Studies with RegCM4:
Cyclones over South Atlantic and diurnal cycle of precipitation, new microphysics scheme and seasonal forecast over South America

Photo: Benedito Silva

Team:

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Julio Pablo R. Fernandez

Marta Llopart

Lívia M. M. Dutra

Marcelo Rodrigues

Rosmeri P. da Rocha

Cyclones over the Southwestern South Atlantic Ocean

The purpose of this study:

→ to project the cyclones climatology over the Southwestern South Atlantic Ocean (SAO)

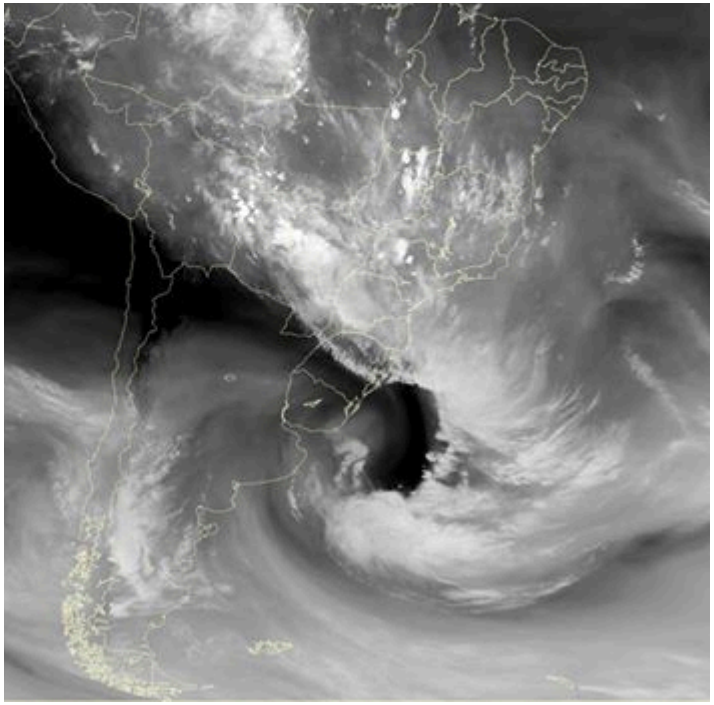
→ Regional Climate Model (RegCM4) nested in HadGEM2-ES

→ present: 1979-2005

→ two time-slices: 2020-2050 and 2070-2098

→ RCP8.5

22-11-2014 15 UTC



Methodology

Simulation Design

Horizontal resolution: 50 km

Vertical levels: 18

Boundaries: HadGEM2-ES

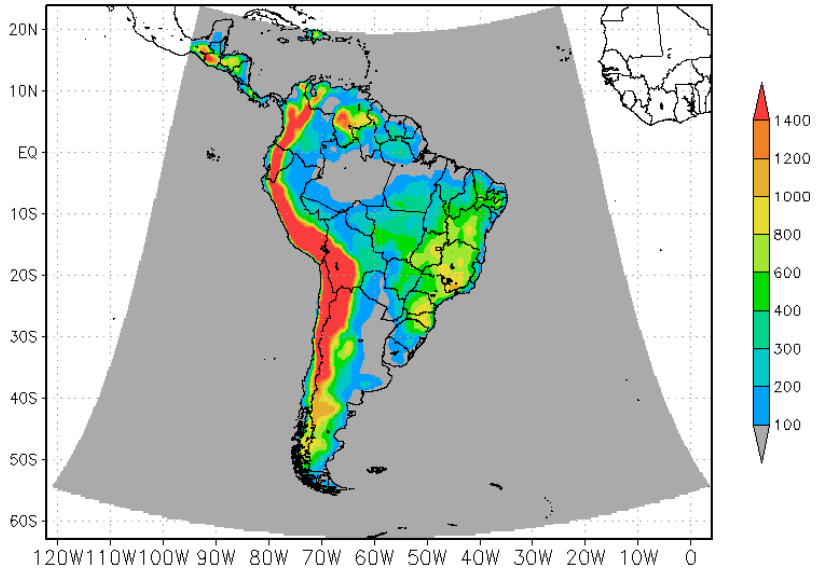
Simulated period: 1970 a 2098

Domain: suggested by CORDEX project

Ocean Fluxes Param.: Zeng et al. (1998)

Surface-atmosphere interaction: BATS

Cumulus convection: *Mixed* 1
(Grell over the continent and Emanuel over the ocean).



Domain and topography of simulation.

Studied Periods	
Present	**RCP8.5**
1979-2005	2020-2050
	2070-2098

More details of this simulation in da Rocha et al. (2014) Climate Research

Methodology

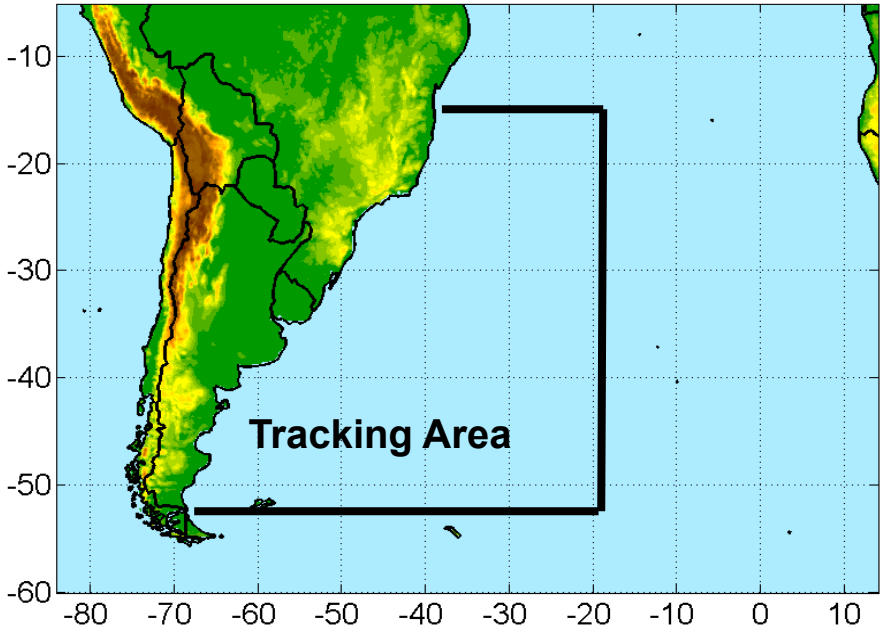
Cyclones Tracking Algorithm

Based on: Sugahara (2000) and Reboita et al. (2010)

It searches by minima of wind relative vorticity (nearest neighborhood method) at 925 hPa

Cyclones selected to climatology:

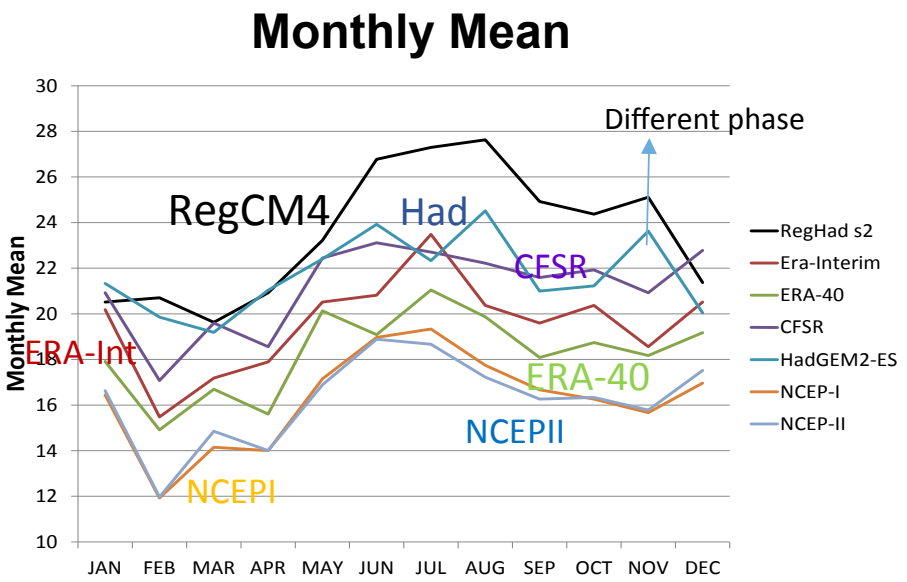
Lifetime ≥ 24 hours
Initial relative vorticity ≤ 1.5 x 10^{-5} s^{-1} and with genesis over SAO

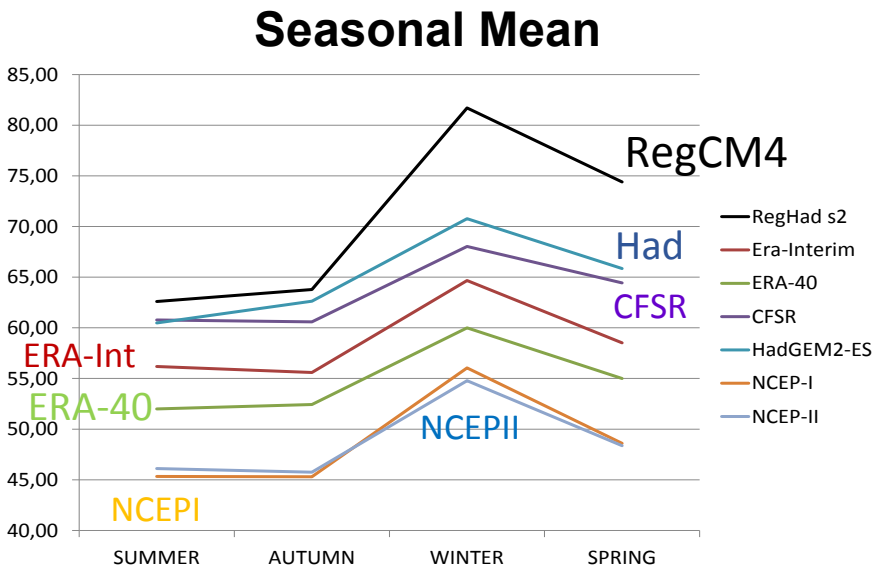


Some works that used this algorithm Reboita et al. (2010); Krüger et al. (2012); Gozzo et al. (2014)

Results

Monthly and Seasonal Mean of Cyclones over SAO Present Climate





All dataset have the same resolution (1.5º x 1.5º)

Winter is the season more cyclogenetic.
The cyclones frequency is higher in ECMWF than NCEP reanalysis.
RegCM4 overestimates the reanalysis.

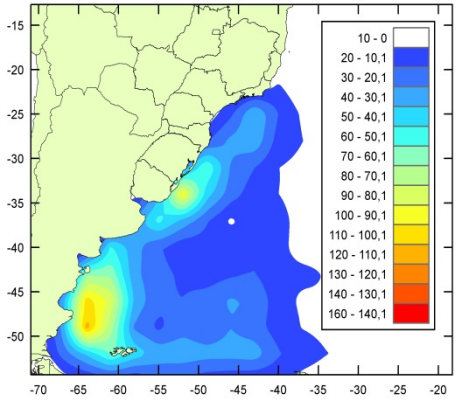
Results

Annual Mean Cyclogenesis Density in the Present Climate

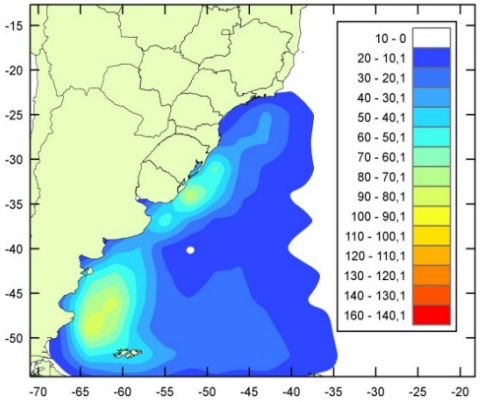
Total of systems in boxes of 3ºx3º and the results divided by the boxes area.

