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Scope

About the report

Weather and climate extremes are a central part of the climate system and are already affecting regions across all continents. Events such as extreme heat, heavy rainfall and drought can and do have large impacts on people, infrastructure, and natural systems. Understanding what drives these extremes and how they evolve is an ongoing priority for the climate research community.

This is the first report of the Annual assessment of Weather and Climate Extremes (AWCE) Working Group, an activity that sits within the World Climate Research Programme (WCRP) Regional Information for Society (RIfS) Global Extremes Platform (GEP). It is intended to complement existing annual climate assessments by providing a single framework focused on weather and climate extremes in 2025 that places them in historical perspective, combining extreme-event monitoring, analyses of long-term trends, attribution, regional assessments, physical drivers and dynamical mechanisms and detailed case studies. Our framework is designed to be re-applied each year; the use of the same indices, regions and evaluation windows will make results comparable between annual reports although this would not preclude the inclusion of additional indices moving forward. Examples of the different types of existing assessment reports and their primary emphasis, including where this report sits, are shown in **Table 1**.

Assessment	Monitoring of extremes	Trends in extremes	Attribution	Physical drivers & dynamics	Regional analyses	Case studies / event analyses	Primary emphasis	Reference
IPCC AR6 WGI	✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓	Assessment of evidence on observed and projected changes in extremes, attribution, and physical understanding.	IPCC, 2021, 2023
WMO State of the Global Climate (+ supplement)	✓✓✓	✓	●	●	✓✓✓	✓✓✓	Annual synthesis of climate indicators, impacts, and significant weather and climate events worldwide.	WMO, 2026
BAMS State of the Climate	✓✓✓	✓✓	✗	●	✓✓	✓✓	Comprehensive annual assessment of climate conditions and notable weather and climate events in global and regional context.	Blunden et al., 2026
NOAA climate monitoring products	✓✓✓	✓✓	●	●	✓✓	✓	Operational monitoring and reporting of climate indicators and weather and climate extremes.	NOAA NCEI, 2026
C3S European State of the Climate	✓✓✓	✓✓	●	✓	✓✓✓	✓✓	Monitoring and assessment of climate conditions, extremes, and impacts, particularly across Europe.	C3S/ECMWF and WMO, 2026
World Weather Attribution (WWA)	●	●	✓✓✓	✓✓	✓✓	✓✓✓	Rapid attribution of individual high-impact events and assessment of the role of climate change.	WWA, 2026
Indicators of Global Climate Change (IGCC)	✓	✓✓	✓✓	✓✓✓	●	✗	Tracking annual changes in emissions, forcing, energy imbalance, human-induced warming, and climatic impact drivers between IPCC assessments.	Forster et al., 2026

AWCE Annual Report	✓✓✓	✓✓✓	✓✓	✓✓	✓✓✓	✓✓✓	Integrated assessment of prior year weather and climate extremes combining monitoring, trends, attribution, dynamics, regional analyses, and case studies.	Schumacher et al., 2026
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Table 1: Comparison of the scope and primary emphasis of major international assessments relevant to weather and climate extremes. The table is non-exhaustive but is intended to recognise the important and often complementary contributions that these assessments bring regarding weather and climate extremes. ✓✓✓ major emphasis ✓✓ substantial coverage ✓ included ● limited/selective information ✗ not a primary component. The symbols in the AWCE row are italicized to represent our aspirational targets rather than what we have achieved in our first report. Note that "monitoring" is used here in a broad sense; activities differ in *what* is monitored and *how* (the IPCC assesses published evidence, WMO and BAMS document each year's notable events and indicators, NOAA and C3S maintain operational indicator series, WWA attributes individual events, and this report tracks a fixed set of daily extreme indices annually).

For regional context we use the regions outlined by the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) and as defined by Iturbide et al. (2020).

What this report covers

- Global and regional timeseries of the annual peak daytime and nighttime temperatures (TXx and TNx), i.e. the highest temperatures each year reaches during day and night, and of the highest daily precipitation total (Rx1day).
- Maps of statistics of TXx and TNx, with a focus on the IPCC AR6 regions and on the last five years.
- Context for selected extreme events in terms of driving mechanisms, impacts, and attribution through a series of case studies.

What this report does not cover

- Extremes other than those associated with high temperature and heavy precipitation.
- Our own attribution assessments.
- Climate projections.

The report is not intended to be a comprehensive assessment of all research, but rather a clear and timely overview of a selection of daily extreme statistics to be updated annually.

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Key messages

- In 2025, new high temperature (TXx) records were set across about 3% of global land, well below the El Niño-influenced years of 2023 and 2024. Of the 44 considered AR6 regions, only West-central Asia set a new regional record.
- 2025 nonetheless ranks ninth by the proportion of global land in which TXx was the highest recorded during 1980–2025. Moreover, in every year from 2021 to 2025, new TXx records were set across a larger share of land than would be expected under a stationary climate.
- In almost every AR6 region, most of the land reached the highest 1980–2025 TXx and TNx values in 2021–2025.
- 2024 remains the year with the most widespread heat records since 1980: 11 of the 44 AR6 regions set a new TXx record, and 14 for TNx.
- Dynamically linked heatwaves occurred across Southern Hemisphere land regions in February 2025, fostering record-breaking temperatures in Argentina, Uruguay and Australia. A similarly widespread event in the Northern Hemisphere in June shattered temperature records across the Eastern United States.
- Attribution analyses indicate that the assessed heatwaves in 2025 would have been virtually impossible (China, Japan, South America) or at least ten times less likely (South Sudan, Fennoscandia) without human-induced climate change.
- Datasets used to calculate global extreme precipitation observations are highly uncertain, but evidence points to an increasing trend in the wettest day of the year (Rx1day) from in situ-based and reanalysis datasets over global land areas [60°S–60°N] since 1991. In particular, 2025 was a record year for Rx1day in the CPC dataset.

Temperature and precipitation extremes in 2025 in context

Weather and climate extremes are increasingly documented through a range of international assessment and monitoring activities (**Table 1**). The IPCC provides authoritative policy-relevant assessments of observed and projected changes in climate extremes, their physical causes, and the role of human influence, concluding that hot extremes have become more frequent and intense across most land regions and that heavy precipitation events have intensified across many regions (IPCC, 2021, 2023). Annual assessments produced by the World Meteorological Organization (WMO) (WMO 2026), the State of the Climate reports of the Bulletin of the American Meteorological Society (BAMS) (Blunden et al., 2026), NOAA (NOAA NCEI, 2026), and the Copernicus Climate Change Service (C3S) (C3S and WMO, 2026) document the evolving state of the climate system and the occurrence of major weather and climate events, providing regional perspectives and historical context for extremes. World Weather Attribution (WWA) has demonstrated the growing influence of anthropogenic climate change on the probability and intensity of individual extreme events (WWA, 2026), while the annual Indicators of Global Climate Change updates (Forster et al., 2026) track key indicators of human influence on the climate system, including human-induced warming, Earth's energy imbalance, and global temperature extremes over land and ocean. Collectively, these assessments show that many forms of extreme weather, particularly heat extremes and heavy precipitation events, are changing in response to anthropogenic climate change.

As summarized in **Table 1**, the various reports differ in their primary emphasis, ranging from climate-system monitoring and event documentation to attribution, physical understanding, and assessment. Outside of annual assessments, the scientific literature also analyses recent extremes in near-real time: Green et al. (2026), for example, survey 46 of the most damaging rainfall events of 2025 — including the Texas flash floods assessed among our case studies — and document widespread exceedance of local records at sub-daily to multi-day durations. This report builds on these complementary efforts by bringing these perspectives together within a single framework focused on weather and climate extremes in 2025, combining extreme-event monitoring, analyses of long-term trends, attribution, regional assessments, physical drivers and dynamical mechanisms, and detailed case studies.

Specifically, in this report we assess global and regional trends in temperature and precipitation extremes, mostly focusing on the peak daytime temperature (TXx, the highest daytime temperature of each year), peak nighttime temperature (TNx, the highest nighttime temperature of each year) and daily maximum precipitation (Rx1day, wettest day of each year) metrics, a subset of standard indices that were recommended by the Expert Team on Climate Change Detection and Indices (ETCCDI; Zhang et al., 2011). We select these three indices because each captures impact-relevant characteristics of extreme weather at the daily timescale, and because they are commonly used in other assessments (**Table 1**), facilitating the comparison of our results. Regions follow the IPCC AR6 land reference regions (Iturbide et al., 2020; **Fig. S1**) except for case studies, where event-specific region definitions are employed.

In several parts of the world, 2025 brought record seasonal heat. It was the warmest summer on record in Japan (JMA, 2025), South Korea (KMA, 2026) and the UK (Met Office, 2025). It ties 2024 as the hottest summer in China (WMO, 2026), and was also the 4th warmest summer in Europe (C3S, 2025b).

These national and regional seasonal records did not, however, translate into an exceptional year for peak temperatures at the global scale. About 3% of global land reached its 1980–2025 TXx maximum in 2025, above expectation for a stationary climate but well below the El Niño-fuelled years of 2023 (~8%) and 2024 (~10%; ranked against the full 1980–2025 period, **Table S2**). The same holds regionally: of the 44 AR6 land regions, only West-central Asia (WCA) set a new TXx record in 2025, compared with 11 regions in 2024 and eight in 2023. The contrast reflects how exceptional

2023 and 2024 were rather than any lack of extremes in 2025. By the proportion of land holding its 1980–2025 TXx maximum, 2025 still ranks ninth, surpassed only by years from 2010 onward.

The statistics above are best read against existing long-term climate change assessments. AR6 concluded that hot extremes have become more frequent and intense across most land regions since the 1950s, driven primarily by human influence. Our results extend that finding beyond AR6's assessment period: in each of 2021–2025, new TXx records were consistently set over a larger share of land than a stationary climate would produce. Substantial anthropogenic warming had already occurred before our analysis period begins, so the changes documented here only represent a portion of the total anthropogenic change. That portion is nonetheless interpretable, since hot extremes over land have been shown to scale near-linearly with global mean temperature (Seneviratne et al., 2016; Seneviratne & Hauser, 2020), with no detectable departure from that scaling in recent decades (Vautard et al., 2024) - consistent with the near-linear scaling we find over global land (**Fig. S2b**).

For precipitation extremes, 2025 produced several high-impact events, three of which feature among our case studies: the catastrophic flooding in Bahía Blanca (Argentina), Central Texas, and Mozambique. Many of the year's most damaging rainfall events exceeded local records at sub-daily and multi-day durations (Green et al., 2026), which a gridded daily index such as Rx1day cannot capture, since it neither resolves sub-daily intensity nor multi-day accumulation. Substantial uncertainty remains across observational products — not only in how extremes are estimated, both within and between product types, but also in how inhomogeneities affect the representation of long-term trends (Alexander et al., 2020; Sun et al., 2018; Sun et al., 2021). However, global trends in Rx1day across products broadly agree although magnitudes vary (e.g., Alexander et al., 2020). Therefore, we refrain from attempting a regional ranking of Rx1day comparable to that for temperature: despite general agreement in the direction of the trend, observational products for daily precipitation extremes disagree strongly in actual Rx1day values even at the global scale, unlike temperature extremes (**Fig. 1**), hence single-product record statistics akin to those for TXx (**Figs. 2–4**) would be difficult to interpret. However, in the context of existing assessment reports and scientific literature, Rx1day and rainfall extremes generally have increased over land (e.g., Alexander et al., 2020) although trends vary substantially by region and time period (e.g., Dunn et al., 2020; Douville et al., 2021). For this assessment, Rx1day over land between 60°S and 60°N has increased since 1991 across in situ and reanalysis products (**Fig. 1c**, in % of the 2001–2020 mean), though the magnitude remains highly uncertain (see supplementary material). However, in CPC — the only in situ-based product in the FROGS database (Roca et al., 2019) with continuous coverage over our 1991–2025 analysis period — the global mean Rx1day value was higher in 2025 than in any other year.

Global evolution of peak temperatures and heavy precipitation

AR6 assessed changes in both hot extremes and heavy precipitation as robust, though with higher confidence for the former, partly reflecting the more localized and episodic character of heavy precipitation compared to extreme heat but also the relatively small change in precipitation compared to its variability (Seneviratne et al., 2021). Nonetheless, successive IPCC assessments have shown that human-induced climate change has increased the frequency and intensity of extreme precipitation events over most land regions where sufficient observations exist, consistent with the increased moisture holding capacity of a warming atmosphere. It is within this context that we assess the 2025 values of the hottest day (TXx), warmest night (TNx) and wettest day (Rx1day).

Annual peak day- and nighttime temperatures, TXx and TNx, have risen in close step since 1960 over global land, each by about 0.24 °C per decade (area-weighted mean of per-pixel Theil–Sen slopes; by product, in the order ERA5/Berkeley/HadEX3, that is 0.28/0.23/0.21 °C per decade for TXx and 0.25/0.22/0.24 °C per decade for TNx; **Fig. 1a, b**). All available years were used for each product (see Methods). The products agree closely, not only on these trends, but also on year-to-year variability. That agreement is established at the global-mean level and need not extend to smaller scales, particularly where the station network is sparse (Dunn et al., 2022). Per-product regional series are shown in the supplementary material (**Figs. S11–S22**). For the more spatially detailed analyses below we rely on ERA5.

These full-period trends conceal a steepening over time. Global mean temperature has warmed faster since about 1990 than before (Samset et al., 2023), and there is growing evidence for a further increase in the last 10–15 years (Forster et al., 2026; Foster & Rahmstorf, 2026). A similar acceleration is also evident for smoothed continental and global land TXx series, where no trend windows are imposed (**Fig. S2a**). To illustrate its magnitude with two 30-year windows from 1961–1990 to 1991–2020, the TXx trend nearly tripled, from about 0.12 to 0.34 °C per decade (0.17/0.12/0.08 °C per decade rising to 0.39/0.32/0.31 °C per decade). These are the two most recent WMO standard normal periods, and while other windows would yield slightly different trends, the contrast we highlight here is not sensitive to their placement: any pair of non-overlapping 30-year windows within 1960–2025 gives a higher TXx trend in the latter window. This also holds for TNx in ERA5 and HadEX3, though to a lesser extent, whereas Berkeley Earth shows no change (0.16/0.19/0.17 to 0.33/0.18/0.28 °C per decade). The full set of per-period, per-product trend values is provided in **Table S3**.

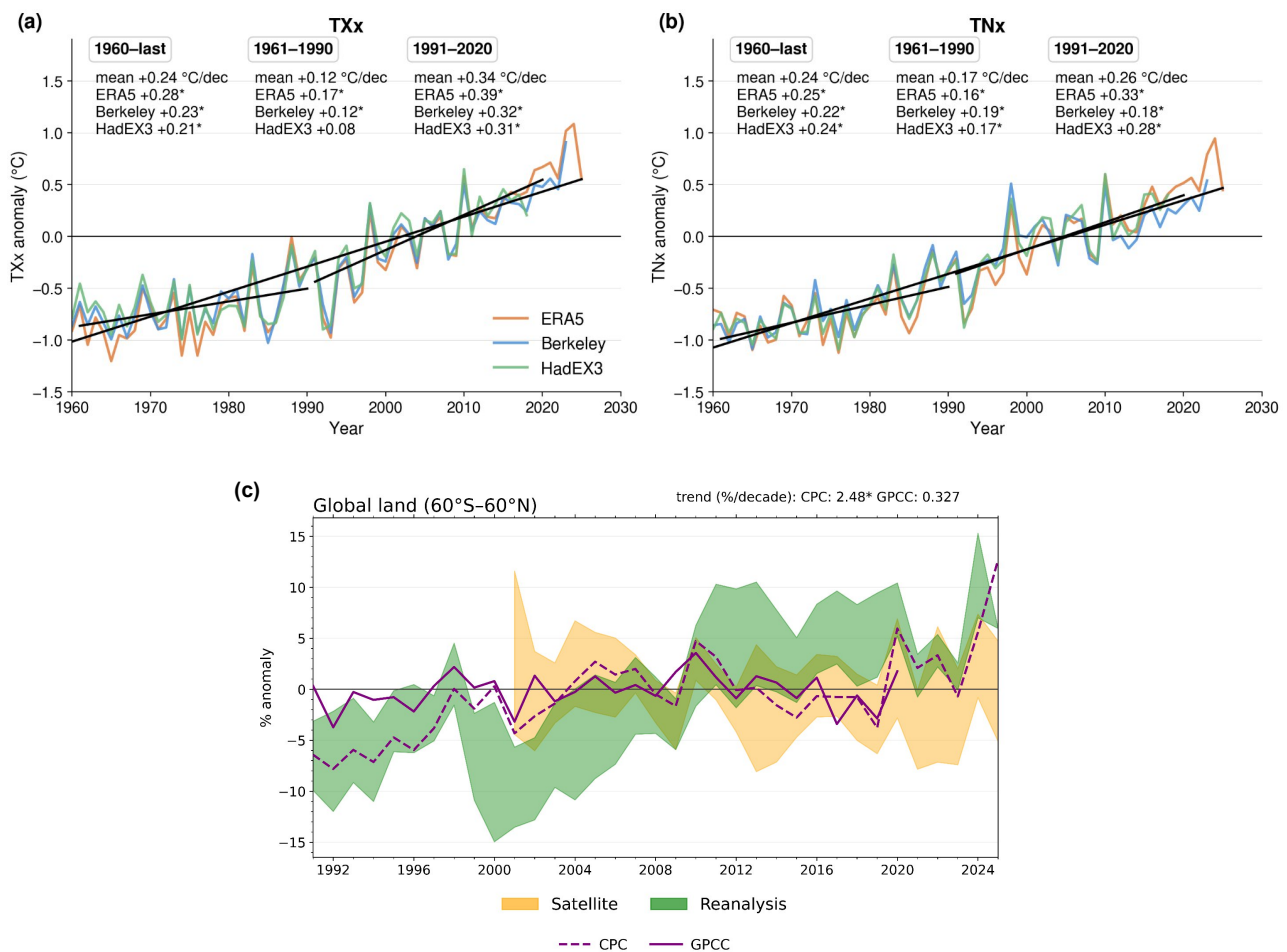
For TXx, the acceleration appears in all three products, and global mean temperature itself accelerated over the same periods (0.14 to 0.25 °C per decade; **Table S3**), so a correspondingly steeper trend in peak temperatures is what the near-linear scaling between TXx and global mean temperature suggests (about 1.47 °C per °C over 1960–2025; **Fig. S2b**). The scaling slope is nonetheless somewhat larger over 1991–2020 than over 1961–1990 (1.53 versus 1.23 °C per °C), so a smaller part of the acceleration might reflect a steepening response of extremes. Candidate mechanisms include the transition from widespread surface solar dimming to brightening over parts of the Northern Hemisphere (Wild, 2009), soil moisture feedbacks (Vogel et al., 2017) and circulation changes (Rousi et al., 2022).

A separate question is how these trends compare with the warming of the mean climate. Over the full period, both TXx and TNx rise faster than the ERA5 global mean temperature (0.19 °C per decade since 1960; **Table S3**), but that gap reflects land warming faster than the ocean rather than anything specific to extremes. Compared instead with land warming of boreal summer, in which most land reaches its peak temperatures, TXx warms at nearly the same rate (0.28 versus 0.26 °C per decade in ERA5). Thus, to first order, peak daytime temperatures track the warming of the season in which they occur.

For precipitation extremes, specifically the wettest day (Rx1day), there is much less agreement in annual estimates of Rx1day between products but overall relative trends are positive since 1991

(**Fig. 1c**) which aligns with our theoretical understanding that extreme rainfall should increase. This also agrees with previous studies (e.g., Alexander et al., 2020; Bador et al., 2020) that showed positive trends in Rx1day between 1988–2013 across all product types (*in situ*, satellite, reanalyses) which sits in the longer-term context of increasing trends since 1901 using HadEX3 (Dunn et al., 2020). Satellite products tend to produce the smallest trends, with reanalyses indicating the largest trends. Nonetheless, the sign of the change being consistent across product types, despite their well-documented differences and the lower signal-to-noise ratio of precipitation extremes compared with temperature, marks a notable result. Two *in situ*-based products, GPCC_FDD_2022 (Ziese et al., 2022) and CPC_v1.0 (Xie et al., 2010), are in reasonably good agreement with each other although the magnitude of change in CPC is larger. Regional series are considerably more uncertain than the global mean (see supplementary material), sometimes with trends of opposite sign between products; the global-scale signal is thus a more robust indicator. For example, for Rx1day, **Fig. S26** shows a significant positive trend in CPC and a significant negative trend in GPCC for South-east Asia, a region which is known to have a sparse precipitation network and large uncertainties in extreme precipitation (Nguyen et al., 2020).

For trends across IPCC regions refer to the supplementary material.



* Indicates a significant trend at the 5% level using the Mann-Kendall trend test. Trend magnitudes are Sen's slopes expressed as % per decade.

Fig. 1: Global land-average anomalies of (a) annual peak daytime temperature (TXx) and (b) annual peak nighttime temperature (TNx) relative to 1991–2020 for ERA5 (Hersbach et al., 2020), Berkeley Earth Surface Temperature (undocumented daily product; see Methods) and HadEX3 (Dunn et al., 2020), with the multi-product mean in black and each product in its respective colour. Land areas southward of 60°S are excluded. Linear trends (°C per decade) are given for three periods (1960–present, 1961–1990, 1991–2020) as area-weighted means of per-pixel Theil-Sen slopes over land, with a star marking significance at the 5% level (Mann-Kendall test); the black trend line

in (a) and (b) is a separate Sen's-slope fit to the multi-product mean series, shown for reference, and need not exactly match these per-pixel-based values. (c) shows relative percentage anomaly changes (compared to 2001-2020 mean) in annual wettest day precipitation (Rx1day) averaged over 60°S–60°N land areas for data products with sufficient data from the FROGS database (Roca et al., 2019). The spread across products is shown for satellite-based products (yellow shading) and reanalyses (green shading), while two in situ products (purple) are shown as a solid line (GPCC) and dashed line (CPC). The trend calculated over 1991–2020 (to ensure sufficient precipitation data and to match one of the linear trend periods for temperature extremes) using Sen's-slopes (in % per decade) is shown for *in situ* products GPCC and CPC in the plot title. A star indicates a significant trend at the 5% level, again using a Mann-Kendall test. Note that at the time of writing IMERG had not been updated in FROGS and ERA5 was the only reanalysis product with data available so the interproduct spread of values for Rx1day in 2025 for both satellites and reanalyses is reduced accordingly.

*See “Datasets and methods” to find out how plots are created.

Record-breaking regional peak temperatures

Long-term trends describe the gradual shift of a variable's distribution and are central to detection and attribution, but they say little about how unusual any single recent year was, or where and when the highest values are concentrating. We examine this for TXx using ERA5 at the regional scale; **Fig. S3** shows how much the ranking changes if Berkeley Earth is used instead, and the TNx equivalents are given in the supplementary material (**Figs. S6–S8**).

We ask two questions here and answering them requires different statistics. First, when did different parts of the global land reach the highest TXx within 1980–2025 (**Fig. 2**)? Second, how often did each recent year set a new record, i.e. exceeding all preceding years back to 1980, judged at the respective time (**Figs. 3, 4**)? In short, the first indicates standing maxima in time, the second effectively measures record-breaking as it happened.

For each AR6 region, **Fig. 2** shows the fraction of land whose 1980–2025 maximum falls within successive five-year periods. Under stationarity a grid cell's maximum is equally likely to fall in any year, hence no period should systematically hold more than another. Instead the fractions rise through the period, and 2021–2025 holds by far the largest share in many regions, as expected under sustained warming.

Fig. 3 asks the second question: for each year from 2021 to 2025, at which grid cells did that year set a new TXx record, judged against every preceding year back to 1980? Each grid cell has a $1/N$ chance of setting a record in a given year, where N is the number of years up to and including that year, so on average $1/N$ of all cells do. The land fraction we report is precisely that — the share of cells at rank 1 — and for 2025, with $N = 46$, it should equal about 2.2% under stationarity. In each of the last five years the fraction has exceeded this expectation, most strongly in 2024.

Temperature is spatially correlated over hundreds to thousands of kilometres, so records are broken in large patches rather than independently at each grid cell. This does not alter the expected fraction, but it does mean that individual years scatter widely around it, particularly at the scale of individual AR6 regions. Averaging over global land is far less affected, since it combines many regions too distant to share the same weather.

Rankings begin in 1980, since coverage and homogeneity problems limit the reliability of daily temperature extremes before around that date in several regions (Vautard et al., 2024), and analyses of heat extremes commonly begin at a similar point for this reason. Extending the period back to 1960 lowers the record fractions slightly, since more preceding years must be exceeded, but leaves the ordering of recent years unchanged (**Fig. S5**); the conclusions therefore do not depend on this choice.

Placing 2025 among all years since 1980 requires a common reference, so **Table S2** ranks every year at every grid cell against the full 1980–2025 period; for 2025 itself, holding the 1980–2025 maximum and setting a new record are identical, so its value matches (**Fig. 3**). Its ninth place puts it below 2021 and 2022, which were cooler years globally, because 2025 lacked individual heatwaves as intense and extensive as the 2021 western North American or 2022 European events. The ten years with the most widespread 1980–2025 maxima all fall between 2010 and 2025.

At the regional scale, records are now also turning over rapidly. Of the eight regions setting new TXx records in 2023 (**Fig. 4**), four were surpassed again in 2024, so only half of those records still stood at the end of 2025 (**Fig. S4**). All records set in 2024 still stand, and 2025 added one more. Taken together, 2025 appears unremarkable only against the years preceding it: the baseline has shifted so far that a year of this kind would rank among the most extreme prior to 2010.

