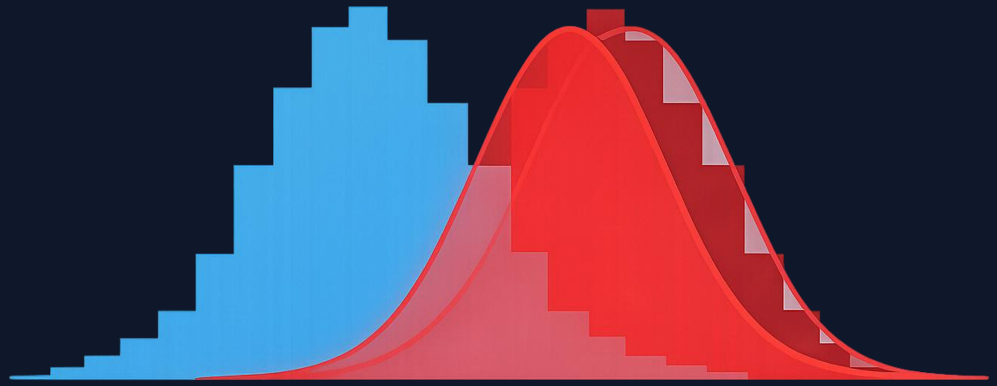
12th Seminar for Homogenization and Quality Control in Climatological Databases and 7th Interpolation Conference – May 2026

Shifting Baselines, Shifting Trends

The Hidden Impact of Global Warming on Percentile-Based Indices
Indices

Yizhak Yosef



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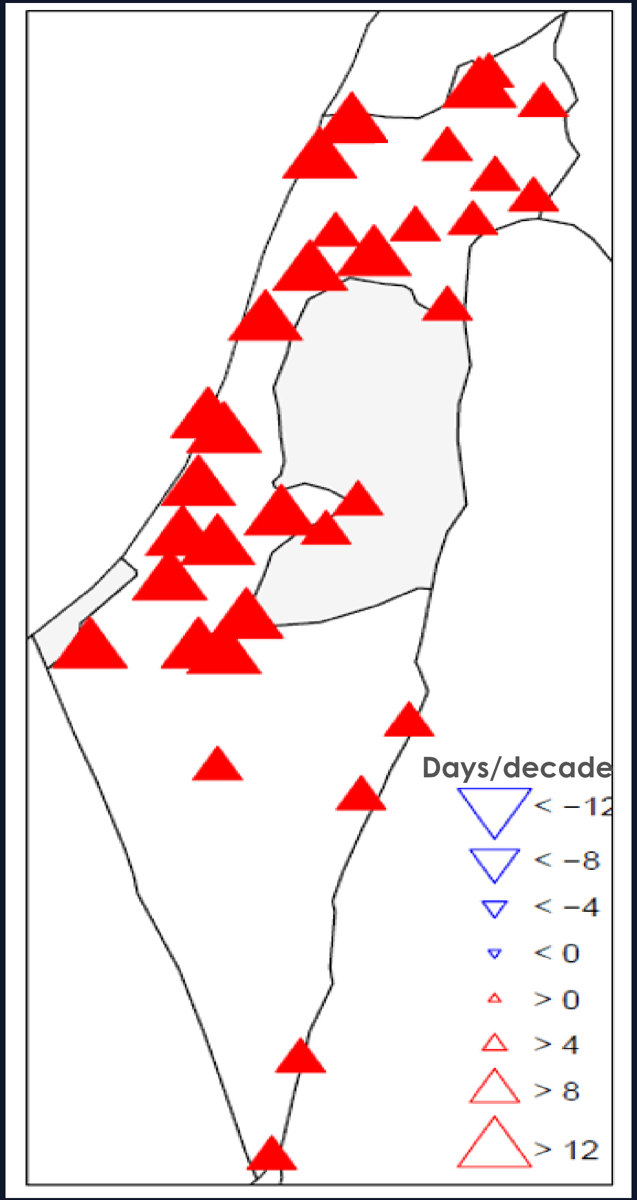
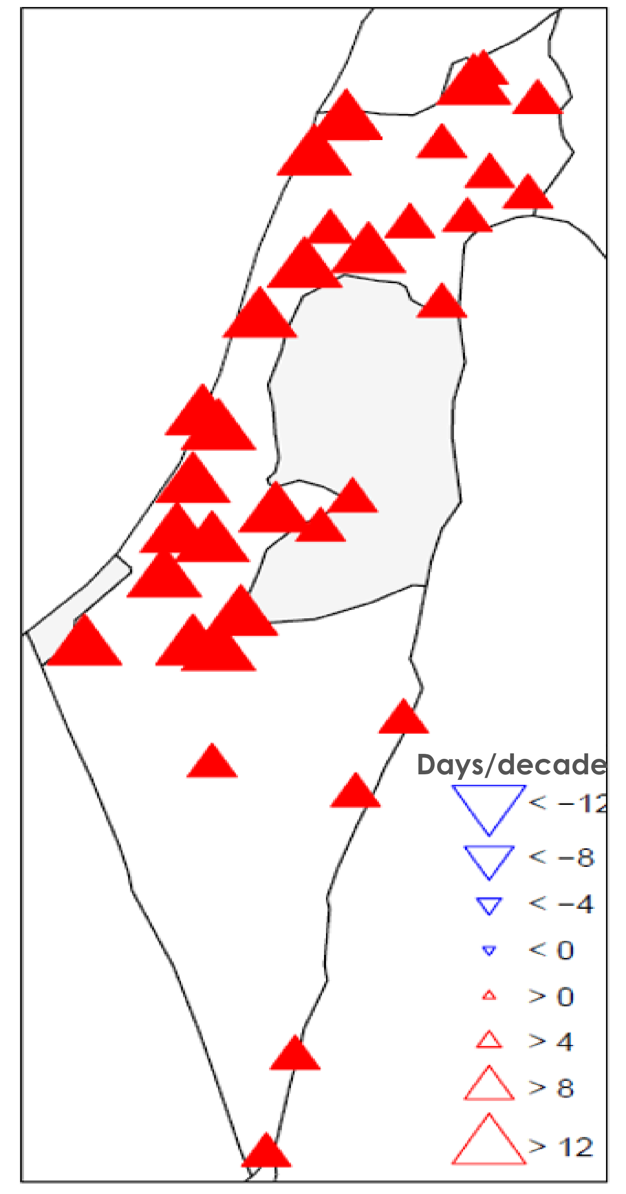
Trends in the Tropical Nights Index (TN > 20°C) over 1988 to 2017

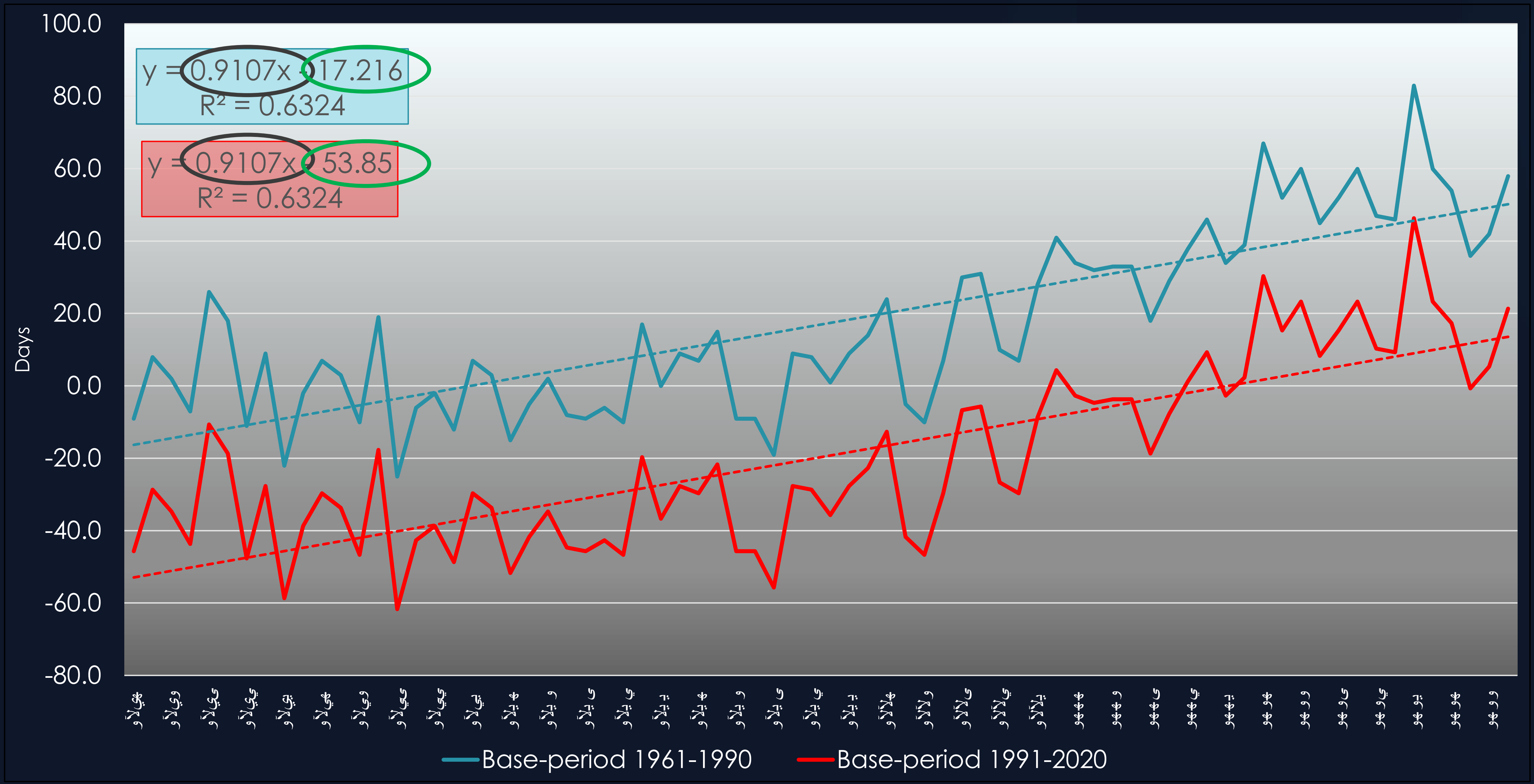
1988-2017
reference period 1961-1990



1988-2017
reference period 1988-2017



Anomalies in the number of days when minimum temperature was above 20 °C (TN>20 °C, tropical nights)

