Implementation and forecast quality assessment of sub-seasonal predictions in Brazil

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- Configuration and assessment of INPE/CPTEC global model for sub-seasonal predictions
- An inter-comparison performance assessment of INPE/CPTEC global model sub-seasonal predictions against four sub-seasonal to seasonal (S2S) prediction project models
- Examples of implemented sub-seasonal prediction and verification products: New INPE/CPTEC web portal
- Development and implemention of a multi-model ensemble sub-seasonal precip. prediction system for Brazil

WGNE and JWGFVR workshop on Numerical predictions for strategic sectoral applications:
Modeling and verification approaches and challenges
INPE, São José dos Campos, Brazil, 31 October and 1 December 2023

Configuration and assessment of INPE/CPTEC Global Atmospheric Model for sub-seasonal predictions

What is the most adequate model configuration for producing predictions 1 to 4 weeks ahead?

Model: Brazilian Global Atmospheric model [BAM (Figueroa et al., 2016)] used at INPE/CPTEC for numerical global weather and seasonal climate predictions

This was the first outcome of the use of BAM for sub-seasonal predictions aiming to determine which model configuration presents the best performance for this time scale: Aligned with WWRP/WCRP S2S project
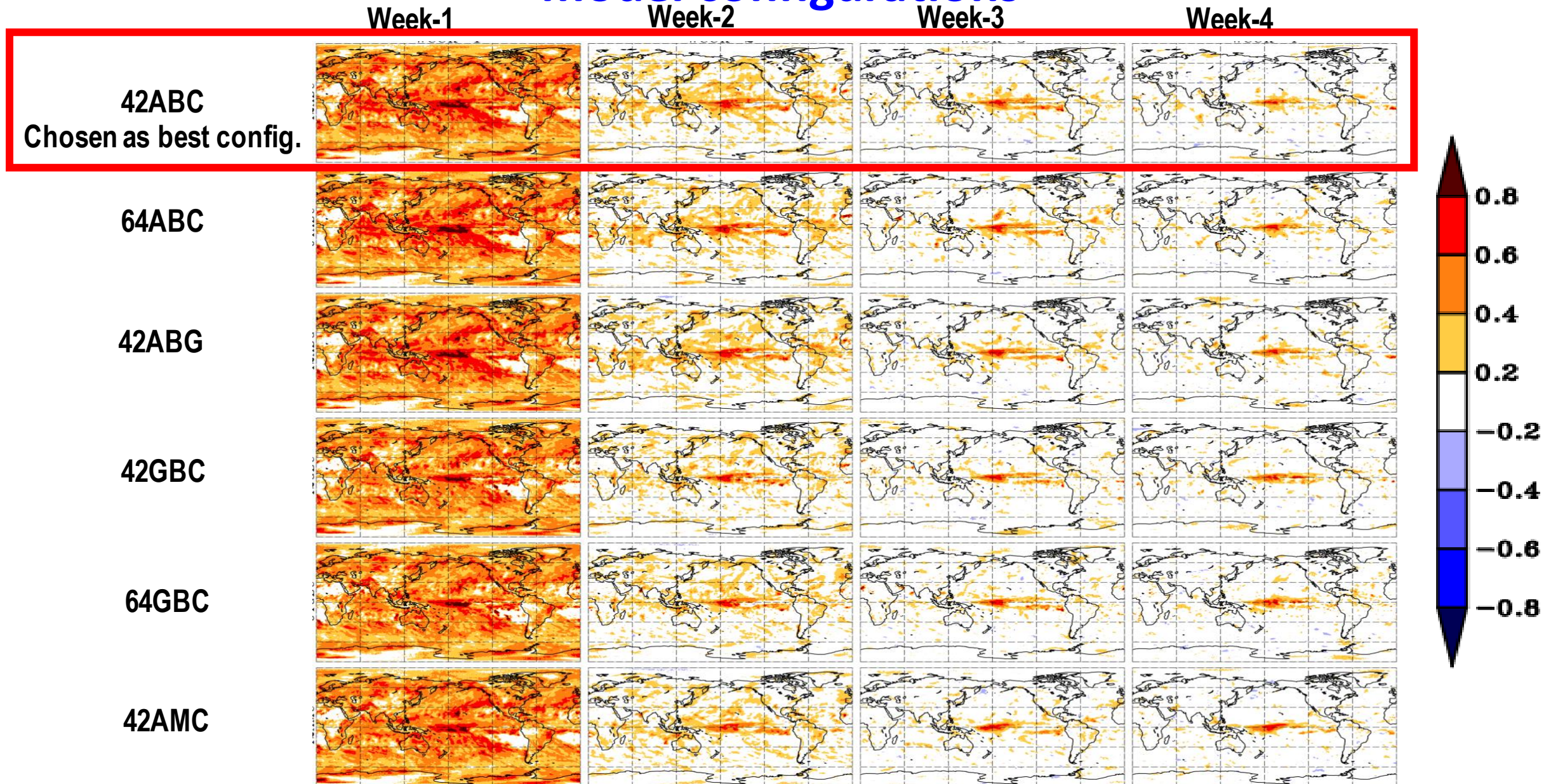

Special attention given to characteristics such as vertical resolution, deep convection and boundary layer parameterizations as well as soil moisture initialization
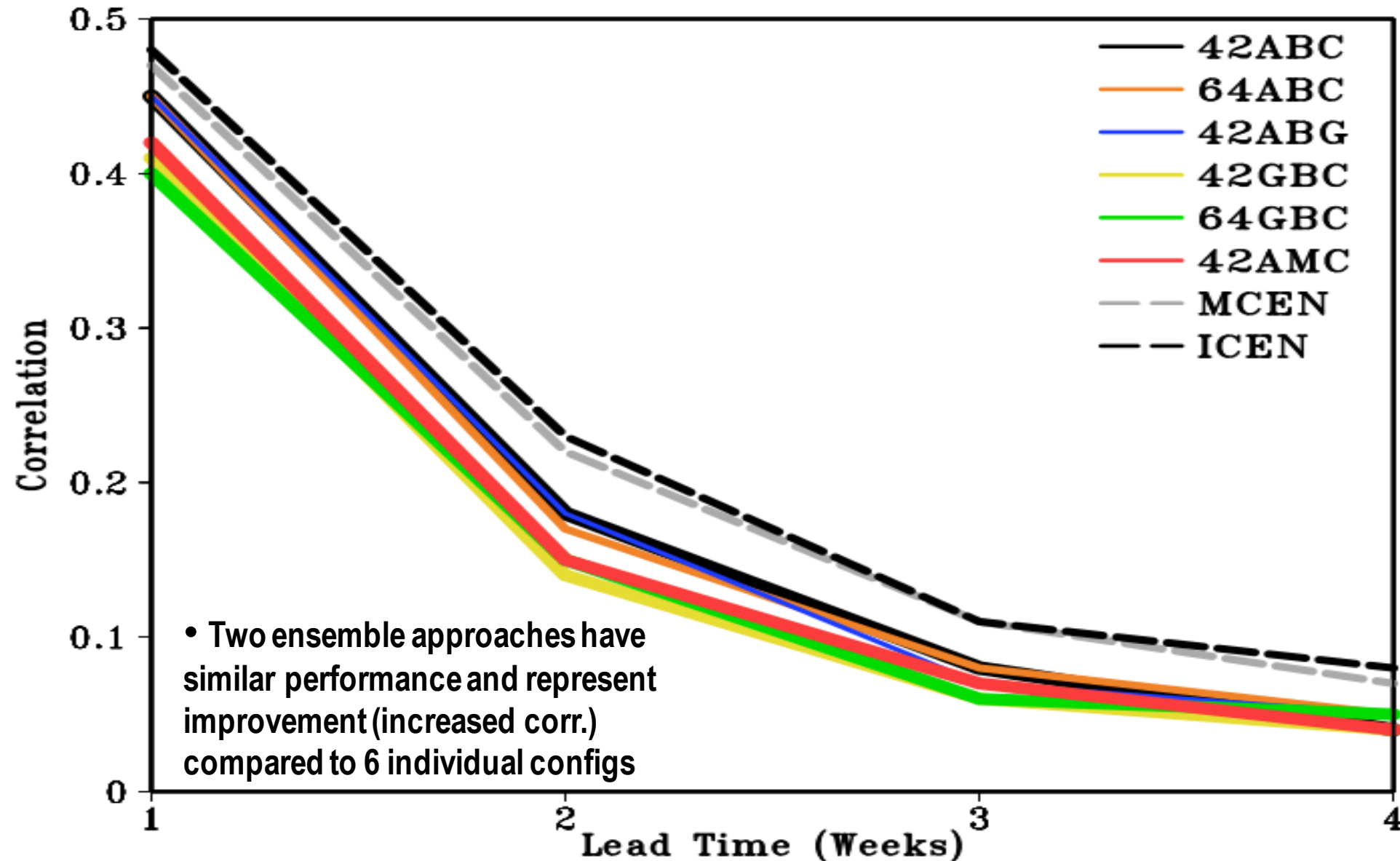
Chosen horizontal resolution: T126 (~100 km)

Hindcast ensemble produced twice a month for 12 extended austral summers (Nov-Mar): 1999/2000 to 2010/2011

Corr. btw predicted and observed precipitation anomalies for the six model configurations

Guimarães et al. (2020)

Global mean correlation for precipitation anomalies averaged over 60ºN and 60ºS

• Two ensemble approaches have similar performance and represent improvement (increased corr.) compared to 6 individual configs

How does INPE/CPTEC model compare with S2S project models?

