

**Assessment of the performance of
a multi-model ensemble of inter-
decadal climate change simulations
(preliminary results)**

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The overall aims are to assess

- the general performance of contemporary coupled models in simulating observed trends in extremes;
- if combined multi-model trend patterns are more plausible than those reproduced by individual participating models.

Derived annual indices for temperature

FD [days]	Frost Days: annual number of days with $T_{\min} < 0^{\circ}$
Tn10 [%]	Annual proportion of time with T_{\min} below the 10 th percentile of the 1961-1990 daily T_{\min} distribution (the percentage of cold nights in a year)
Tx10 [%]	Annual proportion of time with T_{\max} below the 10 th percentile of the 1961-1990 daily T_{\max} distribution
Tn90 [%]	Annual proportion of time with T_{\min} above the 90 th percentile of the 1961-1990 daily T_{\min} distribution
Tx90 [%]	Annual proportion of time with T_{\max} above the 90 th percentile of the 1961-1990 daily T_{\max} distribution (the percentage of warm days in a year)

Derived annual indices for precipitation

R10 [days]	Annual number of days with precipitation ≥ 10 mm
SDII [mm/day]	Simple Daily Intensity Index: total annual precipitation divided by the number of days with precipitation
R5d [mm]	Annual greatest consecutive 5-day precipitation total
CDD [days]	Consecutive Dry Days: the annual maximum number of consecutive days with precipitation < 1 mm/day
R95 [mm]	Contribution to annual total precipitation from very wet days (with precipitation above the 95th percentile of the 1961-1990 wet day precipitation distribution)

Observational data

Grid-point archive of annual indices – presented in

**Alexander, L.V., X.Zhang, T.C. Peterson, J.Caesar,
B.Gleason, A.Klein Tank, M. Haylock, D.Collins, B.Trewin,
F.Rahim, A.Tagipour, R.Kumar Kolli, J.V.Revadekar,
G.Griffiths, L. Vincent, E.Mekis, D.Stephenson, J.Burn,
E.Aguilar, M.Brunet-India, M.Taylor, M.New, P.Zhai,
M.Rusticucci, J.Luis Vazquez Aguirre (2005):
Global observed changes in daily climate extremes of
temperature and precipitation. *J. Geophys. Res.- Atmospheres,*
*in press***

Resolution: $3.75^\circ \times 2.5^\circ$ (HadCM3 grid)

Period: 1951-2000

IPCC AR4 models used in this study

AOGCM	Modeling Centre	Number of runs
HadCM3	Hadley Centre (UK)	4
HadGEM1	Hadley Centre (UK)	1
MIROC3.2	NIES / CCSA (Japan)	4
CM3	Institute for Numerical Mathematics (Russia)	1
MK3	CSIRO (Australia)	1