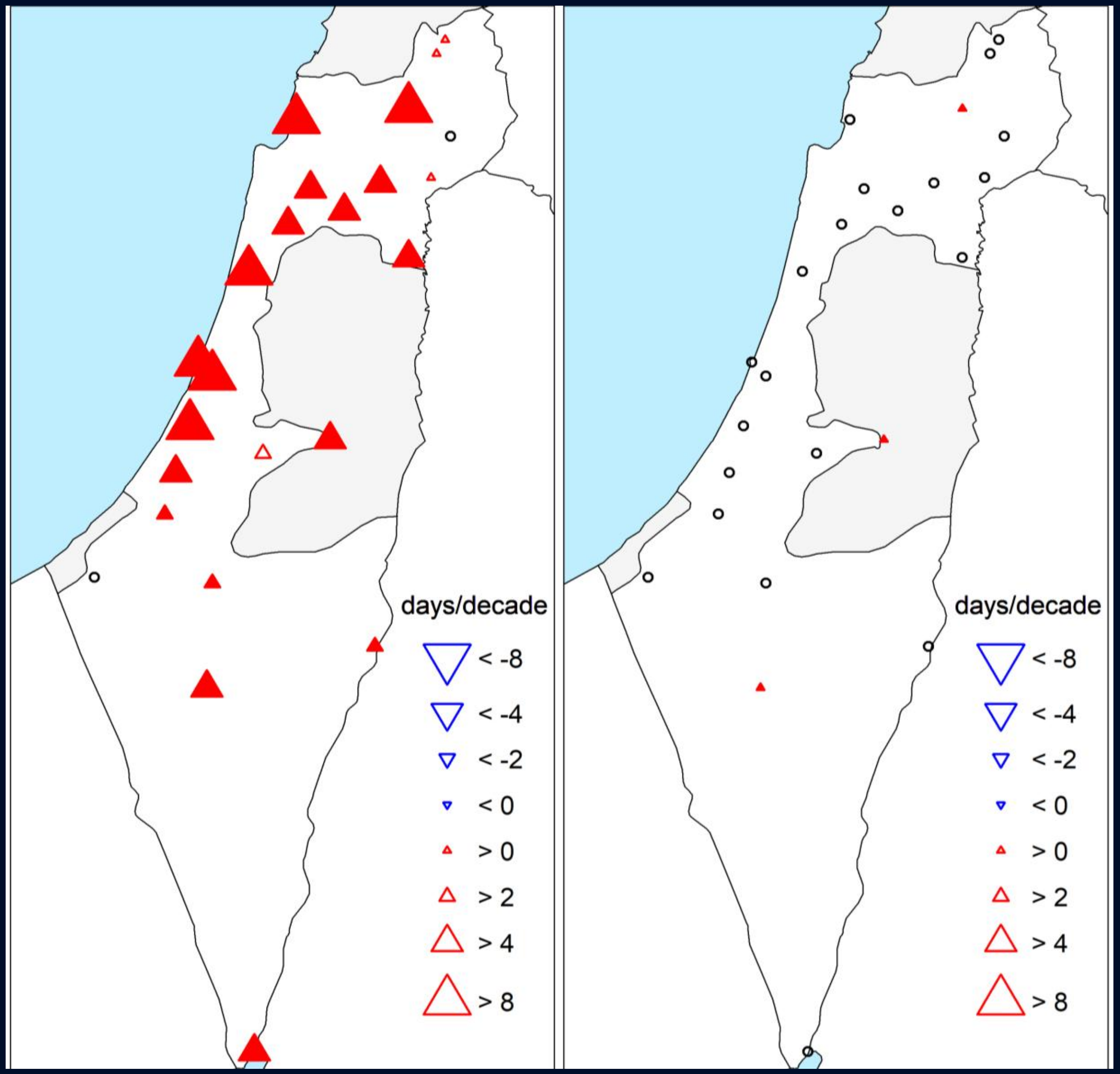


Warm Spell Duration Index (WSDI) trends over 1988-2017

WSDI: Annual count of days with at least 6 consecutive days when $TX>90^{th}$ percentile

1988-2017
reference period 1961-1990

1988-2017
reference period 1988-2017



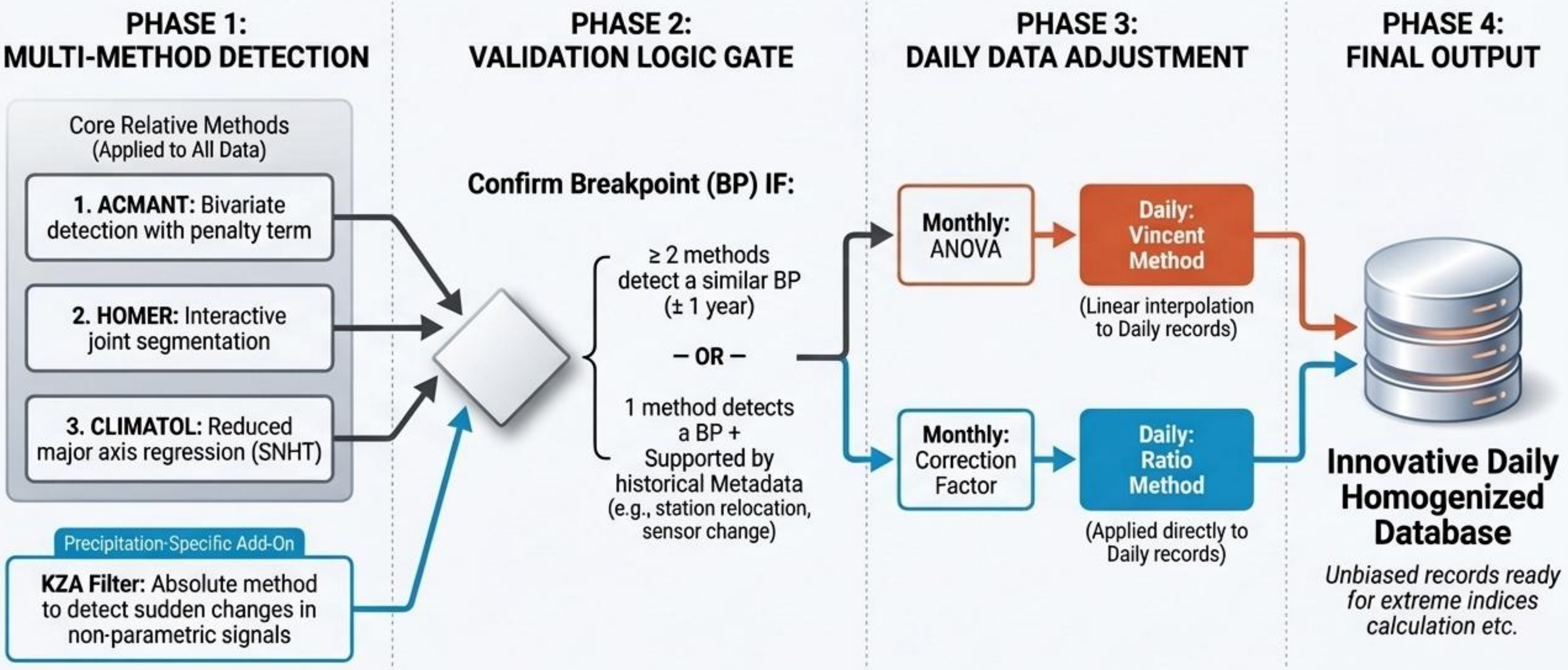
Upward facing red triangles represent increasing trends. Filled triangles mark significant changes (p≤0.05; units: days/decade). Circle denote no trend. (Yosef et al., 2021)

OUTLINES

- **Homogenization procedure.**
- **Short overview** on extreme temperature percentile-based indices.
- **Results** – Examples of Warm/Cold spell duration, Warm/Cold days and nights indices.
- **Conclusions**

The Homogenization Scheme

A rigorous, multi-method pipeline for detecting and adjusting **non-climatic breakpoints** in long-term meteorological records.

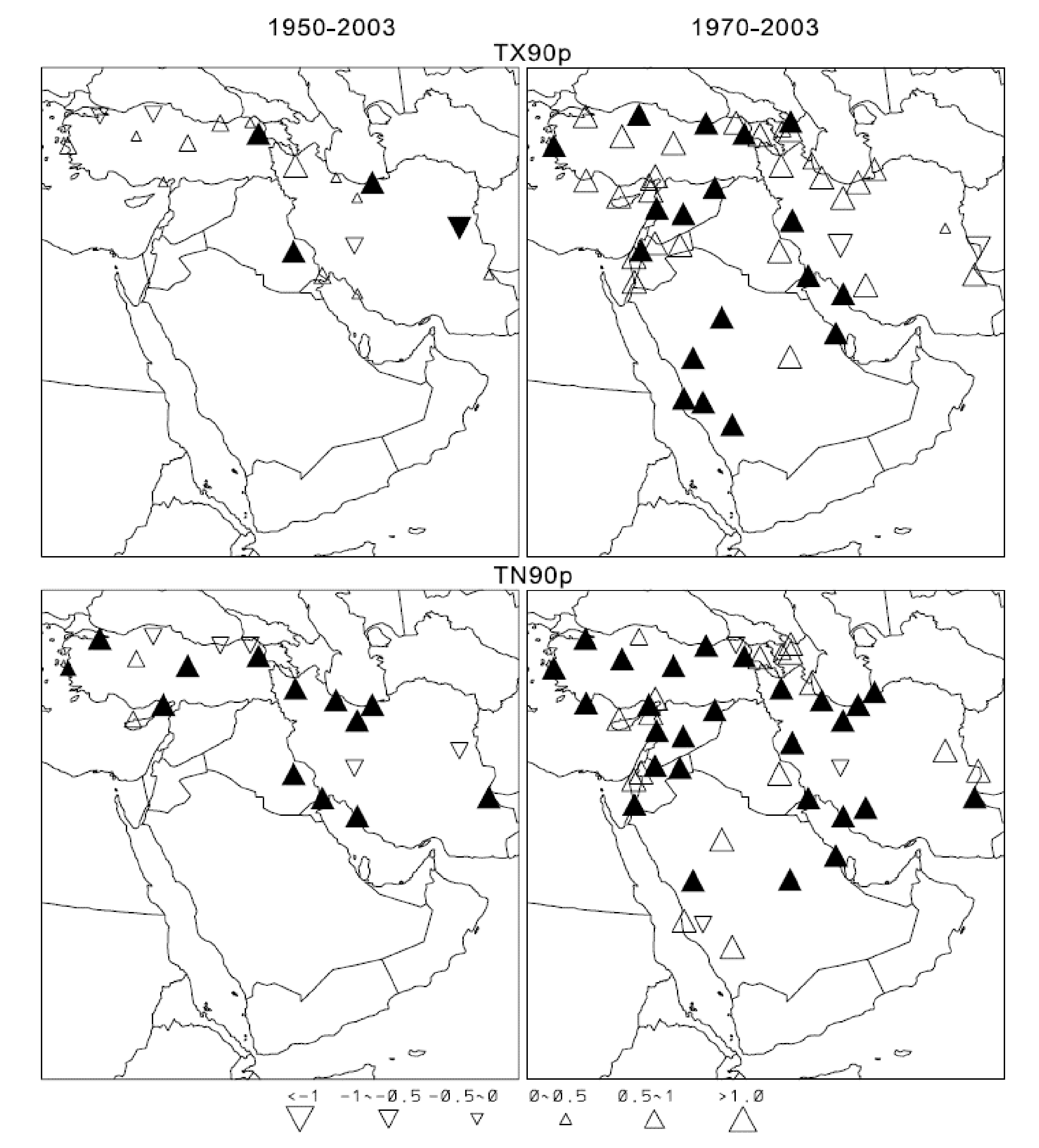


Percentile-based extreme indices recommended by the Expert Team on Climate Change Detection and Indices (ETCCDI) & Expert Team on Sector-specific Climate Indices (ET-SCI)

