



Instituto Nacional de Pesquisas Espaciais - INPE  
Centro de Previsão de Tempo e Estudos Climáticos - CPTEC

# 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:**

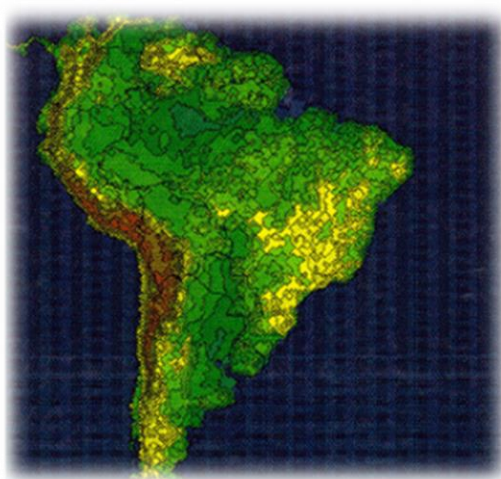
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**Apoio:** Marcele Dourado



# 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<sub>s</sub>, 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.**

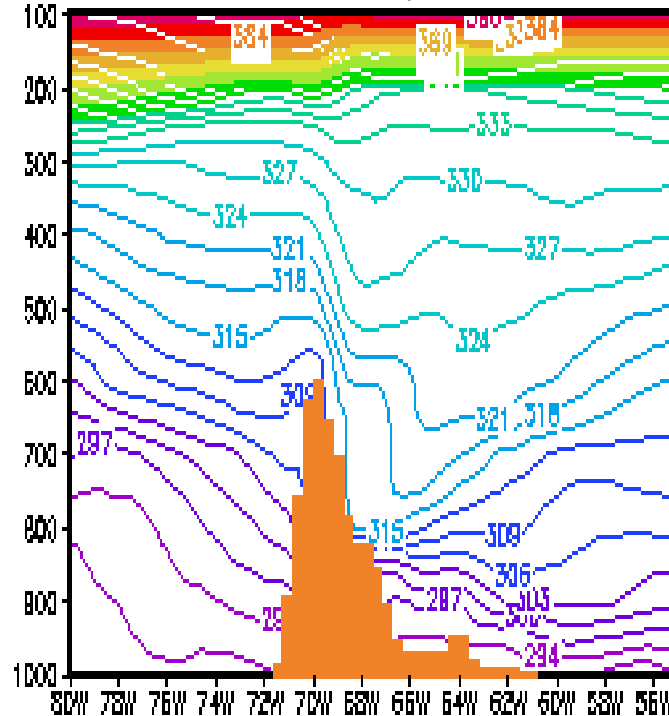
# Why CPTEC adopted Eta model?

Andes Cordillera  
steep mountains in Chile

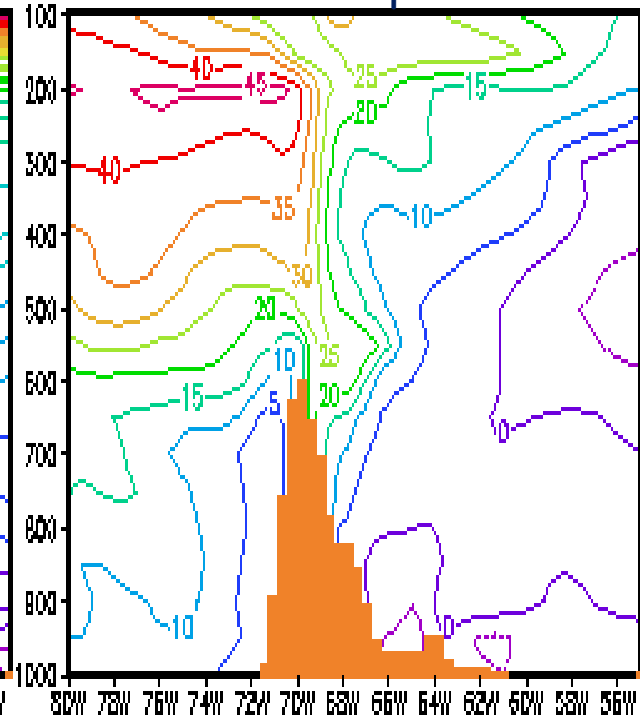


Los caracoles

## Potential Temperature



## U-wind component

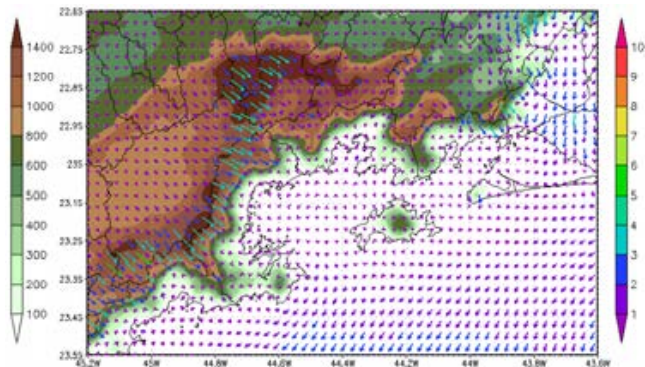


Zonda Wind  
(foën wind)  
**30oS**

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.

# Eta Model Portfolio at CPTEC: SHORT-RANGE forecasts

1 km

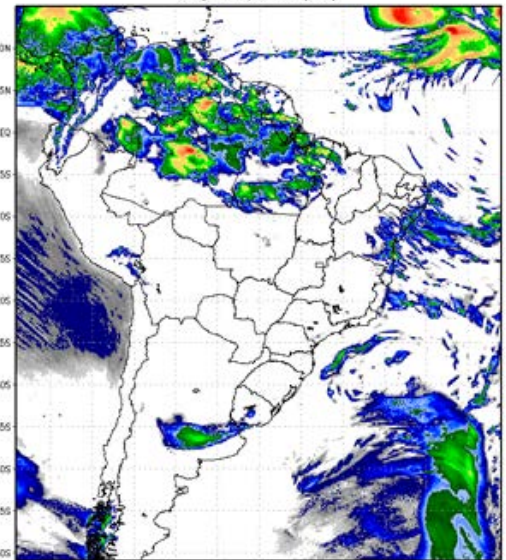


10-m winds

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

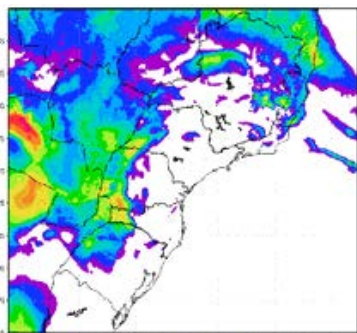
5 km

CPTEC/INPE Experimental  
Fct 2018090800+36h, 12UTC to 09/09/2018, 12UTC  
Daily Precipitation (mm)

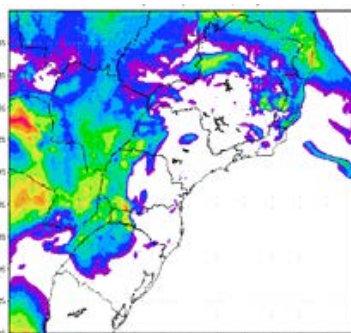


5 km

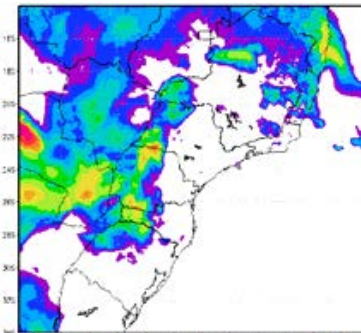
5-member ensemble, precipitation production schemes



