Urban Heat Index Report

Kirklees Council

The report provides a summary of the Urban Heat Index data provide to Kirklees Council. It provides an outline of the methodology used and how the data can be interpreted for different use cases

Date: 3 September 2026

1 What this report tells you

This report shows where land surfaces in Kirklees Council are relatively hotter or cooler than local green spaces. It uses satellite data to create a map layer that can help Kirklees Council identify local heat hotspots and compare them with other evidence, such as housing, health, green space, transport and asset data.

The main purpose is to support practical decisions on climate adaptation, planning, public health and local investment. The report gives an overview for non-specialist readers, while the method and data sections provide more detail for Geographic Information System (GIS) users who need to inspect or use the data directly.

2 Introduction

The West Yorkshire Combined Authority contracted CAG Consultants to conduct a regional climate risk and vulnerability assessment. A key element of this climate risk assessment is understanding the temperature profile of the region. As part of CAG Consultants' social value offer, we have used the Urban Heat Index to develop an Urban Heat data layer for each of the five local authorities in the combined authority. As part of this research a local urban heat data layer was created for Kirklees Council using satellite data. The data can support work across several council functions, including:

- identifying local heat hotspots;
- combining heat data with local evidence, such as housing, health, green space or asset data;
- supporting climate adaptation and resilience planning;
- informing planning policy, business cases and funding bids;
- targeting cooling measures such as trees, shade and cool materials.

The data is provided as a spatial layer (GeoTiff files) that the Kirklees Council can incorporate into their own spatial analysis software and platform.

3 Interpreting the data

The Urban Heat Index data is provided as a "surface urban heat island (SUHI)" layer and a Urban thermal field variance (UTFVI) layer. This report is accompanied by a QGIS project file with a set of spatial layers. The key data layers are the:

- **UHI_SUHI_Median_Composite**
- **UHI_UTFVI_Median_Composite**

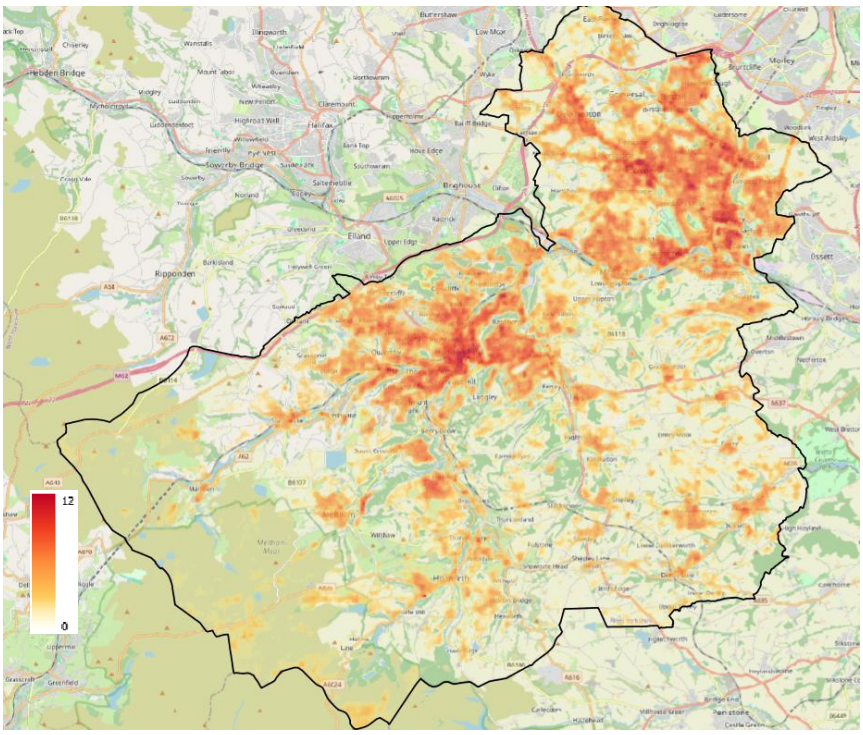
These are single-band GeoTIFF raster in British National Grid (EPSG:27700) at 30 m resolution, which can be imported directly into any GIS package such as QGIS, ArcGIS, or Python/R.

