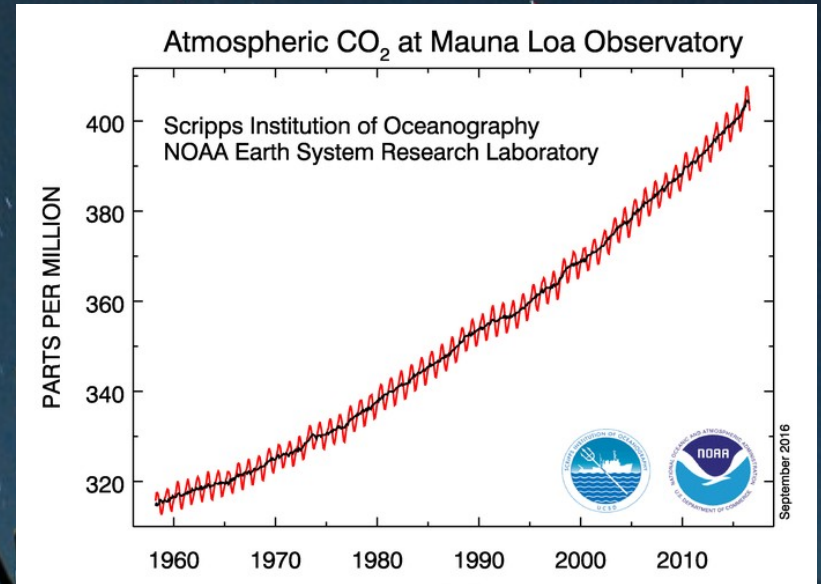
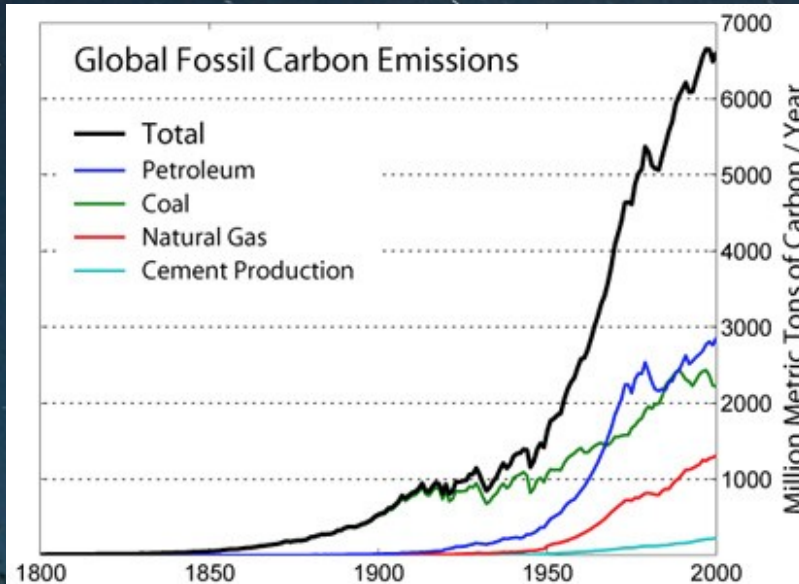
A night sky with a star trail and a silhouette of a cactus against a dark blue background. The star trail is a long, thin, white line of light, likely from a satellite or a bright star, moving across the sky. The cactus is a tall, columnar cactus with many vertical stems, silhouetted against the dark blue sky. The background is a dark blue night sky with a star trail.

Mudanças Climáticas e Impactos sobre os Recursos Hídricos no  
Nordeste Brasileiro: um Debate Necessário

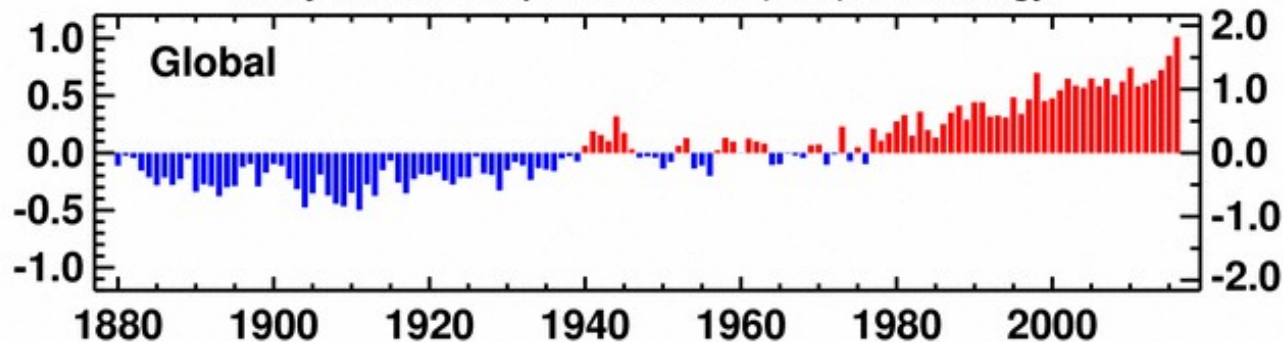
Alexandre Costa  
UECE

# Contexto: Mudanças Climáticas Globais

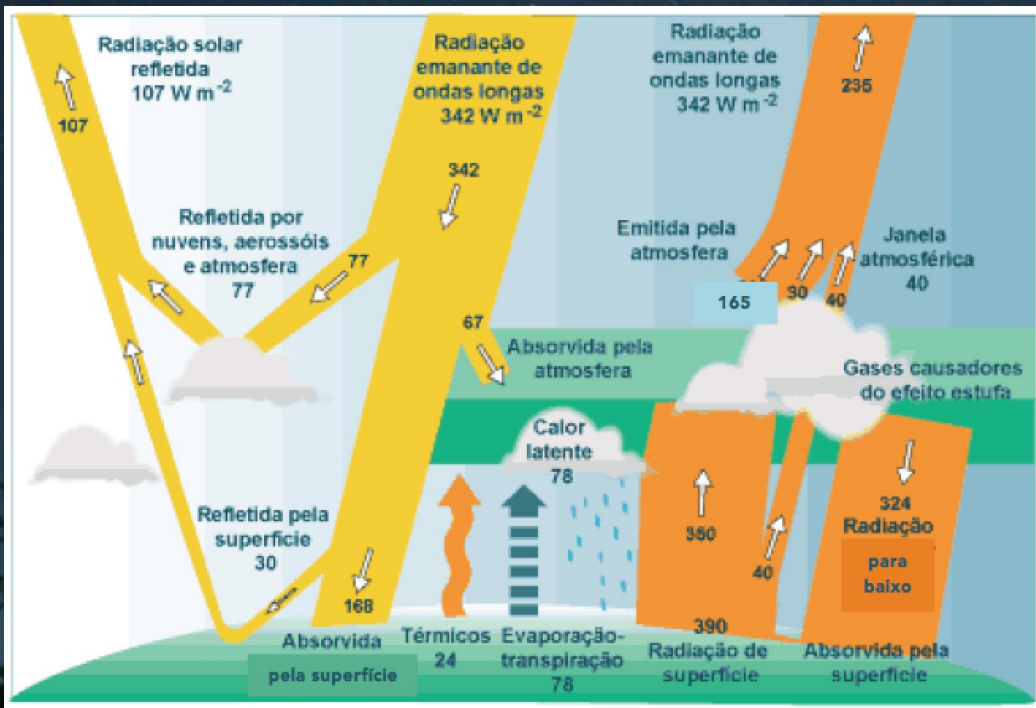


## Jan-Aug Land & Ocean Surface Mean Temp Anomalies NCEI/NESDIS/NOAA

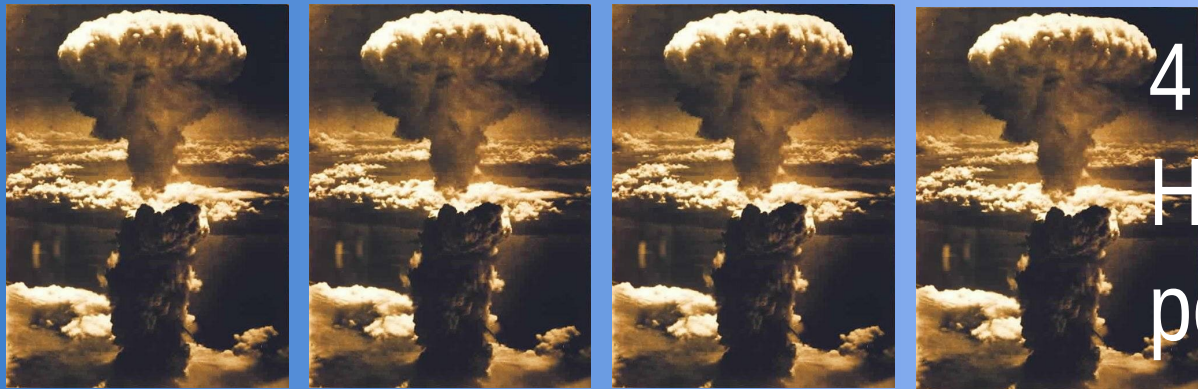
Analysis is based upon Smith et al. (2008) methodology.



# É um processo bem quantificado do ponto de vista do balanço energético



Substância emitida	Derivados na atmosfera	Forçante Radiativa associada à substância emitida e derivados	
		Forçante Radiativa (W m⁻²)	Intervalo (W m⁻²)
<b>Forçantes antropogênicas</b>			
<b>Gasos de efeito estufa de vida longa</b>			
CO <sub>2</sub>	CO <sub>2</sub>	1.68	[1.33 to 2.03]
CH <sub>4</sub>	CO <sub>2</sub> , H <sub>2</sub> O, O <sub>3</sub> , CH <sub>4</sub>	0.97	[0.74 to 1.20]
Halo-carbons	O <sub>3</sub> , CFCs, HCFCs	0.18	[0.01 to 0.35]
N <sub>2</sub> O	N <sub>2</sub> O	0.17	[0.13 to 0.21]
<b>Forçantes antropogênicas de vida curta e aerossóis</b>			
CO	CO <sub>2</sub> , CH <sub>4</sub> , O <sub>3</sub>	0.23	[0.16 to 0.30]
NM VOC	CO <sub>2</sub> , CH <sub>4</sub> , O <sub>3</sub>	0.10	[0.05 to 0.15]
NO <sub>x</sub>	Nitrate, CH <sub>4</sub> , O <sub>3</sub>	-0.15	[-0.34 to 0.03]
<b>Gasos de vida curta e aerossóis</b>			
Aerossóis and precursors (Mineral dust, SO <sub>2</sub> , NH <sub>3</sub> , Organic Carbon and Black Carbon)		-0.27	[-0.77 to 0.23]
Cloud Adjustments due to Aerosols		-0.55	[-1.33 to -0.06]
Albedo Change due to Land Use		-0.15	[-0.25 to -0.05]
<b>Natural</b>			
Changes in Solar Irradiance		0.05	[0.00 to 0.10]
<b>Total Anthropogenic RF relative to 1750</b>			
		2011	2.29 [1.13 to 3.33]
		1980	1.25 [0.64 to 1.86]
		1950	0.57 [0.29 to 0.85]



4 Bombas de Hiroshima por segundo

# Ondas de Calor



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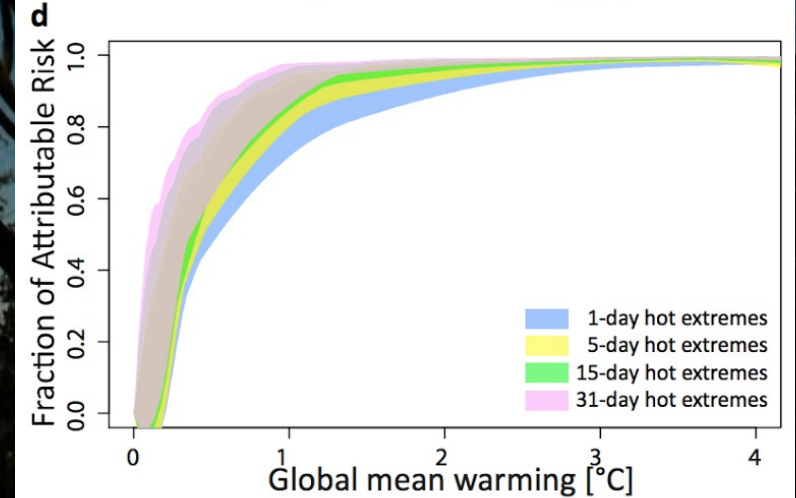
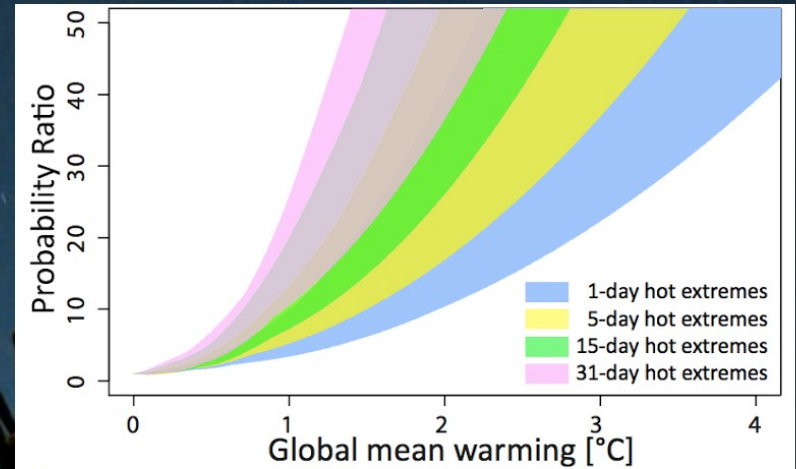
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Joint Faculty Positions at the Center for Quantitative Biology and Peking-Tsinghua Center for Life Sciences  
Center for Quantitative Biology and Peking-Tsinghua Center for Life Sciences, Peking

