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International Centre for Theoretical Physics

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WCRP and ICTP Interpreting Climate Change Simulations: Capacity Building for Developing Nations Seminar

26 - 30 November 2007

Regional patterns of climate change from the CMIP3 ensemble.

Filippo Giorgi

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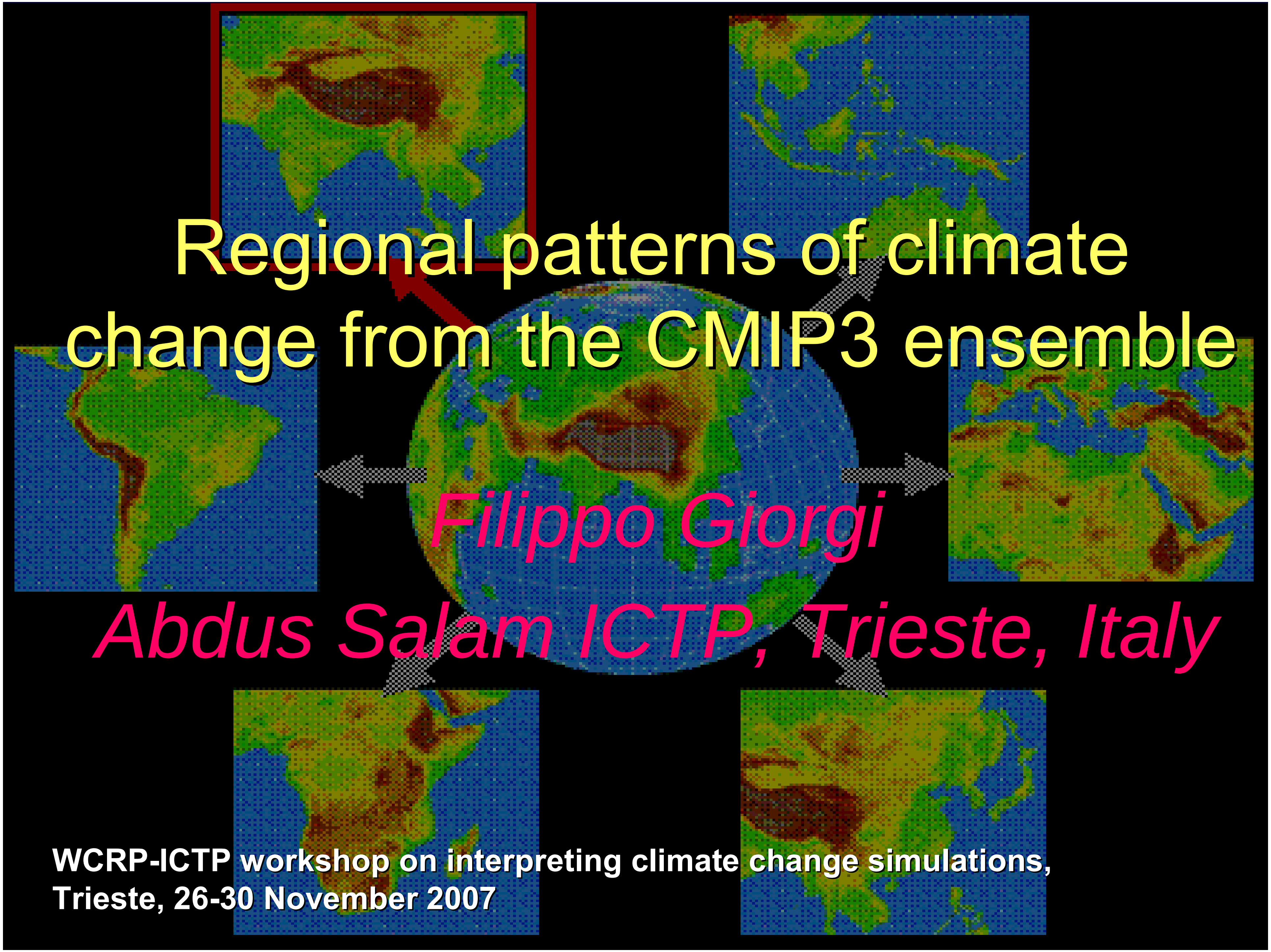


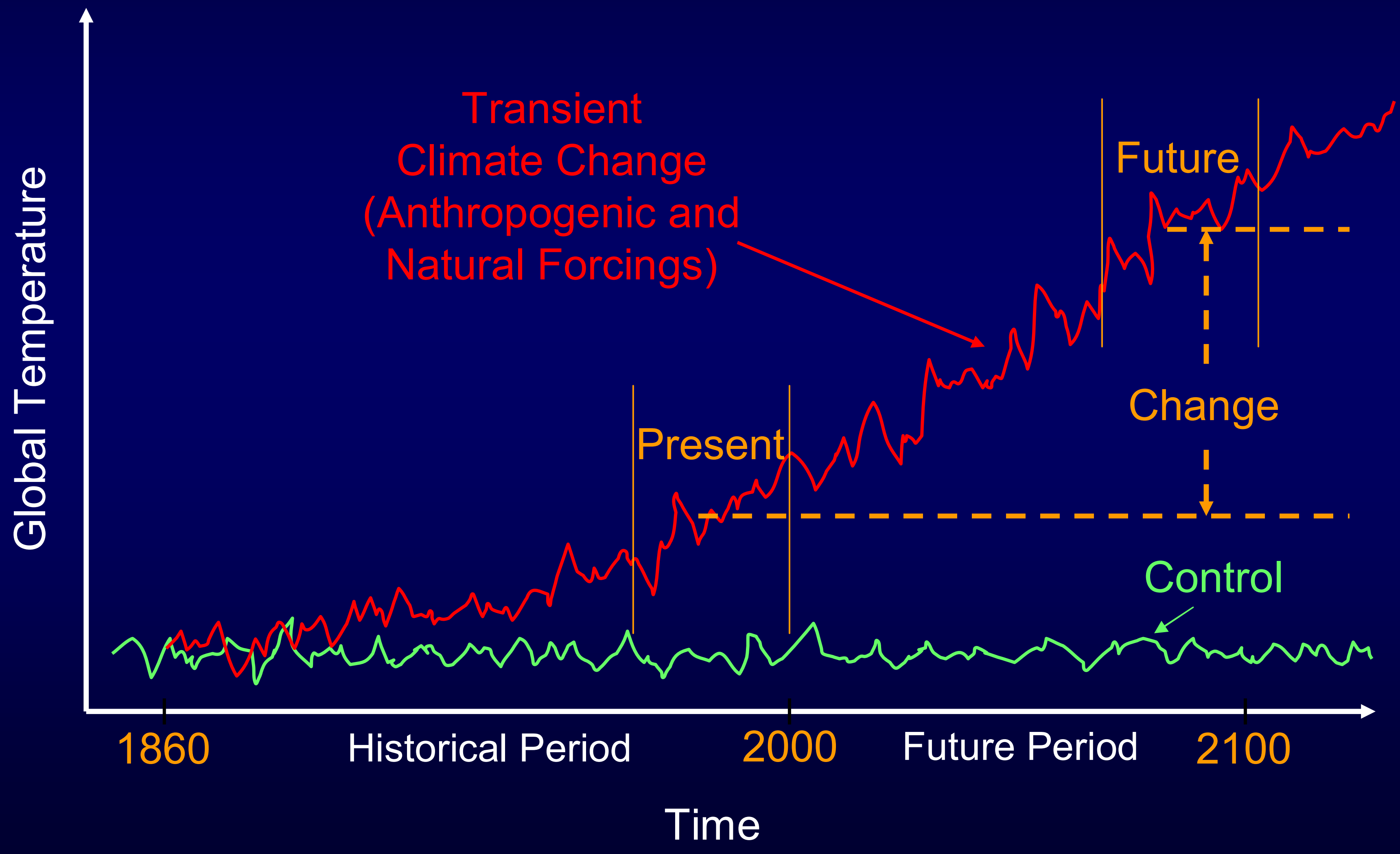
Regional patterns of climate change from the CMIP3 ensemble

Filippo Giorgi

Abdus Salam ICTP, Trieste, Italy

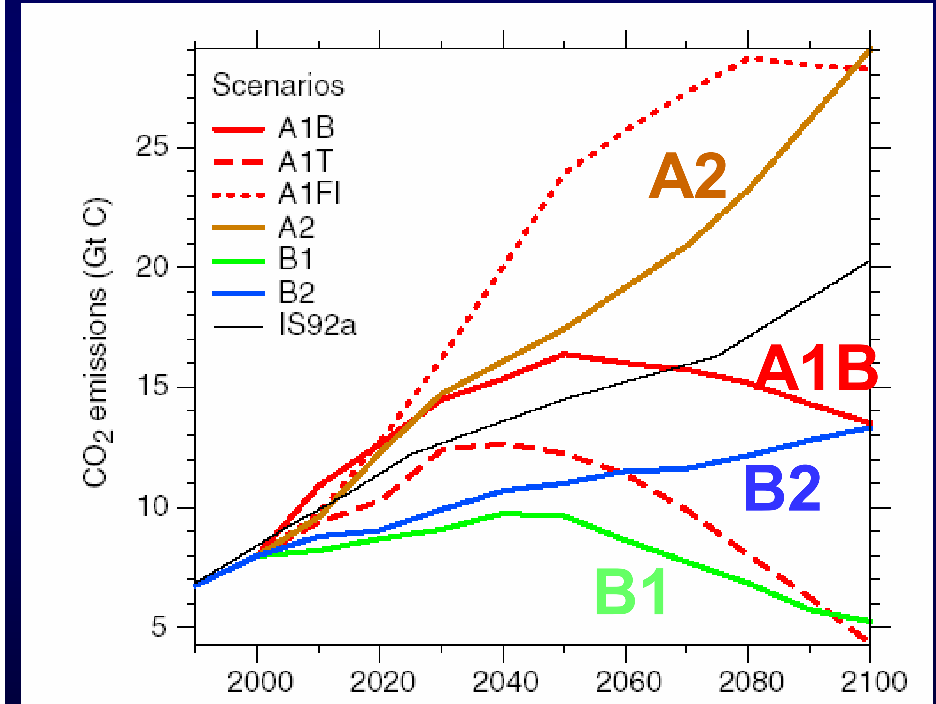
WCRP-ICTP workshop on interpreting climate change simulations,
Trieste, 26-30 November 2007

Transient Climate Change Simulation

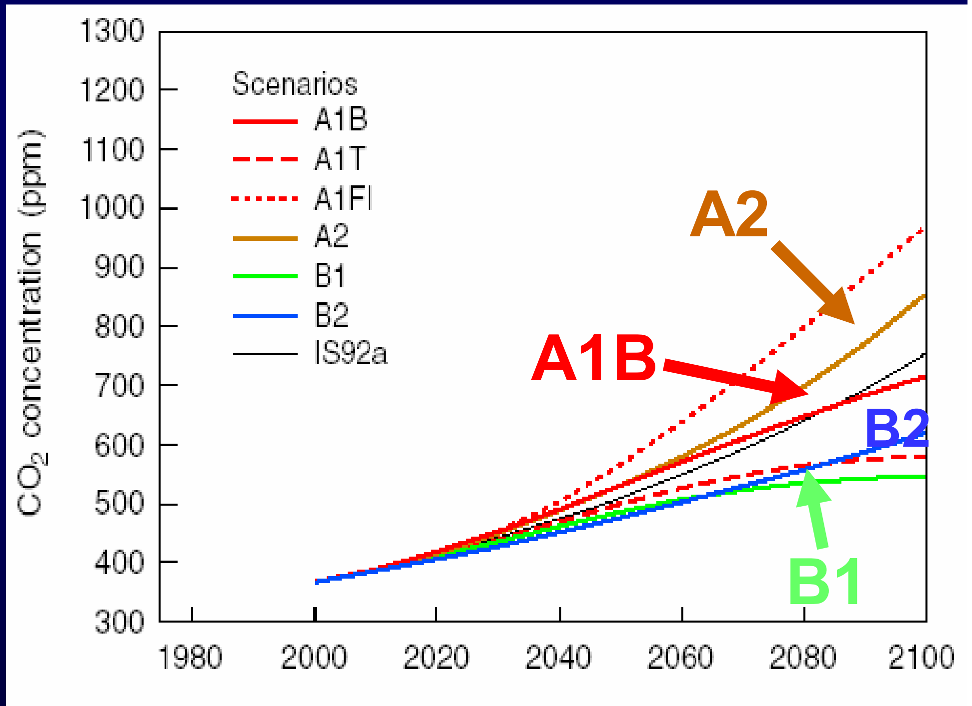


Greenhouse gas emission and concentration scenarios (IPCC-2000)

CO2 emissions

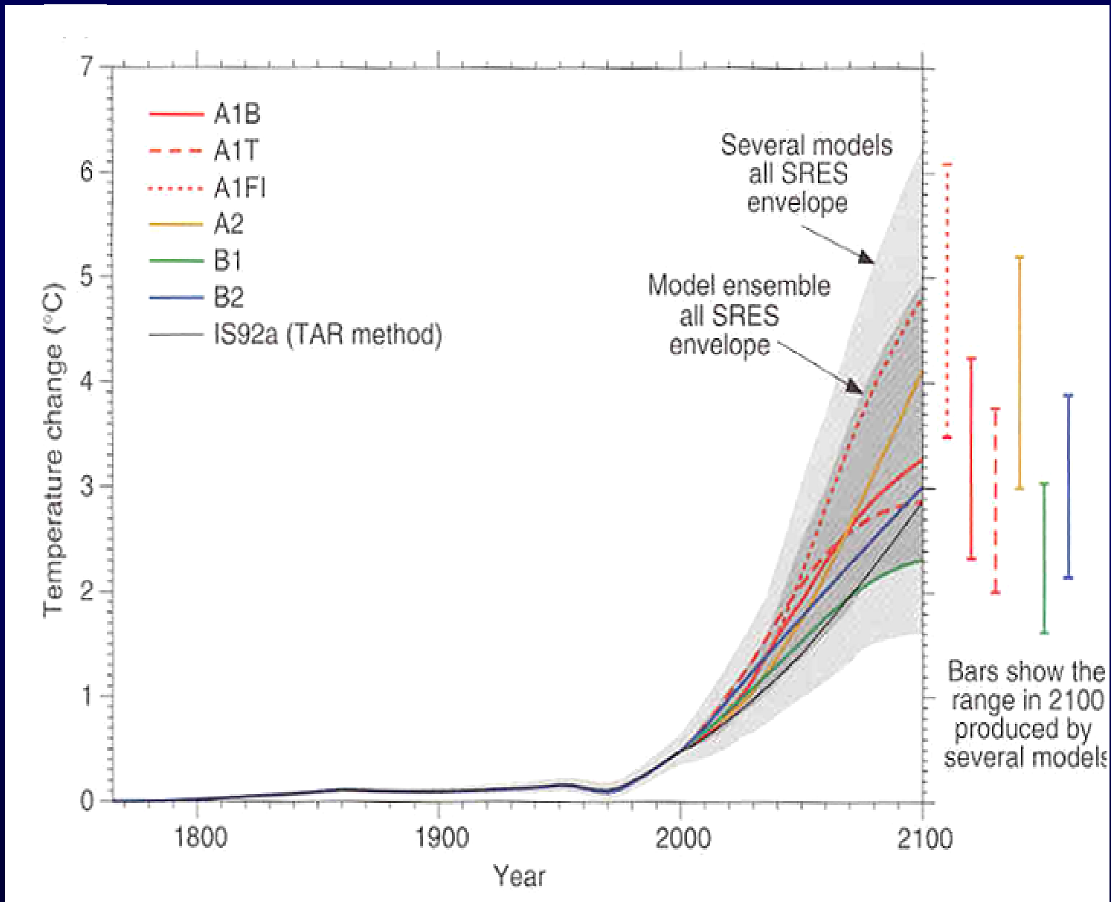


CO2 Concentrations



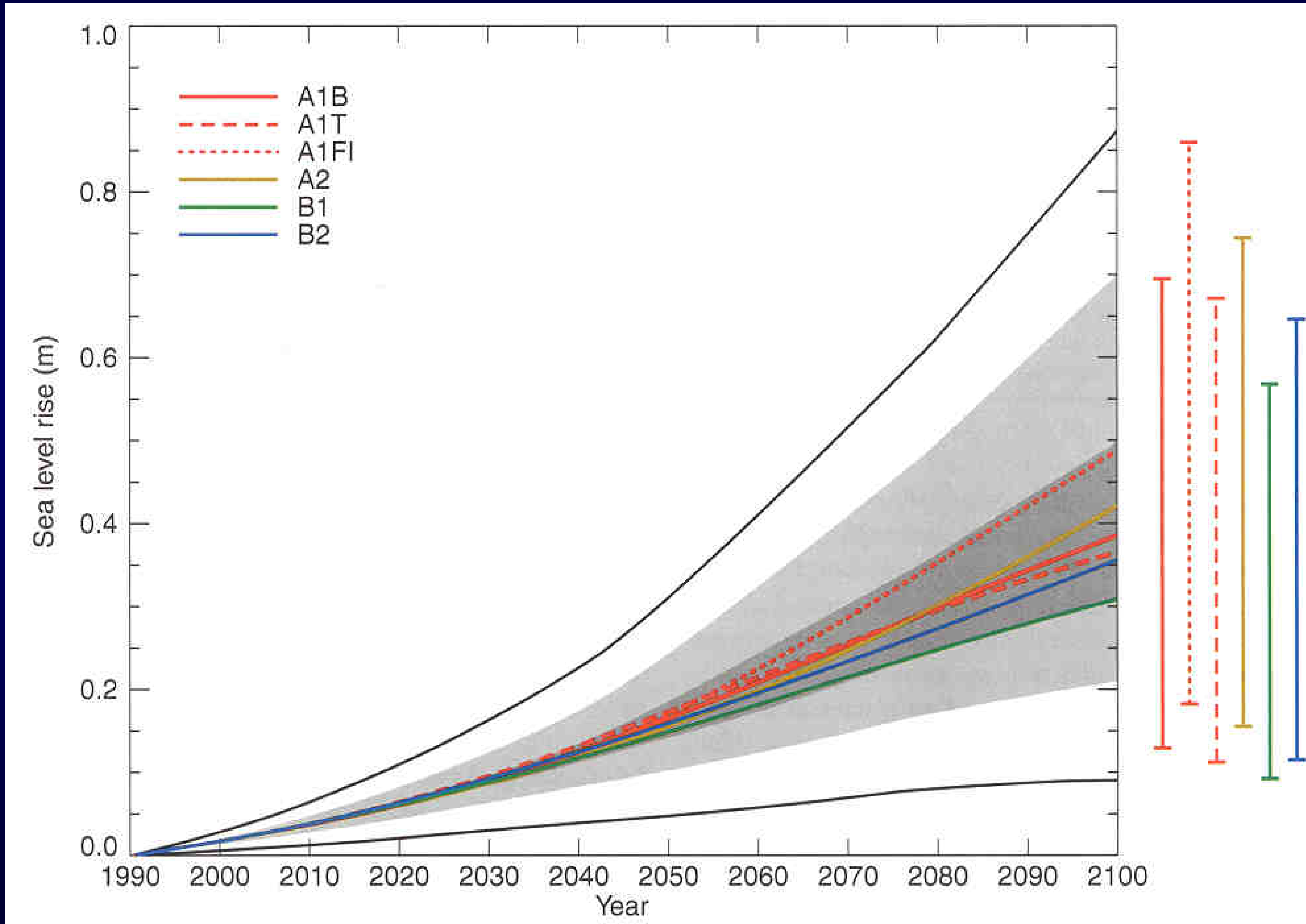
A brief review of the TAR results

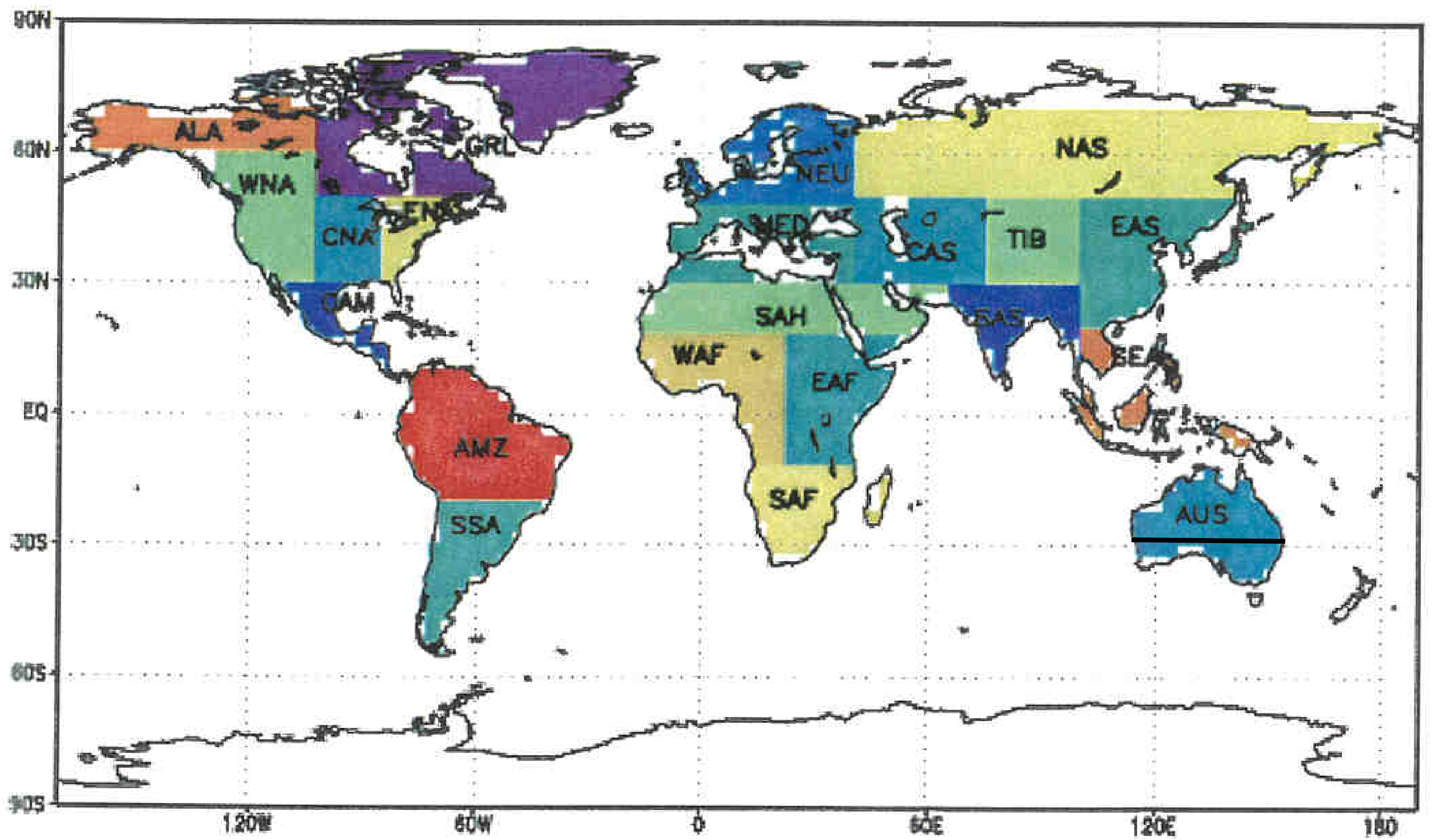
The globally averaged surface temperature is projected to increase 1.4 to 5.8 degrees from 1990 to 2100



