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Estimating the impact of climate change on Brazil's agricultural sector

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Agriculture Session
07/08/2018

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Supported by:



Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

Brazil in the Paris Agreement

Brazilian NDC

TARGET

GHG emission:
37% by 2025
43% by 2030
(2005 levels)

MEASUREMENTS

Sustainable
biofuels:
18% of energy
mix by 2030

Enforcement of Forest Code

No illegal deforestation in Amazon

Restoration of 12Mha of forest by
2030

Sustainable agriculture
measurements

Restoration of 15Mha of
degraded pasture land

5Mha of
ICLF



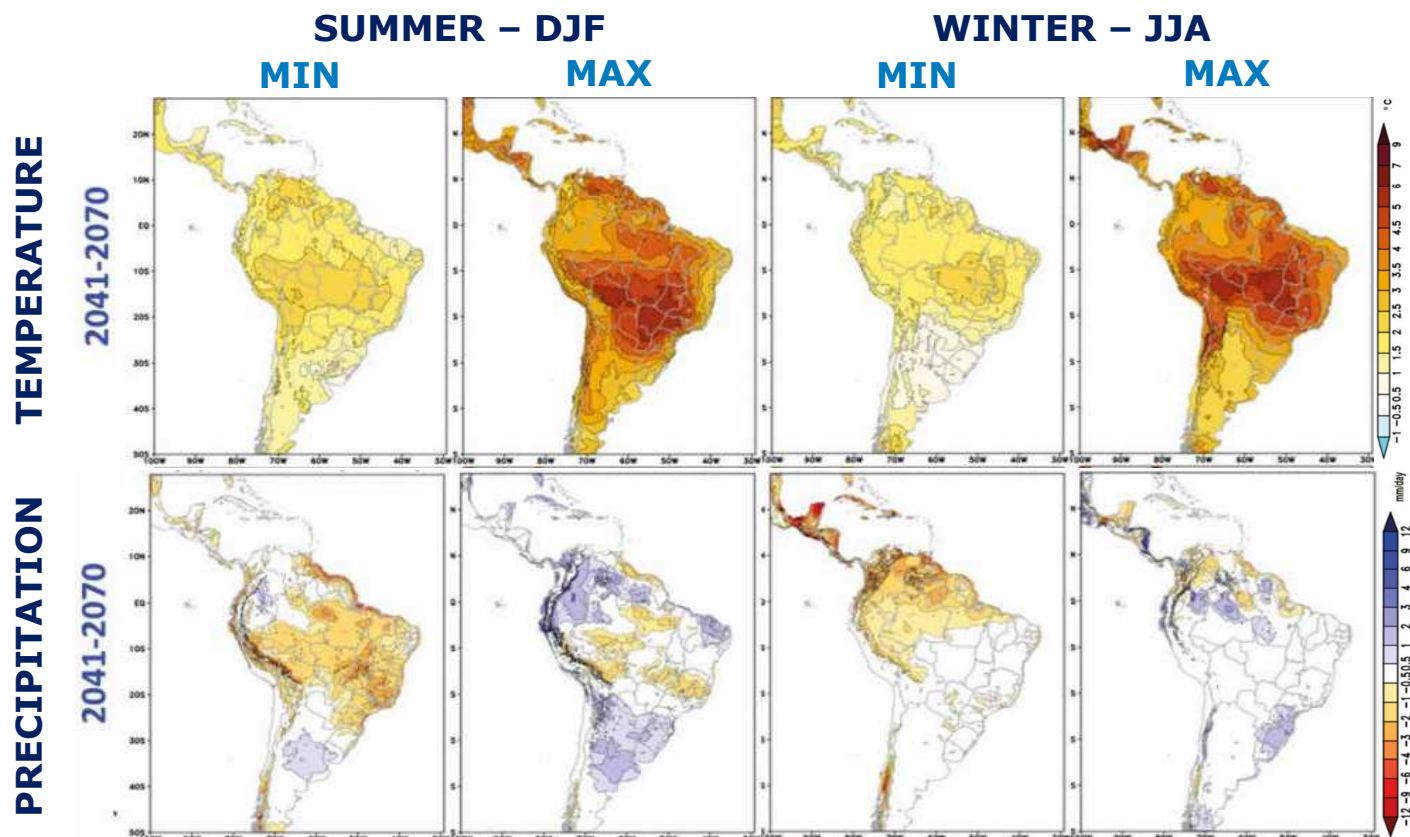
Importance of Brazilian Agriculture

Agriculture (arable + livestock) in Brazil

- 25% of the GDP (agroindustry)
- From 1991-2010:
 - ↑147% production
 - ↑ 25% areainvestments
in technology
- > 90% of the area is rainfed
- 36% of the national exportations
- Main exported commodities: sugar cane, soya, corn, and beef

Future Climate Projections

- Global Models:
MIROC5
HadGEM2-ES
- Eta regional model
- Emission scenarios:
RCP2.6
RCP8.5



Source: Third National Communication of Brazil to the United Nations Framework Convention on Climate Change

Impacts on Land Use Competition

Biophysical Impacts

- Negative impacts in wheat, rice, and corn production (IPCC AR5, 2103)
- In Brazil – Studies based on agroecological zoning (Assad et al 2013):
 - Index also used to define suitability regions and rural credit
 - Lower risk over South Brazil
 - Increase of climatic risk over central-east and northeast

Integrated Land Use Change Impacts

- Based on socioeconomic models (Ricardian models)
- Cropland advancing over abandoned grassland and natural forest
- Reduction of areas suitable for agriculture, mostly over South, including areas of soy crops
- Migration toward North, Northeast, and Center-West, mostly over Cerrado biome.



Impacts on Land Use Competition

Previous Studies

- Changes in production based areas becoming unsuitable, not accounting for productivity changes in areas still considered as suitable.
- Focus on Brazil, not accounting for changes (economic and biophysical) in other regions of the world

GLOBIOM Brazil Model

- Partial equilibrium economic model
- Global spatially explicit bottom-up model
- Considers market dynamics, including changes in 30 regions of the world
- Considering land use competition among agriculture, pasture, and forestry sectors
- Includes future demands from bioenergy sector
- Accounts for public policies

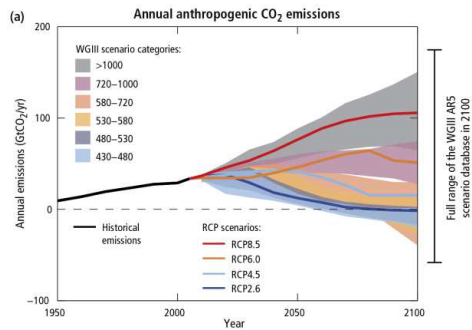


Impacts on Land Use Competition

Anthropic Disturbances

GHG Emissions and RCPs

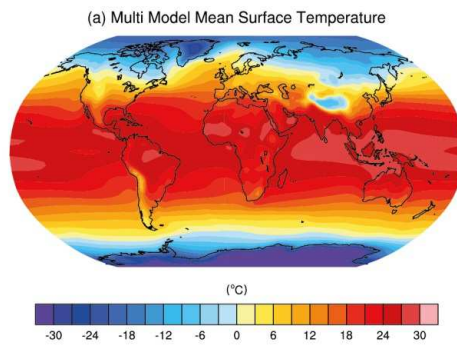
Radiative forcing and climatic scenarios



Climatic Impacts

Global Climate Model Projections

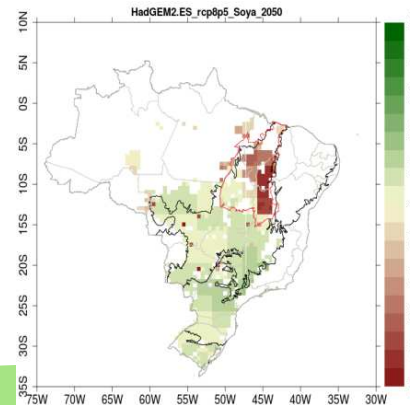
Global projections of temperature, precipitation, moistures



Biophysical Impacts

Global Crop Model: EPIC – ISIMIP

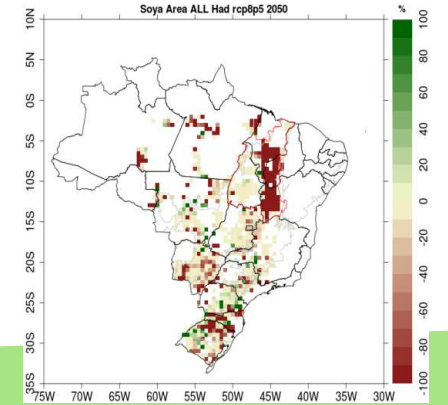
Global projections of crop productivity (18 crops + grass)



RESTORE+ BRAZIL MODELING GROUP Economic Impacts

GLOBIOM Brazil

Global changes in land use, supply and demand, bilateral trade, ...





