MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Escenarios de Cambio Climático: Experiencias en America del Sur

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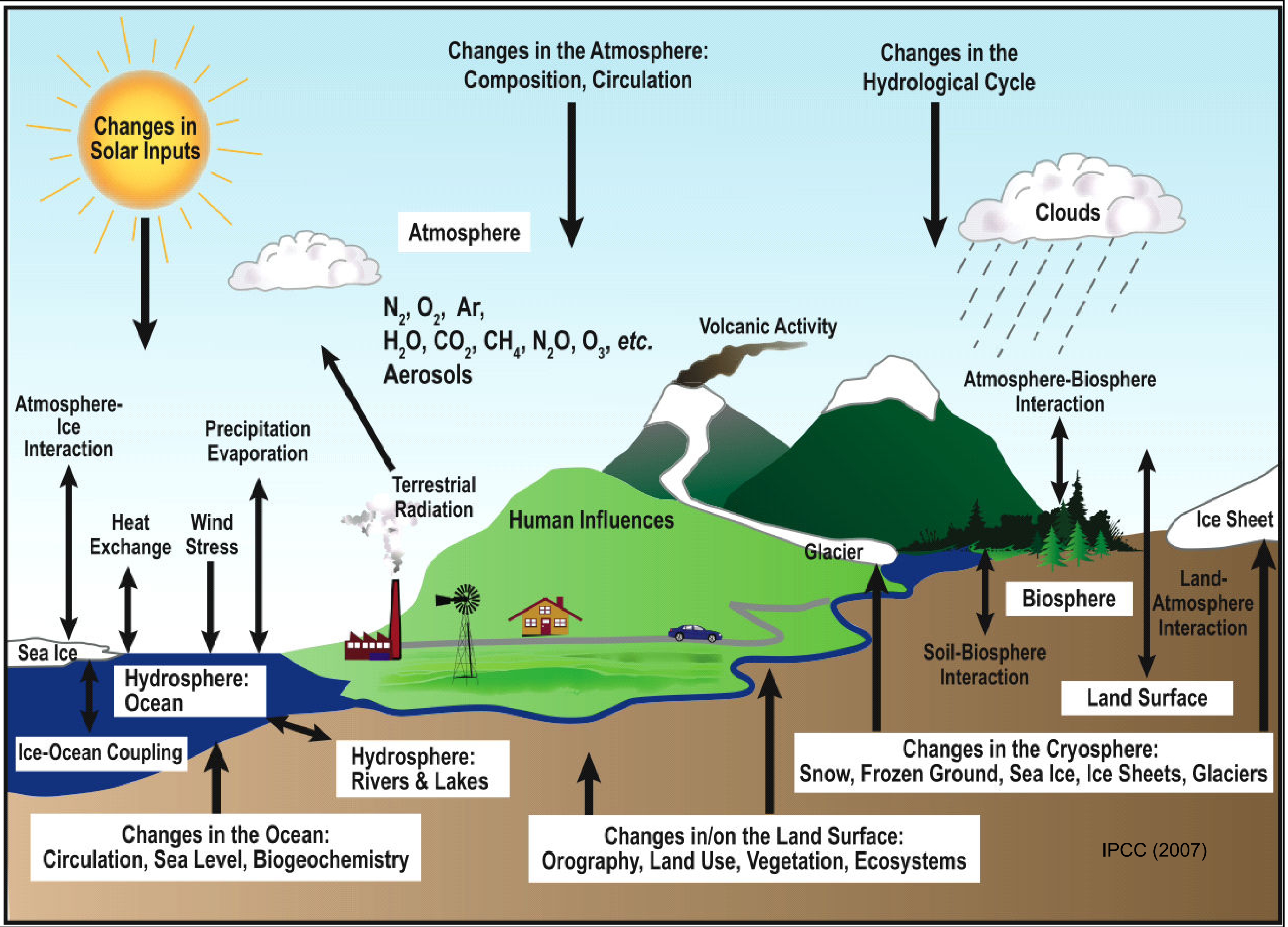
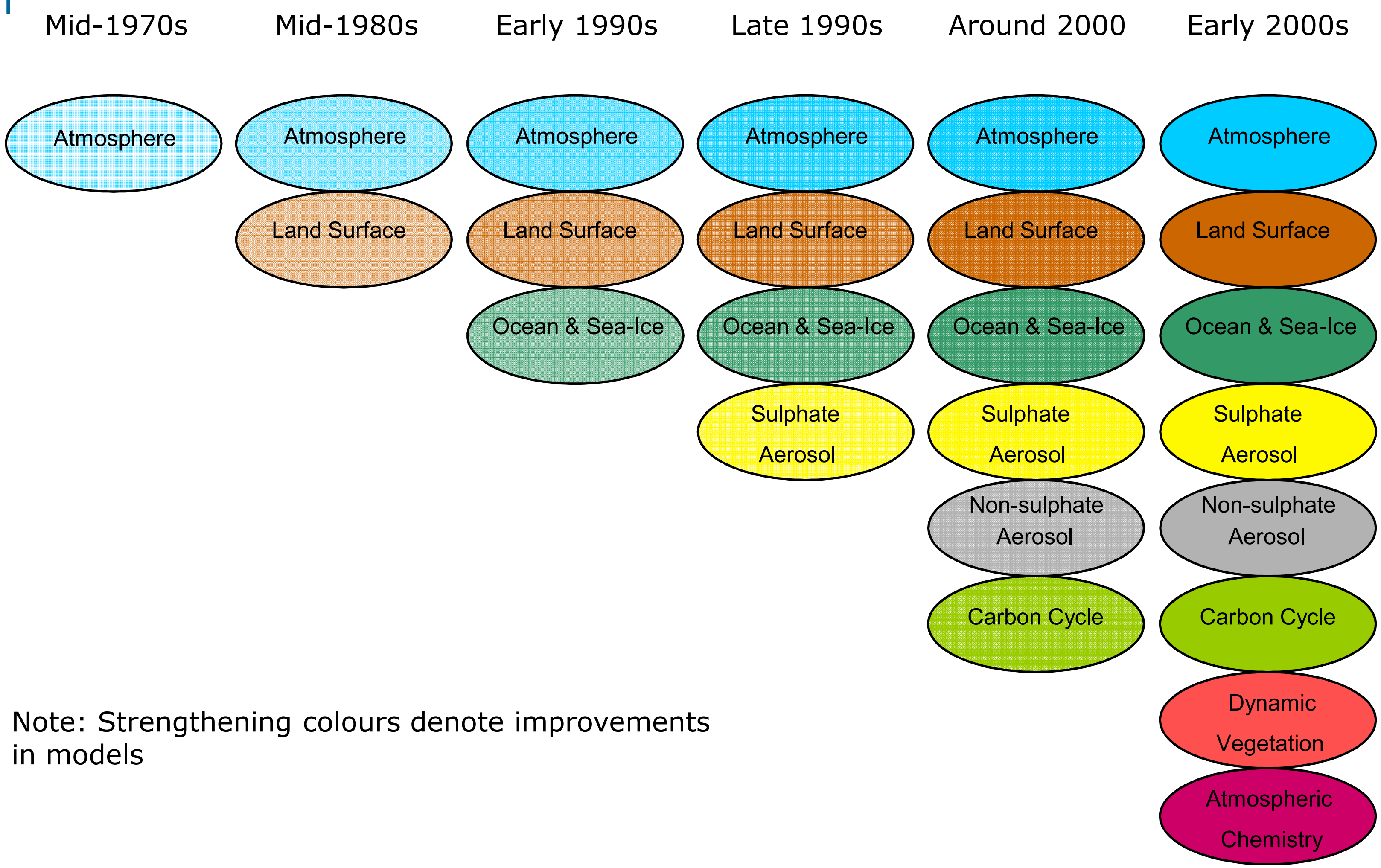
GEF PROBIO Earth System Science Partnership Foreign & Commonwealth Office

O sistema climático



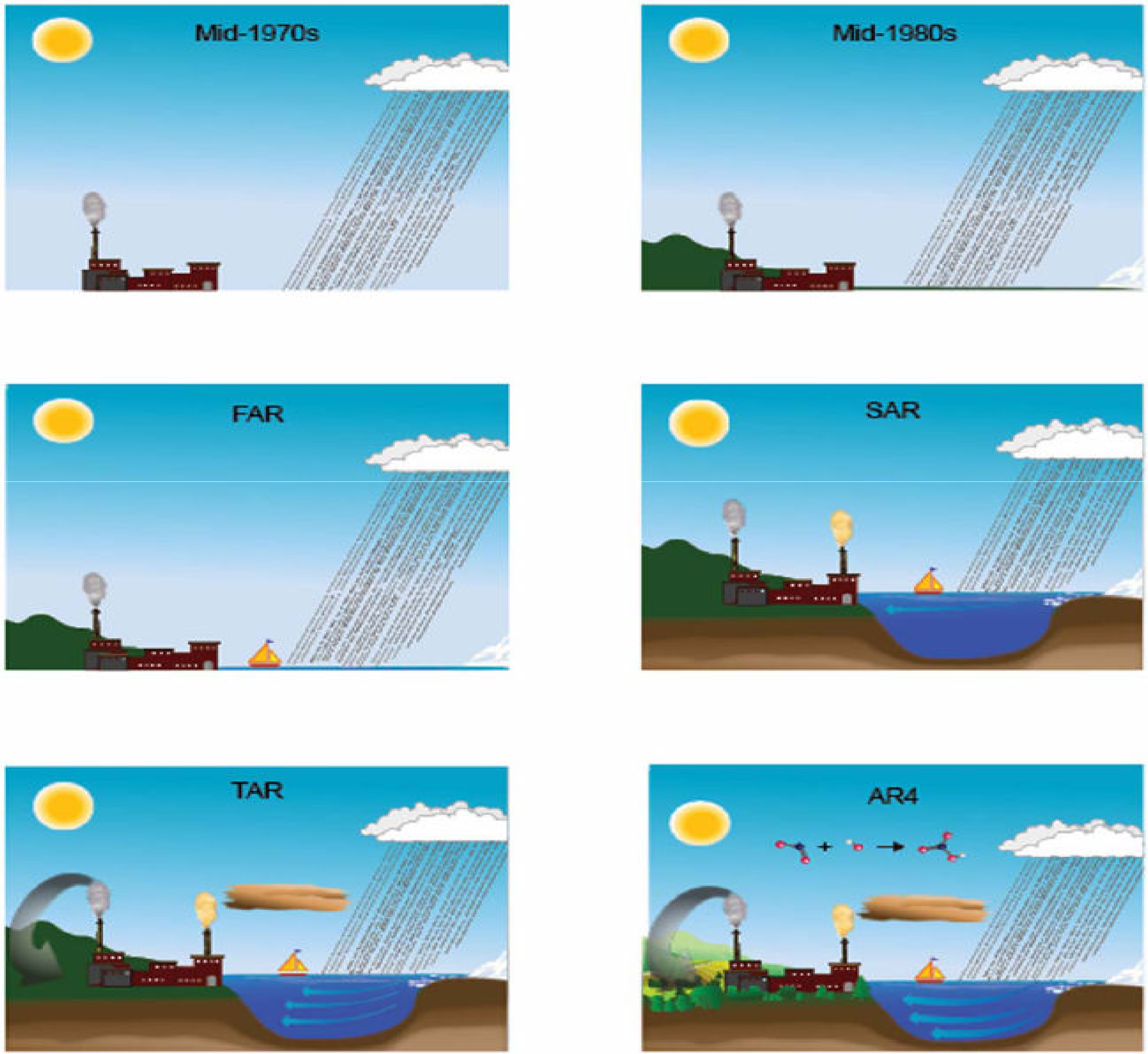
IPCC (2007)

Histórico de desenvolvimento de modelos

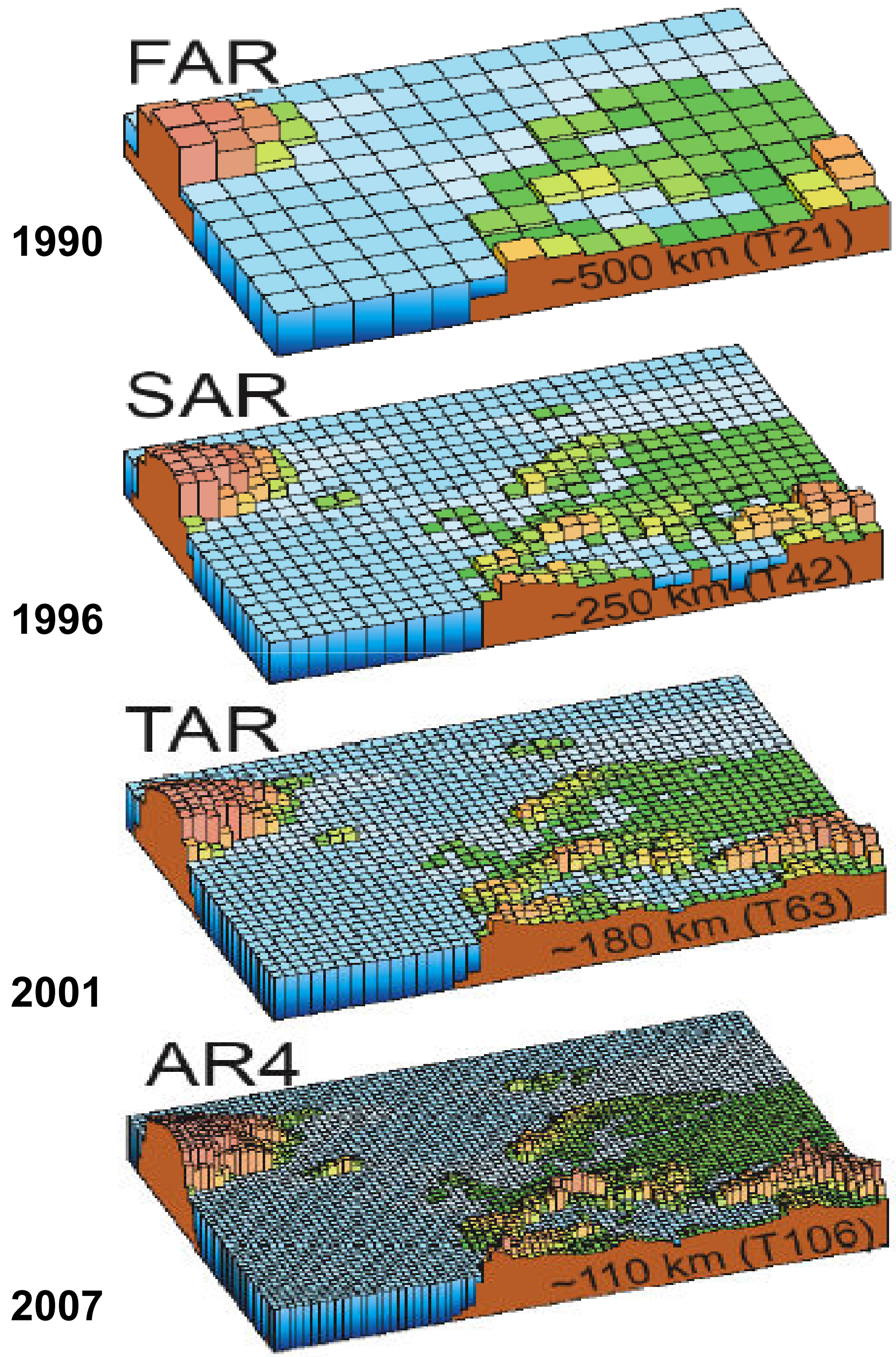


Note: Strengthening colours denote improvements in models

The World in Global Climate Models



The complexity of climate models has increased over the last few decades. This is shown pictorially by the different features of the world included in the models.



Geographic resolution characteristic of the generations of climate models used in the IPCC Assessment Reports: FAR (1990), SAR (1996), TAR (2001), and AR4 (2007). The

CLIMATE CHANGE

There is a generalized consensus among IPCC-AR4 models that precipitation changes projected over South America are mainly:

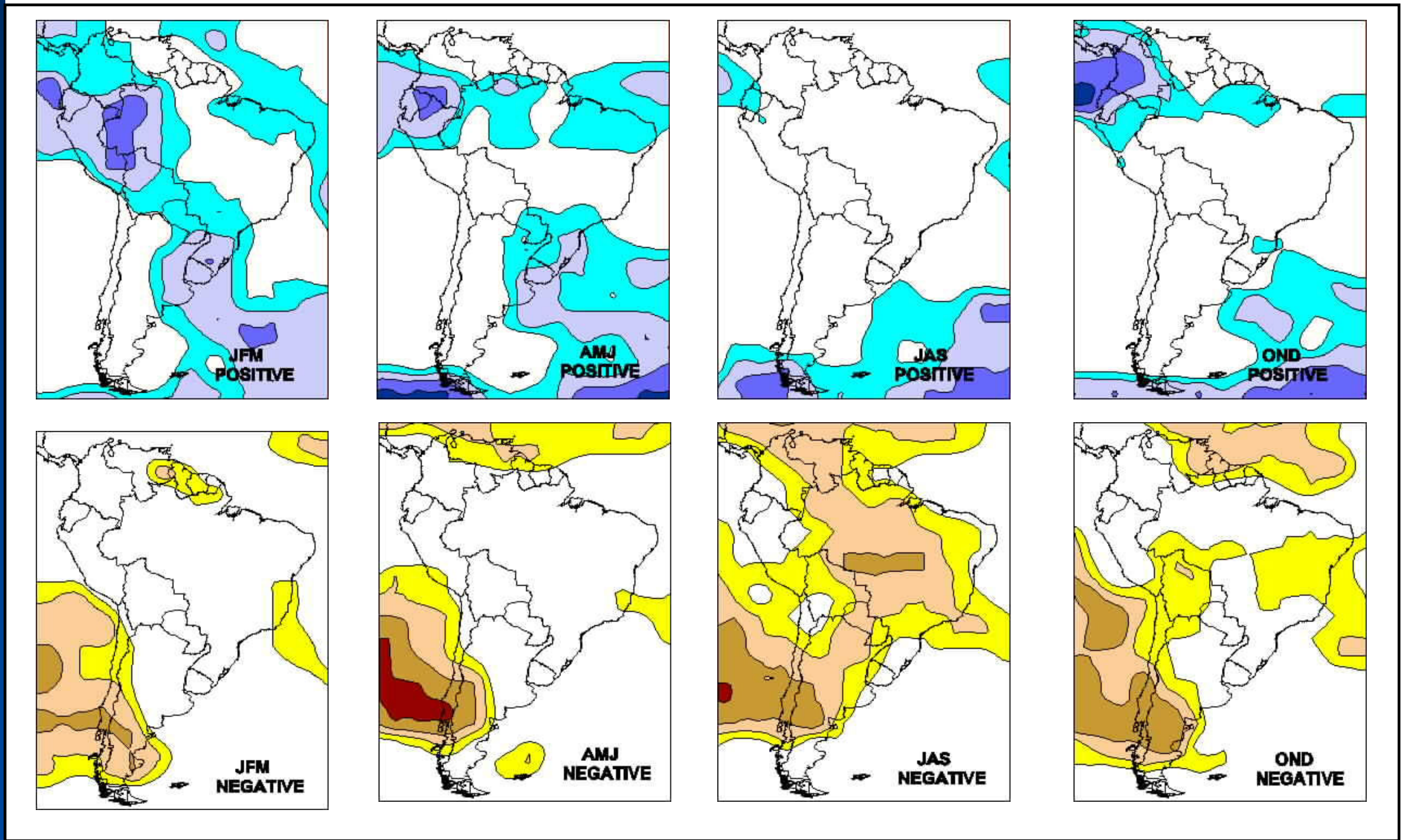
i) Increase of summer precipitation over southeastern subtropical South America and northern Andes;

ii) Reduction of winter precipitation over most of the continent; and

iii) Reduction of precipitation along the southern Andes.

(+)

(-)

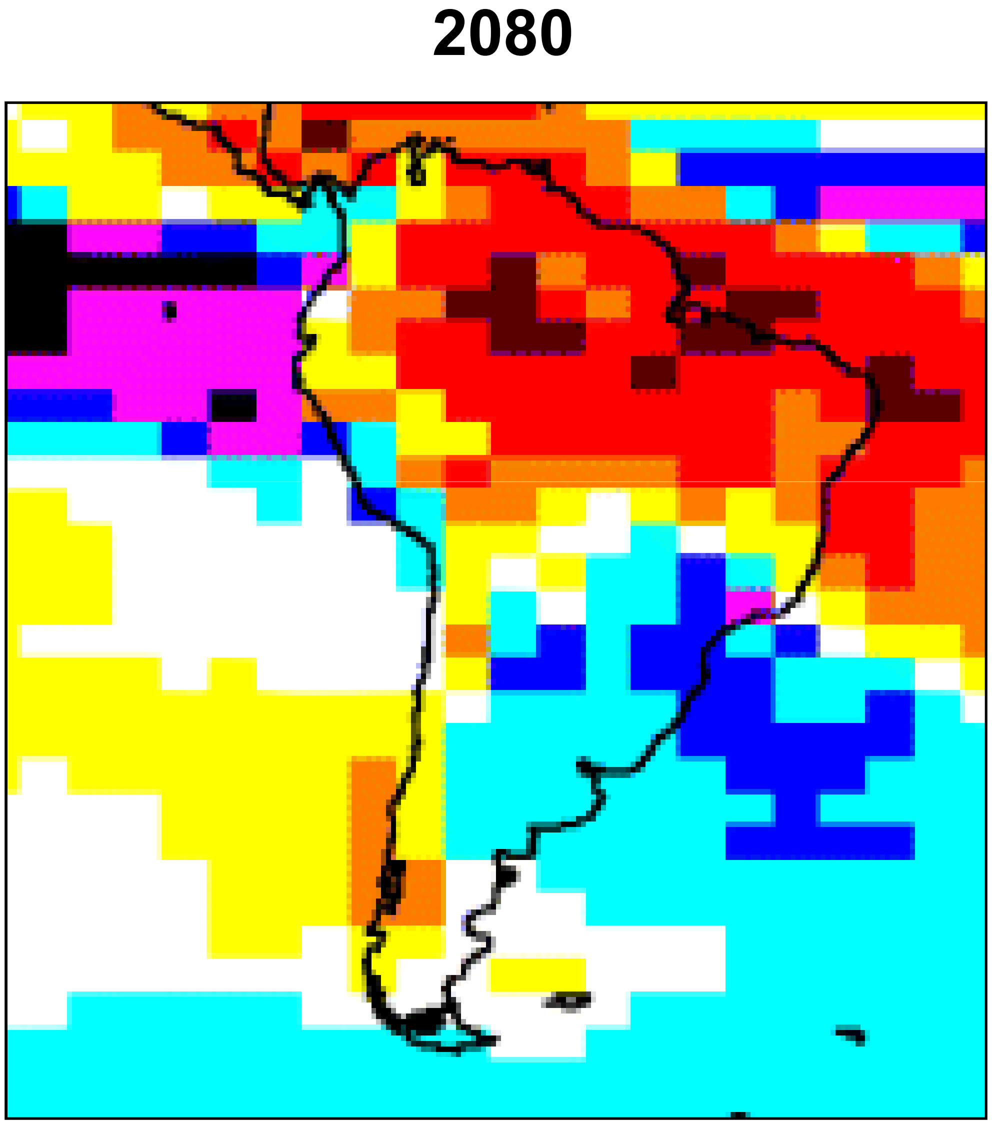


Vera et al. (2006)

Number of models depicting (1st row) positive changes and (2nd row) negative changes between 2070-2099 and 1970-1999 periods. Contour level is 1, values larger than 4 are shaded.

