Assesment of fine resolution RegCM simulations over south-southeast Brazil

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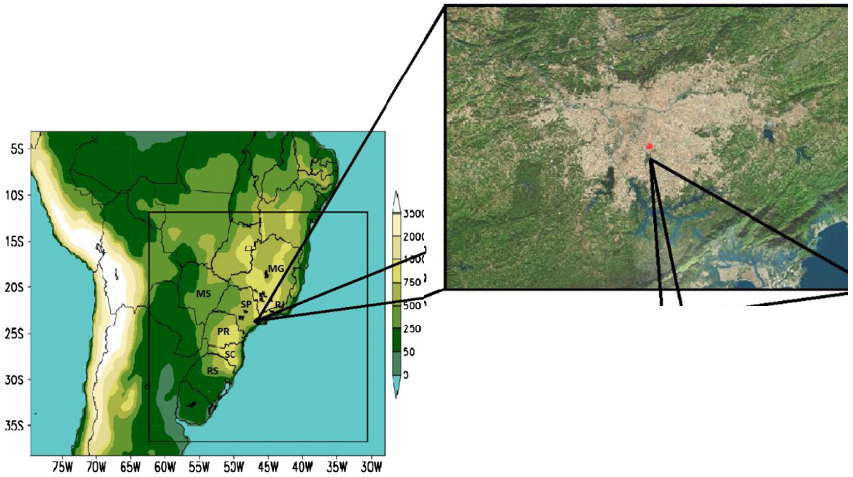
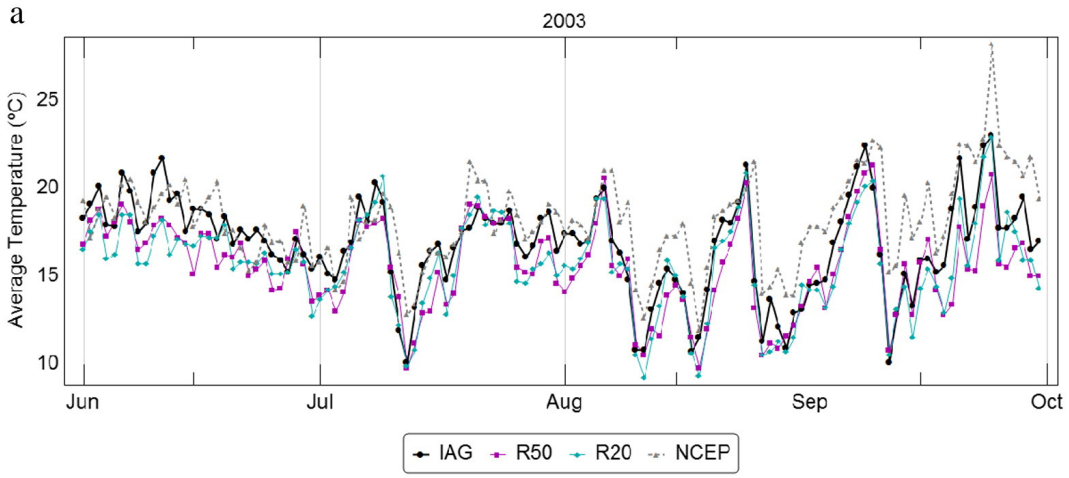
Previous studies – south-southeast Brazil

- da Rocha et al. (2015) – compared two (2003 and 2004) austral winter simulations (JJAS) using RegCM3 with 50 and 20 km grid spacing → local features of climate over São Paulo city are more realistic using 20 km.



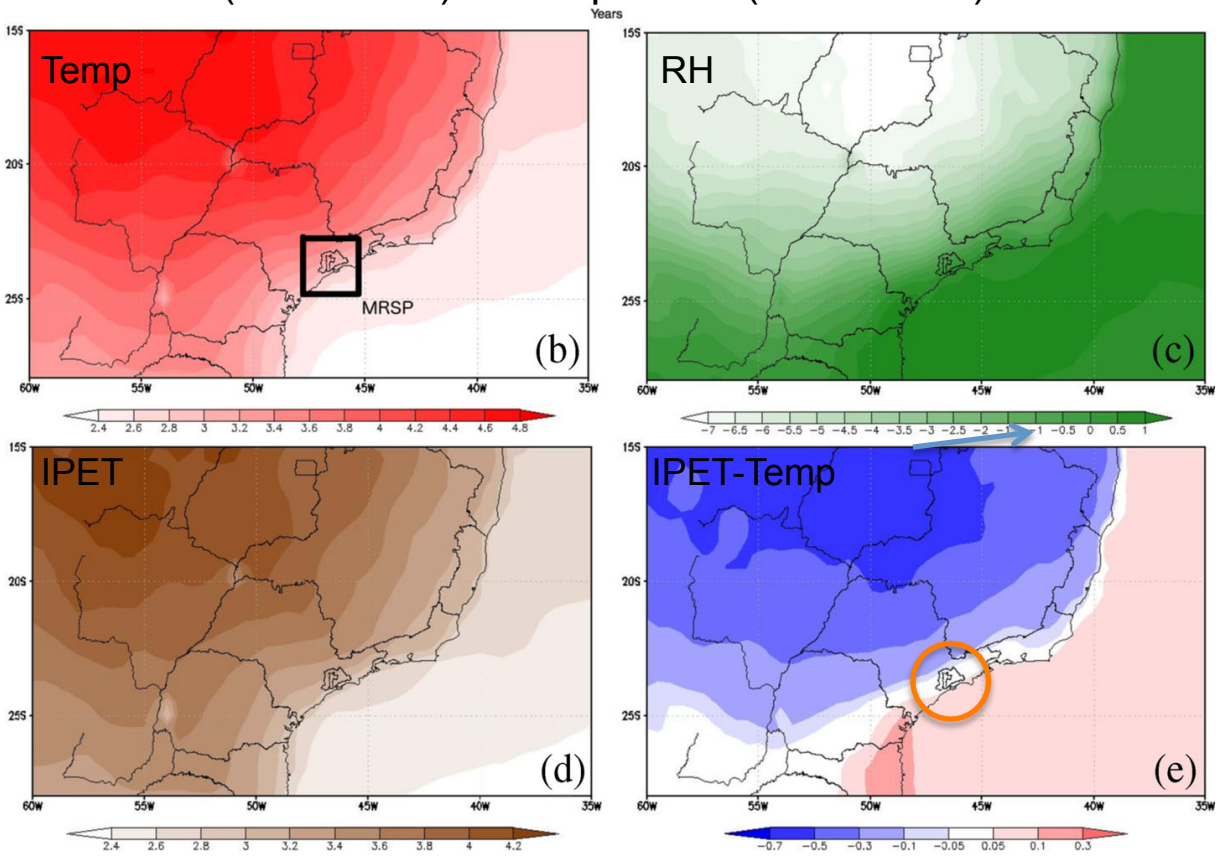


- 20 km simulation was used to characterize the mean conditions favoring fog events over São Paulo city → moist air is transported by an anticyclone located southward of the city

Previous studies – south-southeast Brazil

- Application studies: thermal comfort in São Paulo megacity under climate change RCP8.5 scenario using RegCM4-50 km of grid

Future (2065-2099) minus present (1975–2005) climate



Increase of air temperature is compensated by decrease of relative humidity;

IIPET-Temp: São Paulo is in a transicion region of positive/ negative values;

This study has shown the needing of fine resolution projections to better understand the climate change impacts

(Batista et al., 2015)

Motivation and objectives

As CORDEX-WCRP initiatives:

South America Pilot Study Flagship (SESA-FPS) – "*Extreme precipitation events in Southeastern South America: a proposal for a better understanding and modeling*" – PI – M. Laura Berttolli.

Objective is to evaluate the hability of fine resolution simulations with RegCM4 to reproduce regional and local features of climate over south-southeastern Brazil

Simulations set-up

Model version: RegCM4.6.1

Simulation period: 01/12/2009 – 31/21/2010 (analysis – 2010)

→Initial and boundary conditions: ERA-Interim (~ 75km) – Dee et al. (2011)

→Convective scheme: Emanuel over all domain

→Large scale precipitation: SUBEX

→Number of vertical levels: 23

→Surface schemes: BATS and CLM4.5

→Hydrostract (H) or non-Hydrostact (NH)

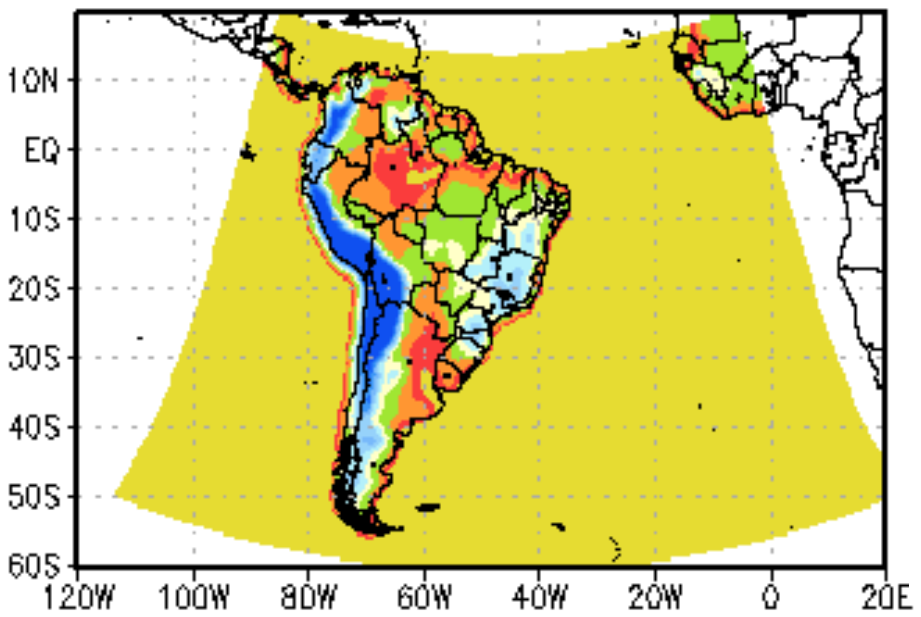
3 large domains - LD - (ds= 100, 50, 25 km)

