Sensitivity analyses regarding NO$_2$ exposure assessment and health impacts at EU scale

Maiheu$^1$ B., Lefebvre$^1$ W., Walton$^2$ H., Dajnak$^2$ D., Janssen$^1$ S., Williams$^2$ M., Blyth$^1$ L., Beevers$^2$ S.

$^1$VITO – Flemish Institute for Technological Research
$^2$King’s College London
• Project factsheet
• Recommendations from an expert workshop
• Sensitivity studies w.r.t. NO$_2$ exposure and health impact assessment
• Conclusions & recommendations
EU Service contract 070201/2015/SER/717473/C.3 for DG ENV – Improved Tools for Assessing NO₂ Exposure

Objective: “Propose methods and tools that are coherent with the exposure metric used when deriving the appropriate exposure response relationships and compatible with currently used integrated assessment modelling tools of the EU”

Project team:
Guidelines for an NO\textsubscript{2} health impact assessment methodology:

• Flexibility w.r.t. Concentration Response Functions (CRF’s) → HRAPIE, COMEAP,…
• Applicable for whole of Europe
• Finer scales than existing chemistry-transport models (CTMs) → resolution ~100m
• Ignore street canyons for time being
• Long term NO\textsubscript{2} health impact is more important short team → annual averages
• Sensitive to emission (changes) & NO\textsubscript{2}/NOx-emission ratio
• Coupling to Integrated Assessment Models (e.g. GAINS) → method should be fast

Sensitivity analyses of elements in the HIA → this presentation

Resulting NO\textsubscript{2} mapping module → presentation by Wouter Lefebvre
SENSITIVITY ANALYSES

SPATIAL RESOLUTION
CONCENTRATION RESPONSE FUNCTION
POPULATION DATA SETS
BASELINE MORTALITY
STATIC VS DYNAMIC EXPOSURE
### Sensitivity analysis: Spatial Resolution

<table>
<thead>
<tr>
<th>City/Region</th>
<th>Contact</th>
<th>Institute</th>
<th>Model Type</th>
<th>Grid Scale</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flanders</td>
<td>Stijn Janssen (<a href="mailto:stijn.janssen@vito.be">stijn.janssen@vito.be</a>)</td>
<td>VITO</td>
<td>IFDM (Gaussian)</td>
<td>25 m</td>
<td>2012</td>
</tr>
<tr>
<td>London</td>
<td>Jenny Stocker (<a href="mailto:jenny.stocker@cerc.co.uk">jenny.stocker@cerc.co.uk</a>)</td>
<td>CERC</td>
<td>ADMS Urban (Gaussian)</td>
<td>20 m</td>
<td>2012</td>
</tr>
<tr>
<td>Stockholm</td>
<td>Kristina Eneroth (<a href="mailto:kristina@sib.nu">kristina@sib.nu</a>)</td>
<td>Environment and Health Administration, City of Stockholm</td>
<td>Airviro (Gaussian)</td>
<td>30 m</td>
<td>2015</td>
</tr>
<tr>
<td>Styria</td>
<td>Dietmar Öttl (<a href="mailto:dietmar.oettl@stmk.gv.at">dietmar.oettl@stmk.gv.at</a>)</td>
<td>Umwelt Steiermark (Austria)</td>
<td>GRAL (Lagrangian)</td>
<td>25 m</td>
<td>2010</td>
</tr>
<tr>
<td>Vienna / Salzburg / Klagenfurt</td>
<td>Rafael Reifeltshammer (<a href="mailto:reifeltshammer@ivt.tugraz.at">reifeltshammer@ivt.tugraz.at</a>)</td>
<td>TU Graz (Austria)</td>
<td>GRAL (Lagrangian)</td>
<td>10 m</td>
<td>2010</td>
</tr>
<tr>
<td>Barcelona</td>
<td>Joan Marc Craviotto i Arnau (<a href="mailto:jcraviotto@bcn.cat">jcraviotto@bcn.cat</a>)</td>
<td>Departament d'Intervenció Ambiental, Barcelone</td>
<td>ADMS Urban (Gaussian)</td>
<td>5 m</td>
<td>2013</td>
</tr>
</tbody>
</table>
Sensitivity analysis: Spatial Resolution

Resolution degrading (simple averaging)

- Native (~20 m) → 100 m → 20 km
- Assessing population weighted mean concentration

\[ C_p = \frac{\sum C \cdot P}{\sum P} \]

- Using JRC population map (Gallego, 2010)
Sensitivity analysis: Spatial Resolution

