The Abdus Salam International Centre for Theoretical Physics

United Nations Educational, Scientific and Cultural Organization
IAEA International Atomic Energy Agency

1934-1

Fourth ICTP Workshop on the Theory and Use of Regional Climate Models: Applying RCMs to Developing Nations in Support of Climate Change Assessment and Extended-Range Prediction

3 - 14 March 2008

Regional Climate Modelling in the Climate Change Problem: Recent Advances and future direction

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Regional Climate Modelling in the Climate Change Problem:

Recent Advances and future directions

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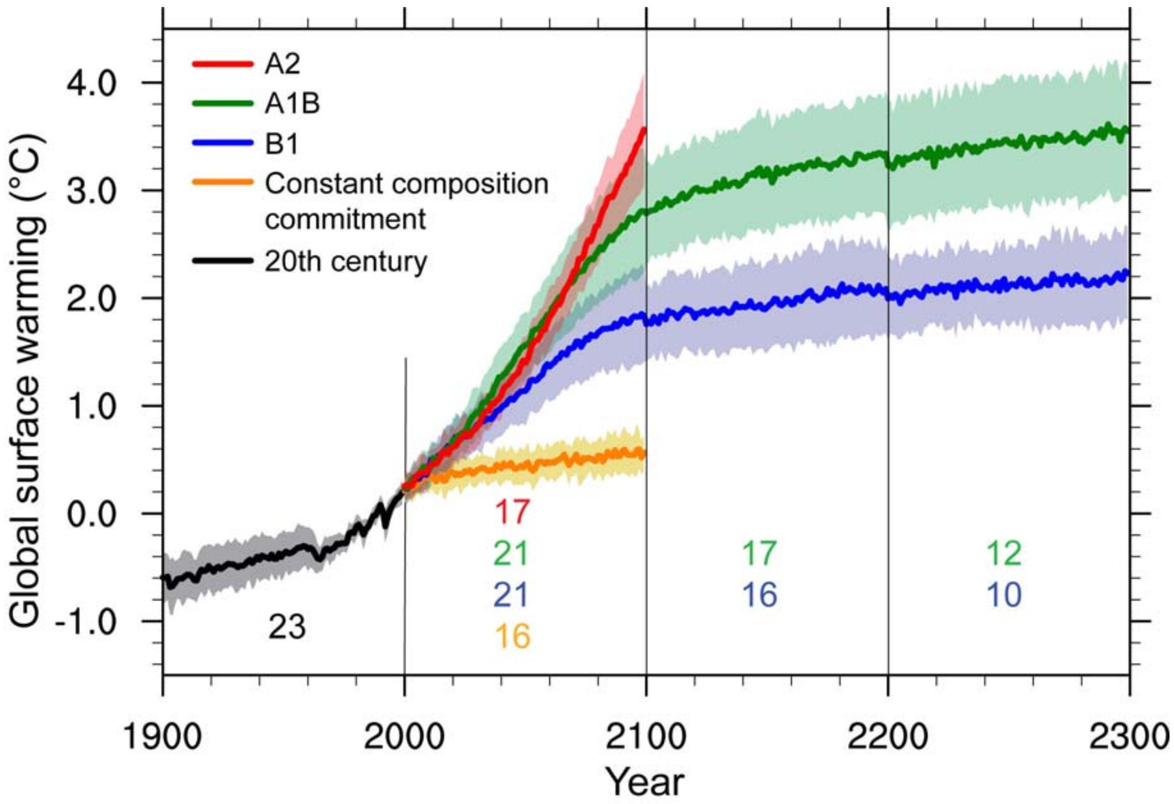
Danish Meteorological Institute

http://www.dmi.dk

4th ICTP Workshop on the Theory & Use of REGional Climate Models
'Applying RCMs to Developing Nations in Support of Climate Change Assessment & Extended-Range Prediction'
March 3 - 14, 2008

Outline

- Regional climate change – the IPCC approach
- Europe as an example
  - *Issues*
  - *Dynamical downscaling*
- Research needs
- Summary and conclusions



(Anomalies relative to 1980-99)

Unprecedented coordinated climate change experiments from 16 groups (11 countries) and 23 models collected at PCMDI (31 terabytes of model data), openly available, accessed by over 950 scientists; nearly 200 papers

Committed warming averages 0.1°C per decade for the first two decades of the 21st century; across all scenarios, the average warming is 0.2°C per decade for that time period (recent observed trend 0.2°C per decade)

Future climate

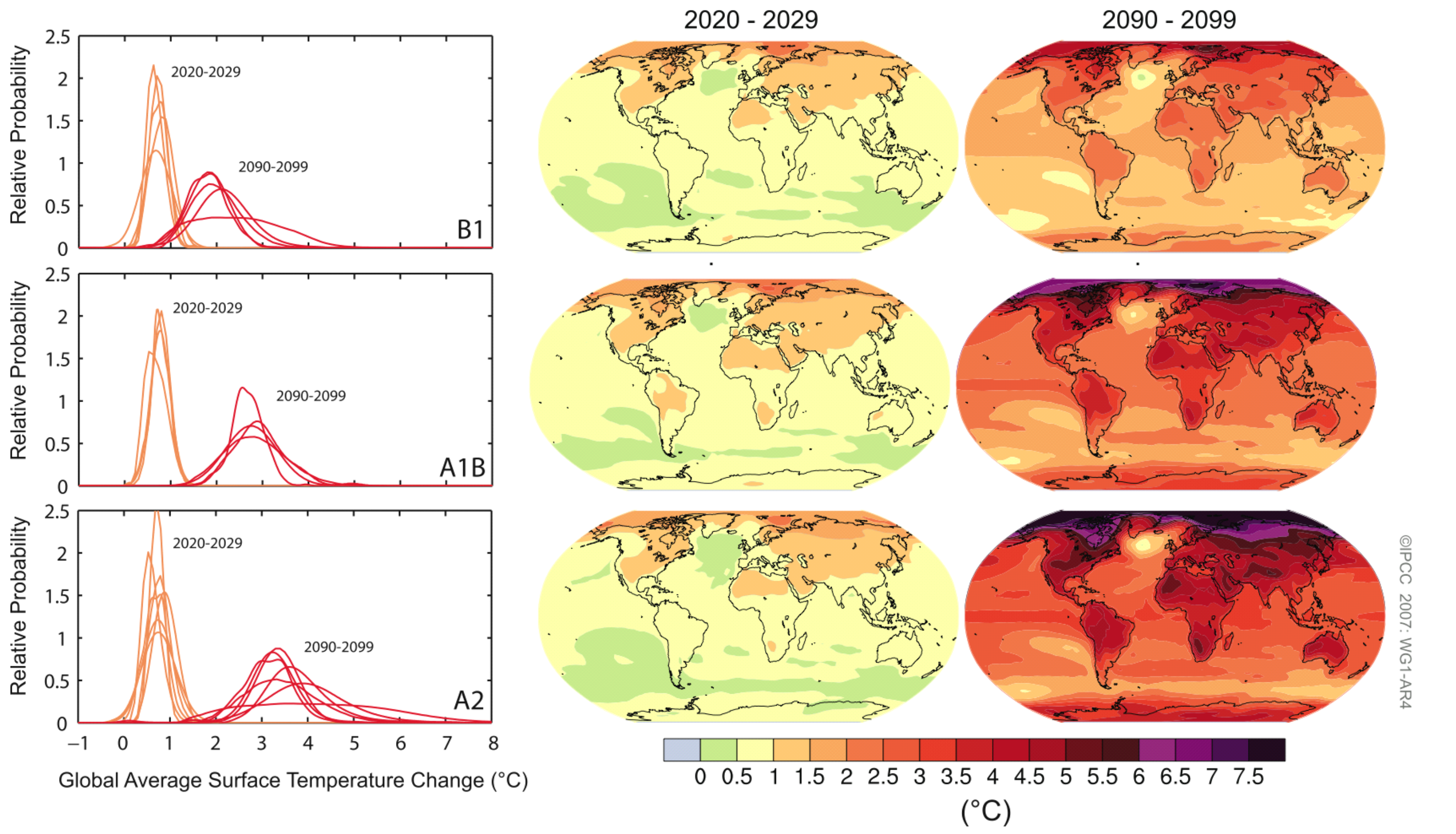
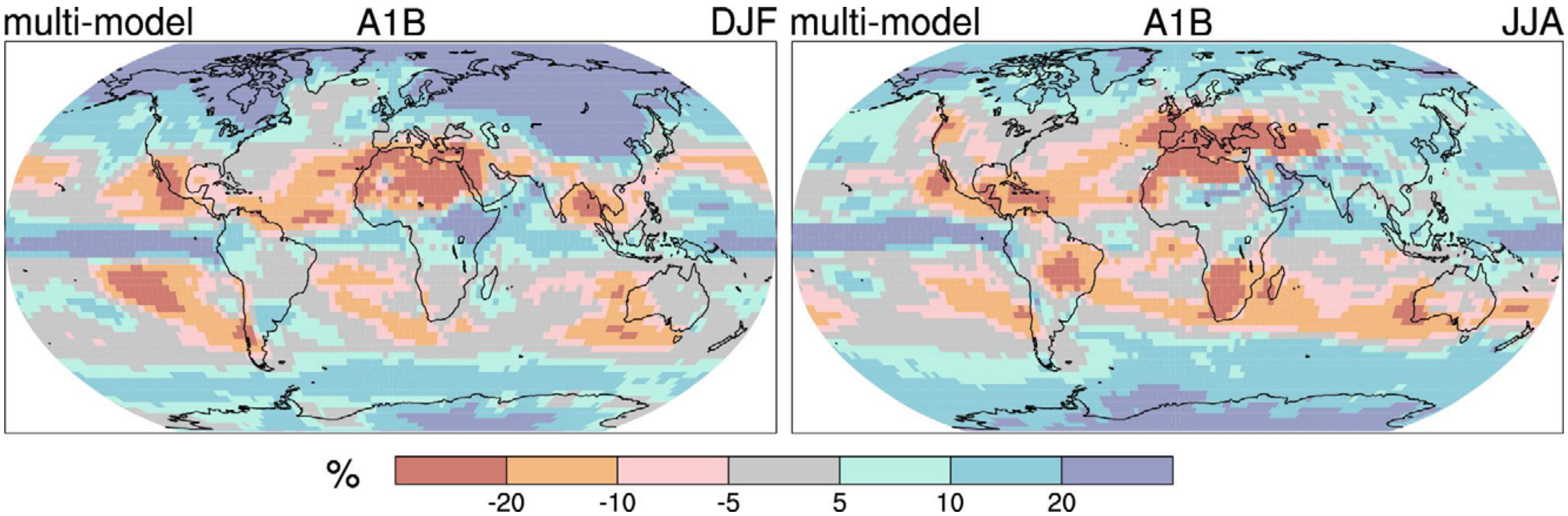
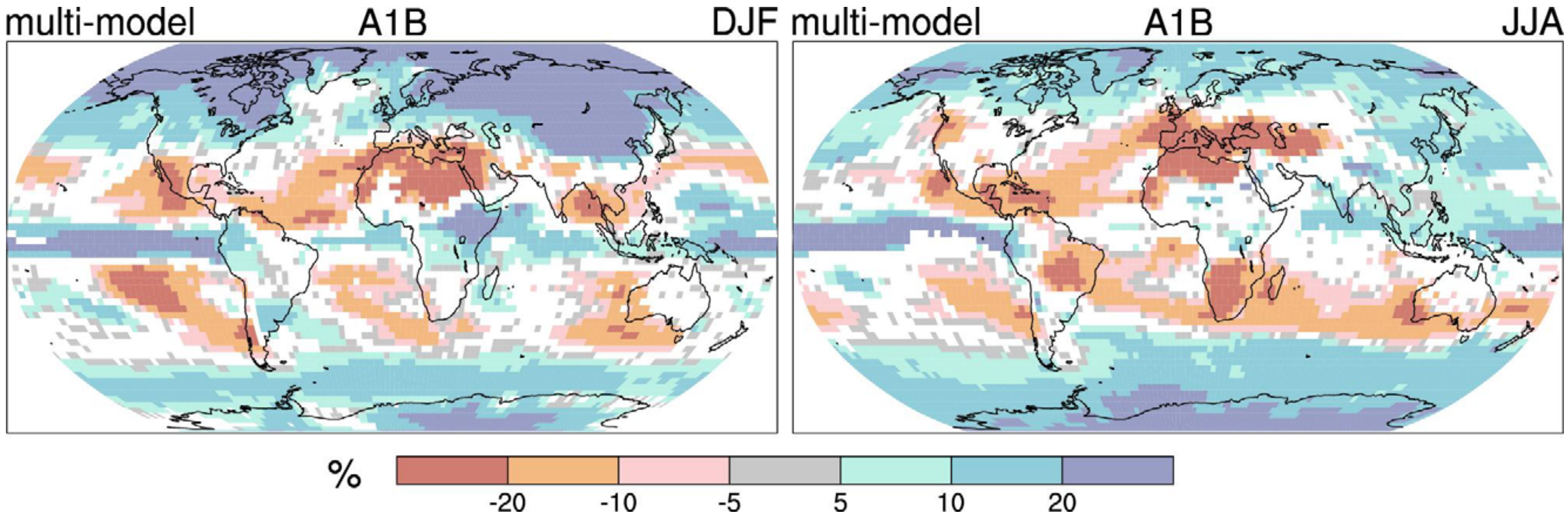


