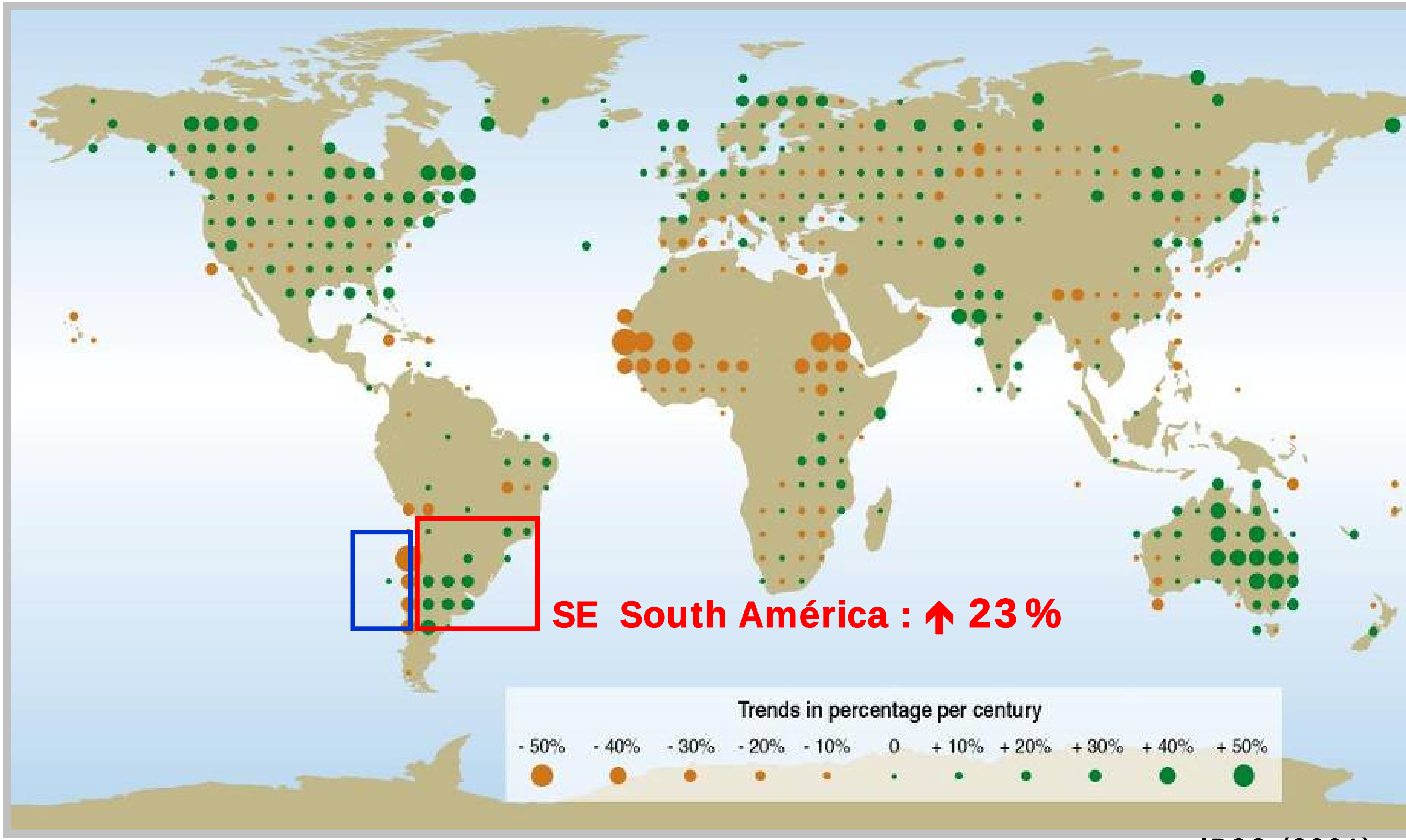

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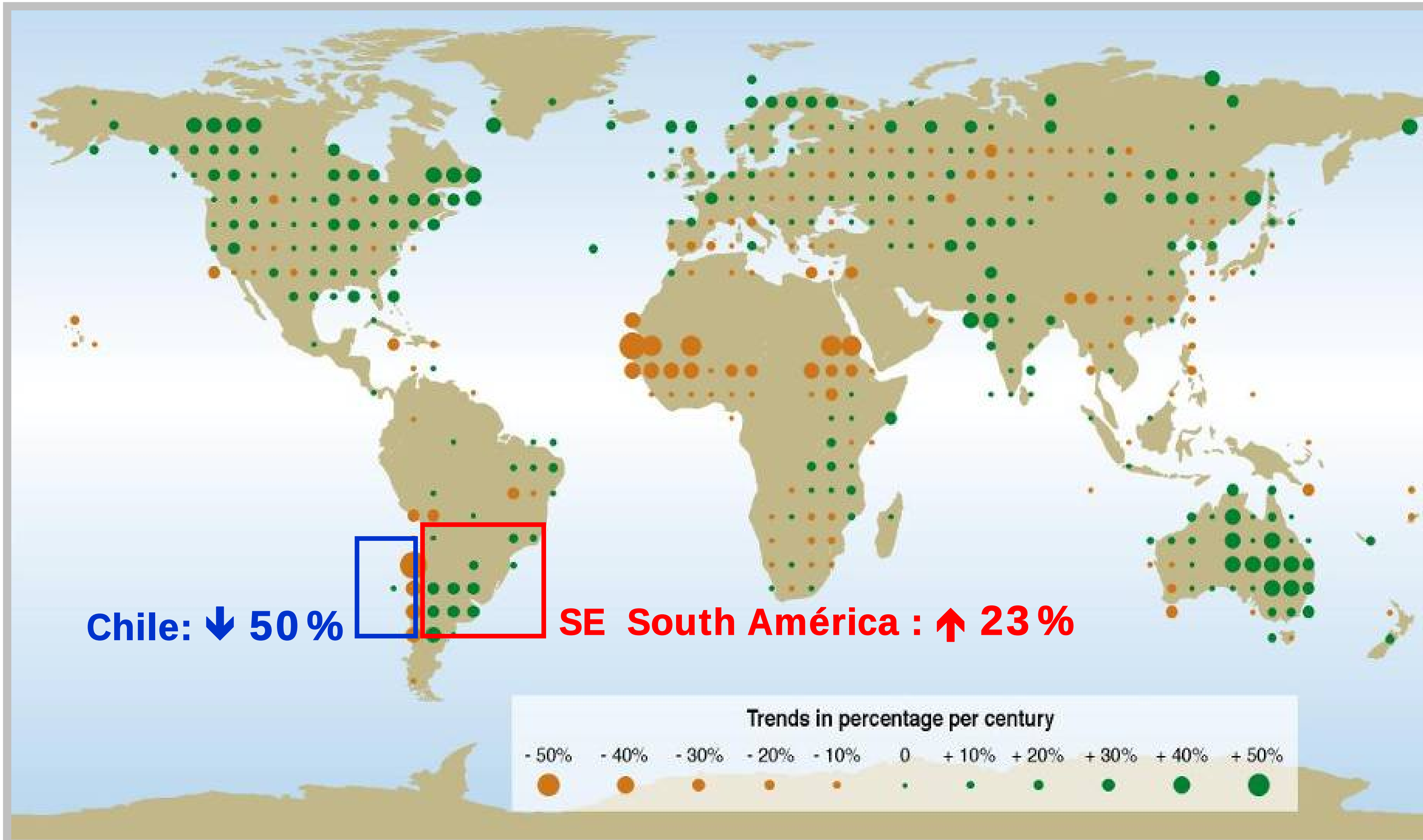


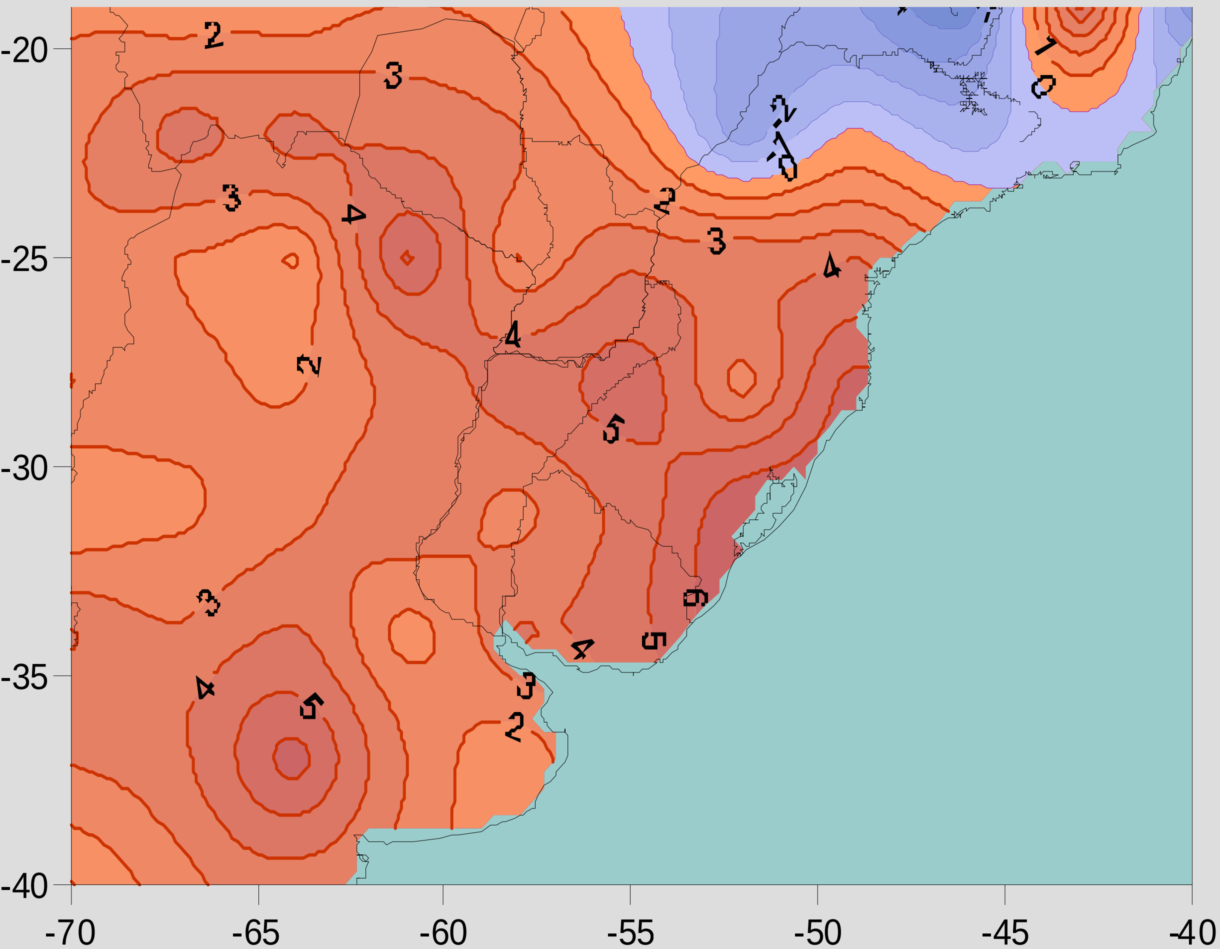
IPCC (2001)

PRECIPITATION
between 20 and 40° latitude

REGION	TRENDS (%)
Chile	- 50
SE Sudamérica	+ 23
W Australia	- 23
E Australia	+ 20
W América Norte	- 10
E América Norte	+ 20
W Europa - África	- 17
E Asia	+ 2

