



National Institute for Space Research – INPE
Center for Weather Forecasts and Climate Studies - CPTEC

**Downscaling projections of climate change over
South America and Central America
under RCP4.5 and RCP8.5 emission scenarios**

Sin Chan Chou
chou@cptec.inpe.br

Downscaling team

André Lyra, Caroline Mourão, Claudine Dereczynski, Isabel Pilotto, Jorge Gomes, Josiane Bustamante, Priscila Tavares, Adan Silva, Daniela Carneiro, Diego Campos, Diego Chagas, Dragan Latinovic, Gracielle Siqueira, Gustavo Sueiro

Regional Climate Model: The Eta Model

Resolutions: 20km, 8km/38 layers.

Grid-point model Arakawa E grid and
Lorenz vertical grid

eta vertical coordinate

(Mesinger, 1984) + cut-cells (Mesinger et al, 2012)

Time integration: 2 level, split-explicit

Adjustmet: forward-backward

Horizontal Advection: first forward and then centered

Vertical Advection: Piecewise linear scheme

Prognostic variables: T, q, u, v, p_s , TKE, cloud water/ice, and hydrometeors

Convection scheme: Betts-Miller-Janjic

Cloud scheme: Zhao scheme

Turbulence: Janjic 1994 (MY 2.5), Monin-Obhukov surface layer

Radiation: GFDL package

Land surface scheme: NOAH scheme, 4 soil layers,

LBC: update every 6h

Initial soil moisture: monthly climatology

Initial albedo: seasonal climatology

CO2 –eq: RCP4.5 and RCP8.5 emission scenarios

Sea Surface Temperature from global climate models

- Mesinger F, et al. (2012) An upgraded version of the Eta model. MAAP. Vol 116 (3), 63-79
- Chou SC et al. (2014) Assessment of Climate Change over South America under RCP4.5 and 8.5 Downscaling Scenarios. AJCC,3, 512-527.

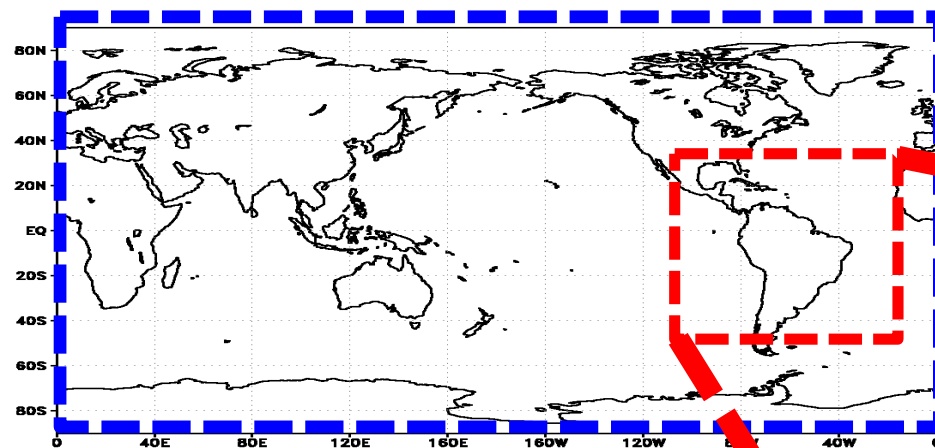
Global Climate Models

HadGEM2-ES: Met Office Hadley Centre Global Environmental Earth System Model. Collins et al, 2011. Horizontal resolution about 1.875° longitude x 1.250° latitude. 38 atmospheric layers. Ocean model has 40 layers and about 1° degree horizontal resolution increasing up to about $1/3$ degree near the equator.

MIROC5: Model for Interdisciplinary Research on Climate version 5) . Watanabe et al., 2010). Horizontal resolution of about 150km. 40 atmospheric layers. Ocean model has 50 layers and about 1° degree horizontal .

CanESM2: Canadian Earth System Model. Arora et al., 2011; Chylek et al., 2011. Horizontal resolution about 2.8125° longitude x 2.75° latitude. 35 atmospheric layers. Ocean model has 40 layers and about 1.41° x 0.94 degrees in the horizontal .

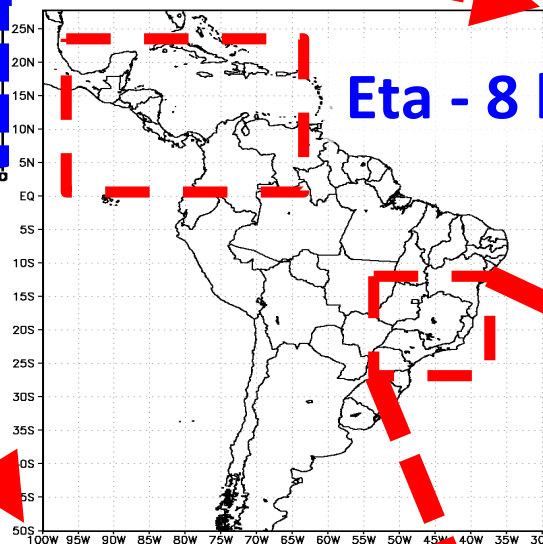
DYNAMICAL DOWNSCALING



Global models, 150 ~300 km
HadGEM2-ES
MIROC5
CanESM2
BESM

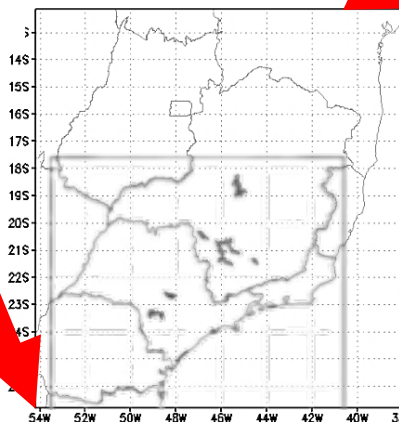
Emission
Scenarios

Historical
RCP4.5
RCP8.5



Eta - 8 km

Eta - 20 km



Eta - 5 km

High resolution suitable for impact studies

PRECIPITATION

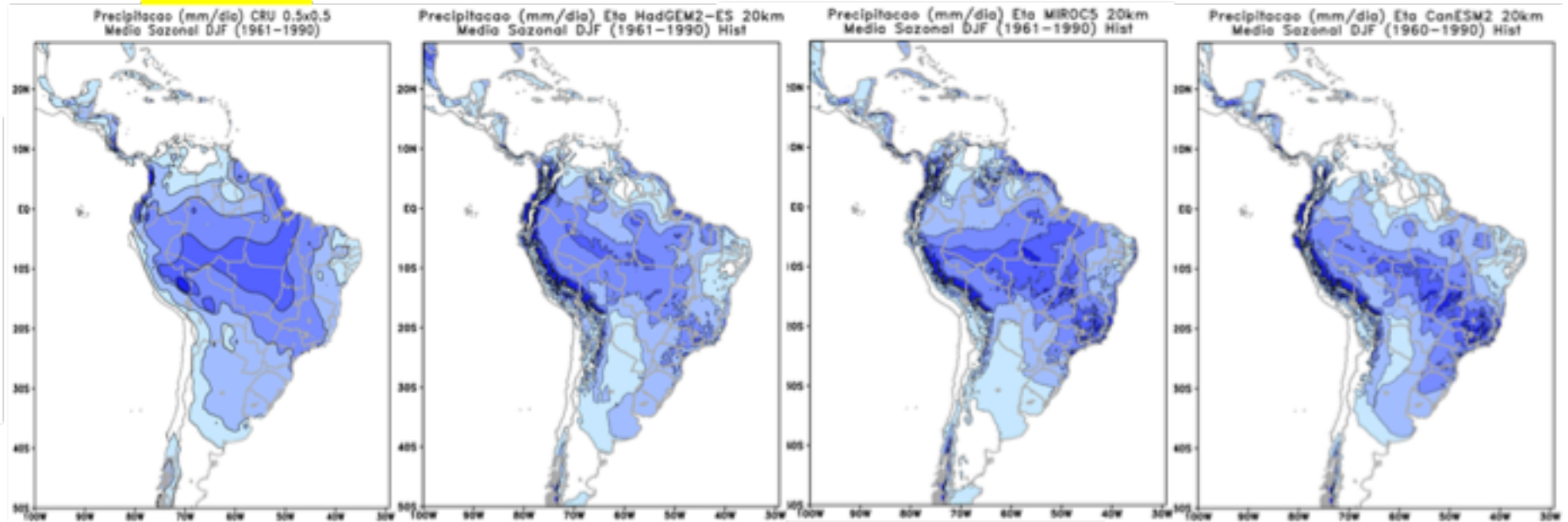
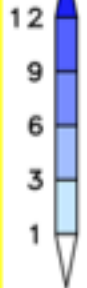
OBS
(CRU)

Eta-HadGEM2-ES

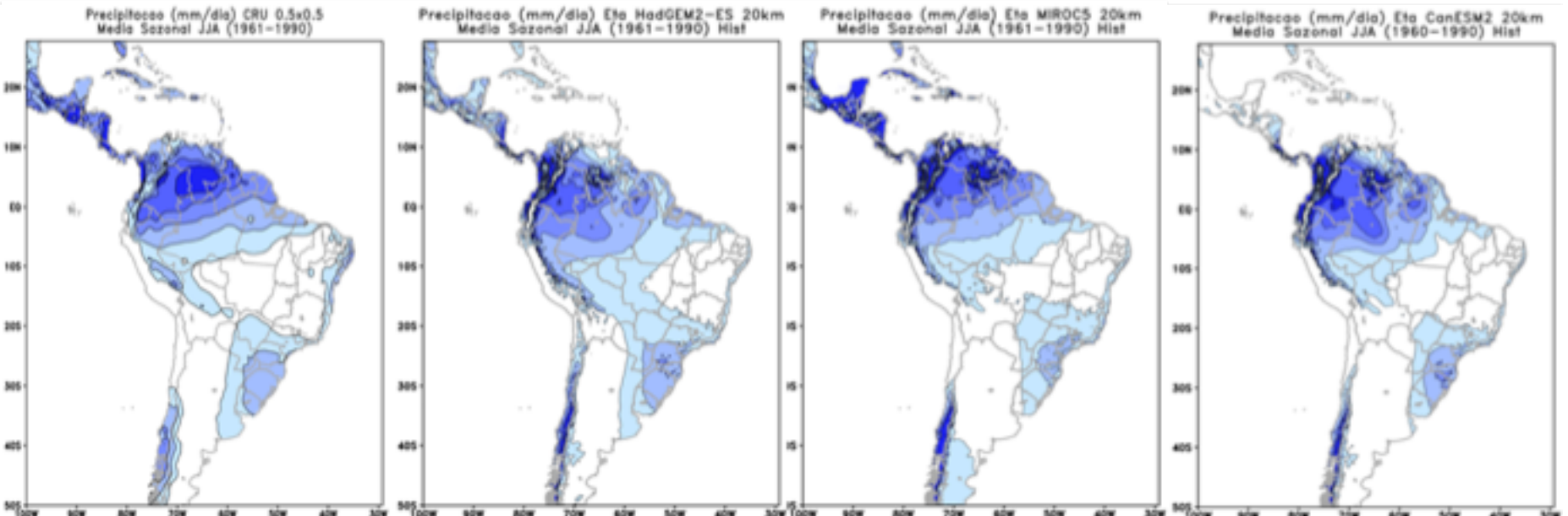
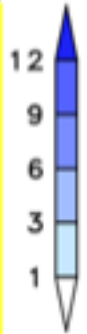
Eta-MIROC5

