Predicting Climate Extremes: the need for a Brazilian Earth System Model.

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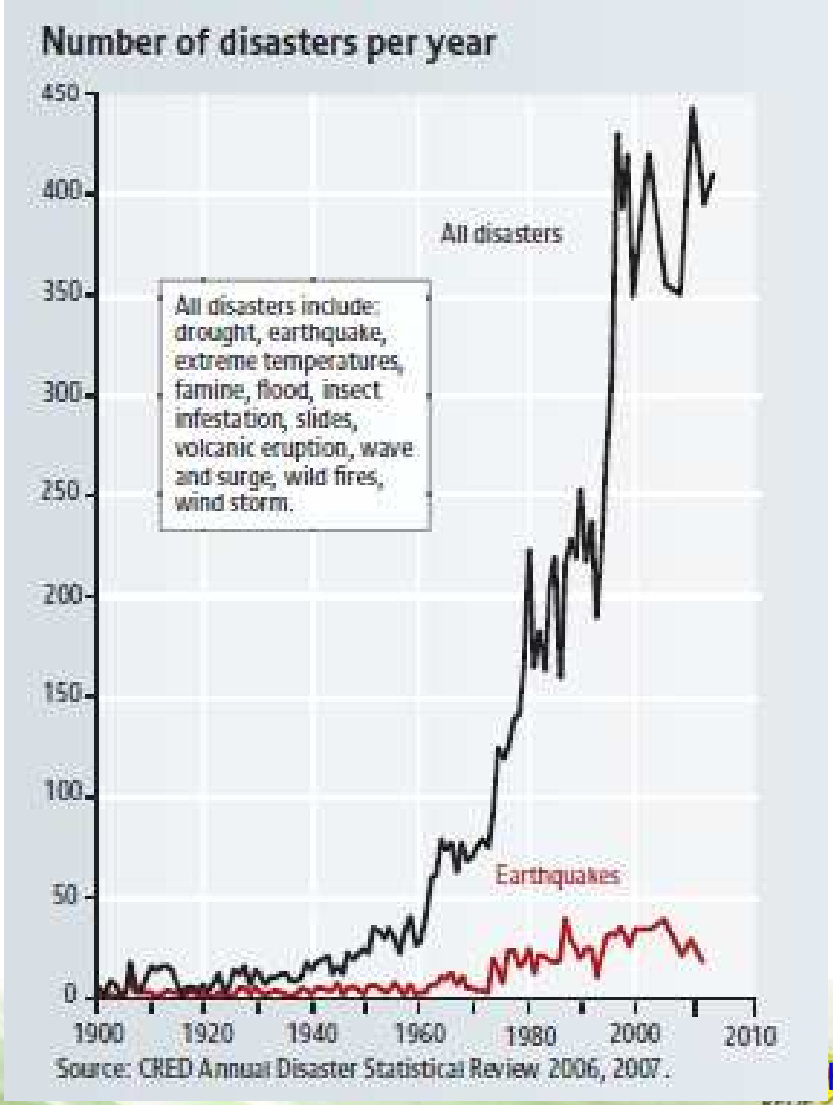
National Institute for Space Research – INPE

FIOCRUZ Symposium on Climate and Health:
Seminário Eventos climáticos extremos, desastres e impactos sobre a saúde. O que dizem os sistemas de informação?

Rio de Janeiro, 07 May 2014

Global Climate Change
Extreme Events Fast Growth

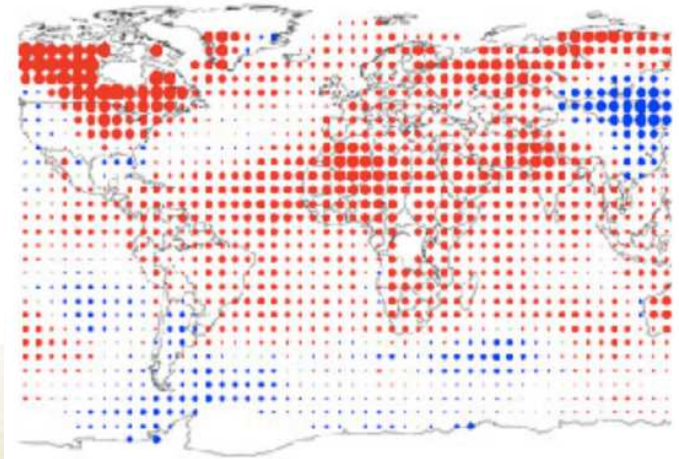


The Blue Carbon Report - UNEP

Hurricane Catarina (2004)

Hadley Centre, UK

JFMA 2010: Hottest Period on Record



Source: NOAA (2010)

Climate-related Health Issues

- Heat waves
  - 2003 Europe ~ 70,000 deaths: excess heat
  - 2010 Russia ~ 40,000 deaths: temperature+pollution from fires
- Flooding
  - Rio Madeira 2014: drinkable water contamination
- Drought
  - Caruaru, 1996: cyanobacteria and dialysis
  - São Paulo 2014: the use of “death volume” Cantareira
- …

The enhanced risk of disease proliferation due to over exposition.

Focal Points Rede CLIMA

Brazilian Network for Global Climate Change Research

Why do we need our own ESM?

