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

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Downscaling team
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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.

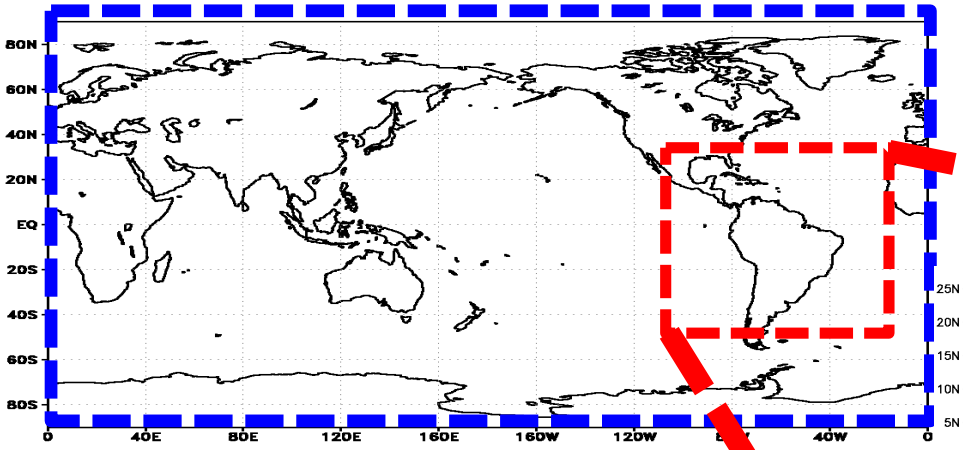
Global Climate Models

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 1º 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 1º 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

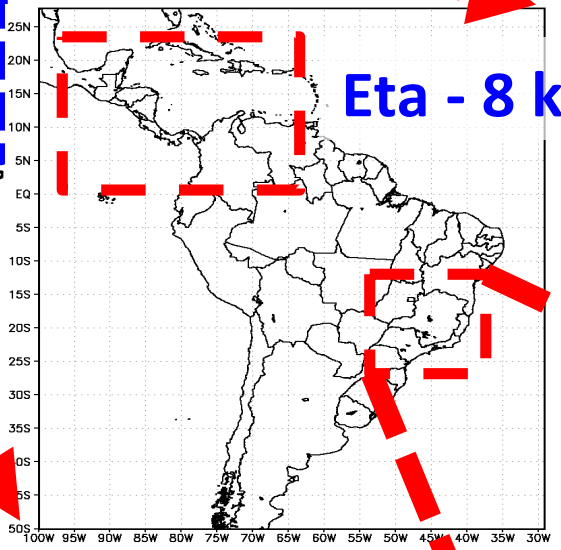


Emission Scenarios

- Historical
- RCP4.5
- RCP8.5

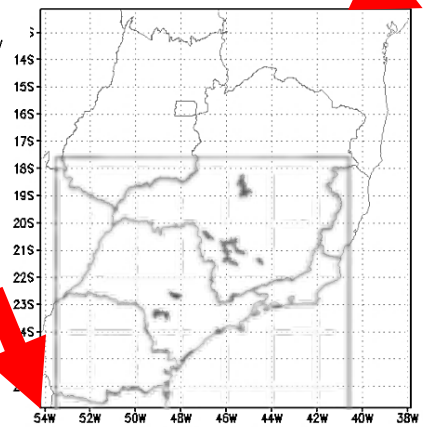
Global models, 150 ~300 km

- HadGEM2-ES
- MIROC5
- CanESM2
- BESM



Eta - 8 km

Eta - 20 km



Eta - 5 km

High resolution suitable for impact studies

PRECIPITATION

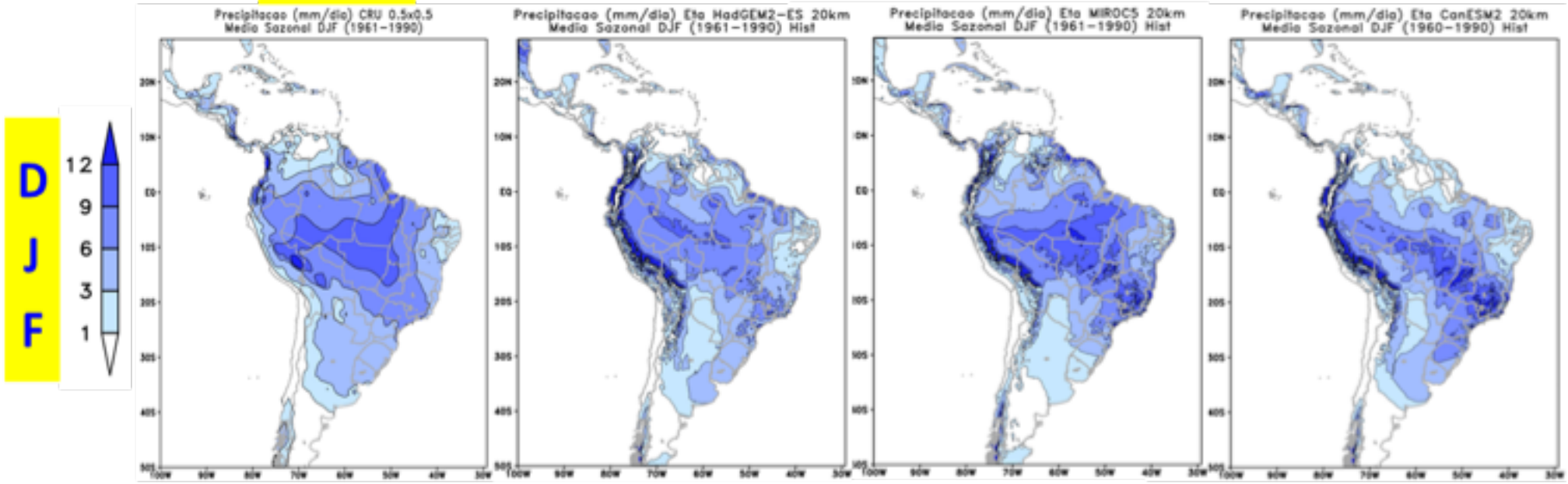
OBS (CRU)

Eta-HadGEM2-ES

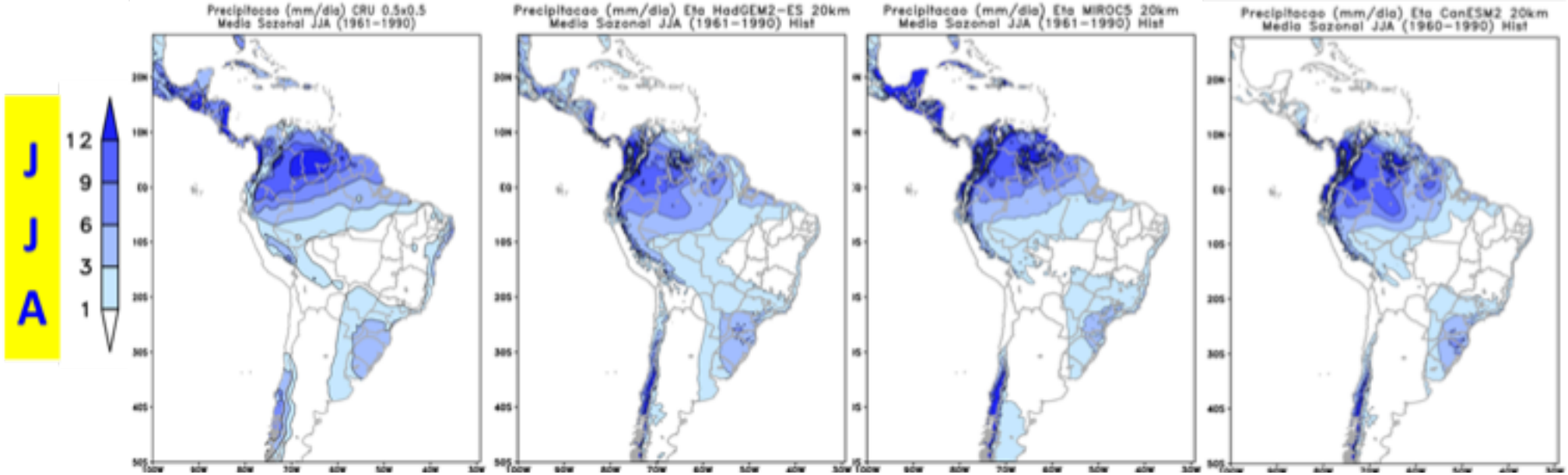
Eta-MIROC5

Eta-CanESM2

D J F



J J A



2-m TEMPERATURE

OBS (CRU)

