Integrated Theme 13
Regional Climate Change Scenarios for Impacts-Vulnerability-Adaptation (IVA) Studies and Assessments

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INCT
PARA MUDANÇAS CLIMÁTICAS

On Dynamic Downscaling of future climates

The reduced resolution grid of global models implies a need for downscaling methods that may be used in climate change scenarios that are built from global models with regional models nested on them, so that they obtain more detailed projections for states, valleys or regions, with higher spatial resolution than that provided by a global climate model.

Therefore, downscaling is of great use for climate change impacts studies on management and operation of water resources, natural ecosystems and agricultural activities as well as on health care and on the spread of diseases.

It is important to emphasize that future climate projections will show uncertainties that are inherent to all models, which, on one hand, recommend caution with respect to interpretations of data and information, and on the other hand, motivate the search for technical and scientific improvement.

A lot of progress since the first regional climate change scenarios appeared in 2007 (INCT MC started in 2009)

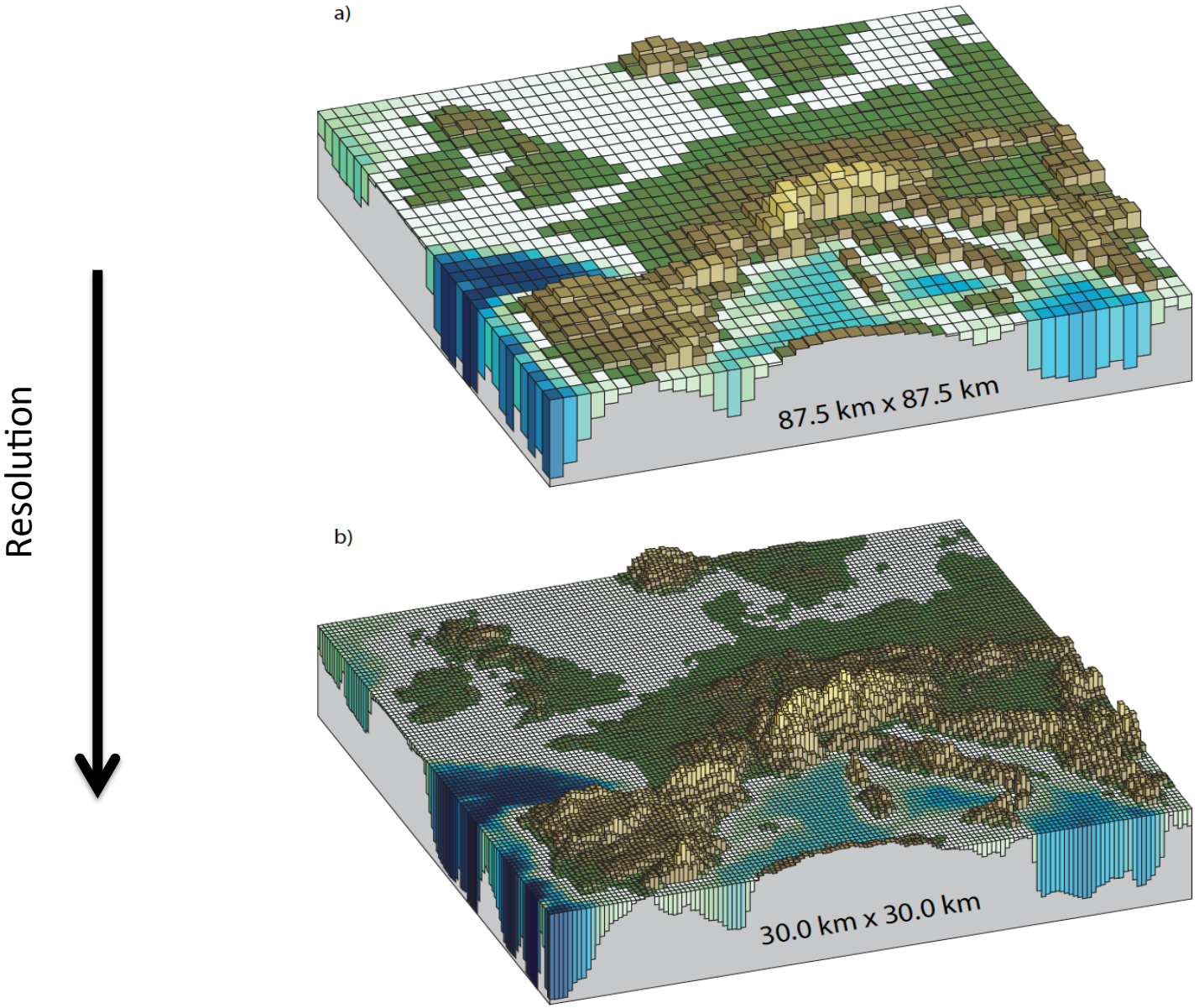
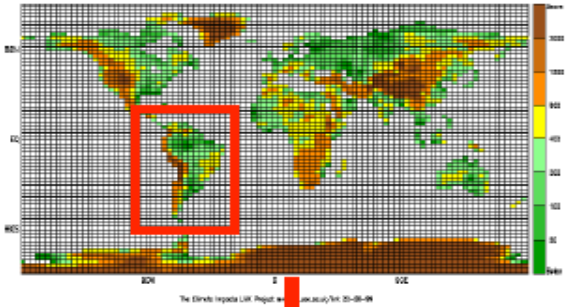


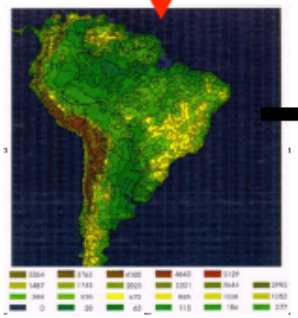
Figure 1.14 | Horizontal resolutions considered in today's higher resolution models and in the very high resolution models now being tested: (a) Illustration of the European topography at a resolution of 87.5 × 87.5 km; (b) same as (a) but for a resolution of 30.0 × 30.0 km.

Downscaling strategy developed in the INCT-MC for IVA studies (INPE, CEMADEN)

Modelos globais do IPCC AR4 e AR5 (HadCM3, HadGE2 ES, MIROC5, BESM)



Downscaling (20-50 km)
Cenários : A1B, RCP 4.5 e 8.5



Modelo regional Eta

Detecção e atribuição

Desenvolvimento de estudos e aplicações setoriais e avaliação de incertezas

Impactos

Vulnerabilidade

Adaptação e mitigação

Aplicações setoriais

Dimensões humanas

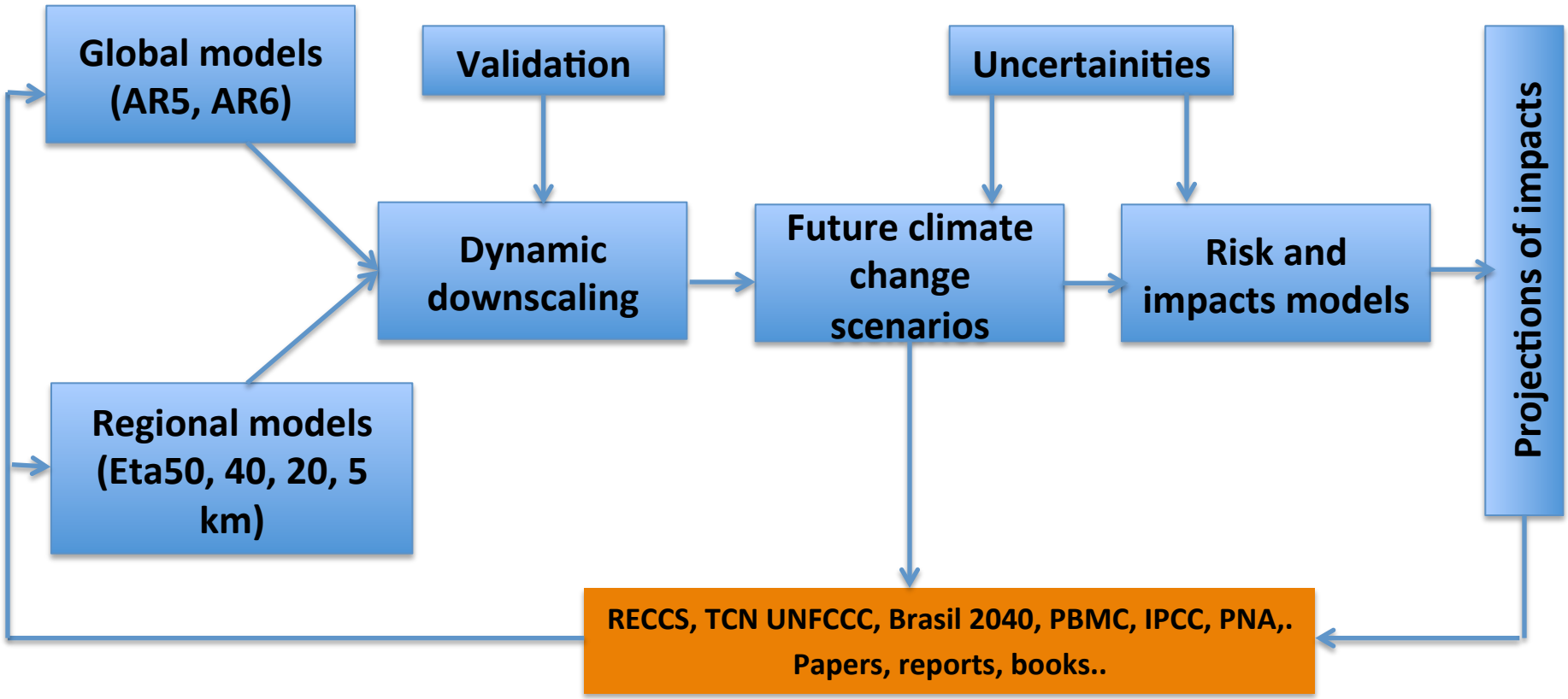
Usuarios: comunidade cientifica, governo, sociedade civil, academia..

