

# TEMPO E CLIMA - IMPACTOS EM ÁGUA E ENERGIA

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# ***PALEOCLIMA***

## Clima Global do Passado

- Temperatura global durante boa parte da história 8° a 15° C mais quente do que o presente clima, ausência das geleiras polares
- Períodos glaciais (e.g. 700 e 300 milhões de anos atrás (maa), mais recente: 2 maa - pleistoceno - idade do gelo)

Geleiras - 10 % da área da Terra, principais Antártica e Groenlândia  
18.000 anos atrás se estendiam sobre latitudes médias.

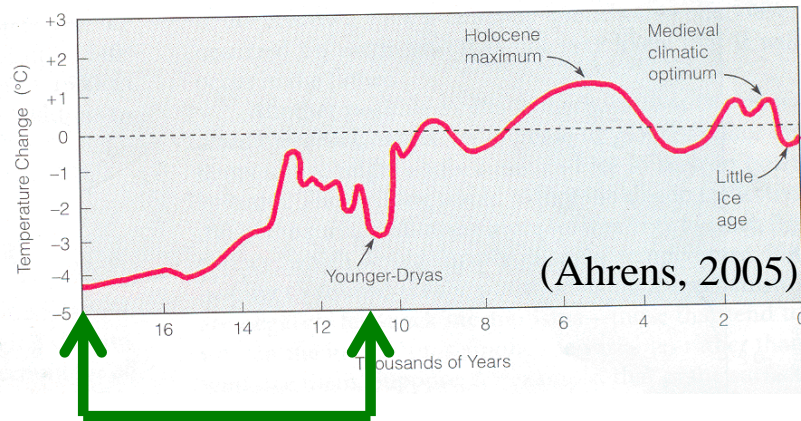
Avanço das geleiras - idade do gelo - períodos mais frios

Avanços e recuos das geleiras -> evidência geológica -> constante  
mudança do clima global

Evidências: sedimentos terrestres e oceânicos, e geleiras.

**FIGURE 18.4**

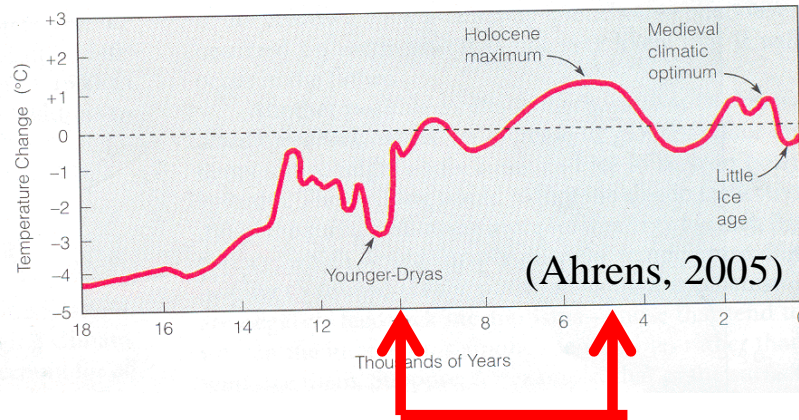
The average air temperature variations for the past 18,000 years. (Modified from J. T. Houghton et al., *Climate Change: The IPCC Assessment*, Cambridge University Press, Cambridge, England, 1990.)



- **18 a 22 mil anos atrás, geleiras sobre a América do Norte atingem máxima profundidade. Oceanos mais baixos ~125 m -> conexão entre Alasca e Sibéria (Estreito de Bering).**
- **14 mil anos atrás, diminuição das geleiras sobre a América do Norte.**
- **11 mil anos atrás, aumento das geleiras na América do Norte e Europa.**

**FIGURE 18.4**

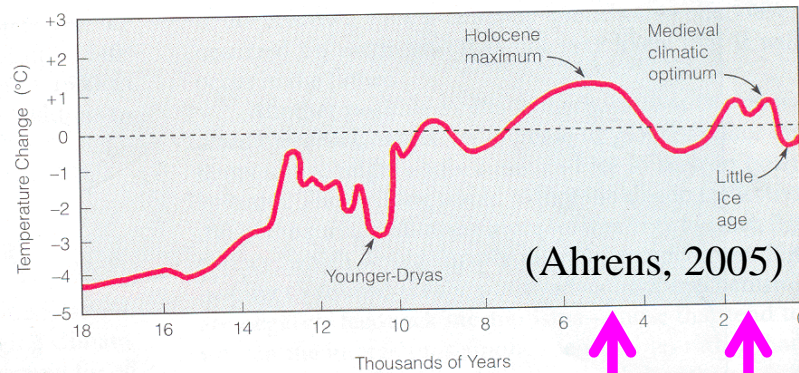
The average air temperature variations for the past 18,000 years. (Modified from J. T. Houghton et al., *Climate Change: The IPCC Assessment*, Cambridge University Press, Cambridge, England, 1990.)



- **Período de glaciação durou cerca 1000 anos (Younger-Dryas).**
- **8 mil anos atrás, fim das geleiras sobre a América do Norte.**
- **6 - 5 mil anos atrás, temperatura global em torno de 1 °C acima da presente. Período interglacial mais quente - clima ótimo**

**FIGURE 18.4**

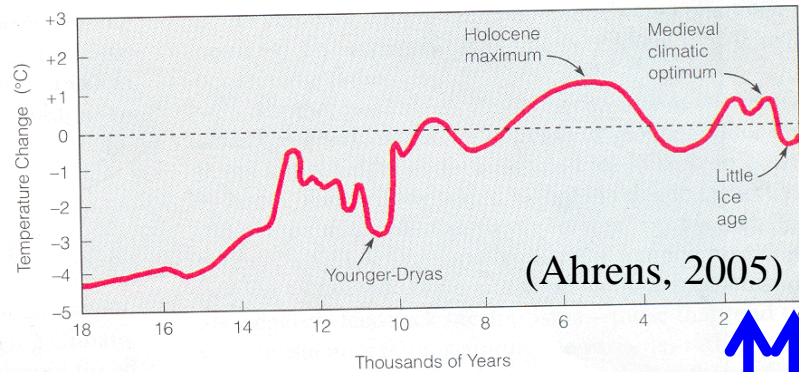
The average air temperature variations for the past 18,000 years. (Modified from J. T. Houghton et al., *Climate Change: The IPCC Assessment*, Cambridge University Press, Cambridge, England, 1990.)



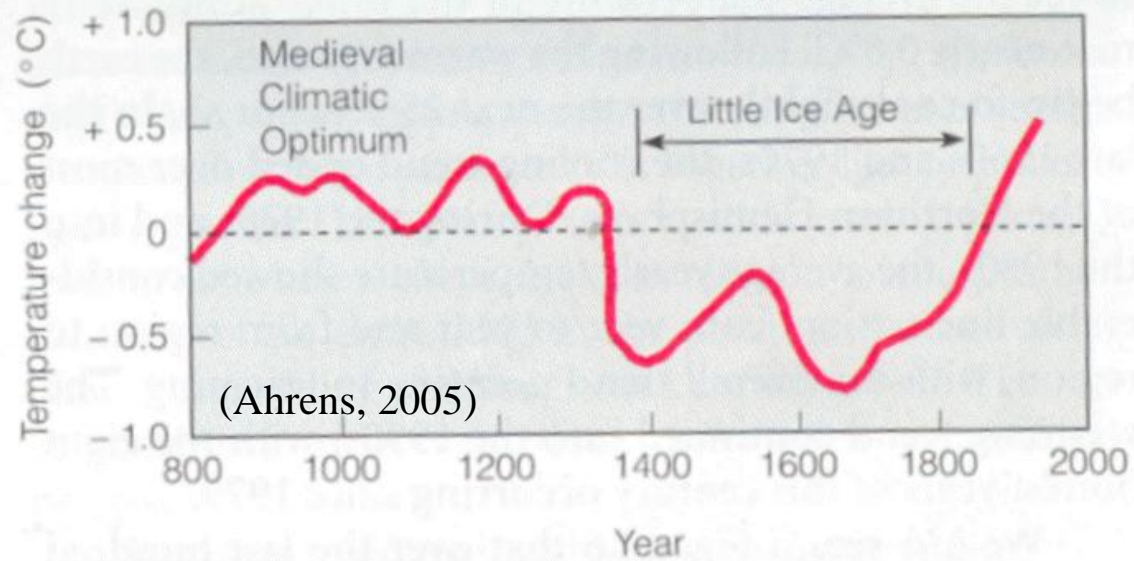
- **5 mil anos atrás, volta das geleiras sobre os Alpes, porém sem formação de gelo sobre áreas continentais.**
- **1 mil anos atrás, clima medieval ótimo, verões secos e quentes.**
- **Por volta de 1200 D.C. , o clima começou a variar abruptamente: secas, enchentes, invernos rigorosos seguidos de invernos amenos.**

**FIGURE 18.4**

The average air temperature variations for the past 18,000 years. (Modified from J. T. Houghton et al., Climate Change: The IPCC Assessment, Cambridge University Press, Cambridge, England, 1990.)



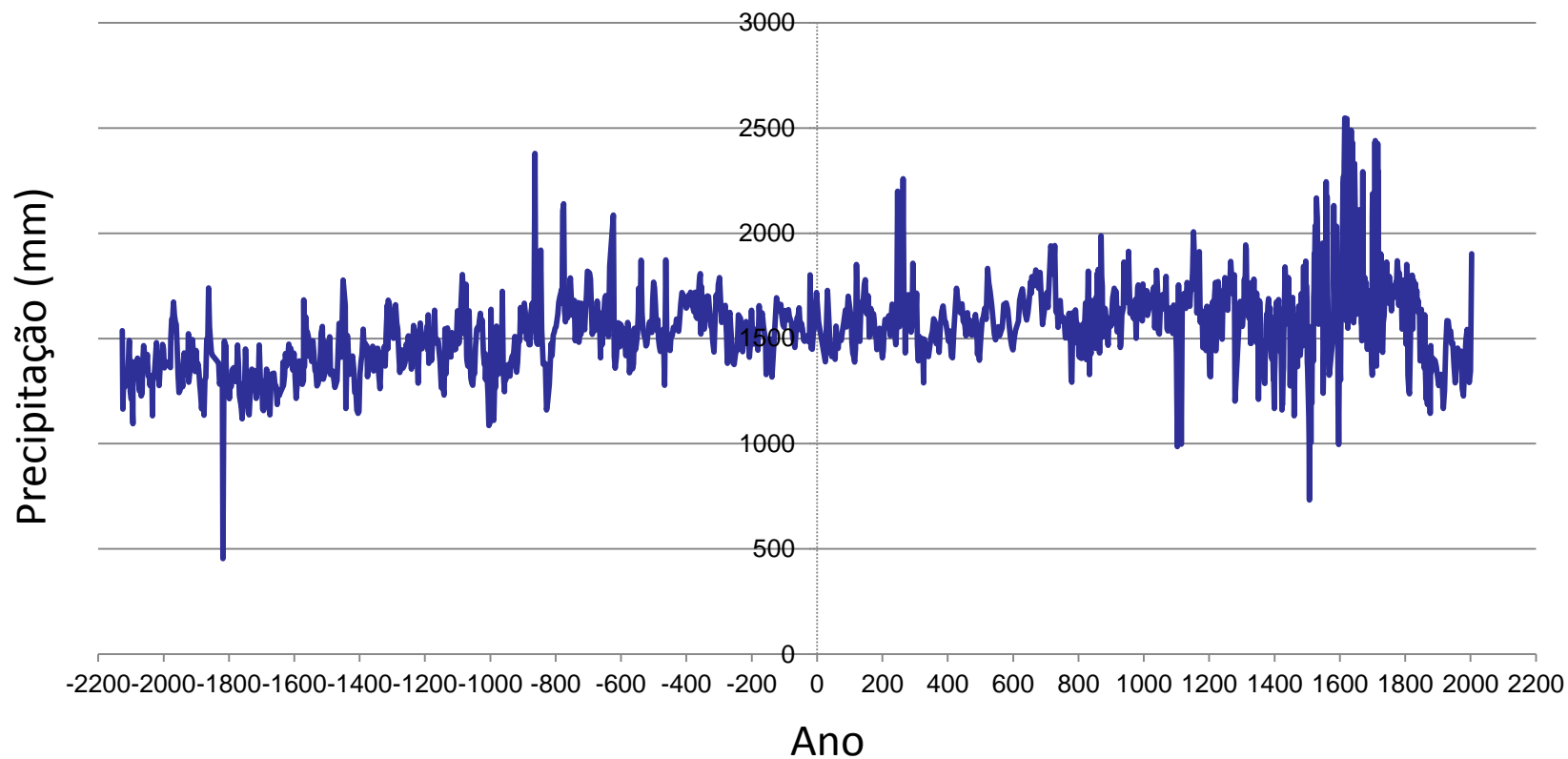
- **Entre 1400 e 1550 D.C, o clima foi moderado, seguido de novo período frio.**
- **Pequena idade do gelo: 1400 - 1900 D.C.**
- **Parte do presente aquecimento global causado pelo efeito estufa (CO<sub>2</sub> entre outros fatores)**



**FIGURE 18.5**

*The average temperature variations of eastern Europe for about the last 1200 years.*

# Chuvas São Paulo - 4000 anos



(Pereira e Frigo, 2010)

## Possíveis Causas das Mudanças Climáticas

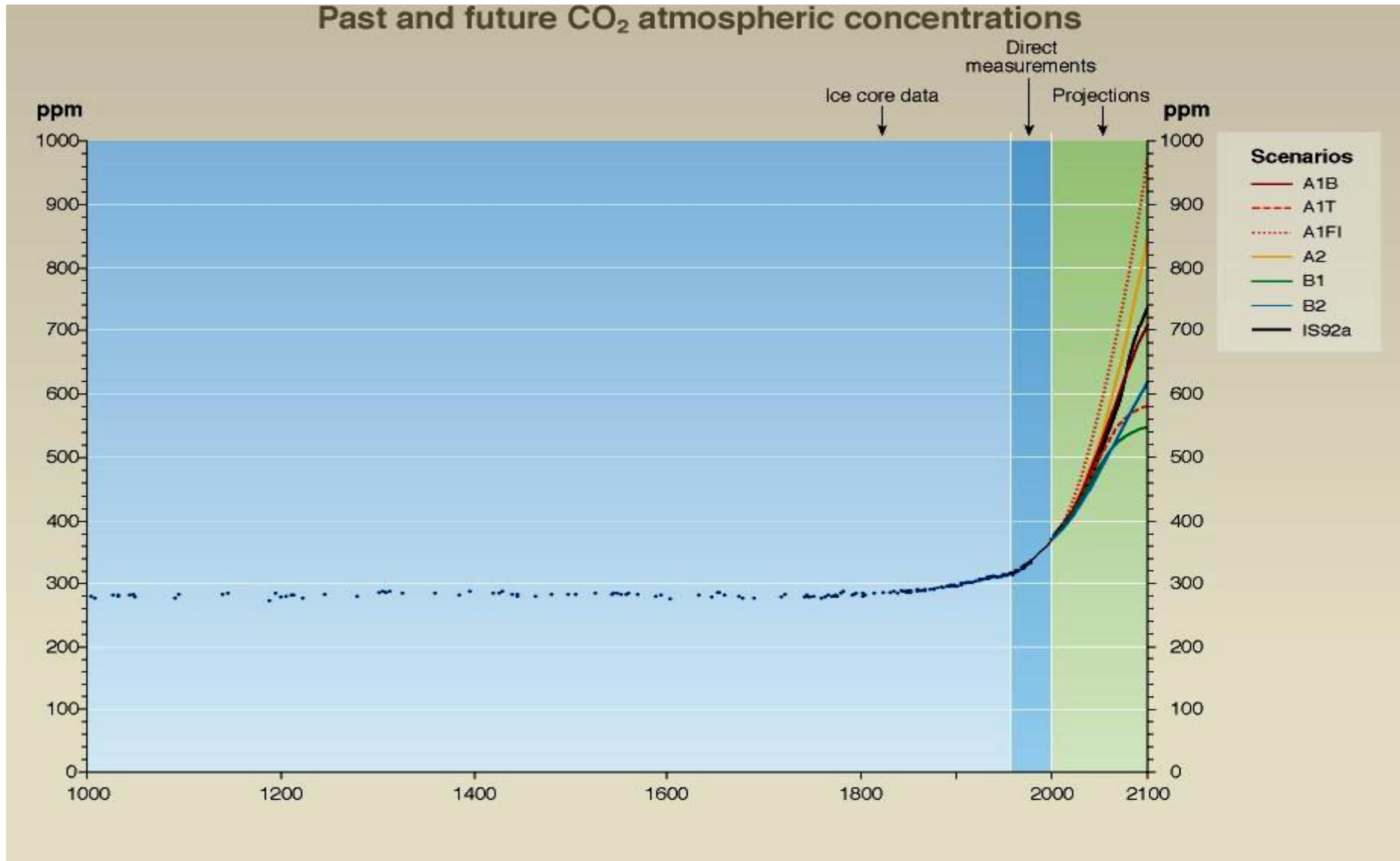
Interações complexas entre atmosfera, hidrosfera, criosfera, litosfera e biosfera determinam o clima.

- Mecanismos de feedback
- Teoria da Tectônica de Placas
- Órbita Terrestre - Teoria de Milankovitch
  - Excentricidade 100.000 anos
  - Precessão 23.000 anos
  - Obliquidade 41.000 anos

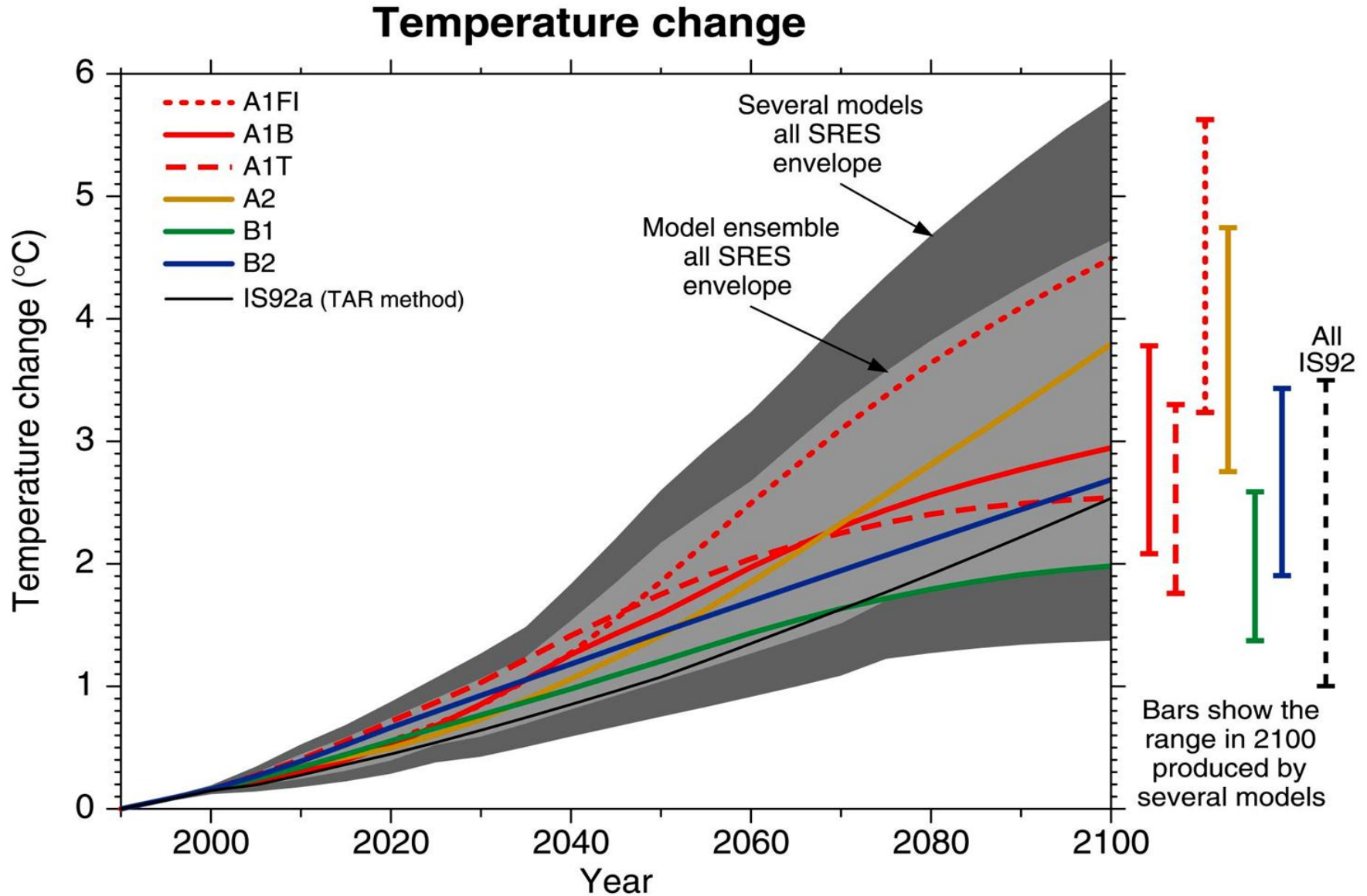
# ***MUDANÇAS CLIMÁTICAS***

## ***IPCC***

# Projeção da concentração de CO<sub>2</sub> - IPCC



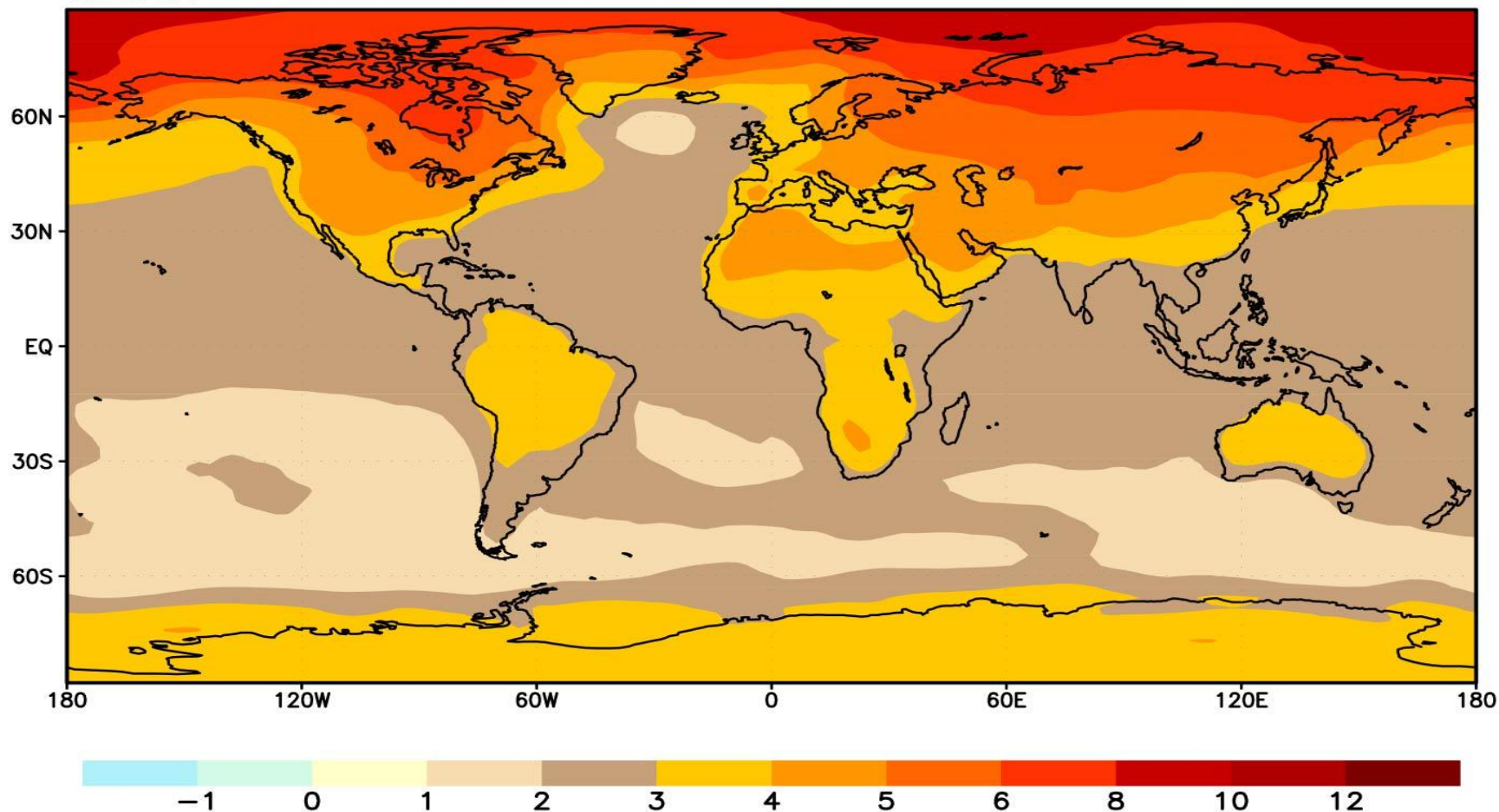
# Projeção do aquecimento global - IPCC



# Projeção de aquecimento global 2071 a 2100- IPCC

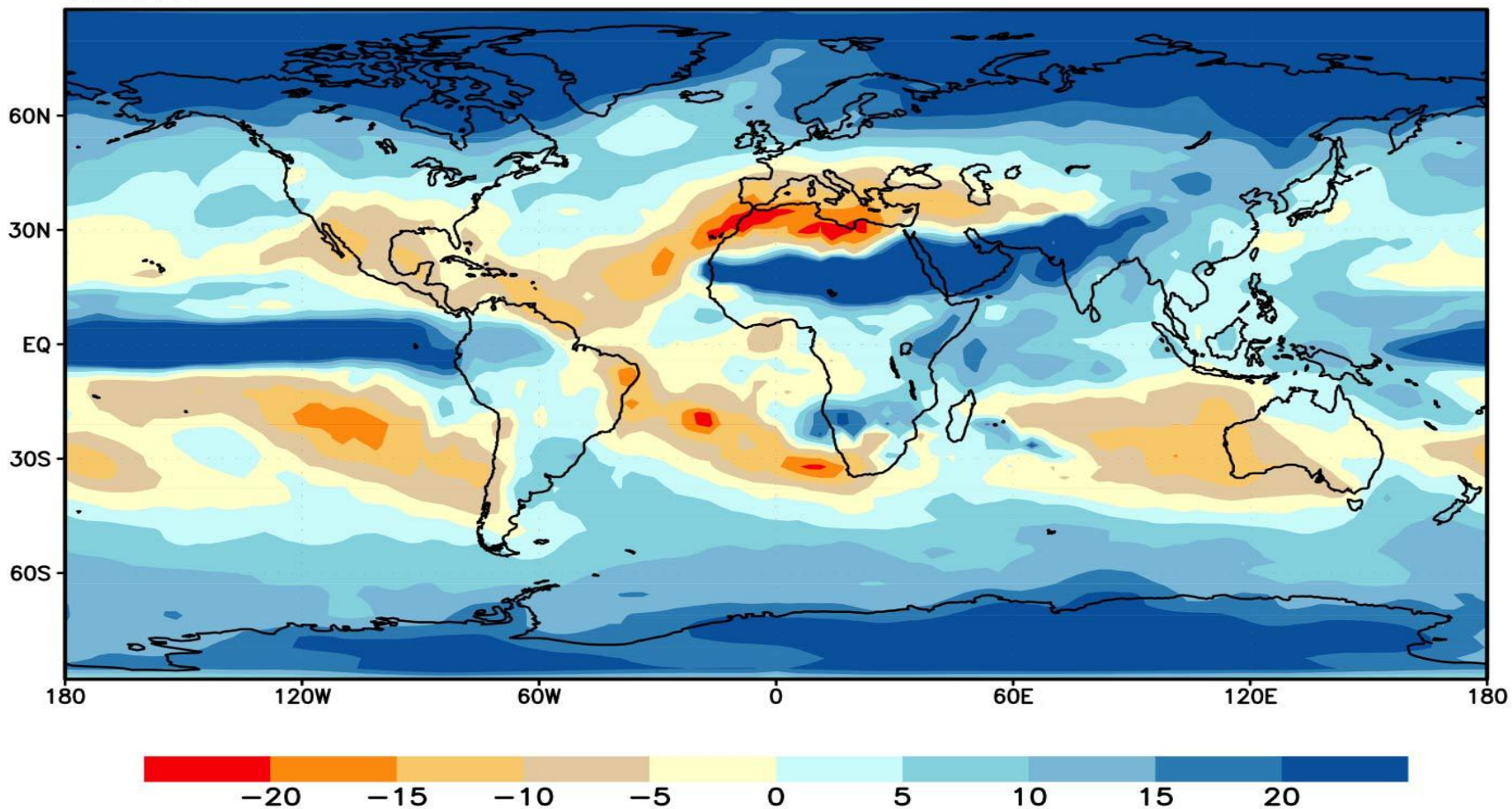
Média global (2085) = 3.1°C

SRES A2

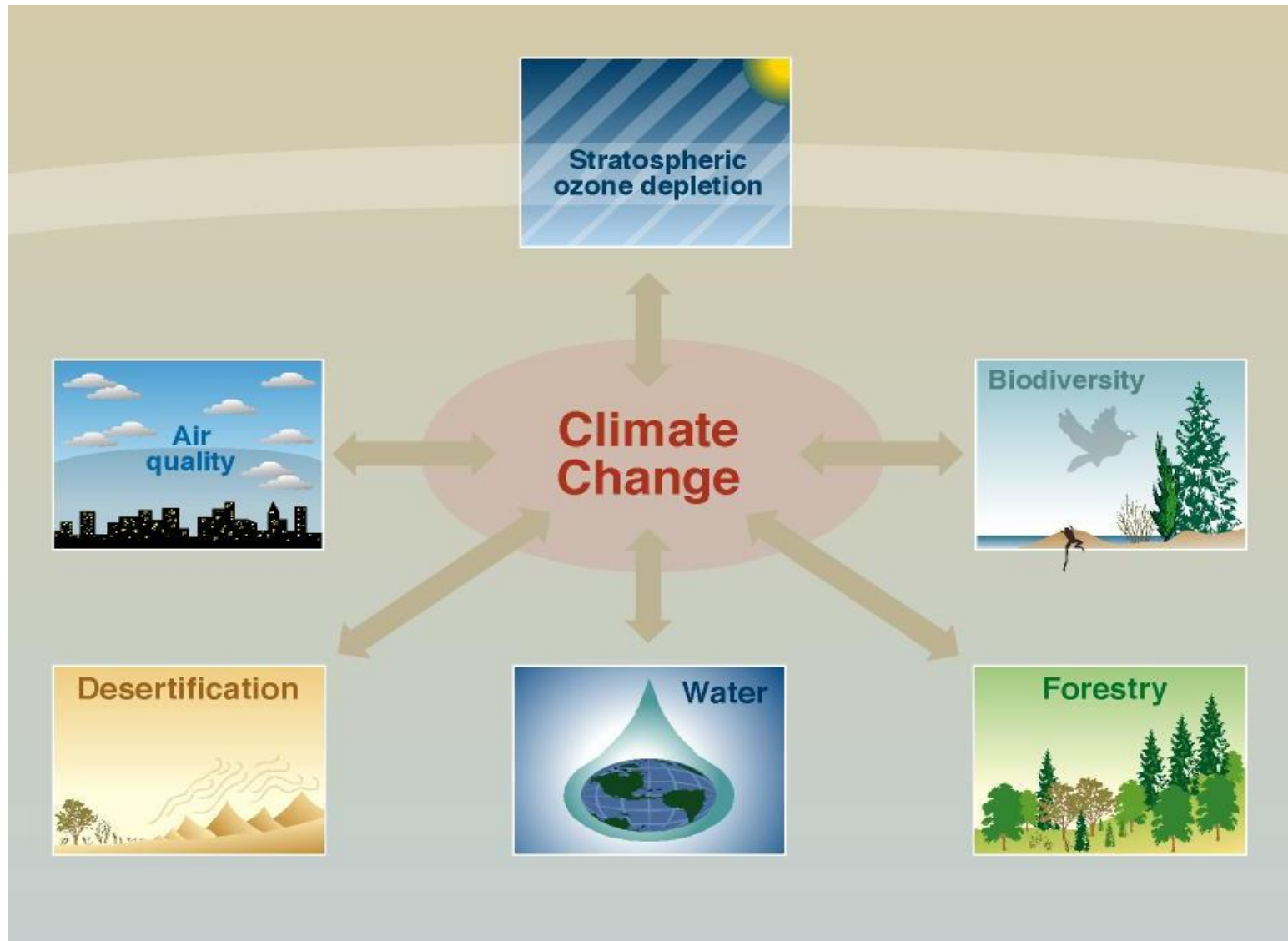


# Projeção de aumento da chuva 2071 a 2100 - IPCC

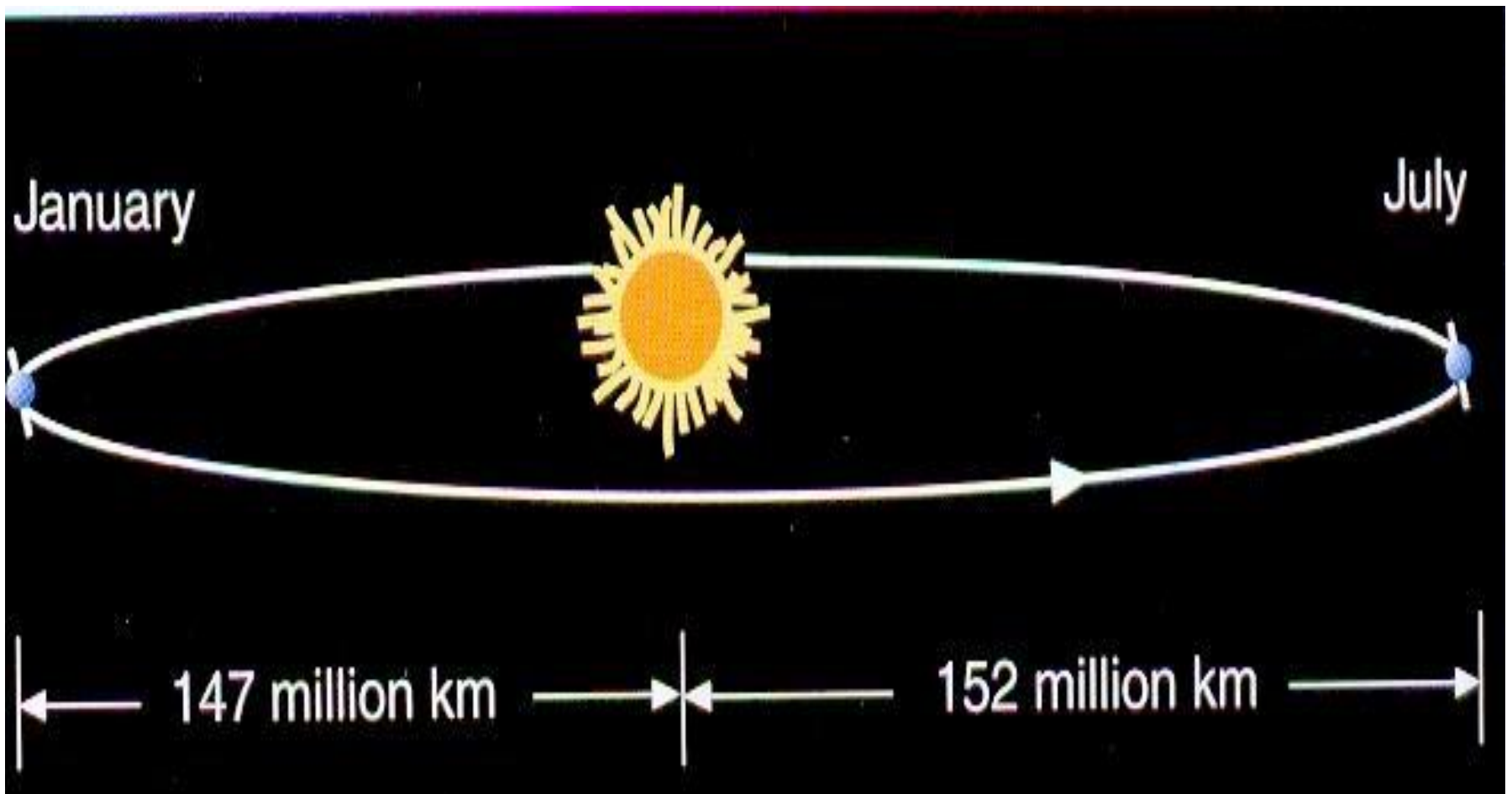
SRES A2



# INTERRELAÇÃO ENTRE CLIMA E AMBIENTE

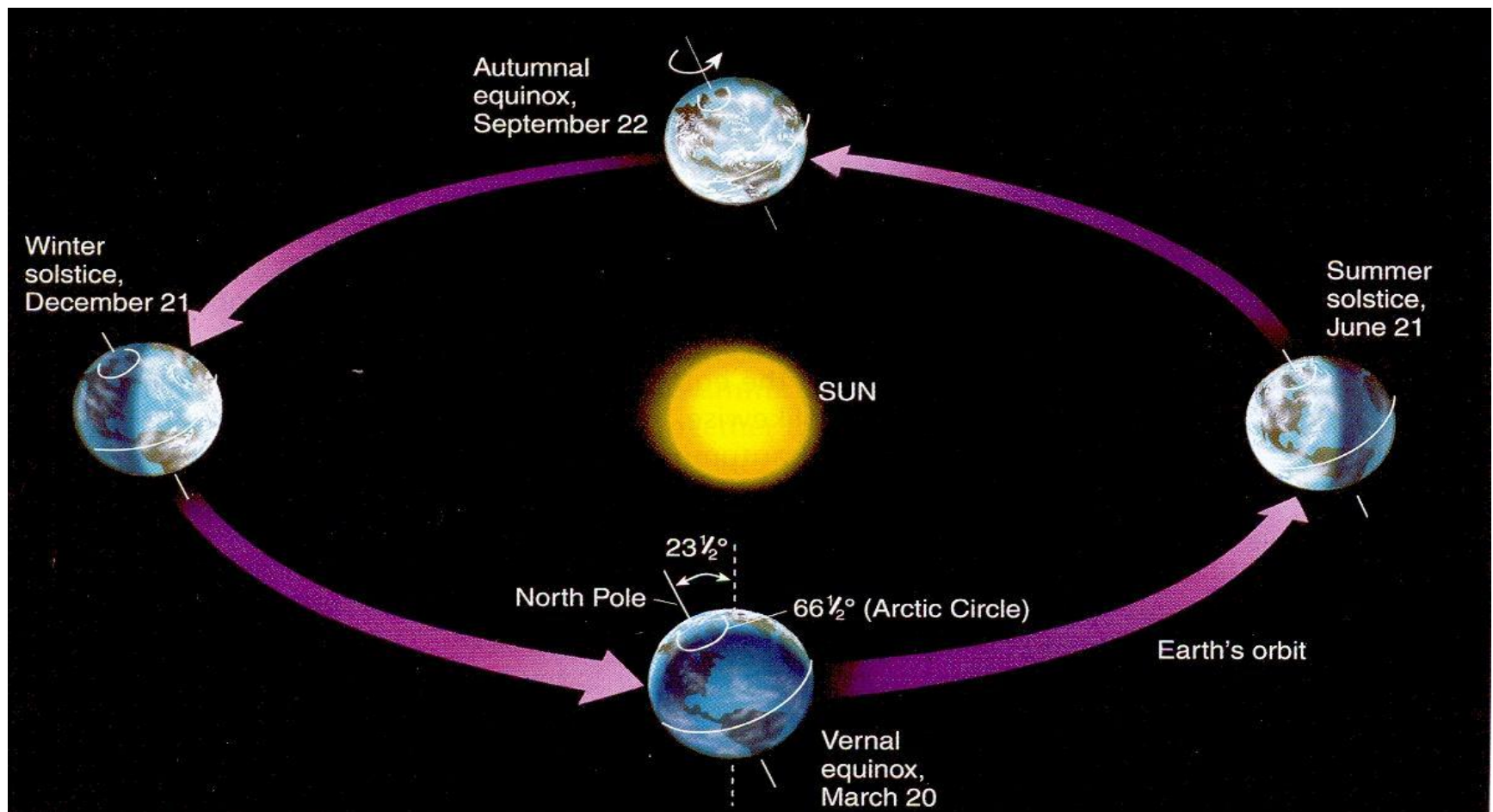


# ***TEMPO E CLIMA***



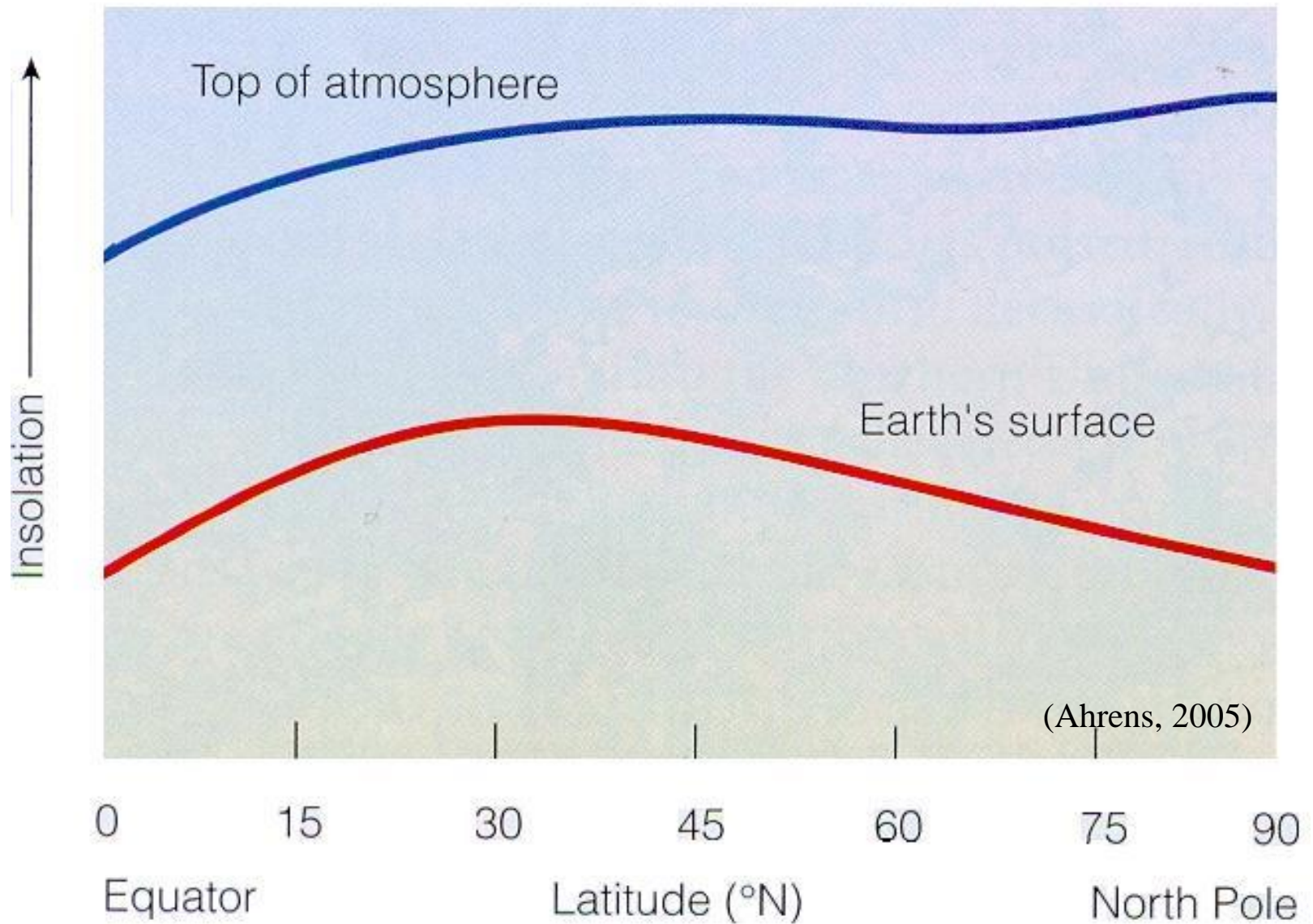
(Ahrens, 2005)

**Figure 3.1** The elliptical path (highly exaggerated) of the earth about the sun brings the earth slightly closer to the sun in January than in July

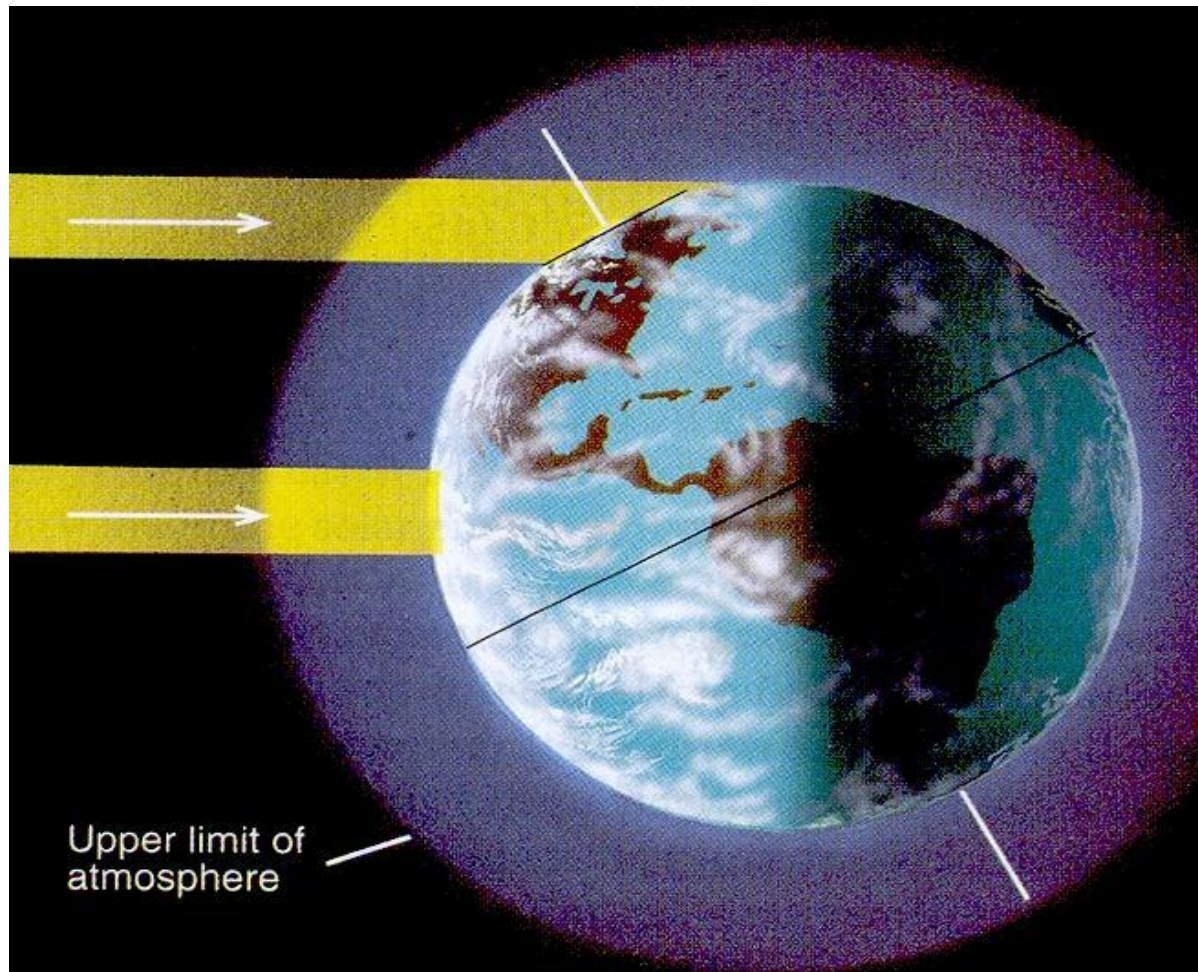


(Ahrens, 2005)

**Figure 3.2** As the earth revolves about the sun, it is tilted on its axis by an angle of  $23\frac{1}{2}^\circ$ . The earth's axis always points to the same area in space (as viewed from a distant star). Thus, in June, when the Northern Hemisphere is tipped toward the sun, more direct sunlight and long hours of daylight cause warmer weather than in December, when the Northern Hemisphere is tipped away from the sun.