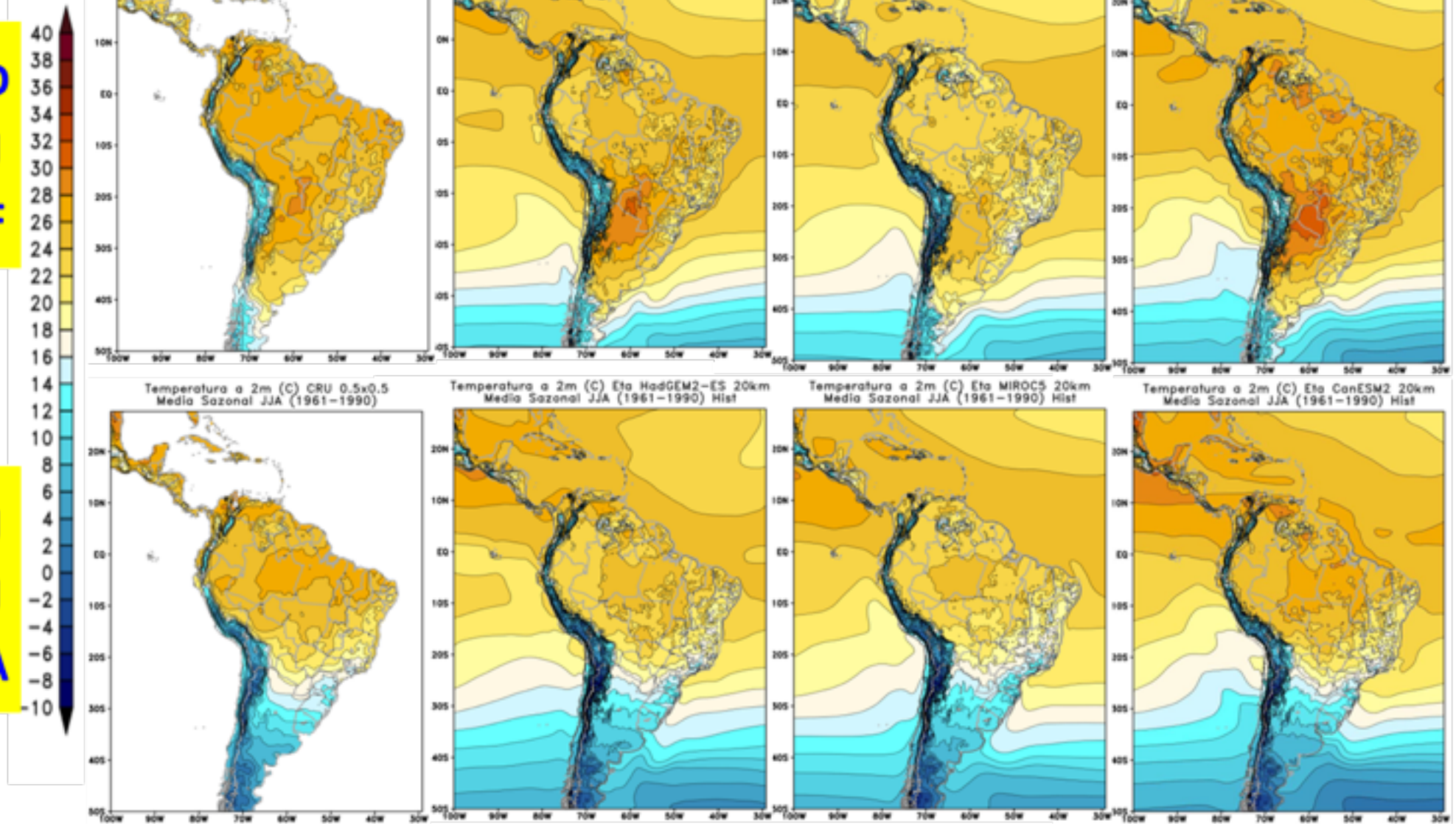
Eta-HadGEM2-ES

Eta-MIROC5

Eta-CanESM2

D J F

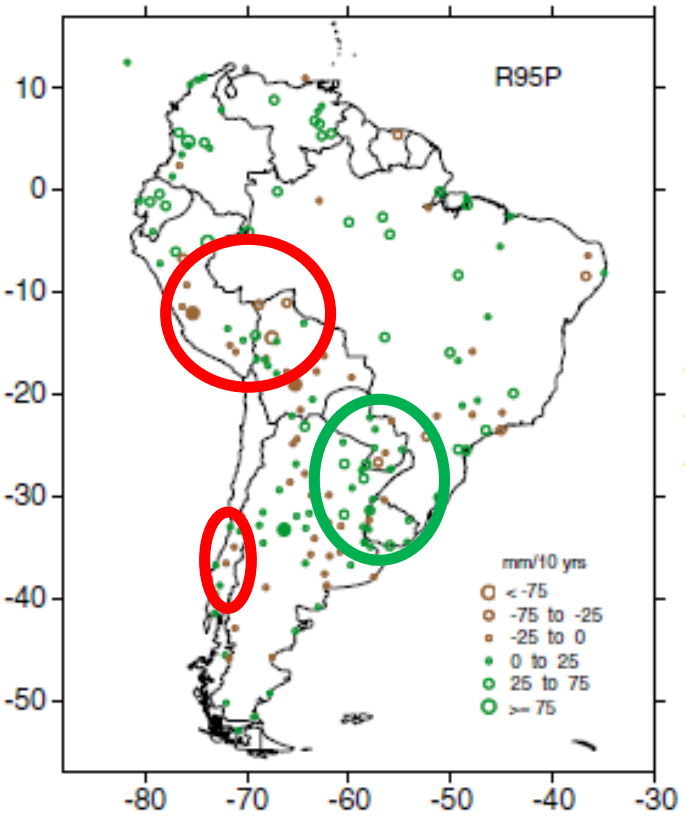
J J A

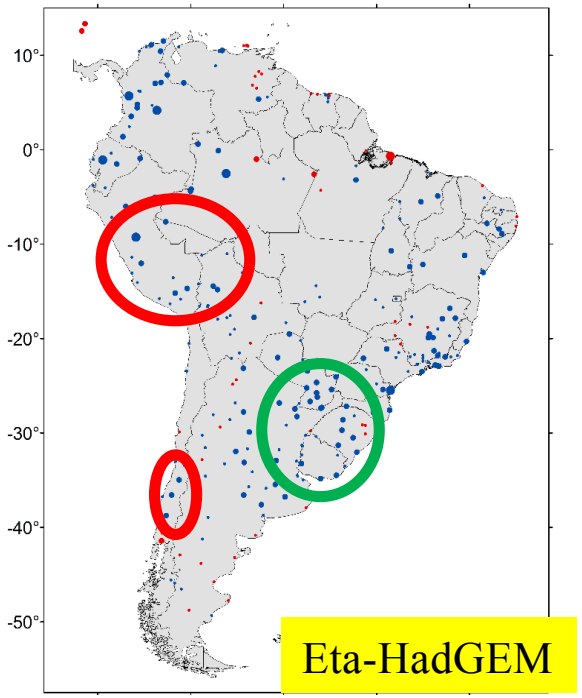


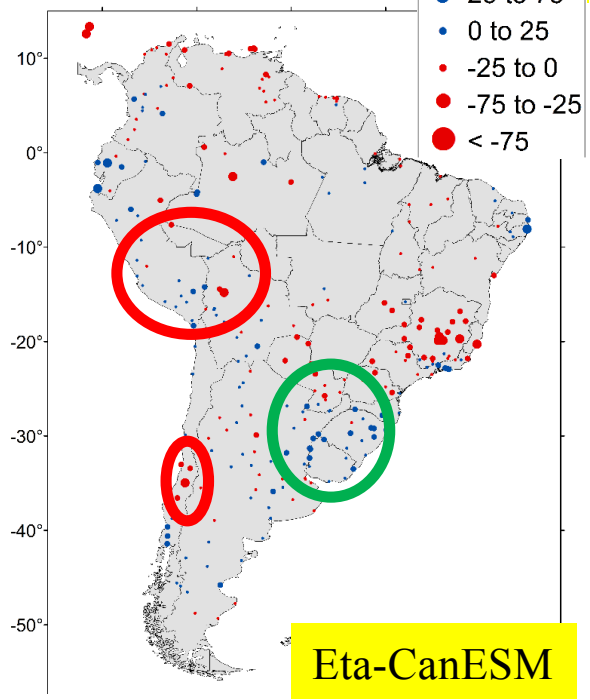
Análise dos Extremos climáticos

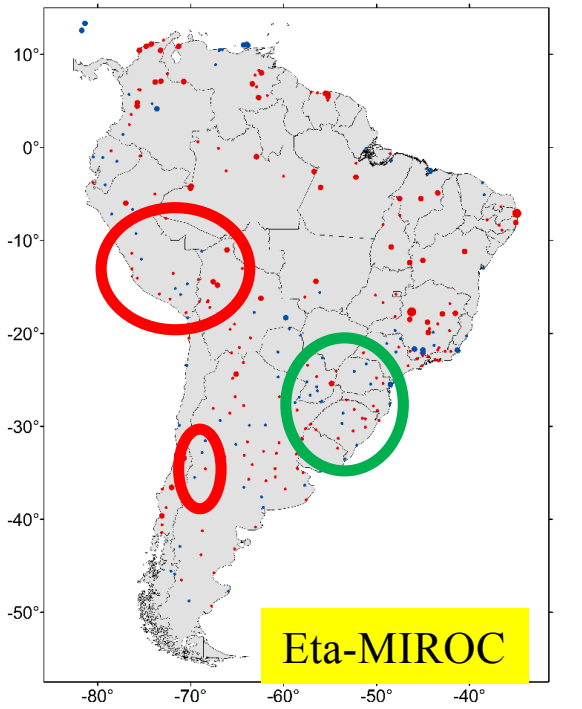
R95p

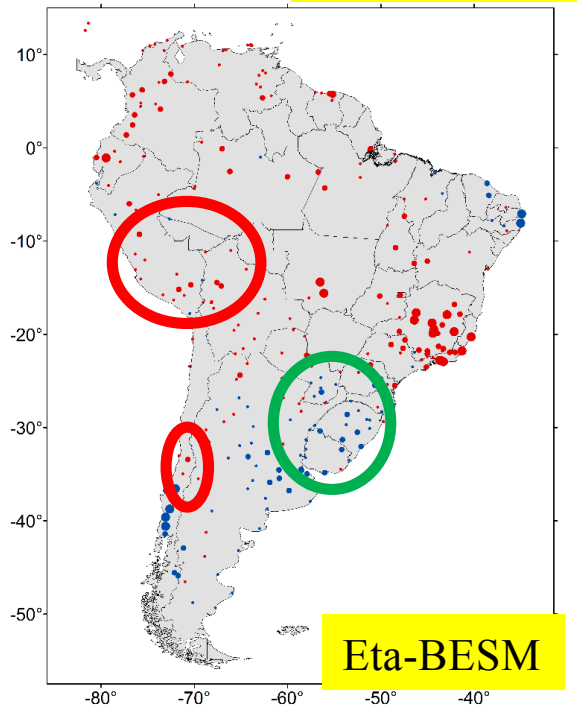
Observado (1969-2009 – Skansi *et al.*, 2013)







