CAPABILITY OF THE STANDARD (K,EPS) MODEL FOR SIMULATING ATMOSPHERIC DISPERSION OVER A NPP SITE

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Background:

• Impact and safety studies: distribution of radionuclides or other air transported pollutants on a Nuclear Power Plant site

• Wind tunnel experiments at **LMFA***, founded by **IRSN****, **EDF***** Bugey NPP site (Méjean 2005)

Means:

• CFD & dispersion simulation with the **STARCD** code

Objective:

• Check capability of basic modelling options to simulate this flow by inter-comparing with the wind tunnel data

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Characteristics of experiment:

- Model
  - scale 1/500, similarity of $\vec{V}$, Re distortion 1/500
  - inlet and ground devices simulate the neutral ABL
  - 2 opposite wind directions, 3.7 m/s at 50m height
  - 2 types of source: stack or containment building
- Measurements
  - at 15 streamwise positions from the source, horizontal profiles available at 4 heights and vertical profiles available at X=0
  - mean velocity components $\overline{U}$, $\overline{V}$, $\overline{W}$ and r.m.s. of stream wise fluctuating component v' by LDA*
  - instant concentration of tracer (ethane) by FID**

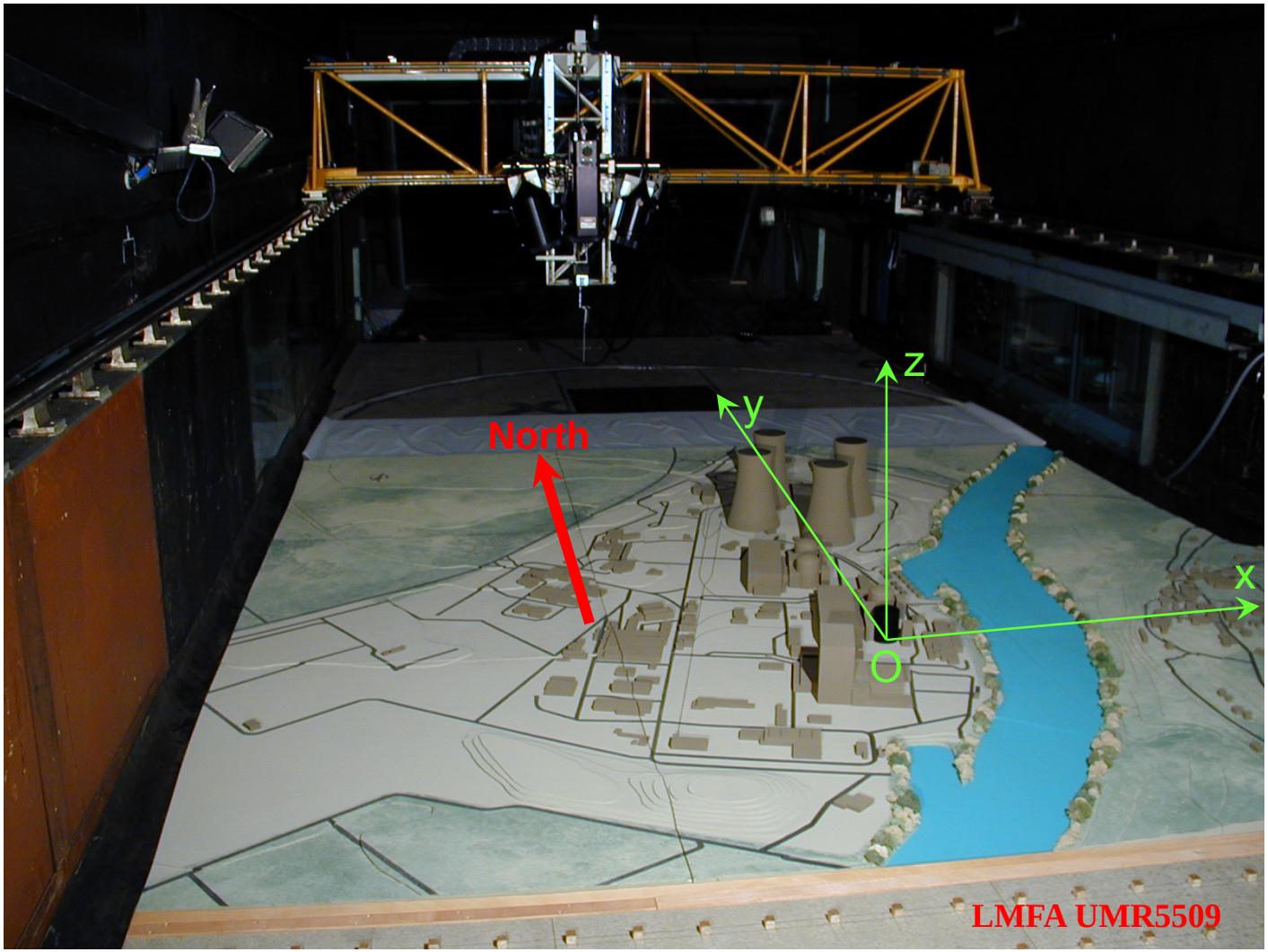
* Laser Doppler Anemometry ** Flame Ionisation Detector

