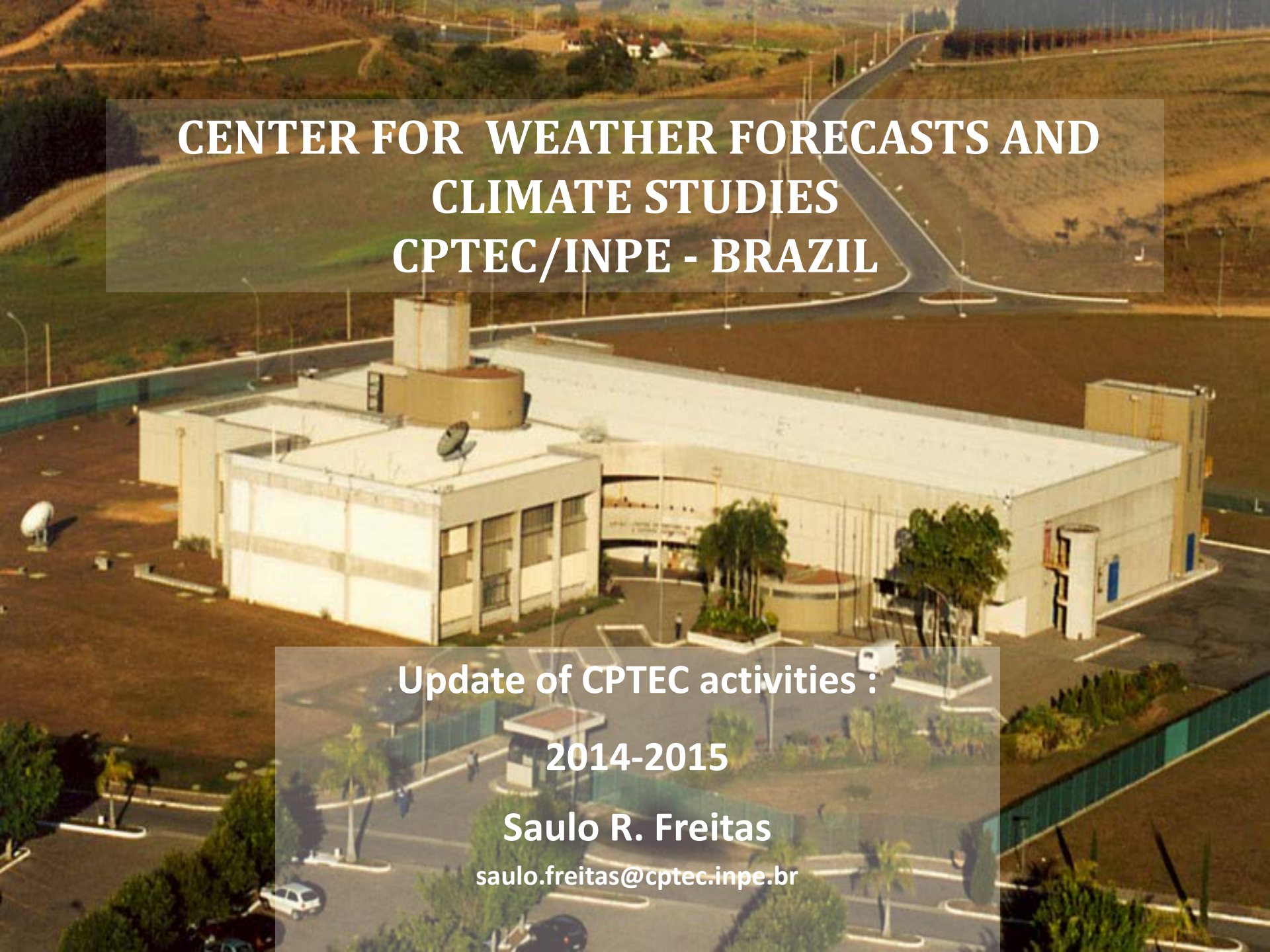


CENTER FOR WEATHER FORECASTS AND CLIMATE STUDIES
CPTEC/INPE - BRAZIL

Update of CPTEC activities :

2014-2015

Saulo R. Freitas

saulo.freitas@cptec.inpe.br

CPTEC/INPE supercomputer 2010-2015

Cray XT6 supercomputer

1272 nodes, 2 six-core AMD Opteron, 192 Gflops, 32 GB, SeaStar2

Performance: 244 Tflops (storage capacity: 3,84 PB)

Sustained: 15.8 Tflops (CPTEC benchmark)

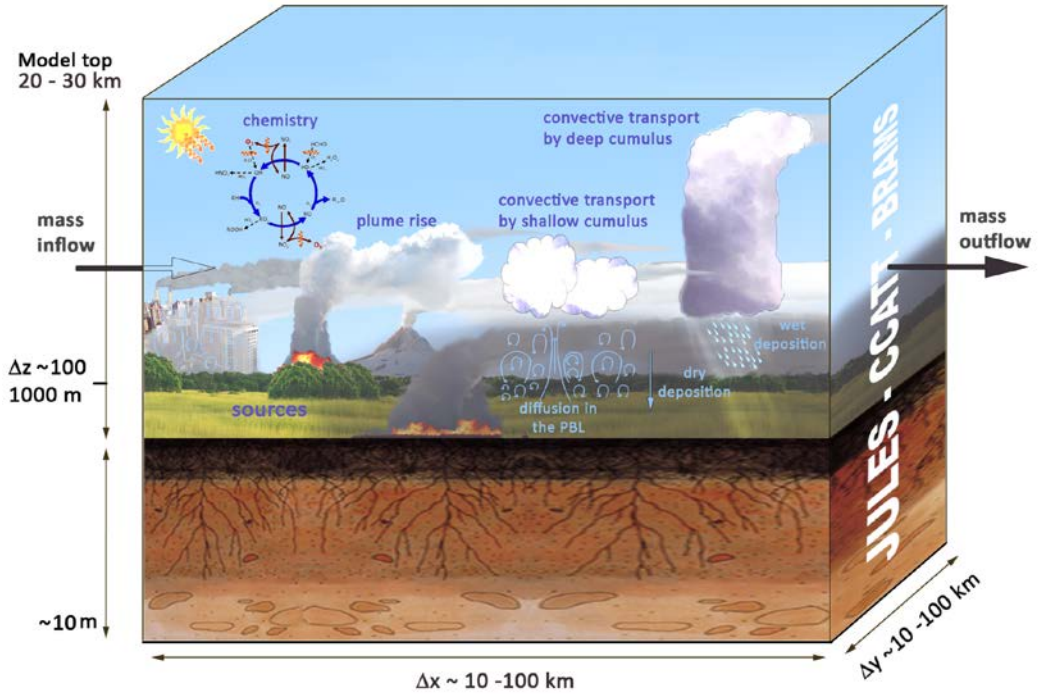
Peak performance: ~ 250 Tflops

Models configuration

MODEL – FOCUS - DOMAIN – FORECAST TIME LENGHT	Year 2014	Year 2015
BRAMS – severe weather – 500x500 km^2 over S. America – 1 ½ day (on-demand)	1 km	1 km
BRAMS – weather– S. America – 3.5 days (00 and 12 UTC)	5 km	5 km
Eta - weather – S. America - 11 days (00 and 12 UTC)	15 km	15 km
CCATT – weather + Air Quality (on-line) – S. America – 3 days (00 UTC)	25 km	15 km
AGCM with NCEP analysis – weather – Global – 7 days	T299L64	T666L96
AGCM with 3dVAR/GSI analysis – weather – Global- 7days	T299L64	T299L64
OA-GCM– 30 days– global	T126L28	80 km / L42
Eta – seasonal climate – S. America - 5 days	40 km	40km
AGCM – Ensemble 15 members – 15 days	T126L28	T126L28
Ocean Waves – 3 days – global domain	0.25 degree	0.25 degree

