Thermal stress during the severe heat wave of 18–28 June 2026 in Luxembourg

A high-resolution reconstruction of felt temperature across the country

Author: Luca Mathias

MeteoLux (Administration de la navigation aérienne)

9 November 2026

Abstract

From 18 to 28 June 2026 residents of Luxembourg experienced eleven consecutive days of elevated thermal stress. This report reconstructs the event at a high spatial resolution (1 km x 1 km) in terms of the Universal Thermal Climate Index (UTCI), the felt temperature of a person outdoors, by downscaling the ERA5 reanalysis over the national terrain and land cover, and calibrating the result against 17 stations of the national observation network. In every part of the country a level of very strong heat stress (UTCI ≥ 38 °C) was reached on at least three afternoons, with a national peak of 44.9 °C in the Moselle valley on 26 June. By day the thermal stress was similar across the lowlands; the largest differences between places occurred at night, when the UTCI over the built-up south of the country stayed above 20 °C for several consecutive nights while in most rural valleys it cooled well below that value. The product resolves these contrasts at the scale of a town and can be repeated for future and past events.

1. Introduction

From 18 to 28 June 2026, residents of Luxembourg experienced eleven consecutive days of elevated thermal stress. Air temperature alone does not describe what such an episode means for the human body: humidity, wind, and sunshine determine how much heat the body gains and can shed, and two places with the same thermometer reading can feel quite different. This report therefore works with the Universal Thermal Climate Index (UTCI), an internationally established measure of felt temperature that combines air temperature, humidity, wind, and radiation into a single value in degrees Celsius (Bröde et al., 2012).

Hourly UTCI values are read against fixed international thresholds: 26 to 32 °C indicates moderate heat stress, 32 to 38 °C strong heat stress, 38 to 46 °C very strong heat stress, and values above 46 °C extreme heat stress. In addition, MeteoLux classifies whole days by their daily mean UTCI: a day counts as one of moderate heat stress when the daily mean reaches 22 °C, strong heat stress at 24 °C, and very strong to extreme heat stress at 27 °C. The hourly categories describe the load at a given moment while the daily thresholds describe the load of a 24-hour period, including the night, and are the basis of the heat warnings issued by MeteoLux (Fig. 1). Both are used in this report.

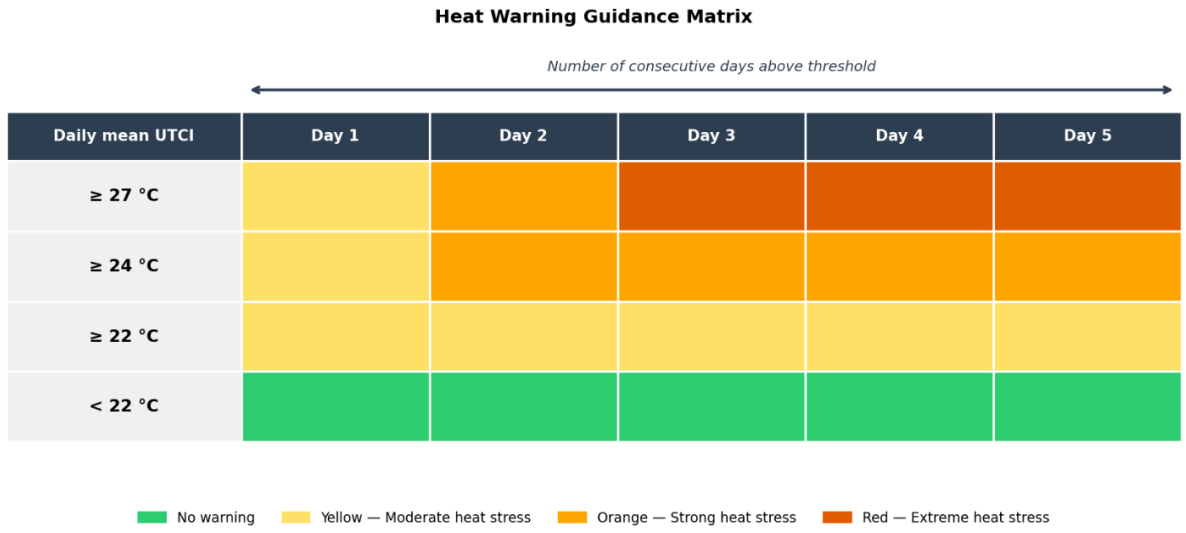

Figure 1: Operational heat warning thresholds used by MeteoLux.

