

Emissivity Inputs for High Resolution LST Retrievals and Downscaling

Charlotte Paton^{1,2}, Darren Ghent^{1,2}, Mike Perry^{1,2}, John Remedios^{1,2}

¹ University of Leicester, Earth Observation Science, School of Physics and Astronomy, UK

² National Centre for Earth Observation, Space Park Leicester, University of Leicester, UK

1 Introduction

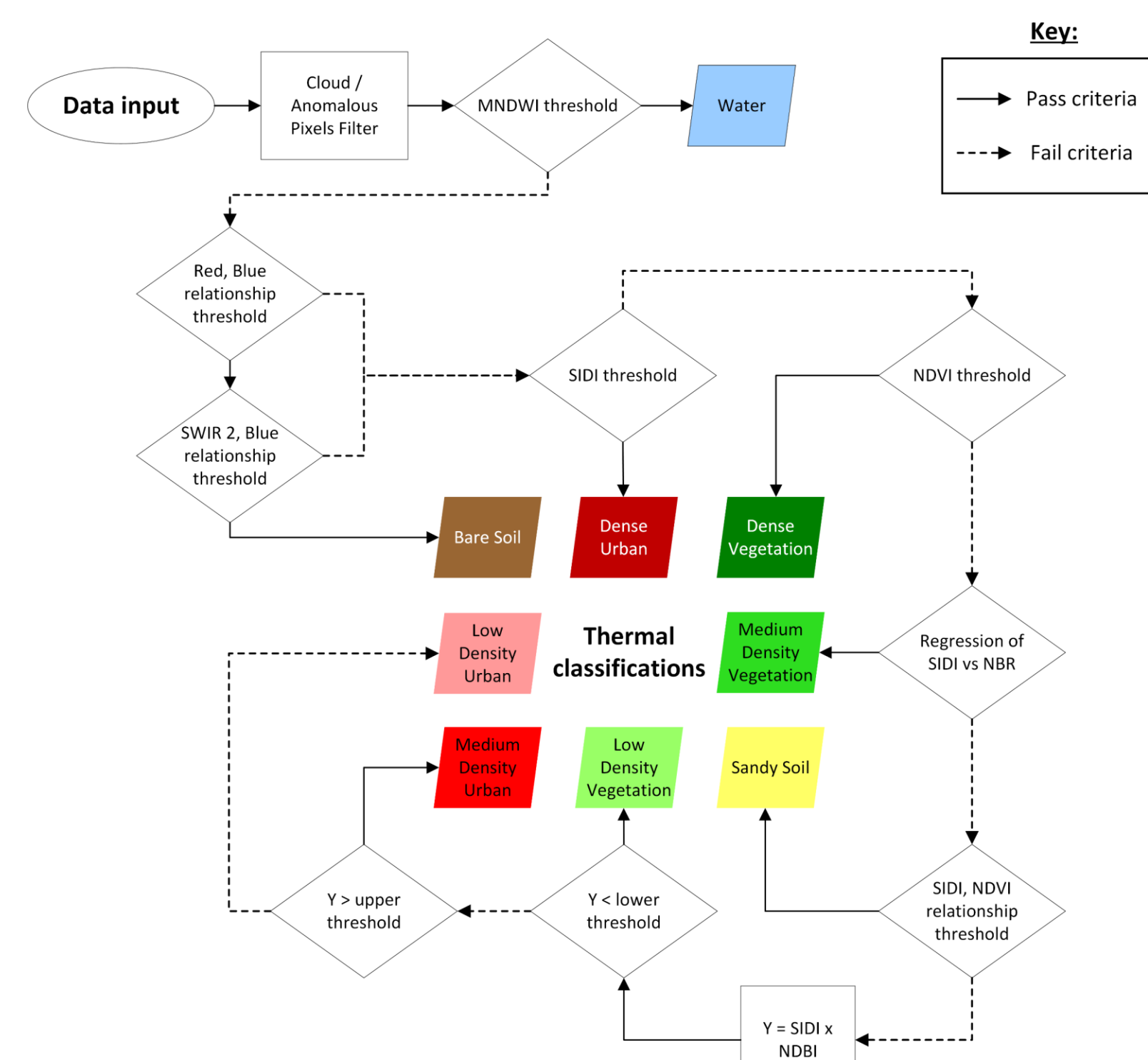
LSTs derived from satellite measurements are highly affected by atmospheric effects as well as surface radiative and thermodynamic properties, of which, emissivity (defined as the ratio of the radiance emitted by a given object to that emitted by a black body at the same temperature) can be selected as a key factor. However, many operational satellites do not have enough TIR channels to simultaneously retrieve both LST & LSE parameters. Therefore, auxiliary datasets are frequently used to provide this information instead.