1 small domain – SD - (ds=5 km)

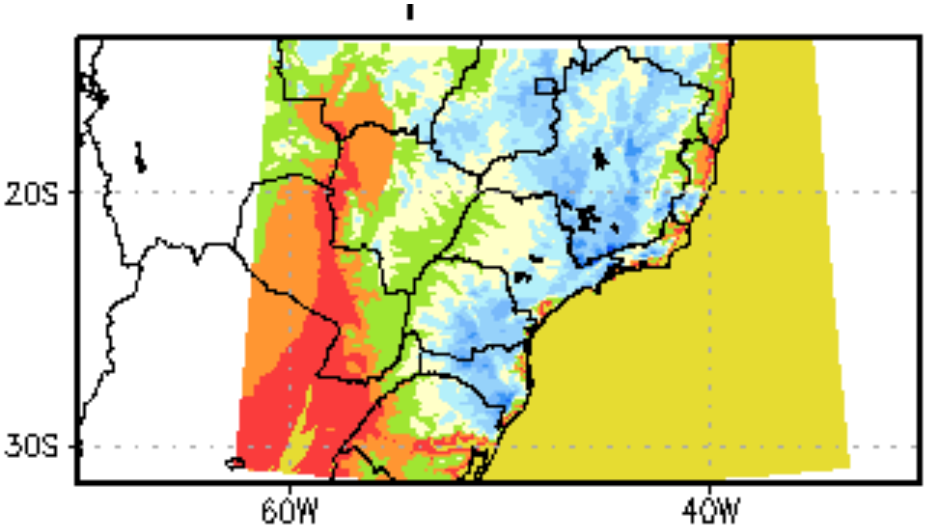
Ds (km)	100	50	25	5
BATS	H/LD	H/LD	H/LD	NH/SD
CLM	H/LD	H/LD	H/LD	NH/SD
Number of grid points	90x109	174x218	345x431	381x561
Time step (s)	150	100	50	15

Domains (topography and landuse):

Ds=100, 50, 25 km

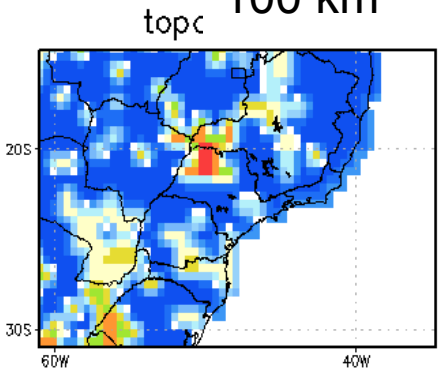


ds=5km

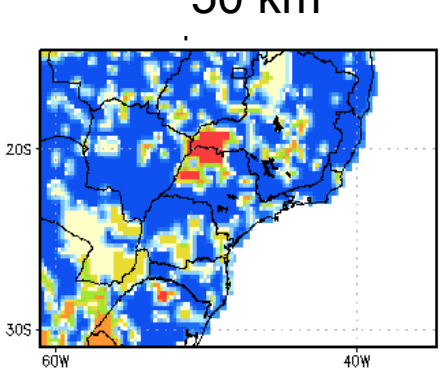


Landuse: zoom over south-southeast Brazil

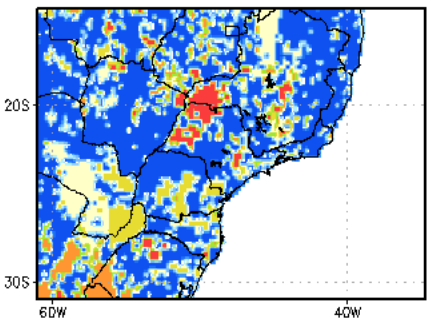
100 km



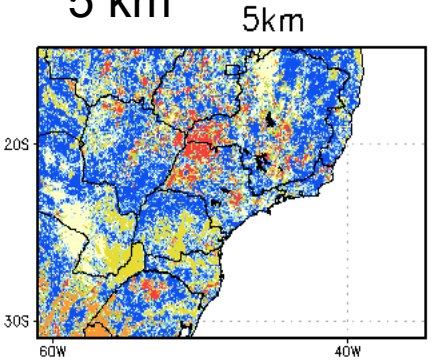
50 km

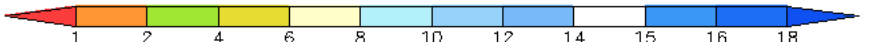


25 km



5 km





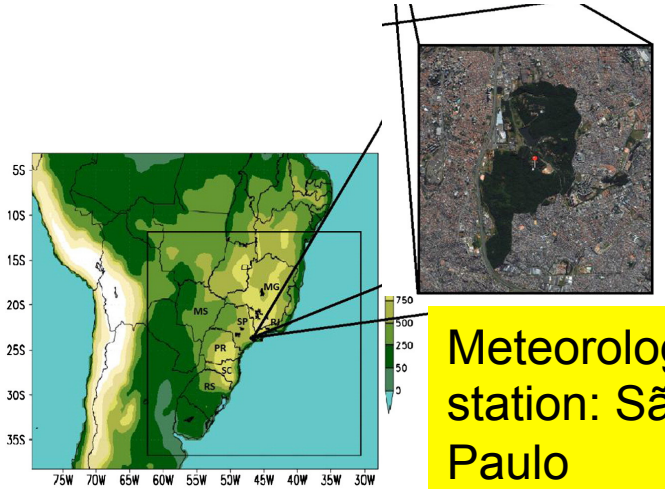
Data to evaluate the simulations:

Various analysis/reanalysis are used to compare simulations with observations:

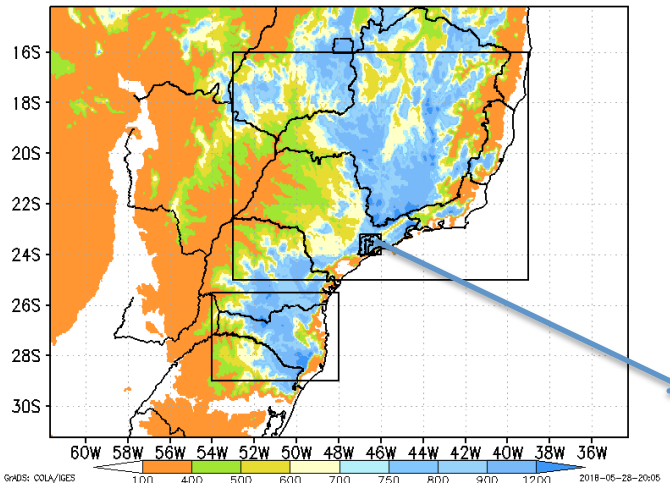
Precipitatiion			Temperature		
Data	Description	Resolution	Data	Description	Resolution
TRMM – 3B42	sattelite product	25 km	CFSR	reanalysis	30 km
CPC	daily raingauge analysis	50 km	ERA5	reanalysis	30 km

Local observations:

Station data for São Paulo city: wind and air temperature at each 3 hours



Meteorological station: São Paulo



Annual cycles over 3 subdomains

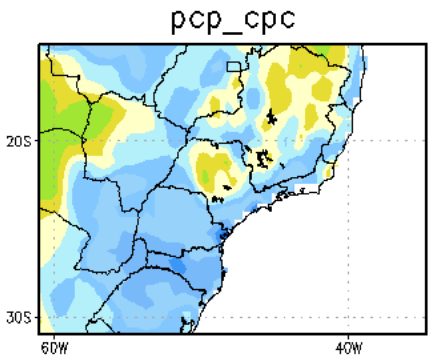
Big – SE

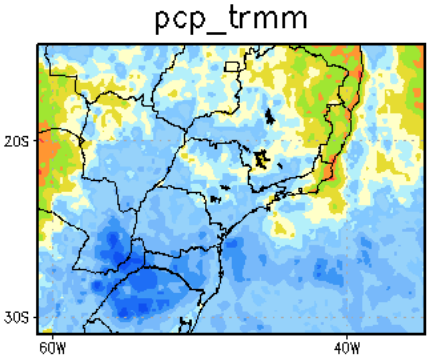
Medium – SU

Small - SP

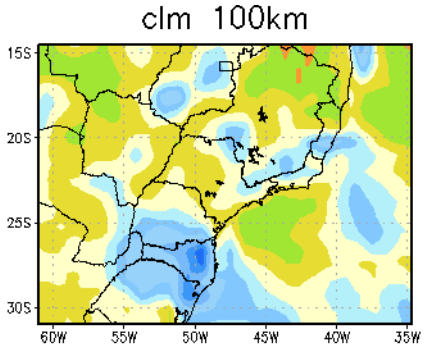
Annual mean rainfall – 2010

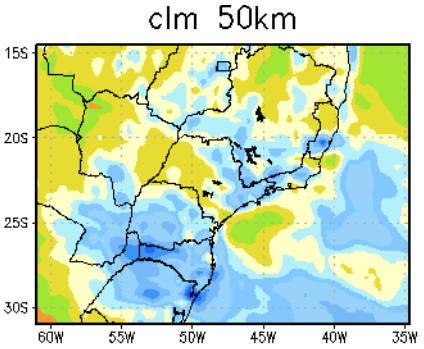
OBS

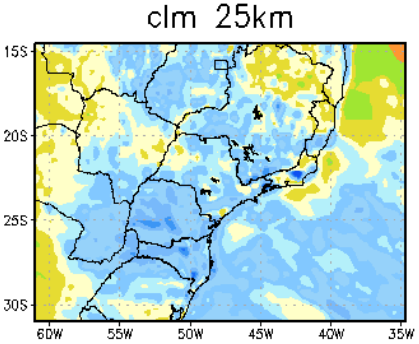


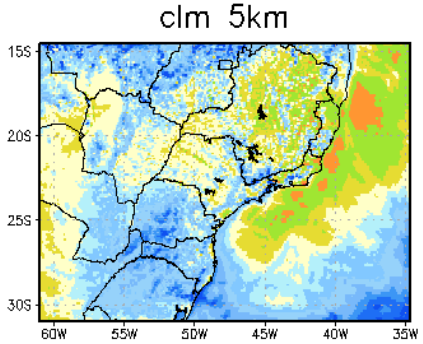


CLM

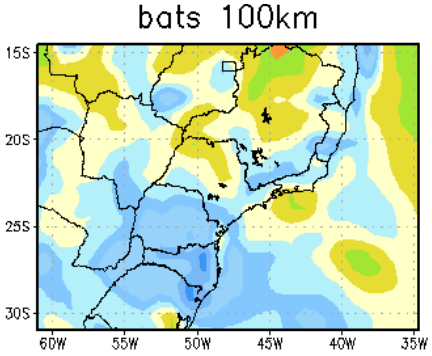


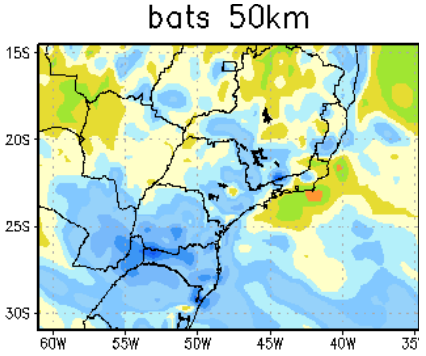


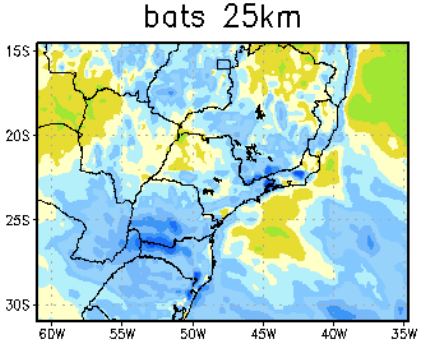


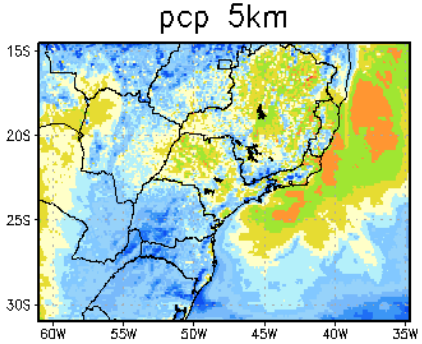


BATS







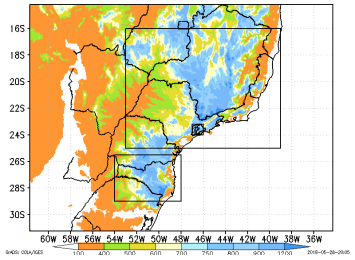


→Location of more intense rainfall over south Brasil/Paraguay: BATS has greater agreement with observations; positive impact of high resolution

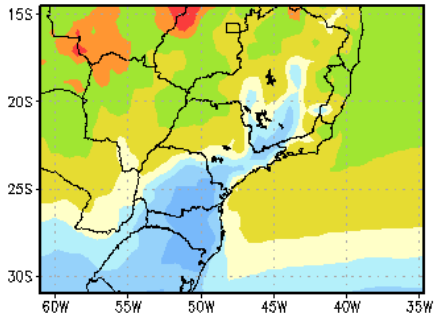
→ Fine resolution: deficit of rainfall over part of southeast Brazil