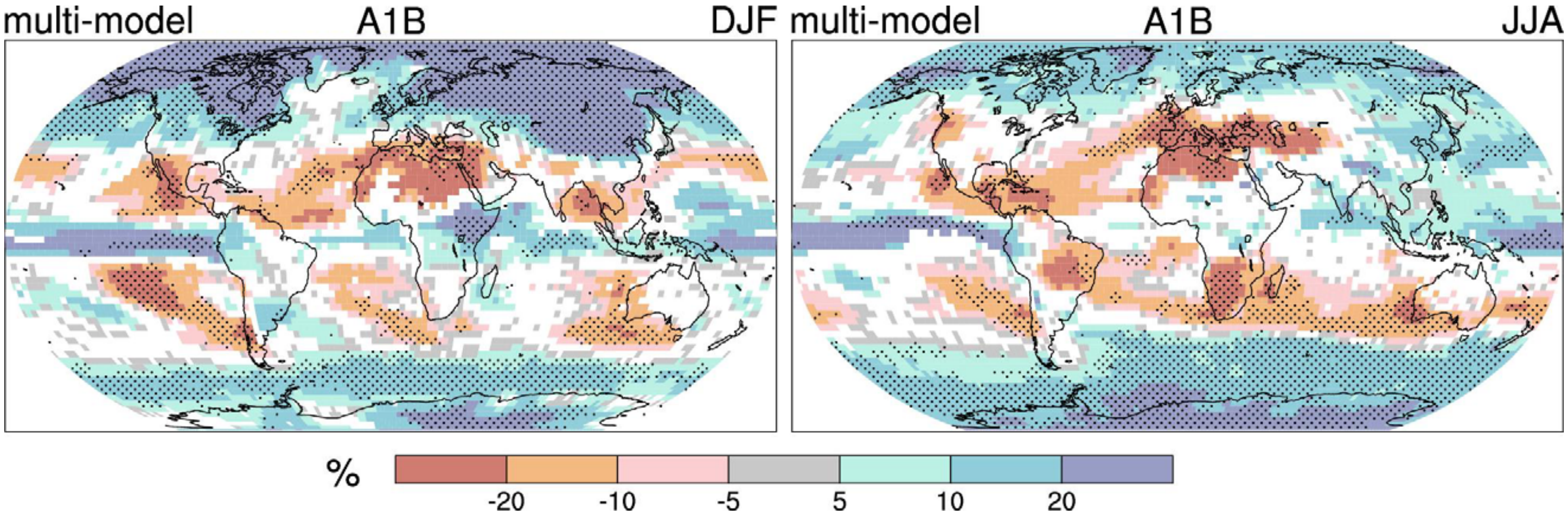
Figure TS.28



Multi-model average precipitation % change, medium scenario (A1B), representing seasonal precipitation regimes, total differences 2090-99 minus 1980-99



White areas are where less than two thirds of the models agree in the sign of the change



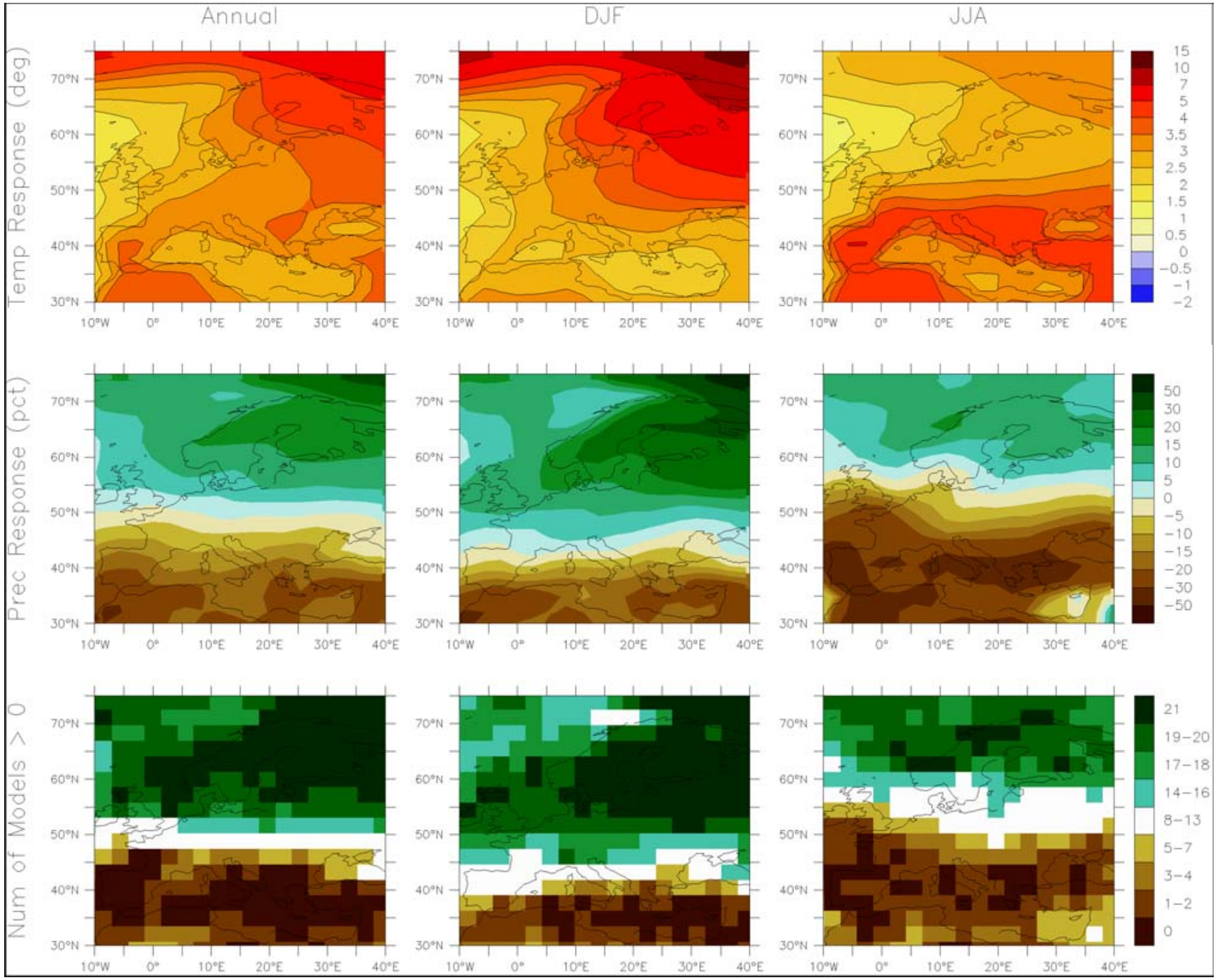
Stippled areas are where more than 90% of the models agree in the sign of the change

Precipitation increases very likely in high latitudes

Decreases likely in most subtropical land regions

This continues the observed patterns in recent trends

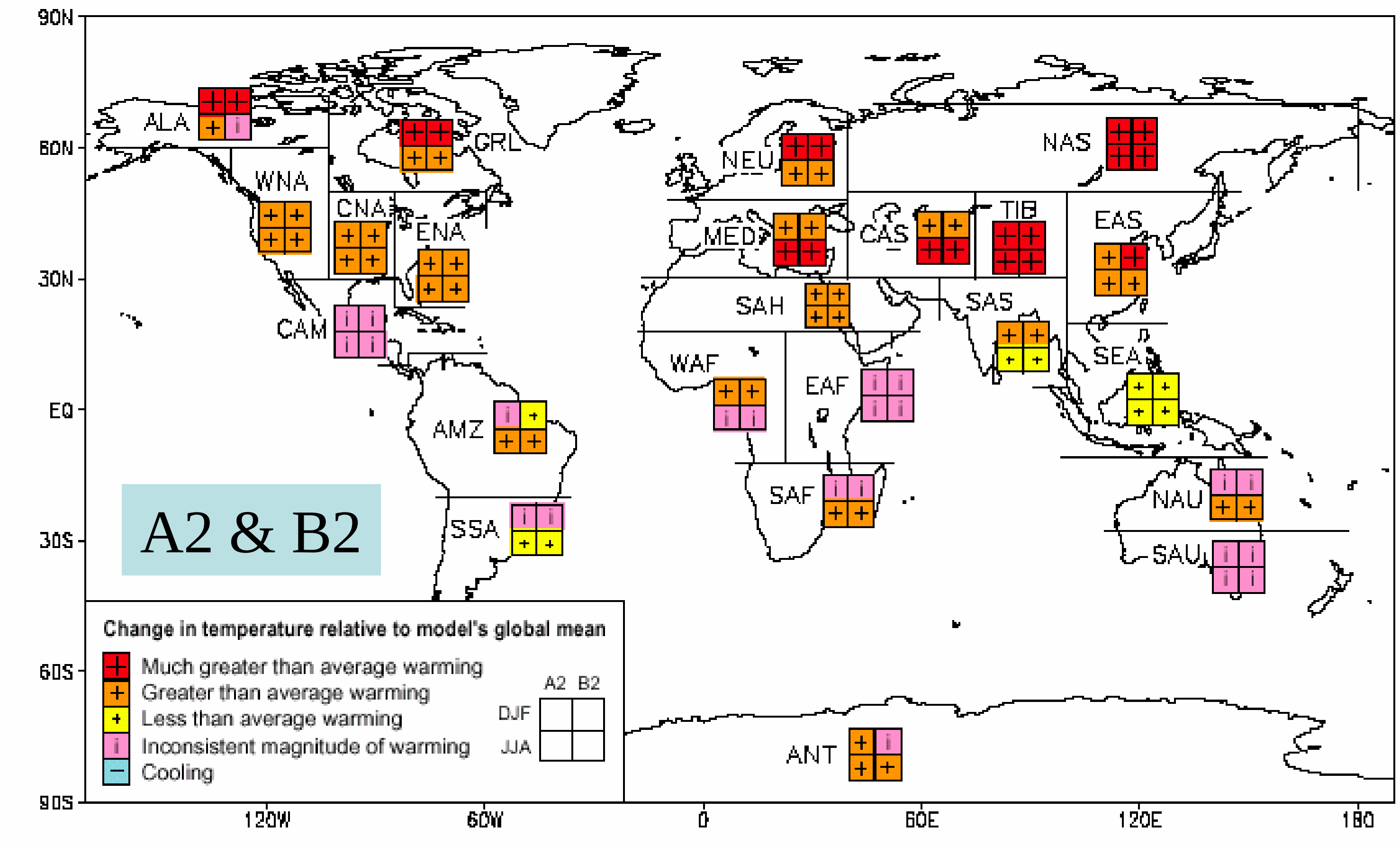
Agreement amongst AR4 GCMs (21 models) in the A1B scenario