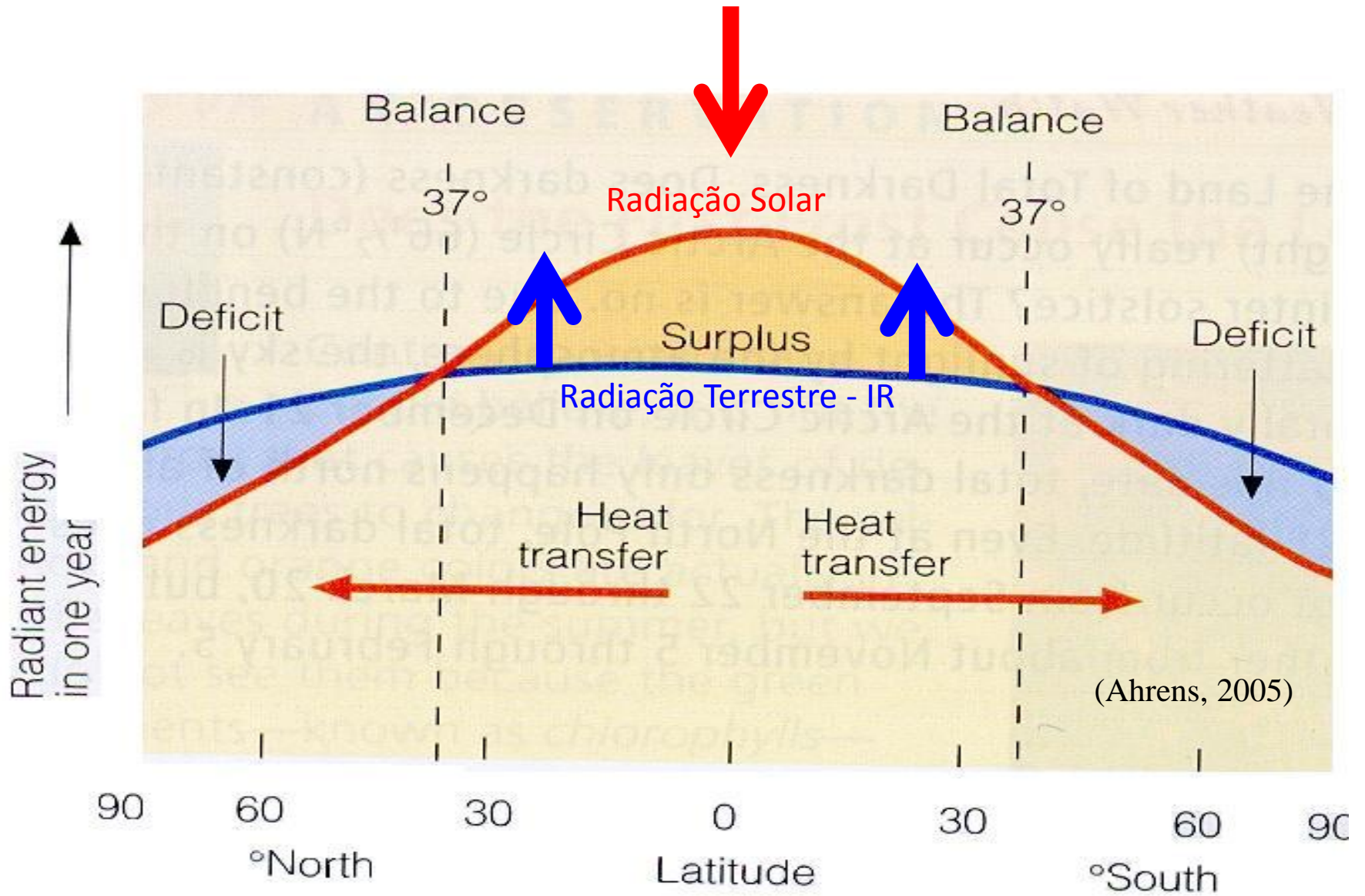


**Figure 3.3** The relative amount of radiant energy received at the top of the earth's atmosphere and at the earth's surface on June 21 – the summer solstice.

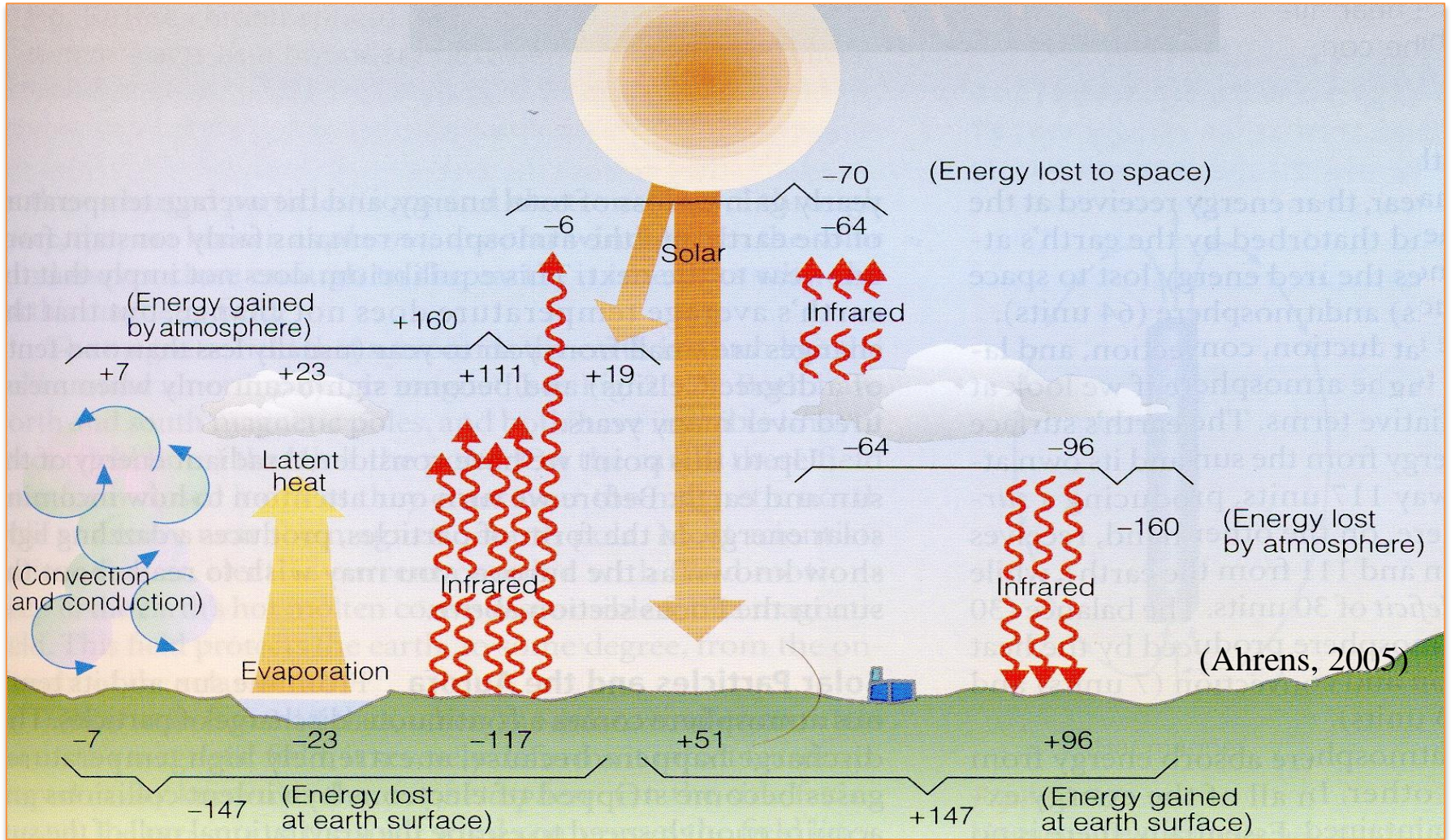


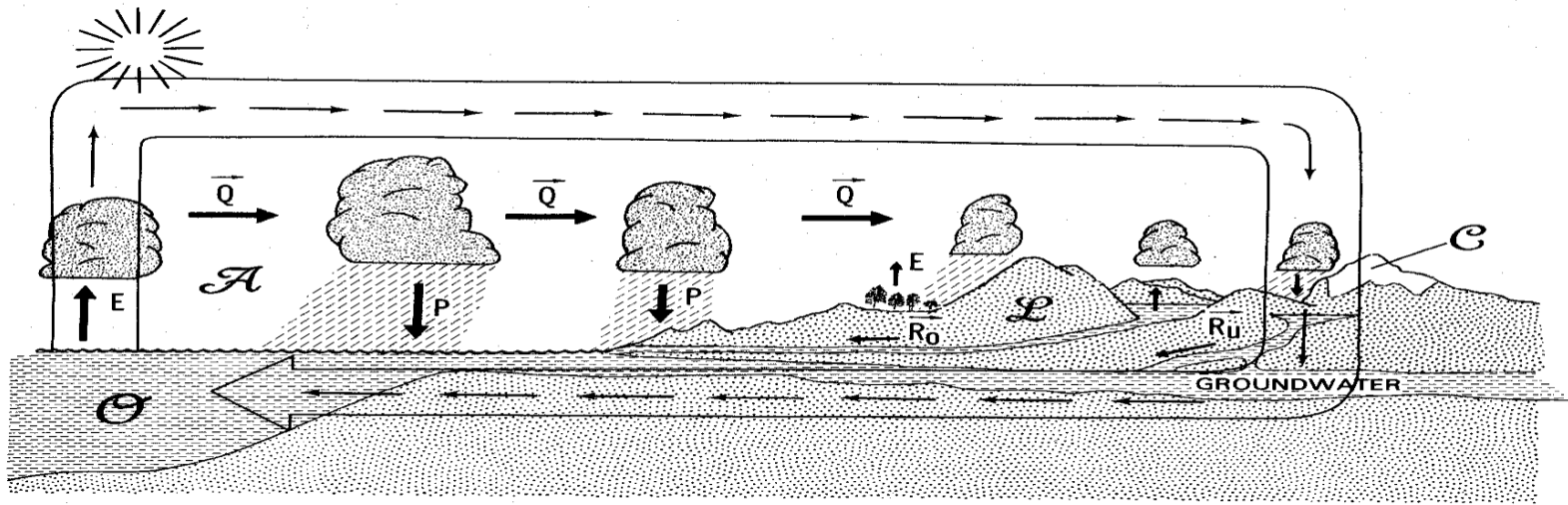
(Ahrens, 2005)

**Figure 3.4** During the Northern Hemisphere summer, sunlight that reaches the earth's surface in far northern latitudes has passed through a thicker layer of absorbing, scattering, and reflecting atmosphere than sunlight that reaches the earth's surface farther south. Sunlight is lost through both the thickness of the pure atmosphere and by impurities in the atmosphere. As the sun's rays become more oblique, these effects become more pronounced.



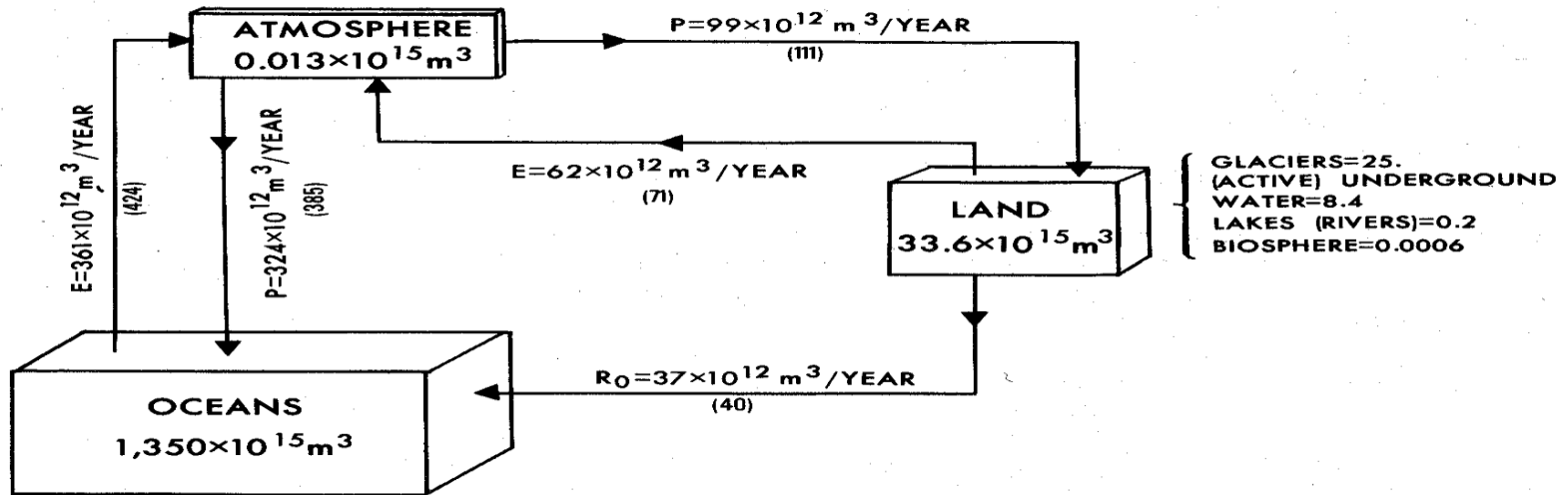
# Efeito Estufa





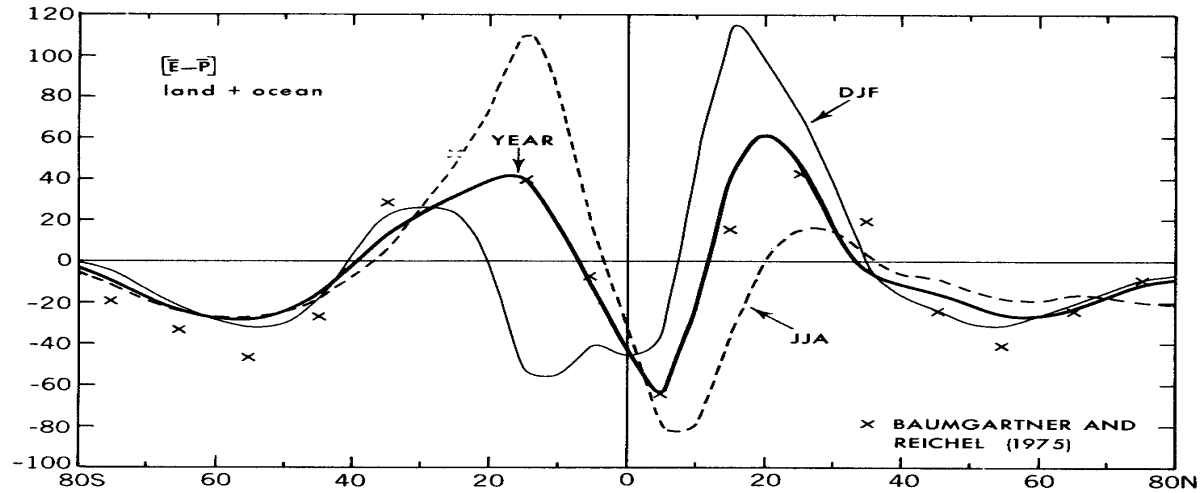
**FIGURE 12.1.** Schematic diagram of the atmospheric and terrestrial branches of the hydrological cycle showing the importance of evaporation  $E$ , advection of water vapor in the atmosphere  $\bar{Q}$ , precipitation  $P$ , river runoff  $R_0$ , and underground runoff  $R_u$ .

(Peixot & Oort, 1992)



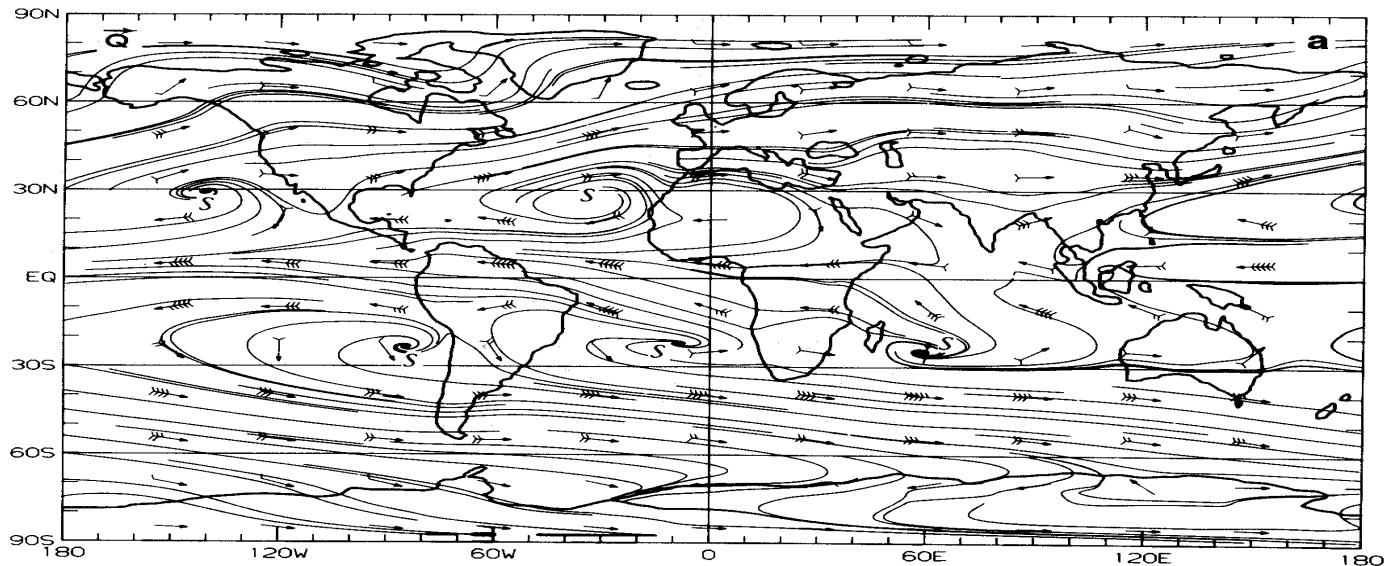
**FIGURE 12.2.** The amounts of water stored in the oceans, land, and atmosphere, and the amounts exchanged annually between the different reservoirs through evaporation, precipitation, and runoff (estimates are from Peixoto and Kettani, 1973, and, in parentheses, from Baumgartner and Reichel, 1975).

## Divergência do vapor d'água – média zonal $0,01 \text{ m ano}^{-1}$

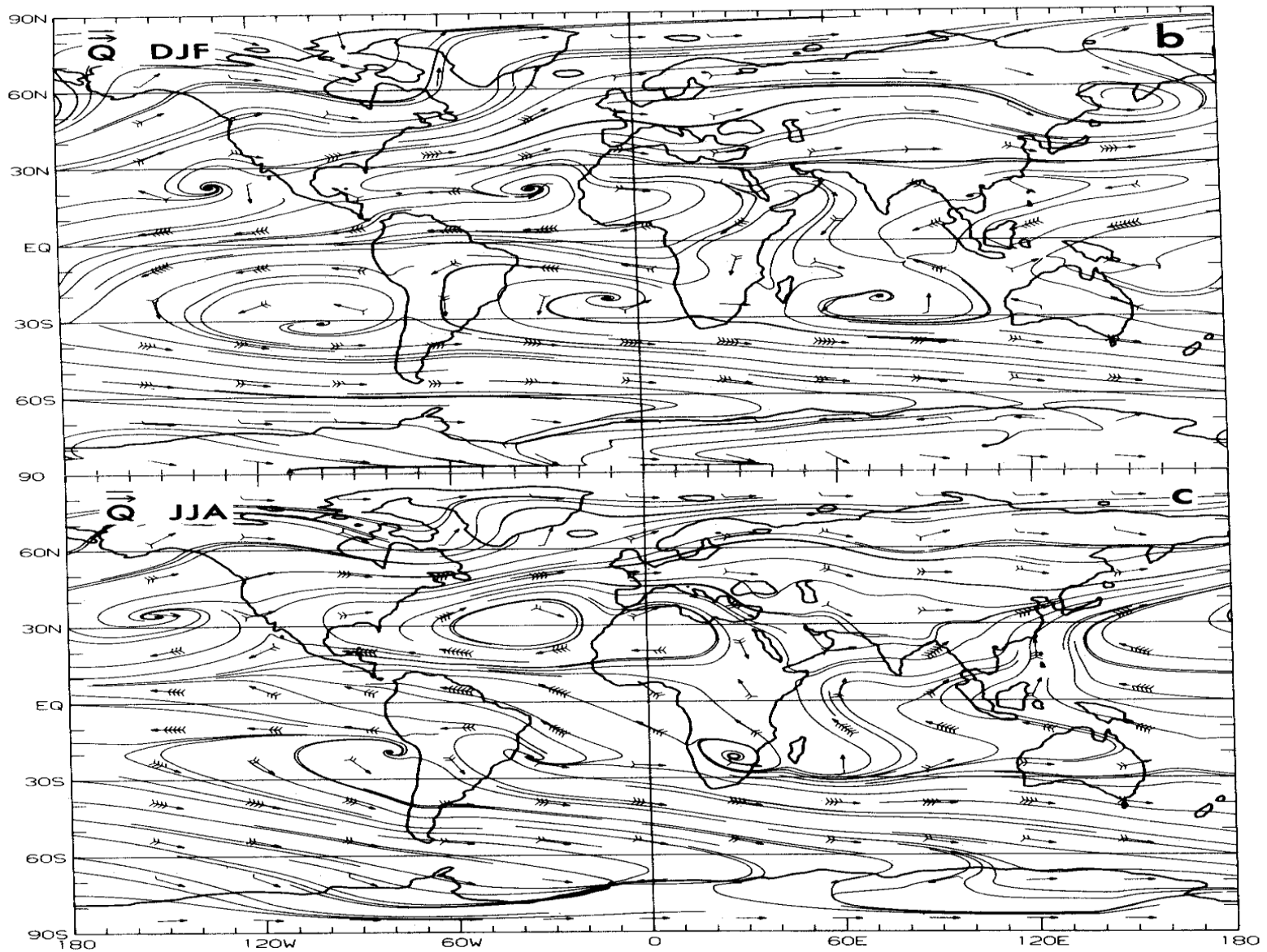


**FIGURE 12.16.** Meridional profiles of the zonal-mean divergence of the total water vapor transport  $[\text{div } \mathbf{Q}] \approx [\bar{E} - \bar{P}]$  in  $0.01 \text{ m yr}^{-1}$  for annual, DJF, and JJA mean conditions. Some annual-mean estimates of  $E - P$  by Baumgartner and Reichel (1975) are added for comparison (see also Table 7.1).

(Peixot & Oort, 1992)



**FIGURE 12.17a**

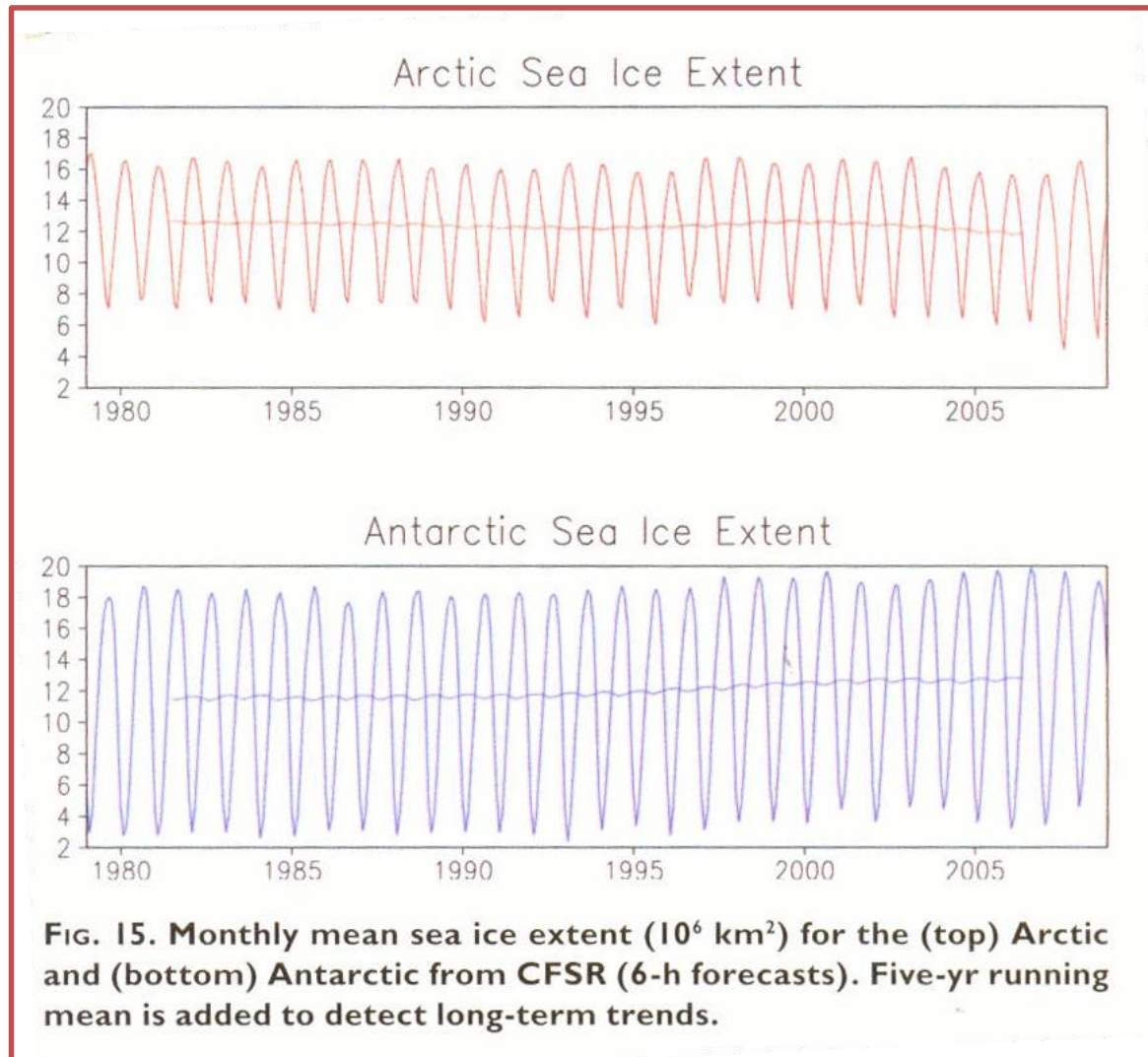


**FIGURE 12.17.** Global distributions of the total aerial runoff  $Q$  and some corresponding streamlines for annual (a), DJF (b), and JJA (c) mean conditions. Each barb on the shaft of an arrow indicates a value of  $2 \text{ m s}^{-1} \text{ g kg}^{-1}$  (from Peixoto and Oort, 1983).

(Peixot & Oort, 1992)

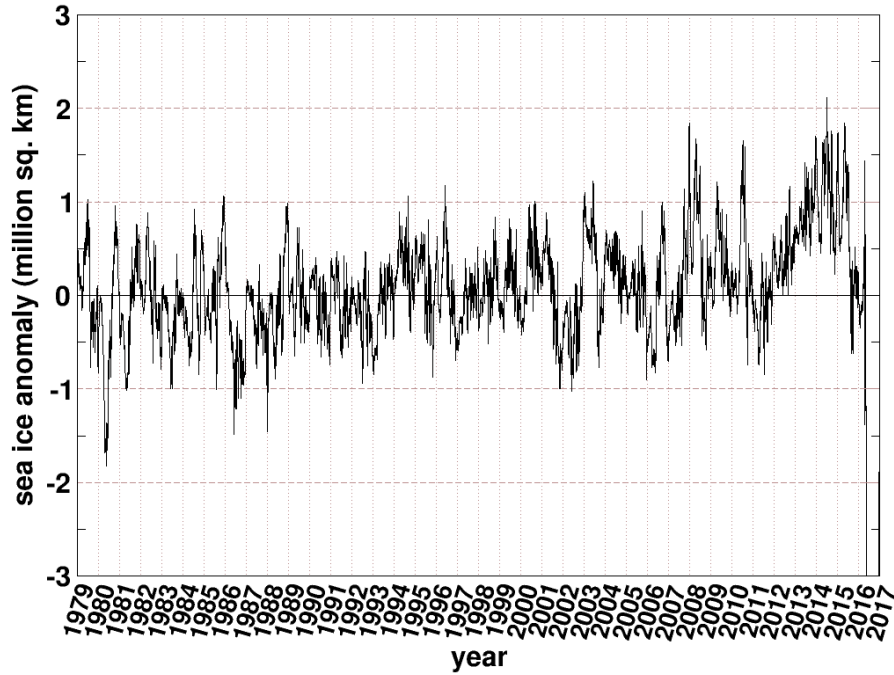
# Resultados NCEP 2010

(Saha et al. 2010)



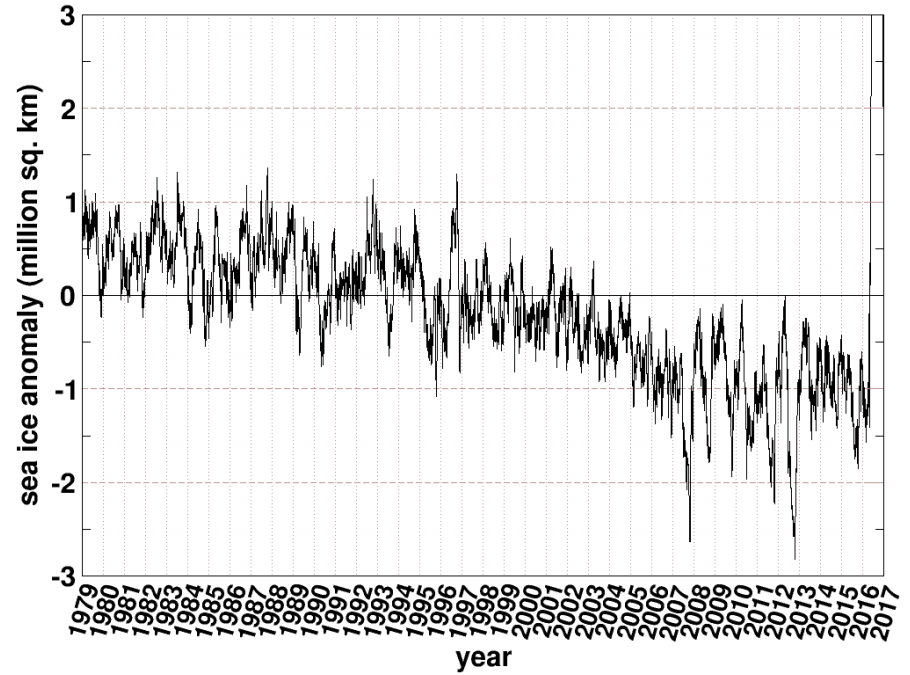
### Southern Hemisphere Sea Ice Anomaly

Anomaly from 1979-2008 mean

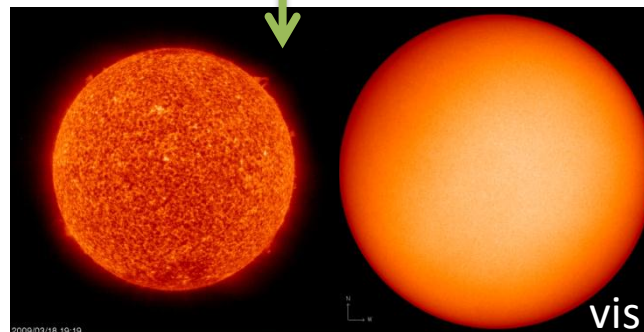
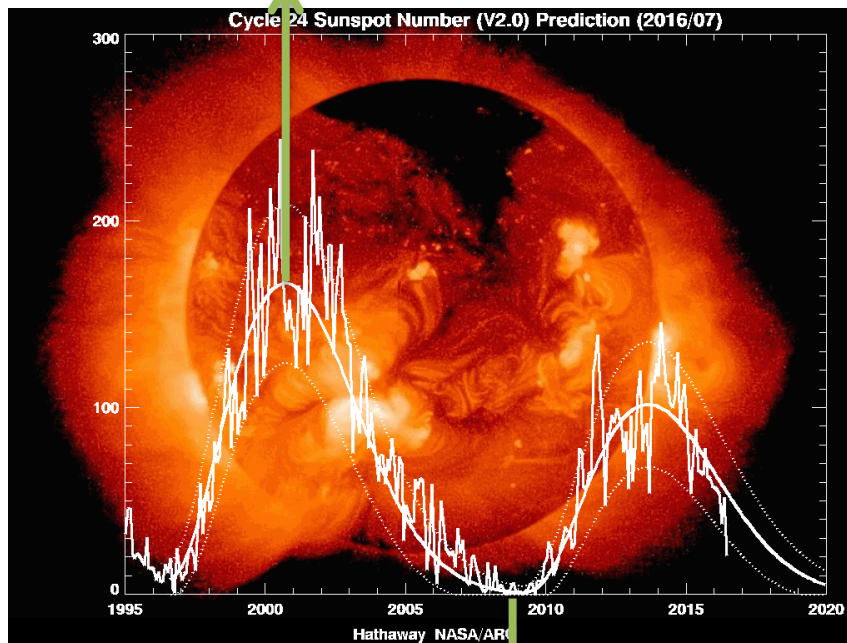
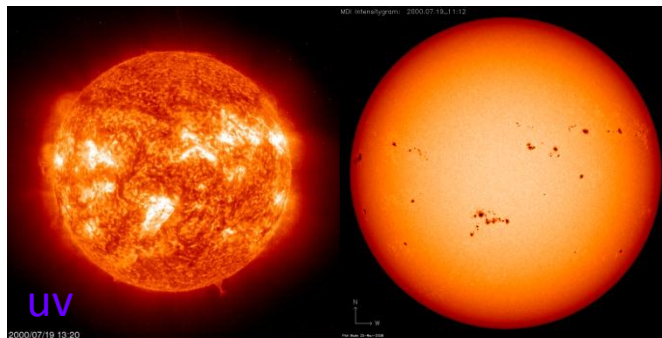


### Northern Hemisphere Sea Ice Anomaly

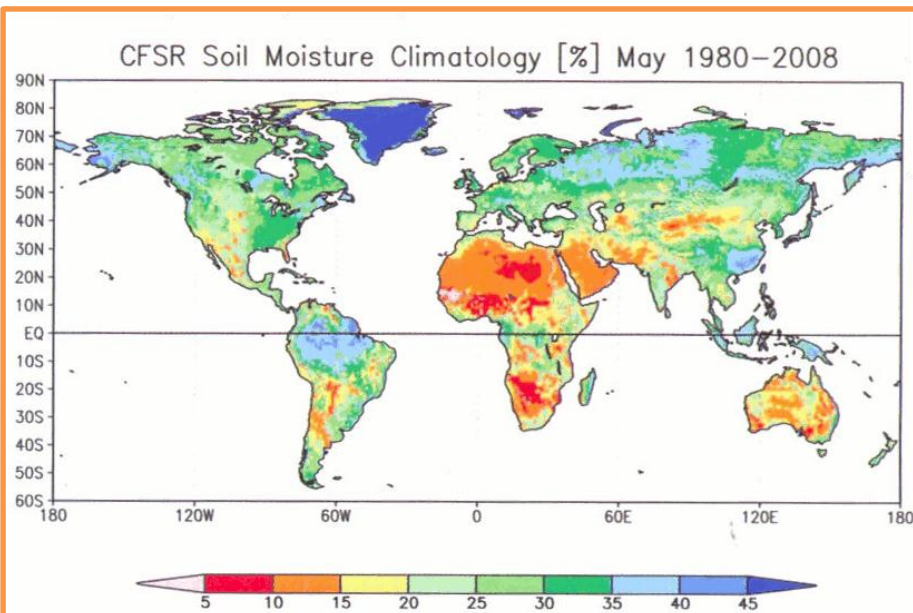
Anomaly from 1979-2008 mean



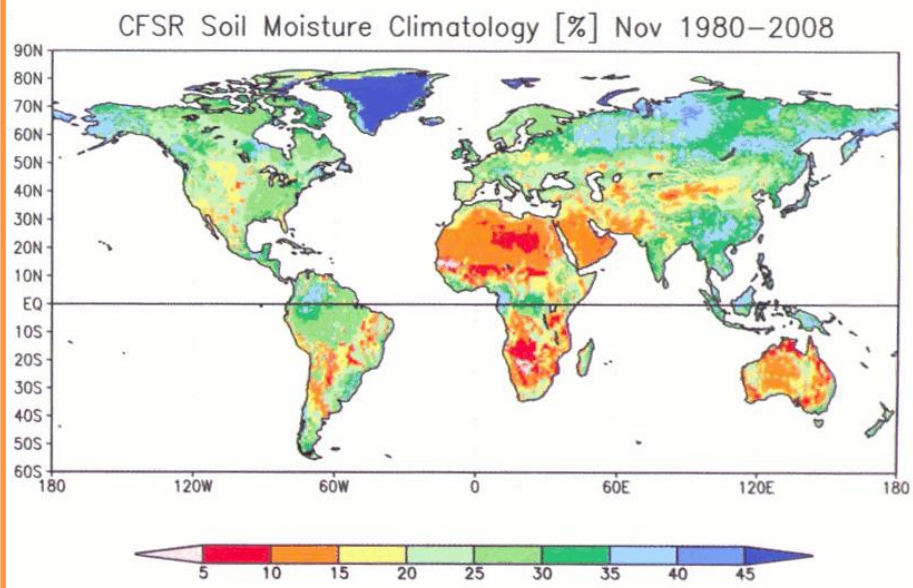
<http://arctic.atmos.uiuc.edu/cryosphere/>