M. Doyle

Mean annual precipitation trends (mm/year): 1960-2000



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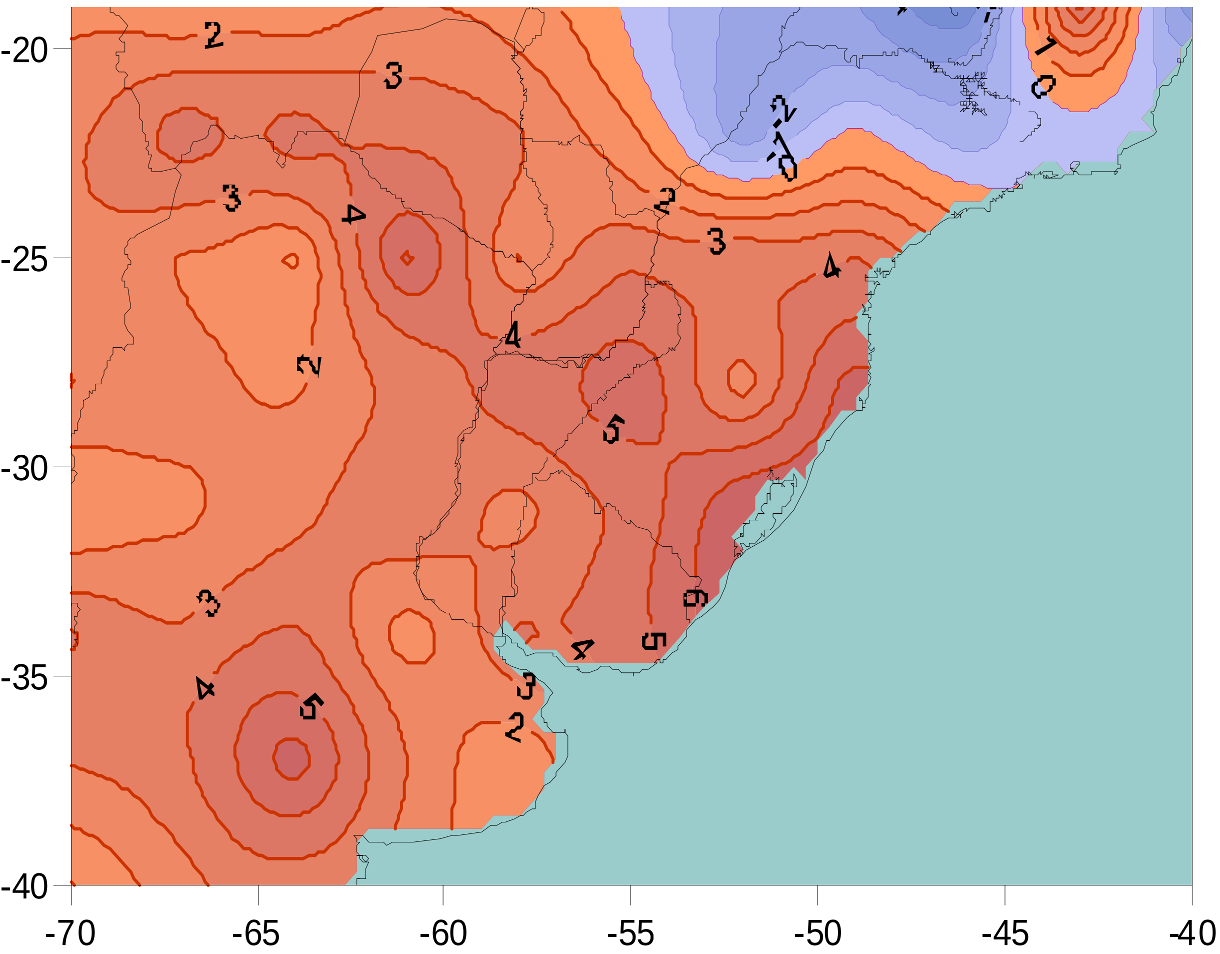
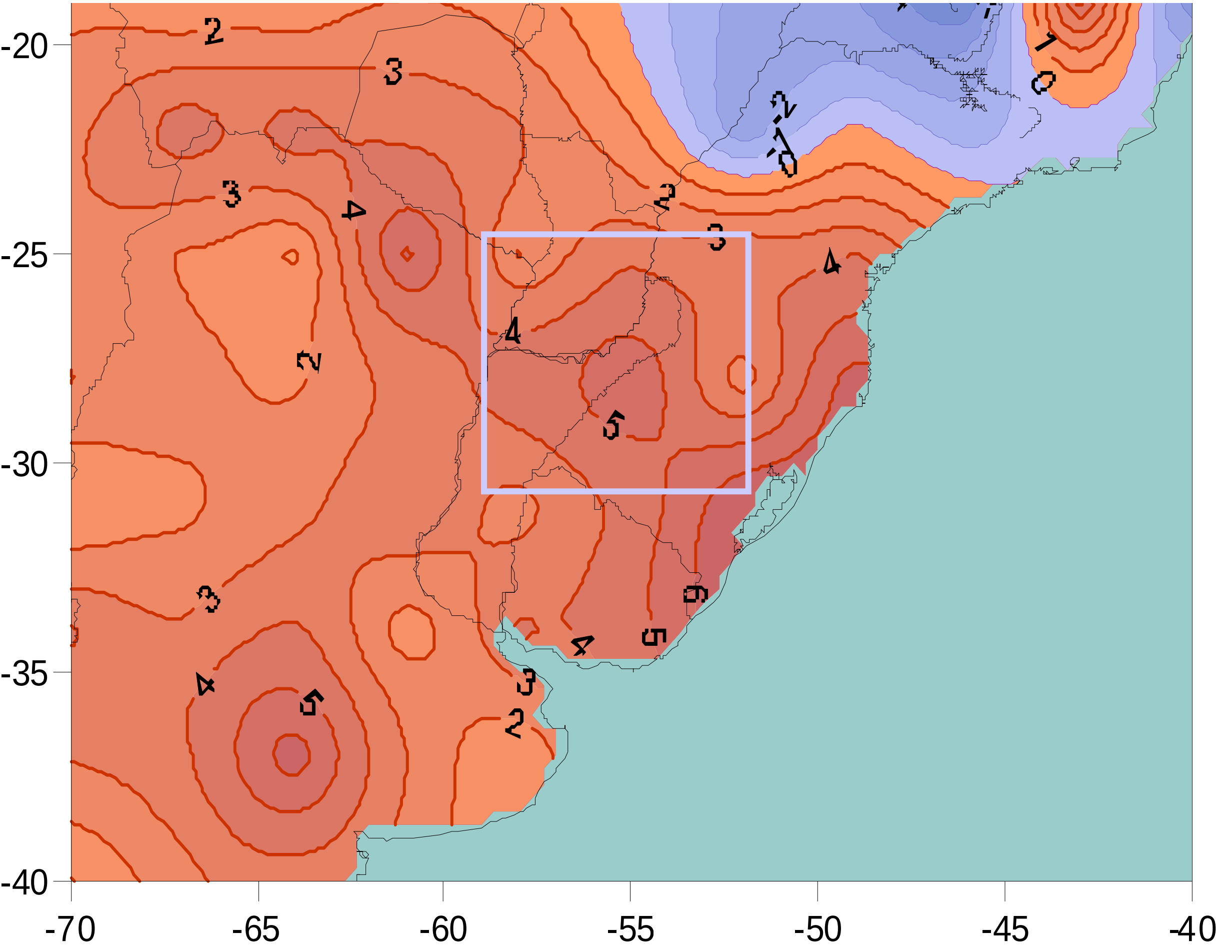


Annual rainfall increases 10 % to 40 %

Mean annual precipitation trends (mm/year): 1960-2000



Annual rainfall increases 10 % to 40 %

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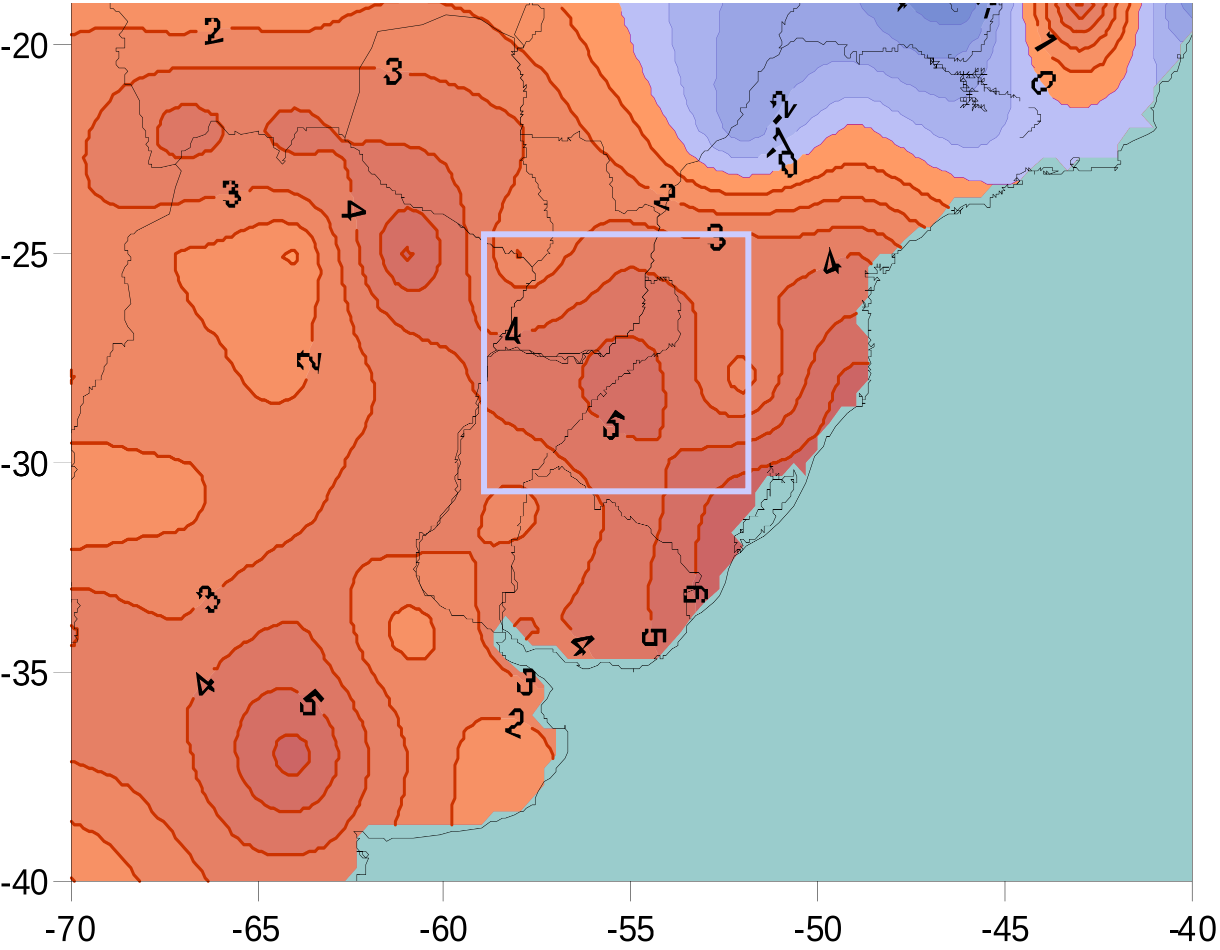
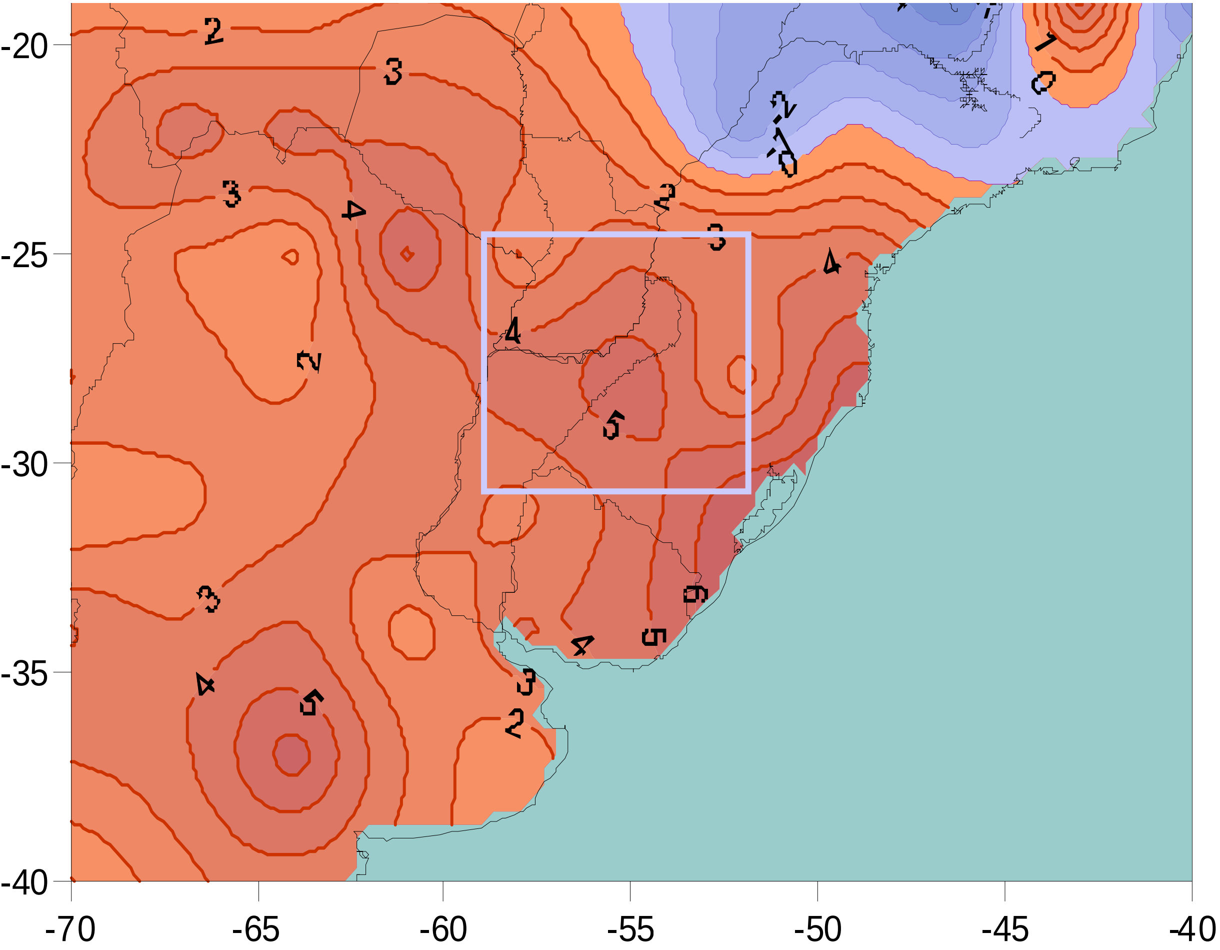