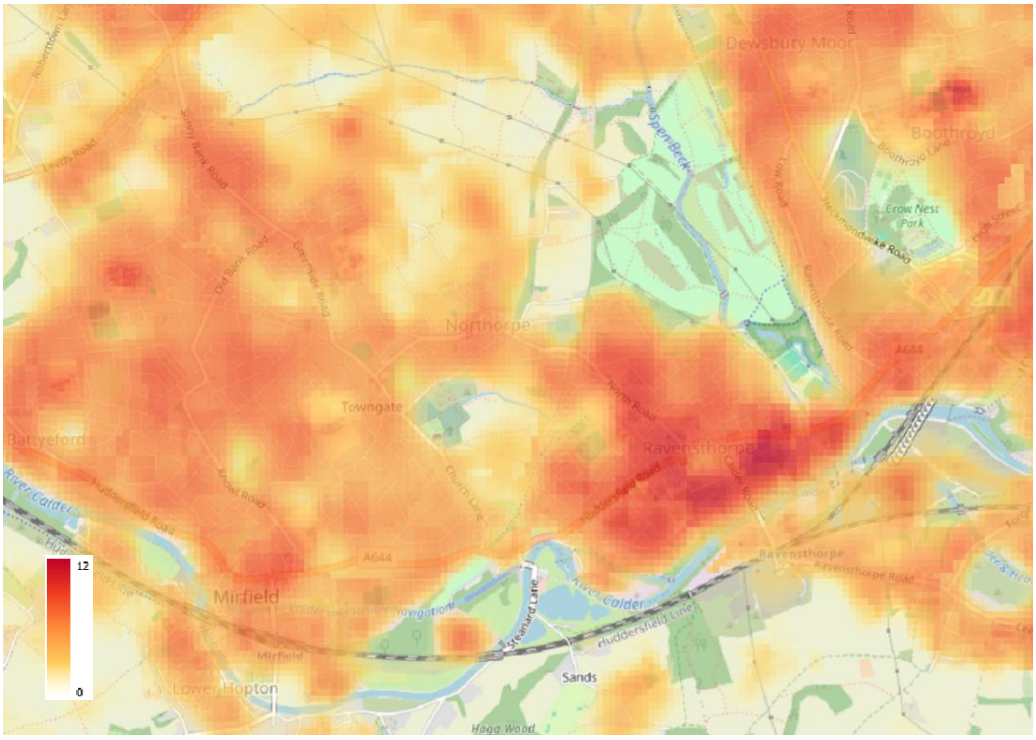
3.1 What the SUHI values mean

In the surface urban heat island (SUHI) layer, each pixel represents the degrees Celsius difference to the temperature of the vegetation in the same study area. The SUHI therefore represents how much hotter or cooler that pixel is compared to the study area's cool vegetated baseline. Specifically:

Value	Interpretation
> 0 °C	Warmer than the cool green-space baseline, a positive SUHI signal
≈ 0 °C	Similar in temperature to typical green spaces
< 0 °C	Cooler than the baseline (e.g. shaded woodland, water bodies, coastal zones)

The strongest positive anomalies (e.g. 12 °C) are generally found over dense urban cores, industrial estates, and major transport corridors, while the strongest negative anomalies (e.g. -6 °C) correspond to dense woodlands, water bodies, and coastal margins.





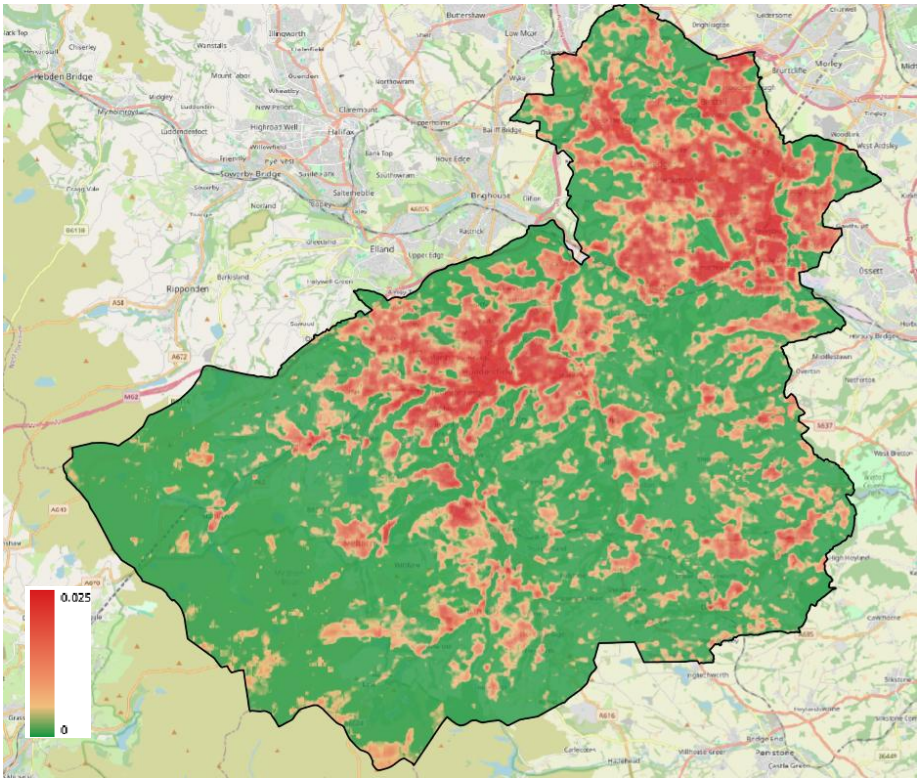
3.2 What the UTFVI values mean

Whereas the SUHI anomaly measures absolute temperature difference from a vegetated baseline (in degrees Celsius), Urban thermal field variance (UTFVI) represents the relative thermal difference from the areas overall mean[1]. The UTFVI therefore is not calculated in temperature degrees, rather each pixel expresses surface temperature as a **proportional difference from the study-area mean**.

