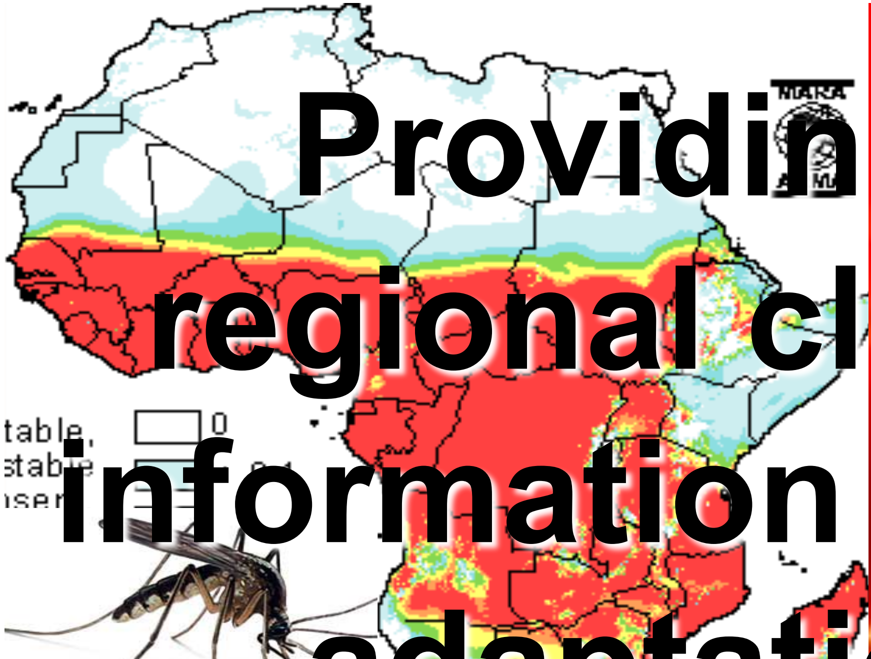
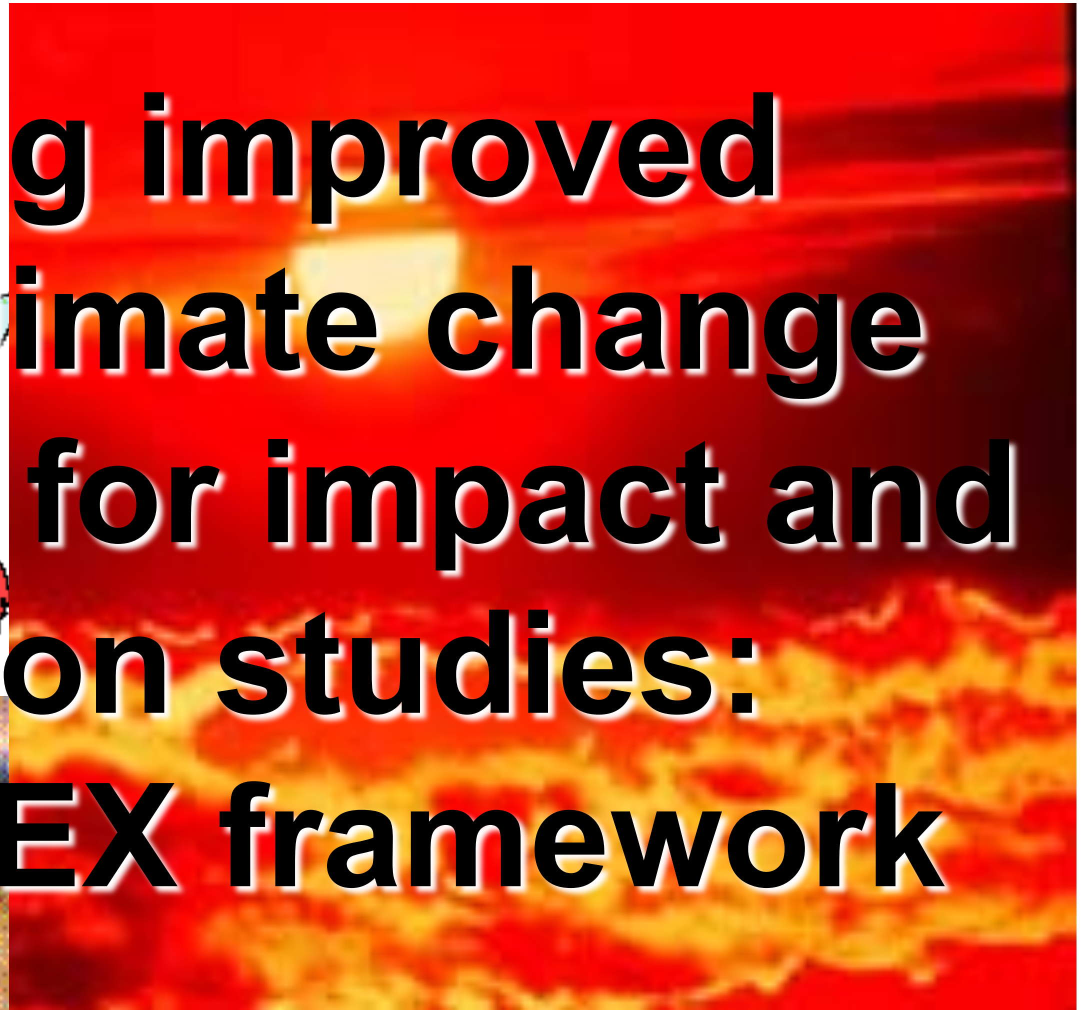
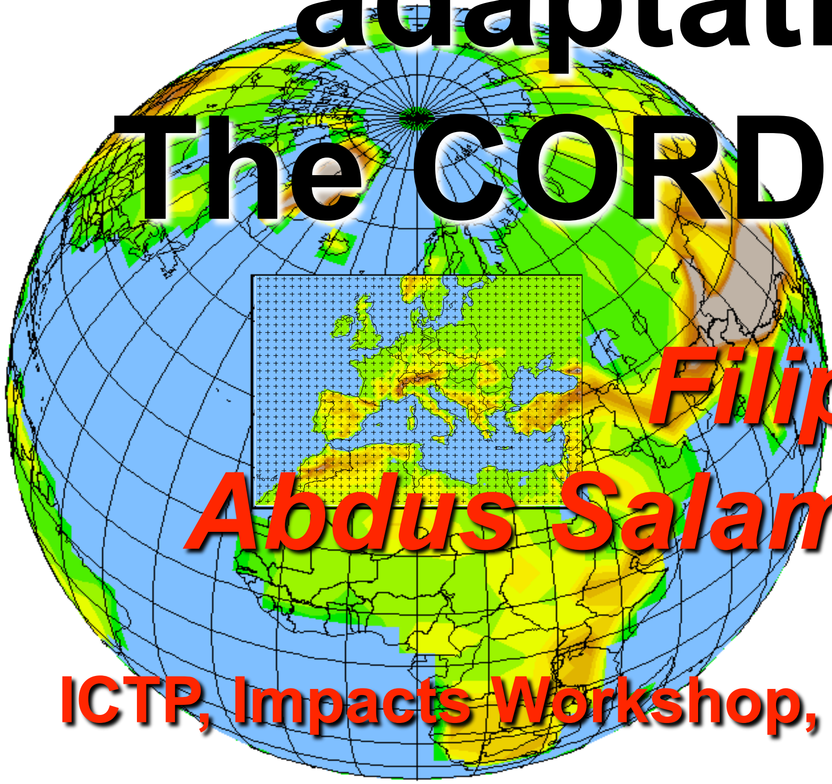






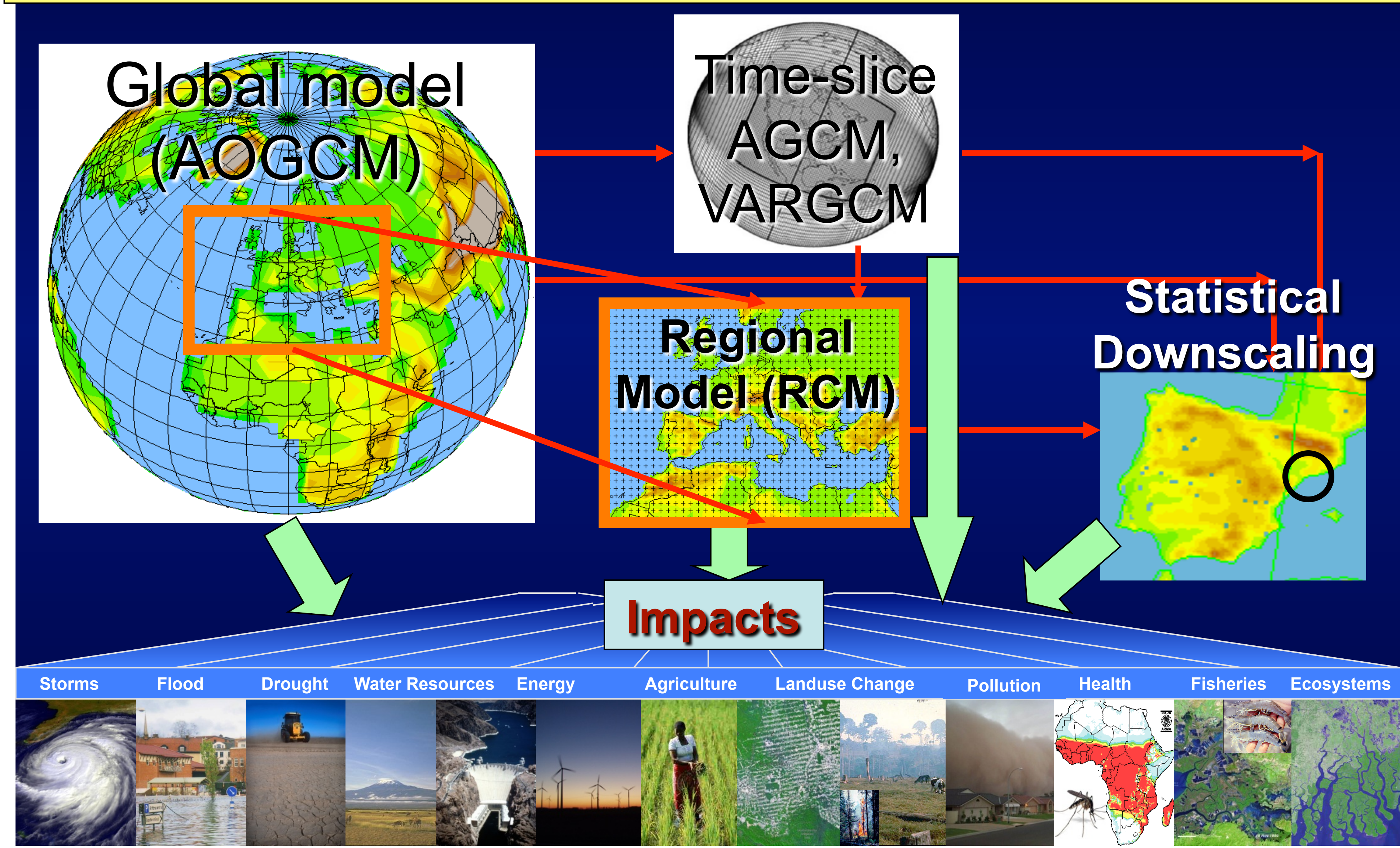
Providing improved regional climate change information for impact and adaptation studies: The CORDEX framework

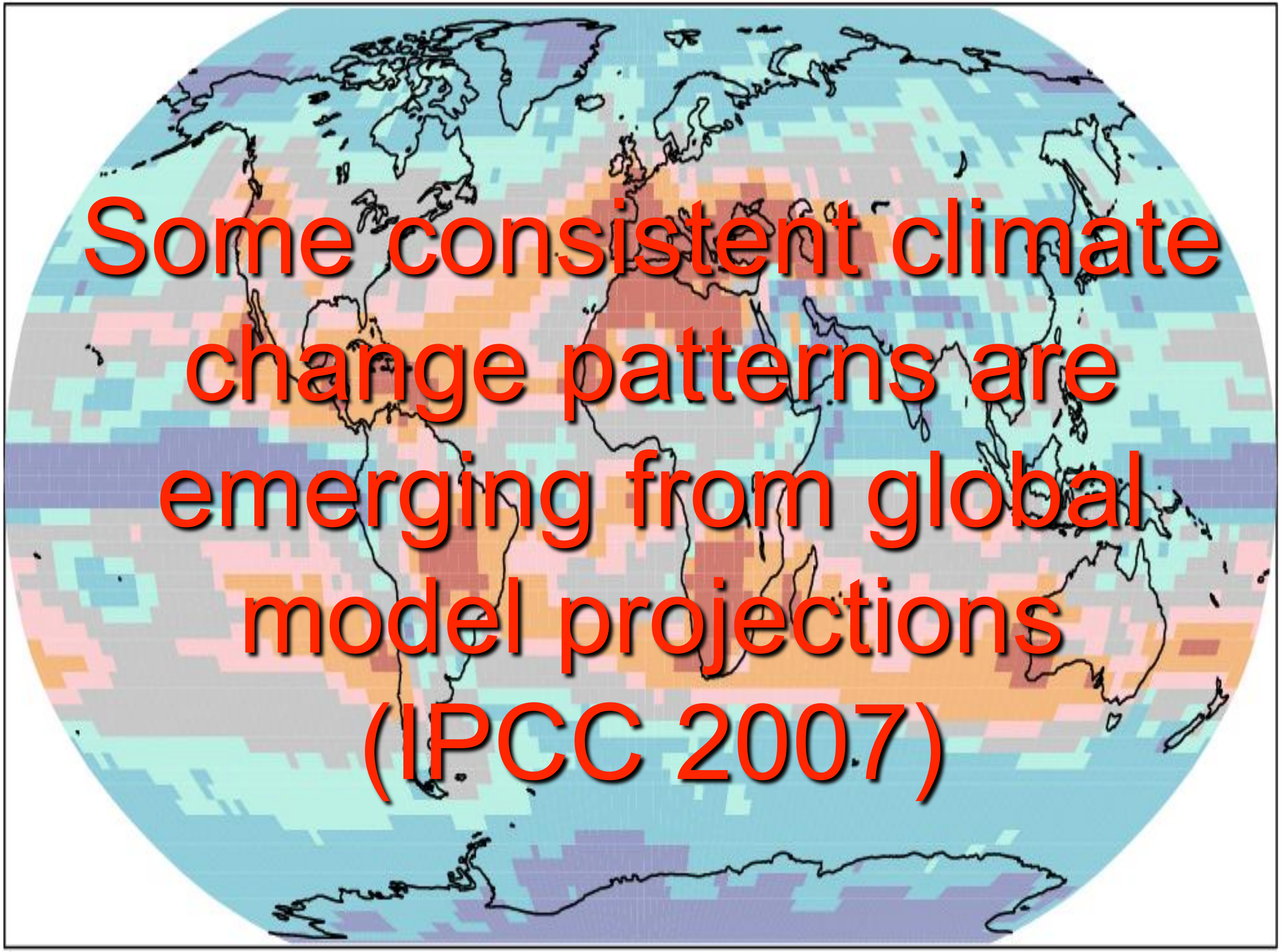
Filippo Giorgi

Abdus Salam ICTP, Trieste, Italy

ICTP, Impacts Workshop, 5-16 September 2011

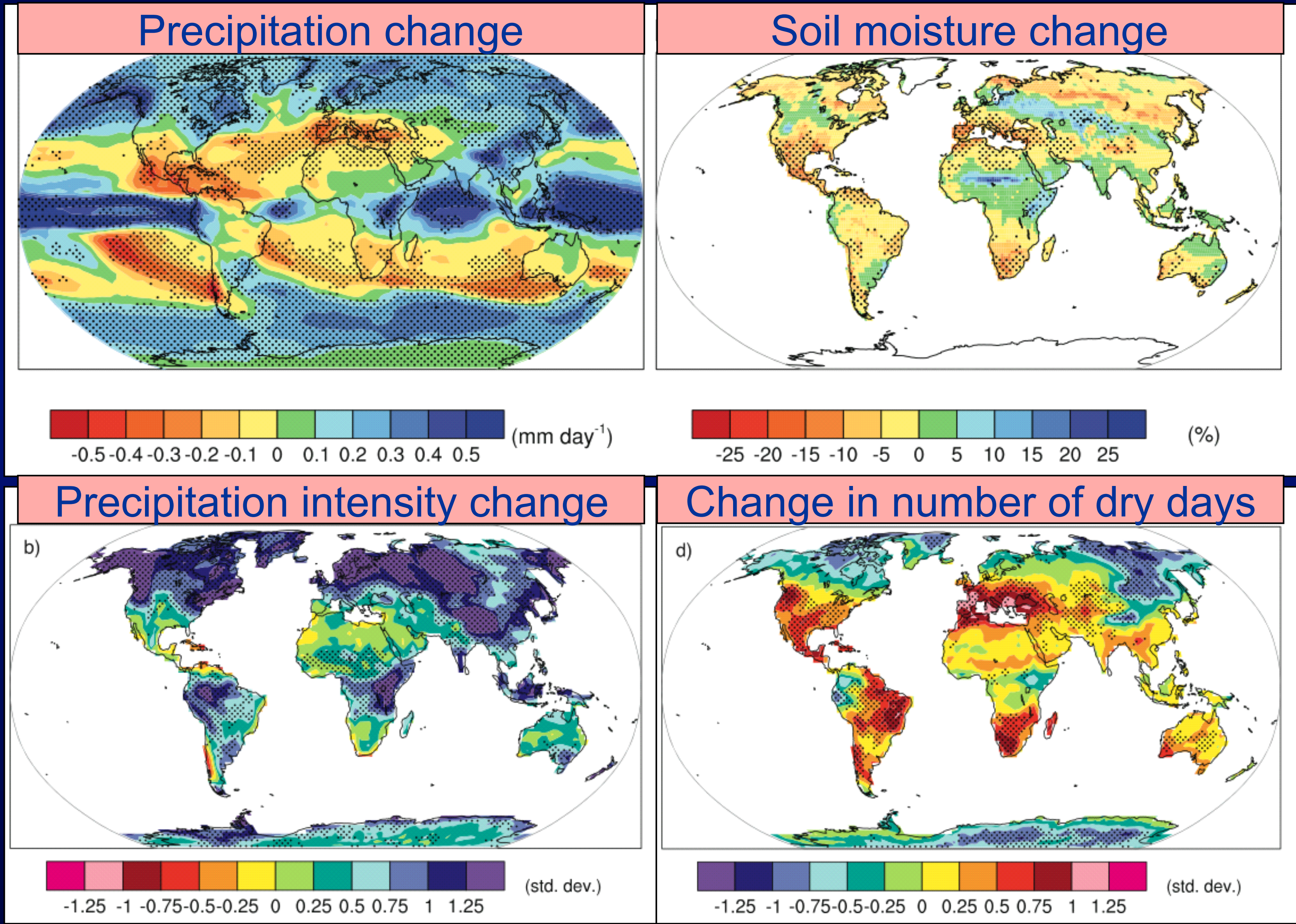
Various tools are today available to produce regional and local climate change information