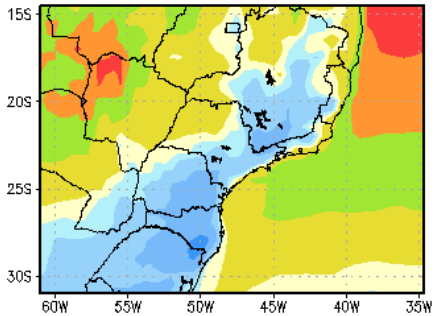
Annual mean 2m air temperature – 2010

Topography

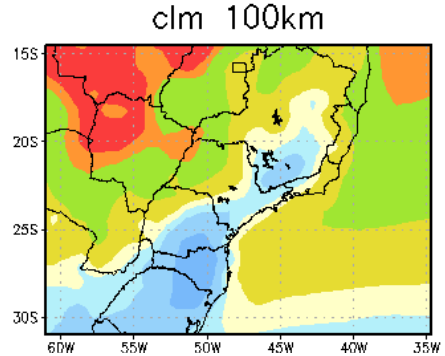


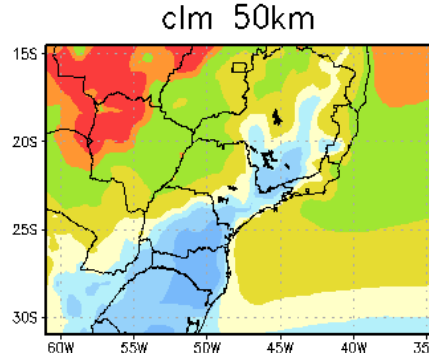
OBS

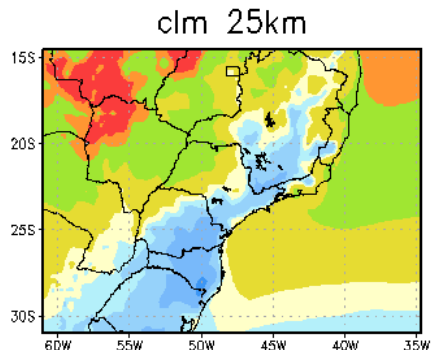


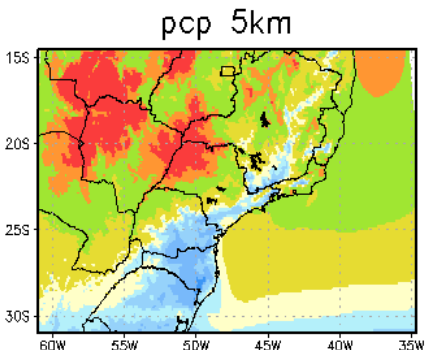


CLM

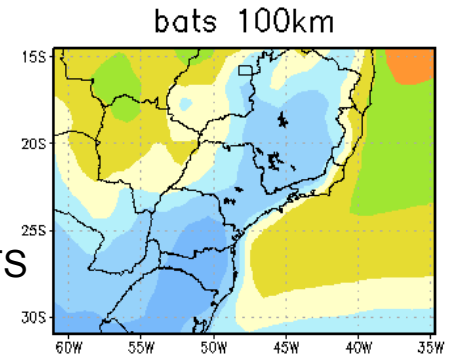


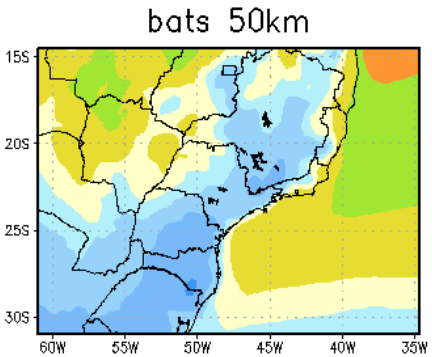


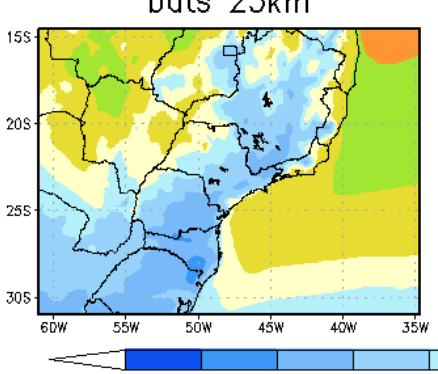


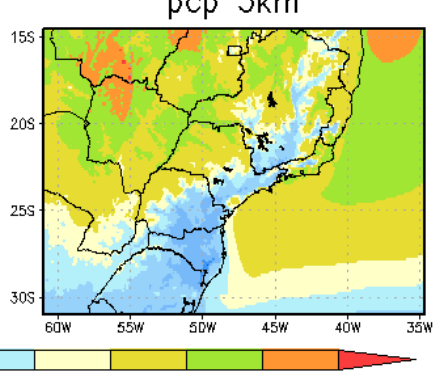


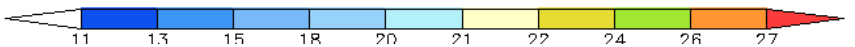
BATS









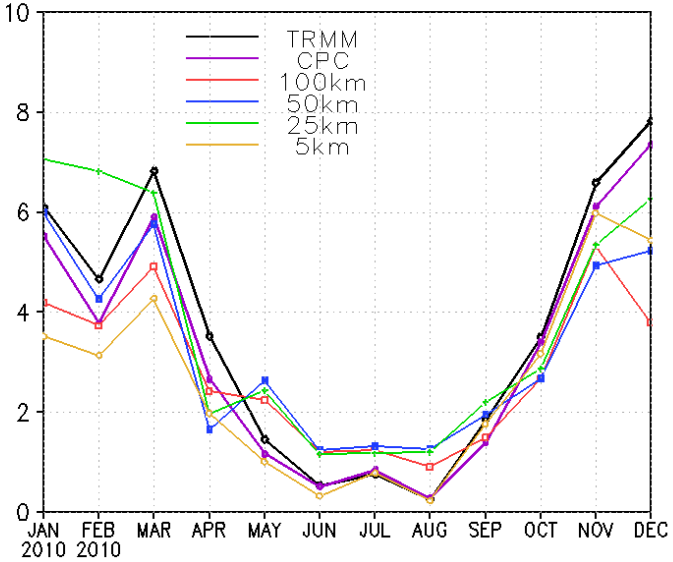


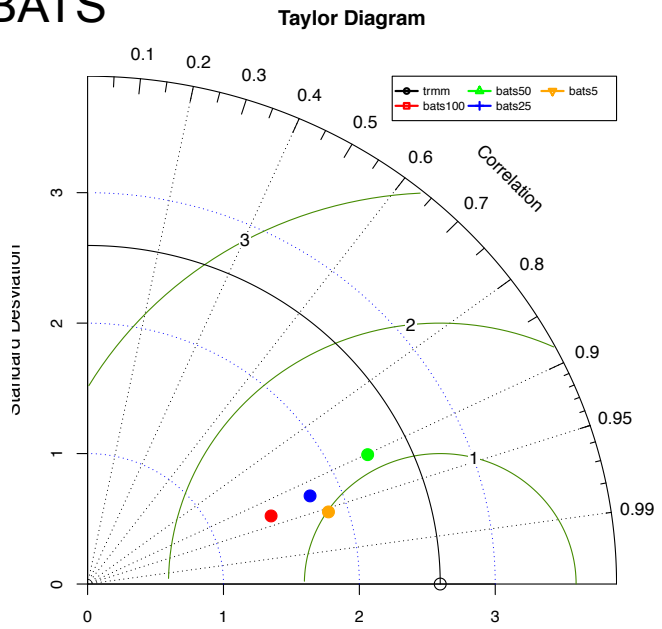
BATS - increase of resolution defines better areas of low/high temperatures → values/spatial pattern are similar to ERA5;
CLM – a sistematic warm biases over NW domain (increase in fine grid simulation);

It is necessary mesoscale analysis for validate fine resolution

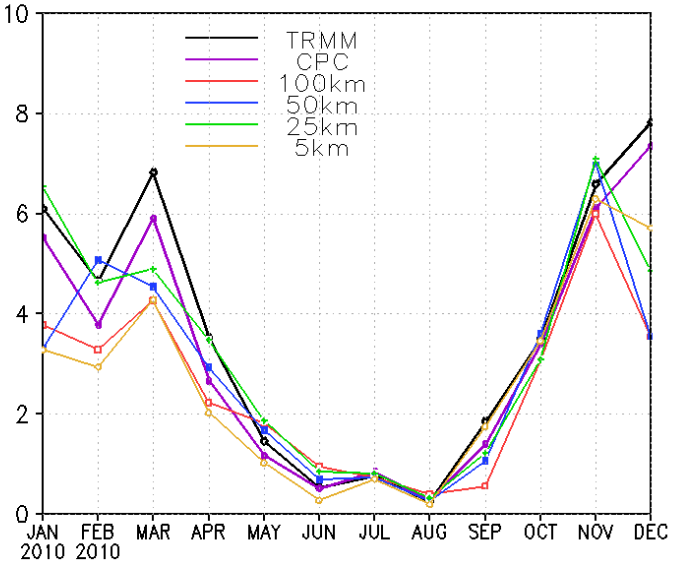
Annual Cycle – 2010 - rainfall over SE (big subdomain)

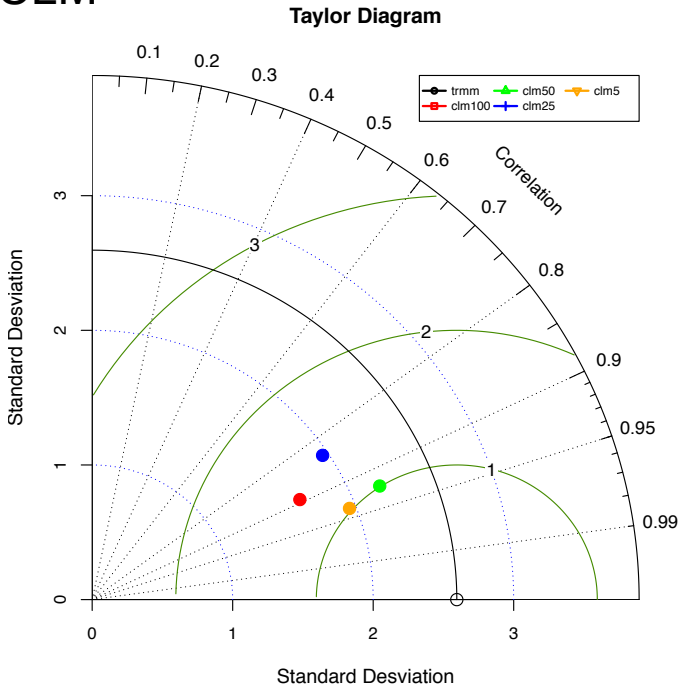
BATS





CLM





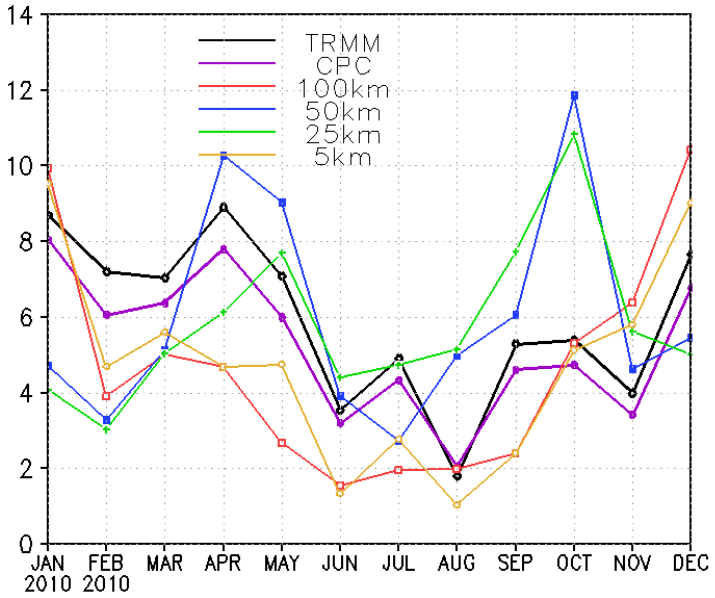
Phase of annual cycle is realistically captured by all simulations → overperformce of 5 km experiments (CLM and BATS) → +

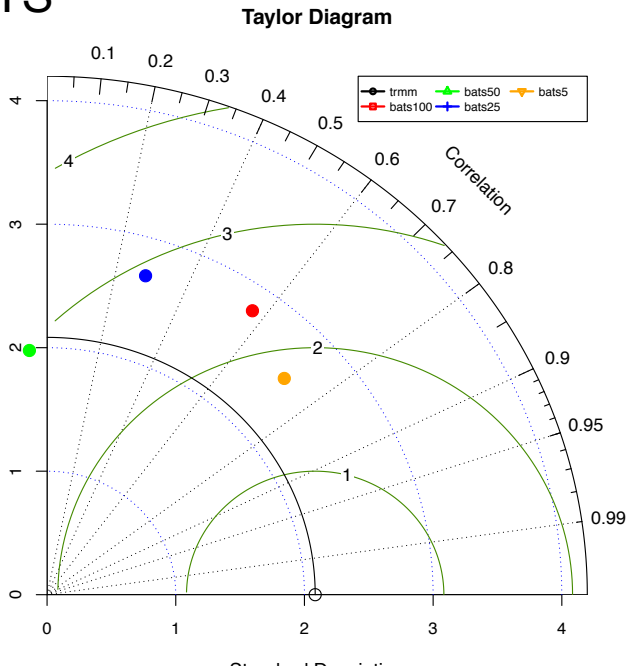
BATS – only 5km simulates the observed low rainfall rate on dry season (MJJA)

CLM → dry season rainfall is less dependent of the resolution (statiscal indices are too closer)

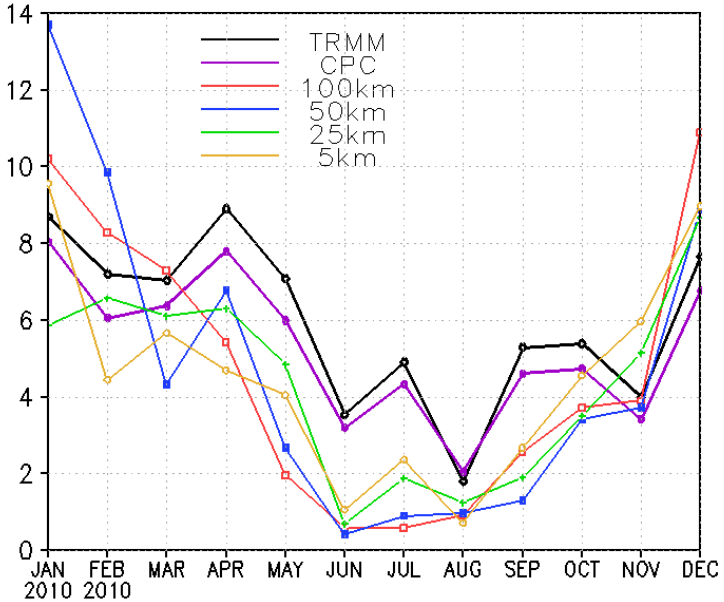
Annual Cycle of Rainfall – 2010 – SU subdomain (medium subdomain)