Objectives



Quantify the future impacts of climate change on Brazil's agricultural sector through the year 2050.



Translate the agricultural biophysical impacts into changes in land use and technological improvements



Define pathways through which Brazil can fulfill its NDC and still maintain its agricultural production



Quantify changes in area, production, and productivity in a spatially explicit framework

GLOBIOM BRAZIL

MODEL'S CHARACTERISTICS

- Partial equilibrium bottom-up economic model
- Spatially explicit (50km in Brazil and 250km in the rest of the world)
- Temporal resolution: 5 years
- Represents:
 - Land use competition (agriculture, livestock, biofuels, and forestry)
 - Supply, demand, market, and bilateral trade (30 global regions)

SCENARIOS:

- Socioeconomic – SSP2
- Emissions – RCP2.6 and RCP8.5
- Climatic projections – 5 GCMs from ISIMIP (HadGEM2-ES; IPSL-CM5A-LR; GFDL-ESM2M; MIROC-ESM-CHEM; NorESM1-M)
- Crop productivity projections: EPIC using ISIMIP protocol
- Forest Code fully enforced

5 GCM + 2 RCP =
10 CLIMATIC SCENARIOS



10 PRODUCTIVITY
SCENARIOS (EPIC)



GLOBIOM BRAZIL



10 LAND USE CHANGE
+ BASELINE (noCC)

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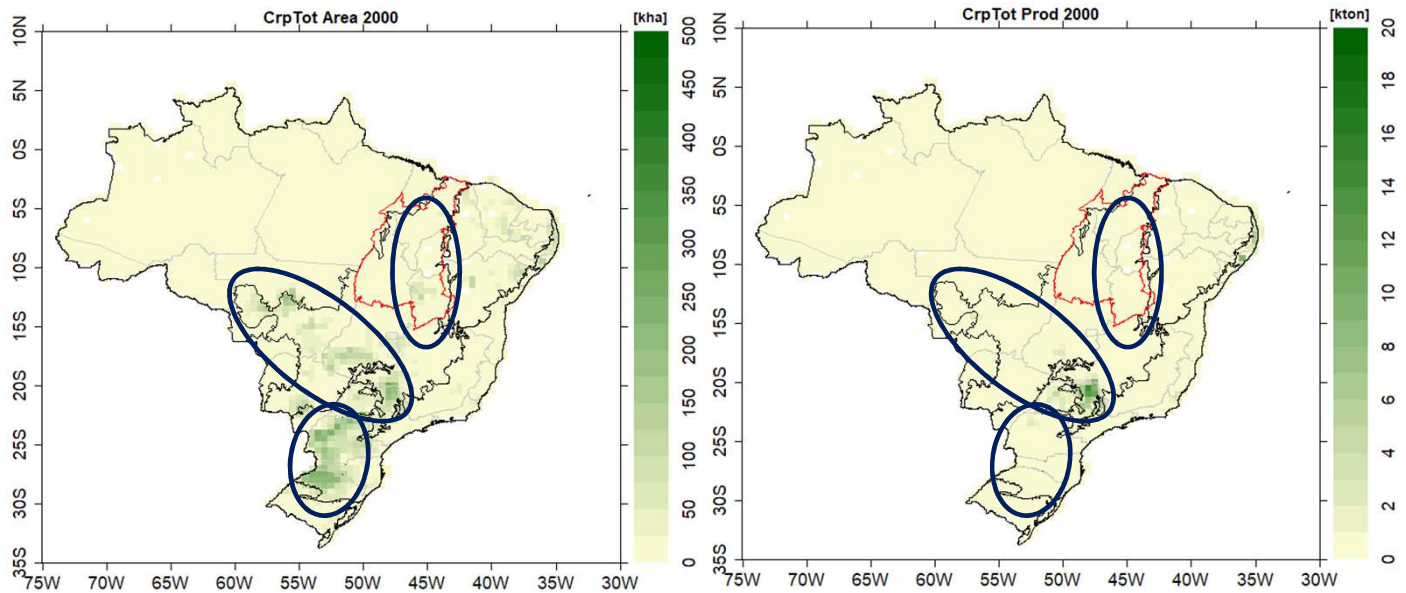
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2000	Area (Mha)	Prod (Mton)	Yield (ton/ha)
Brazil	42.6	435.7	10.23
Matopiba	2.0	8.3	4.1
South Cerrado	12.6	184.4	14.57
South	15.0	54.1	3.61
2050	Area (Mha)	Prod (Mton)	Yield (ton/ha)
Brazil	117.8	1,539.0	13.06
Matopiba	16.4	109.2	6.64
South Cerrado	38.6	454.2	11.76
South	24.7	196.8	7.97



Scenarios for Cropland in 2050

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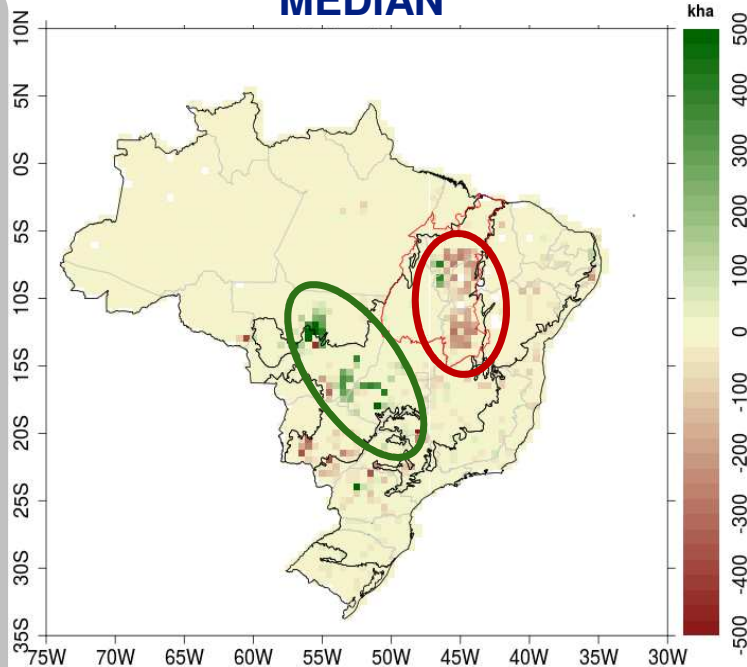
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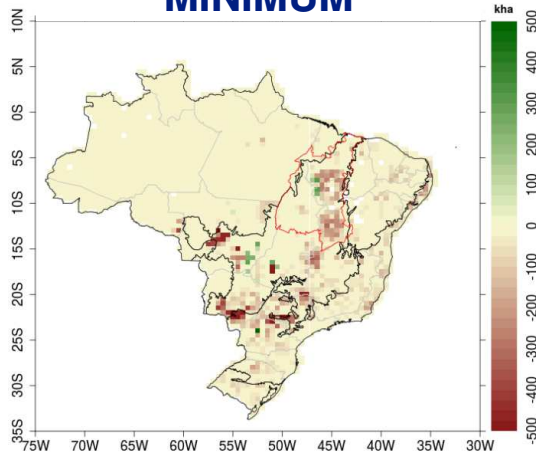
Area

