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FAOSTAT ANALYTICAL BRIEF 39

Temperature change statistics 1961–2021

Global, regional and country trends

>> FAO Statistics Division

HIGHLIGHTS

- → **The FAOSTAT Temperature change dataset, produced in collaboration with NASA, covers the period 1961–2021 for 197 countries and 41 territories.**
- → **The 2021 global mean annual temperature change over land was 1.4 °C, joining 2019 as the third warmest year on record since 1961. This value represented statistically significant warming compared to the reference climatology of the period 1951–1980.**
- → **The last ten years (2012–2021) were on average 1.3 °C warmer than 1951–1980; this represented a warming of 0.3 °C over the previous decade (2002–2011), and a 0.7 °C warming compared to 1992–2001.**
- → **Northern America registered the largest mean annual temperature change (1.9 °C), followed by Europe (1.6 °C), Asia (1.5 °C) and Africa (1.4 °C). Warming in South America and Oceania was 1.0 °C and 0.6 °C, respectively.**
- → **In 2021, mean annual temperatures were warmer than normal in more than 170 countries and territories. Of these, temperatures in 125 countries and territories were much warmer than normal.**

FAOSTAT TEMPERATURE CHANGE

INTRODUCTION

Increases in land surface air temperature associated with rising greenhouse gas concentrations threaten the livelihoods of farmers and communities throughout the world. The FAOSTAT Temperature Change statistics provide country-level information on observed warming trends on land, as a basis to help identify risk and design the responses necessary to safeguard the agriculture, forestry and fisheries sectors.

The FAOSTAT Temperature Change statistics are disseminated for the period 1961–2021 for 197 countries and 41 territories. They are produced in collaboration with the NASA Goddard Institute for Space Studies (NASA–GISS) and are based on regularly updated time series of temperature readings from a vast array of meteorological stations around the world forming a well-established international network. Temperature change data in FAOSTAT are disseminated as monthly, annual and seasonal (winter, spring, summer and autumn) means. The data provide information on mean temperature changes, characterizing them as (statistically significant) ''warmer,'' ''much warmer'' or ''colder'' anomalies with respect to the climatology of the period 1961–1980, taken to represent the climatic normal.

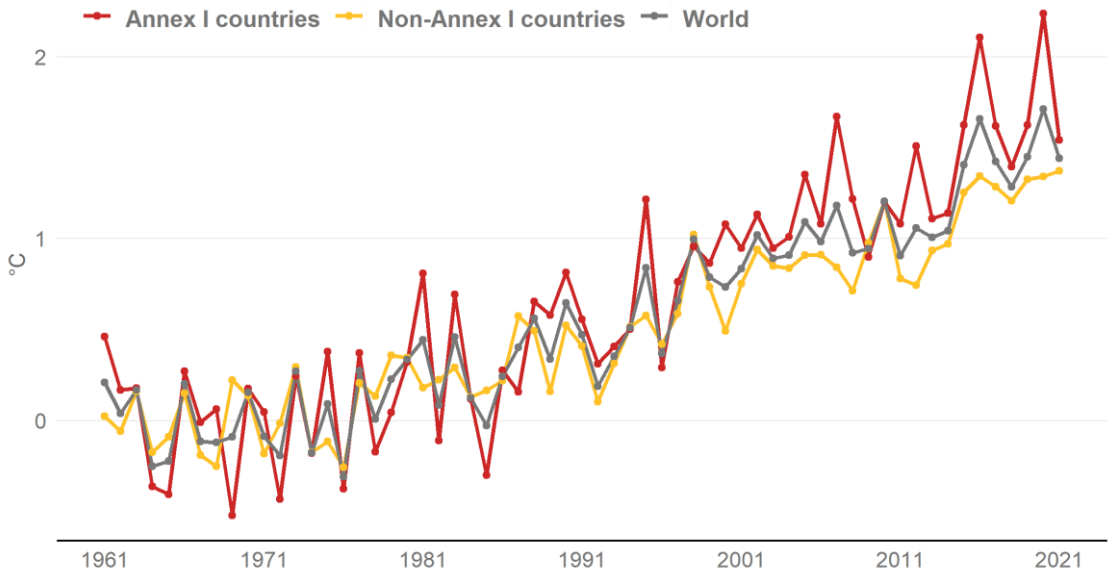
More specifically, warmer (or colder) temperatures are defined as anomalies exceeding the 95 percent confidence interval (CI) of the reference climatology, while much warmer (or much colder) temperatures

are anomalies exceeding the 99 percent CI. Conversely, normal temperatures correspond to anomalies within the 95 percent CI, representing the range of expected interannual variability. For instance, the interannual variability of the mean global annual temperature change on land, which is also disseminated in the database for each country and territory alongside mean values, was computed from all available data to be ± 0.4 ºC.

