Changes in temperature and precipitation extremes in the IPCC AR4 multi-model ensemble

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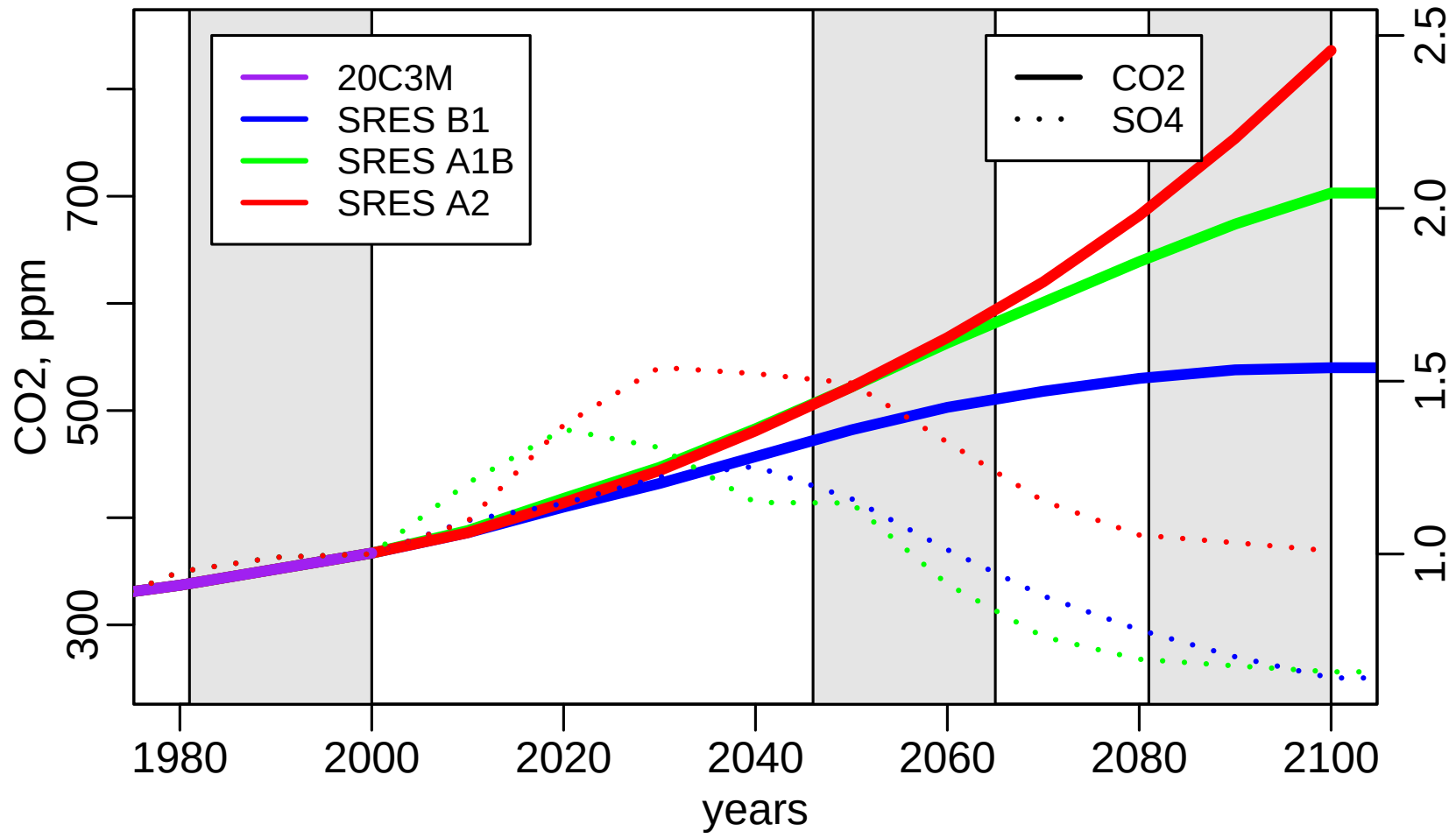
1. IPCC simulations/scenarios/time periods
2. Changes in extremes vs. changes in mean climate
3. Conclusions

IPCC AR4 scenarios



IPCC AR4 models (∼400 GByte).

Model	Grid size	Institution
CGCM3.1(T47)	96×48	Canadian Center for Climate Modelling & Analysis
CGCM3.1(T63)	128×64	Canadian Center for Climate Modelling & Analysis
CNRM-CM3	128×64	Centre National de Recherche Meteorologique, France
GFDL-CM2.0	144×90	Geophysical Fluid Dynamics Laboratory, USA
GFDL-CM2.1	144×90	Geophysical Fluid Dynamics Laboratory, USA
GISS-AOM	90×60	Goddard Institute for Space Studies Laboratory, USA
GISS-ER	72×46	Goddard Institute for Space Studies Laboratory, USA
INM-CM3.0	72×45	Institute of Numerical Mathematics, Russia
IPSL-CM3.0	96×72	Institut Pierre Simon Laplace, France
MIROC3.2(hires)	320×160	Center for Climate System Research, Japan
MIROC3.2(medres)	128×64	Center for Climate System Research, Japan
ECHAM5/MPI-OM	192×96	Max-Planck-Institut für Meteorologie, Germany
MRI-CGCM2.3.2	128×64	Meteorological Research Institute, Japan
NCAR-CCSM3	256×128	National Center for Atmospheric Research, USA
NCAR-PCM	128×64	National Center for Atmospheric Research, USA

Return values of annual extremes

The T-yr *return value* is the threshold that is exceeded by an annual extreme with probability $1/T$.

Variables:

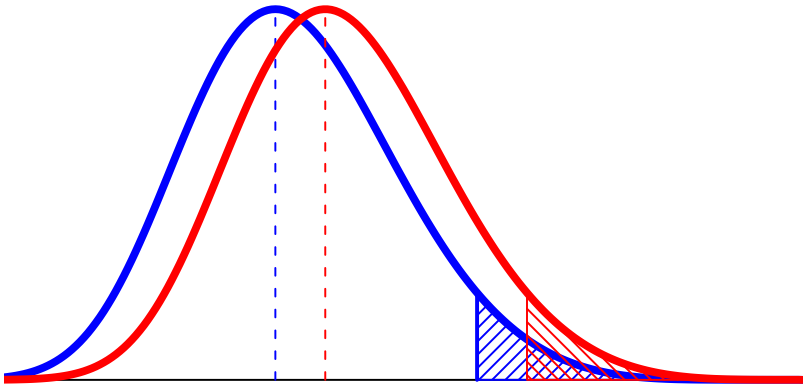
- $\mathrm{T_{max}}$, annual maximum of daily maximum surface temperature,
- $\mathrm{T_{min}}$, annual minimum of daily minimum surface temperature,
- P, annual maximum of 24-h or 5-day precipitation rate.

Method:

- GEV distribution for annual extremes,
- L-moments method (Hosking 1990, 1992),
- Dupuis and Tsao (1998) modification to ensure feasibility.