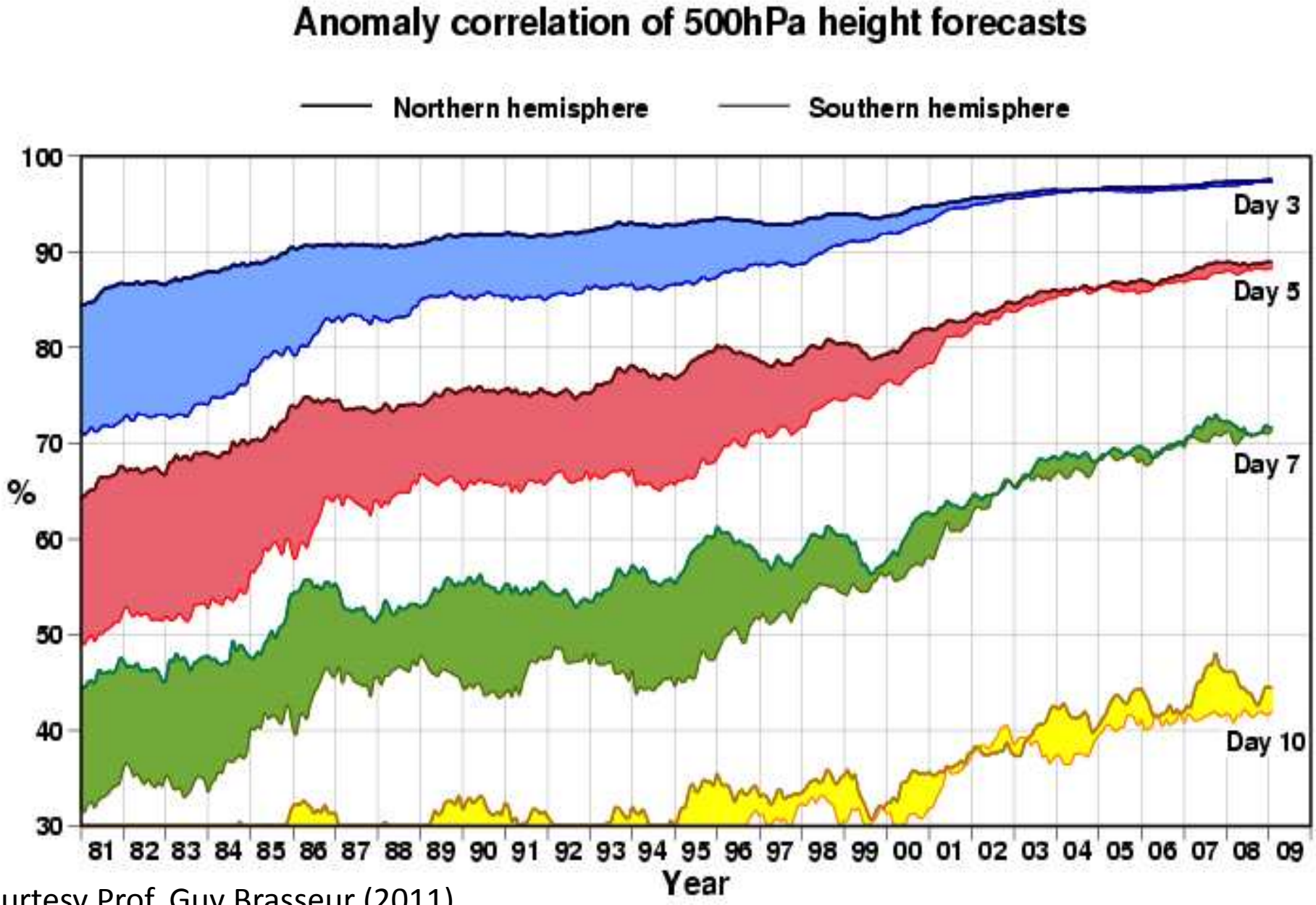
- Develop in-country capacity to generate future environmental change scenarios
- Represent processes that are important to us and may be considered secondary in other models
- Benefit from and integrate with multiple large research programs in Brazil, like LBA, PRODES, GEOMA, BIOTA, etc.
- Form a new generation of land surface, ocean, atmosphere, chemistry… climate modelers
- Advance climate science
- Collaborate with countries with similar interests

Three Great Challenges

of Global Climate Change Research

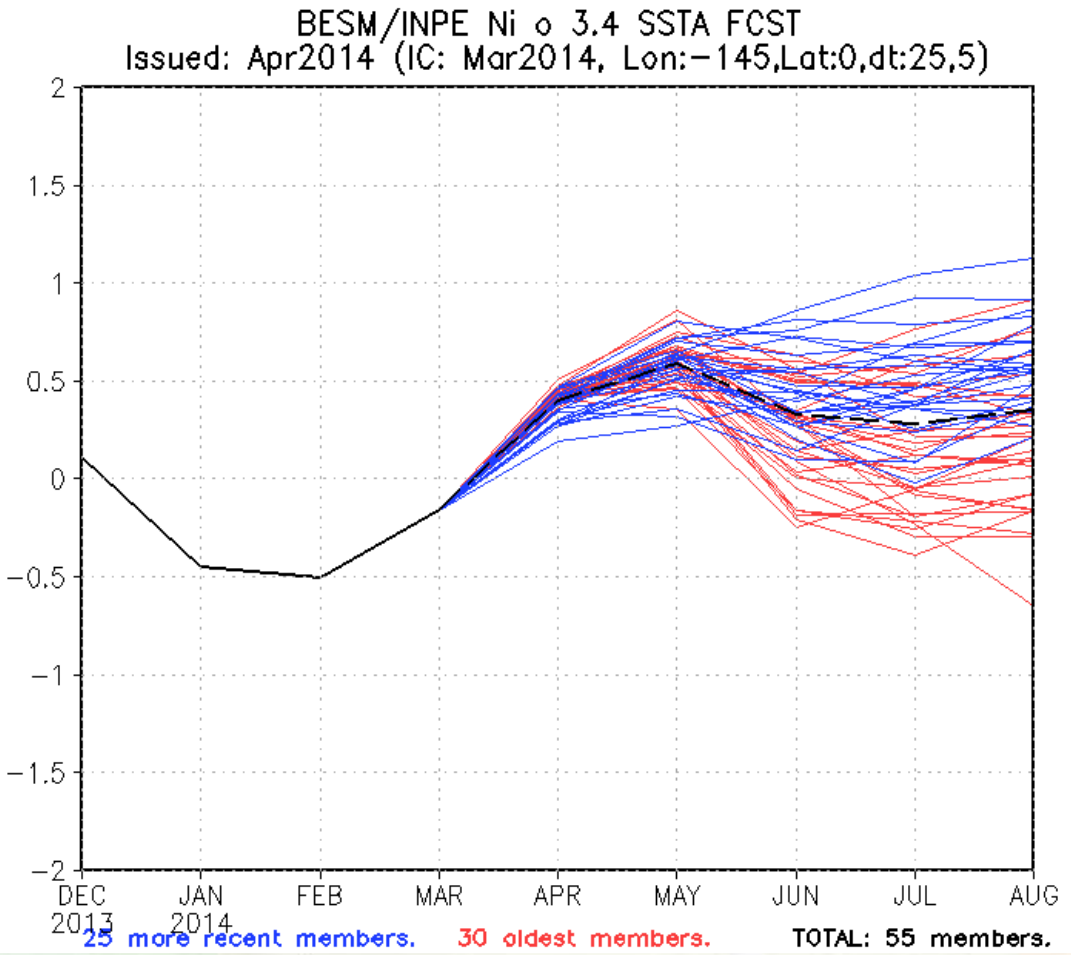
- The **First** Great Challenge: Numerical Weather Prediction
  - The deterministic laws of fluid mechanics should apply to the atmosphere: weather can be predicted (Bjerknes, Charney, Smagorinsky…)
- The **Second** Great Challenge: Climate Change Prediction
  - The effects of green house gases (Arhenius, Manabe)
- The **Third** Great Challenge: *The Earth as a Complex Nonlinear Interactive System*
  - Chaos, Carbon Cycle, Gaya (Lorenz, Bolin, Lovelock)

Advances in Weather Forecasts



Courtesy Prof. Guy Brasseur (2011)

