



RISCO DE FOGO

Anuário 2023

Registro histórico de todos os mapas de Risco de Fogo de 2023 e sua metodologia.



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RESUMO

Esse documento tem como objetivo mostrar de forma resumida os cálculos para obter o Risco de Fogo, uma variável importante que fornece informações sobre a possibilidade de uma determinada região iniciar uma queimada na vegetação de origem antrópica. O método é baseado no uso de algumas variáveis meteorológicas (precipitação, umidade relativa mínima e temperatura máxima do ar à superfície) e de vegetação, alguns cálculos matemáticos e correções também são feitas para obter o Risco de Fogo. O produto final deste documento consiste em mapas diários de Risco de Fogo desde o dia 01 de janeiro a 31 de dezembro de 2023.

Palavras-chave: risco de fogo, precipitação, temperatura, umidade relativa

ABSTRACT

This document aims to summarize the calculations to obtain the Fire Risk, an important variable that provides information on the possibility of a given region starting a fire in vegetation of anthropogenic origin. The method is based on the use of some meteorological variables (precipitation, minimum relative humidity and maximum surface air temperature) and vegetation, some mathematical calculations and corrections are also made to obtain the Fire Risk. The final product of this document consists of daily Fire Risk maps from January 1st to December 31st, 2023.

Keywords: fire risk, precipitation, temperature, relative humidity

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1 Introdução

O Risco de Fogo (RF) aumenta proporcionalmente ao número de dias seguidos sem chuva em um determinado local. Os efeitos do tipo da vegetação e do ciclo natural de desfolhamento, da temperatura máxima e umidade relativa mínima do ar diária, assim como a presença de fogo na área de interesse também são considerados.

O RF foi desenvolvido no Centro de Previsão de Tempo e Estudos Climáticos/Instituto Nacional de Pesquisas Espaciais (CPTEC/INPE), com base na análise da ocorrência de centenas de milhares de queimadas/incêndios nos principais biomas e tipos de vegetação do País durante as últimas décadas, em função das condições e históricos meteorológicos (SETZER et al., 1992; SISMANOGLU e SETZER, 2004). A primeira versão operacional data de 2002. O cálculo do RF é um dos produtos do Programa Queimadas do INPE (<http://terrabrasilis.dpi.inpe.br/queimadas/portal/>), por sua vez inserido na Ação 20V9 do MCTIC no atual PPA-Plano Pluri Anual do Governo Federal.

A base dos cálculos do RF está no conceito dos "Dias de Secura" ou "Secura" (PSE), que corresponde ao número de dias seguidos sem nenhuma precipitação durante os últimos 120 dias em relação à data de interesse. No caso de ocorrência de precipitação no período analisado, o PSE calcula um número hipotético correspondente de dias consecutivos sem chuva. É fundamental levar em conta que o RF indica quão propícia a vegetação está para ser queimada do ponto de vista meteorológico e, que o fogo na grande maioria dos casos é iniciado pelo homem e não naturalmente, como por exemplo, por raios.

2 Fonte de Dados

Para o cálculo do Risco de Fogo são necessárias informações diárias das seguintes variáveis meteorológicas: precipitação (mm/dia), temperatura do ar (°C) e umidade relativa (décimos).

2.1 PRECIPITAÇÃO

O campo de precipitação, que é a componente de maior peso do RF, é obtido na resolução espacial de 10 km a partir das estimativas de precipitação do IMERG - Integrated Multi-satellite Retrievals for GPM (HUFFMAN et al., 2014, 2015), as quais combinam dados observacionais das estações de superfície com as medidas em micro-ondas dos atuais satélites do programa Global Precipitation Measurement (GPM, HOU et al., 2014) e dos antigos Tropical Rainfall Measuring Mission (TRMM, VILA et al., 2008). As estimativas IMERG são particularmente indicadas nas áreas com baixa densidade de estações de superfície, como por exemplo, na Amazônia. Exemplo desse campo pode ser observado na Figura 2.1.

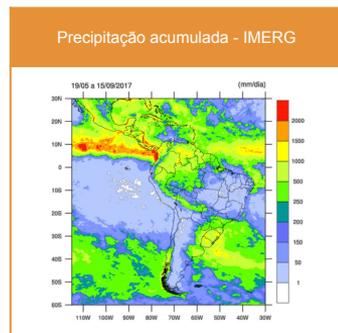


Figura 2.1

Precipitação acumulada para 120 dias (19 de maio a 15 de setembro de 2017) obtida do IMERG. Estes campos são produzidos diariamente para períodos de 1 a 120 dias anteriores em relação ao dia do cálculo.

2.2 TEMPERATURA E UMIDADE DO AR À SUPERFÍCIE

Os campos de temperatura máxima (°C) e de umidade relativa mínima do ar (décimos) no horário das 18UTC à superfície são obtidos das análises do modelo GFS (Global Forecast System, <http://www.emc.ncep.noaa.gov/GFS/doc.php>) na resolução espacial de 25 km. Exemplos desses campos podem ser observados na Figura 2.2a e 2.2b.

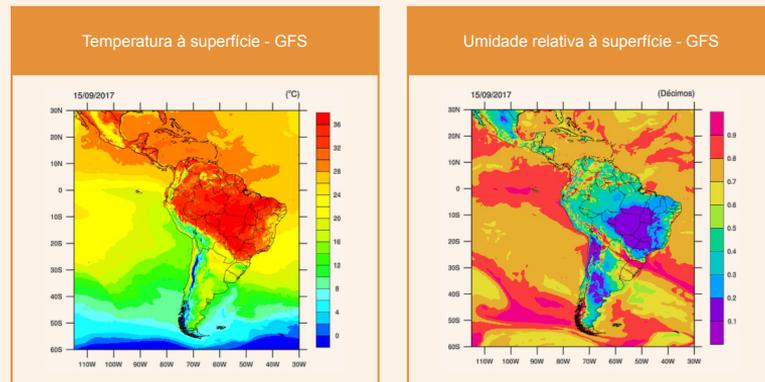


Figura 2.2

a) Temperatura do Ar à superfície às 18UTC;
b) Umidade Relativa do Ar à superfície às 18UTC.

2.3 MAPA DE VEGETAÇÃO

O mapa de tipos de vegetação (Figura 2.3) para os cálculos do RF foi adaptado do produto anual do International Geosphere-Biosphere Programme (IGBP, <http://www.igbp.net>), por sua vez gerado pela National Aeronautics and Space Administration (NASA) a partir dos mosaicos do Moderate Resolution Imaging Spectroradiometer (MODIS) com resolução espacial de 1 km do satélite AQUA (FRIEDL et al., 2010). O mapa do IGBP é referente a 2017.

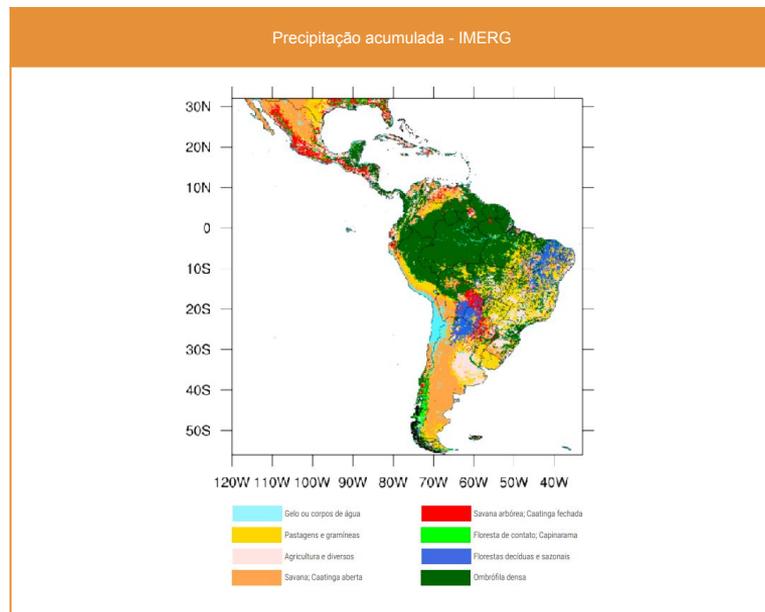


Figura 2.3
Mapa de vegetação do IGBP combinado com o MapBiomas utilizado no cálculo do Risco de Fogo observado.

As 17 classes originais (Tabela 2.1) de vegetação adotada pelo IGBP foram condensadas em sete classes principais:

- 1) Pastagens e Gramíneas;
- 2) Agricultura e Diversos;
- 3) Savana; Caatinga aberta;
- 4) Savana arbórea; Caatinga fechada;
- 5) Floresta de contato; Campinarana;
- 6) Florestas decíduas e sazonais;
- 7) Ombrófila densa.

A nomenclatura usada foi a do Instituto Brasileiro de Geografia e Estatística (IBGE), apresentada em <http://mapas.ibge.gov.br/tematicos/vegetacao.html>. O "-x" indica que não é atribuído nenhum valor a essa constante. Os valores da constante "A" (constante de inflamabilidade) são utilizados para calcular o Risco de Fogo.

A partir desse mapa de vegetação foram feitas atualizações apenas para o Brasil utilizando o projeto MapBIOMAS (<http://mapbiomas.org>).

As informações são disponibilizadas desde 2016 até 2017. Dessa forma, a representação das mudanças no padrão de vegetação podem ser avaliadas anualmente. As informações do mapa de vegetação são utilizadas para informar o quão propícia a vegetação estará para iniciar um incêndio dependendo do seu tipo.

Tabela 2.1 - Classes de Vegetação, classes principais e valores da constante "A".

Classes de vegetação do IGBP	Classes principais	Classes IBGE (agrupadas)	Constante "A"
0 Water	0	Corpos d'água	-x
1 Evergreen Needleleaf forest	5	Floresta de contato; Campinarana	2,0
2 Evergreen Broadleaf forest	7	Omrófila densa	1,5
3 Deciduous Needleleaf forest	5	Floresta de contato; Campinarana	2,0
4 Deciduous Broadleaf forest	6	Florestas decíduas e sazonais	1,72
5 Mixed forest	5	Floresta de contato; Campinarana	2,0
6 Closed shrublands	4	Savana arbórea; Caatinga fechada	2,4
7 Open shrublands	3	Savana; Caatinga aberta	3,0
8 Woody savannas	4	Savana arbórea; Caatinga fechada	2,4
9 Savannas	3	Savana; Caatinga aberta	3,0
10 Grasslands	1	Pastagens e gramíneas	6,0
11 Permanent wetlands	0	Alagados permanentes	1,5
12 Croplands	2	Agricultura e diversos	4,0
13 Urbanand built-up	0	Áreas urbanas e construídas	-x
14 Cropland/Natural vegetation mosaic	2	Agricultura e diversos	4,0
15 Snow and ice	0	Neve e gelo	-x
16 Barren or sparsely vegetated	0	Solos expostos; mineração	-x

3 Metodologia para o cálculo do Risco de Fogo

Inicialmente, calculam-se as precipitações acumuladas para 11 períodos distintos que serão utilizados para obter os fatores de precipitação. Obtido esses fatores, calculam-se os dias de secura (PSE) combinados com o tipo de vegetação para em seguida gerar o Risco de Fogo Básico. Posteriormente, a partir da Umidade Relativa Mínima e da Temperatura Máxima do Ar à superfície realizam-se alguns cálculos matemáticos para obter-se o Risco de Fogo Observado. Finalmente, realiza-se a correção do risco por meio das ocorrências dos focos de queimadas nos últimos 3 dias.

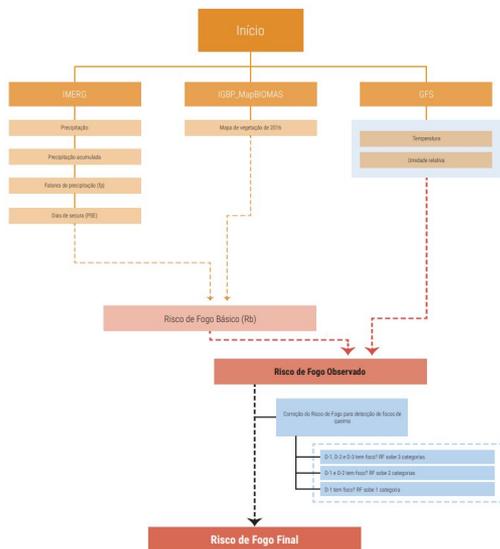


Figura 3.1 - Mapa de vegetação do IGBP combinado com o MapBiomas utilizado no cálculo do Risco de Fogo observado.

Para informações mais detalhadas sobre o cálculo do Risco de Fogo, acessar o link abaixo: http://queimadas.cptec.inpe.br/~rqueimadas/documentos/RiscoFogo_Sucinto.pdf

Após calcular o Risco de Fogo Final, é feita a sua classificação por categorias, como mostra a Tabela 3.1.

Tabela 3.1 - Categorias de Risco de Fogo.

Risco	Valores do Risco de Fogo (RF)	Cor
Mínimo	$RF \leq 0,15$	
Baixo	$0,15 < RF \leq 0,40$	
Médio	$0,40 < RF \leq 0,70$	
Alto	$0,70 < RF \leq 0,95$	
Crítico	$RF > 0,95$	

A Figura 3.2 mostra graficamente o resultado do cálculo do Risco de Fogo para o dia 15 de setembro de 2017 com base nas informações das Figuras 2.1, 2.2 e 2.3.

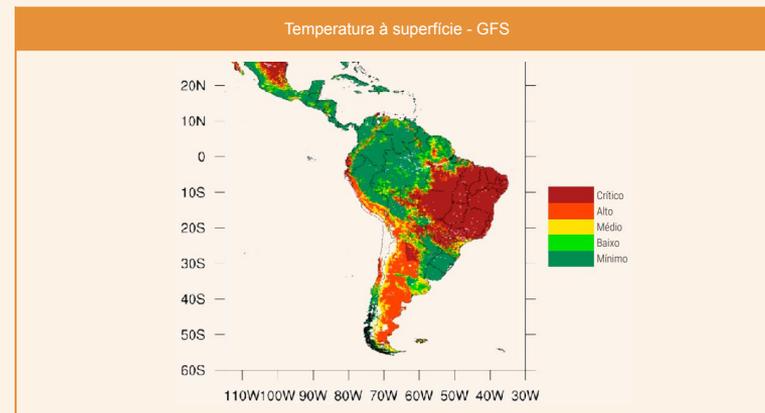
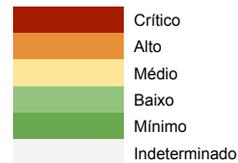
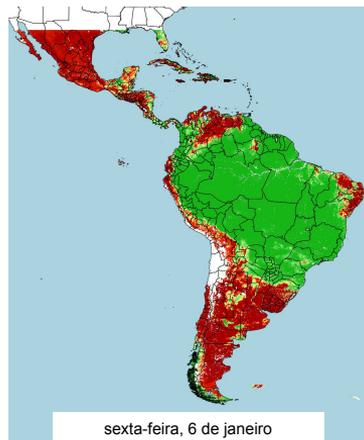
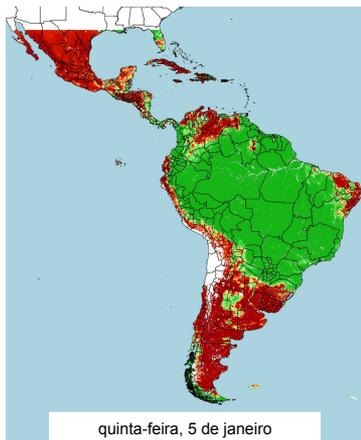
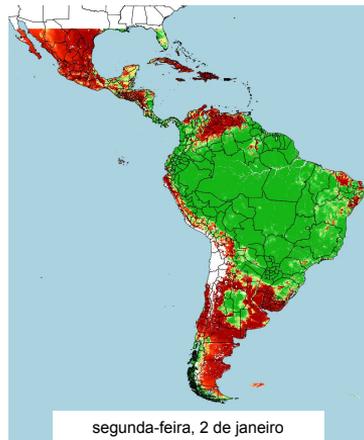
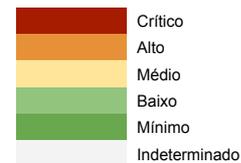
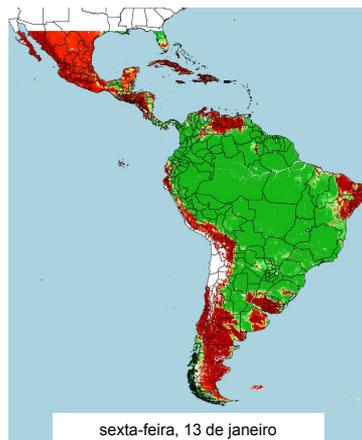
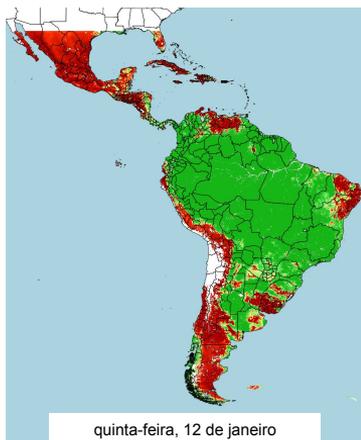
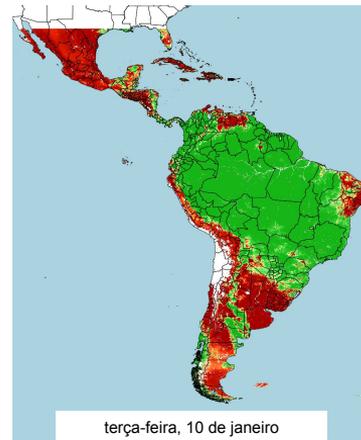


Figura 3.2 Risco de Fogo Observado para o dia 15 de setembro de 2017 e classificado em 5 categorias que variam de mínimo (verde = 0) a crítico (marrom = 1).