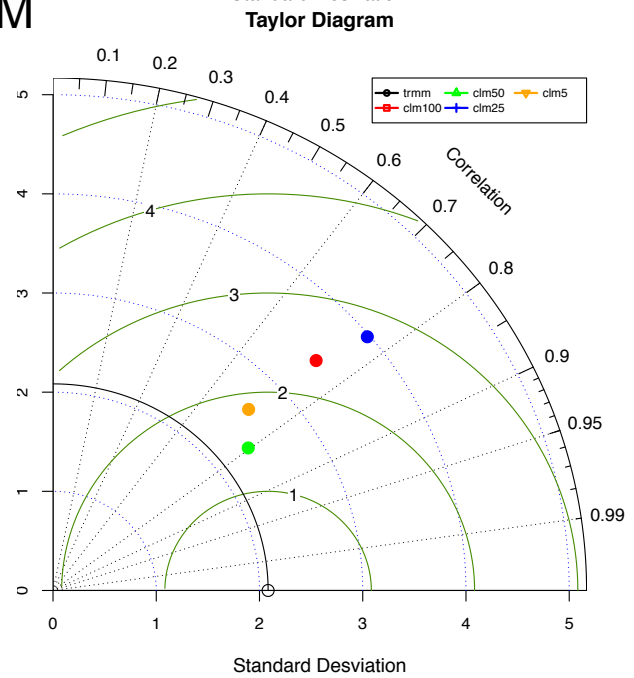
BATS





CLM





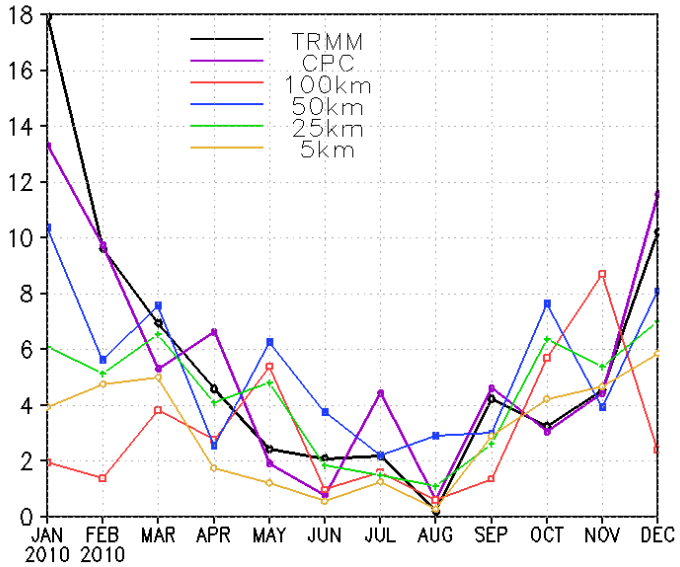
Considerable differences occur between BATS and CLM:

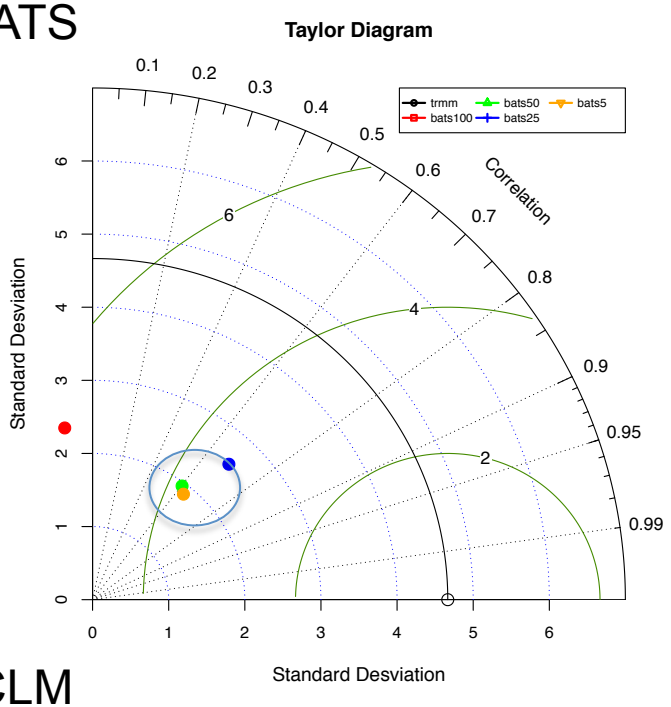
BATS: phase of annual cycle better captured by 100 and 5 km → smaller RMSE; however both underestimate the rainfall rate mostly during April (more rainy month)

CLM – phase of annual cycle (correlation) and intensity of rainfall are less sensitive to the grid resolution;

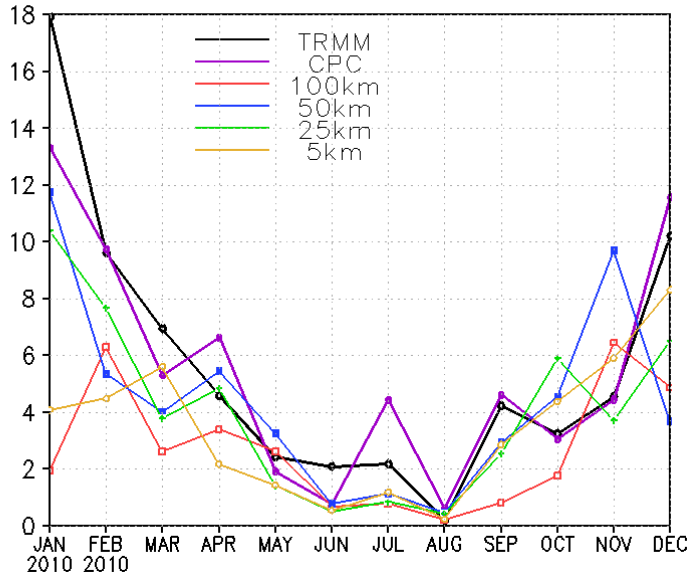
Rainfall Annual Cycle – 2010 – SP subdomain (local)

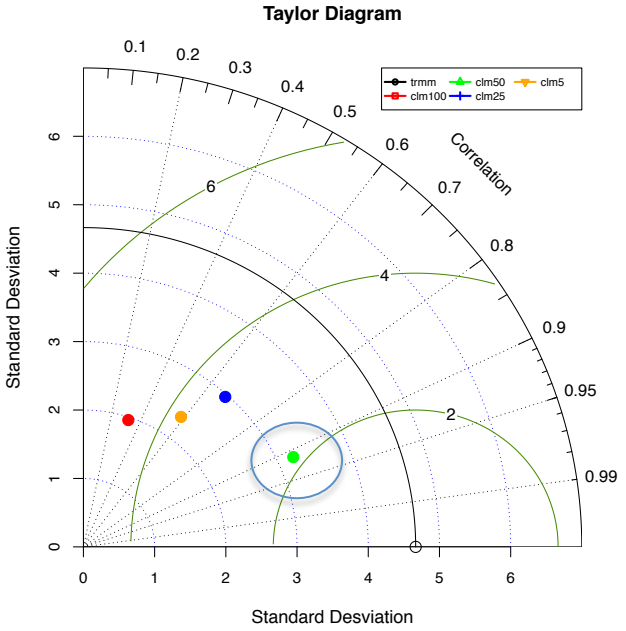
BATS





CLM





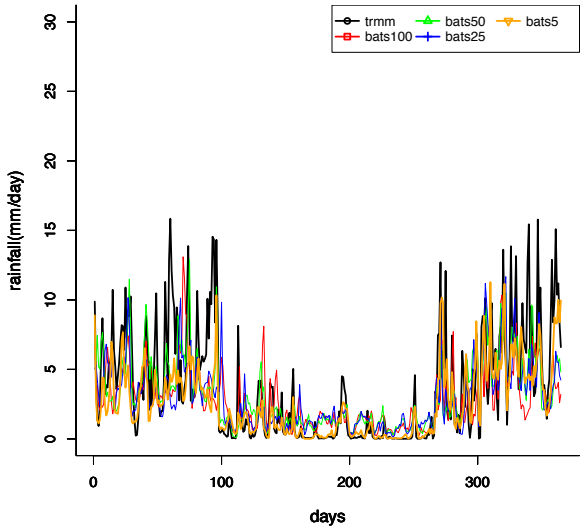
At local scale there is greater disagreement among observations and also simulations;

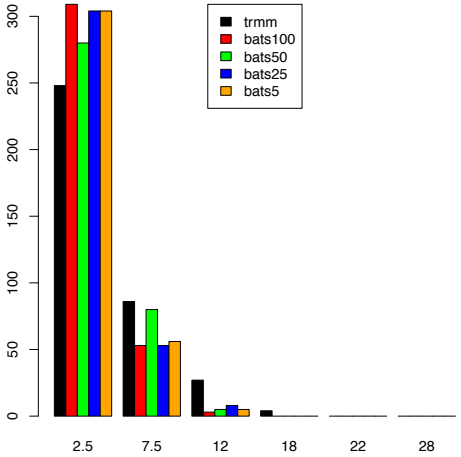
Compared with TRMM:
BATS - No clear improvement of the simulated annual cycle as function of resolution;

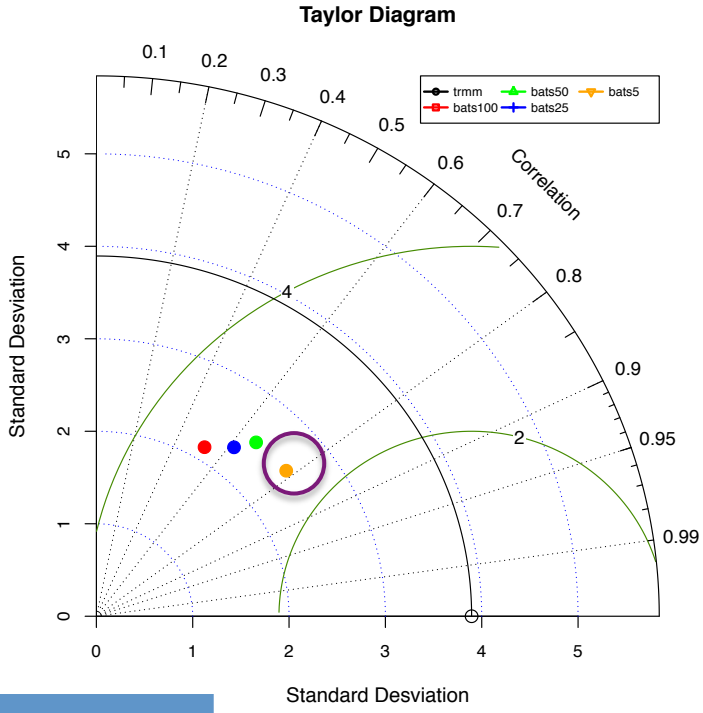
CLM – small overperform of 50 km

Daily rainfall – 2010 – synthesizing statistical indices (RMSE, SD and correlation)

