Climate Change Scenarios and Modelling

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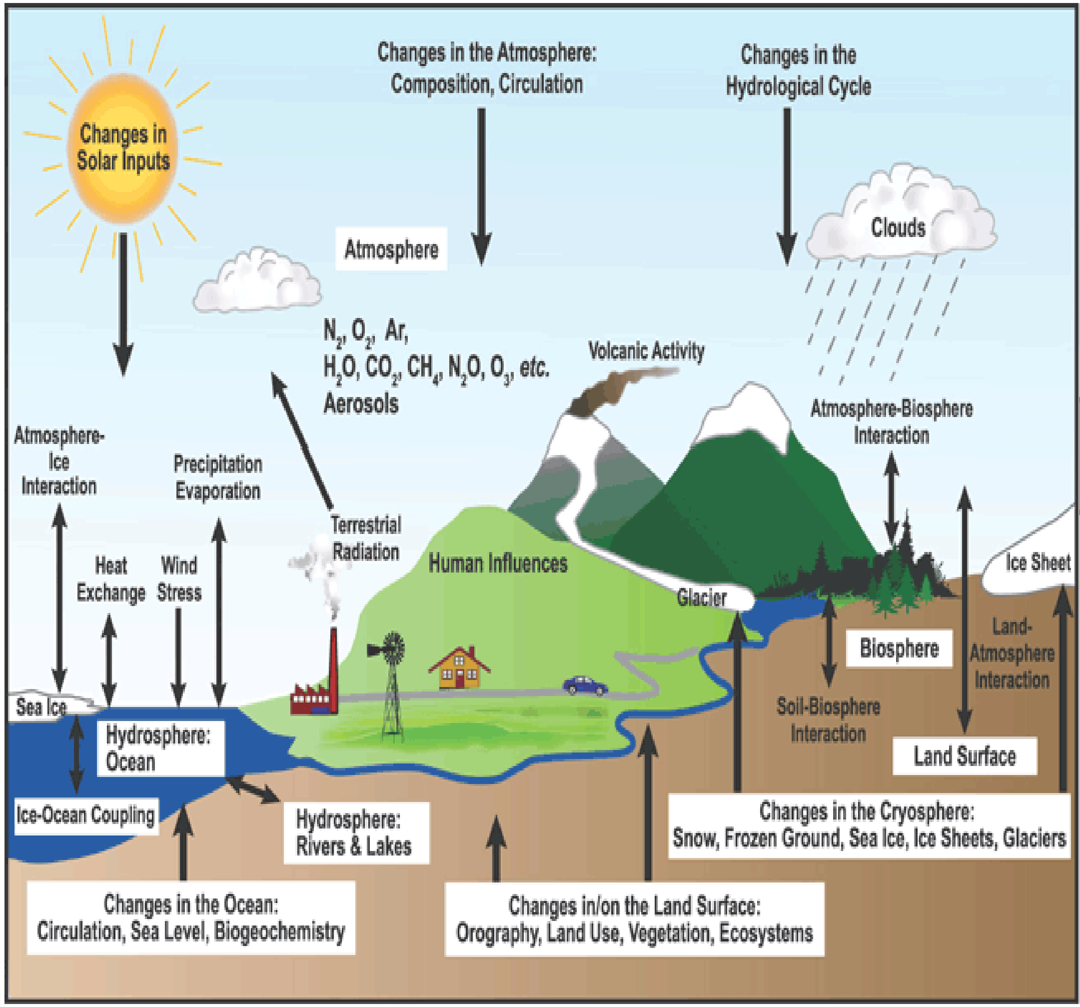
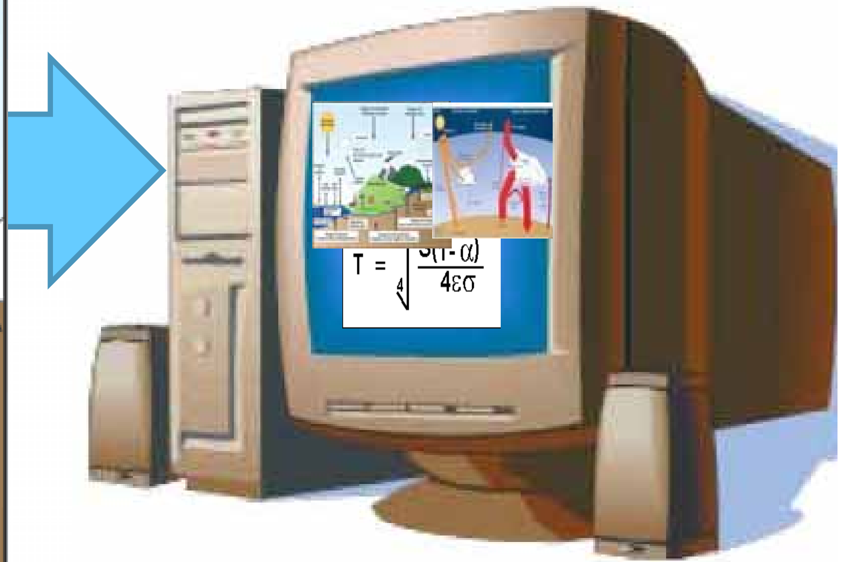
The Global Climate System and Modeling