**FONTE:**  
<http://solarscience.msfc.nasa.gov/predict.shtml>



**FIG. 17.** The 2-m volumetric soil moisture climatology of CFSR for May averaged over 1980–2008.

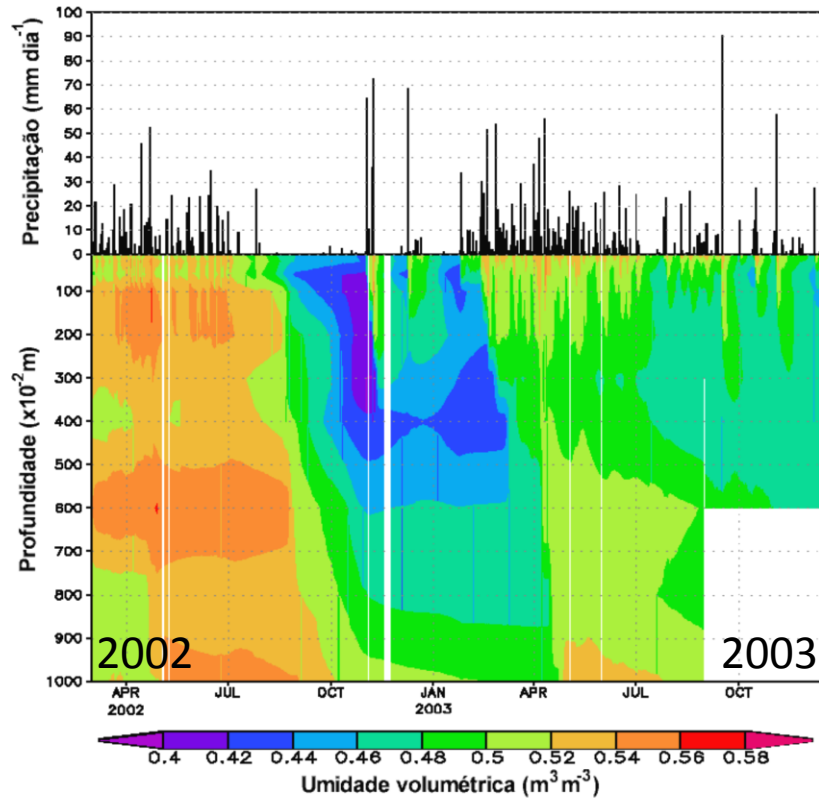


**FIG. 18.** As in Fig. 17, but for Nov.

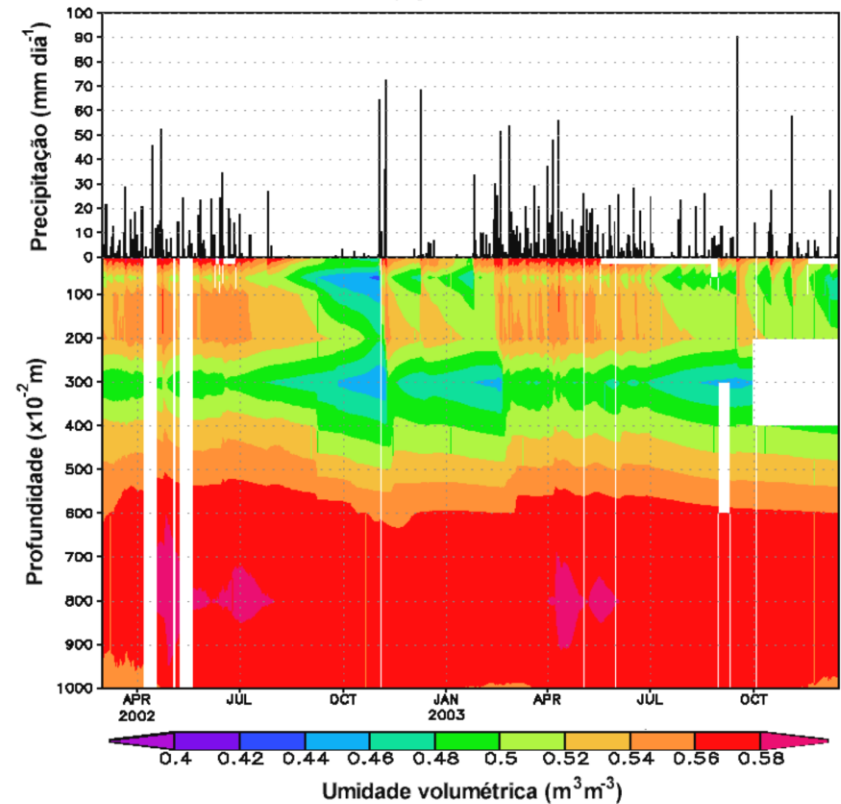
(Saha et al. 2010)

# Floresta Amazônica

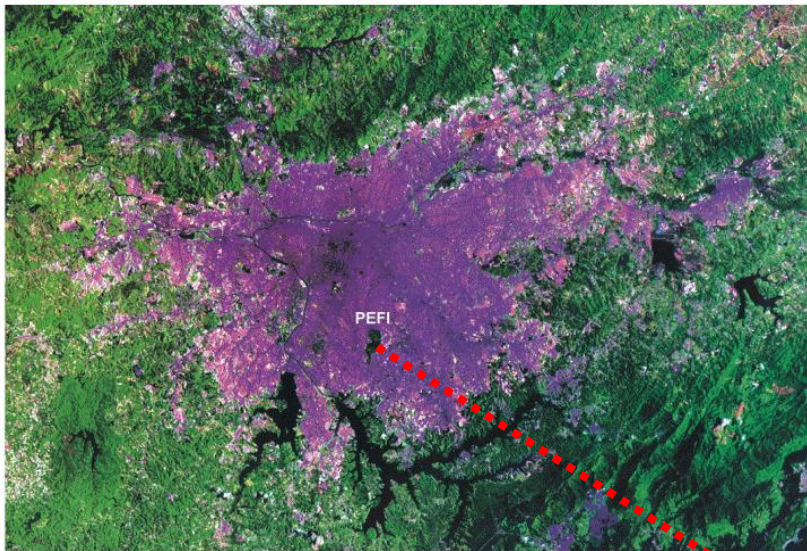
Floresta Tropical Úmida (não perturbada)  
FLONA Tapajós, Santarém/PA



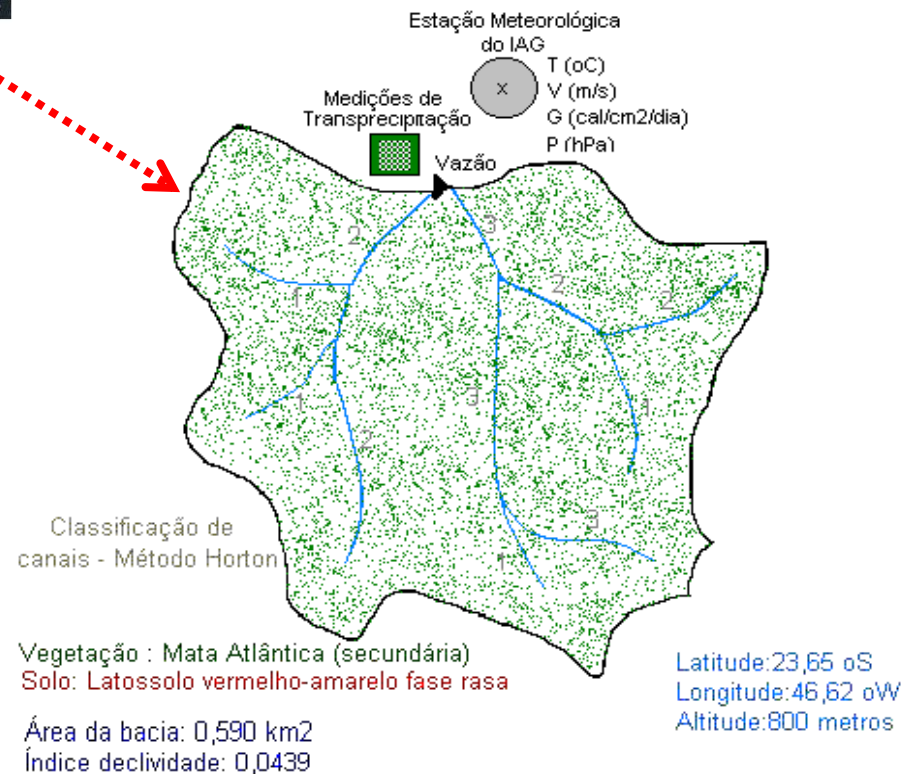
Floresta Tropical Úmida (clareira)  
FLONA Tapajós, Santarém/PA



Bruno e Rocha (2004)

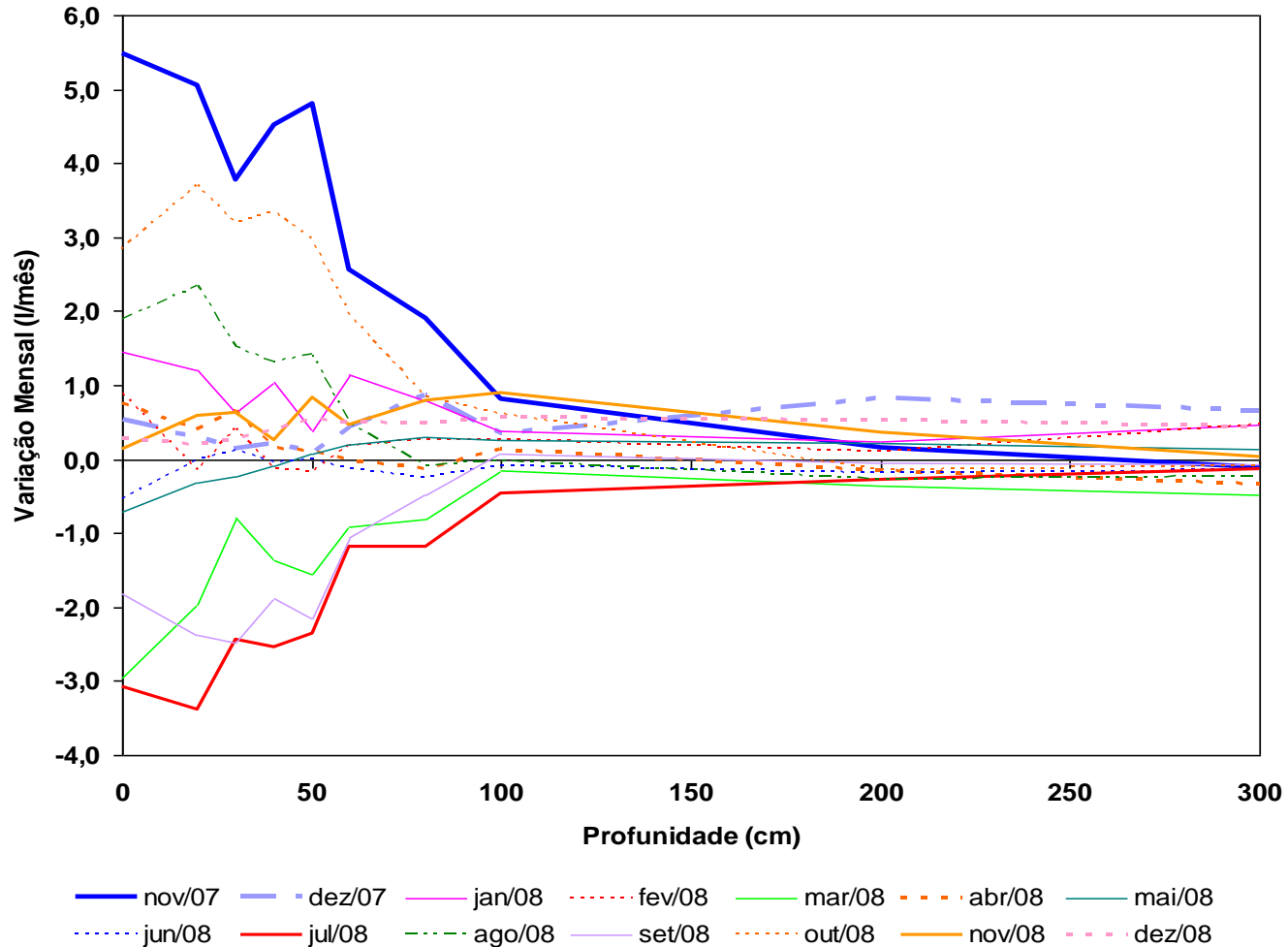


Bacia do IAG



(Pereira Filho et al., 2002)

# Variação da Umidade do solo - PEFI



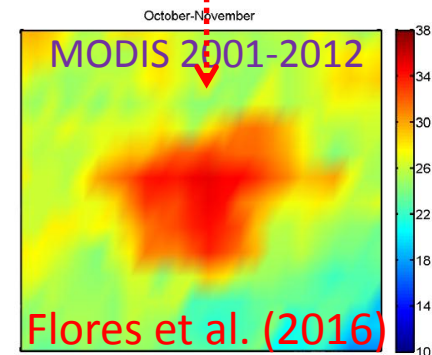
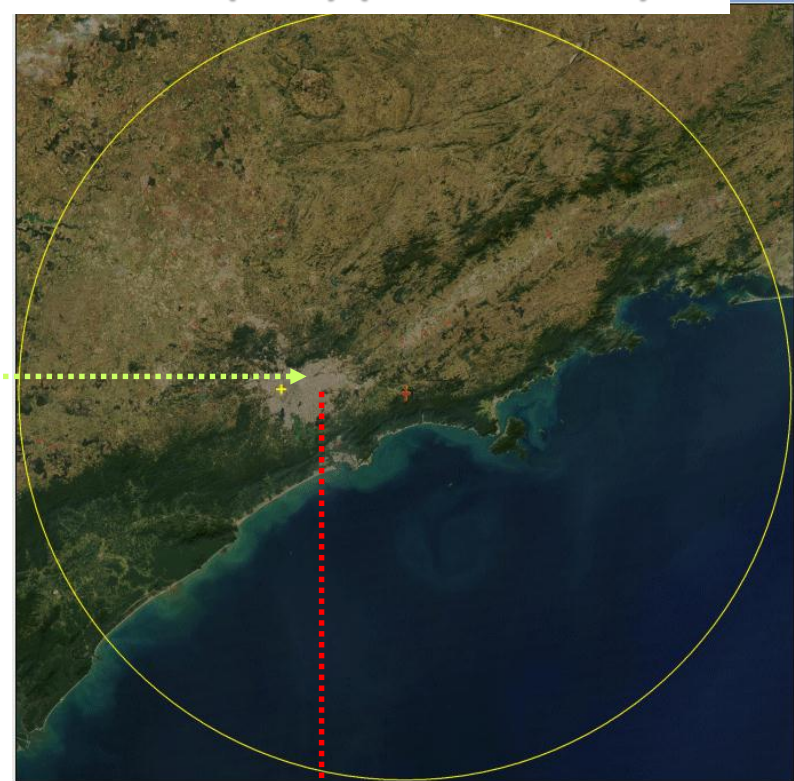
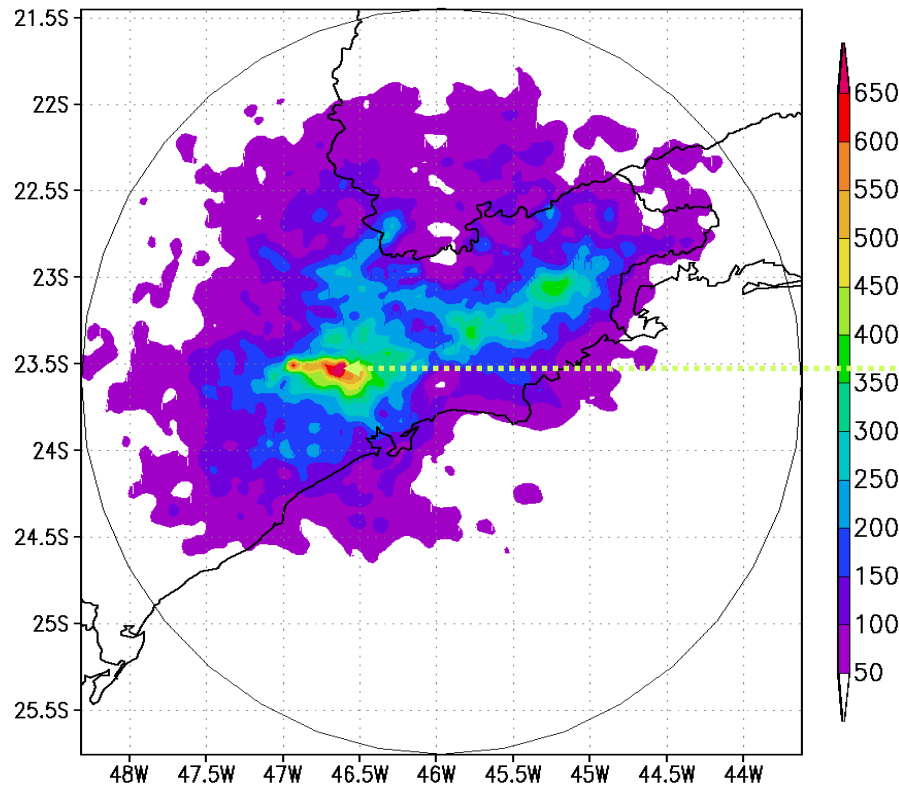
(Pereira Filho, 2010)

## Balanço Hídrico - PEFI (mm)

Precipitação (P)	1290,5
Transprecipitação (T)	1002,1
Interceptação (I)	288,4
Vazão (Q)	285,6
Evapotranspiração (ET <sub>o</sub> )	1004,9

(Pereira Filho et al., 2002)

# Efeitos Ilha de Calor e Brisa na Distribuição de chuva (mm) (2002 – 2004)



# BRASIL – SÃO PAULO - RMSP



Caracas

Venezuela

Bogotá

Colombia

Guyana

Guyane  
(French Guiana)

Suriname

Roraima

Amapá

Amazonas

Pará

Maranhão

Ceará

Rio Grande  
do Norte

Paraíba

Pernambuco

Alagoas

Sergipe

Perú  
(Peru)

Acre

Brasil  
(Brazil)

Tocantins

Piauí

Rondônia

Mato  
Grosso

Bahia

La Paz

Bolivia

Goiás

Brasília

Minas  
Gerais

Mato Grosso  
do Sul

Belo  
Horizonte

Espírito  
Santo

Paraguay

São Paulo

São Paulo

Rio de  
Janeiro

Rio de  
Janeiro

Asuncion

Paraná

Santa  
Catarina

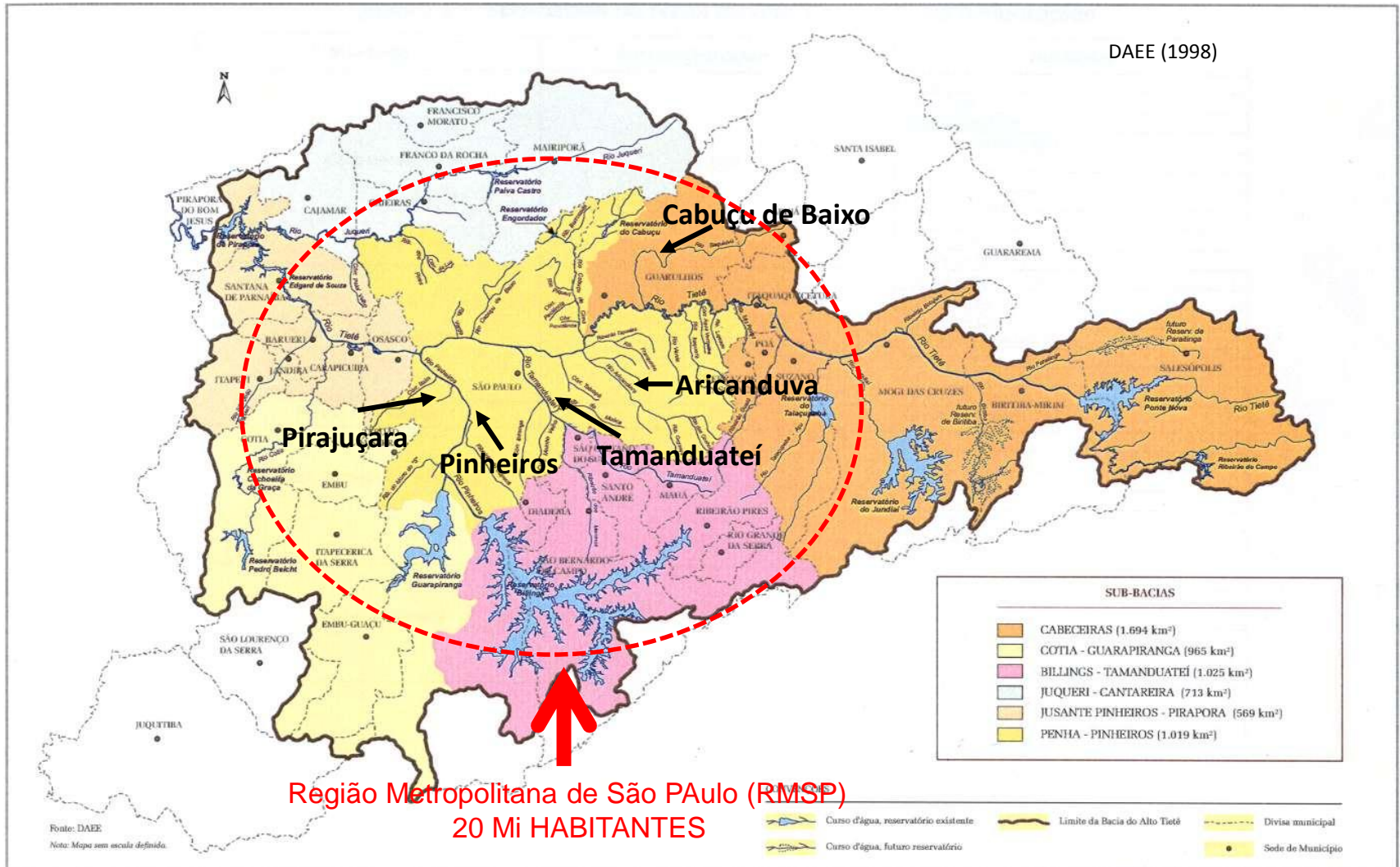
Chile

Rio Grande  
do Sul

Uruguay

Santiago

# BACIA DO ALTO TIETÊ (6,000 km<sup>2</sup>)



# CRESCIMENTO URBANO 1905 - 2005

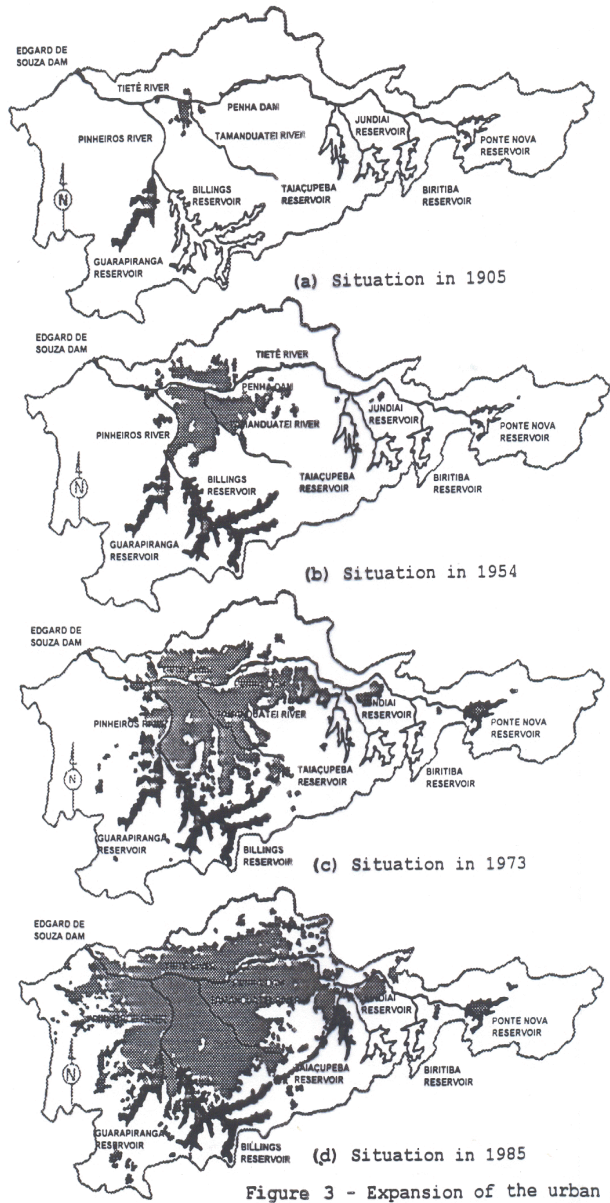
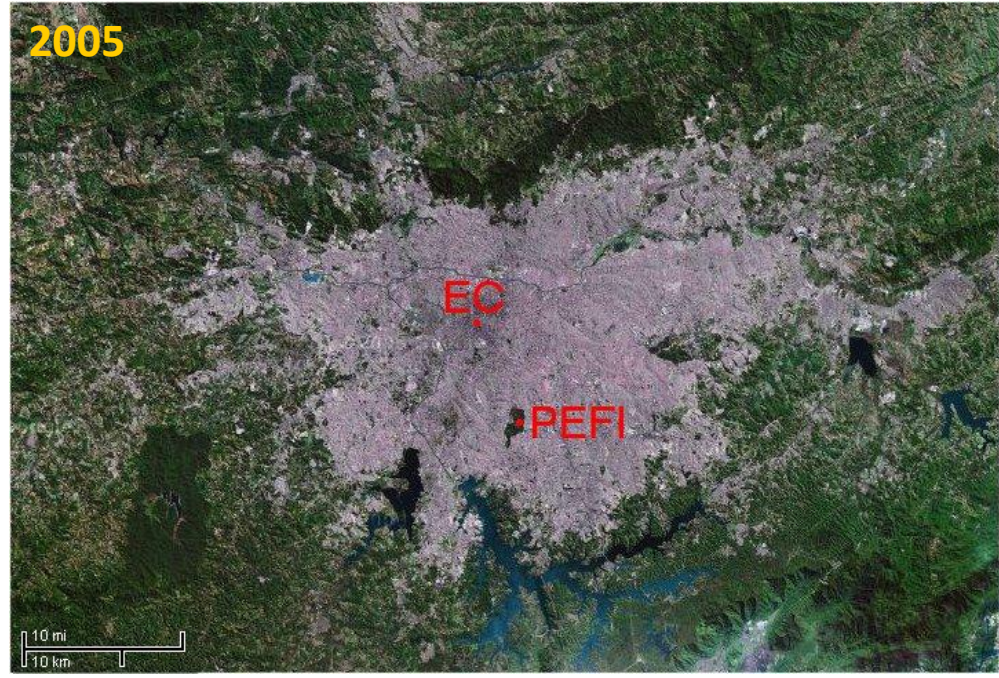


Figure 3 - Expansion of the urban area.



# REPRESA DE GUARAPIRANGA - 1933



SANTO AMARO, RIVIERA PAULISTA

# REPRESA DE GUARAPIRANGA - HOJE



# AEROPORTO DE CONGONHAS - 1950



# AEROPORTO DE CONGONHAS HOJE



# SÃO PAULO, TERRA DA GARÇA - 1954



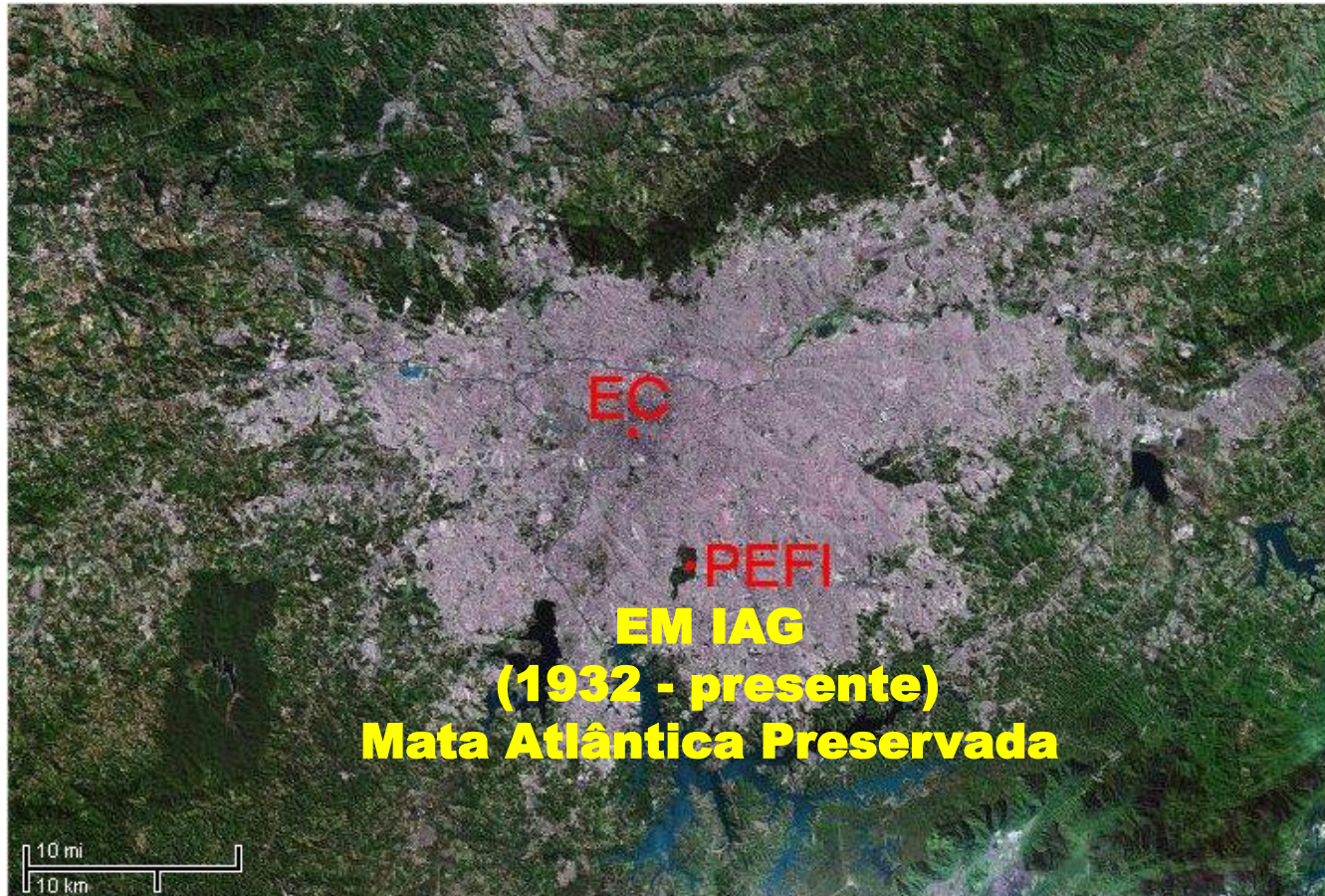
# SÃO PAULO, DESERTO URBANO - HOJE



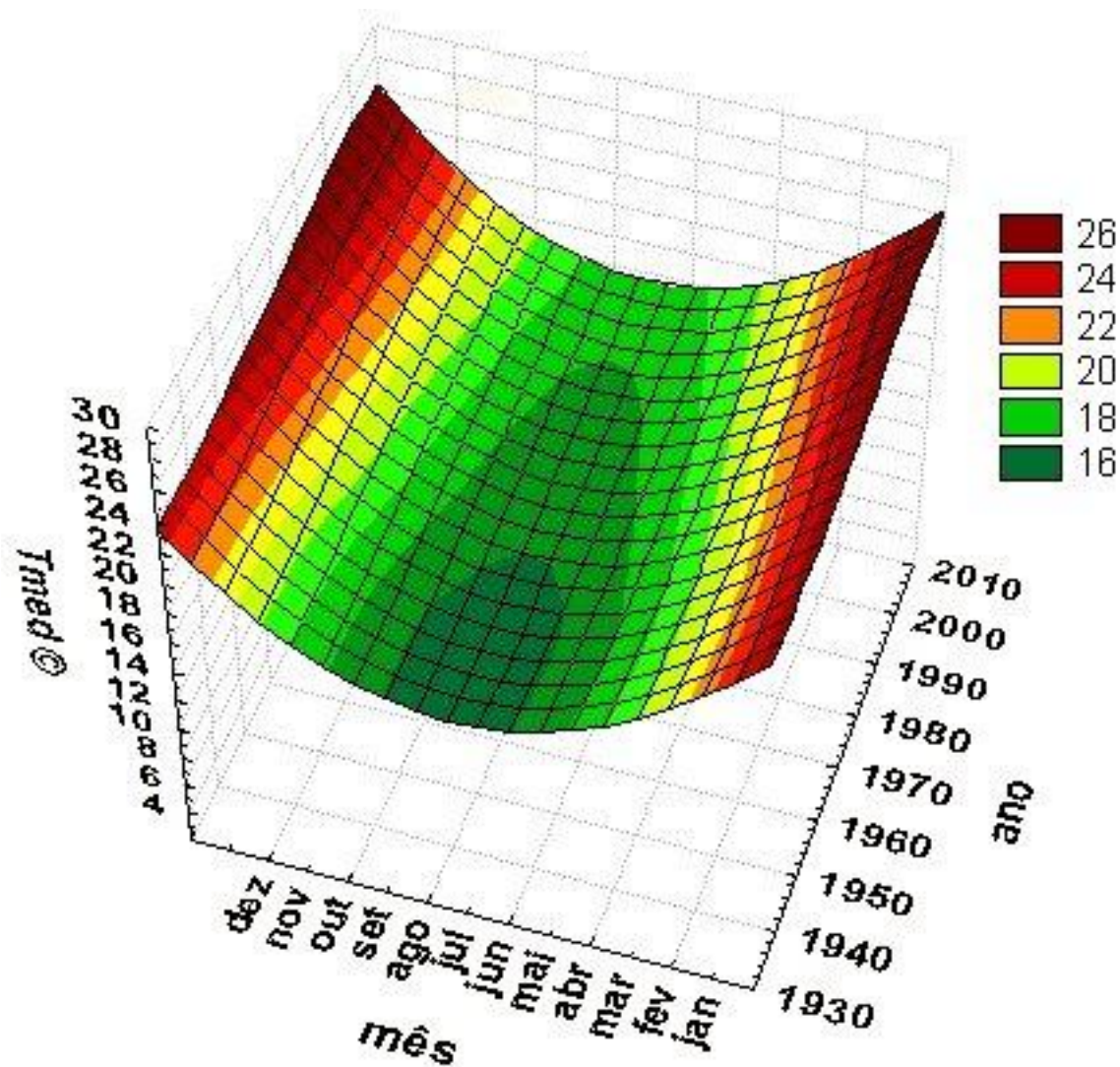
(FSP ,2011)

