UNIVERSITÄT LEIPZIG

Record warm July 2023

Introduction

There has been much talk of the string of hottest days since records began throughout the month of July. In addition, we have seen record heat over many continental regions as well as the North Atlantic ocean, potentially fueled by the slowly unfolding El Niño in the tropical Pacific. It is therefore only natural to ask whether July did in fact end up being the warmest July since records are kept. Given that we have mere days left to go, it is now possible to reliably predict the average July temperature using forecast data from weather models for the remainder of the month. As further detailed in the method section, the results are based on gridded weather model data (~50km grid spacing), which themselves are guided by weather station data from across the globe (land and ocean), as well as radiosonde and satellite data. Note that all data are provided in terms of anomalies rather than absolute temperatures.

Below, the headline figures based on the latest NCEP Global Forecast System (GFS) data are provided, followed by methodological details and my assessment of the July outcome in context of human-induced climate change and historic data.

Headline numbers

Preliminary analysis suggests that global average near-surface temperature in July will exceed the previous warmest July by a considerable margin. Using GFS forecast data (see methods) until the end of the month, I find that July will be more than 0.2°C (+/- 0.1°C) warmer than July 2019, which is the current warmest. It is therefore virtually certain that July 2023 will set a new global temperature record.

Given this analysis is calibrated against observation-based temperature data from NASA GISTEMP (which only provides data from 1880 onwards), the temperature level with regard to the Paris target - which is defined relative to the 1850-1900 reference period - can only be estimated using other observational products. Taking Berkeley Earth global temperature data as reference, July 2023 will be approximately 1.5°C (+/- 0.2°C) above pre-industrial levels. Note that some winter months have already had higher anomalies wrt the same 1850-1900 reference period.

However, the fact that July is the warmest month with respect to absolute global average temperatures, we just lived through the warmest of any months over the last couple hundreds or thousands of years. We may have to go back all the way to the Eemian warm period (~120.000 years ago) to find similarly warm conditions. But since paleo temperature records (so called climate proxies) do not provide high enough temporal resolution, we cannot say with certainty that this July hasn't been hotter during the peak of the current interglacial.

Methodology

Analysis and forecast data from the NCEP Global Forecast System (GFS) are used to estimate the temperature deviation from the long-term mean relative to reanalysis data (Climate Forecast System v2). Validated GFS model analysis data are used up until now (25 July). All temperature anomaly data are provided at ~50km grid resolution, i.e. regional estimates are available as well (http://karstenhaustein.com/climate).

The raw data that nudge the model towards 'reality' are coming from weather station data globally, radiosondes and satellite remote sensing. Weather station data are from automated networks, routinely monitored and maintained by the respective national weather services. GFS forecast data are used to calculate the deviation of the remaining few days. In this case, weather station data are used to initialize the model. The respective forecast error over those days is rather small (+/- 0.02°C). The remaining uncertainty to predict the GISTEMP anomaly for July 2023 is +/- 0.08°C. Thus the uncertainty attached to this preliminary analysis is approximately +/- 0.1°C, which is considerably smaller than the margin of the expected July temperature record.

Both NCEP GFS and CFSv2 reanalysis data are freely accessible on the respective institutional download servers. All I do is to 'connect' the analysed and forecast global temperature data such that an 'early', i.e. preliminary estimate becomes possible. The calculated anomalies are calibrated against NASA GISTEMP global temperature observations to remove systematic biases in the GFS analysis. Basically, this way I ensure optimal comparability, i.e. making sure we compare apples with apples. Such biases are common in weather forecast models, even though they are extremely small compared to the inevitable inaccuracies in the regional temperature forecast.

I provide the global average temperature relative to 1981-2010. GISTEMP uses the 1951-1980 interval. The time series bar chart and the respective data I provide are also relative to the 1951-1980 interval. The difference between 1951-1980 and 1850-1900 is 0.34°C (based on Berkeley Earth). At 1.17 +/- 0.1°C relative to 1951-1980, July 2023 in GISTEMP corresponds to 1.51 +/- 0.1°C relative to 1850-1900. The previous warmest year (2019) was 0.94°C relative to 1951-1980. For completeness, the difference between 1951-1980 and 1981-2010 is 0.4°C (based on GISTEMP).

Discussion

Based on preliminary data, including forecast temperatures until the end of the month, it is virtually certain that July 2023 is going to be the warmest July by a wide margin with ~0.2°C (+/-0.1°C) above the previous record. Not only will it be the warmest July, but the warmest month ever in terms of absolute global mean temperature. We may have to go back thousands if not tens of thousands of years to find similarly warm conditions on our planet. The reason why we cannot say for sure July 2023 was warmer than any other month since the Eemian, is that our climate proxy data from tree rings etc have very coarse temporal resolution. Maybe there was the odd month during the Holocene that was warmer, as unlikely as it seems.

The record July comes as El Niño has just been declared in the tropical Pacific. While contributing to the warmth, the fundamental reason for why we are seeing such records is the continued release of vast amounts of greenhouse gases by humans. Since the effects of El Niño only fully emerge in the 2nd half of the year, June - and now July - are likely followed by more record warm months up until at least early 2024.

Such dramatic climatic changes also trigger unprecedented marine and continental heat waves, increasing the risk for record shattering temperature extremes across the globe. China, Southern Europe and North America all saw record or near-record temperatures these past weeks. So does the North Atlantic ocean. Ironically, this does not exclude rather unsettled conditions in some regions. In fact, Northern and parts of Western Europe were lucky enough to sit under clouds for much of the month, while most other densely populated regions saw above average temperatures … just as one would expect on a rapidly warming planet.

Additional material

Global temperature estimate up until the end of the month:
http://www.karstenhaustein.com/reanalysis/gfs0p5/ANOM2m_mollw/ANOM2m_fcstMTH_mollw.html
Regional temperature estimate up until the end of the month:
http://www.karstenhaustein.com/reanalysis/gfs0p5/ANOM2m_europe/ANOM2m_fcstMTH_europe.html

GISTEMP temperature anomaly data can be found here:
https://data.giss.nasa.gov/gistemp/tabledata_v4/GLB.Ts+dSST.txt
GISTEMP plotting tool:
https://data.giss.nasa.gov/gistemp/maps/

July temperature anomaly Figure v1:
https://drive.google.com/file/d/1fF2WHfImKMIpn9yZl75ZWe2cFold67TO/view
July temperature anomaly Figure v2:
https://drive.google.com/file/d/1rfPUVSgRsXrszUzuh8k2o-0i-xPaRj_2/view

Monthly temperature data in txt format:
https://drive.google.com/file/d/1hjvzh7PVo8gRnSymNUWLSpYMxx_01mA-/view
Monthly temperature data in excel format:
https://docs.google.com/spreadsheets/d/1vyQ09_glJa5JBj76RK_WEJp89n9ZKnPW/edit?usp=sharing&ouid=109809605278618512484&rtpof=true&sd=true

Climate Reanalyzer for context:
https://climatereanalyzer.org/clim/t2_daily/