Current methods to determine LSE values frequently possess limitations, especially over urban areas, as they frequently only partitioning land into vegetation and soils. Where urban landscapes are considered, they are often described by a single land-use classification which is insufficient to fully document their heterogenous nature.

In order to address this we :

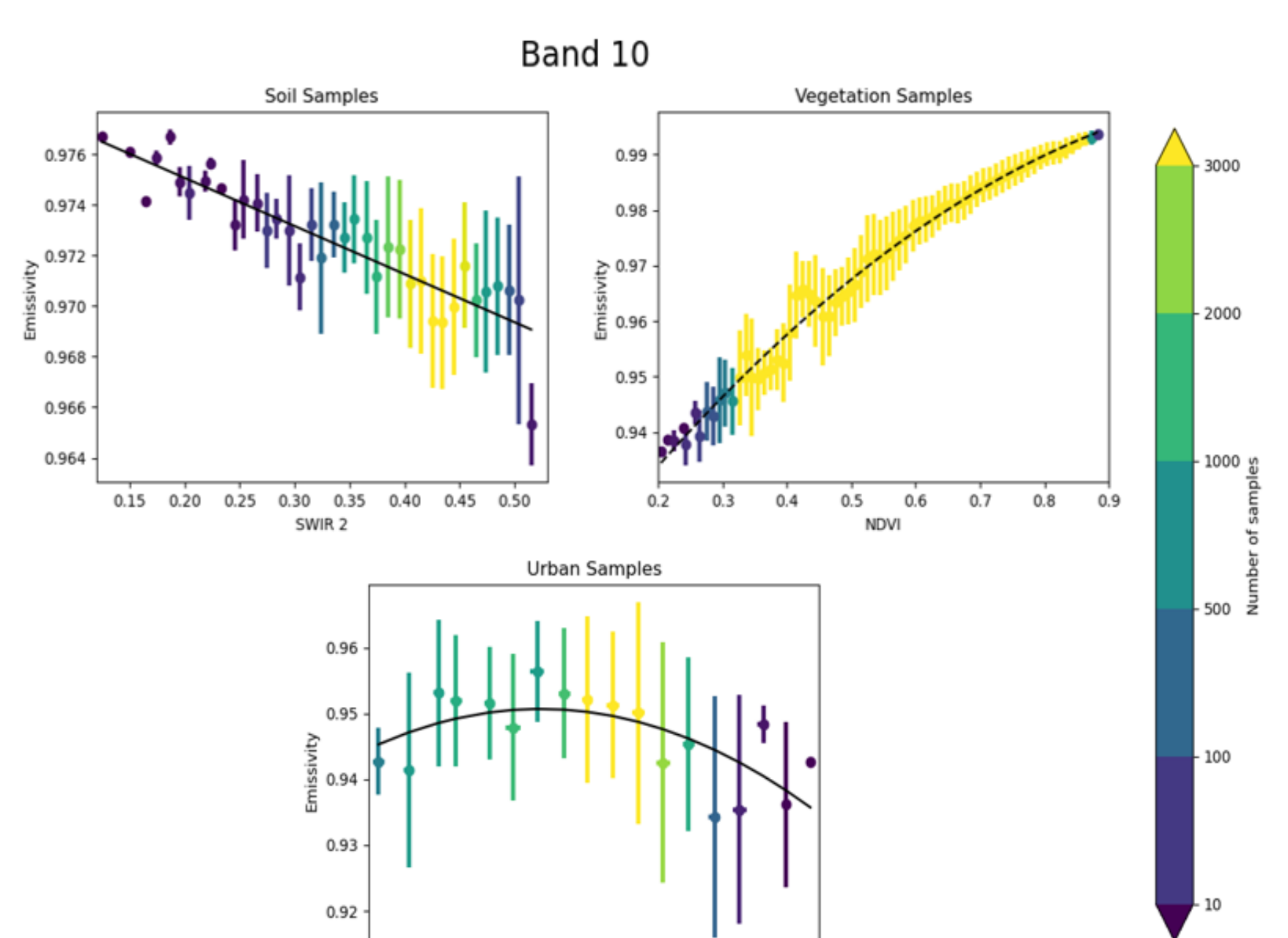
- 1) Generate a novel classification algorithm based on the thermal properties of surfaces
- 2) Utilise the classification algorithm for better representation of surface emissivities and, consequently, enhance estimation of LSTs