Overview of Bugey NPP model in wind tunnel

Oy axis points to the north

Cooling tower height 140 m

$\varnothing_{top}$ 70 m



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Location of sources

Release from ventilation stack

28 000 m3/h

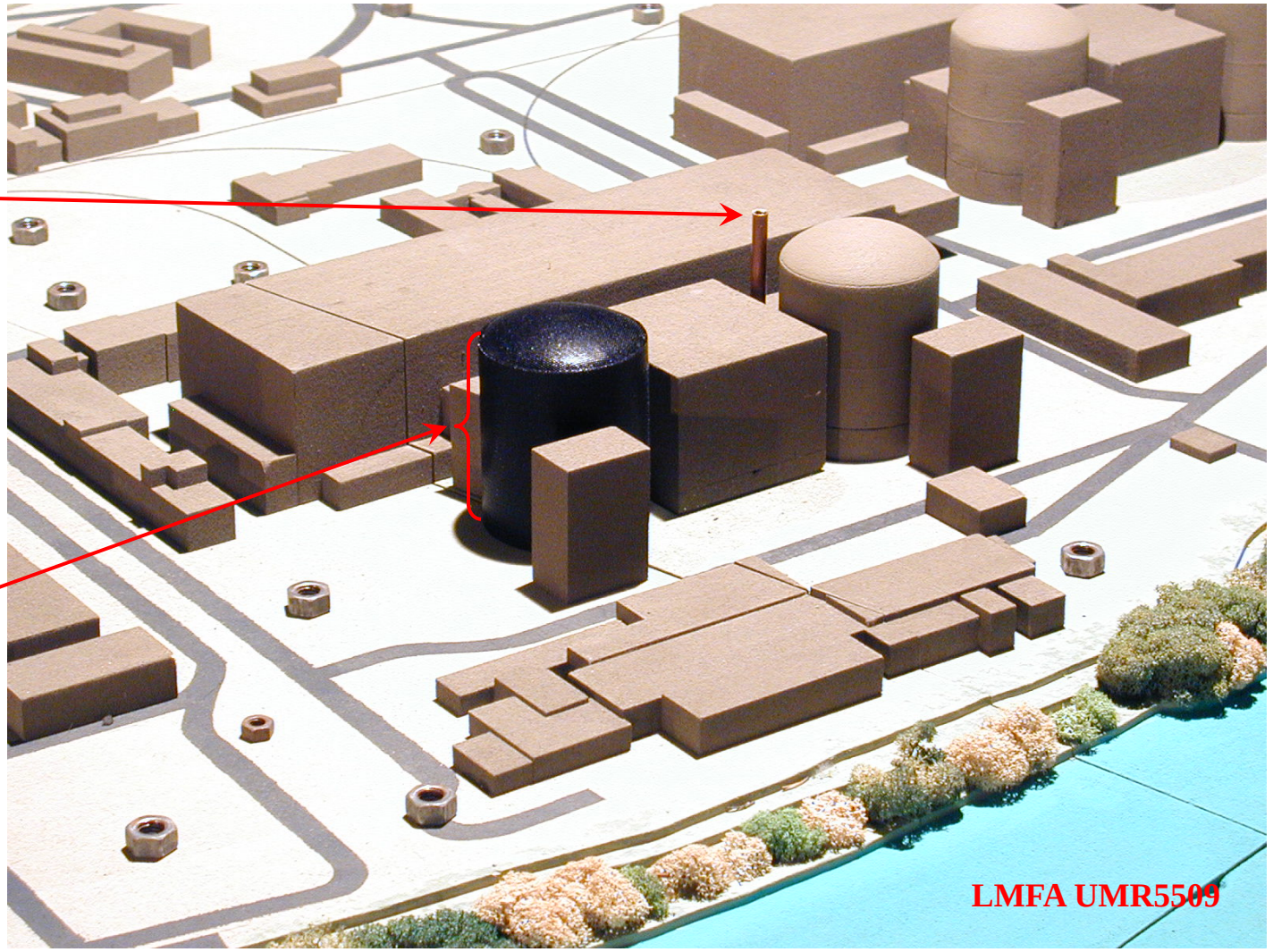
height 55 m

speed W=20m/s

Release from containment building skin

17000 m3/h

(height 50 m)



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Characteristics of (k,ε) computation:

- Grid
  - Domain 1000m x 3000m x 300m
  - Minimum cell size horizontally 0.3m, vertically 0.5m
  - Total mesh comprises 0.41 to 0.65 10^6 cells

- Boundary conditions
  - Simulate the neutral stability homogeneous SBL
  - Inlet profiles as by Richards & Hoxey
  - Rough wall at ground (aerodynamic rugosity 0.04m)
  - Smooth walls on buildings
  - Profile values at h=300m imposed on top boundary

