Predicting highly-resolved traffic noise (using data available as a by-product of Urban Traffic Management and Control systems)

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Background

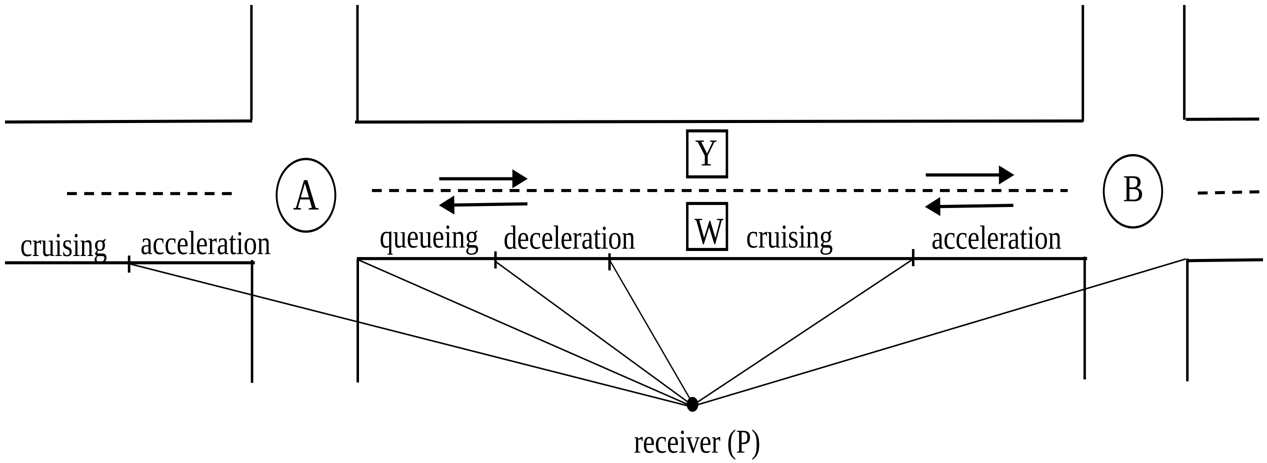
- Modelling noise has been a topic since the 1960s.
- Since the END 2002, there has been the need for noise maps every 5 years in ‘agglomerations’ – last 2017

- Recognition that we can calculate noise very well for freely-flowing traffic conditions, but less well for interrupted flows
- Can we use the wealth of UTMC information to assist in calculation and mapping?
- Can we control for noise? (and would we want to?)

A Spatio-Temporal Model

Spatially:

- We have a network made of ‘nodes and links’
- We have a fleet of multiple vehicle types (car, MGV, HGV/Bus)
- Our vehicles have four operational modes
  - Cruising, Accelerating, Decelerating, Idling



Temporally, we have two operational modes:

- Uninterrupted operation under a green signal
- Interrupted operation by a red signal

Calculating Sound

- Use CNOSSOS-EU based procedure
  - Calculate Sound Power Level (SPwL)
  - 2x sources on an individual vehicle (Rolling & Power)
  - 8x octave bands for broadband total

- Calculate look-up table of Sound Exposure Level values (SELs) for individual vehicle modes
- Scale by vehicle flow in mode
- Propagate and convert contributions from all sources to get L_{Aeq} levels

Calculating Sound (Simplified…)

Basic CNOSSOS-EU Sound Power (speed and vehicle type dependent):

- $L_{Veh} = f(L_{power} + L_{rolling})$, $L_{rolling} = a + b\ log_{10}[\frac{V}{V_{ref}}]$, $L_{power} = c + d\ [\frac{V - V_{ref}}{V_{ref}}]$

Correction of Sound Power to SELs (speed and geometry dependent):

- $SEL_{Veh} = L_{Veh} - 10log_{10}v + 10log_{10}d + 10log_{10}a - 10log_{10}[4\pi d'^2] - \Delta Lg$

Sound 'Energy' contribution from a vehicle class in a period:

- $E_{Veh} = 10log_{10}[(10^{0.1E_{Veh,idl}}.Q_{Veh}) + (10^{0.1E_{Veh,cru}}.Q_{Veh}) + (10^{0.1E_{Veh,acc}}.Q_{Veh}) + (10^{0.1E_{Veh,dec}}.Q_{Veh})]$

Correction to $L_{Aeq,T}$:

- $L_{Aeq}(T) = 10log_{10}[\frac{1}{T}(E_{car} + E_{MGV} + E_{HGV} + (T - Q_{car} - Q_{LGV} - Q_{HGV}).10^{0.1L_{back}}]$

