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FAOSTAT ANALYTICAL BRIEF 84

Temperature change statistics 1961–2023

Global, regional and country trends

>> FAO Statistics Division

HIGHLIGHTS

- → **The 2023 global mean annual temperature change on land was 1.8 °C compared to the 1951–1980 baseline, the highest on record. The last nine years since 2015 were the nine warmest years on record.**
- → **The Paris Agreement limit of 1.5 °C was surpassed in all regions in 2023, except in Oceania (0.9 °C).**
- → **In 2023, monthly mean global temperatures on land were the highest on record from July to December.**
- → **Europe recorded the largest temperature increases (2.4 °C) among regions, with 2023 the seventh of the last nine years with warming above 2 °C. Asia experienced the second highest temperature change (1.8 °C); Oceania the lowest (0.9 °C).**
- → **Among subregions in 2023, warming was strongest in Western and Eastern Europe and in Central Asia (2.5 °C). The lowest warming was observed in Australia and New Zealand, Polynesia and Melanesia (0.9 °C).**
- → **In 2023, 121 countries and territories experienced mean annual warming greater than 1.5 °C, of which 68 with warming greater than 2.0 °C. The Svalbard Islands (Norway) recorded the largest warming (3.6 °C). The top 10 countries with the highest warming in 2023 were all in Europe, with temperature change well above 2.5 °C.**
- → **For the first time on record, the countries exposed to warming greater than 1.5 °C represented in 2023 more than half the world population (4 billion people), more than half the world's cropland area (nearly 900 million hectares) and 60 percent of the agricultural area (about 3 billion hectares). Europe was the region most at risk in terms of shares of its population (80 percent) and agricultural land (95 percent) located in countries with warming above 1.5 °C.**

TEMPERATURE CHANGE

INTRODUCTION

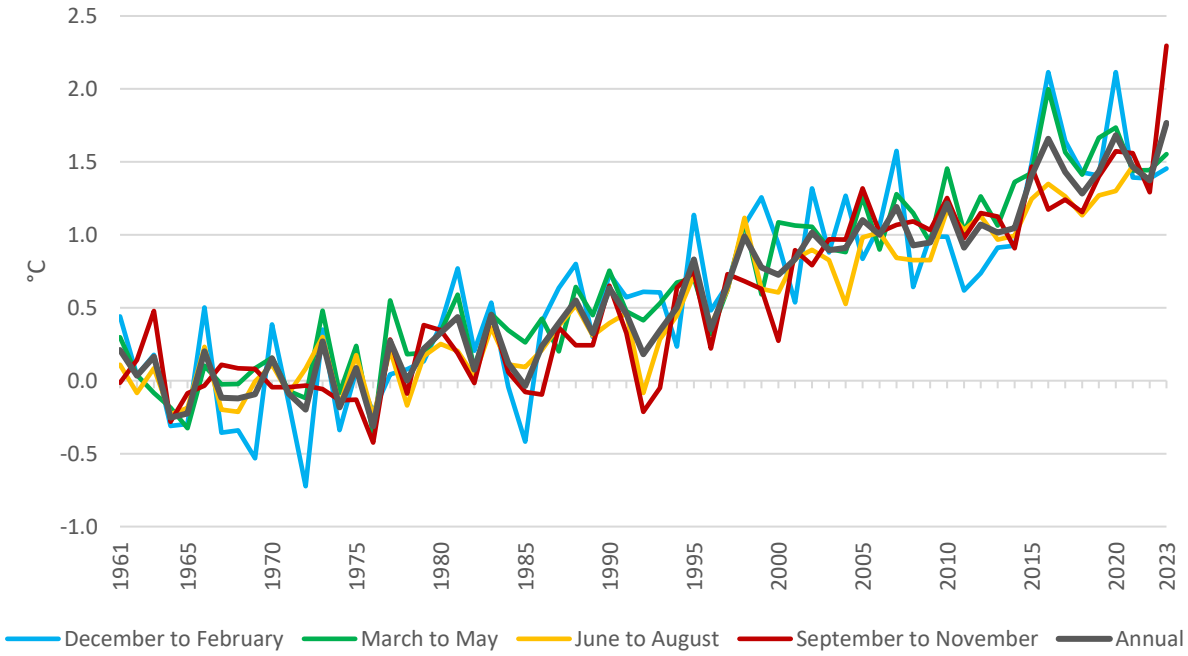
Anthropogenic greenhouse gas emissions cause global warming. Their abatement is at the core of the existing international policy commitments to reduce future projected and increasingly observed climate impacts on livelihoods throughout the world – and in particular to safeguard food production (IPCC, 2023). The Paris Agreement seeks to limit warming to below 2 °C and possibly to no more than 1.5 °C. The FAOSTAT Temperature change on land dataset allows to monitor the observed warming trends on

land at the country, regional and global level, with annual, seasonal and monthly means, to help gauge expected risks to food and agriculture. The data are disseminated for the period 1961–2023 for 198 countries and 39 territories. They are produced in collaboration with the NASA Goddard Institute for Space Studies (NASA–GISS). Temperature changes are computed with respect to a reference climatology corresponding to the period 1951–1980 (see Explanatory Notes).