The existing global heat-stress dataset ERA5-HEAT (Di Napoli et al., 2021) describes conditions on a native grid of about 31 km. At that resolution Luxembourg is represented only by a few grid points, and the differences residents experience, for example between the Moselle valley and the higher elevations in the Oesling, do not appear. The analysis presented here reconstructs the heat wave on a 1 km x 1 km grid covering the national territory for the daily mean, the afternoon maximum and the overnight minimum of the felt temperature. It is intended for the public and for the civil-protection, health and municipal authorities.

Section 2 describes how the reconstruction was produced, Section 3 shows the results, and Section 4 discusses how the results should be interpreted.

2. Methodology

2.1 Starting point: the ERA5 reanalysis

The basis of the analysis is ERA5 (Hersbach et al., 2020), the global atmospheric reanalysis of the European Centre for Medium-Range Weather Forecasts (ECMWF). ERA5 provides an hourly, physically consistent reconstruction of the atmosphere from 1940 onwards on a native grid spacing of about 31 km and is the dataset behind the European ERA5-HEAT thermal-comfort record. Hourly surface fields (temperature, humidity, wind, pressure, radiation) and the vertical profile of the lower atmosphere (pressure levels 1000 to 900 hPa) were retrieved for the period of the event, using the consolidated ERA5 release.

2.2 From 31 km to 1 km: elevation downscaling

Luxembourg's terrain spans approximately 430 m between the lowest point in the Moselle valley and the highest point in the Oesling, while the ERA5 terrain retains barely half of that relief. The reanalysis fields were therefore transferred onto a 1-km elevation model (Copernicus DEM; ESA, 2022) using established schemes: temperature, humidity, and pressure interpolated along the reanalysis vertical profile to the true elevation of each cell (TopoSCALE; Fiddes and Gruber, 2014), the 10-m wind adjusted for the exposure or shelter of the terrain (following Liston and Elder, 2006), and incoming long-wave and short-wave radiation adjusted for the high-resolution elevation, the local sky-view factor, and terrain shading. From the downscaled fields, the mean radiant temperature and the UTCI were computed with the thermofeel library (Brimicombe et al., 2022), the same formulation used for ERA5-HEAT, so the product remains directly comparable with the reference dataset. One principle applies throughout: corrections are only made to the input fields (temperature, humidity, wind, radiation) and the UTCI is then recomputed from these corrected fields. The UTCI value itself is never adjusted afterwards, since it depends on its inputs in a strongly non-linear way.

2.3 Land cover

Satellite land-cover data (Copernicus Climate Change Service, 300 m; C3S, 2019) and the Copernicus High Resolution Layer of imperviousness (sealed-surface density, 100 m; CLMS, 2025) give each cell realistic surface roughness, albedo and, in built-up areas, a reduced sky view. These act on the wind and on the radiation reaching a person: built-up and forested cells are sheltered while open farmland stays better ventilated. Averaged over the event, this step adds up to about +1.1 °C of felt temperature in the most densely built-up cells and changes little elsewhere. The statistical correction described in Section 2.4 is fitted to the differences that remain after this step, so the urban effect is not counted twice.