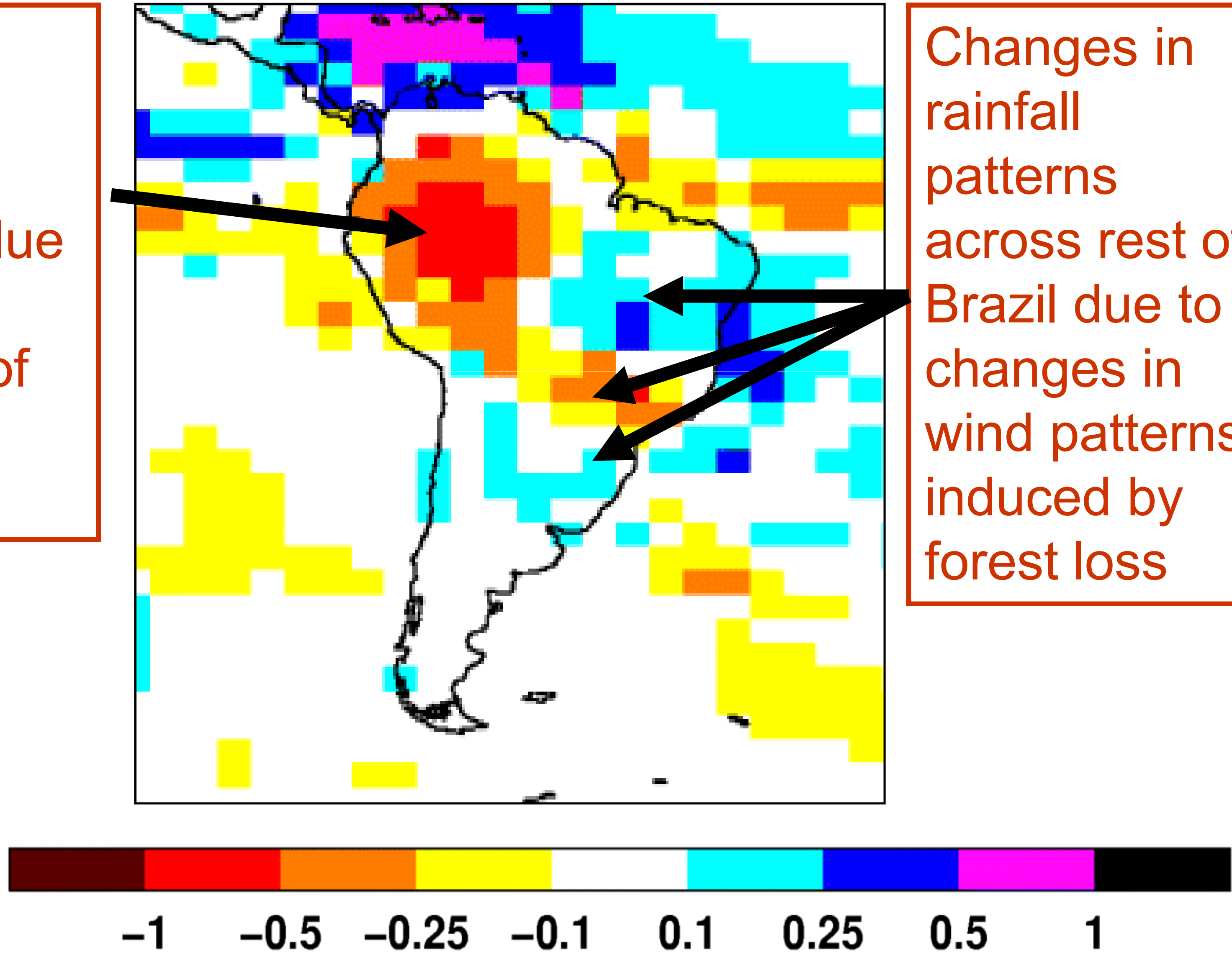
Importance of feedback process for climates across Brazil

- Precipitation changes relative to 2000 (mm day^{-1})
- Global average precipitation (rainfall + snowfall) increases with global warming
- Rainfall declines across northern Brazil due to responses to sea surface temperature changes in Atlantic and Pacific



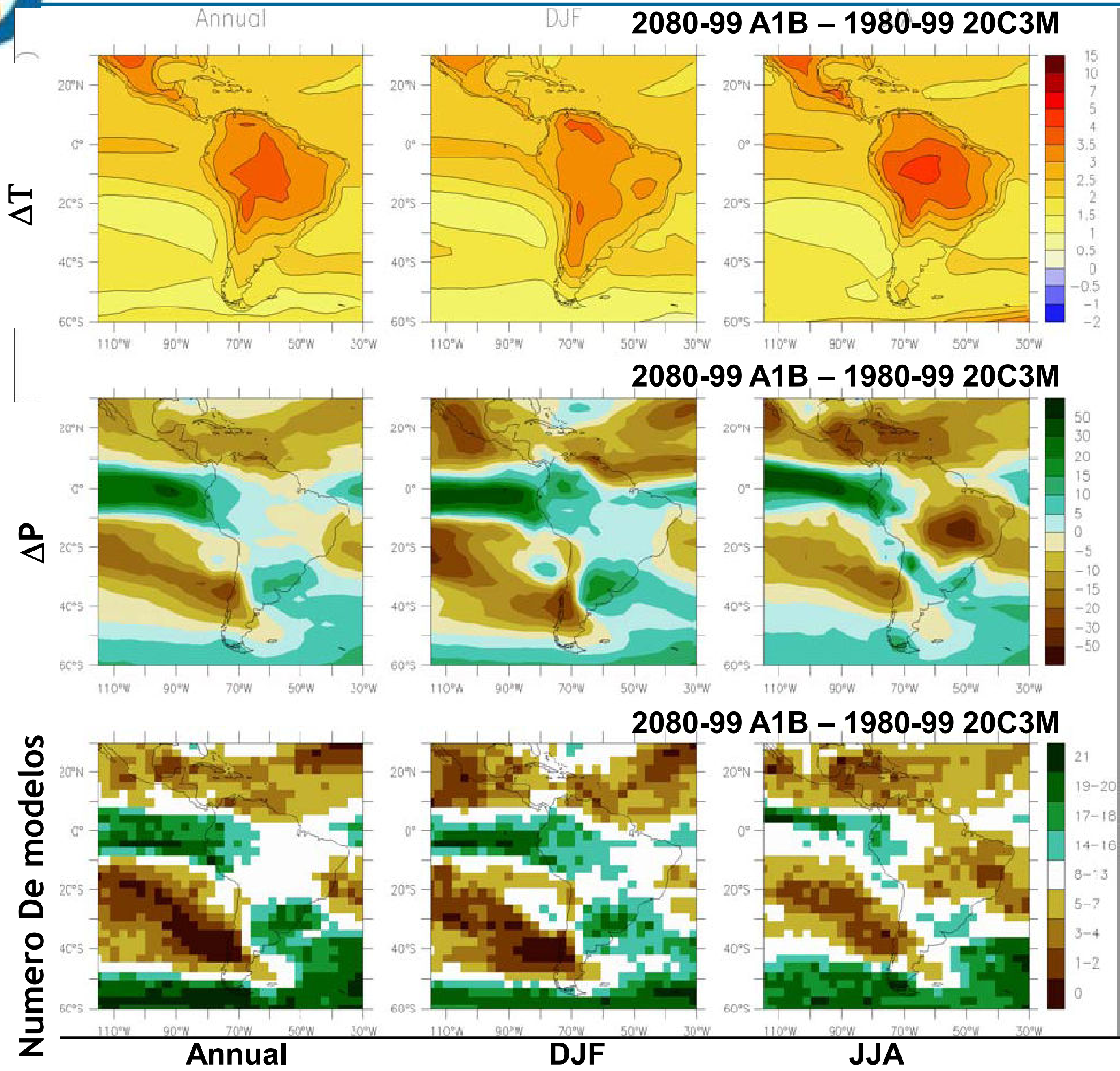
Implications of loss of forests for Brazilian climate

Further reduction in rainfall in Amazonia due to reduced “recycling” of water after forest loss



Changes in rainfall patterns across rest of Brazil due to changes in wind patterns induced by forest loss

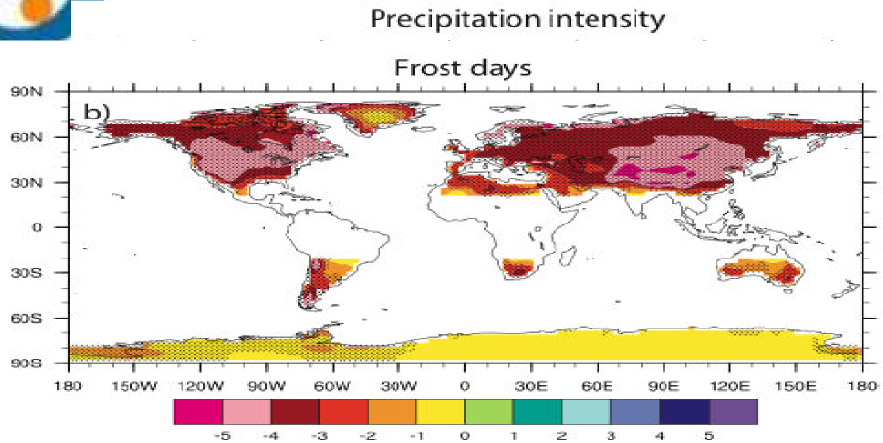
Rainfall change (mm day-1) due to forest changes

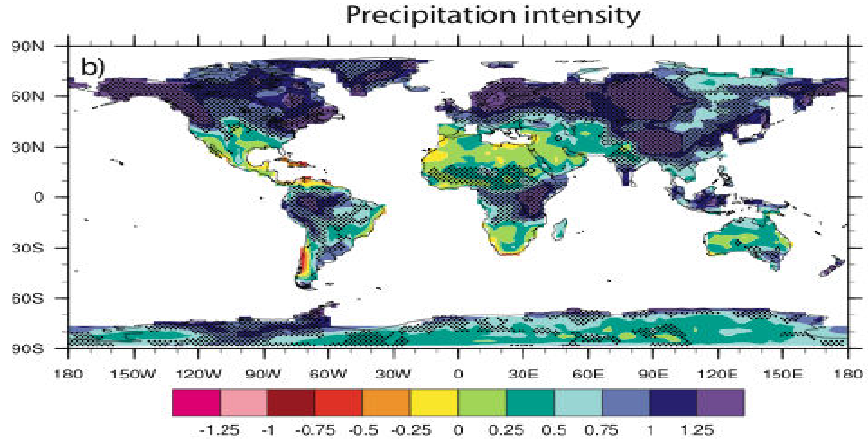


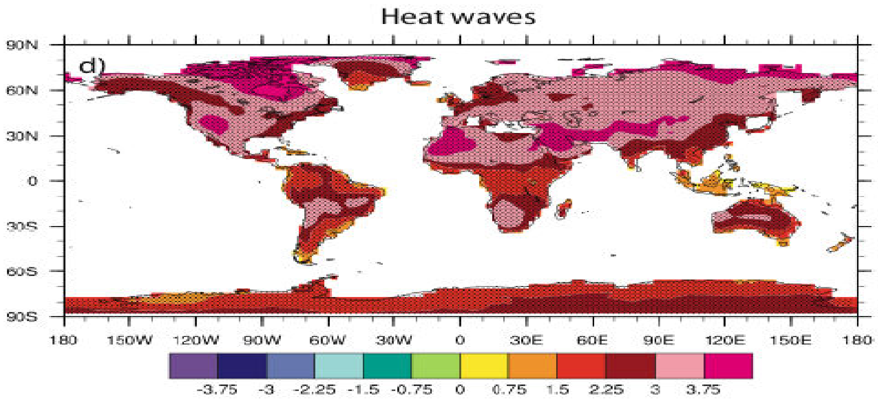
Consensus AR4 GCM A1B temperature and precipitation changes over Central and South America. Top row: Annual mean, December-January-February, and June-July-August temperature change between 1980–1999 in the 20C3M simulations and 2080-2099 in A1B, averaged over 21 models. Middle row: same for fractional change in precipitation. Bottom row: number of models out of 21 that project precipitation to increase.

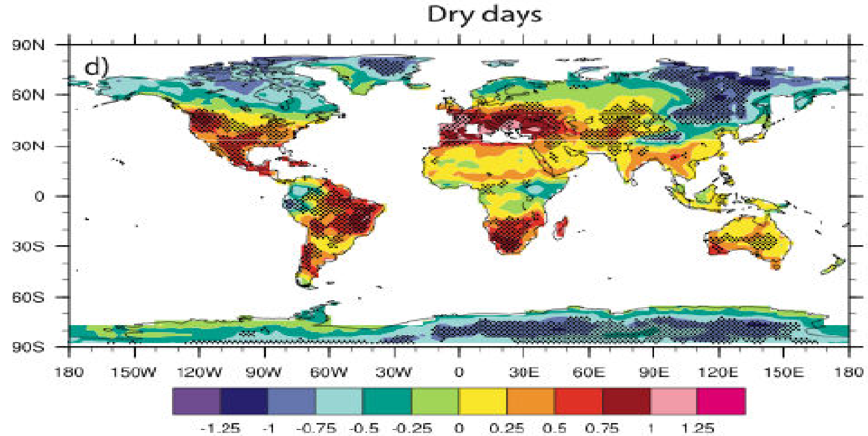
Chapter 11

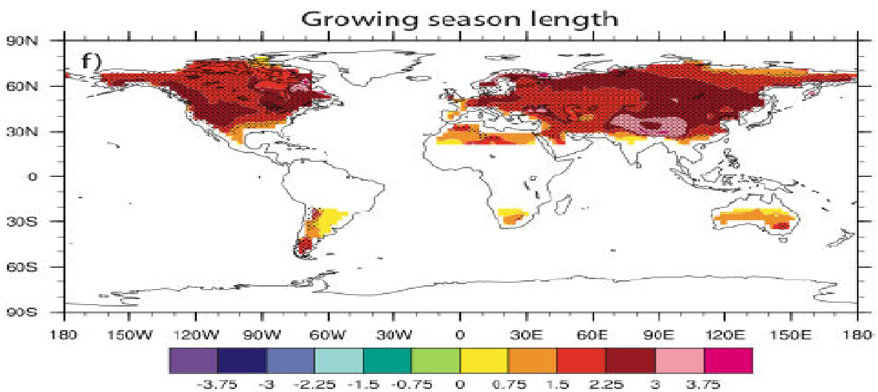
Proyecciones de extremos climáticos hasta 2100











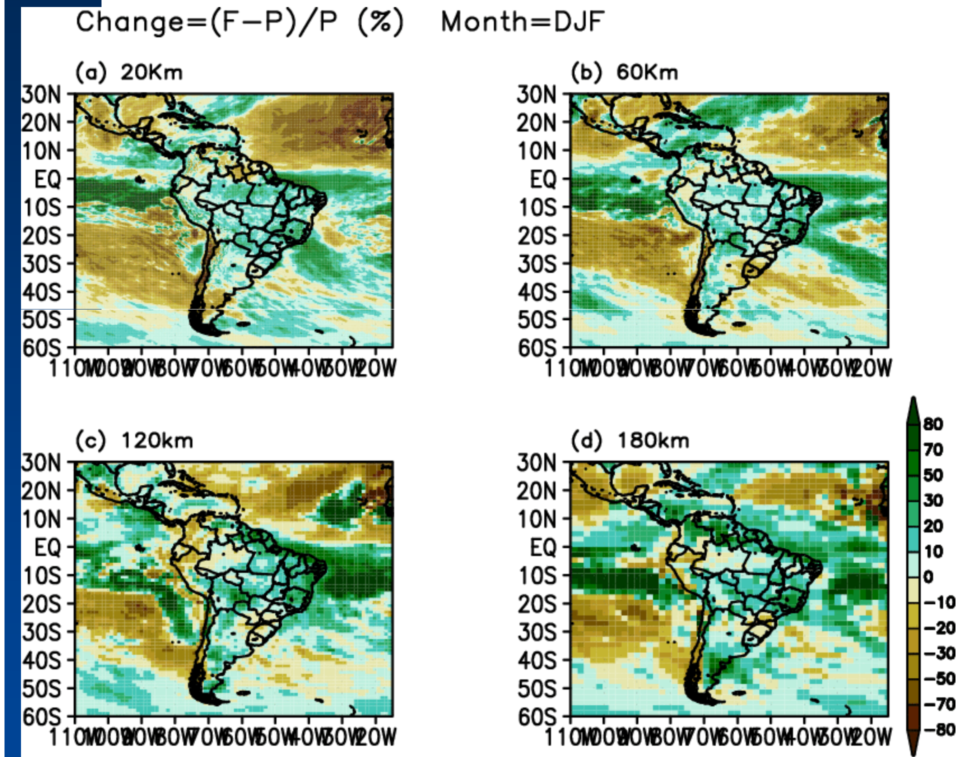
Cambios en la tendencia de indices extremos de temperatura y precipitación (lluvias intensas y veranillos o períodos secos) projectadas para el periodo 2080–2099 en relación a 1980–1999 para el escenário A1B.

Precipitation change over South America (%)

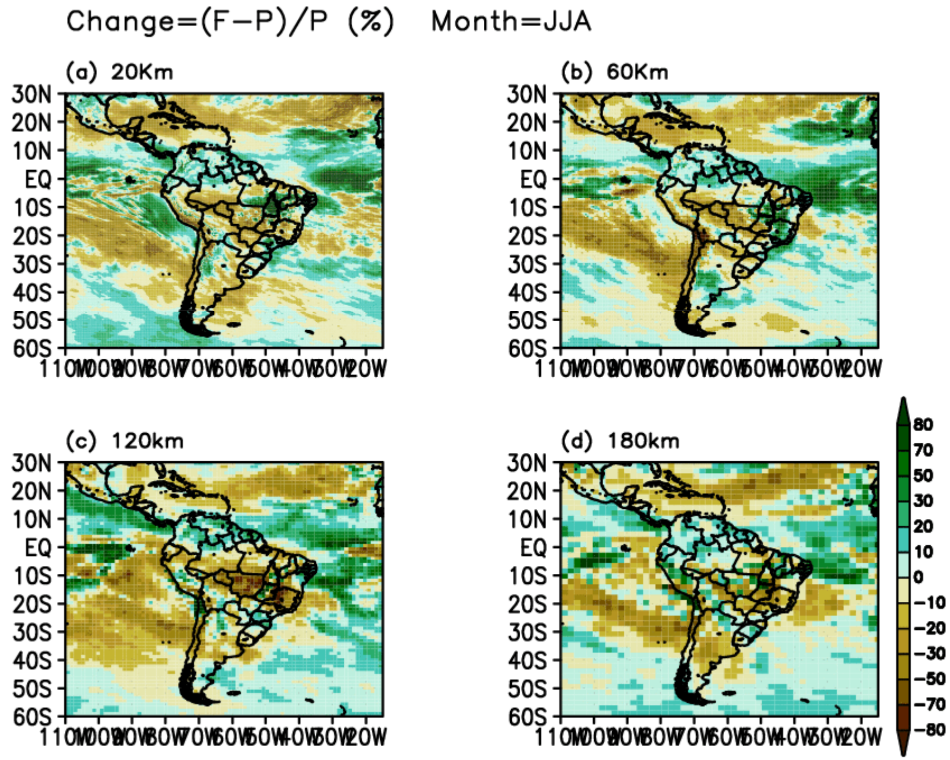
Precipitation change with respect to 1979 to 1988