The projected rate of warming is much larger than the observed changes during the 20th century and it is very likely to be without precedent during the last 10,000 years

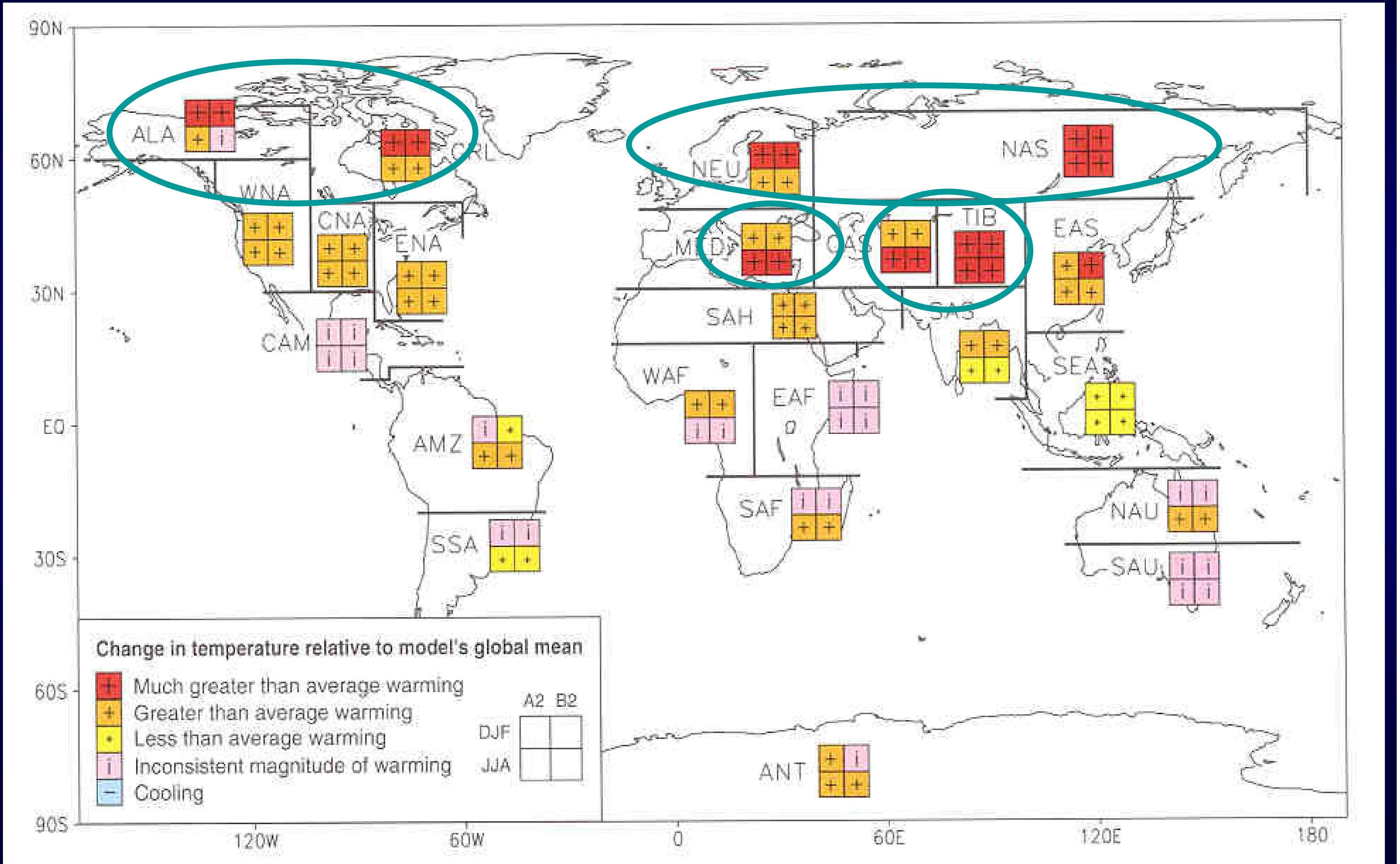
Sea Level Rise



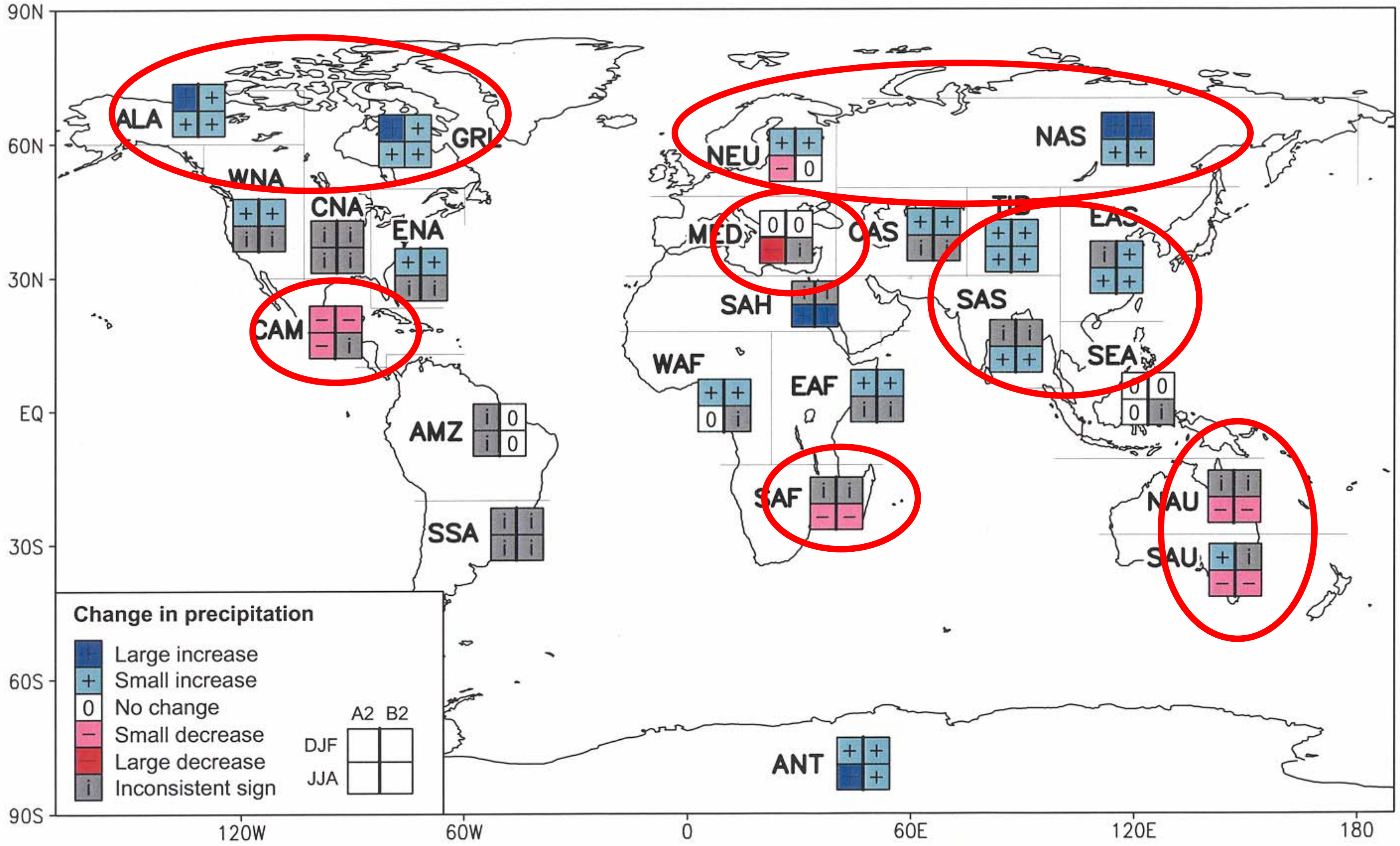


Regions used in the analysis conducted for the TAR (9 AOGCMs)

Inter-model agreement in the simulation of temperature change



Inter-model agreement in the simulation of precipitation change



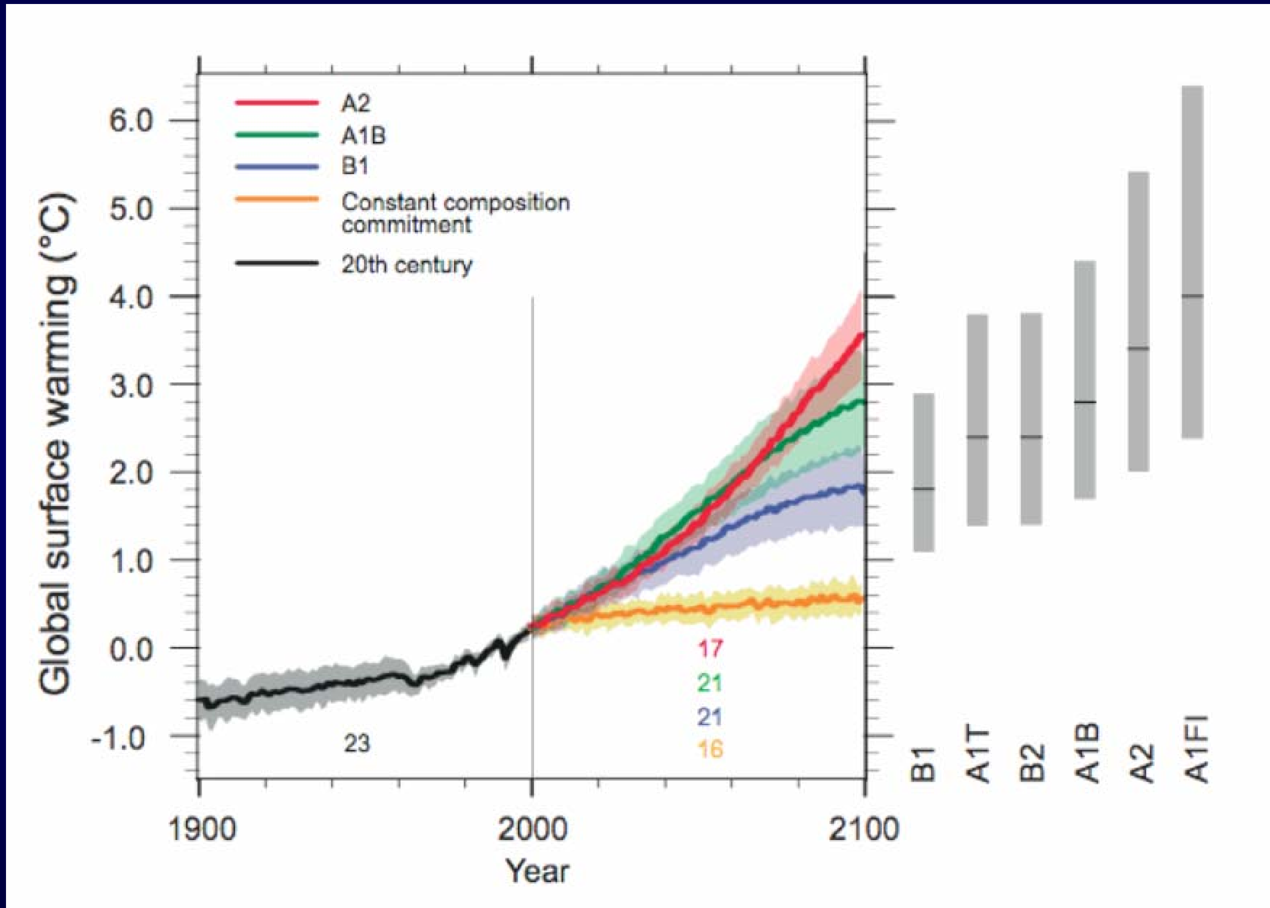
AOGCM Simulations in the CMIP3 ensemble

The CMIP3 ensemble

Table 1. List of models and simulations used in the analysis.

Model	20 Cent.	A1B	A2	B1
BCCR-BCM2-0	1	-	1	1
CCMA-3-T47	5	4	2	4
CNRM-CM3	1	1	1	1
CSIRO-MK3	2	1	1	1
GFDL-CM2-0	3	1	1	1
GFDL-CM2-1	3	1	1	-
GISS-AOM	2	2	-	2
GISS-EH	5	4	-	-
GISS-ER	1	2	1	1
IAP-FGOALS	3	3	-	2
INMCM3	1	1	1	1
IPSL-CM4	1	1	1	1
MIROC3-2H	1	1	-	1
MIROC3-2M	3	3	3	3
MIUB-ECHO-G	5	3	3	3
MPI-ECHAM5	3	2	3	3
MRI-CGCM2	5	5	5	5
NCAR-CCSM3	8	6	4	8
NCAR-PCM1	4	3	4	2
UKMO-HADCM3	1	1	1	1

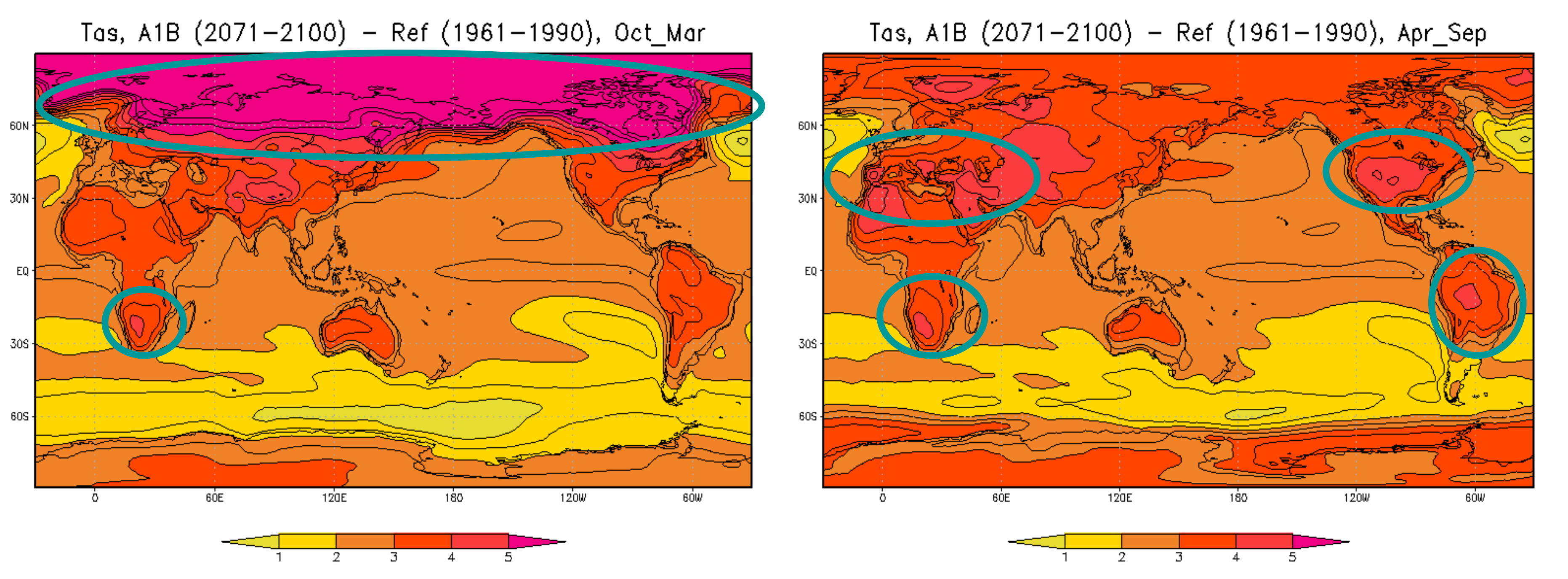
IPCC – 2007: Global temperature change projections for the 21st century



The range of projected global sea level rise by 2100 is 19-58 cm

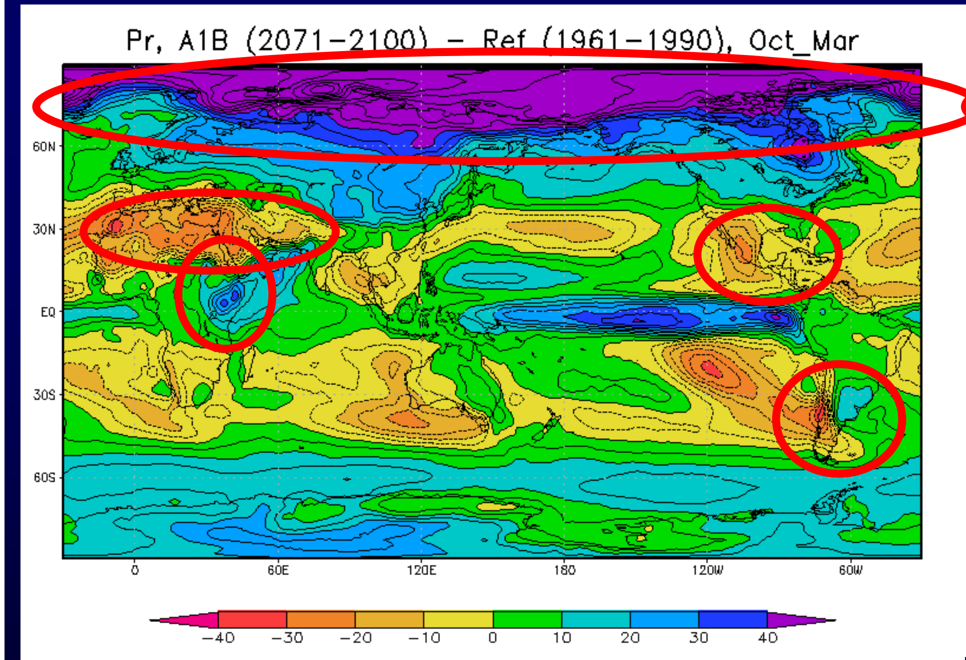
Change in surface air temperature (2071-2100) – (1961-1990)

October – March   April – September

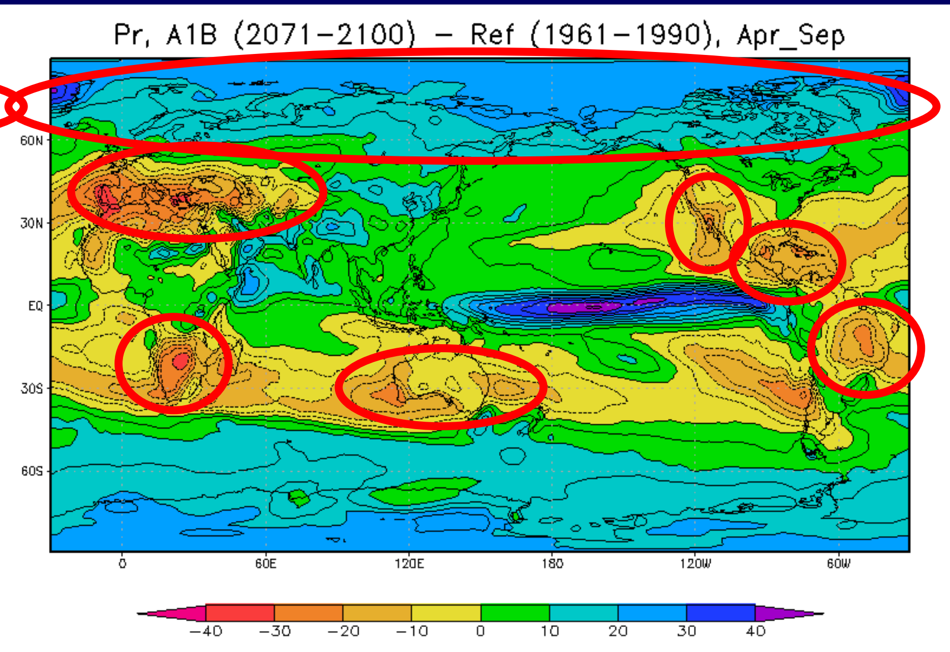


Change in precipitation (2071-2100) – (1961-1990)

