High temperatures, delays and the London Underground

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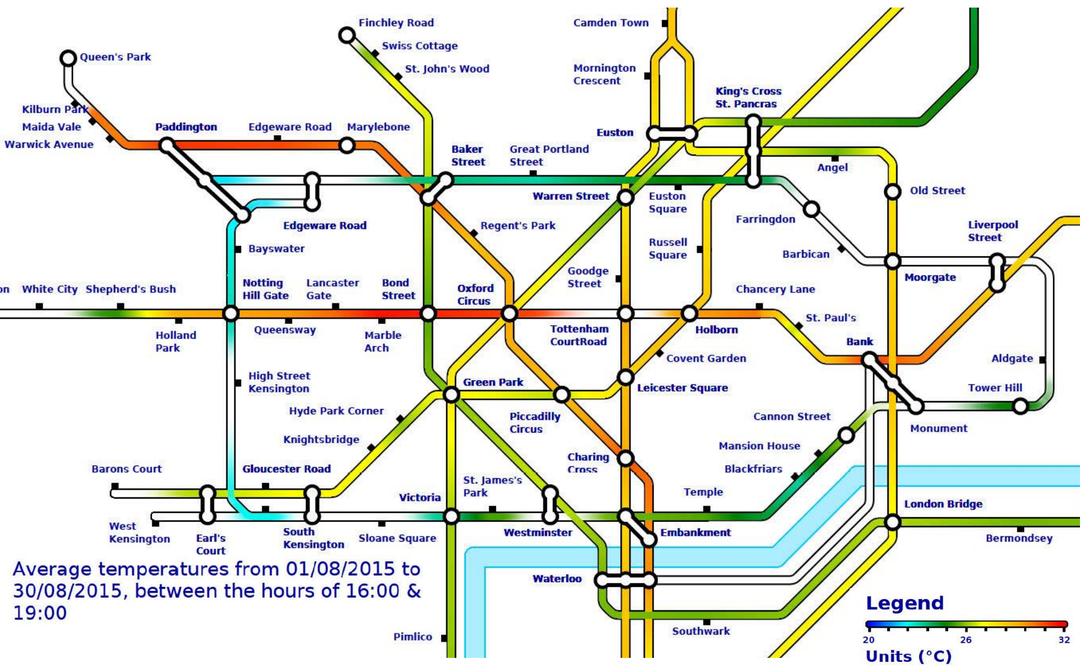
1. Heat on the London Underground network

- High temperatures cause problems for railway infrastructure in general e.g. track buckling, signal failures and carriage overheating.
- Failure of these assets leads to disruption and delays to customers, as well as significant financial costs to TfL.
- Track speed restrictions can be enforced to mitigate the risk of track buckling but this also leads to delays as the service is slowed down.
- Heat is exacerbated underground due to train braking, passengers and re-radiation from tunnel walls. Asset failures underground risk increases in thermal discomfort and consequently, further delays.
- As extreme heat events increase under future climate scenarios, more asset failures and delays are expected without climate adaptation.



2. Approach

Meteorological data (MIDAS) ⟷ Delay data* (LCH) Lost Customer Hours

Statistical testing between delays and temperature (per 1°C)

Delay metrics:
Mean daily frequency
Mean daily length
Mean daily LCH
Mean delay length
Mean delay LCH

Variables:
By line
By location
By asset type

↓

Identify annual number of days above critical upper temperature thresholds for rail infrastructure (24°C)

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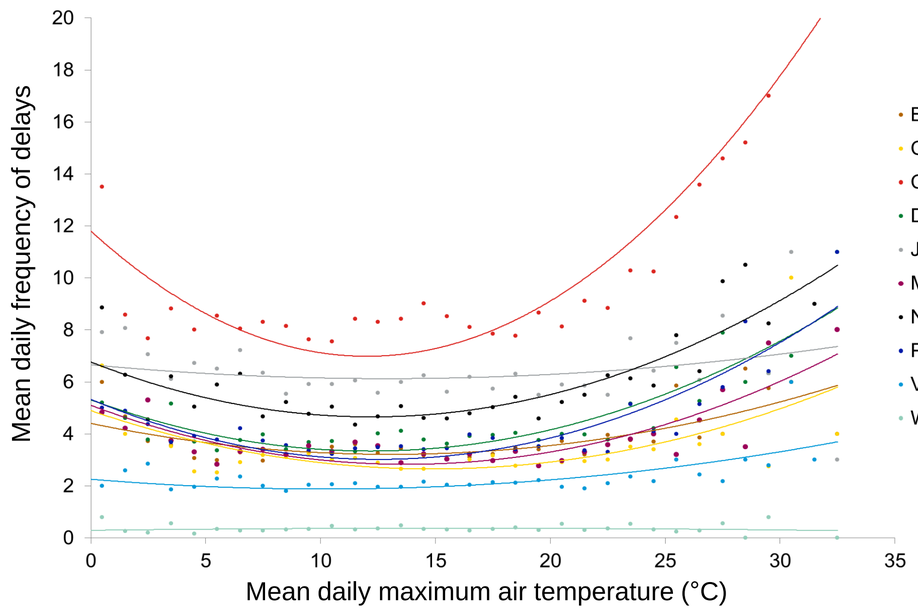
Apply UKCP09 projections to identify change in annual number of days reaching these thresholds

