



# From subseasonal to seasonal forecasts over South America using the Eta Model

**Sin-Chan Chou, Nicole Resende, Maria Luiza da Rocha, Claudine P. Dereczynski, Jorge L. Gomes, and Gustavo Sueiro**

## Team:

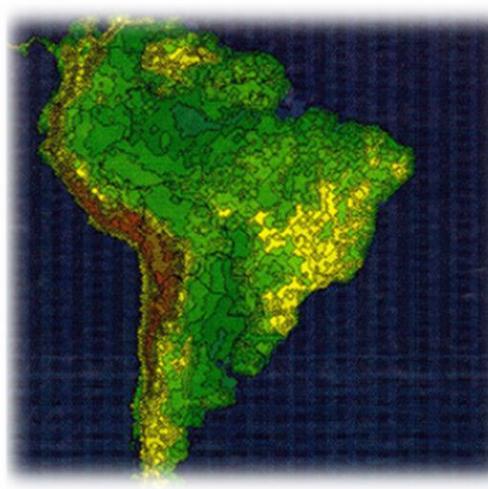
**PosDocs:** André Lyra, Isabel Pilotto, Thiago Lucci, Vinicius Mateus, Priscila Tavares, Nicole Resende, Dragan Latinovic, Daniela Carneiro

**Assistants:** Gustavo Sueiro, Luís Felipe Alves, Diego Chagas, Gracielle Siqueira, Elisa Giornes, Wellington Jr

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**Apoio:** Marcele Dourado



# INPE Eta Model characteristics

Operations started in dec 1996

- **Resolution:** 40km, 15km, 5km, 1km;
- **Grid-point model**
  - Arakawa E grid and Lorenz grid
- Vertical coordinate: **Cut-cell eta vertical coordinate**  
(Mesinger, 1984; Mesinger et al, 2012)
- **Prognostic variables:** T, q, u, v,  $p_s$ , TKE, cloud water/ice, hydrometeors
- **Time integration:**
  - 2 level, split-explicit
- **Adjustmet:** forward-backward
- **Horiz. Advection:** first forward and then centered
- **Vert Advection:** Piecewise Linear Scheme
  - > **finite volume model**
- **USGS '90m-** original topography resolution

## • Convection:

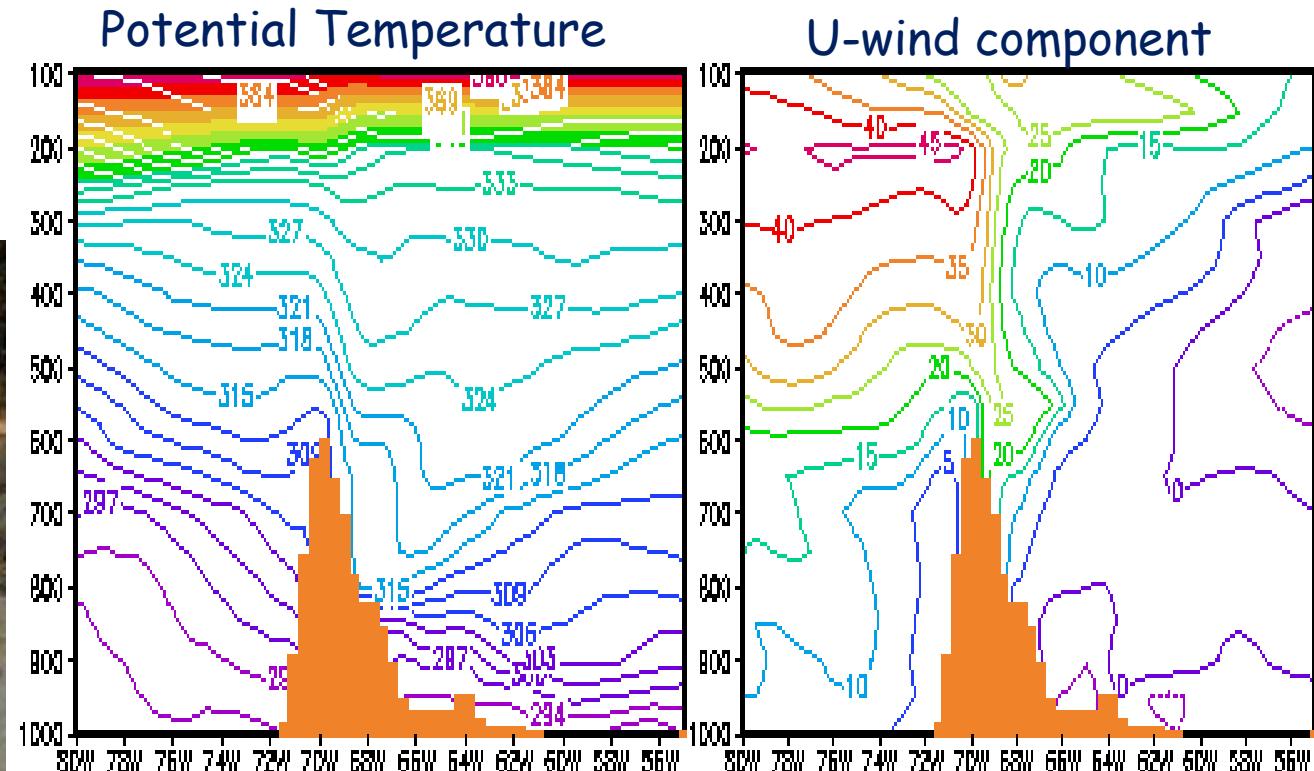
1. Betts-Miller-Janjic scheme,
  2. Kain-Fritsch + Mom Flux,  
**Precip partition parameter**
- **Microphysics rain:** 1. Ferrier scheme  
2. Zhao scheme
  - **Turbulence:** Mellor Yamada 2.5, MO surface layer, Paulson Functions/ BH fcs
  - **Radiation:** GFDL package/ RRTM
  - **Land surface scheme:**
    - NOAH, -**MP schemes, 4 soil layers**
  - **Initial conditions**
    - NCEP, **analyses**
  - **L.B.C. :** CPTEC GCM, Reanalyses
  - **Initial soil moisture :** monthly climatology
  - **Initial albedo:** seasonal climatology
  - **SST** 0.25x0.25 degree lat/lon
  - **Changes in calculations of Ps, fluxes over ocean, 10-m winds.**

# Why CPTEC adopted Eta model?

Andes Cordillera  
steep mountains in Chile



Los caracoles



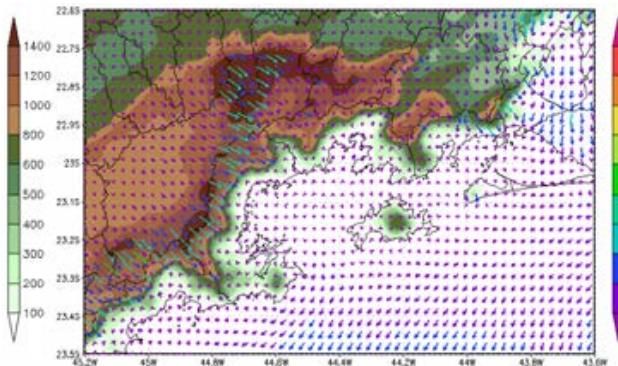
1. Figueroa (1992) developed an atmospheric model and showed that the summer circulation over South America was better described using the eta coordinate.

2. Computational efficient.

Zonda Wind  
(foëن wind)  
**30°S**

# Eta Model Portfolio at CPTEC: SHORT-RANGE forecasts

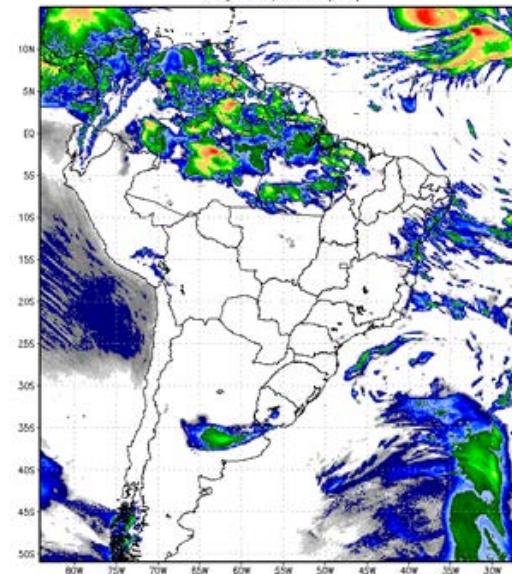
1 km



10-m winds

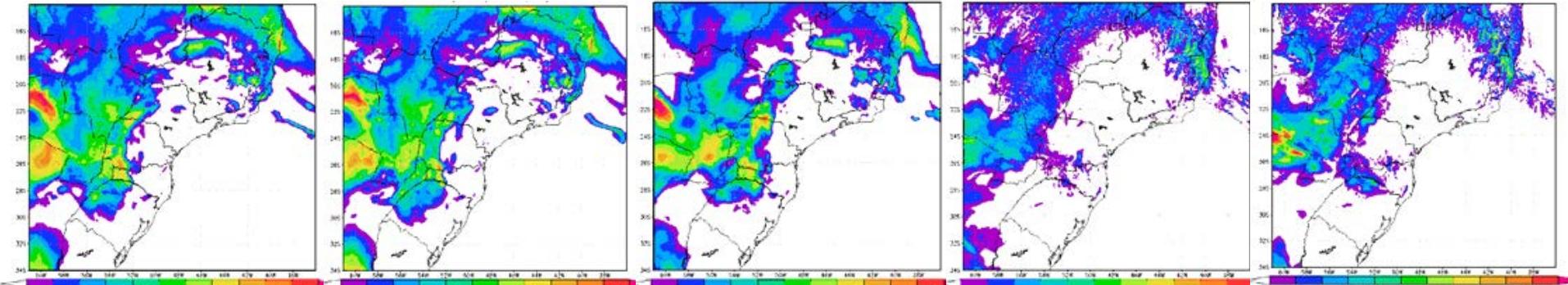
1-km NPP  
5-km Continental  
5-km ensemble