October – March

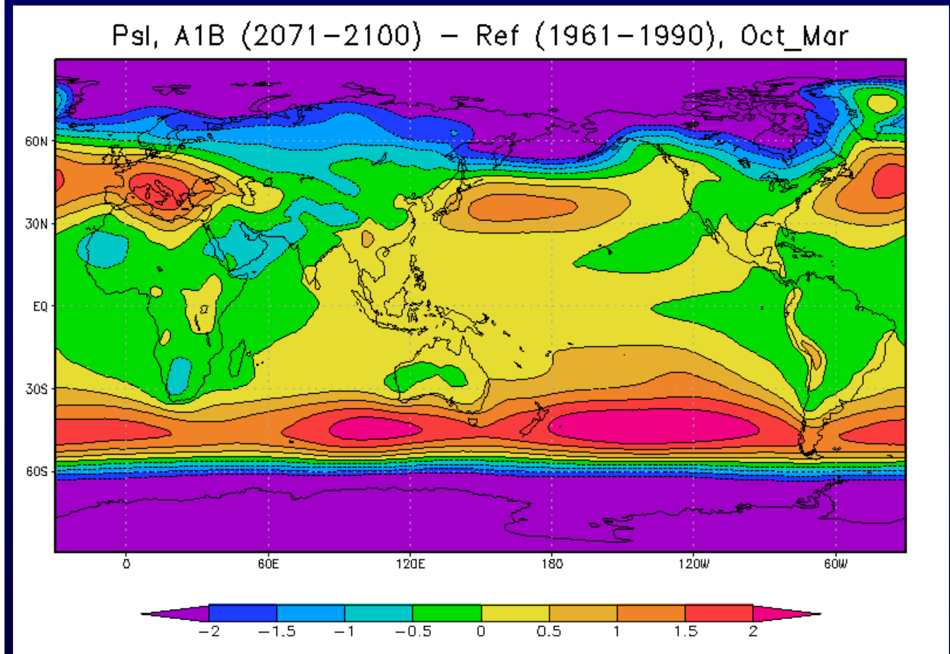


April – September

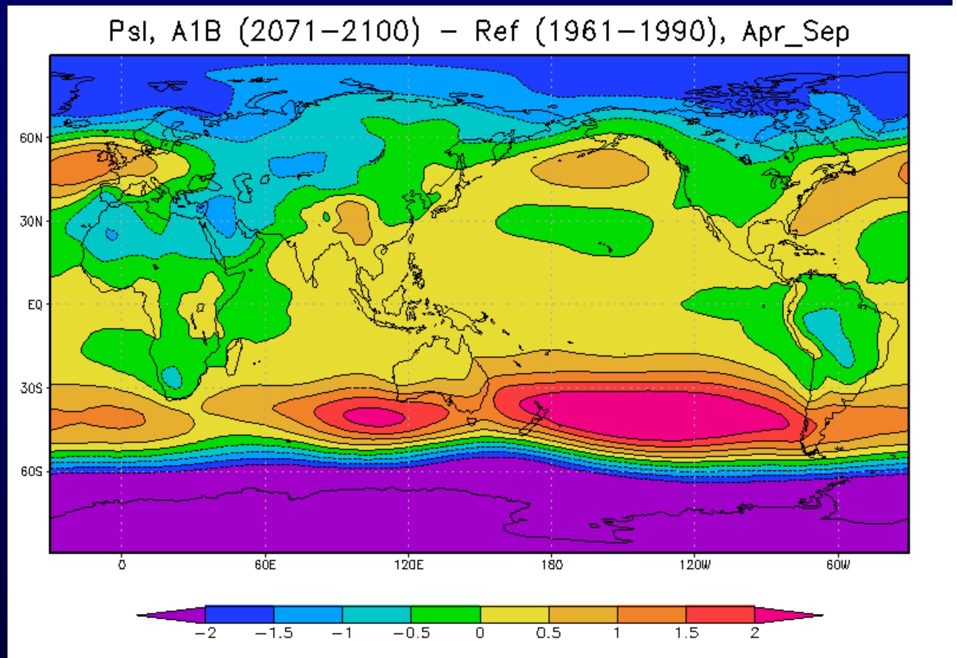


Change in sea level pressure (2071-2100) – (1961-1990)

