



Centro de Previsão de
Tempo e Estudos Climáticos

CPTEC / INPE

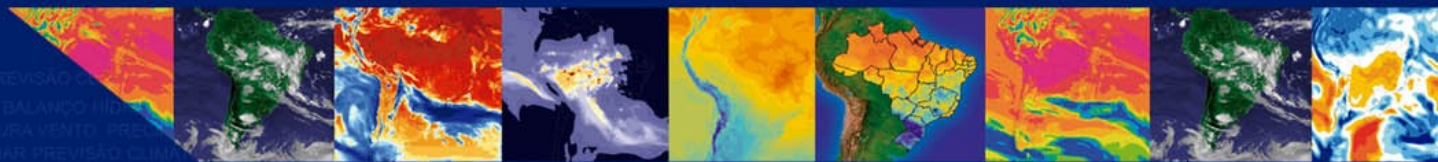
www.cptec.inpe.br

Estudo sobre secas na Amazônia e sul do Brasil e avaliação da destreza das previsões mensais do AGCM/CPTEC

**Workshop sobre Pesquisas básicas em clima e
suas aplicações para a melhoria da previsão
sazonal**

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Instituto Nacional de Pesquisas Espaciais
Centro de Previsão de Tempo e Estudos Climáticos
Grupo de Previsão Climática
Maio de 2013**

**Ciência e
Tecnologia
a serviço
da sociedade**



- **Avaliação das previsões climáticas sazonais mensais do MCGA/CPTEC para o início da estação chuvosa de 2011**
- **Análise das características atmosféricas associadas a episódios de estiagem no Estado do Rio Grande do Sul**
- **Climate diagnostics of three major drought events in the Amazon and illustrations of their seasonal precipitation predictions**



Ariane Frassoni dos Santos de Mattos , Caio A. S. Coelho - XVII CBMet

Do ponto de vista estratégico, as previsões climáticas sazonais são uma ferramenta poderosa no planejamento de diversas atividades socioeconômicas

Precipitação: variável de maior interesse da população

Maior grau de dificuldade de previsão

Habilidade preditiva dos modelos variável: depende da localidade e época do ano

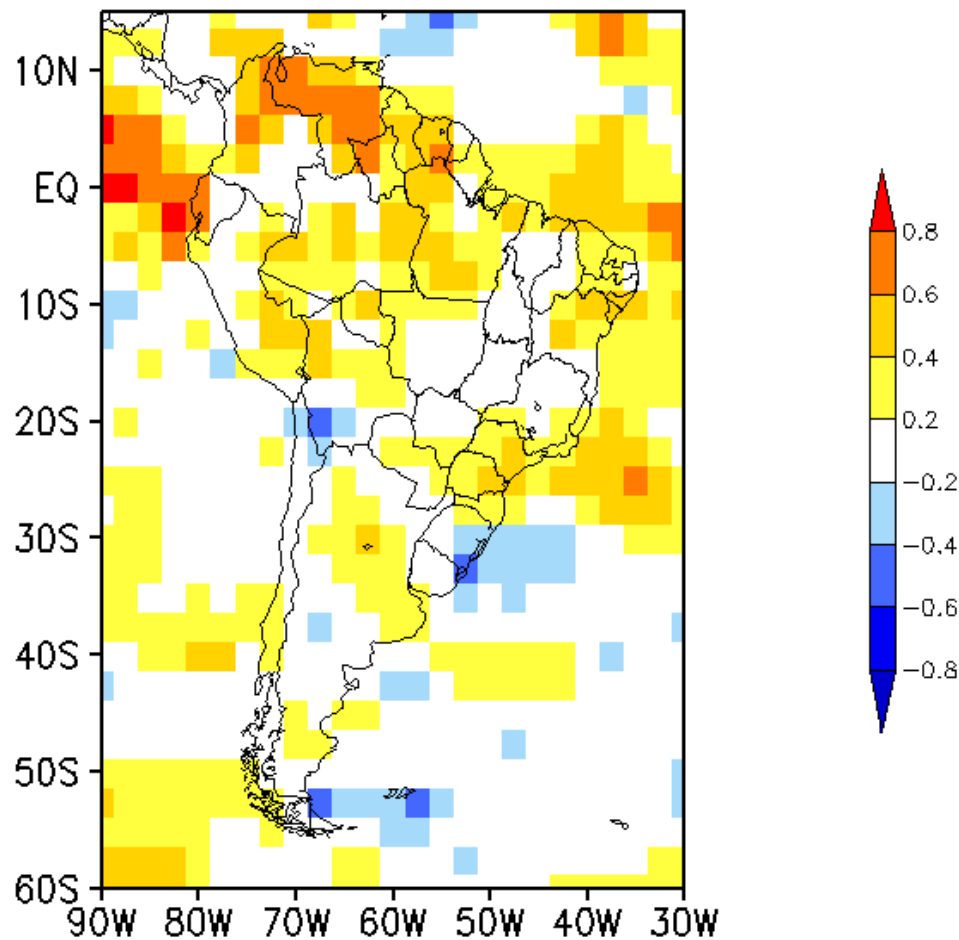
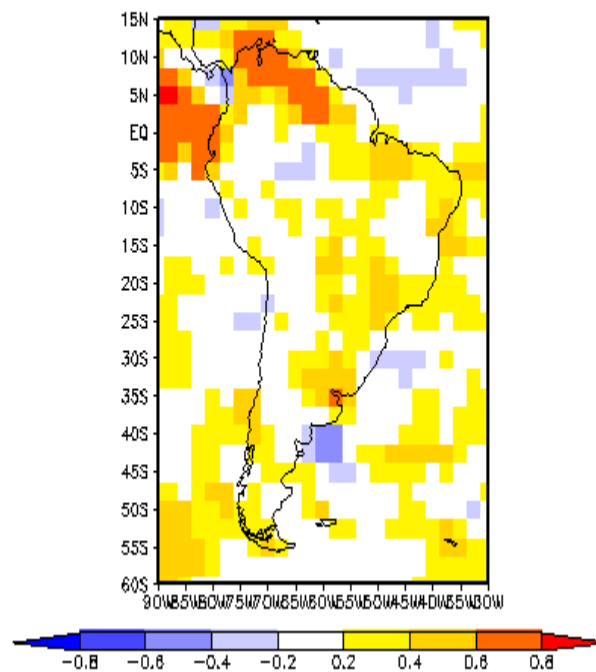
Objetivo: avaliar a capacidade do modelo de previsão climática do CPTEC/INPE em reproduzir previsões mensais para o início da estação chuvosa da região central do Brasil

Análise da destreza das previsões retrospectivas do modelo → correlação entre média do conjunto de previsões do MCGA/CPTEC e as observações (versão 2.2 precipitação do *GPCP*)

Comparação das previsões de anomalia de precipitação para setembro, outubro e novembro de 2011 produzidas no mês de agosto de 2011 com dados observados

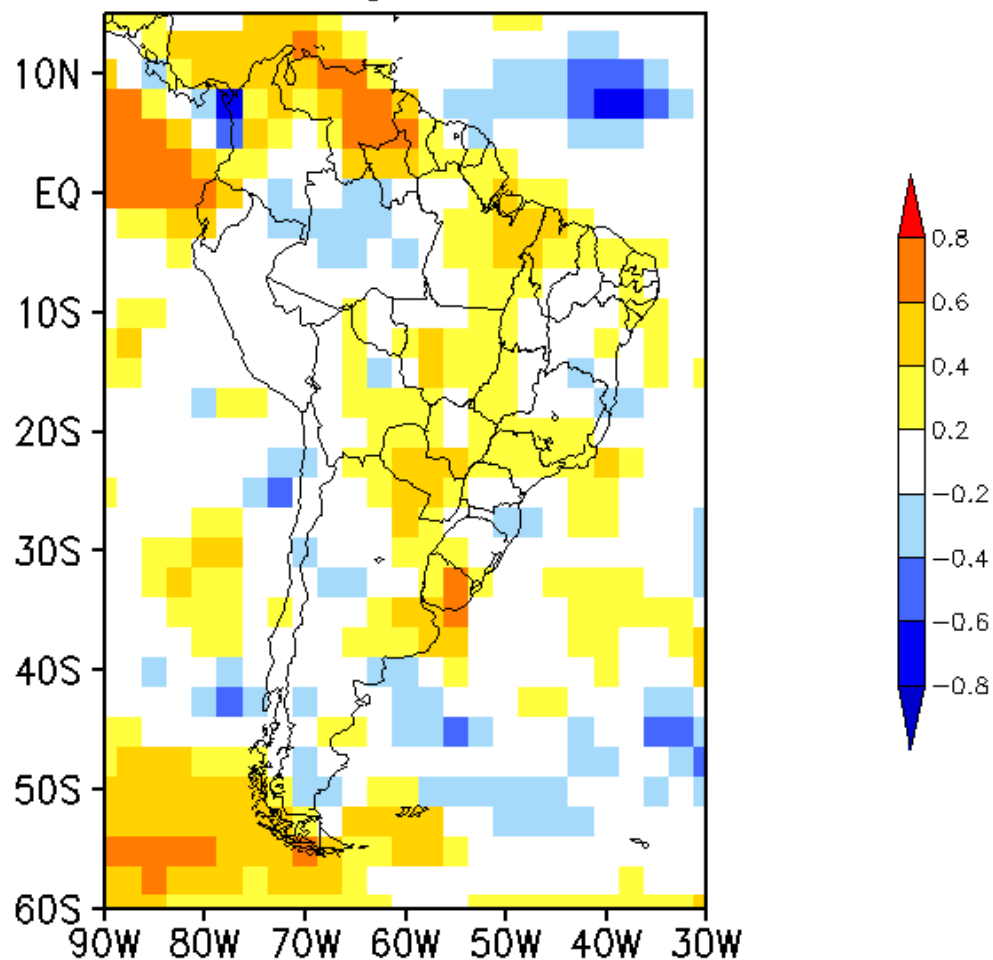
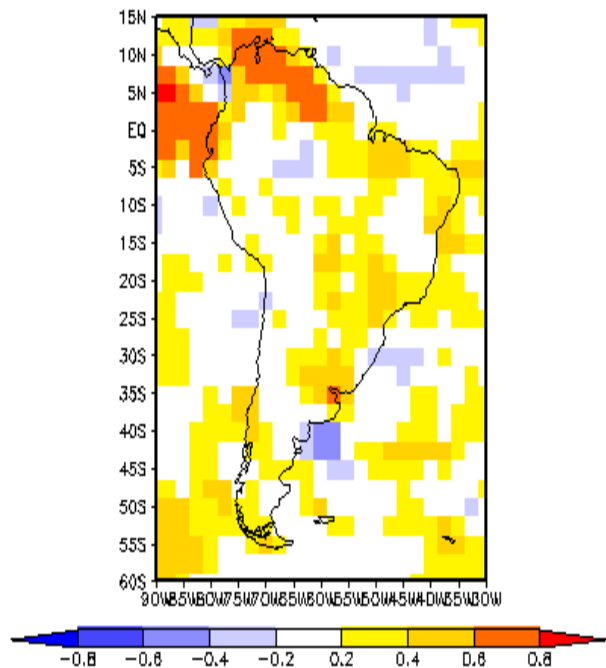
Correl. forec. and obs. CPTEC Precip. (1979–2001) – GPCP V2.2
 Issued: Aug Valid for Sep

Correlation between forecast and obs. anomaly
 CPTEC: Precipitation (1979–2001) – Data: GPCP V 2.1
 Issued: Aug Valid for SON
 Region: South America



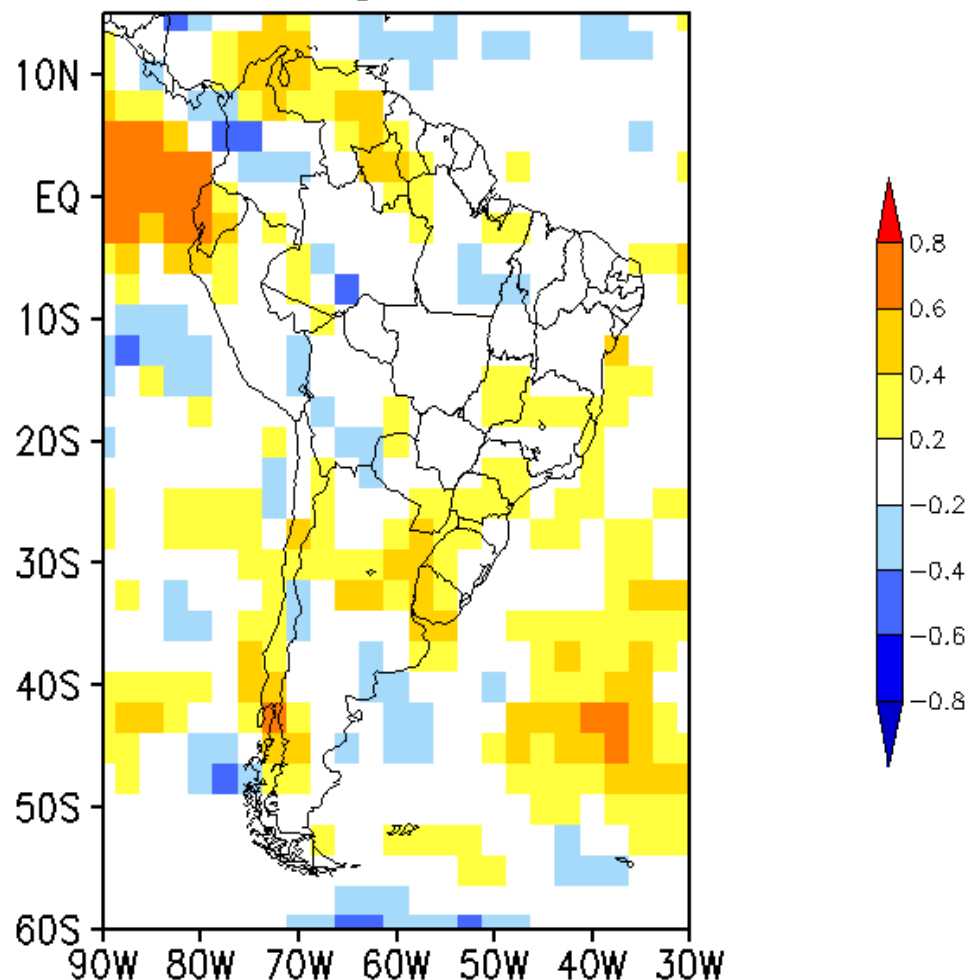
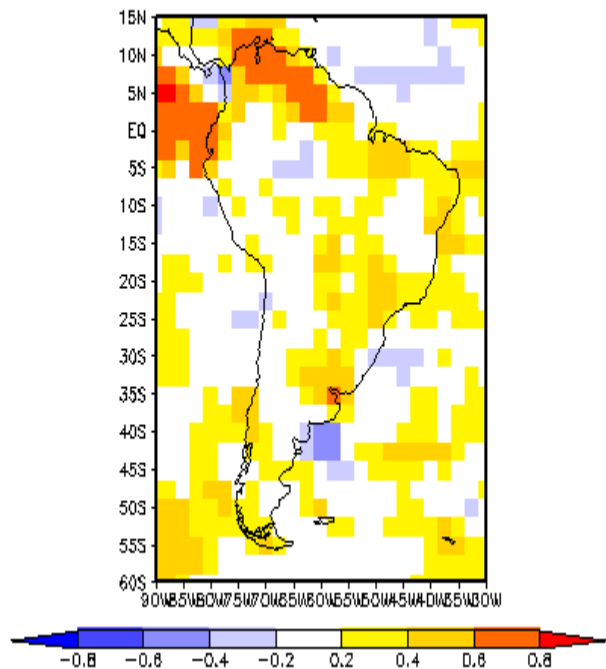
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Correlation between forecast and obs. anomaly
 CPTec: Precipitation (1979–2001) – Data: GPCP V 2.1
 Issued: Aug Valid for SON
 Region: South America



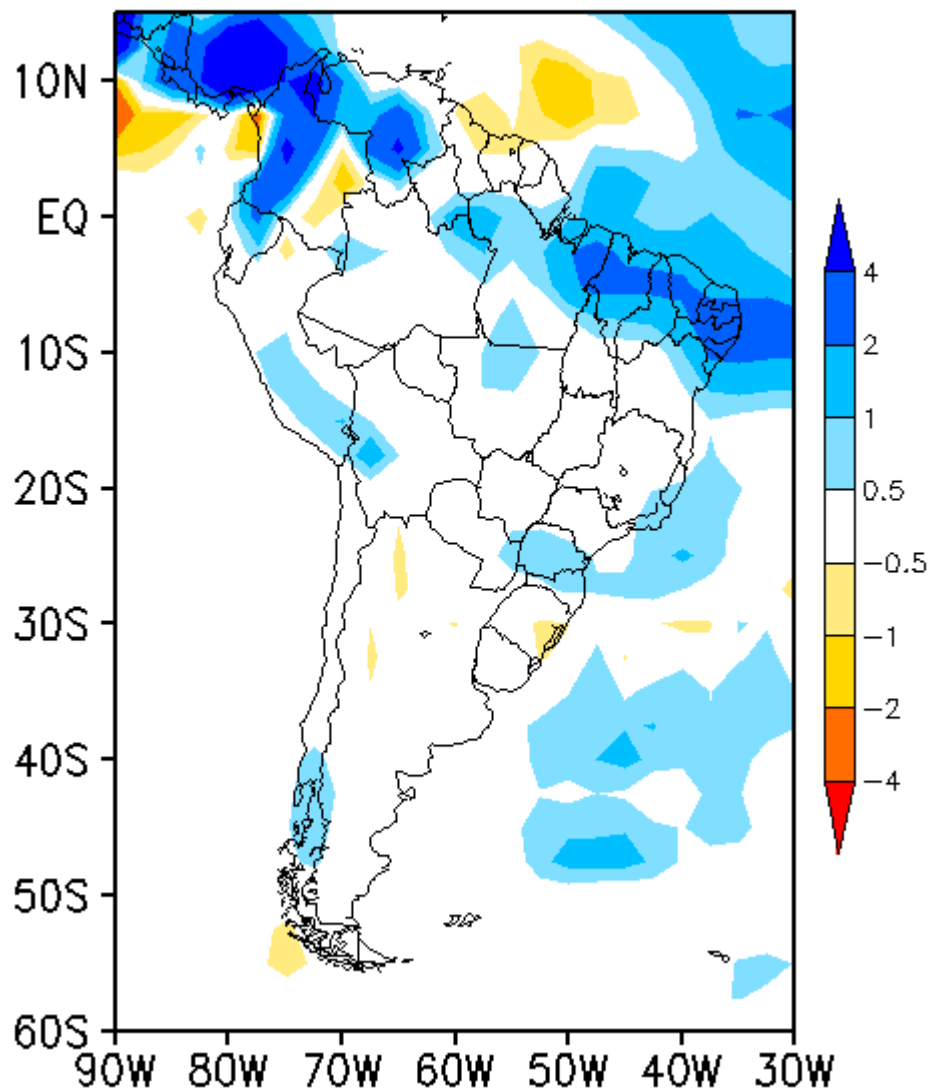
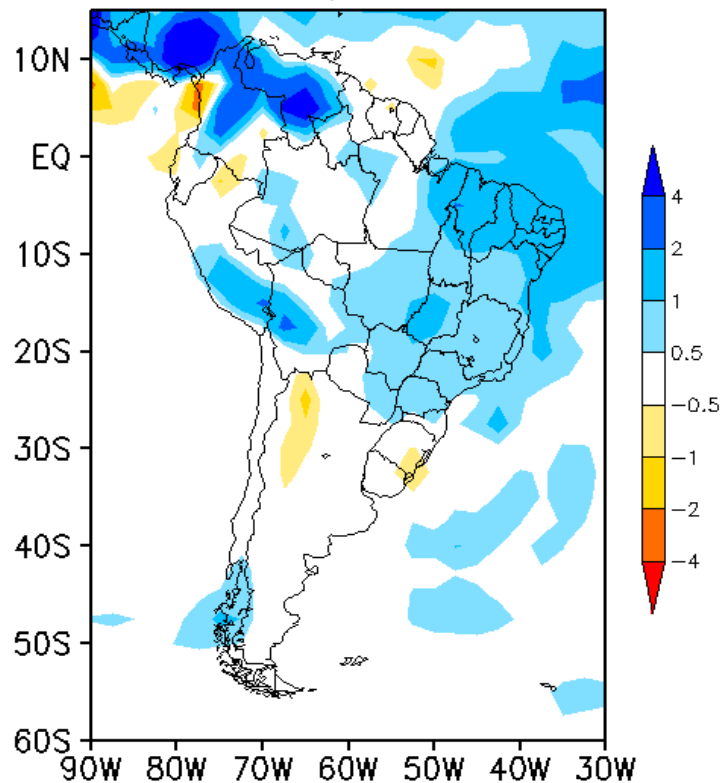
Correl. forec. and obs. CPTec Precip. (1979–2001) – GPCP V2.2
 Issued: Aug Valid for Nov