- Regional Scale

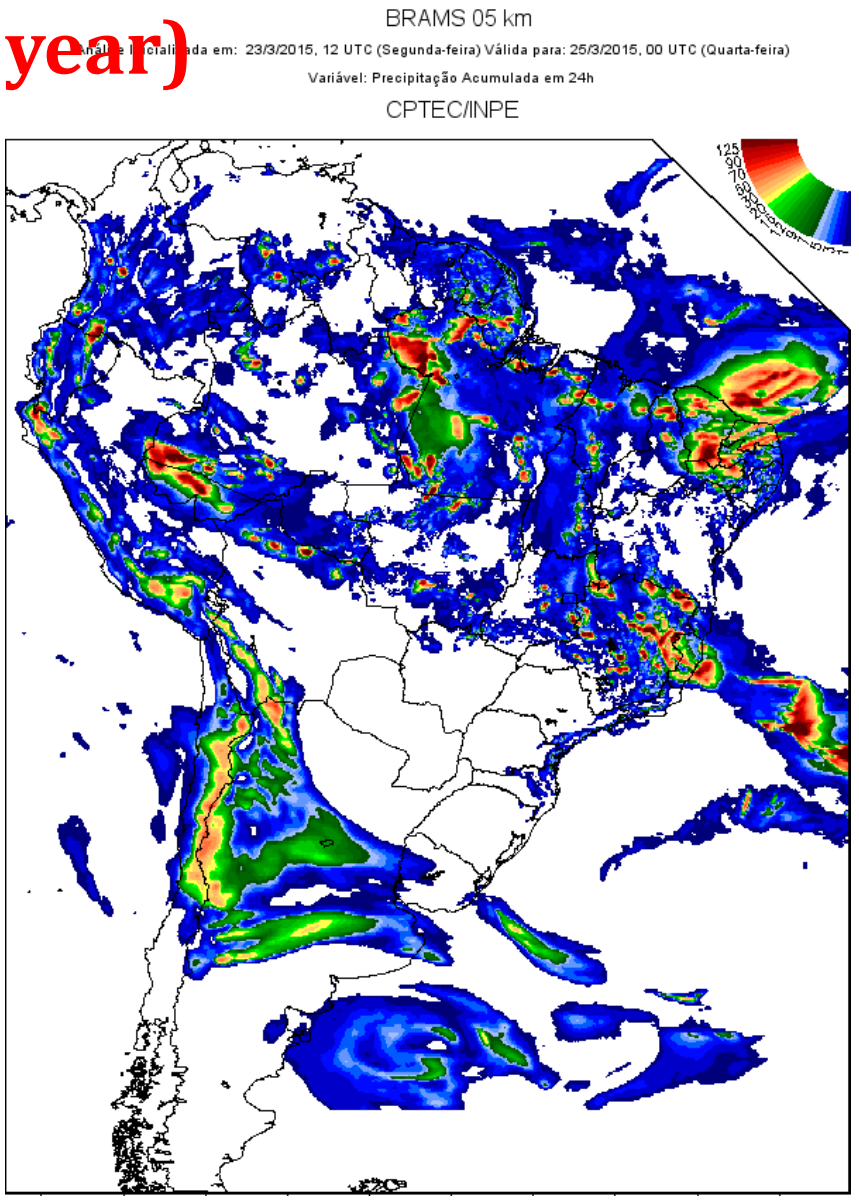
Brazilian developments on the RAMS Model version 2015



- Regional to local scales.
- Chemistry – aerosols - on-line with meteorology and including feedbacks.
- monotonic advection for scalars, 2-moment cloud microphysics, scale and aerosol aware convective parameterization, TEB urban surface scheme, MYNN turbulence scheme
- Running over a massive parallel system using MPI
- Includes JULES surface scheme: fully interactive carbon cycle; urban surface
- Includes now RRTMG radiation scheme and MATRIX aerosol model

Regional weather forecast for South America on 5km resolution with BRAMS model **(2nd year)**

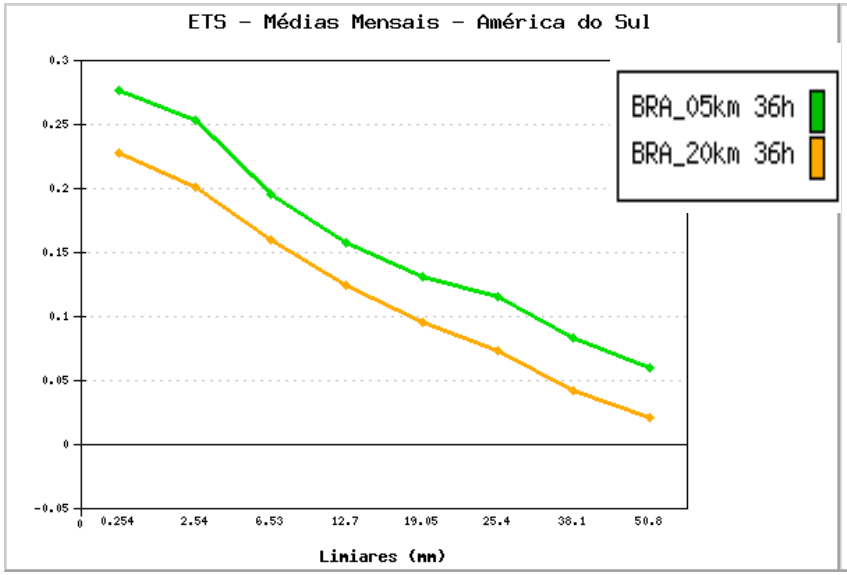
- Grid spacing:
  - Horizontal: 5 km x 5 km.
  - Vertical: 50 to 800 meters
- Time step: 15 seconds
- Model domain:
  - # grid points: 1360 x 1489 x 55 ~ 100 x 10^6
  - Model top at 21 km height ASL
- Forecast length:
  - 3 ½ days, starting at 00, 12 UTC.
- Execution time :
  - 20 mn on 9600 cores produces 1 day forecast (I/O is the bigger bottleneck)



Evolution of ETS and BIAS of precipitation forecast of with BRAMS 05 km at CPTEC/INPE

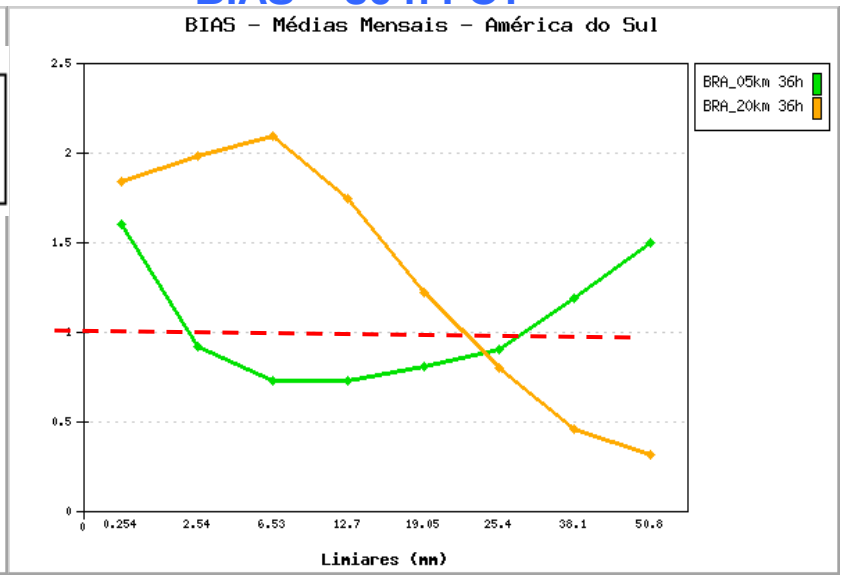
Evaluation data for South America (2013-2014)

ETS – 36 h FCT



Threshold (mm)

BIAS – 36 h FCT



Threshold (mm)

OLD 20km **NEW 05km**

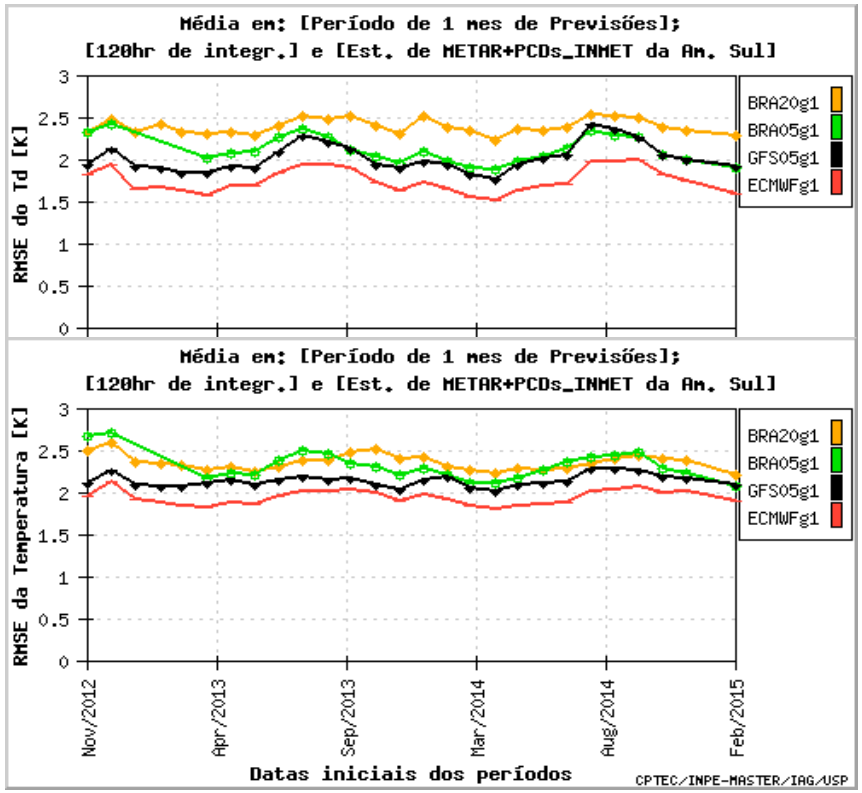
Evolution of RMSE with BRAMS at CPTEC/INPE