IPCC 2007

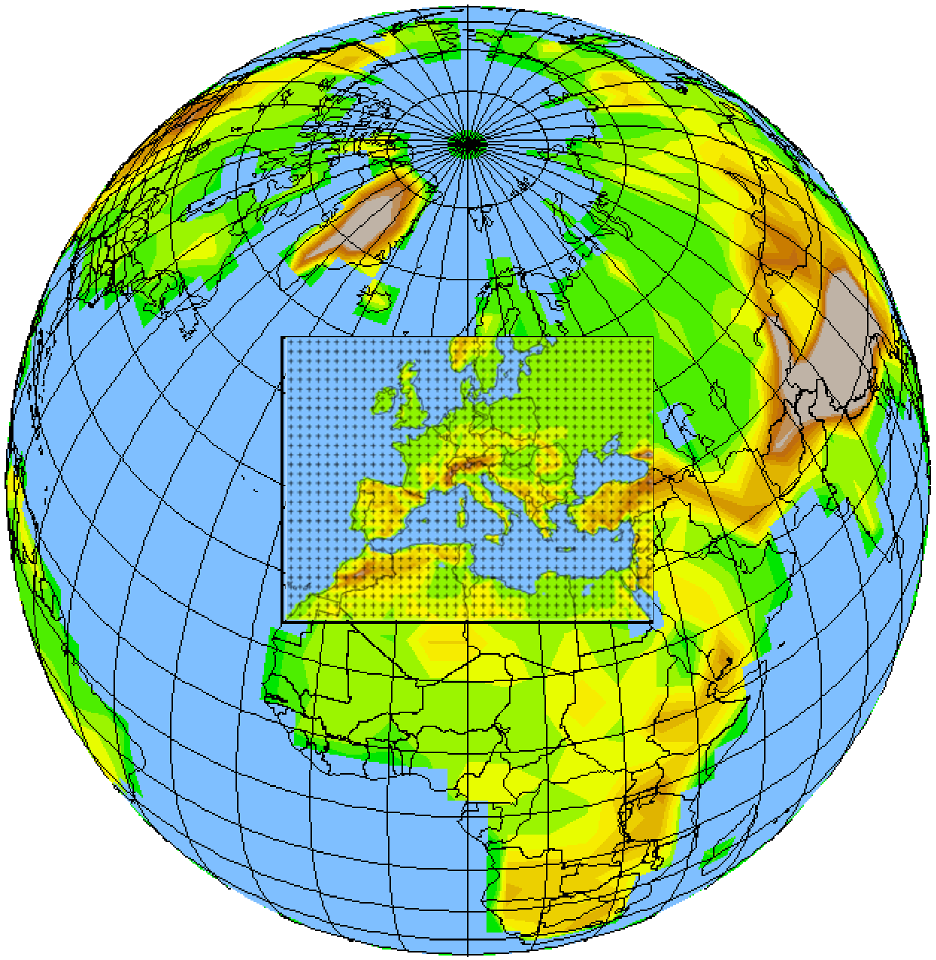
Regions defined in the TAR/AR4

Temperature change relative to global mean



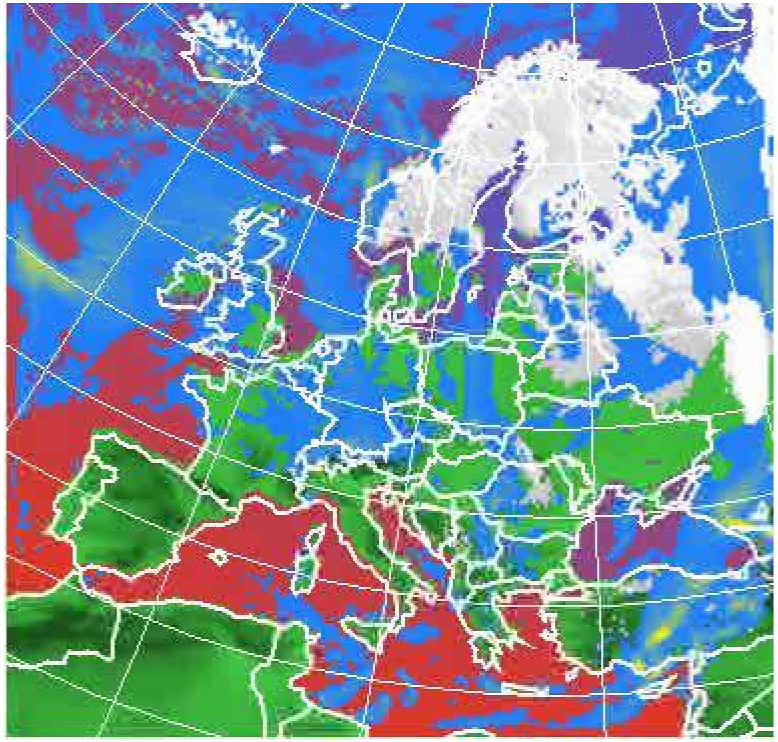
(Giorgi *et al.* GRL, 2001)

The RCM approach



PRUDENCE special issue in
Climatic Change, 2007, **81 Supl. 1**

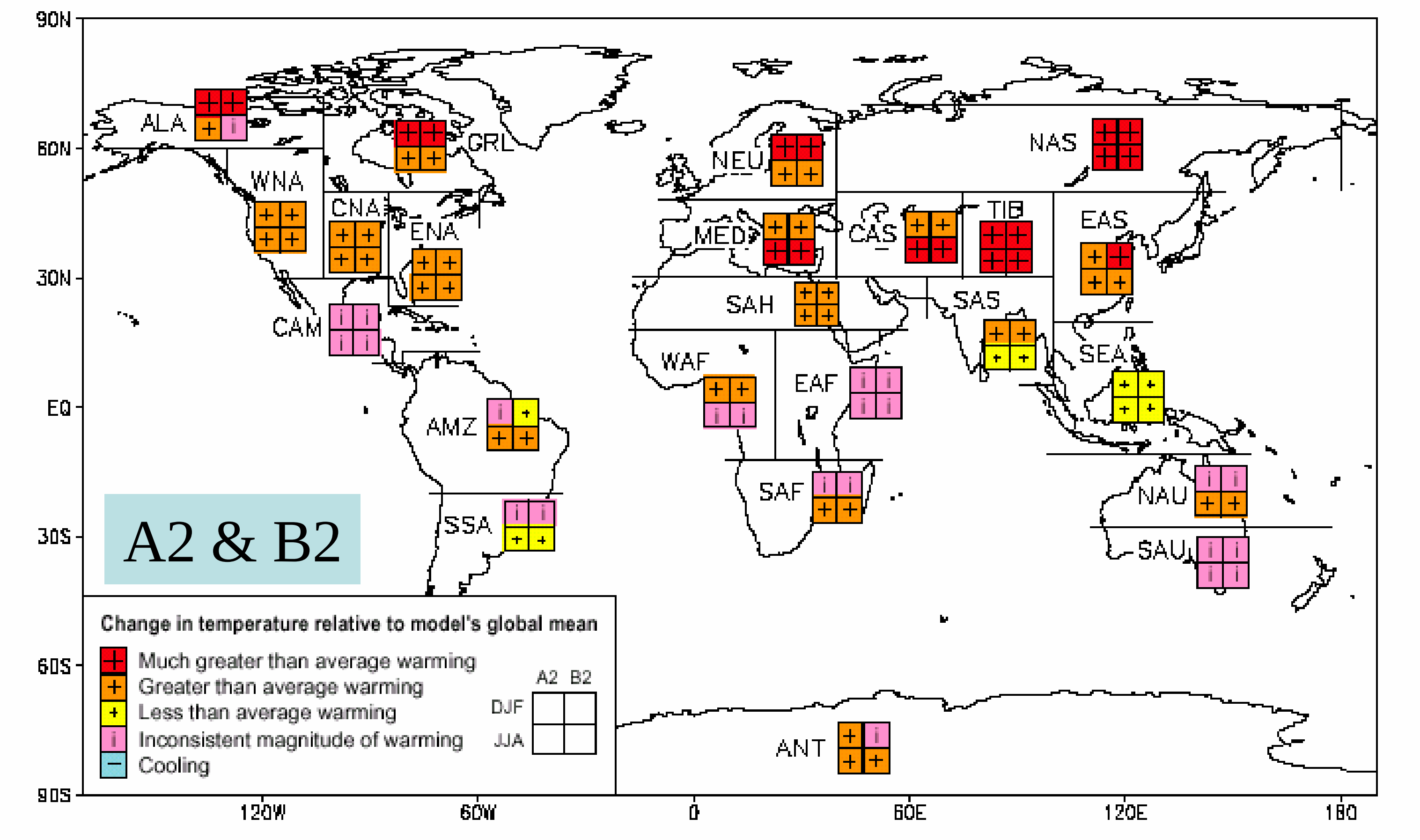
The RCM



With acknowledgement to
Ole B. Christensen

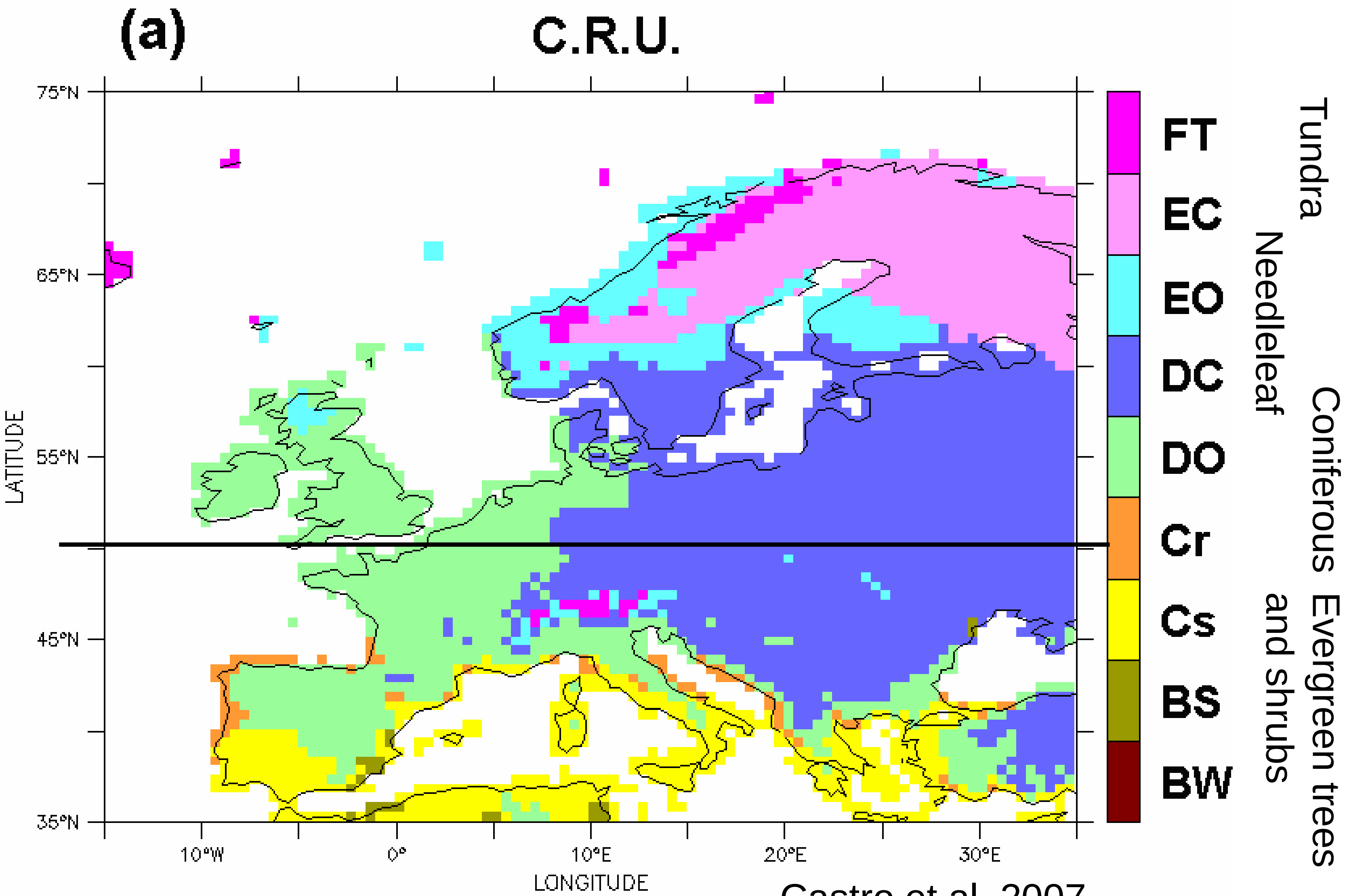
Regions defined in the TAR/AR4

Temperature change relative to global mean



(Giorgi *et al.* GRL, 2001)