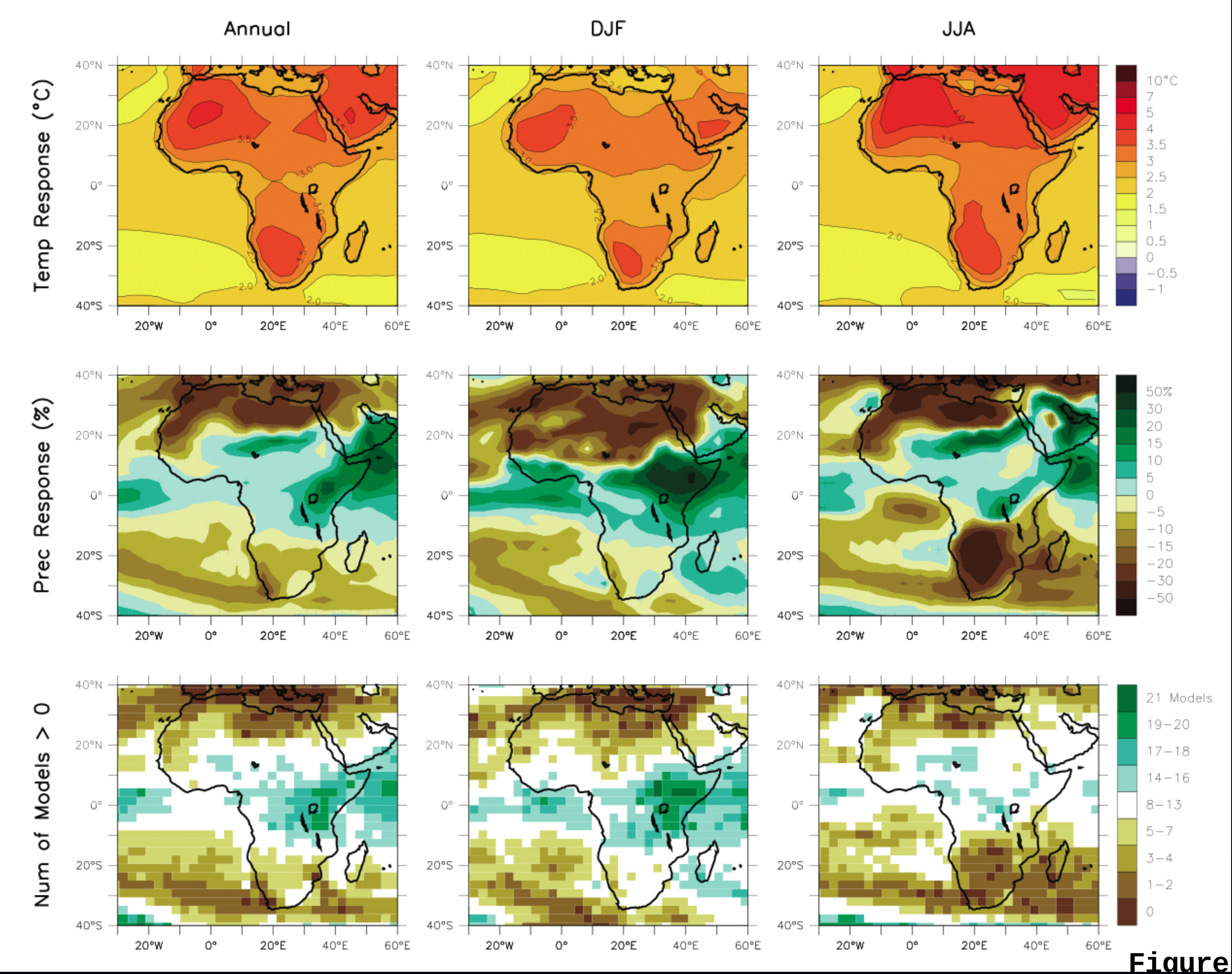
October – March



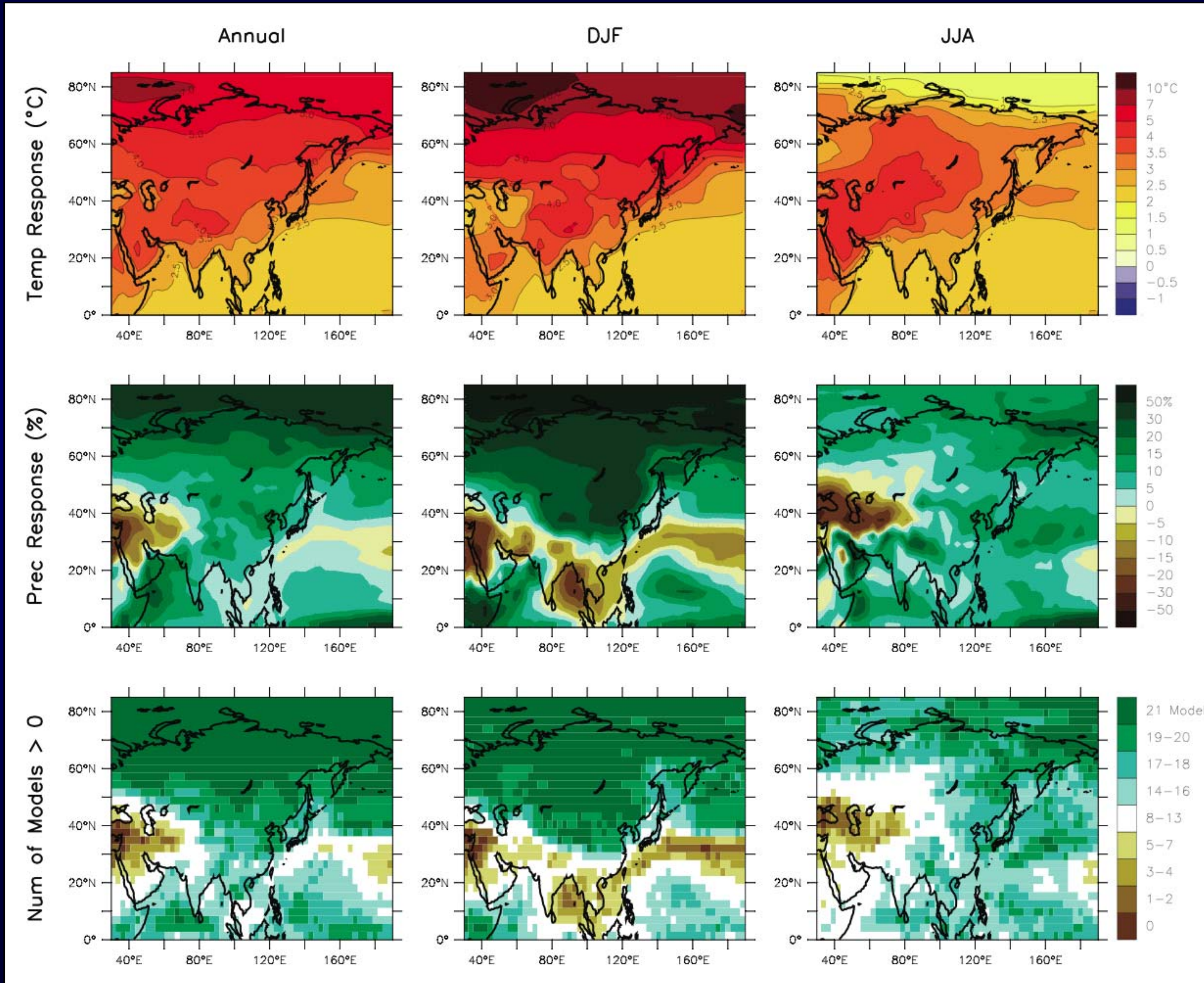
April – September



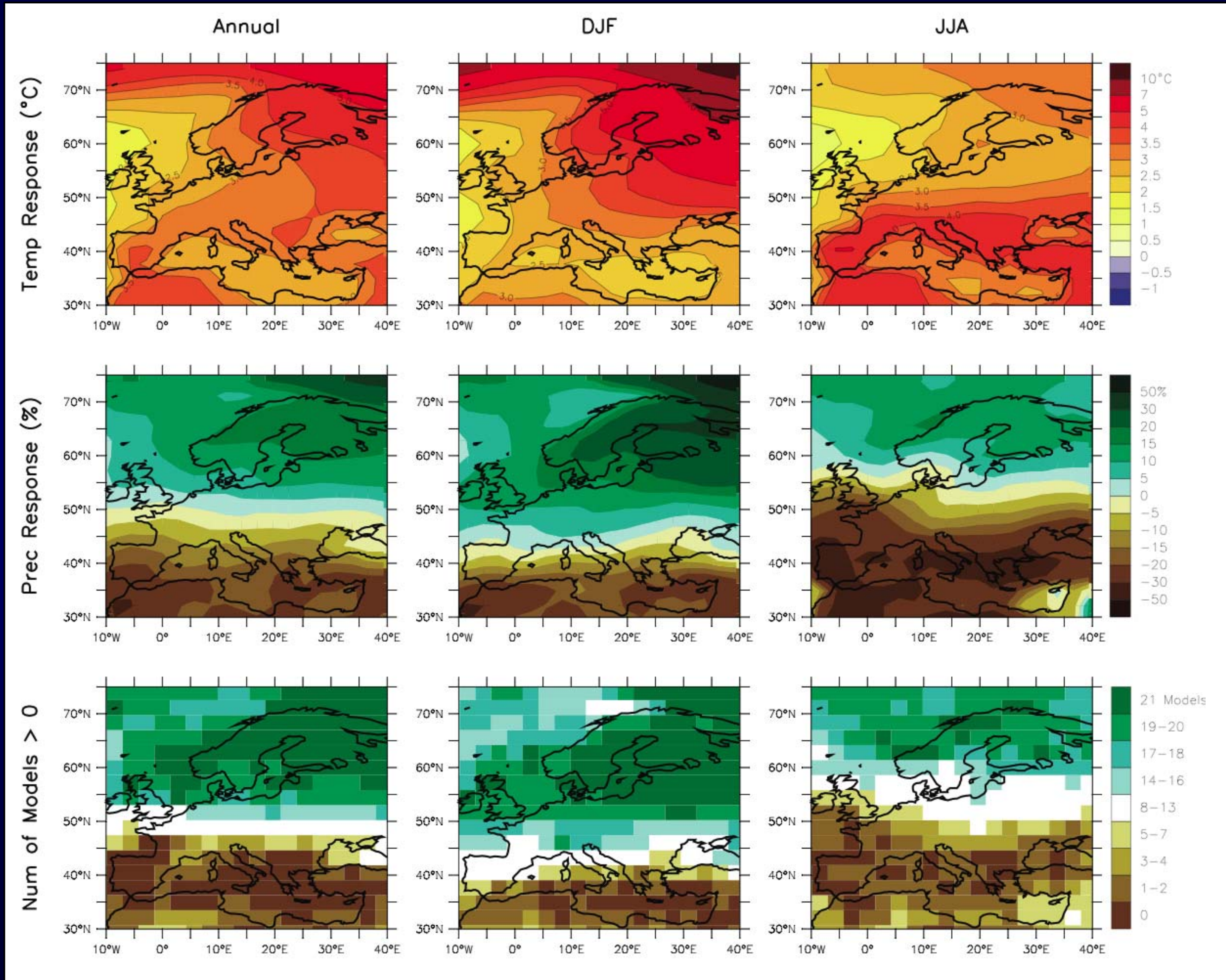
Regional changes: AFRICA



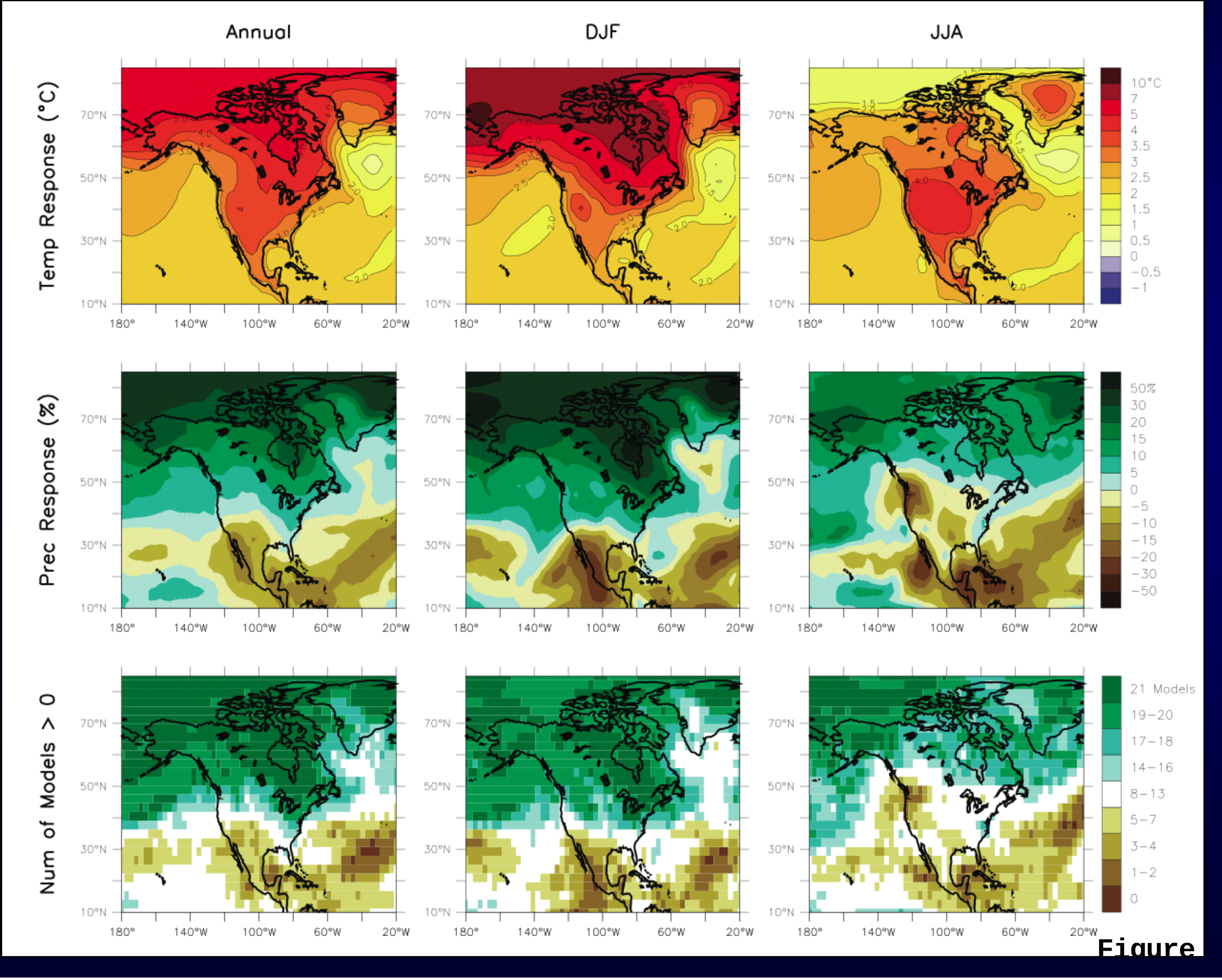
Regional changes: ASIA



Regional changes: EUROPE



Regional changes: N. AMERICA



Regional changes: S. AMERICA

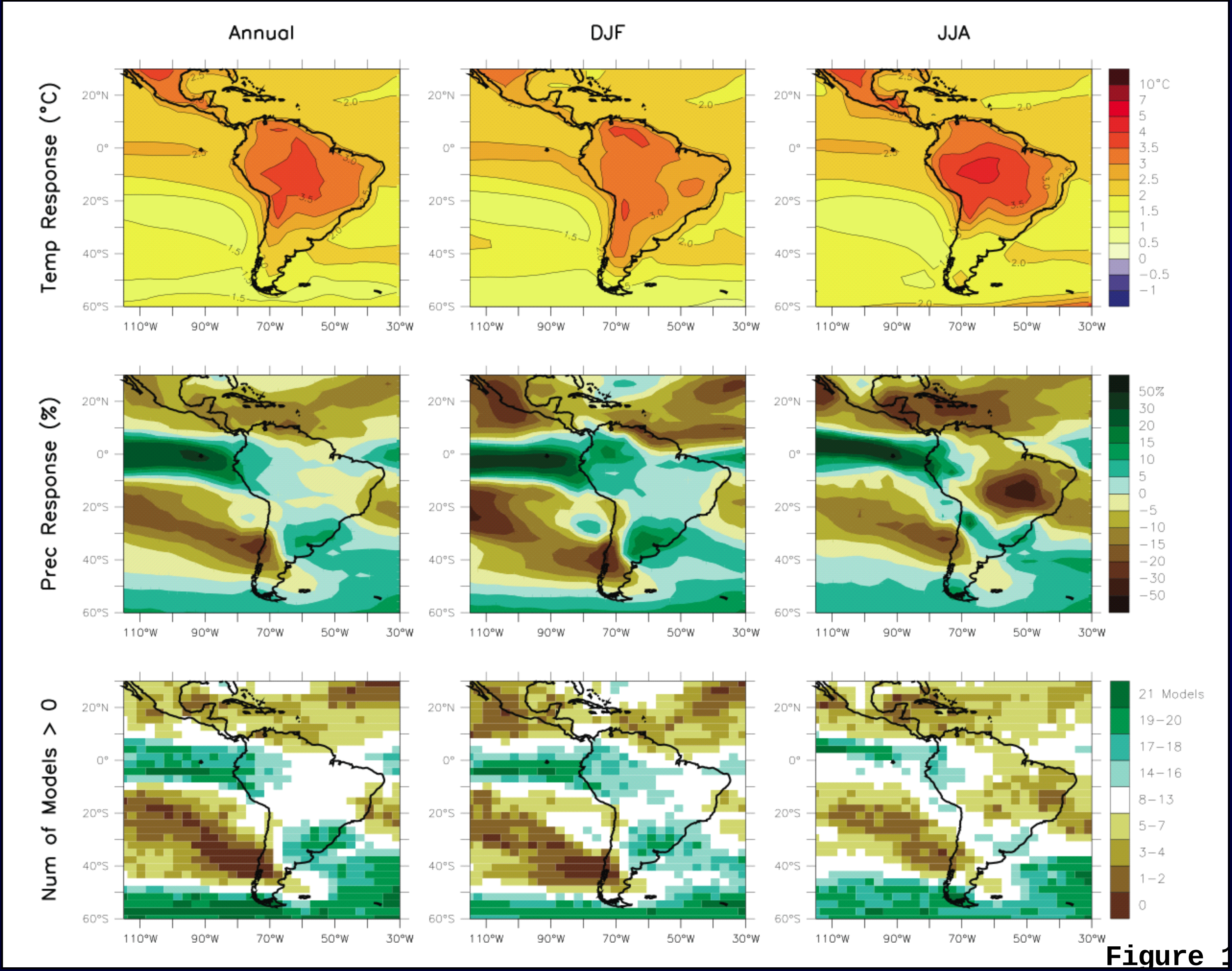


Figure 1

Regional changes: AUSTRALIA

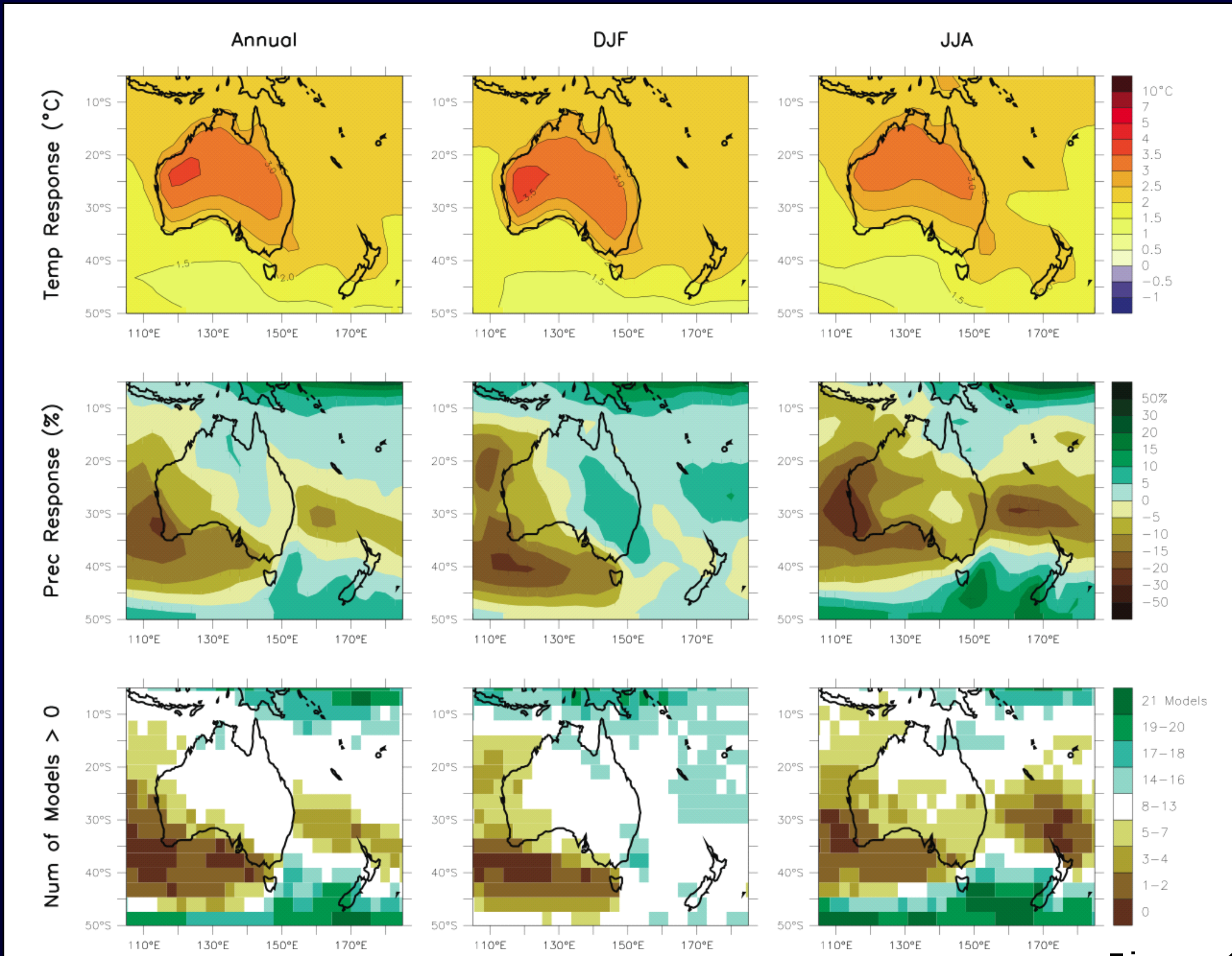
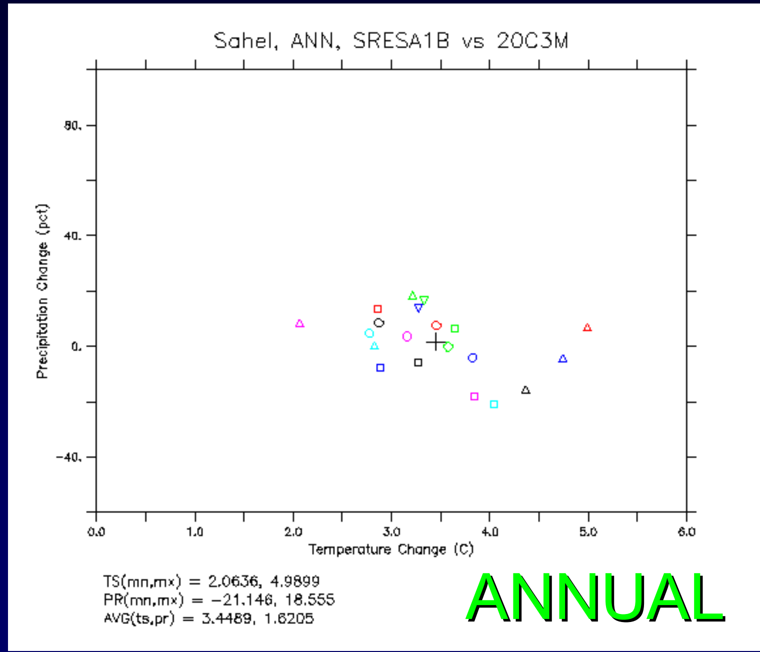
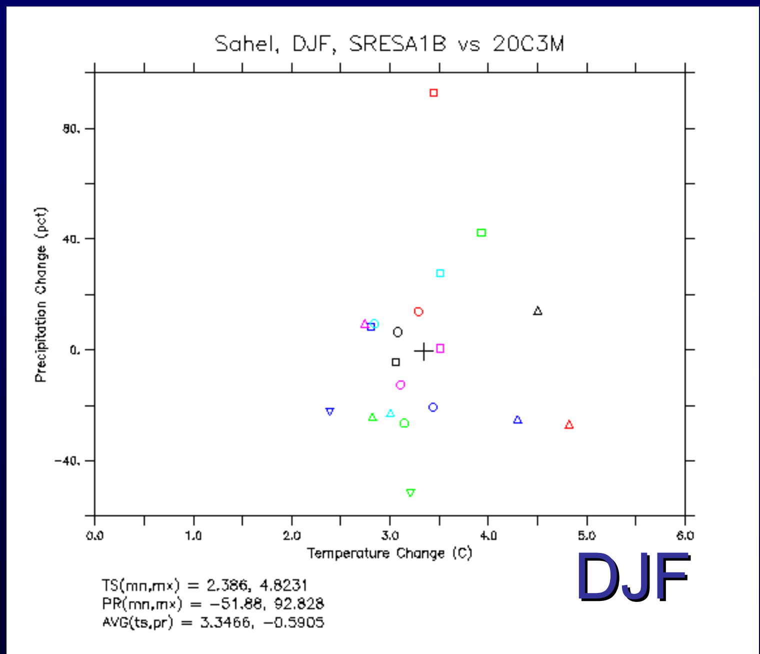


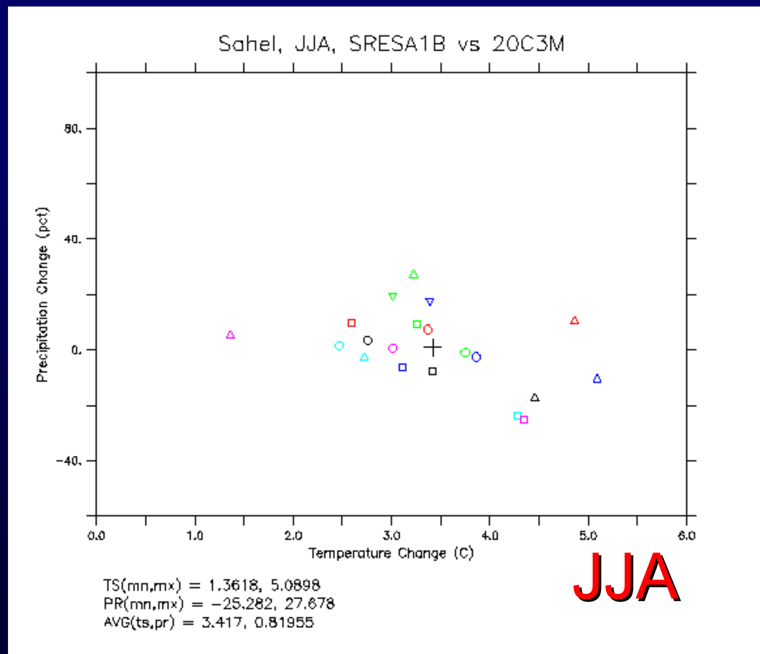
Figure 1

Example of inter-model spread



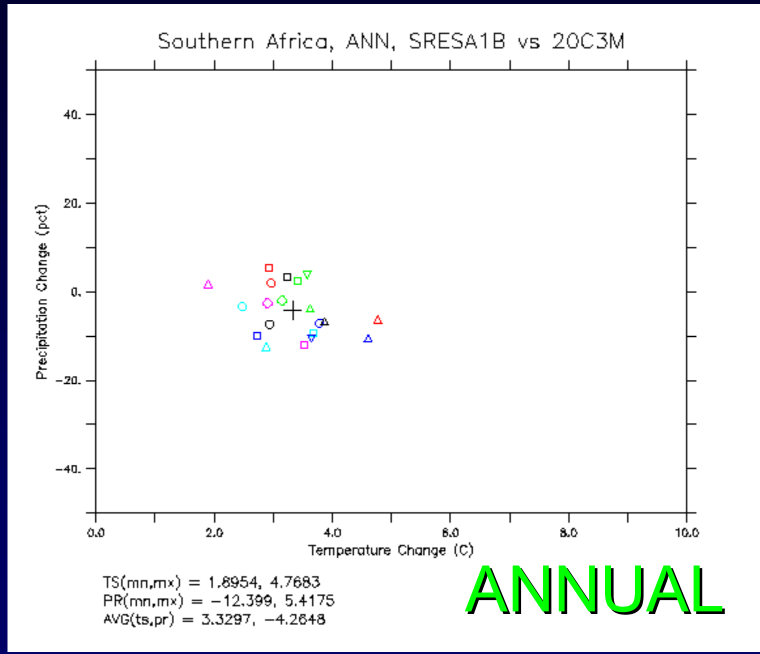
Sahel region,
P-change vs. T-change
(2079-2098) – (1979-1998)
A1B scenario, 21 models

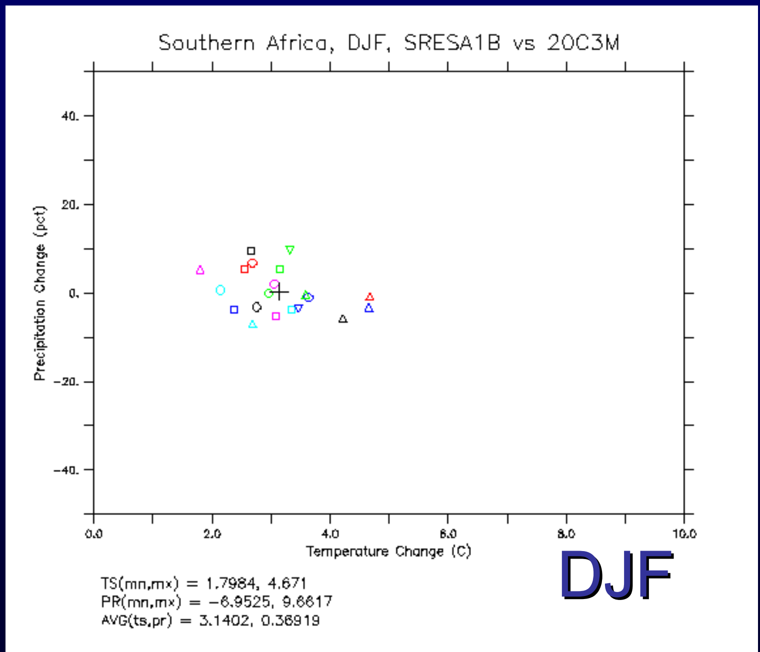


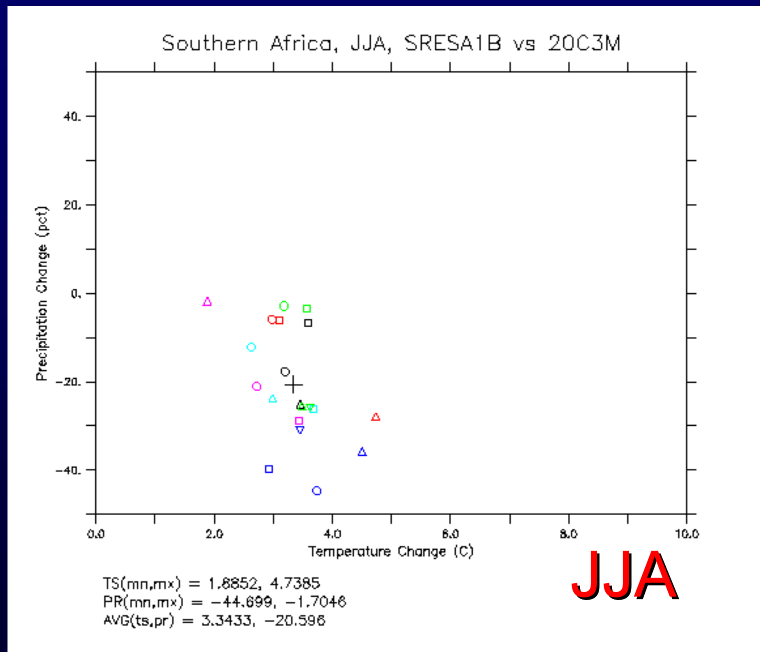


Example of inter-model spread

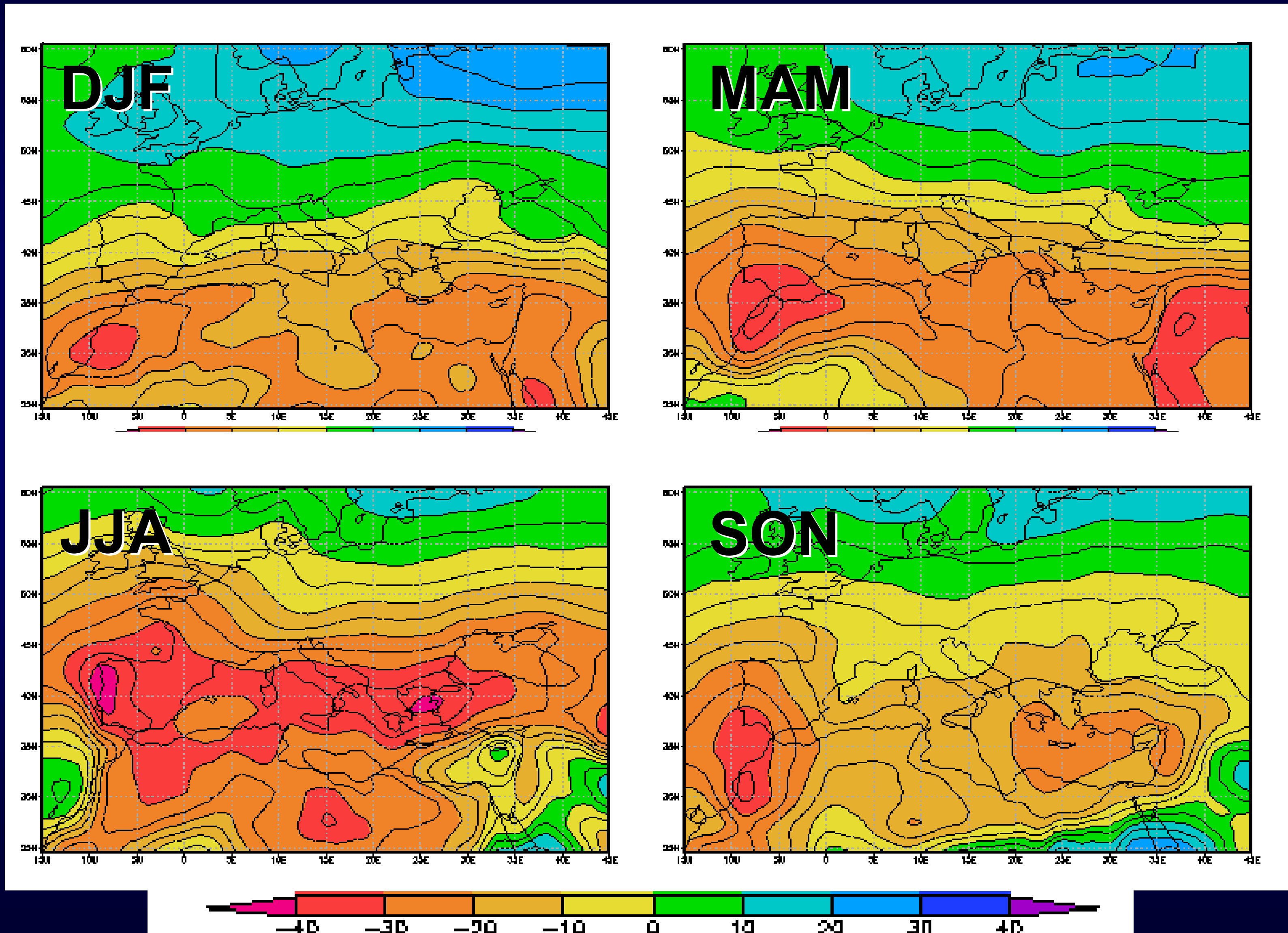
Southern Africa region,
P-change vs. T-change
(2079-2098) – (1979-1998)
A1B scenario, 21 models



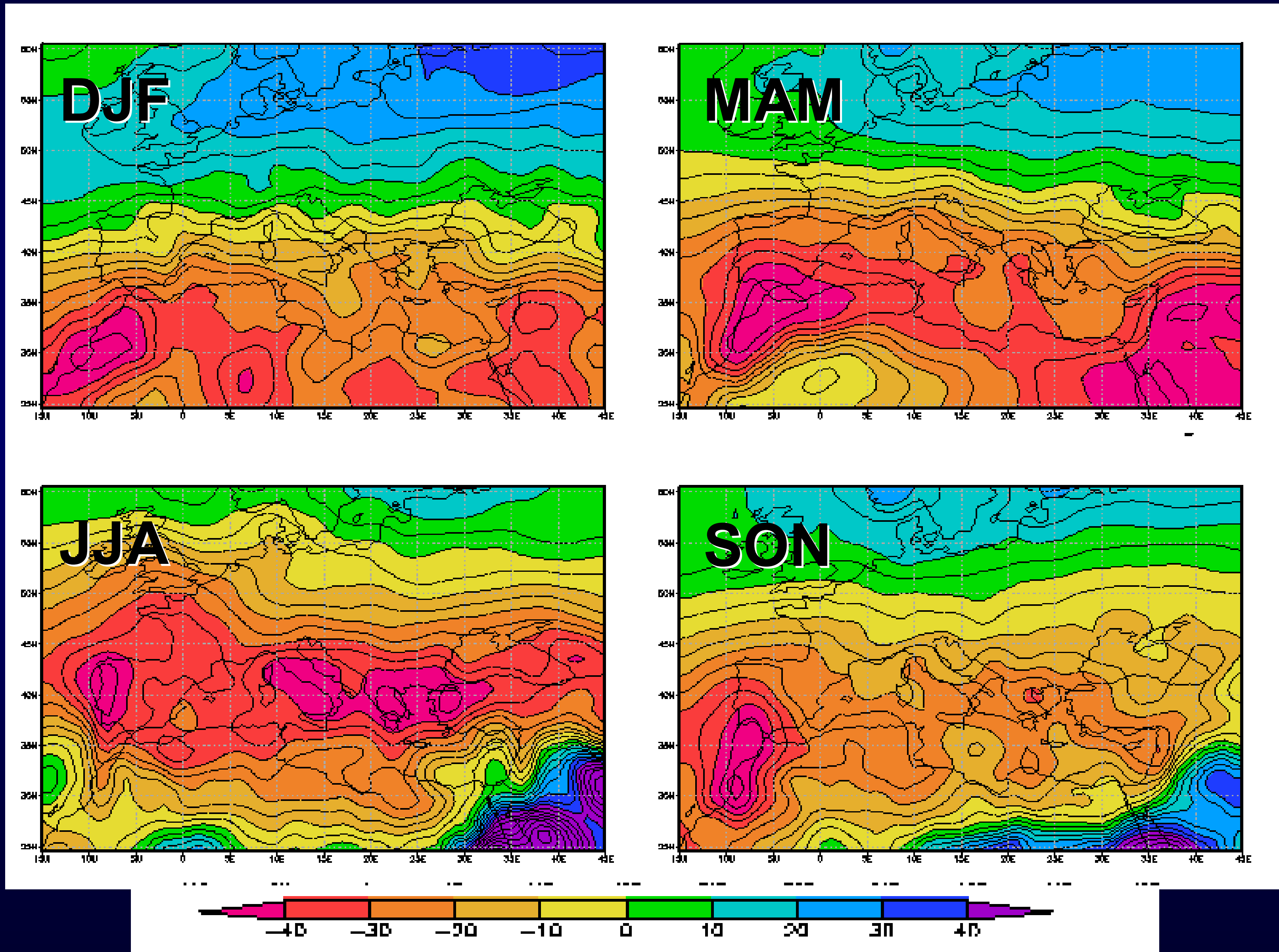




The scalability of climate change
Prec. change (%, 2071-2100 minus 1961-1990), A1B scen.