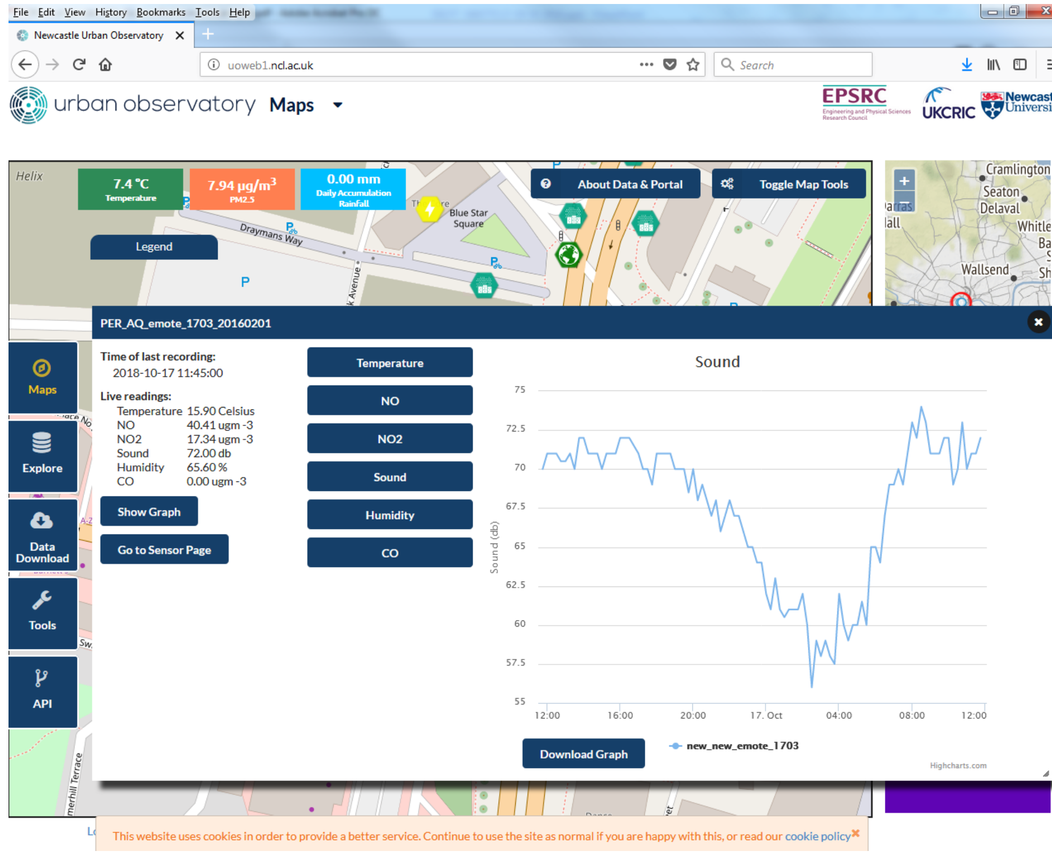
We're glossing over loads of assumptions regarding CNOSSOS parameters (e.g. road surface) here! – see also Paoprayoon *et al.*, 2005 and Watts et al., 2004

Where to get Traffic Data?

- Use Newcastle City Council's SCOOT (Split, Cycle, Offset, Optimisation) system (TRL UK, Hunt *et al.*, 1981)
- Data either measured or generated from SCOOT used in this research include:
  - Flow: an estimate of stop-line arrival flow in veh/h or veh/5min;
  - Delay: an estimate of the total delay experienced by all vehicles arriving at the stop-line, in units of 1/10th vehicle hours/hour;
  - Occupancy: the number of quarter-second intervals a traffic loop detector embedded in the road pavement is occupied by vehicles during the overall time period (in this study 5 min)
- Collected via NUIDAP (Newcastle University Integrated Data Access Platform)

