Coupling
time domain acoustical and mesoscale meteorological models

GDR Visible – Bron

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Introduction

Influence of meteorology on sound propagation…

Objective :

Using a reference model coupling a meso-scale meteorological model (MESO-NH) and a time domain acoustic model (TLM) in order to investigate this phenomena

Outline

- Introduction
- Time domain acoustic model: *Transmission Line Matrix*
  - Model presentation
  - How to take into account meteorogical effects ?
- Meteorological model
- Preliminary results
- Conclusion

Acoustic model

Choice

Characteristics required by this model:

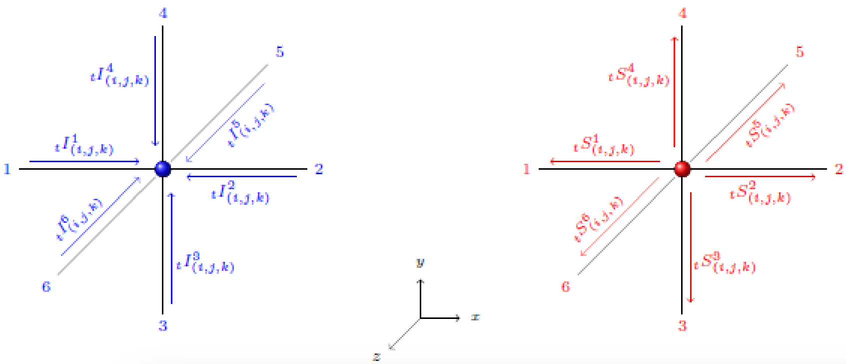
- Strong accuracy !
- Taking into account different geometries, materials, …
- Taking into account atmospherical effects…

A choice:

Transmission Line Matrix

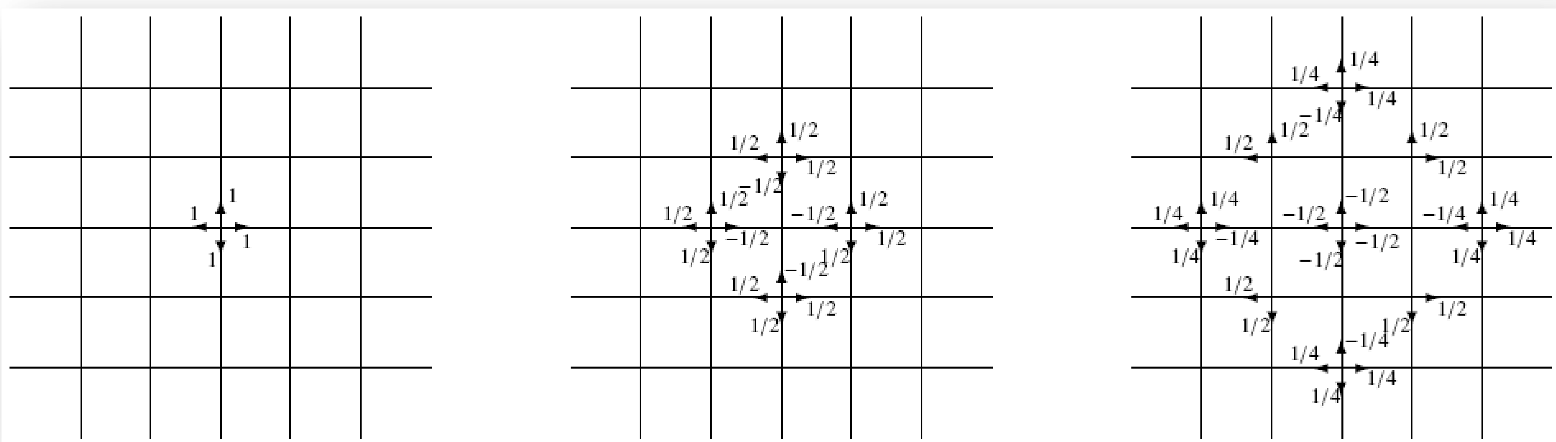
G. Guillaume, « *Implementation of complex impedance conditions and absorbing layers into a transmission line matrix model for urban acoustics applications* » *Euronoise, 2009*

Principles



Connection law between each nodes
« Diffusion node by node »

