Ministério da Ciência e Tecnologia
Instituto Nacional de Pesquisas Espaciais

RCM experience in INPE in support for Climate Change studies

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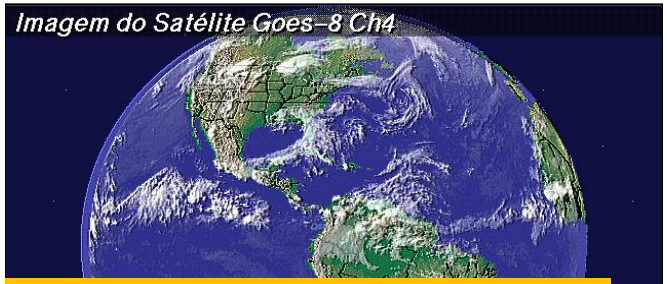
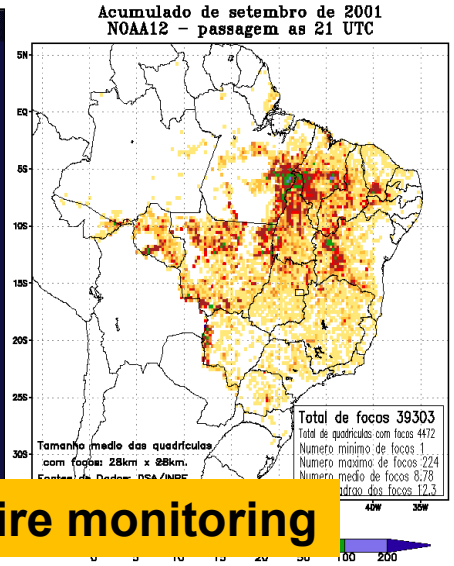
VAMOS/CORDEX, Lima, 2013