Velocity vector field at z = 10m

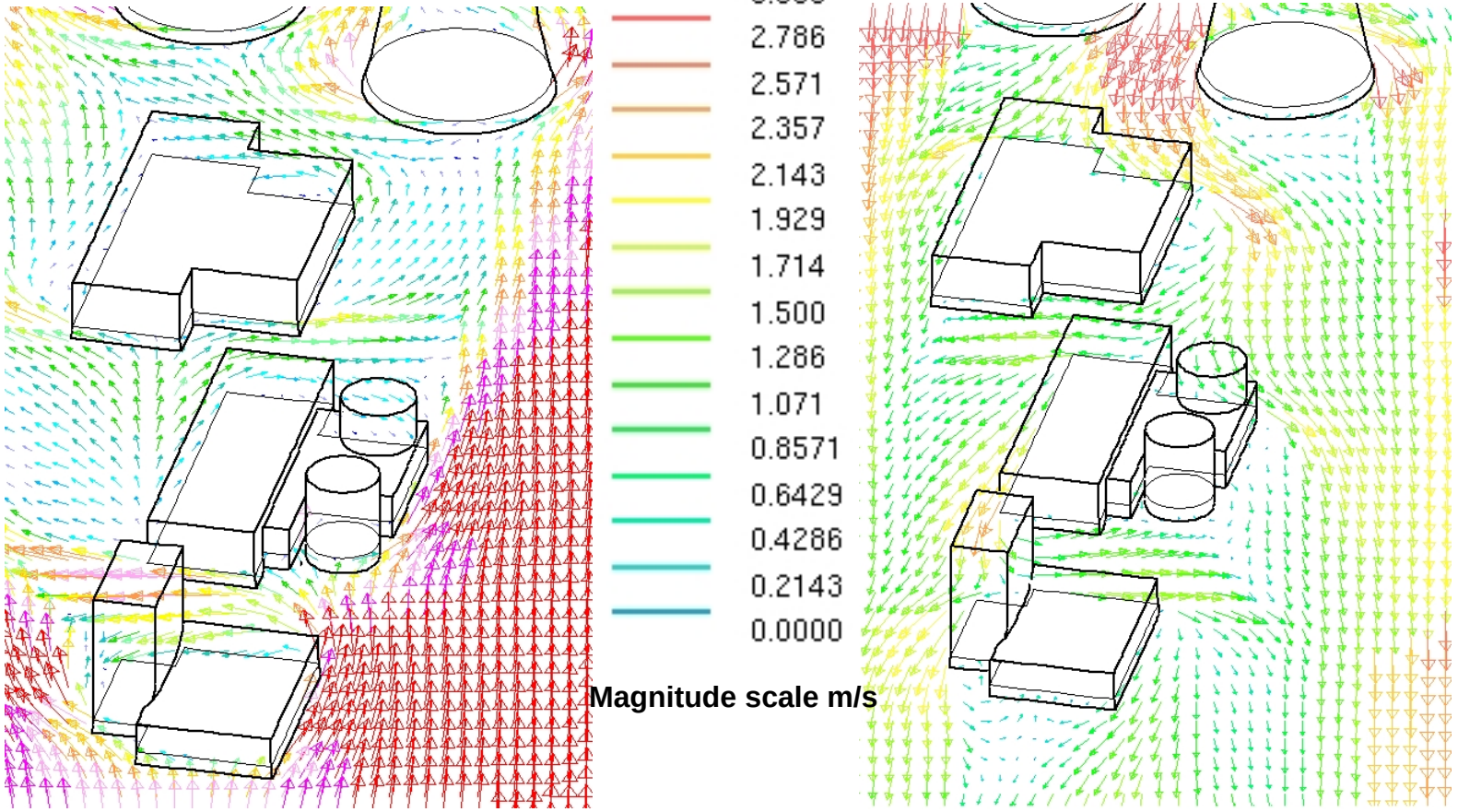
- South wind
- North wind

Y=450 m

Y=200 m

Y=0 m

Y=-200 m



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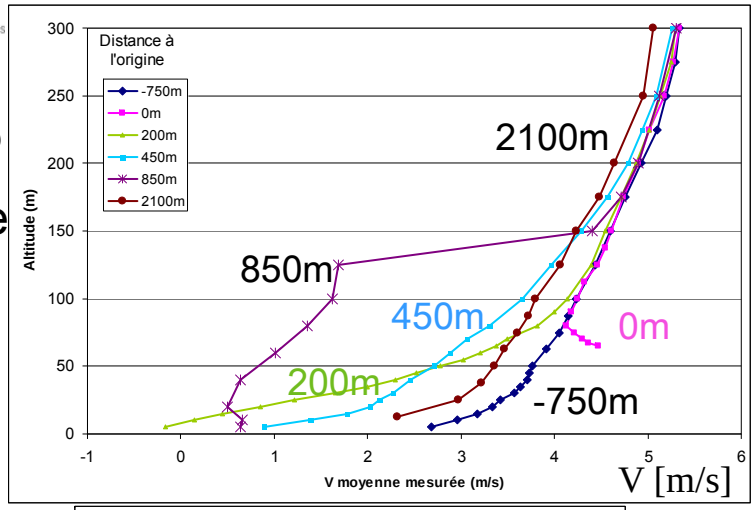
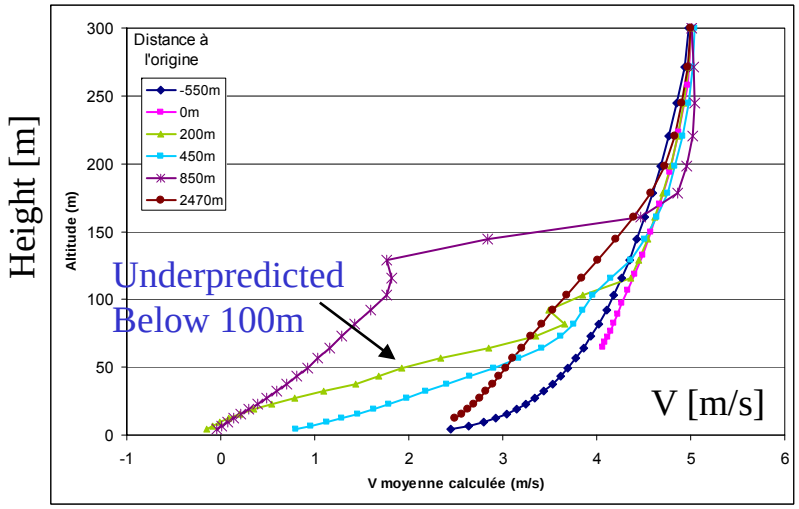
Results for velocity field : U and V profiles by south wind

measured

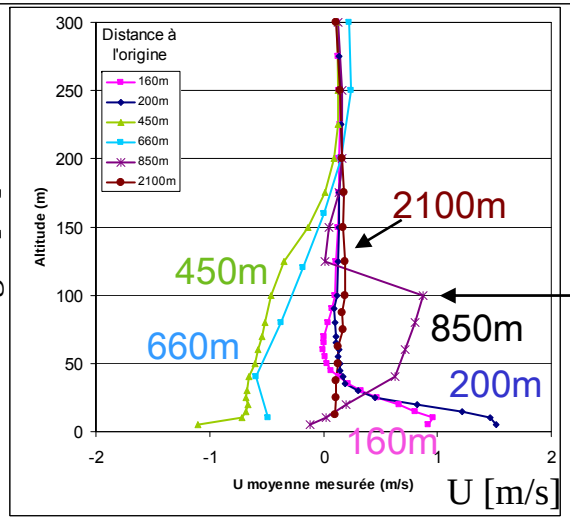
computed

Streamwise Wind V



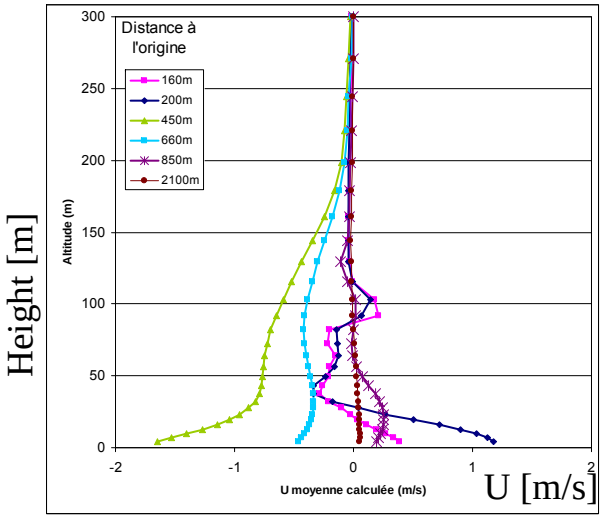


Crosswise Wind U



Good qualitative agreement

Wake of the Cooling tower



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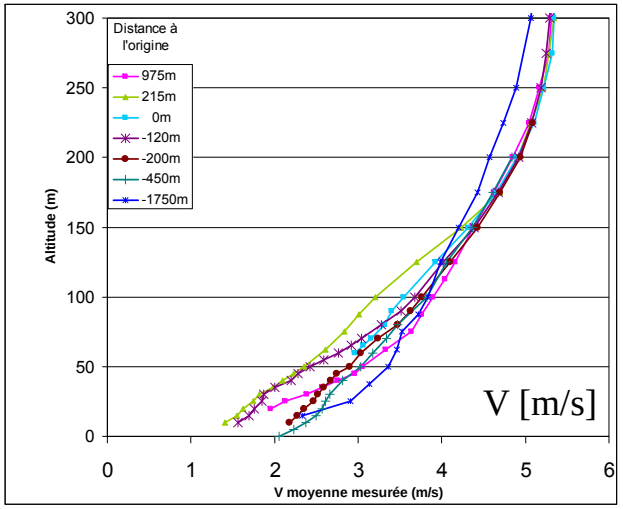
Results for velocity field : U and V profiles by north wind

