National NO$_2$ Model

Ian Longley, Ayushi Kachhara
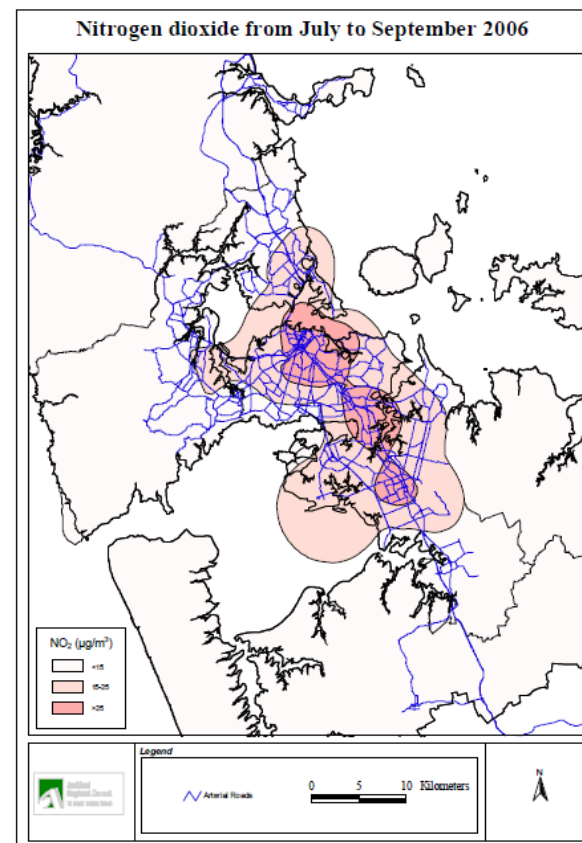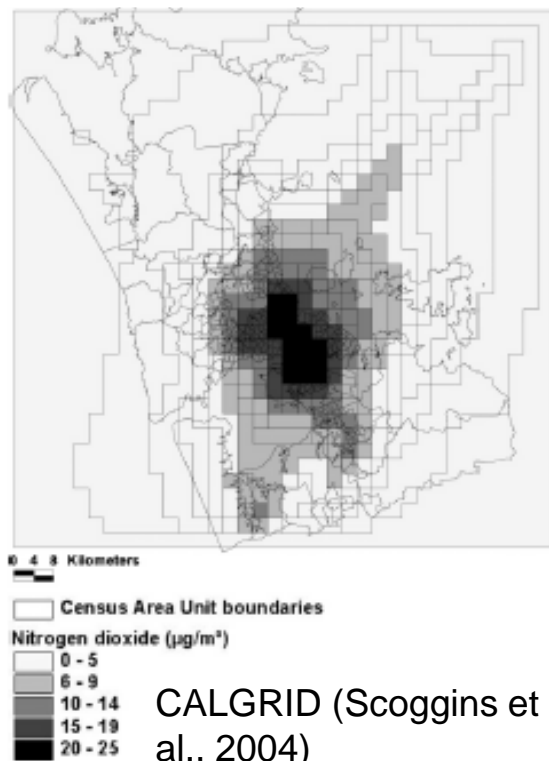
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Coming up…

- Purpose and scope of the model

- Basis of the model

- Some initial learnings

- Current limitations

- Access to the model and its future development

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Past attempts at mapping NO$_2$

CALGRID (Scoggins et al., 2004)

Interpolation of passive monitoring (ARC, 2007)

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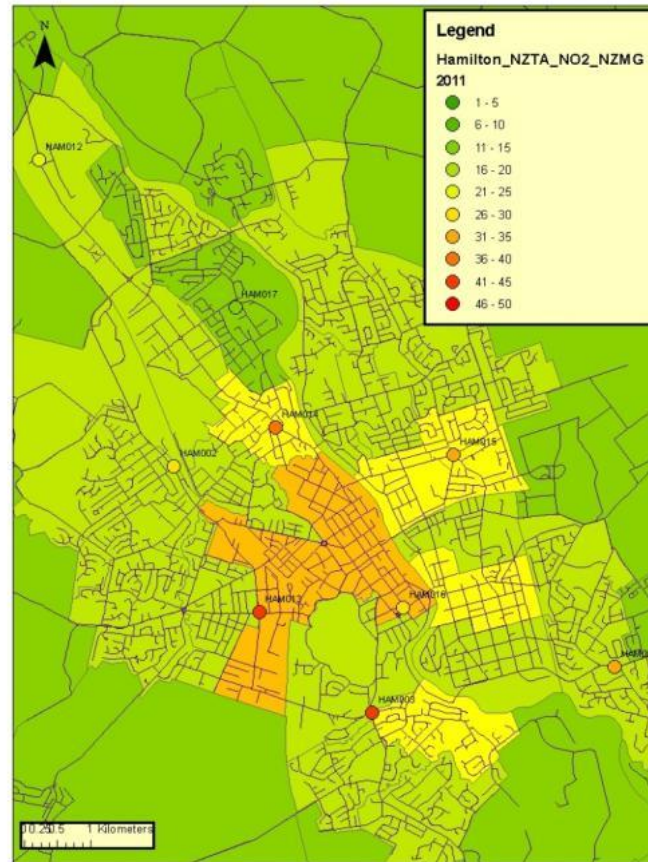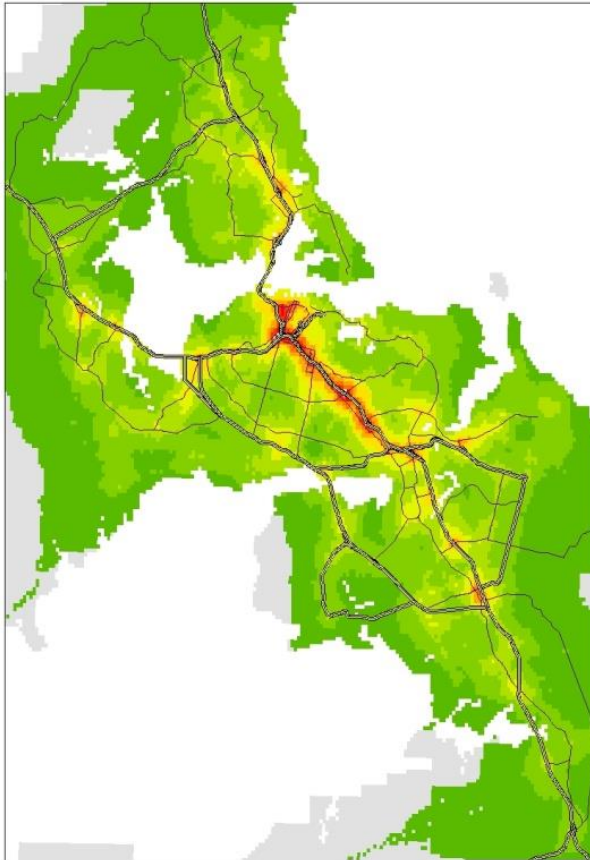# Introducing... Traffic Impact Model Version 2 (2019 release)

