Regional Climate Simulations and Projections over South America

André de Arruda Lyra[1,2], Dragan Latinović[1], Sin Chan Chou[1], José Antônio Marengo[2]

1. Center for Weather Forecast and Climate Studies
2. Earth System Science Center, National Institute for Space Research

1.INTRODUCTION

Developing climate change scenarios at regional scale is very important for the understanding of climate impacts under global warming conditions, directed to the provision of information to be used for vulnerability assessments, and for the design of measures and strategies for climate change adaptation. The regional Eta Model is used by INPE to produce long-term integrations (Chou et al., 2012; Marengo et al., 2012) for A1B emissions scenario. In this study, the Eta Model was configured over South America and Central America. and applied to downscale HadGEM2-ES for RCP 4.5.

2.OBJECTIVES

To assess the climate simulations and projections over South America using the regional climate Eta Model driven by fully coupled Earth System Model HadGEM2-ES of the Met Office Hadley Centre. The evaluation will be focused on DJF and JJA seasons, which are the austral summer and rainy season and the austral winter and dry season, respectively.

3. METHODOLOGY

GCM: HadGEM2-ES

The HadGEM2-ES is a coupled Earth System Model being used by the Met Office Hadley Centre. It was designed to run the major scenarios for IPCC AR5 and comprises Earth system components such as terrestrial and ocean carbon cycle and tropospheric chemistry.
 - Atmospheric GCM - N96 and L38 horizontal and vertical resolution
 - Ocean GCM with a 1-degree horizontal resolution (increasing to 1/3 degree at the equator) and 40 vertical levels.
 - Earth system components:
   Terrestrial and ocean carbon cycle and tropospheric chemistry.
   Terrestrial vegetation and carbon is represented by the dynamic global vegetation model, TRIFFID.
   Ocean biology and carbonate chemistry are represented by diat-HadOCC
   Tropospheric chemistry is represented by the UKCA model.

RCM: Eta Regional Model

Resolution:	20km/38 layers.
Grid-point model	Arakawa E grid and Lorenz grid

Eta vertical coordinate
Mesinger, 1984; added refinements in Mesinger et al (2012)
Time integration: 2 level, split-explicit
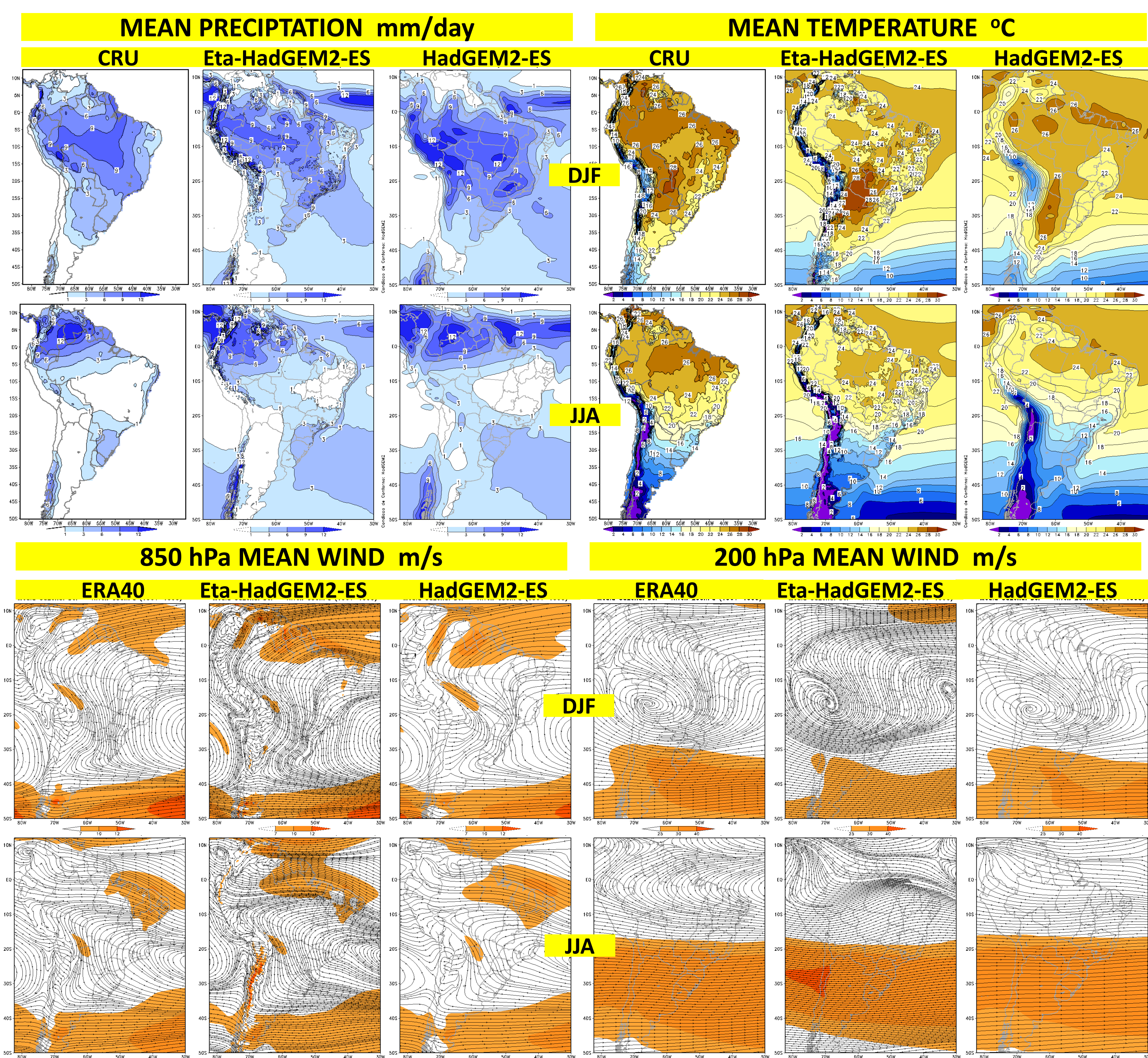**Adjustmet:** forward-backward
Horizontal Advection: first forward and then centered
Vertical Advection: Piecewise linear scheme
Prognostic variables: T, q, u, v, p_s, TKE, cloud water/ice, hydrometeors