F-Future
P-Present

summer

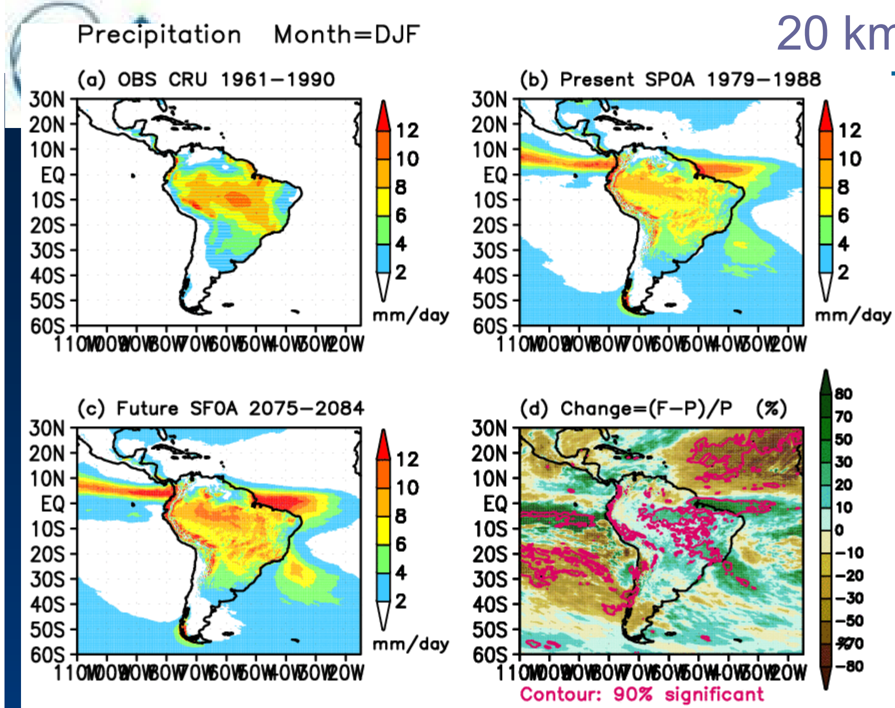


winter

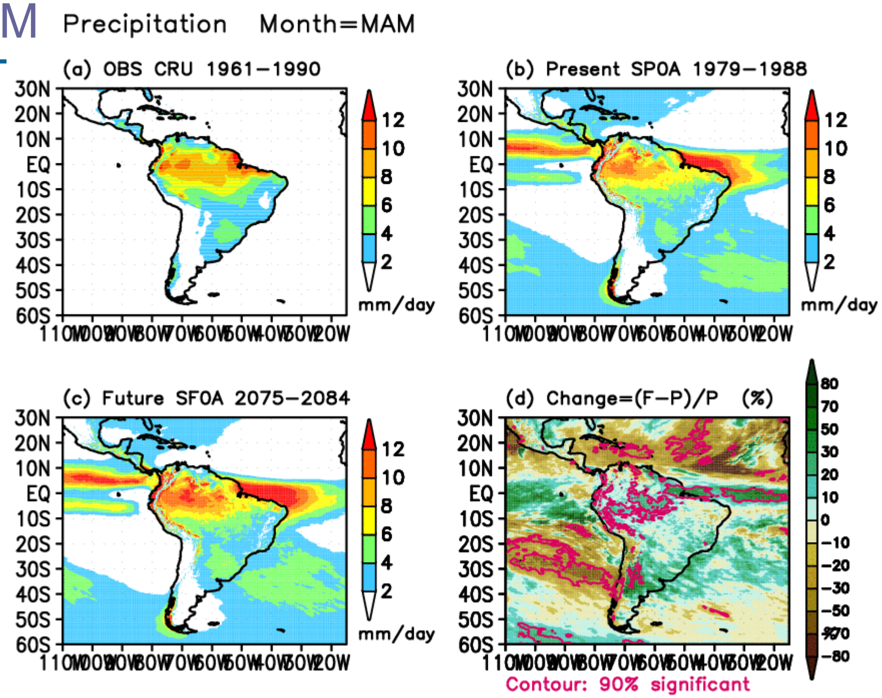


Modelo MRI (Earth Simulator): Fuente Lincoln Alves, Jose Pesquero

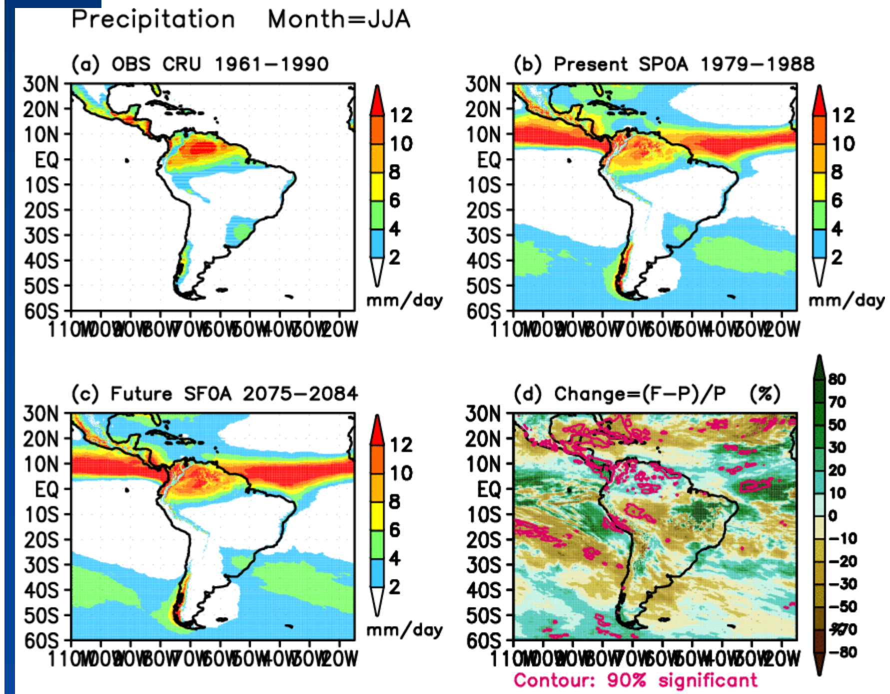
20 km AGCM



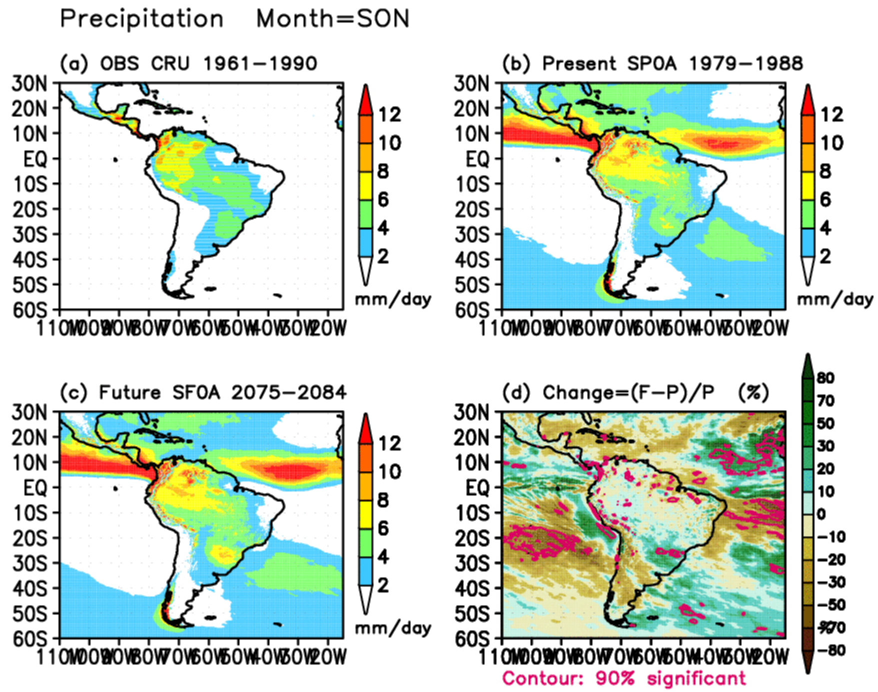
Precipitation Month=DJF
(a) OBS CRU 1961–1990
(b) Present SP0A 1979–1988
(c) Future SF0A 2075–2084
(d) Change=(F–P)/P (%)
mm/day
Contour: 90% significant



Precipitation Month=MAM
(a) OBS CRU 1961–1990
(b) Present SP0A 1979–1988
(c) Future SF0A 2075–2084
(d) Change=(F–P)/P (%)
mm/day
Contour: 90% significant



Precipitation Month=JJA
(a) OBS CRU 1961–1990
(b) Present SP0A 1979–1988
(c) Future SF0A 2075–2084
(d) Change=(F–P)/P (%)
mm/day
Contour: 90% significant

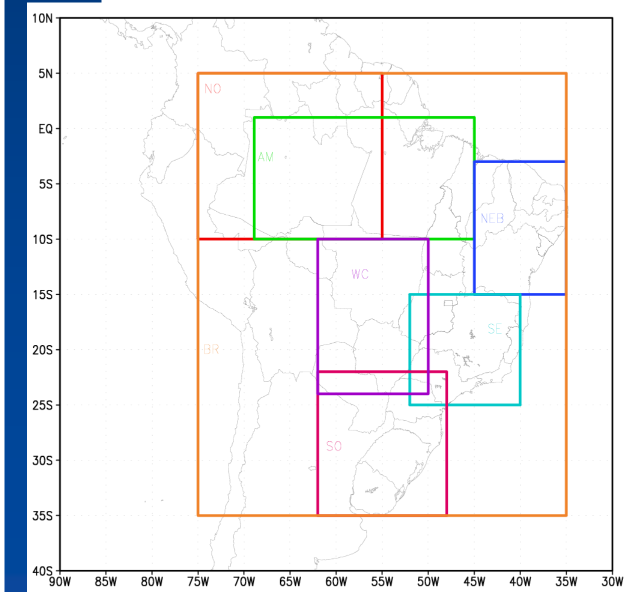


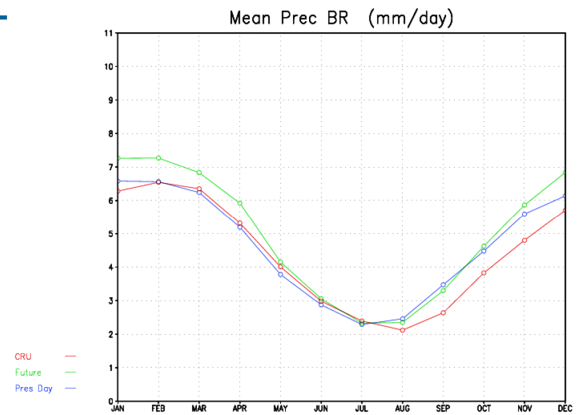
Precipitation Month=SON
(a) OBS CRU 1961–1990
(b) Present SP0A 1979–1988
(c) Future SF0A 2075–2084
(d) Change=(F–P)/P (%)
mm/day
Contour: 90% significant

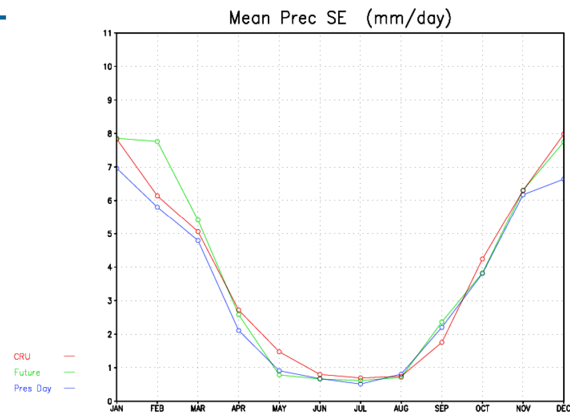
Annual cycle of observed and modelled rainfall in several regions (mm/day)

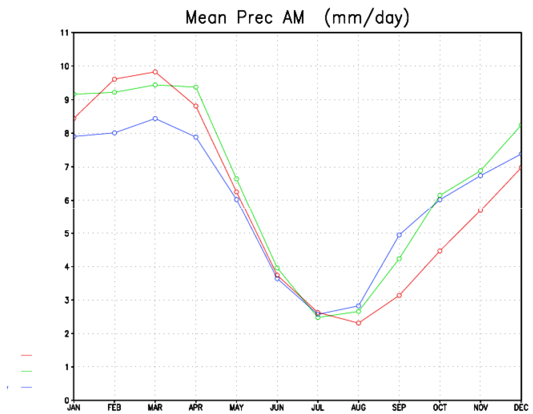
20 km mesh

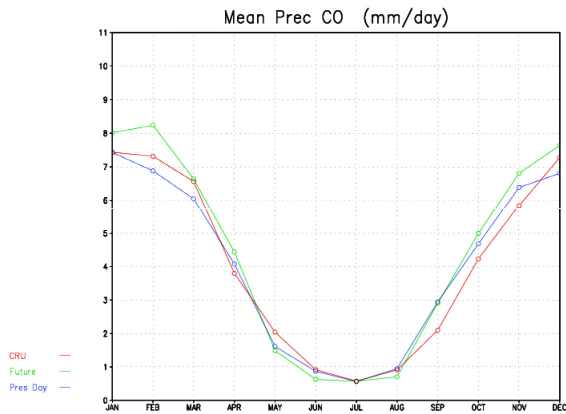
Red-CRU
Green-Future
Blue-Present

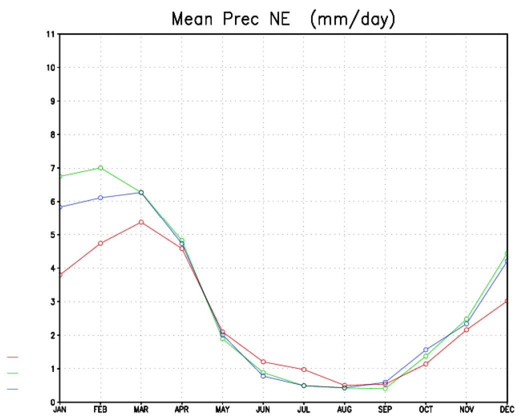


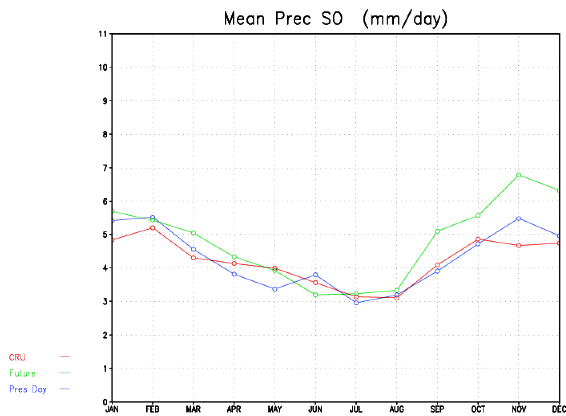






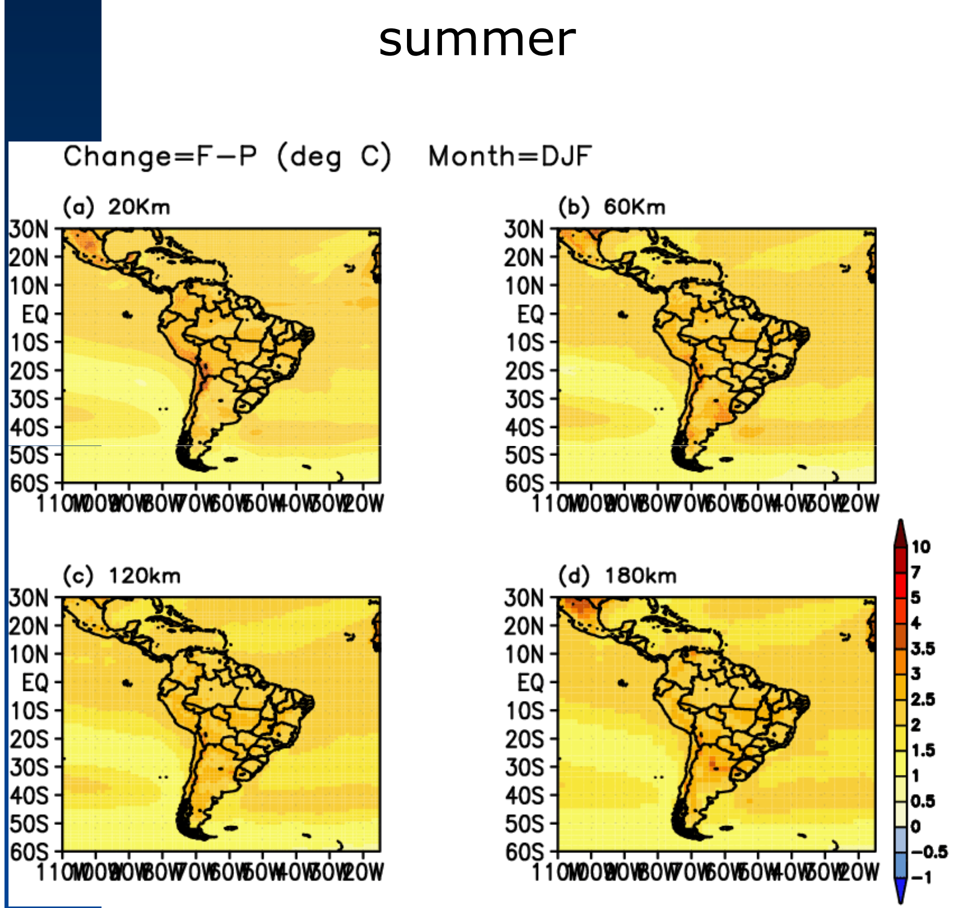


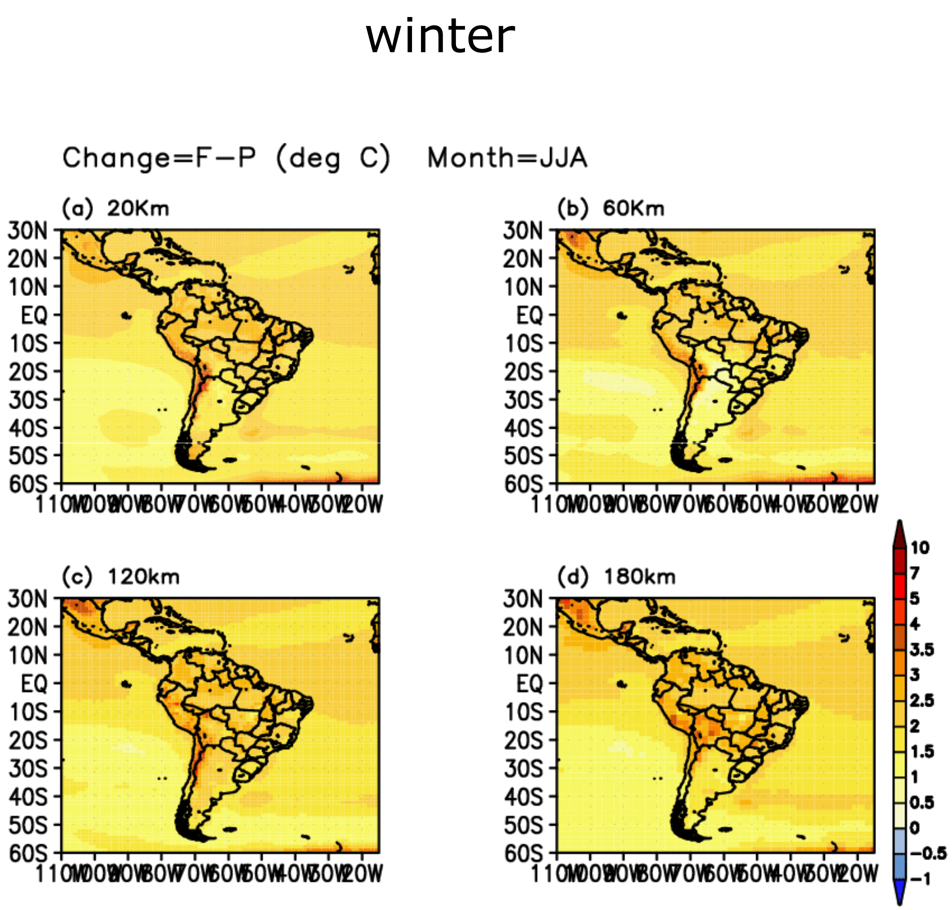




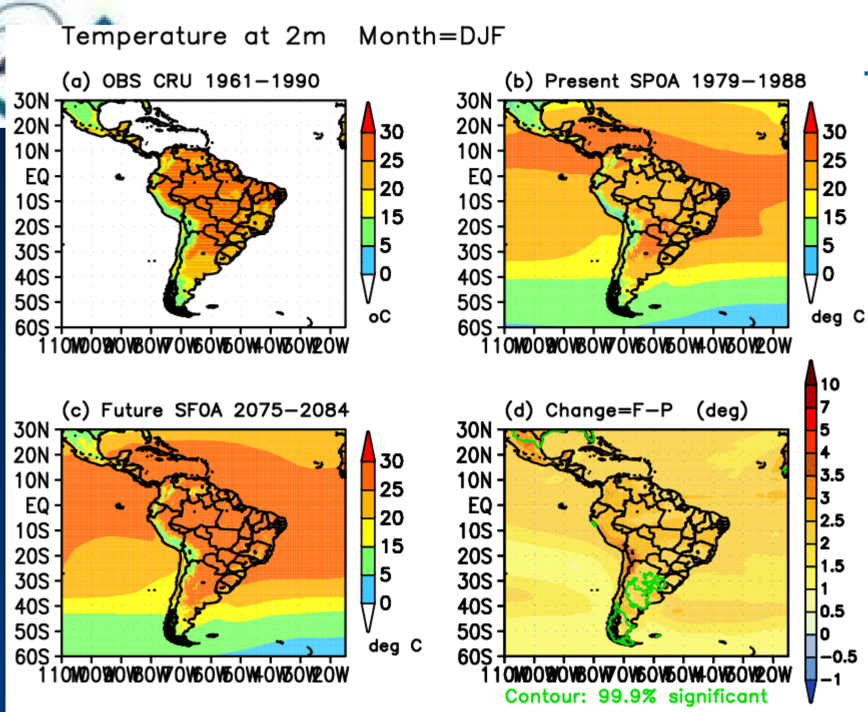
Temperature change over South America (%)

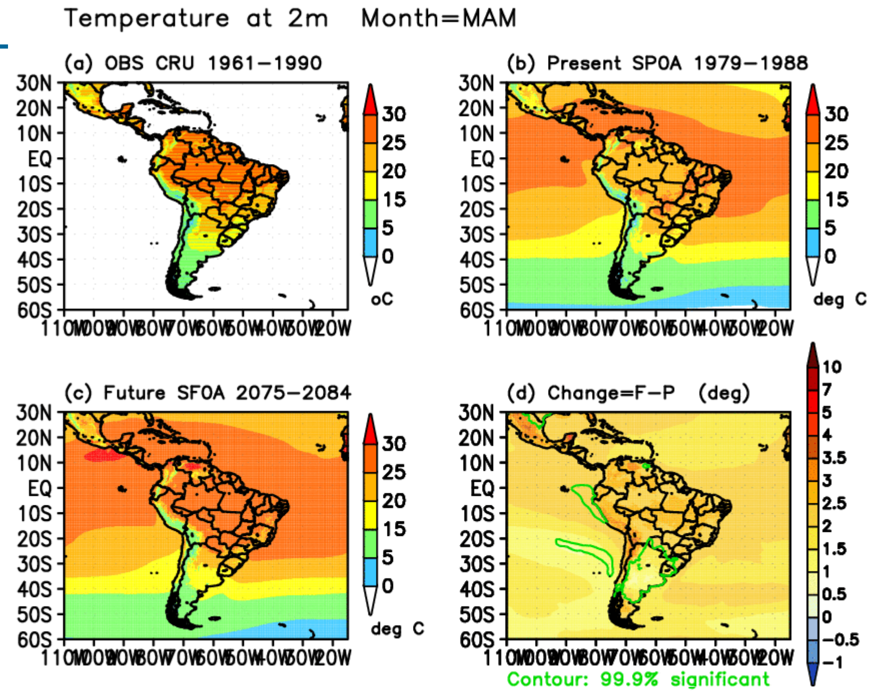
Temperature change with respect to 1979 to 1988