The same picture holds for peak nighttime temperatures: 1980–2025 maxima cluster in the same recent years, and in 2024, the most widespread record-breaking year, new TNx records covered

about 14% of global land against 10% for TXx (Table S2; Figs. S6–S8). The fifteen years with the most widespread 1980–2025 maximum are nearly identical for the two indices (Table S2), and regional records turn over in much the same way (cf. Figs. S4 and S10).

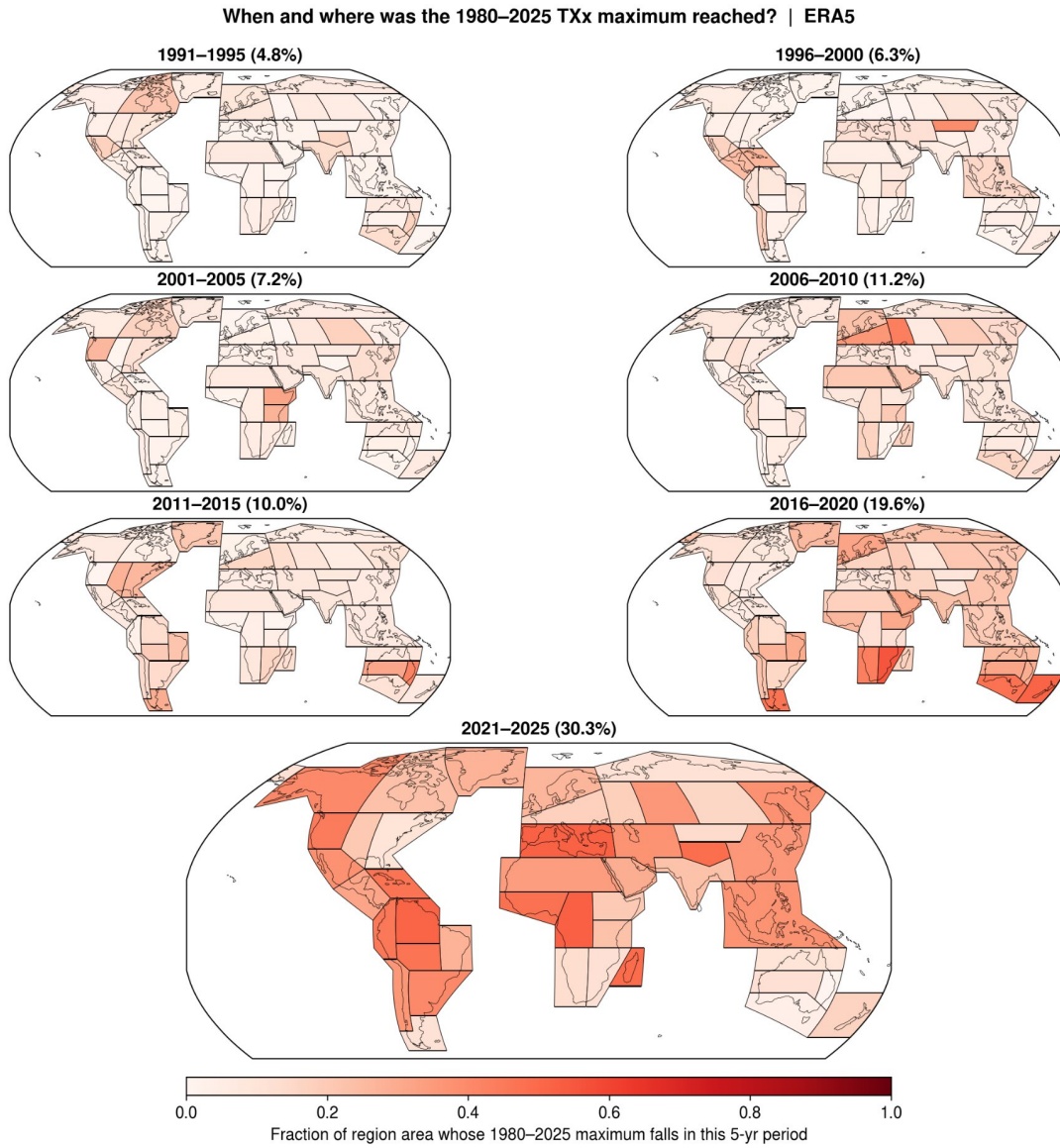


Fig. 2: When and where the 1980–2025 TXx maximum was reached, based on ERA5. Each grid cell within land AR6 regions has one year in which the highest TXx was reached and contributes to one of the 5-year periods. Regions are coloured by the area-weighted fraction of their land area whose record year falls in each respective 5yr period. The bottom panel is enlarged to highlight the most recent 5-year period. Global land fractions are given in brackets in each panel title; the remaining fraction of land reached its maximum in 1980–1990 (not shown). Land areas southward of 60 °S are excluded as in Fig. 1a, b. TNx equivalent: Fig. S6.

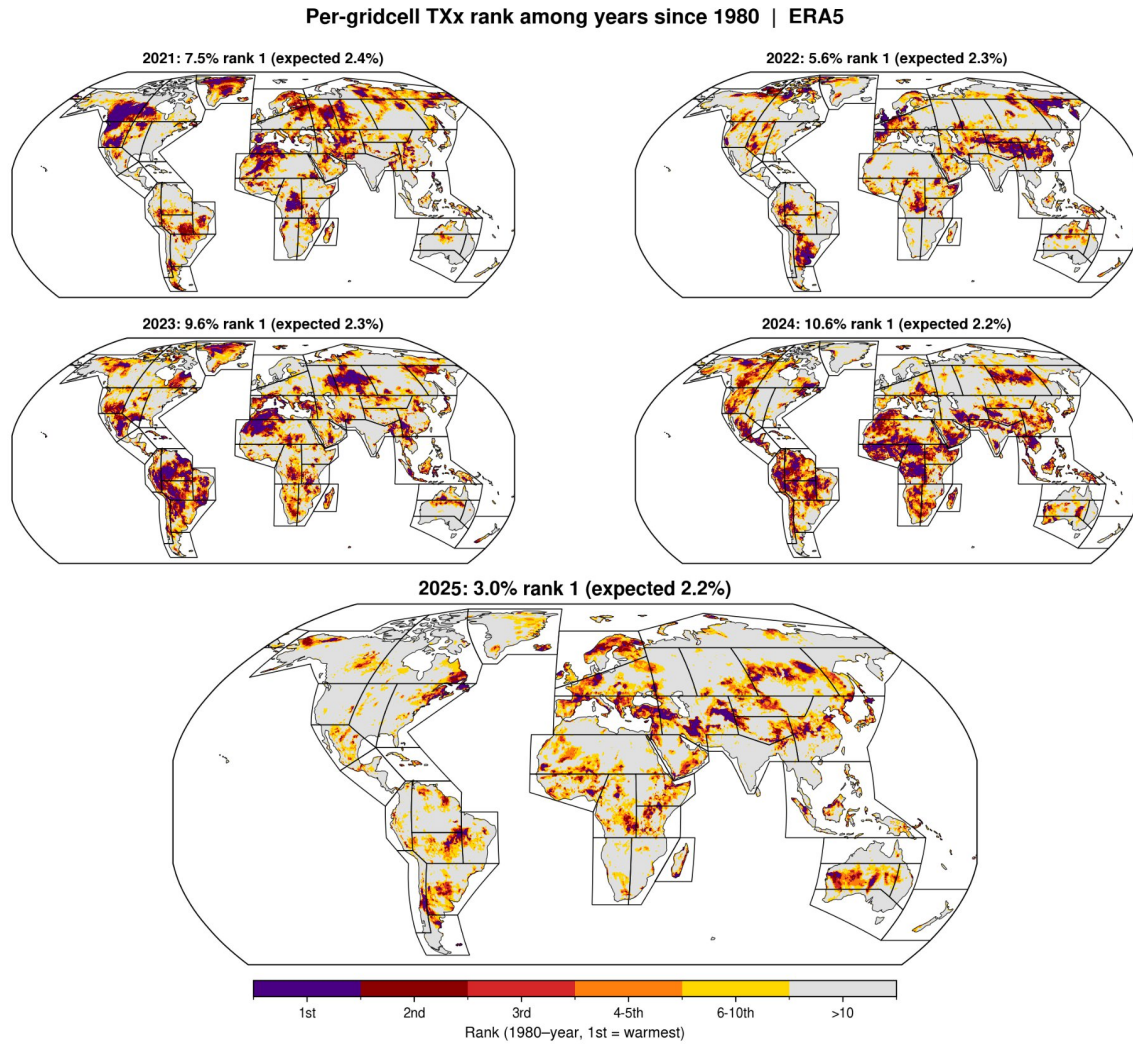


Fig. 3: Per-grid cell rank of the peak daytime temperature (TXx) for each year from 2021 to 2025, based on ERA5. Rank 1 (purple) indicates the highest value since 1980; higher ranks fade to grey (>10th). The percentage in each panel title gives the area-weighted fraction of land where that year set a new record; the value in brackets is the fraction expected in a stationary climate ($1/N$). The reference period grows with each evaluation year (e.g., 2021 is ranked against 1980–2021, 2025 against 1980–2025); as such, setting a new record becomes progressively harder. The same analysis with the period beginning in 1960 rather than 1980 is shown in **Fig. S5** and yields similar results for recent years; the fixed-window equivalent, with every year ranked against 1980–2025, underlies **Table S2** and **Fig. S4**. Land areas southward of 60°S are excluded. TNx equivalent: **Fig. S7**.

AR6 regional-mean TXx rank among years since 1980 | ERA5

	2021	2022	2023	2024	2025
Sahara (SAH)	6	27	2	2	14
Western Africa (WAF)	7	8	10	1	5
Central Africa (CAF)	3	4	4	1	8
North-eastern Africa (NEAF)	13	4	13	2	9
South-eastern Africa (SEAF)	7	7	3	3	4
West-southern Africa (WSAF)	18	22	2	2	18
East-southern Africa (ESAF)	7	32	5	3	27
Madagascar (MDG)	4	11	1	1	7
Russian Arctic (RAR)	3	13	5	12	24
West Siberia (WSB)	1	16	1	16	10
East Siberia (ESB)	20	19	12	4	4
Russian Far East (RFE)	3	1	4	19	22
West-central Asia (WCA)	1	2	7	10	1
East-central Asia (ECA)	8	5	7	8	10
Tibetan Plateau (TIB)	17	1	10	2	8
East Asia (EAS)	4	1	3	2	5
Arabian Peninsula (ARP)	4	5	5	1	5
South Asia (SAS)	40	20	30	1	37
South-east Asia (SEA)	14	20	2	1	13
Northern Australia (NAU)	16	5	6	27	31
Central Australia (CAU)	31	6	12	6	3
Eastern Australia (EAU)	39	38	29	25	20
Southern Australia (SAU)	35	41	35	8	18
New Zealand (NZ)	11	4	9	14	19
Greenland/Iceland (GIC)	3	19	4	24	8
Northern Europe (NEU)	2	2	17	19	3
Western and central Europe (WCE)	8	5	8	6	3
Eastern Europe (EEU)	3	19	7	15	23
Mediterranean (MED)	1	6	1	3	2
North-western North America (NWN)	1	3	4	2	15
North-eastern North America (NEN)	10	5	4	6	24
Western North America (WNA)	1	7	4	2	24
Central North America (CNA)	8	2	3	18	24
Eastern North America (ENA)	24	16	15	13	13
Northern Central America (NCA)	13	17	1	1	6
Southern Central America (SCA)	21	20	7	1	15
Caribbean (CAR)	12	12	1	3	5
North-western South America (NWS)	6	6	1	1	14
Northern South America (NSA)	15	12	1	1	13
North-eastern South America (NES)	7	20	2	4	17
South American monsoon (SAM)	4	10	2	1	7
South-western South America (SWS)	6	26	2	2	9
South-eastern South America (SES)	10	2	1	6	7
Southern South America (SSA)	2	7	6	7	22
Global land (all regions)	1	5	1	1	8

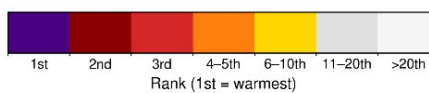


Fig. 4: Rank of the AR6 land regional-mean peak daytime temperature (TXx) for each year from 2021 to 2025, based on ERA5. For each region, the area-weighted mean TXx is computed per year and ranked against all preceding years back to 1980 (rank 1 = warmest). The reference period grows with each evaluation year as for **Fig. 3**. Purple marks a record, i.e. the highest regional-mean TXx up to that year; lighter shades indicate lower ranks. Land areas southward of 60°S are excluded as elsewhere, i.e. the two Antarctic IPCC land regions are not shown, and 44 land regions are displayed. TNx equivalent: **Fig. S8**.

Case studies — overview

To put our assessment of temperature and precipitation extremes in context, Working Group members chose a number of regional case studies to analyse in more detail. Case studies were chosen through discussion due to their record breaking intensity, persistence and/or impact. The minimum criterion was at least one event per continent. Ultimately, 11 events were agreed upon and are shown in the timeline below (**Fig. 5**) with the two events in South America discussed together.

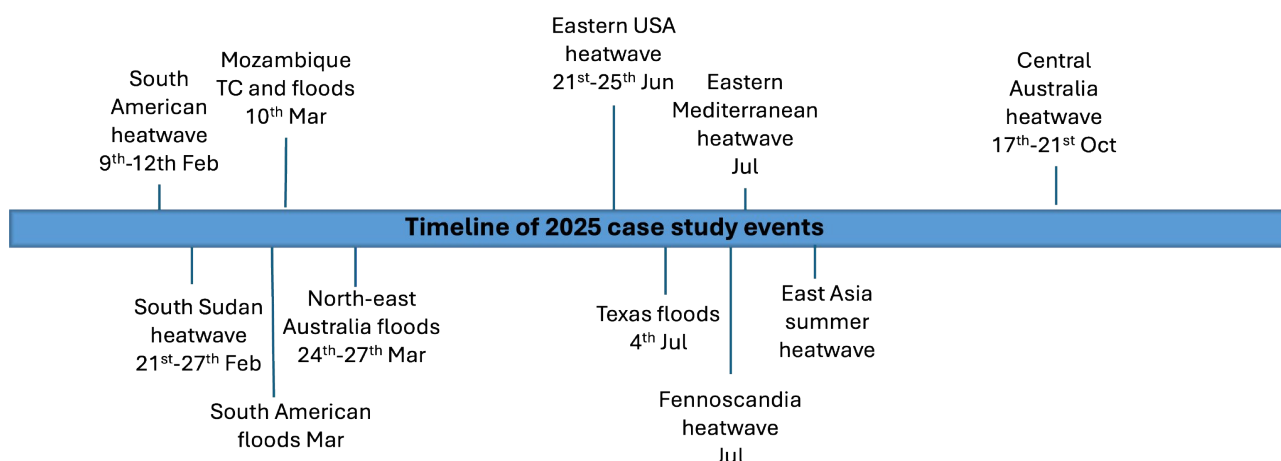


Fig. 5: Timeline of all assessed 2025 extreme events in this report.

For the extreme heat events, we summarise the evolution of daily temperatures for the respective 2025 season, indicating how the event compares to other years (**Fig. 6**). We see that some events are primarily characterized by their excessive heat on individual days (e.g., Australia), whereas the persistence of other events stands out (e.g., Fennoscandia), though there are also highly intense and long-lasting events (e.g., East Asia).

We do not show a comparable summary for the heavy precipitation events; the seasonal envelope used in **Fig. 6** for temperature cannot convey intensity and persistence in the same way for daily precipitation, and the case studies below use different, event-specific accumulation periods. Product choice also matters more: unlike temperature, precipitation is not assimilated in ERA5 (except for gauge data in the USA since mid-2009; Hersbach et al., 2020), and no single daily product is well constrained across all the regions considered here. For these reasons, the precipitation extreme case studies are based on different products suited to each event.

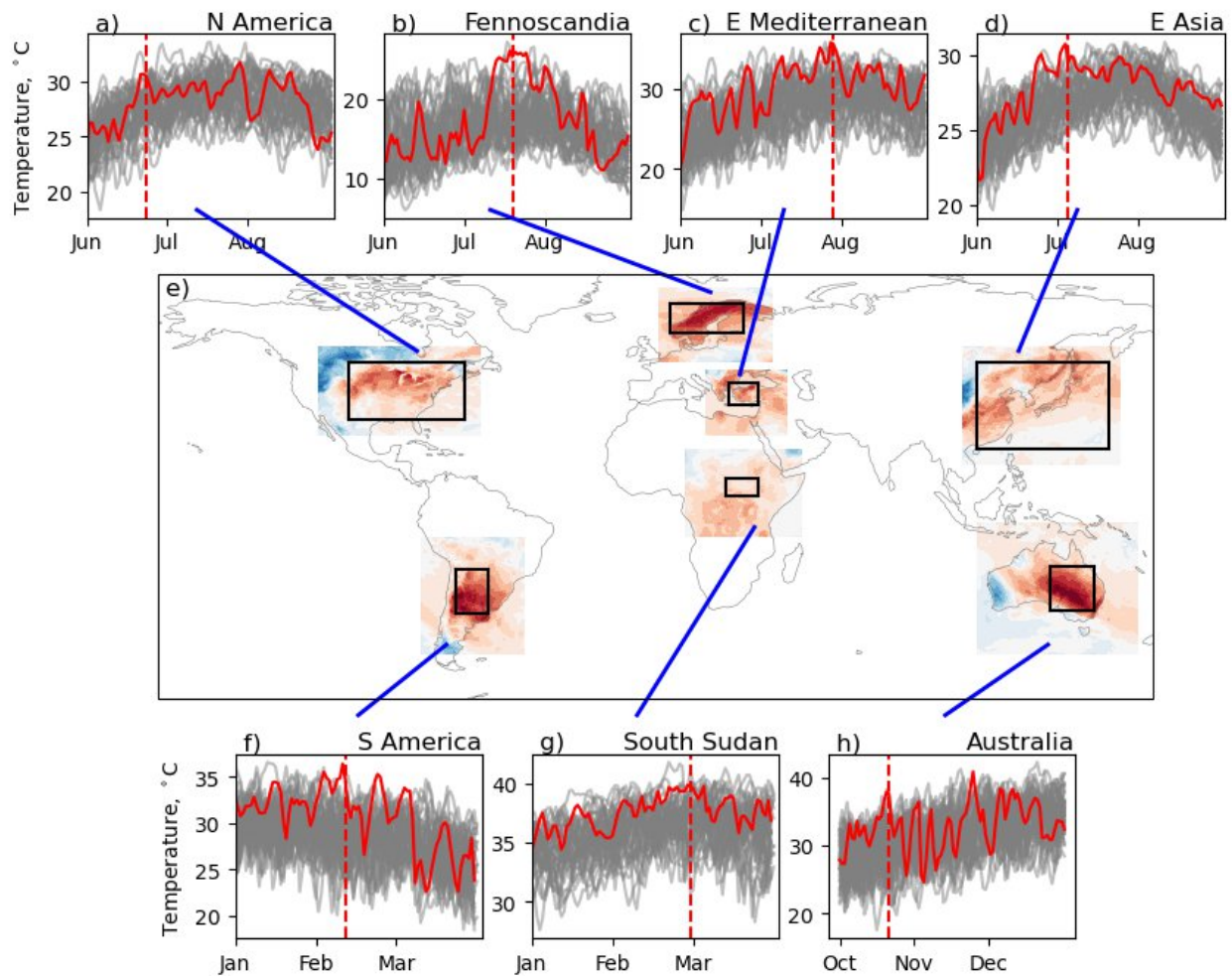


Fig. 6: Heat extreme case studies. (a–d, f–h) Daily maximum temperature evolution for the period of the event in all years (1950–2024; grey) and 2025 (red) for different events. All timeseries are calculated as land-only area-weighted averages of the respective analysis regions (black edges). Red dashed vertical lines mark the day of the peak temperature anomaly relative to 1991–2020, which is not necessarily the day of the highest absolute temperature: the events in (a) and (h) struck early in the warm season, in late June and October respectively, when climatological temperatures were still rising, so higher absolute values occur later in these panels. (e) Map of the temperature anomalies for each of the events, relative to 1991–2020, for the day marked by the red dashed vertical lines, small boxes indicate the hazard regions used in the timeseries in (a–d) and (f–h).

South America: subtropical heatwave & related flood, February & March

Key messages

- An intense heatwave affected much of central and northern Argentina, Paraguay, Uruguay, and southern Brazil.
- Compound weather extremes developed across South America: the same persistent circulation drove severe flooding in Peru and the Altiplano, while further south, the catastrophic storm that struck Bahía Blanca with 18 associated fatalities formed in the immediate aftermath of the heatwave, whose hot, exceptionally humid air mass plausibly preconditioned the environment for extreme convection (Zachariah et al., 2025).
- The large-scale circulation pattern over the Southern Hemisphere extratropics was also associated with a concurrent heatwave over northern, central and southeastern Australia.

Description of event

February 2025 brought intense heat to much of subtropical South America — northern Argentina, Paraguay, Uruguay, southern Brazil and central Chile — with monthly temperatures nearly 5 °C above the 1981–2020 mean over northwestern Argentina (**Fig. 6f**). The most intense spell brought 46.5 °C at Rivadavia (Argentina) on 4 February; on 10–11 February, 45 °C at La Rioja Airport and 42.1 °C at Salto (Uruguay) were among all-time records set at several stations, alongside new February records near Buenos Aires. A second warm spell followed in late February and early March (SMN, 2025a, b; INUMET, 2025).

Dynamically-linked catastrophic rainfall struck Bahía Blanca (south of Buenos Aires) on 7 March, with 290 mm recorded in one day (Revollo et al., 2025; Garreaud & Vergara, 2025; SMN, 2025c), far exceeding any previous daily total in the station record (Zachariah et al., 2025) — nearly double the previous record (150.9 mm in February 1975) — causing 18 fatalities and widespread evacuations. The event developed along a sharp dryline where a moist tropical air mass met cooler, drier air from northern Patagonia, enabling deep convection over the city.

Through a hemispheric wavetrain (**Fig. 7a**), the heat was dynamically linked to extremes elsewhere in the Southern Hemisphere. South Australia recorded its warmest February mean maximum on record (3.43 °C above average), while 11–13 February saw widespread heat across Australia with maxima 6–12 °C above average (**Fig. 7c**). Several central Australian stations set February daily maximum records, including 48.7 °C at Oodnadatta Airport (77-year record).

Across southern South America, peak daytime temperatures have risen strongly over the last decades: best estimates about 0.22 °C (SES) and 0.20 °C per decade (SSA) since 1960, accelerating to roughly 0.63 and 0.54 °C per decade over 1991–2020 (**Fig. S11**). Only ERA5 and Berkeley are available, but they agree closely, and the event is consistent with this clear and accelerating regional intensification.

Causes and attribution

The February heatwave developed under a persistent mid- to upper-level high over central South America — a strengthened Bolivian High — (**Fig. 7a**) accompanied by low pressure at the surface. This strengthened the low-level jet and drove warm, humid advection from tropical South America toward northern Argentina and the Pampas (Zachariah et al., 2025), a typical configuration of heatwaves in this region (Suli et al., 2023; Vera et al., 2006). The same circulation favoured wetter-than-normal conditions across the Altiplano of Chile and Bolivia and the Peruvian Andes (WMO, 2026), where heavy rainfall, floods, and landslides affected tens of thousands of people (UNICEF, 2025).

World Weather Attribution analysed both events (Zachariah et al., 2025). Human-induced climate change played a dominant role in the extreme heat: the observed summer temperatures were deemed virtually impossible in a pre-industrial climate, that is 1.3 °C cooler than today, and remain rare in the present climate (return period of 50–100 years). Model projections suggest such heat could become common in a world 2.6 °C warmer than pre-industrial, i.e. double the observed global warming. Attribution of the Bahía Blanca storm is less conclusive. All 35 weather stations in the region show an intensification of heavy rainfall of 7–30% with the observed warming, and climate models largely agree, consistent with physical expectations in a warmer atmosphere. Gridded reanalysis products, however, show on average a decreasing trend, and Rx1day trends assessed here indicate both increasing and decreasing trends across the South American AR6 regions (**Fig. S24**). Since station and gridded data disagree on even the sign of the change, Zachariah et al. (2025) refrain from a conclusive attribution statement.

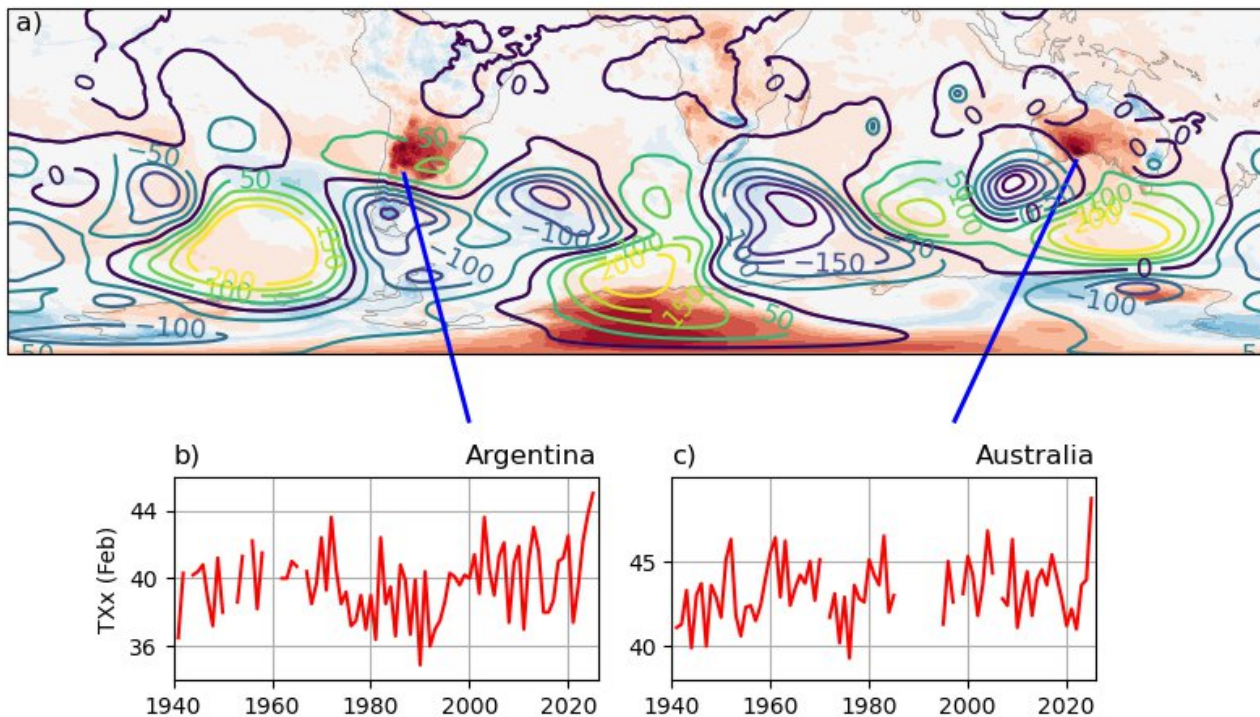


Fig. 7: (a) ERA5 daily maximum temperature anomaly (1991–2020 baseline), for 10th February 2025 (shaded, °C) and 500 hPa geopotential height anomaly (contours, gpm). (b–c) Timeseries of TXx for February 1940–2025, for Argentina (La Rioja station data) and Australia (Oodnadatta station data); gaps indicate no available data for that year.

