Climate change scenarios in the sub-tropical Brazil: possible adaptations through Research and Development of crop germplasm

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Embrapa Temperate climate, Embrapa

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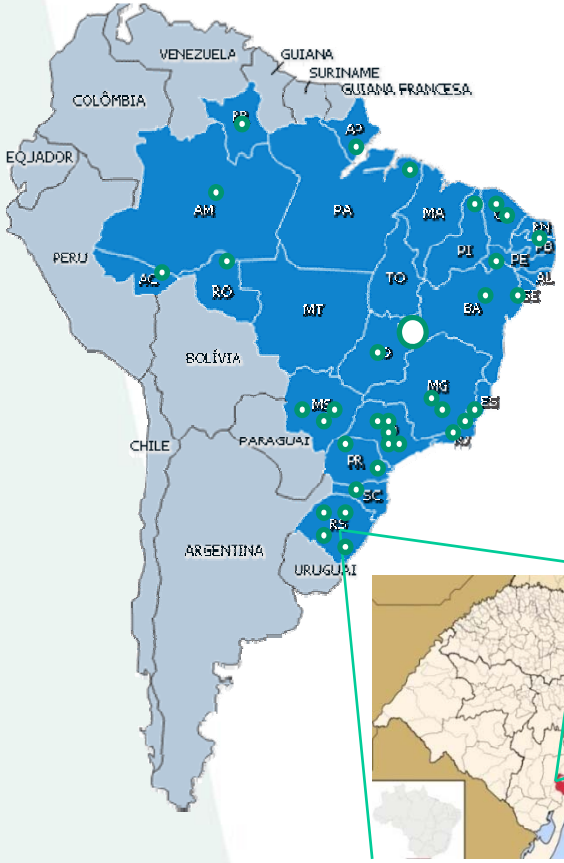
Clima Temperado

EMBRAPA - Brazilian Agricultural Research Agency



Embrapa Temperate climate, Embrapa

Pelotas-RS (31°40'S; 52°26'W)

Professional preparation:

Atmospheric Science, B.S. 2003.

Atmospheric Science, M.S. 2005.

Agrometeorology, Ph.D. 2010.

Appointments

2010-2012. Associate Professor; CEFET/RJ.

2012-Present. Embrapa.

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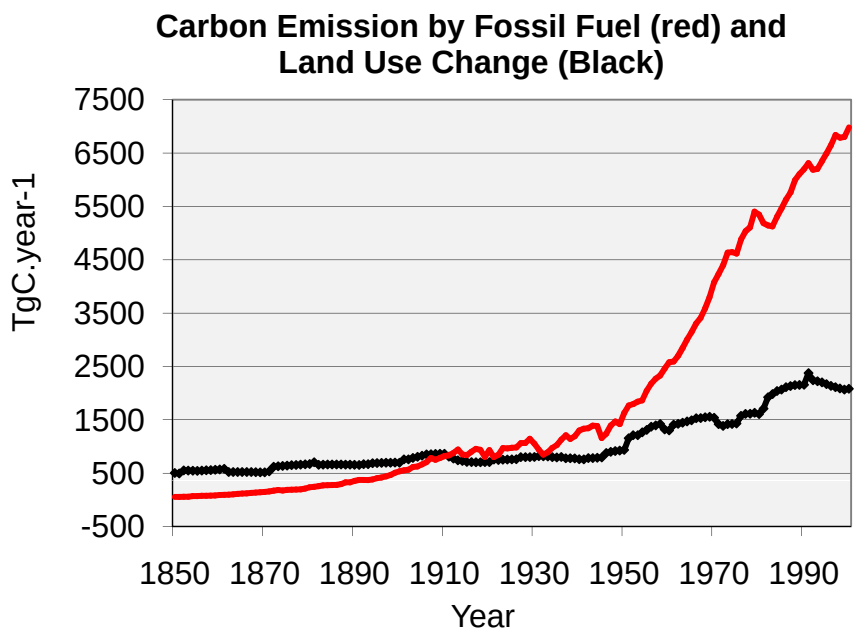
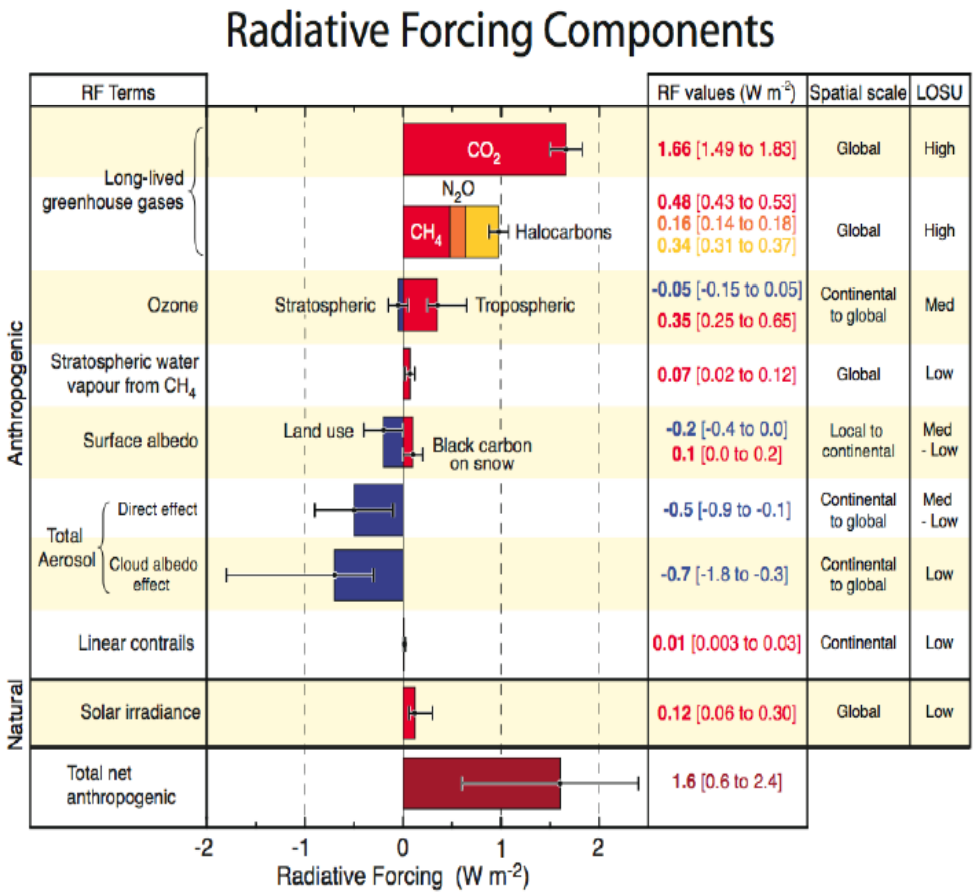
Climate Change

Drivers





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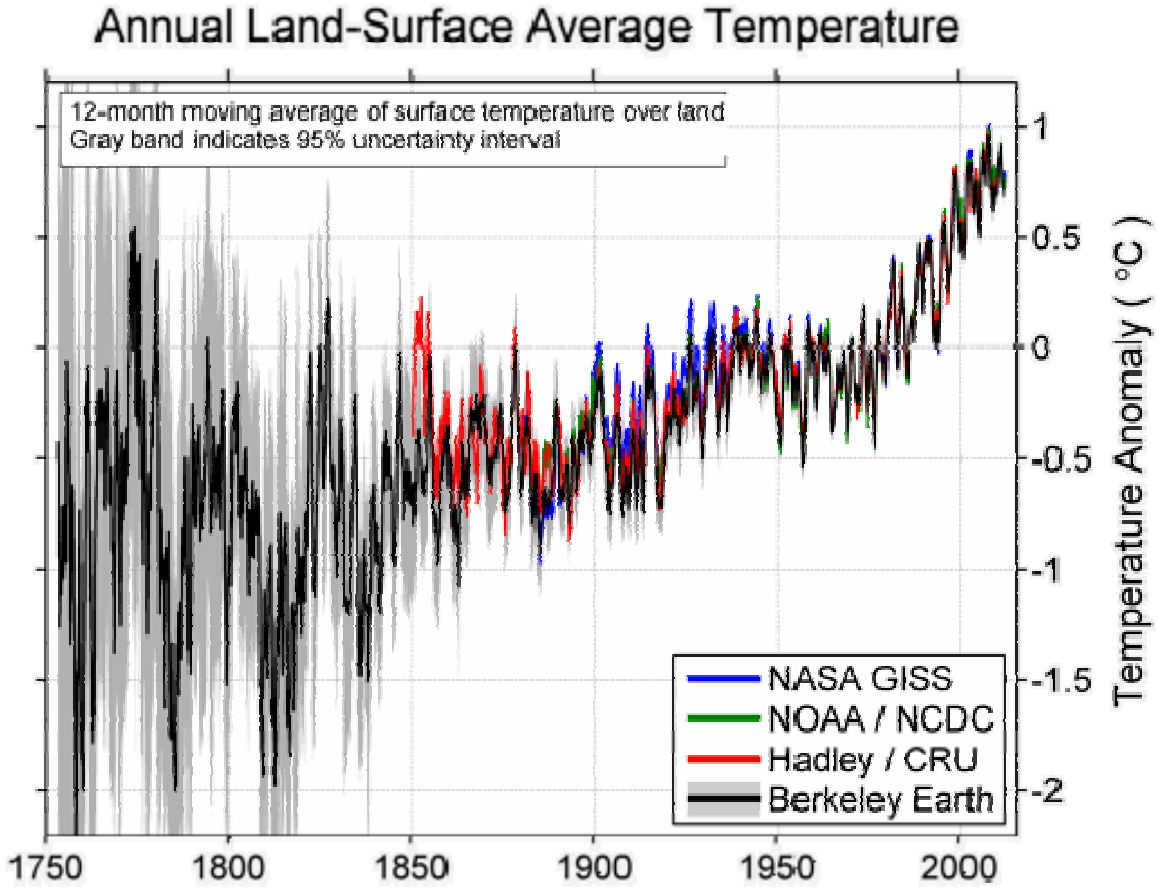
Climate Change - GLOBAL

Evidences:

Berkeley Earth Team
Surface Temperature trends



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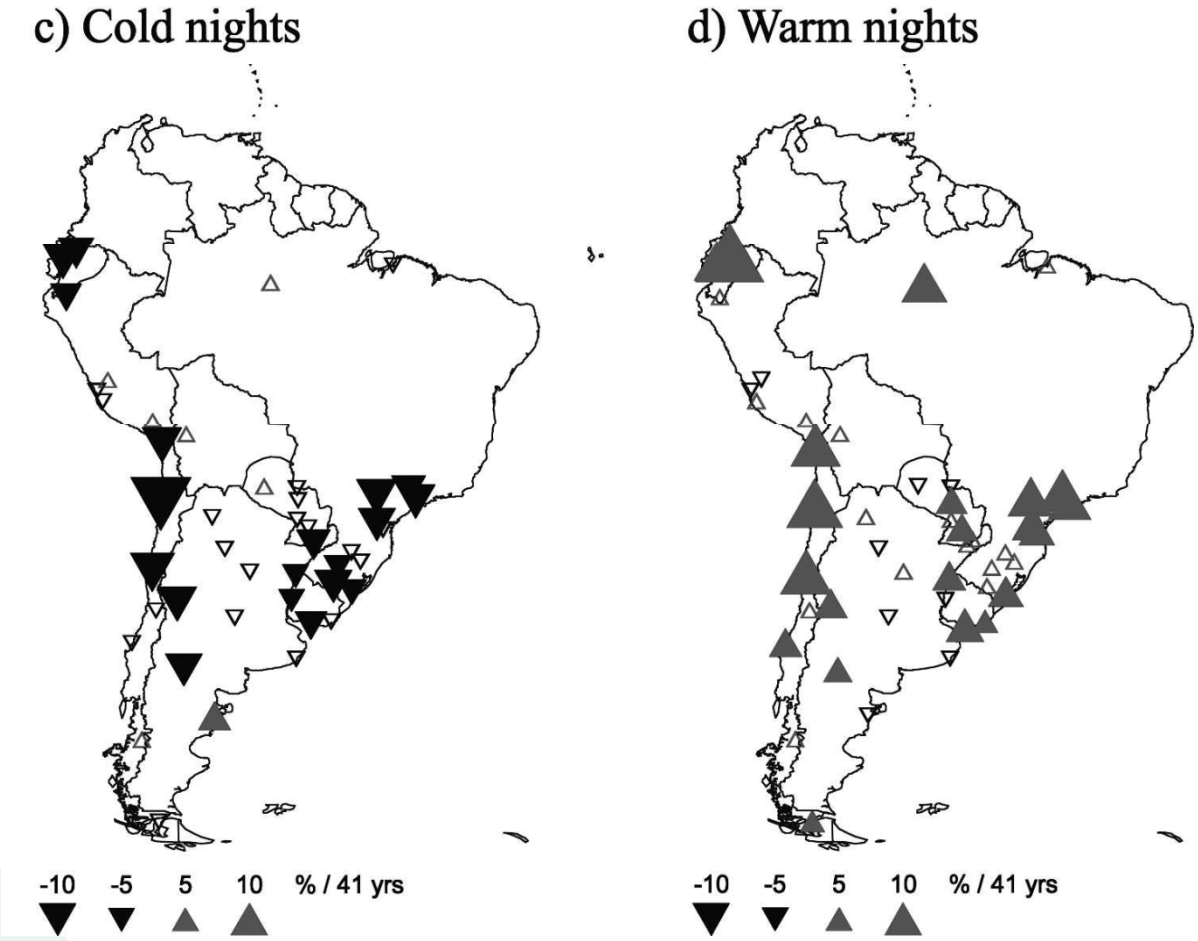
Climate Change - REGIONAL

Evidences:

