Assessment & Mitigation of PM pollution in the border regions of Austria & Slovenia

U. Uhrner, R. Reifeltshammer, M. Steiner B. Lackner, R. Forkel & J.P. Sturm
Motivation/Aim

- Frequent breeches AQ standards (mainly winter)
- Aim: support sustainable improvement of AQ in project region (PM, NO$_2$; GHG) and thus to reduce health risks for residents → develop effective AQMP
Background - previous Source-Receptor Modelling Klagenfurt AM PM10 2005

Traffic exhaust
Traffic non-ex
Dom. heating
Trade/Industry

51.4% bg at busy road?

Transport?
Secondary PM?

Kurz, 2008

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Outline Air Quality Assessment in PMinter

- Important characteristics:
  - Complex terrain, low wind speed
  - Wood popular fuel, K, LB, MB not much industry

- Better quantified understanding of PM10
  - Secondary inorganic aerosol (SIA)
  - Wood in residential heating
  - Regional & local PM
  - Development multi-scale model approach
    - Regional & micro-scale emission data
    - Validation (standard meteo & AQ monitoring + aethalometer + filter)

- Scenarios → effective AQMP
Multi-Scale Approach

- WRF-Chem multi nesting $\Delta x, y \sim 25$ km, 5 km, 1 km; RADM2, MADE/SORGAM – ECMWF ERA-Interim
- GRAMM/GRAL GRAz Meteorological Model / Lagrangian Particle Model $\Delta x, y$ 10 m, no chemistry – 3 core areas K, LB, MB
- Emissions MACC (TNO) $\sim 7$ km, ARSO SLO, local inventories, base data
Emission Processing

- resolve emissions in basins & valleys already @ $\Delta x,y \ 1 \ km$
- merge & harmonize different local inventories & data from ARSO SLO, Styria, Carinthia, Klgf, MB, TUG
- WRF-Chem/GRAL emissions must complement – double counting avoided
- Work
  - (dis-)aggregating & processing
  - coord systems & resolutions
  - missing values (MACC ~7 km used)
- all road transport with NEMO (Rexeis & Hausberger 2009)
- domestic heating MB/K bottom up processing
Processed Emissions – NH3 agriculture (SIA precursor) D02/D03b

Coarse resolution D02

D03b data on 1 km x 1km
Residential Combustion Emission Processing

- Elevated area source (150 m x 150 m) → chimney release height
- Approaches based on fuel consumption data & heat demand each building & assignment of EFs (each fuel), aggregation on 150 m x 150 m
- Particularly wood wide range of PM EFs
- Micro-scale simulations – comparisons aethalometer, monit. PM10, selection of „wood EFs“

<table>
<thead>
<tr>
<th>Fuel</th>
<th>EF PM [mg/MJ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>gas</td>
<td>0</td>
</tr>
<tr>
<td>heating oil</td>
<td>0.45</td>
</tr>
<tr>
<td>coal</td>
<td>85</td>
</tr>
<tr>
<td>pellets</td>
<td>21</td>
</tr>
<tr>
<td>wood logs</td>
<td>250</td>
</tr>
<tr>
<td>single stoves</td>
<td>250</td>
</tr>
<tr>
<td>unidentified</td>
<td>76</td>
</tr>
</tbody>
</table>
Processed Emission Data Residential Heating, various data sources D03a/b (1 km x 1 km)
Mean PM10 January 2010 regional (WRF-Chem)
Mean PM10 SIA January 2010 D03a&b
PM10 Jan 2010 Base Maribor WRFchem/GRAL
PM10 Jan 2010 Base Leibnitz WRFchem/GRAL
Simulation PM10 Jan 2010 vs. Measurements

- Base D01 (25 km)
- Base D02 (5 km)
- Base D03a/b (1 km)
- Combined (1 km / 10 m)
- Measured
WRF-Chem comp (reg) & GRAL sources (loc)

- SOA Reg
- SIA Reg
- Salts Reg
- PIA Reg
- EC Reg
- OC Reg
- ANT Reg
- TrafExh Loc
- TrafNonExh Loc
- ResHeat Loc
- Ind&Com Loc

PM10 [μg/m³]

K E-Z, K Ost, K VM, LB KG, LB Cen, MB Tab, MB VP
Regional/Transported or local SIA vs EC/OC

- SIA Loc
- SIA Trans
- Carb Loc
- Carb Trans
- Not Spec

PM10 [µg/m³]

- K E-Z
- K Ost
- K VM
- LB KG
- LB Cen
- MB Cen
- MB VP

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Validation

![Graph 1](image1.png)