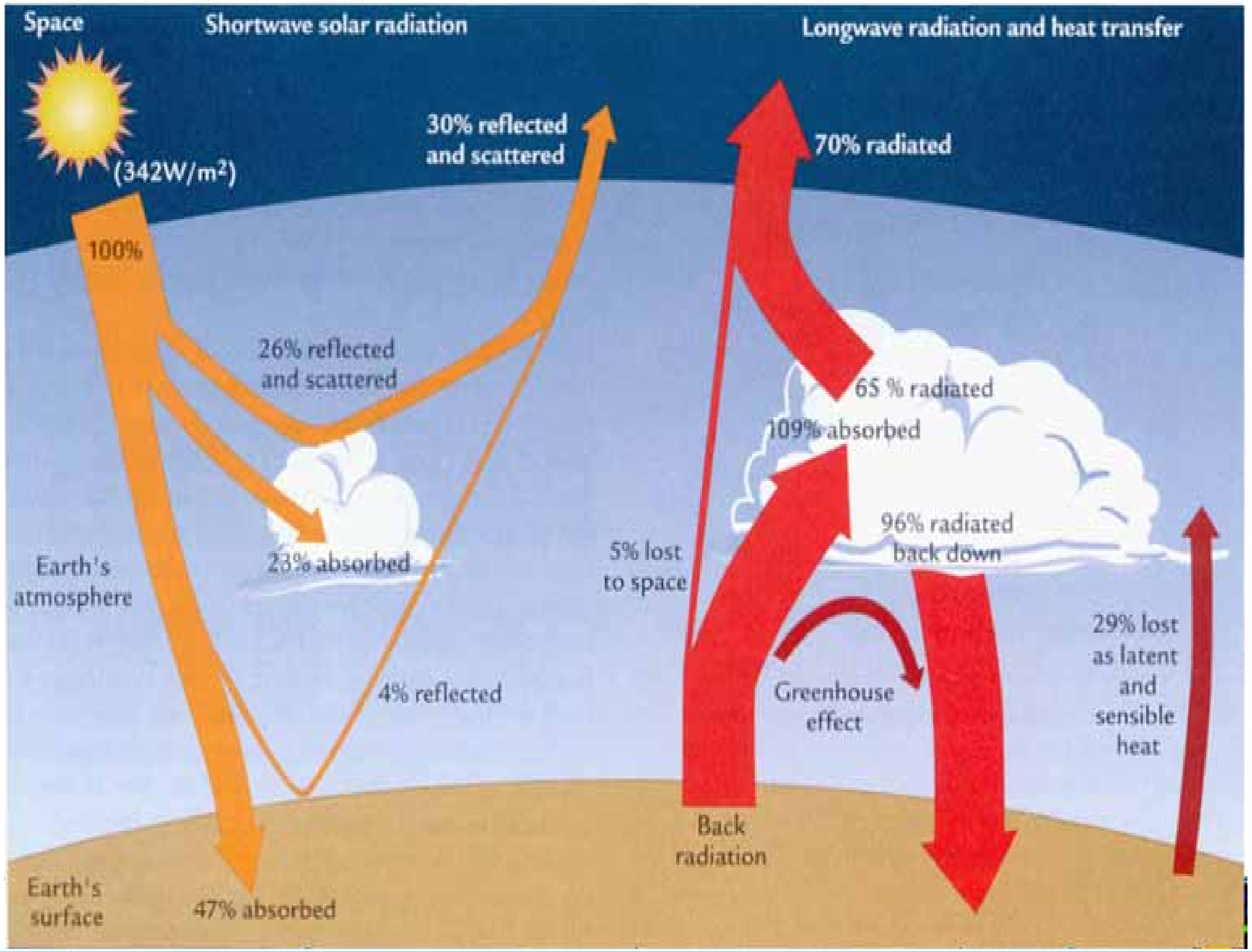
GCM



The Global Climate System and Modeling

The Earth's energy balance

=> *Solar radiation in = Terrestrial radiation out*



$$T = \sqrt[4]{\frac{S(1-\alpha)}{4\varepsilon\sigma}}$$

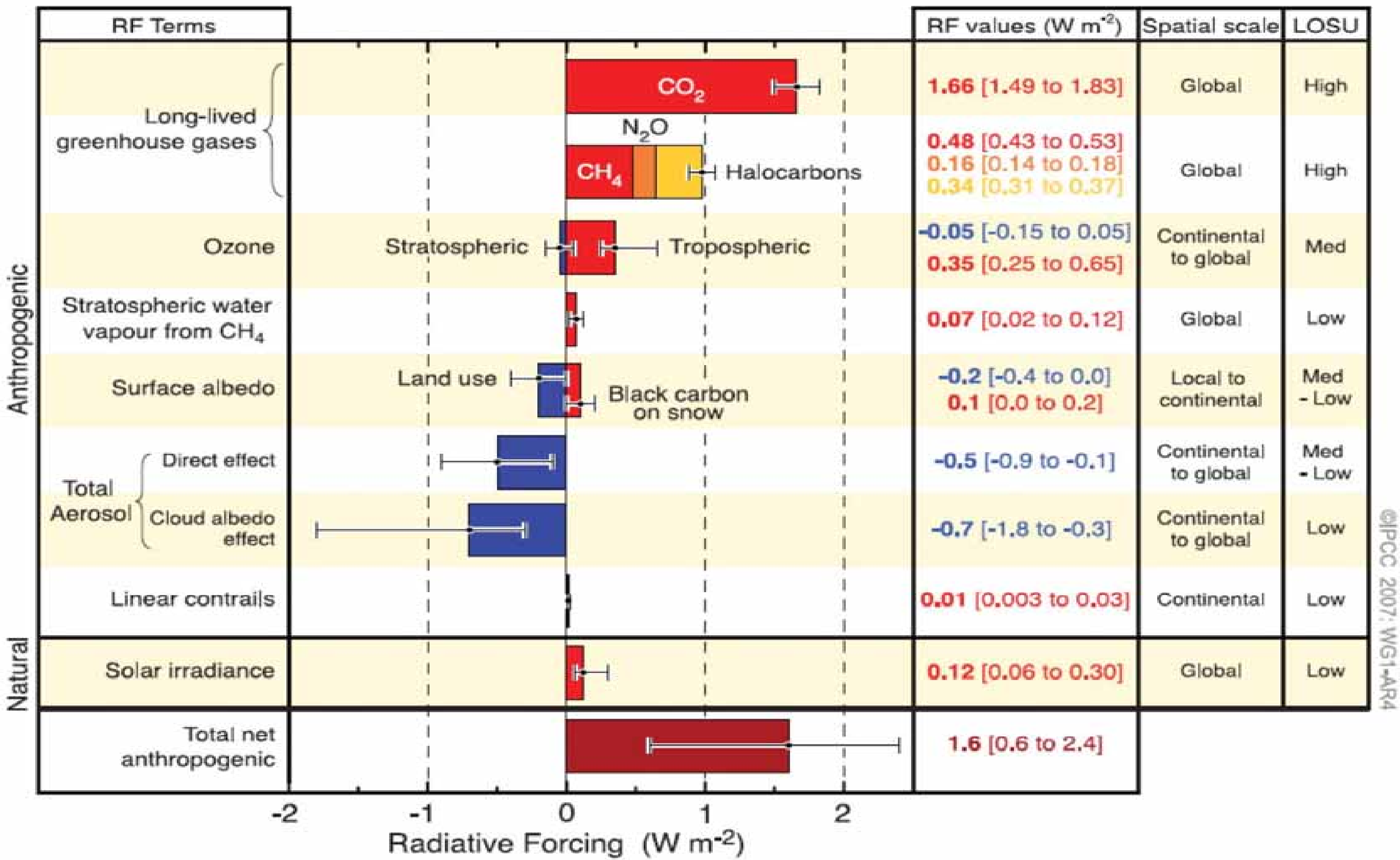
Climate Forcing: The driver of climate change

- Natural Factors
  - -Sun-Earth geomerty
  - -Solar activity
  - -Volcanic eruption
  - -Oceanic changes
- Human-induced Factors
  - -Greenhouse gases
  - -Aerosols
  - -Land surface changes

Climate Forcing

An external change that generates a perturbation to the net radiative (energy) balance at the top of the atmosphere

RADIATIVE FORCING COMPONENTS



_, Emission Scenarios

Forcing the future climate

Future climate change requires information about future climate forcing:

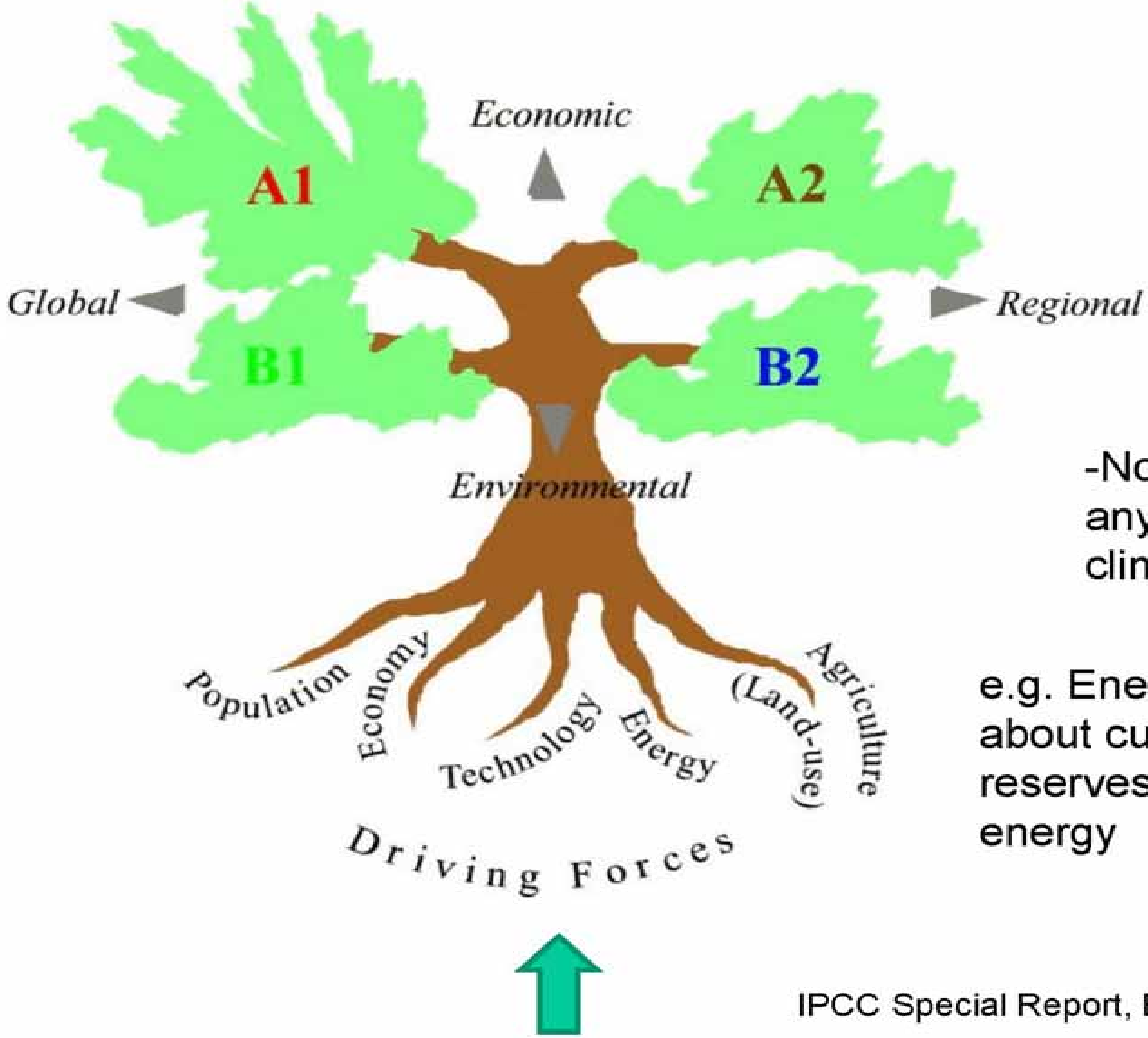
- Greenhouse gas emissions
- Aerosol emissions
- Land use changes

We have no idea what future natural forcings may be, although in time anthropogenic forcings will dominate.

→ An exception would be a large asteroid impact.