GLOBAL

In 2021, the global mean annual temperature anomaly was 1.4 ºC. 2021 tied with 2019 as the third warmest year over the period 1961–2021 (Figure 1), following 2016 (1.6 ºC) in second position and 2020 (1.7 ºC) as the warmest year on record. Furthermore, the last ten years (2012–2021) were on average 1.3 ºC warmer than 1951–1980; this represented a warming of 0.3 ºC over the previous decade (2002–2011), and a 0.7 ºC warming compared to 1992–2001. Figure 1 illustrates trends in temperature change globally as well as for the Annex I and Non-Annex I groups of parties[1] reporting to the United Nations Framework Convention on Climate Change (UNFCCC) due to the relevance of this indicator of climate change. The two groups differ in their commitments for reporting and action under the Convention. Annex I countries usually have a more affluent economy and stricter requirements for reporting. These countries, which are often located at higher latitudes, recorded relatively more warming compared to tropical and subtropical countries.

Figure 1: Mean annual temperature anomalies over land

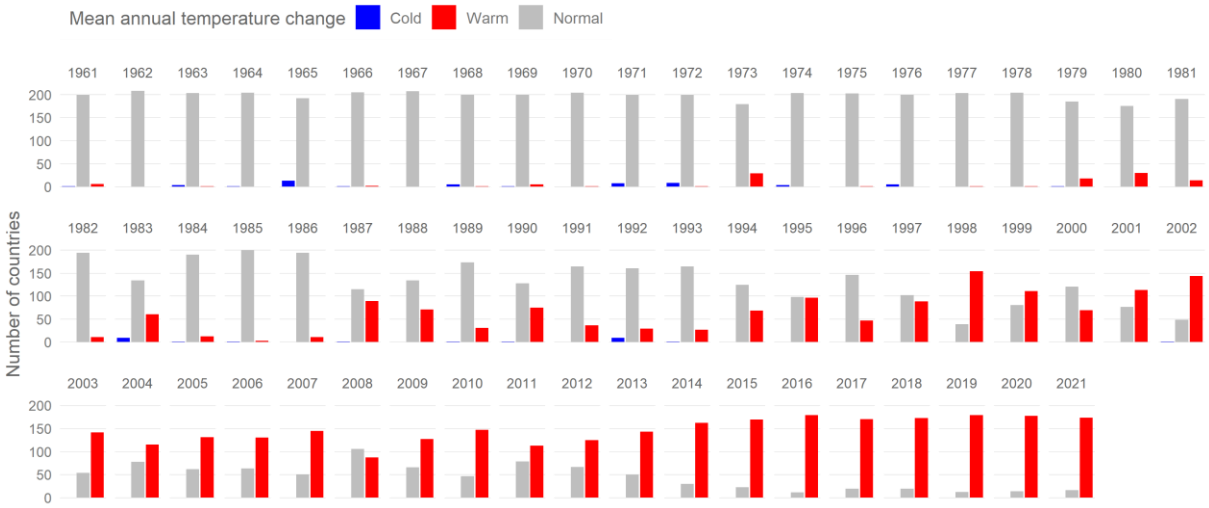


Source: FAO. 2022. FAOSTAT: Temperature Change. In: *FAO*. Rome. Cited March 2022. http://www.fao.org/faostat/en/#data/ET

[1]The list of the type of parties to the UN Climate Convention is reported in the Annex and is drawn from https://unfccc.int/process/parties-non-party-stakeholders/parties-convention-and-observer-states. For corresponding FAOSTAT area codes, please also see the tab 'Country Group' in FAOSTAT Definitions and Standards http://www.fao.org/faostat/en/#definitions.

In order to further qualify the statistical significance of the global temperature signal, the collective statistics of the 197 countries and 41 territories in the database were also analysed. In 2021, the mean annual temperatures were warmer than normal in 171 countries and territories (Figure 2). In fact, in 125 of these (that is, in almost three-quarters of all countries and territories in the database), the mean annual temperatures were much warmer than normal. Additionally, since 2002, no country or territory had colder temperatures than normal.