2meters – T and Td for S. America

New BRAMS 5km (BRA05), old BRAMS 20km (BRA20), GFS and ECMWF

RMSE 2m-Dew-Point Temp

RMSE 2m-Temp



BRA20g1
BRA05g1
GFS05g1
ECMWFg1

NOV 2012

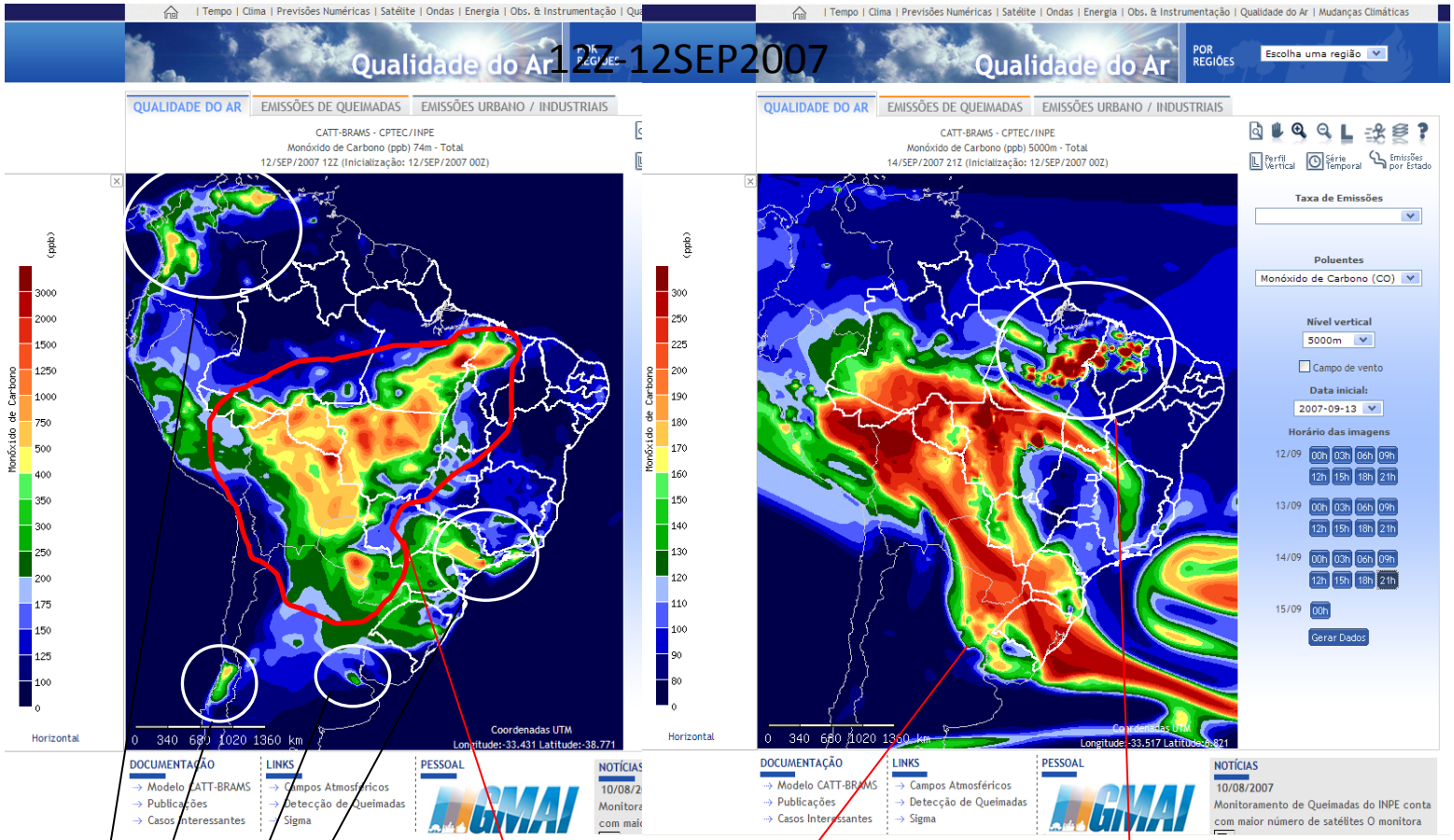
FEB 2015

New surface scheme (JULES)

Real Time Air Quality and Weather Forecasts for South America: http://meioambiente.cptec.inpe.br

Surface level CO (ppbv)

500 hPa CO (ppbv)



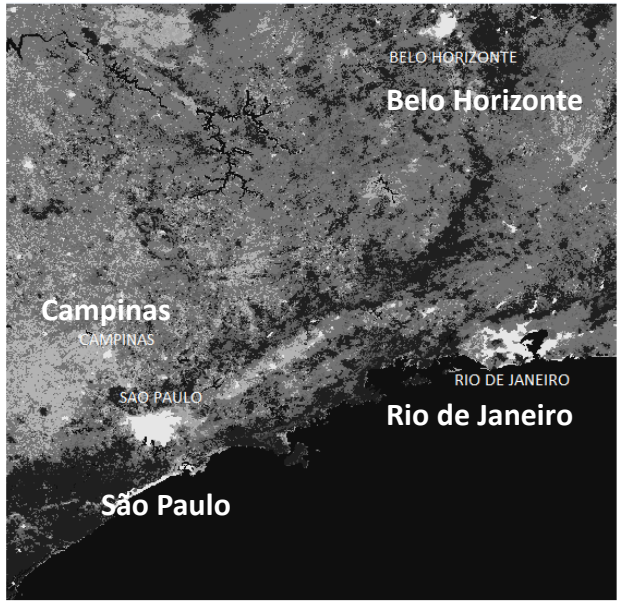
Mega Cities pollution

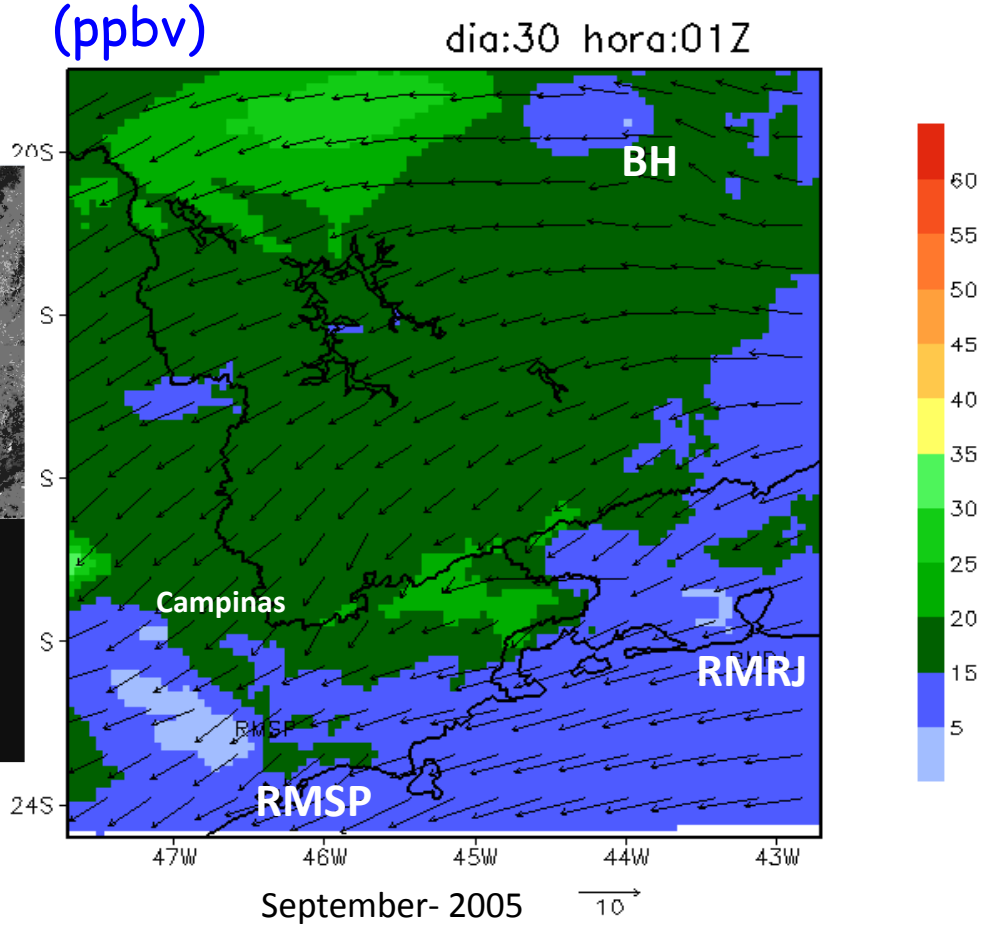
Old biomass burning pollution plumes

new fresh plumes injected by pyrocumulus

High resolution air quality forecast for the main metropolitan areas of Brazil

Near surface Ozone (ppbv)