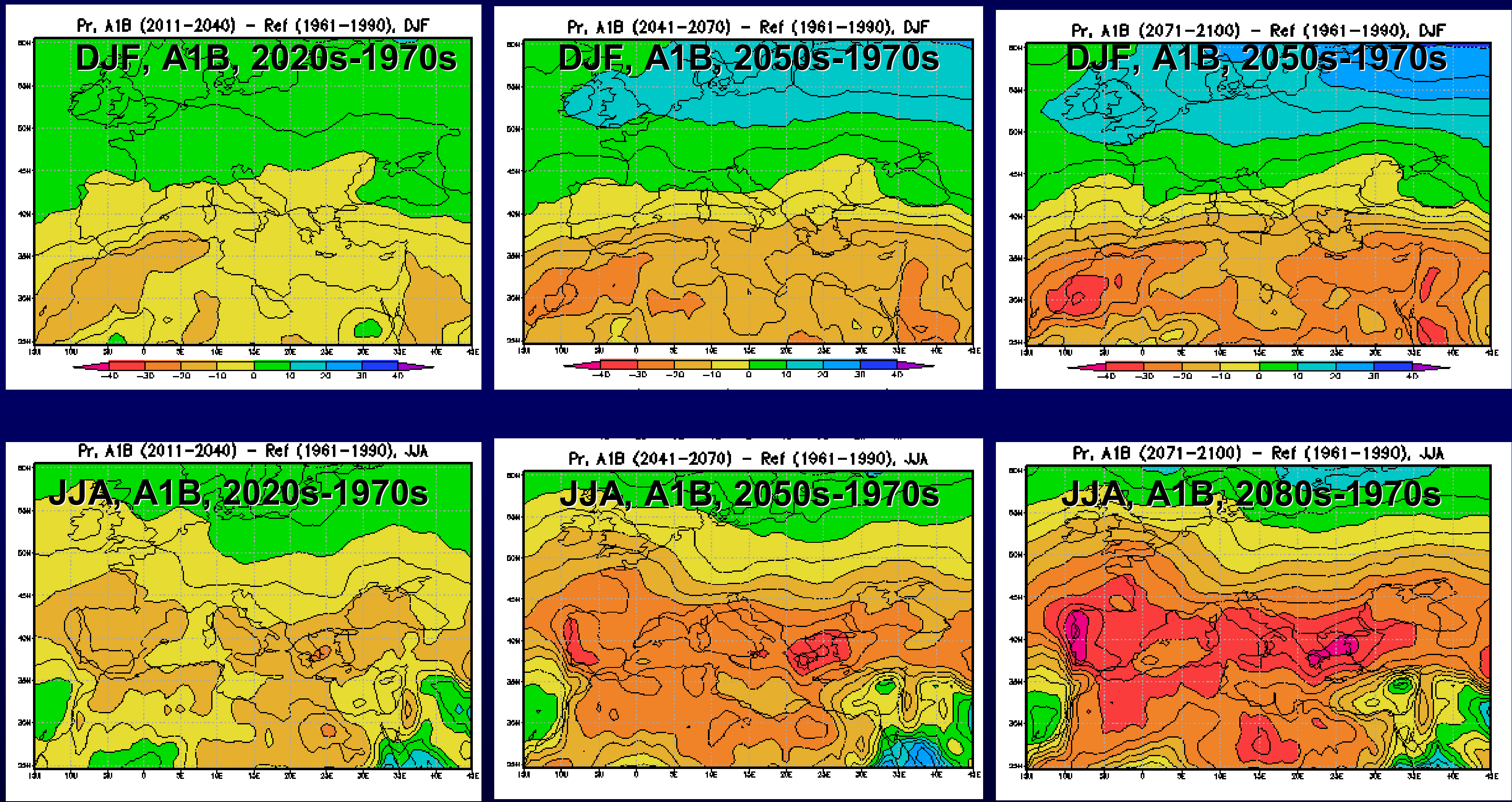


The scalability of climate change
Precip. change (%, 2071-2100 minus 1961-1990), A2 scen.



The scalability of climate change

Precipitation change as a function of time



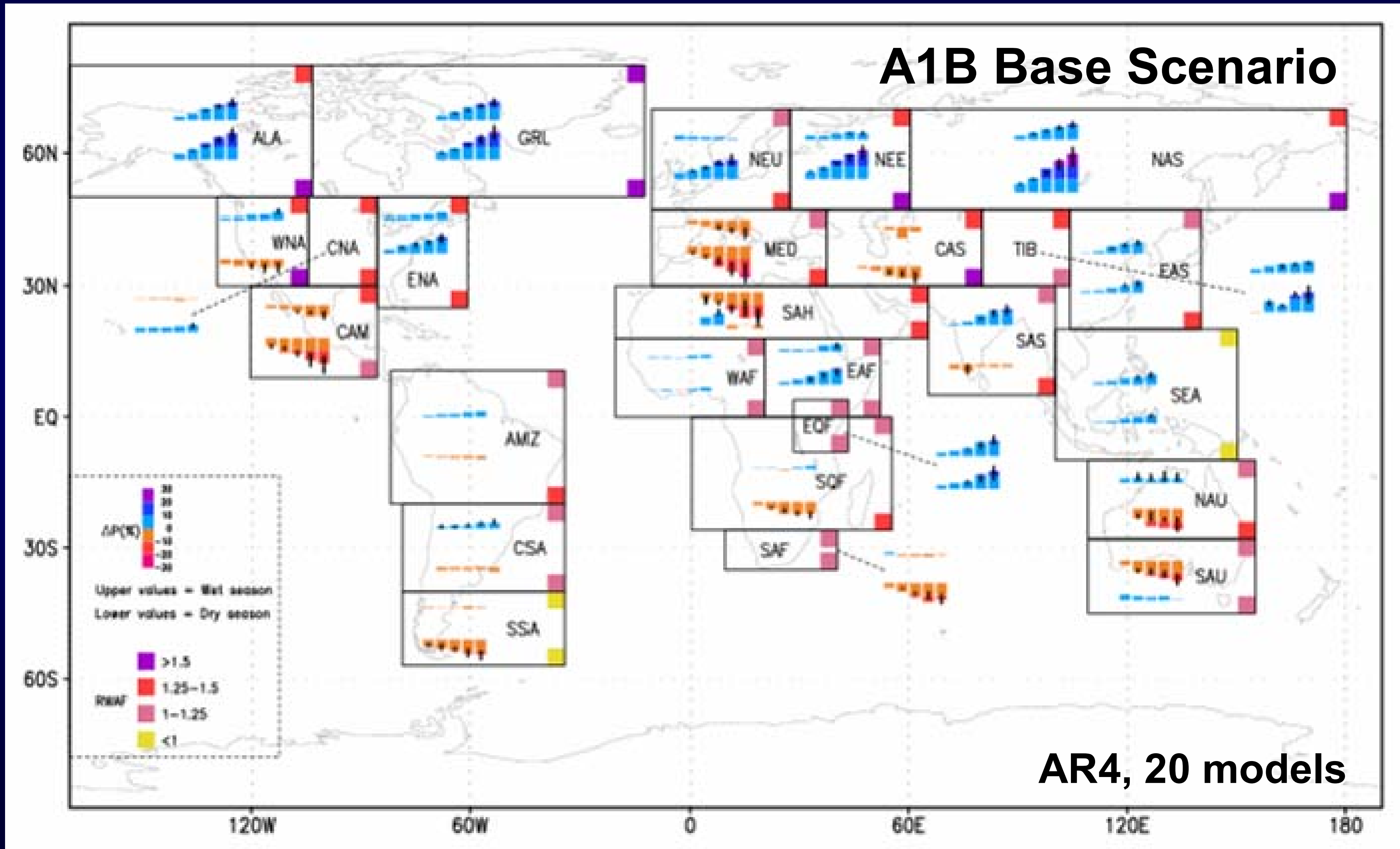
A regional analysis of the CMIP3 ensemble.

Regions and "seasons" used in the analysis

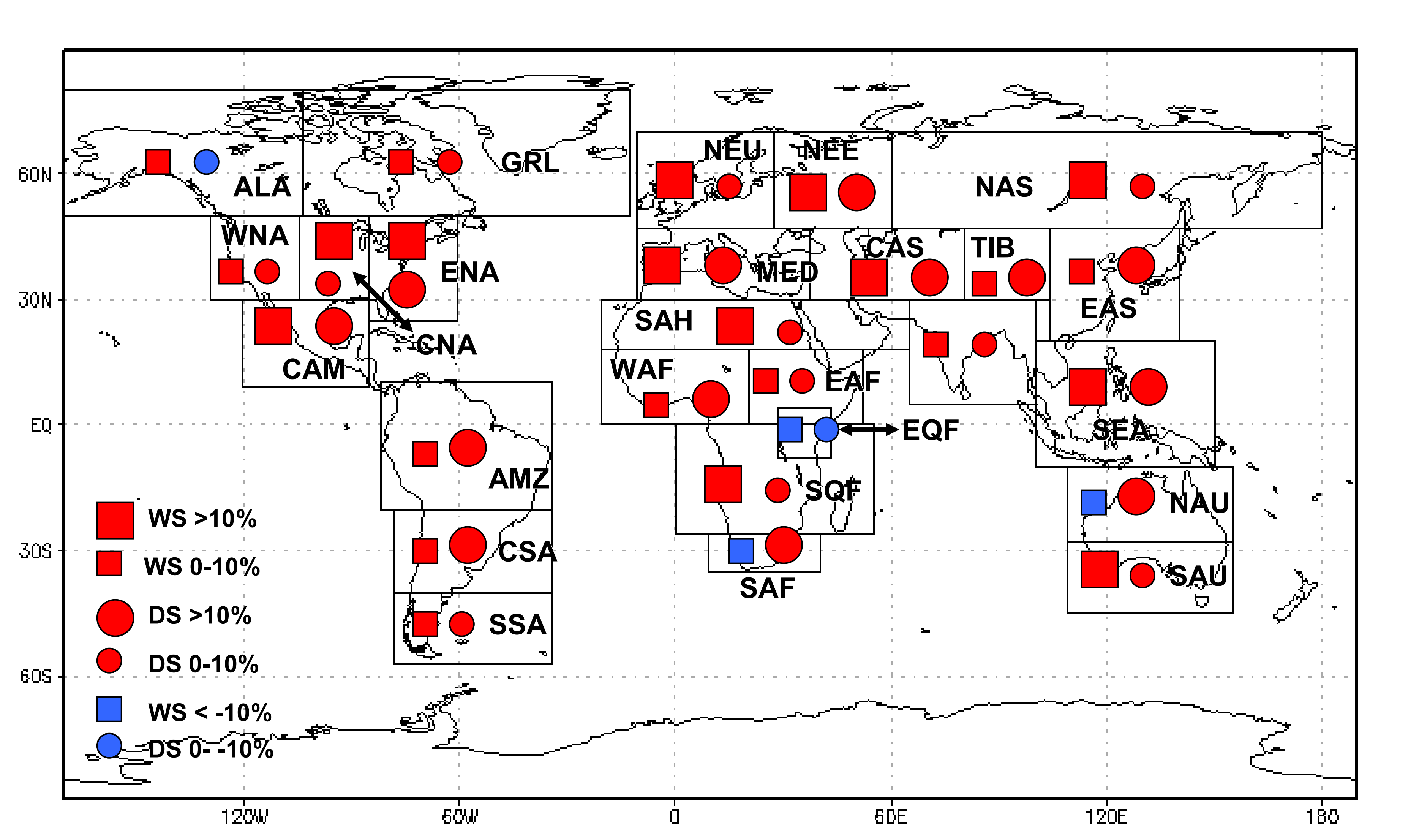
Table 2. Definition of "wet season" and "dry season" for the regions in Figure 1

Region	Lat; Lon	Wet Season	Dry Season
NEU	47 - 70 N; 10.5 W - 27.5 E	May-Oct.	Nov.-Apr.
MED	30 - 47 N; 10.5 W - 37.5 E	Oct.-Mar.	Apr.-Sept.
NEE	47 - 70 N; 27.5 - 60.5 E	May-Oct.	Nov.-Apr.
NAS	47 - 70 N; 60.5 - 180.5 E	May-Oct.	Nov.-Apr.
CAS	30 - 47 N; 37.5 - 80.5 E	Nov.-Apr.	May-Oct.
TIB	30 - 47 N; 80.5 - 104.5 E	Apr.-Sept.	Oct.-Mar.
EAS	20 - 47 N; 104.5 - 140.5 E	Apr.-Sept.	Oct.-Mar.
SAS	5 - 30 N; 104.5 - 140.5 E	May-Oct.	Nov.-Apr.
SEA	10 S - 20 N; 100.5 - 150.5 E	Apr.-Sept.	Oct.-Mar.
NAU	28 - 10 S; 109.5 - 155.5 E	Nov.-Apr.	May-Oct.
SAU	45 - 28 S; 109.5 - 155.5 E	May-Oct.	Nov.-Apr.
SAH	18 - 30 N; 20.5 W - 65.5 E	Nov.-Apr.	May-Oct.
WAF	0 - 18 N; 20.5 W - 20.5 E	May-Oct.	Nov.-Apr.
EAF	0 - 18 N; 20.5 - 52.5 E	May-Oct.	Nov.-Apr.
EQF	8 S - 4 N; 28.5 - 43.5 E	Feb.-July	Aug.-Jan.
SQF	26 - 0 S; 0.5 - 55.5 E	Nov.-Apr.	May-Oct.
SAF	35 - 26 S; 9.5 - 40.5 E	Oct.-Mar.	Apr.-Sept.
ALA	50 - 87 N; 179.5 - 103.5 W	June-Nov.	Dec.-May
GRL	50 - 87 N; 103.5 - 12.5 W	June-Nov.	Dec.-May
WNA	30 - 50 N; 129.5 - 103.5 W	Oct.-Mar.	Apr.-Sept.
CNA	30 - 50 N; 103.5 - 85.5 W	Apr.-Sept.	Oct.-Mar.
ENA	25 - 50 N; 85.5 - 60.5 W	Apr.-Sept.	Oct.-Mar.
CAM	12 - 30 N; 120.5 - 83.5 W	May-Oct.	Nov.-Apr.
AMZ	20 S - 10 N; 78.5 - 34.5 W	Nov.-Apr.	May-Oct.
CSA	40 - 20 S; 78.5 - 34.5 W	Oct.-Mar.	Apr.-Sept.
SSA	56 - 40 S; 78.5 - 34.5 W	Apr.-Sept.	Oct.-Mar.

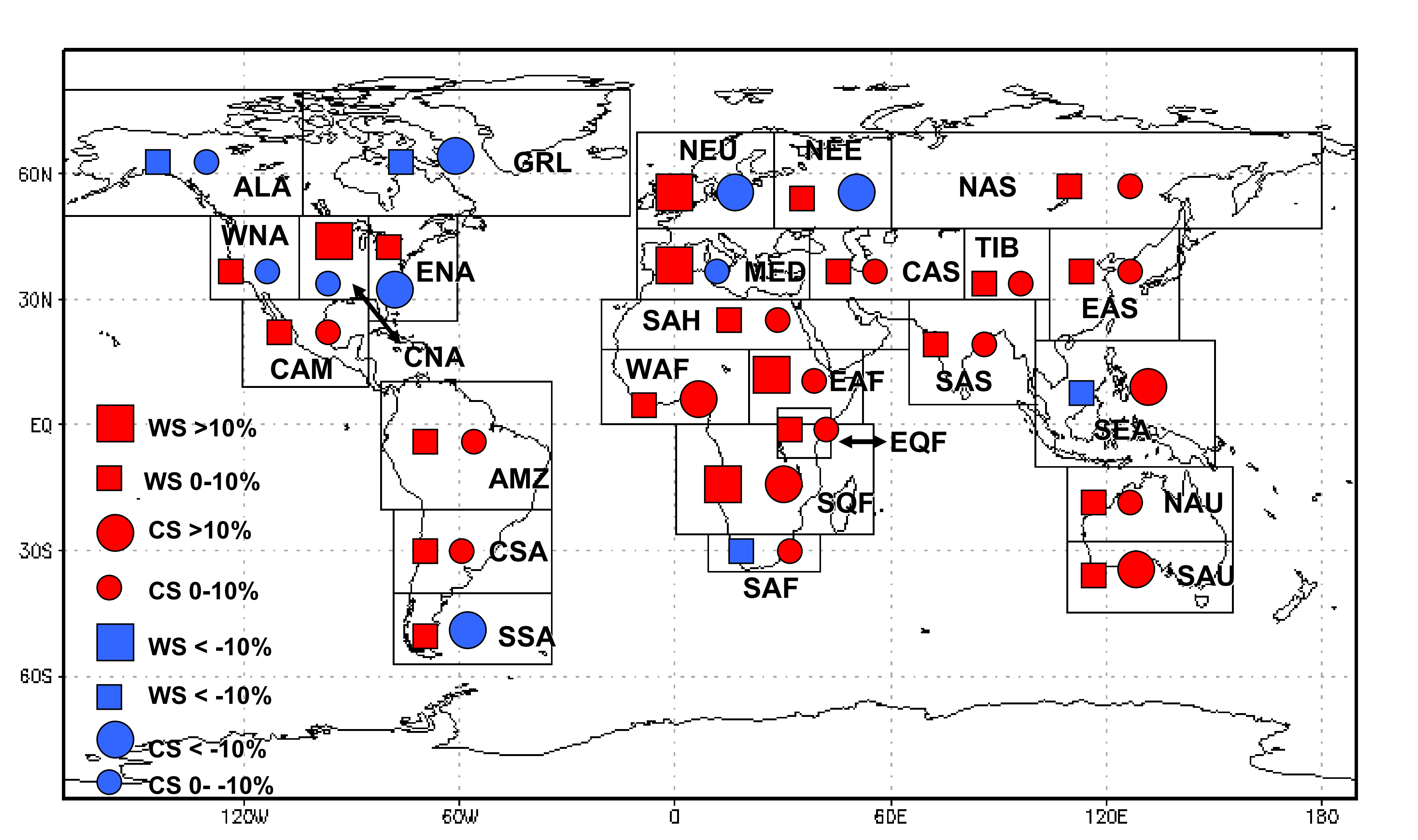
CMIP3 ensemble average regional temperature and precipitation change



Change in precipitation interannual variability
(2080-2099, 20 models, A1B-A2-B1 scenarios)