GLOBAL

In 2023, the global mean annual land temperature anomaly was the highest on record, 1.8 °C above the climate normal of the period 1951–1980. This confirms both the observed warming trends since 1961 and their recent acceleration that saw the last nine years be the nine warmest on record since 1880, the beginning of direct measurements. Figure 1 illustrates trends in the world mean annual and seasonal temperature change on land. It shows the near linear warming trends observed since the mid-1980s, with the last decade having reached a ‘’new normal’’ around +1.5 °C, representing the Paris Agreement threshold that humanity should not cross to avoid catastrophic climate change. The figure also shows how seasonal temperature change has even already surpassed +2.0 °C in different seasons over the last decade.

Figure 1: Mean annual and seasonal temperature change on land



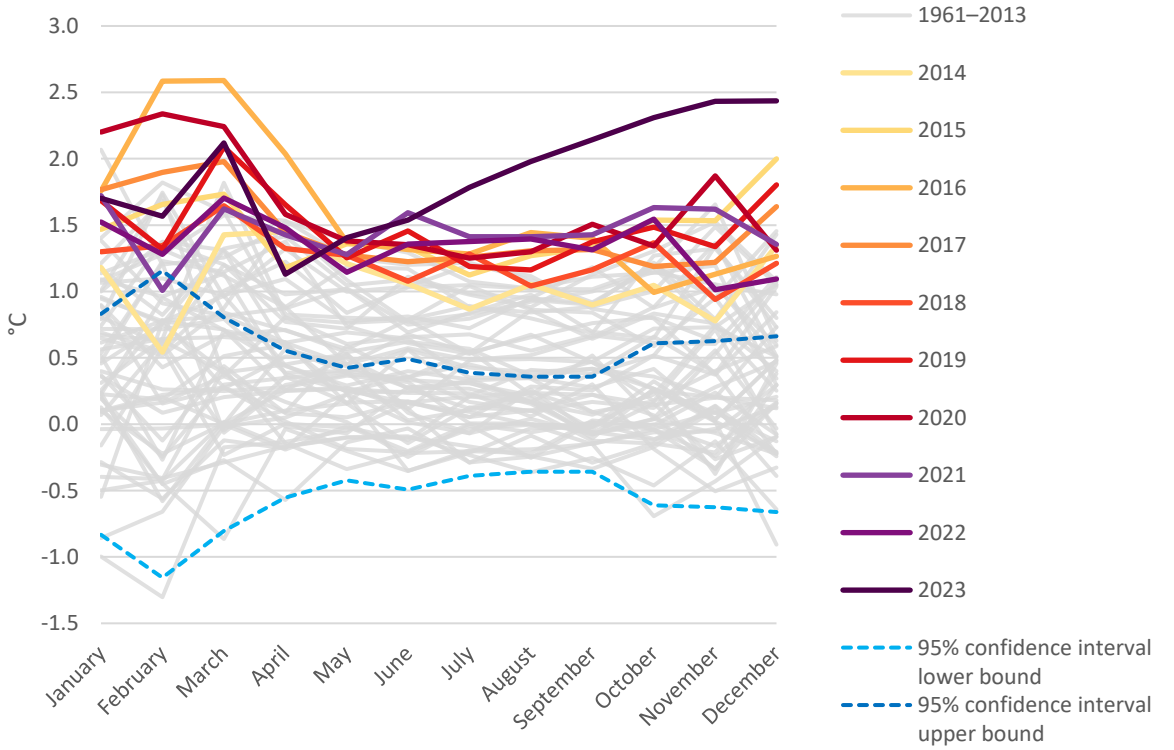
Note: The concepts of winter, spring, summer and autumn represent seasons that occur during opposite months in the two hemispheres. For instance, December, January and February correspond to winter in the northern hemisphere and summer in the southern hemisphere.

Source: FAO. 2024. Temperature change on land. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/ET

Figure 2 illustrates the extent to which 2023 was one more exceptional year, and how each month from June to December of that year was the warmest on record by a wide margin. In fact, each month of each year in the last decade was much warmer than the corresponding 1951–1980 baseline, with the levels

of observed temperature change well above the 95 percent confidence interval upper limit of that reference climatology for all months but two. The figure represents the concept of the “loaded dice”, first put forward by NASA climatologist Jim Hansen in the 1990s (Hansen, 2012). The visible effects of climate change can be seen as cumulatively increasing the probability that future years – and months in the year – break records compared to unperturbed climate.