D=(number of systems/km^2)10^6

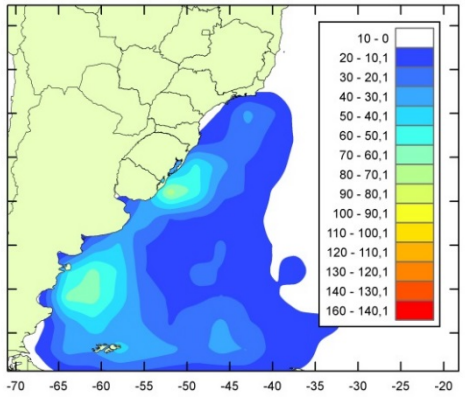
ERA-Interim



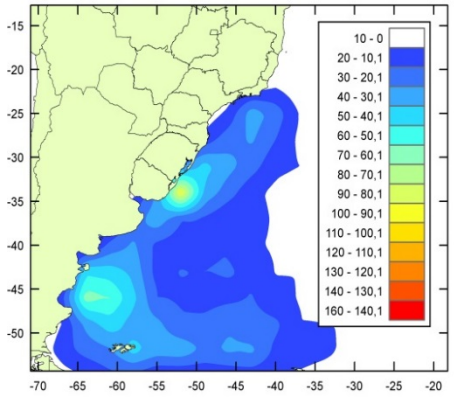
ERA-40



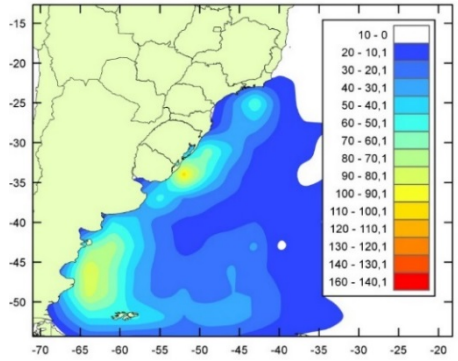
NCEP-1



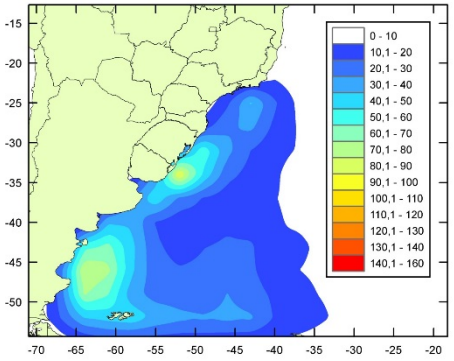
NCEP-2



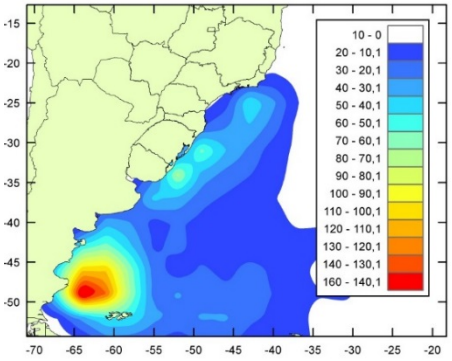
CFSR



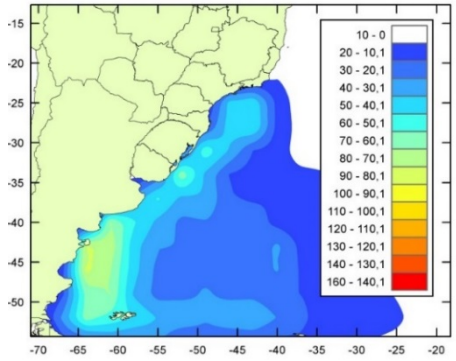
Ensemble Reanal.



HadGEM2-ES



RegCM4



Results

Annual Mean Cyclogenesis Density in the Present Climate

Total of systems in boxes of 3ºx3º and the results divided by the boxes area.

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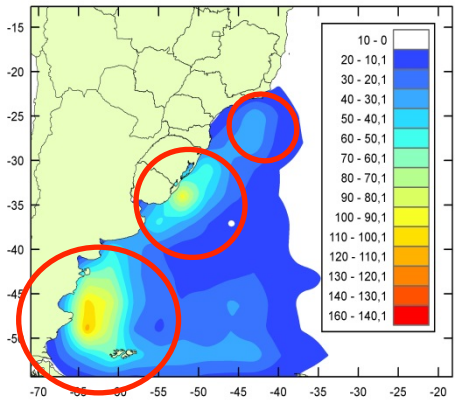
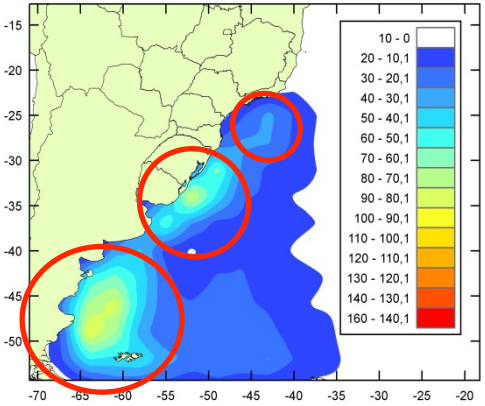
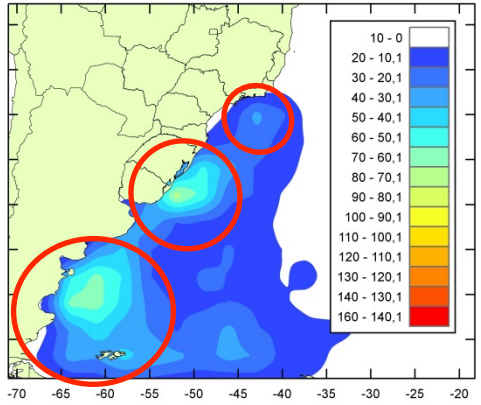


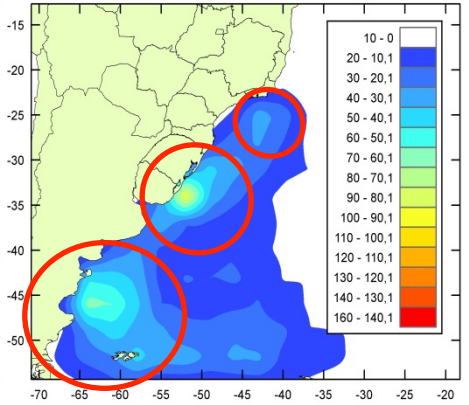
ERA-40



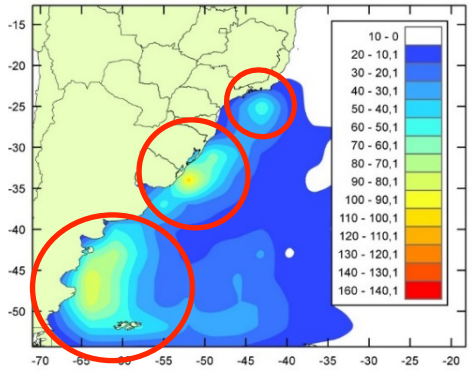
NCEP-1



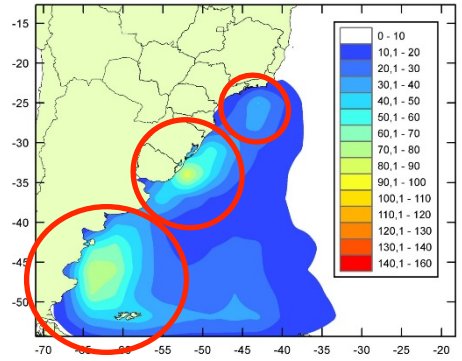
NCEP-2



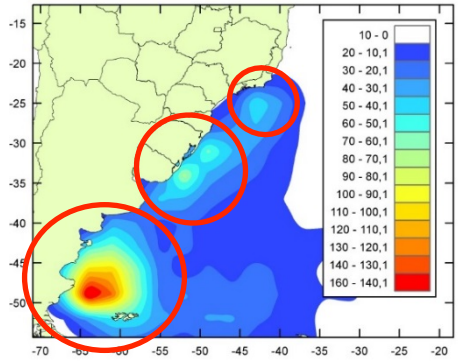
CFSR



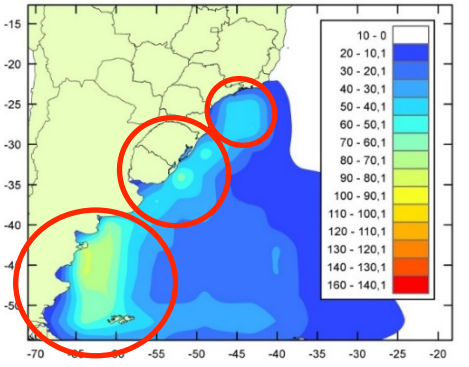
Ensemble Reanal.



HadGEM2-ES



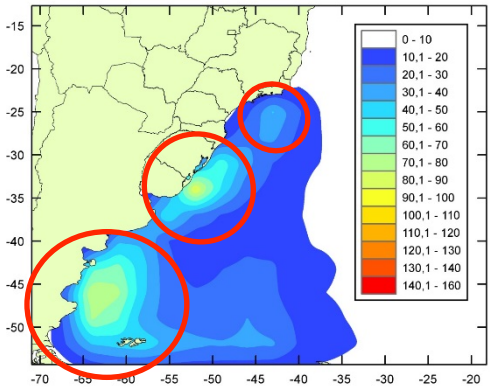
RegCM4



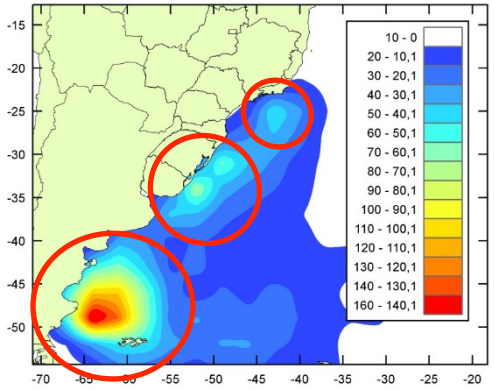
All datasets present three cyclogenetic regions near eastern coast of South America

Results

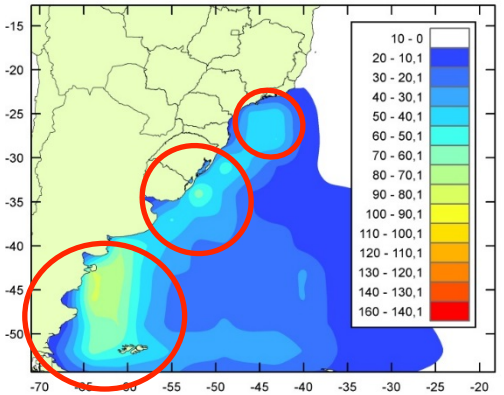
Ensemble Reanal.



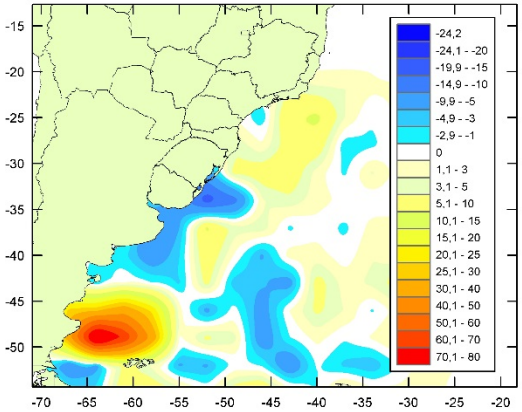
HadGEM2-ES



RegCM4

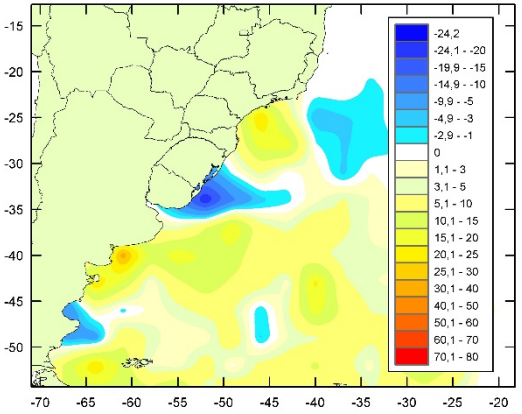


HadGEM2 - Ensemble



→ HadGEM2-ES overestimates the cyclones density near southern Argentina

RegCM4 - Ensemble

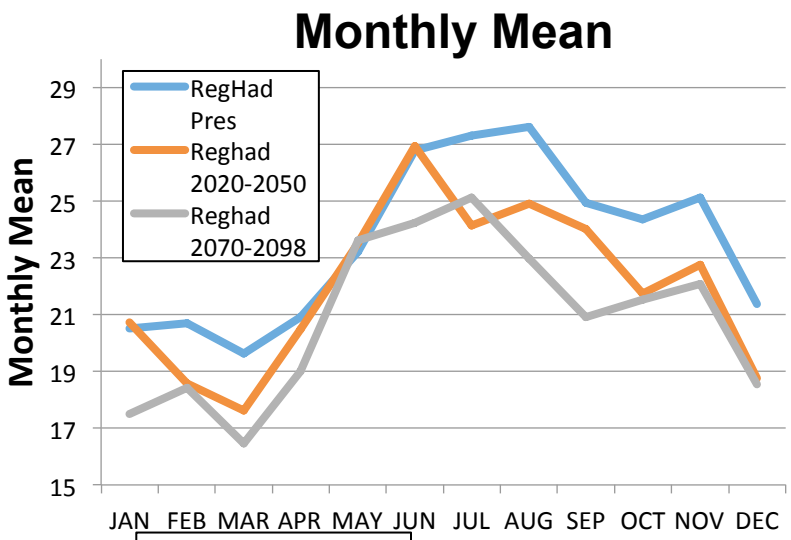


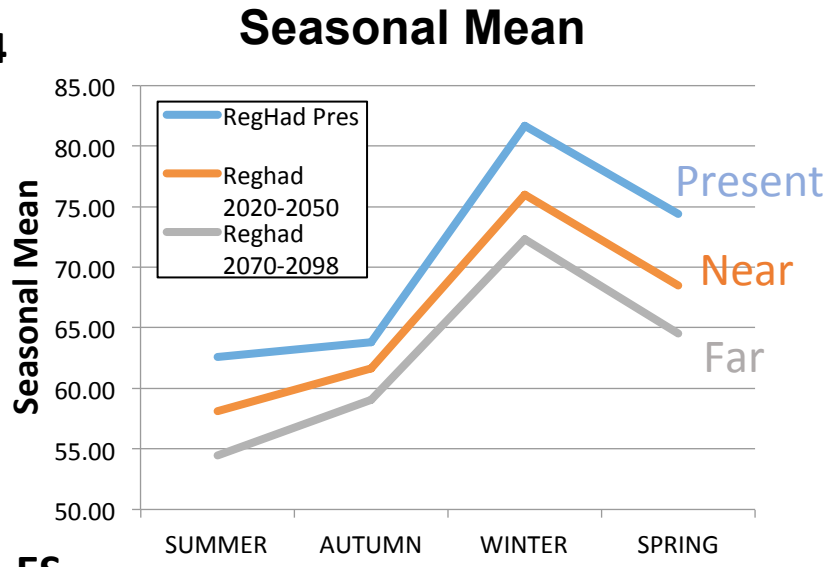
→ In RegCM4 the overestimates are distributed over the South Atlantic.