Classifying Climate Regimes



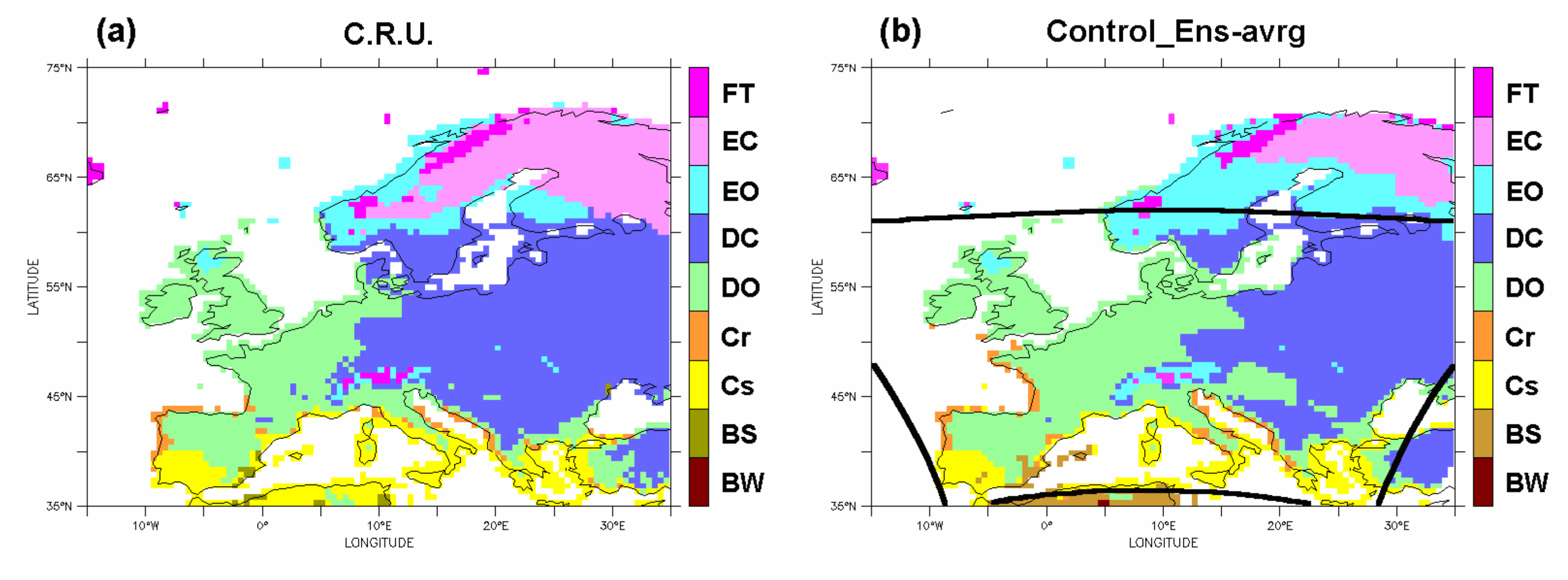
Castro et al. 2007

PRUDENCE GCM-RCM

	CNRM	DMI	ETHZ	GKSS	HC	ICTP	KNMI	MPI	SMHI	UCM
A2+HadAM3H		3	1	1	3	1	1	1	1	1
A2+ECHAM4		1							1	
A2+ARPEGE3	1									
B2+HadAM3H					1	1			1	1
B2+ECHAM4		1							1	
B2+ARPEGE3	3									