Correlation between forecast and obs. anomaly
 CPTec: Precipitation (1979–2001) – Data: GPCP V 2.1
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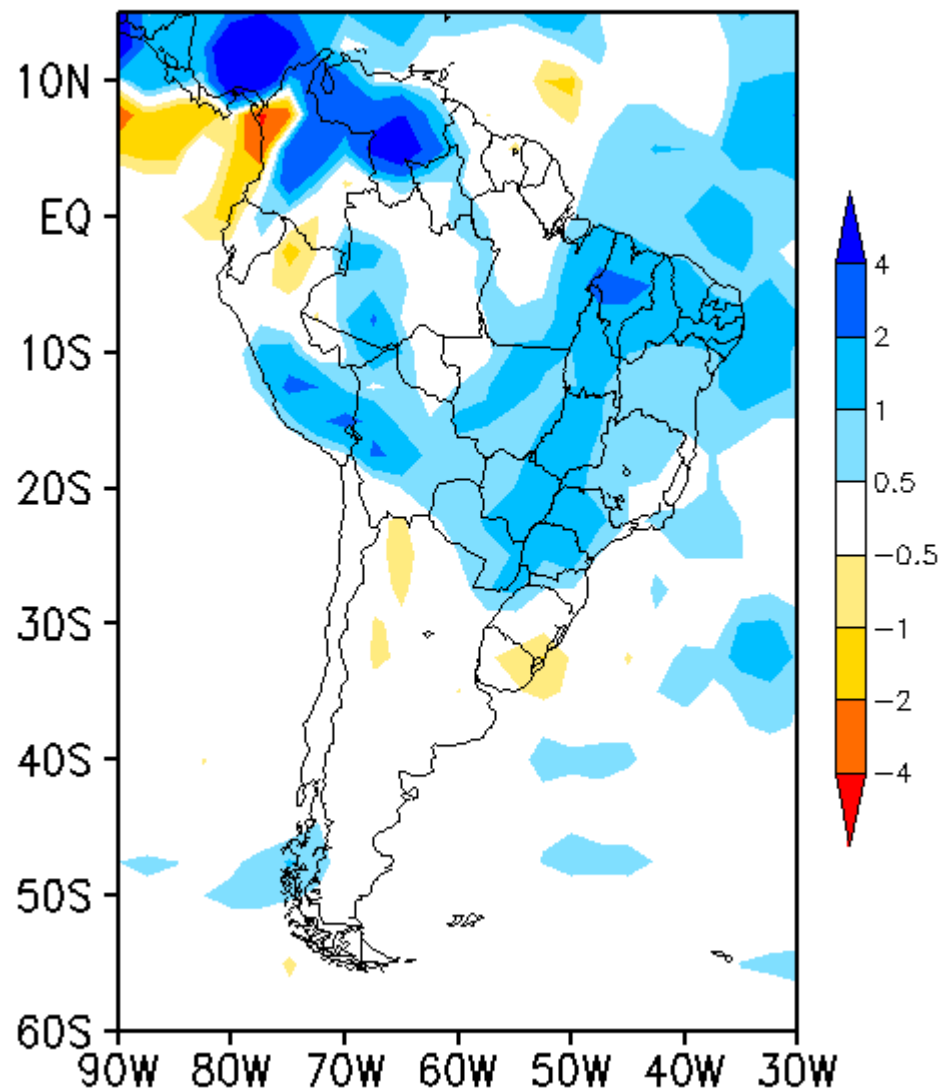
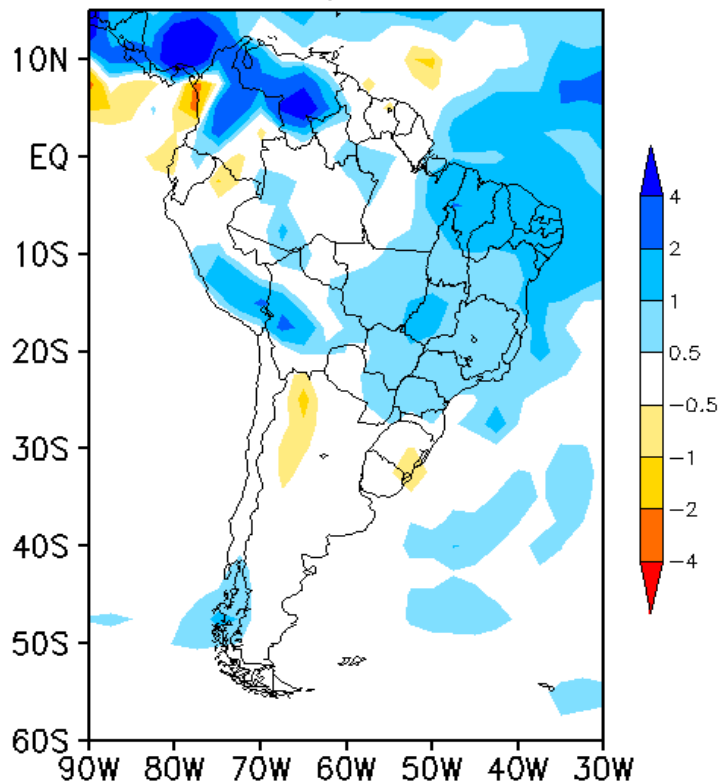
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ANOMALIA DE PRECIPITACAO – KUO
SON/2011



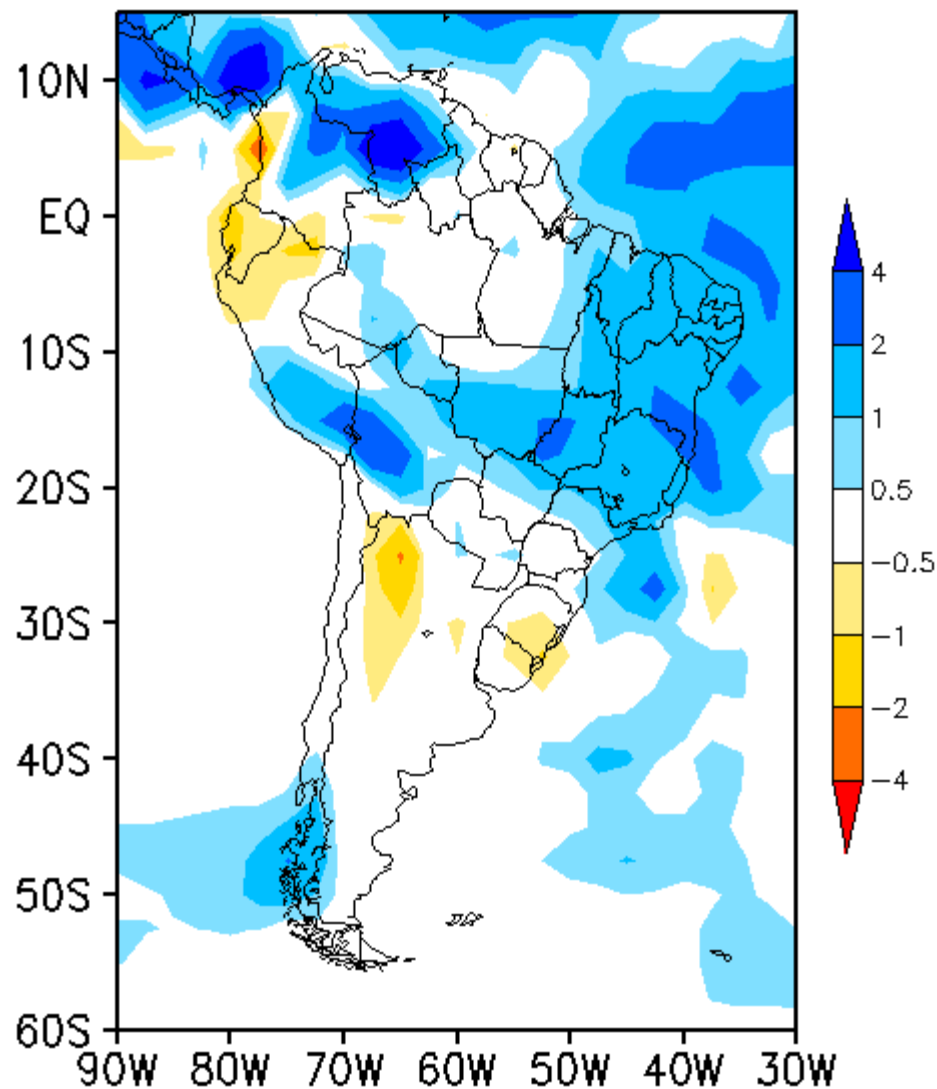
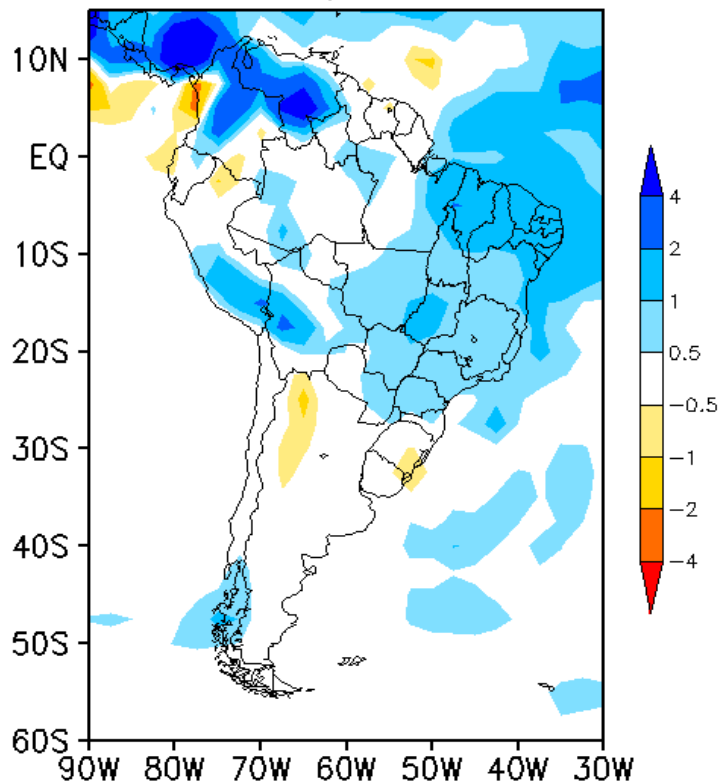
ANOMALIA DE PRECIPITACAO – KUO OUTUBRO/2011

ANOMALIA DE PRECIPITACAO – KUO
SON/2011

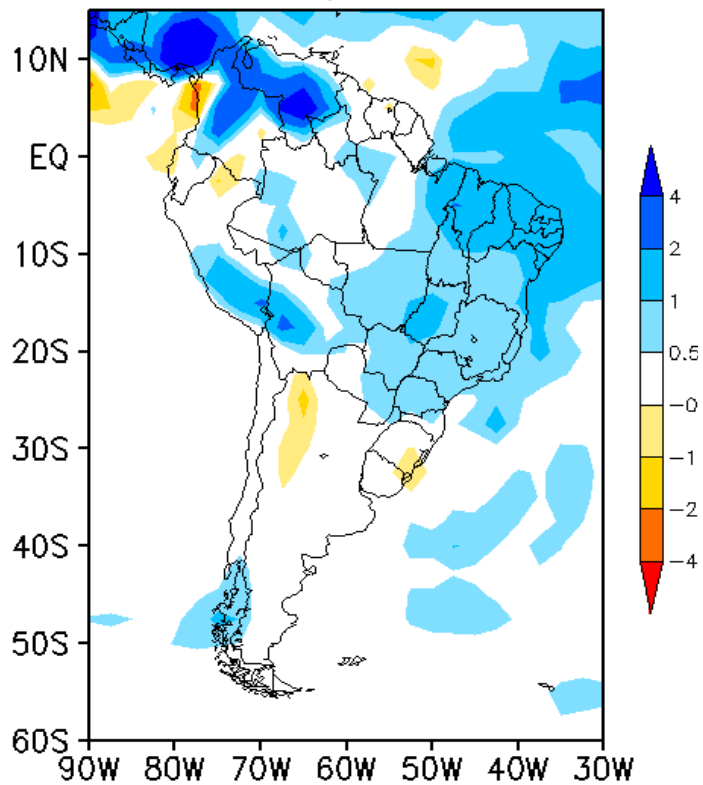


ANOMALIA DE PRECIPITACAO – KUO NOVEMBRO/2011

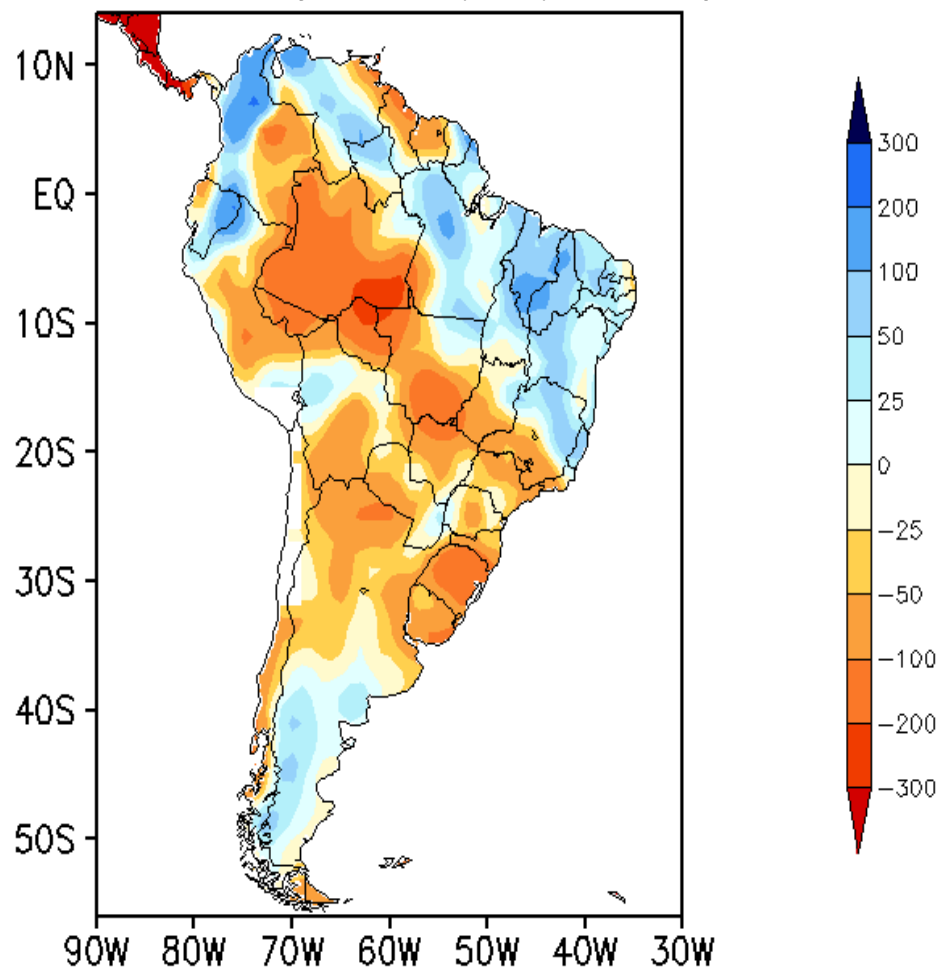
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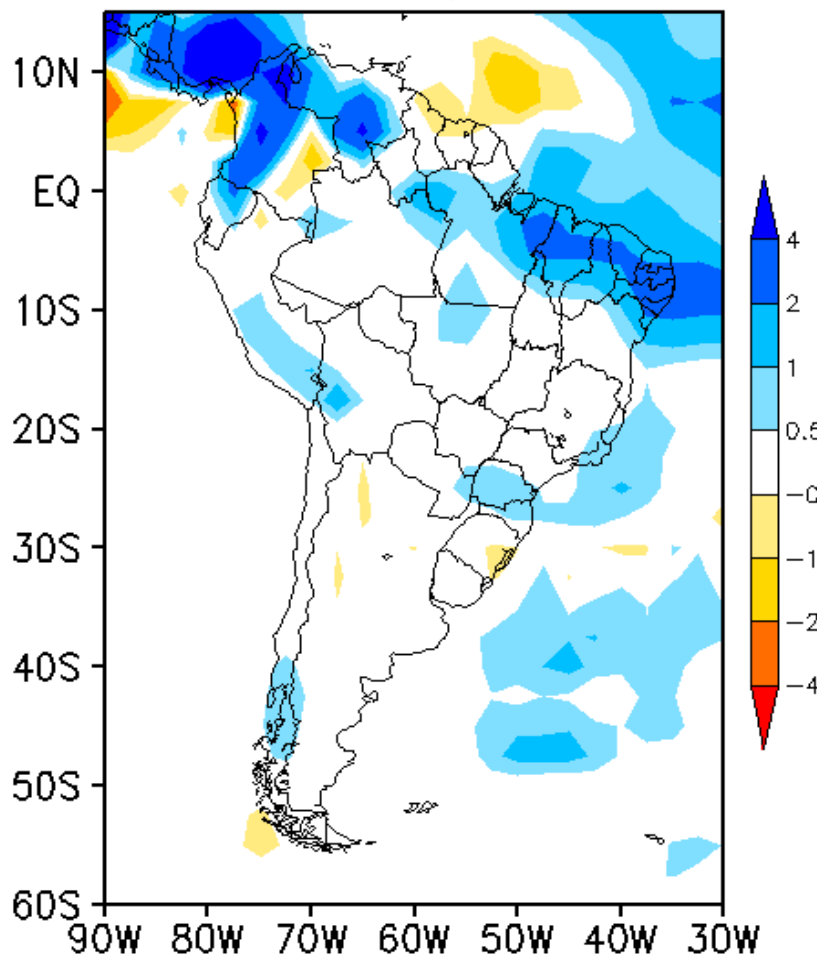
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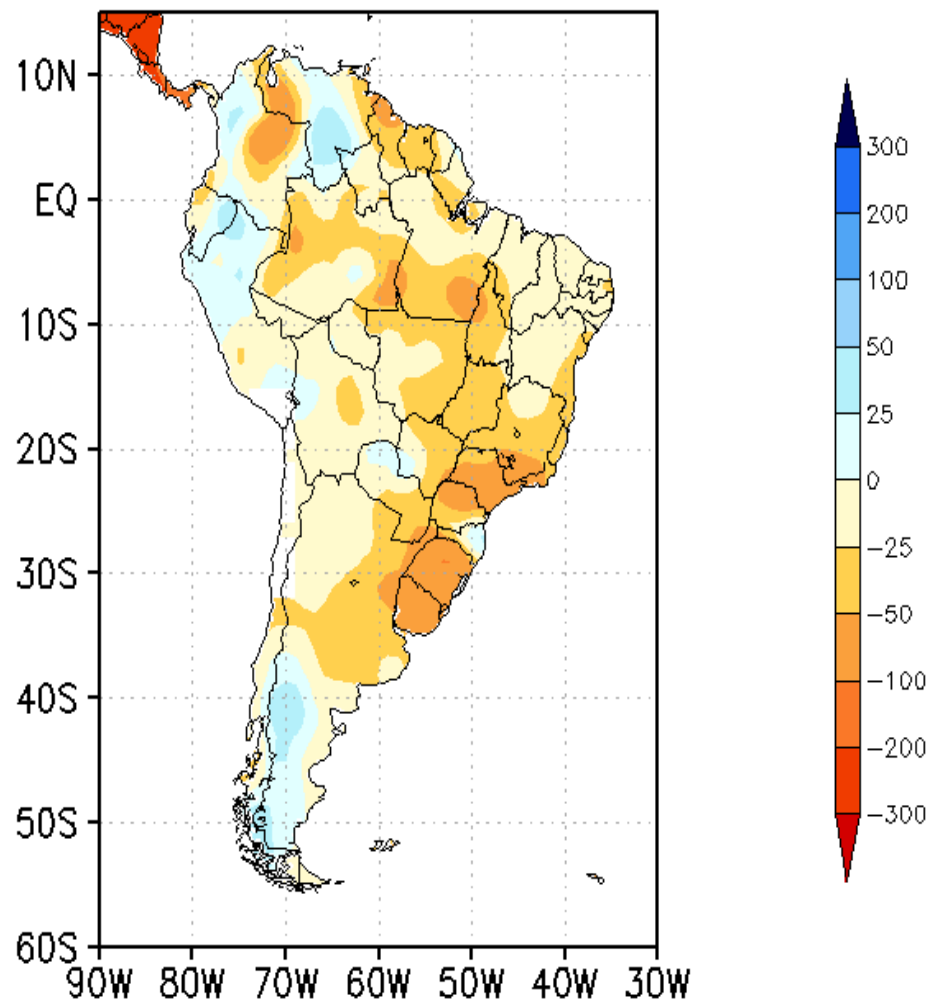
Anomalia de Precipitacao (mm) – SON/2011