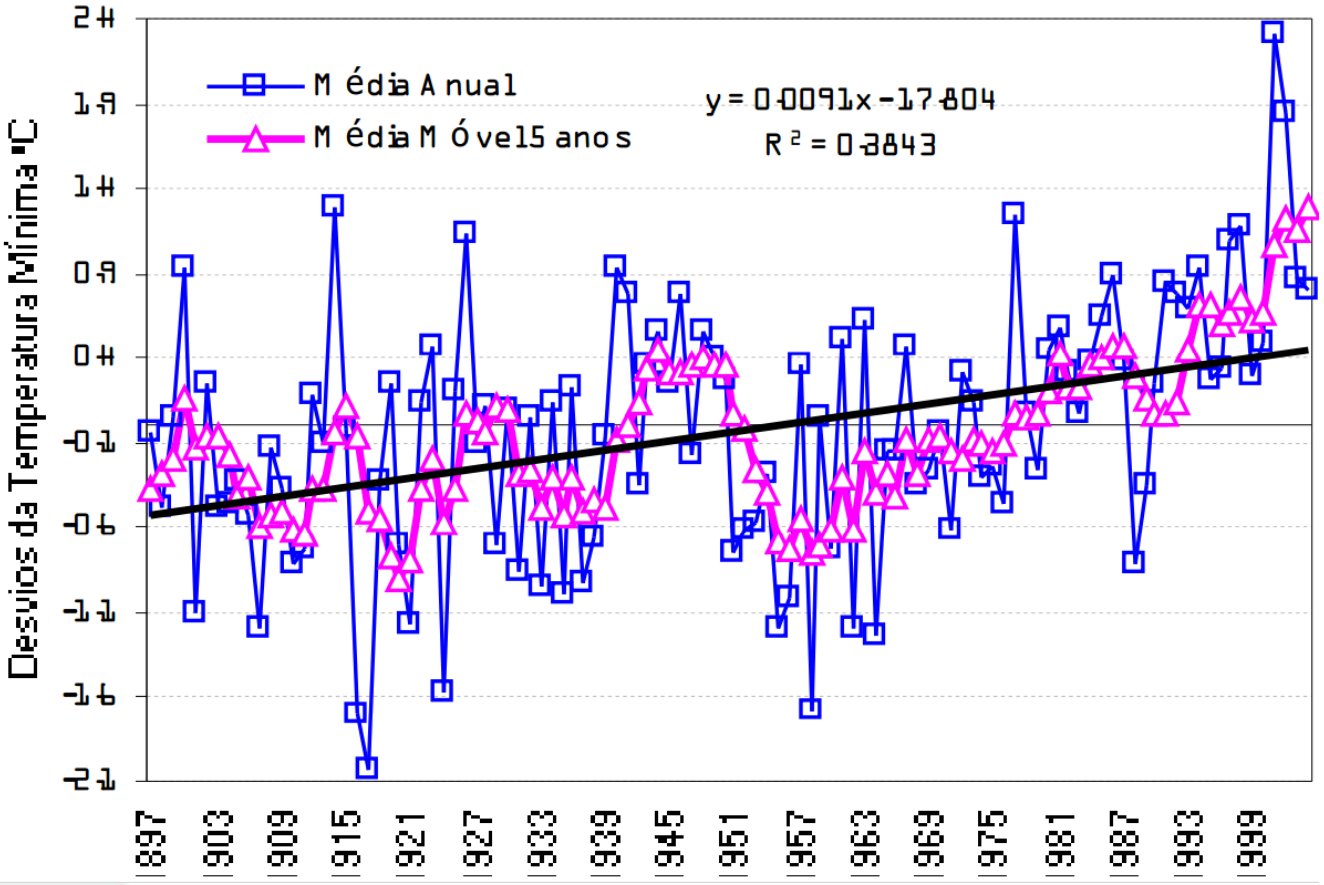
- **Cold nights: Percentage of days with Tmin 10th percentile %**
- **Warm nights: Percentage of days with Tmin 90th percentile %**



Climate Change - LOCAL

Evidences:

» Minimum Temperature trend over Pelotas (Embrapa's Station)



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Climate Change and the Agriculture

Climate change mitigation and adaptation

Mitigation (of climate change)		Adaptation
A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHG).		Initiatives to reduce the vulnerability of natural and human systems against actual or expected climate change effects.
Driver (Climate Change)	Mitigation	Adaptation
		

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Climate Change Mitigation

Mitigation: Embrapa supports the “Program for Low Carbon Agriculture (ABC)”

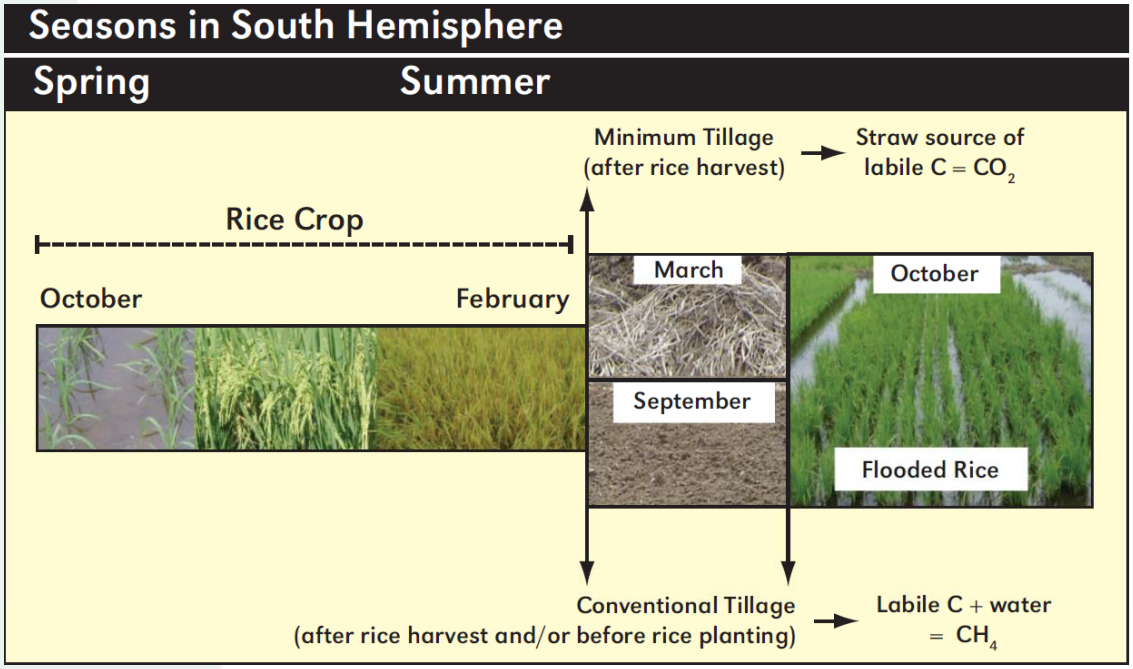
Goals: promote the adoption of technologies that reduce GHG emissions in agriculture

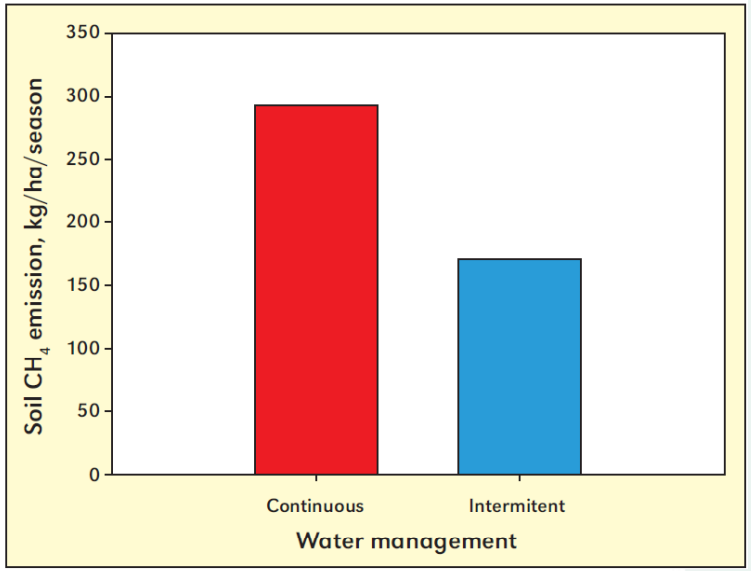
Ex. No-Tillage System

- **Minimizes fossil fuel use**
- **Increase soil C**

Climate Change Mitigation

Mitigation: ex. Conventional tillage and minimum tillage technologies adopted by southern Brazilian farmers.





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Climate Change Mitigation

Mitigation: Reduce fossil fuel use

Biofuel: Ethanol & Biodiesel	
•Ethanol of first generation	**•Ethanol of second generation**
Sugarcane  Sucrose	Sugarcane  Bagasse
Rice (giant)  Starch	Rice  Husk/straw

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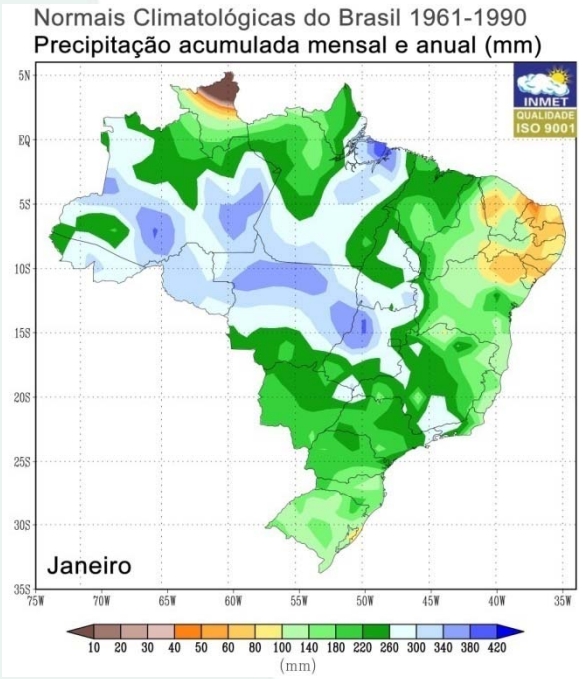
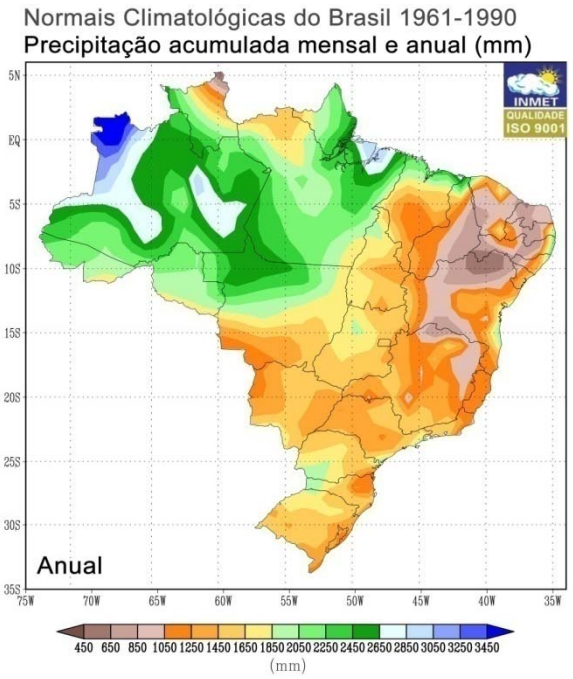
Climate Change Adaptation

Research and Development on crop germplasm

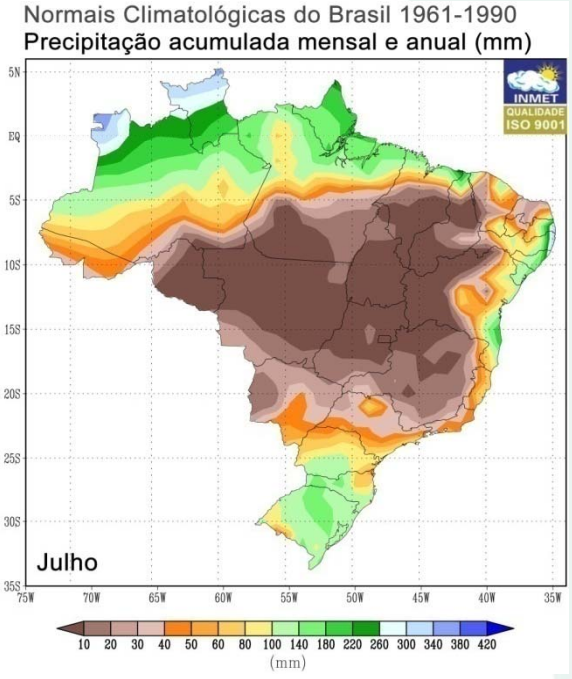
January



Annual



July



Climate Over Brazil - Precipitation

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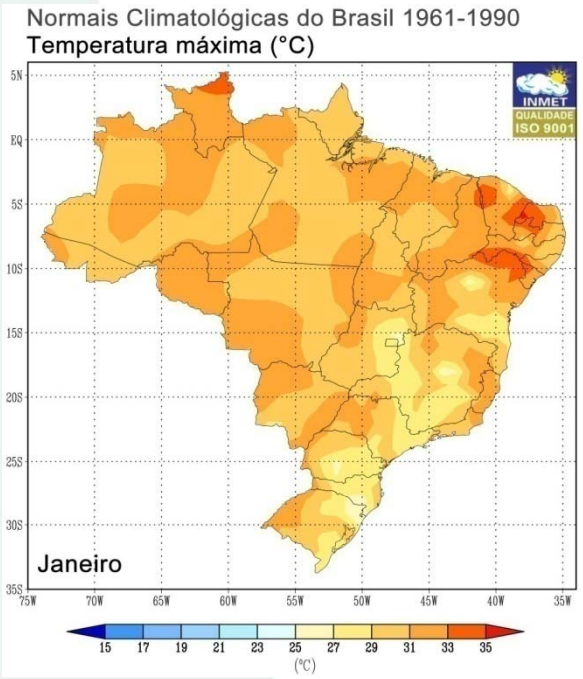
Climate Change Adaptation