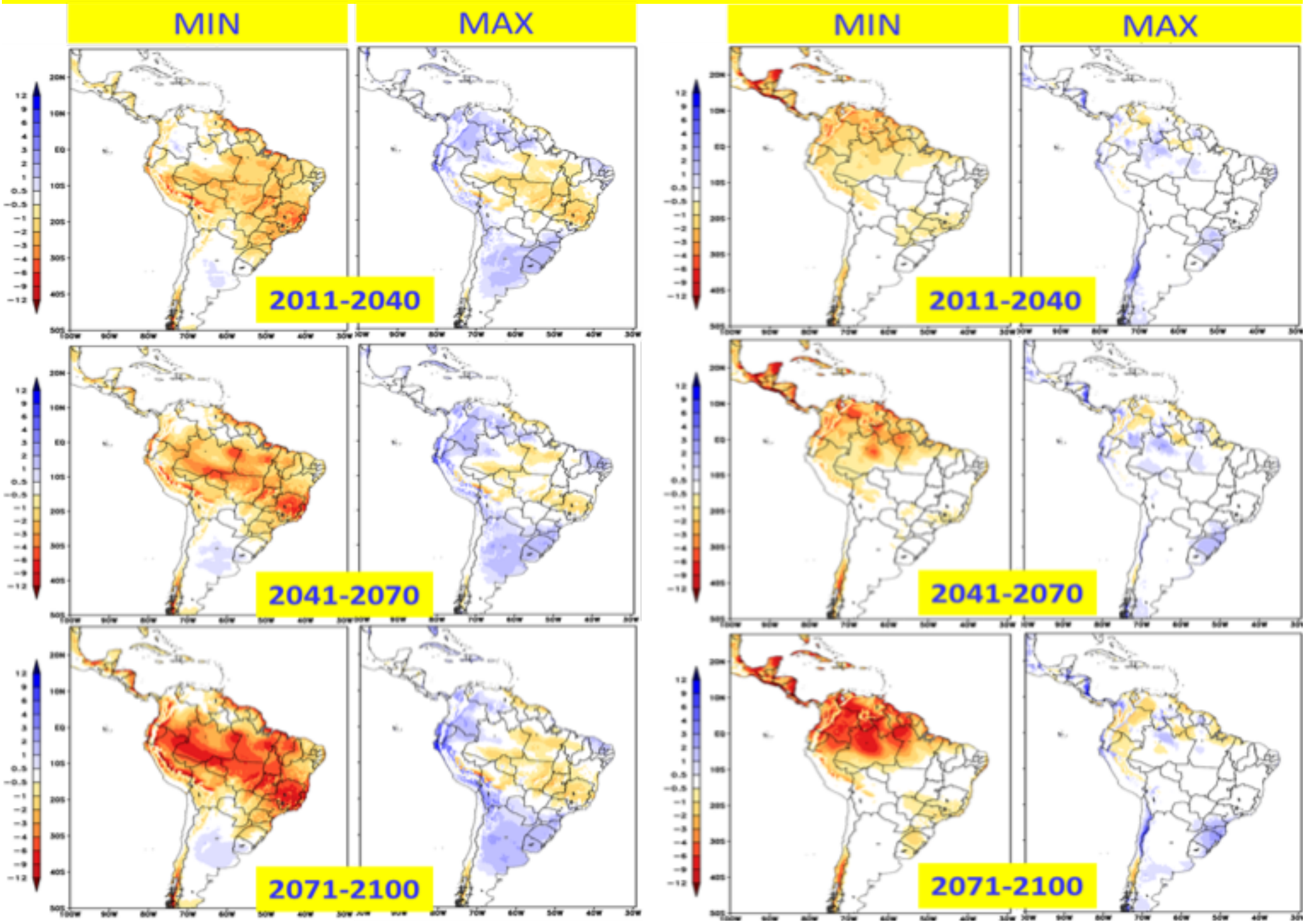


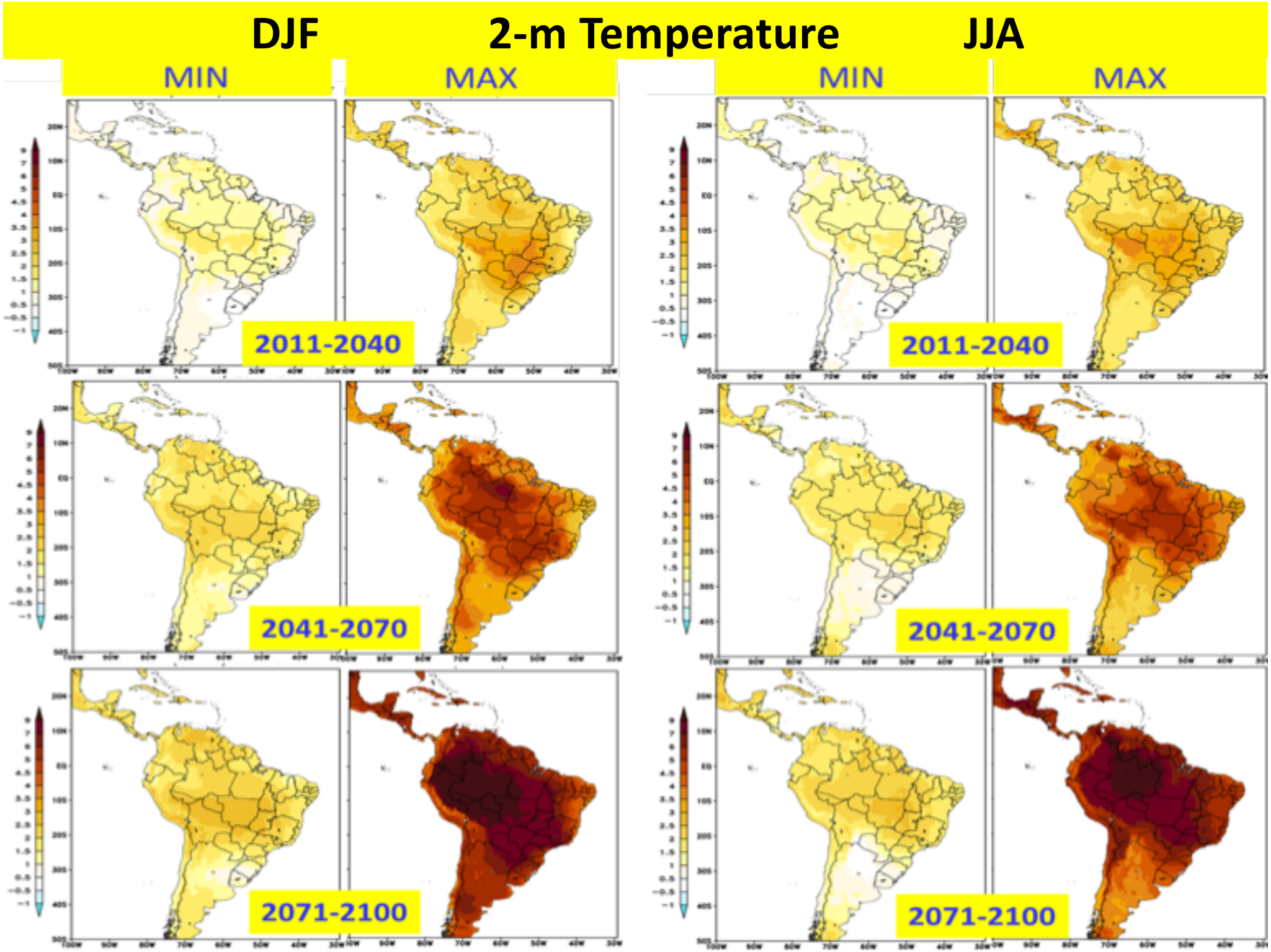


Bolsista IC

PROJECTIONS OF CLIMATE CHANGE

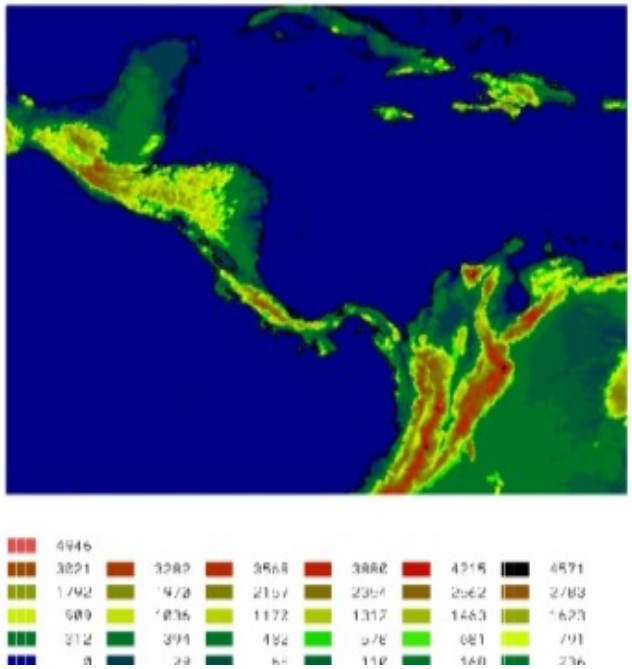
DJF PRECIPITATION JJA



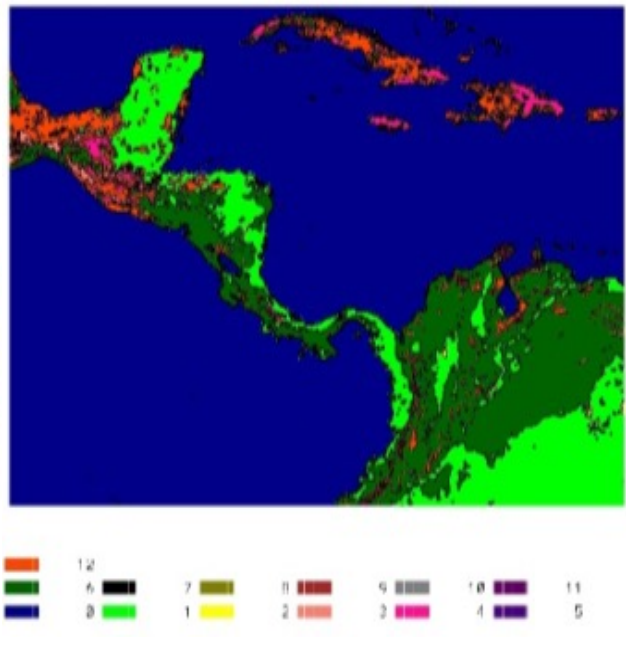

DJF
2-m Temperature
JJA
MIN
MAX
MIN
MAX
2011-2040
2011-2040
2041-2070
2041-2070
2071-2100
2071-2100

Eta RCM at 8-km resolution over Central America

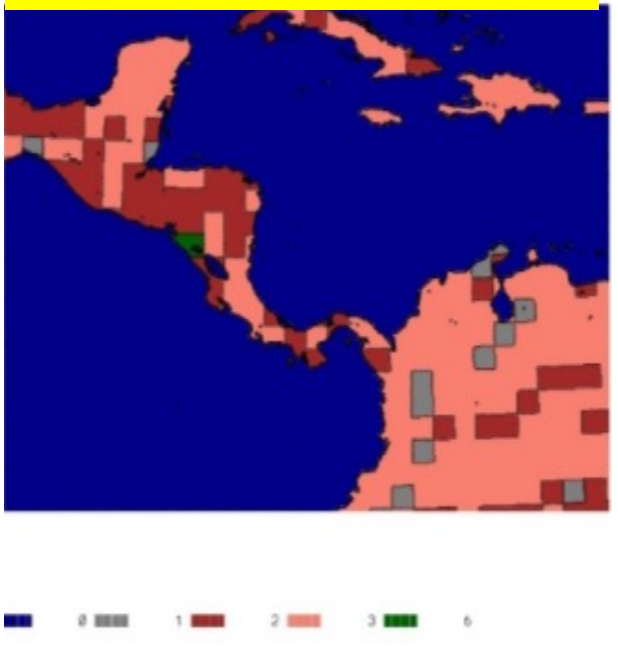
TOPOGRAPHY



VEGETATION



SOIL TEXTURE



(d) VEGETATION TYPES

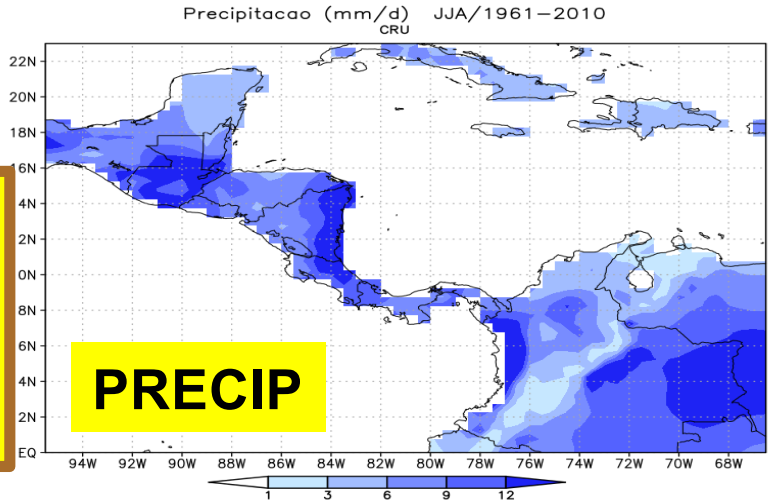
1: BROADLEAF-EVERGREEN TREES (TROPICAL FOREST)
2: BROADLEAF-DECIDUOUS TREES
3: BROADLEAF AND NEEDLELEAF TREES (MIXED FOREST)
