Analysing Extreme Events in RCM Outputs

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Climate changes: mean and variability

many combinations:
- mean
- mean+both tails
- mean+one tail
- only tails
- only one tail

depends on:
- variable
- region
- season
- model
How to express variability/extremes

✓ variance/standard deviation
   assumption: normal distribution
   time scales: interannual, intra-seasonal

✓ percentiles
   0.1, 1, 5 (left tail) or 95, 99, 99.9 (right tail)

✓ different indices
   heat wave, drought and flood indices (consecutive days)

✓ return period
   the threshold that is exceeded any given year with the probability $1/T$, e.g. 20-, 50-, 100-, 500-yr events
   *(simplified: the threshold that is exceeded once every $T$ years)*
**Outputs Available from RCMs**

**Example:**
**CORDEX Specified outputs**

| Tier 1: Daily average output (for some variables minimum, maximum) |
|-----------------------------|-----------------------------|-----------------------------|
| 1  2-metre Air Temperature   | K                           |
| 2  Maximum 2-metre Air Temperature | K                        |
| 3  Minimum 2-metre Air Temperature | K                        |
| 4  Precipitation             | kg/m²·s                      |
| 5  Surface Pressure          | Pa                          |
| 6  Mean Sea Level Pressure   | m                          |
| 7  2-metre Specific Humidity | %                          |
| 8  10-metre Wind Speed      | m/s                         |
| 9  Maximum 10-metre Wind Speed | m/s                        |
| 10 Total Cloud Cover         | %                          |
| 11 Sunshine Hours            | s                           |
| 12 Surface Downwelling Shortwave Radiation | W/m²                   |
| 13 Surface Downwelling Longwave Radiation | W/m²                   |
| 14 Surface Latent Heat Flux  | W/m²                       |
| 15 Surface Sensible Heat Flux| W/m²                       |

**Total specified:**
- monthly – 43 variables
- daily – 59 variables

(many also sub-daily, 3- & 6 hr)
Climate change in warm extremes

20-yr ret. val. of T2max  **CTL: 1961-1990  SCN: 2071-2100**

- all simulations show an intensification of warm extremes
- similar north-south gradient with varying magnitude
Change in warm extremes (Baltic)

20-year return values of T2max (wrt 1961-1990)

- Common gradual increase
Climate change in precipitation extremes

20-yr ret. val. of Pmax  

**CTL:** 1961-1990  
**SCN:** 2071-2100

- a somewhat tendency to increase in northern and decrease in southern Europe
- large variability on local scale
Change in precipitation extremes (Baltic)

20-year return values of $P_{\text{max}}$ (wrt 1961-1990) Summer

common tendency to more intense precipitation events
large decadal and multi-decadal variability
Climate change in precipitation extremes

20-yr ret. val. of Pmax  **CTL: 1961-1990  SCN: 2071-2100**

- **Intensification of precipitation extremes over most of Europe**
- **Ensemble mean**: significant increase only in Scandinavia and north-eastern Europe (above 10%)
20-year return values of Pmax (wrt 1961-1990)   Winter

a tendency to more intense precipitation extremes
20-yr ret. val. of Pmax  **CTL:** 1961-1990  **SCN:** 2071-2100

recurrence time of intense precipitation reduces from 20 years in **CTL** to 6-10 years in **SCN** over northern and central Europe in summer and to 2-4 years in Scandinavia in winter
Climate change in wind extremes

50-yr ret. val. of $W_{max}$ **CTL**: 1961-1990  **SCN**: 2071-2100

- Noisy and disperse patterns of the change

![Map showing climate change in wind extremes](image)
Change in wind extremes (Baltic)

50-year return values of $W_{\text{max}}$ (wrt 1961-1990)

- diverse behaviour of individual projections with large variability
- some increase in the end: forced signal or natural variability?
Overview

The joint CCI/CLIVAR/JCOMM Expert Team (ET) on Climate Change Indices (ETCCDI) has a mandate to address the need for measurement and characterization of climate variability, providing international coordination and helping organize climate change detection and indices relevant to climate change. The ET works with the World Meteorological Organization (WMO), the Intergovernmental Panel on Climate Change (IPCC), the United Nations Framework Convention on Climate Change (UNFCCC), and the Conference of the Parties (COP) to the UNFCCC. It is closely linked with other international initiatives such as the Global Climate Observing System (GCOS) and the World Climate Research Programme (WCRP). The ETCCDI has developed a set of Climate Change Indices definitions and indices relevant to climate change.

The main purpose of this website is to provide:

- ET approved definitions and guidance on the calculation of climate change indices, along with standard software packages.
- Practical guidance on the homogenization of climate indices.
- Materials for use in ETCCDI training workshops.
- Access to online resources of climate indices.
- A place for the submission of new or updated indices.

Information on terms of reference, recent news, and reports can be found here.

This website is created and maintained by Xuebin Zhang of Climate Environment Canada under the auspices of ETCCDI.