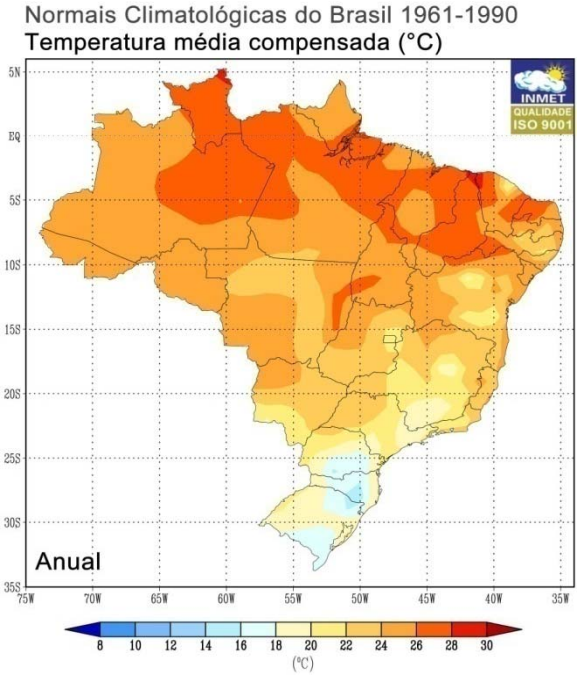
Research and Development on crop germplasm

Ex. Potato breeding for tropical and subtropical ecosystems of Brazil

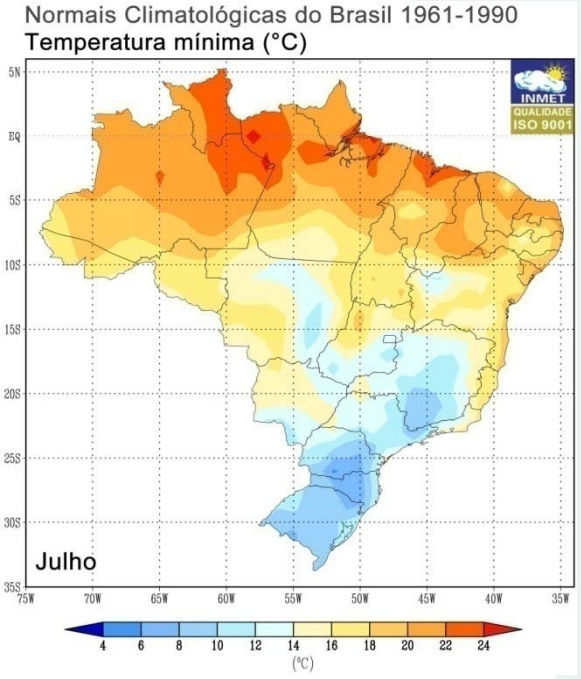
January (max)



Annual (avg)



July (min)



Climate Over Brazil - Precipitation

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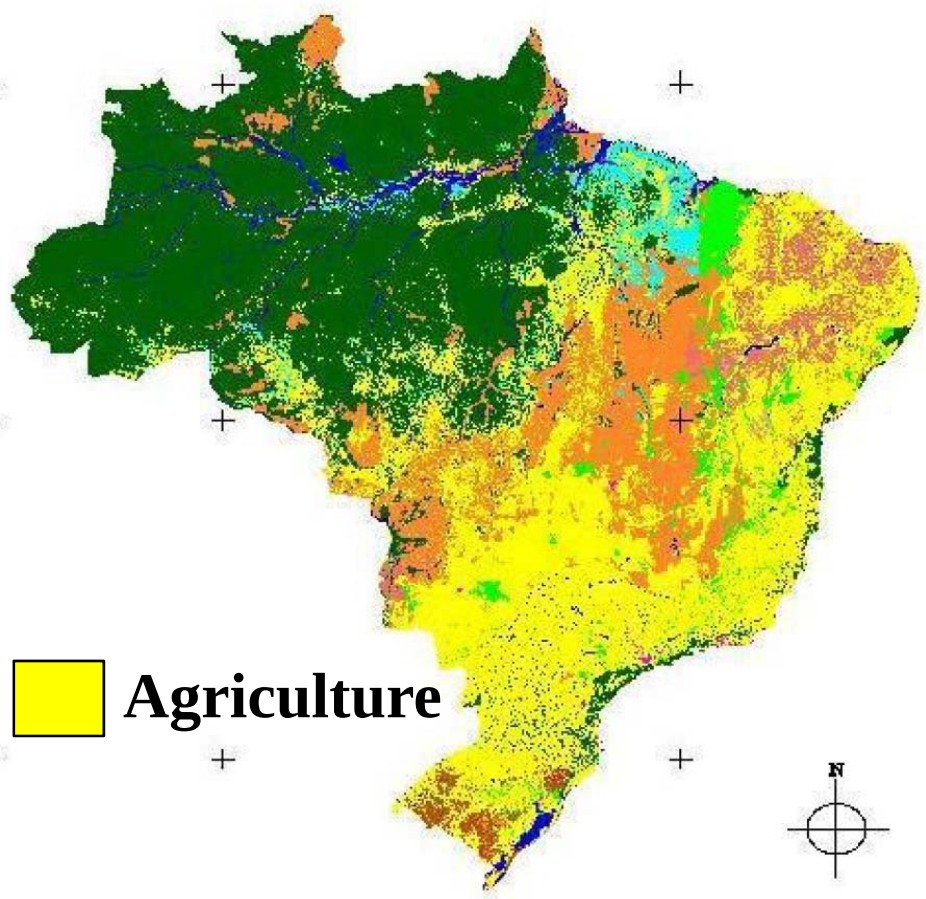
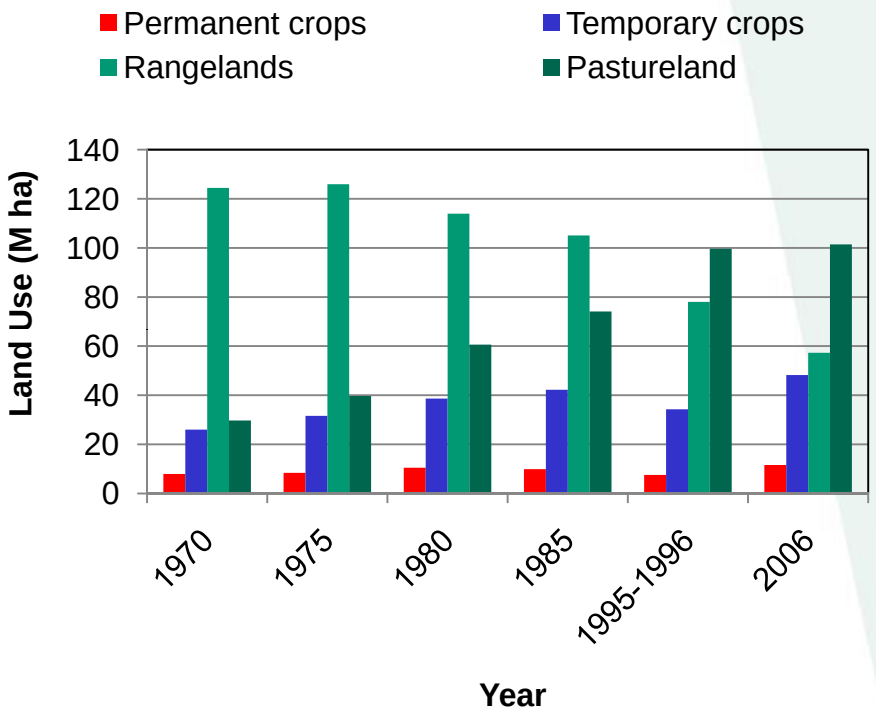
Climate Change Adaptation

Research and Development on crop germplasm

Land available for agriculture expansion





Climate Change Adaptation

Research and Development on crop germplasm (Embrapa Temperate climate)

PEACH :

- Low need for chilling and heat tolerance in early flowering
- Identify sources of resistance to the fungal disease (e.g., Monilinia fructicola)

PEACH (greenhouses)

PEACH (fungal disease)

Contact: Maria Do Carmo Bassols Raseira <maria.bassols@embrapa.br>

Bernardo Ueno <bernardo.ueno@embrapa.br>

Climate Change Adaptation

Research and Development on crop germplasm (Embrapa Temperate climate)

PEACH (greenhouses):
Pistil abortion after occurrence of high temperature (Temperature > 29 ºC, during July) at flower bud swelling stage.

Blackberry (greenhouses) :
From left to right: fruits from plants grown in the field, plants kept at 20 ºC, and plants subjected to 29 ºC for 10 days.

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Bernardo Ueno <bernardo.ueno@embrapa.br>

Climate Change Adaptation

Research and Development on crop germplasm (Embrapa Temperate climate)

STRAWBERRY:

- P

STRAWBERRY (hydroponic production in greenhouses)

Contact: Luis Eduardo Correa Antunes <luis.antunes@embrapa.br>

Carlos Reisser Junior <carlos.reisser@embrapa.br>

Climate Change Adaptation

Research and Development on crop germplasm (Embrapa Temperate climate)

POTATO :

- Application of DNA-markers for development of drought tolerant potato germplasm

POTATO (greenhouses)

POTATO (drought tolerance)

	MSTT (g/plant)					
Genotype	**Spring**		**Fall**		**Averag.**	**CV (%)**
	Control	**Dry**	**Control**	**Dry**		
Agata	20,41b	0,62c	12,72bcd	7,41cde	10,10c	81,3
Ana	0,29b	0,12c	**29,55a**	24,95b	18,23b	114,6
Atlantic	**24,99ab**	5,56b	8,84cd	6,08cde	10,06c	80,9
Baronesa	17,54b	1,42c	7,00cd	4,31de	6,93cd	92,9
C2337-06-02	0,00b	0,00c	16,72bc	12,13cde	9,62c	118,4
C2360-07-02	4,64b	0,00c	**34,77a**	**47,56a**	28,22a	106,3
CIP388615	0,65b	0,09c	16,01bc	14,58bcd	10,32c	110,3
Caesar	0,11b	0,46c	1,66d	1,98e	1,31d	86,2
Clara	**46,53a**	**10,34a**	**23,54ab**	17,32bc	23,10ab	64,2
Desiree	15,06b	0,81c	12,46bcd	9,10cde	9,83c	66,2
Macaca	9,15b	2,45c	5,69cd	4,17de	5,22cd	53,1
PCDAG 03-11	2,08b	0,35c	7,32cd	4,92de	4,48cd	83,9
General Average	11,79A	1,85B	14,71A	12,88A		55,9

Contact: Caroline Marques Castro; Carlos Reisser Jr.; Arione da Silva Pereira.

Climate Change Adaptation

Research and Development on crop germplasm (Embrapa Temperate climate)

POTATO :

- Selection of germplasm with good tuber growth and tuber without deformities

Spring/Summer field experiment

POTATO (Heat Tolerance)

Tolerance

Contact: Caroline Marques Castro; Carlos Reisser Jr.; Arione da Silva Pereira.

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Climate Change: Towards IPCC AR5

Fifth Assessment Report (AR5) 2013

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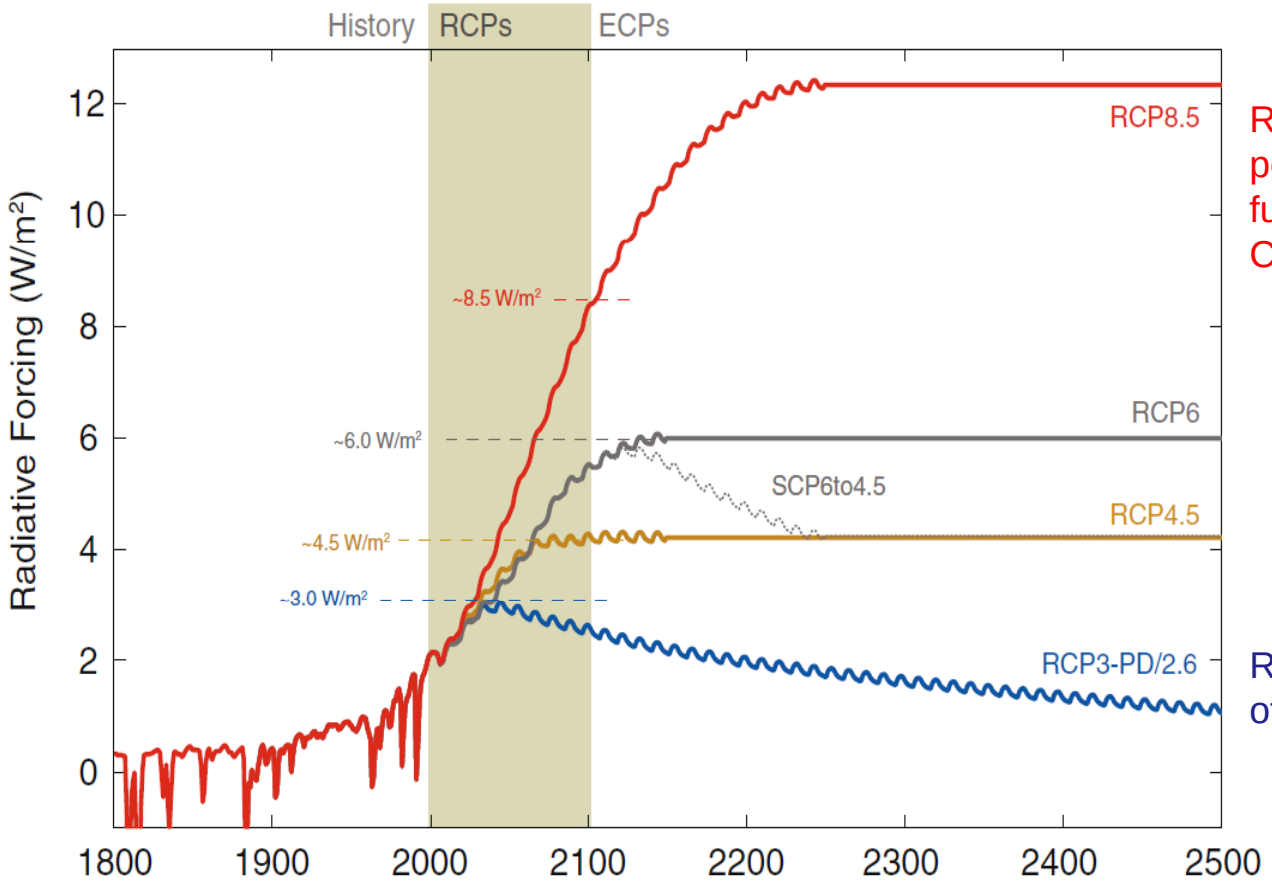
Climate Change: Towards IPCC AR5

Projections: New Scenarios

Representative Concentration Pathways (RCPs)