# CLIMATOLOGIA DA RSMP

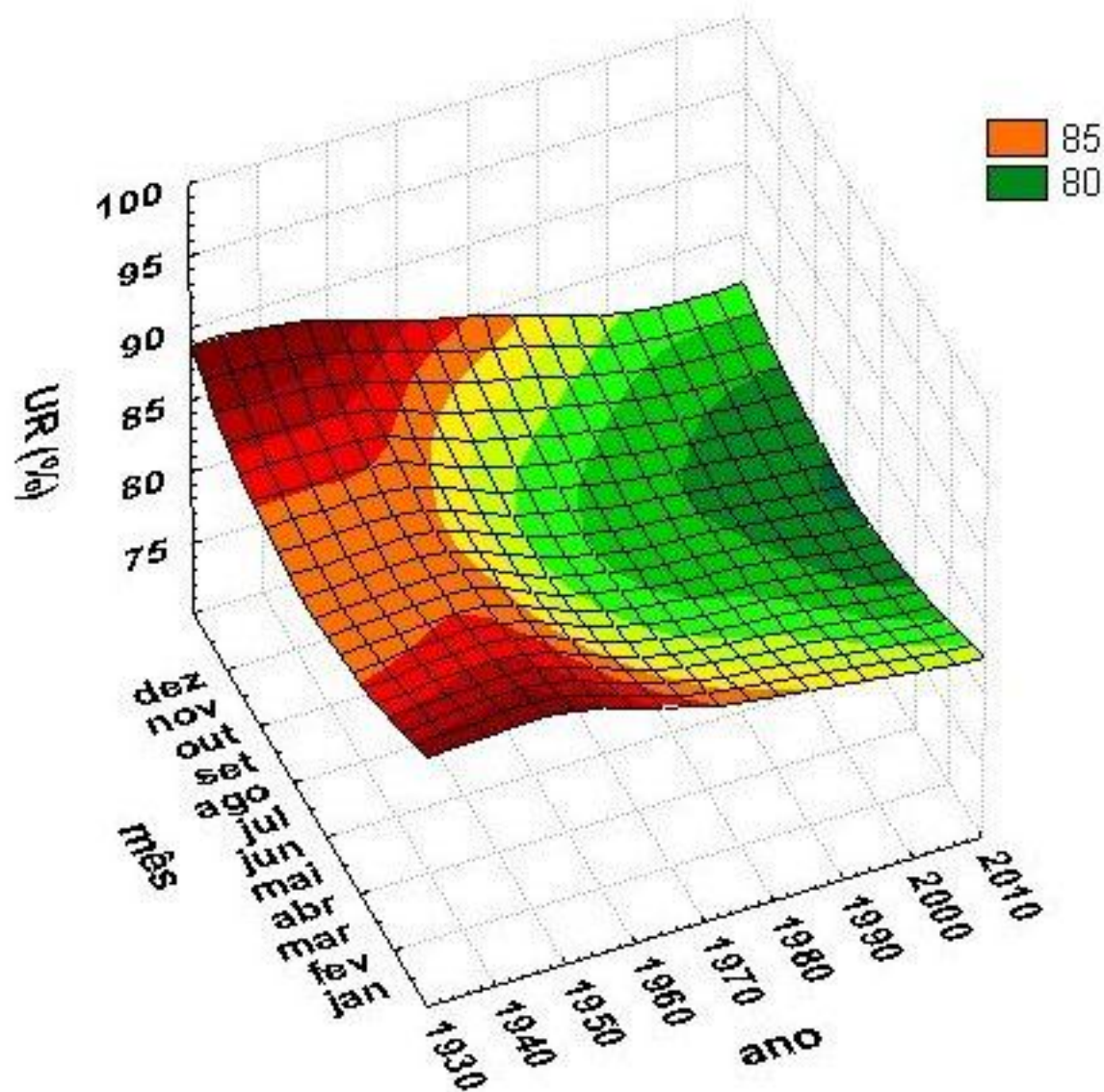
## 1936 - 2005



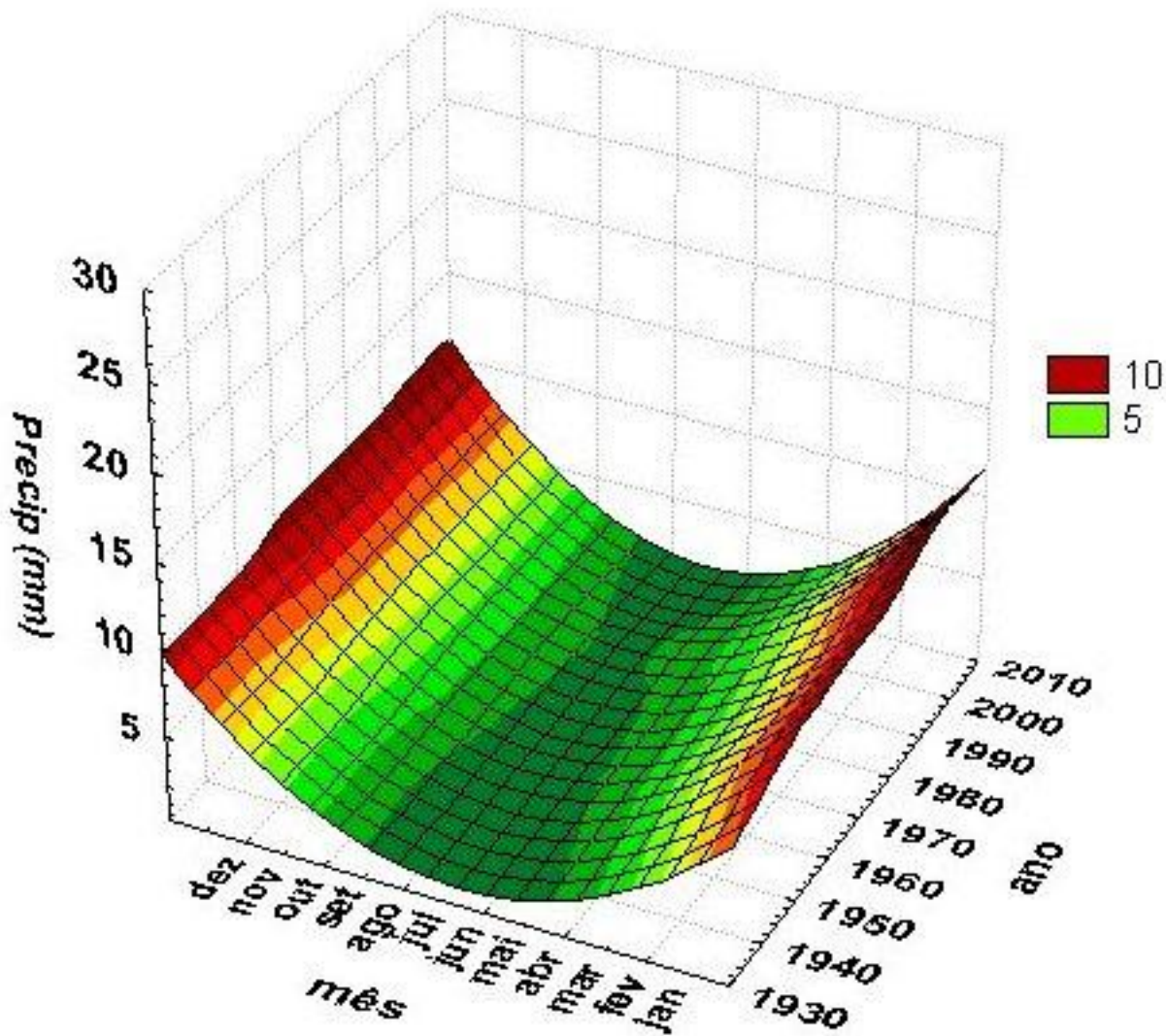
# TEMPERATURA DO AR DIÁRIA 1936 - 2005



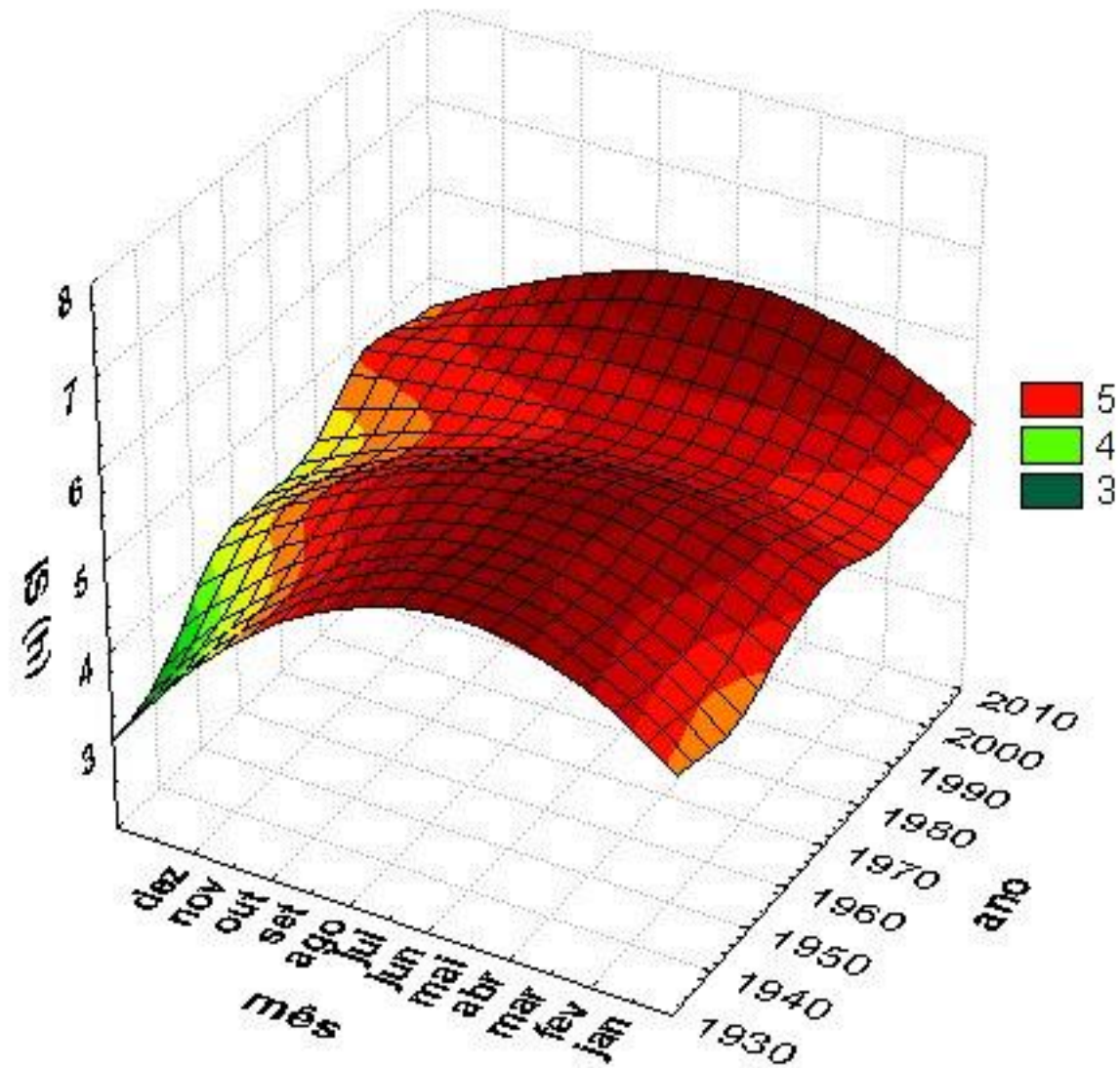
# UMIDADE RELATIVA DIÁRIA 1936-2005



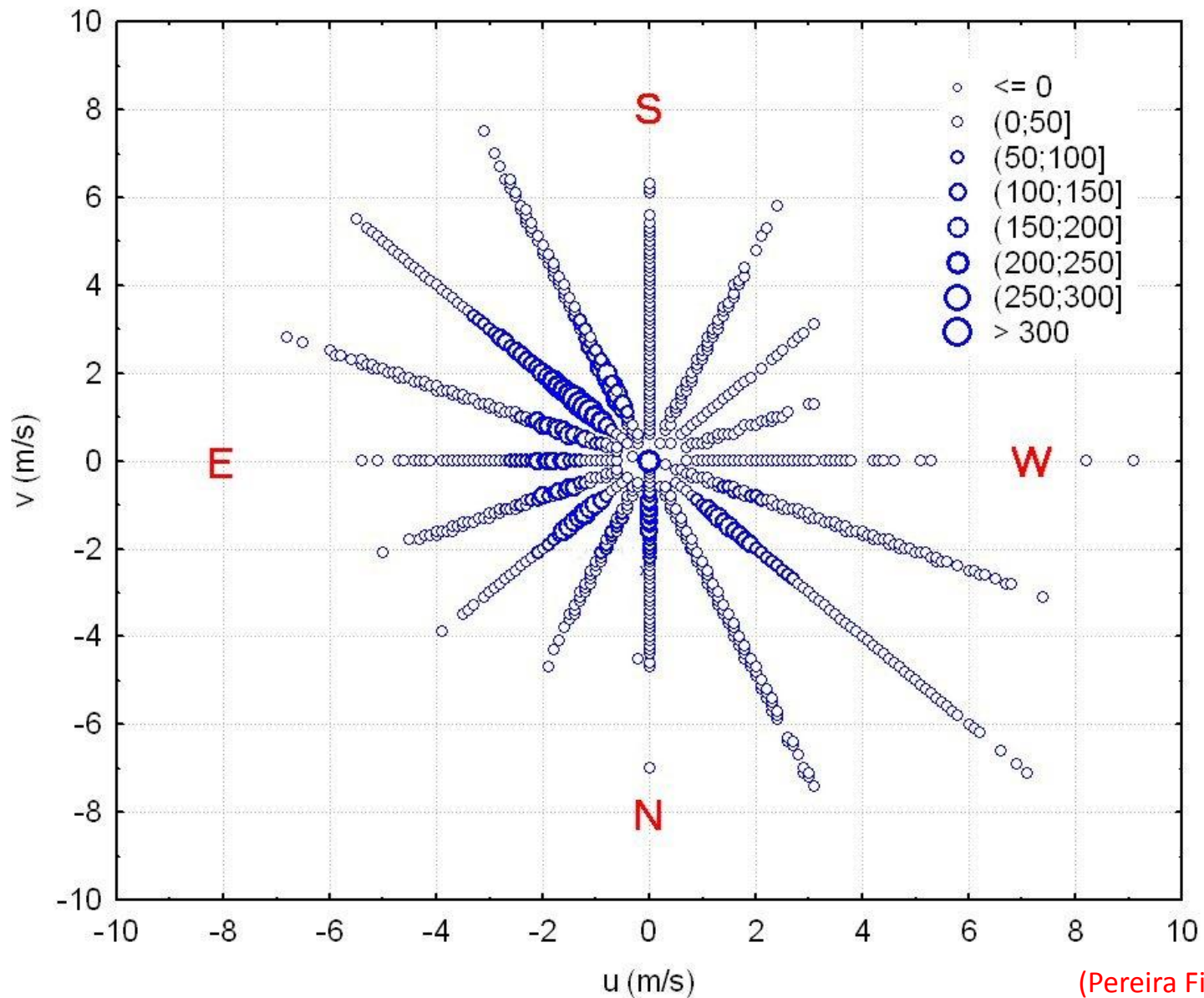
# CHUVA DIÁRIA 1936 -2005



# INSOLAÇÃO DIÁRIA 1936 -2005



# ROSA DOS VENTOS 1936 -2005



# **MUDANÇAS CLIMÁTICAS NA RMSP:**

**MAIS QUENTE**

**SECO**

**MAIS TEMPESTADES**

**MENSO GAROA**

**MAIS POLUIÇÃO DO AR**

**AS MUDANÇAS CLIMÁTICAS  
SÃO LOCAIS OU GLOBAIS?**

# TAR & UR 1936 -2005

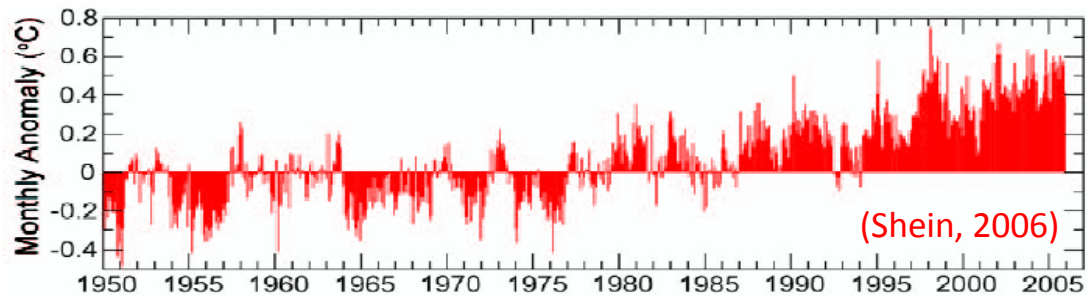
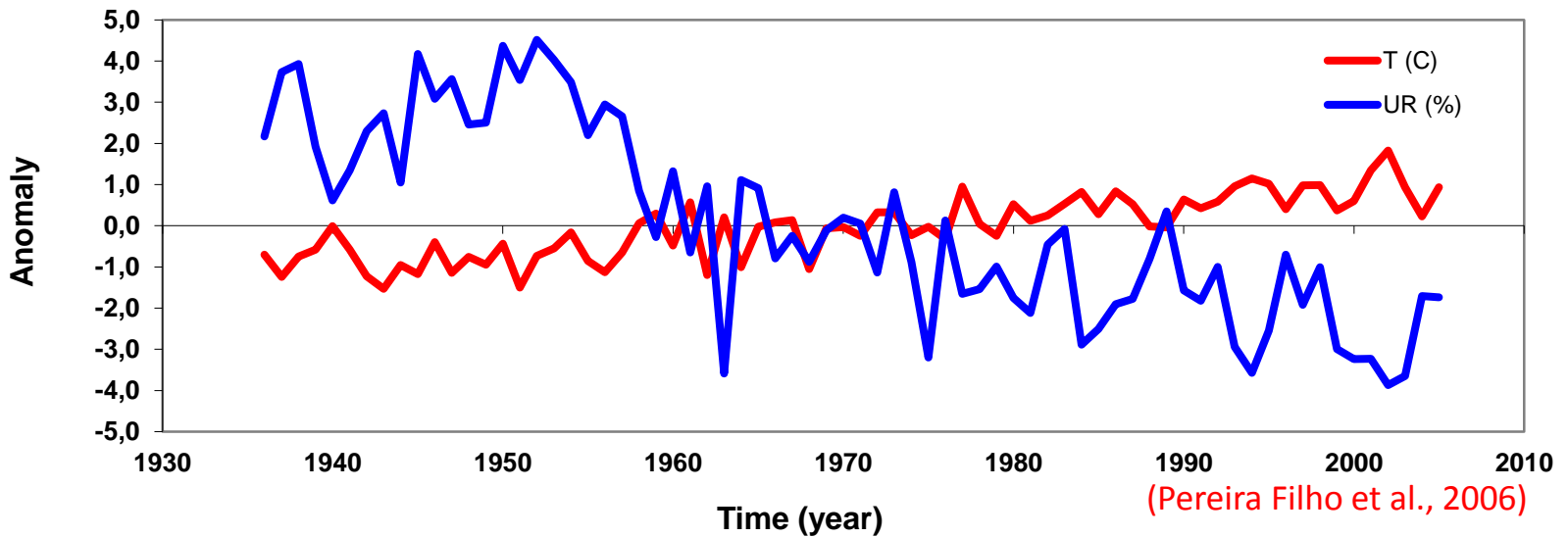
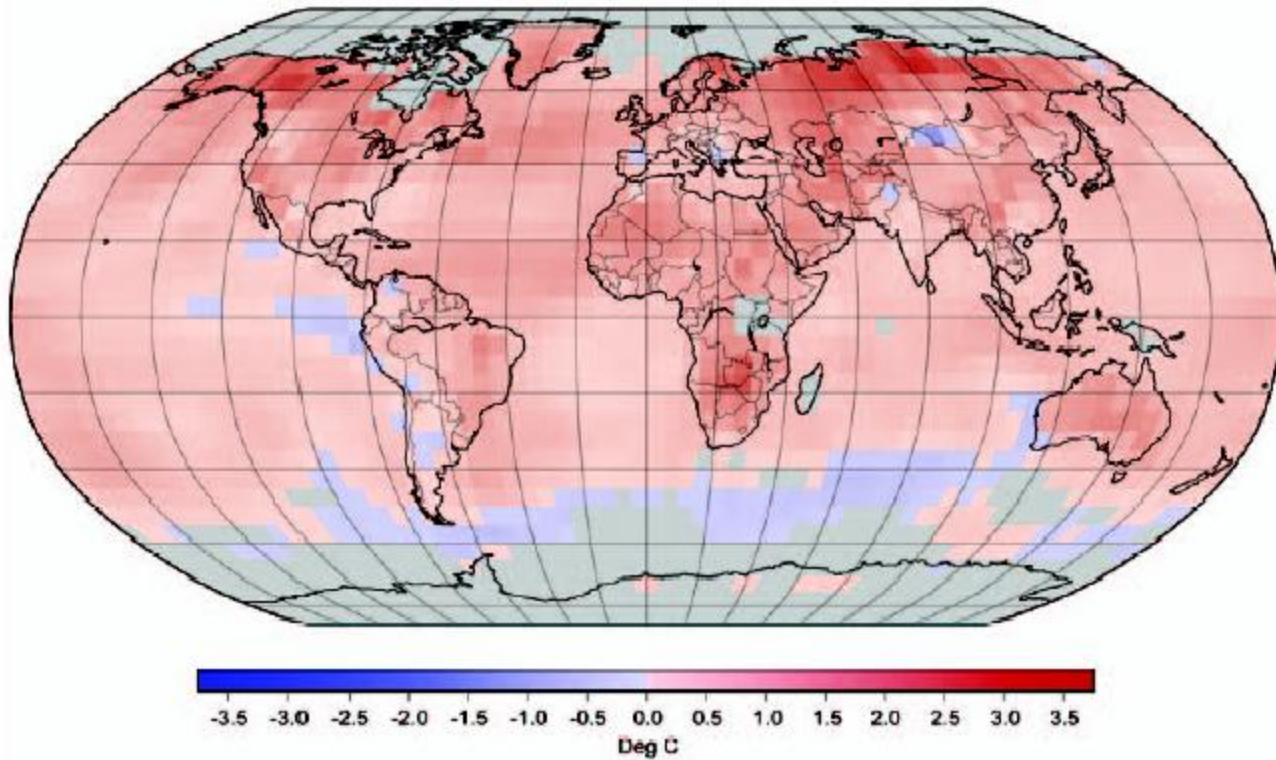
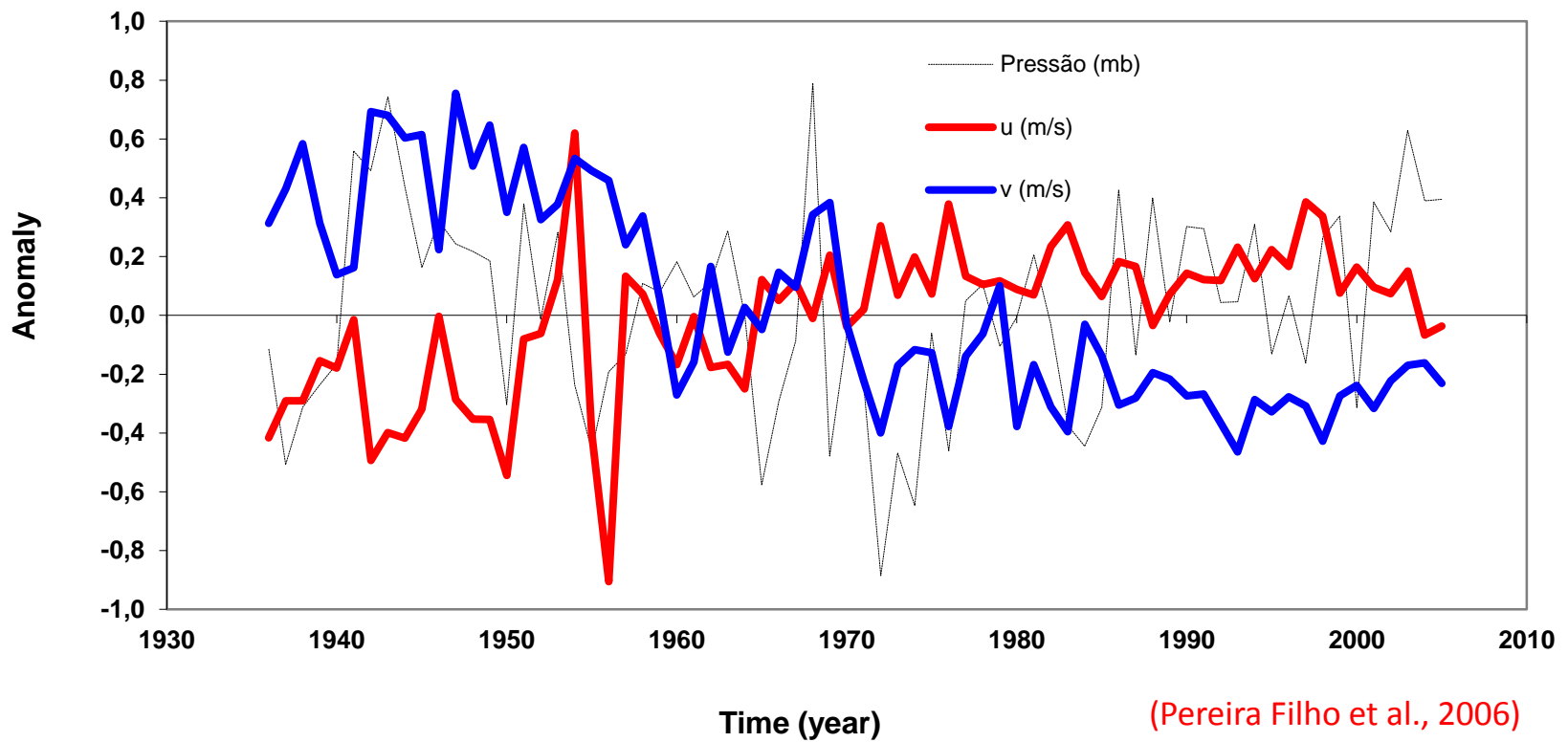


FIG. 2.2. Serial monthly surface temperature anomalies (°C) relative to a 1961–90 base period, based on Quayle et al. (1999). [Source: NOAA/NCDC]

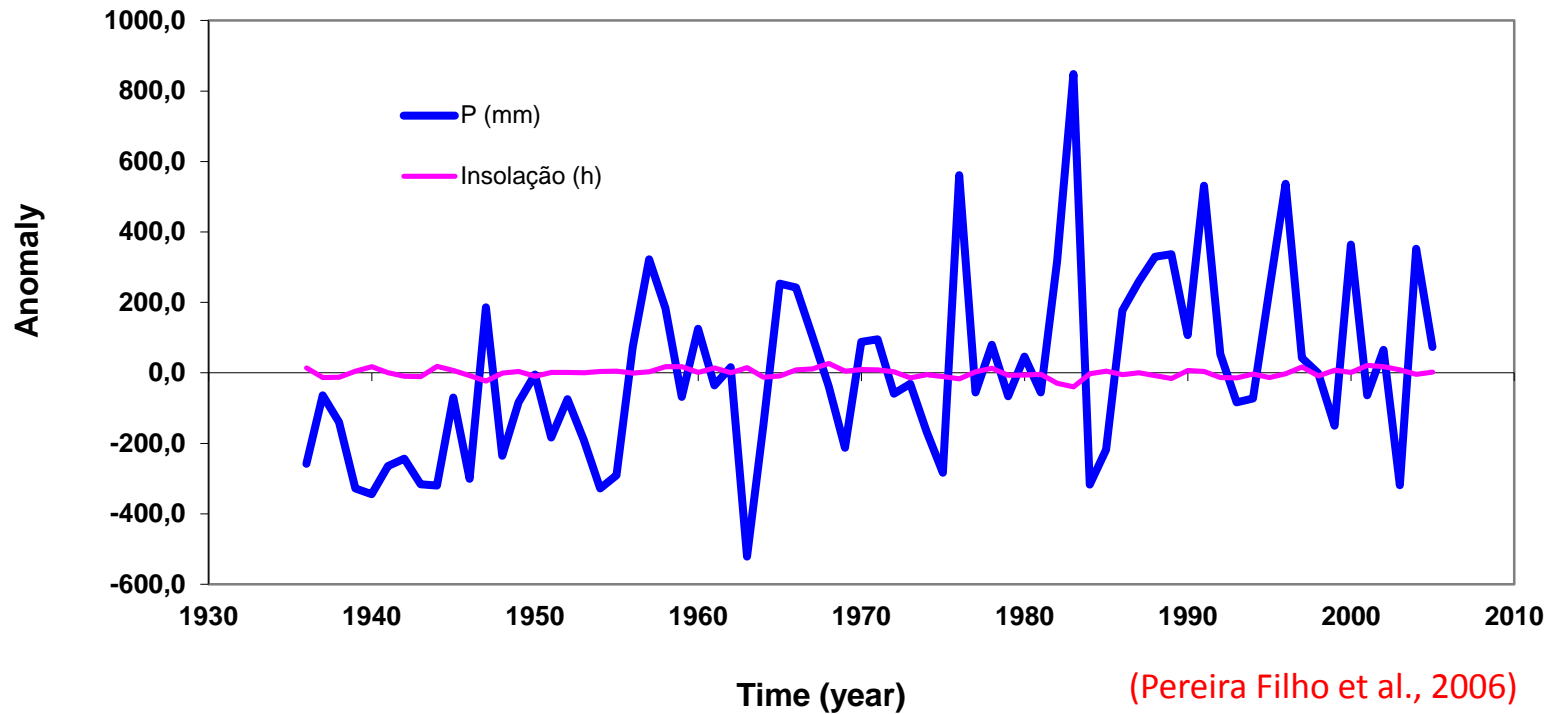


**FIG. 2.4. Geographic distribution of surface air temperature anomalies (°C) in 2005 relative to the 1961-90 mean. [Source: NOAA/NCDC]**  
(Shein, 2006)