2.4 Calibration against the national observation network

The downscaled ERA5 fields were compared, hour by hour, with observations from 17 stations: 16 agrometeorological stations of the ASTA network and the MeteoLux station at Luxembourg-Findel (WMO 06590). The station reference dataset used here therefore combines the measured air temperature and humidity with the wind and the mean radiant temperature of the downscaled 1 km ERA5 field at that station's cell, and the index is computed from those combined inputs. Since the downscaling already accounts for elevation, the remaining differences between downscaled ERA5 fields and the reference observation dataset isolate the processes the physical scheme cannot

produce, mainly the urban heat island effect and the pooling of cold air in narrow valleys on clear, calm nights. These residuals were modelled statistically as a function of sealed-surface fraction, terrain position and time of day. By day, the corrections for built-up areas and valleys are switched off whenever five oktas of cloud or more are observed at Luxembourg-Findel, and are further reduced cell by cell where the ERA5 radiation indicates cloud. At night, they are reduced in proportion to the observed cloud cover and switched off entirely under overcast skies with rain. Humidity was also calibrated alongside temperature. A residual night-time bias remained after this: it was removed hour by hour by adjusting the downscaled temperature field to the station mean, so that the level of the nocturnal UTCI values is set by the measurements.

The calibration improves the downscaled ERA5-based product. Measured against the observation-anchored station series, the root-mean-square error (RMSE) fell by about 1 °C and the mean difference from +0.8 °C to −0.02 °C (Fig. 2). The stations used for the calibration are the same as those used for this verification.

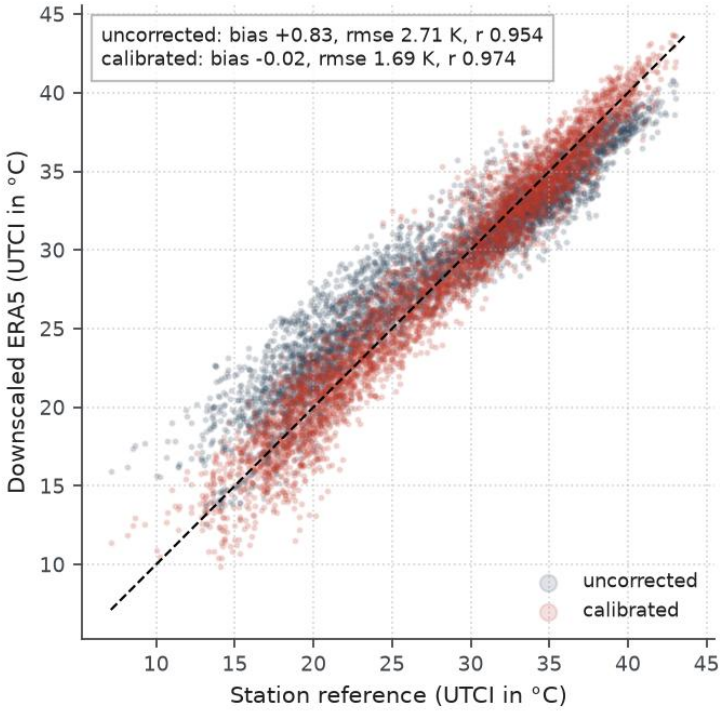

Figure 2: Hourly UTCI of the downscaled ERA5 field against the station reference at the 17 calibration stations for the period 18 June 2026 06 UTC to 29 June 2026 06 UTC, before (grey) and after (red) calibration. The dashed line is the 1:1 line. Calibration reduces the bias from +0.83 to −0.02 °C and the RMSE from 2.71 to 1.69 °C; the improvement is largest at the cool end of the range, i.e. at night.

2.5 Conventions

Statistics are computed over days running from 06 UTC (08 CEST) to 06 UTC (08 CEST) the next day, following synoptic practice. Each day therefore contains its own afternoon maximum and the minimum of the following night. For heat-stress exposure during the night, the period 20 to 05 UTC was used. National statistics are computed strictly within the borders of the Grand Duchy, while the computation itself extends beyond them to avoid artefacts at the borders.