RCP8.5 - represents the more pessimistic of the non-mitigation futures. Representative Concentration Pathways (RCPs)

RCP2.6 represents the lower end of possible mitigation strategies

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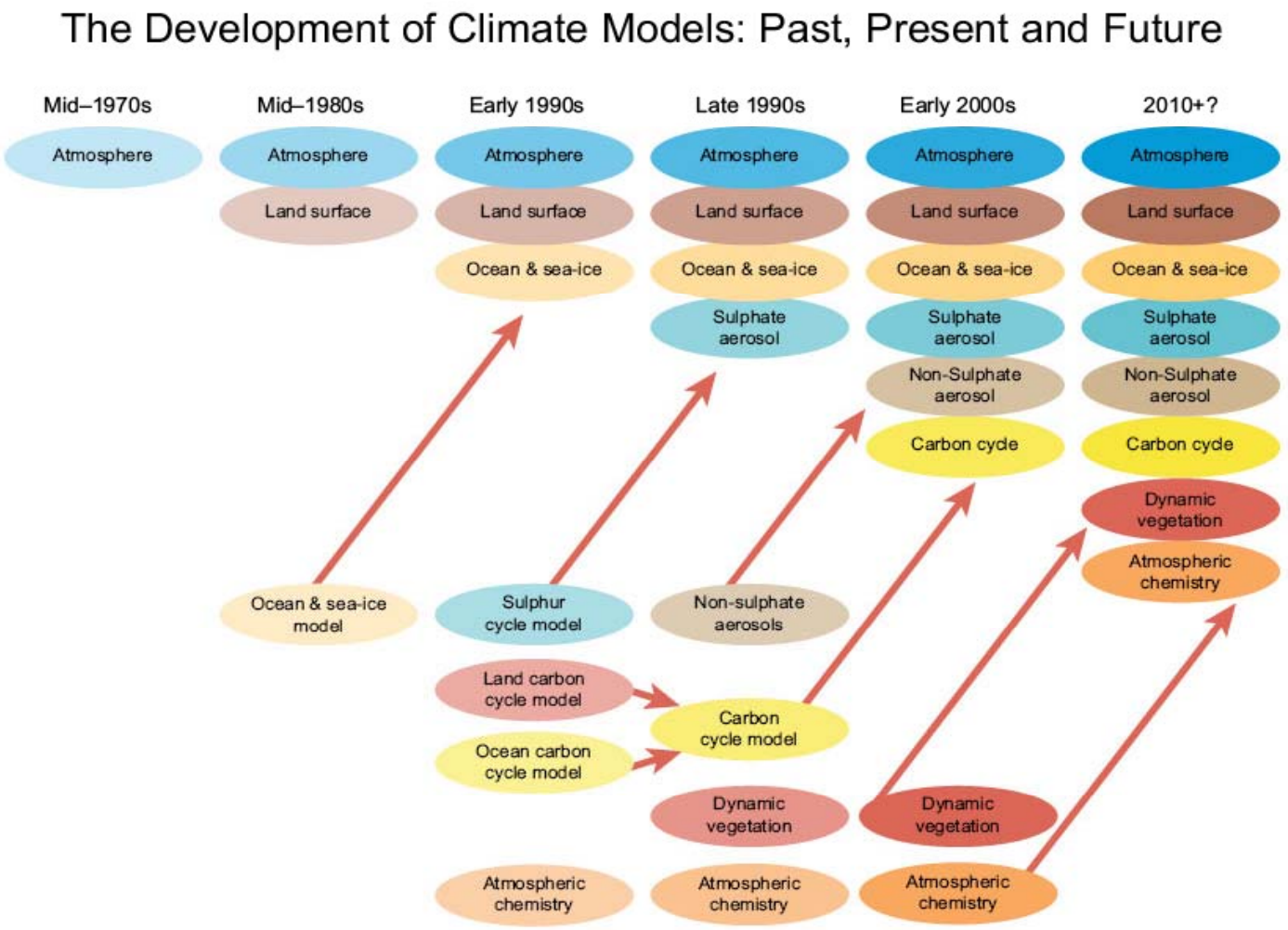
Projections: Earth system Models



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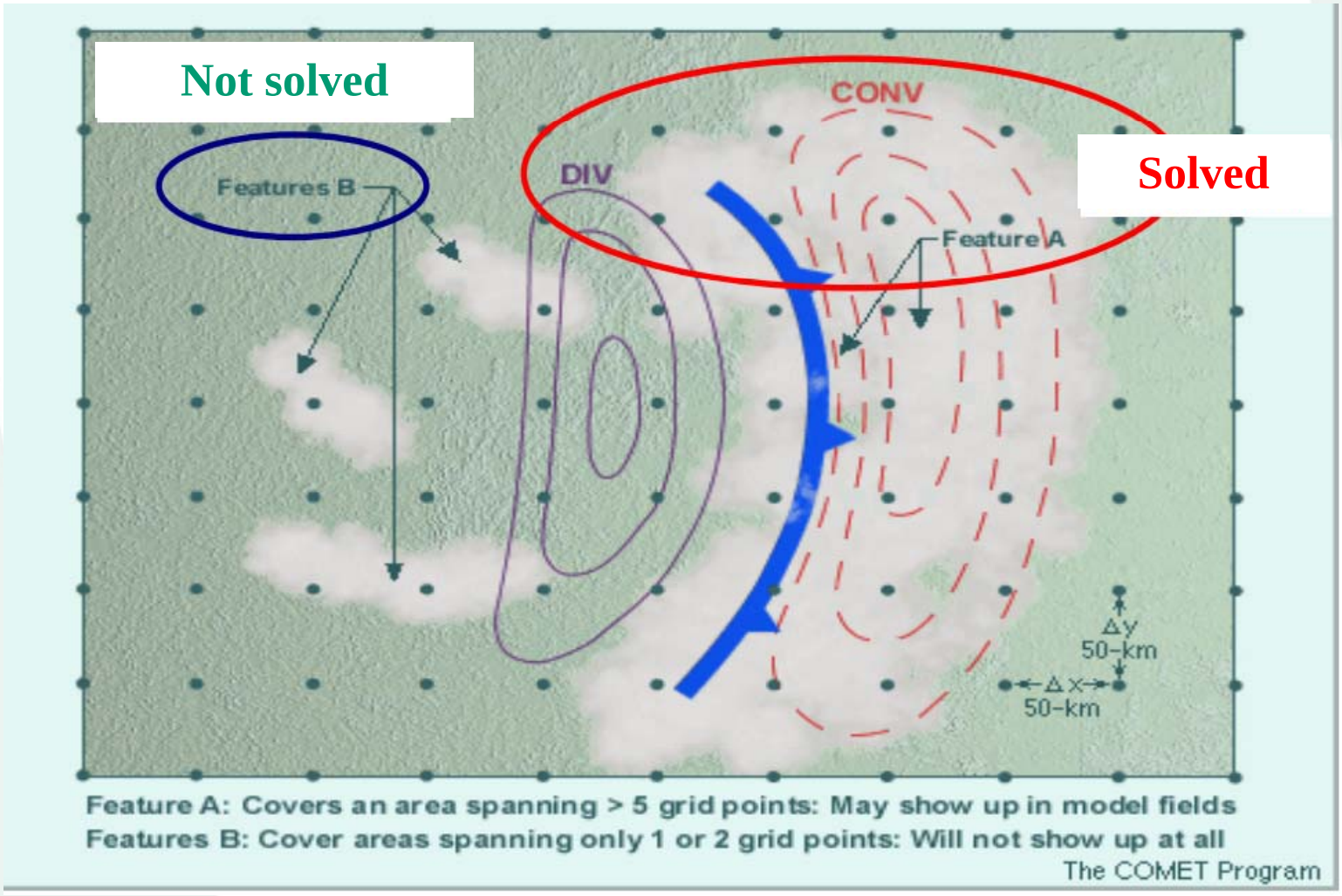
Climate Change: Towards IPCC AR5

Projections: Atmosphere Models



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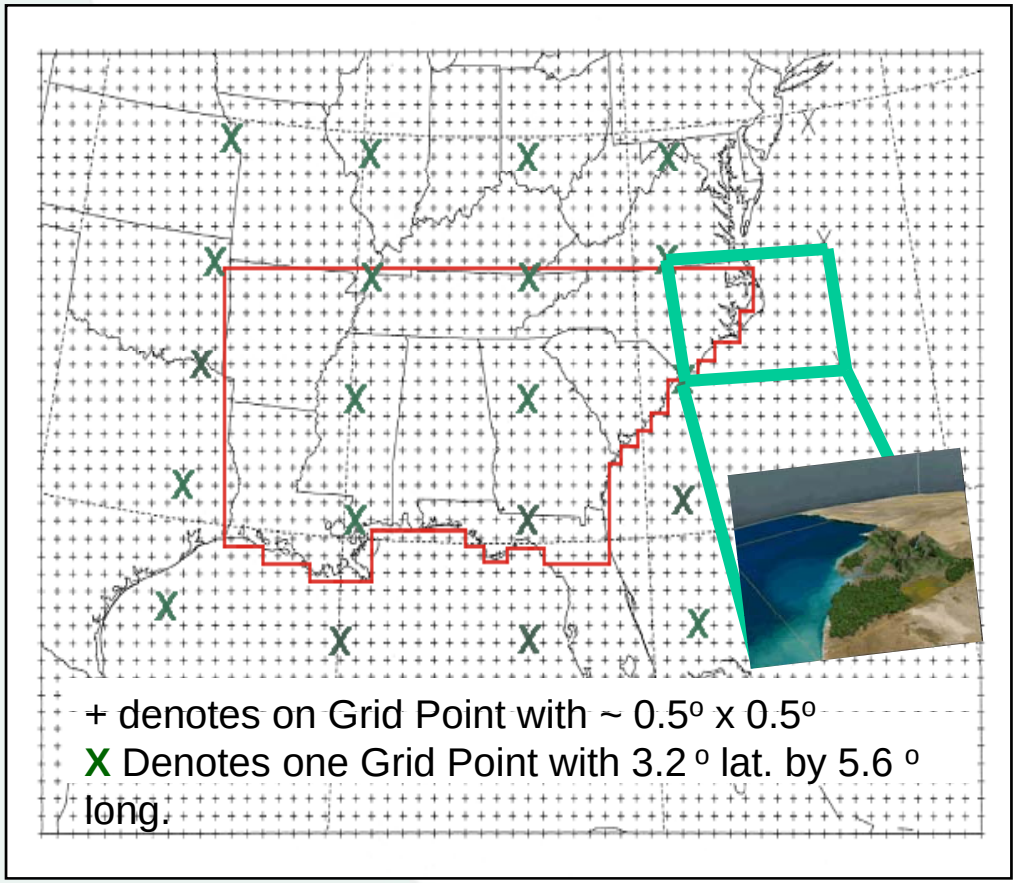
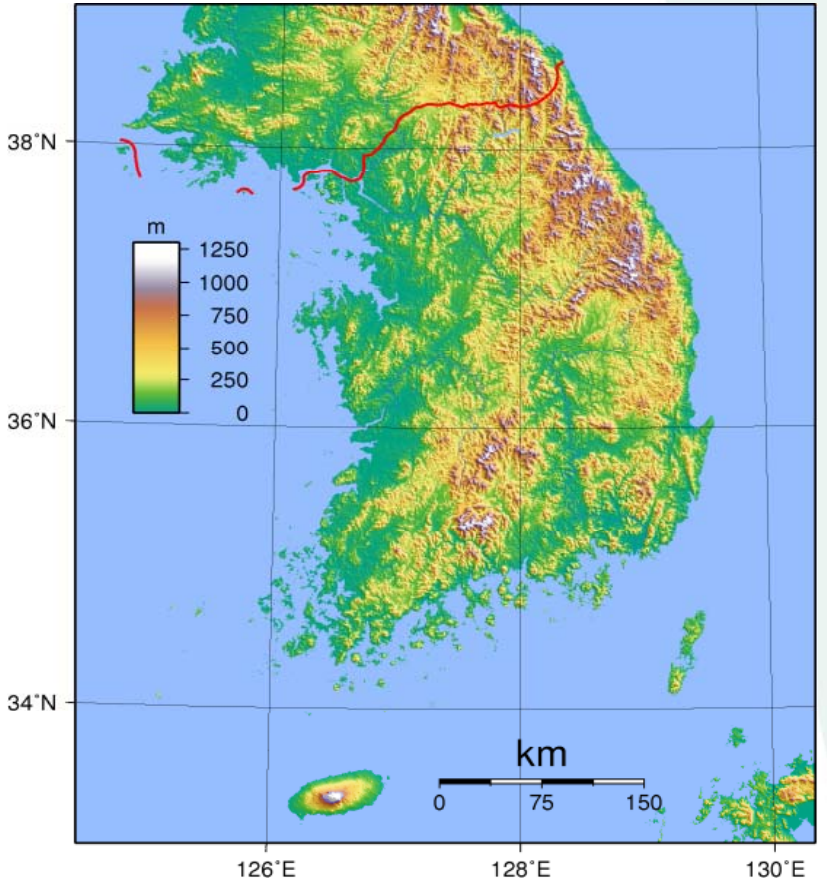
Projections: Model Grid Resolution

The spatial resolution of CMIP5 coupled models will range for the atmosphere component from 0.5° to 4°





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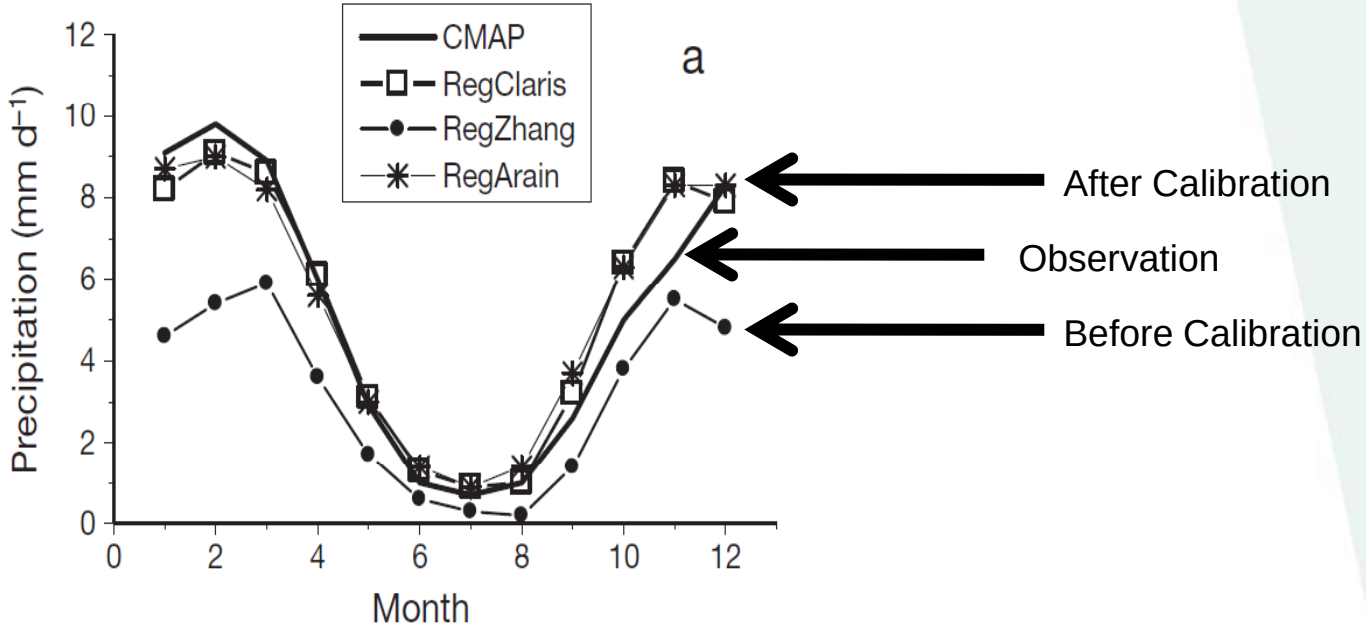
Climate Change: Towards IPCC AR5

Projections: Regional Climate Models

May improve not only resolution but also parameterizations



da Rocha et al. (2012) – Climate Research.