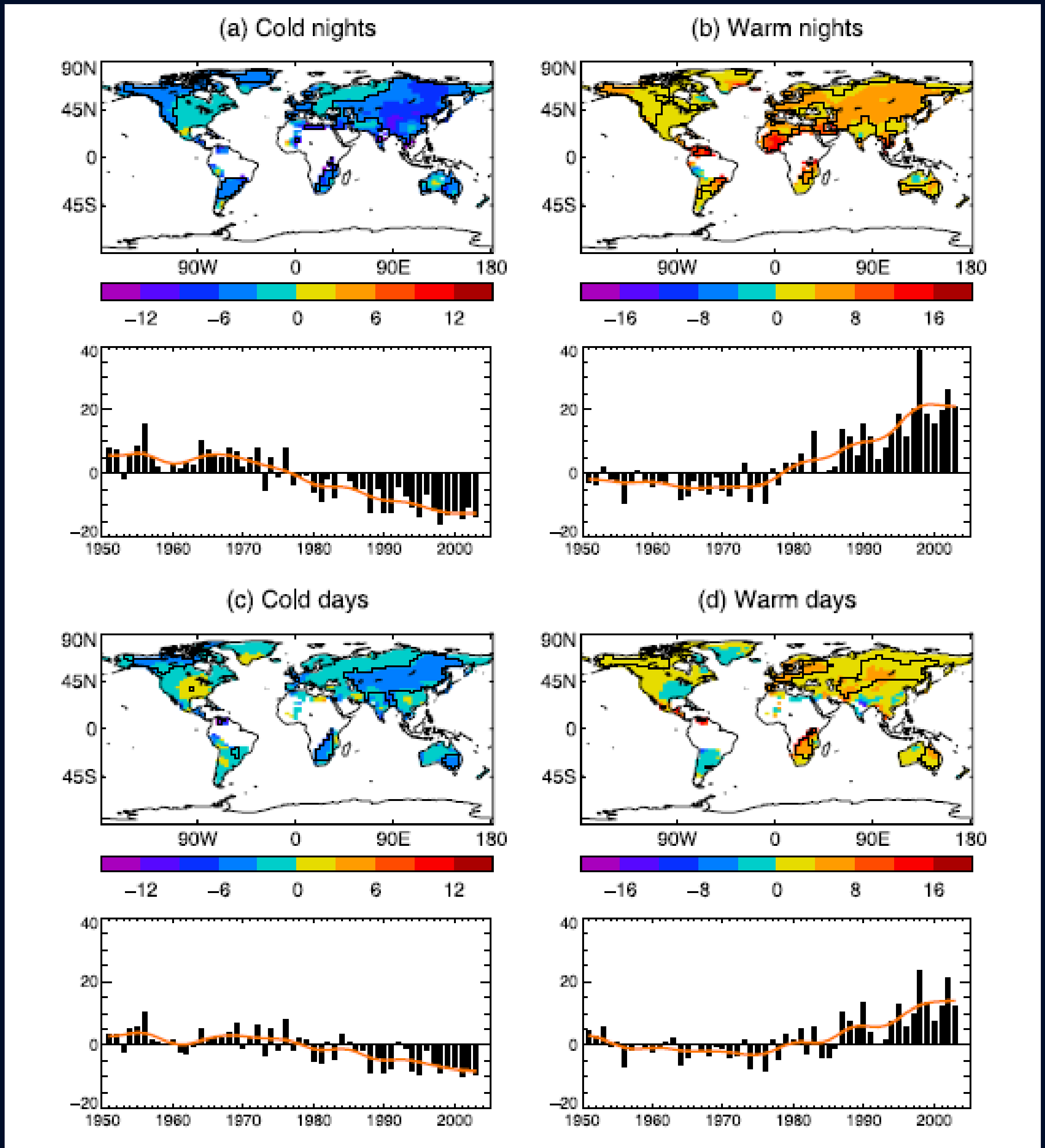
Index	Indicator name	Definitions	ET	Unit
TX10p	**Cool days**	Percentage of days when TX<10th percentile	ETCCDI	%
TX90p	**Warm days**	Percentage of days when TX>90th percentile	ETCCDI	%
TN10p	**Cool nights**	Percentage of days when TN<10th percentile	ETCCDI	%
TN90p	**Warm nights**	Percentage of days when TN>90th percentile	ETCCDI	%
WSDI	**Warm spell duration indicator**	Annual count of days with at least 6 consecutive days when TX>90th percentile	ETCCDI	Days
WSDI3	**Warm spell duration indicator**	Annual count of days with at least 3 consecutive days when TX>90th percentile	ET-SCI	Days
CSDI	**Cold spell duration indicator**	Annual count of days with at least 6 consecutive days when TN<10th percentile	ETCCDI	Days
CSDI3	**Cold spell duration indicator**	Annual count of days with at least 3 consecutive days when TN<10th percentile	ET-SCI	Days

And more…

These indices help provide a standardized method for tracking changes in climate extremes globally



(Zhang et al., 2005. **Base period, 1971-2000**)



(Alexander et al., 2006. **Base period 1961-1990**)

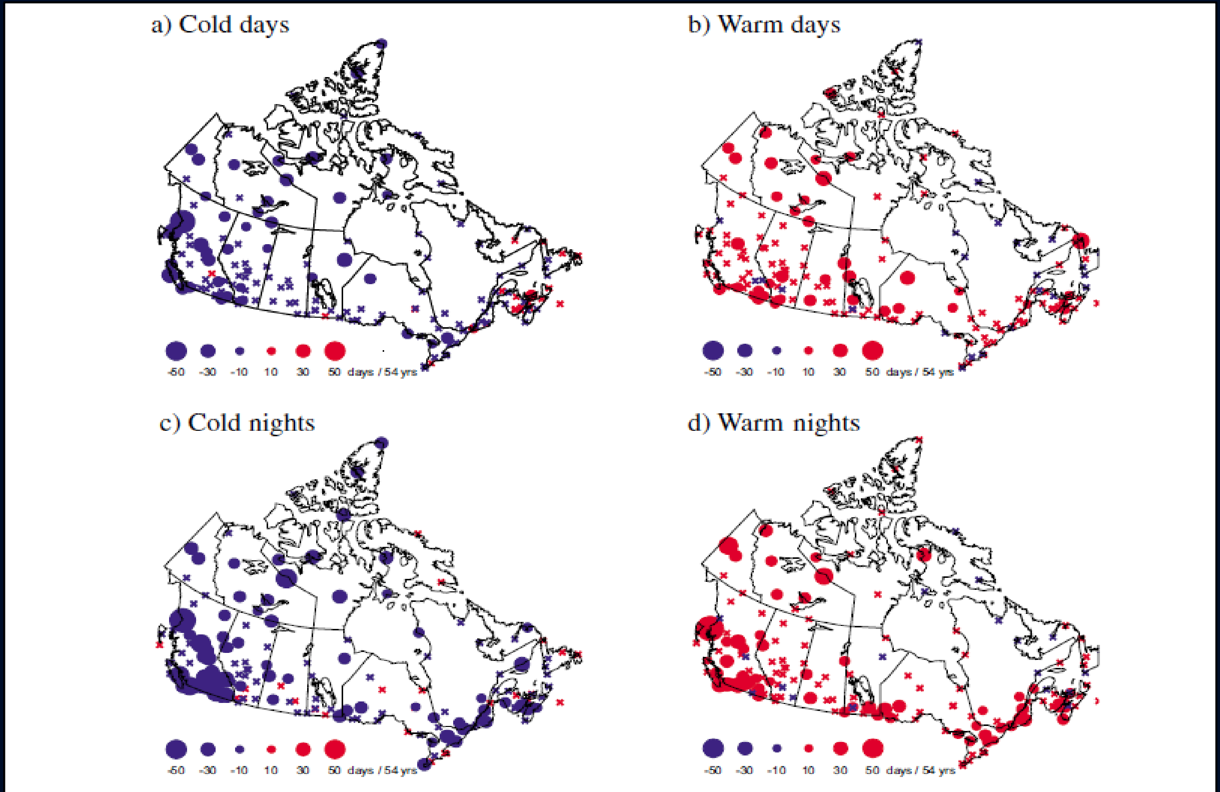
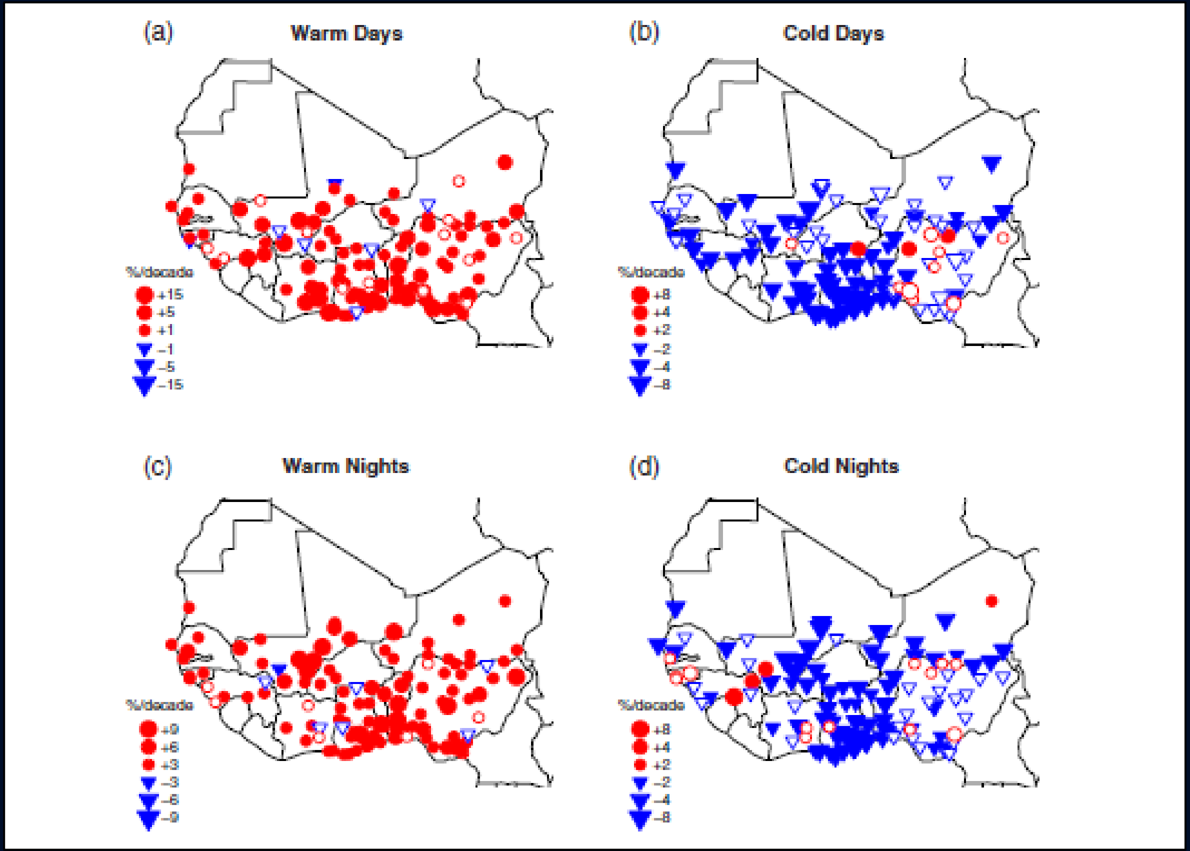
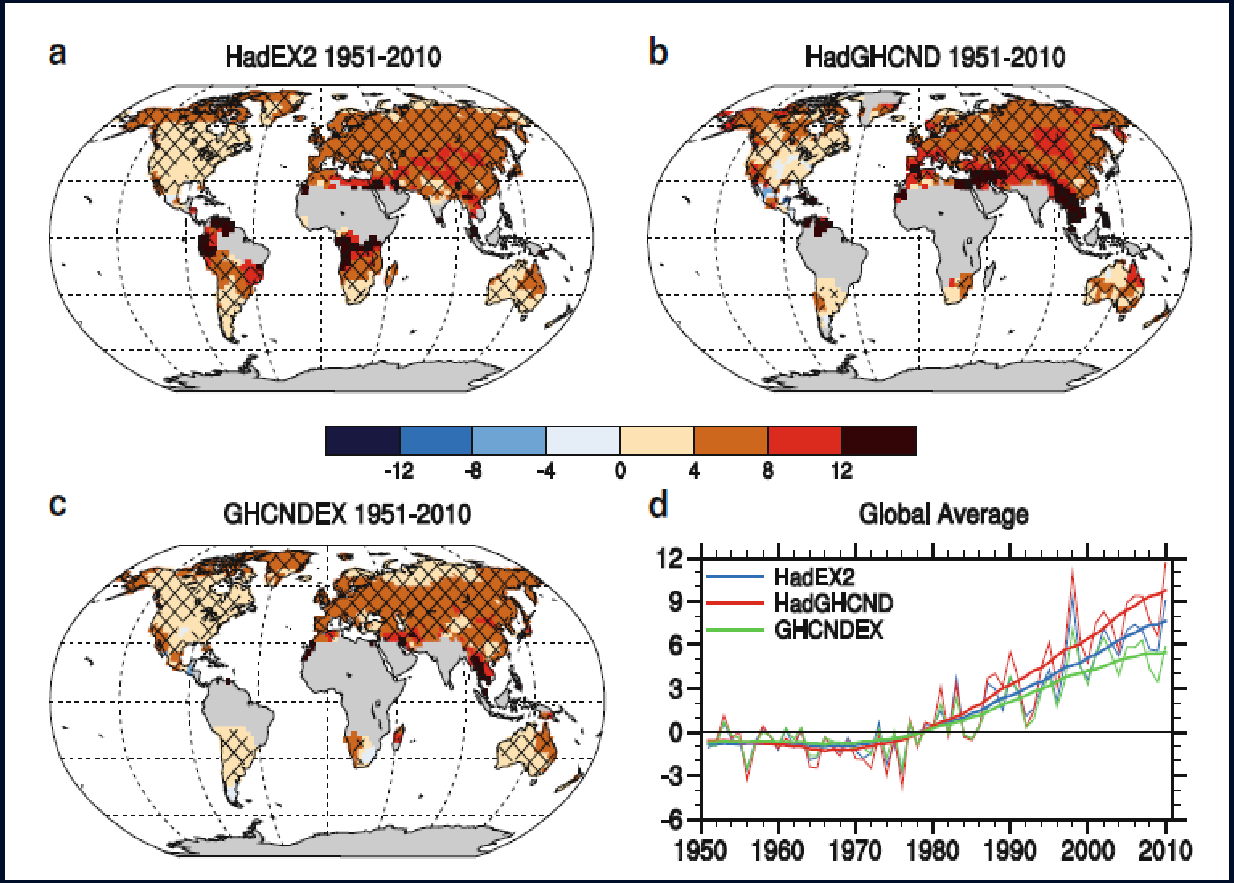


Fig. 2 Trends in four temperature indices for 1950–2003. Blue and red dots indicate trends significant at the 5% level. The size of the dots is proportional to the magnitude of the trend. Crosses denote non-significant trends.