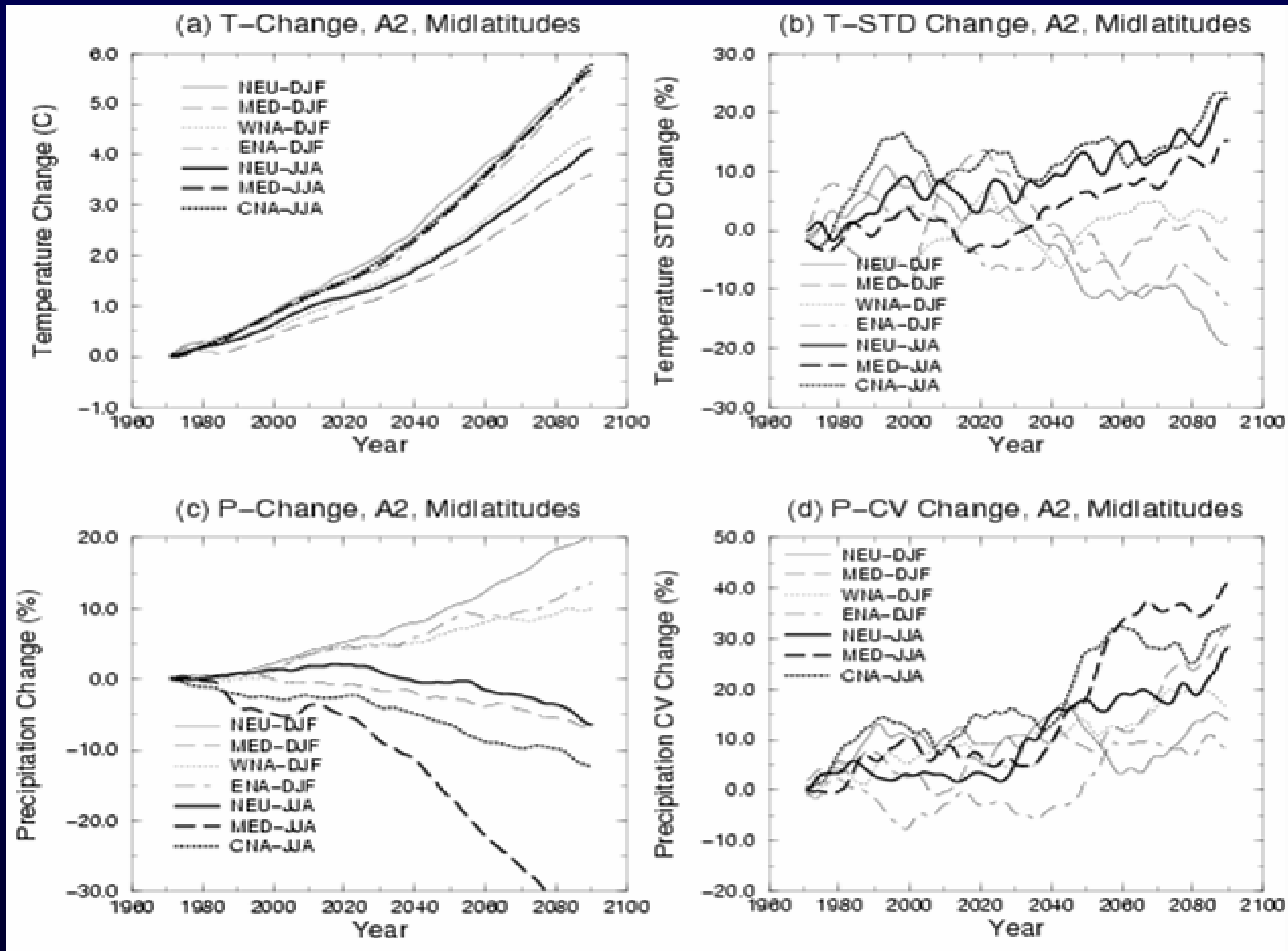


Change in temperature interannual variability
(2080-2099, 20 models, A1B-A2-B1 scenarios)



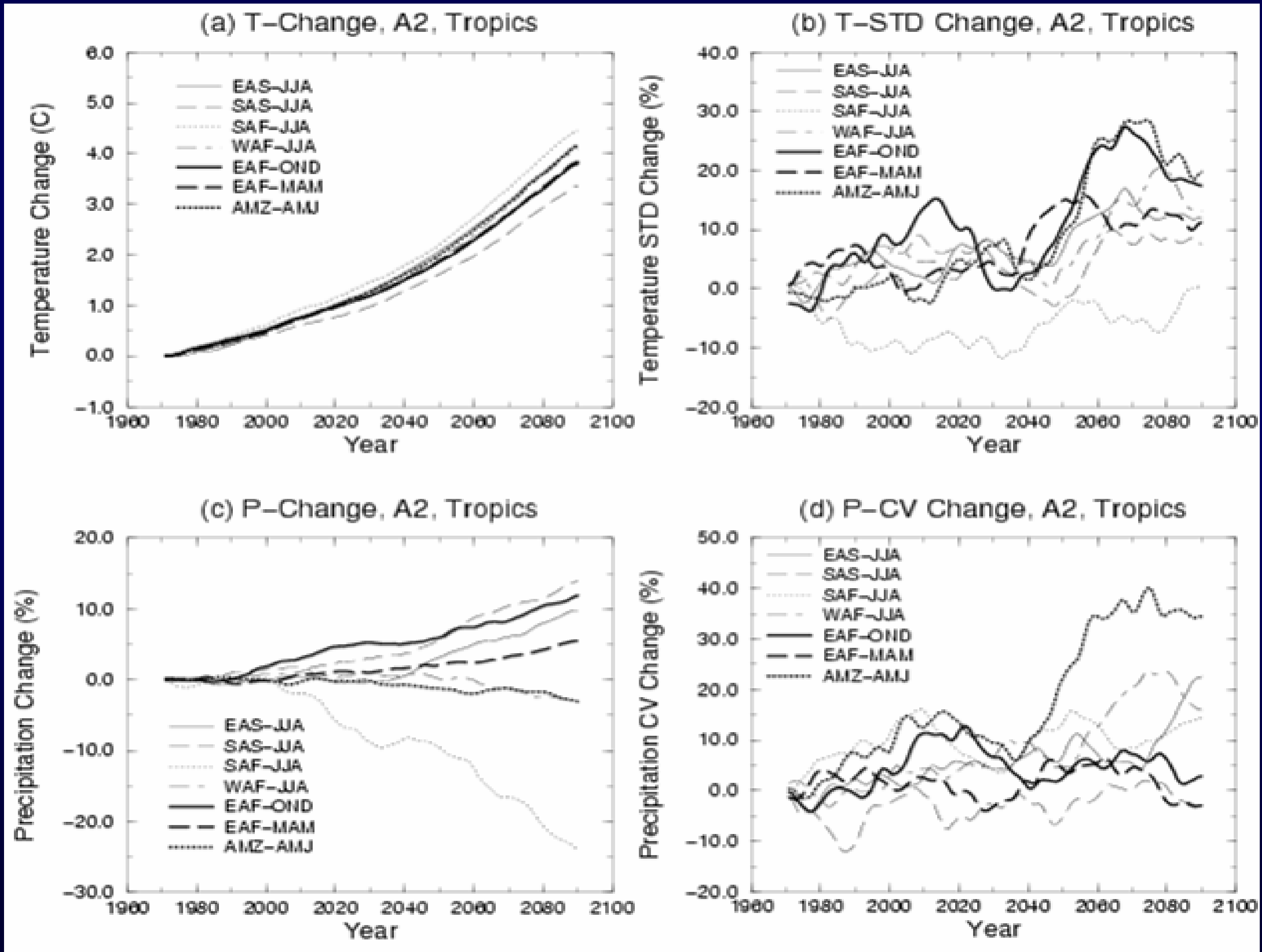
Ensemble average change in regional temperature and precipitation variability for the 21st century

Mid-latitude regions, A2 scenario, 18 models



Ensemble average change in regional temperature and precipitation variability for the 21st century

Tropical regions, A2 scenario, 18 models



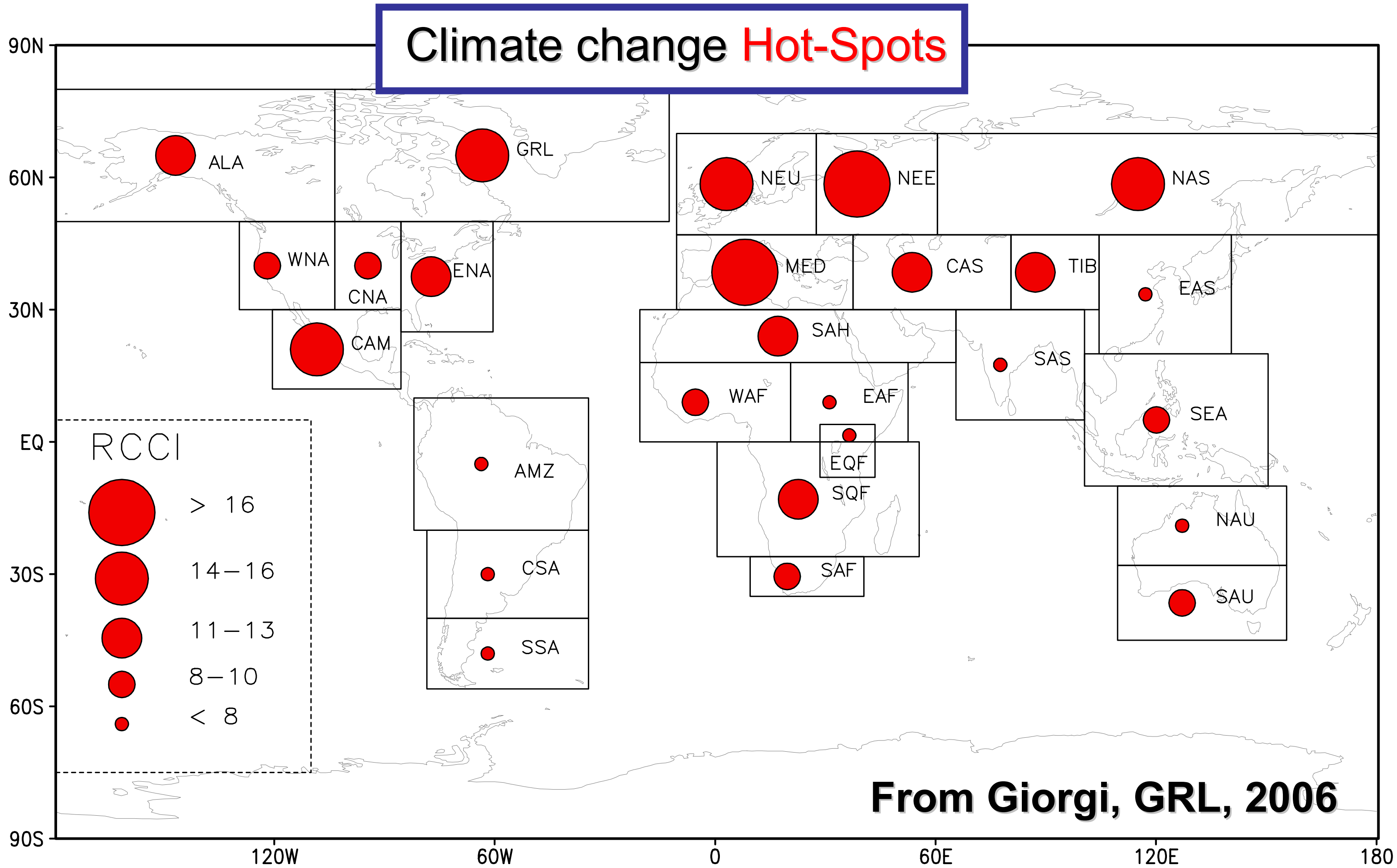
Regional Climate Change Index (RCCI)

$$RCCI = [n(\Delta P) + n(\Delta\sigma_P) + n(RWAF) + n(\Delta\sigma_T)]_{WS} +$$

$$[n(\Delta P) + n(\Delta\sigma_P) + n(RWAF) + n(\Delta\sigma_T)]_{DS}$$

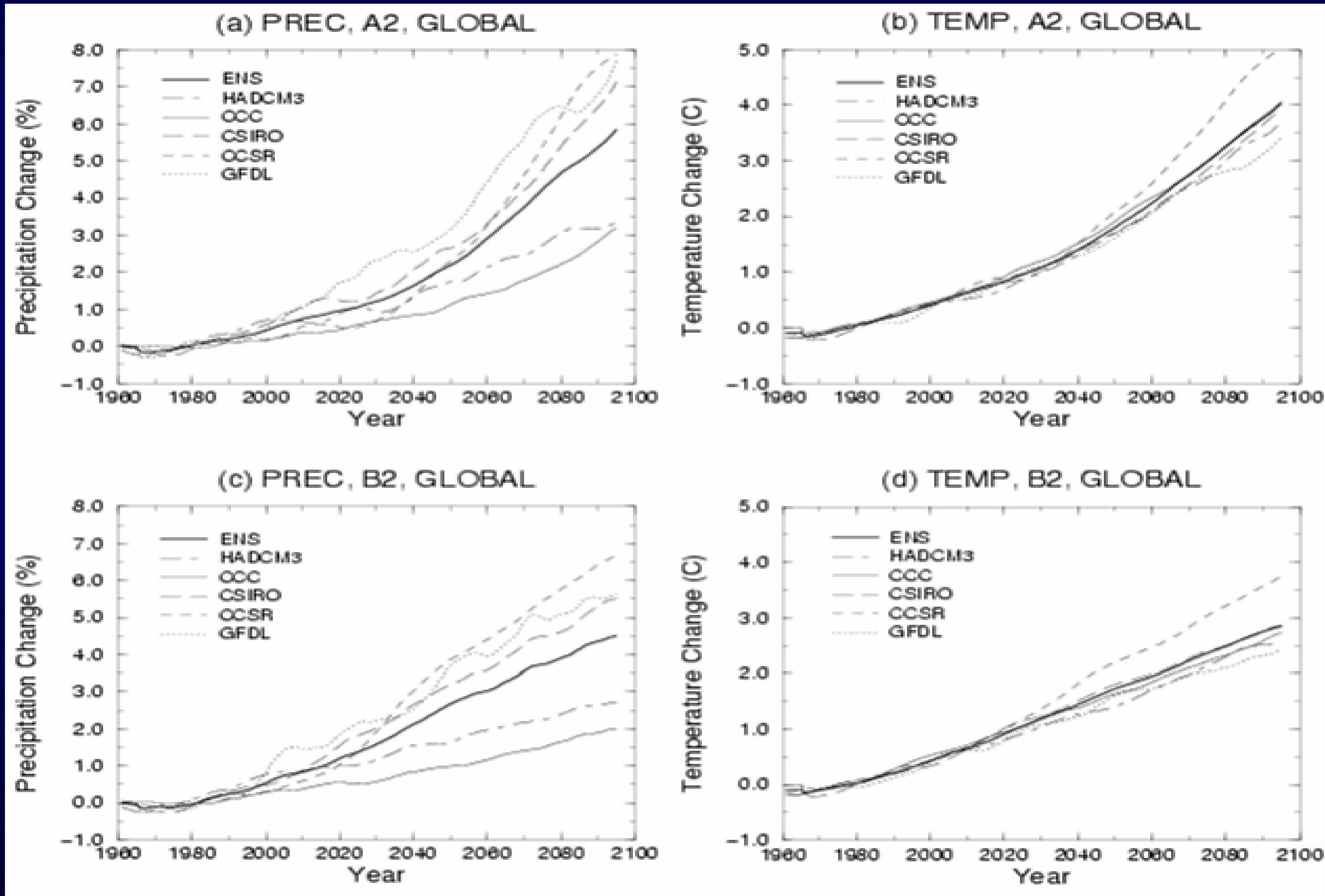
n	ΔP	$\Delta\sigma_P$	RWAF	$\Delta\sigma_T$
0	$< 5\%$	$< 5\%$	< 1.1	$< 5\%$
1	$5-10\%$	$5-10\%$	$1.1-1.3$	$5-10\%$
2	$10-15\%$	$10-20\%$	$1.3-1.5$	$10-15\%$
4	$> 15\%$	$> 20\%$	> 1.5	$> 15\%$