CPTEC/INPE Activities and products

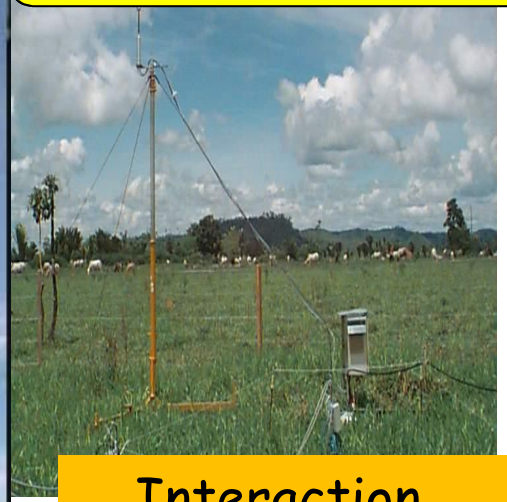
CPTEC



Satellite derived products

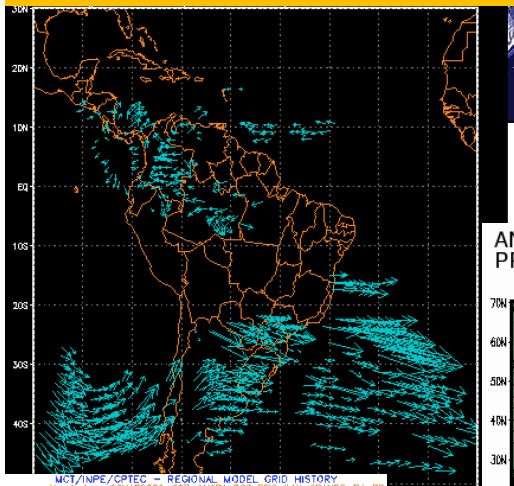


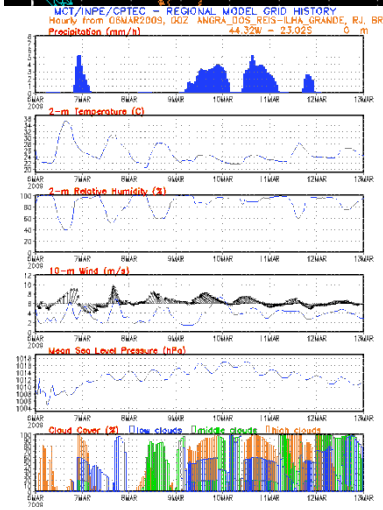
Fire monitoring

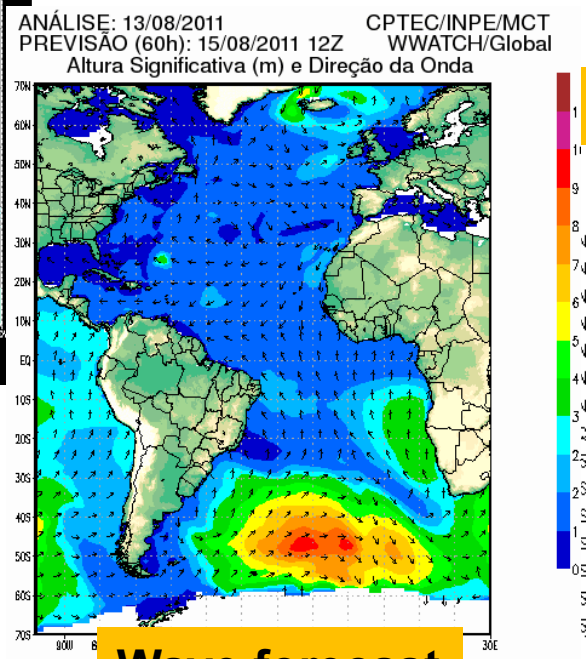


Interaction land-atmosphere

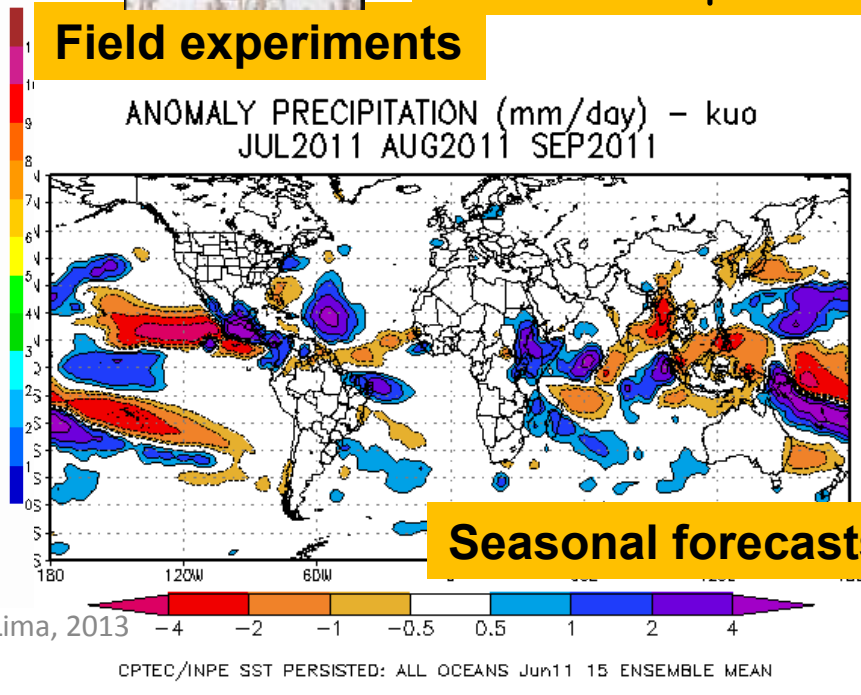
Field experiments







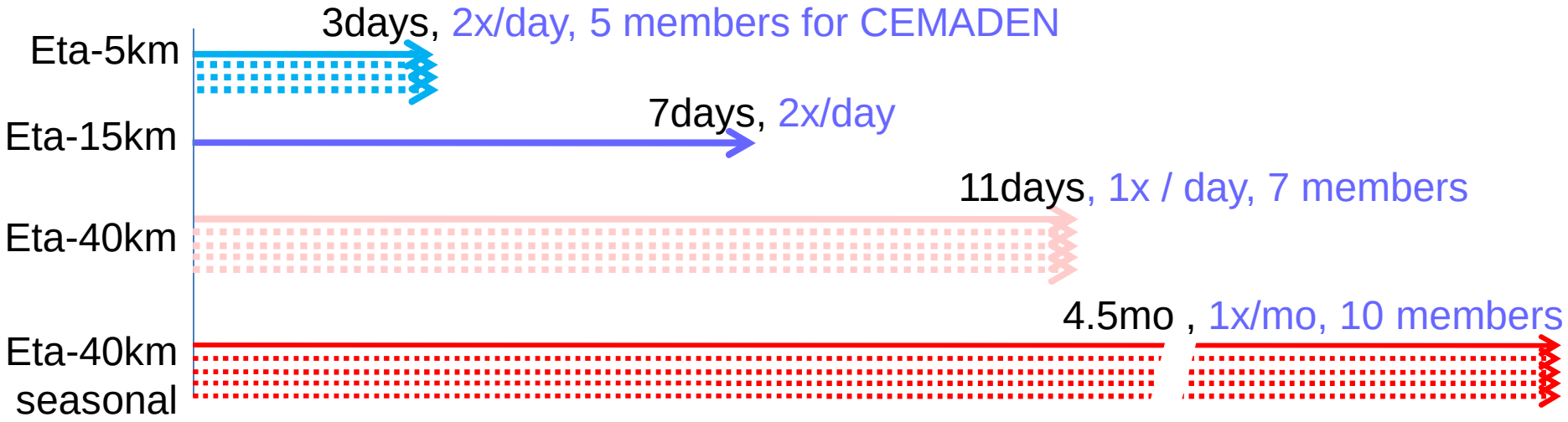
Wave forecast



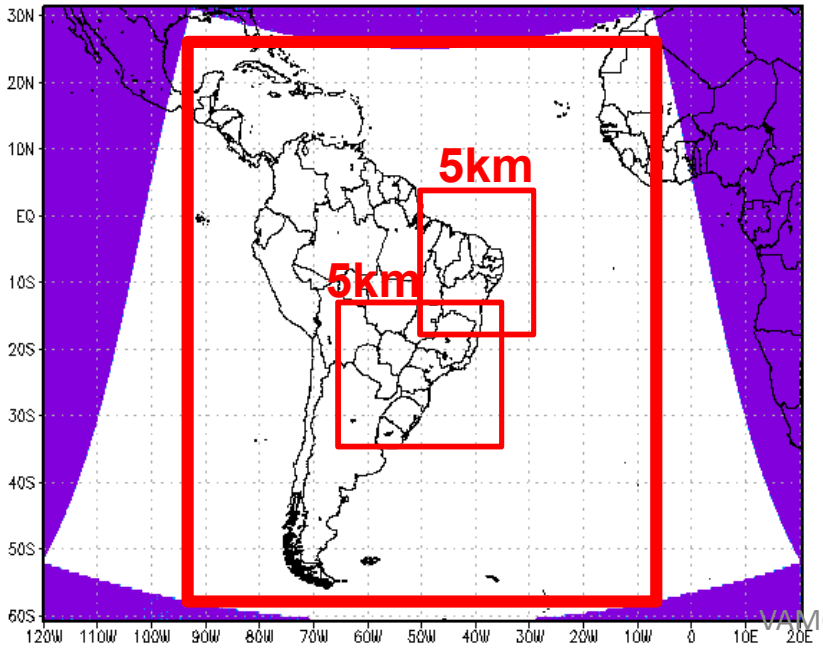
Seasonal forecasts

CPTEC/INPE SST PERSISTED: ALL OCEANS Jun11 15 ENSEMBLE MEAN

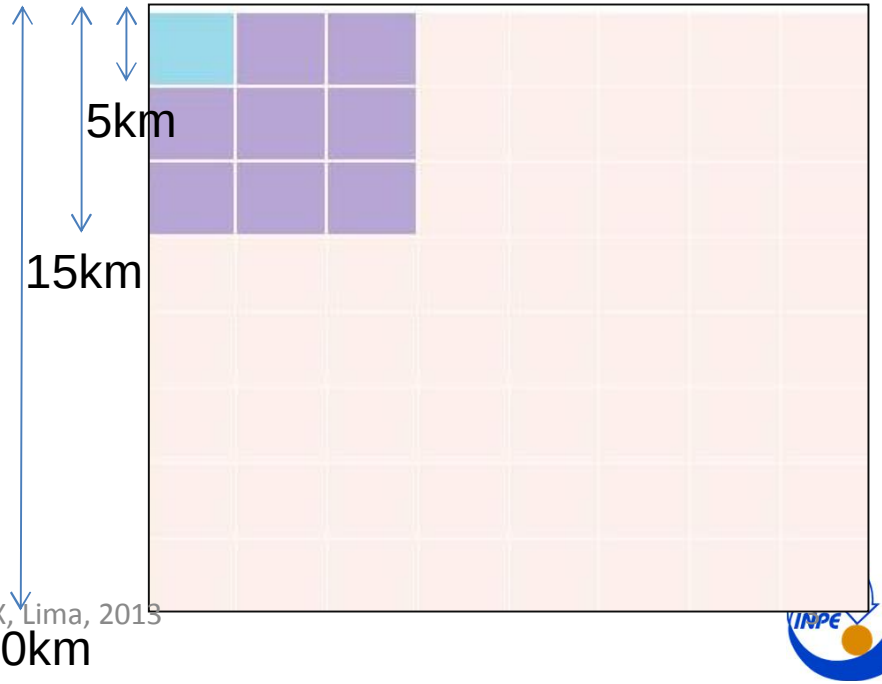
CPTEC Eta Model Operational Suite



Domains



Grid size relations



Supercomputer MCTI/FAPESP

CRAY XE6

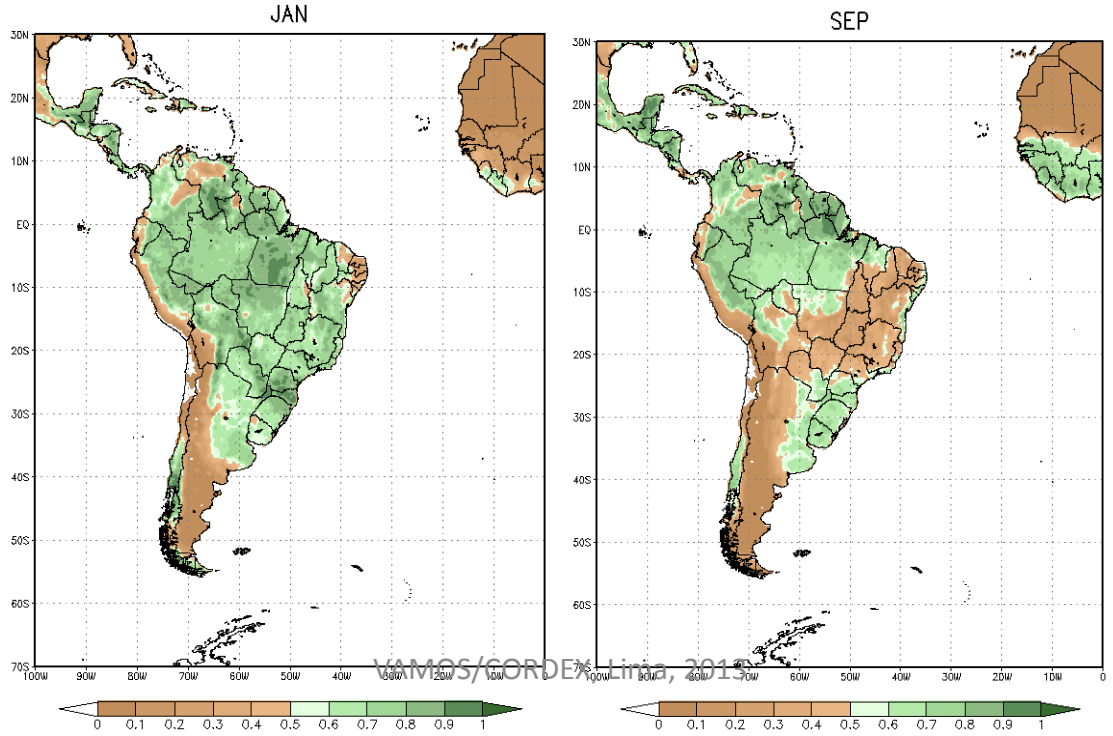
- Nodes: 1280, 24 cores each node
- Total processing cores: 30720
- Effective Velocity: 258 TFlop/s.
- Primary storage: 866TB
- HSM storage: 3.84PB
- HSM tape: 6PB

1961-1990 simulations using Eta Model forced by HadCM3 historical 4-member runs

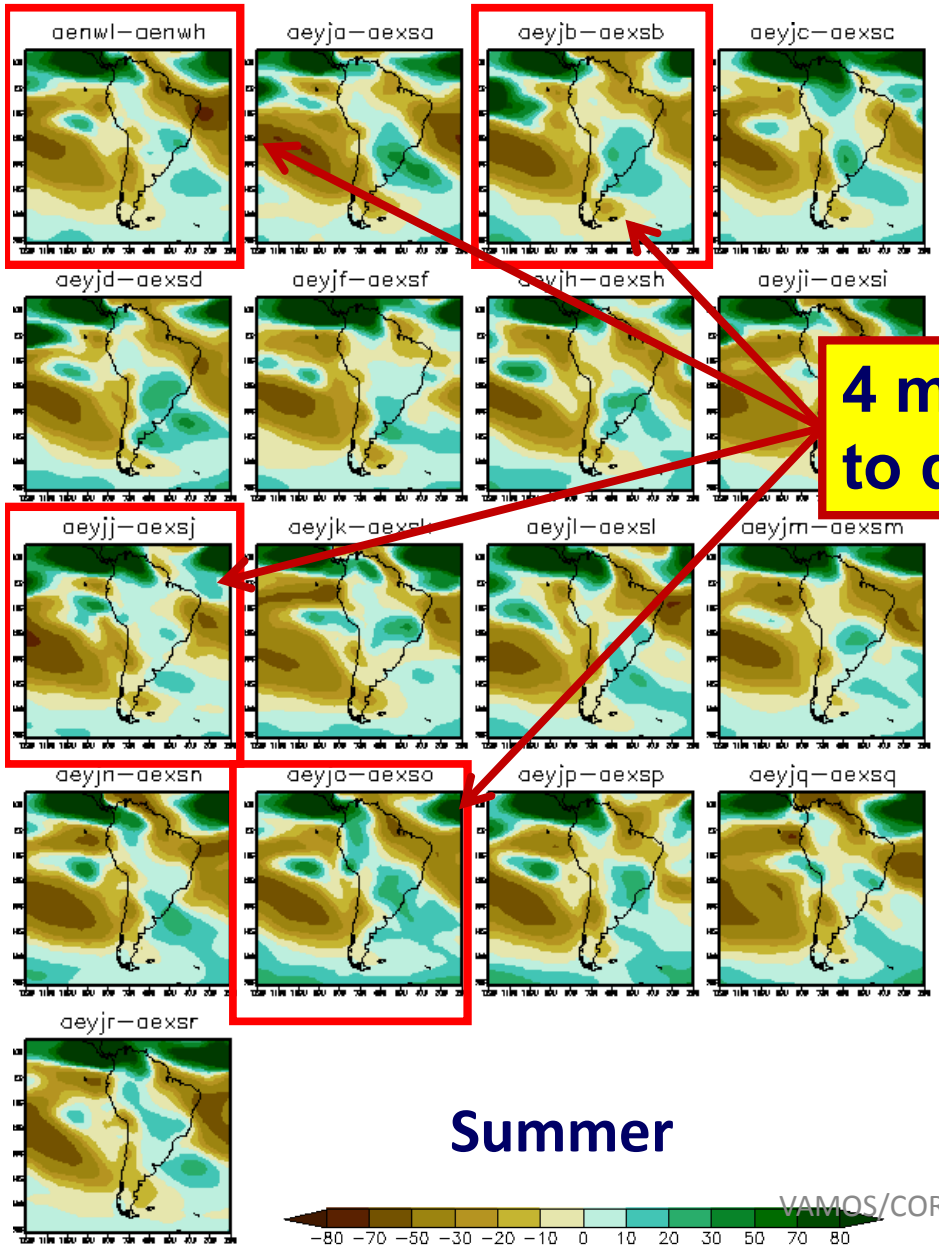
(Chou et al 2012, CliDy)

Eta Model: from Weather to Climate Change version

1. **360-day year calendar**;
2. **Equivalent CO2 concentration, update every 5 years;**
3. **HadCM3 Monthly Sea Surface Temperature**, daily update
4. **Monthly Vegetation Greeness, daily update;**
5. **Interface to read HadCM3, output**



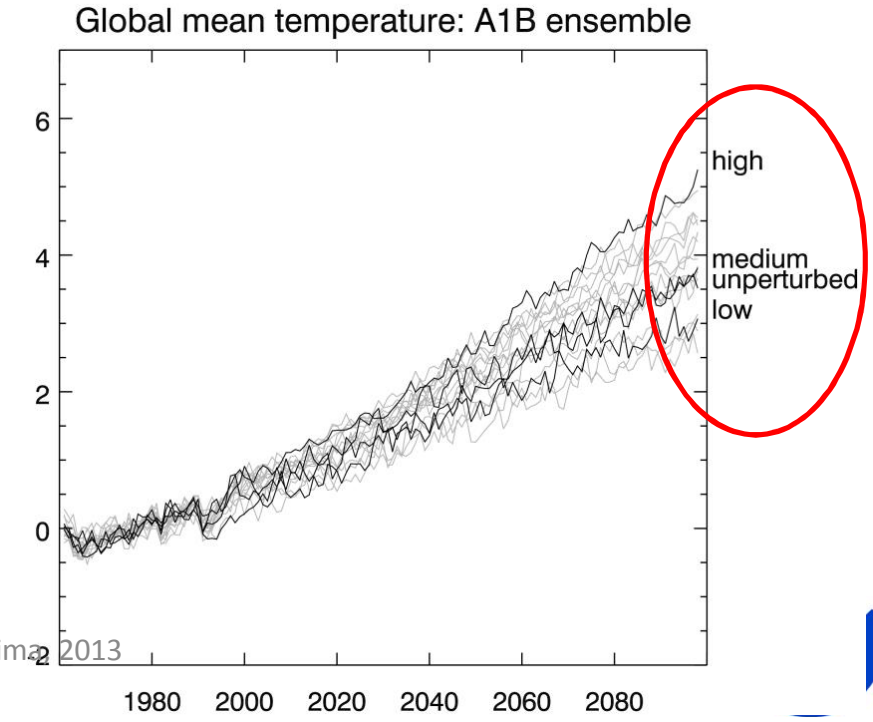
Veg greeness



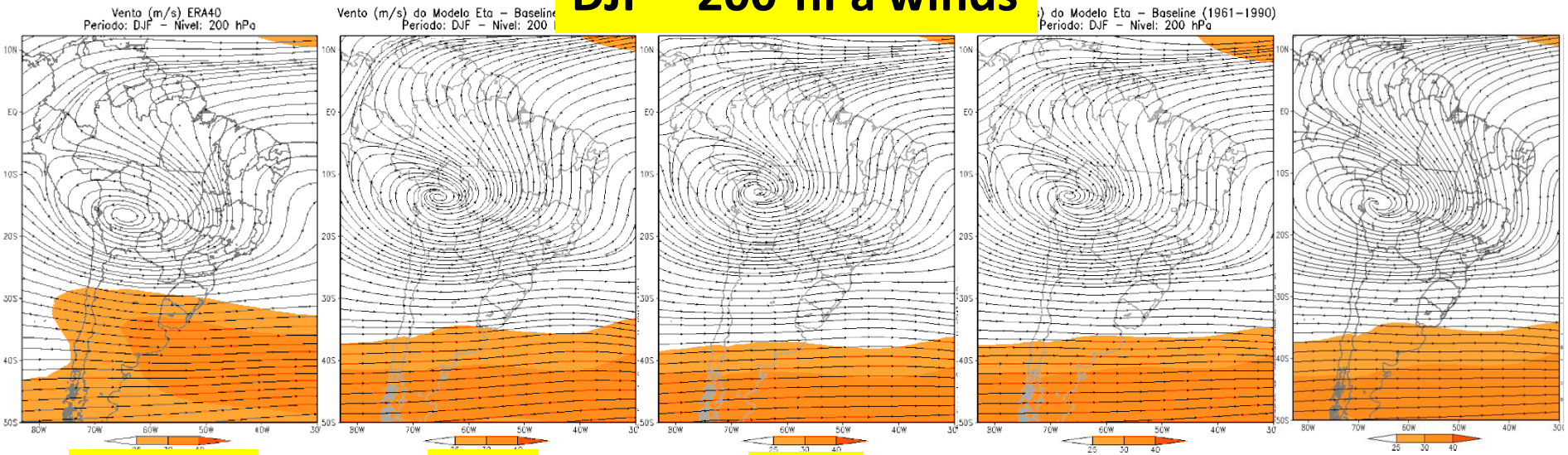
Summer

Percentage of precipitation change in 2071-2099 with respect to 1961-1990 in HadCM3 runs