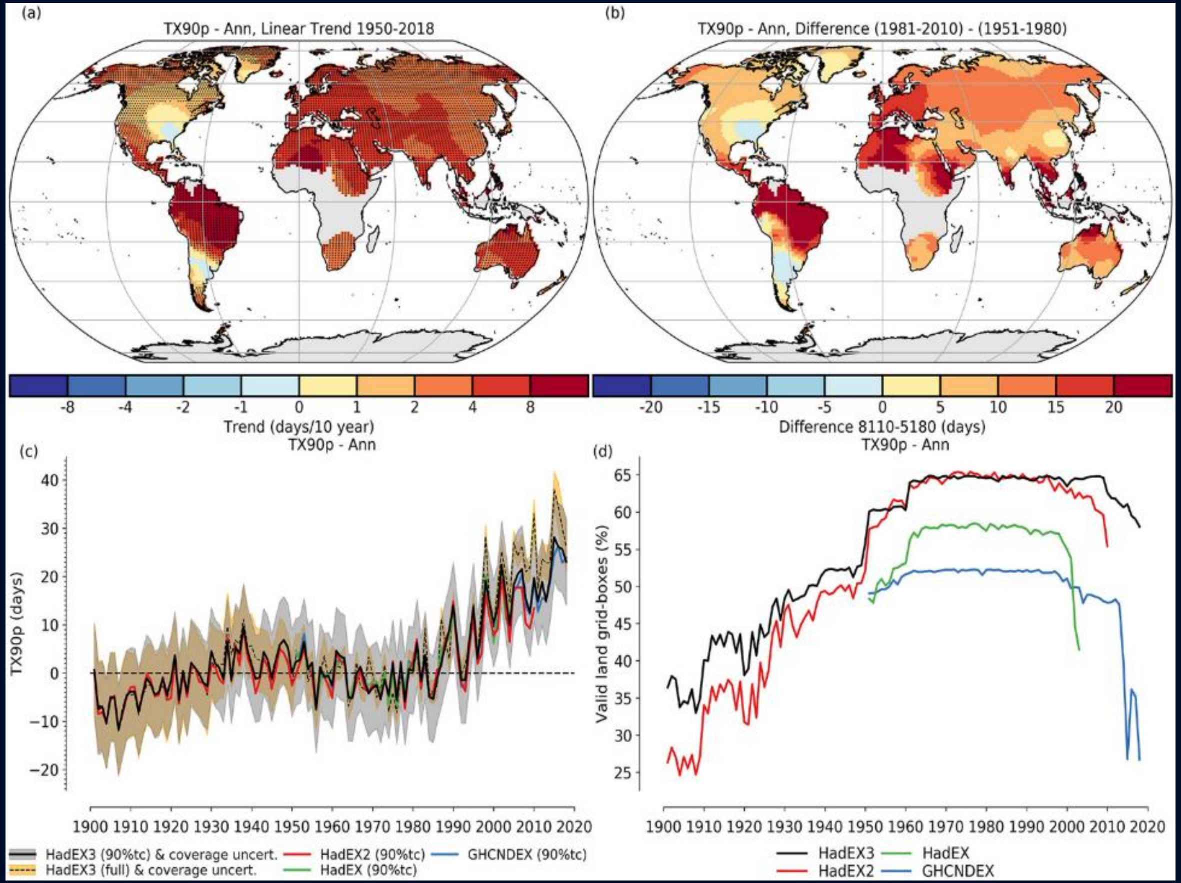


(Vincent & Mekis, 2006. **Base period1961-1990**)

(Barry et al., 2018. **Base period 1981-2010**)

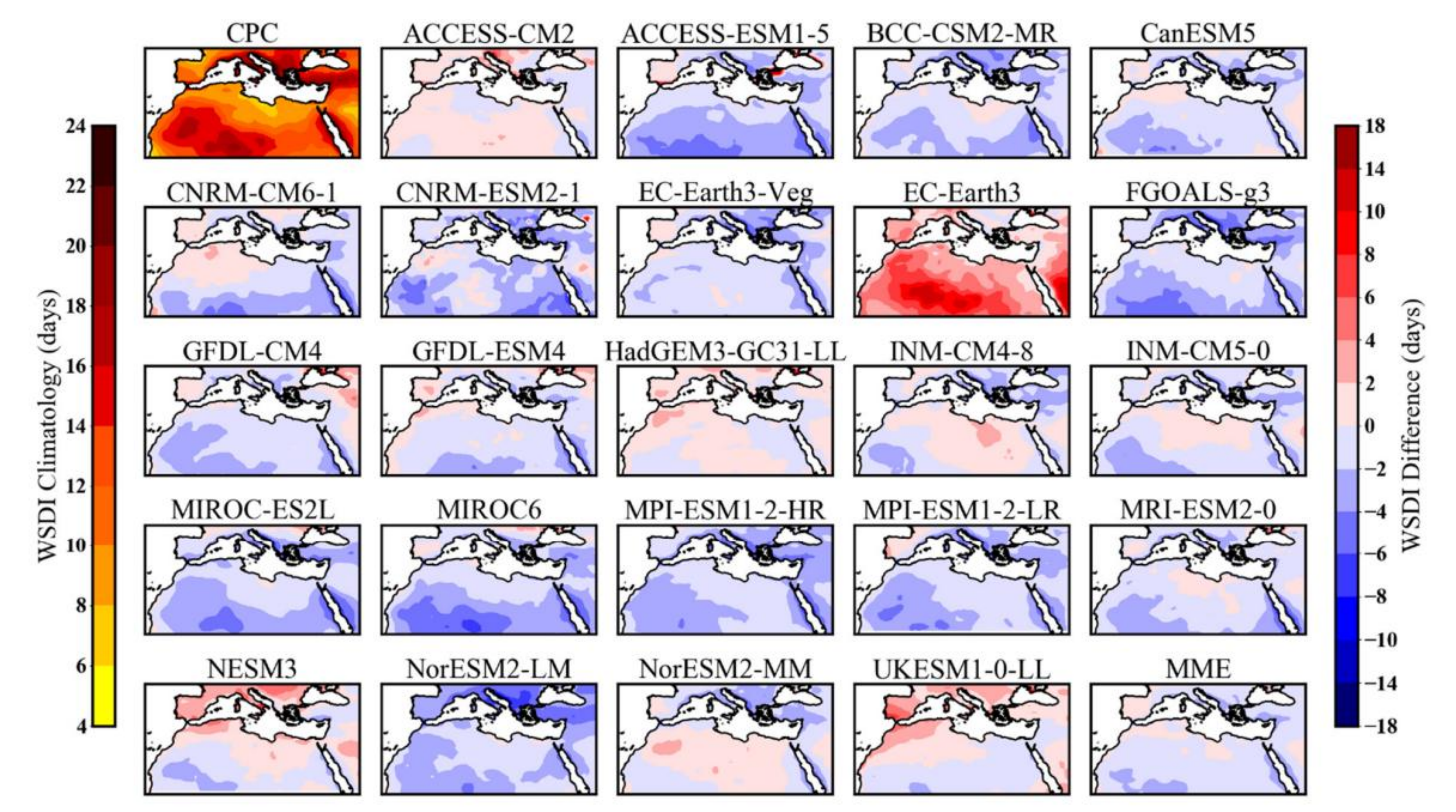


(Zwiers et al., 2013. **Base period1961-1990**)



(Dunn et al., 2020. **Base period1961-1990** and **1981-2010**)

CIMP6: Warm Spell Duration Index – WSDI



(Babaousmail et al., 2022. **Base period 1995-2014**)

Calculating Percentiles based indices

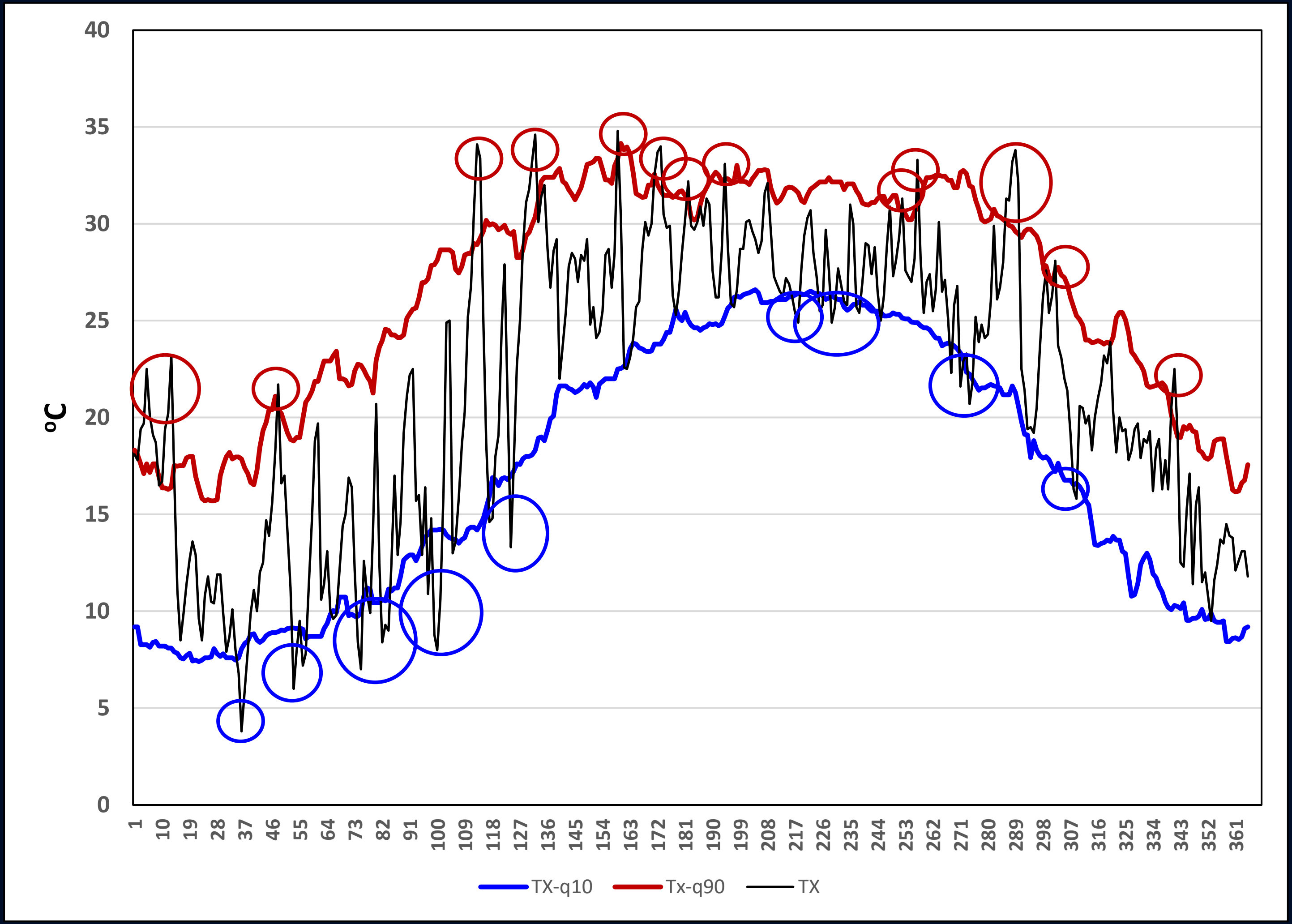
Reference period
(length 30 years)