Annual rainfall increases 10% to 40%

In some regions, annual precipitation increases 200 mm or more in 40 years

Mean annual precipitation trends (mm/year): 1960-2000



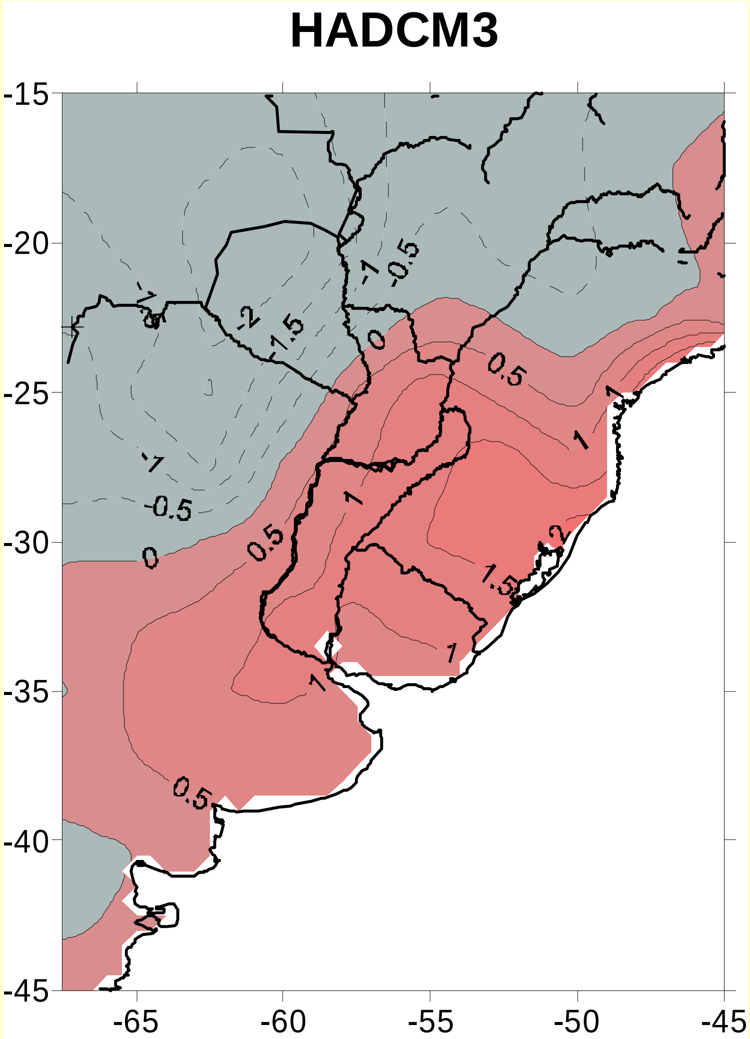
Annual rainfall increases 10% to 40%

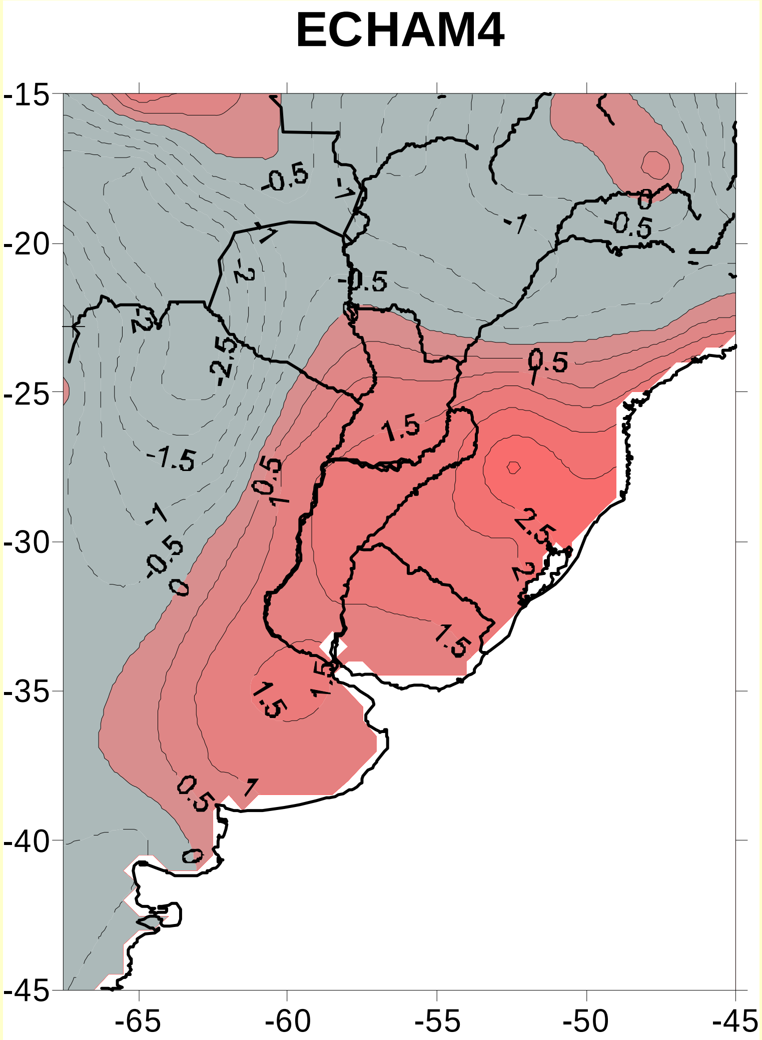
In some regions, annual precipitation increases 200 mm or more in 40 years

IMPACTS

THE CAUSE ?

Diferencia entre la precipitación anual observada y la de los MCGs (mm/día) 2001

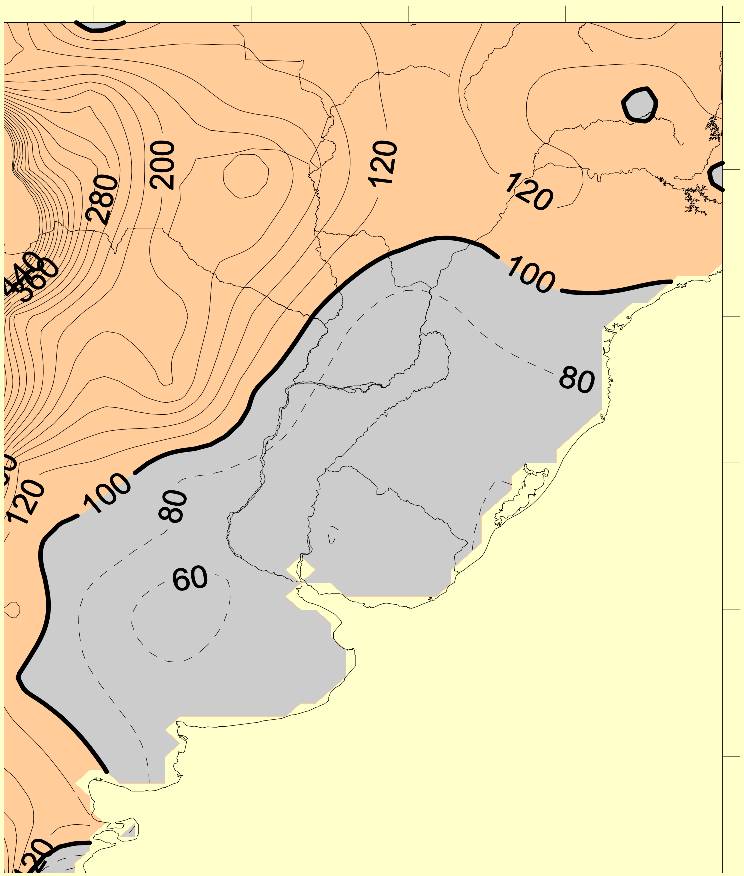




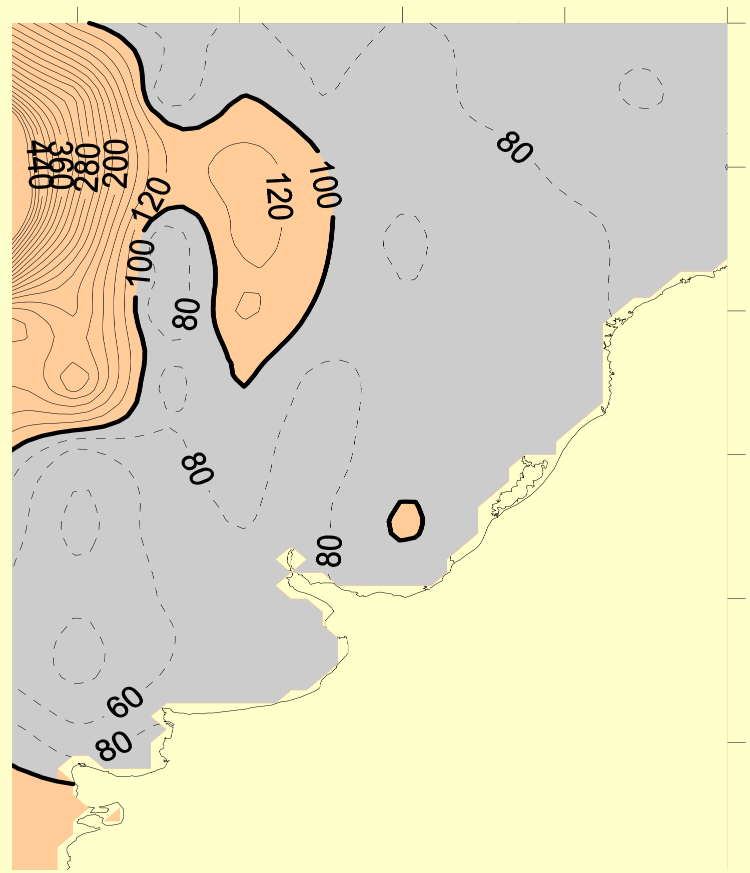
I. Camilloni y Bidegain, 2005

Diferencia entre la precipitación anual observada y la de los MCGs (%) 2006

HADCM3



ECHAM5



I. Camilloni, 2006

Precipitation trends in southeastern South America: relationship with ENSO phases and the low-level circulation, 2006:

Theoretical and Appl. Climatology In press.

V. Barros, M. Doyle and I. Camilloni.

Theorem

- **When splitting a series in various sub series, the linear trends of these sub series, weighted by the number of their elements, add up to the same value as the linear trend of the entire series if each of the sub series has its elements ordered in time around the same mean value with the same variance as the complete series.**

- **A linear trend is a special case of a linear regression slope when the independent variable is time. Therefore, the more general case on regression slopes is formalized as follows**:

- Being ***xi*** and ***yi*** two series with ***i = 1, …………, N,*** the slope of the linear regression of ***yi = f(xi)*** is

$$a = \frac{\frac{1}{N}\sum_{i=1}^{N} x_i y_i - \bar{x}\,\bar{y}}{S_x^2} \qquad (1)$$

- If the series ***x*** and ***y*** are split in ***M*** subsets, ***j = 1, …., M,*** according to index ***i,*** such that each has ***nj*** disjoint (non common) elements, such that

$$\sum_{j=1}^{M} n_j = N \qquad (2)$$

- that is to say, all the elements from ***i = 1, …. , N*** are included in one and only one subset ***j***, then for any variable α

$$\sum_{j=1}^{M}\sum_{i=1}^{n_j}\alpha_i = \sum_{i=1}^{N}\alpha_i \qquad (3)$$

- Each ***j*** subset is not necessarily composed of subsequent ***i*** elements. Then, under the assumption that

$$\bar{x}_j = \bar{x} \quad (4) \qquad \text{and} \qquad S_{xj}^2 = S_x^2 \quad (5)$$

- for all ***j***:

$$a = \frac{1}{N}\sum_{j=1}^{M} n_j a_j \qquad (6)$$

- Proof:

$$\frac{1}{N}\sum_{j=1}^{M} n_j a_j = \frac{1}{N}\sum_{j=1}^{M} n_j \frac{\left[\frac{1}{n_j}\sum_{i=1}^{n_j} x_i y_i - \bar{x}_j \bar{y}_J\right]}{S_{xj}^2} \qquad (7)$$

- By (4) and (5), equation (7) becomes:

$$\frac{1}{N}\sum_{j=1}^{M} n_j a_j = \frac{1}{S_x^2 N}\left[\sum_{j=1}^{M}\sum_{i=1}^{n_j} x_i y_i - \bar{x}\sum_{j=1}^{M}\bar{y}_j n_j\right] \quad (8)$$

- But

$$\sum_{j=1}^{M}\bar{y}_j n_j = N\,\bar{y}$$

- So

$$\frac{1}{N}\sum_{j=1}^{M} n_j a_j = \frac{1}{S_x^2}\left[\frac{1}{N}\left[\sum_{j=1}^{M}\sum_{i=1}^{n_j} x_i y_i\right] - \bar{x}\,\bar{y}\right]$$

- Applying (3), the above equation becomes

$$\frac{1}{N}\sum_{j=1}^{M} n_j a_j = \frac{\left[\frac{1}{N}\sum_{i=1}^{N} x_i y_i - \overline{x}\,\overline{y}\right]}{S_x^2} \qquad (9)$$