Africa: Mozambique floods, January and March

Key messages

- Three tropical cyclones struck Mozambique across the 2024–25 season — Chido (December 2024), Dikeledi (January 2025) and Jude (March 2025) — compounding flooding and infrastructure damage.
- No event-specific attribution exists, but anthropogenic warming is expected to intensify tropical-cyclone rainfall, so these storms likely produced heavier rainfall than they would have in a pre-industrial climate.

Description of event

The 2024–2025 Tropical Cyclone (TC) season in the South-West Indian Ocean (SWIO) was highly active, with a sequence of TCs striking Mozambique: Chido in December 2024, Dikeledi in January 2025, and Jude in March 2025. Chido was an intense and exceptionally costly cyclone (Mawren & Reason, 2026); Dikeledi and Jude, both making landfall as comparatively weaker systems (OCHA, 2025), brought vast amounts of rainfall (100–400 mm, **Fig. 8**) and widespread flooding. In Mozambique alone, Cyclone Jude affected over 390,000 people (83,933 families), causing 16 fatalities, with at least 1.416 million hectares of land inundated across seven affected provinces — Cabo Delgado, Manica, Nampula, Niassa, Sofala, Tete, and Zambezia (ACAPS, 2025). Dikeledi affected 283,334 individuals as of 27 January 2025 (OCHA, 2025), with 11 fatalities reported (ECHO, 2025). Because the storms arrived in succession, each struck areas not yet recovered from the previous one, compounding the flooding and infrastructure damage.

Causes and attribution

Landfalling TCs in Mozambique were favoured by the prevailing large-scale circulation: the Mascarene High was displaced northwestward under a negative Indian Ocean Dipole, producing easterly flow and steering cyclones toward the coast (Mawren & Reason, 2026; Jury & Matyas, 2022). A weak La Niña was also present, though the regional circulation differed from that typical of La Niña summers (Mawren & Reason, 2026). With roughly two to three tropical cyclones affecting Mozambique in a typical year (Mavume et al., 2009), the landfall count itself was not unusual — but the 2024–25 South Indian Ocean season was one of the more energetic on record, with accumulated cyclone energy about 150% of the 1991–2020 average and fifth highest since 1956 (NOAA NCEI, 2025a), under anomalously warm sea surface temperatures (Mawren & Reason, 2026).

No event-specific attribution exists for these cyclones, but the expectations are well established: anthropogenic warming is expected to increase TC rainfall intensity, while changes in frequency remain uncertain (Seneviratne et al., 2021). For the comparable 2022 Madagascar–Mozambique–Malawi floods, Otto et al. (2022) found that human-induced climate change increased both the likelihood and intensity of the associated rainfall. Trends in Rx1day in the ESAF AR6 region are positive in most datasets since 1991 with CPC indicating a significant trend of 3.64% per decade (although GPCC indicates a slight negative trend; **Fig. S25**). It is therefore likely the 2025 TCs that struck Mozambique produced more intense rainfall than in a pre-industrial climate.

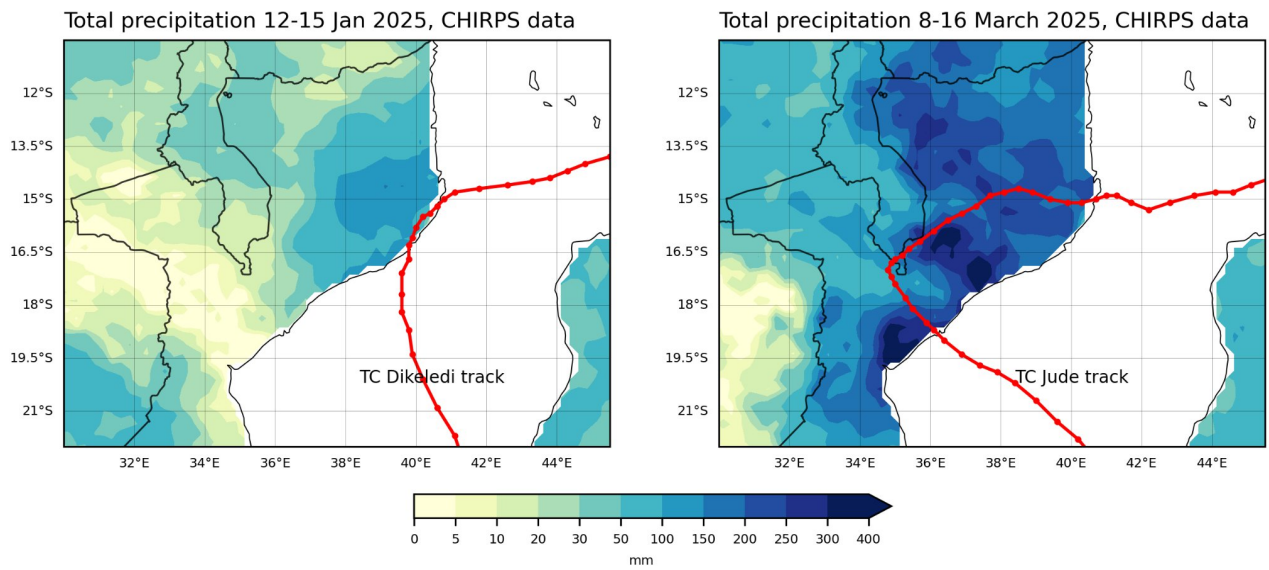


Fig. 8: Remotely sensed precipitation when tropical cyclones a) Dikeledi and b) Jude made landfall in Mozambique in January and March 2025, respectively. Precipitation is sourced from CHIRPS (Funk et al., 2015).

Africa: South Sudan heatwave, February

Key messages

- South Sudan's February 2025 heatwave brought peak-season heat about three weeks early and sustained it for five weeks, part of a broader East African heat episode, with peak temperatures above 40 °C that forced a two-week nationwide school closure after dozens of students collapsed in Juba.
- A World Weather Attribution rapid study found the heat at least 2 °C hotter and, conservatively estimated, at least 10 times more likely due to human-induced climate change.

Description of event

In South Sudan the hottest weather normally comes at the end of the dry season, with daily maximum temperatures peaking in early March before the onset of the rains (based on the ERA5 1991–2020 climatology; not shown). In 2025, peak-season heat arrived about three weeks early and then persisted: from mid-February, regional daily maxima stayed at or above the climatological seasonal peak for five weeks. The hottest week, 22–28 February, featured peak temperatures in excess of 40 °C (**Fig. 9a**), several °C above the 1991–2020 expectation (**Fig. 9b**). After dozens of students collapsed from heat exhaustion in the capital Juba, with the government reporting around 12 collapses per day, schools were closed nationwide for two weeks from 20 February, and the population was advised to stay indoors and hydrate (New York Times, 2025; Kew et al., 2025). Impacts fell hardest on a population with limited capacity to cope, with iron-roofed housing, little cooling, constrained access to water and electricity, and over a million people displaced by conflict into poorly ventilated shelters. Women and girls were disproportionately affected (Kew et al., 2025).

South Sudan lies in north-eastern Africa (NEAF), where peak daytime temperatures have warmed at about 0.25 °C per decade since 1960 (**Fig. S12**). The trend is notably linear and stable across all periods considered, with ERA5 and Berkeley, the two available data products, in good agreement. The event is consistent with this steady, robust regional warming.

Causes and attribution

The heat developed under an intensified Arabian high-pressure system, a known driver of East African spring heat that strengthens the prevailing northerly to north-easterly low-level flow, transporting warm, dry air into the region and displacing the Intertropical Convergence Zone (ITCZ) (Lashkari & Jafari, 2021; Okoola, 1999). Subsidence beneath the anticyclone promoted adiabatic warming and clear-sky insolation. A World Weather Attribution rapid study (Kew et al., 2025) analysed the hottest seven-day window (22–28 February, over a South Sudan box) and concluded the event was at least 2 °C hotter and at least 10 times more likely because of human-induced climate change. Notably, the observational analysis alone implies a far larger intensification (~4 °C) and probability change, with CMIP6 models underestimating the observed trend. Such February heat, once rare, now recurs roughly every two years and is projected to intensify further at 2.6 °C of global warming, double the ~1.3 °C observed to date. South Sudan issued its first-ever Common Alerting Protocol (CAP) heatwave warning in response (WMO, 2025).

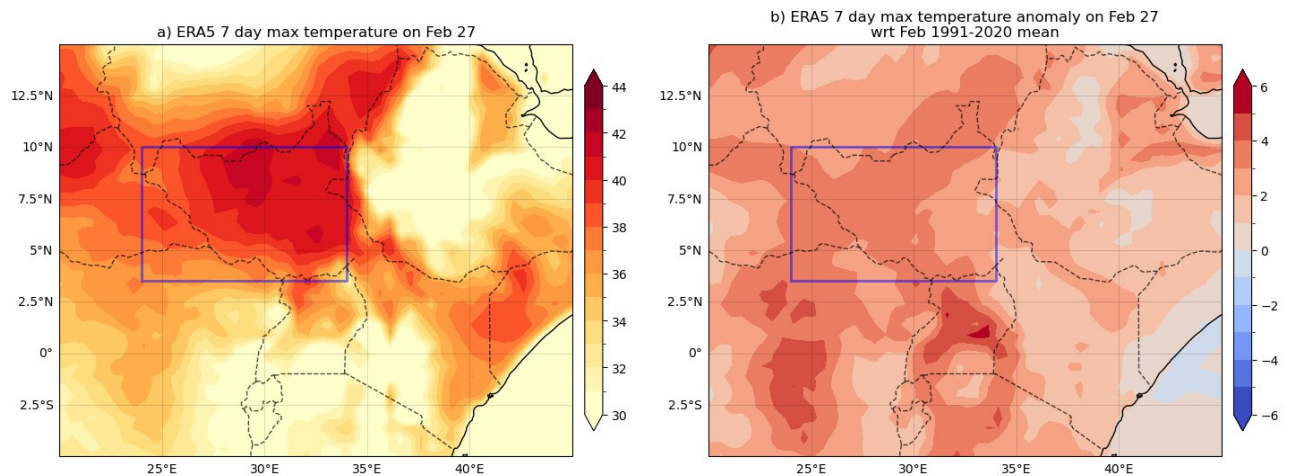


Fig. 9: 7-day mean of ERA5 daily maximum temperatures centred on February 27, for Eastern Africa. a) absolute values and b) anomalies w.r.t. the 1991–2020 norm period.

North America: Northeast and Midwest heatwave, June

Key messages

- From 22 to 25 June 2025, persistent high pressure anomalies produced extreme heat across the Midwest and Northeast United States, with temperatures up to 7 °C above the 1991–2020 climatology and widespread hazardous humidity.
- Hundreds of daily maximum temperature records were broken from the Plains to the East Coast, including major urban corridors from Chicago to Boston. Exceptionally warm nighttime temperatures amplified health risks by limiting overnight recovery from daytime heat stress.
- The event coincided with record-breaking heat across East Asia, Alaska, and Europe (mid-June to early July), dynamically linked by a Rossby wave train.

Description of the event

Between 22 and 25 June 2025, persistent high pressure anomalies developed over central and eastern North America, suppressing cloud formation and allowing intense solar heating to accumulate (NOAA NCEI, 2025b). The event produced widespread extreme heat and humidity across the Midwest and Northeast United States, with temperature anomalies locally exceeding +7 °C relative to the 1950–2025 mean (Faranda & Alberti, 2025). Hundreds of daily record high temperatures were set or tied across the Plains and East Coast. Major urban centres experienced dangerous heat index values driven by the combination of high temperatures and elevated moisture, while exceptionally warm nighttime conditions further amplified heat stress and public health risks (New York City Department of Health and Mental Hygiene, 2026).

The event was embedded within a broader hemispheric-scale circulation pattern characterized by amplified Rossby wave activity in the Northern Hemisphere mid-latitudes (**Fig. 10a**). North-central and parts of eastern Asia and Europe also experienced exceptionally high June peak temperatures (**Fig. 10b, c**), with several European records broken (C3S, 2025a).

This event is noteworthy for its impacts on densely populated cities such as Chicago, New York and Philadelphia. More than 100 million people across 726 counties experienced record heat (NOAA NCEI, 2025b). Compared with similar synoptic events in the past, temperatures were up to ~1.5 °C (Faranda & Alberti, 2025) higher during this event, posing greater challenges for heat preparedness. In New York City, 19 heat-stress deaths (caused directly by heat) were recorded during the event, compared with an average of 7 per year from 2016–2025 (New York City Department of Health and Mental Hygiene, 2026).

This event struck a region where the change in peak temperatures is weak (**Fig. S16**). In eastern North America (ENA), TXx trends are weak and largely non-significant, about 0.09 °C per decade since 1960 and TNx only somewhat stronger at ~0.17 °C per decade, matching AR6's "low agreement in the type of change" (Seneviratne et al., 2021). This warming suppression of both mean and extreme summer temperatures seems rooted in circulation changes that enhance rainfall, with unknown contributions from internal variability and climate change itself (Banerjee et al., 2017; Eischeid et al., 2023; Singh et al., 2023), and other factors such as aerosol and land-cover and land-use changes have also been proposed (Mascioli et al., 2017; Yu et al., 2014; Alter et al., 2018).

Causes and attribution

The heatwave developed under quasi-stationary ridging that displaced the jet stream poleward and suppressed the passage of transient disturbances and cold fronts (**Fig. 10a**). Subsidence within the ridge produced adiabatic warming and inhibited cloud formation, promoting sustained clear-sky insolation and multi-day surface heat accumulation. At the same time, southerly flow from the Gulf of Mexico and western Atlantic transported anomalously high low-level moisture into the region,

raising boundary-layer humidity and heat-index values (>43.3 °C in several cities) and limiting nocturnal cooling.

A ClimaMeter attribution analysis suggests that circulation patterns like this one produce higher temperatures in a warmer background climate (Faranda & Alberti, 2025), though the extent to which thermodynamic versus dynamic changes dominate remains uncertain. The weak regional trend should not be read as a small human contribution. It may itself reflect cancellation between the externally forced warming and the offsetting influences discussed above, from multi-decadal internal variability to circulation, aerosol and land-use changes, and it does not rule out a thermodynamic contribution to this event. Because the thermodynamic contribution to a single event need not scale with a multi-decadal trend that integrates these offsetting factors, attribution approaches resting on the observed local trend alone may understate the human contribution here.

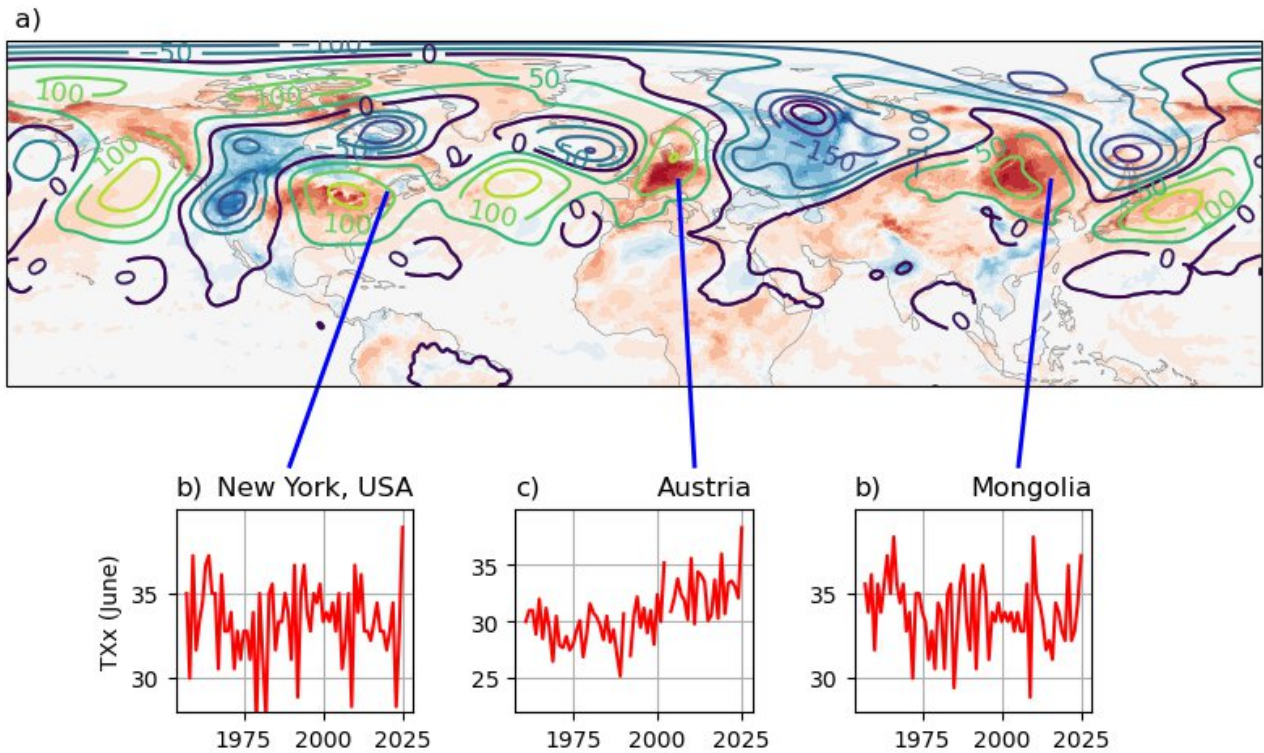


Fig. 10: (a) ERA5 maximum temperature anomaly, relative to 1991–2020, for 22nd June 2025 (shaded, °C) and 500 hPa geopotential height anomaly (contours, gpm). (b-d) Timeseries of TXx for June 1956–2025, for JFK airport New York, USA; Feistritz ob Bleiburg, Austria; and Chinggis Khaan International Airport, Mongolia, gaps indicate no available data for that year.

North America: Texas floods, July

Key messages

- In early July 2025, Central Texas experienced extreme rainfall leading to catastrophic flash flooding, with particularly severe impacts along the Guadalupe River basin.
- Approximately 140 fatalities were reported, including a large number of children at a riverside camping site.
- The flooding was driven by mesoscale convective systems in a highly moisture-laden, weakly forced environment. While there is substantial uncertainty in attribution of large-scale dynamical drivers, thermodynamic intensification of extreme rainfall is more robustly supported.

Description of the event

Beginning on 3 July 2025, Central Texas experienced a high-impact flash flooding event caused by persistent convective clustering, with hourly rainfall rates exceeding 50–75 mm (CW3E, 2025). The storm produced extreme spatially concentrated precipitation totals, with localized 4-day accumulations exceeding 400 mm (**Fig. 11a**), breaking existing records (**Fig. 11b**). The associated hydrological response was extremely rapid due to high antecedent soil saturation in parts of the basin, steep terrain in the Hill Country, and low infiltration capacity, leading to flash flooding. The Guadalupe River and tributary networks experienced rapid stage rises exceeding major flood thresholds within hours, producing catastrophic inundation across narrow valley corridors, widespread infrastructure damage, and high mortality, including vulnerable populations in recreational and camping areas along riverbanks (Galarneau et al., 2026).

Causes and Attribution

The event was driven by a combination of extreme thermodynamic moisture availability and mesoscale dynamical organization within a weakly forced synoptic environment. Remnant tropical moisture associated with Tropical Storm Barry contributed to an anomalously deep tropical moisture plume, while a mesoscale convective vortex promoted mesoscale ascent and low- to midlevel convergence and repeated convective regeneration. A surface boundary intersecting the mesoscale convective vortex-related flow helped initiate the persistent, quasi-stationary convection, while weak storm motion and efficient precipitation production enhanced localized rainfall accumulation (Galarneau et al., 2026).

Attribution is more robust on thermodynamic than dynamical aspects. Observations and modelling studies consistently indicate that a warmer Gulf of Mexico and atmosphere increase precipitable water and the intensity of short-duration extreme rainfall via Clausius–Clapeyron scaling, although local deviations occur due to convective organization and storm dynamics (Fowler et al., 2021; Risser & Wehner, 2017). The extent to which climate change modified the synoptic setup, mesoscale vortex evolution, or event probability is less certain and sensitive to model representation of convection. Consequently, while general thermodynamic intensification is well supported, attribution of changes in event likelihood and circulation forcing remains conditional and uncertain (Trenberth et al., 2015).

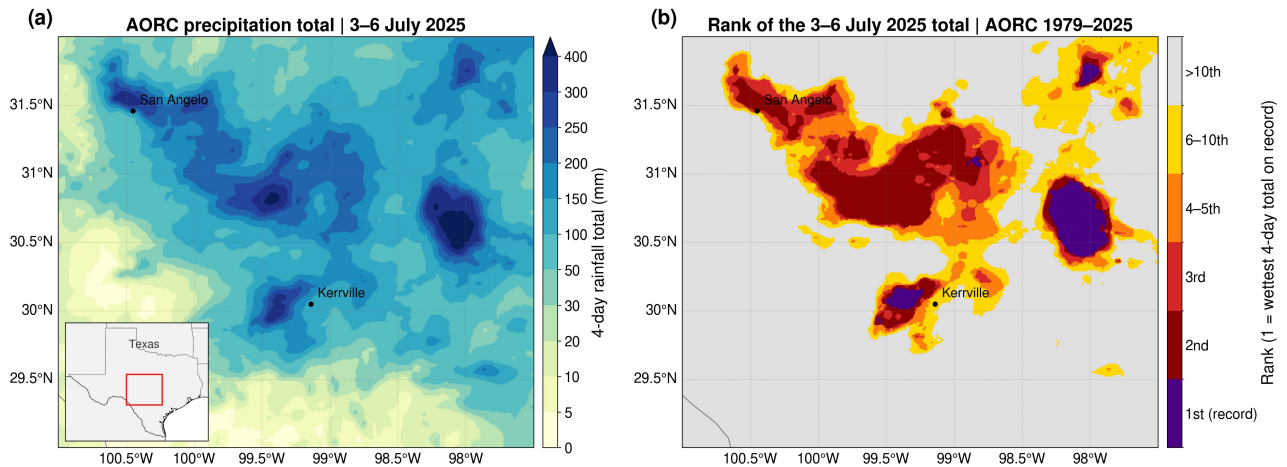


Fig. 11: Rainfall during the 3–6 July 2025 Central Texas flood, from the NOAA Analysis of Record for Calibration (AORC; ~1 km, hourly precipitation). (a) Total accumulated rainfall (mm) over the four-day event (3–6 July 2025). (b) Event severity expressed as a non-parametric rank: for each grid cell, the 2025 four-day total is ranked against the annual-maximum four-day totals of every year from 1979 to 2025 (a 47-year record), so that rank 1 (purple) marks cells where this was the wettest four-day total on record, grading through to grey for rank > 10. Markers show San Angelo and Kerrville. Data: NOAA AORC, a multi-source product; it blends gauge-based analyses with radar-gauge multisensor estimates (see Fall et al., 2023 for details).

Asia - East Asian heatwave – June to August

Key messages

- The exceptionally hot summer of 2025 broke high temperature intensity and duration records across Japan, the Republic of Korea and several regions of China, dynamically driven by an intensified North Pacific Subtropical High and Tibetan High, along with unusually warm North Pacific sea surface temperatures.
- Attribution shows the event was virtually impossible without human-induced warming in Japan and in the most affected regions of China, and 10–20 times more likely elsewhere in China.

Description of event

Summer 2025 was the hottest on record in Japan and the Republic of Korea, and tied with 2024 as the hottest in China, with temperatures 1–3 °C above the 1991–2020 mean and even higher local exceedances (**Fig. 12a**). Japan averaged 2.36 °C above the 1991–2020 mean — much warmer than the previous records of 2023 and 2024 (+1.76 °C). A new national record of 41.8 °C was set at Iseaki on 5 August, and 40 °C was reached 30 times across the AMeDAS station network (counting each station and day separately), by far the most since at least 2010 (JMA, 2025). China's summer mean temperature was 1.1 °C above the 1991–2020 normal, matching 2024 as the highest since 1961, and its national number of summer hot days (maximum temperature $\geq 35^{\circ}\text{C}$) reached 13.7 days, 5.7 days above the 1991–2020 average and second only to 2022 (CCCCB, 2026). Central and eastern provinces were most affected (Sun et al., 2026); Shandong, Henan and Hubei each set new summer hot day records (CCCCB, 2026). In the Republic of Korea, numerous sites set records for the greatest number of heatwave days (maximum temperature $> 33^{\circ}\text{C}$) or local tropical nights (minimum temperature $> 25^{\circ}\text{C}$). Seoul experienced 46 tropical nights, more than three times the average of 12.5 days and the most since measurements began in 1908 (KMA, 2026).