# PRESSÃO DO AR E VENTO 1936 -2005



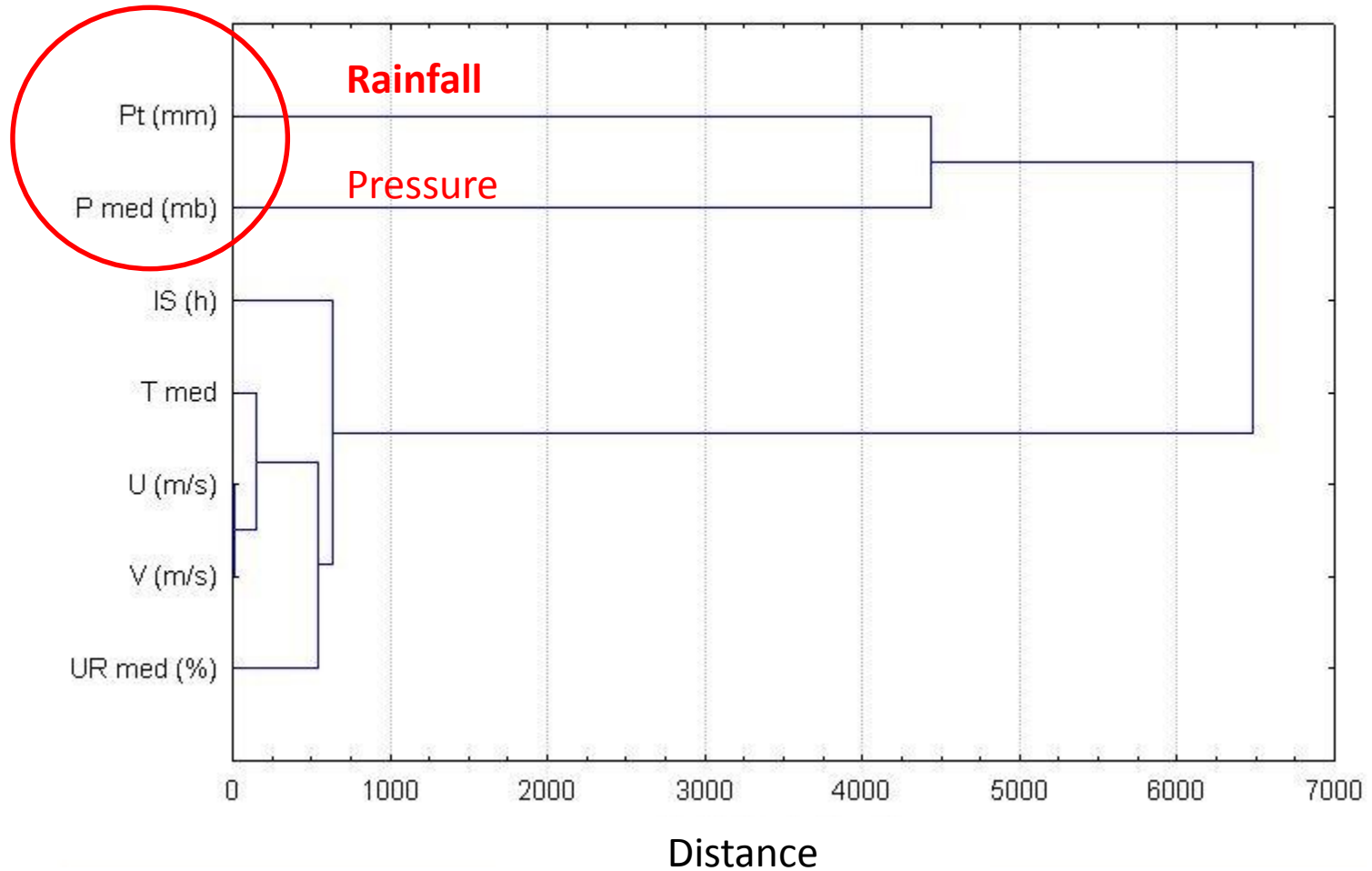
# CHUVA E INSOLAÇÃO 1936 -2005



**MUDANÇAS NO CLIMA  
LOCAL (+) E GLOBAL (-)**

# ANÁLISE DE AGRUPAMENTO (ANUAL) 1936-2005

Seven Variables  
Euclidean Distances

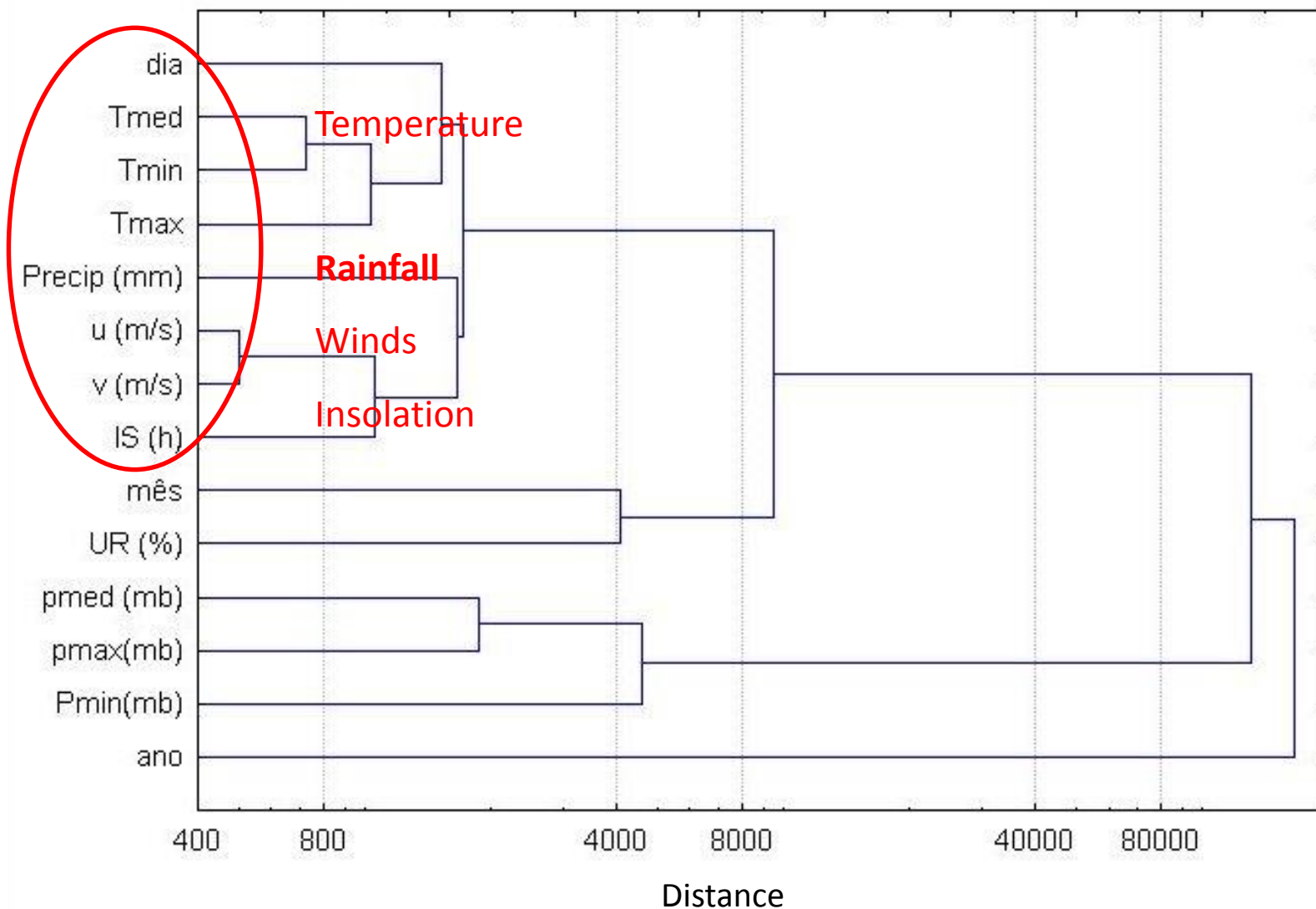


# ANÁLISE DE AGRUPAMENTO (DIÁRIA)

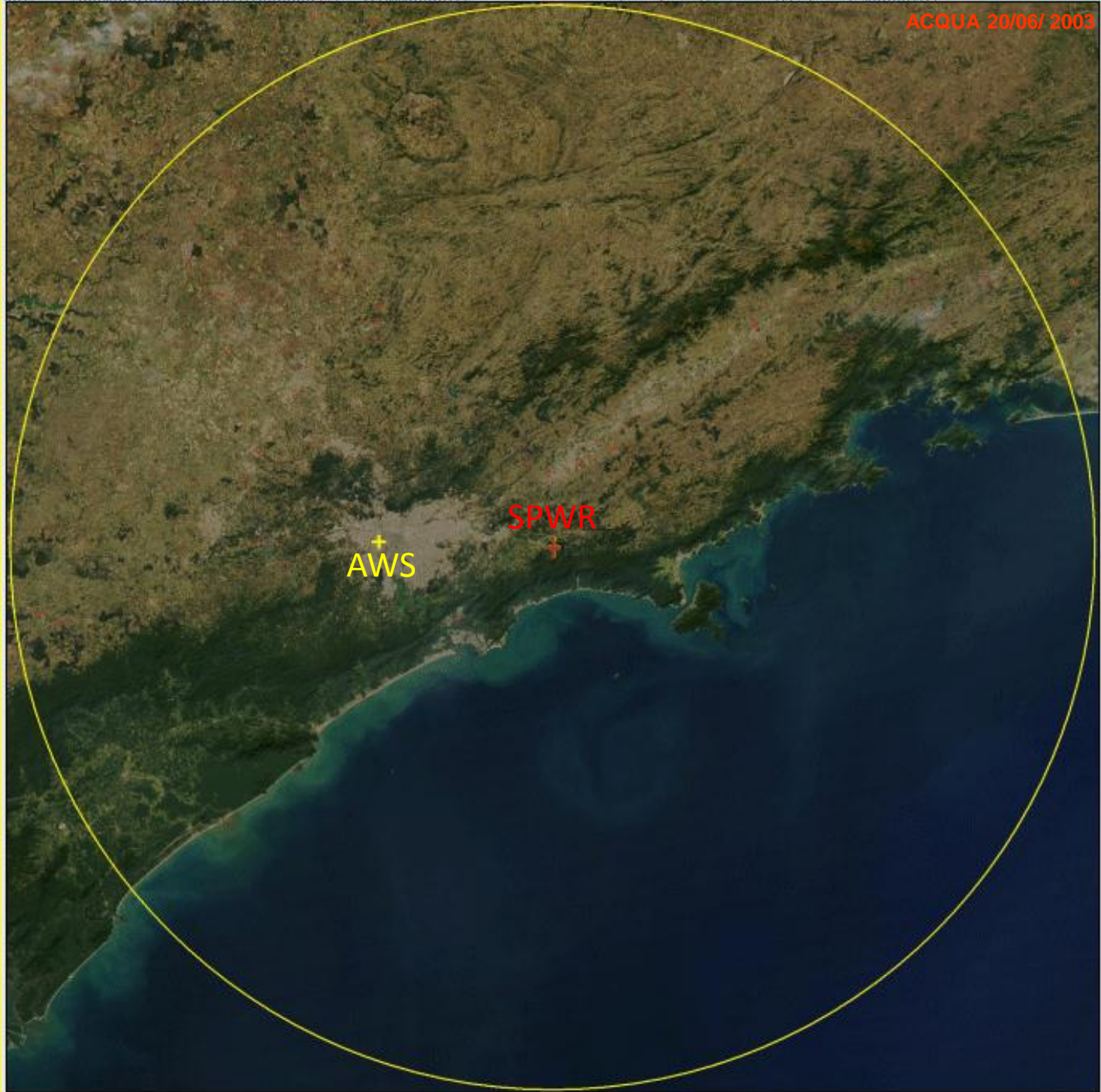
## 1936-2005

Fourteen Variables

Euclidean Distances



# **IMPACTOS DAS MUDANÇAS CLIMÁTICAS LOCAIS NA CHUVA SOBRE A RMSP**



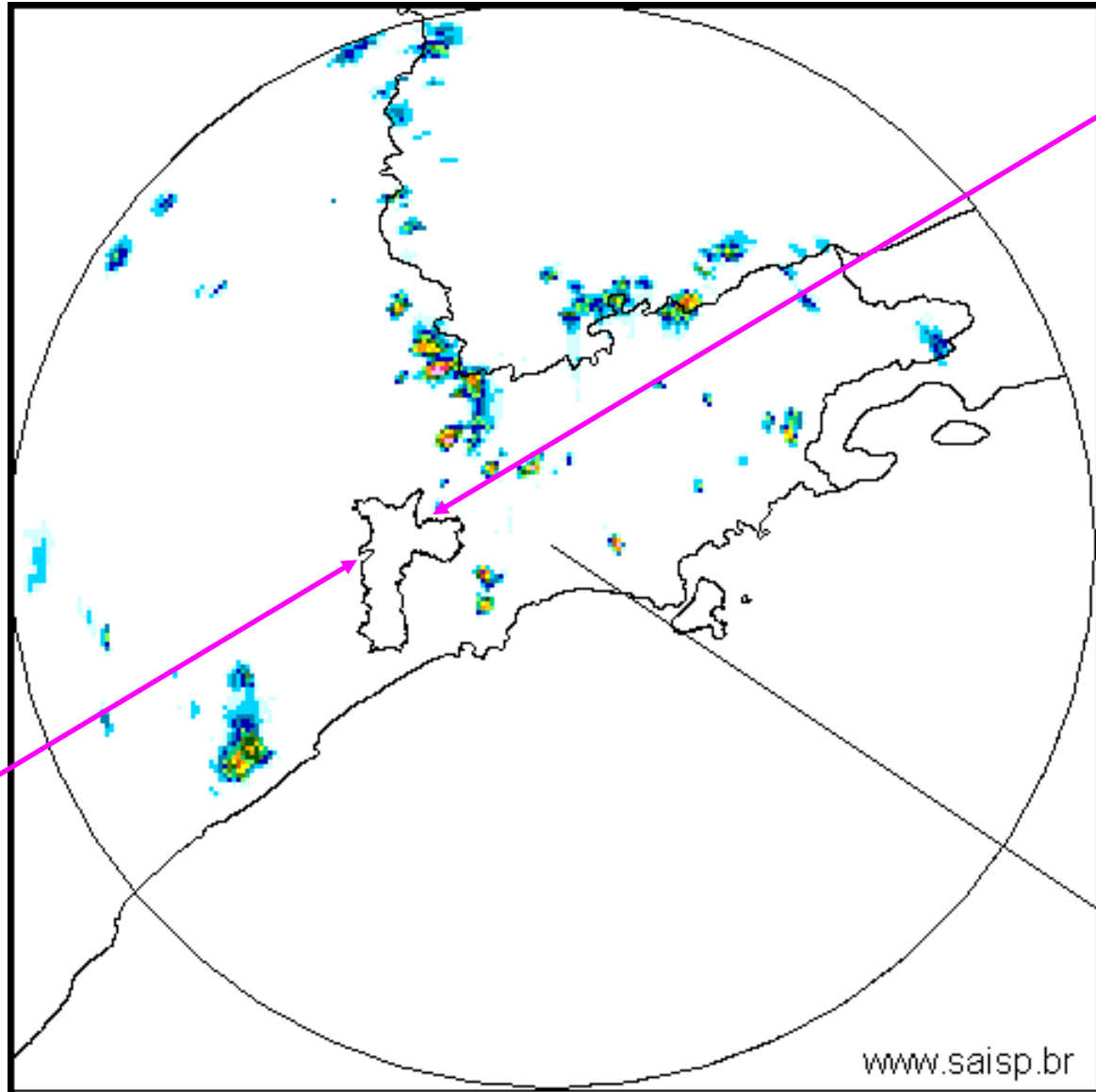
+

AWS

+

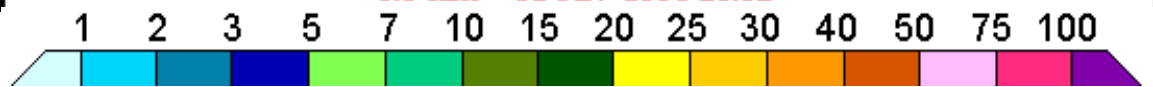
SPWR

**ZONA SUL**



**ZONA LESTE**

**3.0 Km - 02 FEV 2004 18:01**

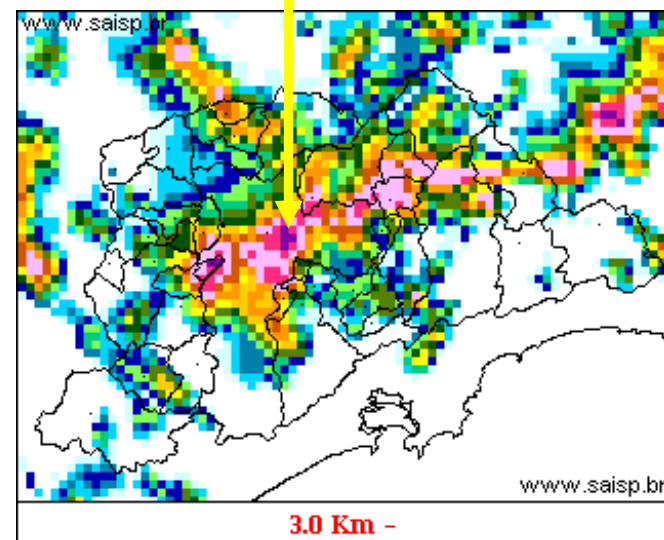


**(mm h<sup>-1</sup>)**

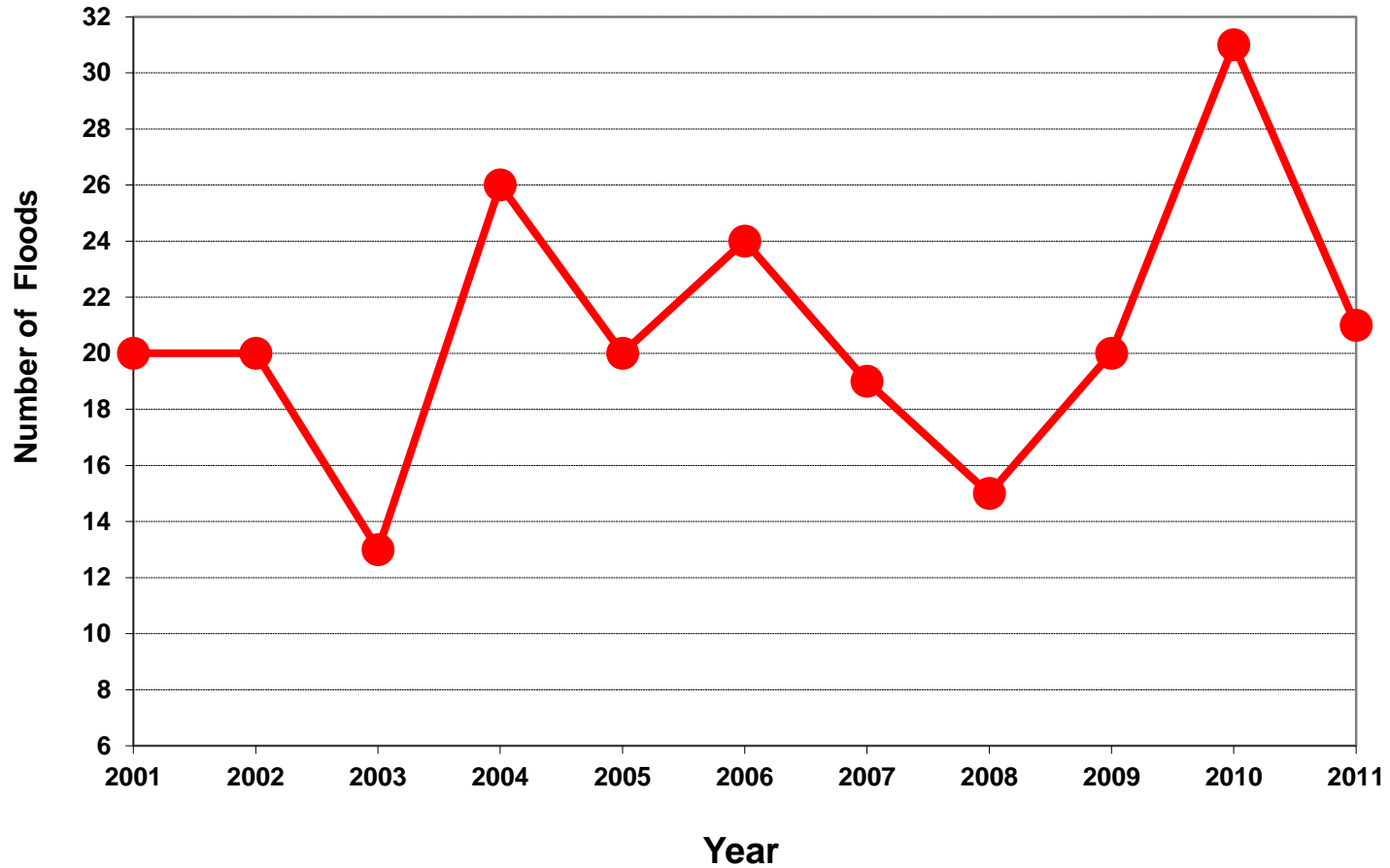
# ENCHENTES



## RIO ARICANDUVA



# NÚMERO DE ENCHENTES NA CIDADE DE SÃO PAULO 2001 A 2011

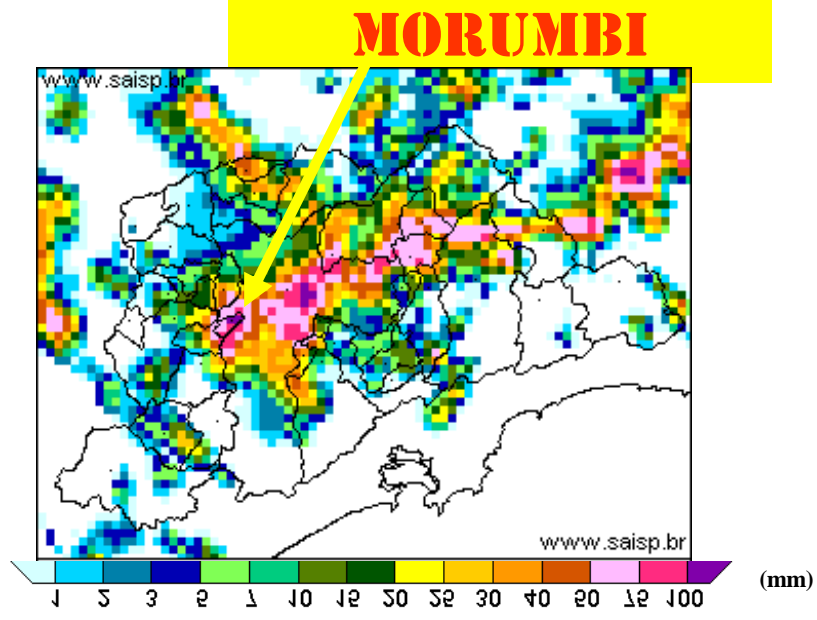




Fonte: OESP

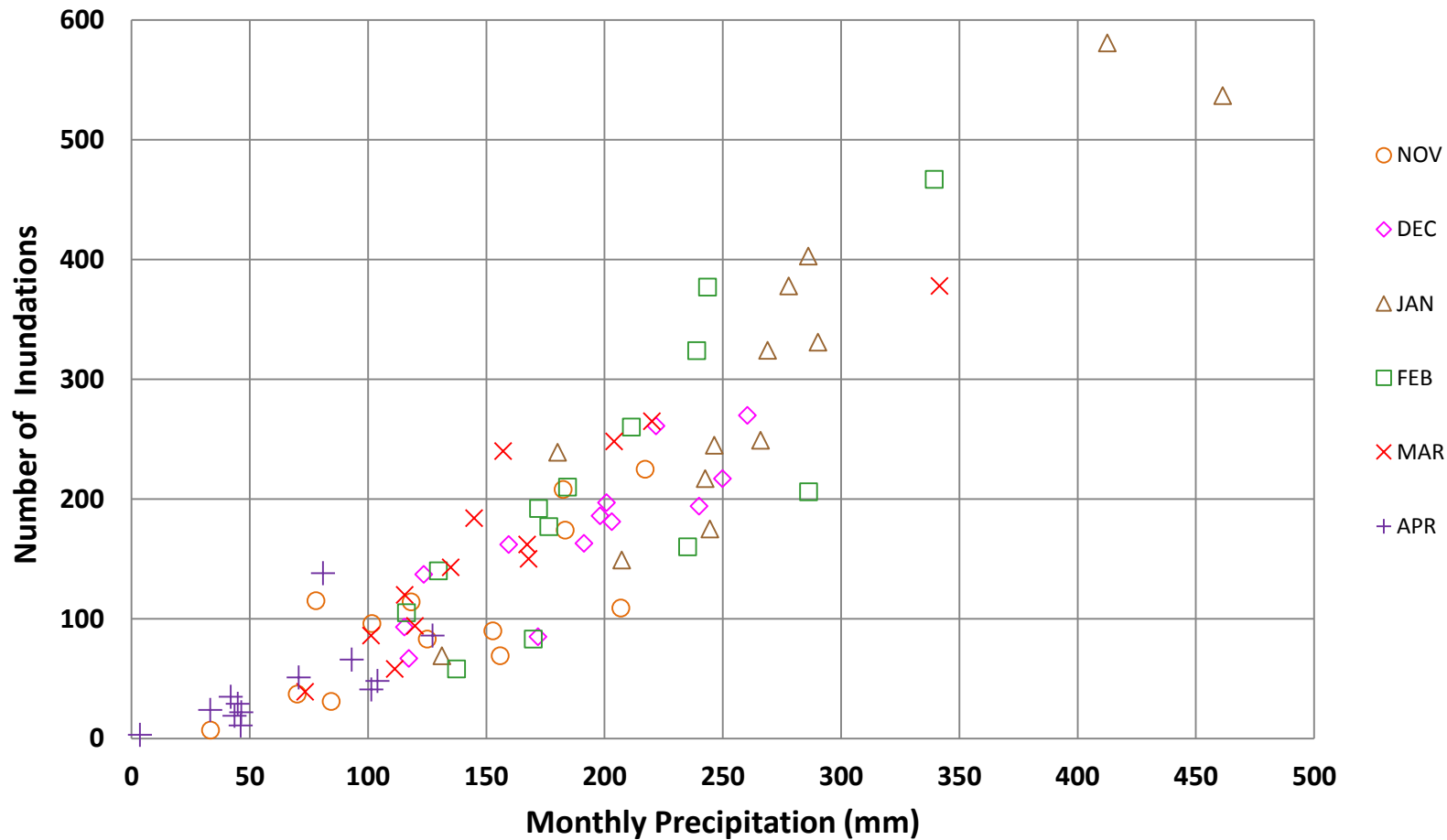
# Inundação

02-02-2004

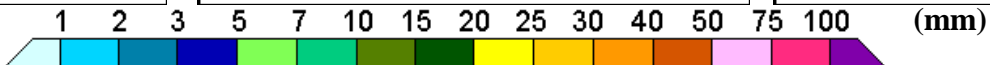
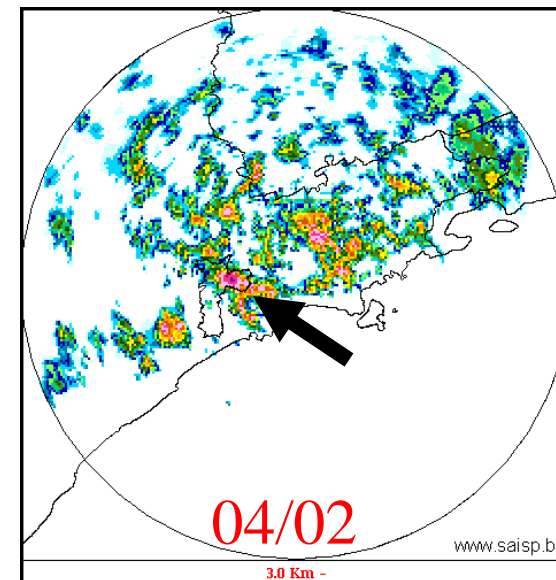
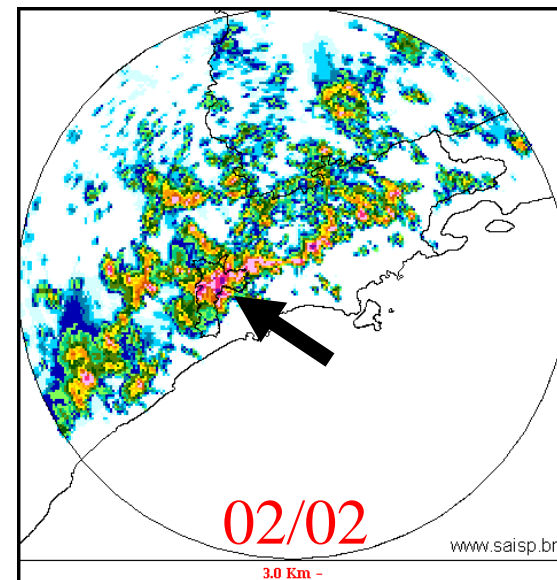
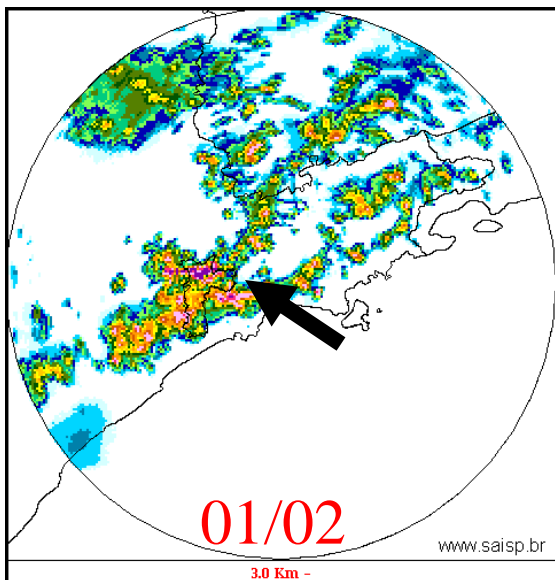
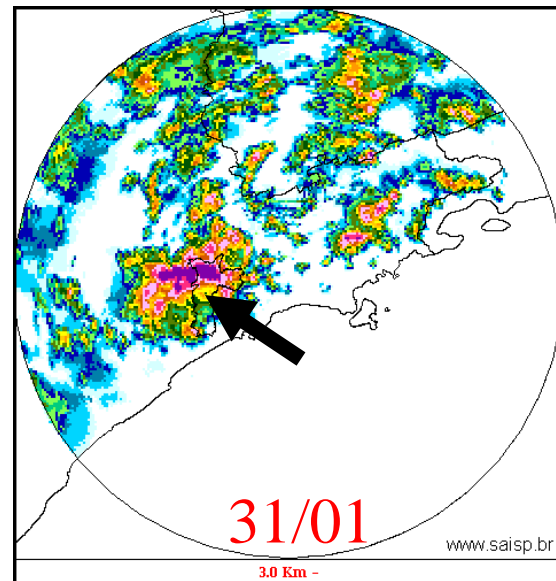
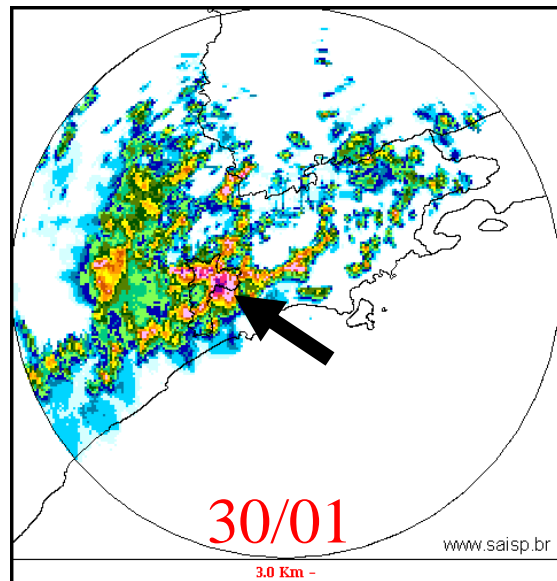
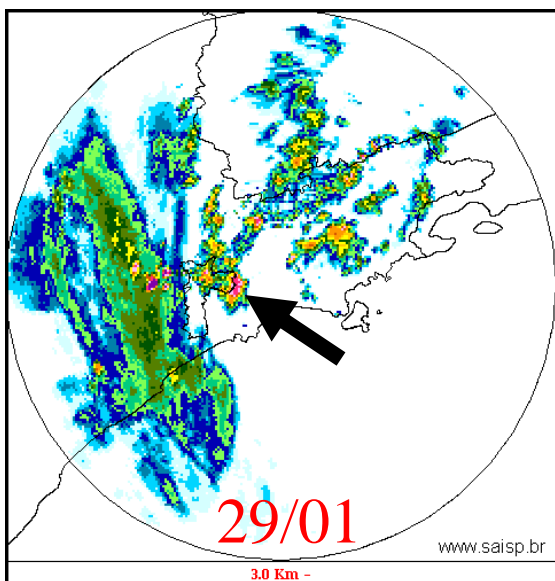


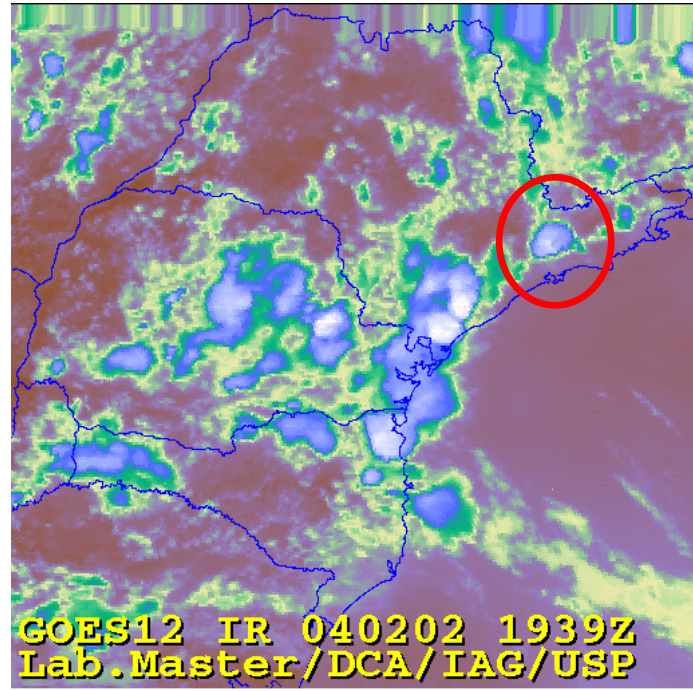
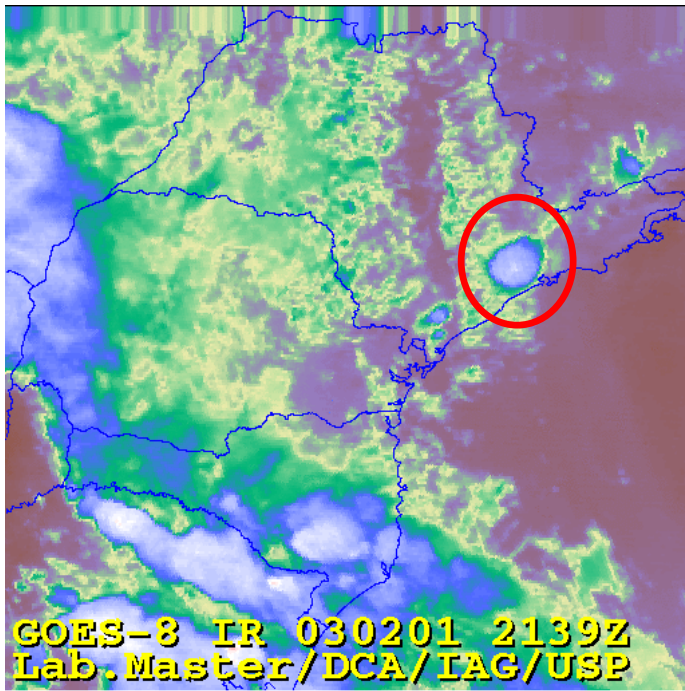
Fonte: OESP

# Inundações na Cidade de São Paulo 1999 to 2011

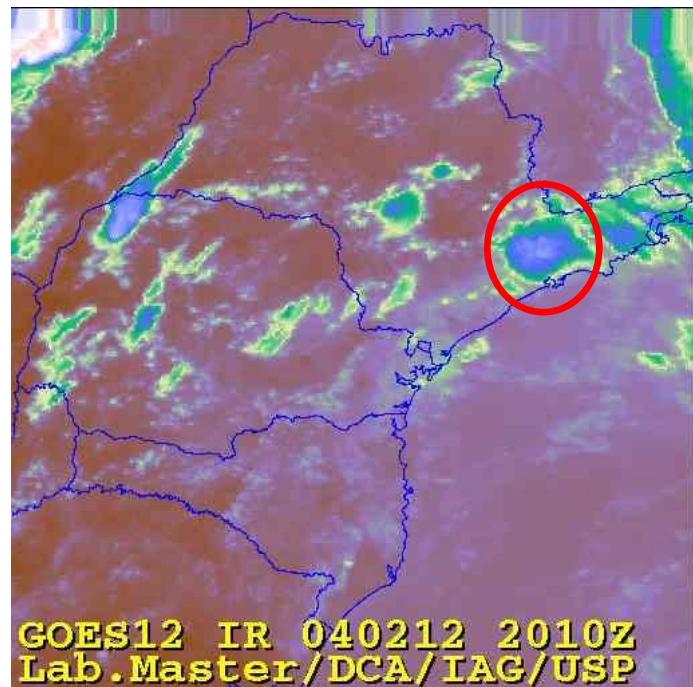
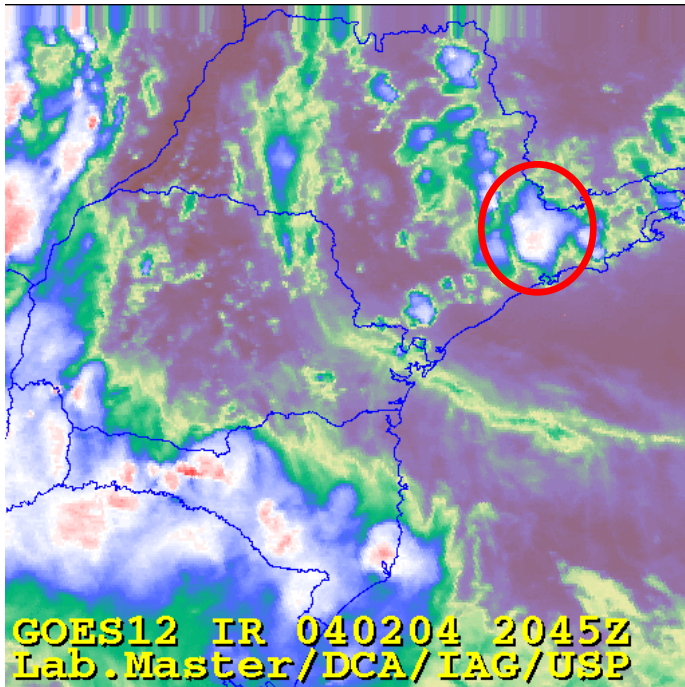


# CHUVA DIÁRIA NA RMSP - ENCHENTES DE 2004

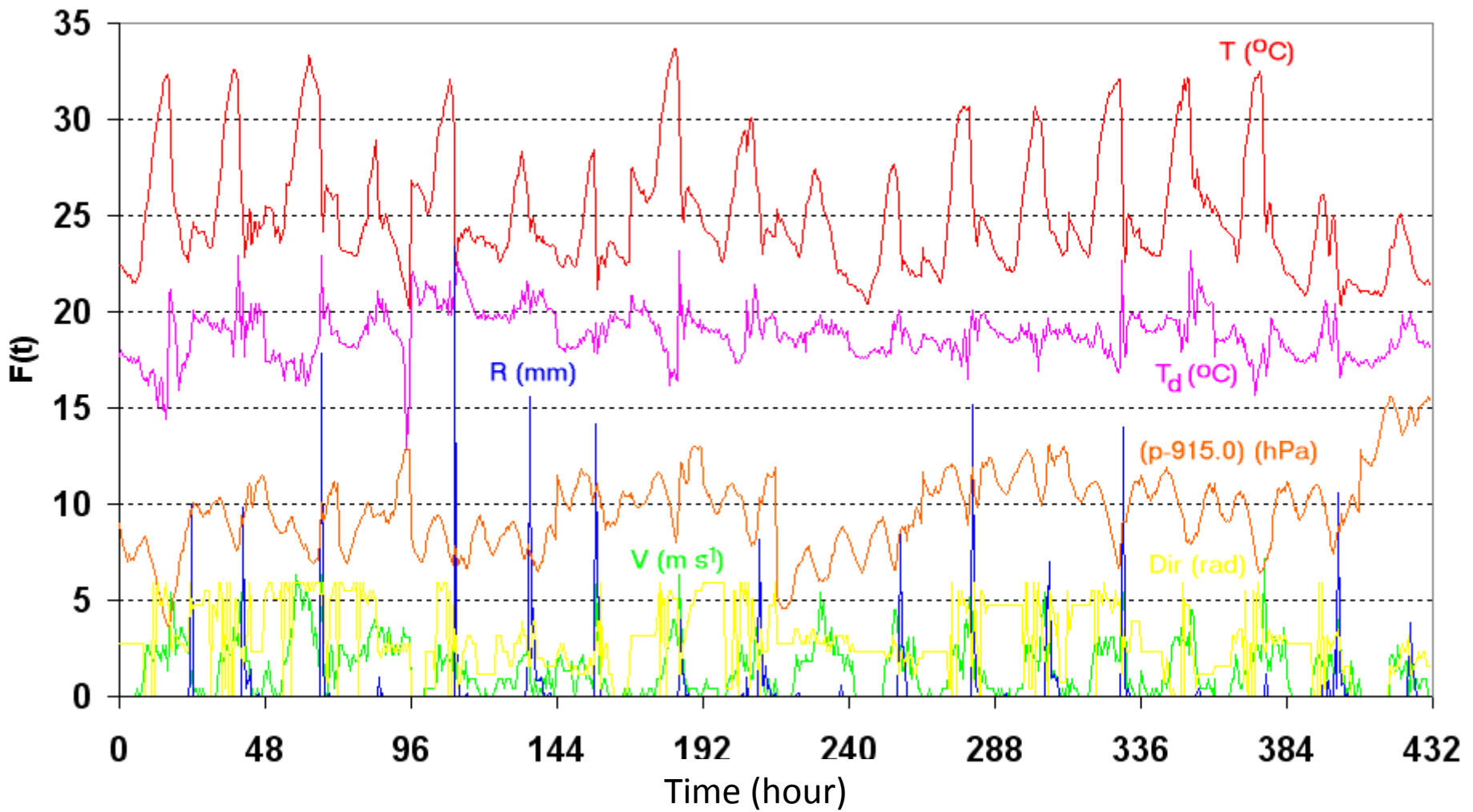




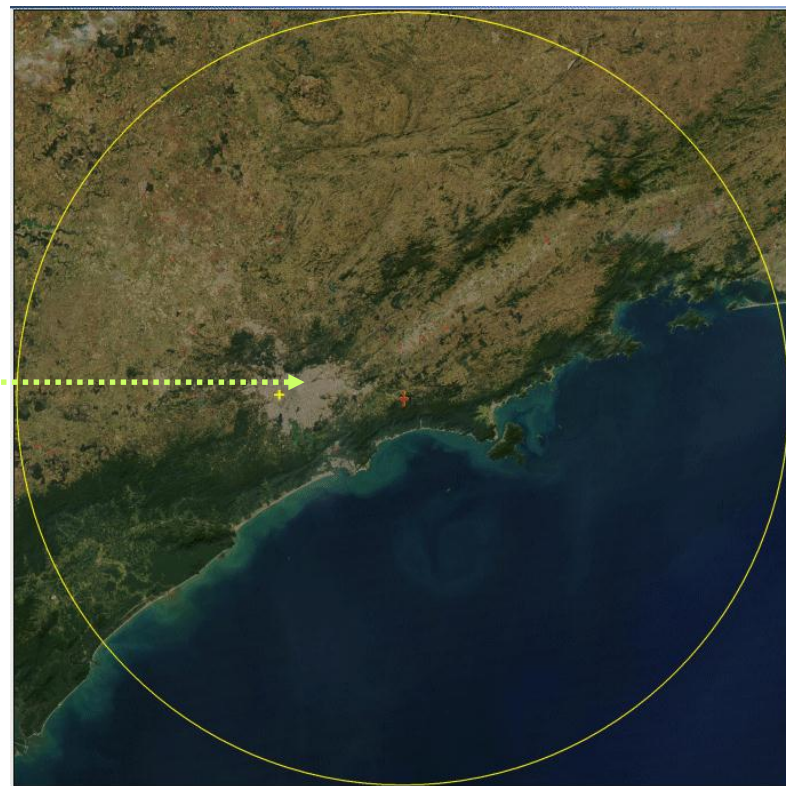
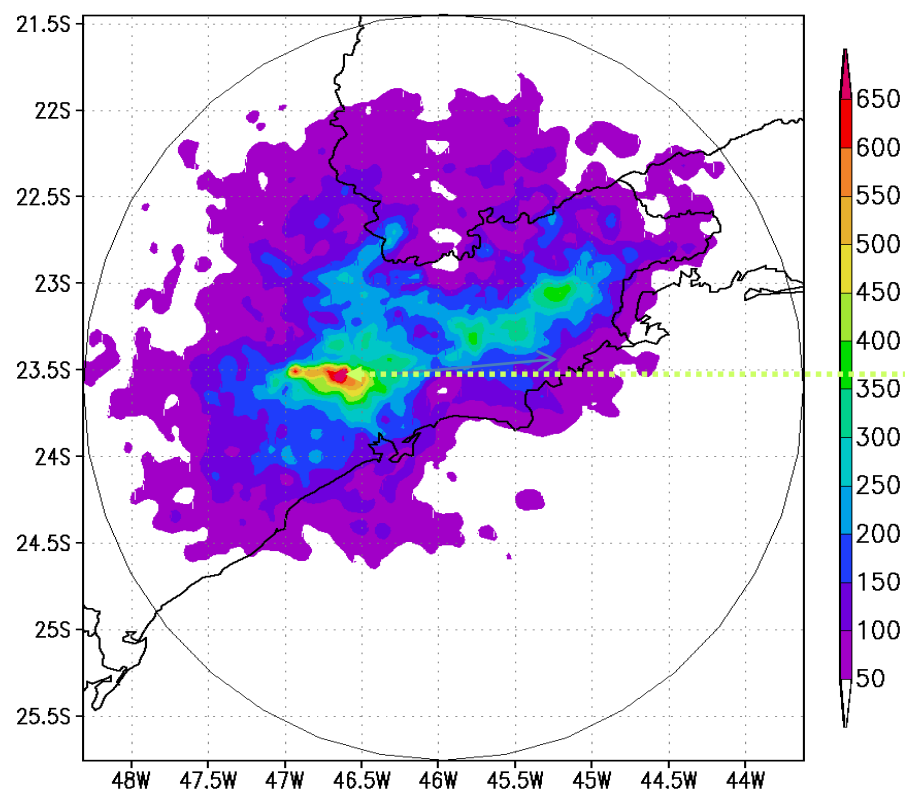
**GOES-12 IR**



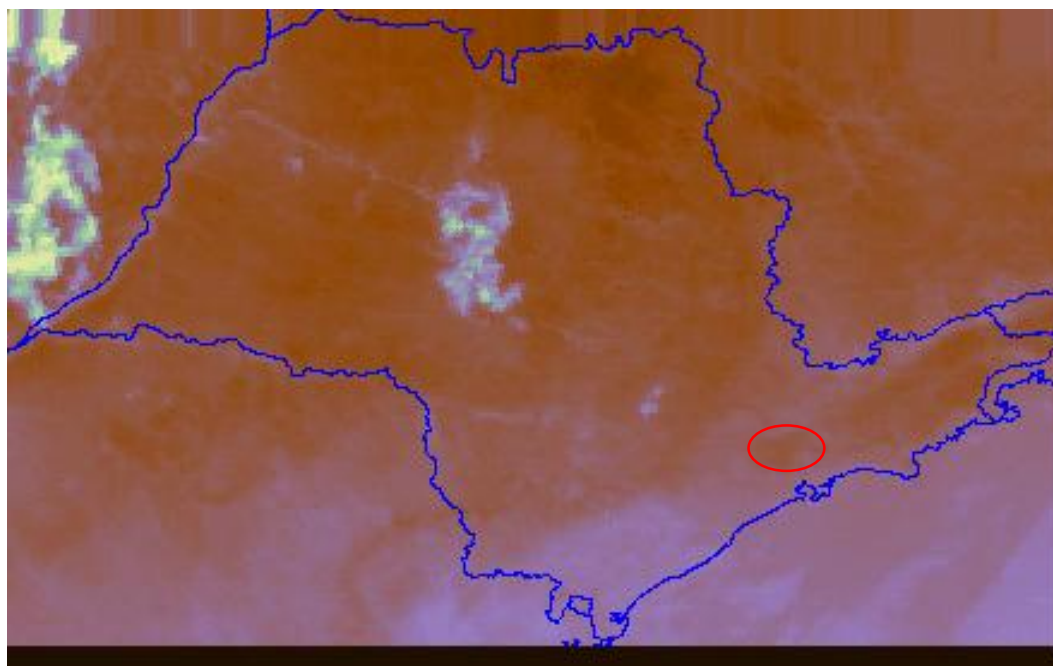
# ENCHENTES CAUSAS PELA ILHA DE CALOR E BRISA MARINHA 2002 A 2004



## CHUVA TOTAL (mm) – BRISA & IC (2002 – 2004)

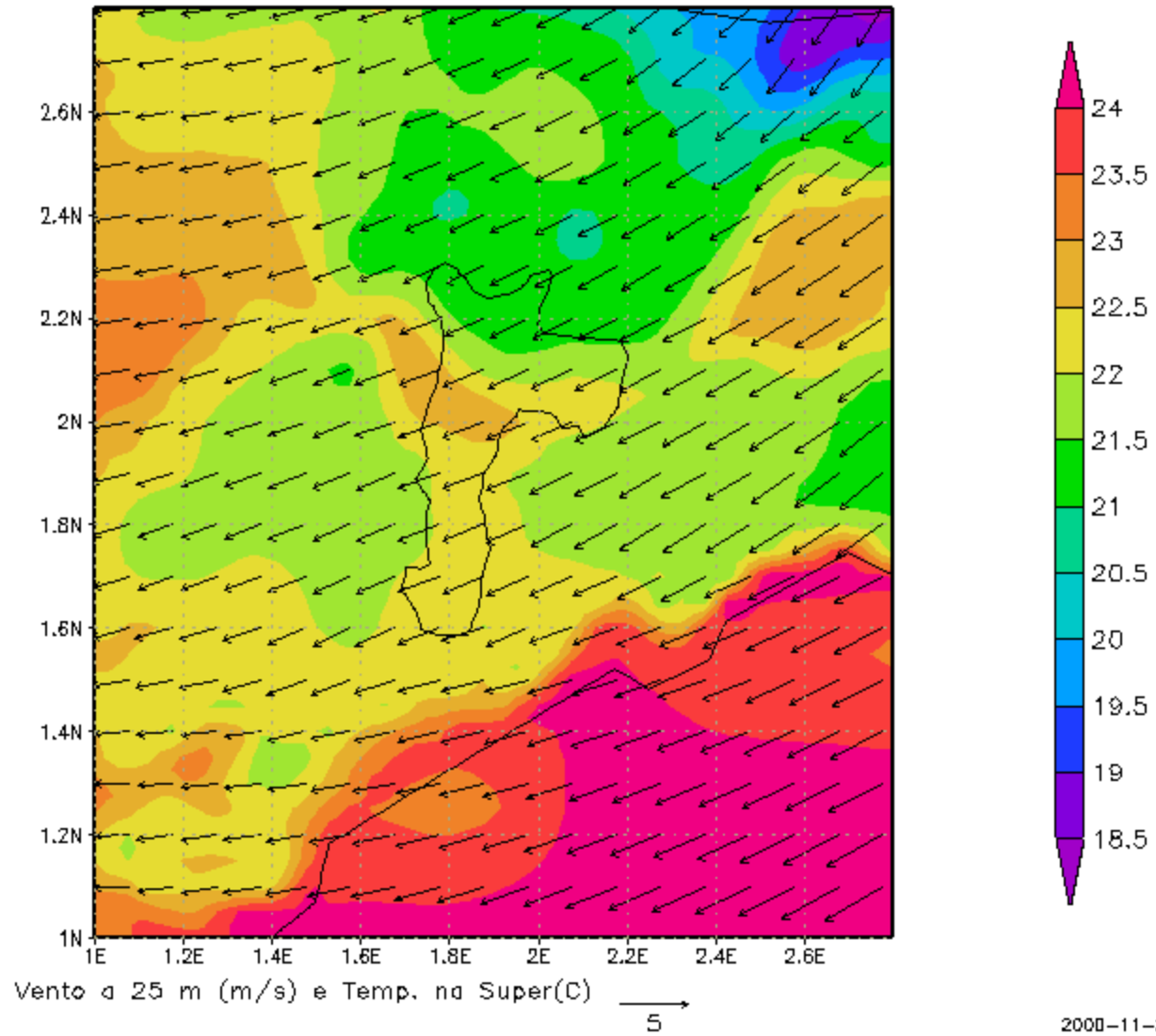


# ILHA DE CALOR NA RMSP

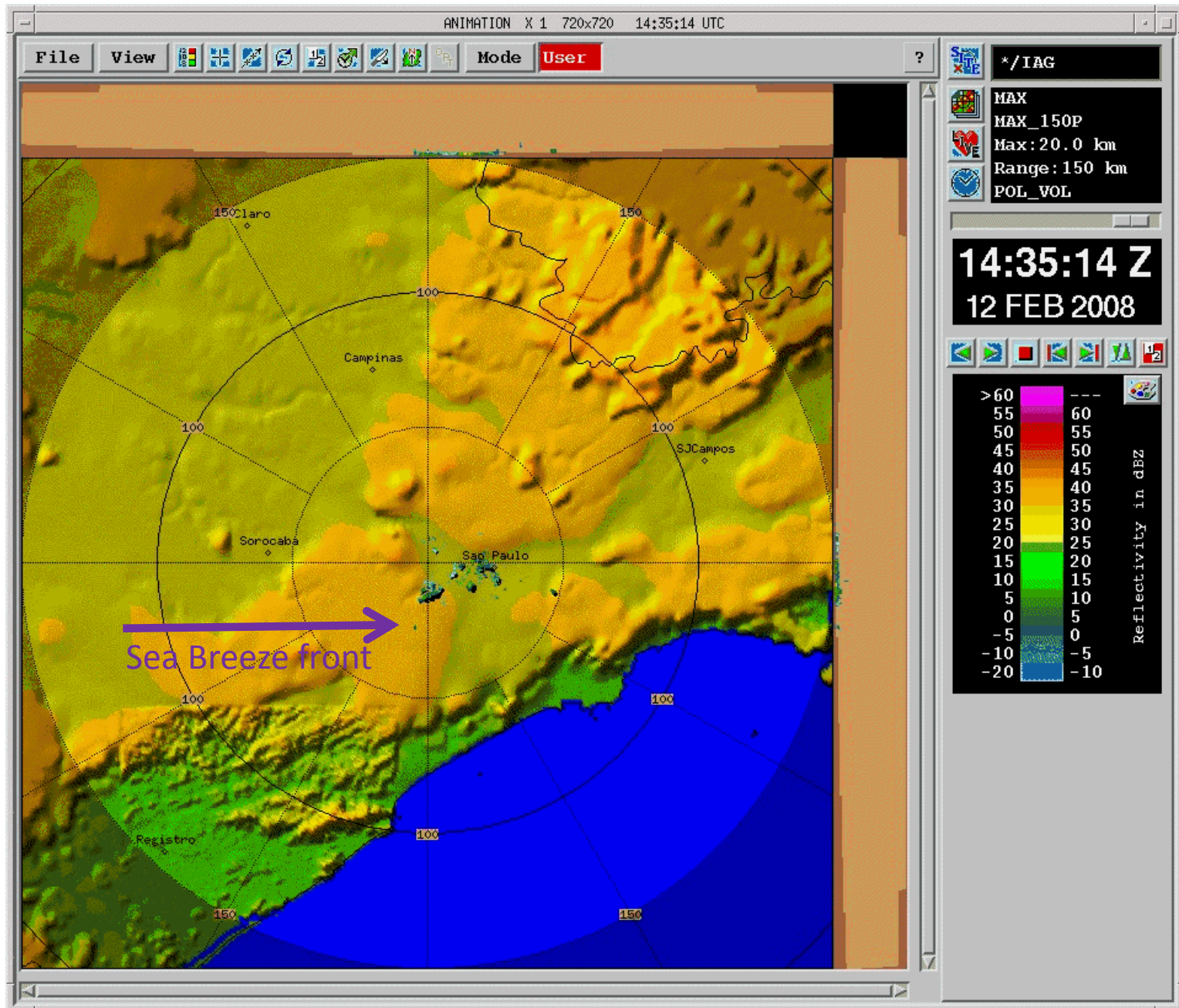


# Brisa do Mar simulada com ARPS

Horario: 1 Z



# RADAR MXPOL – LABHIDRO IAG USP

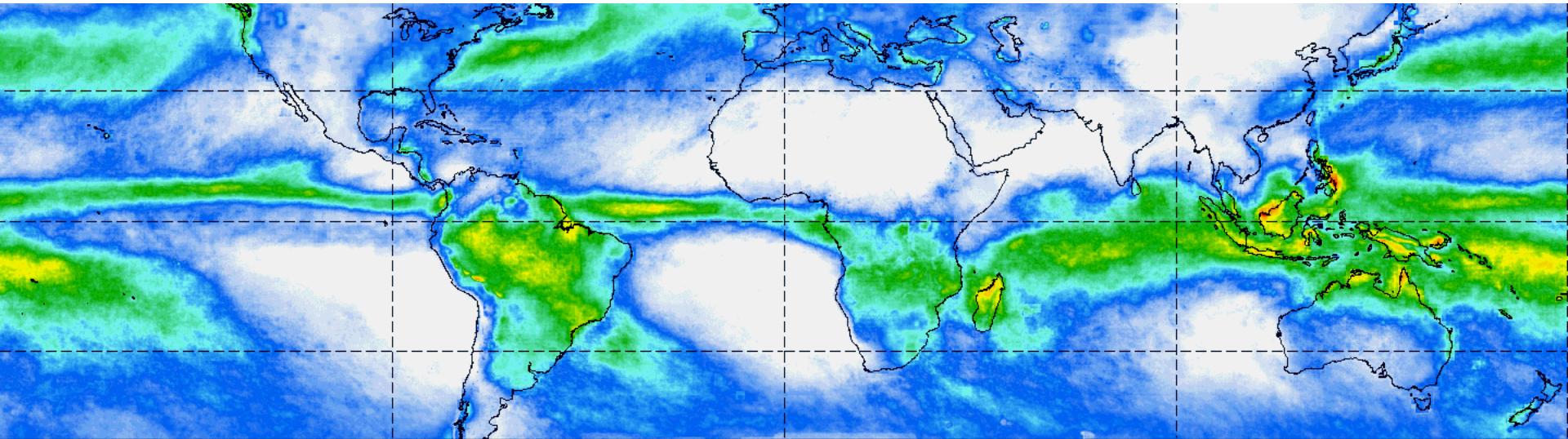


# CONCLUSÃO

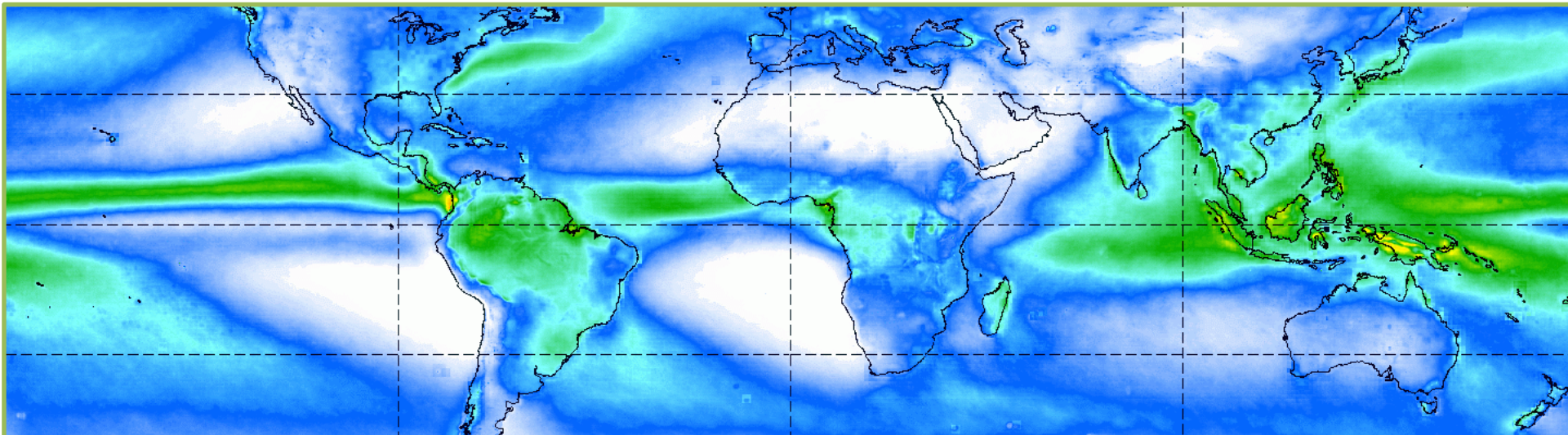
- **CAUSA DAS MUDANÇAS CLIMÁTICAS LOCAIS:**  
**REDUÇÃO DA VEGETAÇÃO**  
**CRESCIMENTO URBANO**  
**POLUIÇÃO DO AR (INVERNO)**  
**EFETOS GLOBAIS MENOR IMPACTO;**
- **$T_{AR} + 2,1^{\circ} C$ ; ↑**
- **CHUVA + 395 MM; ↑**
- **VENTO ZONAL (E)+ 0,5 M S<sup>-1</sup>;↑**
- **VENTO MERIDIONAL (S) - 1,0 M S<sup>-1</sup>;↓**
- **UMIDIDADE RELATIVA - 7%.↓**