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: HadGEM2-ES, updated 6h/6h
Initial soil moisture: monthly climatology
Initial albedo: seasonal climatology
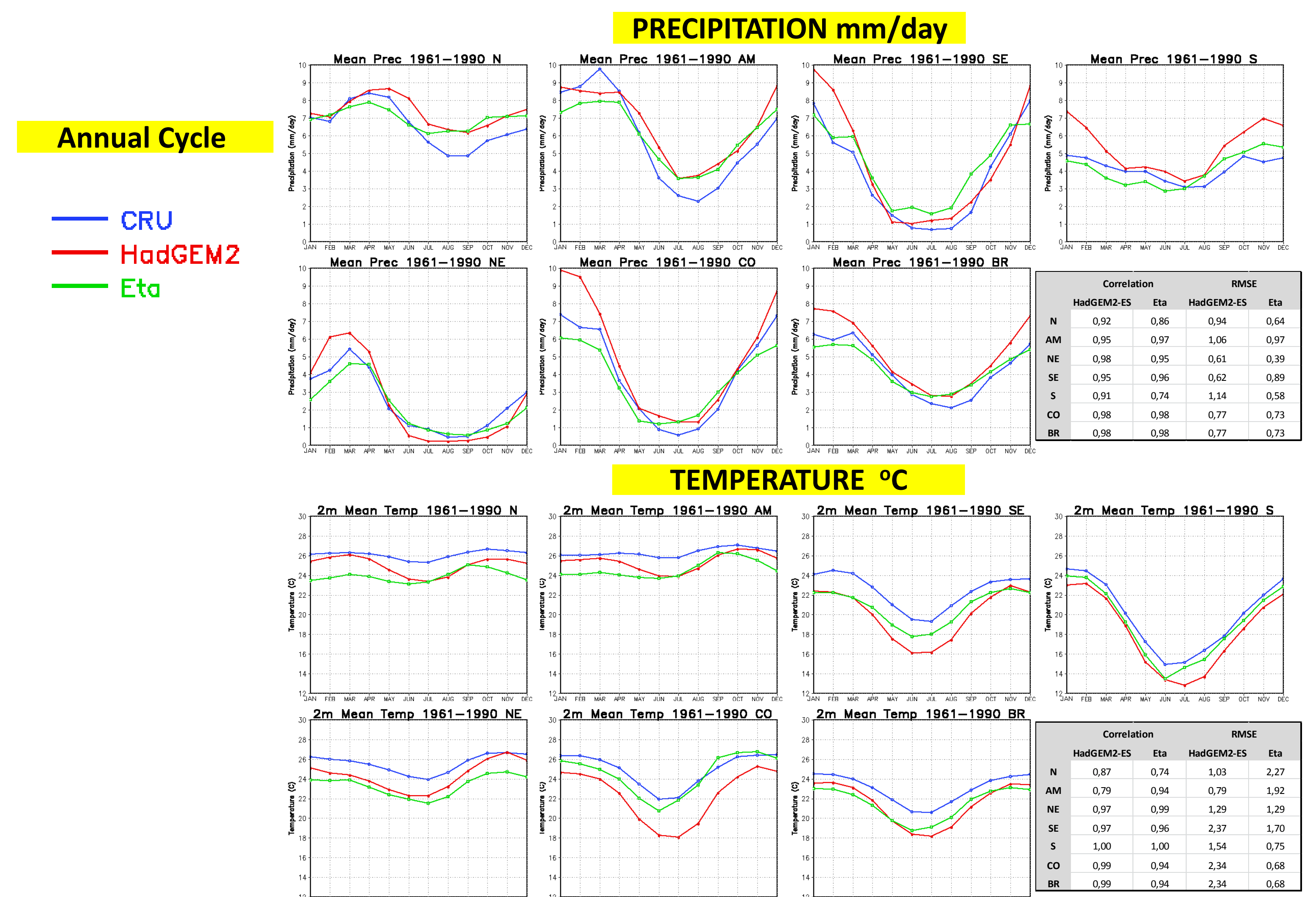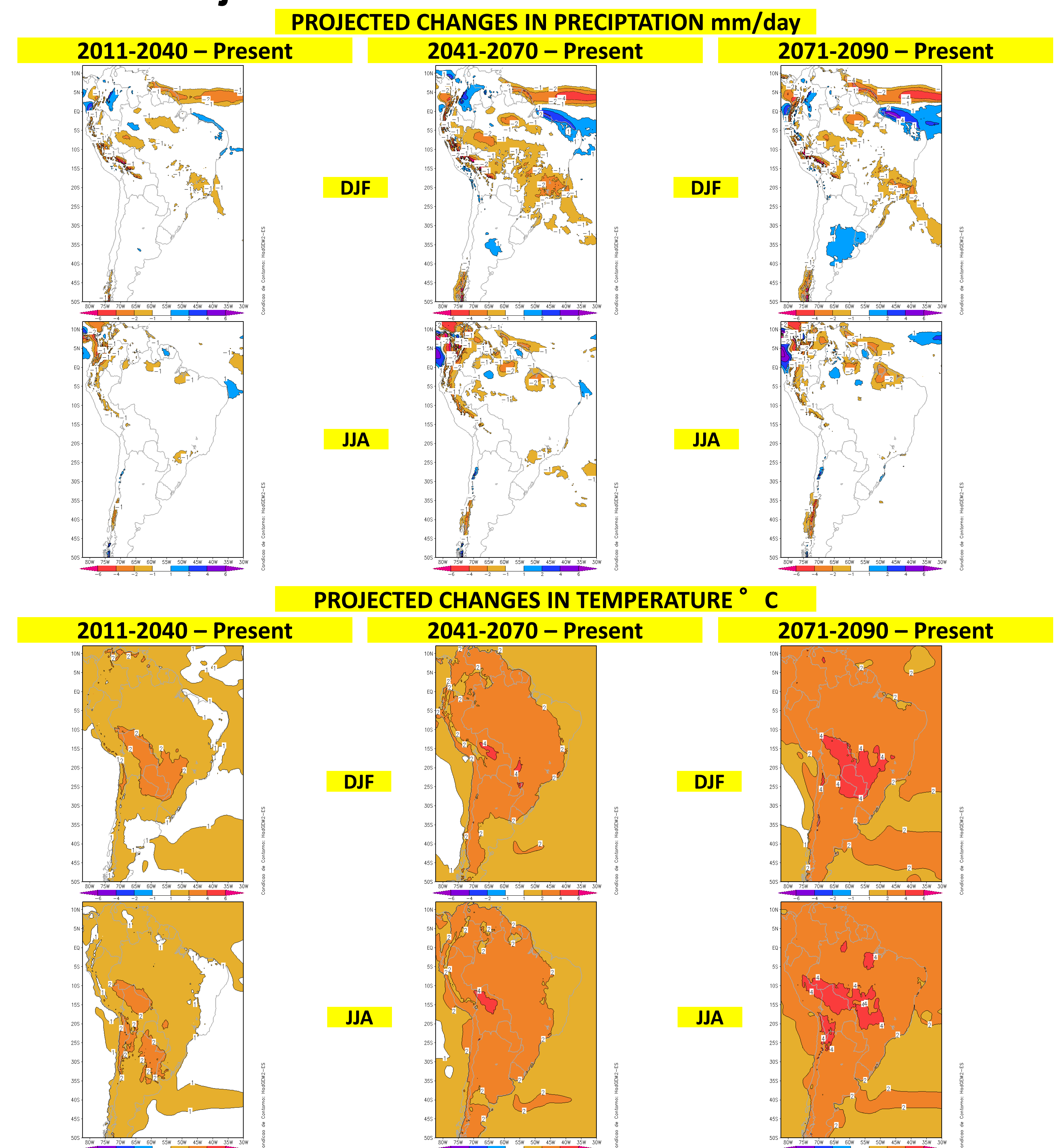**CO2** RCP4.5
SST from HadGEM2-ES simulations