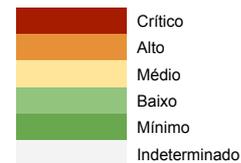
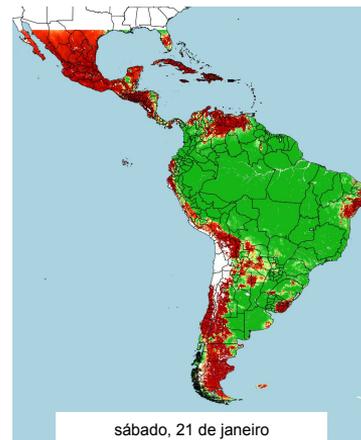
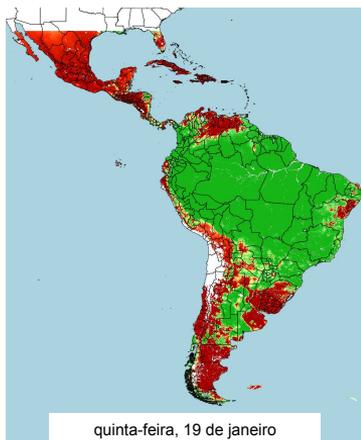
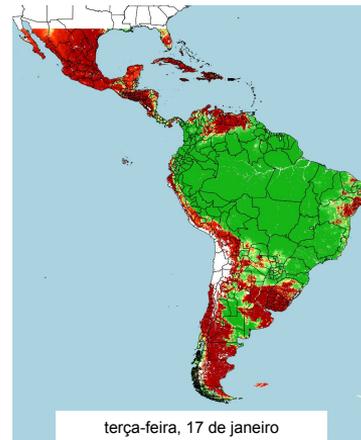
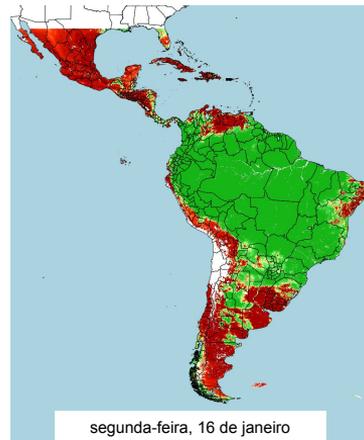
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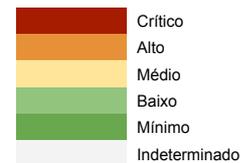
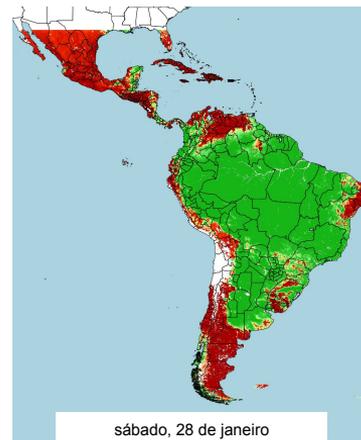
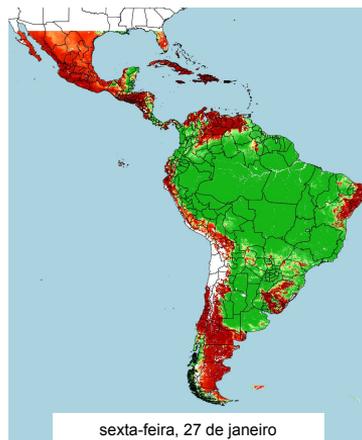
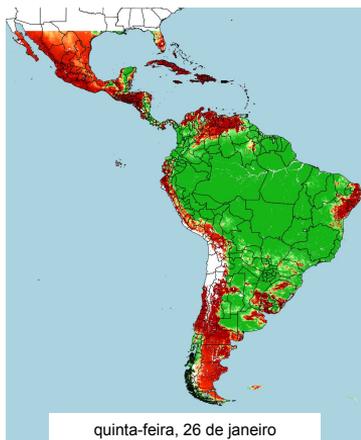
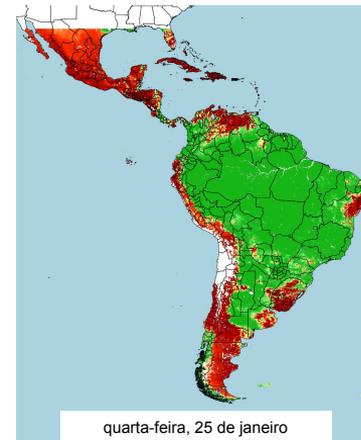
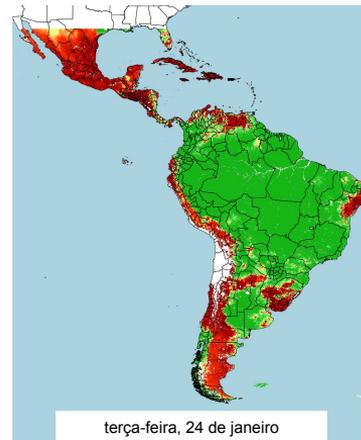
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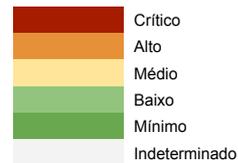
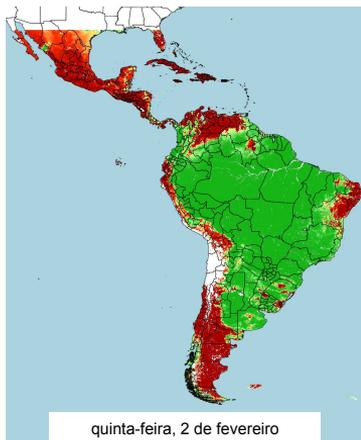
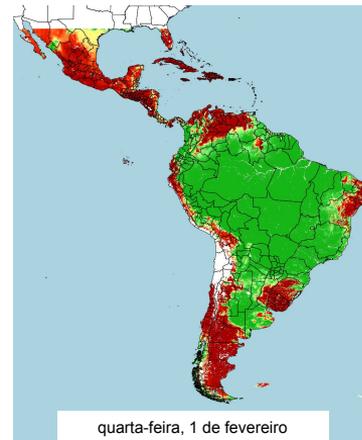
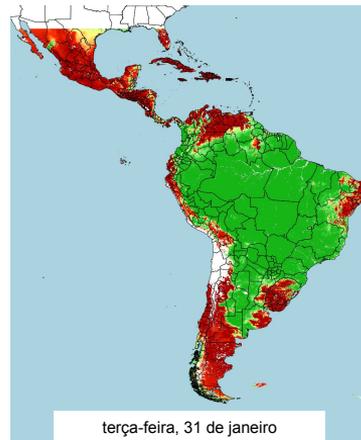
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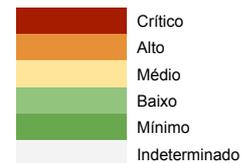
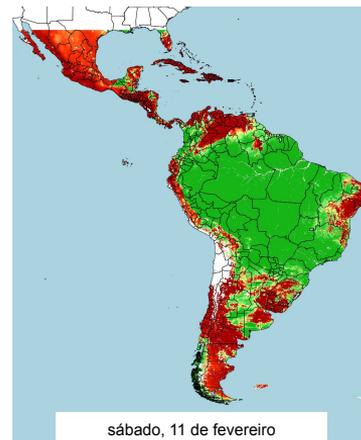
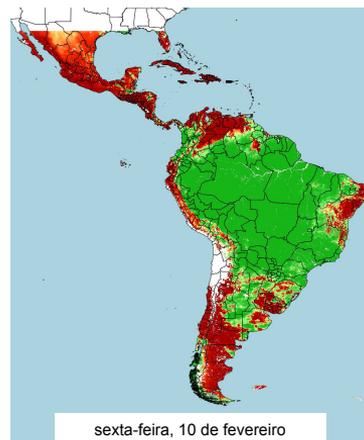
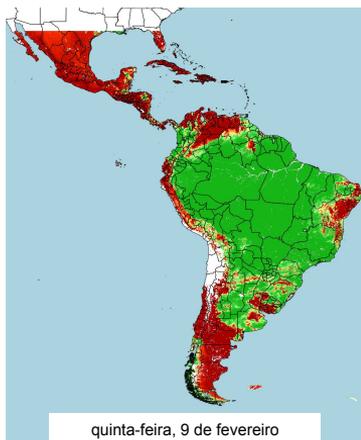
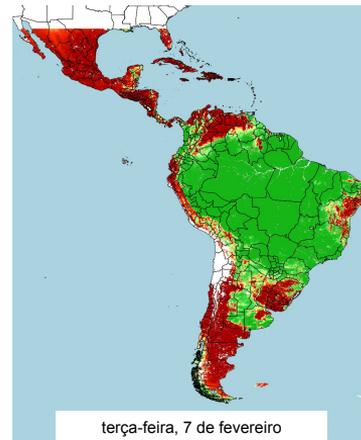
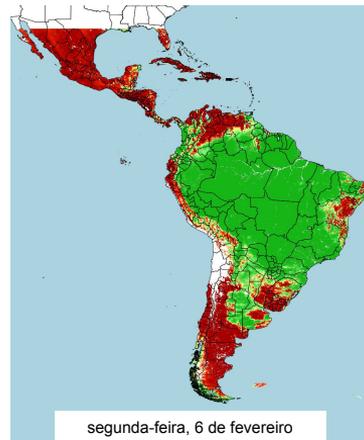
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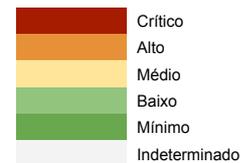
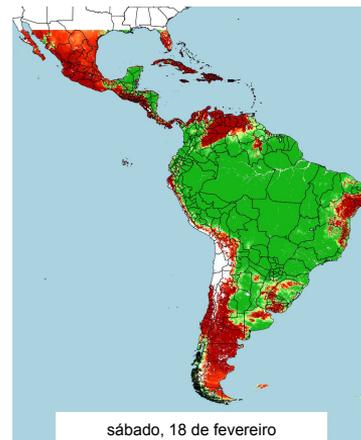
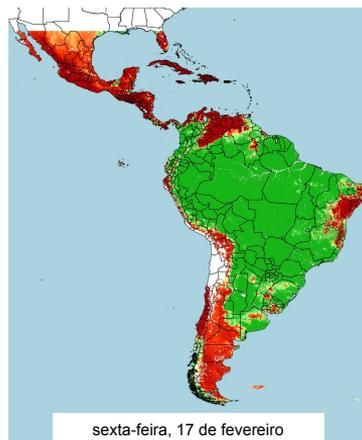
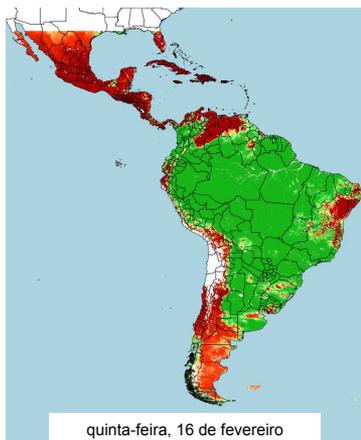
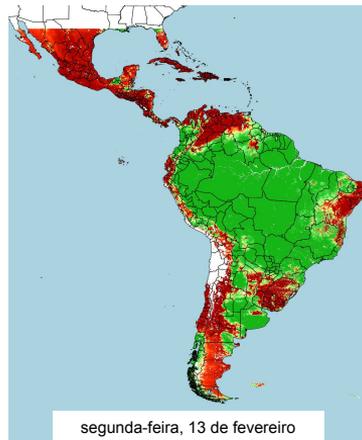
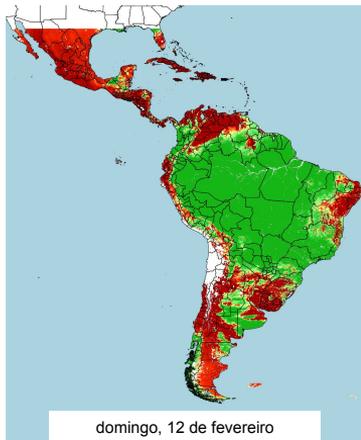
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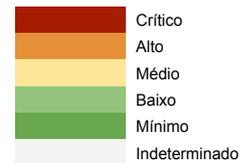
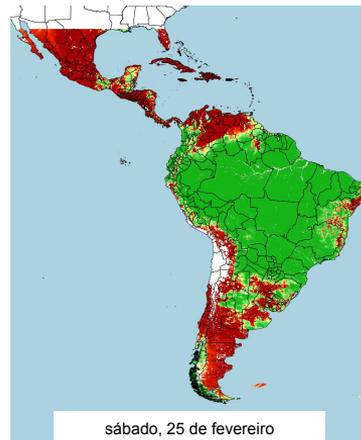
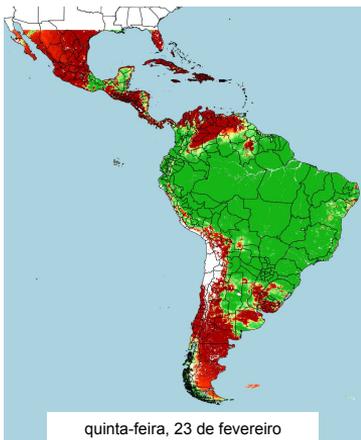
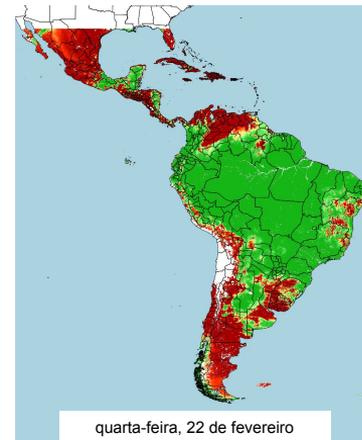
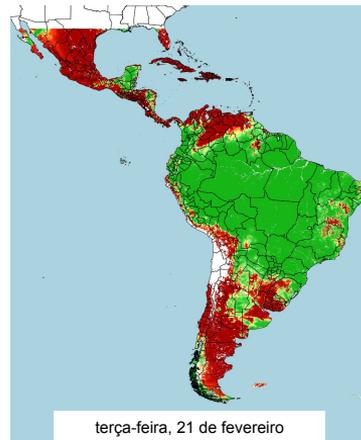
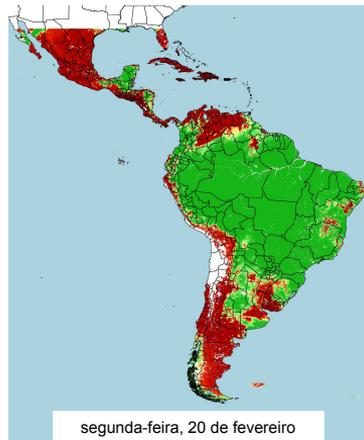
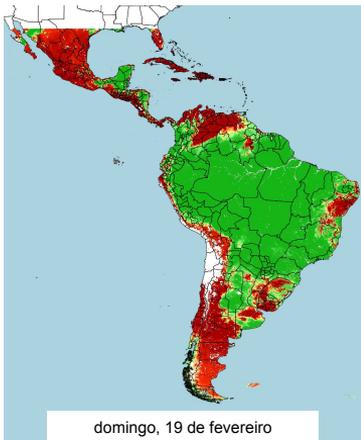
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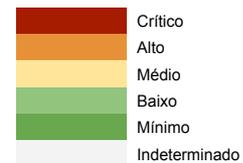
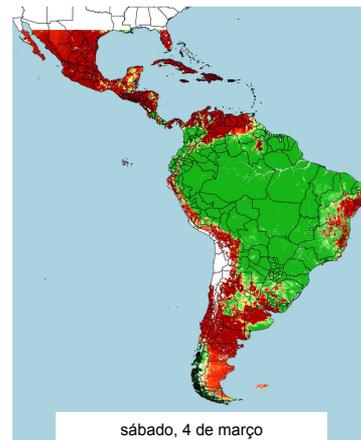
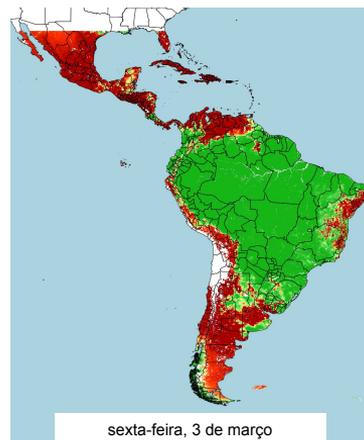
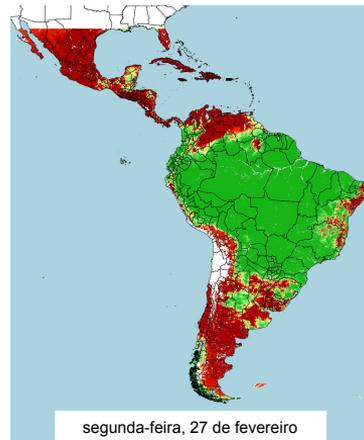
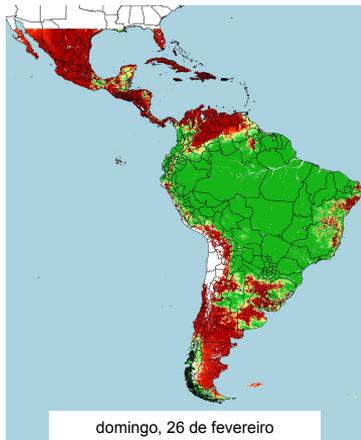
FEVEREIRO / 2023