4 members of HadCM3 PPE used to drive Eta Model



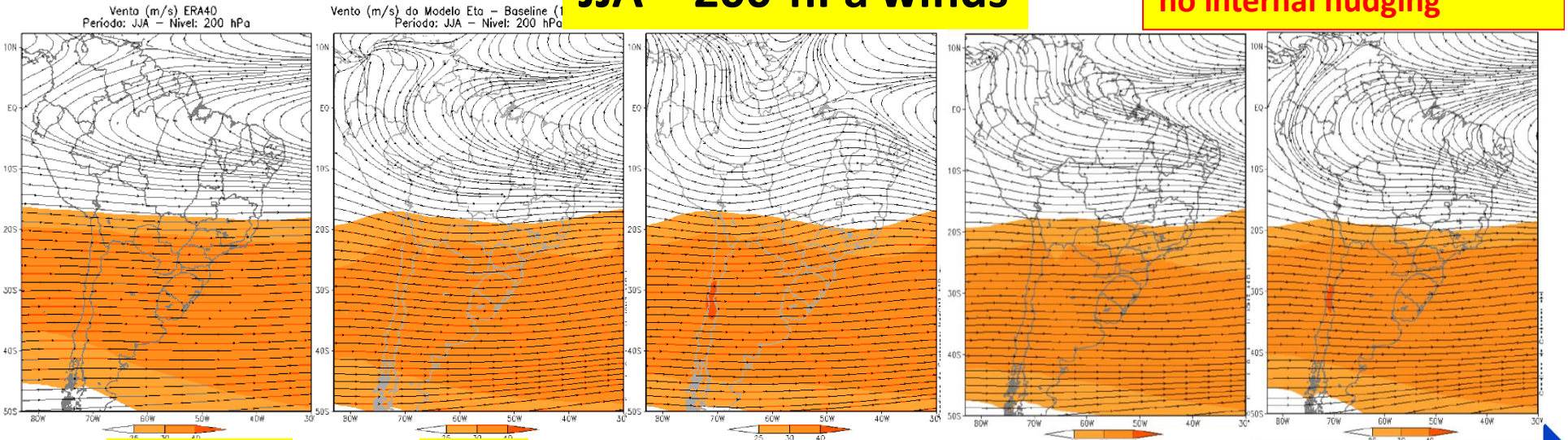
DJF – 200-hPa winds



ERA-40 | low | mid | high | std

JJA – 200-hPa winds

1lbc row, no lbc relaxation, no internal nudging

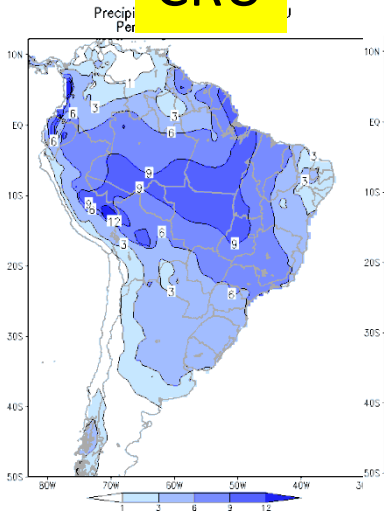


ERA-40 | low | mid | high | std

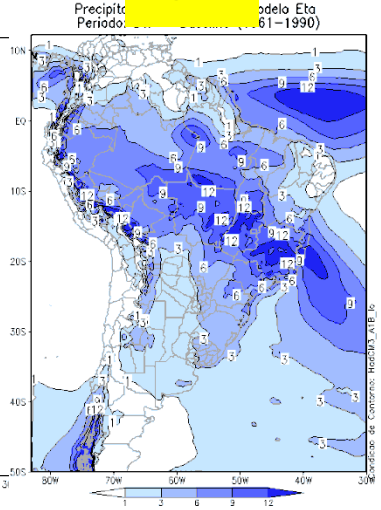
1961-1990 PRECIPITATION

DJF

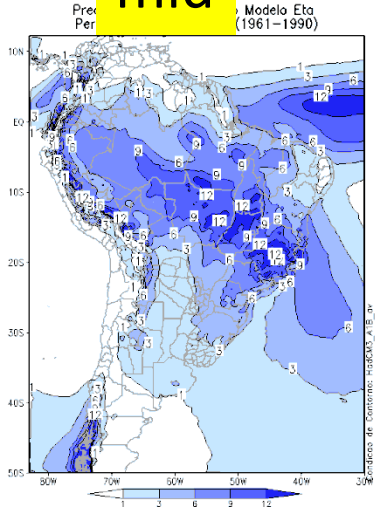
CRU



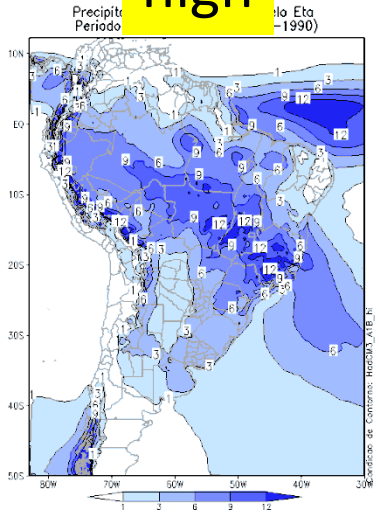
low



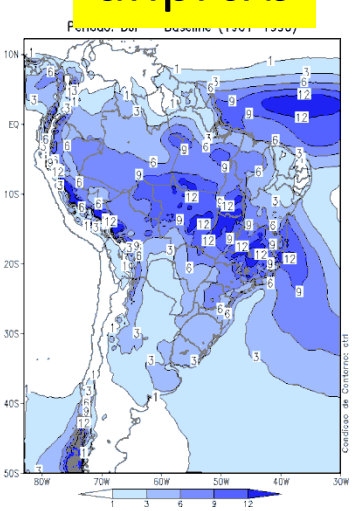
mid



high

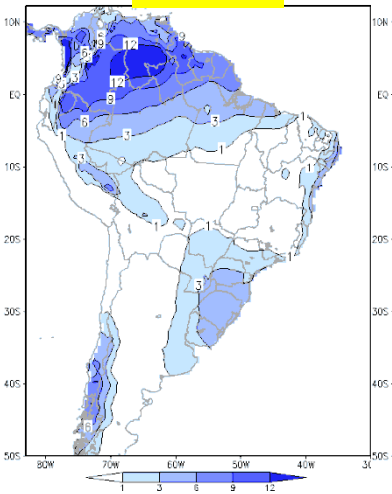


unprtrb



JJA

CRU



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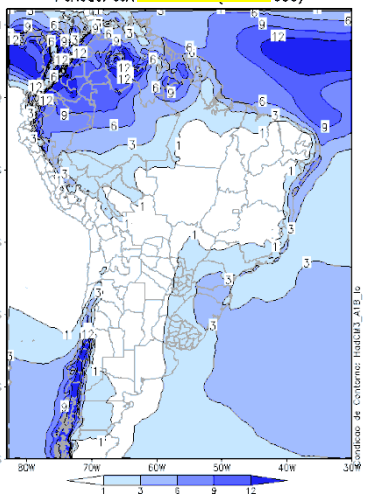

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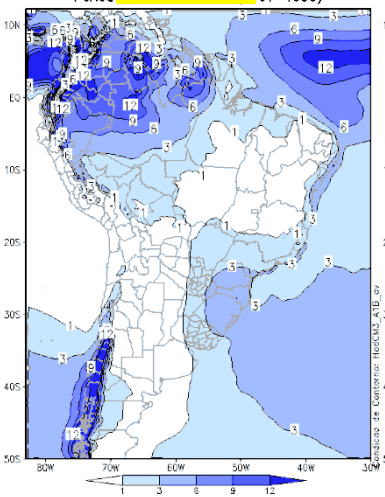

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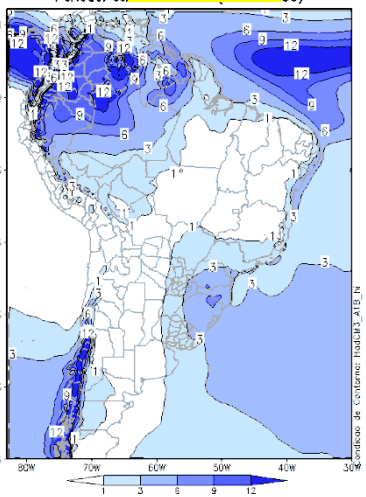

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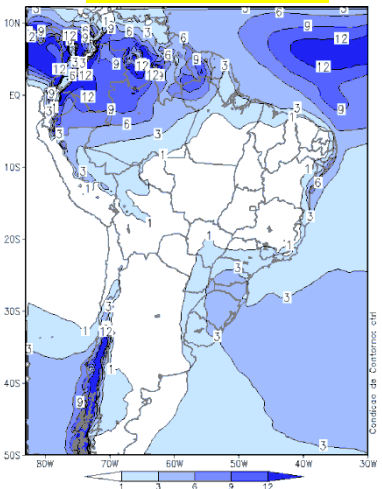
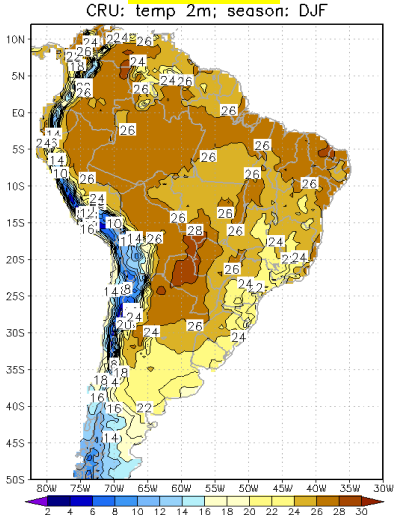


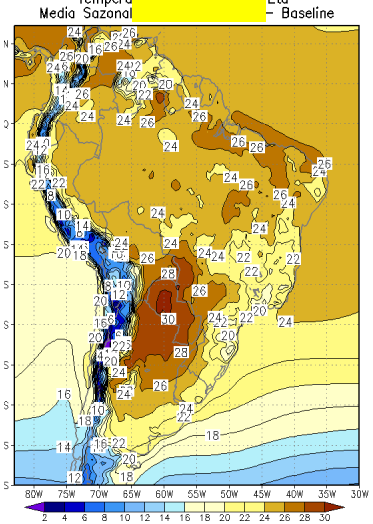
1961-1990 mean TEMPERATURE

DJF

CRU



low



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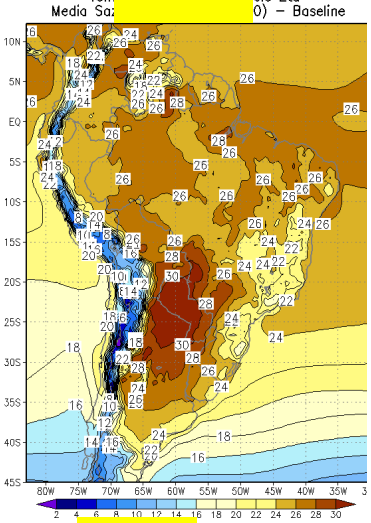

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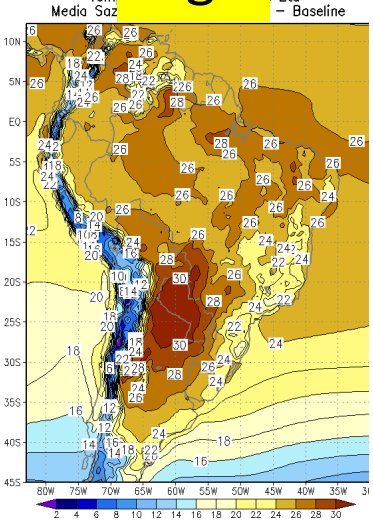

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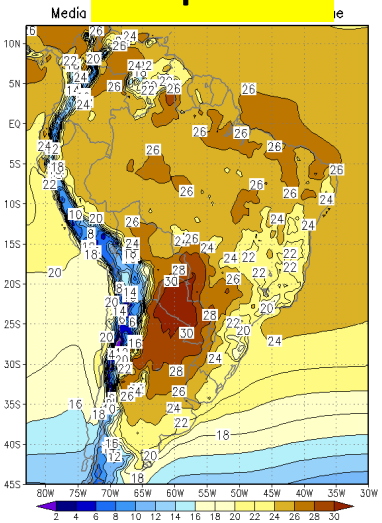
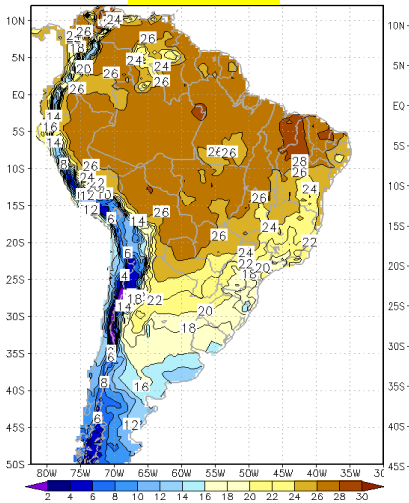
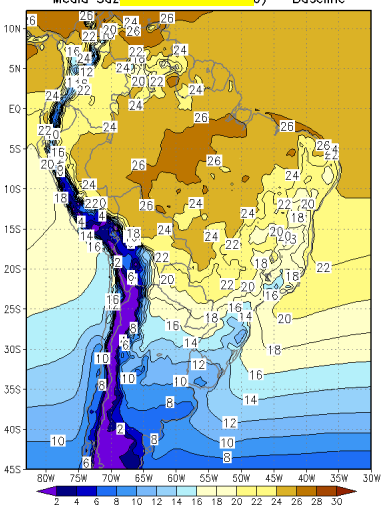


JJA

CRU



low



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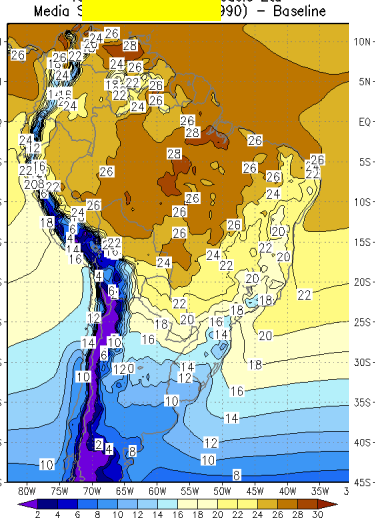

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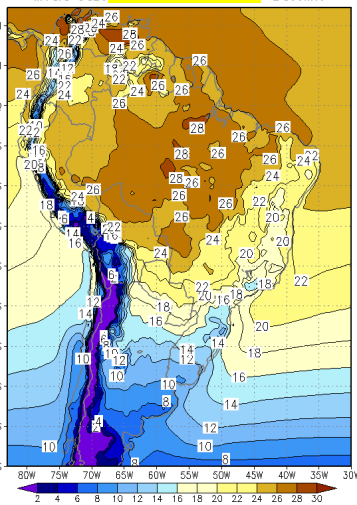