This study performed a global assessment of INPE/CPTEC model (BAM-1.2) when producing sub-seasonal predictions, focusing on an inter-comparison with four S2S project models (JMA, ECCC, ECMWF and BoM)

Special attention devoted to performing a fair comparison between INPE/CPTEC and these four S2S project models in terms of using the same hindcast samples size, the same hindcast period (1999/2000-2010/2011) and the same number of ensemble members

Main characteristics of investigated models

	Model version	Resolution	Ensemble Size	Ocean Coupling
CPTEC	BAM-1.2	TQ126 L42 (~100 km)	11	NO
JMA	GEPS1701	Tl479 / Tl319 L100 (~40 / 55km)	5	NO
ECCC	GEPS5	0.35°/ L45 (~39 km)	4	NO
ECMWF	CY43R1	Tco639 / Tco319 L91 (~16 / 32km)	11	YES
BoM	POAMA(24a)	T47 L17 (~250 km)	11	YES

S2S Project models (JMA, ECCC, ECMWF, BoM)

Common ensemble size: 4 members of all models (det. assessment of ens. mean)
**11 members for CPTEC, ECMWF and BoM (prob. assess.)**

Corr. btw predicted and observed precipitation anomalies for INPE/CPTEC and S2S models
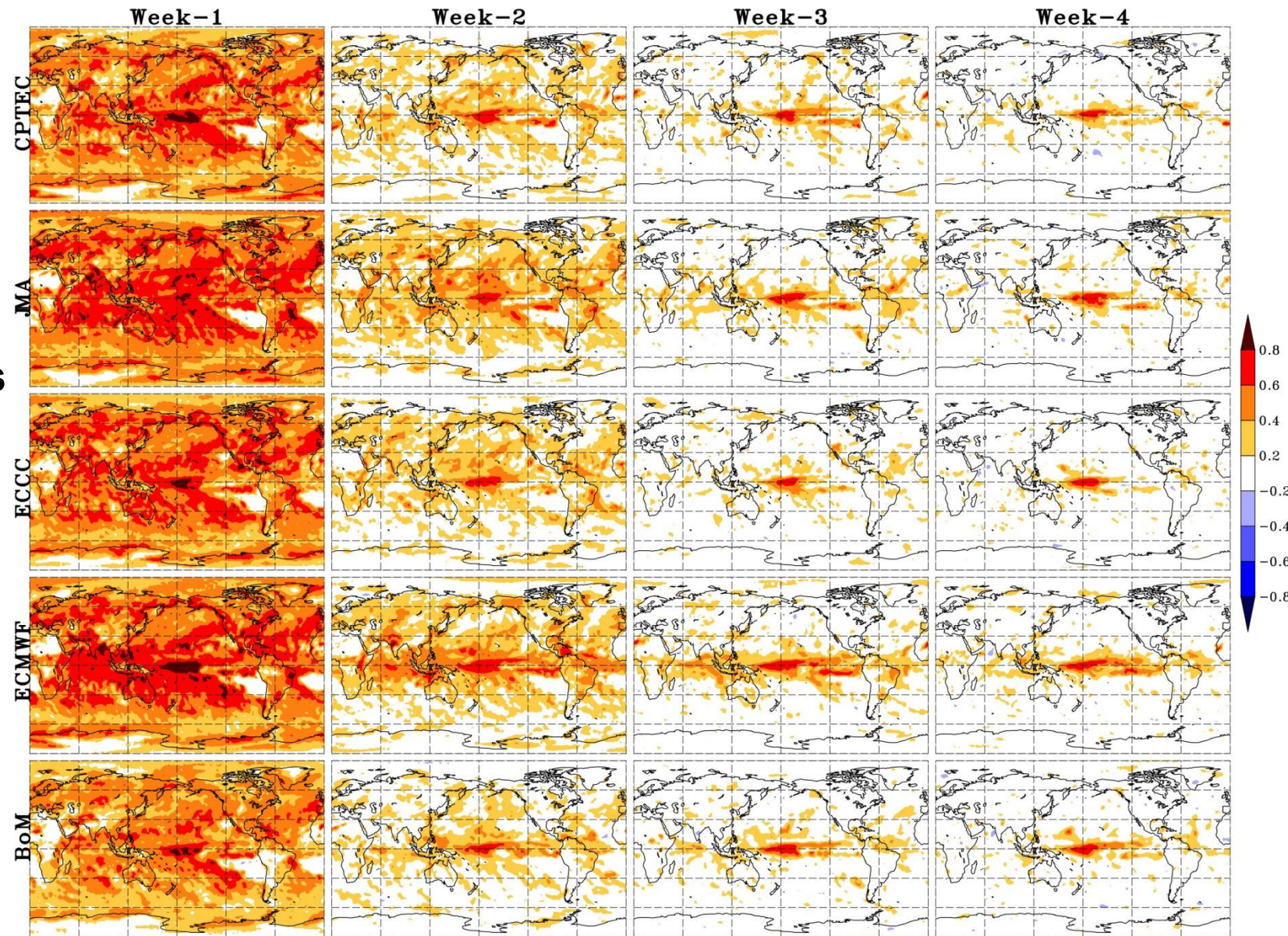
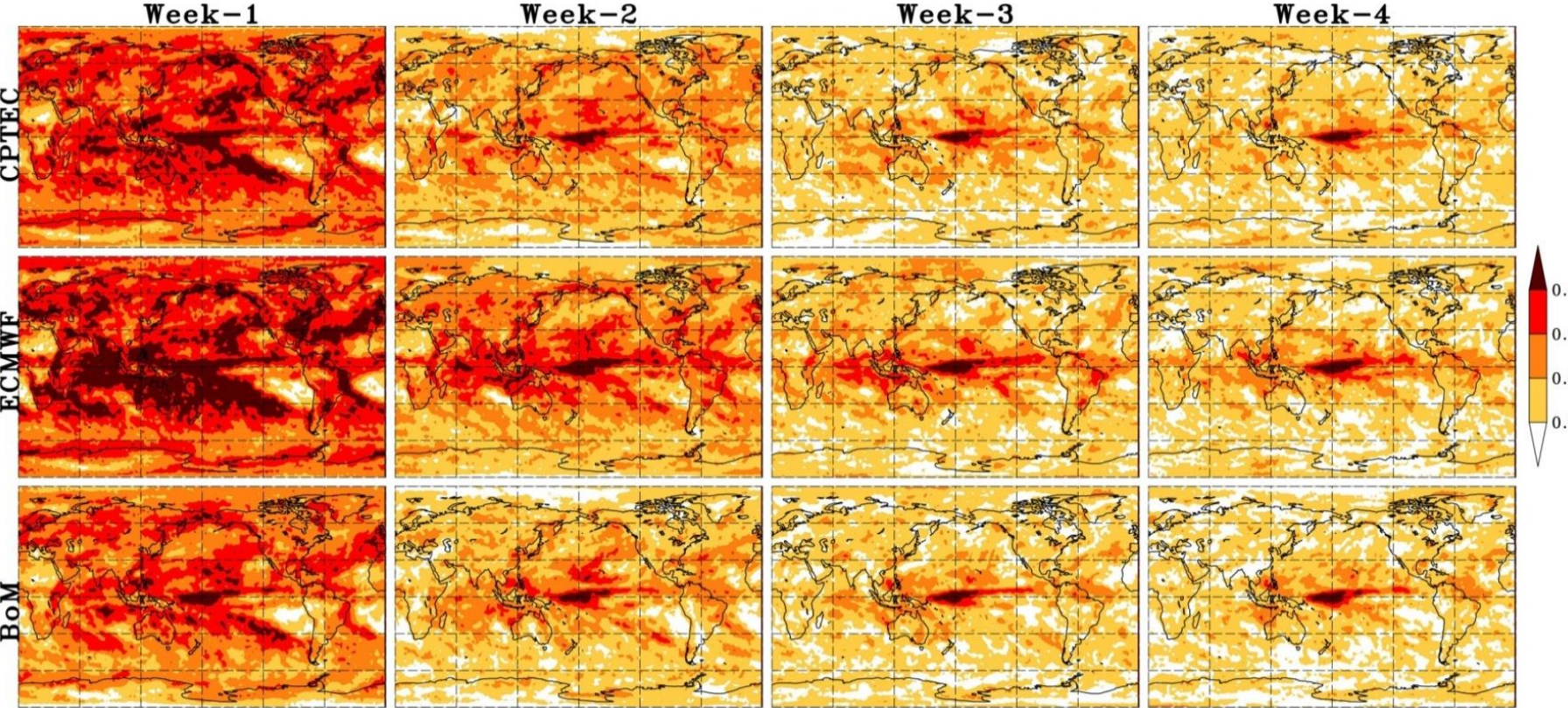