Modelos de Impactos

Produtos: (arquivos digital usáveis em GIS)
-Mapas de cenários de mudança de clima, A1B, RCPs 4.5 e 8.5 e estimados de incerteza
-Relatórios, publicações, apresentações...

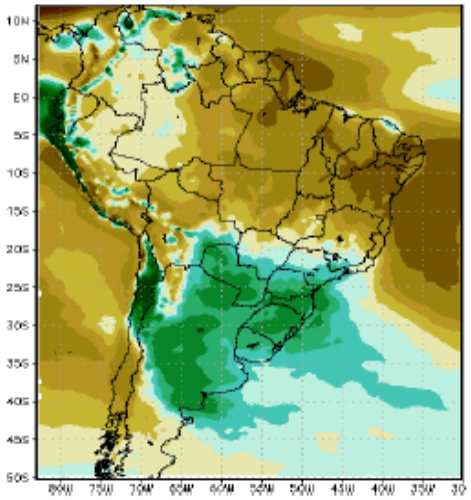
Formação de recursos humanos

Projections of impacts due to climate change

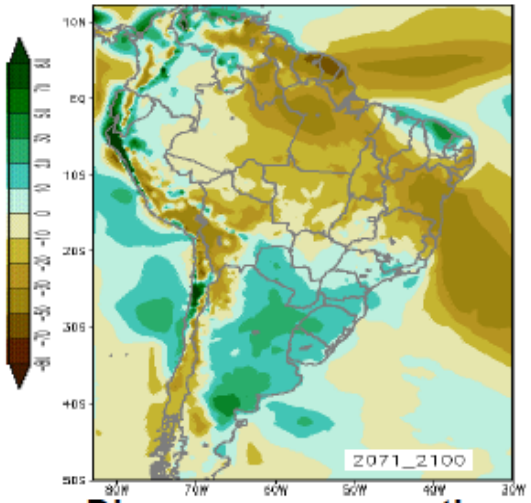


Changes in rainfall, temperatures and rainfall extremes (HadCM3, A1B, Eta) scenarios developed in 2012

Precipitação anual

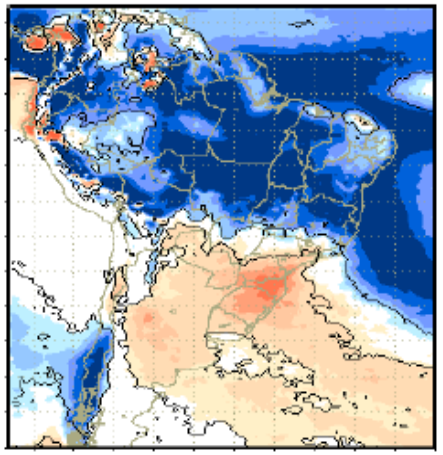


Precipitação-Evaporação

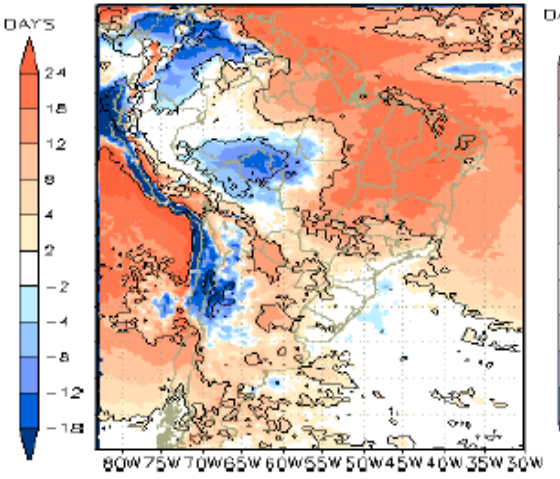


Mudanças de clima projetados pelo Eta-HadCM3, cenário A1B para 2071-2100

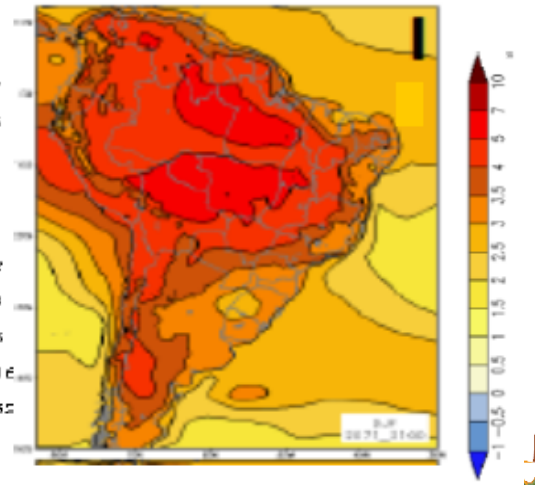
Precipitação intensa



Dias secos consecutivos

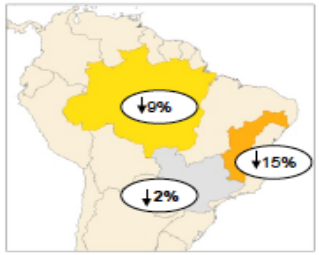
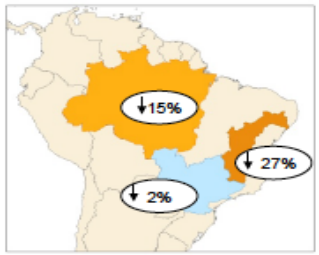
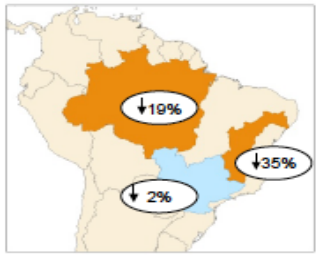


Temperatura media



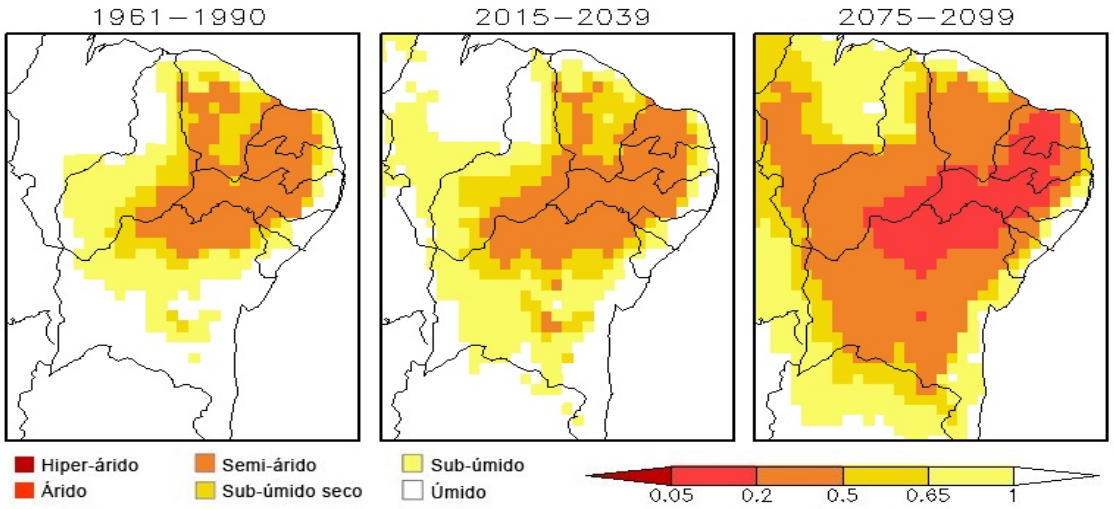
Chou et al 2012, Marengo et al 2012

Projected changes rainfall and temperature in the three main basins in Brazil (HadCM3, A1B, Eta)

Decade (30-year mean centred on)	% change in annual rainfall relative to 1961-90 mean	Change in annual mean temperature in the basins and Brazil	Change in annual mean temperature: Global	Atmospheric CO2 concentrations
2020s		AMZ:+1.9°C SF: +1.5°C PAR: +1.8°C +1.7 °C	+1.3 °C	418 ppm
2050s		AMZ:+3.5°C SF: +2.8°C PAR: +3.2°C +3.2 °C	+2.5 °C	523 ppm
2080s		AMZ:+4.9°C SF: +3.8°C PAR: +4.5°C +4.5 °C	+3.3 °C	638 ppm

Marengo et al 2012

Índice de Aridez derivado do modelo Eta 40 km, A1B eun with HadCM3



O risco de aridização pode afetar irreversivelmente a caatinga e outros ecossistemas naturais na região semiárida.

Com a degradação do solo existe o alto risco de aumentar a migração para as cidades costeiras, agravando ainda mais os problemas urbanos, gerando ondas de “refugiados ambientais”, aumentando os problemas sociais já existentes nos grandes centros urbanos do Nordeste e do Brasil.