![Graph 2](image2.png)

![Graph 3](image3.png)

![Graph 4](image4.png)

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EIONET Workshop, Ljubljana 06.10.2015
Comparison main simulated PM10 comp. vs. macro-tracer (mainly filter based- TUW)
Klagenfurt PM10 from Traffic
~ 25% exhaust & 75% non-exhaust
Scenario Replacement Individual Heating Facilities by Biomass District Heating

- Additional 95 MW biomass district heating plant
- Additional 175 GWh district heating available
- Replacement indiv. burners/stoves for light fuel oil & solid fuels

DJF PM10 residential heating Klagenfurt base
Scenario Replacement individual heating facilities by biomass district heating Klagenfurt

AM PM10 biomass heating plant

Dif AM PM10 scenario - base
NO\(_x\) emissions: \(-35\%\) NO\(_x\) emission scenario

- traffic emissions in cities and close to major roads
- involved in formation of HNO\(_3\), a SIA precursor
−35% traffic NO$x$ scenario: NO$_2$ changes w.r.t. base
−35% NO\textsubscript{x} scenario: PM10 changes w.r.t. base case
−35% NH₃ scenario: PM10 changes w.r.t. base case
Conclusions & Summary

- Detailed regional to local scale model system developed & tested in complex terrain applications
- Resolution matters!
- Regional winter PM dominated by SIA (agric/traffic+heat)
- Local winter PM dominated by “wood smoke”
  - Strong PM near surface source @ unfavourable dispersion conditions
  - Sustainable concerning GHG (local timber)
- Traffic exhaust/non-exhaust near main arterial roads major PM source (annual means)
### Summary Integral Assessment Scenarios

<table>
<thead>
<tr>
<th>Scenario:</th>
<th>Effect PM10 &amp; extent</th>
<th>Effect NO₂ &amp; extent</th>
<th>Estimated Health Impact</th>
<th>Impact GHG</th>
<th>Other impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>individual heating to biomass district heating</strong></td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>-2 to –3 µg/m³</td>
<td>≤ –1.5 µg/m³ in Klagenfurt DJF</td>
<td>≤ –1 µg/m³ in Klagenfurt DJF</td>
<td>urban (local) Klagenfurt</td>
<td>-30% res. heat. - 27000 t/a CO₂</td>
<td>comfort more space</td>
</tr>
<tr>
<td><strong>–35% reg. NH₃ agric. emissions</strong></td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>(-) to +</td>
<td>++</td>
</tr>
<tr>
<td>-2 to –4 µg/m³</td>
<td>≤ –1 µg/m³ in regional DJF</td>
<td>≤ –1 µg/m³ in regional DJF</td>
<td>regional area-wide</td>
<td>improved technology/less indiv. traffic</td>
<td>Eutrophication</td>
</tr>
<tr>
<td><strong>–35% reg. NOₓ traffic emissions</strong></td>
<td>(+)</td>
<td>++</td>
<td>+</td>
<td>(+) to +</td>
<td>++</td>
</tr>
<tr>
<td>≤ –0.15 µg/m³ reg.</td>
<td>–2 to –3 µg/m³ reg.</td>
<td>≤ –2 µg/m³ reg.</td>
<td>regional area-wide</td>
<td>improved technology/less indiv. traffic</td>
<td>Eutrophication</td>
</tr>
<tr>
<td><strong>Env Zone</strong></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td><strong>Access, P+R</strong></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>noise in env. zone</td>
</tr>
<tr>
<td><strong>Scenario 2</strong></td>
<td>(+)</td>
<td>+</td>
<td>(+)</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Speed limit A2 &amp; A9 motorways Styria, reg.</strong></td>
<td>(+)</td>
<td>+</td>
<td>(+)</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

- **Klagenfurt DJF** ≤ -1.5 µg/m³ in Klagenfurt DJF
- **regional area-wide** ≤ –1 µg/m³ in regional DJF
- **regional area-wide** ≤ –0.15 µg/m³ in regional DJF
- **AMV near roads** ≤ -1.5 µg/m³ in AMV near roads
- **A2, A9 DJF motorways** ≤ -2 µg/m³ in A2, A9 DJF motorways
- **Regional, localized close to motorway**
- **Noise near motorway**
- **Eutrophication**
- **CO₂ traffic** -30.6 % CO₂ traffic - 55 000 t/a CO₂
- **CO₂ traffic** -2.2 % CO₂ traffic - 124 000 t/a CO₂
THANK YOU FOR YOUR ATTENTION!

Acknowledgements

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