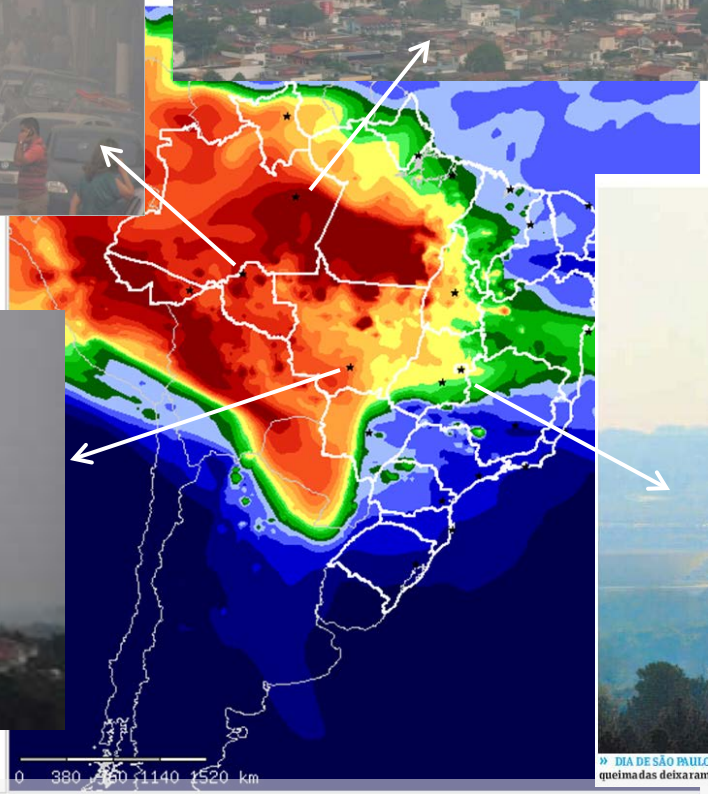


September- 2005

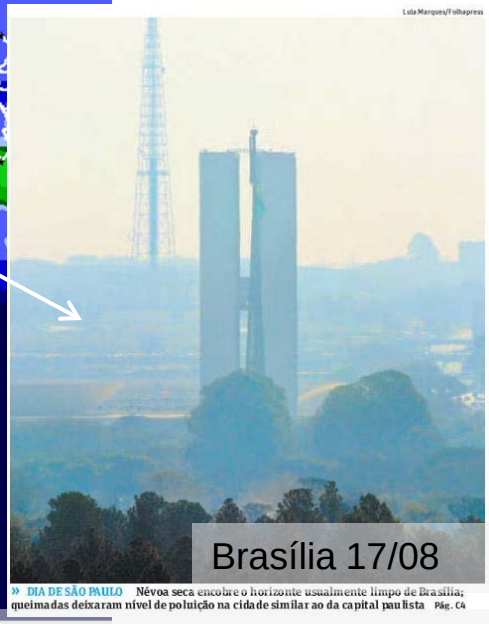
Biomass Burning Smoke and the main urban areas of Amazonia and Central part of Brazil 17-18/08/2010

Porto Velho 18/08

Manaus 17/08



Cuiaba17/08

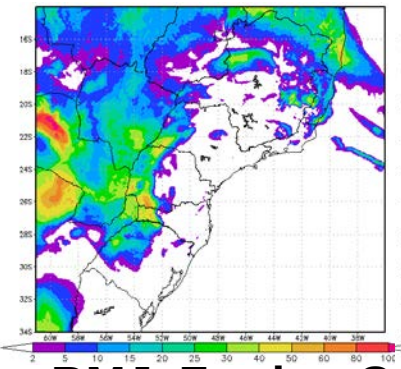


Brasília 17/08

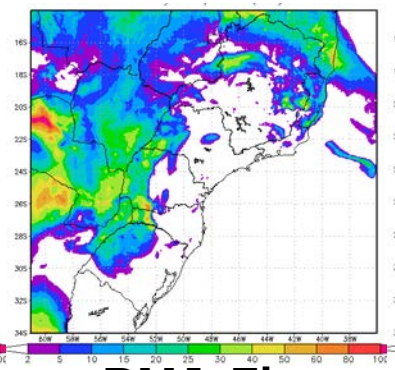
CATT-BRAMS PM2.5 surface concentration
Forecast for 18UTC 17/08/2010 – Initialized on 00UTC 16/08/2010

Mesoscale Eta/INPE model
High-resolution (5 km) physics ensemble

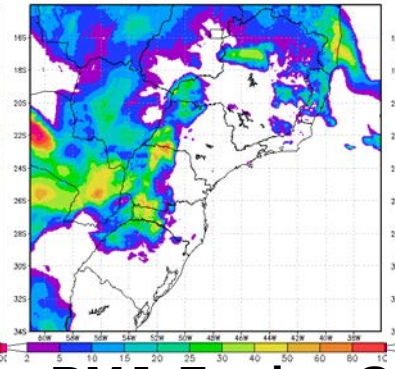
5 members by combination of 3 convection and 2 cloud microphysics schemes