5 km



5 km

5-member ensemble, precipitation production schemes



BMJ\_Ferrier\_C

BMJ\_Zhao

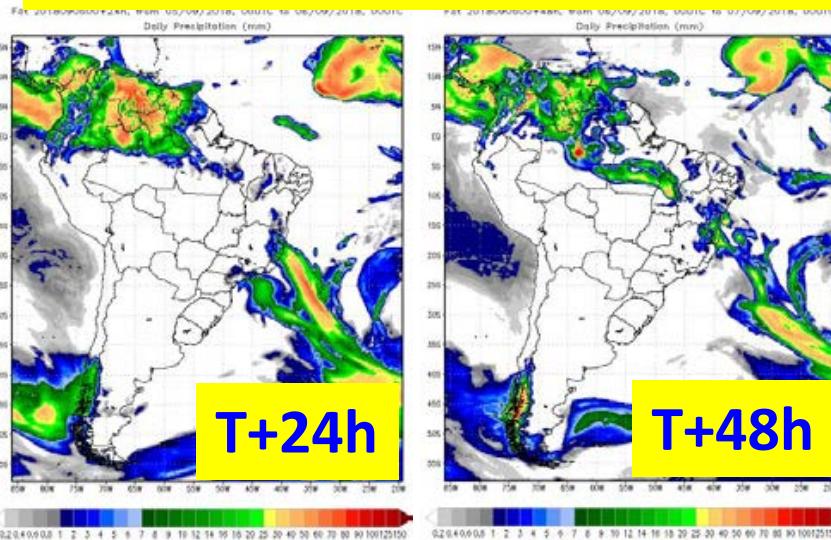
BMJ\_Ferrier\_G

KF\_G

KF\_M\_G

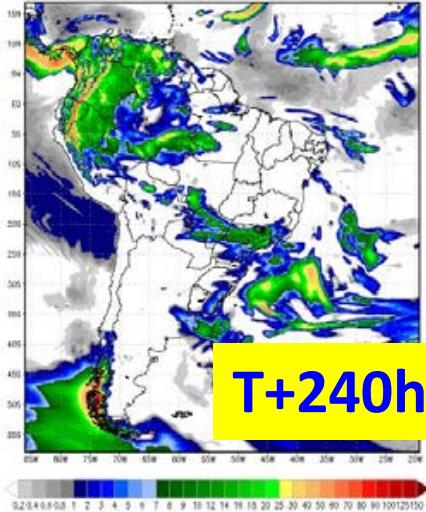
# Eta Model Portfolio at CPTEC: MEDIUM-RANGE forecasts

**15-km, 1 member, 10-day forecast**

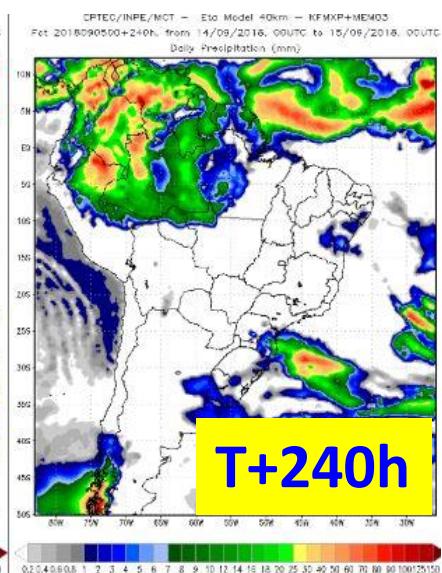
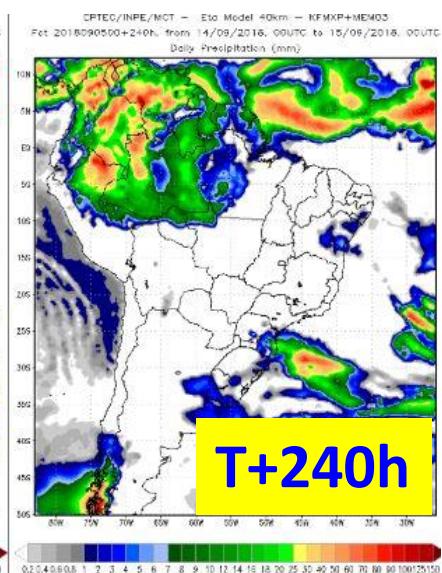
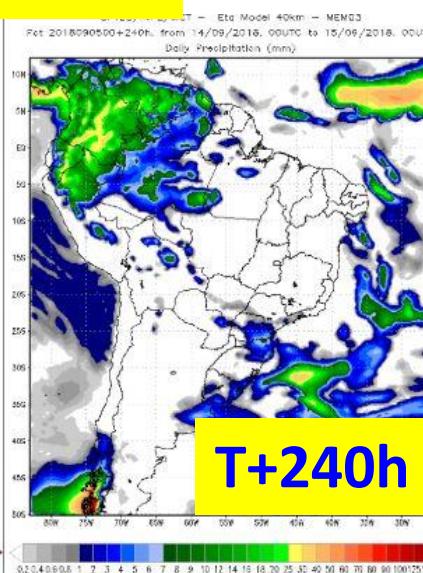
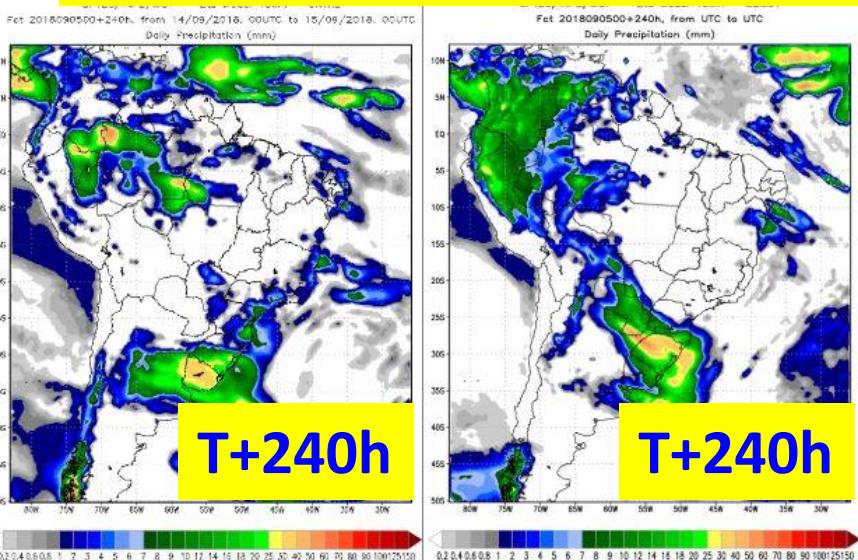


CPTEC/INPE/MCT - Eta Model 15km - CFS  
Fet 2018090500+240h, from 14/09/2018, 00UTC to 15/09/2018, 00UTC  
Daily Precipitation (mm)

• • •



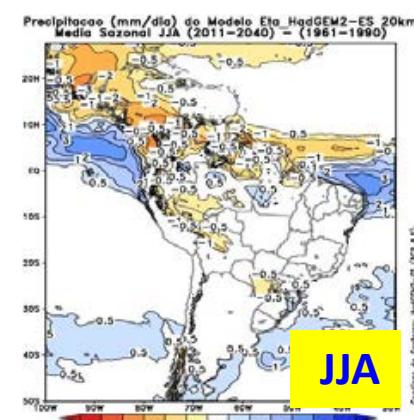
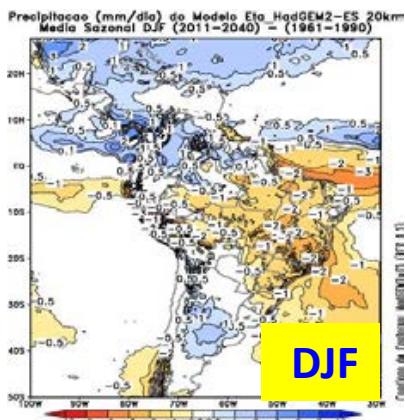
**40-km, 7 members, 10-day forecast**



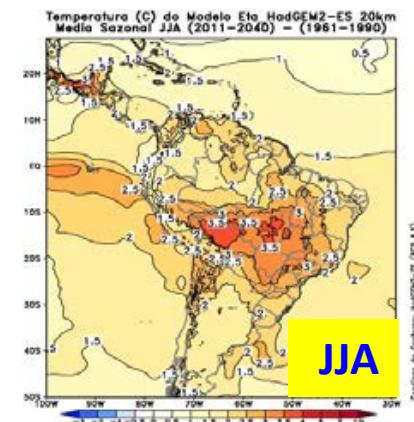
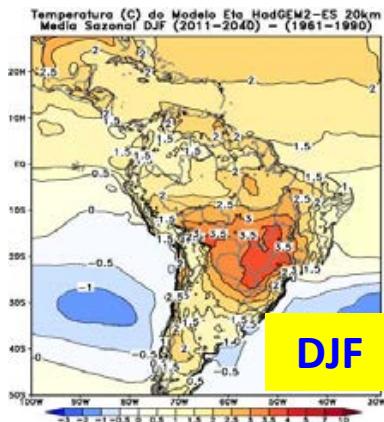
# Eta Model Portfolio at CPTEC: Climate Change Projections

## Downscaling at 20-km and 5-km over South America and Central America Supported Brazilian National Communication to UNFCCC

Mean seasonal change in **precipitation** (mm/day),  
between 2011-2040 and 1961-1990



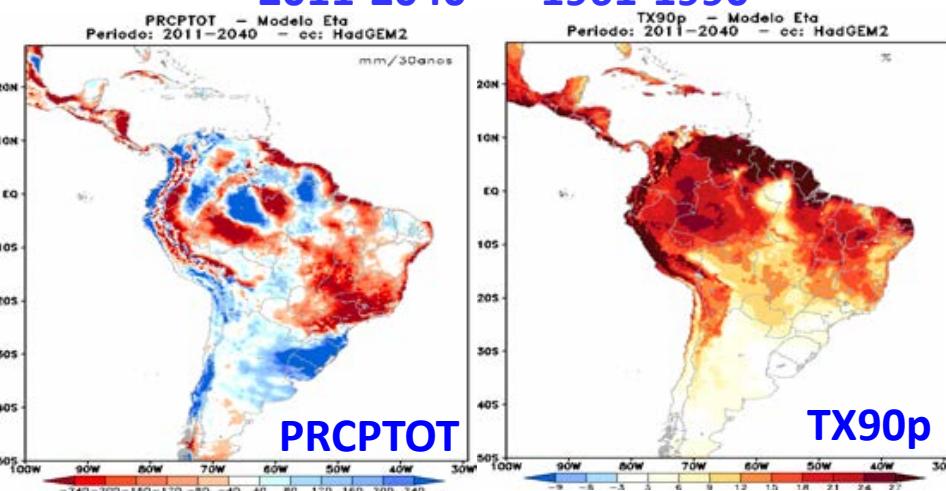
Mean seasonal change in **temperature** (oC),  
between 2011-2040 and 1961-1990