SRES Scenarios

Scenarios families (storylines) → models → individual scenarios



-Note: do not include any assumptions of climate policies!!

e.g. Energy – assumptions about current fossil fuel reserves and renewable energy

IPCC Special Report, Emissions Scenarios, 2000

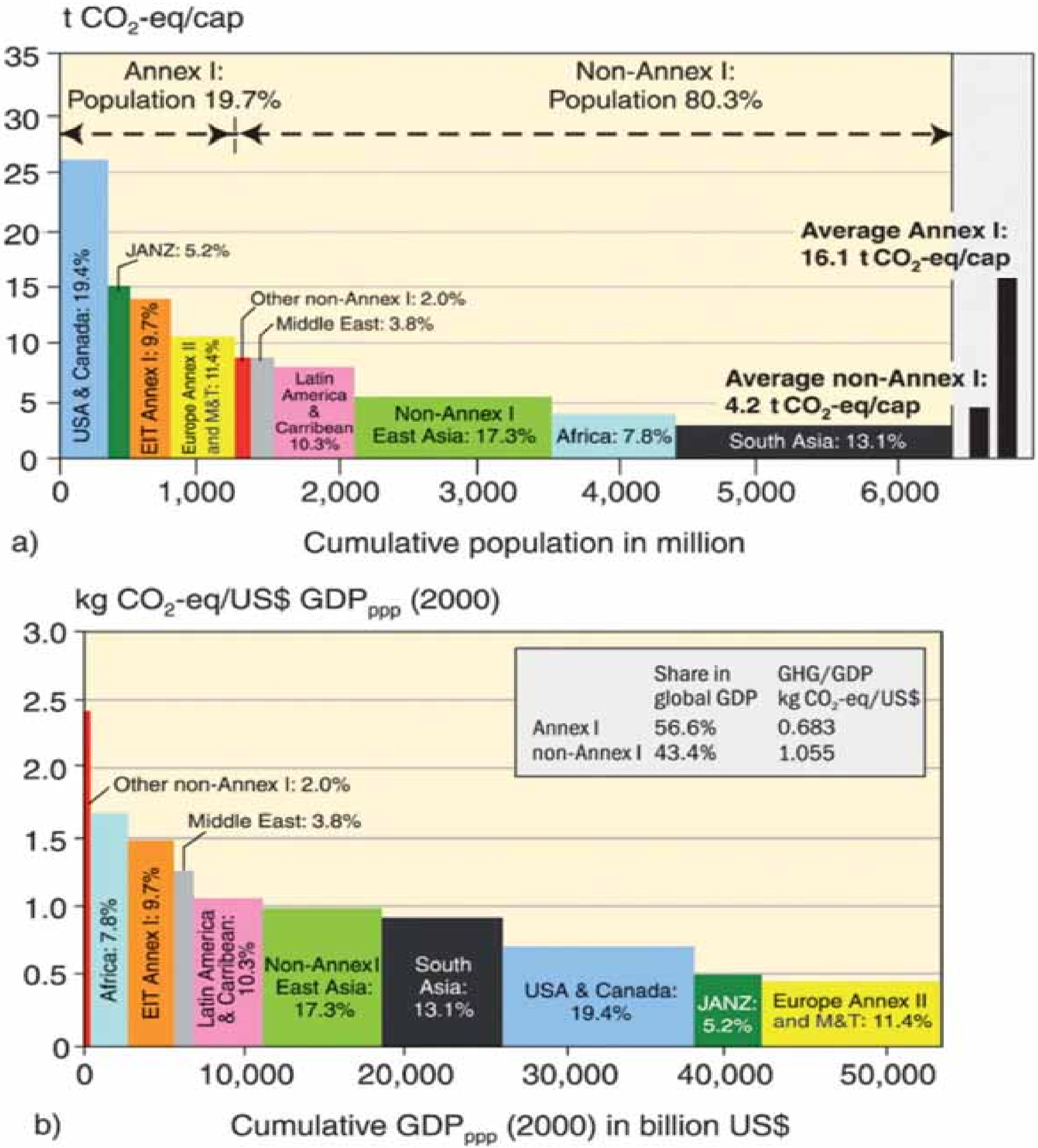
IPCC Special Report, Emissions Scenarios, 2000

Main drivers over the 21st century

Main quantitative indicators:

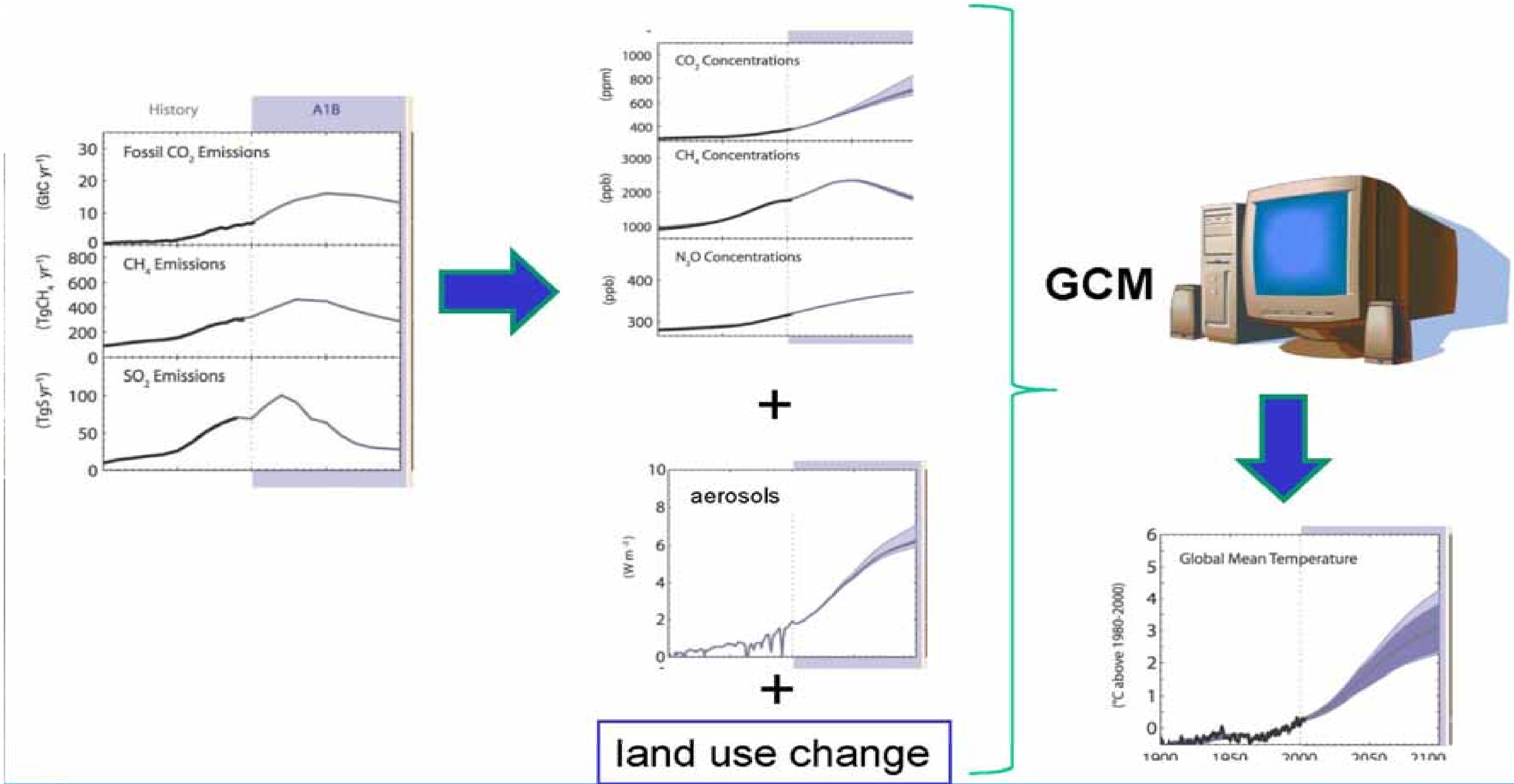
1) global population (15, 10, and 7 billion by 2100 in scenarios A2, B2, and both A1 and B1,respectively)
2) global gross domestic product (GDP) by 2100 (in 1990 US dollars, US$550 trillion for A1, US$250 trillion for A2, US$350 trillion for B1, and US$250 trillion for B2).

Each “forcing” is converted to a CO_2 equivalent for different world regions



Emission scenarios to climate scenarios:

These emission curves are then used to drive our current state of the art climate models into the future. The climate model simulations result in climate scenarios.