- Long-term mean NO_2
- Static maps
- Urban areas (where traffic data available)
- Road transport sources only
- 10 m resolution
- Available as rasters for GIS

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Scope

Versions 1, 2	Future versions
NO_2	PM, BC, NOx, UFP
Long-term mean	Probability of short-term peaks
Residential/low-rise	Commercial, high-rise
Road traffic only	Airports, seaports
Urban	Rural

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Whatever happened to version 1?

"TOTUS"

Why a version 2?

- Now have 10000+ NO_2 samples from 1000+ sites

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NZTA National NO$_2$ Monitoring Network

Annual average nitrogen dioxide concentrations
2010–13
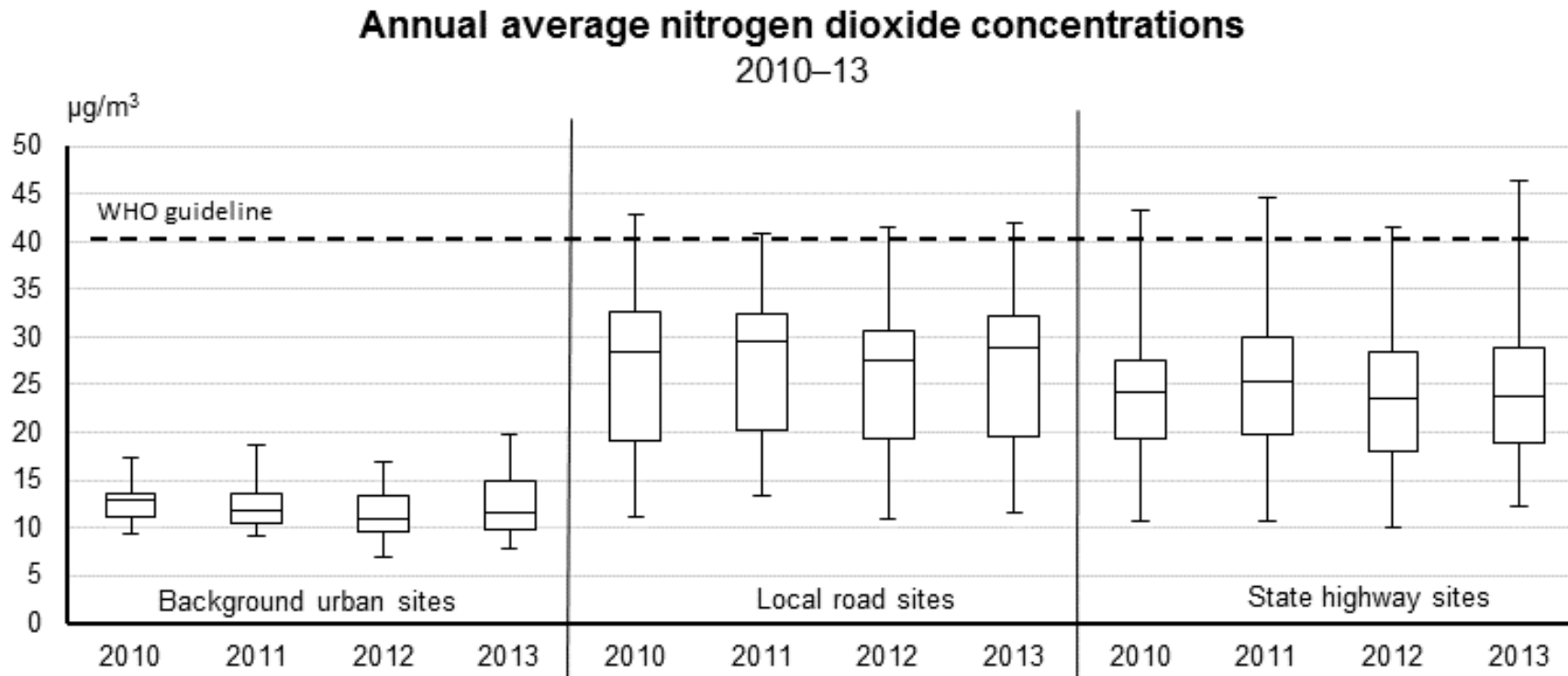
Source: New Zealand Transport Agency