Figure 2: Mean monthly world temperature change on land by year

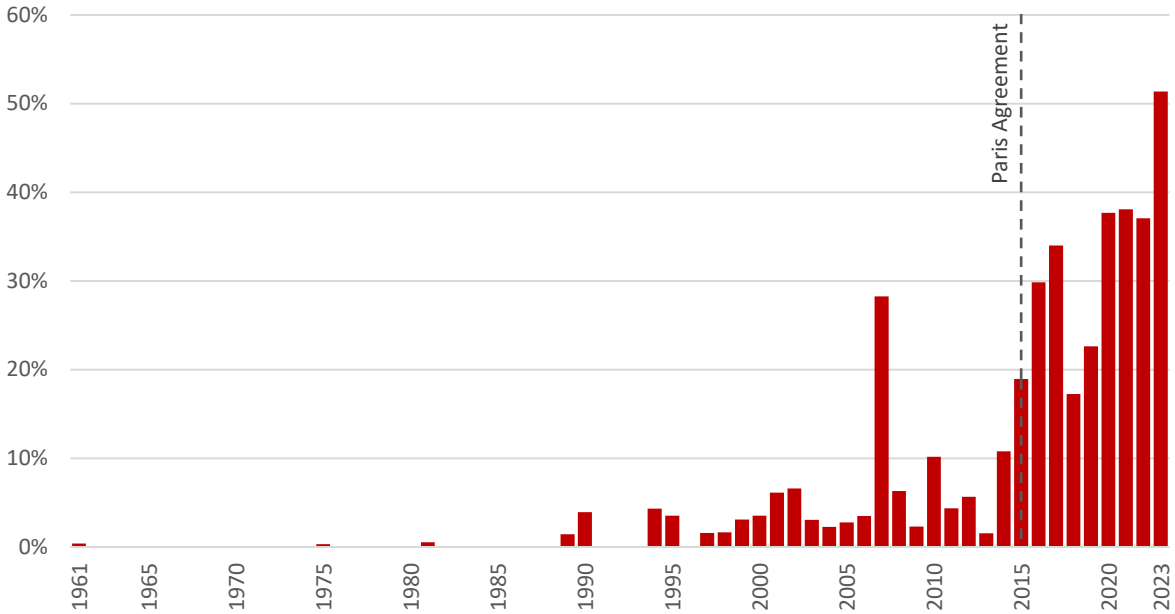


Source: FAO. 2024. Temperature change on land. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/ET

Temperature change data in each country and territory were analysed as normal, warm or cold anomalies based on their distance from the 1951–1980 mean (i.e. within or outside the 95 percent confidence interval). In 2023, mean annual temperatures were warmer than normal in 193 countries and territories and much warmer (99 percent confidence interval) than normal in 135 of them.

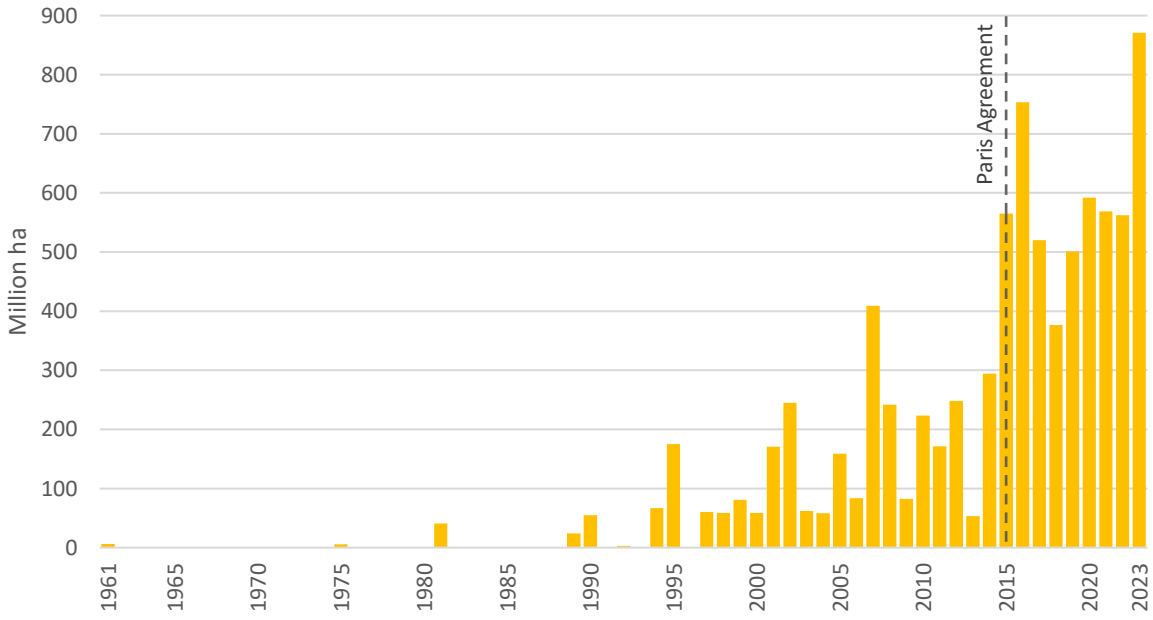
In 2023, the observed annual warming was greater than 1.5 °C in 121 out of 237 countries and territories, representing, for the first time, over 50 percent of the world population (4.1 billion people) (Figure 3). Of these, about two-thirds lived in urban areas and one-third in rural areas, each environment posing specific challenges under such warming. Furthermore, the countries with warming above 1.5 °C had 60 percent of the world’s agricultural area (2.8 billion hectares) and over half of its cropland area (870 million hectares) (Figure 4). Both the population and area in countries with more than 1.5 °C warming were 10 times larger in 2023 than in 2003, underscoring the much larger potential impact risks resulting from climate change.