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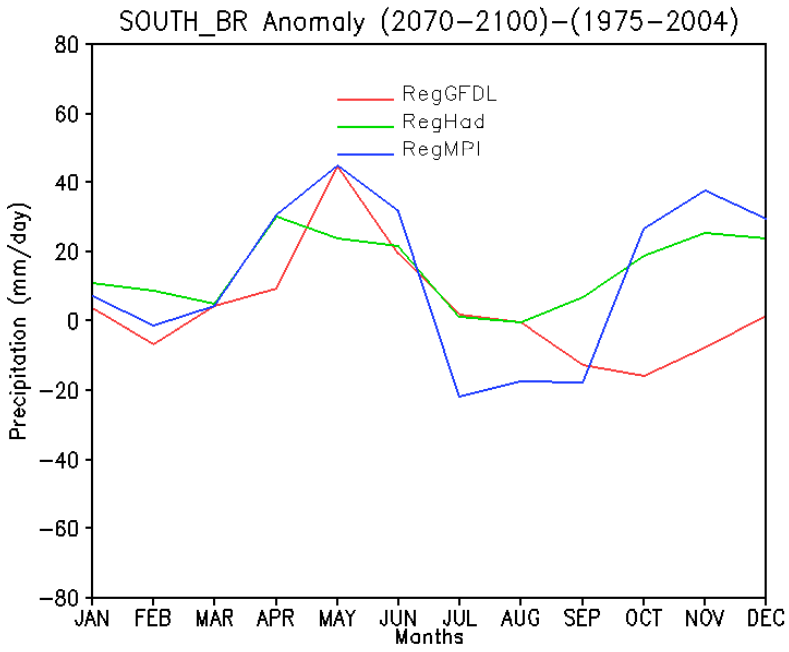
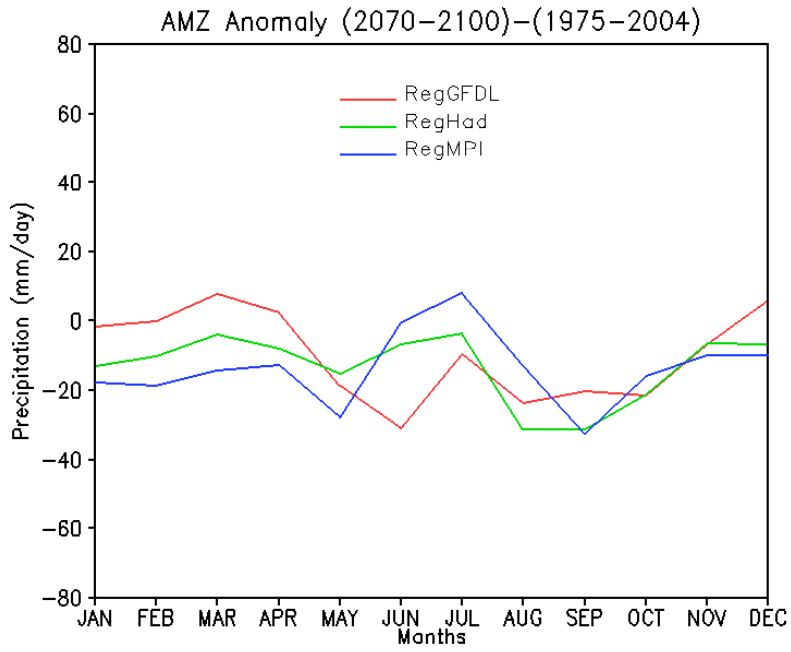
Climate Change: Towards IPCC AR5

IPCC (RegCM4) – Present generation Regional Climate Model Projections





Llopart et al. (2013) – Climatic Change special issue, submitted.

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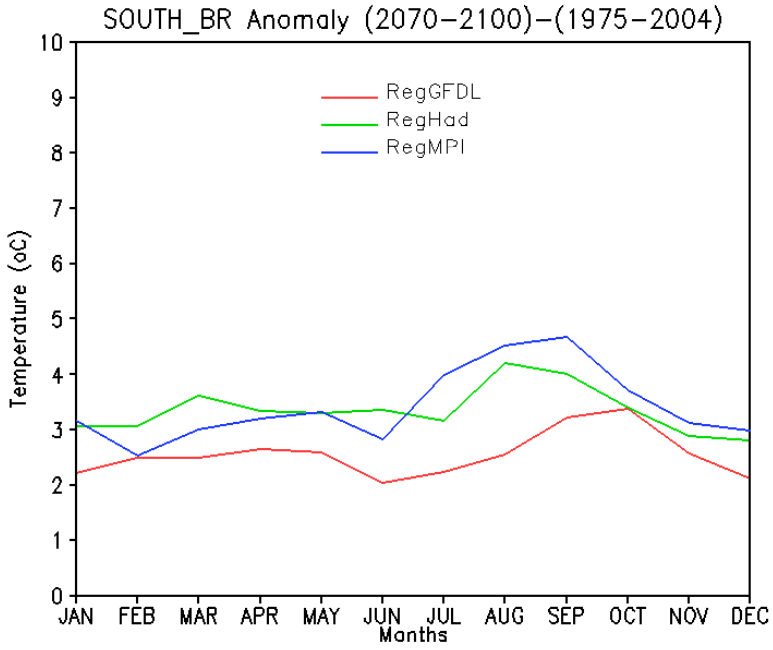
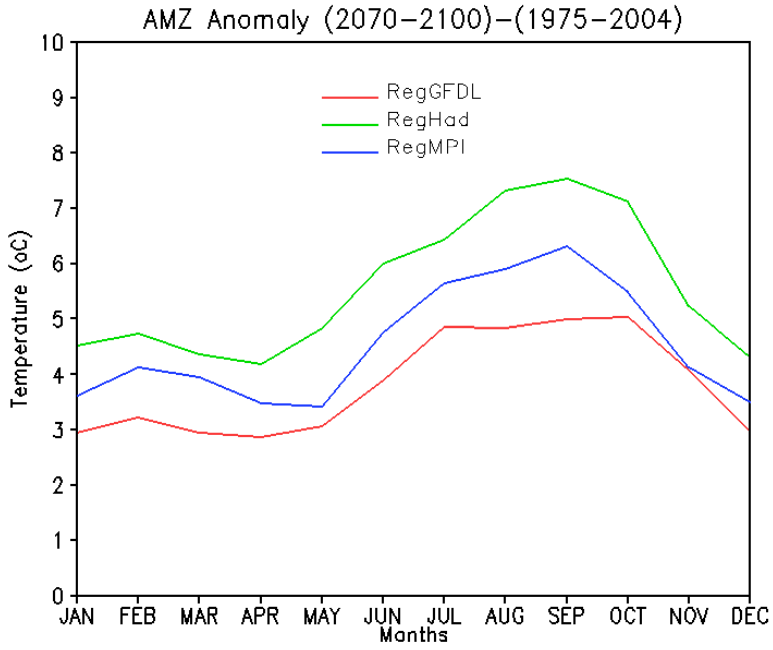
Climate Change: Towards IPCC AR5

IPCC (RegCM4) – Present generation Regional Climate Model Projections





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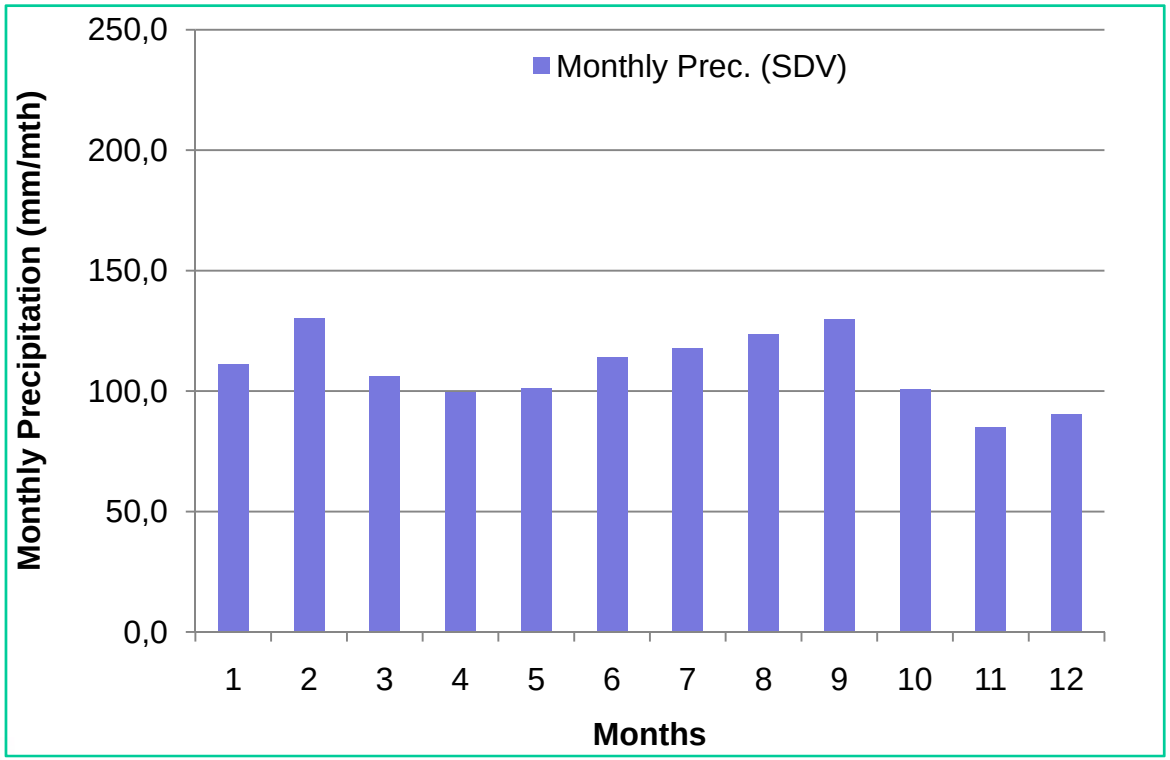
Climate Change: Towards IPCC AR5

How important is the Precipitation Average and Standard Deviation?



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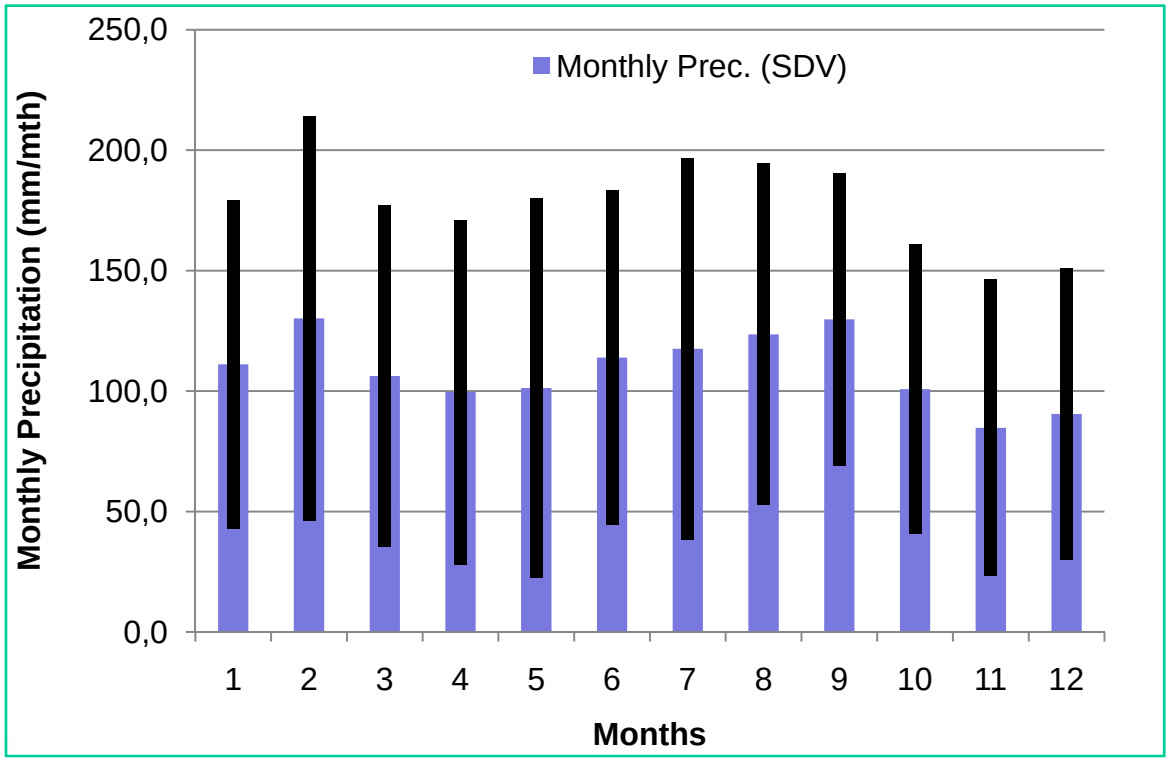
Climate Change: Towards IPCC AR5

How important is the Precipitation Average and Standard Deviation?