E. M. Fischer & R. Knutti

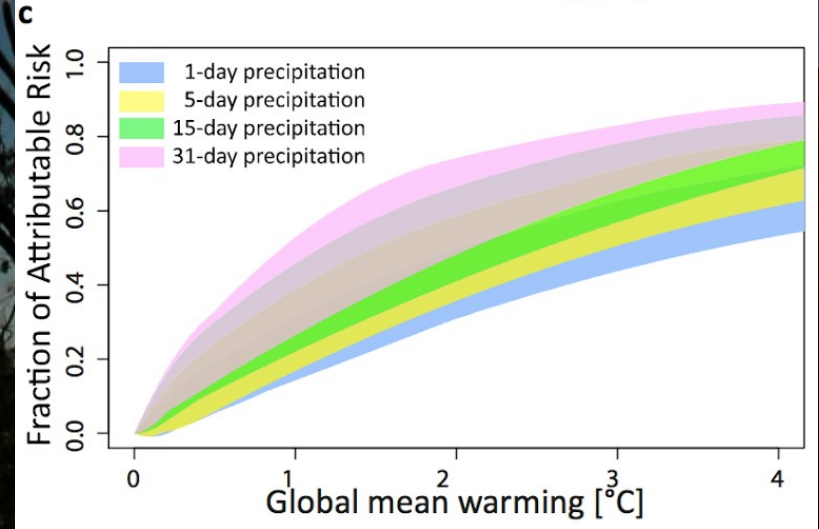
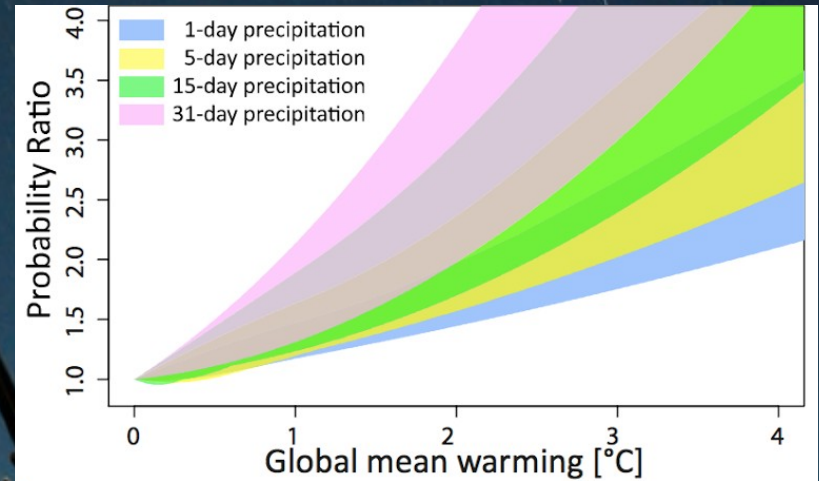
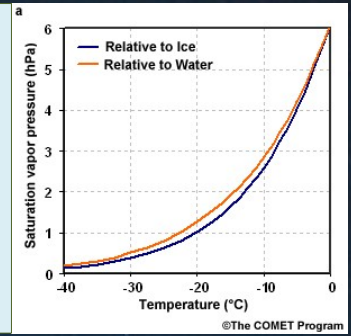
Affiliations | Contributions | Corresponding author

Nature Climate Change 5, 560–564 (2015) | doi:10.1038/nclimate2617  
Received 27 November 2014 | Accepted 18 March 2015 | Published online 27 April 2015




# Enchantes

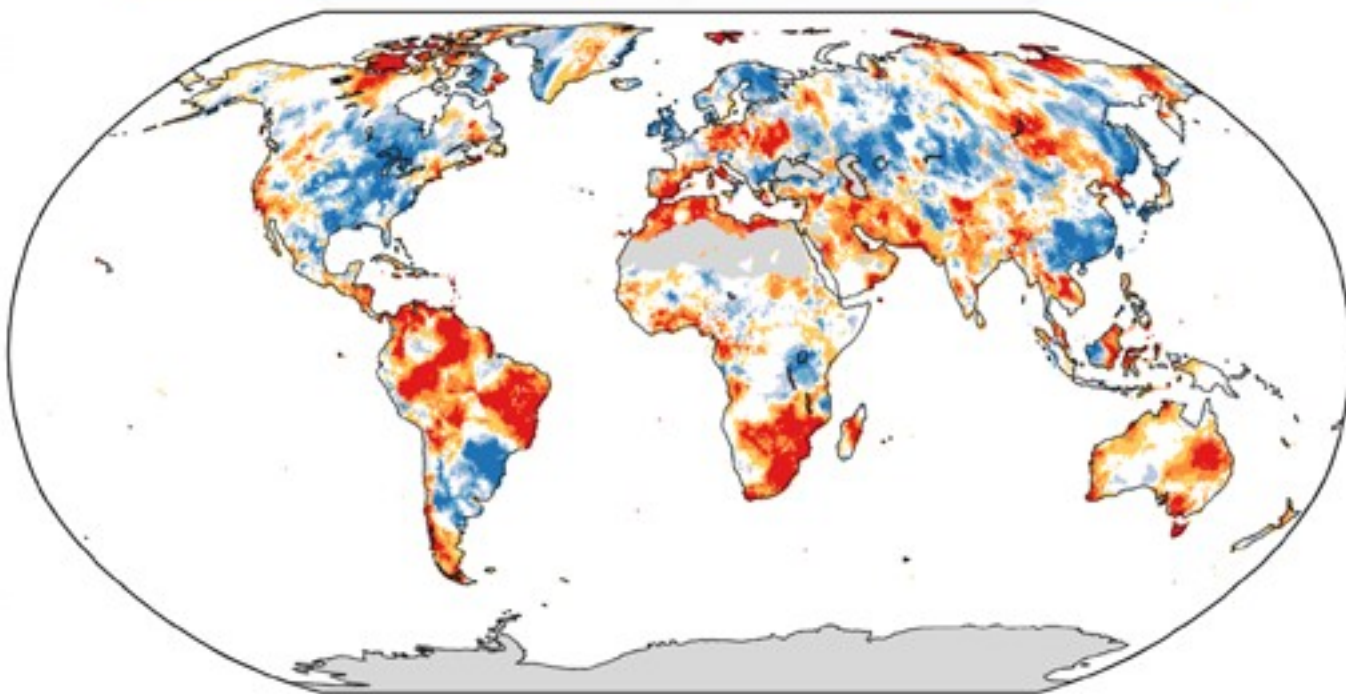
$$\frac{de^*}{dT_g^n} = \frac{l_g * e^* T_g^n}{R_v * T_g^{n+2}}$$



## Severe Drought Was Common in 2016

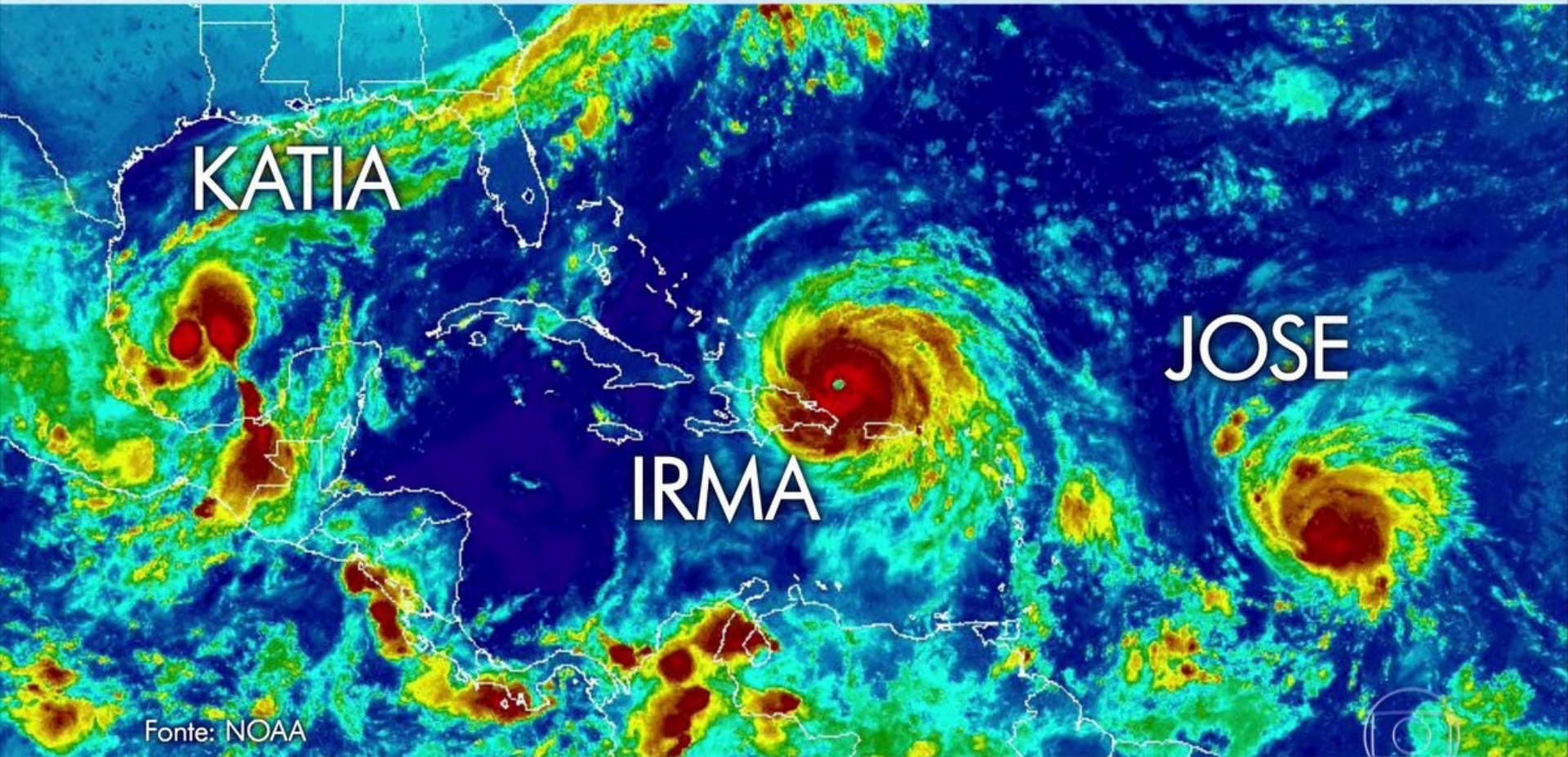
In every month of 2016, at least 12% of global land was in severe drought, the State of the Climate in 2016 report shows.

DRY   WET



SOURCE: Osborn et al., 2017

InsideClimate News

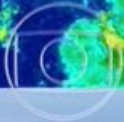


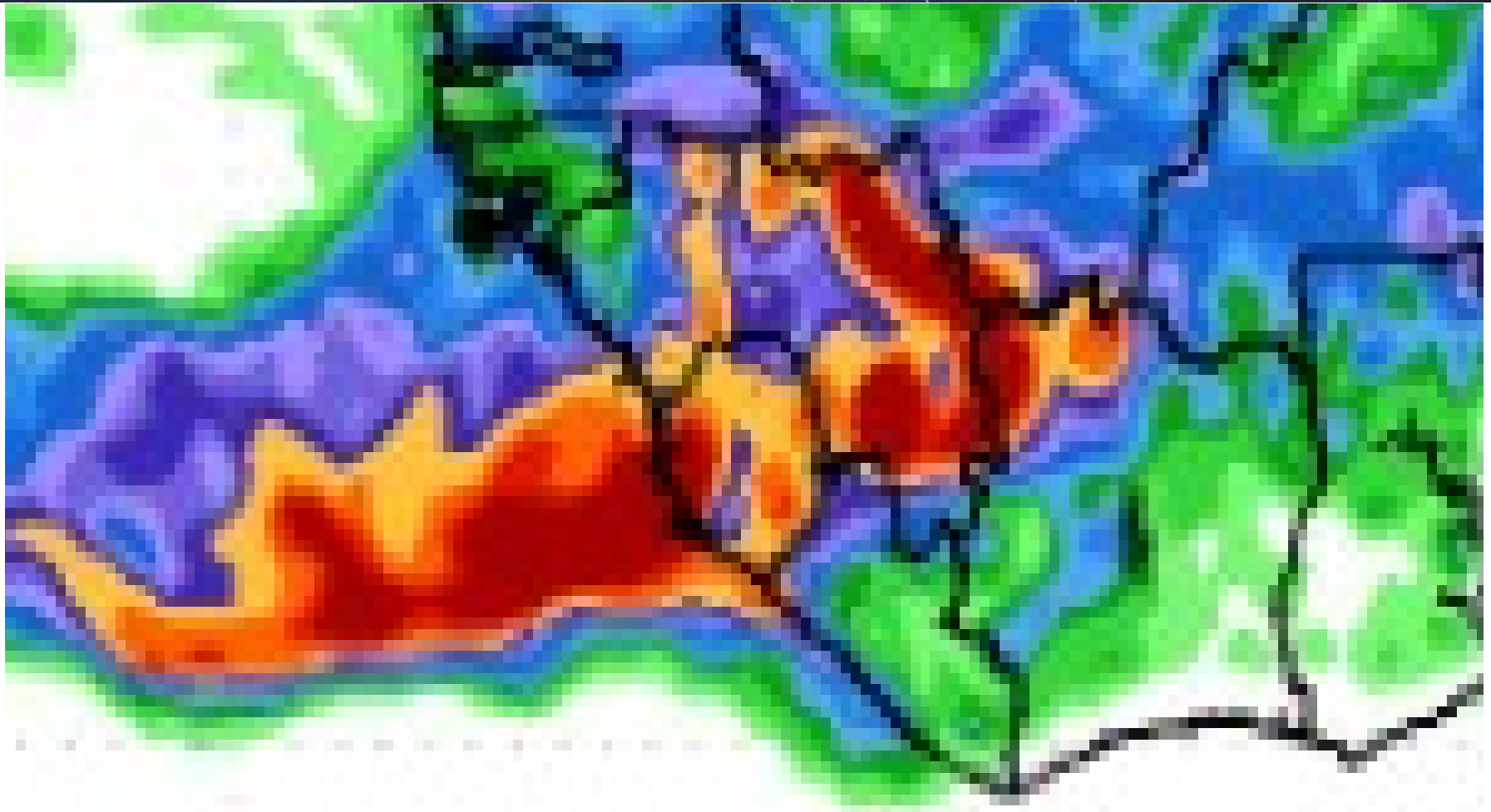
KATIA

JOSE

IRMA

Fonte: NOAA









## IMAGES SHOW NEW MUDSLIDE THREAT IN SIERRA LEONE

At least 331 people killed in Monday's mudslide

CNN

KOSPI ▼ -3.30

@CNBRK

WORLD LEADERS CONDEMN THE TERROR ATTACK IN BARCELONA, SPAIN



# MUDANÇAS CLIMÁTICAS E CICLO HIDROLÓGICO



# MUDANÇAS CLIMÁTICAS E CICLO HIDROLÓGICO



Aquecimento  
Global



# MUDANÇAS CLIMÁTICAS E CICLO HIDROLÓGICO

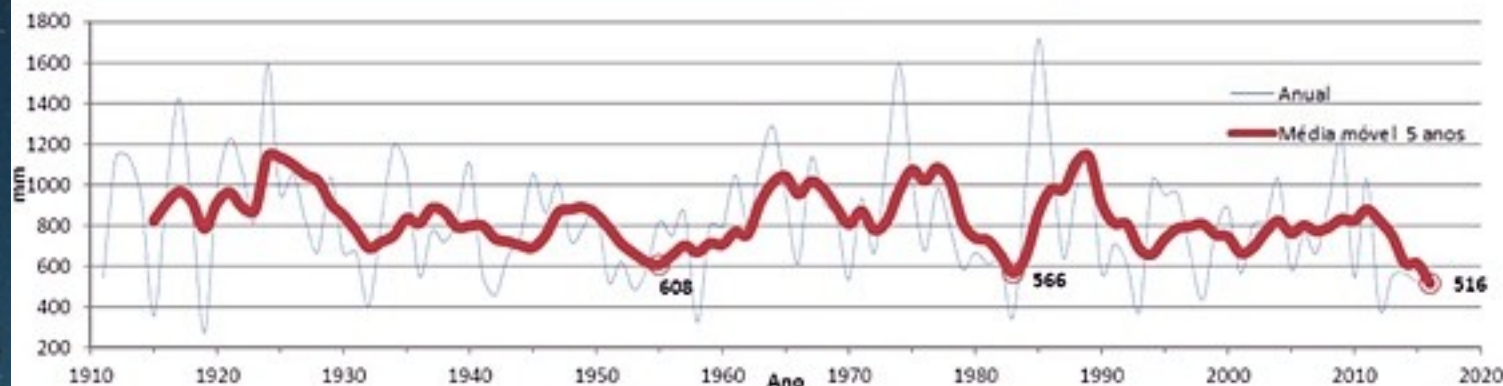
Mais calor

Mais evaporação

MAIS  
SECAS!