Indices

Definition
Calculation
Homogeneity
Examples
Software
Data
Workshops
Home

Number of frost days: Annual count of days when TN (daily minimum temperature) ≤ −5°C.

Number of summer days: Annual count of days when TX (daily maximum temperature) ≥ 25°C.

Number of icing days: Annual count of days when TX (daily maximum temperature) ≤ −5°C.

Number of tropical nights: Annual count of days when TN (daily minimum temperature) > 20°C.

Growing season length: Annual (1st Jan to 31st Dec in Northern Hemisphere, NS) or 15th July to 15th Aug in Southern Hemisphere (SH) count from first span of at least 6 days with daily mean temperature TG > 6°C and first span after July 15th (1st Jan in SH) of 6 days with TG < 5°C.

Growing season length: Annual (1st Jan to 31st Dec in Northern Hemisphere, NS) or 15th July to 15th Aug in Southern Hemisphere (SH) count from first span of at least 6 days with daily mean temperature TG > 6°C and first span after July 15th (1st Jan in SH) of 6 days with TG < 5°C.

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Growing season length: Annual (1st Jan to 31st Dec in Northern Hemisphere, NS) or 15th July to 15th Aug in Southern Hemisphere (SH) count from first span of at least 6 days with daily mean temperature TG > 6°C and first span after July 15th (1st Jan in SH) of 6 days with TG < 5°C.

Number of tropical nights: Annual count of days when TN (daily minimum temperature) > 20°C.
17. RxD1 day: Monthly maximum 1-day precipitation:

Let $RR_{ij}$ be the daily precipitation amount on day $i$ in period $j$. The maximum 1-day value for period $j$ are:

$$Rx1\text{day}_j = \max (RR_{ij})$$

18. Rx5day: Monthly maximum consecutive 5-day precipitation:

Let $RR_{kj}$ be the precipitation amount for the 5-day interval ending $k$, period $j$. Then maximum 5-day values for period $j$ are:

$$Rx5\text{day}_j = \max (RR_{kj})$$

19. SDII: Simple precipitation intensity index: Let $RR_w$ be the daily precipitation amount on wet days, $W (RR \geq 1\text{mm})$ in period $j$. If $W$ represents number of wet days in $j$, then:

$$SDII_j = \frac{\sum_{w \in W} RR_{w}}{W}$$

20. R10mm: Annual count of days when PRCP $\leq 10\text{mm}$: Let $RR_j$ be the daily precipitation amount on day $i$ in period $j$. Count the number of days where:

$$RR_j \geq 10\text{mm}$$

21. R20mm: Annual count of days when PRCP $\geq 20\text{mm}$: Let $RR_j$ be the daily precipitation amount on day $i$ in period $j$. Count the number of days where:

$$RR_j \geq 20\text{mm}$$

22. Rnmm: Annual count of days when PRCP $\geq n\text{mm}$: Let $RR_j$ be the daily precipitation amount on day $i$ in period $j$. Count the number of days where:

$$RR_j \geq n\text{mm}$$

23. CDP: Maximum length of dry spell, maximum number of consecutive days with RR $< 1\text{mm}$: Let $RR_j$ be the daily precipitation amount on day $i$ in period $j$. Count the largest number of consecutive dry days where:

$$RR_j < 1\text{mm}$$

24. CWL: Maximum length of wet spell, maximum number of consecutive days with RR $\geq 1\text{mm}$: Let $RR_j$ be the daily precipitation amount on day $i$ in period $j$. Count the largest number of consecutive wet days where:

$$RR_j \geq 1\text{mm}$$

25. R95pTOT: Annual total PRCP when RR $> 95\%$: Let $RR_w$ be the daily precipitation amount on a wet day $w (RR \geq 1.0\text{mm})$ in period $i$ and let $RR_{w95}$ be the 95th percentile of precipitation on wet days in the 1961-1990 period. If $W$ represents the number of wet days in the period, then:

$$R95_p = \sum_{w=1}^{W} RR_{wj} \text{ where } RR_{wj} > RR_{w95}$$

26. R99pTOT: Annual total PRCP when RR $> 99\%$: Let $RR_w$ be the daily precipitation amount on a wet day $w (RR \geq 1.0\text{mm})$ in period $i$ and let $RR_{w99}$ be the 99th percentile of precipitation on wet days in the 1961-1990 period. If $W$ represents the number of wet days in the period, then:

$$R99_p = \sum_{w=1}^{W} RR_{wj} \text{ where } RR_{wj} > RR_{w99}$$

27. PRCPTOT: Annual total precipitation in wet days: Let $RR_{ij}$ be the daily precipitation amount on day $i$ in period $j$. If $I$ represents the number of days in $j$, then:

$$PRCPTOT_j = \sum_{i=1}^{I} RR_{ij}$$
Summary

• We can calculate a number of different metrics to describe extremes in climate projections

• It is a matter of defining what is interesting/relevant for applications

• However, depends on how well the processes are represented in the models

• Comparisons for change should be made within model periods (e.g. future compared to present climate in the model)