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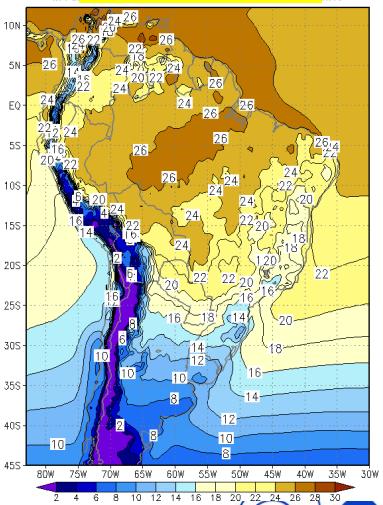
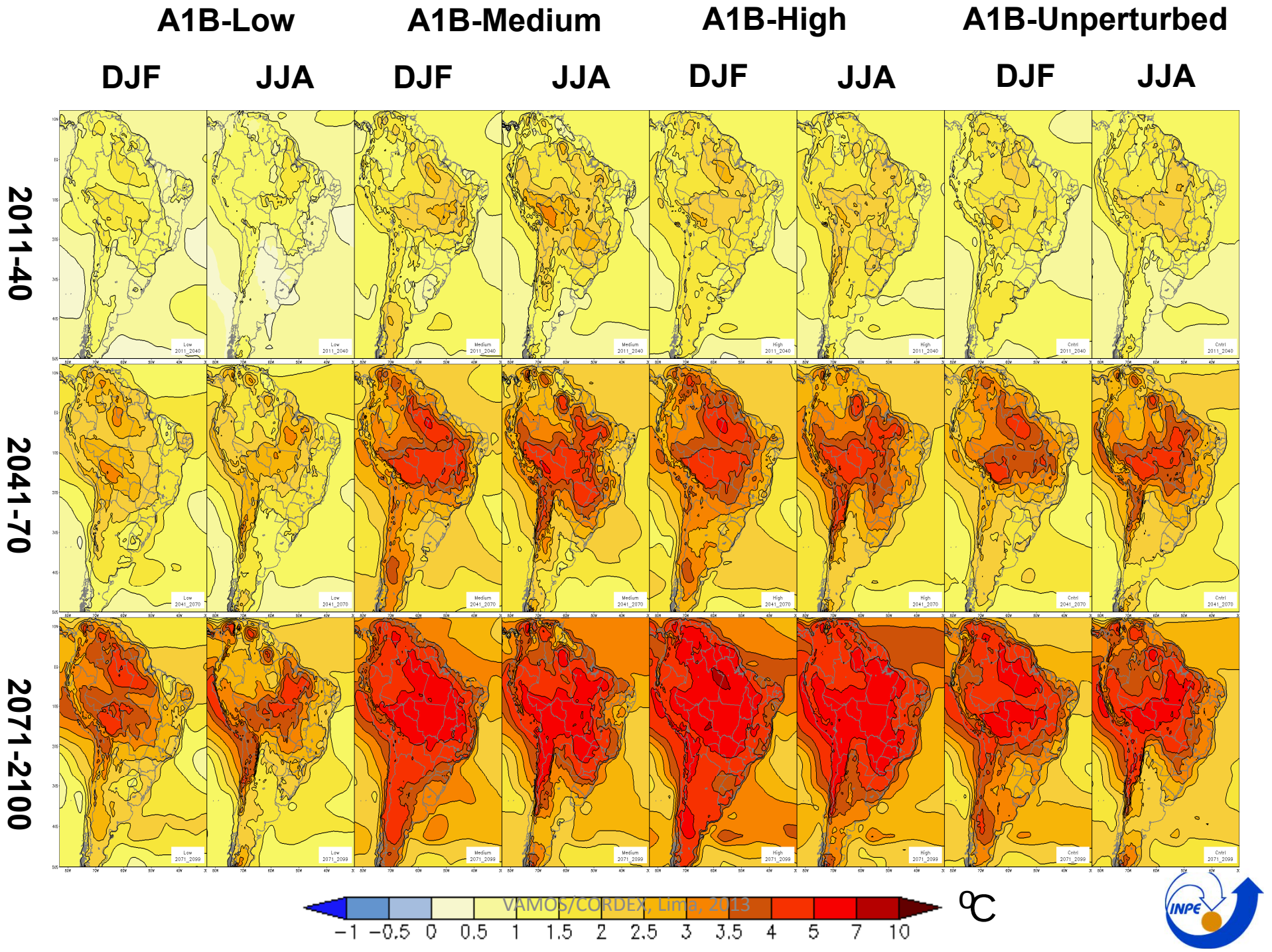


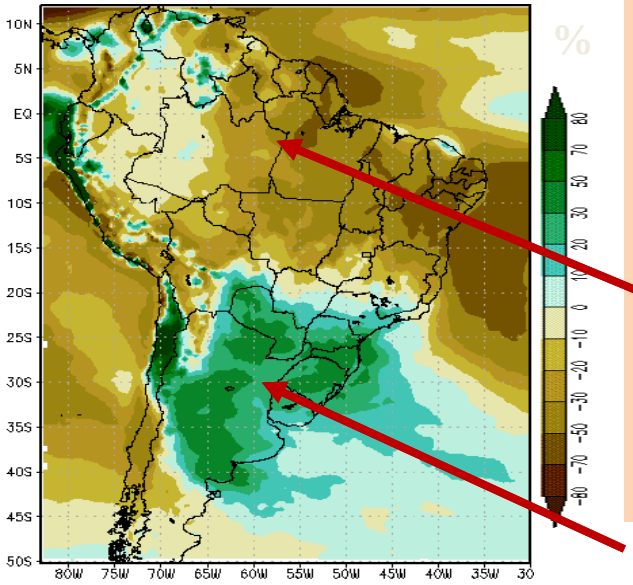
A1B scenario downscaling in SA

(Marengo et al 2012, CliDyn)


A1B-Low
A1B-Medium
A1B-High
A1B-Unperturbed
DJF
JJA
DJF
JJA
DJF
JJA
DJF
JJA
2011-40
2041-70
2071-2100
−1 −0.5 0 0.5 1 1.5 2 2.5 3 3.5 4 5 7 10
°C
VAMOS/CORDEX, Lima, 2013

Cenários futuros de clima

As projeções sugerem que as mudanças do clima apresentam <u>variabilidade regional</u>



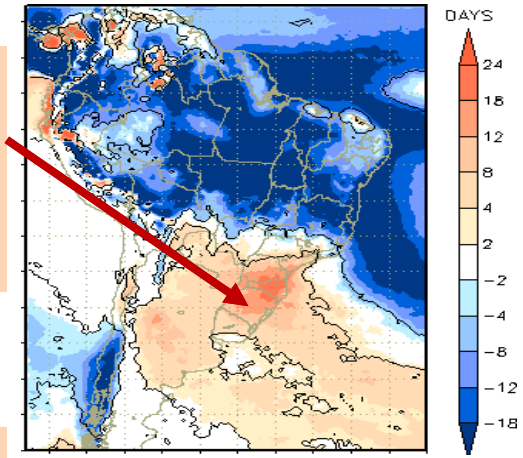
Mudanças na chuva (%) em 2071-2100 relativo a 1961-90.

<u>Amazonia e Noreste do Brasil →deficiencia de chuvas</u>

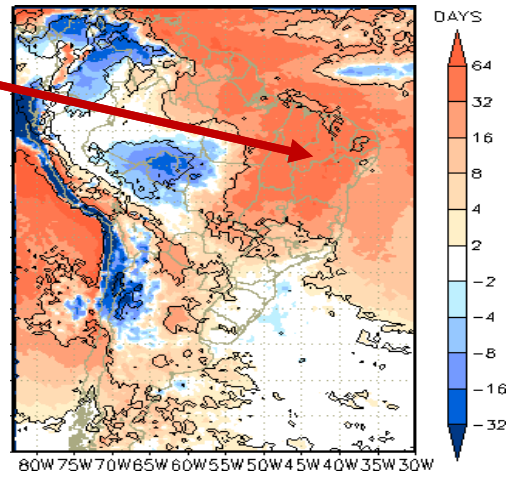
<u>Sudeste da America do Sul →raumento nas chuvas</u>

Projeções até finais do Século XXI mostram <u>mudanças nos extremos de chuva, com chuvas mais intensas ou com mais áreas com seca extrema</u>

Aumento na *<u>freqüência de chuvas intensas em</u>* 2071-2100 relativo a 1961-90

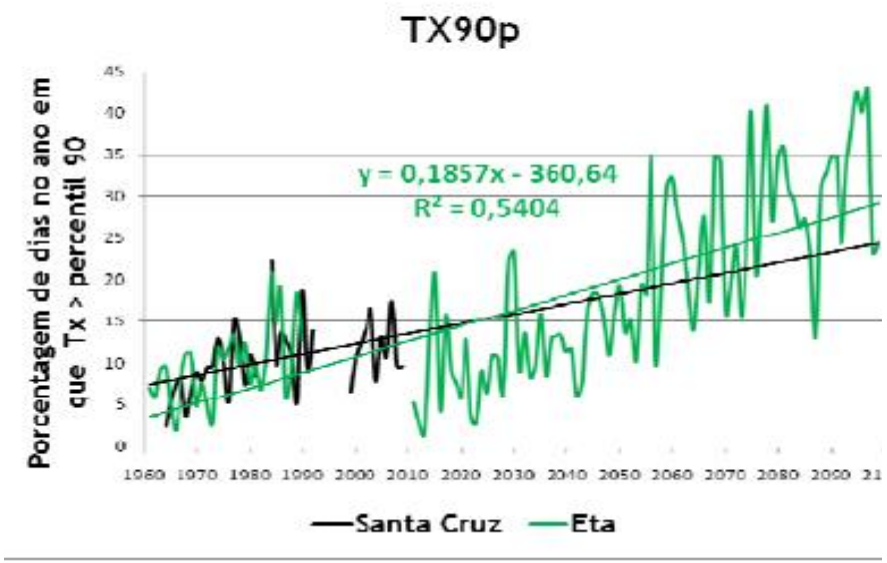


Aumento no *<u>número de dias secos consecutivos</u>* em 2071-2100 relativo a 1961-90

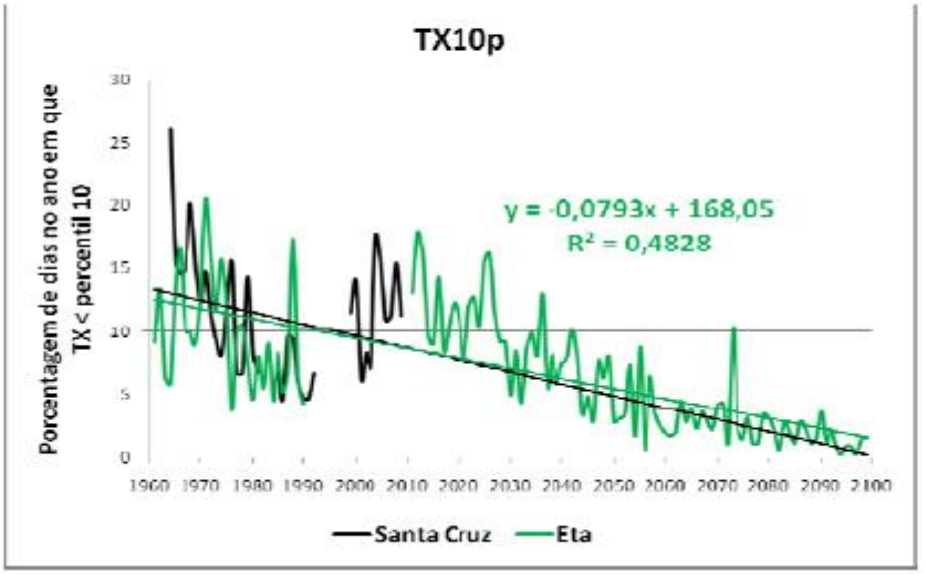


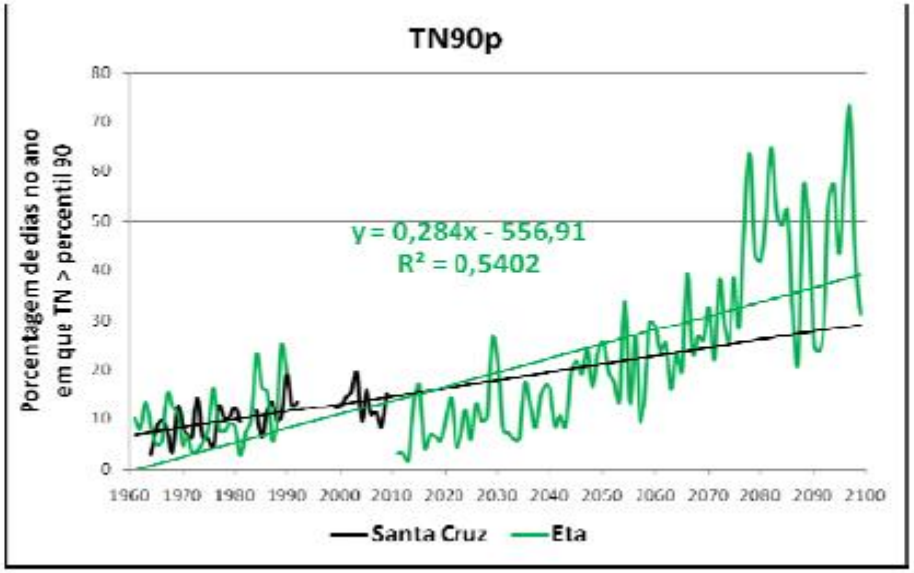
Extremes

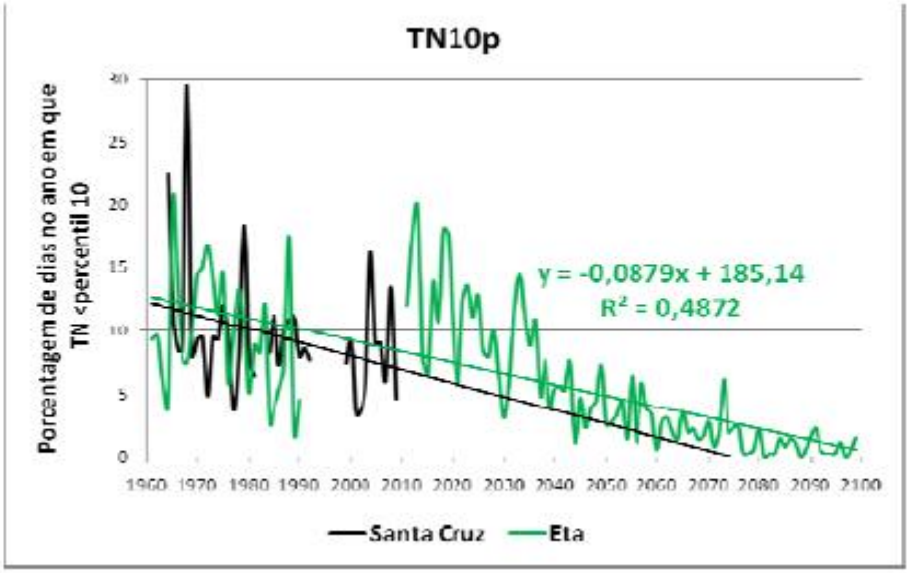
(b) TX90p



(c) TX10p



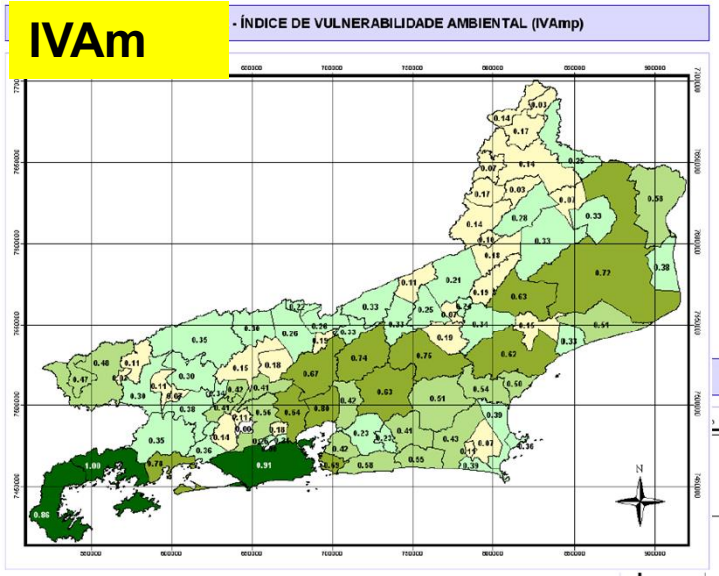




(Silva e Dereczynski, 2011)