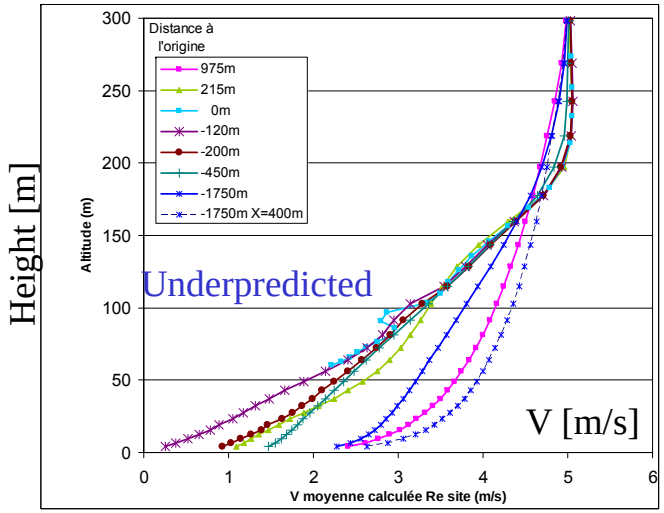
measured

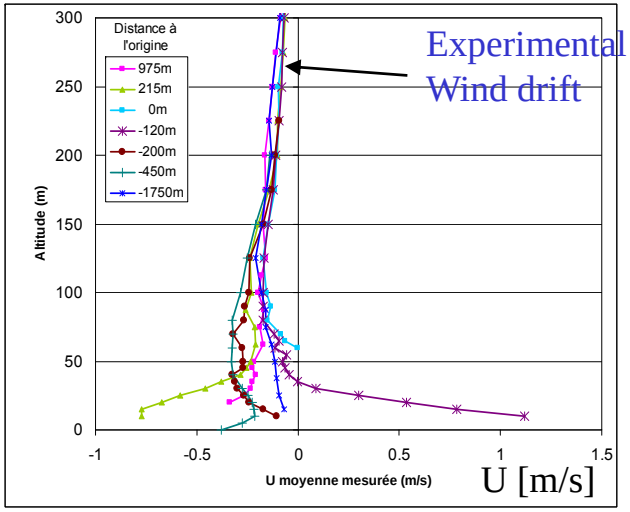
computed

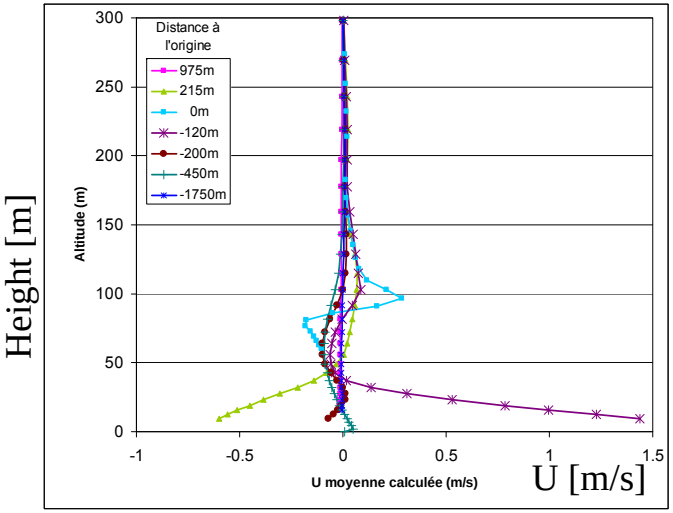
Streamwise Wind V

Crosswise Wind U









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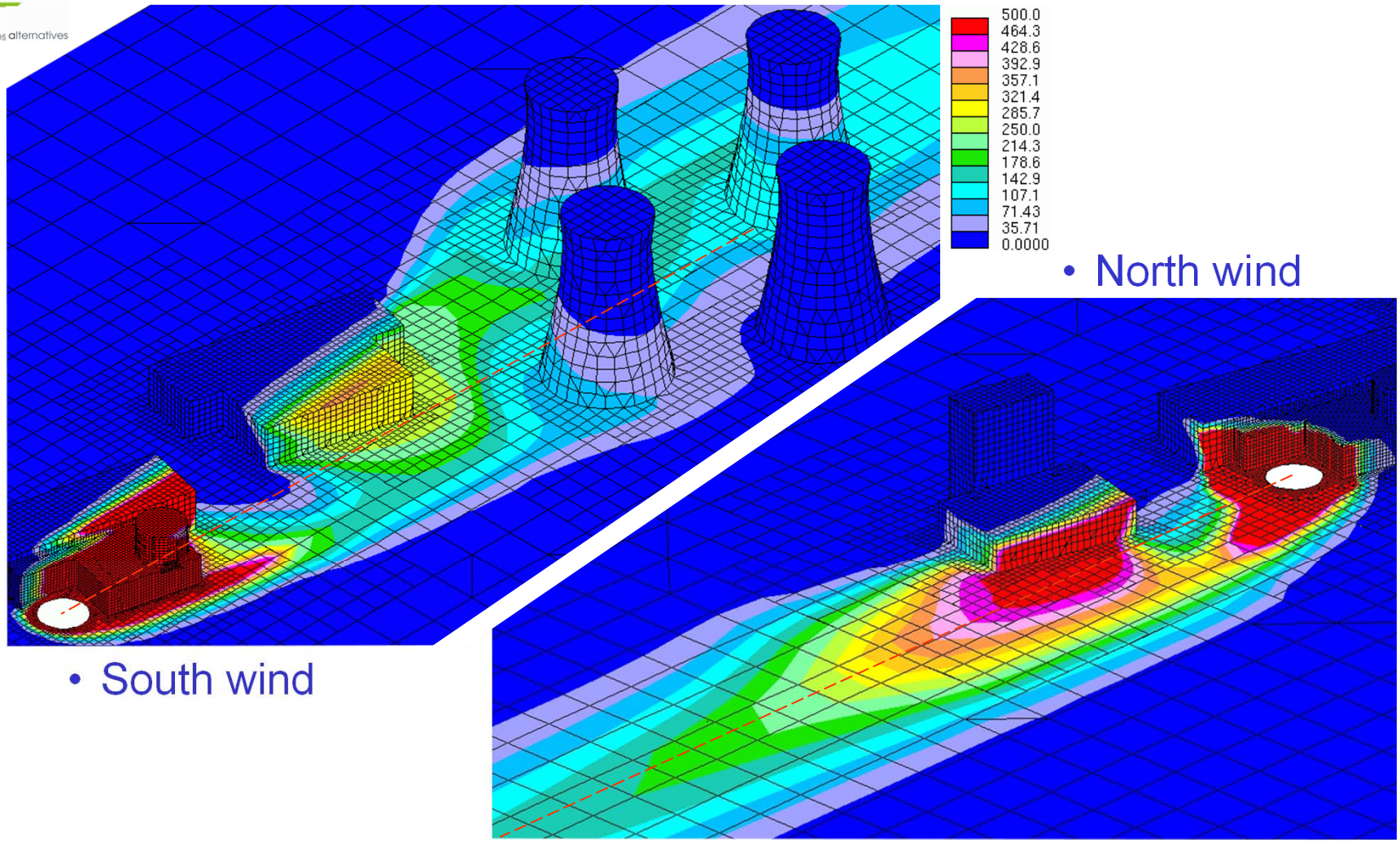
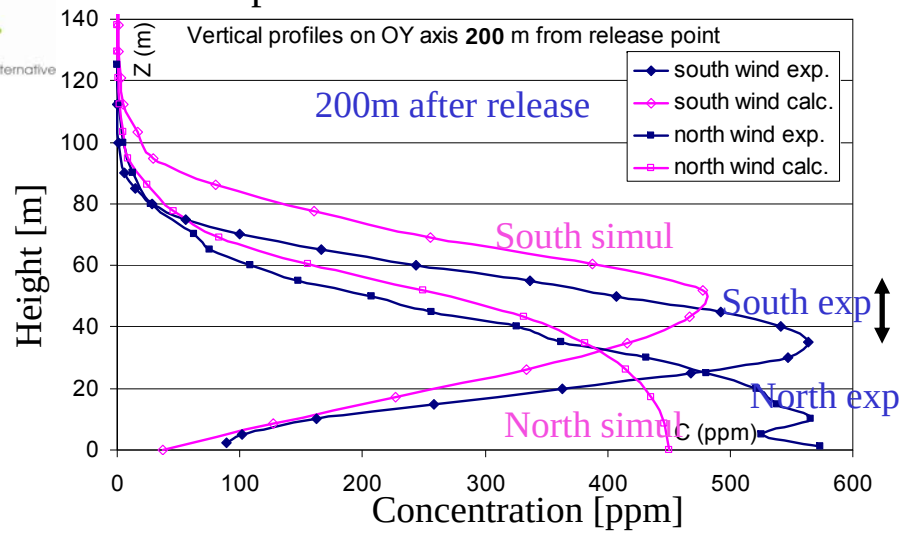
Concentration field (ppm) at z=1m for building release