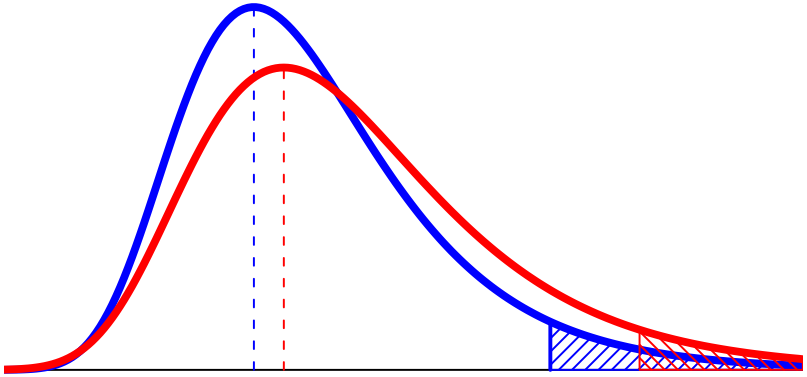
Changes in extremes

Change in location



changes in T_{max} and T_{min} extremes

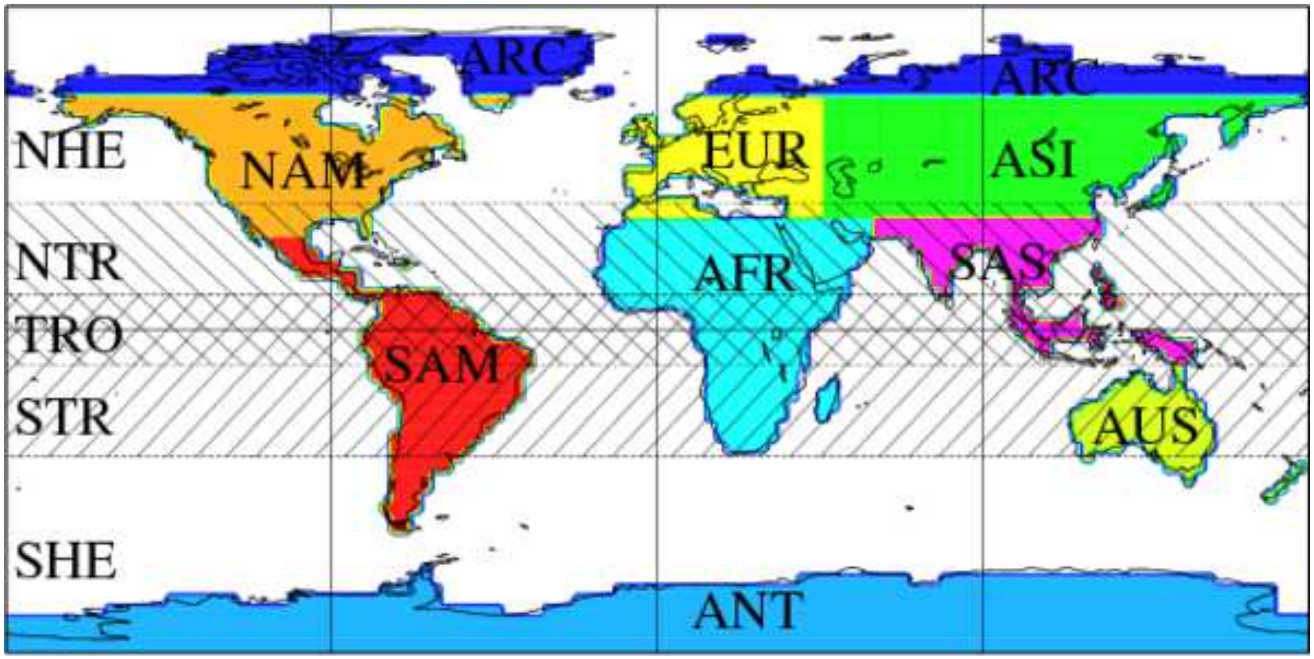
Change in location & scale



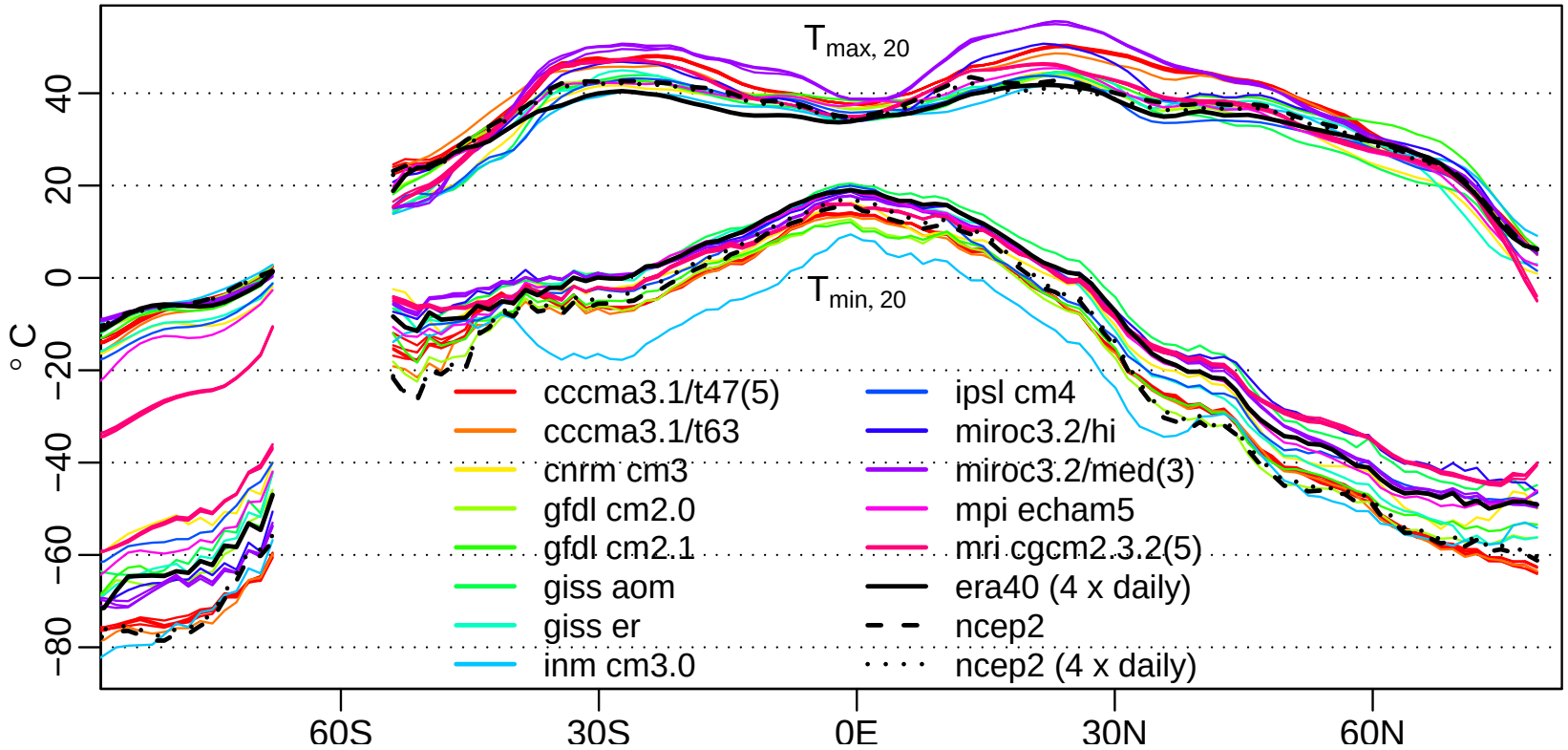
changes in P extremes

(Kharin and Zwiers 2005)