Some consistent climate
change patterns are
emerging from global
model projections
(IPCC 2007)

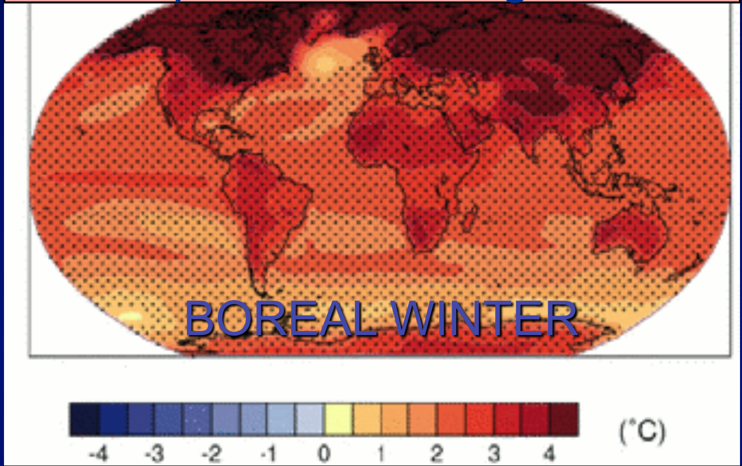
Projected changes in the hydrologic cycle

A1B Scenario, 2090-2100, 23 Global models

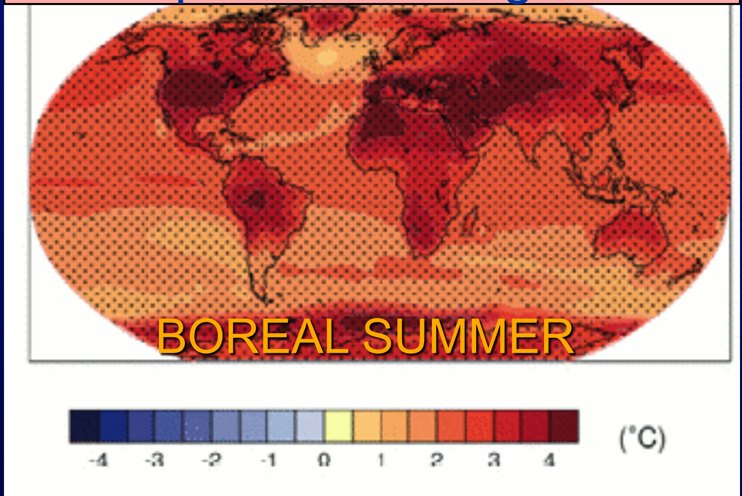


Projected changes in temperature indicators
A1B Scenario, 2090-2100, 23 Global models

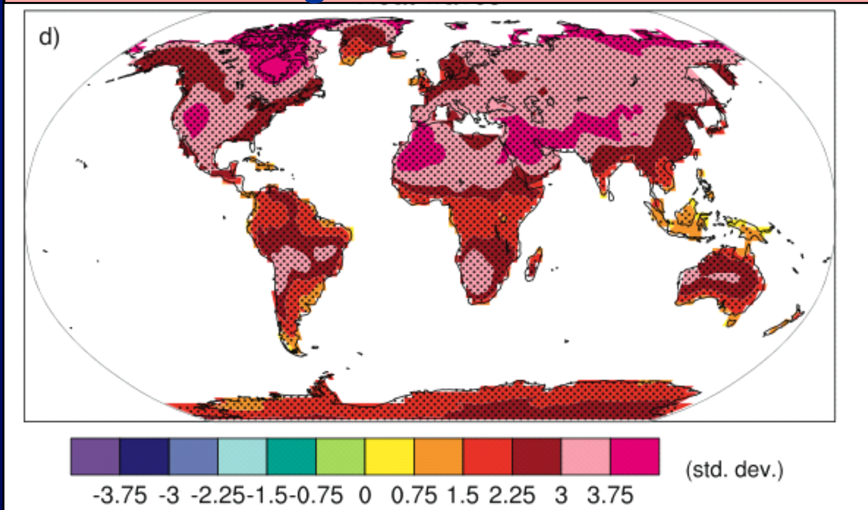
Temperature change DJF



Temperature change JJA

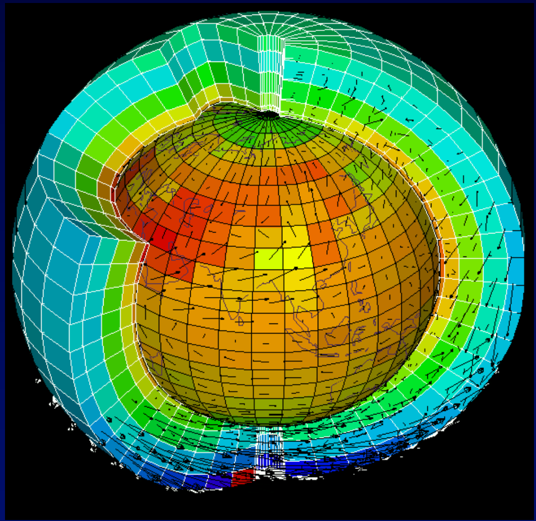


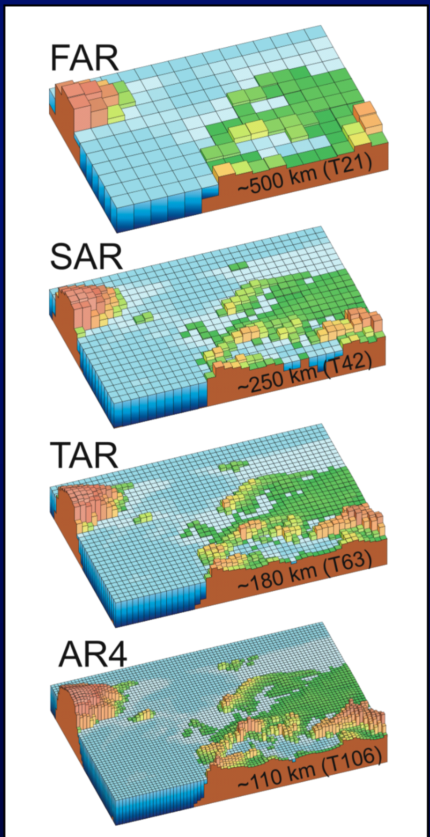
Change in heat waves

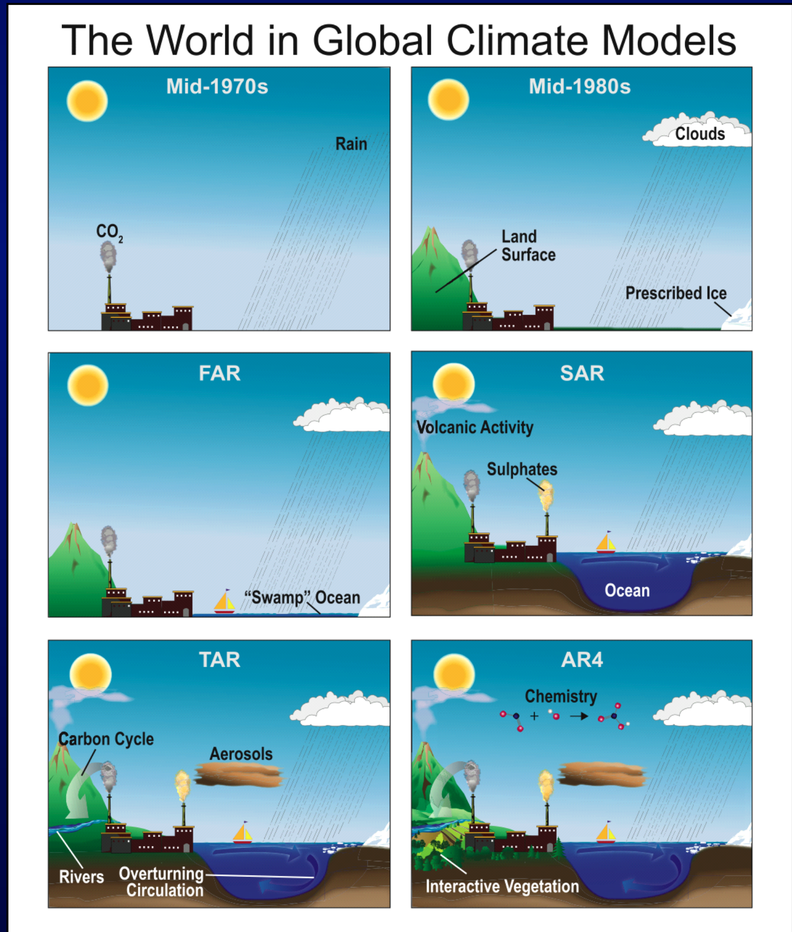


The primary tool for simulating climate:

Global Climate System Model (CSM, AO-GCM)

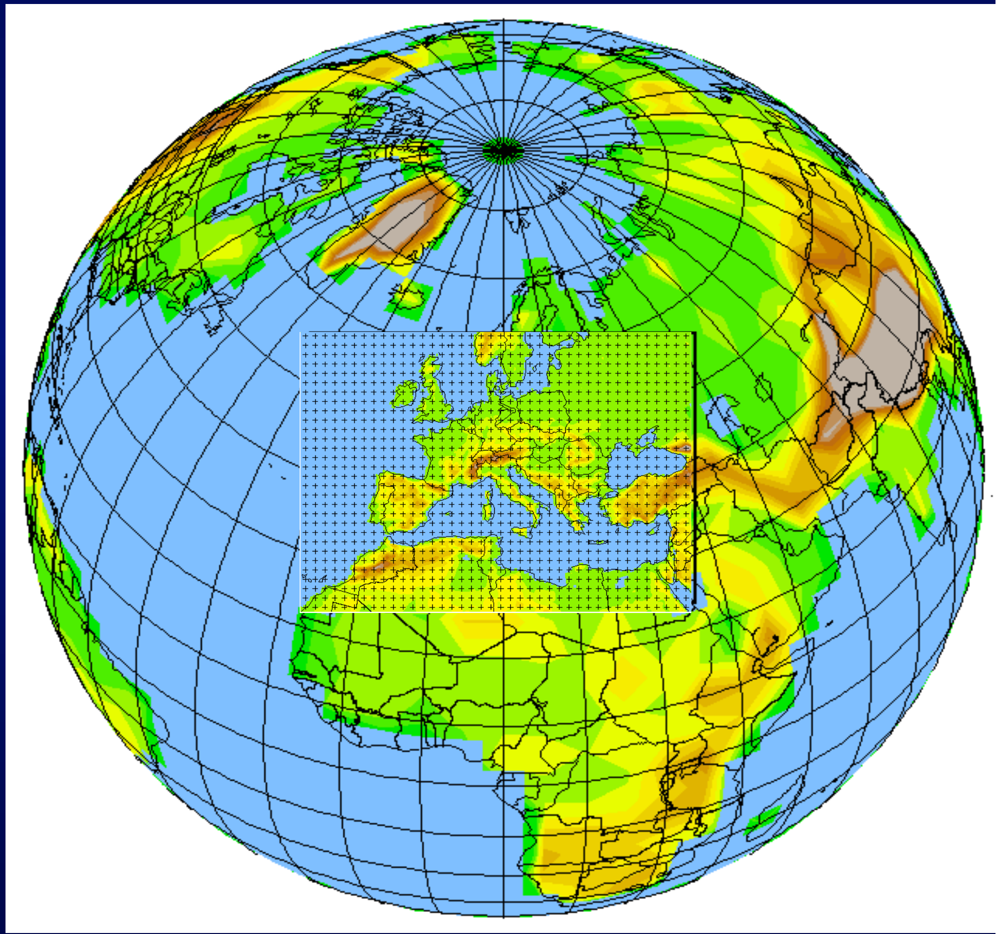




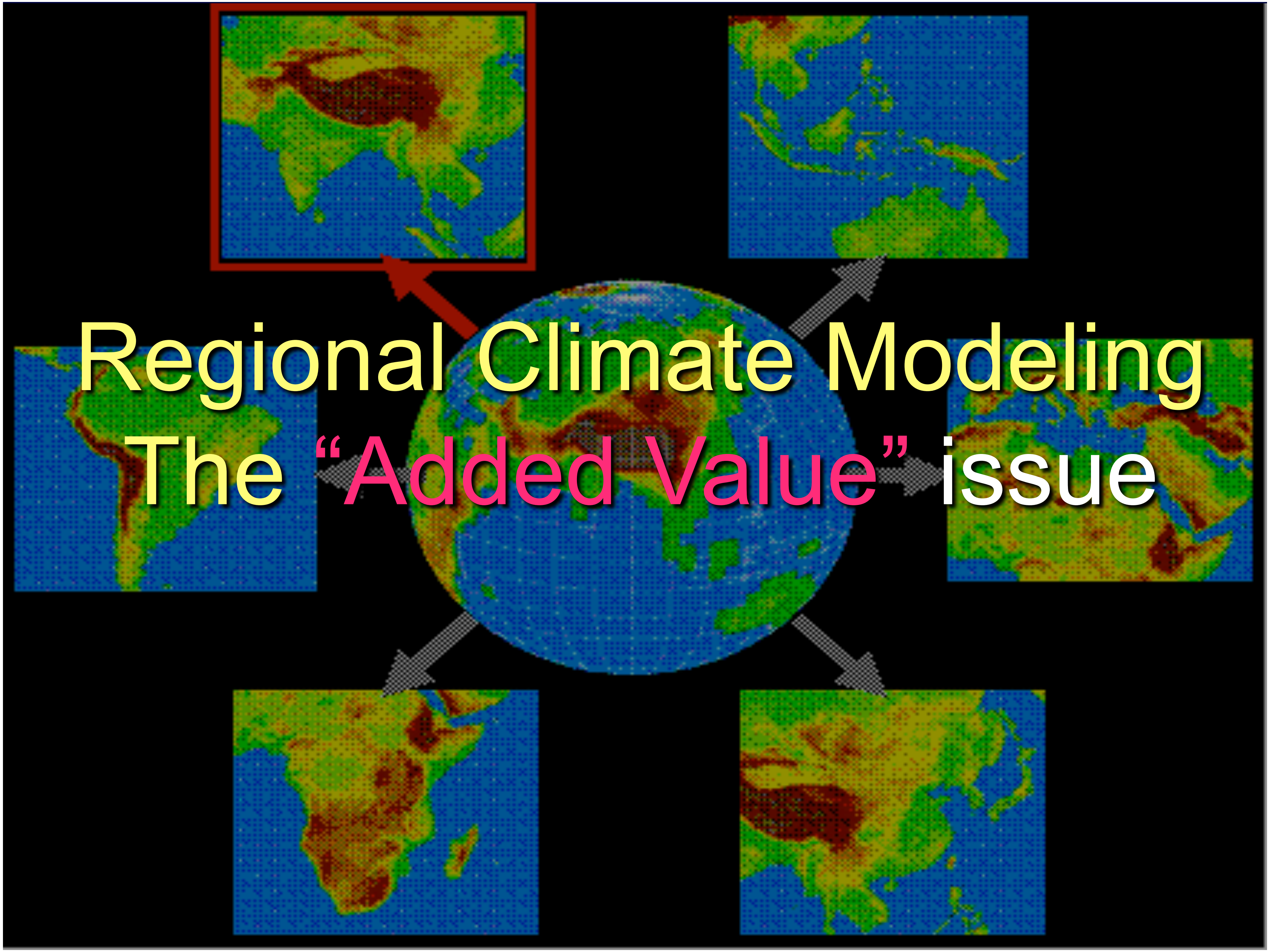


“Nested” Regional Climate Modeling: Technique and Strategy

- Motivation: The resolution of GCMs is still too coarse to capture regional and local climate processes
- Technique: A “Regional Climate Model” (RCM) is “nested” within a GCM in order to locally increase the model resolution.
  - Initial conditions (IC) and lateral boundary conditions (LBC) for the RCM are obtained from the GCM (“One-way Nesting”) or analyses of observations (perfect LBC).
- Strategy: The GCM simulates the response of the general circulation to the large scale forcings, the RCM simulates the effect of sub-GCM-grid scale forcings and provides fine scale regional information
  - Technique borrowed from NWP