4: NEEDLELEAF-EVERGREEN TREES
5: NEEDLELEAF-DECIDUOUS TREES (LARCH)
6: BROADLEAF TREES WITH GROUNDCOVER
7: GROUNDCOVER ONLY (PERENNIAL)
8: BROADLEAF SHRUBS WITH PERENNIAL GROUNDCOVER
9: BROADLEAF SHRUBS WITH BARE SOIL
10: DWARF TREES AND SHRUBS WITH GROUNDCOVER (TUNDRA)
11: BARE SOIL
12: CULTIVATIONS

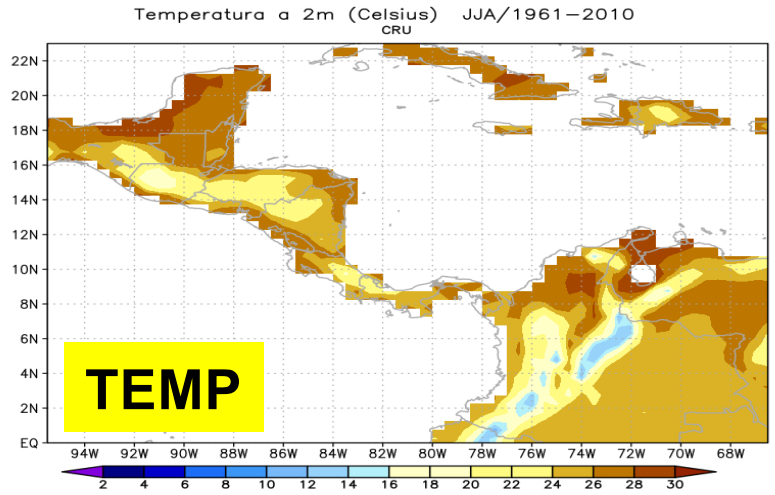
(e) SOIL TYPES: TEXTURE COMPOSITION

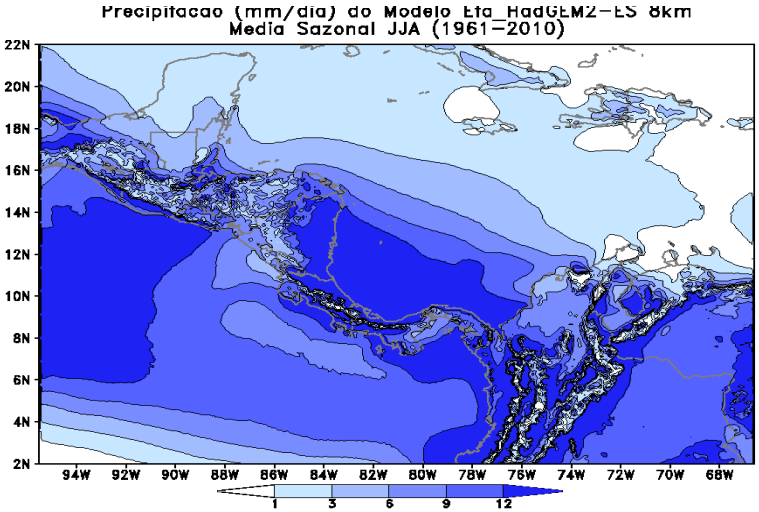
1: COARSE LOAMY SAND
2: MEDIUM SILTY CLAY LOAM
3: FINE LIGHT CLAY
6: MEDIUM-FINE CLAY LOAM

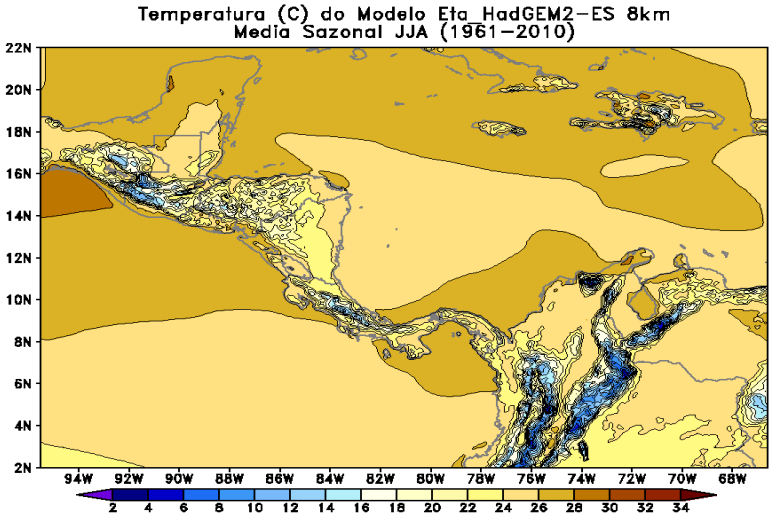
- Imbach P et al. (2018) Future climate change scenarios in Central America at high spatial resolution PlosOne