MEDIAN

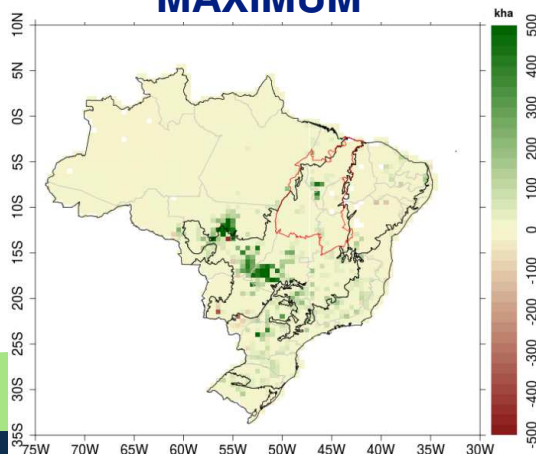
(SCENARIO - BASELINE) YEAR



MINIMUM

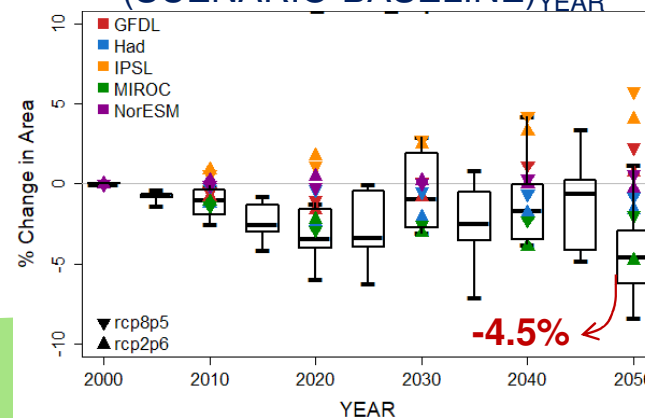


MAXIMUM



	Area (Mha)	Annual growth (%a.a.)
Baseline [2000]	42.6	
Baseline [2050]	117.9	2.2%
Minimum [2050]	108.1	2.0%
Median [2050]	112.5	2.1%
Maximum [2050]	119.3	2.2%

(SCENARIO-BASELINE) YEAR



Scenarios for Cropland in 2050

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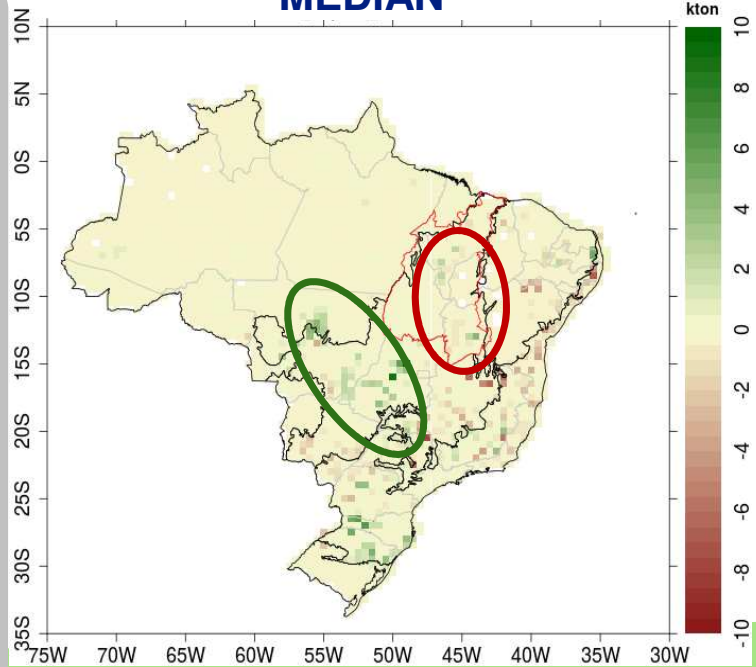
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Production

MEDIAN

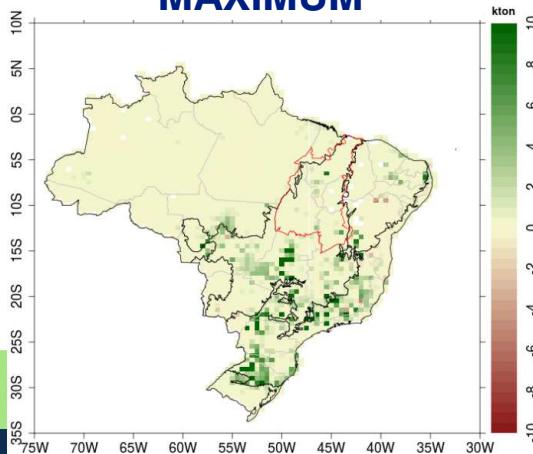
(SCENARIO - BASELINE)_{YEAR}



MINIMUM

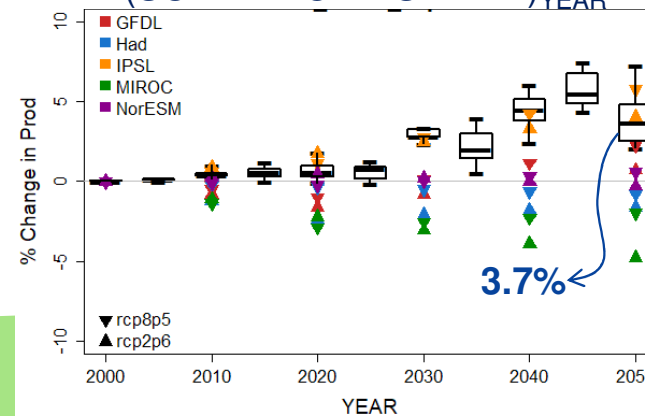


MAXIMUM



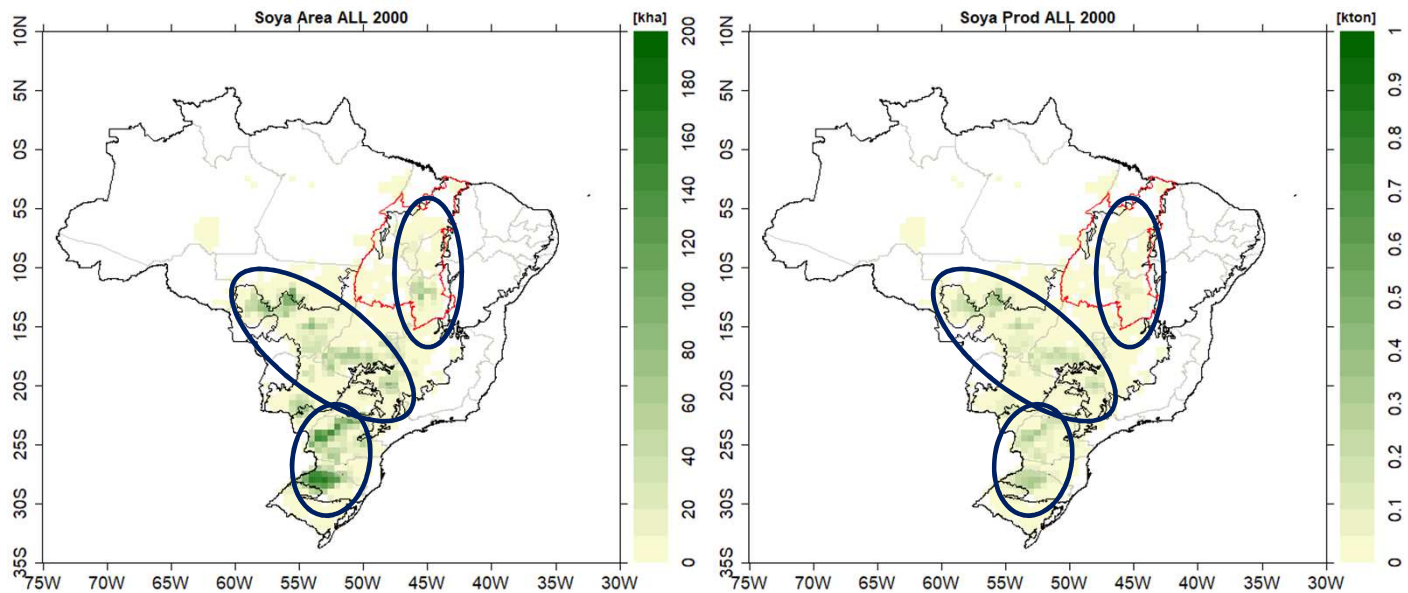
	Prod. (Mton)	Annual growth (%a.a.)
Baseline [2000]	435.7	
Baseline [2050]	1539.0	2.79%
Minimum [2050]	1571.2	2.84%
Median [2050]	1595.7	2.88%
Maximum [2050]	1651.3	2.95%