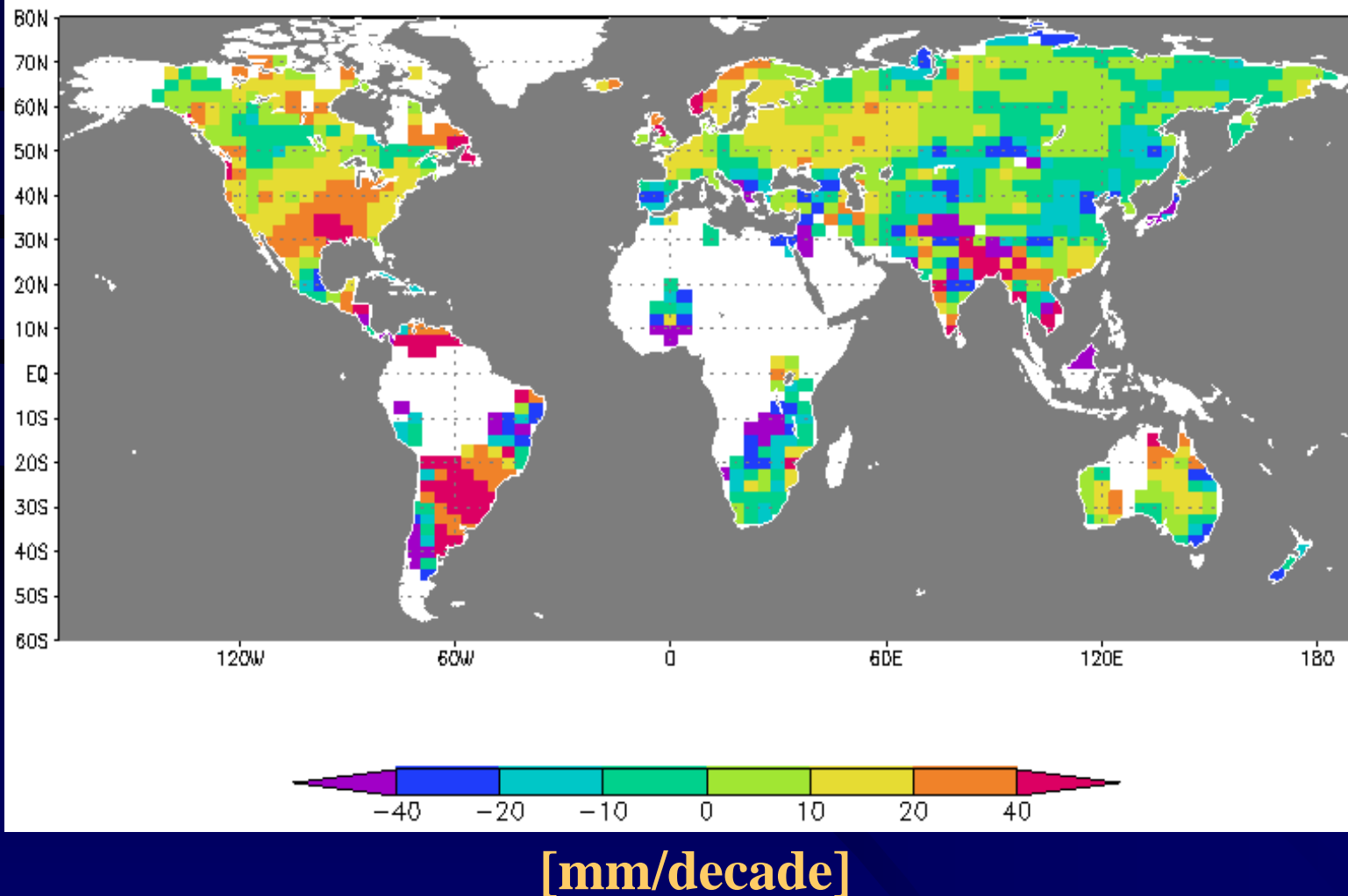
Bootstrap estimation of trend uncertainty

1. Subtract linear trend from an original time series to produce time series of residuals (“noise”);
2. Resample residual time series 1000 times to produce 1000 new ‘plausible’ time series of noise;
3. Add original linear trend onto 1000 resampled time series of noise and re-estimate trends to produce 1000 new ‘plausible’ trend values.

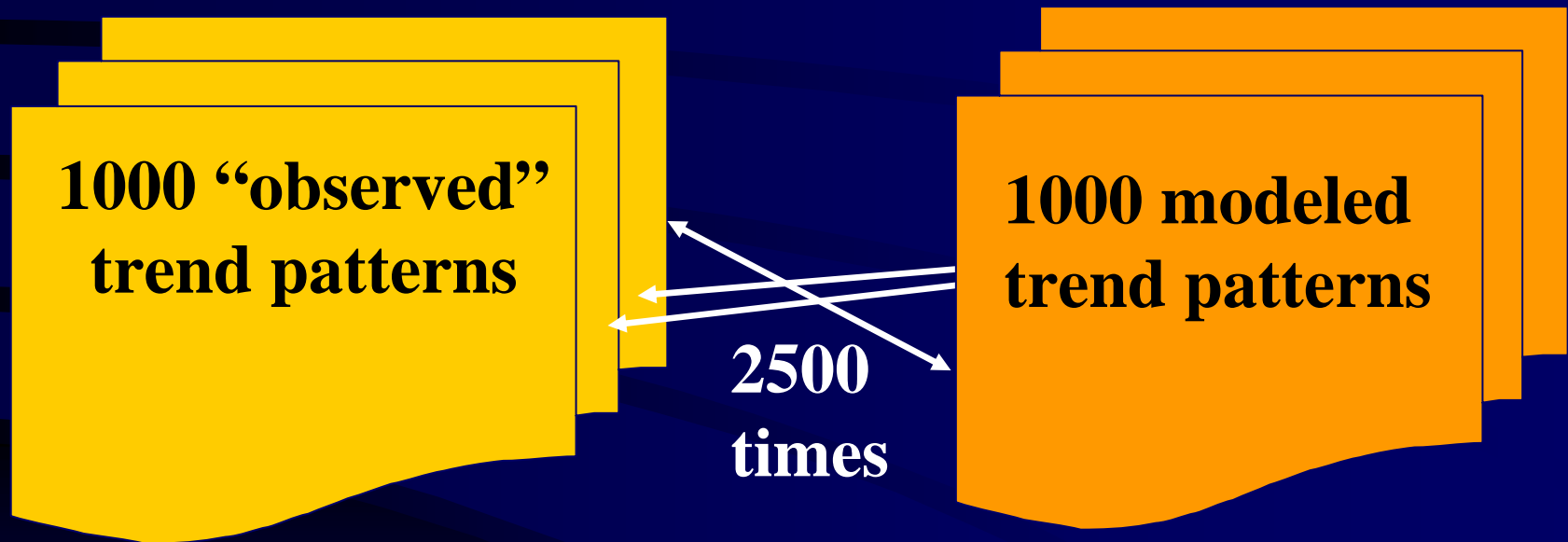
To preserve spatial coherence of trends we resampled patterns of trend residuals rather than individual local time series