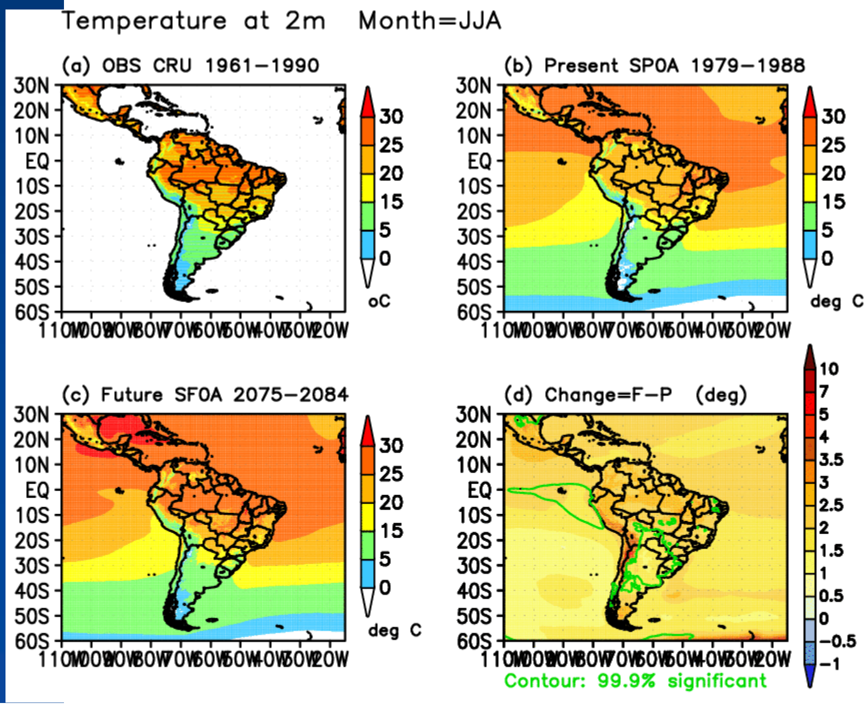




Modelo MRI (Earth Simulator): Fuente Lincoln Alves, Jose Pesquero


Temperature at 2m Month=DJF
(a) OBS CRU 1961−1990
(b) Present SP0A 1979−1988
(c) Future SF0A 2075−2084
(d) Change=F−P (deg)
Contour: 99.9% significant
oC
deg C


Temperature at 2m Month=MAM
(a) OBS CRU 1961−1990
(b) Present SP0A 1979−1988
(c) Future SF0A 2075−2084
(d) Change=F−P (deg)
Contour: 99.9% significant
oC
deg C


Temperature at 2m Month=JJA
(a) OBS CRU 1961−1990
(b) Present SP0A 1979−1988
(c) Future SF0A 2075−2084
(d) Change=F−P (deg)
Contour: 99.9% significant
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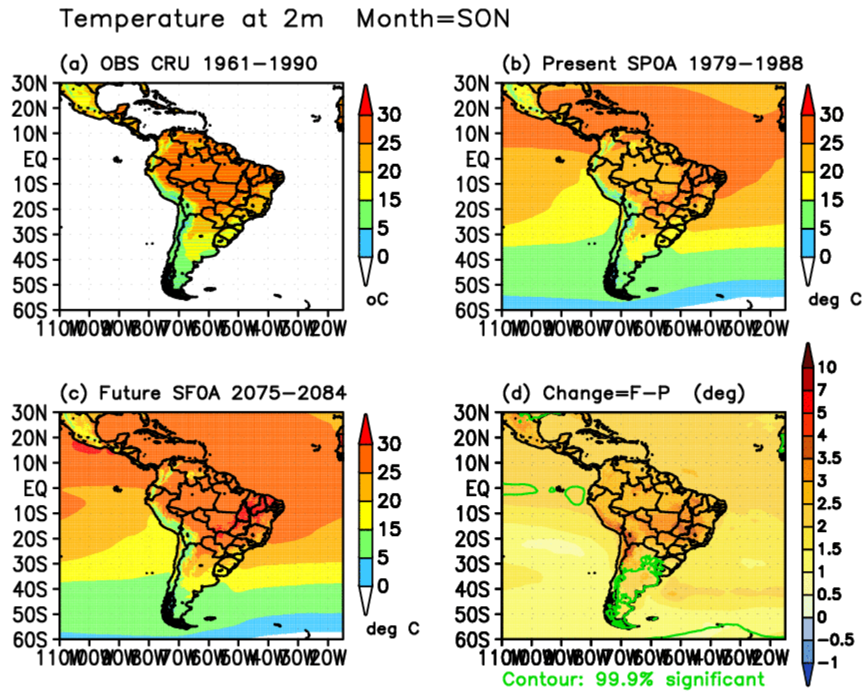
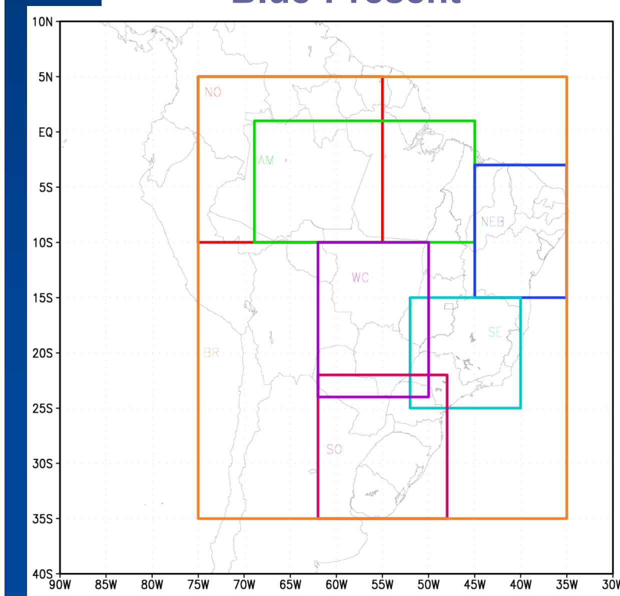
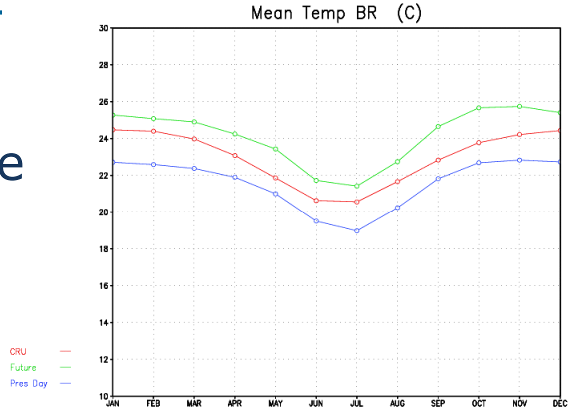

Temperature at 2m Month=SON
(a) OBS CRU 1961−1990
(b) Present SP0A 1979−1988
(c) Future SF0A 2075−2084
(d) Change=F−P (deg)
Contour: 99.9% significant
oC
deg C

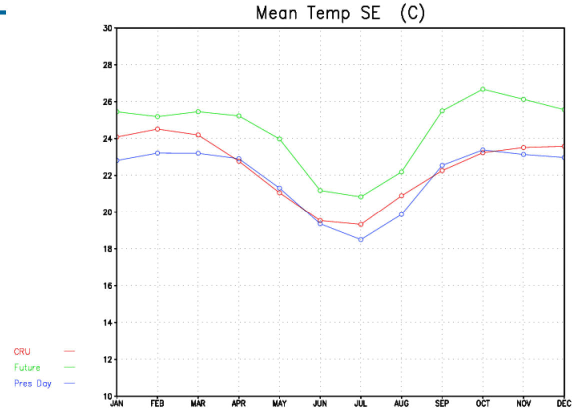
Annual cycle of observed and modelled temperature in several regions (mm/day)

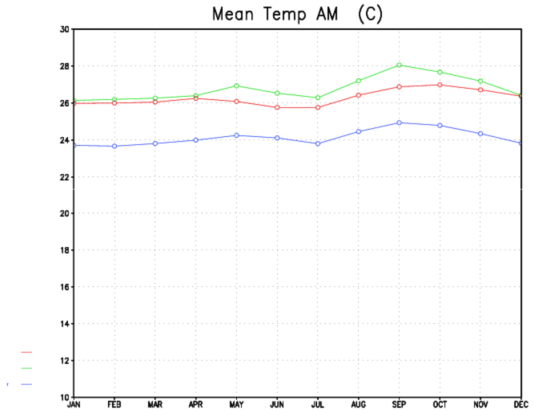
20 km mesh

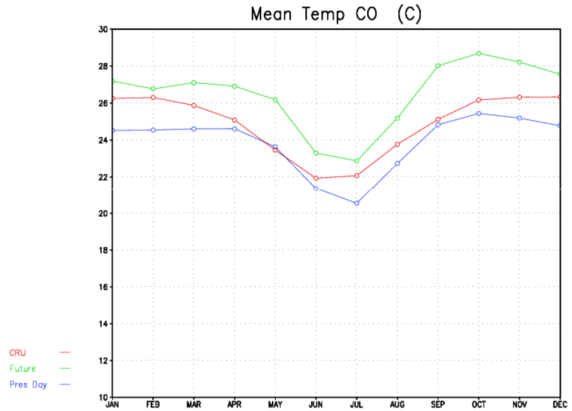
Red-CRU
Green-Future
Blue-Present

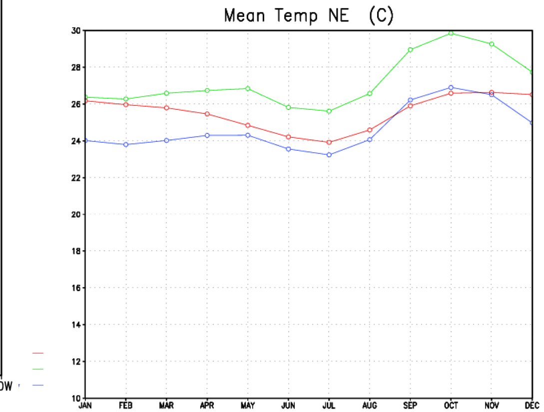


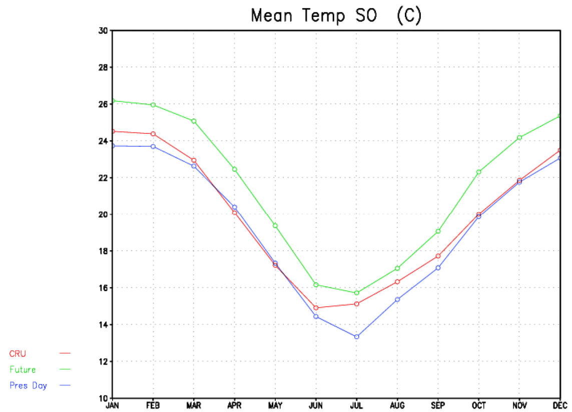








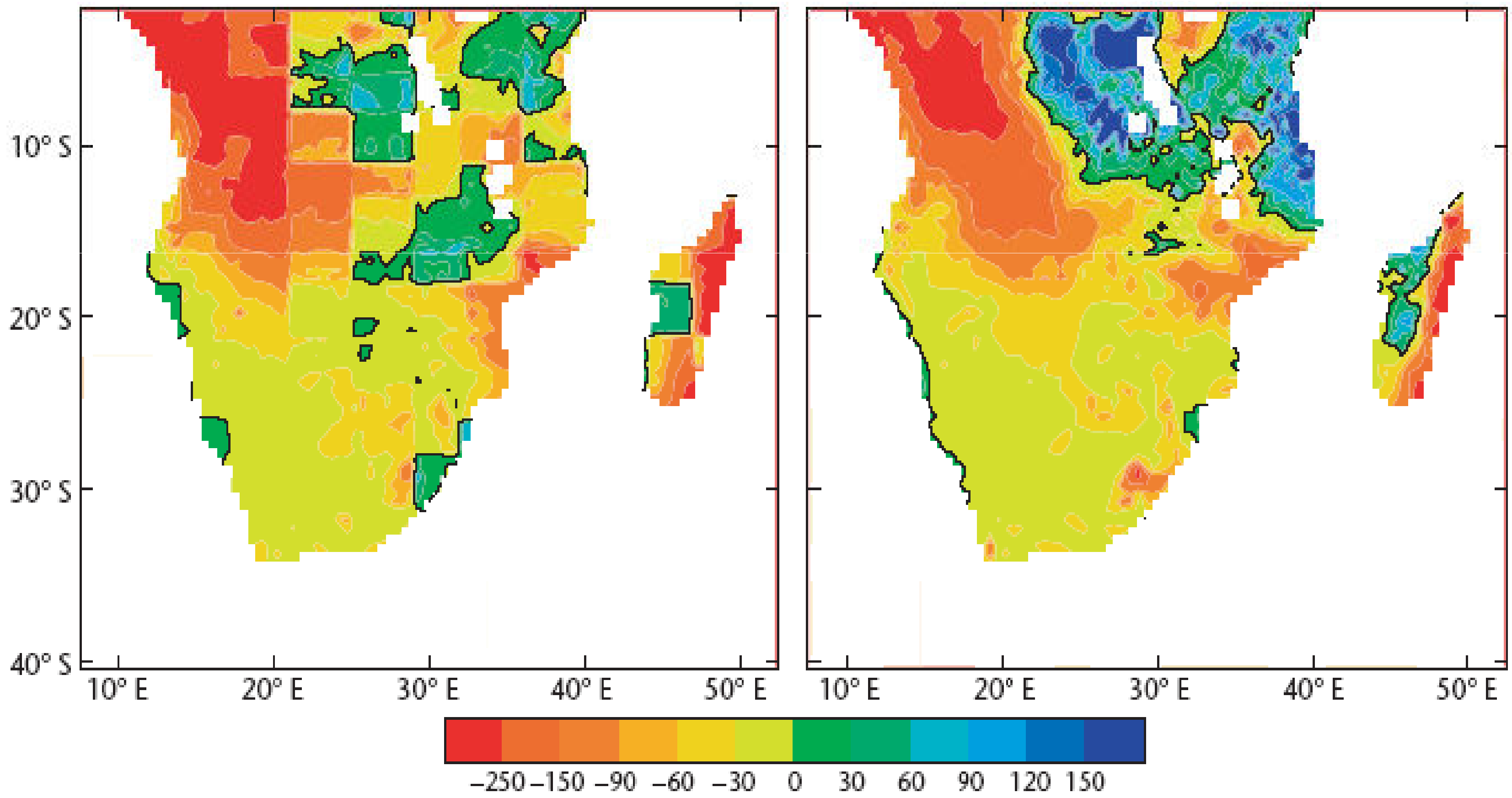




PRECIS-Africa
Changes in River discharge in Africa for 2071-2100

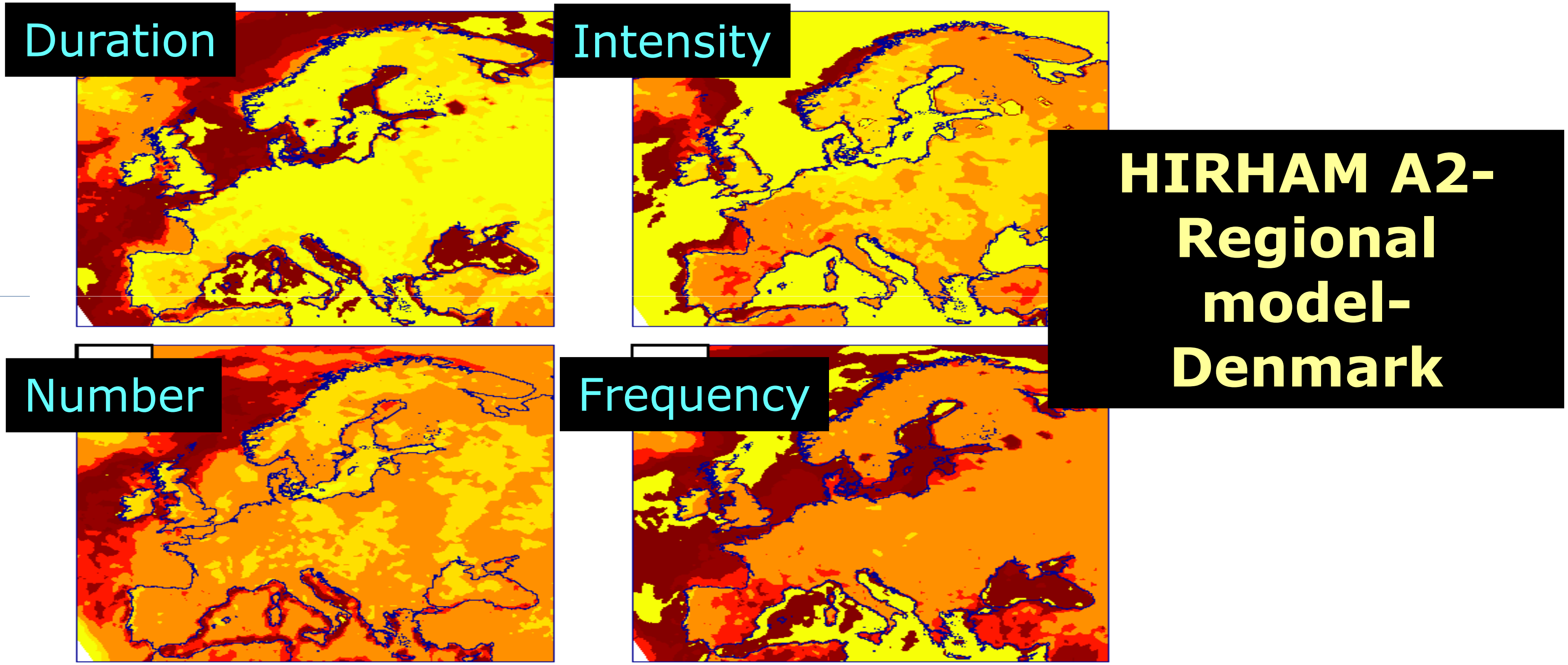
Global model HadAM3P

Regional model HadRM3P



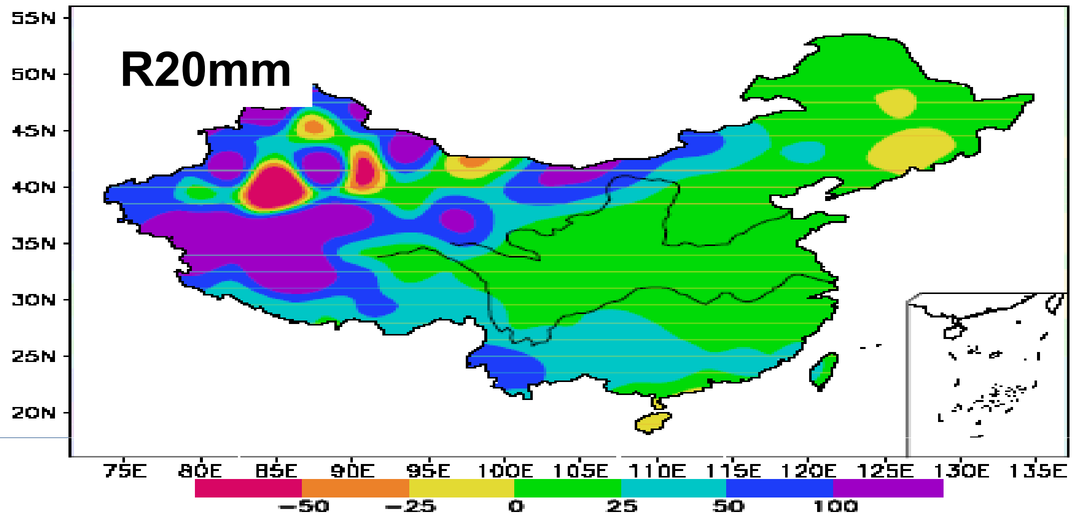
Discharge anomalies (mm/year), A2 scenario
[(2071-2100) – (1961-90)]

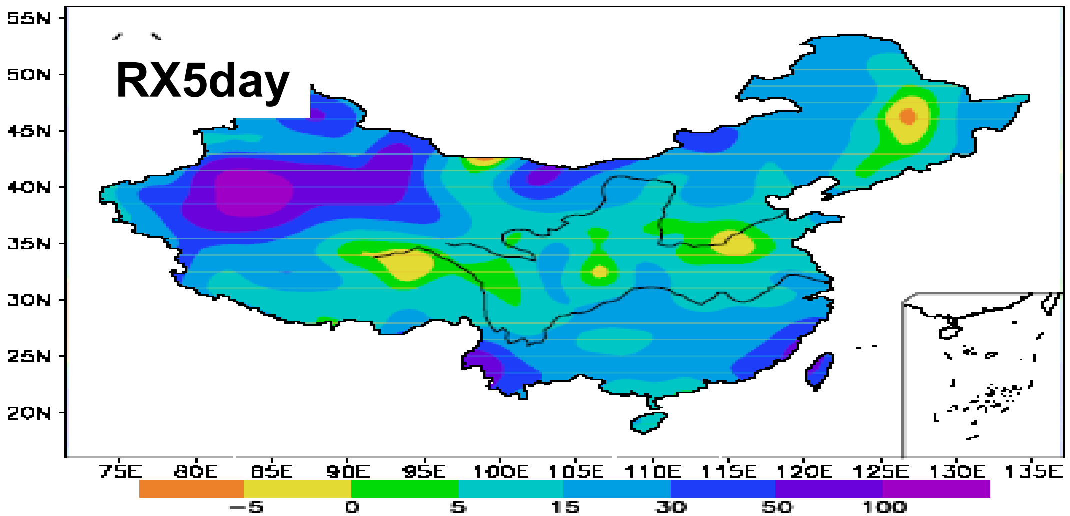
Downscaling Experiences:
PRUDENCE
Changes in heat wave index in Europe
(A2- 2100)