East Asia (EAS) has warmed by about 0.21 °C per decade since 1960 in both peak daytime (TXx) and nighttime (TNx) temperatures, with the three products in close agreement (**Figs. S14 and S20**). Both indices show clearly larger 1991–2020 than 1961–1990 trends, with TXx even dipping slightly in the early period before its recent intensification. We consider the record-breaking tropical nights, a defining feature of the East Asian heatwave, consistent with this accelerating regional warming across both day- and nighttime extremes.

Causes and attribution

The dominant synoptic driver was an unusually strong and westward-expanded North Pacific Subtropical High (NPSH) pressure system (**Fig. 12b**). NPSH expanded earlier than normal in June and remained anomalously strong and westward-extended through the summer. From June onward, the Tibetan High extended northeastward in the upper troposphere. Enhanced Asian monsoon convection drove Rossby wave propagation along the subtropical jet in a Silk Road pattern, extending the Tibetan High towards Japan, while record convection northeast of the Philippines triggered a Pacific/Japan pattern that extended the NPSH (Takemura et al., 2026; KMA, 2026). In addition, abnormally warm Sea Surface Temperatures (SSTs) in the North Pacific contributed to elevated tropospheric temperatures and helped sustain the poleward-shifted subtropical jet (Takemura et al., 2026).

An event attribution by the Japan Meteorological Agency and partners concluded that the Japanese summer was virtually impossible without global warming; such temperatures are now expected about once in 60 years in the 2025 climate, compared with once in 500 years under the 1991–2020 climate (JMA, 2025). Rapid analyses conducted through the 2025 summer by the Beijing Climate Centre (BCC, 2025a, b, c) and reviewed afterwards by Sun et al. (2026) find a clear anthropogenic signal across China. Monthly means reached record levels in Northwest China in June and in Northwest China, Northeast China, the Tibetan Plateau and the middle–lower Yangtze valley in July,

at 3.0 to 5.0 standard deviations above the 1961–1990 baseline. Without human influence, heat of this magnitude in Northwest China and on the Tibetan Plateau would have had an occurrence probability below 0.1 %. Elsewhere in China, anthropogenic forcing raised the likelihood of the observed heat by factors of about 10 to 20, varying by region and month (Sun et al., 2026).

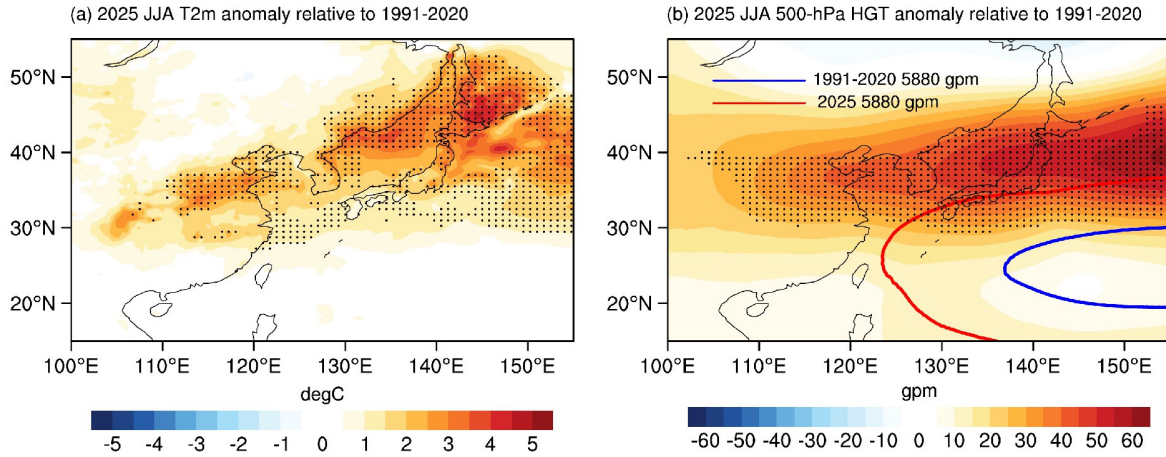


Fig. 12: East Asian heatwave temperatures and dynamical conditions. a) JJA mean temperature anomalies in 2025 relative to the 1991–2020 average, based on ERA5. Stippling indicates regions where the 2025 temperature exceeded the previous record (1980–2024). b) JJA mean 500 hPa geopotential height anomaly in 2025 relative to the 1991–2020 average, using ERA5 data. Stippling indicates regions where the 2025 500 hPa geopotential height exceeded the previous record (1980–2024). The blue and red contours show the 5880 gpm contour for the 1991–2020 climatology and 2025, respectively. The 5880 gpm contour is used to indicate the position of North Pacific Subtropical High.

Europe - Eastern Mediterranean, July

Key messages

- July 2025 brought record-breaking heat to the eastern Mediterranean, notable for its absolute magnitude, with Türkiye setting a new national temperature record of 50.5 °C (C3S and WMO, 2026).
- The heat, preceding drought, and strong winds drove deadly wildfires across Türkiye, Greece and Cyprus with the fire-weather conditions made about ten times more likely by climate change.

Description of event

A severe heatwave affected the eastern Mediterranean in July 2025. Türkiye recorded its hottest July since 1971, with a national mean of 26.9 °C, 1.9 °C above the 1991–2020 normal, and 66 stations set new maximum temperature records (TSMS, 2025). On 25 July, Silopi in the southeast recorded 50.5 °C, the first 50 °C exceedance ever observed in Türkiye (C3S and WMO, 2026). Greece experienced a record heatwave above 45 °C. Parts of the Balkans, Greece and Türkiye reached extreme heat stress — feels-like temperature ≥ 46 °C — on at least one day (C3S, 2025b). Fuel dryness in 2025 was among the most extreme on record; average pre-fire-season (October–April) rainfall has declined by about 14% across the region relative to a pre-industrial climate (Keeping et al., 2025). Combined with strong northerly Etesian winds, the heat and dryness drove hundreds of wildfires. The fires killed at least 20 people across the three countries and forced more than 80,000 to evacuate. Türkiye was hit hardest, with 17 deaths, including ten firefighters and rescue workers trapped by shifting winds near Eskişehir, and over 50,000 evacuated, mainly from İzmir, Bursa and Çanakkale. Greece evacuated some 32,000 people (including 5,000 tourists on Crete), and in Cyprus the fires burned about 1% of the island, its worst in decades (Keeping et al., 2025). Across Europe, 2025 became the worst wildfire year in terms of area burned since monitoring began in 2006, with more than one million hectares burned (Keeping et al., 2026; EFFIS, 2026).

In the Mediterranean, peak daytime temperatures have risen strongly over recent decades — about 0.35 °C per decade since 1960 in the multi-product best estimate (**Fig. S15**). Product spread is wider here than for the other continental European AR6 regions, driven mainly by HadEX3 (likely due to a lack of observations), but the long-term increase still emerges very robustly. The acceleration has been linked to declining aerosol loading and possibly to circulation changes (Nabat et al., 2014; Vautard et al., 2023; Singh et al., 2023; Schumacher et al., 2024). We consider the event consistent with the observed clear long-term regional intensification.

Causes and attribution

The heat was associated with a high-pressure system over the Aegean Sea that drove both the extreme temperatures and the strong northerly winds. A World Weather Attribution study assessed whether dynamics have changed through circulation analogues using 500 hPa geopotential height (Keeping et al., 2025). Comparing 1951–1980 with 1994–2023, such high-pressure ridges have become more intense and extend further north, implying more intense heat and stronger northerly winds in similar events.

Keeping et al. (2026) examined the meteorological conditions favouring wildfires across the eastern Mediterranean (Greece, Cyprus and Türkiye), finding an exceptionally strong climate-change signal toward hotter and drier conditions. Observations indicate that such fire-weather, roughly a once-per-century event before industrial warming, now recurs about once every 20 years. Incorporating climate models, the increase attributable to human-induced climate change is about a factor of ten in likelihood and around 22% in intensity.

Europe - Fennoscandia, July

Key messages

- This heatwave was notable for its persistence, lasting three weeks; it also almost doubled the previous 2018 record of strong heat-stress days in sub-Arctic Fennoscandia (C3S and WMO, 2026).
- Attribution found the event to be 2 °C hotter and at least 10 times more likely due to human-induced climate change.

Description of event

In July, Fennoscandian countries (Norway, Sweden and Finland) were hit by a heatwave that persisted for 21 days, almost doubling the previous longest event in sub-Arctic Fennoscandia (11 days; C3S and WMO, 2026). Across two weeks, peak daytime temperatures averaged 25–30 °C over much of Sweden and Finland and into the sub-Arctic, locally up to 10 °C above the 1991–2020 normal (**Fig. 13**). Minimum temperatures were less anomalous but also clearly elevated; the strongest anomalies were confined to latitudes 63–67 °N in Norway and Sweden. In Norway, Namsskogan and Gartland experienced more than 30 °C for 13 consecutive days, marking a new national record (C3S, 2025c; C3S and WMO, 2026). At Ylitornio, Meltosjärvi, in Finnish Lapland, 25 °C was exceeded for 26 days (Barnes et al., 2025); Finland also saw more than 30 °C for 22 consecutive days, one of the longest such streaks on record (C3S and WMO, 2026). Some locations as far north as the Arctic Circle also passed 30 °C. This region normally sees no more than two days of strong heat stress (feels-like temperature > 32 °C) per year, but experienced up to 12 such days in July 2025, with local feels-like temperatures reaching 36 °C around the Gulf of Bothnia. Averaged over sub-Arctic Fennoscandia, this was the highest number of strong heat-stress days and nearly doubled the previous 2018 record. The persistence observed in the 2025 heatwave over Fennoscandia amplified impacts on human health and substantially strained healthcare systems, especially as it occurred during the peak Nordic holiday season. Hospitals struggled to cope, with air conditioning failing or entirely absent, operations cancelled and patients turned away (NRK, 2025; TV 2, 2025). The heatwave led to at least 67 drowning deaths in the three countries (EUMETSAT, 2026), as many people sought relief in open water. Wildfires also broke out across the region, including in Lapland (Barnes et al., 2025).

In Northern Europe, peak daytime temperatures have risen by about 0.23 °C per decade since 1960 (**Fig. S15**), with a clear acceleration over the period, in common with the rest of Europe. Agreement across products is high — unusually so, holding even back into the 1960s — making this one of the most robust regional trends in the assessment. The event is therefore consistent with a clearly and confidently intensifying regional background.

Causes and attribution

The surface heat was enabled by a high pressure system, specifically an omega blocking pattern over the Norwegian Sea and Fennoscandia, which stalled over the area. The persistent atmospheric blocking led to warm air advected into the region from the south. Such blocking patterns are the usual driver of Fennoscandian heatwaves, and there is no robust trend in their frequency: the 2025 circulation, like that of 2018, is largely attributable to internal variability, while the underlying warming is a robust thermodynamic signal of climate change (Barnes et al., 2025).

World Weather Attribution findings showed that human-induced climate change made the event about 2 °C hotter and increased the probability of similar events by at least ten times, giving a present-day return period of roughly 50 years (Barnes et al., 2025). Warming has also raised the odds relative to the recent past, with similar heatwaves now about twice as likely as during the comparable 2018 event (Barnes et al., 2025).

14-day mean temperature anomalies: 12–25 July 2025 relative to 1991–2020 climatology

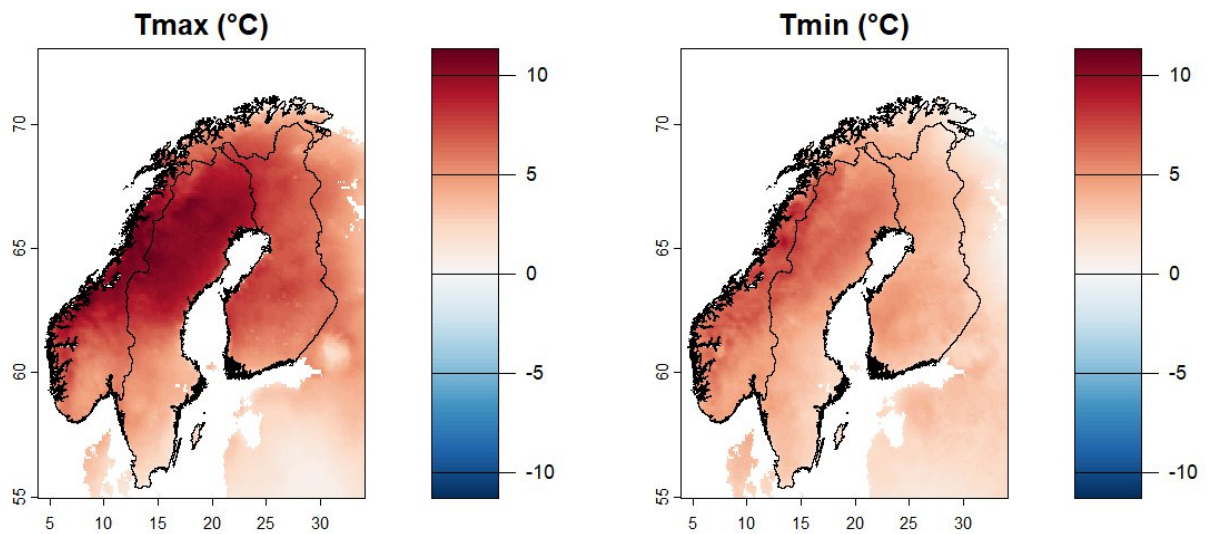


Fig. 13: The 14-day temperature anomalies of daily maximum (left) and daily minimum (right) temperature during 12–25 July, 2025, relative to the respective 1991–2020 climatology, over the Fennoscandian countries. Based on ERA5-Land 2 metre air temperature.

Oceania – Australia October heatwave 2025

Key messages

- Major spring heatwave in interior Australia, with state October records for New South Wales and Queensland.
- Extreme spring heat in the region is unusual during La Niña, but characteristic of periods with negative Southern Annular Mode.

Description of event

A major spring heatwave affected much of the interior of Australia in mid-October 2025 (**Fig. 14**). Extreme heat developed in the western interior on 17 October and then moved eastwards over the following days, peaking in the eastern interior on 20 and 21 October before moving to the east coast on 22 October. While conditions then cooled in southern Australia, it remained very hot in Queensland for much of the rest of the month.

Many sites in inland Queensland and New South Wales had their hottest October day on record on 20 or 21 October. State records for October were set on the 21st in both states (Bureau of Meteorology, 2026). Birdsville (Queensland) reached 46.1 °C and Wanaaring (New South Wales) 44.9 °C, each 1.0 °C above the respective previous records. A number of records were also set for persistent October heat, including 9 consecutive days above 40 °C at Longreach and 3 consecutive days above 40 °C at Alice Springs. It went on to be the hottest October on record for Queensland and the Northern Territory.

Causes and attribution

At the time of the heatwave, La Niña conditions were developing and there was a strongly negative Indian Ocean Dipole, while the Southern Annular Mode (SAM) was strongly negative. The October 2025 monthly value of the Climate Prediction Center (CPC) SAM index was -1.24, the third-lowest for October in 47 years of data after -2.56 in 2002 and -2.31 in 1988. These broadscale drivers, in isolation, have conflicting influences on spring temperatures in eastern Australia. La Niña is typically associated with below-average mean seasonal maximum temperatures in spring in most of eastern Australia, while the negative Indian Ocean Dipole is associated with below-average temperatures outside the tropics and above-average temperatures north of 20 °S (Bureau of Meteorology, 2026). However, negative SAM is strongly associated with above-average spring maximum temperatures in most of the region (Hendon et al., 2007). The two previous instances when an October SAM below -0.5 occurred with La Niña conditions in place (1988 and 2024) also had abnormal heat in interior eastern Australia, with 2025, 2024 and 1988 being Queensland's three hottest Octobers on record. This indicates that the SAM influence has outweighed other influences in this situation.

No known study of the influence of anthropogenic climate change on this heatwave has been carried out at the time of writing. However, October is the fastest-warming month in Australia, with a warming trend of 0.18 °C/decade over the 1910–2025 period.

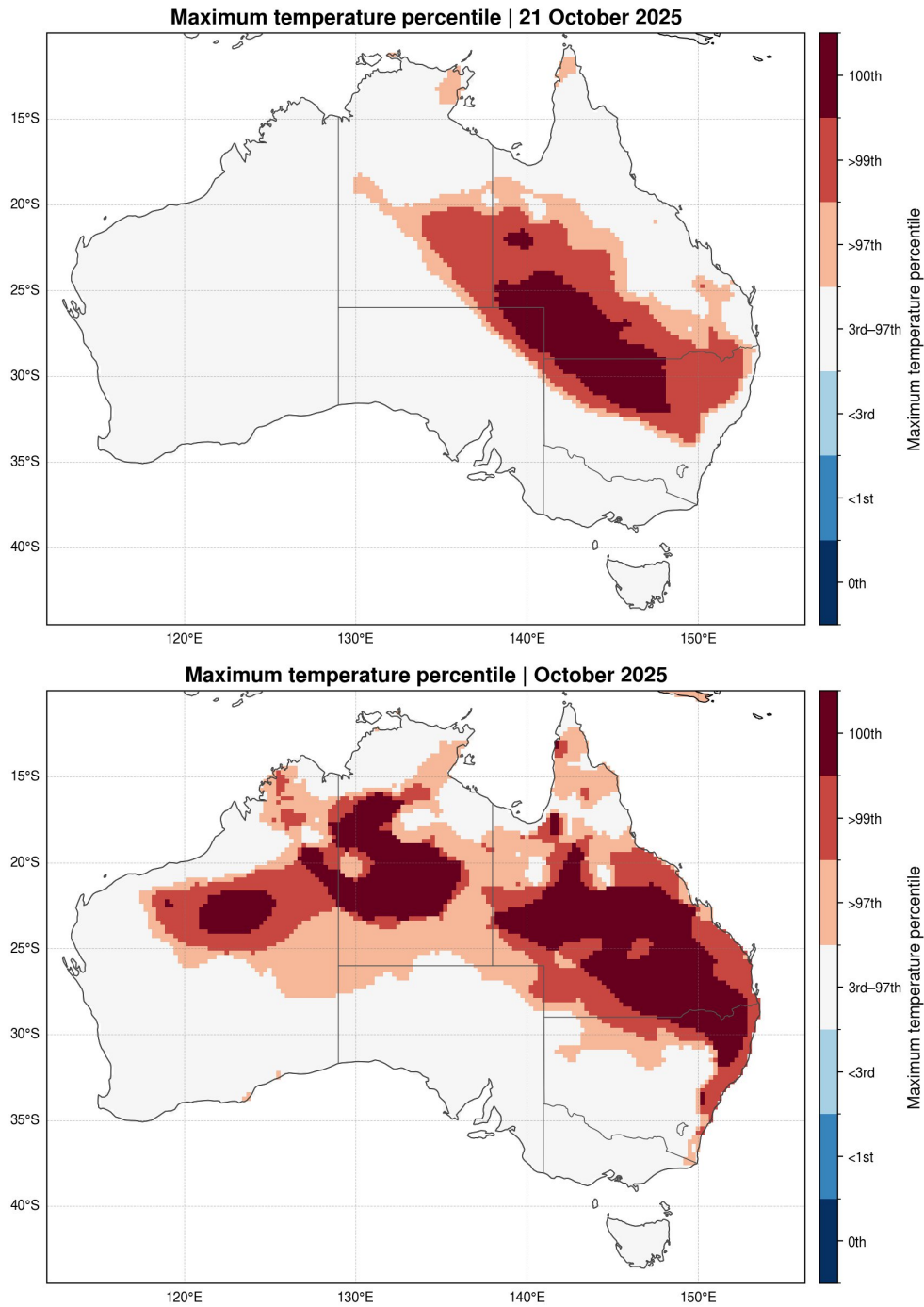


Fig. 14: Percentile map for daily maximum temperature on 21 October 2025 (top) and mean monthly maximum temperature for October 2025 (bottom). Percentiles are based on the Australian Gridded Climate Data dataset (Jones et al., 2009) for Octobers in the 1910–2024 period. Areas mapped as 100th percentile are highest on record for October for the post-1910 period.

Oceania - March floods in inland Queensland

Key messages

- Exceptional rainfall fell in late March in normally semi-arid areas of inland Queensland, leading to extensive and long-lived flooding.
- Inland Australia is susceptible to occasional extreme rainfall from tropical low pressure systems associated with the monsoon.

Description of event

Exceptional rainfall fell in normally semi-arid parts of inland Queensland in late March (**Fig. 15**). The rain was associated with a low-pressure system which formed over the eastern Northern Territory on 23 March and drifted slowly eastwards into western Queensland over the following days, with a moist northerly flow on its eastern side.

The most extreme rainfall totals occurred in the area south of Longreach. Weekly totals over parts of this region for the week ending 27 March exceeded 400 mm, in a region where annual mean rainfall is generally in the 300-400 mm range. Sunbury received 347 mm on 27 March and 633 mm in total for the four days 24-27 March, and numerous other sites in the region had daily totals above 200 mm during the event (Bureau of Meteorology, 2026).

The event led to exceptional flooding on many rivers in the region (Bureau of Meteorology, 2026). Record flood heights were reached in the Thomson, Paroo and Bulloo rivers and Cooper Creek. Much of the town of Thargomindah, on the Bulloo, was inundated, transport was severely disrupted for an extended period and there were significant losses of livestock. As is typical of floods in this very flat region, the flood peaks moved very slowly downstream over the following months, with the Cooper Creek flood eventually reaching Kati Thanda-Lake Eyre in late July.

Causes and attribution

Occasional extreme rainfalls associated with tropical lows are a feature of the climate of the semi-arid regions of northern inland Australia. These lows can be the post-landfall remnants of tropical cyclones or can be independent of tropical cyclones (as the March 2025 system was) and typically draw on tropical moisture associated with the monsoon. Rainfall in northwestern Australia has increased substantially since the 1960s (Dey et al., 2019) but the signal is less clear in inland Queensland.

No specific attribution study of the March event relating to anthropogenic influence has been carried out to date. Broad-scale climate drivers which affect the Australian region, such as ENSO, the IOD and SAM, were in a generally neutral state during this event.

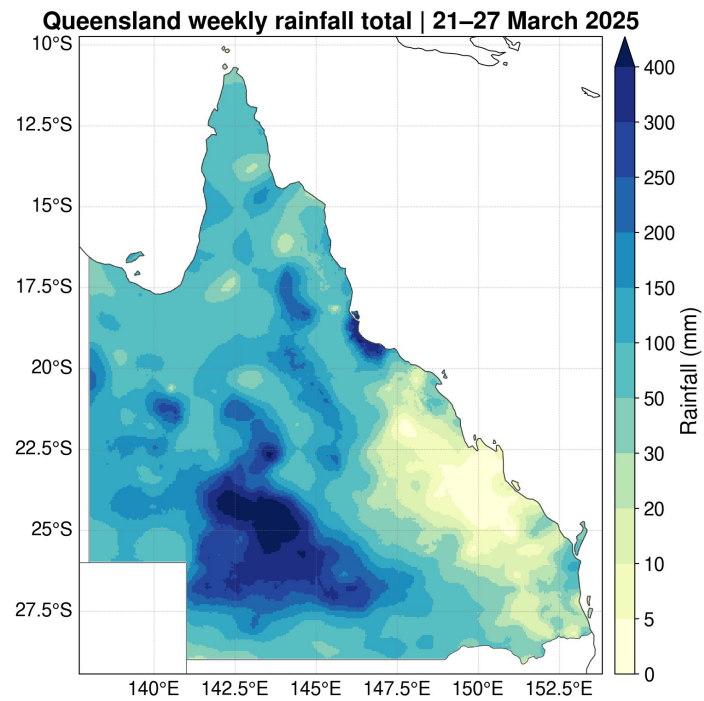


Fig. 15: Weekly rainfall totals for Queensland for 21–27 March 2025, from the Australian Gridded Climate Data dataset (Jones et al., 2009).

The future of reports

In line with the aims of the AWCE Working Group, we will produce an annual synthesis to place extreme events in a long-term historical perspective and in the context of human-induced climate change, with a comprehensive global focus that better encompasses the Global South than existing literature and reports.

In this inaugural report we have chosen to assess three commonly used indices representing measures of maximum and minimum temperature and precipitation extremes (TXx, TNx, Rx1day). In future reports, we may expand on this to include additional indices or extremes other than those simply defined by temperature and precipitation. We will seek community feedback, perhaps through a GEP questionnaire; but the exact mechanism for this is yet to be determined.

Annex 1 - Datasets and methods

Here we outline the datasets that have been used in this report along with a description of how we have made the figures.

Dataset name	Dataset type	Extremes Index	Reference
ERA5	Reanalyses	TXx, TNx, Rx1day	Hersbach et al., 2020
Berkeley Earth	In situ	TXx, TNx	Rohde et al., 2013 (monthly; daily product experimental and undocumented)
HadEX3	In situ	TXx, TNx	Dunn et al., 2020
CPC_v1.0	In situ	Rx1day	Xie et al., 2010
GPCC_FDD_2022	In situ	Rx1day	Ziese et al., 2022
CHIRPS_v2.0	Satellite (blend)	Rx1day	Funk et al., 2015
CMORPH_v1.0_CRT	Satellite	Rx1day	Xie et al., 2017
GPCP_v3.2*	Satellite	Rx1day	Huffman et al., 2001
GSMAP-gauges-NRT-v8.0	Satellite	Rx1day	Kubota et al., 2007
IMERG-v07B-FC	Satellite	Rx1day	Huffman et al., 2023
PERSIANN_v1_r1	Satellite	Rx1day	Ashouri et al., 2015; Sorooshian et al., 2014
MSWEPV2	Satellite (blend)	Rx1day	Beck et al., 2019
CFSR	Reanalysis	Rx1day	Saha et al., 2010
JRA-3Q	Reanalysis	Rx1day	Kosaka et al., 2024
MERRA2	Reanalysis	Rx1day	Gelaro et al., 2017

Table S1: Datasets and indices used to calculate global and IPCC AR6 region values in this report along with relevant references. Other datasets are used for the case studies but these are referenced in the main text accordingly. *GPCPv1.3 is also used to supplement GPCPv3.2 from 2001-2025 (see text below).

