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

MARCIA ZILLI
INPE, BRAZIL
marciatz@gmail.com
Agriculture Session
07/08/2018

COLABORATORS: Marluce C. Scarabello, Aline C. Soterroni, Aline Mosnier, Hugo Valin, Alexandre X. Y. Carvalho & Fernando M. Ramos

Supported by:
Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
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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% area

  } investments in technology
- > 90% of the area is rainfed
- 36% of the national exportations
- Main exported commodities: sugar cane, soya, corn, and beef

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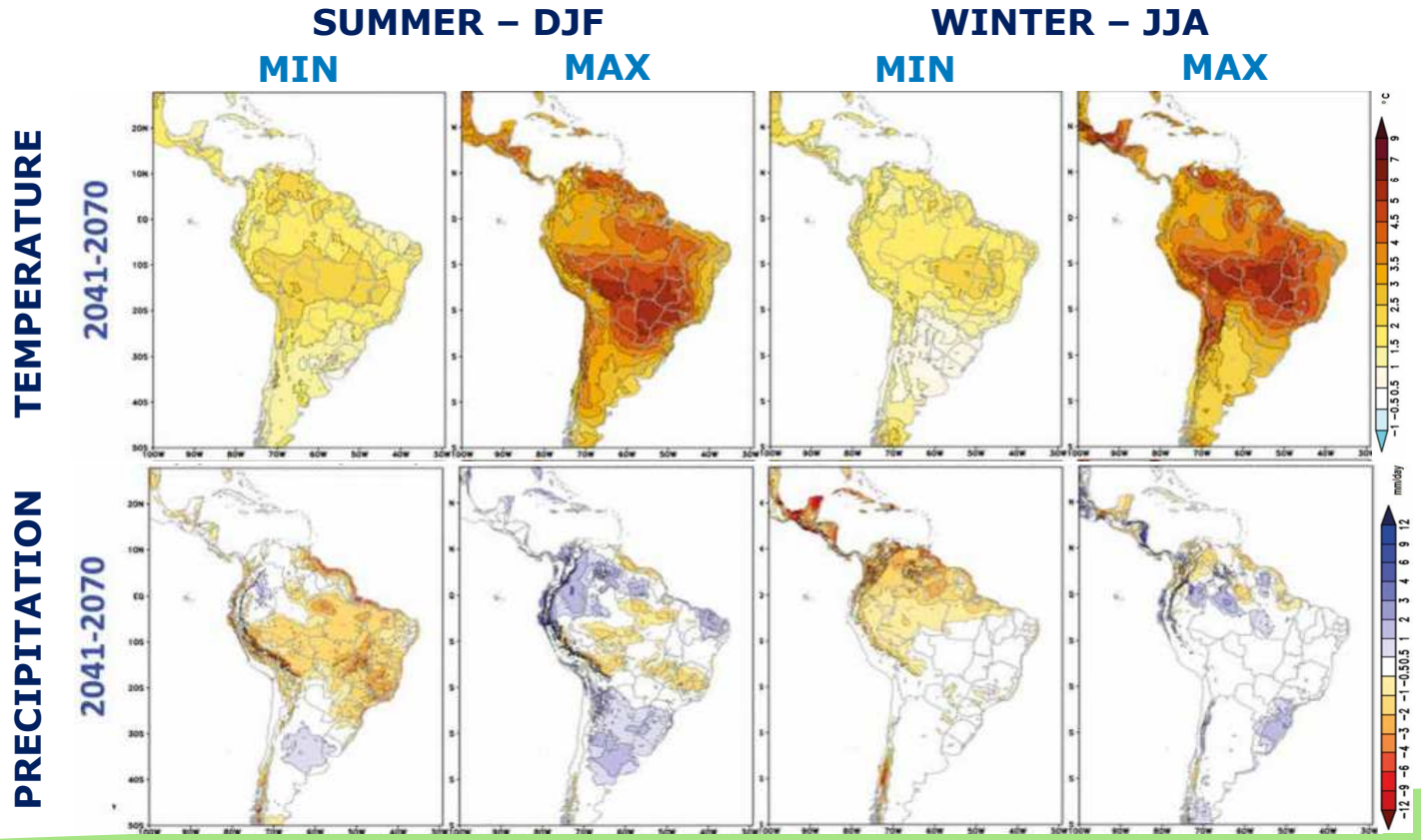
Future Climate Projections

- 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 is 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

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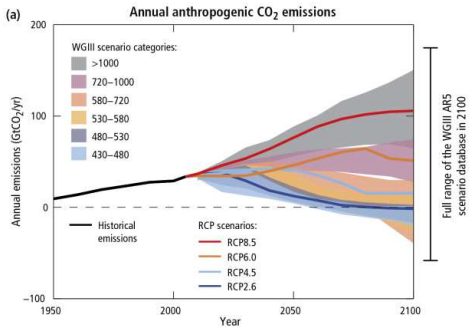
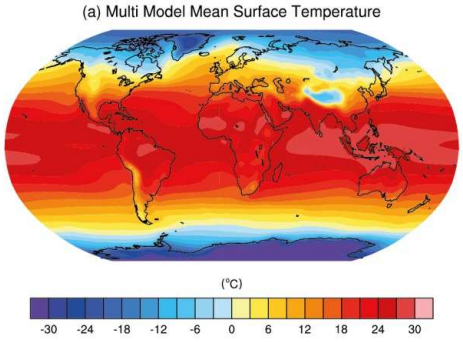
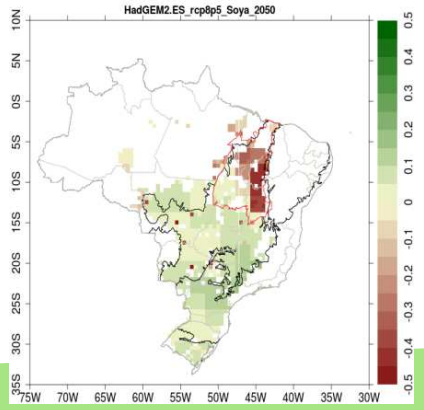
Impacts on Land Use Competition

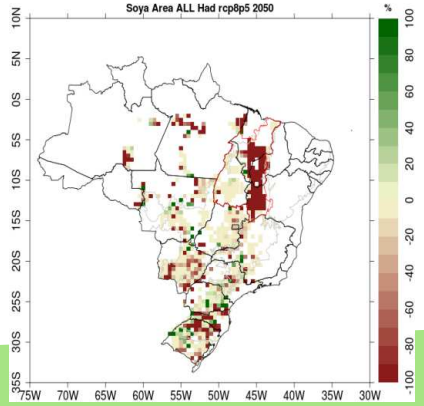
RESTORE+ BRAZIL MODELING GROUP

Anthropic Disturbances	Climatic Impacts	Biophysical Impacts	Economic Impacts
GHG Emissions and RCPs	Global Climate Model Projections	Global Crop Model: EPIC – ISIMIP	GLOBIOM Brazil
Radiative forcing and climatic scenarios	Global projections of temperature, precipitation, moistures	Global projections of crop productivity (18 crops + grass)	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

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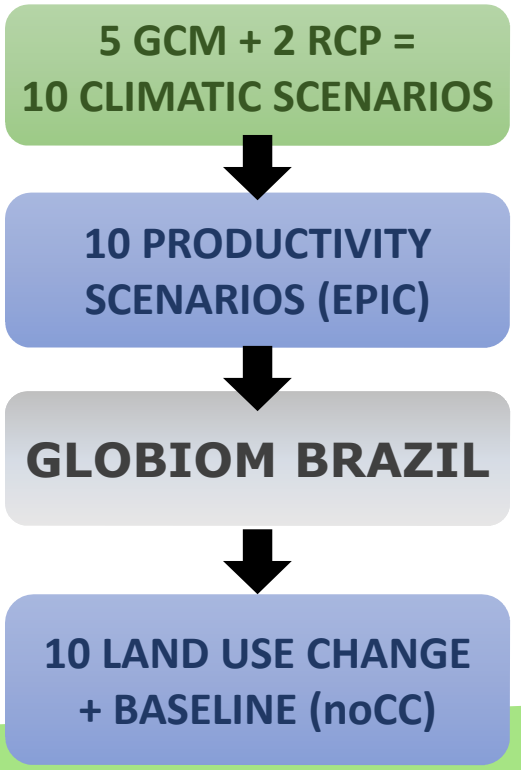
GLOBIOM BRAZIL

