Incertezze nelle proiezioni climatiche regionali

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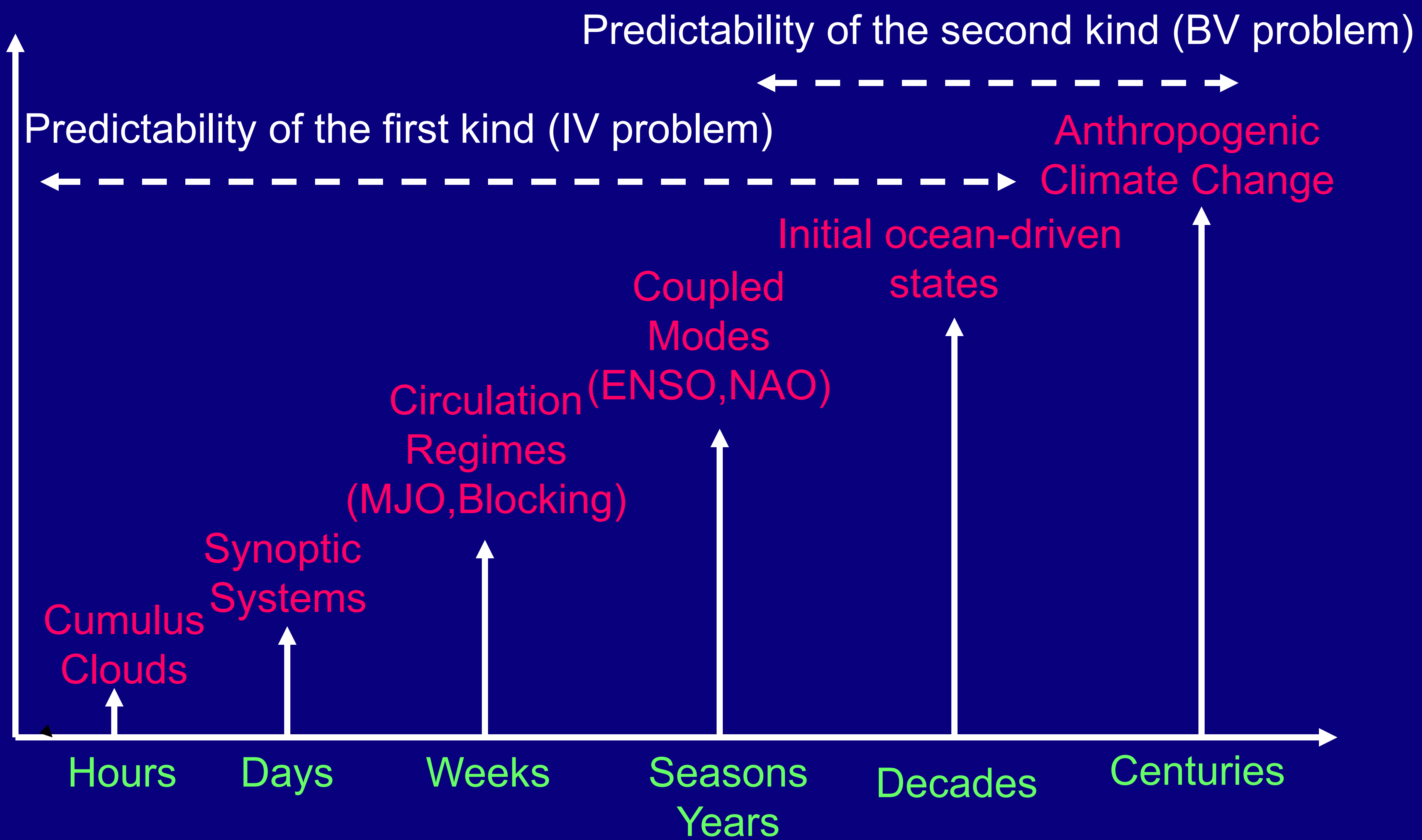
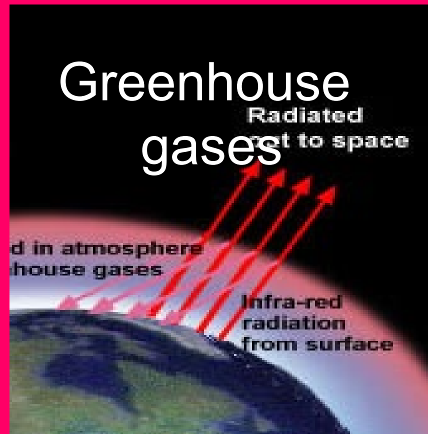
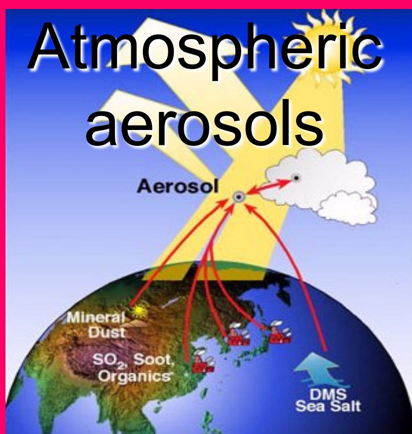
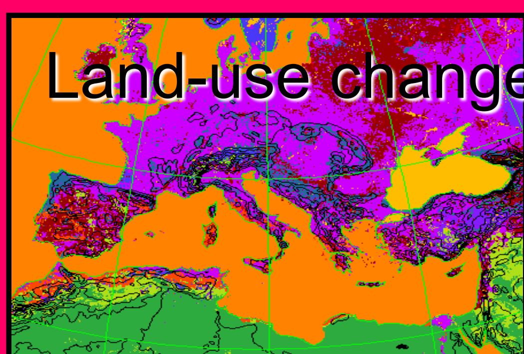
Range of Predictability for Different Phenomena