All models with 4 members

- All models show similar correlation patterns

- Corr. high during first week in most regions and drops rapidly as lead time increases

- High corr. in first two lead times (part. at week-1) assoc. to the pred. prov. by the ICs, high corr. in last two lead times over eq. Pac. assoc. to pred. prov. by ENSO and the MJO

- In general, CPTEC corr. values are larger (smaller) than BoM (ECMWF) and broadly comparable to JMA and ECCC models

Global (60°N – 60°S) and South America (0°–30°S, 55°W–35°W) mean corr. and RMSE (mm/day) btw predicted and obs. prec. anoms.
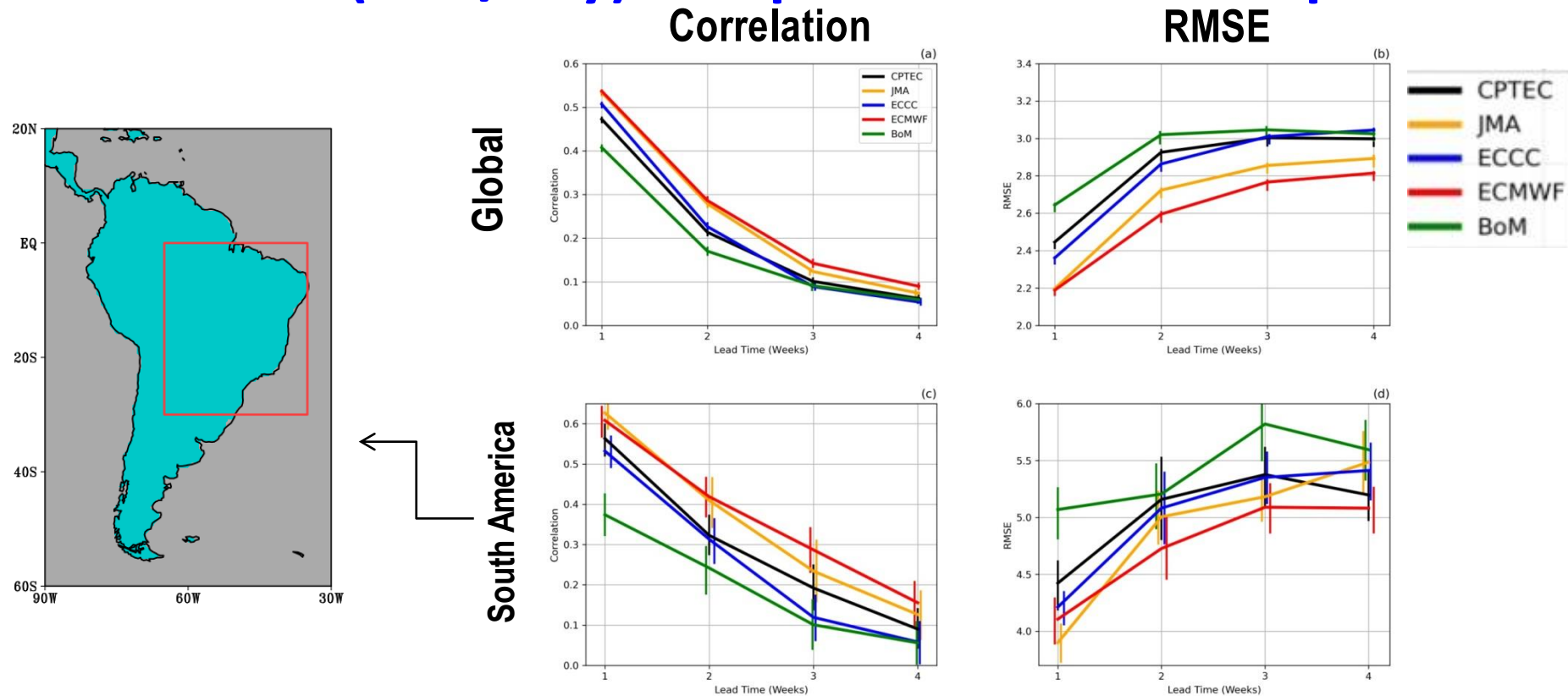

- All models show a similar drop (rise) in corr. (RMSE) as a function of lead time

- ECMWF (red line) shows the best performance followed by JMA (orange line)

- INPE/CPTEC (black line) has similar performance to the other models over global and South America region

- Vertical bar: bootstrap 95% confidence intervals

Area under ROC curve (AROC) for INPE/CPTEC and S2S models: event pos. precip. anom.
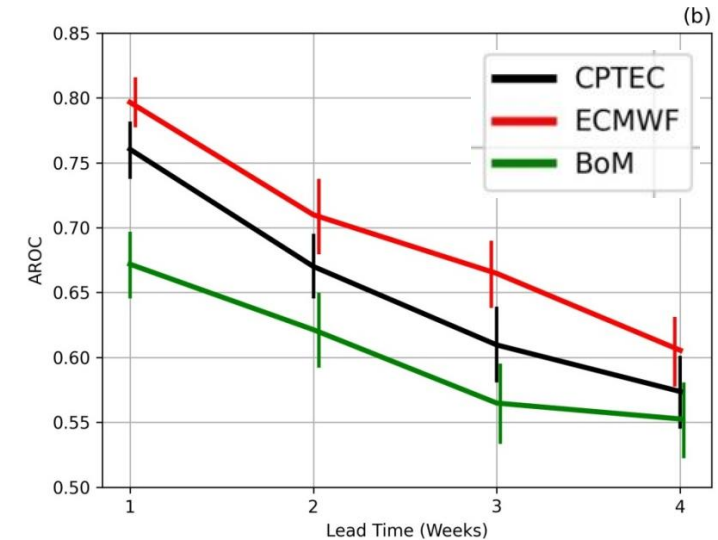
ROC area for South America (0°–30°S, 55°W–35°W) region: mean values for event positive precipitation anomalies

All models with 11 members

- AROC computed for probabilistic predictions for the event positive precipitation anomaly for assessing discrimination ability
- The three models have comparable AROC spatial patterns
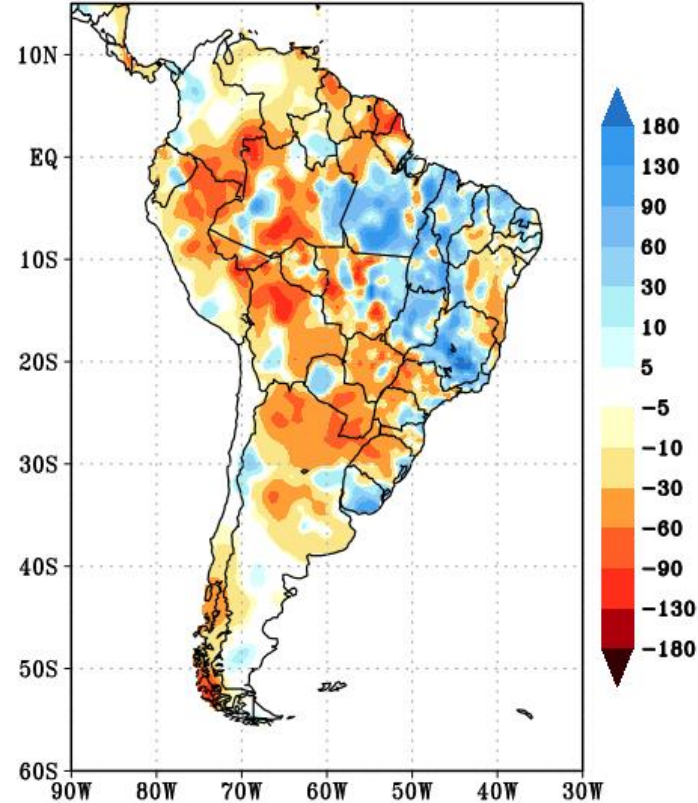- ECMWF ranks as the best model, followed by CPTEC and BoM