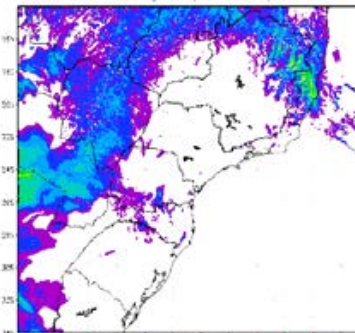
BMJ\_Ferrier\_C



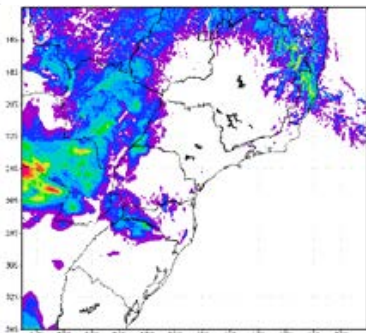
BMJ\_Zhao



BMJ\_Ferrier\_G



KF\_G

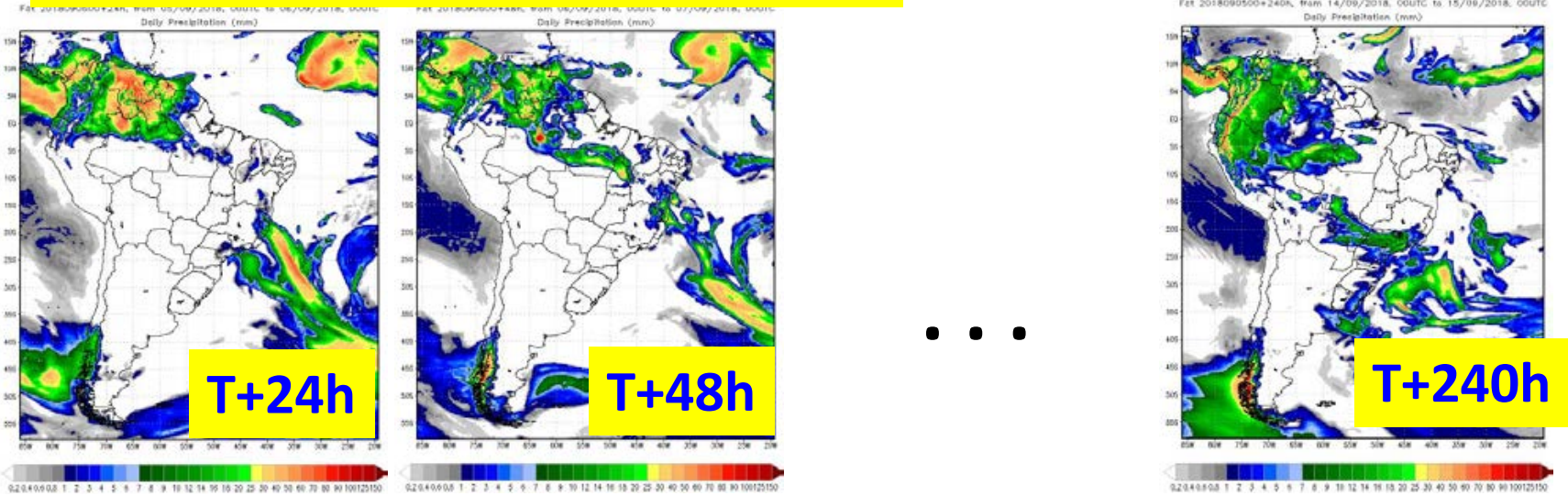


KF\_M\_G

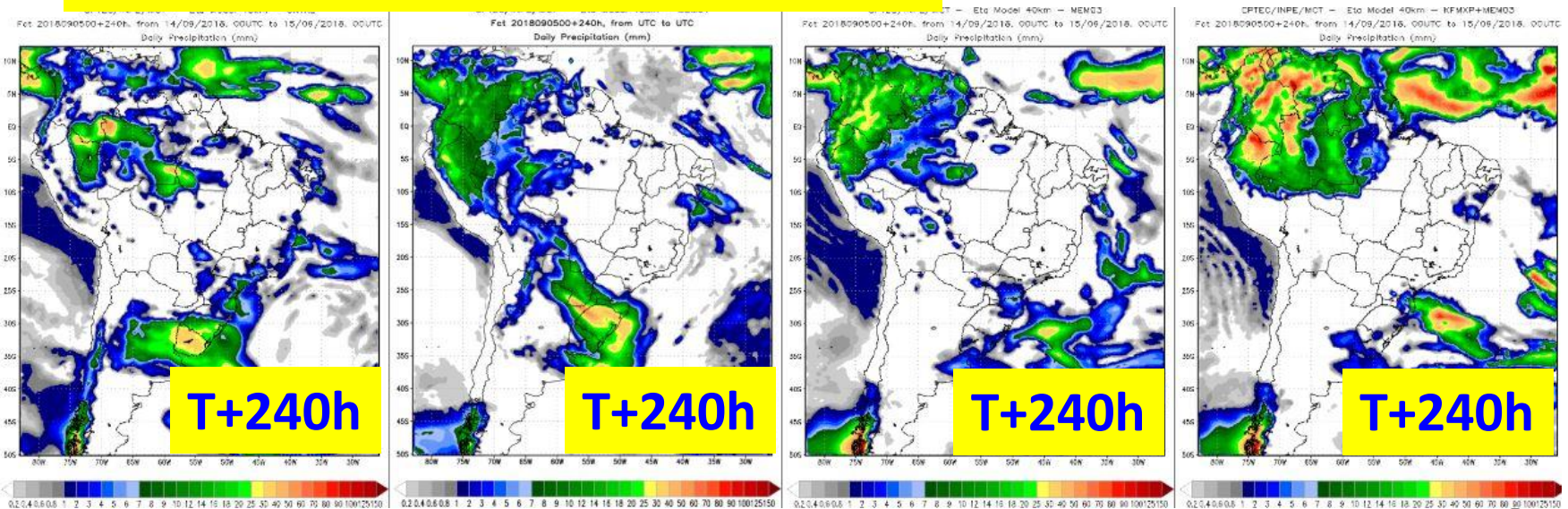


# Eta Model Portfolio at CPTEC: MEDIUM-RANGE forecasts

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



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



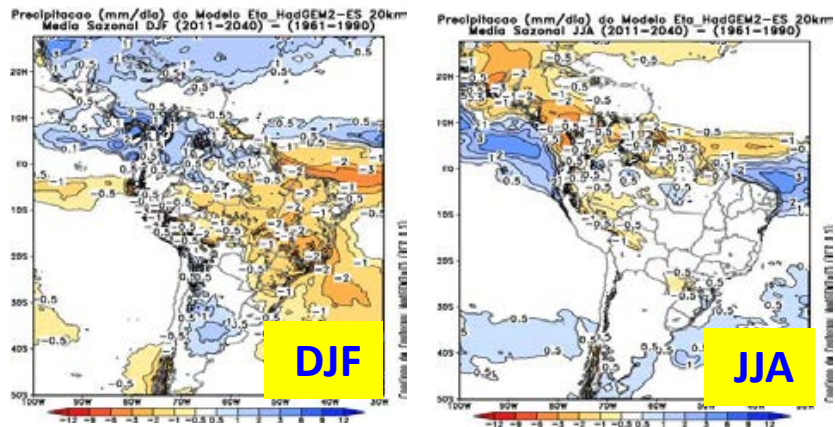


# Eta Model Portfolio at CPTEC: Climate Change Projections

## 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

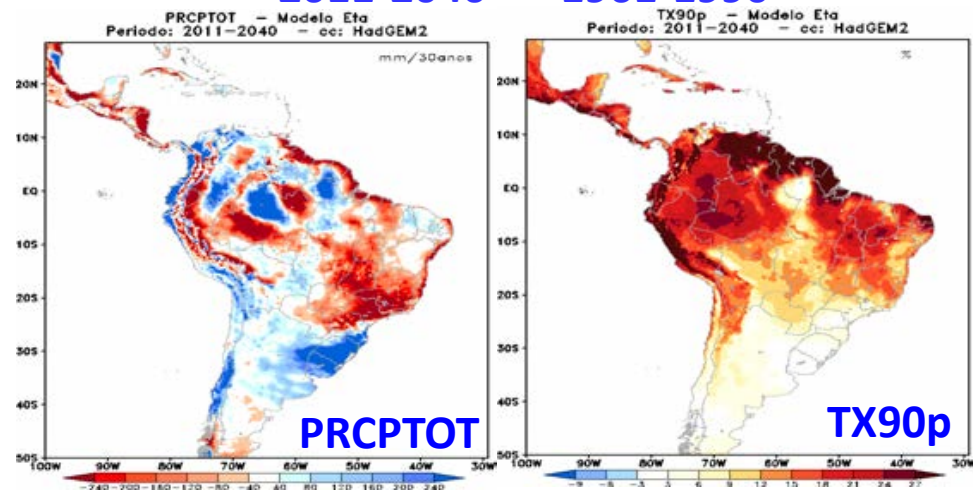


Eta/HadGEM2-ES – RCP 8.5

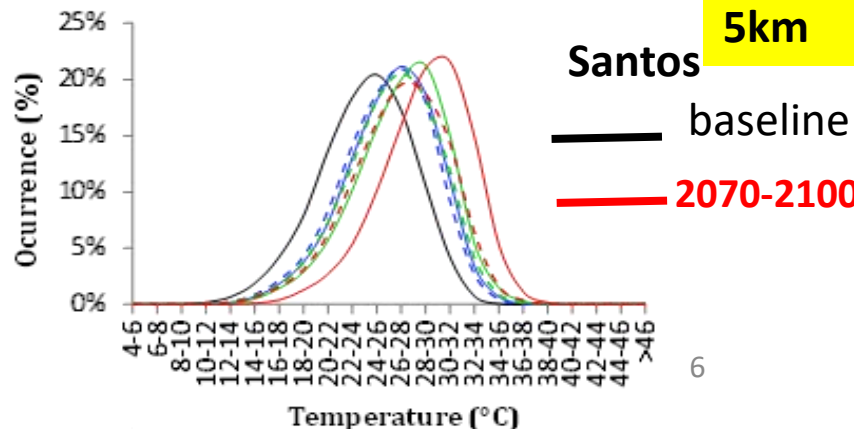
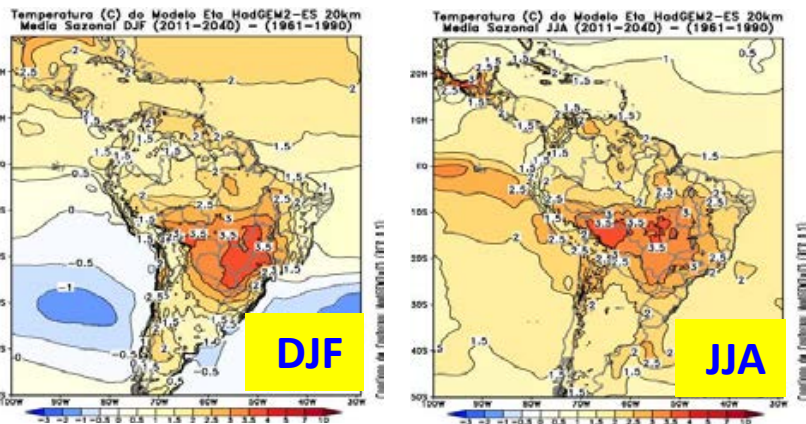
Tendência de extremos