SE subdomain





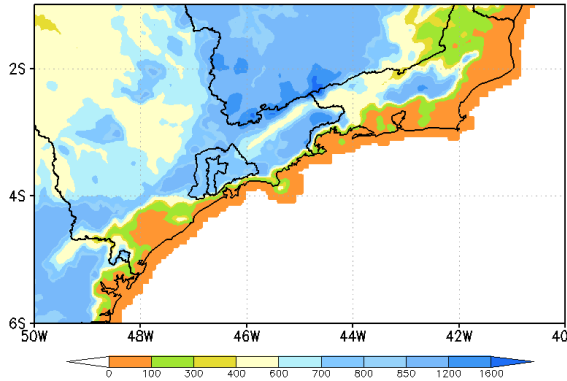


Ds (km)	100	50	25	5
SDE	BATS -		CLM-	CLM+ BATS+
SU	CLM- BATS-			CLM+ BATS+
SP	CLM- BATS-			CLM+ BATS+

Some improvemments of the annual cycle of rainfall and spatial pattern of simulated variables in high resolution experiments (CLM and BATS) → “Added Value”

Next → Local features of climate in the 5km simulations

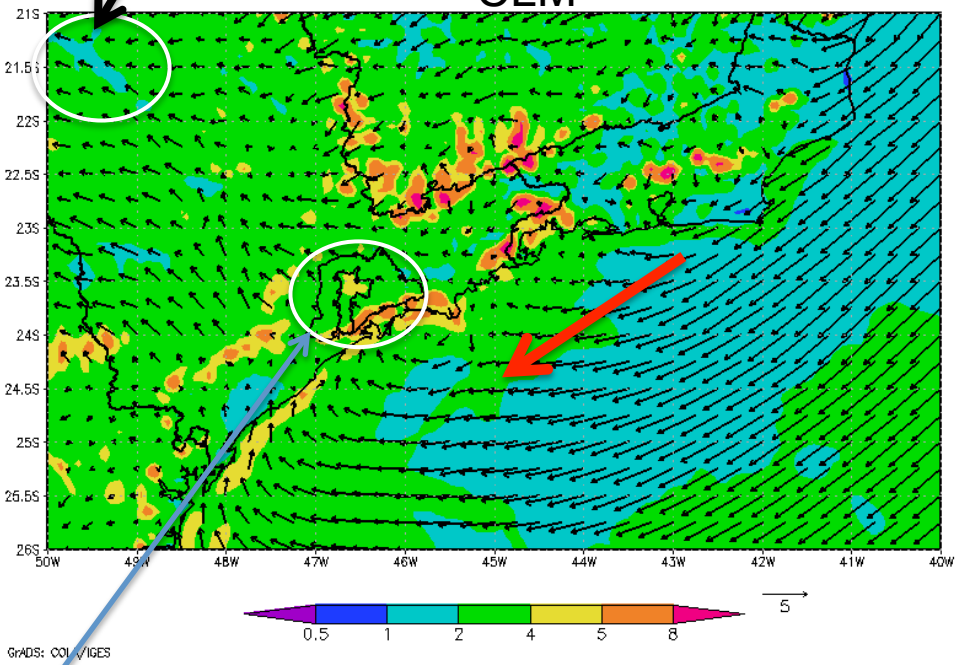
Mesoscale circulations over eastern southest Brazil: 5 km



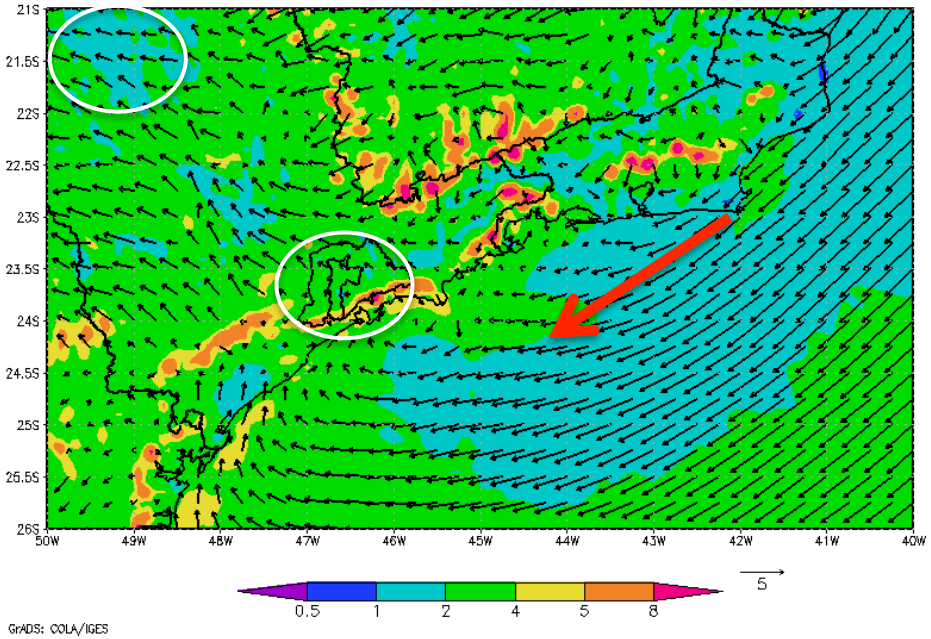
Tiete river basin

Annual mean (2010): 10-m wind and rainfall

CLM



BATS

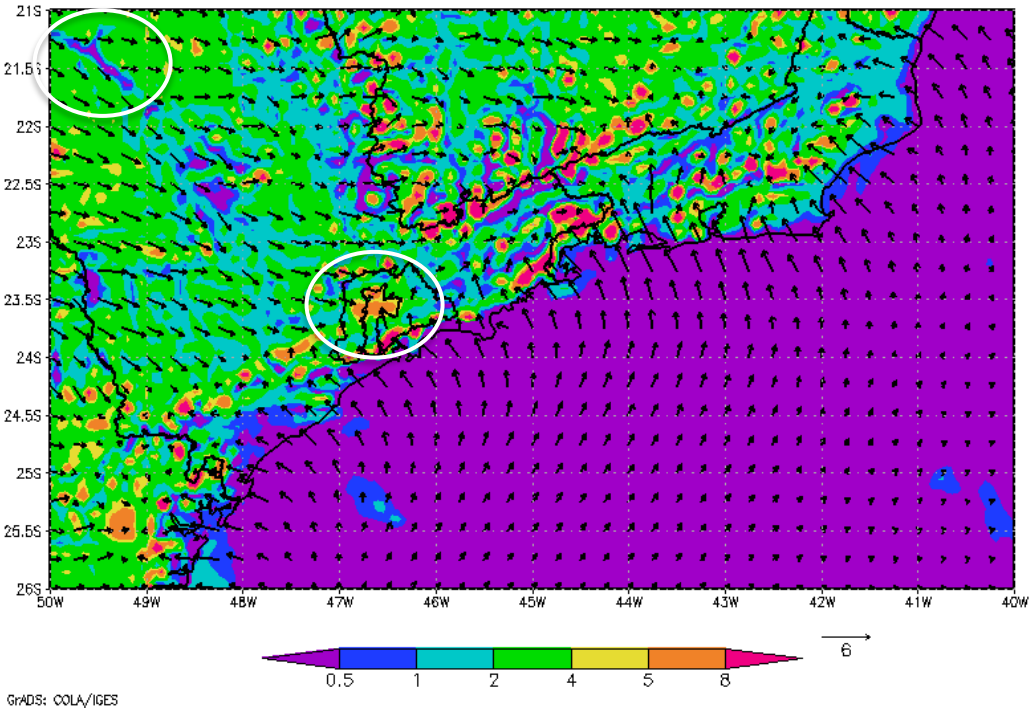


São Paulo city

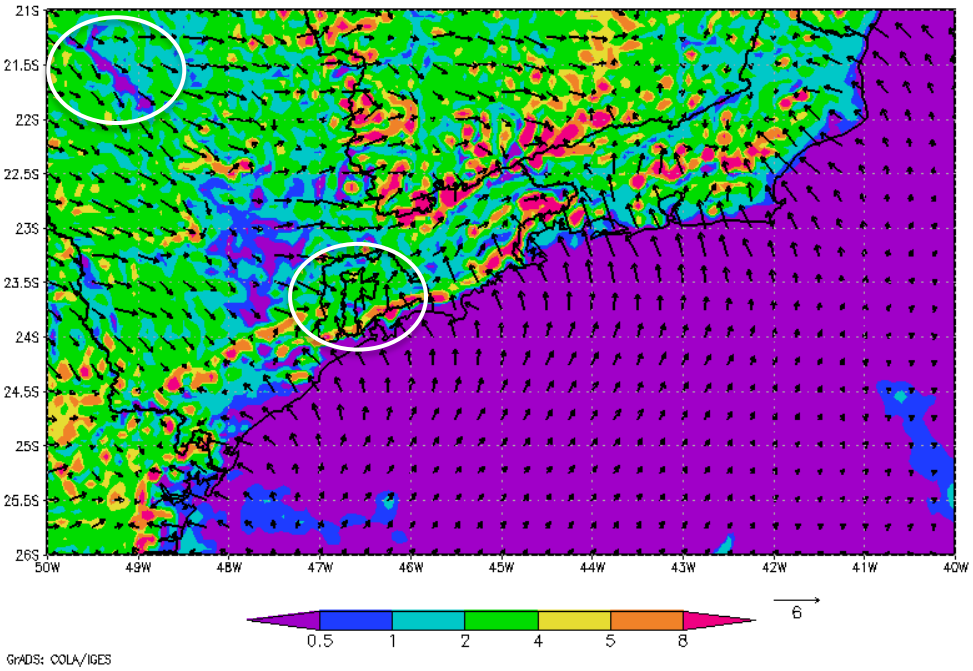
Main patterns of mean circulation/rainfall are similar in CLM and BATS;
Local features → CLM simulates less rainfall in the main SP river basin (Tiete) and more rainfall over Sao Paulo city.