# Há evidências de mudanças climáticas em curso sobre nossa região?

## Chuva no Ceará (1910 a 2016)



Ano	chuva
1951	522
1952	624
1953	484
1954	587
1955	820
Média	608

Ano	chuva
1979	584
1980	667
1981	613
1982	618
1983	350
Média	566

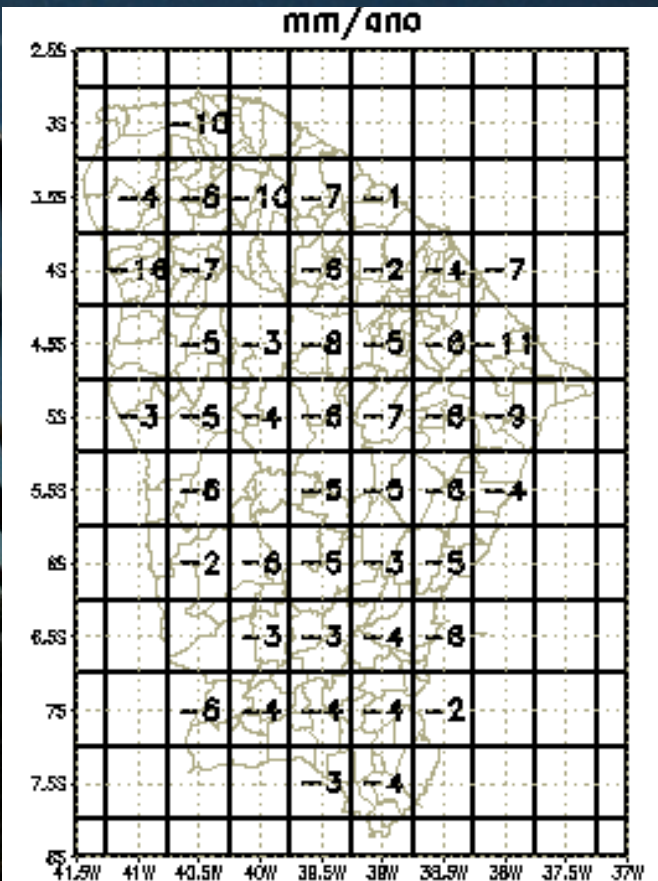
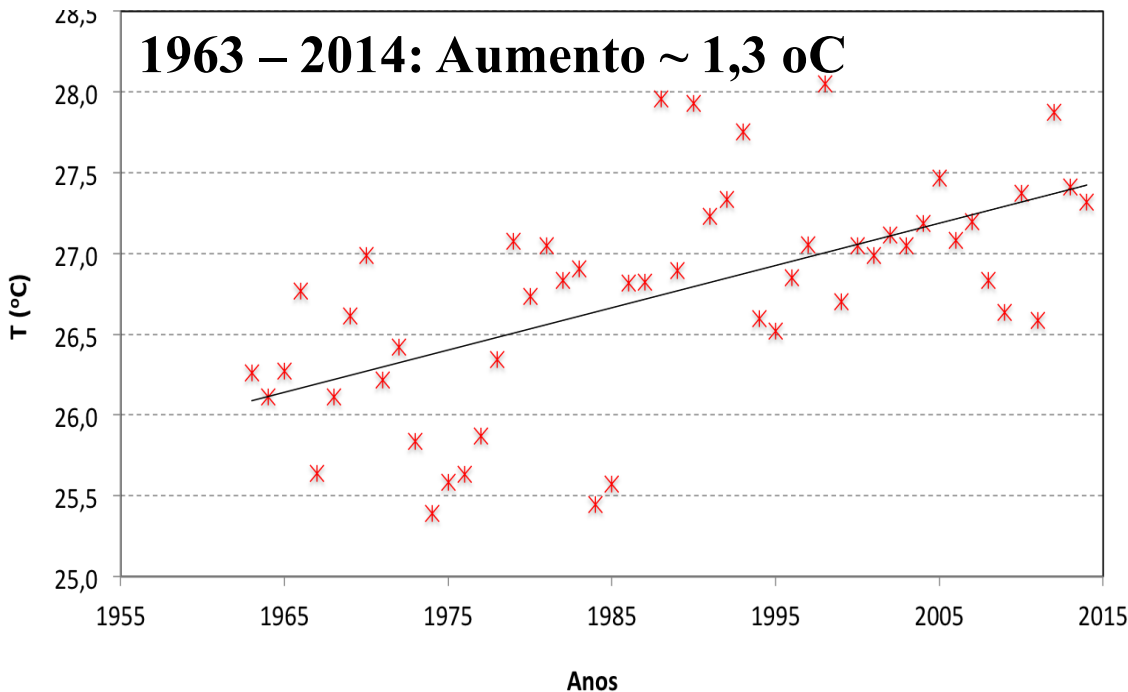
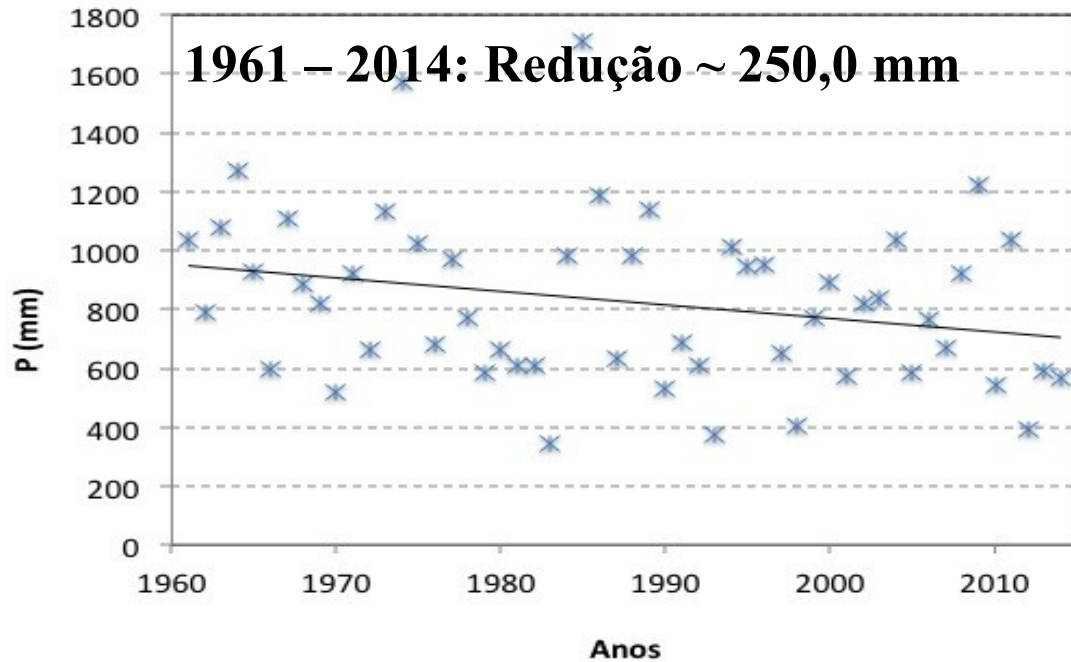
Ano	chuva
2012	388
2013	552
2014	565
2015	524
2016	550
Média	516

Por: David Ferran Moncunill



# Mudanças de Precipitação e Temperatura

## Dados: Funceme



# Quais as tendências apontadas por modelos?

Figura 2 – Projeção de mudança na umidade relativa para meados do século XXI (painel superior) e final do século XXI (painel inferior), de acordo com a média do conjunto de modelos do CMIP5. Cores quentes implicam em redução da umidade relativa. A projeção no cenário de emissões mais elevadas para o final do século é de queda de vários pontos percentuais na umidade relativa média (2 a 7 pontos) em quase todo o território brasileiro, com exceção da região Sul. Fonte: IPCC, 2013

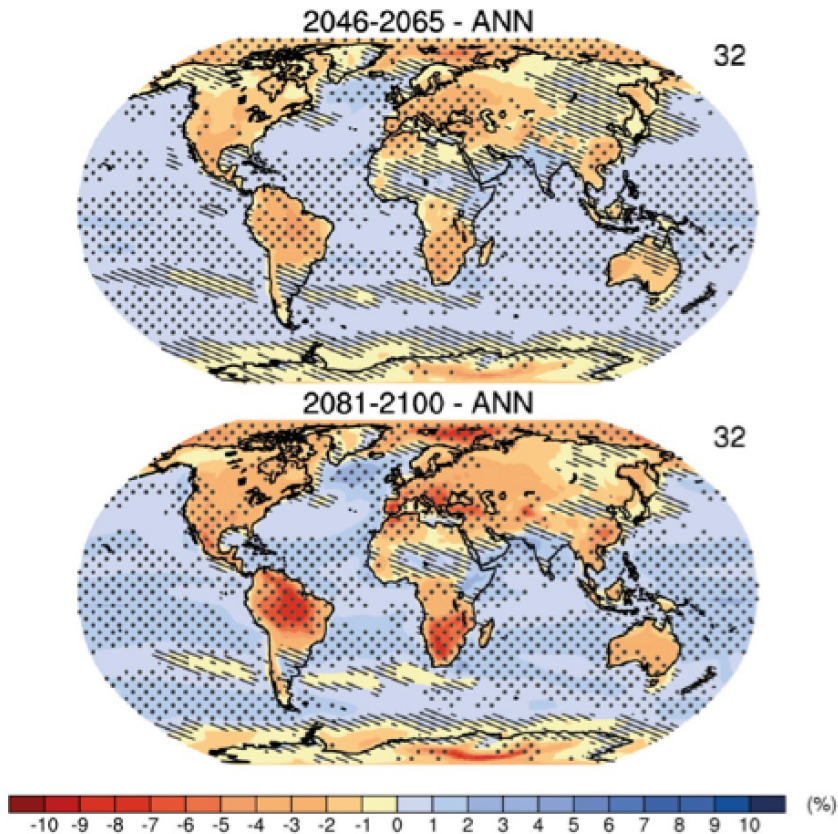
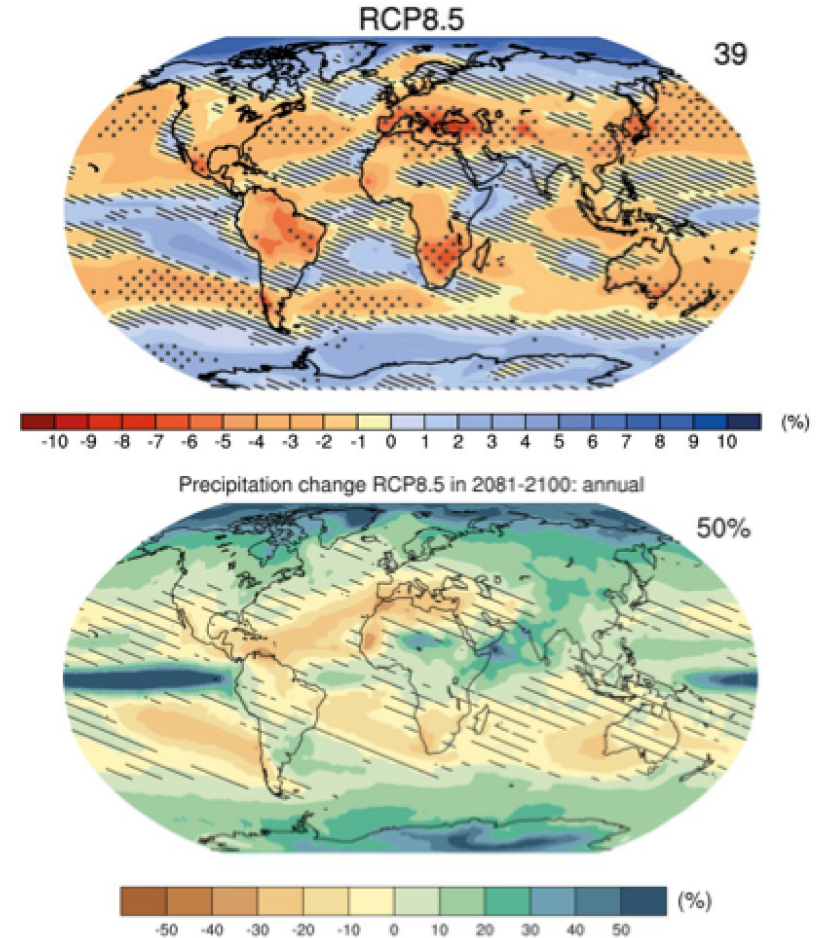
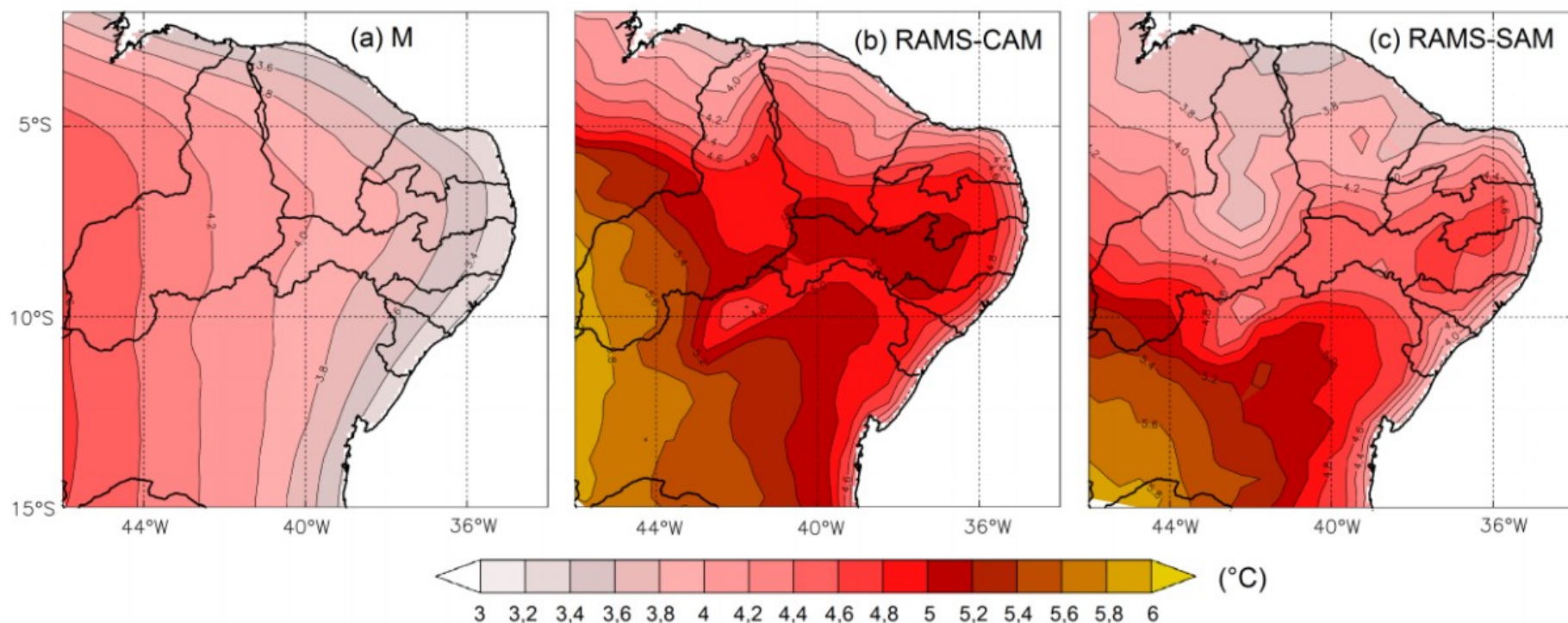