To retain some serial correlation we resampled residual patterns in blocks of several consecutive years

Bootstrapped observed trend patterns for annual precipitation totals (1951-2000)



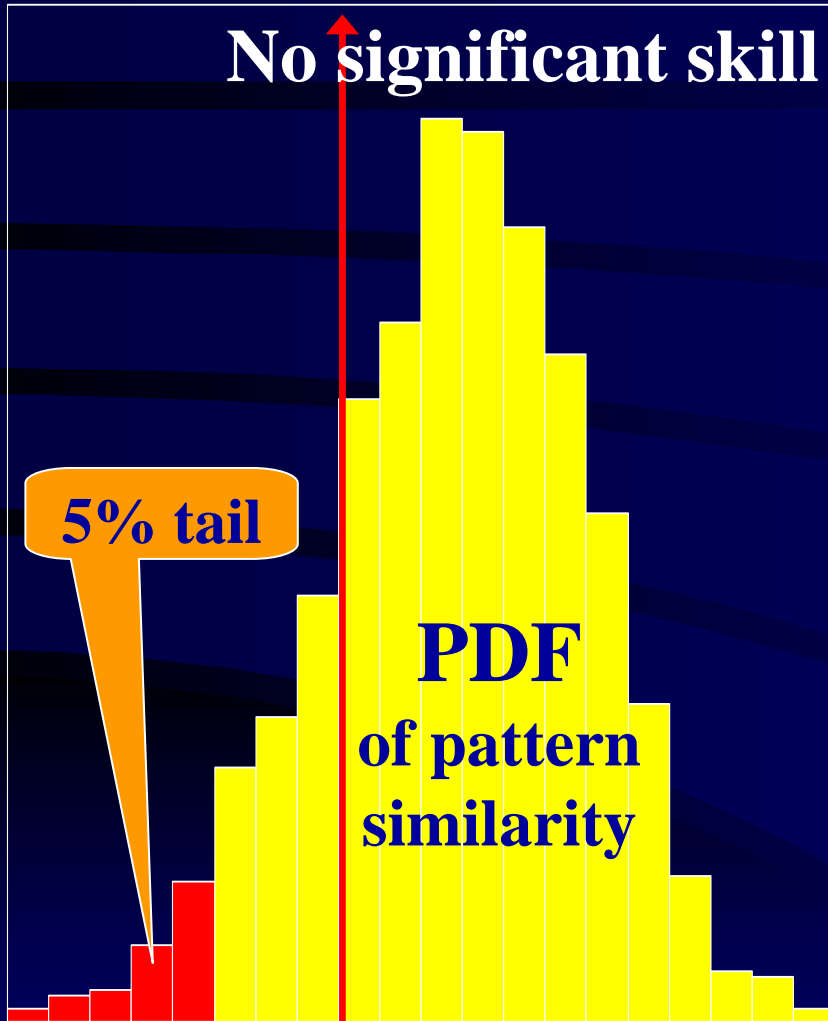
Bootstrap procedure for assessment of pattern similarity uncertainty