2011-2040 -- 1961-1990

20km



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

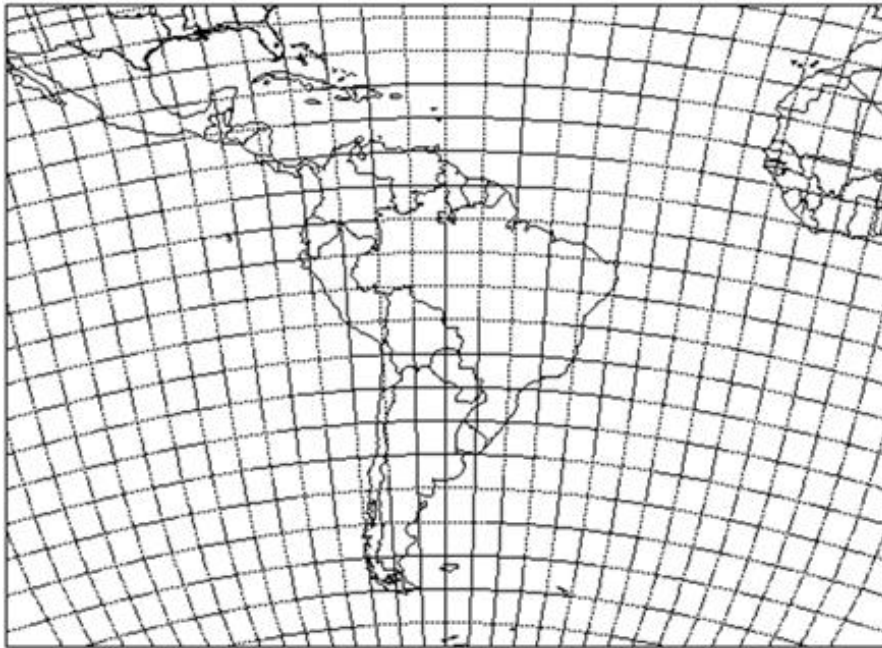


# OBJECTIVE

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

# Seasonal Forecasts

Eta-40km



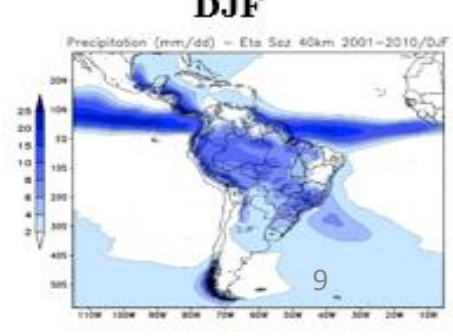
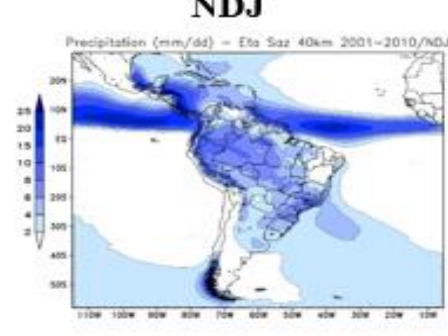
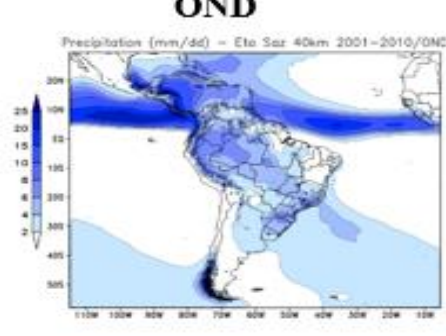
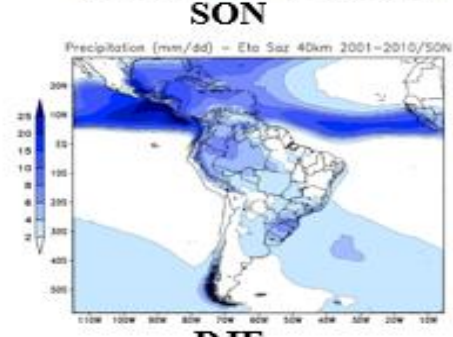
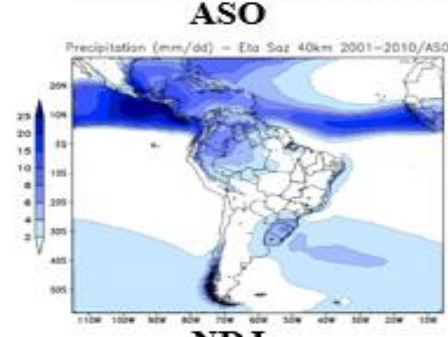
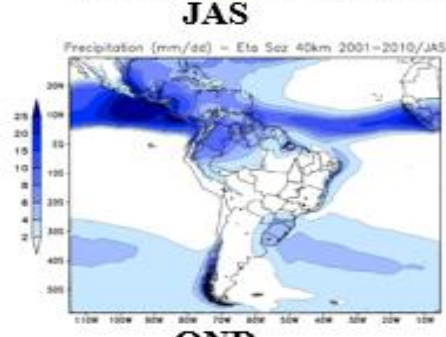
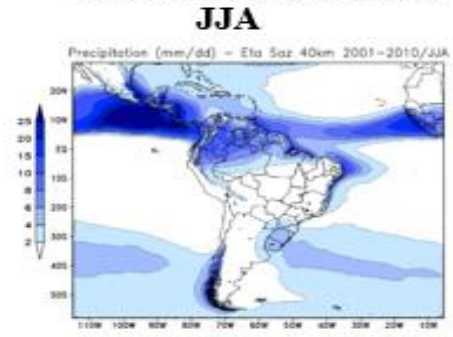
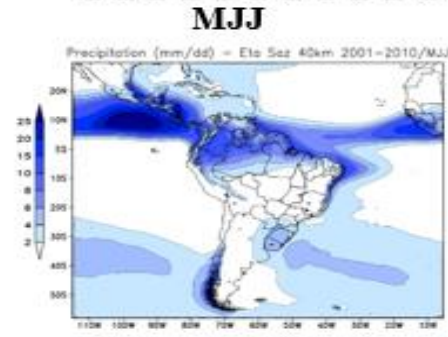
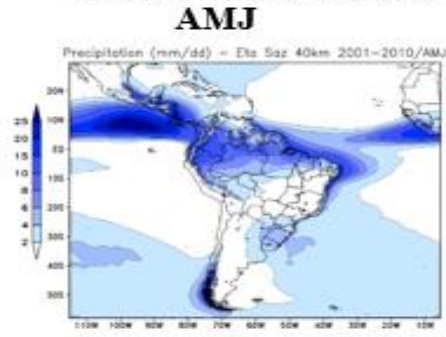
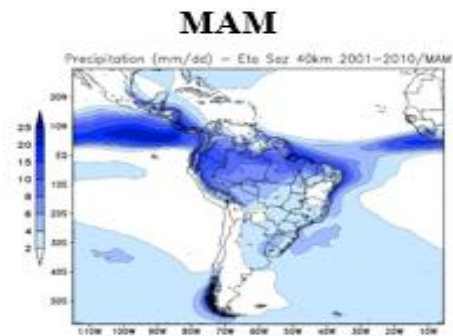
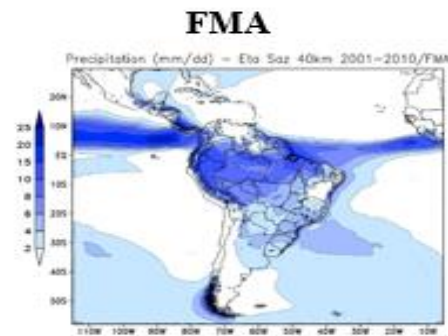
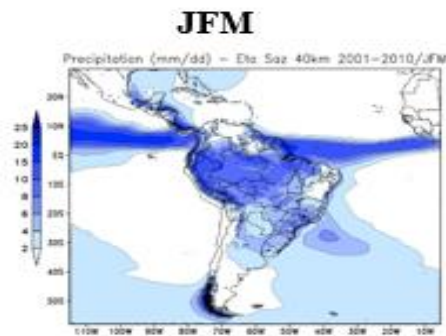
**10-year, 5-member RE-FORECASTS**  
**40-km resolution,**  
**driven by CPTC AGCM T62L28**  
**Persisted SST anomaly**  
**Large Domain**