Figura 3 – Projeção de mudança, ao final do século XXI, para o cenário RCP8.5, da fração da área coberta por nuvens (acima) e precipitação (abaixo). Cores quentes indicam redução da nebulosidade e da precipitação e cores frias indicam aumento da nebulosidade e da precipitação.



# Projeção de elevação de temperatura segundo os modelos globais do CMIP/IPCC e os modelos regionais da UECE

Diferenças entre RCP85 *Long* (2079-2099) e Historical (1985-2005) da média anual





# Balanço Hídrico

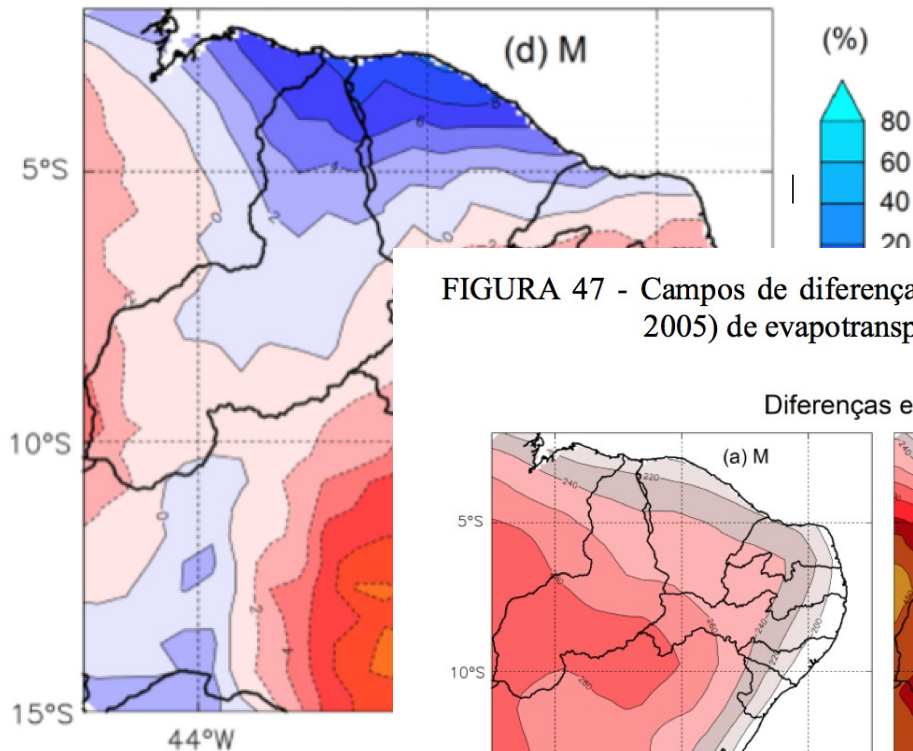
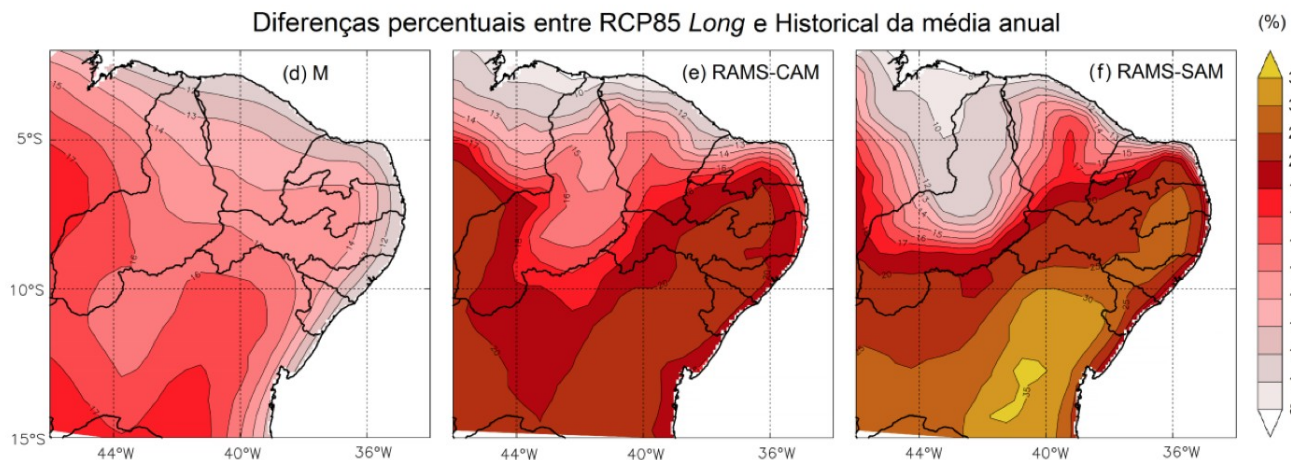
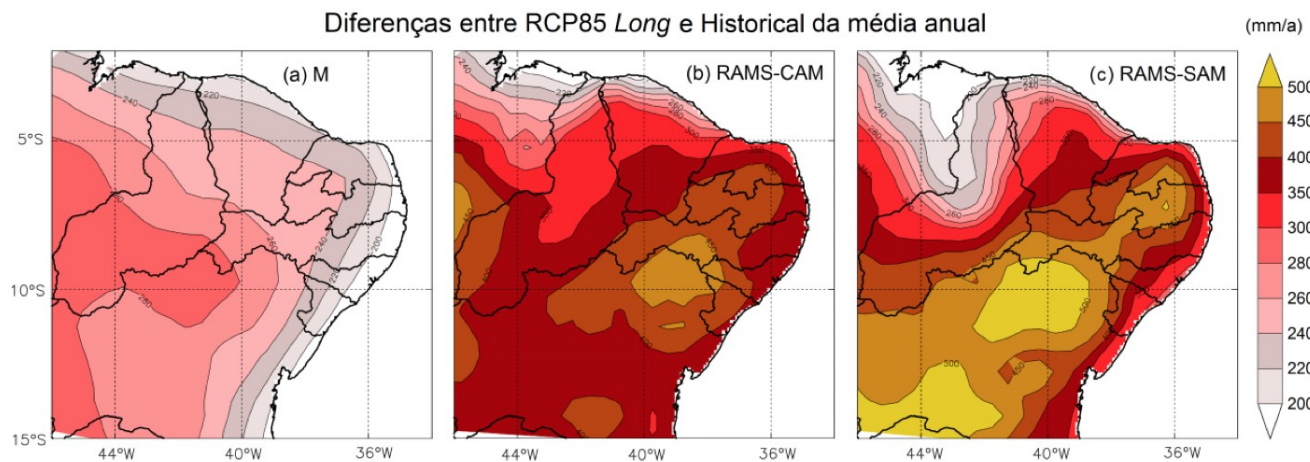
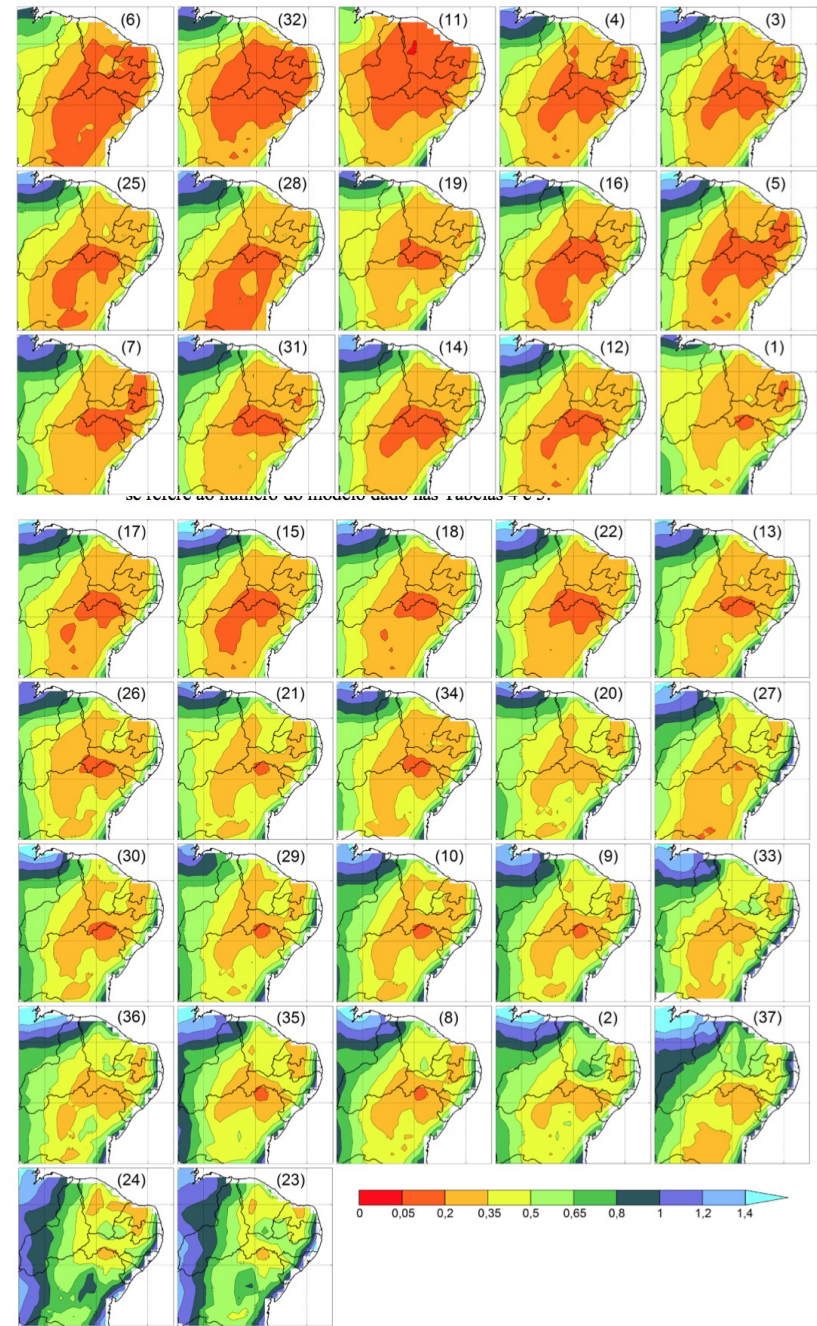
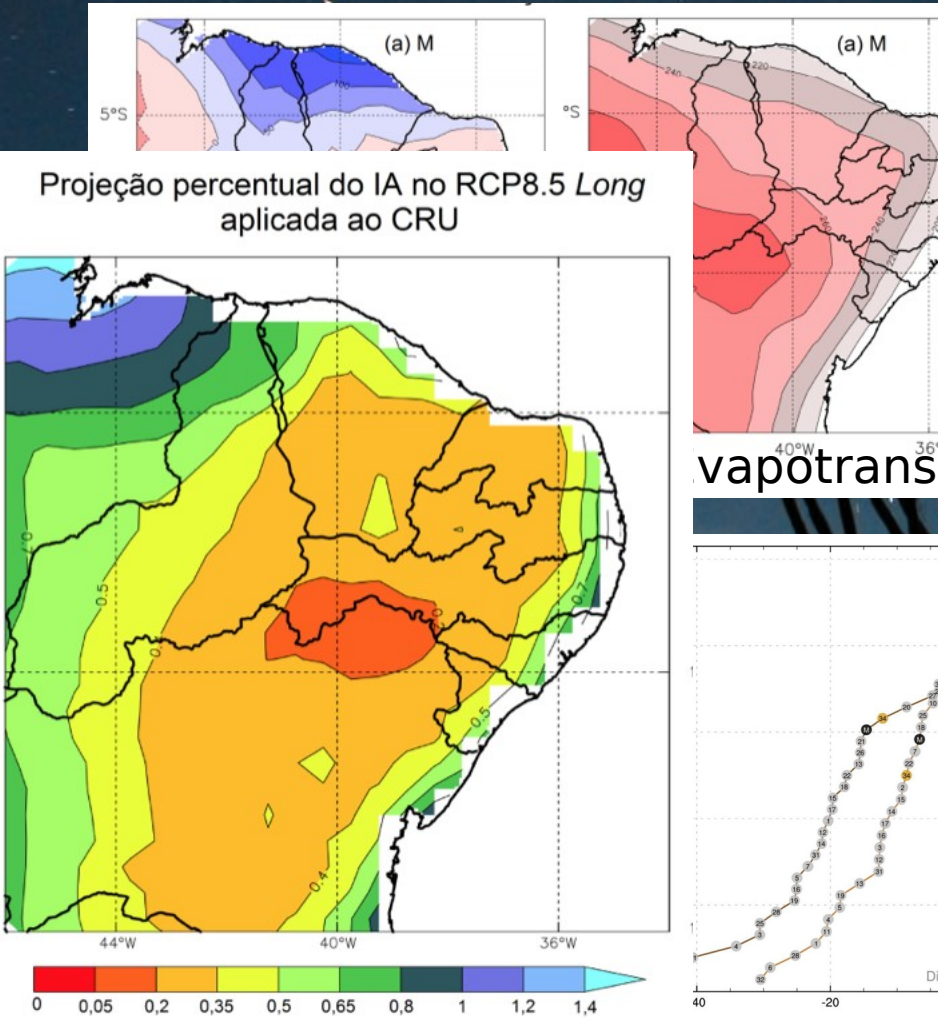


