image et ville

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

UNIVERSITÉ LOUIS PASTEUR STRASBOURG

Ecole Polytechnique Fédéral de Lausanne

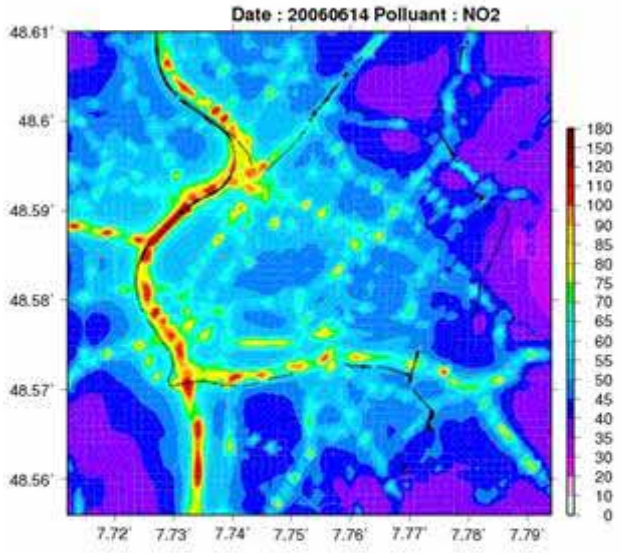
DIRECTION DU DEVELOPPEMENT ET DE LA COOPERATION DDC

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

Nadège Blond, Luis C. Belalcazar, Adil Rasheed, Alain Clappier, Sebastian Huttner, Michael Bruse

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:

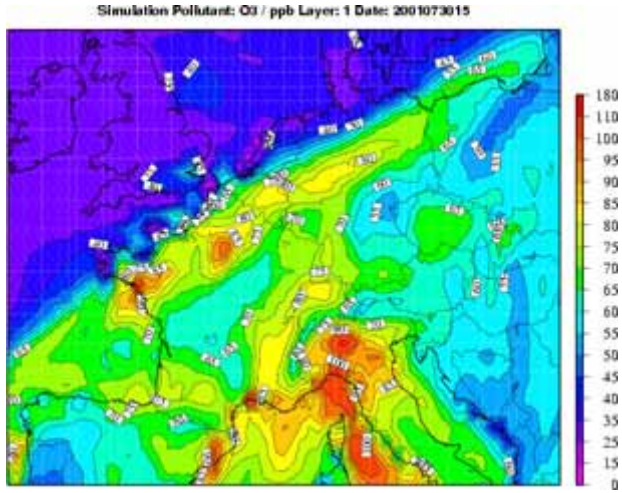
- improve air pollution forecasts over cities (ex: Paris).
  L. Menut - LMD, INERIS (Paris), A. Clappier (EPFL).
- estimate population exposure to air pollution and health impacts
  S. Glatron - LIV (Strasbourg), D. Bard - EHESP (Rennes).
- understand vegetation ecological function (impact on air pollution).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

Numerical models running at LIV :

The chemistry-transport model CHIMERE (coordinator: L. Menut, LMD, Paris):

http://euler.lmd.polytechnique.fr/chimere

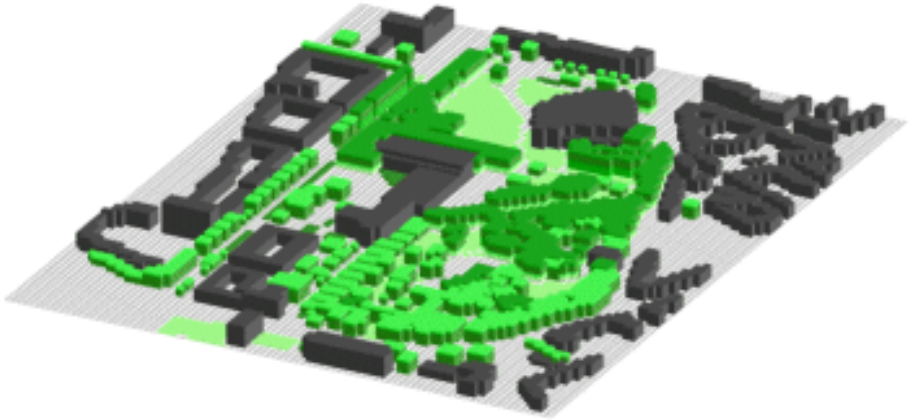
Muti-scale model – runs over a range spatial scale from regions and urban areas.

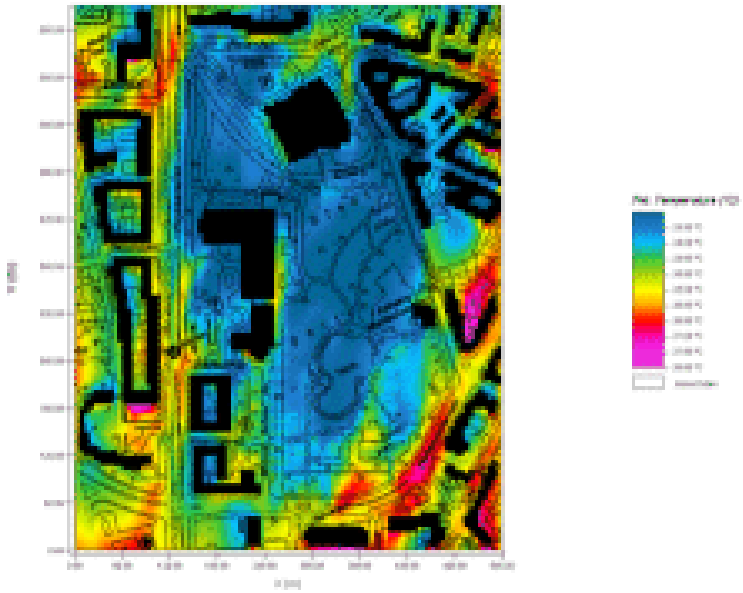


The RANS model ENVImet (coordinator: M. Bruse, Univ. Mainz):

http://www.envi-met.com

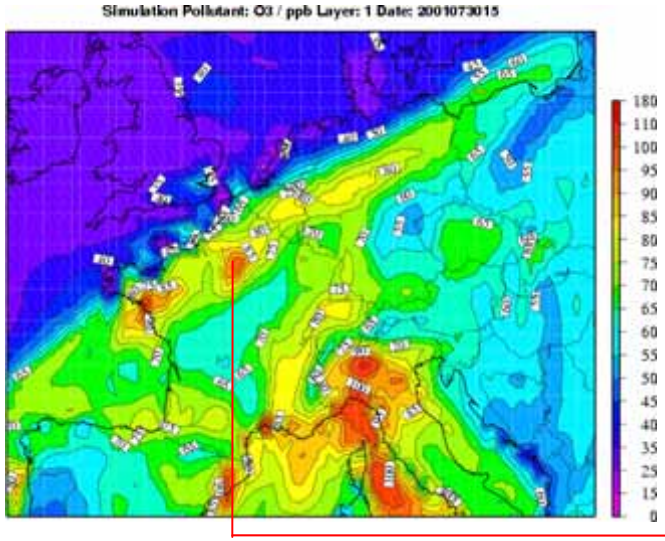
Studies over few streets.