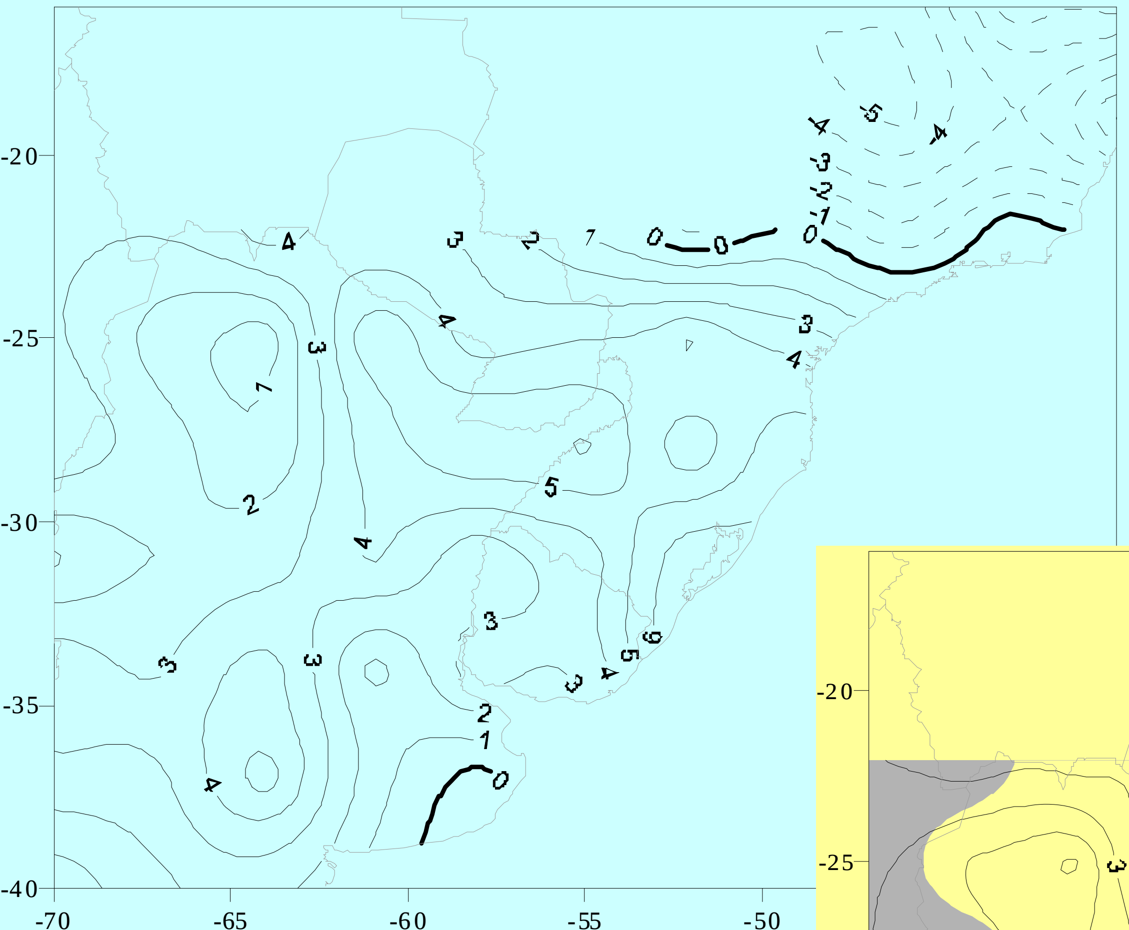
- Thus, according to (1) $\quad \frac{1}{N}\sum_{j=1}^{M} n_j a_j = a$

In the particular case of annual or seasonal precipitation series, its linear trend is the slope of the linear regression of these variables as a function of the year

: Mean and Standard Deviation of El Niño, La Niña and Neutral events 1960 – 1999

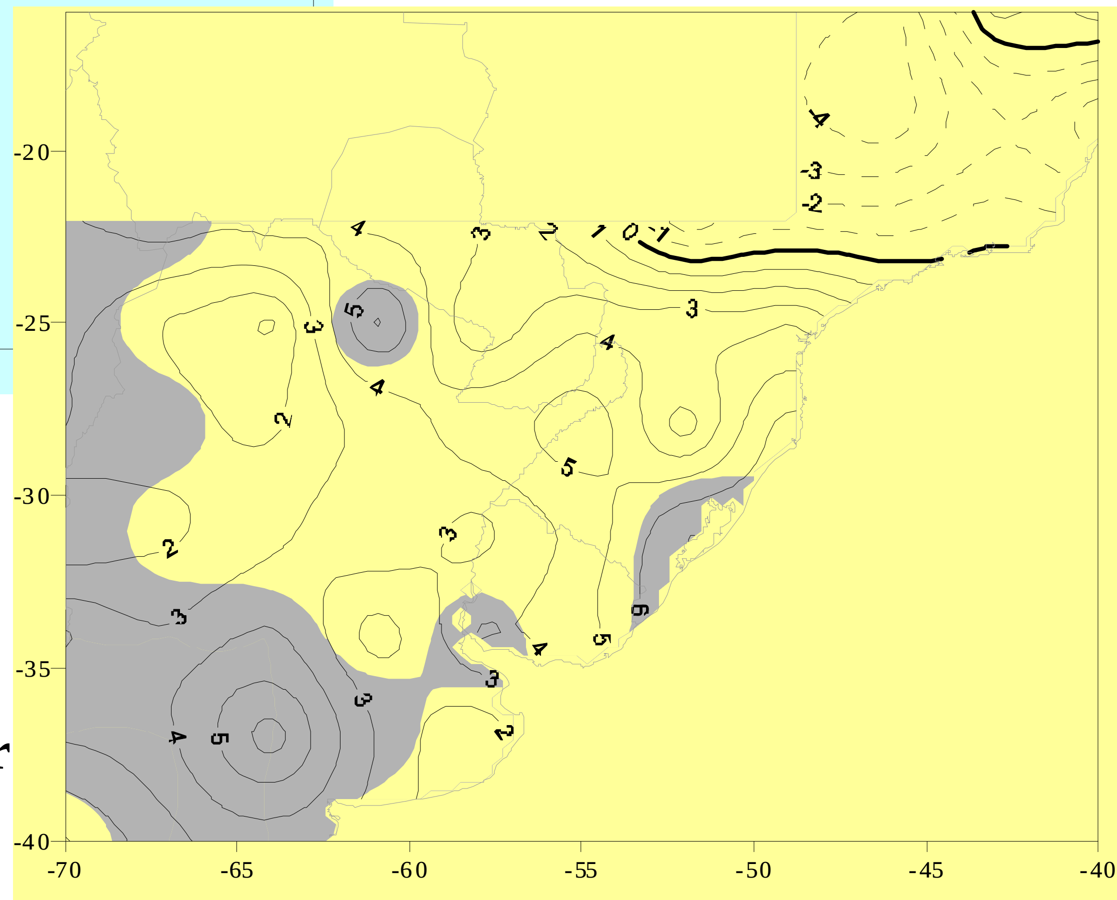
MONTHS	EL NIÑO		LA NIÑA		NEUTRAL	
	Mean	Stand Dev	Mean	Stand Dev	Mean	Stand Dev
January	1980	10.9	1980.2	11.4	1978.6	13.1
February	1981.1	11.4	1983.1	10.7	1976.7	12.2
March	1982.6	10.9	1983.1	10.7	1975.8	12.1
April	1984.2	10.8	1981.3	10.1	1976.2	12.1
May	1981.5	11.7	1980.6	11.5	1978	12.1
June	1981.1	12.5	1979.8	11.1	1978.2	12
July	1981.9	11.7	1979.8	13.4	1977.7	11.3
August	1980.9	11.5	1979.8	13.4	1978.4	11.7
September	1980	11.5	1981	12.4	1977.9	12
October	1979	10.9	1981	12.4	1978.9	12.6
November	1979	10.9	1981	12.4	1978.9	12.6
December	1979	10.9	1981	12.4	1978.9	12.6
Weighted Mean	1980.8	11.3	1980.9	11.9	1977.8	12.2

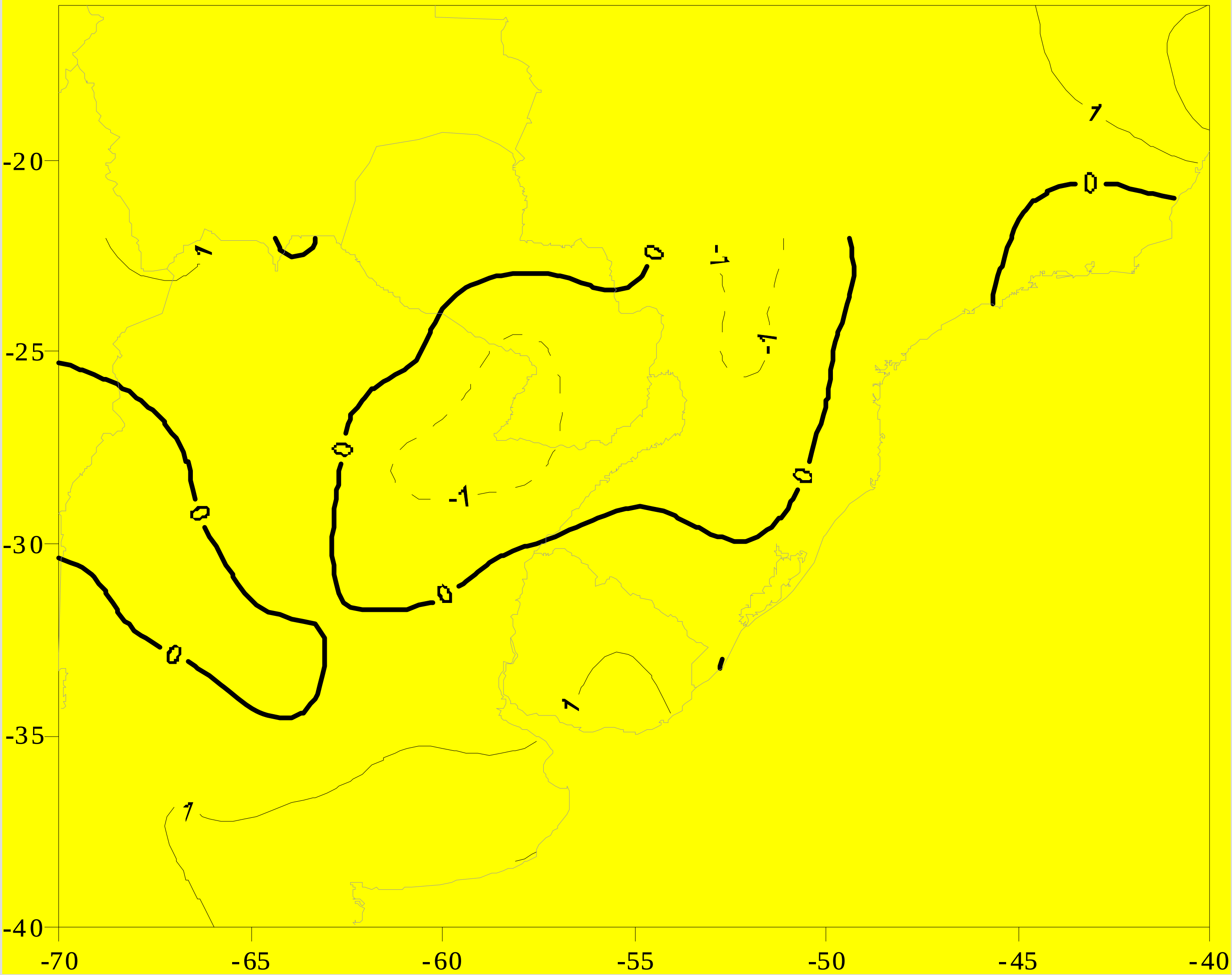
SOME DOUBT ?