Observed roadside NO$_2$ gradients in Auckland & Wellington
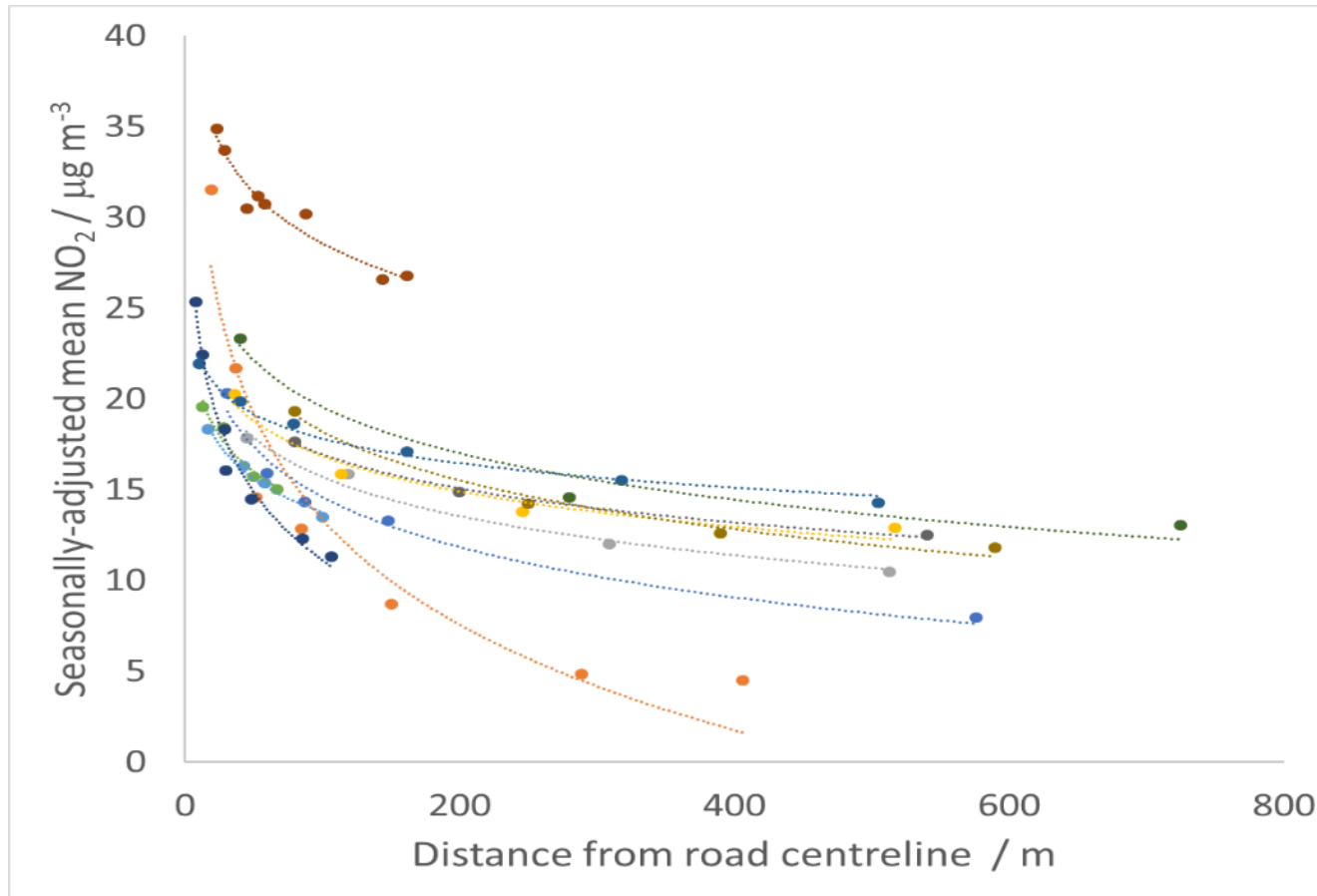
- Roadside increments in NO$_2$ ~10 µg m^{-3} across several urban settings

- Roadside NO$_2$ locally enhanced at intersections

- Sharper decay in medium density urban and rural settings

- Shallower decay in low-rise suburban settings

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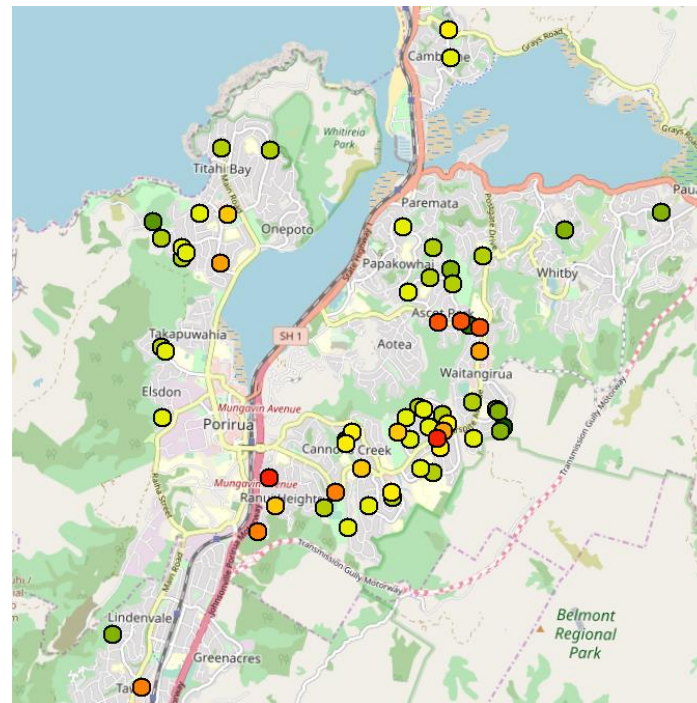
Urban Background

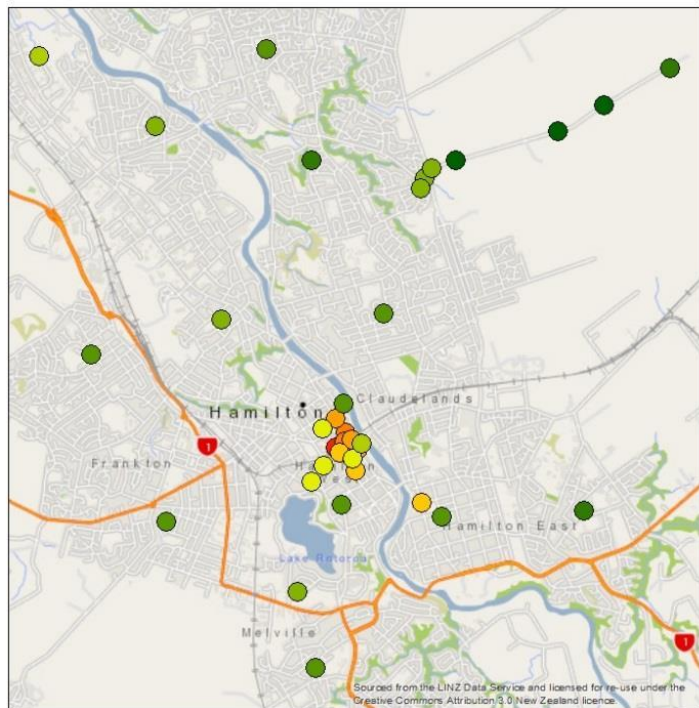- Urban background varies little across flat cities
- Urban background varies more (and is lower) in hilly cities
- Urban background lower in Greater Wellington