D	S	T	Q	Q	S	S
			32	33	34	35
36	37	38	39	40	41	42
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57	58	59				

CALENDÁRIO JULIANO



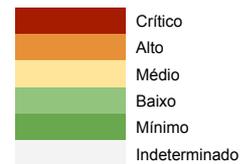
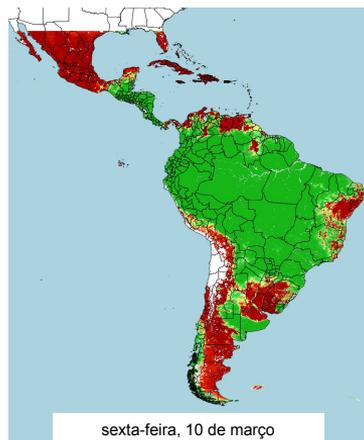
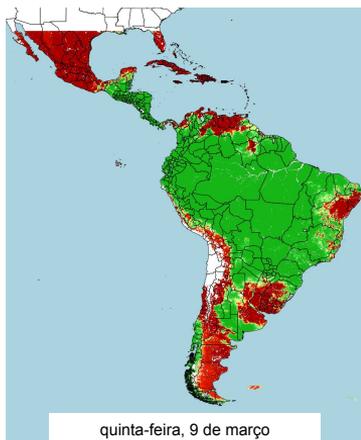
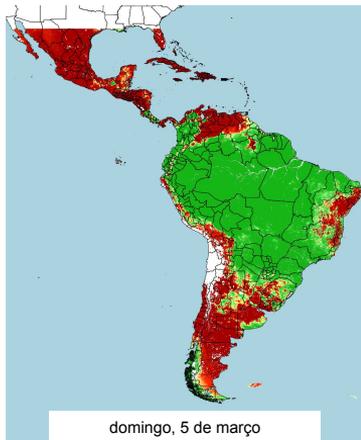
FEVEREIRO / 2023						
D	S	T	Q	Q	S	S
			32	33	34	35
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57	58	59				



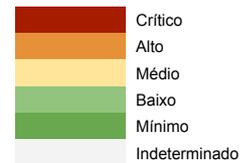
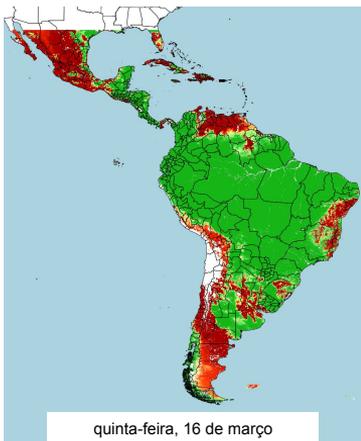
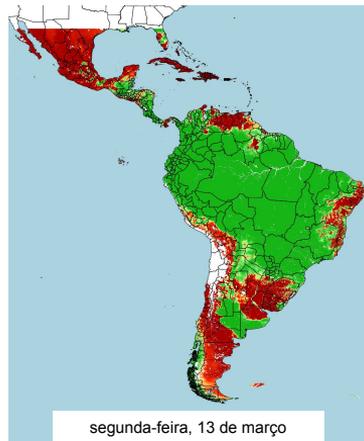
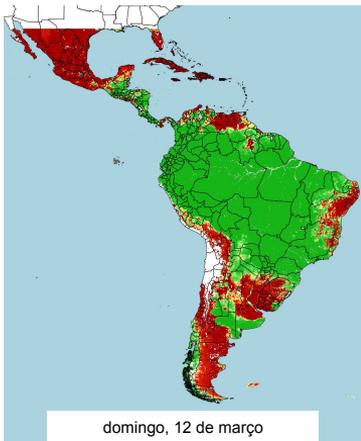
MARÇO / 2023

D	S	T	Q	Q	S	S
57	58	59	60	61	62	63
64	65	66	67	68	69	70
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78	79	80	81	82	83	84
85	86	87	88	89	90	

CALENDÁRIO JULIANO

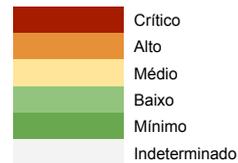
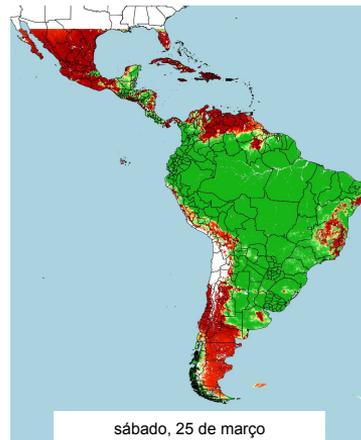
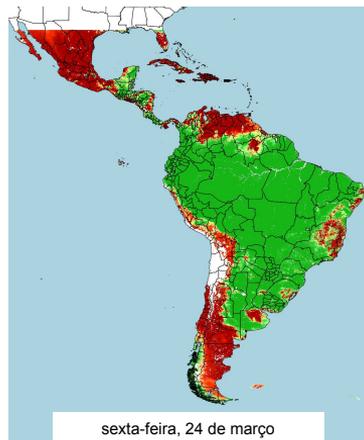
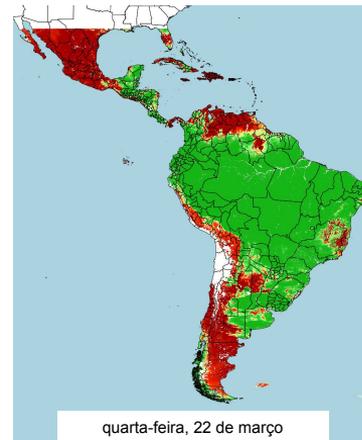
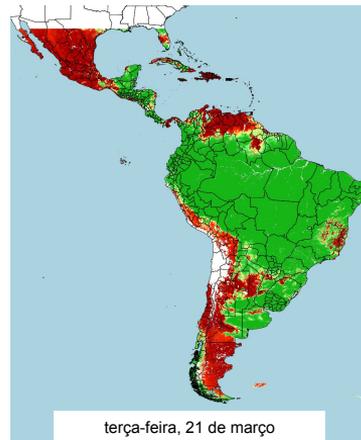
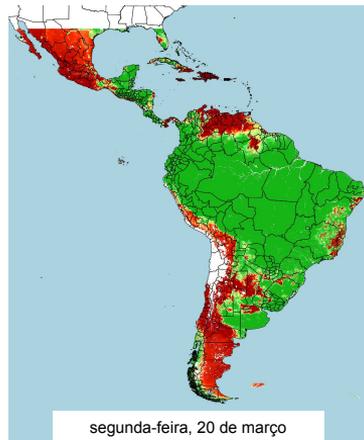
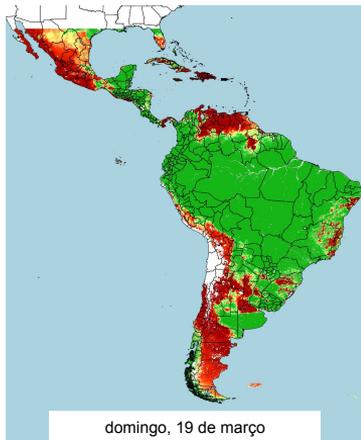


MARÇO / 2023							
D	S	T	Q	Q	S	S	
			60	61	62	63	
64	65	66	67	68	69	70	
71	72	73	74	75	76	77	
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85	86	87	88	89	90		



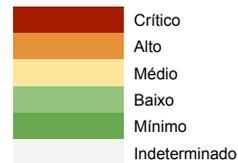
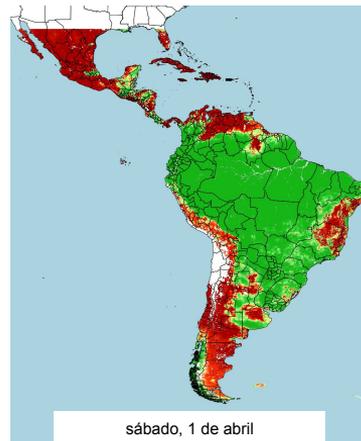
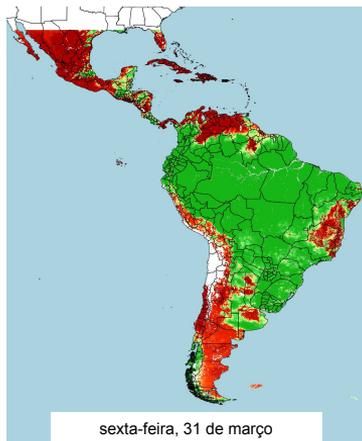
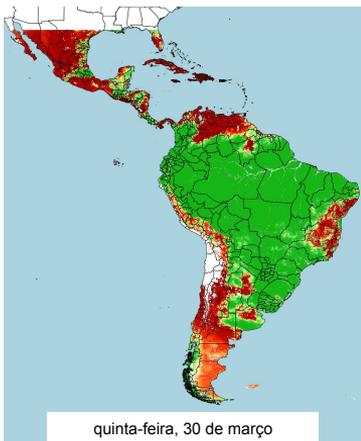
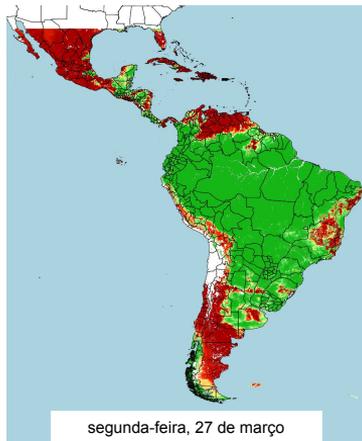
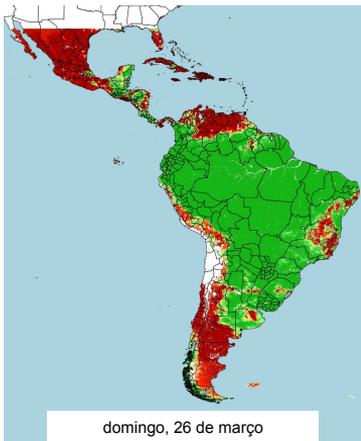
MARÇO / 2023

D	S	T	Q	Q	S	S
			60	61	62	63
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85	86	87	88	89	90	



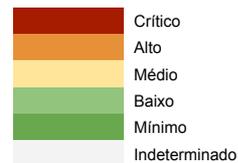
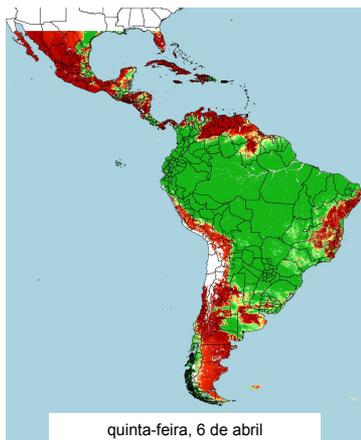
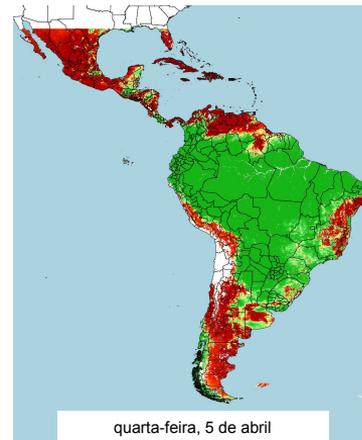
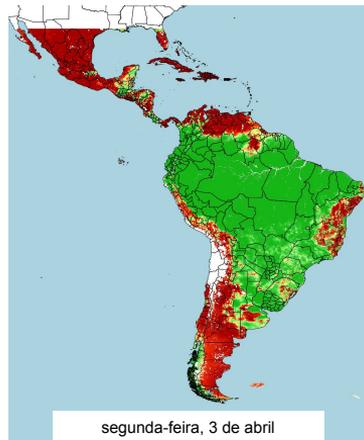
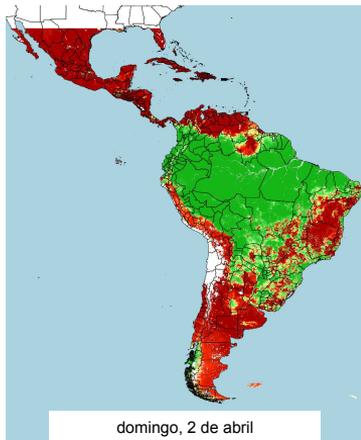
MARÇO / 2023

D	S	T	Q	Q	S	S
			60	61	62	63
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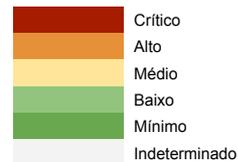
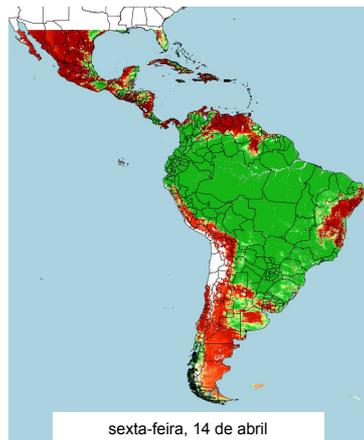
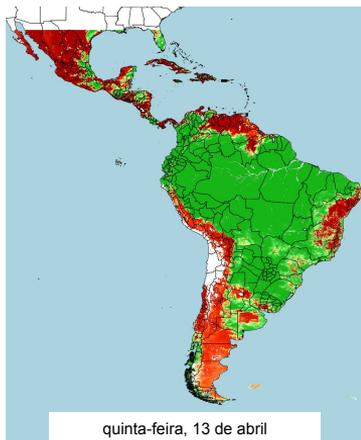
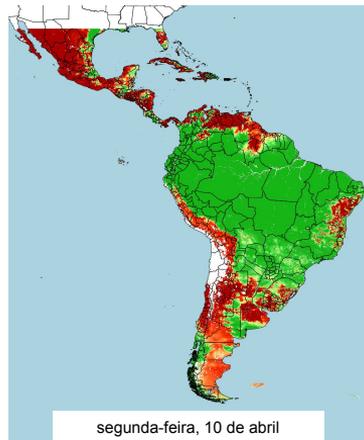
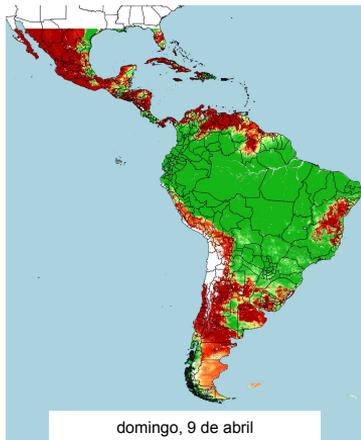