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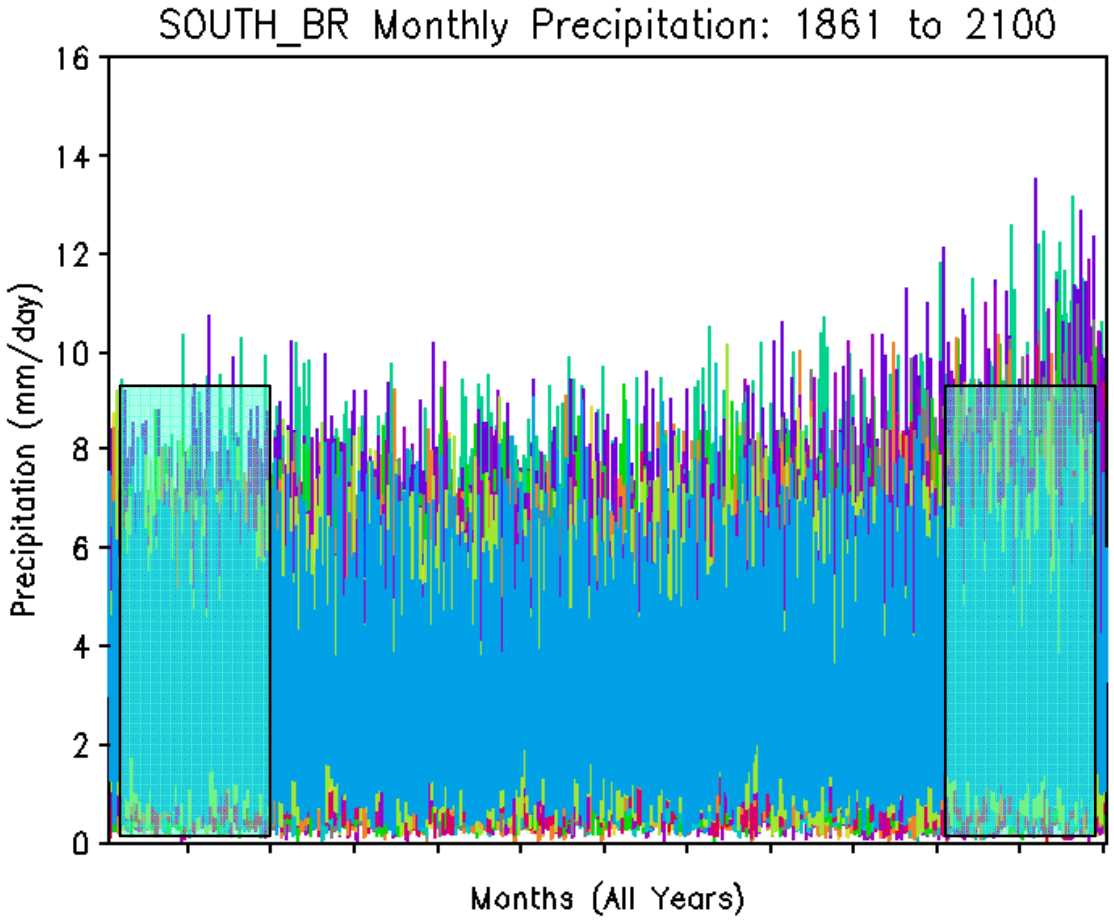
Climate Change: Towards IPCC AR5

IPCC (CMIP5) – Present generation GLOBAL Climate Models Projections



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Climate Change: Towards IPCC AR5

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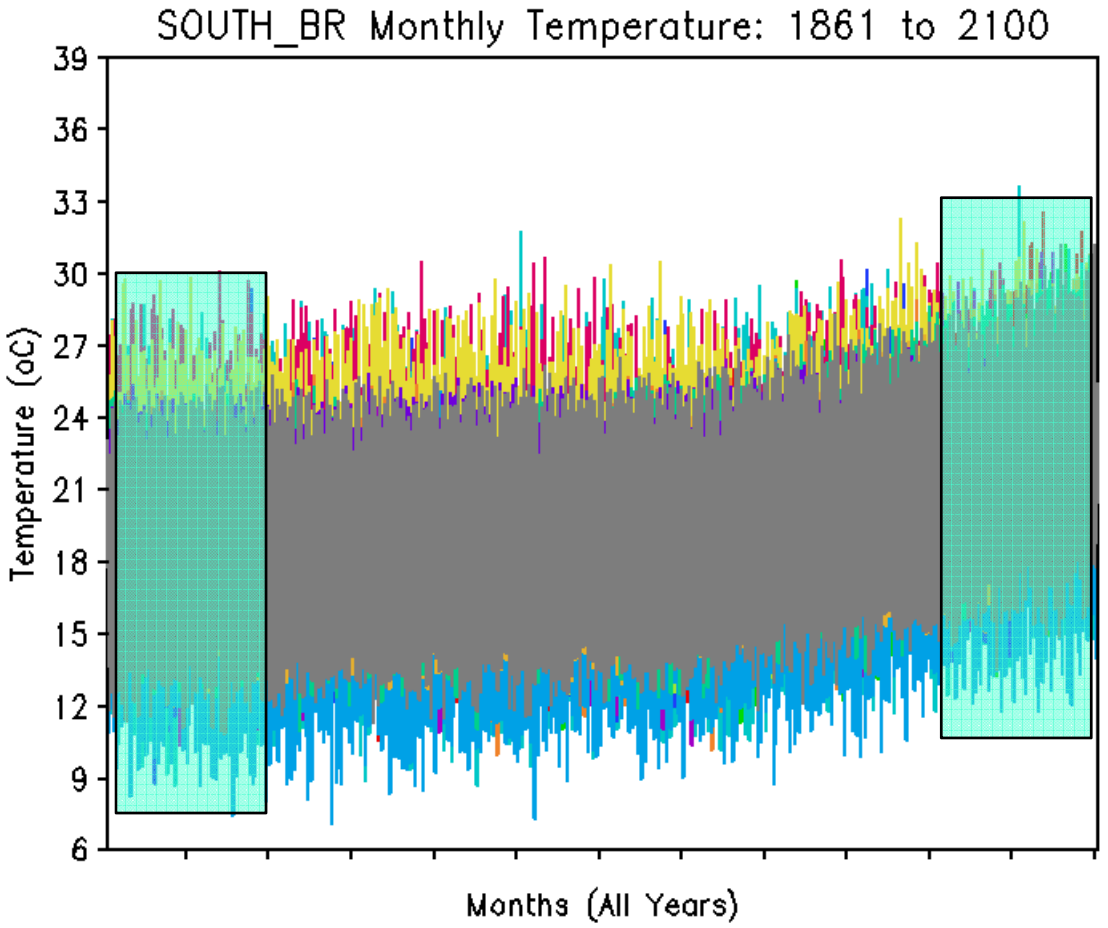

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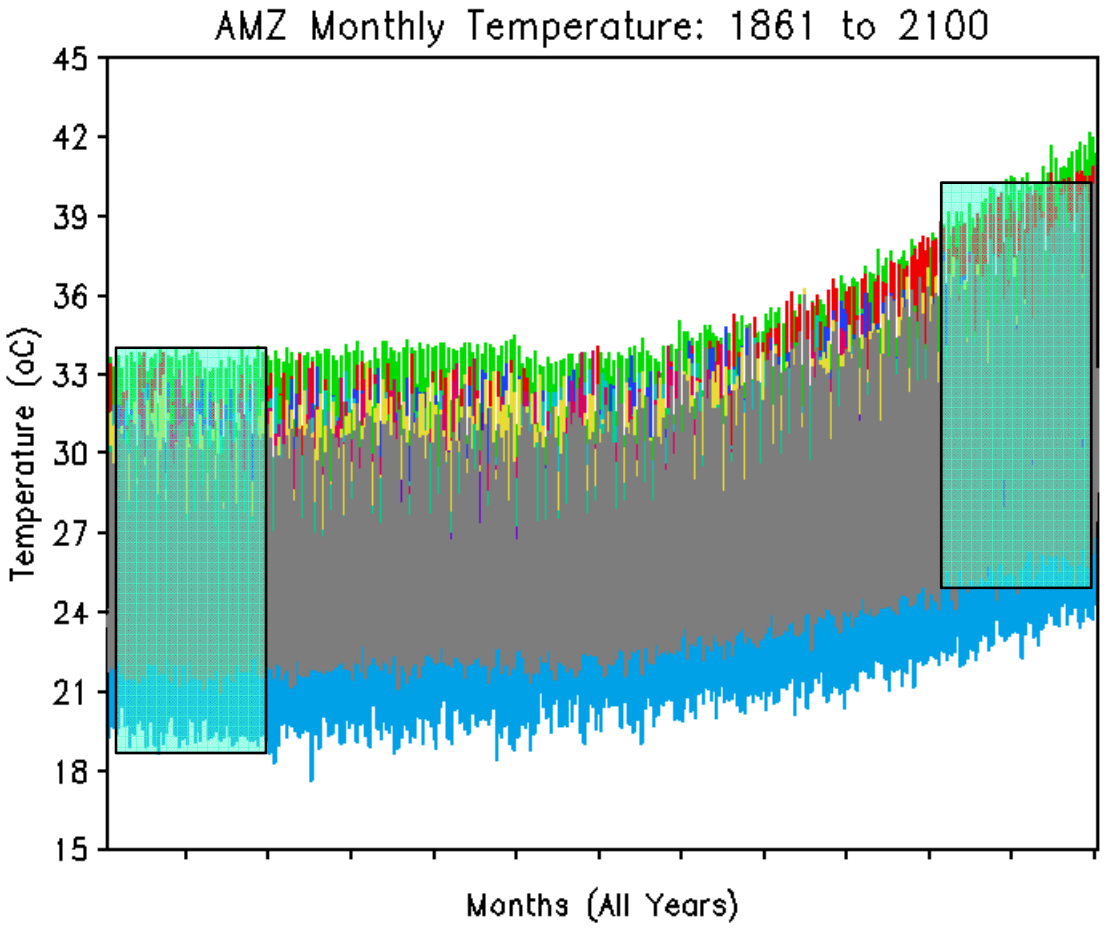
Climate Change: Towards IPCC AR5

IPCC (CMIP5) – Present generation GLOBAL Climate Models Projections



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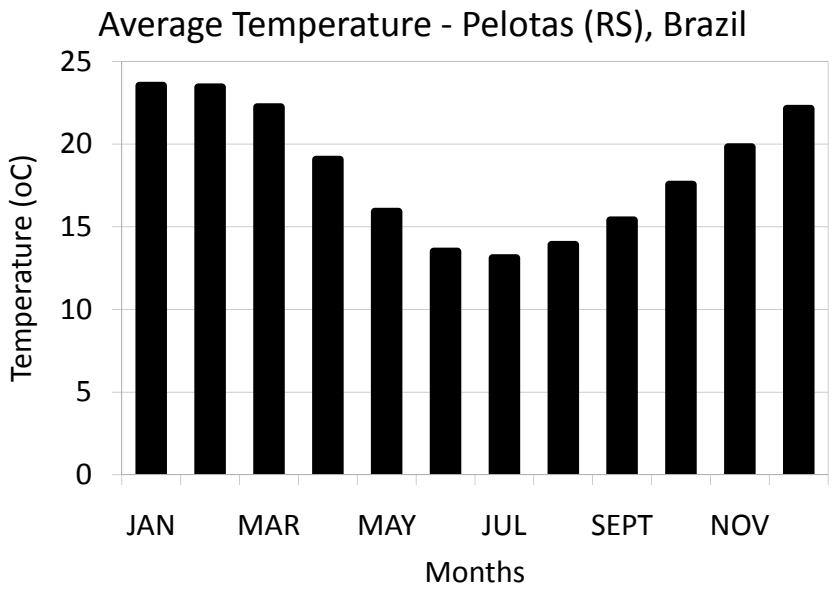
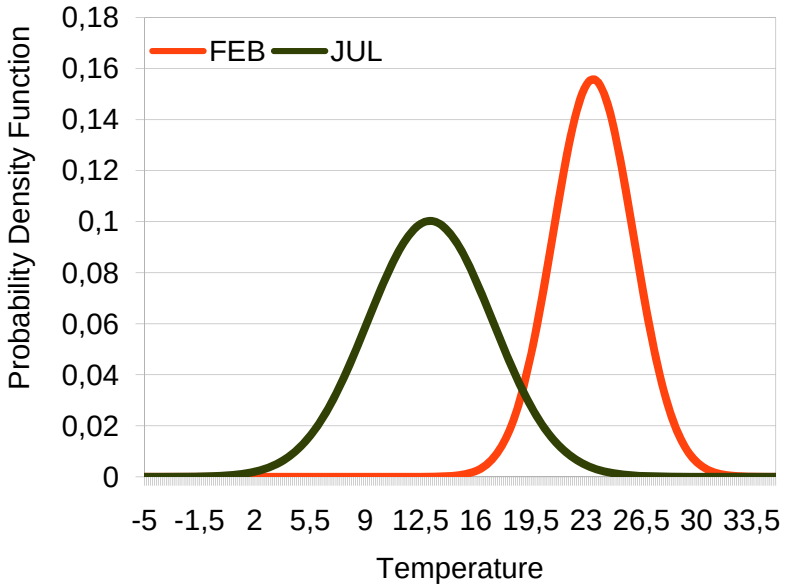
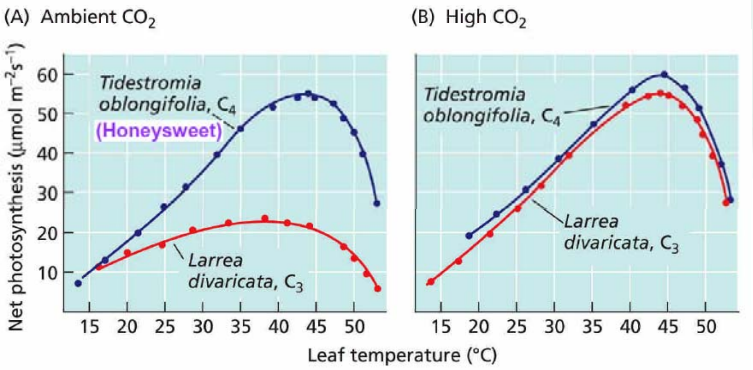
Climate Change: Towards IPCC AR5

Should we include Standard Deviation?