3. Results

3.1 General overview

The heat wave falls into three phases: a build-up from 18 to 23 June, a peak from 24 to 27 June, and a breakdown from 28 to 29 June, when a nocturnal frontal passage with rain ended the episode. The country-mean felt temperature rose from about 25 °C at the start of the period to nearly 32 °C on 26 June, the most severe day. Table 1 gives the daily national figures.

Date (2026)	Daily average	Daily maximum	Highest maximum*	Daily minimum	Highest minimum*
18 June	25.6	34.8	37.5	15.4	19.1
19 June	25.4	35.9	39.4	13.5	18.4
20 June	26.2	37.1	40.3	15.5	19.8
21 June	27.3	37.7	40.3	17.1	20.6
22 June	26.3	37.0	40.2	15.7	19.2
23 June	27.4	35.7	38.6	17.9	21.1
24 June	30.6	40.3	42.4	21.1	23.9
25 June	29.5	40.3	43.2	19.4	23.4
26 June	31.7	41.6	44.9	21.8	24.7
27 June	30.9	41.4	44.7	18.6	22.9
28 June	23.9	36.2	39.3	12.2	18.1

Table 1: Daily national UTCI statistics (in °C), 06–06 UTC days. The daily average, maximum and minimum are means over all 1 km cells of the country. (*The highest maximum is the value reached by the hottest grid cell that day; the highest minimum is the value reached by the warmest grid cell during the following night.)

Judged by the MeteoLux heat thresholds, every day of the period was at least a day of strong heat stress countrywide by the national daily mean (at or above 24 °C), apart from 28 June, which still qualified as moderate. On six days, 21 and 23 to 27 June, the national daily mean exceeded 27 °C, the threshold for very strong to extreme heat stress. On each of the four peak days (24–27 June), the daily maximum felt temperature averaged 40 to 42 °C across the country, whereas the daily minimum averaged 19 to 22 °C.

3.2 Spatial pattern

The single highest value of the event, 44.9 °C, was reached on 26 June in the Moselle valley near Grevenmacher. The warmest night was that of 26 to 27 June, when the felt temperature on a vineyard slope near Wellenstein did not fall below 24.7 °C (Fig. 3).

Averaged over the eleven days (Fig. 4), the daily mean felt temperature across Luxembourg ranged from 25.8 to 30.2 °C. The warmest area lay in the densely built-up south of the capital (285 m, 85 % sealed surface), whereas the coolest area was situated slightly north of Troisvierges in the Oesling (473 m). Note that even the coolest area of the country sat above the 24 °C daily mean threshold on average, hence, taken over the whole 11-day period, all of Luxembourg was under at least strong heat stress. The period-mean daily maximum UTCI ranged from 35.9 °C on the heights of the Oesling to

40.6 °C in the Moselle valley, and the period-mean overnight minimum from 14.5 °C, in the upper Wiltz valley, to 20.5 °C on the plateau of the Airport Luxembourg-Findel.

The contrasts between locations were larger at night than during the day: the spread across the country averaged 5.7 °C by day and 7.7 °C at night, reaching more than 10 °C on the most contrasted night. Daytime heat was governed mainly by elevation, with the Moselle and Alzette valleys hottest and the Oesling coolest. Night-time heat was governed by settlement and terrain position. On clear, calm nights cold air collects in the valleys, so enclosed rural valleys cooled sharply after sunset while the higher ground above this shallow cold layer stayed milder; built-up areas retained heat. During the peak phase the capital recorded four nights in a row on which the felt temperature never fell below 20 °C, whereas most rural valleys fell below that value on all but two or three nights.