Experimental INPE/CPTEC sub-seasonal precipitation prediction for 14 days accumulation (5-18 Jan 2022) issued on 5 Jan
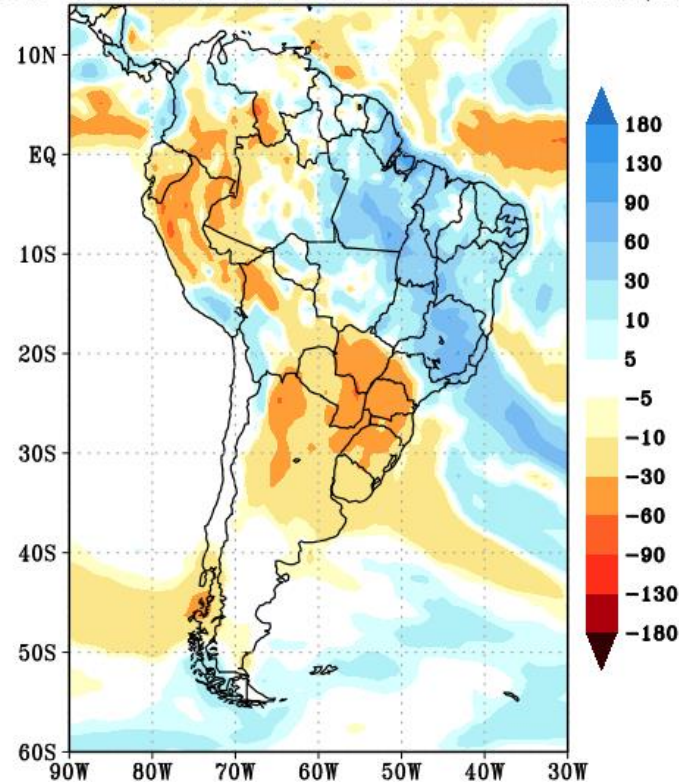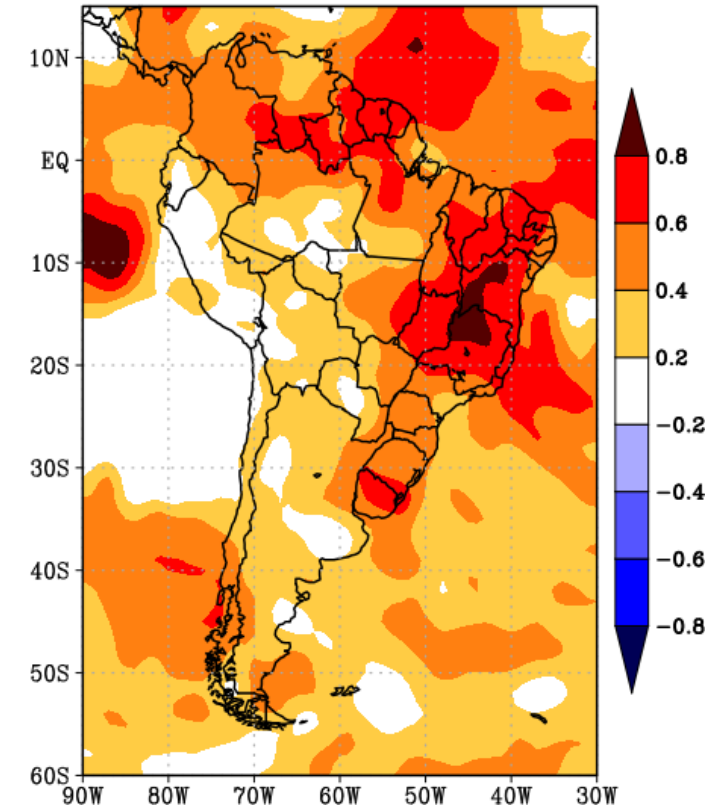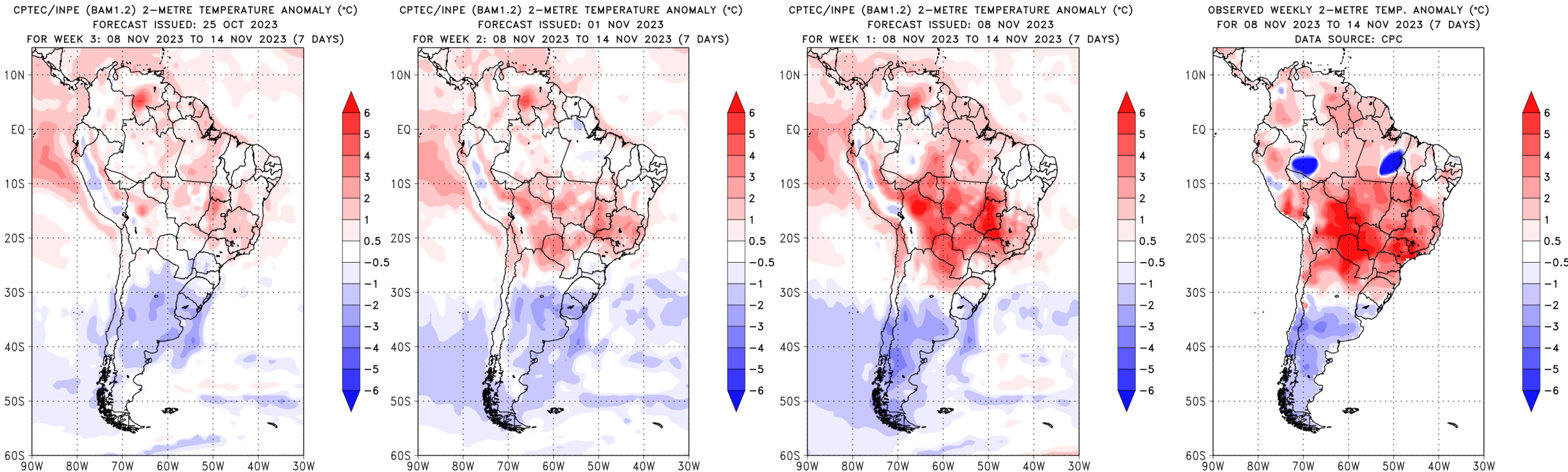

Reasonable performance in representing the observed South Atlantic Convergece Zone and precipitation anomalies over northern northeast and south Brazil

Real time INPE/CPTEC sub-seasonal temperature prediction for 7 day means (8-14 Nov 2023)

CPTEC/INPE (BAM1.2) 2-METRE TEMPERATURE ANOMALY (°C)
FORECAST ISSUED: 25 OCT 2023
FOR WEEK 3: 08 NOV 2023 TO 14 NOV 2023 (7 DAYS)

CPTEC/INPE (BAM1.2) 2-METRE TEMPERATURE ANOMALY (°C)
FORECAST ISSUED: 01 NOV 2023
FOR WEEK 2: 08 NOV 2023 TO 14 NOV 2023 (7 DAYS)

CPTEC/INPE (BAM1.2) 2-METRE TEMPERATURE ANOMALY (°C)
FORECAST ISSUED: 08 NOV 2023
FOR WEEK 1: 08 NOV 2023 TO 14 NOV 2023 (7 DAYS)

OBSERVED WEEKLY 2-METRE TEMP. ANOMALY (°C)
FOR 08 NOV 2023 TO 14 NOV 2023 (7 DAYS)
DATA SOURCE: CPC

Reasonable performance in predicting temperature anomalies over Argentina and central Brazil during a recent heatwave event

New CPTEC/INPE sub-seasonal prediction web portal

New CPTEC/INPE sub-seasonal prediction products

PREVISÃO SUBSAZONAL

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

http://subsazonal.cptec.inpe.br

Home Tempo Clima Previsão Numérica Satélite Ondas Dados Observacionais Instrumentação Bacias Qualidade do Ar Pós Graduação Português English

| Forecasts | Comparison | Verification | Downloads | Documentation | BAM-1.2 - CPTEC/INPE |