**4.5-month integrations**



## Precipitation Mean seasonal forecasts

12 months x  
5 members x  
10 year =  
600 runs



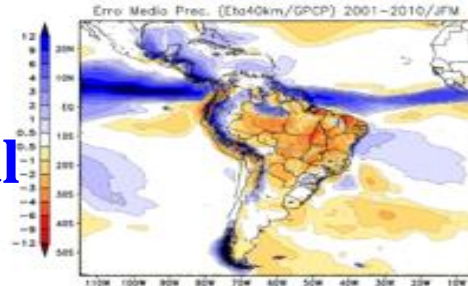
# PRECIPITATION ERRORS

Precipitation  
Mean seasonal  
forecast  
Errors

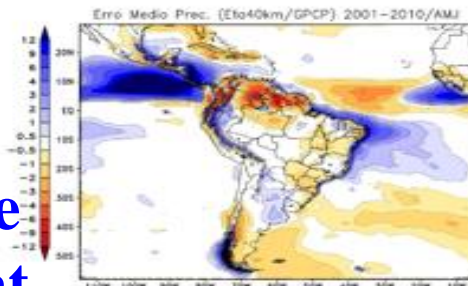
Underestimate  
Over continent

Overestimate  
over ITCZ

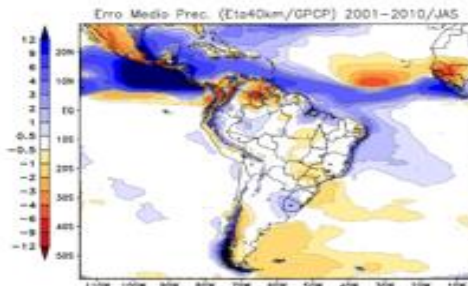
JFM



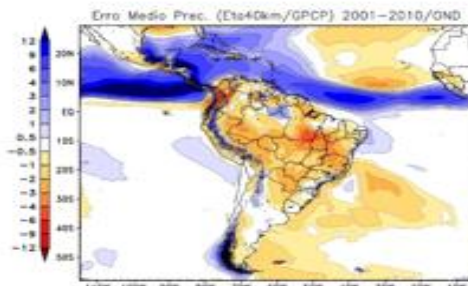
AMJ



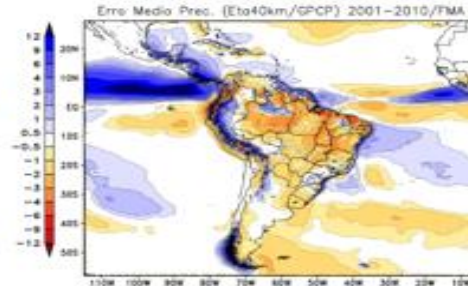
JAS



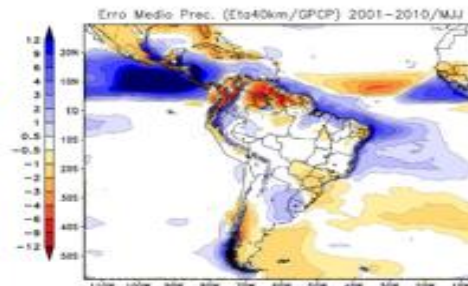
OND



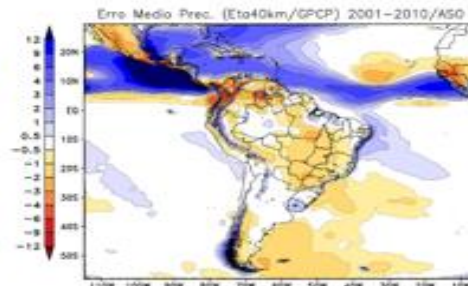
FMA



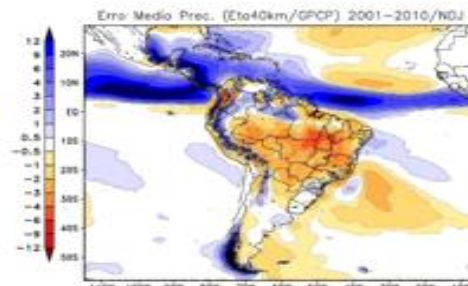
MJJ



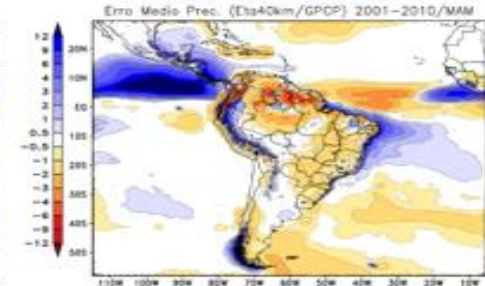
ASO



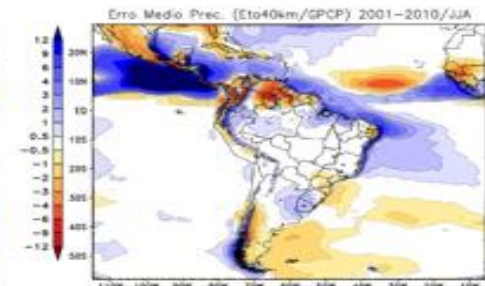
NDJ



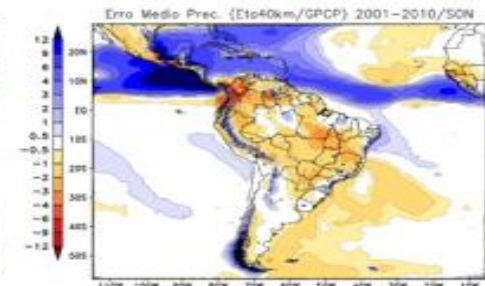
MAM



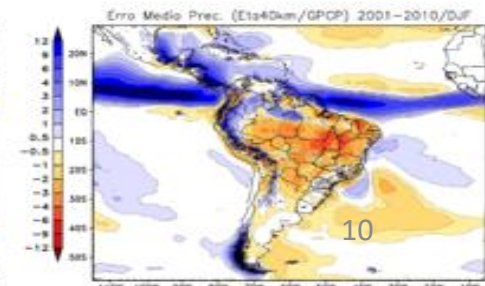
JJA



SON

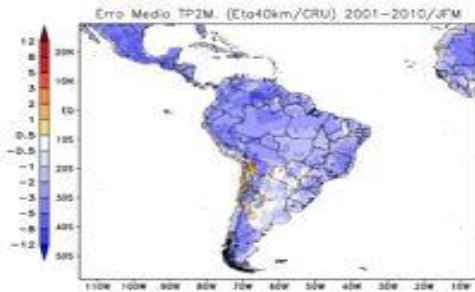


DJF

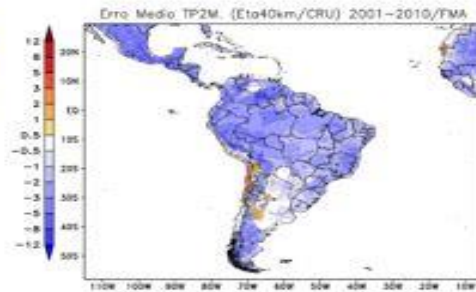


# TEMPERATURE ERRORS

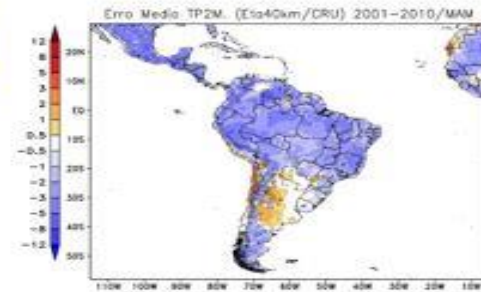
JFM



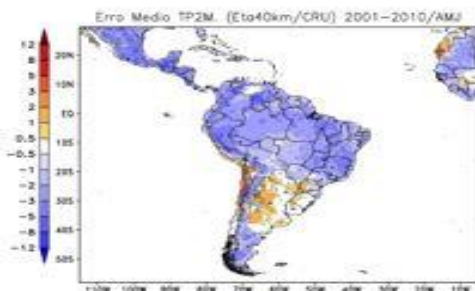
FMA



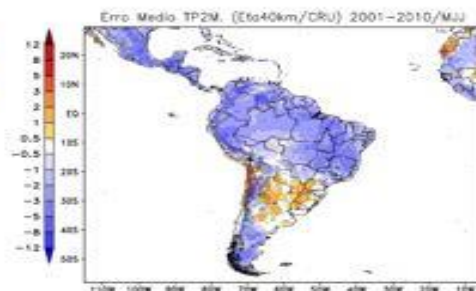
MAM



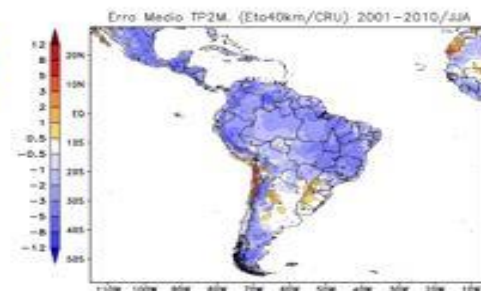
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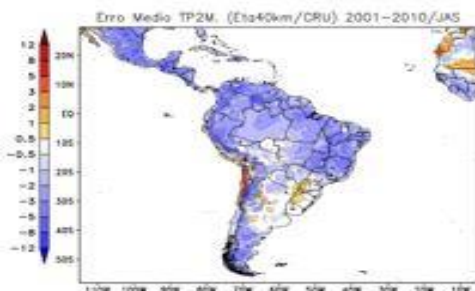
MJJ



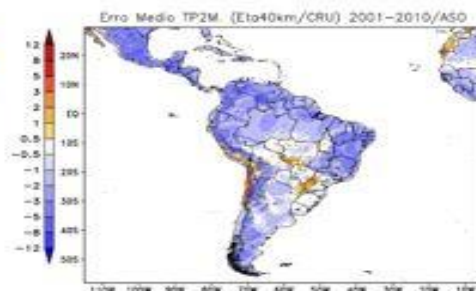
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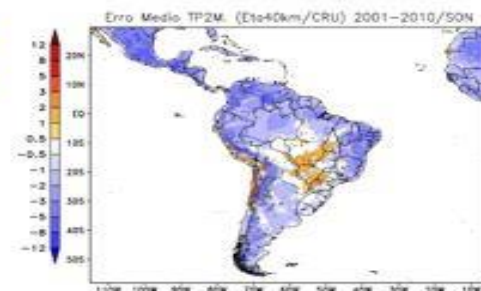
JAS



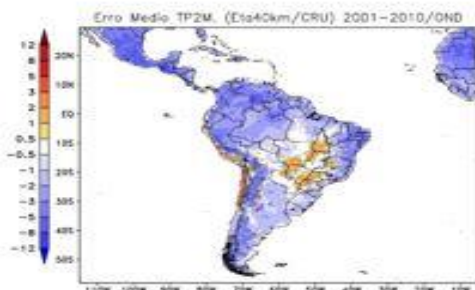
ASO



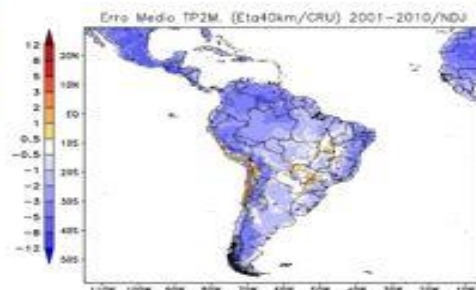
SON



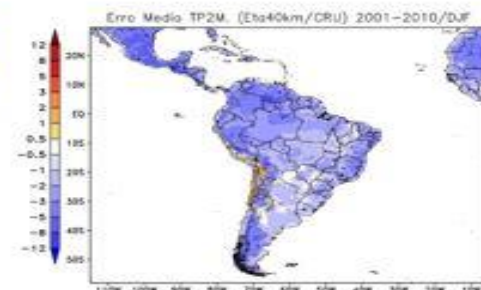
OND



NDJ



DJF



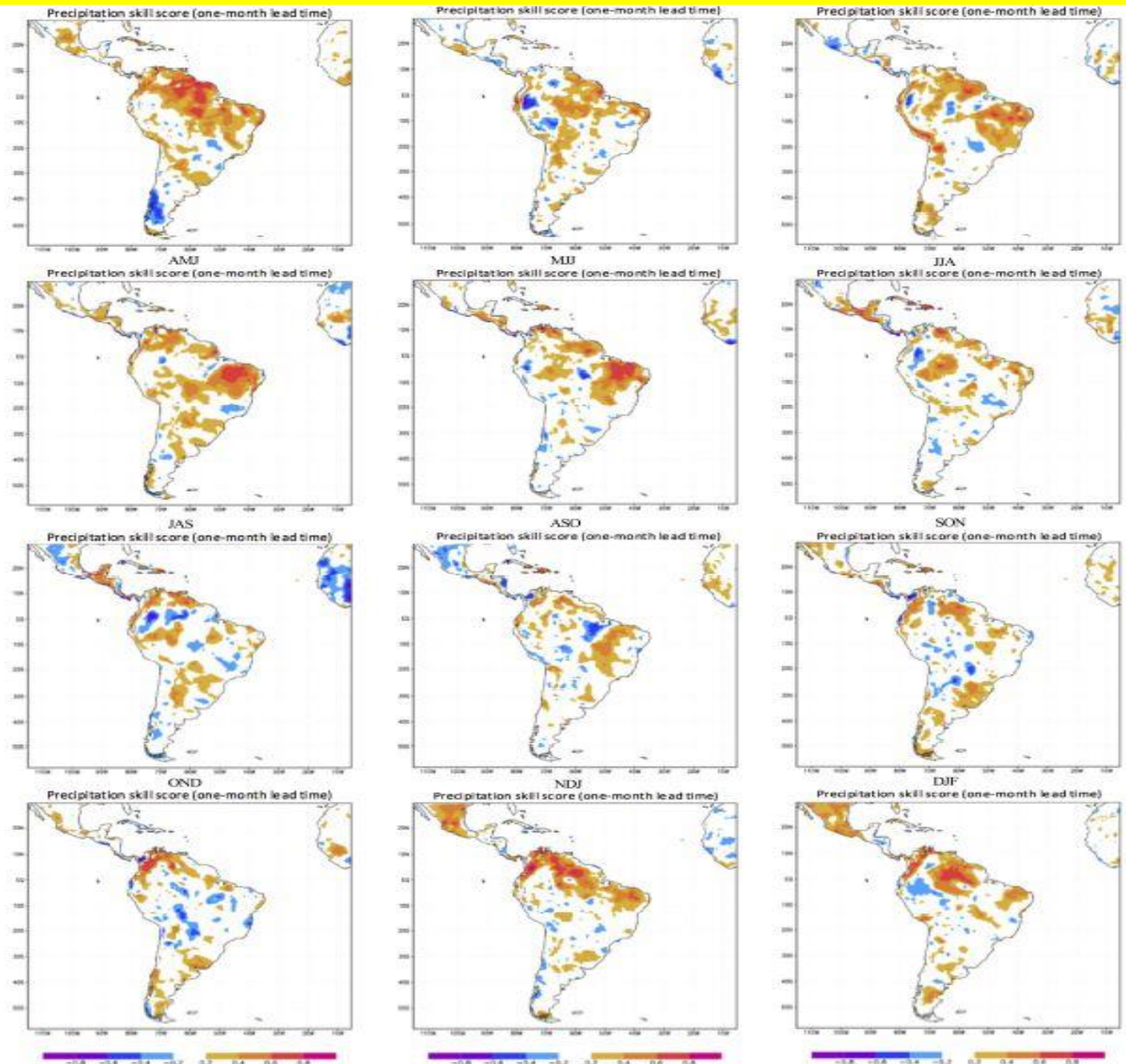
In general,  
cold bias in all  
trimestres