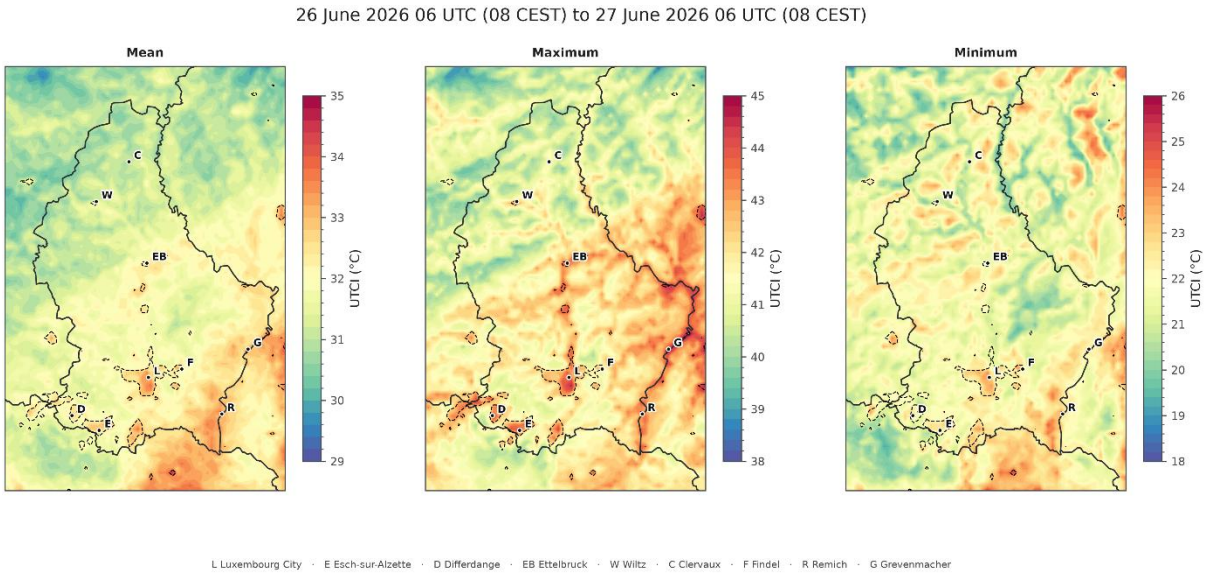

Figure 3: Mean, maximum and minimum UTCI (in °C) for the period 26 June 2026 06 UTC to 27 June 2026 06 UTC (based on the calibrated and downscaled ERA5 reanalysis). The dashed lines indicate the urban areas (25%-threshold of sealed environment).