Human factors

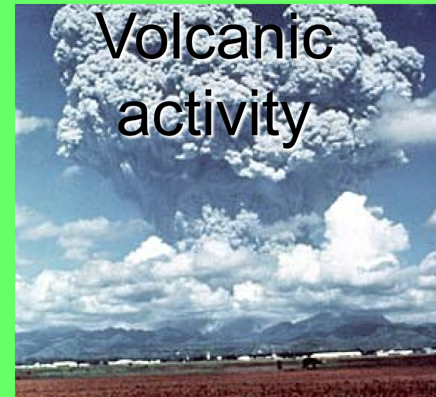


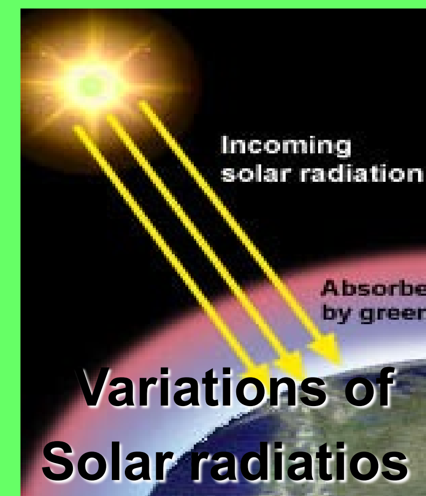


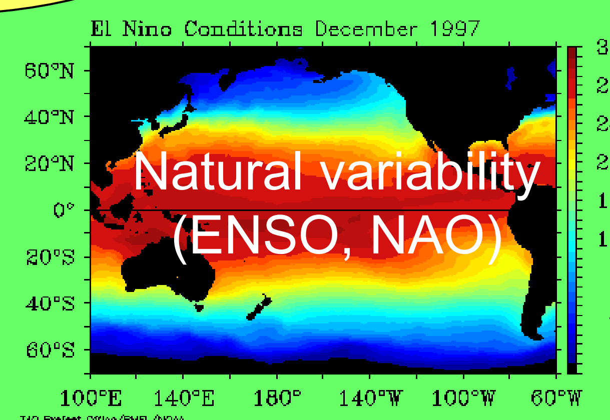


The earth's climate can change because of anthropogenic or natural factors

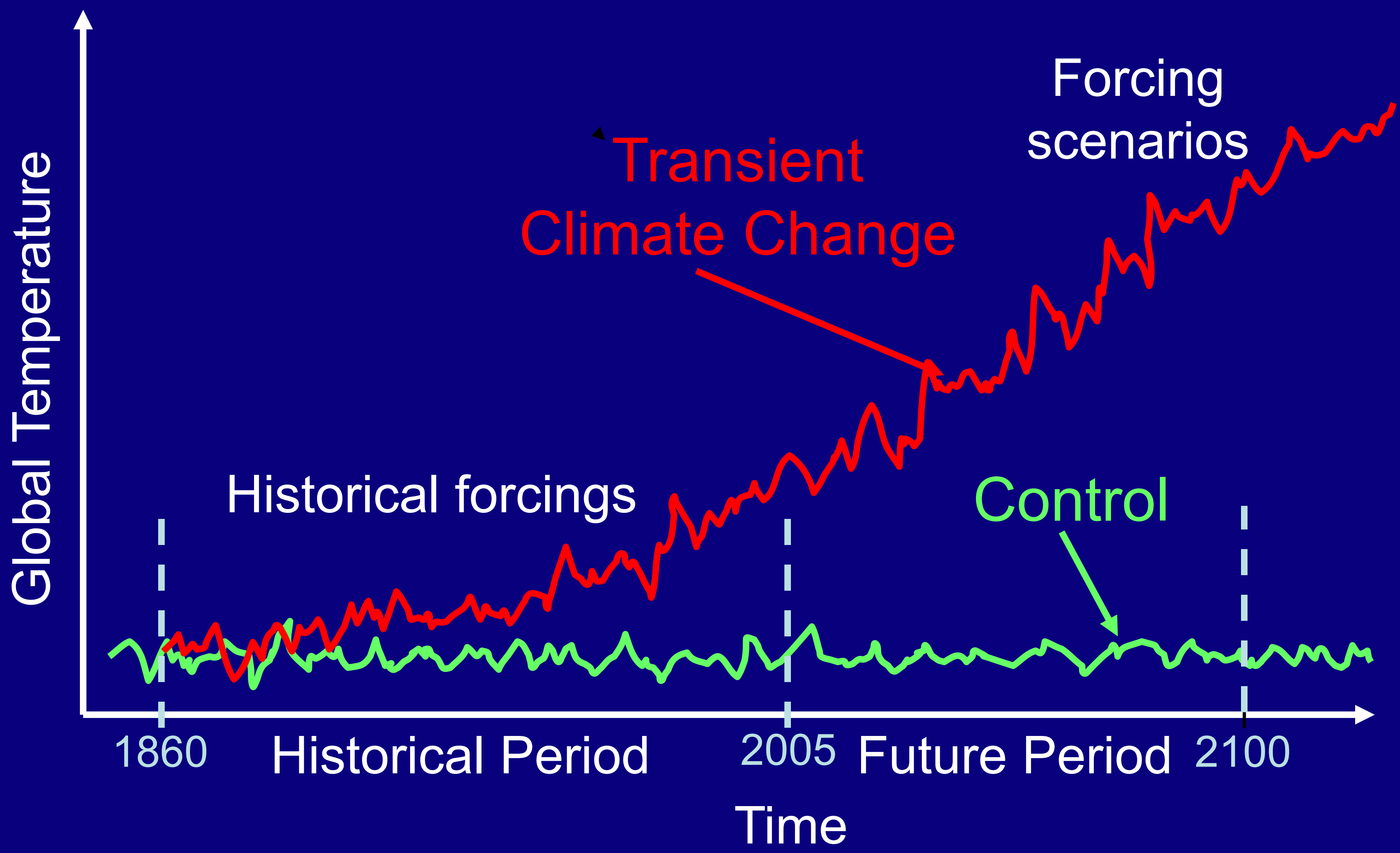
Natural factors







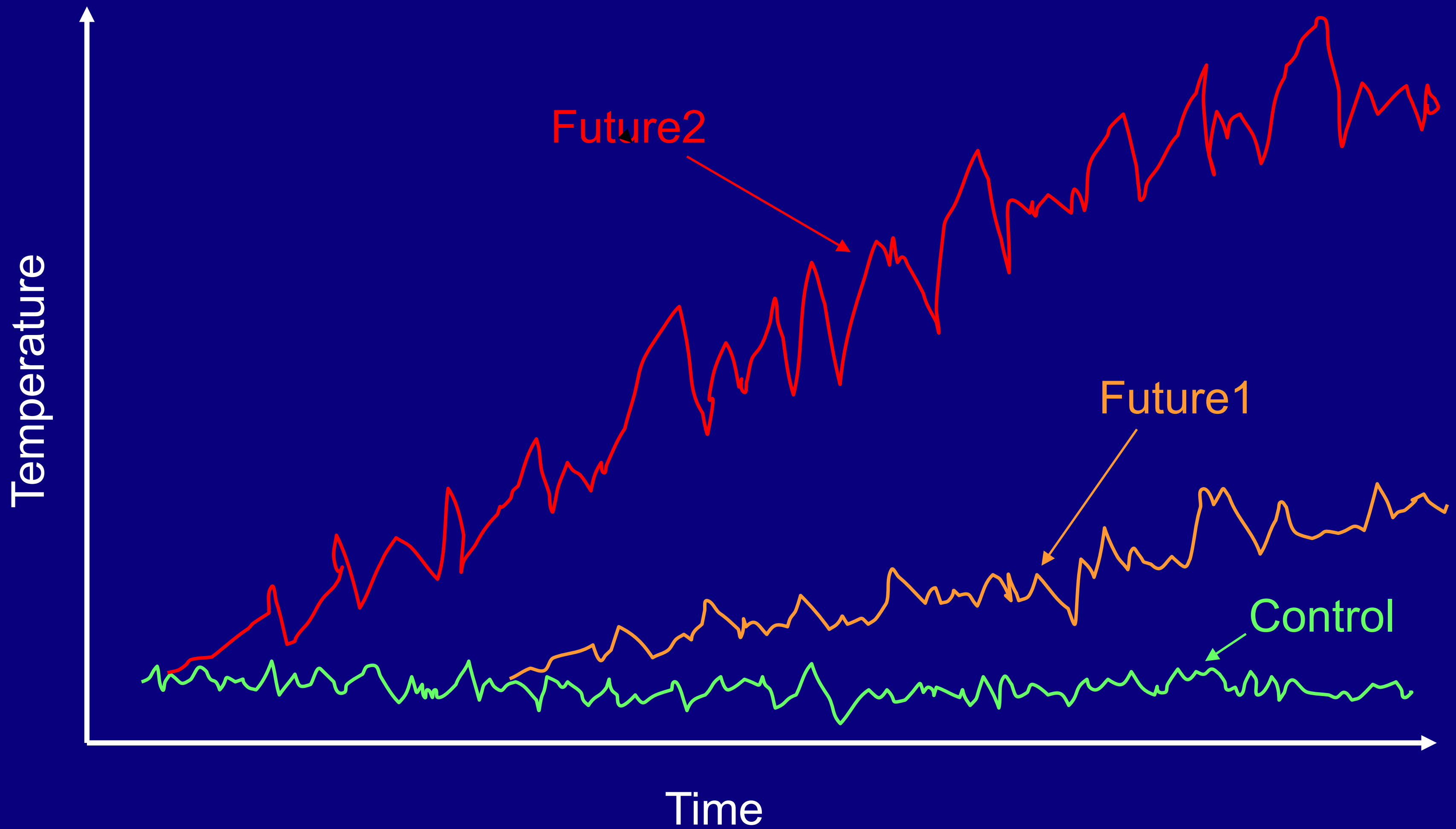
Transient Climate Change Simulation



Intrinsic Uncertainties in Climate Change Prediction:
Initial Conditions of the Climate System

- We do not know with good accuracy what the initial conditions of the climate system were at the beginning of the "Industrialization Experiment"
  - Initial ocean state
  - Initial biosphere state
  - Initial cryosphere state

Climate can evolve differently depending on the initial conditions of its slow components



Intrinsic Uncertainties in Climate Change Prediction: Unpredictability of External Forcings

- Unpredictable Natural Forcings
  - Volcanic activity
  - Solar activity
- Unpredictable, or little predictable, anthropogenic forcings (e.g. GHG and aerosol emissions, land-use change)
  - Social and economic development
  - Technological advances
- Development of scenarios rather than predictions of forcings
  - "Projection" vs. "Prediction" of climate change

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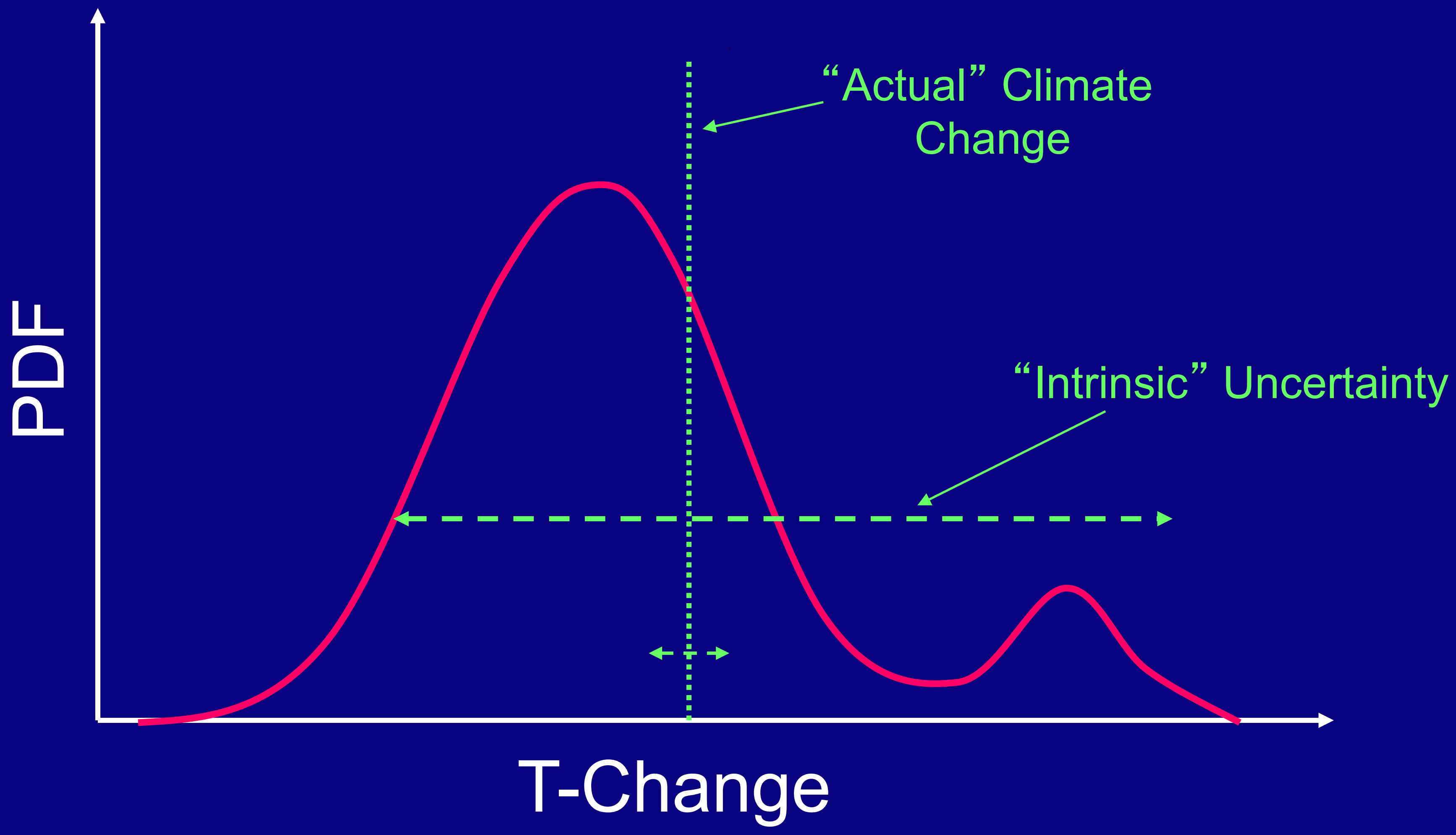
Intrinsic Uncertainties in Climate Change Prediction:
Non-linearities,Thresholds and Feedbacks

- Feedbacks within the climate system can enhance its non-linearity and thus decrease predictability
  - Cloud feedback
  - Tropical convection
  - Snow and sea-ice albedo feedback
  - Biogeochemical / hydrologic feedbacks
  - Adaptation / mitigation feedbacks
- Threshold behaviors also enhance nonlinearity and decrease predictability
  - Shut down of the Thermohaline Circulation
  - Melting of Greenland and Antarctic Ice Sheets

The Climate Change Prediction Problem

Because of the internal variability and non-linearity of the climate system, the presence of feedbacks, and the random component of the external natural and anthropogenic forcings, the “actual” climate change is only one (essentially unpredictable) realization within a range of possible realizations, each characterized by a certain likelihood to occur

Climate Change PDF



The Climate Change Prediction Problem

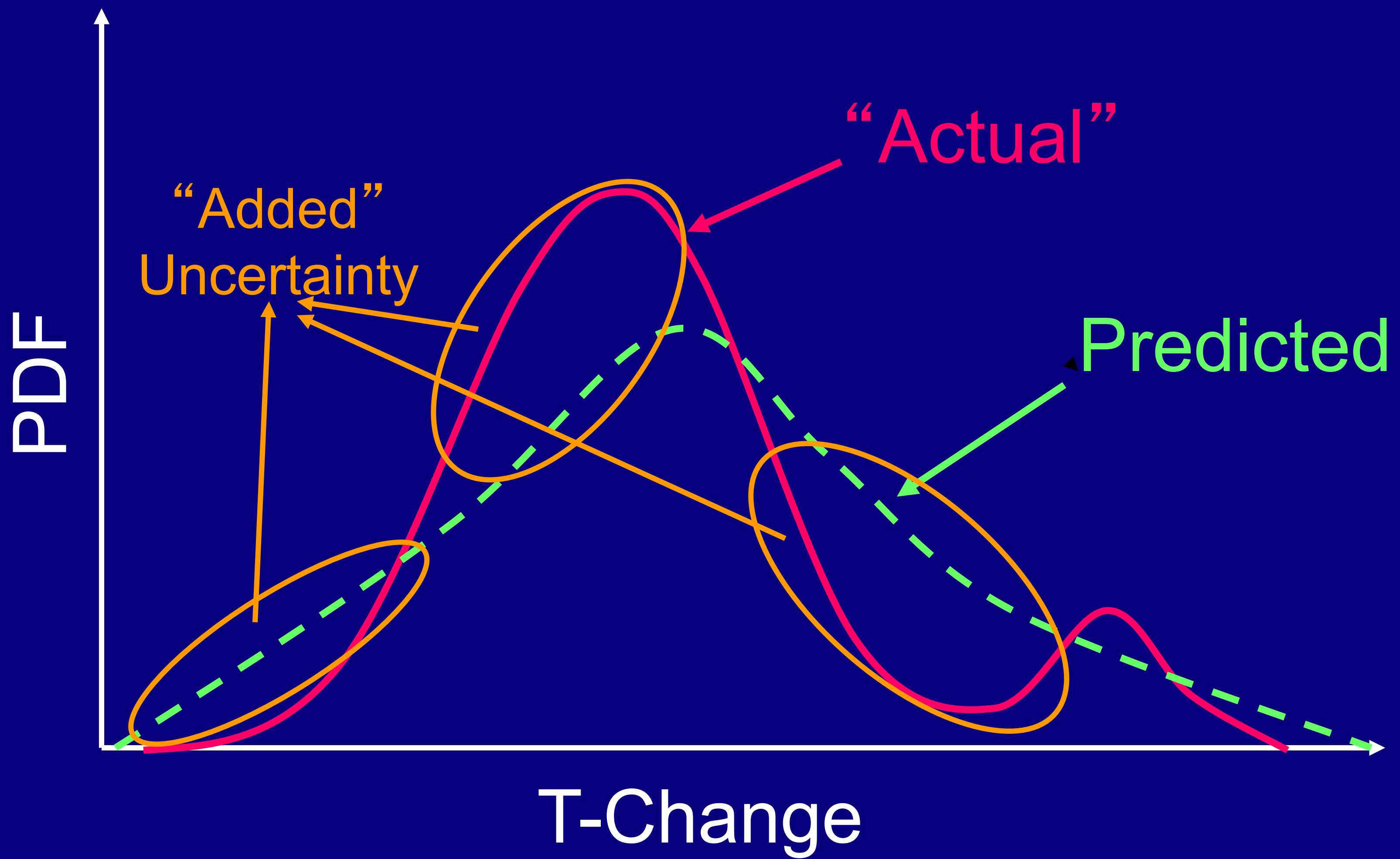
The purpose of climate prediction is not to predict what will be the exact climate of the future, but to reconstruct as closely as possible the PDF of possible future climates. This implies that:

Climate change prediction needs to be approached in a probabilistic way.

There are also many sources of “added” uncertainty:

- Imperfect knowledge of processes
- Imperfect observations
- Imperfect models
- Imperfect analyses and approaches
- And probably many more ...