Marengo and Bernasconi 2015

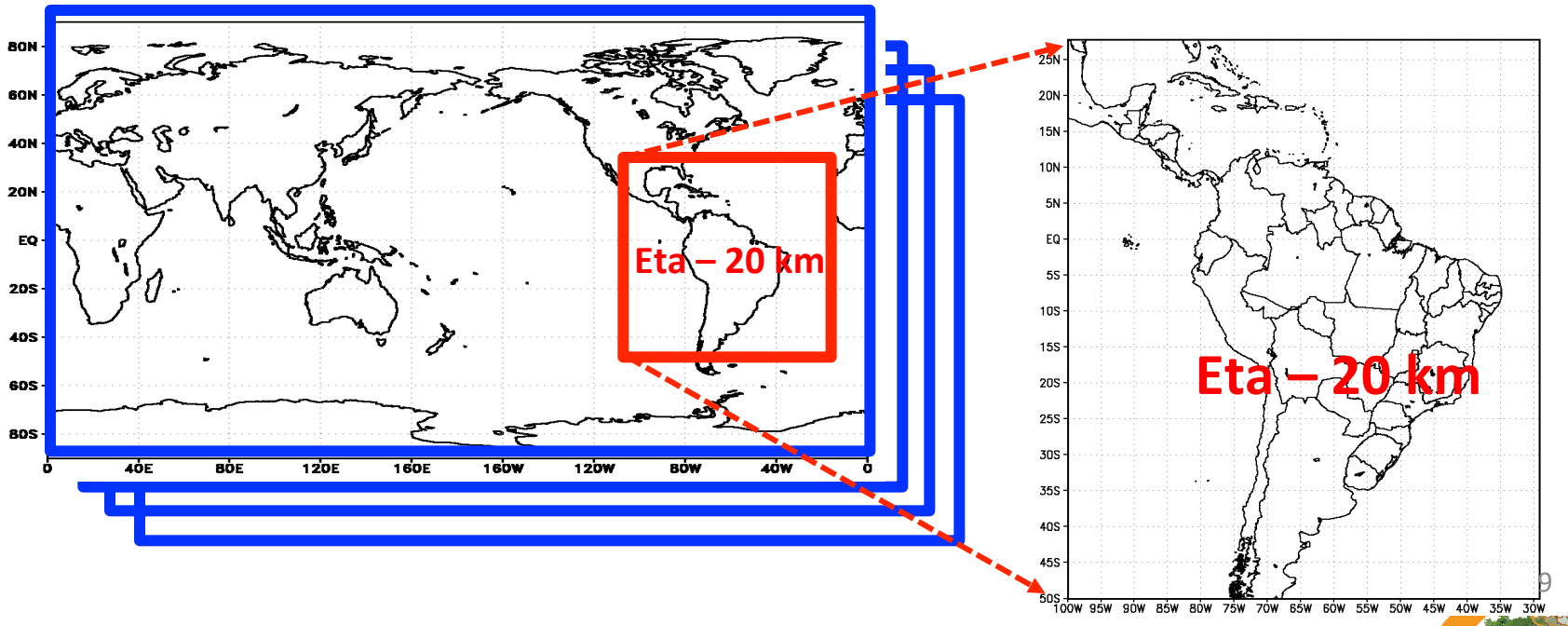
New downscaling process for climate change scenarios (2015)

TNC to UNFCCC, PNA, BRASIL 2040

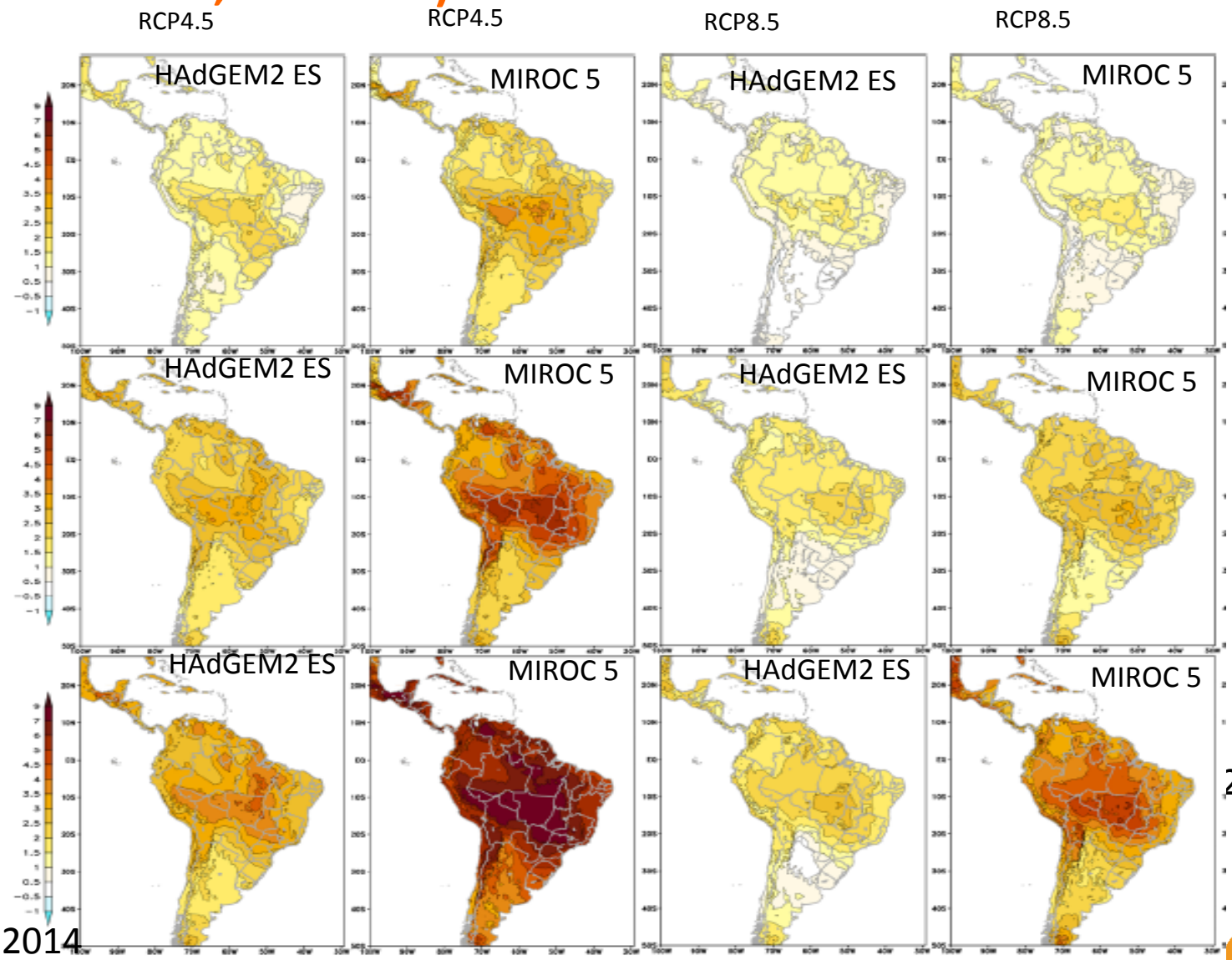
- **3 Global models**
- **2 Emission scenarios**
- **Eta regional model**