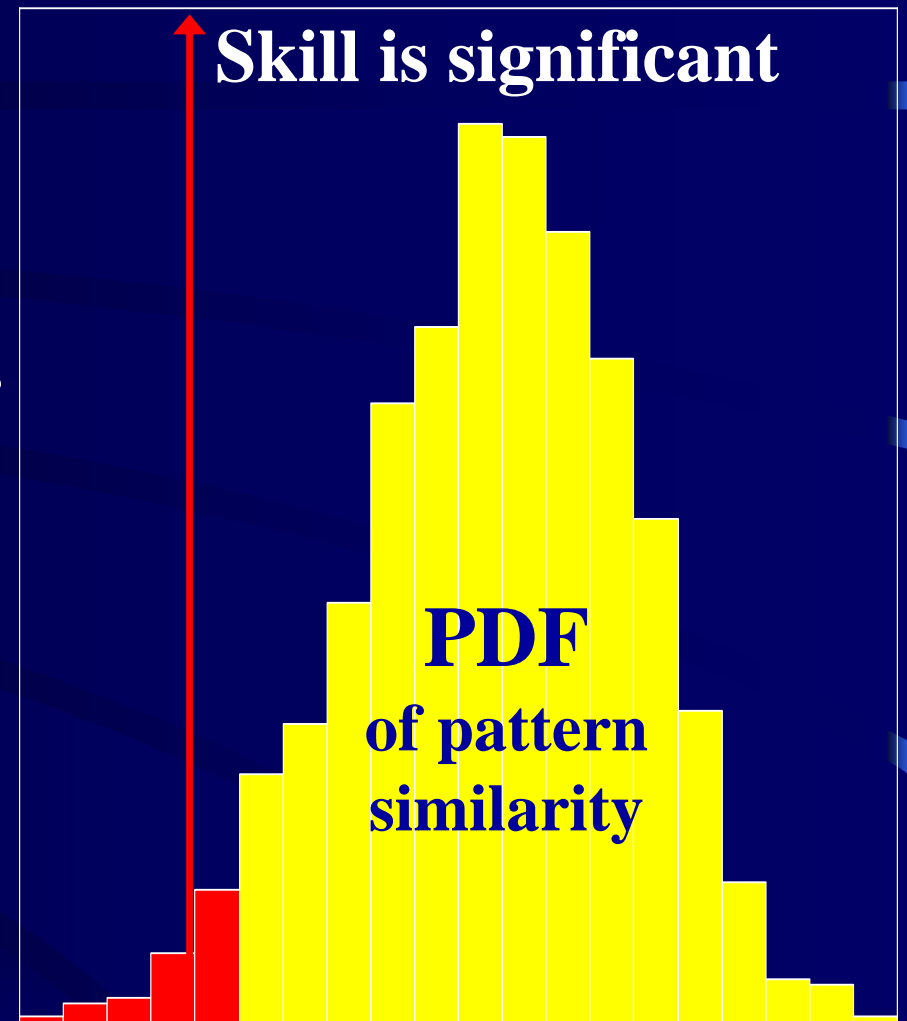
Pattern similarity was assessed for 2500 pairs of bootstrapped observed and simulated trend patterns

Testing of statistical significance of model skill.