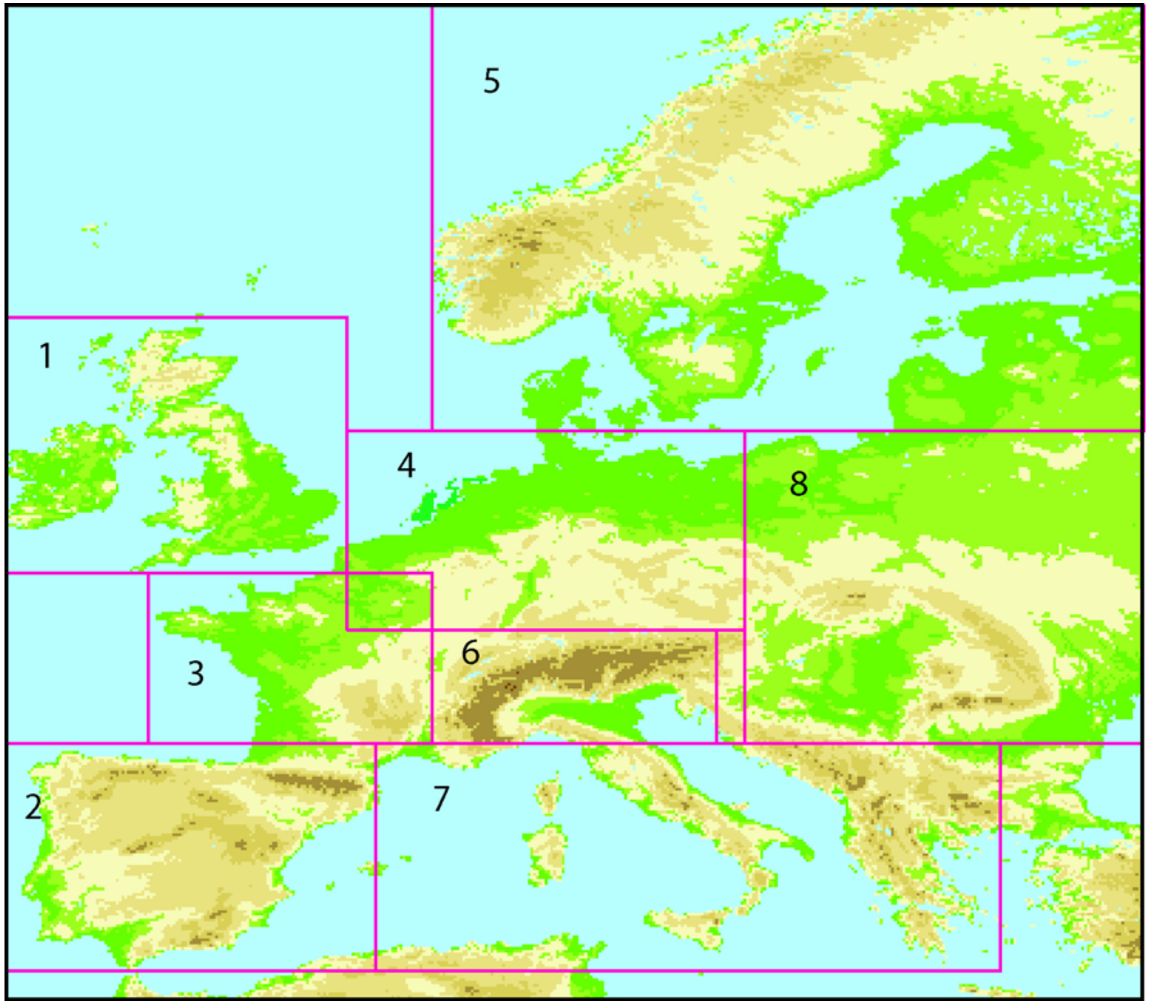
EU FP5 project 2001-2004

Classifying Climate Regimes

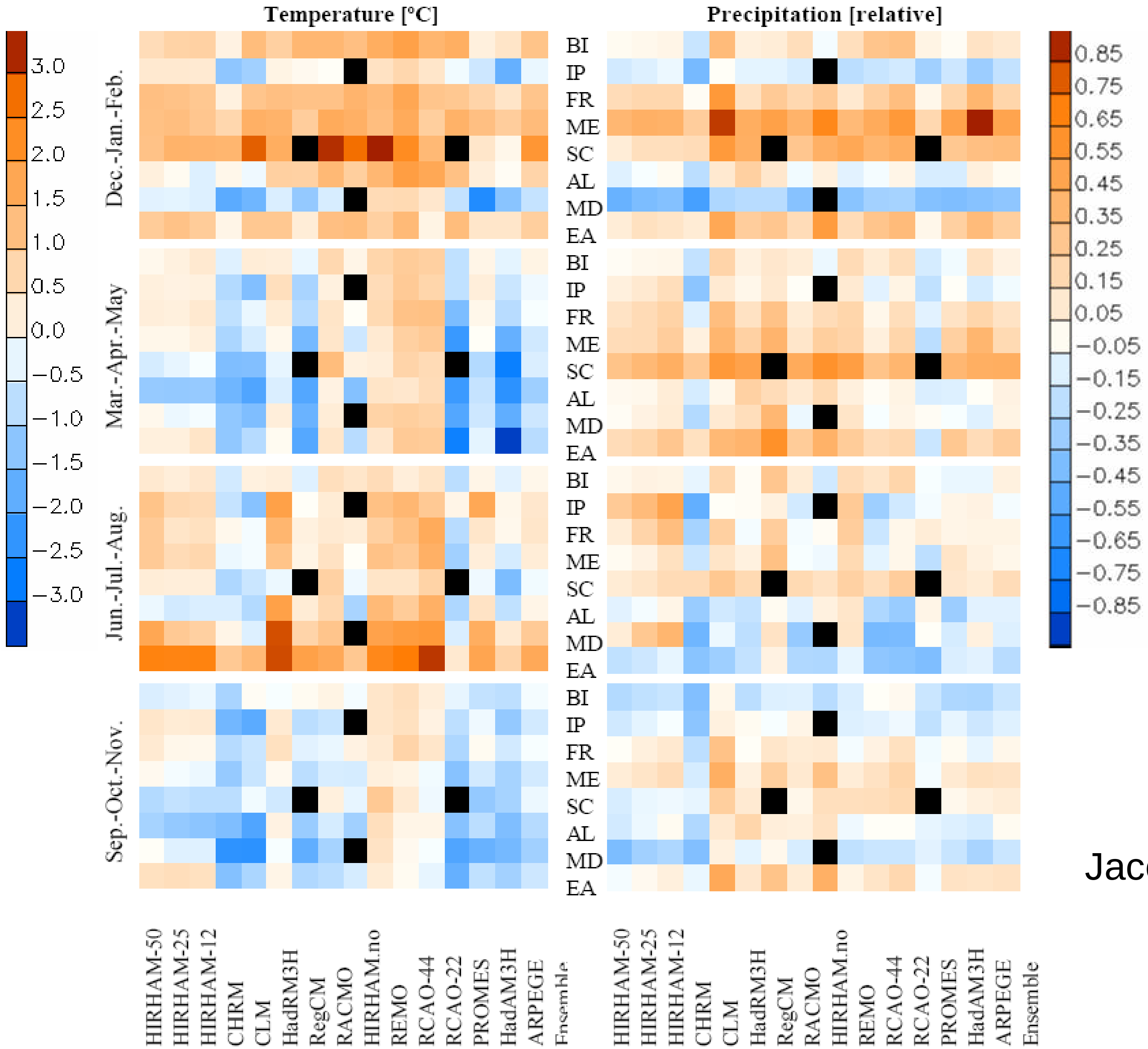


Castro et al. 2007

PRUDENCE domains



Model bias



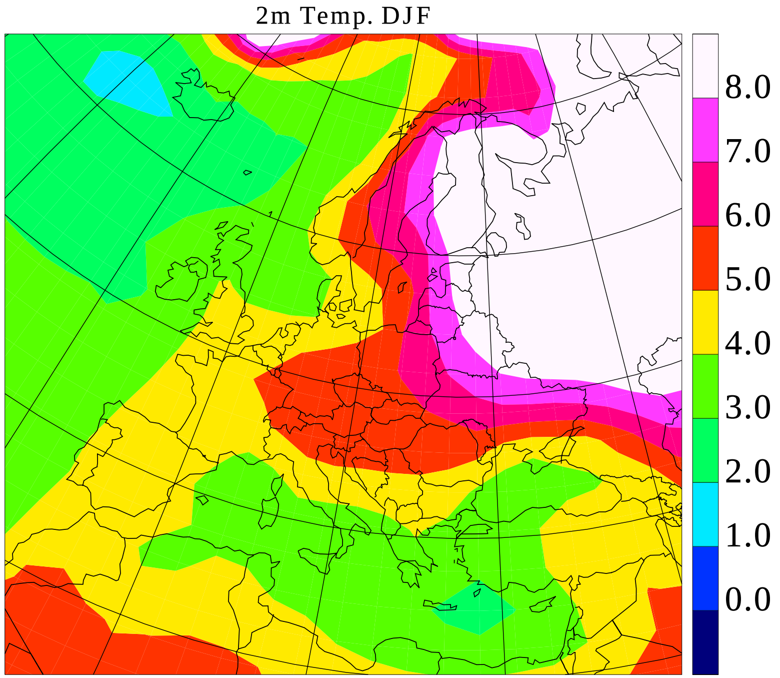
Jacob *et al.* 2007

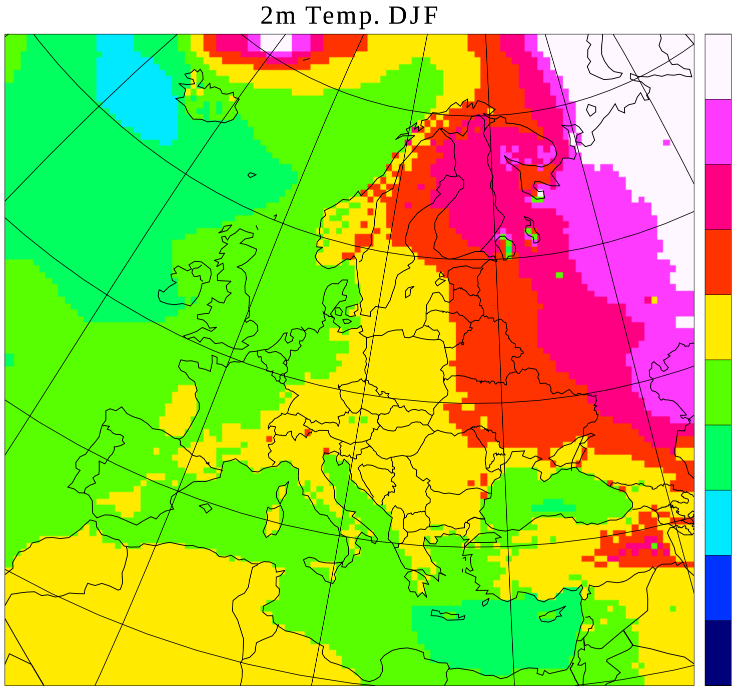
Change in mean temperature

ECHAM

HIRHAM

Winter



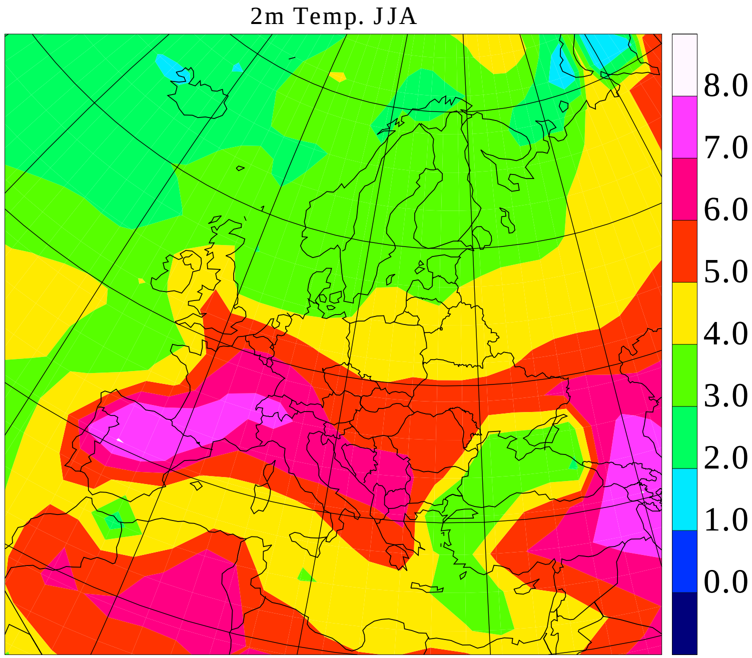


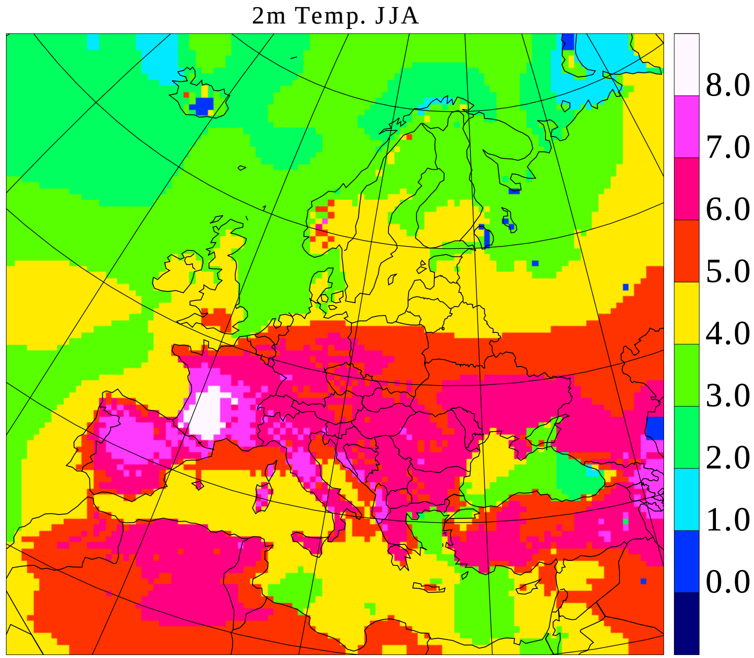
Change in mean temperature

ECHAM

HIRHAM

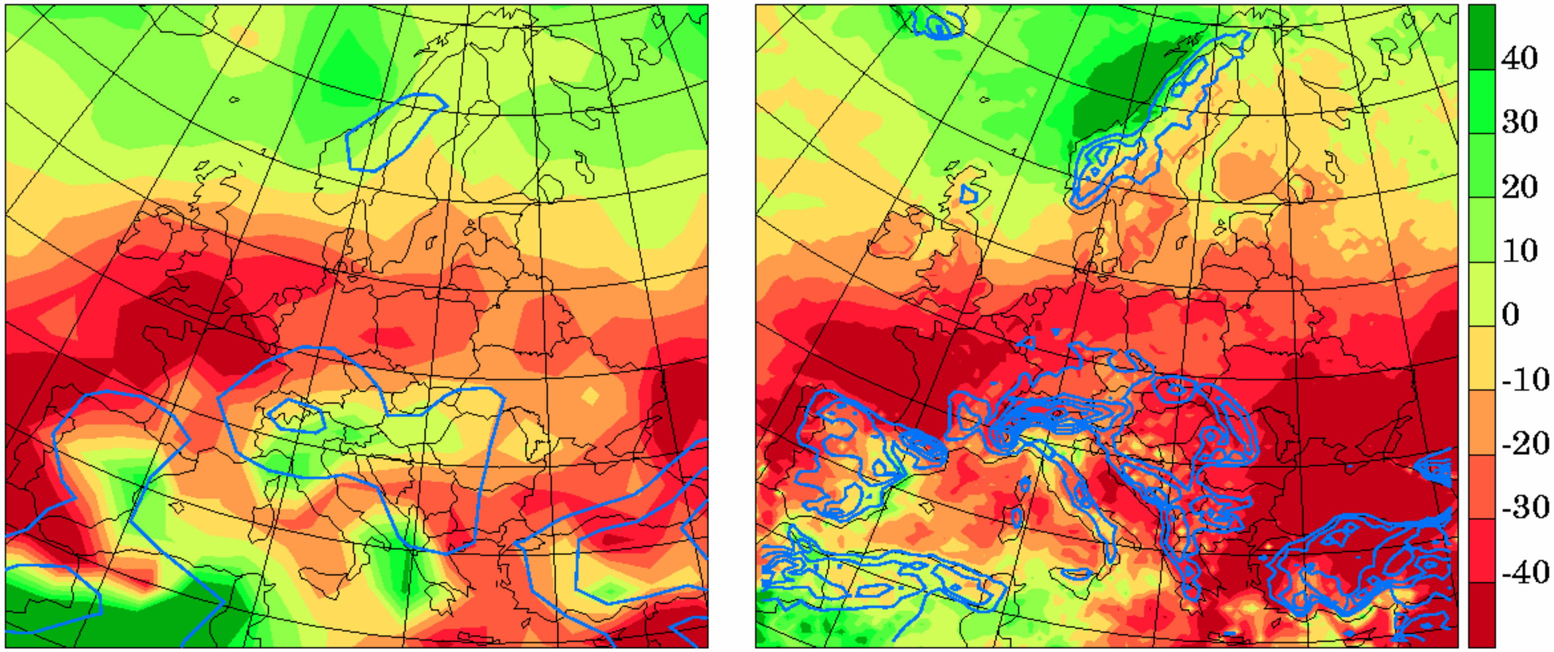
Summer





Change in precipitation (%)

Change in JAS mean precip (2071-2100 minus 1961-1990)

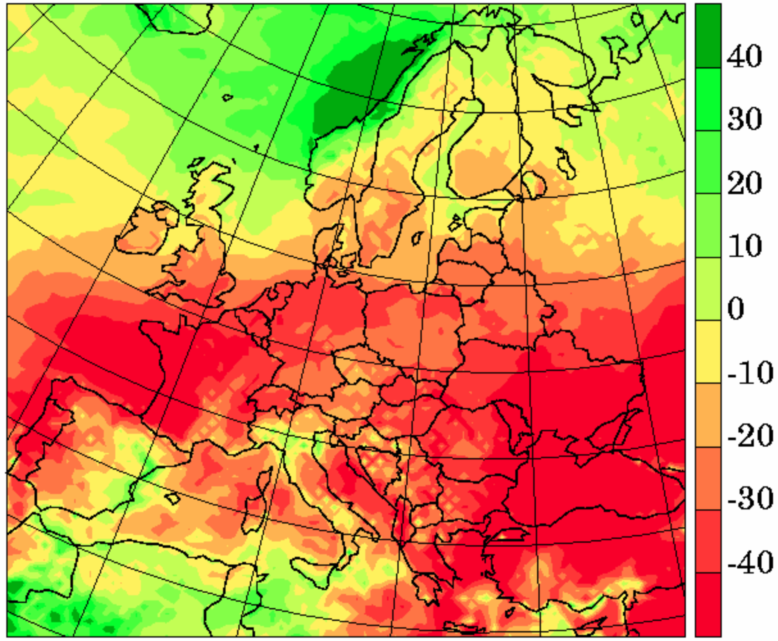


EU PRUDENCE project

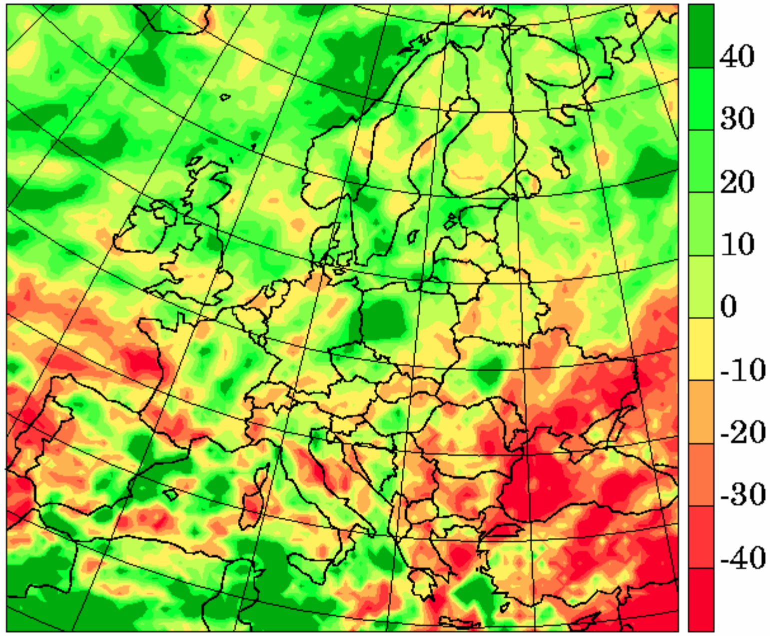
Christensen & Christensen *Nature* 2003

Change in precipitation (%)