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Seasonal variation and predictability

- Urban background sites have very predictable seasonal variation
- Seasonal variation at peak sites is relatively attenuated and more variable
- Sub-annual data can be adjusted to estimated annual mean with quantified uncertainty
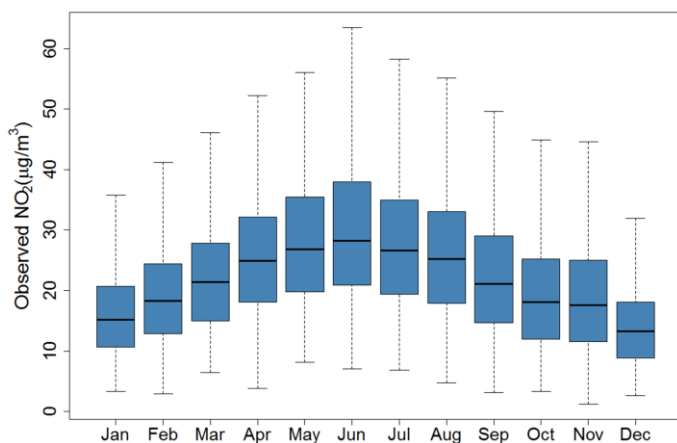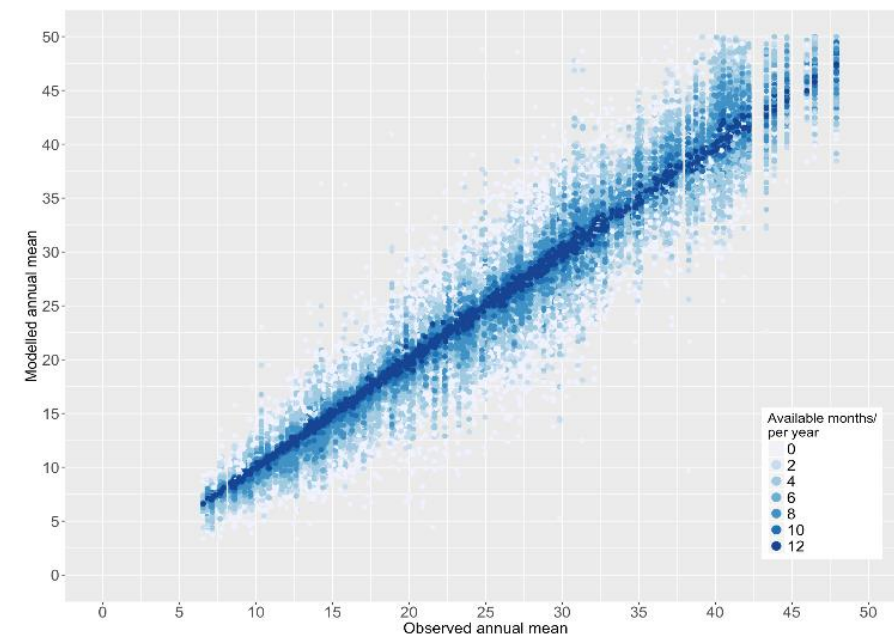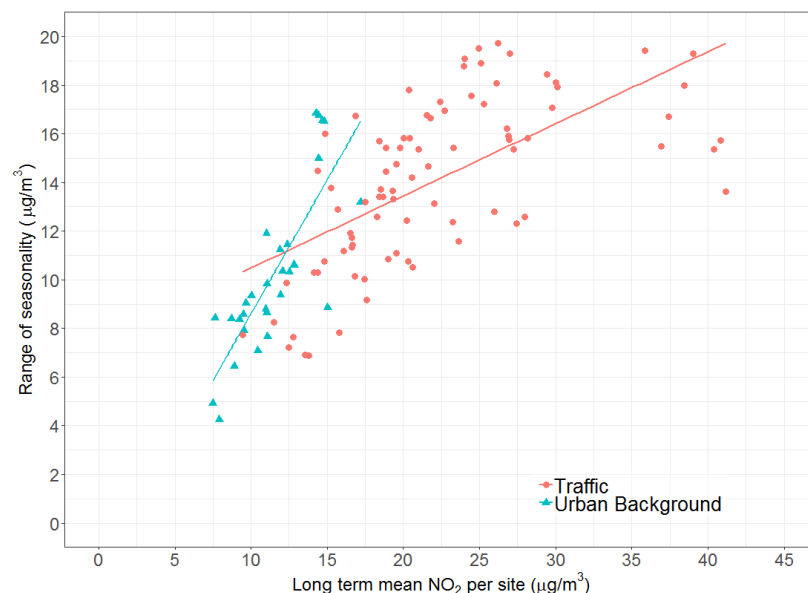
(*why we didn't build a*) Land-use regression model
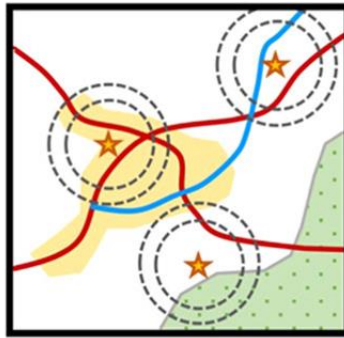
GIS variables

All sites LUR model: $OP = \alpha Var_1 + \beta Var_2 + ... + c$
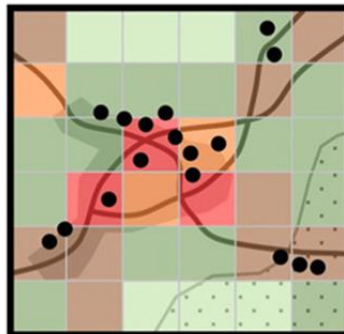
- NO$_2$ is function of land-use within arbitrary circular buffer
- Widely used in research and health studies
- No physical basis
- Prone to multiple errors
- Rarely work outside original study area