Predicted vs. “Actual” Climate Change PDF



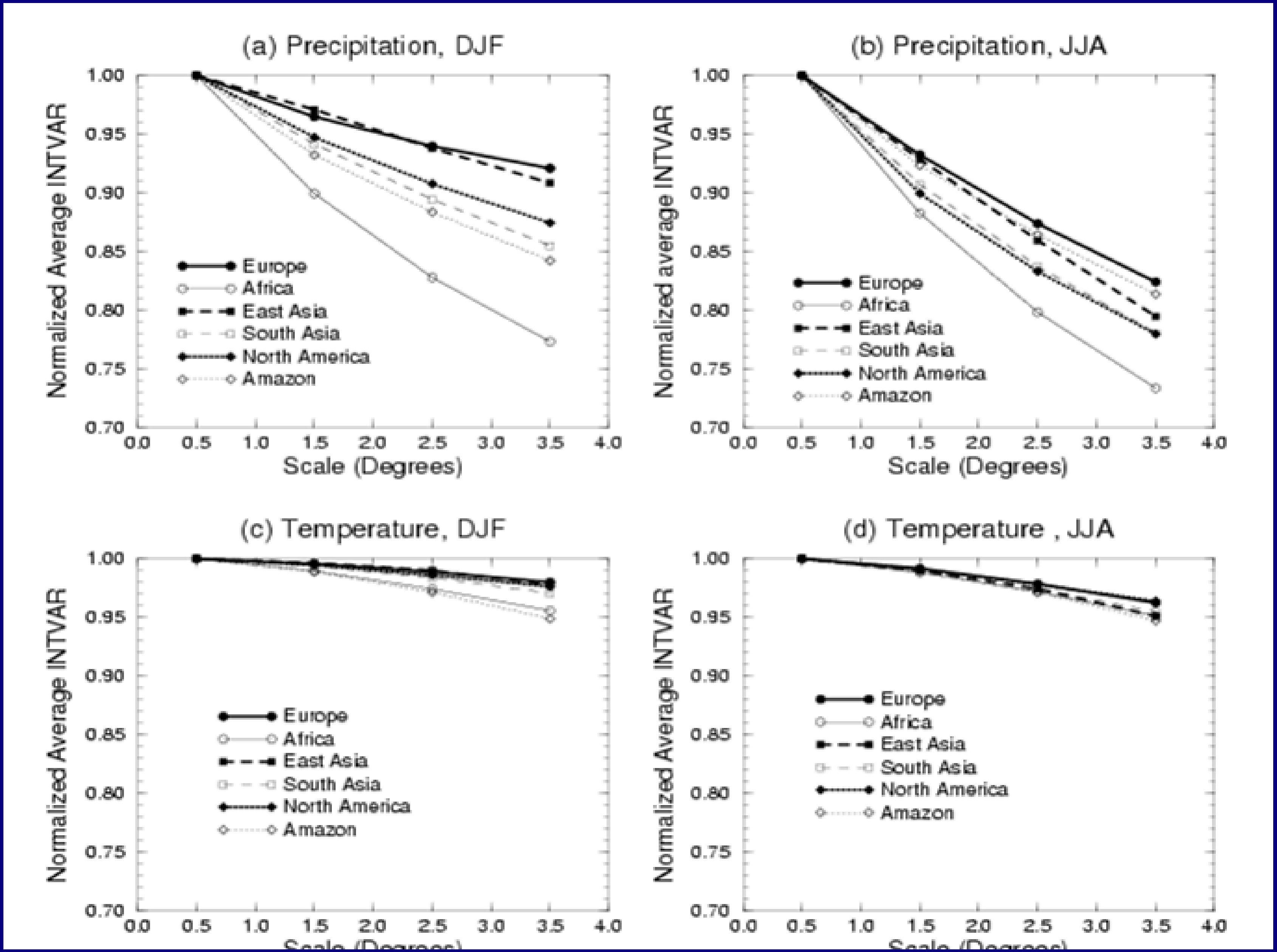
The uncertainty “dilemma”

- We need to characterize as much as possible the “intrinsic” uncertainty
  - Wide PDF
- But we need to reduce as much as possible the “added” uncertainty
  - Narrow PDF
- We do not have specific case studies to test our anthropogenic climate change “predictions”, e.g. as in weather and seasonal forecast, and as a result it is critical to evaluate and possibly quantify their reliability
  - Process understanding
  - Model fidelity
  - Seemless prediction
  - Inter-model agreement
  - Consistency with observed trends
  - Multiple evidence

Regional vs. Global Climate Change Prediction

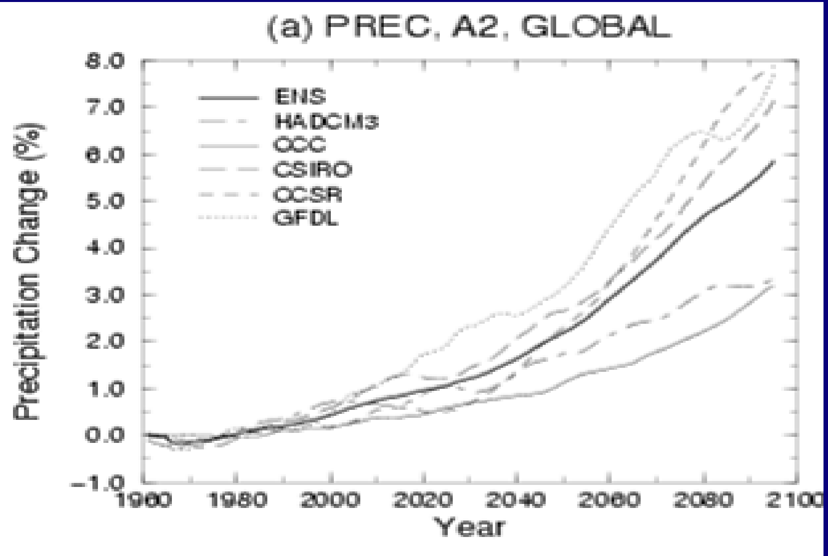
- Climate change prediction is more difficult at the regional than the global scale
  - Natural variability increases at finer scales, which makes the extraction of the change signal from the underlying noise more difficult
  - Changes in circulation structure, regimes and natural climate modes are more important at the regional scale: regional climate is more non-linear
  - Regional climates are affected by local scale forcings and processes that are not adequately resolved by climate models

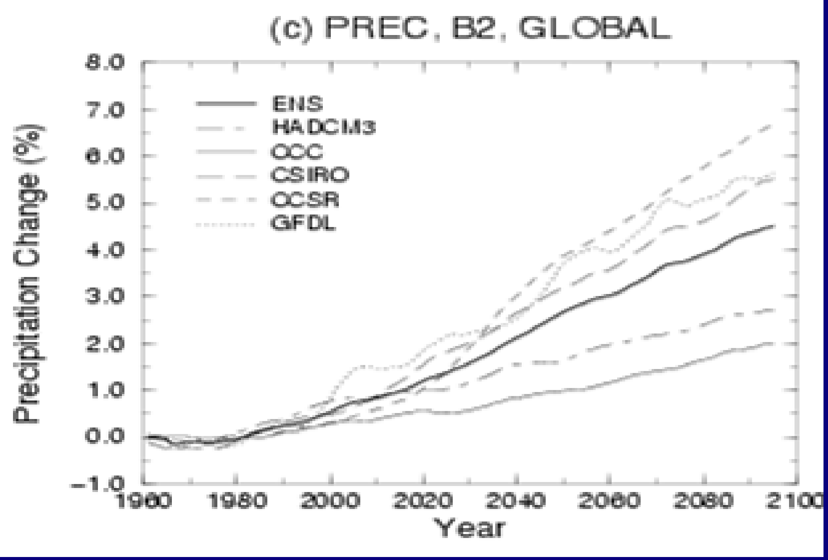
Sensitivity of interannual variability to spatial scale (Giorgi 2003)



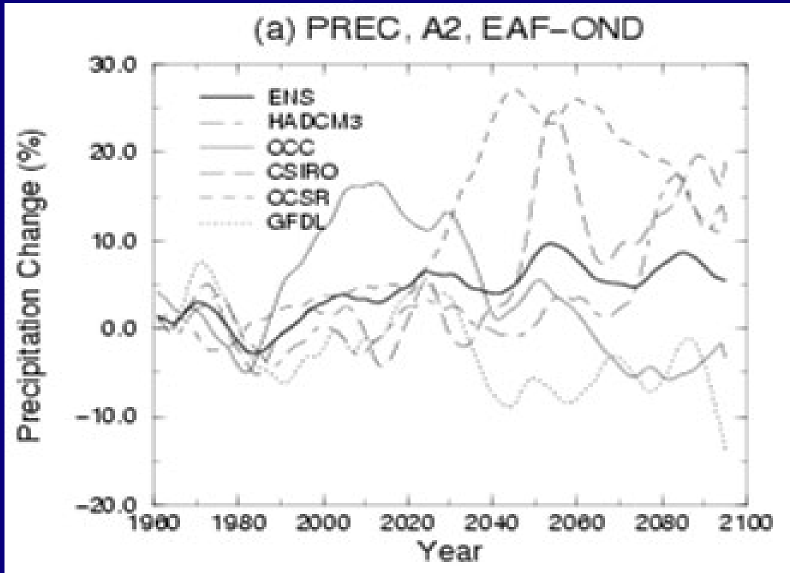
Precipitation change

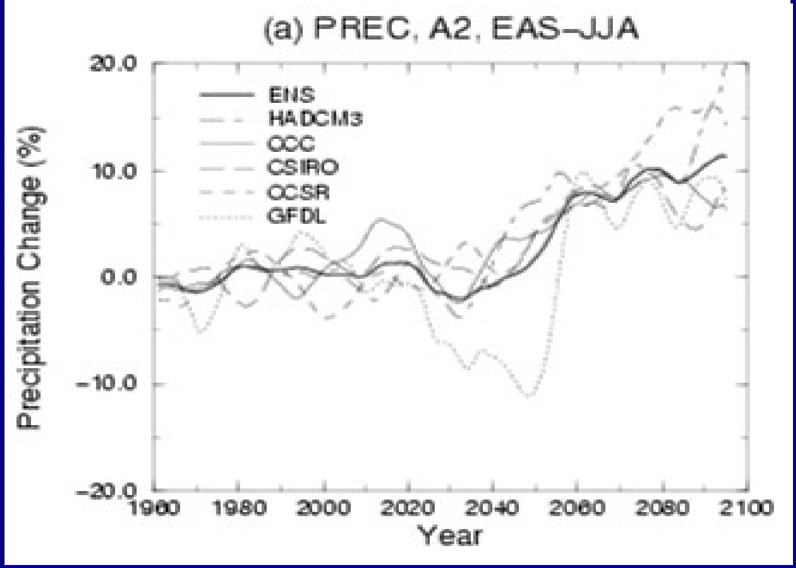
Global





Regional





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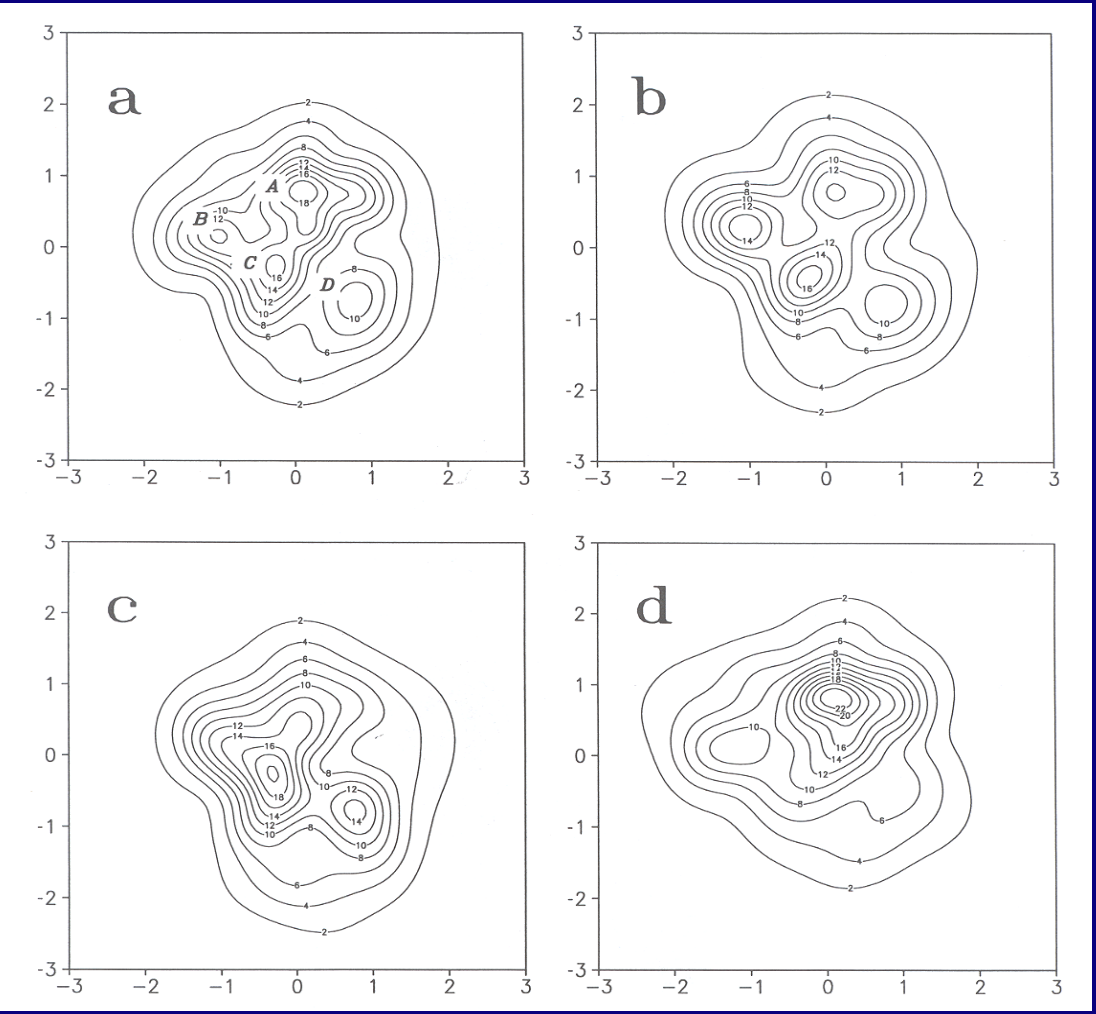
PDF of 500 Hpa Height (Corti et al. 1999)