Mean

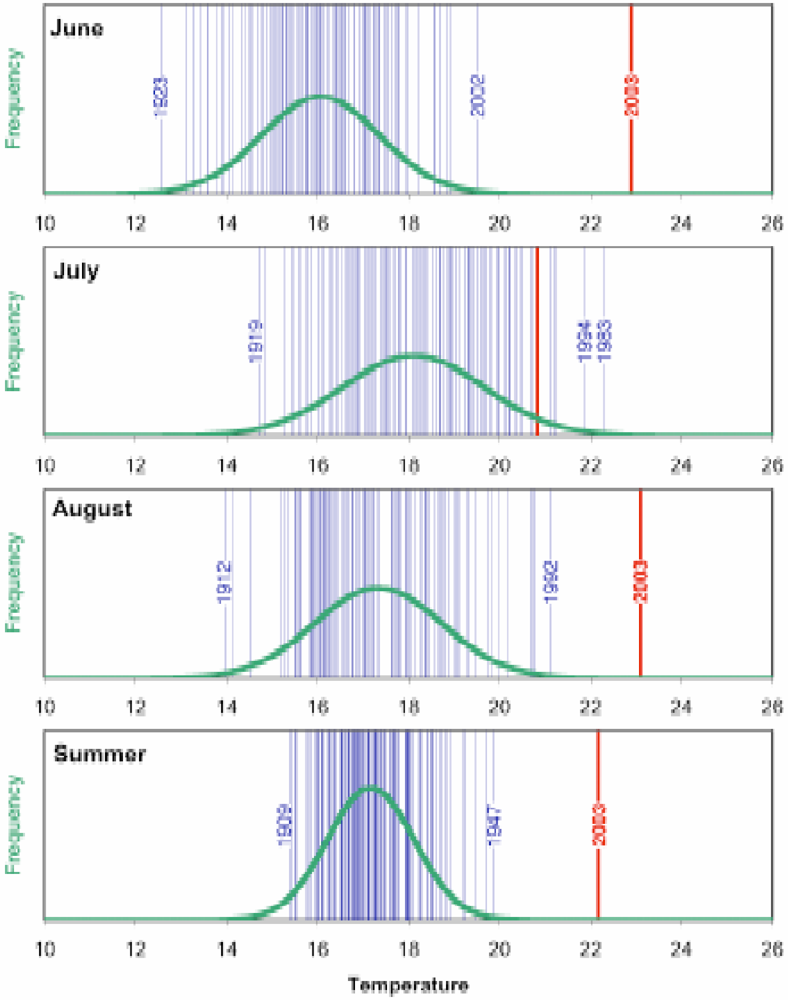


> 99% percentile



Christensen & Christensen *Nature* 2003

Summer Temperatures 1864-2003

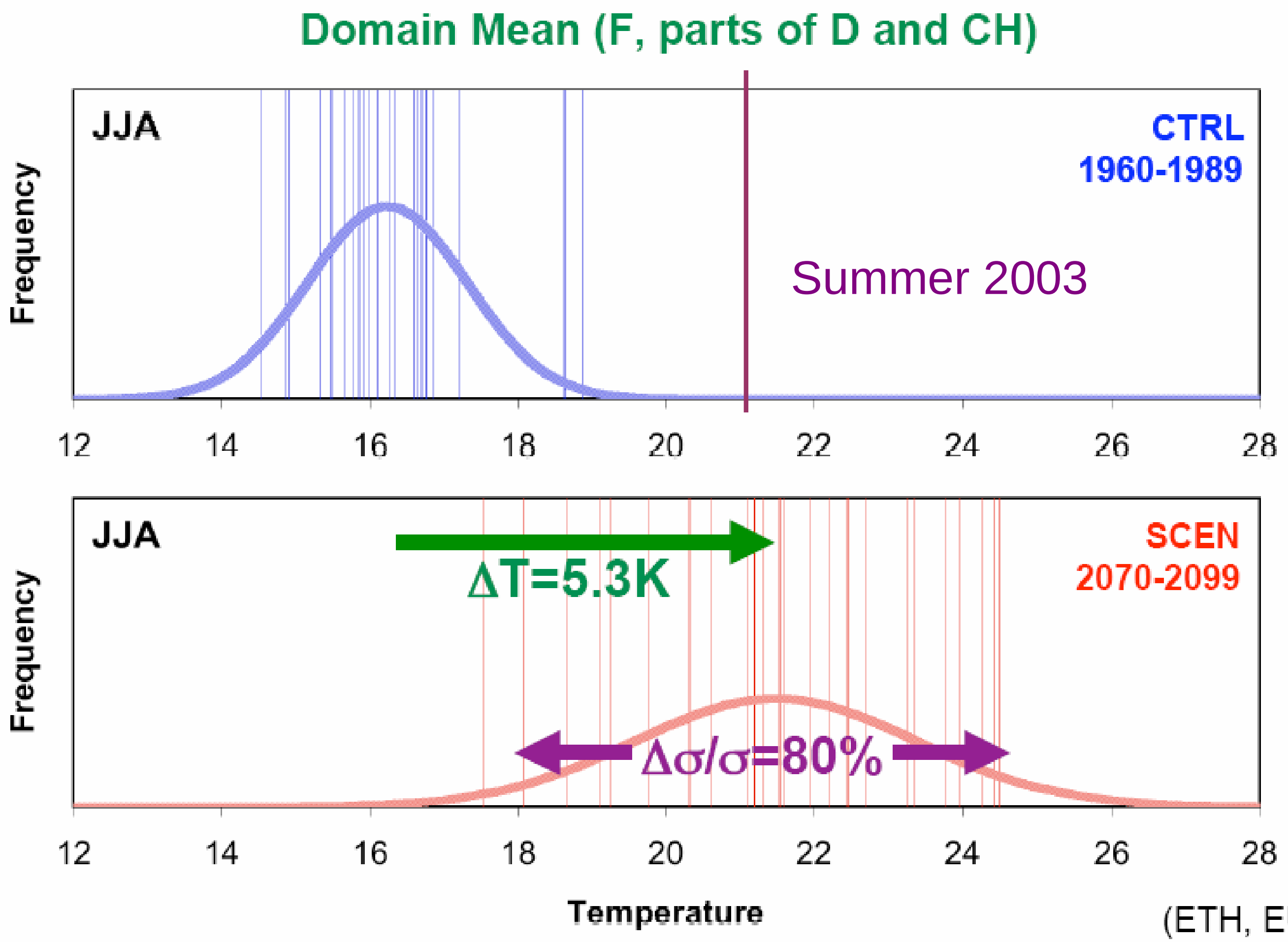


Schär, ETH Zürich

- **June, August, and JJA have the characteristics of outliers**
- **There is no other event (other months, cold and warm events) of this kind in the whole data series**

Schär *et al. Nature* 2004

Summer Temperatures



Gridpoint near Zurich

Simulated:
T = 15.8 °C
σ = 0.97 °C

Observed:
T = 17.2 °C
σ = 0.94 °C

Dramatic increase in variability

(ETH, EU-Project PRUDENCE)

Schär *et al. Nature* 2004

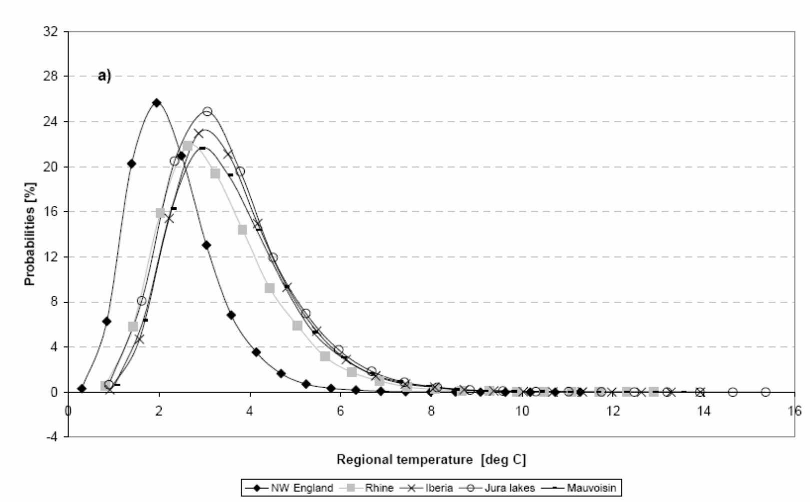
Assessing uncertainty of regional changes

- Construct a probability distribution function (*PDF)* of climate change
- Combine *PDF* from
  - global annual mean temperature increase
  - change in regional temperature/precipitation
    - per degree of global temperature increase (Jones, 2000)
- (Uniform distributions from within a range)
- Normal distribution* of *PDF* for the scaling variables, log normal for global increase
- Full range of uncertainty

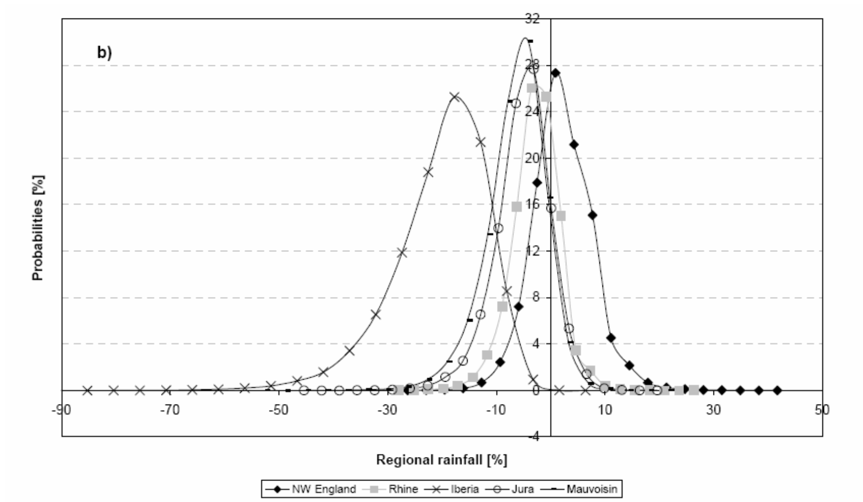
*(estimated from ANalysis Of VAriance (ANOVA))

(2071-2100) wrt. (1961-1990)