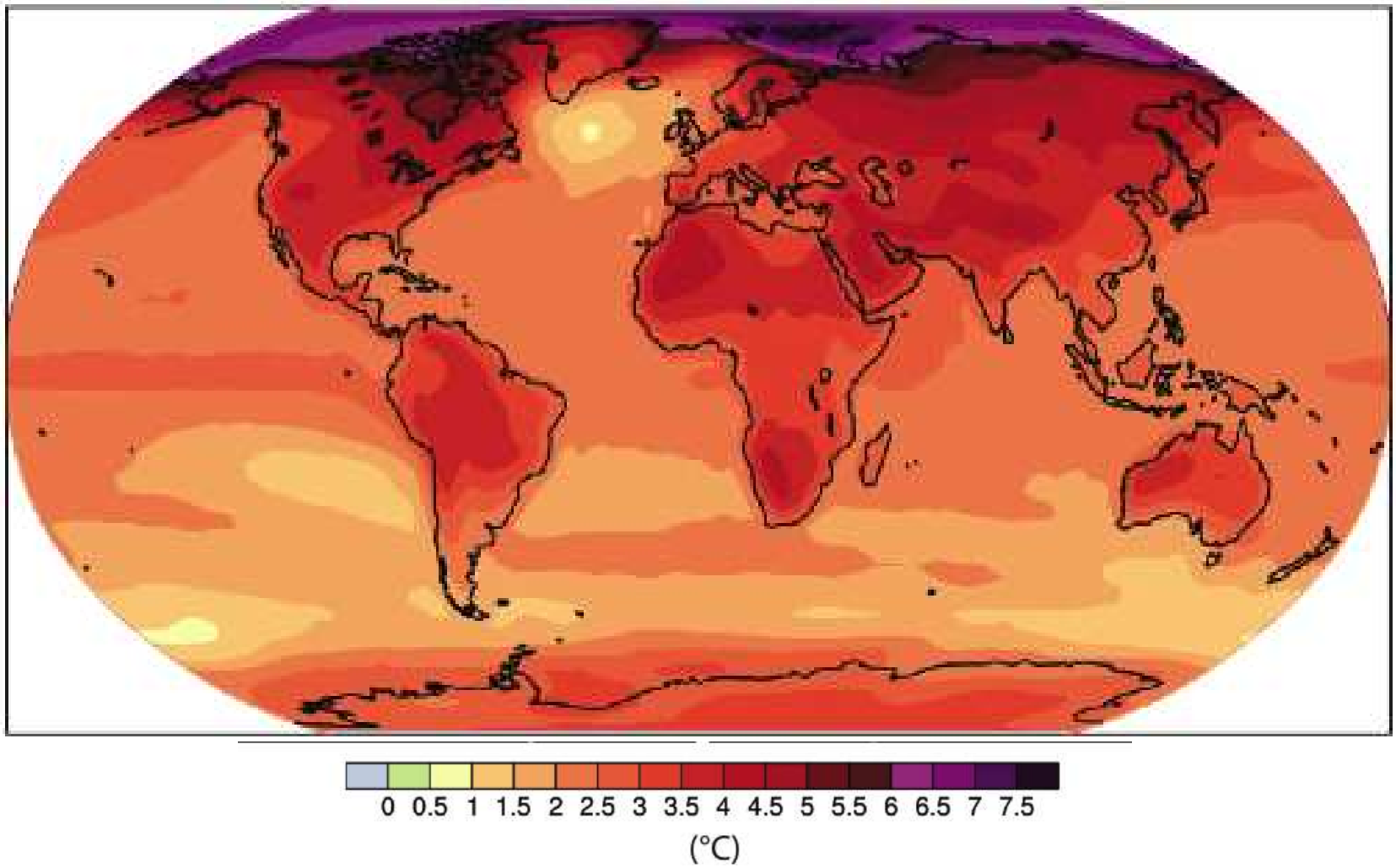
BESM Niño 3.4 SSTA FCST



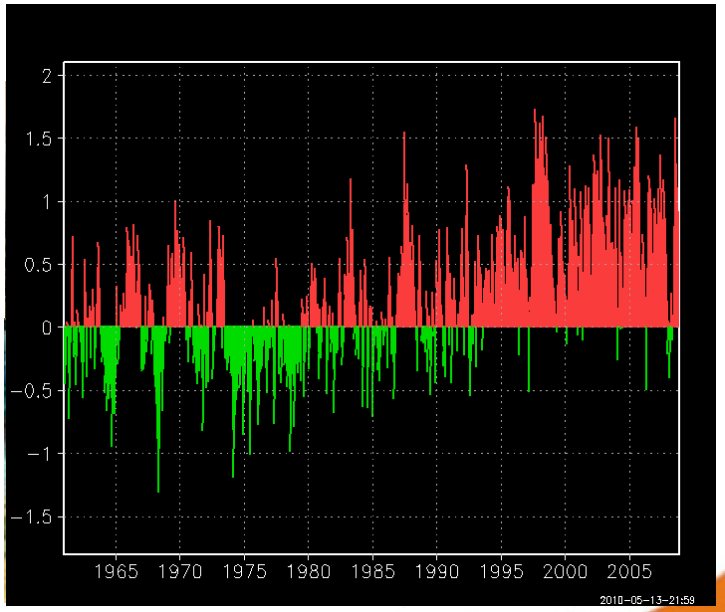
M. Malagutti (pers. Comm.)

A1B is a typical “business as usual” (2090-2099) scenario:

Global mean warming 2.8^{o}C;
Much of land area warms by ~3.5^{o}C
Arctic warms by ~7^{o}C; would be less for less emission