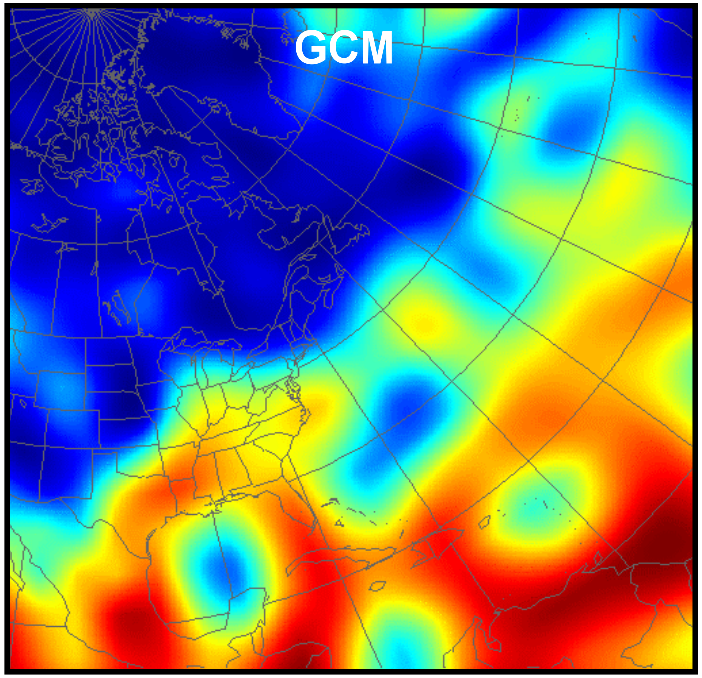


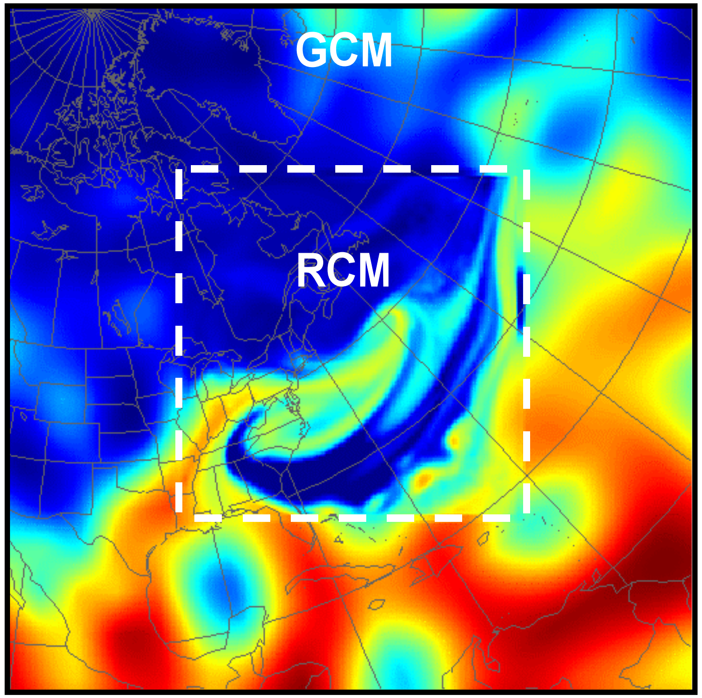
Regional Climate Modeling
The "Added Value" issue

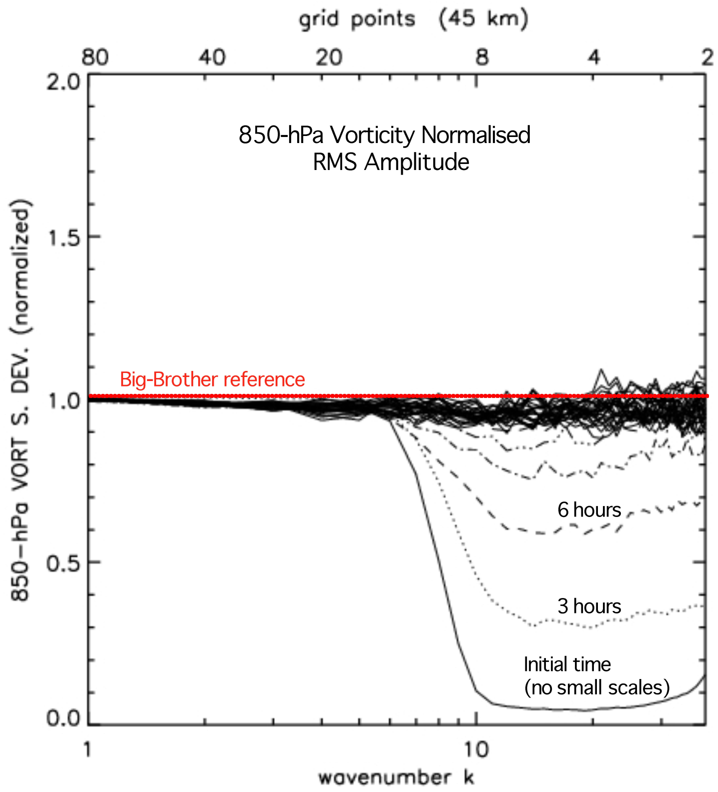


Dynamical Downscaling

Generation of small scales by a high-resolution RCM driven by low-resolution GCM data (900 hPa specific humidity)







Large scales Short scales

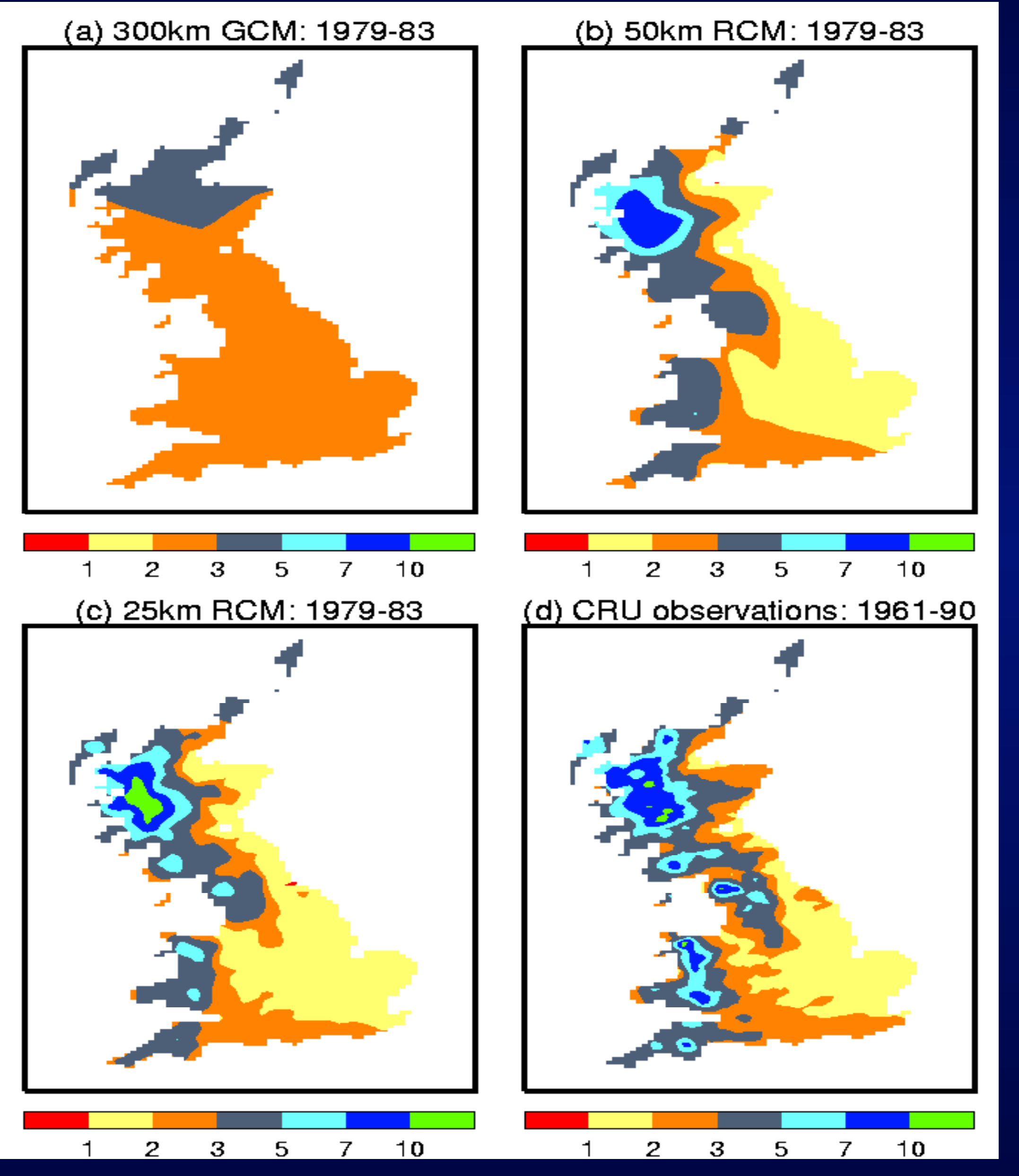
WINTER PRECIPITATION OVER BRITAIN

300km Global Model

50km Regional Model

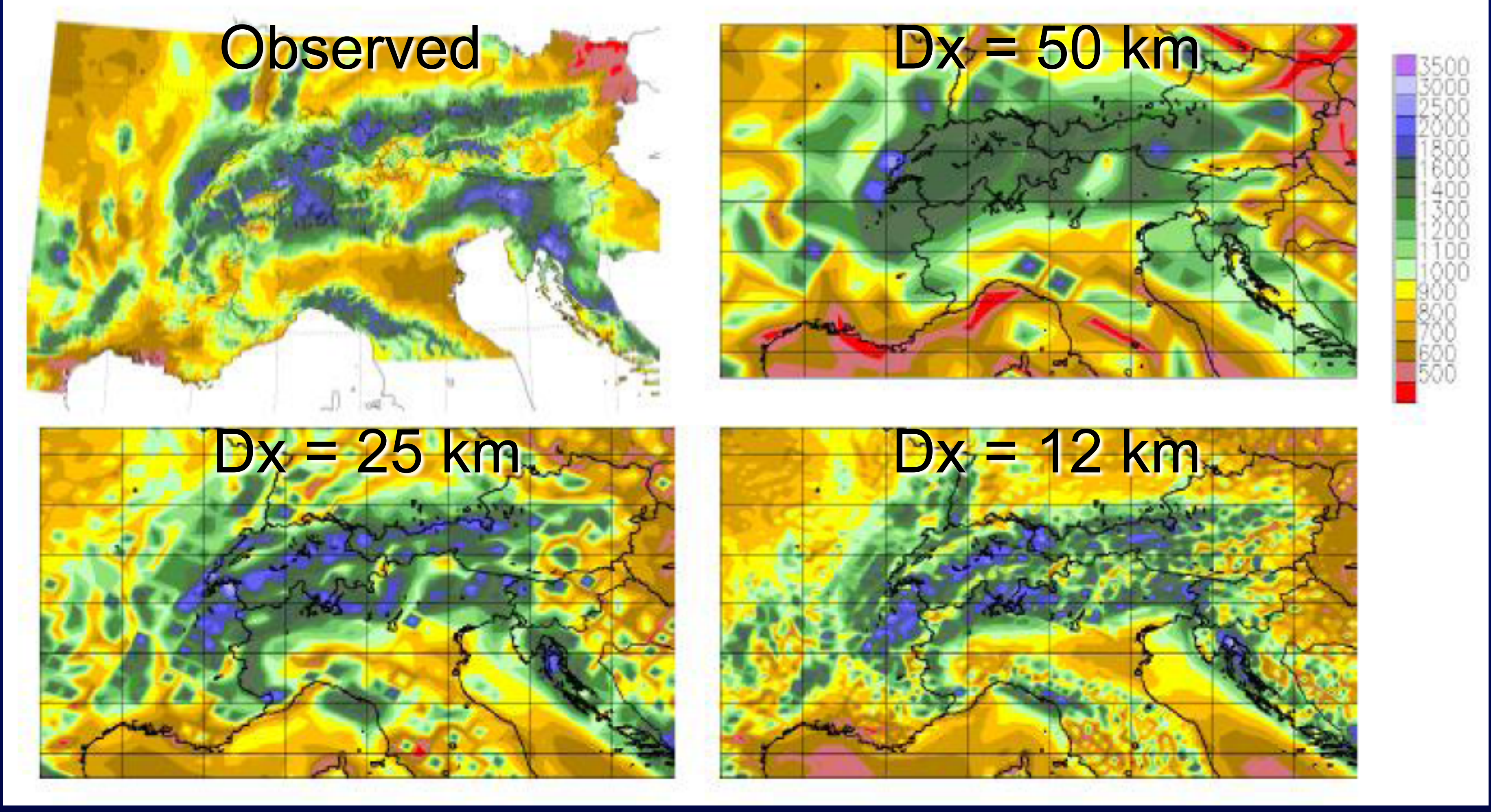
25km Regional Model

Observed



RCM simulation of precipitation at different resolutions over the Alps

Mean annual precipitation (mm/day)



From Christensen et al. 2005

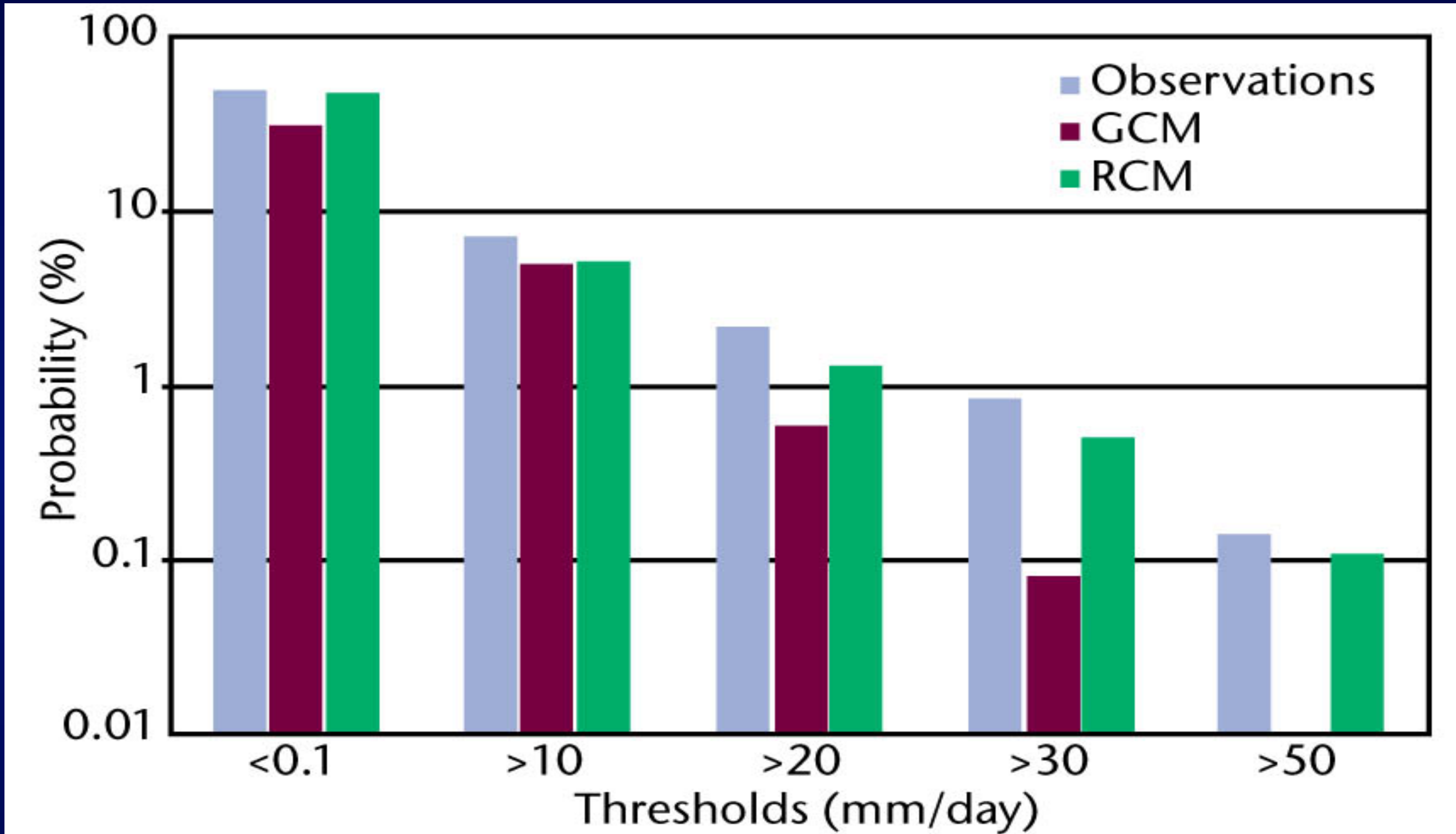
CRU obs

GCM (FVGCM)

RCM (RegCM)