4. RESULTS (Baseline evaluation)

MEAN PRECIPITATION mm/day

CRU | Eta-HadGEM2-ES | HadGEM2-ES

MEAN TEMPERATURE ºC

CRU | Eta-HadGEM2-ES | HadGEM2-ES

DJF

JJA

850 hPa MEAN WIND m/s

ERA40 | Eta-HadGEM2-ES | HadGEM2-ES

200 hPa MEAN WIND m/s

ERA40 | Eta-HadGEM2-ES | HadGEM2-ES

DJF

JJA

PRECIPITATION mm/day

Annual Cycle

CRU
HadGEM2
Eta

Mean Prec 1961-1990 N | Mean Prec 1961-1990 AM | Mean Prec 1961-1990 SE | Mean Prec 1961-1990 S
Mean Prec 1961-1990 NE | Mean Prec 1961-1990 CO | Mean Prec 1961-1990 BR

	Correlation		RMSE	
	HadGEM2-ES	Eta	HadGEM2-ES	Eta
N	0,92	0,86	0,94	0,64
AM	0,95	0,97	1,06	0,97
NE	0,98	0,95	0,62	0,39
SE	0,95	0,96	0,62	0,89
S	0,95	0,74	1,14	0,58
CO	0,98	0,98	0,77	0,73
BR	0,98	0,98	0,77	0,73

TEMPERATURE ºC

2m Mean Temp 1961-1990 N | 2m Mean Temp 1961-1990 AM | 2m Mean Temp 1961-1990 SE | 2m Mean Temp 1961-1990 S
2m Mean Temp 1961-1990 NE | 2m Mean Temp 1961-1990 CO | 2m Mean Temp 1961-1990 BR

	Correlation		RMSE	
	HadGEM2-ES	Eta	HadGEM2-ES	Eta
N	0,87	0,74	1,03	2,27
AM	0,79	0,94	0,79	1,92
NE	0,97	0,99	1,29	1,29
SE	0,97	0,96	2,37	1,70
S	1,00	1,00	1,54	0,75
CO	0,99	0,94	2,34	0,68
BR	0,99	0,94	2,34	0,68

Future Projections

PROJECTED CHANGES IN PRECIPITATION mm/day

2011-2040 – Present | 2041-2070 – Present | 2071-2090 – Present

DJF

JJA

PROJECTED CHANGES IN TEMPERATURE ° C

2011-2040 – Present | 2041-2070 – Present | 2071-2090 – Present

DJF

JJA

5. CONCLUSIONS

The Eta model reproduced satisfactorily the South America present climate when compared with observational data and reanalysis. The downscaling with Eta model improved the simulation of the seasonal cycle of precipitation and temperature over Brazil and some regions when compared with HadGEM2-ES. The projections suggested increases in DJF and JJA temperature of up to 4 ºC in continental South America, with more intense changes occurring in the second half of the twenty-first century. The precipitation projections showed the major changes in summer.

REFERENCES

Chou, S. C. *et al*. (2012) Downscaling of South America present climate driven by 4-member HadCM3 runs. *Climate Dynamics*, 38, 635-653. http://dx.doi.org/10.1007/s00382-011-1002-8

Marengo, J. A. *et al*. (2012) Development of regional future climate change scenarios in South America using the Eta CPTEC/HadCM3 climate change projections: Climatology and regional analyses for the Amazon, São Francisco and the Parana River Basins. *Climate Dynamics*. 38, 1829-1848. http://dx.doi.org/10.1007/s00382-011-1155-5