Eta-CanESM2

D
J
F



J
J
A



2-m TEMPERATURE

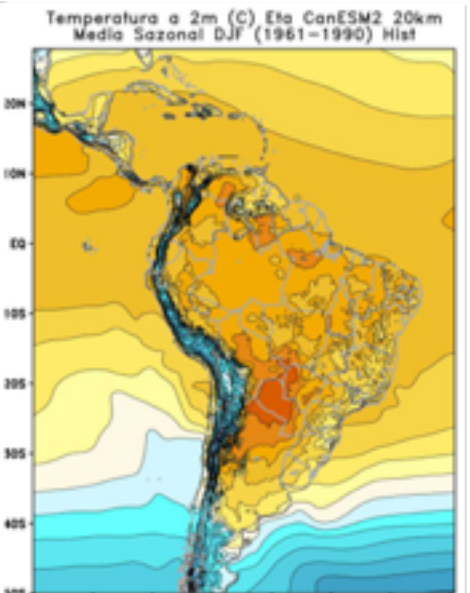
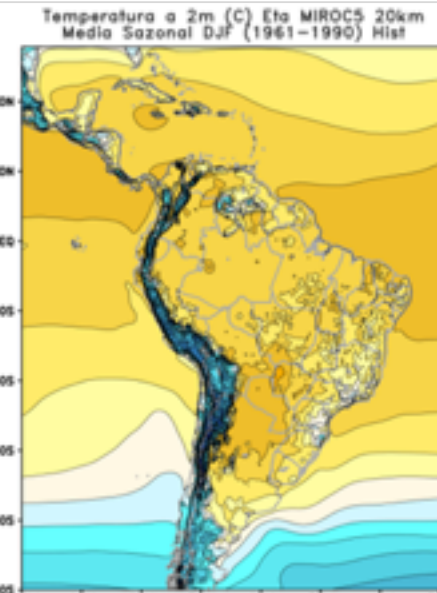
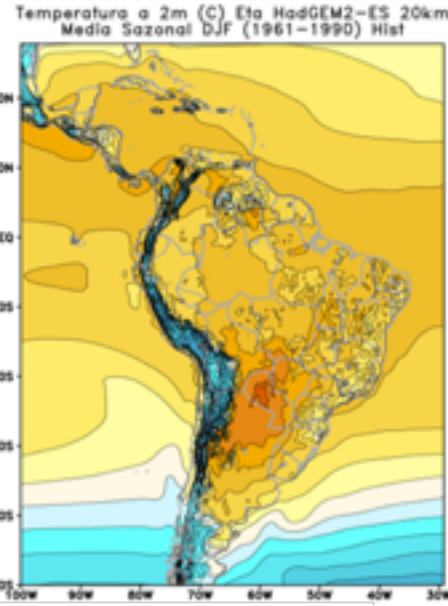
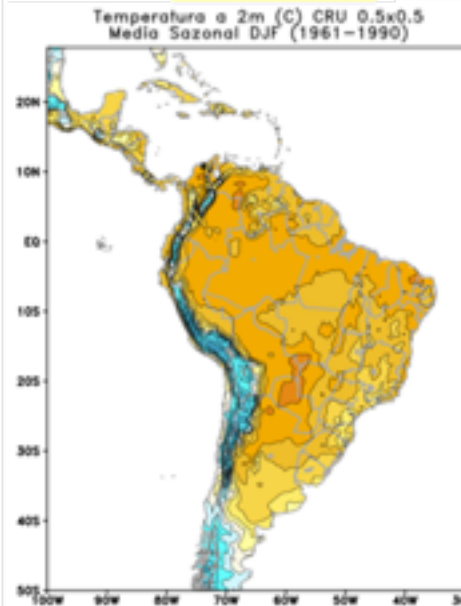
OBS
(CRU)

Eta-HadGEM2-ES

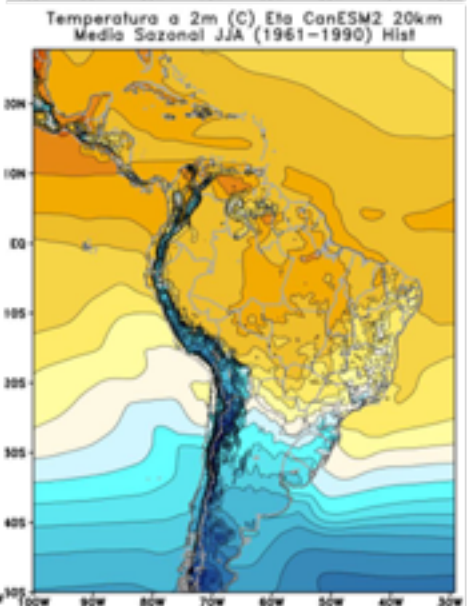
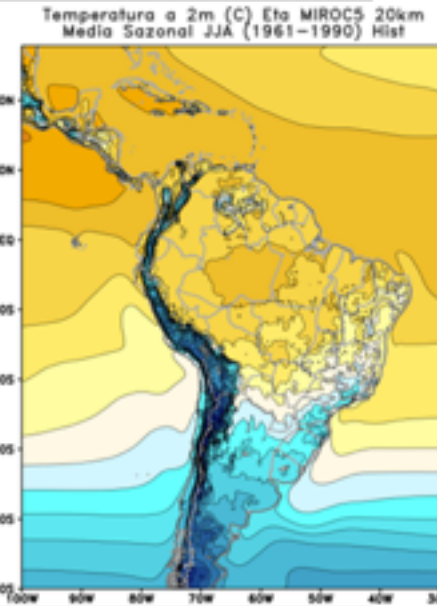
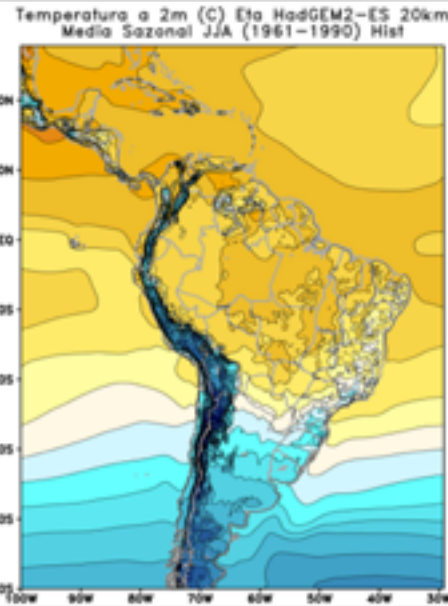
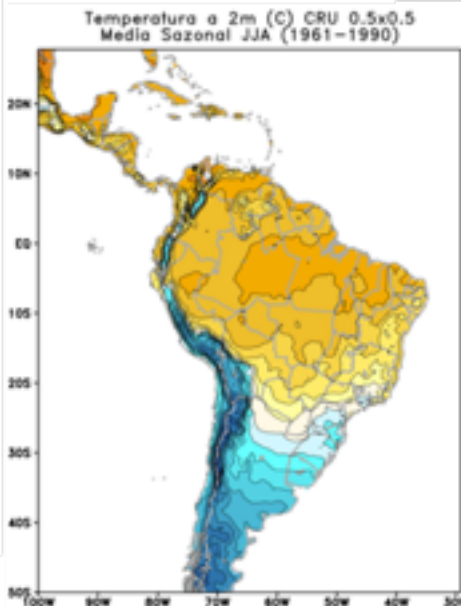
Eta-MIROC5

Eta-CanESM2

D
J
F



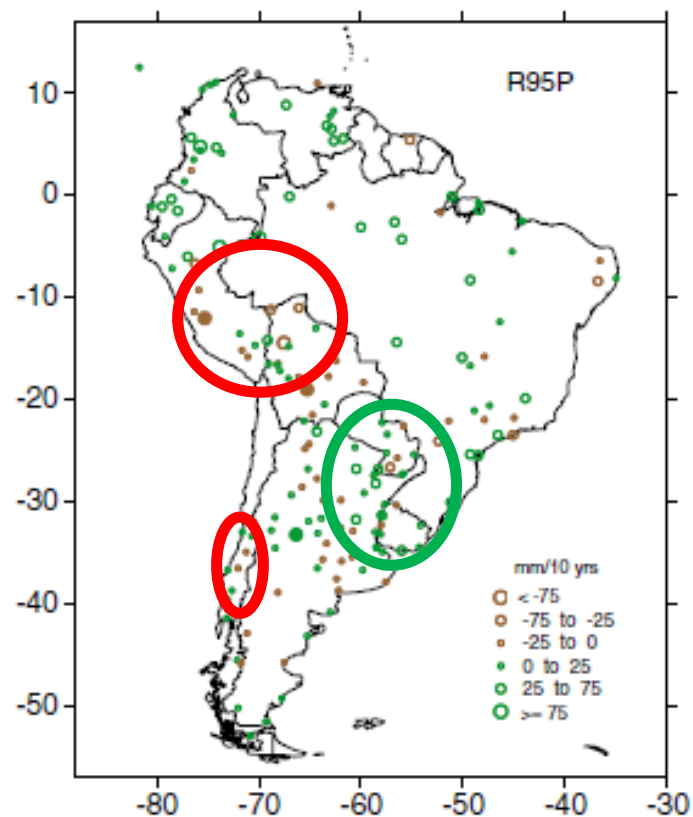
J
J
A



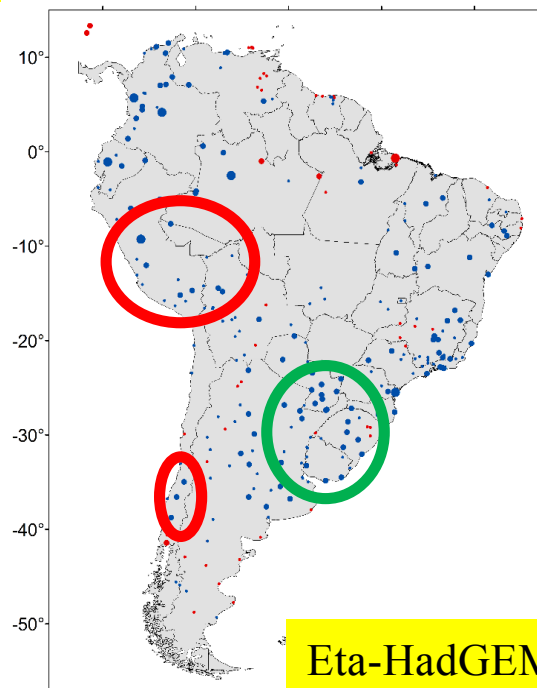
Análise dos Extremos climáticos

R95p

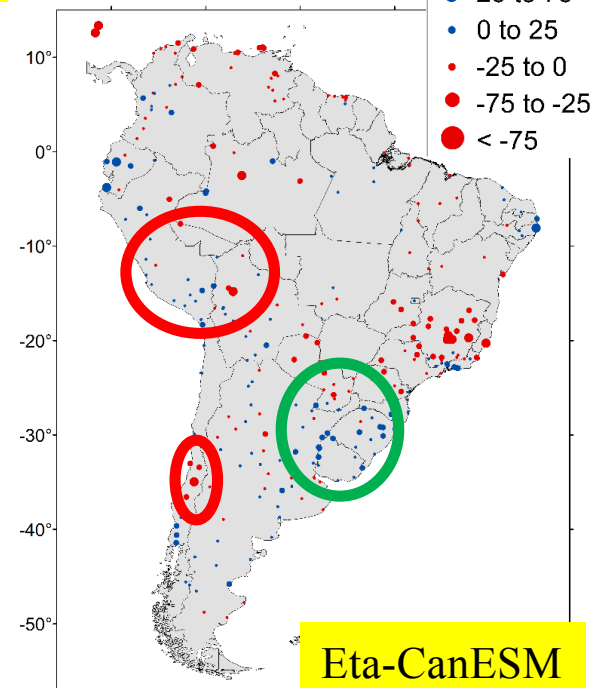
Observado (1969-2009
– Skansi *et al.*, 2013)