H0: No positive skill



0 Pattern similarity



0 Pattern similarity

Measures of similarity

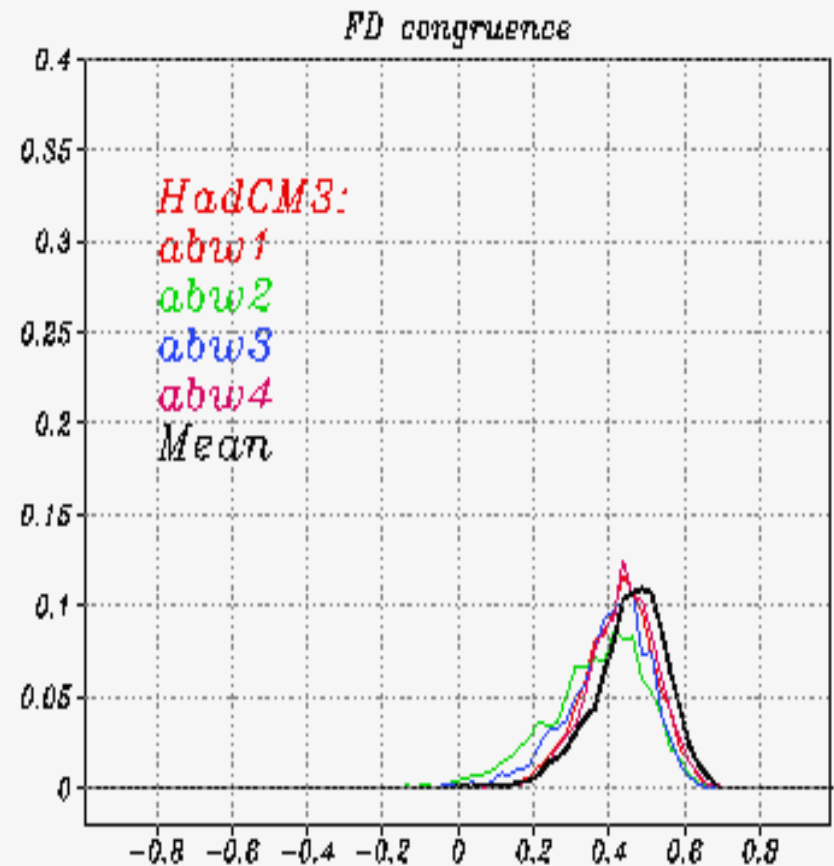
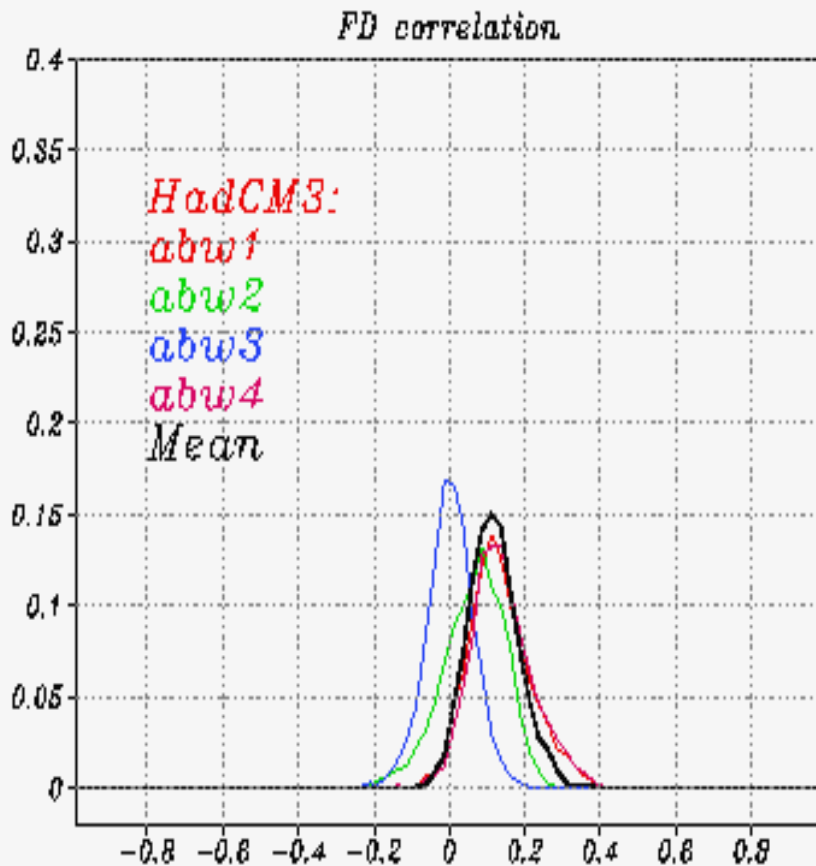
between observed (X) and modelled (Y) trend patterns

Centred measures	Uncentred measures
Correlation $\rho_1 = \frac{M[(X-m_X)(Y-m_Y)]}{\sigma_{X-m_X} \sigma_{Y-m_Y}}$	Congruence (uncentred correlation) $\rho_2 = \frac{M[XY]}{\sigma_X \sigma_Y}$
Regression $\rho_3 = \frac{M[(X-m_X)(Y-m_Y)]}{\sigma_{X-m_X}^2}$	Amplitude (uncentred regression) $\rho_4 = \frac{M[XY]}{\sigma_X^2},$