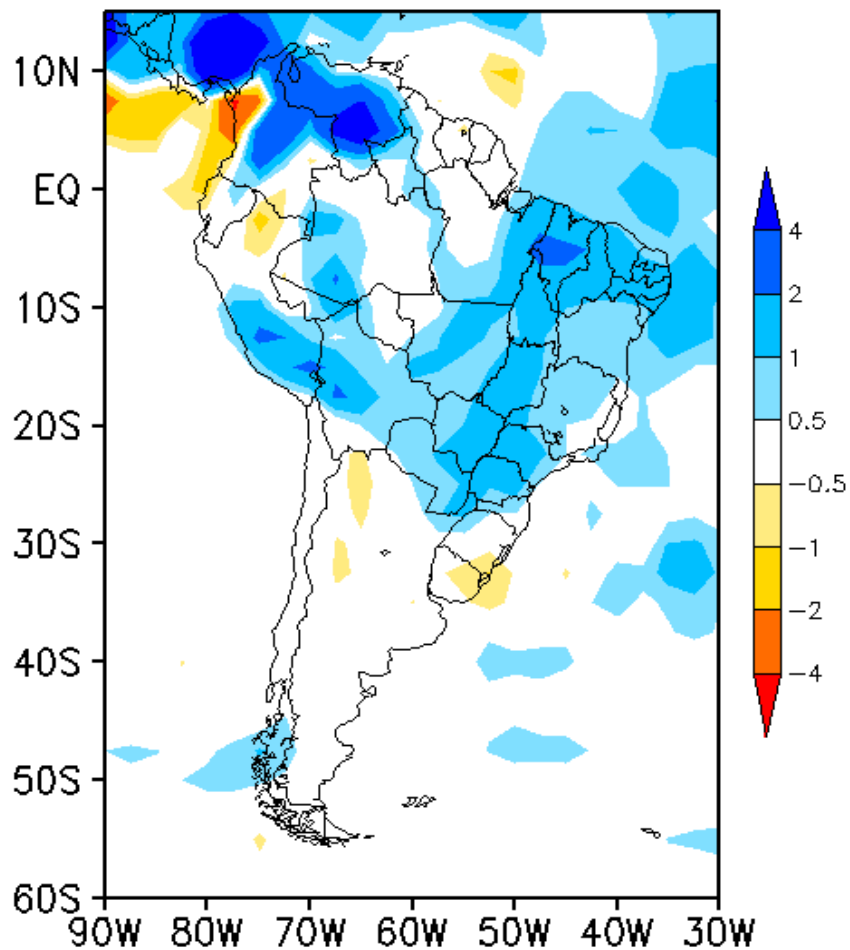
ANOMALIA DE PRECIPITACAO – KUO
SETEMBRO/2011



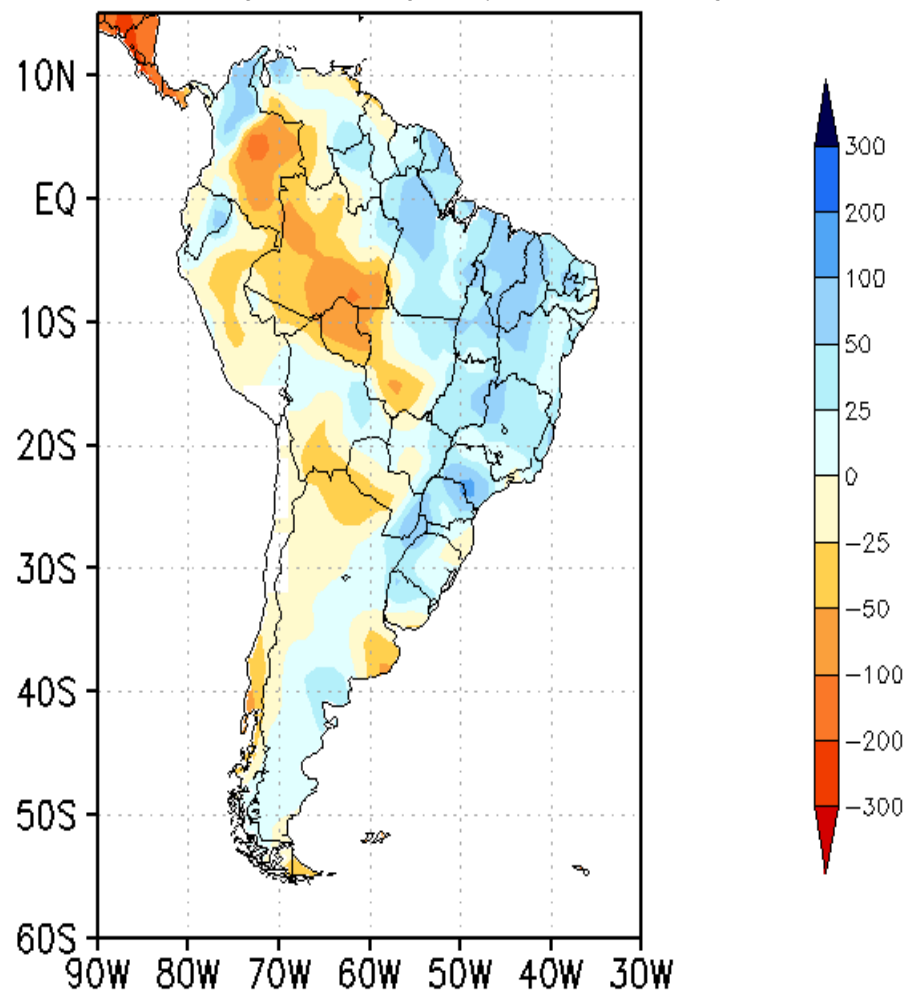
Anomalia de Precipitacao (mm) – Setembro/2011



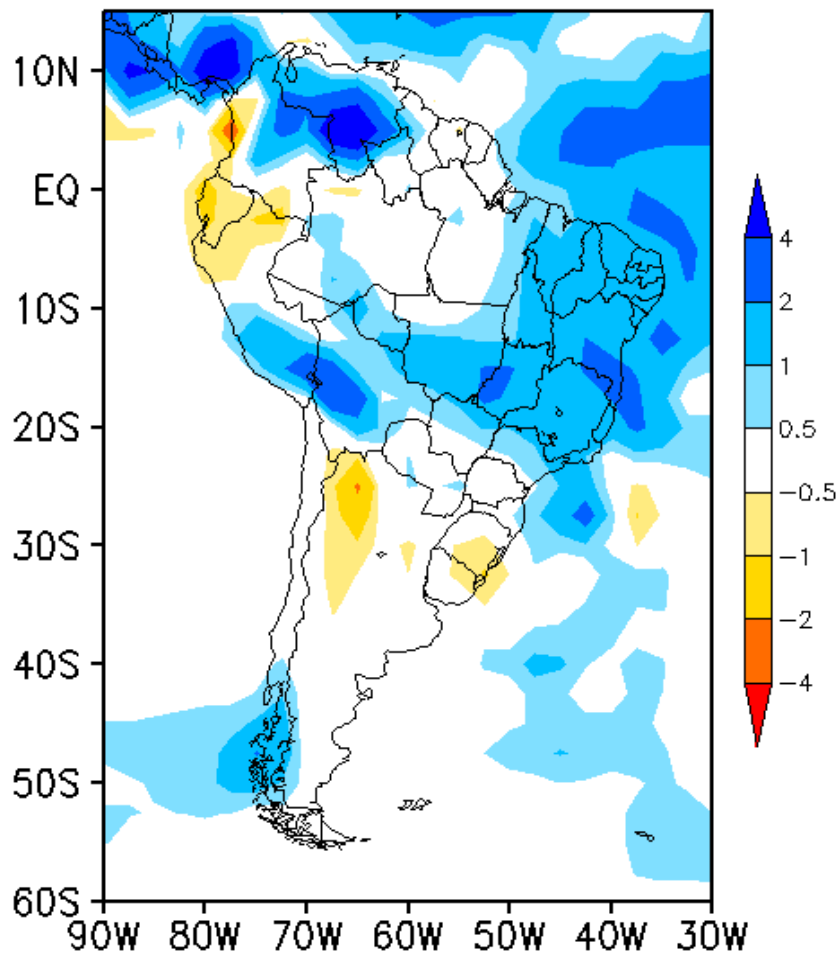
ANOMALIA DE PRECIPITACAO – KUO
OUTUBRO/2011



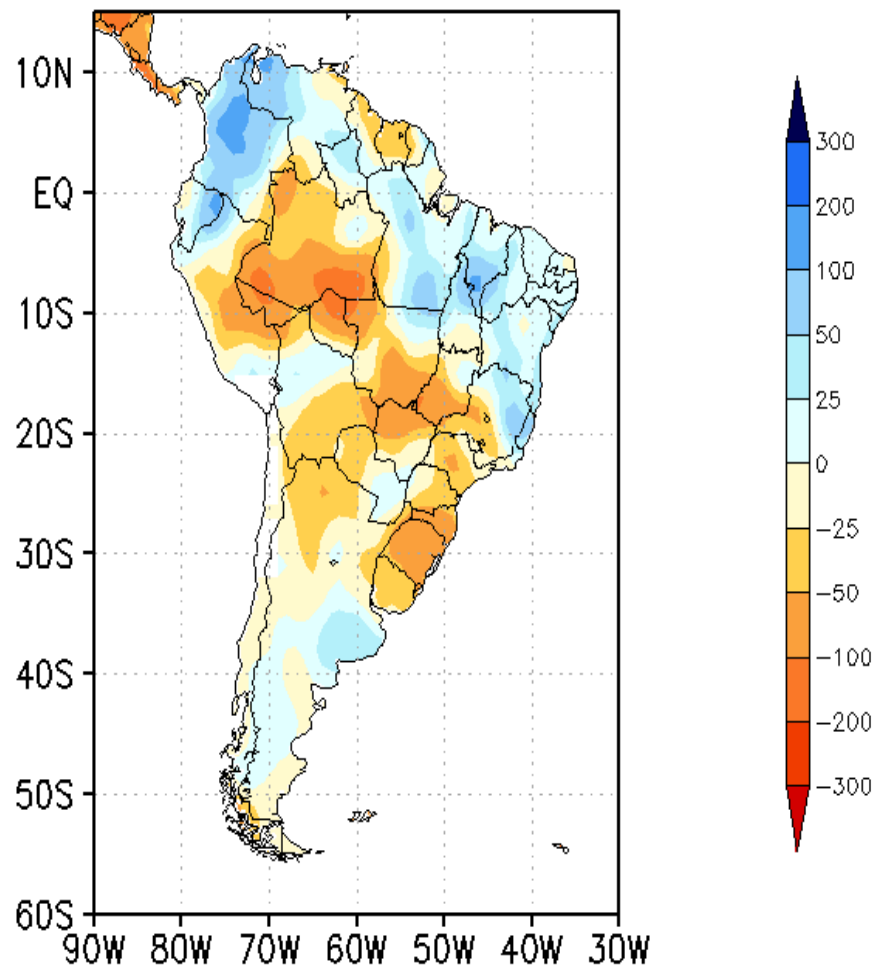
Anomalia de Precipitacao (mm) – Outubro/2011



ANOMALIA DE PRECIPITACAO – KUO
NOVEMBRO/2011



Anomalia de Precipitacao (mm) – Novembro/2011



Considerações

MCGA/CPTEC responde principalmente às forçantes de grande escala relacionadas aos padrões de TSM sobre o Oceano Pacífico – ENOS

Principais regiões da América do Sul cujos padrões de precipitação estão relacionados com o ENOS são o sul e o norte do continente (Ropelewski e Halpert, 1987)

Resultados promissores, indicando que há uma boa correspondência entre as previsões mensais e as anomalias de precipitação observadas



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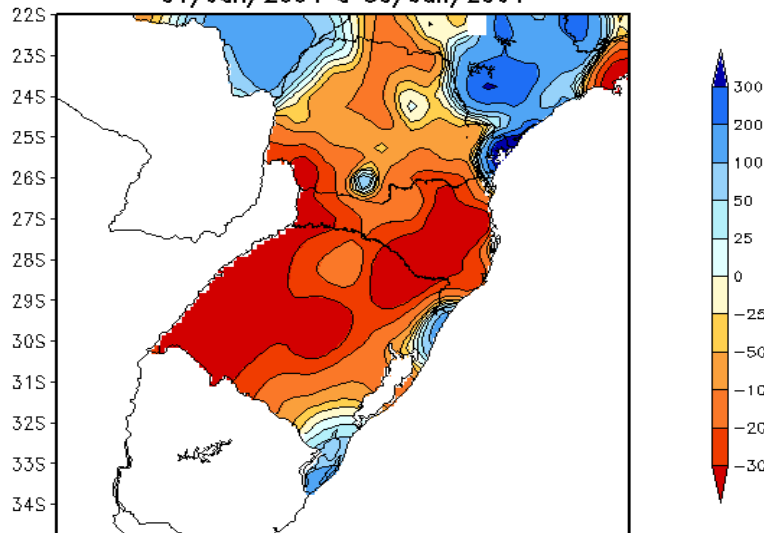
Objetivo: investigar os padrões atmosféricos de grande escala associados a quatro episódios de estiagem no Rio Grande do Sul registrados na última década (2000-2012)

Primeiro semestre de 2012: noticiado o mais intenso da última década

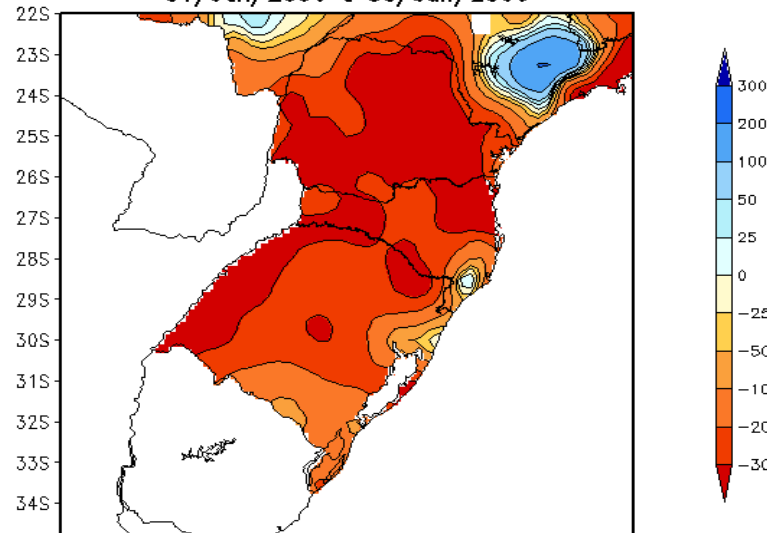
Analisados:

- Mapas de anomalias de precipitação - dados observados interpolados de 2000 a 2012
- Análise de compostos dos anos de 2004, 2006, 2009, 2012 (janeiro a junho)
- Anomalias de circulação e umidade atmosférica produzidos a partir de dados de reanálises

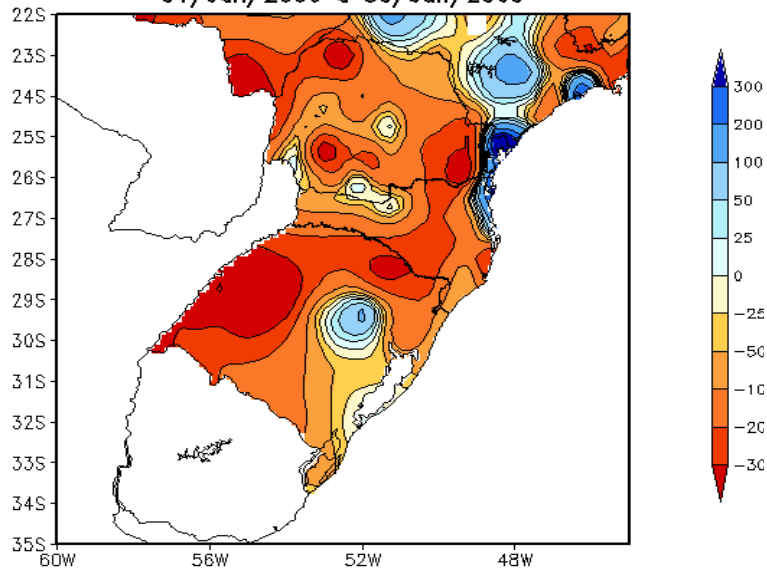
Anomalia de Prec. (mm)
01/Jan/2004 a 30/Jun/2004



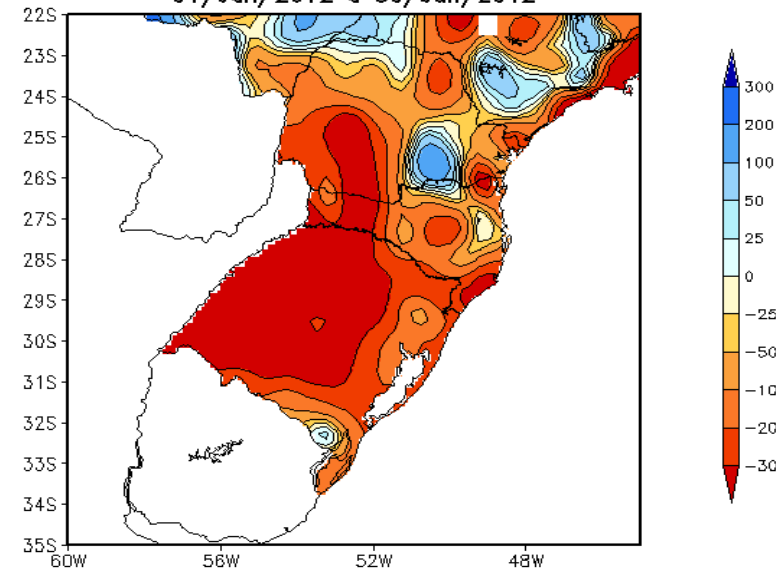
Anomalia de Prec. (mm)
01/Jan/2006 a 30/Jun/2006



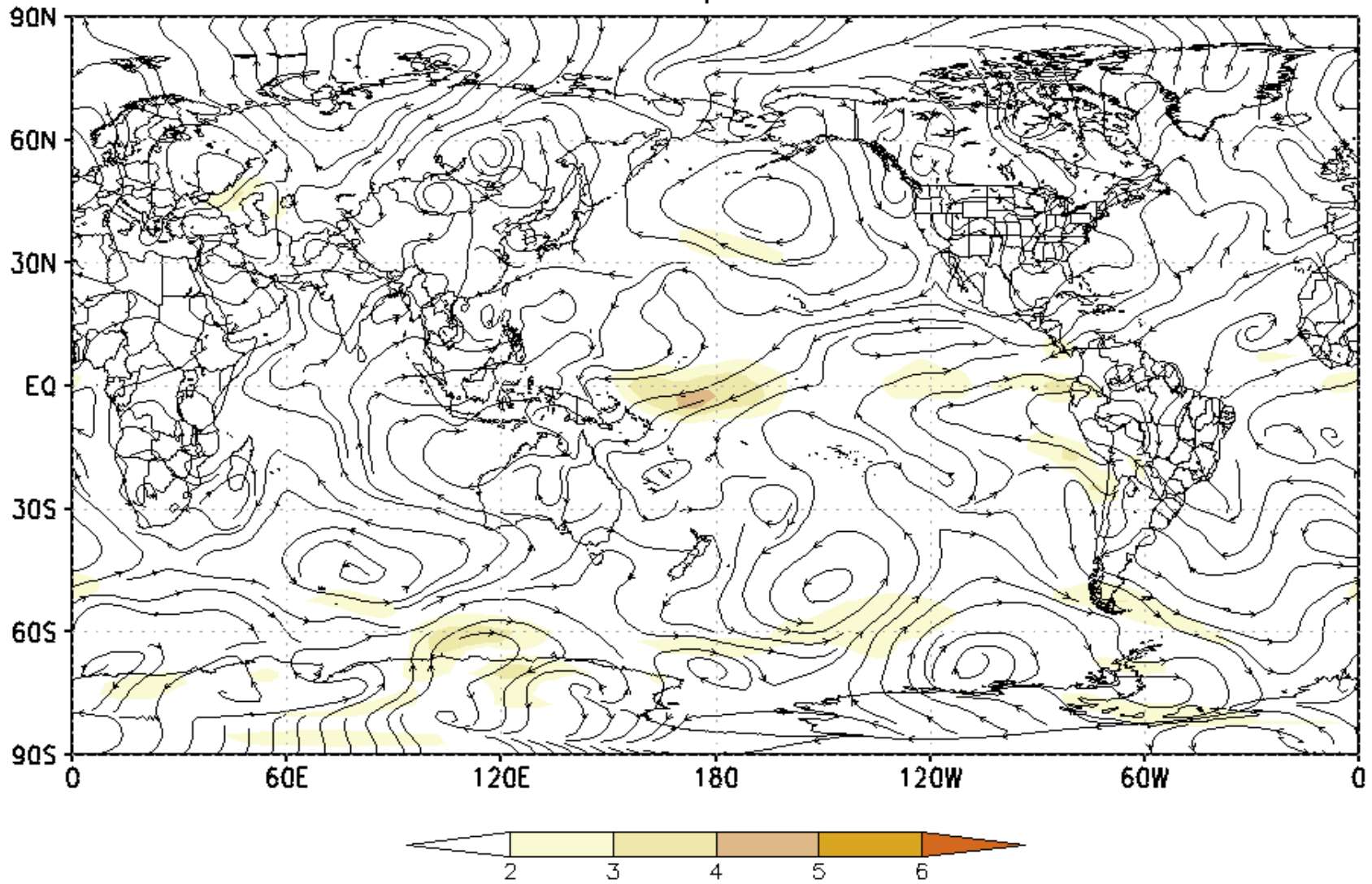
Anomalia de Prec. (mm)
01/Jan/2009 a 30/Jun/2009



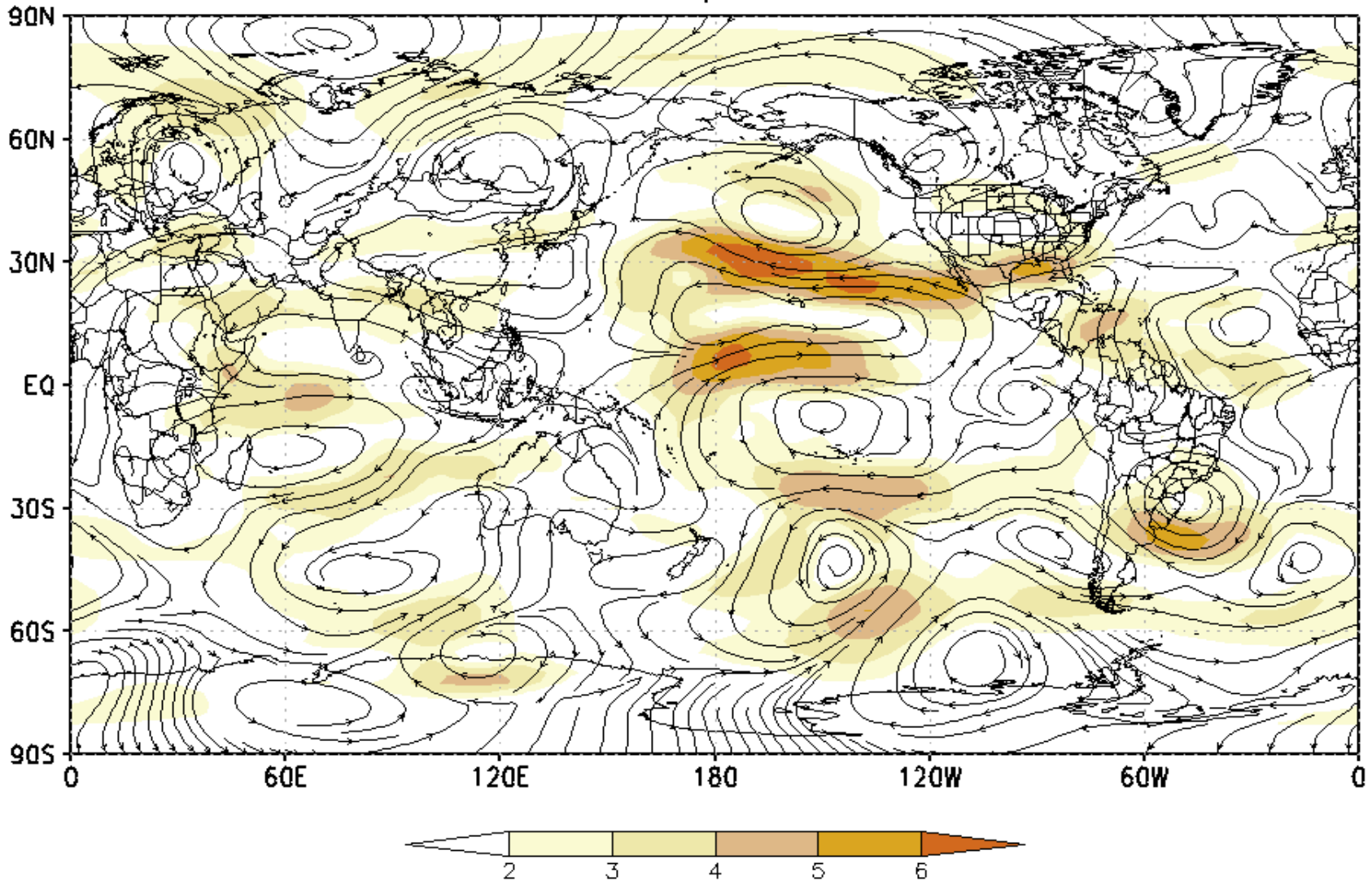
Anomalia de Prec. (mm)
01/Jan/2012 a 30/Jun/2012



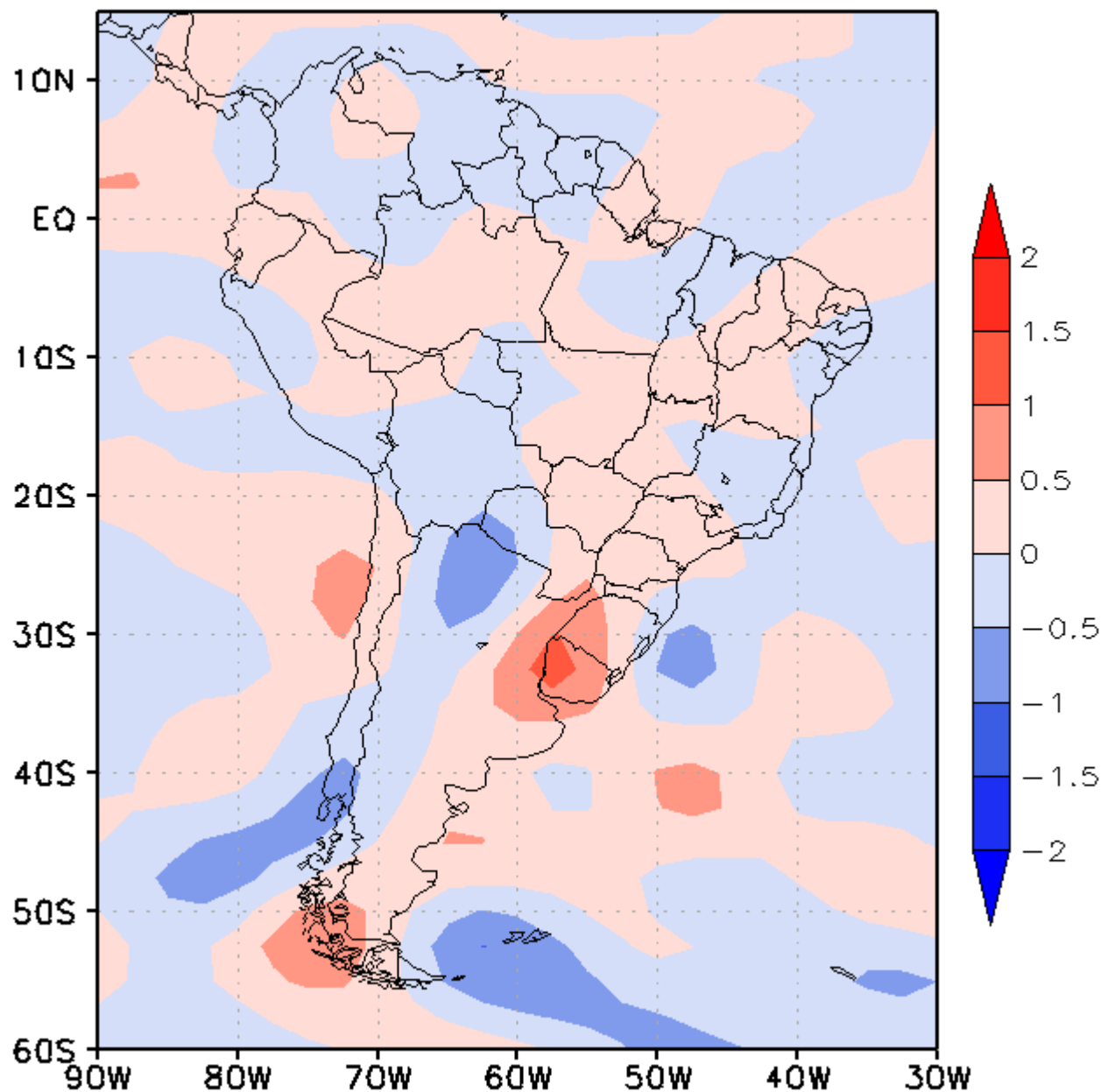
850 hPa Streamline and Wind anomaly (m/s) JAN–JUN Composite

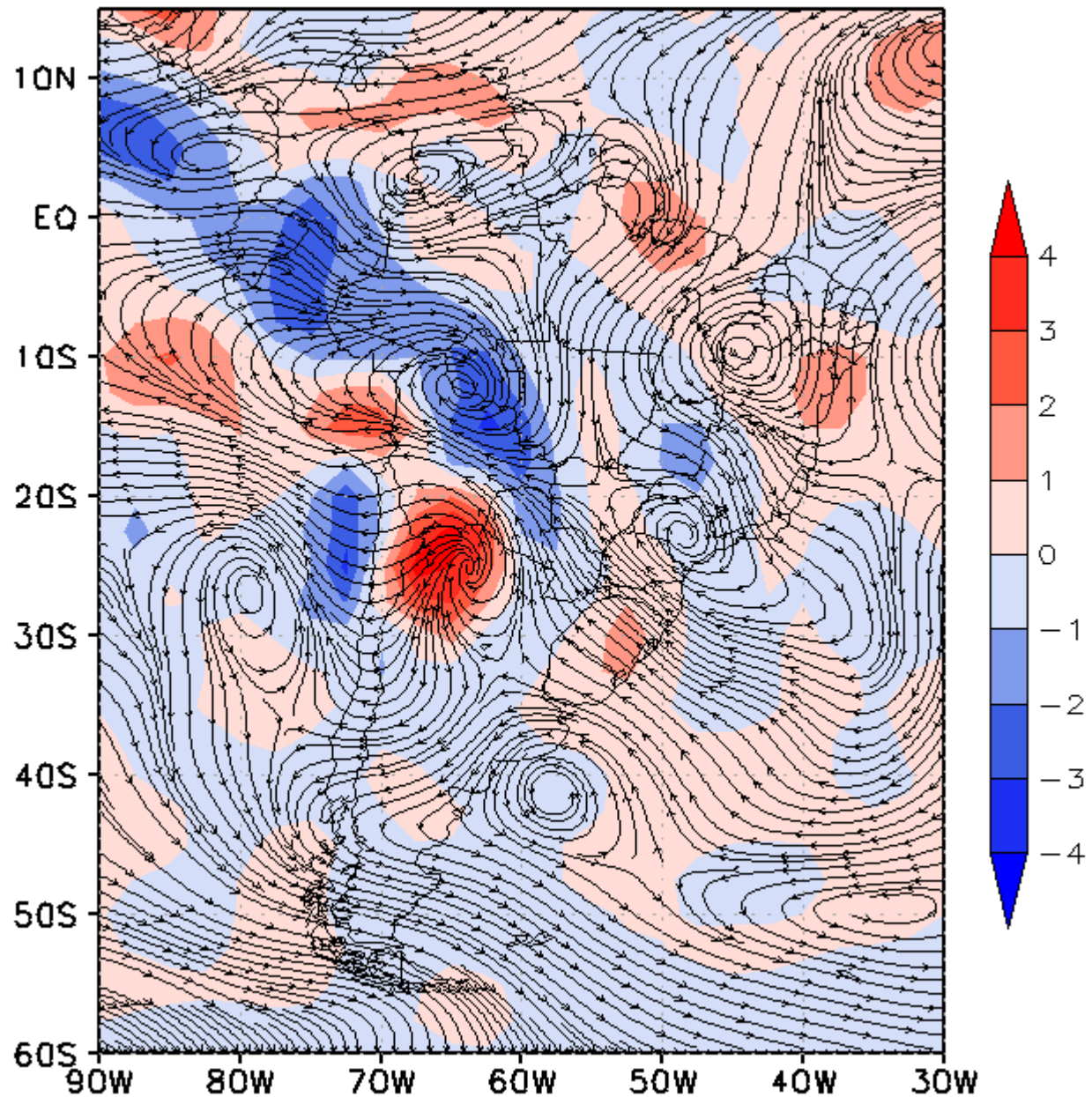


200 hPa Streamline and Wind anomaly (m/s) JAN–JUN Composite



500 hPa Vorticity advection anomaly JAN–JUN Composite



Humidity flux div. and streamlines anomaly JAN–JUN
Composite

Considerações

O padrão de circulação anômala observado em altos níveis mostrou-se similar ao padrão típico durante a manifestação de episódios de La Niña: par de ciclones anômalos associados à falta de chuva no Pacífico central