2 Method



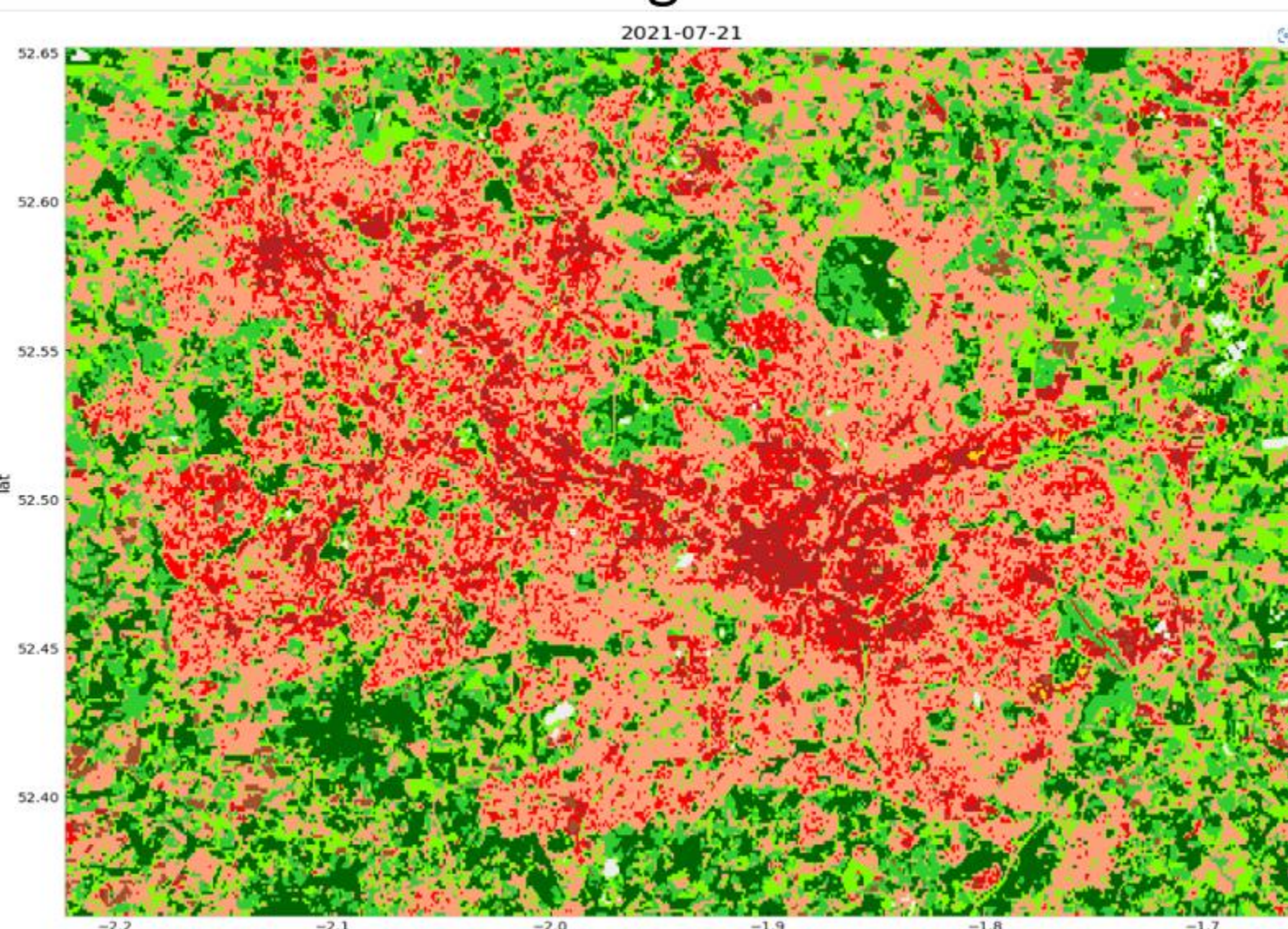
Samples from the ECOSTRESS & SLUM spectral libraries are partitioned into soil, vegetation and urban groups and relationships between a given VIS / SWIR parameter and the library emissivity values are derived. By then running the spectral library samples through the thermal classification, scaling factors are calculated. A pixels classification, and VIS / SWIR properties therefore allow for a unique LSE per pixel