MARÇO / 2023

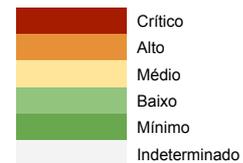
D	S	T	Q	Q	S	S
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64	65	66	67	68	69	70
71	72	73	74	75	76	77
78	79	80	81	82	83	84
85	86	87	88	89	90	91



ABRIL / 2023							
D	S	T	Q	Q	S	S	
							91
92	93	94	95	96	97	98	
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120							



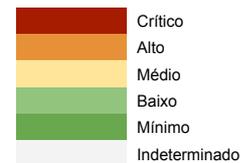
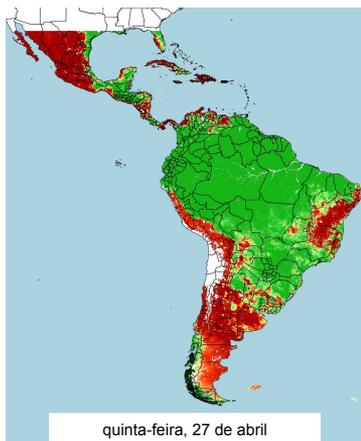
ABRIL / 2023							
D	S	T	Q	Q	S	S	
							91
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120							



ABRIL / 2023

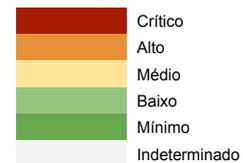
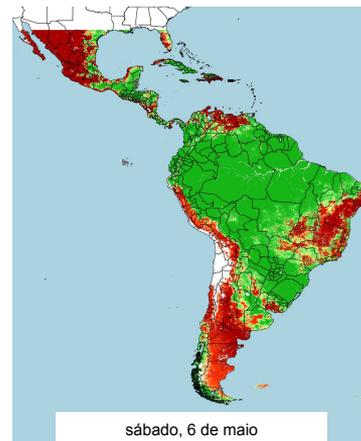
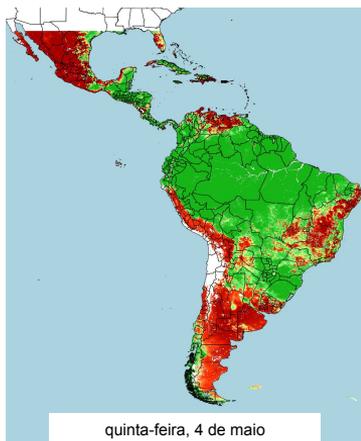
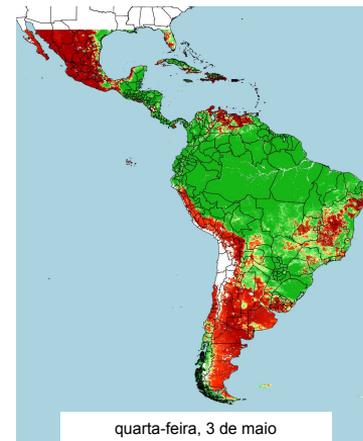
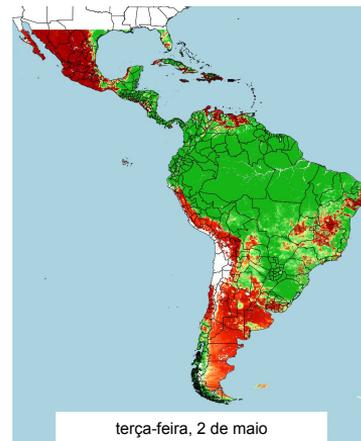
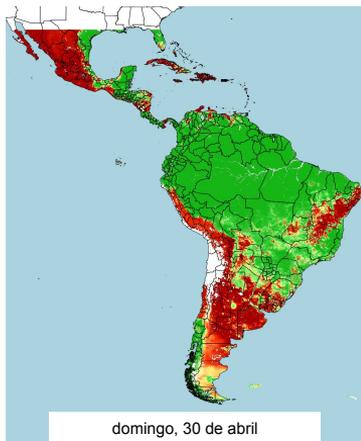
D	S	T	Q	Q	S	S
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92	93	94	95	96	97	98
99	100	101	102	103	104	105
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120						

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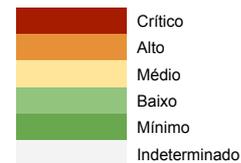
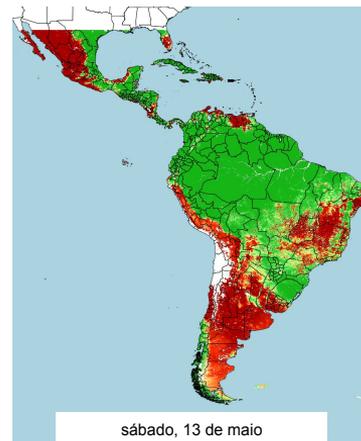
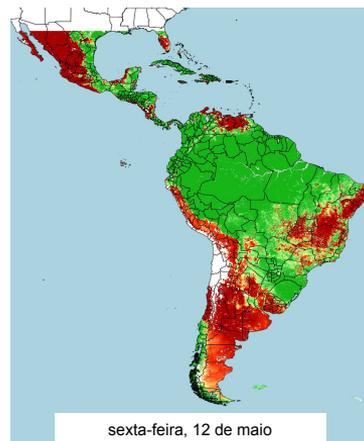
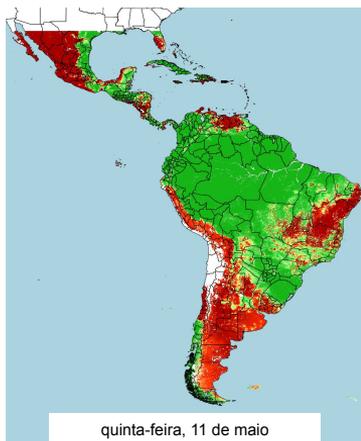
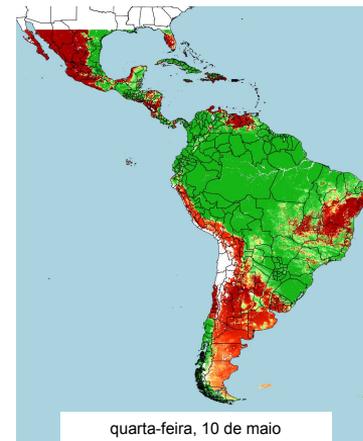
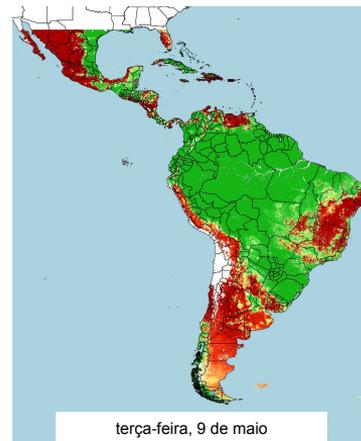
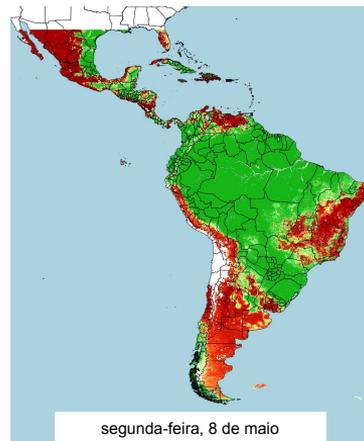
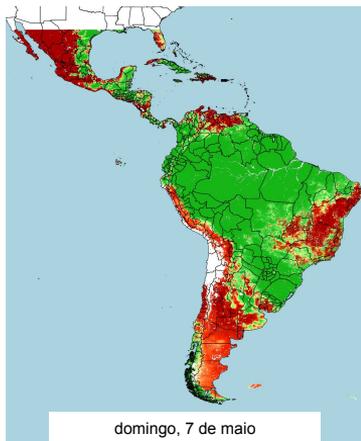
D	S	T	Q	Q	S	S
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92	93	94	95	96	97	98
99	100	101	102	103	104	105
106	107	108	109	110	111	112
113	114	115	116	117	118	119
120						



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D	S	T	Q	Q	S	S
120	121	122	123	124	125	126
127	128	129	130	131	132	133
134	135	136	137	138	139	140
141	142	143	144	145	146	147
148	149	150	151			

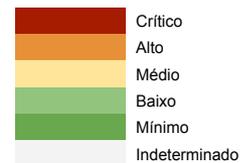
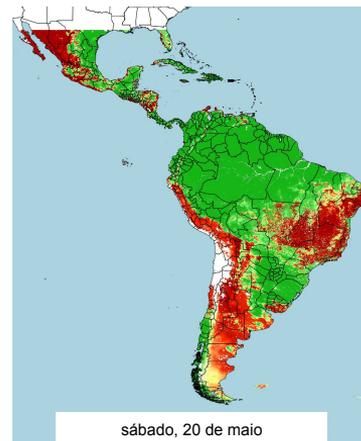
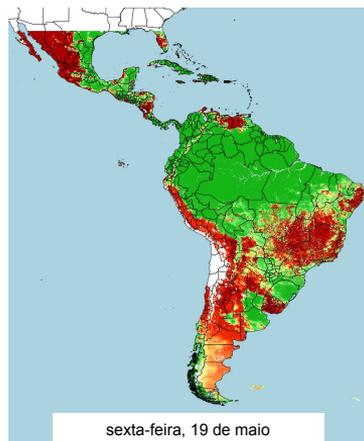
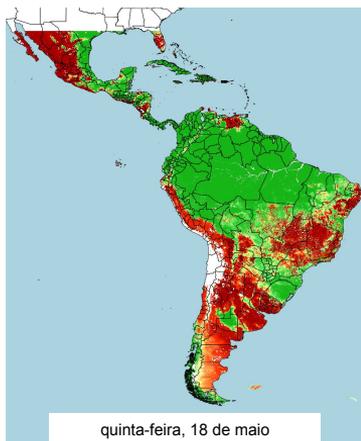
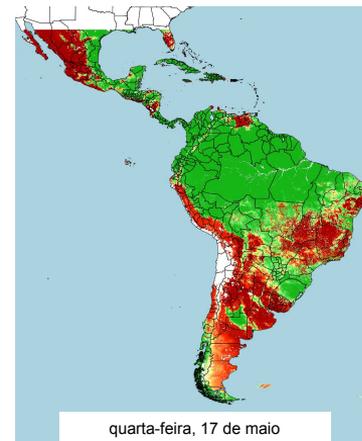
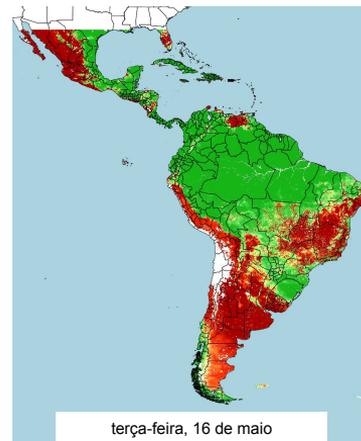
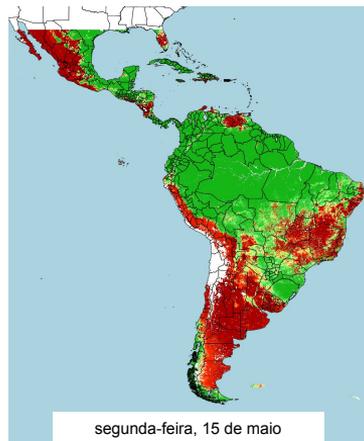
CALENDÁRIO JULIANO



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D	S	T	Q	Q	S	S
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127	128	129	130	131	132	133
134	135	136	137	138	139	140
141	142	143	144	145	146	147
148	149	150	151			

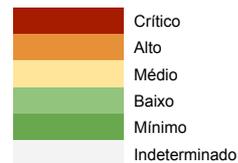
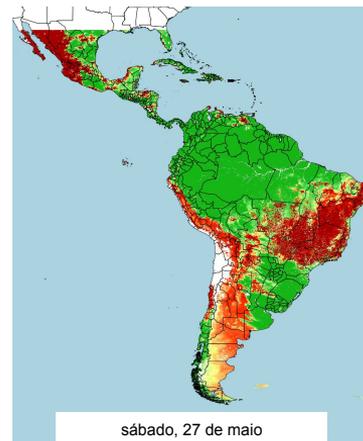
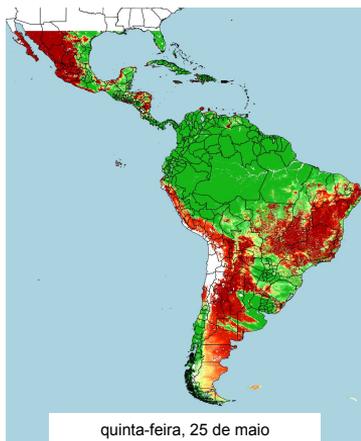
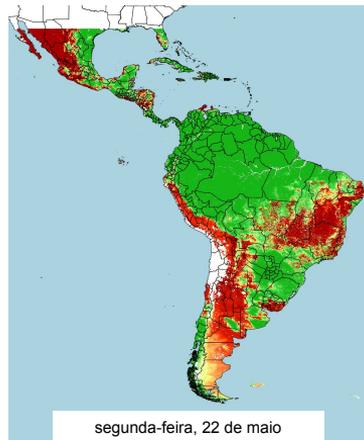
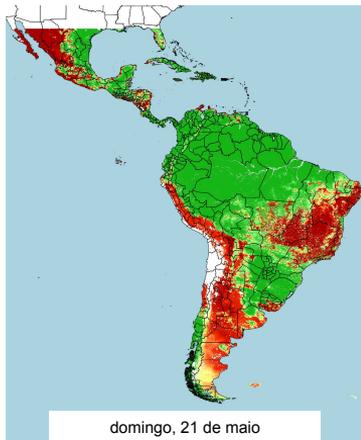
CALENDÁRIO JULIANO



MAIO / 2023

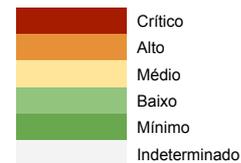
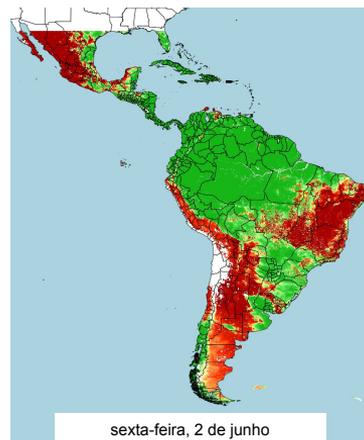
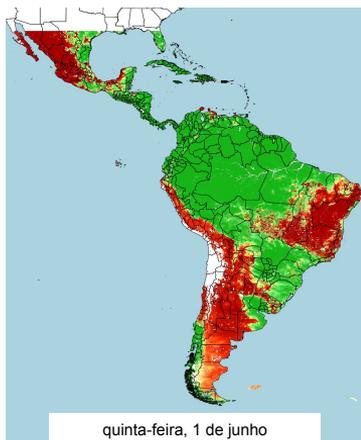
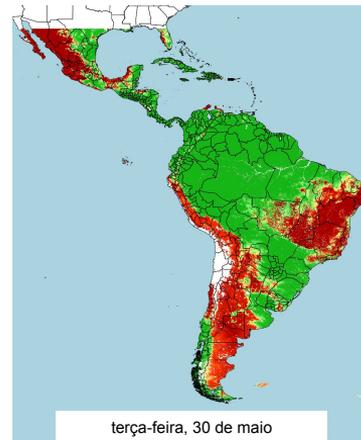
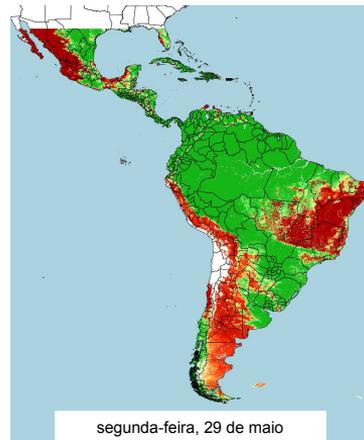
D	S	T	Q	Q	S	S
	121	122	123	124	125	126
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148	149	150	151			

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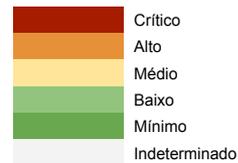
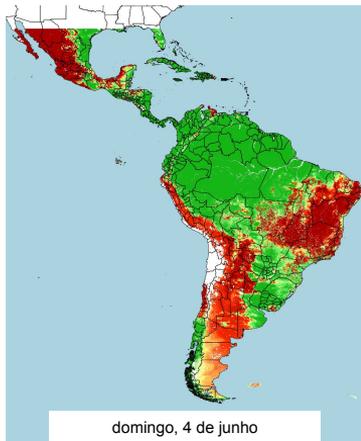
D	S	T	Q	Q	S	S
	121	122	123	124	125	126
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148	149	150	151			