Climate change hot-spots



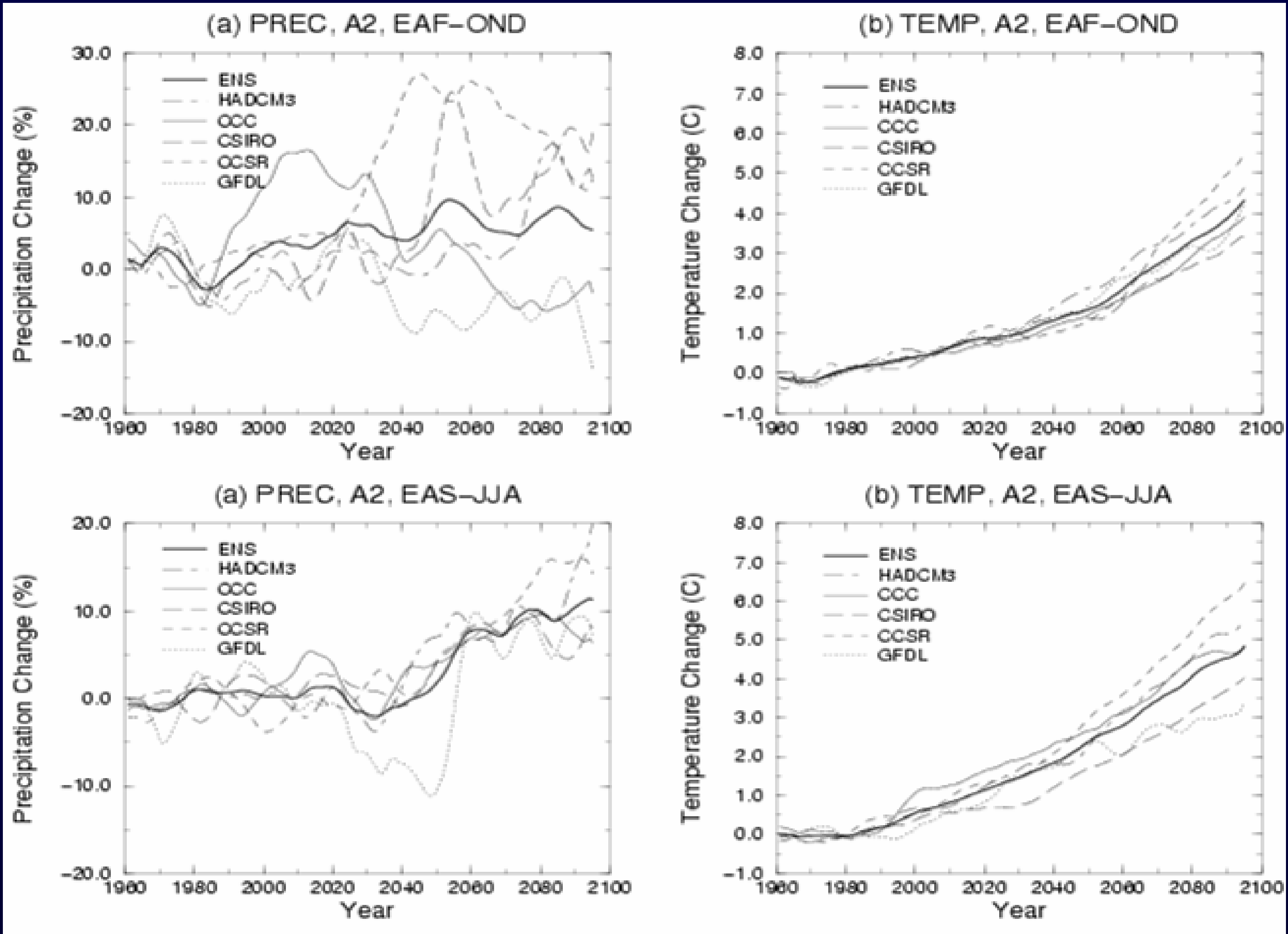
Global vs. regional climate change

Global

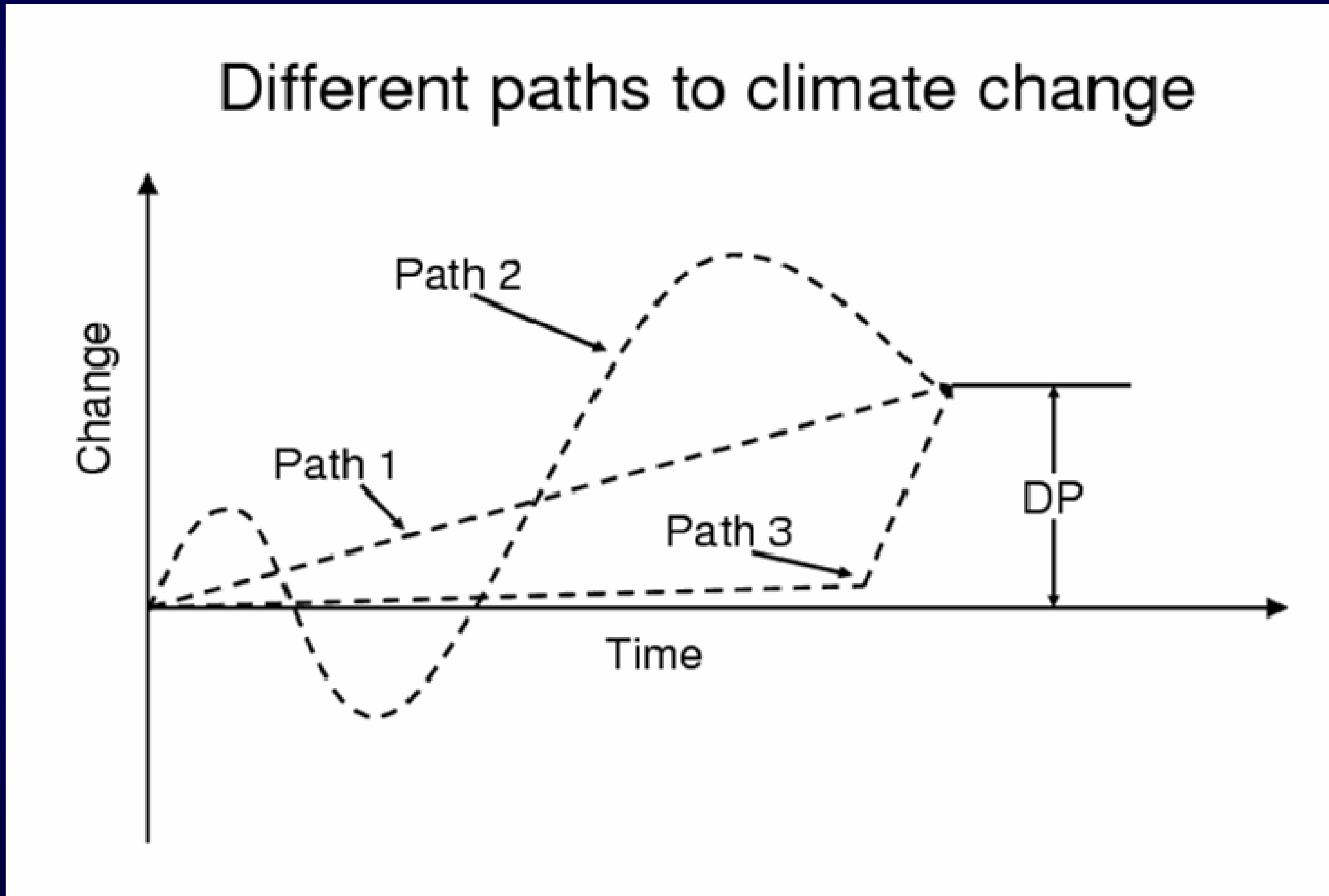


Global vs. regional climate change

Regional



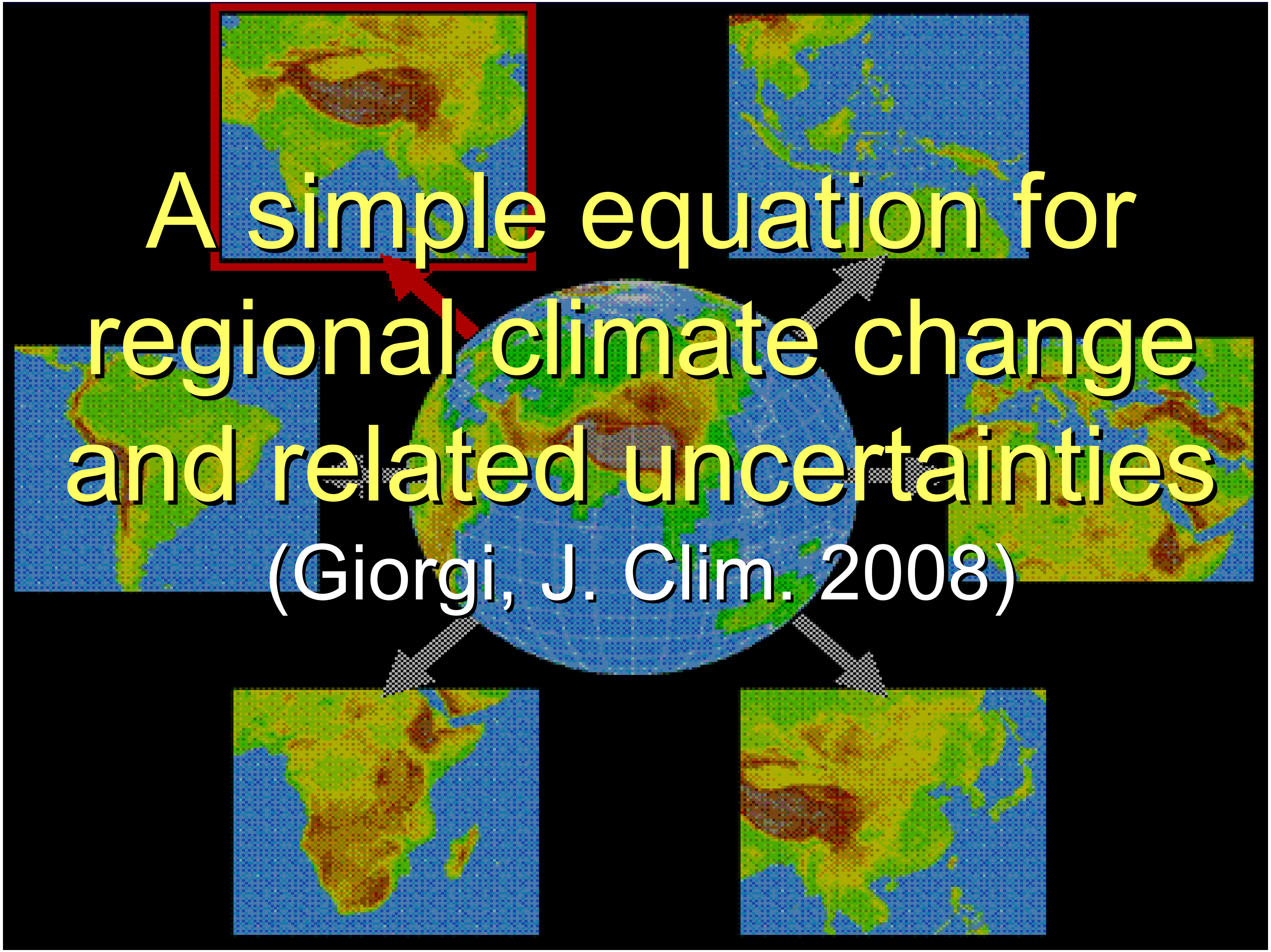
The "path" to regional climate change is important for impacts and may change across models and realizations



Need to add "decadal" noise to ensemble average signal

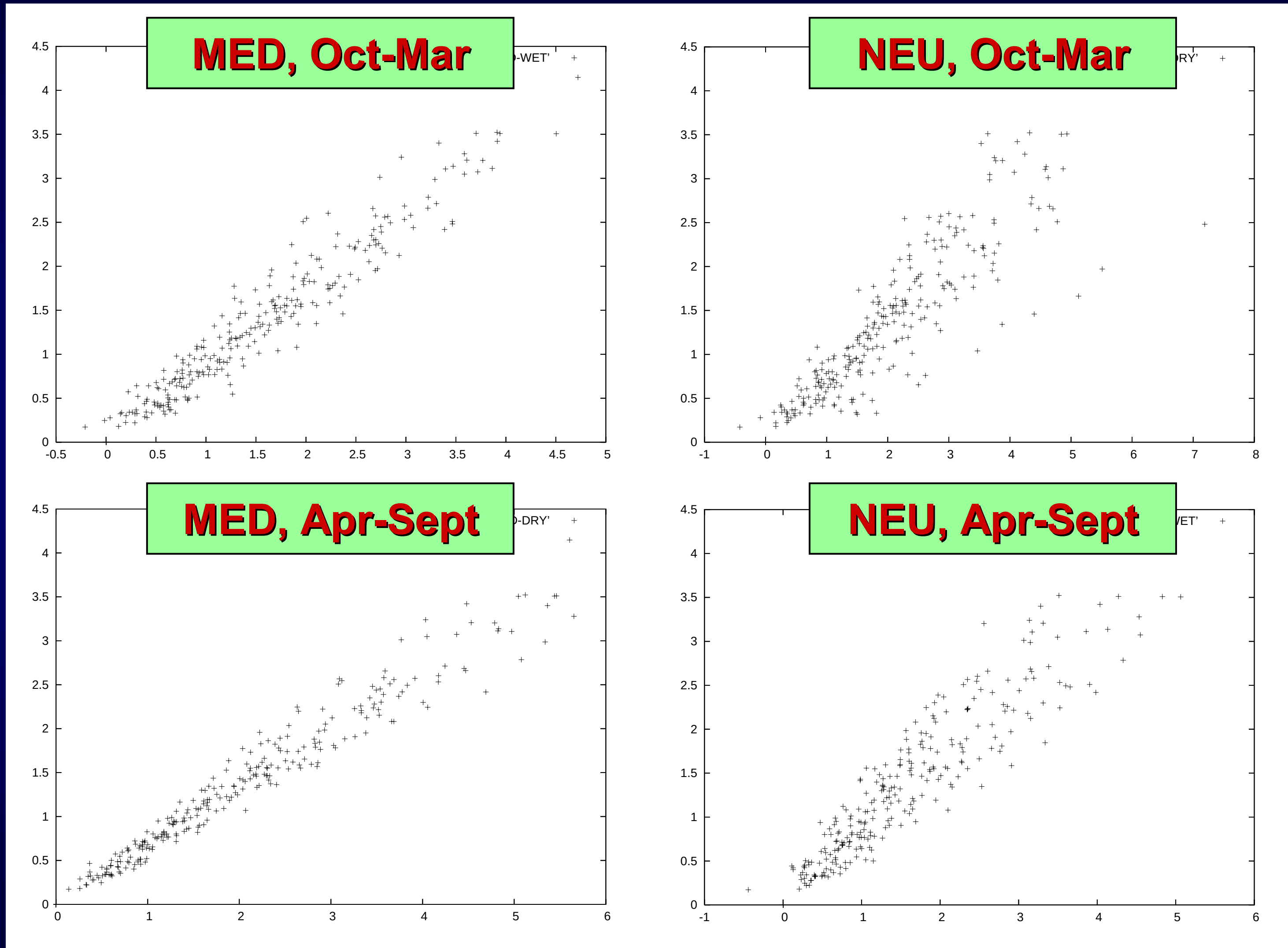
A simple equation for regional climate change and related uncertainties

(Giorgi, J. Clim. 2008)



Global vs. regional climate change: Temperature

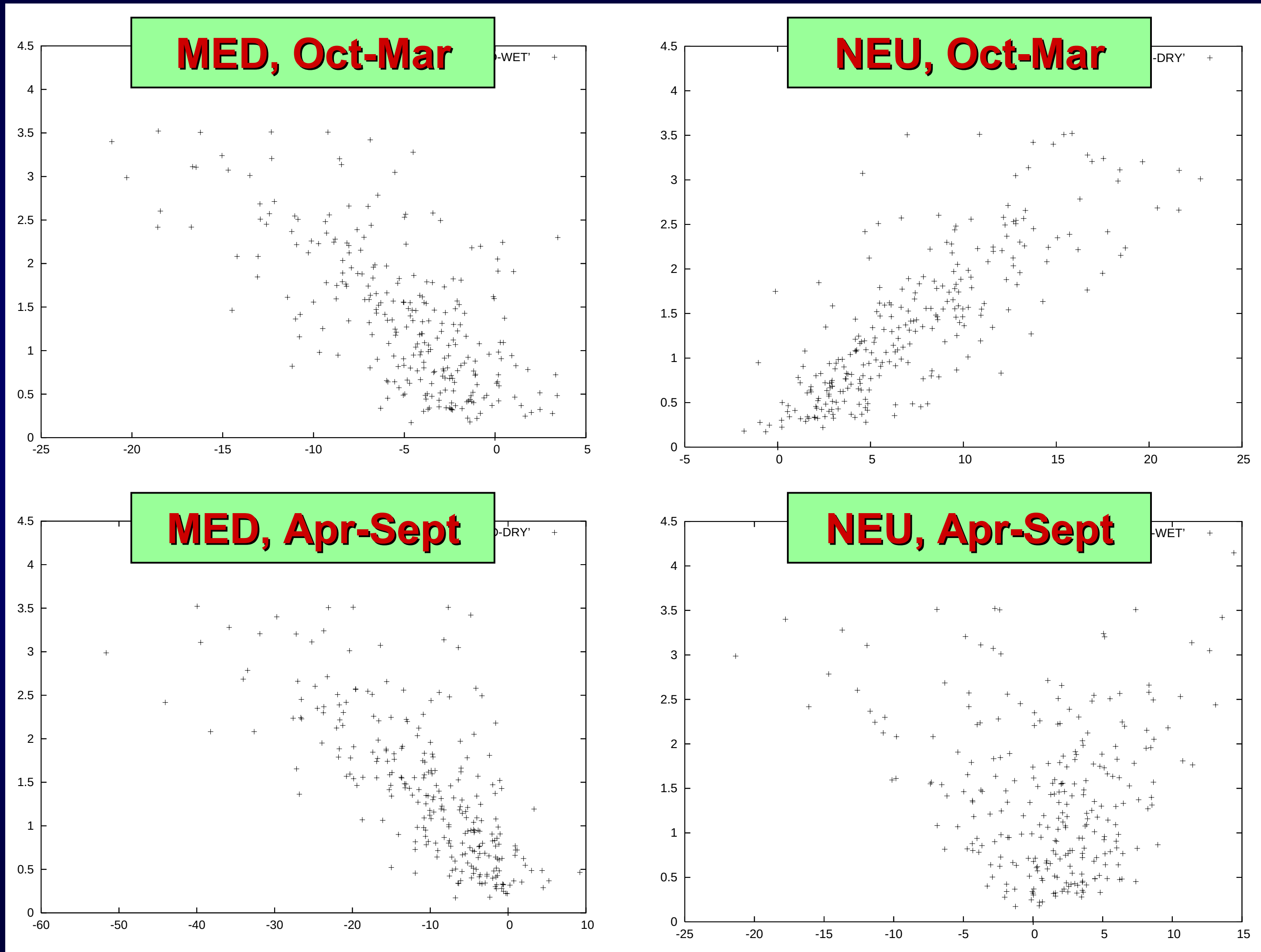
Global temperature change



Regional temperature change

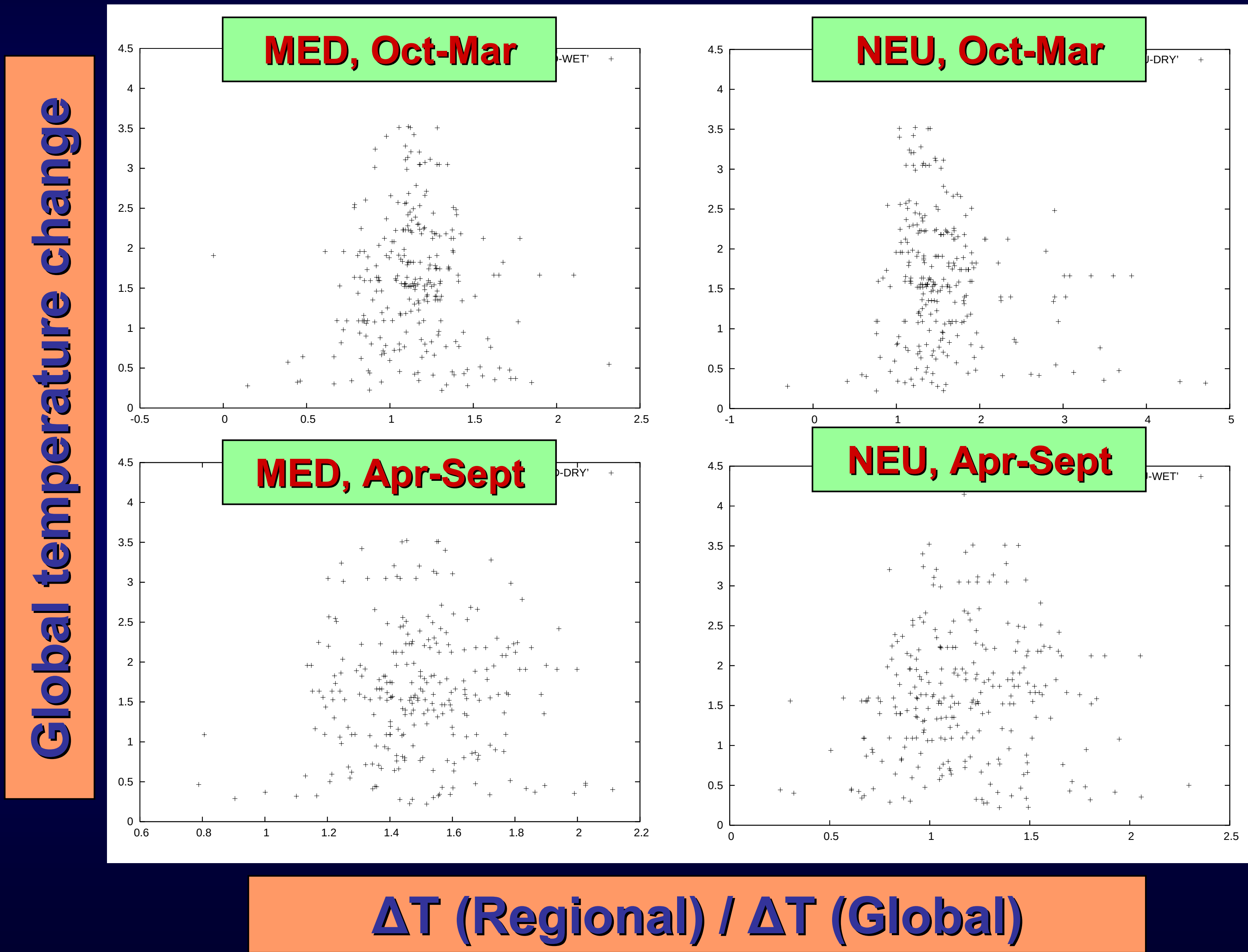
Global vs. regional climate change: Precipitation

Global temperature change

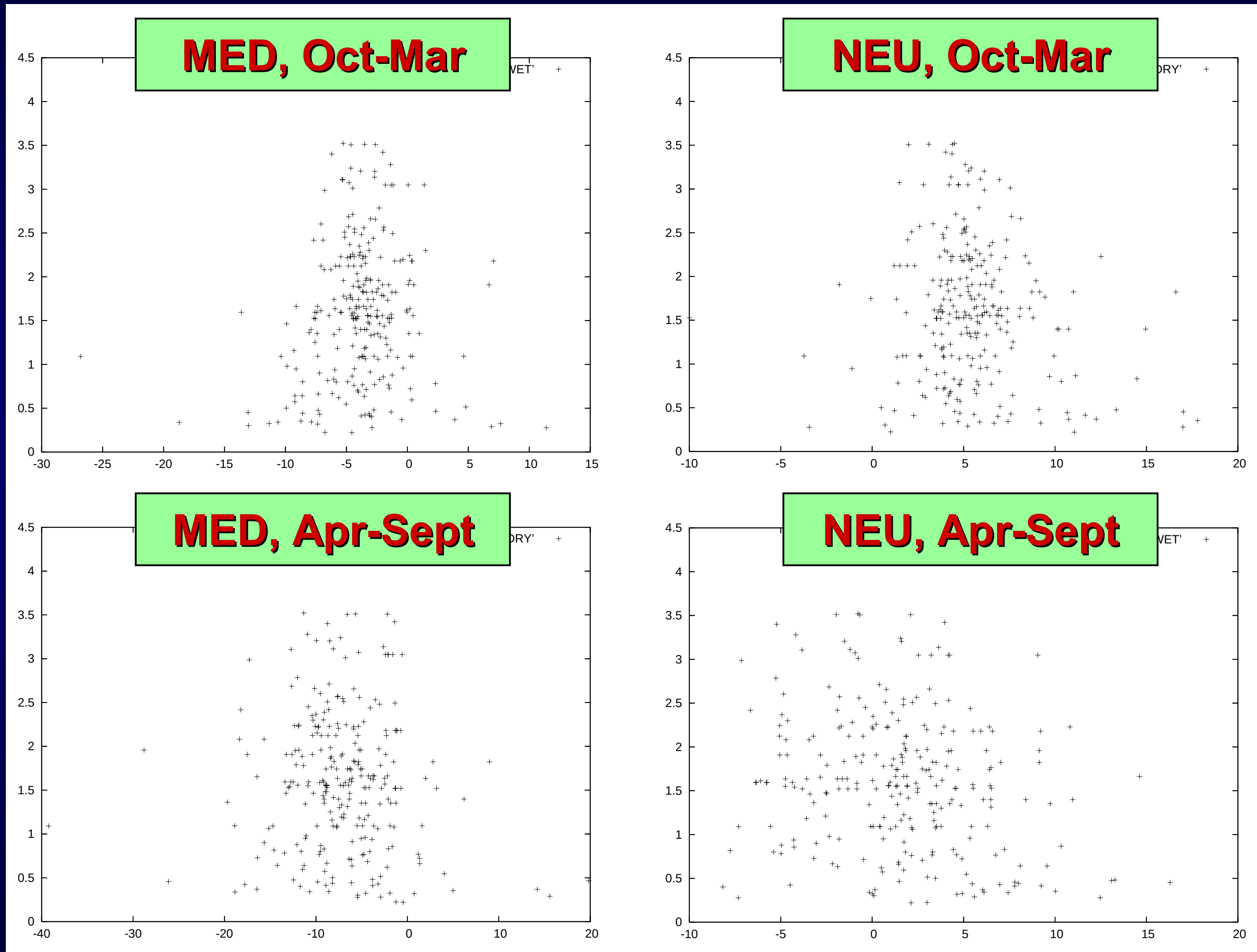


Regional precipitation change

Global vs. regional climate change: Temperature



Global vs. regional climate change: Precipitation



Global temperature change

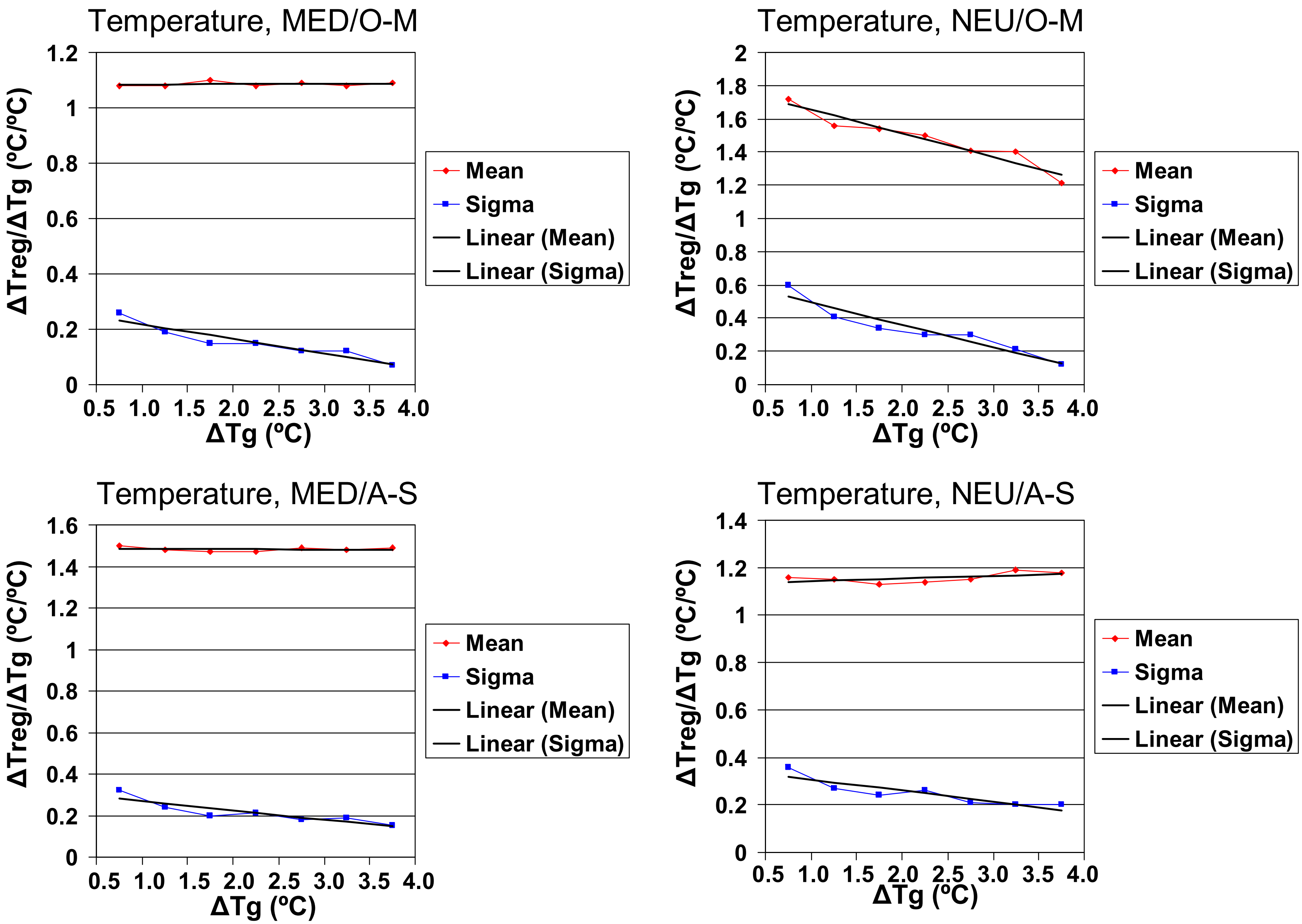
ΔP (Regional) / ΔT (Global)