Verification precipitation and 2-metre temperature



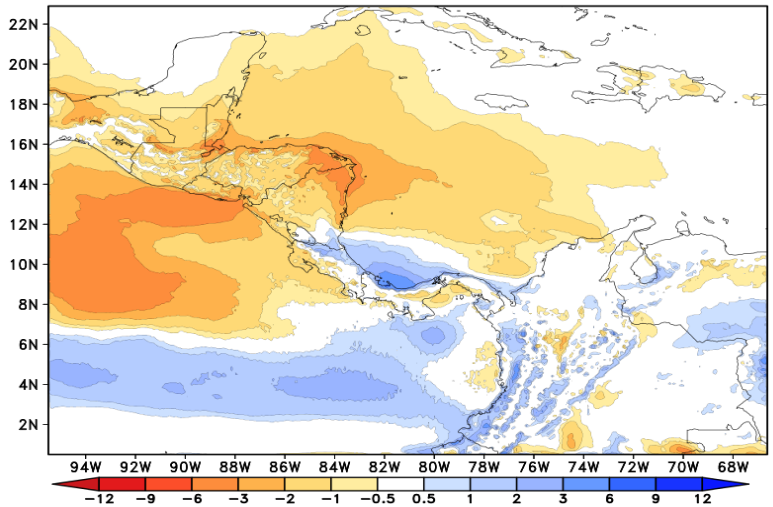


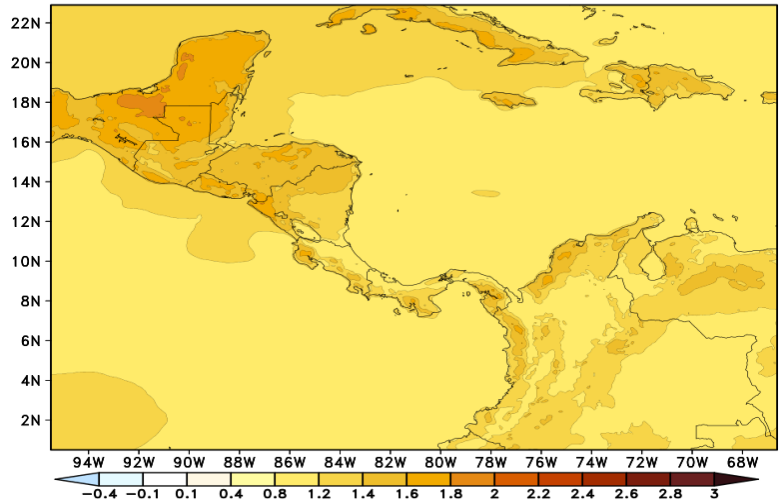




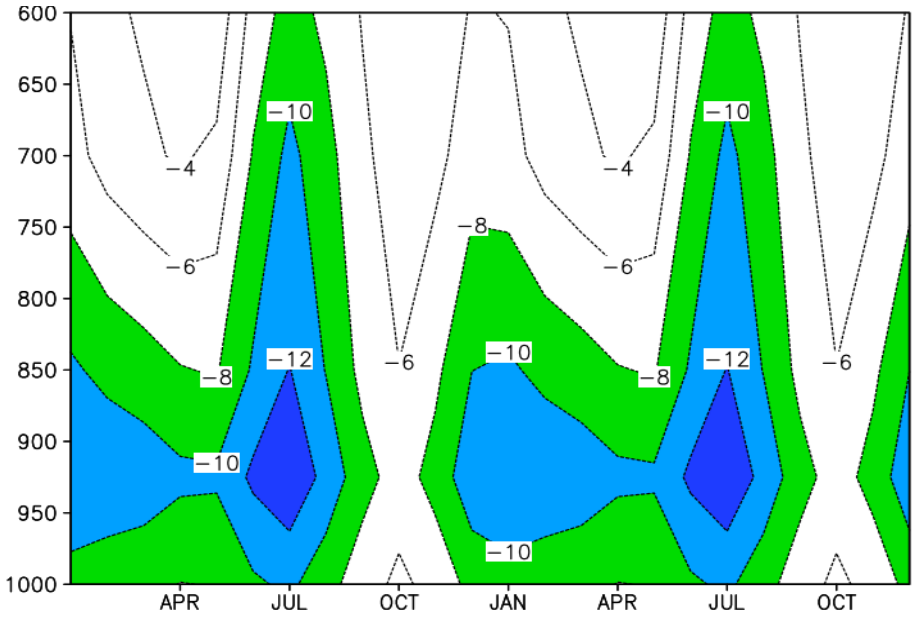
Projections

2011_2050 minus 1071_2010



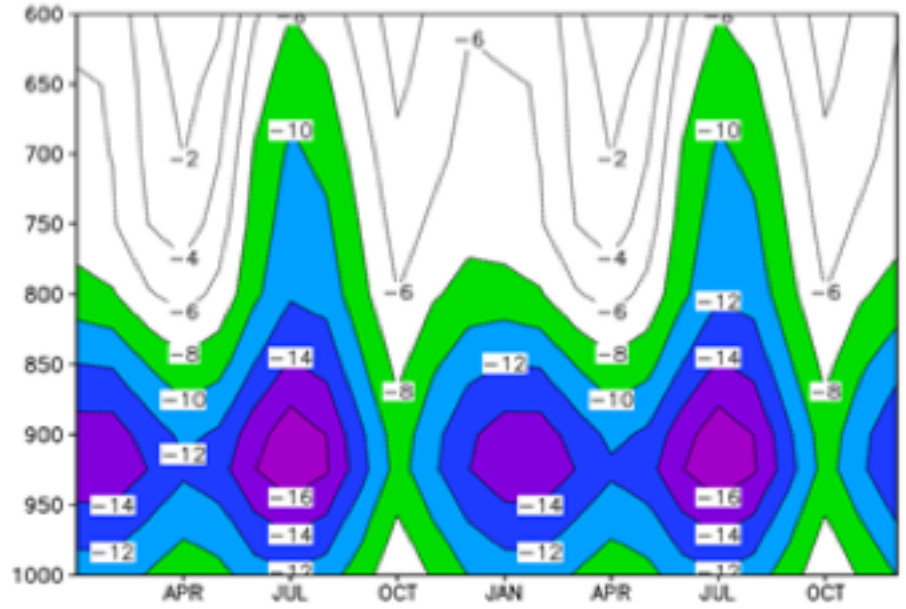


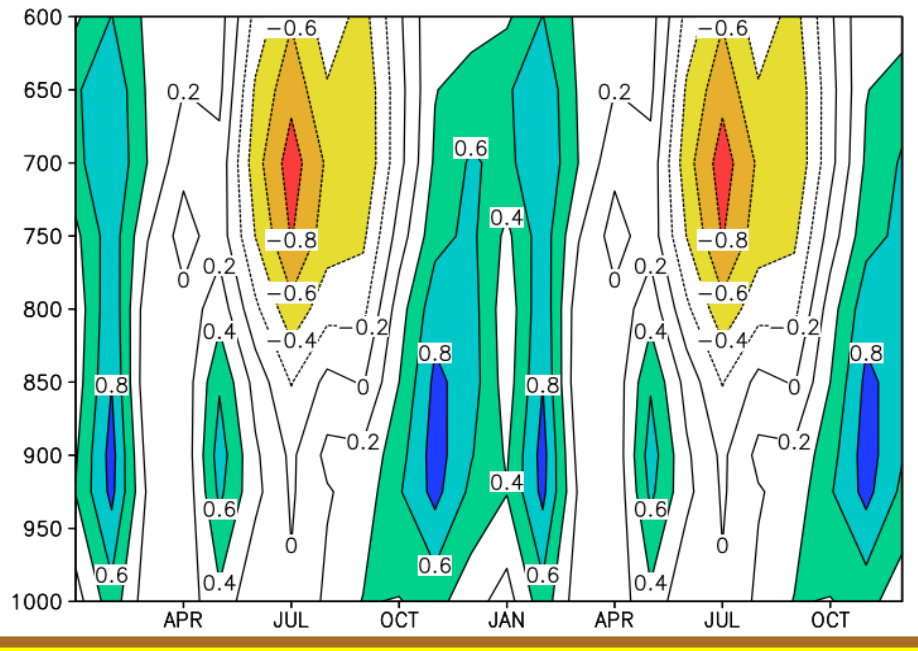
CARIBBEAN LOW LEVEL JET



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.