FIGURA 47 - Campos de diferença da média anual RCP8.5 Long (2079-2099) e Historical (1885-2005) de evapotranspiração potencial para o NEB.



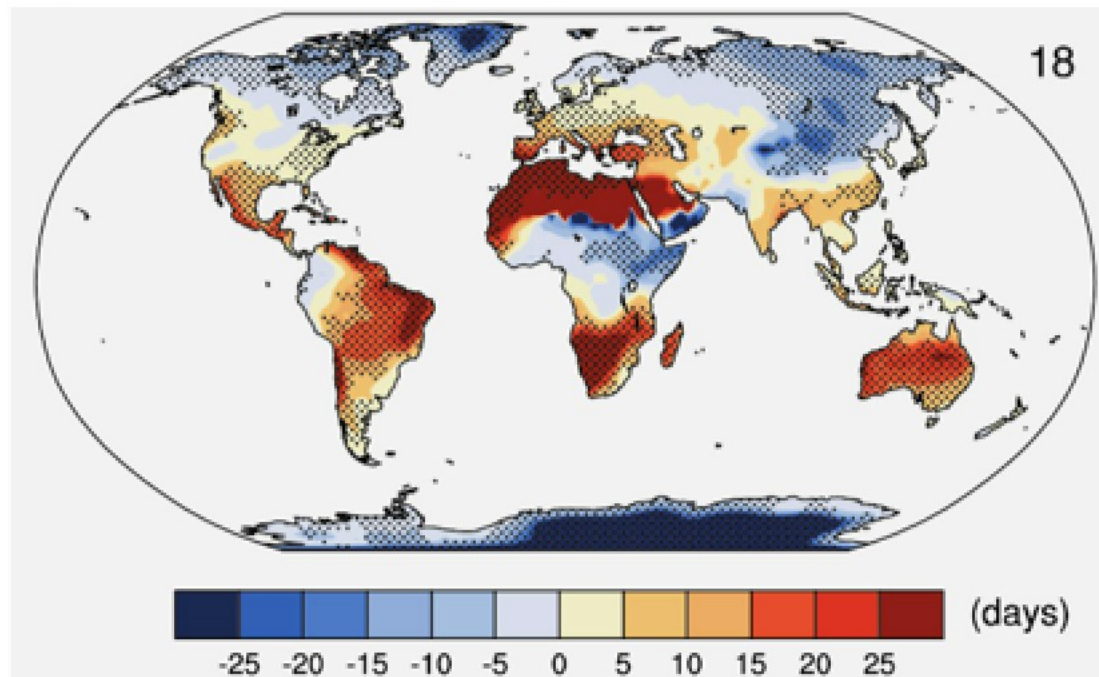
# Índice de aridez

FIGURA 56 - Projeção do índice de aridez do CRU para o NEB no RCP8.5. A numeração dos quadros se refere ao número do modelo dado nas Tabelas 4 e 5.

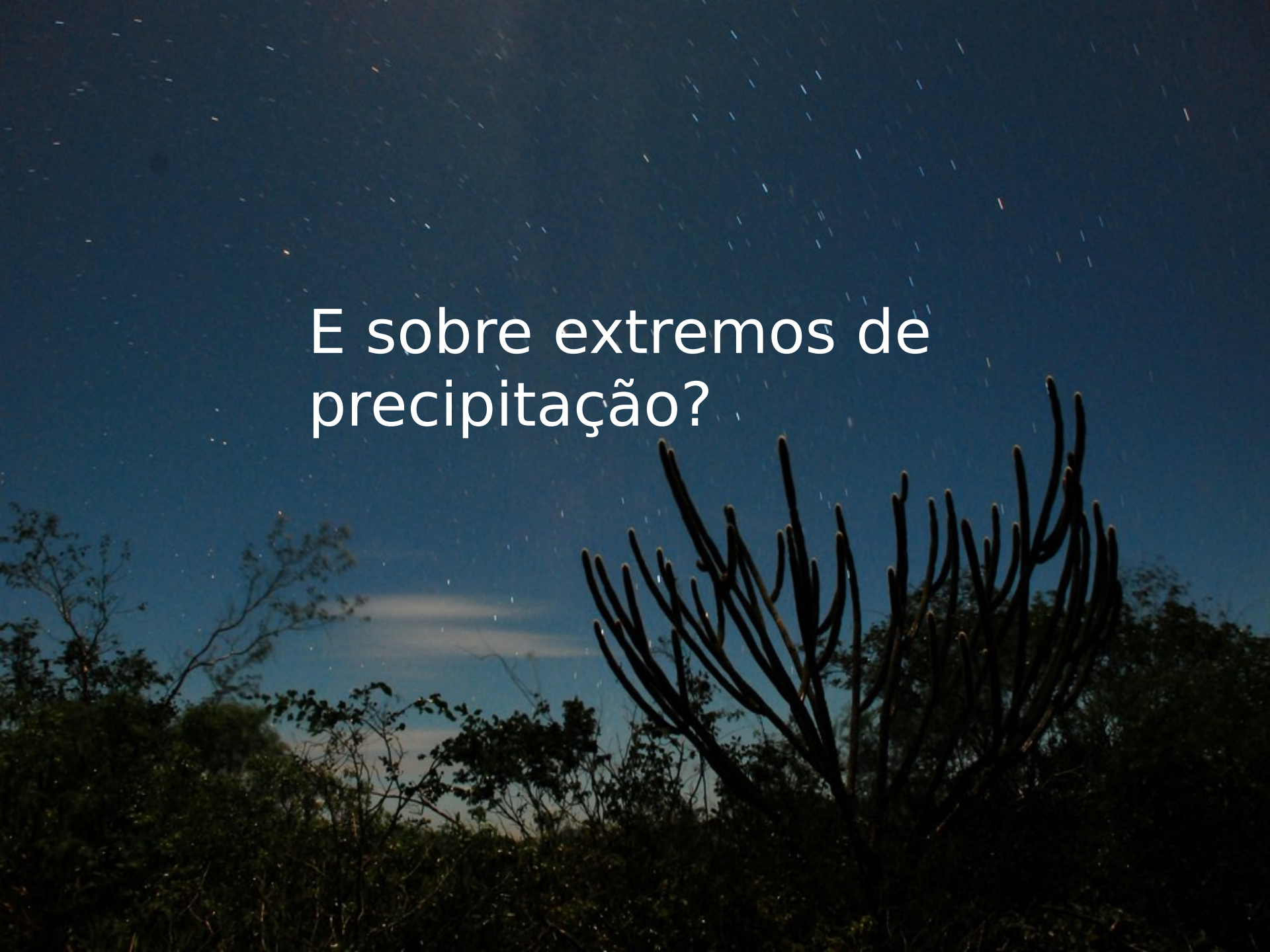


# E os veranicos?

Figura 4 - Projeção de mudança no número de dias consecutivos sem chuva, de acordo com a média do conjunto de modelos do CMIP5. Cores quentes implicam em períodos secos mais prolongados. A projeção no cenário de emissões mais elevadas para o final do século leva a um aumento nos períodos secos de 15 a 25+ dias na maior parte do território brasileiro, com exceção da Amazônia ocidental e da região sul. Fonte: IPCC, 2013



E sobre extremos de precipitação?

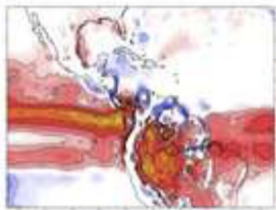
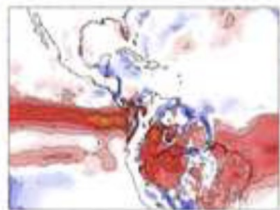
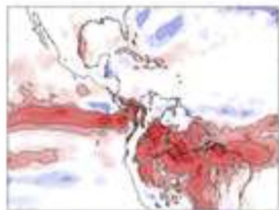


2015-2035

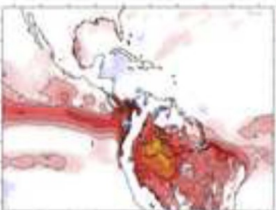
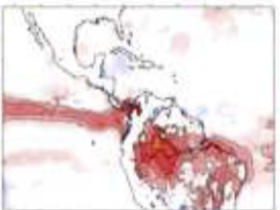
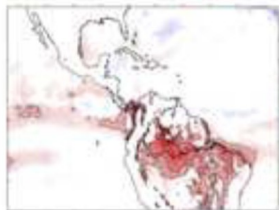
2045-2065

2079-2099

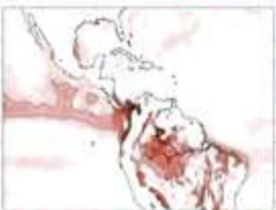
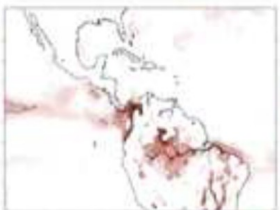
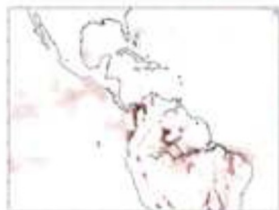
R10



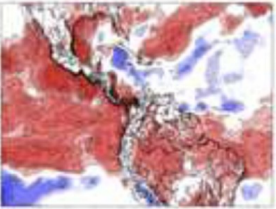
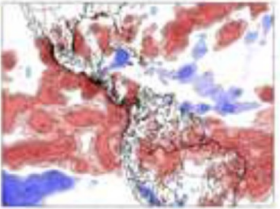
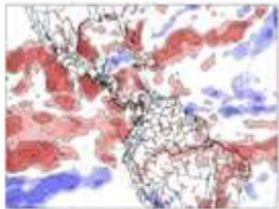
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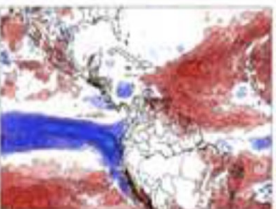
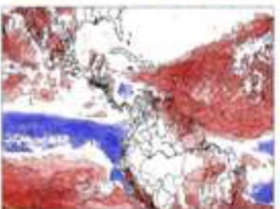
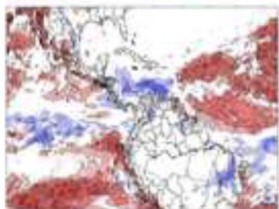
R30



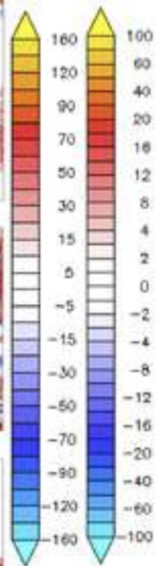
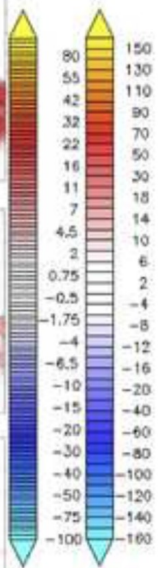
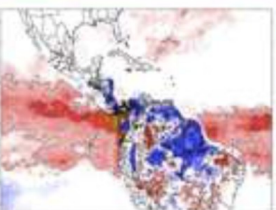
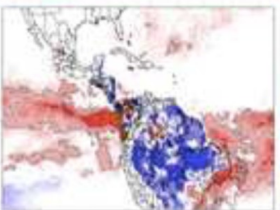
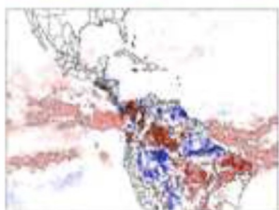
Rx5