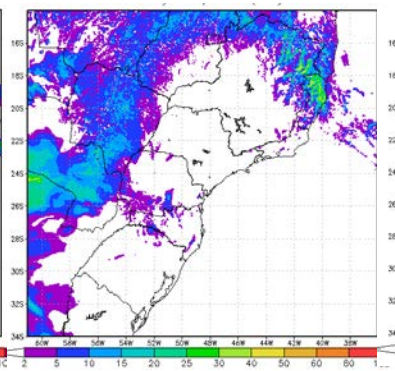
BMJ_Ferrier_C



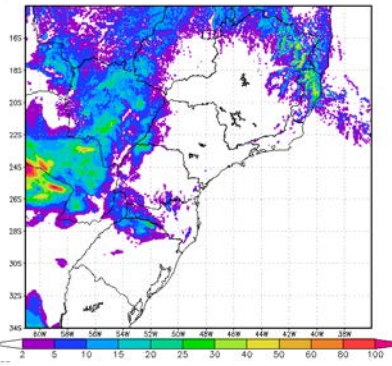
BMJ_Zhao



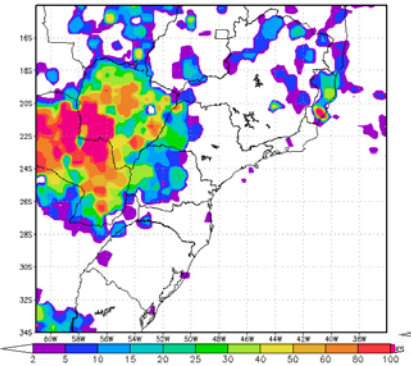
BMJ_Ferrier_G



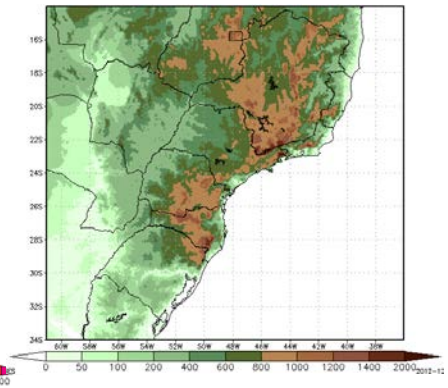
KF_G



KF_M_G



OBSERVATIONS

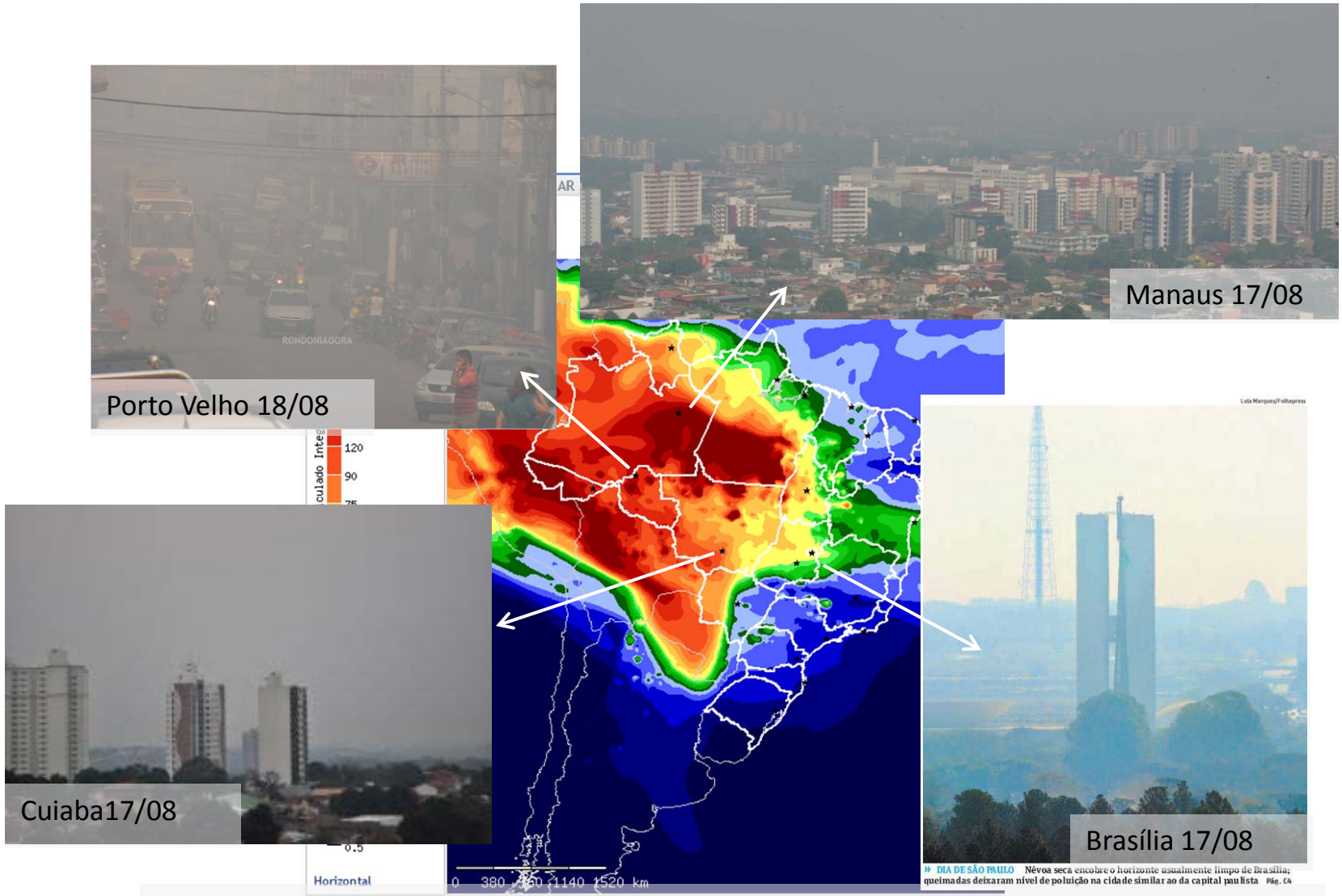


Model orography

Eta model, version of Mesinger et al 2012

- Convection schemes: BMJ, KF, KFM
- Cloud microphysics schemes: Ferrier, Zhao
- LBC: Eta-40km, GFS
- Runs daily twice: 00Z and 12 Z.
- Domain: Southeast part of Brazil

Biomass Burning Smoke and the main urban areas of Amazonia and Central part of Brazil 17-18/08/2010



CATT-BRAMS PM2.5 surface concentration

Forecast for 18UTC 17/08/2010 – Initialized on 00UTC 16/08/2010

Global scale atmospheric modeling

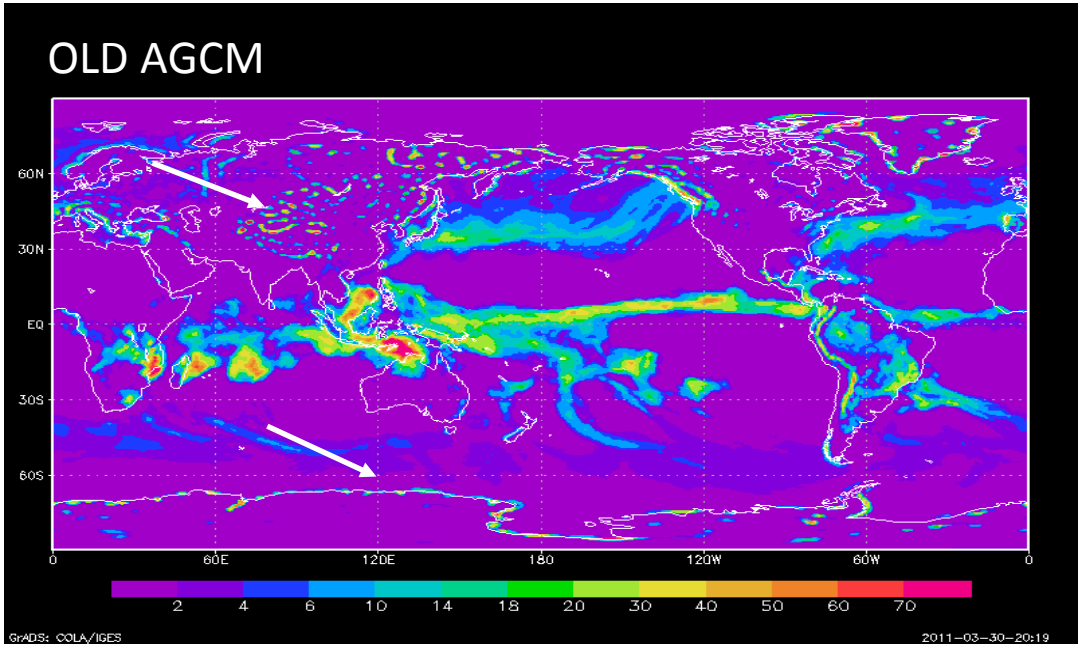
IMPROVEMENTS on CPTEC AGCM

A new version of the CPTEC AGCM has been developed recently:

- transport using a semi-Lagrangian scheme
- new physical parameterizations:
  - double-moment microphysics,
  - cumulus parameterization with six mass flux closures,
  - IBIS surface scheme, including dynamic vegetation,
  - non-local PBL,
  - RRTMG radiation,
  - gravity-wave with low level blocking.
- Evaluation of the new version in weather and long term time-scale are in progress.

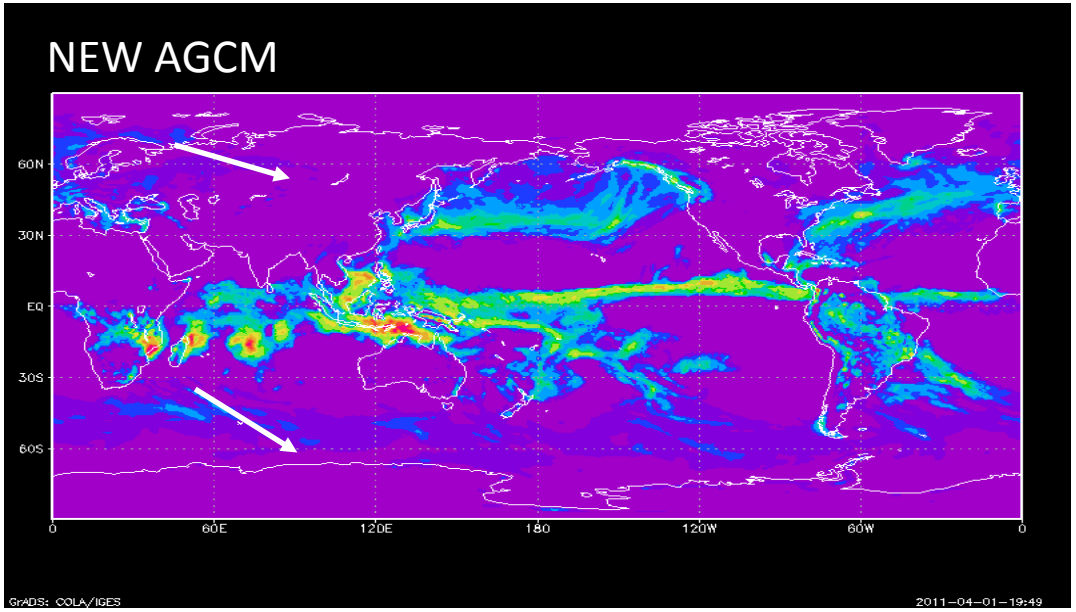
OLD DYNAMIC CORE CPTEC AGCM

The previous dynamics core is a Eulerian spectral model in a Divergence-Vorticity formulation.