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)

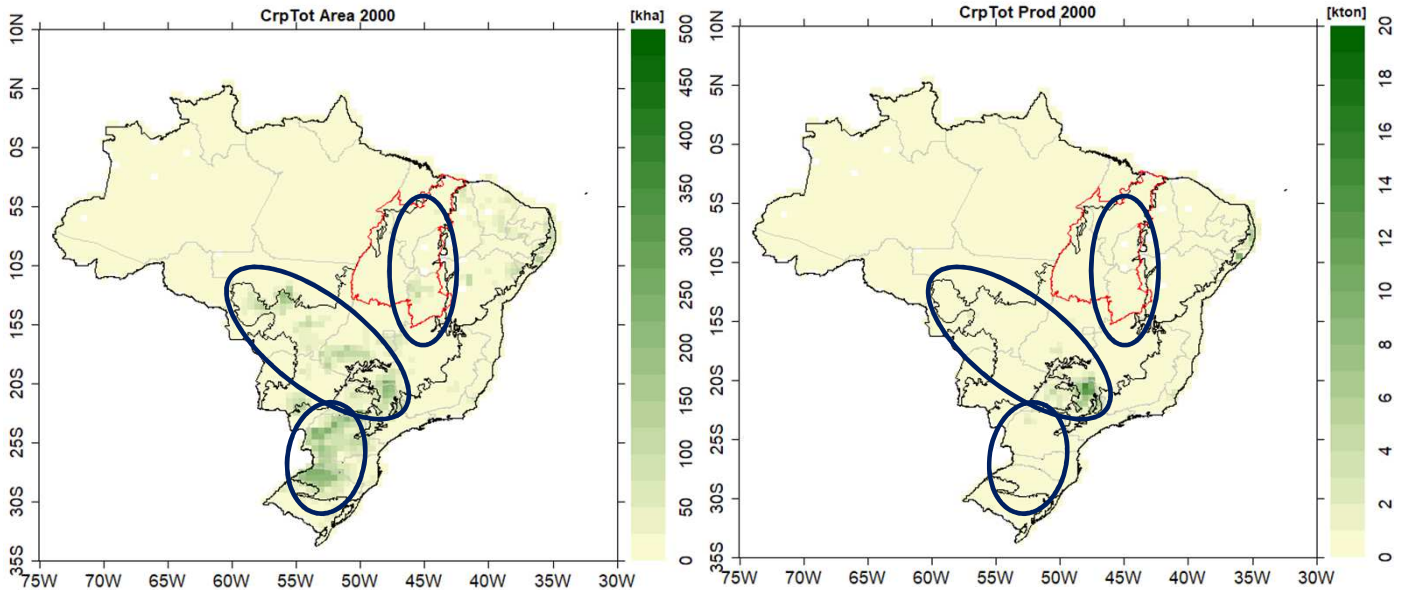
SCENARIOS:

- 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



Baseline Scenario Cropland 2050

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



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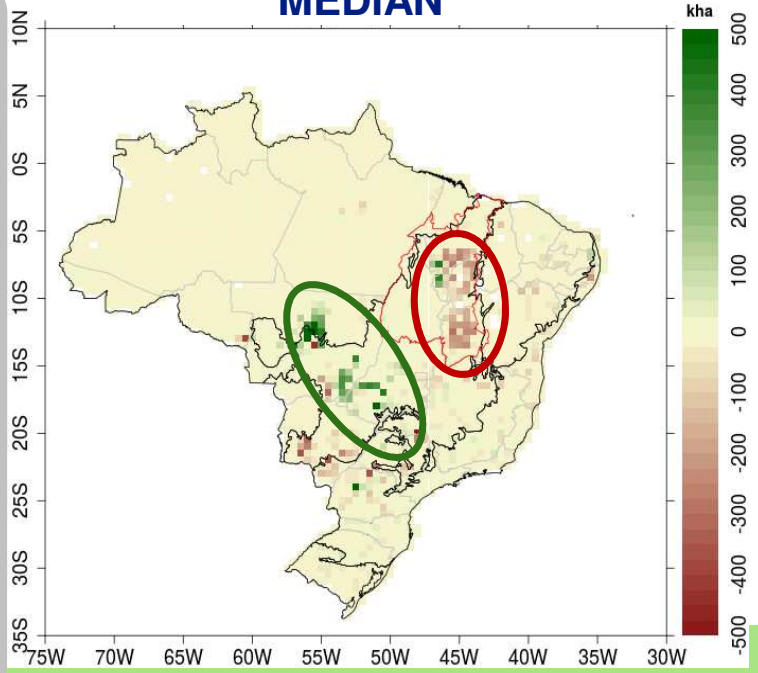
Scenarios for Cropland in 2050

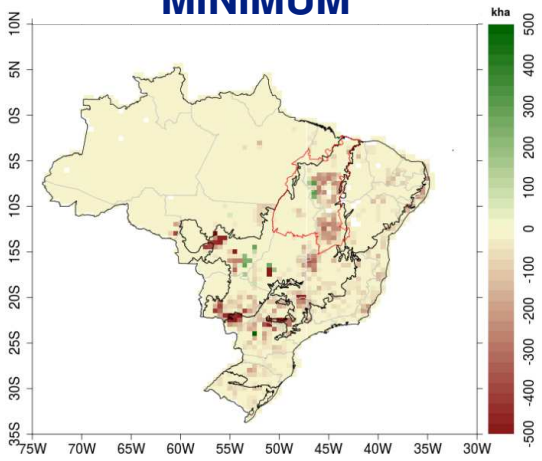
Area

(SCENARIO – BASELINE)$_{YEAR}$

MEDIAN



MINIMUM



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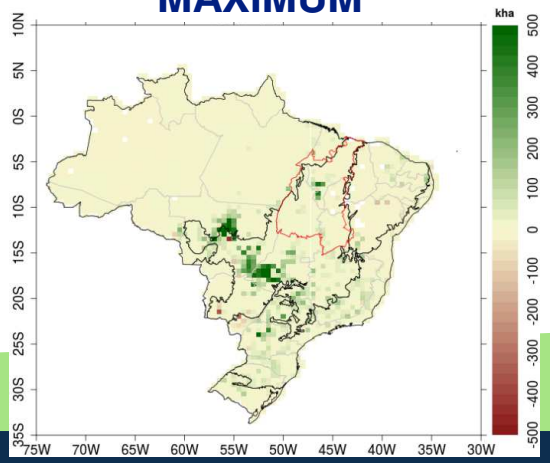
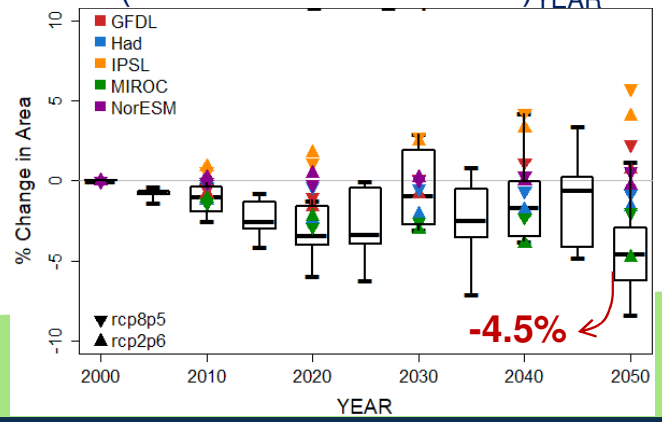