DJF precipitation
30-year nested
RCM simulation,
1961-1990,
20 km grid spacing

WINTER DAILY RAINFALL OVER THE ALPS

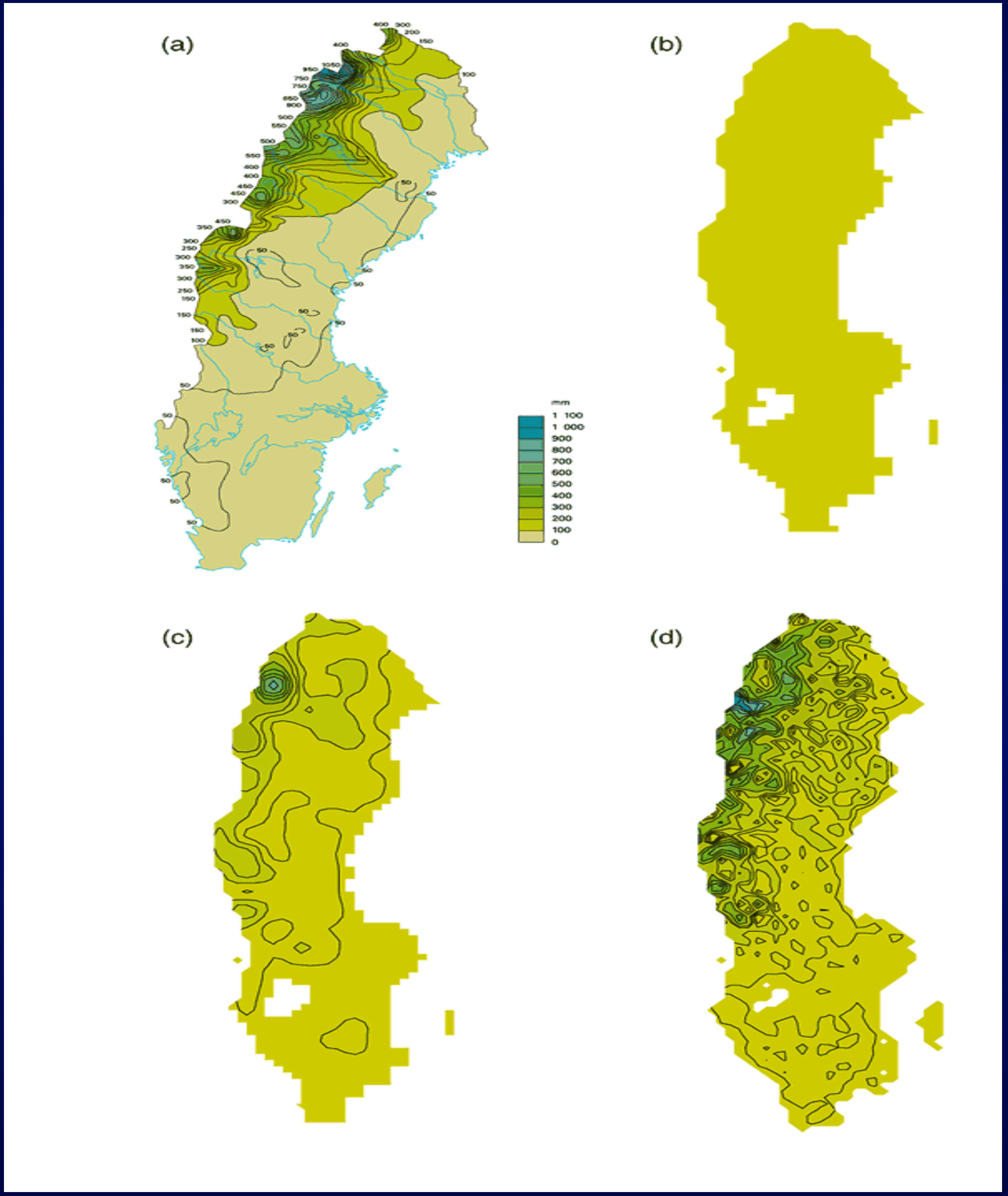


RCMs simulate extreme rainfall much

Summer Runoff in Sweden

Observations

GCM

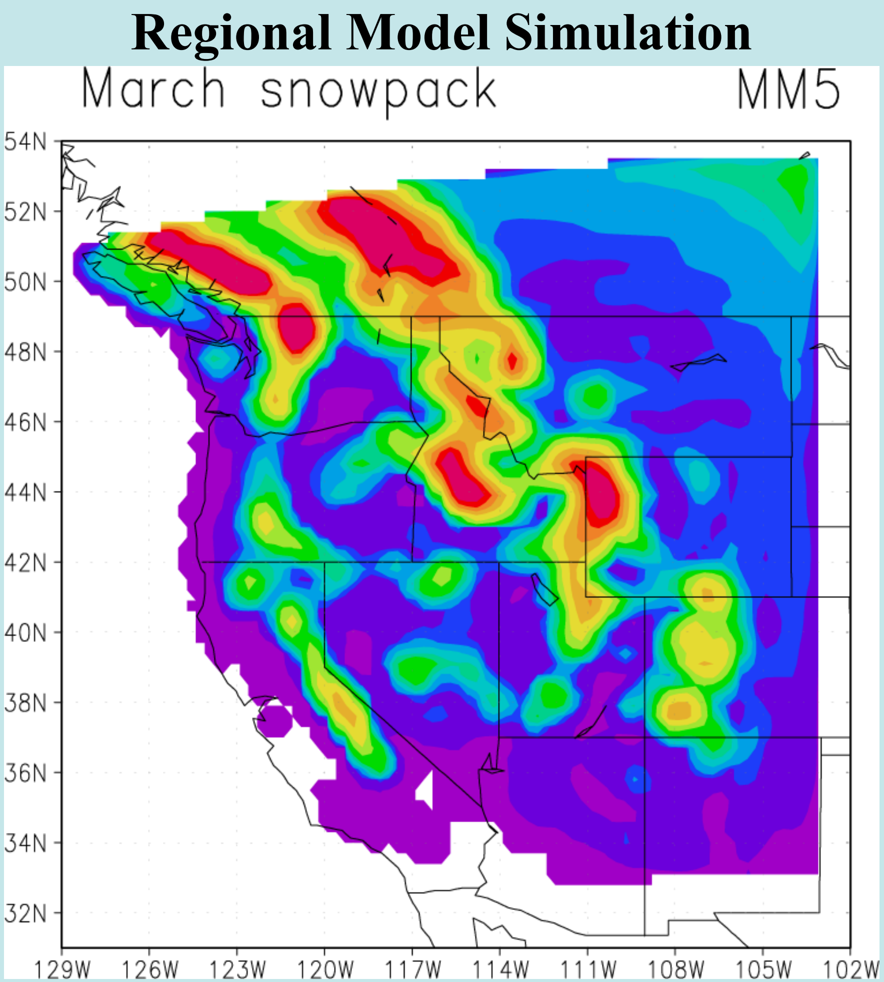


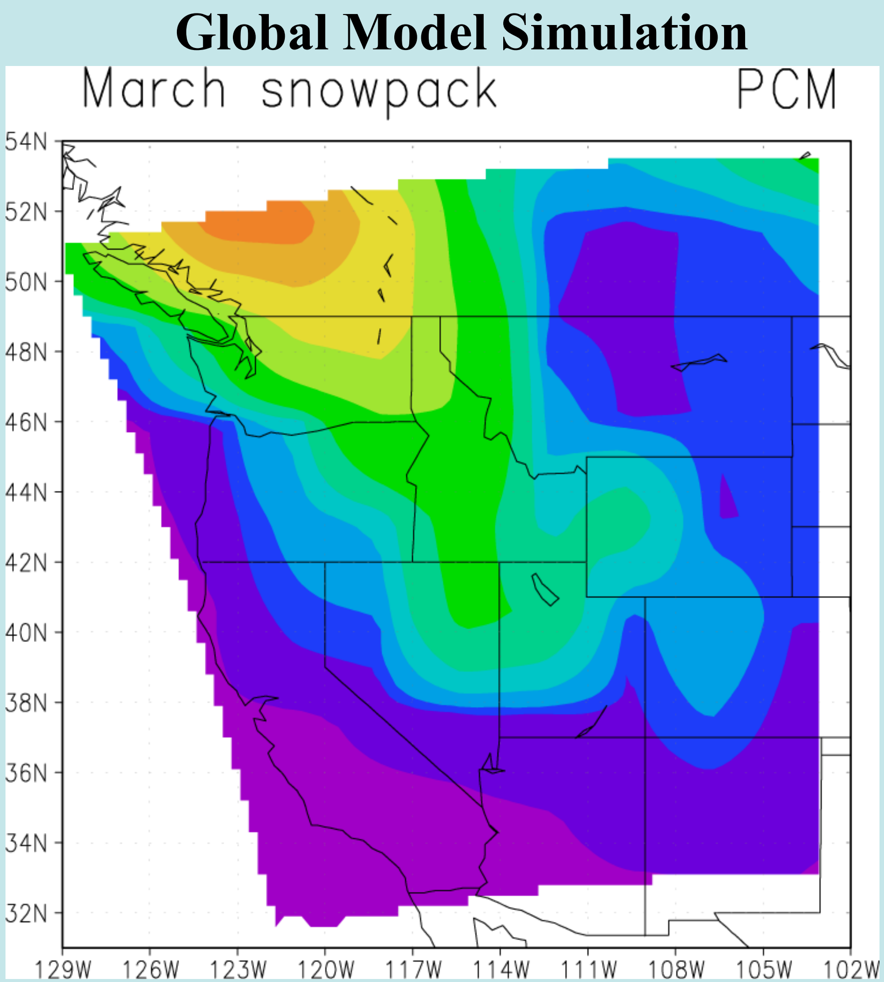
RCM – 55 km

RCM - 18 km

Global and Regional Simulations of Snowpack

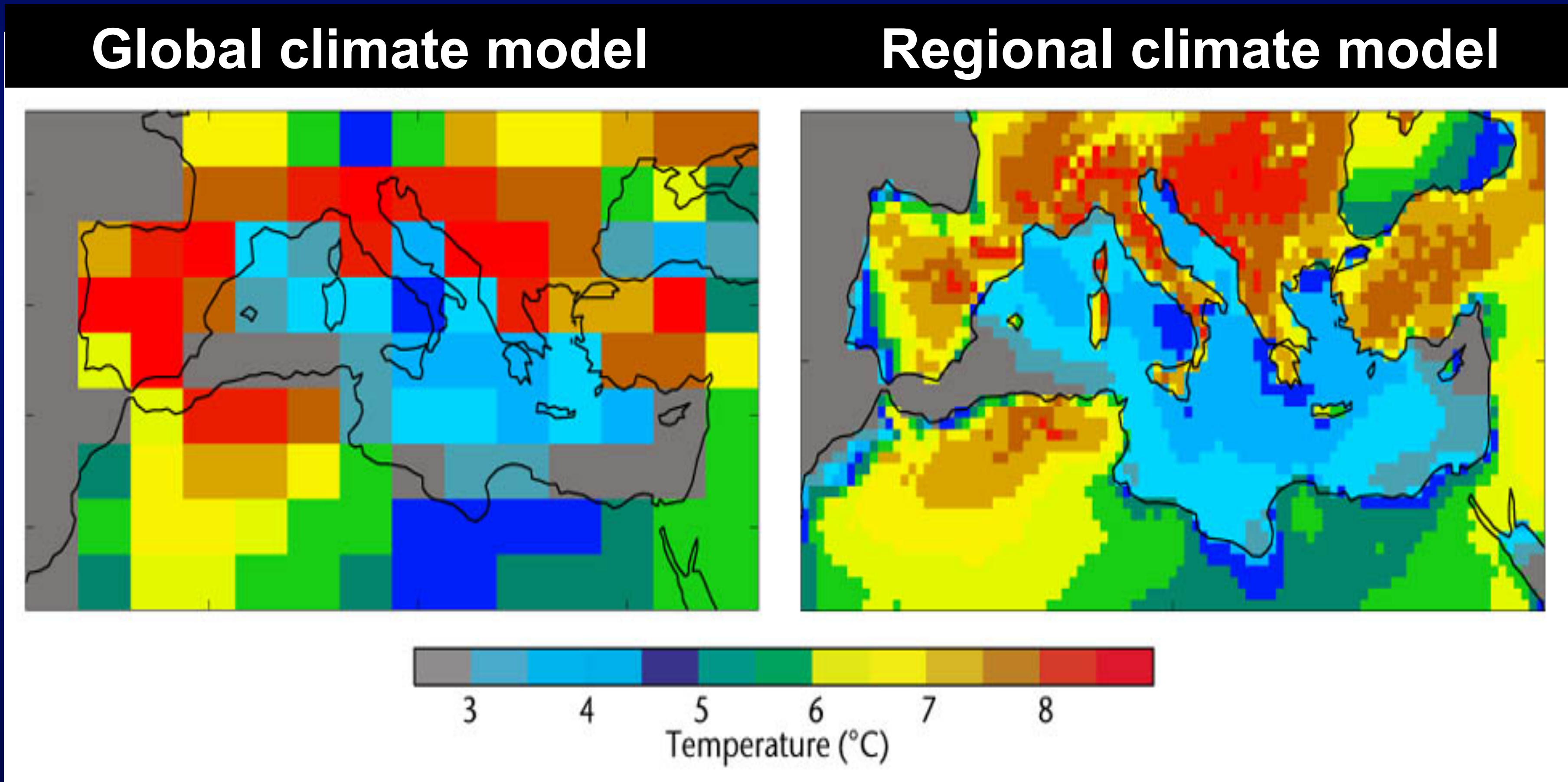
GCM under-predicts and misplaces snow





High resolution RCMs improve regional climate Projections, e.g over the Mediterranean region

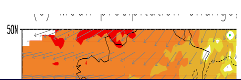
Summer temperature change, A2 Scenario, 2090-2100,



The effect of topography on the climate change signal (Gao et al. 2006)

Mean precipitation change, A2 – Present

DJF



Use of high resolution RCM information for health impacts

Increase of pathologies related to heat stress

Days with Tmax > 35C

Days with Tmin > 20C

High danger heat index

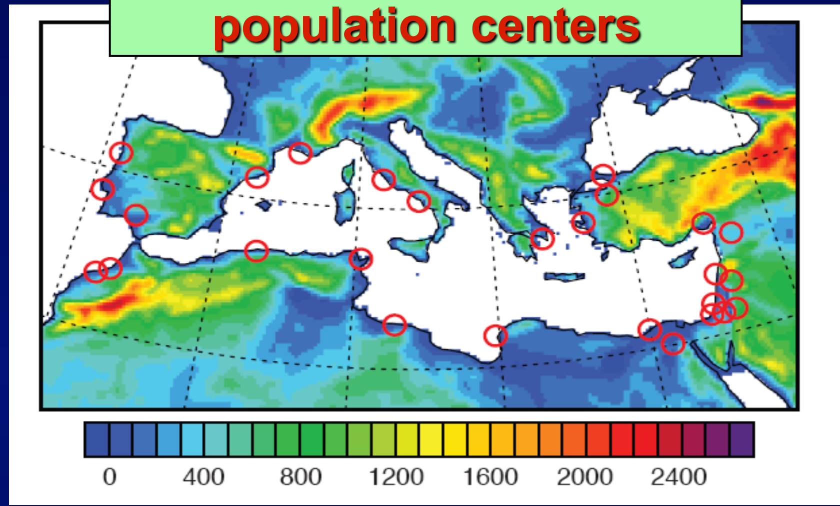
RegCM, dx = 20 km
A2 scenario

The heat index is obtained from a polynomial regression formula based on temperature and relative humidity