Data is acquired from Landsat 8 & 9 satellites at 100m spatial resolution, and series of indices are calculated using VNIR / SWIR bands. The scheme then works, through a series of statistically derived thresholds on the relationships between indices, to partition land into 8 classifications; three densities (low, medium and high) of urban and vegetation expanse as well as additional classifications for bare soil and coastal regions.



3 Results

Birmingham UK

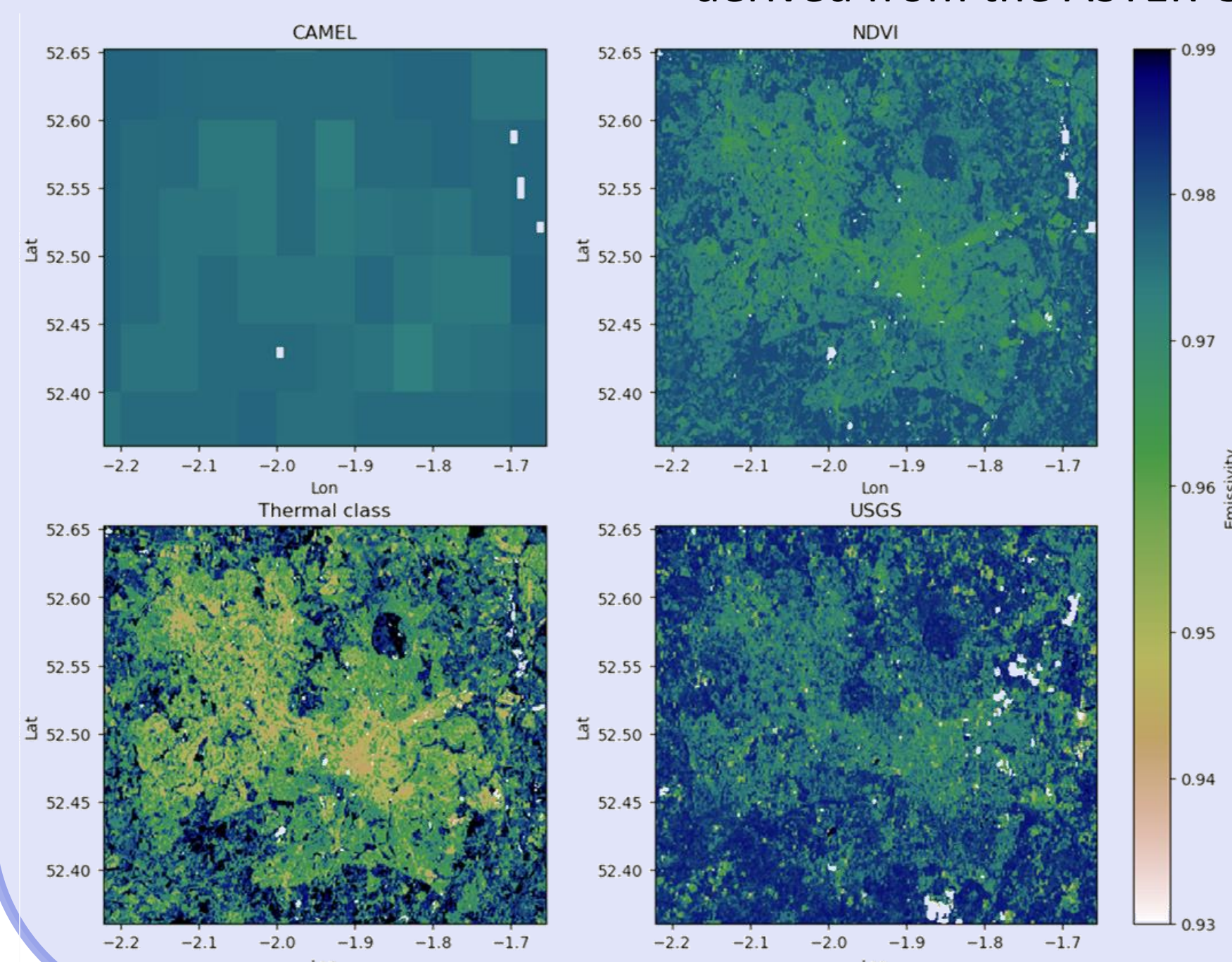


Output Classifications:
Dense Urban
Mid-density Urban
Low-density Urban
Dense Vegetation
Mid-density Vegetation
Low-density Vegetation
Sandy Soil
Bare Soil

The classification shows denser urban regions situated towards the centre and a gradual reduction towards vegetation in the surrounding rural locations. This gradient reflects typical urban morphology, consistent with the concentric nature of UK cities. Further, the classification is able to effectively delineate between fine scale structures such as parklands, roads, and airports. Additionally, seasonal changes in both the distribution and volume of each thermal classification are also noticeable.

Emissivity Comparisons

Using a scene over Birmingham, UK, on 27th June 2018 four different LSE methods could be compared; from the CAMEL database, using a common NDVI method, through the thermal classification created within this work, and USGS' Landsat 8 emissivity product derived from the ASTER GED



The CAMEL database results in LSEs that are inadequate for depicting the fine scale differences in an areas structure whilst NDVI and USGS methods both have a smaller range in emissivity due to a lack of lower end values. This results in much smaller differences between emissivity ranges for vegetation and urban classifications. Each method also features unique differences, such as USGS having a much less defined urban / suburban boundary

