National NO$_2$ Model

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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
Past attempts at mapping NO$_2$

CALGRID (Scoggins et al., 2004)

Interpolation of passive monitoring (ARC, 2007)
Introducing... Traffic Impact Model Version 2 (2019 release)

- Long-term mean NO\textsubscript{2}
- Static maps
- Urban areas (where traffic data available)
- Road transport sources only
- 10 m resolution
- Available as rasters for GIS
### Scope

<table>
<thead>
<tr>
<th>Versions 1, 2</th>
<th>Future versions</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO$_2$</td>
<td>PM, BC, NOx, UFP</td>
</tr>
<tr>
<td>Long-term mean</td>
<td>Probability of short-term peaks</td>
</tr>
<tr>
<td>Residential/low-rise</td>
<td>Commercial, high-rise</td>
</tr>
<tr>
<td>Road traffic only</td>
<td>Airports, seaports</td>
</tr>
<tr>
<td>Urban</td>
<td>Rural</td>
</tr>
</tbody>
</table>
Whatever happened to version 1?
Why a version 2?

- Now have 10000+ NO$_2$ samples from 1000+ sites
NZTA National NO₂ 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
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

NOTE: maps to different scales
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

- \( \text{NO}_2 \) 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
Traffic Impact Model concept

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

- **Total Traffic Impact Factor** = \( \sum (A \times AADT(e^{-Bx})) \)
- \( NO_2[\mu g \ m^{-3}] = f(\text{Total Traffic Impact Factor}) \)
- 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
Calibration/validation
Traffic volume threshold to generate $2 \mu g \text{ m}^{-3}$ of NO$_2$

<table>
<thead>
<tr>
<th>Distance / m</th>
<th>Minimum AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>90,000</td>
</tr>
<tr>
<td>100</td>
<td>28,500</td>
</tr>
<tr>
<td>50</td>
<td>9,000</td>
</tr>
<tr>
<td>20</td>
<td>4,500</td>
</tr>
</tbody>
</table>

![Graph showing the relationship between AADT and corridor width/m](image)
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

\[ RI = 0.014 \times AADT(e^{-0.23x}) \]  
(conservative model) for planning purposes
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)
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
<table>
<thead>
<tr>
<th>Calibrated model</th>
<th>Uncalibrated model</th>
<th>No model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auckland*</td>
<td>Rotorua</td>
<td>Christchurch</td>
</tr>
<tr>
<td>Wellington</td>
<td>New Plymouth</td>
<td>Dunedin</td>
</tr>
<tr>
<td>Upper Hutt</td>
<td>Nelson</td>
<td></td>
</tr>
<tr>
<td>Lower Hutt*</td>
<td>Whangarei</td>
<td></td>
</tr>
<tr>
<td>Hamilton</td>
<td>Invercargill</td>
<td></td>
</tr>
<tr>
<td>Tauranga</td>
<td>Whanganui</td>
<td></td>
</tr>
<tr>
<td>Palmerston North</td>
<td>Blenheim</td>
<td></td>
</tr>
<tr>
<td>Porirua</td>
<td>Pukekohe</td>
<td></td>
</tr>
<tr>
<td>Napier</td>
<td>Timaru</td>
<td></td>
</tr>
<tr>
<td>Hastings</td>
<td>Taupo</td>
<td></td>
</tr>
<tr>
<td>Gisborne</td>
<td></td>
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</tr>
</tbody>
</table>

*inconsistent traffic data
Overlaid on census meshblocks...
...Or building footprints

- 74% of buildings in Auckland CC residential zone are exposed to urban background (10 - 15 $\mu$g m\(^{-3}\)) NO\(_2\)
- 26% exposed to +5 $\mu$g m\(^{-3}\) roadside NO\(_2\)
- 7% exposed to +10 $\mu$g m\(^{-3}\) roadside NO\(_2\)
- 3% exposed to +15 $\mu$g m\(^{-3}\) roadside NO\(_2\)
- Model under-estimates canyon effects but does not include high-rise residences
National NO$_2$ Indicator
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

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