Figure 2: Mean annual temperature change over land expressed as anomalies by country



Source: FAO. 2022. FAOSTAT: Temperature Change. In: *FAO*. Rome. Cited March 2022. http://www.fao.org/faostat/en/#data/ET

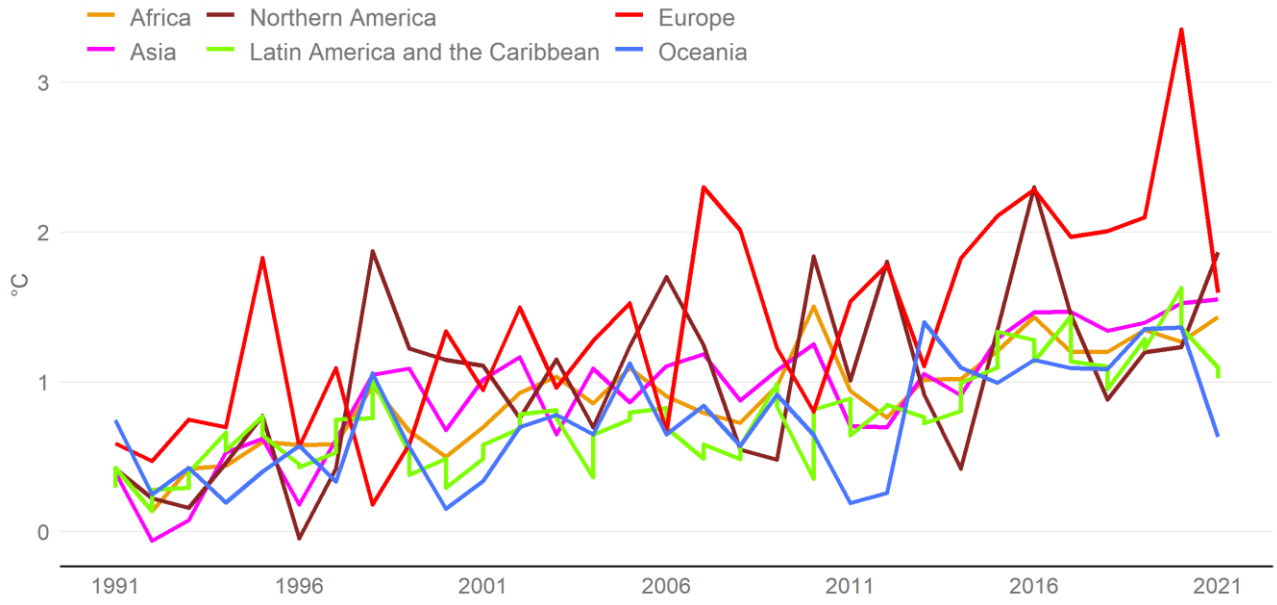
Annual bars in Figure 2 represent the number of FAOSTAT countries and territories in the three temperature anomalies categories of normal (within 95 percent CI), warm (positive anomalies outside of the 95 percent CI) or cold (negative anomalies outside of the 95 percent CI).

REGIONAL

In 2021, land in the northern hemisphere saw larger warming than in the southern hemisphere. Northern America registered the largest mean annual temperature change (1.9 ºC), followed by Europe (1.6 ºC) that in FAOSTAT aggregates includes the Russian Federation, then Asia (1.5 ºC) and Africa (1.4 ºC). Warming in Latin America and the Caribbean (composed of the South and Central America FAOSTAT regions) and Oceania was 1.0 ºC and 0.6 ºC, respectively. The observed temperature anomalies were statistically significant in all regions except for Oceania, where the observed annual warming was just below the 95 percent CI of the reference climatology (± 0.62 ºC). All regions recorded an upward trend in the past three decades (Figure 3).