# Precipitation anomaly correlation

## Precipitation seasonal reforecast Skill

Higher skill over the north and northeast of the continent

Winter and spring show the lowest skills



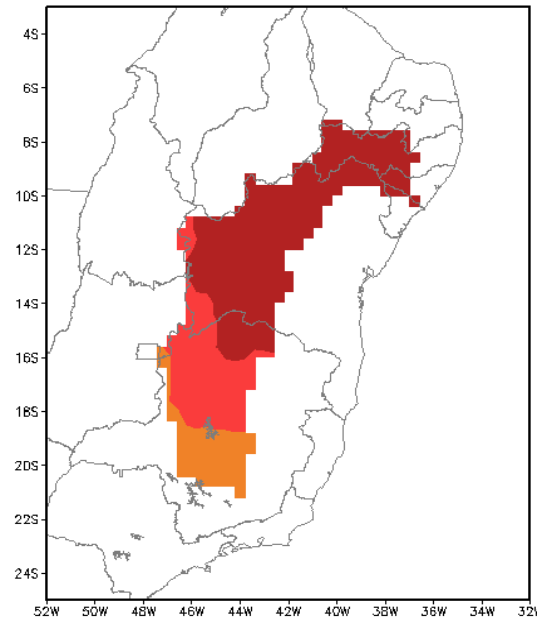
# Sao Francisco River Basin Seasonal forecasts

	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

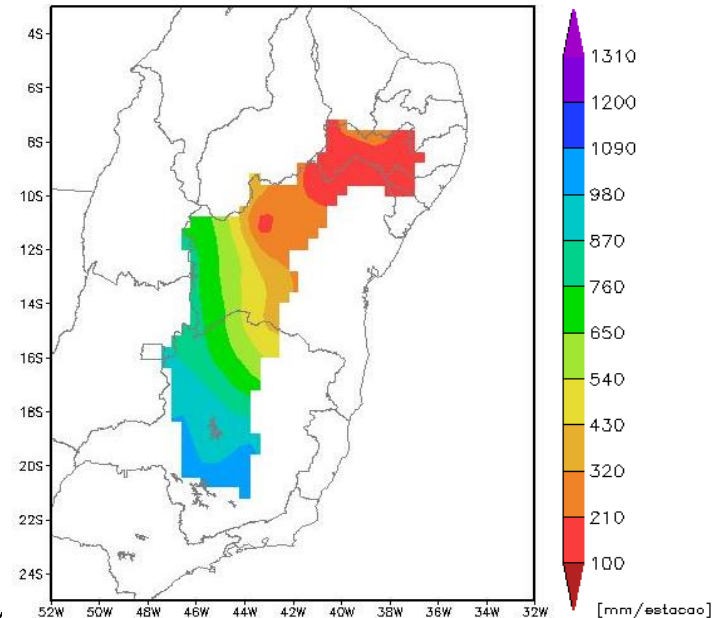
## Major water conflict

Energy x agriculture x social x  
supply x tourism x fishery

Acum. Prec - Eta  
(2002-2012)

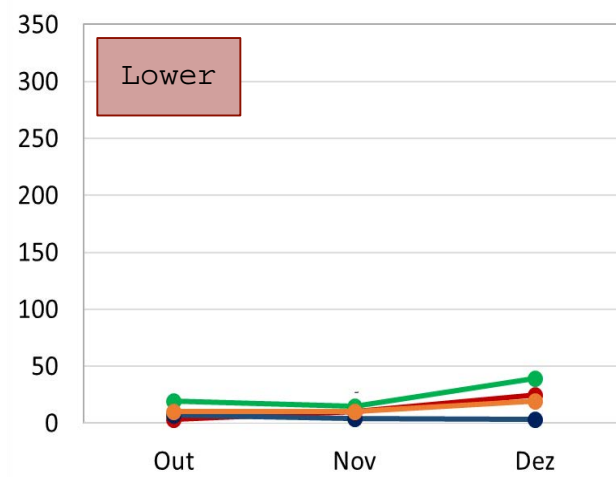
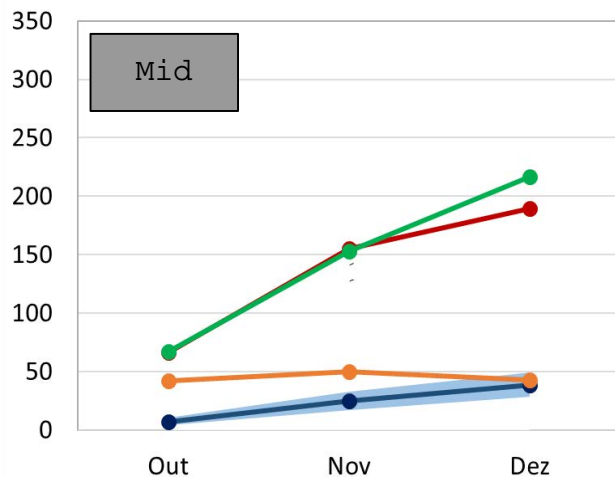
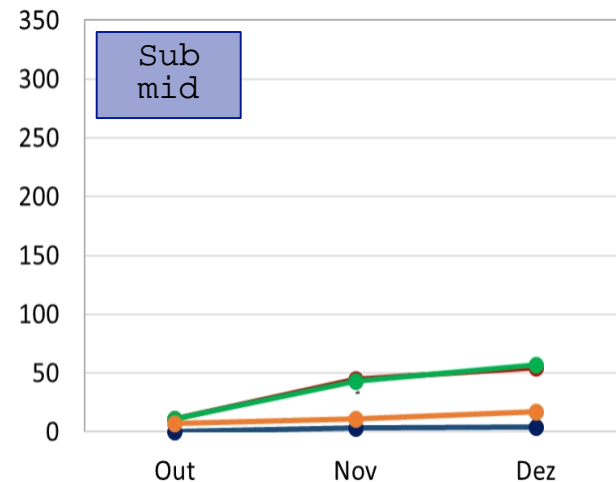
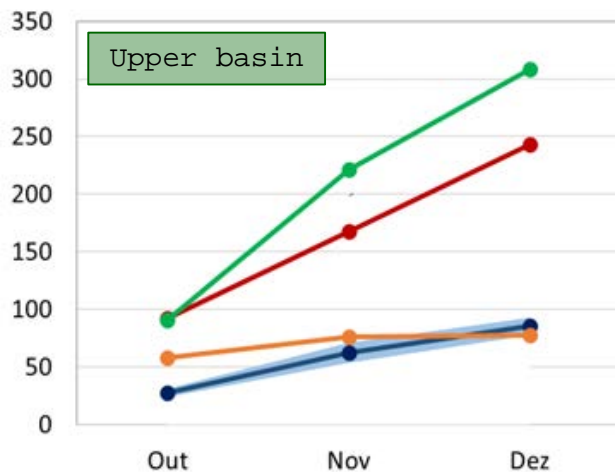
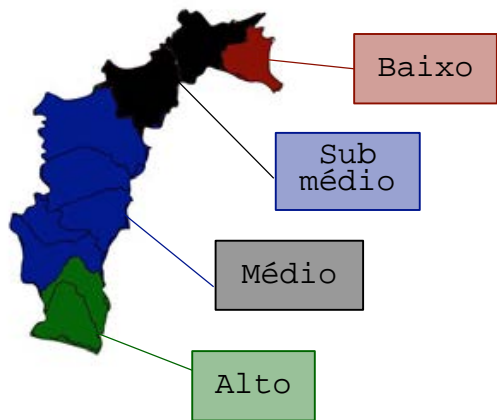


Acum. Prec- CRU  
(2002-2012)



# Seasonal precipitation forecast over Sao Francisco Basin

## Monthly precipitation(2001-2007)

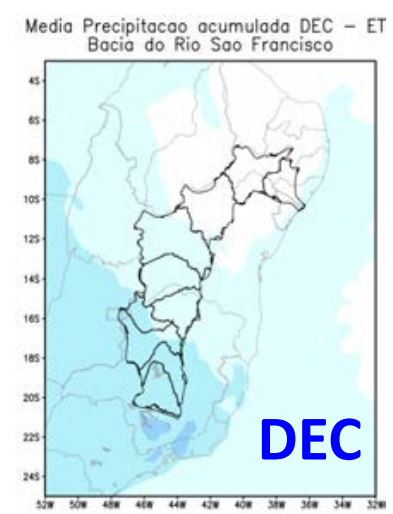
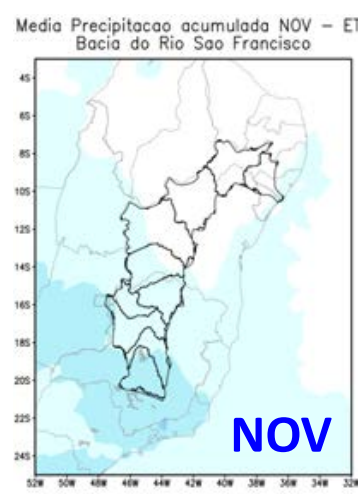
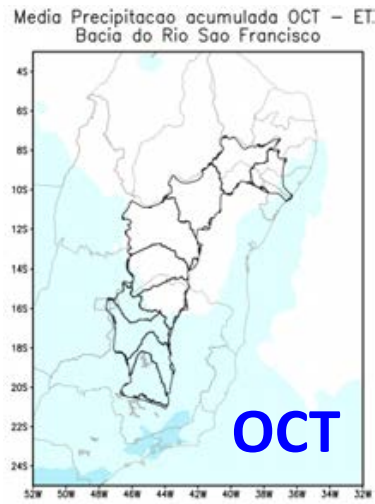