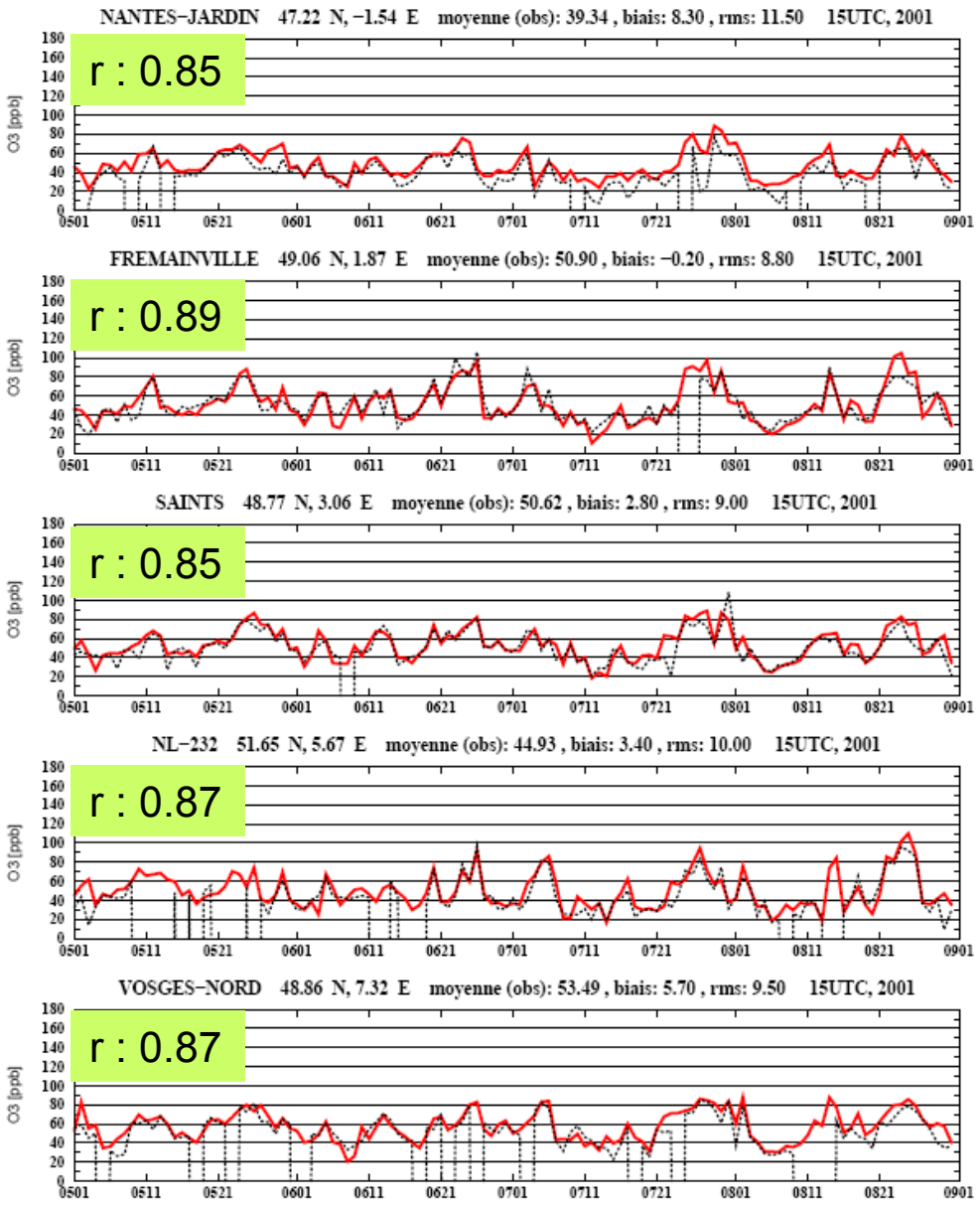




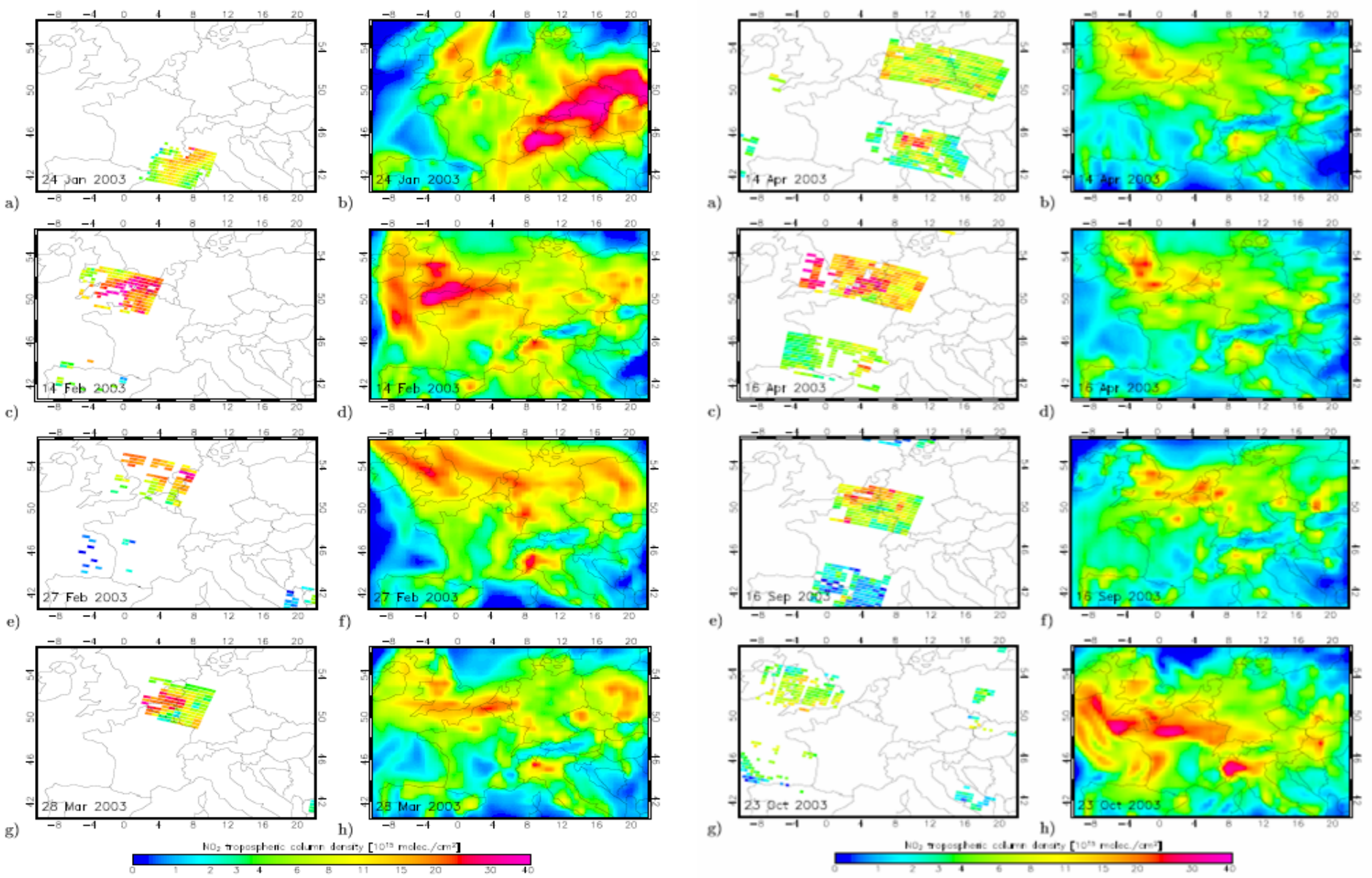
Pictures taken from http://www.envi-met.com

CHIMERE validation using surface data





Comparison of CHIMERE with satellite data (collaboration with H. Eskes from KNMI)



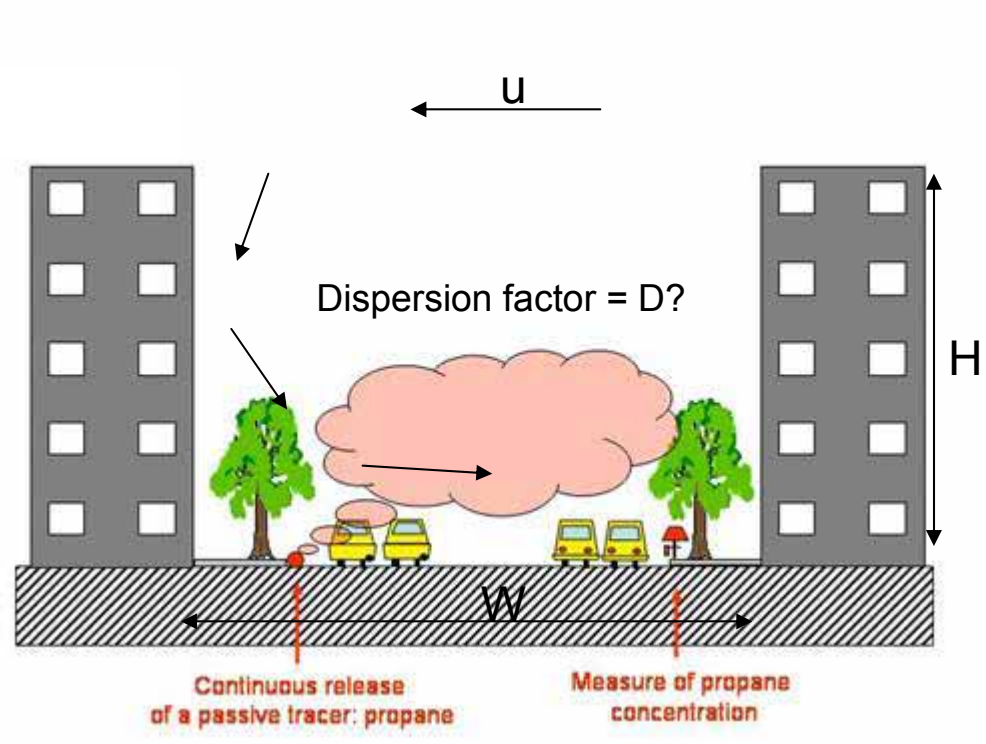
Recent work: use of ENVImet to understand air pollution dispersion in a street in Ho Chi Minh (Vietnam).