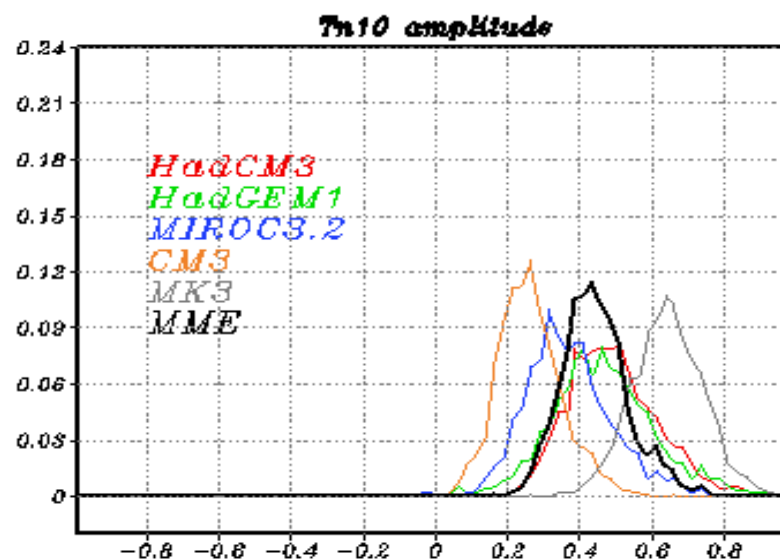
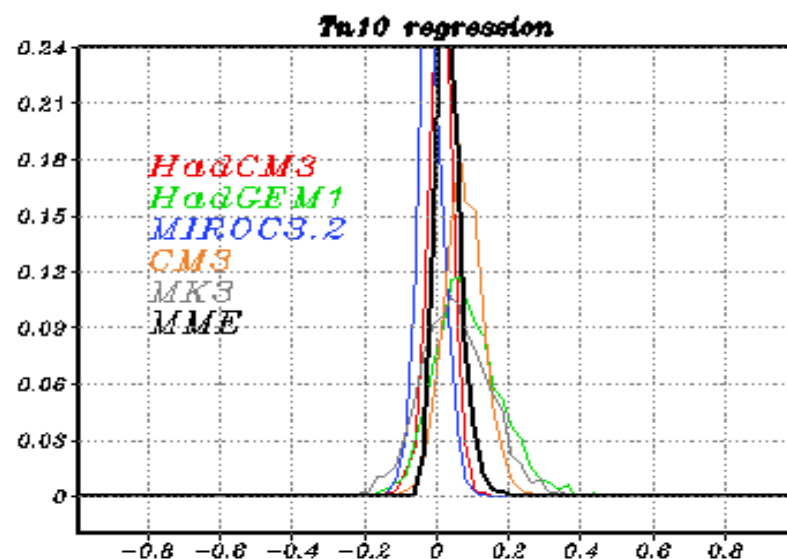
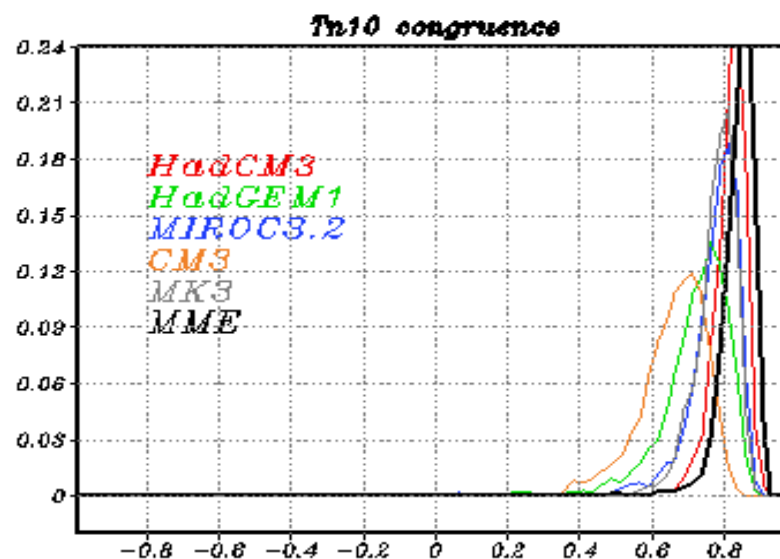
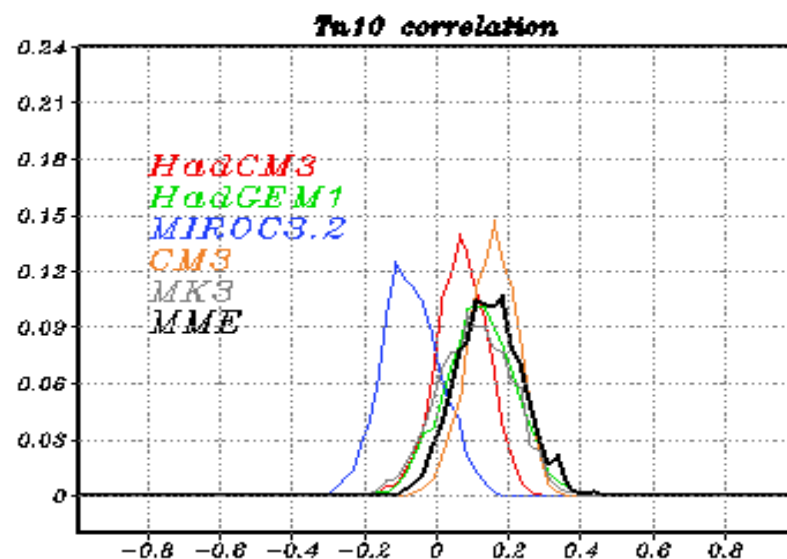
The comparison was carried out only for land areas covered with observational data