	Area (Mha)	Annual growth (%a.a.)
Baseline [2000]	42.6	
Baseline [2050]	117.9	2.2%
Minimum [2050]	108.1	2.0%
Median [2050]	112.5	2.1%
Maximum [2050]	119.3	2.2%

(SCENARIO-BASELINE)$_{YEAR}$



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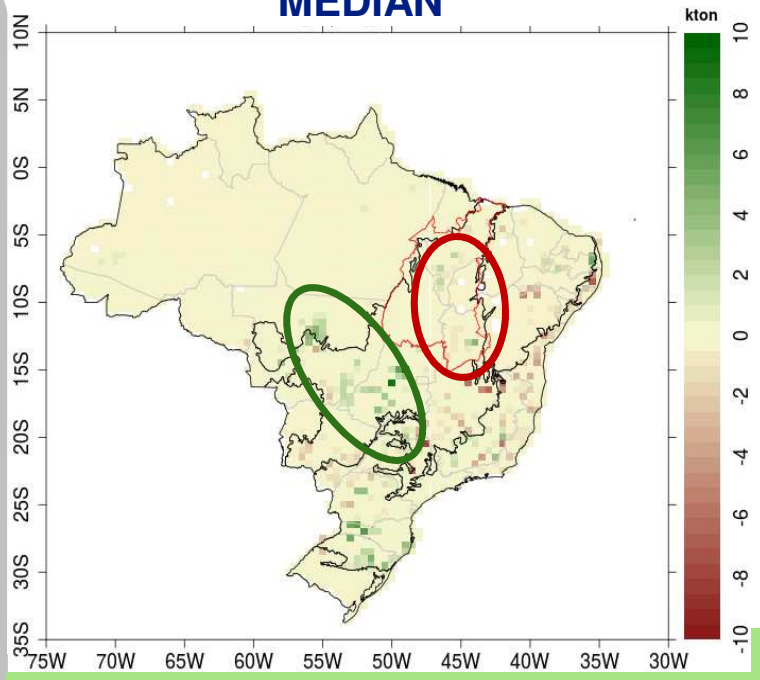
Scenarios for Cropland in 2050

Production

(SCENARIO – BASELINE)$_{YEAR}$

MEDIAN



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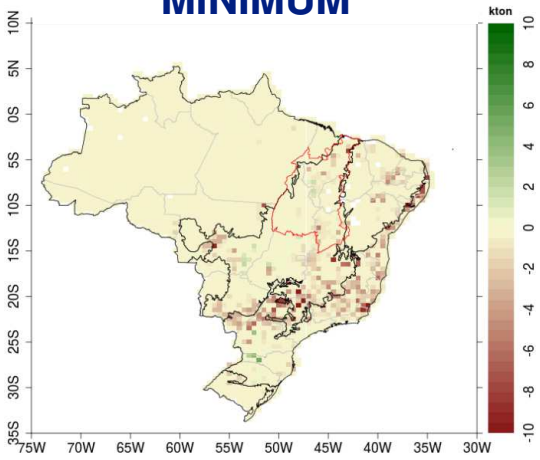

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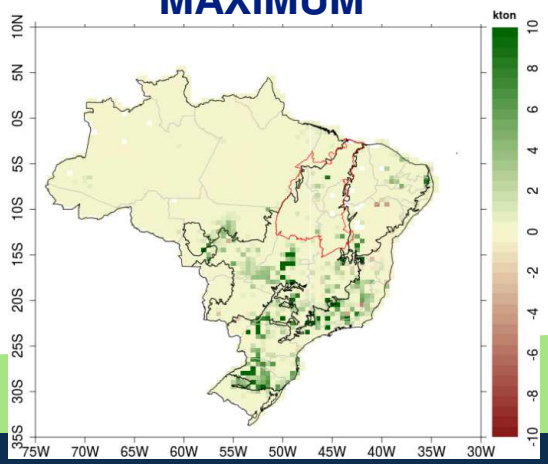
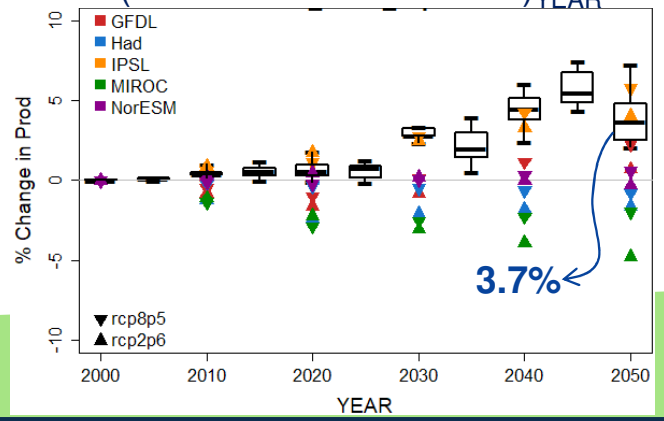


	Prod. (Mton)	Annual growth (%a.a.)
Baseline [2000]	435.7	
Baseline [2050]	1539.0	2.79%
Minimum [2050]	1571.2	2.84%
Median [2050]	1595.7	2.88%
Maximum [2050]	1651.3	2.95%

(SCENARIO-BASELINE)$_{YEAR}$



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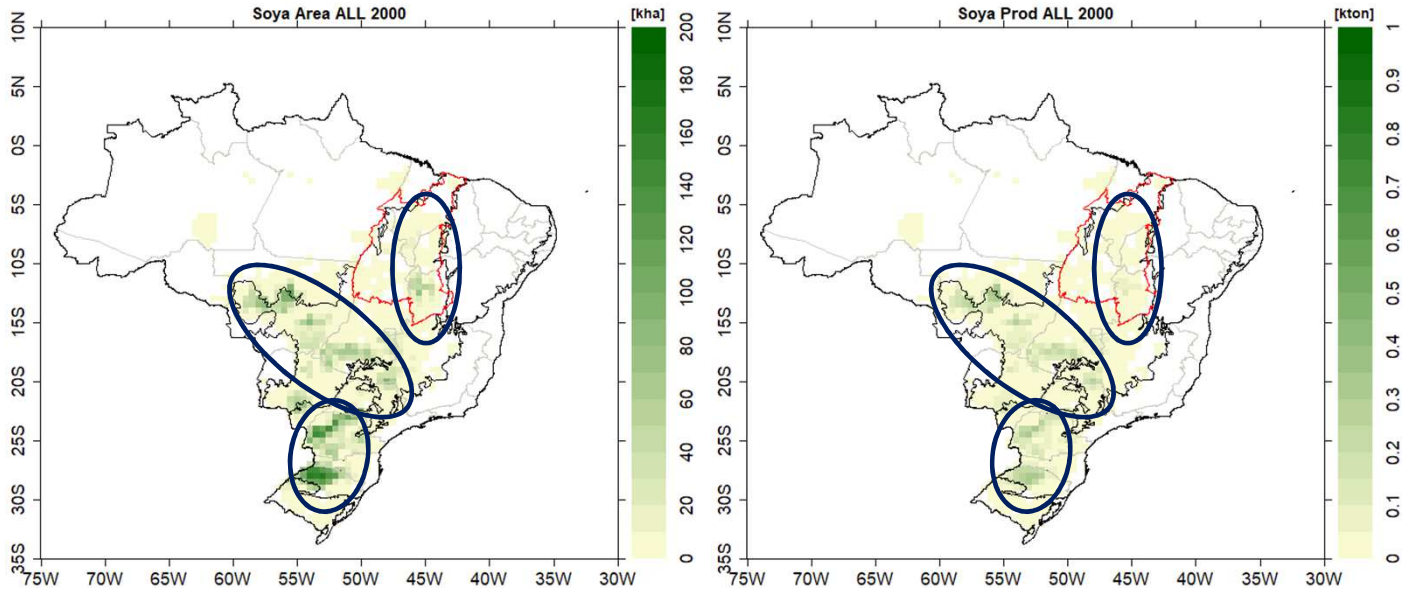
Baseline Scenario Soyland 2050