→Increase in the frequency, intensity, duration of heat waves

PRECIS-China



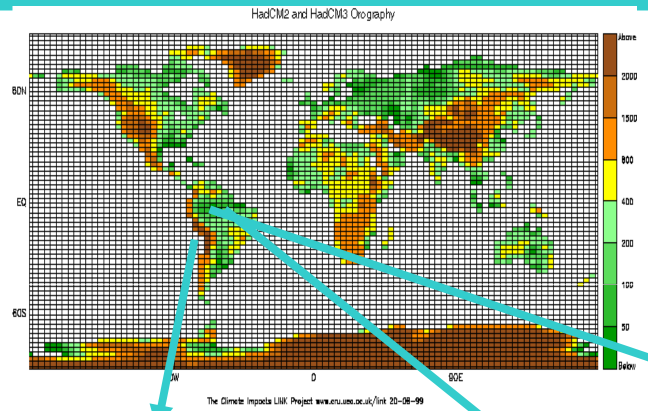


The spatial distribution of the simulated increment of two rainfall extremes indices in China: R20mm-day with rainfall above 20 mm/day, RX5day-days with rainfall that may produce floods, (Unit: %)

Future under the IPCC SRES B2 scenario for 2071-2100 relative to the present) in precipitation extremes in China:

Escenarios regionales de Cambio Climático para America del Sur
Version 1 –MCT/MMA PROBIO/GOF UK
(www.cptec.inpe.br/mudancas_climaticas)

Modelo Global HadAM3P

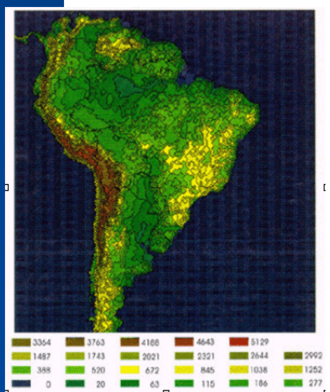


Climatología 1961-90

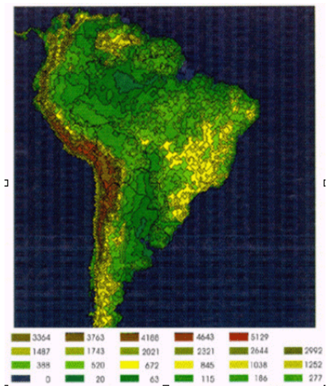
Escenarios IPCC TAR A2, B2

Anomalías (futuro-presente), período 2071-2100 menos 1961-90, A2, B2

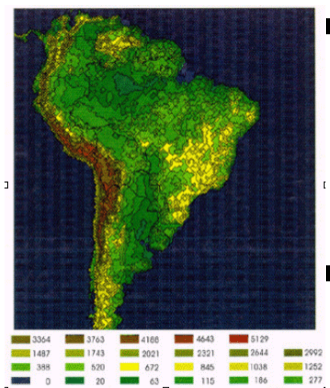
Modelos Regionales-50 km



RegCM3



HadRM3



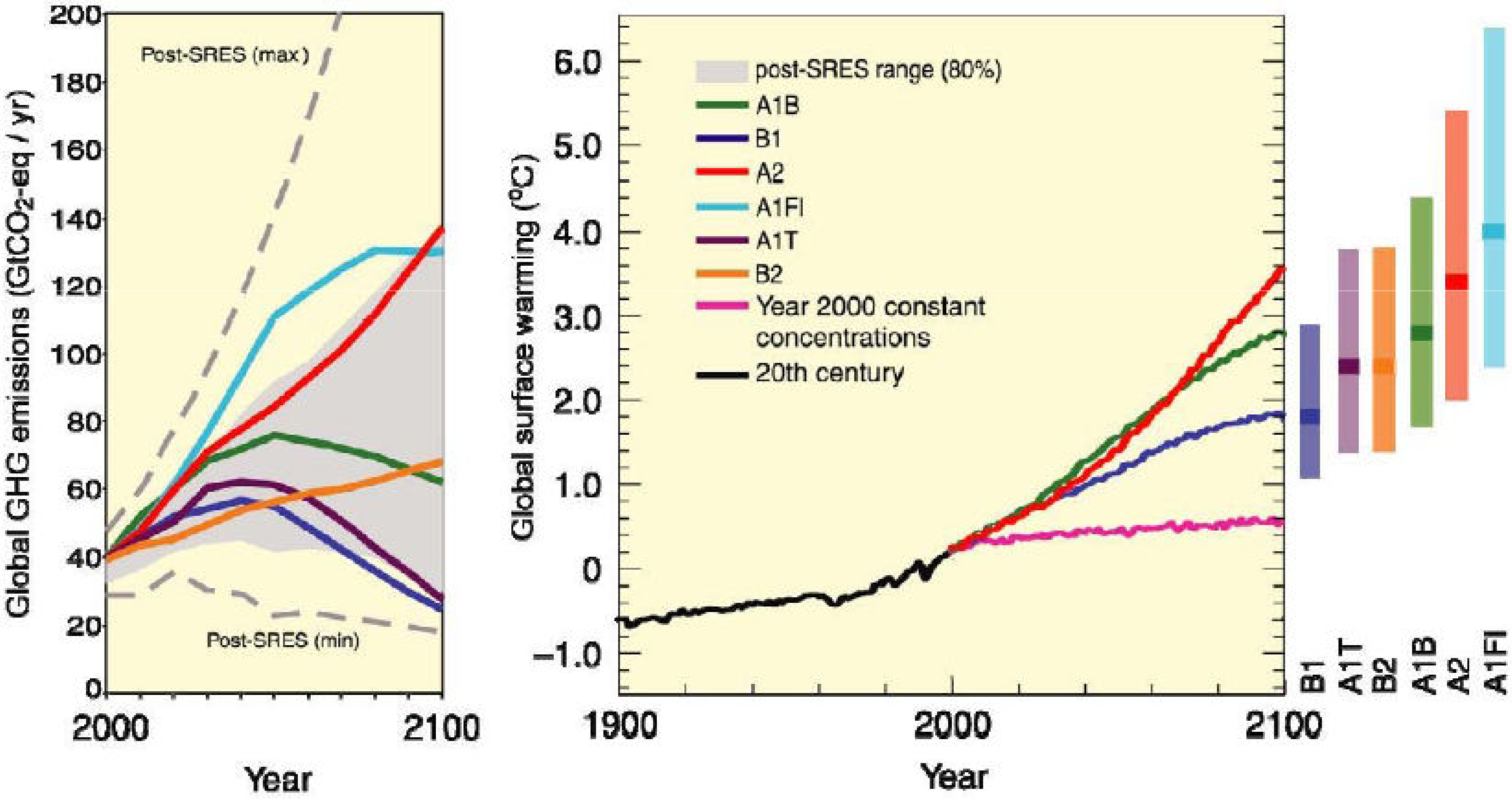
Eta CCS

Climatologia modelos regionales 1961-90

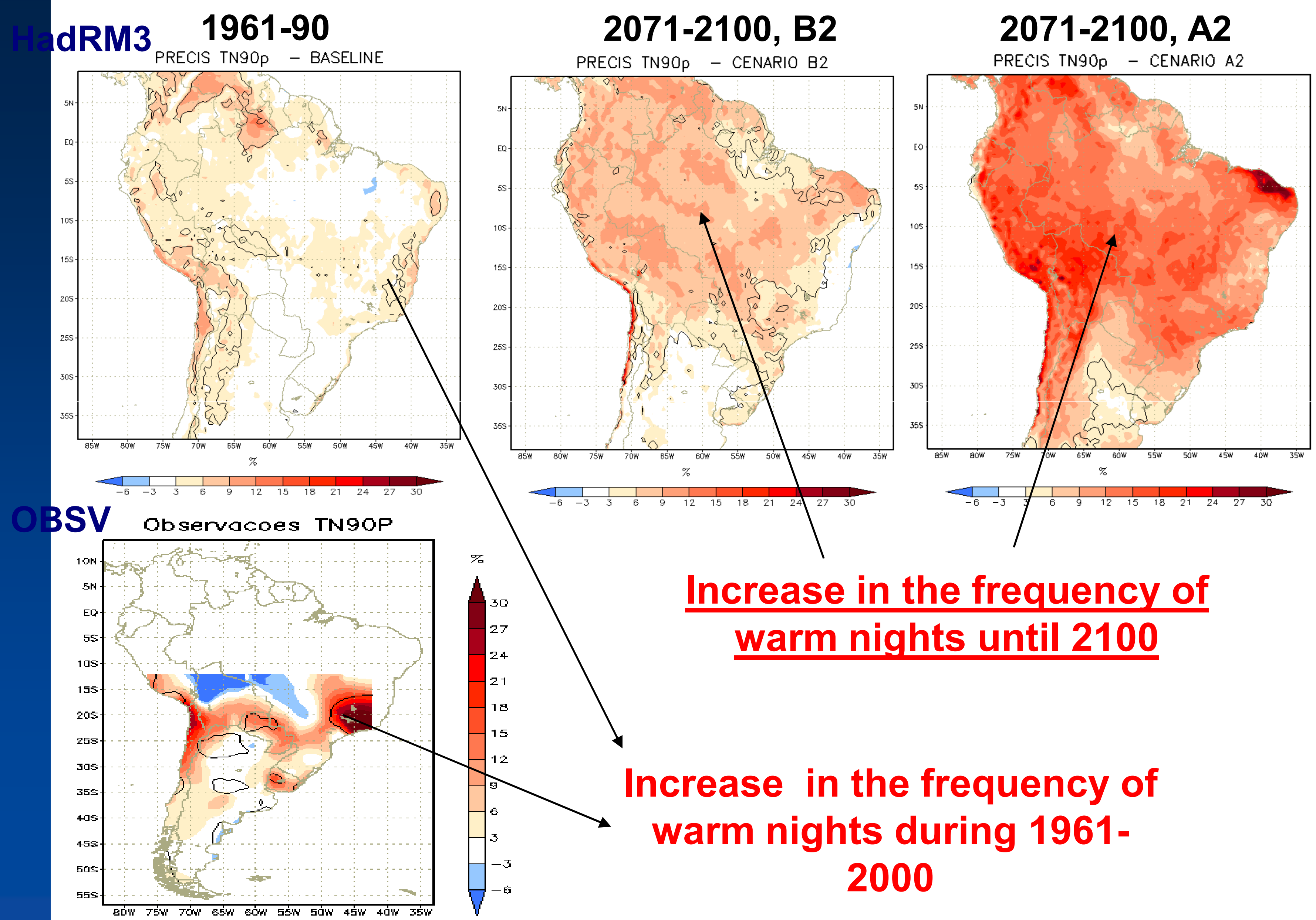
Mapas de anomalías, e indices de extremos para 2071-2100, A2, B2

Source: IPCC, AR4 (2007)

Climate projections without mitigation



Warm nights index (TN90) [(2071-2100)- (1961-90)]

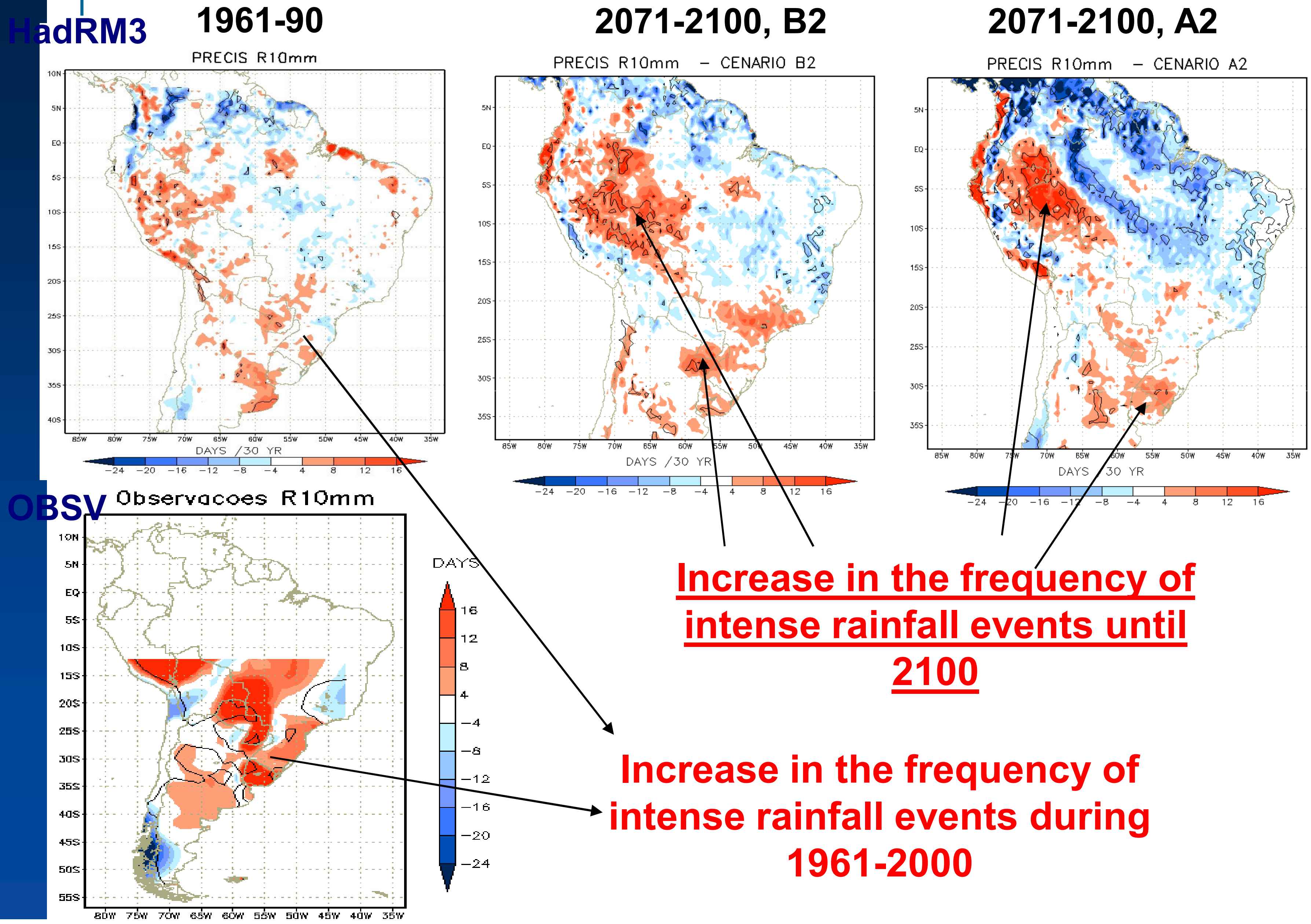


Increase in the frequency of warm nights until 2100

Increase in the frequency of warm nights during 1961-2000

Intense rainfall index (R10) [(2071-2100)- (1961-90)]

HadRM3



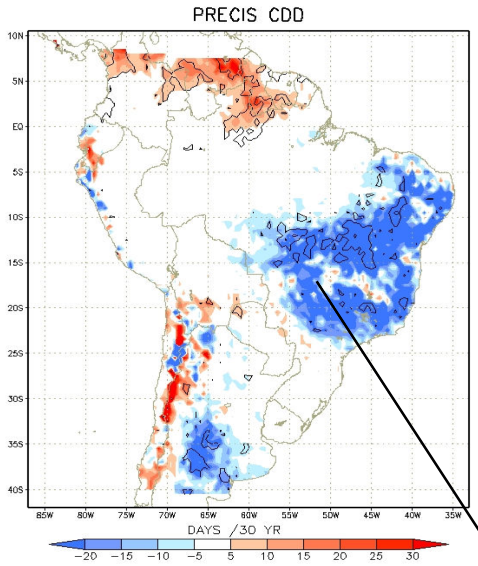
Increase in the frequency of intense rainfall events until 2100

Increase in the frequency of intense rainfall events during 1961-2000

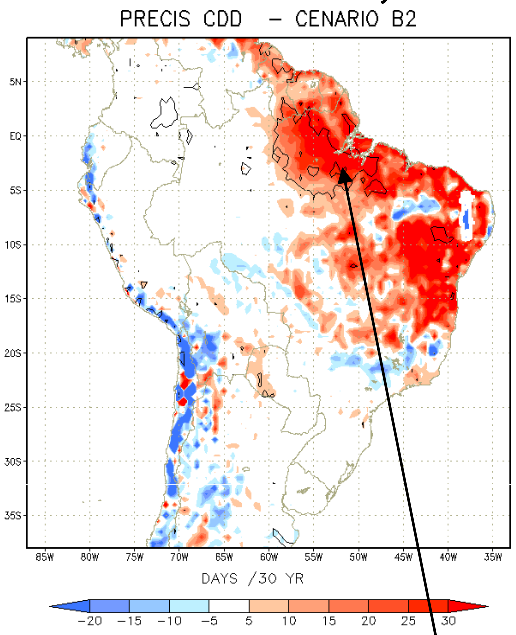
Consecutive dry days index (CDD) [(2071-2100)- (1961-90)]