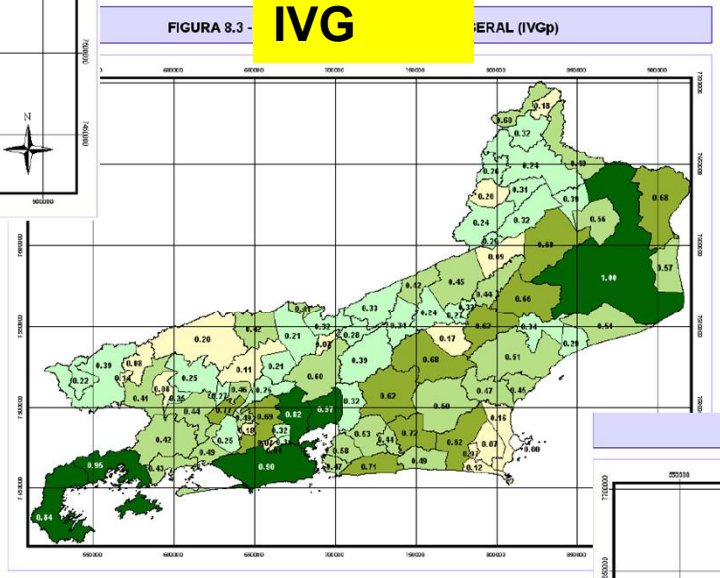
Vulnerability Indices

IVAm



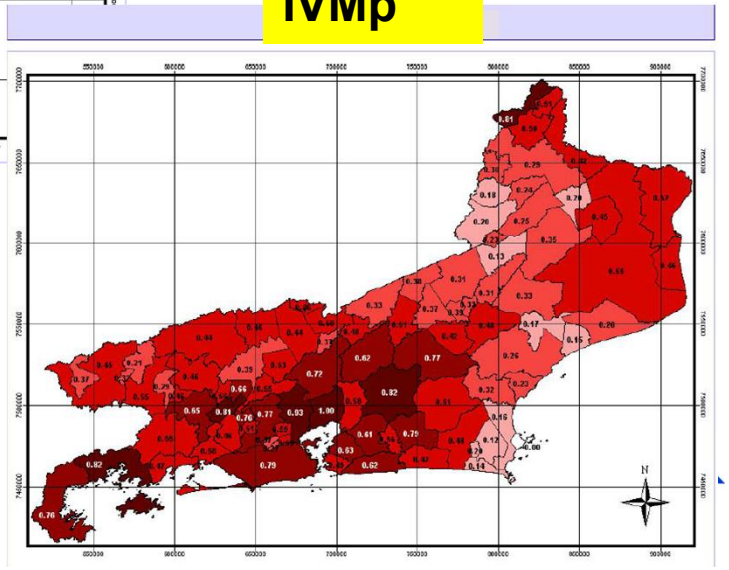
for RJ in A1B downscaled by Eta model

IVG



Municipality Index = IVG + ICC (Climate change Index)

IVMp



Saúde Família Ambiente

$$IVG = \frac{(IVS_p + IVSF_p + IVAm_p)}{3}$$

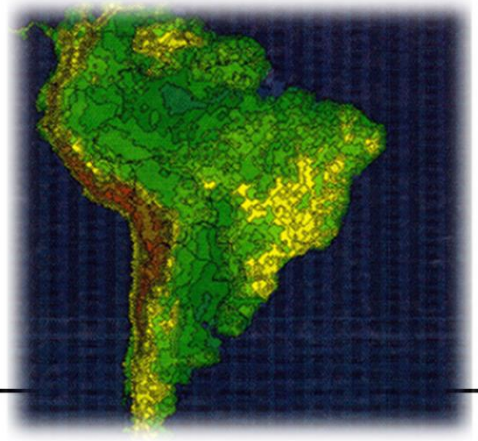
Barata and Confalonieri, 2011

New model version
New emission scenarios

Eta Model at INPE

Wea since 1996, RCM since 2002

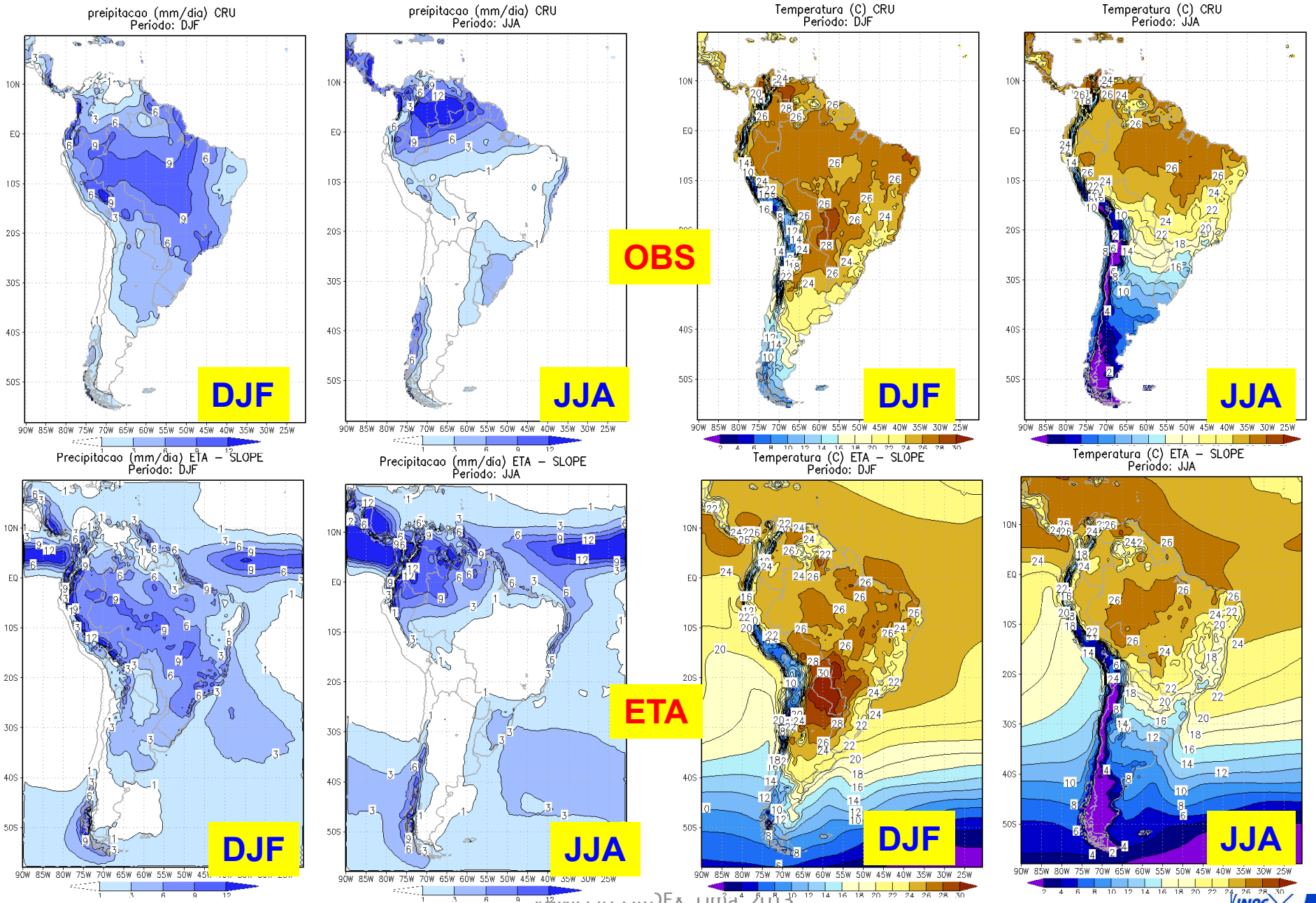
Operational characteristics



- ***Domains***
  - Most part of South America
  - Southeast Brazil
  - ***Resolution***: 40 km/38 layers;
    20km/50 layers;
    5km/50 layers NH
- ***Grid-point model***
  - Arakawa E grid and Lorenz grid
- ***Eta vertical coordinate*** (Mesinger, 1984; refinement by **Mesinger et al 2012**)
- ***Prognostic variables:***
- T, q, u, v, p_s, TKE, cloud water/ice,
- ***Time integration:*** 2 level, split-explicit
- **Adjustmet**: forward-backward
- **Hz Advection**: first forward and then centered
- Vrt Advection: Piecewise Linear Scheme
- **FULL FINITE VOLUME MODEL**

- ***Convection***:
  1. Betts-Miller-Janjic scheme, **precip efficiency**
- **Stratiform rain**:
  1. Zhao scheme
- ***Turbulence***:
  - Mellor Yamada 2.5, MO surface layer, Paulson functions
- ***Radiation***:
  - GFDL package
- ***Land surface scheme***:
  - NOAH scheme, 4 soil layers,
- ***Initial conditions***
  - NCEP T126L28 analyses, T213L42
- ***L.B.C.***
  - CPTEC T126L28 GCM, T213L42, uptd 6/6 h,
- ***Initial soil moisture***: monthly climatology
- ***Initial albedo:*** seasonal climatology

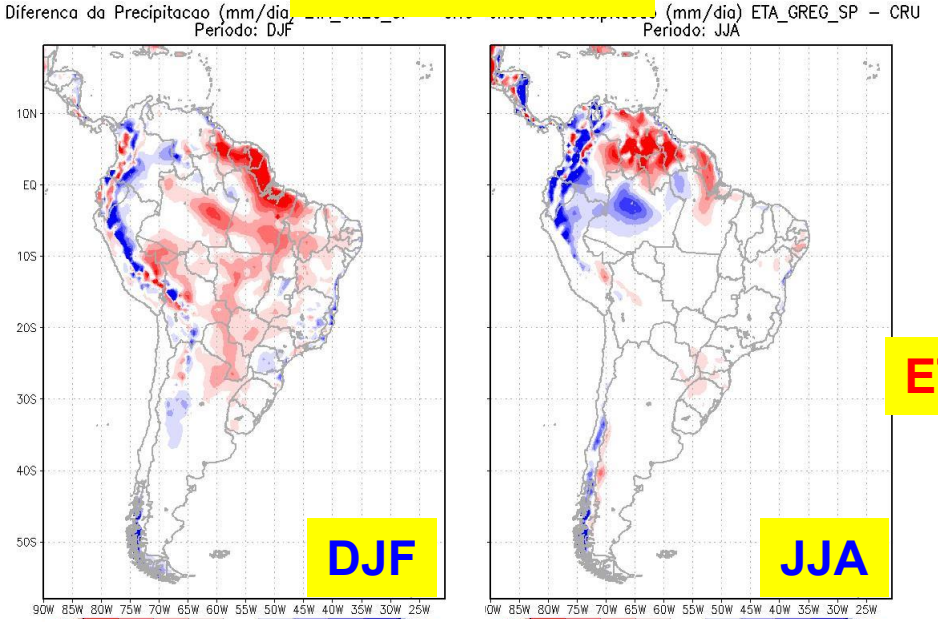
LPB - CORDEX: Eta–50km driven by Era-Interim, 1990-2008



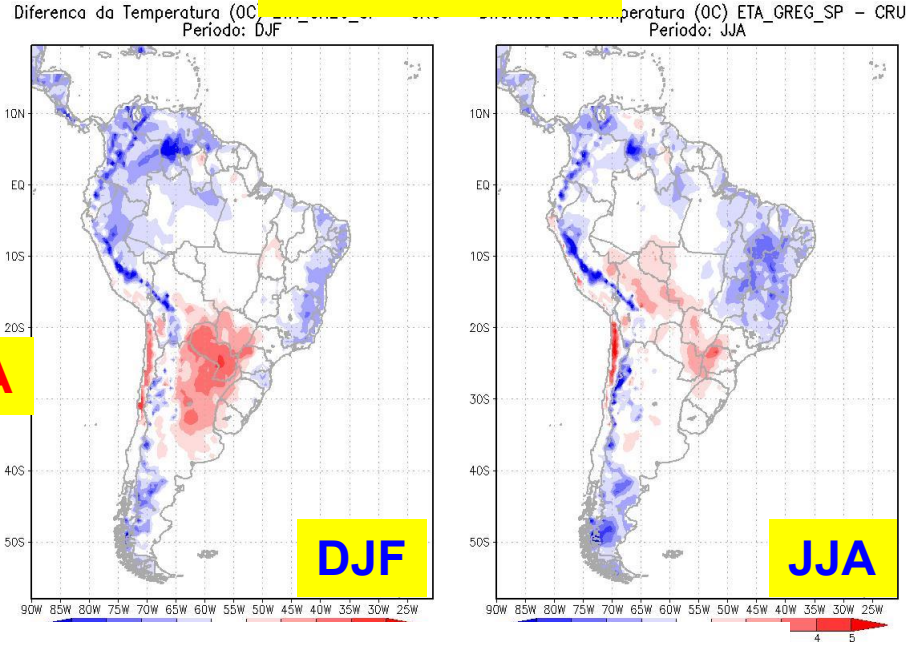
CORDEX type run: Eta–50km driven by Era-Interim