Membros Eta-AGCM CMORPH CRU Média Eta-AGCM Eta-OAGCM

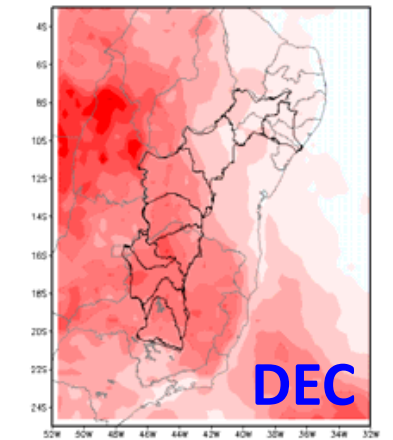
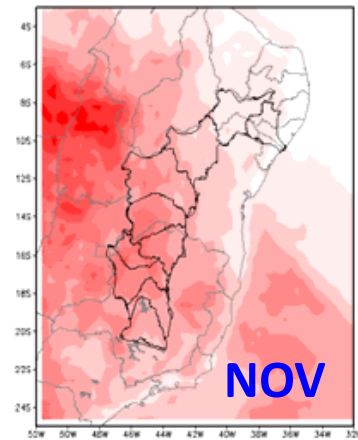
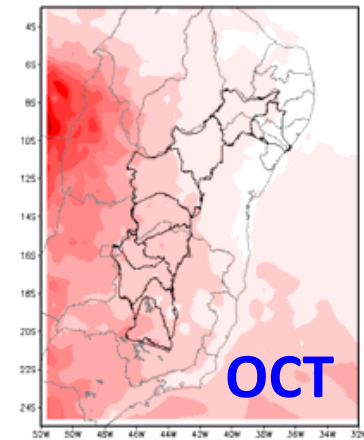
Strong precipitation underestimate

Use of OAGCM as LBC may provide more spread.

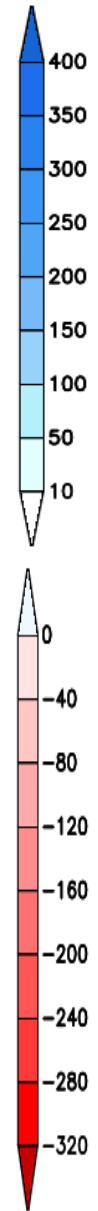
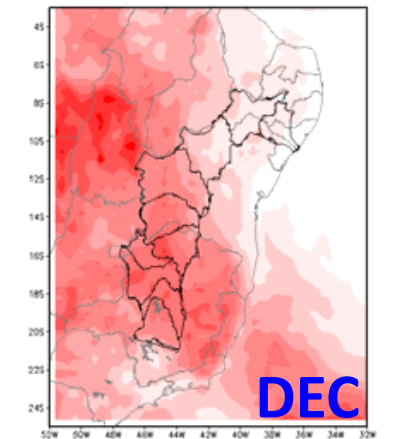
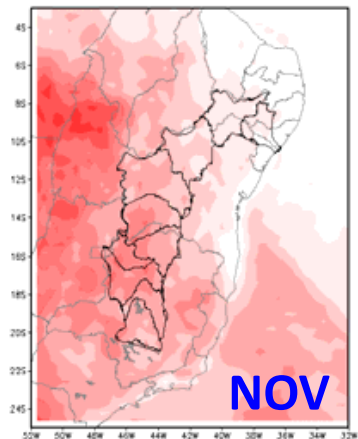
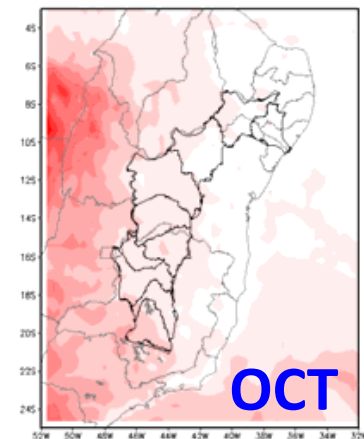
ETA\_AGCM  
FORECASTS



ETA\_AGCM  
ERRORS



ETA\_OAGCM  
ERRORS



# SUBSEASONAL FORECASTS

## 30-60 dias



# MOTIVATION

Fill the GAP between weather and seasonal forecasts

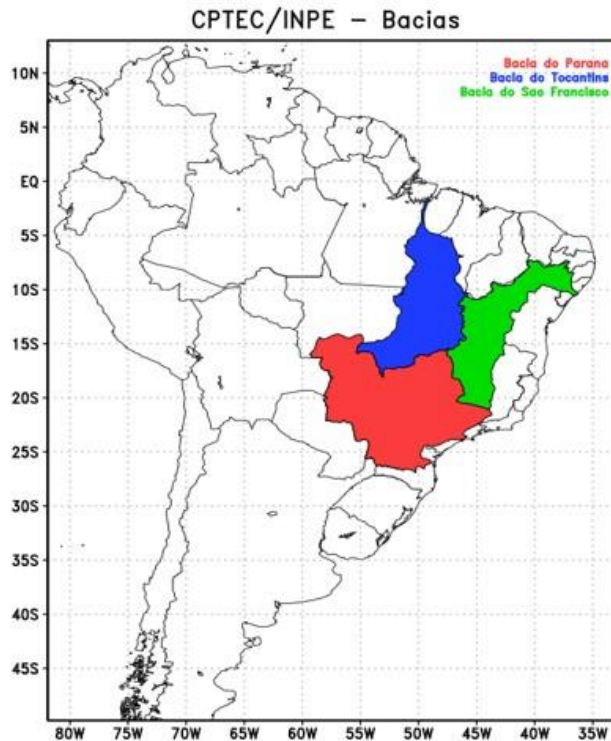
Beyond medium range and less than 90 days

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



- 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.