Continental-wide regions

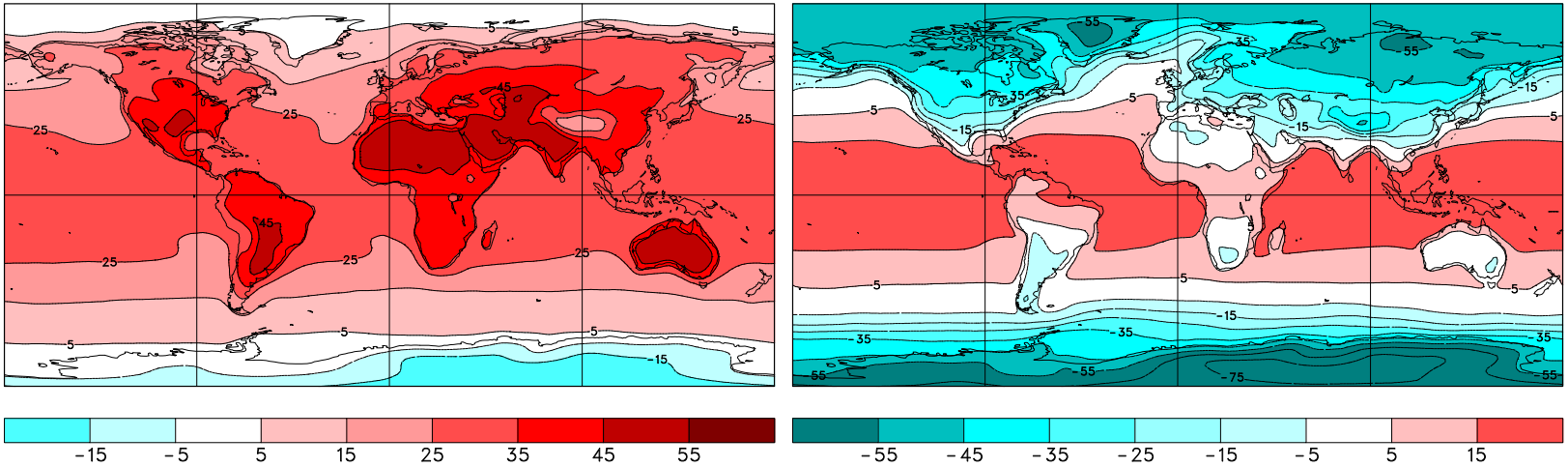


Temperature extremes $T_{max,20}/T_{min,20}$ zonal averages over land



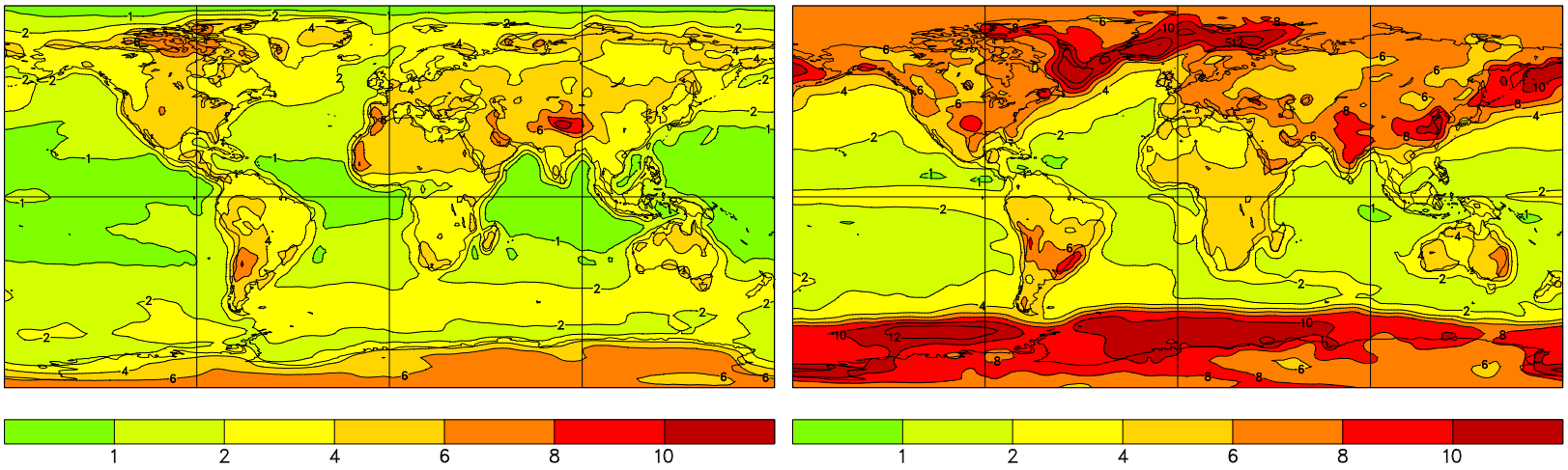
Ensemble mean and σ for $T_{max,20}/T_{min,20}$