1, 2, 3, 4, 5, 6, 7, 8,…,365

5 Days X 30 Years = 150 records

10% **90%**

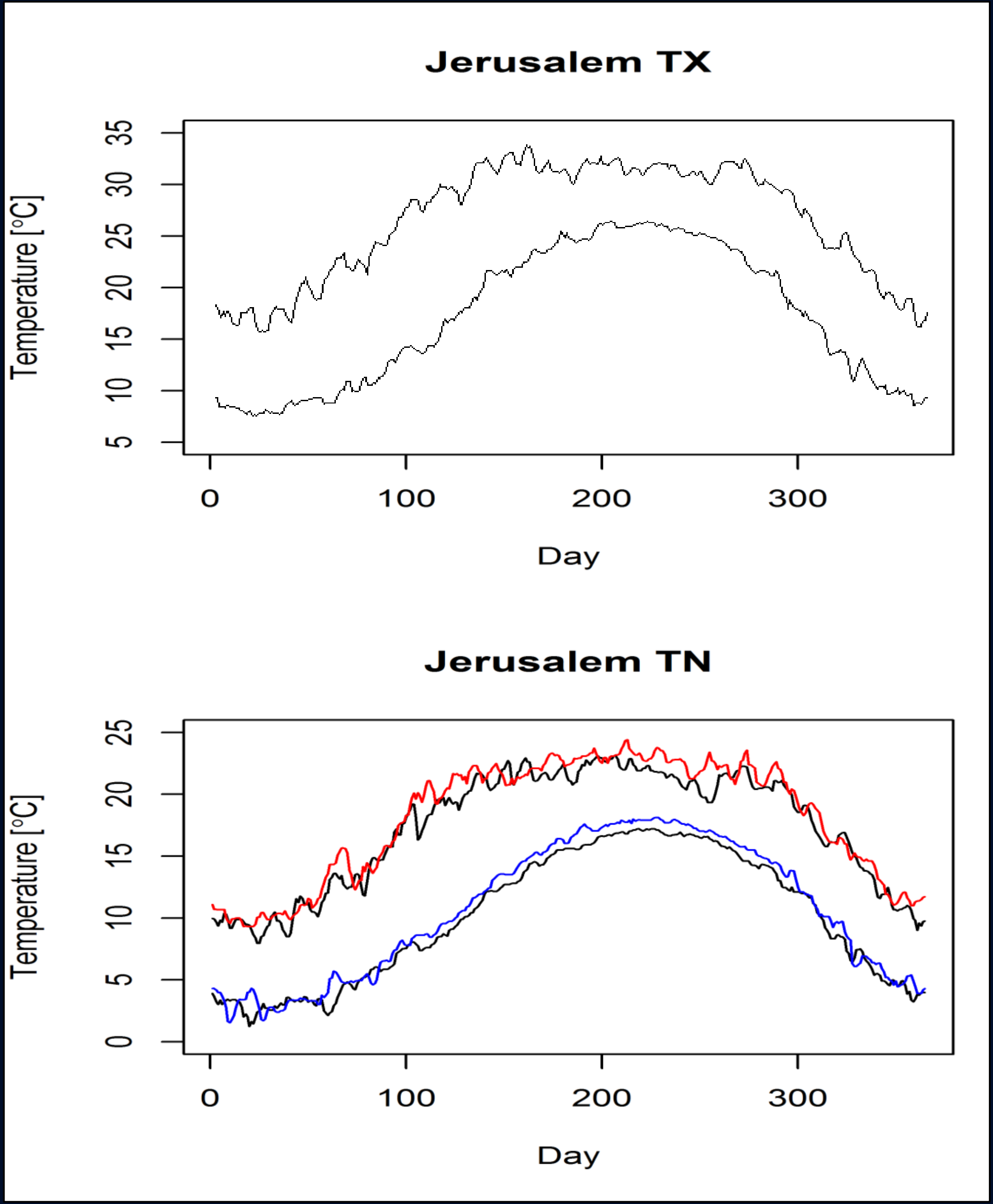
1, 2, 3, 4, 5, 6, 7, 8,…,365



And a bootstrap procedure by Zhang et al. [2005] was applied to ensure that there are no artificial jumps at the boundaries of the in-base and out-of-base period.

The percentile-based thresholds derived from two base periods

Jerusalem –
Mountainous region



Black lines, percentiles derived from **1961-1990**

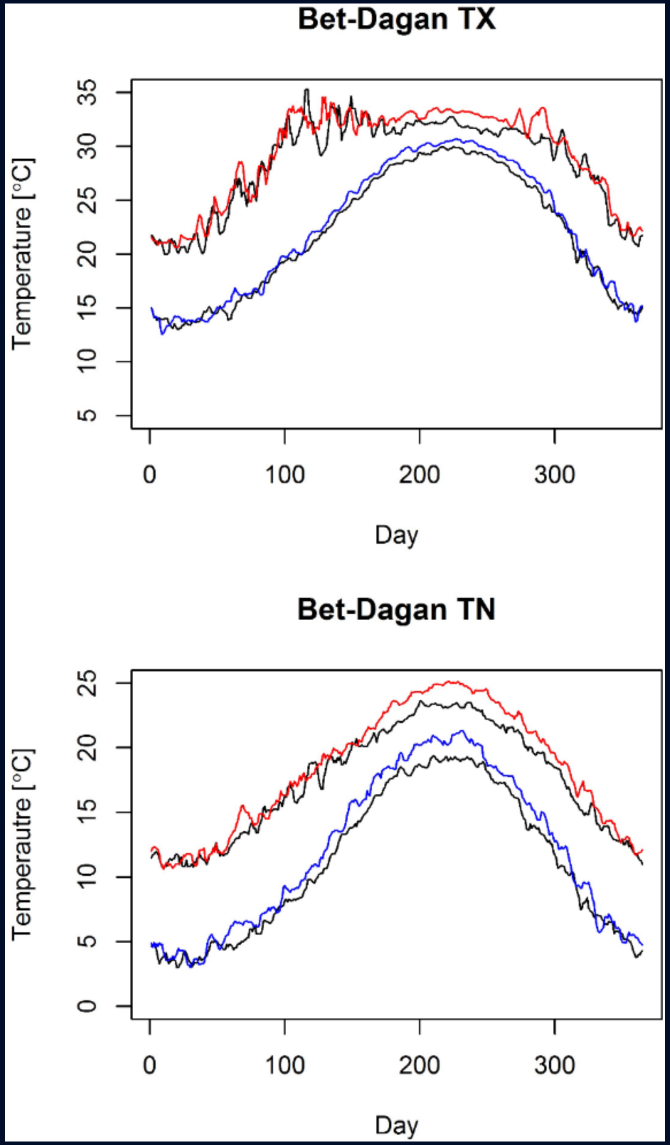
Red lines, 90th percentile derived from **1988-2017**

Blue lines, 10th percentile derived from **1988-2017**

The upper curves denote the 90th percentile and the lower curves denote the 10th percentiles (Yosef et al., 2021).

The percentile-based thresholds derived from two base periods

Bet Dagan – Coastal plain



Black lines, percentiles derived from **1961-1990**

Red lines, 90th percentile derived from **1988-2017**

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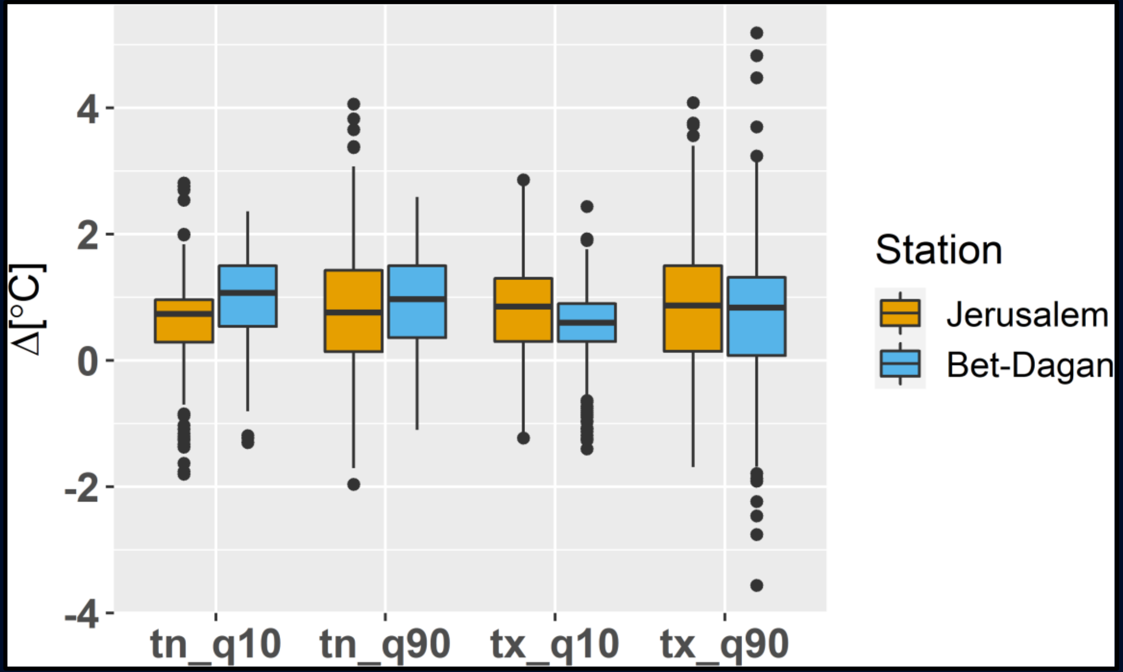
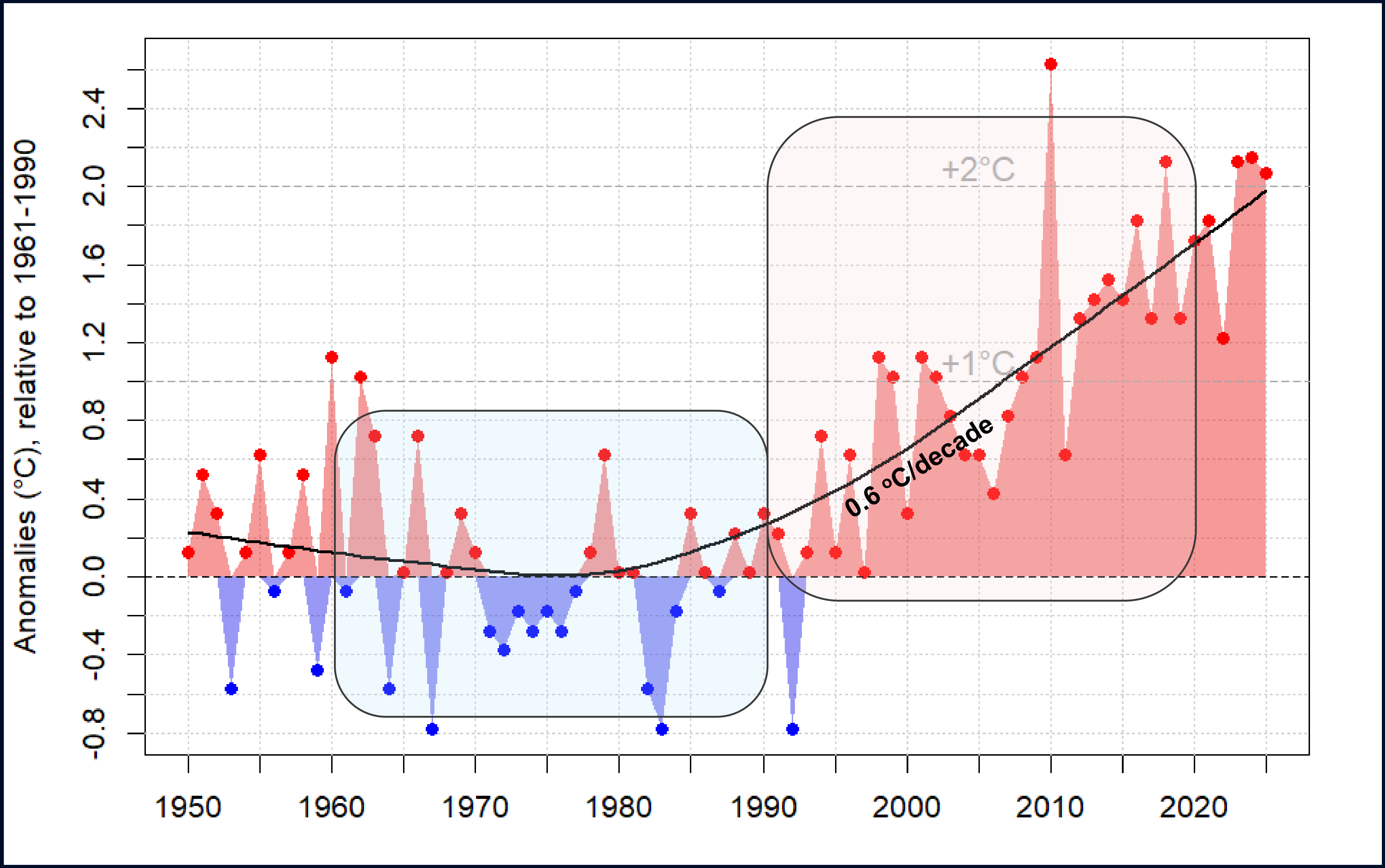