**20km**

**Eta/HadGEM2-ES – RCP 8.5**

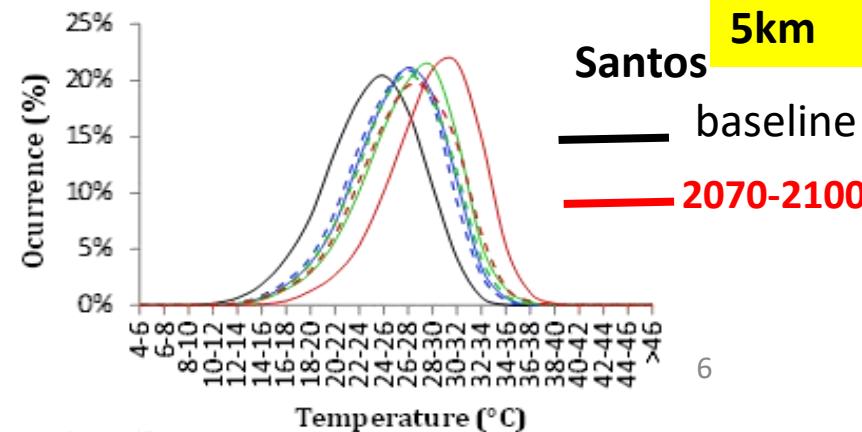
**Tendência de extremos  
2011-2040 -- 1961-1990**



**PRCPTOT**

**TX90p**

**Santos** **5km**

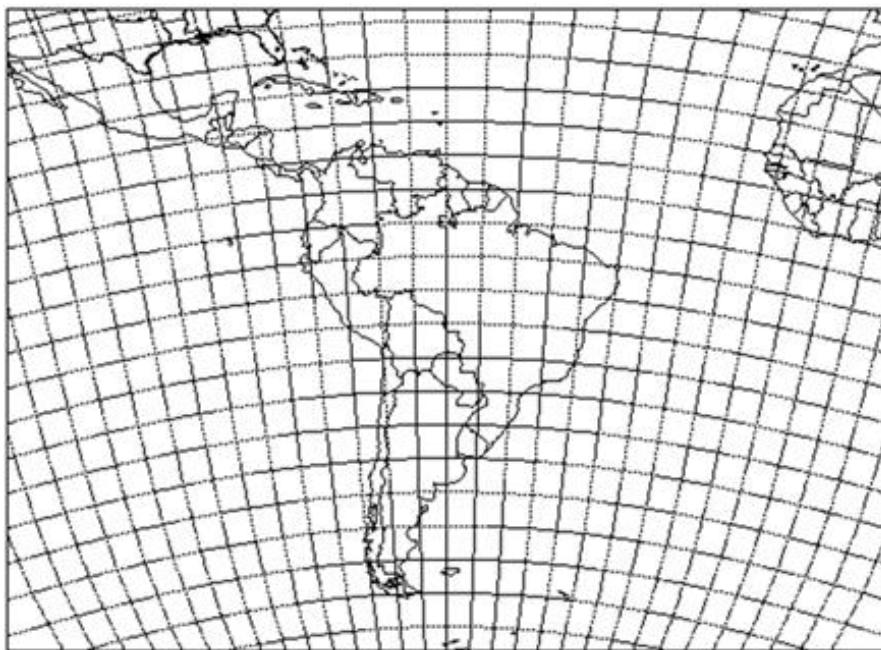


# OBJECTIVE

To evaluate the Eta model forecast skill at  
**seasonal** and **sub-seasonal** ranges over  
South America.

# Seasonal Forecasts

Eta-40km



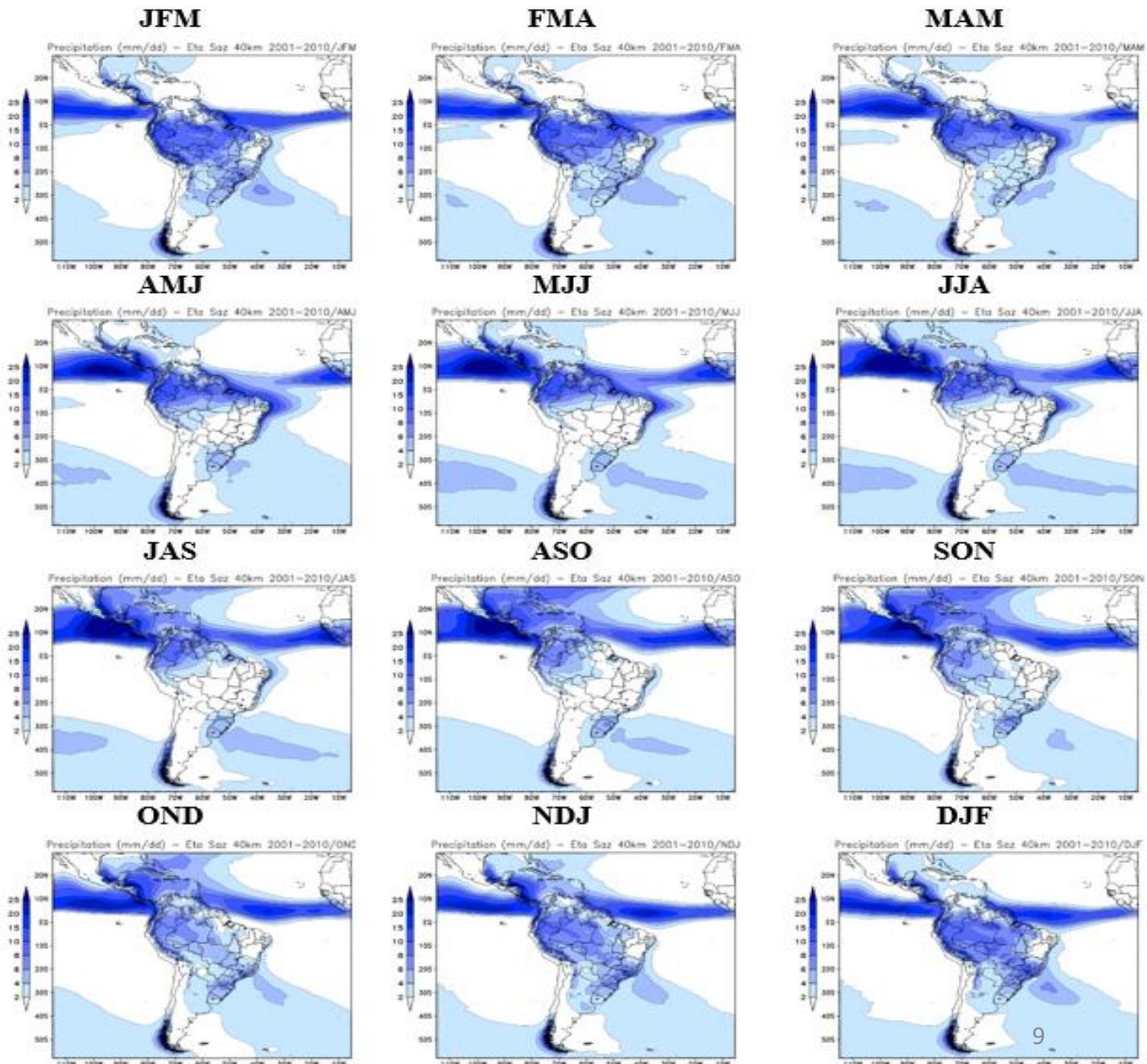
**10-year, 5-member RE-FORECASTS  
40-km resolution,  
driven by CPTEC AGCM T62L28  
Persisted SST anomaly  
Large Domain**