$T_{max,20}$, 1981–2000, 20C3M



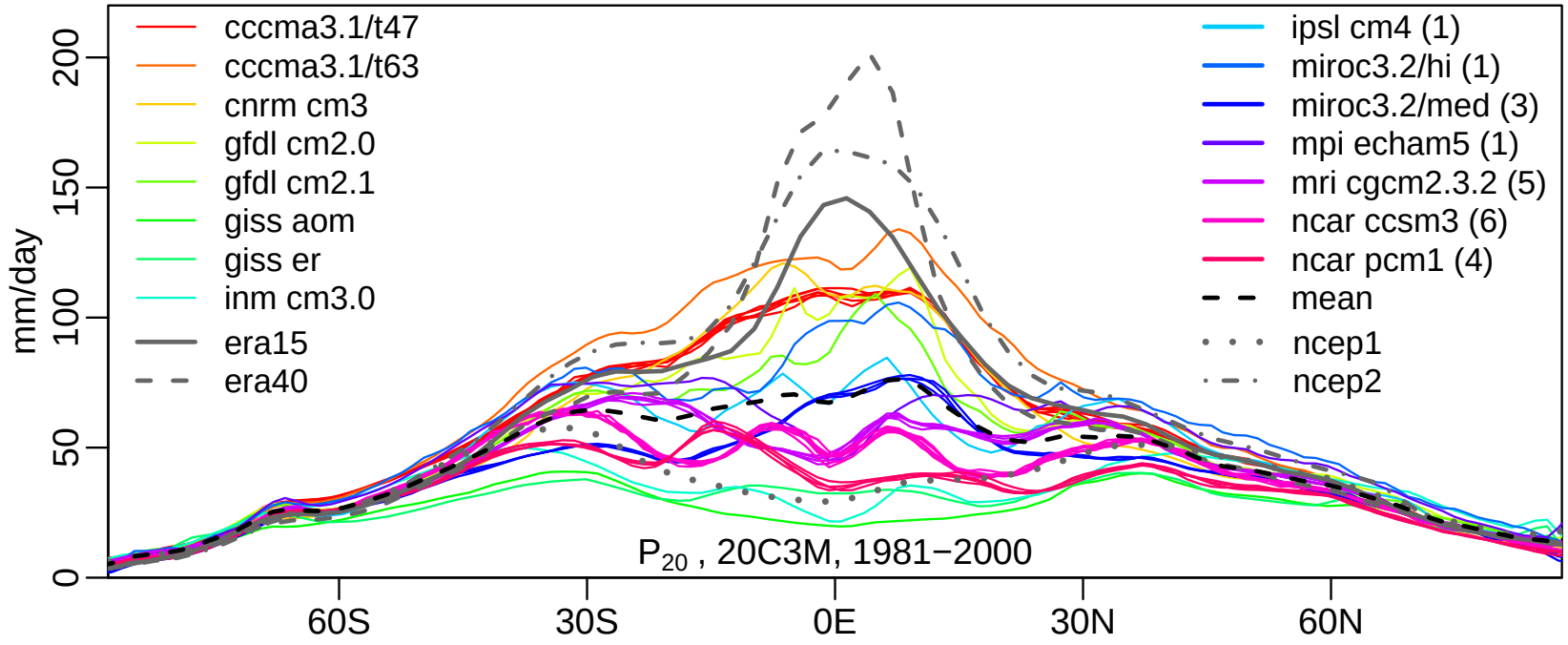
$T_{min,20}$, 1981–2000, 20C3M

$\sigma(T_{max,20})$, 1981–2000, 20C3M



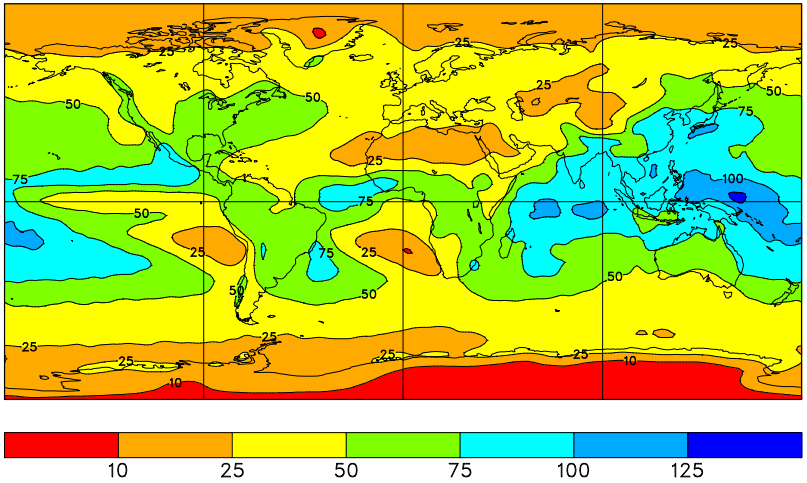
$\sigma(T_{min,20})$, 1981–2000, 20C3M

Precipitation extremes P_{20}: zonal averages

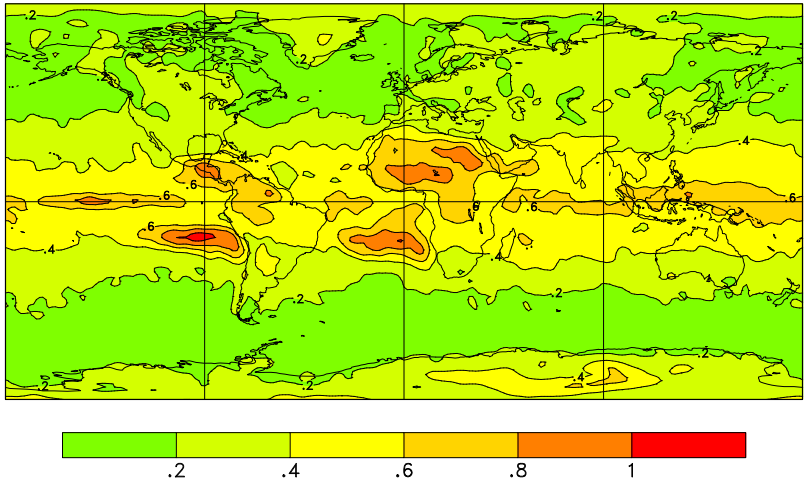


Precipitation extremes P_{20}: 1981–2000

$\langle P_{20} \rangle$, mm/day

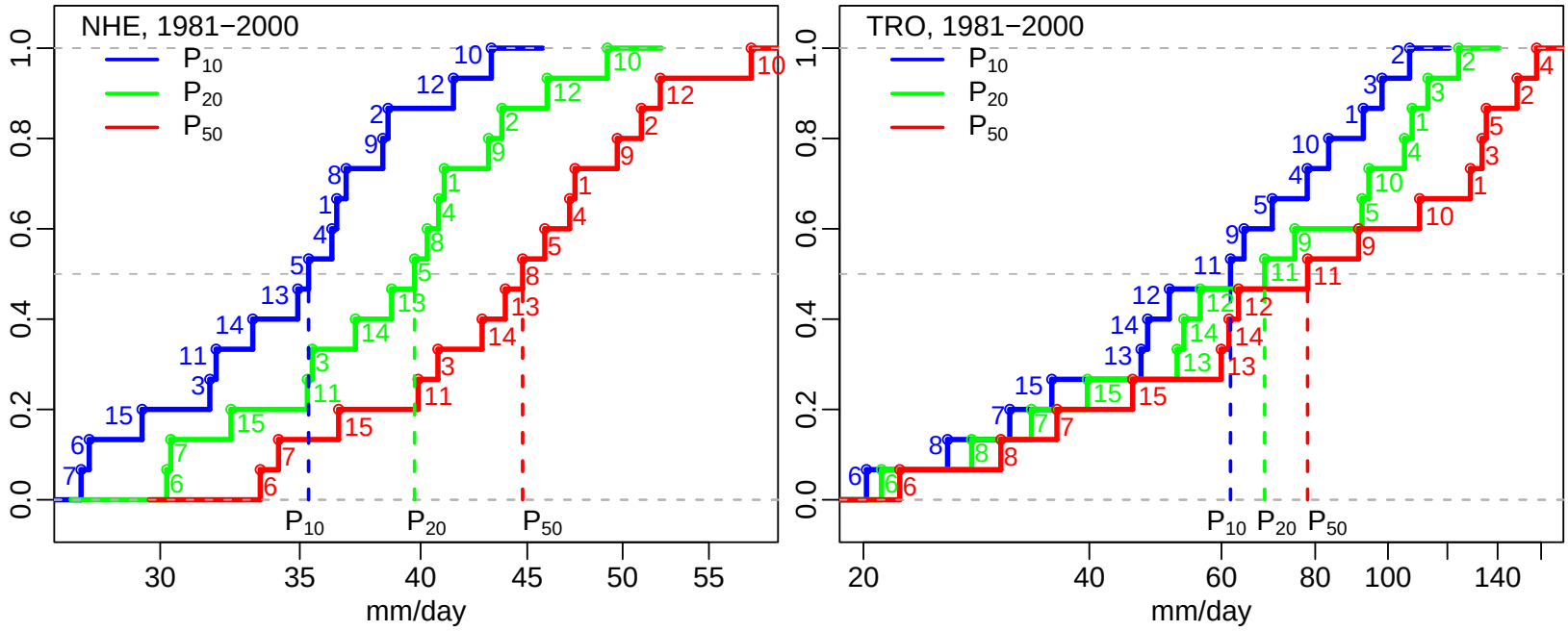


$\sigma(P_{20})/\langle P_{20} \rangle$



Multi-model ensemble mean of 20-yr return values of annual precipitation extremes simulated by the 16 IPCC models. Units are mm/day.