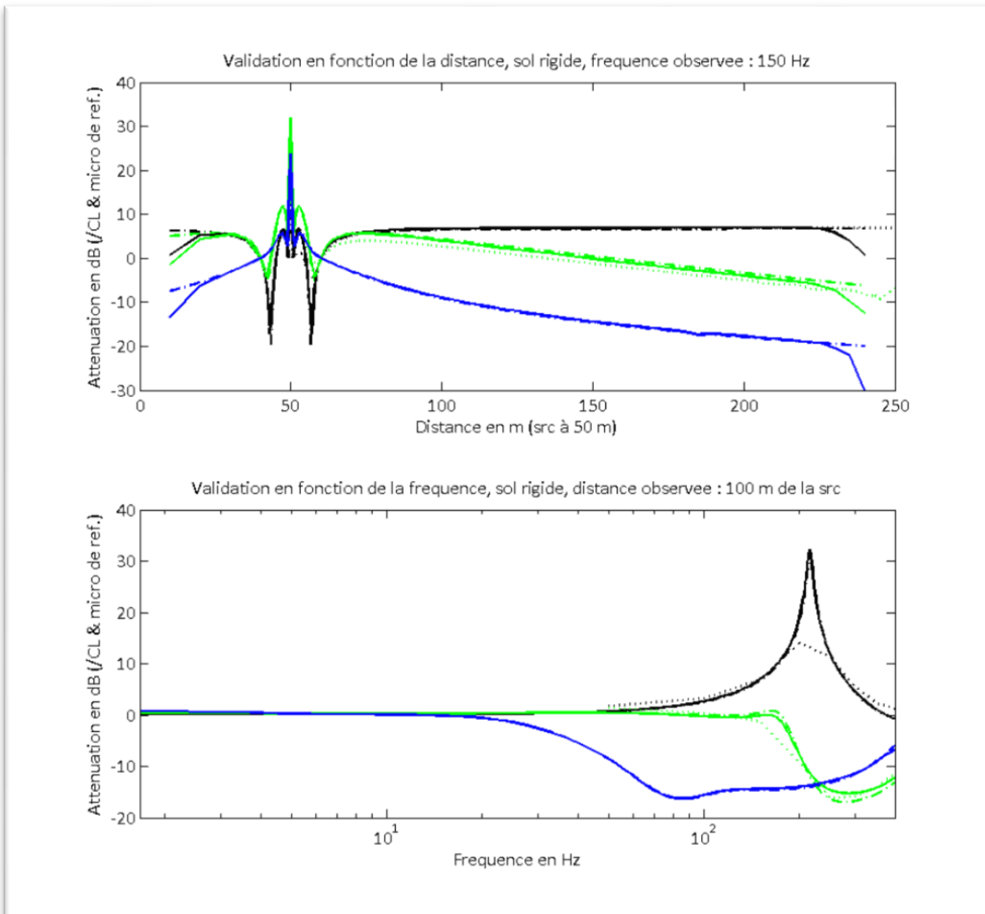
~ finite difference of the propagation equation



G. Guillaume, *« Implementation of complex impedance conditions and absorbing layers into a transmission line matrix model for urban acoustics applications » Euronoise, 2009*