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Traffic Impact Model concept

- Physically-based regression model
- No buffers – impacts are distance-weighted (exponential decay)

x

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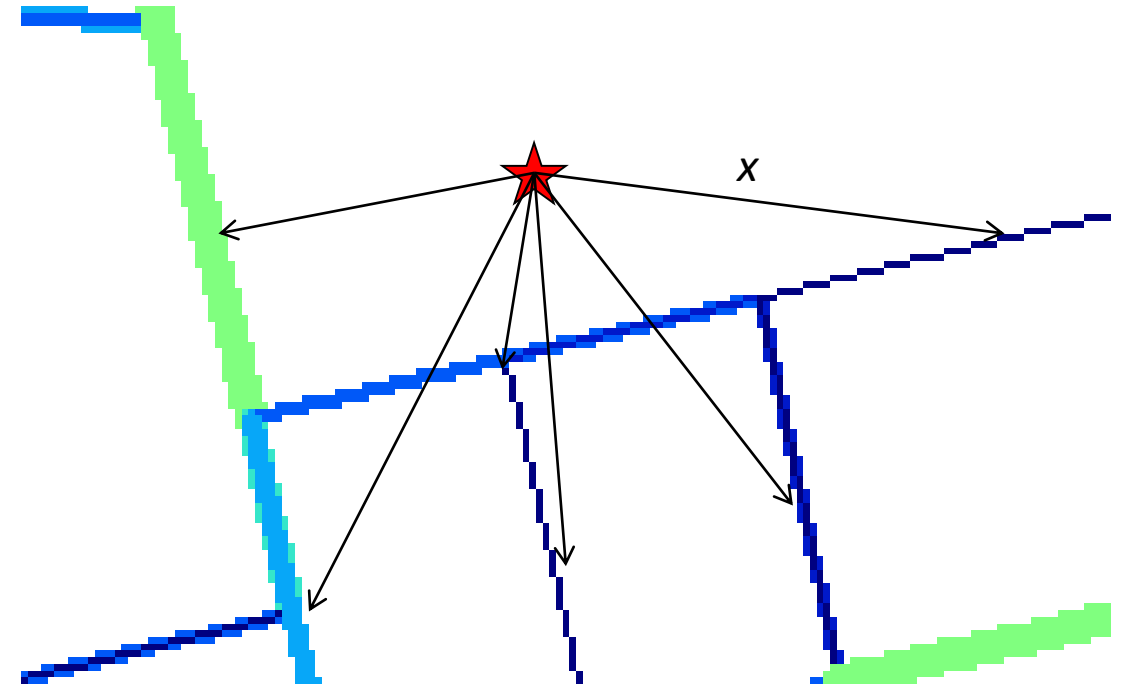
General empirical model

- $Total\ Traffic\ Impact\ Factor = \sum(A \times AADT(e^{-Bx}))$
- $NO_2[\mu g\ m^{-3}] = f\ (Total\ Traffic\ Impact\ Factor)$
- Calibrated using local data (or national dataset if local data unavailable)

- *AADT* = annual average daily traffic for each road
- *x* = shortest distance to centreline of each road
- A, and B are empirical factors

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Calibration/validation

Legend
gisborne
NO2 ug/m3
0 - 2
3 - 4
5 - 6
7 - 8
9 - 10
11 - 12
13 - 14
15 - 16
17 - 18
19 - 20
21 - 22
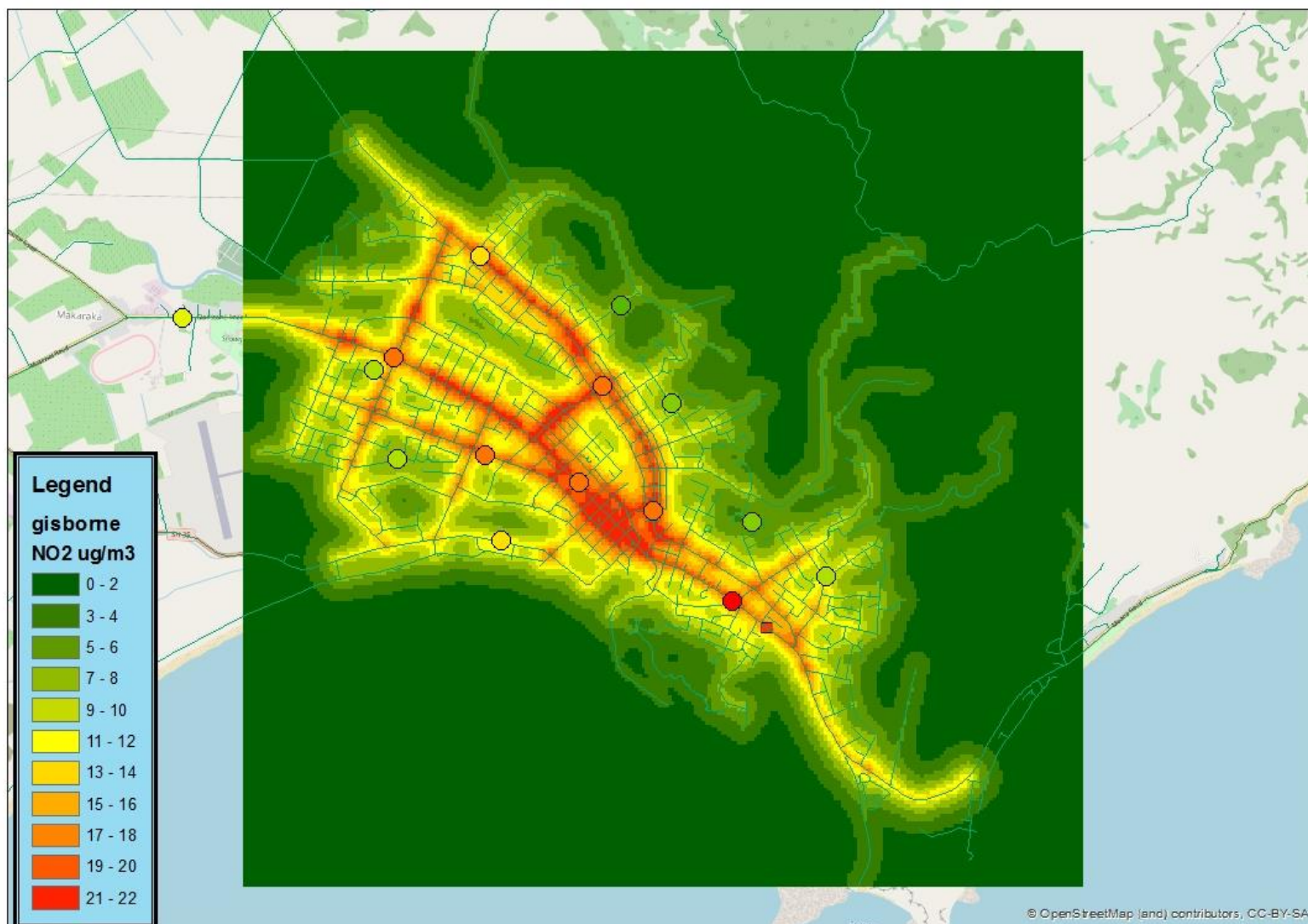
Traffic volume threshold to generate 2 $\mu g\ m^{-3}$ of NO_2