**4.5-month integrations**

## PRECIPITATION mm/day

# Precipitation Mean seasonal forecasts

12 months x  
5 members x  
10 year =  
600 runs

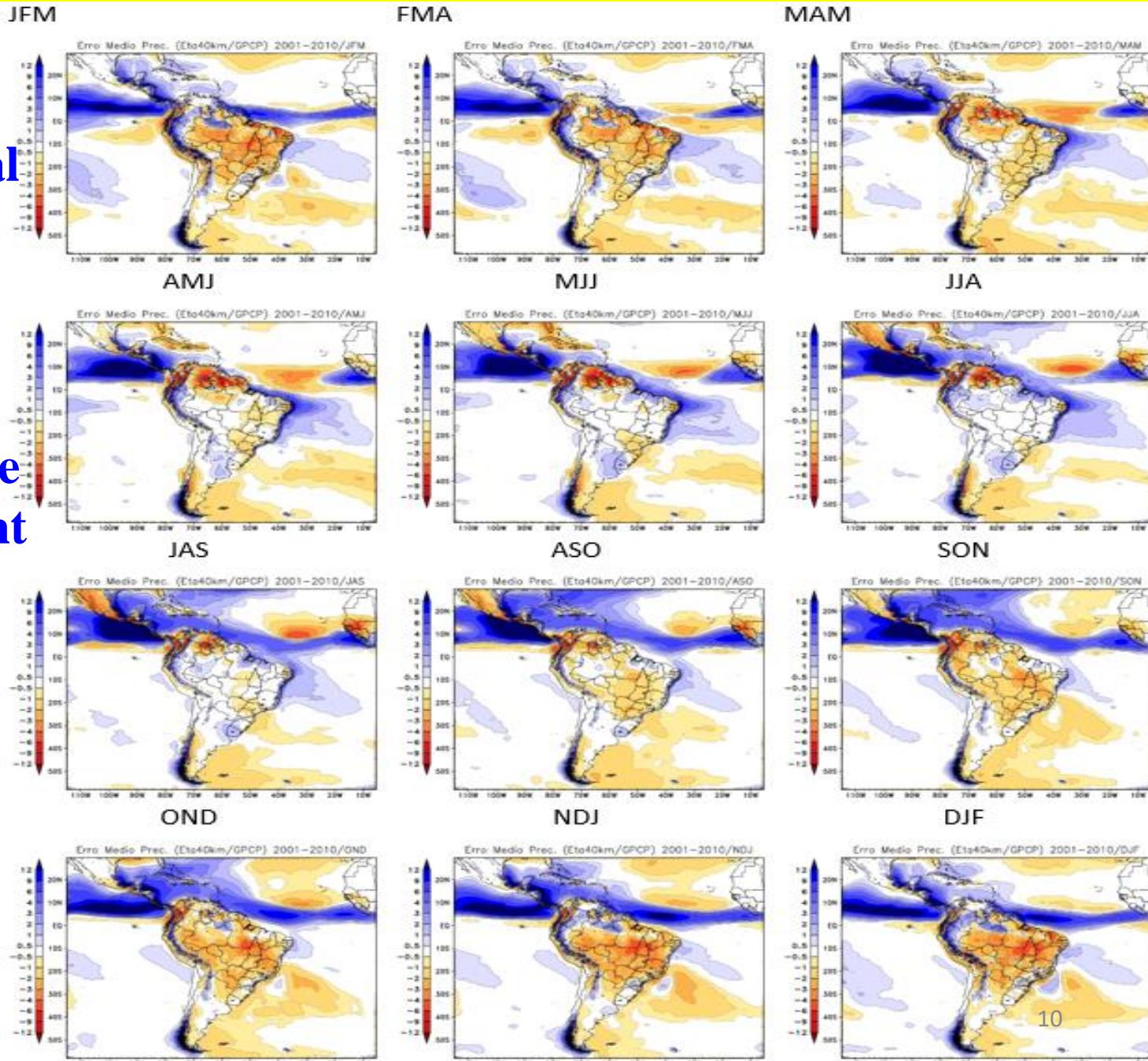


# PRECIPITATION ERRORS

## Precipitation Mean seasonal forecast Errors

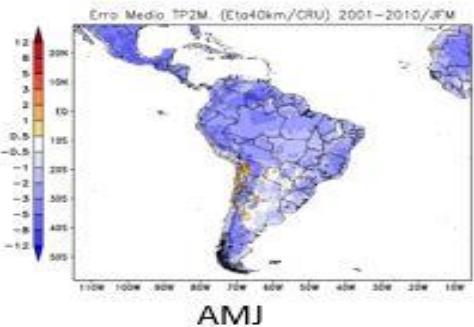
Underestimate  
Over continent

Overestimate  
over ITCZ

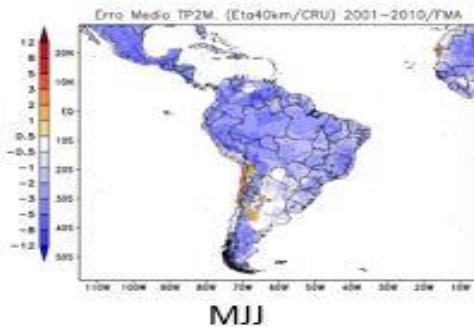


# TEMPERATURE ERRORS

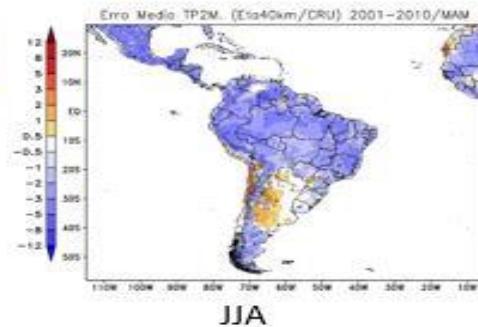
JFM



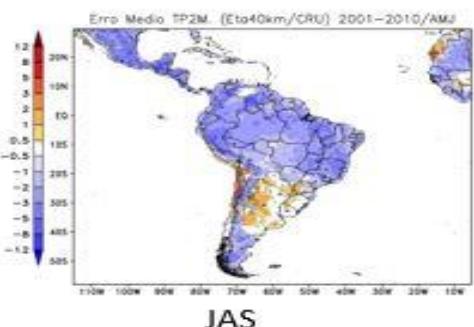
FMA



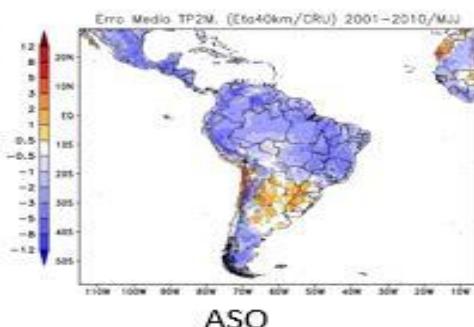
MAM



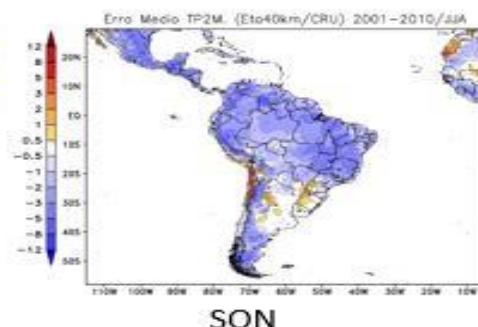
AMJ



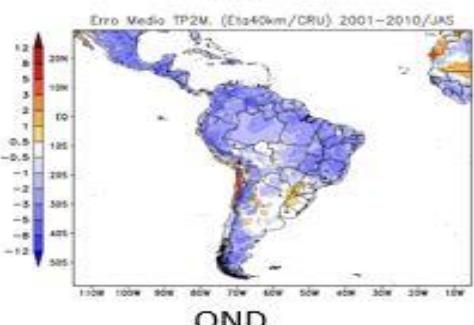
MJJ



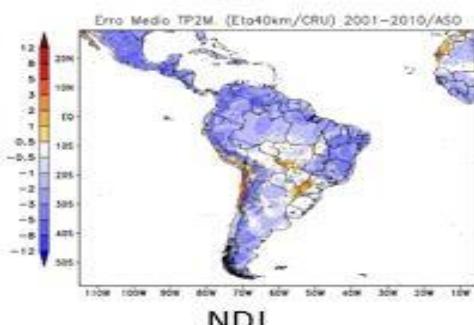
JJA



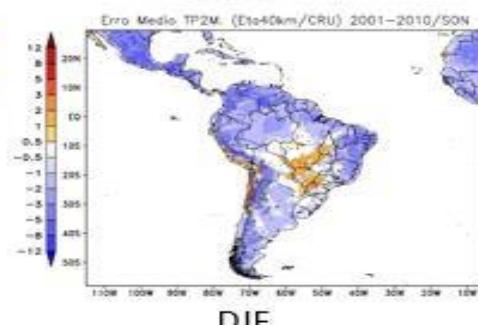
JAS



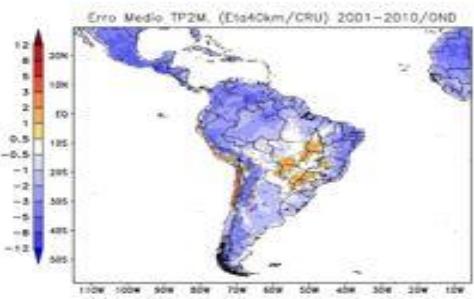
ASO



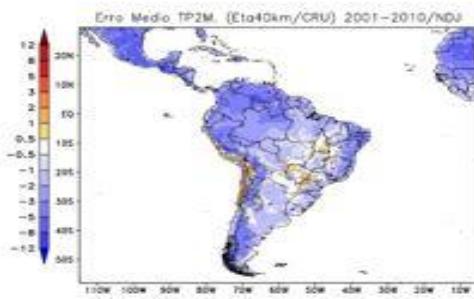
SON



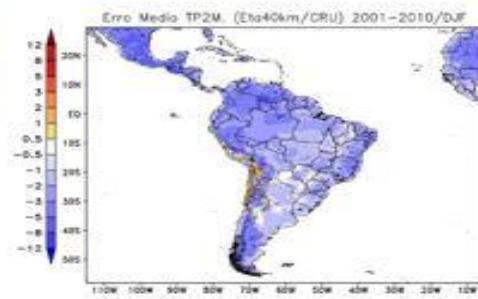
OND



NDJ



DJF



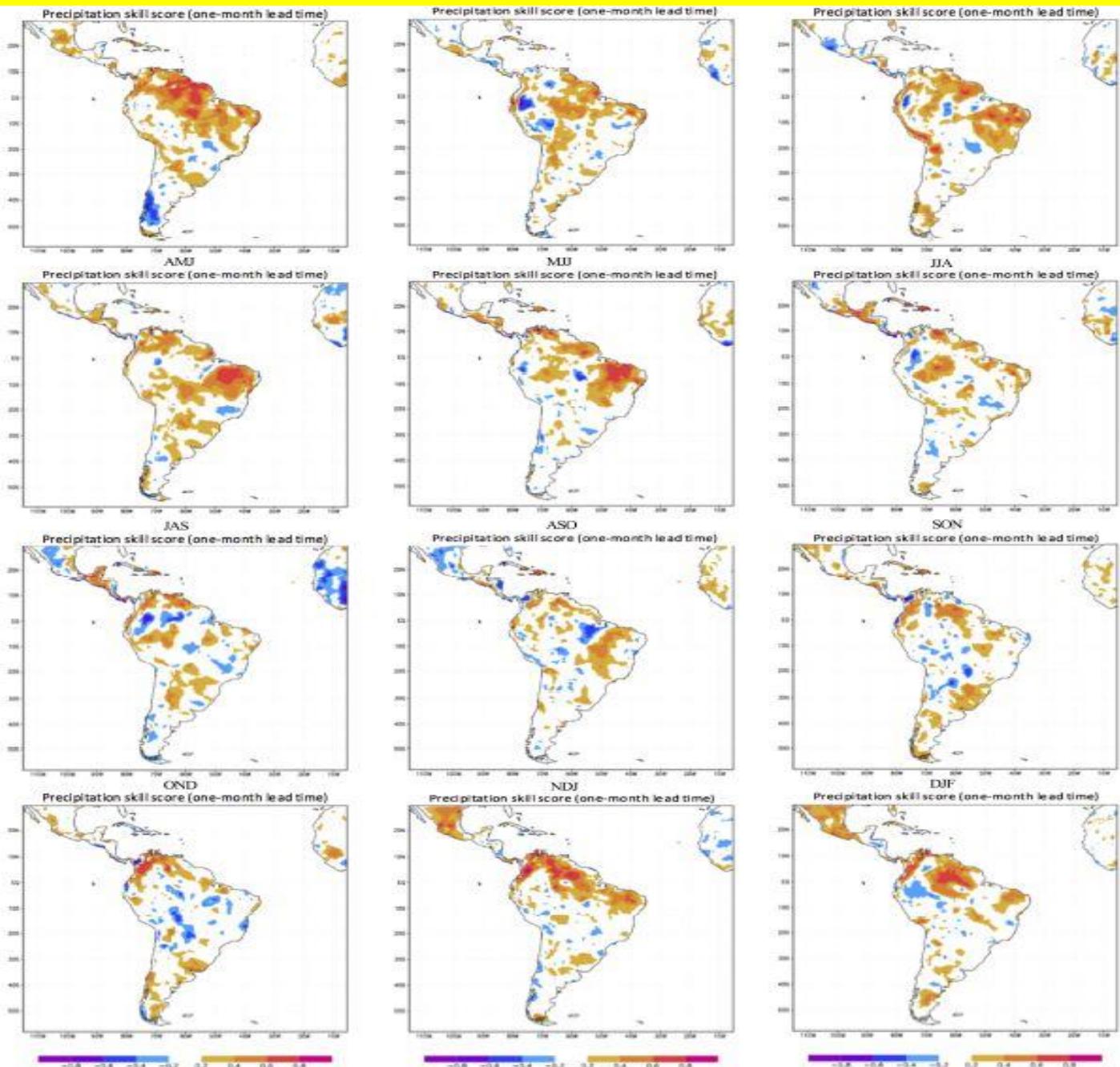
In general,  
cold bias in all  
trimestres