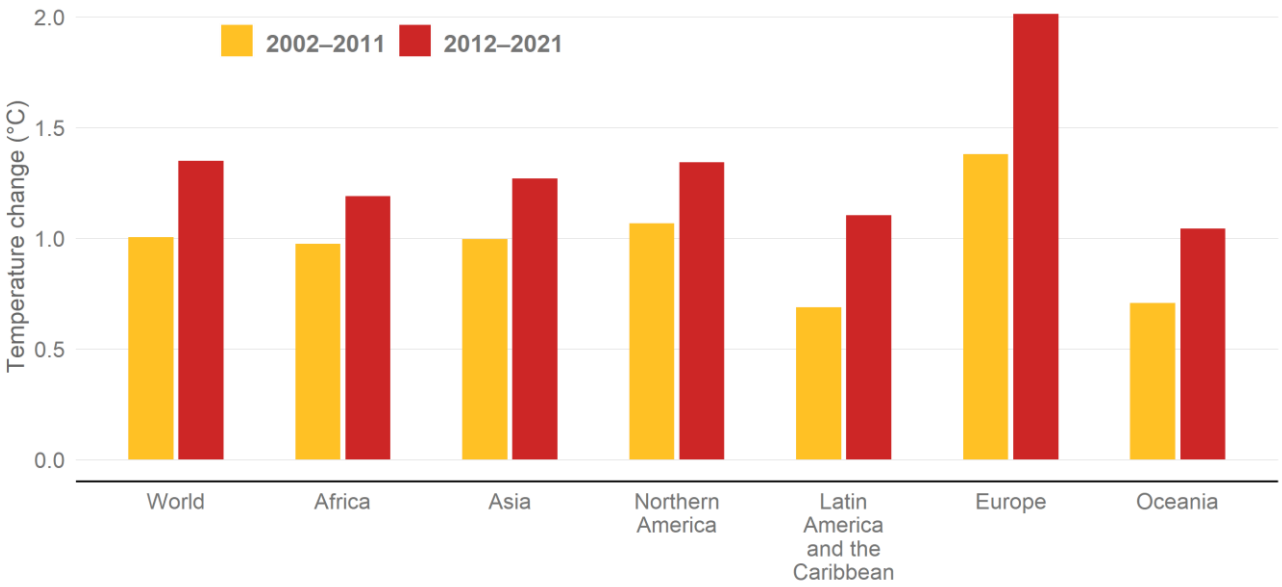
In all regions, the decadal mean warming was greater in the last decade (2012–2021) compared to the previous one (2002–2011) (Figure 4). The largest absolute increase was recorded in Europe, where the more recent decade was about 0.6 ºC warmer than previous one. The smallest absolute increase was in Africa, where the 2012–2021 decade was 0.2 ºC warmer than 2002–2011. Nonetheless, the comparison of regional trends (and country trends, relevant to the next section) may be biased due to uneven coverage and time evolution of meteorological stations in the different regions (see also the Explanatory Notes).

Figure 3: Regional trends in mean annual temperature changes measured over land



Source: FAO. 2022. FAOSTAT: Temperature Change. In: *FAO*. Rome. Cited March 2022. http://www.fao.org/faostat/en/#data/ET

Figure 4: Mean annual temperature changes measured over the land, global and regional trends by recent decades



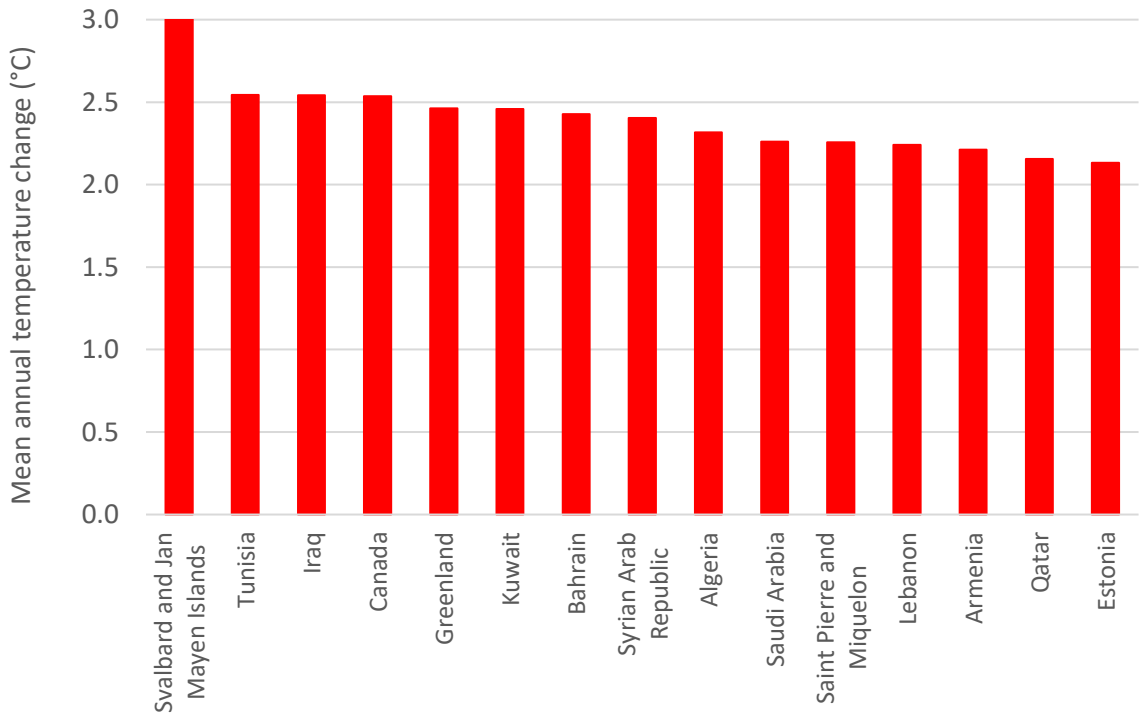
Source: FAO. 2022. FAOSTAT: Temperature Change. In: *FAO*. Rome. Cited March 2022. http://www.fao.org/faostat/en/#data/ET