Ho Chi Minh City measuring campaign
January - March 2007

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

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

$C_l = D*Qs$
D computed using the model STREET
$D(z)=k(H-z)/[HW(u+0.5)]$



Emission rate = Qs directly links to the EF

Concentration on leeward side=C_l

Ba Thang Hai street

14 000 motorcycles/hour (95% of the fleet distribution)

Tracer liberation and measurements

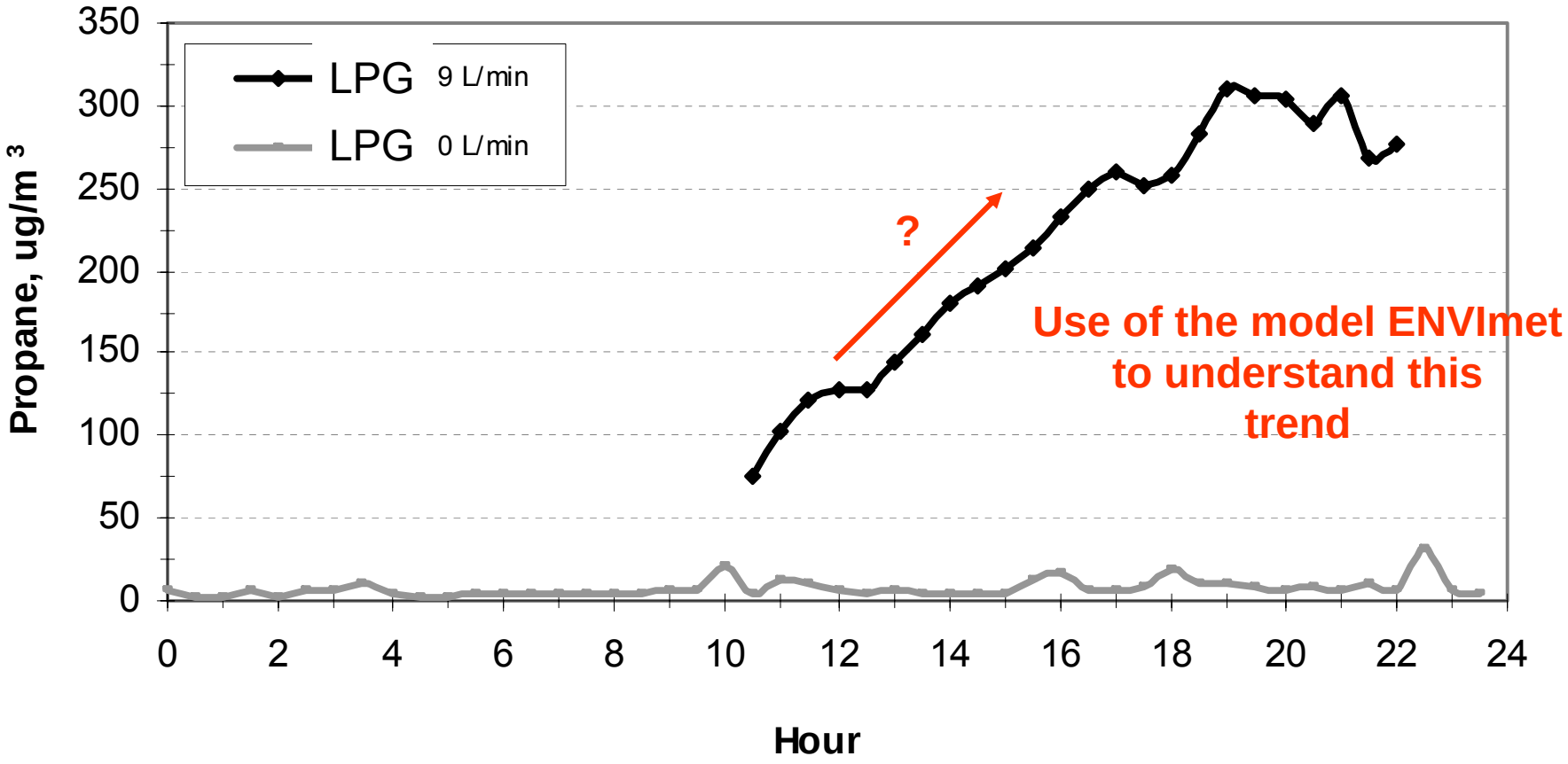
(2) Tracer liberation:
n-Propane from LPG (non toxic): 12 h/day, 30 days

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

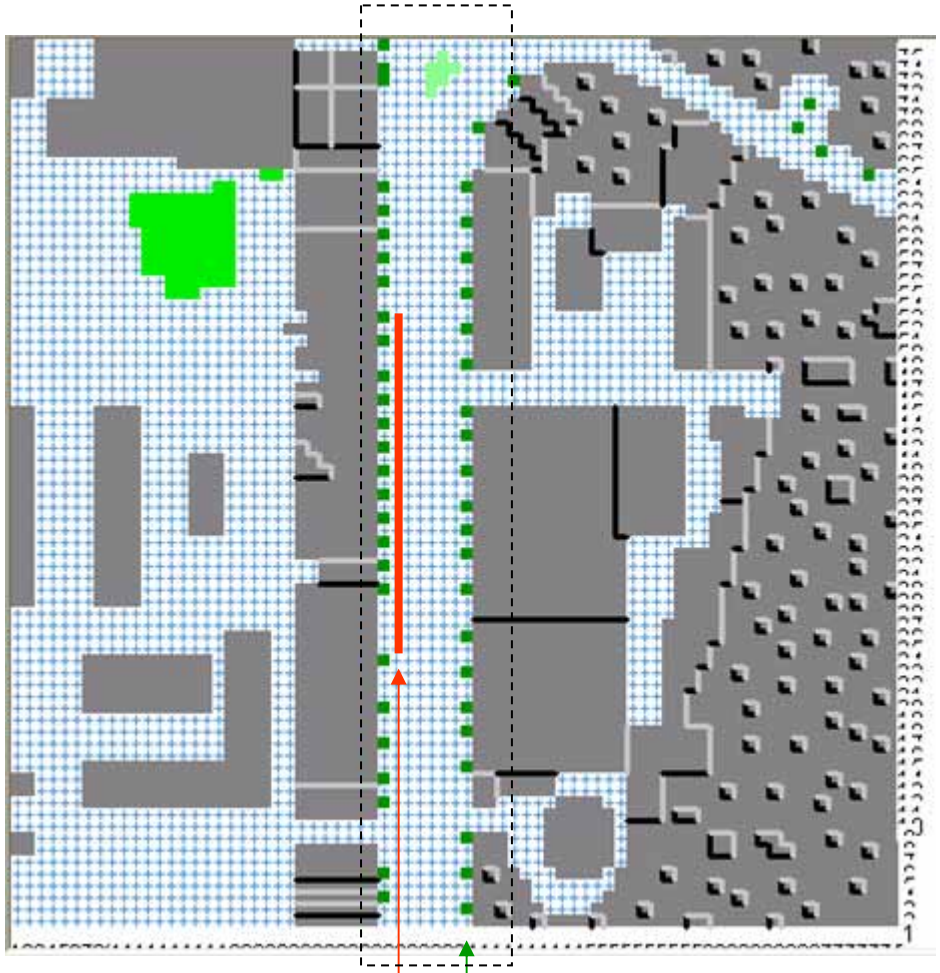
(4) Meteorology

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

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



Setup of first ENVImet simulations



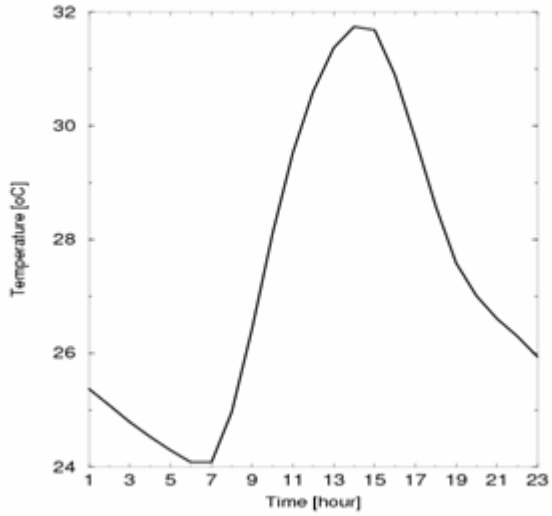
Horizontal resolution 4x4m^2

Model initialization and simulations

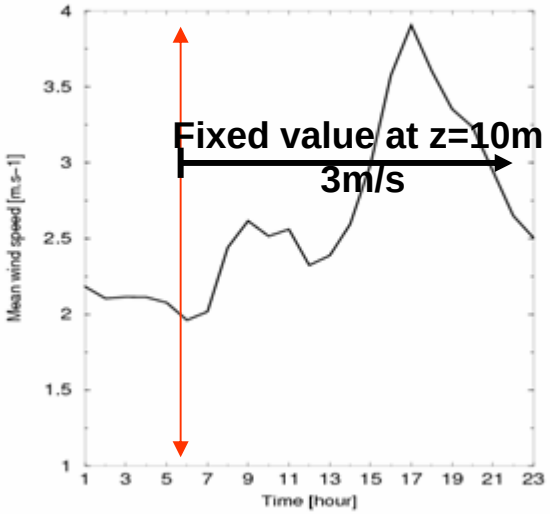
Initialization of the model
at 6h (local time) with **typical values** computed using
the meteorological observations.
Θ(z=2500m)=290K, RH=50%
Initial values: Tsoil/surface=25°C,
Tinside-building=25°C