TRENDS CALCULATED AS THE SUM OF TRENDS OF EL NIÑO, LA NIÑA AND NEUTRAL CASES mm/year

TRENDS CALCULATED DIRECTLY FROM ALL DATA mm/year



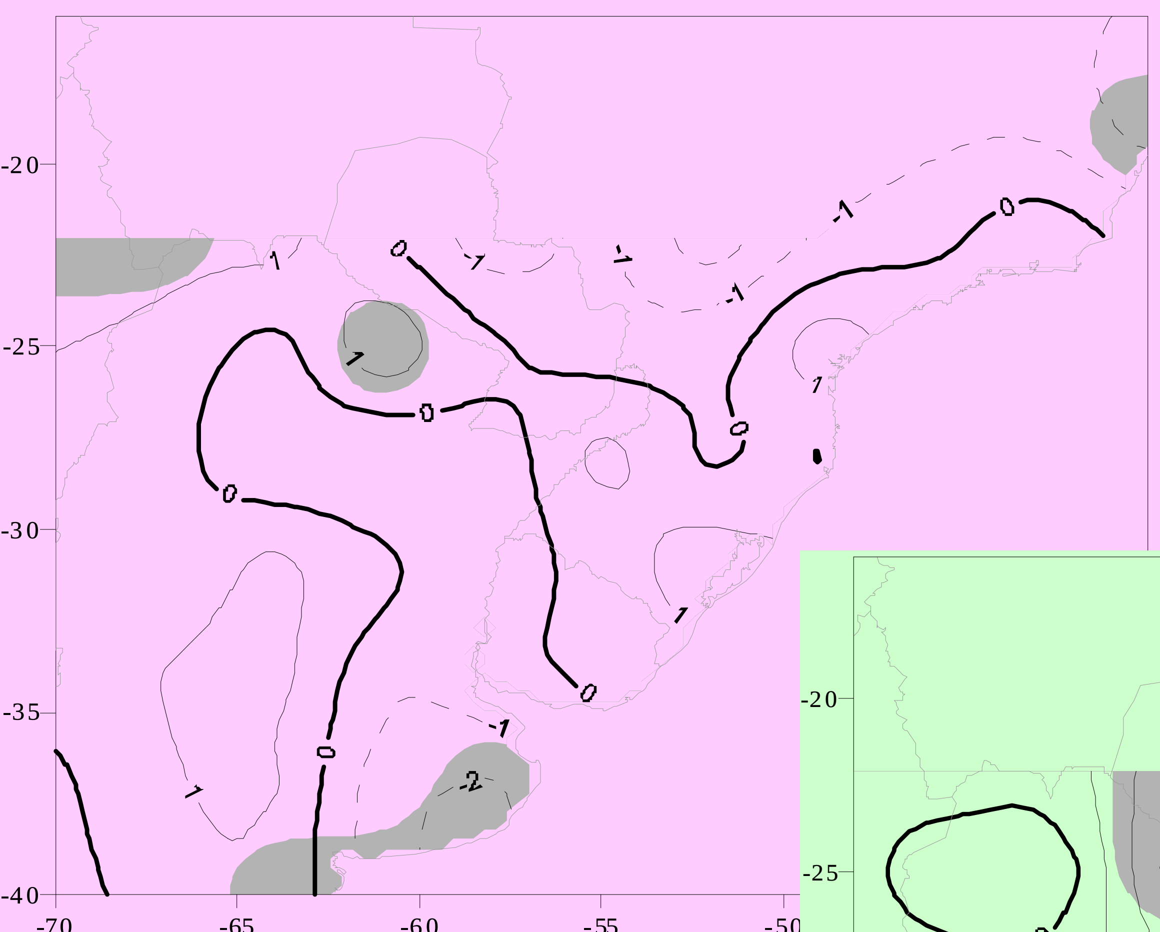


DIFFERENCE BETWEEN THE SUM OF EL NIÑO, LA NIÑA AND NEUTRAL TRENDS AND THE TRENDS CALCULATED DIRECTLY FROM ALL DATA

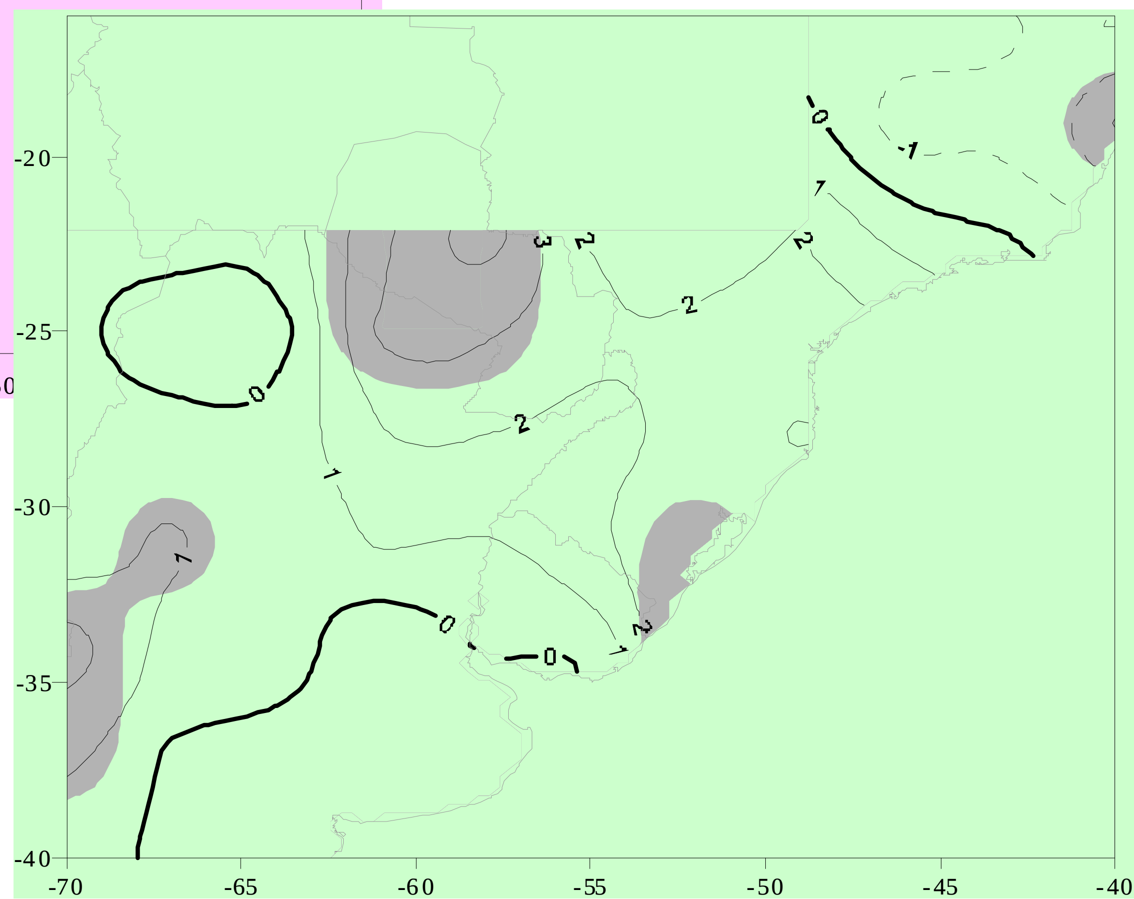
WHO WAS?

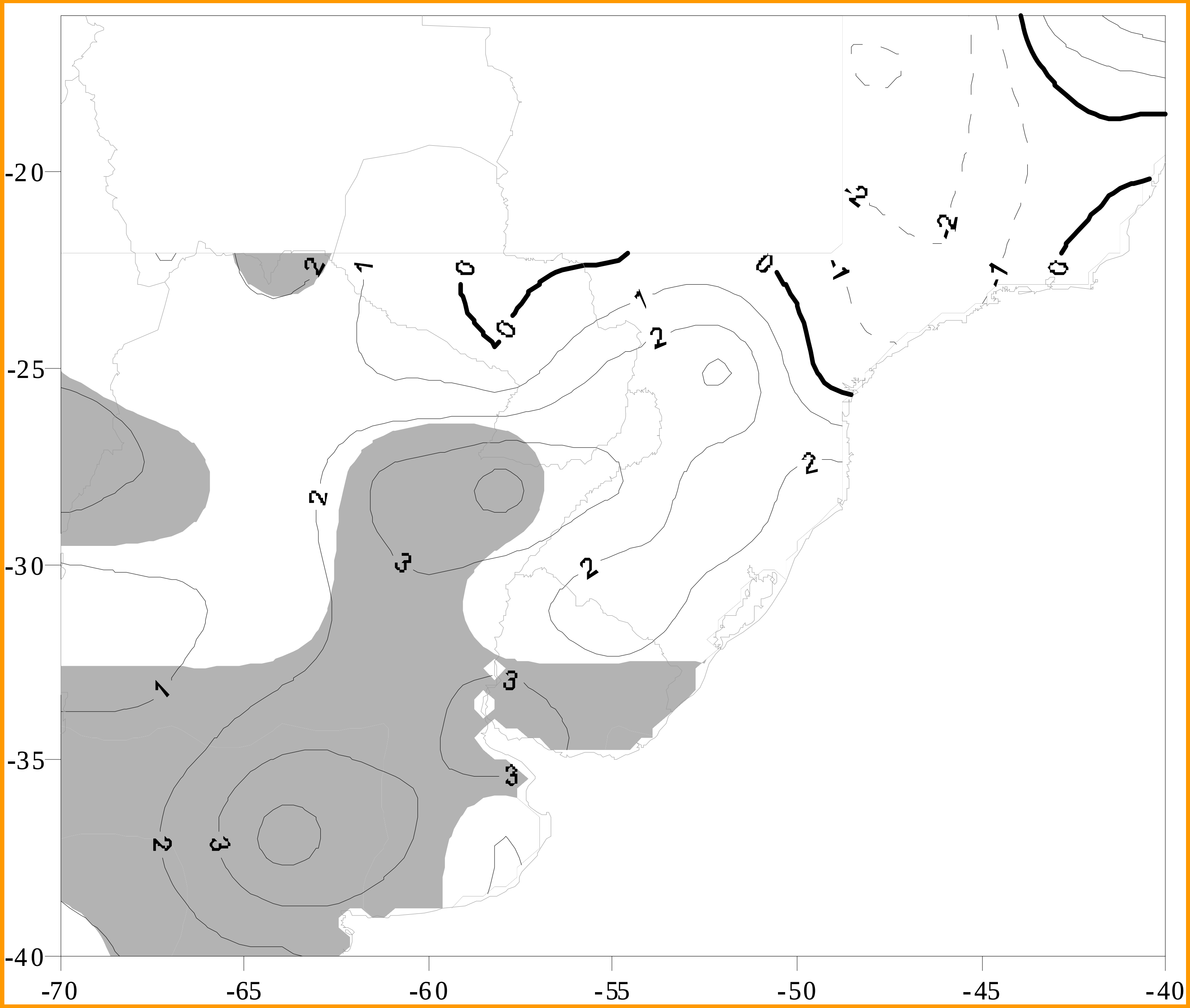
AND WHERE?