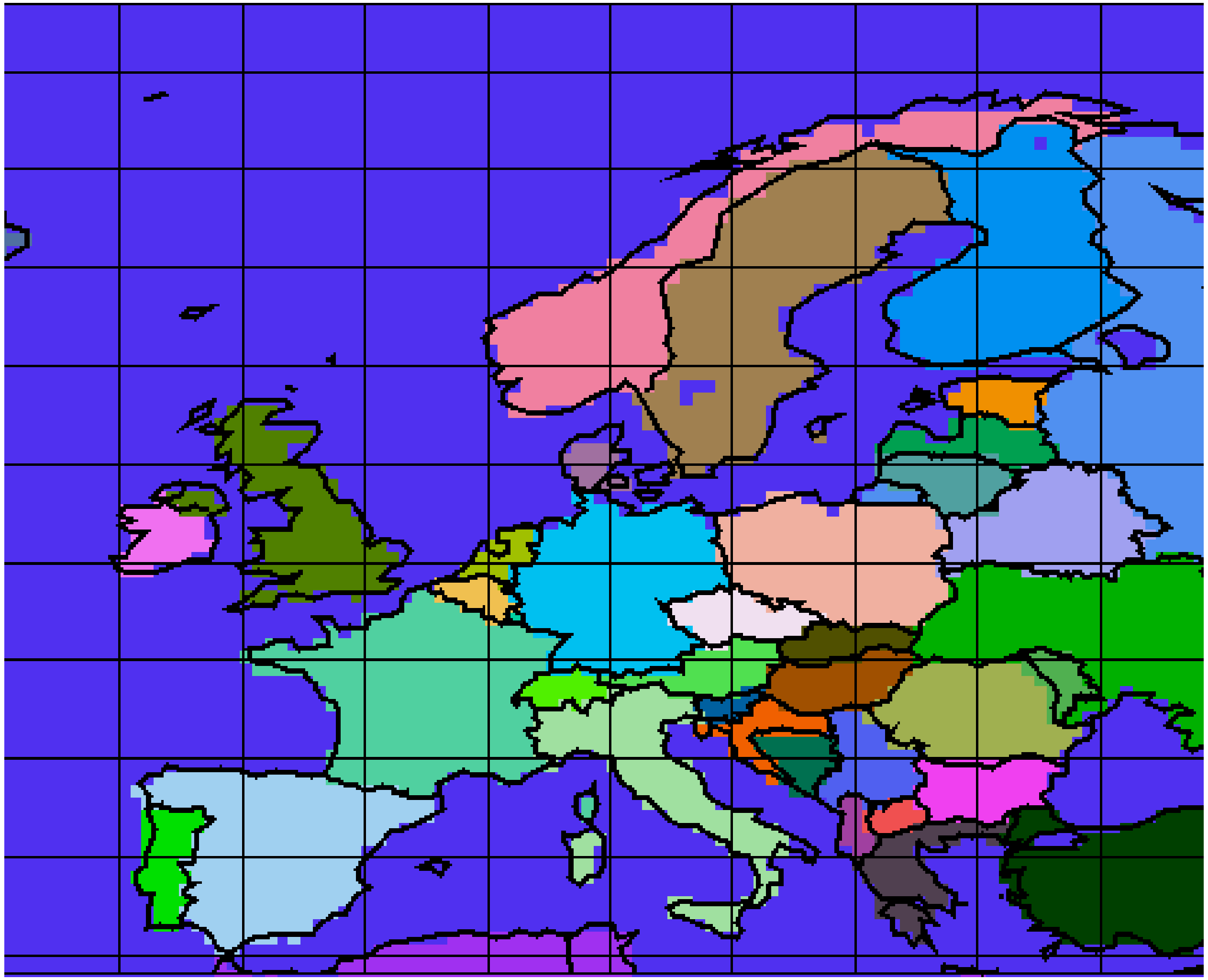
Temperature



Precipitation

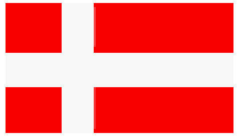


Ekström *et al*. (2005)

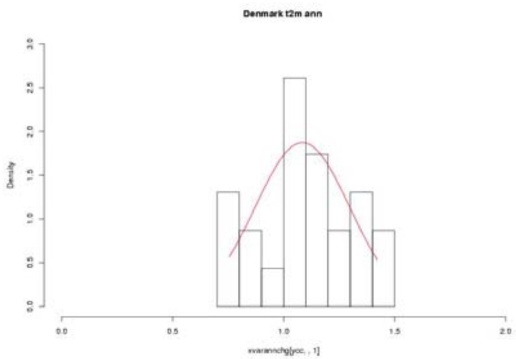


Example: Denmark

Change /°C global warming



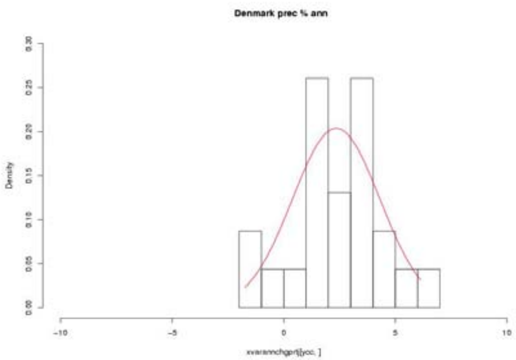
Temperature[ºC] (ann)
<x>=1.1
<s>=0.2
<med>=1.1
<p95>=1.4(1.3,1.5)
<p50>=1.1(1.0,1.2)
<p05>=0.7(0.6,0.8)



0.0 1.0 2.0

Temperature[ºC] (DJF)	(MAM)	(JJA)	(SON)
1.0	1.0	1.1	1.2
0.2	0.2	0.2	0.2
1.1	1.0	1.0	1.2
1.4(1.3,1.6)	1.4(1.3,1.5)	1.4(1.3,1.5)	1.6(1.5,1.7)
1.0(1.0,1.1)	1.0(0.9,1.1)	1.1(1.0,1.1)	1.2(1.2,1.3)
0.6(0.5,0.8)	0.6(0.5,0.8)	0.7(0.6,0.8)	0.9(0.7,1.0)

Precipitation [%] (ann)
<x>=2.4
<s>=2.0
<med>=2.5
<p95>=5.6(4.5,6.6)
<p50>=2.4(1.7,3.0)
<p05>=-0.9(-1.9,0.2)

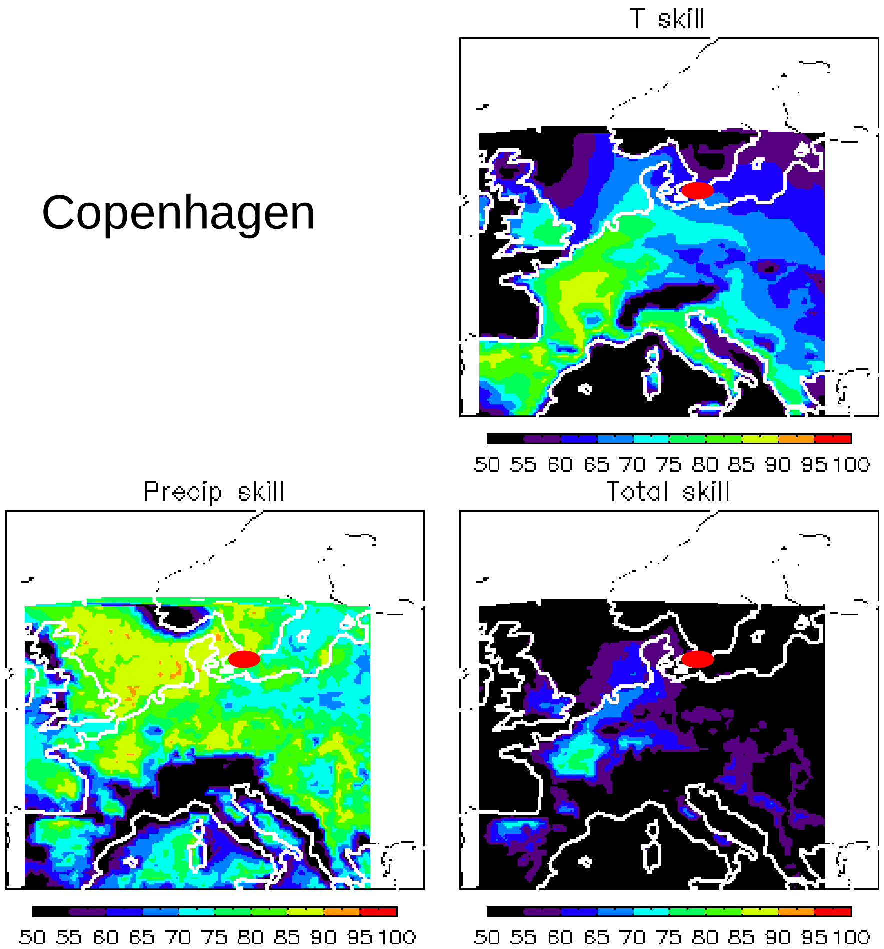


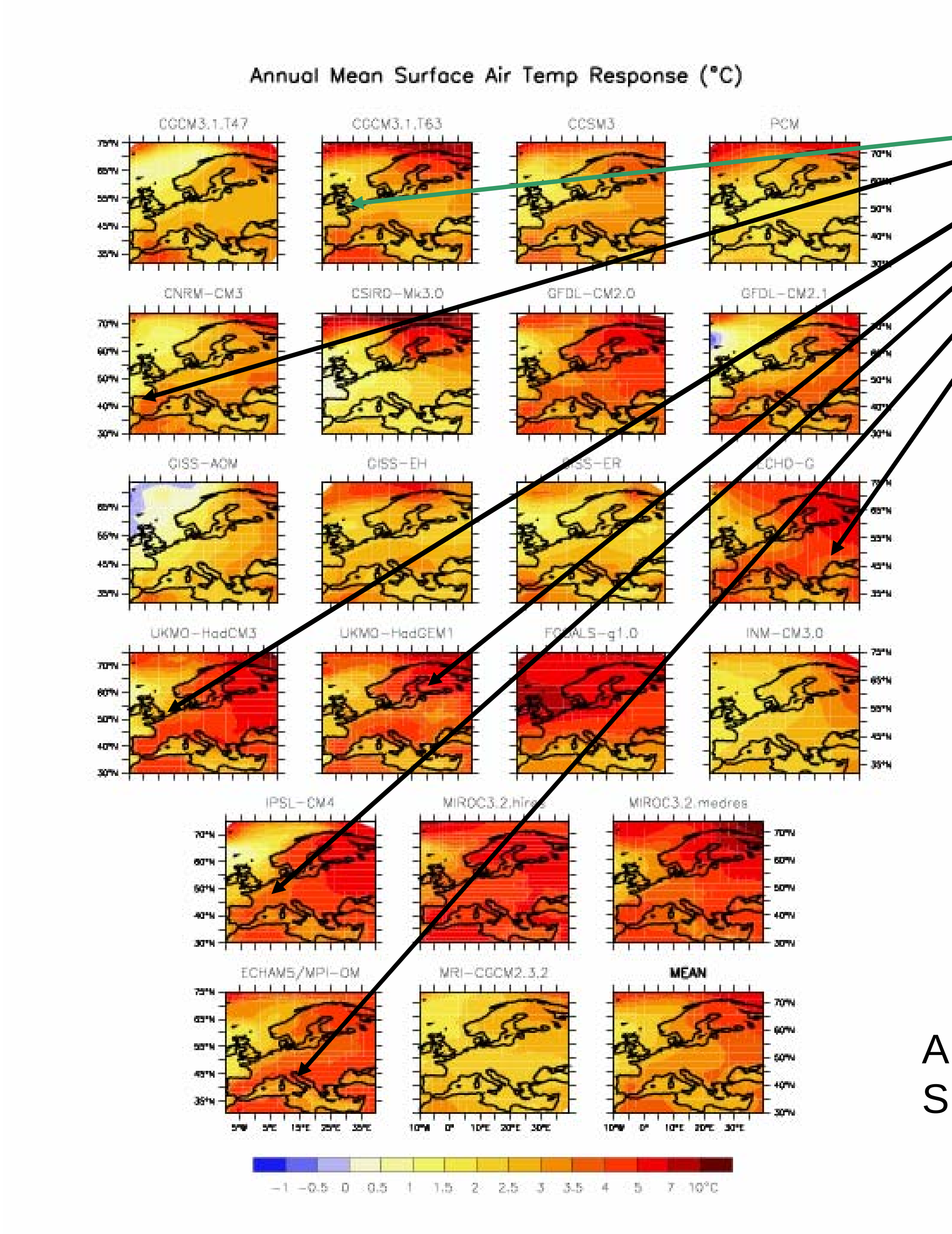
-5.0 0.0 5.0

Precipitation [%] (DJF)	(MAM)	(JJA)	(SON)
9.8	3.6	-6.4	1.5
3.7	2.2	3.5	4.1
10.1	3.3	-7	1.7
15.9(13.8,17.9)	7.3(6.1,8.4)	-0.6(-2.3,1.2)	8.3(6.1,10.5)
9.8(8.5,11.1)	3.6(2.9,4.4)	-6.4(-7.5,-5.2)	1.5(0.0,2.9)
3.7(1.7,5.7)	-0.0(-1.2,1.1)	-12.2(-14.1,-10.3)	-5.3(-7.5,-3.0)

Analogues based on daily values

Copenhagen





ENSEMBLES

AR4, WGI, Ch11
Suppl. Mat.