A value of +0.010 means the pixel is 1% hotter than the landscape average, while a negative value means it is cooler than average. The index is classified into six categories of urban heat island intensity and associated ecological condition:

Legend Colour	UTFVI Range	UHI Intensity Category	Ecological / Comfort Level
	< 0.000	None	Excellent environmental quality and high thermal comfort
	0.000 - 0.005	Weak	Good thermal comfort
	0.005 - 0.010	Medium	Normal, moderate comfort
	0.010 - 0.015	Strong	Environment slightly degraded
	0.015 - 0.020	Stronger	Environment deteriorated
	> 0.020	Strongest	Highly deteriorated / Urban hotspot

[1] Predicting land use dynamics, surface temperature and urban thermal field variance index in mild cold climate urban area of Pakistan - ScienceDirect



The highest UTFVI categories (Strong, Stronger, and Strongest) are typically found over dense urban cores, industrial estates, and major transport corridors, where impervious surfaces absorb solar radiation and re-radiate it as heat. The lowest categories, including negative UTFVI values (None), correspond to well-vegetated parks, woodlands, water bodies, and coastal margins, where shading and evaporative cooling moderate surface temperatures. Because UTFVI is calculated relative to the study-area mean rather than an external reference, the classification is self-calibrating to the thermal conditions of the specific landscape under study.

3.3 Using the data

The Urban Heat Index layer can be imported into a Geographic Information System (GIS) package such as QGIS and overlaid with local datasets. This allows users to compare hotter and cooler areas with for example education facilities, health facilities, green spaces, housing, transport routes and other council assets. The heat layer can also be filtered to show only locations above a chosen temperature anomaly threshold, helping users concentrate on the areas with the strongest heat signal. The next section gives a short technical note on filtering and symbolising the layer in QGIS.

4 Method

The method uses high-resolution (30m X 30m pixel) Landsat 8-9 Thermal Infrared data[2]. The images for the base data layer for the Urban Heat Index. A composite heat layer is developed by combining five high resolution Landsat images of the study site. These images are taken from the recent past 2021 - 2026.

4.1 Image selection

Landsat 8-9 images are only taken over 16 days. As a result, there are approximately two images per month. These images, on average, include more than 75% cloud cover. Images are therefore filtered for those five that have the least percentage cloud cover. When cloud cover exceeds 95% of the study area, then these images are processed to "in-paint" the cloud gaps (see below). Images with more than 20% overall cloud cover are not included.

4.2 Temperature conversion

Landsat data is provided as Geospatial Tiff images, where each pixel has a standard "digital numbers" (DN) that represents the temperature at that time. This DN must be converted to Kelvin and then Celsius degrees. The USGS provides a scaling factor for this conversion[3].

These Land Surface Temperatures (LST) are typically more extreme than air temperature and can be higher than 60˚C. The data pack provided with this report contains the five source Landsat LST files with temperature ranges in the region of 20 - 50˚C

4.3 Surface urban heat island calculation

To better represent the temperature range, temperature data is presented in how different a particular pixel is to the "cool vegetated baseline". The intention with this calculation is to say that area X has a surface temperature that is 7˚C hotter than typical green spaces in the study area, whereas area Y us only 2˚C hotter. The Surface urban heat island (SUHI) is calculated as follows:

$$SUHI = LST - LSTbaseline$$

Where:

- SUHI = Surface Urban Heat Island
- LST = Land Surface Temperature
- LSTbaseline = Cool vegetated baseline

To calculate the "cool vegetated" baseline the vegetation in the study area is identified using the Landsat Normalized Difference Vegetation Index (NDVI)[4]. This is a different sensor on the Landsat that records red (R) and near infrared (NIR) data. NDVI is the ratio between

[2] USGS EROS Archive - Landsat Archives - Landsat 8-9 OLI/TIRS Collection 2 Level-2 Science Products | U.S. Geological Survey
[3] Landsat Collection 2 Surface Temperature | U.S. Geological Survey
[4] Landsat Normalized Difference Vegetation Index | U.S. Geological Survey

the red (R) and near infrared (NIR) and is the standard method for identifying vegetation. A threshold of >=0.4 NDVI is used (also see *Other layers*).