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



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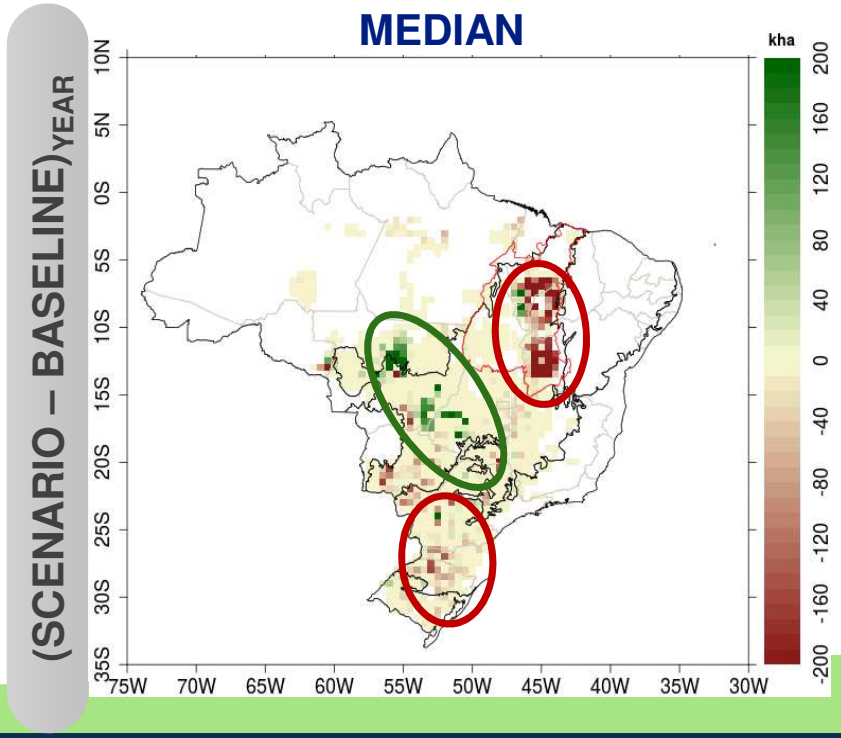
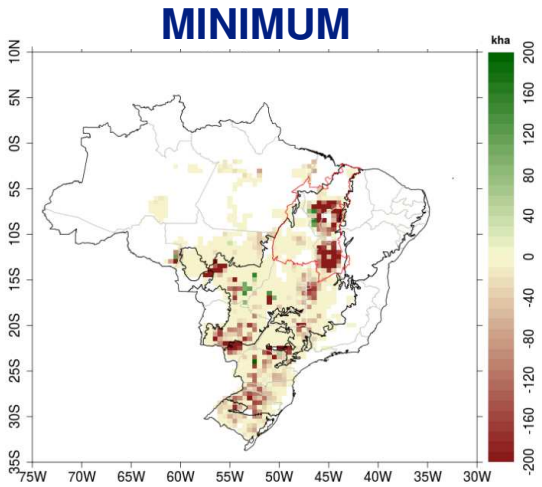
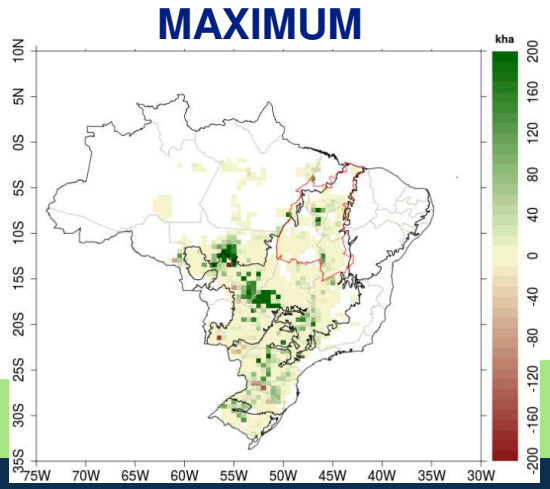
Scenarios for Soyland in 2050

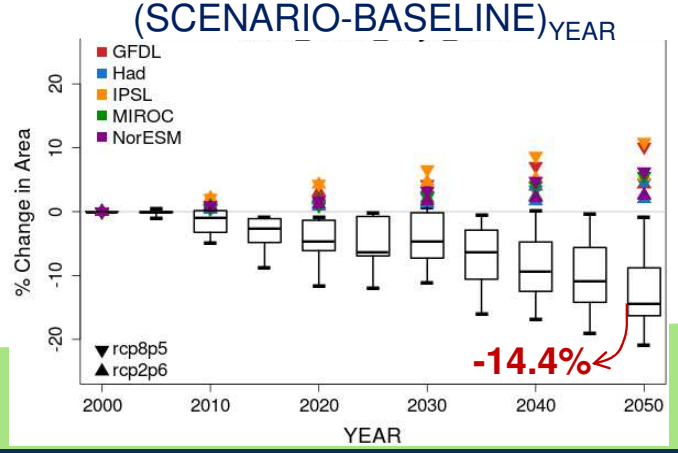
Area







	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%



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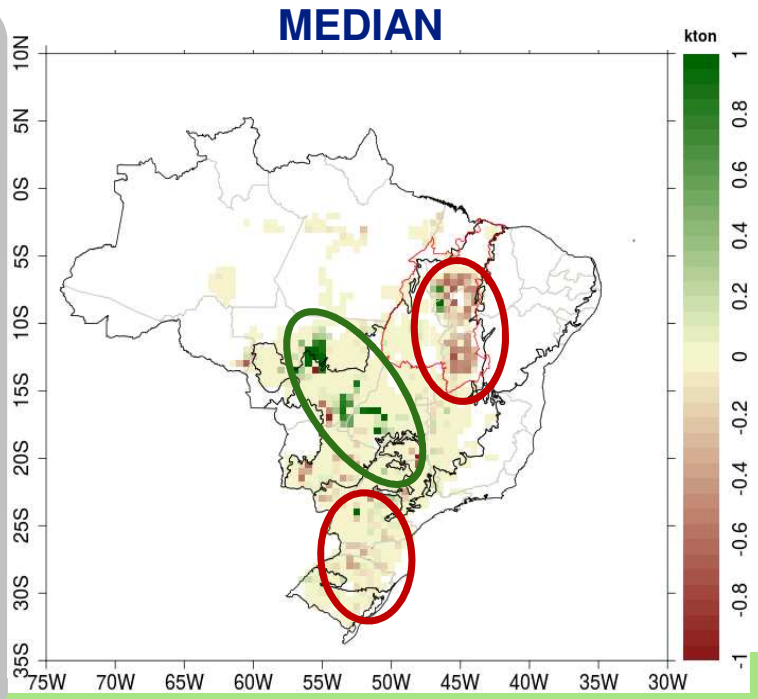
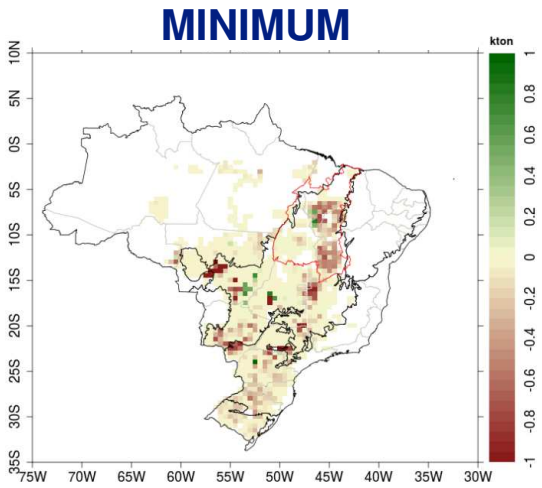
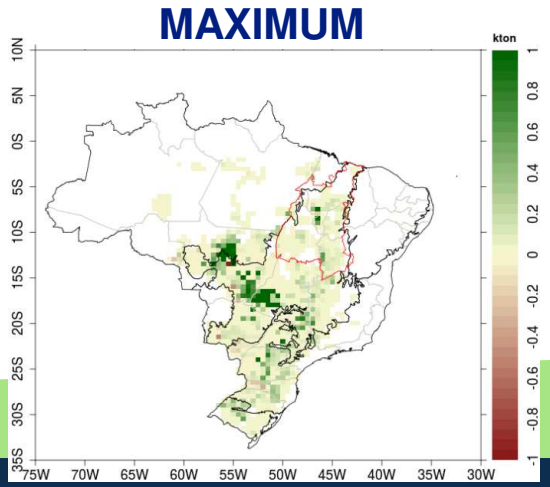
Scenarios for Soyland in 2050