Disparo de trem de ondas de Rossby que atingem a América do Sul

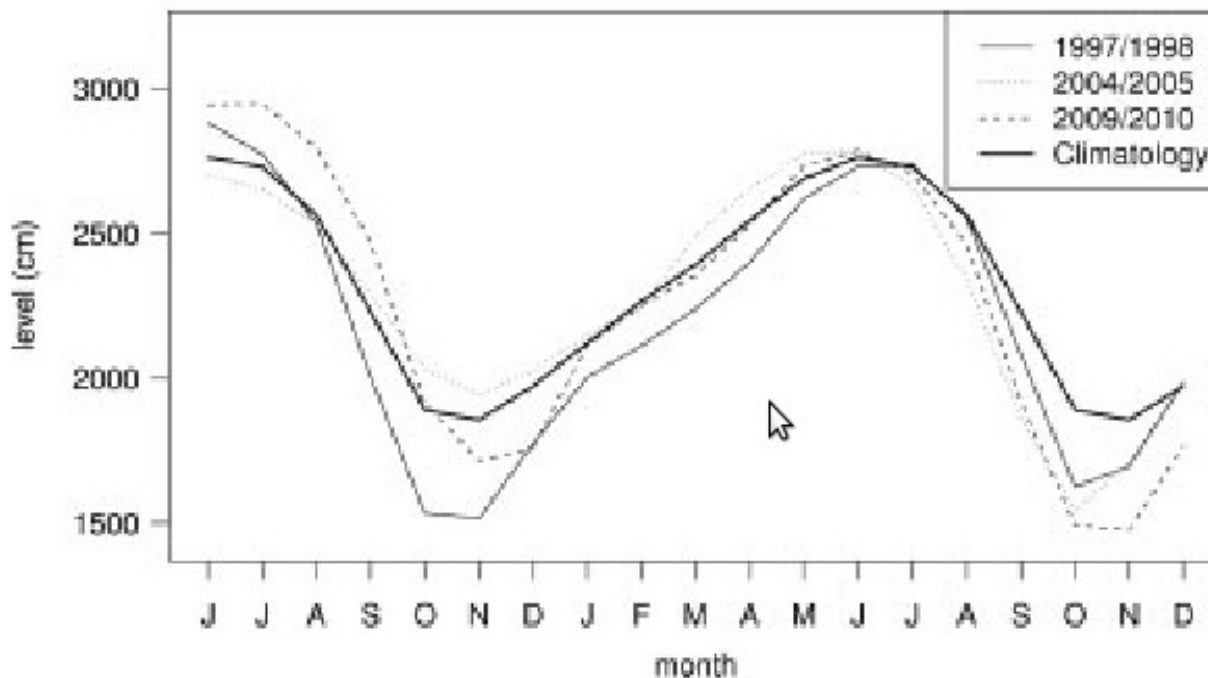
Manutenção da circulação ciclônica em altos níveis impediu a formação de atividade convectiva do sul da América do Sul

Predomínio de advecção de vorticidade anticiclônica em 500 hPa contribuiu para aumentar o movimento subsidente na região

Condições dinâmicas desfavoráveis e a redução da disponibilidade de umidade verificada no padrão do composto de anomalias de divergência de umidade em baixos níveis: fatores adicionais que contribuíram para as condições de estiagem observadas no Rio Grande do Sul nos 4 episódios analisados

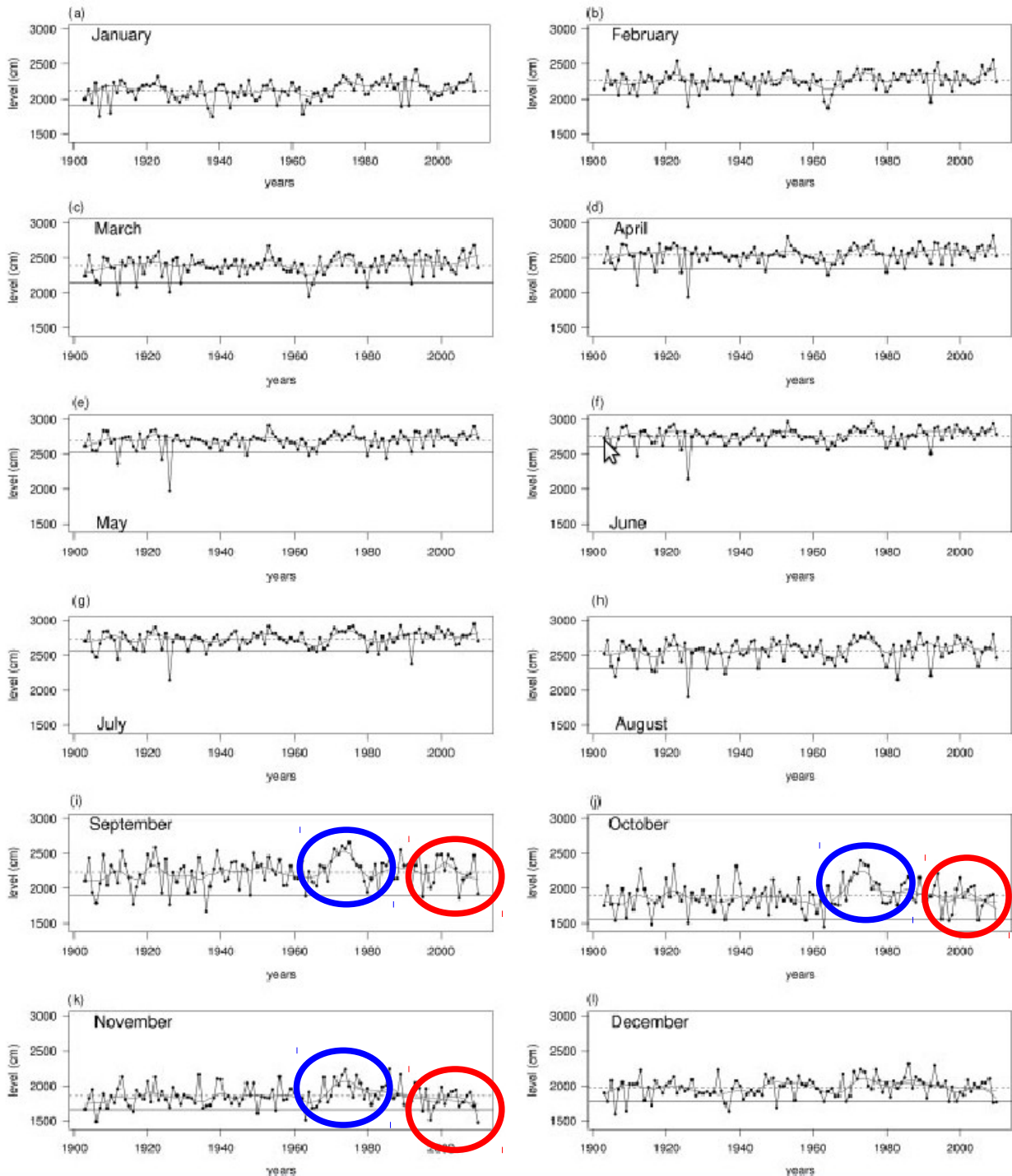
Climate diagnostics of three major drought events in the Amazon and illustrations of their seasonal precipitation predictions

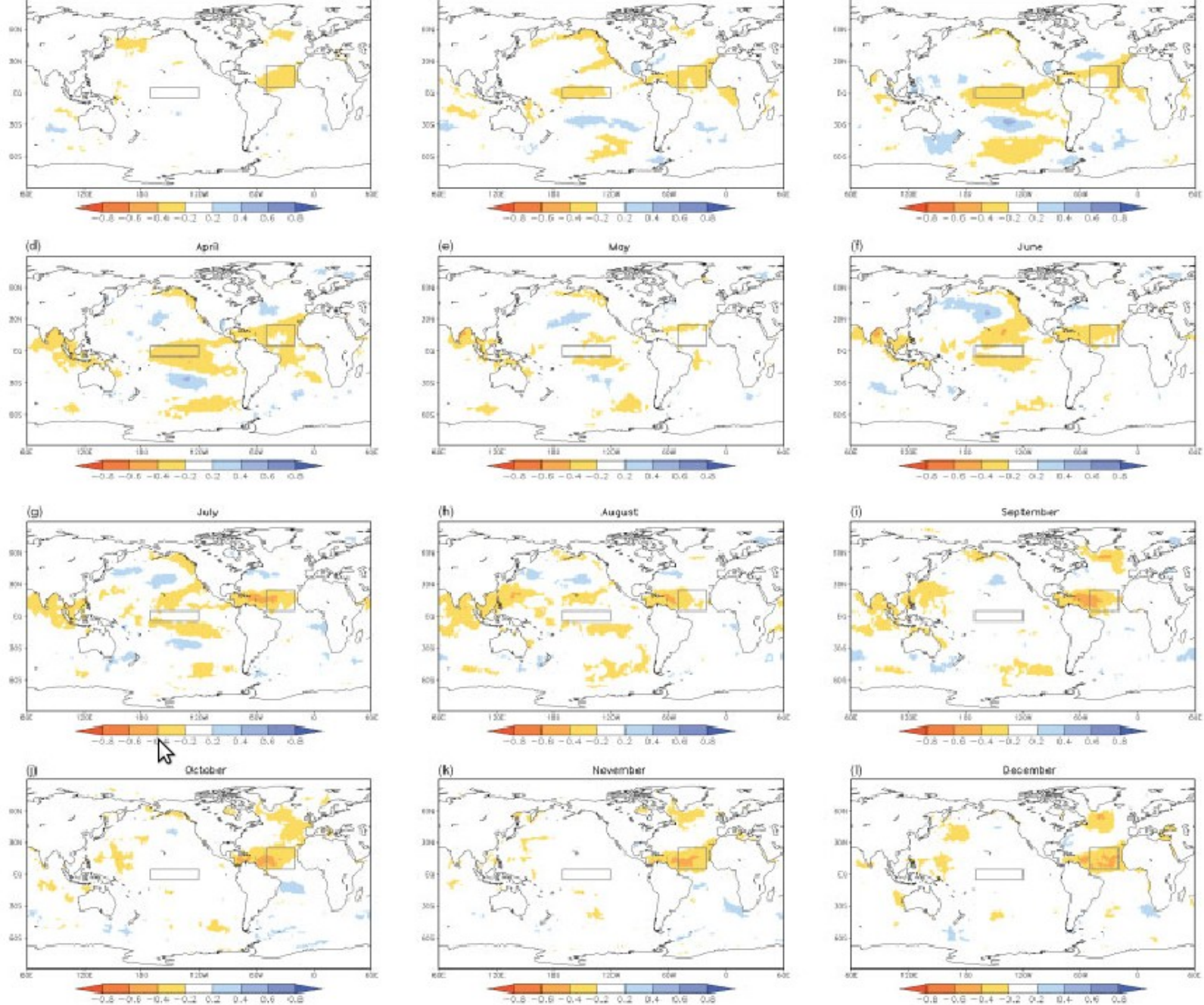
Caio A. S. Coelho,^{a*} Iracema A. F. Cavalcanti,^a Simone M. S. Costa,^a Saulo R. Freitas,^a Ester R. Ito,^a
Giovana Luz,^a Ariane F. Santos,^a Carlos A. Nobre,^b José A. Marengo^b and Alexandre B. Pezza^c
^a *Centro de Previsão de Tempo e Estudos Climáticos, Instituto Nacional de Pesquisas Espaciais, Cachoeira Paulista, SP, Brazil*
^b *Centro de Ciência do Sistema Terrestre, Instituto Nacional de Pesquisas Espaciais, São José dos Campos, SP, Brazil*
^c *School of Earth Sciences, The University of Melbourne, Victoria, Australia*



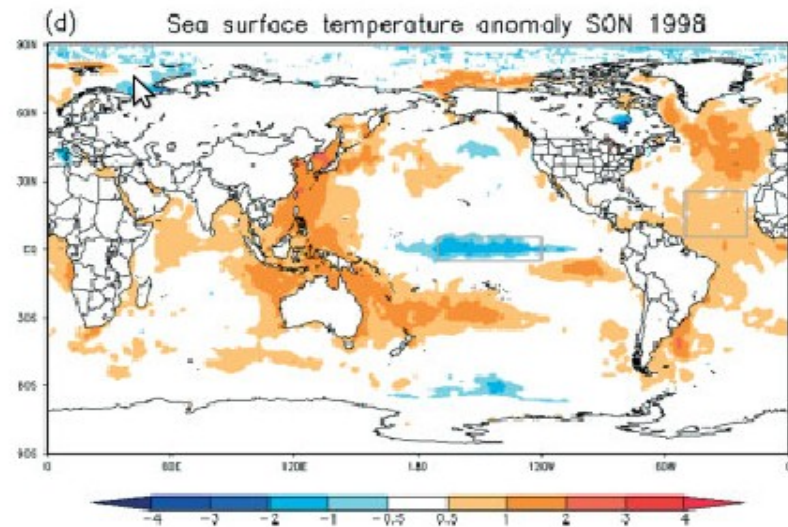
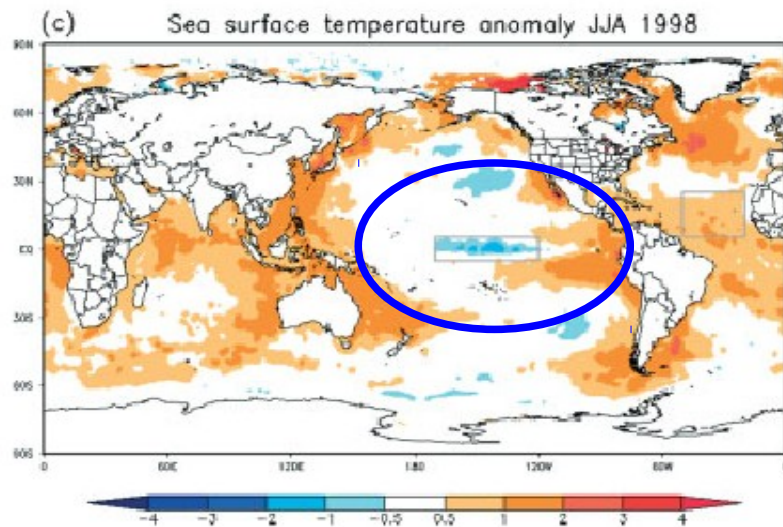
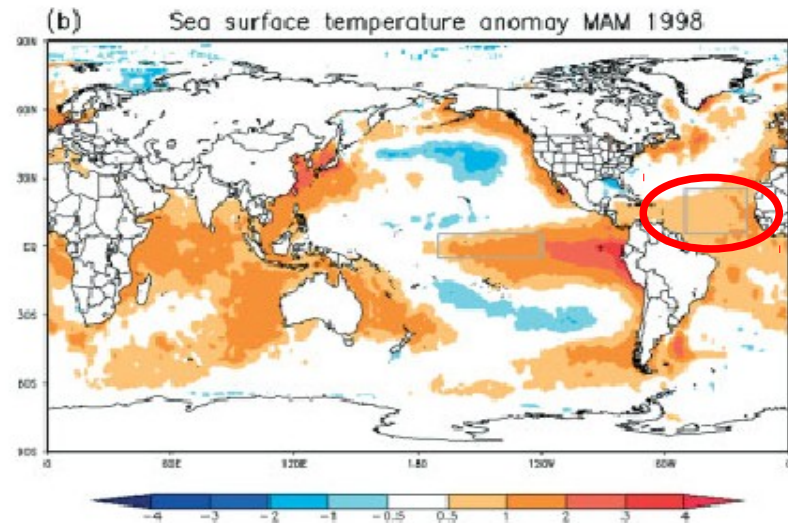
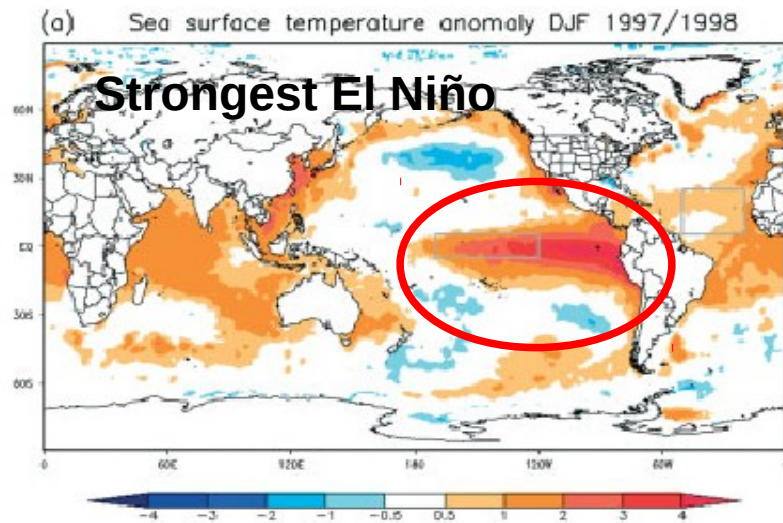
Negro river level annual cycle (cm) given by the monthly mean river level from June to December. The solid thick line represents the long term 1903–2010 monthly mean annual cycle. The solid thin line is the observed monthly mean river level from June 1997 to December 1998. The dotted line is the observed monthly mean river level from June 2004 to December 2005. The dashed line is the observed monthly mean river level from June 2009 to December 2010

Monthly (January to December, panels (a) to (l)) mean Negro River level (cm) time series for the period 1903–2010. The dashed horizontal lines are the 1903–2010 long term means. The smooth solid blue curves are the long term trends that represent decadal variability. The horizontal solid lines are the 7.5th quantiles of monthly mean river level values (black dots). The red solid lines in panels (j) to (l) are the 1976–2010 linear trends for October, November and December. The p-values for the null hypothesis of no trend are 0.10, 0.02 and 0.07 for October, November and December, respectively





Teleconnection maps given by the simultaneous correlation for the period 1903–2010 between Negro monthly mean river levels and sea surface temperature (Rayner *et al.*, 2003) for all 12 months of the years (panels (a) to (l)). Both linear time trends in river level and sea