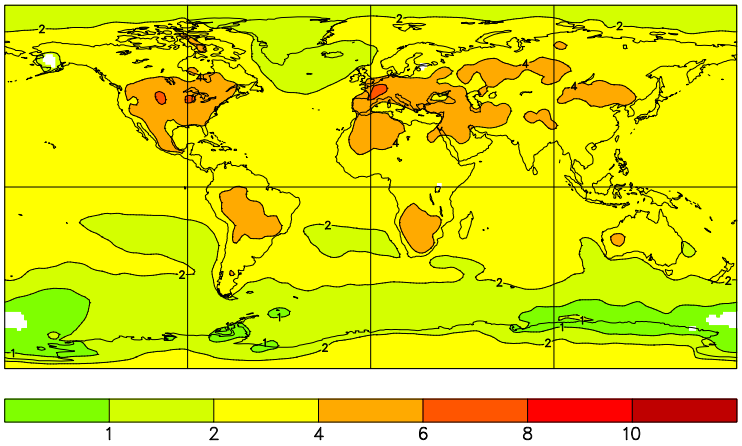
10-, 20-, 50-yr RV of precipitation extremes : 1981–2000



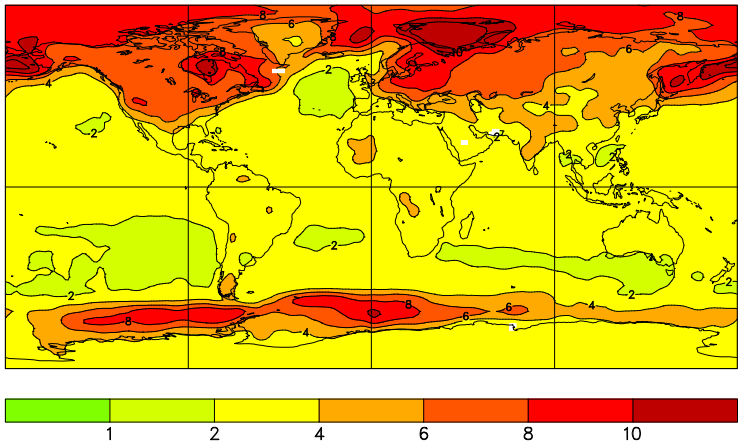
Distribution of 10-, 20-, and 50-yr return values of annual precipitation extremes averaged over the tropics and in the northern extratropics as simulated by the IPCC AR4 models.

Change in temperature extremes: 2081–2100, SRES A1B

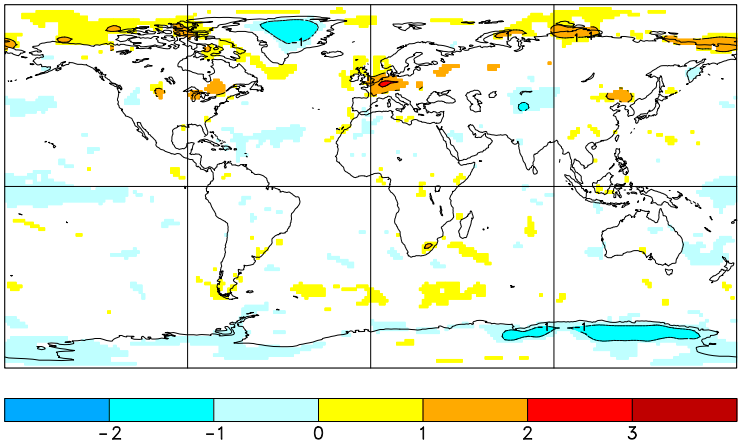
$\Delta T_{max,20}$, °C, 2081–2100, SRES A1B



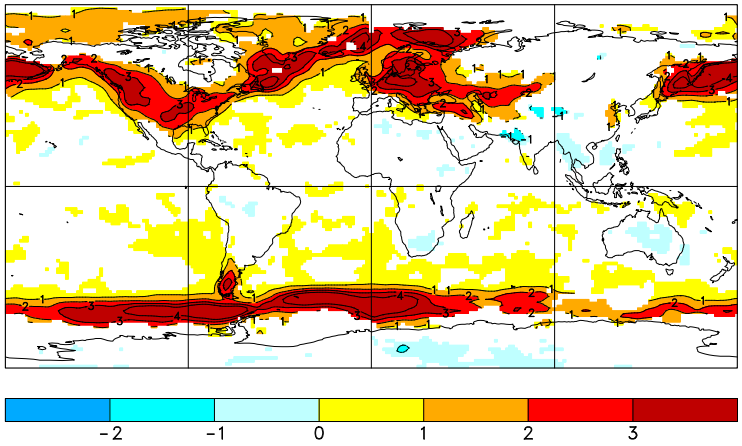
$\Delta T_{min,20}$, °C, 2081–2100, SRES A1B