Regions: South America

Variables: Precipitation

Precipitation
Calibrated Precipitation
2 Metre Temperature
Calibrated 2 Metre Temperature
Sea Level Pressure
Outgoing Longwave Radiation
Temperature at 850 hPa
Geopotential Height at 500 hPa
Zonal Wind at 850 hPa
Zonal Wind at 200 hPa
Meridional Wind at 850 hPa
Meridional Wind at 200 hPa
Circulation at 850 hPa
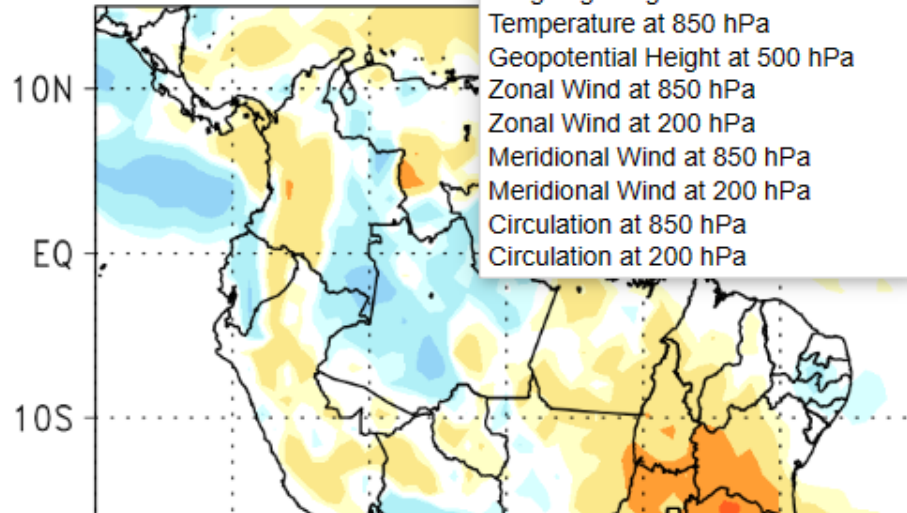Circulation at 200 hPa

Map Type: Anomaly

Time range: 7 days

Date Issued: Mont Year 2023-11-22

CPTEC/INPE (BAM1.2) ... (mm)
FORECAST IS...
FOR WEEK 1: 22 NOV ... DAYS)

CPTEC/INPE (BAM1.2) PRECIPITATION ANOMALY (mm)
FORECAST ISSUED: 22 NOV 2023
FOR WEEK 2: 29 NOV 2023 TO 05 DEC 2023 (7 DAYS)
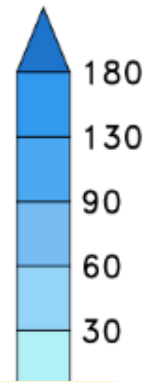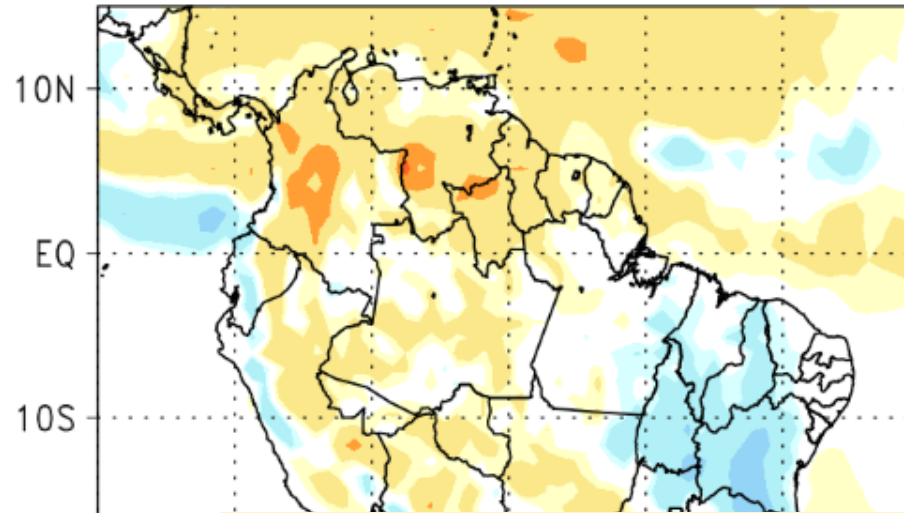
Forecasts issued Every Wednesday for weeks 1 to 4, fortnights 1 and 2, 21 and 30 days
Verification products produced using hindcasts over the 1999-2018 period (20 Years)

Calibrated predictions based on linear regression of ensemble mean forecasts on observed precipitation

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| Forecasts | Comparison | Verification | Downloads | Documentation | BAM-1.2 - CPTEC/INPE |

Regions: South America

Variables: Precipitation

Map Type: Anomaly

Time range: 7 days

Date Issued: Mont | Year | 2023-11-15

CPTEC/INPE (BAM1.2) PRECIPITATION ANOMALY (mm)
FORECAST ISSUED: 15 NOV 2023
FOR WEEK 1: 15 NOV 2023 TO 21 NOV 2023 (7 DAYS)
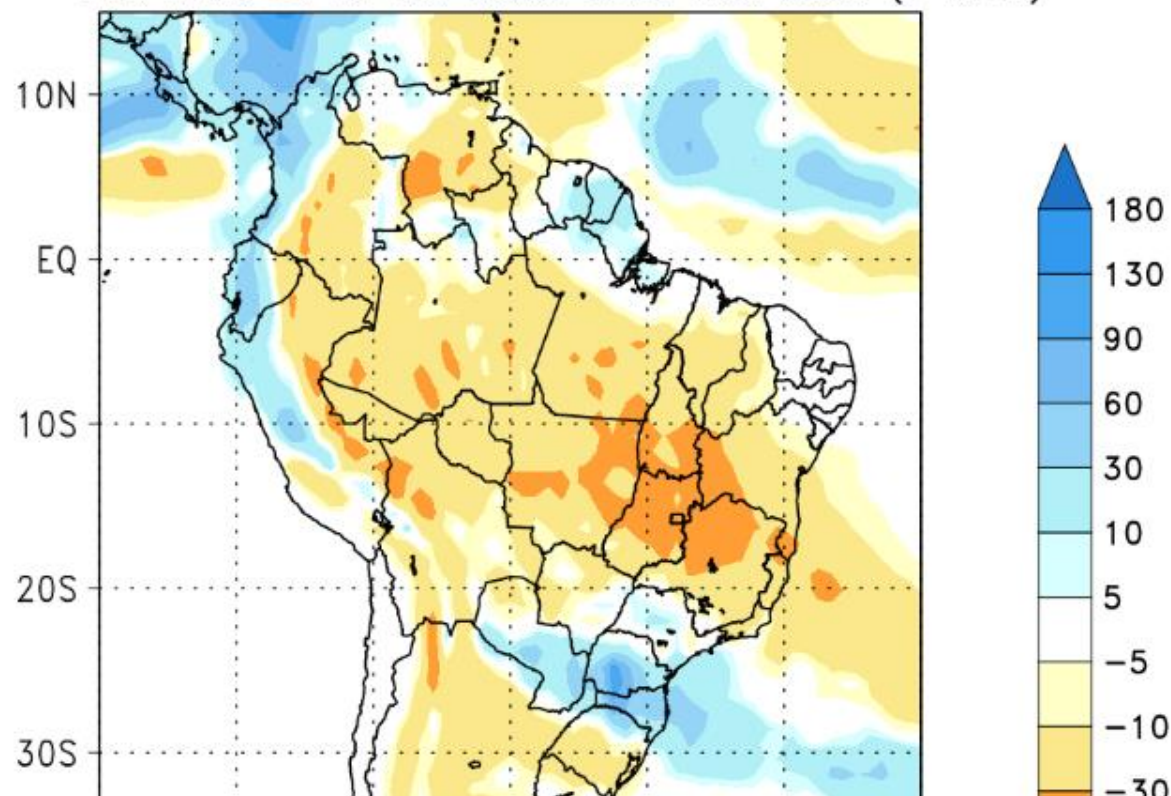
OBSERVED WEEKLY PRECIPITATION ANOMALY (mm)
FOR 15 NOV 2023 TO 21 NOV 2023 (7 DAYS)
DATA SOURCE: CPC