Model systematic Errors

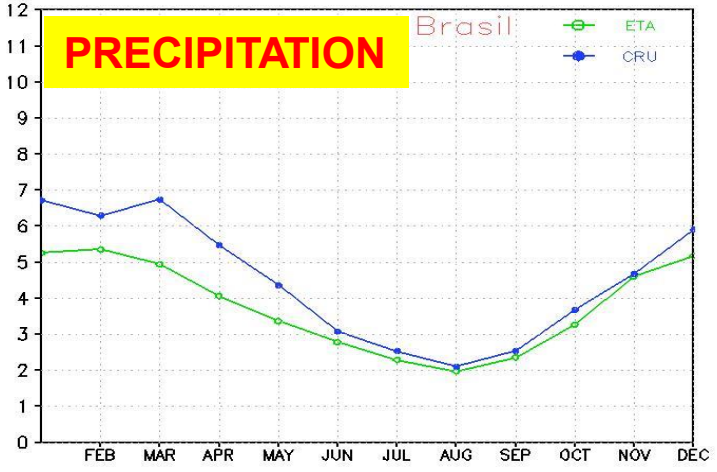
PRECIPITATION

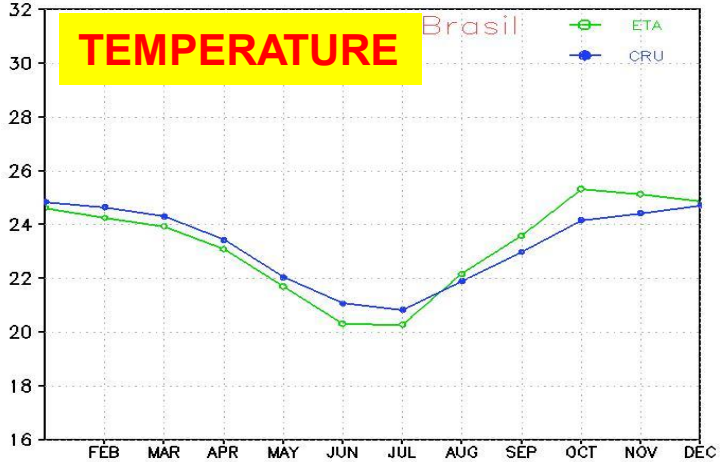


TEMPERATURE

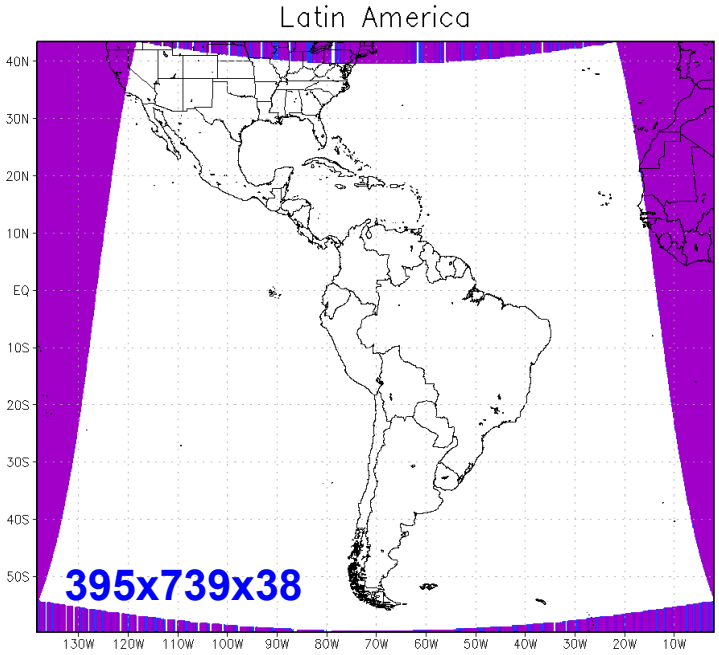


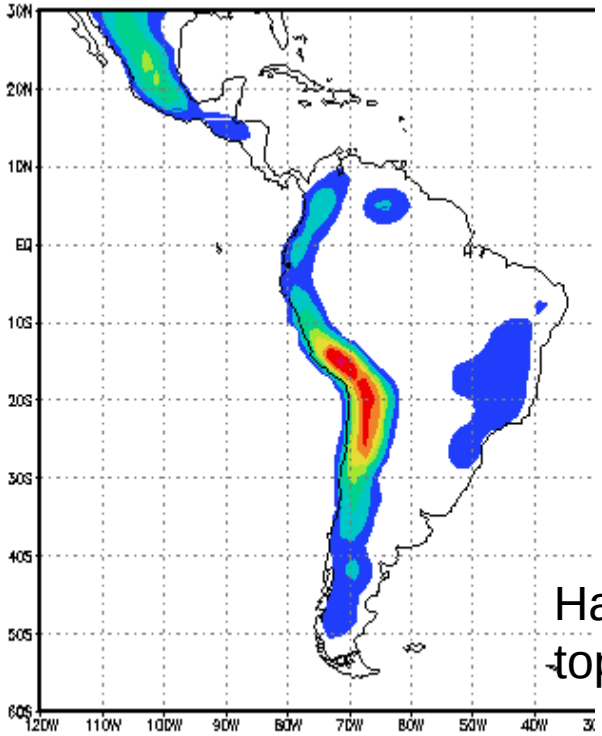
ETA



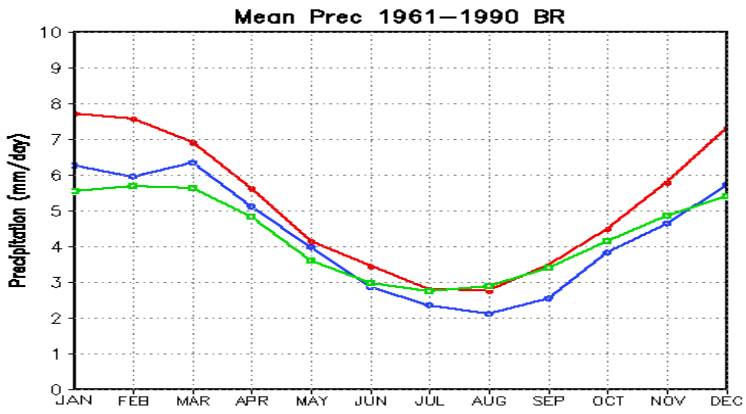


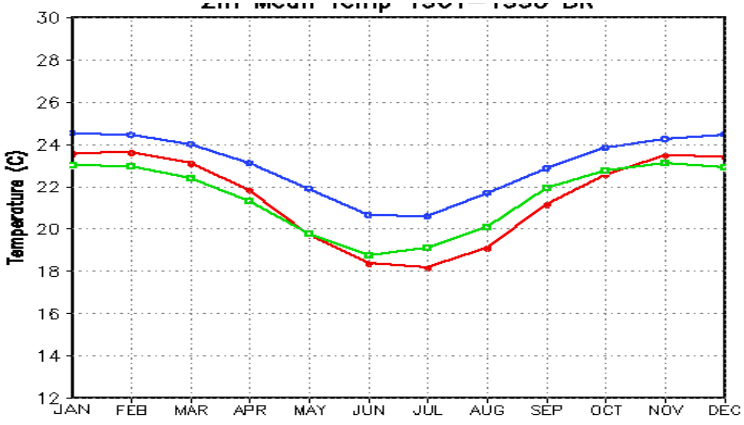
Eta–20km driven by HadGEM2-ES, 1961-1990
South and Central Americas + Caribbean domain