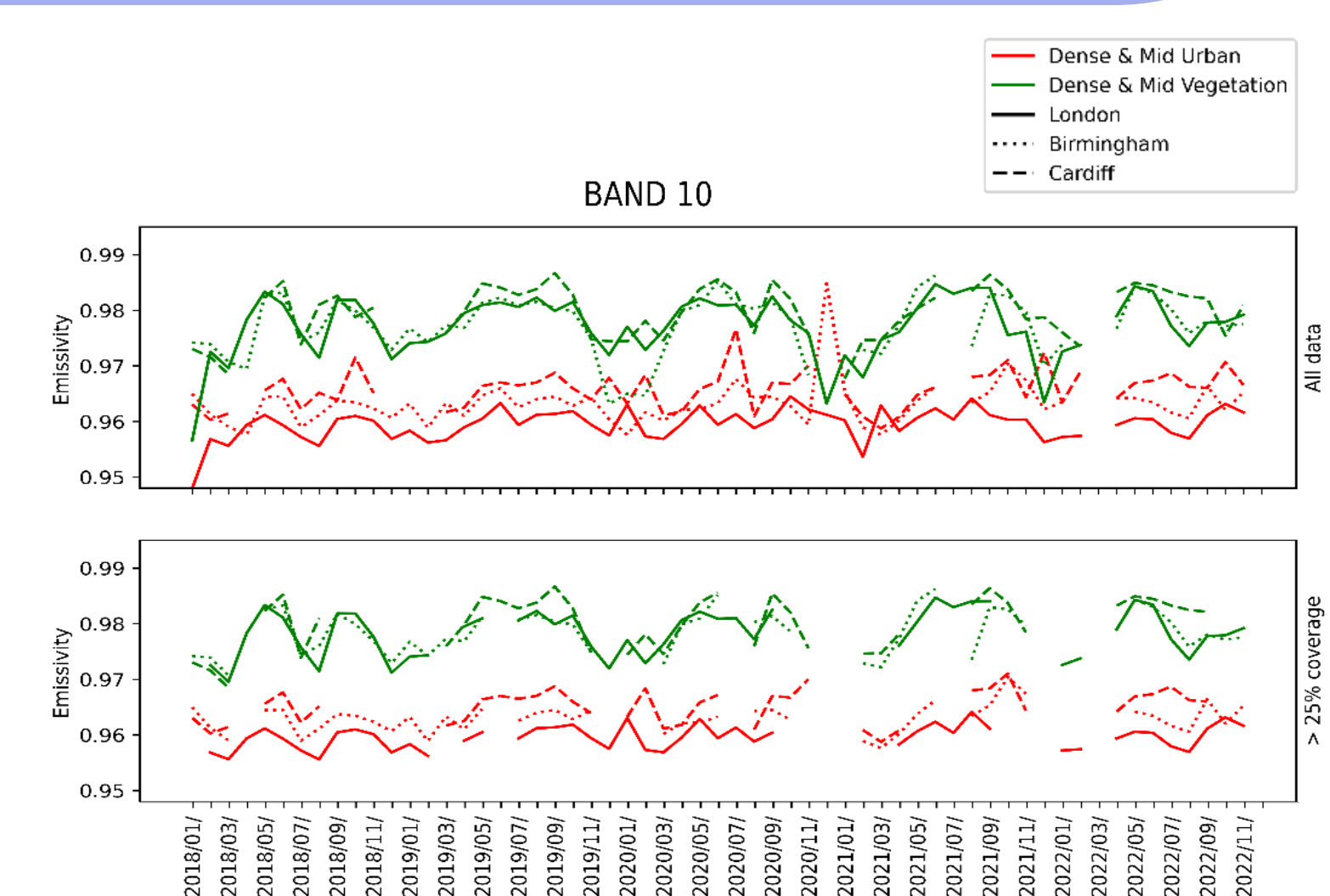
Classification Comparisons

Ray Hall Triangle in the West Midlands takes its name from the characteristic configuration that connects the M6 and M5 motorways



Under the CORINE classification, the land within the triangle is classified as industrial use, and to the side is classified as discontinuous urban fabric. Within the thermal classification scheme however, all of the pixels shown are determined to be vegetation. Whilst the two schemes therefore show significant disagreement the thermal classification more closely aligns with actual surface materials. It is therefore expected that it would much more representative of the highlighted pixels thermal properties.

LSEs follow the same patterns as the thermal classification with lower values towards the city centres. Harsh boundaries between pixels values are infrequent, and where they do occur these areas exhibit much greater contrast in surface properties such as large parklands and the surrounding urban landscape. Seasonal cycles in LSE can also be observed with vegetation classifications showing greater differences. This can be attributed to the phenological cycles of vegetation.



Outliers to time series of LSE are found during winter scenes as a results of a significant reduction in data points due to cloud. These are removed when considering pixels >25% coverage