(SCENARIO-BASELINE)_{YEAR}



Baseline Scenario Soyland 2050

2000	Area (Mha)	Prod (Mton)	Yield (ton/ha)
Brazil	13.3	32.7	2.46
Matopiba	0.8	1.4	1.71
South Cerrado	5.4	16.7	3.07
South	6.0	11.8	1.97
2050	Area (Mha)	Prod (Mton)	Yield (ton/ha)
Brazil	47.9	173.0	3.61
Matopiba	12.0	34.1	2.85
South Cerrado	16.6	73.9	4.45
South	11.5	31.7	2.75

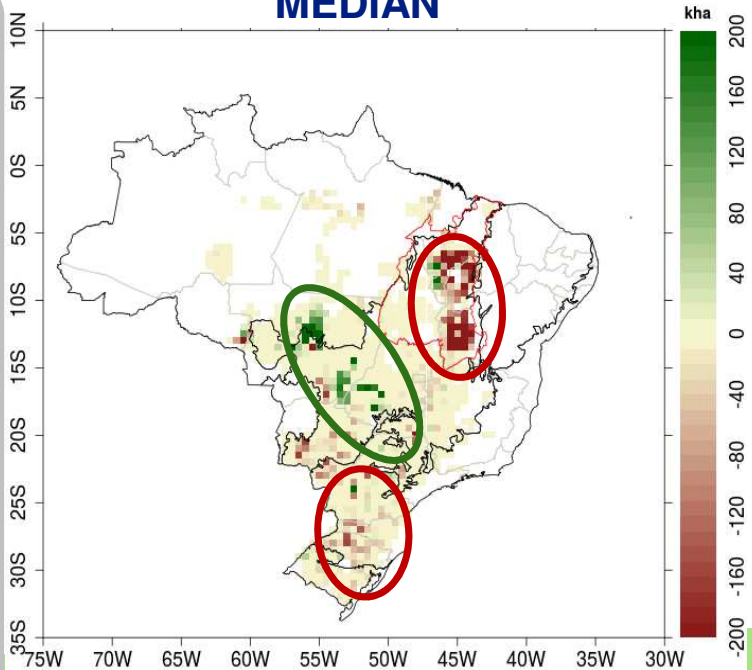


Scenarios for Soyland in 2050

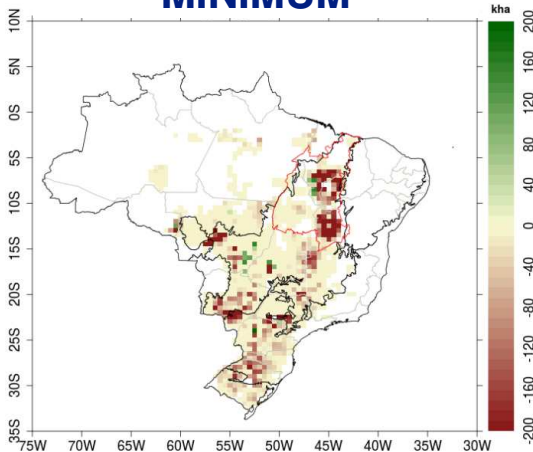
Area

MEDIAN

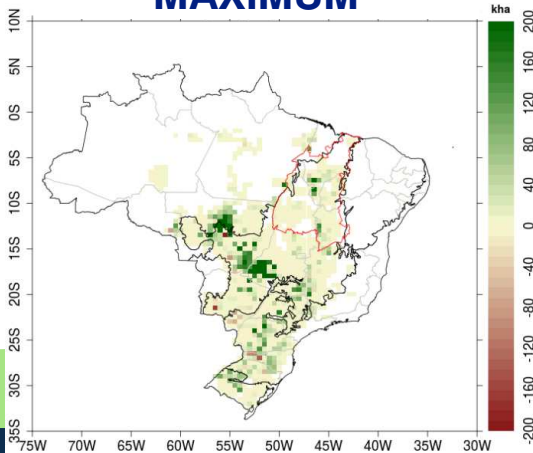
(SCENARIO - BASELINE) YEAR



MINIMUM

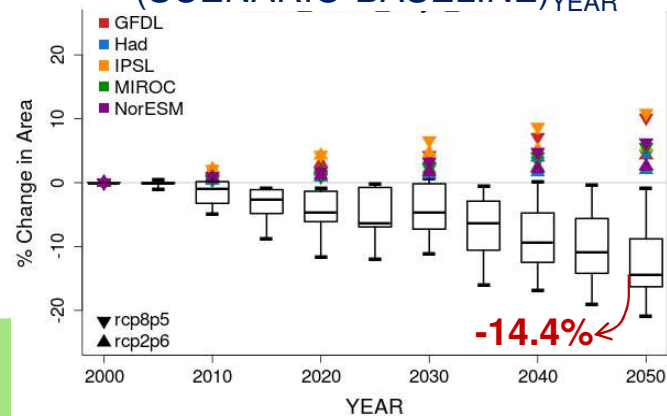


MAXIMUM



	Area (Mha)	Annual growth (%a.a.)
Baseline [2000]	13.3	
Baseline [2050]	47.9	2.9%
Minimum [2050]	37.9	2.4%
Median [2050]	41.0	2.6%
Maximum [2050]	47.5	2.9%