Diurnal cycle: day (15-21 LT) minus nigth (03-09 LT) (as in da Rocha et al., 2009)

CLM



BATS



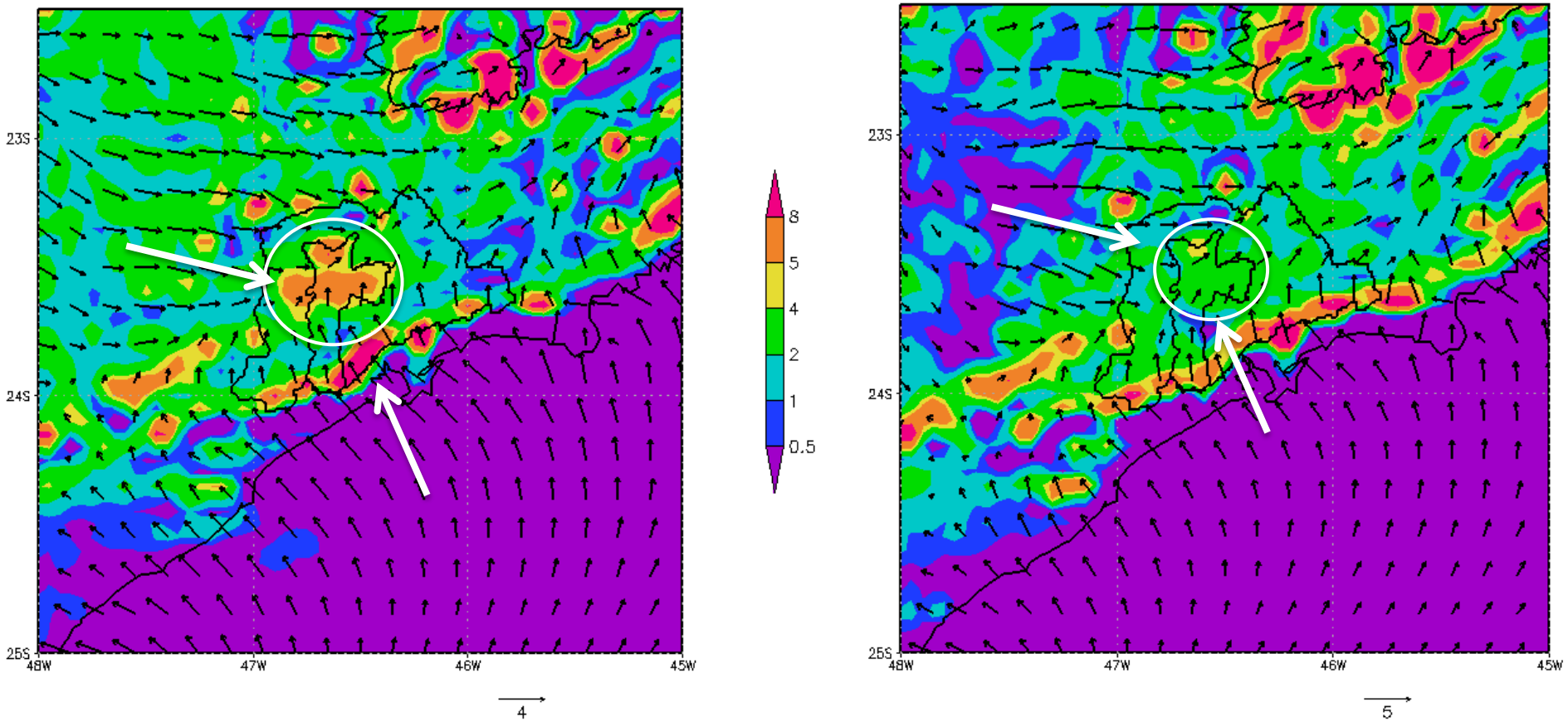
Diurnal rainfall over mountains, along the shore and in São Paulo city;

Nocturnal rainfall in Tiete river basin;

Day (15-21 LT) minus nigth (03-09 LT) – zoom

CLM

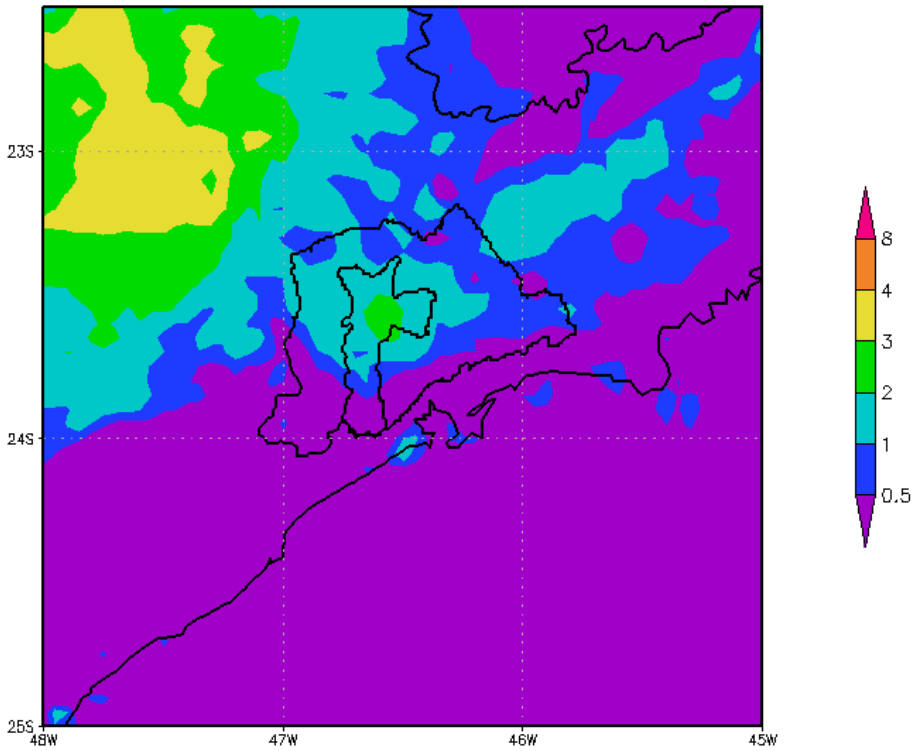
BATS



During the day SE winds and along shore rainfall → sea breeze in CLM → greater amount of rainfall over São Paulo during the day (urban effect?)

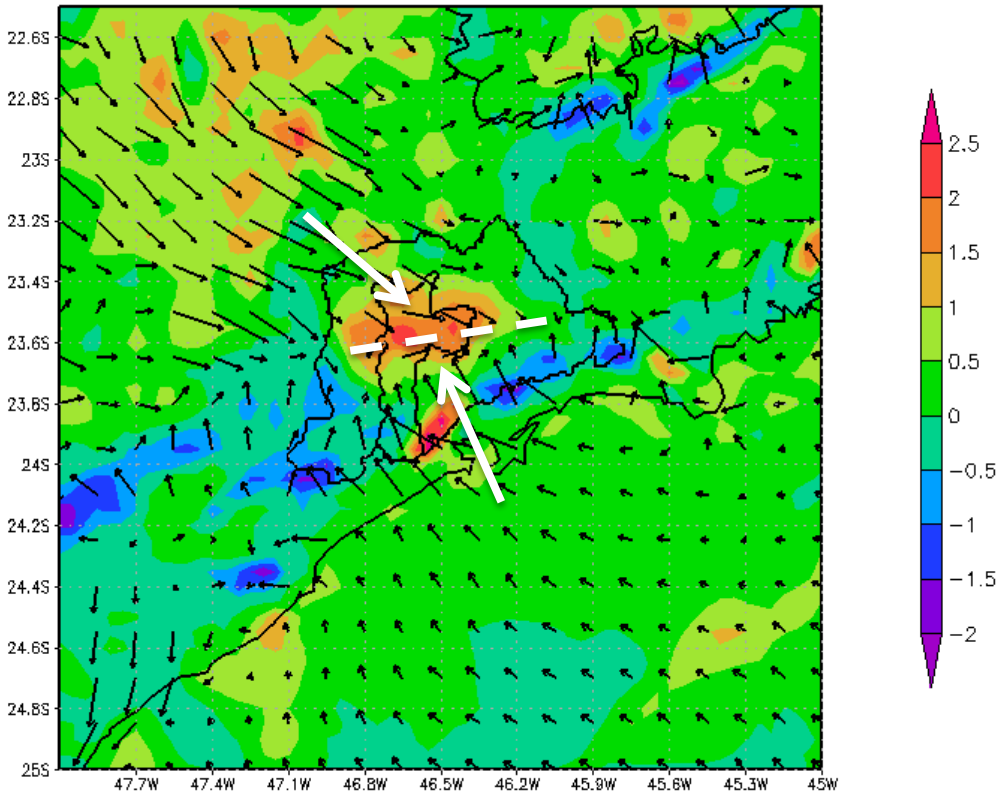
Annual mean differences: CLM minus BATS

2-m air temperature



CLM simulates higher temperatures over São Paulo (urban effect?) and along the valey