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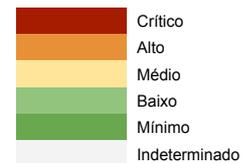
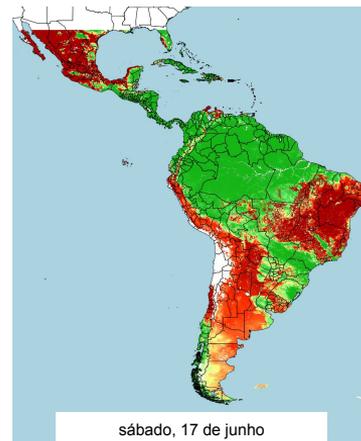
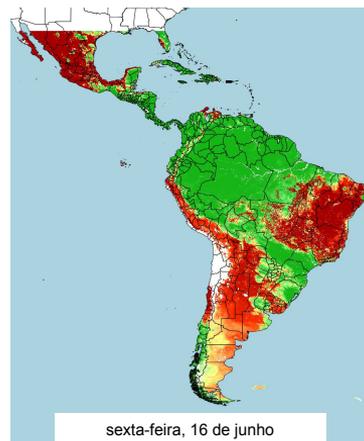
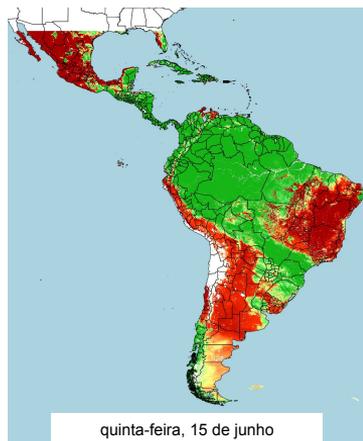
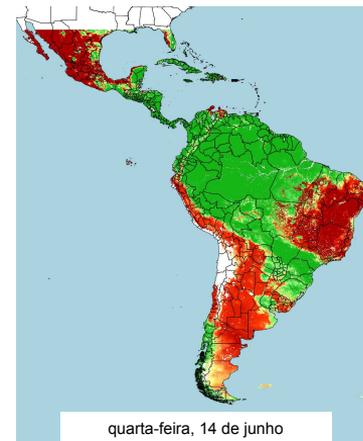
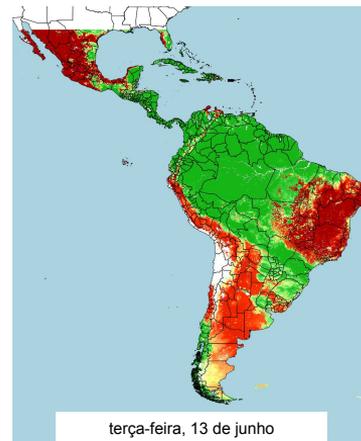
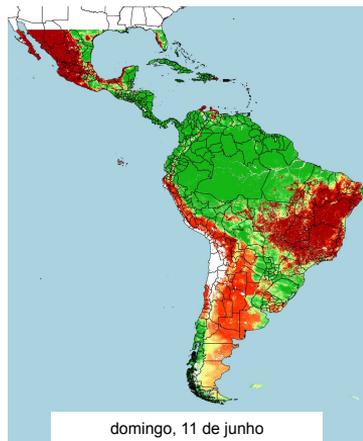
D	S	T	Q	Q	S	S
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134	135	136	137	138	139	140
141	142	143	144	145	146	147
148	149	150	151	152	153	154