Figure 3: Share of population of countries with warming above 1.5 °C in world population



Source: Based on FAO. 2024. Temperature change on land. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/ET and FAO. 2022. Annual population. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/OA

Figure 4: Total cropland area of countries with warming above 1.5 °C



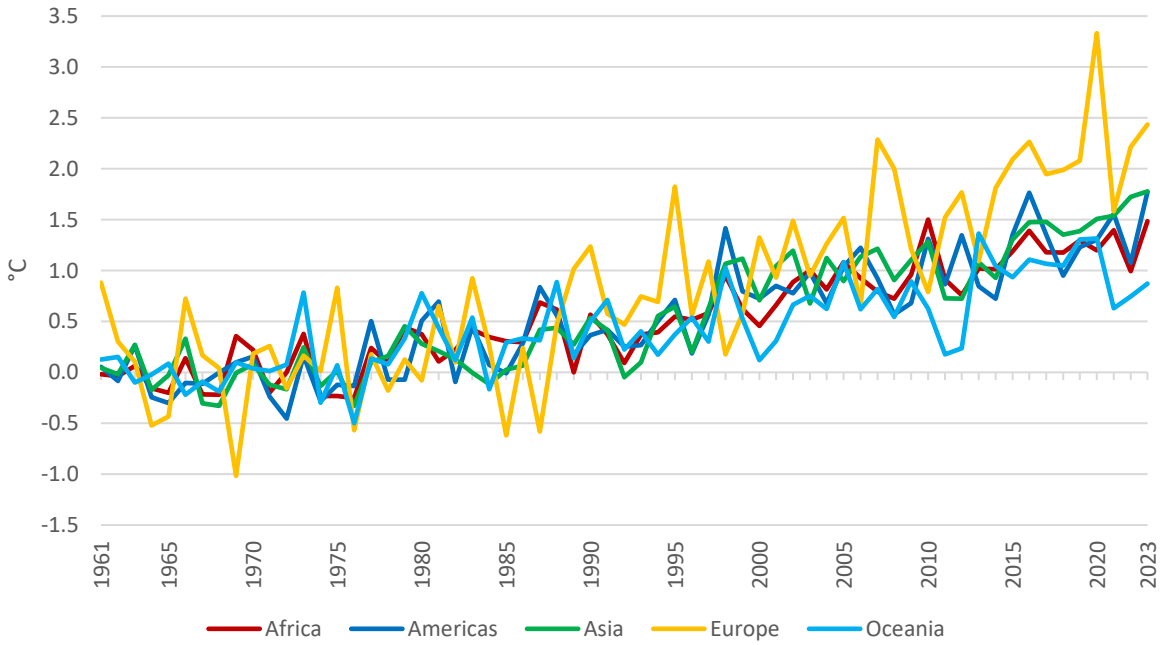
Source: Based on FAO. 2024. Temperature change on land. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/ET and FAO. 2023. Land Use. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/RL

REGIONAL

Europe recorded the largest temperature increase (2.4 °C) among regions, with 2023 the seventh of the last nine years with warming above 2.0 °C (Figure 5). Western and Eastern Europe were the subregions with the largest temperature change (2.5 °C). Europe (and Eastern Europe) was the only world region that experienced recent temperature change over 3.0 °C (in 2020). Asia experienced the second largest warming among regions (1.8 °C), with Central Asia exhibiting warming in 2023 at the level of Europe (2.4 °C). The Americas (1.8 °C) and Africa (1.5 °C) had substantial warming in 2023, at or above the Paris threshold, while Oceania had a less pronounced, but nonetheless substantial, warming of 0.9 °C.