1. HadGEM2-ES
2. BESM (only present)
3. MIROC5 *

1. RCP 4.5
2. RCP 8.5

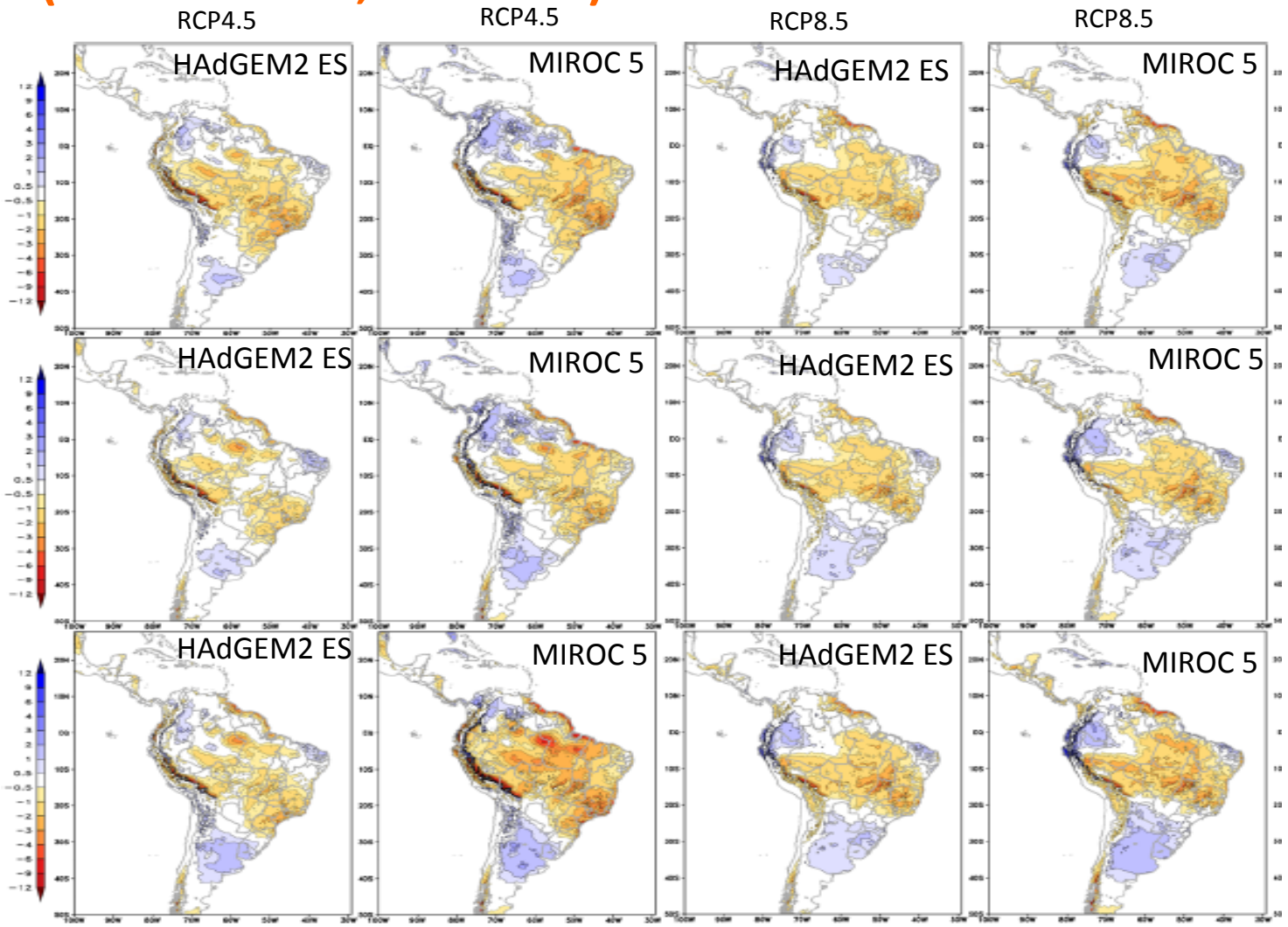


DJF temperature (C) changes over South America under RCP 4.5 and 8.5 (HadGEM2 ES, MIROC 5)



Chou et al 2014

DJF mean rainfall (mm/day) changes over South America under RCP 4.5 and 8.5 (HadGEM2 ES, MIROC 5)



Chou et al 2014

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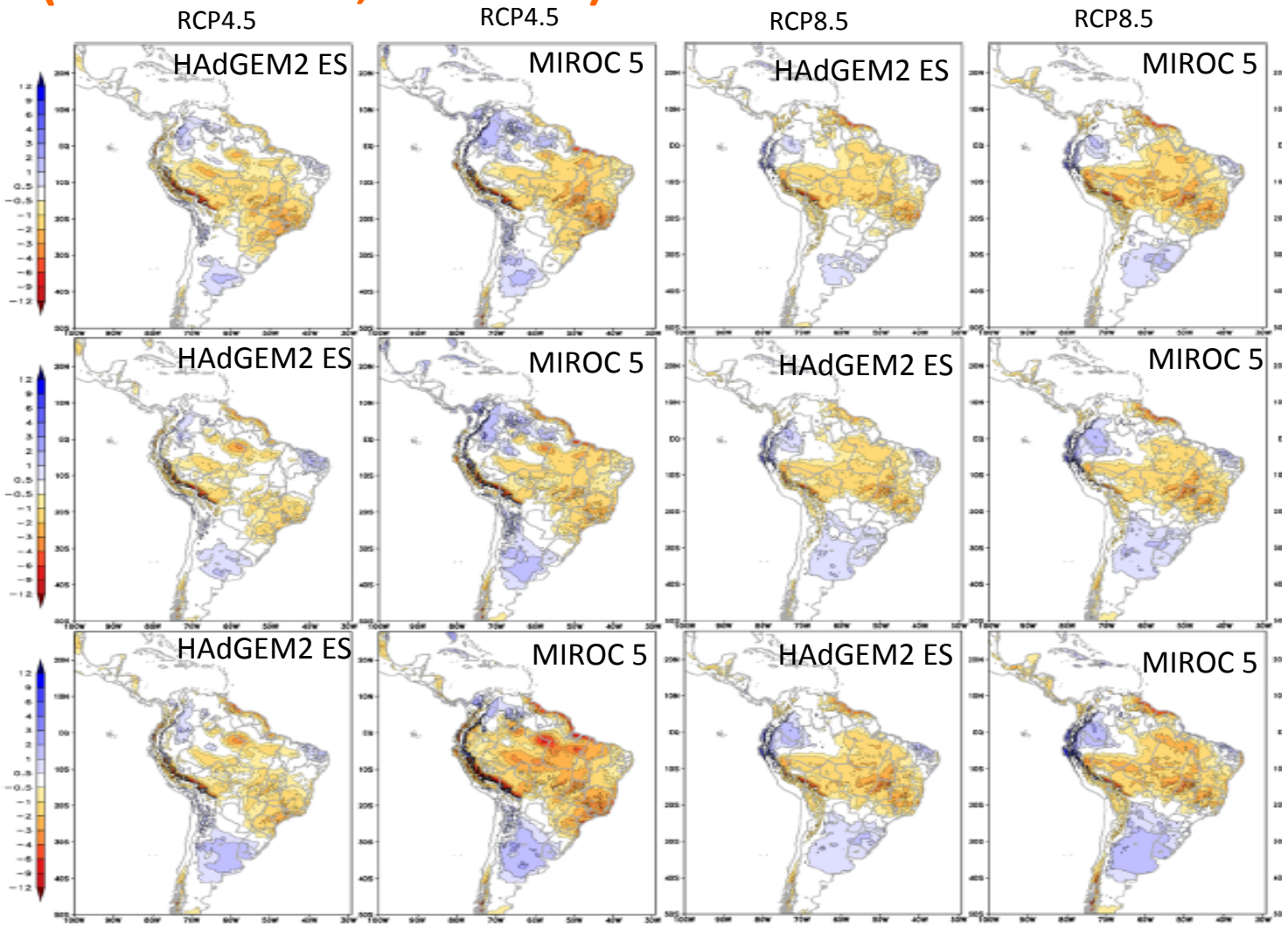
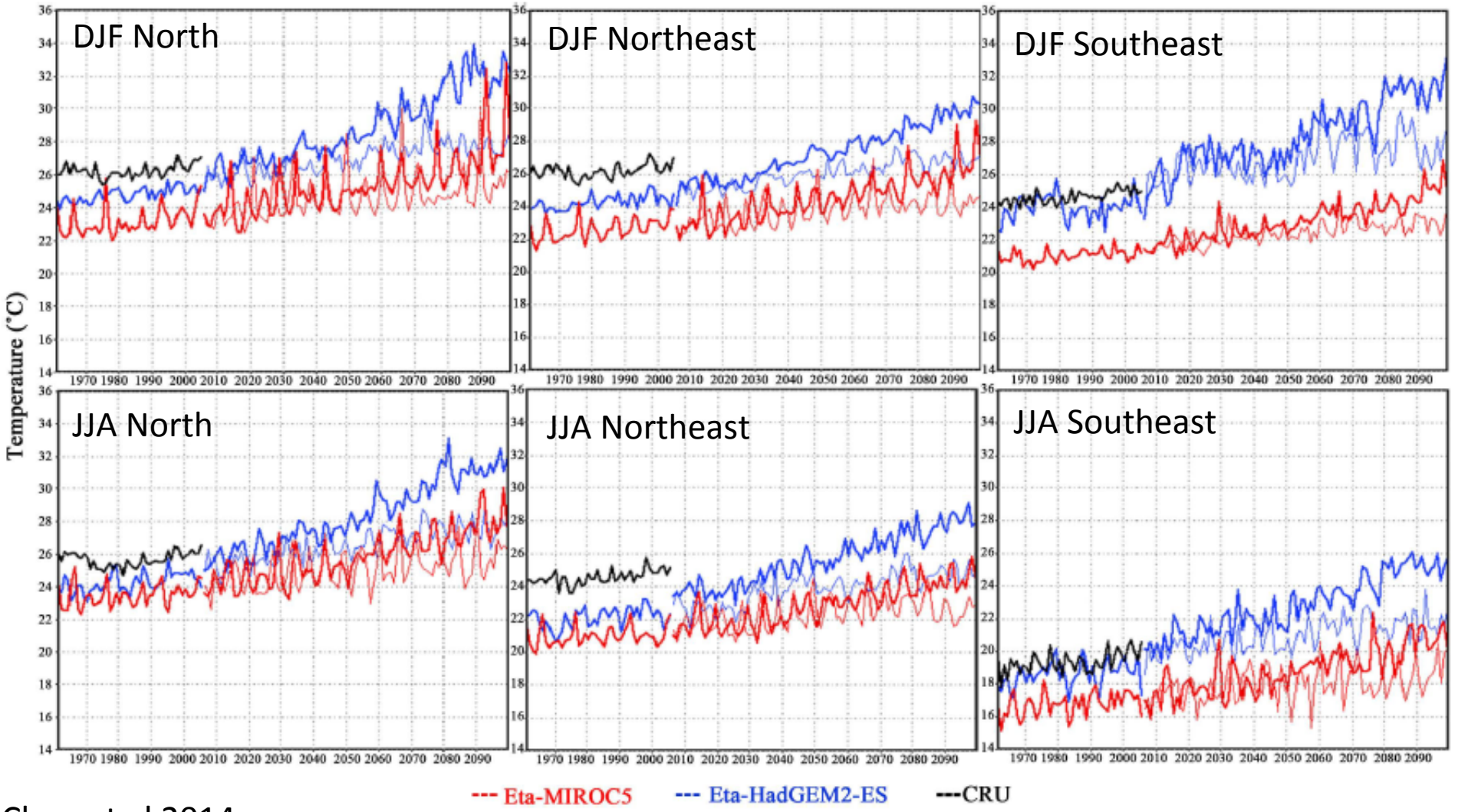