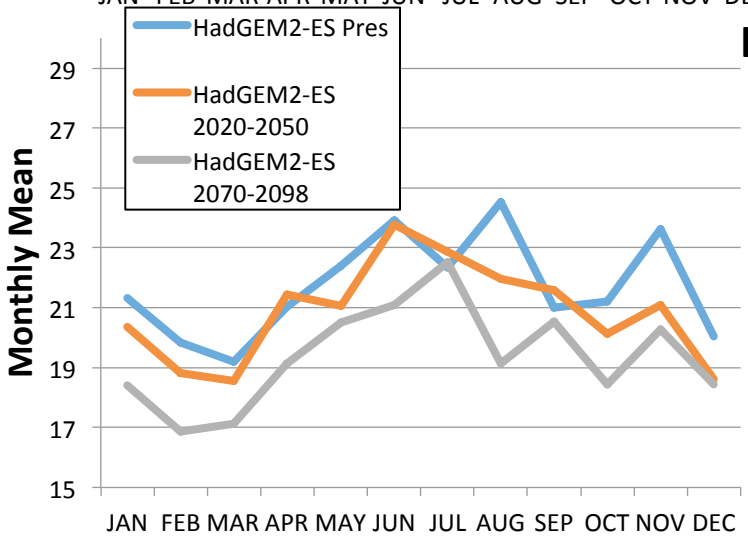
→ Near Uruguay and southern Brazil there is underestimate.

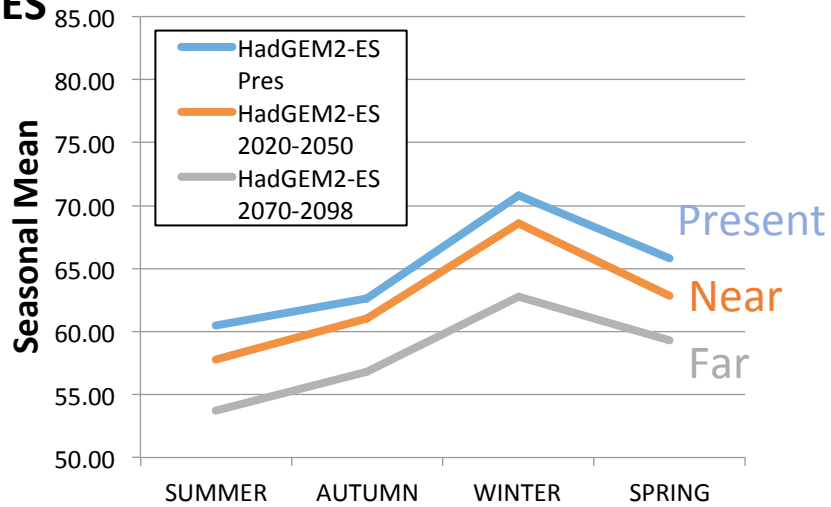
Results

Monthly and Seasonal Mean of Cyclones over SAO Future Climate









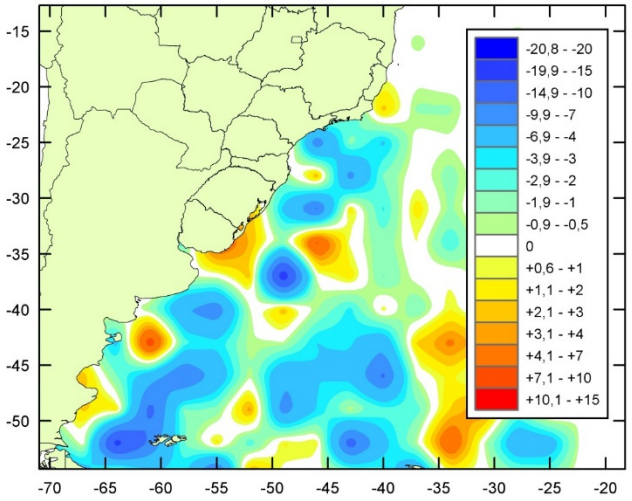
Results

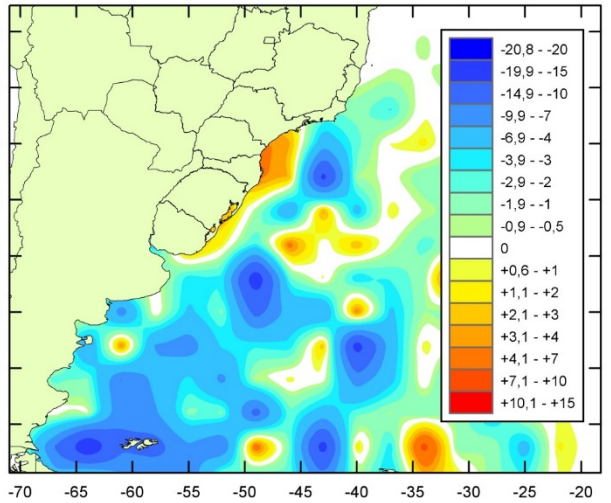
Annual Cyclogenesis Density: Future minus Present Climate

(2020 to 2050) – (1979 to 2005)

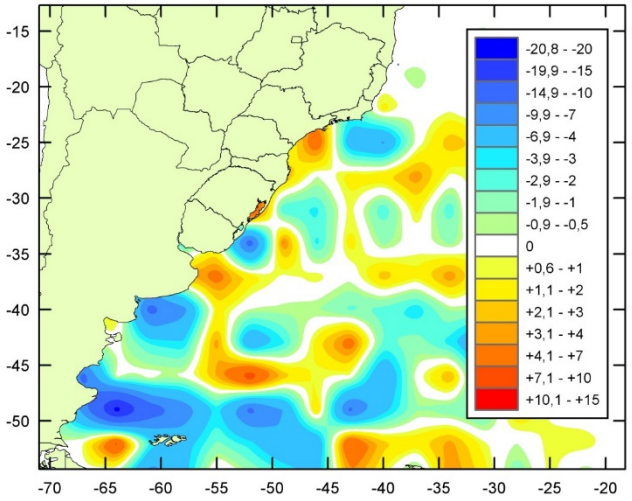
(2070 to 2098) – (1979 to 2005)

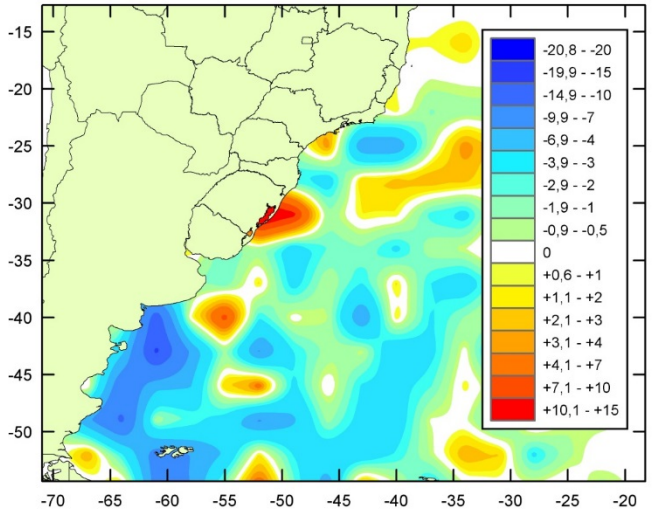
RegCM4





HadGEM2-ES





Conclusions

Main conclusions:

- all datasets show three cyclogenetic regions near eastern coast of South America
- RegCM4 overestimates the number of cyclones due to the higher number simulated away from the coast.
- the annual cycle amplitude is higher in RegCM4 than HadGEM2-ES
- both models projected a reduction in the frequency of cyclones over Southwestern South Atlantic Ocean.
- this reduction will be higher in the far future than in the near future.
- Does RegCM4 add value in simulation compared with HadGEM2-ES?

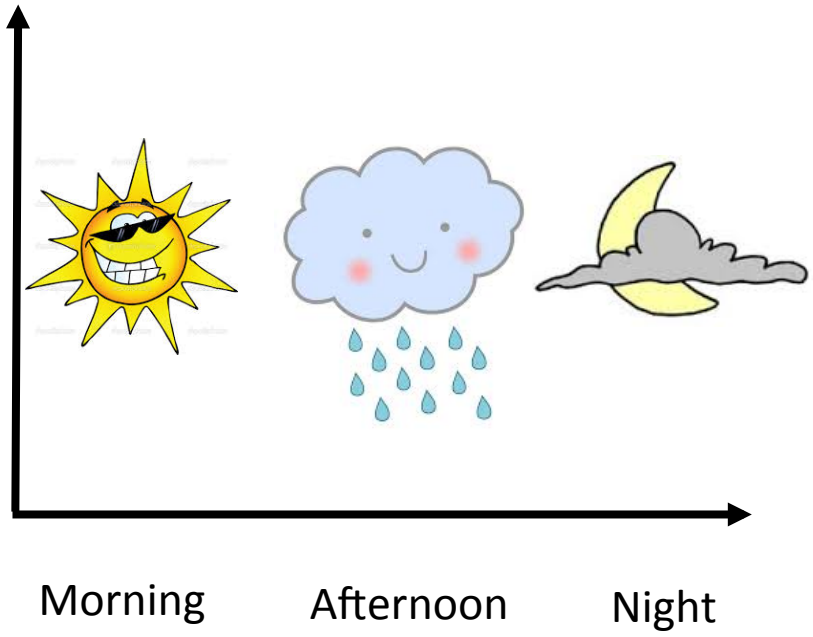
Diurnal Cycle

Diurnal Cycle of Precipitation in South America during DJF

DCP

- da Rocha et al. (2009) evaluated the DCP over South America simulated wih RegCM3

- Now, we are interested in evaluating the performance of RegCM4 nested in HadGEM2-ES.



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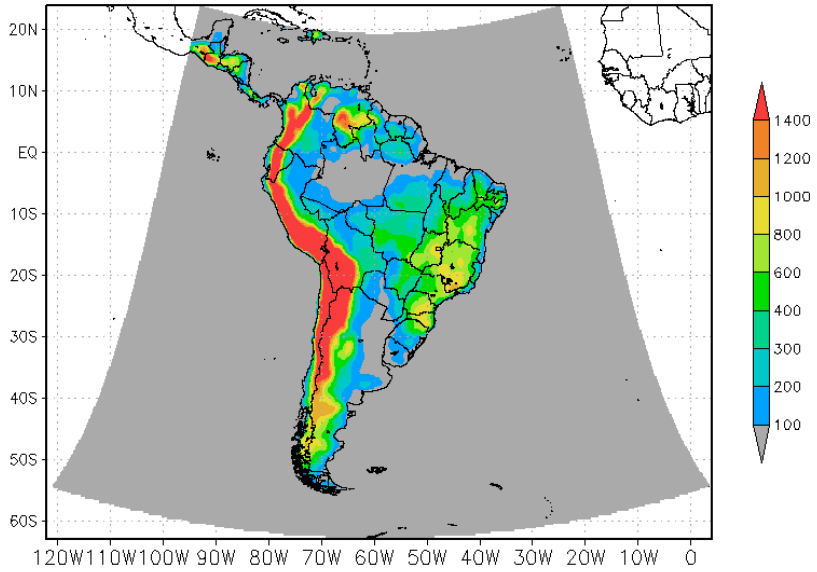


Domain and topography of simulation.