All observed regional temperature changes in 2023 were statistically significant at the 95 percent confidence level.

Figure 5: Mean annual temperature change on land by region

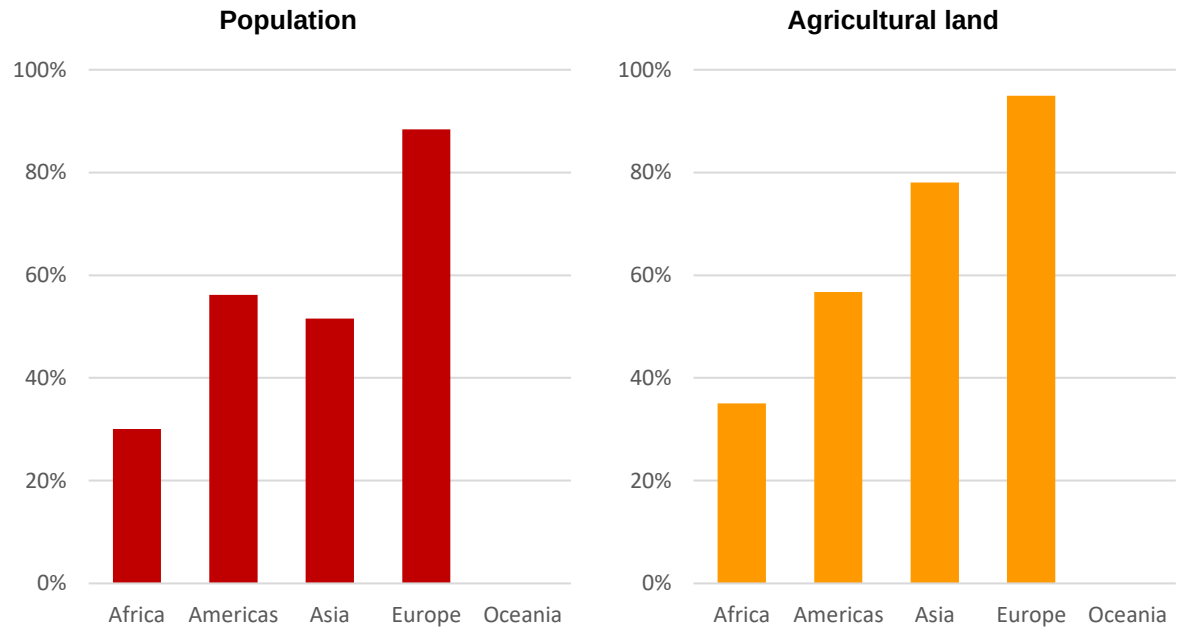


Source: FAO. 2024. Temperature change on land. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/ET

In 2023, the population living in countries with warming above 1.5 °C was 2.4 billion in Asia, 660 million in Europe, 600 million in the Americas, 440 million in Africa and less than 20 000 in Oceania. In terms of risk, Europe was most exposed, with almost 90 percent of its population living in countries with temperature change above 1.5 °C, followed by the Americas (56 percent), Asia (52 percent), Africa (30 percent) and Oceania (1 percent) (Figure 6).

Agricultural land area in countries experiencing warming above 1.5 °C was the largest in Asia (1 300 million hectares), followed by the Americas (638 million hectares), Europe (437 million hectares), Africa (407 million hectares) and Oceania (less than 5 million hectares). When expressed in relative shares, Europe was again the most exposed region, with nearly 95 percent of its agricultural land area in countries with warming above 1.5 °C, followed by Asia (78 percent), the Americas (57 percent), Africa (35 percent) and Oceania (less than 1 percent) (Figure 6).

Figure 6: Regional share of countries with warming above 1.5 °C (2023)