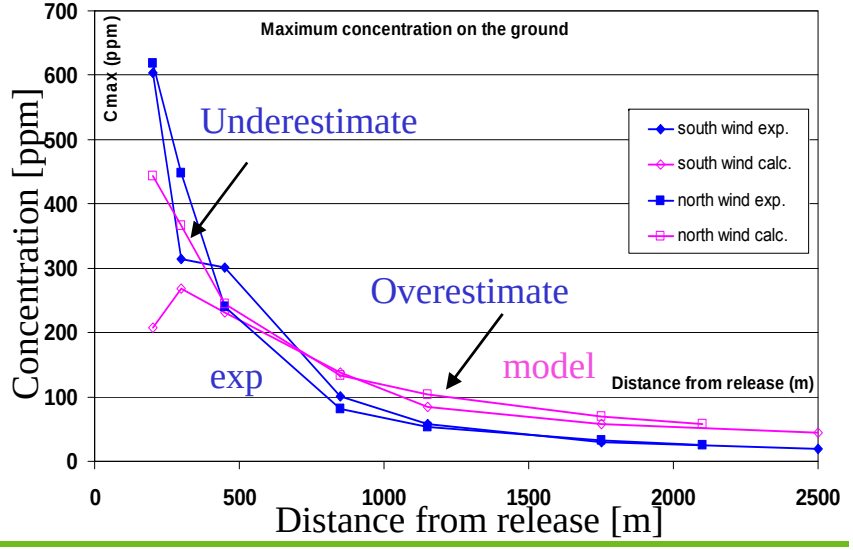
- South wind
- North wind

Concentration profiles for **building** release

Vertical profile 200m downwind from release



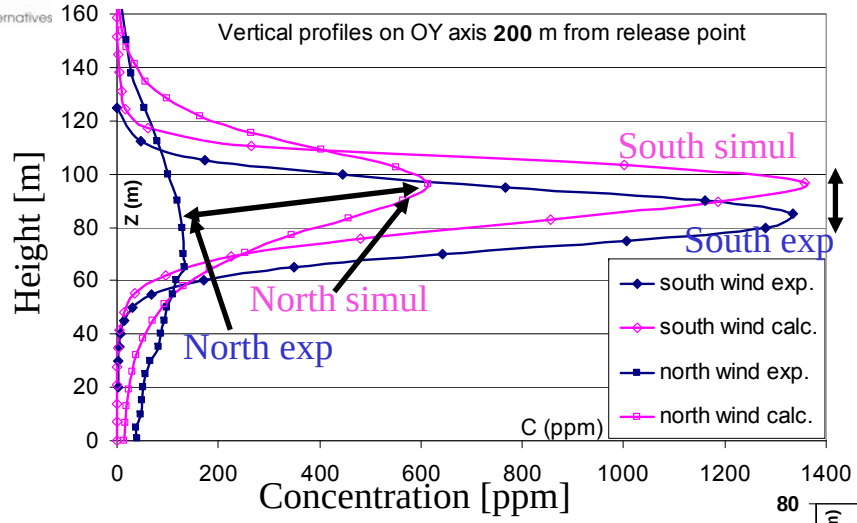
Streamwise ground concentration



- Qualitative agreement
- Model underestimates the near field ground concentration
- Model overestimates far field (>500m)