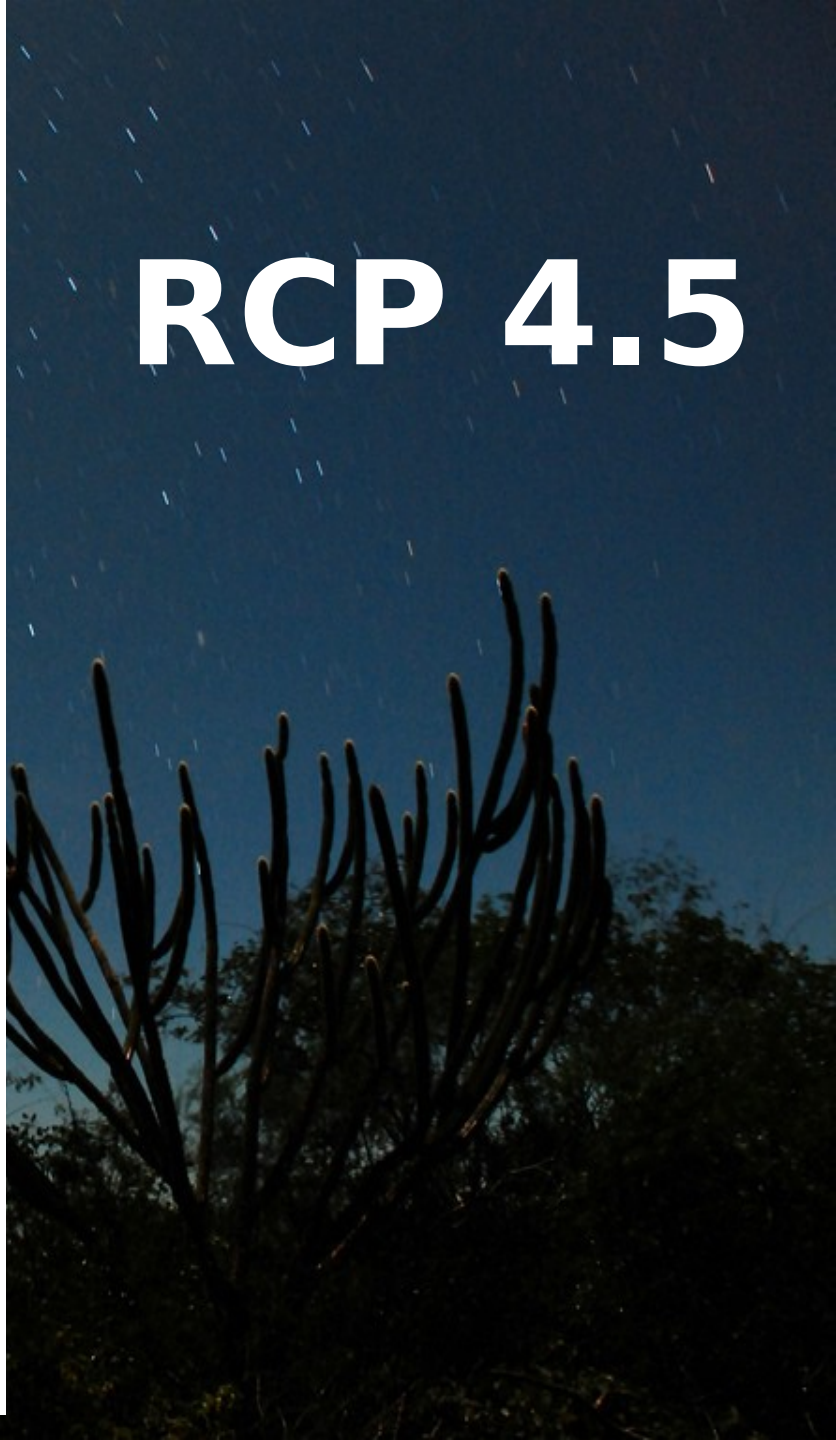
CDD



CWD



# RCP 4.5

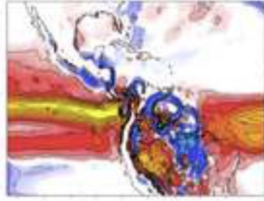
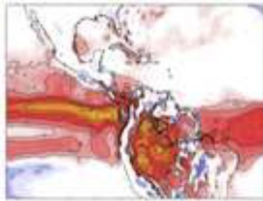
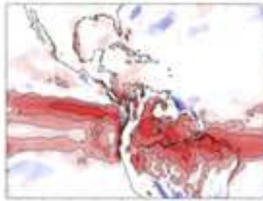


2015-2035

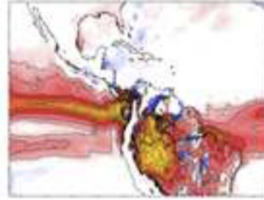
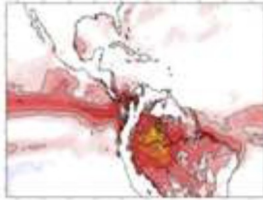
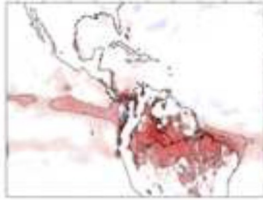
2045-2065

2079-2099

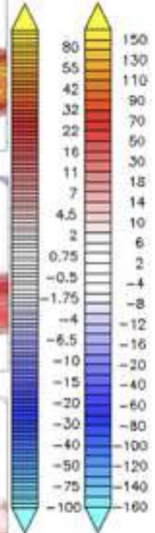
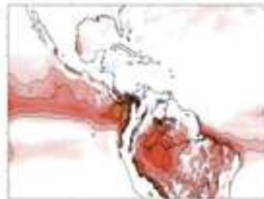
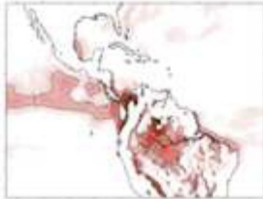
R10



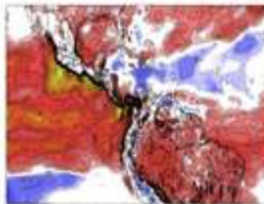
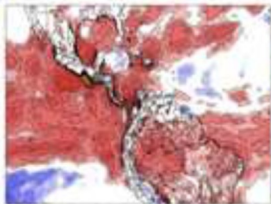
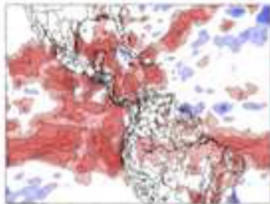
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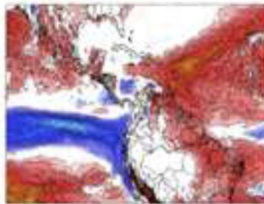
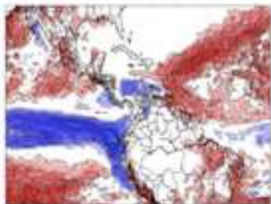
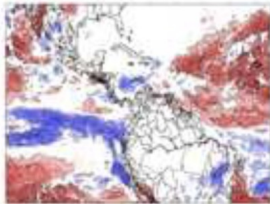
R30



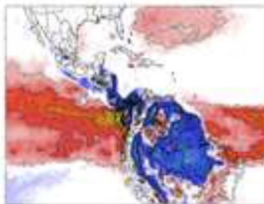
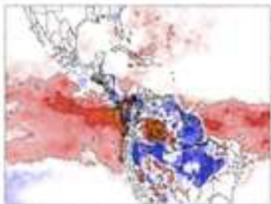
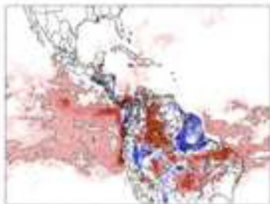
Rx5



