Air Pollution Levels at Copenhagen Airport estimated by measurements and Nested Regional Eulerian, Local Gaussian Plume and CFD Models

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Outline

• Background
• Method
  - Three one-way nested models
    (regional DEHM, local OML and MISKAM)
  - Emission inventories
• Results
• Conclusions
Background

• Possible work-related health problem in the airport
• Focus on the apron
• Measurements and dispersion modelling for 2010
• Limit values
• Point out possible major sources
  => reduction strategy
• Several air pollutants measured,
  but only NO\textsubscript{x} and NO\textsubscript{2} are presented here
DEHM (Danish Eulerian Hemispheric Model)

- Horizontal grid size:
  - 150 km x 150 km
  - 50 km x 50 km
  - 5.6 km x 5.6 km

- 3D chemical transport model
  - Transport and dispersion
  - Chemical reactions
  - Wet and dry deposition
The OML model

Gaussian plume model

- Point sources
  - Plume rise
  - Building effects
- Area sources
- Disp. continuous function of hourly $u^*$, $L$, $z_0$, $H_{mix}$
- Hourly conc.
- Chemical scheme for NO-NO$_2$-O$_3$ as in OSPM
MISKAM

- CFD model
- Grid size in centre: 5 m x 5 m

Apron monitor, B4
Emission inventories

- The airport: A very detailed emission inventory
- **Danish road traffic**: Danish road database *(Jensen et al., 2009)*
- **Other Danish sources**: 1km x 1km inventory *(Plejdrup et al., 2011)*
- European sources: EMEP inventory
- Hemisphere sources: EDGAR2000 and GEIA
- **SNAP categories** *(Selected Nomenclature for Air Pollution; ETC/AEM – CITEPA, 1996)*: combustion, industries, transport, waste, agriculture, etc.
DEHM: 5.6 km x 5.6 km

OML non-vehicle emission: 1 km x 1 km

OML domain: 10 km x 10 km

MISKAM domain: 1100 m x 700 m
Traffic emission grid
250 m x 250 m, used in OML
Airport emission inventory

- Based on flight operations for 4 typical days with use of 4 possible runways
- Aircraft emission divided into taxi, take-off, climb-out, approach and landing
- Databases:
  - ICAO (Intern. Civil Aviation Org.) emissions
  - LASPORT (LASat for airports, Janicke 2010) fuel consumption
- Source categories
  - Aircraft main engines
  - APU (auxiliary power units)
  - Handling equipment
  - Vehicle traffic inside the airport
Choice of one of four emission days / runways

4 typical days/runways:
• 22 L+R
• 04 L+R
• 12
• 30

Choice determined by wind speed and direction for the current hour
Tracks of landing and take-off, taxi and dock-in and push-back
NO$_x$ emission at the apron
Results
OML
Yearly NO$_2$
Results
OML
Yearly $\text{NO}_x$
Source categories

- Background (regional from DEHM)
- Local sources (10 km x 10 km) outside airport
- Aircraft main engines
- APU (auxiliary power units)
- Handling equipment
- Vehicle traffic inside the airport
NO$_x$, 2010

Model differences:
- grid size
- time variation
- atm. stability
Station West

![Graph showing NOx concentration against wind direction.](image)

- Measurement
- OML model
- DEHM background

Wind direction (degrees)

NOx (µg m\(^{-3}\))

Measurement OML model DEHM background
Direction 135-185 towards part of runway 22R with major emissions
Measurements

NOx, monitor West
Dir.: 135-185°

\[ C = 50 \, \text{u}^{-1} + 5 \]

5 point moving avg.
5 weeks campaign with passive samplers mainly at the apron

<table>
<thead>
<tr>
<th>Location</th>
<th>Measures (µg/m³)</th>
<th>OML (µg/m³)</th>
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<tbody>
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<td>East-mon.</td>
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Conclusions

- The relative geographical distribution of the emission at the apron is reproduced well.
- The NO$_x$ level at the apron is overestimated probably due to too high emission from handling equipment.
- The levels at the remote monitors are modelled well.
- Plume rise of aircraft main engines and APU must be accounted for in future studies in order to determine if aircraft emissions are too high.