The relationship between regional temperature/precipitation change and the global temperature change suggests the use of a simple predictive equation

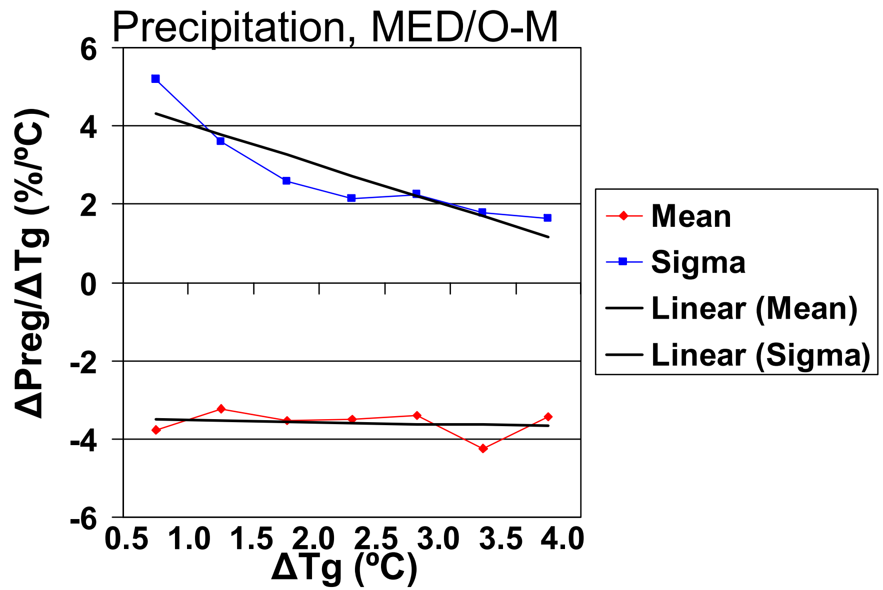
$$\Delta Treg/\Delta Tg = K\ (\Delta Tg)$$
$$\sigma\ (\Delta Treg/\Delta Tg) = K\ (\Delta Tg)$$

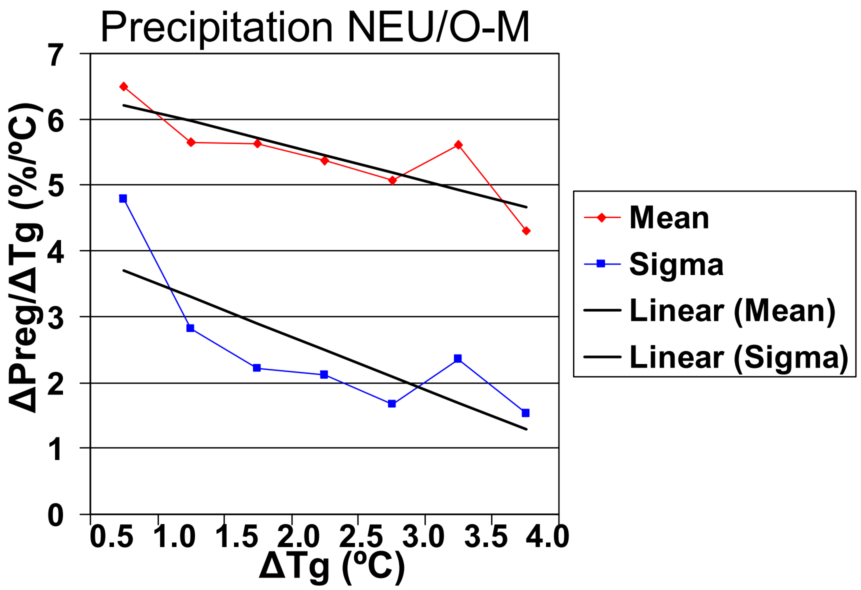
$$\Delta Preg/\Delta Tg = K\ (\Delta Tg)$$
$$\sigma\ (\Delta Preg/\Delta Tg) = K\ (\Delta Tg)$$

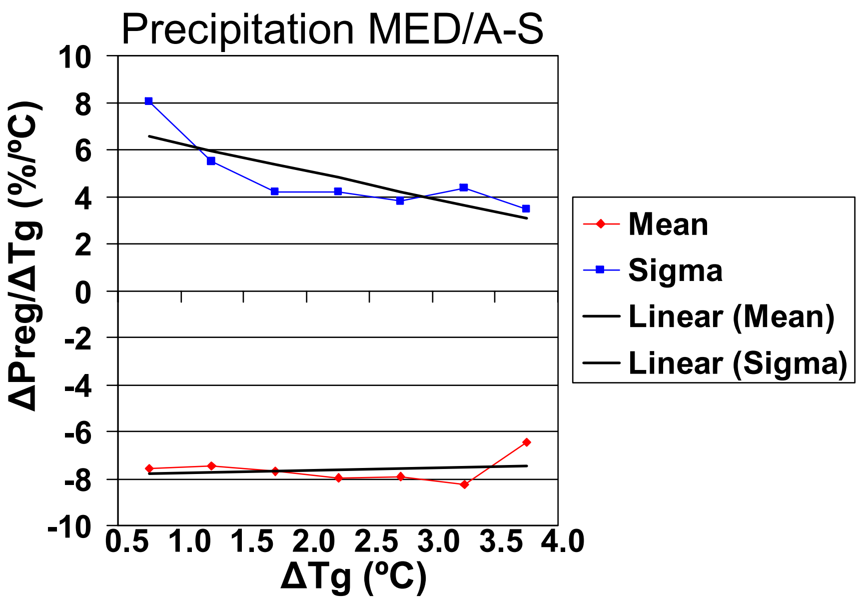
Examples of the function K(ΔTg) for temperature

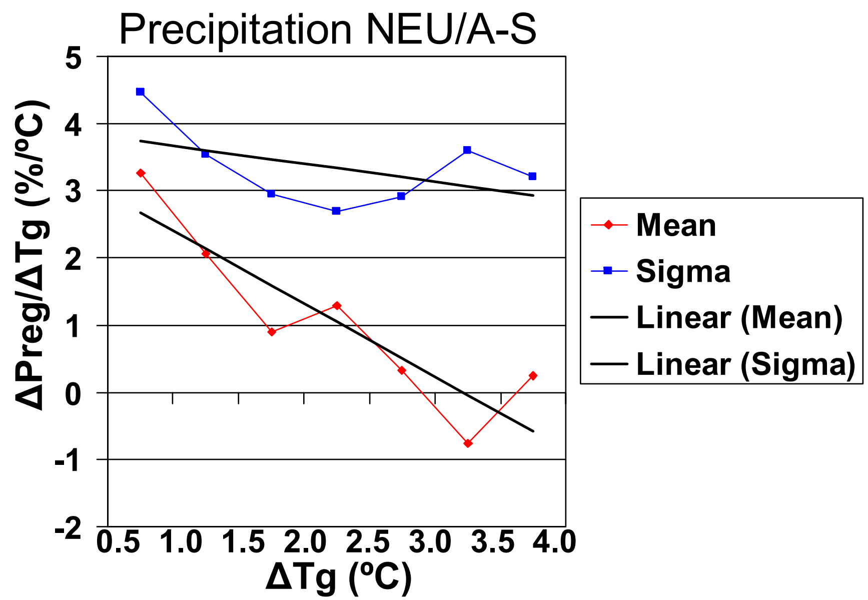


Examples of the function K(ΔTg) for precipitation





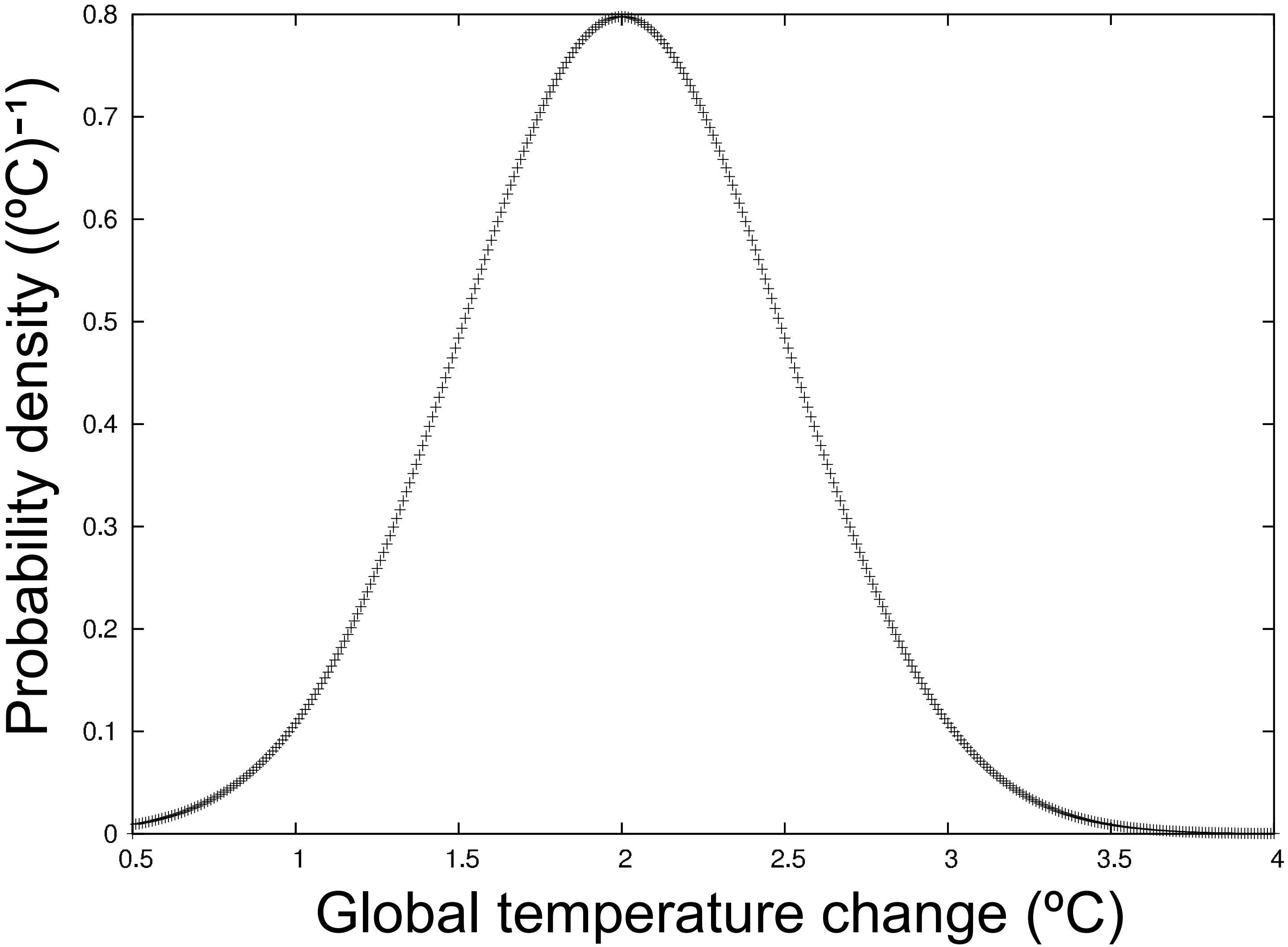




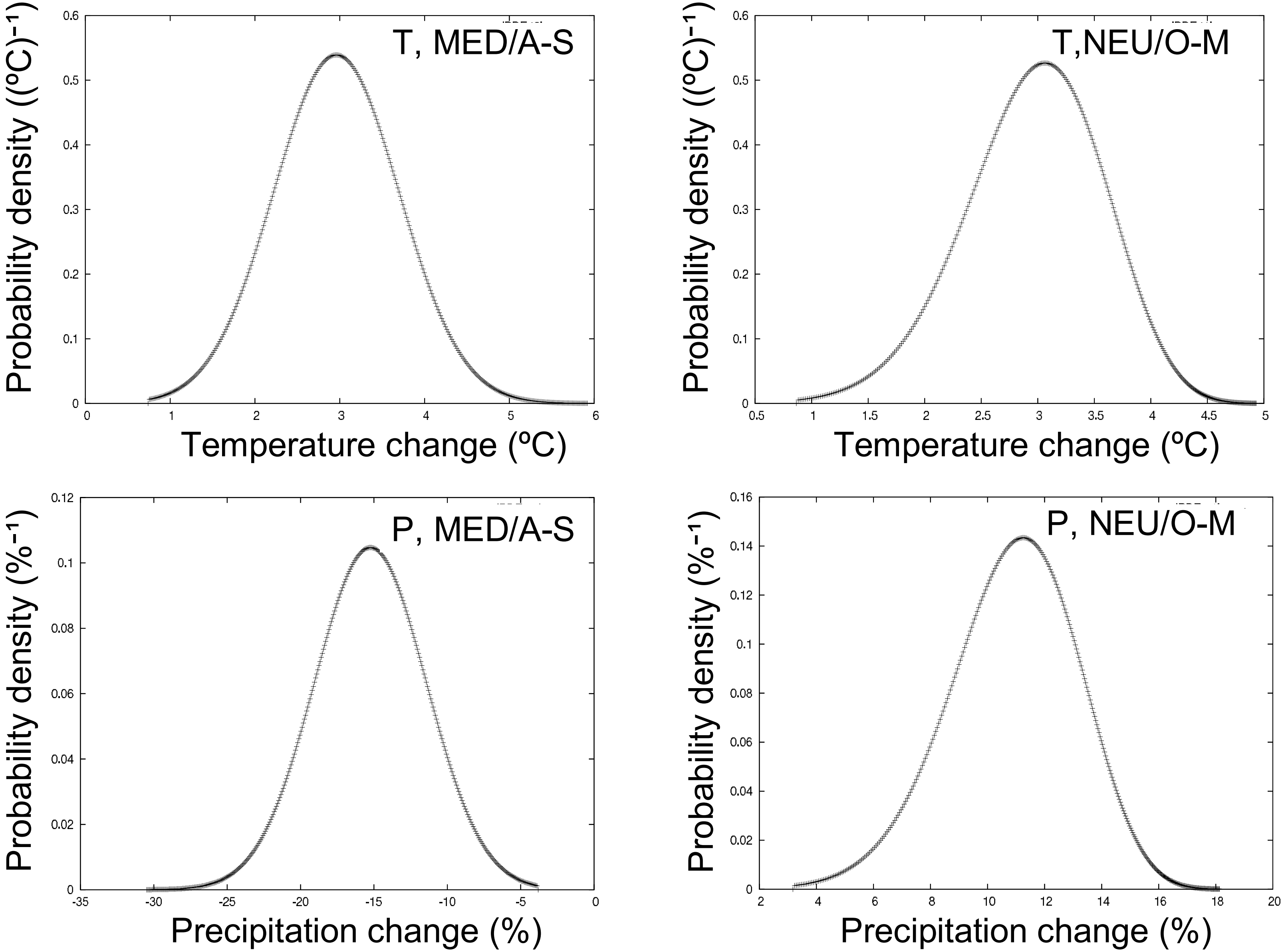
Applications

- Development of PDFs of regional change from PDFs of ΔTg
  - Based on simple or intermediate complexity global models
- Estimates of regional changes corresponding to given target ΔTg stabilization values
  - e.g. European target of 2 degrees global warming
- Estimates of regional changes from small samples of emission scenarios

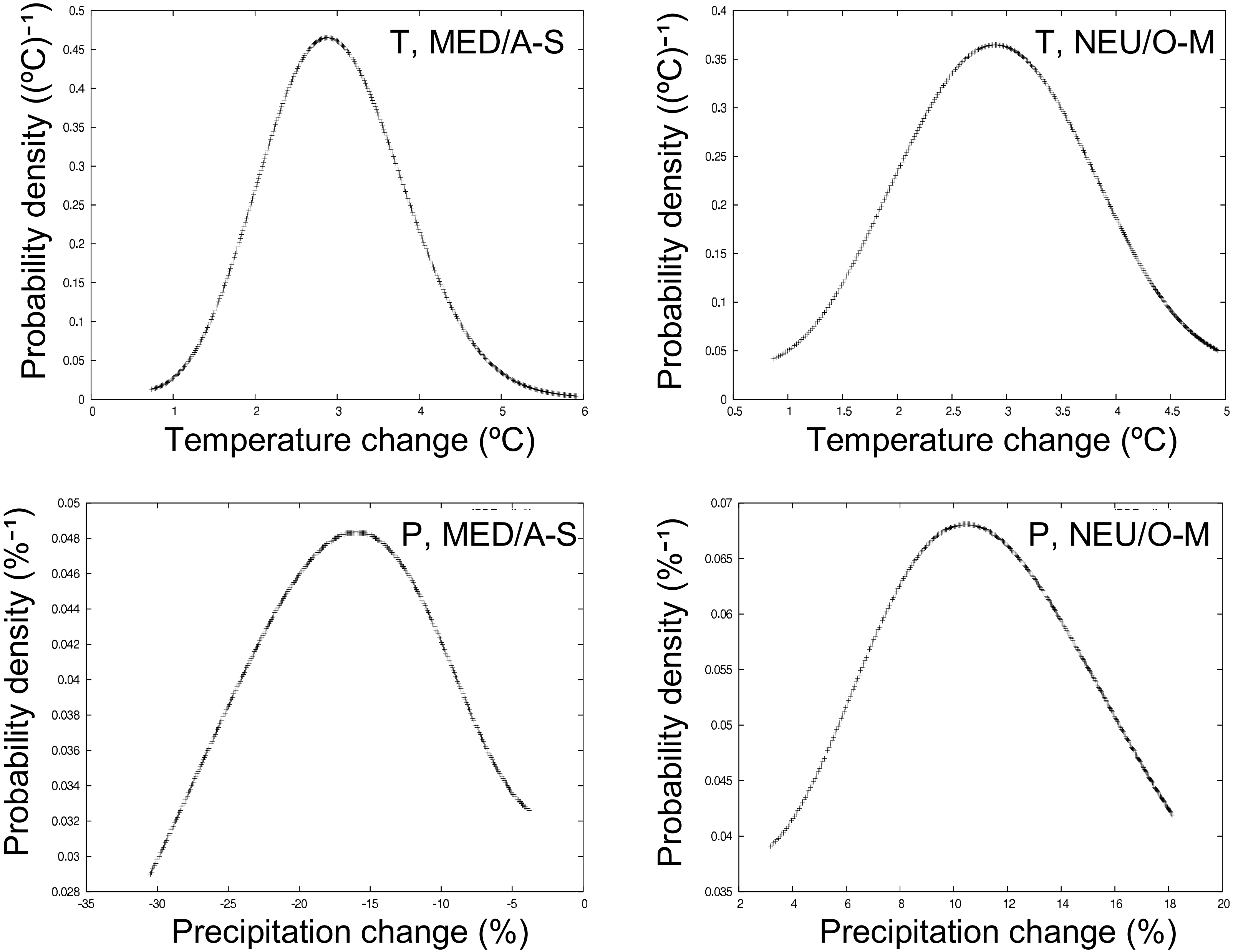
A ΔTg PDF (similar to Wigley and Raper 2001)



Regional change PDFs corresponding to the ΔTg PDF (uncertainty term not included)



Regional change PDFs corresponding to the ΔTg PDF (uncertainty term included)



Limitations and future work

- The equation is essentially based on the scalability assumption
  - Spatial scales of application
  - Application to higher statistical moments (e.g. variability)
  - Effects of local vs. global forcings (aerosols, land-use change)

Conclusions

- Some patterns of regional temperature and precipitation change across the globe are emerging from different generations of models, both for mean and variability change.
- Ensemble average regional temperature and precipitation change signals (when strong) show good scalability characteristics
  - This property can be used to infer regional changes from global temperature change
- The “path” to regional climate change is important, especially for precipitation
  - Need to add multidecadal noise to the ensemble average signal


Thank You