1949 / 94

1949 / 94
No EN-LN



1949 / 71

1971 / 94

Climate Change can modify the frequency and/or structure of weather regimes

Regional vs. Global Climate Change Prediction

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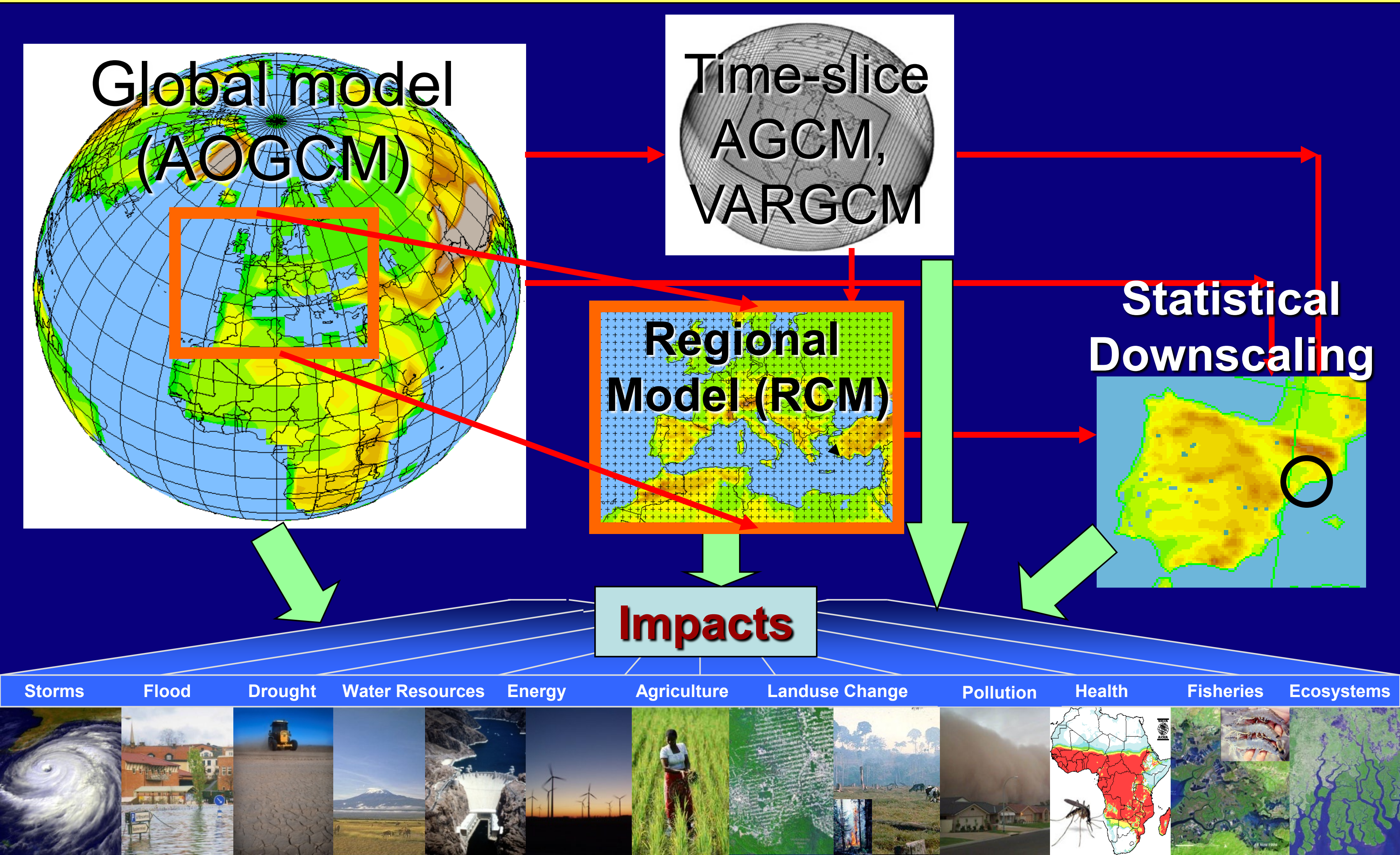
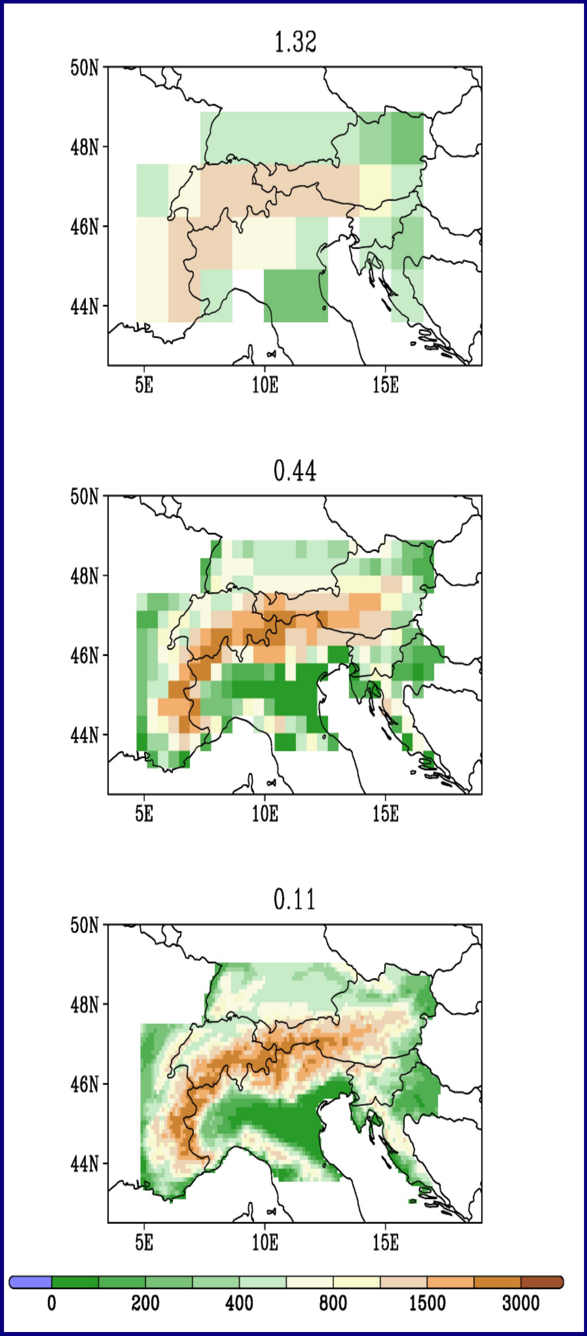
  - Regional climates are affected by local scale forcings and processes that are not adequately resolved by global climate models (topography, landuse, aerosols, extremes etc.)

Several tools are available for producing fine (sub-GCM) scale regional climate information



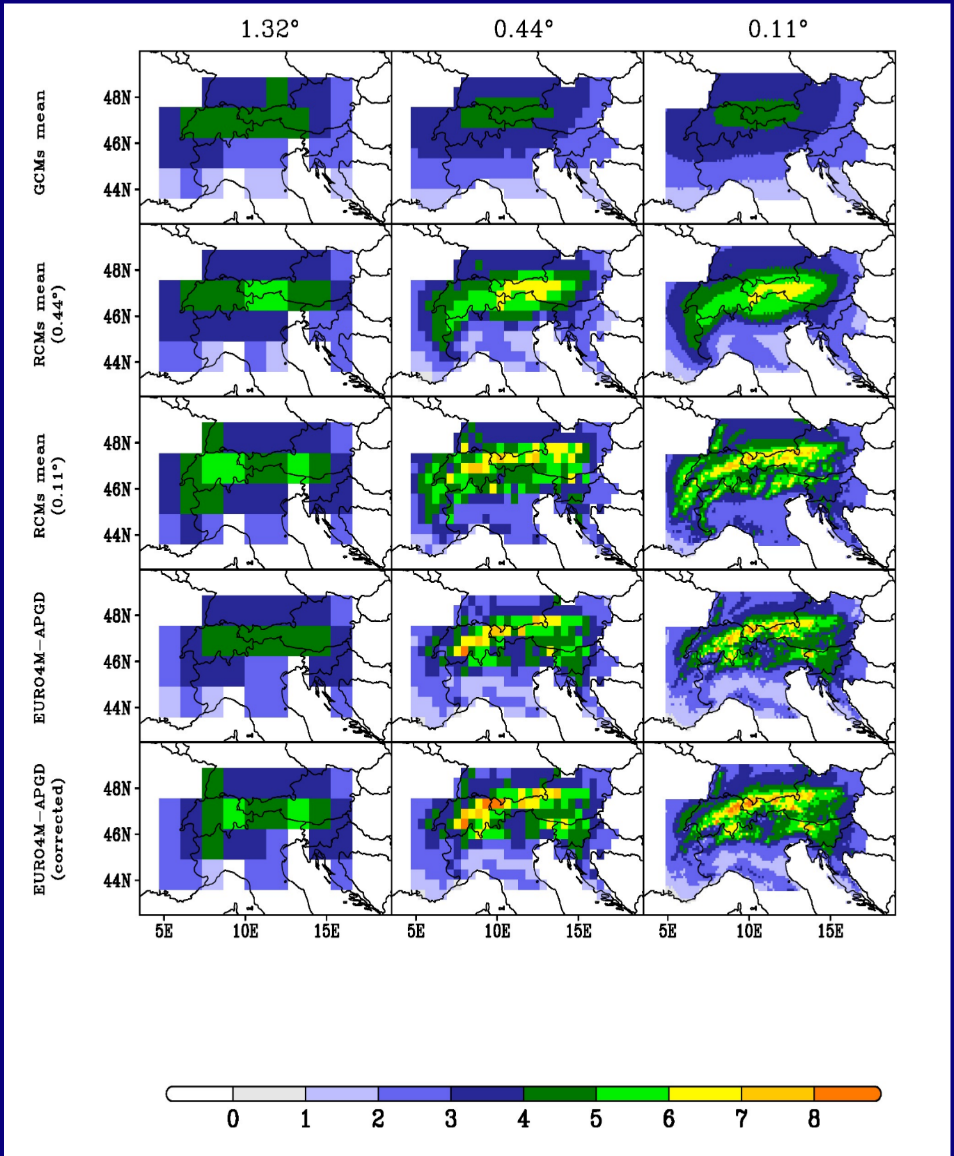
Analysis grids (topography)



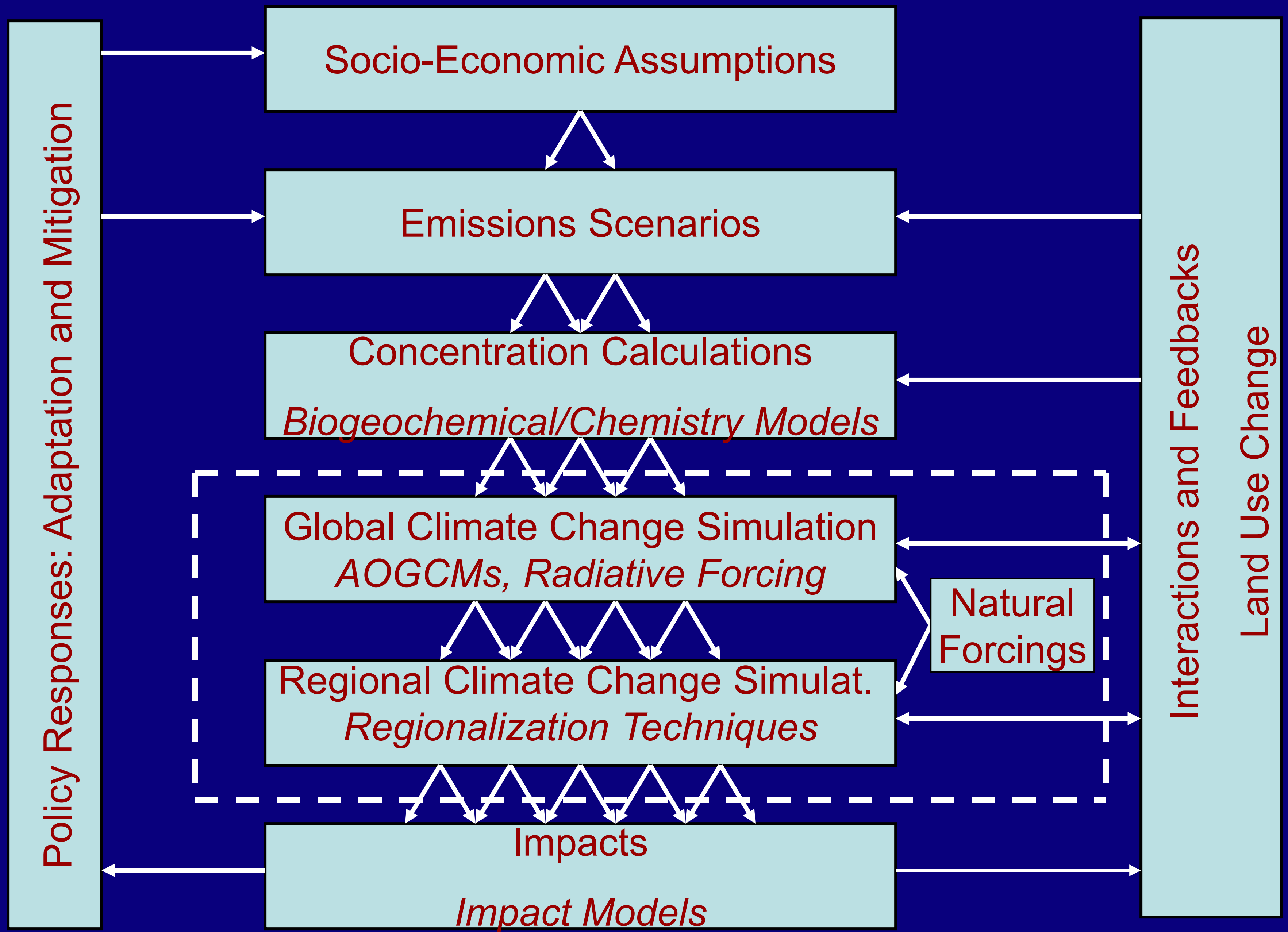
Model ensembles

Model	Modelling group	Resolution	Reference
a, CNRM-CM5	Centre National de Recherches Meteorologiques and Centre Europeen de Recherches et de Formation Avancee en Calcul Scientifique, France	1.40625º x 1.40625º	Voldoire et al., 2012
b, EC-EARTH	Irish Centre for High-End Computing, Ireland	1.125º x 1.125º	Hazeleger et al., 2010
c, HadGEM2-ES	Met Office Hadley Centre, UK	1.875º x 1.2413º	Collins et al., 2011
d, MPI-ESM-LR	Max Planck Institute for Meteorology, Germany	1.875º x 1.875º	Jungclaus et al., 2010
ALADIN (a-MC)	Centre National de Recherches Meteorologiques, France	0.44º/0.11º	Colin et al., 2010
CCLM (d-EC)	Climate Limited-area Modelling Community, Germany	0.44º/0.11º	Rockel et al., 2008
RCA4 (c-EC)	Swedish Meteorological and Hydrological Institute, Rossby Centre, Sweden	0.44º/0.11º	Kupiainen et al., 2011
RACMO (b-EC)	Royal Netherlands Meteorological Institute, The Netherlands	0.44º/0.11º	Meijgaard van et al., 2012
RegCM4 (c-MC)	International Centre for Theoretical Physics, Italy	0.44º/0.11º	Giorgi at al., 2012