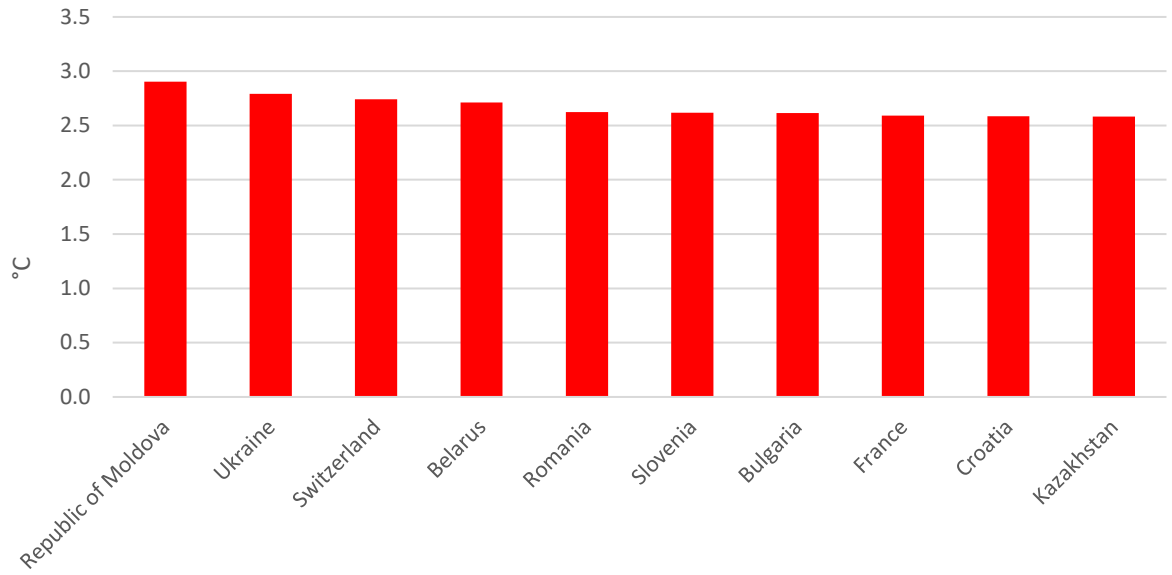
Source: Based on FAO. 2024. Temperature change on land. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/ET, FAO. 2022. Annual population. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/OA and FAO. 2023. Land Use. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/RL

COUNTRY

In 2023, the Svalbard Islands (Norway) experienced again, as in 2022, the largest warming (3.6 °C) among all countries and territories. The ten countries with the most pronounced warming were all in Eastern and Western Europe, with warming ranging 2.6–2.9 °C (Figure 7). The Republic of Moldova led the ranking with 2.9 °C. It was closely followed by Ukraine (2.8 °C), Switzerland and Belarus (2.7 °C), Romania, Slovenia and Bulgaria (2.6 °C), and France, Croatia and Kazakhstan (slightly below 2.6 °C). Most of these countries have large agricultural land areas and animal populations that are potentially at risk from heat stress under the observed temperature changes. In particular, the share of agricultural land in the total land area of Kazakhstan (79 percent), Ukraine (71 percent), the Republic of Moldova (69 percent), Romania (57 percent), France (52 percent) and Bulgaria (46 percent) is much higher than the world average of 37 percent.

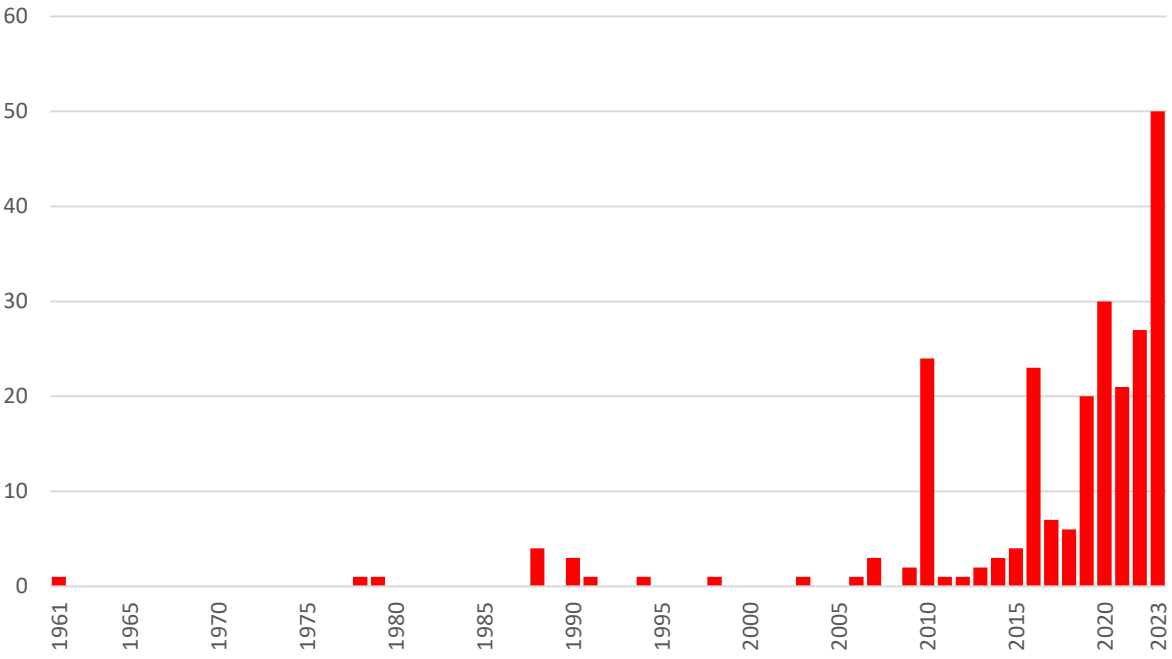
In 2023, 121 countries and territories – more than half of the total – saw mean annual warming above 1.5 °C, of which 68 had warming above 2.0 °C. National mean annual temperature records were broken in 50 countries or territories, the most since 1961 and nearly twice the number of records broken in previous recent years (Figure 8).