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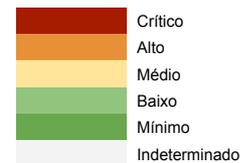
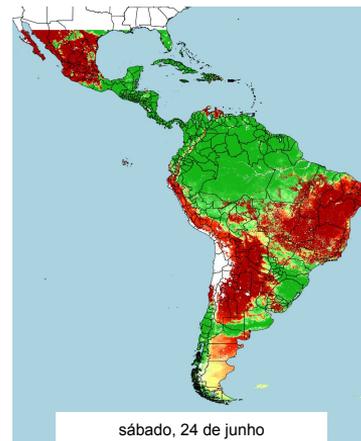
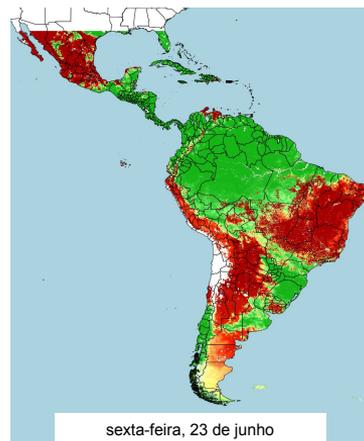
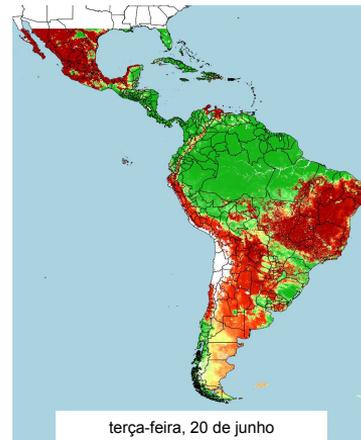
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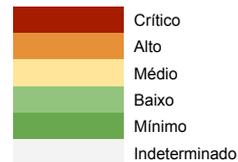
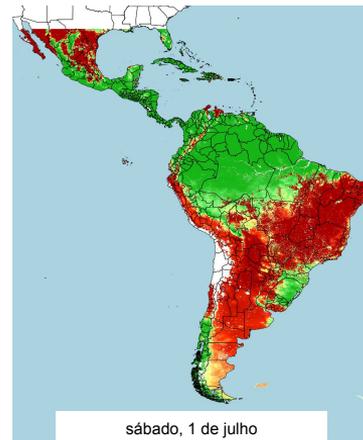
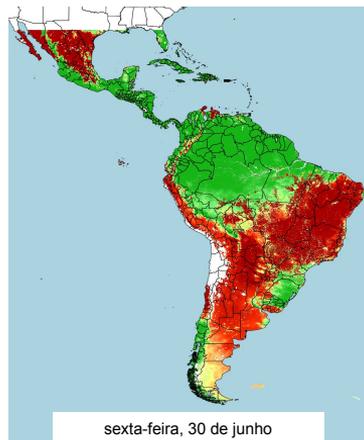
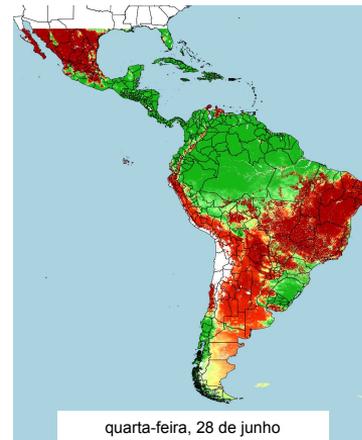
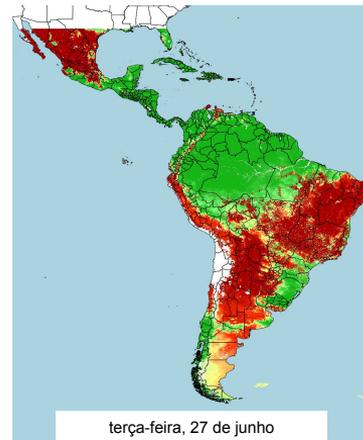
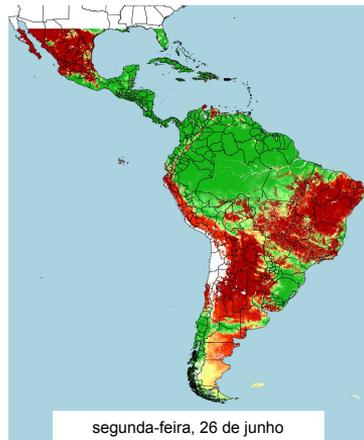
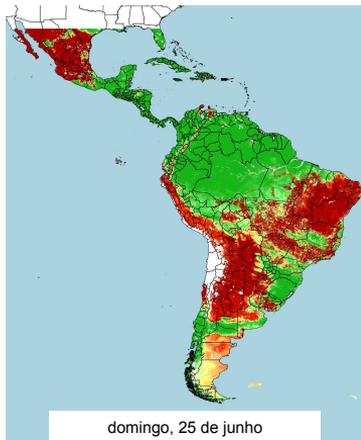
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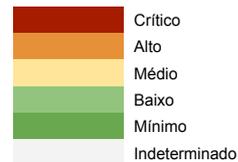
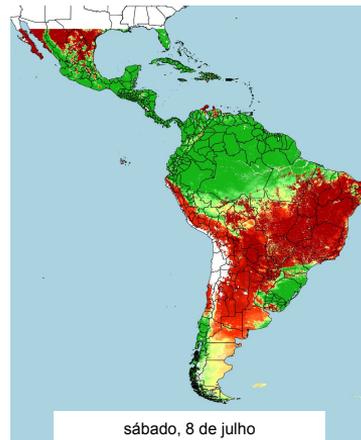
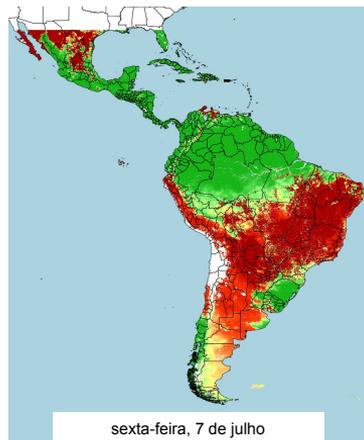
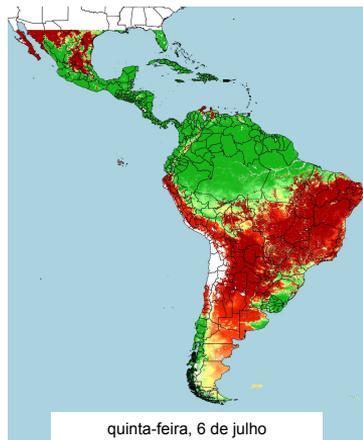
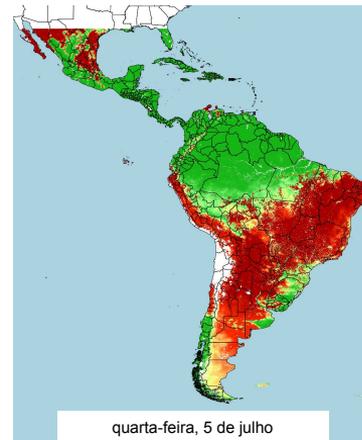
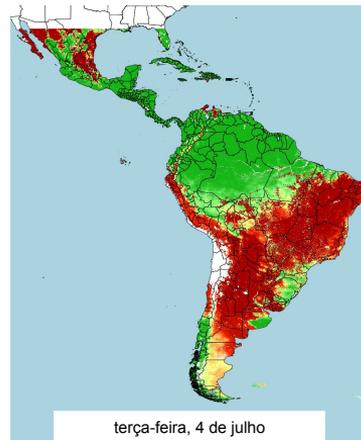
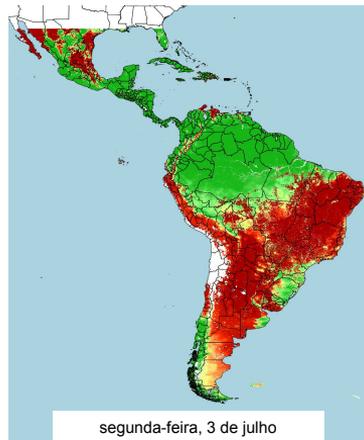
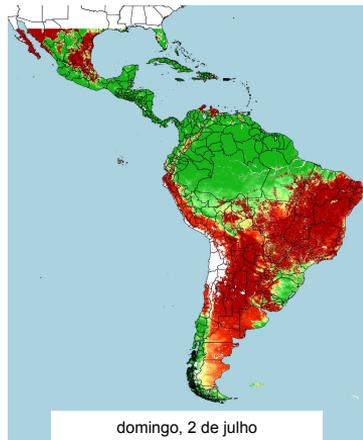
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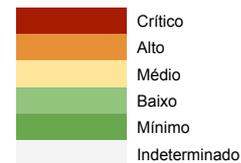
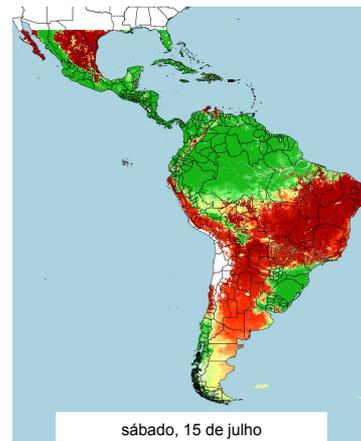
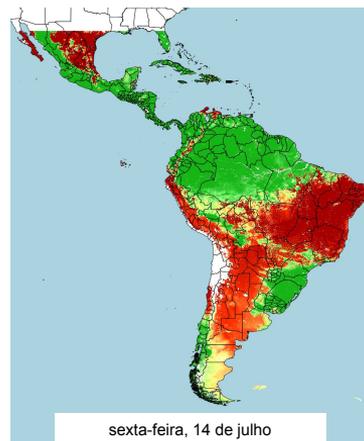
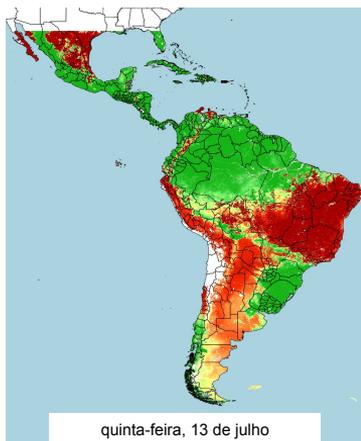
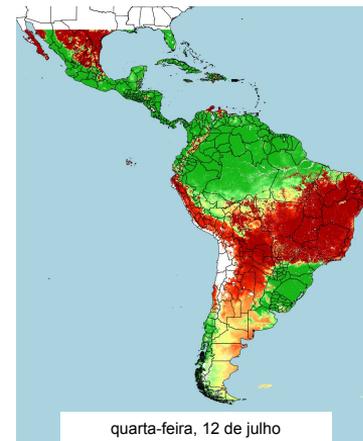
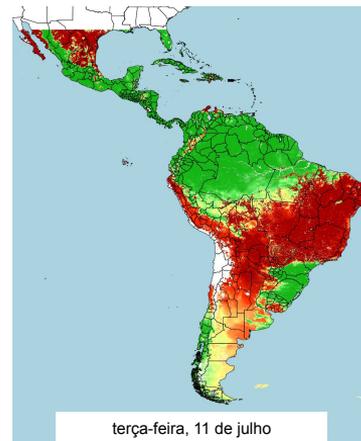
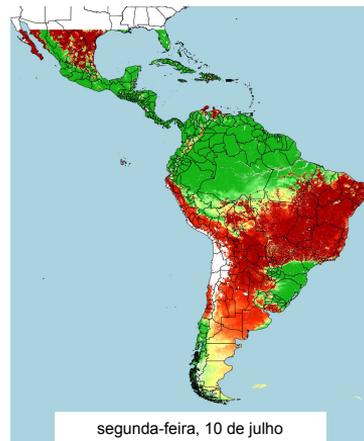
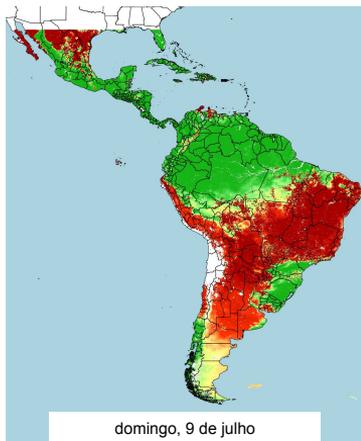
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D	S	T	Q	Q	S	S
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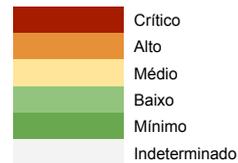
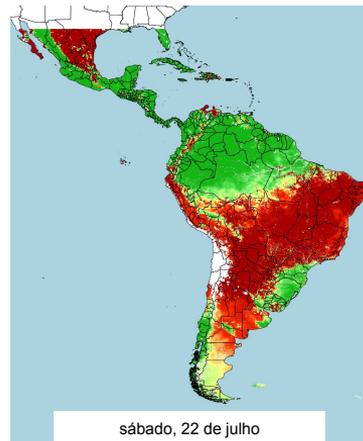
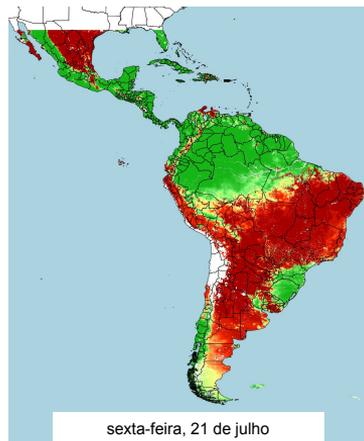
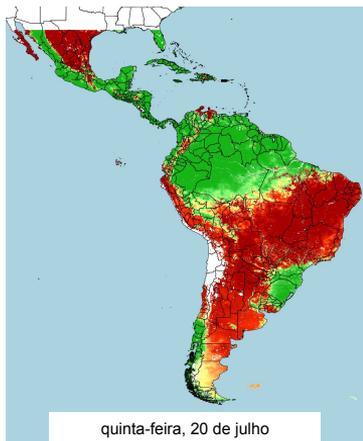
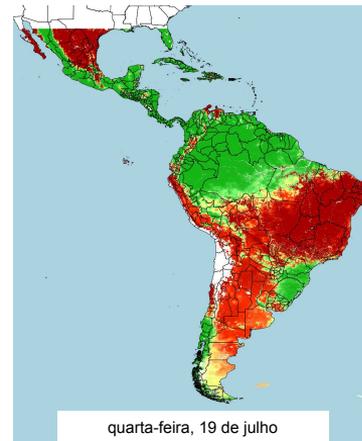
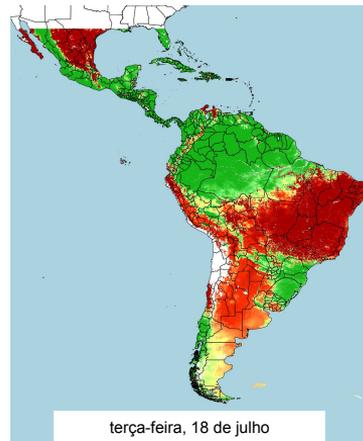
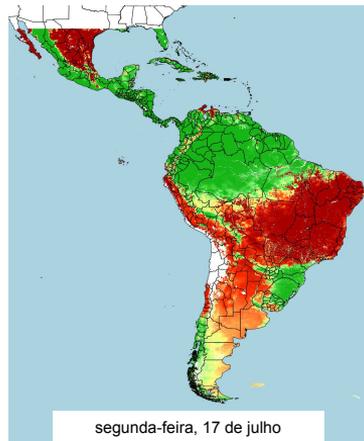
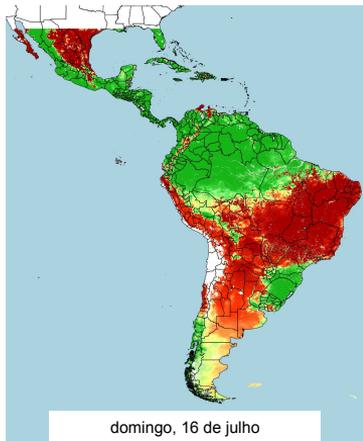
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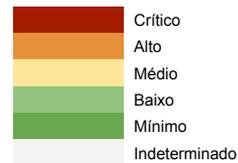
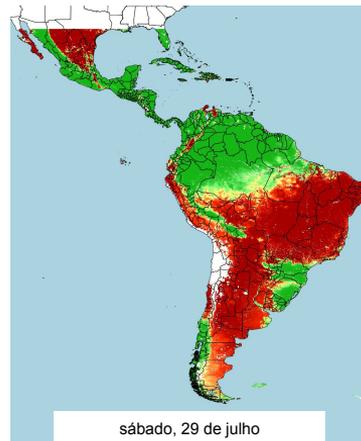
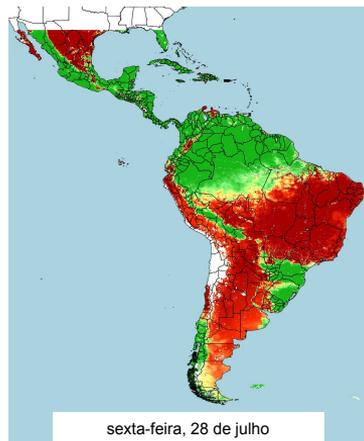
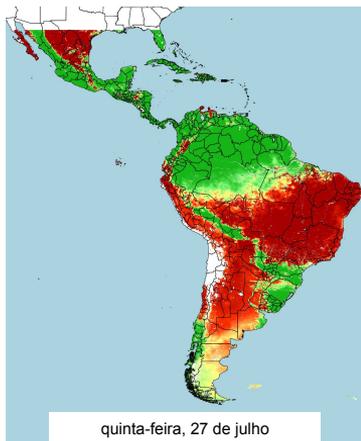
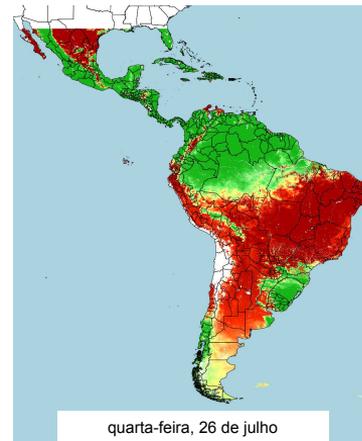
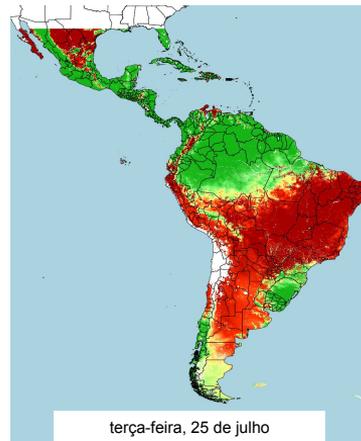
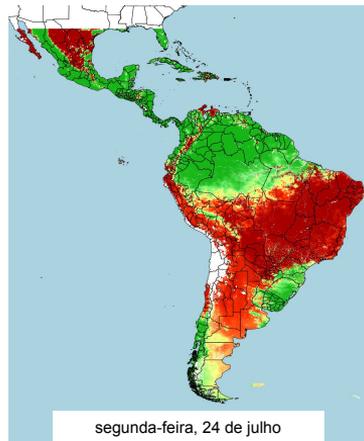
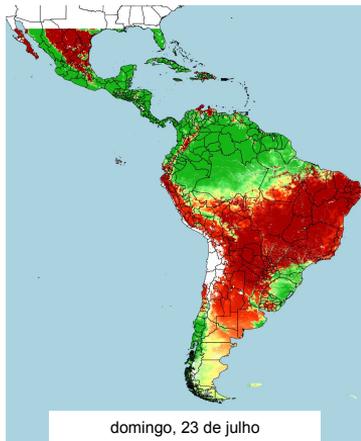
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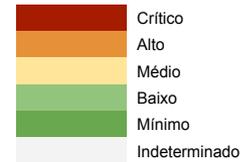
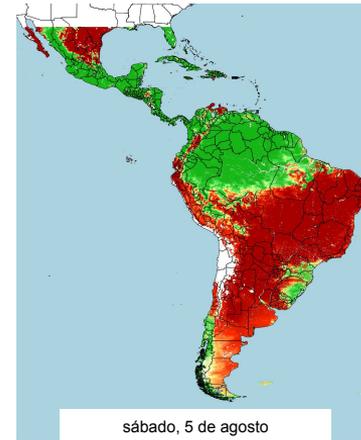
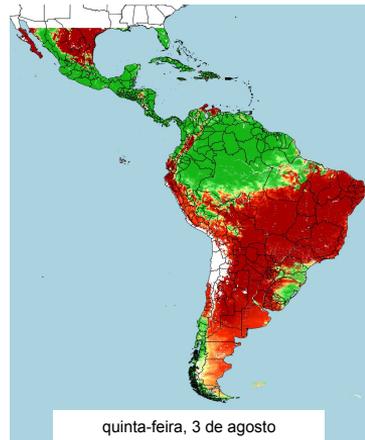
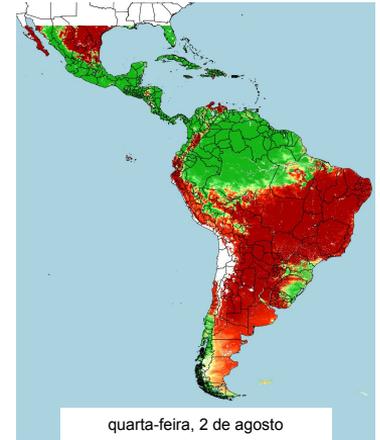
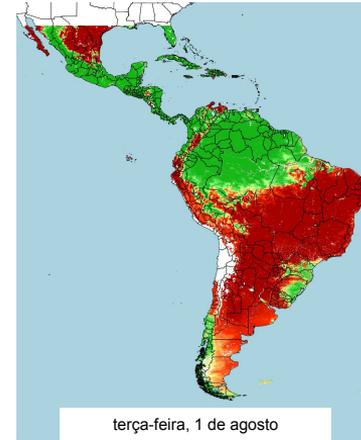
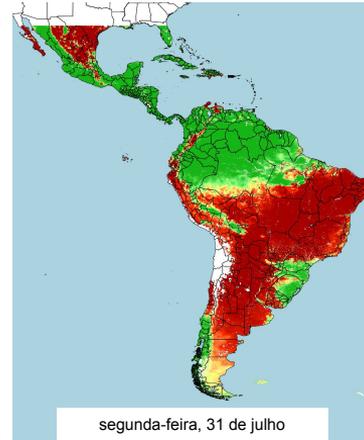
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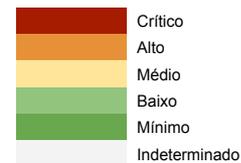
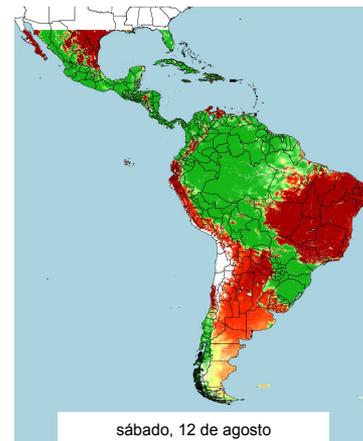
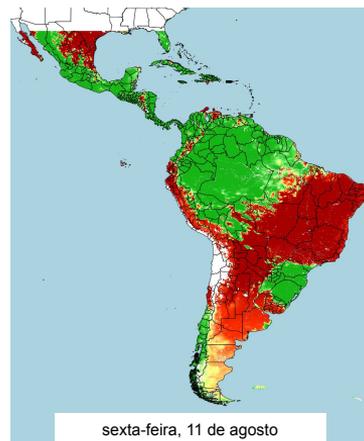
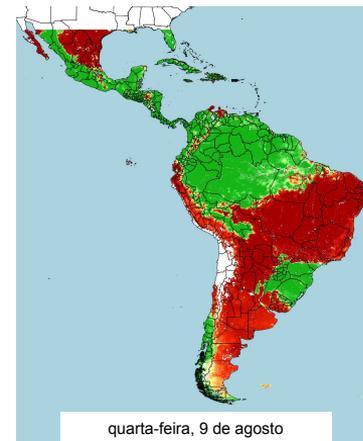
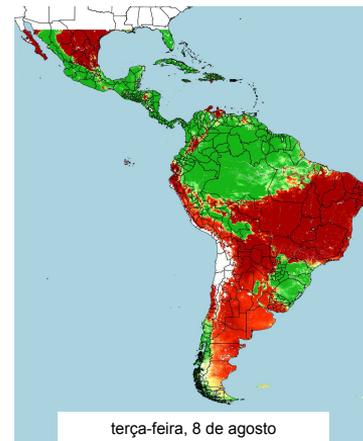
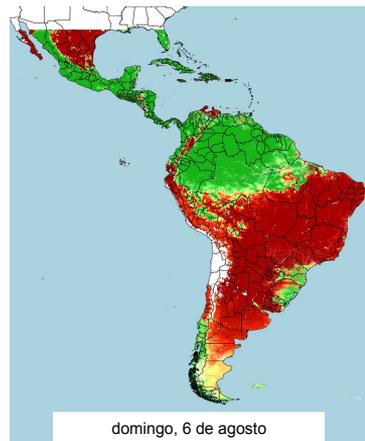
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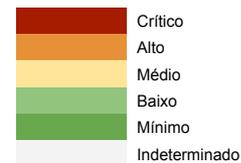
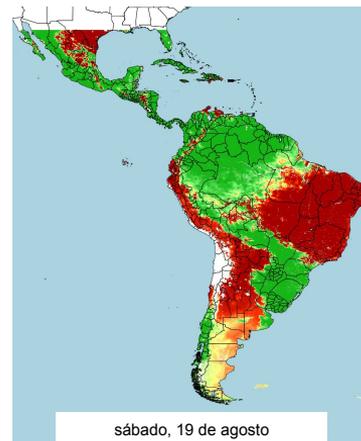
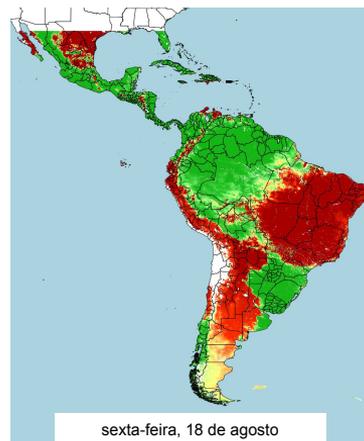
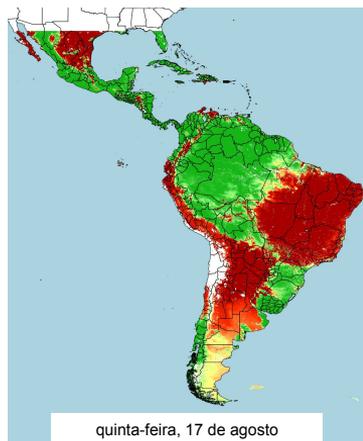
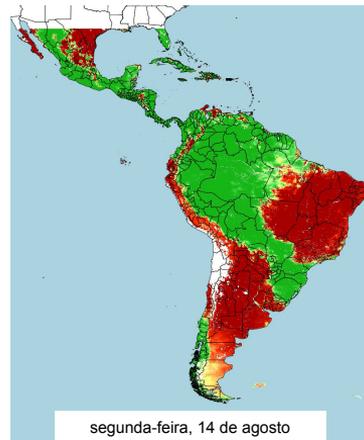
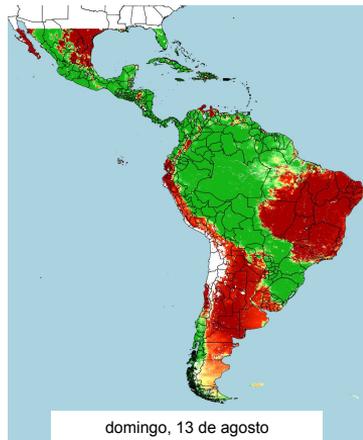
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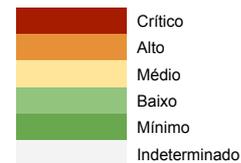
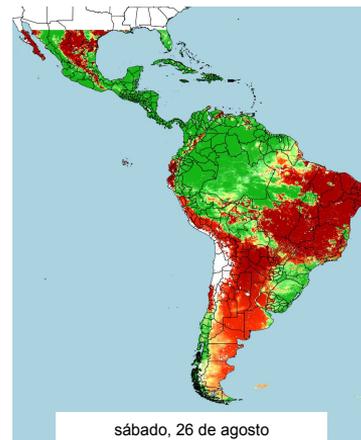
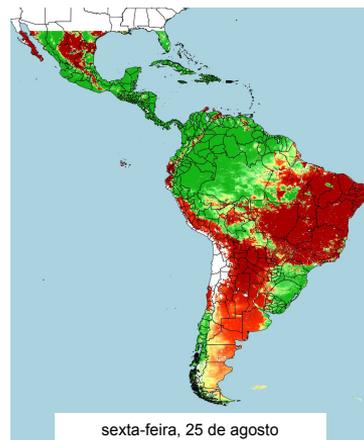
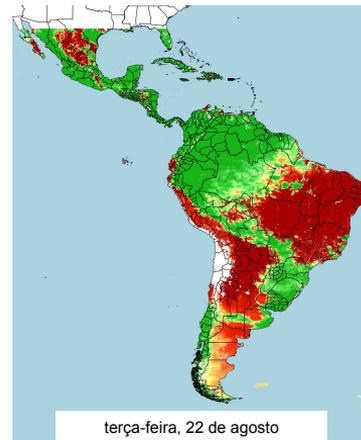
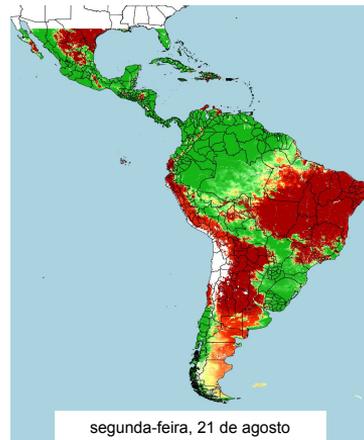
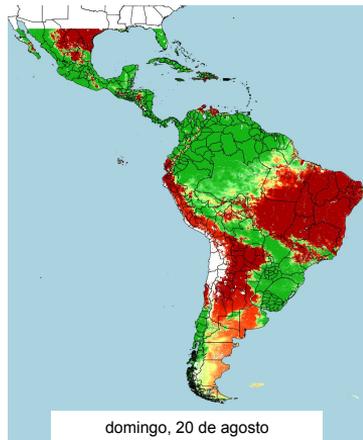
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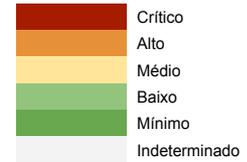
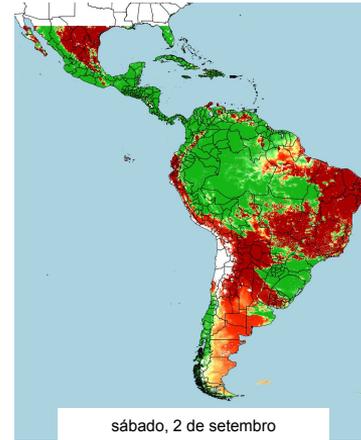
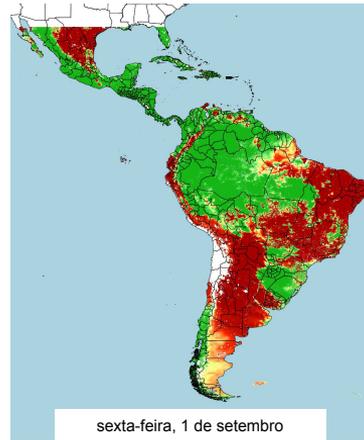
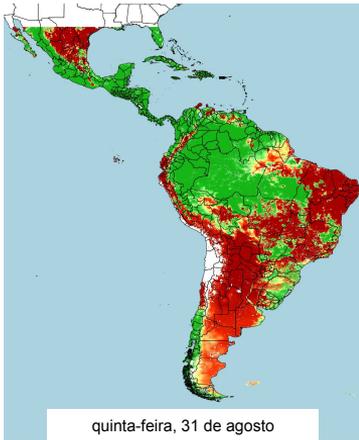
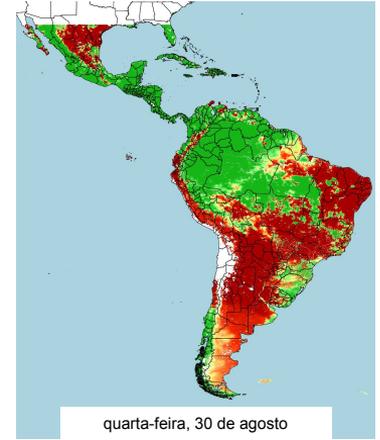
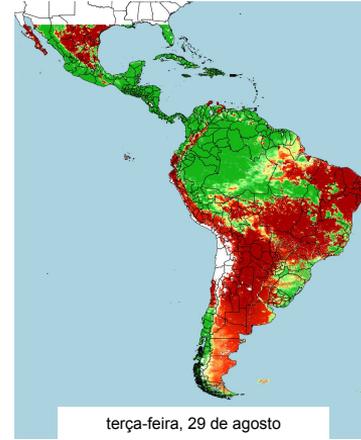
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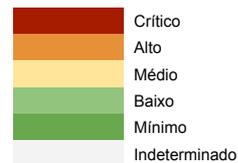
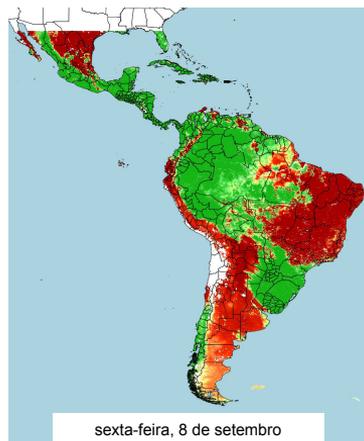
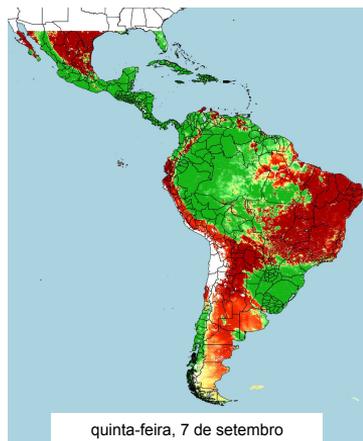
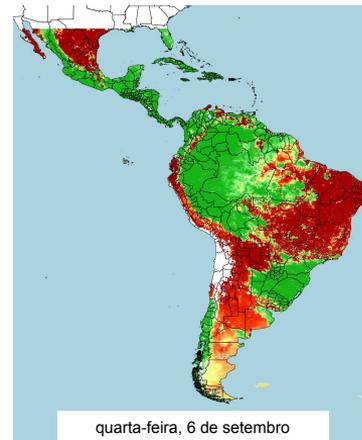
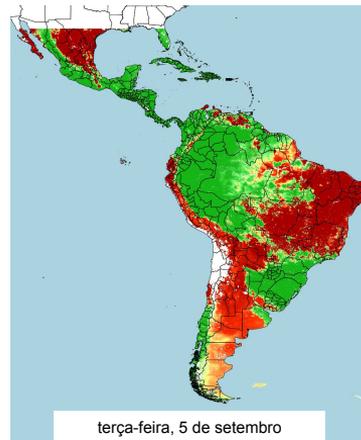
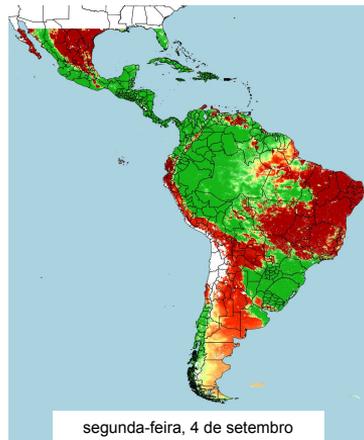
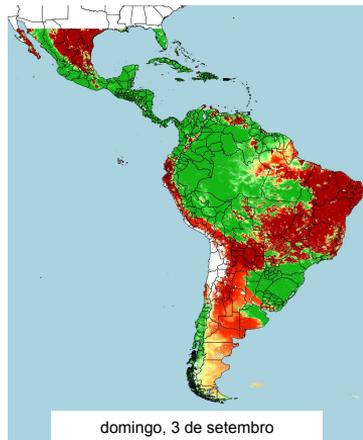
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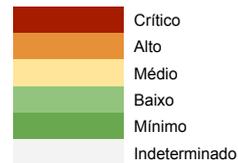
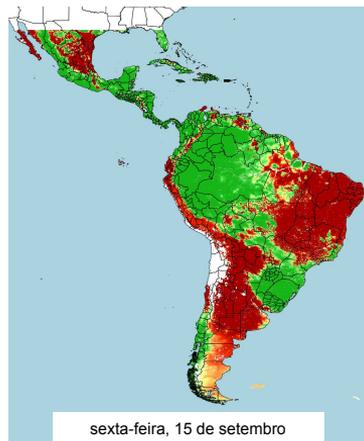
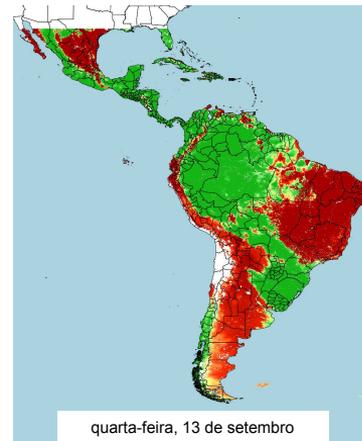
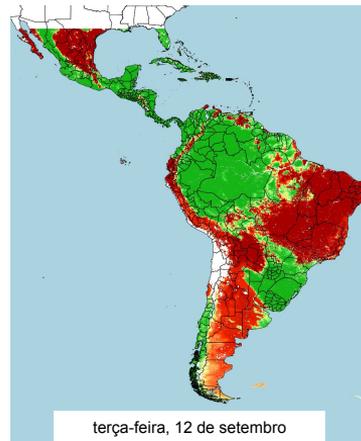
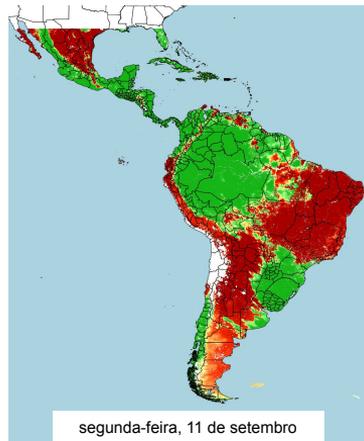
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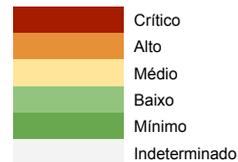
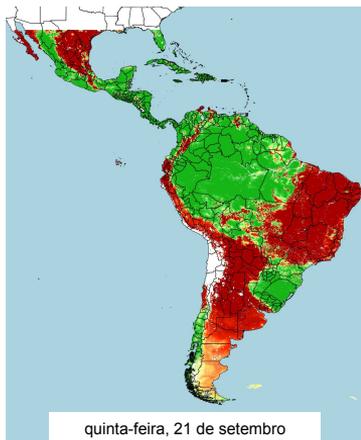
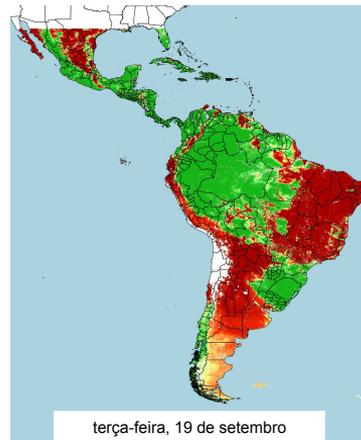
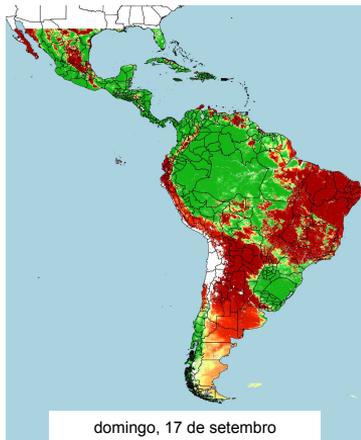
SETEMBRO / 2023