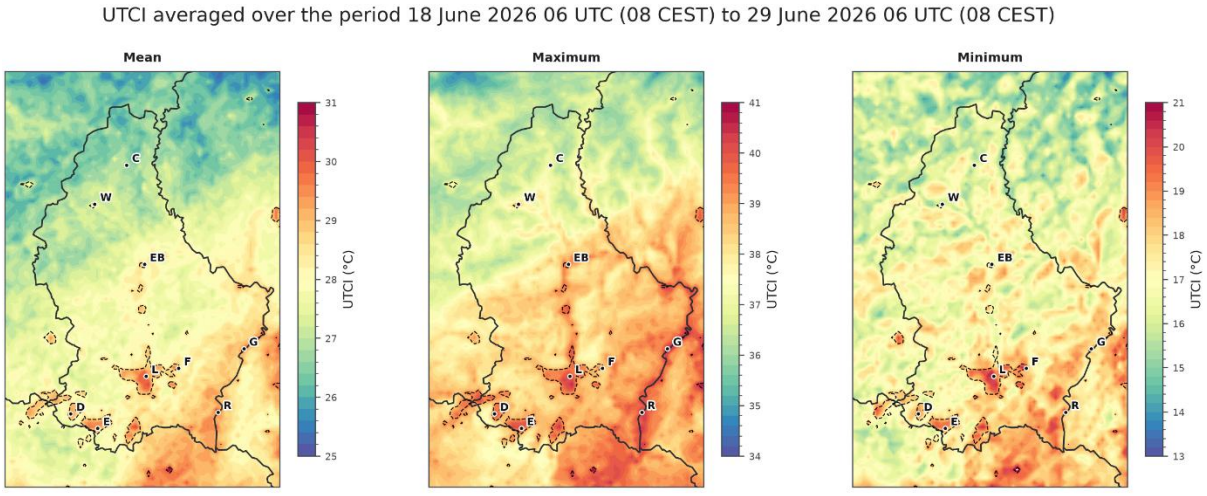

Figure 4: Mean, maximum and minimum UTCI (in °C) averaged over the period from 18 June 2026 06 UTC until 29 June 2026 06 UTC (based on the calibrated and downscaled ERA5 reanalysis). The dashed lines indicate the urban areas (25%-threshold of sealed environment).

3.3 Accumulated exposure

For health impacts, the accumulated time spent under heat stress matters at least as much as the daily statistics. Of the 264 hours of the event, the average area of Luxembourg spent 155 hours with at least moderate heat stress (UTCI ≥ 26 °C), 94 hours with strong heat stress (UTCI ≥ 32 °C), and 19 hours with very strong heat stress (UTCI ≥ 38 °C). The stress was unevenly distributed: hours of very strong heat stress ranged from 2 in the coolest areas of the Oesling to 42 in the hottest areas in the south of Luxembourg.

Counted by days, the picture is similar. Every square kilometre of the country reached very strong heat stress (daily maximum UTCI ≥ 38 °C) on at least three of the eleven days, on 4.8 days on average and on up to 10 days in the warmest areas. The daily mean exceeded the 27 °C threshold for very strong to extreme heat stress on 5.9 days on average, ranging from 3 days on the highest ground to all 11 days in the built-up south. Almost the whole country (99 % of cells) had at least one night on which the felt temperature never fell below 20 °C; the national average was 2.4 of such nights, one cell in eight had four or more, and the maximum was six.

Table 2 summarises nine representative locations chosen to span the country's contrasts, from the most sealed region of the country, in the Bonnevoie-Howald belt south of the capital, to the Oesling plateau.

Location	Elevation (m)	Urban (%)	Mean UTCI (°C)	Mean $UTCI_{max}$ (°C)	Hours UTCI ≥ 32 °C	Hours UTCI ≥ 38 °C	$UTCI_{min}$ ≥ 20 °C
Luxembourg Bonnevoie	285	85	30.2	40.5	116	41	6
Luxembourg City centre	306	63	29.9	39.9	111	34	6
Esch/Alzette	296	72	29.6	40.2	114	36	4
Findel	371	34	29.1	38.9	106	23	5
Remich	145	14	29.6	40.1	116	35	4
Echternach	198	29	29.3	40.1	114	35	3
Ettelbruck	220	47	29.1	40.0	111	36	3
Wiltz	358	47	28.1	38.9	106	25	2
Eschdorf	500	15	27.0	36.8	77	11	2

Table 2: UTCI statistics of representative locations in Luxembourg for the period 18 June 2026 06 UTC – 29 June 2026 06 UTC based on the calibrated and downscaled ERA5 reanalysis. "Urban" is the sealed-surface fraction of the 1 km x 1 km cell. "$UTCI_{min}$ ≥ 20 °C" counts nights on which the felt temperature never fell below 20 °C.

The most sealed area of the country, in Bonnevoie, shows the highest or joint-highest value in every stress column: 116 hours at or above strong heat stress, 41 hours at or above very strong heat stress, six nights above 20 °C, and from 24 to 27 June four consecutive nights on which the felt temperature stayed above 22 °C, with an overnight minimum of 23.8 °C on the warmest of them. The city centre, a kilometre and a half to the north, had a slightly lighter daytime burden and also six nights above 20 °C.