# Precipitation anomaly correlation

## Precipitation seasonal reforecast Skill

Higher skill over the north and northeast of the continent

Winter and spring show the lowest skills



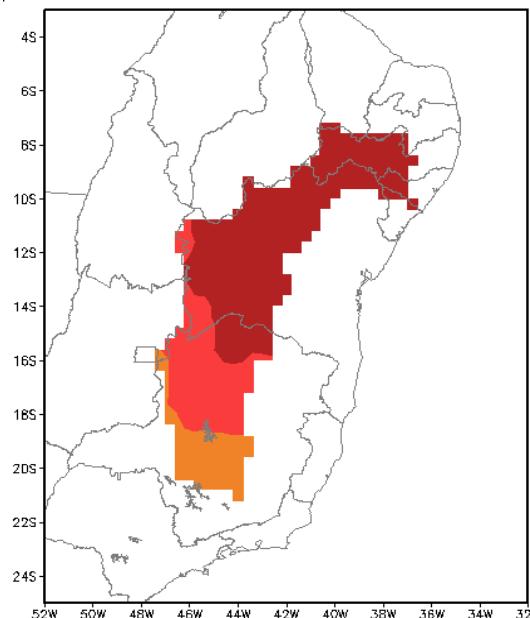
# Sao Francisco River Basin Seasonal forecasts

MODEL SETUP	
Resolution	40 km
Basin	São Francisco River
FCST RANGE	4.5 meses (ONDJ)
IC, LBC	CPTEC AGCM 5 members (13, 14, 15, 16, 17)
Period	2002 - 2012

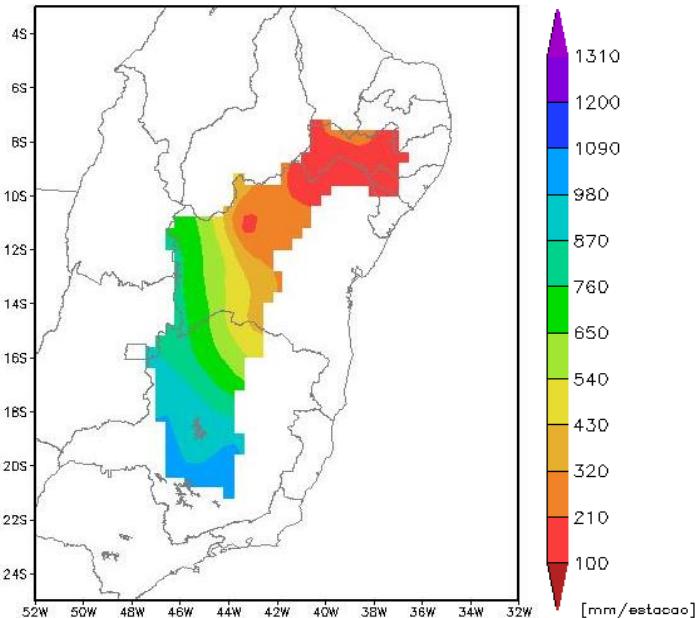
Major water conflict

Energy x agriculture x social x  
supply x tourism x fishery

Acum. Prec - Eta  
(2002-2012)

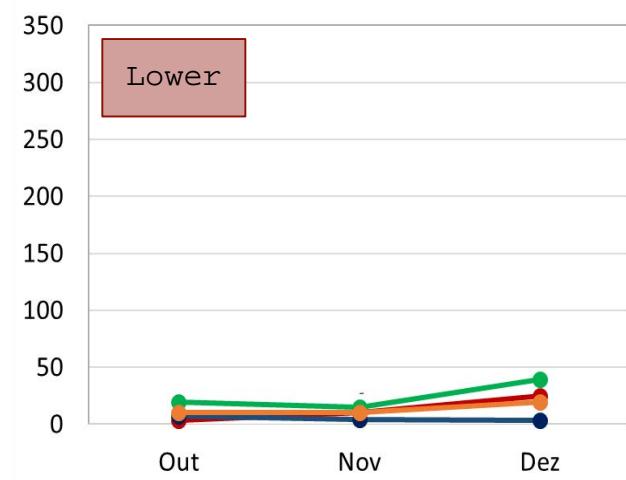
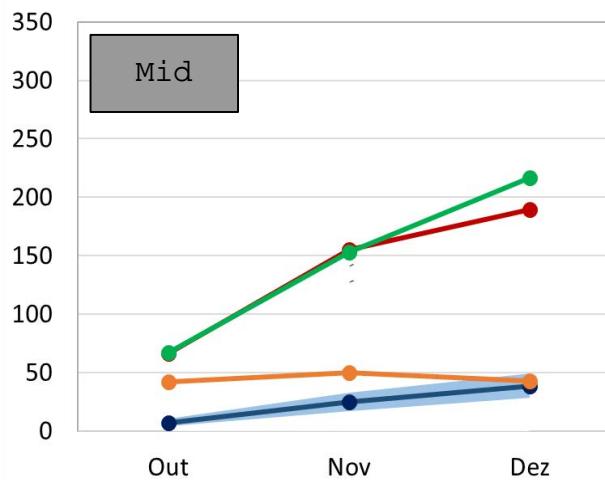
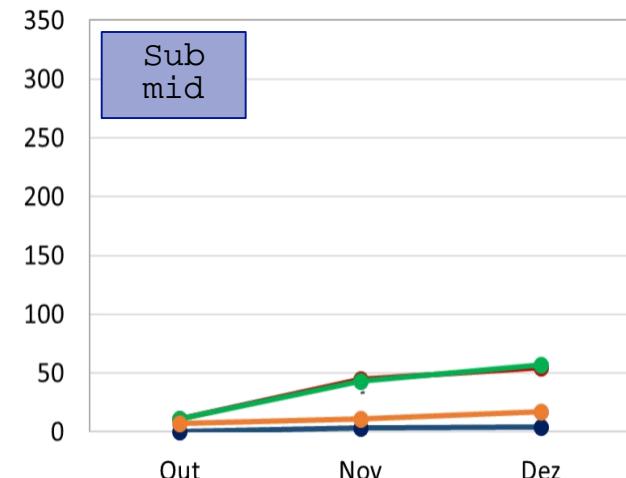
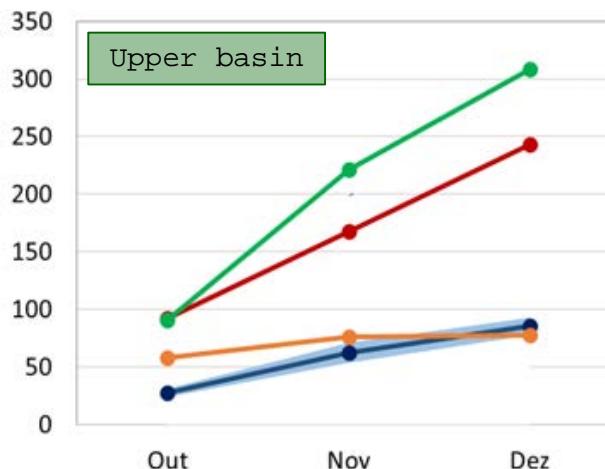
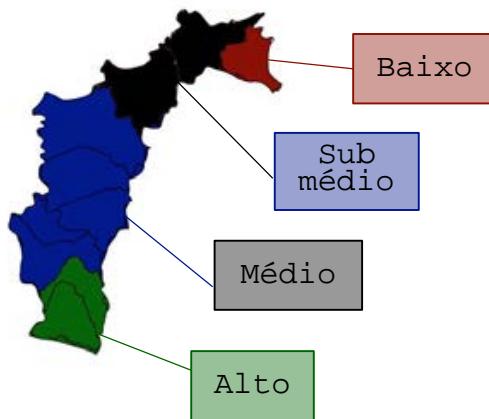


Acum. Prec- CRU  
(2002-2012)



# Seasonal precipitation forecast over Sao Francisco Basin

## Monthly precipitation(2001–2007)

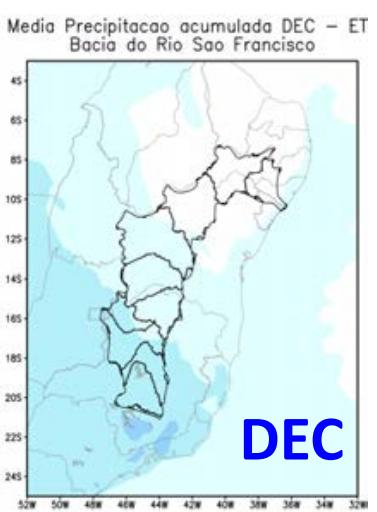
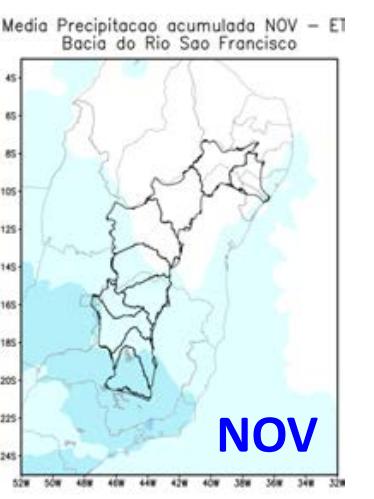
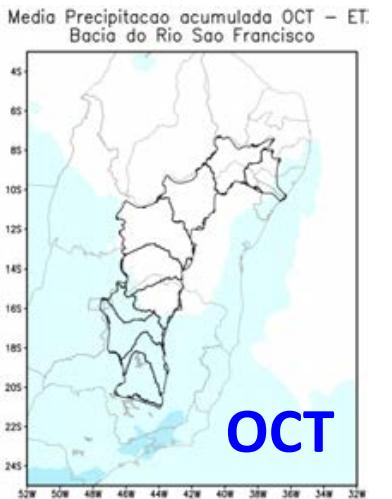