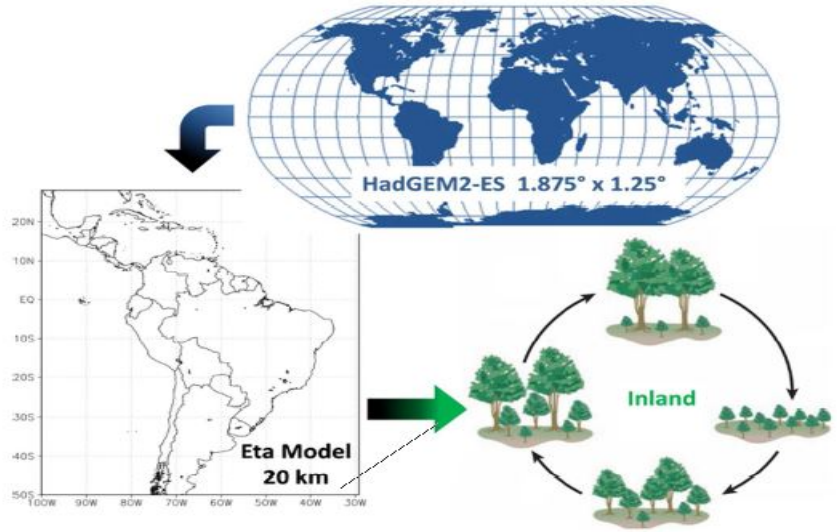
Chou et al 2014

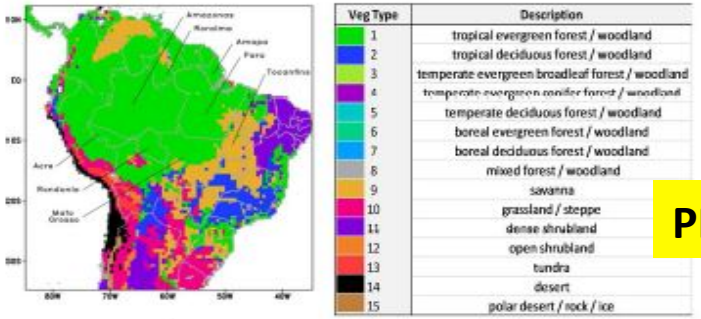
Mean annual temperature (˚C) 1961 until 2100, for RCP 4.5 (thin lines) and RCP 8.5 (thick lines) [HadGEM2 ES, MIROC5, Eta]



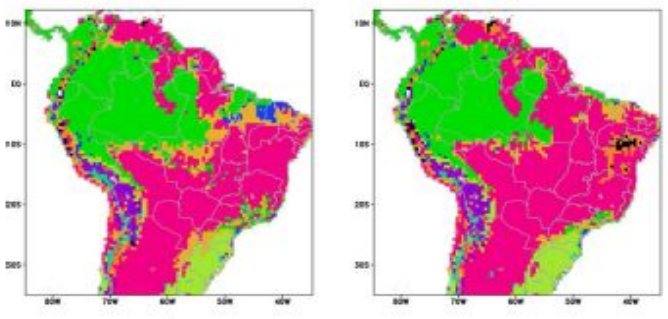
Chou et al 2014

Projections of climate change impacts on South America in natural vegetation under climate change scenarios (HadGEM 2 ES, RCP 4.5 and 8.5, Eta, INLAND)

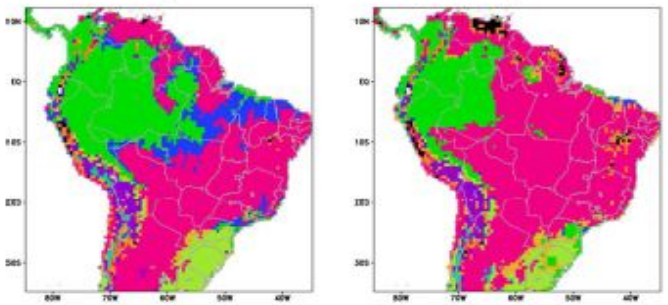




PRESENT



2050



2100

RCP 4.5

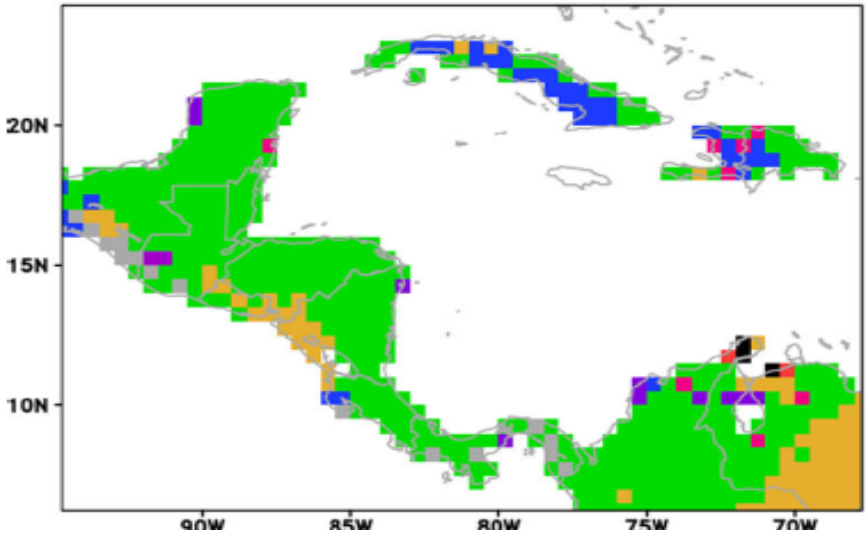
RCP 8.5

Coupled Eta-INLAND version

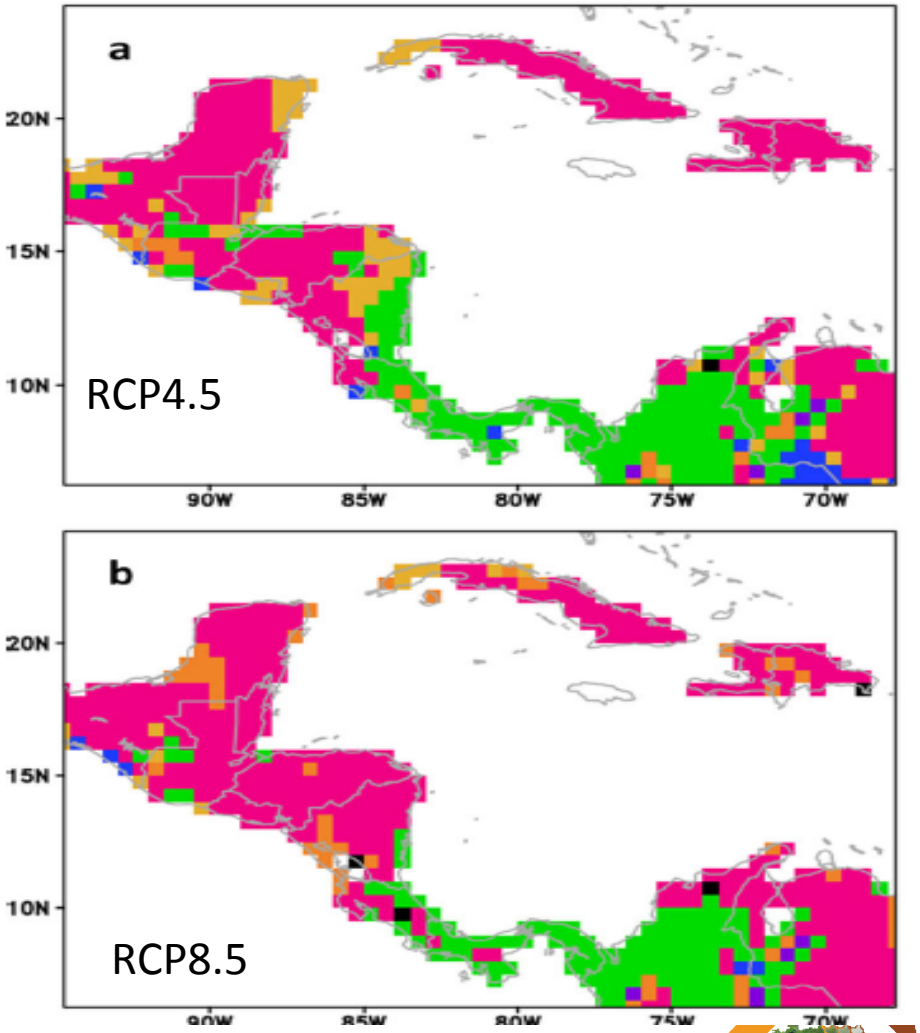
Continued work on INLAND parameters and representation of Brazilian BIOME and national CRO

Projections of climate change impacts on central America tropical rainforest under climate change scenarios (HadGEM2 ES, RCP 4.5 and 8.5, Eta, INLAND)