From Weather Forecasting to Global Climate Change Scenarios



T062L28

T126L42

T213L64

T666L96

1 century

1 year

1 month

5 days

30min

Climate Change

Seasonal Climate

DERF

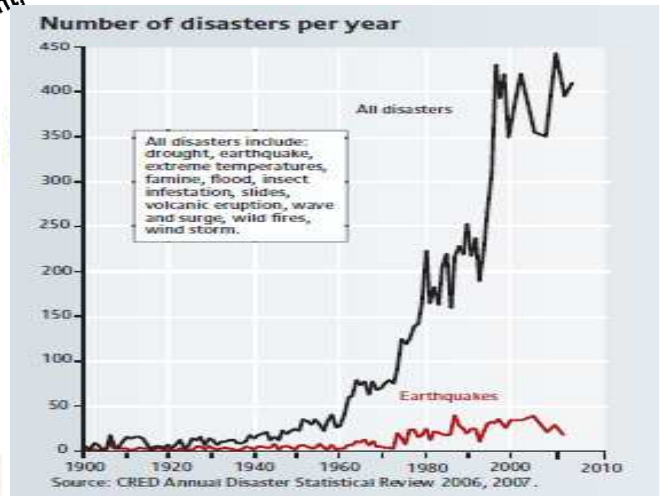
NWP

Government, Public Policies, Strategic Planning

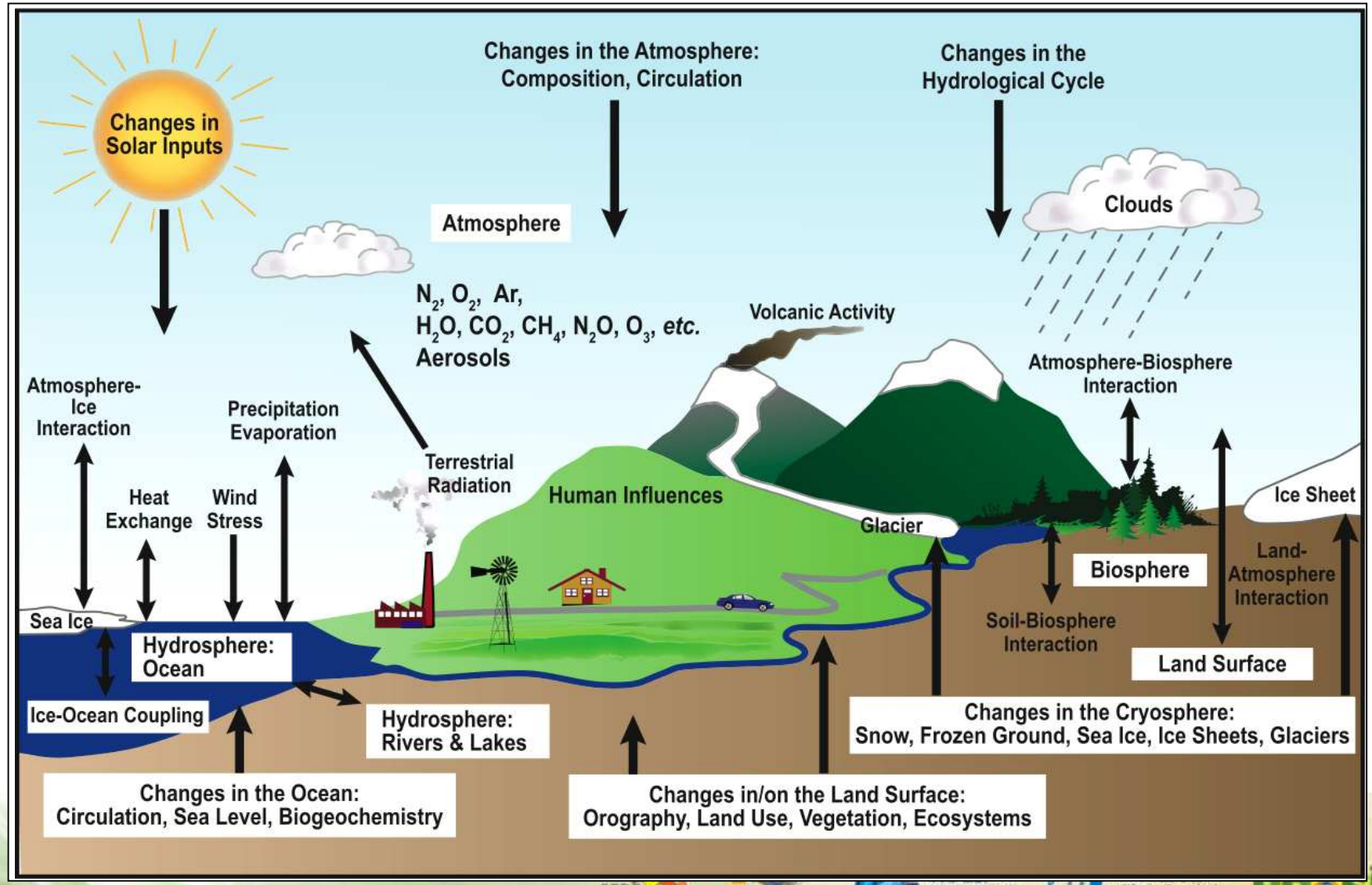
Industry (clouthing, beverages, ice creams)
Agriculture, Water Resources, Energy

Agricuture
Planning
Water Resources
Energy

General Use



The Earth as a Complex Nonlinear Interactive System



Our Challenge:

- ***To build an Earth System Model in Brazil, from state of the art component models in the nation and abroad:***

1. To incorporate expert knowledge (e.g. the LBA program) about ocean-ice-atmosphere-biosphere interactions of relevance to Brazil;
2. To provide the scientific foundations of global climate change scenarios for mitigation and adaptation policies to climate change in Brazil;
3. **To contribute to form a new generation of modeling-capable earth system scientists in the nation.**