NEW DYNAMIC CORE CPTEC AGCM (2014)

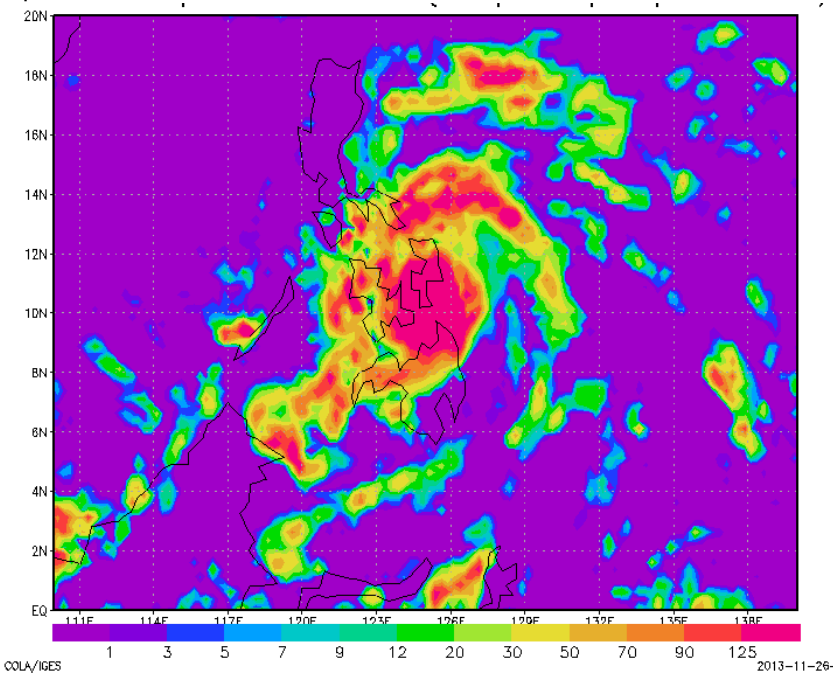
The new dynamics core contains a spectral U-V formulation with a semi-implicit scheme with options for semi-Lagrangian or Eulerian integrations, and a semi-Lagrangian monotonic scheme for the transport of moisture and tracers (details in Figueroa et al. 2015)



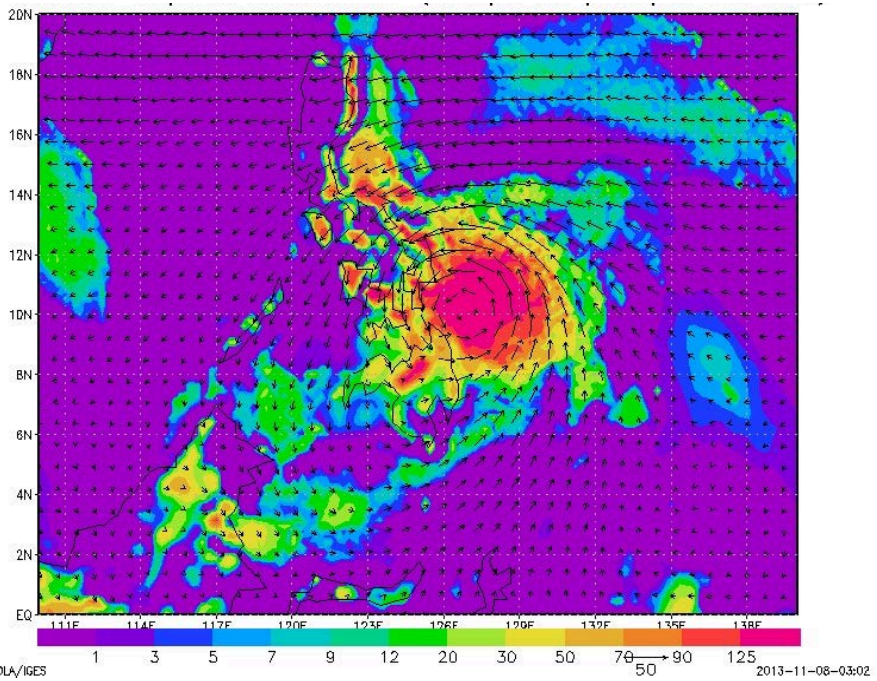
Super Typhoon Haiyan (Philippines) 24 h FCST* by the new CPTEC –AGCM (20 km and 64 vertical levels).

Dynamics: Semi-Lagrangian transport scheme, 400s timestep.
Physics: land surface scheme the Integrated Biosphere Simulator (IBIS), non-local Mellor-Yamada diffusion scheme, new orography gravity-wave scheme with low-level blocking, Morrison double moment microphysics scheme, RRTMG short and long-wave radiation scheme.

24-h Accumulated Precip (TRMM, mm)



24-h Accumulated Precip (AGCM/CPTEC, mm)



* Not in real time

Current Status of Data Assimilation at CPTEC/INPE

Data Assimilation Systems:

- **PSAS** – *Physical-space Statistical Assimilation System* (Variacional 3D, Observer ~10e4, Global/Regional) FORMER OPERATIONAL (discontinued on Jan/2013)

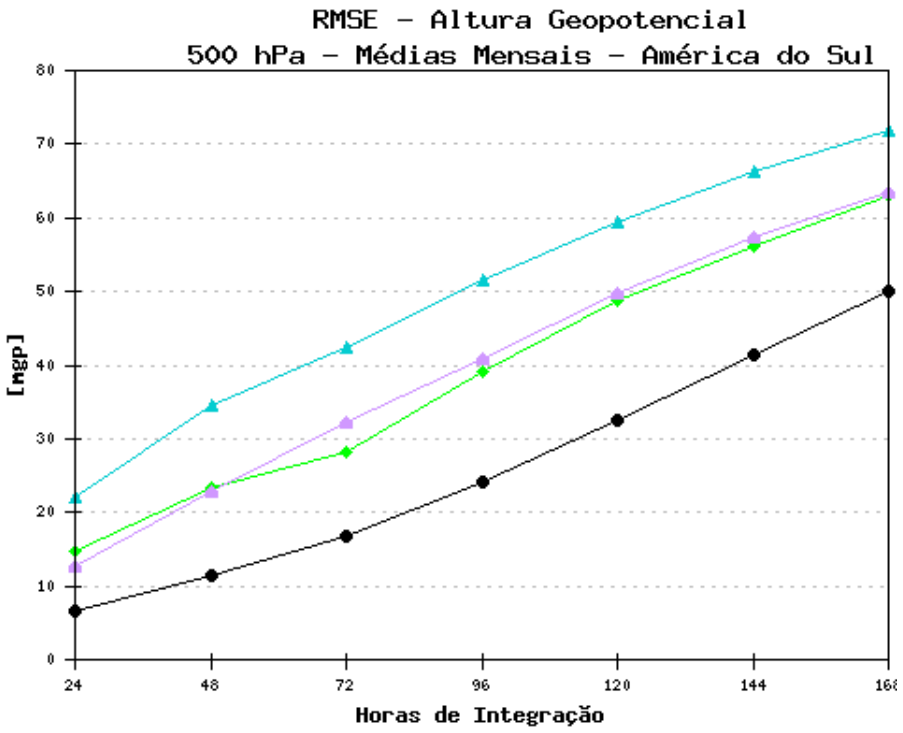
- **GSI** – *Gridpoint Statistical Interpolation* (Variacional 3D/4D, Observer ~10e5, Global) : OPERATIONAL since 2013 (T299).

- **LETKF** – *Local Ensemble Transform Kalman Filter* (Sequencial, Observer ~10e5, Global) RESEARCH MODE (since 2008)

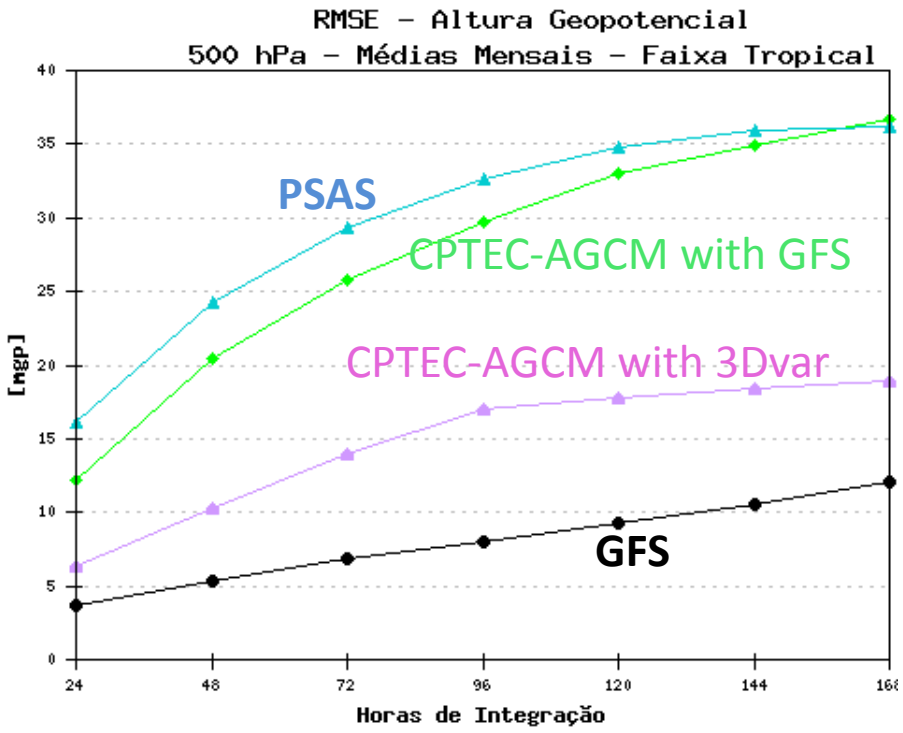
Performance of GSI - 3dVAR versus PSAS
RMSE of Geopotential Height at 500 hPa