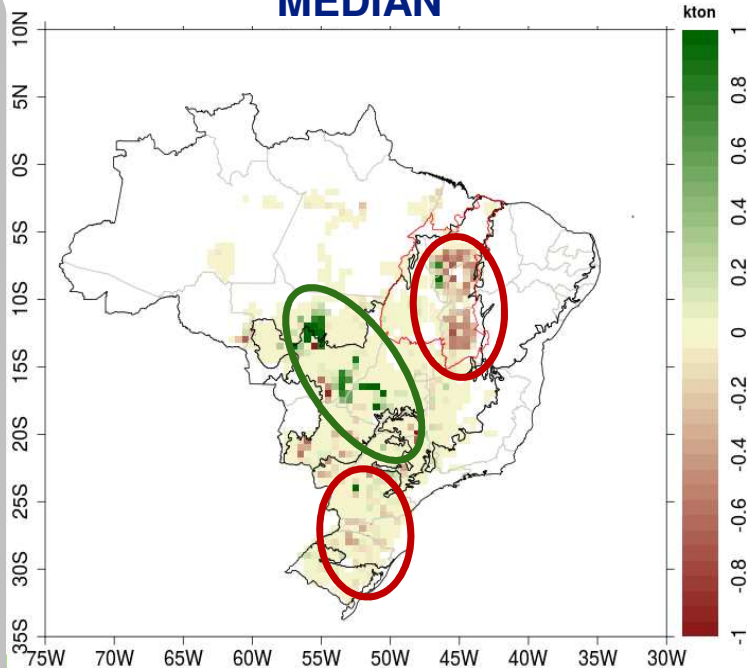
(SCENARIO-BASELINE) YEAR



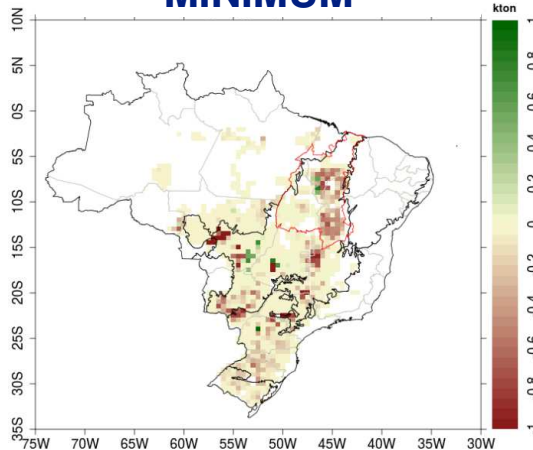
Production

MEDIAN

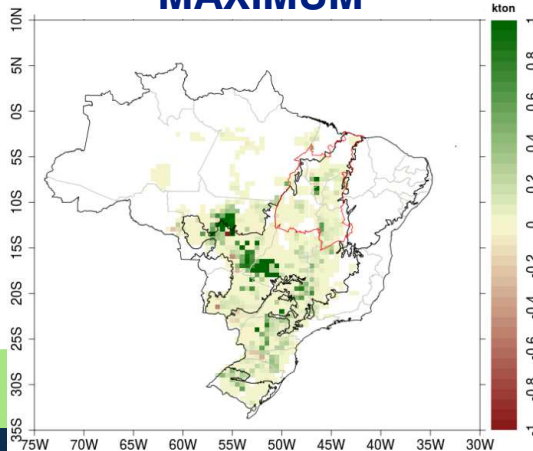
(SCENARIO - BASELINE) YEAR



MINIMUM

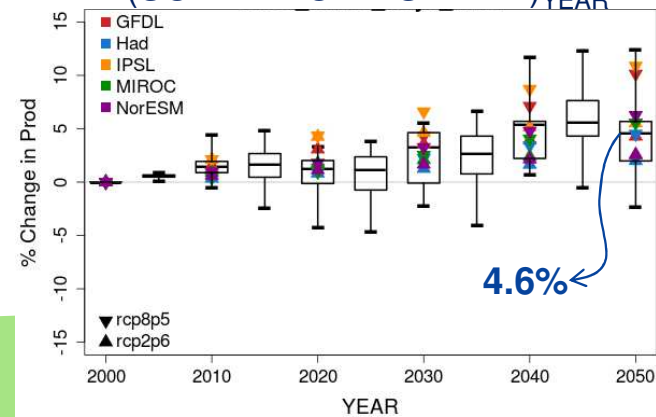


MAXIMUM



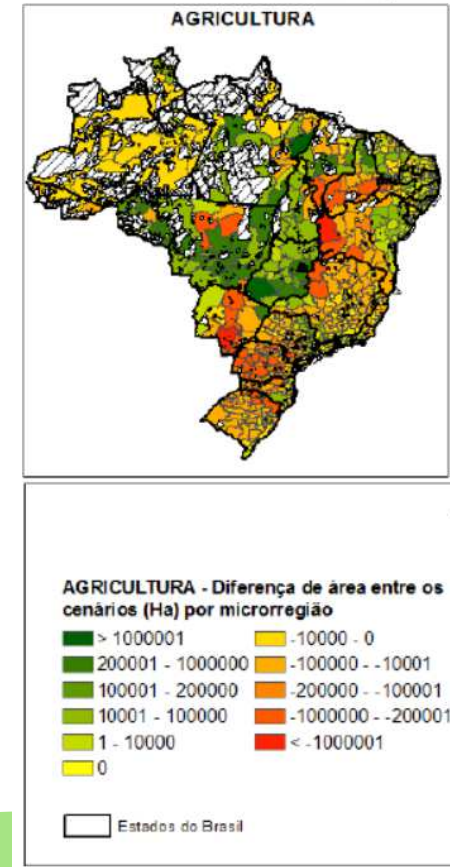
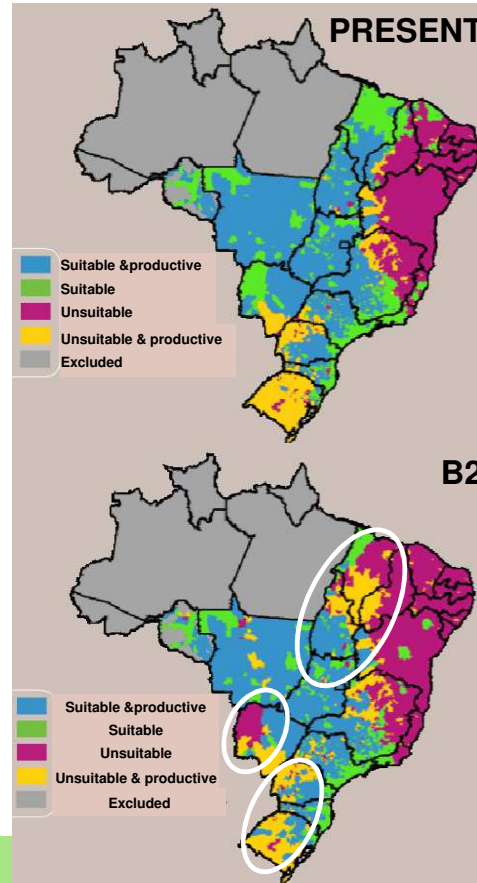
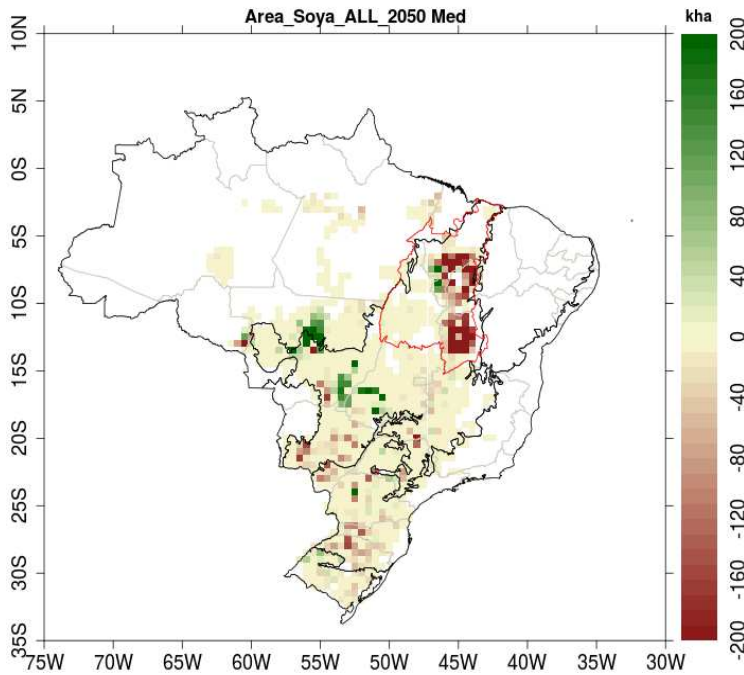
	Prod. (Mton)	Annual growth (%a.a.)
Baseline [2000]	32.7	
Baseline [2050]	173.0	3.91%
Minimum [2050]	168.9	3.85%
Median [2050]	180.8	4.02%
Maximum [2050]	194.5	4.18%

(SCENARIO-BASELINE) YEAR





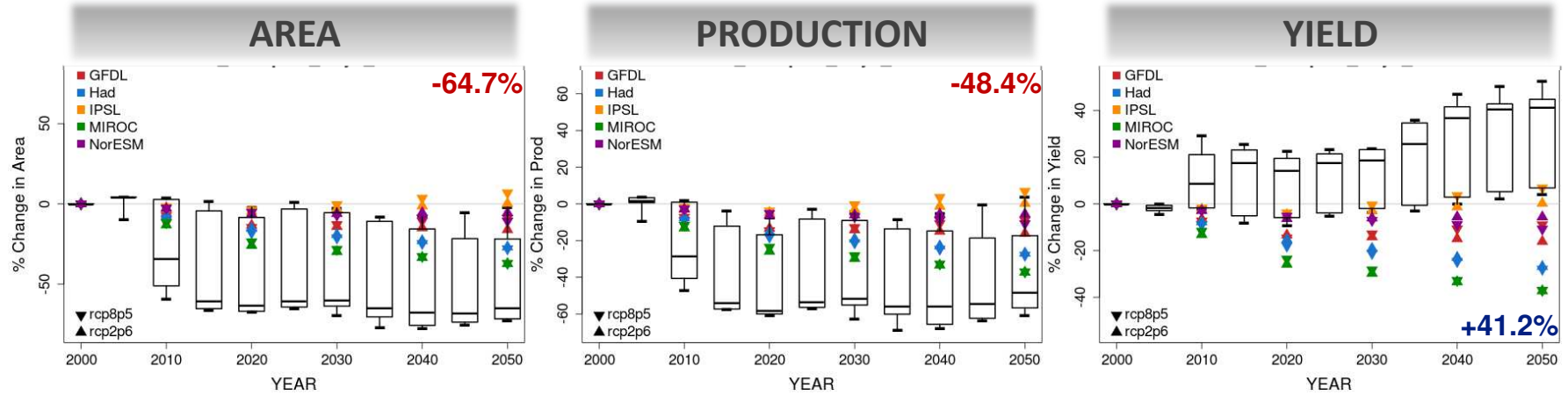
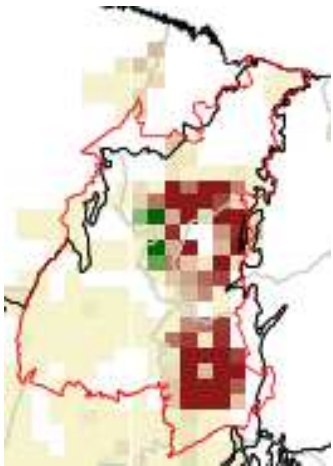
Comparison w/ previous results