HadRM3

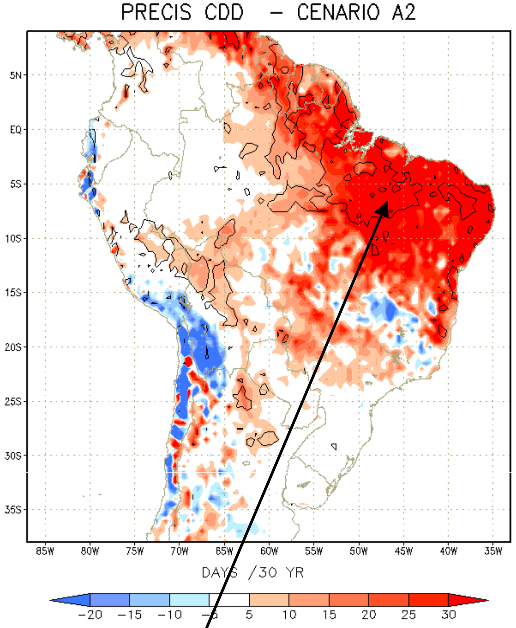
1961-90



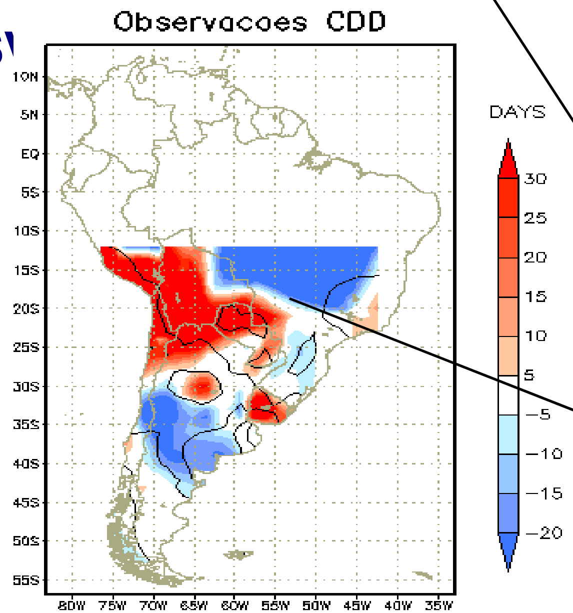
2071-2100, B2



2071-2100, A2

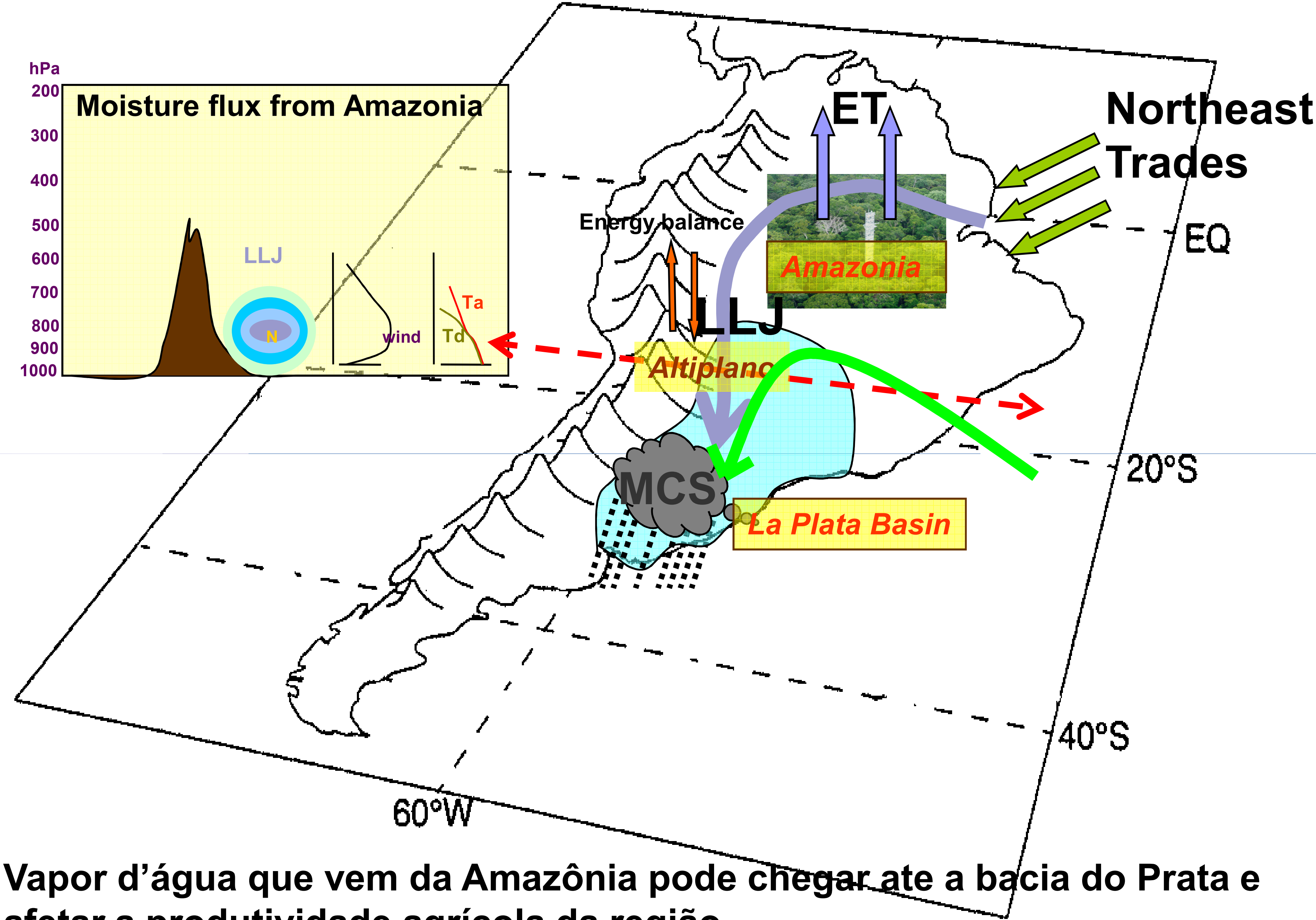


OBS



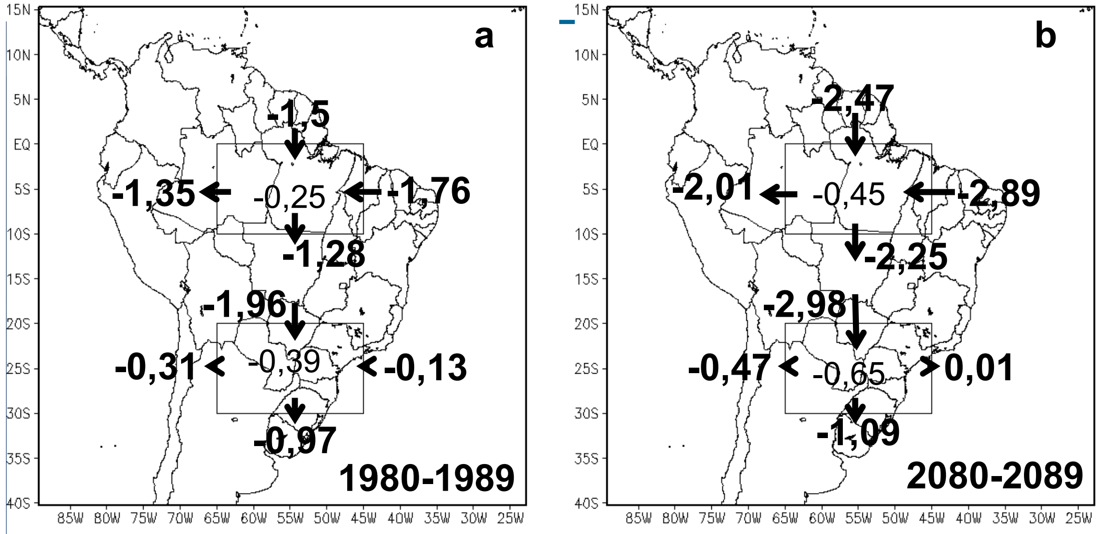
Increase in the frequency of consecutive dry days until 2100

Reduction in the frequency of consecutive dry days during 1961-2000

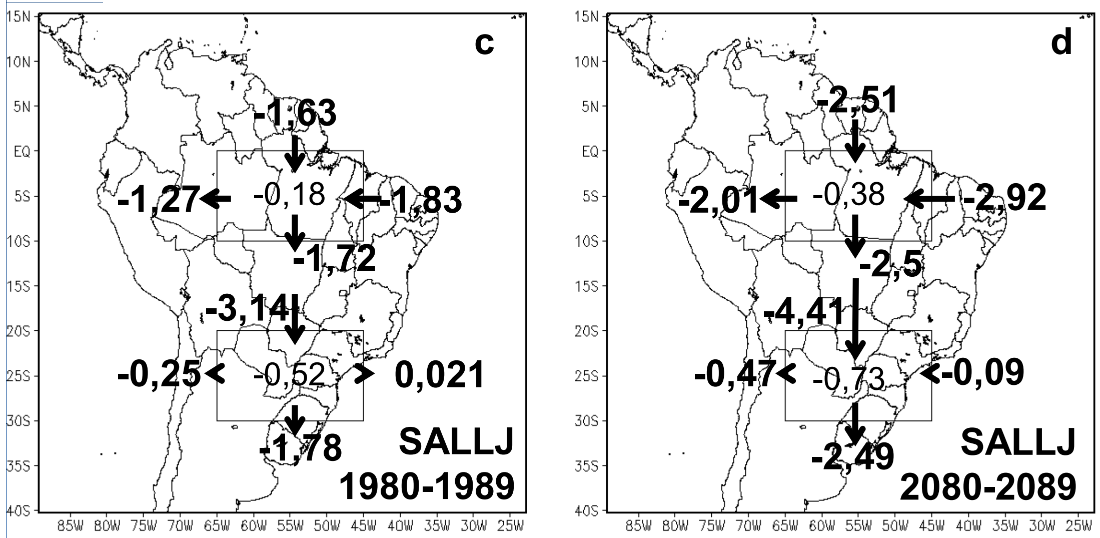


Vapor d'água que vem da Amazônia pode chegar ate a bacia do Prata e afetar a produtividade agrícola da região

DJF-Climatology

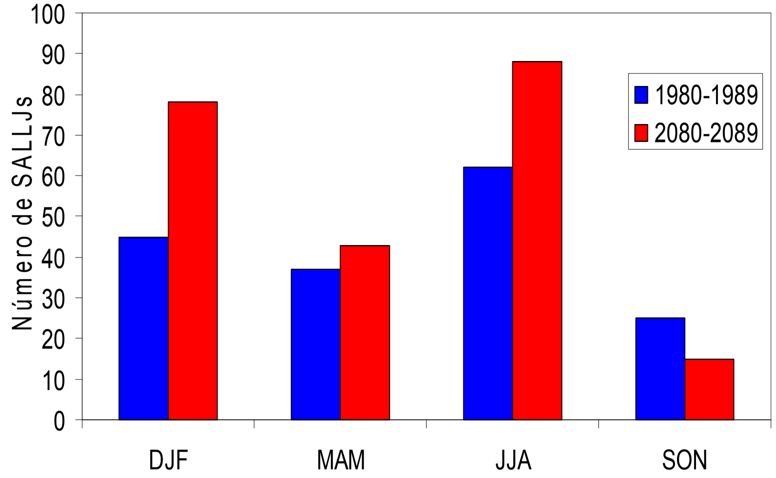


DJF-SALLJ composite

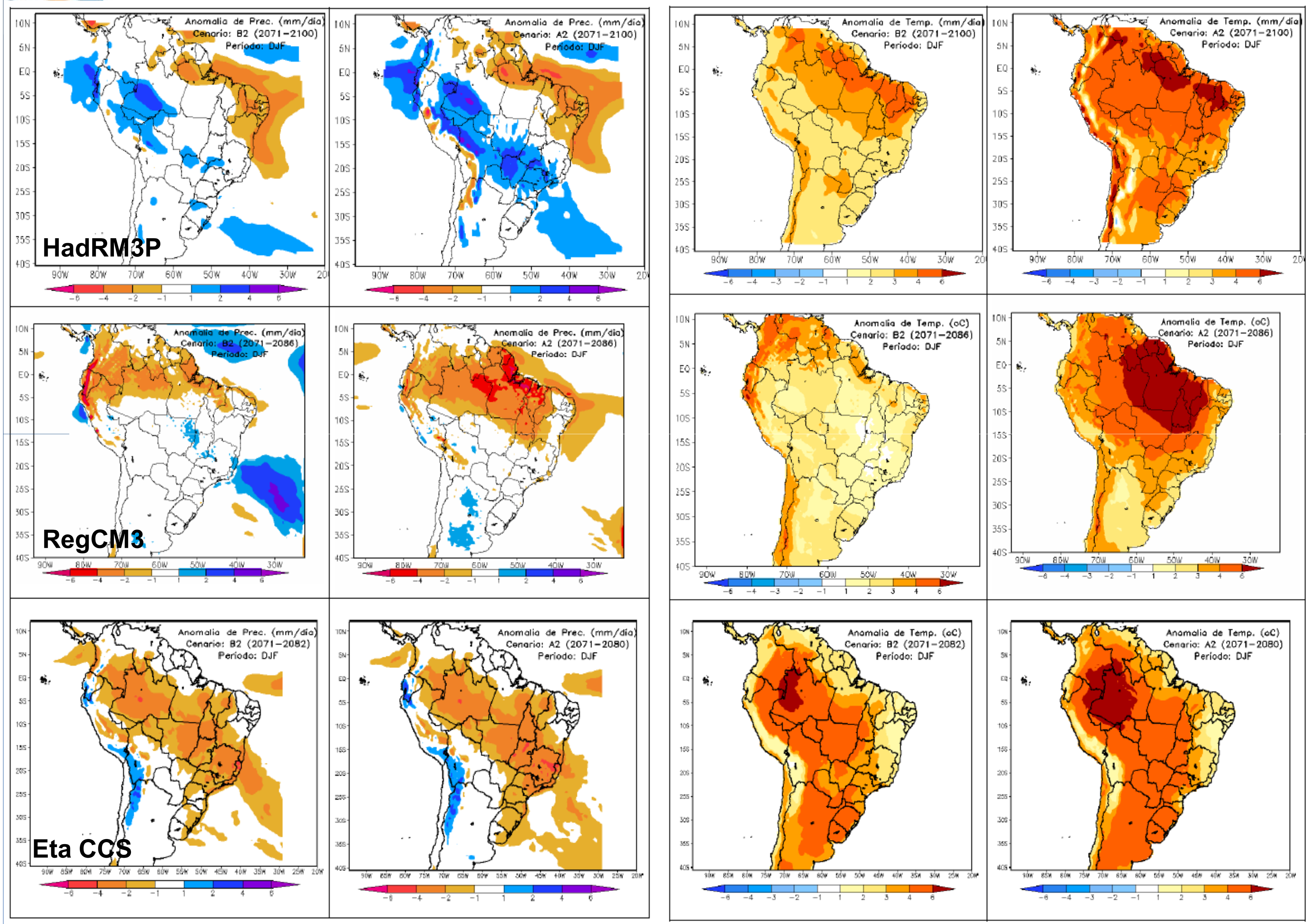


Zonal and meridional components of the integrated moisture flux along-across boxes that represent Amazonia and La Plata basins during DJF. Units are x108kg.s-1

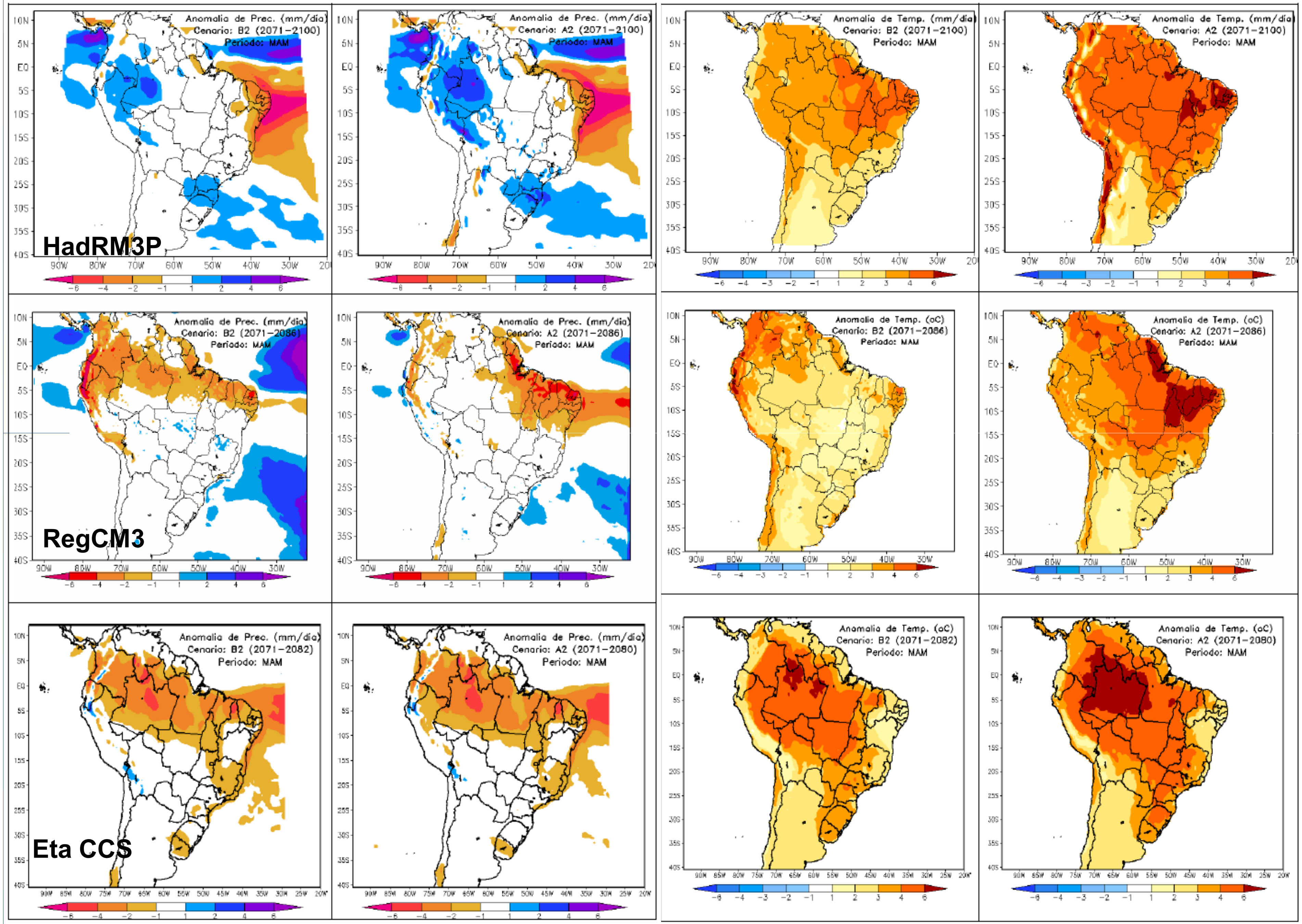
Larger number of SALLJ events detected in the warmer A2 climate scenario for 2080-2099 as compared to 1980-1999 (W. Soares-INPE)



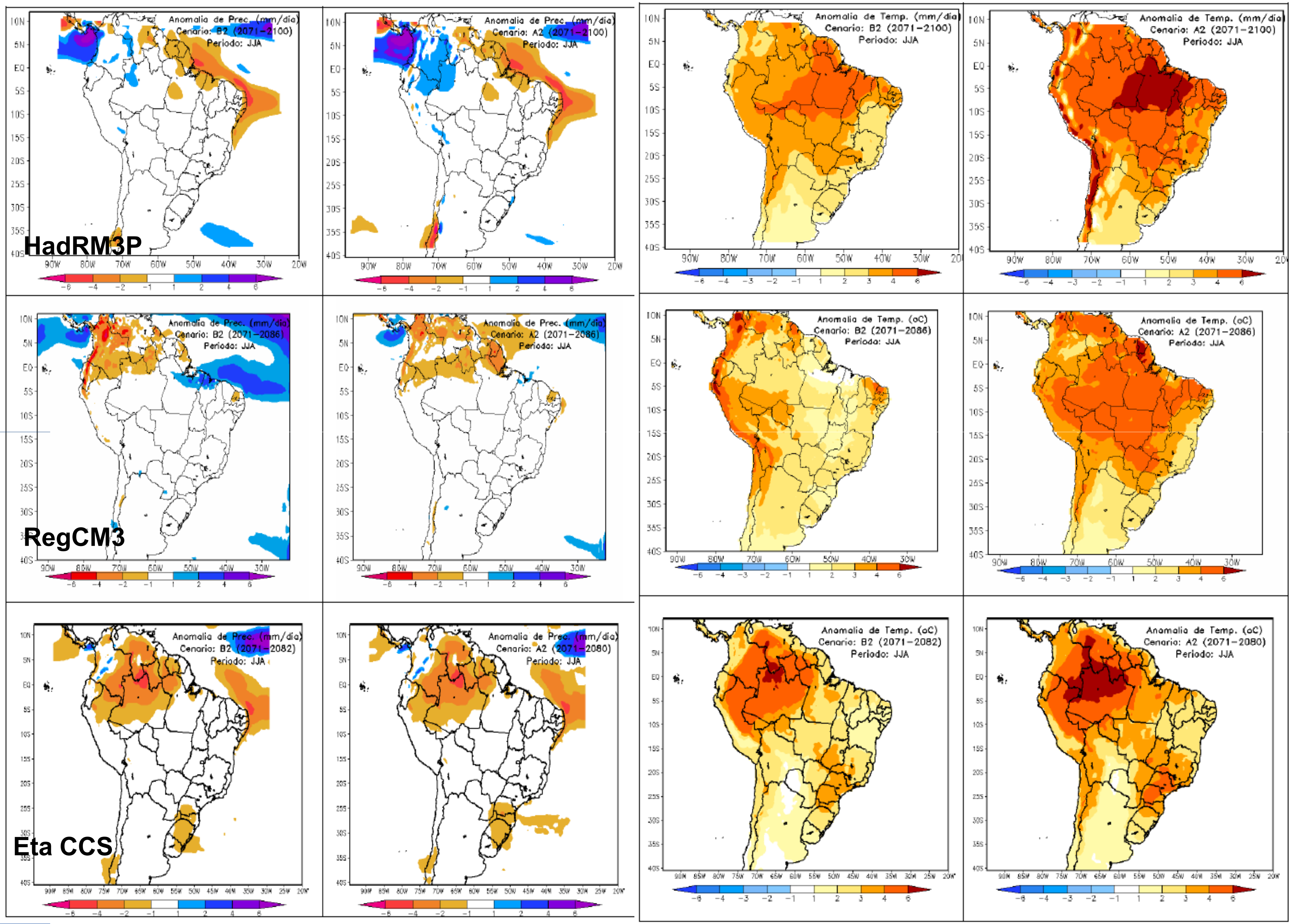
Regional climate change projections (summer DJF): Rainfall and temperature



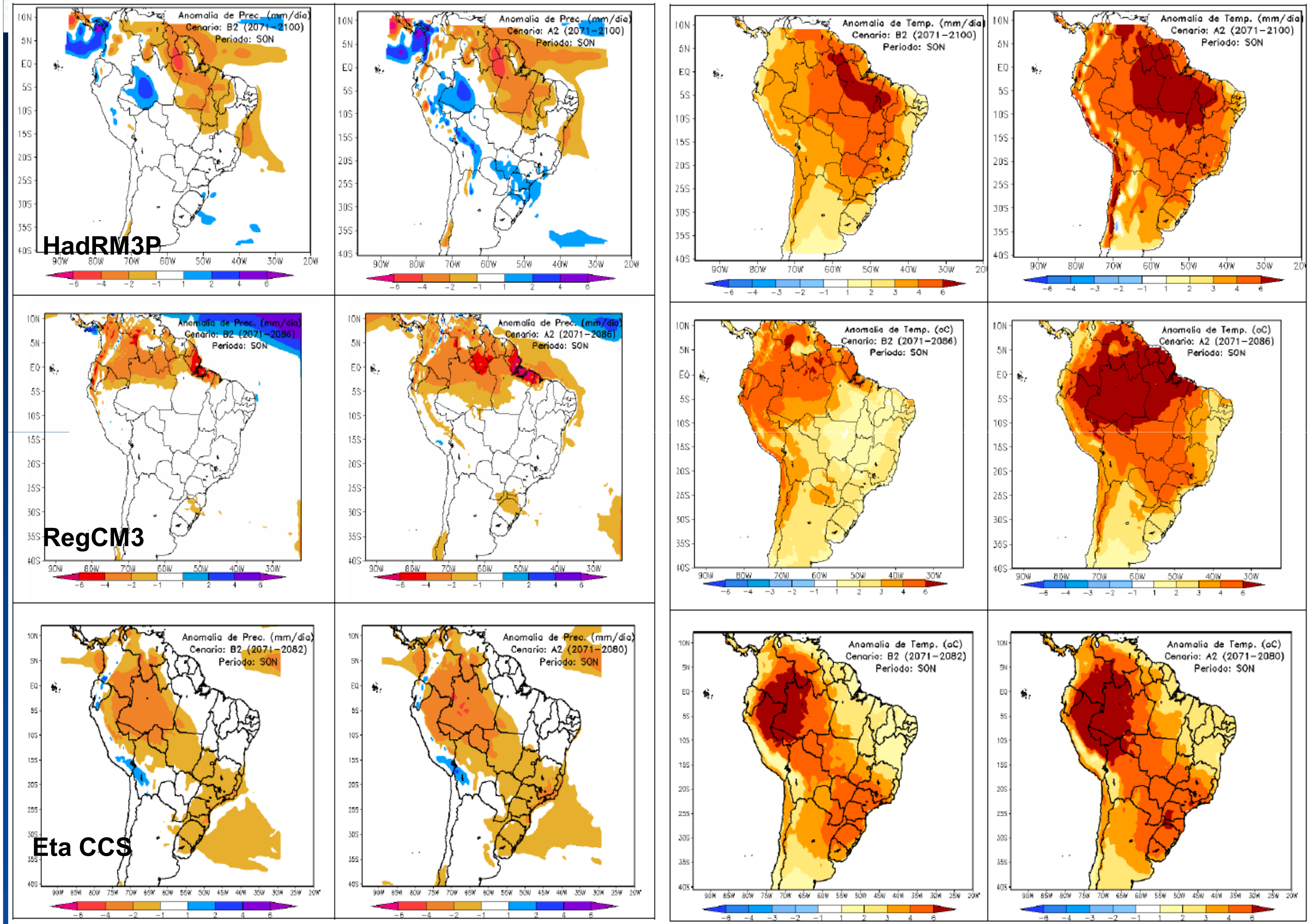
Regional climate change projections (Fall MAM): Rainfall and temperature