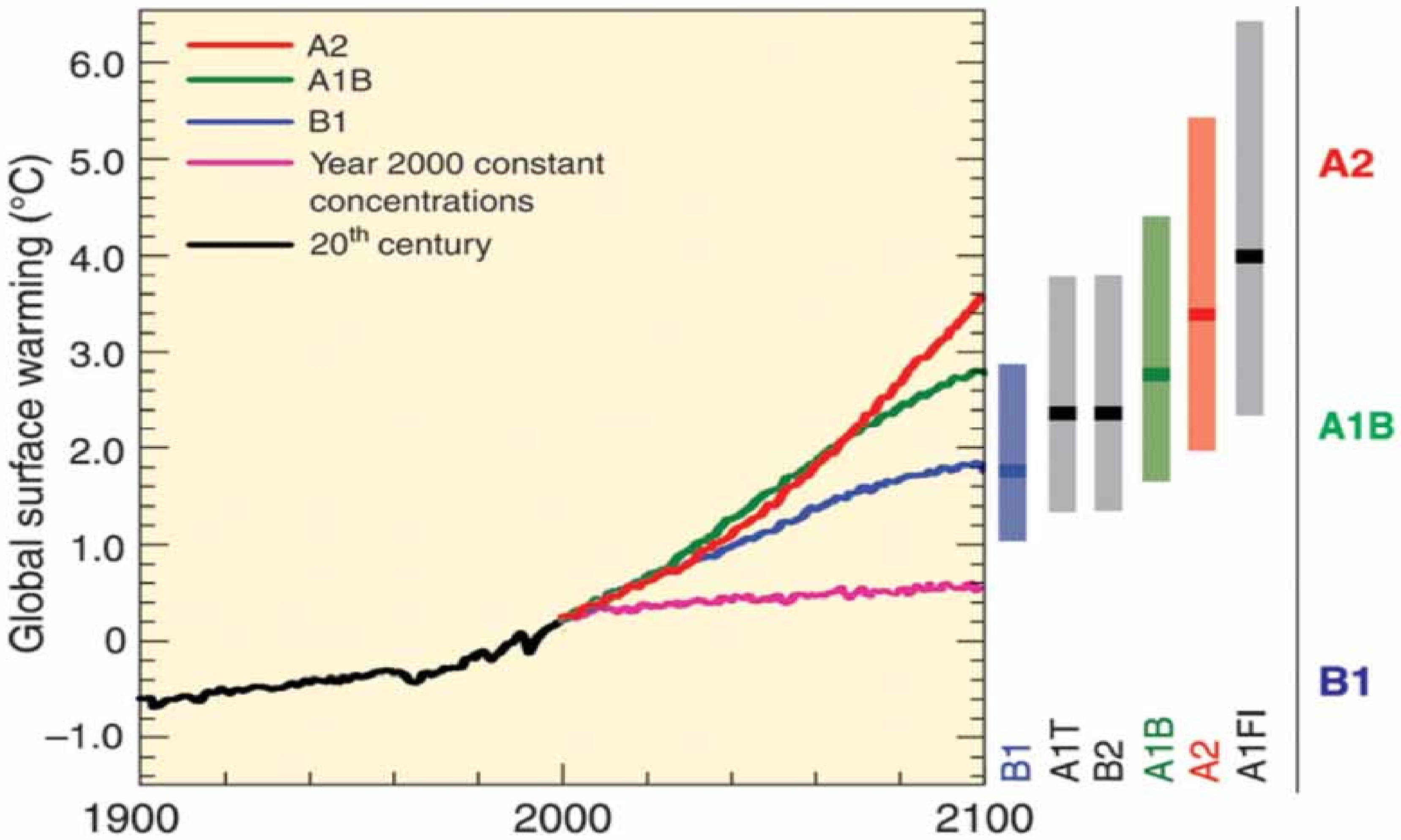
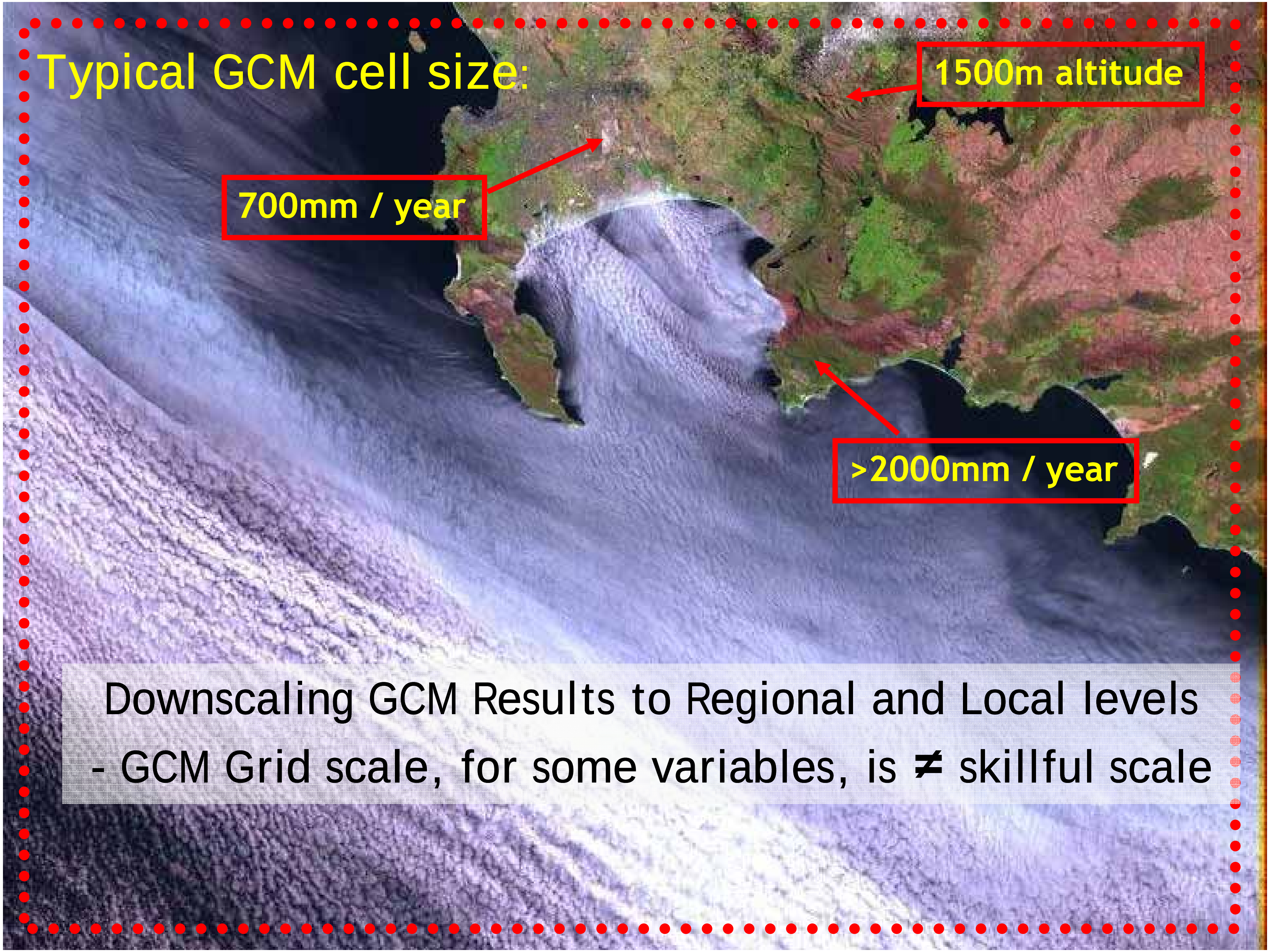


Figure 3.2. Solid lines are multi-model global averages of surface warming (relative to 1980-1999) for the SRES scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. The bars in the middle of the figure indicate the likely range assessed for the six SRES marker scenarios at 2090-2099 relative to 1980-1999 from all AOGCMs. AR4, Synthesis Report


Typical GCM cell size:
1500m altitude
700mm / year
>2000mm / year
Downscaling GCM Results to Regional and Local levels
- GCM Grid scale, for some variables, is ≠ skillful scale

Approach taken at CSAG

A: Characterize the past and present climate as best as possible

- Global station data
- Africa gridded data
- Measured parameters + derivatives (e.g. dry spell duration)

B: Characterize process change to inform understanding

- Consider circulation change as a means to gain confidence in location-specific climate

C: Use as many models as possible future climate projections

- Ideally, focus on AR4 suite of model simulations

D: Downscale where possible

- RCM downscaling
- Empirical downscaling

Empirical Downscaling over Africa
- changes in mean monthly precipitation (mm)