<https://www.agritempo.gov.br/climaeagricultura/soja.html>

Scenarios for Soyland in 2050

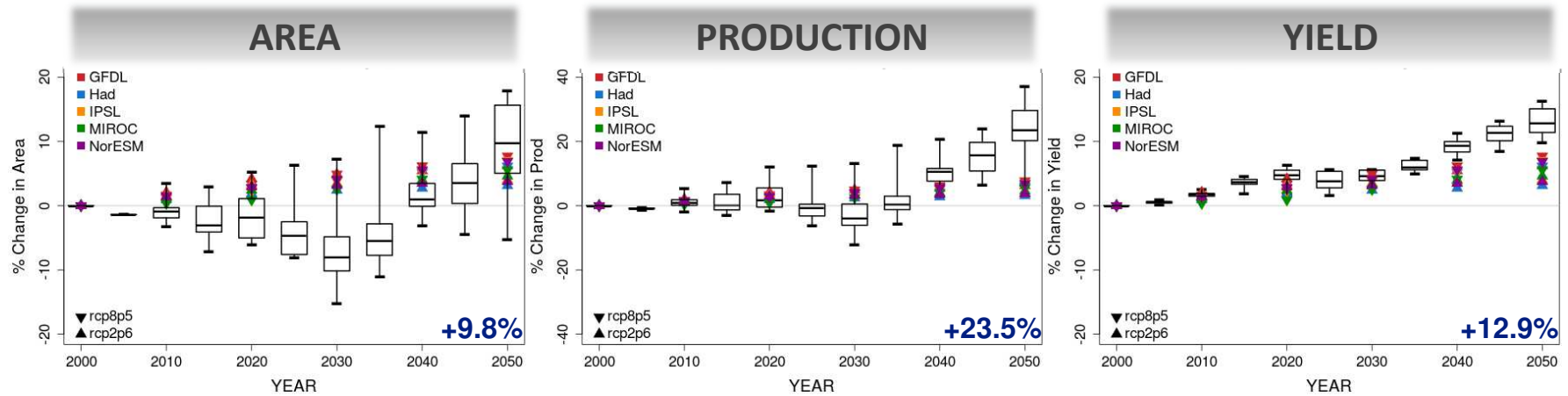
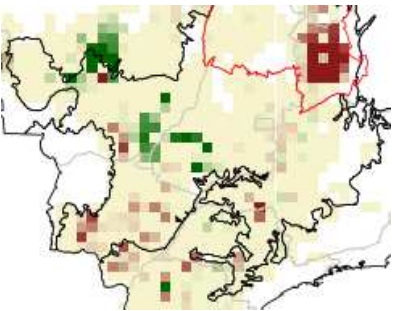
MATOPIBA



	Area (Mha)	Annual growth (%a.a.)	Prod (Mton)	Annual Growth (%a.a.)	Yield (ton/ha)	Annual Growth (%a.a.)
Baseline [2000]	0.8		1.4		1.7	
Baseline [2050]	12.0	6.41%	34.1	7.86%	2.9	1.05%
Minimum [2050]	3.3	3.57%	13.4	5.47%	3.0	1.14%
Median [2050]	4.2	4.14%	17.6	6.15%	4.0	1.83%
Maximum [2050]	11.7	6.35%	35.4	7.92%	4.4	2.05%

Scenarios for Soyland in 2050

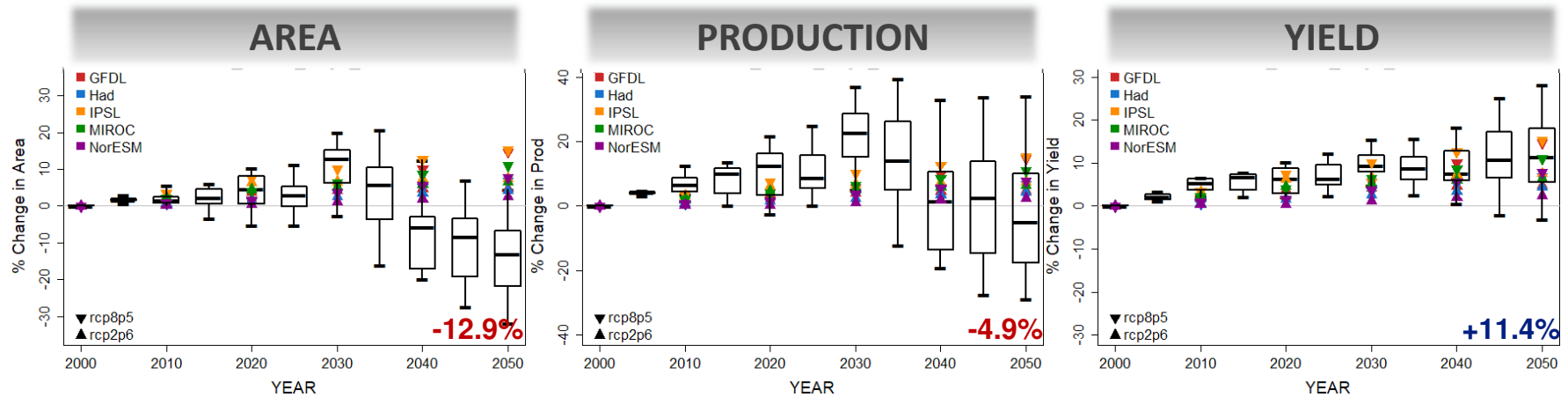
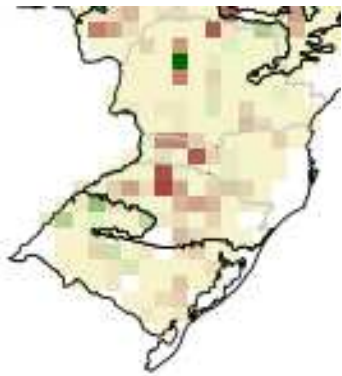
SOUTH CERRADO



	Area (Mha)	Annual growth (%a.a.)	Prod (Mton)	Annual Growth (%a.a.)	Yield (ton/ha)	Annual Growth (%a.a.)
Baseline [2000]	5.5		16.8		3.1	
Baseline [2050]	16.6	2.65%	73.9	3.56%	4.4	0.76%
Minimum [2050]	15.8	2.53%	78.7	3.71%	4.9	0.95%
Median [2050]	18.2	2.84%	91.3	4.02%	5.0	1.01%
Maximum [2050]	19.6	3.02%	101.5	4.29%	5.2	1.07%

Scenarios for Soyland in 2050

SOUTH BRAZIL



	Area (Mha)	Annual growth (%a.a.)	Prod (Mton)	Annual Growth (%a.a.)	Yield (ton/ha)	Annual Growth (%a.a.)
Baseline [2000]	6.0		11.8		2.0	
Baseline [2050]	11.5	1.48%	31.7	2.26%	2.8	0.69%
Minimum [2050]	7.8	0.75%	22.5	1.67%	2.7	0.63%
Median [2050]	10.0	1.25%	30.1	2.24%	3.1	0.91%
Maximum [2050]	12.0	1.60%	42.5	2.94%	3.5	1.21%