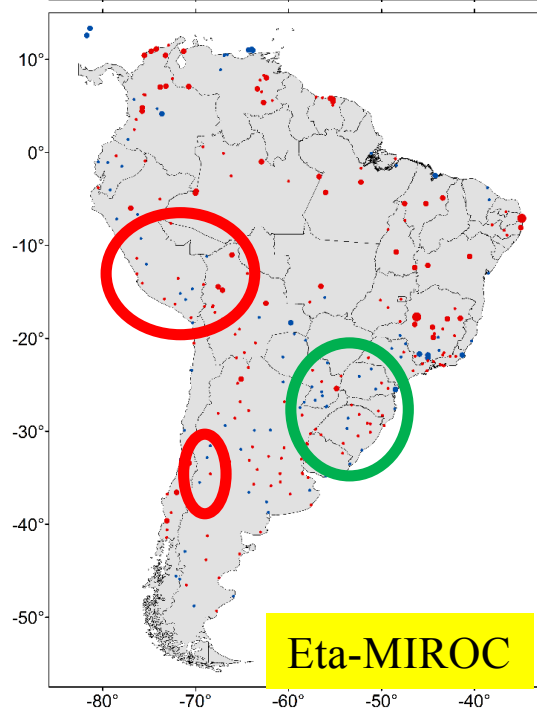
Bolsista IC



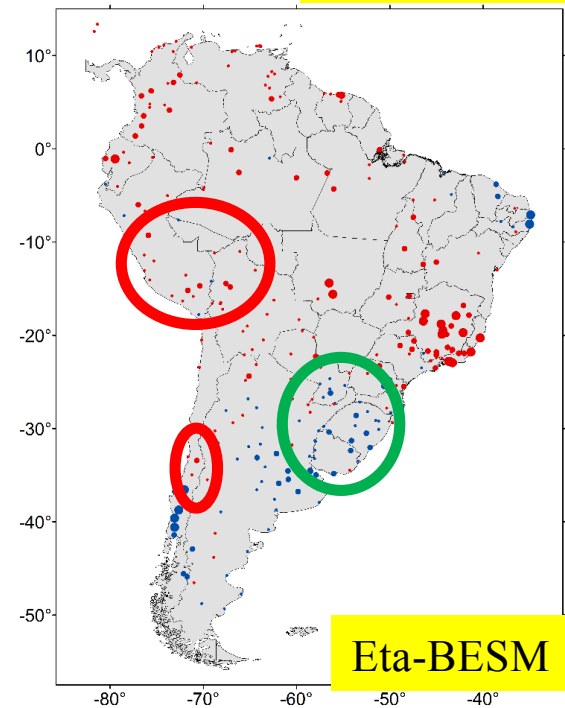
Eta-HadGEM



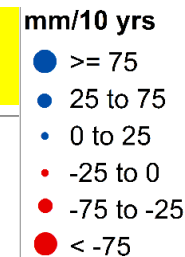
Eta-CanESM



Eta-MIROC



Eta-BESM



PROJECTIONS OF CLIMATE CHANGE

DJF

PRECIPITATION

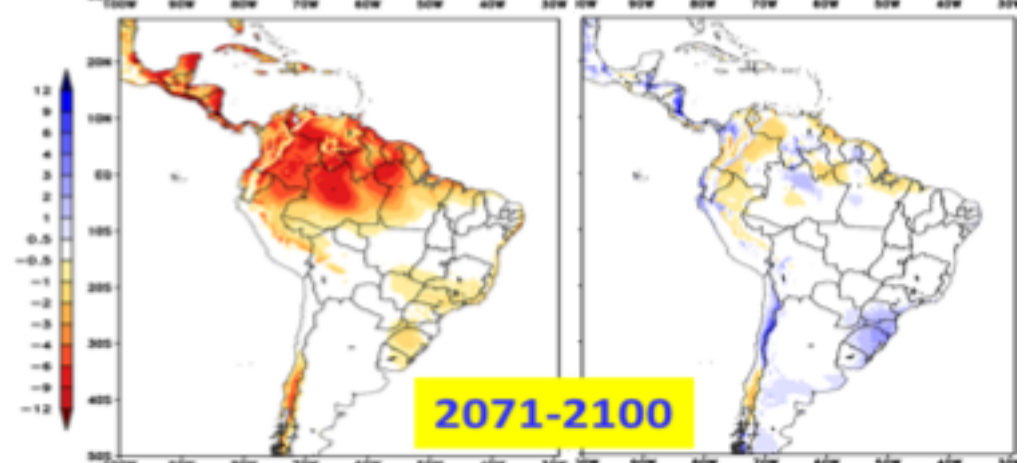
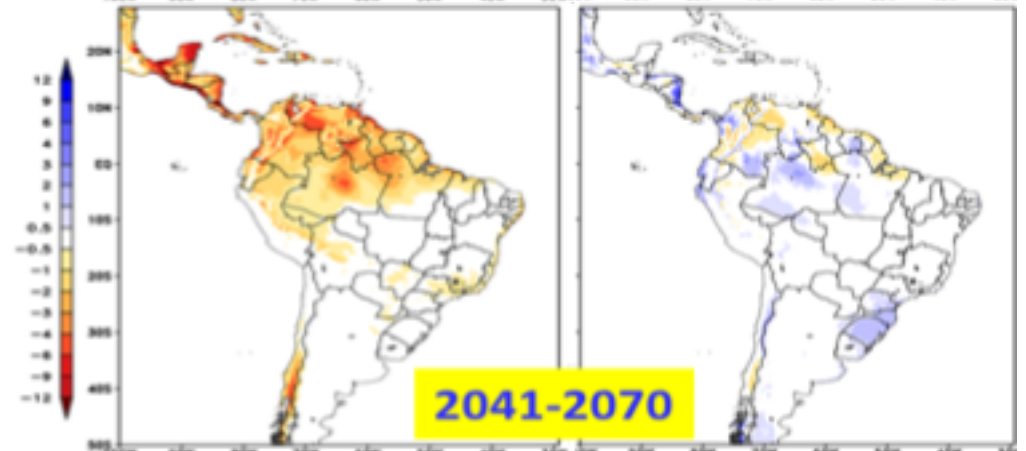
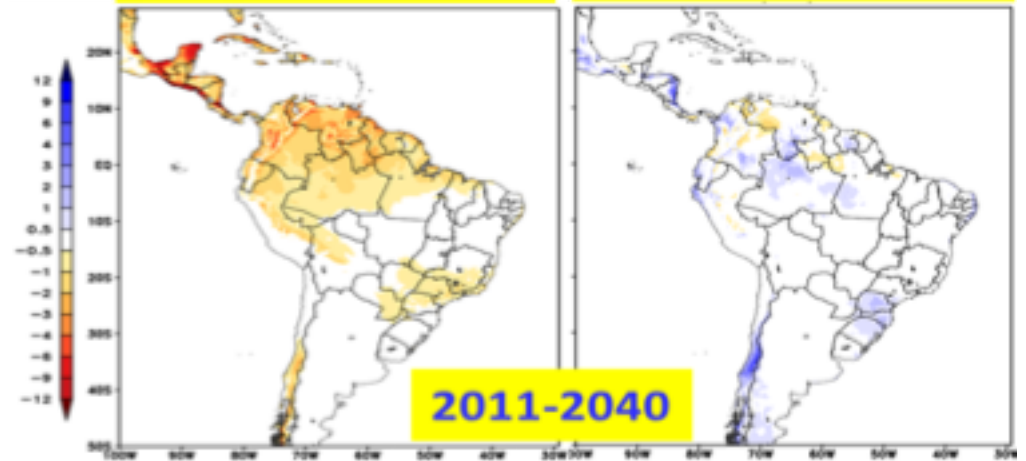
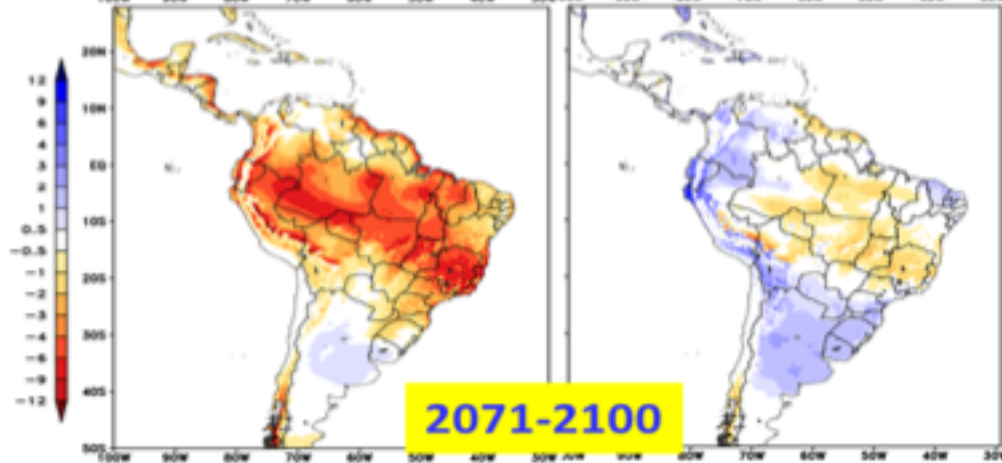
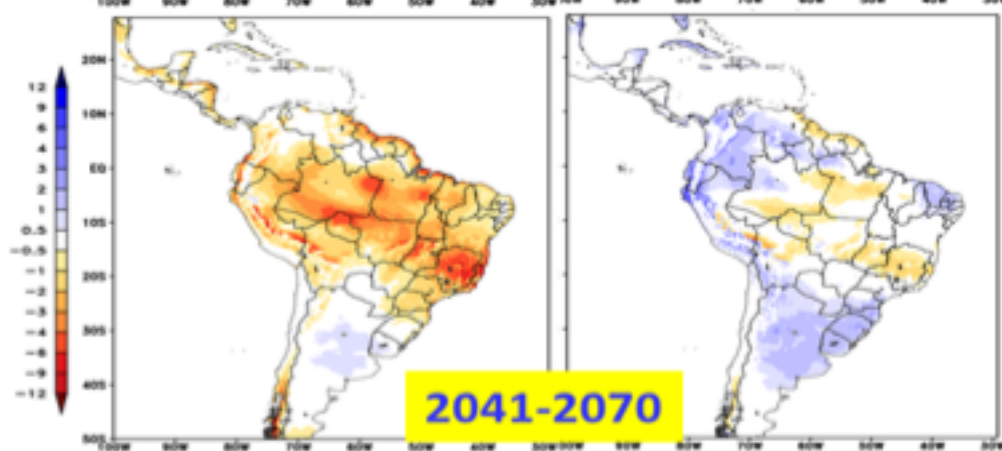
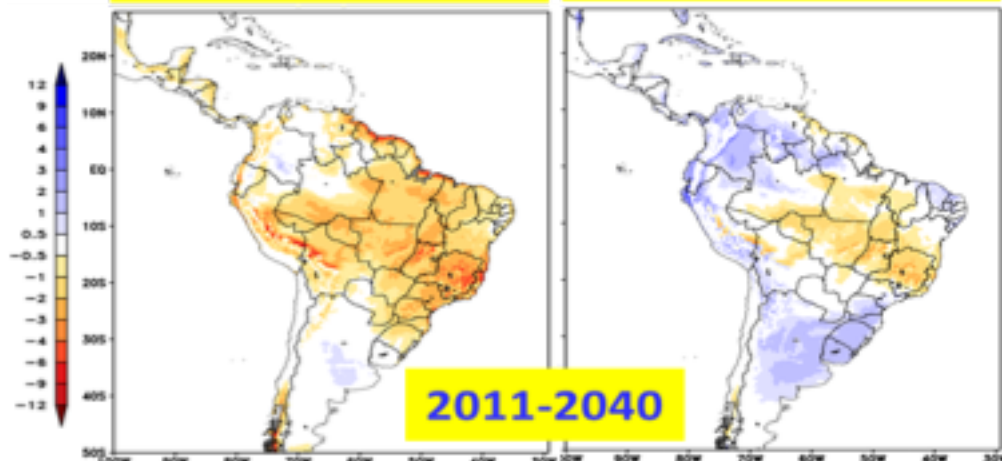
JJA