The distribution of the differences when subtracting the threshold of each day in the warm period **1988–2017** from the cooler period **1961–1990**, at the 10th and the 90th percentiles.

Mean deviation: 0.8 to 1.0°C

ISRAEL REGIONAL AVERAGED ANOMALY MEAN TEMPERATURE

(RELATIVE TO 1961-1990)



Warm Spell Duration Index (WSDI) trends over 1988-2017

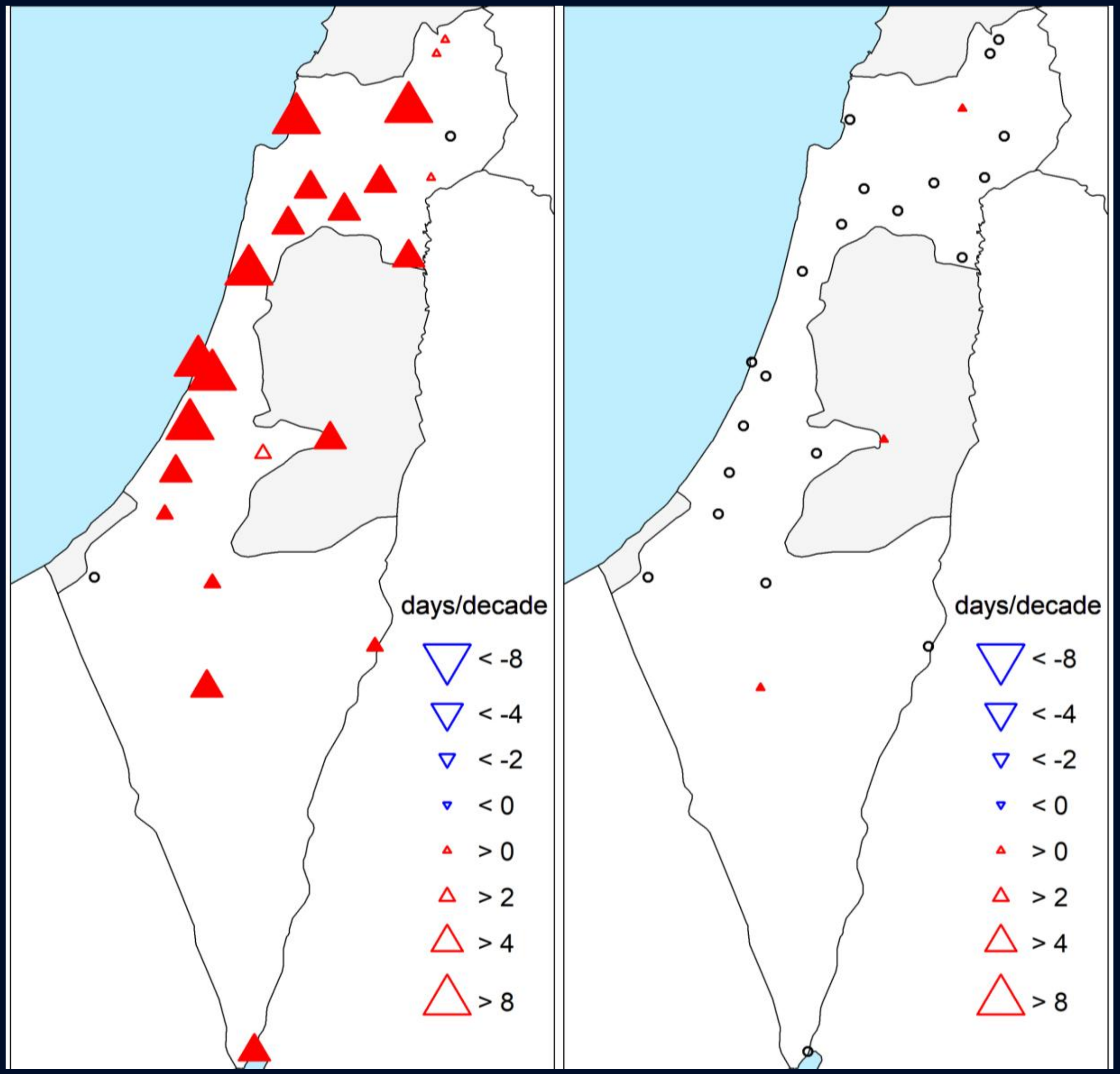
WSDI: Annual count of days with at least 6 consecutive days when TX>90th percentile

Exactly the same time period

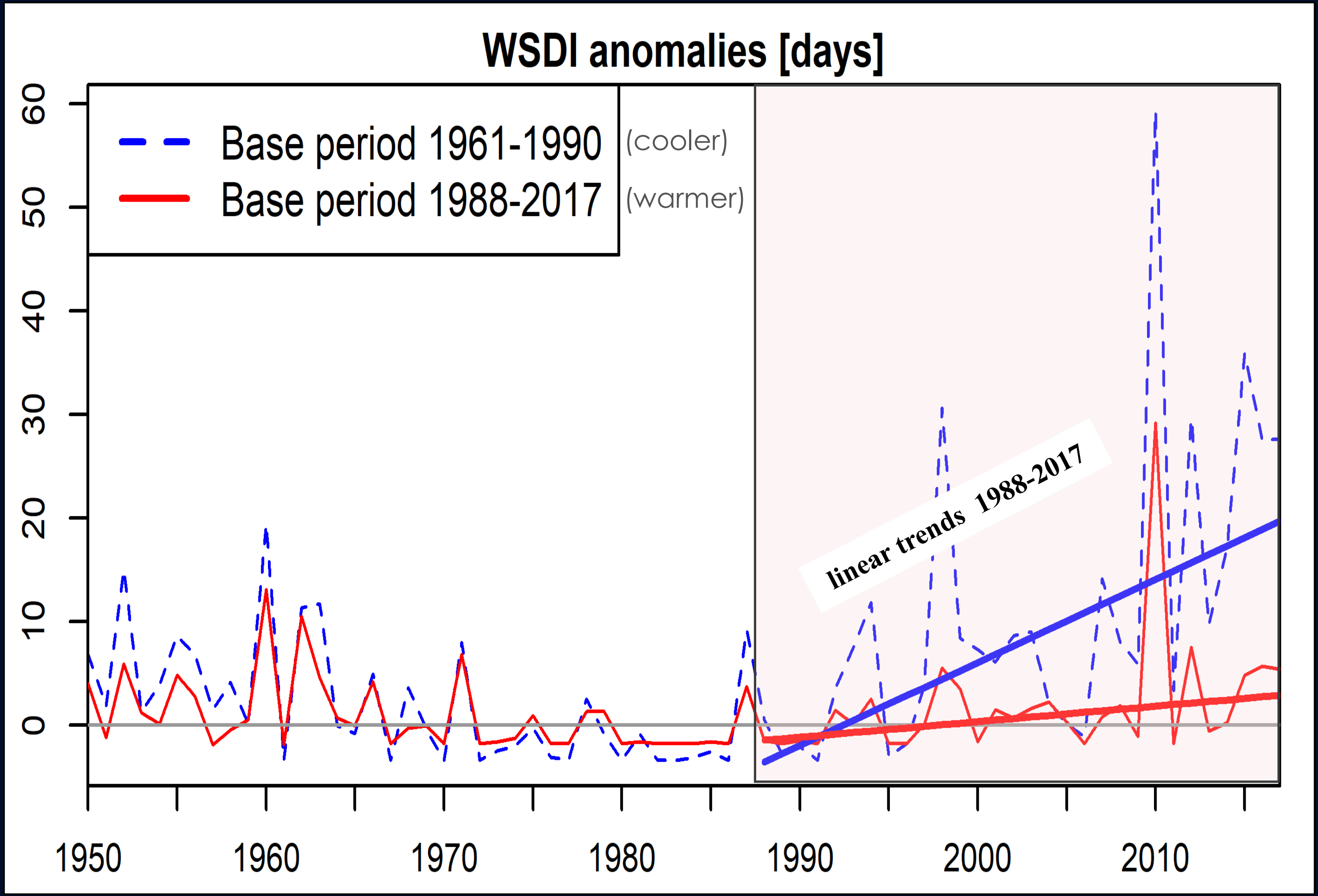
Different trends

1988-2017
reference period 1961-1990

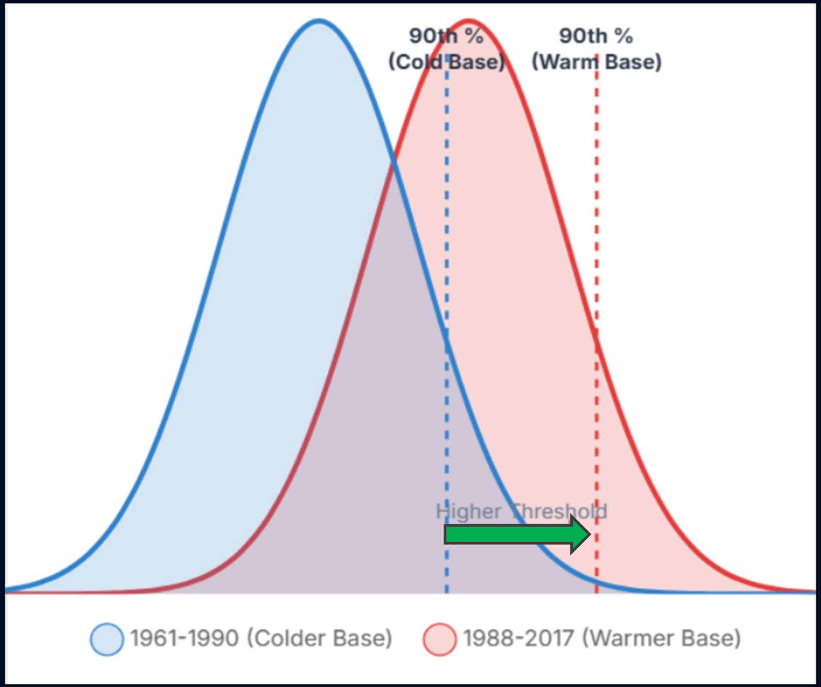
1988-2017
reference period 1988-2017



Regional averaged anomaly series - WSDI



Base-period	1988-2017 (Days/decade)
1961-1990	8.03
1988-2017	1.5



- **The Mechanics:** Deriving percentiles from a distribution shifted to the right results in higher thresholds that need to be exceeded.
- **The Result:** A modern base period forces extreme events to cross a higher threshold, artificially suppressing the count of warm days.