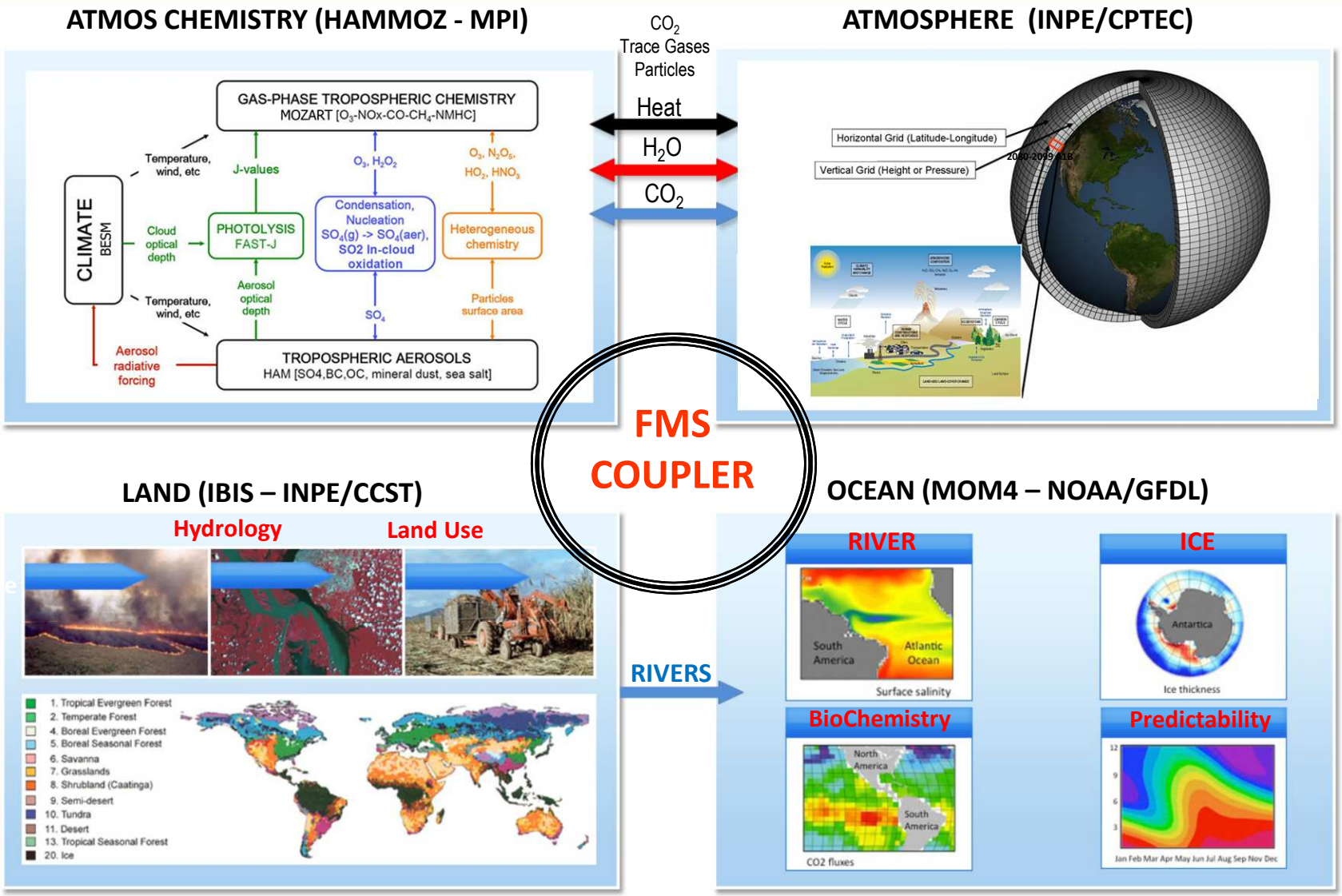
BESM DEVELOPMENT STRATEGY

(i) full use of CPTEC's experience and sub-models

(ii) collaboration with advanced climate change centers abroad

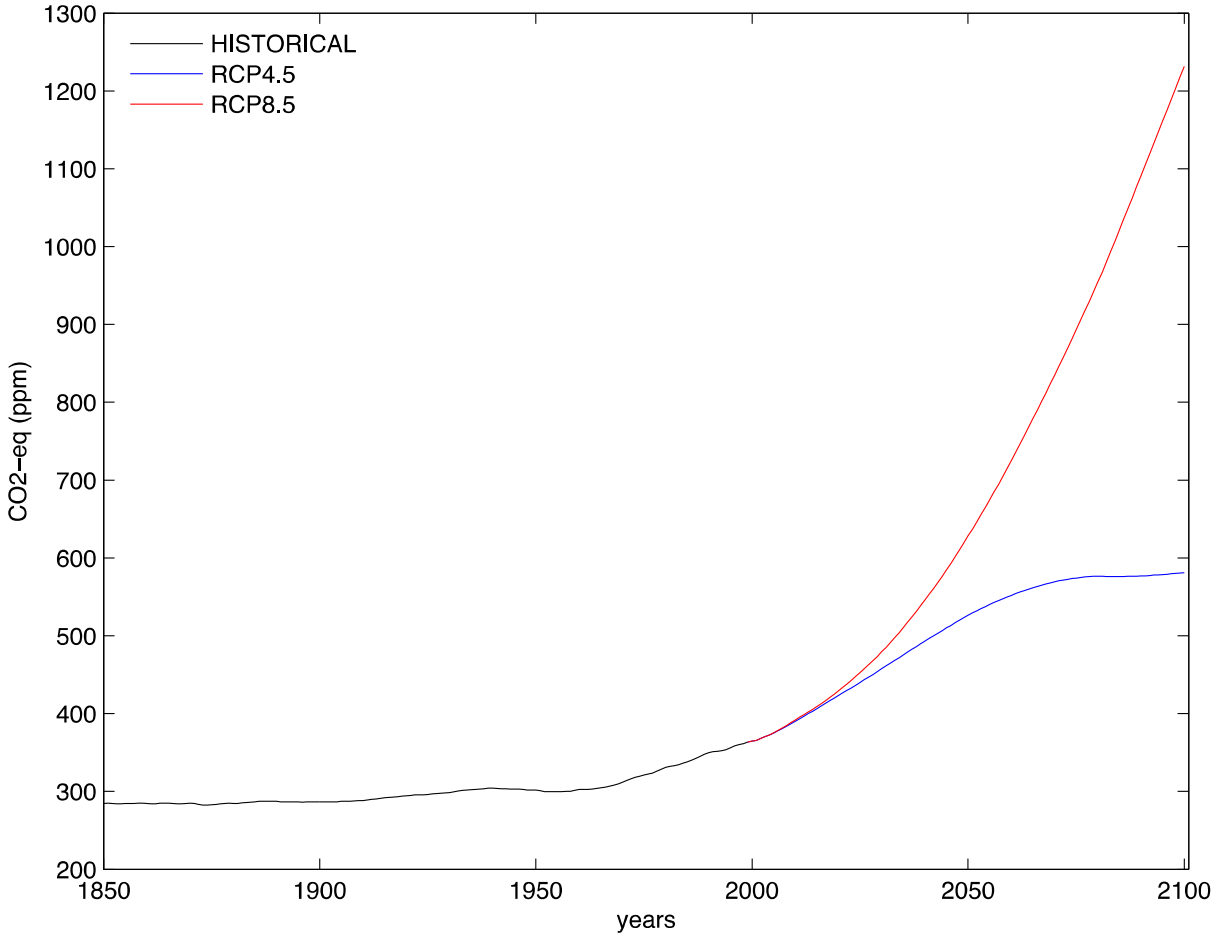
- Take CPTEC Global Coupled Ocean-Atmosphere Model as the structuring building-block
- Use GFDL/FMS coupler to add components:
  - Dynamic vegetation with carbon cycle (INLAND);
  - Continental hydrology-ocean coupling (THMB);
  - Ocean carbon cycle (TOPAZ);
  - Enhanced sea ice and pack ice (SIS);
  - Atmospheric chemistry and aerosols (HAM/MOZART).