Distance / m	Minimum AADT
150	90,000
100	28,500
50	9,000
20	4,500
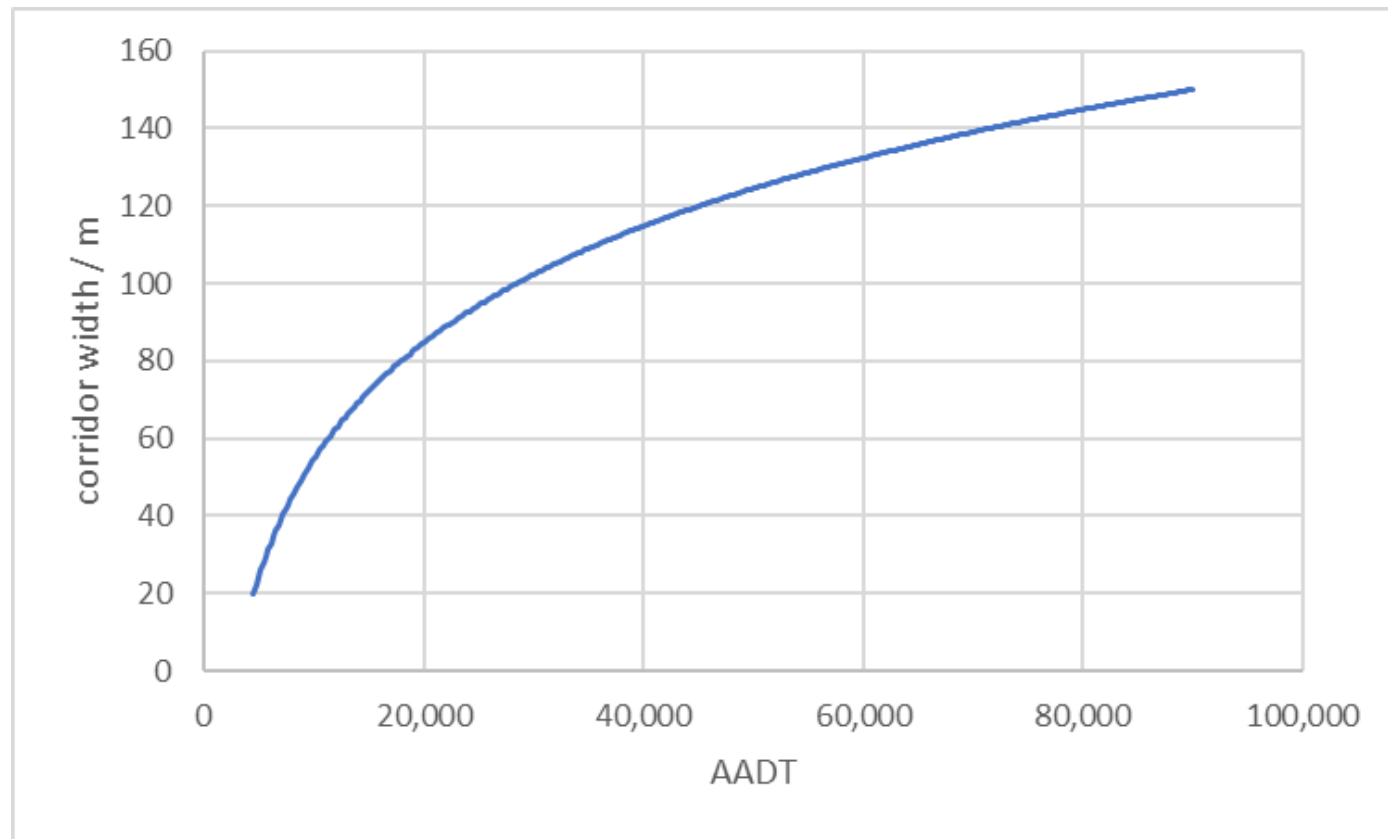
National roadside screening model

Roadside Increment

$$RI = 0.007 \times AADT(e^{-0.023x})$$

(central model)