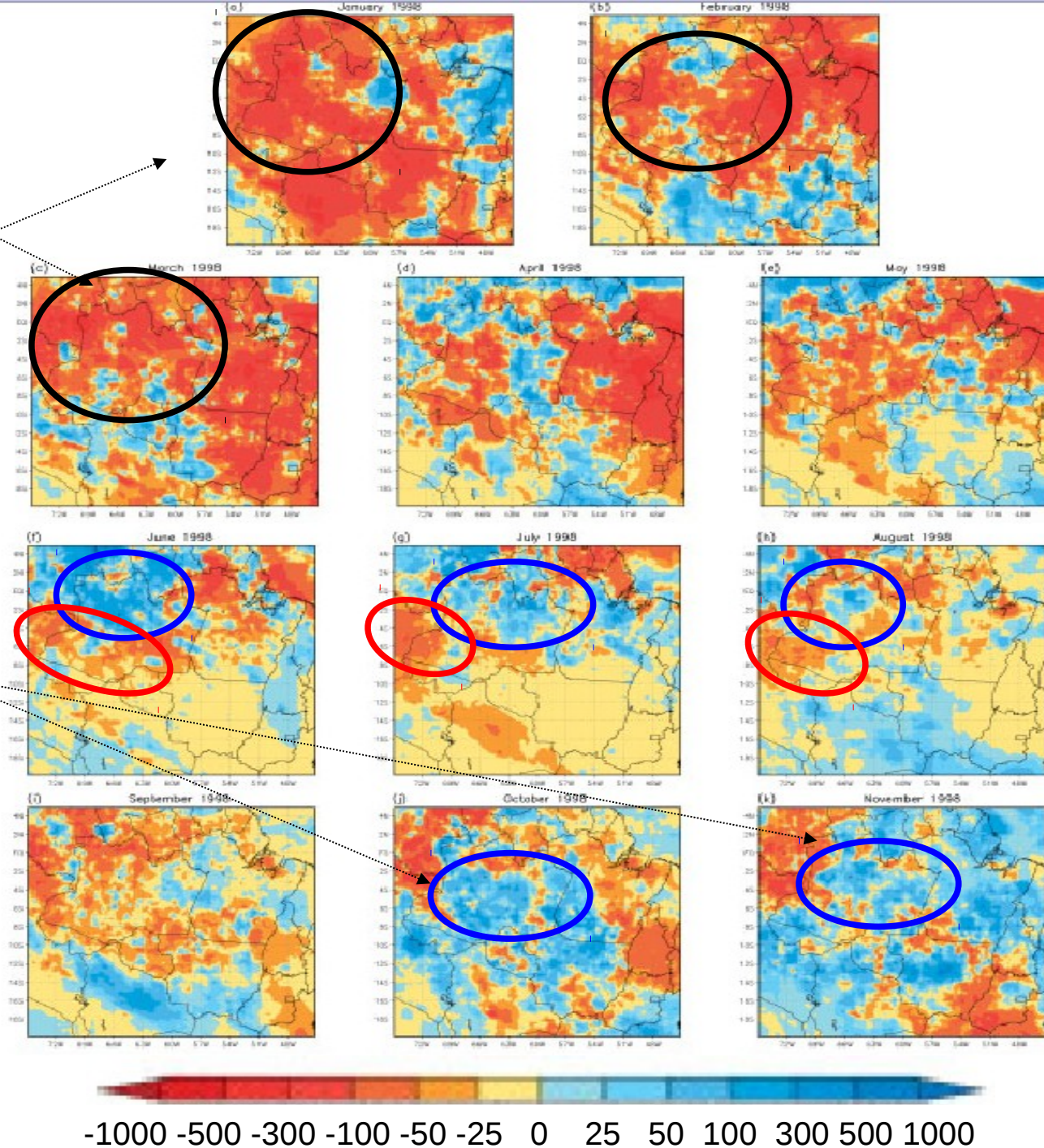


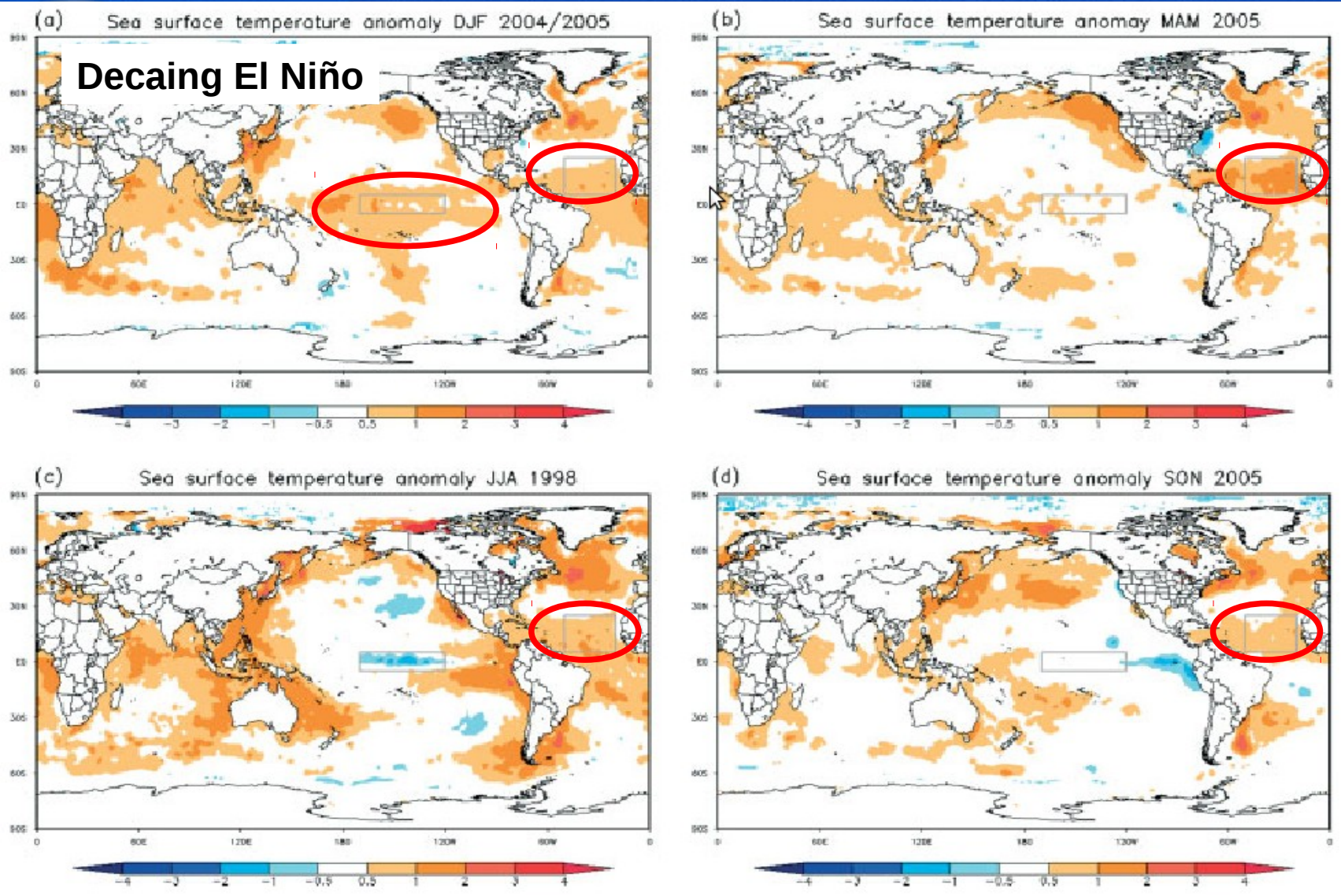
Observed sea surface temperature (Rayner et al., 2003) anomalies during (a) December, January, February 1997–1998, (b) March, April, May 1998, (c) June, July, August 1998 and (d) September, October, November 1998. Anomalies are computed with respect to the 1933–1996 long term mean (climatology). The boxes shown in each panel delimit the Niño-3.4 region (5° N to 5° S, 120° – 170° W) in the Pacific and the tropical north Atlantic region (5° – 25° N, 20° – 70° W)

Precipitation below normal during wet season

La Niña conditions

Observed precipitation anomalies from January (panel a) to November (panel k) 1998 from high resolution Tropical Rainfall Measuring Mission (TRMM) analysis (Huffman et al., 2007). Anomalies are computed with respect to the 1998–2010 long term mean, excluding the month for which anomaly is computed

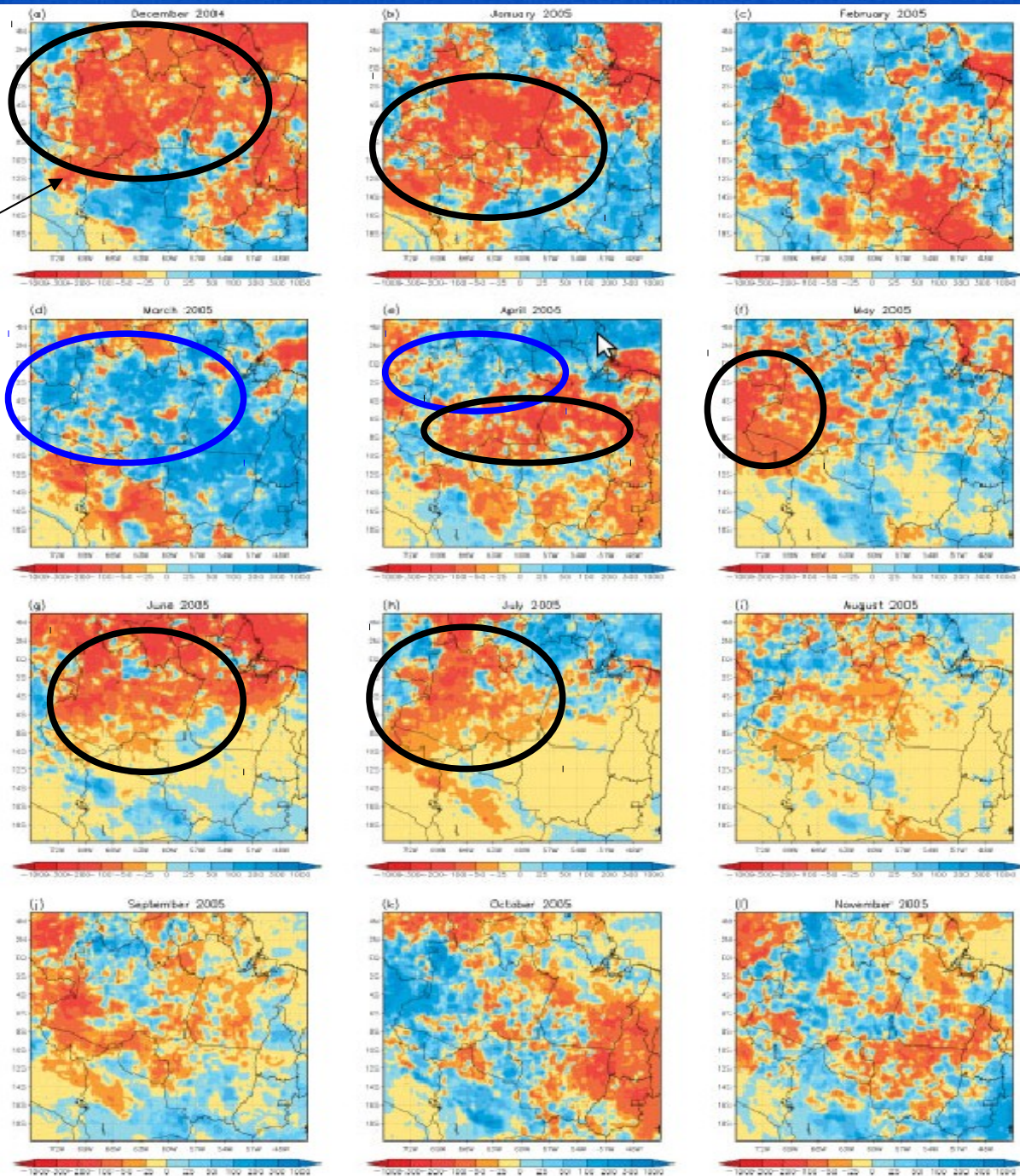


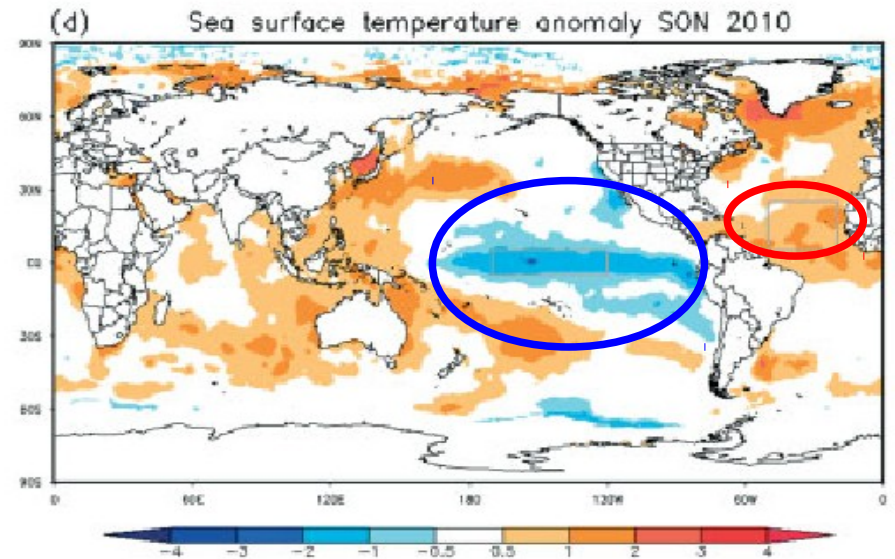
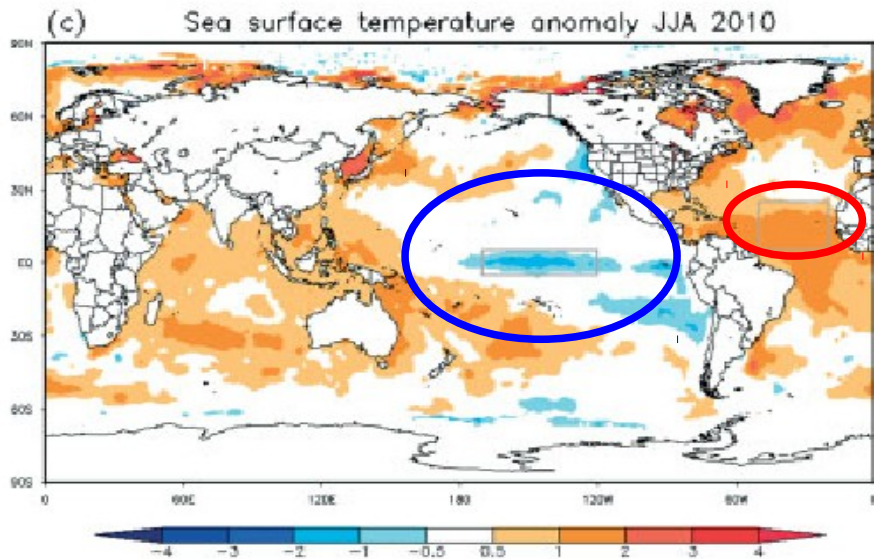
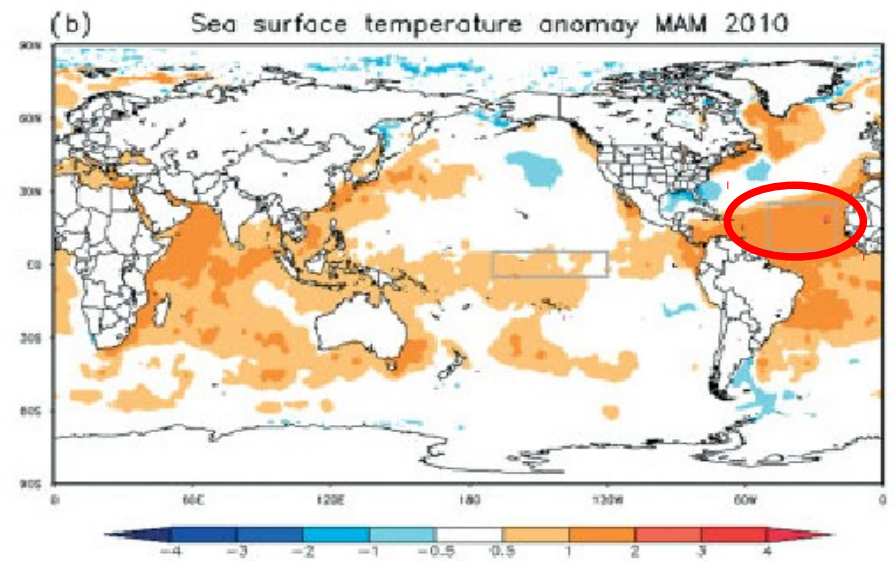
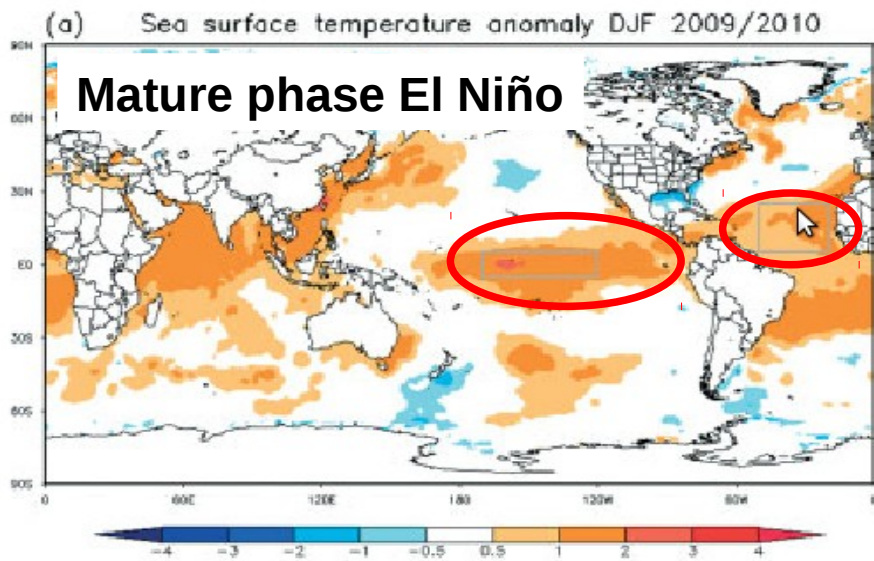


Observed sea surface temperature (Rayner et al., 2003) anomalies during (a) December to February 2004–2005, (b) March to May 2005, (c) June to August 2005 and (d) September to November 2005. Anomalies are computed with respect to the 1903–1996 long term mean (climatology). The boxes shown in each panel delimitate the Niño-3.4 region (5 ° N to 5 ° S, 120–170 ° W) in the Pacific and the tropical north Atlantic region (5–25 ° N, 20–70 ° W)

Precipitation below normal during wet season (El Niño and Atlantic)

Observed precipitation anomalies from December 2004 (panel a) to November 2005 (panel l) from high resolution Tropical Rainfall Measuring Mission (TRMM) analysis (Huffman et al., 2007). Anomalies are computed with respect to the 1998–2010 long term mean, excluding the month for which the anomaly is computed