10-m wind/rainfall

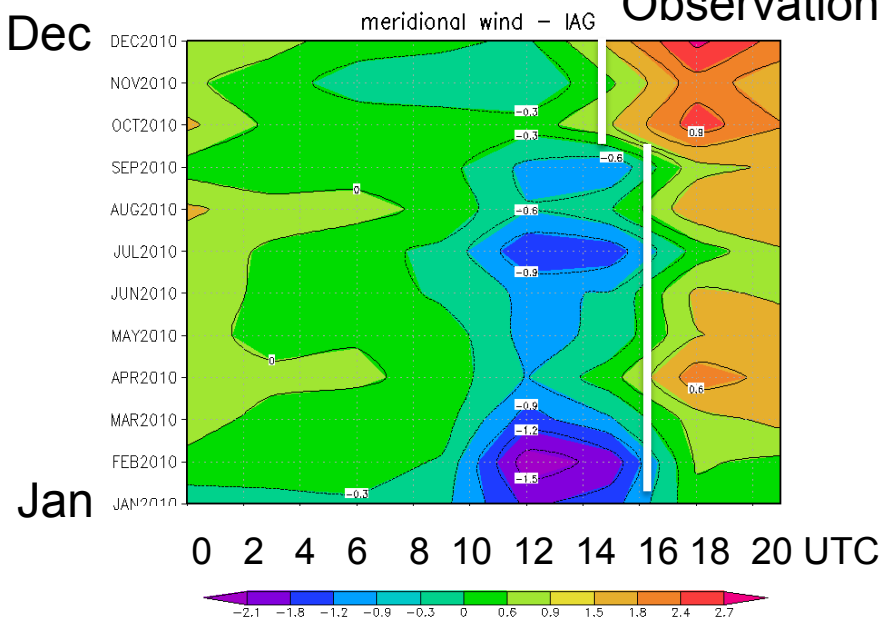


SE winds (sea breeze) and continental NW winds are stronger in CLM than in BATS → contributing to wind convergence over São Paulo→ higher amount of rainfall over center-north of the city in CLM

Local validation: diurnal cycle of meridional wind over São Paulo

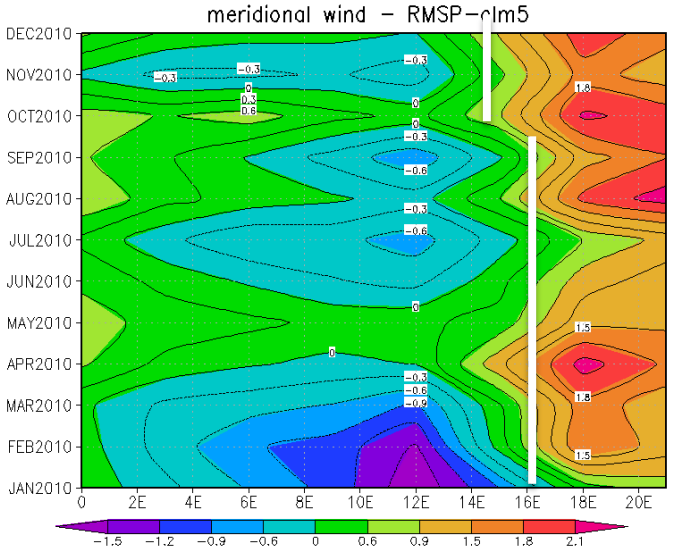
Montlhy mean diurnal cycle

Observation

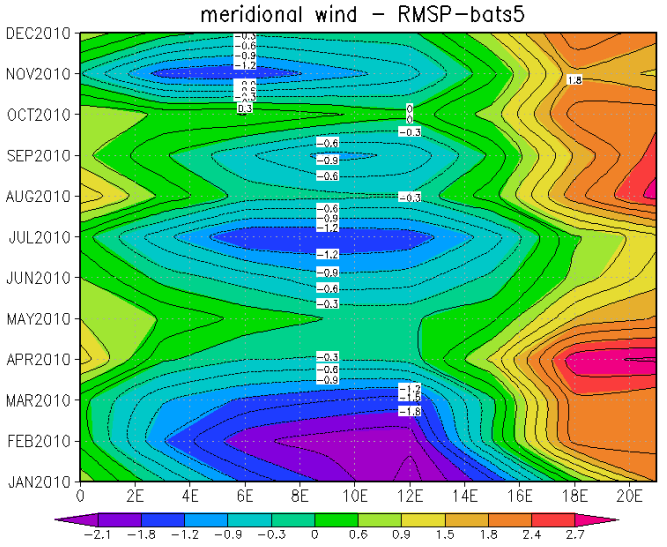


Observation: wind changes from north to south in the early afternoon (13-14 LT → 16-17 UTC; OND 11-12 LT); More intense N winds JF/ 2010

CLM



BATS

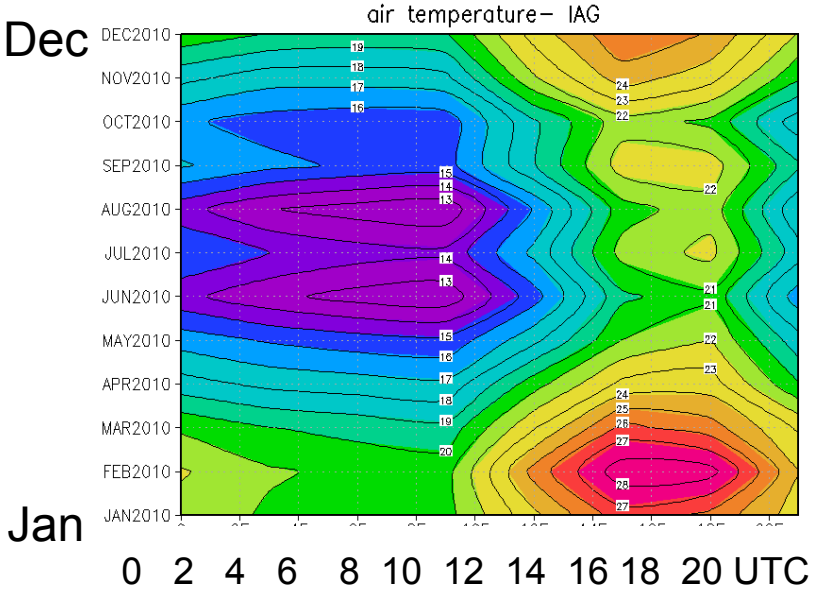


CLM has large hability to reproduce the observation (weaker winds and time of change from N to S) than BATS

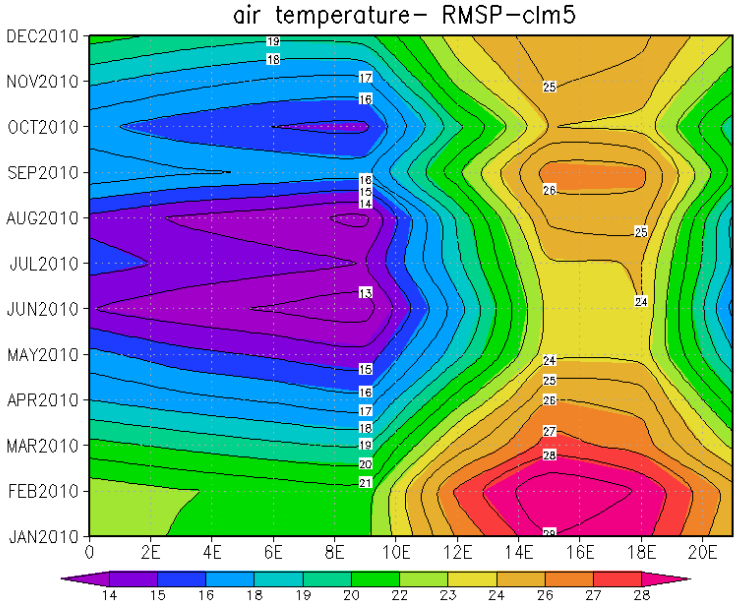
Local validation: diurnal cycle of air temperature over São Paulo

Monthly mean diurnal cycle

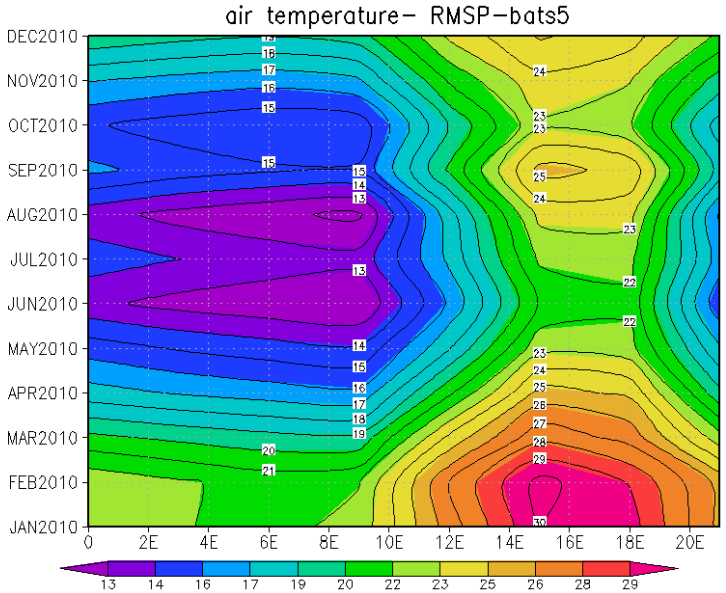
Observation



CLM



BATS



Diurnal cycle of air temperature is realistically simulated by both CLM and BATS

Final comments

- High resolution provides more realistic spatial patterns of rainfall and air temperature;

- Statistical indices (RMSE, SD, time correlation) for annual cycle – some improvements in high resolution experiments (CLM and BATS) → "Added Value"

- High resolution non-hydrostatic RegCM4.6.1 :
  - is able to simulate observed local features: sea breeze, valley-mountain breeze;

  - Simulated diurnal cycles are similar to the observations;

  - CLM overperforms BATS in simulating the diurnal cycle of meridional wind (characterstic of sea breeze in São Paulo) in greater agreement with observation → "urban effect" in reducing the wind velocity over the city;

- Most important: (a) we need mesoscale analysis; (b) local data to evaluate physical processes in the high resolution simulations.

Thanks!
Obrigada!