Strong  
precipitation  
underestimate

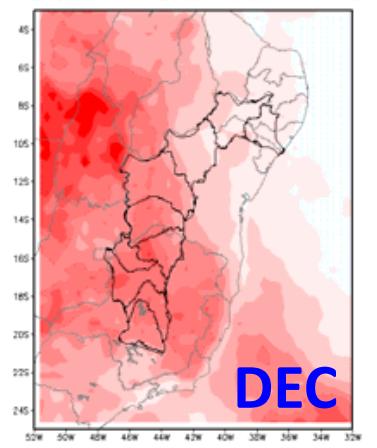
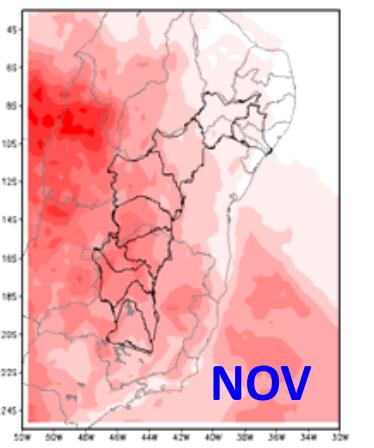
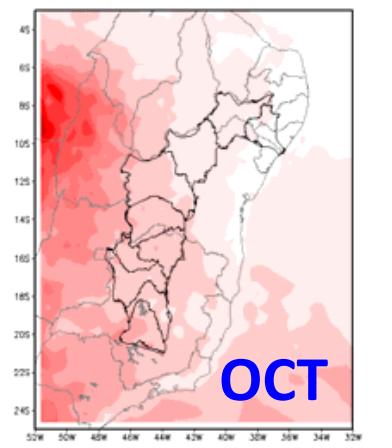
Use of OAGCM as  
LBC may provide  
more spread.

Membros Eta-AGCM CMORPH CRU Média Eta-AGCM Eta-OAGCM

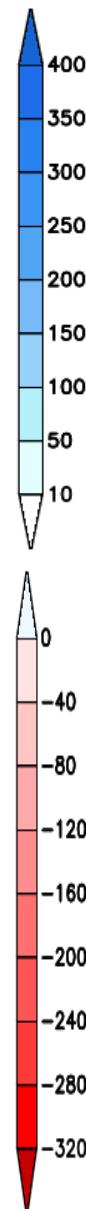
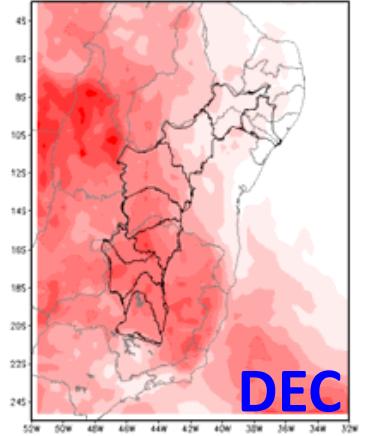
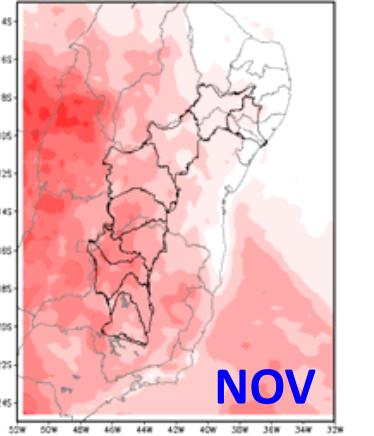
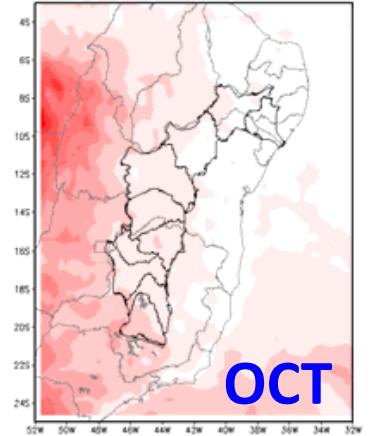
ETA<sub>\_</sub>AGCM  
FORECASTS



ETA<sub>\_</sub>AGCM  
ERRORS



ETA<sub>\_</sub>OAGCM  
ERRORS



# SUBSEASONAL FORECASTS

## 30-60 días

# MOTIVATION

Fill the GAP between weather and seasonal forecasts

Beyond medium range and less than 90 days

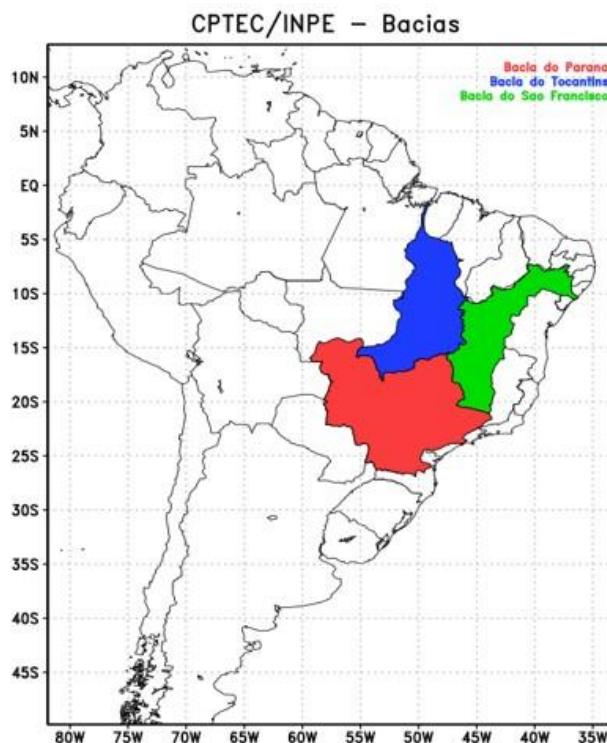
Useful time range for planning ahead

But, what is the forecast skill?

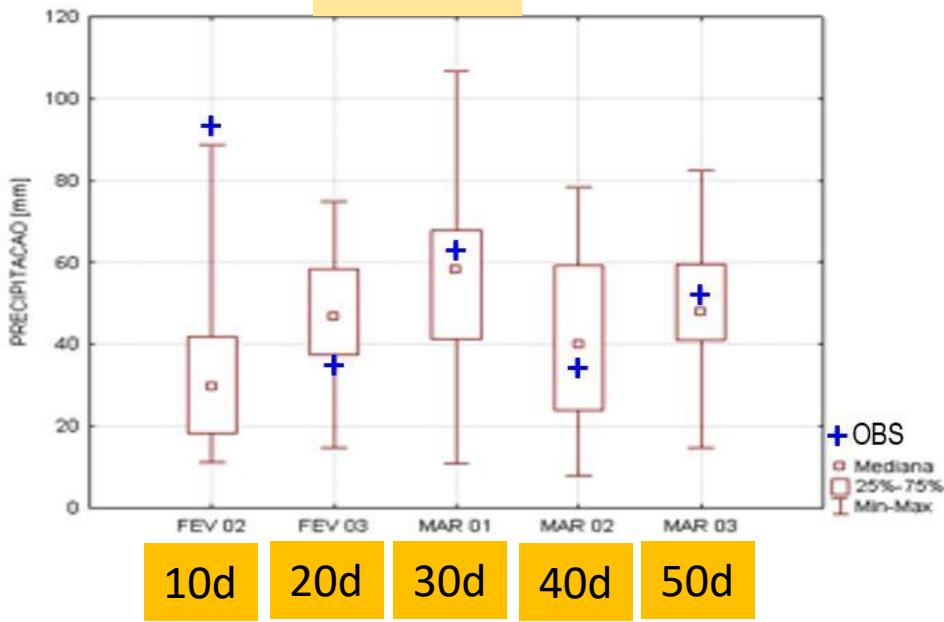
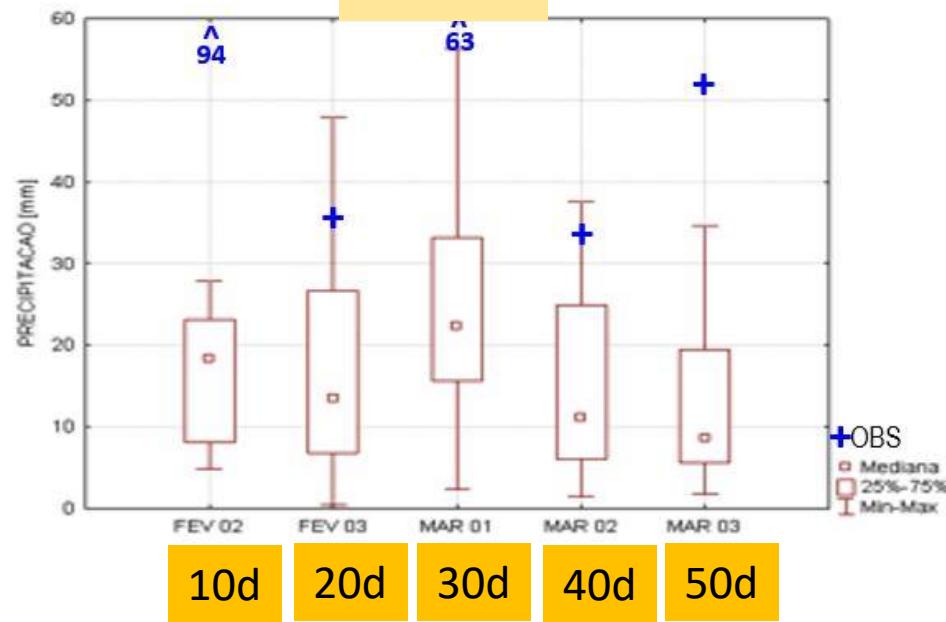
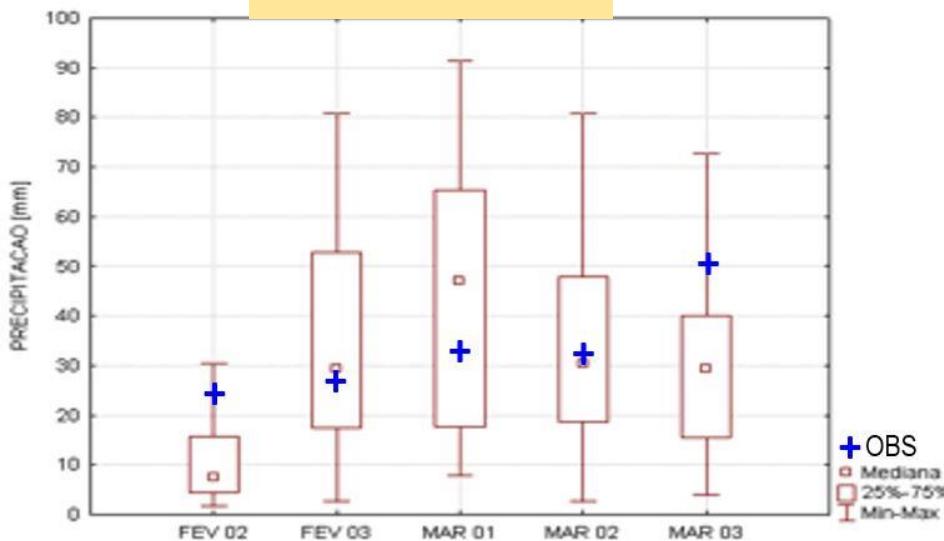
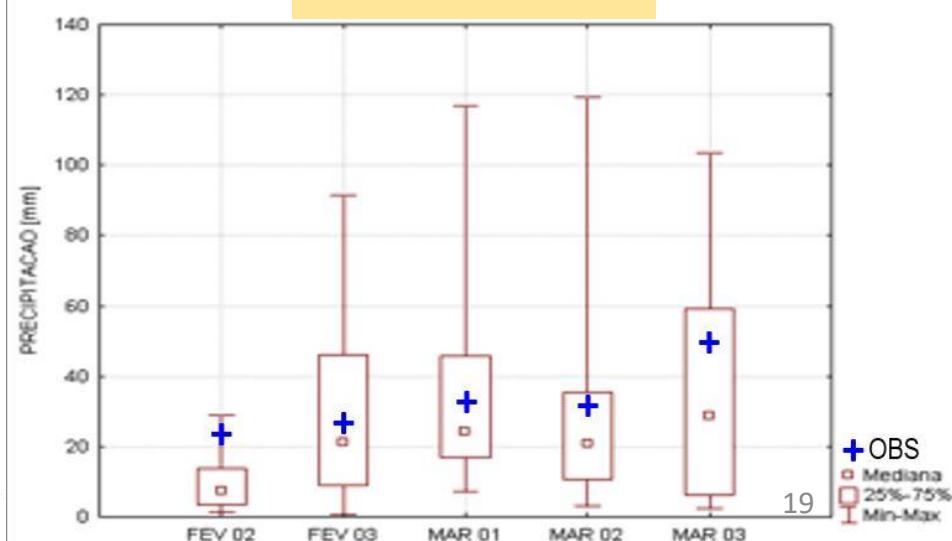
# OBJETIVE