Studied Periods	
Present	**RCP8.5**
1998-2005	2020-2050
	2070-2098

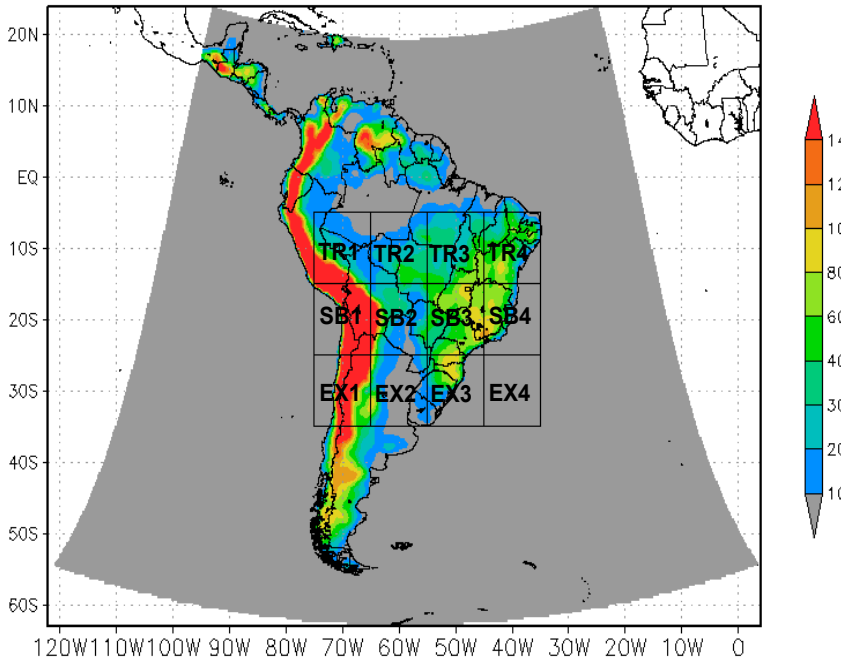
More details of this simulation in da Rocha et al. (2014) Climate Research

Methodology

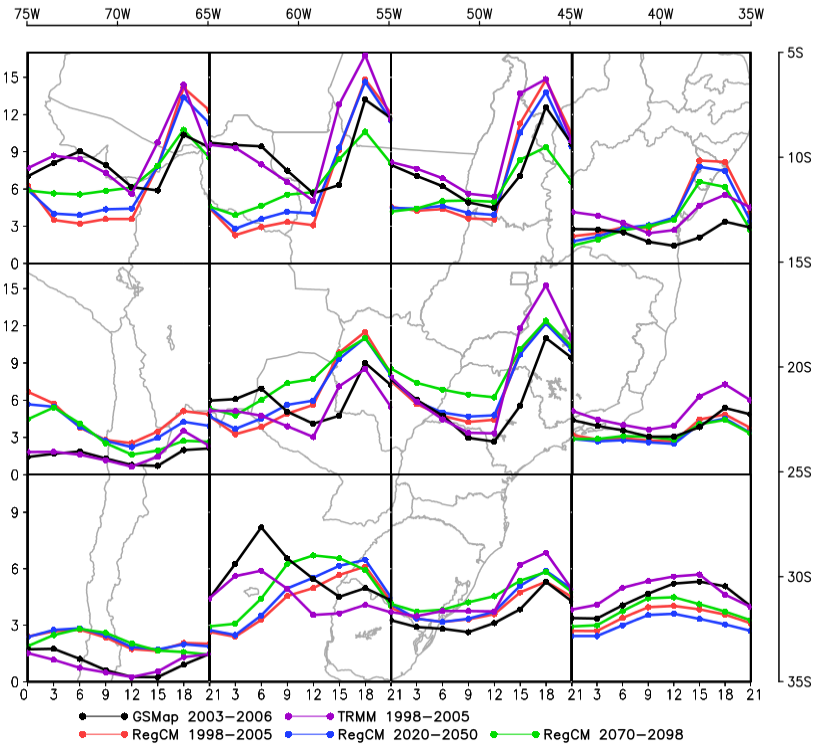
We assessed the **DCP** in 12 subdomains over South America (as in da Rocha et al. 2009) during DJF.

Present simulation was compared with GSMaP and TRMM-3B42.

Gray – domain of simulation



DJF

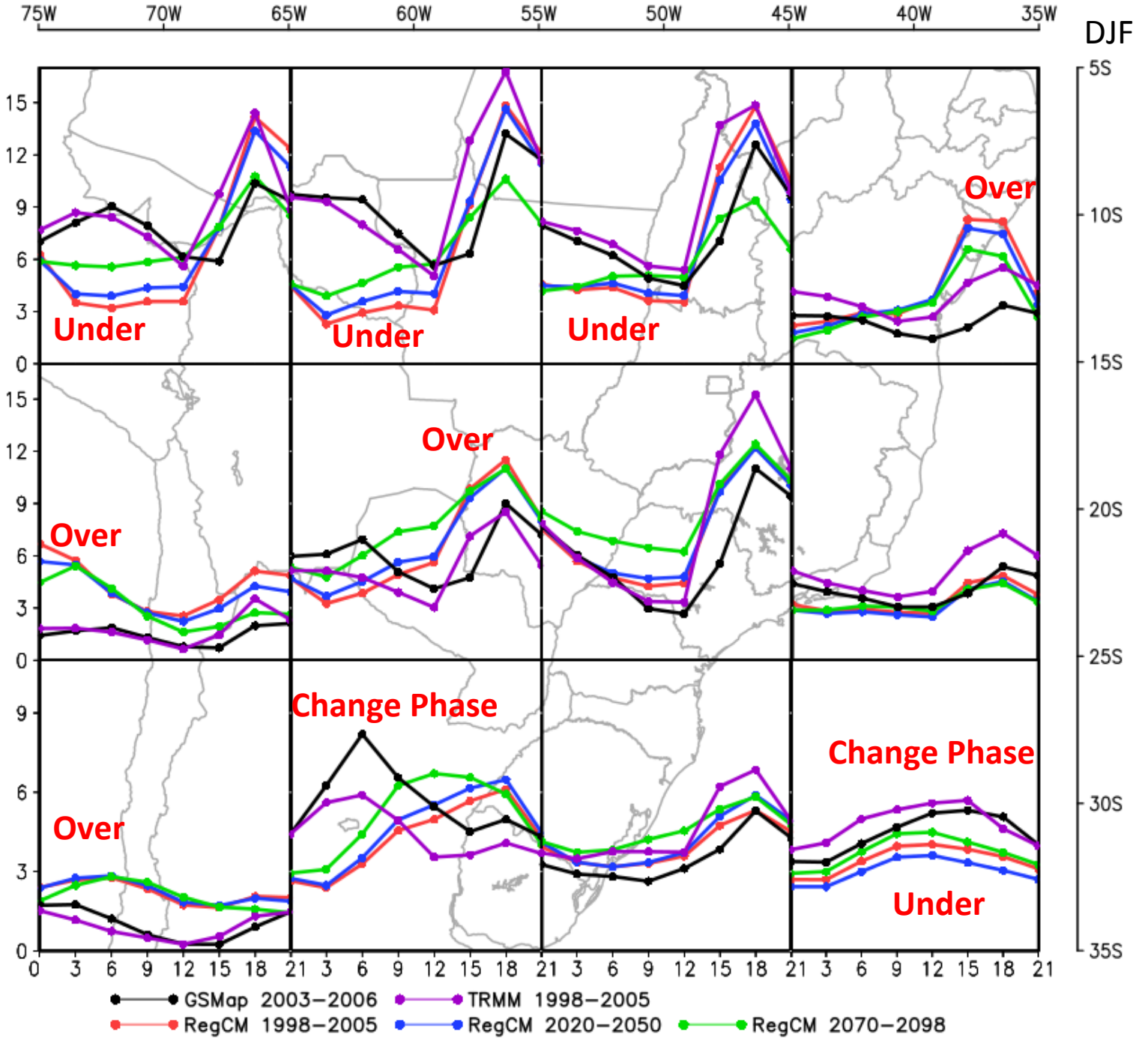


Assessing the present

GSMaP

TRMM

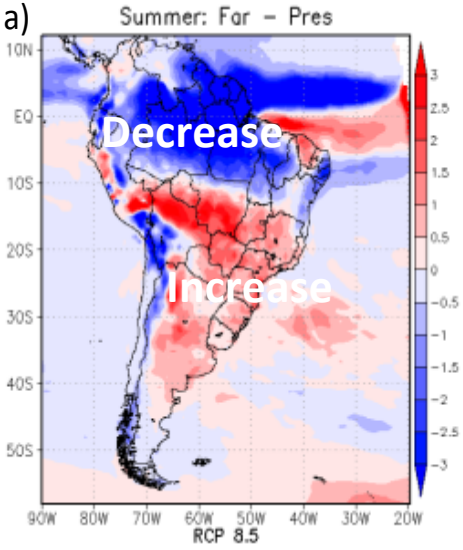
Simulation RegCM4 nested in HadGEM2-ES 1998-2006

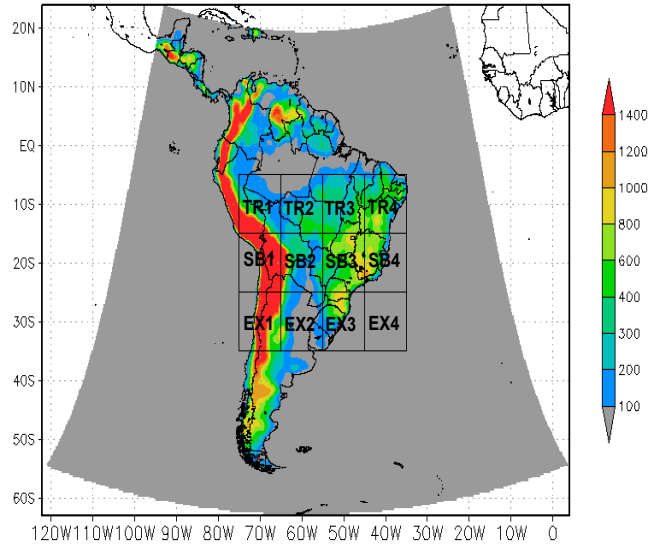


Precipitation DJF

Far Future - Present

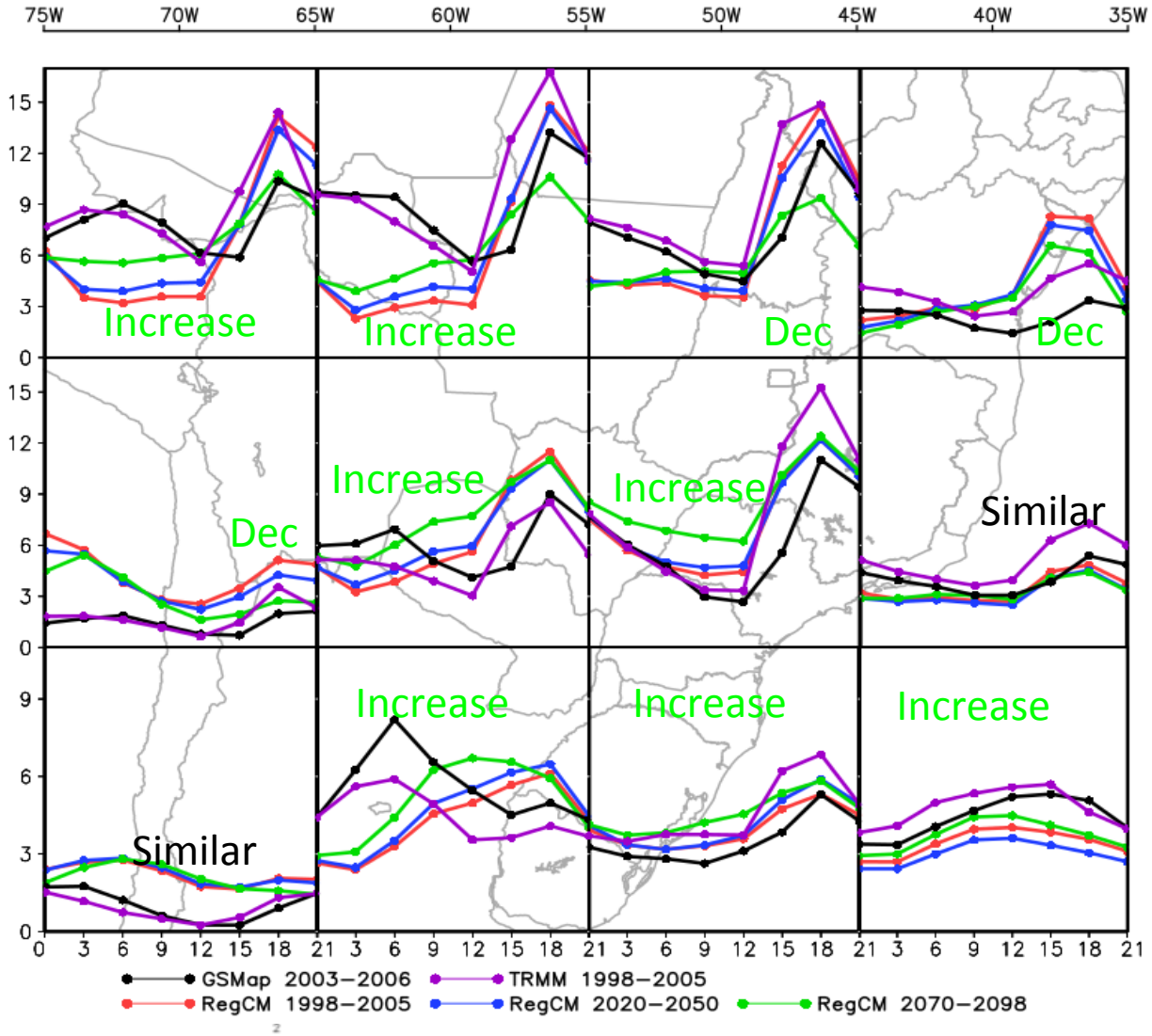
a)





DJF

Comparing the far future with present



Conclusions

Main conclusions:

- Over tropical and subtropical subdomains, the model simulates correctly the hour with maximum precipitation that is 18 UTC.