Peak day- and nighttime temperatures (TXx, TNx)

Data | We use the three temperature products in **Table S1**: ERA5 reanalysis, Berkeley Earth and HadEX3. Berkeley absolute temperatures are reconstructed from its anomaly and day-of-year reference climatology fields (with the latter taken from the earliest decadal file). We analyse 1960 onward, since the spread between products is large before then and earlier values are weakly constrained, especially at the regional scale. In situ networks in the first half of the twentieth century

are sparse and unevenly distributed, and gridded products depend correspondingly more on interpolation the further back the period extends. All analyses are restricted to land and exclude latitudes southward of 60°S.

Note that Berkeley Earth daily data are currently distributed as an experimental product, and the available documentation (Rohde et al., 2013) merely describes the monthly rather than the daily dataset; our enquiries about daily-product processing errors went unanswered. We therefore treat Berkeley Earth as a consistency check on ERA5 and HadEX3 rather than as an independently documented third product, and remark that undocumented changes in the underlying station network cannot be diagnosed here in the way they can for HadEX3.

We deliberately exclude satellite-based products for temperature: satellites estimate skin temperature rather than the 2 m air temperature that defines TXx and TNx, and near-surface temperature varies smoothly enough in space that a reasonably dense in situ network constrains it well — though a sufficient network remains essential. Precipitation differs on both counts (see Wettest day): it varies over far shorter distances than typical gauge spacing, so intense local rainfall can escape the gauge network entirely, and satellite estimates provide coverage that is otherwise unavailable.

Indices | TXx and TNx are the annual maxima of daily maximum and daily minimum 2 m air temperature. For ERA5 and Berkeley Earth, we compute them from daily fields starting in 1960 and going as far as possible, ensuring we only work with complete years. We apply no further per-cell criterion on within-year daily completeness (such as the ETCCDI limit on missing days) before forming the annual maxima. For Berkeley Earth, the distributed daily fields are essentially complete wherever they are defined: from 1960 onward, over 99.6% of contributing land grid cells carry a value on every day of the year, so a completeness screen would remove almost nothing. This near-completeness reflects how the product is constructed rather than how densely it is observed. Berkeley Earth interpolates from a station network, so complete gridded coverage does not imply that each grid cell is observationally constrained, and without documentation of the daily product we cannot assess how far the field is extrapolated in sparsely observed regions. We report the 99.6% only to justify omitting a completeness criterion, and it should not be read as an indication of data density. ERA5 daily maxima and minima are obtained from hourly mean values (with complete spatiotemporal coverage, as typical for reanalysis products). HadEX3 is used as a precomputed index product, inheriting its provider's completeness criteria (Dunn et al., 2020). The trend comparison additionally uses annual-mean 2 m temperature (T_{annual} ; ERA5 and Berkeley) and the summer (JJA, June–August) and winter (DJF, December–February) means (T_{JJA} , T_{DJF} ; ERA5).

Spatial aggregation | Regional means use the 44 AR6 land reference regions and are obtained using the `regionmask` python package, excluding the two Antarctic regions in keeping with the 60°S cutoff; each region is the intersection of its AR6 mask with a Natural Earth land mask. Spatial means are area-weighted by $\cos(\text{latitude})$. On top of the per-product completeness above, a region is treated as missing in any year in which a valid index is available for fewer than 80% of its land grid cells. Where anomalies are shown (**Fig. 1**, the regional series, the GMT scaling), they are relative to a per-pixel 1991–2020 climatology (1991–2018 for HadEX3).

Trends | Trends are Theil–Sen (Sen's slope) estimates in °C per decade over three periods: 1960 to each product's final year, 1961–1990 and 1991–2020; significance, where shown, is assessed with the Mann–Kendall test. Missing years are dropped, and a trend is reported only where at least 90% of the period's years are present. The global land-mean trend (**Fig. 1**) is computed per pixel and then area-weighted, rather than by fitting the spatial-mean series. Regional means are formed first and then ranked (**Fig. 4**) or fitted for trends (**Figs. S11–S22**) using Theil–Sen slopes; within-region coverage changes are not separately corrected beyond the 80% threshold, although we manually crop or entirely remove certain HadEX3 regional timeseries (see separate section below).

Smoothing | The regional and continental overview series are LOWESS-smoothed (Cleveland, 1979), with a 42-year window for the regional series (**Figs. S11–S22**) and a 21-year window for the global and continental-scale overview (**Fig. S2a**); the smoothing fraction is the window divided by the number of valid years. Missing years are dropped before smoothing rather than interpolated, and each series requires at least its window length of valid years. For the multi-product regional mean, the individual smoothed curves are interpolated onto a common set of years and averaged wherever at least two products are available.

Records and ranks | Ranking begins in 1980, since spurious extremes have been noted for earlier decades in sparsely observed regions (Vautard et al., 2024). Data quality also matters more for ranking than for trend estimation, as a single spurious value can affect ranking more than Theil-Sen slopes over several decades. Nonetheless repeating the ranking analysis with the period starting in 1960 lowers the record fractions slightly but does not change the ordering of years (**Fig. S5**).

A year's rank at a pixel or region is its position among the years considered, rank 1 being the warmest, and with ties resolved to the earliest year. We use two windows. In a growing window each year is ranked only against 1980 up to that year, so rank 1 marks a record set at the time; this underlies **Figs. 3 and 4, S7 and S8**, and **Figs. S5 and S9** repeat it from 1960. Early in the period, high ranks are expected by construction — in 1981 every cell is rank 1 or 2 —, which is why we show growing-window results only for recent years in the main analysis, when the reference period spans four decades or more. In a fixed window every year is ranked against the full 1980–2025 period, hence rank 1 marks the 1980–2025 maximum; this is the basis of **Figs. 2, S3, S4, S6 and S10**, and **Table S2**. Here and in the main analysis, “record” always refers to the growing window, and “1980–2025 maximum” to the fixed window.

Under a stationary climate the expected fraction of land at rank 1 in a given year is $1/N$, with N the number of years up to and including that year ($\approx 2.2\%$ for 2025). This does not support a significance test on any individual year: extreme heat is spatially coherent, so records tend to occur in large contiguous patches and the effective number of independent samples is smaller than implied by the number of grid cells. This spatial dependence widens the year-to-year spread around the expectation but does not shift it, and our conclusions accordingly rest on multi-year patterns rather than on single years.

Global mean temperature | GMT, the predictor in the scaling figure, is the area-weighted ERA5 annual-mean temperature over all grid cells, land and ocean and all latitudes; its 1960–2025 linear trend is $0.19\text{ }^{\circ}\text{C}$ per decade.

HadEX3 exclusions | HadEX3 regional series with evident data-quality issues are handled in one of three ways, depending on whether a within-region change in grid-cell coverage locates the problem in time. Firstly, where an artifact coincides with a decline in coverage, the series is cropped rather than removed; the coverage decline serves as the indicator, but the crop point is chosen manually by inspection rather than set by a fixed threshold. Note that these diagnostics rest on gridded coverage: since HadEX3 grid values are averages over contributing stations, the underlying station network can change without any visible change in gridded coverage, so an apparently stable coverage does not rule out additional inhomogeneities (per-year station networks are available from the HadEX3 archive; Dunn et al., 2020). We emphasize that the same caveat almost certainly applies to Berkeley Earth, where the absence of documentation makes it impossible to check (see above). Because TXx and TNx derive from the same underlying station network, a coverage signal in either index is applied to both. On this basis, SES and SSA are cropped at the end of their series (retained through 2017), consistent with the South American station collection — mainly Argentina — ending in 2017; SCA is restricted to 1965–2016, reflecting a decline in Mexican stations from 2010 with a larger drop after 2016; and NAU TXx is cropped (retained through 2016; NAU TNx already removed by the 80% spatial coverage threshold), following the loss of ACORN-SAT after 2016, which leaves few GHCNDEX stations in northern Australia.

Secondly, where a clear artifact has no coverage signal, or where the product is unreliable for other reasons, both indices are excluded in full: SWS (a spurious drop in both indices with no accompanying coverage change), SAM (stable gridded coverage but few stations across a large region, with the series diverging strongly from ERA5 and Berkeley), NWS (trends three to four times steeper than ERA5 and Berkeley even in its highest-coverage window, with few contributing stations after 2010), and NSA (suspicious trends in both indices throughout; interpolation here can also draw on stations from non-matching climates, such as Andean stations into Amazonian grid cells; Dunn et al., 2022, their **Fig. 5**).

Finally, some regions show irregularities towards the end of the series that do not mark a clear artifact and thus no actions are taken: WSB runs low in both indices towards the end of the series; WCA shows lower TXx values over its final three years than other products and than earlier years, coinciding with the loss of Kazakh stations after 2015; and WCE and EEU agree less well with ERA5 and Berkeley in TXx over the last few years. The screening described here reflects the issues we identified rather than an exhaustive audit, and the retained series should not be taken as artifact-free. These exclusions apply only to the AR6 regional series; the global mean calculation is unaffected.

Wettest day (Rx1day)

Data | We use 13 products from the Frequent Rainfall on Grids (FROGS) database (Roca et al., 2019; <https://frogs.ipsl.fr/>) as outlined in **Table S1**. The FROGS database is utilised as it contains a range of in situ, satellite and reanalysis products on a common daily $1^\circ \times 1^\circ$ latitude/longitude grid. Satellite products include datasets that are corrected to in situ (rain gauge) data and uncorrected products. Datasets vary in length, but all contain the common period 2001 to 2019. Only the latest version of each dataset in FROGS V1 (accessed on 5th June 2026) is used (for example, GPCC_FDD_v2022 and not GPCC_FDD_v2020) and only corrected satellite products (i.e. the corrected version is preferred for satellite products that provide a corrected and uncorrected version). There is one exception in that we include GPCPv1.3 rather than GPCPv3.2 in our time series calculations since it was updated in FROGS to 2025. GPCPv3.2 is included in interproduct spread calculations (e.g., **Fig. S23**) since it was available up until 2020. Only data that covers a common period and 80% of the land area (per sub-region) studied is included. Of the 54 products currently in FROGS, 13 meet these criteria. For example, *in situ*-based product, REGEN (Contractor et al., 2020) is not included in the analysis because it ends in 2016. While HadEX3 is not in FROGS, it also contains Rx1day. However, because the spatial coverage is much more limited than for the temperature indices due to shorter decorrelation length scales and issues with the order of operation in which indices are calculated that have a larger effect on rainfall than temperature (e.g., Chen & Knutson, 2008; Avila et al., 2015), we choose not to include it as one of our reference datasets. Where available, data up to 2025 are included in the time series but not all products were available or updated.

Standardising | Rx1day is shown in timeseries plots as a standardised percentage anomaly relative to a 2001–2020 climatology.

Trends | Trends are Theil–Sen (Sen's slope) estimates in % per decade over the period 1991–2020 to provide a consistent comparison period with temperature and to avoid differences in product availability near the ends of the records. Significance, where shown, is assessed with the Mann–Kendall test. Missing years are dropped, and a trend is reported only where at least 90% of the period's years are present. The global land-mean trend (**Fig. 1**) is computed by fitting to the spatial-mean series.

Inter-product spread | This is computed year-by-year using all available products, after standardising each product by its temporal mean and temporal standard deviation over the full available period. Therefore, the final spread is the mean of the annual spread across valid years, thus maximising the use of data even when certain products are missing over certain regions for years. Inter-product spread is presented as a map by IPCC AR6 reference region and is calculated from 2001 onward using all available data through to the latest year of each dataset (**Table S1**) up to and including 2025 where available.

Annex 2 - Supplementary material

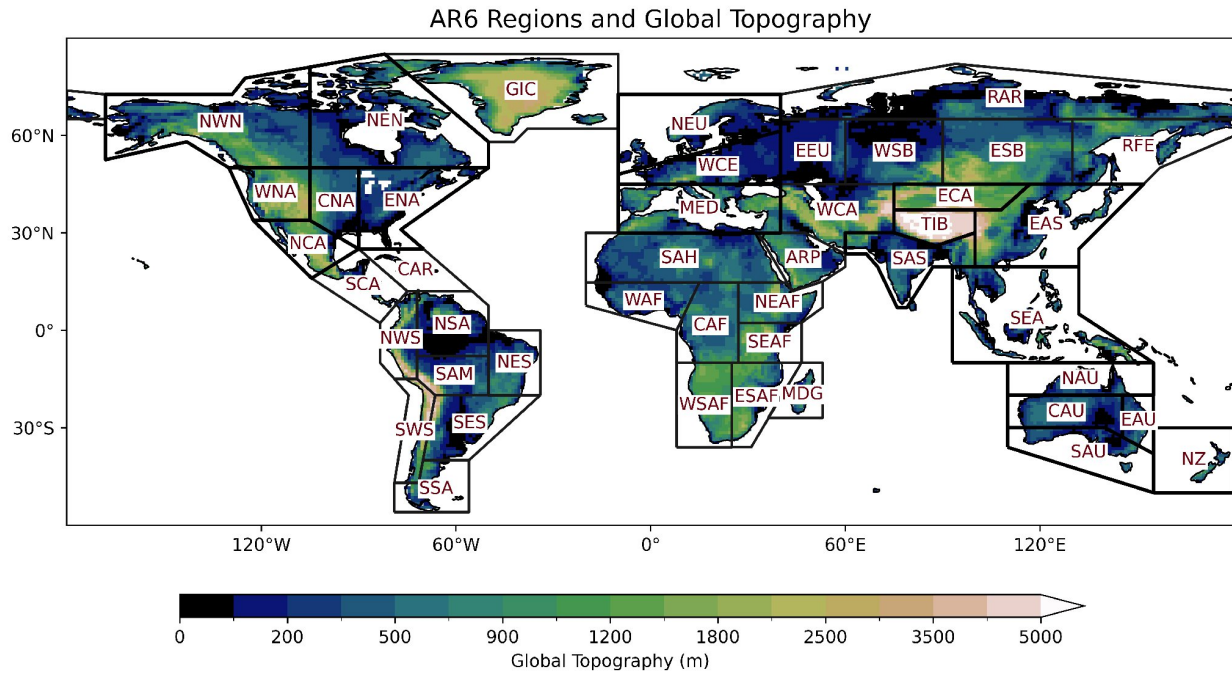


Fig. S1: IPCC regions as defined by Iturbide et al. (2020) together with topography (adapted from Alexander et al., 2025)

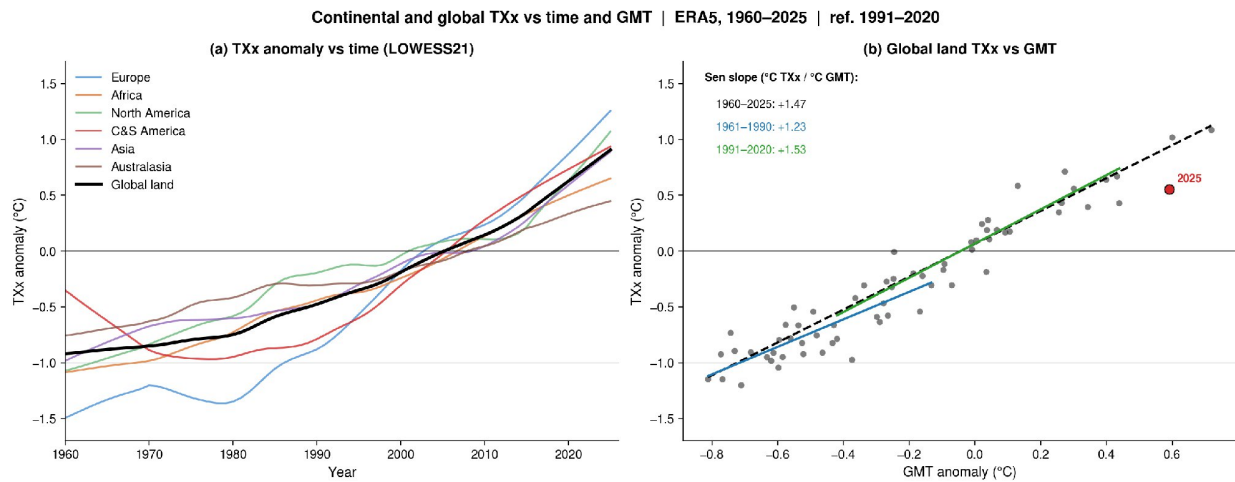


Fig. S2: Peak daytime temperature as a function of time and of global warming, based on ERA5 (1960–2025, anomalies relative to 1991–2020). **(a)** Continental-mean TXx anomalies, 21-year LOWESS-smoothed, with the global land mean in bold black. **(b)** Global land-mean TXx anomaly against the global-mean temperature (GMT) anomaly of the same year. Sen's slopes are fitted over the full period (1960–2025, dashed black) and separately over 1961–1990 (blue) and 1991–2020 (green); each slope (°C per °C) is the change in the extreme per degree of global warming, and 2025 is marked in red. GMT is the area-weighted ERA5 annual-mean 2 m temperature over all grid cells (land and ocean, all latitudes). The scaling is near-linear to first order (1.47 °C per °C over the full period), with a somewhat shallower slope before 1990 (1.23 vs 1.53). The recent and full-period slopes are similar, so the apparent steepening of the TXx trend over time shown in (a) most likely reflects the accelerating rise in GMT rather than a strong change in sensitivity.

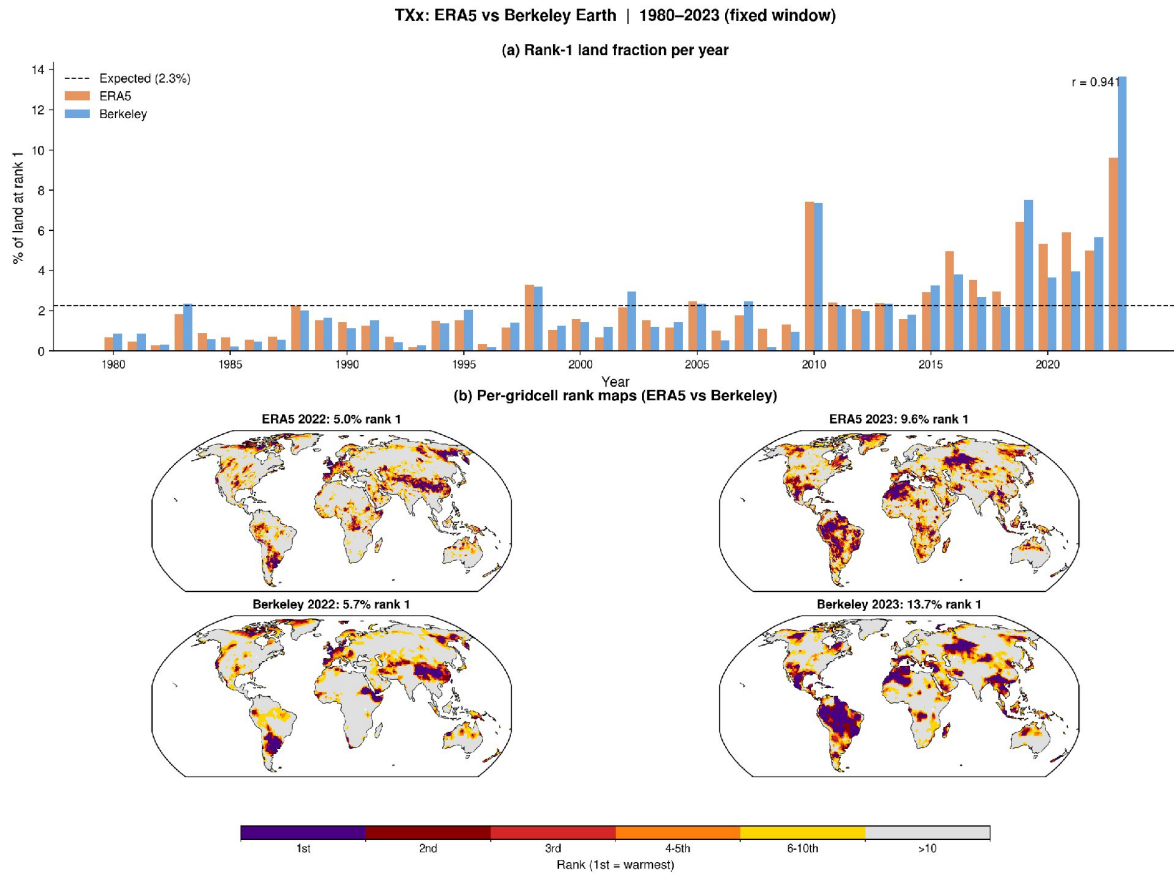


Fig. S3: Robustness of the TXx ranking to the choice of dataset, ERA5 versus Berkeley Earth, over their common period 1980–2023 (fixed window). (a) Area-weighted fraction of land at rank 1 each year for the two products (bars), with the stationary-climate expectation ($1/44$ for this 44-year common period) dashed and their correlation annotated. (b) Per-grid cell rank maps for 2022 and 2023 (rows: ERA5, Berkeley), each on its native grid. Though the rankings are not identical across products, they agree closely enough to justify using ERA5 alone in the main analysis, where it is in any case the only product currently extending to 2024 and 2025.

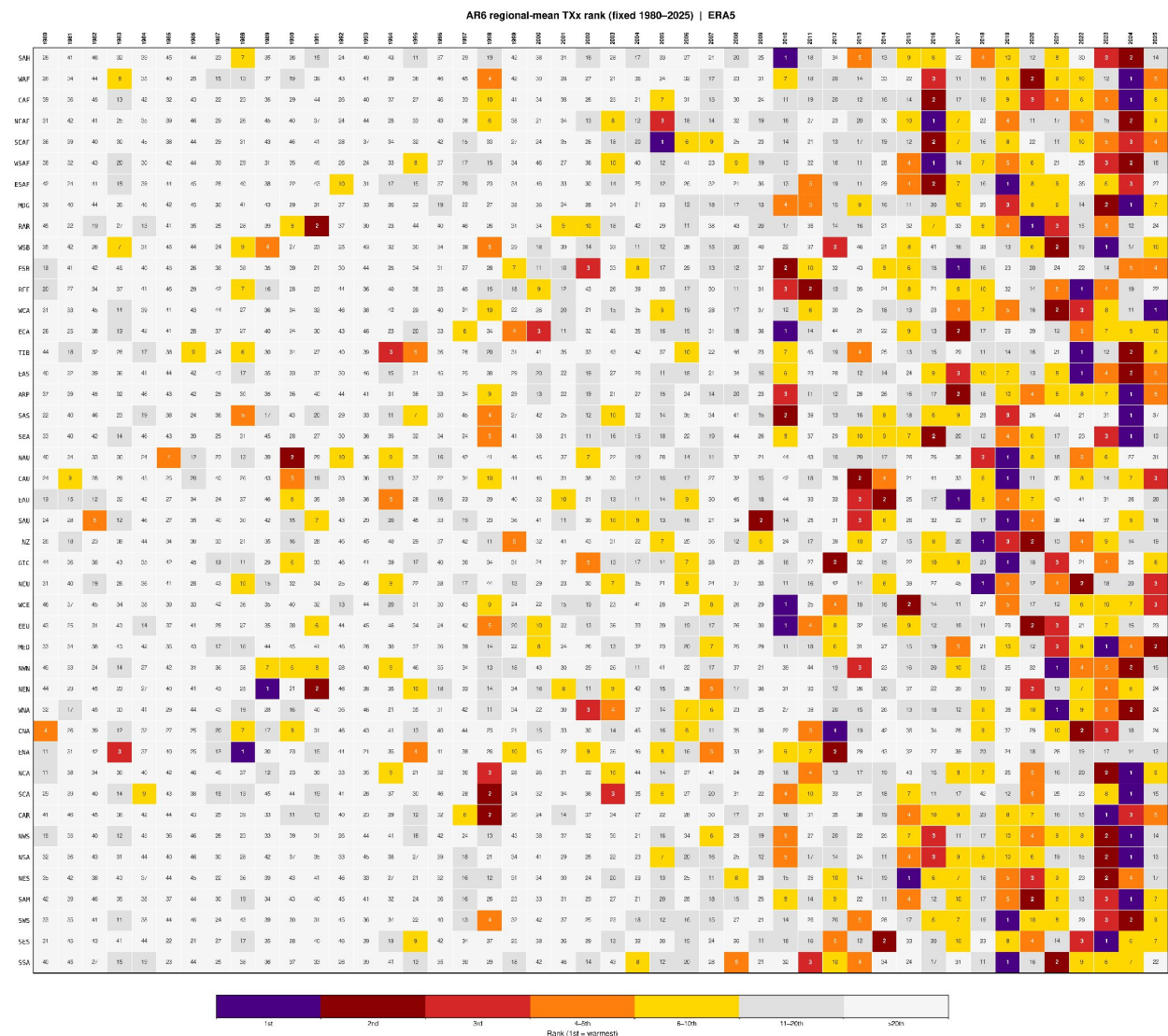


Fig. S4: As Fig. 4 but spanning all years from 1980 to 2025, with each year ranked against the full 1980–2025 period (fixed window; rank 1 = the regional 1980–2025 maximum). This shows which year holds each region's highest TXx of the period; compared with Fig. 4, it also shows how quickly some of the recent records are surpassed: of the eight regional TXx records set in 2023, four are no longer the highest since 1980. Based on ERA5; the 2 Antarctic AR6 regions are excluded (44 shown). [TNx counterpart: Fig. S10]