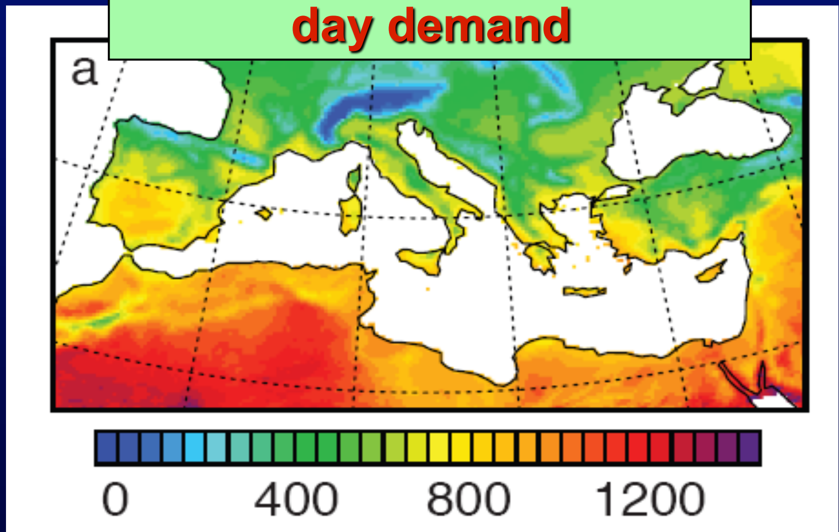
Diffenbaugh et al., GRL, 2007

Use of high resolution RCM information for energy consumption impacts

Location of major coastal population centers



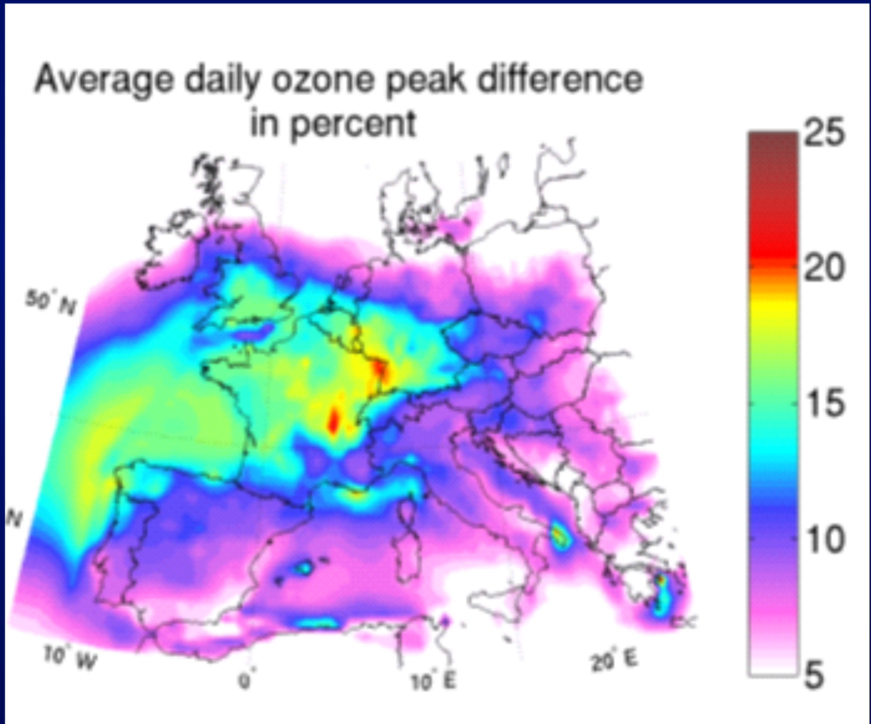
Change in cooling degree day demand

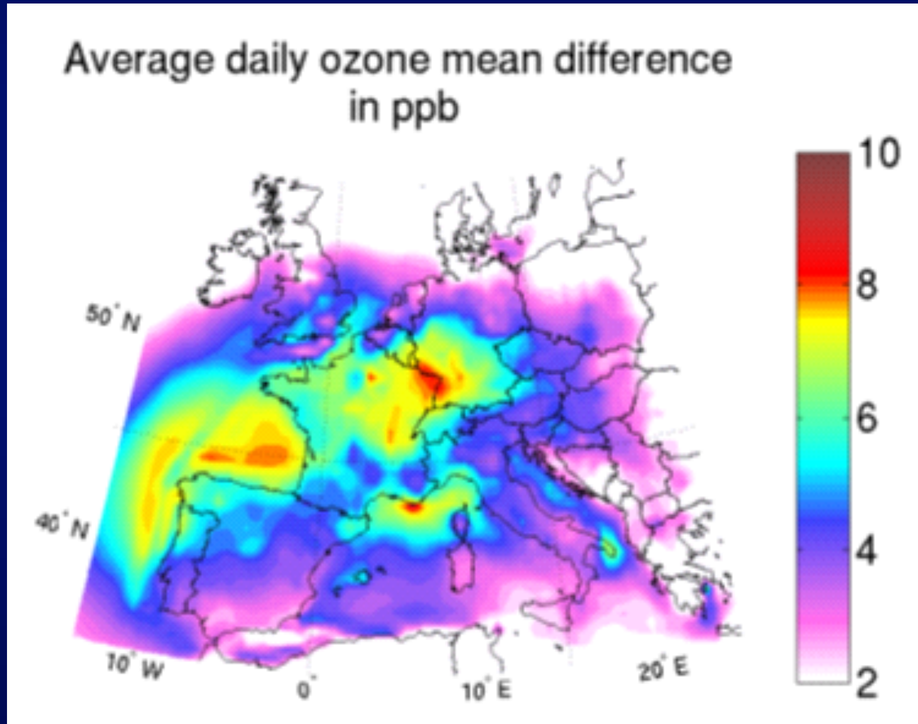


Heat stress will increase the demand or cooling and thus the GHG emissions

Use of high resolution RCM information for air quality impacts

Change in summer ozone concentration statistics, A2 scenario (2071-2100) minus (1961-1990)

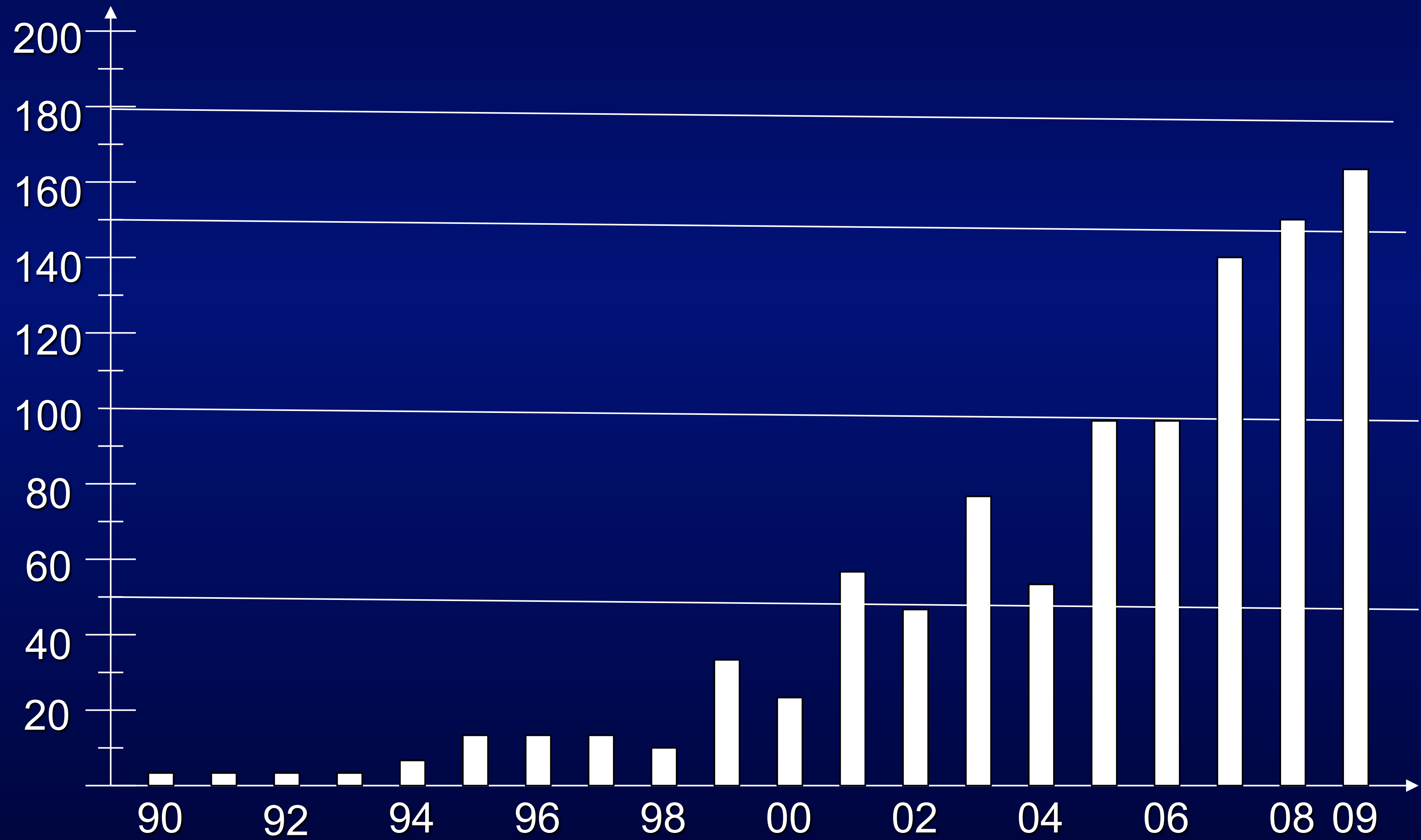




Climate change will increase ozone concentrations over Europe because of higher temperatures, reduced precipitation and more stagnant conditions

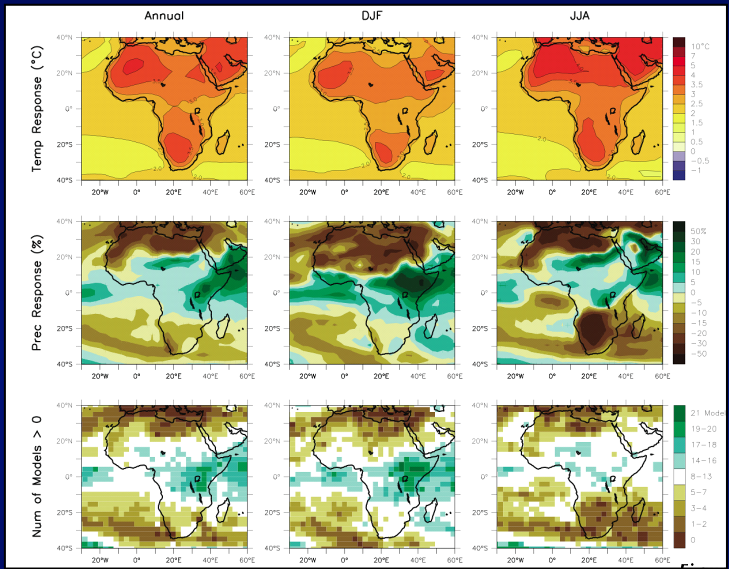
The use of RCMs in the literature has been steadily growing

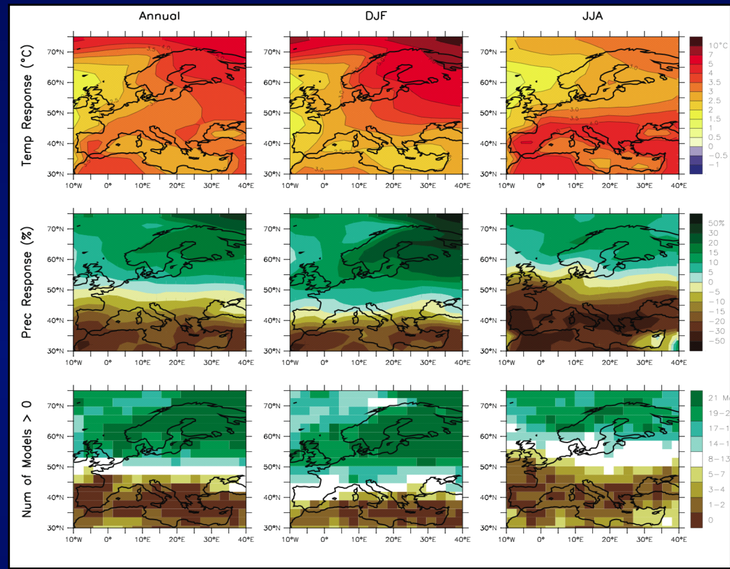
Number of papers in the ISI under "regional climate model"



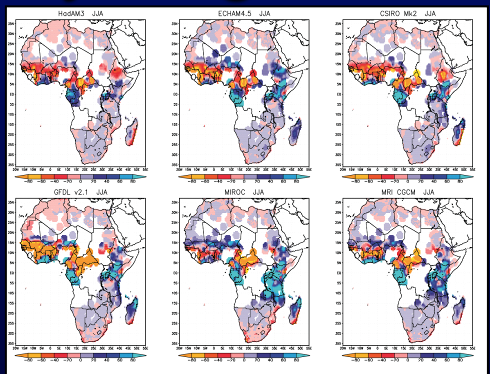
Was this development reflected in the AR4?

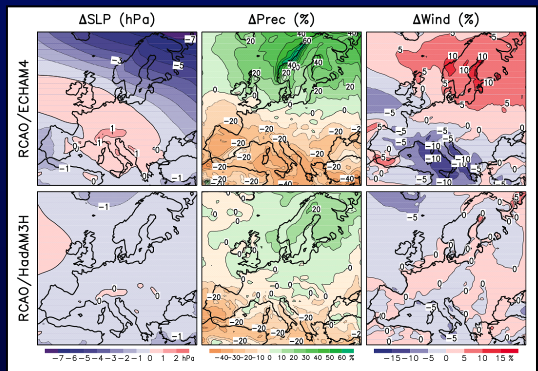
Most regional climate change information in the AR4 was still derived from AOGCMs

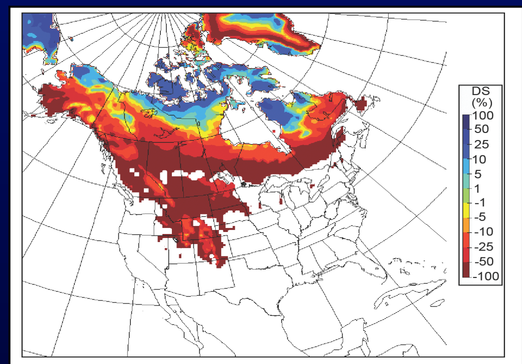




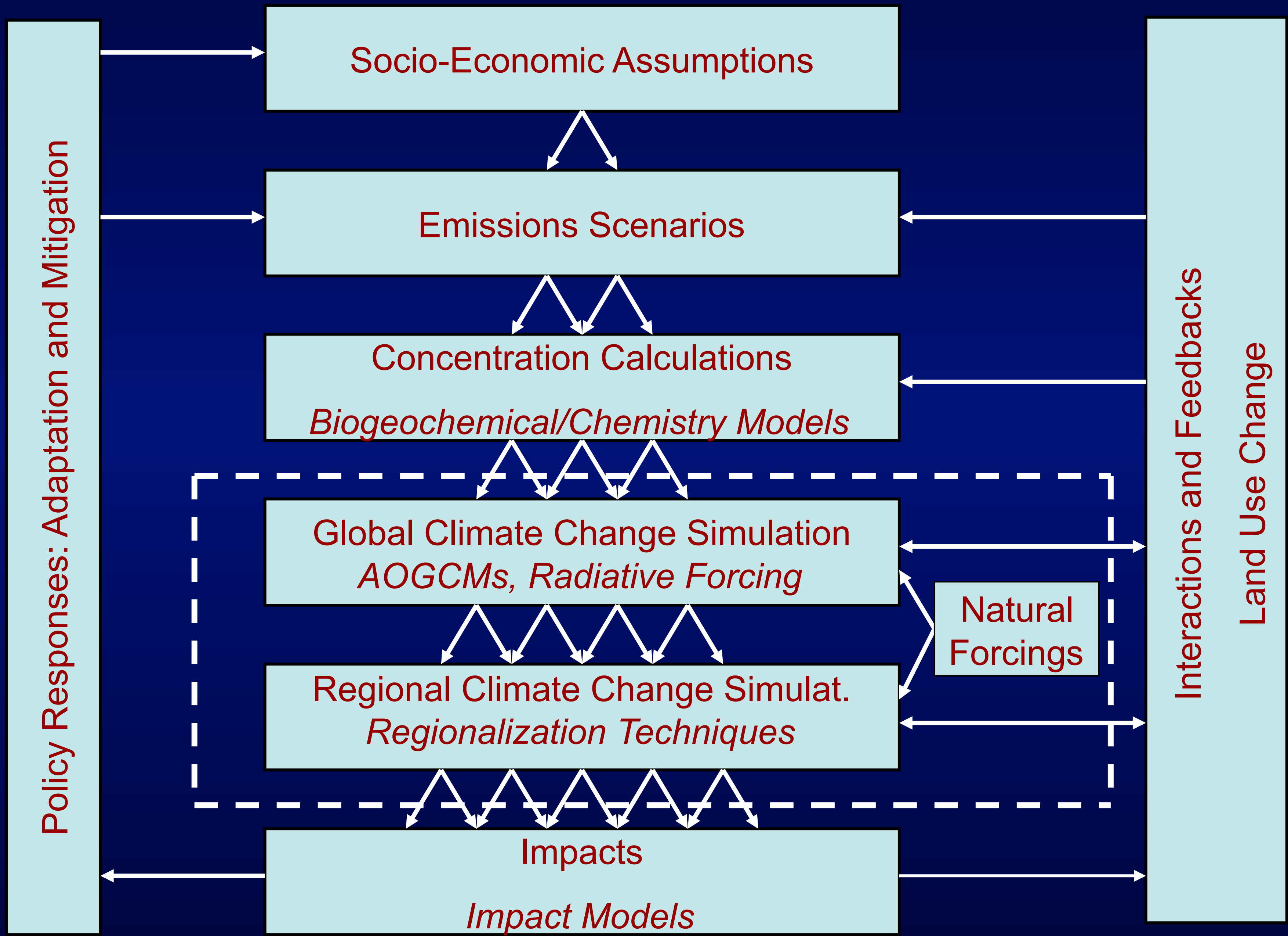
Only 3 figures in Chapter 11 from RCMs or SD (out of 30)







Cascade of uncertainty in climate change prediction

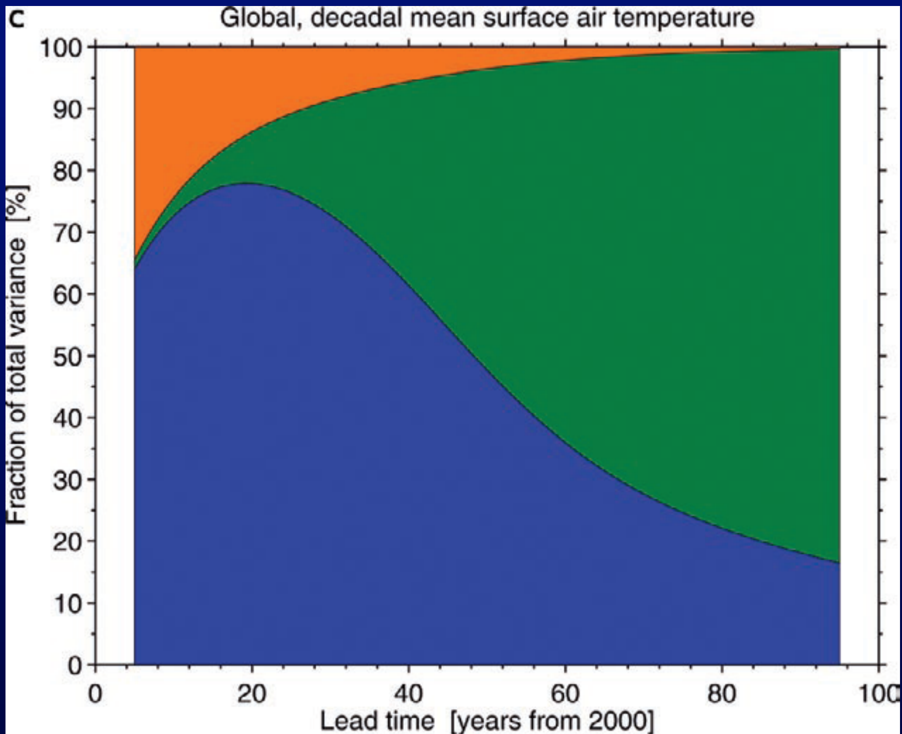


Fraction of uncertainty explained by different sources as a function of lead time