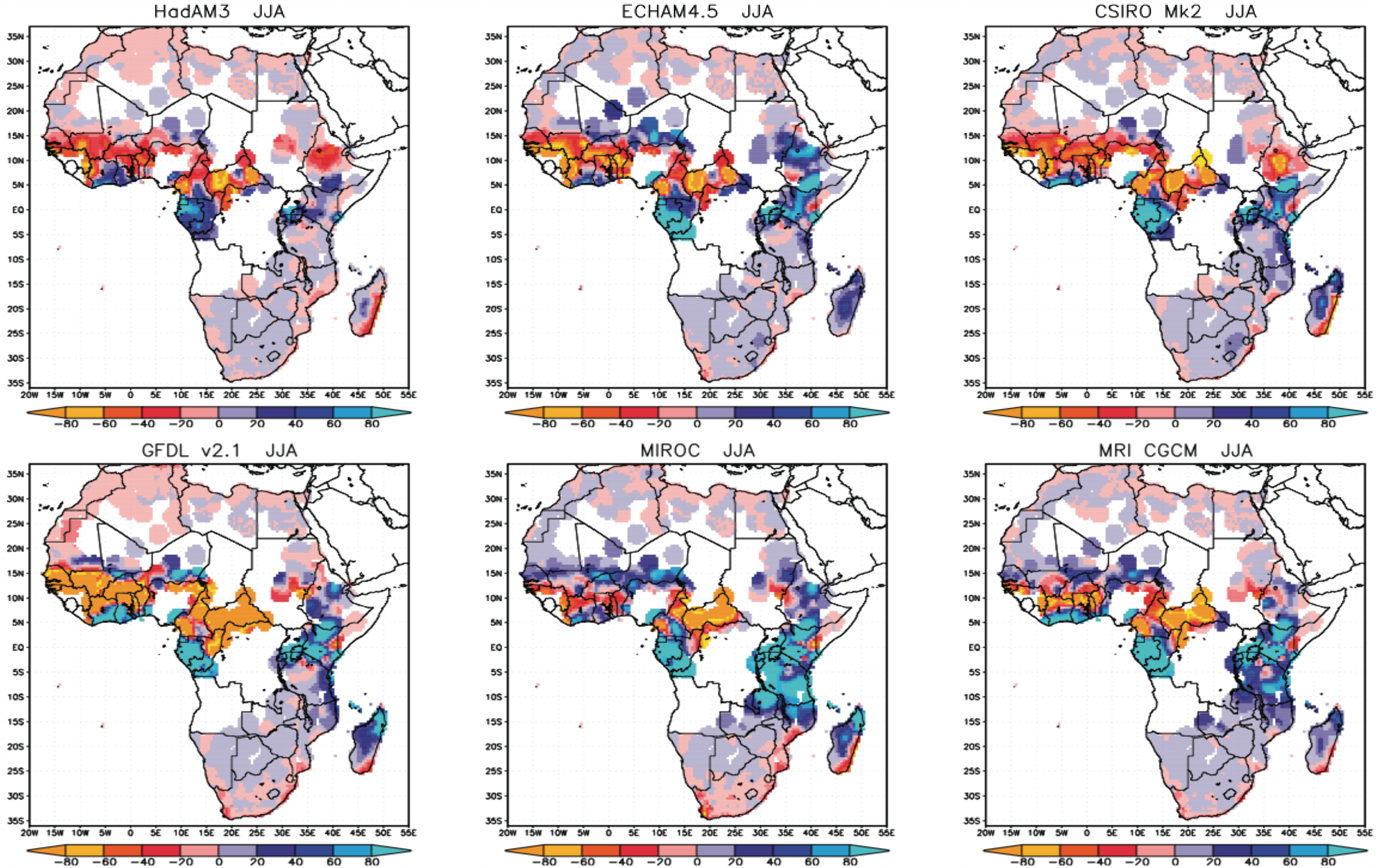
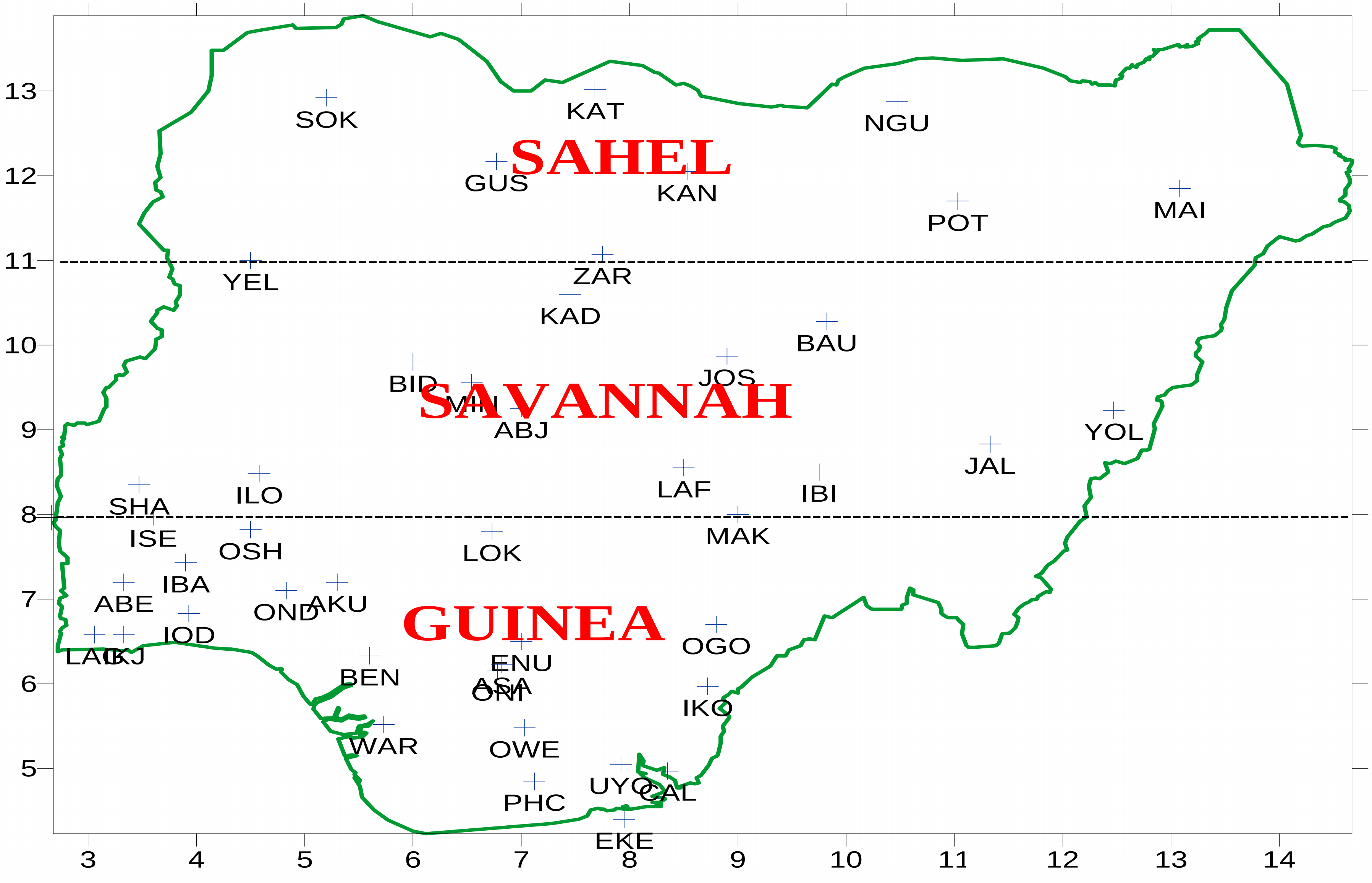
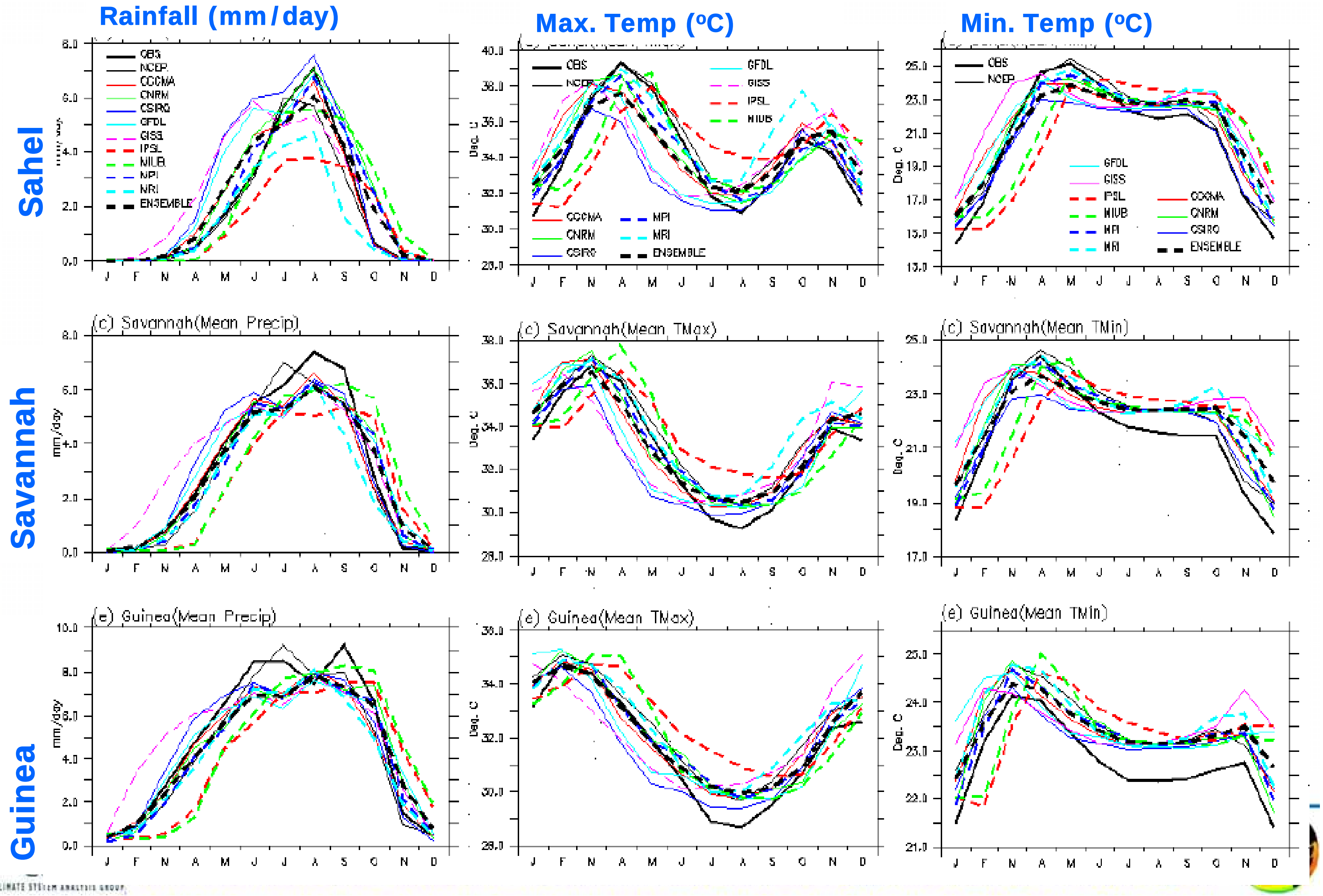