HadGEM topography

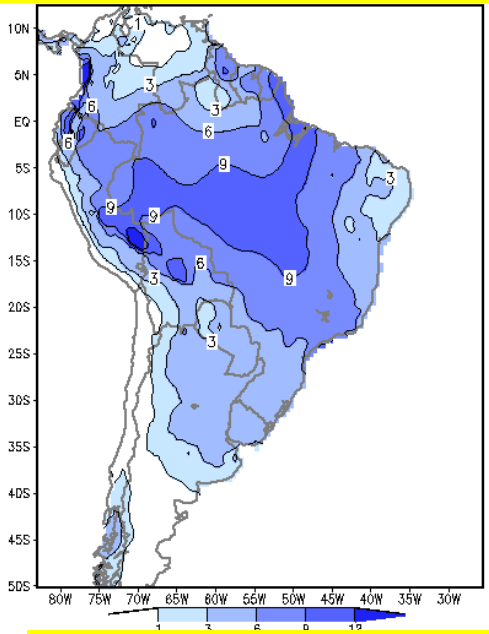




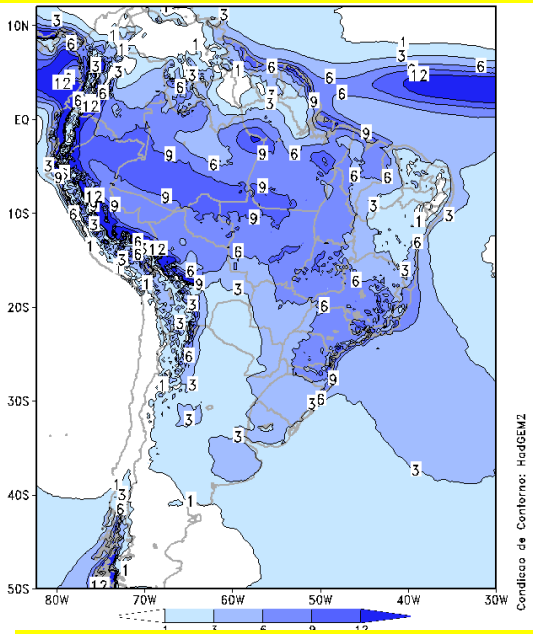
PRECIPITATION (mm/day) – 1961-1990

DJF

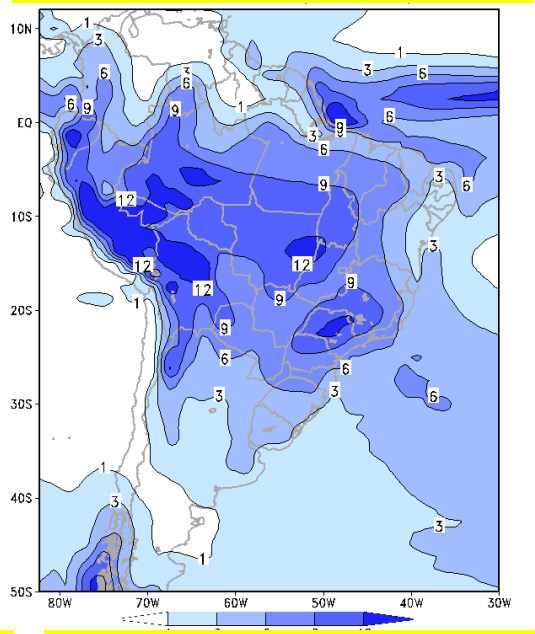
CRU



Eta-HadGEM2-ES

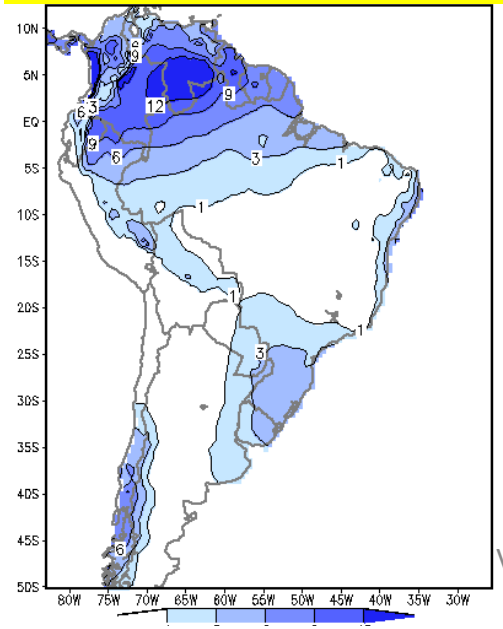


HadGEM2-ES

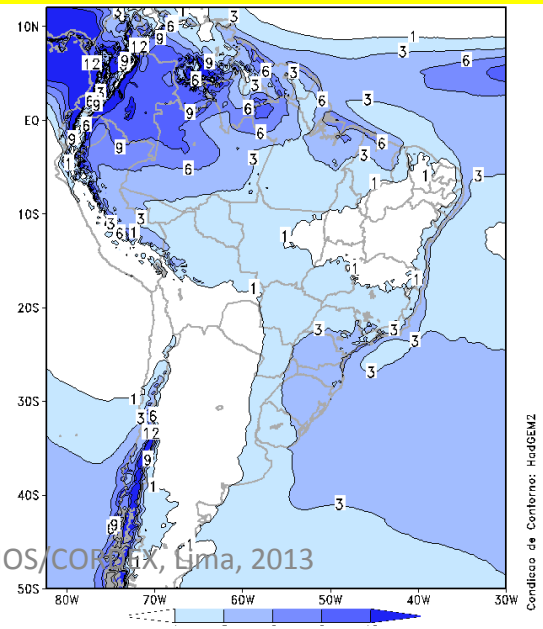


JJA

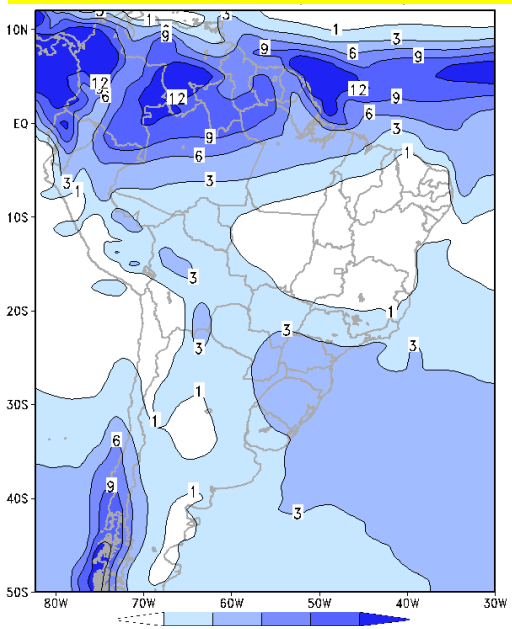
CRU



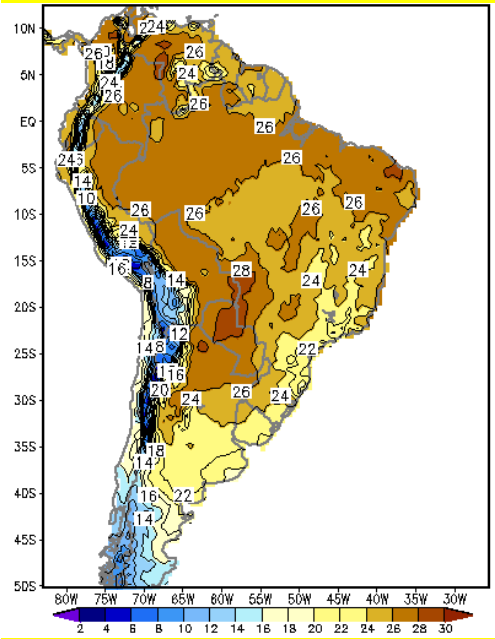
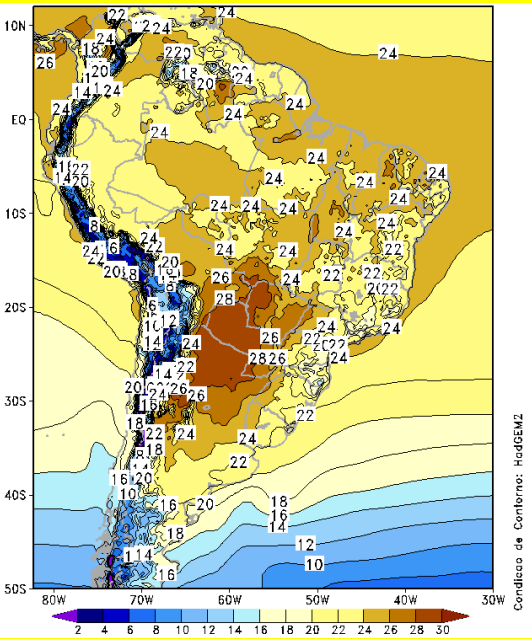
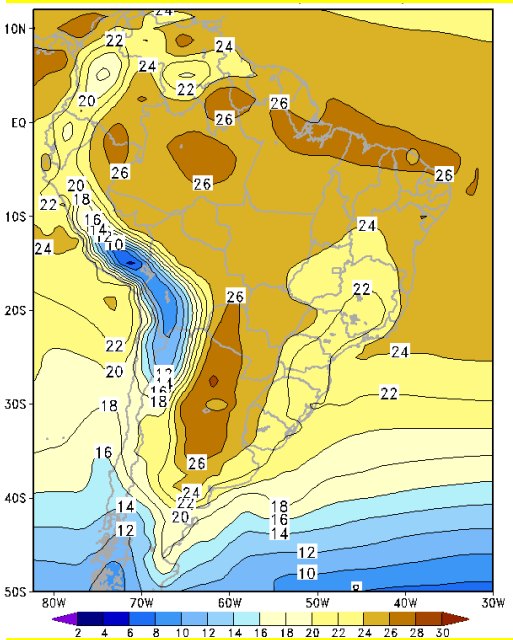
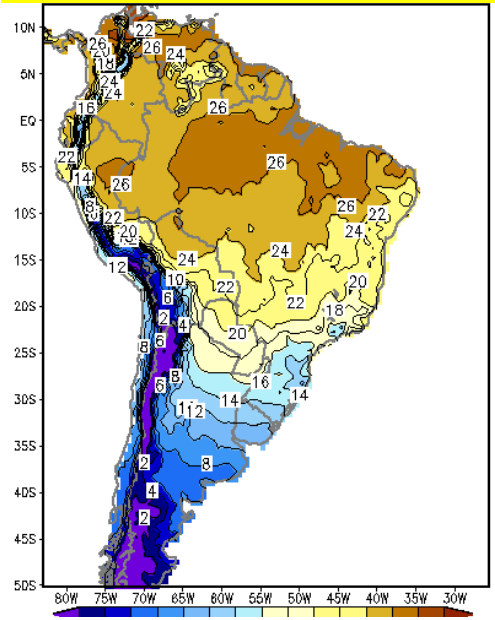
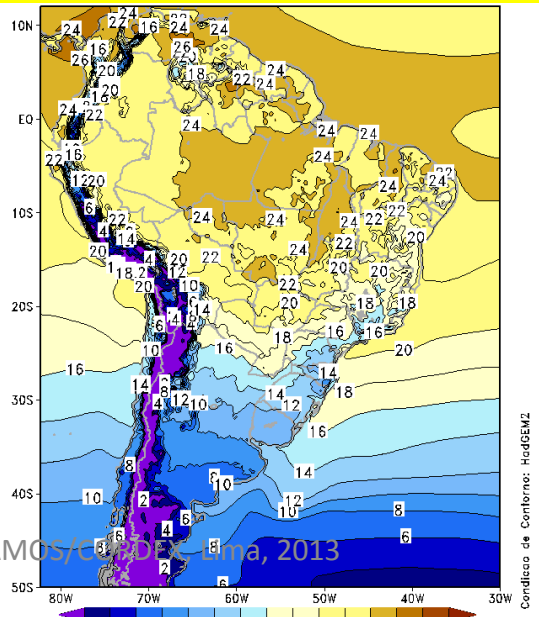
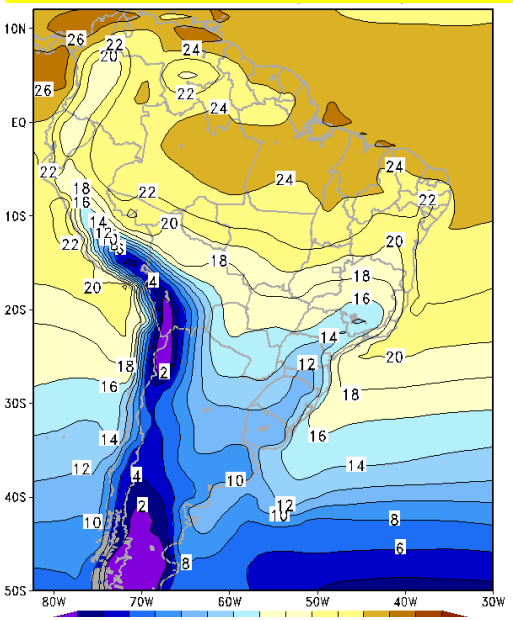
Eta-HadGEM2-ES



HadGEM2-ES



TEMPERATURA (°C) – 1961-1990

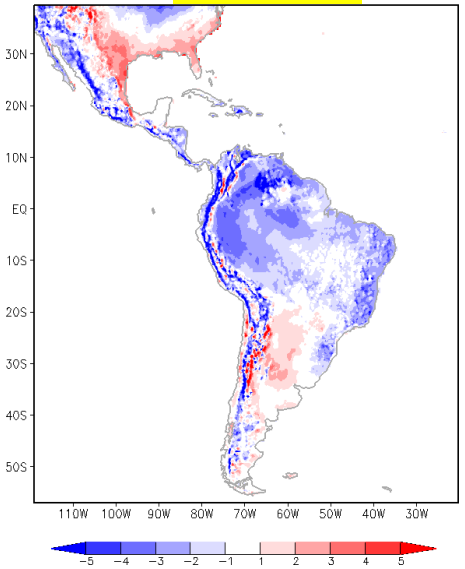
	CRU	Eta-HadGEM2-ES	HadGEM2-ES
DJF			
JJA			

Eta-HadGEM2-ES
minus
CRU

TEMPERATURE ERRORS

PRECIPITATION ERRORS

DJF



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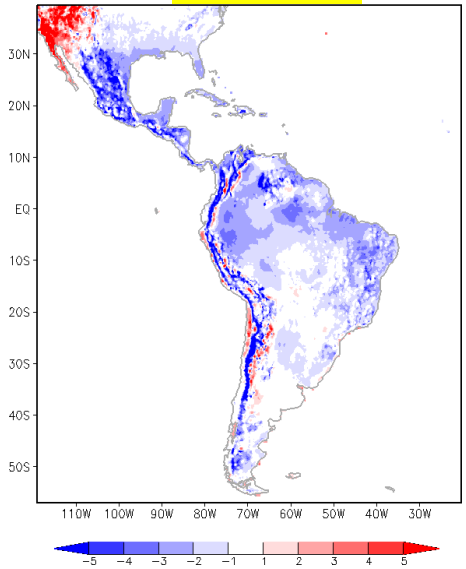

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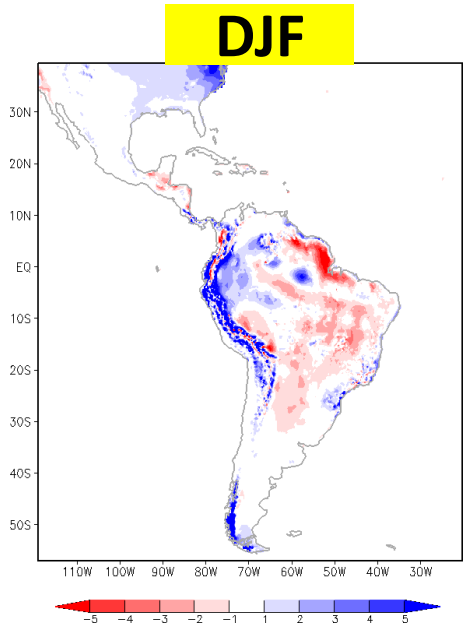

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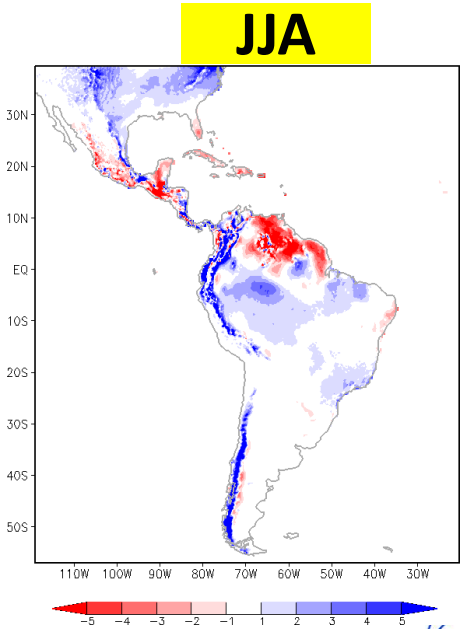
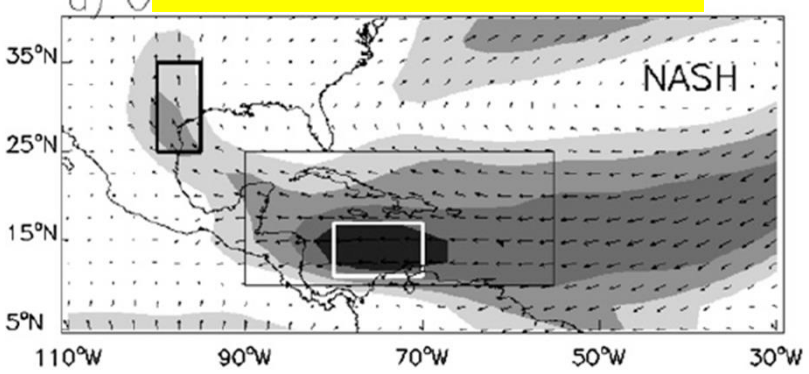


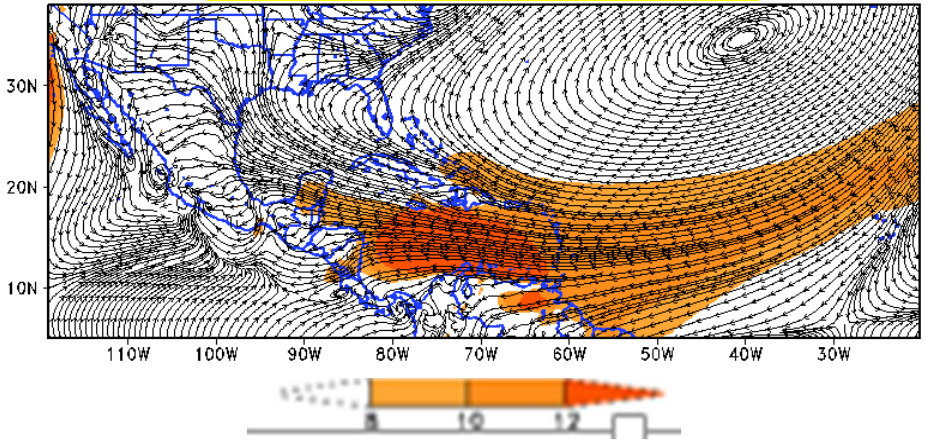
Eta–20km driven by HadGEM2-ES, 1961-1990
Caribbean Low-Level Jet