Once the cool vegetated pixels are identified (NDVI ≥ 0.4), their median temperature (LST) is taken as the reference baseline. The UHI anomaly for any given pixel is then defined as that specific pixel's LST minus this baseline, so that a positive value indicates a surface warmer than typical green space and a negative value indicates a surface cooler than it.

4.4 Urban thermal field variance index calculation

The Urban Thermal Field Variance Index (UTFVI) provides a second, but complementary was to measure the UHI effect. While the anomaly compares each pixel to a vegetated baseline, UTFVI[5] expresses how much a given pixel's temperature deviates from the study-area mean in proportional terms.

UTFVI is calculated as:

$$\mathrm{UTFVI} = \frac{LST - T\bar{m}ean}{T\bar{m}ean}$$

where

- UTFVI = Urban Thermal Field Variance Index
- LST = Land Surface Temperature
- Tmean = Mean Land Surface Temperature of the study area.

Temperature is converted to Kelvin is necessary because Celsius is an interval scale a value of 0 °C does not represent a true zero of thermal energy whereas Kelvin is a ratio scale, making proportional comparisons meaningful. The result is a dimensionless index: a value of +0.010 means the pixel is 1% hotter than the study-area mean, while −0.010 means it is 1% cooler.

The study-area mean is calculated using only pixels that pass a valid-LST filter (0–60 °C), which excludes cloud gaps and implausible values. Water pixels are also excluded from the mean calculation to prevent cold sea or lake surfaces from biasing the mean downward. Pixels that fail the valid-LST filter are set to no-data in the output UTFVI raster.

4.5 Combined maps

The final step in the process is to combine the per-date SUHI maps into a single composite SUHI representation of the study area and then combine the per-date UTFVI maps into a single composite UTFVI representation. For each pixel, the median value is taken across all available dates. Here the median is used because it deals with outlier dates. A single anomalously hot or cold observation (whether due to residual cloud contamination, atmospheric artefacts, or unrepresentative weather on one day) can strongly affect an

[5] Prediction of seasonal urban thermal field variance index using machine learning algorithms in Cumilla, Bangladesh - ScienceDirect

arithmetic mean, whereas the median remains stable as long as most dates in the stack are reliable.

5 Annex: Technical note for GIS users

5.1 Filtering and symbolising in QGIS

Once loaded, the layer can be styled to emphasise the UHI effect:

Show only pixels warmer than the baseline (> 0 °C):

- Open Layer Properties → Symbology.
- Set Render type to Singleband pseudocolor.
- Set Min to 0 and Max to a suitable upper bound.
- Choose a sequential colour ramp (e.g. yellow–orange–red, or the Viridis "plasma" ramp).
- Values below 0 °C will either be left transparent or coloured in a cool tone (blue–green) to distinguish them from the UHI signal.

Cap the maximum displayed temperature:

In the same Symbology panel, set Max to your desired ceiling (e.g. 10 °C). Any pixel above that value will be clamped to the maximum colour, preventing a few extreme pixels from compressing the colour scale.

5.2 Other layers

The data pack also includes the following layers

Vegetation - NDVI_Composite.

This is a single-band GeoTIFF containing the median Normalised Difference Vegetation Index (NDVI) for the study area, composited from all available clear-sky Landsat 8/9 observations across the specified year range (e.g. 2023–2026). NDVI values range from −1 to +1, where values near or below zero represent water, bare soil, and impervious surfaces; values from ~0.2 to 0.4 represent sparse or mixed vegetation; and values above 0.4 indicate dense, actively photosynthesising green cover such as parks, woodlands, and playing fields. This layer is the same one used to identify the cool vegetated reference pixels in the UHI anomaly calculation, and is provided so that users can inspect the relationship between greenness and surface temperature across the study area.

Five Landsat_LST_Celsius

These are the per-date clear-sky Landsat land surface temperature (LST) rasters for the five individual acquisition dates that were composited into the final median anomaly map. Each is a single-band GeoTIFF in degrees Celsius, reprojected to the same 30 m British National Grid (EPSG:27700) as all other layers. Only pixels that passed the conservative cloud, cloud shadow, cirrus, and snow QA filter (Landsat Collection 2 QA_PIXEL bits 0–5) are retained; all other pixels are set to NoData. These layers allow you to inspect conditions on individual

dates, assess how cloud cover varies across the study area, and understand which observations contributed to the multi-date composite.

Council boundary and bounding box layers

These are vector (shapefiles) reference layers provided for spatial context. The council or local authority boundary polygon defines the administrative extent of the study area and can be used for clipping, zonal statistics, or masking the raster outputs to the authority's jurisdiction. The bounding box layer is a rectangular polygon showing the full extent of the 30 m master grid to which all raster data have been aligned. These are in British National Grid (EPSG:27700) and can be overlaid on any of the raster layers for orientation and map production.