Niña mm/year



Niño mm/year





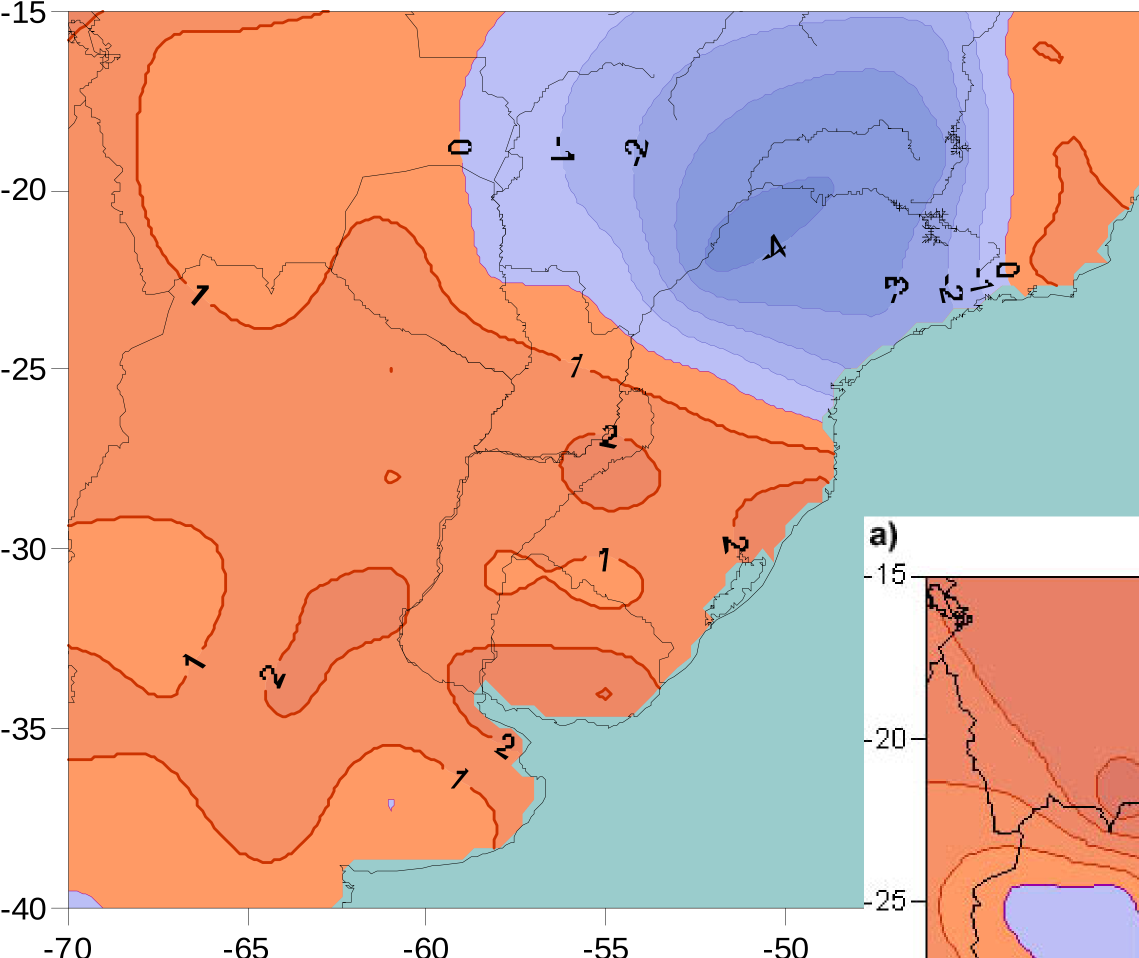
NEUTRAL

PRECIPITATION TRENDS IN THE WEST AND SOUTH OF SUBTROPICAL ARGENTINA WERE MAINLY DUE TO THE TREND DURING NEUTRAL YEARS

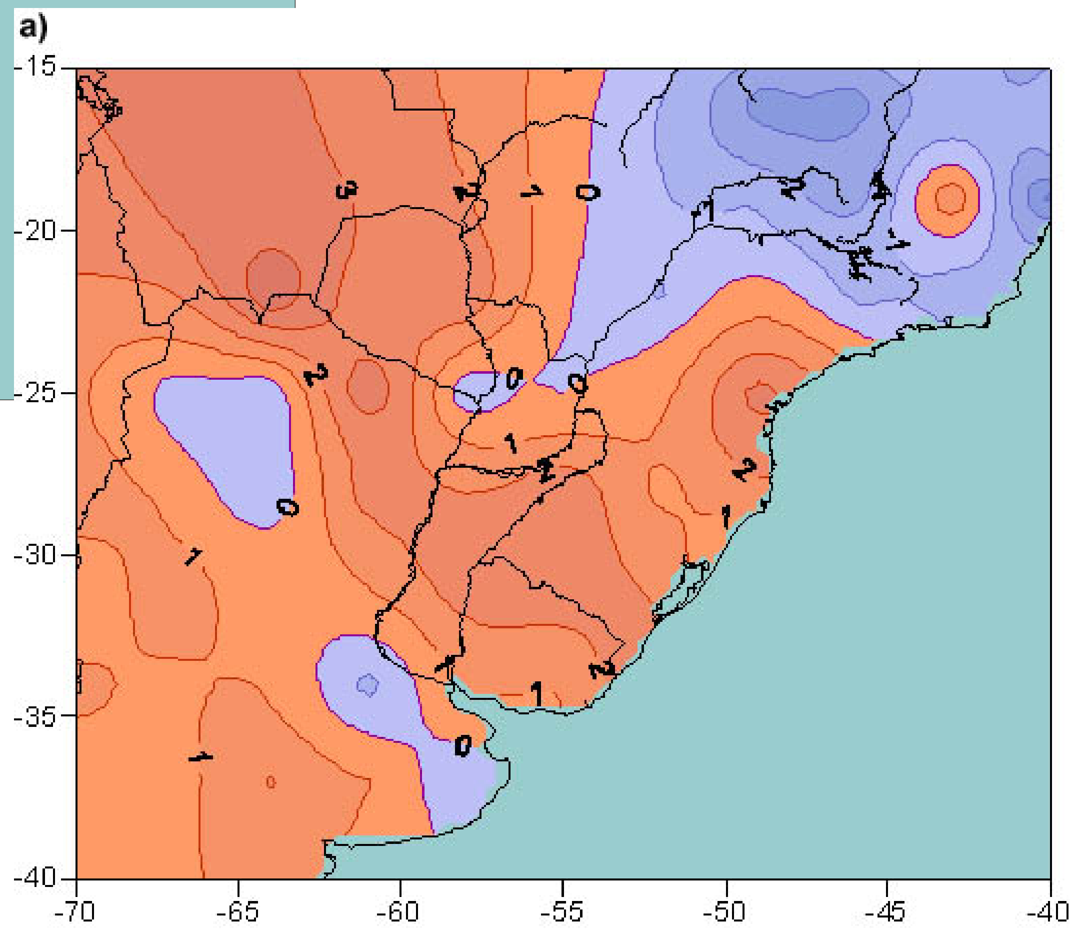
THE TRENDS IN A BAND THAT RUNS FROM THE CHACO REGION THROUGH NORTHEASTERN ARGENTINA TO SOUTHERN BRAZIL WAS MAINLY DUE TO THE TREND DURING EL NIÑO YEARS

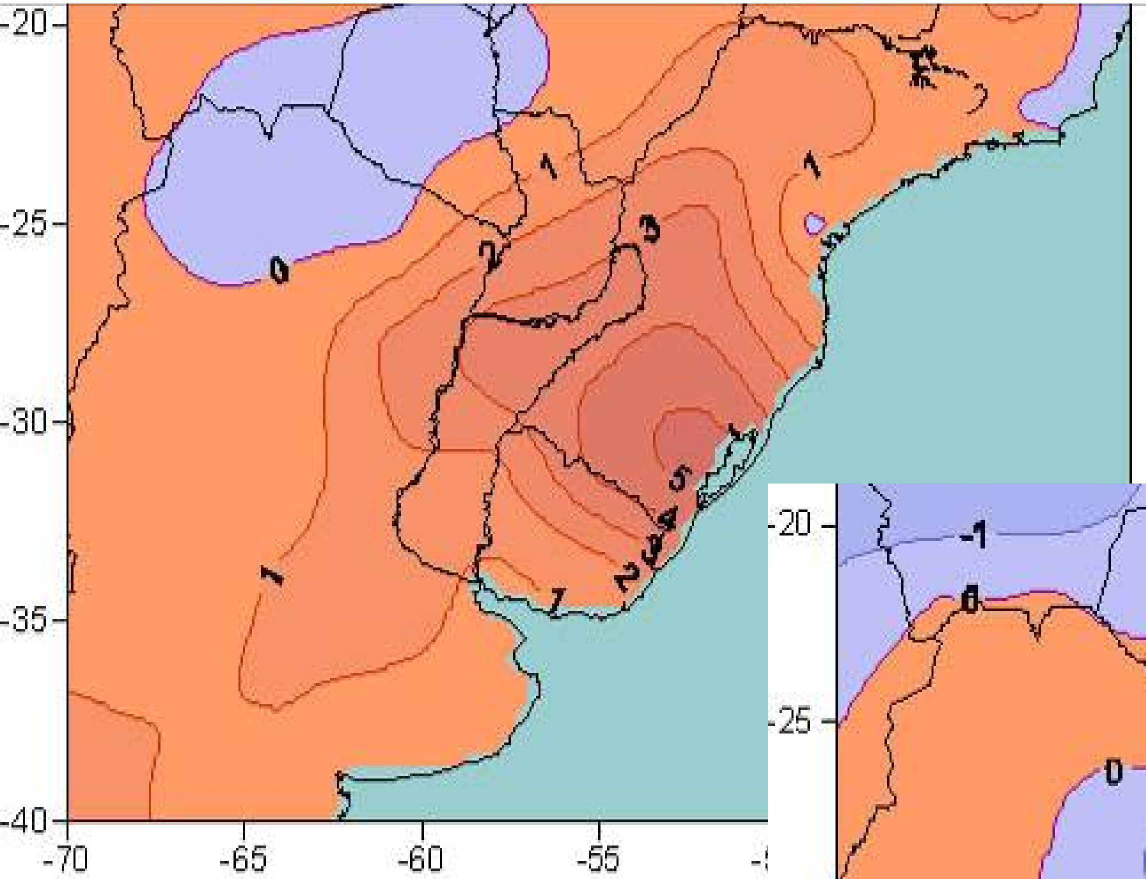
NEUTRAL TREND:
WHAT WAS THE CAUSE?