Ensemble mean summer precipitation (1976-2005)



Cascade of uncertainty in climate change projections



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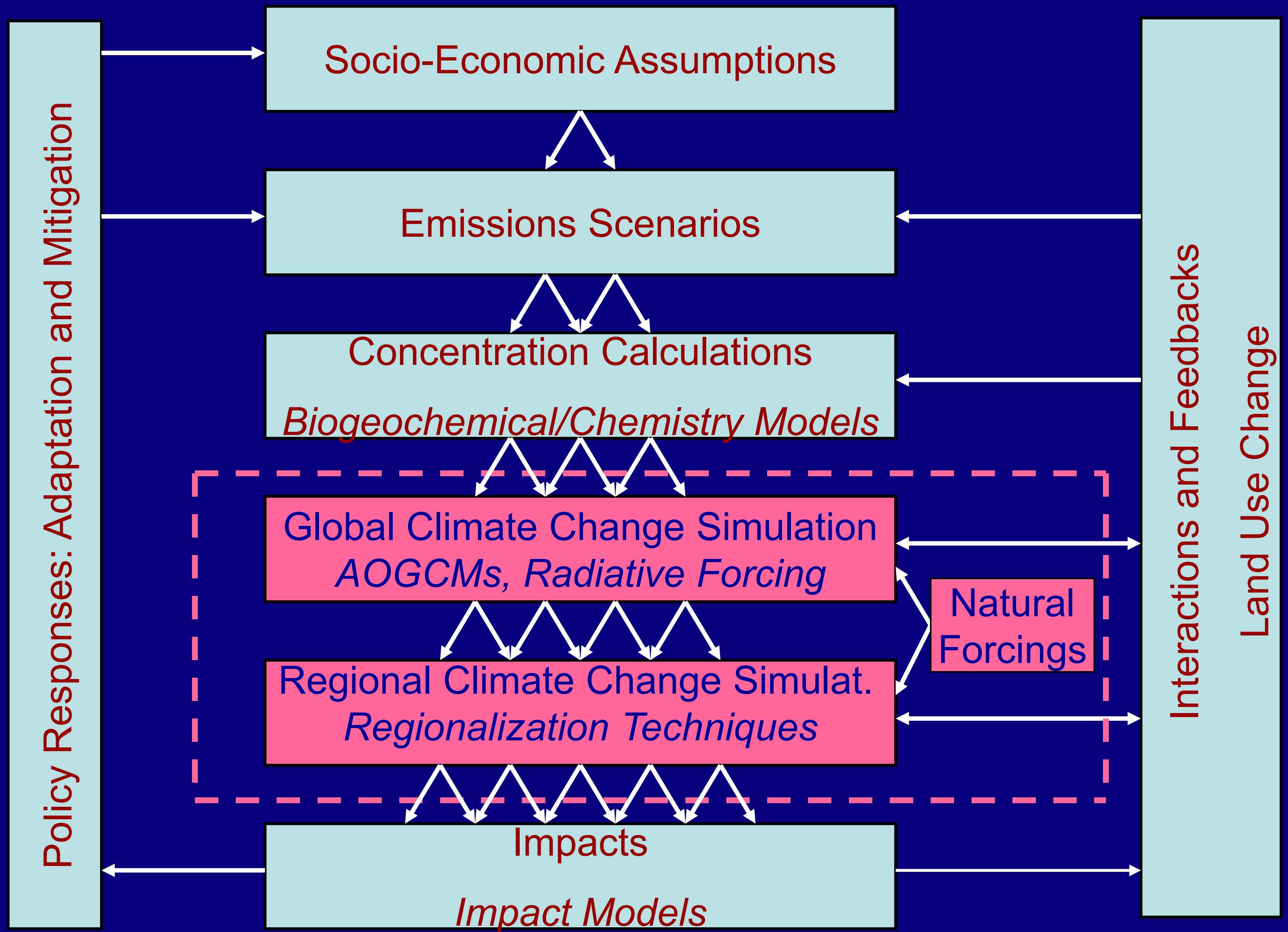
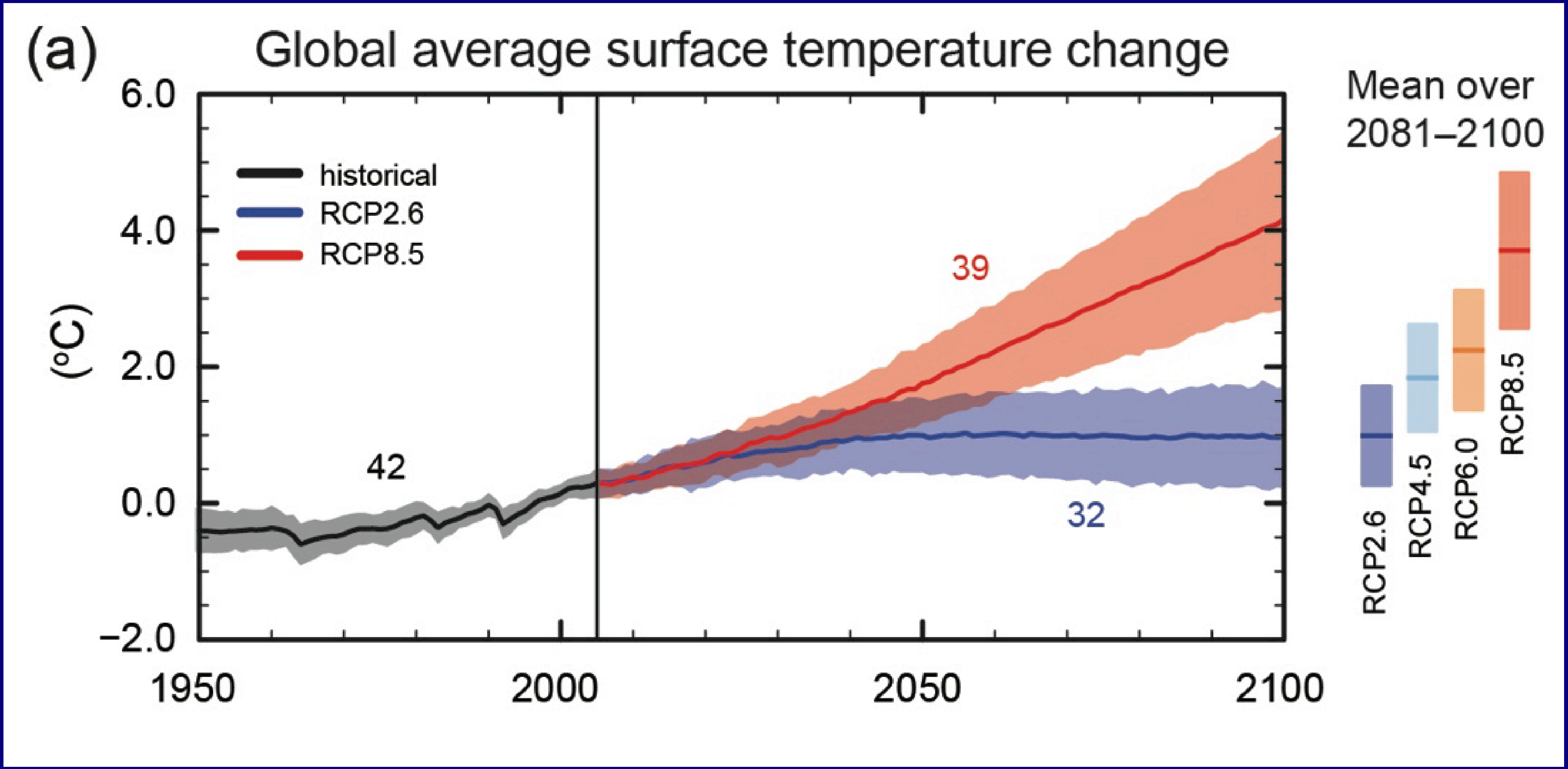
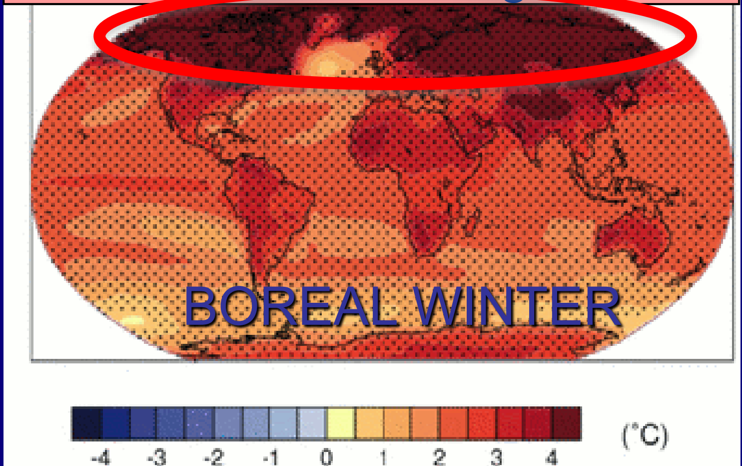