MIN

MAX

MIN

MAX



DJF

2-m Temperature

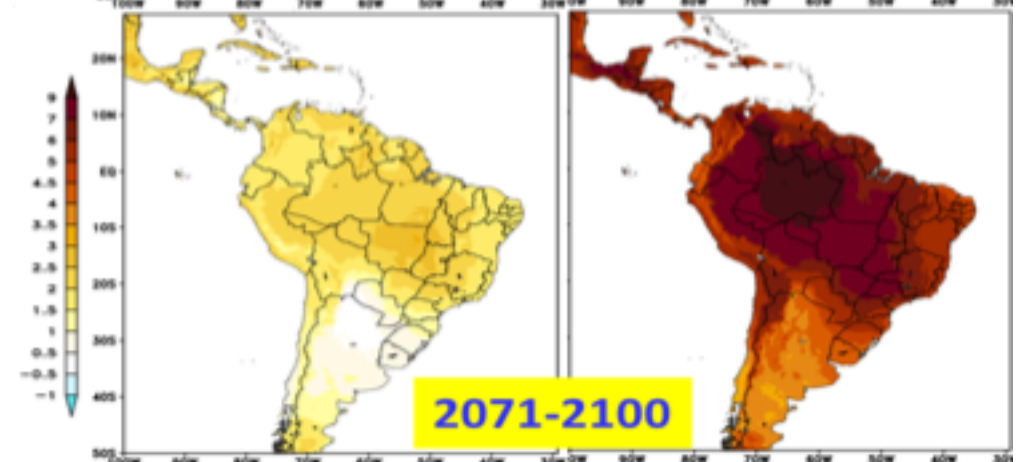
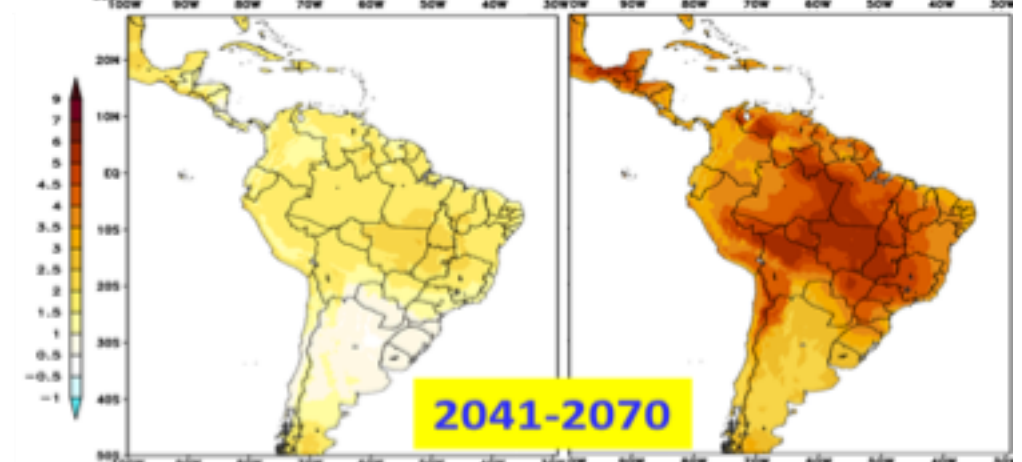
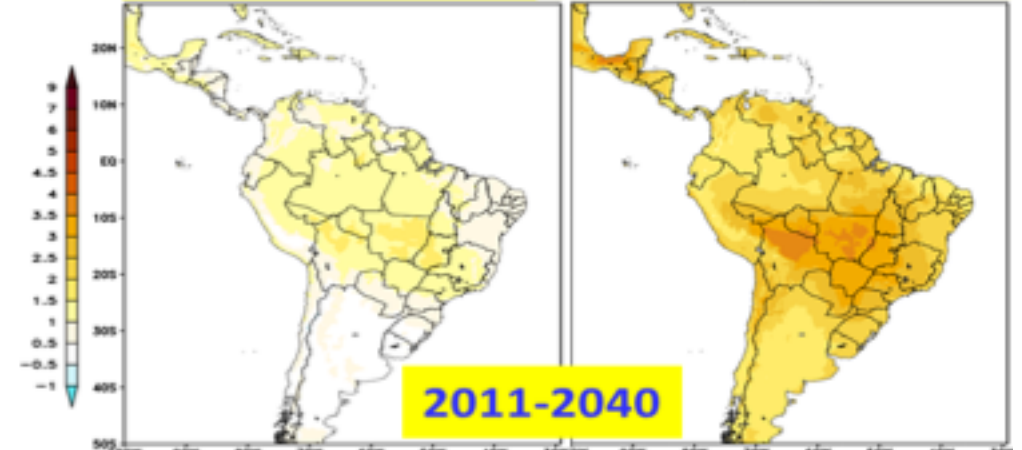
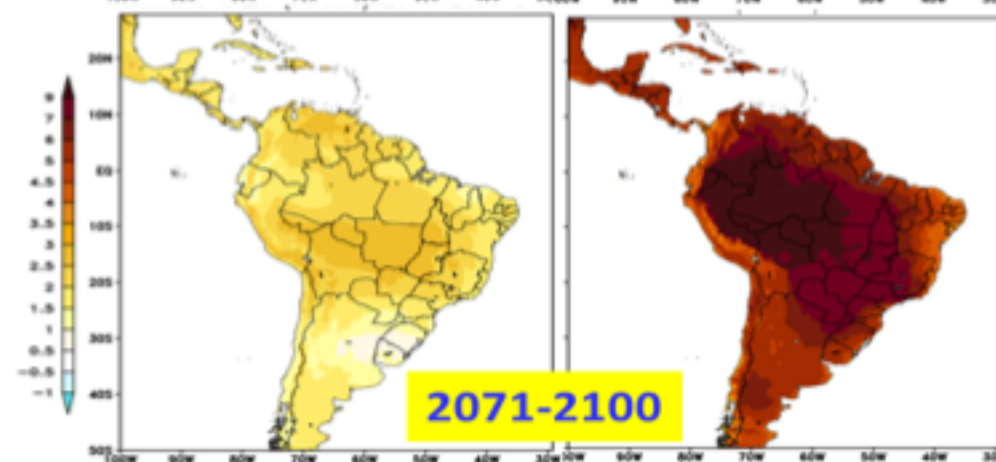
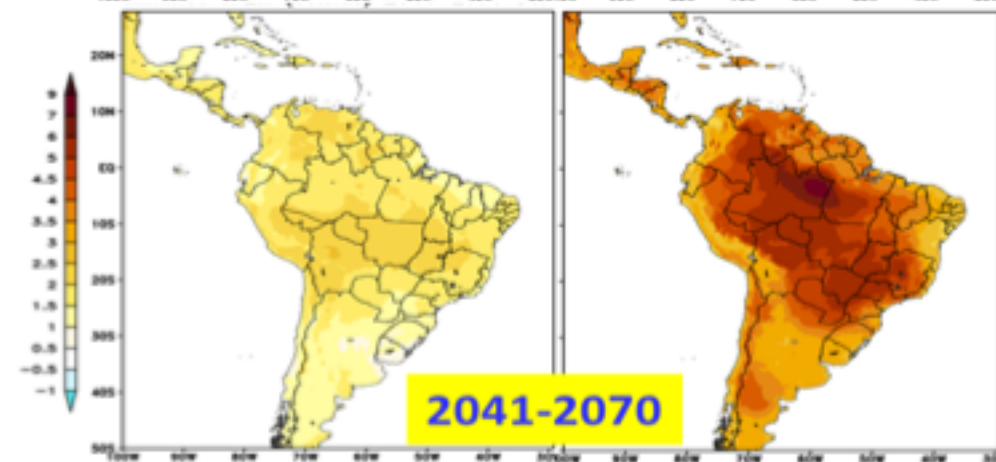
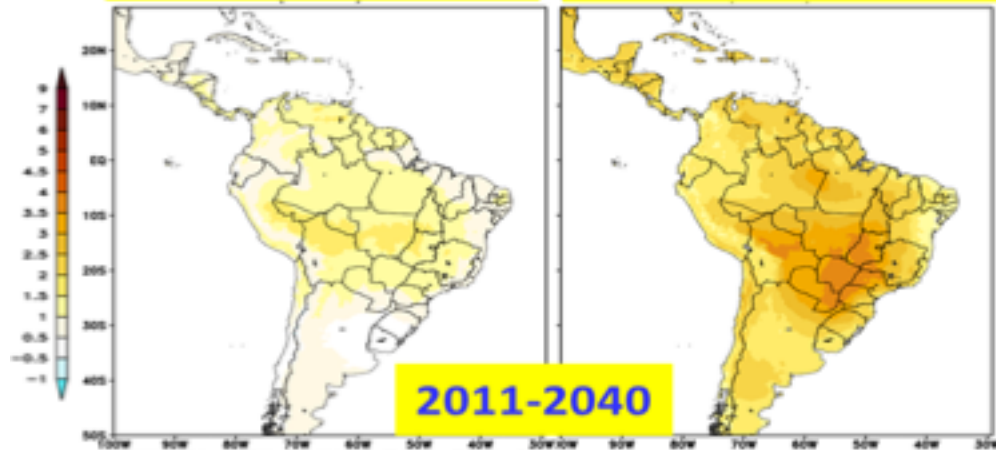
JJA

MIN

MAX

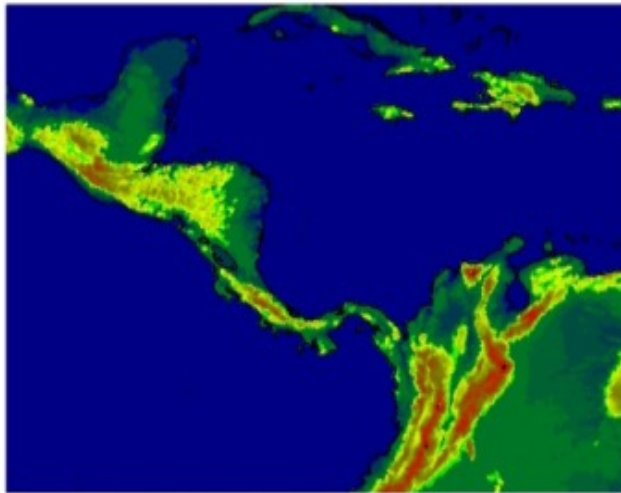
MIN

MAX

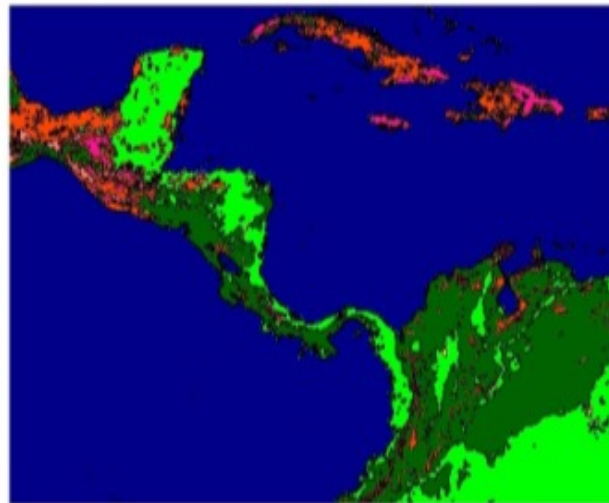


Eta RCM at 8-km resolution over Central America

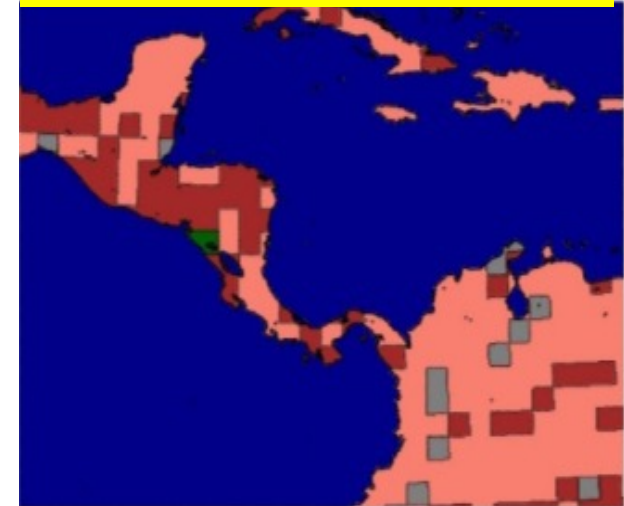
TOPOGRAPHY



VEGETATION



SOIL TEXTURE



(d) VEGETATION TYPES

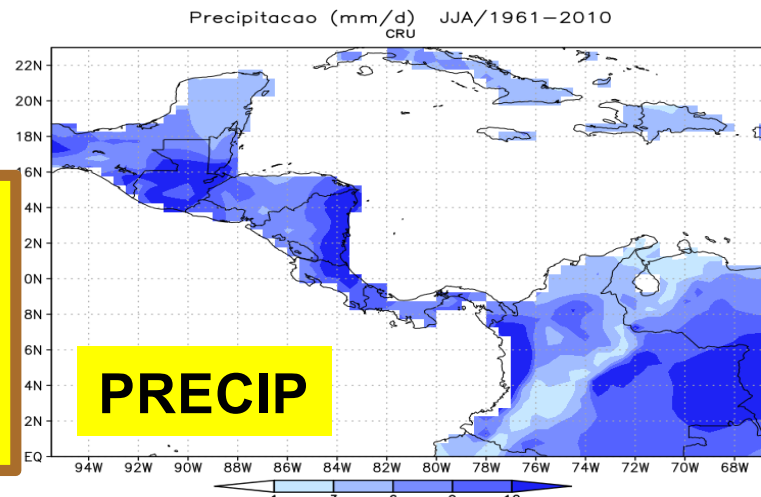
- 1: BROADLEAF-EVERGREEN TREES (TROPICAL FOREST)
- 2: BROADLEAF-DECIDUOUS TREES
- 3: BROADLEAF AND NEEDLELEAF TREES (MIXED FOREST)
- 4: NEEDLELEAF-EVERGREEN TREES
- 5: NEEDLELEAF-DECIDUOUS TREES (LARCH)
- 6: BROADLEAF TREES WITH GROUNDCOVER