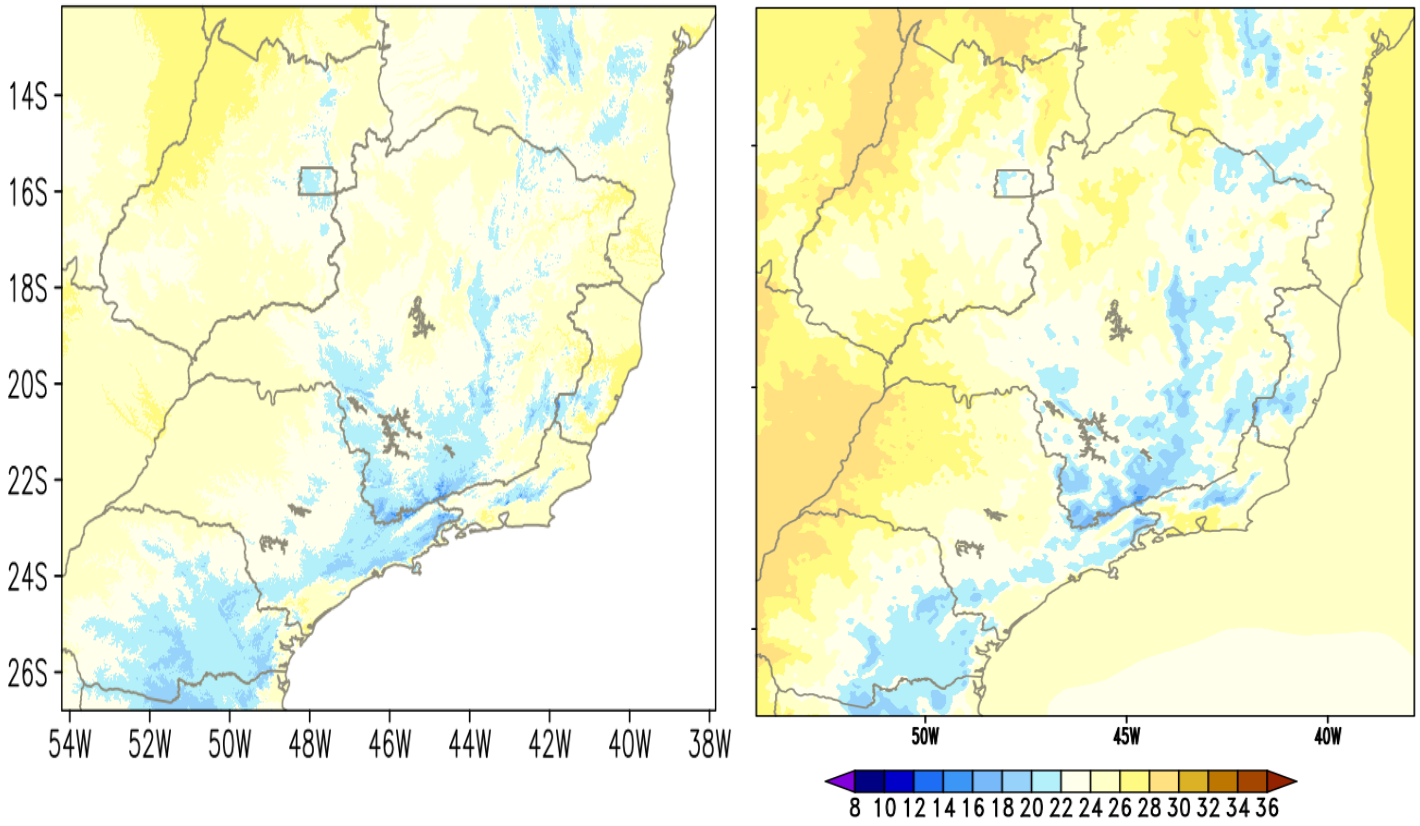




PROJECTIONS OF CLLJ STRENGTHENING

Eta-5km, NON-HYDROSTATIC VERSION

OBS (WorldClim)