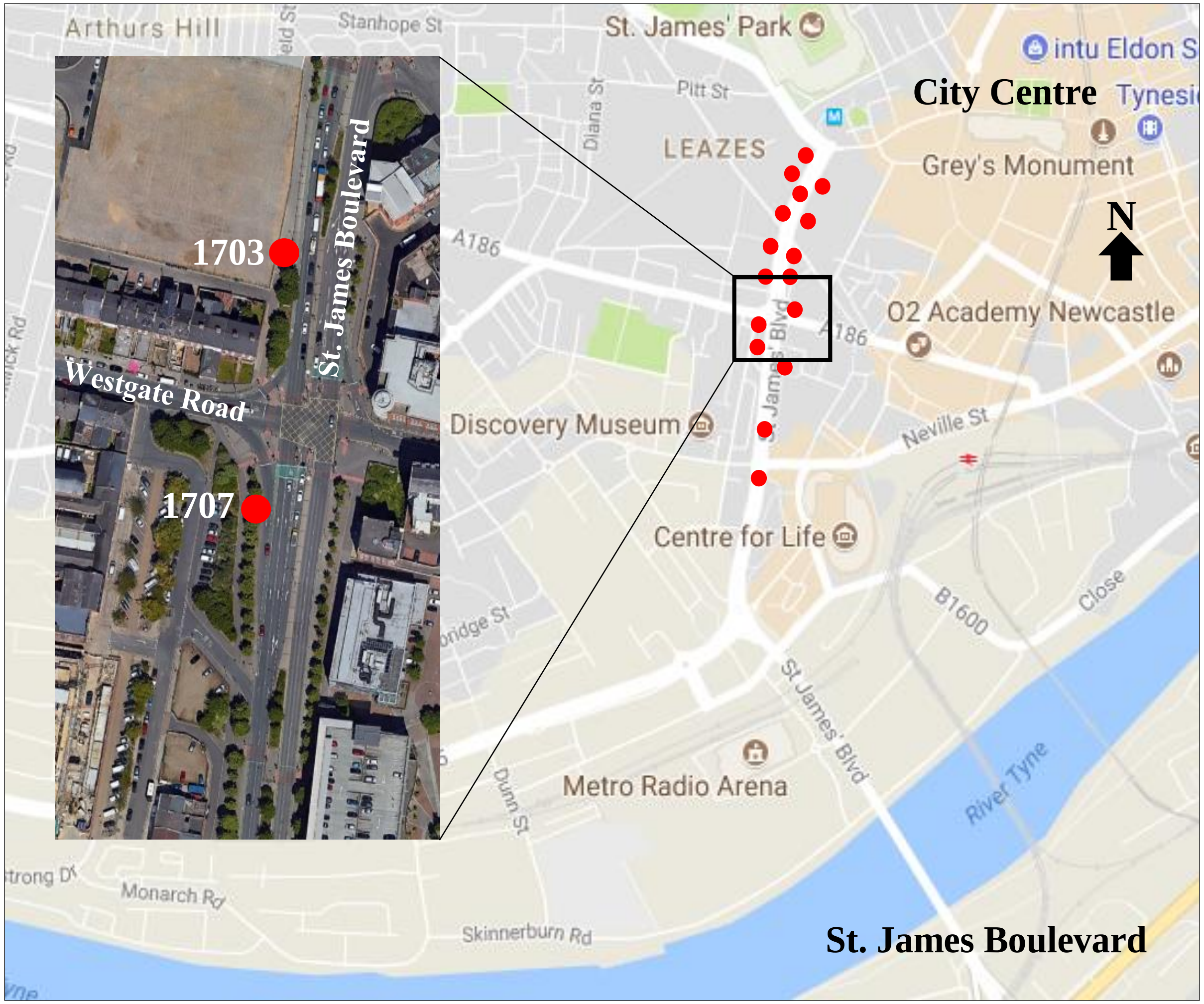
How to Calibrate/Validate?

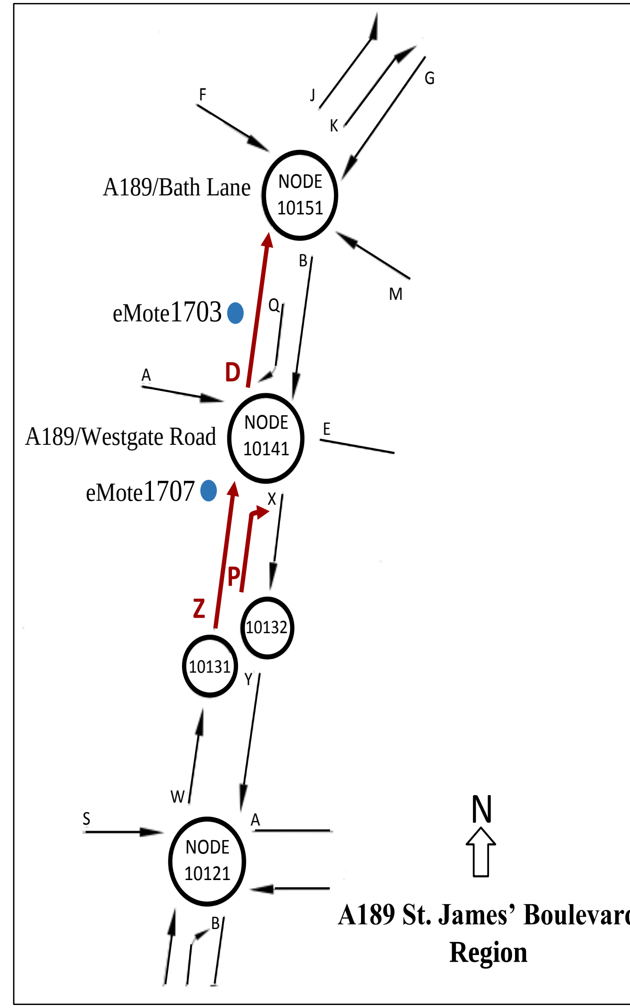
- Use data collected from inexpensive eMote sensors