- RegCM4 underestimates the precipitation in tropical subdomain mainly between 03 and 12 UTC

- Far future: to this period is projected increase of precipitation, mainly between 00 and 12 UTC

New Microphysics

Assessing the performance of the new cloud microphysics scheme in simulating the South America climate

In 2014 RegCM workshop, we assessed the new cloud microphysics scheme over South America with only one month.
Now, we extended the simulations to 3-years.

Ctrl simulation = Subex and 10 experiments

kautoconv autoconversion paramaterization	**vqrx** Rain fall speed		
	2	**4**	**6**
1 Klein & Pincus (2000)	X	√	X
2 Khairoutdinov and Kogan (2000)	√	√	√
3 Kessler (1969)	√	√	√
4 Sundqvist	√	√ default	√

X simulation stopped

(New cloud microphysics - Nogherotto et al. 2016)

Design of the Simulations

Model Version: RegCM4.4.5.10

Domain: CORDEX

Grid Points: 202 latitudes x 192 longitudes

Projection: Rotated Mercator

Horizontal Resolution: 50 km

Temporal Resolution: 120 s

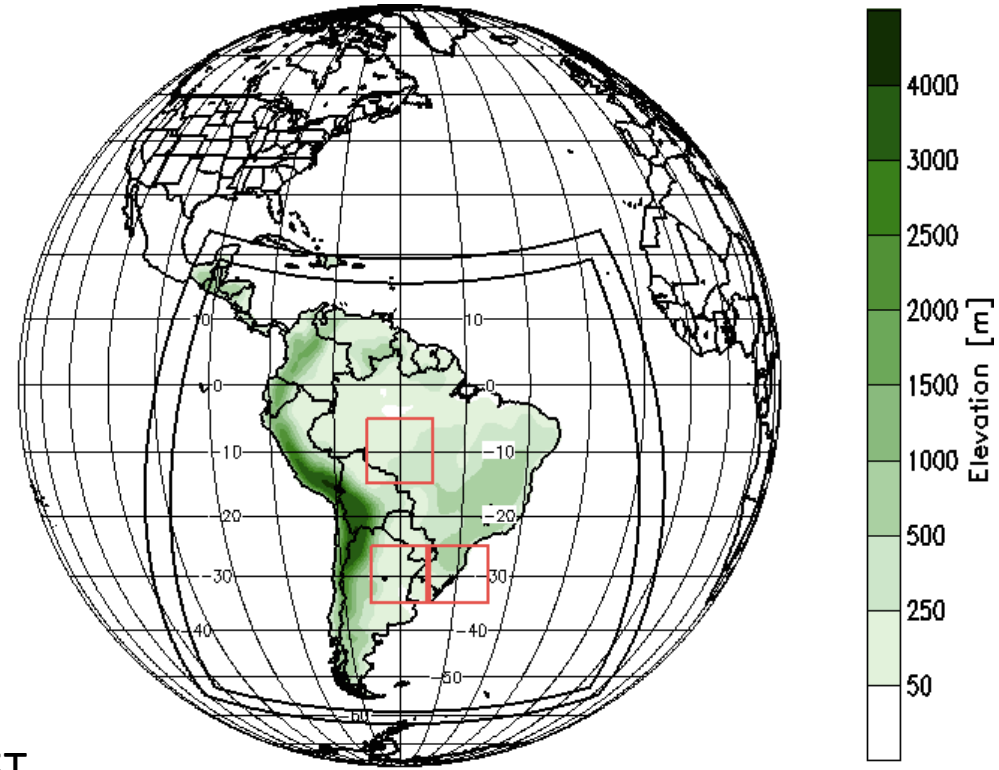
Vertical Levels: 18

Boundary Conditions: ERA-Interim and ERSST

Period: 01/01/1997 – 01/02/2000

Convection Scheme: Grell (land) and Emanuel (ocean)

Ocean Fluxes: Zeng et al. (1998) ; **LSM:** BATS; **PBL**: Holtslag; **RAD**: CCM3



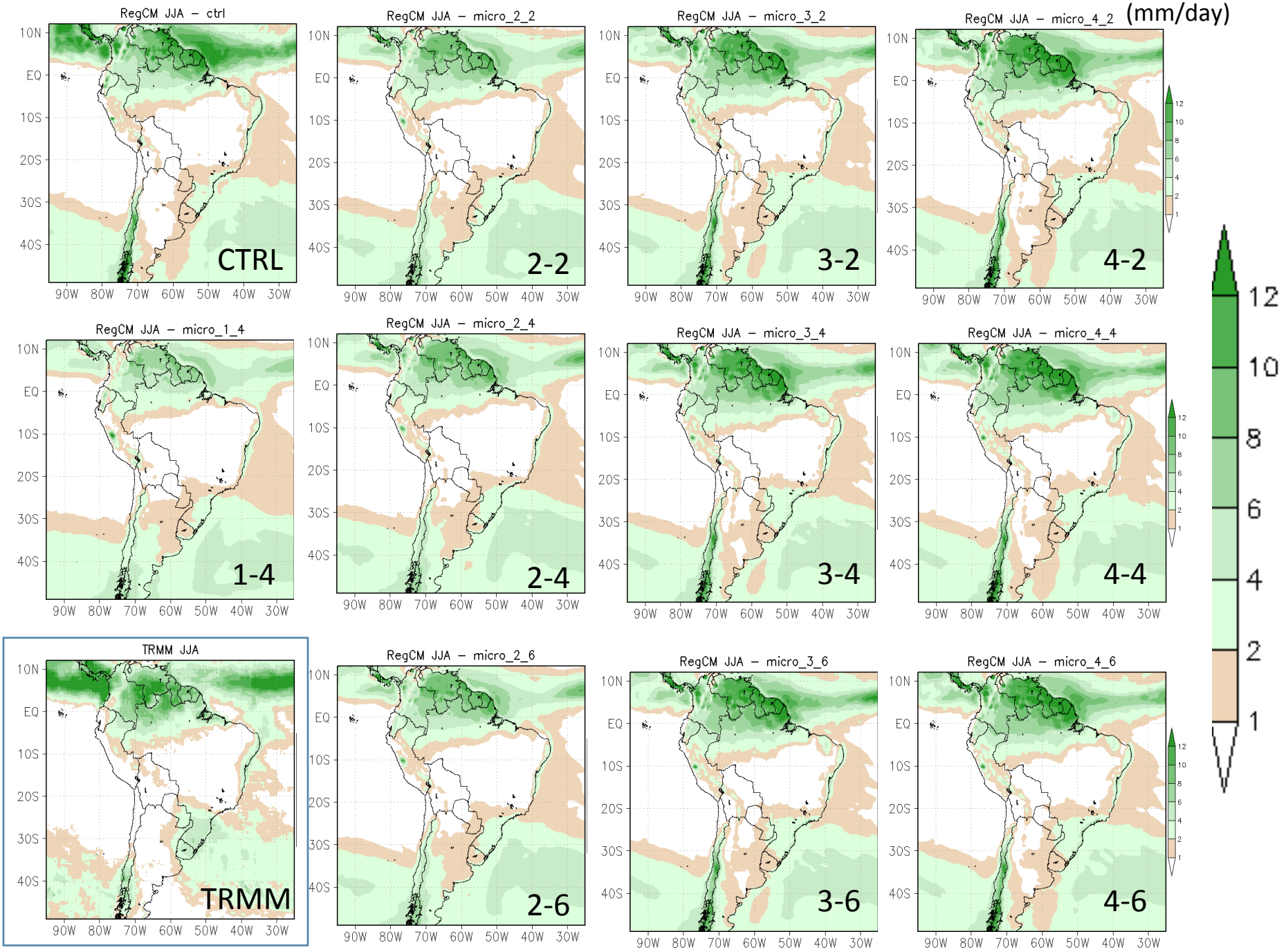
Domain model simulation and topography

Results

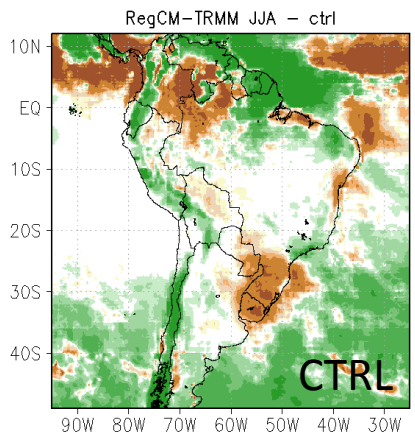
I will show only the austral winter (JJA) for brevity.

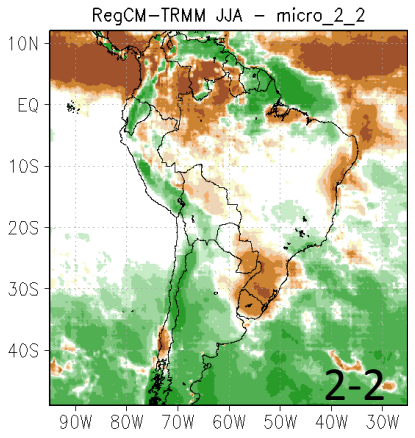
- Precipitation average
- Bias
- % of large scale precipitation

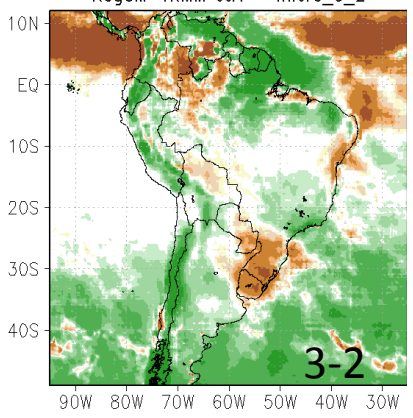
JJA precipitation (mm/day)

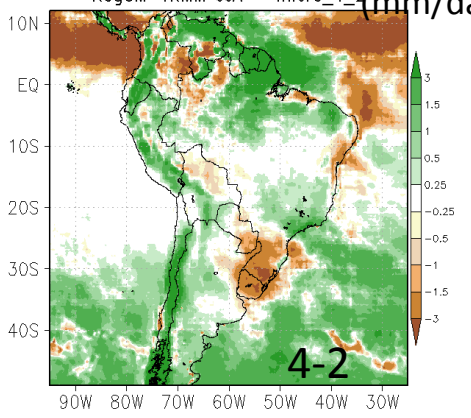


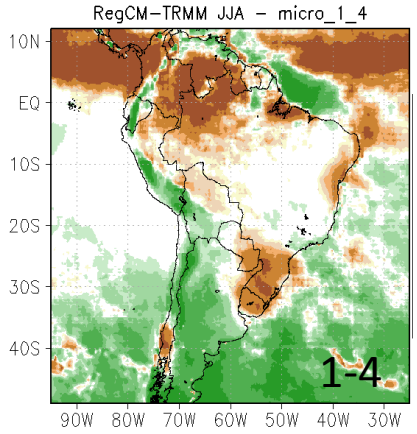
RegCM - TRMM (mm/day)