Figure 11.3 IPCC AR4 (from Hewitson and Crane, 2006)

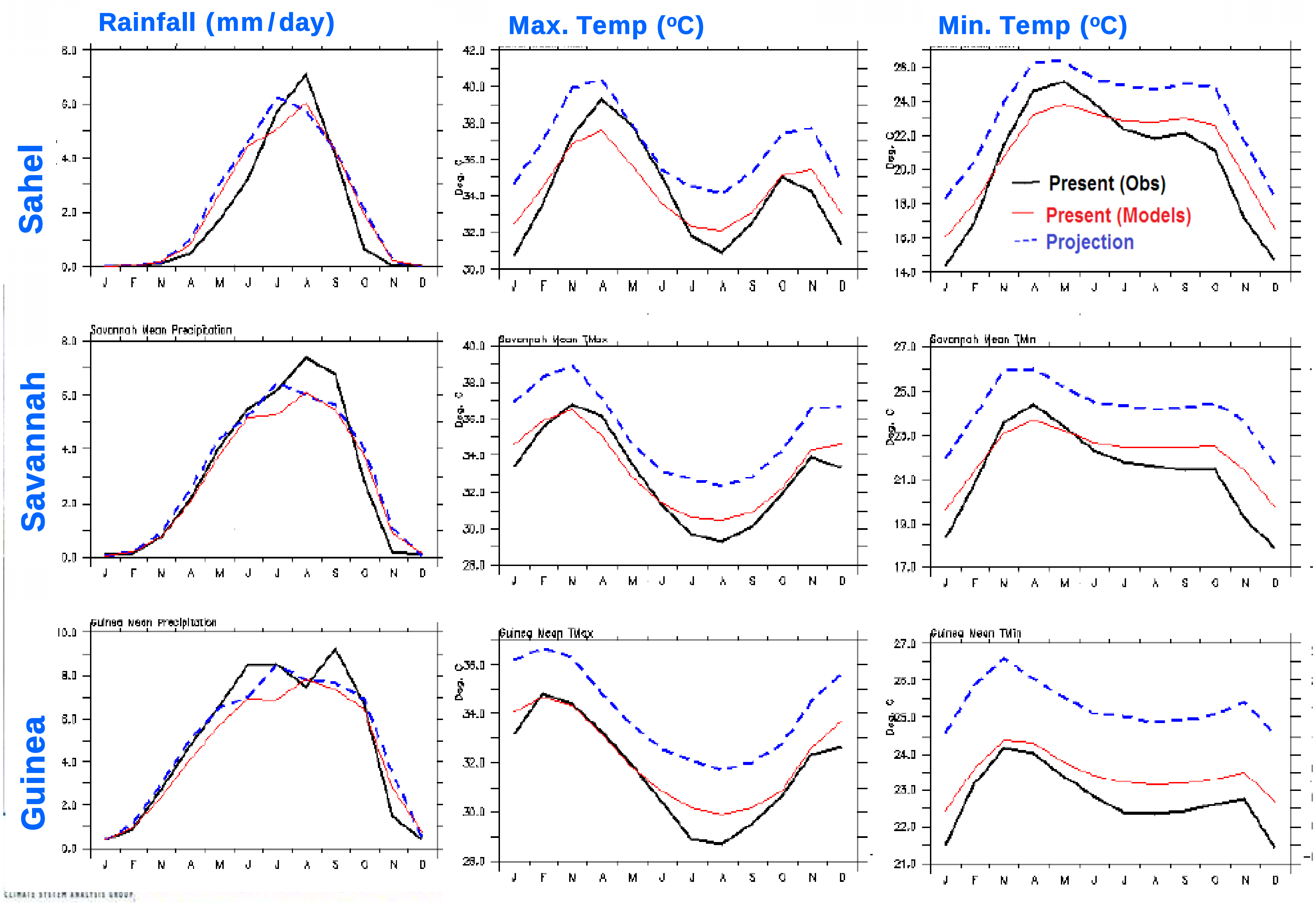
Downscaling climate scenarios over Nigeria (1) : Stations and climatic zones



Downscaling climate scenarios over Nigeria (2) : Model Validation



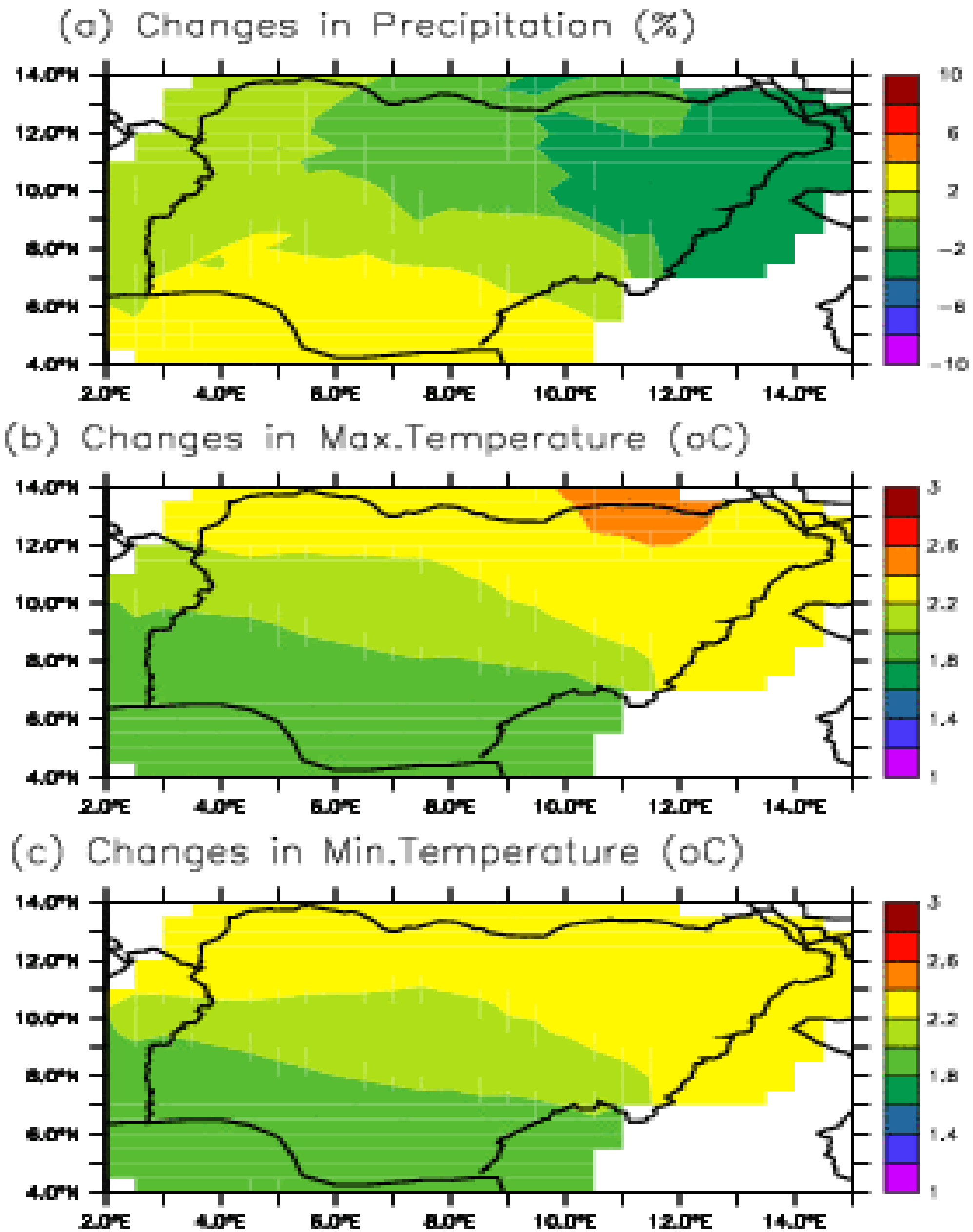
Downscaling climate scenarios over Nigeria (3) : Projections for 2045-2065



Climate Projection over Nigeria (2045-2065)