Figure 7: Countries with largest mean annual temperature change over land (2023)



Source: FAO. 2024. Temperature change on land. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/ET

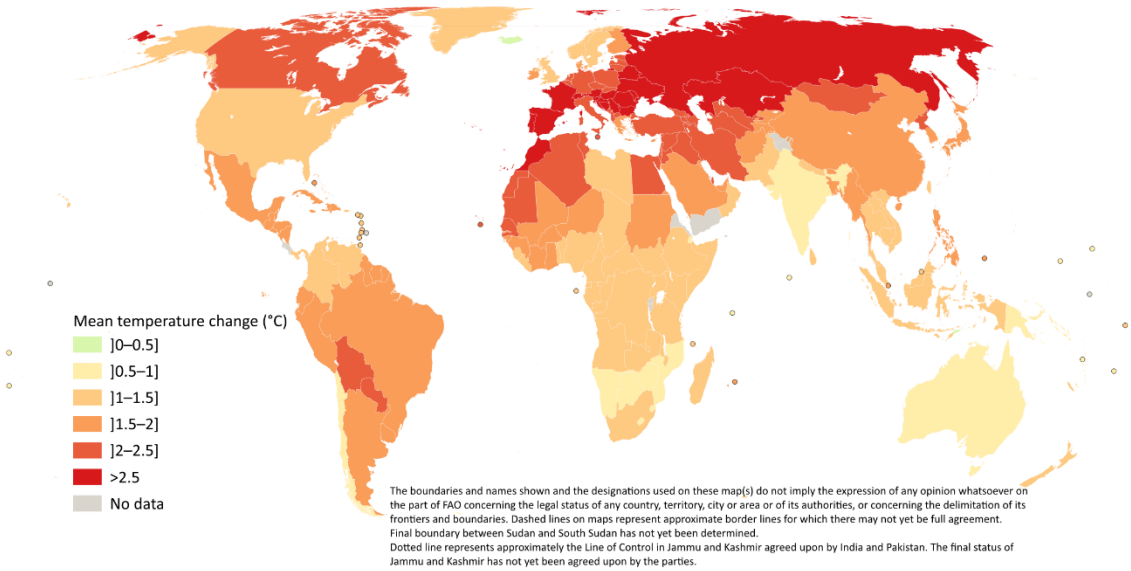
Figure 8: Number of countries and territories with temperature records broken in a single year



Source: FAO. 2024. Temperature change on land. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/ET

The data show that the regional distribution of countries experiencing warming above 1.5 °C expanded significantly in 2023 to cover all latitudes. In previous years, warming had affected mostly countries at medium to high latitudes, especially in the northern hemisphere.

Figure 9: Global map of observed mean annual temperature change, 2023



Source: FAO. 2024. Temperature change on land. In: *FAOSTAT*. Rome. [Cited March 2024]. http://www.fao.org/faostat/en/#data/ET based on UN Geospatial. 2020. Map geodata [shapefiles]. New York, USA, UN.

EXPLANATORY NOTES

The FAOSTAT Temperature change on land domain disseminates statistics of temperature change measured over land by country, with annual updates. The current database covers the period 1961–2023. Statistics are available for 198 countries and 39 territories in 2023. They are available for monthly, annual and seasonal (winter, spring, summer and autumn) temperature anomalies, i.e. temperature change with respect to a reference climatology corresponding to the period 1951–1980. Data are also available for regional aggregates and special groups, including those relevant to the United Nations Framework Convention on Climate Change.