JJA 925-mb winds

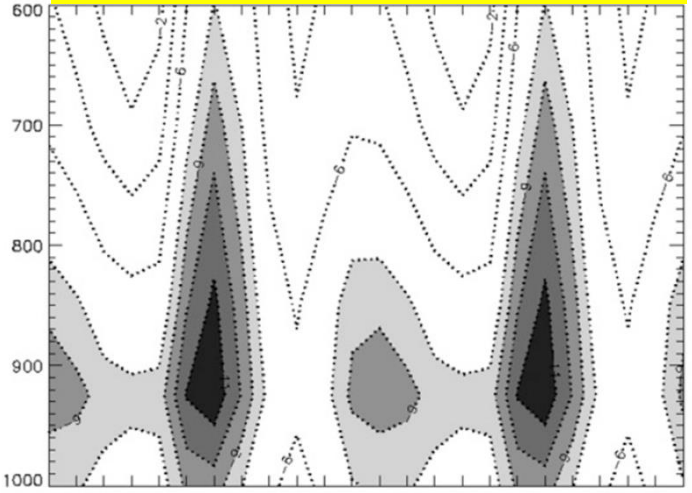
NCEP REANALYSES



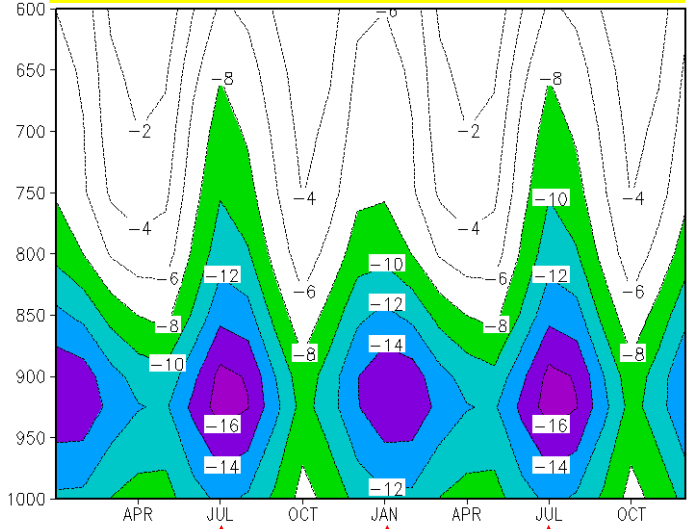
Eta-HadGEM2-ES



NCEP REANALYSES



Eta – HadGEM2-ES



JUL JAN JUL

(OBS figures from Martin and Schumacher, 2011, JC)

Eta–20km driven by BESM, 1962-1990

Eta model downscaling from

BRAZILIAN **E**ARTH **S**YSTEM **M**ODEL

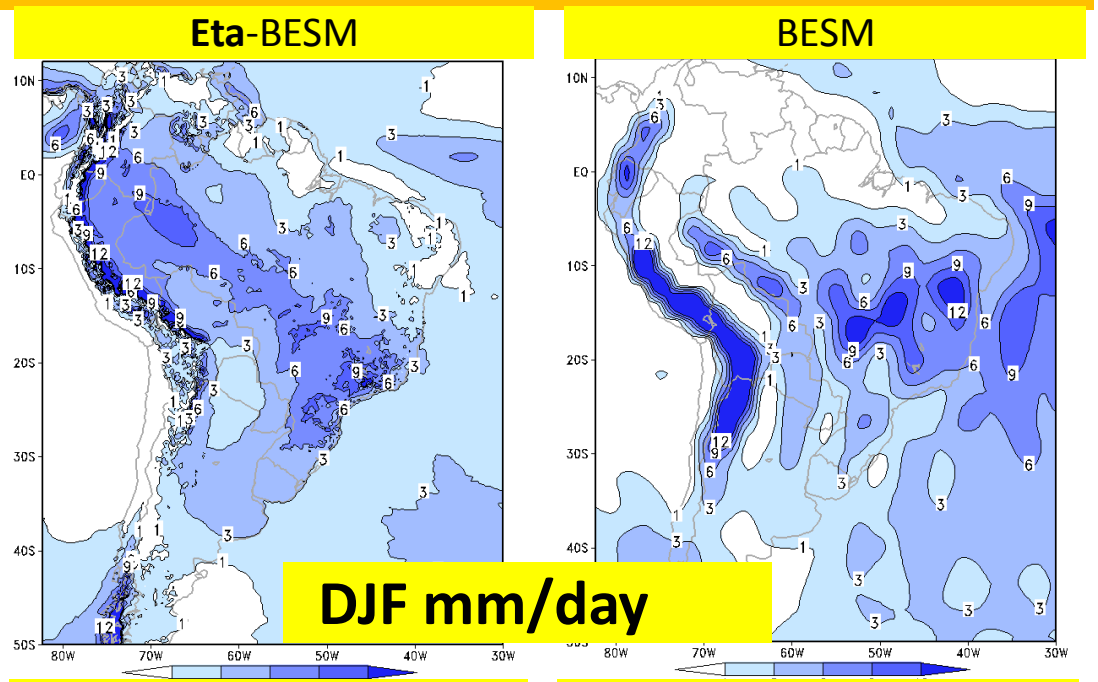
BESM-OA2.3 (Nobre et al 2013)

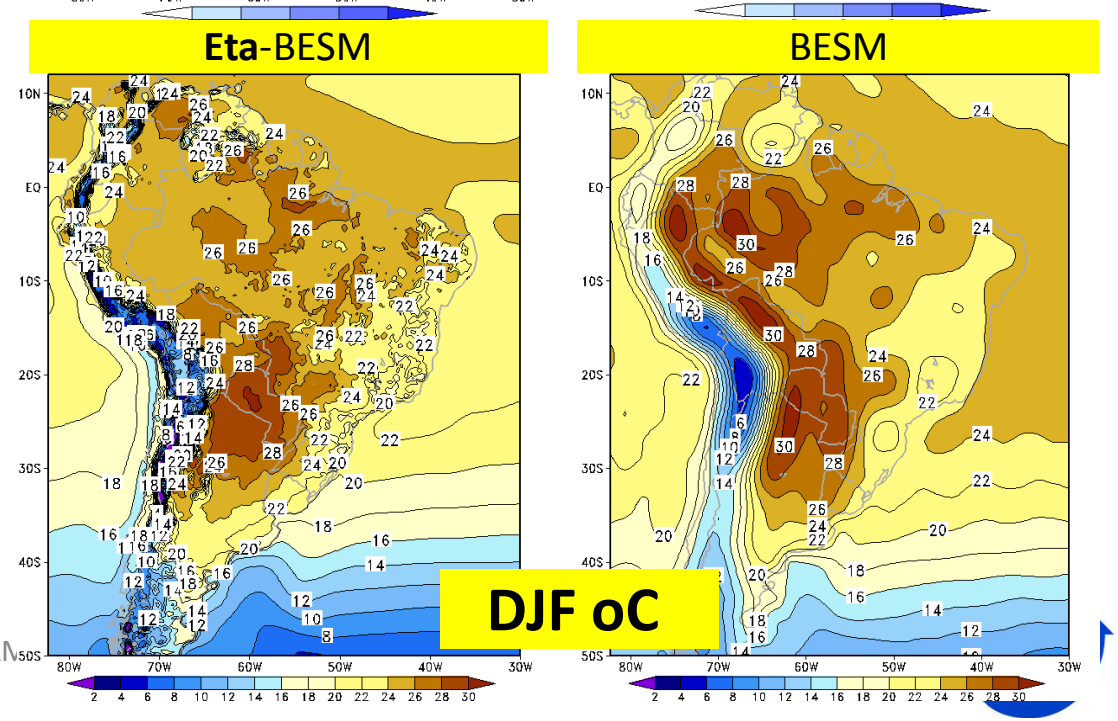
- T62L28 in the atmosphere
  - SSIB continental surface model
  - Grell convection scheme

-GFDL MOM4p1 global ocean model at telescoping resolution from 1x1 extratropics to ¼ x 1 lat-lon equatorial, with 50 vertical levels

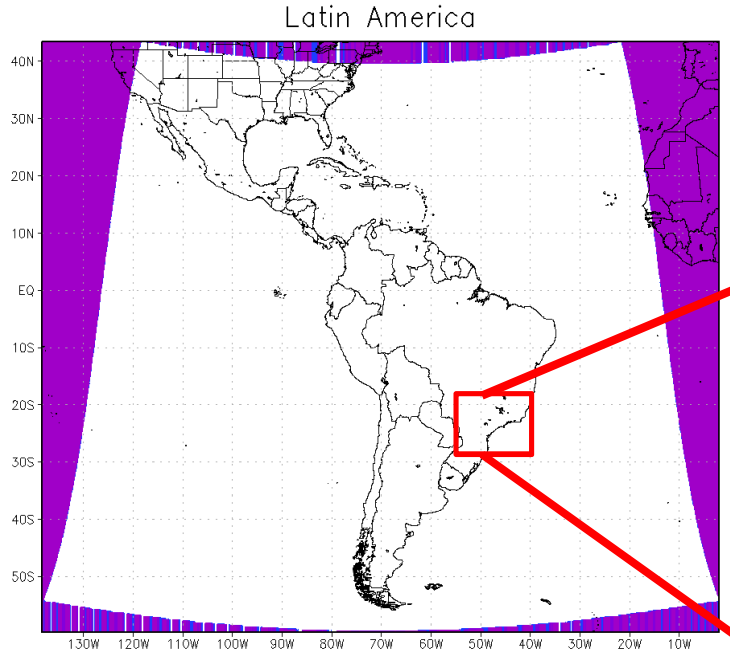
-ISIS ocean ice model

-Topaz ocean biogeochemistry model

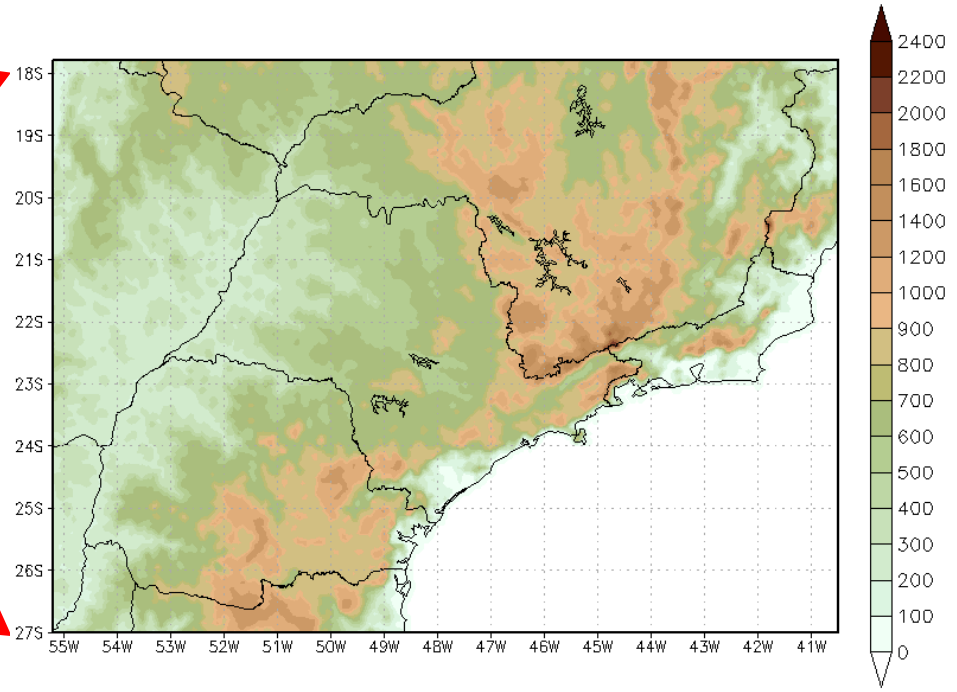


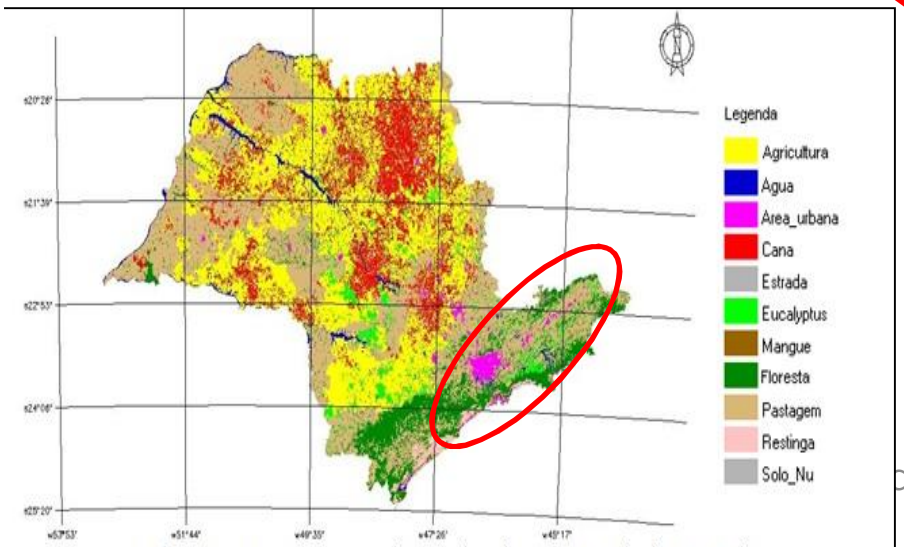


5-km Non-Hydro version of Eta Model: Double nesting



Eta-5km NH





Upgraded version (Mesinger et al 2012), included map of urban areas.

Suitable for local scale impact studies, such as megacities, agriculture crops, etc.

ONGOING RESEARCH/DEVELOPMENT in the Eta model

1. **Inclusion of vegetation dynamics - Inland**
2. **Inclusion of coffee crop - Inland**
3. **Inclusion of flooded areas**
4. **Replace soil classes**
5. **Coupling with ocean model**
6. **Replace radiation scheme**
7. **Atmospheric chemistry transport model**

Etc.

ONGOING PRODUCTION

1. Eta-HadGEM RCP 4.5; RCP 8.5 (20km SAm, Cam, Caribe)
2. Eta-BESM RCP 4.5; RCP 8.5 (20km SAm, Cam, Caribe)
3. Eta-Had/BESM RCP 4.5 (5km, Southeast Brazil)

Data policy and format

- **Data generated by INPE follows open-access policy**
- **Construction of a WEB based Portal : ESG like , plans to participate as ESGF node**
- **Part of gridded data also in Georeferrenced Information System (GIS) format**

Example of ESG

Acknowlegment:

Thanks to BADC (Martin Juckes) for the GCM boundary conditions

Thanks to the programs: PNUD, CCAFS, ANEEL P&D, for partially funding the long term integrations

Gracias!
Thanks!

chou@cptec.inpe.br