- 7: GROUNDCOVER ONLY (PERENNIAL)
- 8: BROADLEAF SHRUBS WITH PERENNIAL GROUNDCOVER
- 9: BROADLEAF SHRUBS WITH BARE SOIL
- 10: DWARF TREES AND SHRUBS WITH GROUNDCOVER (TUNDRA)
- 11: BARE SOIL
- 12: CULTIVATIONS

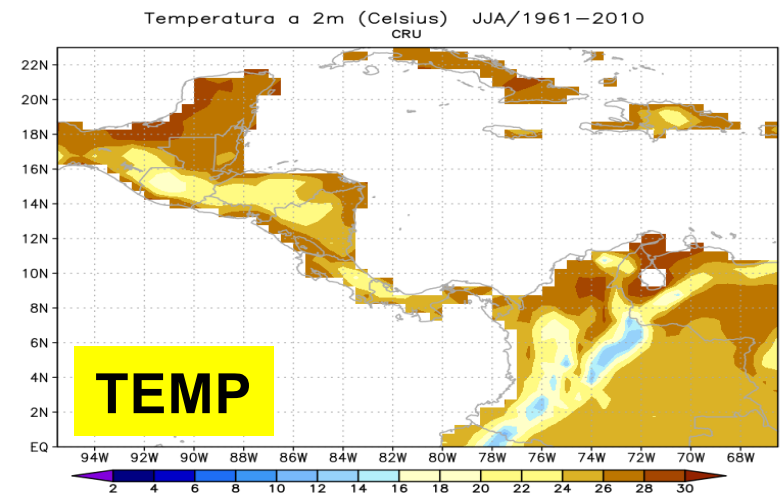
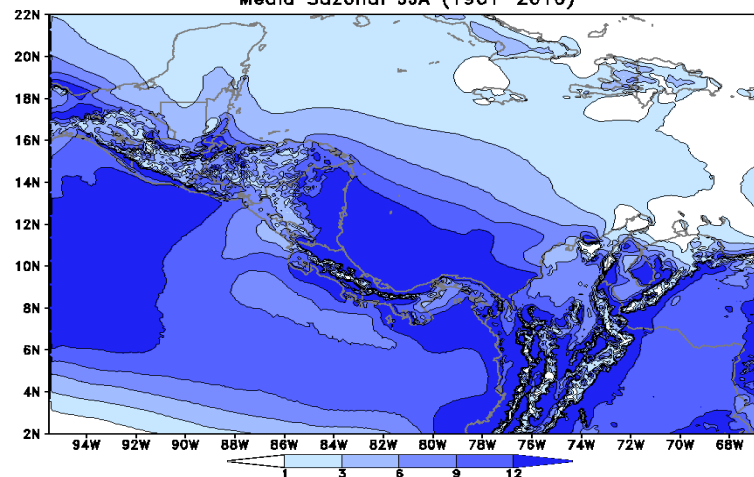
(e) SOIL TYPES: TEXTURE COMPOSITION

- 1: COARSE LOAMY SAND
- 2: MEDIUM SILTY CLAY LOAM
- 3: FINE LIGHT CLAY
- 6: MEDIUM-FINE CLAY LOAM

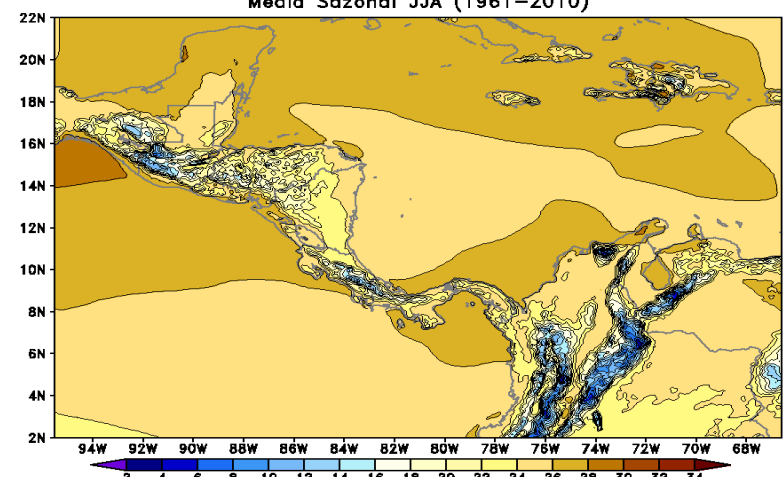
Verification precipitation and 2-metre temperature



Precipitacao (mm/dia) do Modelo Eta HadGEM2-ES 8km
Media Sazonal JJA (1961-2010)

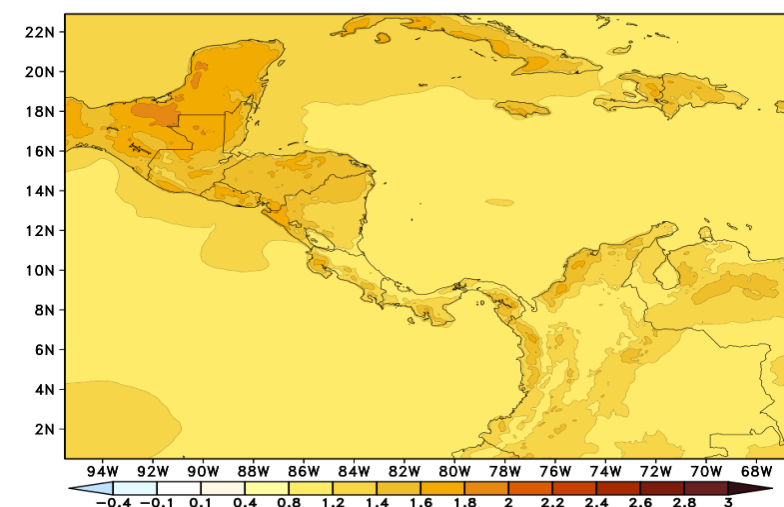
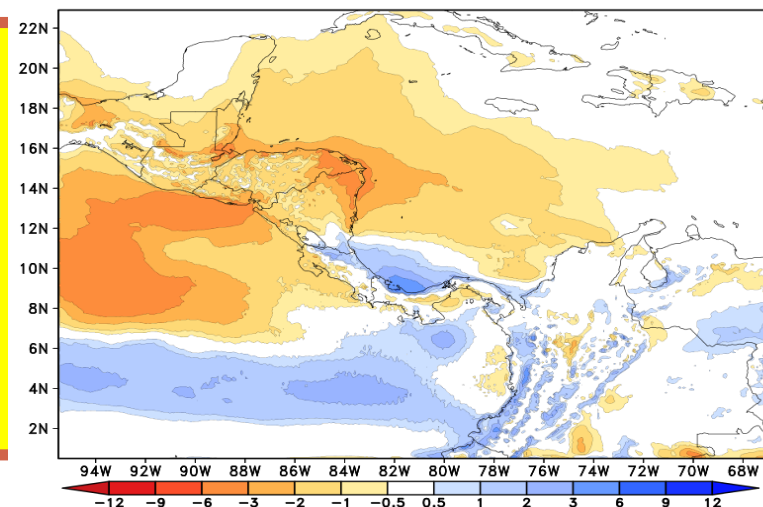


Temperatura (C) do Modelo Eta HadGEM2-ES 8km
Media Sazonal JJA (1961-2010)