*asset only data: all customer/staff related delays removed

3. Metrics vs. Variables

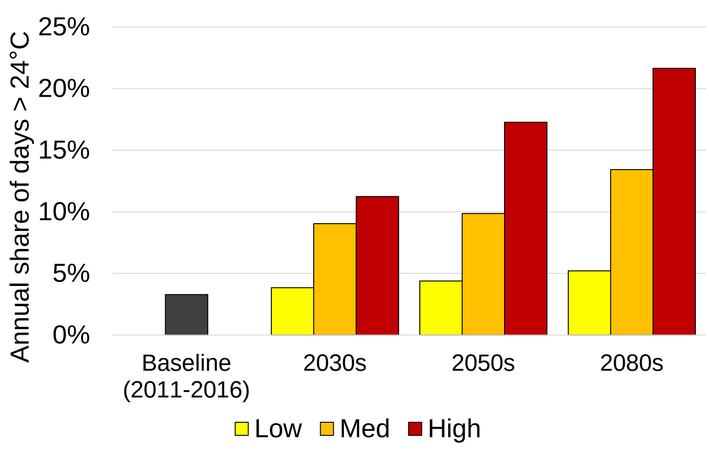
- Change in mean daily frequency of delays is the metric most closely correlated to change in temperature **though this does not determine causality**.
- These relationships differ significantly across the variables tested.



- Of the Underground lines, the **Central line** has the highest frequency of delays with increasing temperatures. This is mainly due to fleet, often associated with heating and ventilation component failure: 2 x 13 minute delays per hot day on average.
- Combined **Circle & Hammersmith, Metropolitan, Northern and Piccadilly line** data shows a strong relationship between temperature and delays within station infrastructure assets. These are mostly lift and escalator failures, but delays are short in length (less than a minute) on a hot day.
- Signalling asset failures due to blown fuses and cable faults on the **District line** show a relationship to heat, from as low as 15°C. Delays are infrequent but long (over 1 hour) on a hot day.
- Spatial analysis was limited due to the quality of data and subjectivity of cause attribution. However, a high-level analysis was carried out comparing in-operation delays between stations below and above ground (as only 45% of the system is below ground). Most delays in a day take place below ground, **until temperatures exceed 25°C** and then more occur above ground.

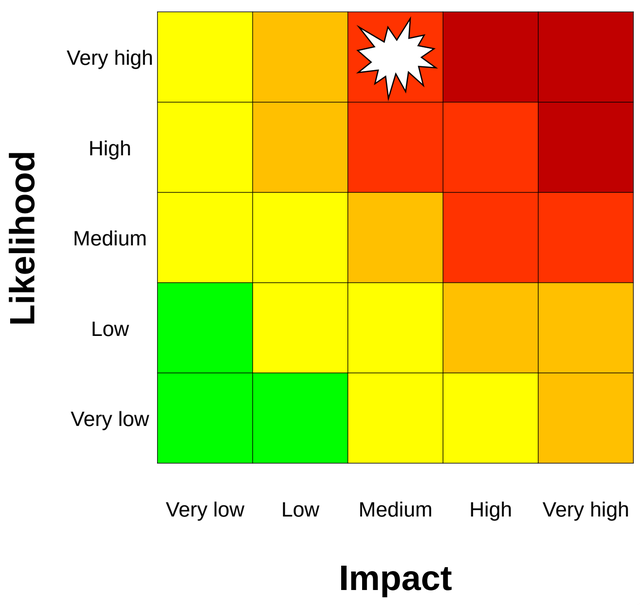
4. Climate Projections

Using UKCP09 projections, the annual number of days exceeding 24°C is expected to increase. Assuming similar future asset performance, and that delays increase due to exceedance of the temperature threshold, the share of annual delays also increases. This increases from a 4.4% baseline, up to 28.8% in the 2080s, high emissions scenario.



5. Implications

- The extreme heat hazard to London Underground is of medium impact and very highly likely, and actions can be taken based on that assessment.
- International mitigation will affect emissions scenarios and consequently the local adaptation actions needed.
- A different adaptation approach (and further research) is required regarding below and above ground assets on the London Underground.
- Measuring and publishing delay frequency amongst several transport networks is an opportunity to benchmark and compare climate resilience.



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