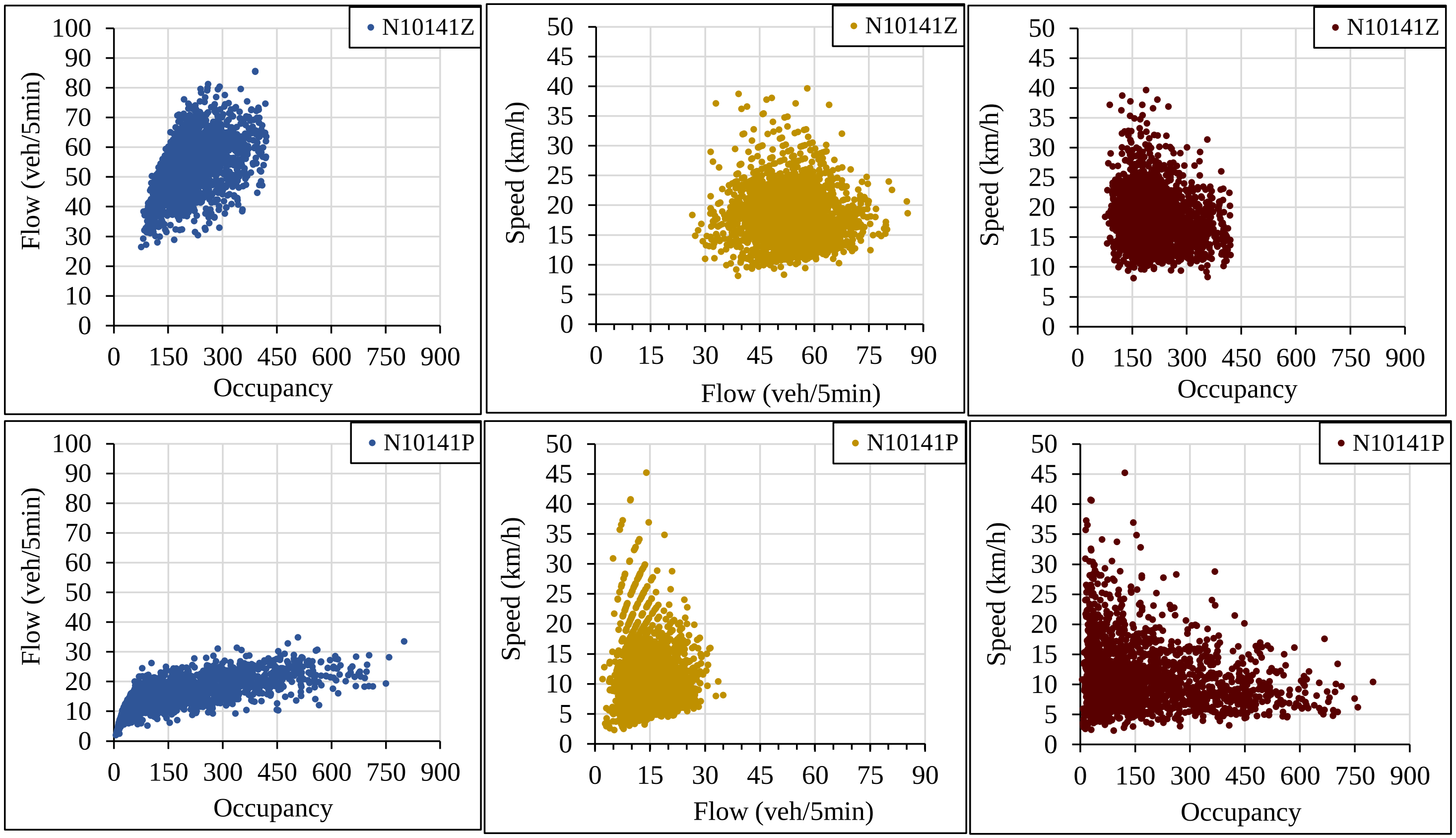
- See for yourself at: www.urbanobservatory.co.uk