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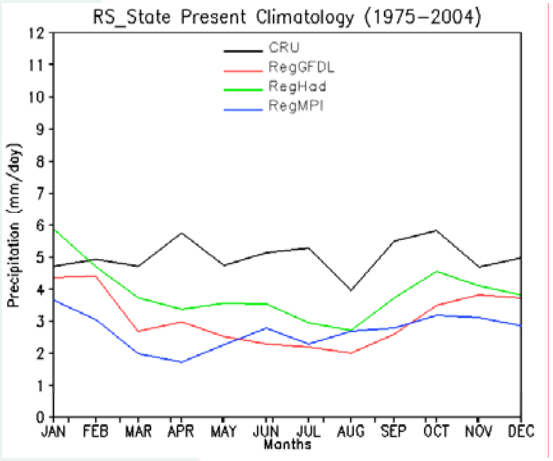
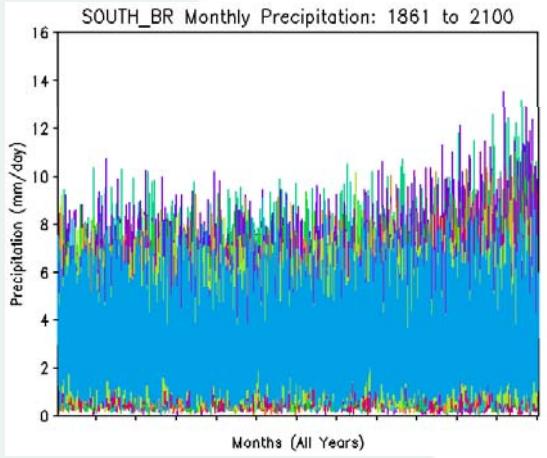
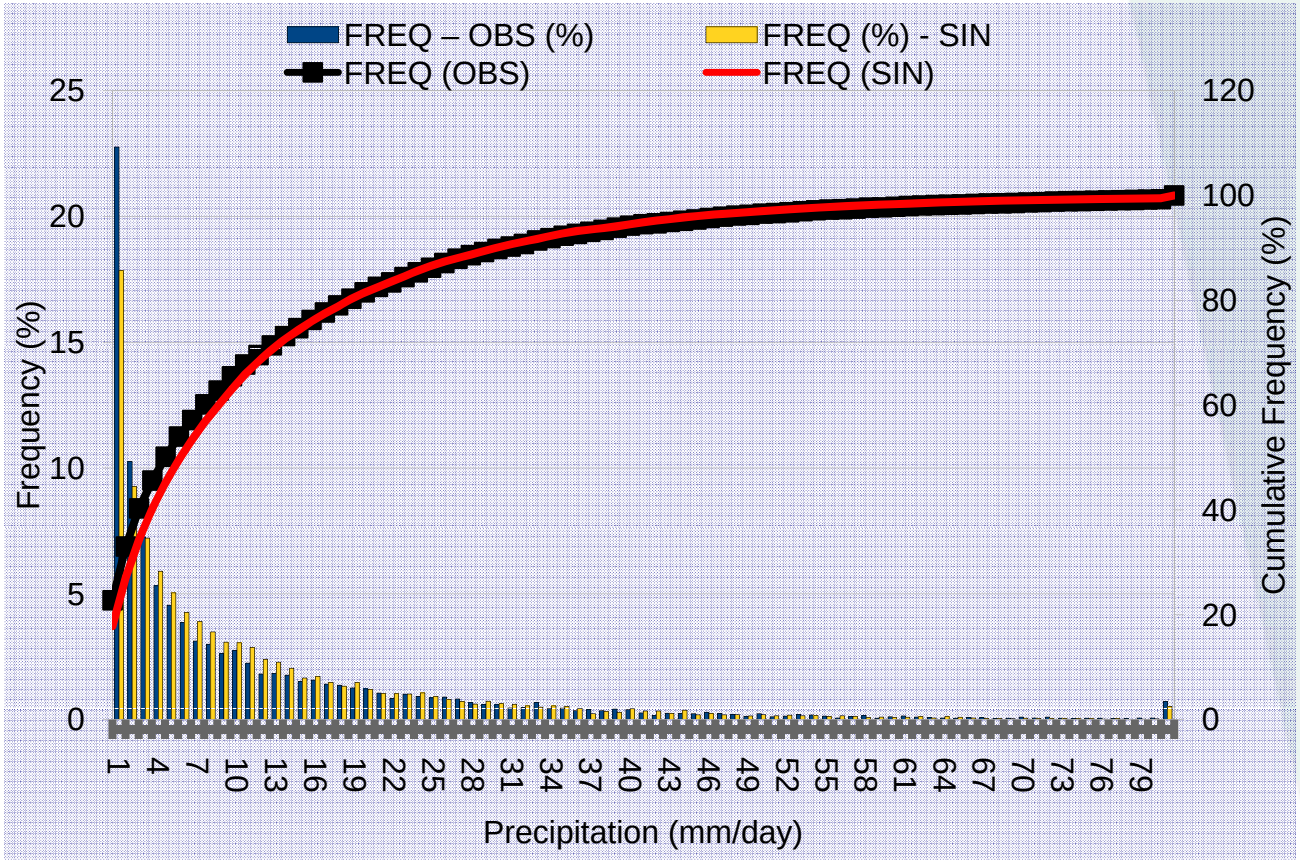
Climate: Average & Variability

How include the climate Changes (Avg. and SD.)?

» Gamma distribution often provides a good fit for Precipitation







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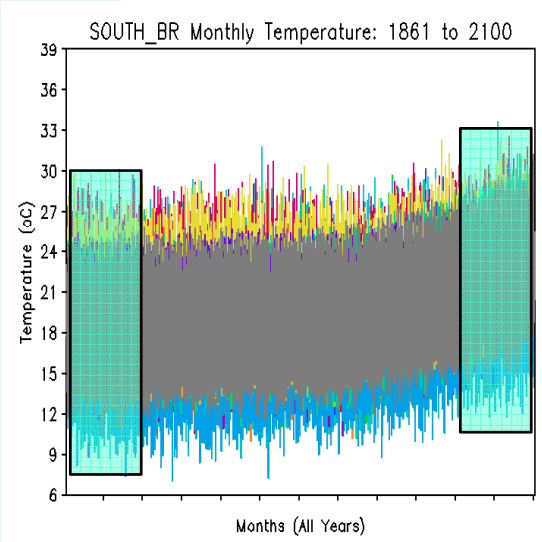
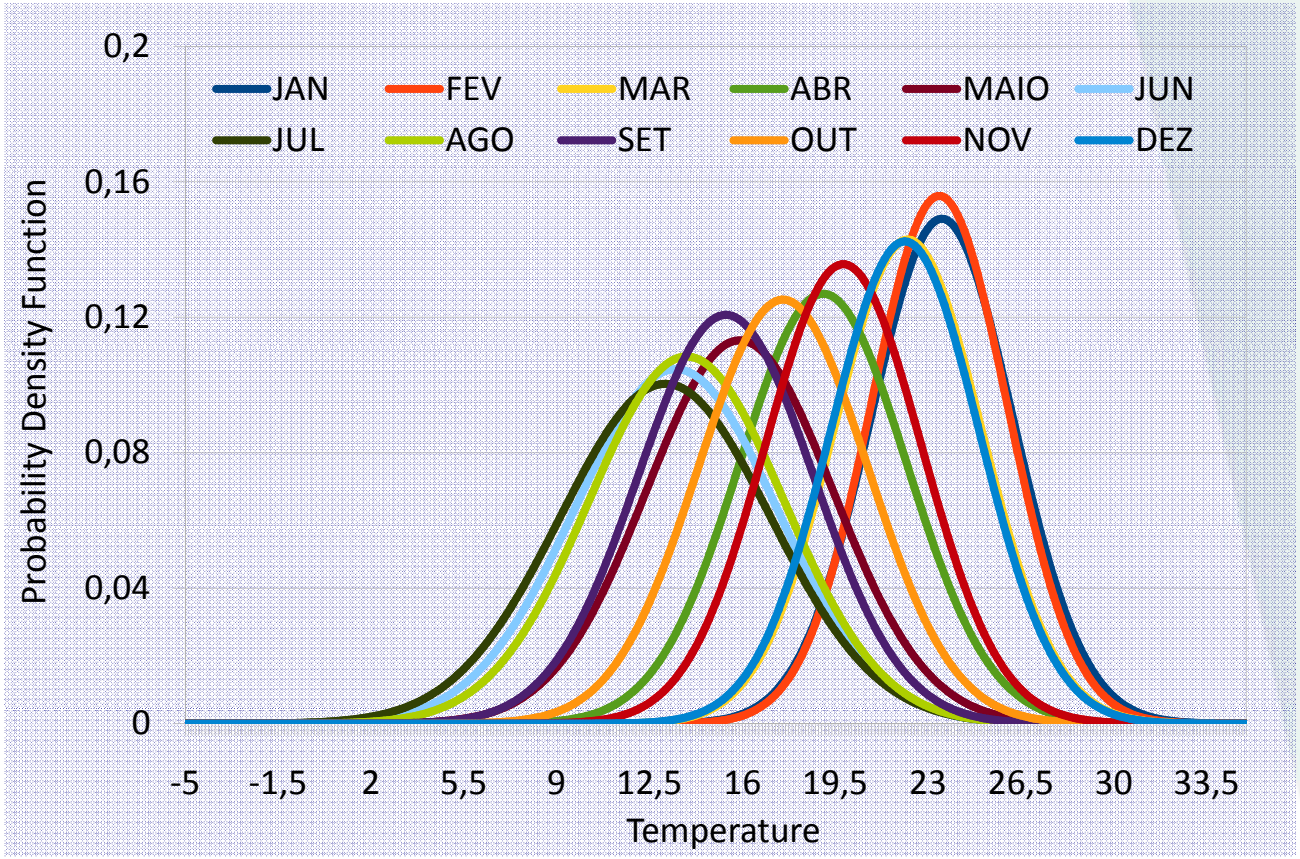
Climate: Average & Variability

How include the climate Changes (Avg. and SD.)?

» Normal distribution often provides a good fit for Temperature





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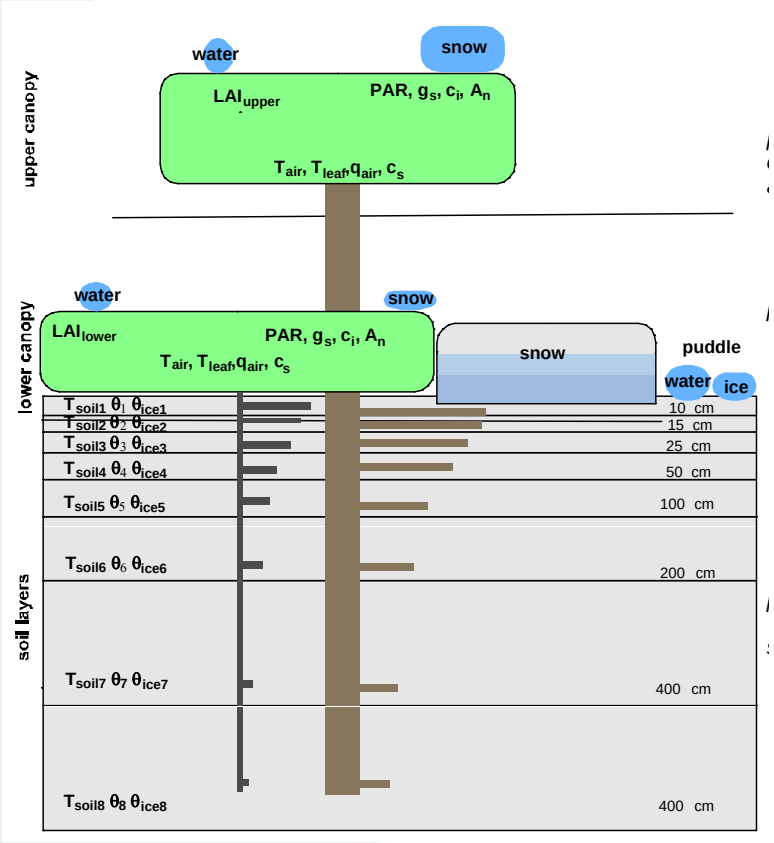
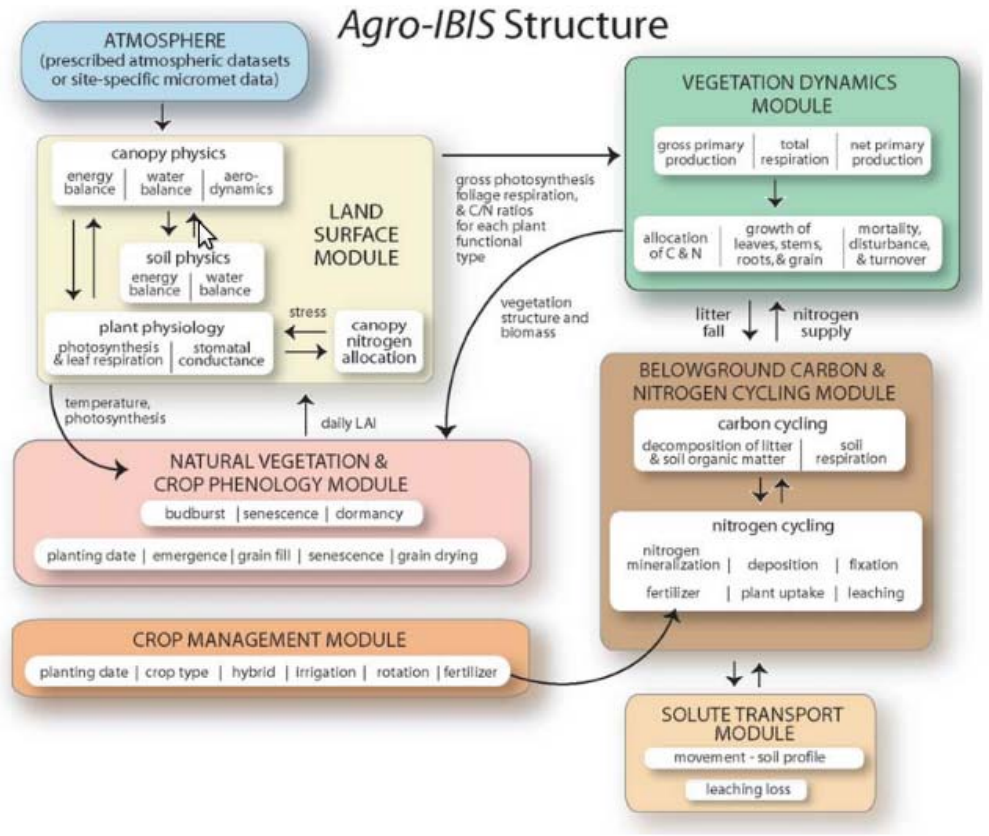
Climate Change