- **CICLOS DE 2 ANOS, 21 ANOS E MAIS LONGOS NA PRESSÃO DO AR, VENTOS, UMIDADE RELATIVA, INSOLAÇÃO E CHUVA.**
- **TEMPERATURA DO AR TEM CICLOS DE 2 A 7 YEAR POR CAUSA DO EL NIÑO, LA NIÑA E OSCILAÇÃO SUL.**
- **ALTA DO ATLÂNTICO SUL CONTROLA A CHUVA ANUAL + OESTE (- LESTE) –(+ ) CHUVA.**

# CLIMATOLOGIA TRMM



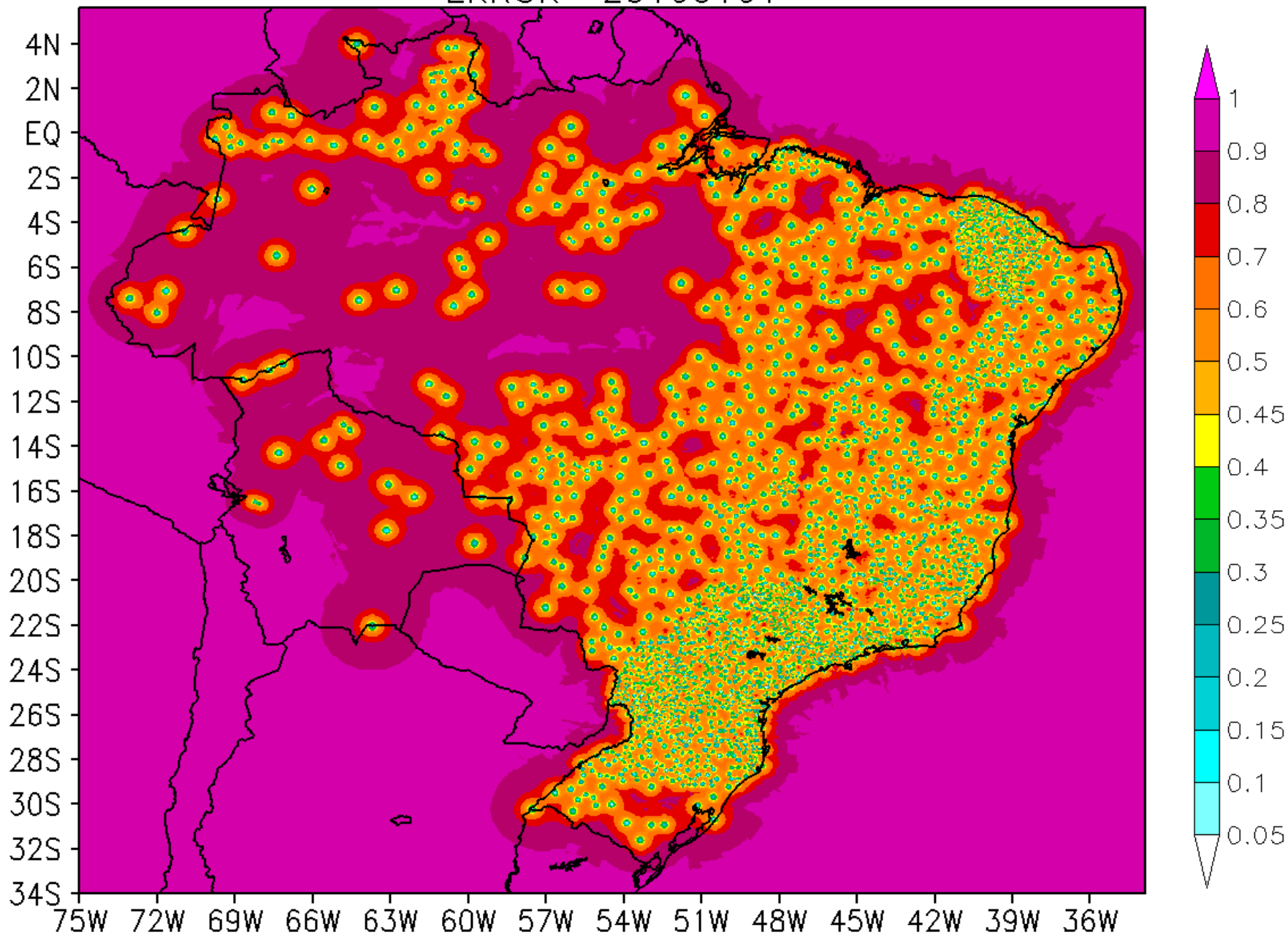
JANUARY Average Rainfall mm/dd (3B43) 1998 to 2011

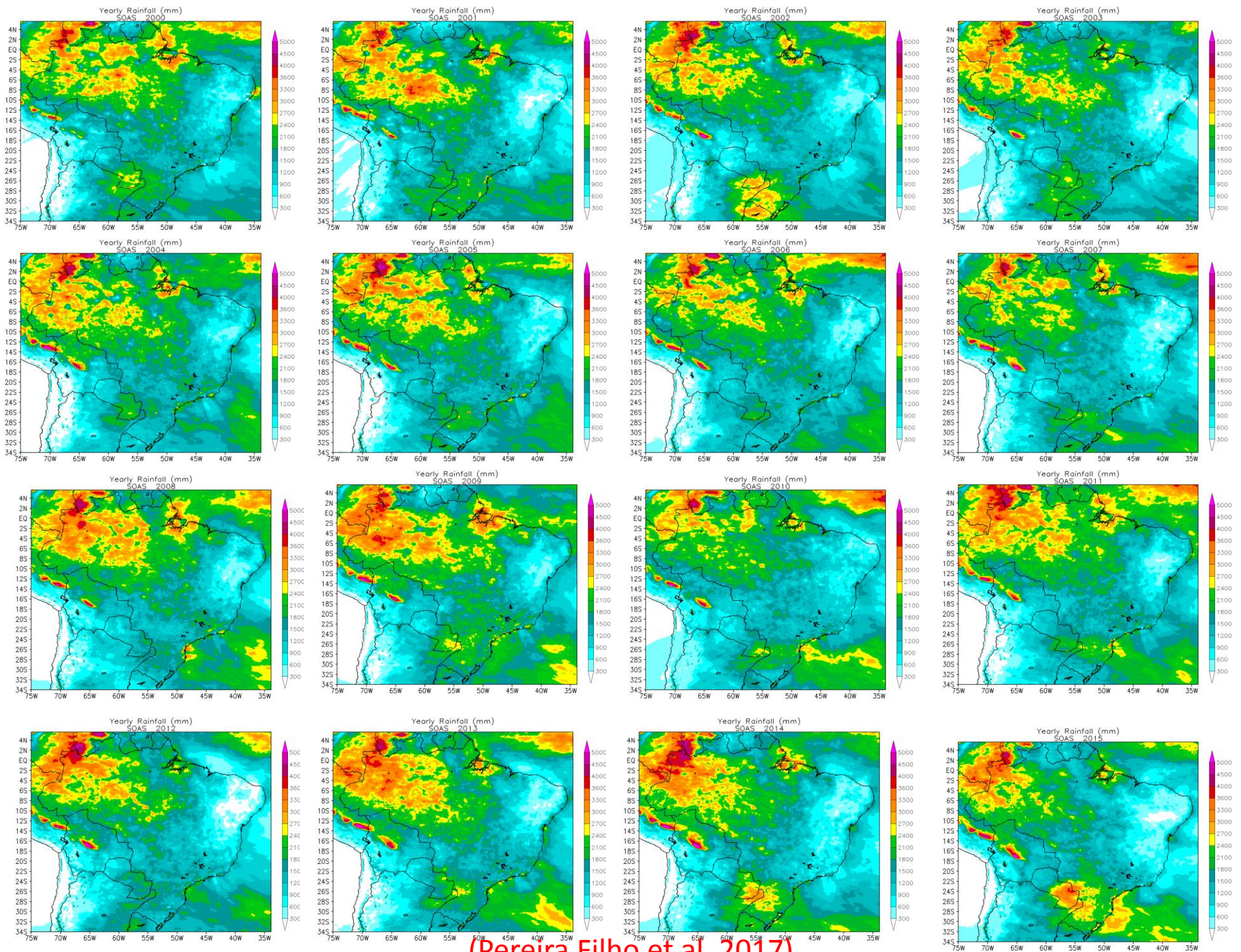


Average of ALL AVAILABLE Rainfall mm/dd (3B43) 1998 to 2011



SOAS  
ERROR 20100101

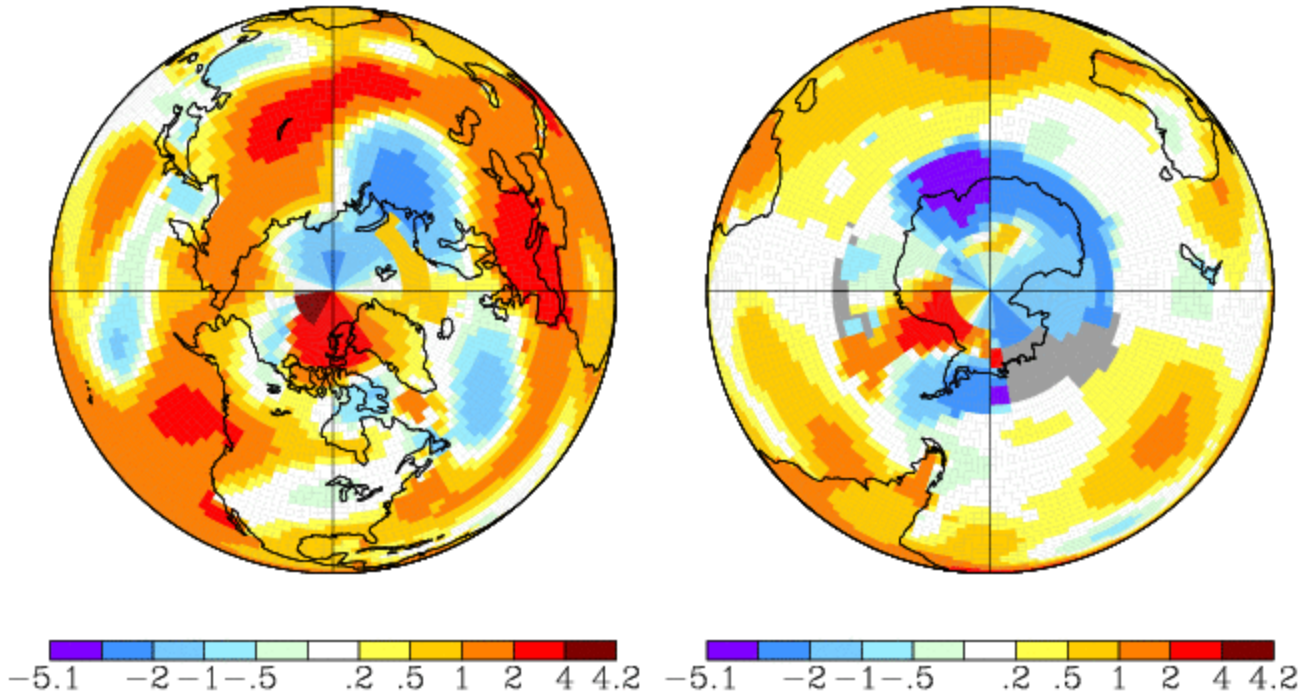




July 2015

L-OTI(°C) Anomaly vs 1961-2000

0.54

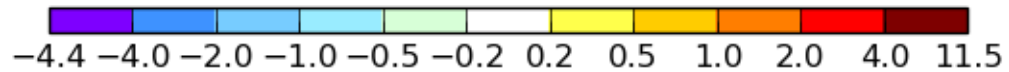
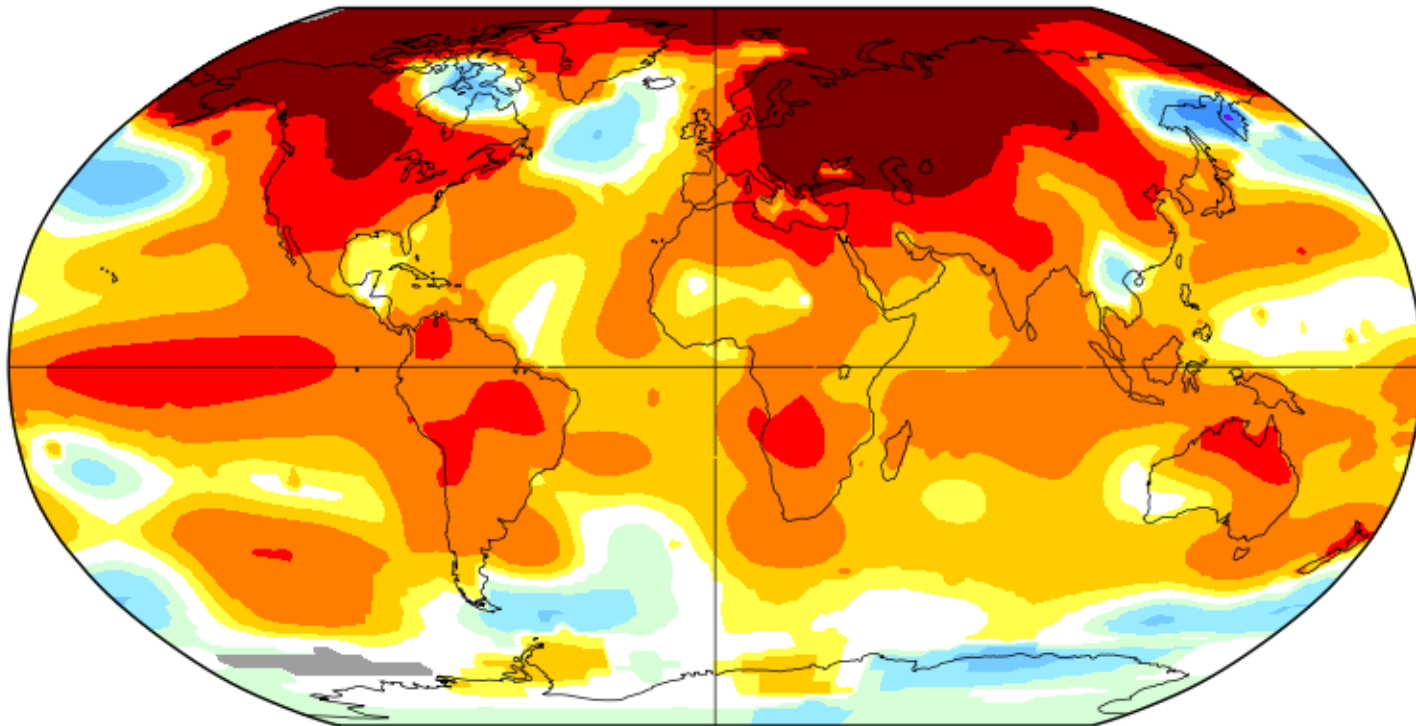


Fonte: <http://data.giss.nasa.gov/gistemp/maps/>

February 2016

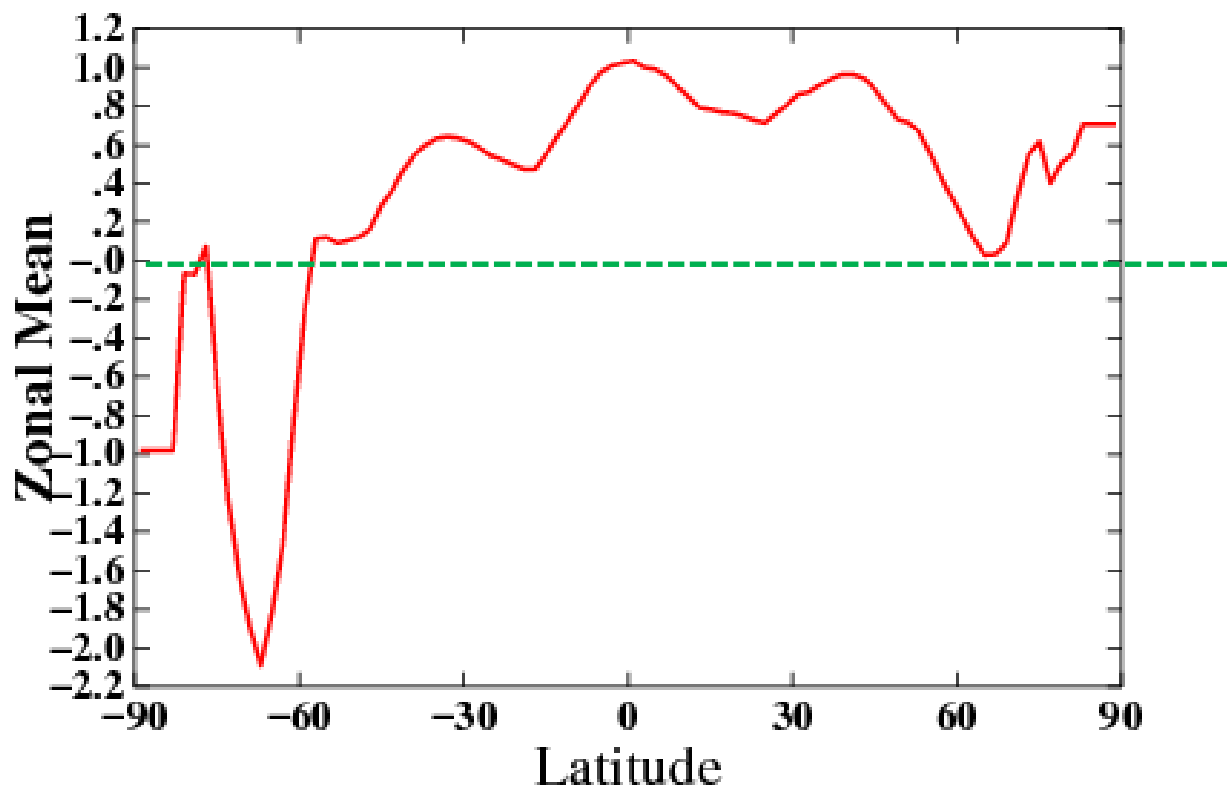
L-OTI(°C) Anomaly vs 1951-1980

1.35



Fonte: <http://data.giss.nasa.gov/gistemp/maps/>

# ANONMALIA (1960-200) JULHO 2015

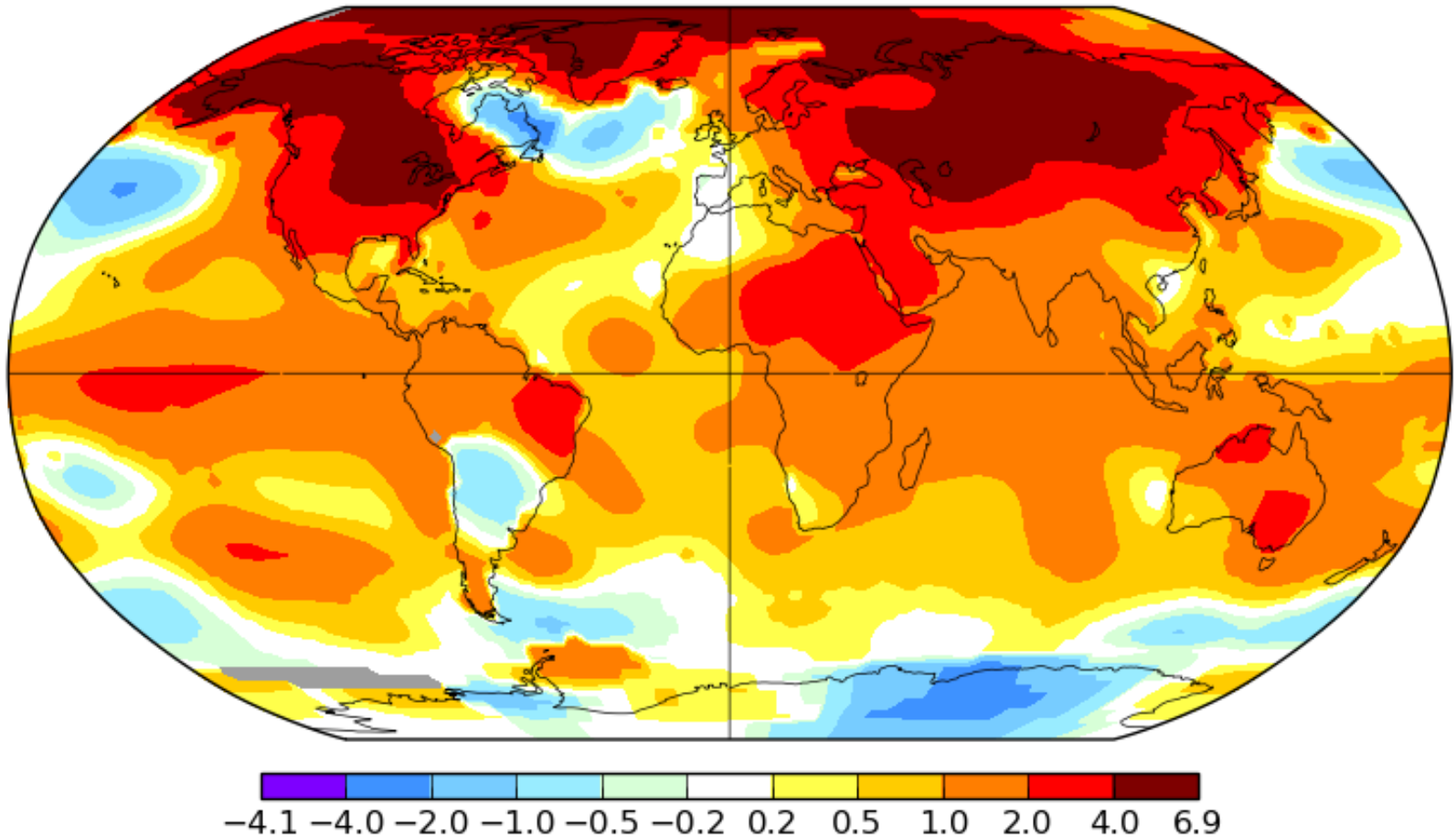


Fonte: <http://data.giss.nasa.gov/gistemp/maps/>

March 2016

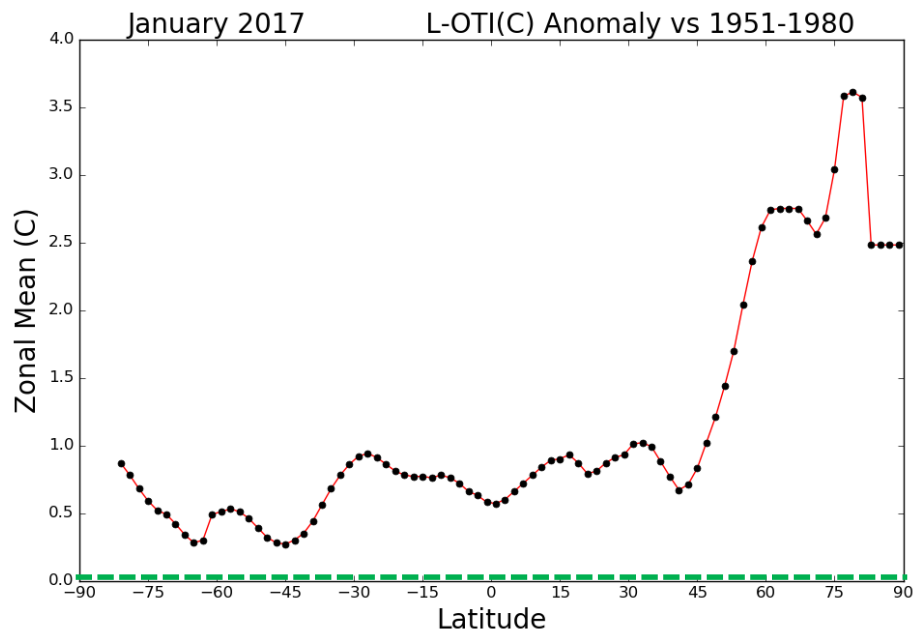
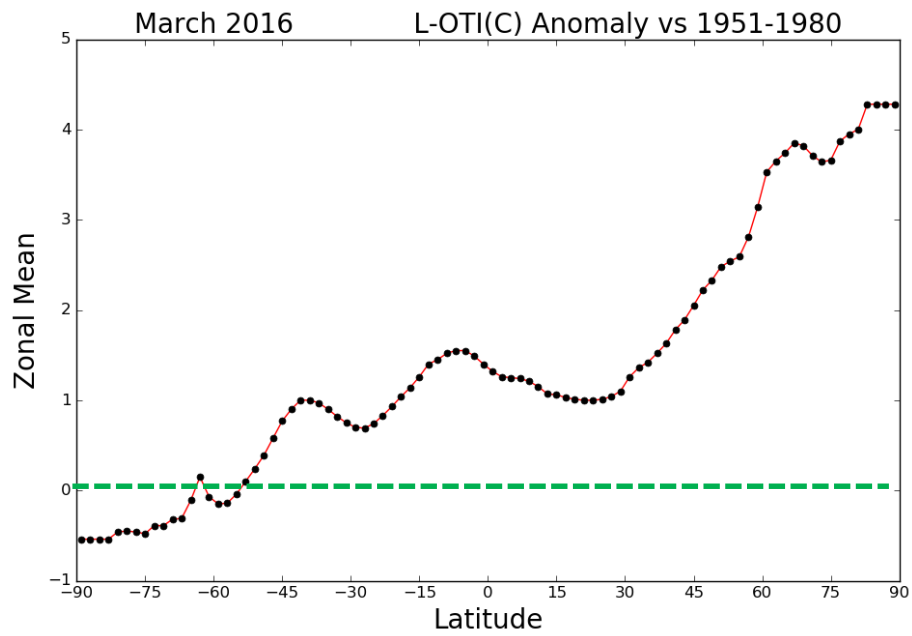
L-OTI(°C) Anomaly vs 1951-1980

1.29



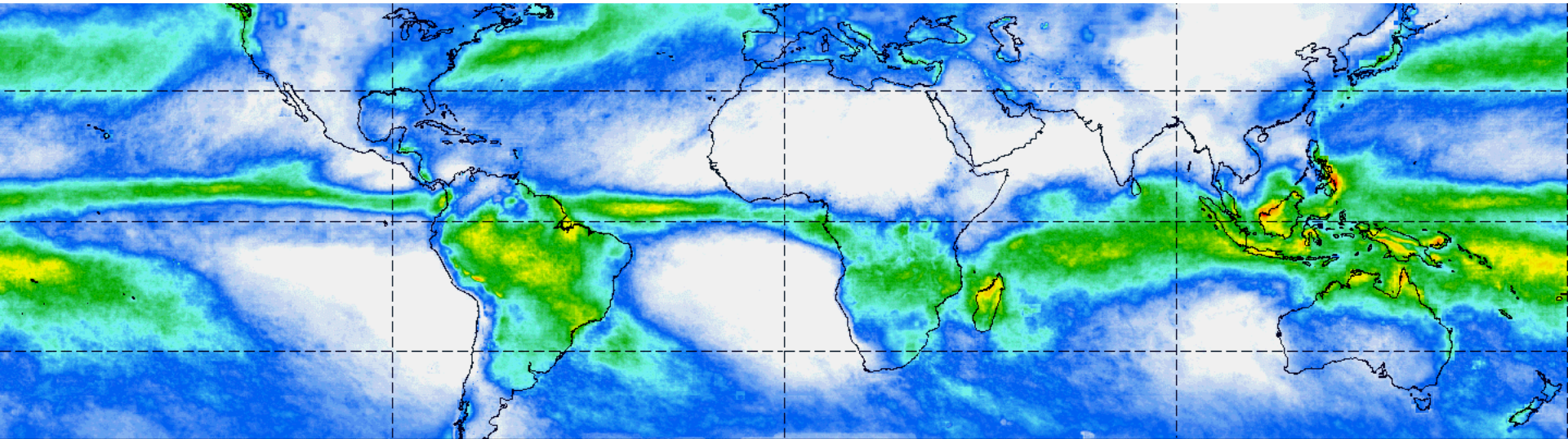
Fonte: <http://data.giss.nasa.gov/gistemp/maps/>

# ANOMALIA (1951-1980)

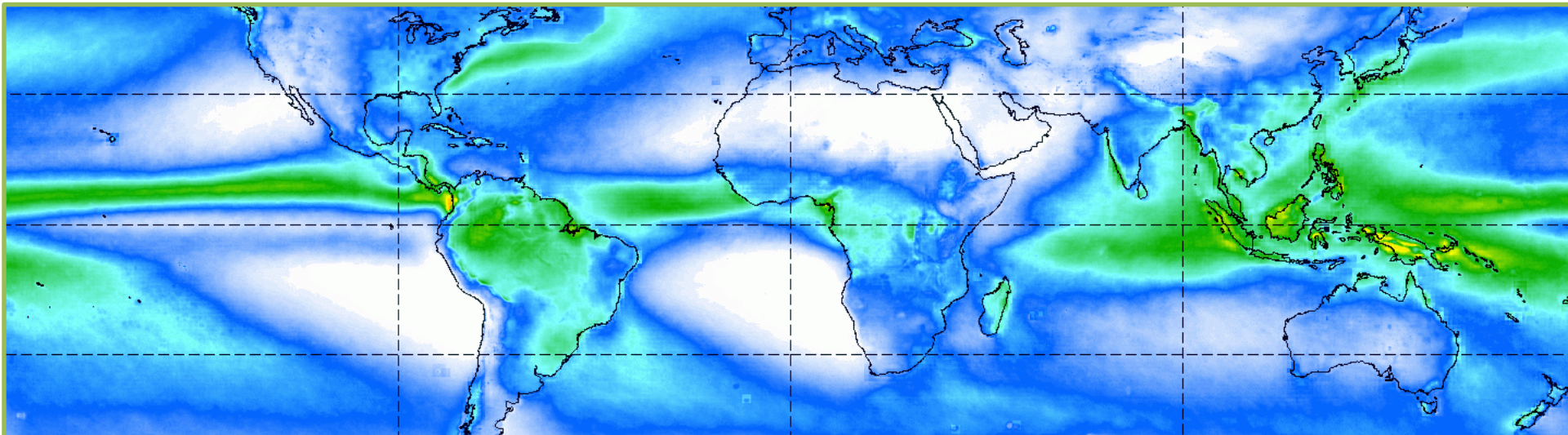


Fonte: <http://data.giss.nasa.gov/gistemp/maps/>

# CLIMATOLOGIA TRMM



JANUARY Average Rainfall mm/dd (3B43) 1998 to 2011

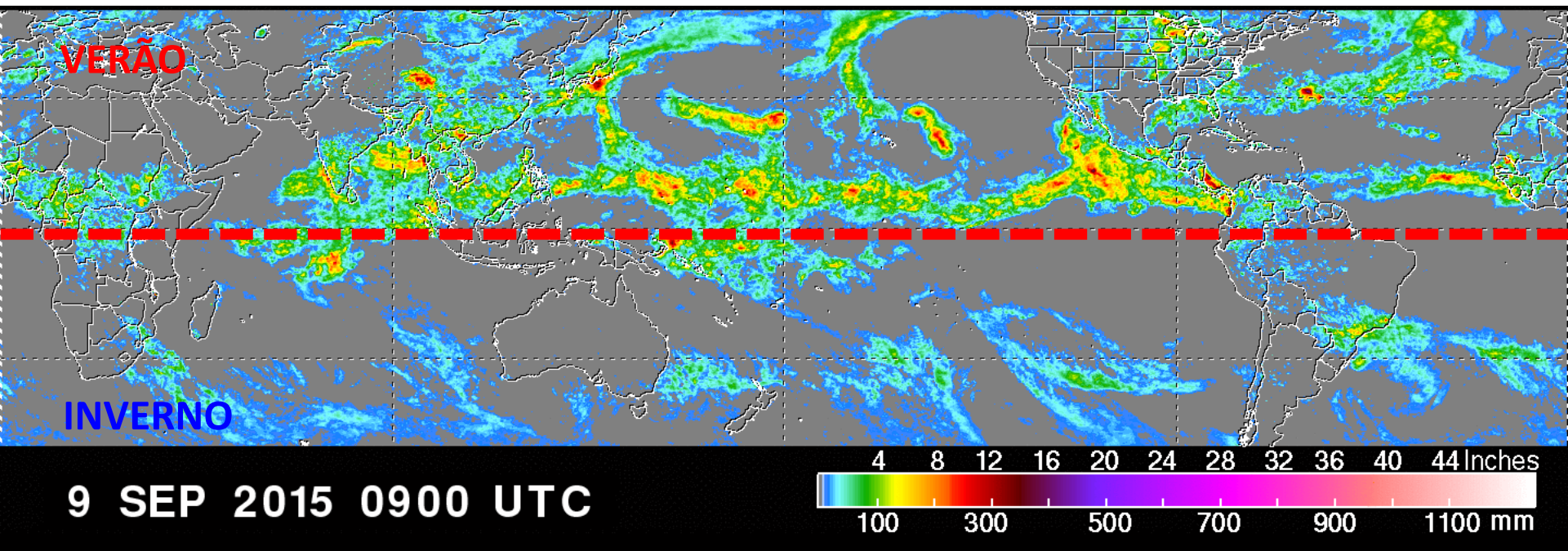


Average of ALL AVAILABLE Rainfall mm/dd (3B43) 1998 to 2011



# PRECIPITAÇÃO GLOBAL

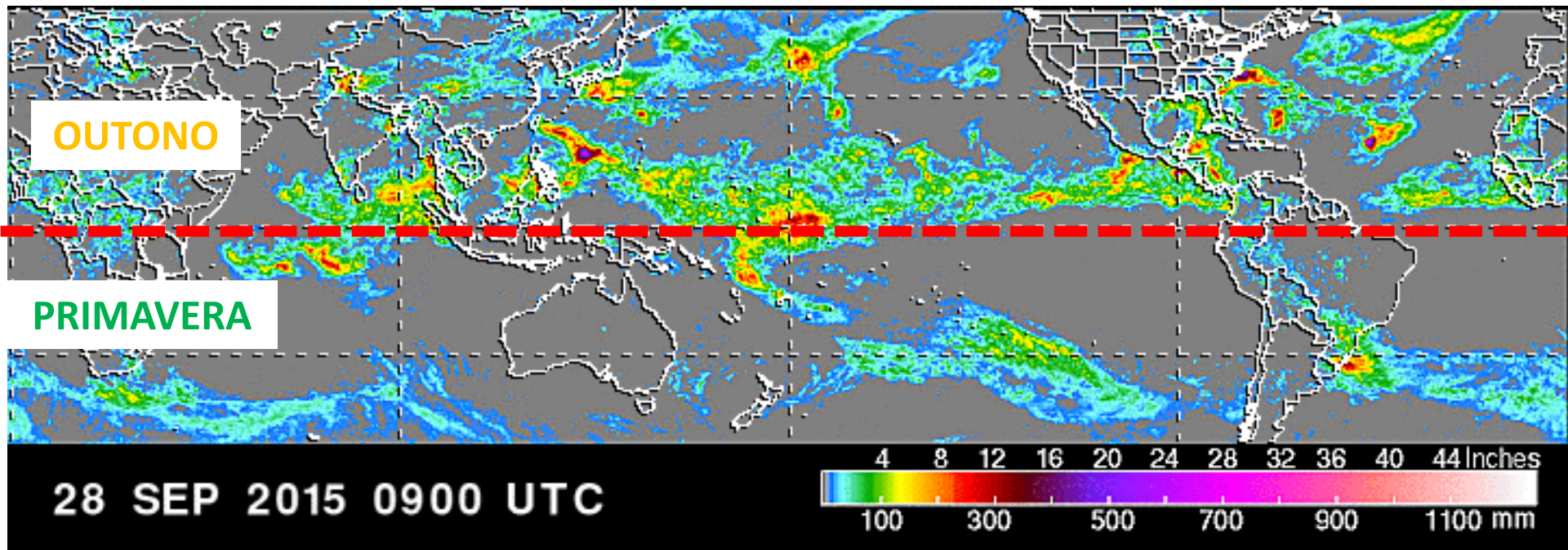
## 02-09 SET 2015



Fonte: [http://trmm.gsfc.nasa.gov/trmm\\_rain/Events/big\\_global\\_accumlation.gif](http://trmm.gsfc.nasa.gov/trmm_rain/Events/big_global_accumlation.gif)

# PRECIPITAÇÃO GLOBAL

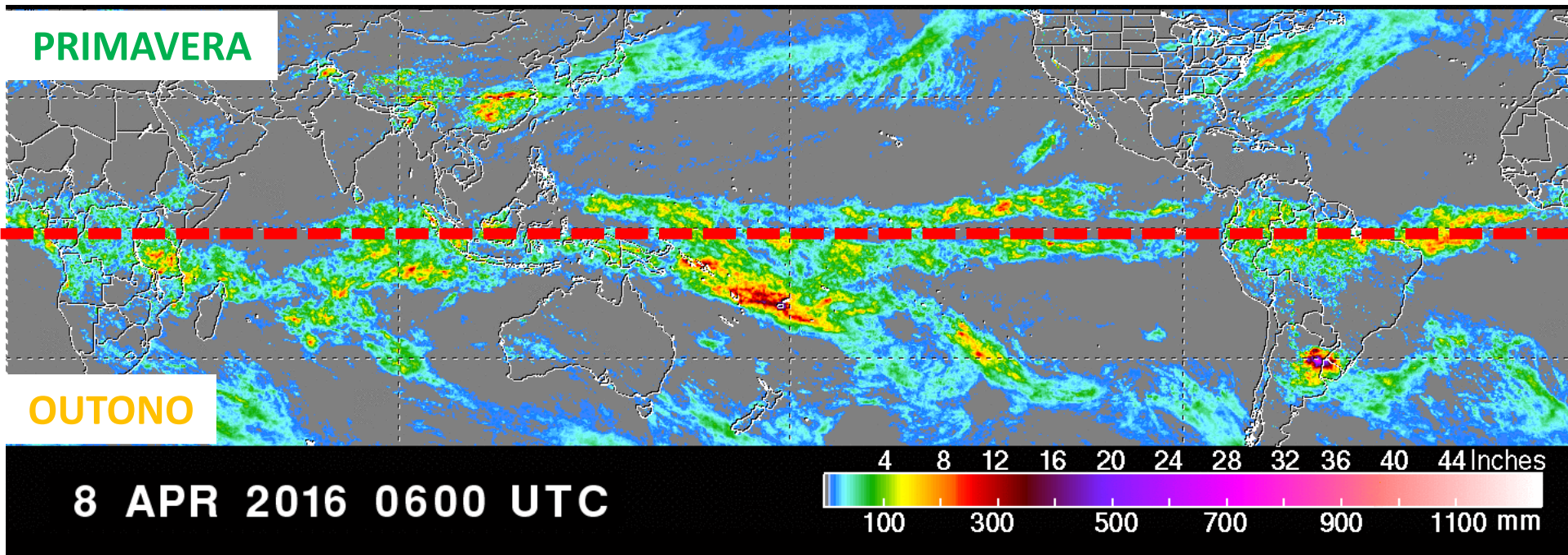
## 21-28 SET 2015



Fonte: [http://trmm.gsfc.nasa.gov/trmm\\_rain/Events/big\\_global\\_accumlation.gif](http://trmm.gsfc.nasa.gov/trmm_rain/Events/big_global_accumlation.gif)

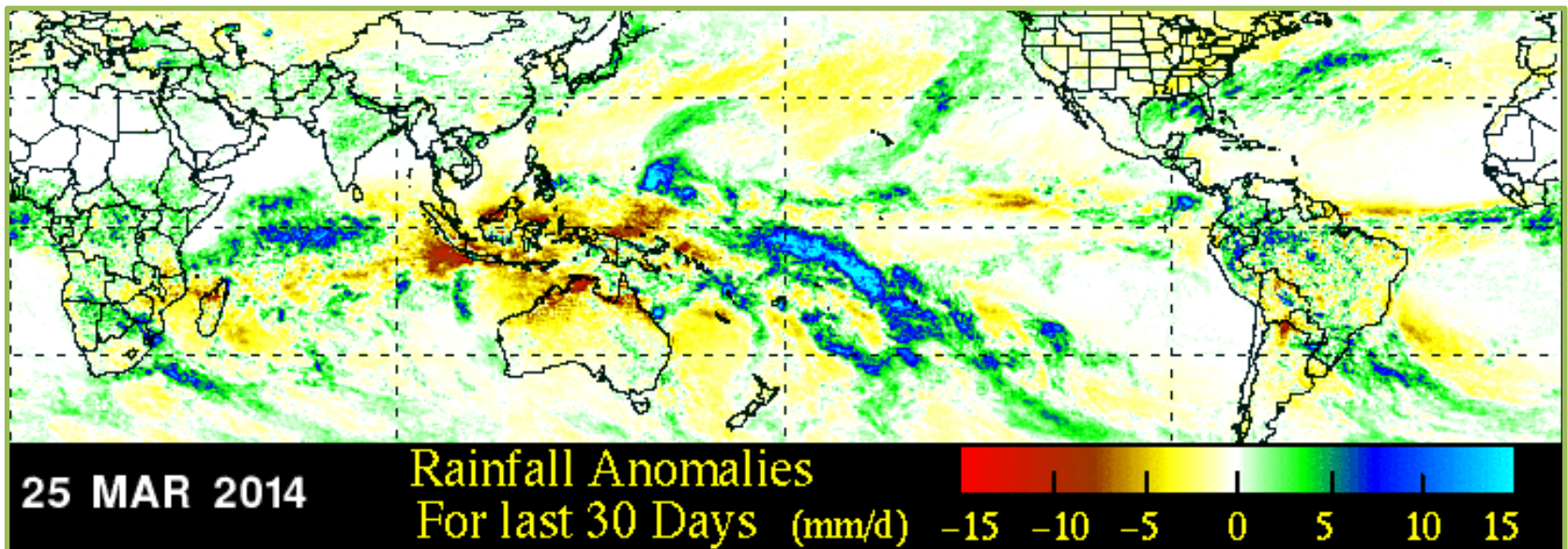
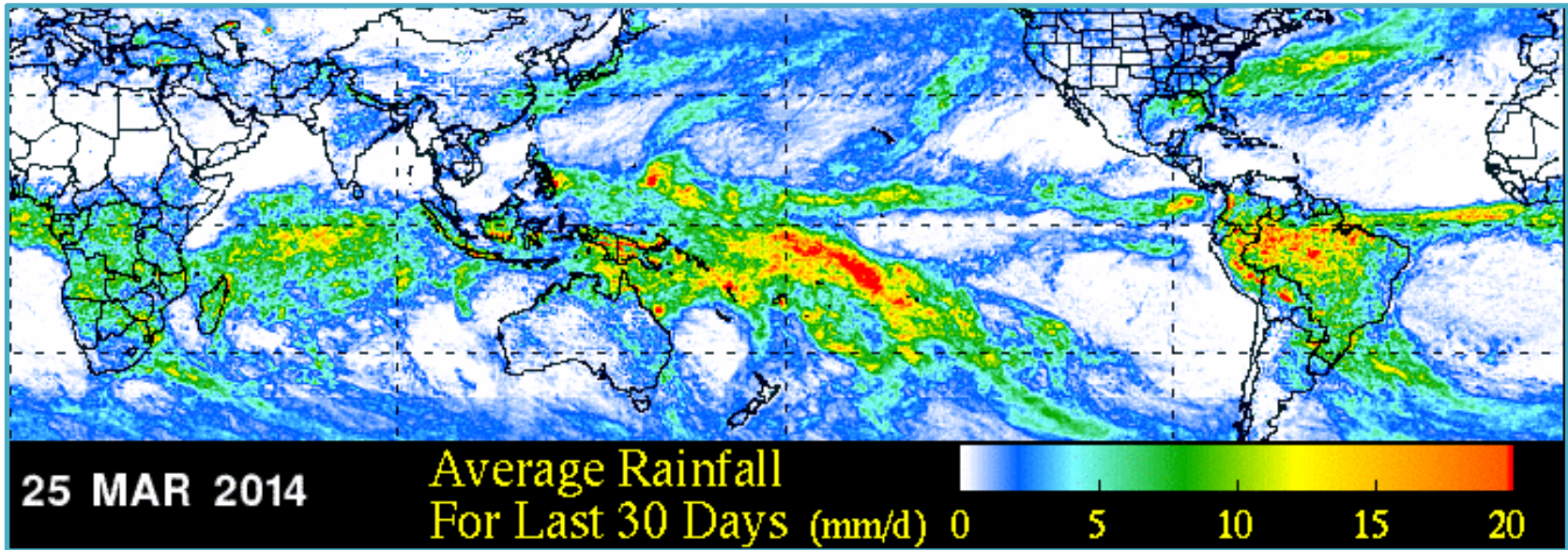
# PRECIPITAÇÃO GLOBAL