New sub-seasonal verification products

Forecasts issued Every Wednesday for weeks 1 to 4, fortnights 1 and 2, 21 and 30 days Verification products produced using hindcasts over the 1999-2018 period (20 Years)

Calibrated predictions based on linear regression of ensemble mean forecasts on observed precipitation

Development and implementation of a multi-model ensemble sub-seasonal precipitation prediction system for Brazil

Join effort between INPE/CPTEC and FUNCEME

Northest Brazil

Ceará State

Main features of used global models

Model	Hincast period	Number of ensemble members (hindcasts/realtime predictions)	Prediction length	Initialization	Characteristics
CPTEC/INPE BAM1.2	1999-2016	11/11	35 days	Every Wednesday	Atmosphere and land components, prescribed sea surface temperature
NCEP/EMC GEFSv12 (SubX)	1999-2016	11/31	35 days	Every Wednesday	Atmosphere and land components, prescribed sea surface temperature
NOAA/ESRL FIM (SubX)	1999-2016	4/4	32 days	Every Wednesday	Coupled ocean-atmosphere-land-sea ice components
NCEP CFSv2 (SubX)	1999-2016	4/4	44 days	Every Day	Coupled ocean-atmosphere-land-sea ice components

The three selected Subseasonal prediction Experiment Project (SubX) models and BAM1.2 produce real time predictions allowing the generation of operational multi-model ensemble predictions

INPE/CPTEC and FUNCEME multi-model ensemble sub-seasonal precipitation predictions

PREVISÃO SUBSAZONAL Multimodelo

Previsão | Verificação

MODELOS:
Multimodelo

PRODUTOS:
○ Precipitação
● Probabilidade

REGIÃO:
América do Sul

ANO DE PREVISÃO:
2023

DATA DE INICIALIZAÇÃO:
2023-06-28

PERÍODO DE PREVISÃO:
14 dias

← →

PREVISÃO SUBSAZONAL - MULTIMODELO CALIBRADO
PROB (%) CHUVA ACIMA DA MÉDIA - Início: 28/06/2023
28/06/2023 - 11/07/2023 (14 dias)
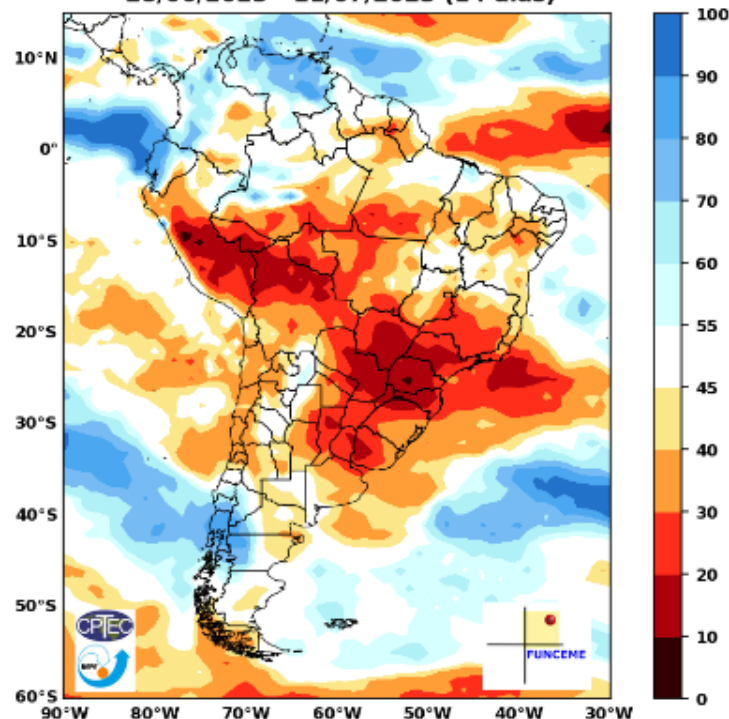
Modelos: BAM-1.2/CPTEC, CFSv2/NCEP, GEFSv12/NCEP, ESRL/NOAA (Fonte: SubX e CPTEC/INPE)

Products for the following regions:
Global, South America,
Northeast Brazil and Ceará State

Models:
BAM-1.2 (INPE/CPTEC)
CFSv2 (NCEP) [SubX]
GEFSv12 (NCEP) [SubX]
FIM (ESRL/NOAA) [SubX]

Calibrated preditions based on linear regression of the multi-model ensemble mean of the 4 models on GPCP observed precipitation

Forecast and verification products for:
Weeks 1 to 4
Fortnigh 1 and 2
30 and 44 days

Calibration and verification performed using 18 years of hindcasts (1999-2016)

http://www.funceme.br/dashboard/subsaz_forecast

Example of calibrated multi-model ensemble precipitation prediction product developed for Ceará

Accumulated precipitation
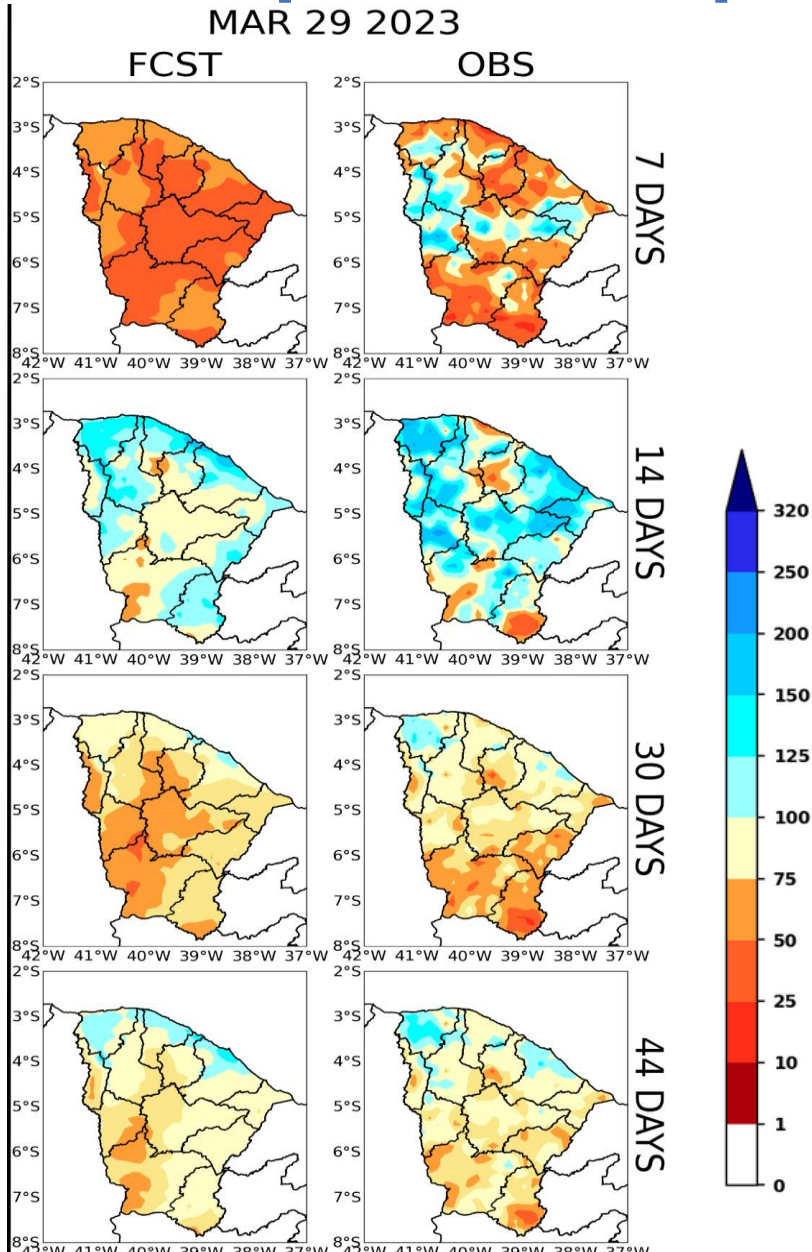
Precipitation anomalies
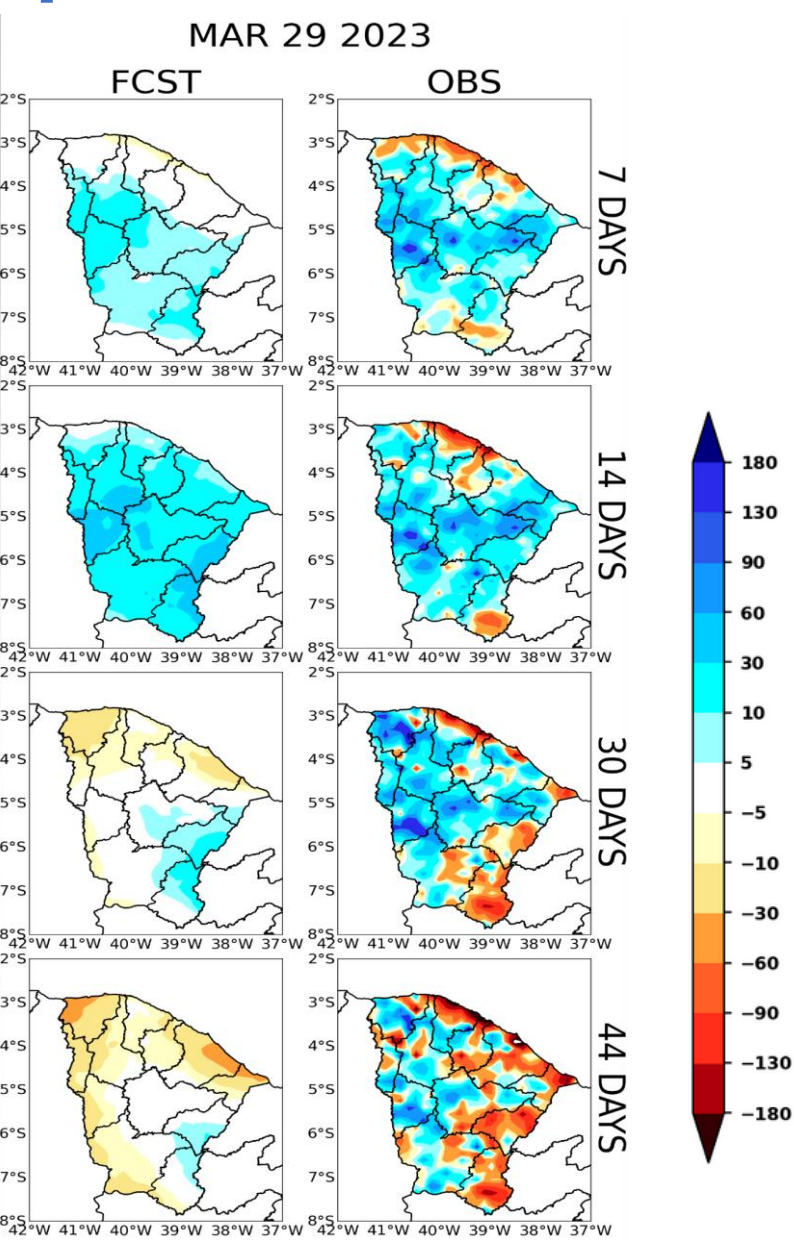
Assessing the benefit of multi-model ensemble calibrated predictions compared to individual models calibrated predictions for Ceará:

Brier Skill Score (BSS) wrt to climatology for the event positive precipitation anomaly
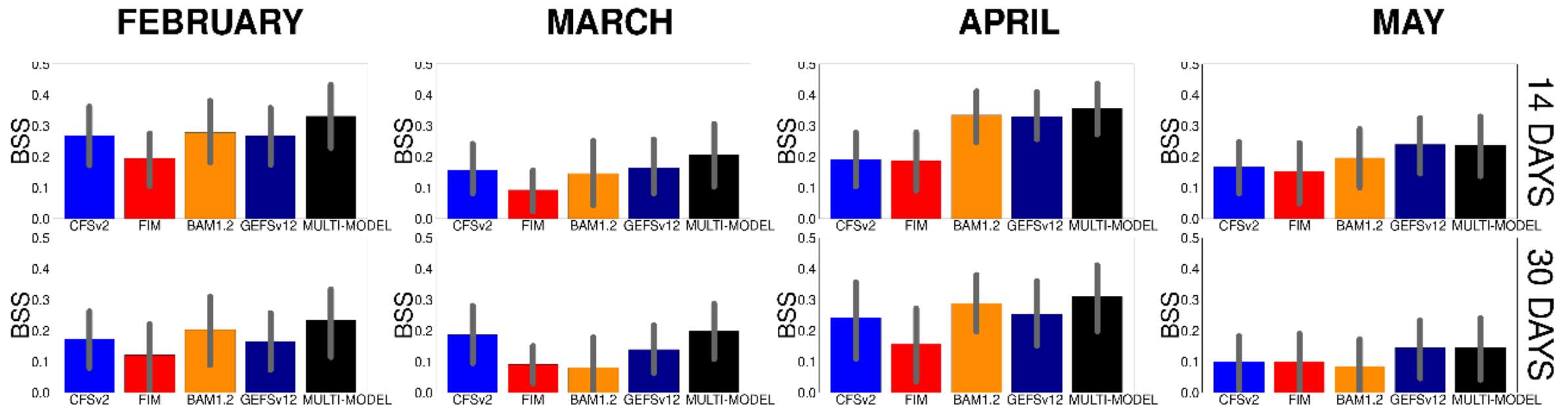
Example of product developed for South America

Calibrated multi-model ensemble prediction:
Probability of positive precipitation anomaly
for the period 15 to 28 March 2023, issued on 15 March
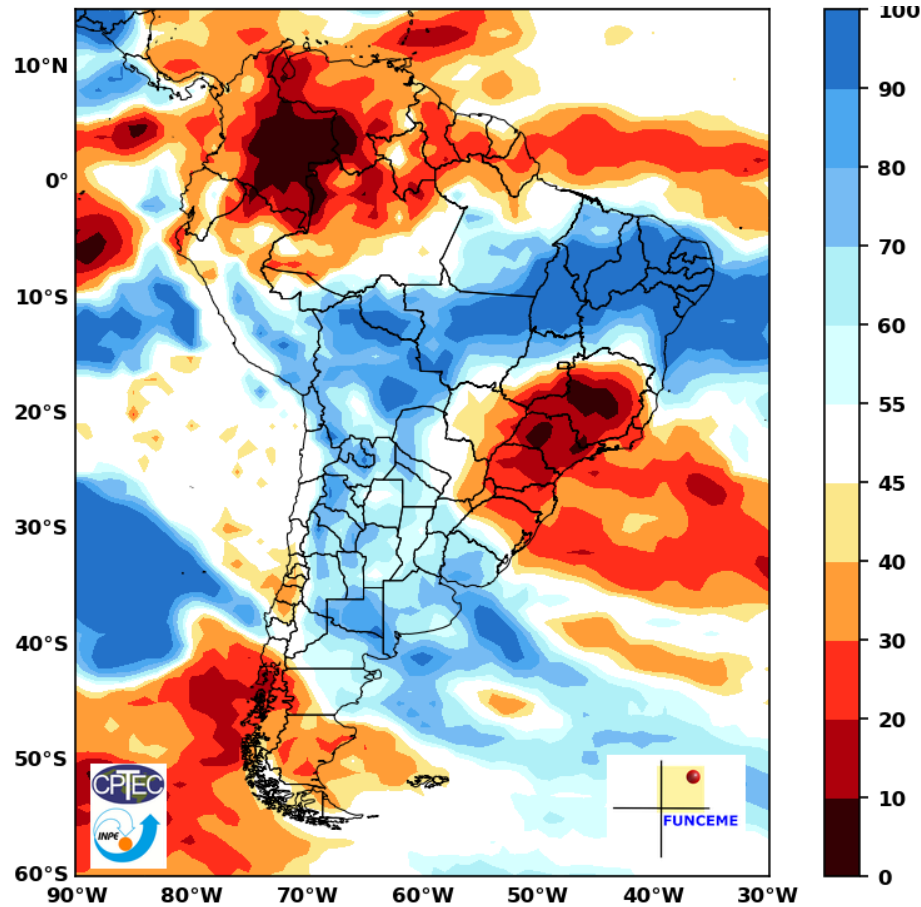
Modelos: BAM-1.2/CPTEC, CFSv2/NCEP, GEFSv12/NCEP, ESRL/NOAA (Fonte: SubX e CPTEC/INPE)