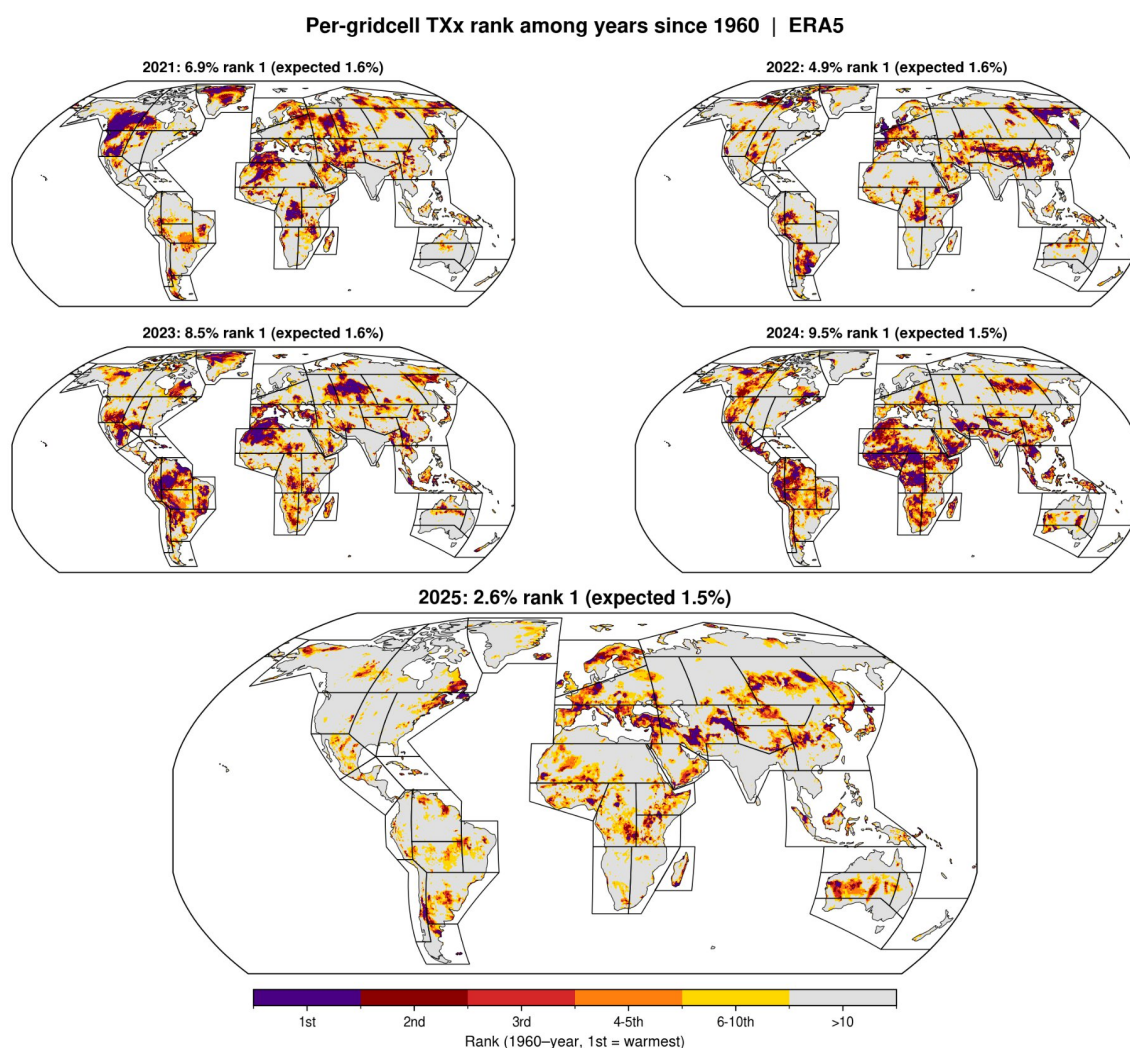


Fig. S5: As Fig. 3 (per-grid cell TXx rank for 2021–2025, ERA5, growing window) but with the reference period beginning in 1960 instead of 1980. The recent picture is unchanged: 2024 remains the clear standout and the ordering of recent years is preserved, with slightly lower rank-1 fractions since more preceding years must be exceeded.

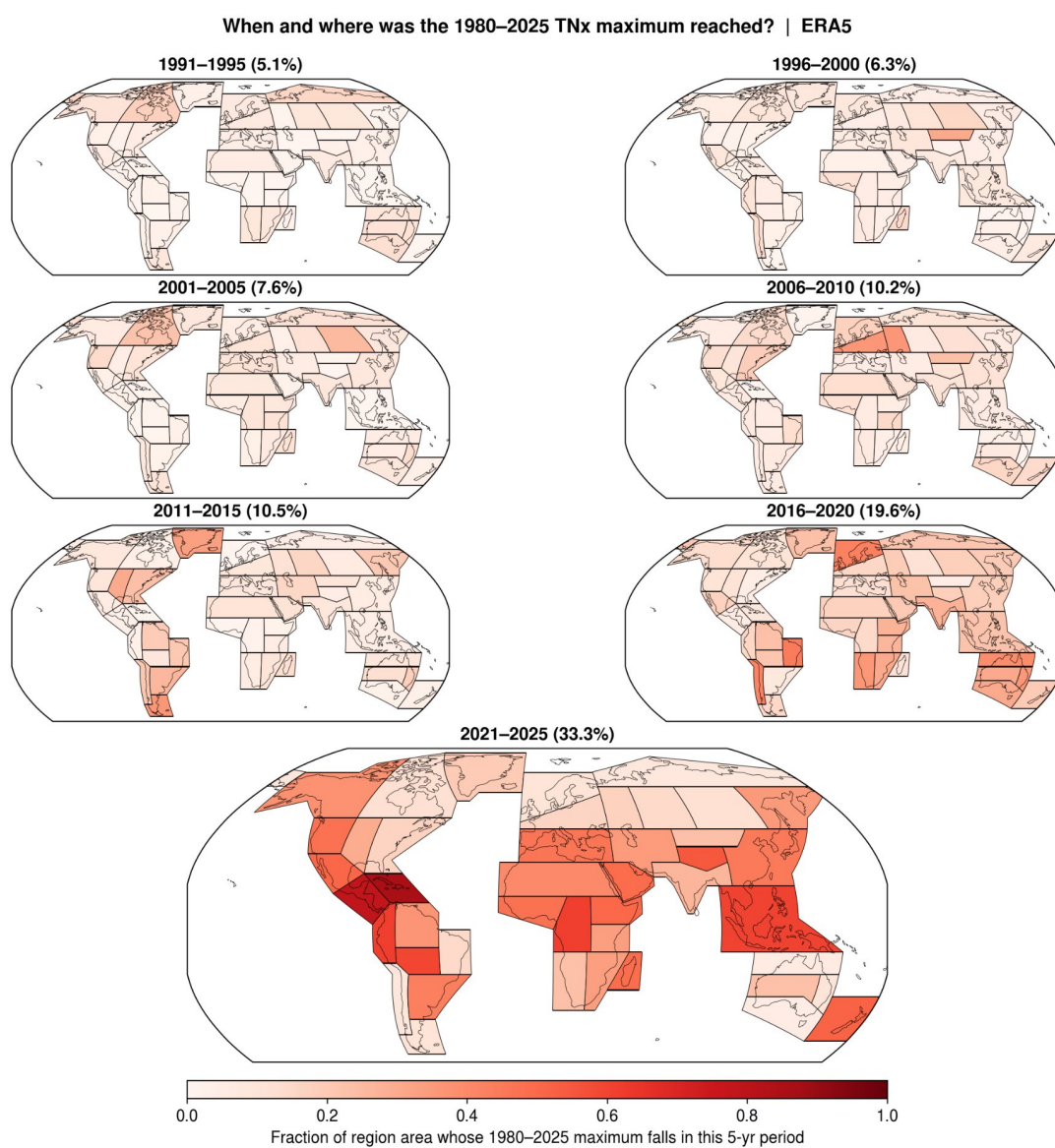


Fig. S6: As Fig. 2, but for TNx instead.

Per-gridcell TNx rank among years since 1980 | ERA5

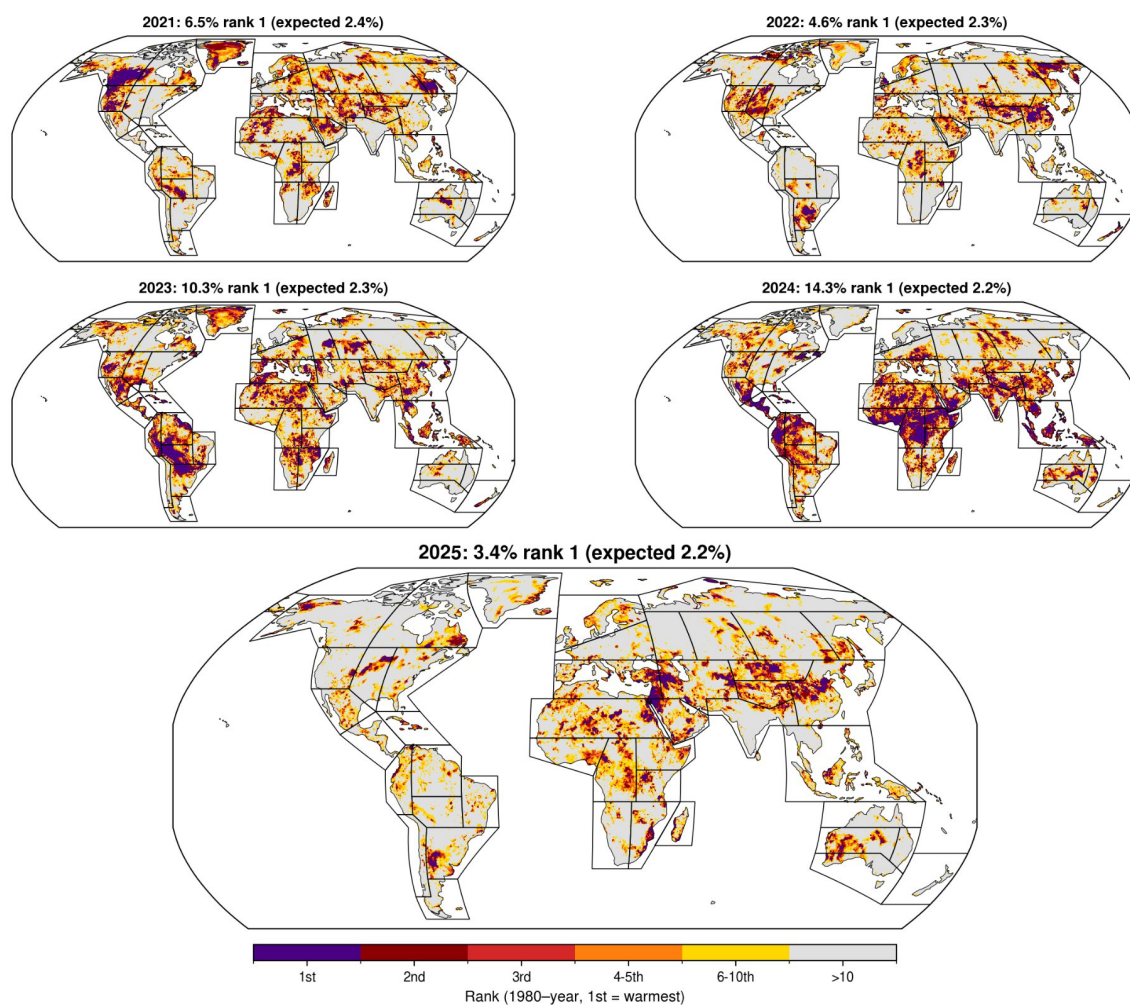


Fig. S7: As Fig. 3, but for TNx instead.

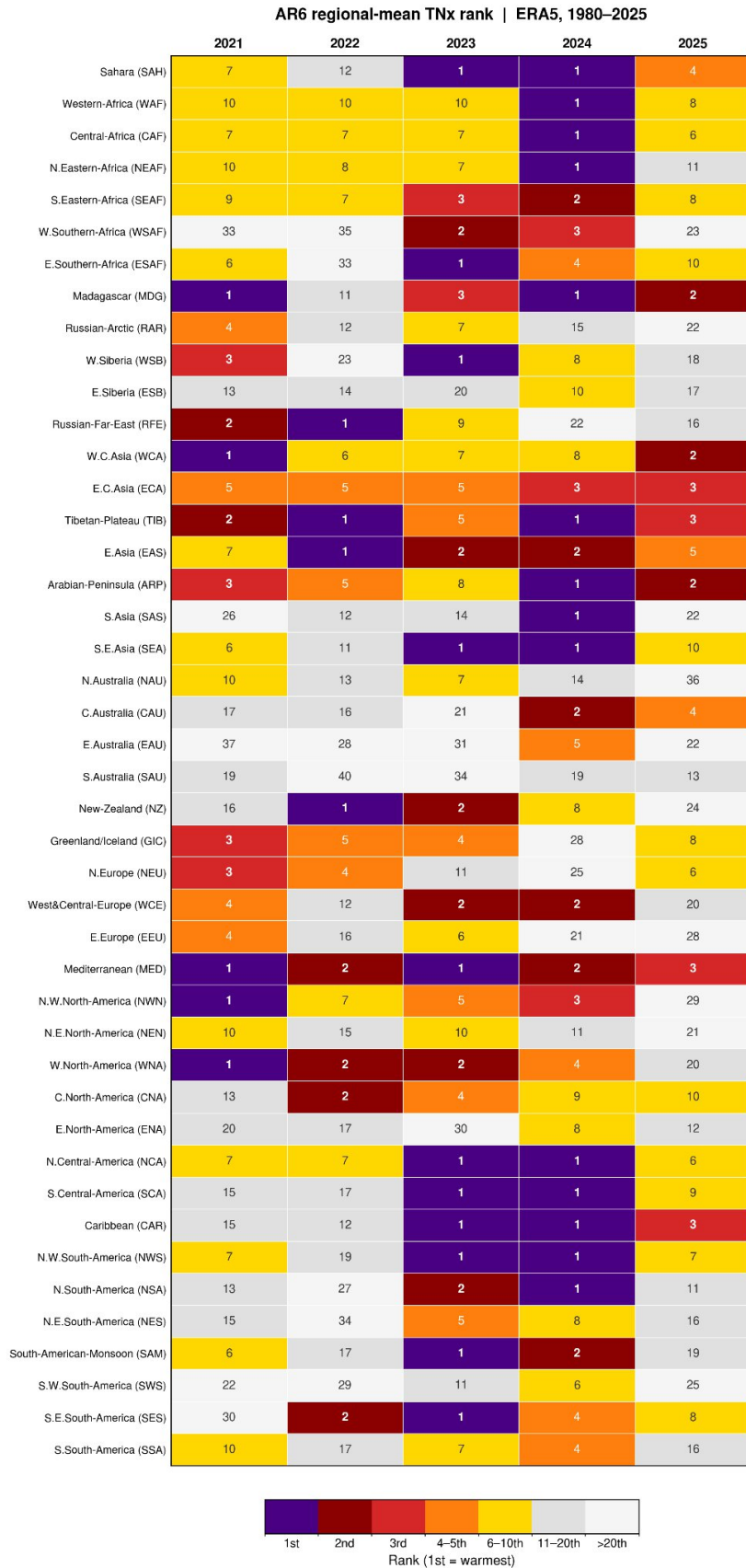


Fig. S8: As Fig. 4, but for TNx instead.

Per-gridcell TNx rank among years since 1960 | ERA5

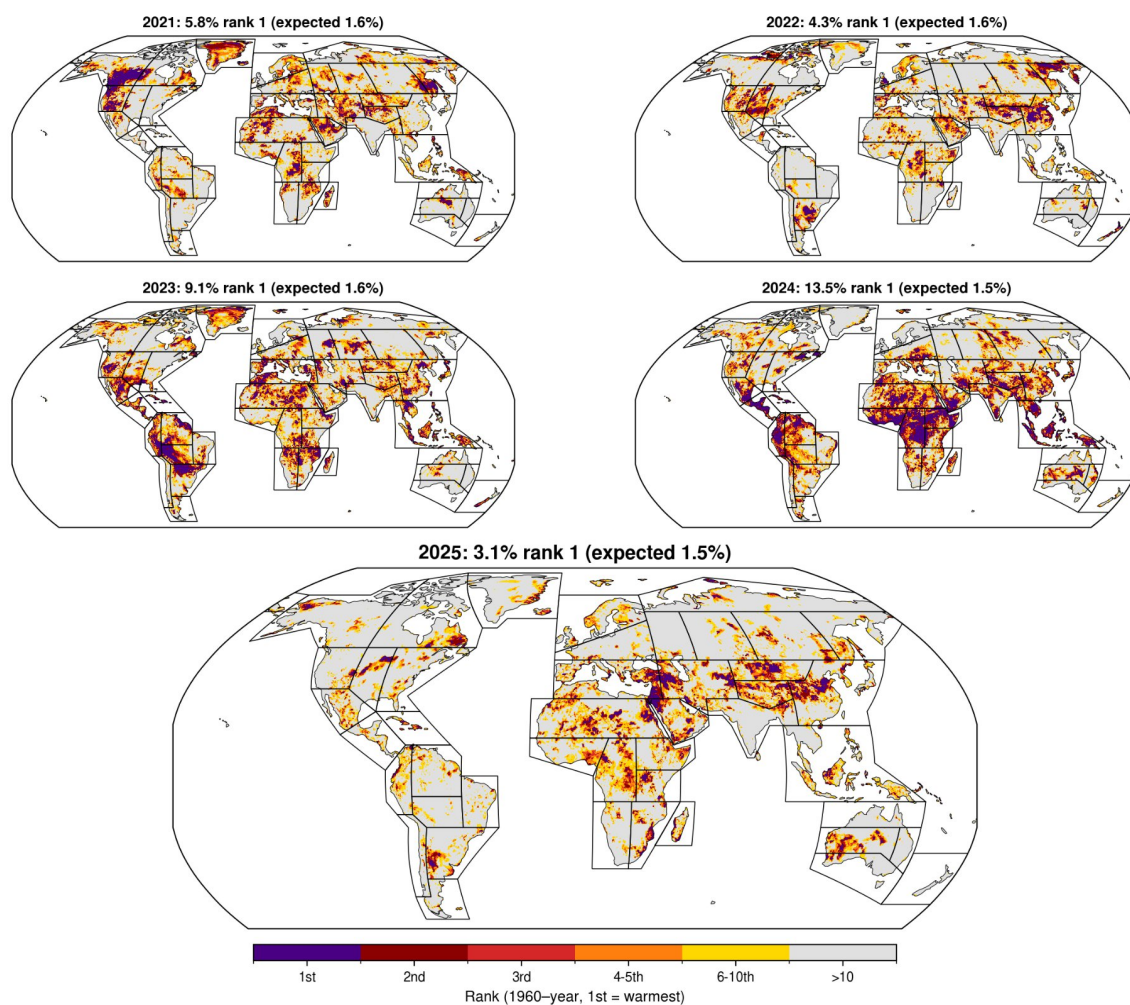
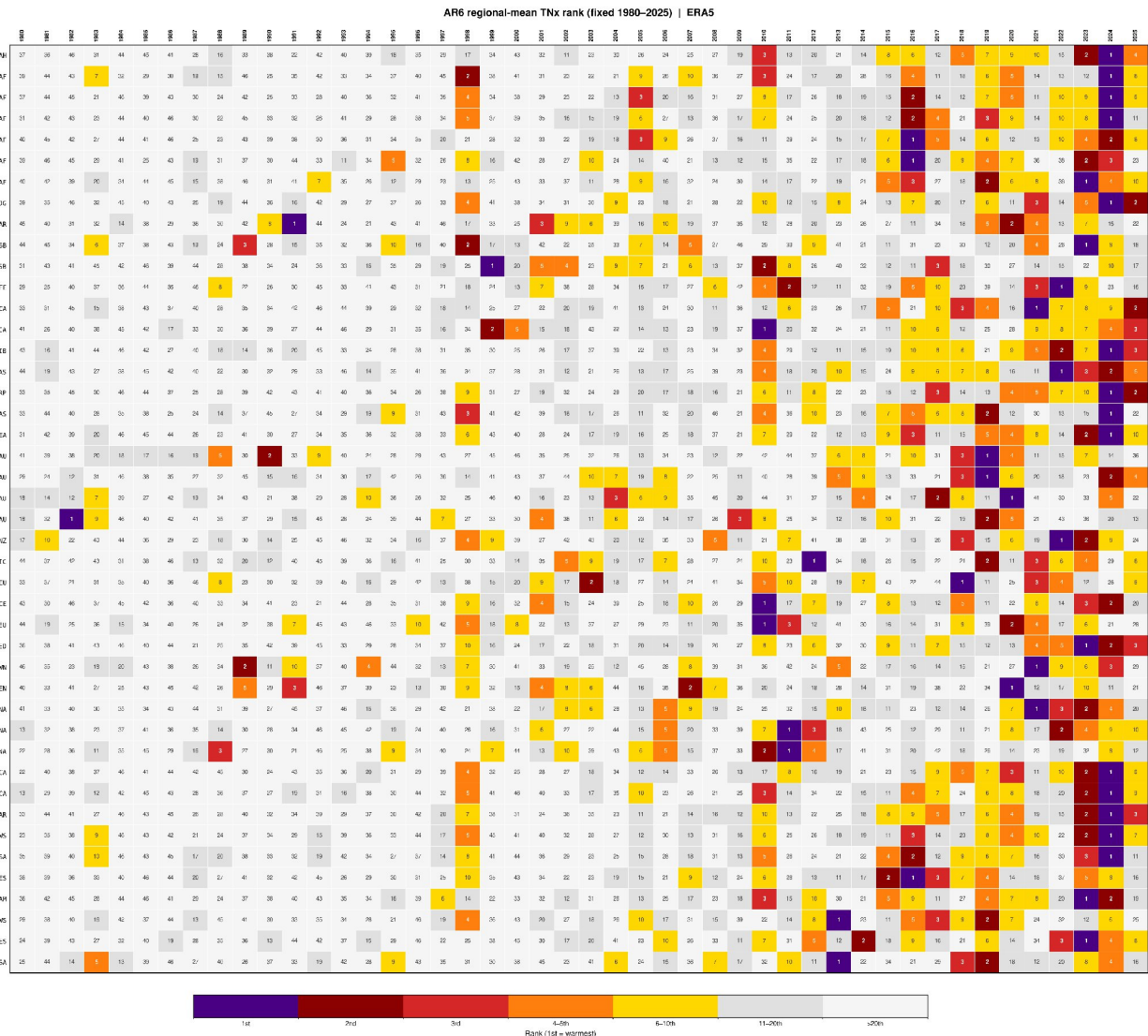


Fig. S9: As Fig. S5, but for TNx instead.



Year	TXx rank 1	TXx ≤3	TXx ≤5	TNx rank 1	TNx ≤3	TNx ≤5
2024	10.0	26.4	37.5	13.9	30.6	42.2
2023	8.0	20.8	30.3	8.2	20.5	30.9
2010	6.7	15.1	22.4	5.8	16.4	25.6
2019	5.7	14.8	23.0	4.9	14.1	22.9
2021	5.0	14.7	22.7	4.5	12.9	21.0
2020	4.4	13.2	21.7	4.4	13.4	21.9
2022	4.3	11.3	17.9	3.4	10.5	17.6
2016	4.0	11.7	18.3	4.6	13.9	22.7
2025	3.0	10.0	17.7	3.4	11.0	18.4
2017	2.9	9.4	16.2	2.4	8.2	14.8
2018	2.6	8.8	15.0	3.4	9.7	16.1
1998	2.6	7.8	13.4	2.6	10.1	17.6
2015	2.5	8.3	14.7	3.3	9.8	16.4
2005	2.2	6.3	11.1	1.9	6.5	11.9
2011	2.2	6.4	11.2	2.1	6.6	11.1

Table S2. Fraction of global land where a given year holds the 1980–2025 maximum of peak daytime (TXx) and nighttime (TNx) temperature, for the 15 years with the highest TXx rank-1 fraction over 1980–2025. Each year is ranked at every grid cell against the full 1980–2025 period (fixed window; rank 1 = the 1980–2025 maximum); columns give the area-weighted percentage of land at rank 1, rank ≤3 and rank ≤5 for each index. Based on ERA5. Under a stationary climate the expected rank-1 fraction is $1/N \approx 2.2\%$. Years are ordered by TXx rank-1; the TNx top 15 is nearly identical (2012 replaces 2005). This table underlies the year ranking quoted in the main text with 2025 highlighted in red.

Index	Source	1960–	1961–1990	1991–2020
TXx	ERA5	0.28	0.17	0.39
TXx	Berkeley	0.23	0.12	0.32
TXx	HadEX3	0.21	0.08	0.31*
TXx	mean	0.24	0.12	0.34
TNx	ERA5	0.25	0.16	0.33
TNx	Berkeley	0.22	0.19	0.18
TNx	HadEX3	0.24	0.17	0.28*
TNx	mean	0.24	0.17	0.26
T _{annual}	ERA5	0.29	0.18	0.38
T _{annual}	Berkeley	0.26	0.18	0.33
T _{annual}	mean	0.28	0.18	0.36
T _{JJA}	ERA5	0.26	0.14	0.35
T _{DJF}	ERA5	0.30	0.24	0.34
GMT (land + ocean)	ERA5	0.19	0.14	0.25

Table S3. Linear trends in temperature indices (°C per decade), estimated as area-weighted means of per-pixel Theil–Sen slopes over land ($\geq 60^\circ\text{S}$), for three periods, by product and as the multi-product mean. TXx and TNx as in Fig. 1; T_{annual}, T_{JJA} and T_{DJF} are the annual-, boreal-summer- (JJA) and boreal-winter- (DJF) mean 2 m temperature. GMT is the global-mean; land + ocean, all latitudes. *HadEX3 ends 2018 and hence does not fully cover 1991–2020.