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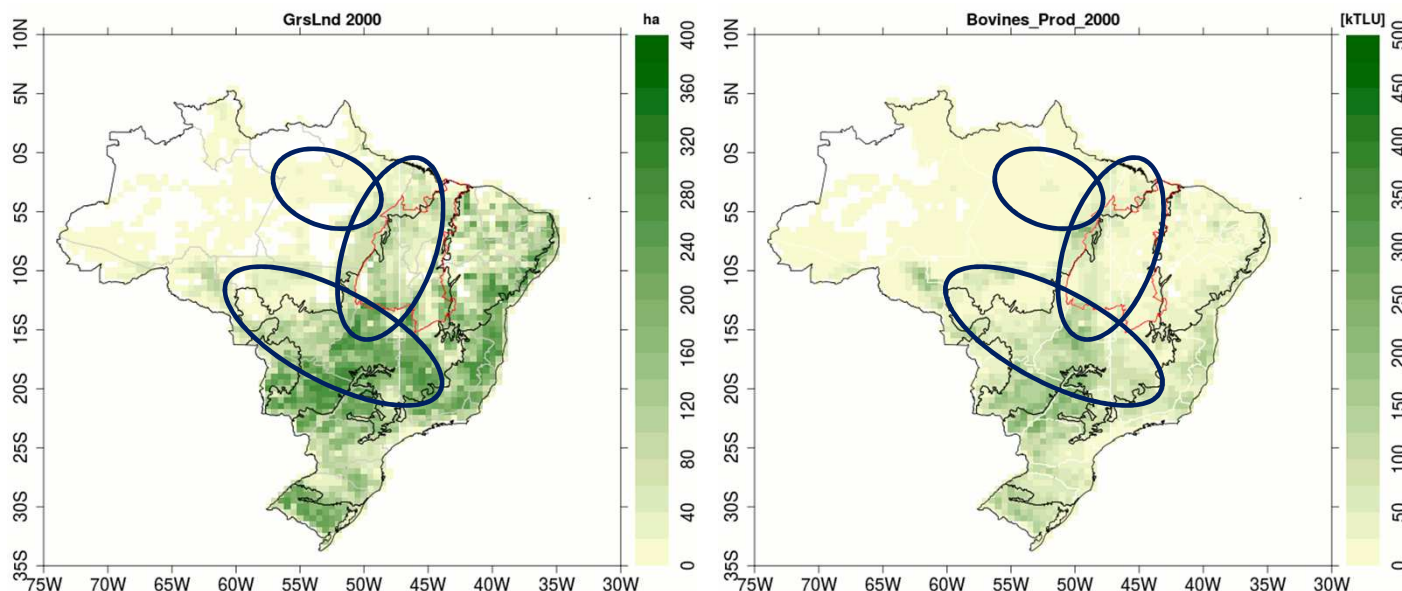
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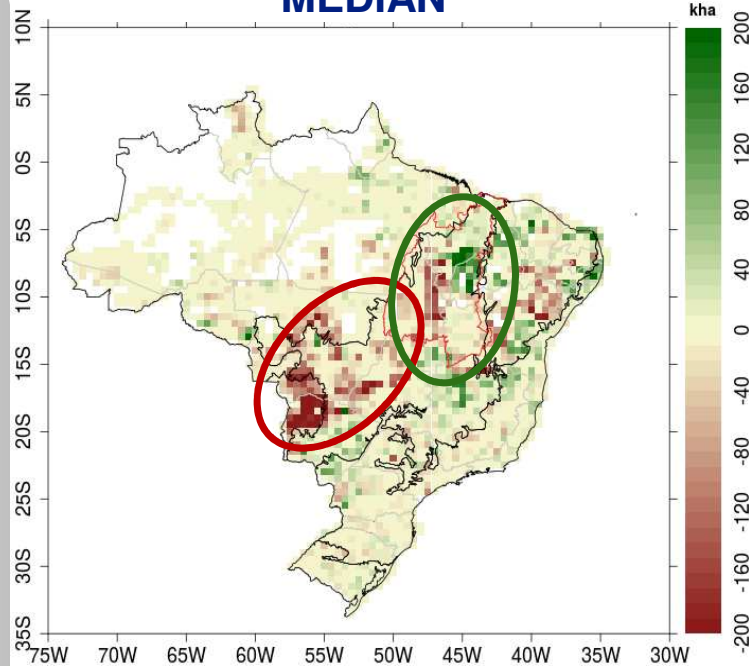
2000	Area (Mha)	Prod (MTLU)	Dens (TLU/ha)
Brazil	211.9	114.0	0.56
Matopiba	16.1	7.3	0.44
South Cerrado	68.2	37.4	0.54
Amazon	20.1	21.0	0.99
2050	Area (Mha)	Prod (MTLU)	Dens (TLU/ha)
Brazil	232.9	213.0	0.90
Matopiba	25.8	20.6	0.79
South Cerrado	69.5	48.5	0.69
Amazon	63.0	105.5	1.66



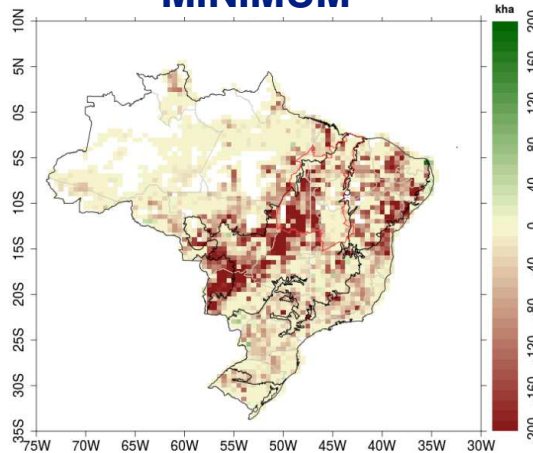
Area

MEDIAN

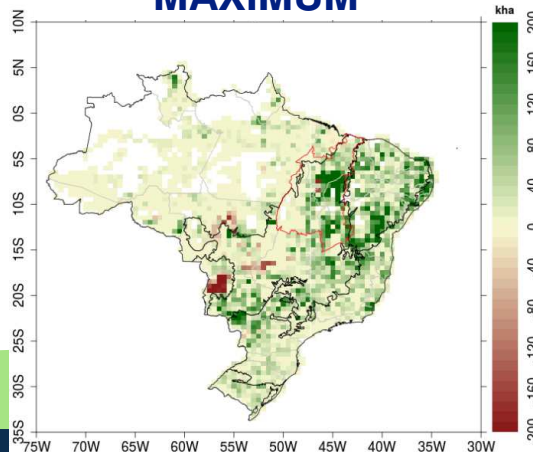
(SCENARIO - BASELINE)_{YEAR}



MINIMUM



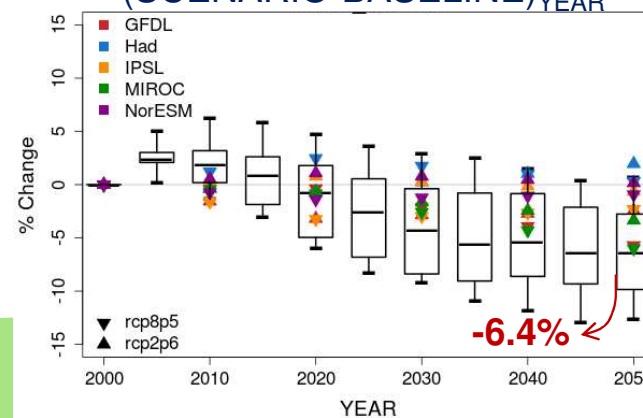
MAXIMUM



Scenarios for Grassland in 2050

	Area (Mha)	Annual growth (%a.a.)
Baseline [2000]	201.9	
Baseline [2050]	232.9	0.29%
Minimum [2050]	203.5	0.02%
Median [2050]	218.0	0.16%
Maximum [2050]	234.5	0.31%