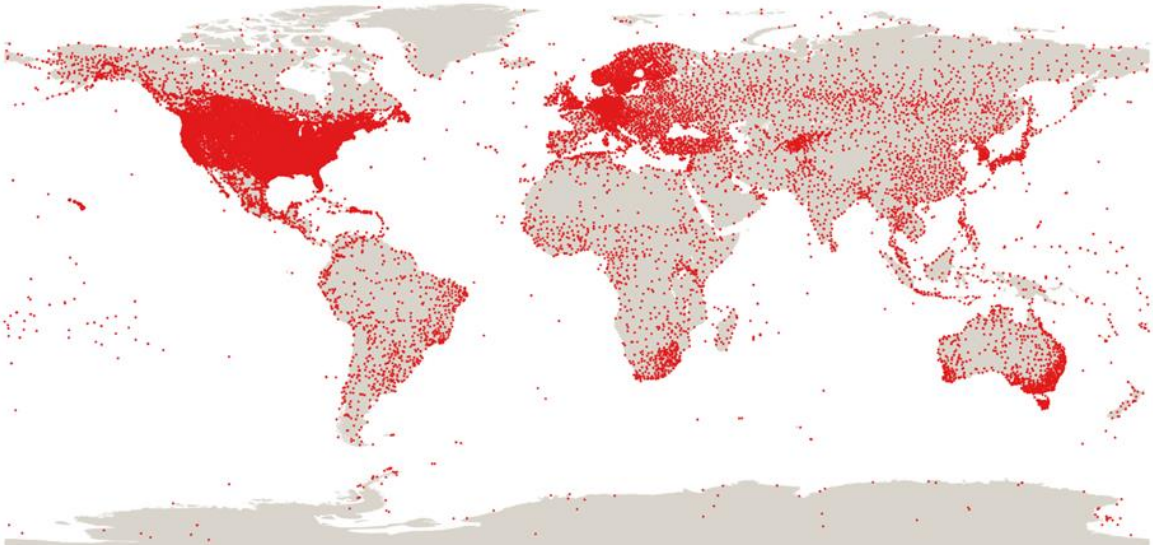
For each country or territory, and for each temperature variable considered, the mean and standard deviation σ of the 1951–1980 climatology was computed and disseminated in the dataset – except in cases with less than 20 available records in the time series. The standard deviation of the climatological mean annual, seasonal and monthly temperatures represents the natural interannual variability of that variable, by country. Warmer (or colder) temperature changes were defined as deviations exceeding 2 σ, hence outside the 95 percent confidence interval (CI). Similarly, much warmer (or much colder) temperature anomalies were those exceeding 3 σ, or outside the 99.7 percent CI. Conversely, temperature deviations within 2 σ from the climatological mean were taken to represent the interannual variability of the reference climatology, specifically ± 0.4 °C for the world; ± 0.5 °C for Africa, Asia and the Americas; and ± 0.9 °C for Europe (95 percent CI).

The FAOSTAT data are based on the publicly available GISTEMP data, the Global Surface Temperature Change data distributed by the National Aeronautics and Space Administration Goddard Institute for Space Studies (NASA–GISS), with information from 1880 onwards. The original GISTEMP analysis generates a set of gridded values (resolution 500 km) from the Global Historical Climatology Network (GHCN v4), composed of continuously updated temperature data from over 26 000 meteorological stations on land around the globe (Figure 10). A finer grid (resolution 250 km) was prepared by NASA-GISS for the purpose of the FAOSTAT dataset, excluding ocean data, and subsequently aggregated at the country level using the FAO Global Administrative Unit Layers (GAUL). The FAOSTAT methodology includes reconstructing the time series to account for the administrative changes that occurred since 1961 (e.g. the split of the Soviet Union in 1991 or the separation of the former Sudan in 2011). Finally, country statistics were area-weighted to compute regional aggregates, using country area data from the FAOSTAT Land Use dataset as weights.

According to NASA, compared to statistics of absolute temperature value, a dataset based on temperature anomalies is more stable and coherent in the face of variations in coverage in space and time of the meteorological stations that underlie the information. The uncertainties of the gridded data, and thus the uncertainty of the FAOSTAT country statistics, which are also disseminated in the dataset, depend on the spatial and temporal coverage of the GHCN stations (Menne *et al.*, 2018; Lenssen *et al.*, 2019). Furthermore, NASA-GISS recomputes the entire time series of temperature change data every year at each grid point based on the most recent set of available stations to increase the temporal comparability of the data. Measurement uncertainty is around 5–10 percent for global and regional aggregates (typically 0.1–0.2 °C), while it can be significantly higher for country values, depending on the density of the underlying network of meteorological stations. For instance, countries in regions with denser station networks, such as Northern America, Europe and Australia have smaller measurement uncertainties whereas data from countries with less dense and reliable networks, such as parts of South America, Africa and the Near East, have greater uncertainty.

A methodological note of the temperature change domain is available in FAOSTAT.

Figure 10: NASA Global historical climatology network (GHCN v4)



Source: National Centers for Environmental Information. 2023. NASA Global Historical Climatology Network (GHCN v4). In: *National Oceanic and Atmospheric Administration*. Washington, DC. [Cited March 2024]. https://www.ncei.noaa.gov/pub/data/ghcn/v4/

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