Annex 3 - Supplementary materials — AR6 region timeseries

Regional evolution of temperature extremes by continent

We display the year-to-year evolution of TXx (Figs. S11–S16) and TNx (Figs. S17–S22) across all AR6 land regions north of 60 °S, one figure per continent. In each, the central map locates the regions and is coloured by their full-period (1960 onward) Sen's-slope trend, expressed in °C per decade. The surrounding panels show, for each region, the per-product anomaly series (thin coloured lines) using 1991–2020 as a reference period, the LOWESS multi-product mean (bold black, thinner where only two products are available), the min–max spread across the per-product LOWESS curves (grey shading), and Sen's-slope trends for the three periods. A regional value is shown only where at least 80% of the region's land area has valid data in that year, so some series have gaps; regions or products with identified data-quality issues are omitted entirely (see Methods).

TXx evolution

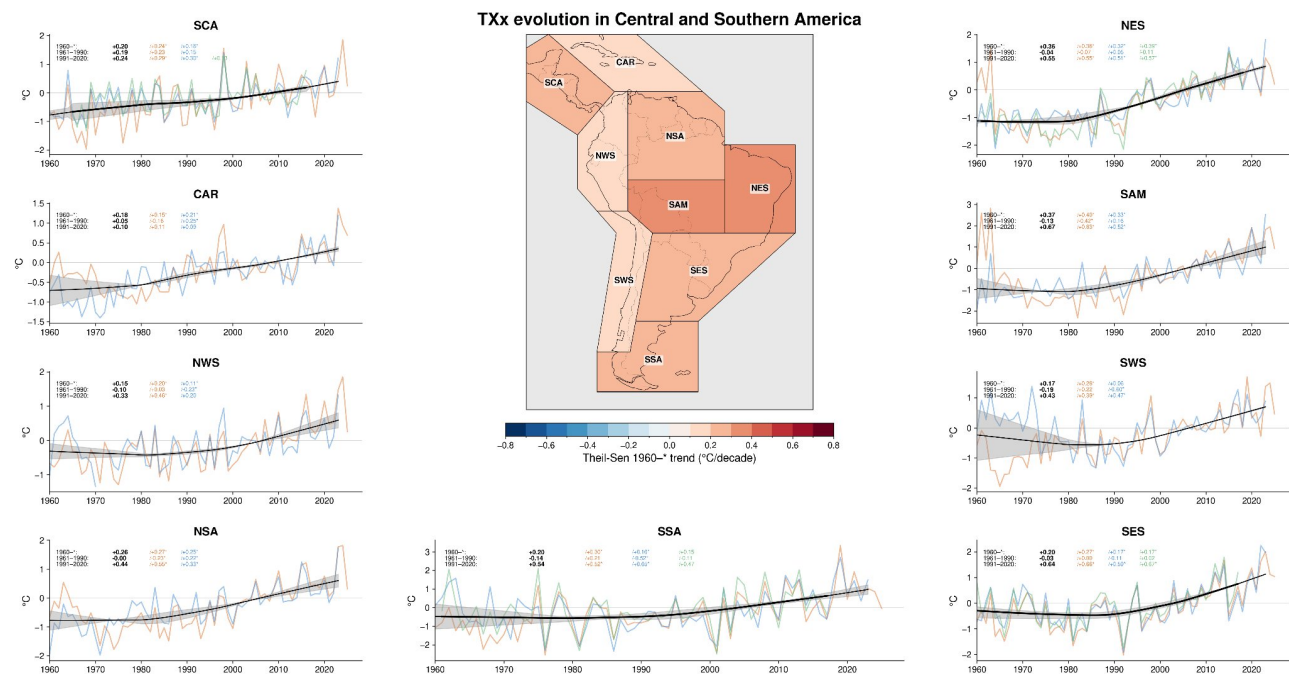


Fig. S11: Regional evolution of peak daytime temperatures (TXx) for Central and South America. Timeseries show land-average annual TXx anomalies (relative to 1991–2020) for each AR6 region in the continent, for ERA5, Berkeley Earth and HadEX3 where available, in their respective colours, with the multi-product mean in black. Sen's-slope trends (°C per decade) are annotated for three periods (1960–present, 1961–1990, 1991–2020), with a star marking significance at the 5% level (Mann–Kendall test). The central map shows the continent's AR6 regions shaded by the full-period (1960 onward) trend from the multi-product synthesis; the per-period trends in the panels, in particular 1991–2020, are more informative where the evolution is strongly non-monotonic. Land areas southward of 60°S are excluded.

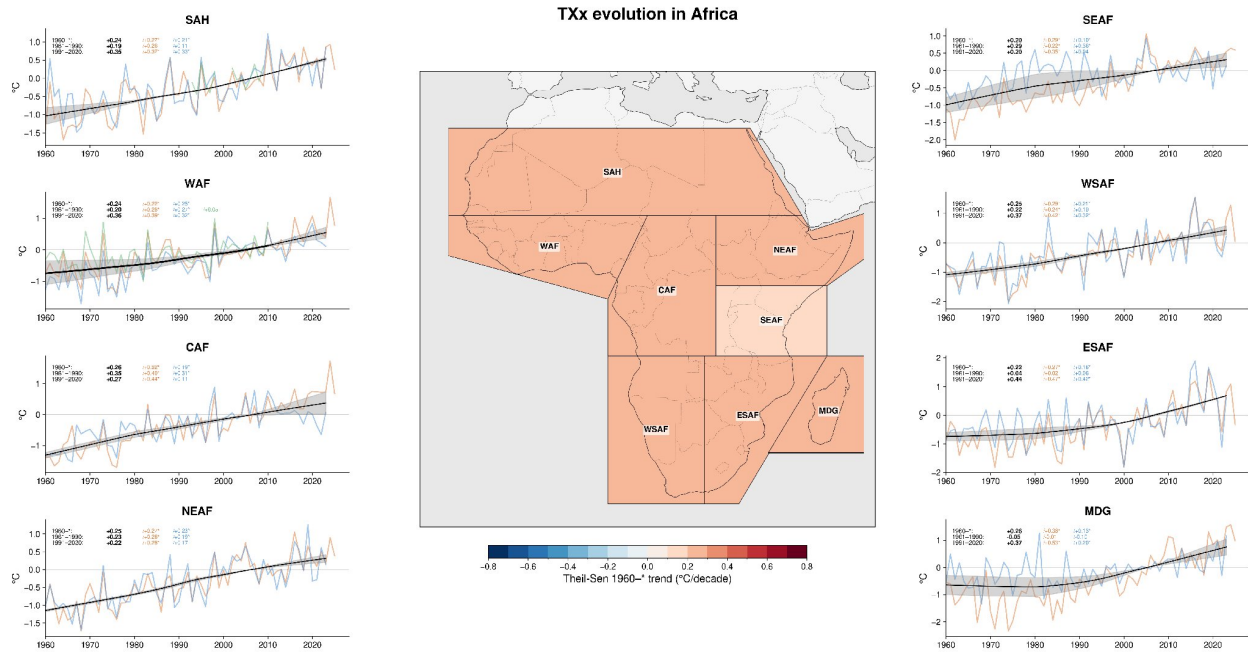


Fig. S12: As Fig. S11, but for Africa instead.

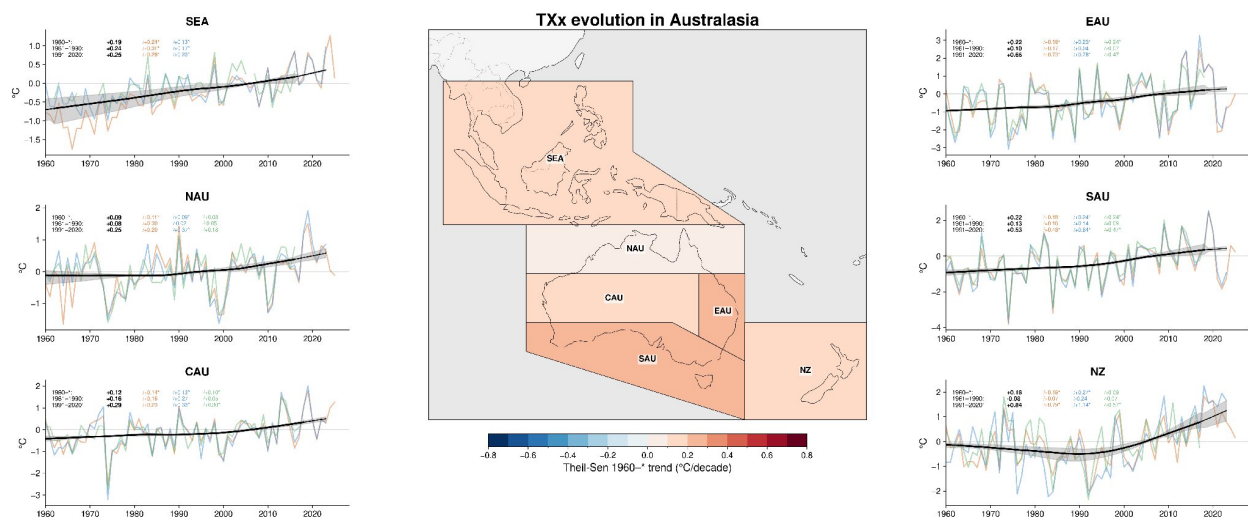


Fig. S13: As Fig. S11, but for Australasia instead.

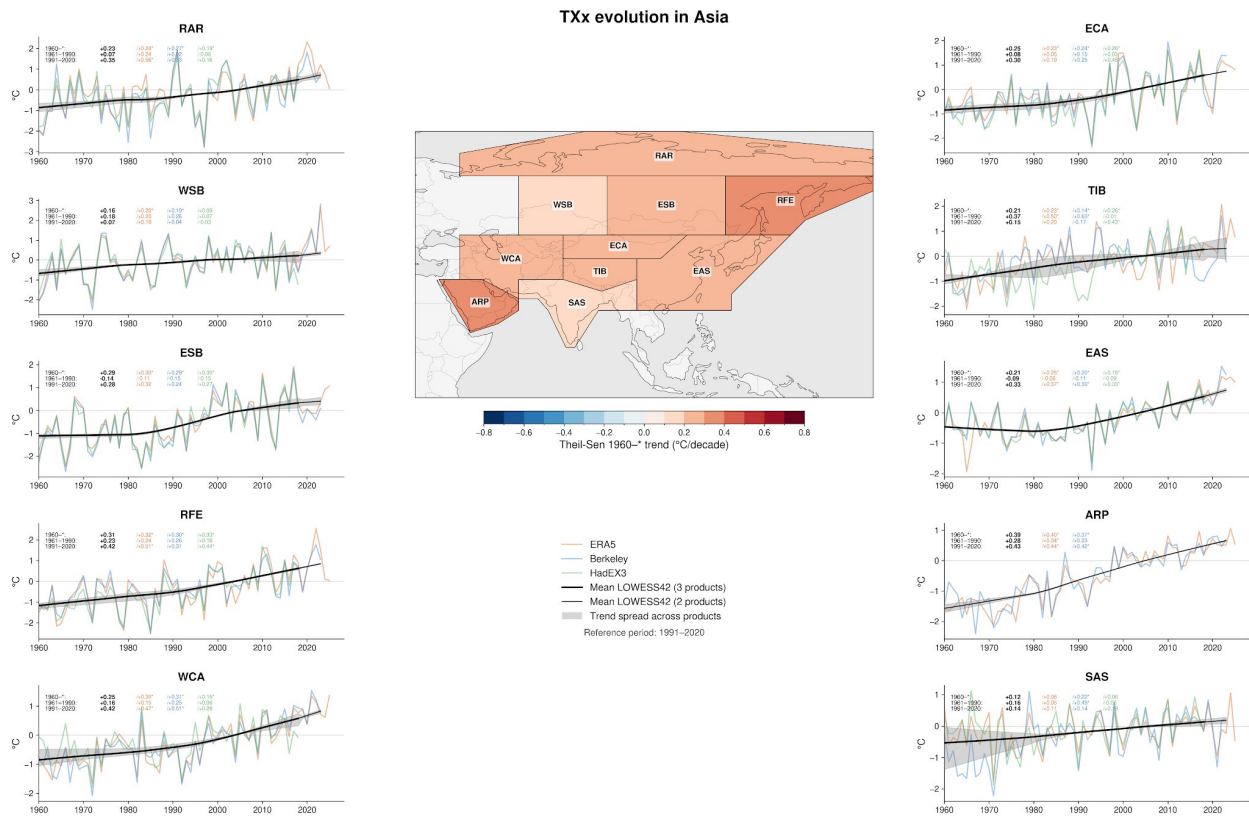


Fig. S14: As Fig. S11, but for Asia instead.

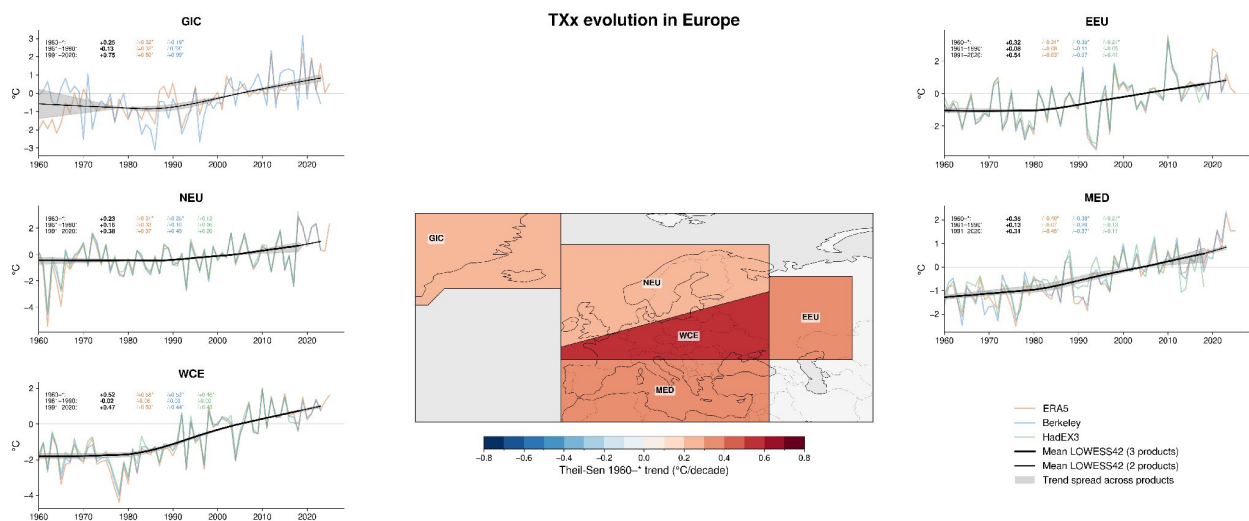


Fig. S15: As Fig. S11, but for Europe instead.

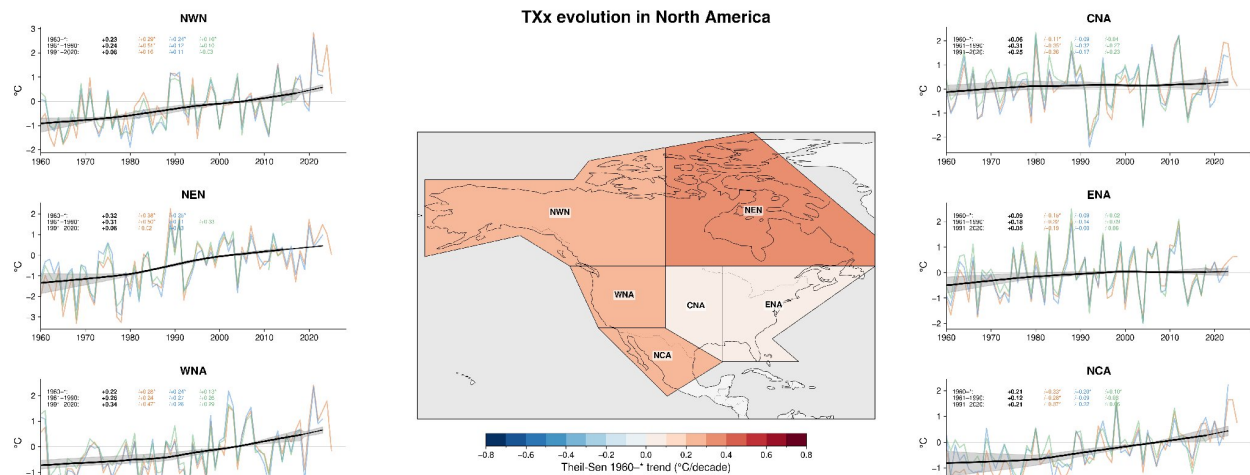


Fig. S16: As Fig. S11, but for North America instead. We note that CNA's relatively strong trends in both sub-periods are largely a window artifact: a late-1980s/early-1990s step-like shift sits at the 1990/1991 boundary, so the earlier period catches it at its end and the later one at its start. Other 30-yr windows unaffected by this shift, as well as the full period, stay weak and ambiguous, in line with AR6's classification of "low agreement in the type of change" for this region (Seneviratne et al., 2021).

TNx evolution

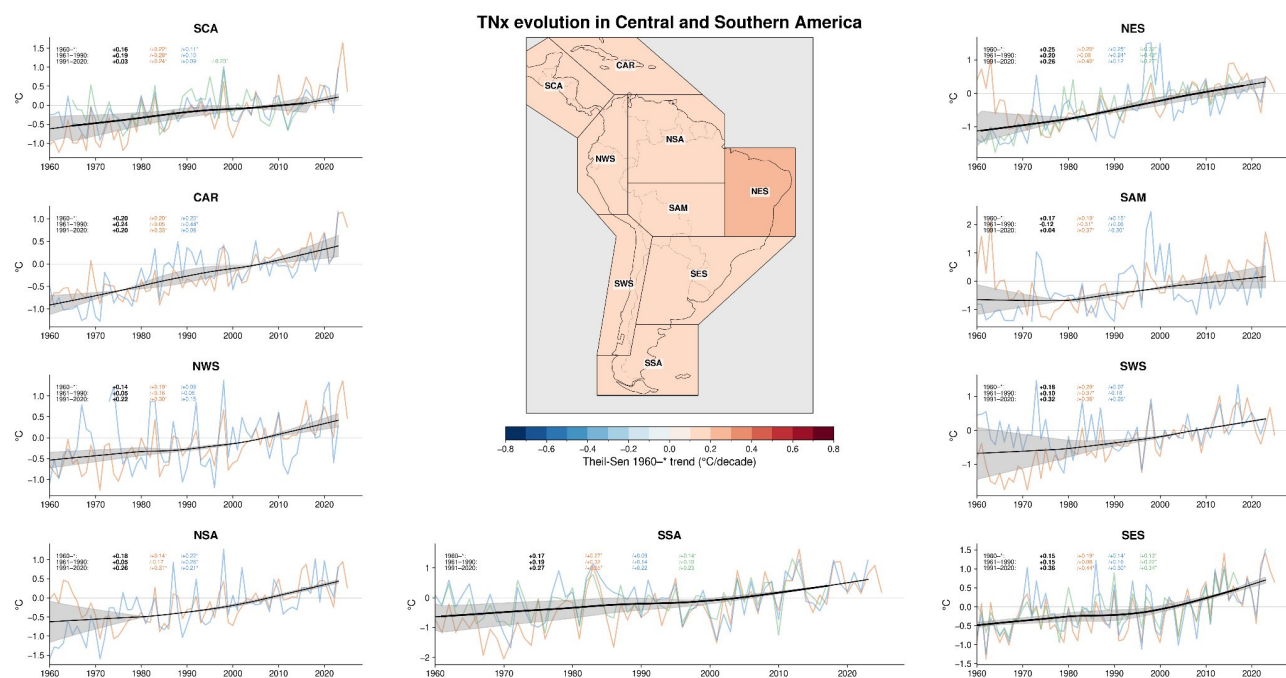


Fig. S17: Regional evolution of peak nighttime temperatures (TNx) for Central and South America; otherwise as Fig. S11.

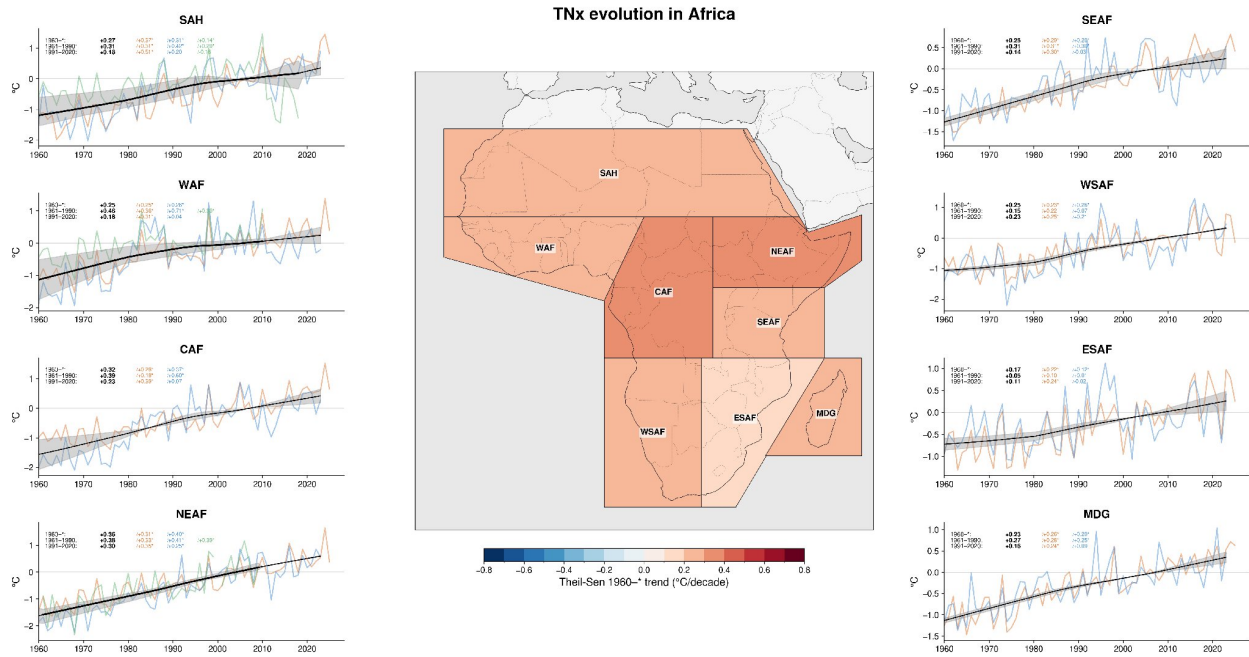


Fig. S18: As Fig. S17, but for Africa instead.

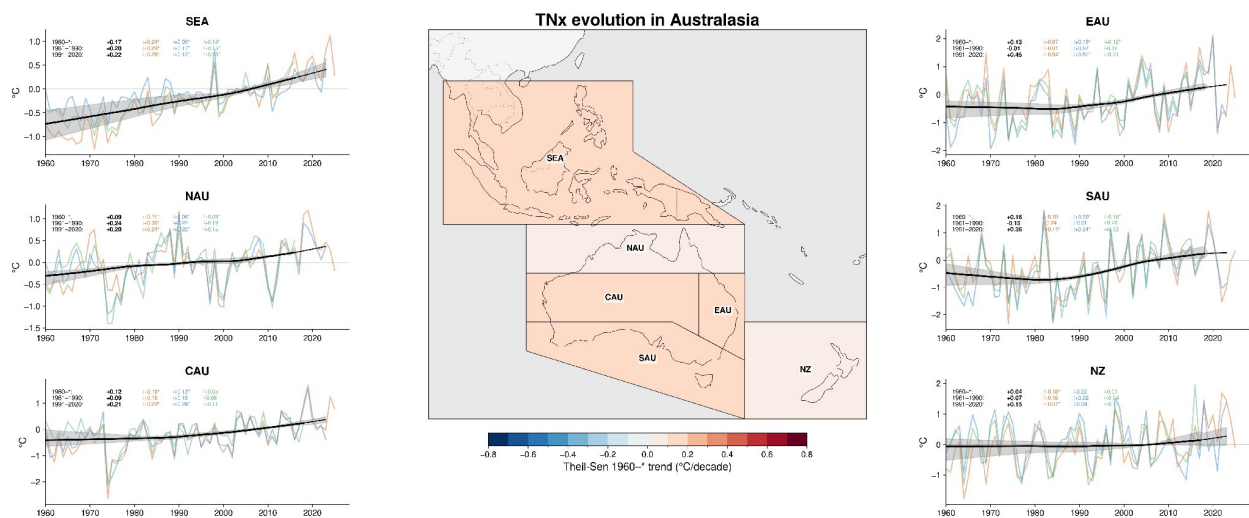


Fig. S19: As Fig. S17, but for Australasia instead.