Regional climate change projections (winter JJA): Rainfall and temperature

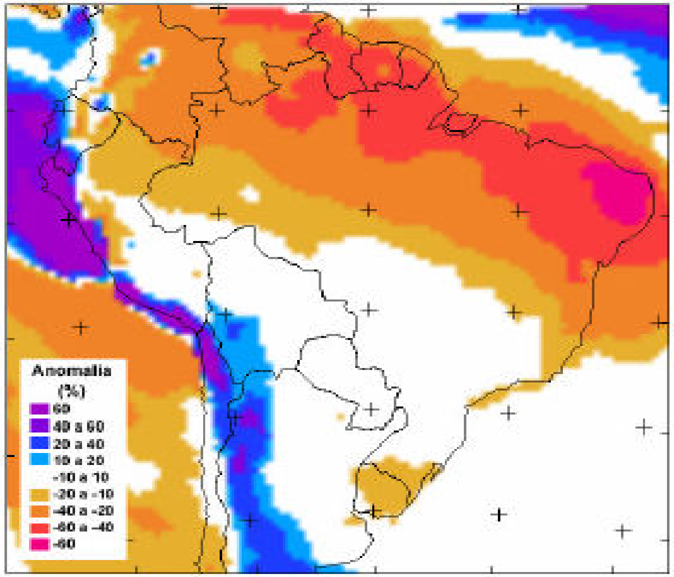


Regional climate change projections (spring SON): Rainfall and temperature

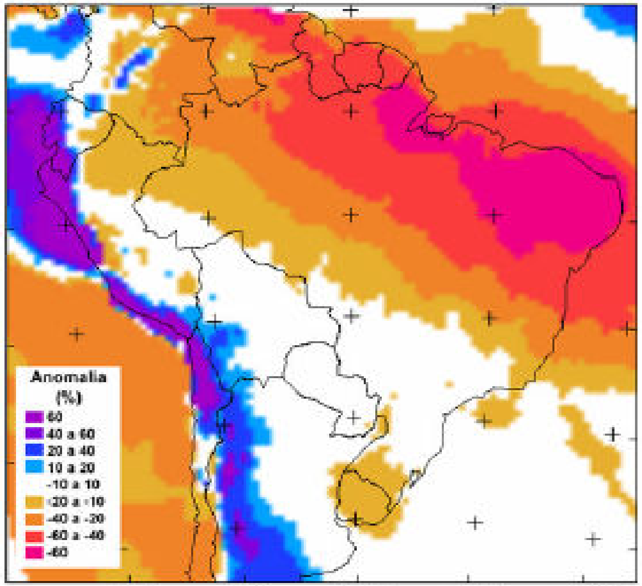


Anomalias de lluvia anual (%) [(2071-2100)- (1961-90)]

Relatorio de Clima do INPE (2007)

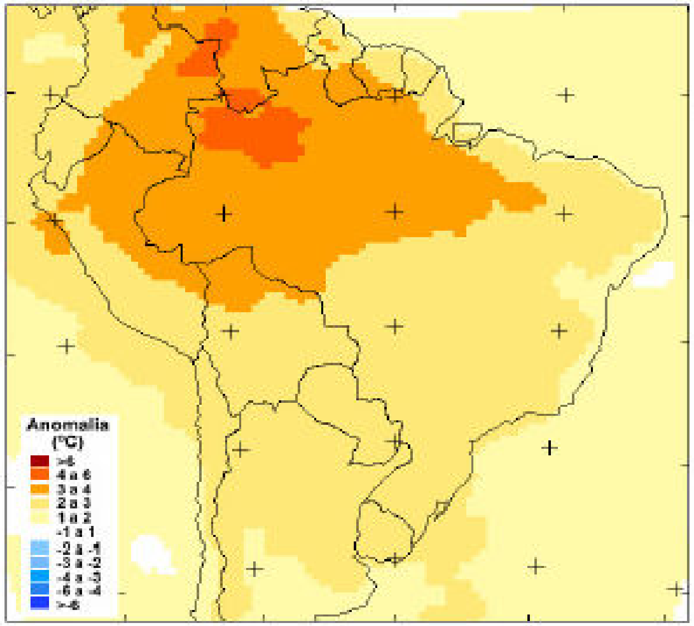


B2

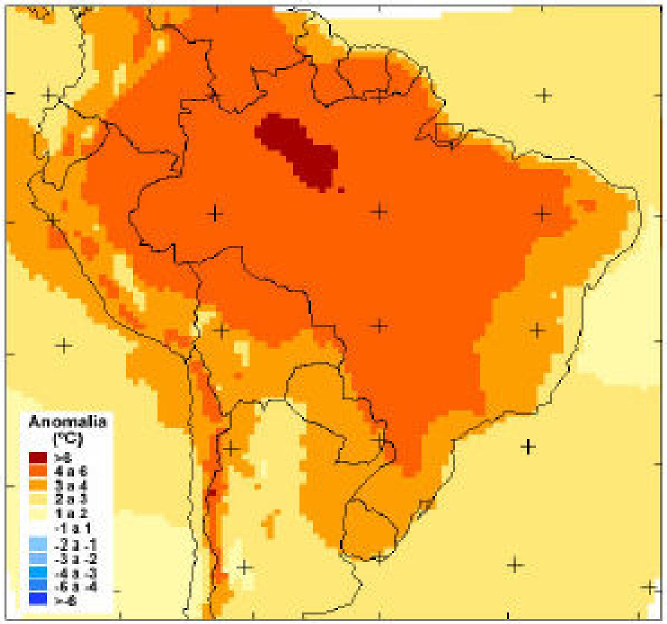


A2

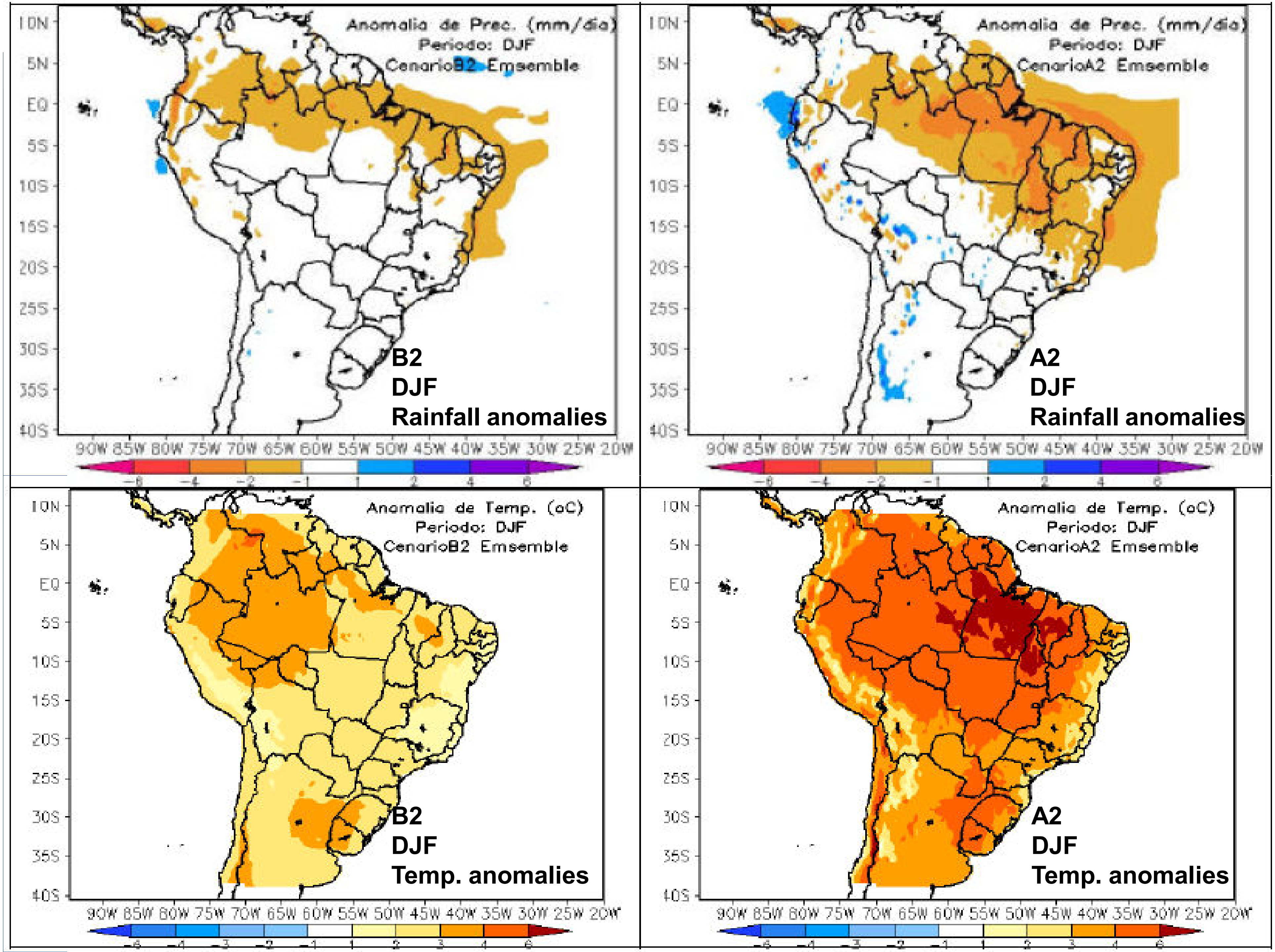
Anomalias de Temperatura anual (C) [(2071-2100)- (1961-90)]

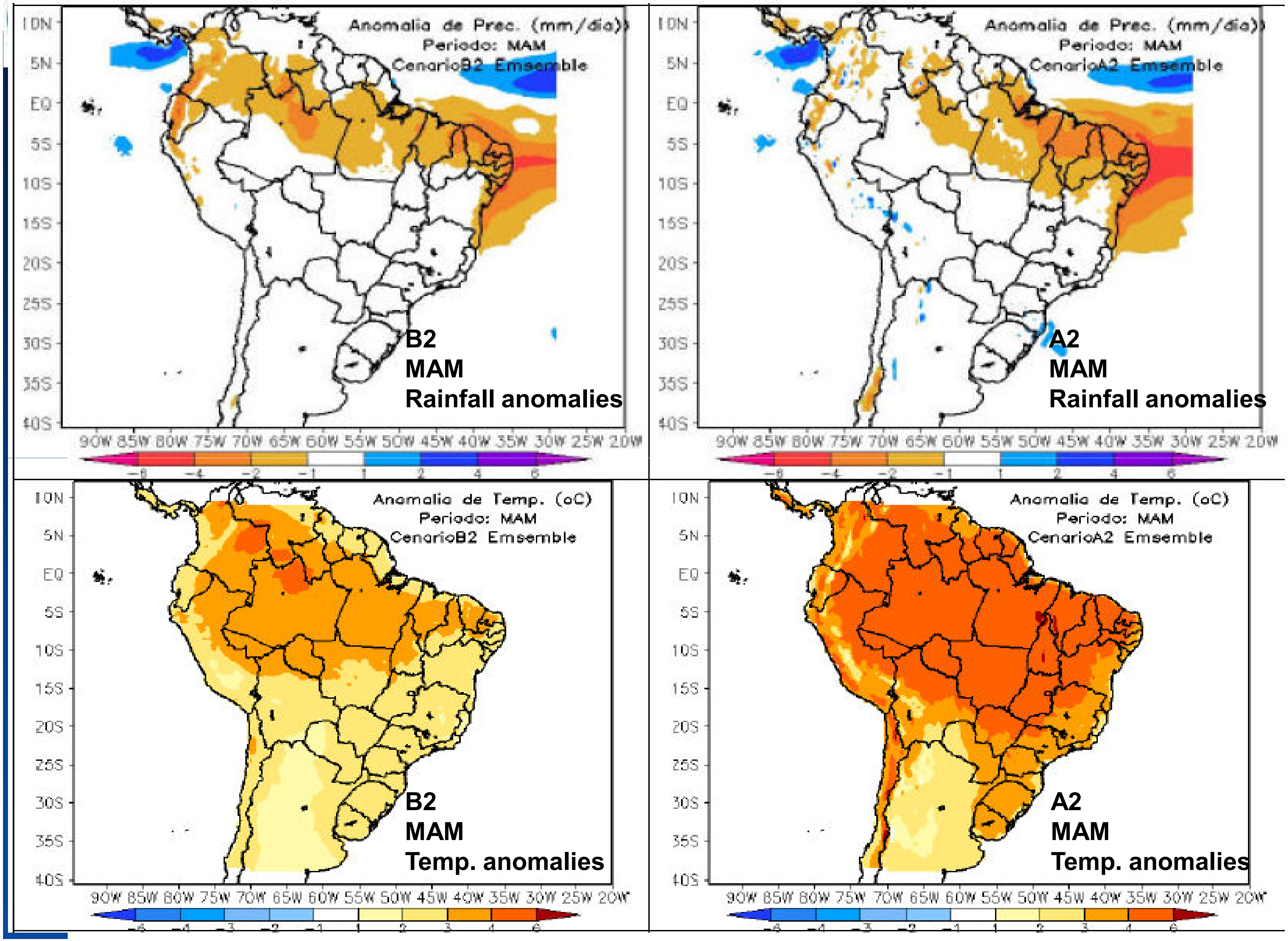


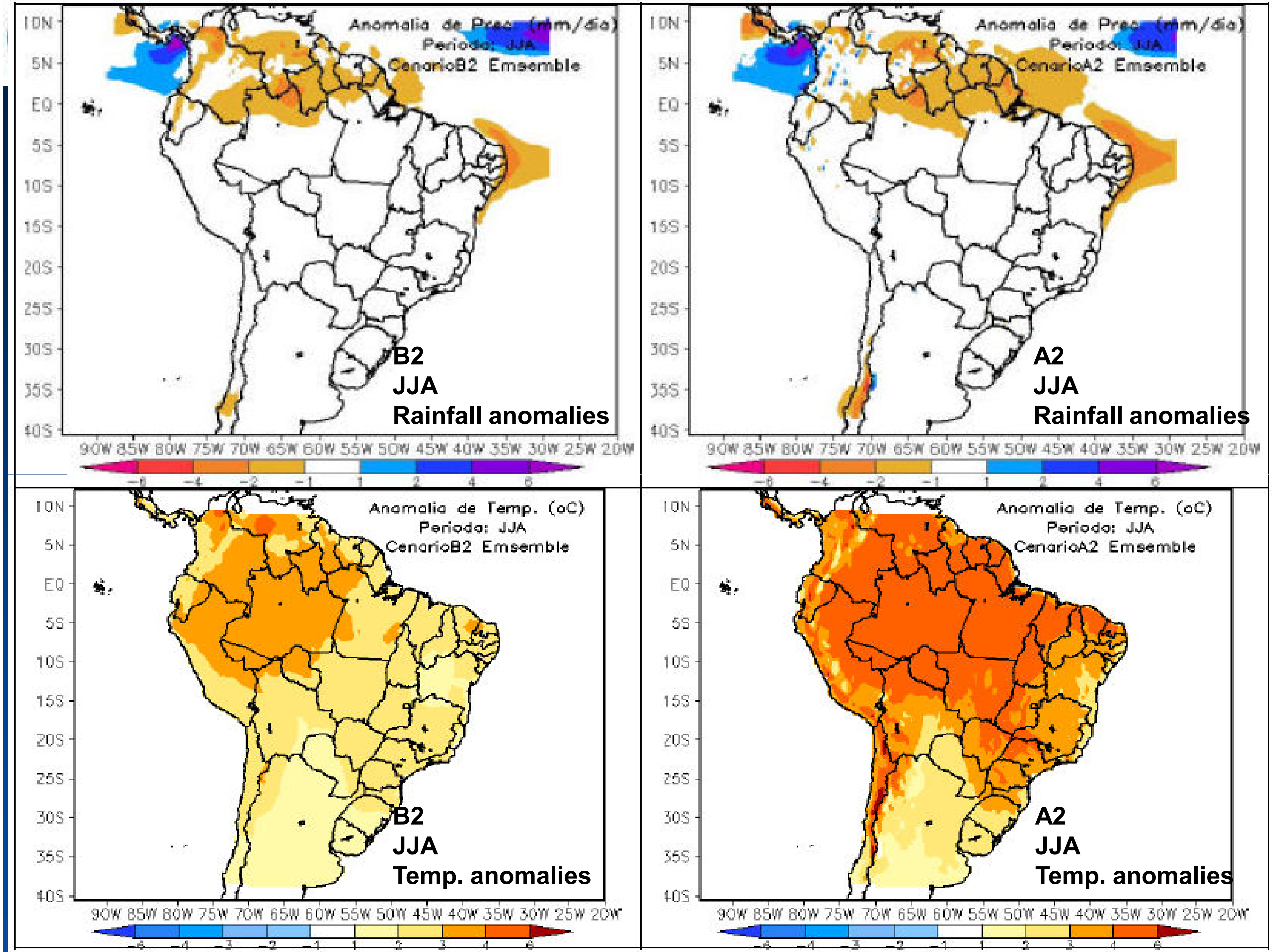
B2

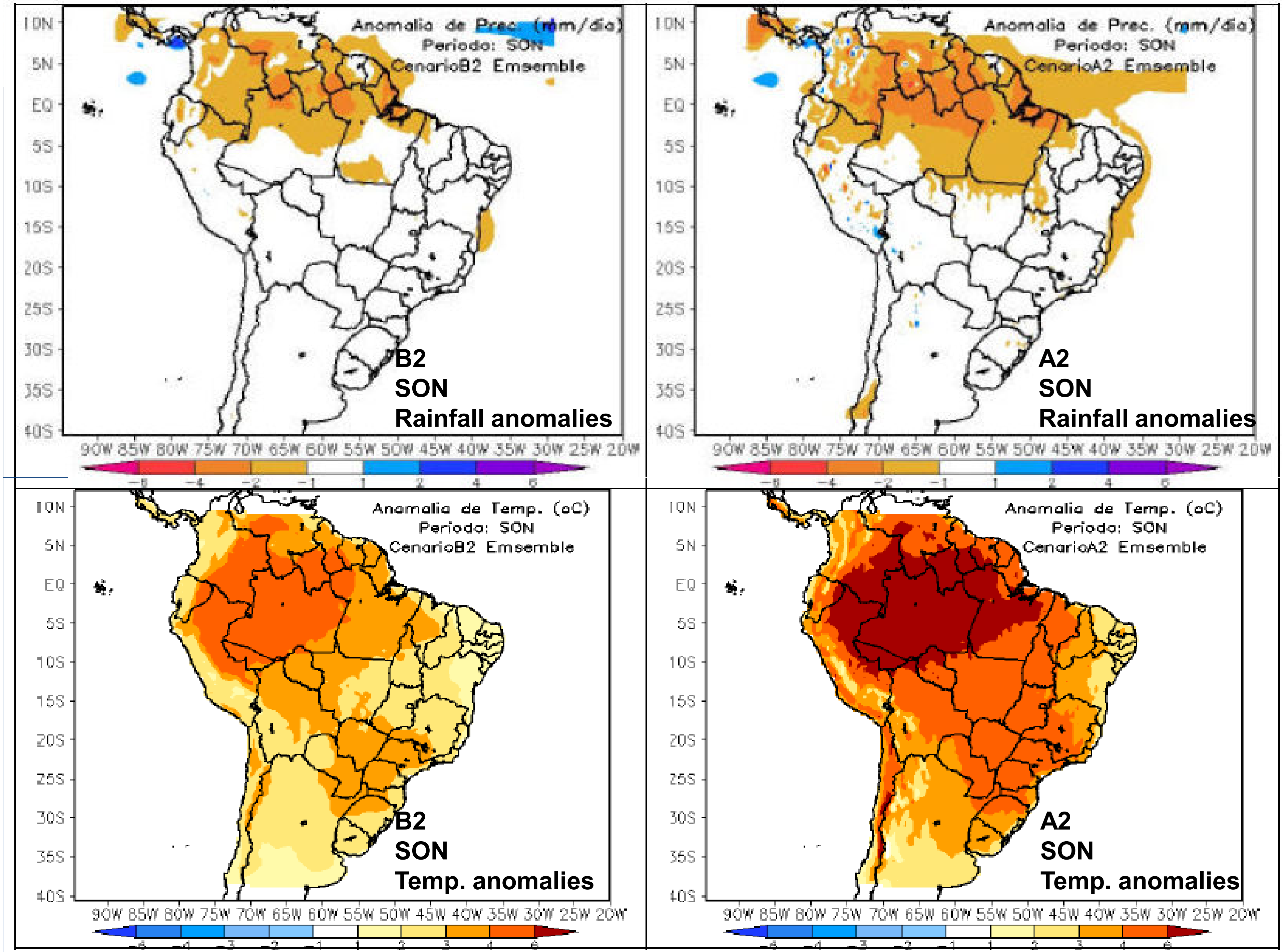


A2


Anomalia de Prec. (mm/dia)
Periodo: DJF
CenarioB2 Emsemble
B2
DJF
Rainfall anomalies
Anomalia de Prec. (mm/dia)
Periodo: DJF
CenarioA2 Emsemble
A2
DJF
Rainfall anomalies
Anomalia de Temp. (oC)
Periodo: DJF
CenarioB2 Emsemble
B2
DJF
Temp. anomalies
Anomalia de Temp. (oC)
Periodo: DJF
CenarioA2 Emsemble
A2
DJF
Temp. anomalies


Anomalia de Prec. (mm/dia)
Periodo: MAM
CenarioB2 Emsemble
B2
MAM
Rainfall anomalies
Anomalia de Prec. (mm/dia)
Periodo: MAM
CenarioA2 Emsemble
A2
MAM
Rainfall anomalies
Anomalia de Temp. (oC)
Periodo: MAM
CenarioB2 Emsemble
B2
MAM
Temp. anomalies
Anomalia de Temp. (oC)
Periodo: MAM
CenarioA2 Emsemble
A2
MAM
Temp. anomalies
10N 5N EQ 5S 10S 15S 20S 25S 30S 35S 40S
90W 85W 80W 75W 70W 65W 60W 55W 50W 45W 40W 35W 30W 25W 20W


Anomalia de Prec (mm/dia)
Periodo: JJA
CenarioB2 Emsemble
B2
JJA
Rainfall anomalies
Anomalia de Prec (mm/dia)
Periodo: JJA
CenarioA2 Emsemble
A2
JJA
Rainfall anomalies
Anomalia de Temp. (oC)
Periodo: JJA
CenarioB2 Emsemble
B2
JJA
Temp. anomalies
Anomalia de Temp. (oC)
Periodo: JJA
CenarioA2 Emsemble
A2
JJA
Temp. anomalies
10N 5N EQ 5S 10S 15S 20S 25S 30S 35S 40S
90W 85W 80W 75W 70W 65W 60W 55W 50W 45W 40W 35W 30W 25W 20W

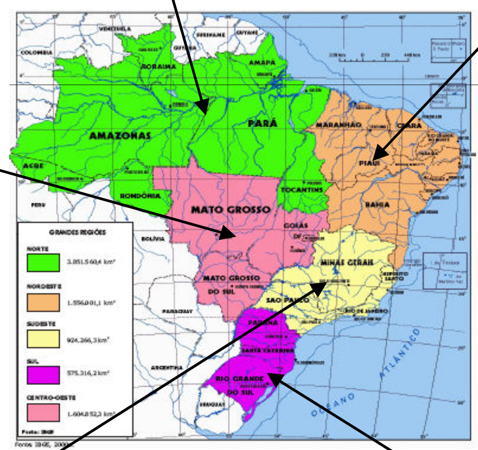

Anomalia de Prec. (mm/dia)
Periodo: SON
CenarioB2 Emsemble
B2
SON
Rainfall anomalies
Anomalia de Prec. (mm/dia)
Periodo: SON
CenarioA2 Emsemble
A2
SON
Rainfall anomalies
Anomalia de Temp. (oC)
Periodo: SON
CenarioB2 Emsemble
B2
SON
Temp. anomalies
Anomalia de Temp. (oC)
Periodo: SON
CenarioA2 Emsemble
A2
SON
Temp. anomalies
10N 5N EQ 5S 10S 15S 20S 25S 30S 35S 40S
90W 85W 80W 75W 70W 65W 60W 55W 50W 45W 40W 35W 30W 25W 20W

Summary of future climate change scenarios for the end of the XXI Century and possible impacts in Brazil

AMAZON REGION
A2: 4-8 C warmer, 15-20% less rainfall
B2: 3-5 C warmer, 5-15 % less rainfall
Possible impacts: High frequency of dry spells in eastern Amazonia and intense rainfall events in western Amazonia, losses in natural ecosystems, rain forest and biodiversity. Low river levels affecting transportation and commerce. Possible impacts on moisture transport and rainfall in Southeastern South America. Impacts on hydroelectric generation. More favorable conditions for spread of forest fires. Impacts on health and commerce due to smoke.