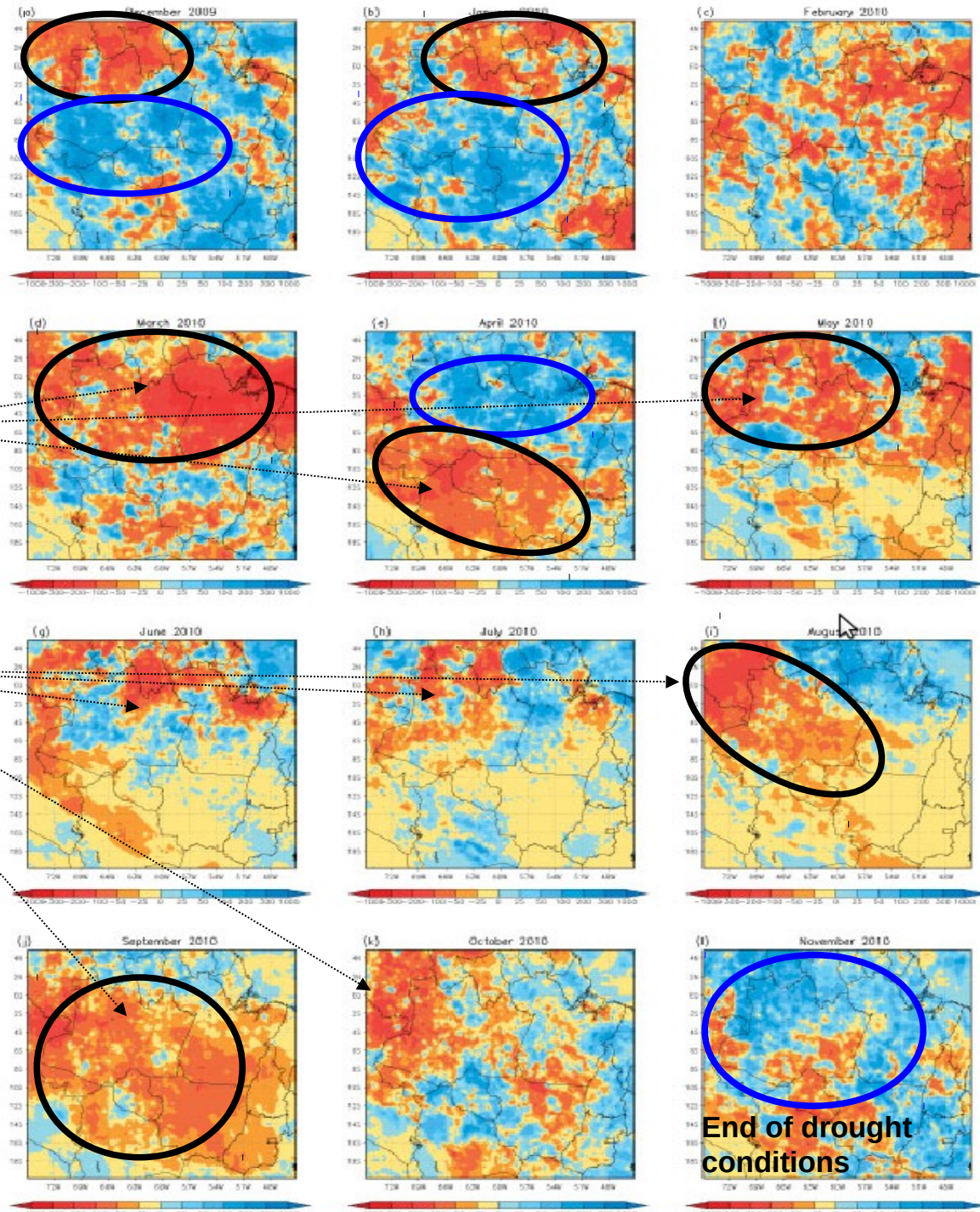


Observed sea surface temperature (Rayner et al., 2003) anomalies during (a) December to February 2009–2010, (b) March to May 2010, (c) June to August 2010 and (d) September to November 2010. Anomalies are computed with respect to the 1903–1996 long term mean (climatology). The boxes shown in each panel delimitate the Niño-3.4 region (5° N to 5° S, 120–170° W) in the Pacific and the tropical north Atlantic region (5–25° N, 20–70° W)

Establishment of drought pattern due to expansion and amplification in magnitude of SSTA in Tropical North Atlantic

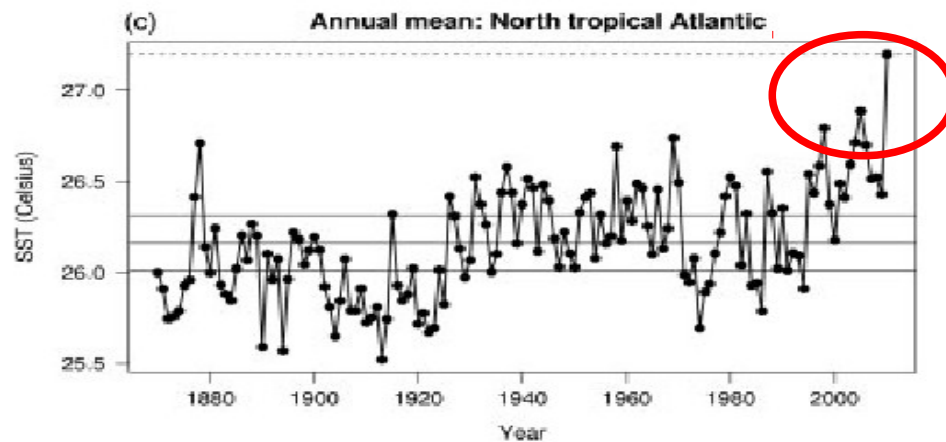
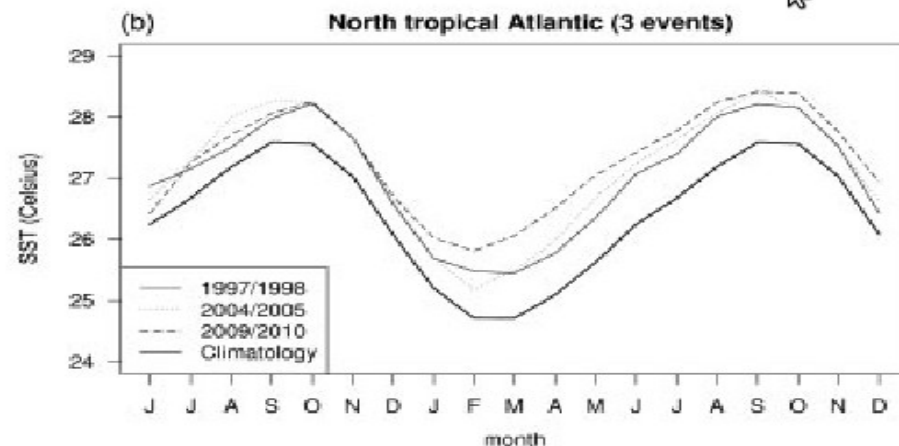
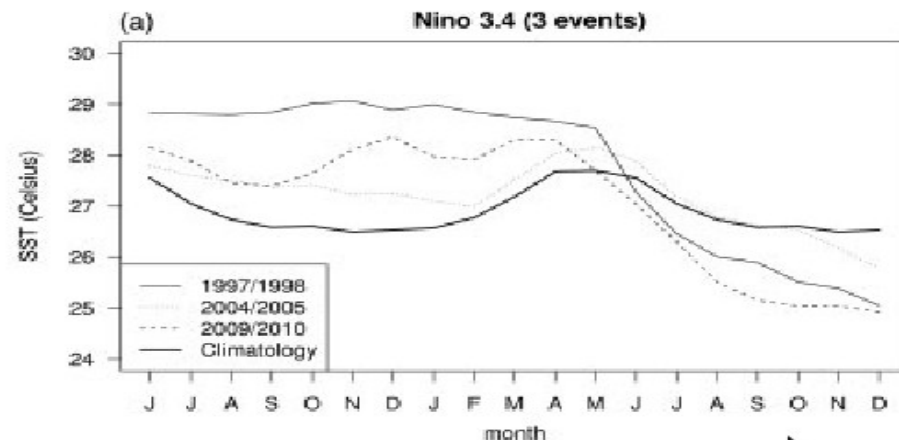
Atlantic conditions prevailing over La Niña conditions

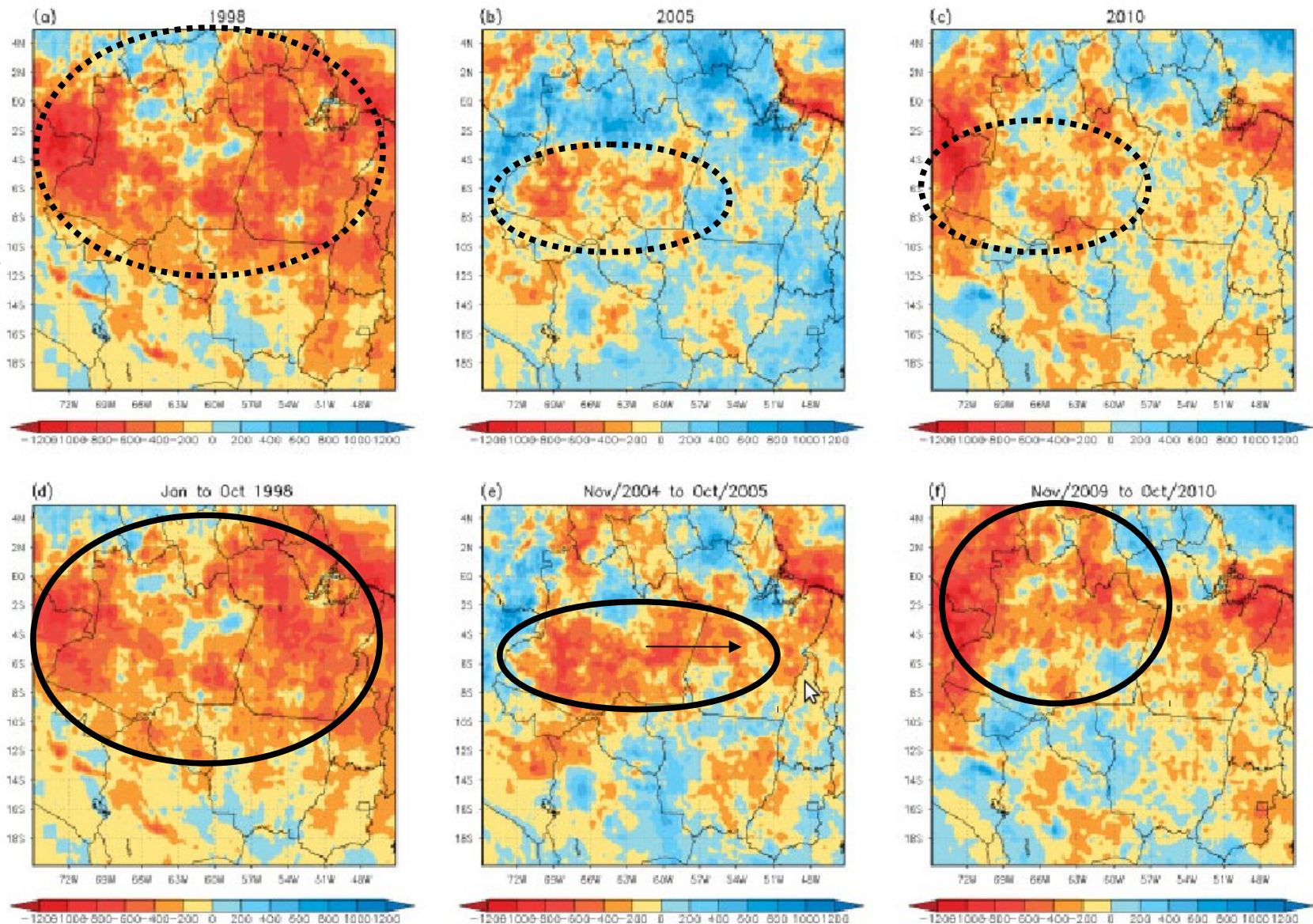
Observed precipitation anomalies from December 2009 (panel a) to November 2010 (panel l) from high resolution Tropical Rainfall Measuring Mission (TRMM) analysis (Huffman et al., 2007). Anomalies are computed with respect to the 1998–2010 long term mean, excluding the month for which anomaly is computed



End of drought conditions

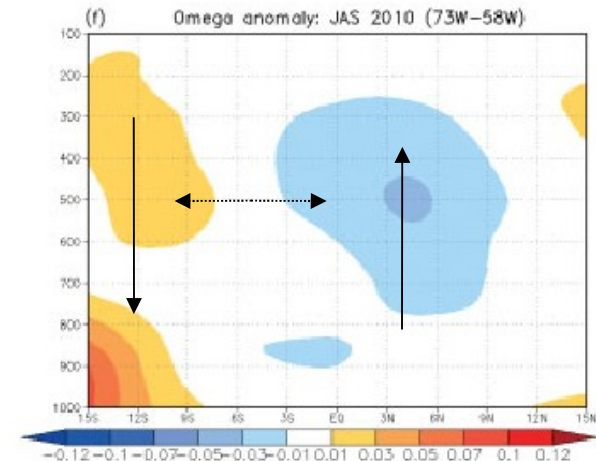
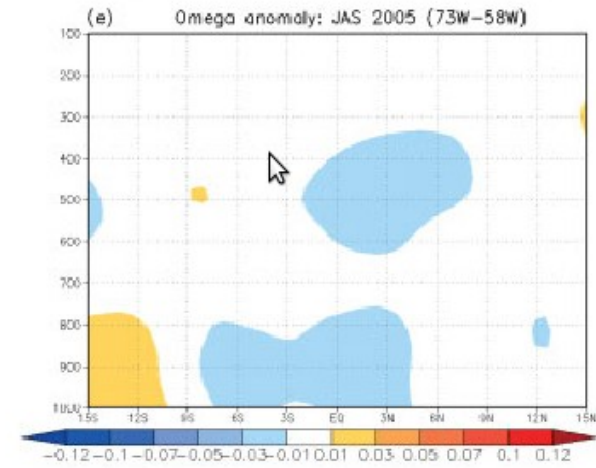
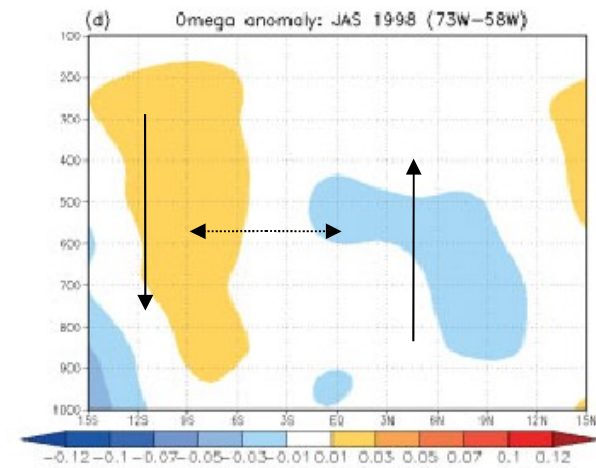
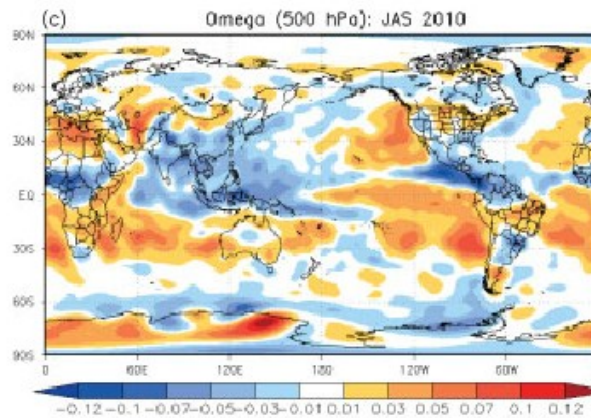
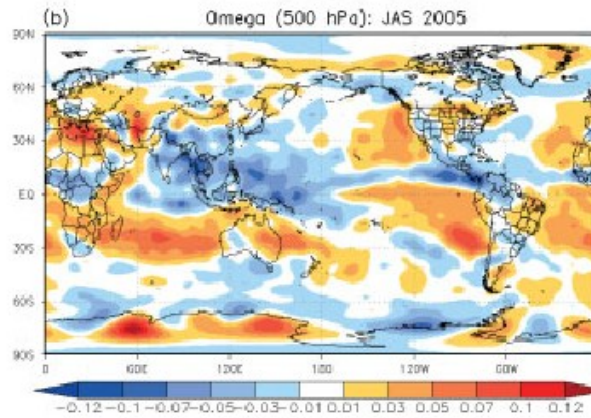
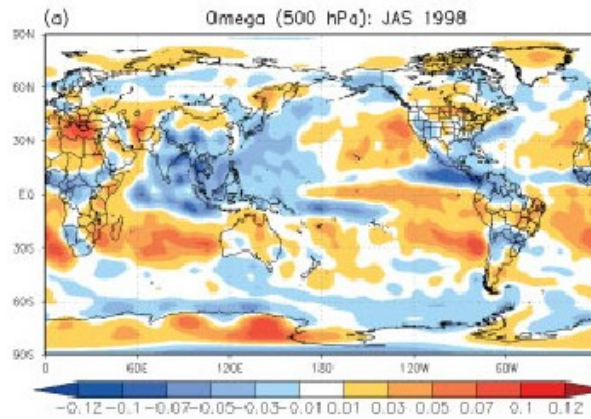
Observed monthly evolution of (a) Niño 3.4 index (average over 5°N to 5°S, 120–170°W) and (b) tropical north Atlantic (average over 5–25°N, 20–70°W) sea surface temperatures (Rayner *et al.*, 2003) for the 1997–1998 (solid thin line), 2004–2005 (dotted line) and 2009–2010 (dashed line). The 1903–1996 climatology is shown with a solid thick line. (c) Time series of annual mean north tropical Atlantic sea surface temperature. The central horizontal solid line is the long-term (1870–2010) annual mean climatology of 26.16°C. The other two solid horizontal lines represent the upper and lower terciles of 26.31 and 26.01°C, respectively. The dashed horizontal line is the value of 27.20°C measured in 2010.