Runs for 24 hours.
Spin up of 6h

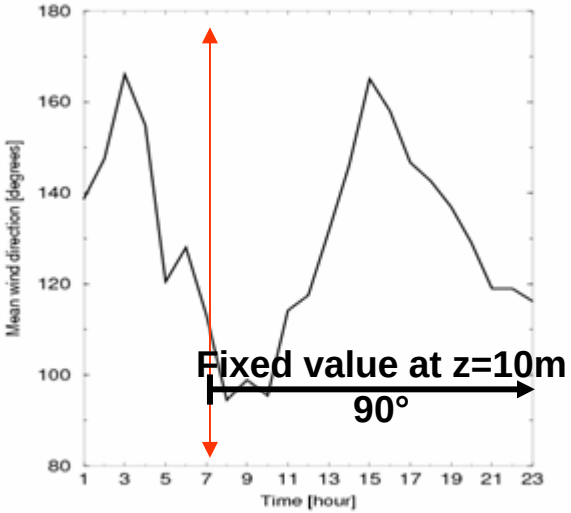
Mean temperature



Mean wind speed

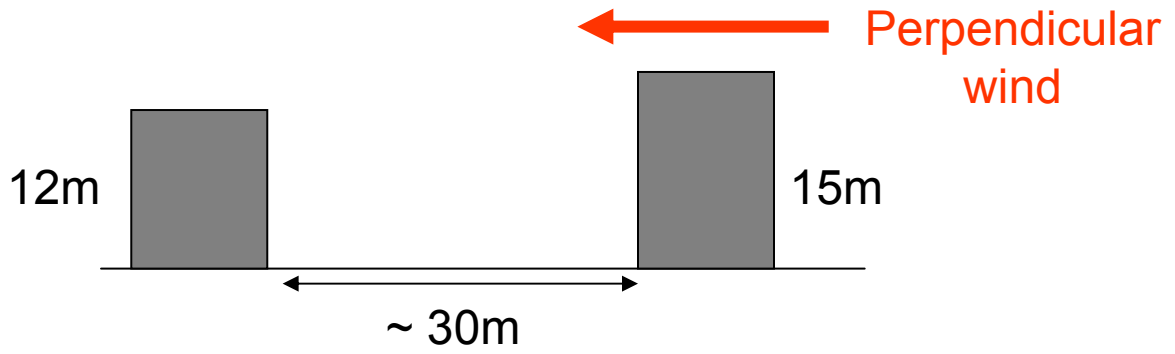


Mean wind direction



Perpendicular wind of 3m/S

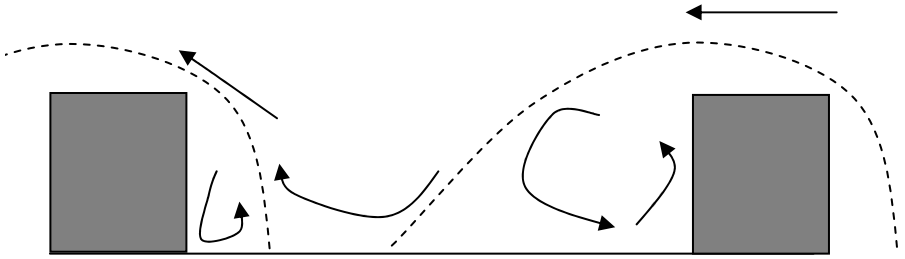
Ba Thang Hai Street case



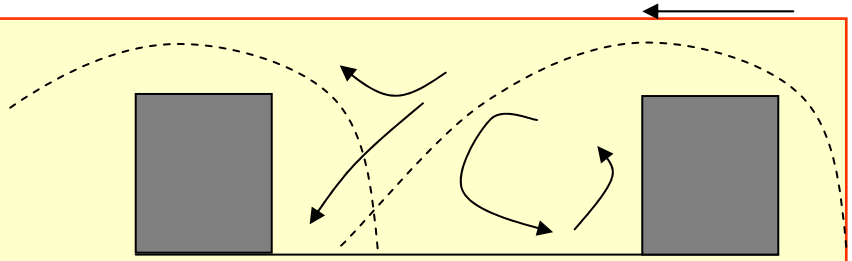
Referring to street canyons studies: ***BTH street is a shallow, long and step down street canyon (H/W~0.5, L/H>10)***

Flow regimes for perpendicular approaching wind direction : Oke, 1988

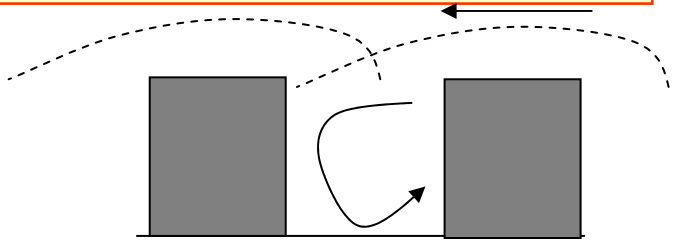
Isolated roughness flow
Flow fields do not interact



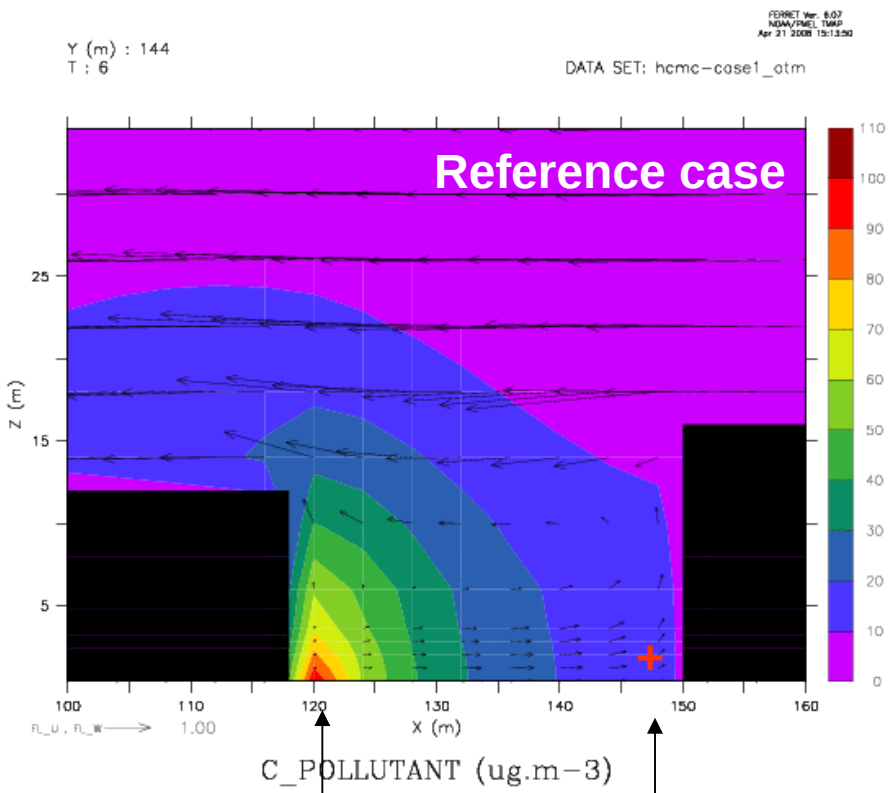
Wake interference flow



Skimming flow
Circulatory vortex is established.