Model configuration uncertainty at the global scale

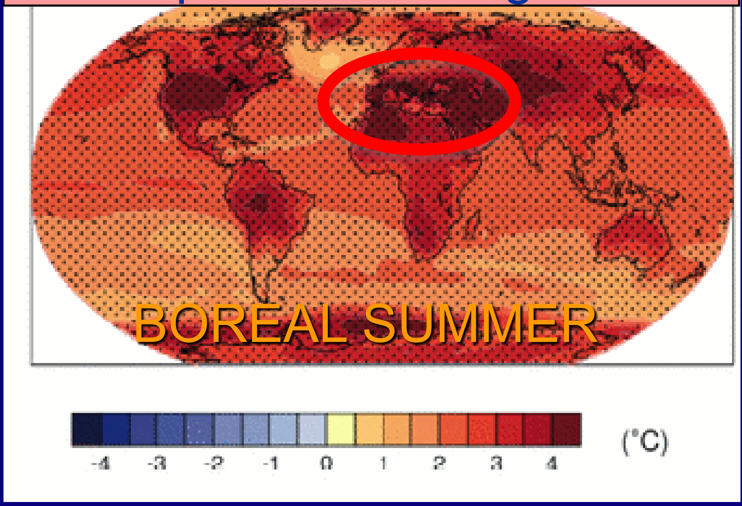


Geographical distribution of temperature and precipitation changes

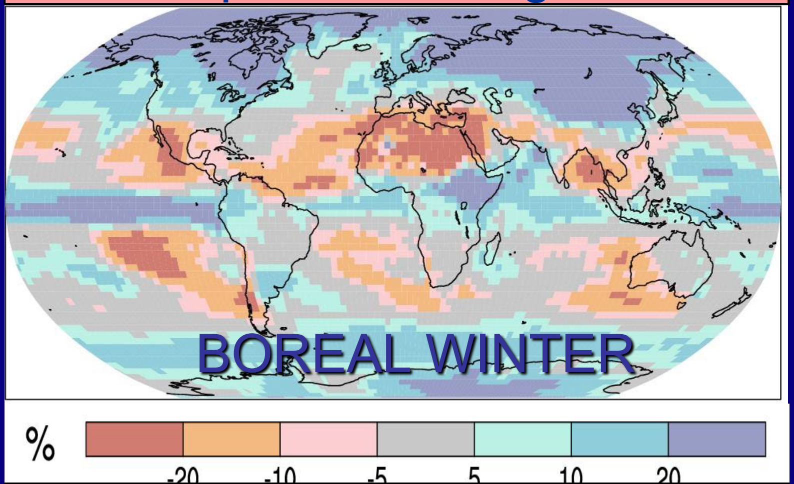
Temperature change DJF



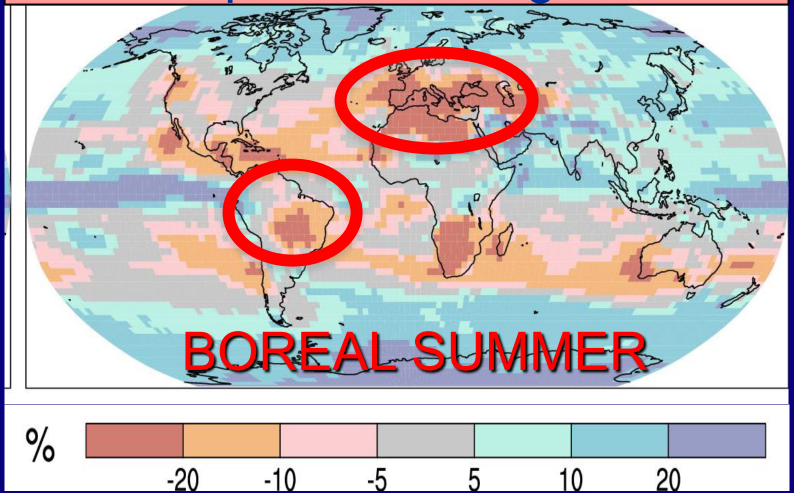
Temperature change JJA



Precipitation change DJF



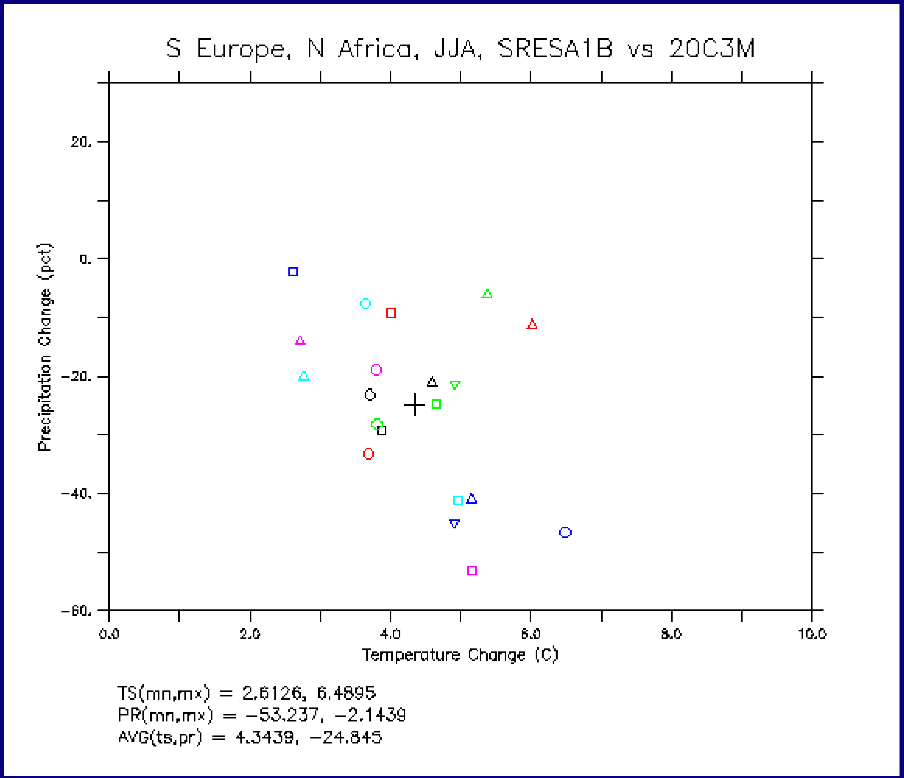
Precipitation change JJA



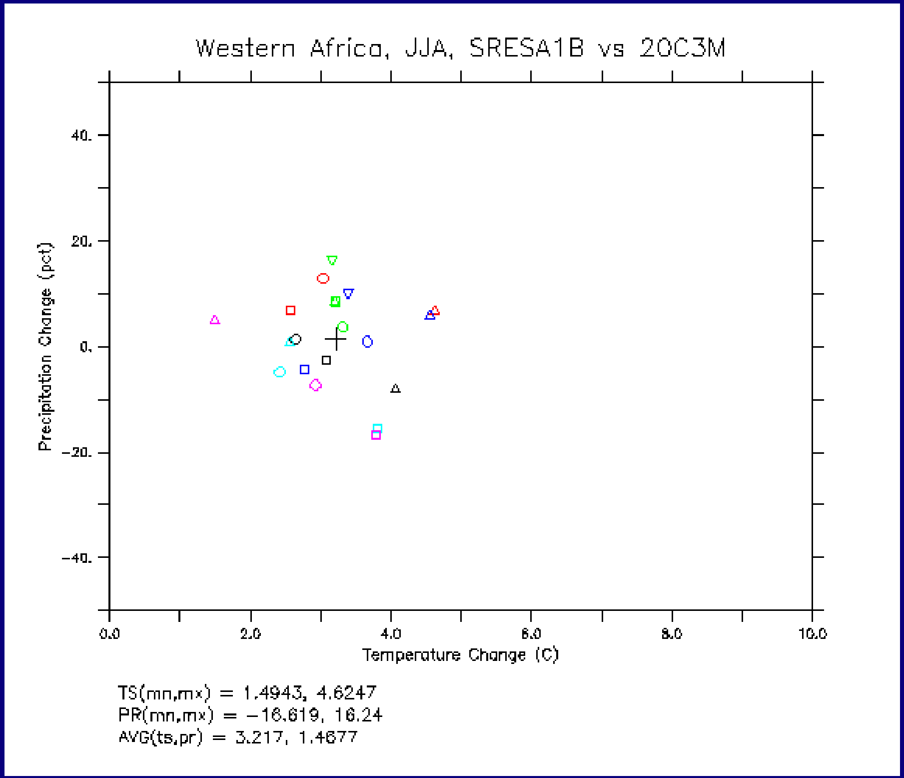
Model configuration uncertainty at the regional scale (AOGCMs)

Regional precipitation vs. temperature change

Mediterranean warm season



West Africa monsoon season

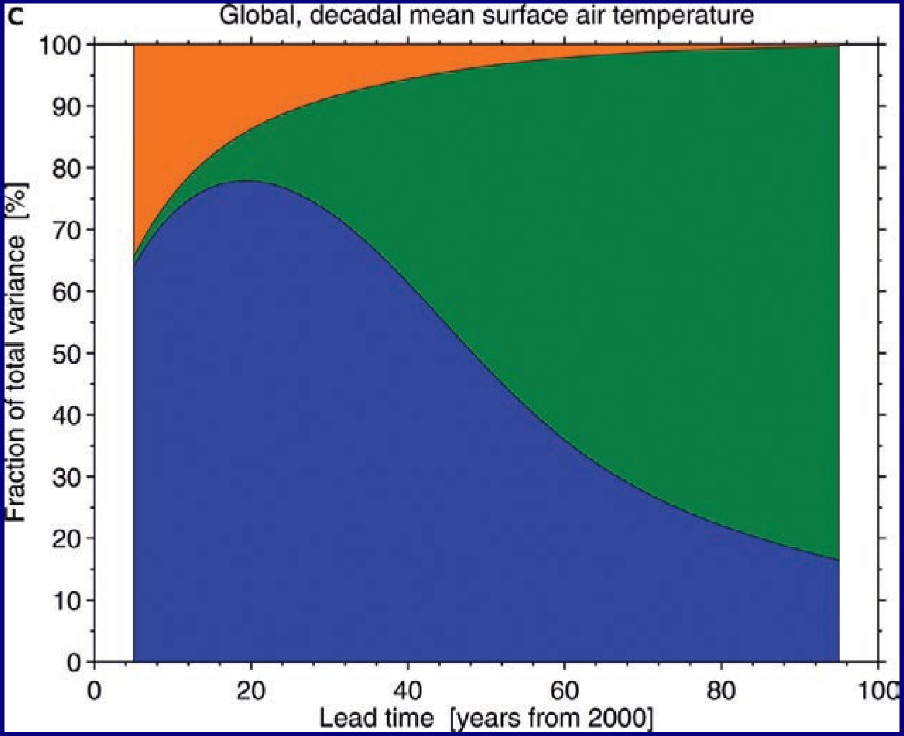


Fraction of uncertainty explained by different sources as a function of lead time

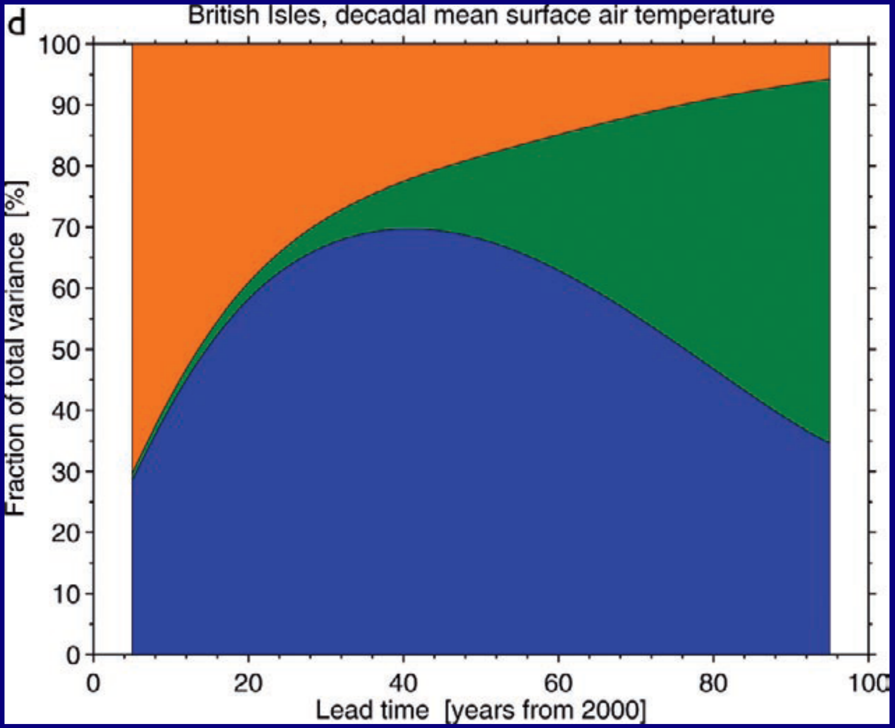
Internal variability
Scenario uncertainty
Model configuration uncertainty

Hawkins and Sutton 2009

Decadal temperature - Global

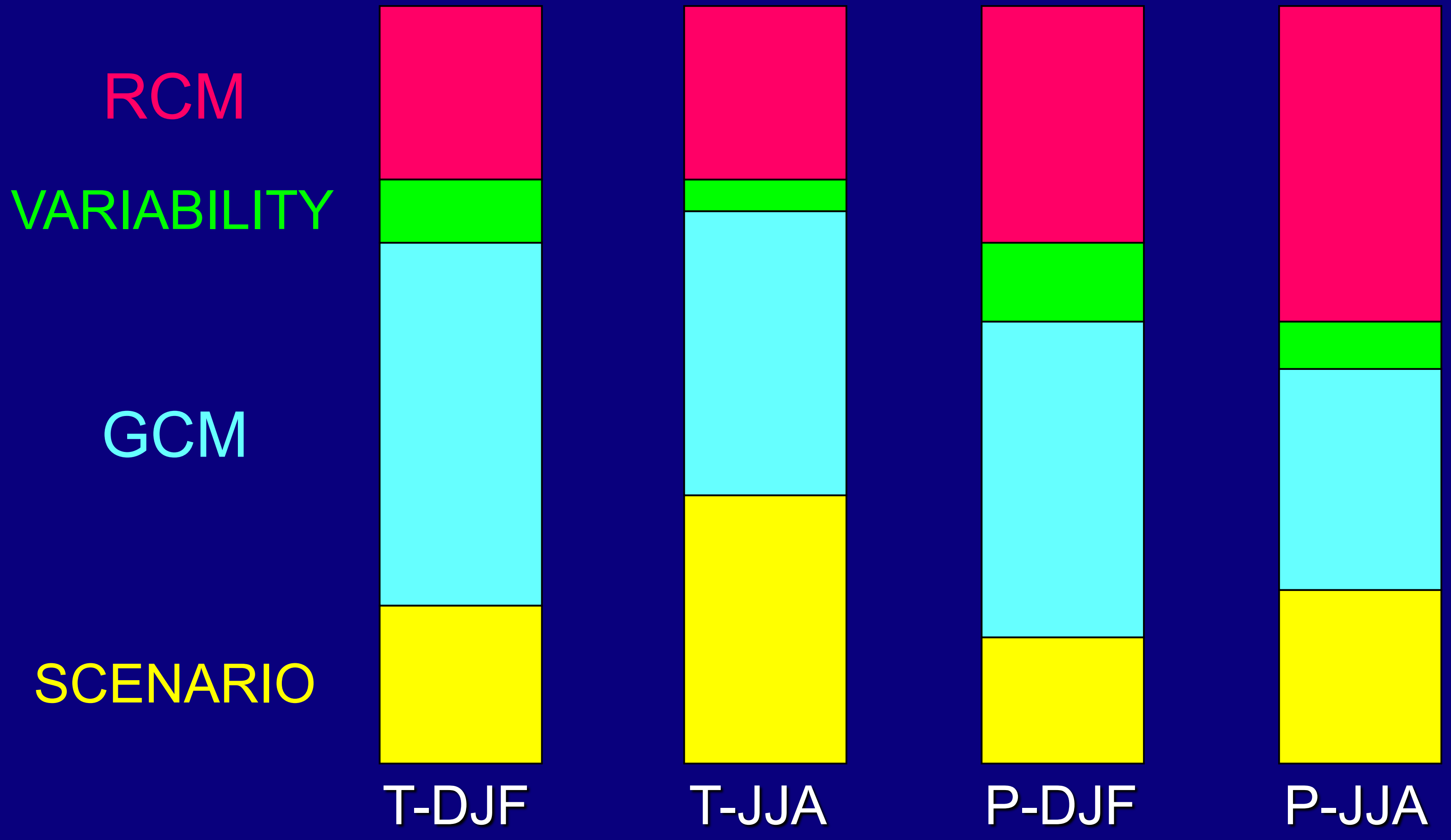


Decadal temperature – British Isles



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)