Figure 5 shows the hours in each stress class at the same locations, split between day and night. By day the river valleys carried a burden comparable to the capital: Remich reached 116 hours of strong heat stress, the same as Bonnevoie; Echternach, Ettelbruck, and Esch/Alzette were within a few hours of it; and all four had 35 to 36 hours of very strong heat stress. At night the picture differs. Ettelbruck had three nights with a felt temperature above 20 °C against six in the capital, and its period-mean overnight minimum was almost 3 °C lower, because the valley cooled by 20 °C or more between the afternoon and the following night on ten of the eleven days. The felt temperature in Echternach behaved the same way whereas Remich in the wider Moselle valley cooled less. The daytime thermal stress was thus shared between the built-up south and the river valleys, whereas the night-time thermal stress was concentrated in the built-up areas.

In the Oesling both stress factors were lighter. Wiltz, at 358 m, still accumulated 106 hours of strong heat stress, as many as Findel, but only 25 hours of very strong heat stress and two nights with a felt temperature above 20 °C. Eschdorf, on the plateau at 500 m, had 77 hours of strong and 11 hours of very strong heat stress, about a quarter of the Bonnevoie value, and a period-mean daily maximum 3 to 4 °C below the capital's.

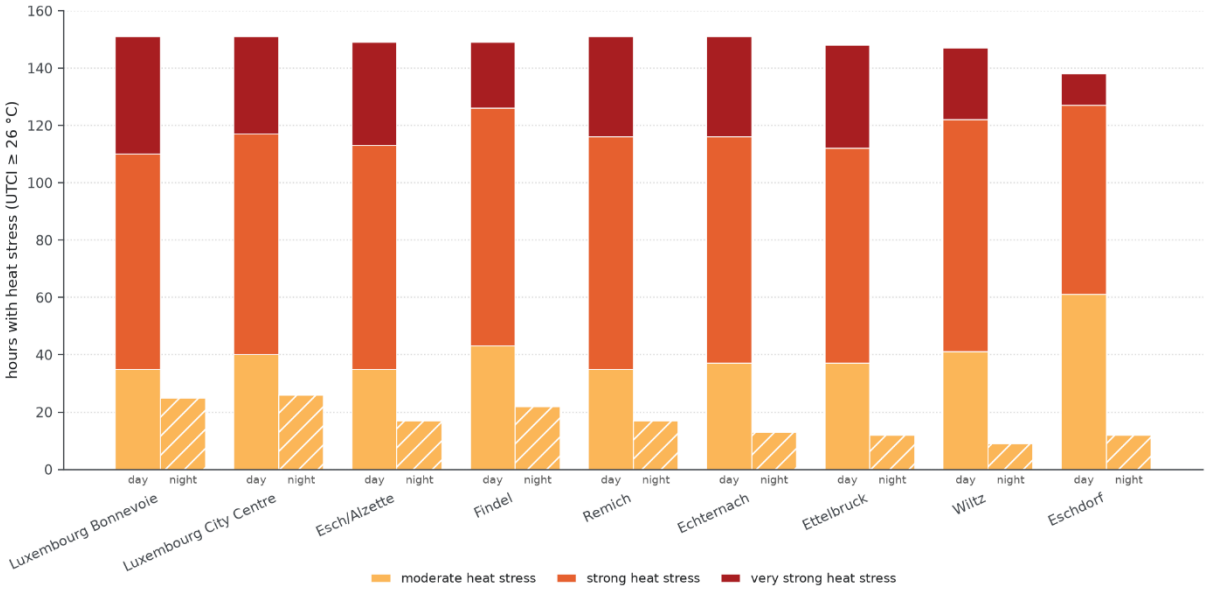

Figure 5: Accumulated heat stress exposure (in hours) for different reference locations in Luxembourg based on the calibrated and downscaled ERA5 reanalysis. The night is defined as the period from 20 UTC (22 CEST) until 05 UTC (07 CEST) the next day.

4. Discussion

4.1 Interpretation

The event brought very strong heat stress to every region of the country on at least three afternoons, and 110 hours or more at or above the strong-stress threshold to the most burdened areas: the capital, the Minett, the Moselle valley and the Sûre and lower Alzette valleys. By day the differences within the lowlands were small and only the Oesling was markedly cooler. The largest differences between places occurred at night, when the built-up south stayed above 20 °C while most rural valleys cooled below that value within a few hours after sunset. A single countrywide assessment therefore describes the daytime stress adequately but not the night-time differences, which this analysis resolves at the scale of individual towns.