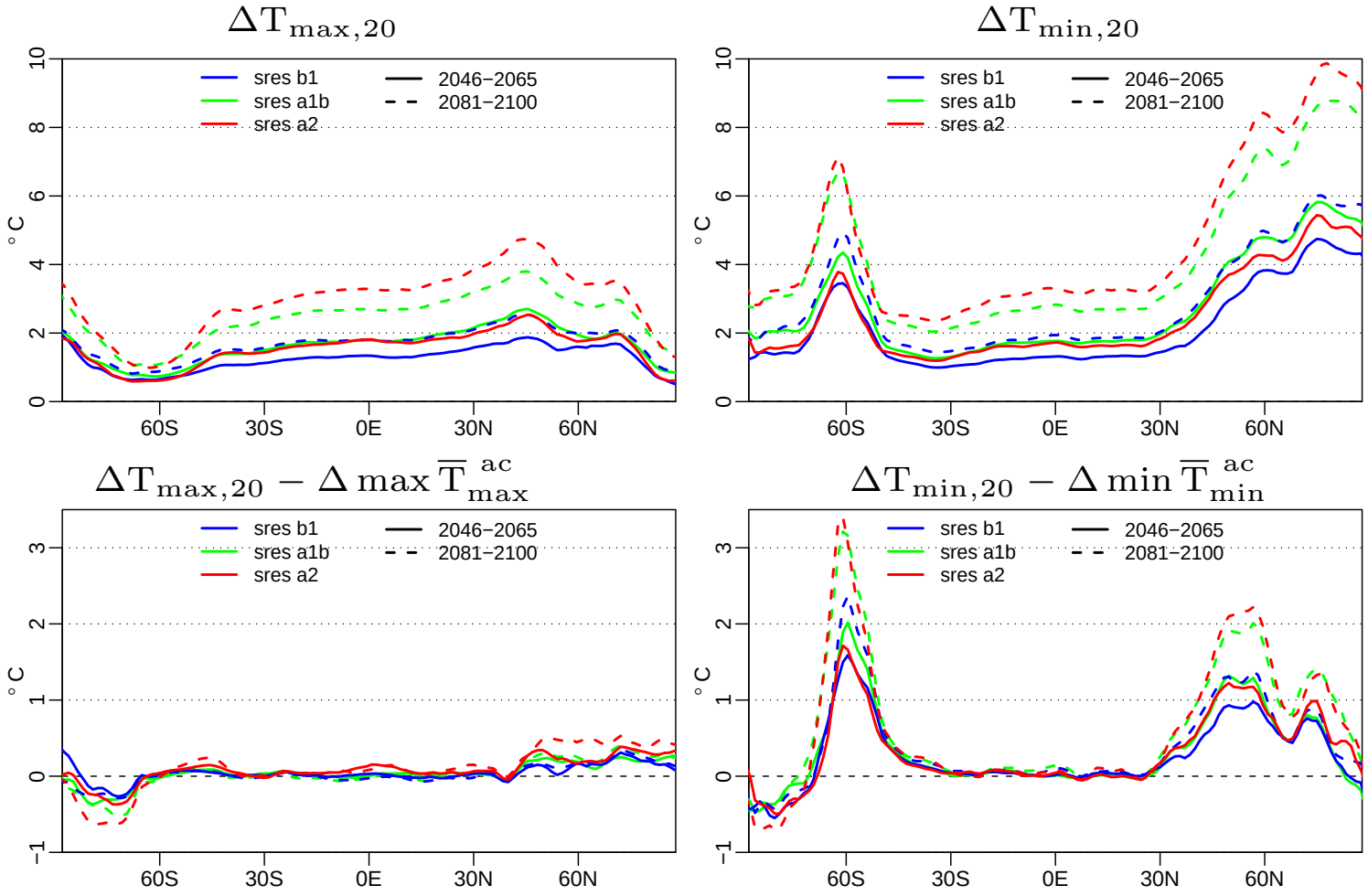
$\Delta T_{max,20} - \Delta \max \overline{T}^{ac}_{max}$, °C



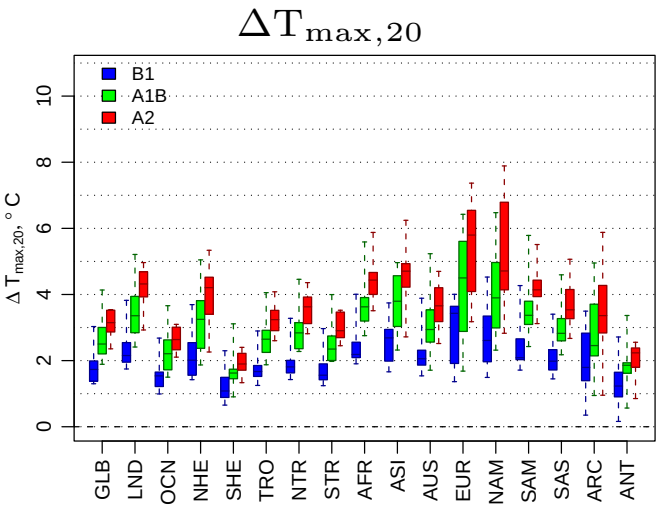
$\Delta T_{min,20} - \Delta \min \overline{T}^{ac}_{min}$, °C

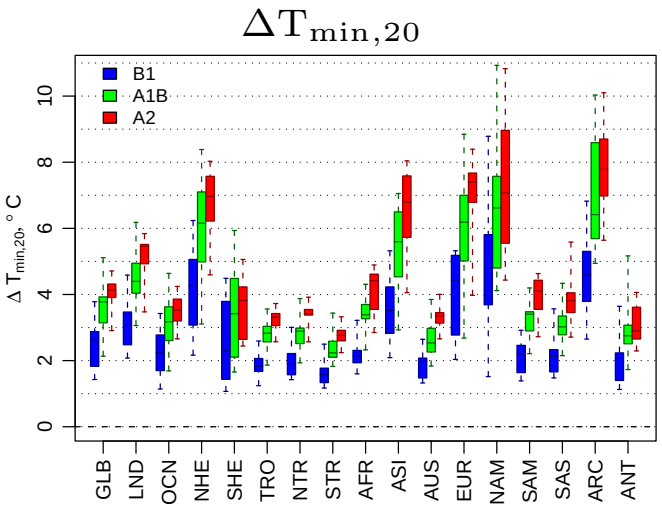


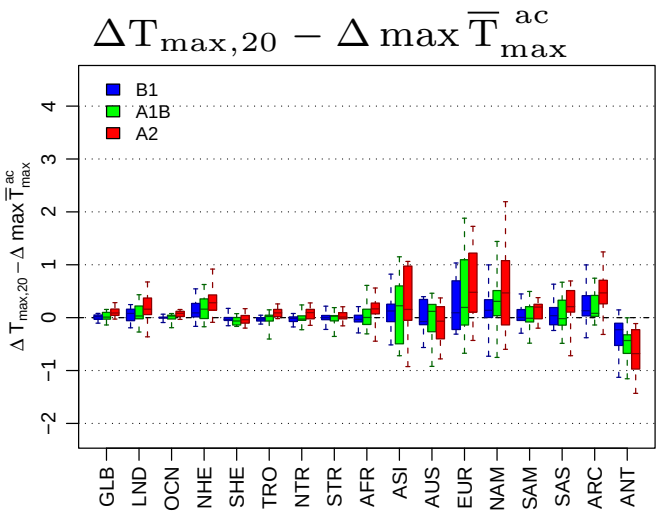
Change in temperature extremes: zonal averages