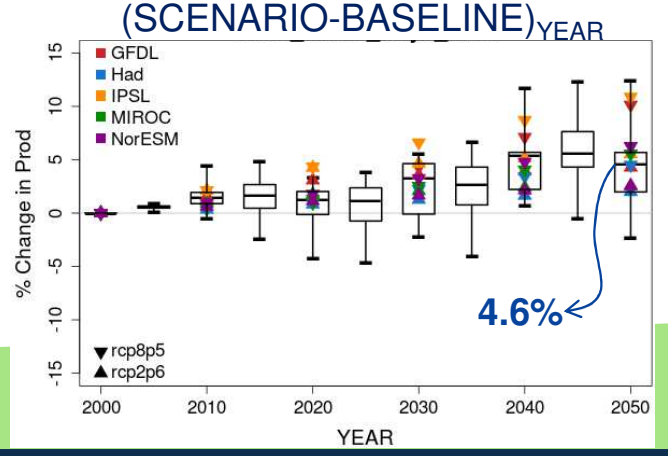
Production







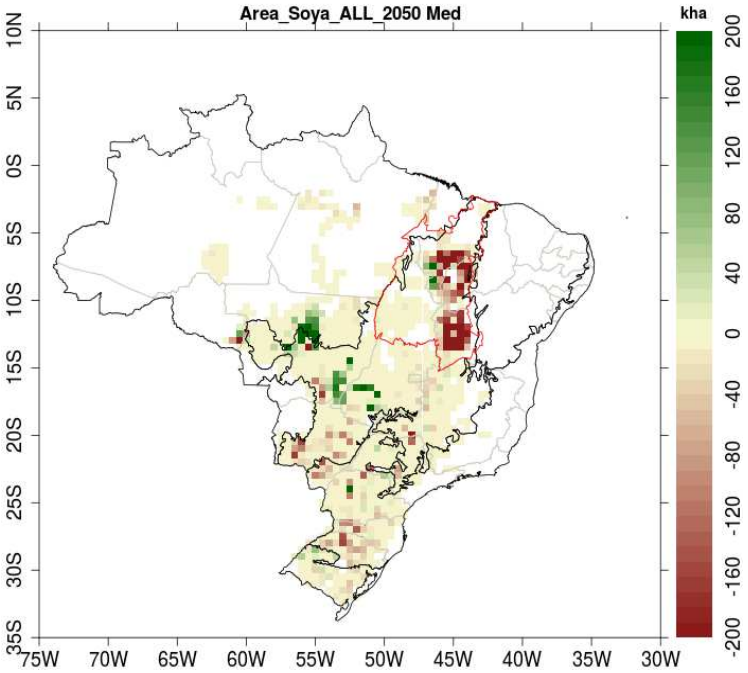
	Prod. (Mton)	Annual growth (%a.a.)
Baseline [2000]	32.7	
Baseline [2050]	173.0	3.91%
Minimum [2050]	168.9	3.85%
Median [2050]	180.8	4.02%
Maximum [2050]	194.5	4.18%