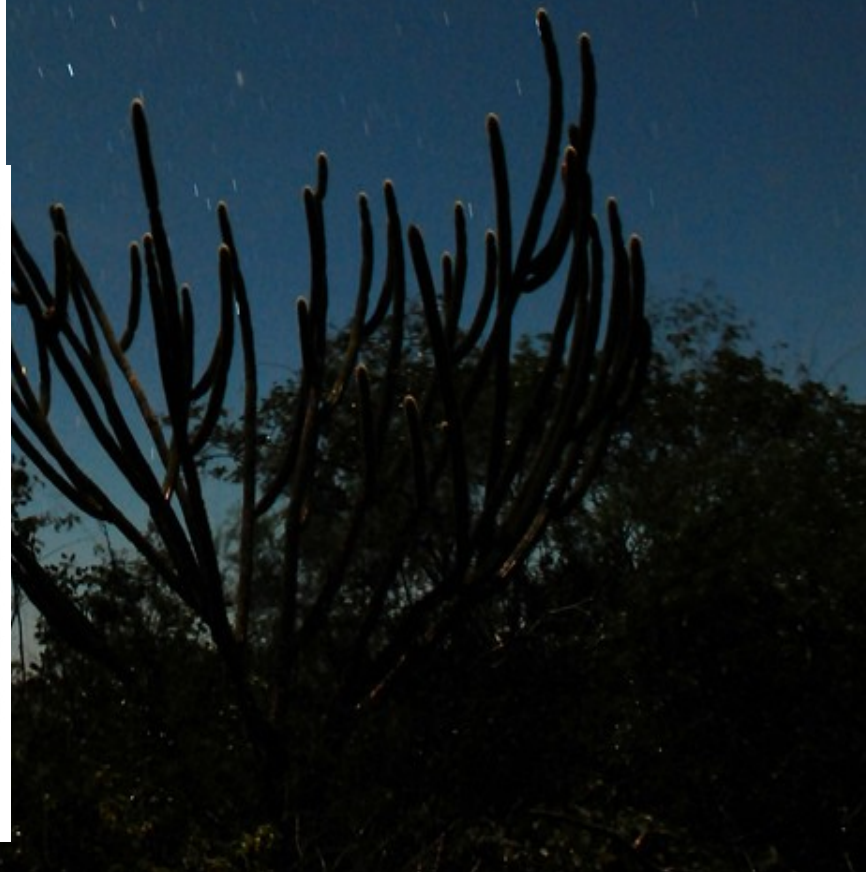
CDD



CWD



# RCP 8.5

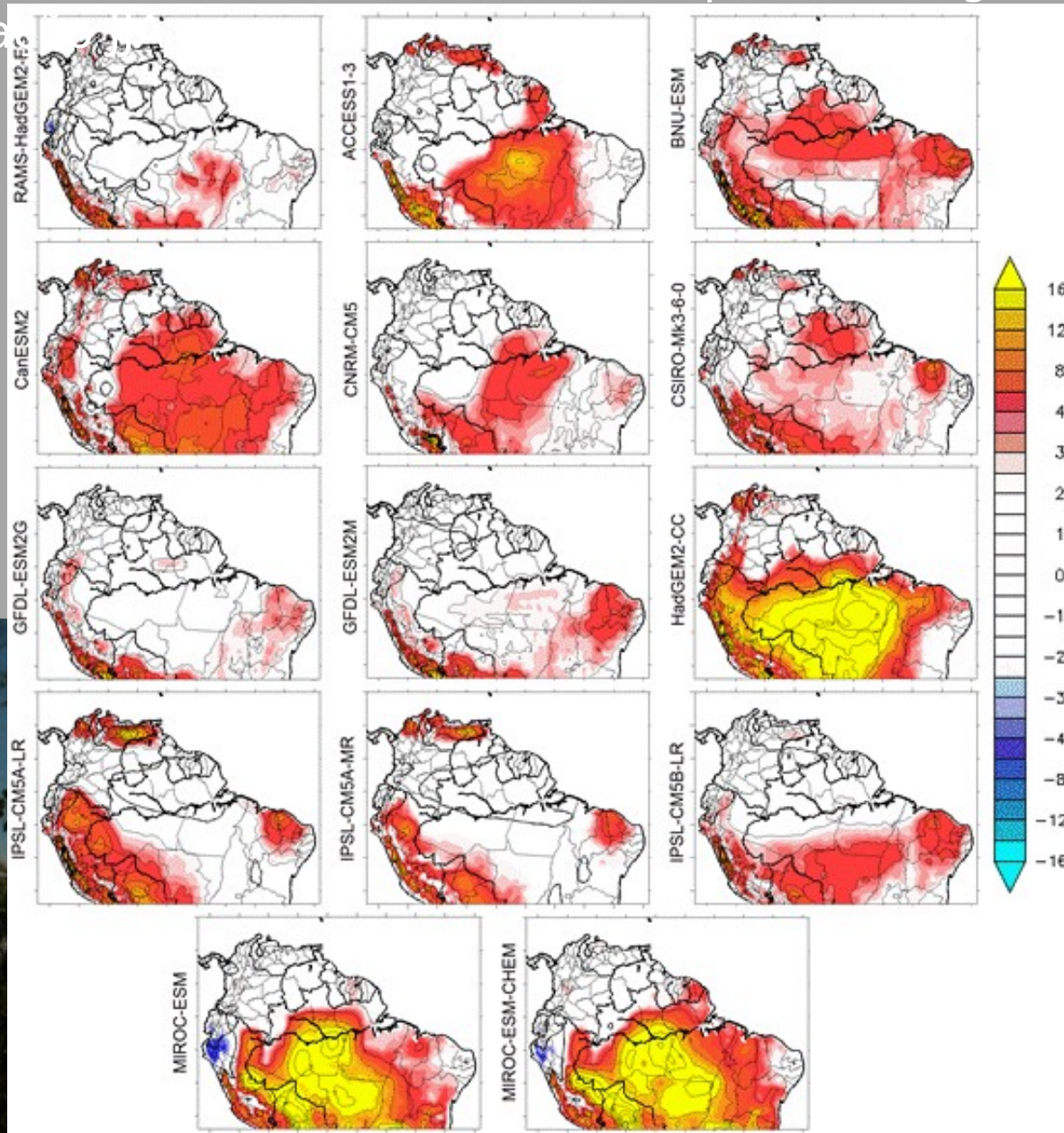


# O Risco de incêndios também muda



# RESULTADOS

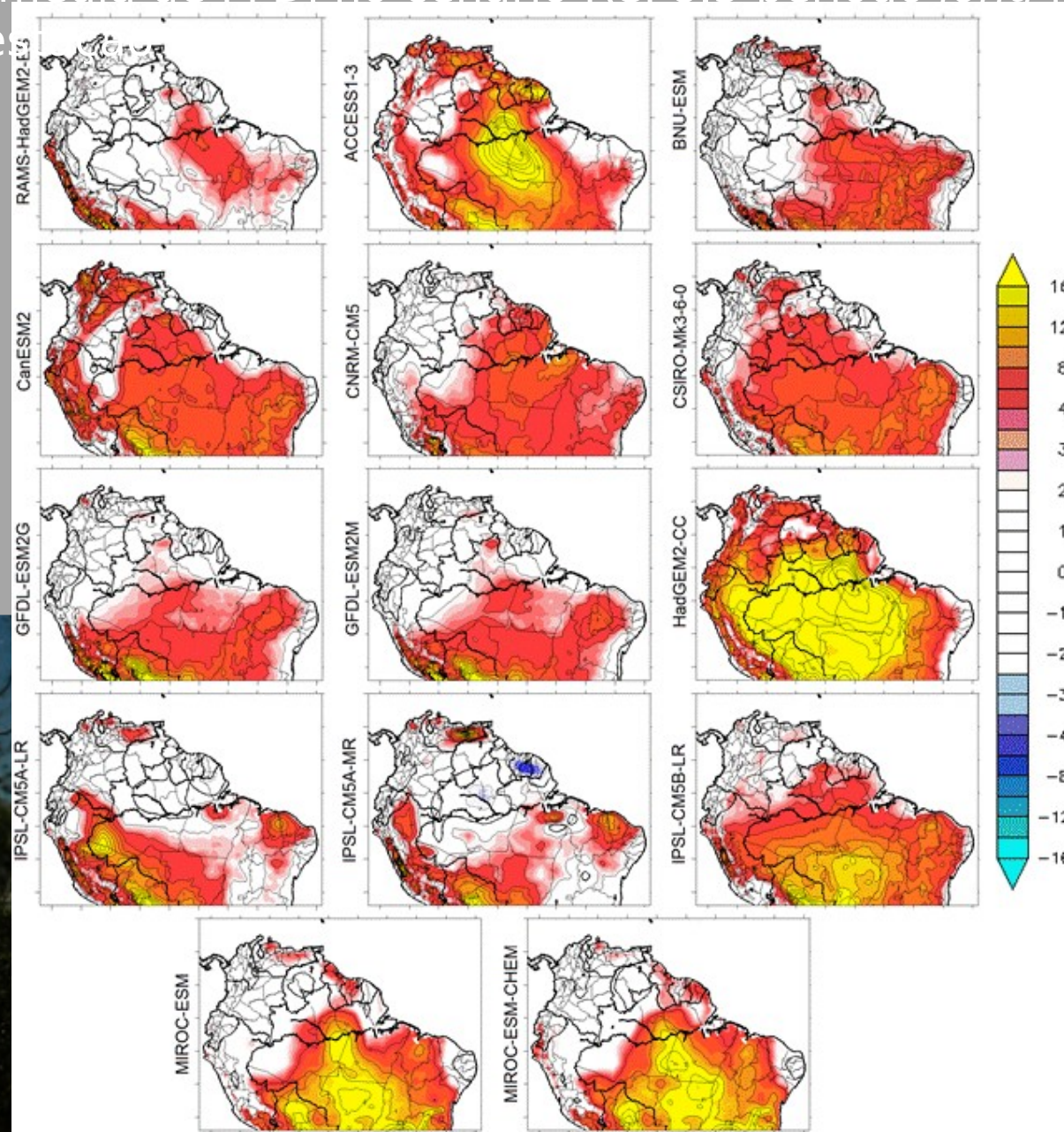
Diferença da média de FFDI no cenário RCP8.5 *período long* menos presente na esta





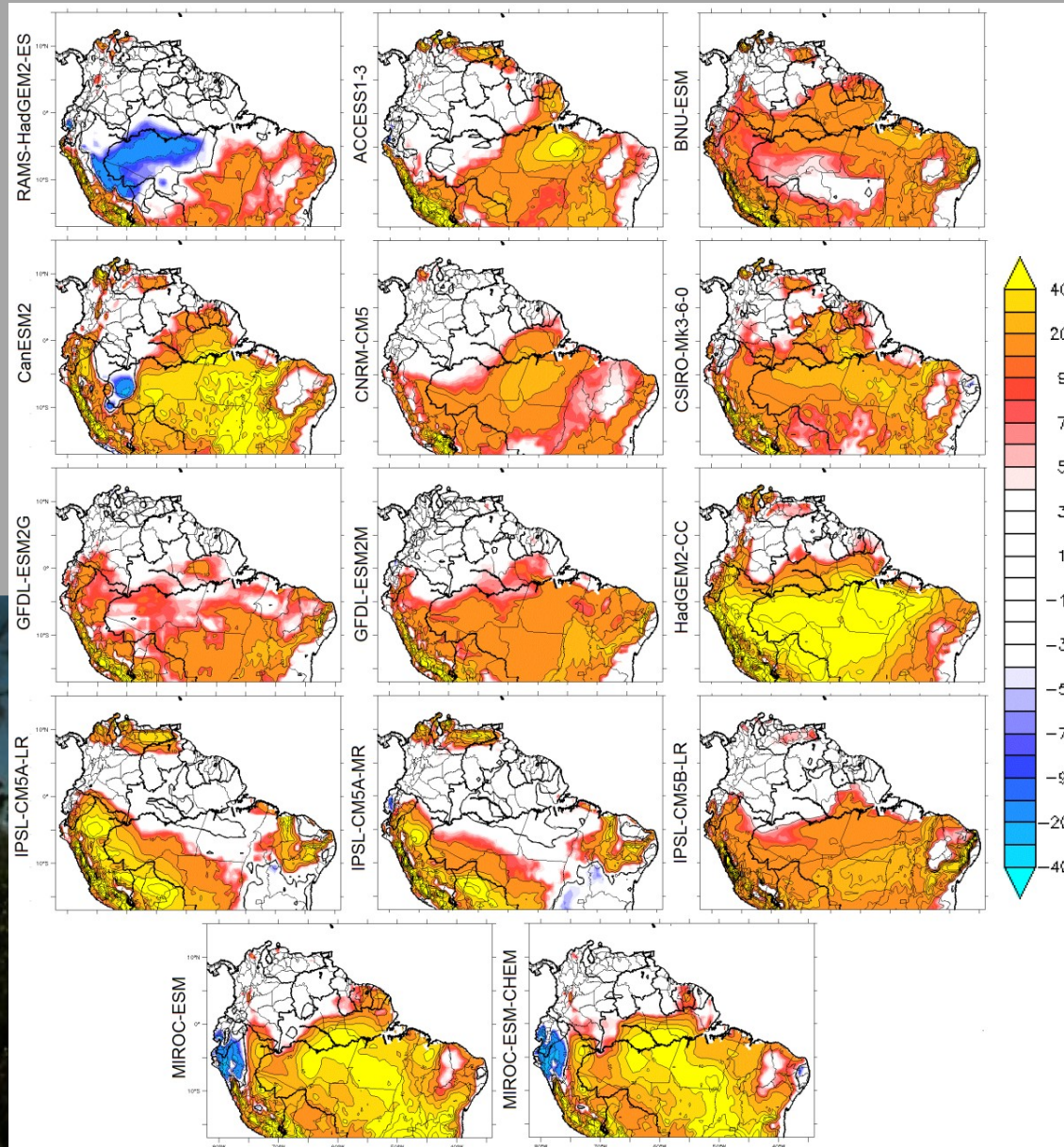
# RESULTADOS

Diferença da média de FFDI no cenário RCP8.5 período *longa* menos presente na e



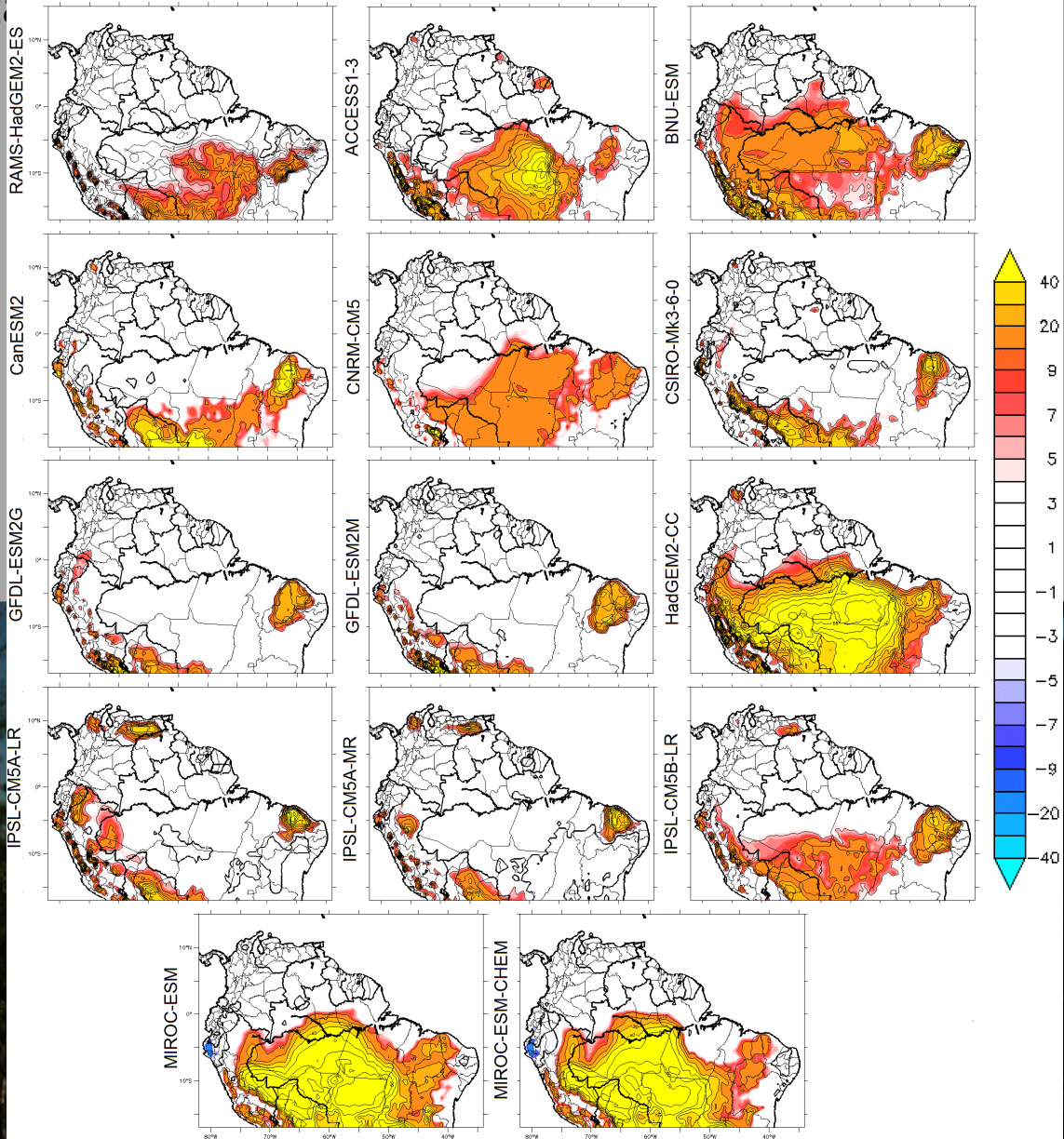
# RESULTADOS

Mapas de diferença da média do número de dias em que o FFDI ultrapassa o limiar classificado como alto do cenário RCP8.5 período *long* e presente na estação JJA.



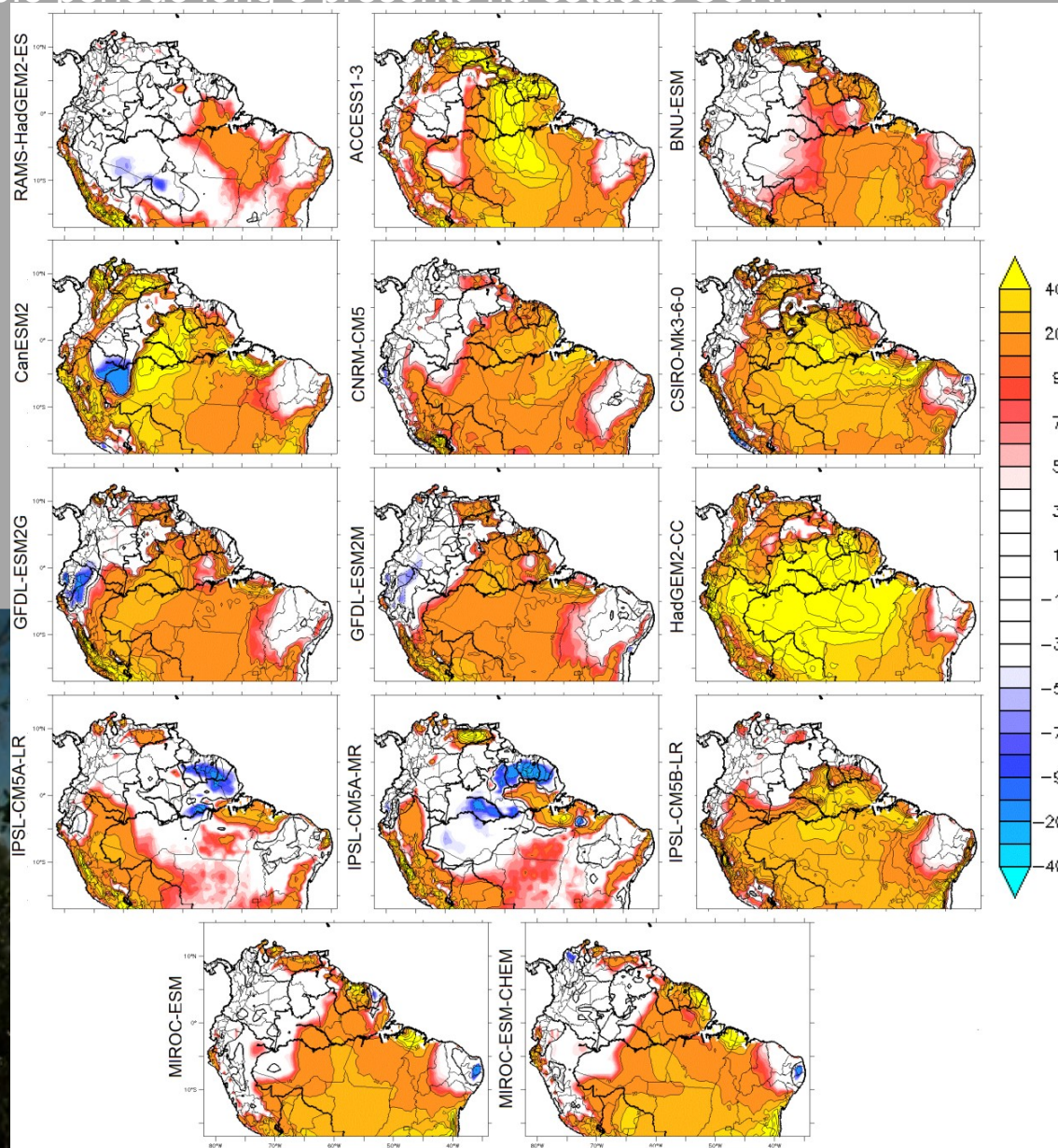
# RESULTADOS

Mapas de diferença da média do número de dias em que o FFDI ultrapassa o limiar classificado como muito alto do cenário RCP8.5 período *long* menos presente na est. 2011-2040