COUNTRY

In 2021, 162 countries and territories – more than 70 percent of the total – experienced annual mean warming above 1.0 ºC. Nearly half of these warmed by more than 1.5 ºC and 20 by over 2.0 ºC.

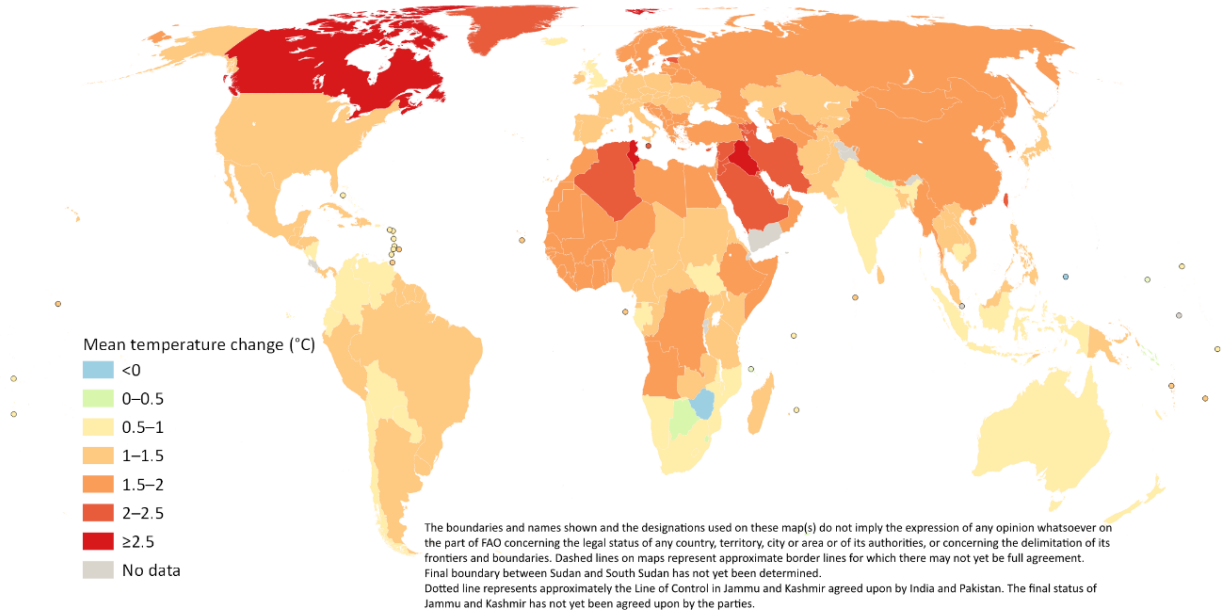
In 2021, the 15 countries or territories with the larger warming (all above 2.2 ºC; see Figure 5) were recorded in northern latitudes such as the Svalbard Islands (Norway), Canada, Greenland (Denmark), Saint Pierre and Miquelon (France), and Estonia as well as in arid and semi-arid regions of the northern hemisphere, specifically Northern Africa and West Asia (Tunisia, Iraq, Kuwait, Bahrain, the Syrian Arab Republic, Algeria, Saudi Arabia, Lebanon and Qatar). In 2021, the country or territory with the greatest warming on land was the Svalbard Islands (3.0 ºC), followed by Tunisia, Iraq and Canada, all with warming above 2.5ºC. Conversely, only three of the 238 country and territories covered in the database experienced virtually no warming in 2021 (Palau, Zimbabwe and Botswana; see Figure 6).