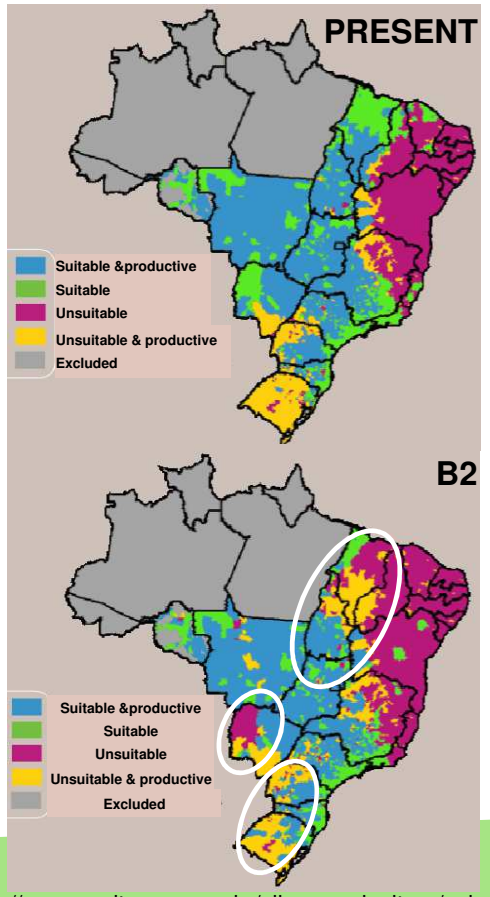


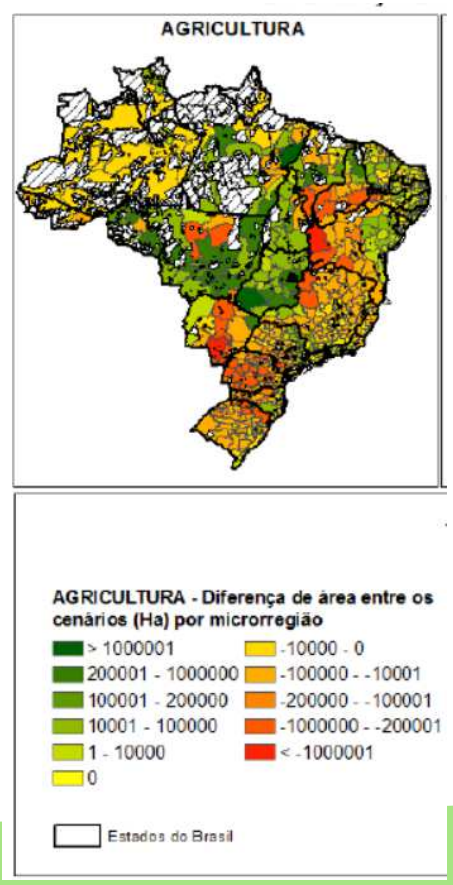
GEO GROUP ON EARTH OBSERVATIONS

@GEOSEC2025
www.earthobservations.org

Comparison w/ previous results







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

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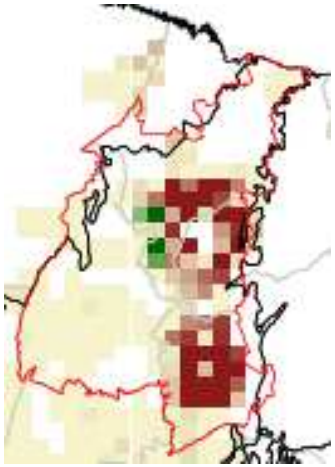
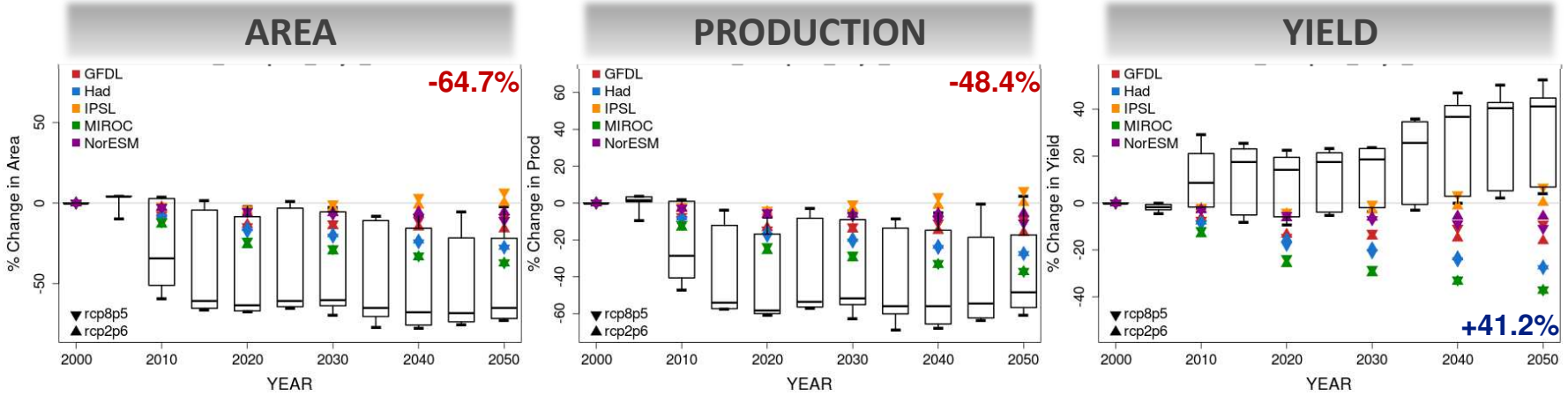
Scenarios for Soyland in 2050

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%

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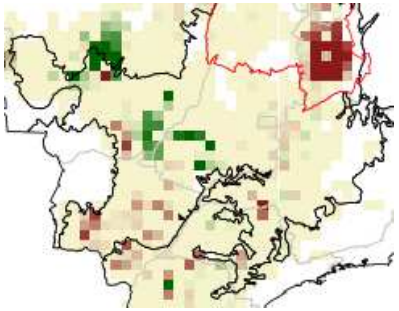
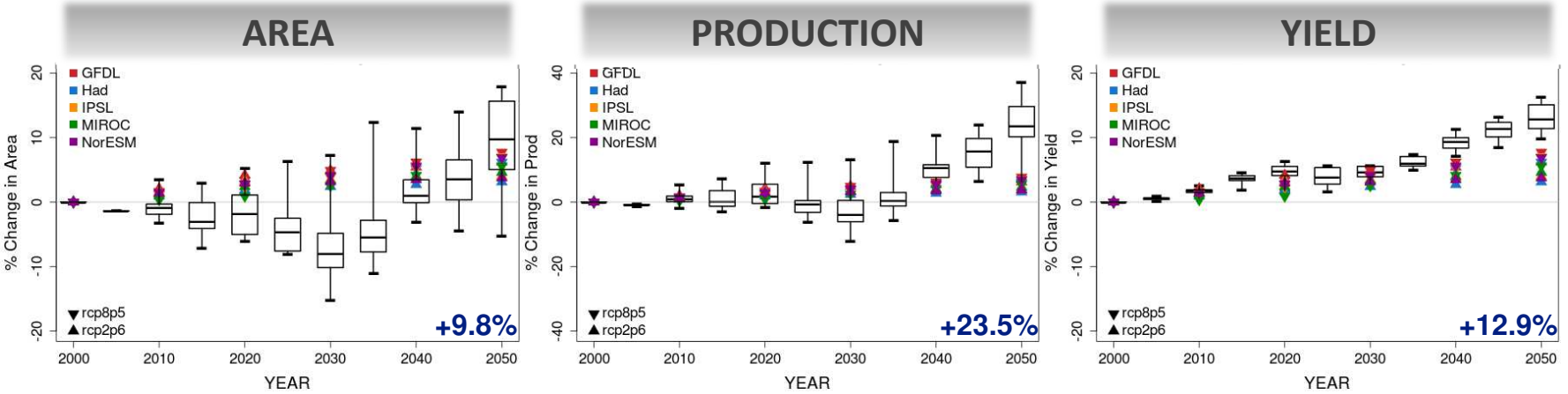
SOUTH CERRADO





	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%

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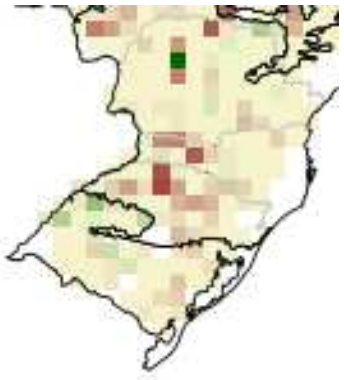
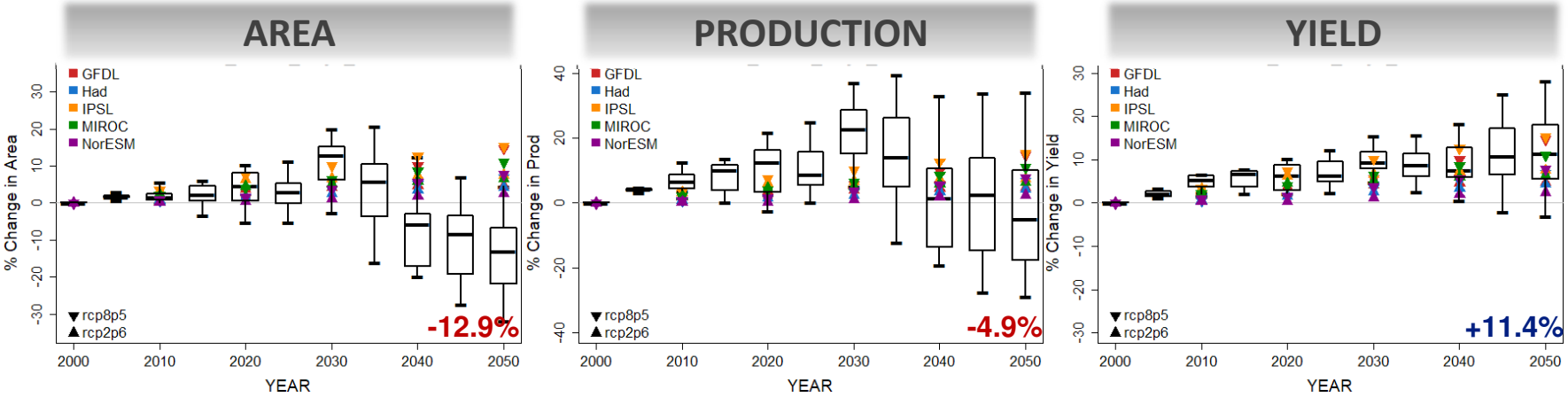
SOUTH BRAZIL