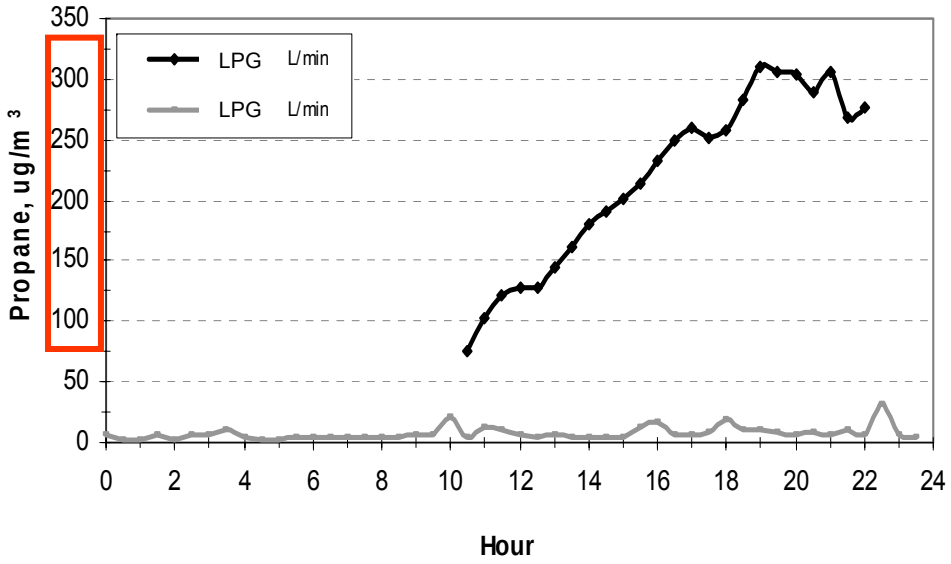
First results

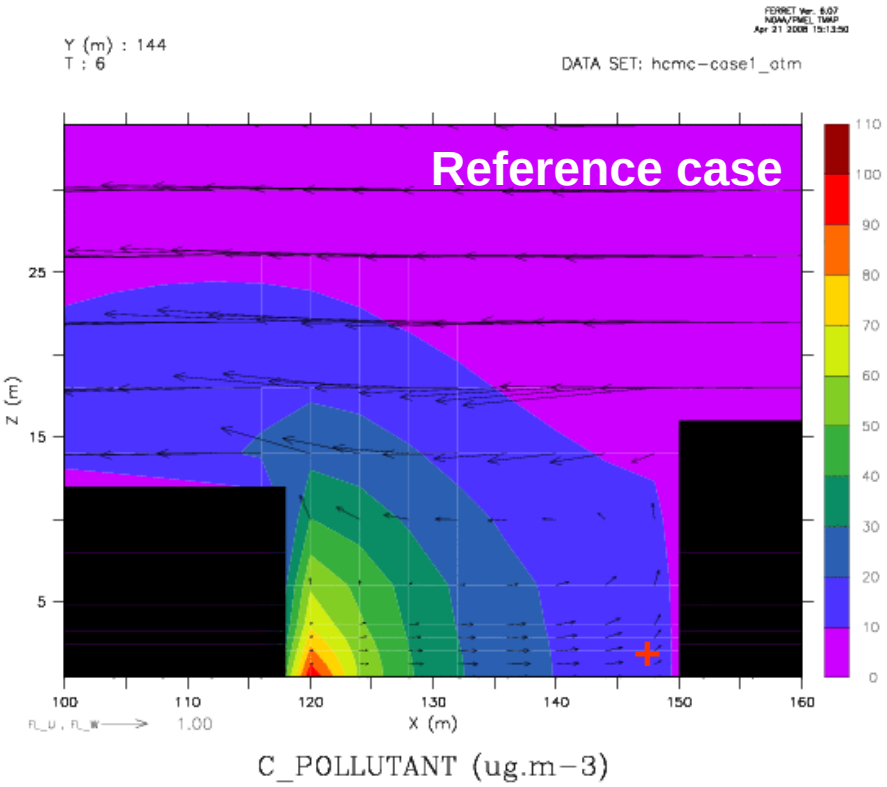


Consistent wind flow.

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

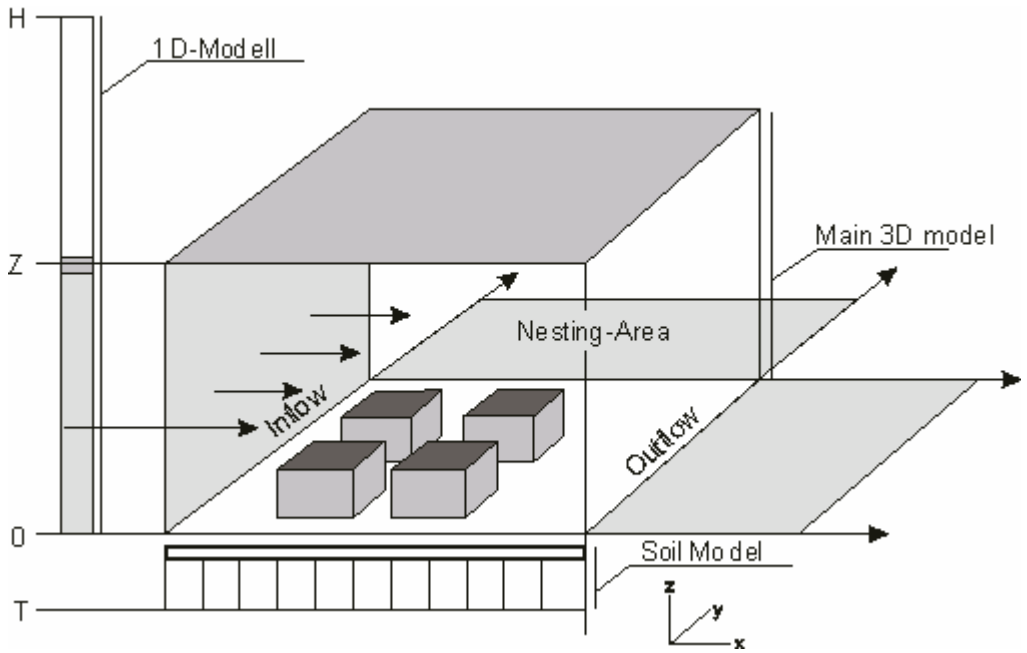
Leeward side:
Low concentrations. Factor 10 compared to the observations.





Differences observations/simulations?
Rôle of turbulent diffusion?
Rôle of thermal effects?
Rôle of the trees?

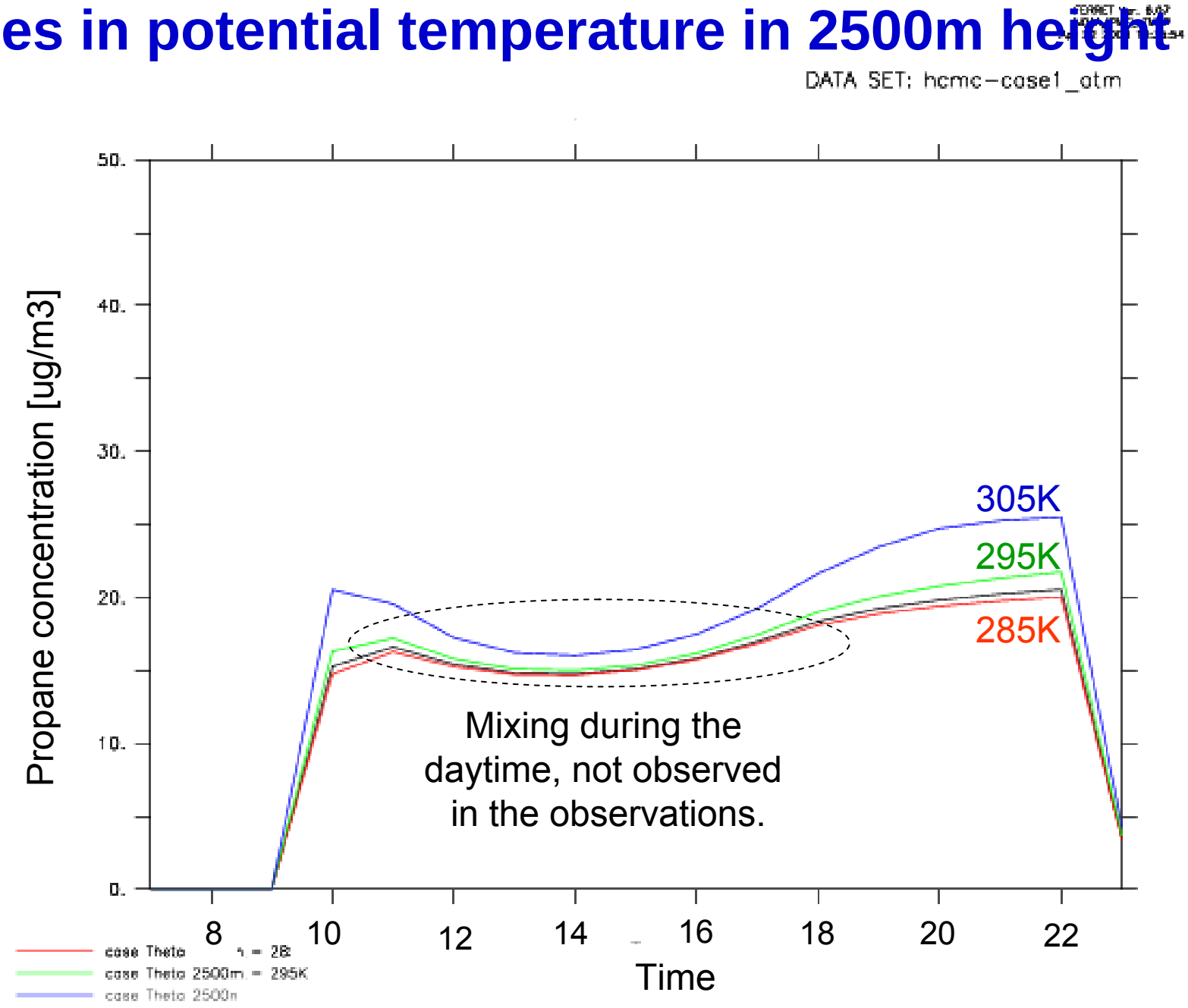
Sensibility studies to input parameters which can influence the turbulent diffusion, thermal effects or the trees effects.