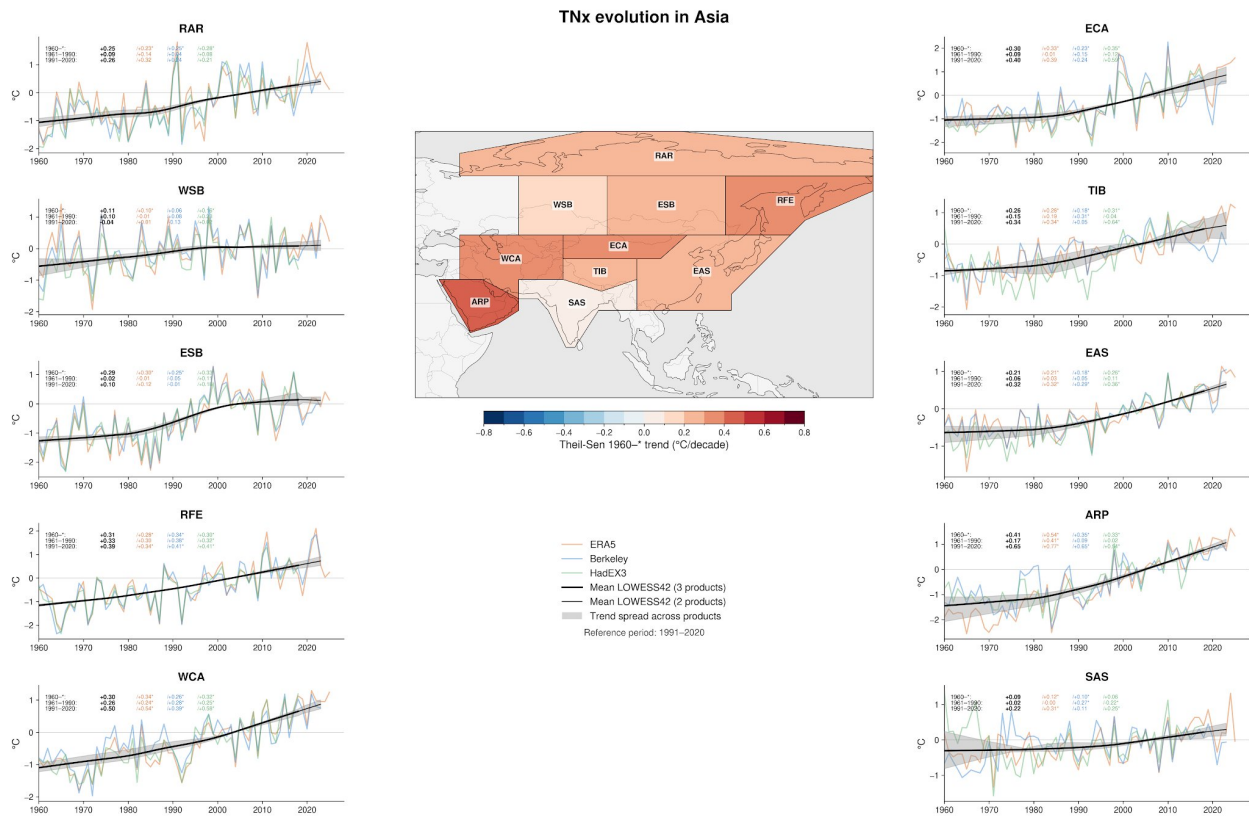


Fig. S20: As Fig. S17, but for Asia instead.

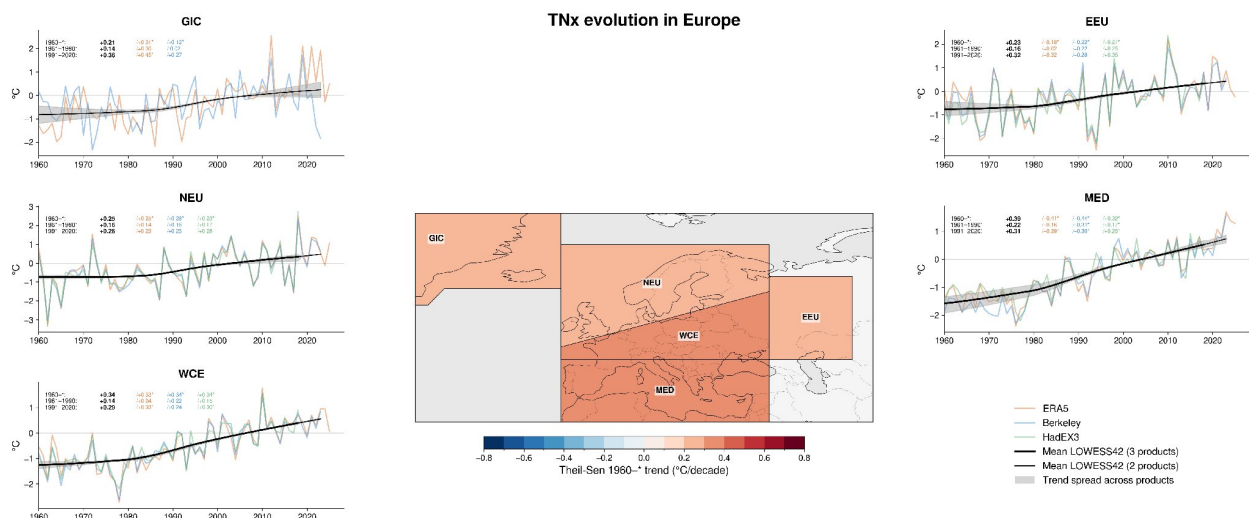


Fig. S21: As Fig. S17, but for Europe instead.

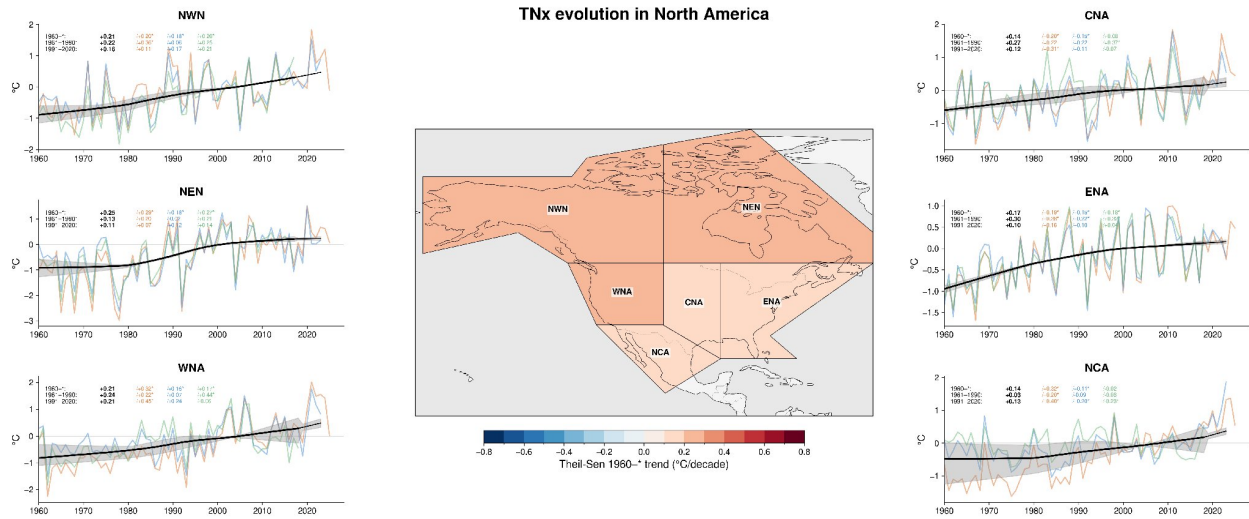


Fig. S22: As Fig. S17, but for North America instead.

Rx1day

Regional evolution of precipitation extremes by continent

We display the year-to-year evolution of Rx1day (**Figs. S23–S29**) across all AR6 land reference regions north of 60 °S, one figure per continent. Somewhat differently to the regional temperature extremes plots since there are many more precipitation datasets, maps are shown as the standardised inter-product spread, the darker colours indicating more divergence among products. Time series are also presented differently, that is, as the inter-product spread of relative change (for reanalyses and satellite-based products) among time series of the spatially-weighted average of the annual wettest day (Rx1day; in mm) over each IPCC sub-region. Only the in situ products (CPC and GPCC) are shown as individual lines with respective Sen's-slope trends for these two products indicated in the plot title in %/decade. We show data from 1991 onwards when precipitation data are much more reliable.

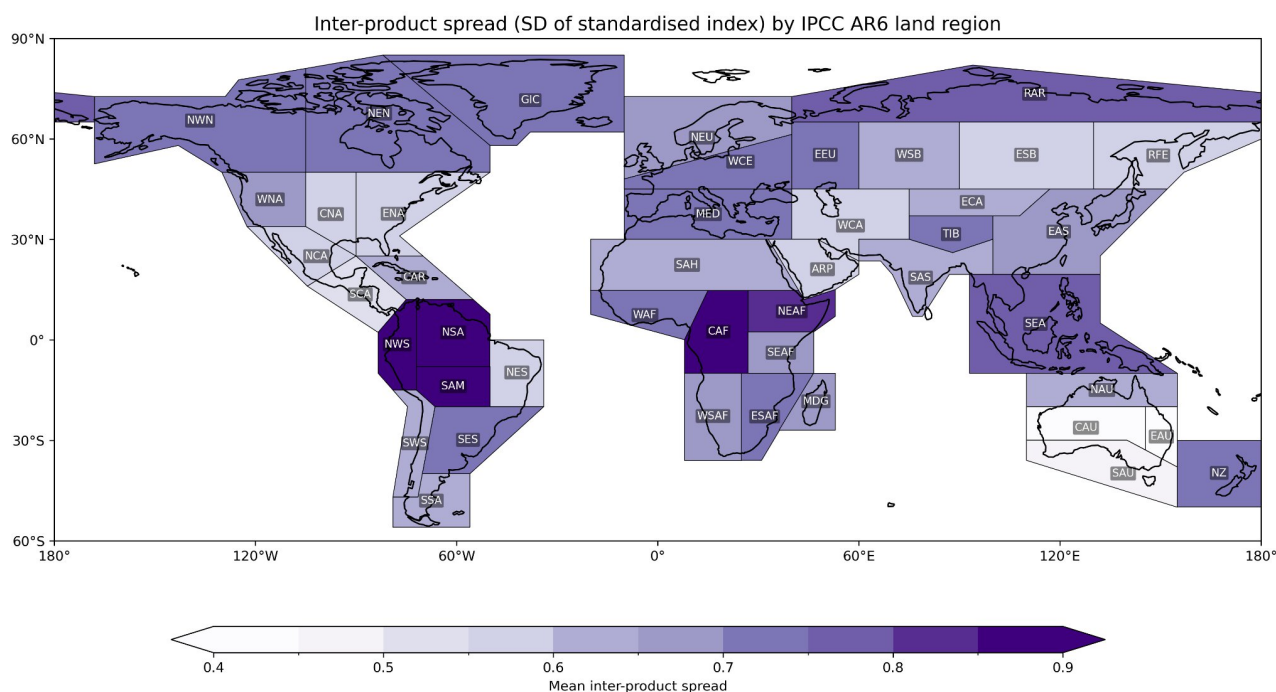


Fig. S23: Interproduct spread of Rx1day across datasets (**Table S1**) for each IPCC AR6 reference region. Rx1day is calculated as a standardised index over 2001–2020 and the standard deviation is calculated. Lighter colours indicate that products are in closer agreement compared to darker colours.

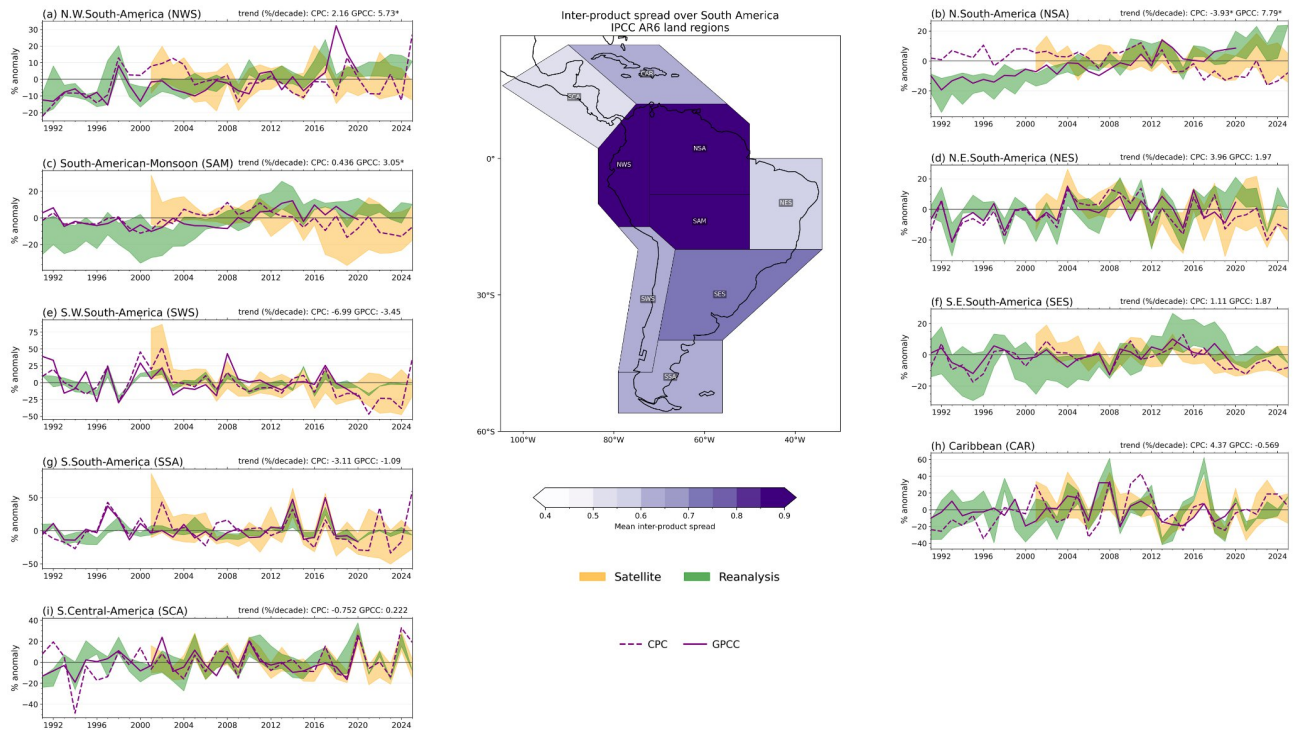


Fig. S24: Regional evolution of annual wettest day precipitation (Rx1day) for Central and South America. Timeseries are shown as relative percentages (compared to 2001-2020 mean) for AR6 region continental land areas using data products with sufficient data from the FROGS database (Roca et al., 2019; Table S1). Lines and shading are calculated as in Fig. 1c. Linear trends (in % per decade) using Sen's-slopes are shown for in situ products GPCC and CPC in the timeseries plot titles. A star indicates a significant trend at the 5% level using Mann-Kendall test. The central map shows the interproduct spread of Rx1day for the region as calculated in Fig. S23.

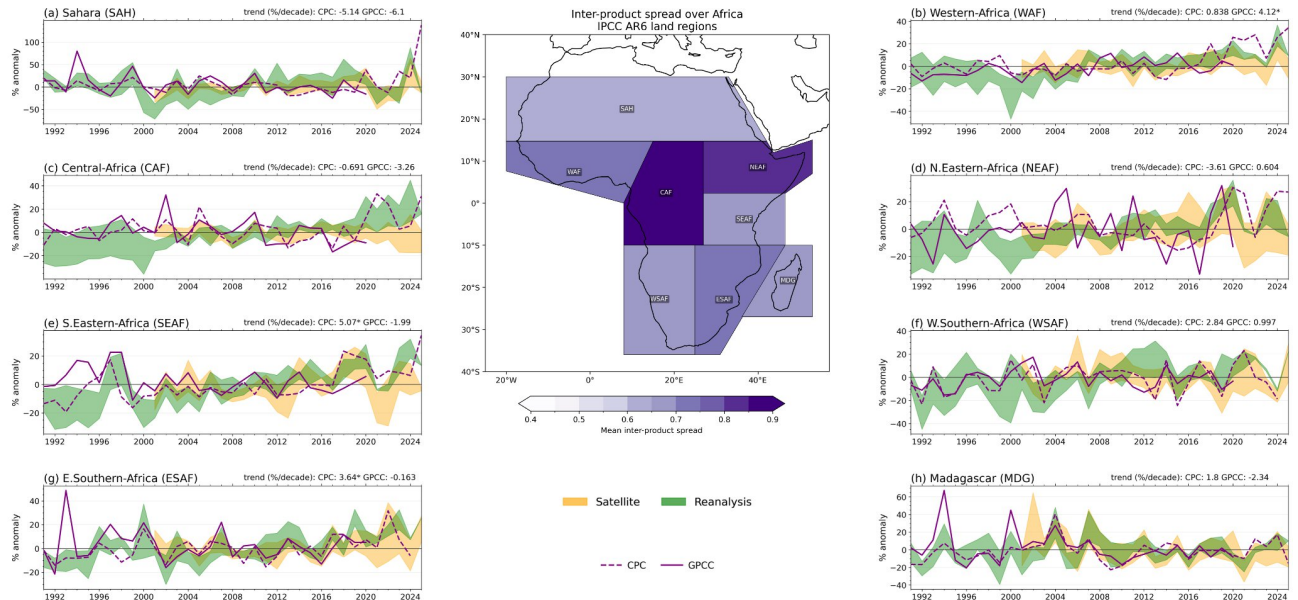


Fig. S25: As Fig. S24, but for Africa.

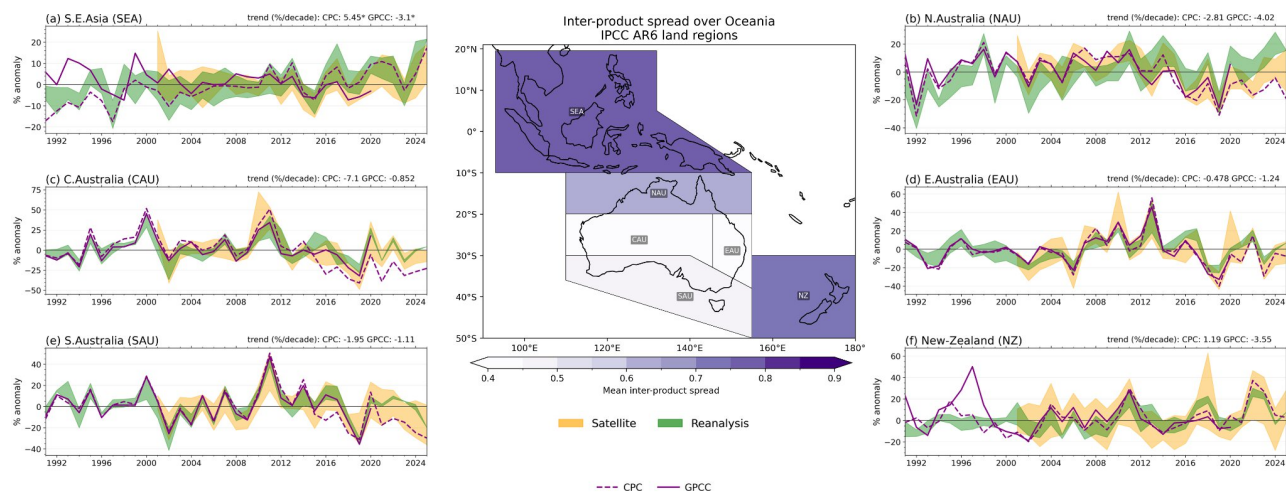


Fig. S26: As Fig. S24, but for South-east Asia and Australasia.

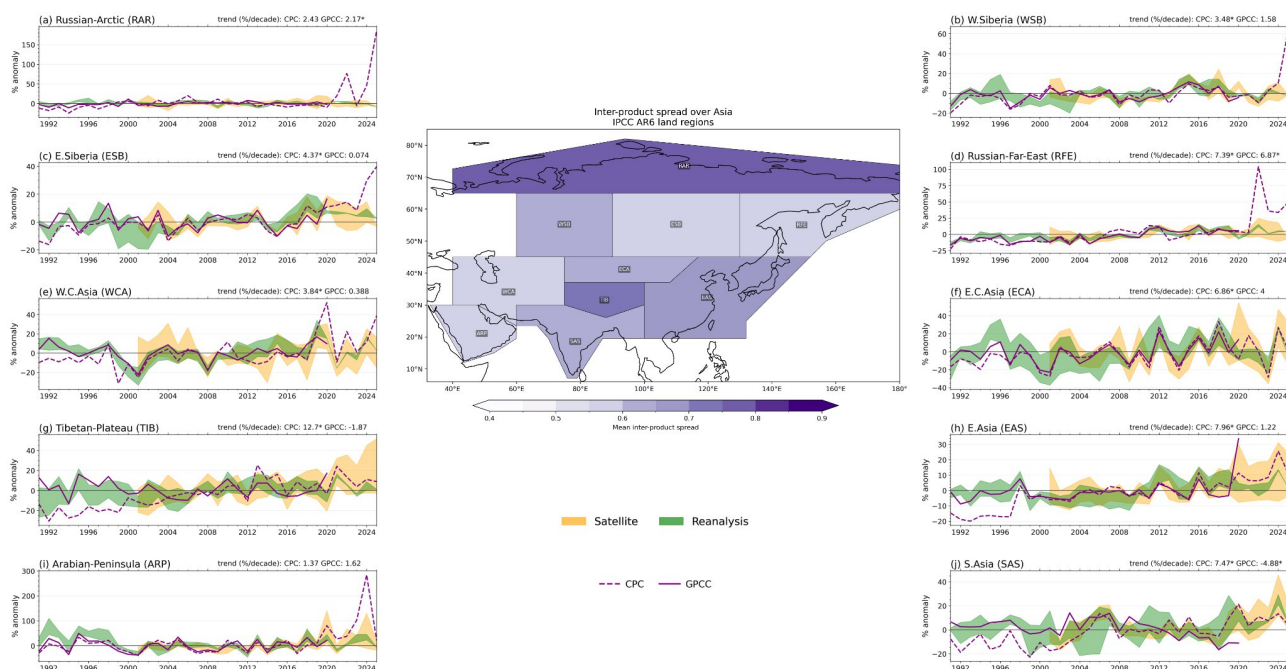


Fig. S27: As Fig. S24, but for Asia.

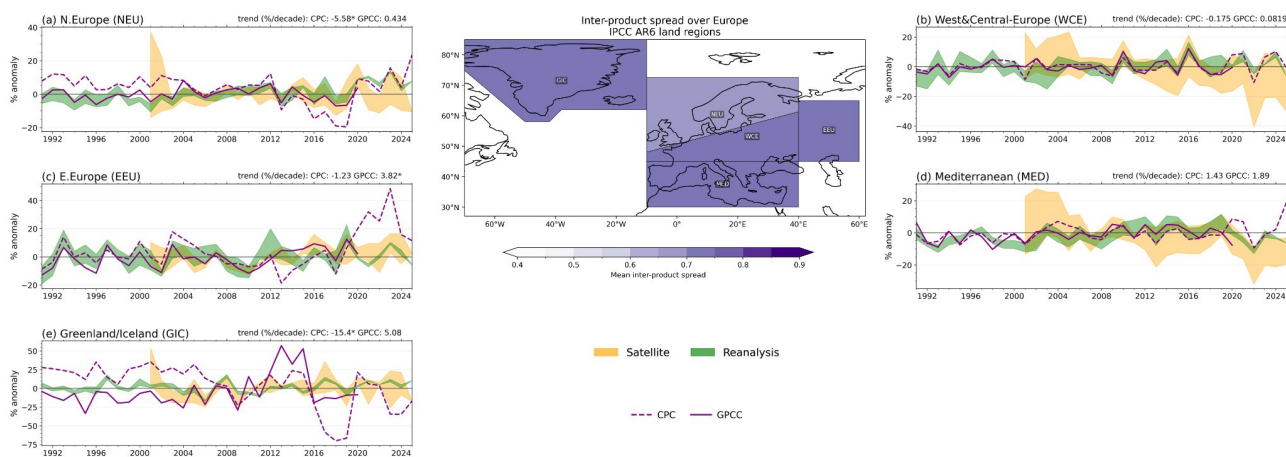


Fig. S28: As Fig. S24, but for Europe.

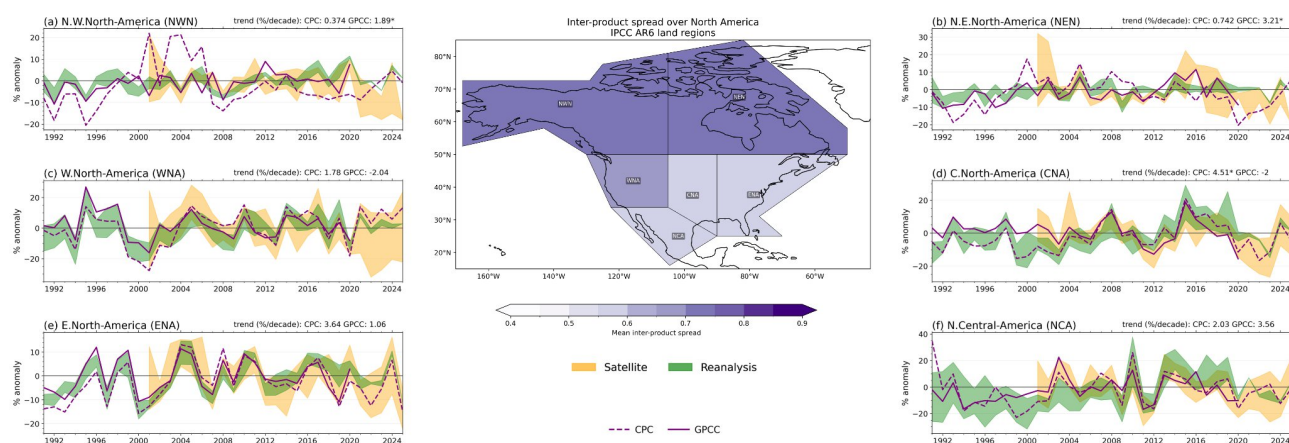


Fig. S29: As Fig. S24, but for North America.

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