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

- 20C3M
- SRES B1
- SRES A1B
- SRES A2
### IPCC AR4 models (~400 GByte).

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<tr>
<th>Model</th>
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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:
- $T_{\text{max}}$, annual maximum of daily maximum surface temperature,
- $T_{\text{min}}$, 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 $T_{\text{max}}$ and $T_{\text{min}}$ extremes

Change in location & scale

changes in P extremes

(Kharin and Zwiers 2005)
Continental-wide regions
Temperature extremes $T_{\text{max, } 20}/T_{\text{min, } 20}$

Zonal averages over land

\begin{figure}
\centering
\includegraphics[width=\textwidth]{temperature_extremes}
\end{figure}
Ensemble mean and $\sigma$ for $T_{\text{max,20}}/T_{\text{min,20}}$

$T_{\text{max,20}},$ 1981–2000, 20C3M

$T_{\text{min,20}},$ 1981–2000, 20C3M

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

$\sigma(T_{\text{min,20}}),$ 1981–2000, 20C3M
Precipitation extremes $P_{20}$:

zonal averages

![Graph showing precipitation extremes $P_{20}$ for different models and experiments.](image)
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.
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

$\Delta T_{\text{max}, 20}, ^\circ\text{C}, 2081–2100, \text{SRES A1B}$

$\Delta T_{\text{min}, 20}, ^\circ\text{C}, 2081–2100, \text{SRES A1B}$
Change in temperature extremes: zonal averages

\[ \Delta T_{\text{max},20} \]

\[ \Delta T_{\text{min},20} \]
Change in temperature extremes:
boxplots of regional changes in 2081–2100

\[ \Delta T_{\text{max,20}} \]

\[ \Delta T_{\text{min,20}} \]

\[ \Delta T_{\text{max,20}} - \Delta \max T_{\text{max}} \]

\[ \Delta T_{\text{min,20}} - \Delta \min T_{\text{min}} \]
Change in precipitation extremes: 2081–2100, SRES A1B
Change in precipitation extremes: zonal averages

\[ \Delta \bar{P}, \% \]

\[ \Delta P_{20}, \% \]
Change in precipitation extremes:
boxplots of regional averages

\[ \Delta \bar{P}, \% , 2081-2100 \]

\[ \Delta P_{20}, \% , 2081-2100 \]
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.