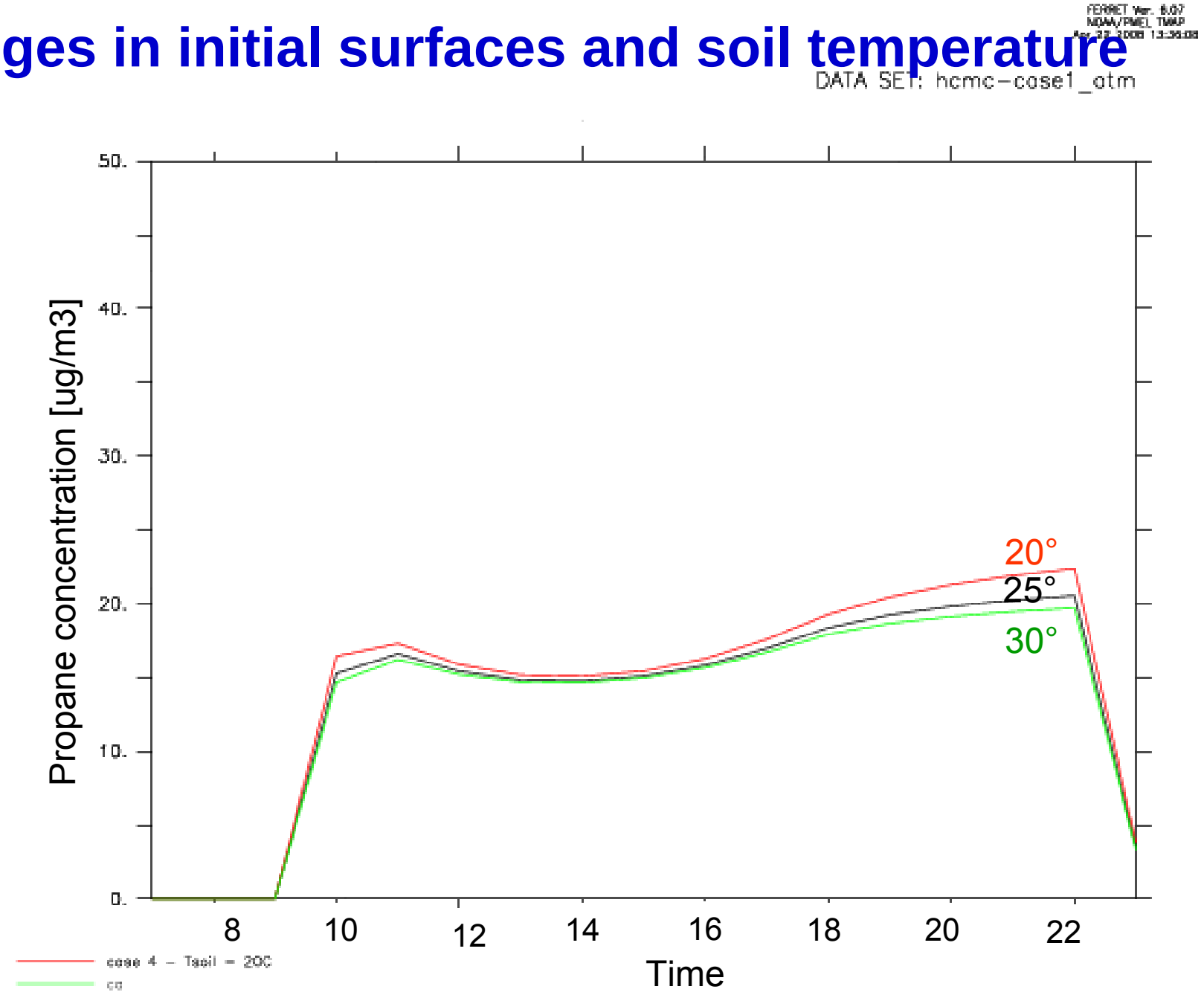
Modified input parameters:

- 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

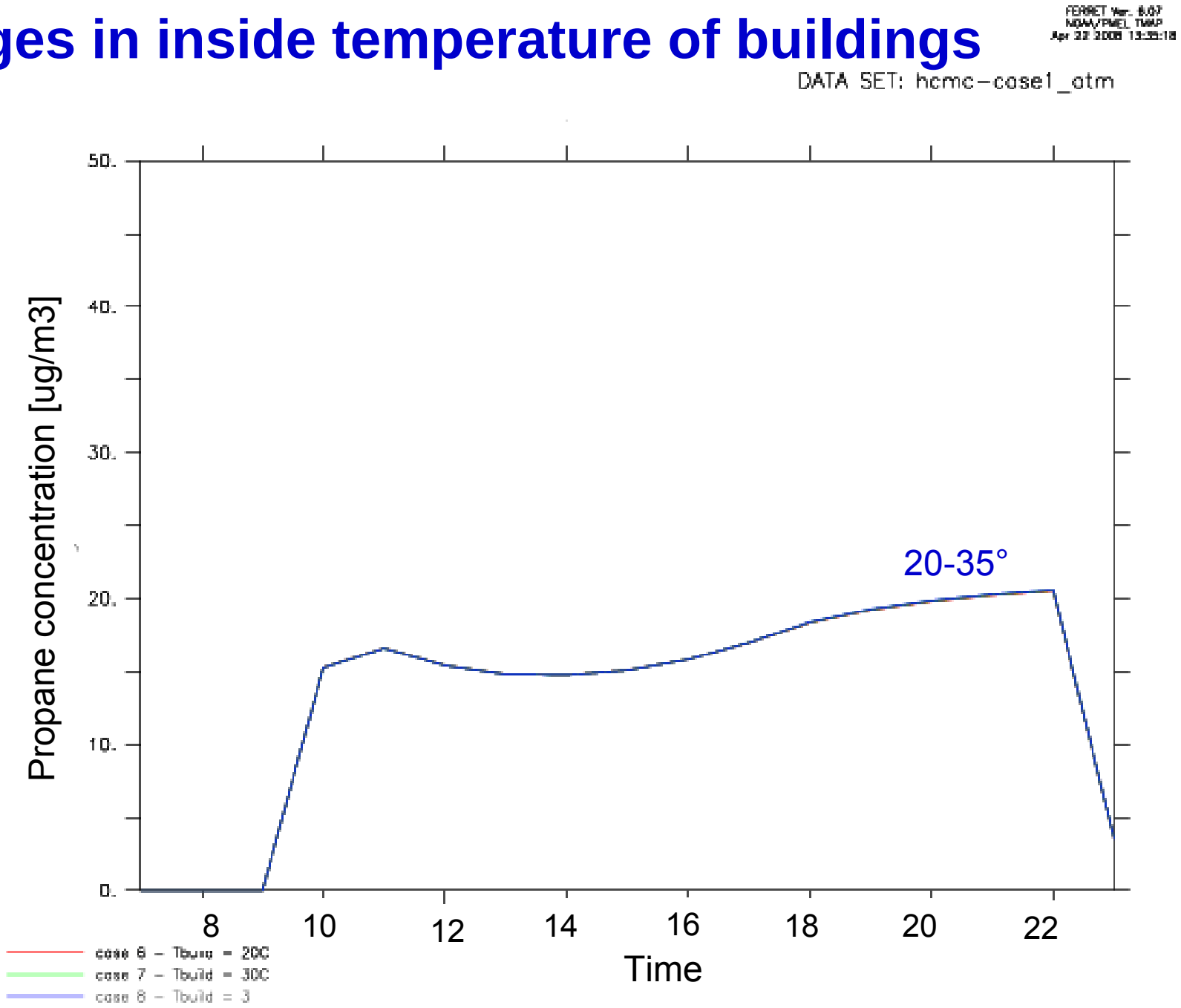
Changes in potential temperature in 2500m height