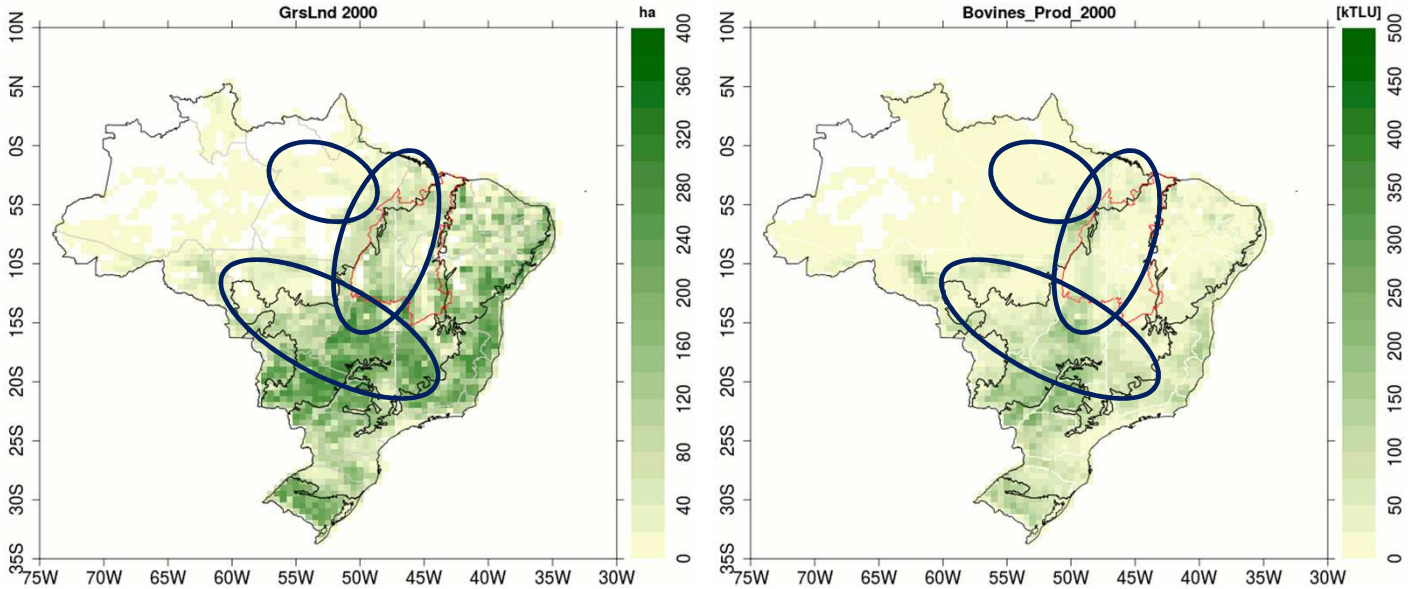




	Area (Mha)	Annual growth (%a.a.)	Prod (Mton)	Annual Growth (%a.a)	Yield (ton/ha)	Annual Growth (%a.a)
Baseline [2000]	6.0		11.8		2.0	
Baseline [2050]	11.5	1.48%	31.7	2.26%	2.8	0.69%
Minimum [2050]	7.8	0.75%	22.5	1.67%	2.7	0.63%
Median [2050]	10.0	1.25%	30.1	2.24%	3.1	0.91%
Maximum [2050]	12.0	1.60%	42.5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

Baseline Scenario Grassland 2050

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



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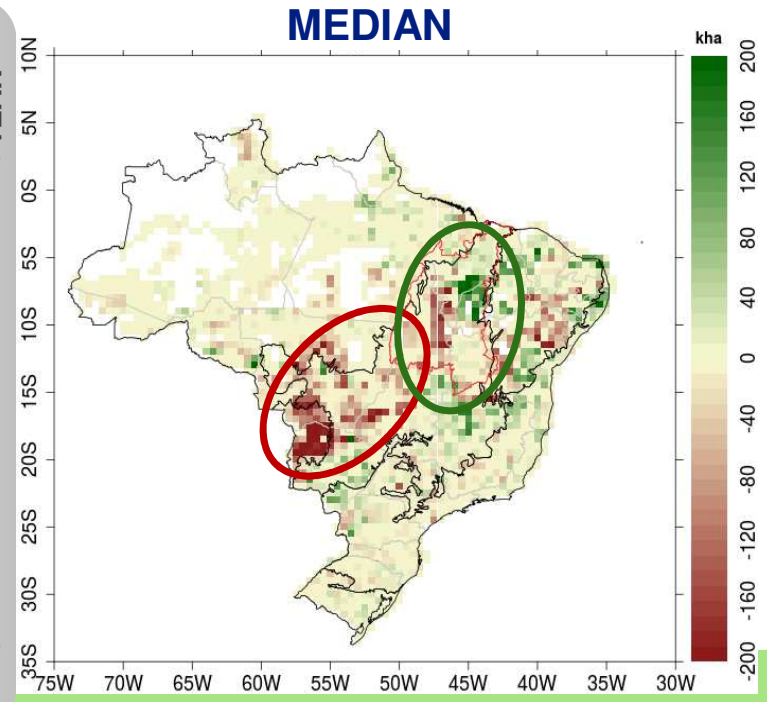
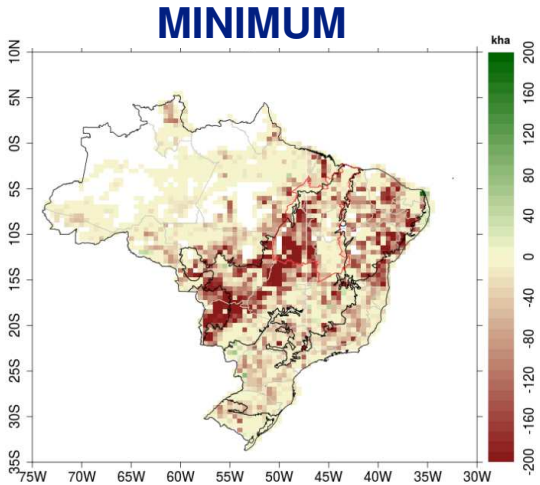
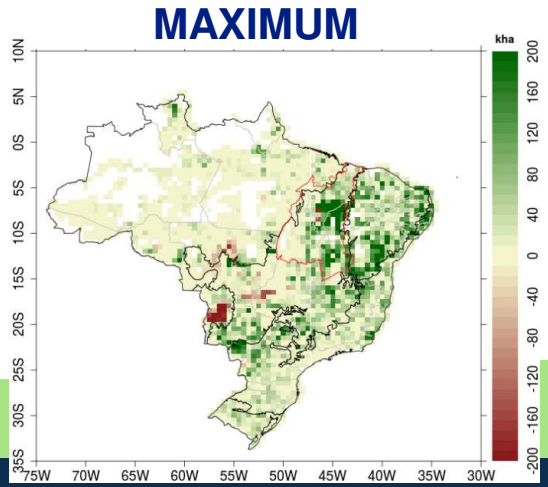
Scenarios for Grassland in 2050