T299_L64 00h
GFS 00h
GPSAS213 00h
G3_D_VAR 00h

South America



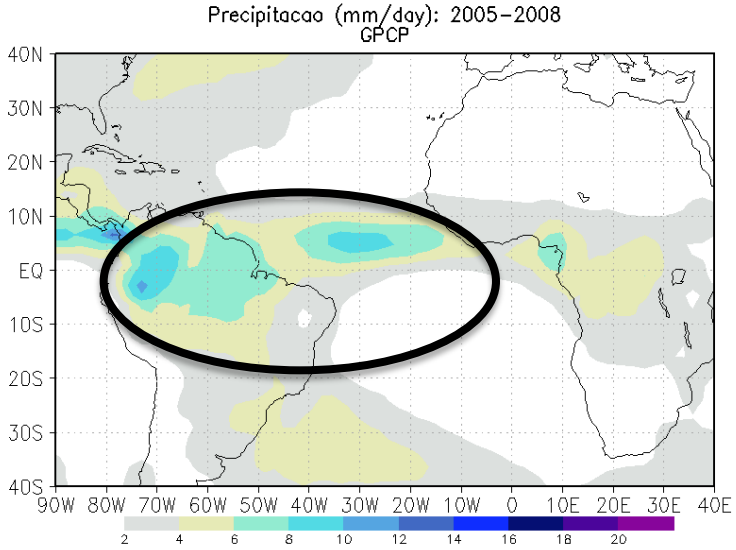
Tropical Area (30S-30N)



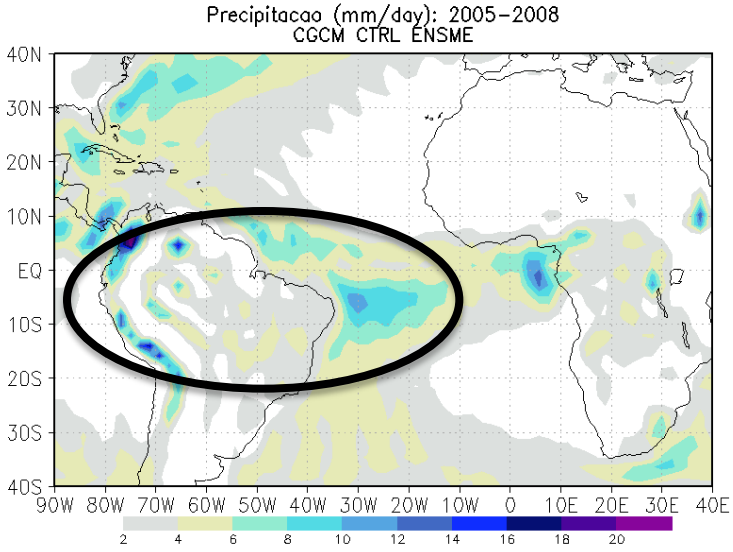
Brazilian Earth System Model (BESM) Ocean-Atmosphere Recent Developments

BESM Rainfall over the Amazon

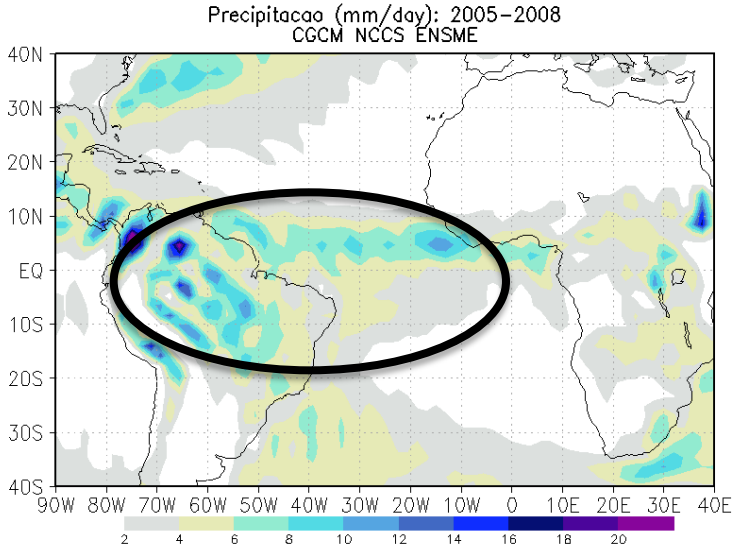
GPCP



BESM 2.3



BESM 2.3.1

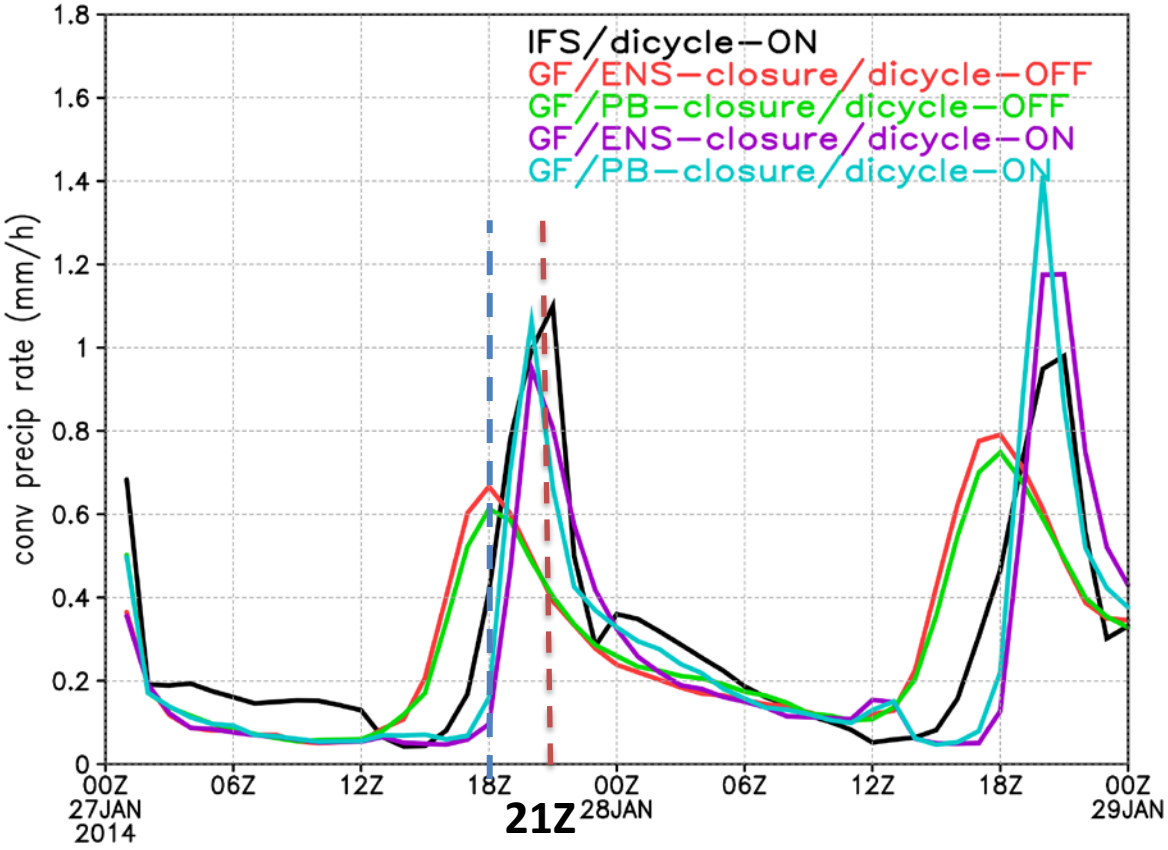


Bottino and Nobre (2014)

- Recent developments

Improving the simulation of the diurnal cycle of the convection over the Amazonia with GF convective parameterization

Conv prec rate (mm/h)
(area average over Amazonia domain)



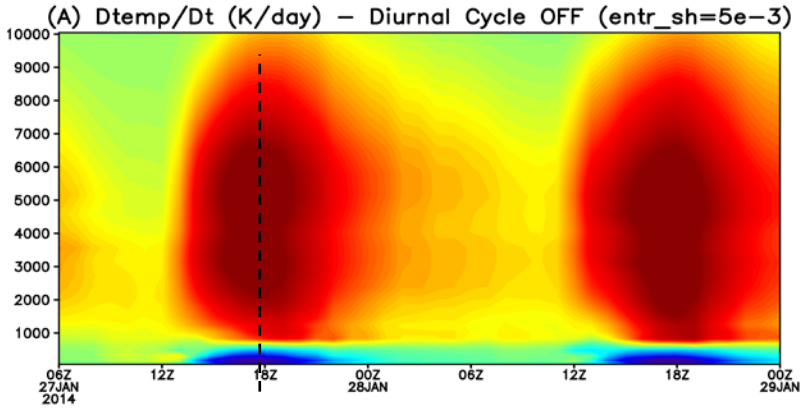
Representing Equilibrium and Nonequilibrium Convection in Large-Scale Models
Bechtold et al., 2014 JAS.