Some research questions

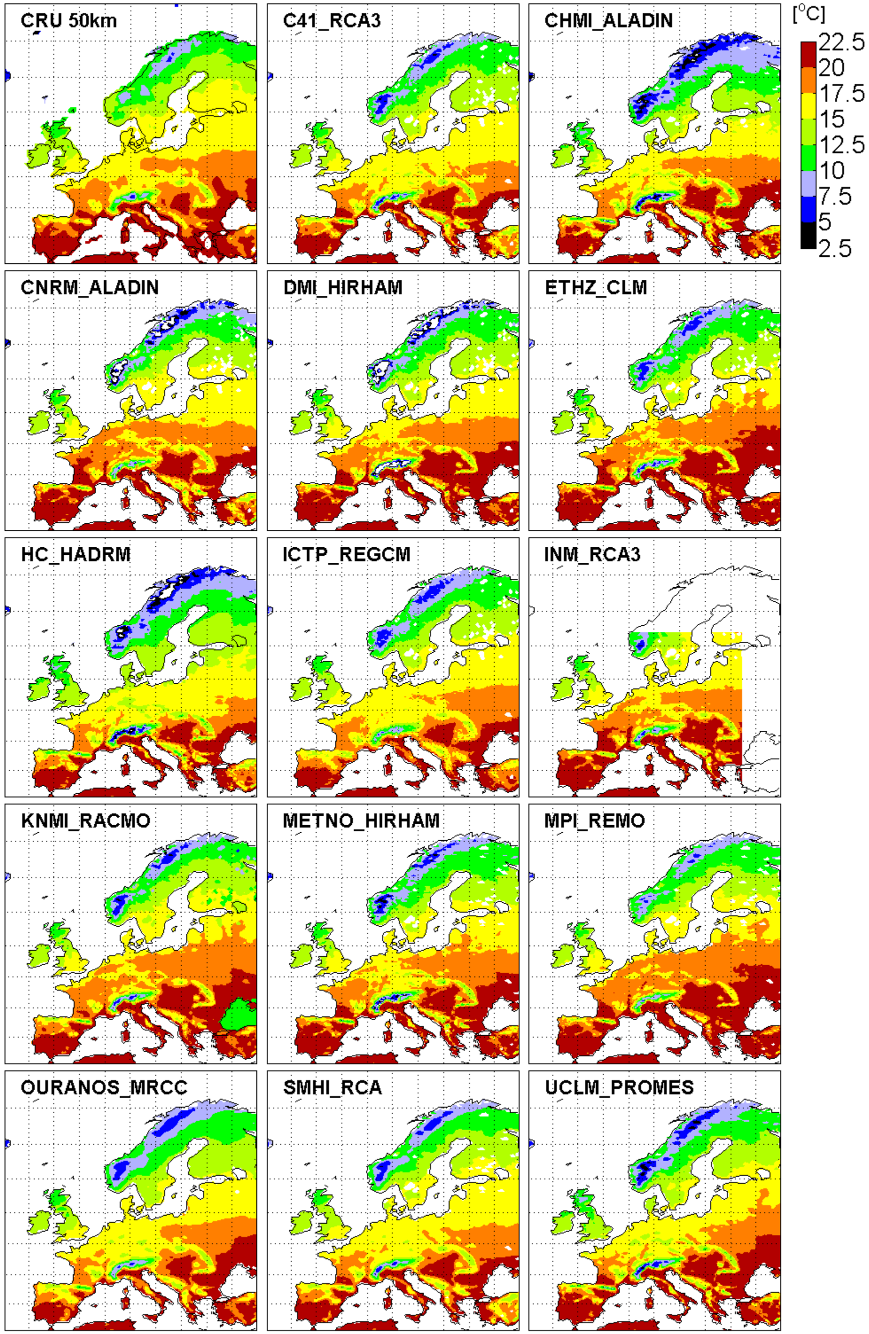
- How do we best assess the quality of models?
- Can we use an ensembles approach that allows us to produce pdf´s based on many models weighted according to some metric?
- How can we define appropriate metrics?
- ENSEMBLES addresses this

ENSEMBLES GCM-RCM Matrix

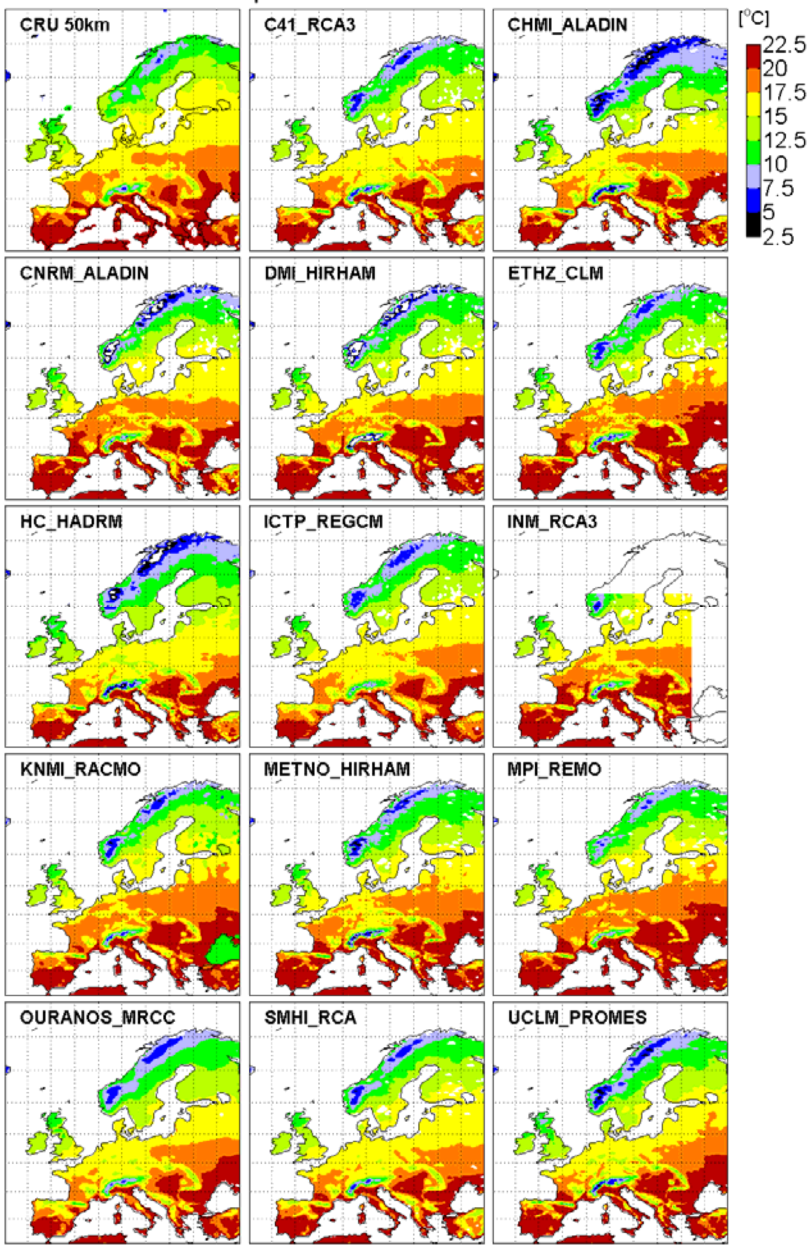
Global model Regional model	METO-HC	MPIMET	IPSL	CNRM	NERSC	CGCM3	Total number
METO-HC	1950-2100[£]	1950-2100					2 (4)
MPIMET		1950-2100	1950-2050*				2
CNRM				1950-2050			2
DMI		1950-2100		1950-2050*			2
ETH	1950-2050						1
KNMI		1950-2050					1
ICTP		1950-2050					1
SMHI	1950-2050				1950-2050*		2
UCLM	1950-2050						1
C4I		1950-2050					1
GKSS**			1950-2050*				1
Met.No**					1950-2050*		1
CHMI**				1950-2050*			1
OURANOS**						1950-2050*	1
Total (1950-2050)	4 (6)	6	2	3	2	1	18 (20)

EU FP6 project

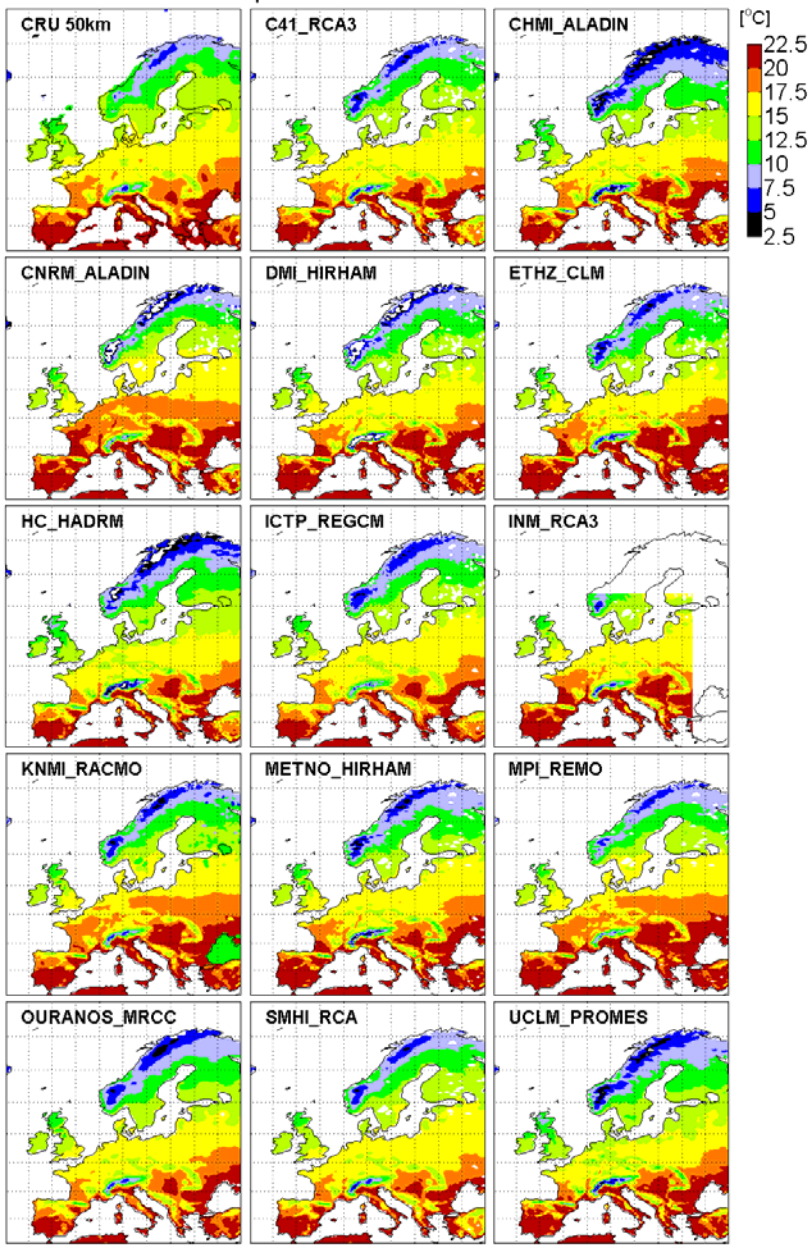
1961-1990 temperature for 10 warmest CRU summers



1961-1990 temperature for 10 warmest CRU summers



1961-1990 temperature for 10 coldest CRU summers



Summary

- The ensembles approach seems to offer new options for scientific achievements
  - RCMs must be used better in connection with GCMs
- We have large data sets for diagnostic works and training of ensemble approaches
- There is still room for the single model approach for in depth process studies and understanding of ‘the case’

Thank you for your attention!