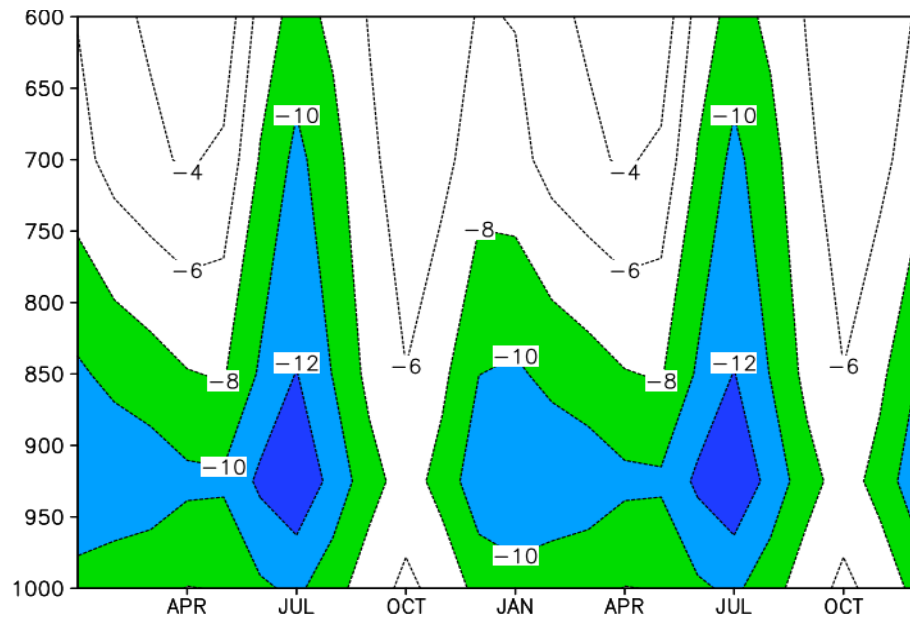


Projections

2011_2050
minus
1071_2010

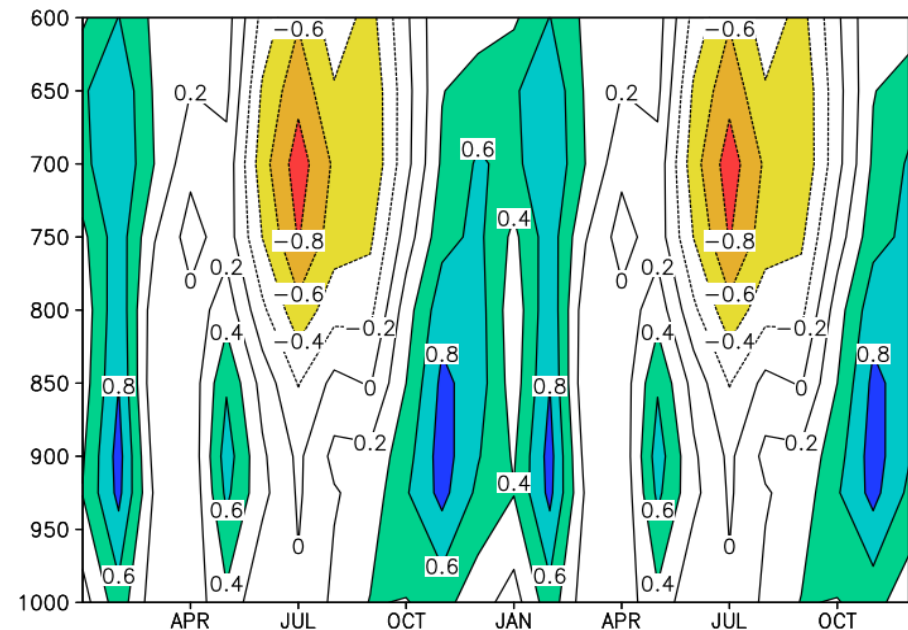
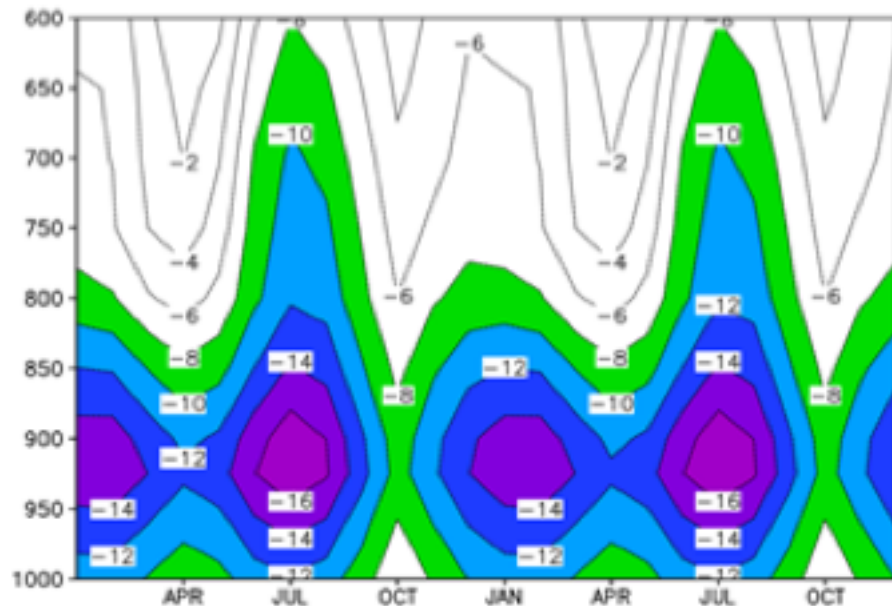


CARIBBEAN LOW LEVEL JET



Annual cycle (repeated twice) of the U-wind profile (m/s) averaged over the CLLJ area (80-70°W, 12-16°N) projected for (a) 2021-2050 and (b) difference of U-wind between 2021-2050 and 1961-1990 period.

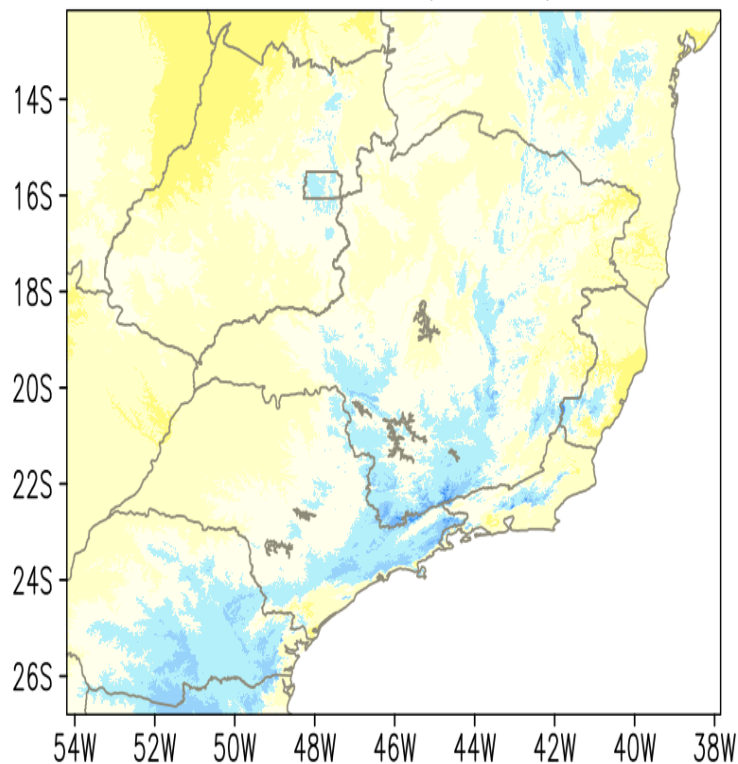
Negative values in (A) refer to easterly winds, whereas negative values in (B) indicate strengthening (orange shading) of easterly winds.



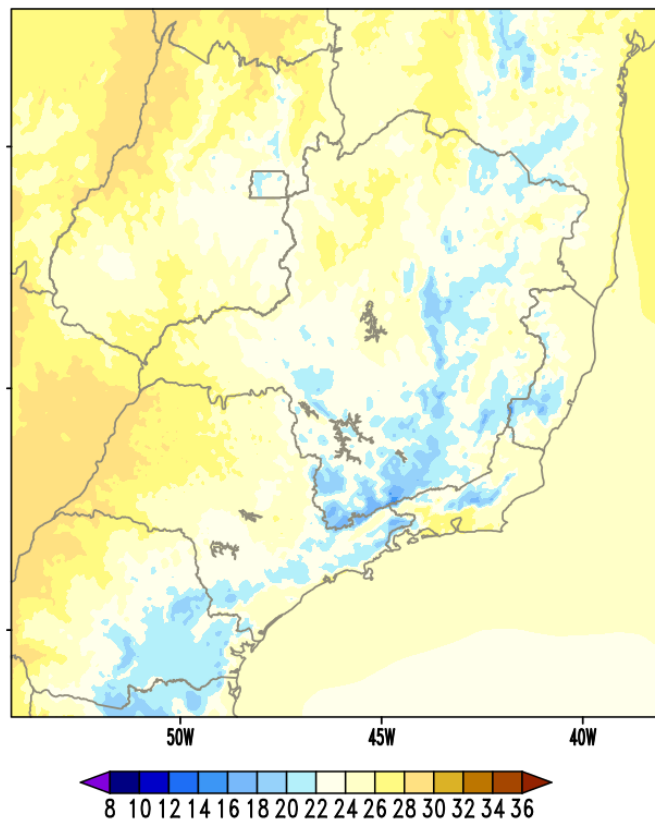
PROJECTIONS OF CLLJ STRENGTHENING

Eta-5km, NON-HYDROSTATIC VERSION

OBS (WorldClim)



Temperatura a 2m (C) – Eta HadGEM2-ES 5km
Media Sazonal DJF (1961–1990) controle



DJF

HadGEM2-ES

1961-2100

RCP4.5 e RCP8.5

**Suitable for
complex
topography
region and local
issues such as
urban climate,
land cover, etc**

TEMP

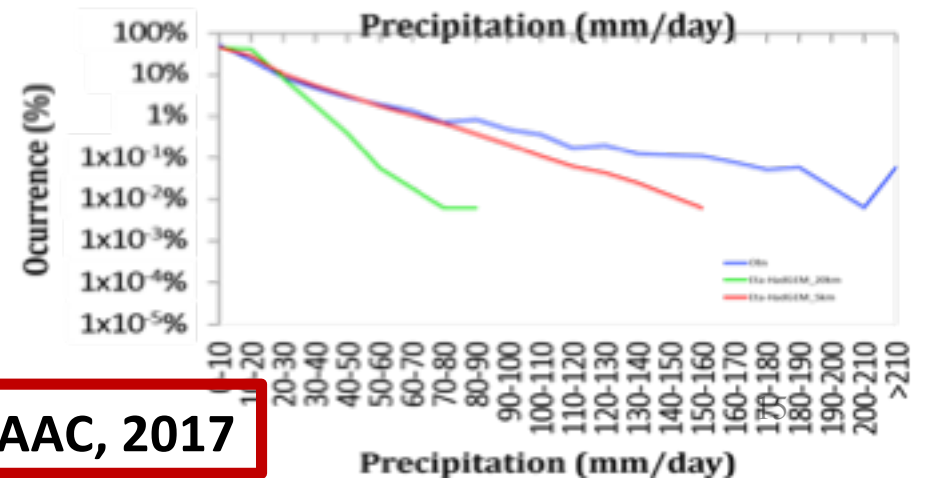
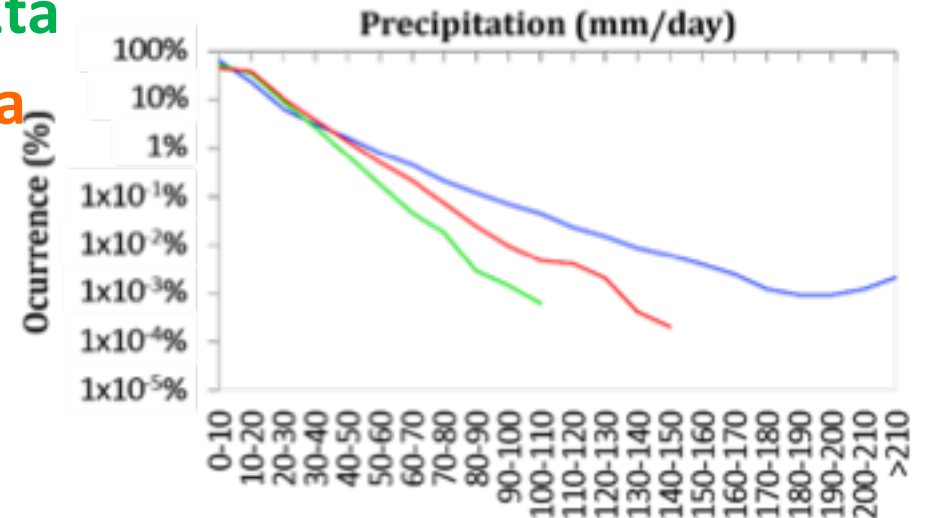
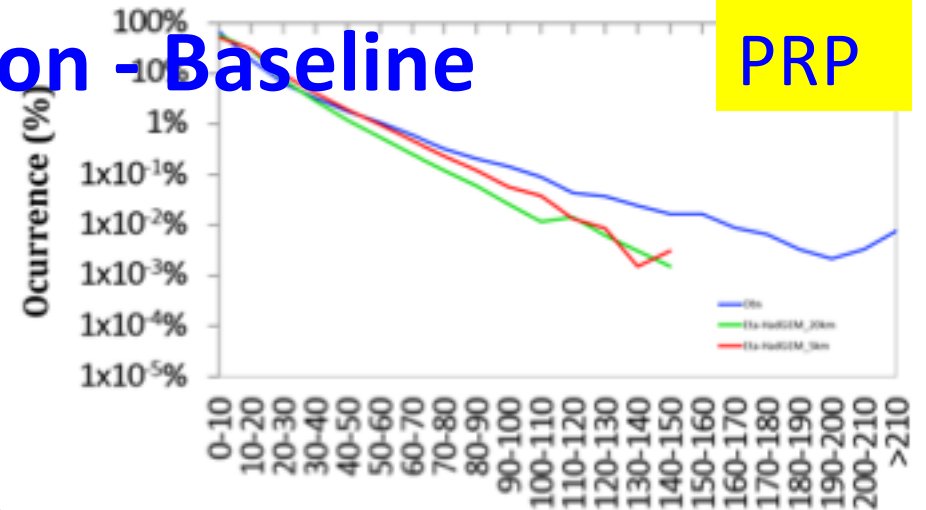
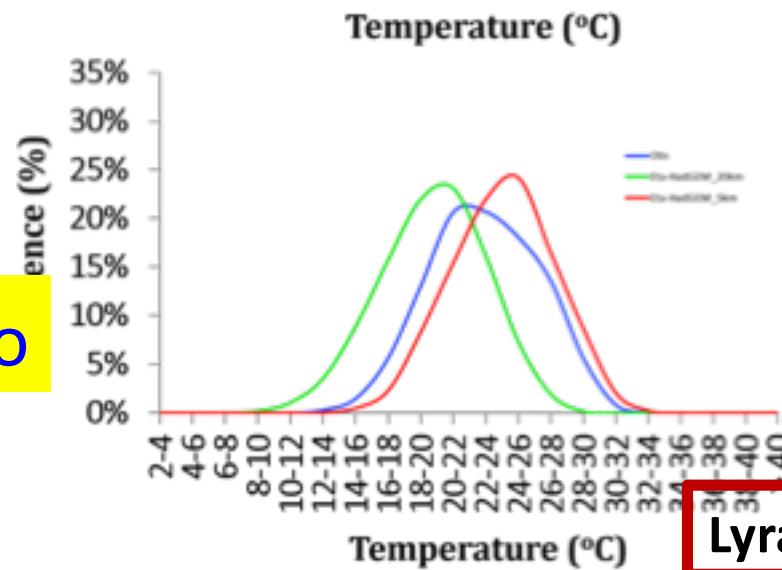
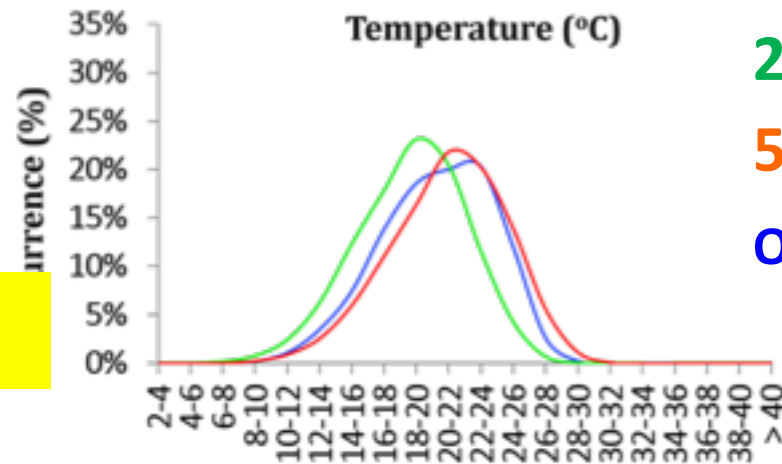
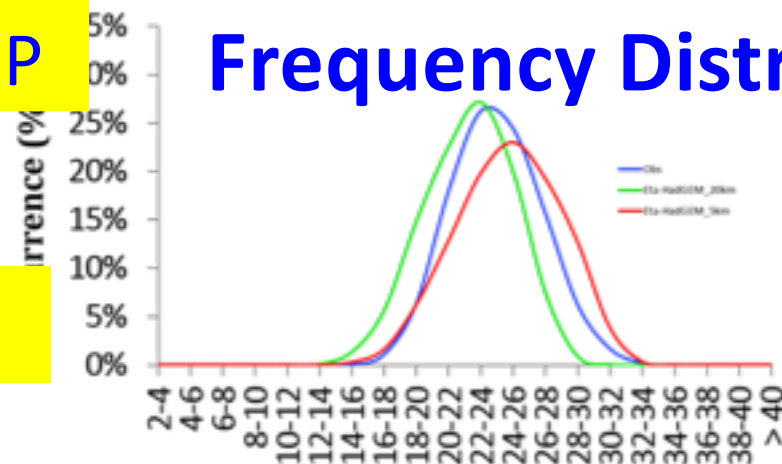
RJ