Differences in skill between individual members of a single-model ensemble

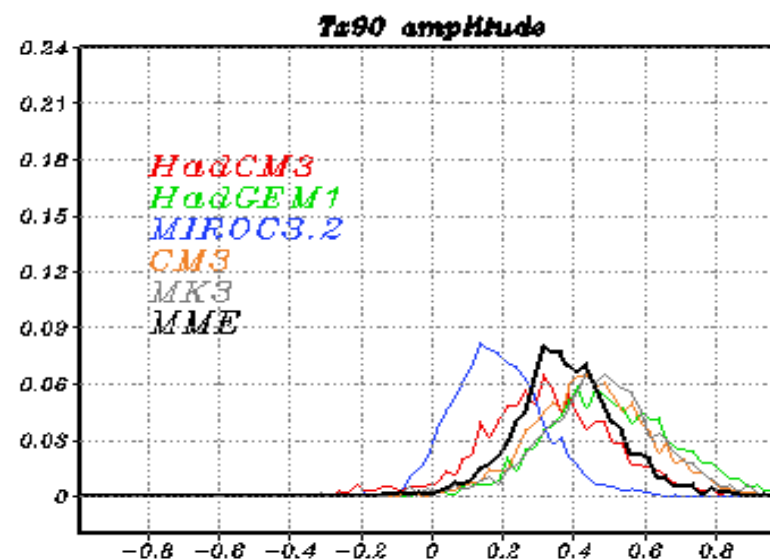
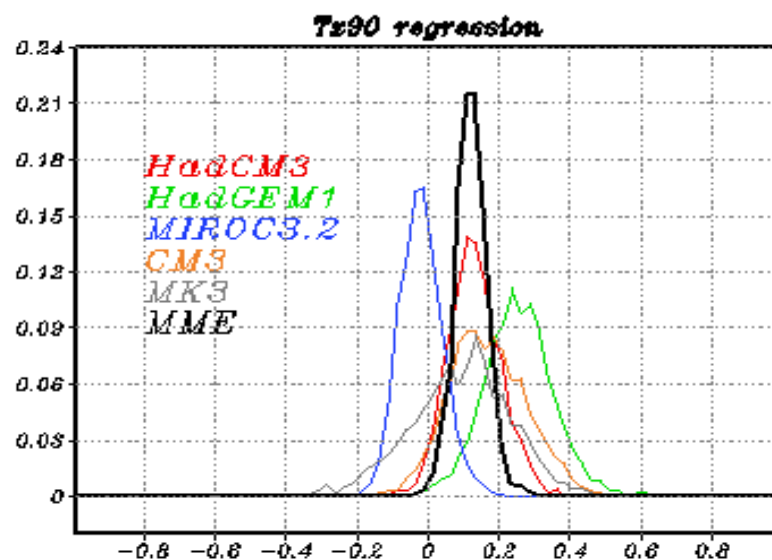
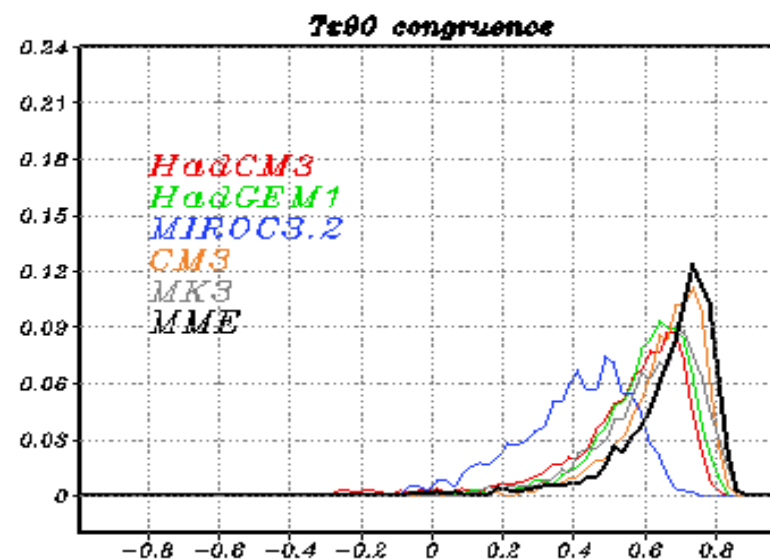
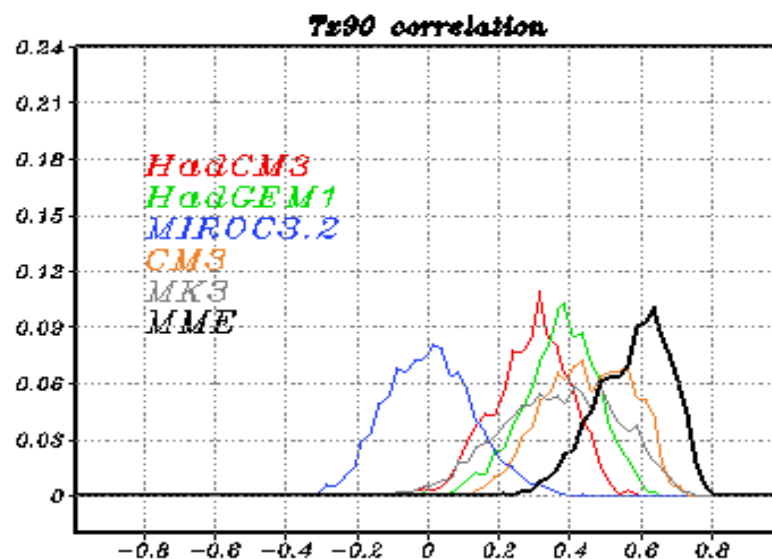
Example: Parameter – FD (number of Frost Days in a year).
PDFs of observed/modeled trend pattern similarity for individual members of HadCM3 ensemble