## 01-08 ABR 2016



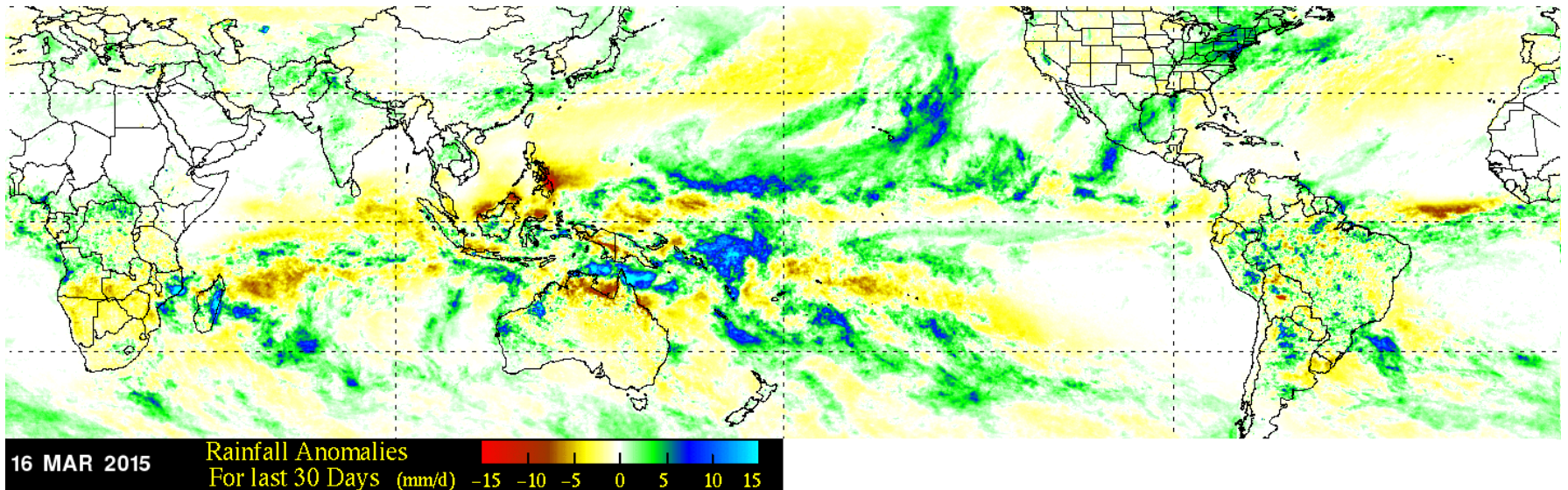
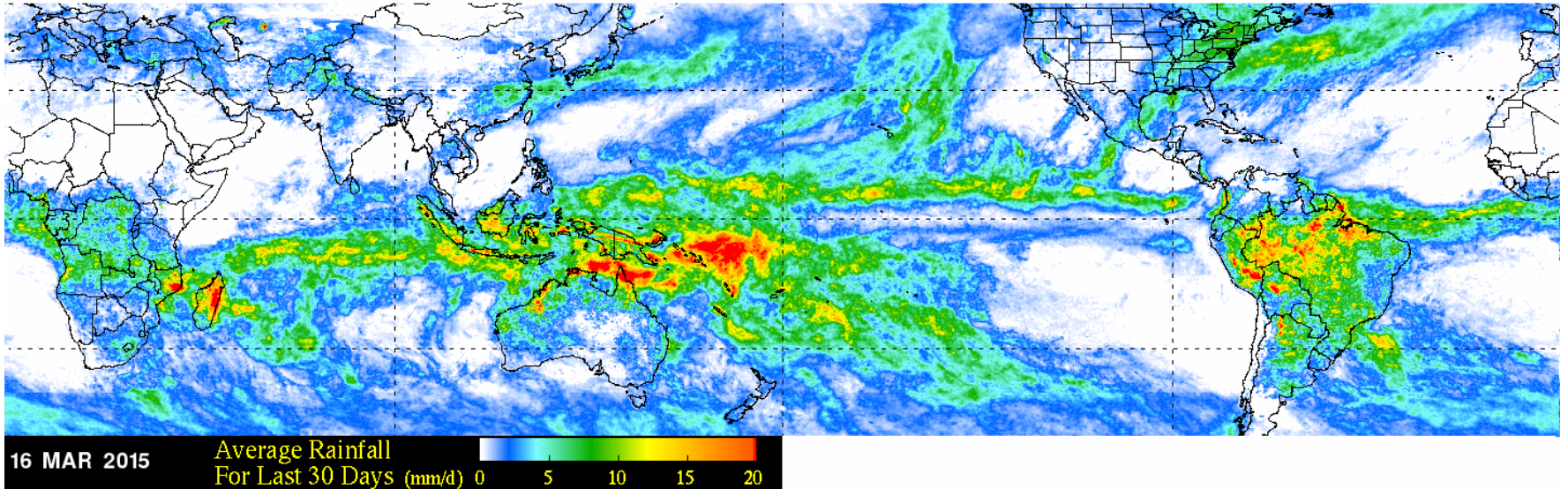
Fonte: [http://trmm.gsfc.nasa.gov/trmm\\_rain/Events/big\\_global\\_accumlation.gif](http://trmm.gsfc.nasa.gov/trmm_rain/Events/big_global_accumlation.gif)

# PRECIPITAÇÃO 30 DIAS -03/2014



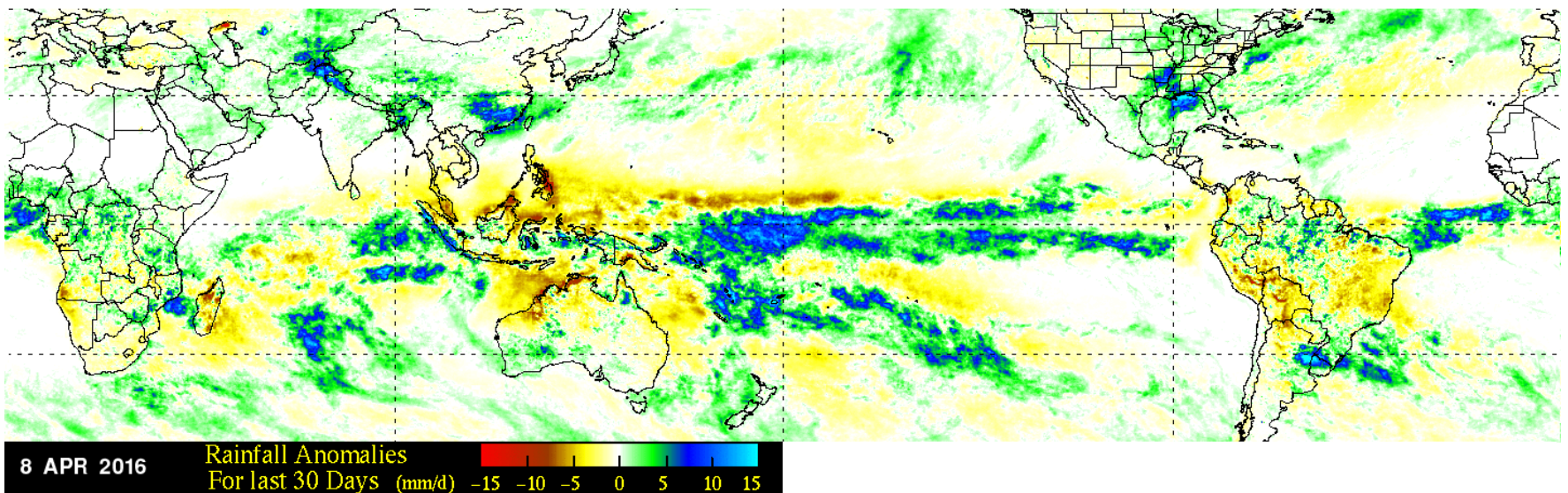
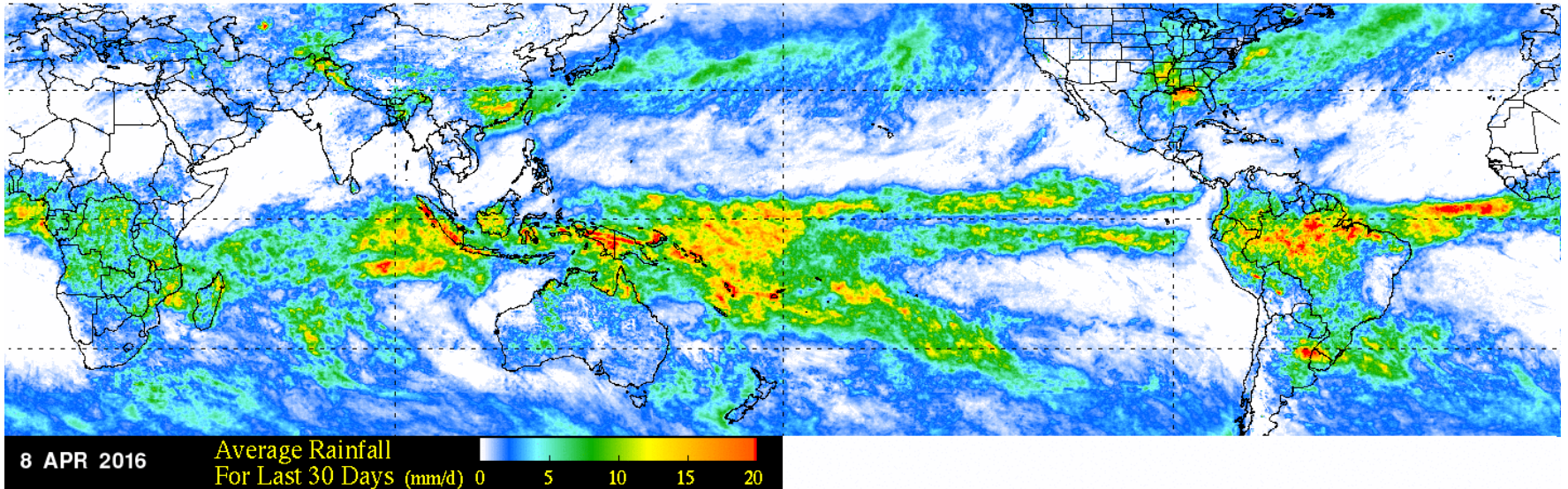
# PRECIPITAÇÃO 30 DIAS - 03/2015

[http://trmm.gsfc.nasa.gov/trmm\\_rain/Events/thirty\\_day.html](http://trmm.gsfc.nasa.gov/trmm_rain/Events/thirty_day.html)



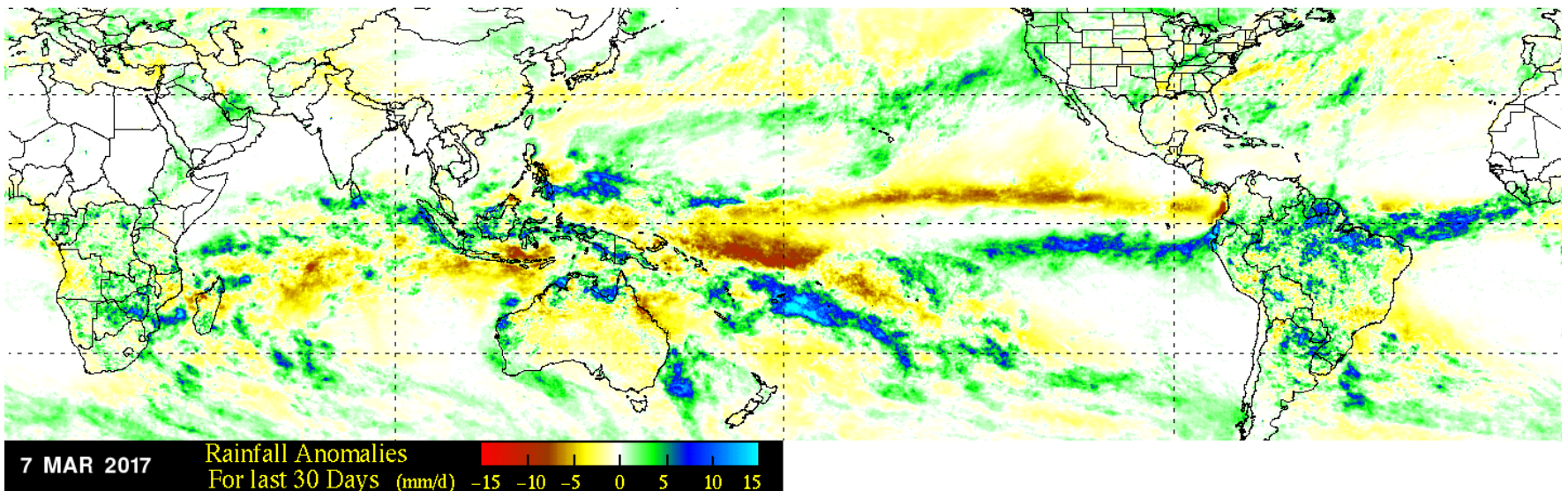
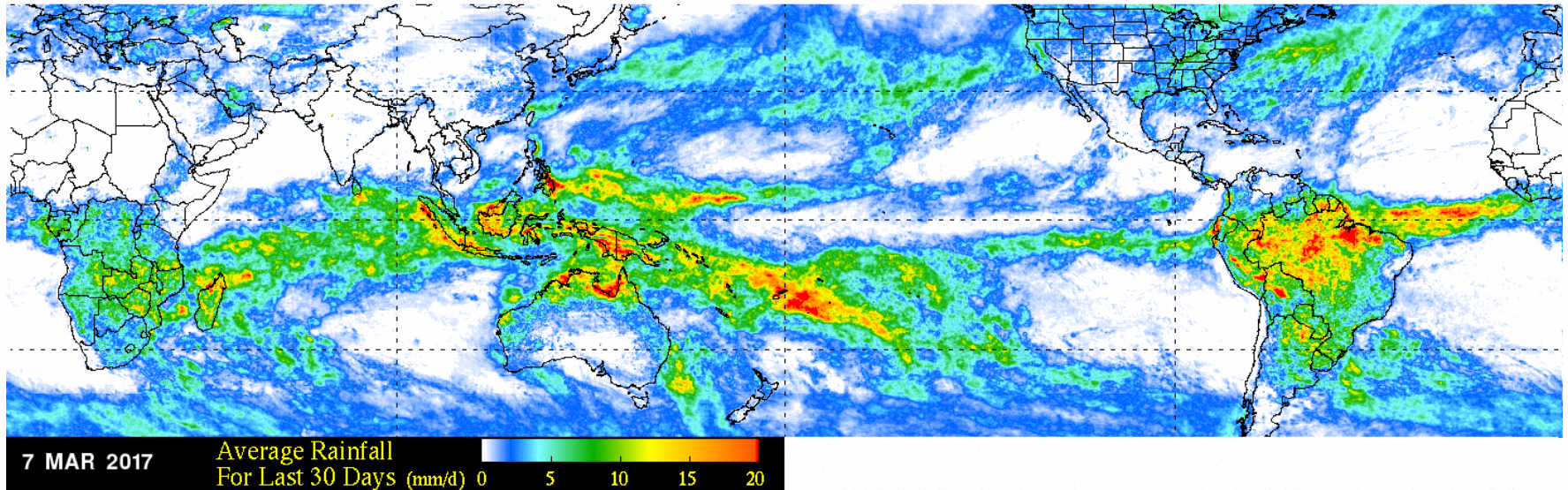
# PRECIPITAÇÃO 30 DIAS - 03/2016

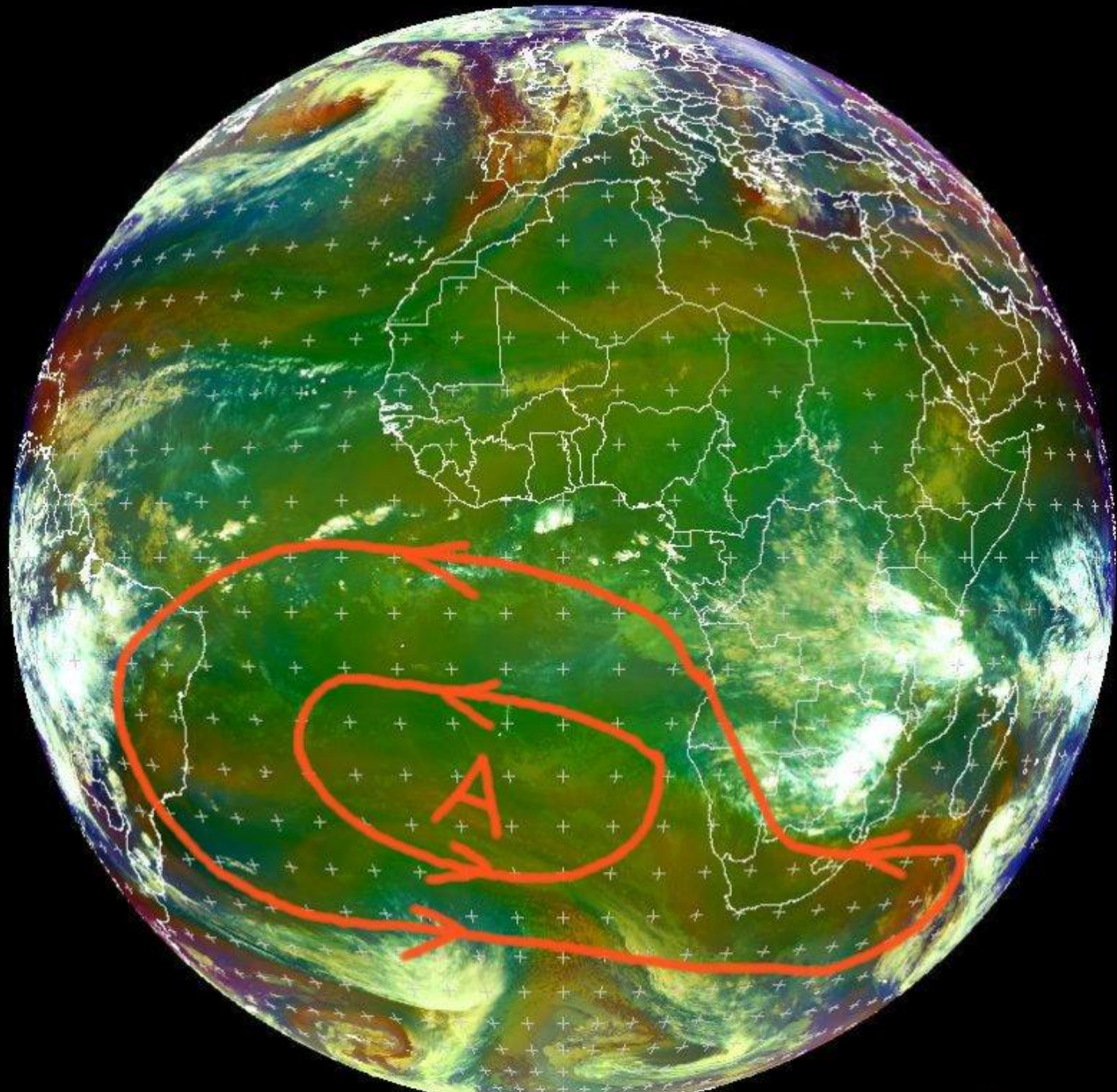
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# PRECIPITAÇÃO 30 DIAS - 03/2017

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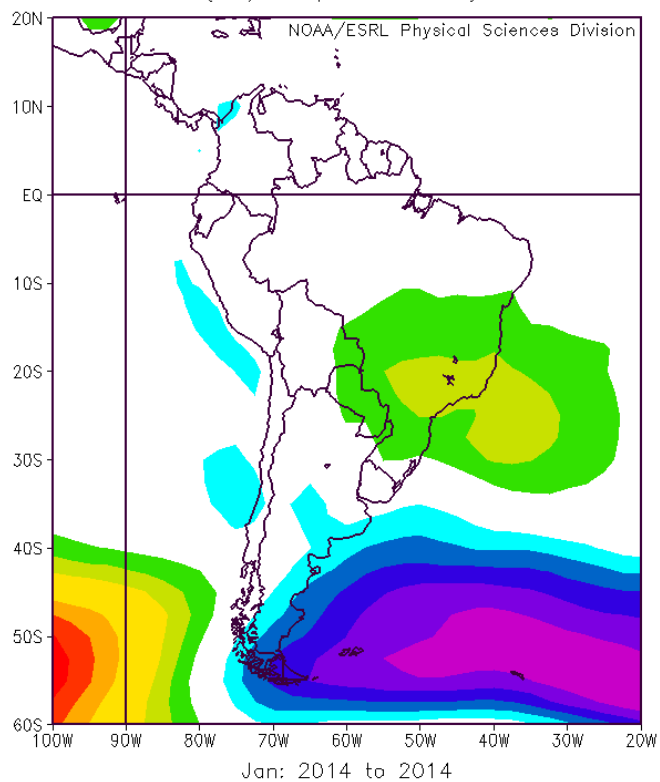




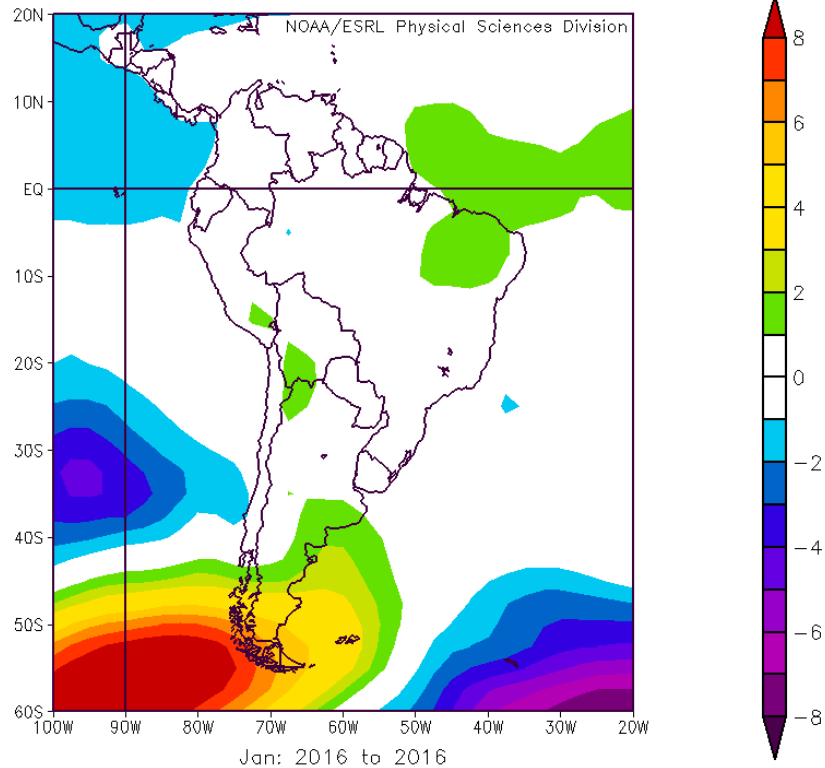
MET10 RGB-Airmass 2014-02-07 01:00 UTC

# Anomalia de pressão

NCEP/NCAR Reanalysis  
Surface Pressure (mb) Composite Anomaly 1981–2010 clima



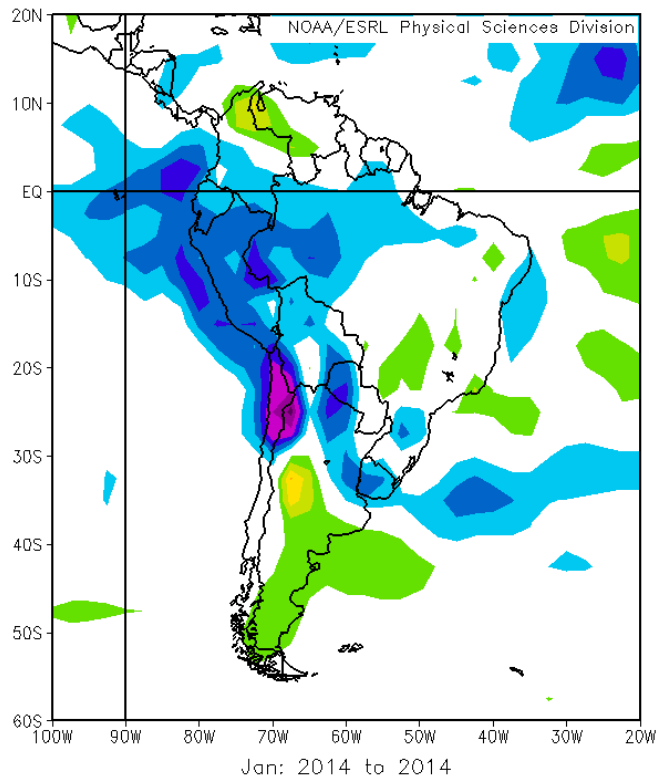
NCEP/NCAR Reanalysis  
Surface Pressure (mb) Composite Anomaly 1981–2010 clima



# Anomalia de Umidade Específica

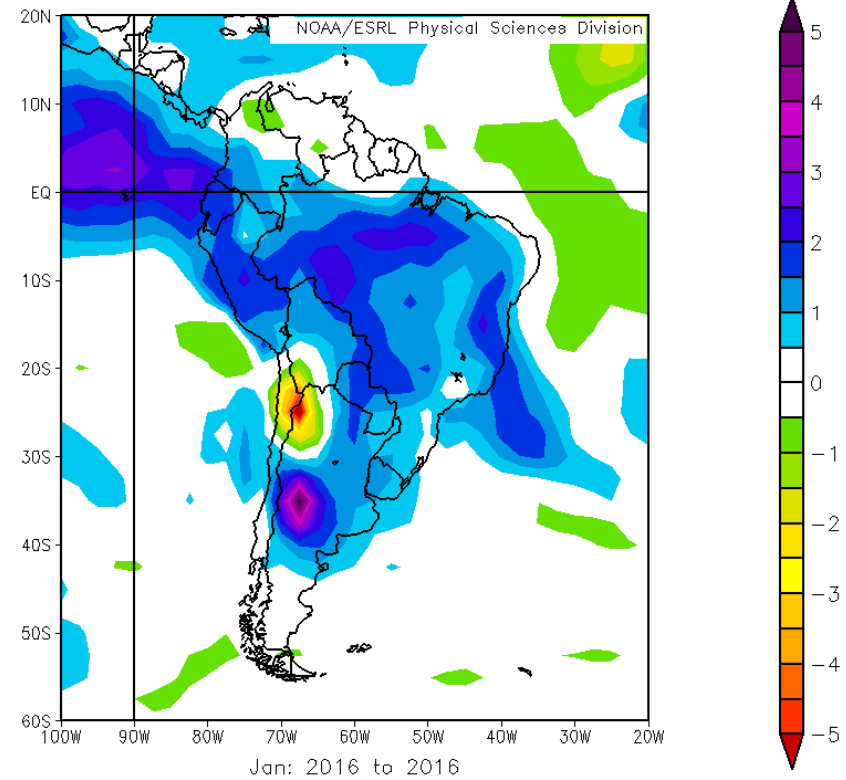
NCEP/NCAR Reanalysis

925mb Specific Humidity (g/kg) Composite Anomaly 1981–2010 clima



NCEP/NCAR Reanalysis

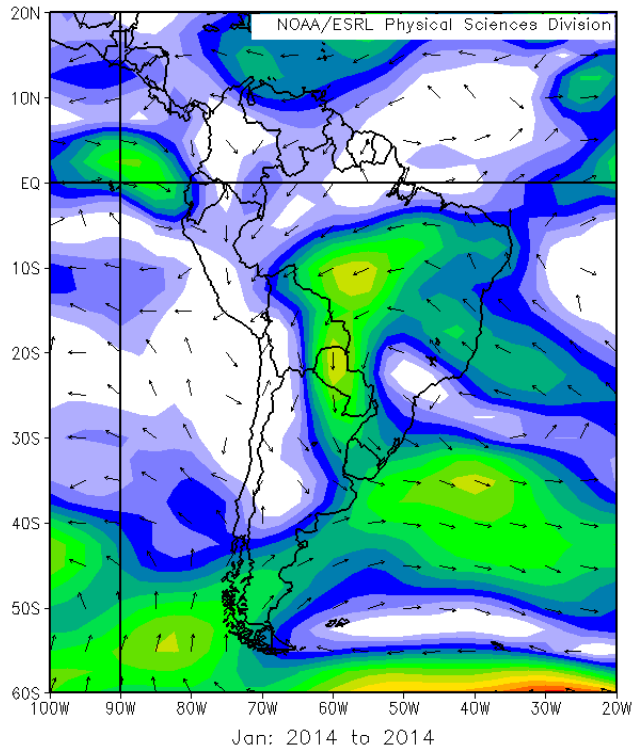
925mb Specific Humidity (g/kg) Composite Anomaly 1981–2010 clima



# Anomalia

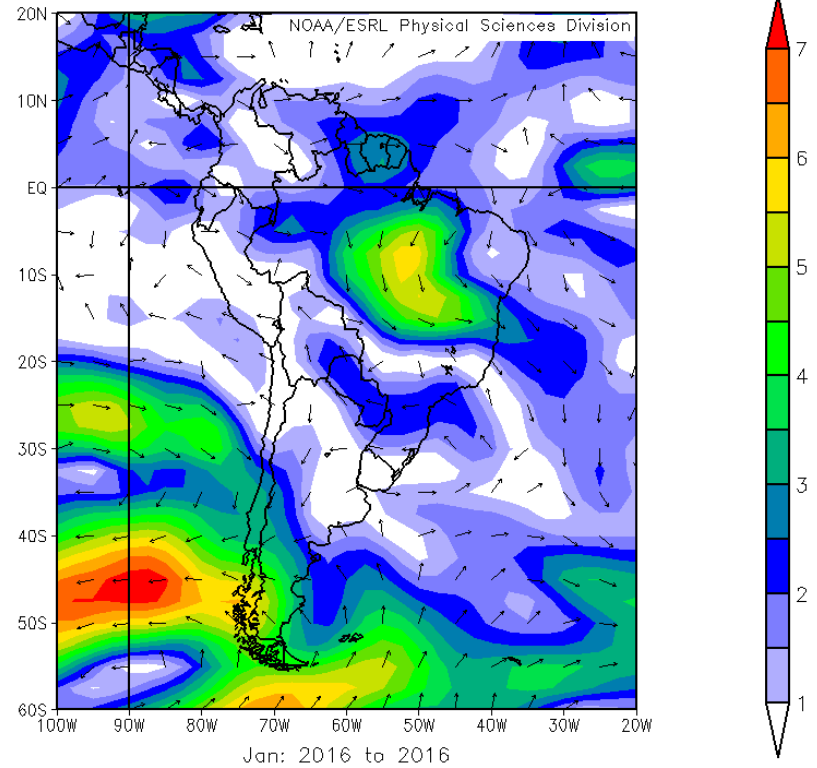
NCEP/NCAR Reanalysis

850mb Vector Wind (m/s) Composite Anomaly 1981–2010 clima



NCEP/NCAR Reanalysis

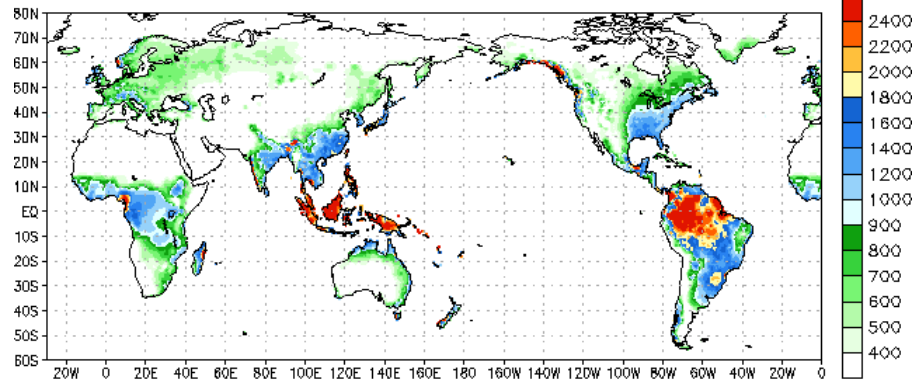
850mb Vector Wind (m/s) Composite Anomaly 1981–2010 clima



# PRECIPITAÇÃO 365 DIAS

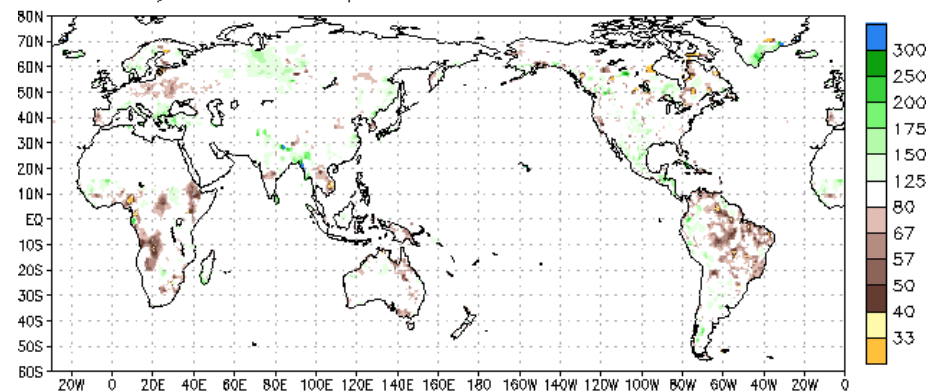
## 2014/2015

Climatological 365-day Accumulated Prcp (mm) 28SEP2014-27SEP2015



Data Source: CPC Unified (gauge-based) Precipitation  
Climatology (1981-2010)

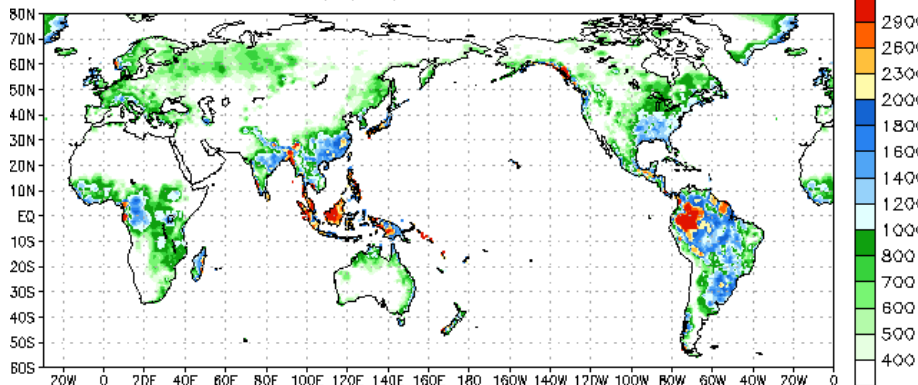
365-day Accumulated Prcp % of Normal 28 SEP 2014 - 27 SEP 2015



Data Source: CPC Unified (gauge-based) Precipitation  
Climatology (1981-2010)

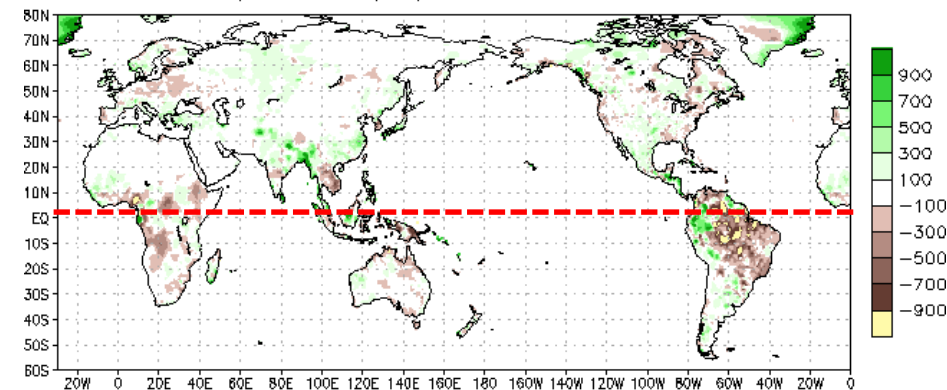
Note: Areas which receive on average 1mm/day are masked out.