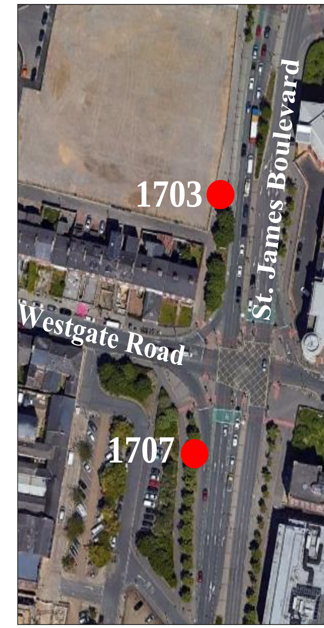
Study Area – eMotes 1707, 1703

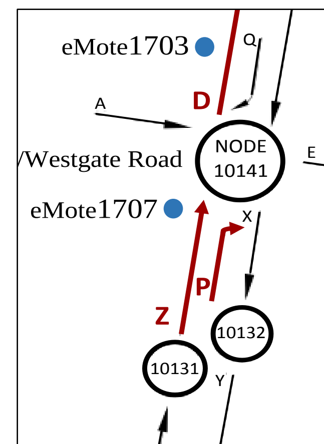




Sample SCOOT data (Flow, Occupancy, Speed)