Evaluation of 50-day forecast, based on ensemble of 20 members, driven by CPTEC OAGCM

# SUBSEASONAL FORECASTS



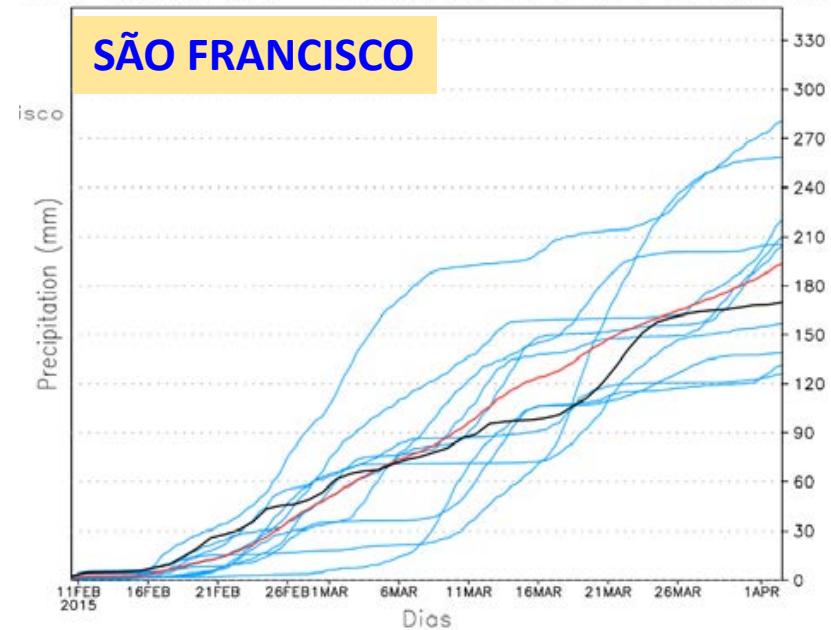
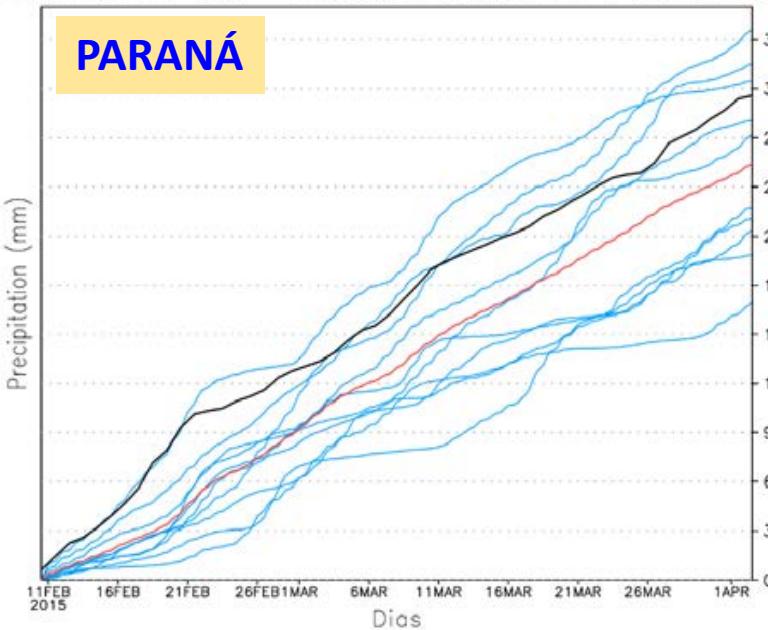
- 60-day integration time, run daily, twice a day.
- 50-day forecast range.
- ‘lagged-ensemble forecasts’
- 5 dekads evaluation
- 3 major river basins: Paraná, Tocantins e São Francisco.
- 10 February - 31 March 2015.

**ETA****PARANÁ****CPTEC OAGCM****PARANÁ****Feb-Mar****SÃO FRANCISCO****SÃO FRANCISCO**

# Previsões para o horizonte de 50 dias

Membros 201502 01/02/.../09/10 12 CC: BESM  
 Prec. Acumul. 60d – Previsão 2015020112 a 2015021012

Membros 201502 01/02/.../09/10 12 CC: BESM  
 Prec. Acumul. 60d – Previsão 2015020112 a 2015021012

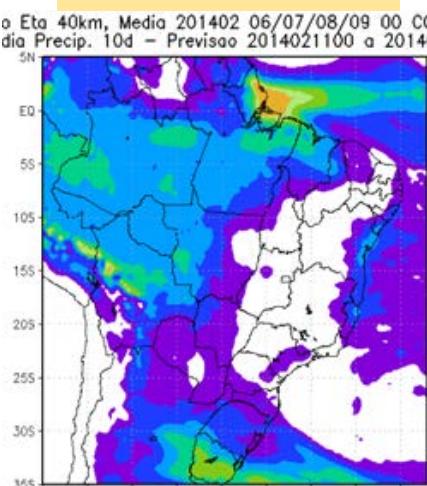


Bacia	Eta	BESM (OAGCM)	Obs	Normal Climat
Paraná	148	51	132	<b>160</b>
São Francisco	108	99	101	<b>136</b>

# Forecast of the end of rainy

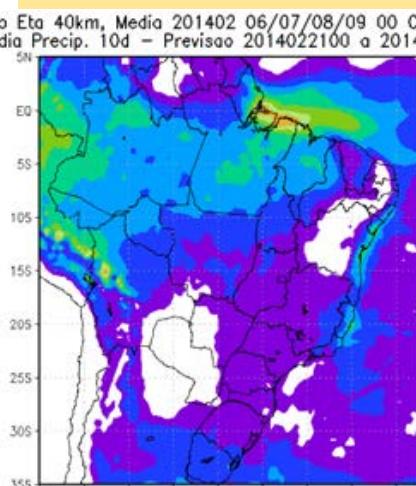
## Beginning of the water crisis in 2014-2015

11-21/Feb2014



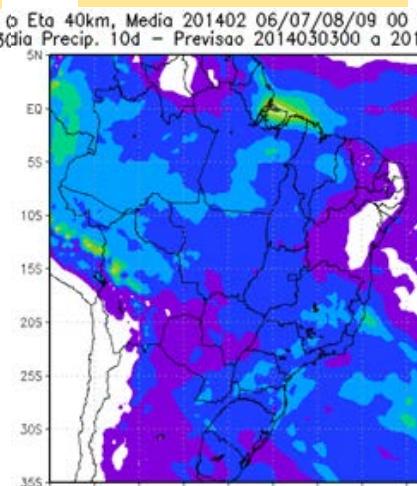
1-10

21/Feb-3/Mar2014



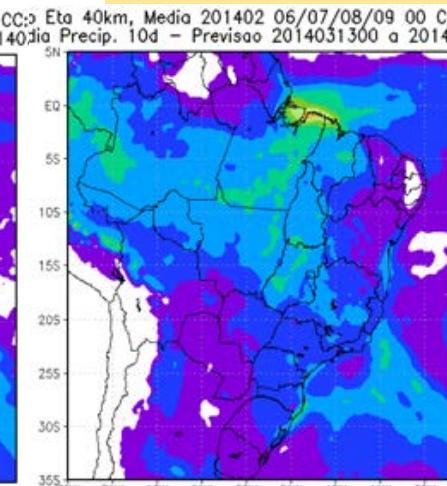
11-20

3-13/Mar2014



21-30

13-23/Mar2014



31-40

Average over 4 members

# SOME CONCLUSIONS

## subseasonal

- Errors in subseasonal range are different from seasonal forecasts. No clear precipitation underestimate in the central part of the continent;
- Need to produce model climatology for subseasonal range;
- Need to identify the situations of higher and lower forecast skill.

## seasonal

1. Seasonal precipitation forecast is underestimated in central part of the continent.
2. Seasonal precipitation forecast in Sfco Basin is strongly underestimated during OND.
3. Seasonal temperature has cold bias
4. Spread among the forecast members is small – (underdispersive?)
5. Positive skill score values a slightly larger than the driver AGCM scores.