Index: Tn10. PDFs of measures of similarity between the patterns of observed and modeled trends



Index: Tx90. PDFs of measures of similarity between the patterns of observed and modeled trends



Original observed vs simulated trend pattern correlations and their significance (at 5% level)

	FD	Tn10	Tx10	Tn90	Tx90
HadCM3	0.115	0.07	0.08	0.57	0.30
HadGEM1	0.05	0.12	0.20	0.44	0.38
MIROC3.2	0.18	-0.07	-0.07	0.37	0.00
CM3	0.06	0.16	0.21	0.26	0.45
MK3	0.16	0.11	-0.04	0.60	0.375
MME1	0.17	0.15	0.155	<u>0.61</u>	<u>0.595</u>
MME2	<u>0.19</u>	0.07	0.08	0.61	0.45

Original observed vs simulated trend pattern correlations and their significance (at 5% level)

	R10	SDII	R5d	R95	CDD	Ptot
HadCM3	<u>0.19</u>	0.13	0.13	0.21	0.06	0.26
HadGEM1	-.....	0.05	-.....	-.....	-.....	-.....
MIROC3.2	0.11	0.06	0.165	0.025	-.....	0.10
CM3	0.10	-.....	0.07	-.....	0.00	0.12
MK3	0.10	-.....	0.10	0.12	0.09	0.13
MME1	0.135	0.06	0.16	0.04	0.01	0.08
MME2	0.13	0.07	<u>0.18</u>	0.04	-.....	0.08

Summary

- **All the models demonstrate reasonable skill at simulating the observed trend patterns in temperature indices especially when the global mean is included in the analysis. None of the models are successful enough at reproducing the trend patterns for precipitation indices.**
- **No model in this study stands out as being “the best” at simulating both changes in observed temperature and precipitation indices.**
- **There is quite large variability in the skill of individual ensemble members from any one model in recreating observed trends. Ensemble averaging reduces the spurious effects of climate noise and leads to more robust assessments of climate change.**
- **The multi-model ensemble does not necessarily perform better than individual contributing members/models. However, this approach seems to work then there is reasonable skill in contributing members. In many cases the “super-ensemble” performs approximately at the level of best ensemble members and in some cases even better.**