BESM Component Models



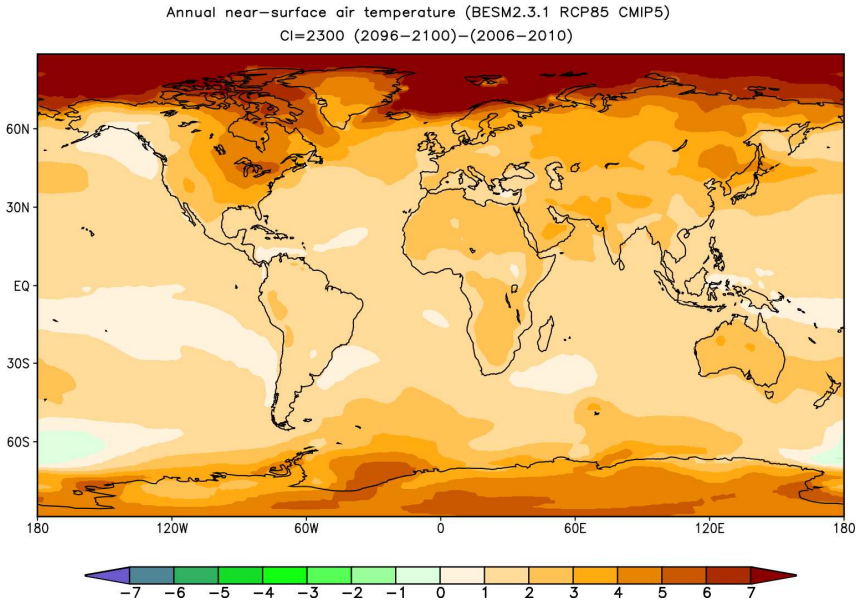
Courtesy: Paulo Nobre

IPCC AR5 RCPs 4.5 & 8.5
CO2 Concentration

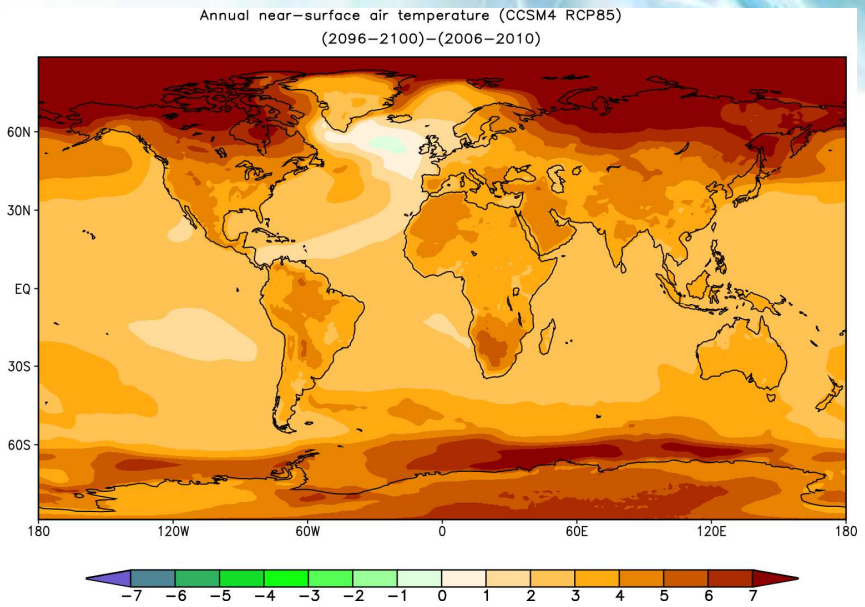


2100 Temperature Change RCP 8.5

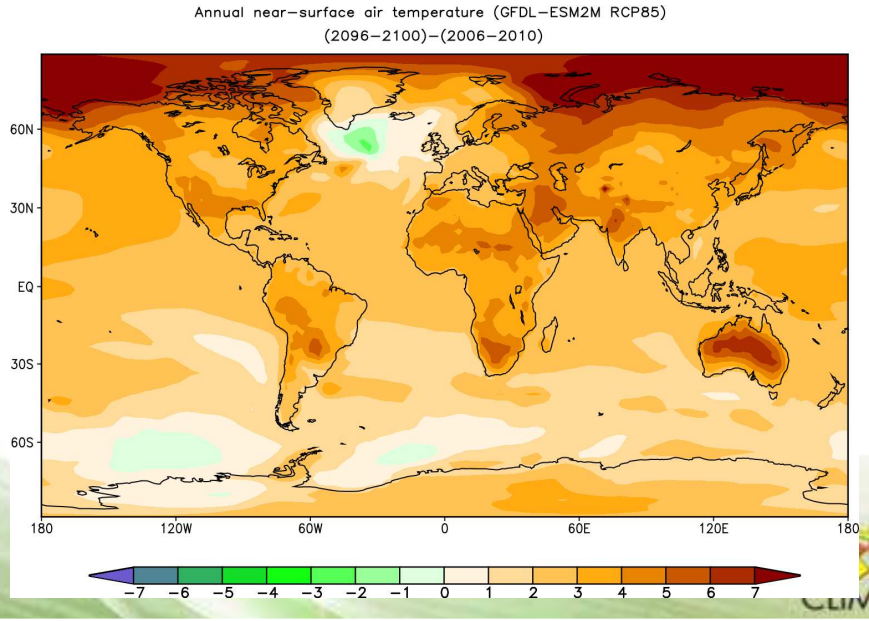
(a) BESM



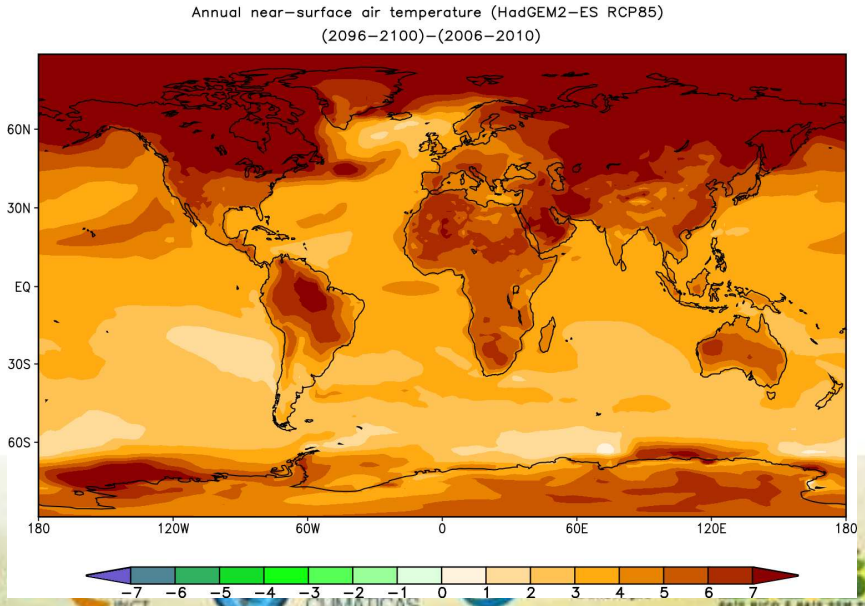
(b) CCSM4



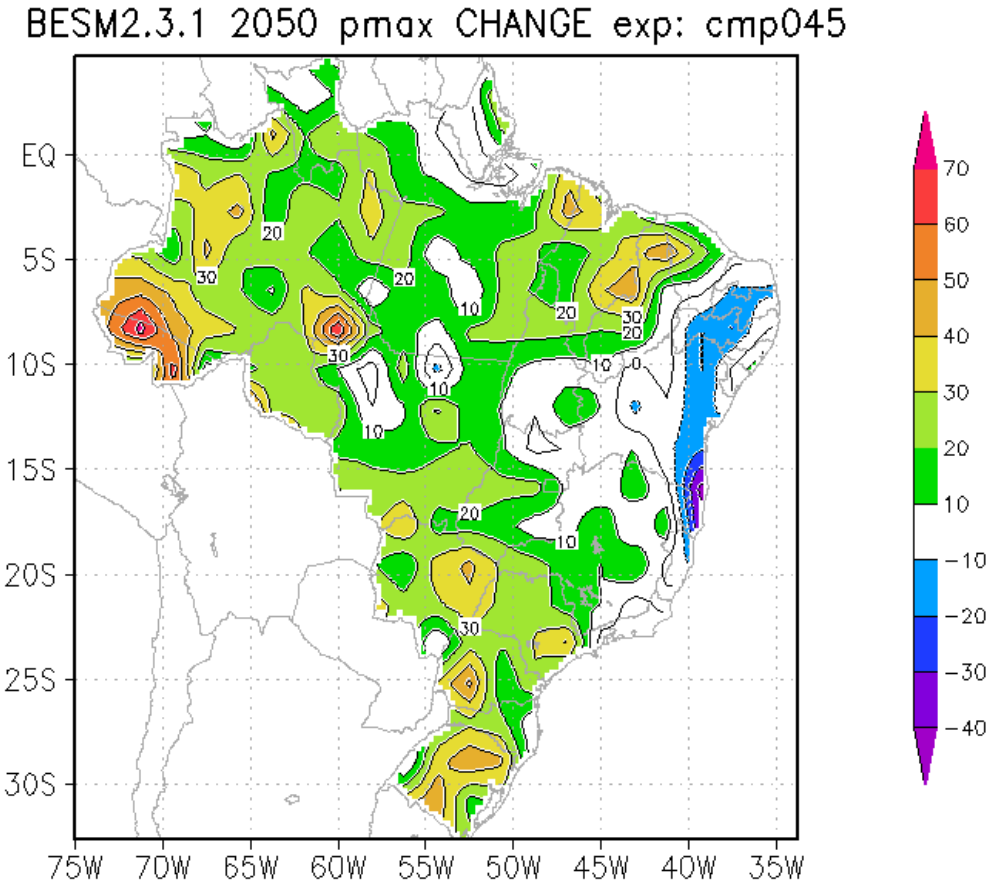
(c) CM2.1