Spring mm/year

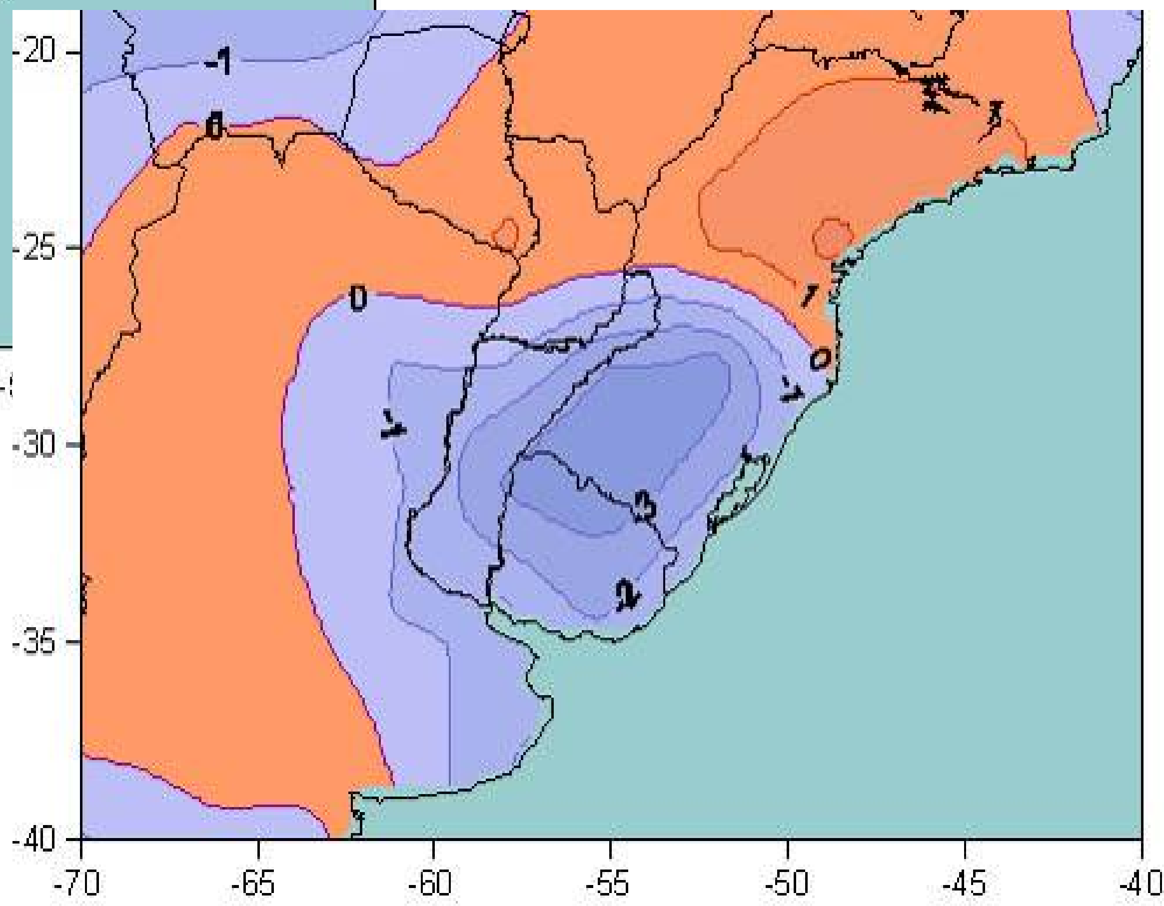


Summer mm/year

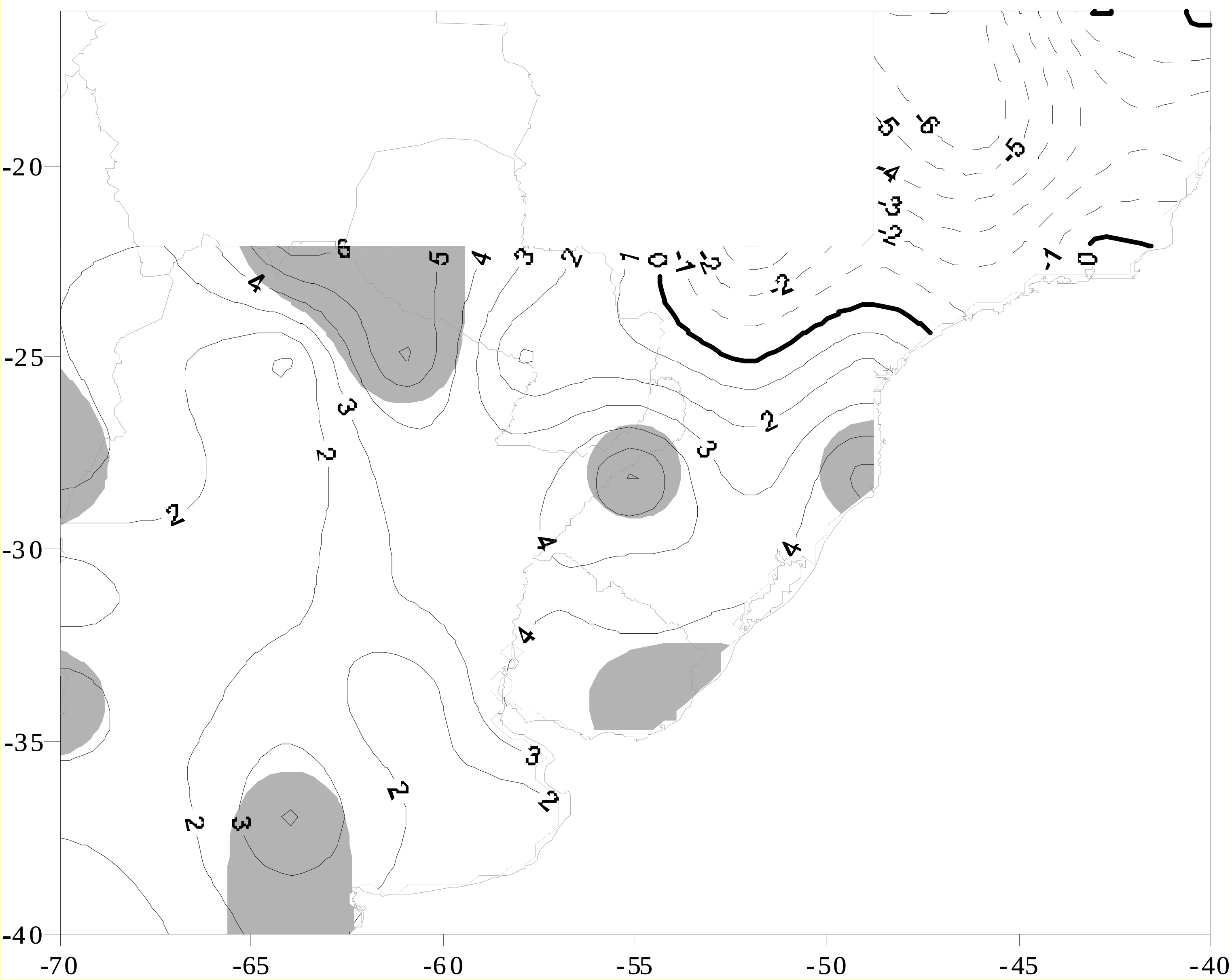




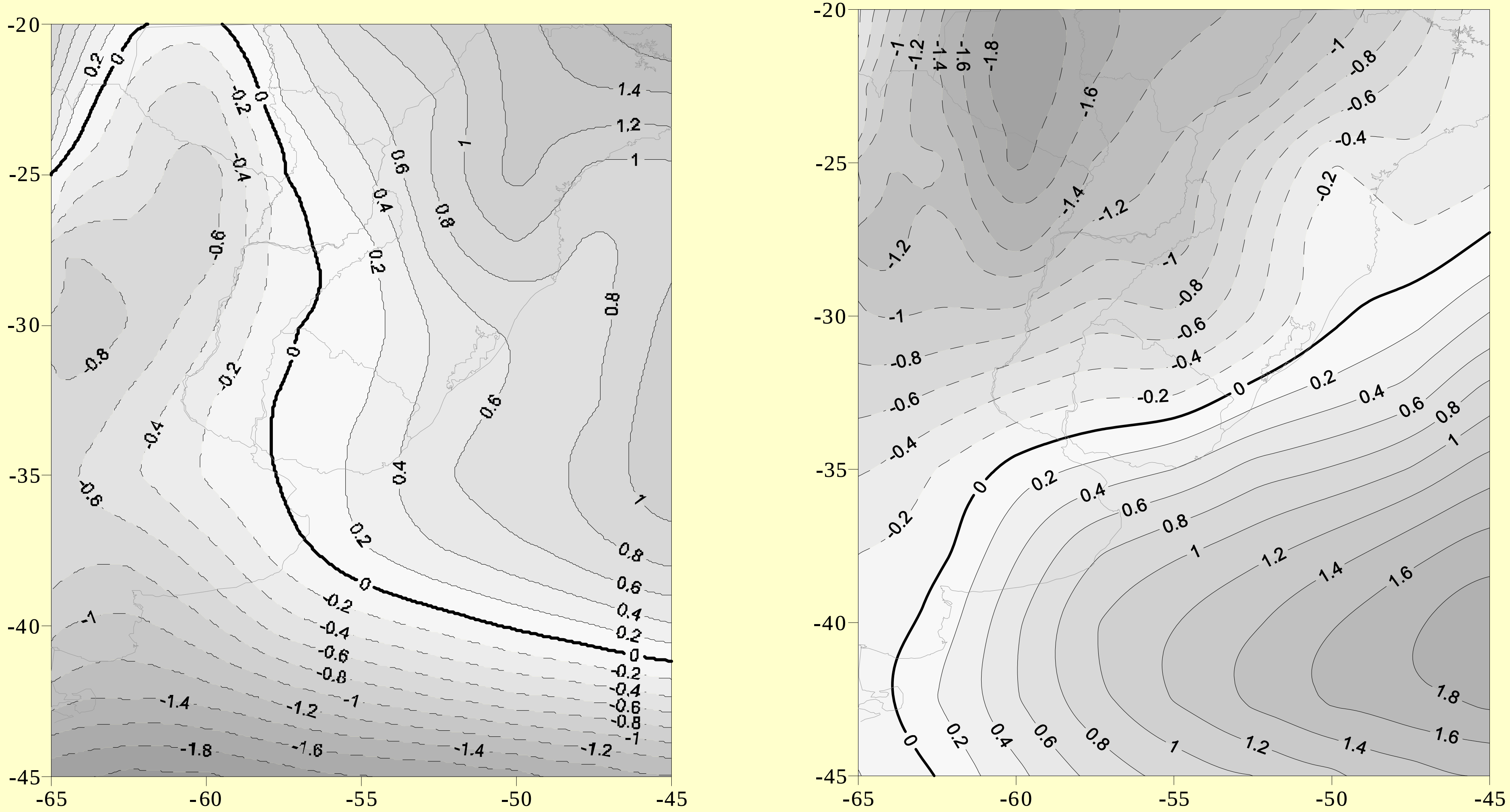
Autumn mm/year



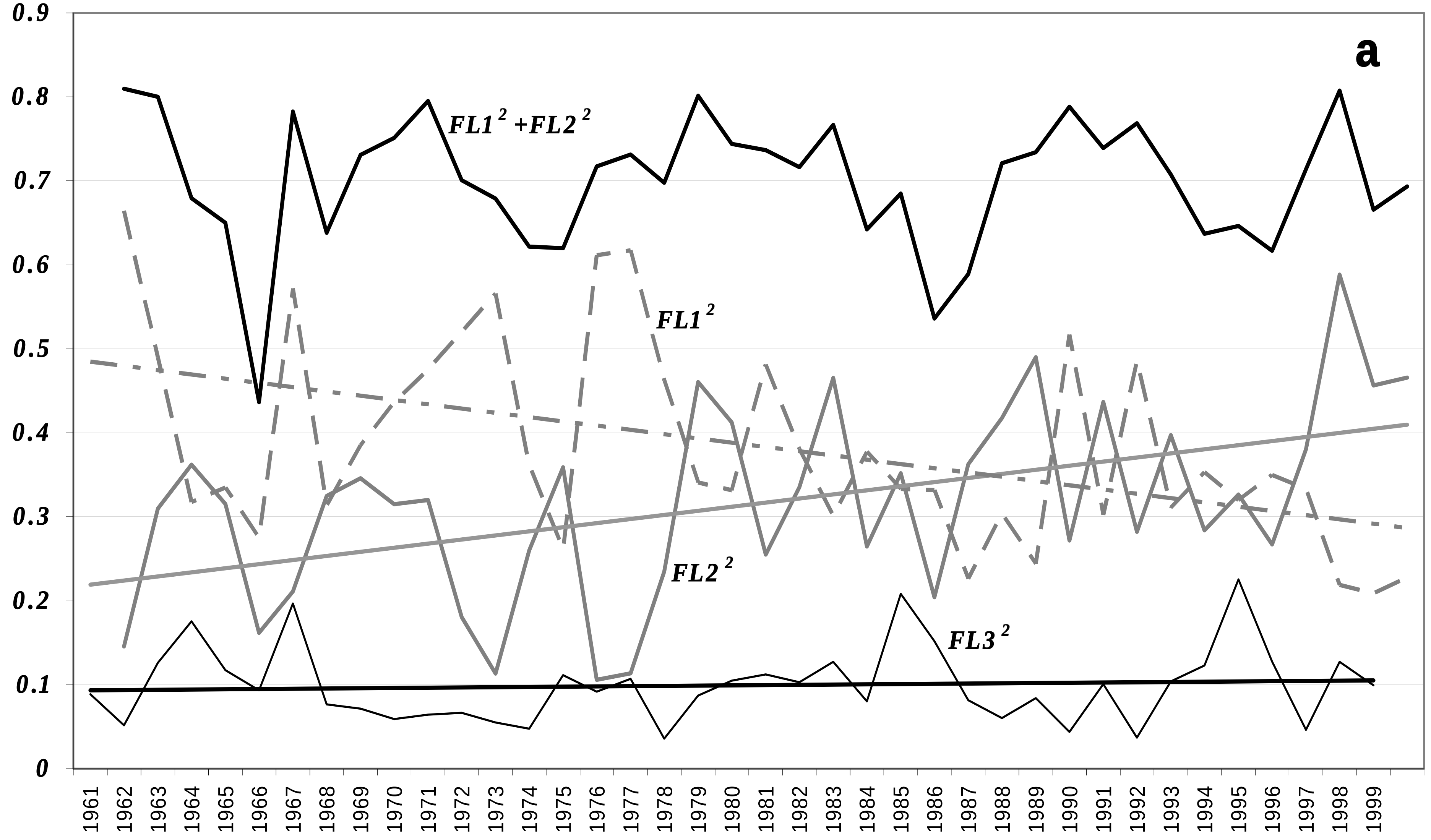
Winter mm/year



Seasonal rainfall linear trends: October – March in mm/year. Periods 1960 – 1999. Shaded area, significant at the 95% level.

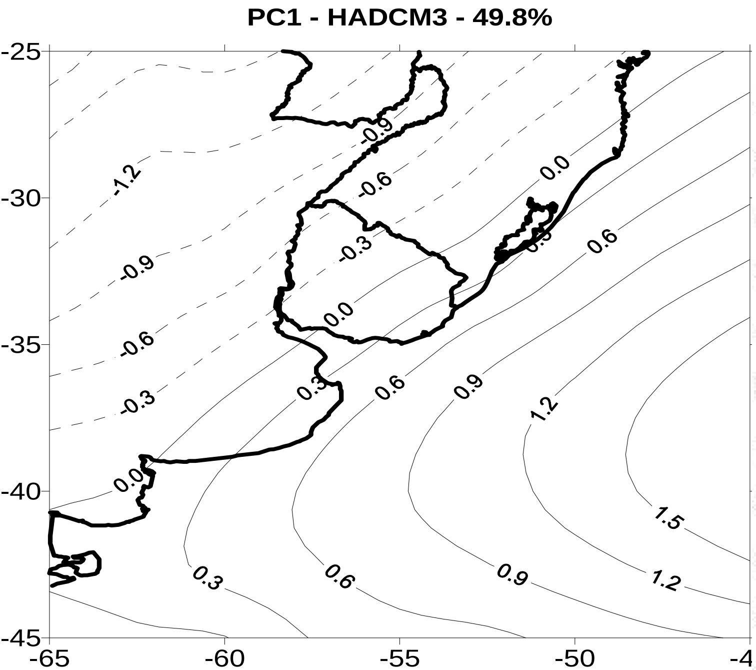


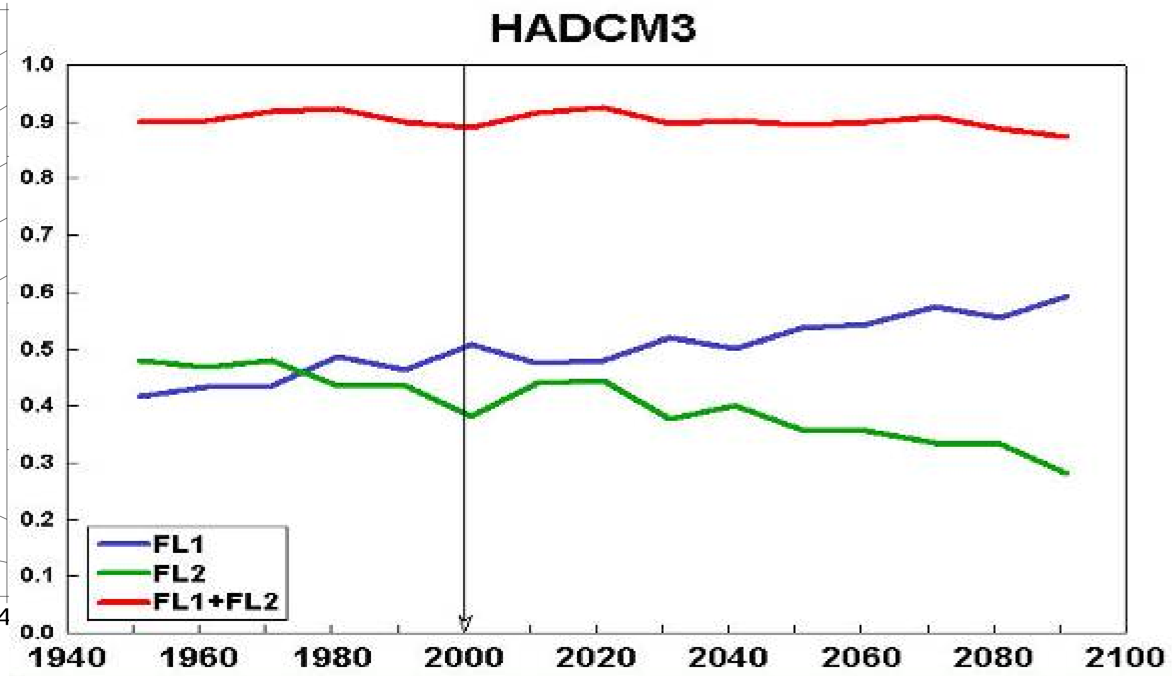
SLP leading modes of the warm semester: left) first, right) second factor scores