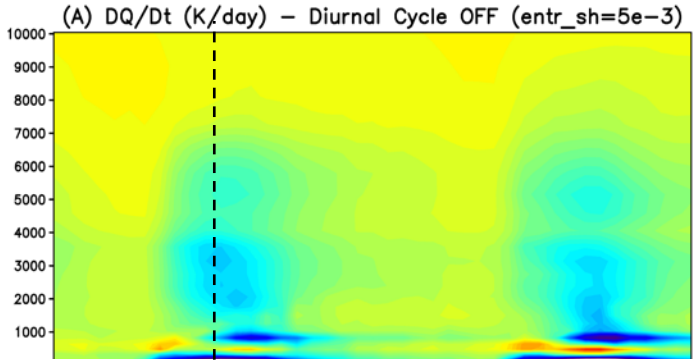
Temperatura Tendency (K/day)

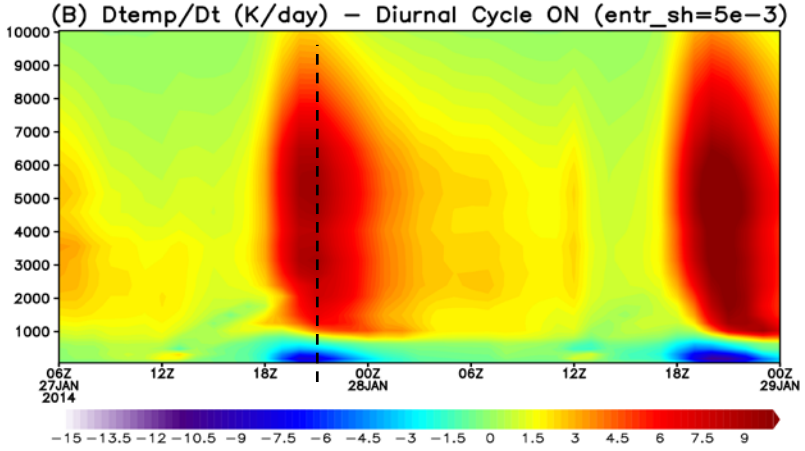
Water vapor Tendency (K/day)

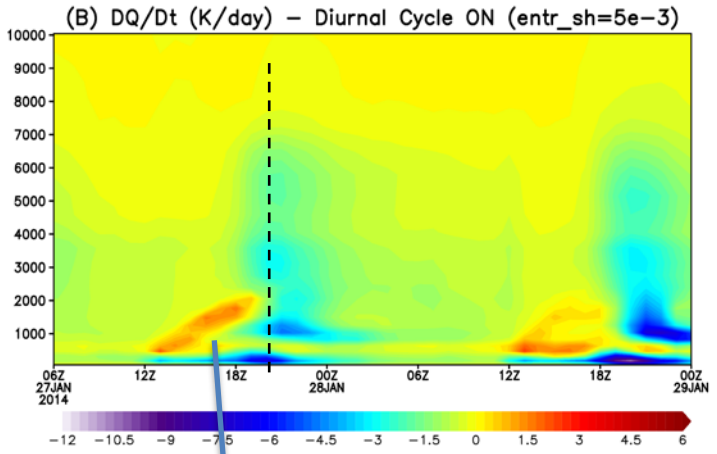
No diurnal cycle closure

diurnal cycle closure









Transition from shallow to deep convection

Thanks for your attention !

Questions ?

Some conclusions

CPTEC recent activities:

- 1 year of a NWP using BRAMS on 5 km resolution covering the entire South America has been completed. Rainfall and several meteo fields forecast presented large improvements.
- BRAMS also has been also integrated with JULES surface scheme.
- On a global scale, preliminary results using an new set of physical parameterizations indicated better scores. More robust evaluation will appear soon.
- The GSI 3d-VAR data assimilation approach has been adopted by CPTEC and this system was applied to the AGCM. The new analysis presents large improvement in comparison with the PSAS system. This year, the same methodology will be applied for regional weather forecasting with BRAMS.
- Global scale ensemble forecast has been improved with new methodology for the application of random perturbations developed at CPTEC and it is operational since 2013.
- Brazilian E. System Model is also under development showing improvements.
- Developments on a regional scale with new time-stepping scheme and aerosol/scale aware cumulus scheme are being made.

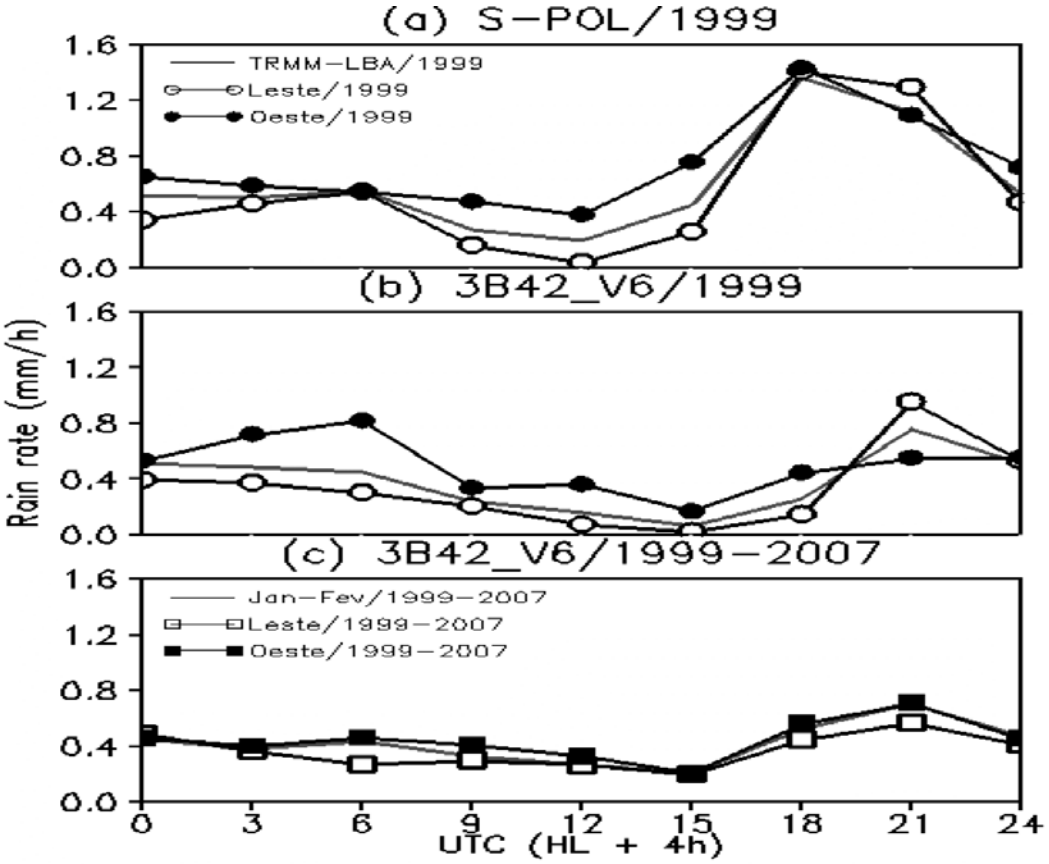


Figura 6.6 – Ciclo diurno: (a) a partir da precipitação do radar S-POL durante o experimento TRMM-LBA dividido em regime de Leste e de Oeste; (b) idêntico a (a), mas para o algoritmo 3B42_V6; (c) idêntico a (b), mas para os anos de 1999 a 2007.

Outline

- Report developments/status on:
  - Regional Atmospheric and Environmental Modeling
  - Global Atmospheric Modeling
  - Data Assimilation, Ensemble Prediction
  - Development of an Earth System Model
- Going-on developments and research