Models as a tool to scaling-up and test hypothesis: Mitigation and Adaptation

» Biophysical Models





Climate Change

Models as a tool to scaling-up and test hypothesis: Mitigation and Adaptation

» Biophysical Models: Photosynthesis

$$A_n = A_g - R_d$$

$$A_g = \min (J_e, J_c)$$

A_n: net photosynthesis
A_g: gross photosynthesis
R_d: maintenance respiration

$$J_e = \alpha_3 \, PAR \, \frac{CO_{2i} - \Gamma_*}{CO_{2i} + 2\Gamma_*}$$

Photosynthesis Limited by light

$$J_c = \frac{V_m \left(CO_{2i} - \Gamma_*\right)}{CO_{2i} + K_c\left(1 + \frac{[O_2]}{K_o}\right)}$$

Photosynthesis Limited by Rubisco

$$V_m = V_{\max} \, T_{vm} \, St$$

Maximum Rubisco efficiency

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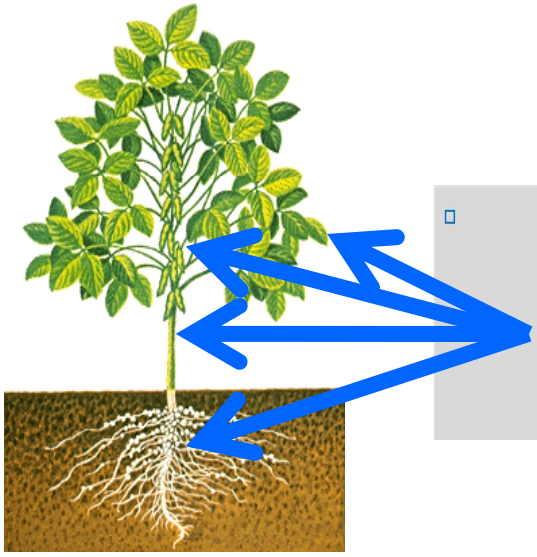
Climate Change

Models as a tool to scaling-up and test hypothesis: Mitigation and Adaptation

- Biophysical Models: Photosynthesis



$$NPP = GPP - Ra \quad (1)$$

$$\frac{\partial C_i}{\partial t} = \sum_{i=1}^{N} a_i NPP - \sum_{i=1}^{N} \frac{C_i}{\tau_i} - D \quad (2)$$

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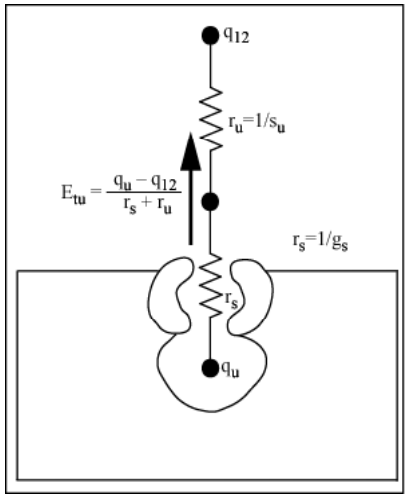
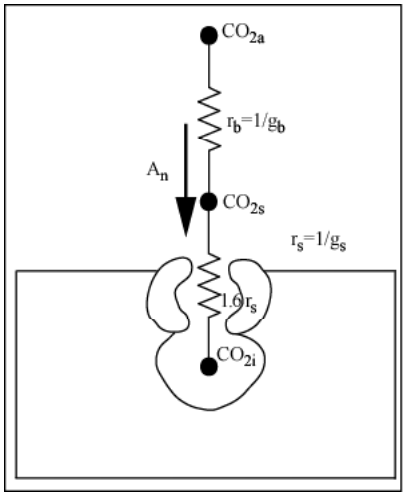
Climate Change

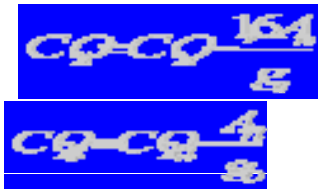
Models as a tool to scaling-up and test hypothesis: Mitigation and Adaptation

» Biophysical Models: Coupling Photosynthesis and Evapotranspiration





Collatz equations (1991):



Leuning equation (1995):

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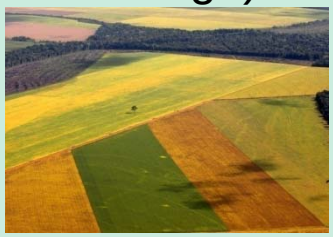
Climate Change and the Agriculture

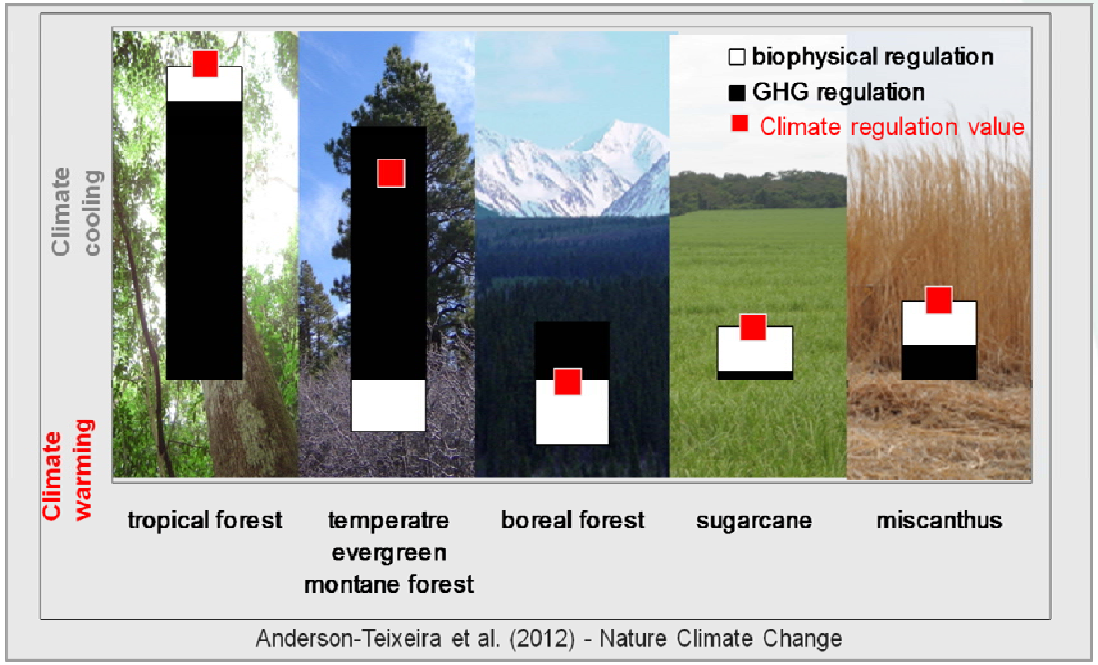
Mitigation (of climate change)

Driver (Climate Change)



Mitigation

» Models may help to planning (scaling-up and testing scenarios) the developmento of the agriculture with lower, as possible, GHGs emissions and direct Climate Impacts



Anderson-Teixeira et al. (2012) - Nature Climate Change

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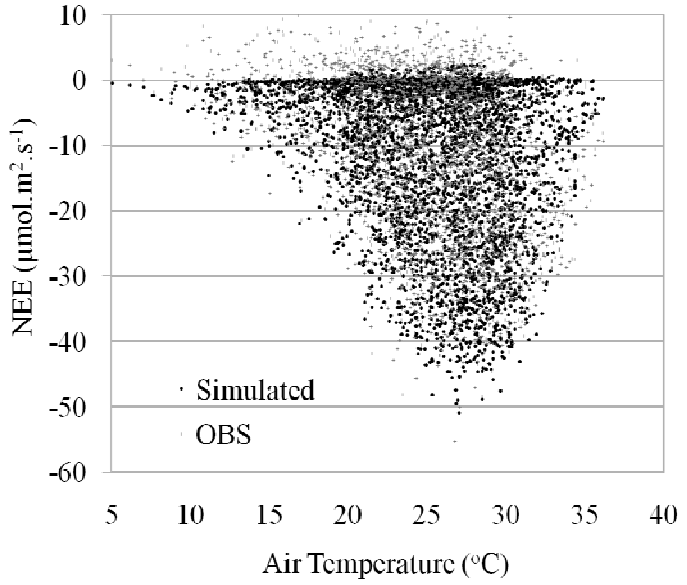
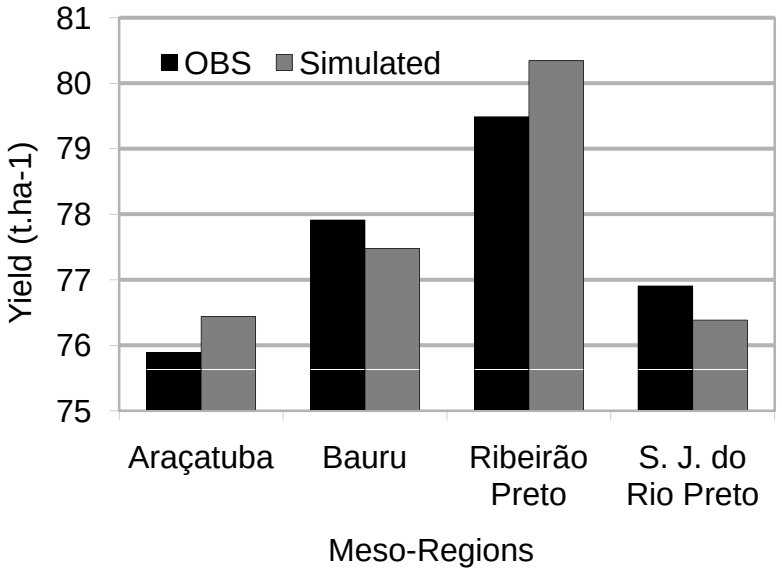
Models as a tool to scaling-up and test hypothesis: Mitigation and Adaptation

» Biophysical Models: Coupling Photosynthesis and Evapotranspiration



» Biophysical Models: May simulate crop growth and yield (considering not only the impacts of average changes but also its distribution)



Cuadra et al. (2012) – Global Change Biology Bioenergy

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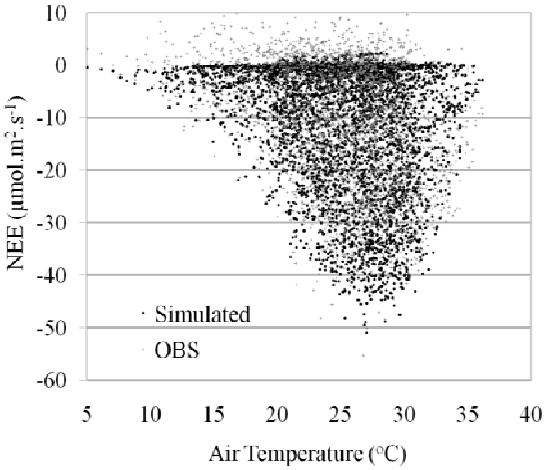
Climate: Average & Variability

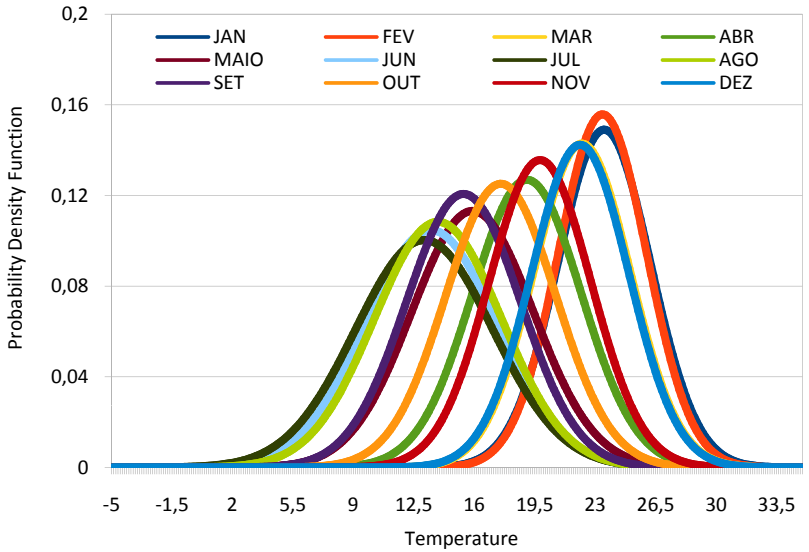
Main recommendation

» Crop development is affected not only by the mean atmospheric conditions (average climate), but also by the frequency of extreme events such as frost, heat waves, floods, and droughts; or even recurrent conditions unfavorable to crop growth.

» Photosynthesis is not linear related with temperature



» GHG may change not only the average, but also the frequency



Many Thanks.

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Ministry of Agriculture, Livestock and Food Supply

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