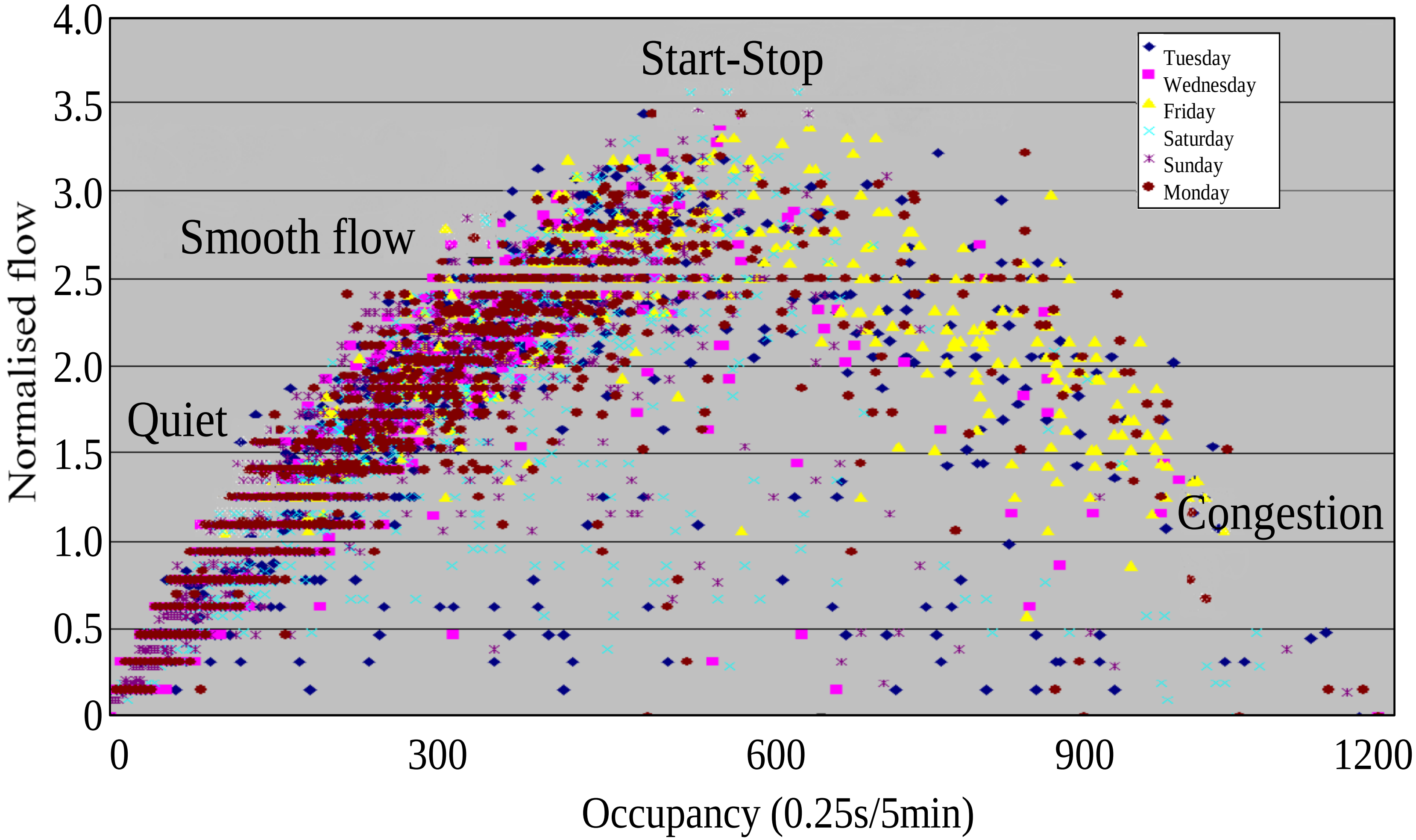






- Link 10141Z is straight-ahead flow, 10141P is a right-turn pocket
- Mote 1707 is near the stop-line whilst 1703 is mid-link.

NUIDAP and Flow States (Hodges *et al.*, 2009)



States provided for each 5 minutes namely Quiet (1) Smooth Flow (2) Start-Stop (3) and Congestion (4) for each five minutes used in CNOSSUS

Models Tested

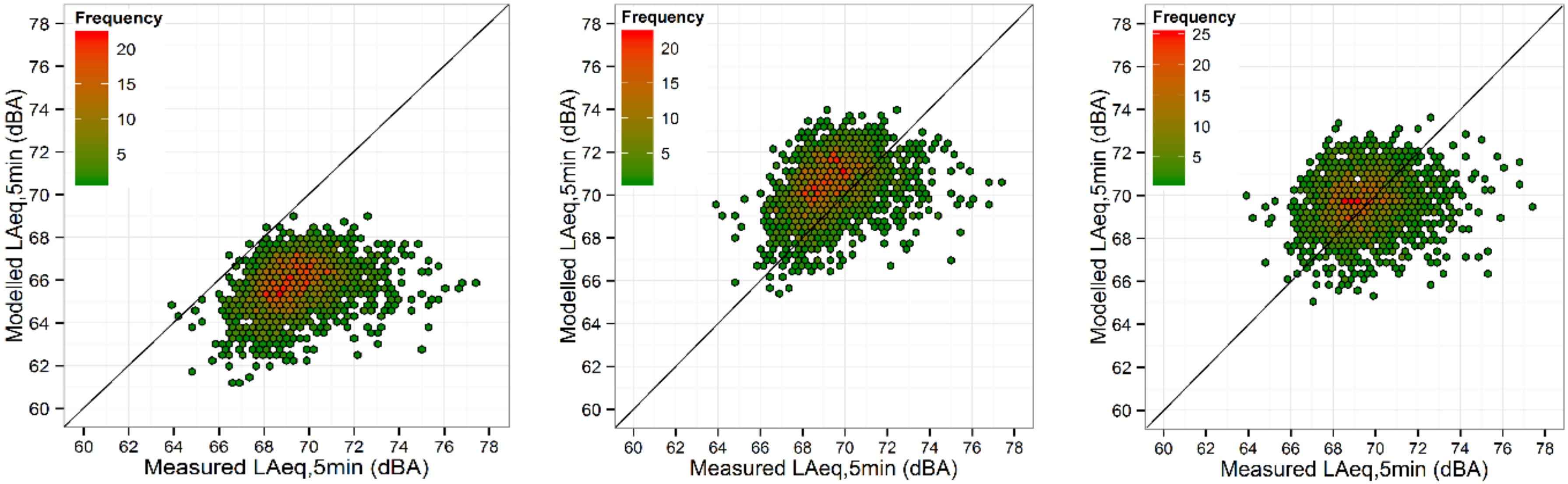
- Three Scenarios (Weekdays 07:00 – 19:00):
  - ‘Free-Flow’ - assumed average flows and speed
  - ‘Free-Flow’ and speed with CNOSSUS junction corrections assuming constant periods of SCOOT state. Each state has defined proportions of traffic mode
    - N10141Z (straight-ahead) quiet and smooth states 40% and 60% respectively
    - N10141P (right-turn movement only) quiet (67%), smooth (24%) and busy (9%).
  - Using SCOOT derived flow and speed with known flow regime for each five minute period and corrected for the spatial changes upstream and downstream of the link.