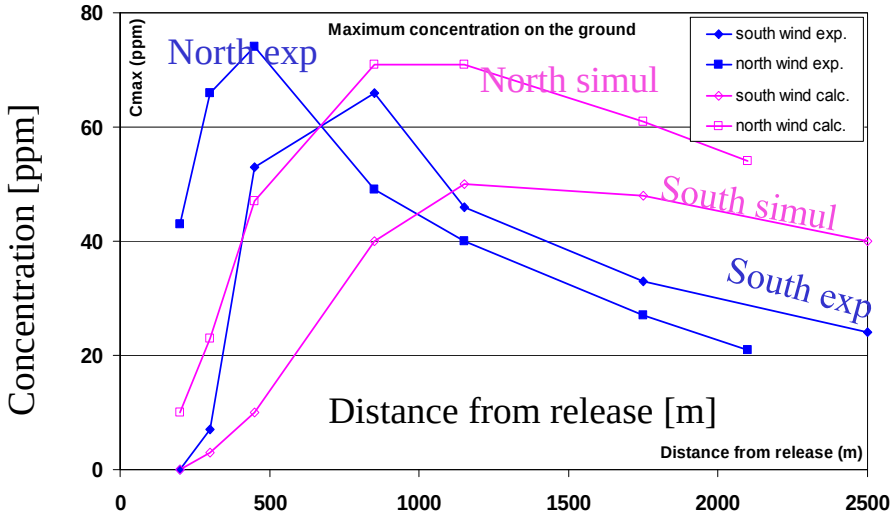
Concentration profiles for **stack** release

Vertical profile 200m downwind from release



- Good agreement for South wind, simuated plume 10m higher due to lack of plume deflexion
- Poor agreement with north wind : the turbulent mixing in the wake of the cooling towers is underpredicted

Streamwise ground concentration



On the ground :

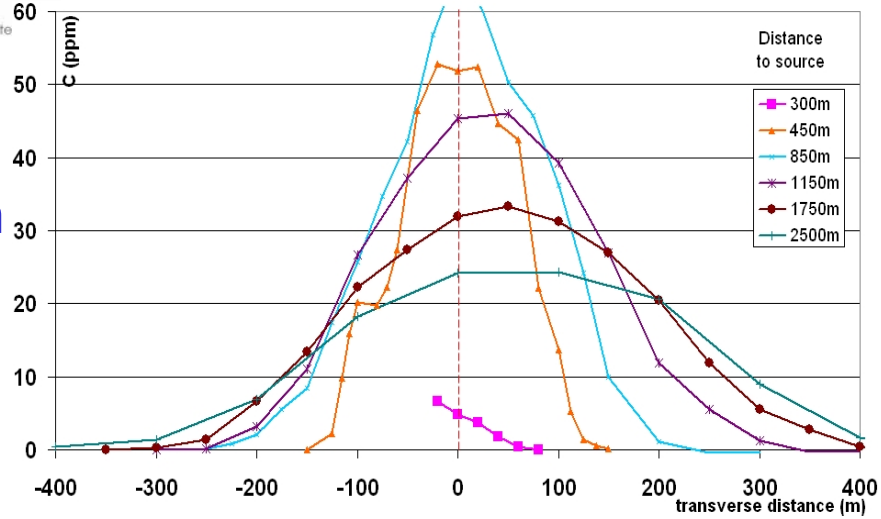
- Underprediction in the near field : lack of mixing and plume too high
- Overprediction in the far field : lack of lateral spreading

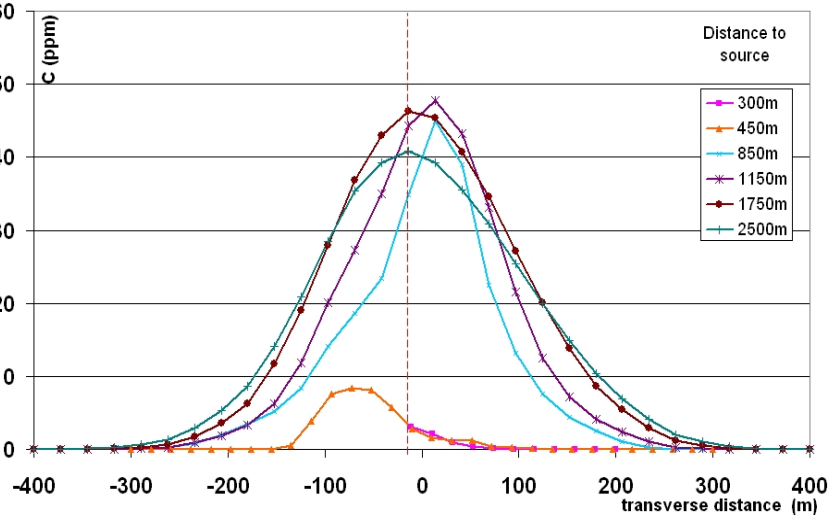
Ground concentration spanwise profiles for stack release