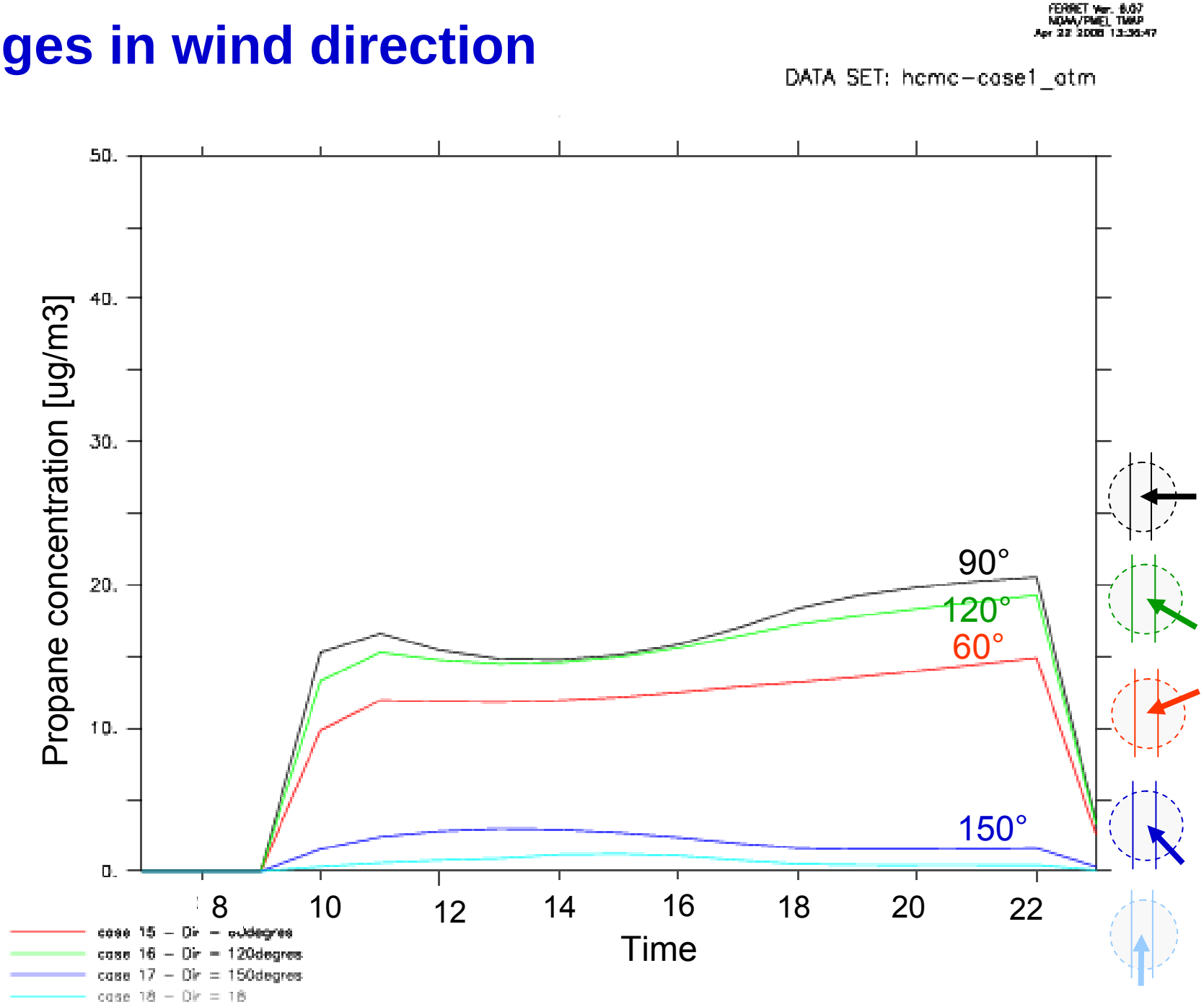
Changes in initial surfaces and soil temperature



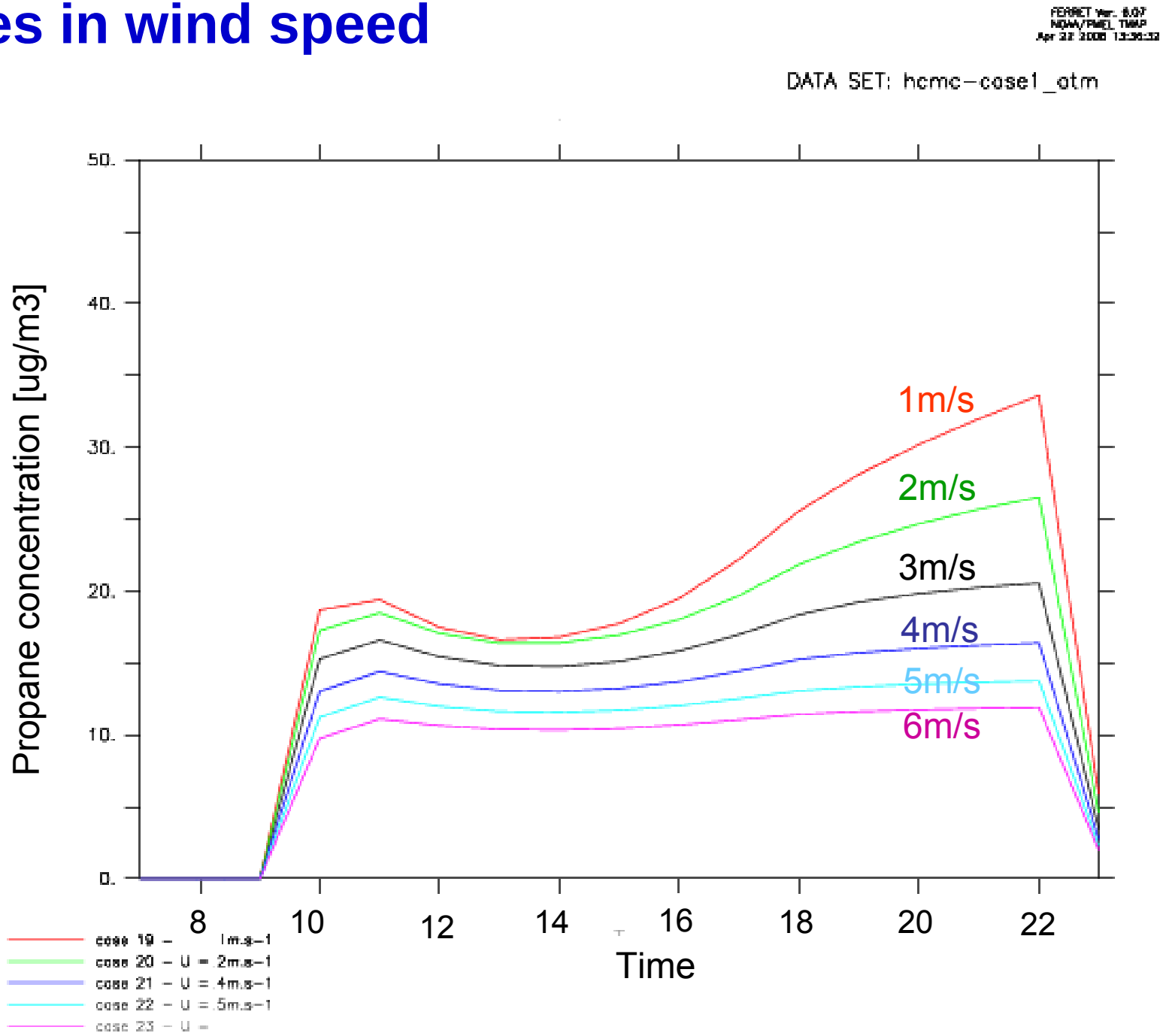
Changes in inside temperature of buildings