- Graphs showing the relationship between spatial resolution and some metric (likely concentration or parameter change) for different locations.
- The x-axis represents spatial resolution in km, ranging from $10^{-2}$ to $10^2$ km.
- The y-axis represents the metric, ranging from 0 to 40.
- Different locations are represented by different colors and markers.
## Sensitivity analysis: Population datasets

<table>
<thead>
<tr>
<th>Label</th>
<th>Census Year / Scale (*)</th>
<th>Scale</th>
<th>References</th>
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<tbody>
<tr>
<td>ghs2015</td>
<td>2011, 1 km</td>
<td>1 km</td>
<td><a href="http://ec.europa.eu/eurostat/statistics-explained/index.php/Population_grids">http://ec.europa.eu/eurostat/statistics-explained/index.php/Population_grids</a></td>
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<tr>
<td>immi3</td>
<td>2012, 25 m</td>
<td>25 m</td>
<td>Flemish authorities</td>
</tr>
</tbody>
</table>
Sensitivity analysis: Population datasets

- Up to 7-8% difference in population exposure
- Large differences between cities
- Interesting effect for high resolution population dataset (Flanders)
• **HRAPIE**: RR of 1.055 per 10 µg/m³ (1.031 – 1.080 95% C.I.) with a cut-off of 20 µg/m³
• **COMEAP Interim (2015 report)**: RR of 1.025 per 10 µg/m³ (1.010 – 1.040) **without** cut-off
• Both to be reduced with 33 % for overlap with PM$_{2.5}$
• Using baseline mortality of 1 % throughout, no age threshold
Sensitivity analysis: CRF’s
Sensitivity analysis: CRF’s & spatial scale
Sensitivity analysis: Baseline mortality

- National vs. local mortality rate → underestimation of the health impact
- Percentage difference in life-years lost

<table>
<thead>
<tr>
<th>CONSTITUENT COUNTRY</th>
<th>COMEAP INTERIM STATEMENT, 5 µg/m3 CUT-OFF</th>
<th>COMEAP INTERIM STATEMENT, NO CUT-OFF</th>
<th>HRAPIE, NO CUT-OFF (TO ILLUSTRATE EFFECT OF CRF SIZE VS CUT-OFF)</th>
<th>HRAPIE, 20 µg/m3 CUT-OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>6%</td>
<td>5%</td>
<td>4%</td>
<td>12%</td>
</tr>
<tr>
<td>Scotland</td>
<td>8%</td>
<td>6%</td>
<td>6%</td>
<td>13%</td>
</tr>
<tr>
<td>Wales</td>
<td>6%</td>
<td>4%</td>
<td>4%</td>
<td>15%</td>
</tr>
<tr>
<td>Great Britain</td>
<td>6%</td>
<td>5%</td>
<td>4%</td>
<td>12%</td>
</tr>
<tr>
<td>Underestimate in life-years lost over 105 years using country not local mortality rates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Great Britain</td>
<td>10%</td>
<td>8%</td>
<td>8%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Underestimate in life-expectancy from birth using country not local mortality rates

UK Office for National Statistics

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• Currently dynamic exposure unfeasible at EU scale
  ➢ Adequate input data (activity data) is lacking
  ➢ No generally accepted CRF

• Differences from literature (incomplete)
  ➢ ~4% increase comparing mobile phone based dynamic population maps with static maps (Dewulf et al., 2016) in Belgium, TECNAIRE-CM project in Spain (Rafael Borge et al), ...
  ➢ 63% reduction taking London travel demand & micro-environment concentrations (outdoor-based indoor estimates) (Smith et al., 2017)
Sensitivity analysis: Summarizing tornado plot

- Reflects this work alone
- CRF uncertainty dominant
- Spatial scale of 10 km inadequate
- Uncertainty in population disaggregation currently larger than uncertainty due to 1 km NO₂ assessment, however may be underestimated
CONCLUSIONS & RECOMMENDATIONS

• Concentration Response Functions (CRF’s) are the main source of uncertainty in NO₂ health impact assessment
• Relevant uncertainties in input data: population, baseline mortality
• For NO₂ exposure assessment 1 km is minimum, but recommended to go down to 100 m
• Efforts for high resolution should not be reduced
  ➢ Many of the EU limit value exceedances are at the level of street canyons
  ➢ High resolution AQ assessments help in reducing uncertainty in CRFs (use in epi-studies, dynamic exposure)
THANK YOU!
stijn.janssen@vito.be