D	S	T	Q	Q	S	S
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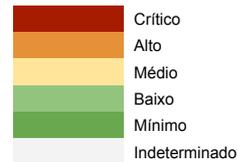
CALENDÁRIO JULIANO



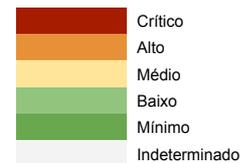
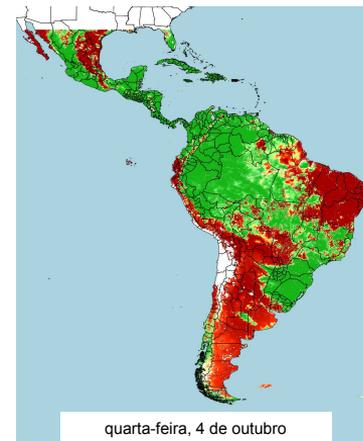
SETEMBRO / 2023							
D	S	T	Q	Q	S	S	
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253	254	255	256	257	258	259	
260	261	262	263	264	265	266	
267	268	269	270	271	272	273	



SETEMBRO / 2023							
D	S	T	Q	Q	S	S	
					244	245	
246	247	248	249	250	251	252	
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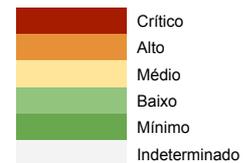
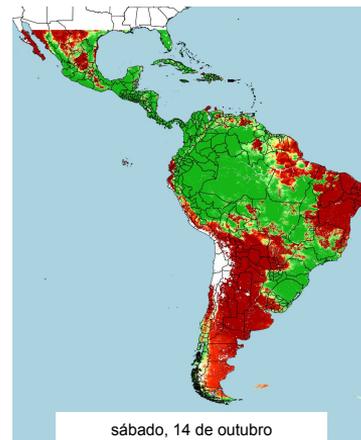
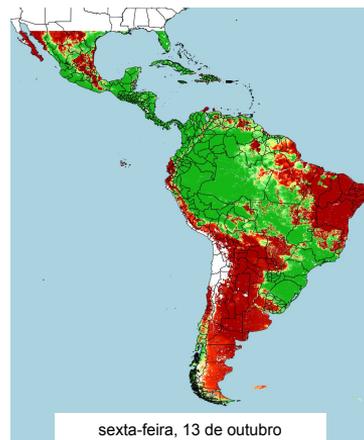
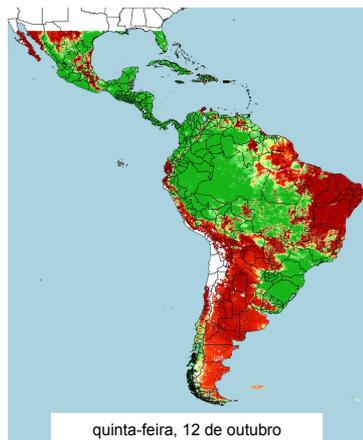
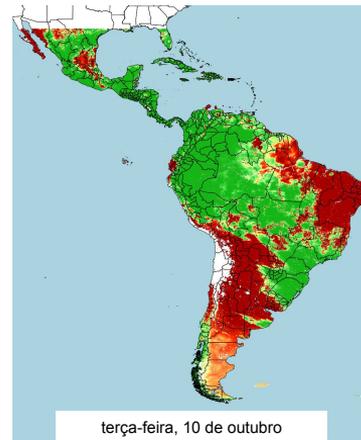
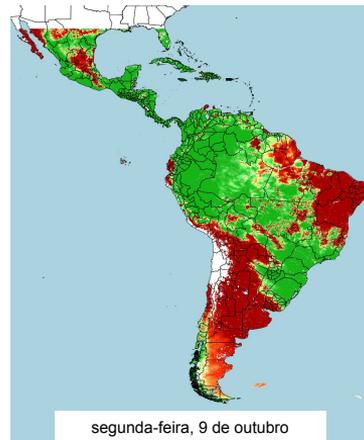
SETEMBRO / 2023						
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253	254	255	256	257	258	259
260	261	262	263	264	265	266
267	268	269	270	271	272	273



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D	S	T	Q	Q	S	S
274	275	276	277	278	279	280
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302	303	304				

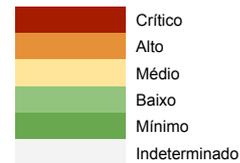
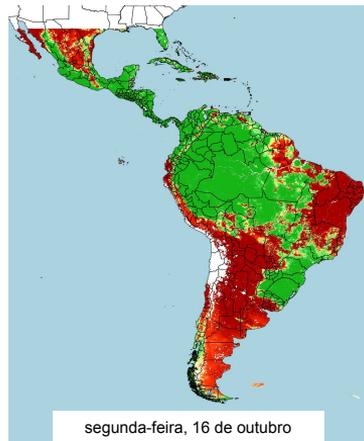
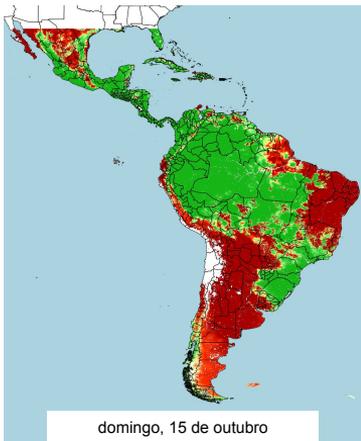
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OUTUBRO / 2023

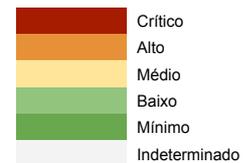
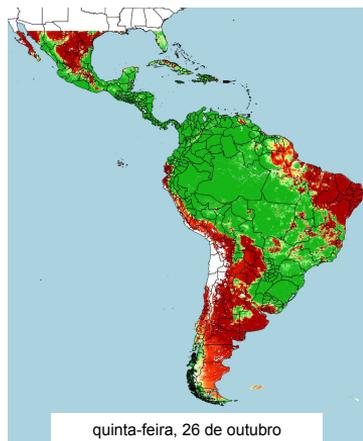
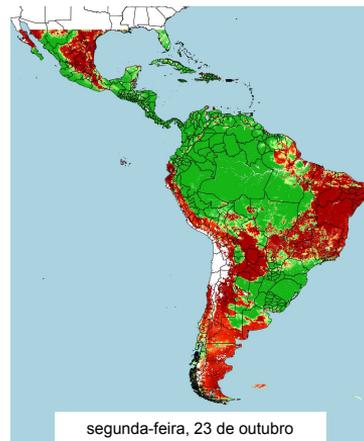
D	S	T	Q	Q	S	S
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302	303	304				