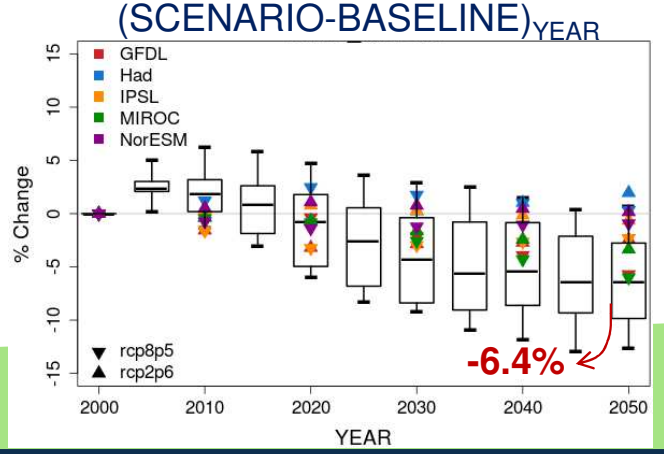
Area







	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%



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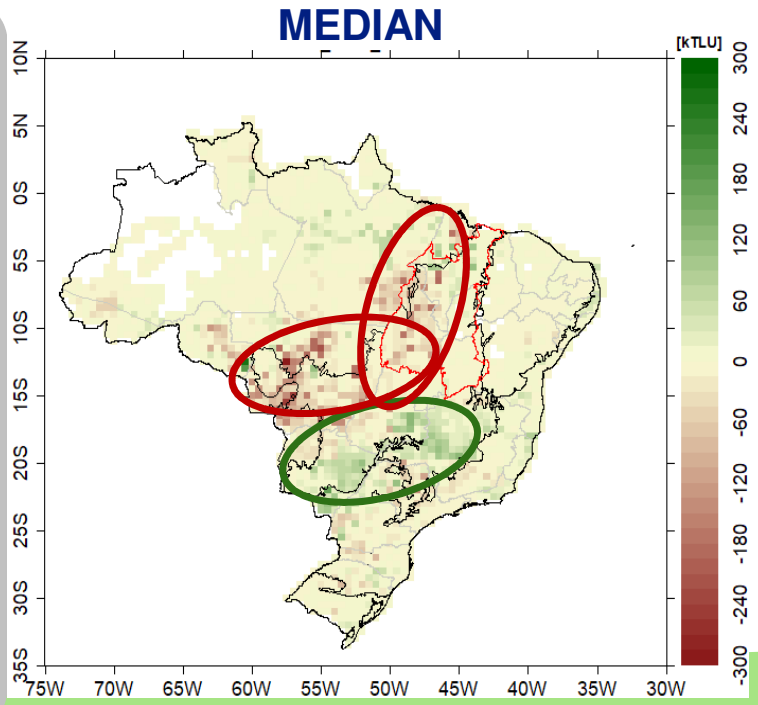
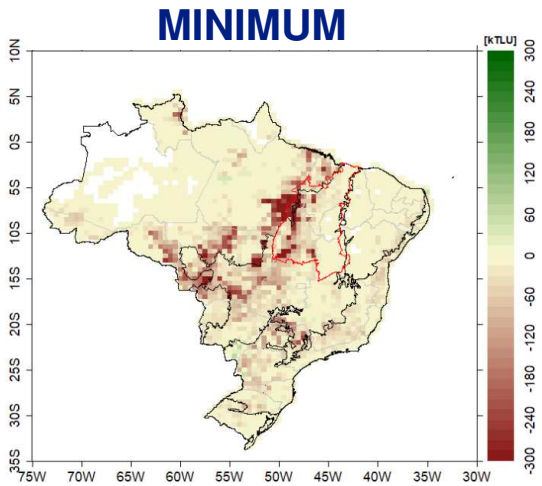
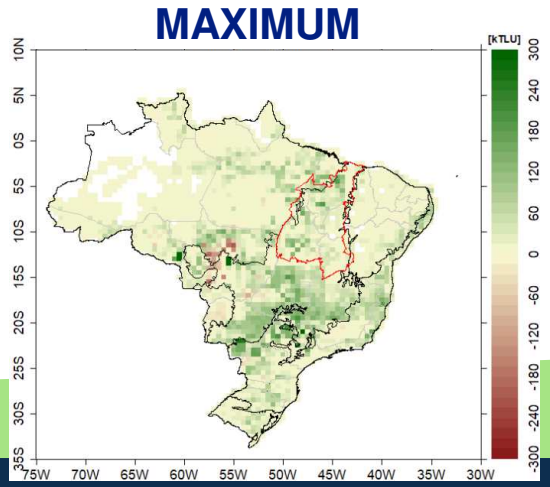
Scenarios for Grassland in 2050

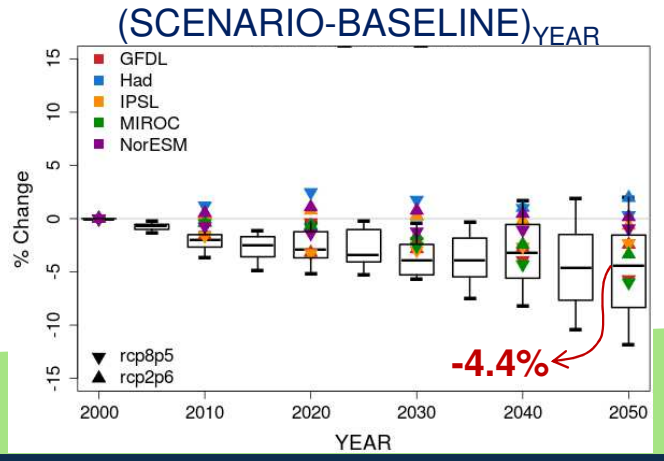
Production







	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%



GEO GROUP ON EARTH OBSERVATIONS

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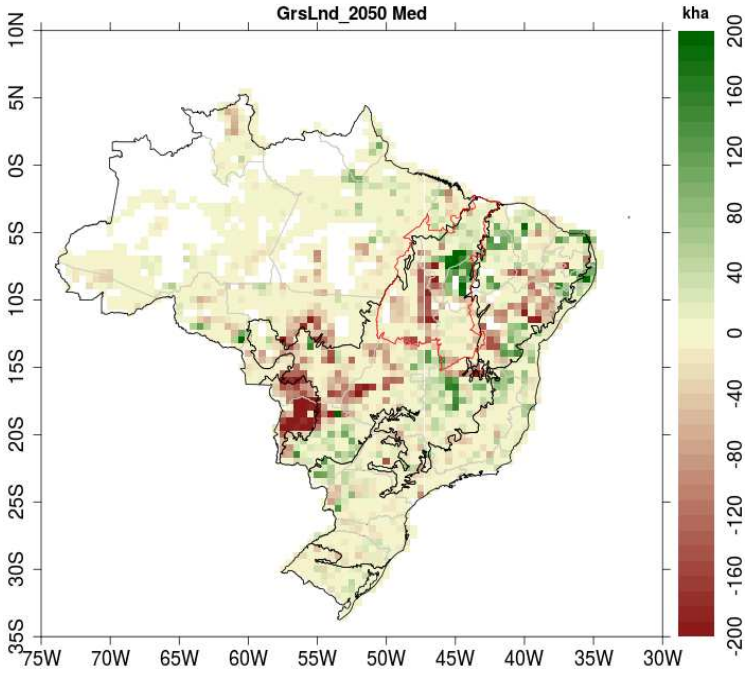
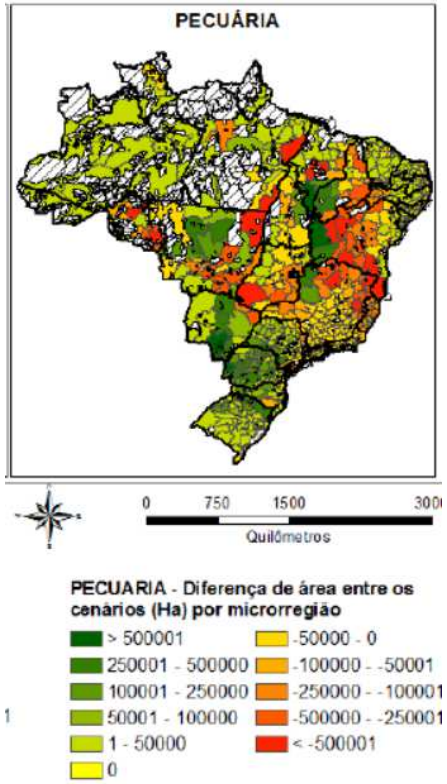
Comparison w/ previous results





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Conclusion

Soybean

↓**14.4%** in area
↑**4.6%** in production
} ↑**21.5%** in productivity

↓
Intensification
Investments in technology

Expansion toward South Cerrado

Decrease in Matopiba and South Brazil

Grassland

↓**6.4%** in area
↓**4.4%** in production
} No significant change in intensity above the baseline

Expansion over the southern portion of South Cerrado and east Matopiba

Decrease along the transition between Cerrado and Amazon

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

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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Thanks!

Contact: marciatz@gmail.com

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