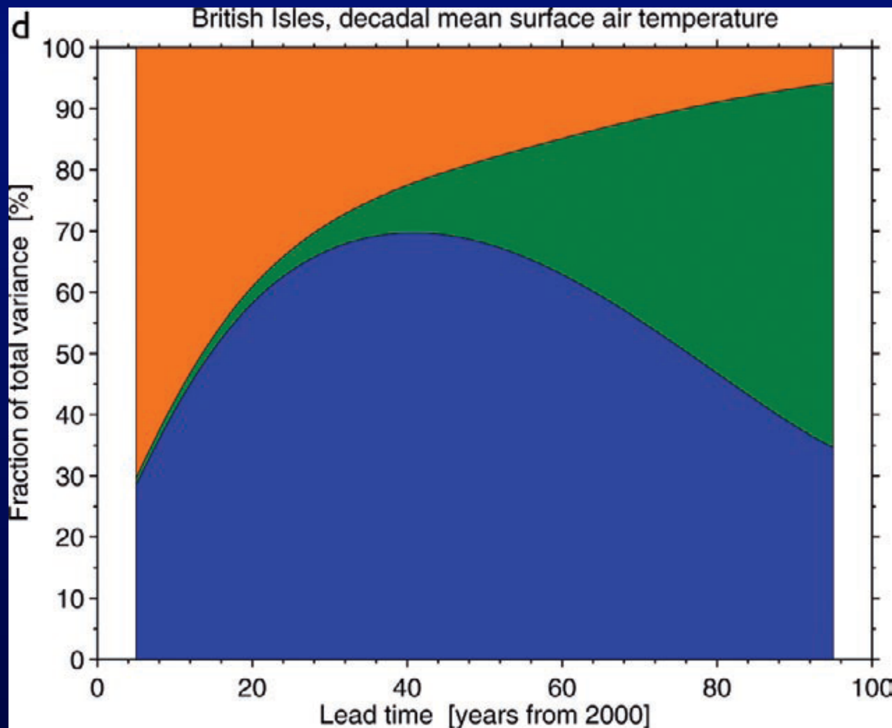
Internal variability
Scenario uncertainty
Model configuration uncertainty

Hawkins and Sutton 2009

Decadal temperature - Global

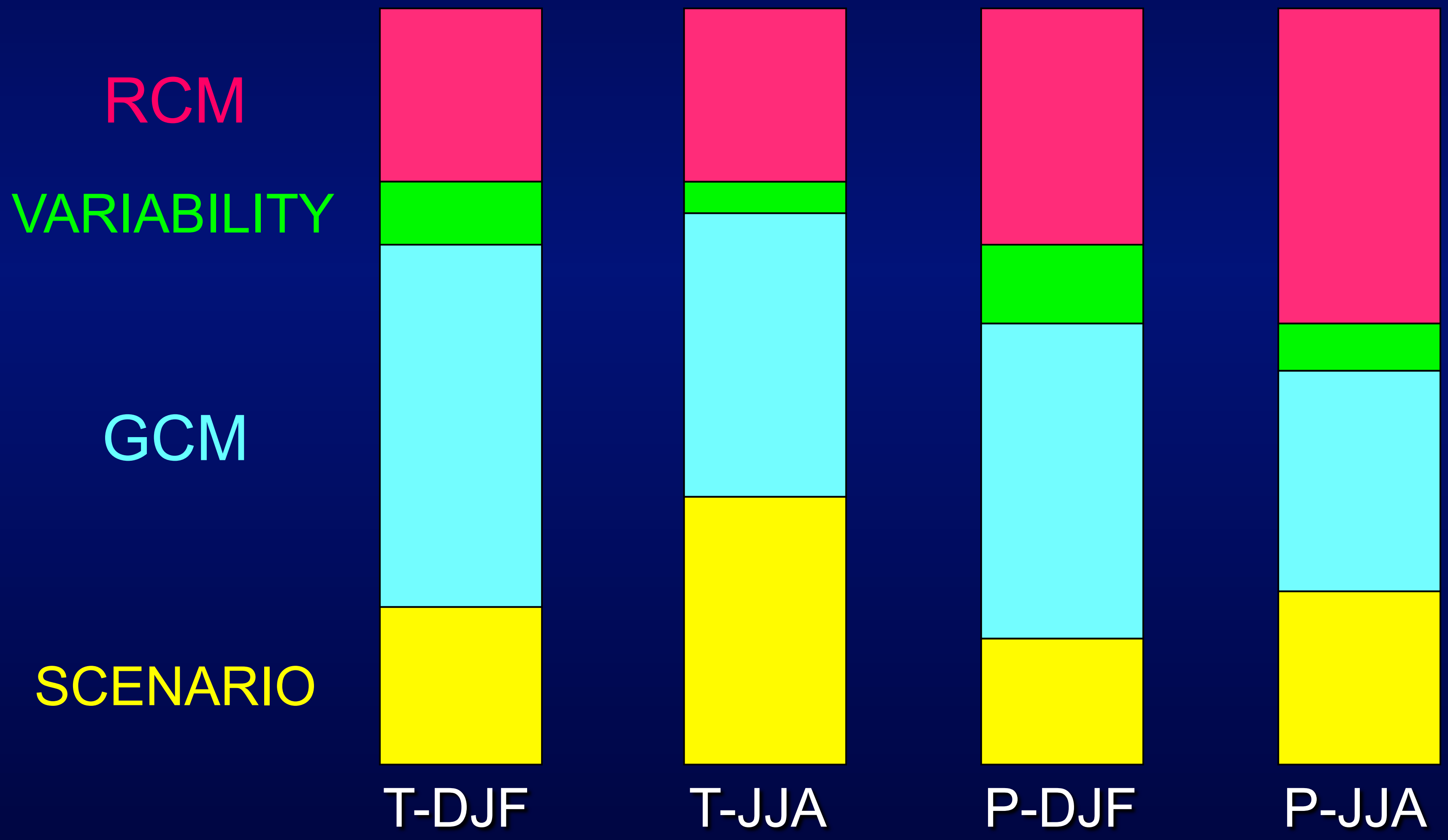


Decadal temperature – British Isles

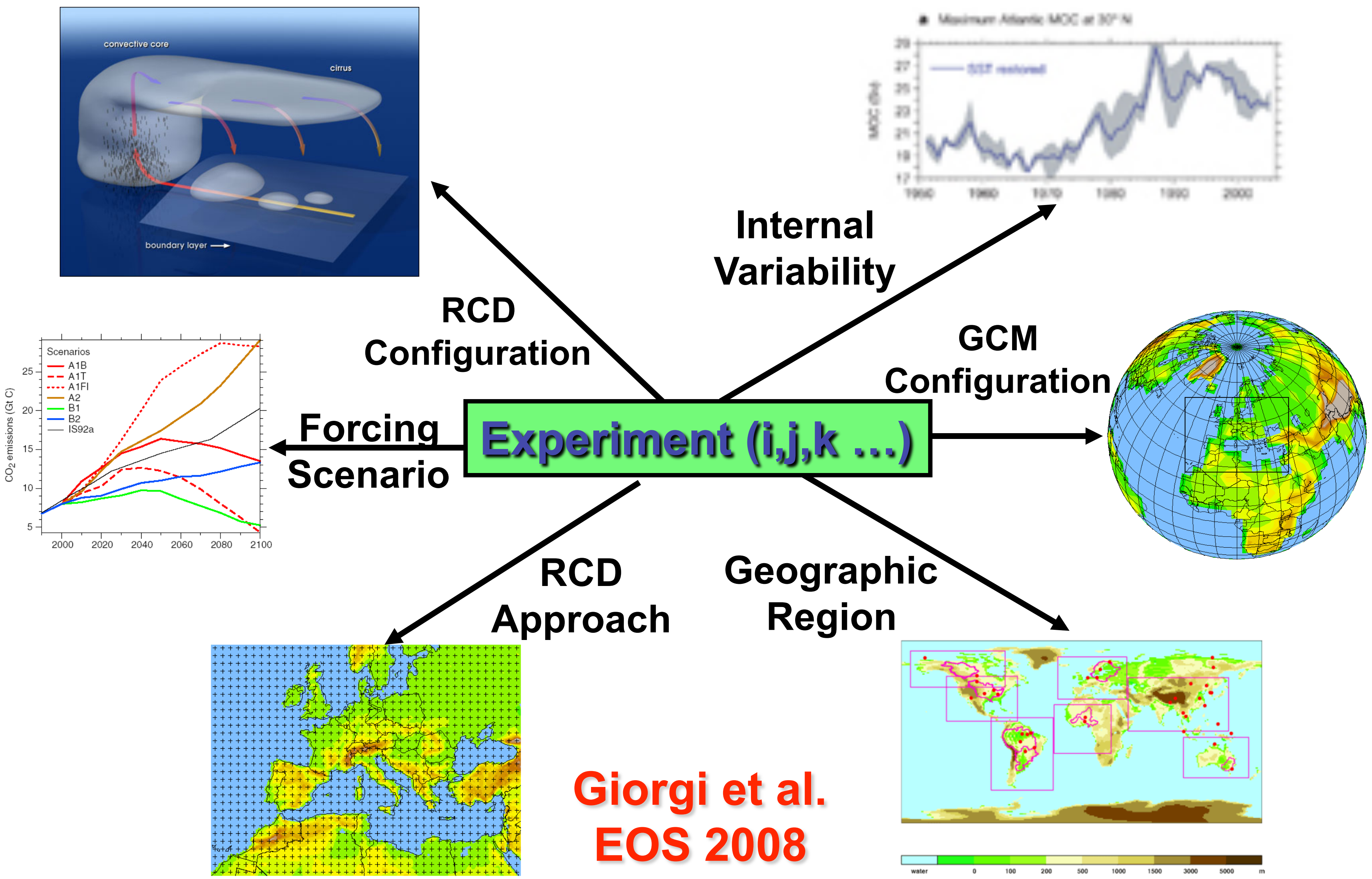


Sources of uncertainty in the simulation of temperature and precipitation change (2071-2100 minus 1961-1990) by the ensemble of PRUDENCE simulations (whole Europe)

(Note: the scenario range is about half of the full IPCC range, the GCM range does not cover the full IPCC range) (Adapted from Deque et al. 2006)

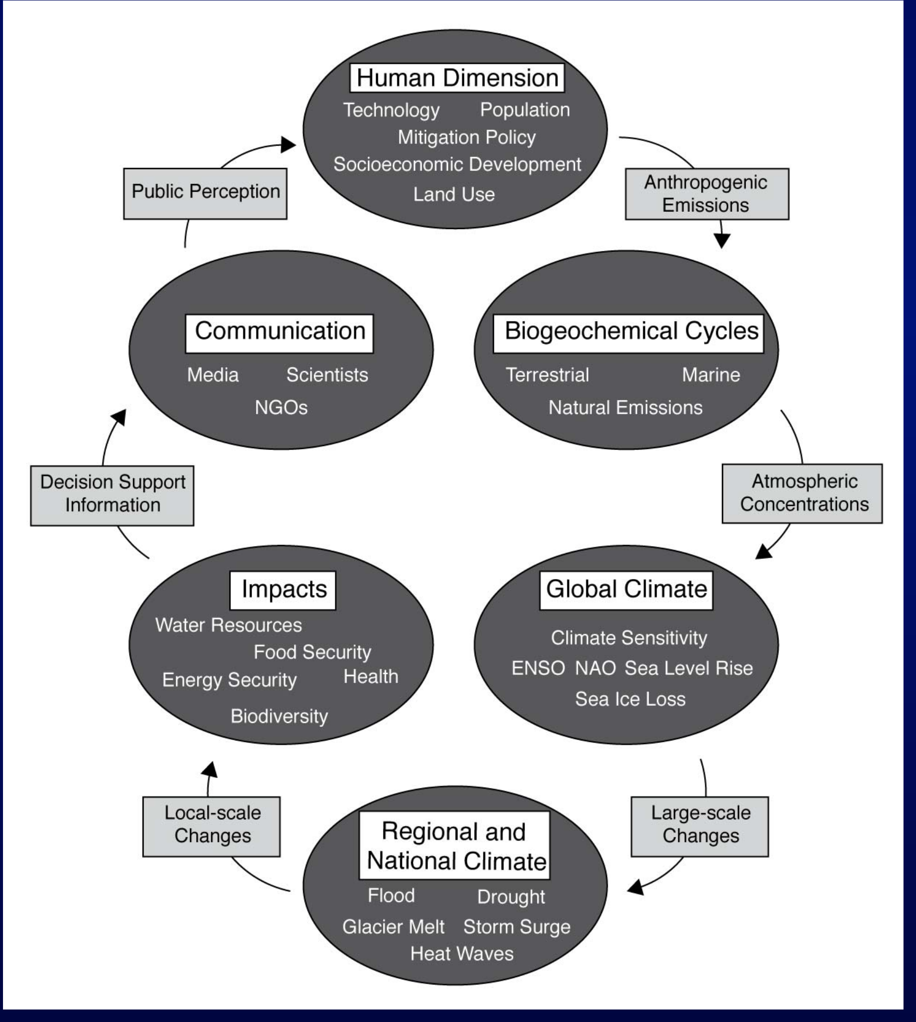


Regional Climate Change "Hyper-Matrix Framework" (HMF)



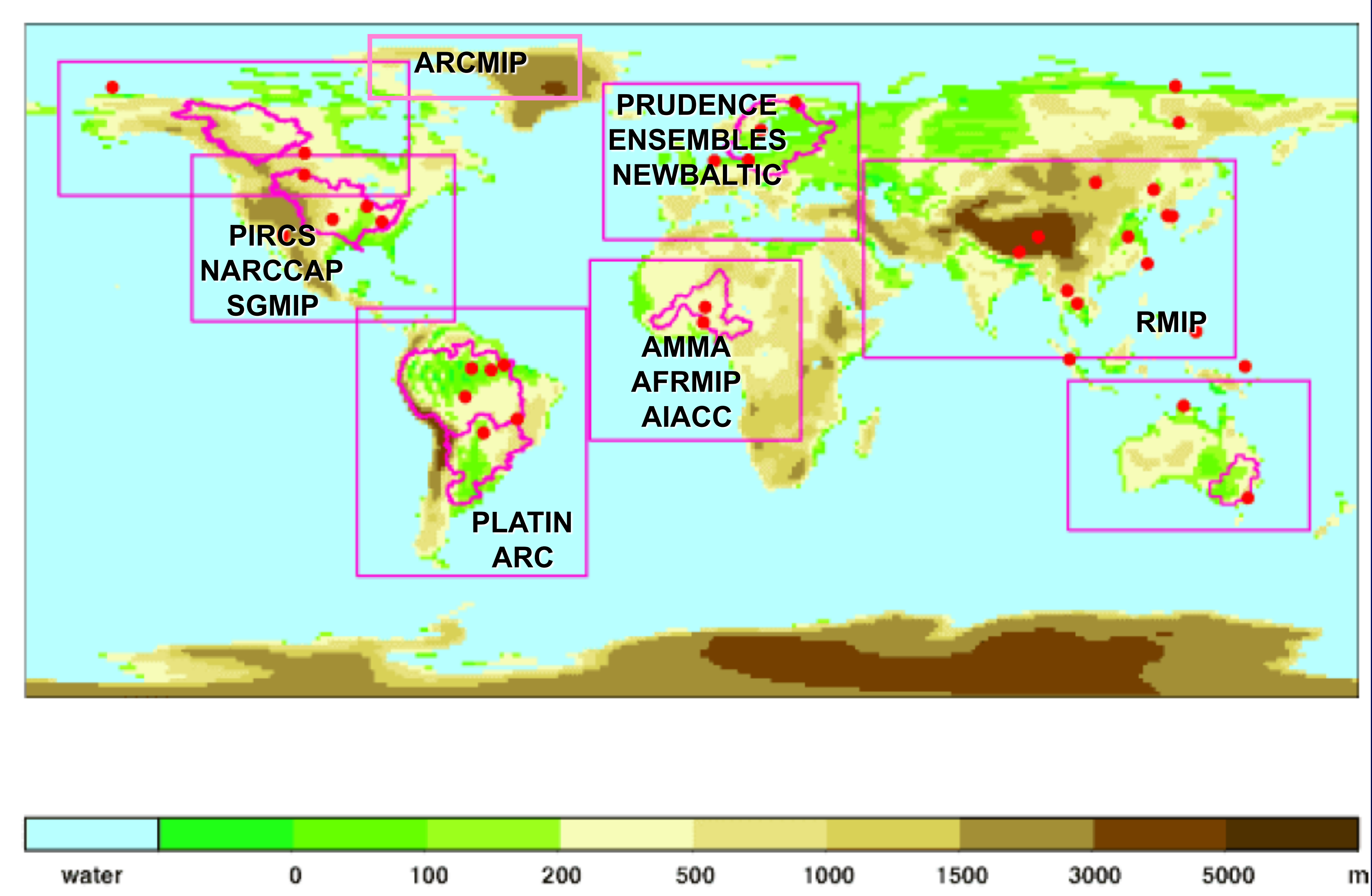
Giorgi et al.
EOS 2008

Why is RCM information under-utilized in the generation of climate change scenarios for impact/adaptation work?