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OUTUBRO / 2023

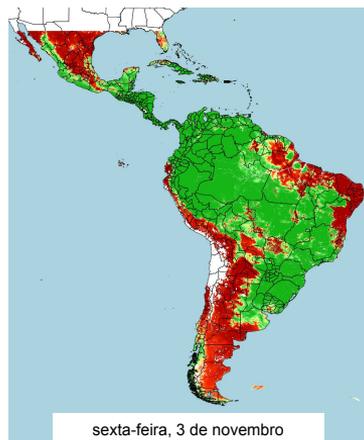
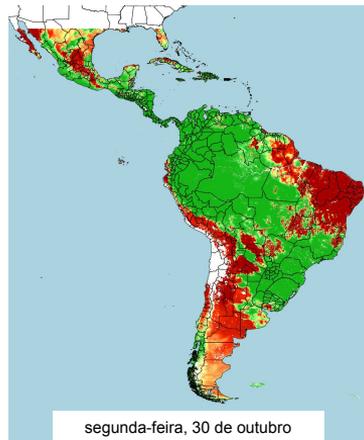
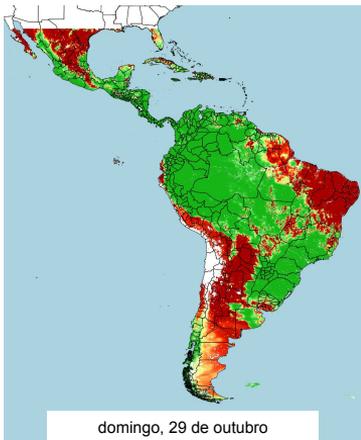
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302	303	304				



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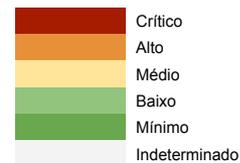
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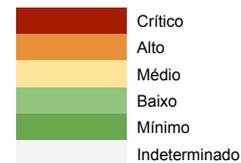
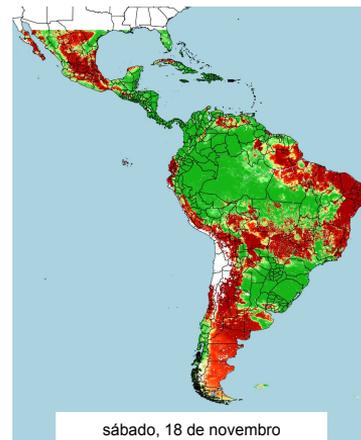
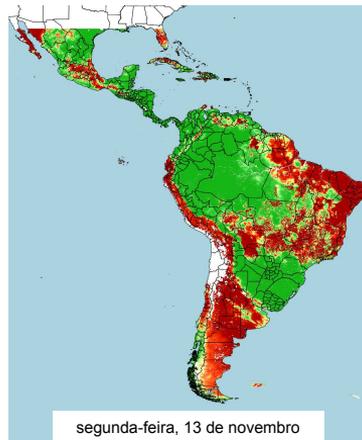
	Crítico
	Alto
	Médio
	Baixo
	Mínimo
	Indeterminado

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D	S	T	Q	Q	S	S	
302	303	304	305	306	307	308	
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330	331	332	333	334			



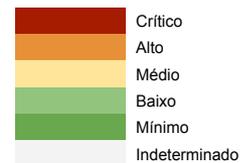
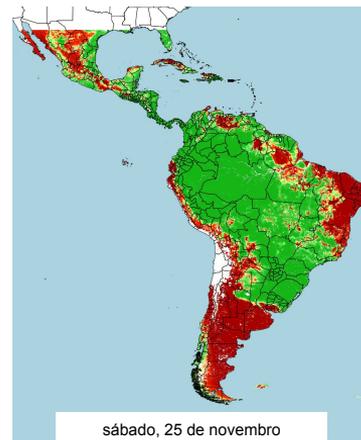
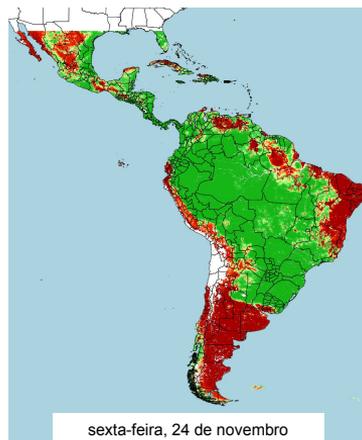
NOVEMBRO / 2023

D	S	T	Q	Q	S	S
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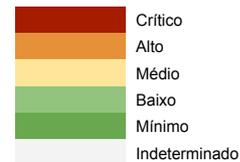
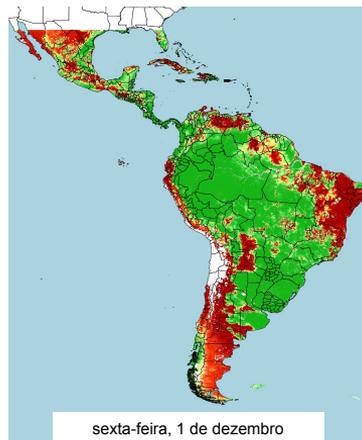
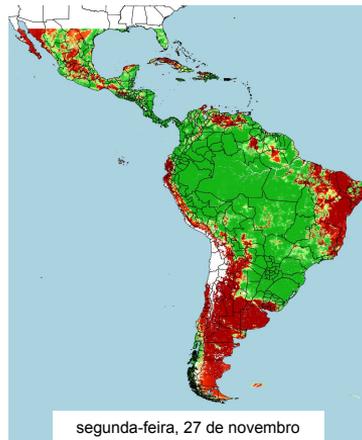
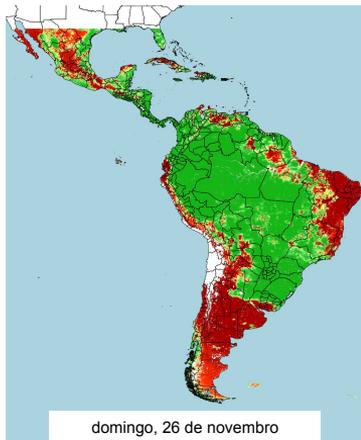
NOVEMBRO / 2023

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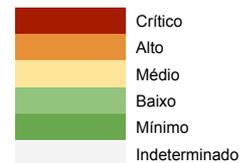
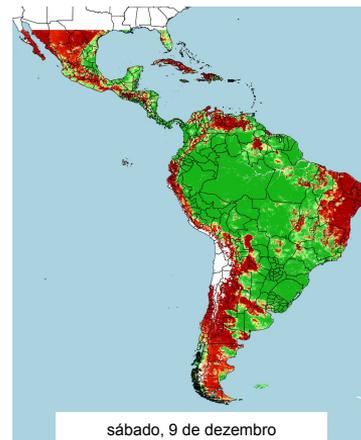
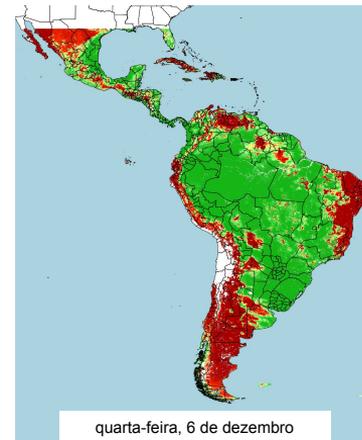
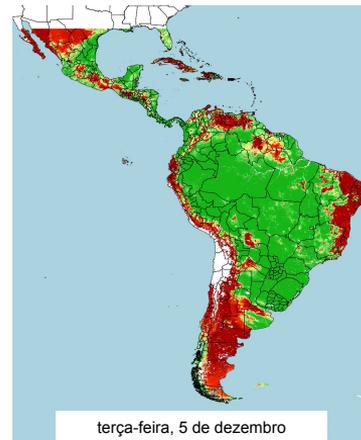
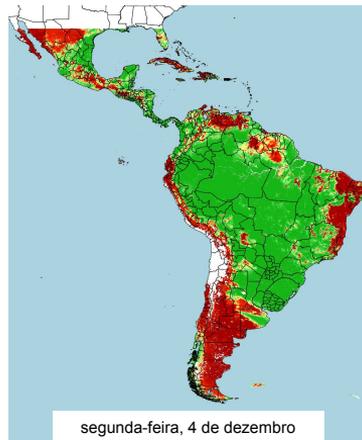
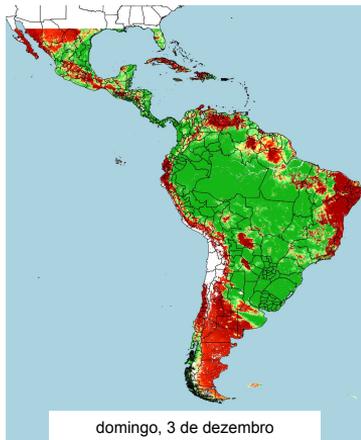
NOVEMBRO / 2023

D	S	T	Q	Q	S	S
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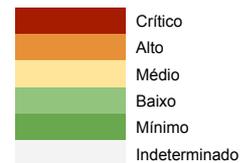
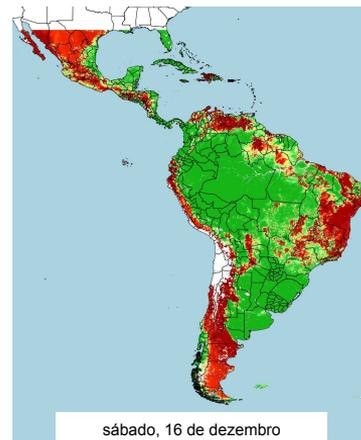
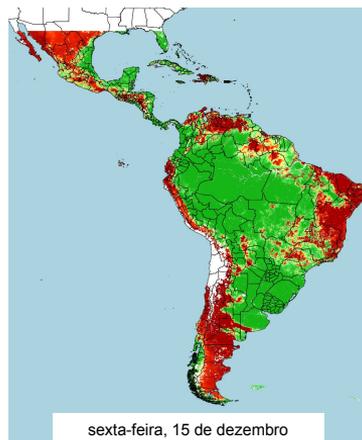
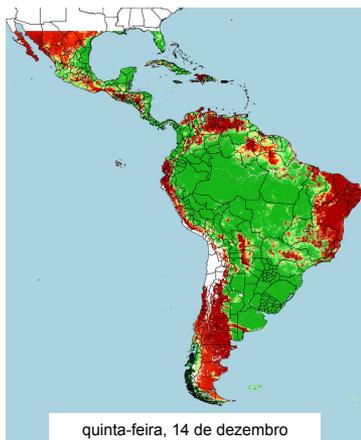
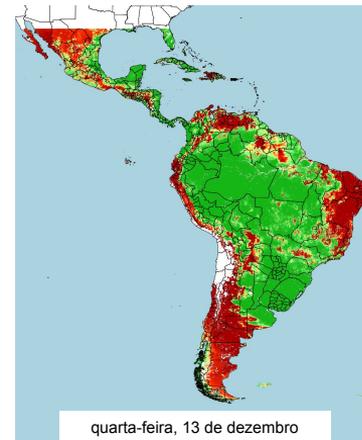
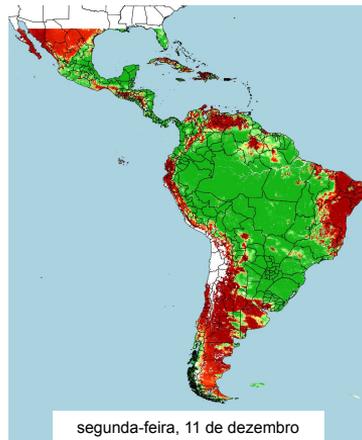


NOVEMBRO / 2023

D	S	T	Q	Q	S	S
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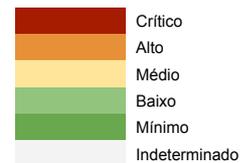
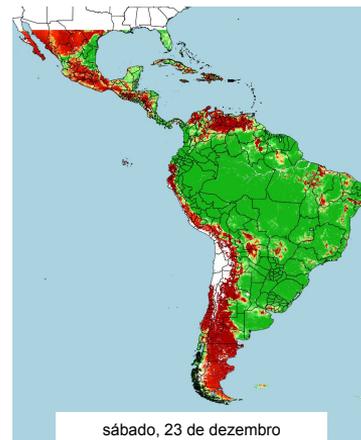
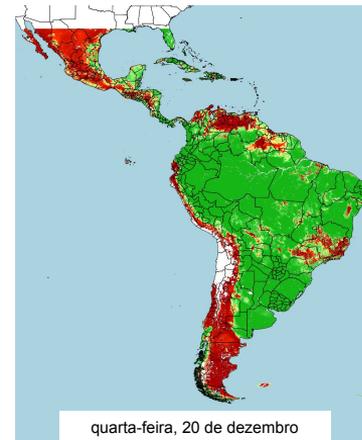
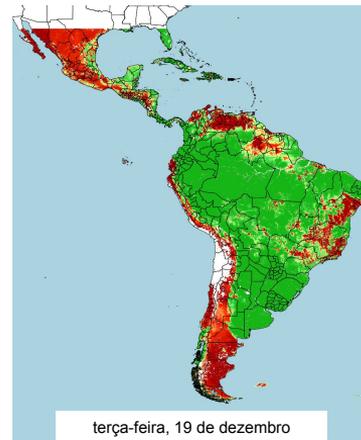
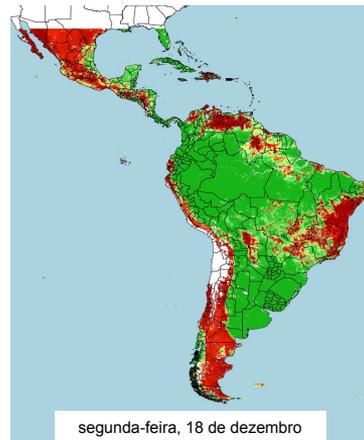


DEZEMBRO / 2023						
D	S	T	Q	Q	S	S
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365						



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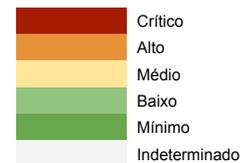
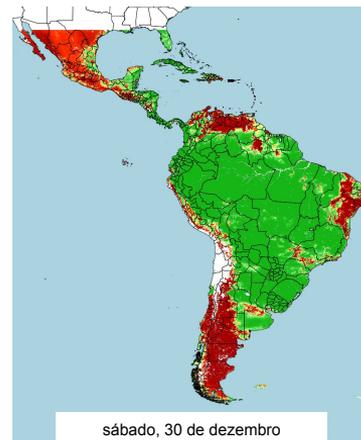
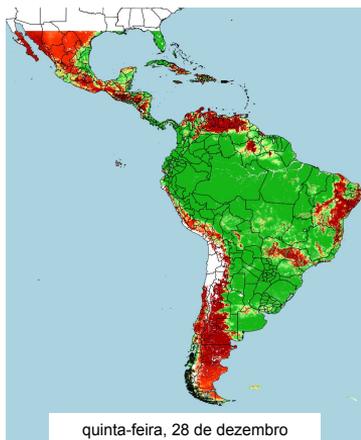
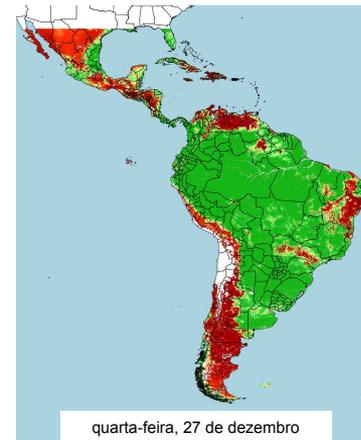
D	S	T	Q	Q	S	S
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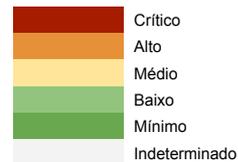
D	S	T	Q	Q	S	S
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DEZEMBRO / 2023

D	S	T	Q	Q	S	S
					335	336
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351	352	353	354	355	356	357
358	359	360	361	362	363	364
365						



DEZEMBRO / 2023							
D	S	T	Q	Q	S	S	
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344	345	346	347	348	349	350	
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365							

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