NORTHEAST BRAZIL
A2: 2-4 C warmer, 15-20% less rainfall
B2: 1-3 C warmer, 10-15 % less rainfall
Possible impacts: High frequency of dry spells and evaporation rates and low soil moisture levels affecting levels of channels and reservoirs. Losses in natural ecosystems caatinga.Tendency towards aridization and desertification in the semiarid region. Water scarsity. Waves of climate refugees migrating towards large cities agravating social problems. Impacts on human health

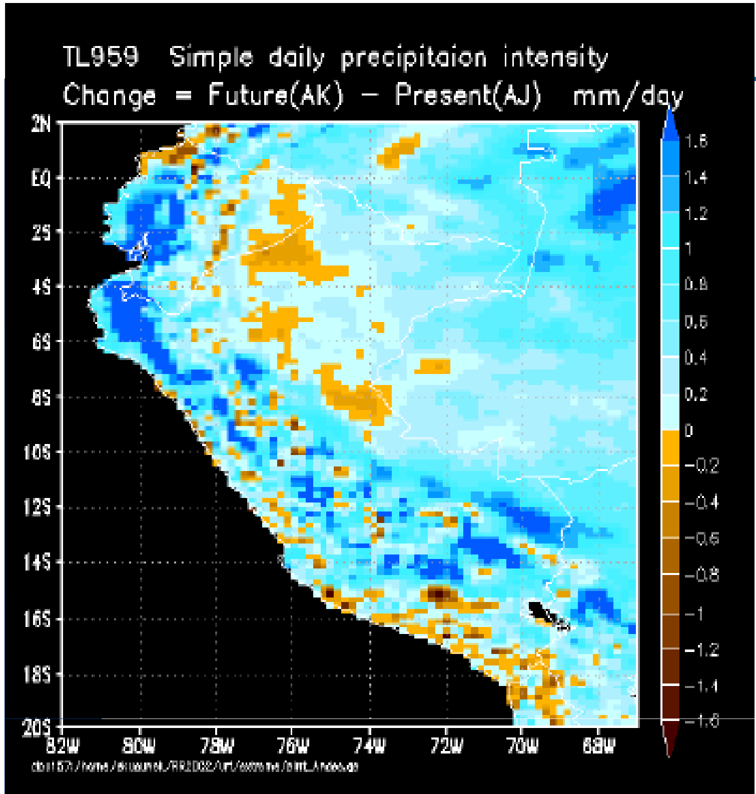
WEST CENTRAL BRAZIL
A2: 3-6 C warmer,
B2: 2-4 C warmer,
Possible impacts: High frequency of intense rainfall events and dry spells. High evaporation rates and lower soil moisture can affect agriculture (coffee) and hydroelectric generation. Soil erosion due to high temperatures and intense dry spells can affect agriculture and natural ecosystems Pantanal and cerrado.



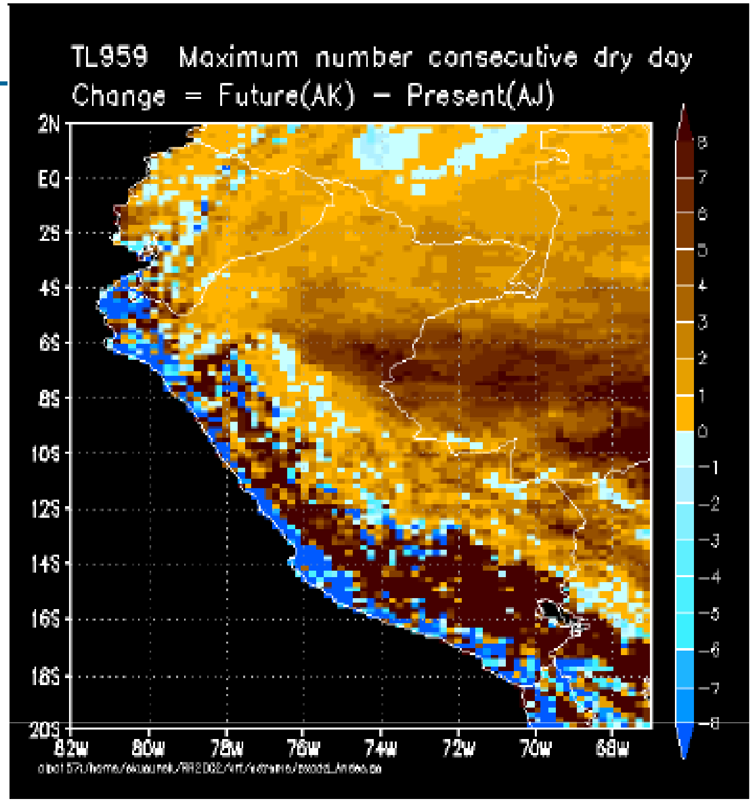
SOUTHERN BRAZIL
A2: 2-4 C warmer, 5-10% more rainfall
B2: 1-3 C warmer, 0-5 % more rainfall
Possible impacts: High frequency of intense rainfall events, increase in warm nights frequency (reduction of cold nights). Intense rainfall and high evaporation due to dry spells can affect agriculture (weath and soybean). Losses in natural ecosystems. High temperatures and intense rainfall can affect human health

SOUTHEASTERN BRAZIL
A2: 3-6 C warmer,
B2: 2-3 C warmer,
Possible impacts: High frequency of intense rainfall events. High evaporation rates and lower soil moisture can affect agriculture (coffee) and hydroelectric generation. High temperatures and intense rainfall can affect human health. Possible sea level rise.

Sources: INPE, MMA-PROBIO, EMBRAPA, CEPAGRI



Tendencias de índices de precipitación intense esporádica y de máximo número de días secos consecutivos en Perú. Derivados del modelo Global del MRI-Earth Simulator, resolución de 20 km lat-lon. Los mapas representan la diferencia entre el clima del futuro (2080-99) menos el presente (1961-90), para el escenario A1B (Avalos 2007)

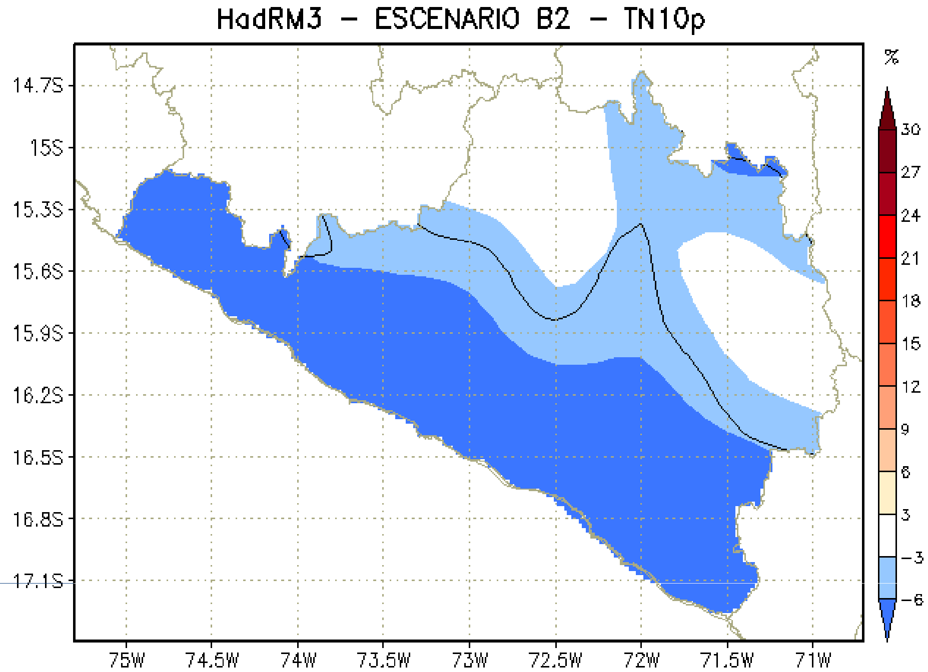


-Los extremos de temperaturas (días con temperaturas mayores a 35 °C) tienden a aumentar en la costa norte y central de Perú, y en la parte sur de la Amazonía Peruana. La frecuencia de noches cálidas también tiende a aumentar en la región norte de Perú.

-Los extremos de lluvia o falta de ella son tal vez más importantes en esta simulación con el ES para la región Andina. El índice de días con precipitación intensa tiende a aumentar en el futuro en el Norte de Perú y en la región de Madre de Dios, así como en los dos flancos de los Andes, lo que puede ser debido a un efecto orográfico. En comparación, en la región sudoeste de los Andes, puede haber déficit de precipitación intensa episódica.

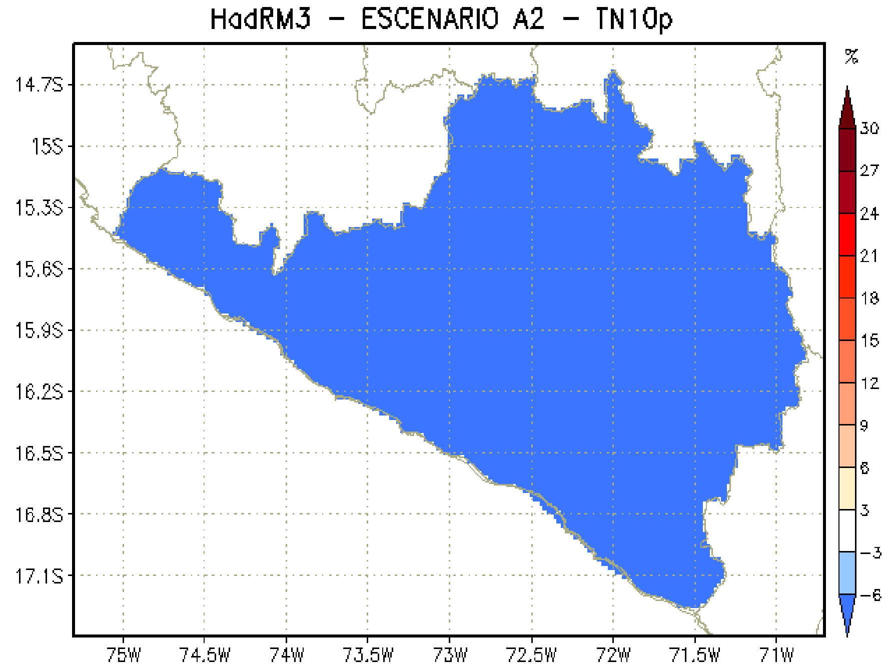
-El índice de días secos consecutivos muestra una tendencia positiva hasta finales de Siglo XXI en regiones como Amazonía (3-5 días) y al sur de 5 °S. Sobre los Andes la tendencia puede aumentar hasta 7-8 días, mientras que en el flanco occidental de los Andes y en la región costera la tendencia es de disminuir el número de días secos consecutivos.

TN10, B2



TN10P-Porcentaje de noches muy frías

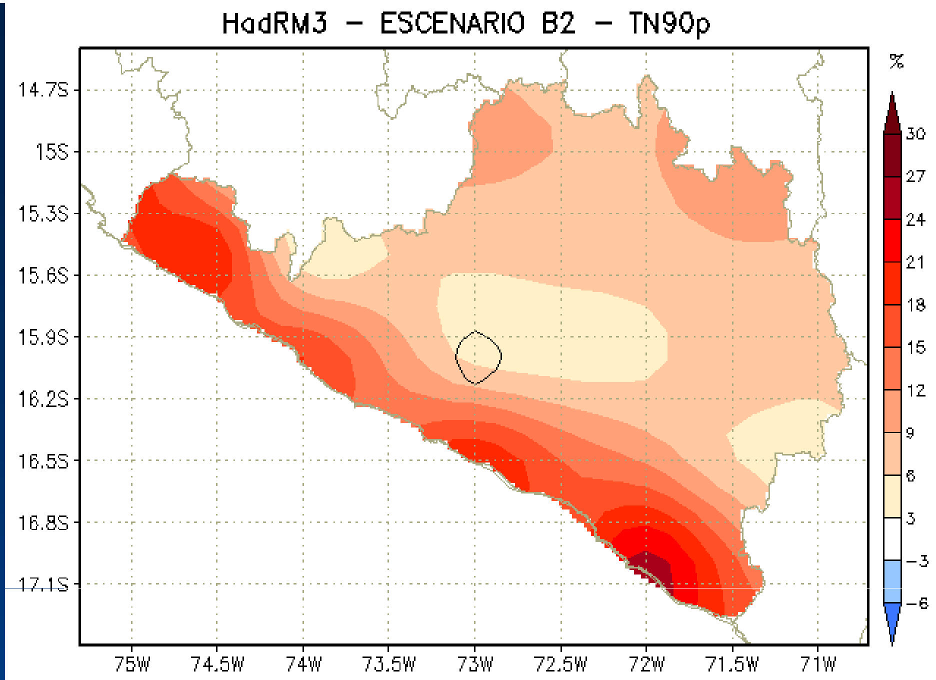
TN10, A2



Anomalías de índices de extremos de temperatura, futuro (2071-2100) menos presente (1961-90)

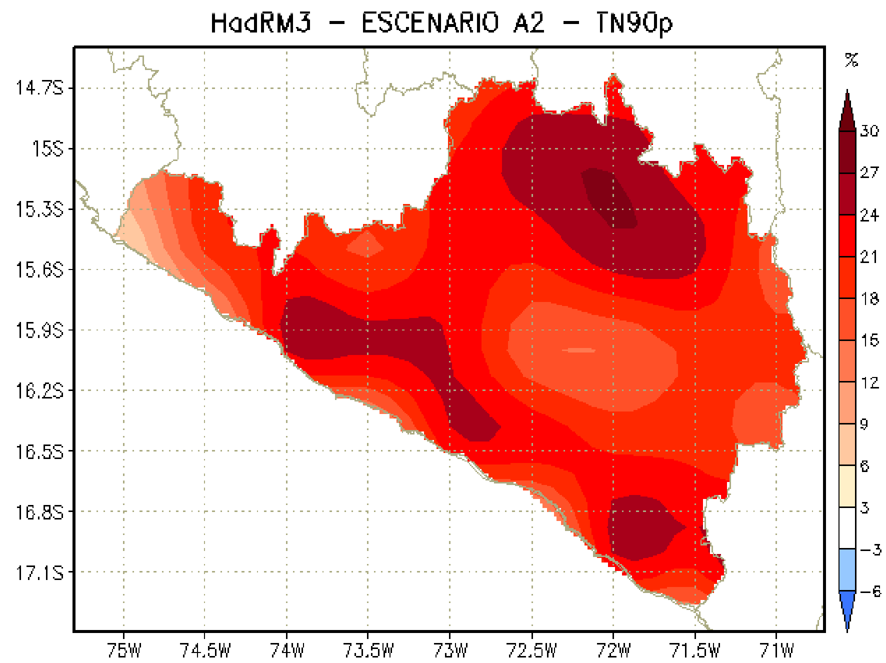
Modelo HadRM3P, 50 km lat-lon

TN90, B2



TN90P-Porcentaje de noches cálidas

TN90, A2



Anomalías de índices de extremos de temperatura, futuro (2071-2100) menos presente (1961-90)

Modelo HadRM3P, 50 km lat-lon

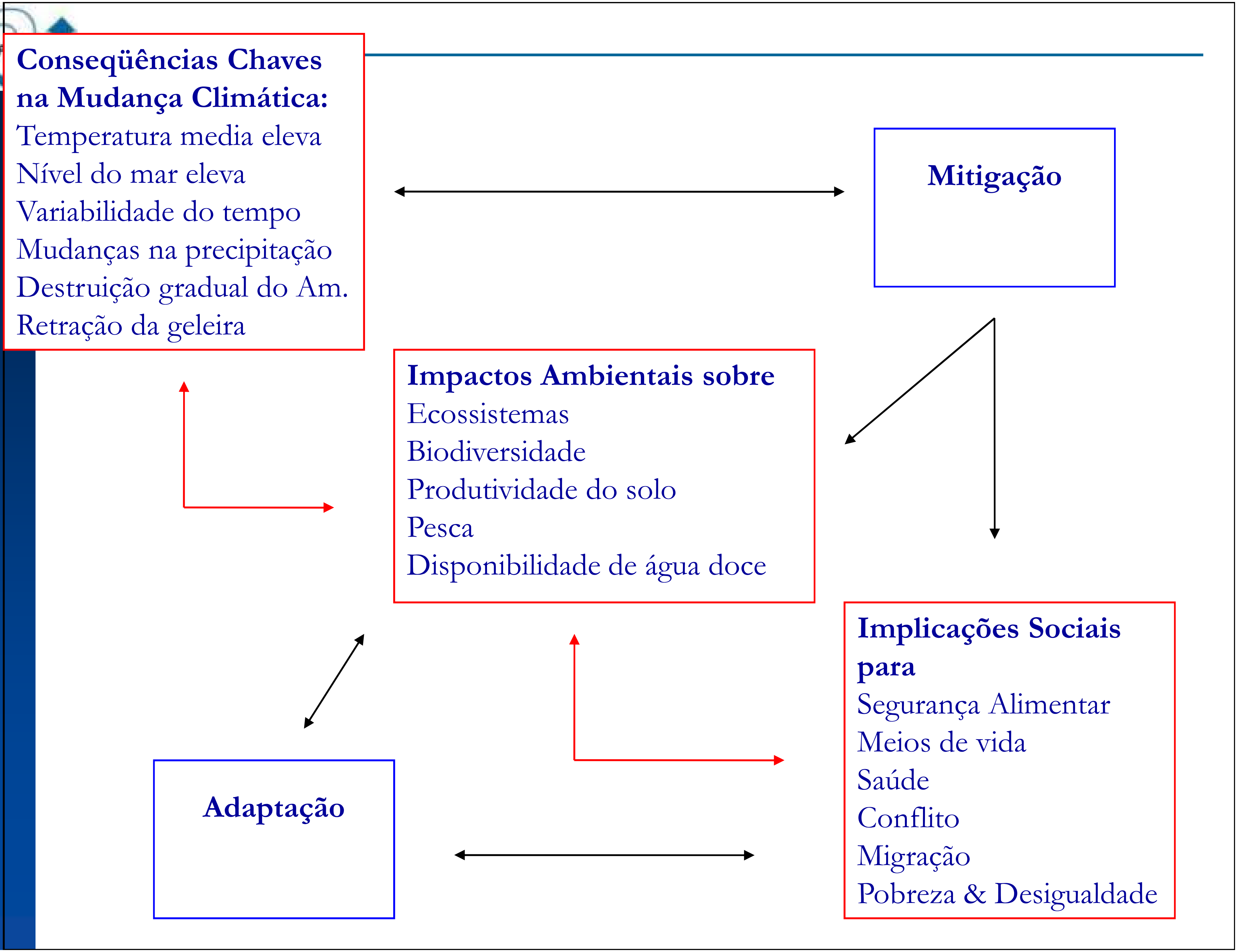

Conseqüências Chaves na Mudança Climática:
Temperatura media eleva
Nível do mar eleva
Variabilidade do tempo
Mudanças na precipitação
Destruição gradual do Am.
Retração da geleira
Mitigação
Impactos Ambientais sobre
Ecossistemas
Biodiversidade
Produtividade do solo
Pesca
Disponibilidade de água doce
Implicações Sociais para
Segurança Alimentar
Meios de vida
Saúde
Conflito
Migração
Pobreza & Desigualdade
Adaptação

Ilustração para o caso de mudanças climáticas globais: Relação DSN dentro do CCST