Initial vegetation type in Central America and Caribbean

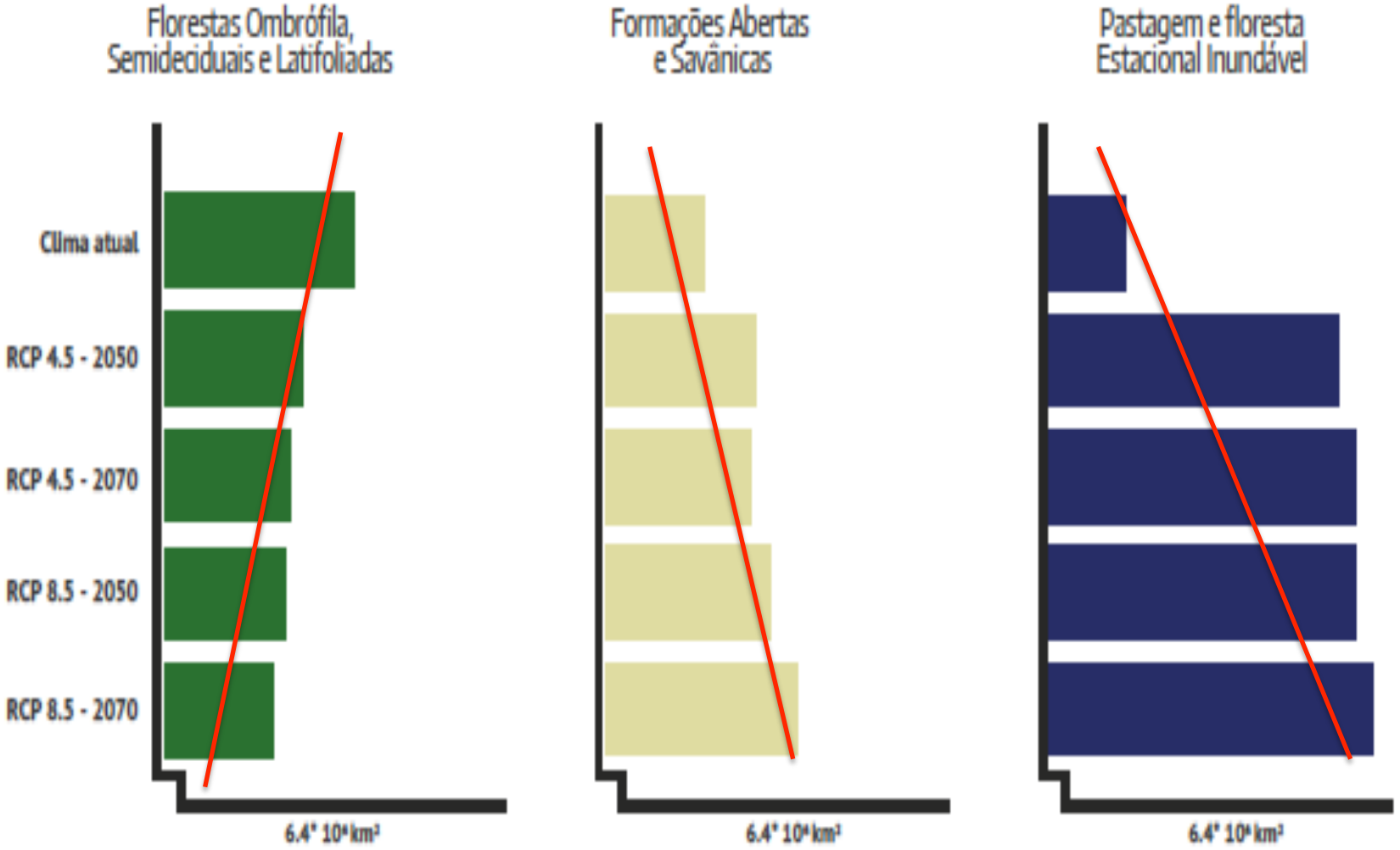


Veg Type	Description
1	tropical evergreen forest / woodland
2	tropical deciduous forest / woodland
8	mixed forest / woodland
9	savanna
10	grassland / steppe
11	dense shrubland
12	open shrubland
13	tundra
14	desert



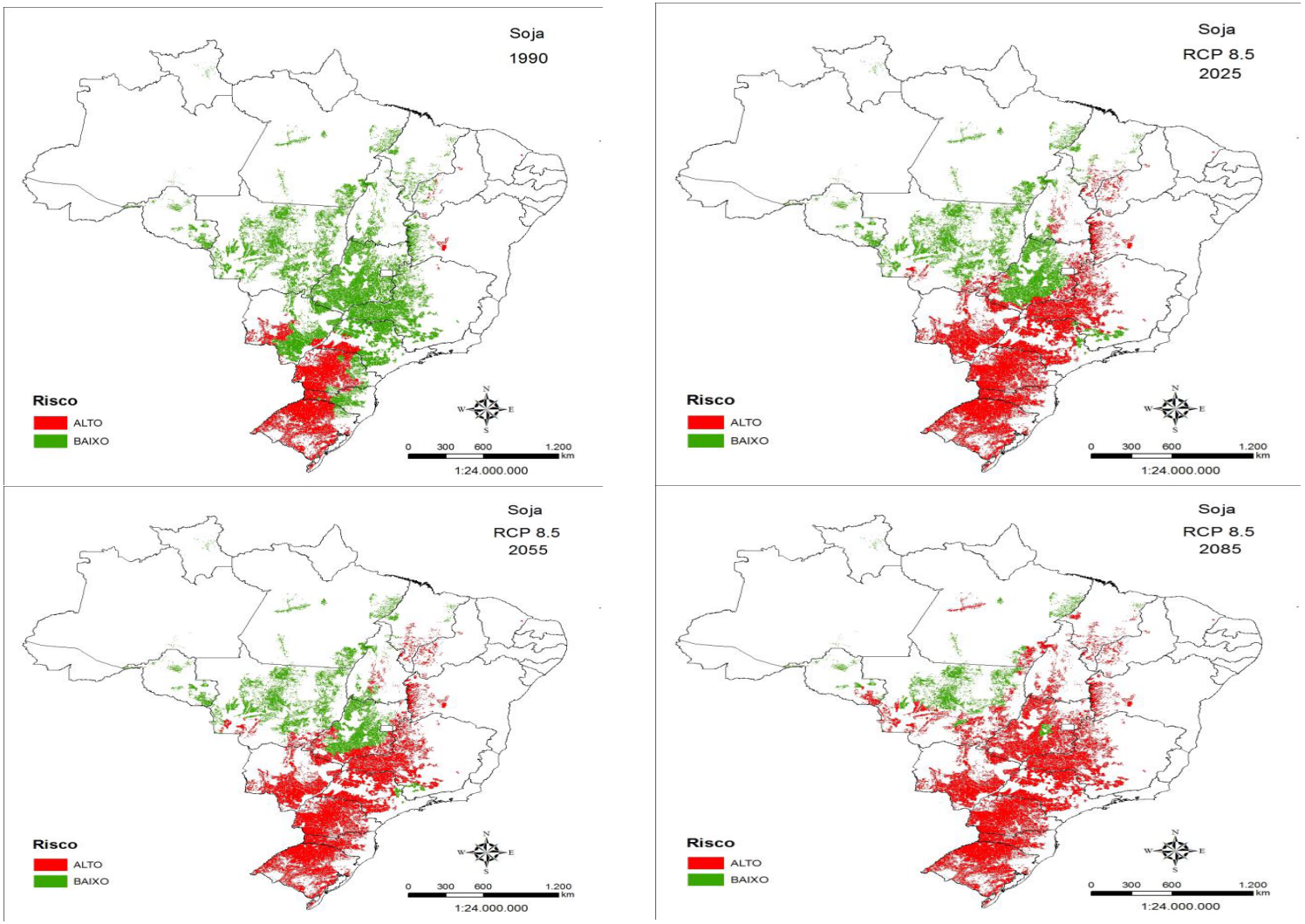
Lira et al 2016

Total area of distribution of habitats in accordance with the anticipated distribution in each climate scenario (HadGEM2 ES)