Accumulated Prcp (mm) 28 SEP 2014 - 27 SEP 2015



Data Source: CPC Unified (gauge-based) Precipitation

Prcp Anomalies (mm) 28 SEP 2014 - 27 SEP 2015

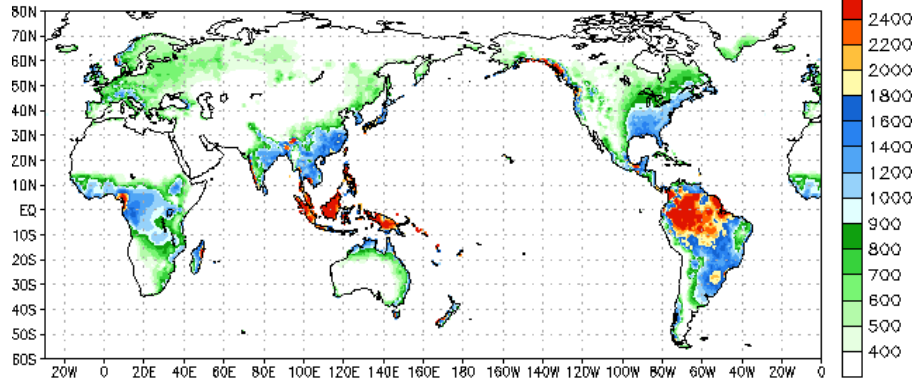


Data Source: CPC Unified (gauge-based) Precipitation  
Climatology (1981-2010)

# PRECIPITAÇÃO 365 DIAS

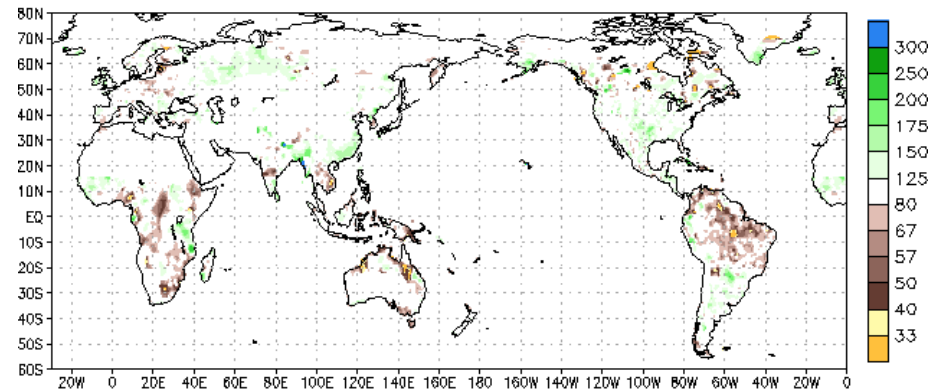
## 2015/2016

Climatological 365-day Accumulated Prep (mm) 07APR2015-05APR2016



Data Source: CPC Unified (gauge-based) Precipitation  
Climatology (1981-2010)

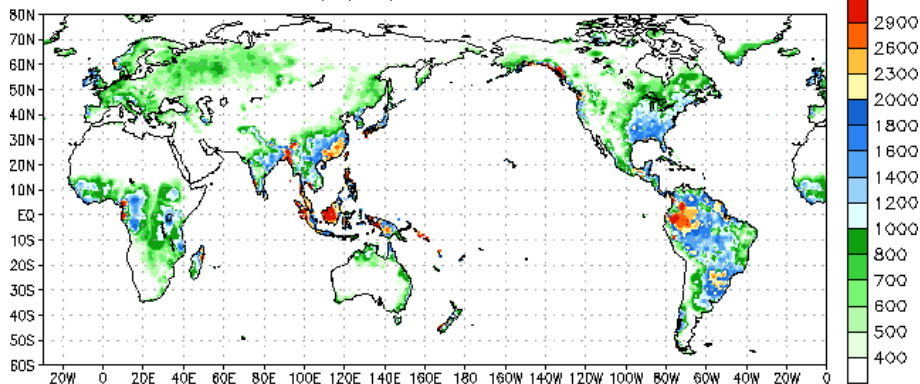
365-day Accumulated Prep % of Normal 07 APR 2015 - 05 APR 2016



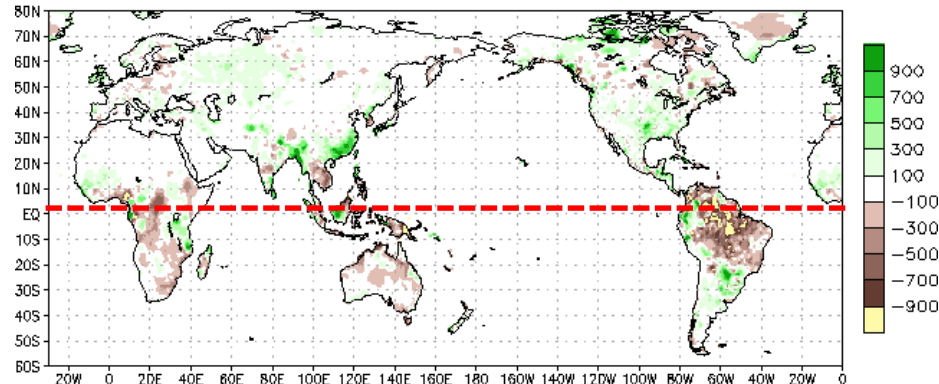
Data Source: CPC Unified (gauge-based) Precipitation  
Climatology (1981-2010)

Note: Areas which receive on average 1mm/day are masked out.  
Prep Anomalies (mm) 07 APR 2015 - 05 APR 2016

Accumulated Prep (mm) 07 APR 2015 - 05 APR 2016



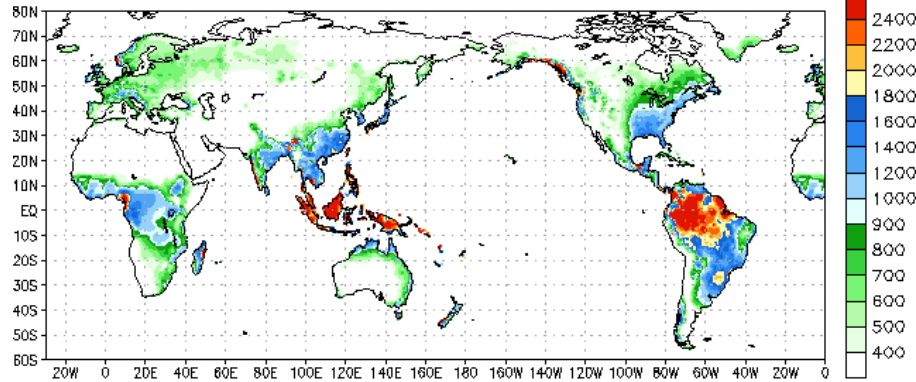
Data Source: CPC Unified (gauge-based) Precipitation



Data Source: CPC Unified (gauge-based) Precipitation  
Climatology (1981-2010)

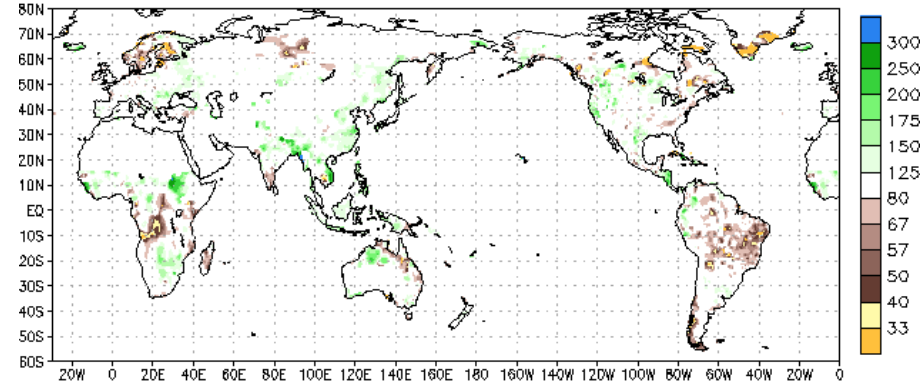
# PRECIPITAÇÃO 365 DIAS 2016/2017

Climatological 365-day Accumulated Prop (mm) 07MAR2016-06MAR2017



Data Source: CPC Unified (gauge-based) Precipitation  
Climatology (1981-2010)

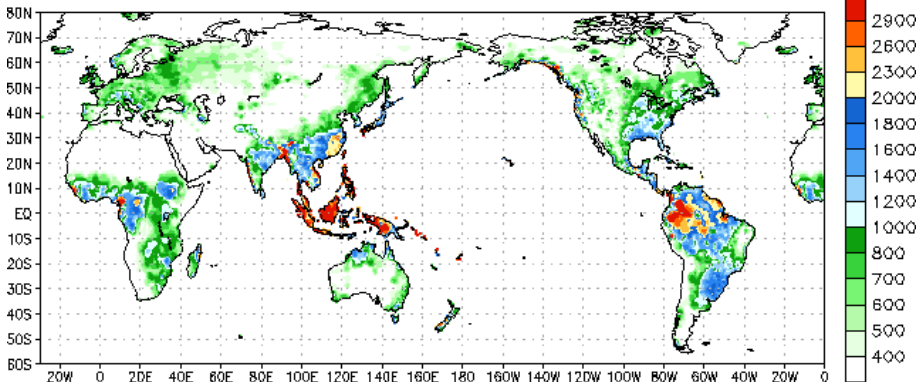
365-day Accumulated Prop % of Normal 07 MAR 2016 - 06 MAR 2017



Data Source: CPC Unified (gauge-based) Precipitation  
Climatology (1981-2010)

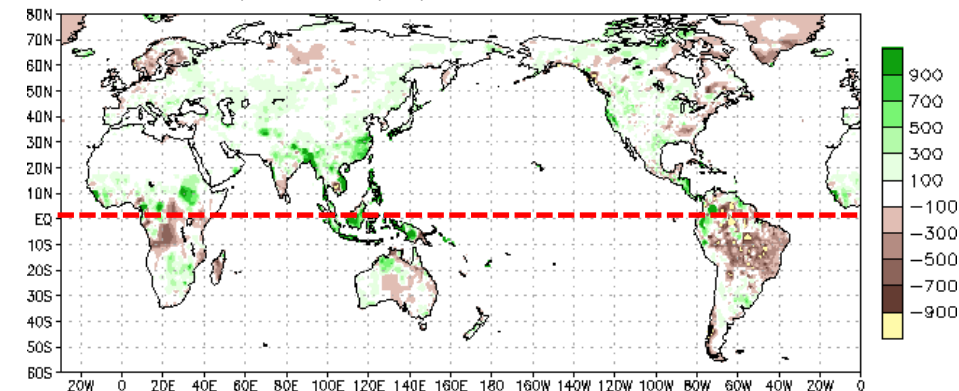
Note: Areas which receive on average 1mm/day are masked out.

Accumulated Prop (mm) 07 MAR 2016 - 06 MAR 2017



Data Source: CPC Unified (gauge-based) Precipitation

Prep Anomalies (mm) 07 MAR 2016 - 06 MAR 2017



Data Source: CPC Unified (gauge-based) Precipitation  
Climatology (1981-2010)

# Período chuvoso Outubro/ano a Março/ano seguinte

## Dados EM-IAG/USP 1933-2014

### + SECOS (mm)

670,5	1941
697,7	1934
730,7	1964
740,9	1943
760,5	1955
798	1954
800,7	1937
803,6	1936
814,6	1969
824	1953
837,5	1939
850,2	1938
<b>887,2</b>	<b>2014</b>
900,5	1946
901,6	1945
913,2	1957
914,7	1935
915,71	1975
916,7	1994
920,1	1985

### + CHUVOSOS (mm)

<b>1259,9</b>	<b>2013</b>
<b>1260,4</b>	<b>2012</b>
<b>1296,8</b>	<b>1970</b>
<b>1339,6</b>	<b>1989</b>
<b>1363,8</b>	<b>1995</b>
<b>1380,2</b>	<b>1983</b>
<b>1385,8</b>	<b>1991</b>
<b>1401,7</b>	<b>2011</b>
<b>1443,1</b>	<b>1996</b>
<b>1775,8</b>	<b>2010</b>

# Evolução do Consumo na RMSP e Projeção para 20 anos

Ano	CHA (m <sup>3</sup> /ano)	PROD (10 <sup>9</sup> m <sup>3</sup> /ano)	CT (10 <sup>9</sup> m <sup>3</sup> /ano)	CT/PROD	HAB (mi)
2003	52,3	1.96	0.93	0.46	18.5
2013	59,9	2.18	1.21	0.55	20.1
2033	78,0	3.27	1.80	0.55 (1)	22.3
2033	78,0	2,33	1.80	0.73 (2)	22.3

## Soluções :

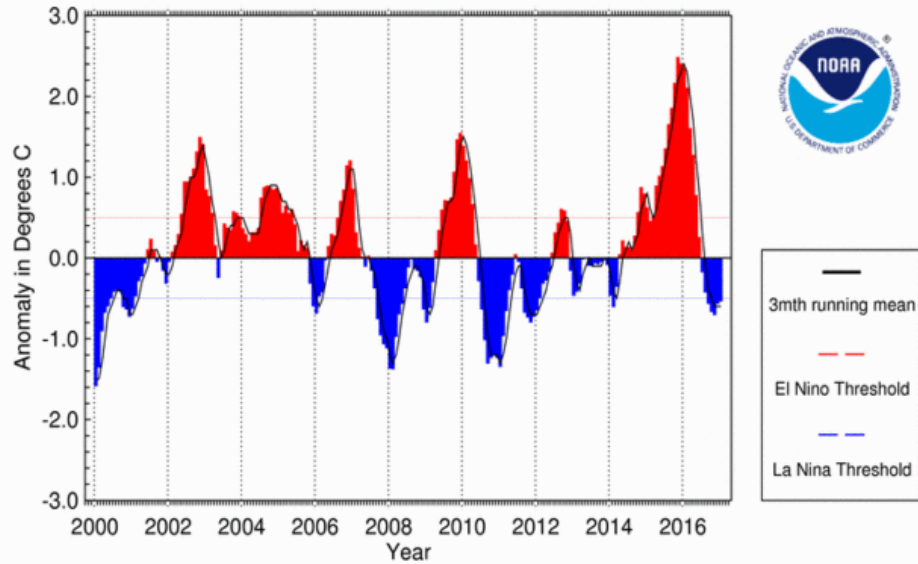
Novas fontes para suprir demanda de + um Cantareira (cenário 1)

Aumentar a razão consumo/produção (cenário 2)

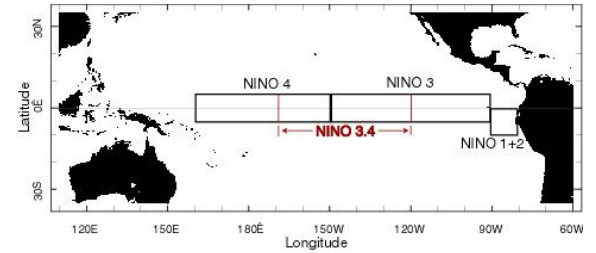
# **PROGNÓSTICO CLIMÁTICO**

## **OUTUNO 2017**

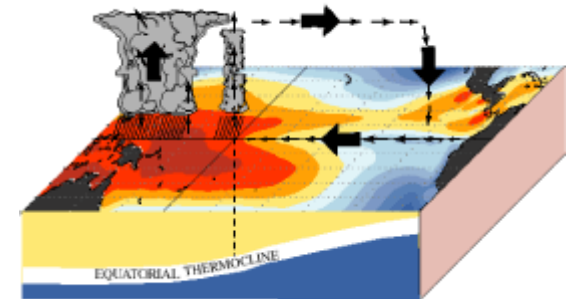
# SST Anomaly in Nino 3.4 Region (5N-5S,120-170W)



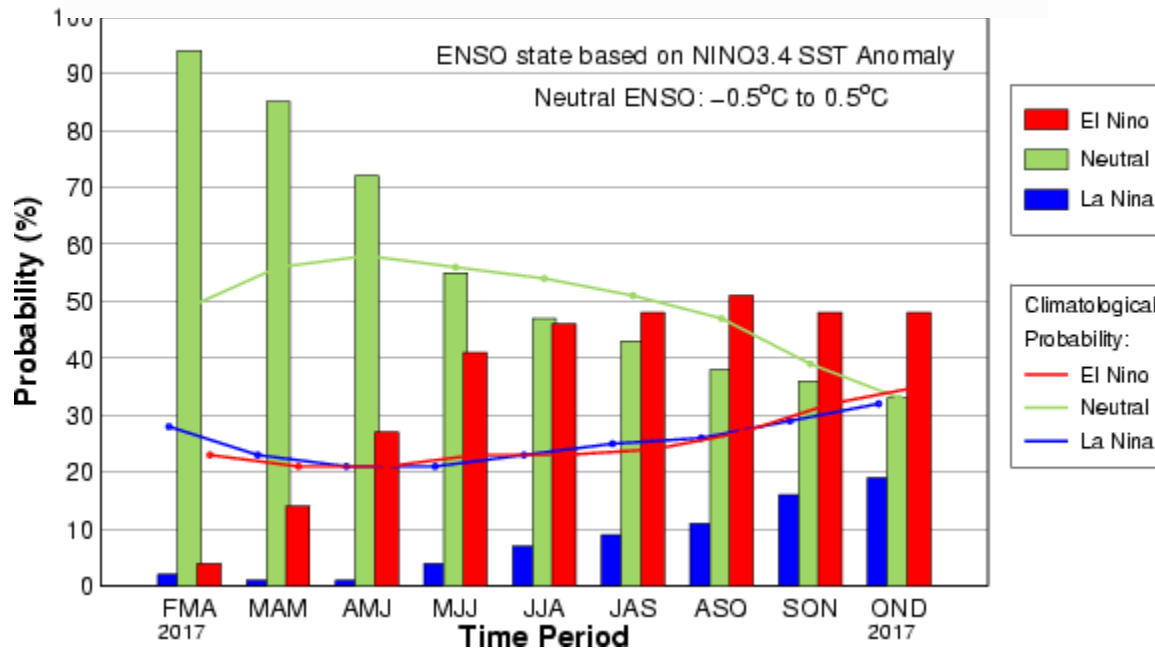
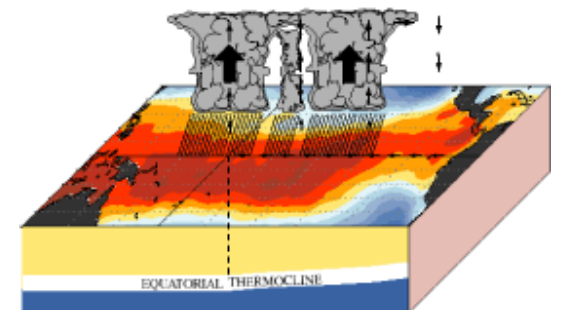
National Centers for Environmental Information / NESDIS / NOAA



## December - February Normal Conditions

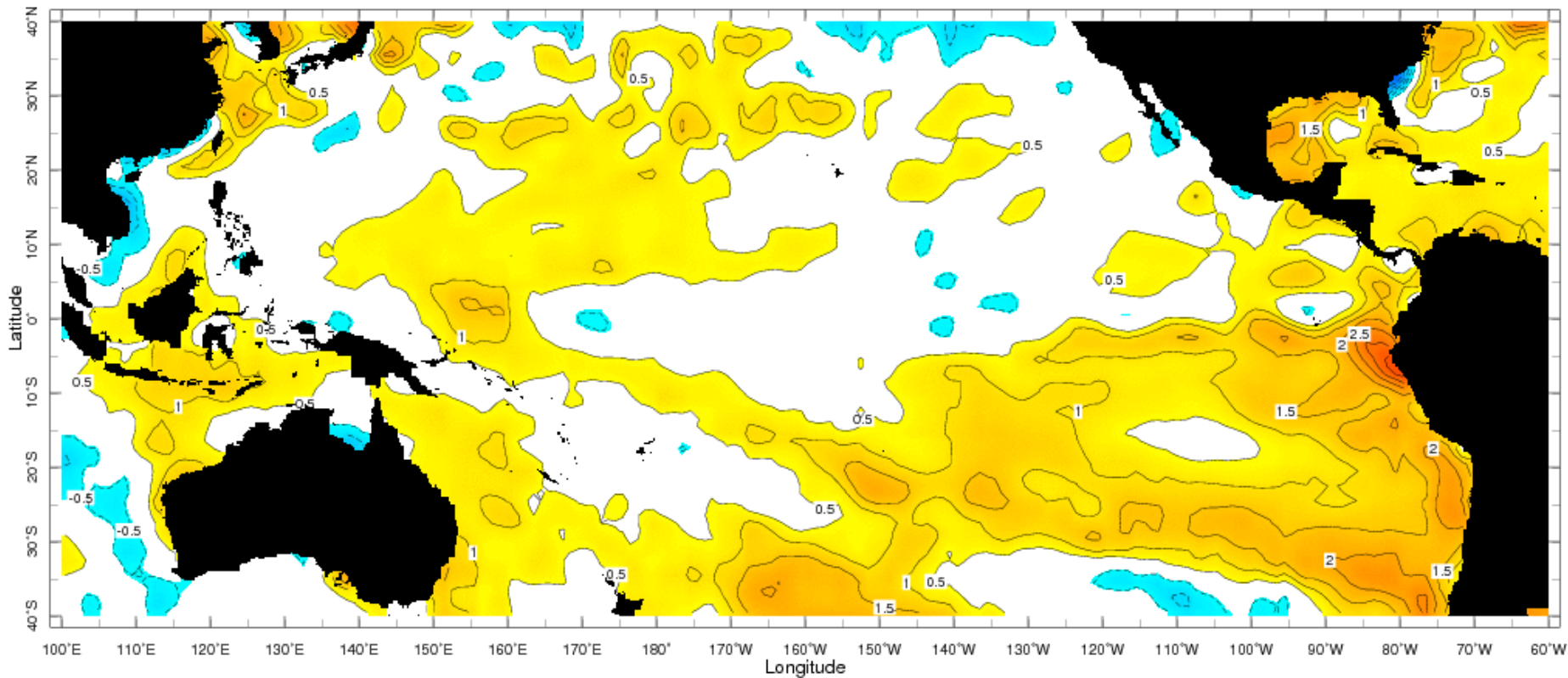


## December - February El Niño Conditions



# TSM PREVISTA

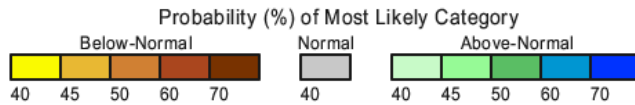
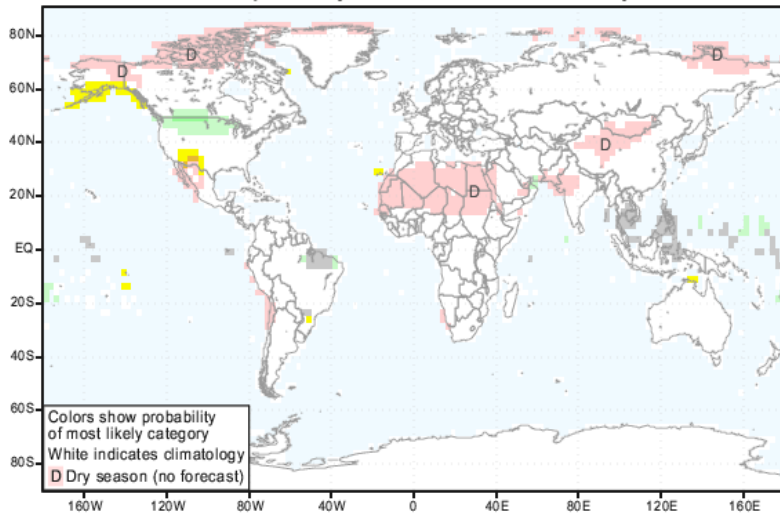
1 Mar 2017



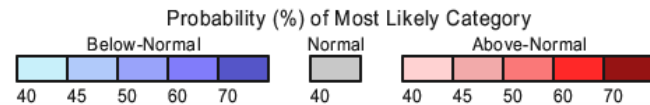
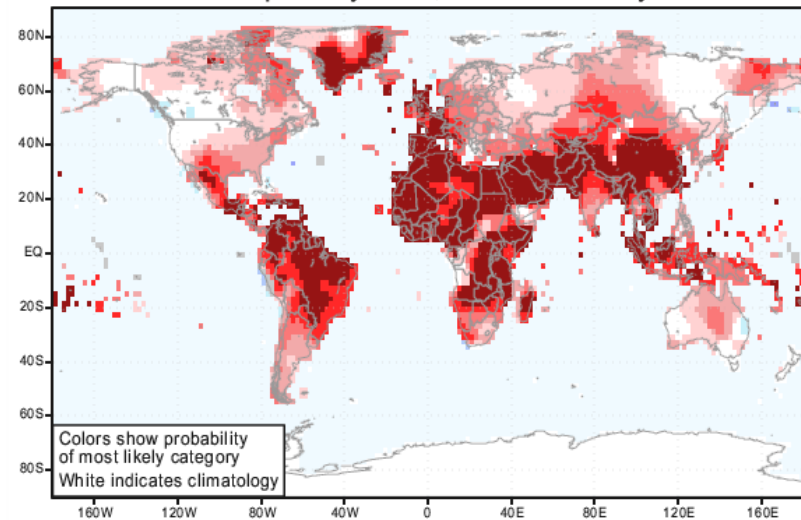
<http://iridl.ldeo.columbia.edu/maproom/Global/Forecasts/SST.html>

# PROGNÓSTICO IRI

IRI Multi-Model Probability Forecast for Precipitation for March-April-May 2017, Issued February 2017



IRI Multi-Model Probability Forecast for Temperature for March-April-May 2017, Issued February 2017



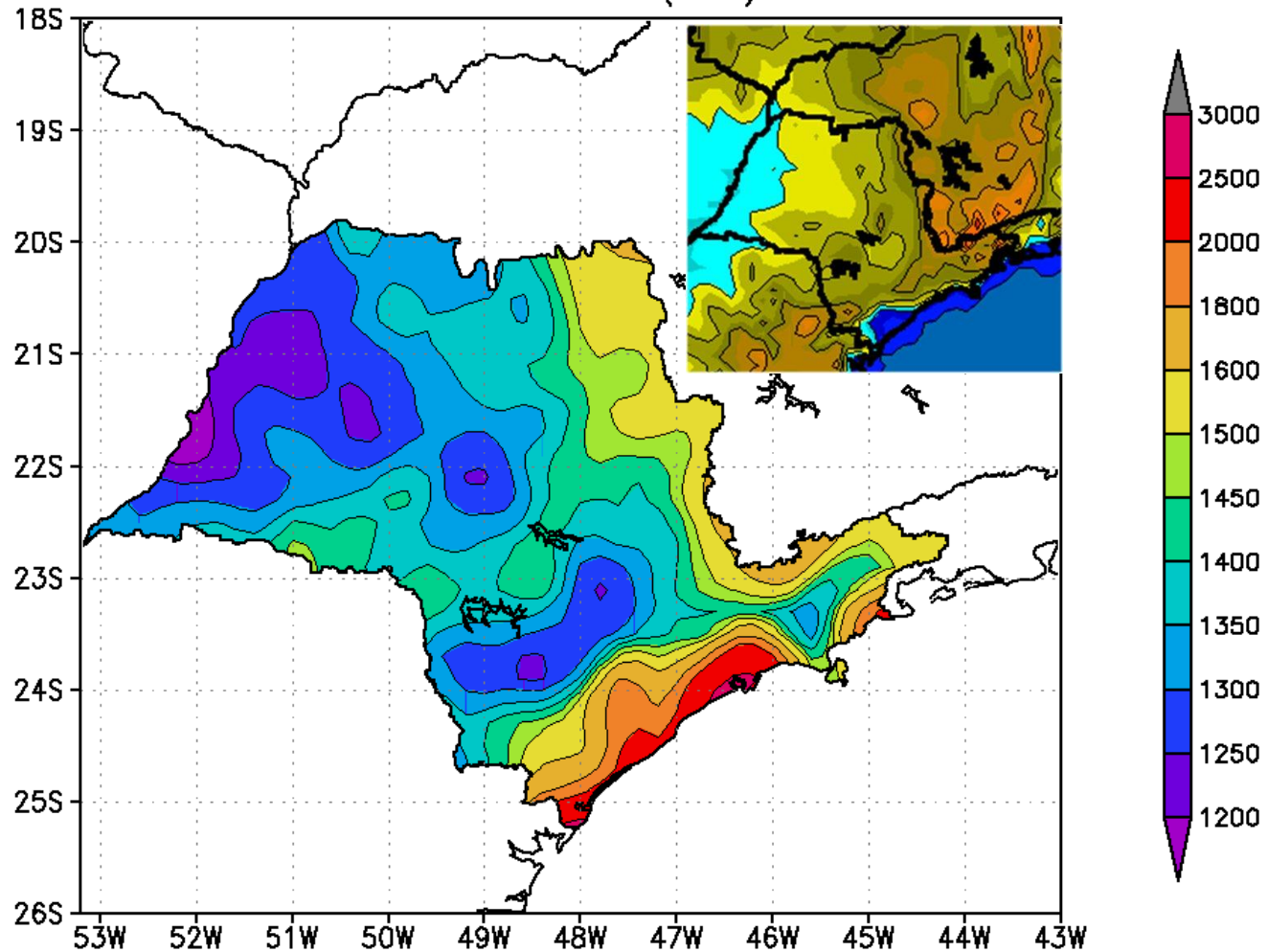
<http://iri.columbia.edu/our-expertise/climate/forecasts/seasonal-climate-forecasts/>

# PRECIPITAÇÃO - SÃO PAULO

Prado, Pereira Filho e Hallak (2006)

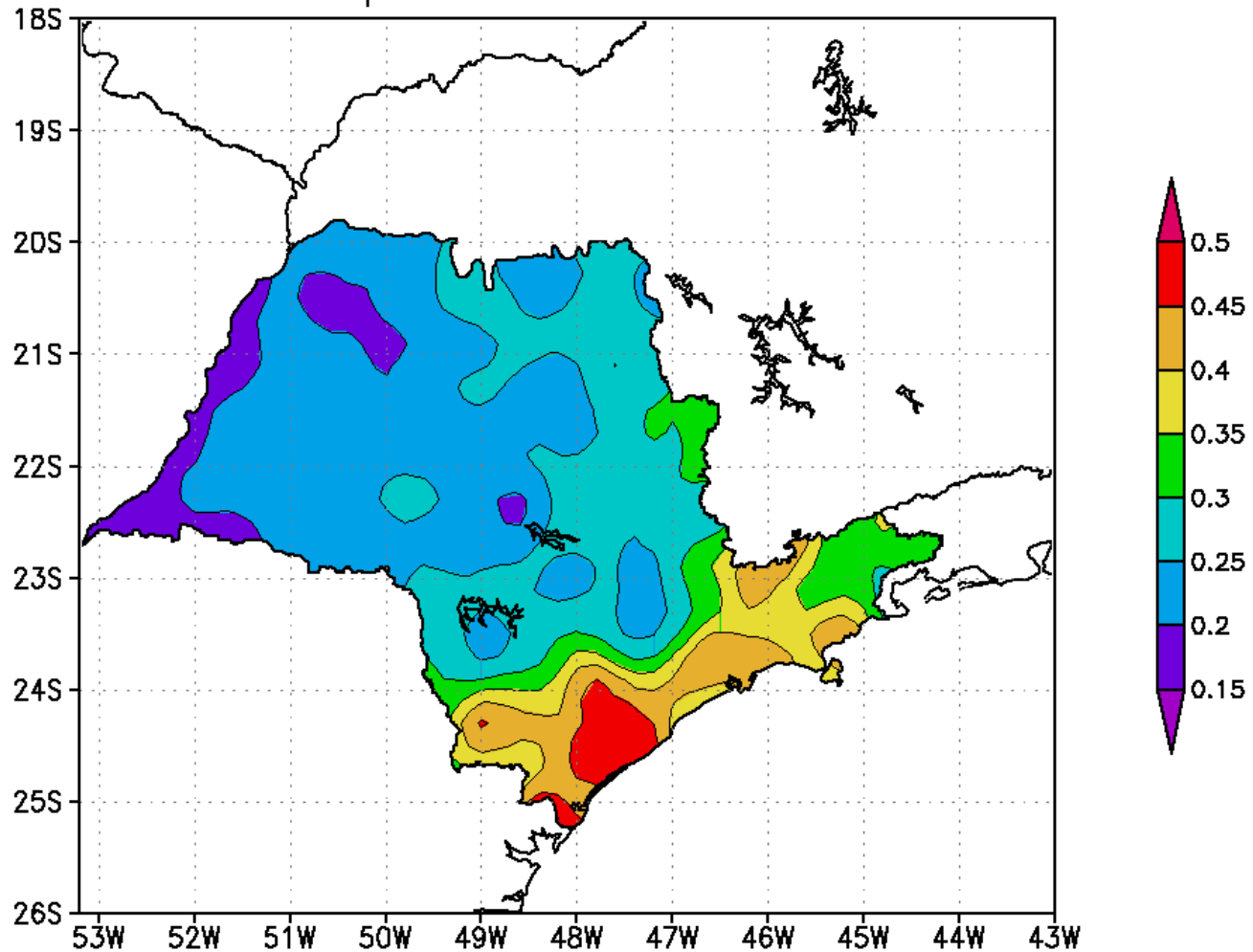
# PRECIPITAÇÃO ANNUAL SP (mm)

Precipitacao media climatologica  
1947 - 1997 (mm)



# FRAÇÃO DE DIAS CHUVOSOS

Razão de dias com chuva pelo total de dias  
no período de 1947 - 1997



REGIÃO	PLANALTO		SERRA DO MAR		SERRA DA MANTIQUEIRA		GERAL	
PARÂMETRO	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$
MES								
JANEIRO	220	34	278	87	262	47	248	68
FEVEREIRO	196	23	237	64	233	38	217	50
MARÇO	150	23	227	88	182	31	185	70
ABRIL	68	12	150	87	87	18	104	69
MAIO	54	10	103	53	54	14	75	43
JUNHO	43	10	71	35	41	8	55	28
JULHO	37	12	69	40	32	9	51	32
AGOSTO	35	7	75	43	42	13	53	35
SETEMBRO	64	12	111	65	63	12	84	50
OUTUBRO	130	15	173	84	147	27	150	60
NOVEMBRO	145	22	173	72	175	27	160	52
DEZEMBRO	209	29	228	78	258	37	221	58
ANUAL	1370	141	1920	754	1569	258	1620	572

TABELA 3.1. - Precipitação média mensal nas áreas cobertas pelo radar meteorológico de Ponte Nova.  $\bar{x}$  é a precipitação média e  $\sigma$  é o desvio padrão dos totais médios mensais, em mm.

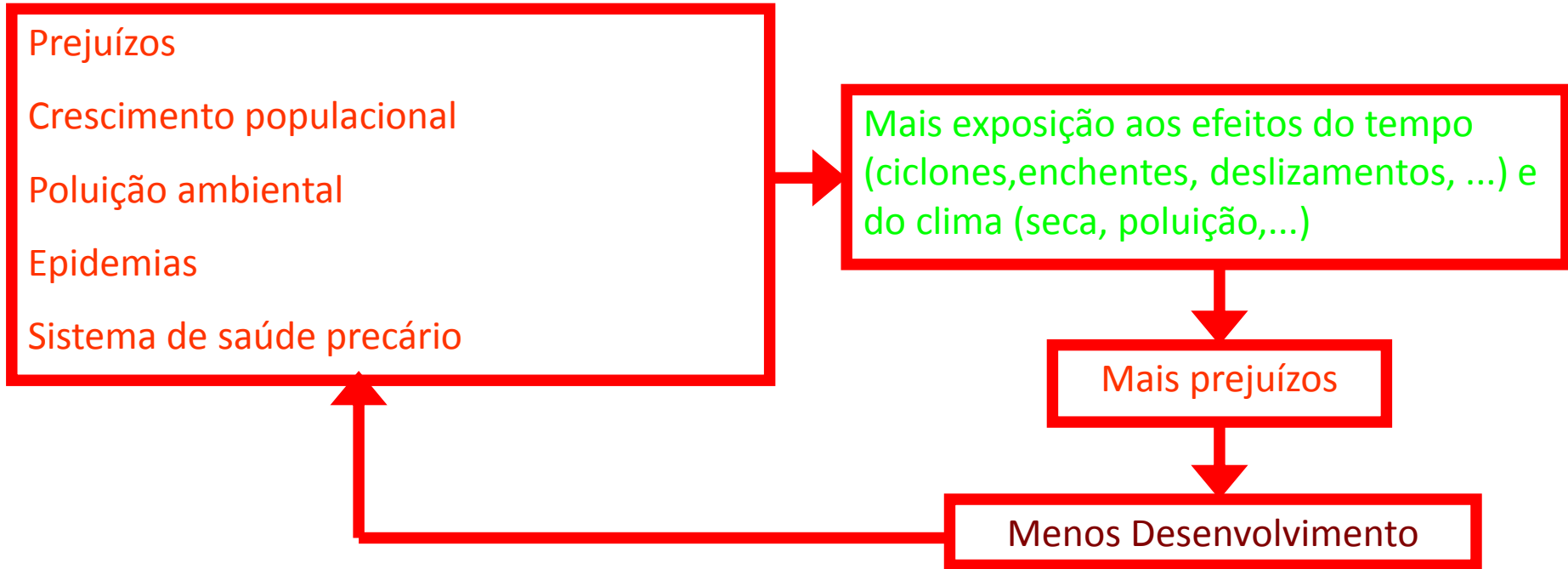
**Frequência de anomalias de precipitação média espacial para eventos de El Niño, La Niña e neutros entre 1947 e 1997.**

	Evento		
Anomalias	El Niño	La Niña	Neutro
Positivas	19,6%	9,8%	23,5%
Negativas	11,8%	11,8%	23,5%

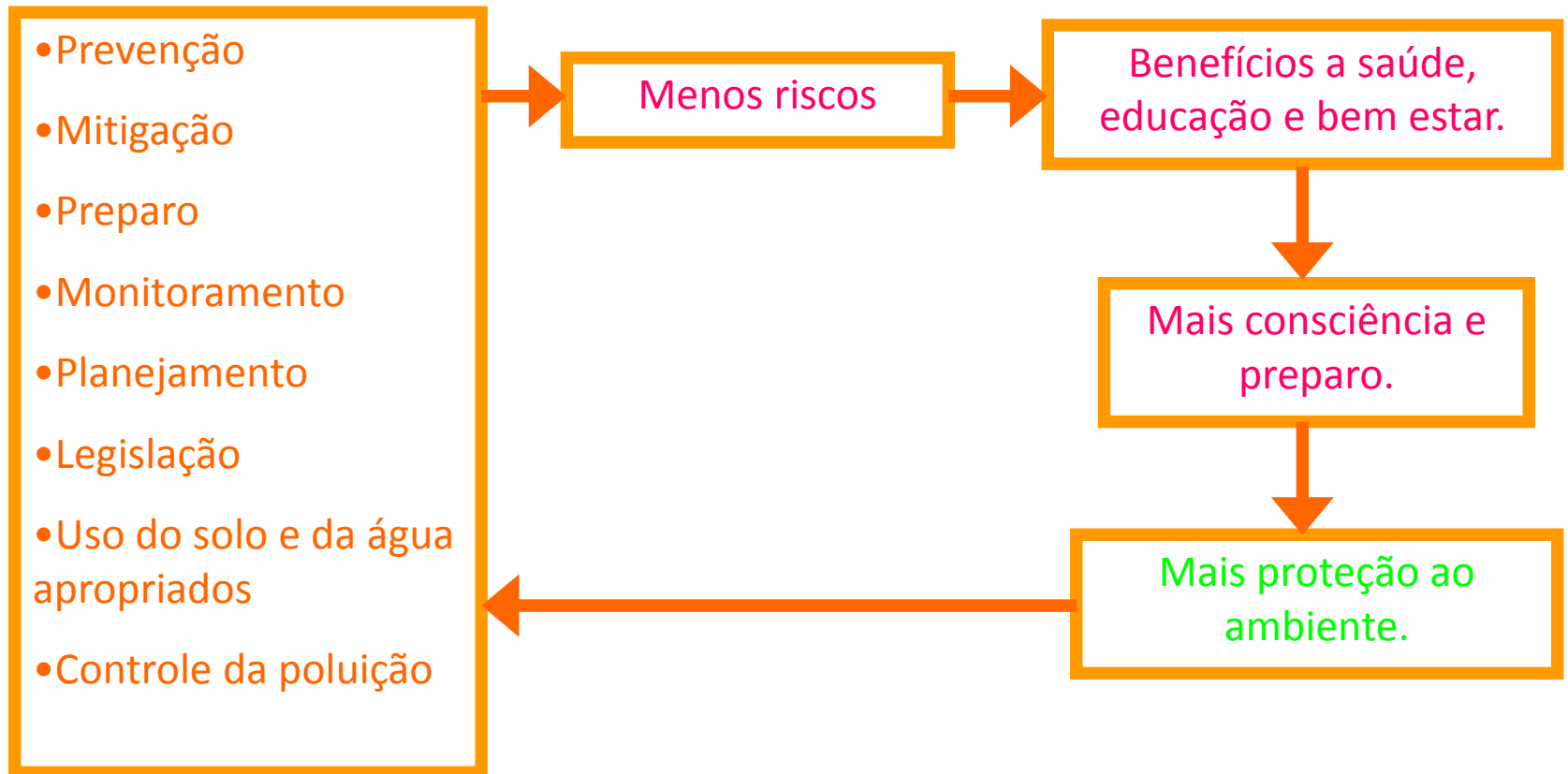
**METEOROLOGIA E  
DESASTRES NATURAIS  
CENÁRIO GLOBAL**

**“As mudanças climáticas devem causar desastres naturais mais frequentes e mais graves”**

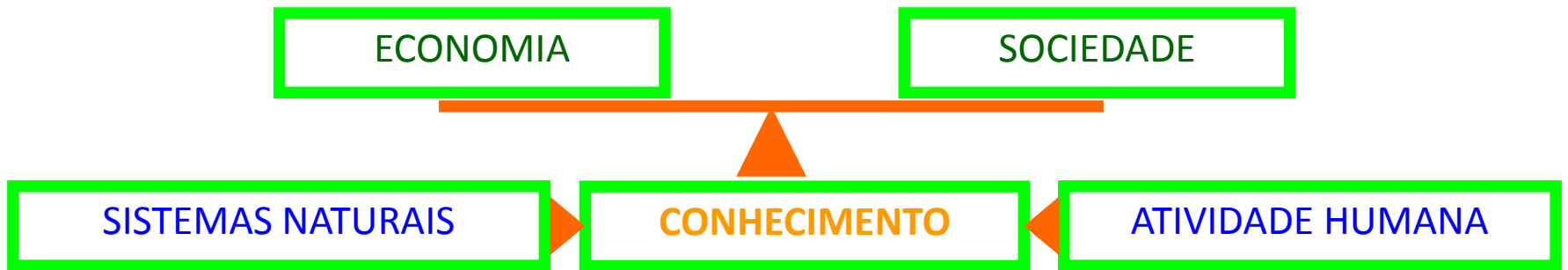
# RETRO-ALIMENTAÇÃO POSITIVA DOS PROBLEMAS



# GESTÃO AMBIENTAL – FATOR PARA O DESENVOLVIMENTO SUSTENTÁVEL



# CIÊNCIA DA SUTENTABILIDADE



OBSERVAÇÃO DA TERRA E DA ATMOSFERA

(Essenciais para a sustentabilidade)



FERRAMENTAS DE PREVISÃO

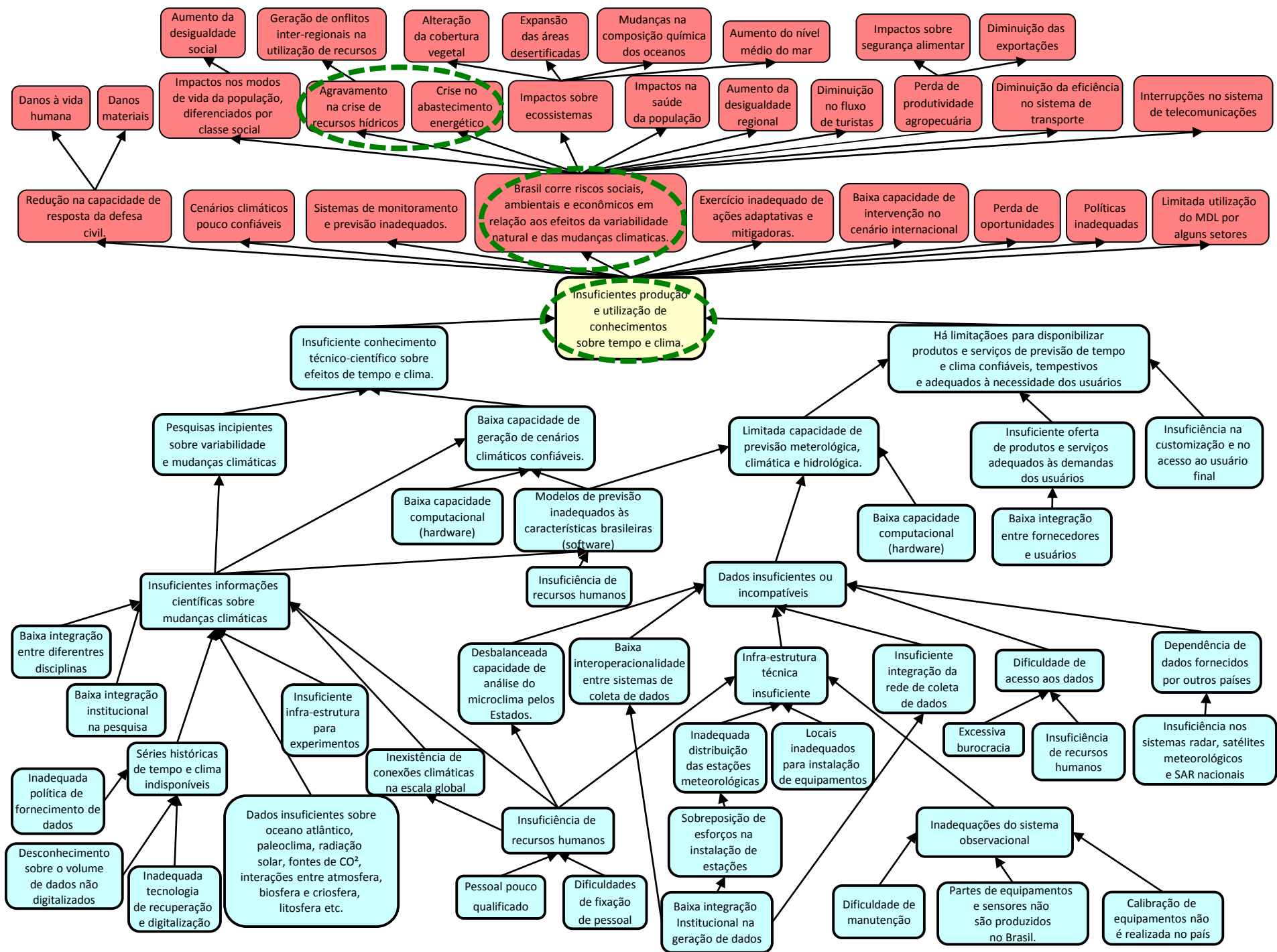
SISTEMAS DE ALERTA

ENTENDIMENTO DO TEMPO E DO CLIMA

INFORMAÇÃO



REDUÇÃO DE RISCOS



***MUITO OBRIGADO!***

***apereira@model.iag.usp.br***