MODELLING THE IMPACTS OF CLIMATE CHANGE ON CITIES: HEAT RELATED IMPACTS ON TUBE PASSENGER DISCOMFORT

ARCADIA FACTSHEET 8
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Underground railway systems can become very warm leading to passenger discomfort. This can become particularly problematic during periods of high temperature. Longer-term effects of climate change on passenger discomfort may also be an important consideration for railway planners. This factsheet highlights the effect of climate change on passenger discomfort in London and an initial assessment of adaptation options aimed at lowering temperatures.

Context

- Underground railway systems generate heat from the operation of trains, equipment, and passengers. This heat raises tunnel and station temperatures above background soil temperatures.
- Hot weather, ventilation assets, changing passenger demand and service expectations have all caused increased attention on thermal comfort on underground railway systems such as London's Tube.
- Of particular concern for London is deep level tube lines which tend to be the warmest, and have limited capacity for natural ventilation and limited space for saloon cooling.
- Improvements to ventilation and saloon cooling will be important to consider.
- However, a longer-term assessment of the effects of different climate change scenarios will also be important to help inform longer-term planning by railway and infrastructure operators, particularly those with limited space for saloon cooling.

Method

- The focus is on passenger discomfort on tunnelled sections of the Bakerloo, Central, Jubilee, Northern, Piccadilly, and Victoria lines (fig.1).
- These are deep level lines and do not currently have cooled trains.
- An external maximum temperature threshold of 27° C is used to define days when passengers will start to feel discomfort on the these lines.
- The temperature threshold are applied to current and future temperature time-series data, provided by the urban spatial weather generator, to provide spatial footprints of daily heat events.

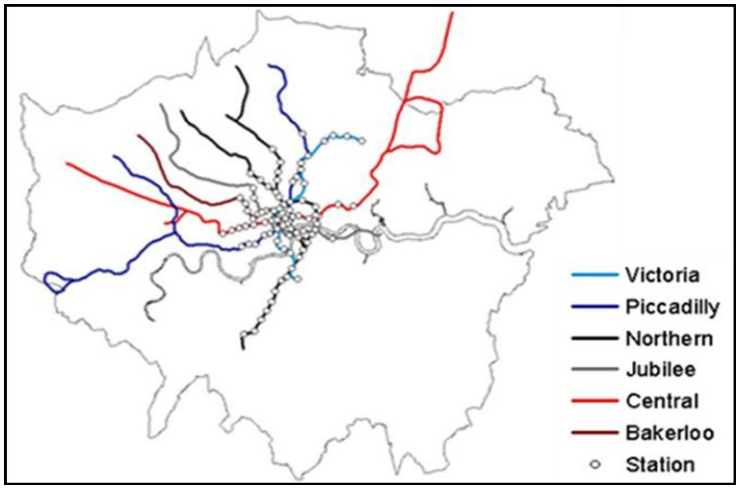

Fig. 1: Geographical position of Tube lines and underground stations covered

- For each Tube line internal temperature data from London Underground (LU) allow ticket hall, station, and train temperatures to be estimated as a function of the external temperature.
- Using this data the number of passengers who are likely to be satisfied or dissatisfied with thermal conditions on the Tube are calculated using a thermal comfort model provided by LU.
- The thermal comfort model considers factors such as outside conditions, duration in the environment and air movement to capture how thermal sensation may vary across a Tube journey.
- As an air conditioned train is expected to be 2 to 4°C cooler than a non-air conditioned train the benefits of adaptation via air conditioning is assessed by adjusting estimated train temperatures by 2 to 4°C.

Future temperatures on the LU

- Internal temperatures were predicted to increase from the baseline on all Tube lines assessed under future scenarios of climate change.
- By the 2050s (high emission scenario) temperatures on the deep level lines increase from the baseline by 1.5 to 1.8°C, 1.2 to 1.3°C, and 1.4 to 1.6°C for platforms, ticket halls and trains respectively (fig. 2).
- If anthropogenic heat emissions also increase by 50% from the present day temperatures increase by an additional 0.2 to 0.3°C.