<u>RCM studies have not been coherent and comprehensive enough to sufficiently characterize uncertainties in regional climate change projections</u>

A number of regional intercomparison projects exist which provide the basis for a more coordinated effort.



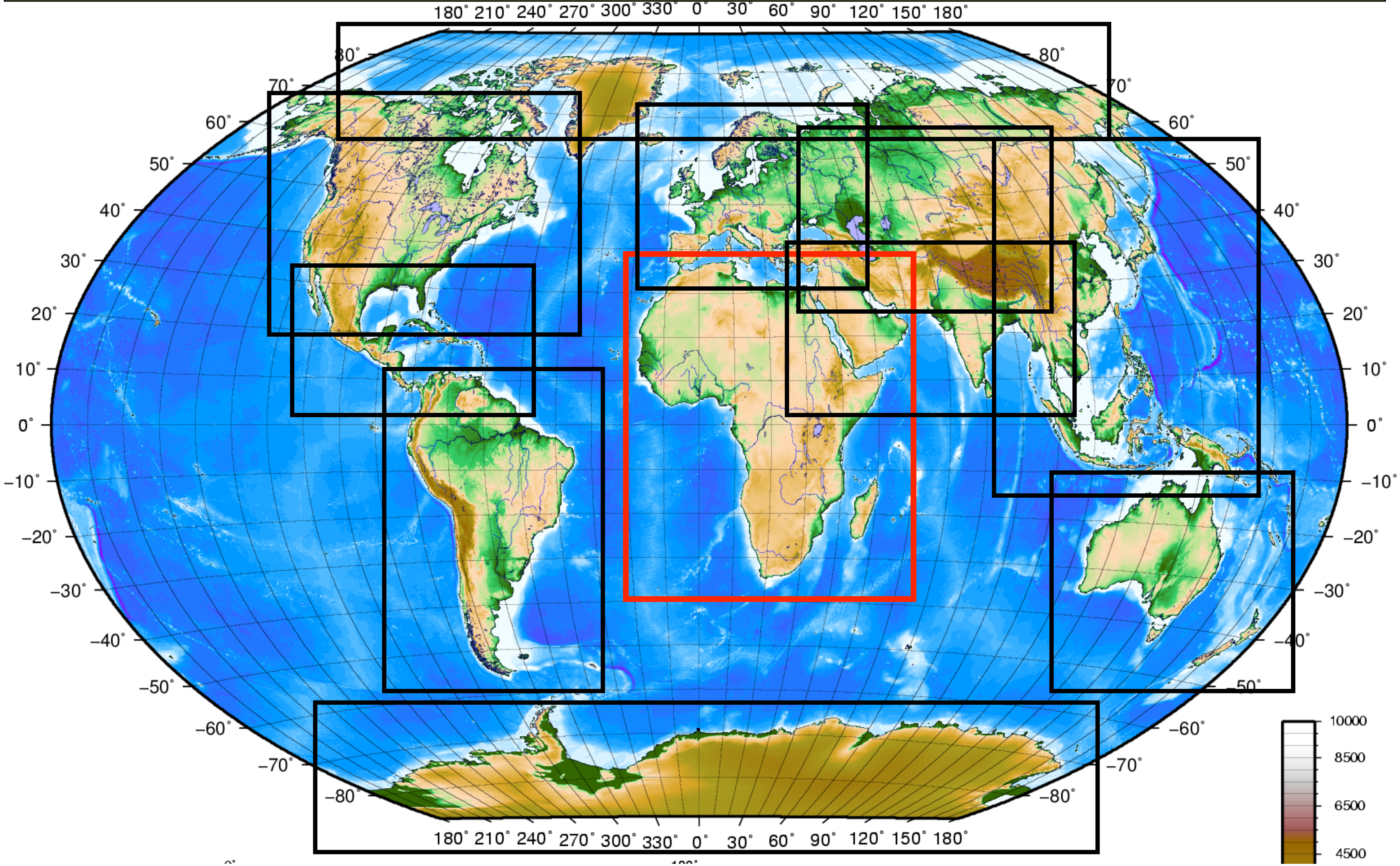
The Coordinated Regional Downscaling Experiment, CORDEX

- Proposal to WCRP at WGCM-12 (Paris, 2008)
- Formal endorsement by WCRP (Dec. 2008)
- Formation of the Task Force on Regional Climate Downscaling (TFRCD) (Dec. 2008)
- Series of meetings
  - Toulouse (Feb 2009)
  - Lund (May 2009)
  - Lille (June 2010)
  - ICTP (March 2011)
- Definition of Phase I experiment set up (2009)

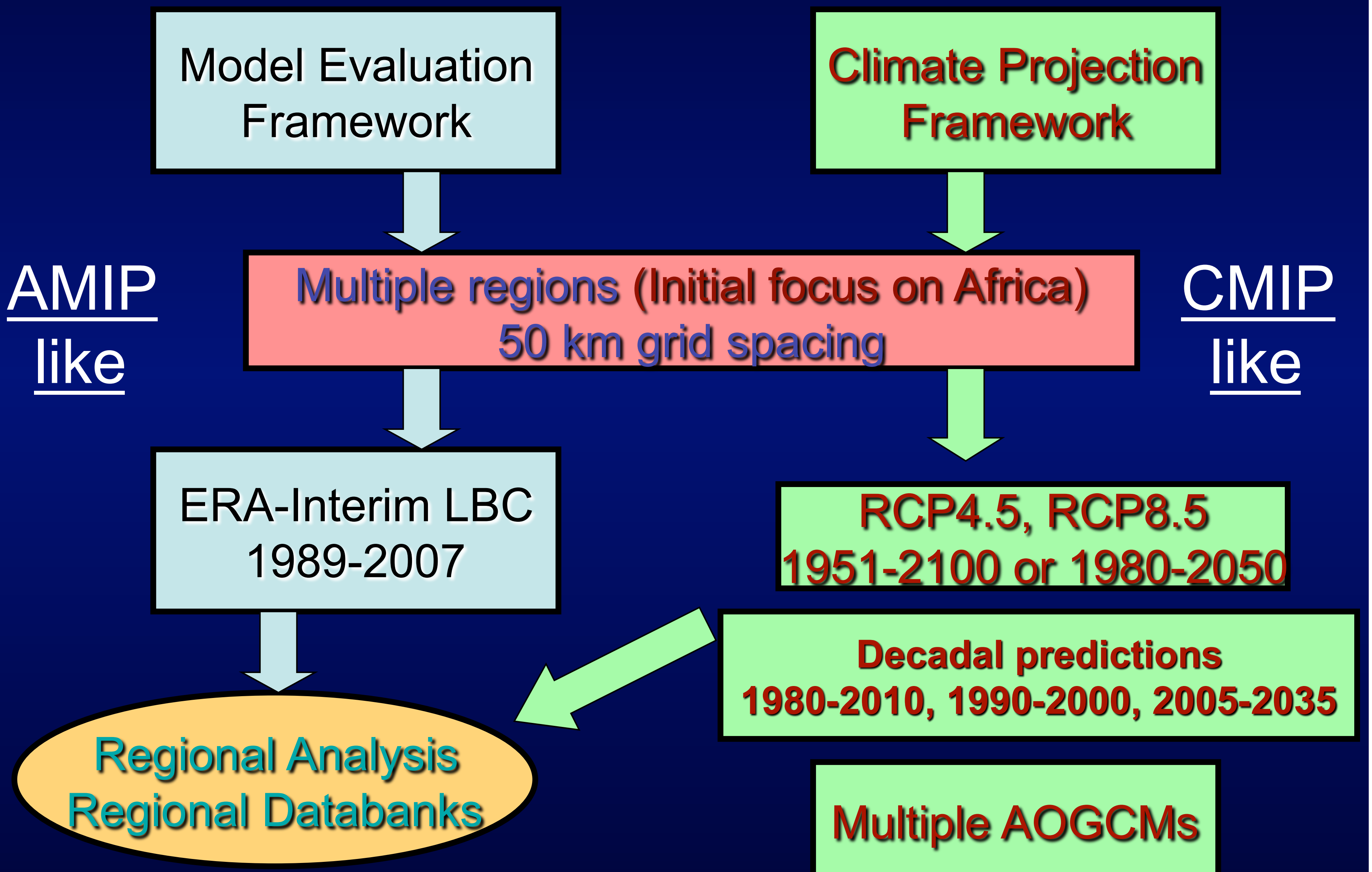
Objectives of CORDEX

- Provide a framework to
  - Evaluate and improve RCD models and techniques
  - Provide a coordinated set of RCD-based projections/predictions over regions worldwide for use in impact assessment/ adaptation studies
  - Facilitate communication with the impact/end user community and involvement of the research community from developing countries

CORDEX domains



CORDEX Phase I experiment design



Progress to date
Africa - CORDEX

- Africa diagnostic/metrics team formed under the leadership of B. Hewitson (UCT)
  - Sponsorship by START
  - Meeting in Cape-Town (UCT) in April 2010
  - Training workshop in Trieste in March 2011
  - Two more training workshops planned in 2011
- Ten groups completed the ERA-Interim driven run
  - SMHI collected the data and performed a first analysis

RCM groups contributing

Data collected and analysis carried out by SMHI

Following slides provided by G. Nikulin from SMHI

HIRHAM5	(DMI, Denmark)
CCLM48	(CCLMcom consortium)
REMO	(MPI, Germany)
RACMO22	(KNMI, Netherlands)
ARPEGE51	(CNRM, France)
RegCM3	(ICTP, Italy)
PRECIS	(University of Cape Town, South Africa)
WRF311	(University of Cantabria, Spain)
MM5	(University of Murcia, Spain)
CRCM5	(Université du Québec à Montréal, Canada)

Simulations and observations

driven by ERA-Interim, Africa domain, 50 km, 1989-2008

<u>RCM data: 3-hourly precipitation:</u>

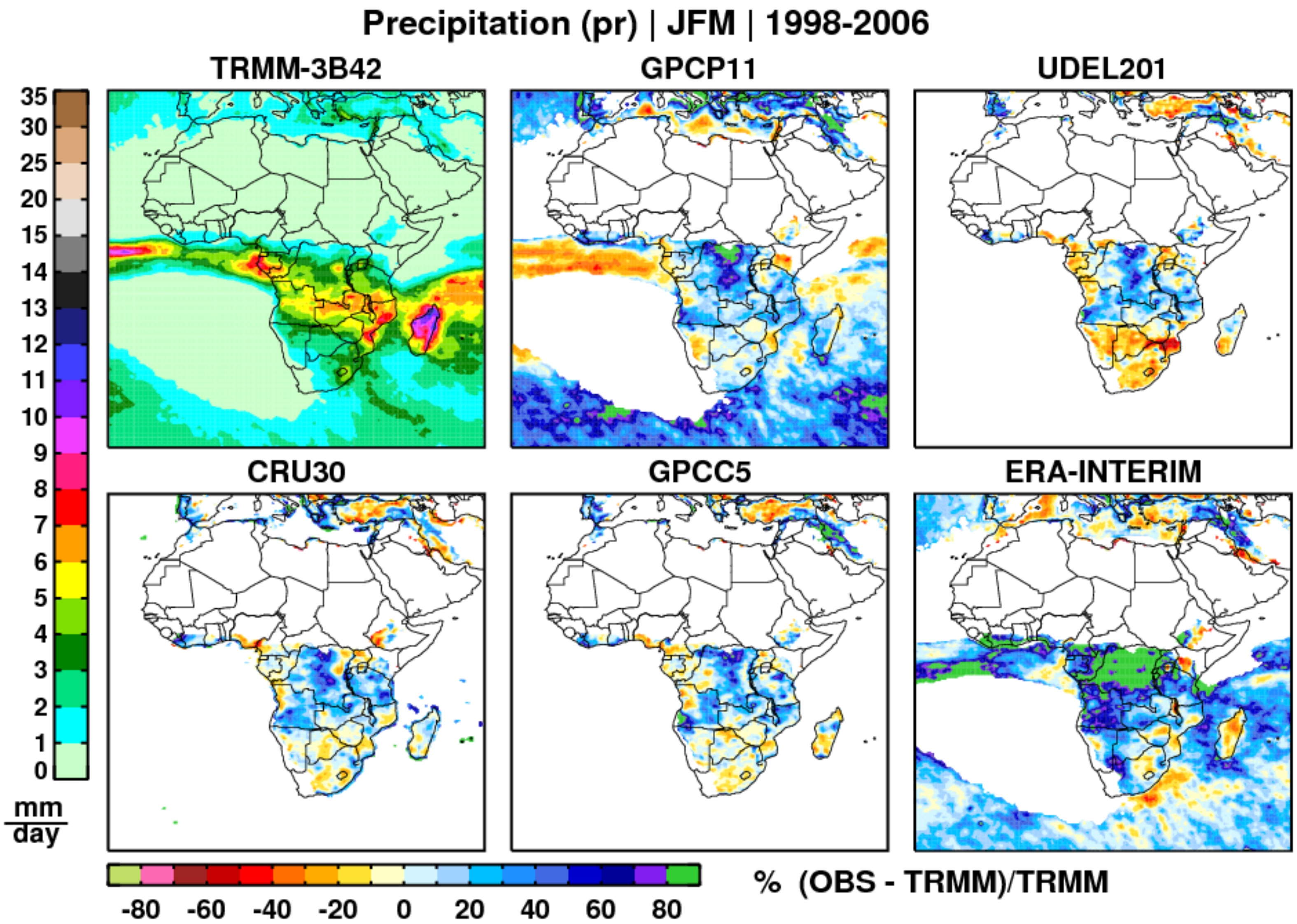
- ✓ **seasonal mean**
- ✓ **annual cycle**
- ✓ **diurnal cycle**

<u>Gridded precipitation products:</u>

- ✓ **TRMM-3B42 (3-hourly, 0.25°, 1998-2008)**
- ✓ **CMORPH (3-hourly,0.25°, 2003-2008)**
- ✓ **GPCP11 (daily, 1°, 1998-2008)**
- ✓ **GPCC5 (monthly, 0.5°, 1989-2008)**
- ✓ **CRU30 (monthly, 0.5°, 1989-2006)**
- ✓ **Univ. Delaware, v. 2.01 (monthly, 0.5°, 1989-2008)**

all different grids remapped onto the same 0.44 rotated grid

Gridded precipitation products



Relative difference can locally reach 50% and more

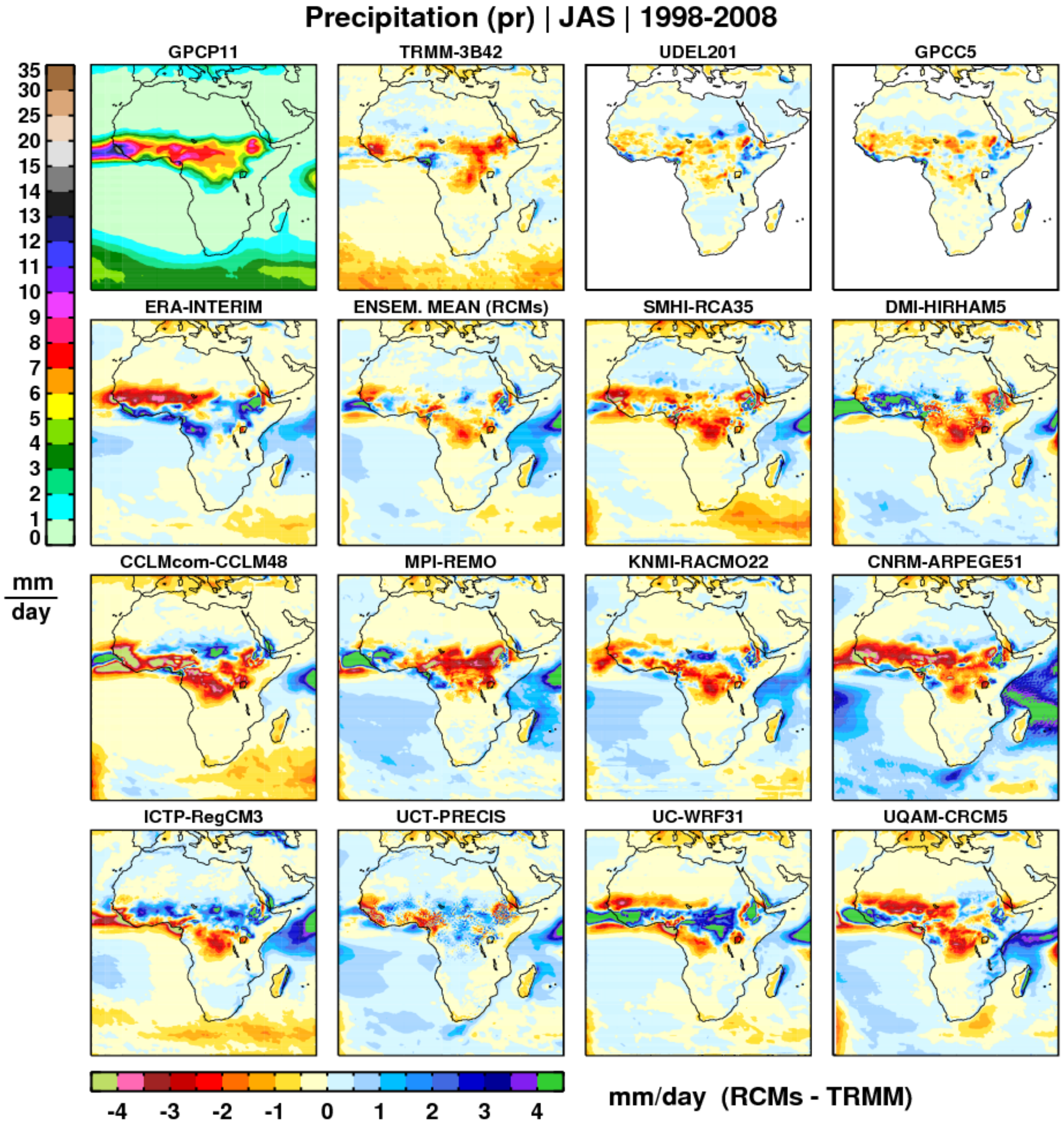
Seasonal means (JAS)

spatial patterns of biases are different

many RCMs show smaller biases than ERA-Interim

common feature is overestimation in eastern part of domain (quality of satellite products ?)