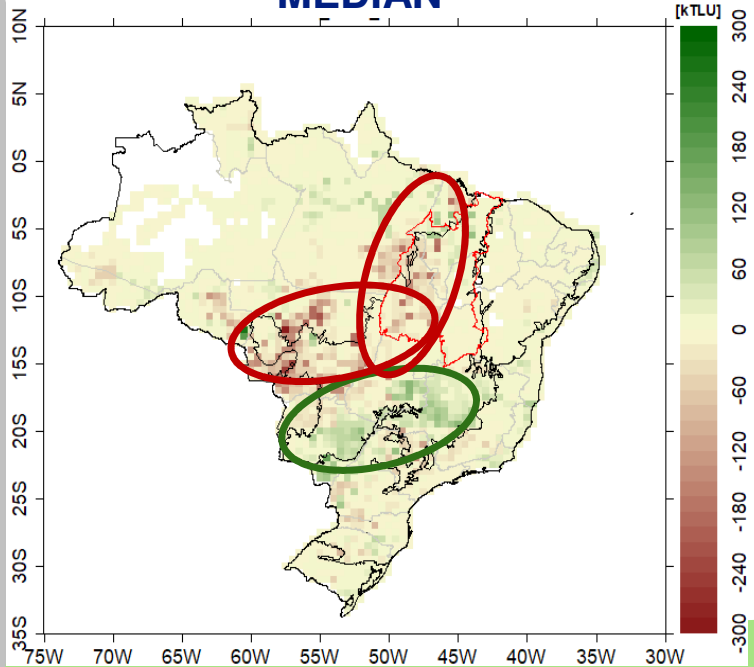
(SCENARIO-BASELINE)_{YEAR}



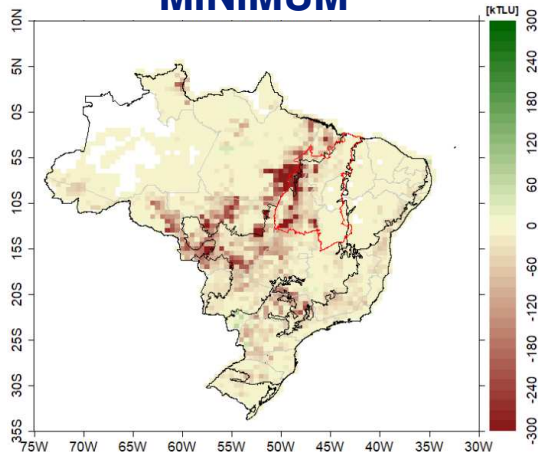
Production

MEDIAN

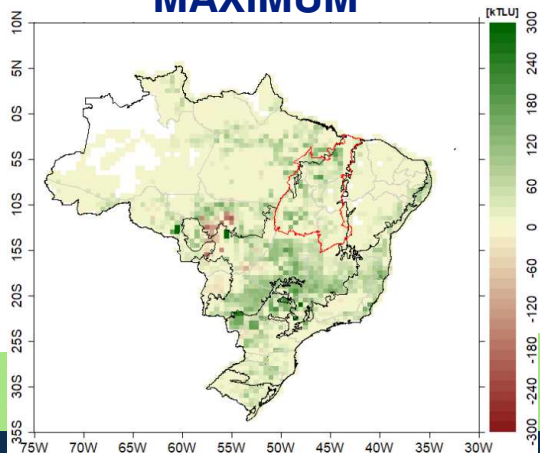
(SCENARIO - BASELINE) YEAR



MINIMUM



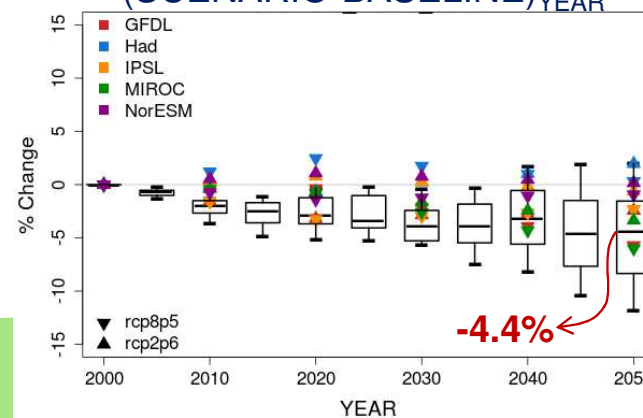
MAXIMUM



Scenarios for Grassland in 2050

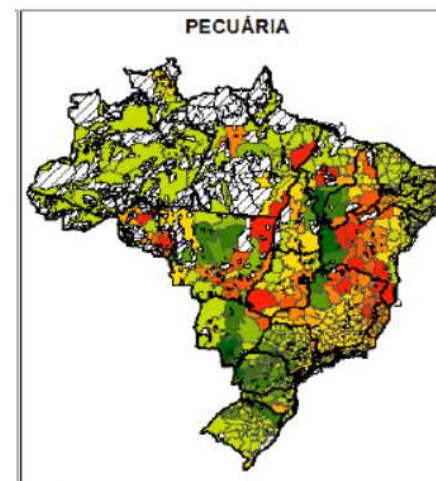
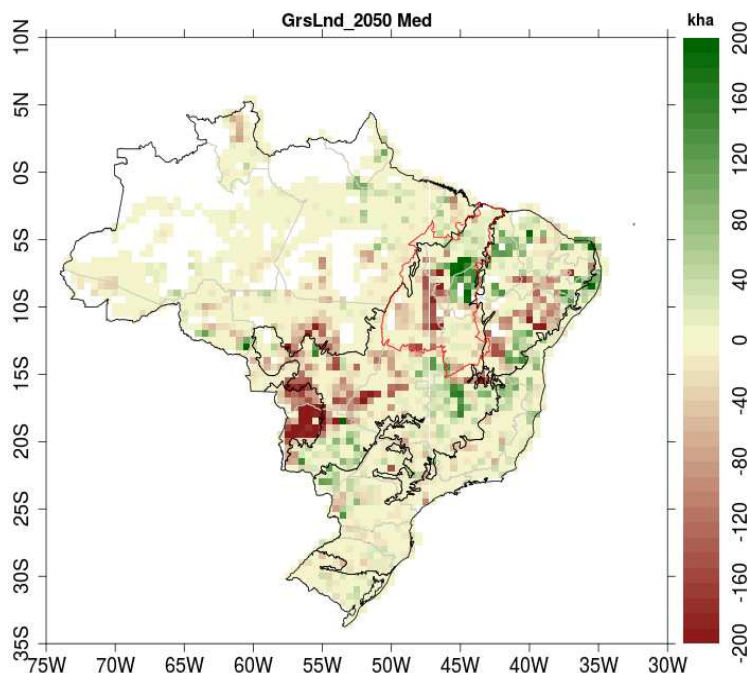
	Prod. (MTLU)	Annual growth (%a.a.)
Baseline [2000]	114.0	
Baseline [2050]	213.0	1.3%
Minimum [2050]	187.8	1.0%
Median [2050]	203.6	1.2%
Maximum [2050]	217.2	1.3%

(SCENARIO-BASELINE) YEAR

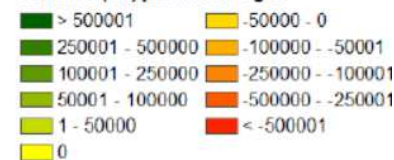




Comparison w/ previous results

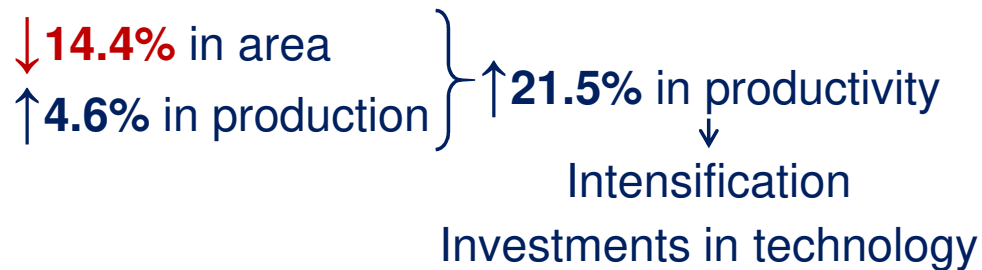


PECUÁRIA - Diferença de área entre os cenários (Ha) por microrregião



Conclusion

Soybean



Expansion toward South Cerrado

Decrease in Matopiba and South Brazil

- Redistribution of production among different Brazilian regions
- Internal and external demand can be met but will require additional productivity gains

Grassland



Expansion over the southern portion of South Cerrado and east Matopiba

Decrease along the transition between Cerrado and Amazon



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Next Steps

- In-depth analysis of intensification and adaptation processes (integrated production systems)
- Evaluation of changes in other cultures (corn, sugar cane, wheat, planted forests, etc)
- Emissions under different climate scenarios
- Irrigation potential – productivity versus water availability
- Inclusion of different governability framework (different levels of forest code reinforcement)
- Evaluation of other crop models
- Inclusion of climate change impact on planted forests



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Contact: marciatz@gmail.com

based on a decision of the German Bundestag