Over-predicts for open settings & smooth traffic flow

Under-predicts for street canyons & start-stop traffic

$$\textbf{RI} = 0.014 \times AADT(e^{-0.23x})$$

(conservative model) for planning purposes

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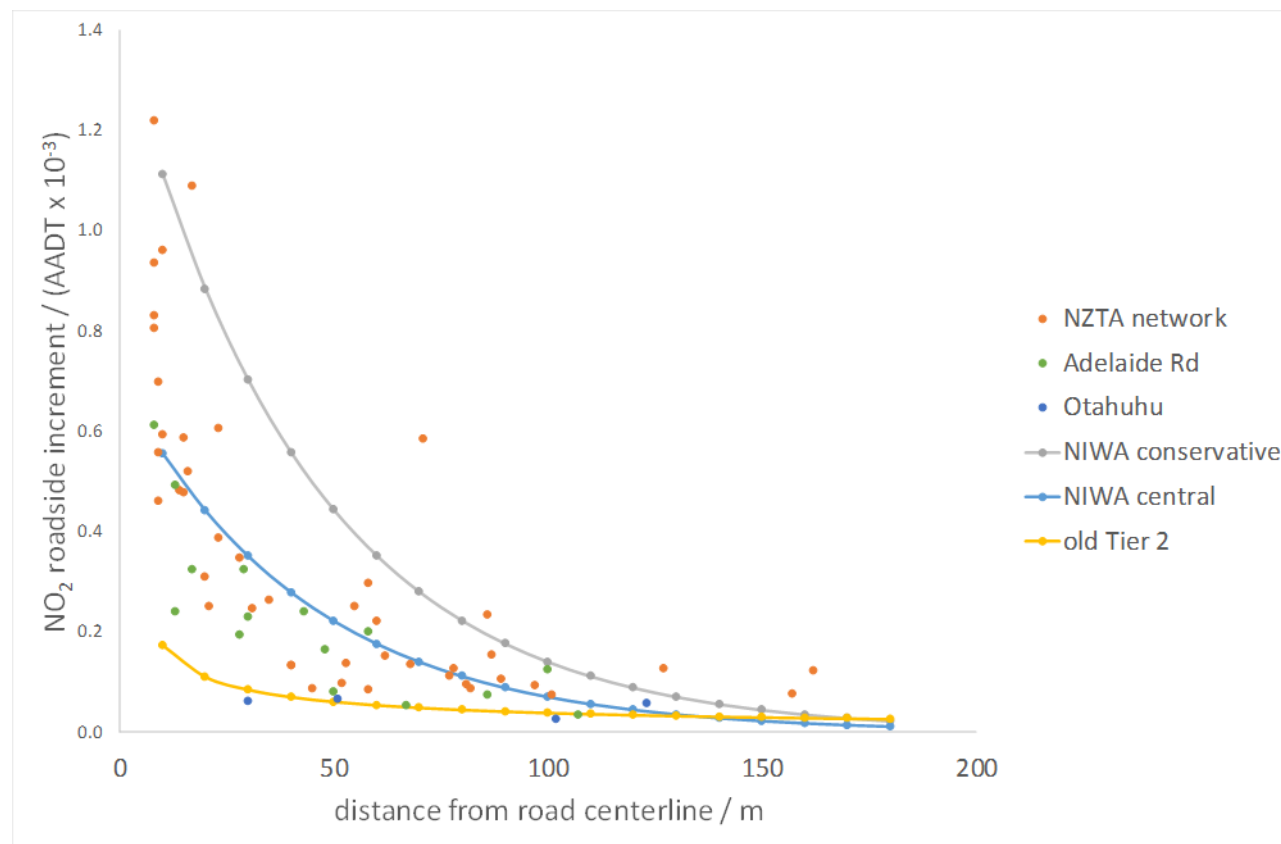
Consistent "errors"

- Model under-estimates..
  - In street canyons
  - Along highly congested roads
  - In sheltered basins/valleys
- Model over-estimates...
  - Behind noise walls or barriers
  - Differences in grade (major road is sunken/elevated)

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Limitations and future research

- Relies on accurate and consistent traffic volume data

- Calibration/validation NO_2 data is patchy

- No model yet for modifying impact of terrain

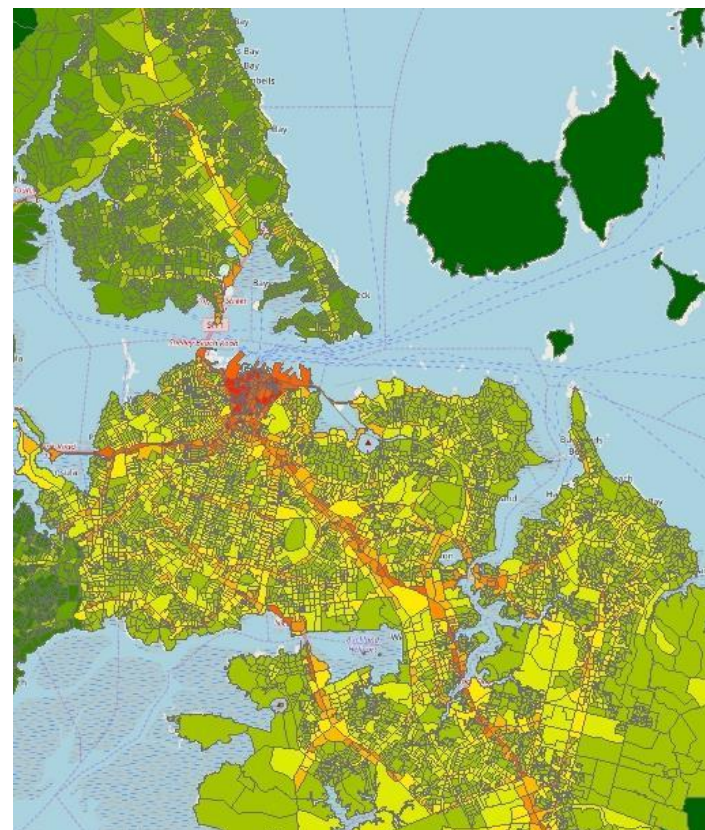- Street canyons (and elevated receptors) remain challenging

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Coverage

Calibrated model	Uncalibrated model	No model
Auckland*	Rotorua	Christchurch
Wellington	New Plymouth	Dunedin
Upper Hutt	Nelson	
Lower Hutt*	Whangarei	
Hamilton	Invercargill	
Tauranga	Whanganui	
Palmerston North	Blenheim	
Porirua	Pukekohe	
Napier	Timaru	
Hastings	Taupo	
Gisborne		

*inconsistent traffic data

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Overlaid on census meshblocks...