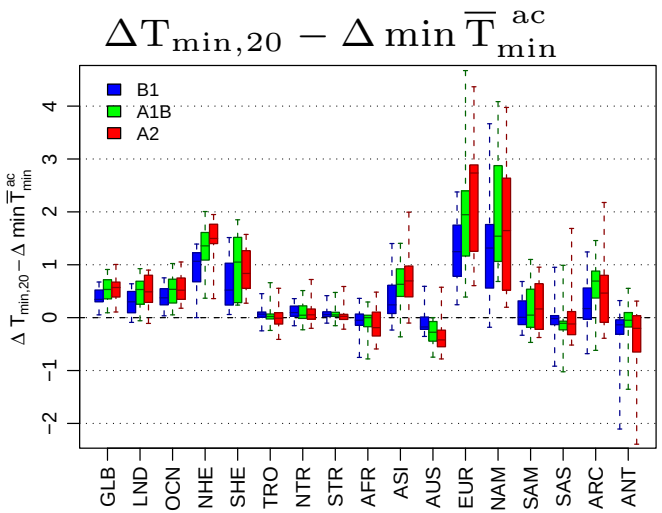


Change in temperature extremes: boxplots of regional changes in 2081–2100



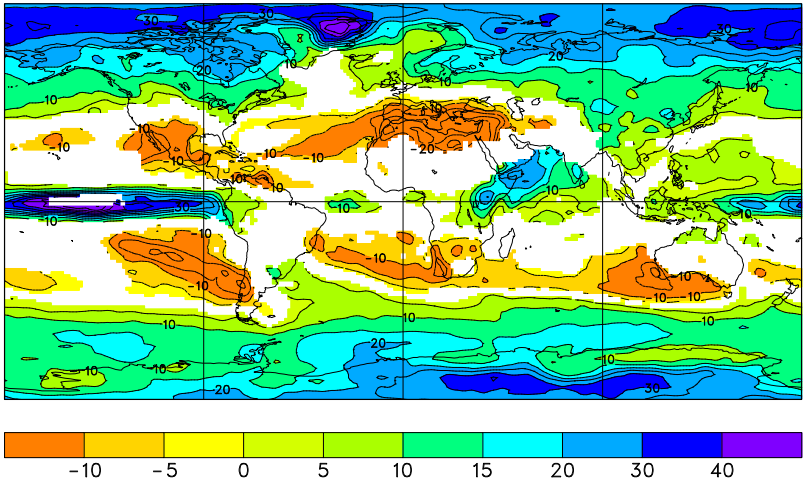




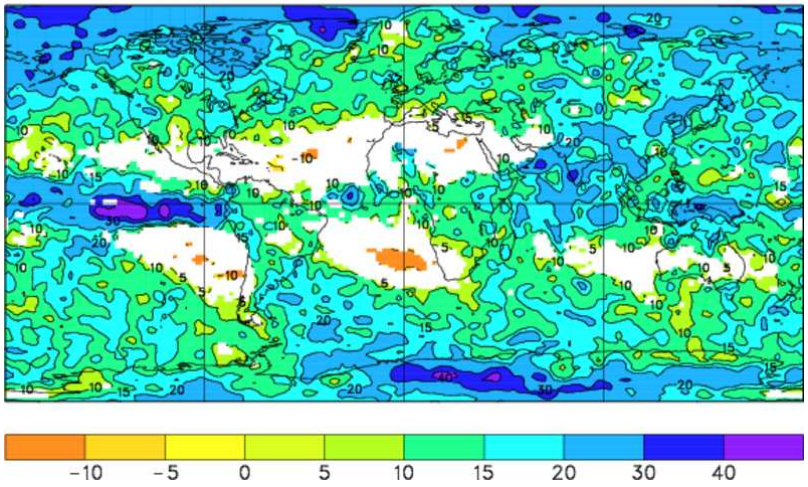


Change in precipitation extremes: 2081–2100, SRES A1B

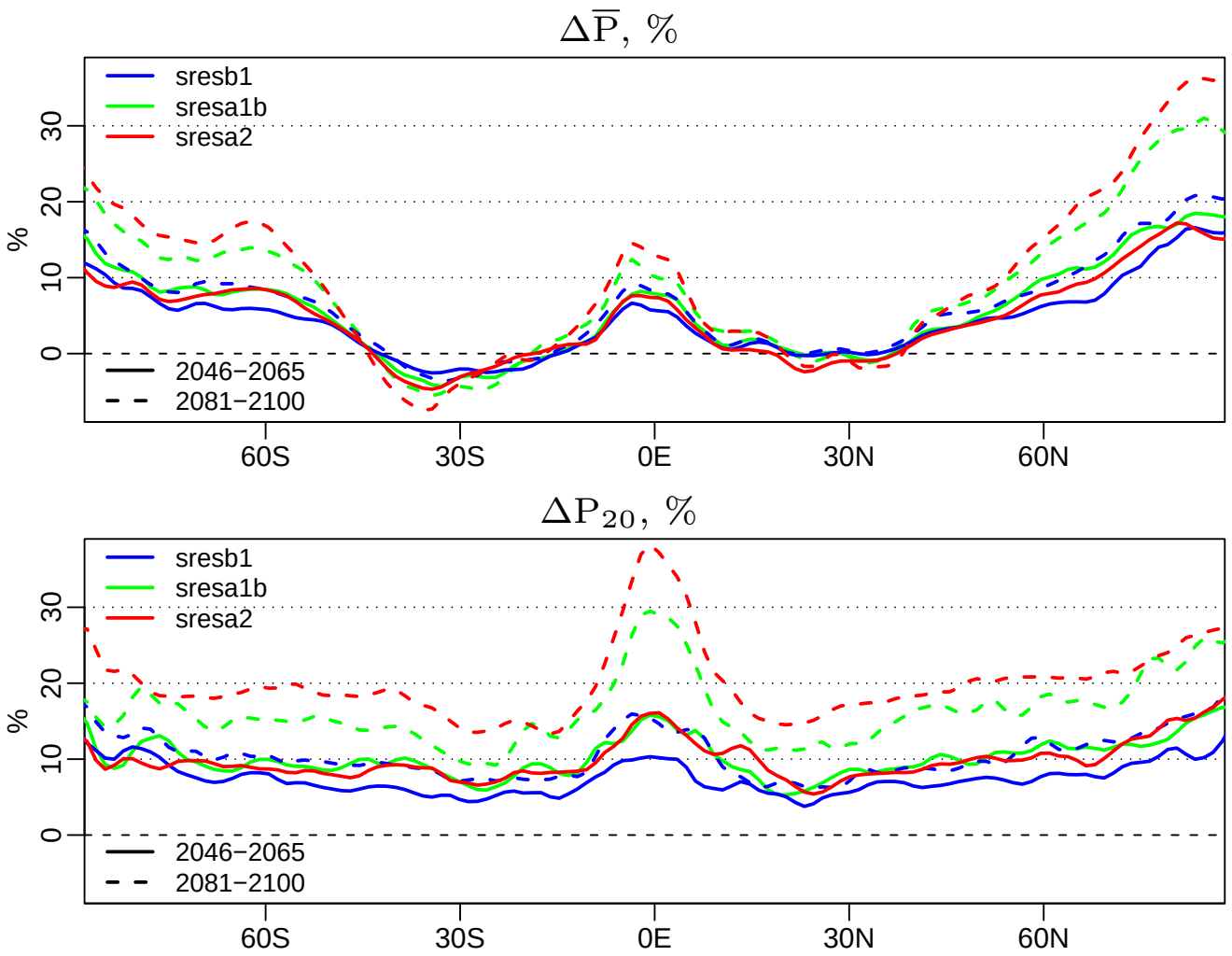
ΔP, %



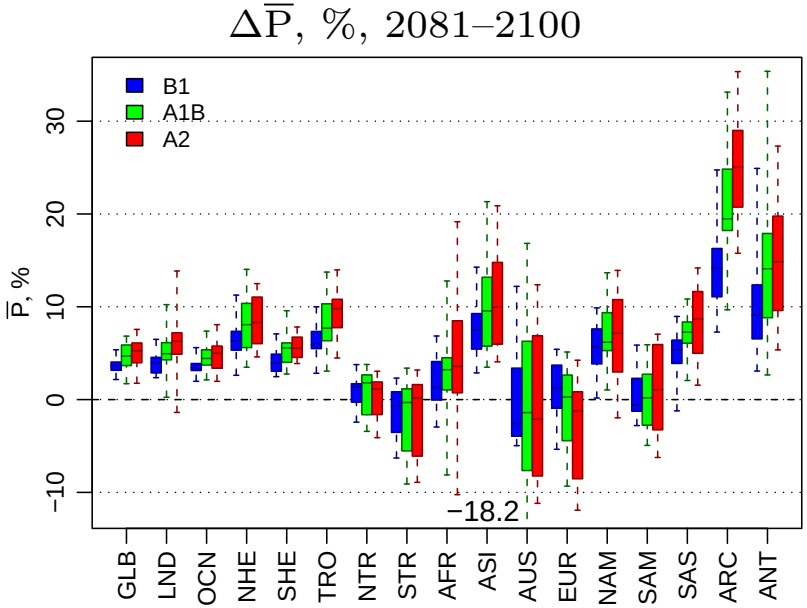
ΔP_{20}, %

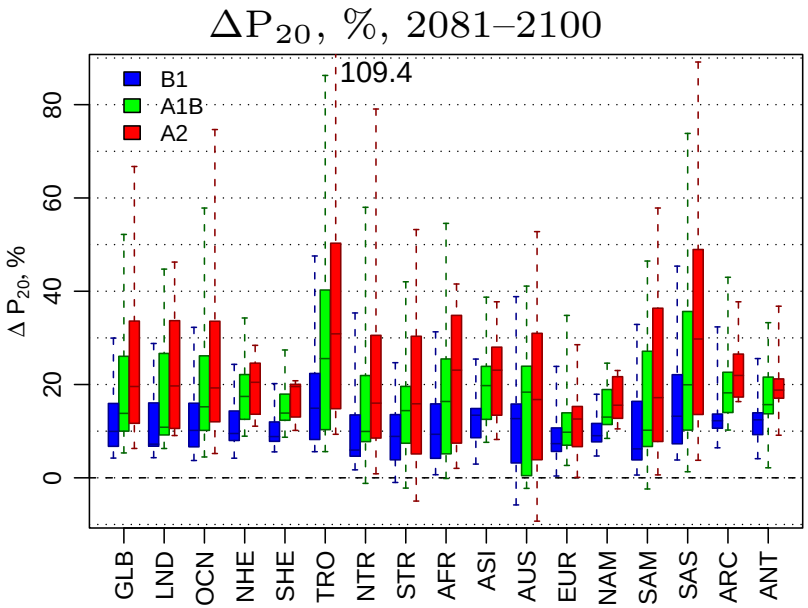


Change in precipitation extremes: zonal averages



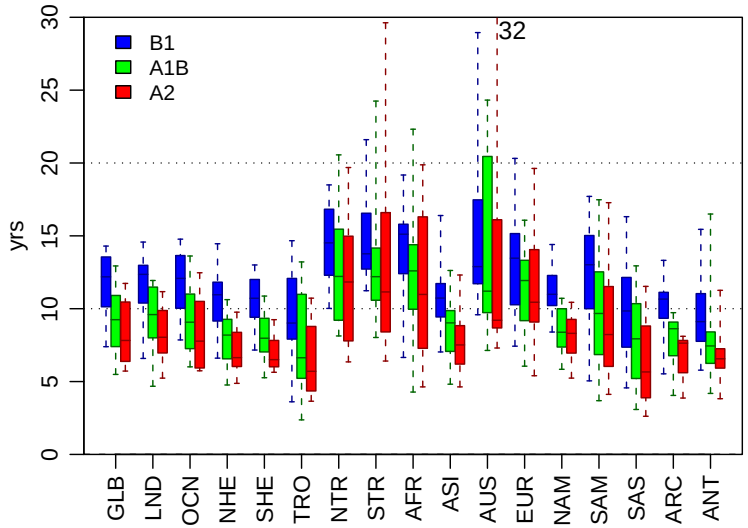
Change in precipitation extremes: boxplots of regional averages



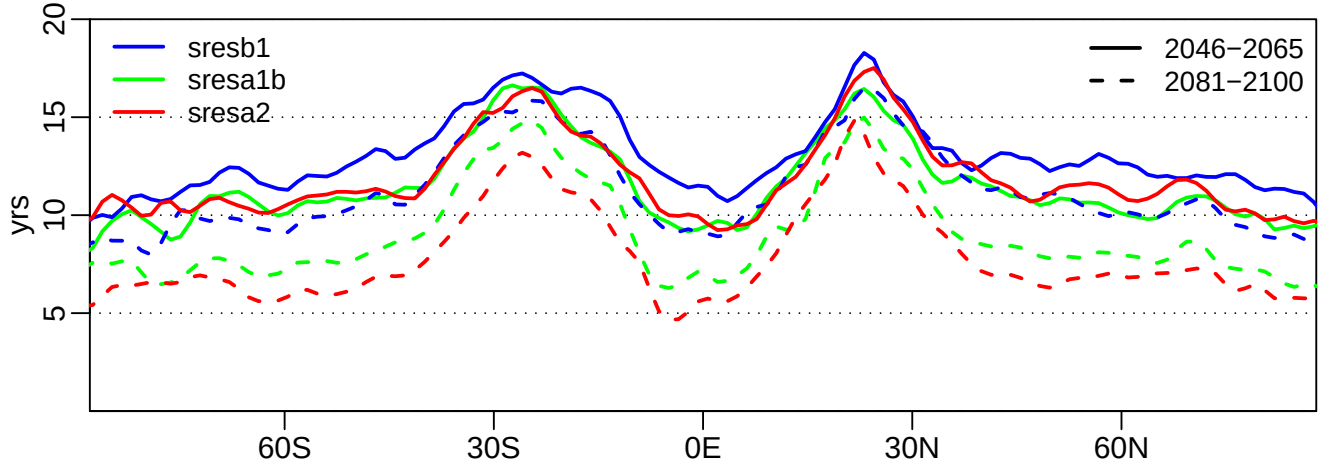


Waiting times for precipitation extremes

Ret. per. of P_{20}(1981–2000) in 2081–2100



Zonal median of return periods of P_{20}(1981–2000)



Summary

- Simulated temperature extremes are "plausible". Inter-model discrepancies are larger for cold extremes than for warm extremes.
- Our confidence in simulated precipitation extremes in the tropics is low. Large differences between models and reanalyses.
- Changes in warm extremes generally follow "summer" mean temperature changes.
- Changes in cold extremes are greater than changes in "winter" mean temperature.
- Models generally simulate larger changes in extreme precipitation than in mean precipitation (except in high latitudes). Waiting times for present day extreme events are reduced in all regions.