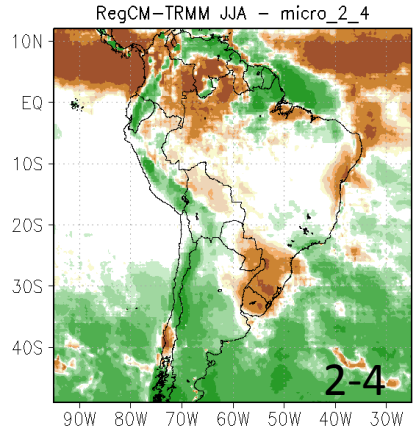


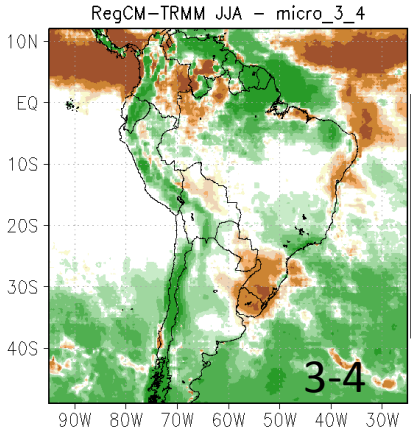


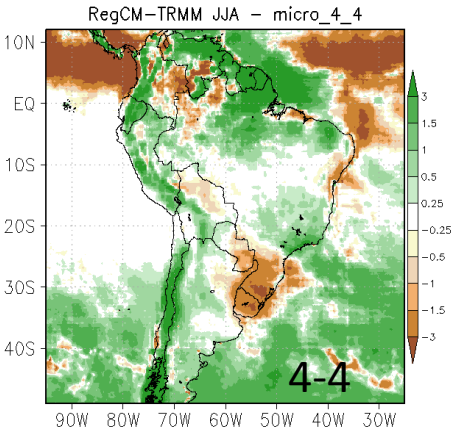


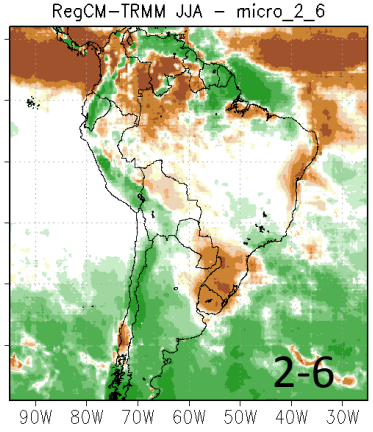


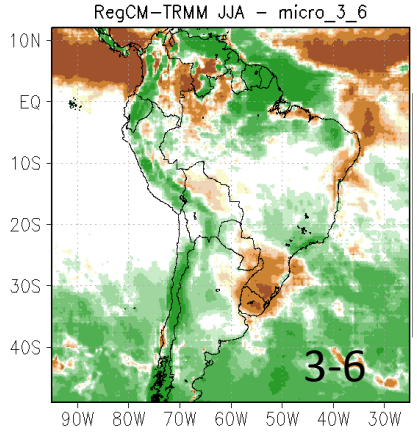


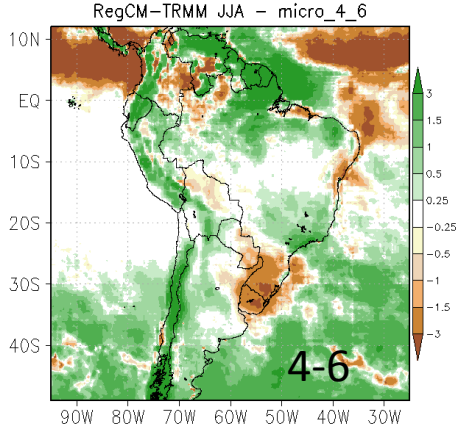


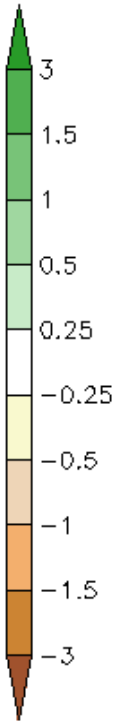








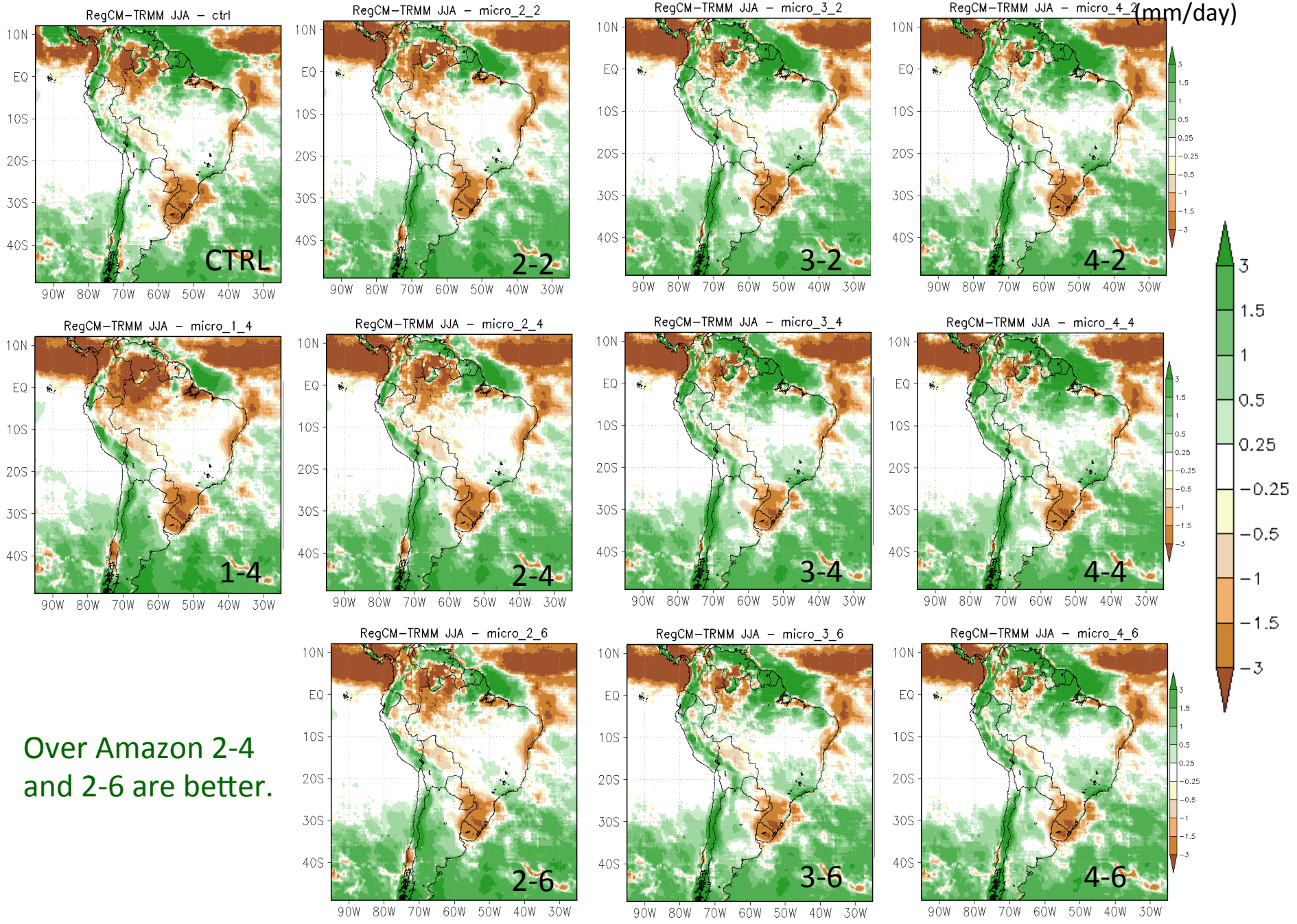




Over southeastern and northeastern Brazil the configuration k=1 and vqrx=4 is better.

Default (4-4) has positive biases.

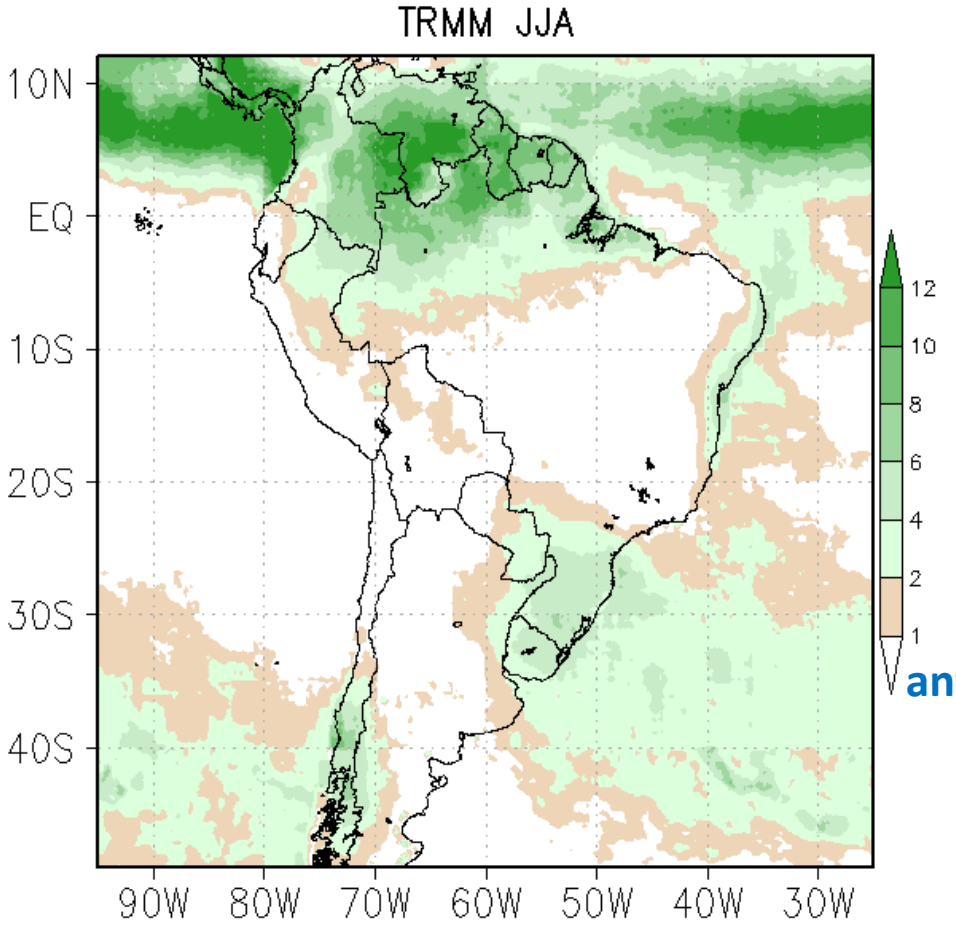
RegCM - TRMM (mm/day)

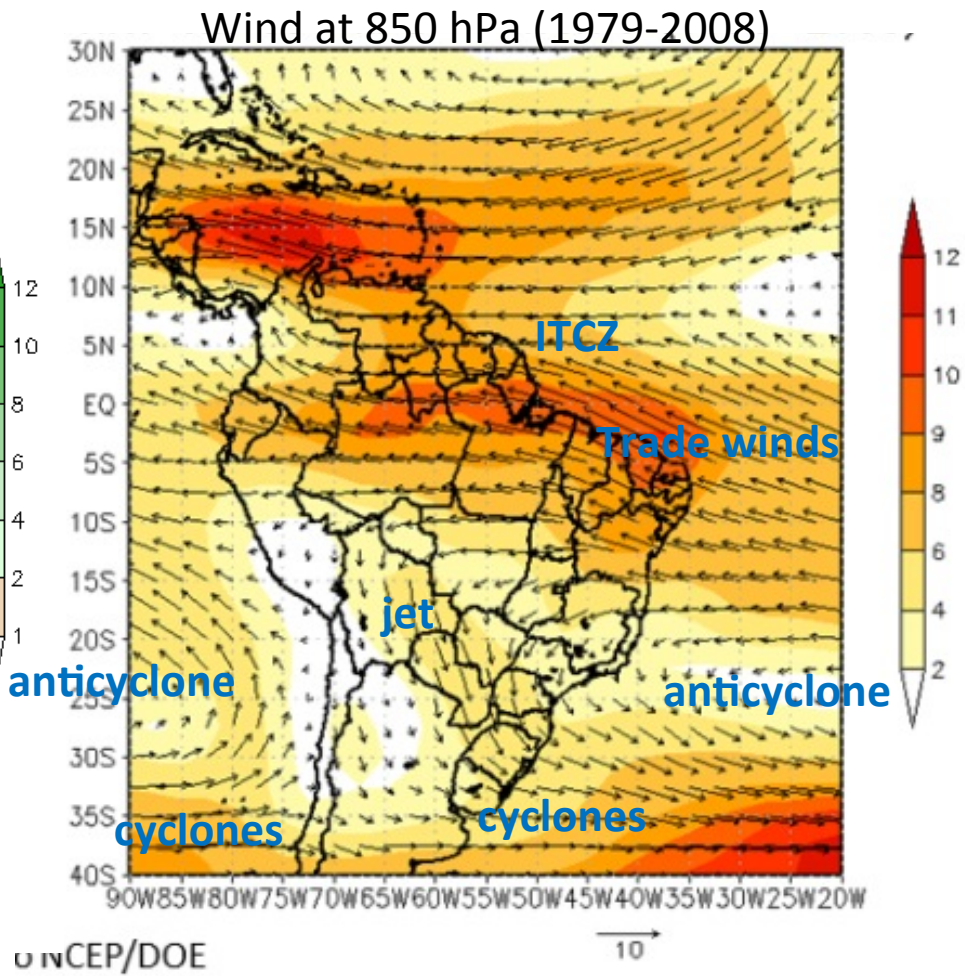


Over Amazon 2-4 and 2-6 are better.