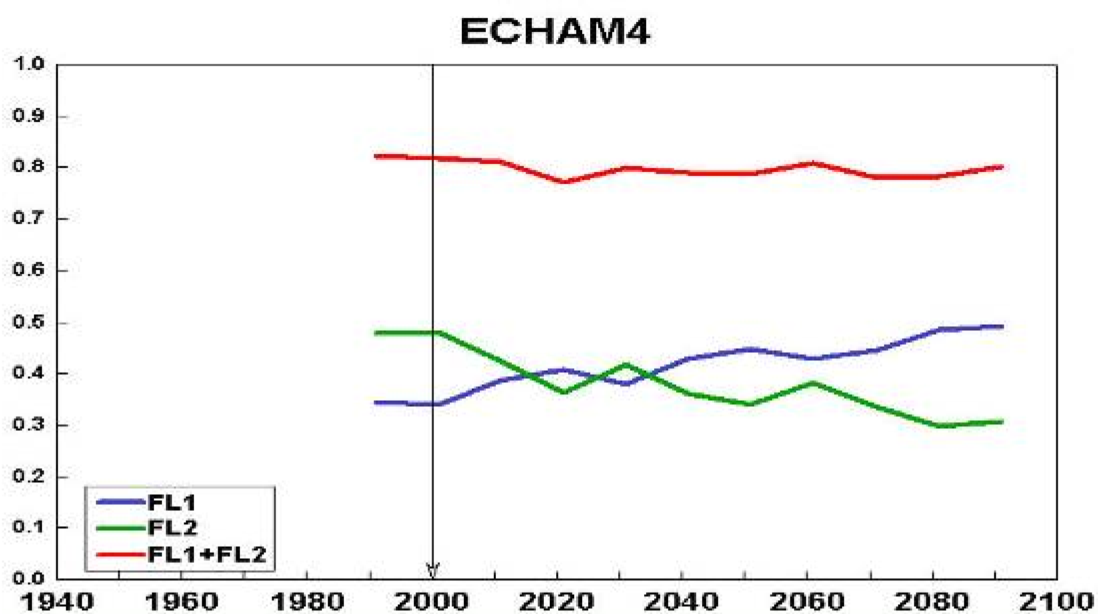


Mean squared leading SLP factor loadings: a) warm semester

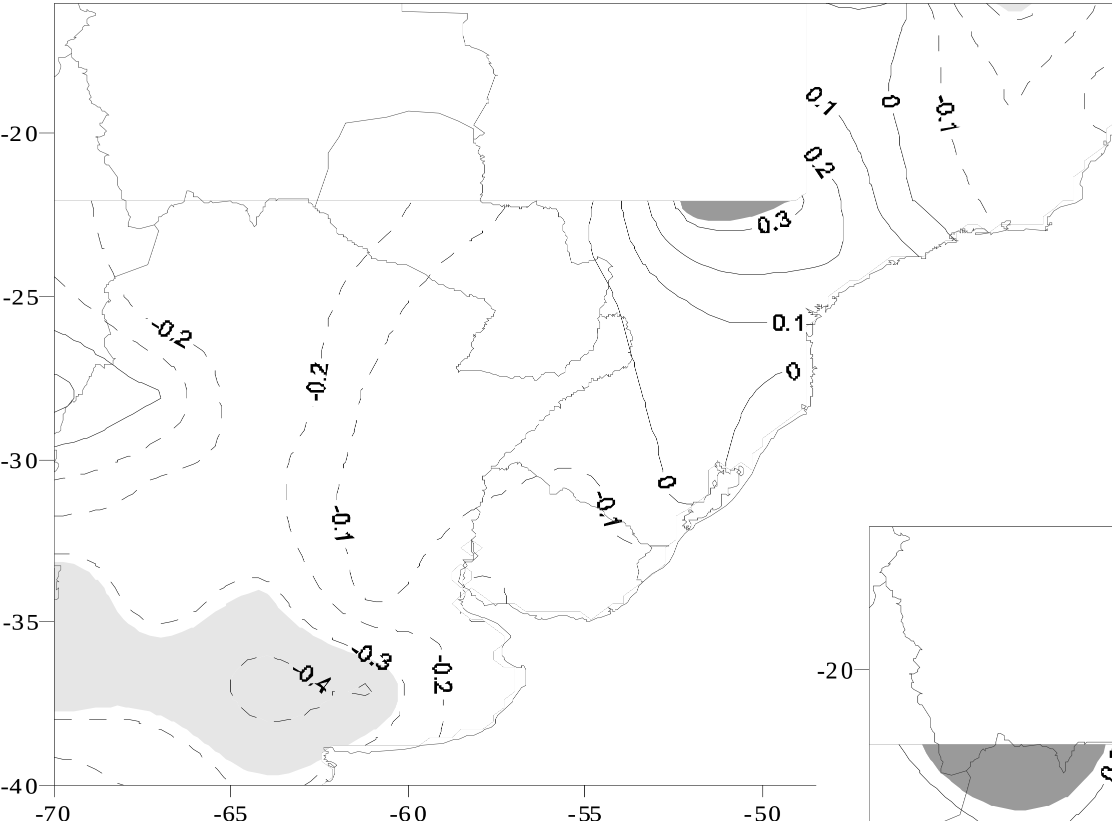
Di Luca, Camilloni 2006

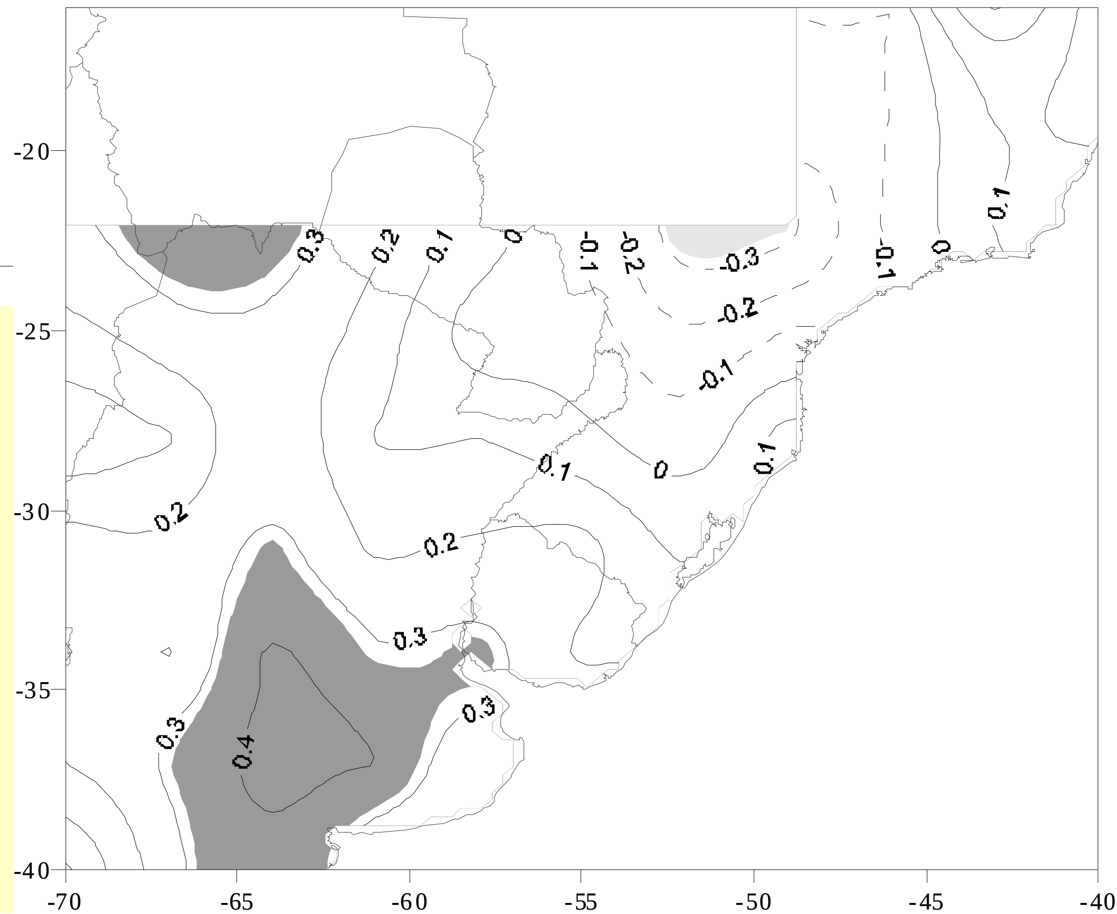




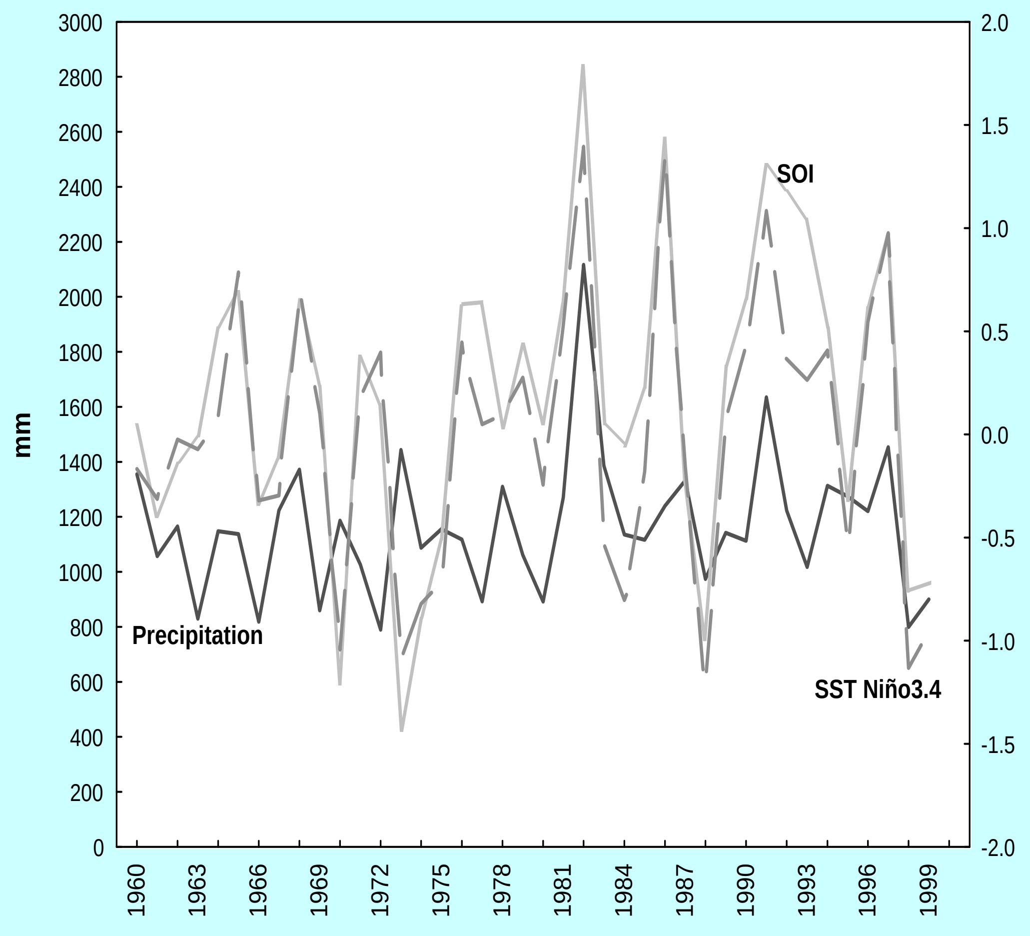


Di Lucca, Camilloni, 2006

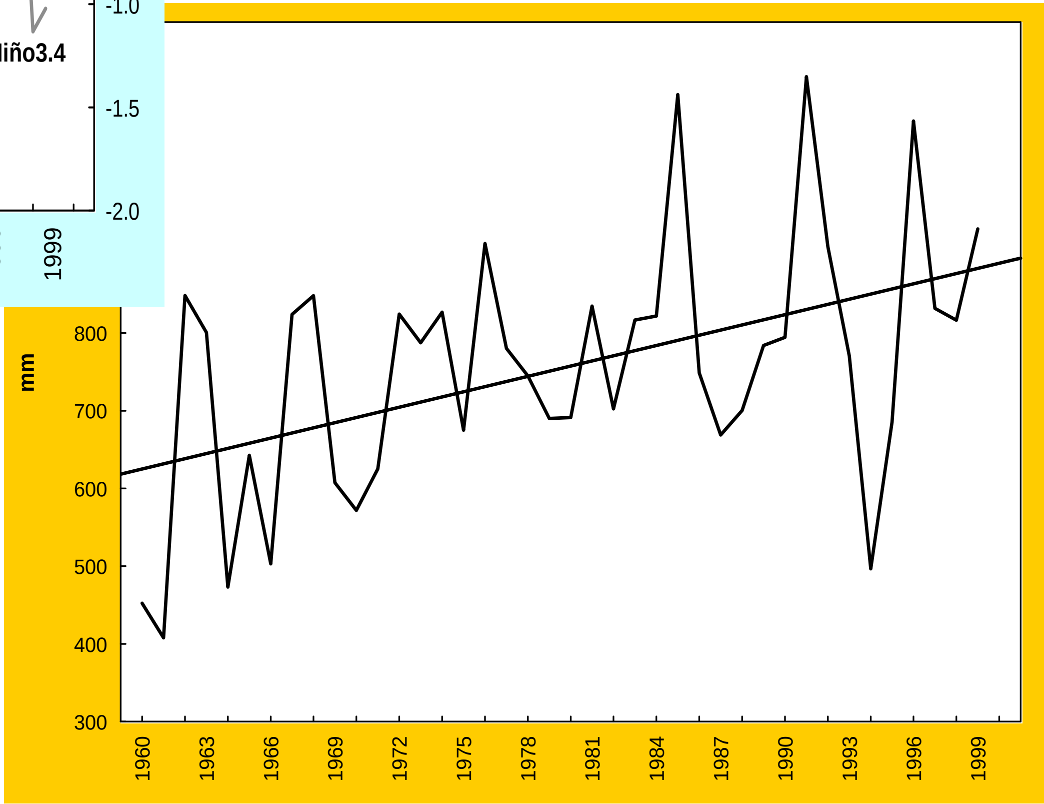




Linear correlation coefficients between rainfall and leading SLP factor loadings (FL) for the warm semester: upper) FL1 and lower) FL 2. Significant areas at a 95% level are shaded.



Annual rainfall time series for 3° latitude by 3° longitude areas. Central grid points centered at: up) 25°S, 58°W and low) 37°S, 64°W.



CONCLUSION

- THERE IS HIGH PROBABILTY THAT TRENDS IN THE WEST AND SOUTH OF SUBTROPICAL ARGENTINA WERE RELATED TO GLOBAL WARMING

- IN THE NORTHEAST OF ARGENTINA, TRENDS WERE RELATED TO EL NIÑO ACTIVITY