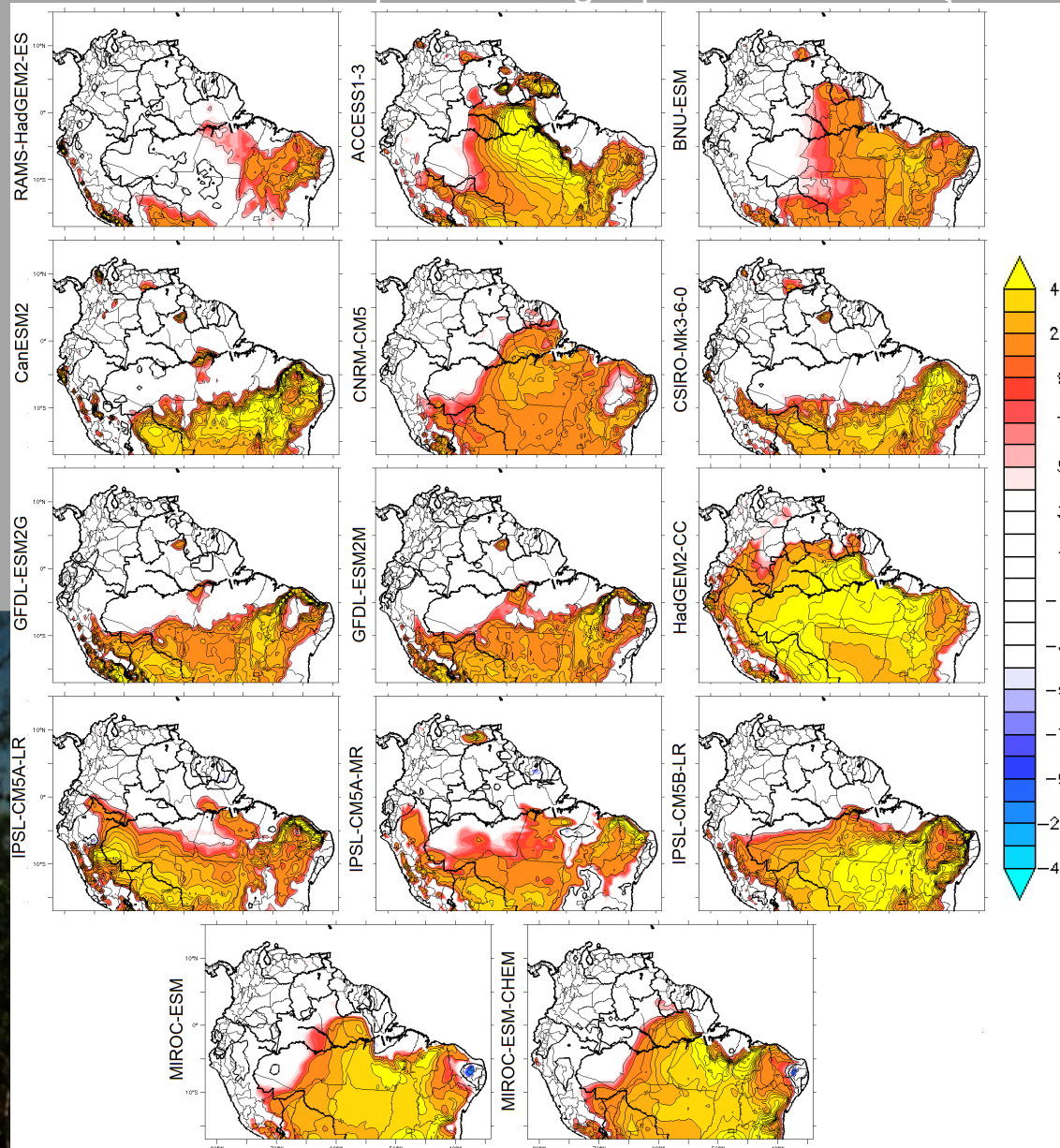
# RESULTADOS

Mapas diferença da média do número de dias em que o FFDI ultrapassa o limiar classificado como alto do cenário RCP8.5 período long e presente na estação SON.

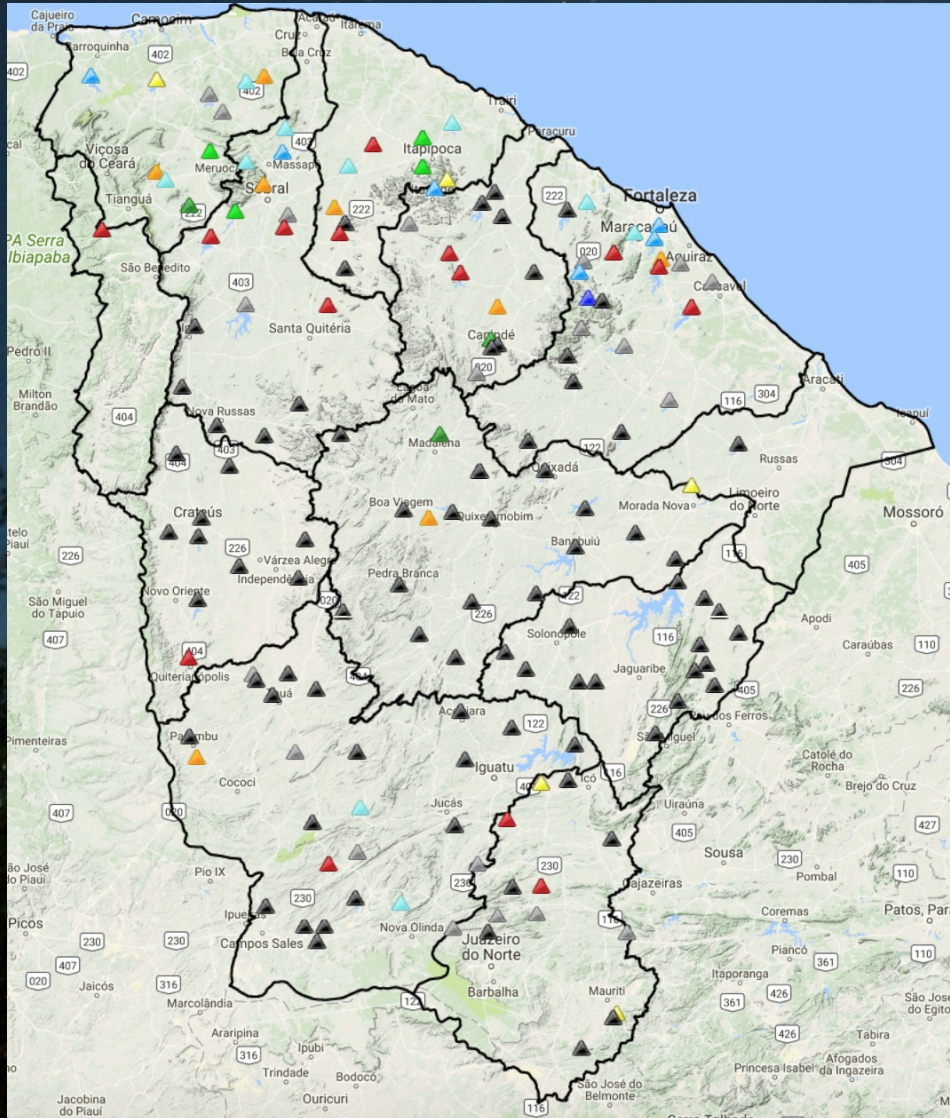


# RESULTADOS

Mapas de diferença da média do número de dias em que o FFDI ultrapassa o limiar classificado como muito alto entre o cenário RCP8.5 período *long* e presente na estação SON.



# PRECISAMOS DEBATER ADAPTAÇÃO, VULNERABILIDADE E MODELO DE DESENVOLVIMENTO



Boletim: Mais Recente

Buscar por reservatório ou município

	Capac. (hm <sup>3</sup> )	Vol. atual (hm <sup>3</sup> )	Vol. perc. (%)
▶ <b>Acaraú</b>	1.718,27 hm <sup>3</sup>	350,28 hm <sup>3</sup>	20,39 %
▶ <b>Alto Jaguaribe</b>	2.778,52 hm <sup>3</sup>	217,88 hm <sup>3</sup>	7,84 %
▶ <b>Baixo Jaguaribe</b>	24,00 hm <sup>3</sup>	0,23 hm <sup>3</sup>	0,96 %
▶ <b>Banabuiú</b>	2.780,36 hm <sup>3</sup>	76,24 hm <sup>3</sup>	2,76 %
▶ <b>Coreaú</b>	308,86 hm <sup>3</sup>	191,48 hm <sup>3</sup>	62,04 %
▶ <b>Curu</b>	1.028,21 hm <sup>3</sup>	112,31 hm <sup>3</sup>	10,92 %
▶ <b>Litoral</b>	214,90 hm <sup>3</sup>	96,69 hm <sup>3</sup>	44,99 %
▶ <b>Médio Jaguaribe</b>	7.386,89 hm <sup>3</sup>	254,54 hm <sup>3</sup>	3,45 %
▶ <b>Metropolitana</b>	1.380,14 hm <sup>3</sup>	311,55 hm <sup>3</sup>	22,57 %
▶ <b>Salgado</b>	482,31 hm <sup>3</sup>	49,70 hm <sup>3</sup>	10,99 %
▶ <b>Serra da Ibiapaba</b>	141,00 hm <sup>3</sup>	32,69 hm <sup>3</sup>	23,18 %
▶ <b>Sertões de Crateús</b>	448,09 hm <sup>3</sup>	2,08 hm <sup>3</sup>	0,46 %

Estado	*Qt	Capac. (hm <sup>3</sup> )	Vol. atual (hm <sup>3</sup> )	Vol. perc. (%)
Ceará	155	18.837,0	1.690,0	8,1

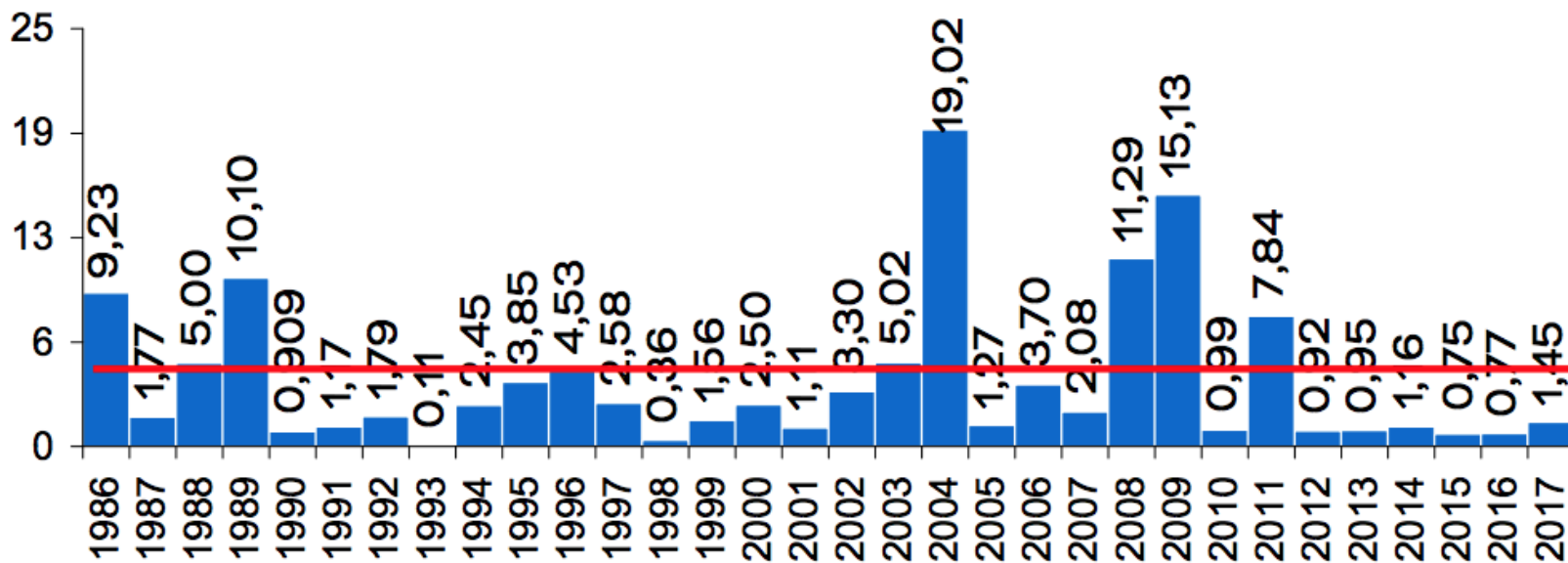
**Reservatórios em Alertas**

- 0 Açúdes Sangrando
- 7 Açúdes com Volumes acima de 90%
- 118 Açúdes com Volumes inferior a 30%

Dados extraídos às 07:20:06 23/10/2017

# Aportes observados nos Açudes Gerenciados entre 1986 – 2017 (em bilhões de m<sup>3</sup>)

## EVOLUÇÃO APORTE, bilhões de m<sup>3</sup> <sup>a</sup>



média: 4,08 bi; mediana: 2,27 bi m<sup>3</sup>

# Conclusões

- As mudanças climáticas provavelmente já estão produzindo impactos no Ceará, incluindo secas mais severas com rebatimento na segurança hídrica e produção de alimentos
- As projeções apontam majoritariamente para um quadro de agravamento das condições de aridez, aumentando a vulnerabilidade e exigindo respostas mais fortes de adaptação e construção de resiliência
- A adaptação a um semiárido (em transformação, mais sujeito a secas severas) não pode ser objeto somente da população rural; precisa ser objeto das políticas públicas em seu conjunto e servir de norte à concepção do próprio modelo de desenvolvimento
- Atividades carbo-hidro-intensivas devem ser desestimuladas nesse contexto, salvaguardando as prioridades do uso da água, harmonizando-se com as metas brasileiras junto ao Acordo de Paris e priorizando atividades econômicas de baixo carbono, pequena utilização de água e reduzido impacto ambiental