Figure 5: Countries and territories with largest mean annual temperature change over land for the year 2021



Source: FAO. 2022. FAOSTAT: Temperature Change. In: *FAO*. Rome. Cited March 2022. http://www.fao.org/faostat/en/#data/ET

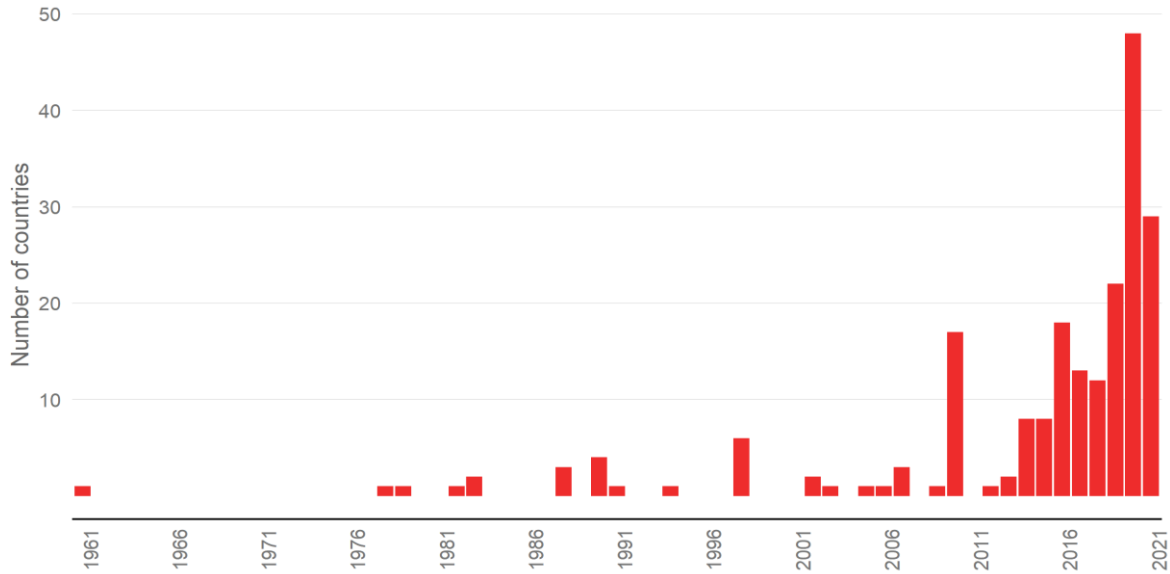
Figure 6: Global map of temperature changes, 2021



Source: FAO. 2022. FAOSTAT: Temperature Change. In: *FAO*. Rome. Cited March 2022. http://www.fao.org/faostat/en/#data/ET based on UN Geospatial, 2020.

29 countries or territories broke their warming record in 2021, compared to the time series 1961–2021. This record-setting in 2021 was second only to the year 2020, when 48 countries had broken their warming record (Figure 7).

Figure 7: Number of countries and territories with record warming



Source: FAO. 2022. FAOSTAT: Temperature Change. In: *FAO*. Rome. Cited March 2022. http://www.fao.org/faostat/en/#data/ET

EXPLANATORY NOTES

The FAOSTAT Temperature Change domain disseminates statistics of temperature change on land by country, with annual updates. The current database covers the period 1961–2021. Statistics are available for 197 countries and 41 territories in 2021. Data are also disseminated for regional aggregates and special groups, such as the Annex I and Non-Annex I Parties to the United Nations Framework Convention on Climate Change (UNFCCC) (see the Annex with the list of countries in each group).

Statistics are available for monthly, seasonal and annual mean temperature anomalies, i.e. temperature change with respect to a reference climatology corresponding to the period 1951–1980. The standard deviation of the reference climatology is also disseminated in the database, by country. 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 the year 1880 onwards.