Rainfall
- increases to the south, and decrease to the north east

Temperature (Tmax and Tmin)
-increase over the entire domain, with the highest increase in the north

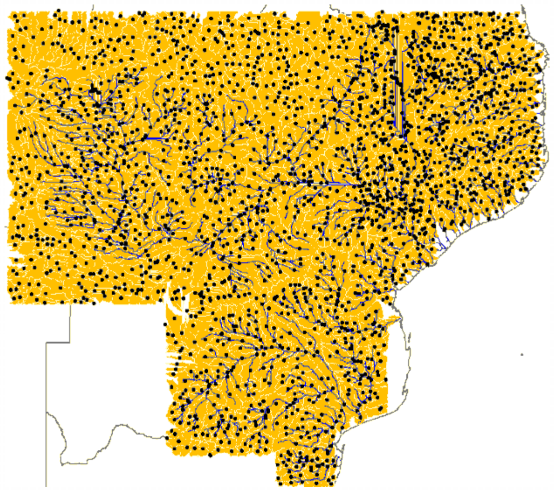


Mozambique – climate change and disaster risk

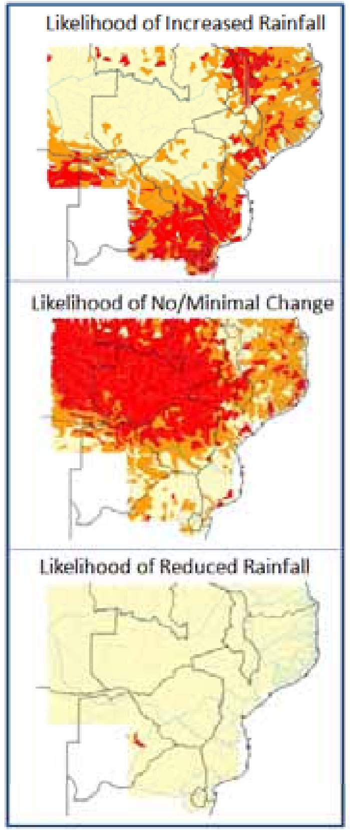
Understand the implications of climate change for the operations of the ministry of disaster risk management (INGC)

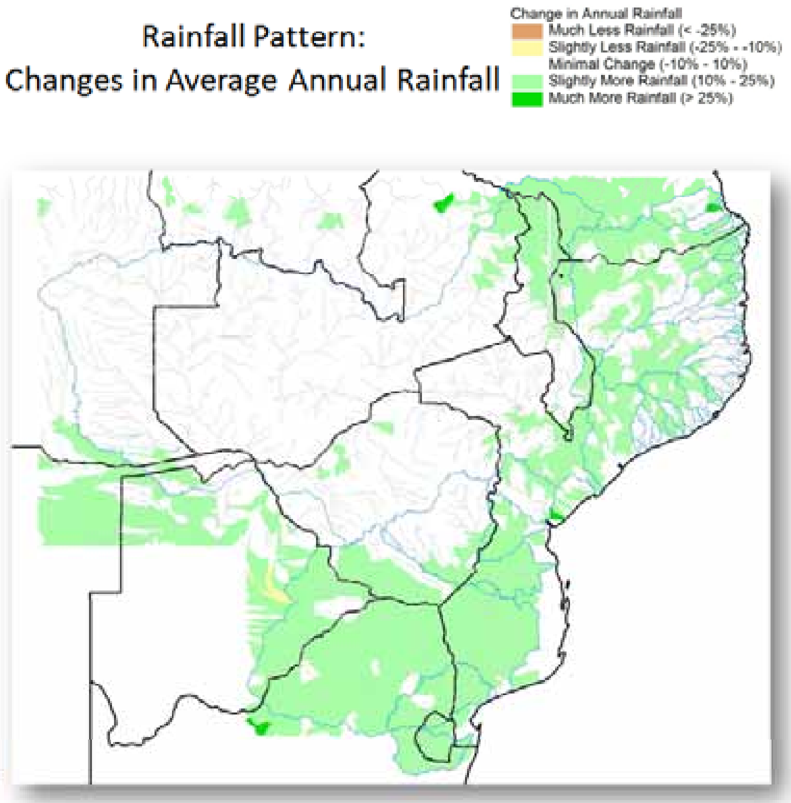
- Involve international and national experts
- Climate component feeding into agricultural/land resource (ministry of agriculture) and flooding (ministry of water affairs) assessment (Kwabena Asante, ClimatUS)
- Scenario and land use development (Marc Metzger, Uni. Edinburgh)
- Sea-level rise and coastal defenses (Geoff Brundrit)
- Human vulnerability assessment (Tony Patt, IIASA)

Mozambique – changes in water resources (2046-2065)



Sub-basins and rivers used in GeoSFM model





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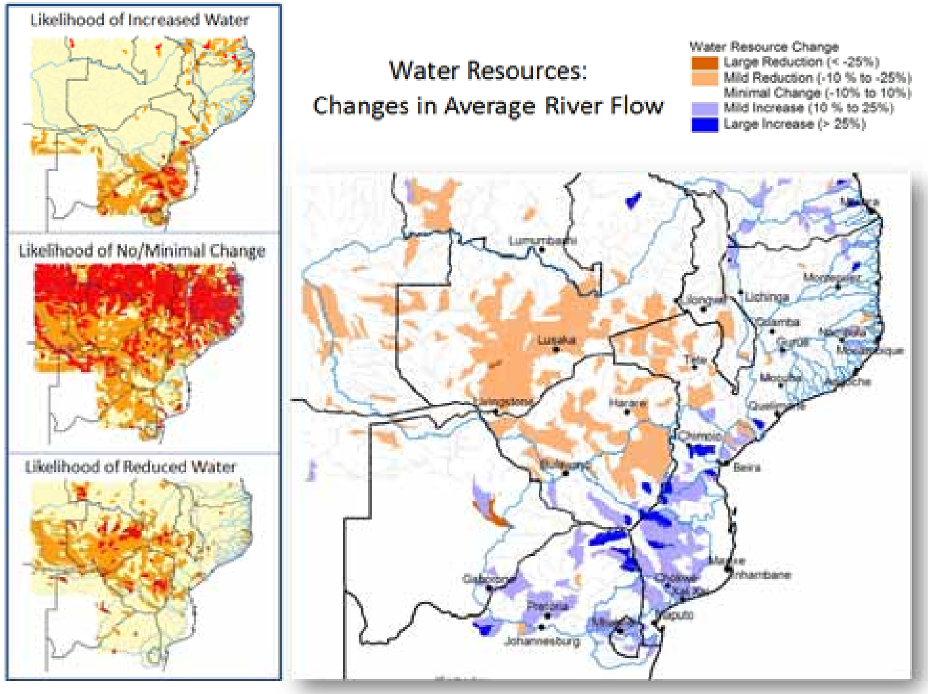
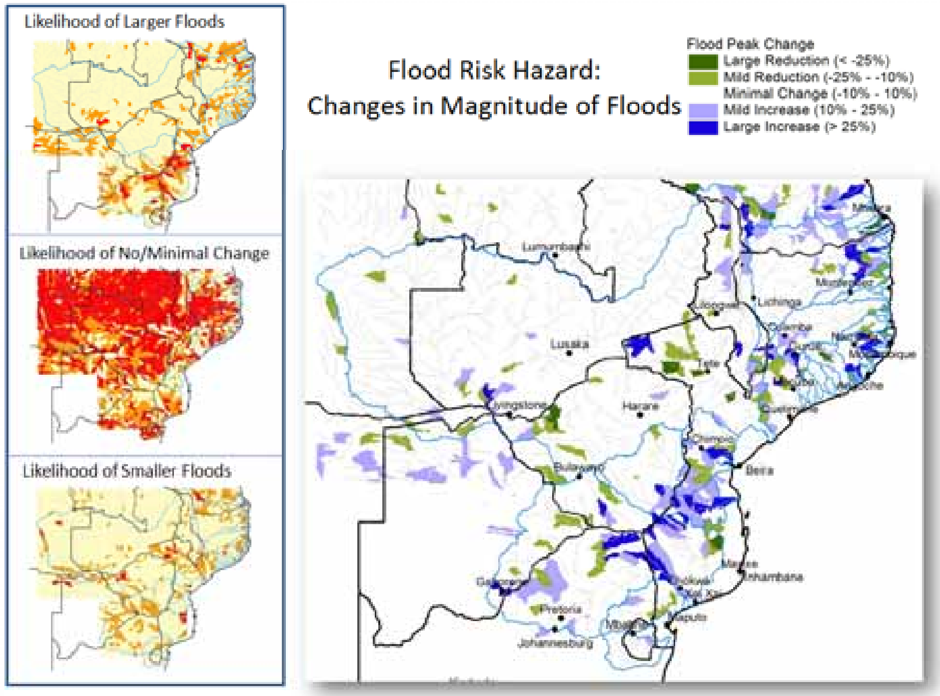
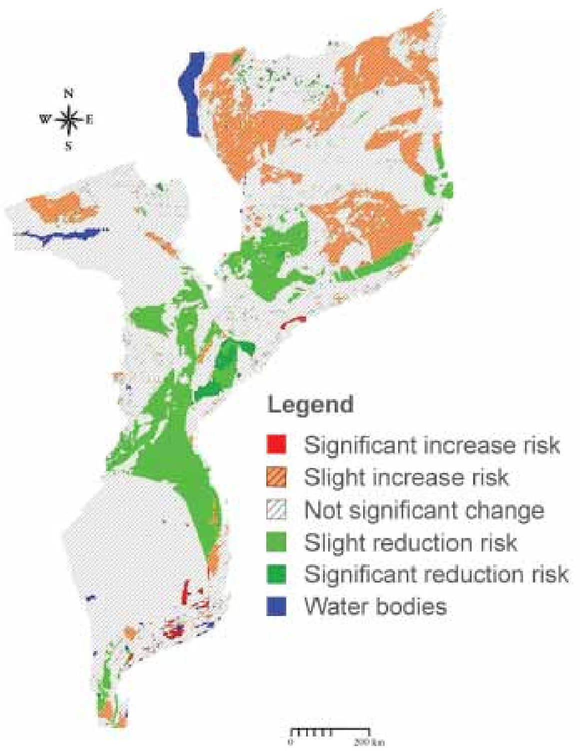