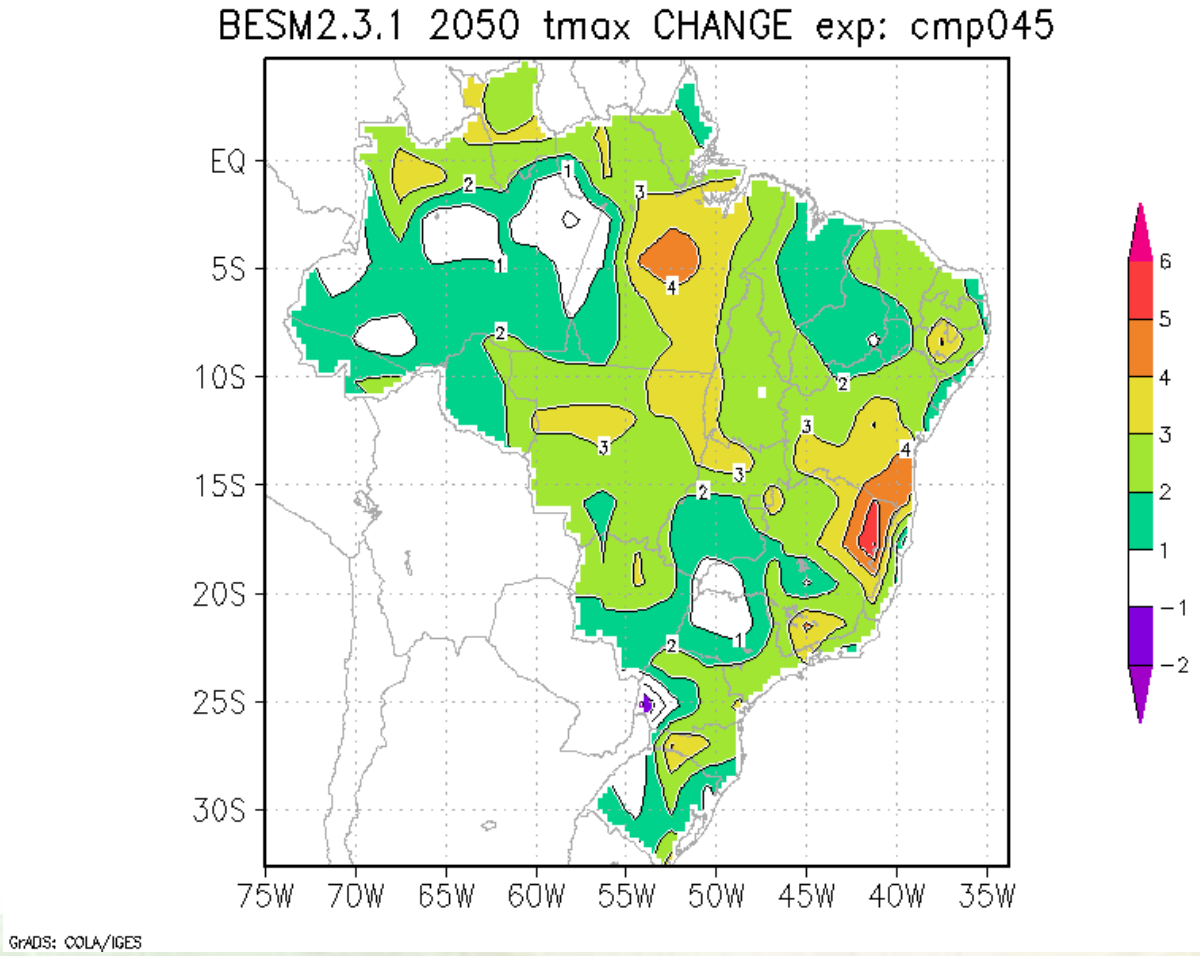
(d) HadGEM2



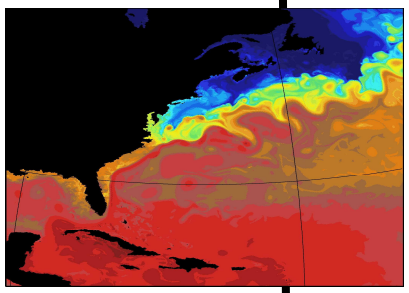
Tendência Extremos Pluviométricos BESM RCP 8.5, em 2050



Tendência Extremos Temperatura BESM RCP 8.5, em 2050

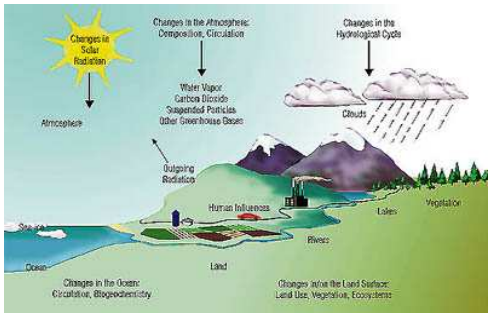


Competing demands of resolution, complexity, uncertainty, and long integrations in Climate System Modelling:



Resolution

Complexity



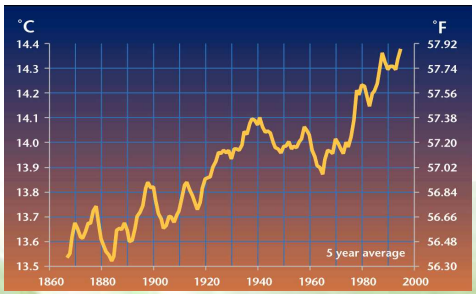
Resolution

Computing Resources

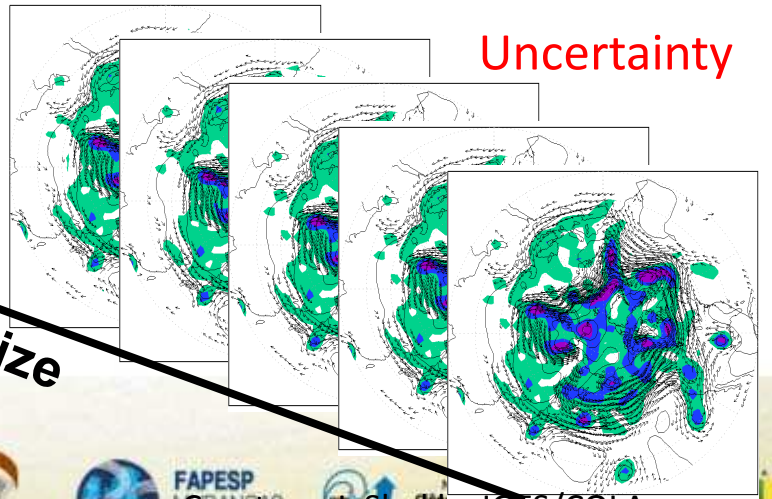
Complexity

Duration and/or Ensemble size

Long simulations

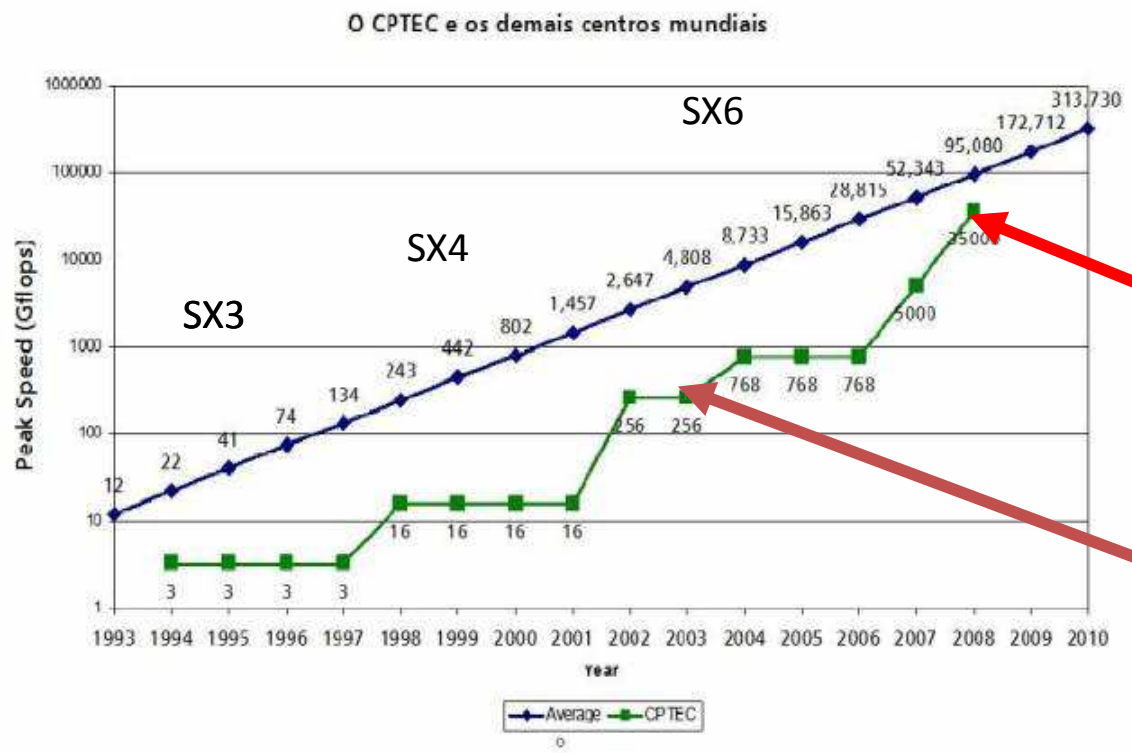


Uncertainty



Courtesy: J. Shukla, IGES/COLA

MCT/INPE-REDE CLIMA-FAPESP
Supercomputer for Climate Change Research



15 TFlops sustained

100 Pbytes disk/tape storage

Courtesy: J. P. Bonatti, INPE/CPTEC

Earth System Grid Federation ESGF

BESM/FAPESP
TRAINNING WORKSHOPS

- Feb2014: **Atmospheric Planetary Boundary Layer**
  - Dr. Sungsu Park (NCAR, USA)
- Mar2014: **Cloud Microphysics**
  - Dr. Hugh Morrison (NCAR, USA)
- JuL2014: **Atmospheric Chemistry and Aerosols**
  - TBA (NCAR, USA)
- Nov2014: **Ocean Turbulent Mixing**
  - Dr. Vittorio Canuto (NASA/GISS, USA)
- Dec2014: **Coupled Ocean-Atmosphere Data Assimilation**
  - Dr. S. Lakshmivarahan (U. Oklahoma, USA)
- Mar2015: **Global Surface Processes**
  - TBA

Challenges Ahead

- Building a trully interactive science-policy making-private sectors network that is capable to understand and use the scenarios and forecasts of **BESM** for decision making;
- Bringing the whole of the scientific community, professors & students, in Brazil and other countries to cooperate for that end.

BESM Science Team

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BESM Contributing Institutions

- **Coordination**: INPE
- **Atmosphere**:
  - INPE/CPTEC, USP, UFSM, UFCG
- **Ocean**:
  - INPE/CPTEC, USP, UFPE, IISc, NASA/GISS, NOAA/GFDL
- **Surface**:
  - INPE/CCST, USP, UFV, UFSM, WHRC, EMBRAPA
- **Chemistry**:
  - UERJ, INPE, NCAR, MPI, IITM, CSRI


Thank you!
Foto: cortesia de Antonio Nobre