Evaluation should be extended to :

- other variables such as:
  - Relative Humidity, Wind, solar radiation , Surface pressure
  - other river basins or regions: Amazon basin, La Plata basin
  - weather systems

# HVALA!

Sin Chan Chou, Jorge Gomes,  
Fedor Mesinger

## **Team:**

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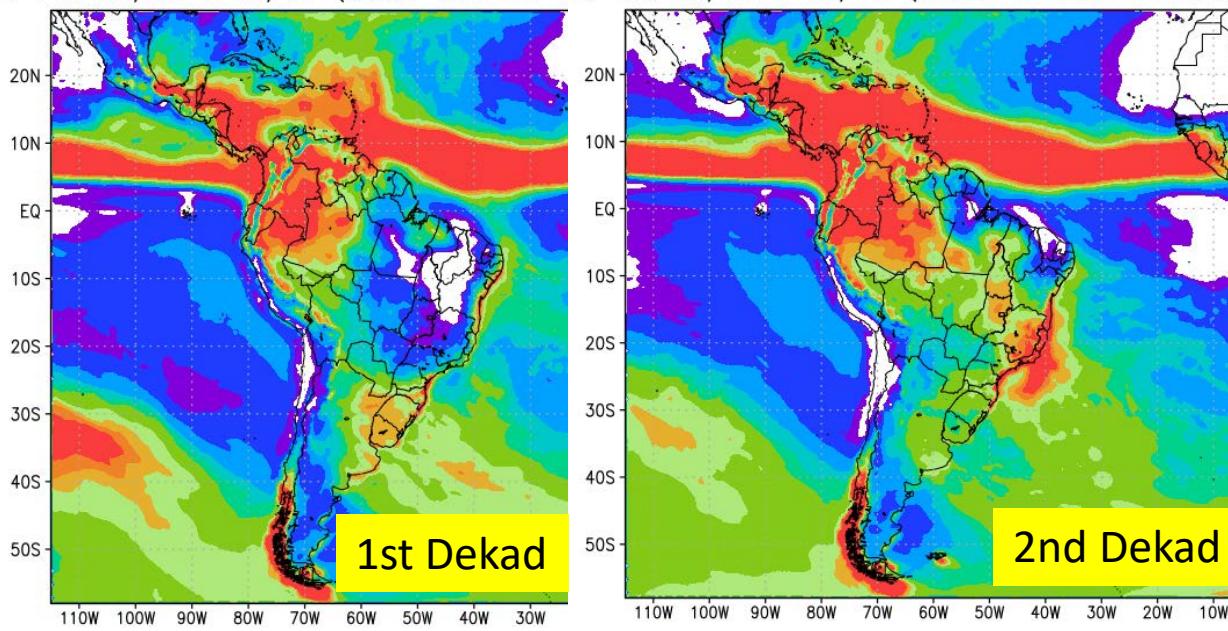
**Graduate Students:** Davi Moura, Diego Campos, Renata Calado, Joao Figueiredo, Pedro Regoto

**Undergraduate:** Gustavo de Oliveira, Maria Luiza Rocha, Marcely Sondermann, Ana Claudia

**Apoio:** Marcele Dourado

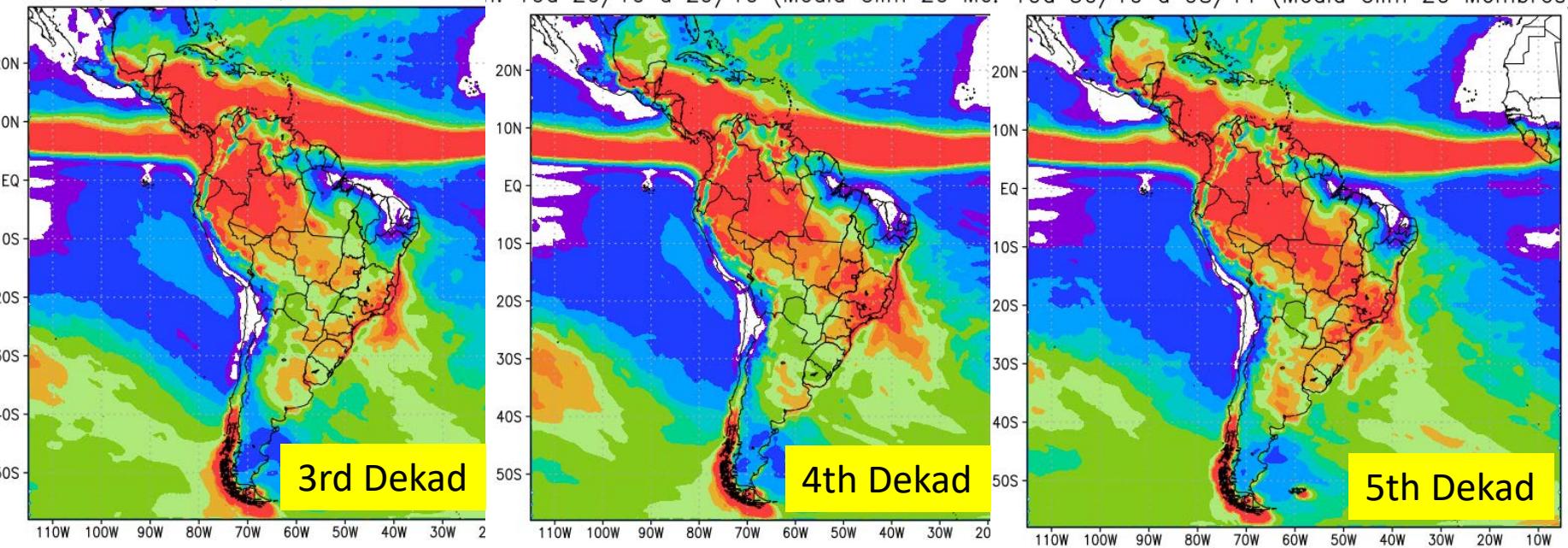
[chou.sinchan@gmail.com](mailto:chou.sinchan@gmail.com)

10d 20/09 a 29/09 (Media Clim 20 M. 10d 30/09 a 09/10 (Media Clim 20 Membros) – Eta



**Product to monitor  
the rainy season  
onset**

10d 10/10 a 19/10 (Media Clim 20 M. 10d 20/10 a 29/10 (Media Clim 20 Me. 10d 30/10 a 08/11 (Media Clim 20 Membros) – Eta

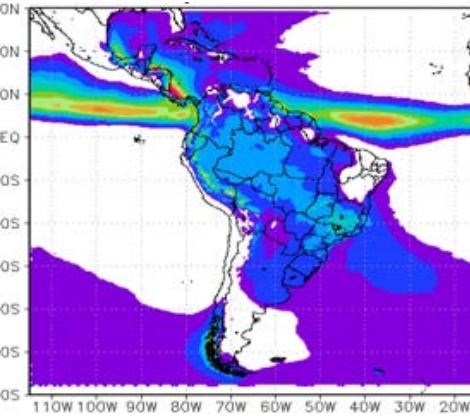


# \* Modelo Eta/INPE \*

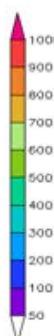
**Previsões sazonais (4,5 meses) com nova versão de modelo Eta climático, 40 km**  
**Construção de previsões sazonais retrospectivas de 10 anos (2001-2010)**

**Previsão por ensemble: 9 membros**

BMJ-Zhao-AGCM

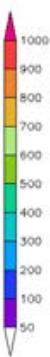
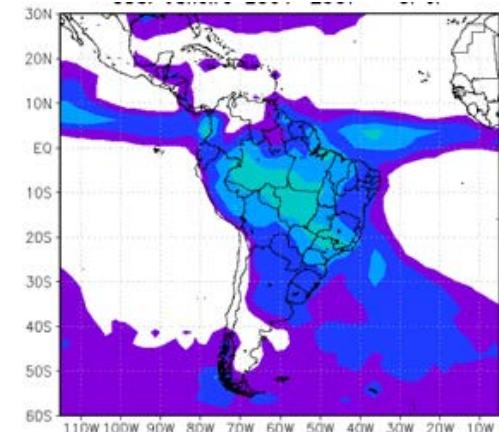


BMJ-Zhao-OGCM

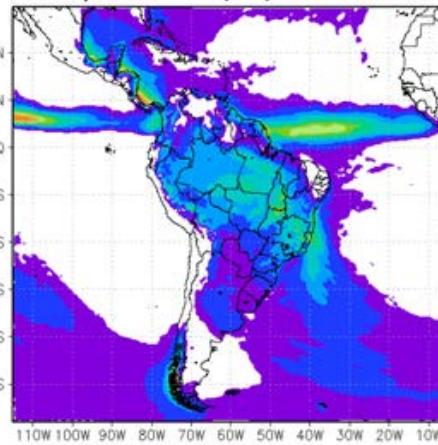


**Média de 10 anos, 5 membros da previsão para JANEIRO, a partir de perturbação de condição inicial**

OBS

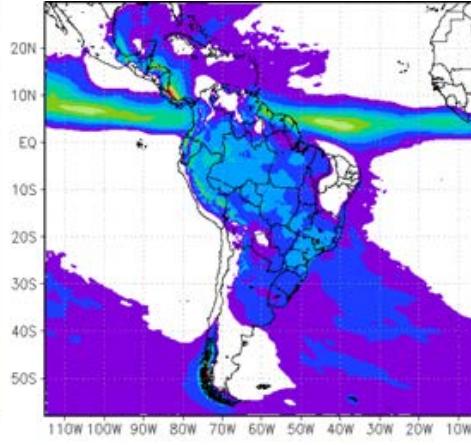


BMJ-FERR-AGCM



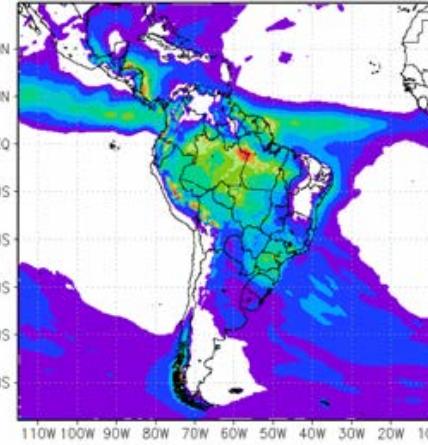
110W 100W 90W 80W 70W 60W 50W 40W 30W 20W 10W

KF-FERRIER-AGCM



110W 100W 90W 80W 70W 60W 50W 40W 30W 20W 10W

KF-FERRIER-OAGCM



110W 100W 90W 80W 70W 60W 50W 40W 30W 20W 10W

**Média de 10 anos da previsão para JANEIRO, a partir de perturbação de física e de condição de contorno inferior e lateral**

# CPTEC AGCM T62L28

## Forecast skill