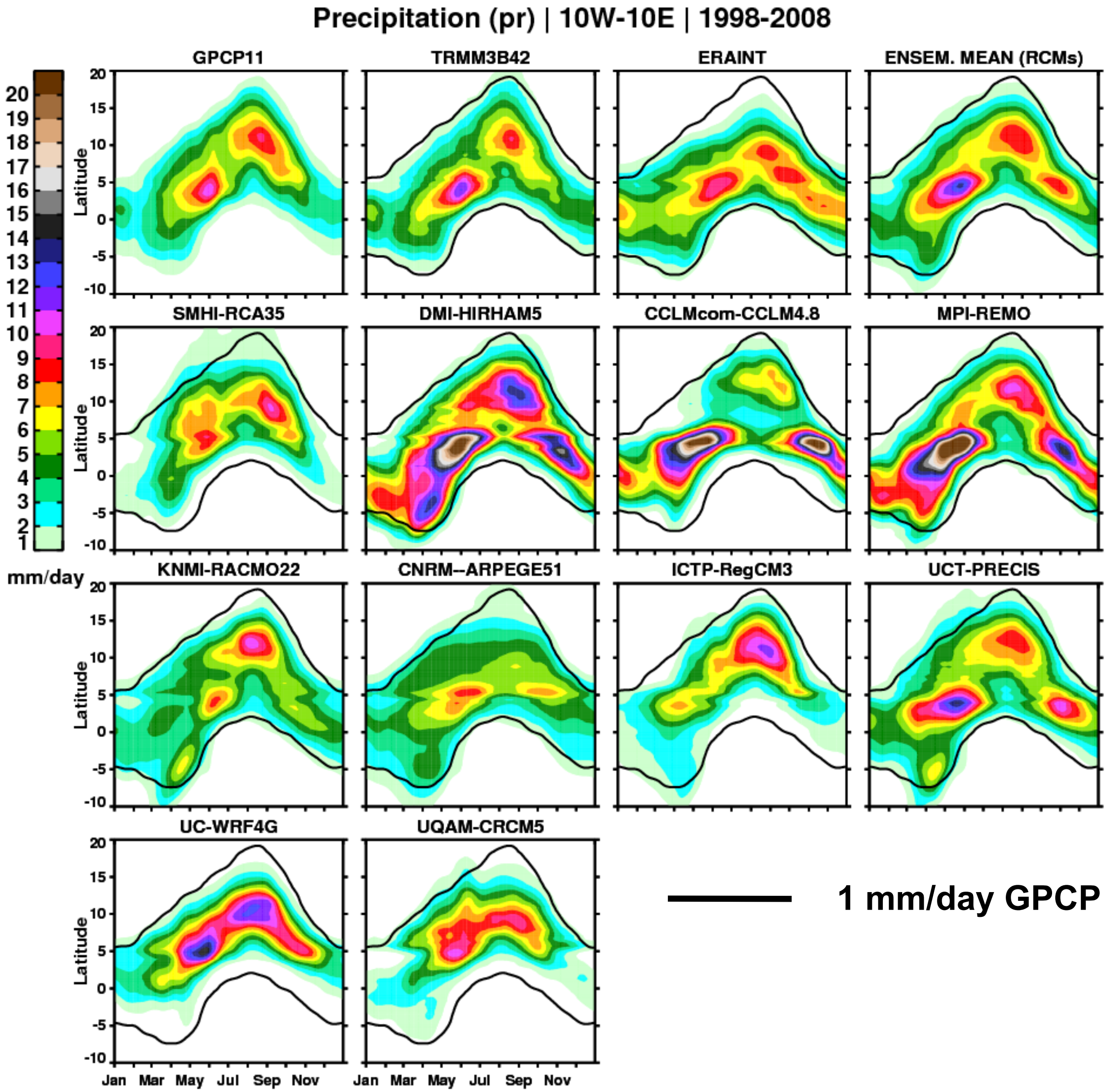
ensemble mean outperforms RCMs (cancelation of biases of opposite sign)



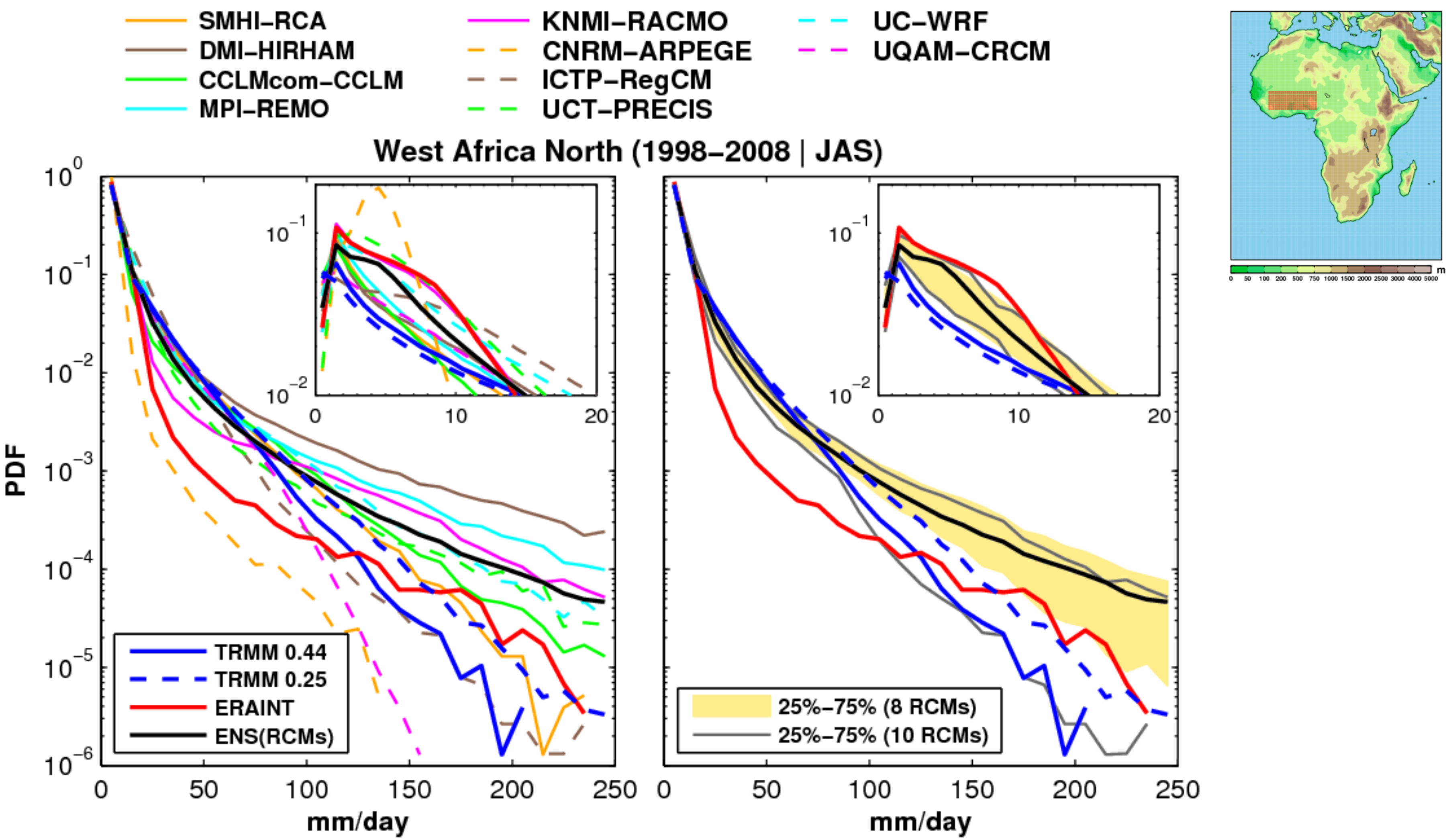
Annual cycle (10W-10E)

All RCMs produce a version of the WAM onset with different degree of distortion

Ensemble mean corrects individual biases

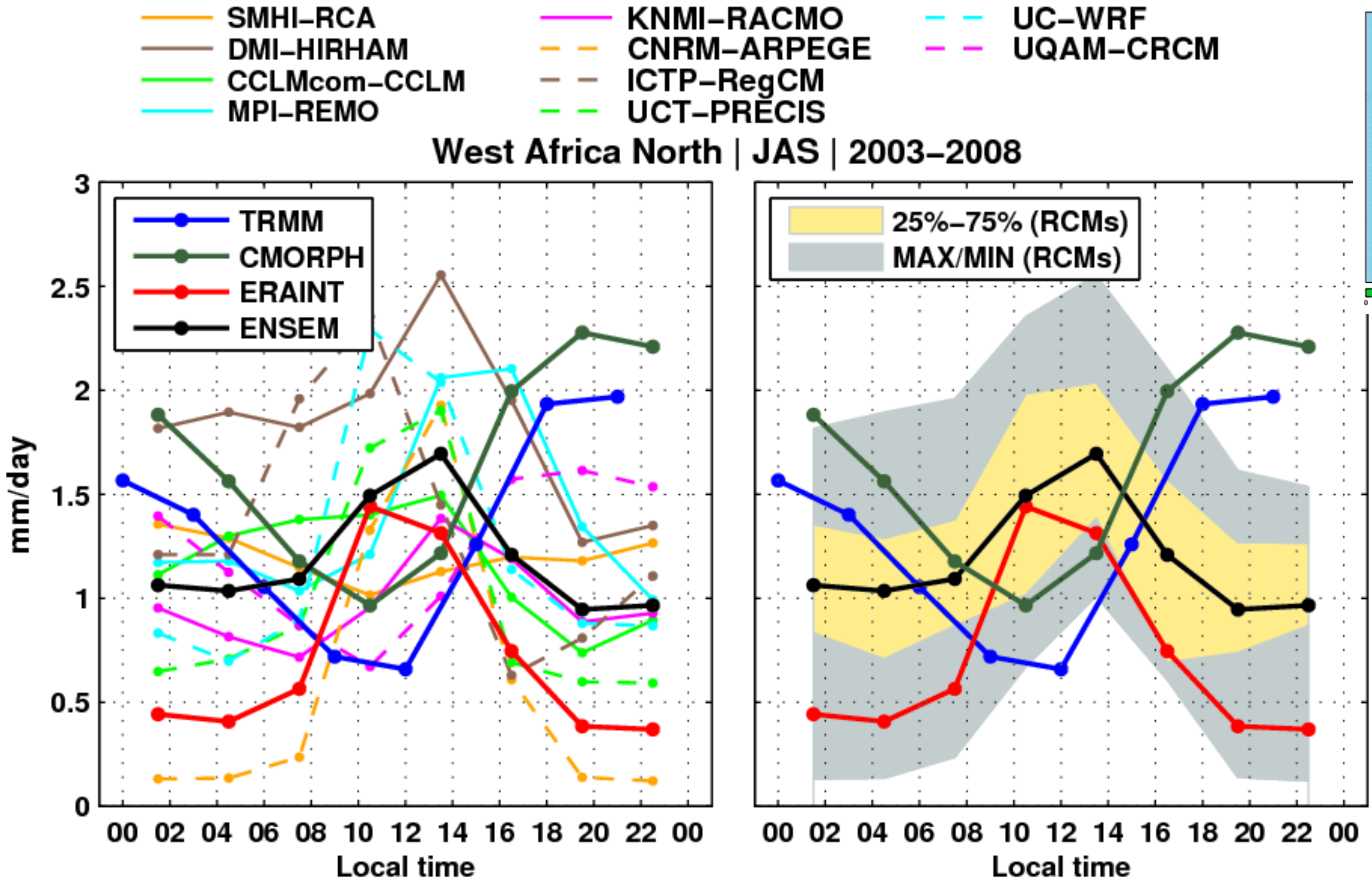


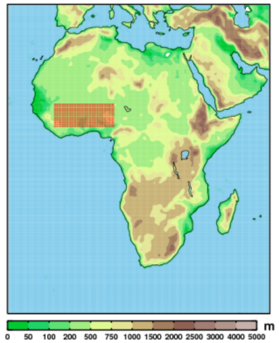
PDF (daily data)



We can expect that TRMM underestimates precipitation

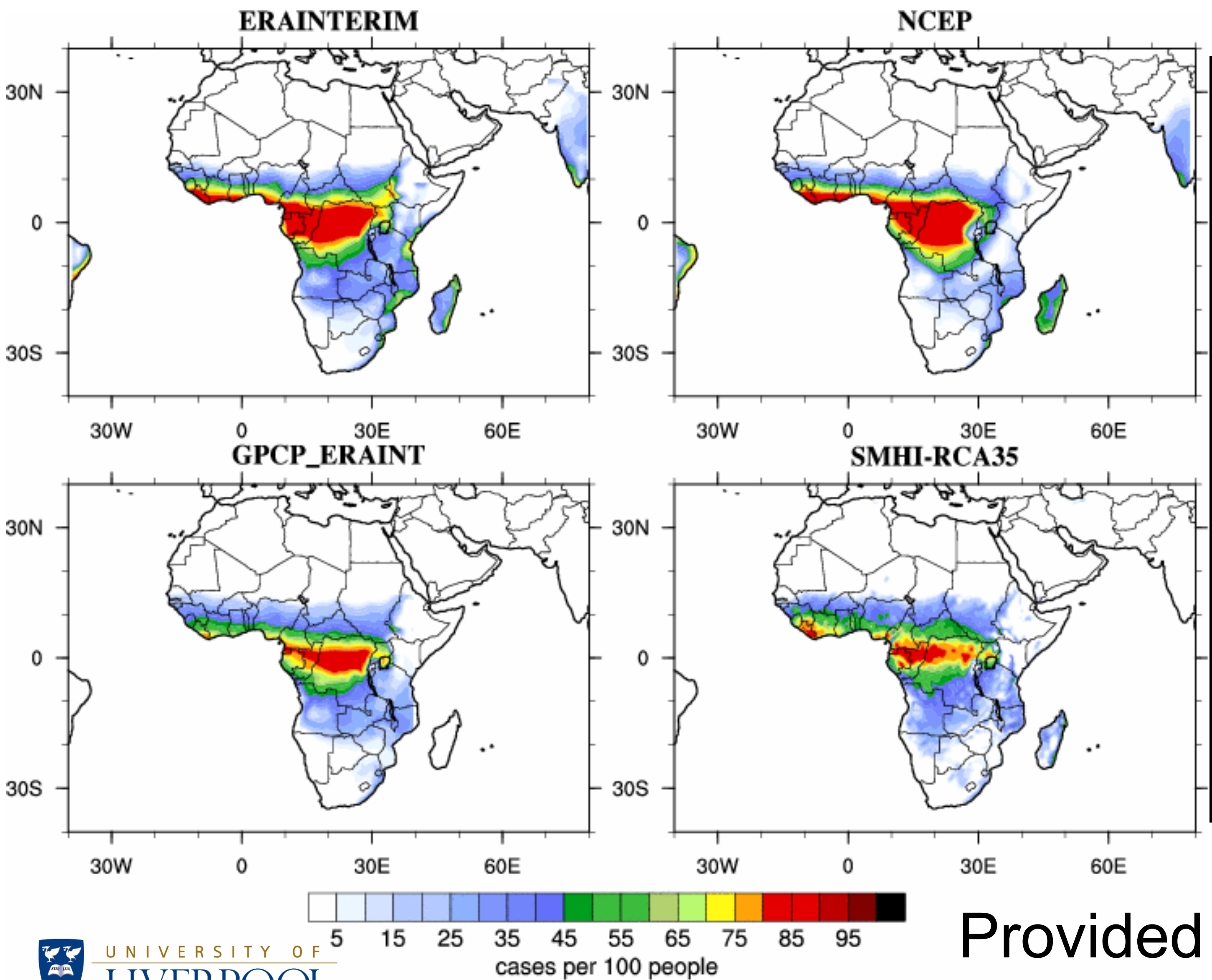
Diurnal cycle





RCA35 has too flat diurnal cycle
only CRCM5 can reproduce diurnal cycle here
ensemble mean cannot correct the phase of diurnal cycle

Health impact examples: Malaria Incidence over Africa: 2000-2008



Mean annual malaria Incidence (%) based on the Liverpool Malaria Model (LMM) for the period 2000-2008.

The LMM has been driven by different observations (NCEP, ERAINTERIM and a hybrid run using GPCP rainfall and ERAINT temperatures) and one RCM from the CORDEX project (SMHI-RCA35, ERAINT control exp).

The RCM fairly well reproduces the mean annual distribution of malaria incidence with respect to the GPCP-ERAINT run.

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UNIVERSITY OF LIVERPOOL

Provided by A. Morse

What data can we expect from CORDEX for use in impact studies

- Multiple RCMs each downscaling multiple GCMs
- Multiple regions (Africa first)
- Historical and future climate experiments for multiple Greenhouse Gas scenarios (or RCP)
- Decadal predictions (second priority)
- Common format of output (NETCDF, CMIP5-like)
- Central (DMI) and regional data archives
- Standardized and region-specific evaluation metrics
- Observations needed for model evaluation


GRAZIE
THANK YOU