Understanding the precipitation partition ...

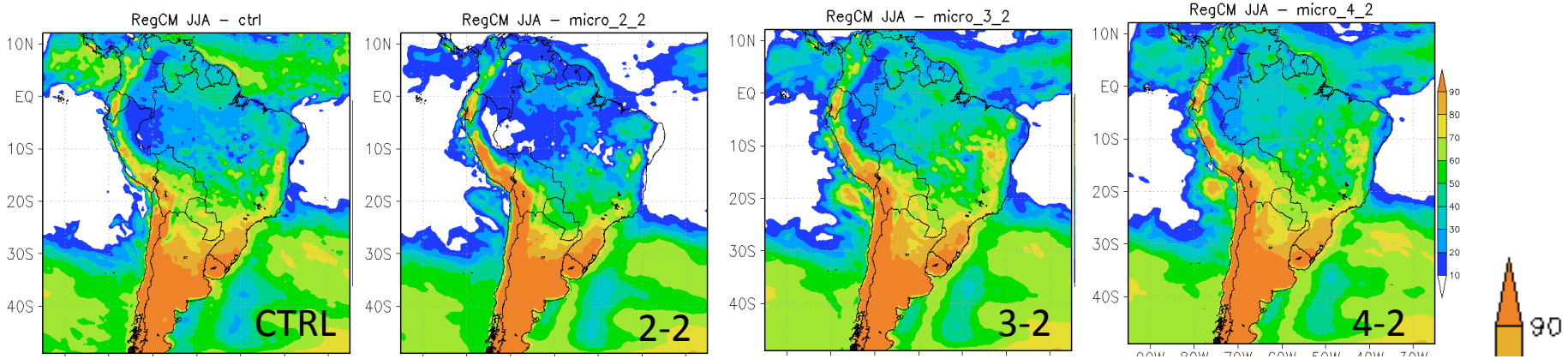
In whole South America precipitation has contribution from convective and large scale



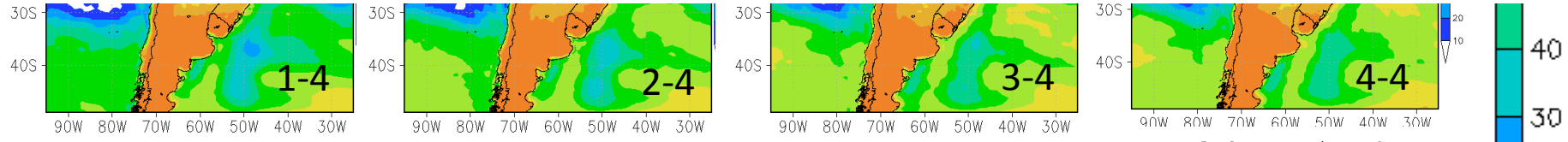


Reboita et al. 2012

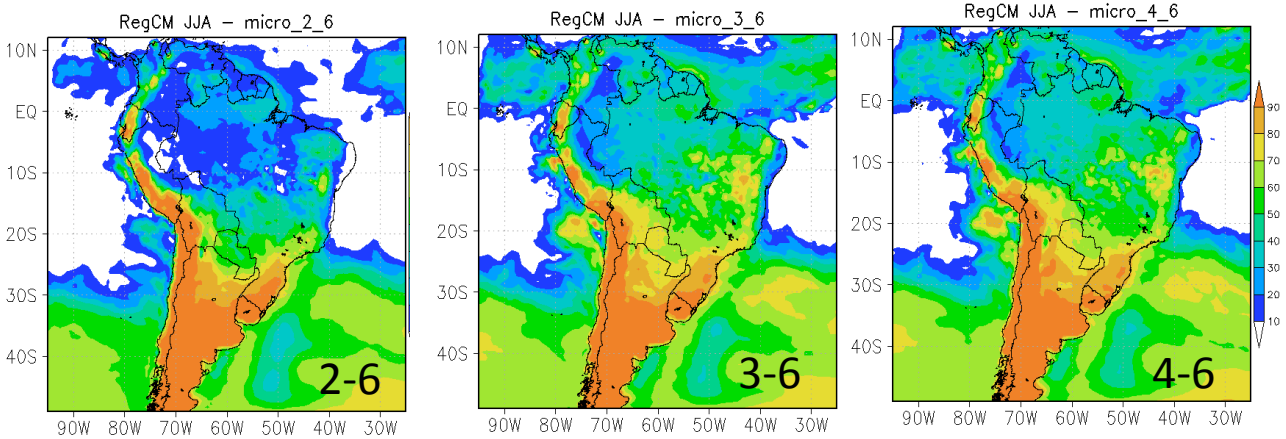
% of large scale precipitation



To validate these results, convective and total precipitation data are necessary. Does someone know some datasets that I can refer to?



Configuration 1-4 simulates well the precipitation over southeastern and northeastern Brazil, but indicates only convective precipitation northwards 10°S.



New Microphysics Default x Convection

In order to show the performance of the

new cloud microphysics default (kautoconversion = 4 and vqrx = 4) over South America we carried out 6 experiments changing the cumulus convection scheme.

It is a suggestion by Nogheroto et al. (2016)

“... assess the scheme's sensitivity to the use of different physics options in the model, particulary convection”.

Design of the Simulations

Model Version: RegCM4.4.5.10

Domain: CORDEX

Grid Points: 202 latitudes x 192 longitudes

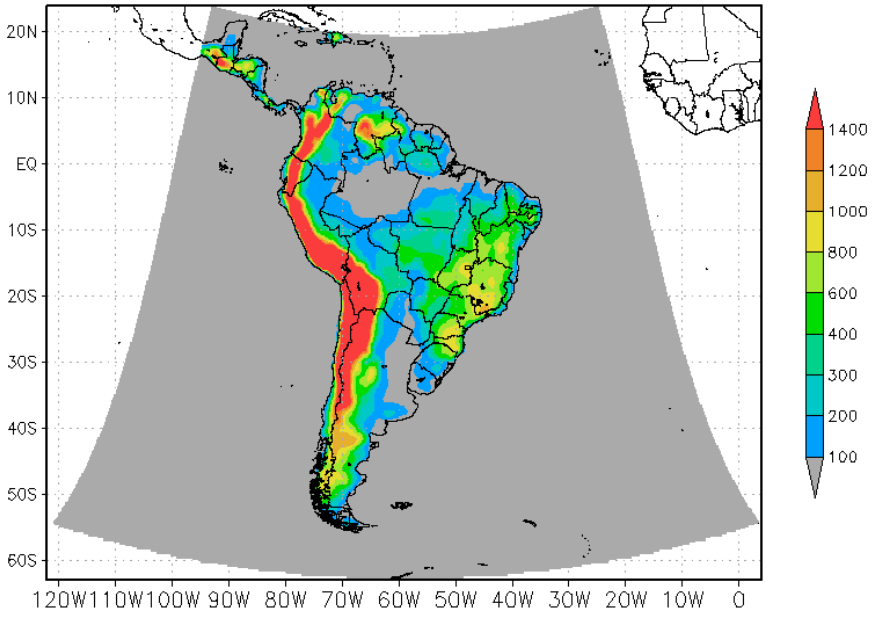
Projection: Rotated Mercator

Horizontal Resolution: 50 km

Temporal Resolution: 120 s

Vertical Levels: 18

Boundary Conditions: EIN15 and ERSST



Domain and topography of the simulations

Period: January 2002 to January 2013 (Spin-up 2002)

Ocean Fluxes: Zeng et al. (1998) ; **LSM:** BATS; **PBL**: Holtslag; **RAD**: CCM3

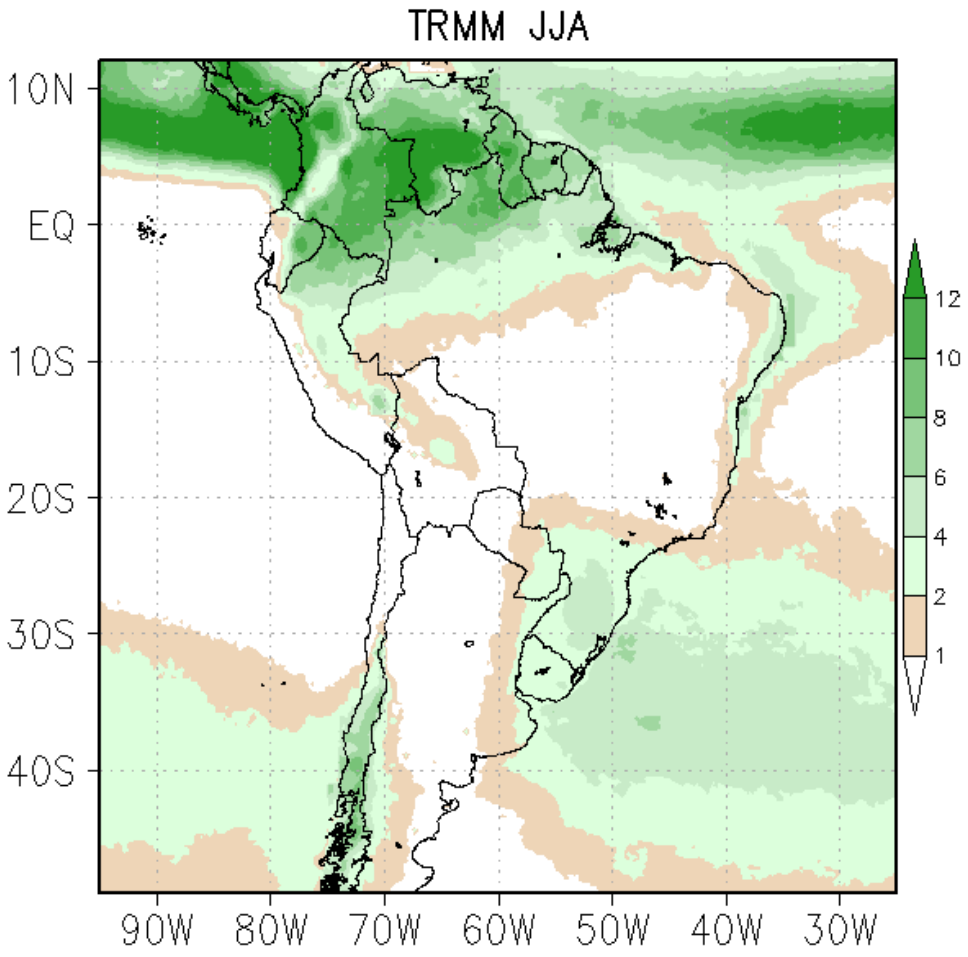
New Cloud Microphysics (default values kautoconversion = 4 e vqxr = 4)

6 experiments changing the cumulus convection:

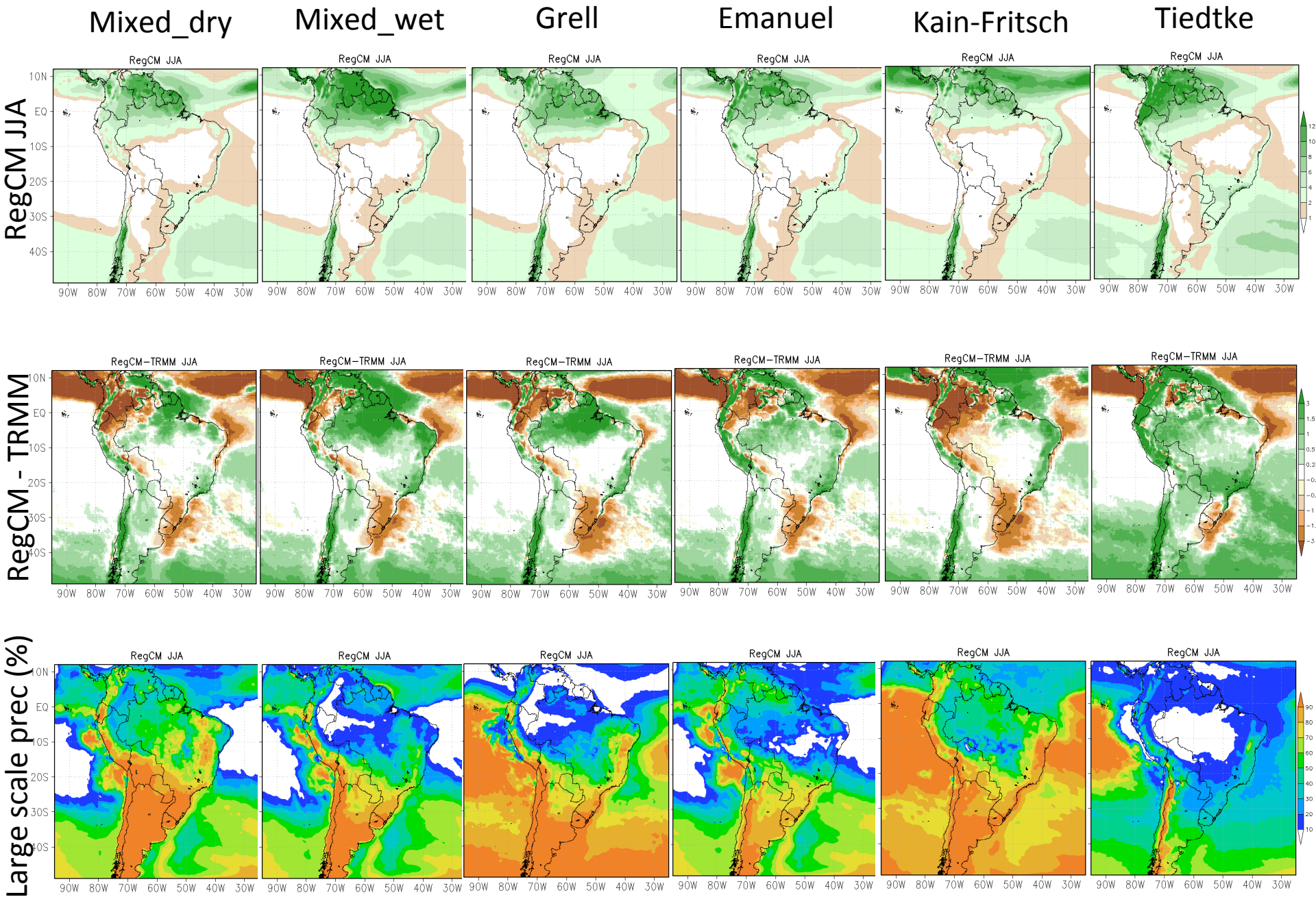
Mixed_dry Mixed_wet Grell Emanuel Kain-Fritsch Tiedtke

See Giorgi et al. 2012 for more details

TRMM precipitation (mm/day) in South America (2003-2012)



RegCM4 Precipitation (mm/day) - JJA



Seasonal Forecast

We are doing seasonal forecast with CFSv2 and RegCM and comparing

RegCM4.3
RegCM4.5

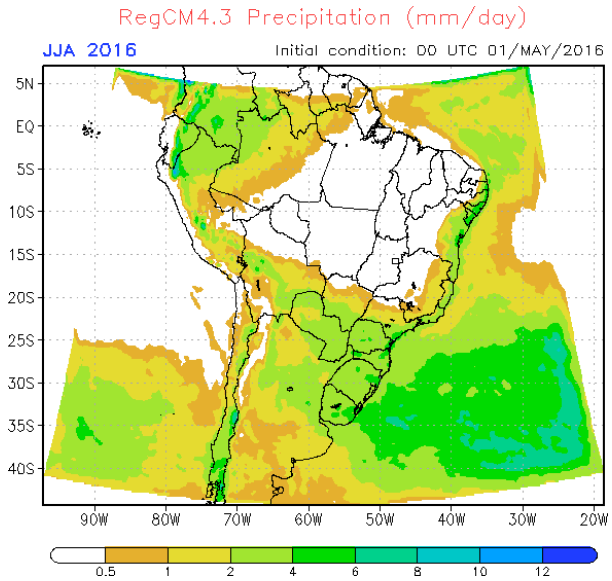
Convection scheme = Kuo (it is only a test ...)

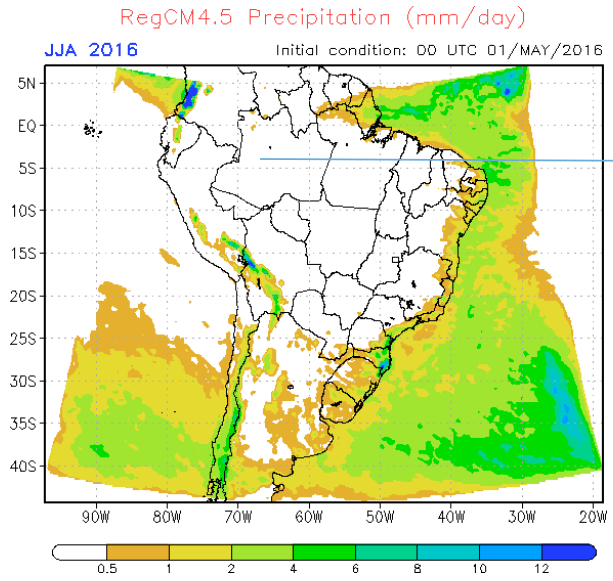
We do not have boundaries from CFSv2 to the past, then we did not validate ...

I would like to thank **Thanh Nguyen Xuan** for help me to prepare the input files.

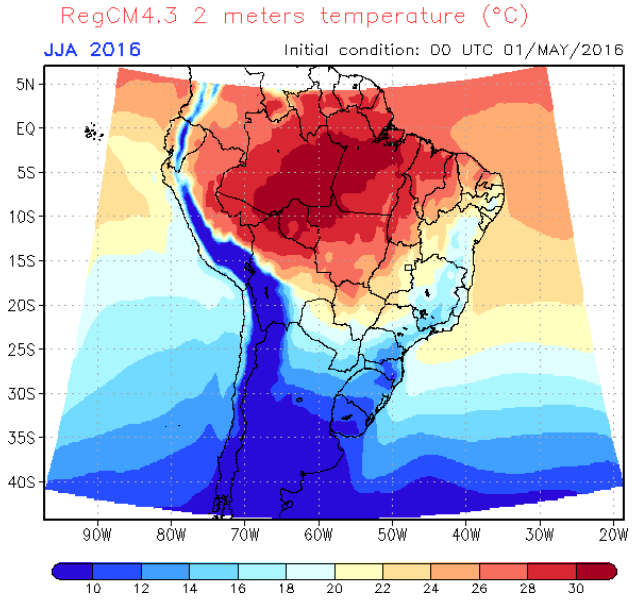
RegCM 4.3

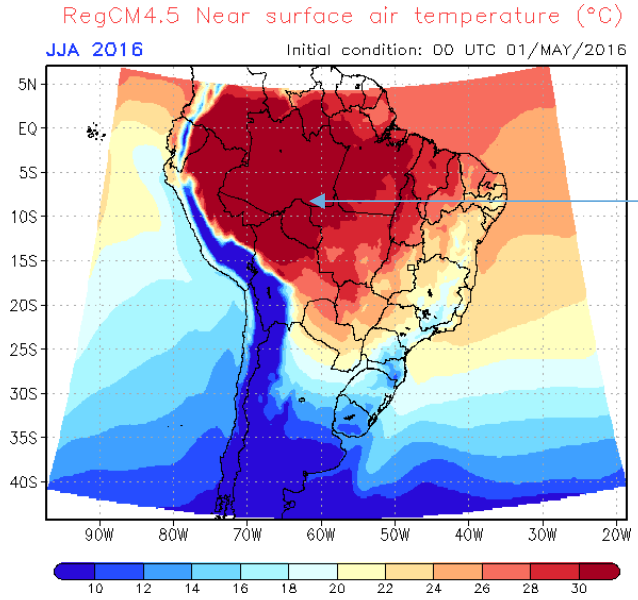
RegCM 4.5





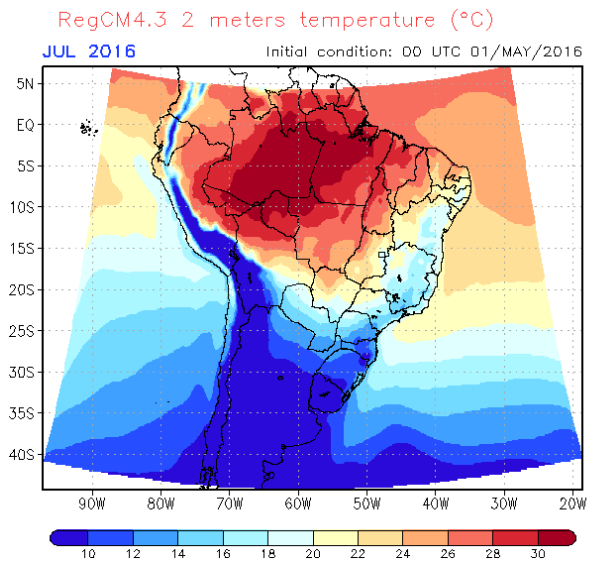
Forecast with RegCM4.5 is dryer than RegCM4.3

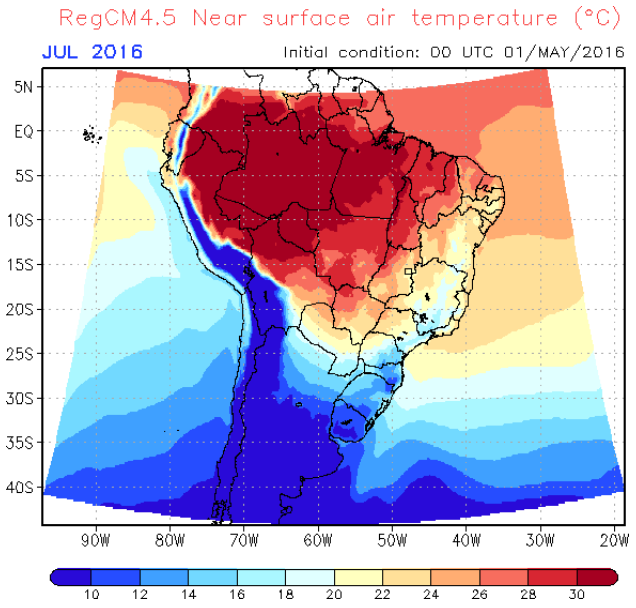


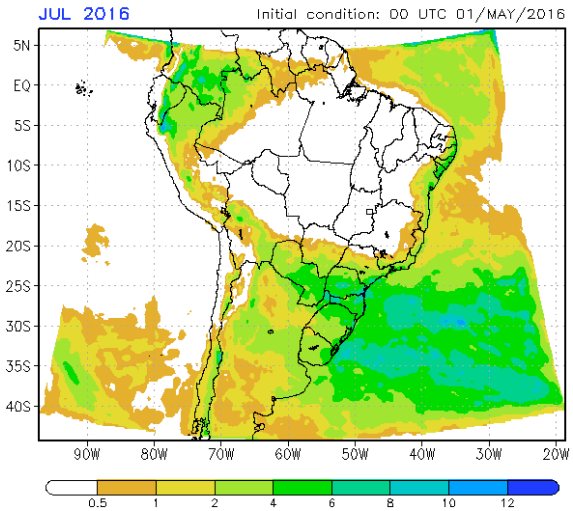


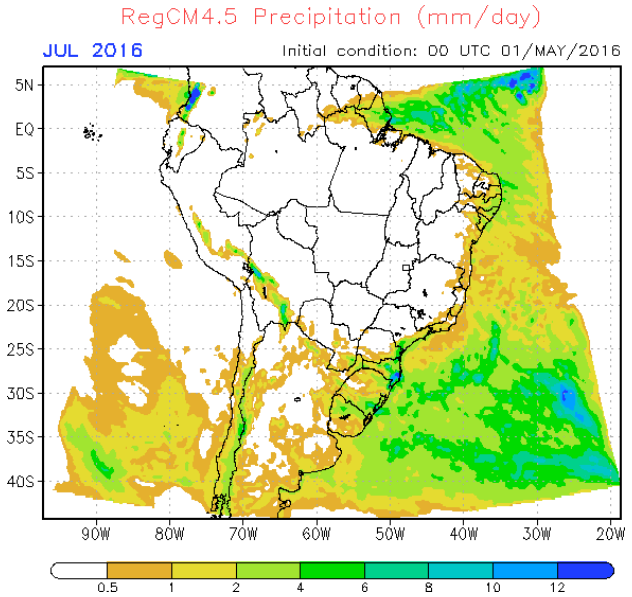
Higher temperatures

I would like to do a climatology driving RegCM with CFSv2. Does someone know if these data are available?









See this site. Maybe that there are the boundaries.
http://cfs.ncep.noaa.gov/cfsv2/downloads.html

Thank you for your attention!

reboita@gmail.com