- measured

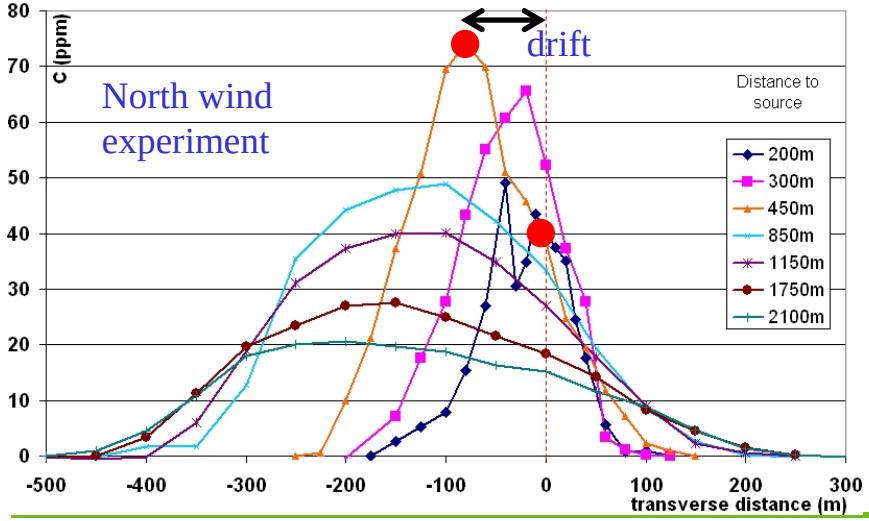
Computed: lack of lateral spreading

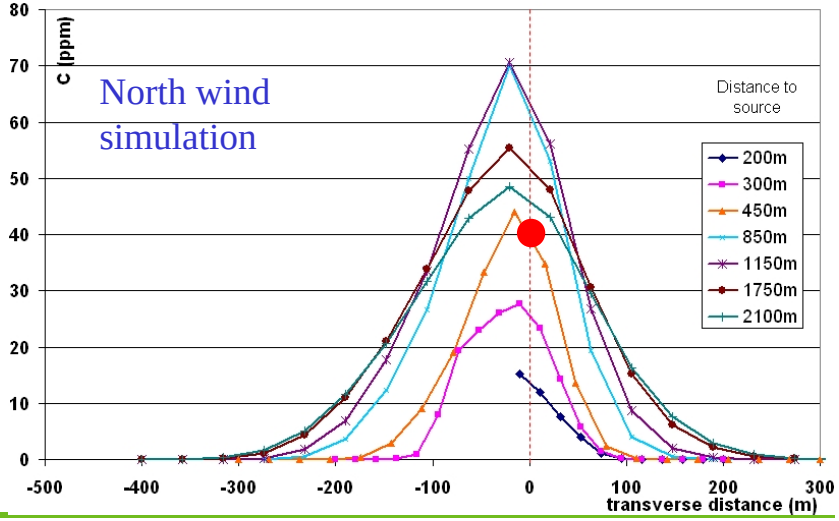
south wind





north wind

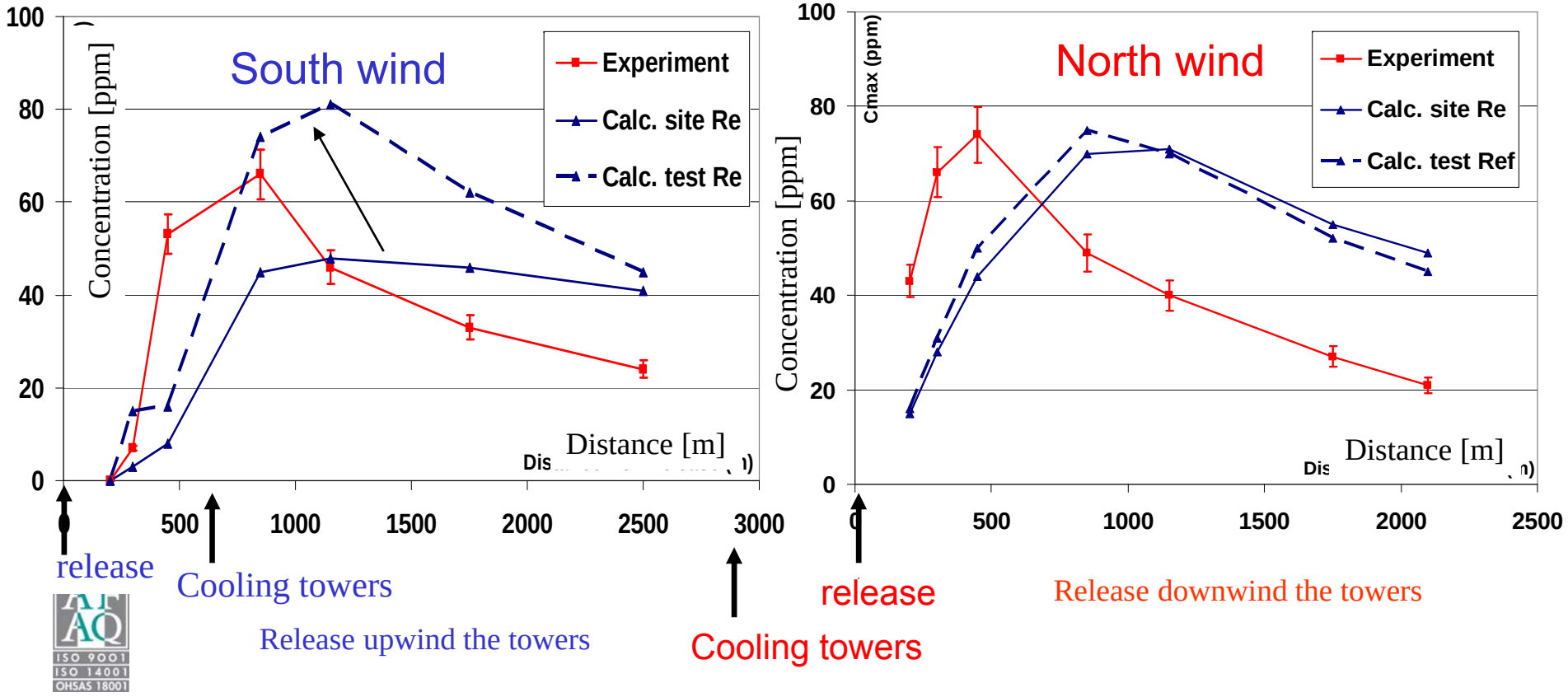




Effect of Reynolds distortion

checked on Oy ground concentration for stack release

Re tunnel = 4 10^4 (subcritical), Re site =2 10^7 (supercritical)