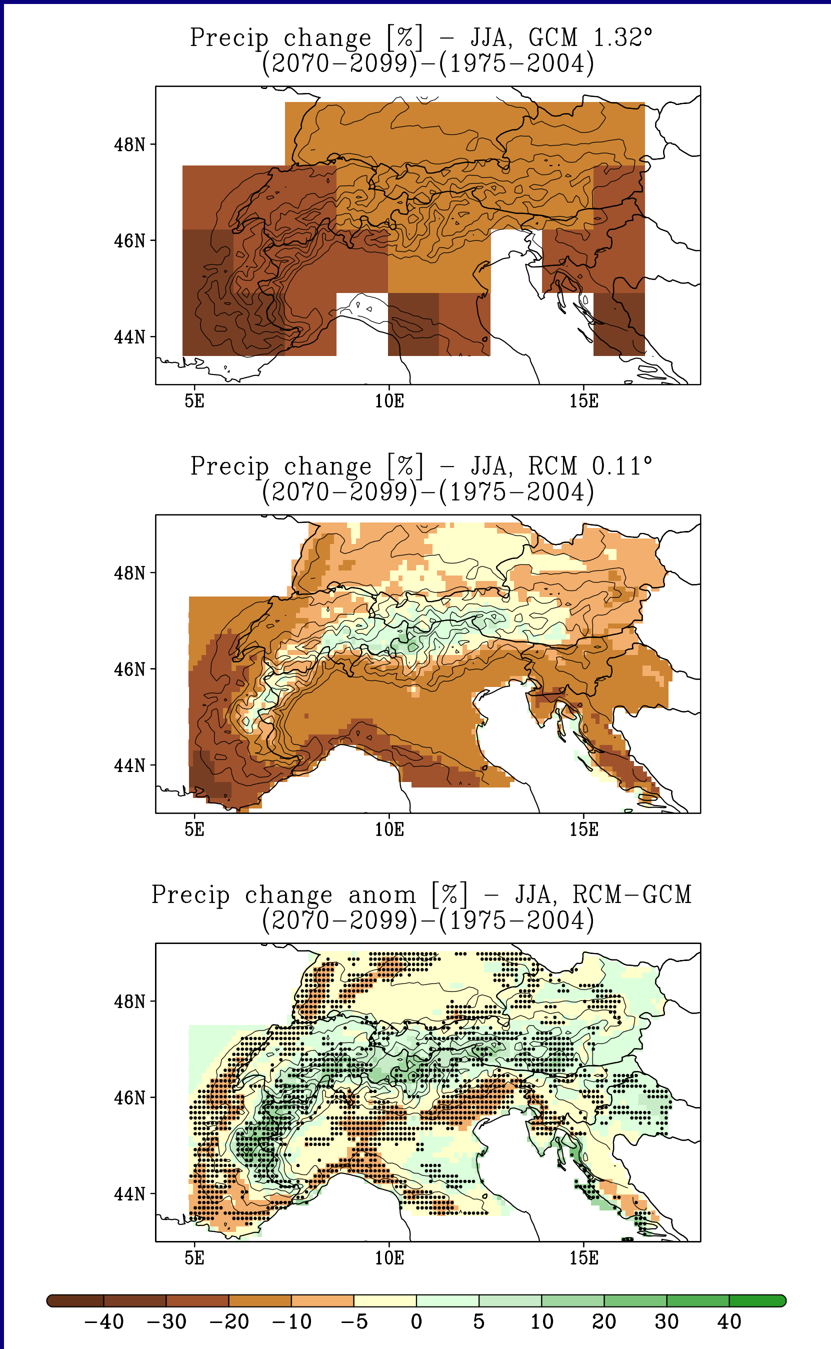


Summer precipitation change

GCMs

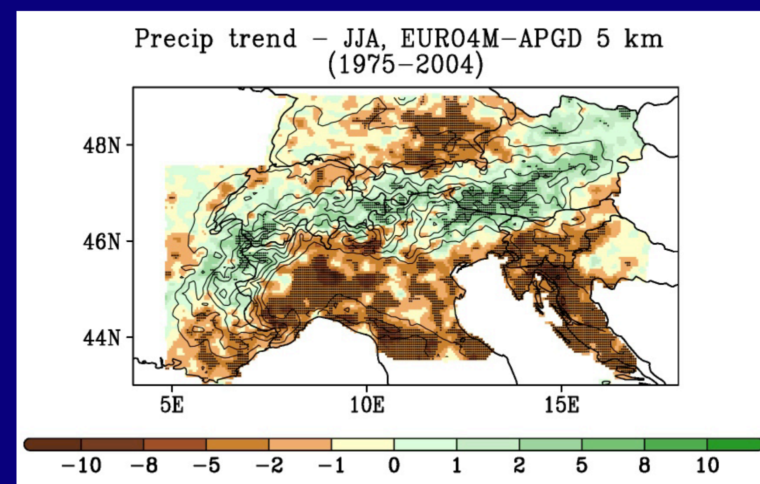
RCMs 0.11°

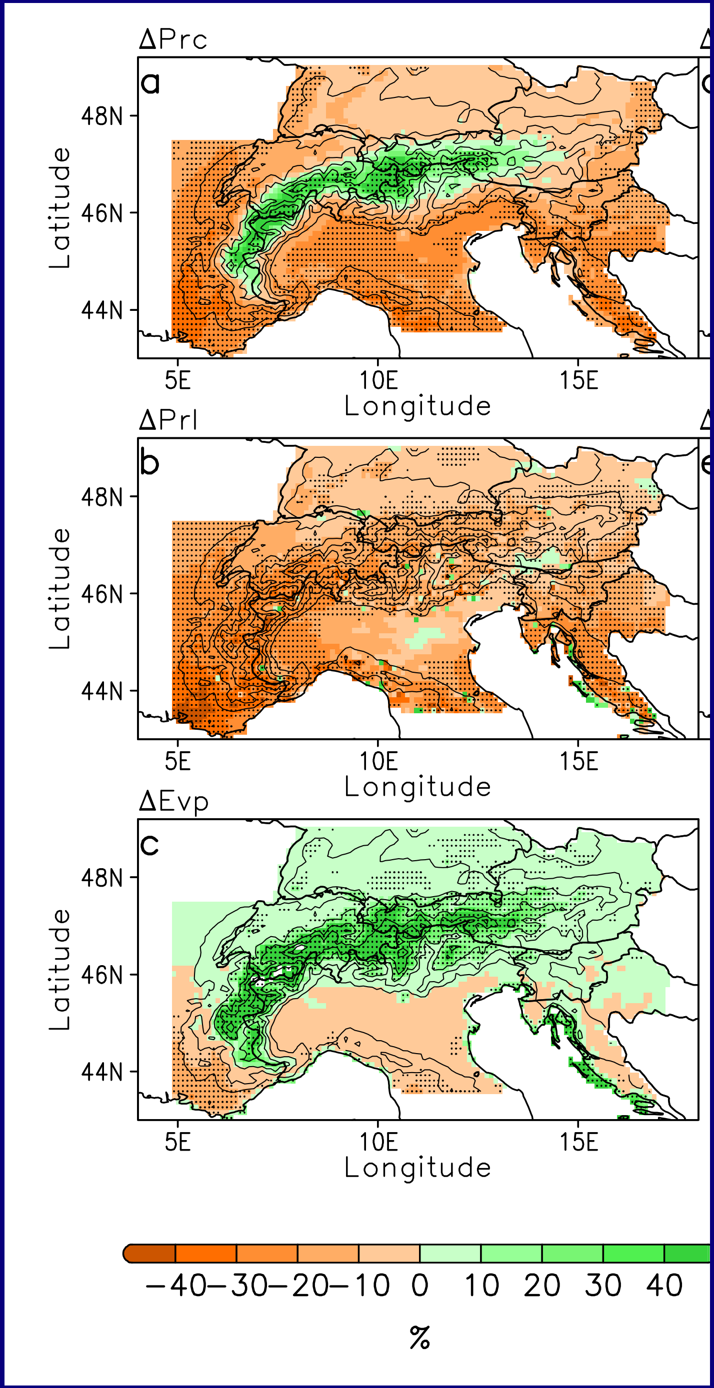
DS



mm/day/century

Observed precipitation trend 1975-2004





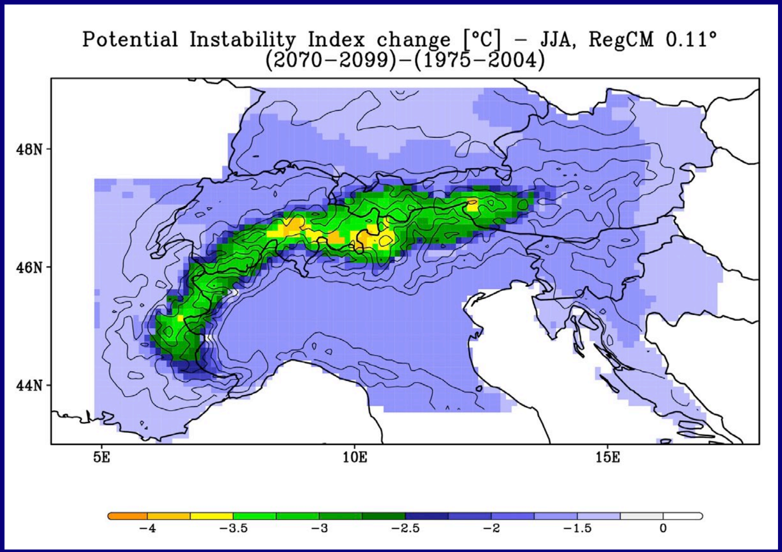
Convective

Non Convective

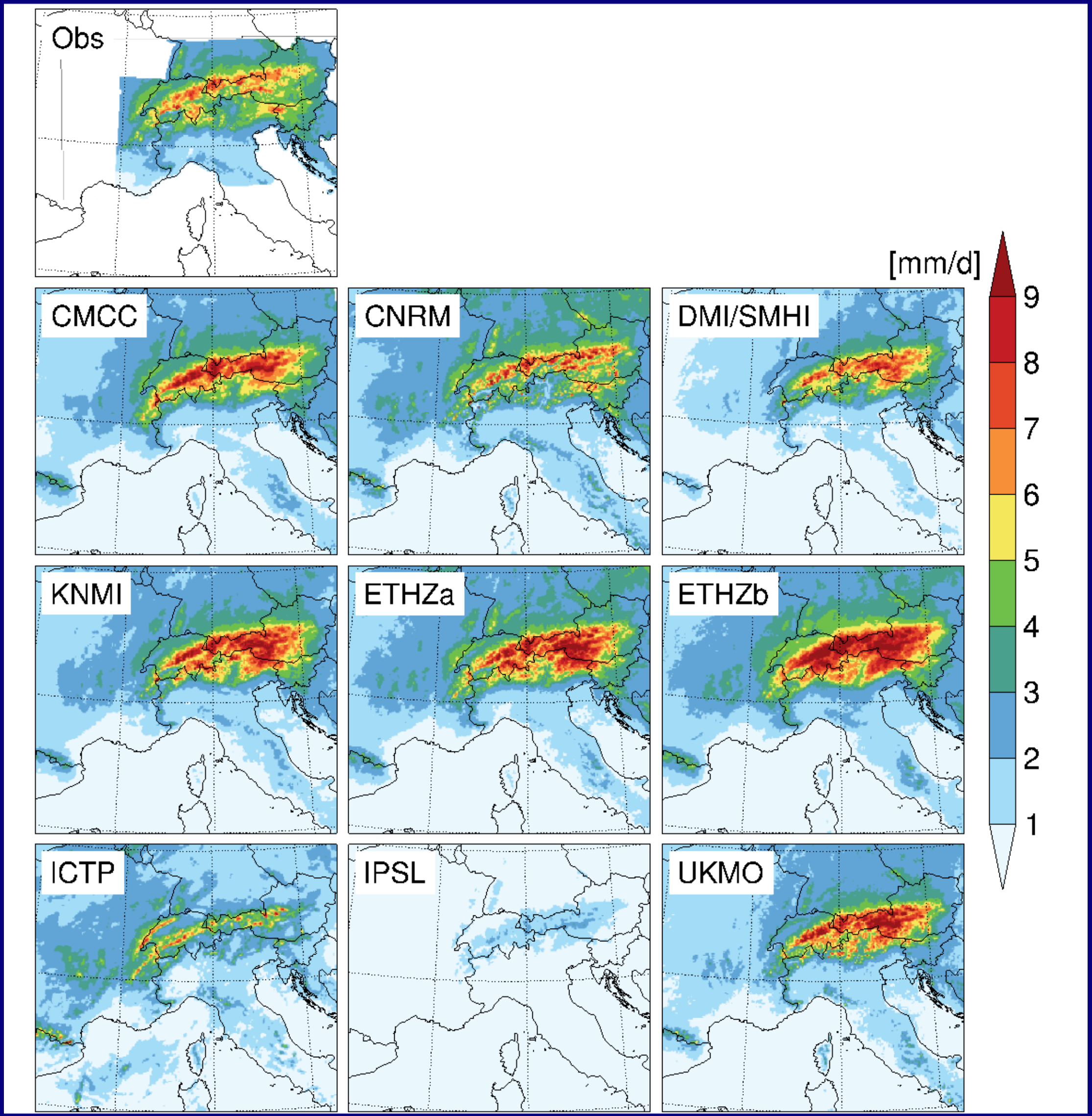
EVP

Summer precipitation change

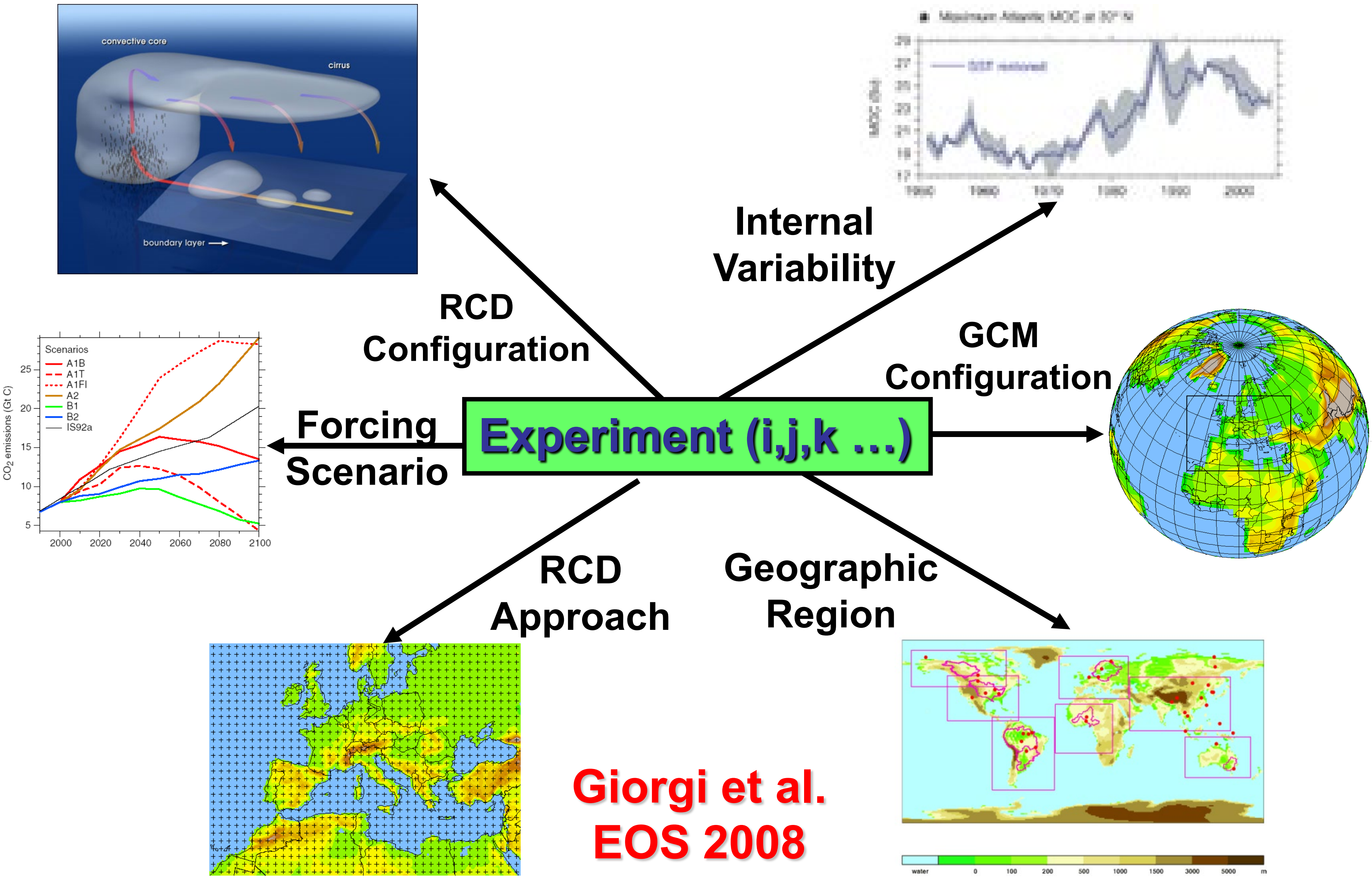
Convection potential



Convection-permitting RCms are being run at ds ~ 1/5 – 3 km

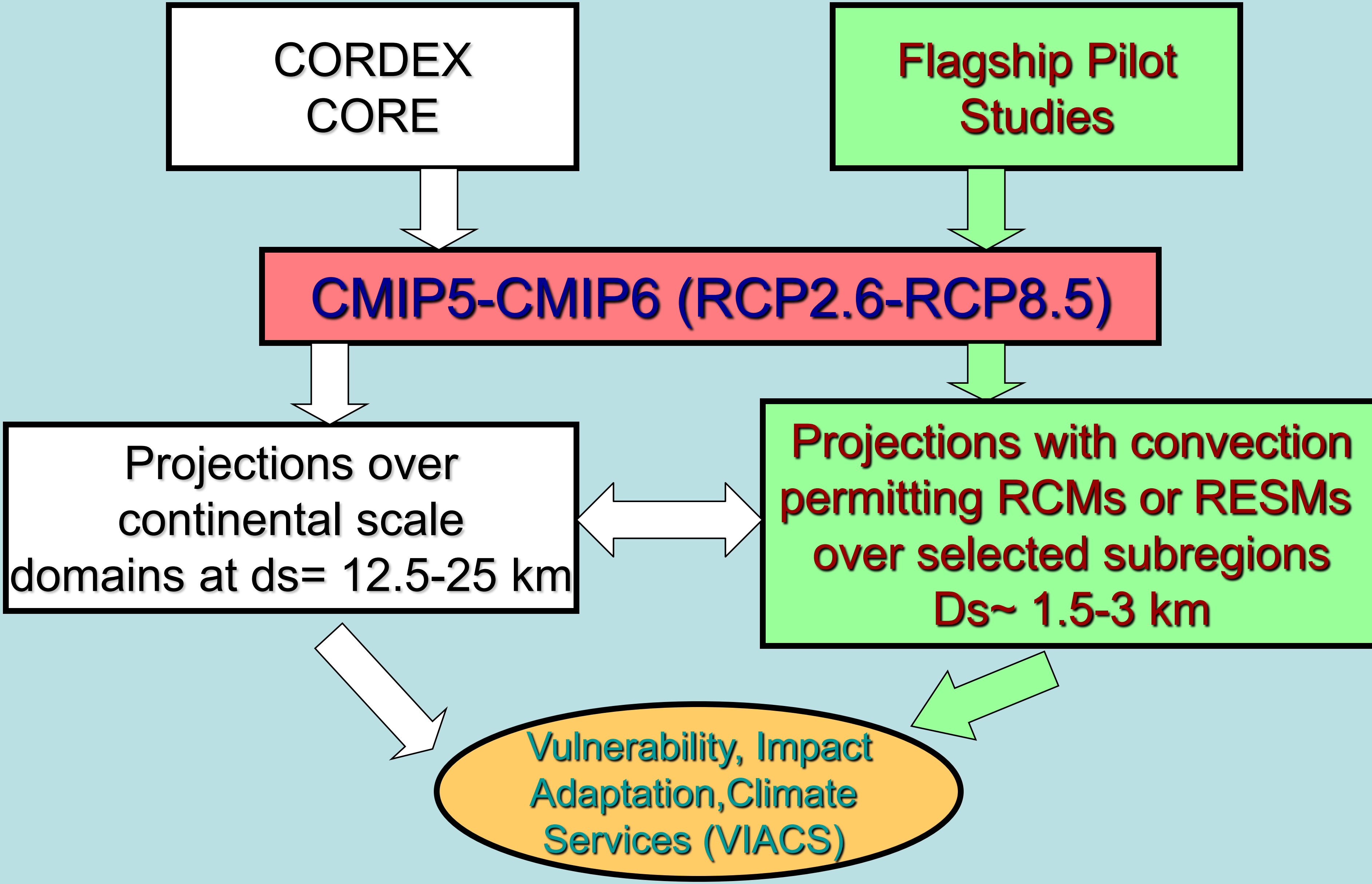


Large ensembles are needed to explore the uncertainty space which need to be properly interpreted (distillation paradigm)



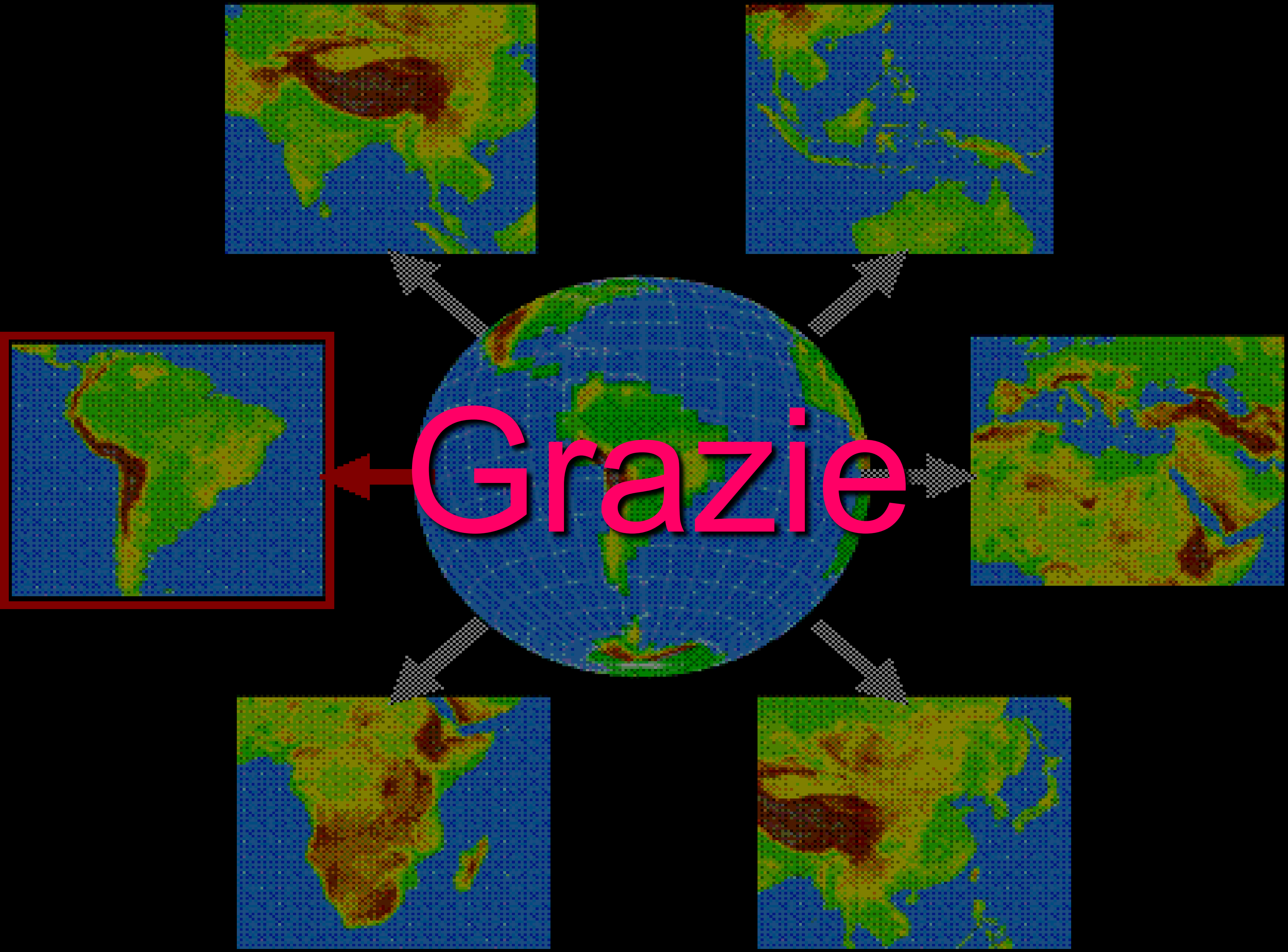
Giorgi et al. EOS 2008

Coordinated regional downscaling experiment (CORDEX)



Qualche considerazione finale

- Se si vuole veramente produrre informazione climatica utile per applicazioni VIACS, bisogna connettersi ai grandi progetti internazionali in corso (CMIP6, CORDEX etc.)
- Bisogna munirsi di un range di modelli (o piu' genericamente "tools") che possano essere usati per problemi di interesse specifico: GCMs, RCMs, ICMs, ESD, etc.
- C'e' bisogno di dataset pubblici e disponibili di osservazioni che coprano il territorio nazionale.
- La strategia delle infrastrutture va pensata molto attentamente, specialmente dal punto di vista della gestione e analisi dei dati.
- Occorre un convolgimento ampio e partecipato della comunita' scietifica nazionale.
- Nell'ottica del punto precedente, si dovrebbero produrre report periodici IPCC-Style, clima, VIACS, etc.
- Bisogna formare una nuova generazione di scienziati che lavori all'interfaccia fra clima e VIACS .


Grazie