Results: Site 1707 - Stopline

1. 'Free Flow'

2. +CNOSSOS Junction Correction

3. Spatio-Temporal using SCOOT data



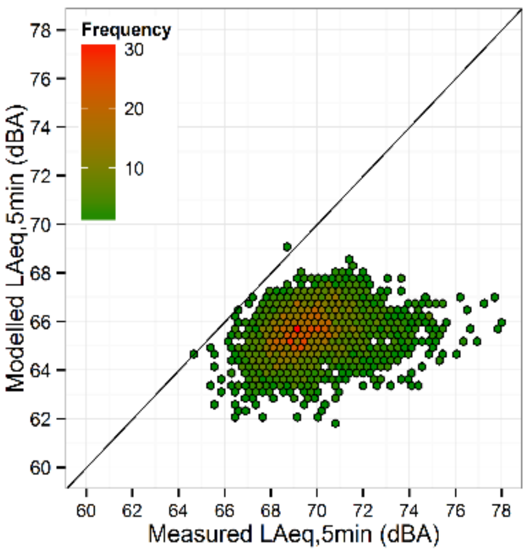
Absolute error:
3.7dBA
RMSE:
4.1dBA

Absolute error:
2.0dBA
RMSE:
2.0dBA

Absolute error:
0.5dBA
RMSE:
1.9dBA

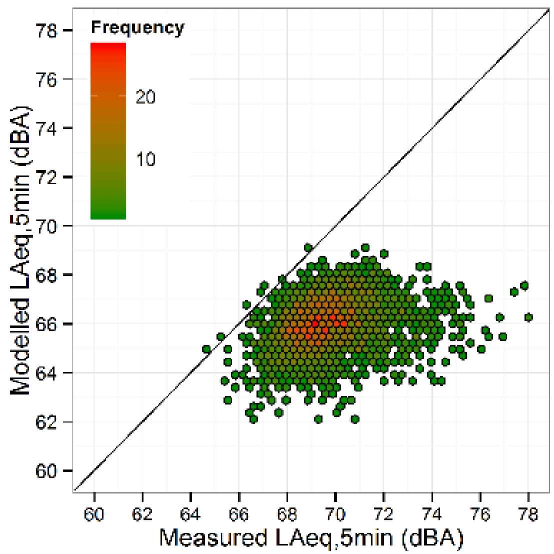
Results: Site 1703 – Mid-Link

1. 'Free Flow'



