Impact of climate change on ozone related mortality and morbidity in Europe

Hans Orru,
Camilla Andersson
Kristie Ebi
Joakim Langner
Christofer Åström
Bertil Forsberg
“Good” and “bad” ozone

“Bad” ground-level ozone (smog)
How “bad” ground-level ozone is formed

\[
\begin{align*}
\text{CO} + \text{OH} & \rightarrow \text{CO}_2 + \text{H} \\
\text{H} + \text{O}_2 & \rightarrow \text{HO}_2 \\
\text{NO} + \text{HO}_2 & \rightarrow \text{NO}_2 + \text{OH} \\
\text{NO}_2 + \nu & \rightarrow \text{NO} + \text{O}, \nu < 420 \text{ nm} \\
\text{O} + \text{O}_2 + \text{M} & \rightarrow \text{O}_3 + \text{M}
\end{align*}
\]
Introduction – Health effects of ozone

- Strong oxidant – oxidative stress
  - Reacts with lipids and proteins etc in lung tissue
    - Inflammations
    - Respiratory effects
- Asthma attacks
- Wheezing, chest tightness
- Lung function decrease
- COPD
- Increased respiratory symptoms
- Cardiovascular effects?
Introduction – CC effects on ozone levels

- All else (e.g. ozone precursors) being equal, ground-level ozone levels could increase as climate will change
  - temperature will increase
  - more heat events occur
  - solar radiation will increase
  - indirect effects, e.g. ozone precursors from vegetation
Introduction – GHG emission scenarios
Aims

- The current study aimed to assess the climate change impacts on ground-level ozone induced mortality and morbidity in Europe in a wider set of time periods than often used.

- Moreover, it intended to illustrate the impact of different greenhouse gas emission scenarios and global climate models on health impact calculations.
Methods – assessing ozone levels

Baselines (1961–1990), current (1990–2009) and future (2021–2050; 2041–2060) ozone concentrations for Europe were modelled according to

- two different emission scenarios (A2) and (A1B)
- using two different global climate models ECHAM4, and HadCM3 with regional climate model RCA3 and ozone chemistry-transport model MATCH4 in 50x50 km grids
Methods – calculation of health impacts

- Baseline non-standardized all-cause mortality and respiratory hospitalization rates (*WHO’s European Health for All Database*)

- ER coefficients (per 10 µgm⁻³ in daily 8-h max)
  - all-cause mortality RR = 1.003 (95% CI 1.001–1.004) (*WHO after Anderson et al., 2004*)
  - respiratory hospitalisations RR = 1.003 (95% CI 1.000–1.007) (*COMEAP, 2004*)
    - Age 15–64 RR = 1.001 (*WHO after Anderson et al., 2004*)
    - Age 65+ RR = 1.005 (*WHO after; Anderson et al., 2004*)

- Health effects were estimated above SOMO_{35} ozone concentrations (*Sum of Ozone daily 8-hour max Means Over 35 ppb in the calendar year*)
Estimated number of ozone related deaths > SOMO\textsubscript{35}

<table>
<thead>
<tr>
<th>Country</th>
<th>MATCH-RCA\textsubscript{3} - ECHAM\textsubscript{4}</th>
<th>MATCH-RCA\textsubscript{3} - HadCM\textsubscript{3}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>381</td>
<td>512</td>
</tr>
<tr>
<td>Italy</td>
<td>5737</td>
<td>6491</td>
</tr>
<tr>
<td>Finland</td>
<td>123</td>
<td>113</td>
</tr>
<tr>
<td>Lithuania</td>
<td>123</td>
<td>113</td>
</tr>
<tr>
<td>UK</td>
<td>1489</td>
<td>1954</td>
</tr>
<tr>
<td>Europe</td>
<td>25672</td>
<td>29171</td>
</tr>
</tbody>
</table>
Estimated number of ozone related respiratory hospitalizations >SOMO$_{35}$

<table>
<thead>
<tr>
<th></th>
<th>MATCH-RCA$_3$-ECHAM$_4$</th>
<th></th>
<th>MATCH-RCA$_3$-HadCM$_3$</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>537</td>
<td>722</td>
<td>745</td>
<td>777</td>
<td>848</td>
<td>882</td>
<td>745</td>
</tr>
<tr>
<td>Italy</td>
<td>6 712</td>
<td>7 594</td>
<td>7 024</td>
<td>7 141</td>
<td>7 667</td>
<td>7 757</td>
<td>7 024</td>
</tr>
<tr>
<td>Finland</td>
<td>273</td>
<td>250</td>
<td>322</td>
<td>306</td>
<td>294</td>
<td>280</td>
<td>322</td>
</tr>
<tr>
<td>Lithuania</td>
<td>278</td>
<td>255</td>
<td>291</td>
<td>292</td>
<td>287</td>
<td>268</td>
<td>291</td>
</tr>
<tr>
<td>UK</td>
<td>1 640</td>
<td>2 152</td>
<td>2 252</td>
<td>2 361</td>
<td>2 413</td>
<td>2 439</td>
<td>2 252</td>
</tr>
<tr>
<td>Europe</td>
<td>35 596</td>
<td>39 998</td>
<td>38 178</td>
<td>39 045</td>
<td>41 313</td>
<td>41 645</td>
<td>38 178</td>
</tr>
</tbody>
</table>
### Sensitivity analysis – based on mortality outcomes

<table>
<thead>
<tr>
<th>SOMO Subtype</th>
<th>ECHAM$_4$ (A2)</th>
<th>HadCM$_3$ (A1B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOMO$_{35}$ annual</td>
<td>25,915</td>
<td>13.7</td>
</tr>
<tr>
<td>SOMO$_{35}$ winter</td>
<td>4,550</td>
<td>9.1</td>
</tr>
<tr>
<td>SOMO$_{35}$ summer</td>
<td>21,342</td>
<td>14.6</td>
</tr>
<tr>
<td>SOMO$_{25}$</td>
<td>47,389</td>
<td>8.2</td>
</tr>
<tr>
<td>SOMO$_{50}$</td>
<td>7,108</td>
<td>35.3</td>
</tr>
</tbody>
</table>
Conclusions

- The projected effects of climate change on ozone levels could influence mortality and morbidity differentially across Europe
  - increase in Southern-, and Central Europe
  - slight decrease in Northern-Europe
- Small impacts have already occurred, larger impacts are projected in the future
Discussion

- The results are affected by choice of GHG emission scenario, global climate model and SOMO value
  - A2 would have larger effects on health
  - HadCM$_3$ model projected some-what higher ozone values compared to ECHAM$_4$ in many countries

- Furthermore, the future numbers will be influenced also by changing demographics, susceptibility, ozone precursors (e.g. NO$_x$, VOC, CO) emissions etc
  - There might be an interaction between ozone and heat on health effects, that would likely increase estimated mortality and morbidity

  Our analysis has shown also CC influence on heat effects in Europe (Aström et al., submitted)
Thank you!


www.climatetrap.eu

The current work has been financed by Climate-Trap project (contract EAHC 20081108), Swedish Environmental Protection Agency (CLEO – Climate Change and Environmental Objectives) and Estonia’s Ministry of Education (SF0180060s09). Attendance of the conference has been supported by European Social Fund’s Doctoral Studies and Internationalisation Programme DoRa.