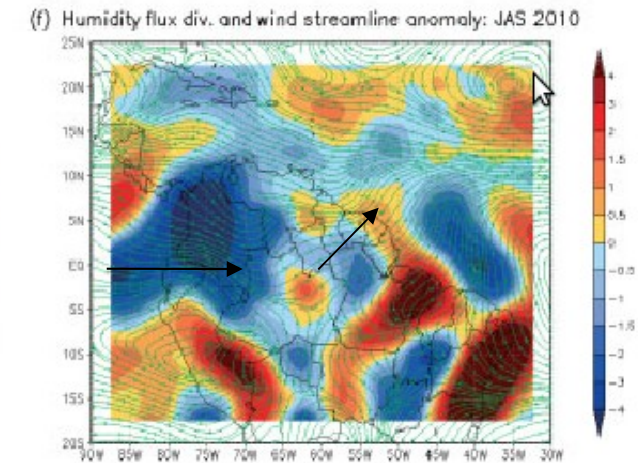
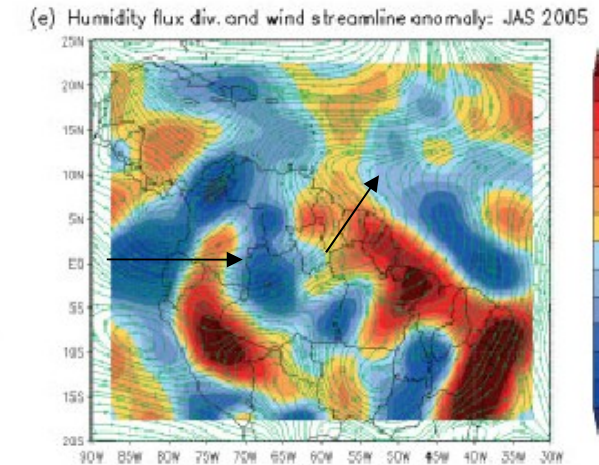
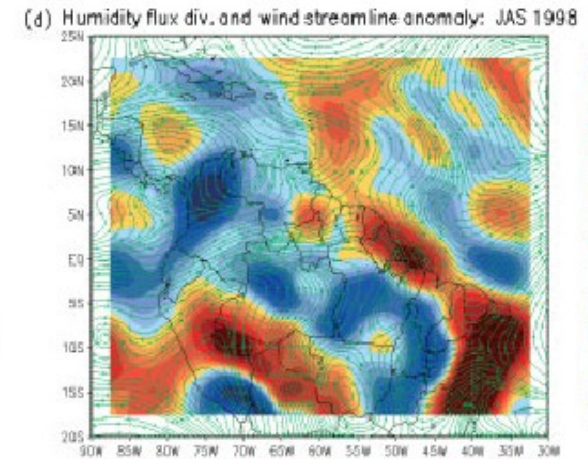
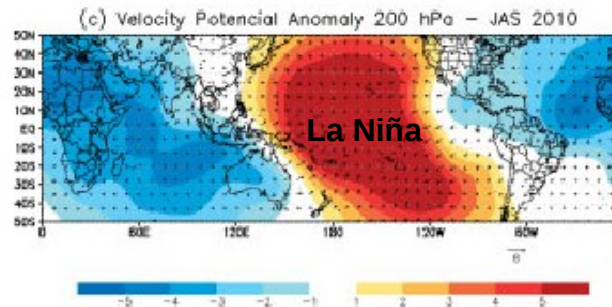
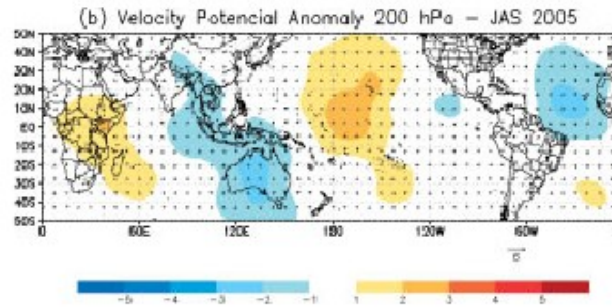
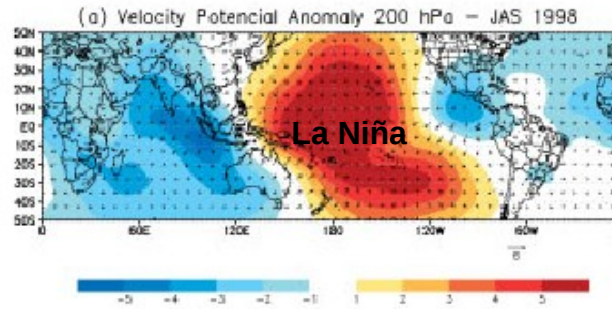
Calendar
yearAnnual
cycle

Observed annual (January to December calendar year) precipitation anomalies for (a) 1998, (b) 2005 and (c) 2010 from high resolution TRMM analysis (Huffman *et al.*, 2007). Anomalies for the period from November of the previous year to October of the current year, i.e. November 2004 to October 2005 for the 2004–2005 event are shown in (e) and for November 2009 to October 2010 for the 2009–2010 event in (f). Panel (d) shows anomalies for the period from January to October 1998 as TRMM precipitation data is only available from January 2008. Anomalies are computed with respect to the 1998–2010 long term mean, excluding the year for which anomaly is computed.

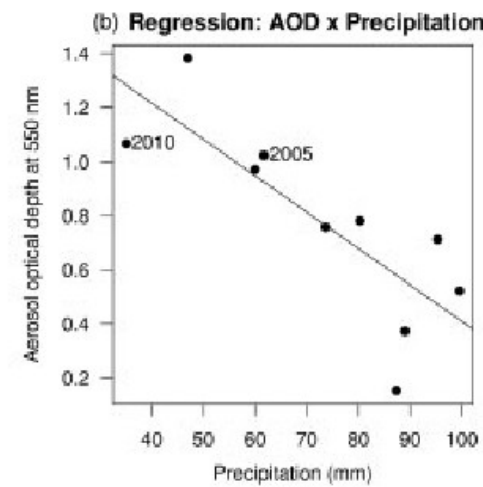
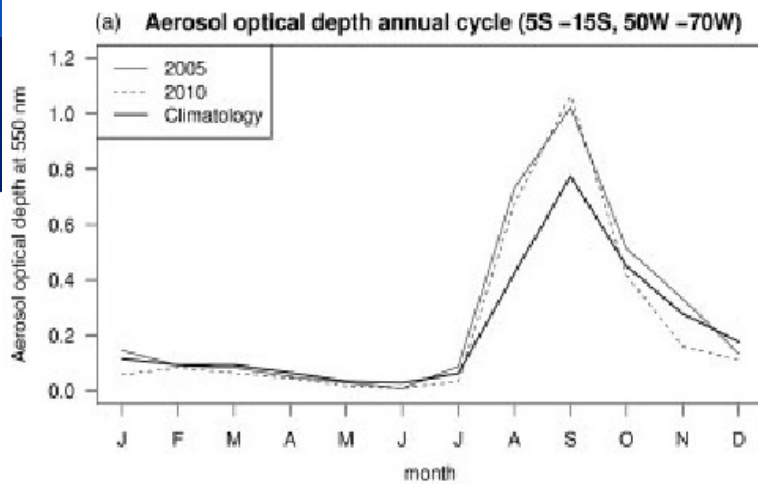
Seasonal mean July to September vertical velocity (omega) (Pa s^{-1}) at 500 hPa for (a) 1998, (b) 2005 and (c) 2010 (Kalnay et al., 1996; Kanamitsu et al., 2002). Meridional cross-section of vertical velocity anomalies (Pa s^{-1}) for the longitude band $73\text{--}58^\circ \text{W}$ from 1000 to 100 hPa for July, August and September (d) 1998, (e) 2005 and (f) 2010. Anomalies are computed with respect to the 1948–2010 climatology



Seasonal mean July to September velocity potential anomalies (106 m² s, shaded) and divergent wind anomalies (m s⁻¹, vectors) at 200 hPa for (a) 1998, (b) 2005 and (c) 2010. Humidity flux divergence (g Kg⁻¹ s⁻¹, shaded) and wind streamline anomalies (green lines) at 850 hPa for July to September (d) 1998, (e) 2005 and (f) 2010



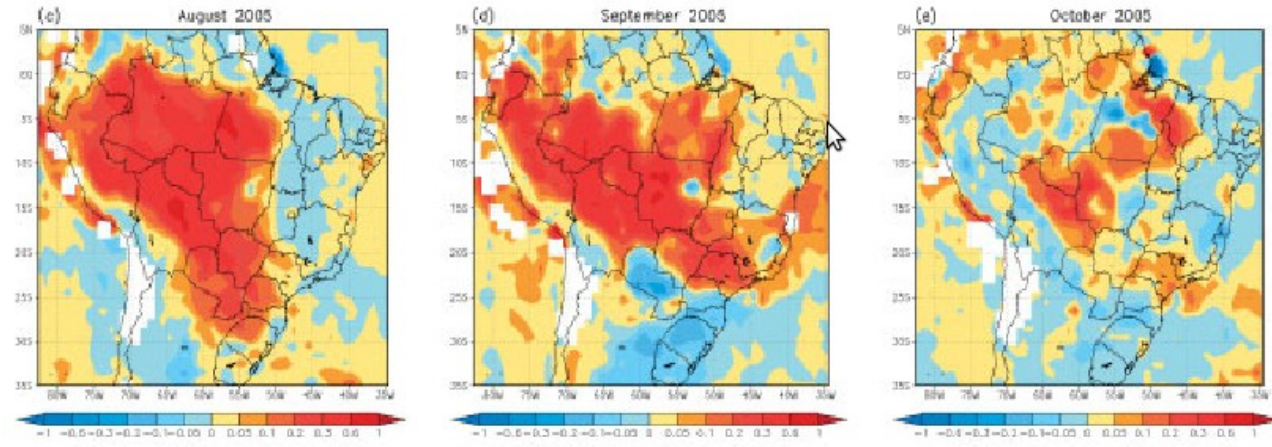
(a) Aerosol optical depth (AOD at 550 nm) annual cycle for region 5–15°S / 50–70°W (MODIS – Terra satellite). Solid thick line is the climatology; solid thin line is annual cycle for 2005 and the dashed line is the annual cycle for 2010



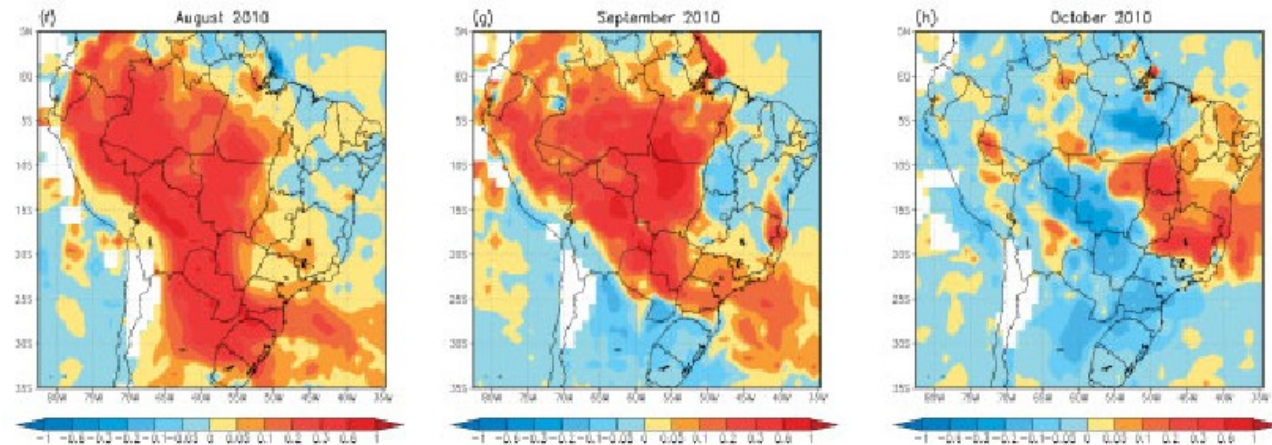
(b) Scatter plot: mean AOD and TRMM precipitation within the region 5–15°S / 50–70°W for September 2001–2010. Black line: regression fit to this sample

Drought events of 2005 and 2010 are indicated in the scatter plot.

Panels (c–e): AOD anomalies for August, September and October 2005



Panels (f–h): AOD anomalies for August, September and October 2010



2001–2010 climatology, excluding the month for which anomaly is computed

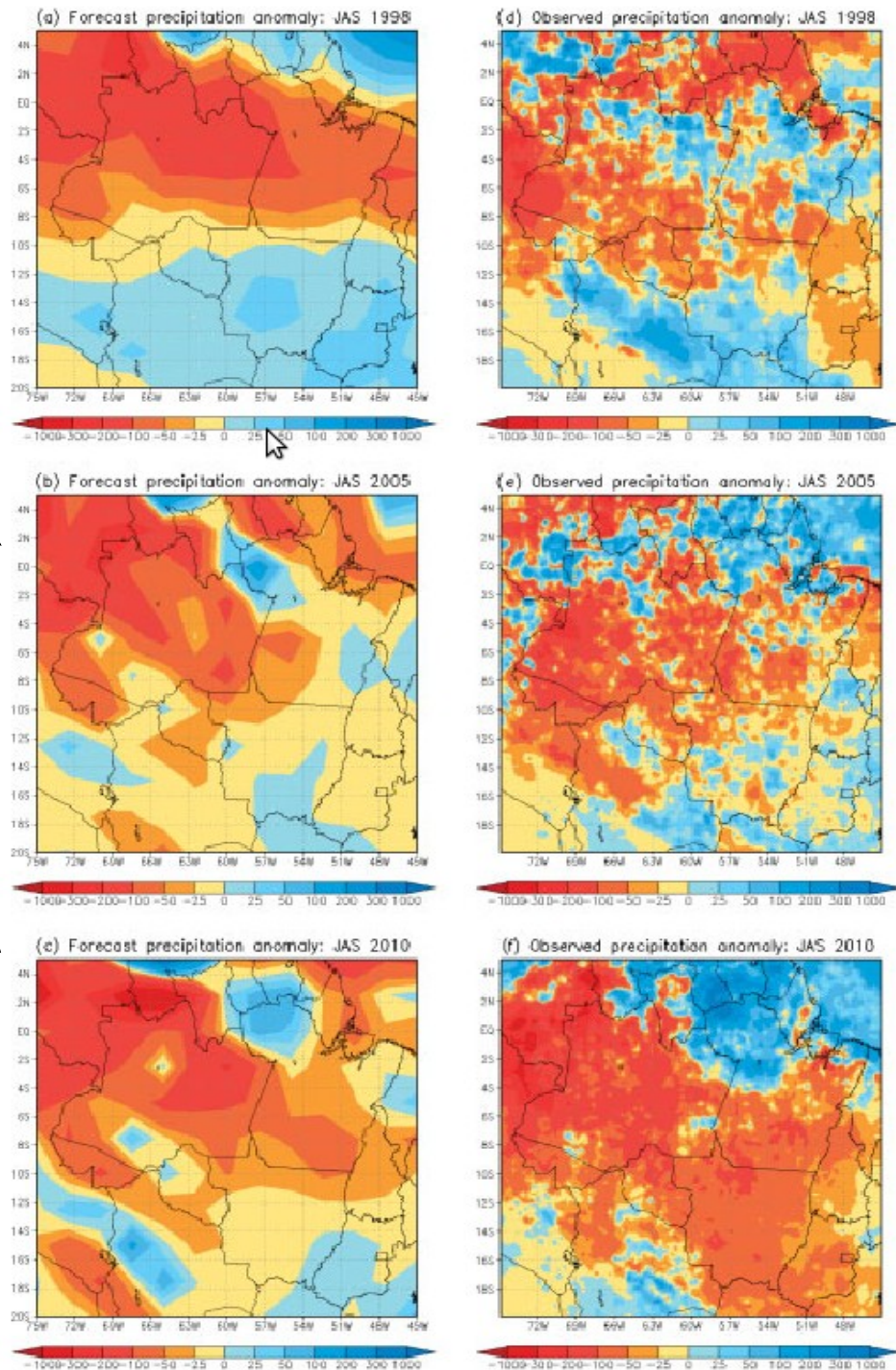
AOD dataset: from NASA GES DISC GIOVANNI system (Acker and Leptoukh, 2007), known as MODIS level-3 monthly mean gridded product at the horizontal regular resolution of 1° in latitude by 1° in longitude

Warning with 1 month in advance

Hindcasts

Real time forecast

Forecast precipitation anomalies (mm) for July, August, September (a) 1998, (c) 2005 and (e) 2010 produced in the previous June with CPTEC/AGCM. Observed precipitation anomalies (mm) for July, August, September (b) 1998, (d) 2005 and (f) 2010 from TRMM analysis (Huffman et al., 2007)



Seca de 2010 – evento extremamente raro, com período de retorno de 24,3 anos

De julho a dezembro, o Oceano Atlântico Norte exerce forte associação negativa com o nível no Rio Negro, em Manaus

De Fevereiro a abril, o Oceano Pacífico na região do Niño 3.4 exerce associação negativa com o nível do Rio Negro

Mudanças nos padrões atmosféricos de grande escala forçados pelos padrões de TSM, afetando padrões de precipitação na Amazônia

Secas de 1997-1998 e 2009-2010 têm características semelhantes com relação ao ENOS

Ambos eventos foram marcados por intensas anomalias de TSM no Atlântico Norte – 2010 foi registrado o recorde de TSM e como consequência, formação de célula de Hadley local

Disponibilidade de umidade em ambos os eventos, mas sem condições dinâmicas para formação de atividade convectiva

Em termos de anomalias de precipitação, evento 1997-1998 foi o mais intenso durante o período úmido de monção; evento de 2004-2005 mais intenso entre julho e setembro, e 2009-2010 durante o período tradicionalmente mais seco da monção

Evento de 1997-1998 mais severo em termos de extensão territorial

Efeito do aumento da quantidade de aerossóis na atmosfera de agosto a setembro pode contribuir para a diminuição da eficiência de precipitação

Também, a fumaça decorrente de queimadas atinge o topo da atmosfera e absorve radiação, diminuindo a radiação que chega na superfície – aumento da estabilidade atmosférica

Aumento de aerossóis pode também ser consequência do atraso da estação chuvosa na Amazônia

Habilidade do MCGA/CPTEC na previsão da precipitação de julho a setembro durante eventos de seca foi investigado

Modelo foi capaz de produzir, com 1 mês de antecedência, as condições de seca observadas

Sistema de previsão sazonal é importante ferramenta na tomada de decisões para reduzir efeitos de eventos de seca na Amazônia



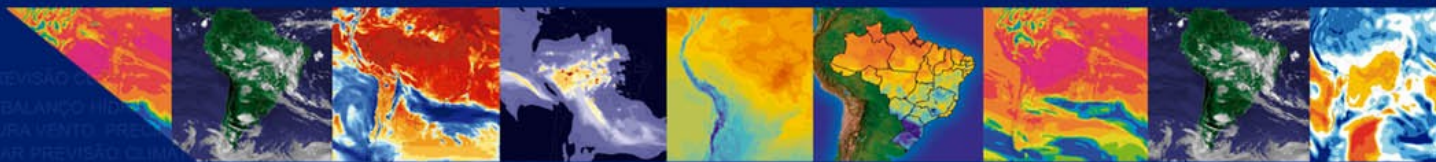
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