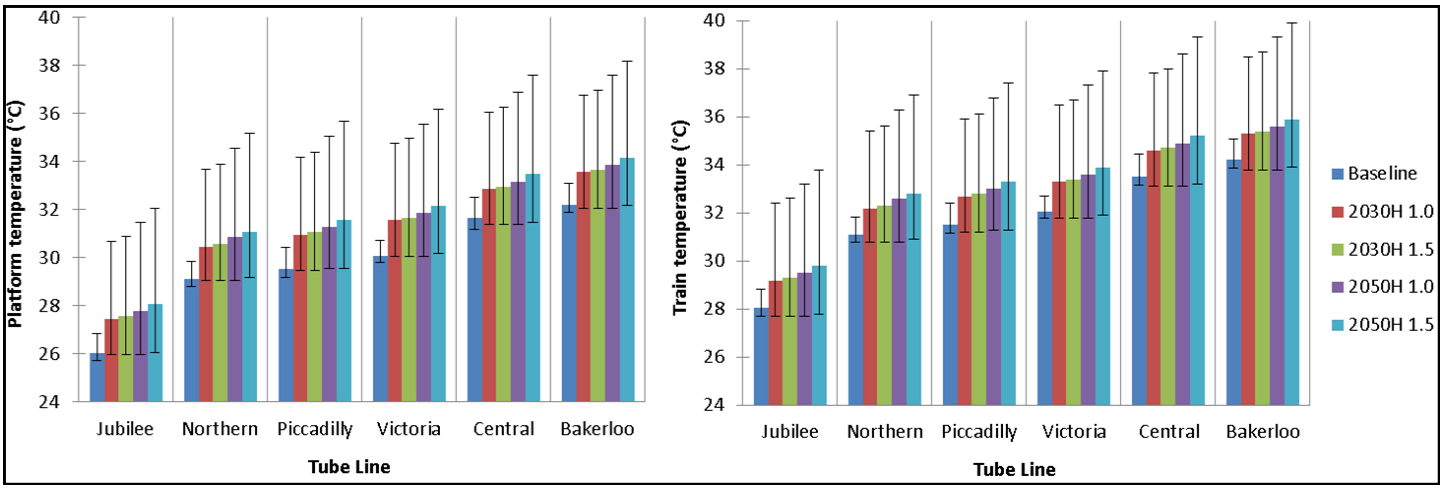

Fig. 2: The impact of various climate change scenarios on internal platform and train temperatures (median results). Black lines denote the 10th and 90th percentile

- The spatial distribution of temperatures across Tube lines can also be mapped (fig. 3).
- This is important to consider for adaptation planning and for identifying specific risk hot spots.
- Median results for the 2050s (high emission scenario, 50% increase in present day anthropogenic heat emissions) result in train temperatures of 34 to 36°C across the Bakerloo and Central lines.

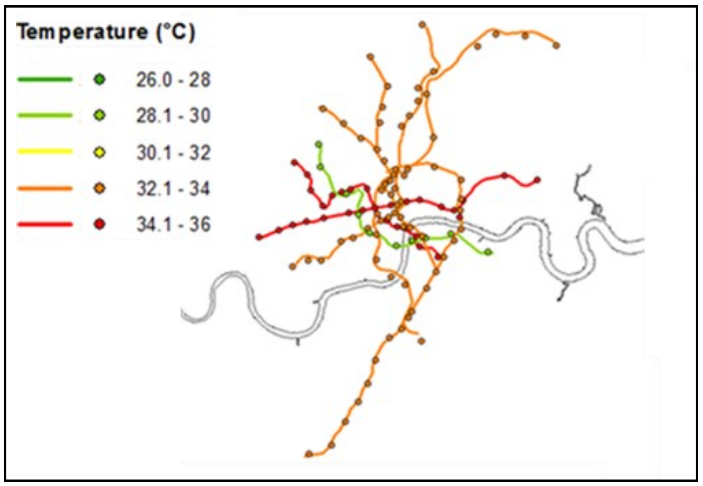

Fig. 3: Spatial pattern of maximum daily temperature on trains (2050 high emission scenario, median result)

Passenger discomfort on the LU

- The Central and Bakerloo lines appear particularly problematic in terms of passenger discomfort.
- As well as saloon cooling further infrastructure measures to reduce tunnel and platform temperatures will be required.
- On the Northern, Piccadilly, and Jubilee lines noticeable benefits could be gained from saloon cooling (fig. 4).
- LU's Deep Tube Programme is proactively investigating ways to provide further capacity as well as saloon cooling as part of upgrades.
- This method can also be informative for other railway and infrastructure operators around the world facing similar issues.

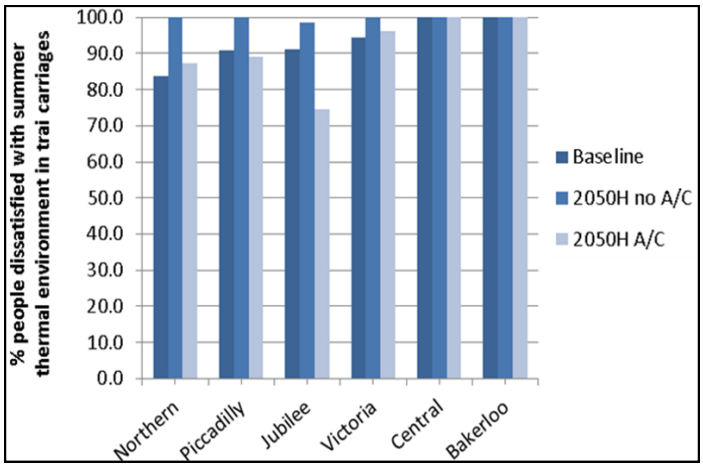

Fig. 4: The effect of air conditioning on passenger discomfort on trains (median results for the baseline and 2050 high emission scenario) assuming air conditioning provides in train cooling of 4°C

For additional information see:

- ARCADIA website: www.arcc-cn.org.uk/project-summaries/arcadia/
- ARCADIA Factsheet 2