OBSERVED FORTNIGHTLY PRECIPITATION ANOMALY
FOR 15 MAR 2023 TO 28 MAR 2023 (14 DAYS)
DATA SOURCE: CPC
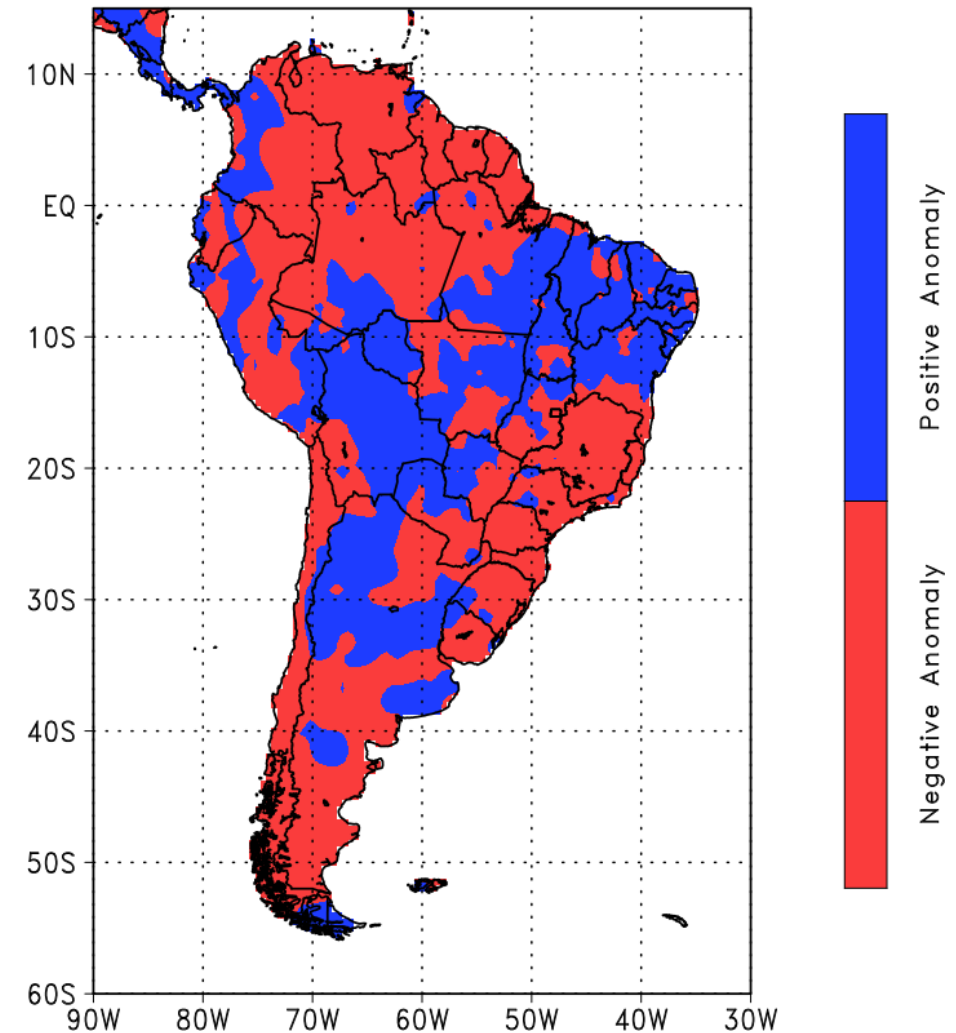
Additional Global and regional prediction and verification products available at http://www.funceme.br/dashboard/subsaz_forecast

Boletim
de monitoramento climático de grandes bacias hidrográficas

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Bacia Amazônica

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Ano III, Volume 11, Número 3

Manaus, 15 de novembro de 2023

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Previsão multi-modelo subsazonal CPTEC/INPE-FUNCEME produzida em 14/11/2023 para os próximos 7 e 14 dias.

A previsão multi-modelo subsazonal calibrada CPTEC/INPE-FUNCEME é gerada através de cooperação científica entre o CPTEC/INPE e a FUNCEME, sendo proveniente do conjunto de 4 modelos globais (um modelo brasileiro, o BAM-1.2/CPTEC, e três modelos dos EUA, CFSv2/NCEP, GEFSv12/NCEP e ESRL/NOAA, estes três últimos do projeto SubX). As anomalias de precipitação previstas são determinadas em relação ao período climatológico de 1999 a 2016. A seguir são apresentadas as saídas para o intervalo de previsão de 07 e 14 dias detalhando o comportamento previsto sobre as bacias de interesse.

PREVISÃO SUBSAZONAL—MULTIMODELO CALIBRADO
Anomalia (mm) de Precipitação Acumulada
(07 Dias) Período: 15/11/2023 – 21/11/2023
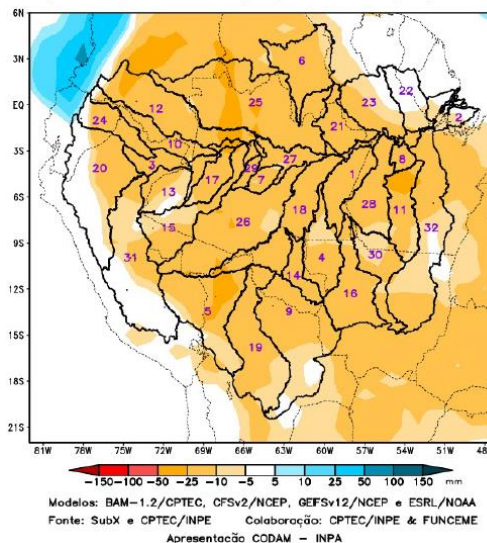
1	Abacaxis
2	Amazonas (BR)
3	Amazonas (PE)
4	Aripuanã
5	Beni
6	Branco
7	Coari
8	Curuá Una
9	Guaporé
10	Içá
11	Iriri
12	Japurá
13	Javari
14	Ji-Paraná
15	Juruá
16	Juruena
17	Jutaí
18	Madeira
19	Mamoré
20	Marañon
21	Marg Esq (AM)
22	Marg Esq (PA) NE
23	Marg Esq (PA) NW
24	Napo
25	Negro
26	Purus
27	Solimões
28	Tapajós
29	Tefé
30	Teles Pires
31	Ucayali
32	Xingu

Modelos: BAM-1.2/CPTEC, CFSv2/NCEP, GEFSv12/NCEP e ESRL/NOAA
Fonte: SubX e CPTEC/INPE   Colaboração: CPTEC/INPE & FUNCEME
Apresentação CODAM – INPA

PREVISÃO SUBSAZONAL—MULTIMODELO CALIBRADO
Anomalia (mm) de Precipitação Acumulada
(14 Dias) Período: 15/11/2023 – 28/11/2023
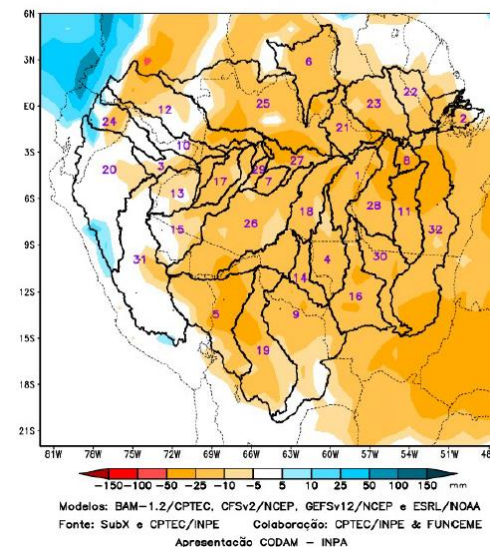
1	Abacaxis
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9	Guaporé
10	Içá
11	Iriri
12	Japurá
13	Javari
14	Ji-Paraná
15	Juruá
16	Juruena
17	Jutaí
18	Madeira
19	Mamoré
20	Marañon
21	Marg Esq (AM)
22	Marg Esq (PA) NE
23	Marg Esq (PA) NW
24	Napo
25	Negro
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Modelos: BAM-1.2/CPTEC, CFSv2/NCEP, GEFSv12/NCEP e ESRL/NOAA
Fonte: SubX e CPTEC/INPE   Colaboração: CPTEC/INPE & FUNCEME
Apresentação CODAM – INPA

Final remarks

- **Stimulated by WMO WWRP/WCRP S2S project: Successfully implemented global numerical sub-seasonal predictions in Brazil (produced every Wednesday)**

- **Brazilian sub-seasonal prediction system performance is broadly comparable to other S2S systems: Plenty of room for improvements**

- **Implemented a multi-model sub-seasonal precipitation prediction system for producing routinely global, regional and local (for Ceará State) predictions**

- **The produced predictions are being disseminated in national level bulletins and briefings for the federal government in Brazil, used to help guide planning water management and agricultural activities in Ceará State, and are also being disseminated in the Amazon basin weekly bulletins**

Thank you for your attention

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