Two things the data do not say should be stated just as clearly. The UTCI is an outdoor index: it describes the thermal stress experienced by a person standing outdoors averaged over a square kilometre. It does not describe conditions inside buildings, and no conclusion about indoor conditions, by day or at night, can be drawn from the values presented here. Felt temperature is also not air temperature: the peak values near 45 °C correspond to air temperatures around 40 °C; the difference comes mainly from solar radiation, weak wind, and elevated humidity.

4.2 Limitations

The limitations follow from the method. The downscaling redistributes the information of a 31 km reanalysis over the terrain and adds no new physics; the urban heat island and the nocturnal cold pools are represented statistically through the station calibration, not simulated. Only one of the calibration stations lies in a densely built-up area, so the urban term rests on a single station, and the values in the most sealed cells should be read as estimates rather than measured values. The accuracy quoted in Section 2.4 was obtained at the stations used for the calibration. Accuracy away from the stations, particularly in the most sealed cells, is likely lower.

4.3 Concluding remark

The heat wave of 18–28 June 2026 affected the whole country, but unevenly. Six days of very strong heat stress by the national daily-mean criterion, felt temperatures approaching 45 °C in the Moselle valley and four consecutive nights above 20 °C in the capital contrast with a much lower thermal stress over the high Oesling. Mapping felt temperature at the kilometre scale shows where the thermal stress of such an event is concentrated and provides a basis for targeting preventive measures. The same analysis can be repeated for future events, and for past ones.

References

Brimicombe, C., et al. (2022): thermofeel: A python thermal comfort indices library. SoftwareX, 18, 101005. https://doi.org/10.1016/j.softx.2022.101005

Bröde, P., et al. (2012): Deriving the operational procedure for the Universal Thermal Climate Index (UTCI). International Journal of Biometeorology, 56, 481–494. https://doi.org/10.1007/s00484-011-0454-1

Di Napoli, C., et al. (2021): ERA5-HEAT: A global gridded historical dataset of human thermal comfort indices from climate reanalysis. Geoscience Data Journal, 8, 2–10. https://doi.org/10.1002/gdj3.102

Fiddes, J., and S. Gruber (2014): TopoSCALE v1.0: downscaling gridded climate data in complex terrain. Geoscientific Model Development, 7, 387–405. https://doi.org/10.5194/gmd-7-387-2014

Hersbach, H., et al. (2020): The ERA5 global reanalysis. Quarterly Journal of the Royal Meteorological Society, 146, 1999–2049. https://doi.org/10.1002/qj.3803

Liston, G. E., and K. Elder (2006): A meteorological distribution system for high-resolution terrestrial modeling (MicroMet). Journal of Hydrometeorology, 7, 217–234. https://doi.org/10.1175/JHM486.1

Data sources

Copernicus Climate Change Service (C3S, 2019): Land cover classification gridded maps from 1992 to present derived from satellite observations. C3S Climate Data Store. https://doi.org/10.24381/cds.006f2c9a

Copernicus Land Monitoring Service (CLMS, 2025): High Resolution Layer Imperviousness Density 2021 (raster 100 m), Europe, 3-yearly. European Environment Agency. https://doi.org/10.2909/569736fc-5b1b-4df0-8742-f4098640e1fb

European Space Agency (ESA, 2022): Copernicus Digital Elevation Model, GLO-30. https://doi.org/10.5270/ESA-c5d3d65

Copernicus Climate Change Service: ERA5 hourly data on single levels and on pressure levels from 1940 to present. C3S Climate Data Store. Single levels: https://doi.org/10.24381/cds.adbb2d47; pressure levels: https://doi.org/10.24381/cds.bd0915c6.