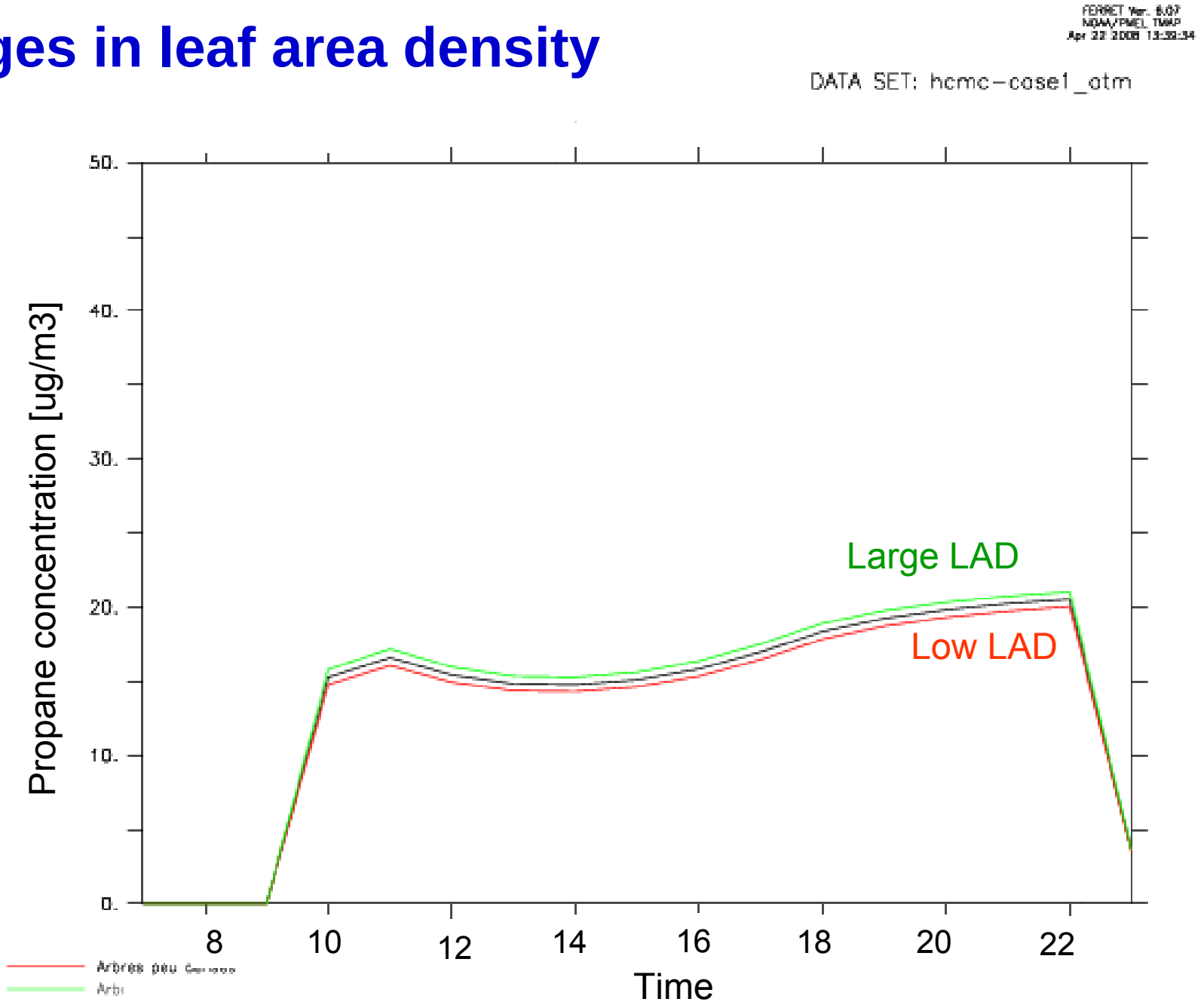
Changes in wind direction



Changes in wind speed



Changes in leaf area density



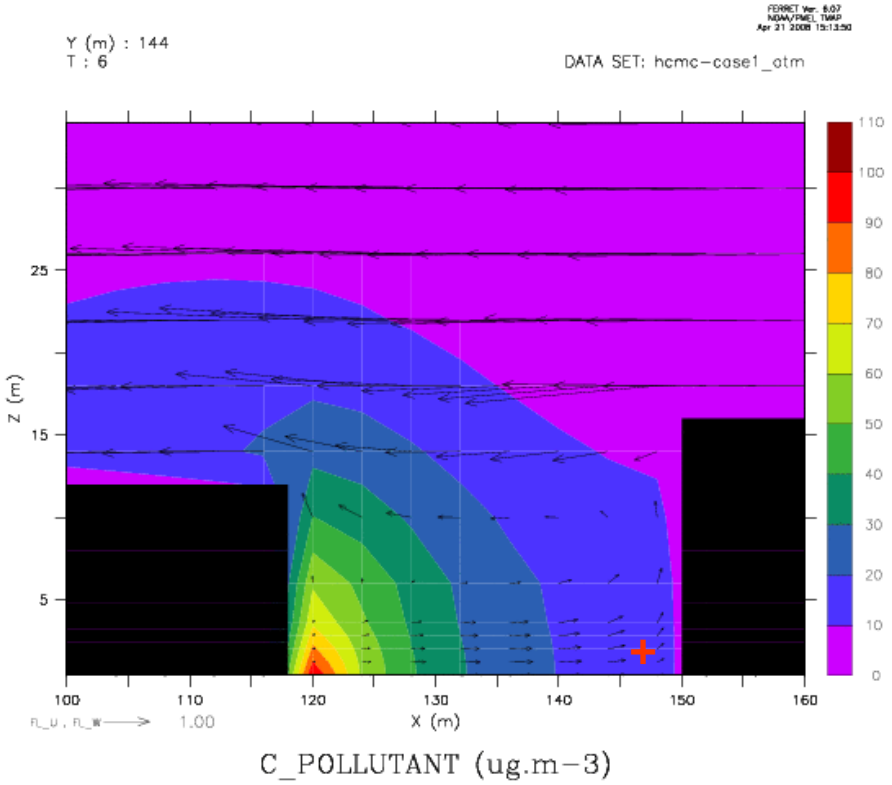
Conclusions

⇨The sensivity 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?

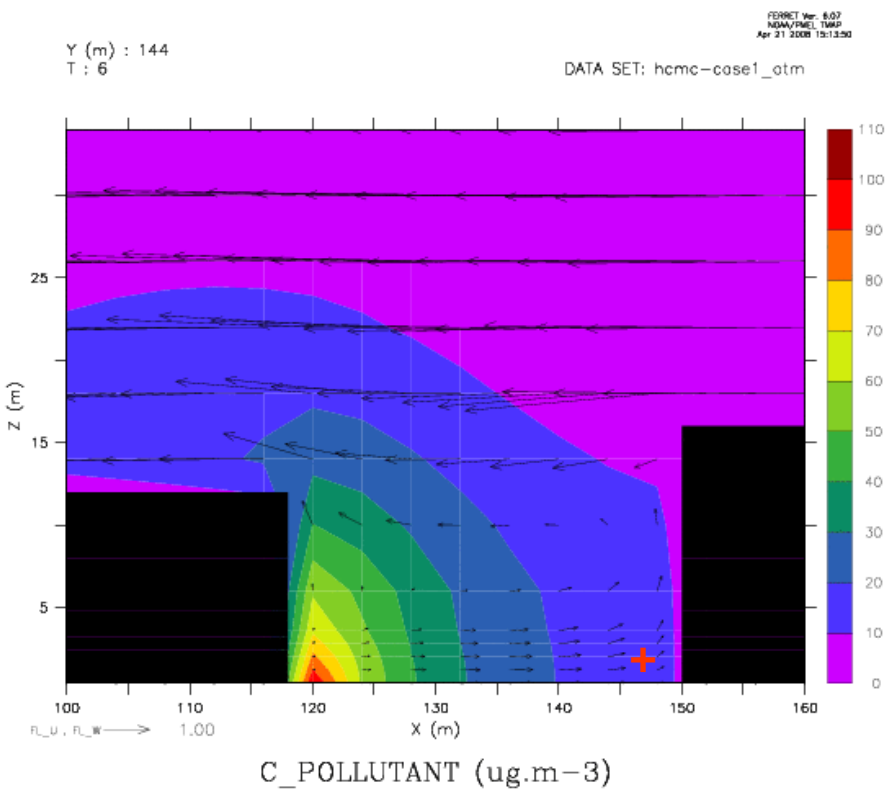
⇨ Look at the impact of spatial resolution.

⇨ 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

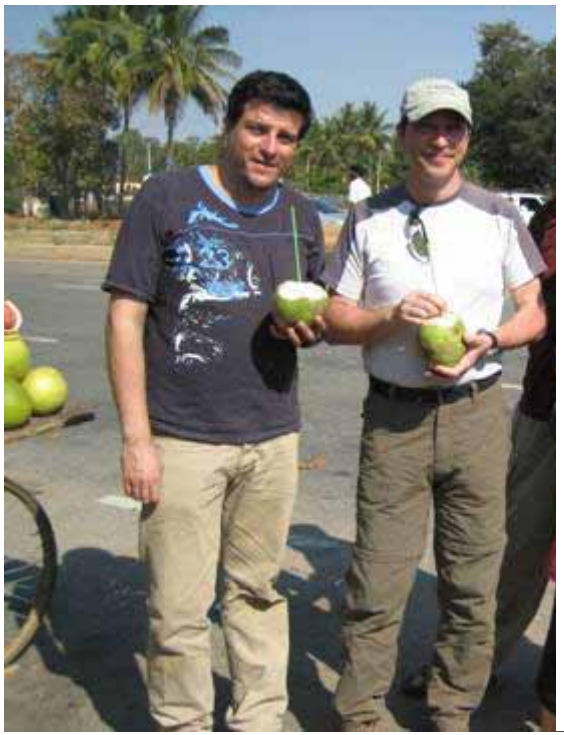


⇨ Check the impact of the trees. Surprising small effects…

⇨ Make tests with a LES model (model used by Adil Rasheed).

Thank you for your attention

Thanks to Jo Vliegen, Stijn Jansen and Koen De Ridder
to give us access to their linux version of ENVImet.



Luis Belalcazar
Alain Clappier