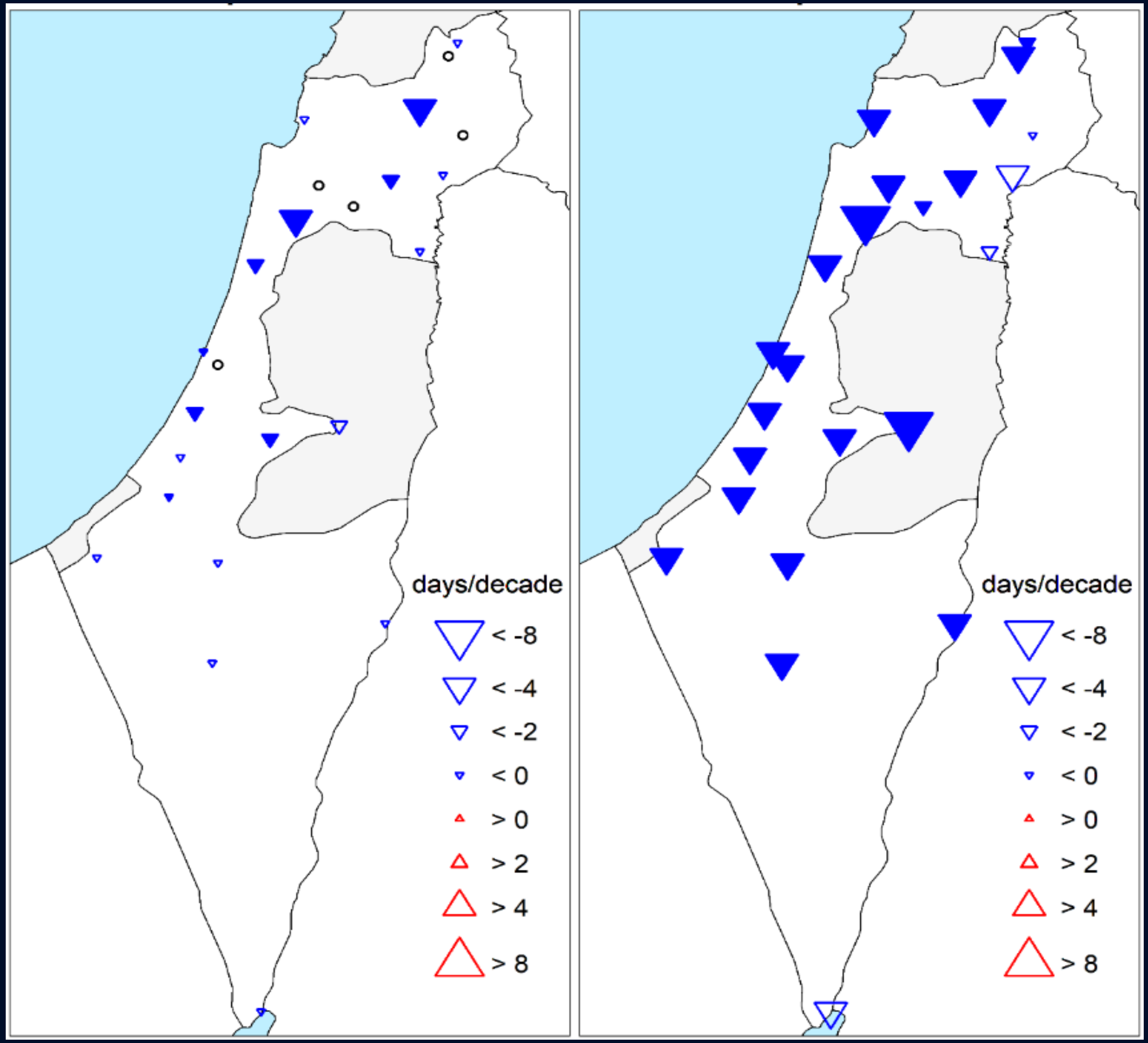
Cold Spell Duration Index (CSDI3) trends over 1988-2017

CSDI3: Annual count of days with at least 3 consecutive days when TN<10th percentile

Exactly the same time period

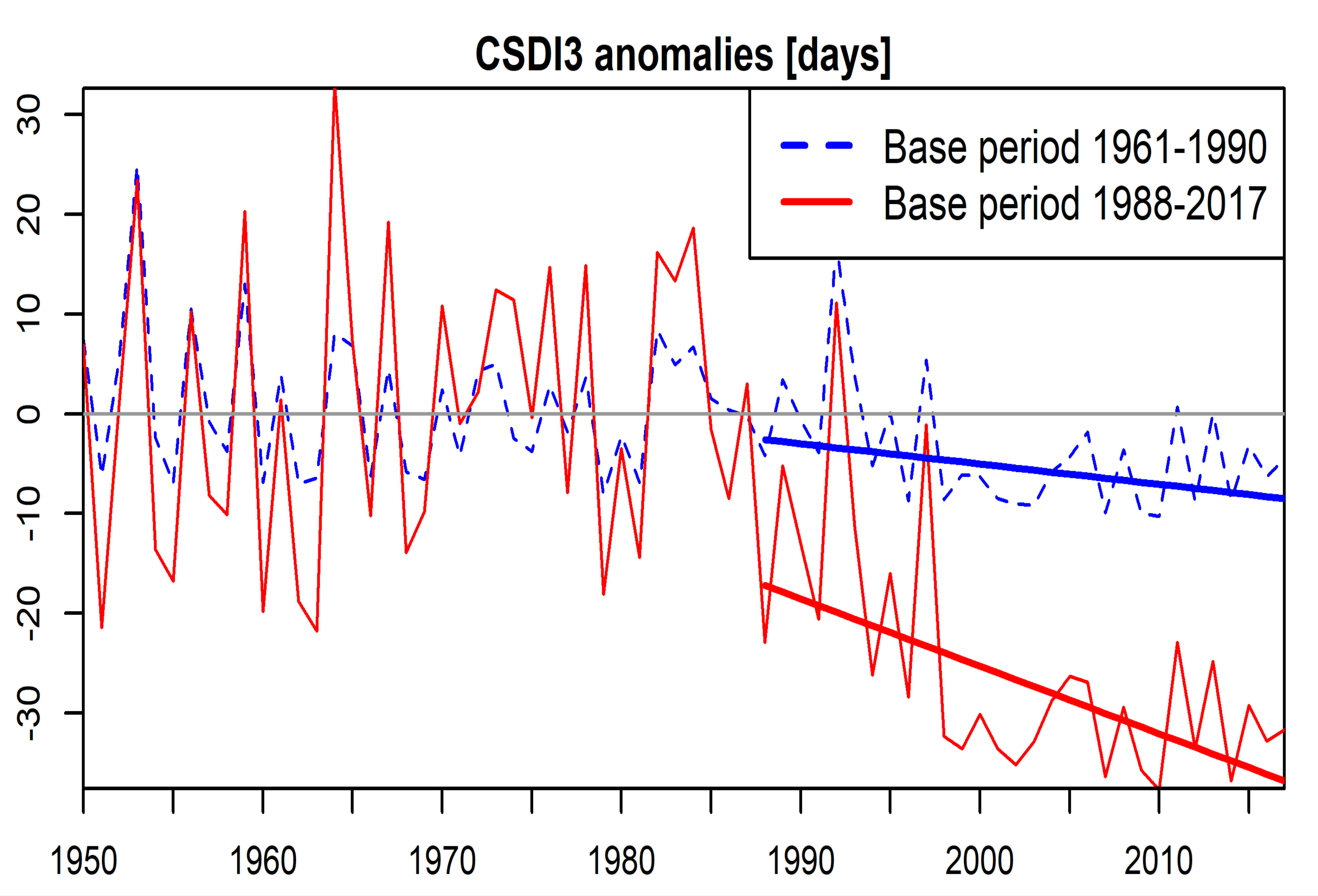
Different trends

1988-2017 reference period 1961-1990	1988-2017 reference period 1988-2017



(Yosef et al., 2021)

Regional averaged anomaly series – CSDI3

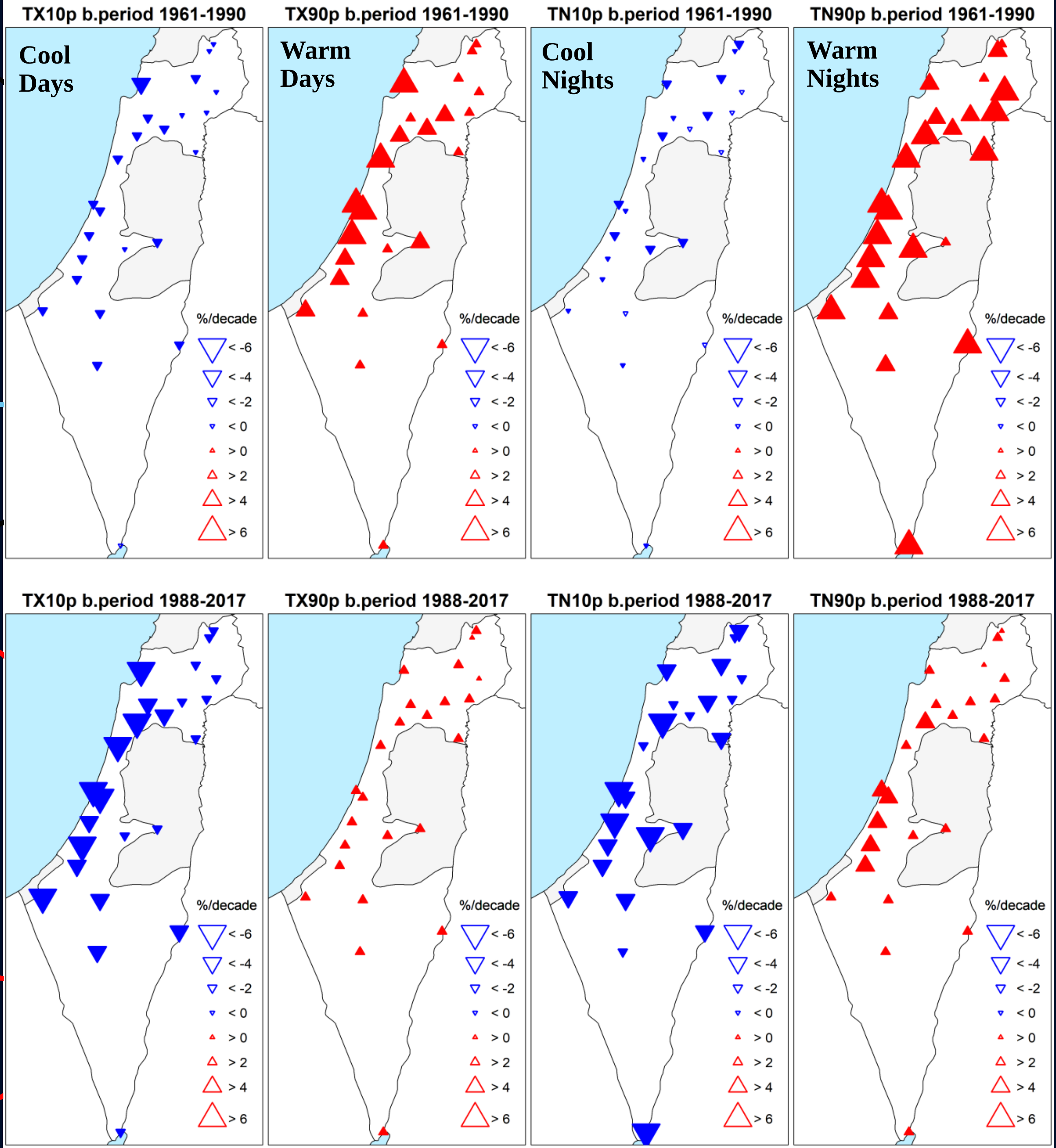


Base-period	1988-2017 (Days/decades)
1961-1990	-2.04
1988-2017	-6.76

(Yosef et al., 2021)

1988-2017
(base-period 1961-1990)

1988-2017
(base-period 1988-2017)



The annual trends in the frequency of:
TX10p (cool days)
TX90p (warm days)
TN10p (cool nights)
TN90p (warm nights)
(unit: % / decade).