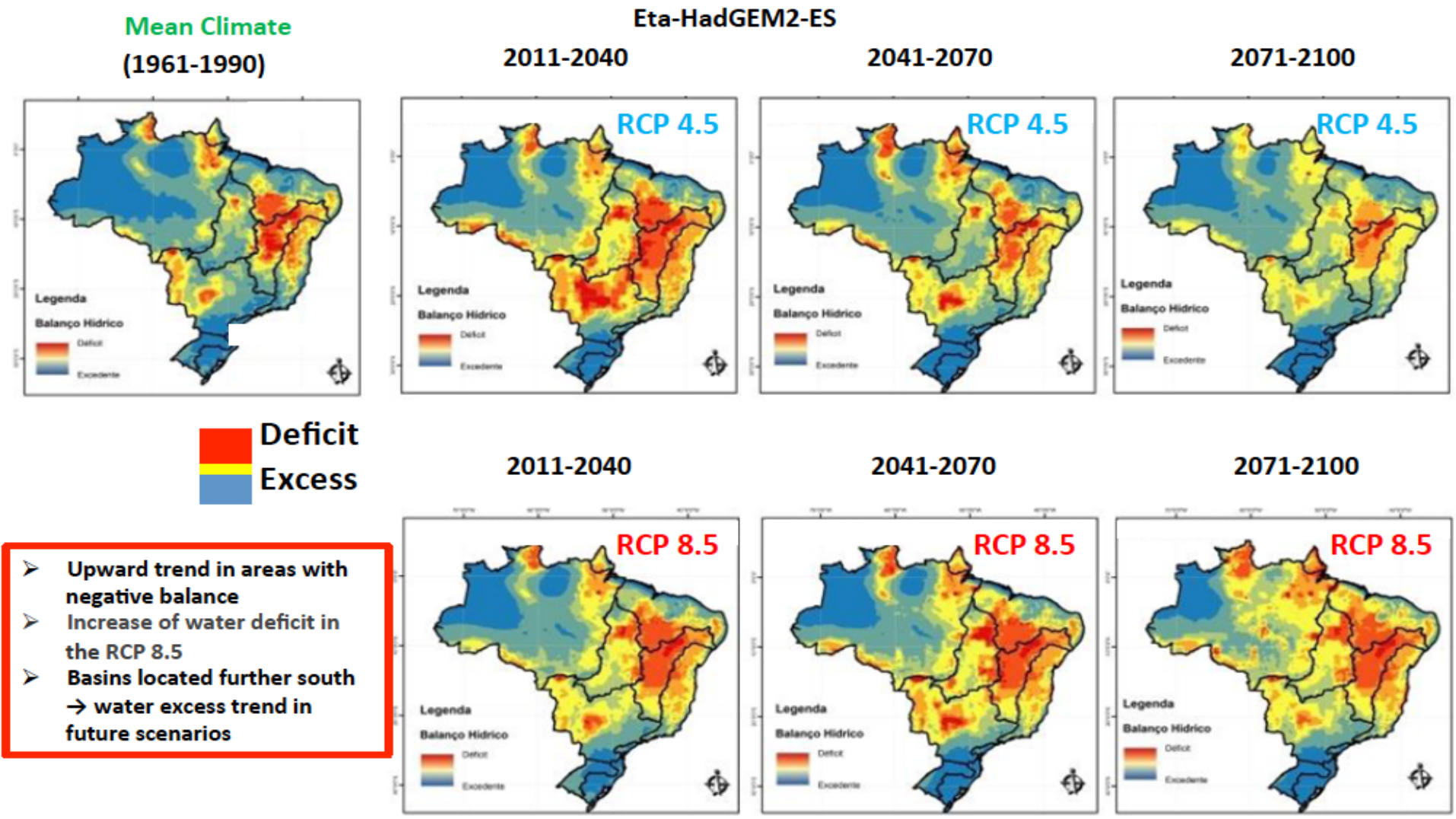
MCTI 2016 – TCN to UNFCCC, Zanin et al 2016

Spatial distribution of the increase in high risk areas of soybean crop cultivation in Brazil (HadGEM2 ES, Eta, RCP 4.5, 8.5)



MCTI 2016 – TCN to UNFCCC, Assad et al 2016

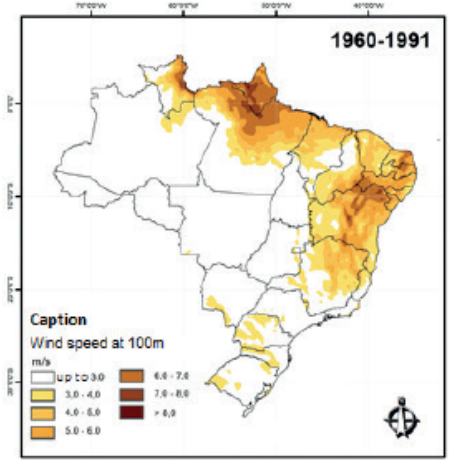
Water balance distribution in Brazil for the present and future periods (HadGEM 2 ES, MIROC5, RCP 4.5 and 8.5, Eta)

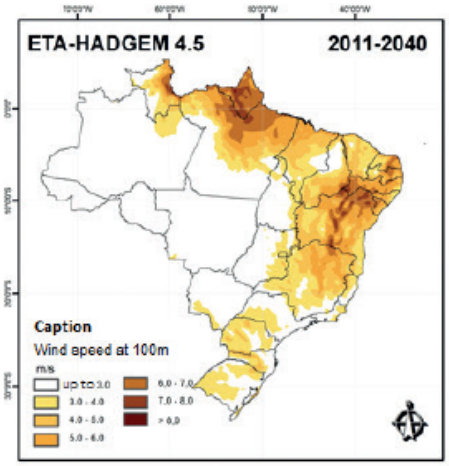


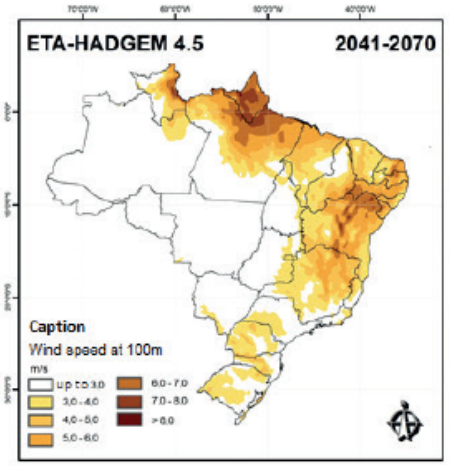
- Upward trend in areas with negative balance
- Increase of water deficit in the RCP 8.5
- Basins located further south → water excess trend in future scenarios

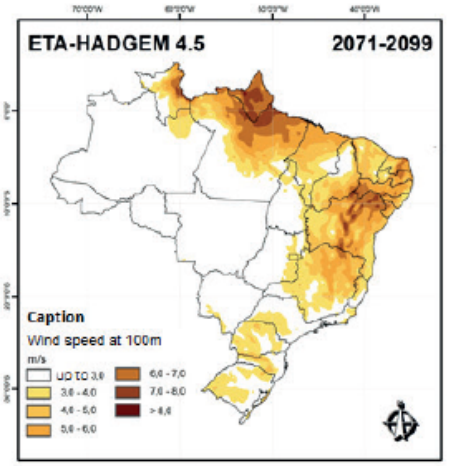
MCTI 2016 – TCN to UNFCCC, Ribeiro Neto et al (2016)

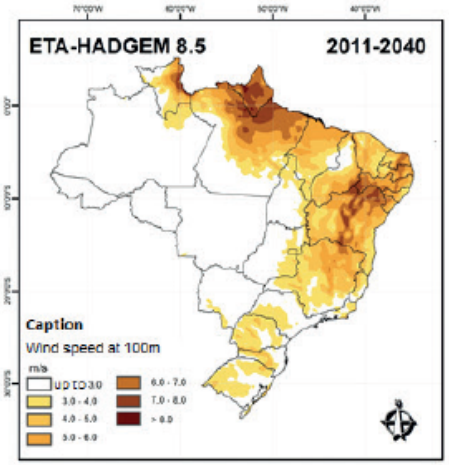
Wind speed intensity classes at 100 m for the present and future periods (HadGEM 2 ES, MIROC5, RCP 4.5 and 8.5, Eta)

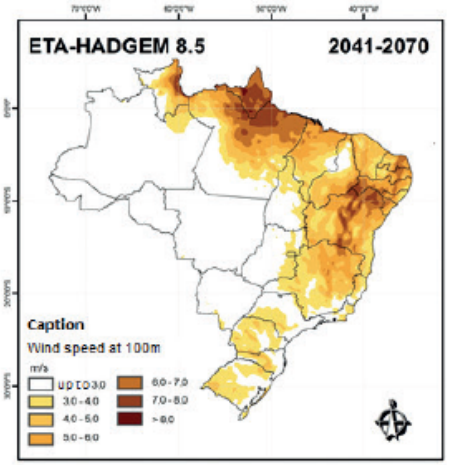


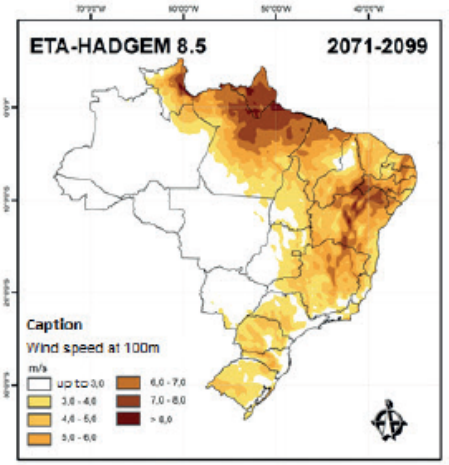












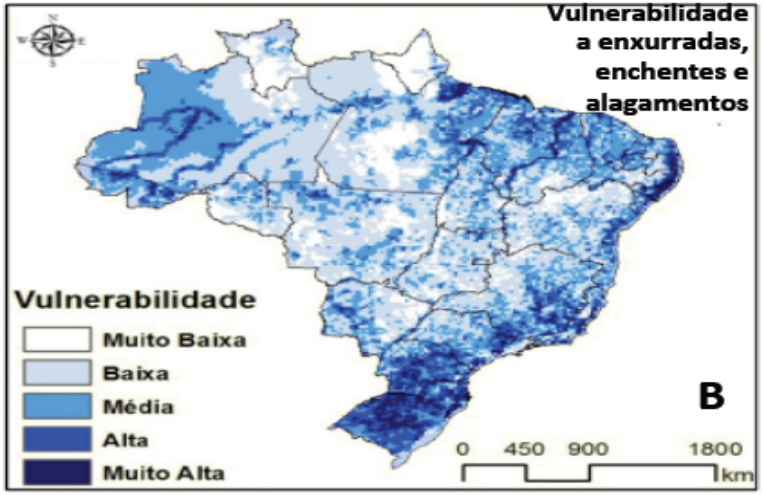
MCTI 2016 – TCN to UNFCCC, Da Silva Oscar Jr 2016