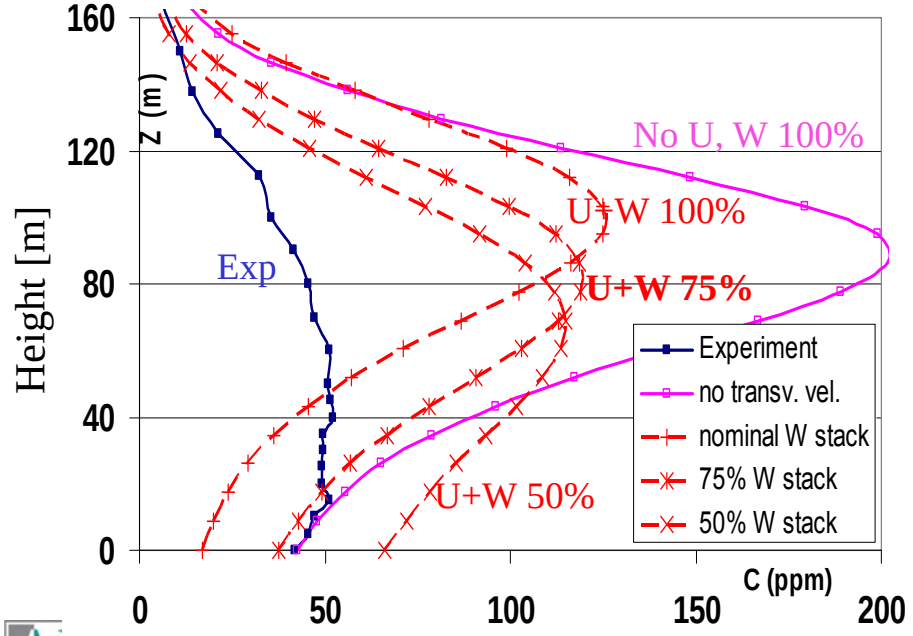


Effect of release speed W & lateral wind U

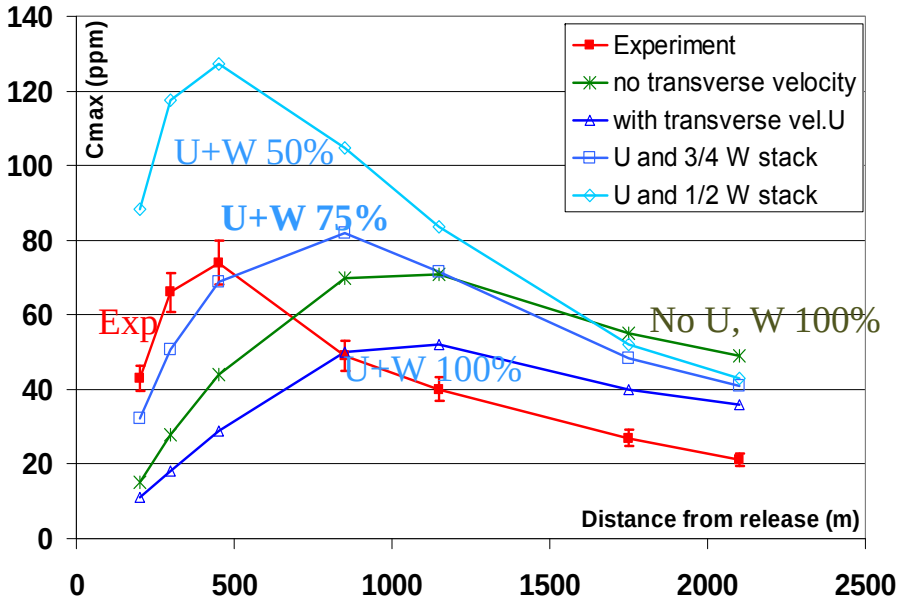
tested for release from stack under north wind

- Less momentum for the stack release W
- Crosswind analytical function U added to the model

Vertical concentration profiles on OY 450m from stack



Ground concentration profiles along OY



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Conclusions

- Effect of large buildings is crucial on an industrial site
- Maximum ground concentration is twofold underpredicted in the near field, due to underprediction of turbulent mixing in the built area
- In the far field maximum concentration is twofold overpredicted due to the lack of lateral spreading by the (k,ε) model
- In case of stack release it is essential to simulate well the initial exhaust plume deflection
- We have to pay attention to Reynolds distortion effects when applying tunnel experiments to the real world
- Effect of wind direction and source type/location is qualitatively well captured by a basic turbulence model

If I can't answer please mail to pierre.roubin@cea.fr

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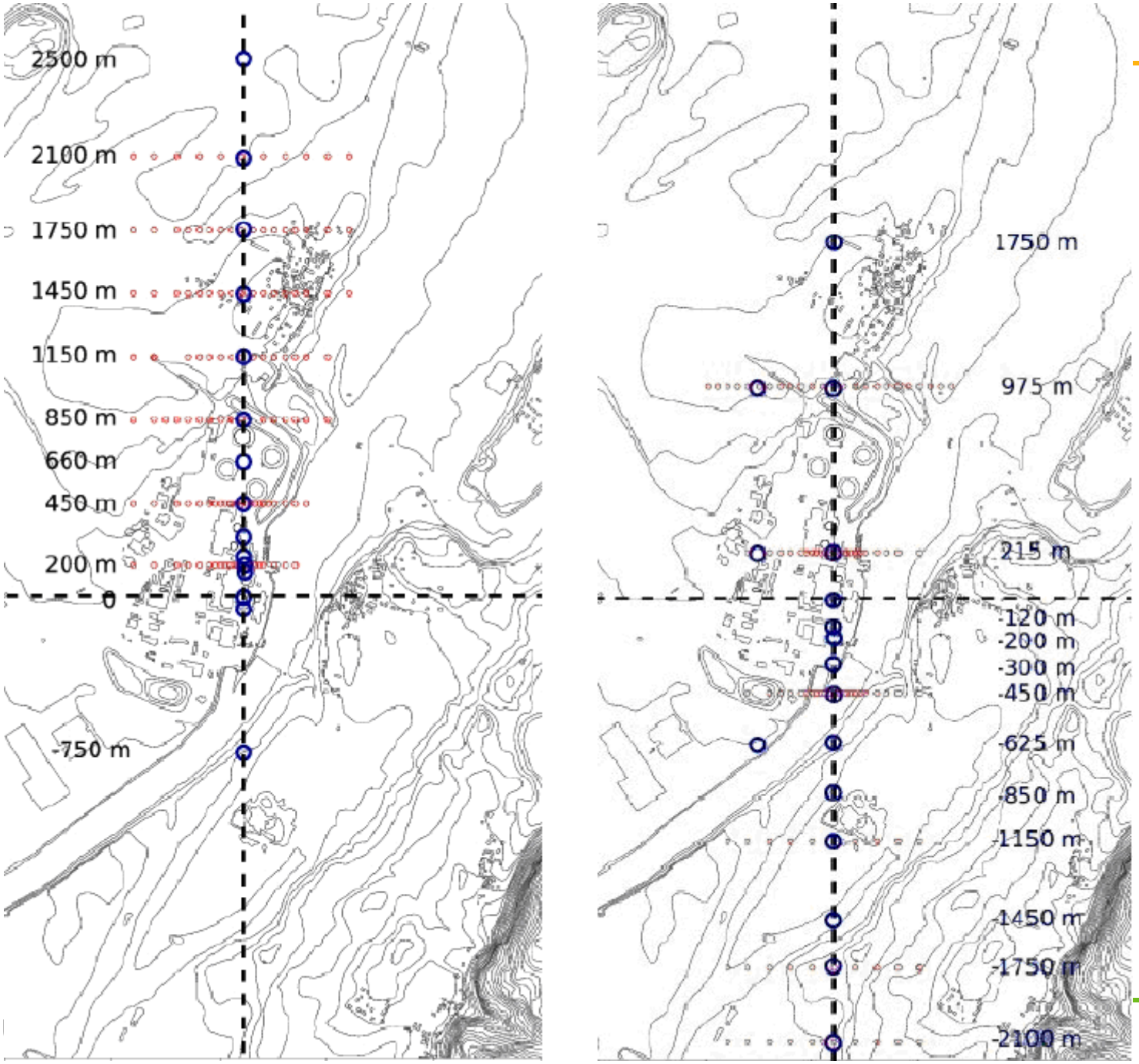
2500 m
2100 m
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1450 m
1150 m
850 m
660 m
450 m
200 m
0
-750 m
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975 m
215 m
-120 m
-200 m
-300 m
-450 m
-625 m
-850 m
-1150 m
-1450 m
-1750 m
-2100 m