Exactly the same time period

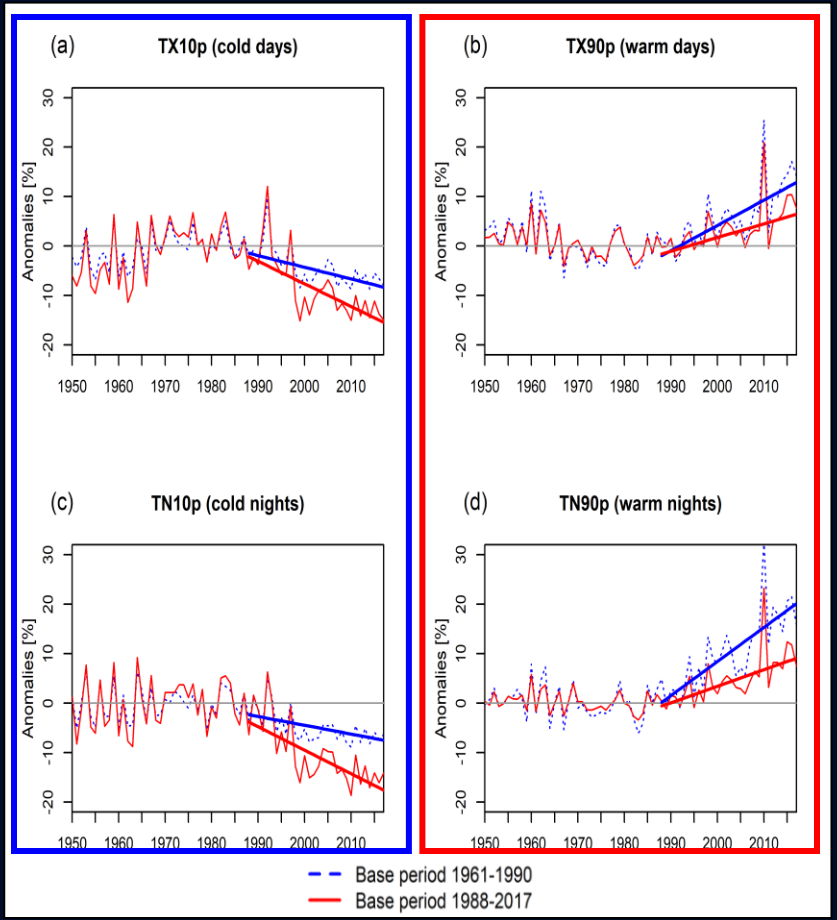
All panels show the trends for 1988-2017

(Yosef et al., 2021)

Regional averaged anomaly series

Red lines, percentile derived from **1988-2017**

Blue lines, percentile derived from **1961-1990**



Index (Unit/Decade)	Base: 1961–1990 (Colder Baseline)	Base: 1988–2017 (Warmer Baseline)	Impact of Warmer Base
WARM EXTREMES (POSITIVE TRENDS)			
WSDI (Warm Spell, days)	+8.03	+1.50	Diminished (~81% ↓)
WSDI3 (Warm Spell, days)	+14.92	+4.59	Diminished (~69% ↓)
TX90p (Warm Days, %)	+2.09%	+1.41%	Diminished (~32% ↓)
TN90p (Warm Nights, %)	+2.76%	+2.00%	Diminished (~27% ↓)
COLD EXTREMES (NEGATIVE TRENDS)			
CSDI3 (Cold Spell, days)	-2.04	-6.76	Amplified (~3.3x ↑)
TX10p (Cold Days, %)	-3.82%	-5.43%	Amplified (~42% ↑)
TN10p (Cold Nights, %)	-2.84%	-5.68%	Amplified (2x ↑)

- Modern baselines dramatically diminish the positive trend magnitude of warm indices.
- Modern baselines strongly amplify the negative trend magnitude of cold indices.

Atmospheric Science Letters
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RESEARCH ARTICLE | Open Access

Sensitivity of Heatwave Characteristics to the Climatic Baseline

Vivian A. Fraser-Leonhardt, Gabriele C. Hegerl, James D. P. Mollard

First published: 08 April 2026 | https://doi.org/10.1002/asl2.70017 | VIEW METRICS

- As baseline temperatures rise, more recent and warmer reference periods systematically underestimate the severity of extremes.
- Shifting from a **1961–1990** to a **1991–2020** baseline can reduce reported heatwave frequency by up to 12 days per summer and intensity by up to 2.0 °C in southern Europe.

ENVIRONMENTAL RESEARCH
LETTERS

LETTER • OPEN ACCESS

On the effect of reference periods on trends in percentile-based extreme temperature indices

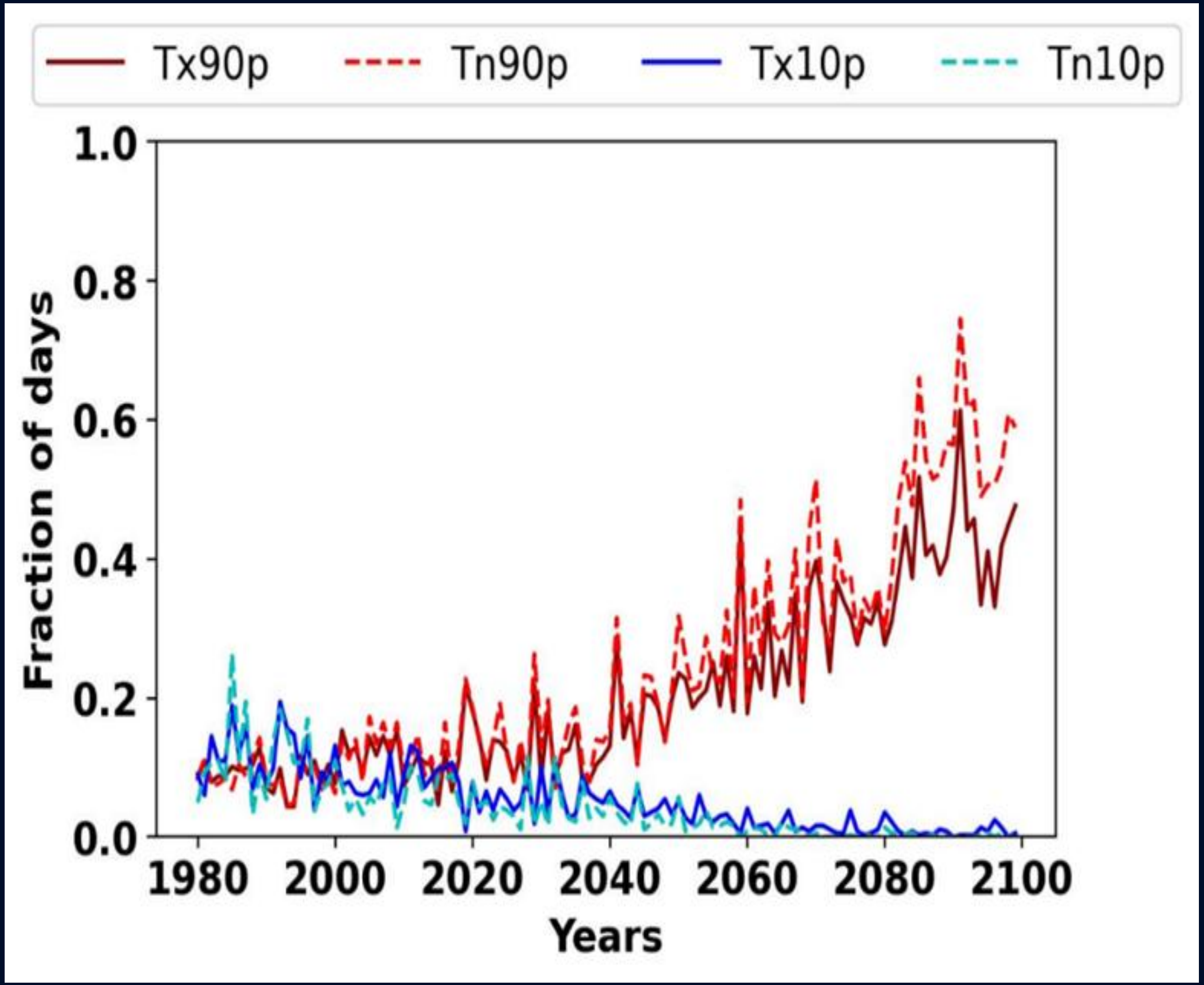
Robert J H Dunn and Colin P Morice

Published 25 February 2022 • © 2022 The Author(s). Published by IOP Publishing Ltd
Environmental Research Letters, Volume 17, Number 3
Citation Robert J H Dunn and Colin P Morice 2022 *Environ. Res. Lett.* **17** 034026
DOI 10.1088/1748-9326/ac52c8

Saturation of Percentile Based Indices:

- Under continued warming, percentile based indices approach their limits (0% or 100%) and lose sensitivity to further changes in extremes.
- Updating reference periods is therefore essential to maintain their usefulness.

Projected Saturation of Percentile Based Temperature Indices under Continued Warming



TX10p (cool days)
TX90p (warm days)
TN10p (cool nights)
TN90p (warm nights)

Beer Sheva station (Israel) – ICON-EC-EARTH (2.5 km), SSP5-8.5. Base period 1980-2014 (Zipori & Yosef)

For more information:

Received: 24 January 2019 | Revised: 25 April 2019 | Accepted: 29 April 2019
DOI: 10.1002/joc.6125
RESEARCH ARTICLE
International Journal of Climatology RMetS

Changes in extreme temperature and precipitation indices: Using an innovative daily homogenized database in Israel

Yizhak Yosef[1,2] | Enric Aguilar[3] | Pinhas Alpert[1]

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[3]Center on Climate Change (C3), Univ... Rovira i Virgili, Tarragona, Spain

Abstract
This study examines the 1950–2017 temporal changes in climate extremes in Israel, which is located in the East Mediterranean (EM), a region which suffers from a scar-

https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/joc.6125

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DOI: 10.1002/joc.6740
RESEARCH ARTICLE
International Journal of Climatology RMetS

Is it possible to fit extreme climate change indices together seamlessly in the era of accelerated warming?

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Abstract
This study examines the problematic impact of selecting a different base period (colder 1961–1990 vs. warmer 1988–2017), on the trend magnitude of widely used percentile-based extreme temperature indices (e.g., warm/cold spells, warm/cold days and nights). The percentile-based indices are part of a core set of indices (27 in total) that have become a common standard for monitoring climate change, as recommended by the Expert Team on Climate Change Detection and Indices (ETCCDI). The indices were designed to be comparable

https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/joc.6740?af=R

CONCLUSIONS

Base Period Sensitivity

Impact of base period selection on results

Percentile-based indices are much more sensitive to the selected base period compared to alternative indices.

When percentiles were derived from a base period that included records from the **last two decades** (e.g., 1981-2010, 1988-2017), significant effects were observed.

Annual Cycle Differential Change

Seasonal temperature trends

Marked increase in summer temperatures (TX and TN) coupled with a milder increase in winter temperatures.

Differential change in the annual cycle, with distinct patterns between seasons.

Trend Magnitude Impact

Effect on warm and cold indices

Trend magnitude of the **warm indices** is **dramatically diminished** when percentiles were derived from a base period including recent decades.

Trend magnitude of **cold percentile-based indices** is **strongly amplified** under the same conditions.

Study Period Coverage

Effect of study duration on findings

These features are **even more pronounced** when the study period covers only the **last 30-40 years**.

Using a recent warmer base period may lead to the erroneous conclusion that there is only a slight increasing trend in the warm indices.

As we continue to experience accelerated warming, the way we interpret and calculate percentile-based climate indices must evolve. The choice of the base period is not just a technical matter; it requires continuous updates.

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Thank you for your attention!