…Or building footprints

- 74% of buildings in Auckland CC residential zone are exposed to urban background (10 - 15 μg m^{-3}) NO_2

- 26% exposed to +5 μg m^{-3} roadside NO_2

- 7% exposed to +10 μg m^{-3} roadside NO_2

- 3% exposed to +15 μg m^{-3} roadside NO_2

- Model under-estimates canyon effects but does not include high-rise residences

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National NO$_2$ Indicator

Legend: Urban Background · Roadside · Peak
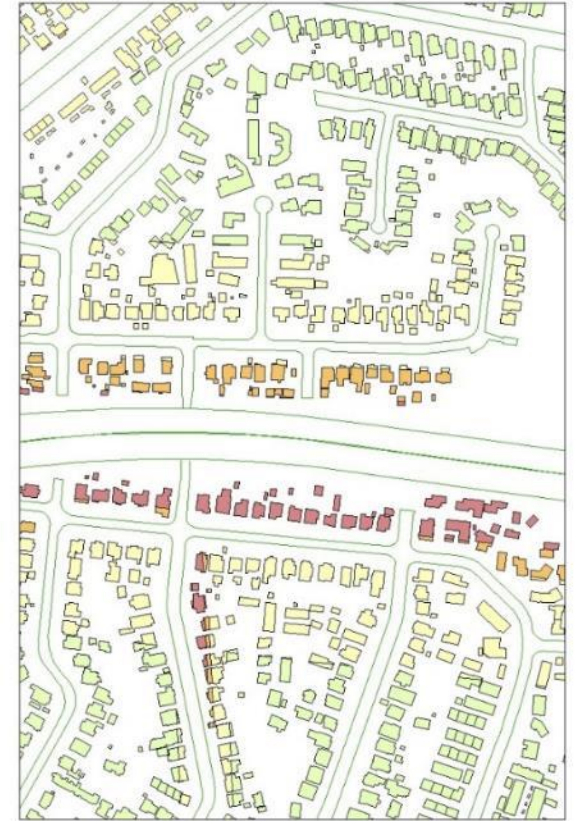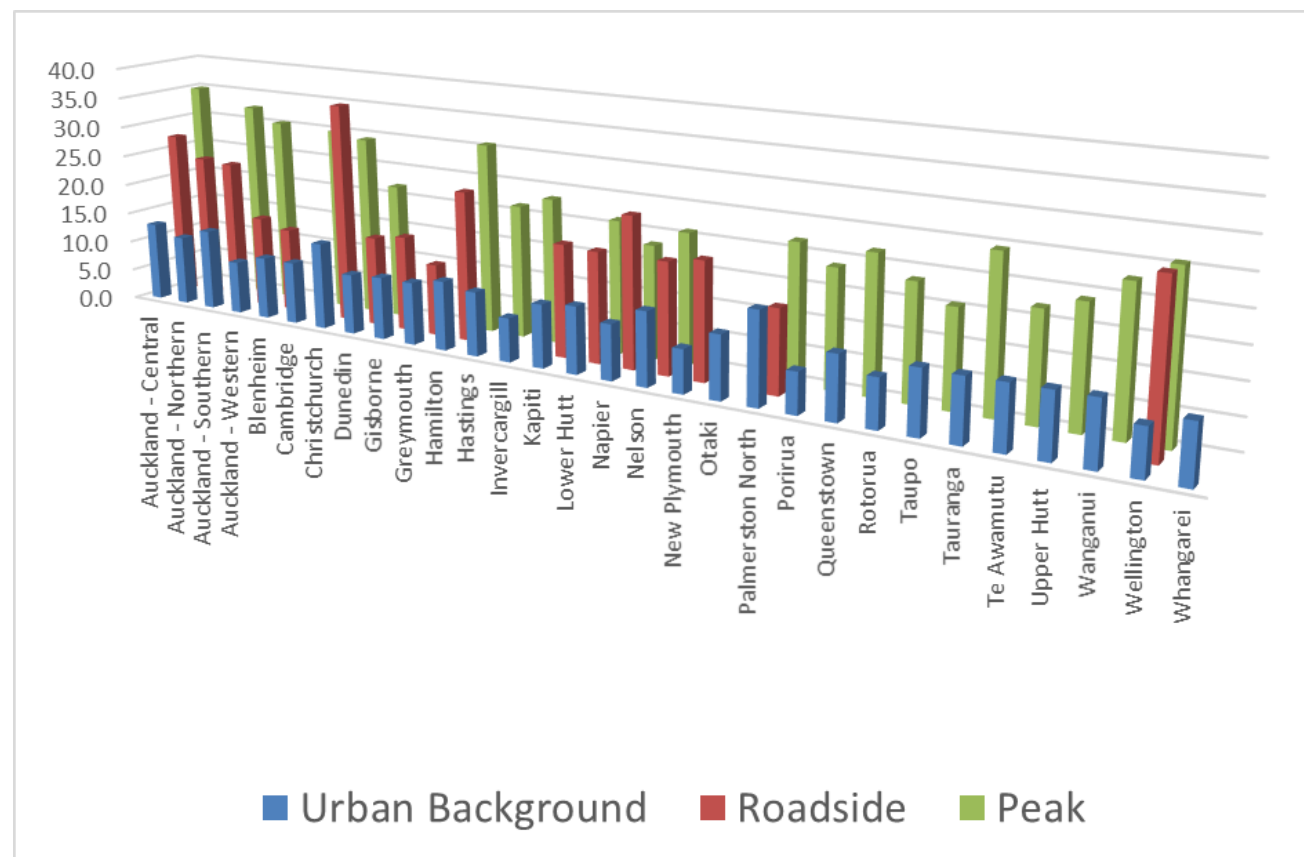
Access

- Coming soon to the NIWA website!

Coming next…

- Review of National Air Quality Monitoring Network
- Review and re-design of Greater Wellington monitoring network
- Further observational validation of the model
- Regular updates of the model

Acknowledgements

- This research was funded by NIWA

- Some of the NO$_2$ data was provided by the New Zealand Transport Agency.

- Other NO2 data was collected on behalf of AC, GDC, HBRC, WRC and GWRC.

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