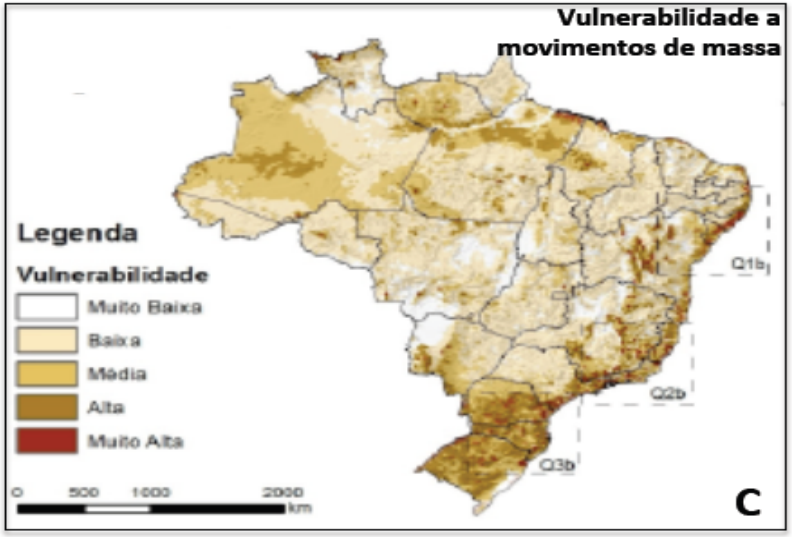
Summary of the main influences of climate change impacts on health in Brazil (HadGEM2 ES, RCP 4.5 and 8.5, Eta)

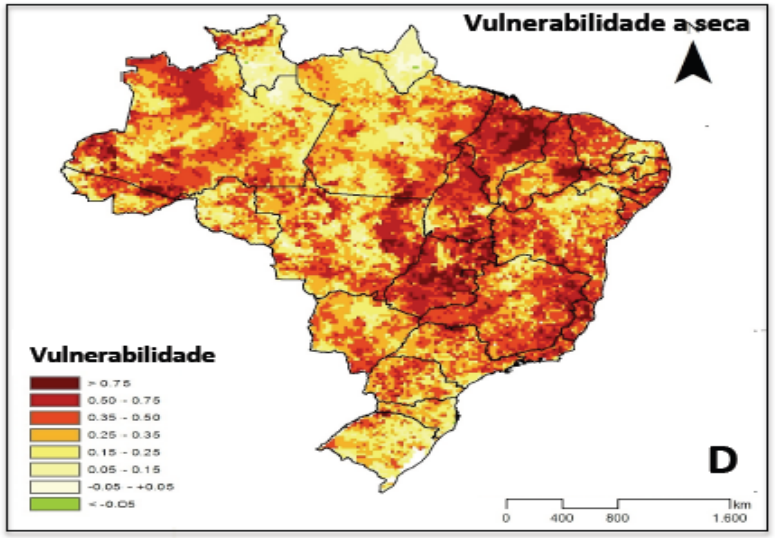
DISEASE	METHOD OF IMPACT	MAIN RESULTS (ETA-HADGEM2)		COMMENTS
		RCP 4.5	RCP 8.5	
Childhood Diarrhea (<5 years old)	+5% on risk of hospitalization per every 1°C warming (McMichael et al., 2004)	+9-15% Hospitalizations	+6-28% Hospitalizations	The Center-West and Northern Regions are the most affected in both models. Precarious conditions of sanitation, education and basic health services explain the severity of impacts.
		8.5 vs 4.5 scenario: +826,096 hospitalizations in Brazil		
Premature mortality due to respiratory diseases	6 x increase on average temperature (Aryes et al., 2009)	7/1000inhab (Goiânia)	14/1000inhab (Goiânia)	Higher mortality rates in the Center-West region, specially, in the State of Goiás, with high level of mortality.
Dengue fever	Multiple Linear Regression Model[74]	Preliminary Analysis: Expansion to the South, North and mountainous areas in the Southwest region. The 8.5 scenario shows the highest increase on probability of endemic transmission.		
General mortality due to increase of heatwave days	+4,24% x increase of heat wave days x daily mortality rate (Anderson et al., 2010)	+70 deaths/year (Northeast)	+17 deaths/year (capital cities of the North)	The Northern Region capitals presented larger increases when compared to other regions. Rio de Janeiro State presents the most worrying increases between all Brazilian states.

MCTI 2016 – TCN to UNFCCC, Hacon et al 2016

Projected changes in vulnerability to natural disasters in Brazil (HadGEM2 ES, MIROC5, RCP4.5 and 8.5 Eta)



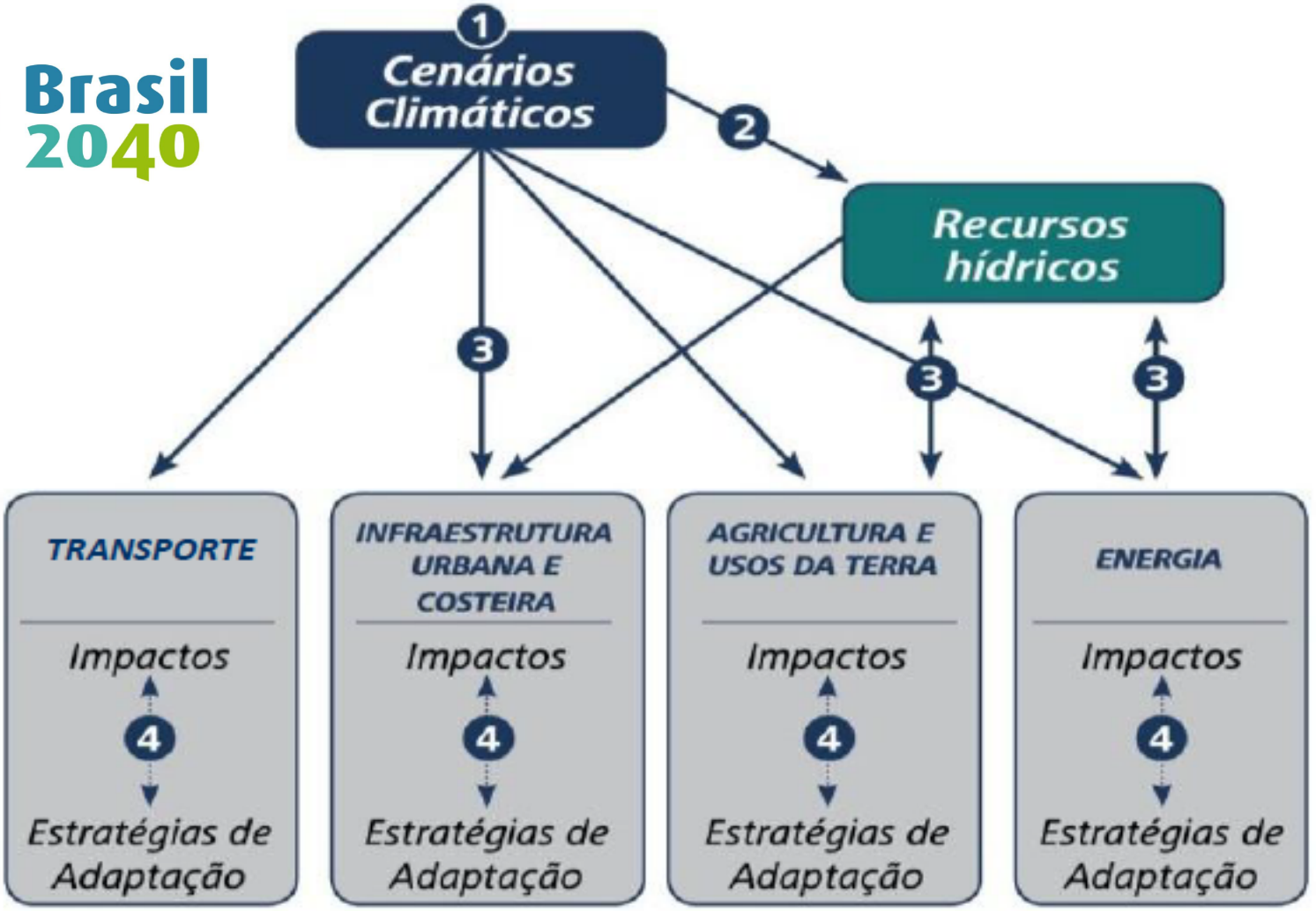




MCTI 2016 – TCN to UNFCCC, Debortoli et al 2016

BRASIL 2040: cenários e alternativas de adaptação à mudança do clima

Brasil 2040



Products generated by the regional climate change scenarios produced by the INCT-MC

Take home messages

Downscaling has been used by the MCTI to support the studies of the TNC to UNFCCC, the Brasil 2040 by the SAE, and the PNA, that have used regional climate change scenarios generated by INPE since 2007. The impacts of climate change in various sectors have been developed using these scenarios.

INPE and CEMADEN together with the INCT-MC and Rede CLIMA, with the support of MCTI, coordinated the preliminary results related to the preparation of regional climate modeling and climate change scenarios as well as research and studies on vulnerability and adaptation of strategic sectors, which are vulnerable to the impacts associated with climate change in Brazil for the TNC.

The data from these simulations has allowed for the elaboration of new reports, books chapters and paper with new results on climate change scenarios aiming at supporting studies on vulnerability. Specific adaptation projects with the appropriate scientific background could be developed thereof, thus enabling increased efficiency in the use of public resources in the implementation of actions dedicated to adaptation strategies to climate change.