SP

Sto

Frequency Distribution - Baseline

PRP



20-km Eta

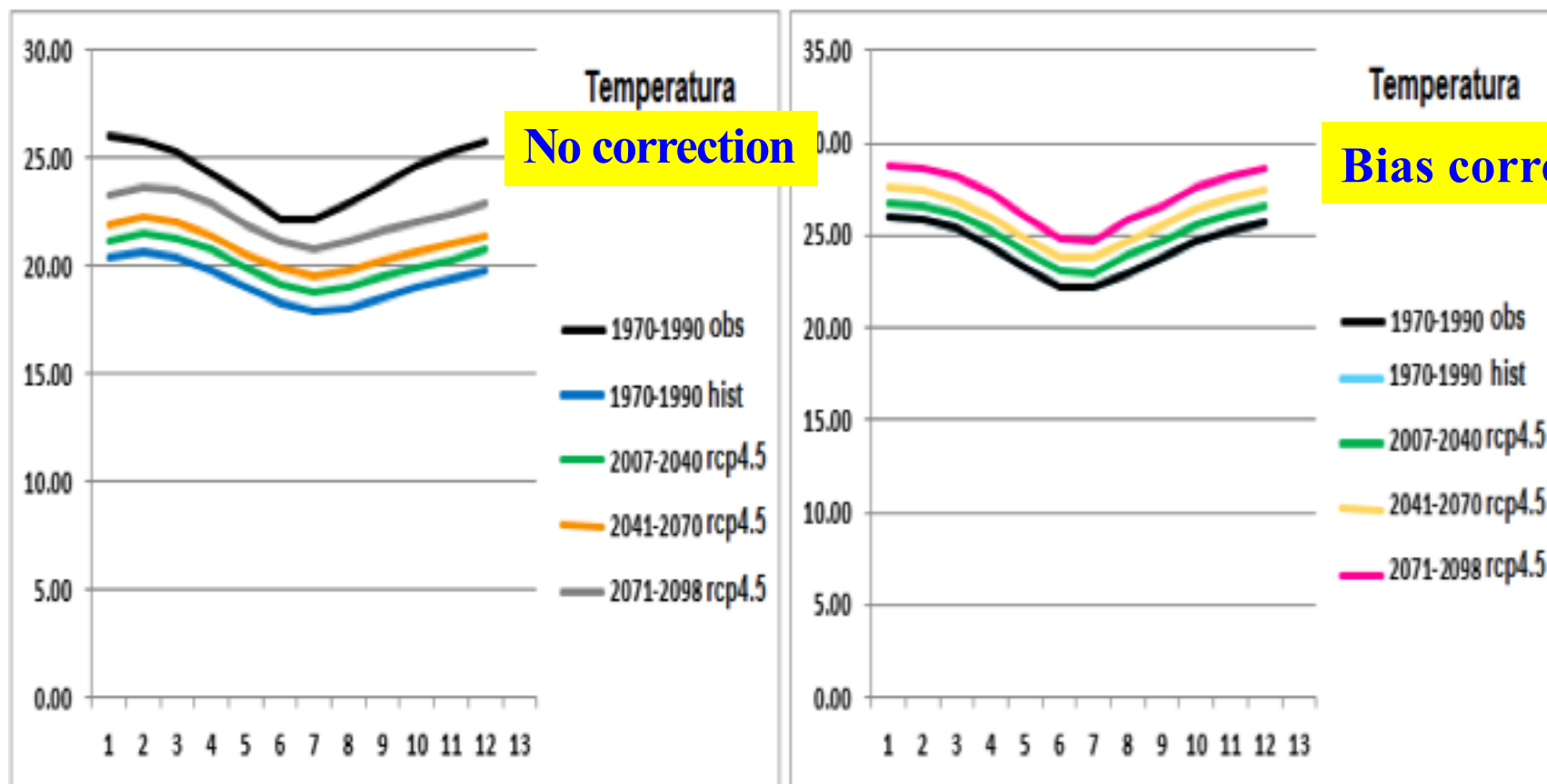
5-km Eta

OBS

Dataset constructed with bias correction

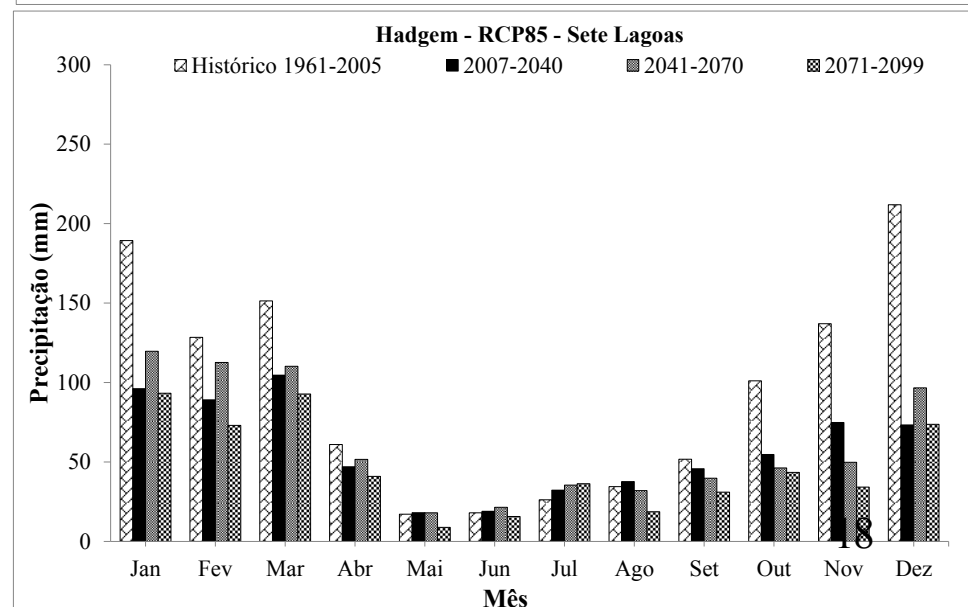
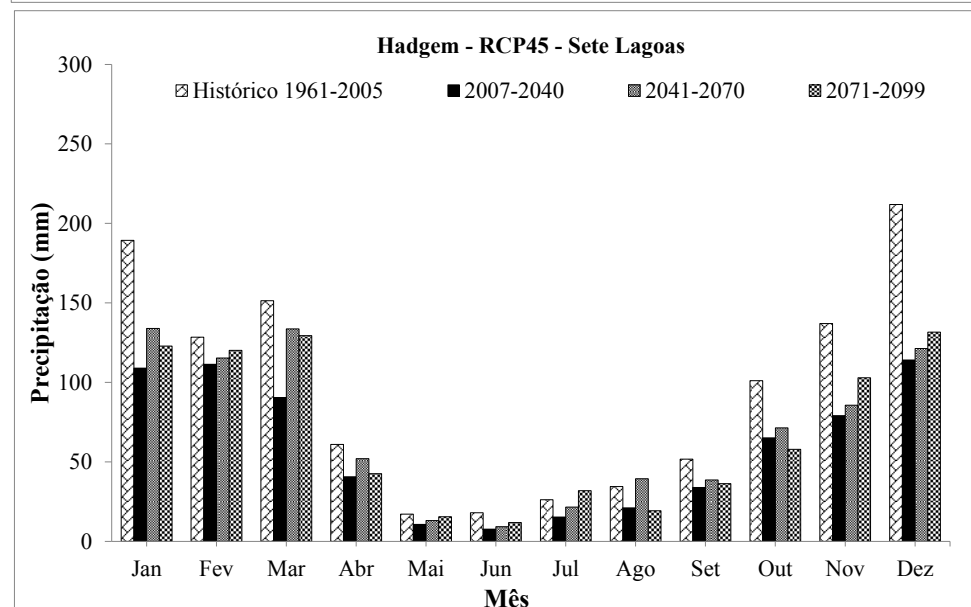
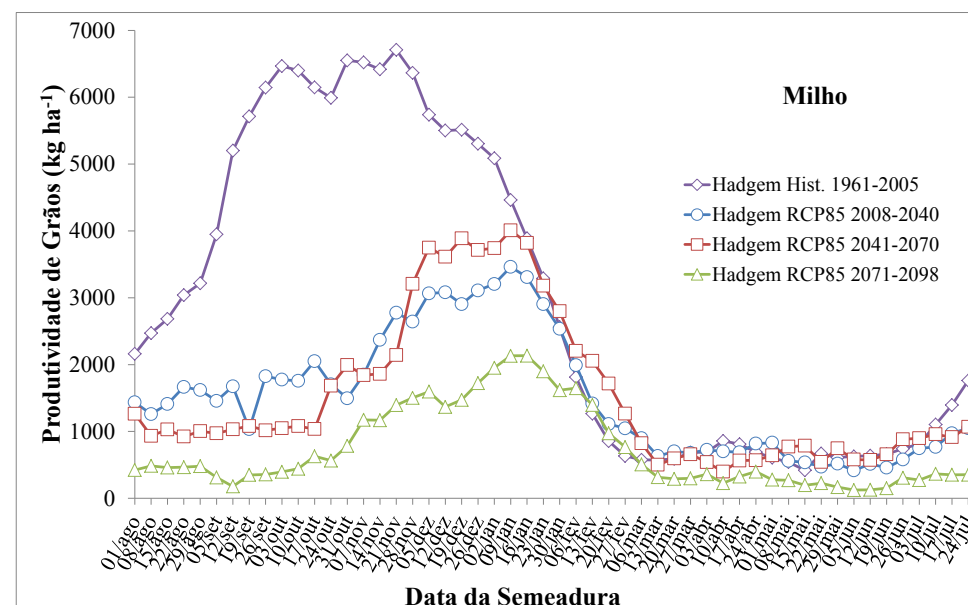
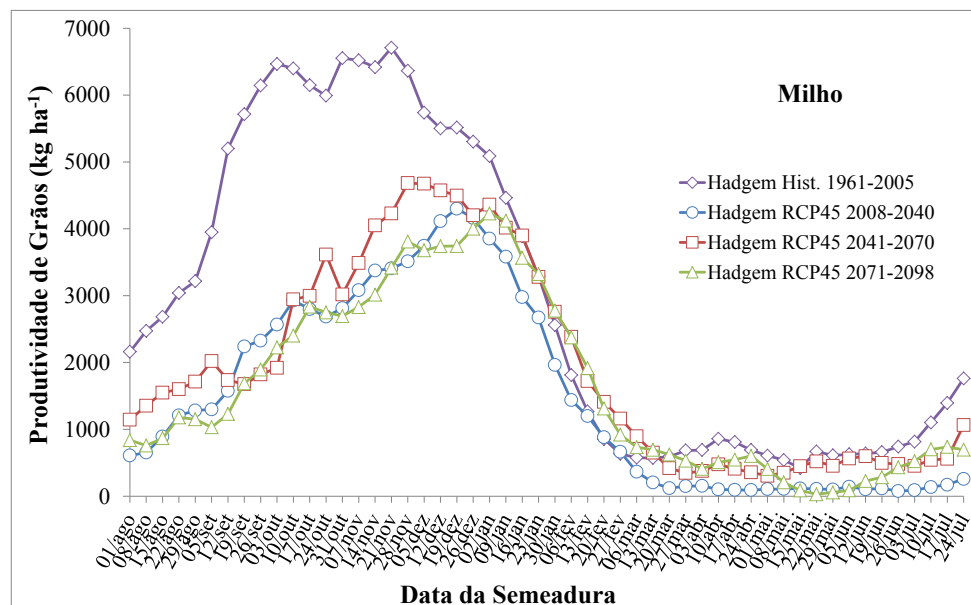
- Bárdossy e Pegram (2011) for precipitation
- Lenderink et al. (2007) for other variables