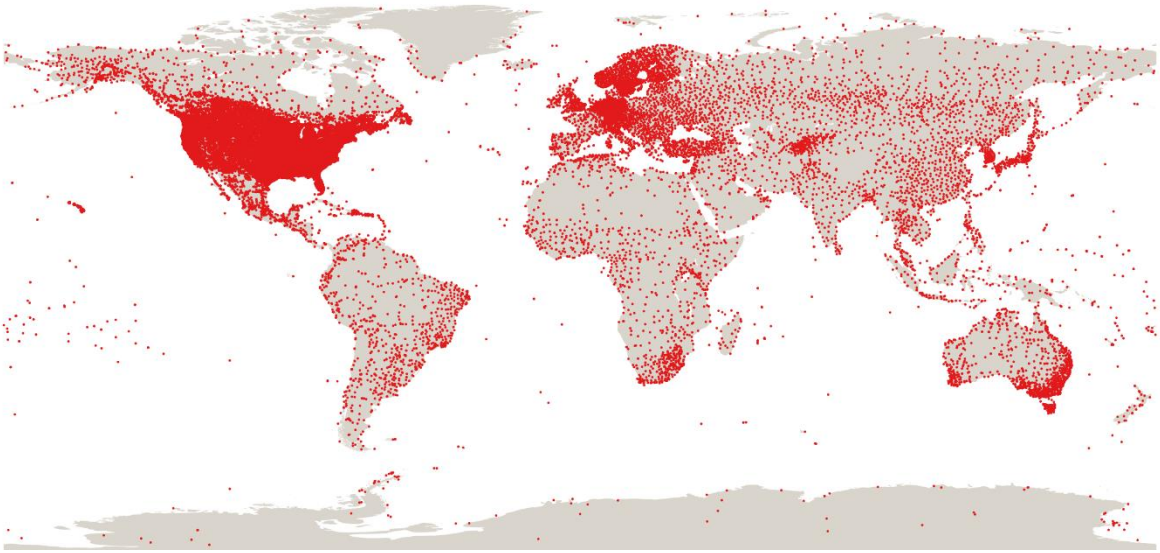
According to NASA, compared to statistics of absolute temperature value, a dataset based on temperature anomalies is more stable and coherent in the face of variations in coverage in space and time of the meteorological stations that underlie the information.

The original GISTEMP analysis generates a set of gridded values from the Global Historical Climatology Network (GHCN v4), composed of continuously updated temperature data from over 26 000 meteorological stations around the globe (Figure 8). The uncertainties of the gridded data, and thus the uncertainty of the FAOSTAT country statistics, depend on the spatial and temporal coverage of the GHCN stations. Smaller uncertainty can be associated with areas with denser station networks, such as Northern America, Europe and Australia. Conversely, data from regions with less dense and reliable networks, such as parts of South America, Africa and the Near East, have greater uncertainty.

A finer grid was prepared for the purpose of the FAOSTAT dataset, excluding ocean data, and subsequently aggregated at the country level using the FAO Global Administrative Unit Layer (GAUL). The FAOSTAT methodology includes reconstructing the time series to take into account the administrative changes that occurred since 1961 (e.g. the split of the Soviet Union in 1991 or the separation of Sudan in 2011). For each country or territory, and for each temperature variable considered, the mean and standard deviation of the 1951–1980 climatology was computed – 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 can be taken to represent the natural interannual variability of that variable, by country. Deviations from the climatological means of two-sigma or three-sigma represent the boundaries of 95 percent and 99 percent confidence intervals, respectively. Positive anomalies outside of these values represent temperature changes warmer and much warmer than normal. Finally, country statistics were area-weighted to compute regional aggregates, using country area data from the FAOSTAT Land Use dataset as weights.

A methodological note of the Temperature Change domain is available in FAOSTAT.

Figure 8: NASA Global Historical Climatology Network (v4)



Source: National Centers for Environmental Information. 2022. NASA Global Historical Climatology Network (GHCN v4). In: National Oceanic and Atmospheric Administration. Washington, D.C. Cited February 2022. https://www.ncei.noaa.gov/pub/data/ghcn/v4/

REFERENCES

FAO. 2022. FAOSTAT: Temperature Change. In: *FAO*. Rome. Cited March 2022. http://www.fao.org/faostat/en/#data/ET

Hansen, J., Johnson, D., Lacis, A., Lebedeff, S., Lee, P., Rind, D. & Russell, G. 1981. Climate impact of increasing atmospheric carbon dioxide. *Science* 213, 957–966.

