Improved representation of street canyons with the CityChem extension of urban-scale air quality model EPISODE

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EPISODE-CityChem model

The new urban chemistry transport model EPISODE-CityChem (based on the Eulerian urban dispersion model EPISODE by NILU) simulates the photochemical transformation of multiple pollutants along with atmospheric diffusion to produce pollutant concentration fields for the entire city on a horizontal resolution of 100 m or even finer and a vertical resolution of 24 layers up to 4000 m height [1]. CityChem contains representations of street canyons and local photochemistry for the sub-grid scale modelling near line sources. A simplified street canyon model (SSCM) is implemented to account for pollutant transfer along streets, including a parameterization of a simplified building geometry at street level. A fundamental assumption is that an hourly averaged recirculation vortex is always formed (see fig. 1), when the wind blows over a rooftop in a street canyon [2].

![Figure 1: Illustration of the flow and dispersion conditions in the street canyon.](image)

**Street canyons in Hamburg**

The street canyon model in CityChem follows in most aspects the Operational Street Pollution Model (OSPM) [3]. The complex and diverse geometry of street canyons is approximated by three generic types. Each line source for which the geometric mid-point is located in a grid cell with urban land use is identified as street canyon. Results from SSCM are compared to the open road dispersion model HIWAY for examples in fig. 2, 3, and 4. Table 1 summarizes the configuration of the tested street canyons.

### Table 1: Street canyon geometry in the presented examples.

<table>
<thead>
<tr>
<th>Canyon</th>
<th>Street orientation</th>
<th>Canyon width</th>
<th>Building height</th>
<th>Wind flow field</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habichtstr.</td>
<td>135°</td>
<td>24 m</td>
<td>18 m</td>
<td>0°-360°, steps of 10°</td>
<td>0.732 g s⁻¹ (NO₂)</td>
</tr>
<tr>
<td>Kieler Str.</td>
<td>127°</td>
<td>24 m</td>
<td>18 m</td>
<td>0°-360°, steps of 10°</td>
<td>0.343 g s⁻¹ (NO₂)</td>
</tr>
<tr>
<td>Wind test</td>
<td>135°</td>
<td>18 m</td>
<td>18 m</td>
<td>0°-360°, steps of 10°</td>
<td>0.20 g s⁻¹ (PM₁₀)</td>
</tr>
</tbody>
</table>

**Wind dependence**

- The dependency of concentrations of an inert tracer in a canyon with street axis in SE-NW direction was examined at different wind speeds.
- SSCM gave higher concentrations because it considers the reduced ventilation inside the canyon and the recirculation of the traffic plume. HIWAY is designed for free dispersion from an open road or highway.
- Both models result in maximum concentration contributions when wind is near parallel to the street.
- At very low wind speed, the traffic generated turbulence dominates. In SSCM, leeward concentrations are higher than windward (grey shaded) concentrations. The opposite is the case in HIWAY.

**Outlook**

- The simplified street canyon model allows for a better treatment of NO₂ at traffic stations.
- The wind dependence of concentrations at a receptor located in a street canyon is as expected from the literature [2].
- SSCM needs to be refined in particular with respect to a better representation of the street canyon geometry; for instance, by using spatially resolved data on building height and street canyon width, for example by extracting this information from the 3-D city building model LoD1-DE Hamburg.

![Figure 3: Measured (blue) and modelled NO₂ concentrations and wind direction (green lines) at two street canyons.](image)

![Figure 4: Wind dependence of tracer concentration in the street canyon for different wind speed, with SSCM (left) and HIWAY (right).](image)

![Figure 5: Monthly mean concentration of NO₂ (µg m⁻³) in Hamburg in June 2012 with SSCM (left) and HIWAY (open road dispersion).](image)