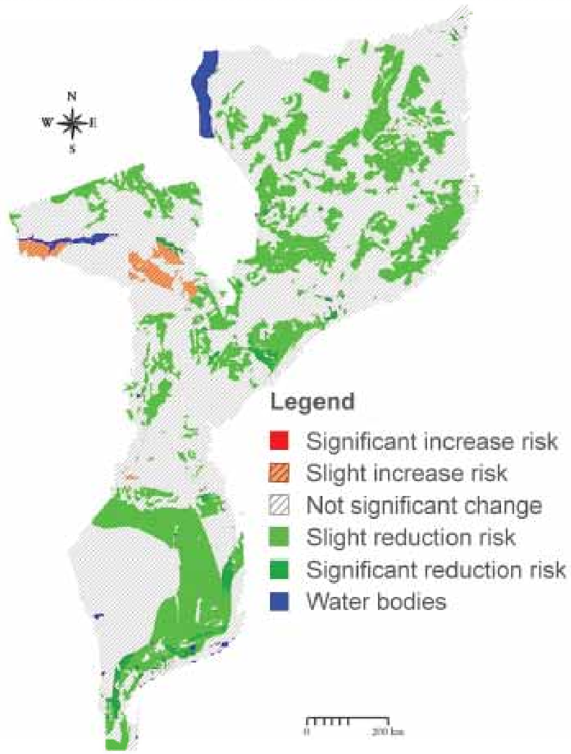


Mozambique – changes in land suitability for crops (2046-2065)

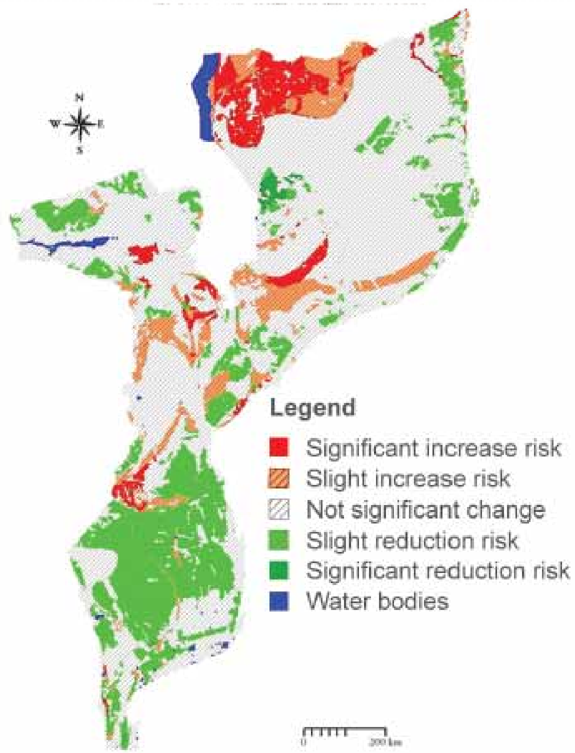
Cassava



Maize



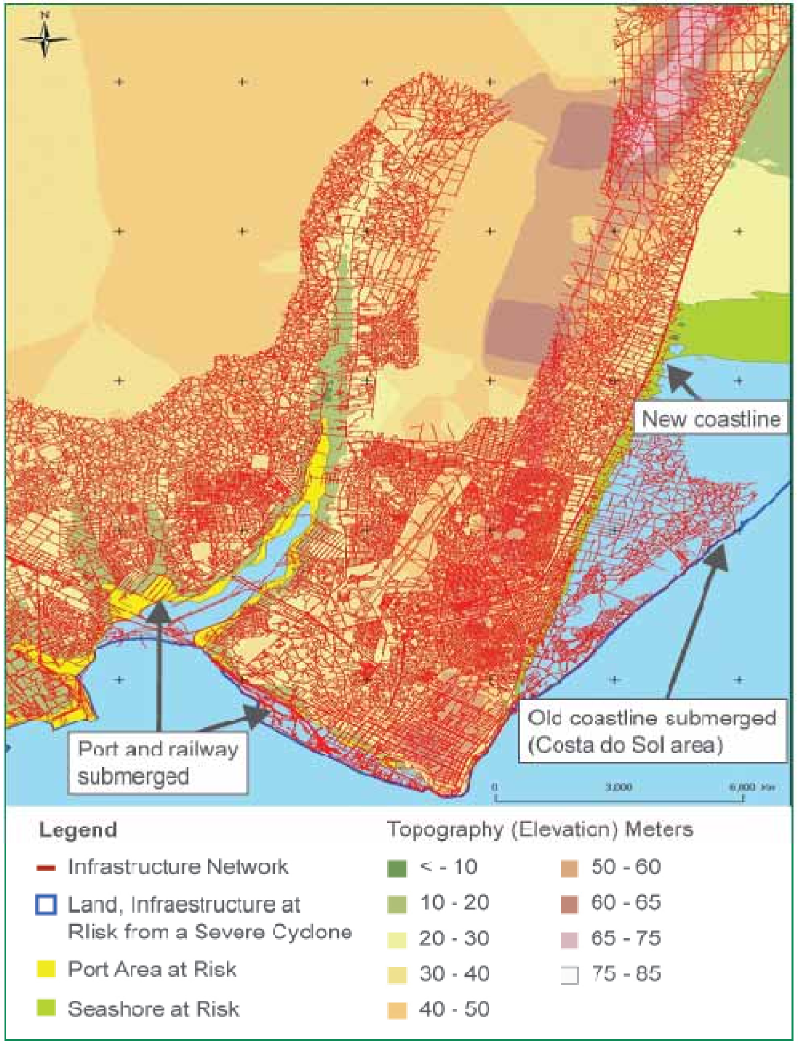
Sorghum



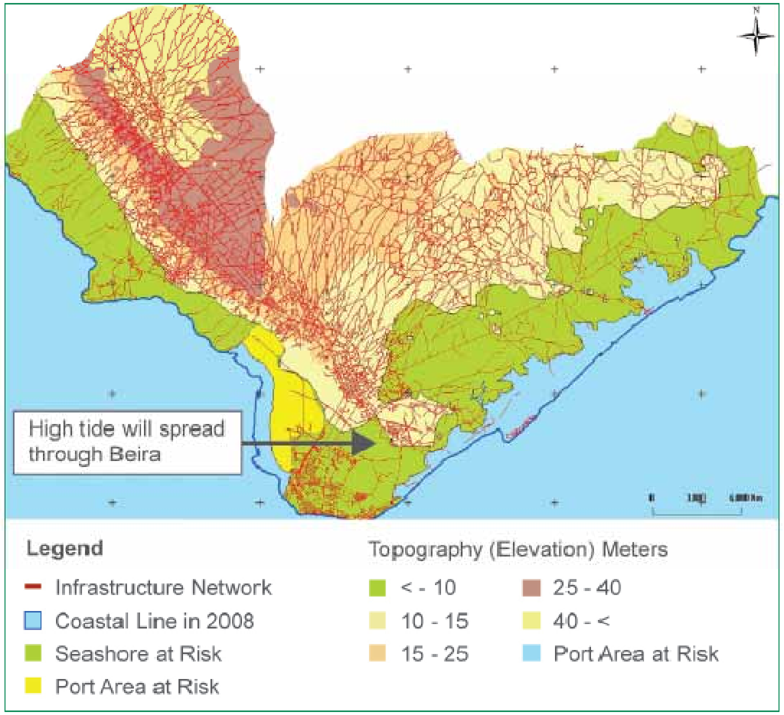
Mozambique – coastal inundation under high sea level rise scenario

Assumed ice melt and 5m sea level rise

Maputo



Beira



From Brundrit & Mavume, 2009

Summary

- Climate change impacts assessment is cross-disciplinary
- Government ministries should dialogue on the best ways to utilise the climate change information for mitigation and adaptation strategy