Study of air pollution dispersion in a street: case of Ho Chi Minh (Vietnam)

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Objectives of LIV work on air pollution modeling

Understand processes driving air pollution over urban areas, human behaviour and the social context of these areas in order to optimize air pollution management.

Current projects:
- improve air pollution forecasts over cities (ex: Paris).
  L. Menut - LMD, INERIS (Paris), A. Clappier (EPFL).
- estimate population exposure to air pollution and health impacts
  S. Glatron - LIV (Strasbourg), D. Bard - EHESP (Rennes).
- understand vegetation ecological function (impact on air pollution).
  C. Weber, A. Wania - LIV (Strasbourg), M. Bruse (Univ. Mainz).
- improve estimate of traffic emission factors.
Numerical models running at LIV:

The chemistry-transport model CHIMERE (coordinator: L. Menut, LMD, Paris):
http://euler.lmd.polytechnique.fr/chimere

Muti-scale model – runs over a range spatial scale from regions and urban areas.

The RANS model ENVImet (coordinator: M. Bruse, Univ. Mainz):
http://www.envi-met.com

Studies over few streets.

Pictures taken from http://www.envi-met.com
CHIMERE validation using surface data
Comparison of CHIMERE with satellite data (collaboration with H. Eskes from KNMI)
Recently work: use of ENVImet to understand air pollution dispersion in a street in Ho Chi Minh (Vietnam).

Ho Chi Minh City measuring campaign  
January - March 2007

Conducted by A. Clappier et al., EPFL, Lausanne.

Objectives of the campaign:
Identify the sources of pollutant.
Estimate traffic emission factors (EF) as previously done in Bogotá (Zarate et al., 2007).

\[ C_i = D \times Q_s \]
D computed using the model STREET
\[ D(z) = k(H-z)/[HW(u+0.5)] \]
Ba Thang Hai street
14,000 motorcycles/hour (95% of the fleet distribution)
Tracer liberation and measurements

(2) Tracer liberation: n-Propane from LPG (non toxic): 12 h/day, 30 days

(1) Traffic recording
24 h/day, 60 days

(3) Monitoring station:
NO, PM$_{2.5}$, 18 VOC

(4) Meteorology
Comparison of propane concentrations when LPG was released (9 L/min) with normal background levels (0 L/min).

Use of the model ENVImet to understand this trend.
Setup of first ENVImet simulations

LPG emission line source with an emission rate of 9L/min

Horizontal resolution 4x4m²
Model initialization and simulations

Initialization of the model at 6h (local time) with typical values computed using the meteorological observations. $\Theta(z=2500\text{m})=290\text{K}$, RH=50%
Initial values: Tsoil/surface=$25^\circ\text{C}$, Tinside-building=$25^\circ\text{C}$

Runs for 24 hours.
Spin up of 6h
Referring to street canyons studies: BTH street is a shallow, long and step down street canyon (H/W~0.5, L/H>10)

Flow regimes for perpendicular approaching wind direction : Oke, 1988

**Isolated roughness flow**
Flow fields do not interact

**Wake interference flow**

**Skimming flow**
Circulatory vortex is established.
First results

Consistent wind flow.

Windward side:
Near sources, concentrations in the range of what we should have on the other side of the street

Leeward side:
Low concentrations. Factor 10 compared to the observations.
Differences observations/simulations?
Rôle of turbulent diffusion?
Rôle of thermal effects?
Rôle of the trees?
Sensibility studies to input parameters which can influence the turbulent diffusion, thermal effects or the trees effects.

Modified input parameters:
- potential temperature in 2500 m height (start value for all layers, fixed at 2500m but re-calculated below)
- Initial surface temperature of surfaces and soil
- Initial inside temperature of buildings
- wind direction (fixed value during the simulation)
- wind speed (fixed value during the simulation)
- leaf area density of the trees
Changes in potential temperature in 2500m height

Mixing during the daytime, not observed in the observations.
Changes in initial surfaces and soil temperature

Propane concentration [µg/m³] vs. Time

- 20°
- 25°
- 30°

Time

0 10 20 30 40 50

Propane concentration [µg/m³]
Changes in inside temperature of buildings

Propane concentration [µg/m³]

Time

Data Set: hcmc-case1_atm

20-35°
Changes in wind direction

Propane concentration [ug/m3] vs Time

- 90°
- 120°
- 60°
- 150°

CASE 15 - Dir = 90 degrees
CASE 16 - Dir = 120 degrees
CASE 17 - Dir = 150 degrees
CASE 18 - Dir = 18
Changes in wind speed

Propane concentration [ug/m3]

Time

1m/s
2m/s
3m/s
4m/s
5m/s
6m/s
Changes in leaf area density

![Graph showing changes in propane concentration over time for Large LAD and Low LAD.](image-url)
Conclusions

- The sensitivity studies performed with ENVImet didn’t help to understand air pollutant dispersion in the BTH street.

Turbulent diffusion and thermal effects cannot explain differences between observations and simulations.

- The most important factors which influence the concentrations are:
  - Wind speed
  - Wind direction.

- Less important factors which influence the concentrations are:
  - Potential temperature in 2500 m height
  - Initial temperature of surface/soil.
  - Initial inside temperature of buildings.
  - Leaf area density of the trees.
Perspectives

Preliminary study, more tests are needed

⇒ Modify the geometry of the street to be closer to the reality. Different flow regime?

⇒ Look at the impact of spatial resolution.

⇒ Add traffic-induced turbulence and test its impact on the dispersion.

⇒ Change parameters from one hour to the other to be closer to the reality.

⇒ Make tests on other streets where we have more climatological data:
  - Basel
  - Lausanne

⇒ Check the impact of the trees. Surprising small effects...

⇒ Make tests with a LES model (model used by Adil Rasheed).
Thank you for your attention

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