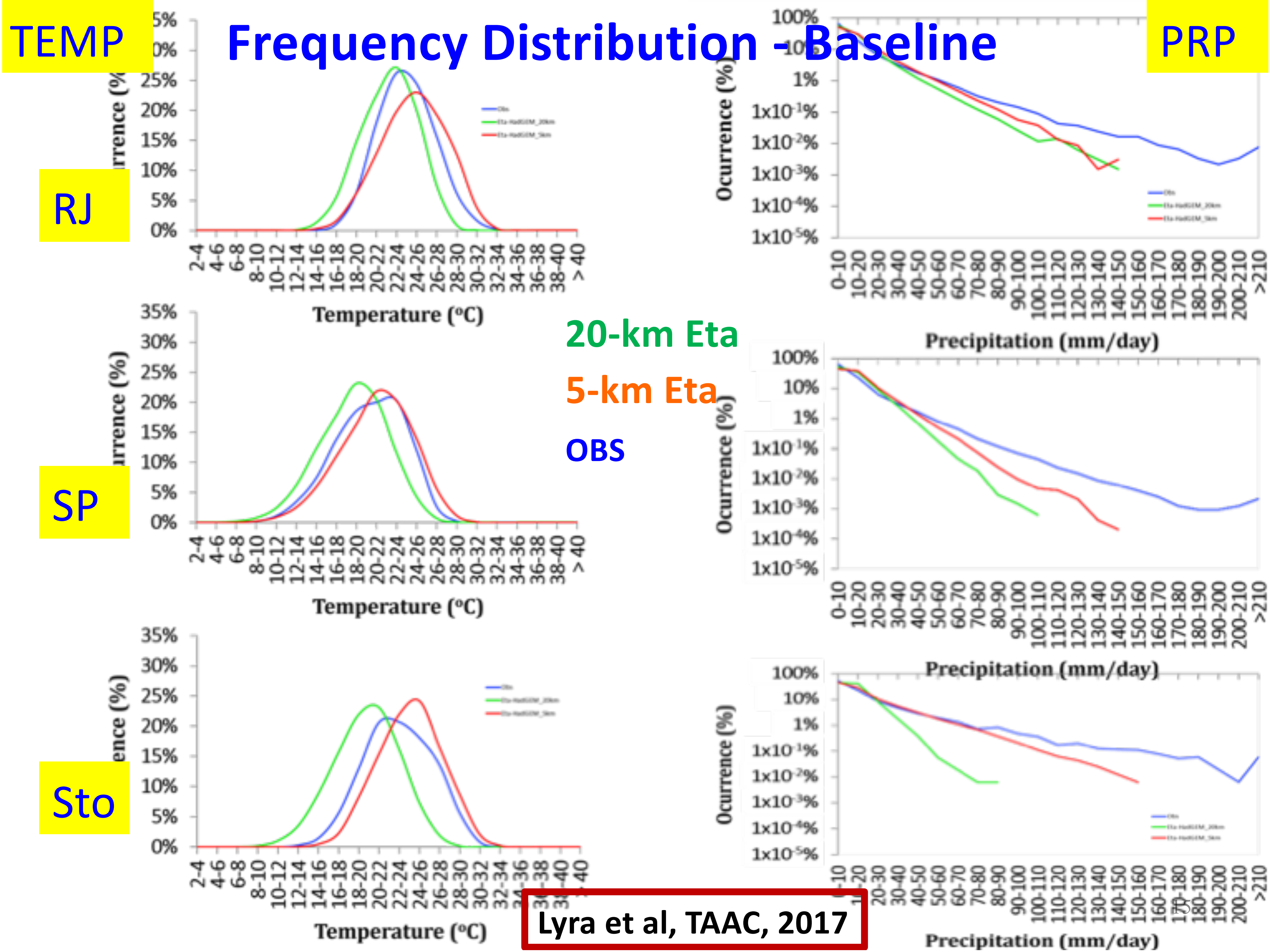


DJF

HadGEM2-ES
1961-2100
RCP4.5 e RCP8.5

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

Frequency Distribution - Baseline



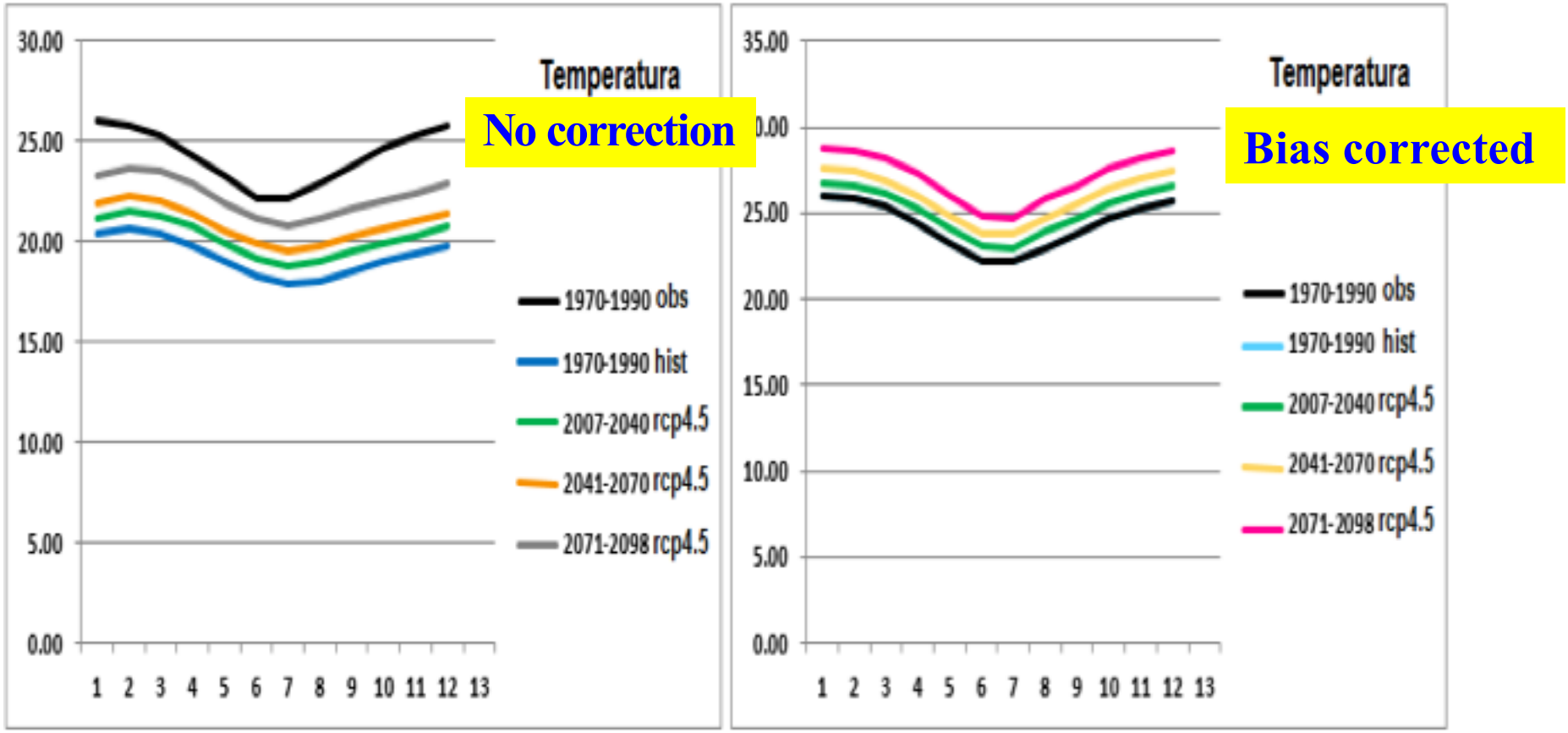
Lyra et al, TAAC, 2017

Dataset constructed with bias correction

- Bárdossy e Pegram (2011) for precipitation

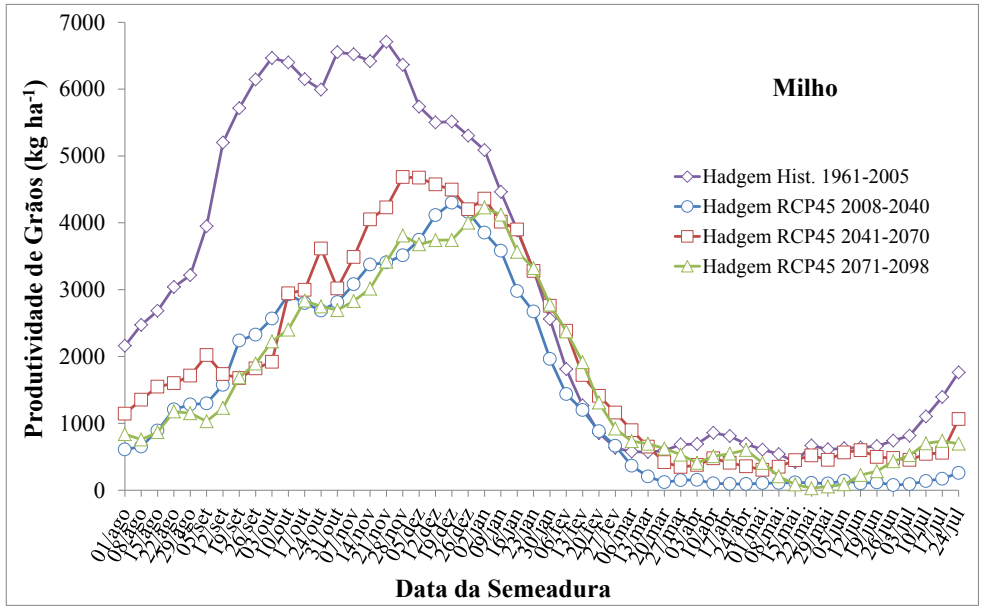
Lenderink et al. (2007) for other variables