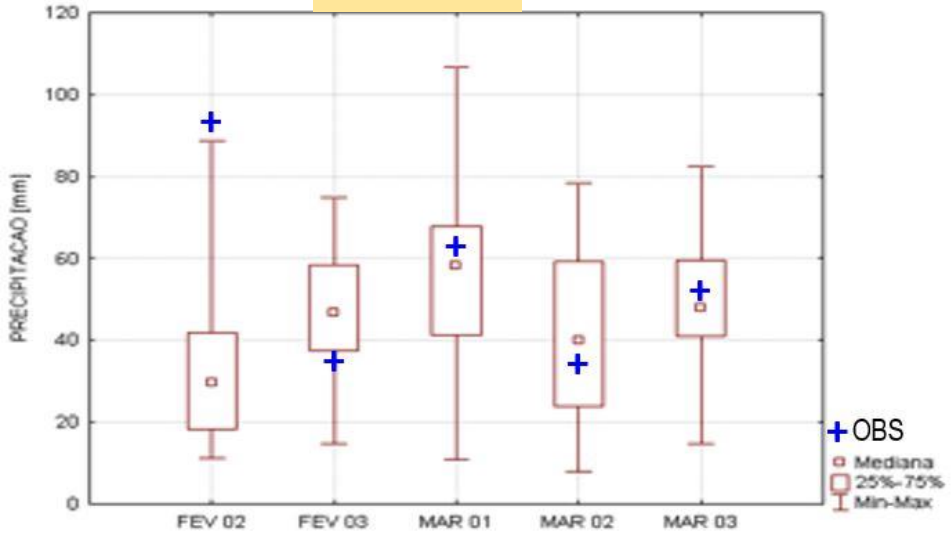
**ETA**

**PARANÁ**

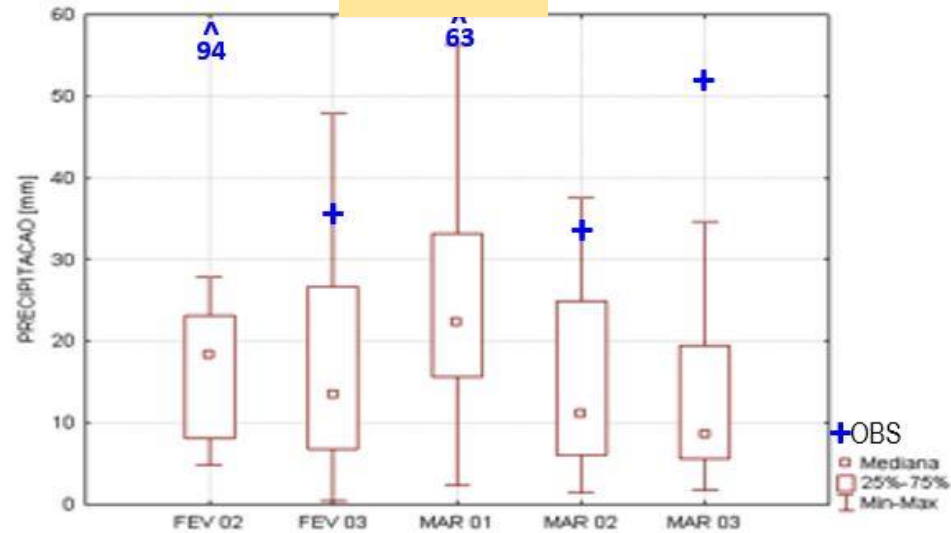
Feb-Mar

**CPTEC OAGCM**

**PARANÁ**

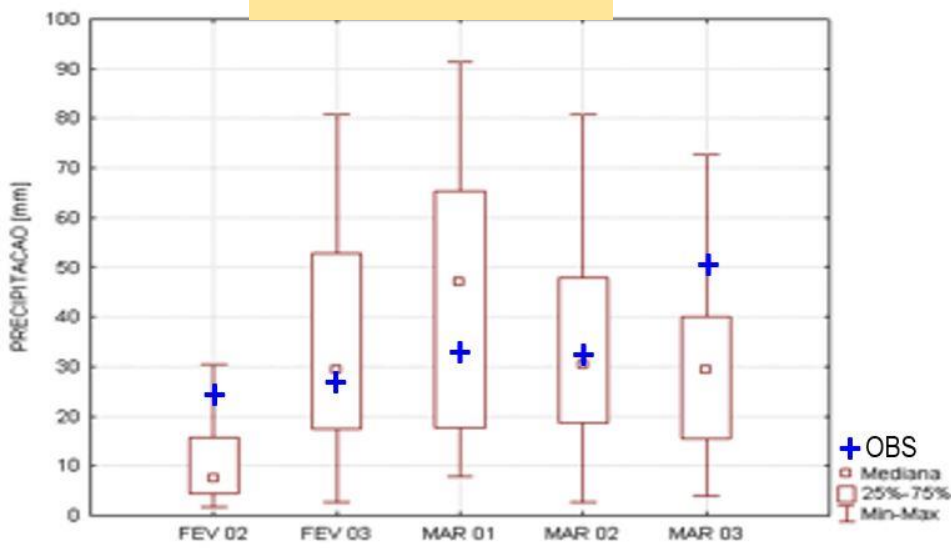


10d 20d 30d 40d 50d

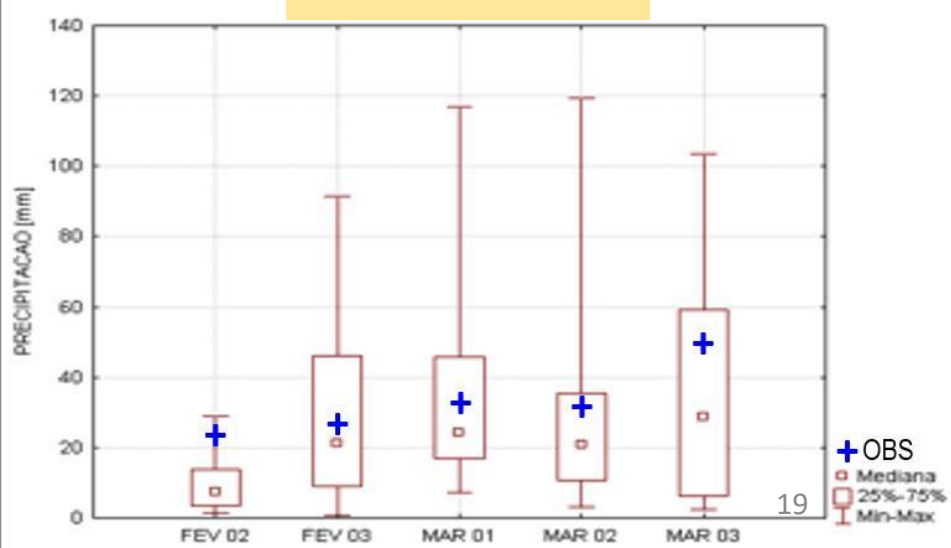


10d 20d 30d 40d 50d

**SÃO FRANCISCO**

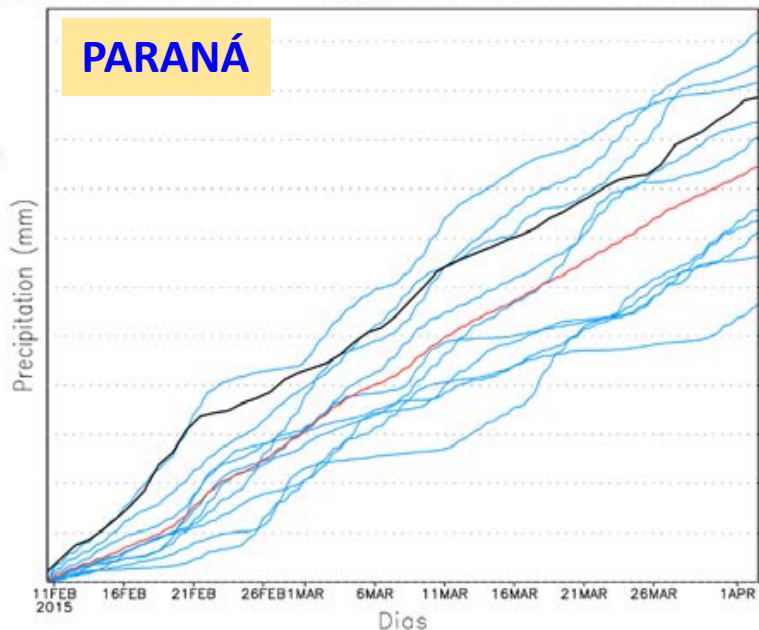


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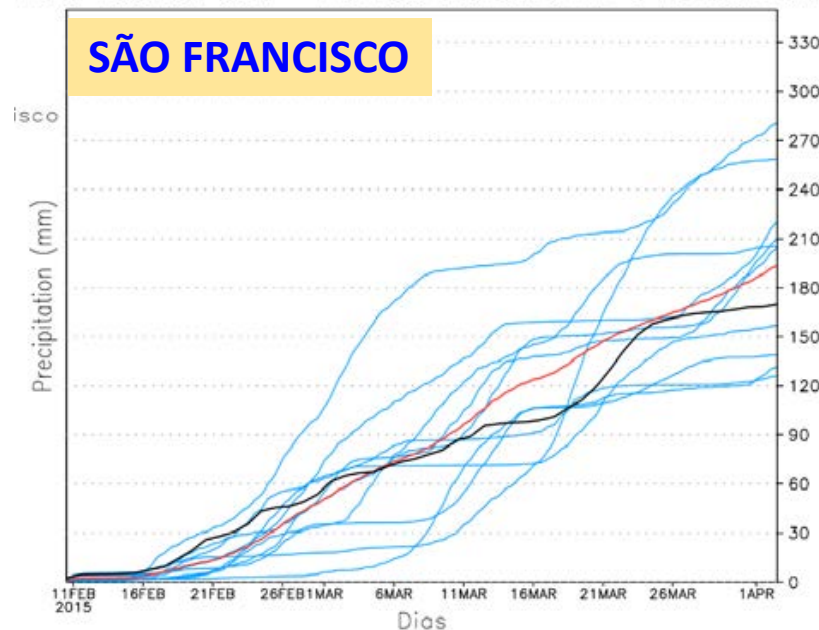


# Previsões para o horizonte de 50 dias

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



Membros 201502 01/02/.../09/10 12 CC: BESM  
 Prec. Acumul. 60d – Previsao 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

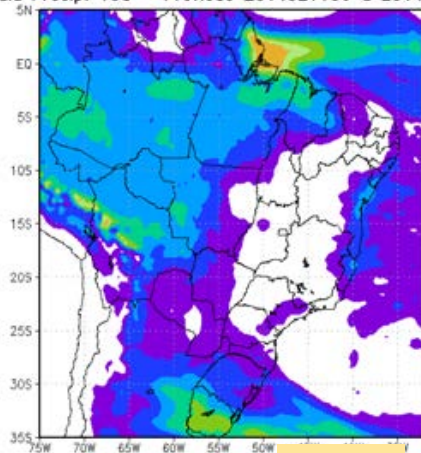
11-21/Feb2014

21/Feb-3/Mar2014

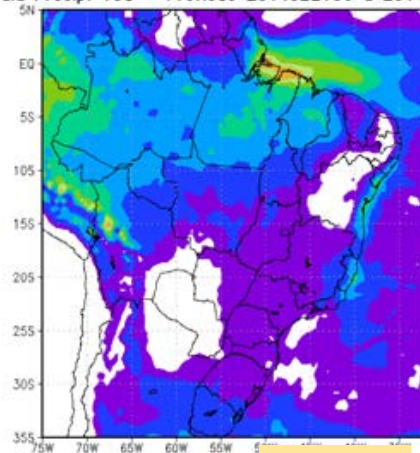
3-13/Mar2014

13-23/Mar2014

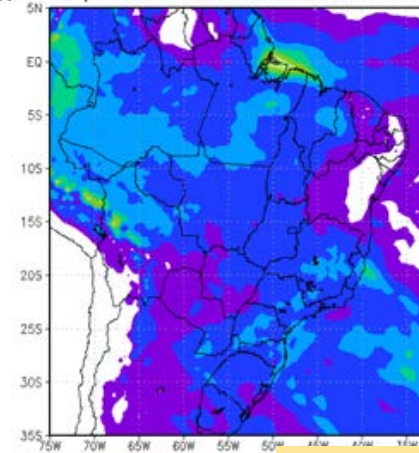
o Eta 40km, Media 201402 06/07/08/09 00 CC: OAO  
dia Precip. 10d - Previsao 2014021100 a 2014022100  
o Eta 40km, Media 201402 06/07/08/09 00 CC: OAO  
dia Precip. 10d - Previsao 2014022100 a 2014030300  
o Eta 40km, Media 201402 06/07/08/09 00 CC: OAO  
dia Precip. 10d - Previsao 2014030300 a 2014031300  
o Eta 40km, Media 201402 06/07/08/09 00 CC: OAGCM  
dia Precip. 10d - Previsao 2014031300 a 2014032300



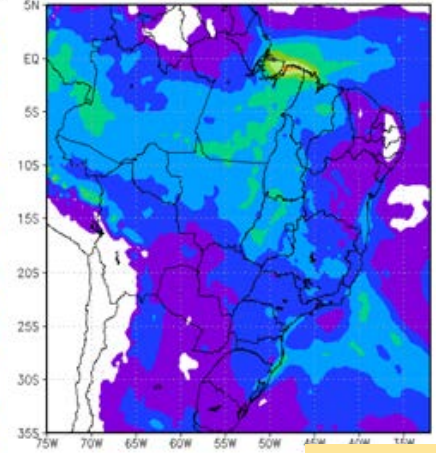
1-10



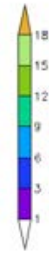
11-20



21-30



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:

**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

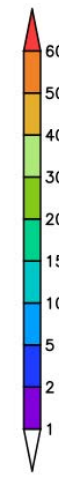
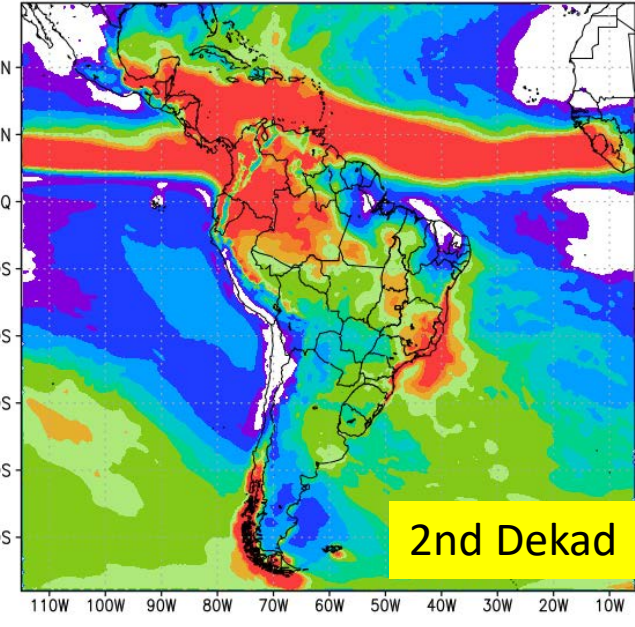
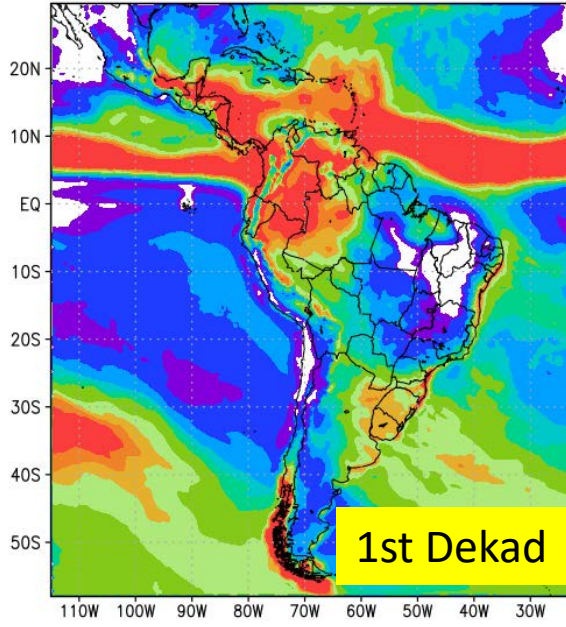
**Graduate Students:** Davi Moura, Diego Campos, Renata Calado, Joao Figueiredo, Pedro Regoto

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

**Apoio:** Marcele Dourado

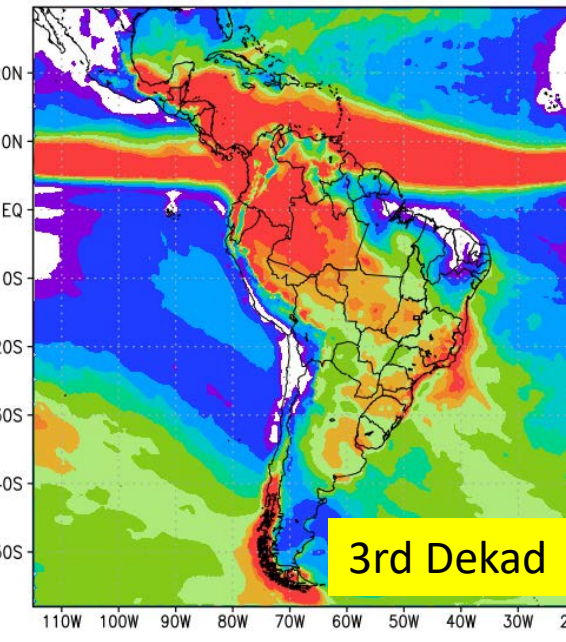
[chou.sinchan@gmail.com](mailto:chou.sinchan@gmail.com)

10d 20/09 a 29/09 (Media Clim 20 Membros) - Eta

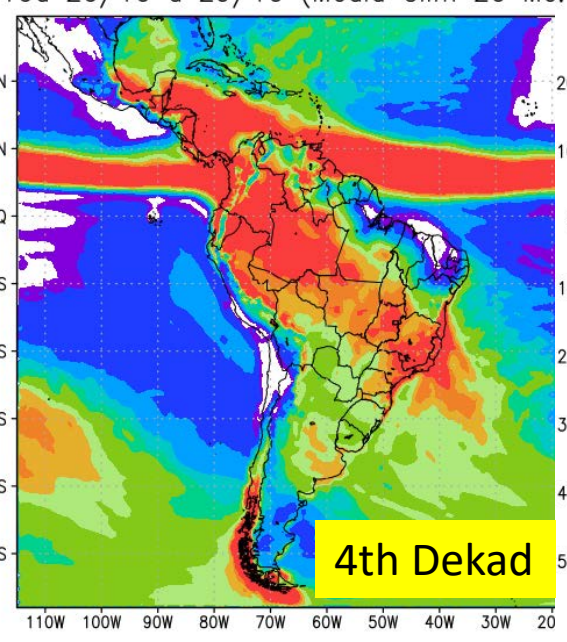


**Product to monitor  
the rainy season  
onset**

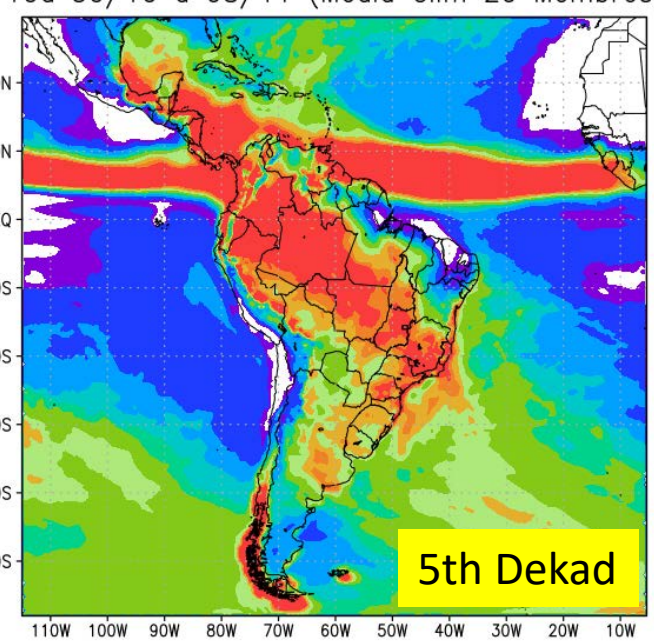
10d 10/10 a 19/10 (Media Clim 20 Membros) - Eta



10d 20/10 a 29/10 (Media Clim 20 Membros) - Eta



10d 30/10 a 08/11 (Media Clim 20 Membros) - Eta





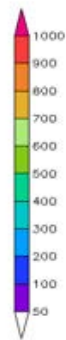
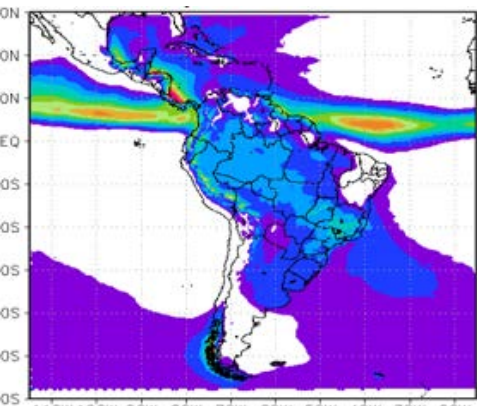
# \* Modelo Eta/INPE \*

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

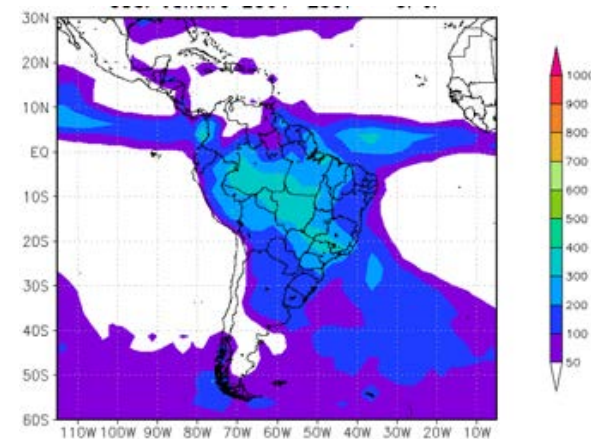
Previsão por ensemble: 9 membros

OBS

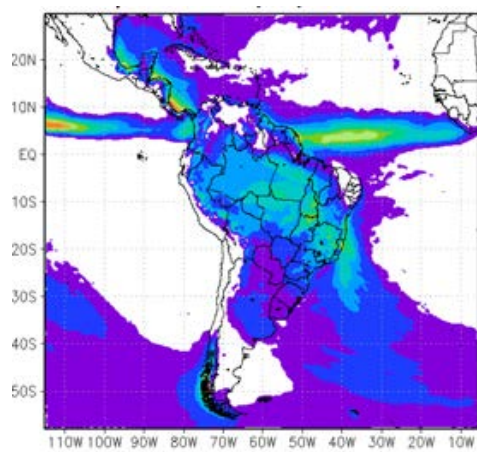
BMJ-Zhao-AGCM



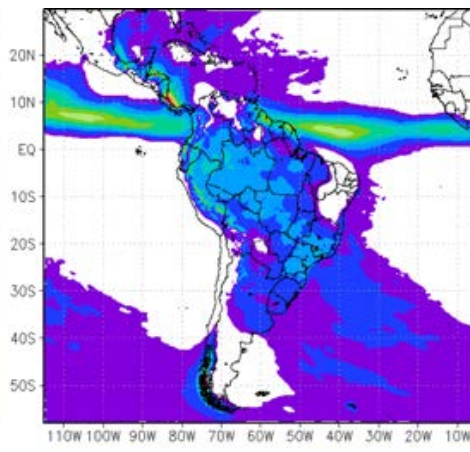
Média de 10 anos, 5 membros da previsão para JANEIRO, a partir de perturbação de condição inicial



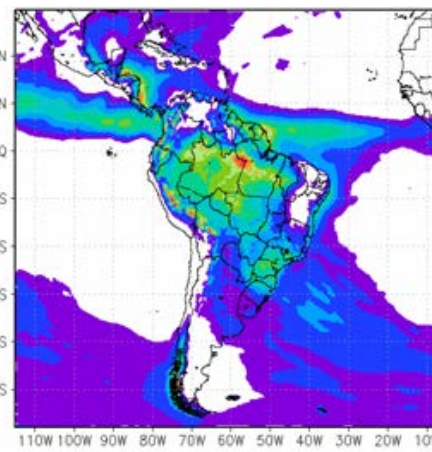
BMJ-Zhao-OGCM



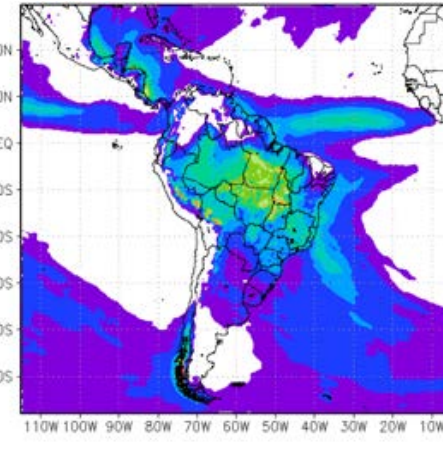
BMJ-FERR-AGCM



KF-FERRIER-AGCM



KF-FERRIER-OAGCM



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