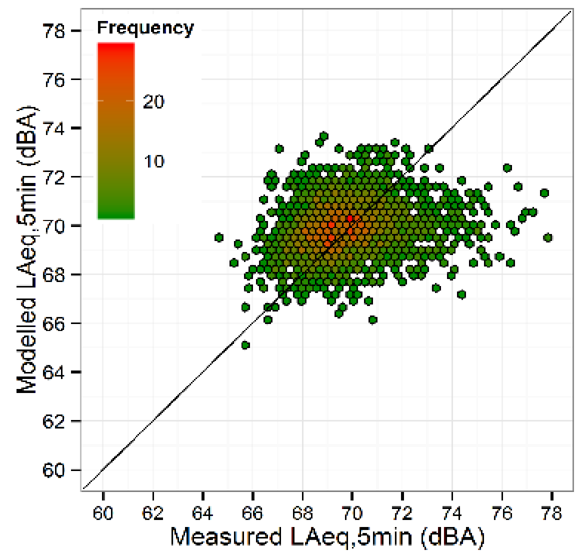
Absolute error:
4.3dBA
RMSE:
4.7dBA

2. +CNOSSOS Junction Correction



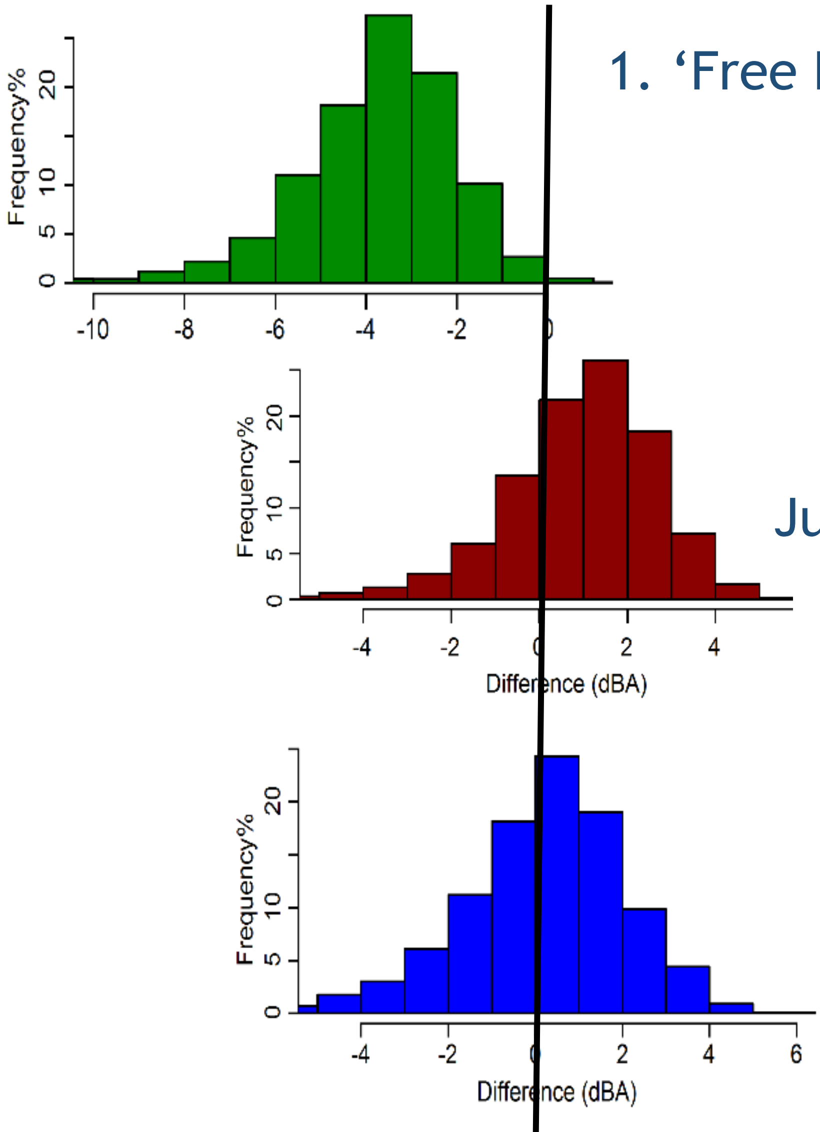
Absolute error:
3.9dBA
RMSE:
4.3dBA

3. Spatio-Temporal using SCOOT data

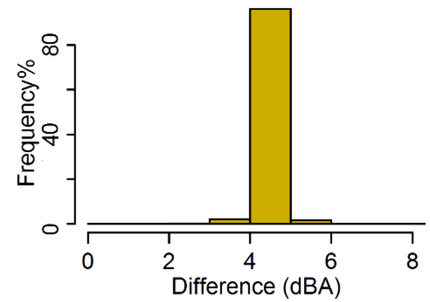


Absolute error:
1.4dBA
RMSE:
1.9dBA

Difference (predicted-measured) in $L_{Aeq,5\text{-}min}$

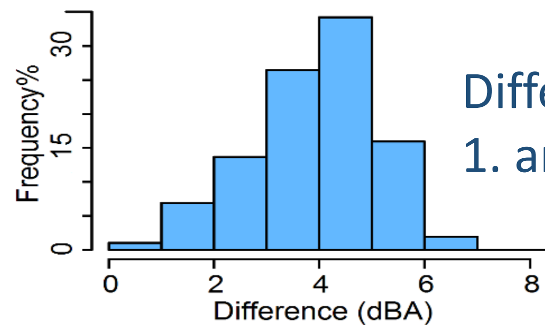


1. ‘Free Flow’



Difference between 1. and 2.

2. +CNOSSOS Junction Correction



Difference between 1. and 3.

3. Spatio-Temporal using SCOOT data

Conclusions and Limitations

- Three variants of a noise prediction model developed – each using UTMC (SCOOT) data in a different way
- Most effective model used breakdown of links into four sections and included flow regimes. Using free-flow, average speed underestimated noise
- Also can obtain distributions of noise, rather than just single values

- Limited by simple calculations of speed from SCOOT occupancy and delay – e.g. masking can occur using inductive loops
- No way (yet) of getting different attributes for different vehicle classes from SCOOT, or in assumptions
- Other effects? Road surface? Site characterstics? Non-traffic noise?
- Nearside links only considered

Thank you for listening
Any questions?
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