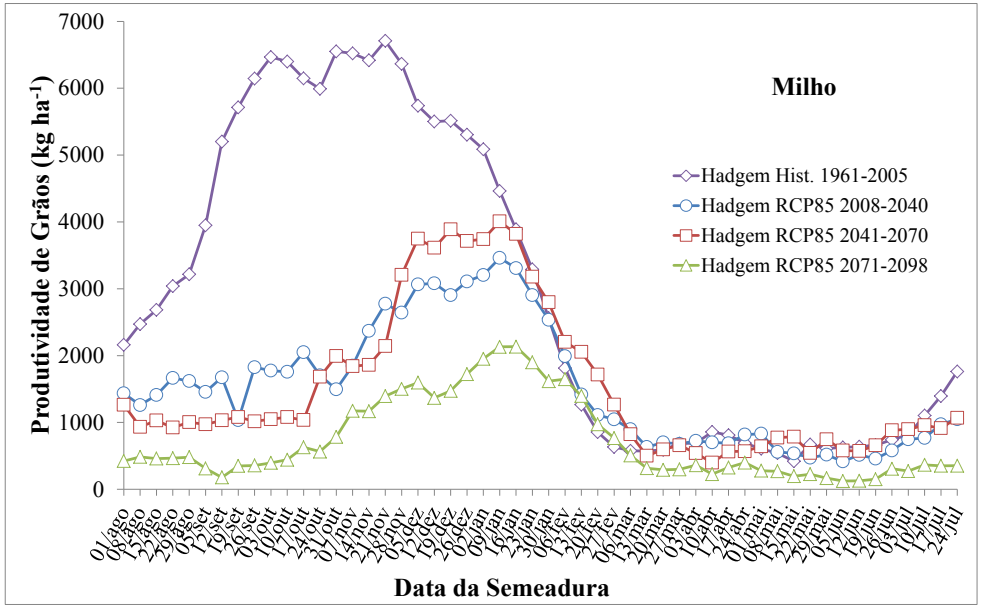
2–meter temperature

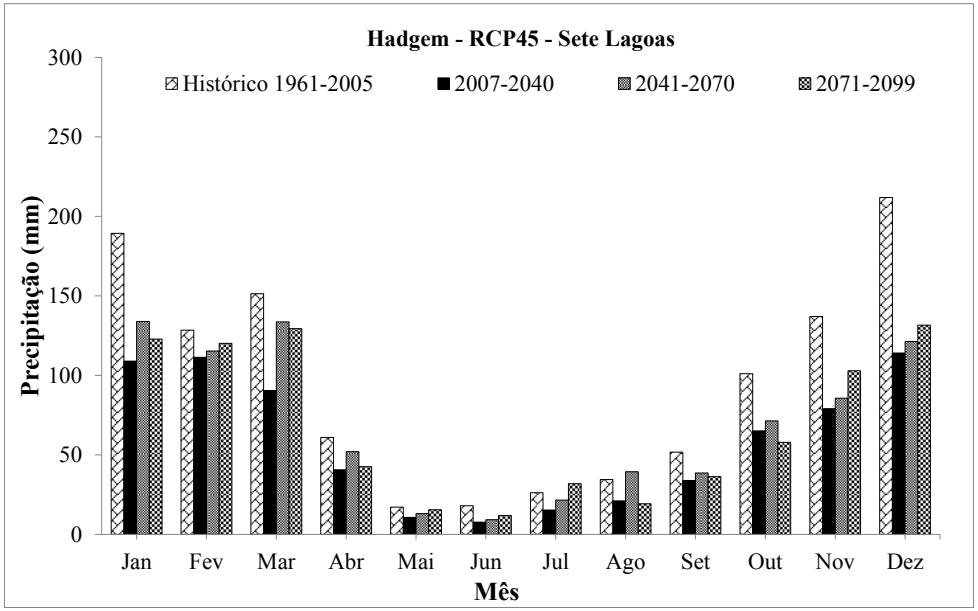


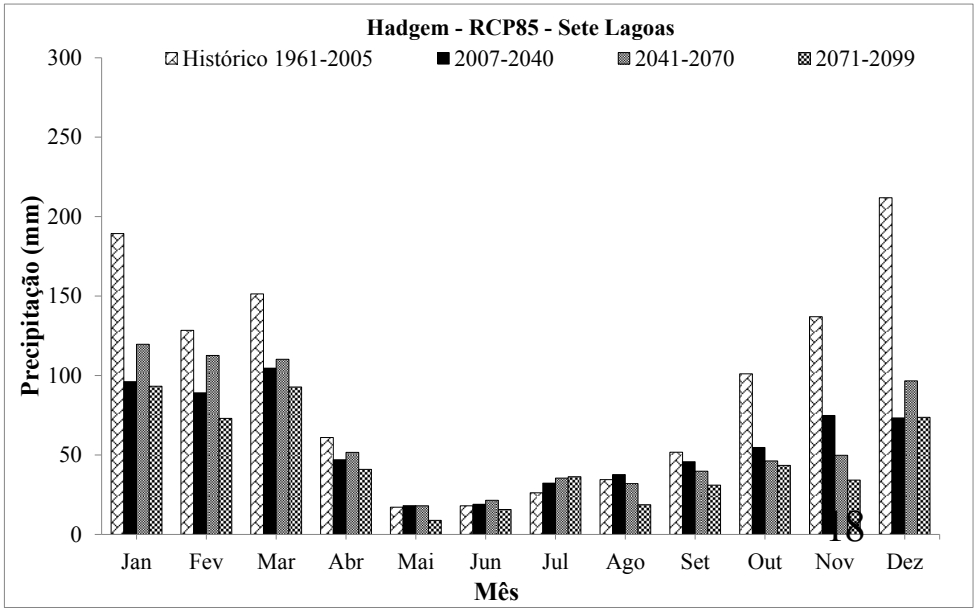
Impact studies in agriculture

CORN YIELD REDUCTION

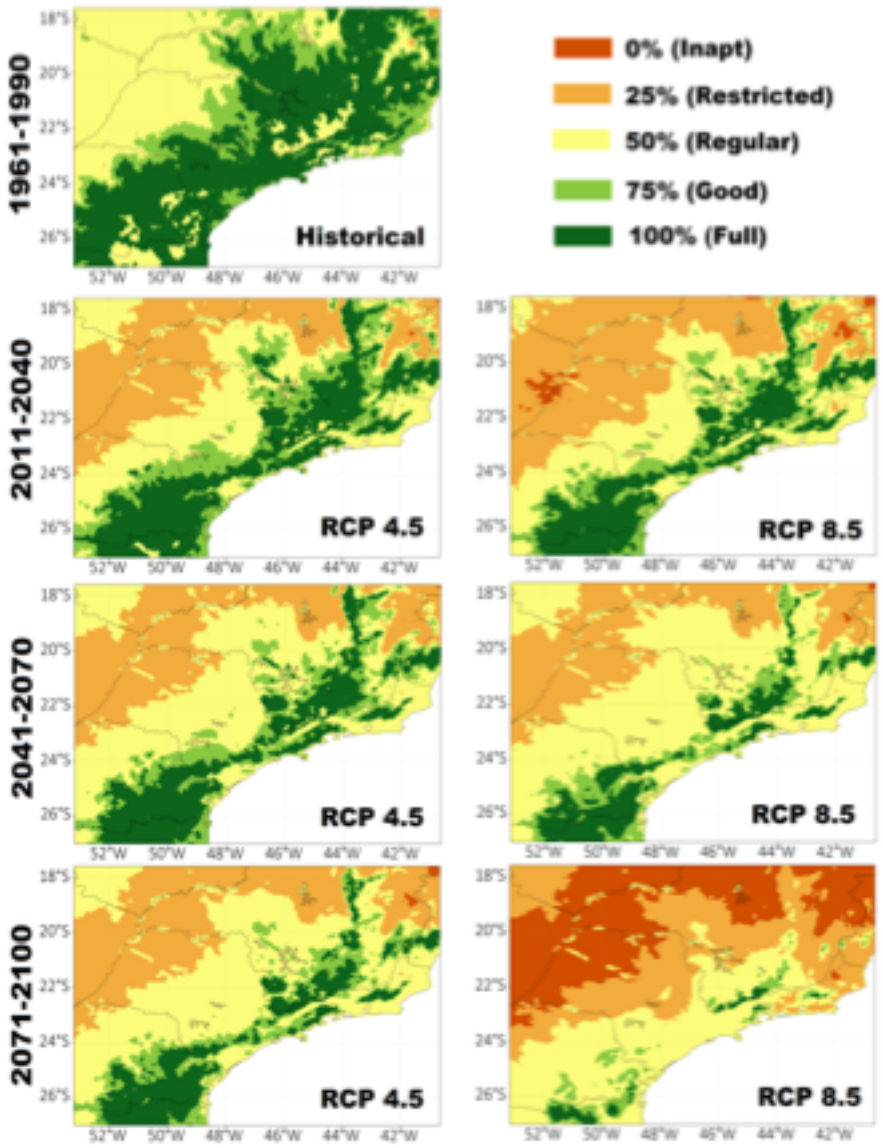








POTENTIAL COFFEE YIELD (kg/ha)



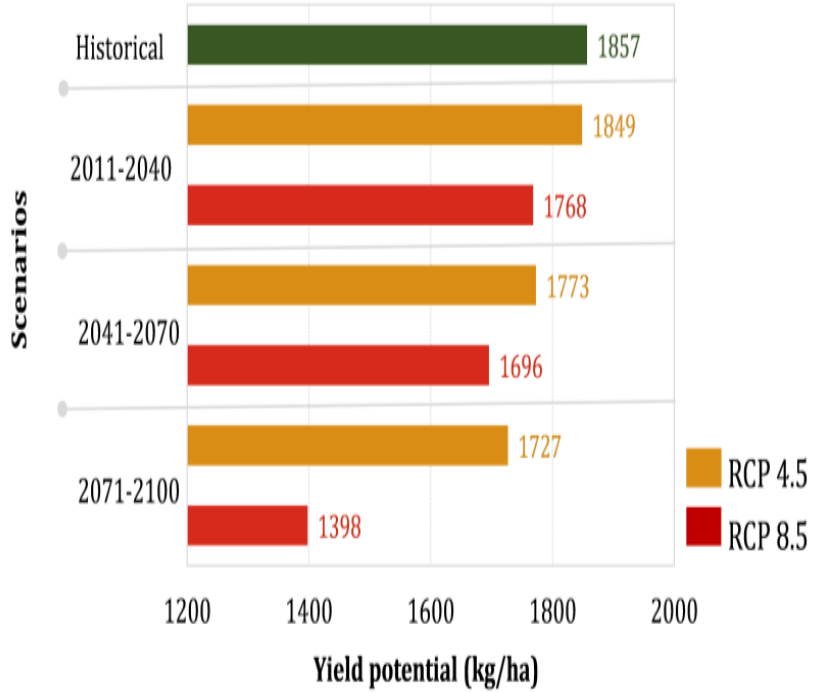


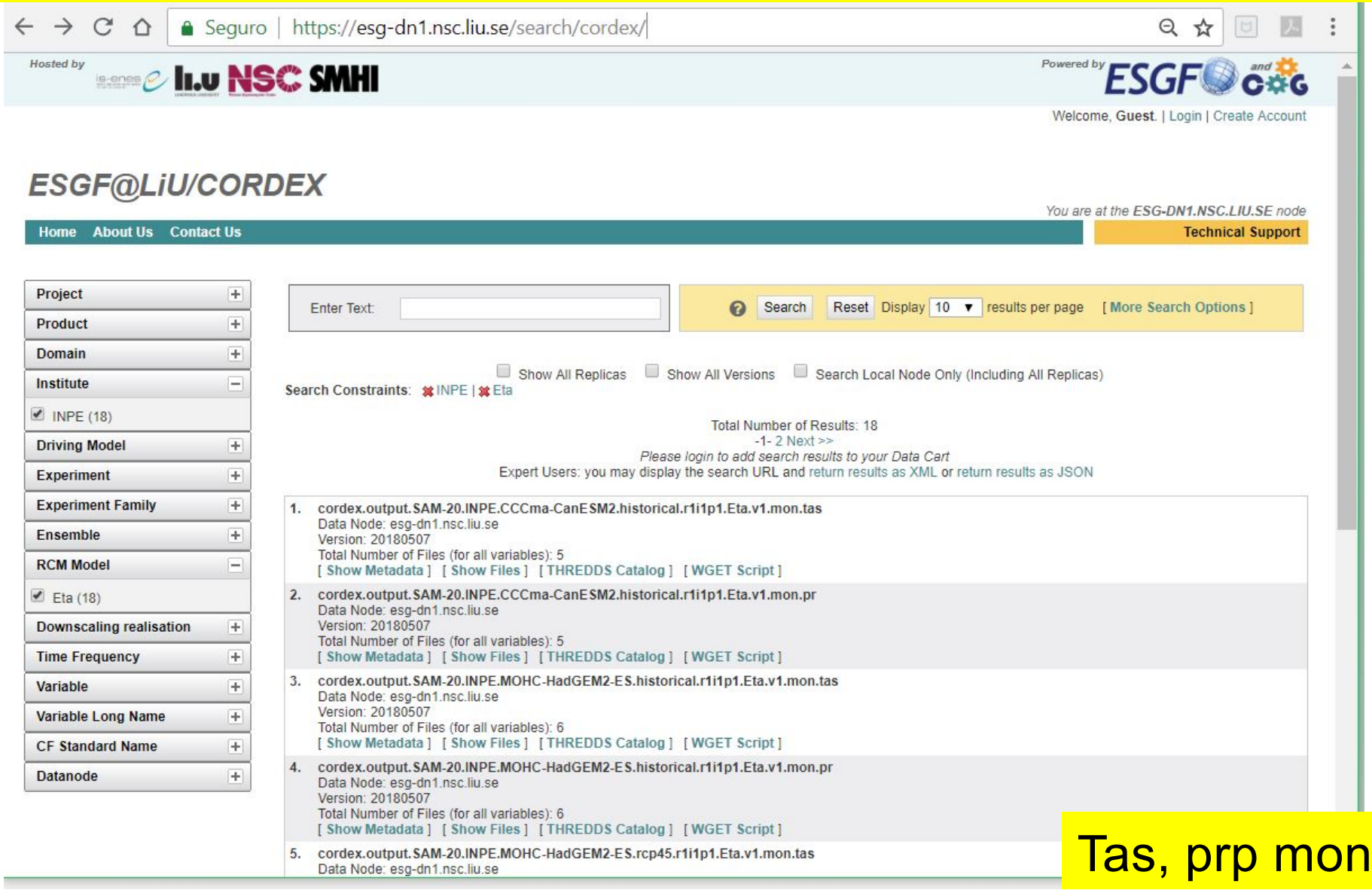
Figura 7. Potential yield of Arabica coffee (kg/ha) for Southern region of Minas Gerais (SMG). Historical scenario (present climate) and future scenarios, RCP 4.5 and RCP 8.5

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

Tavares et al., 2017 REEC.

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

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



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!

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