2-meter temperature



Impact studies in agriculture

CORN YIELD REDUCTION



POTENTIAL COFFEE YIELD (kg/ha)

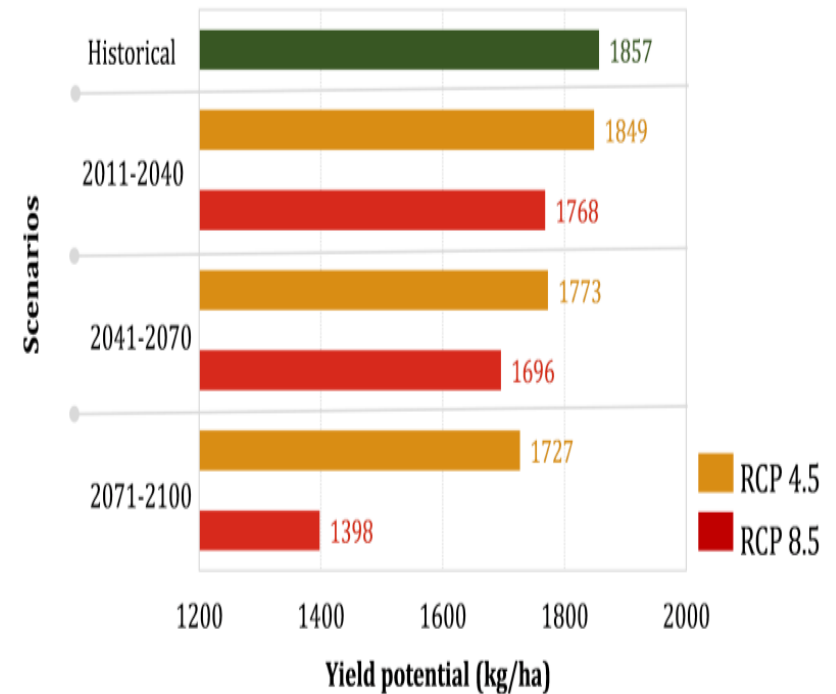
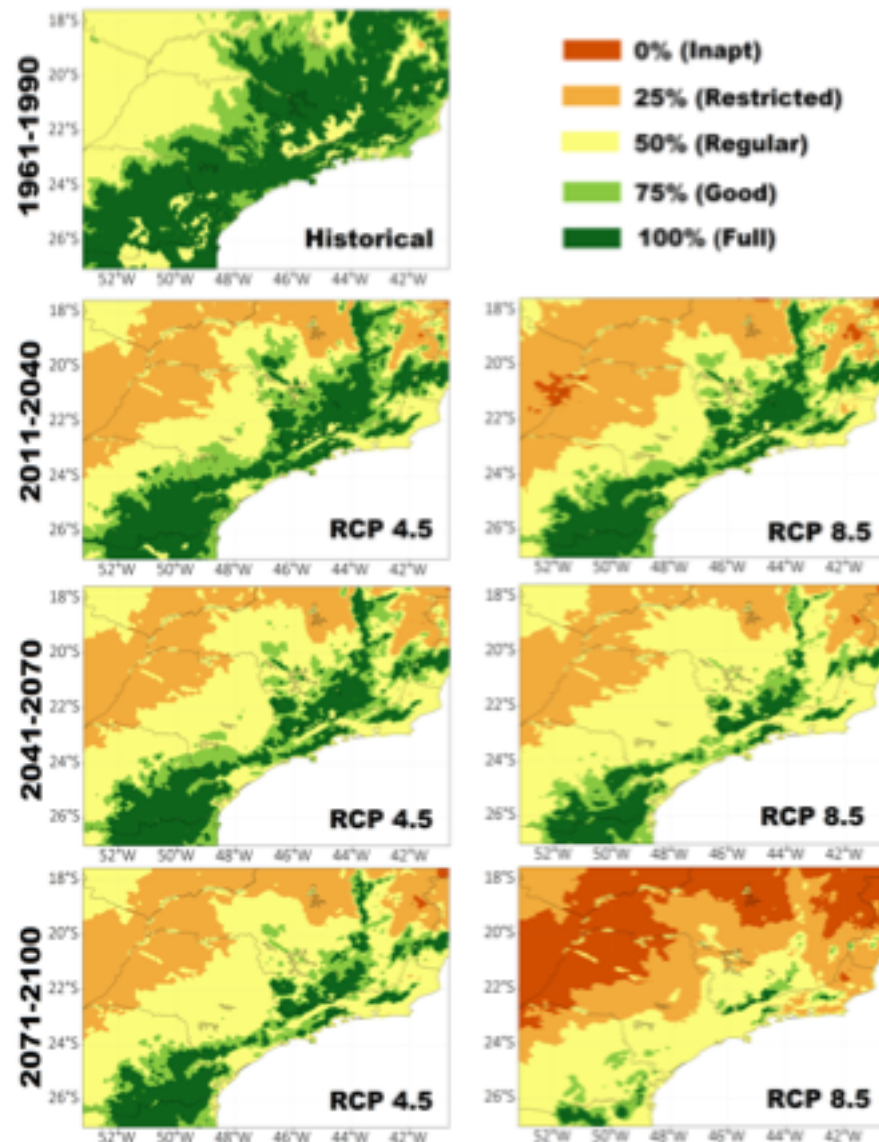


Figura 7. Potential yield of Arabica coffee (kg/ha) for Southern region of Minas Gerais (SMG). Historical scenario (present climate) and future scenarios, RCP 4.5 and RCP 8.5

Suitability percentage of agroclimatic zoning for the cultivation of Arabica coffee in southeastern Brazil, simulated by Eta-HadGEM 5 km. Historical scenario (present climate) and future scenarios, RCP 4.5 and RCP 8.5

Part of dataset uploaded to the **ESGF-CORDEX** thanks to SMHI through Grigory Nikulin.

<https://esg-dn1.nsc.liu.se/search/cordex/>

The screenshot shows the ESGF@LiU/CORDEX search interface. The browser address bar displays the URL <https://esg-dn1.nsc.liu.se/search/cordex/>. The page header includes logos for 'Hosted by' (is-ones, li.u, NSC, SMHI) and 'Powered by' (ESGF and CCG). A navigation bar contains links for 'Home', 'About Us', 'Contact Us', and 'Technical Support'. A sidebar on the left lists search filters: Project, Product, Domain, Institute, INPE (18), Driving Model, Experiment, Experiment Family, Ensemble, RCM Model, Eta (18), Downscaling realisation, Time Frequency, Variable, Variable Long Name, CF Standard Name, and Datanode. The main search area features a text input field, a search button, and a reset button. Below the search bar, there are checkboxes for 'Show All Replicas', 'Show All Versions', and 'Search Local Node Only (Including All Replicas)'. The search constraints are listed as 'INPE | Eta'. The total number of results is 18, with a pagination link '-1- 2 Next >>'. A message prompts users to login to add search results to their Data Cart. Below this, a list of search results is displayed, each with a title, data node, version, and total number of files. The results are as follows:

Result ID	Search Result
1.	cordex.output.SAM-20.INPE.CCCma-CanESM2.historical.r1i1p1.Eta.v1.mon.tas Data Node: esg-dn1.nsc.liu.se Version: 20180507 Total Number of Files (for all variables): 5 [Show Metadata] [Show Files] [THREDDS Catalog] [WGET Script]
2.	cordex.output.SAM-20.INPE.CCCma-CanESM2.historical.r1i1p1.Eta.v1.mon.pr Data Node: esg-dn1.nsc.liu.se Version: 20180507 Total Number of Files (for all variables): 5 [Show Metadata] [Show Files] [THREDDS Catalog] [WGET Script]
3.	cordex.output.SAM-20.INPE.MOHC-HadGEM2-ES.historical.r1i1p1.Eta.v1.mon.tas Data Node: esg-dn1.nsc.liu.se Version: 20180507 Total Number of Files (for all variables): 6 [Show Metadata] [Show Files] [THREDDS Catalog] [WGET Script]
4.	cordex.output.SAM-20.INPE.MOHC-HadGEM2-ES.historical.r1i1p1.Eta.v1.mon.pr Data Node: esg-dn1.nsc.liu.se Version: 20180507 Total Number of Files (for all variables): 6 [Show Metadata] [Show Files] [THREDDS Catalog] [WGET Script]
5.	cordex.output.SAM-20.INPE.MOHC-HadGEM2-ES.rcp45.r1i1p1.Eta.v1.mon.tas Data Node: esg-dn1.nsc.liu.se

Tas, prp monthly

ONGOING ACTIVITIES

- Ongoing development on improving land-surface conditions, properties, etc;
- Convection permitting scale tests are ongoing, 1-km
- Chemistry transport model being included
- Ocean model (MOM6) being coupled
- Radiation scheme being replaced from GFDL to RRMTG
- Global model development
- The output from these simulations are available for applications and impact studies



Thank you!
Gracias!

chou@cptec.inpe.br