Hansen, J., Sato, M., Ruedy, R., Lo, K., Lea, D.W. & Medina-Elizade, M. 2006. Global temperature change. *Proceedings of the National Academy of Sciences* 103, 14288–14293.

Hansen, J., Ruedy, R., Sato, M. & Lo, K. 2010. Global surface temperature change. *Reviews of Geophysics* 48.

Lenssen, N.J., Schmidt, G.A., Hansen, J.E., Menne, M.J., Persin, A., Ruedy, R. & Zyss, D. 2019. Improvements in the GISTEMP uncertainty model. *Journal of Geophysical Research*: *Atmospheres* 124, 6307–6326.

Menne, M.J., Williams, C.N., Gleason, B.E., Rennie, J.J. & Lawrimore, J.H. 2018. The global historical climatology network monthly temperature dataset, version 4. *Journal of Climate* 31, 9835–9854.

NASA–GISS. GISTEMP Team. 2022. GISS Surface Temperature Analysis (GISTEMP), version 4. In: *NASA Goddard Institute for Space Studies*. New York. Cited February 2022. https://data.giss.nasa.gov/gistemp/.

UN Geospatial. 2020. *United Nations Clear Map* [online]. Cited June 2021. https://geoservices.un.org/Html5Viewer/index.html?viewer=clearmap

ANNEX

ANNEX I COUNTRIES

Australia; Austria; Belarus; Belgium; Bulgaria; Canada; Croatia; Cyprus; Czechia; Denmark; Estonia; European Union; Finland; France; Germany; Greece; Hungary; Iceland; Ireland; Italy; Japan; Latvia; Liechtenstein; Lithuania; Luxembourg; Malta; Monaco; Netherlands; New Zealand; Norway; Poland; Portugal; Romania; Russian Federation; Slovakia; Slovenia; Spain; Sweden; Switzerland; Turkey; Ukraine; United Kingdom of Great Britain and Northern Ireland; United States of America.

NON-ANNEX I COUNTRIES

Afghanistan; Albania; Algeria; Andorra; Angola; Antigua and Barbuda; Argentina; Armenia; Azerbaijan; Bahamas; Bahrain; Bangladesh; Barbados; Belize; Benin; Bhutan; Bolivia (Plurinational State of); Bosnia and Herzegovina; Botswana; Brazil; Brunei Darussalam; Burkina Faso; Burundi; Cabo Verde; Cambodia; Cameroon; Central African Republic; Chad; Chile; China; Colombia; Comoros; Congo; Cook Islands; Costa Rica; Côte d'Ivoire; Cuba; Democratic People's Republic of Korea; Democratic Republic of the Congo; Djibouti; Dominica; Dominican Republic; Ecuador; Egypt; El Salvador; Equatorial Guinea; Eritrea; Eswatini; Ethiopia; Fiji; Gabon; Gambia; Georgia; Ghana; Grenada; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; India; Indonesia; Iran (Islamic Republic of); Iraq; Israel; Jamaica; Jordan; Kazakhstan; Kenya; Kiribati; Kuwait; Kyrgyzstan; Lao People's Democratic Republic; Lebanon; Lesotho; Liberia; Libya; Madagascar; Malawi; Malaysia; Maldives; Mali; Marshall Islands; Mauritania; Mauritius; Mexico; Micronesia (Federated States of); Mongolia; Montenegro; Morocco; Mozambique; Myanmar; Namibia; Nauru; Nepal; Nicaragua; Niger; Nigeria; Niue; Oman; Pakistan; Palau; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Qatar; Republic of Korea; Republic of Moldova; Rwanda; Saint Kitts and Nevis; Saint Lucia; Saint Vincent and the Grenadines; Samoa; San Marino; Sao Tome and Principe; Saudi Arabia; Senegal; Serbia; Seychelles; Sierra Leone; Singapore; Solomon Islands; Somalia; South Africa; South Sudan; Sri Lanka; State of Palestine; Sudan; Suriname; Syrian Arab Republic; Tajikistan; Thailand; The Republic of North Macedonia; Timor-Leste; Togo; Tonga; Trinidad and Tobago; Tunisia; Turkmenistan; Tuvalu; Uganda; United Arab Emirates; United Republic of Tanzania; Uruguay; Uzbekistan; Vanuatu; Venezuela (Bolivarian Republic of); Viet Nam; Yemen; Zambia; Zimbabwe.

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