TLM

Validation in standard case



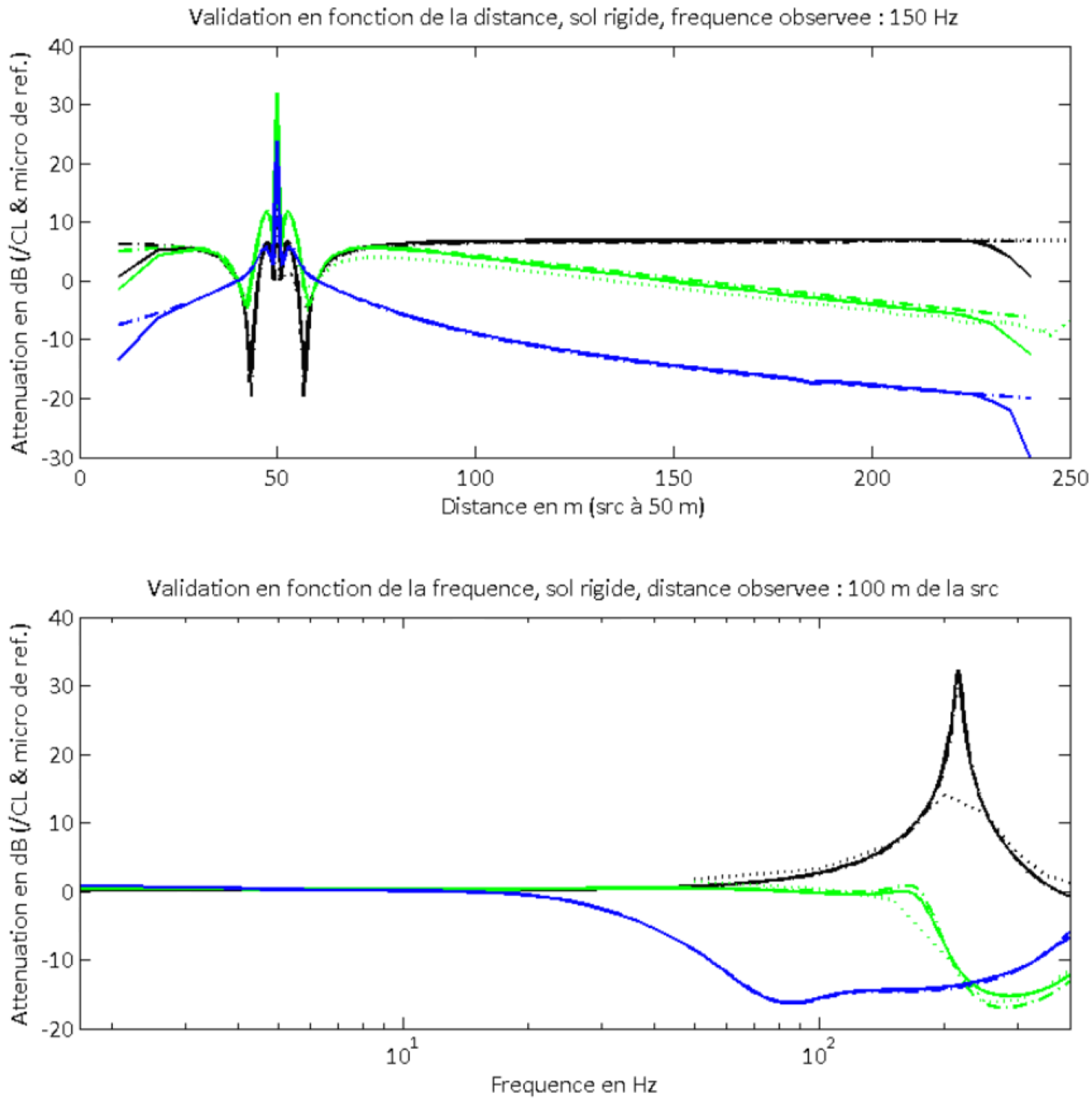
Eq. parabolique
TLM
analytique

Ref.
100 cgs (miki)
10 cgs (miki)

Src. = 2 m
Rec. = 2 m

TL

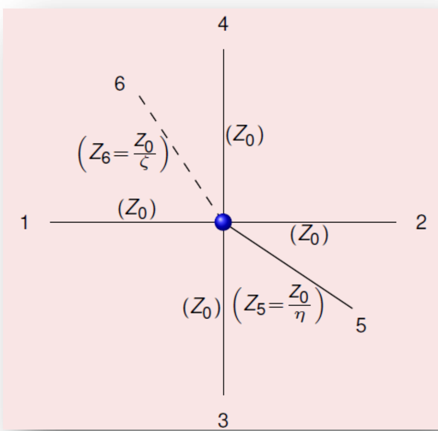
Validat


Validation en fonction de la distance, sol rigide, frequence observee : 150 Hz
Attenuation en dB (/CL & micro de ref.)
Distance en m (src à 50 m)
Validation en fonction de la frequence, sol rigide, distance observee : 100 m de la src
Attenuation en dB (/CL & micro de ref.)
Frequence en Hz

Take into account meteorology

Absorption

$$ {}_t\zeta_{(i,j)} = -\alpha \sqrt{{}_t\eta_{(i,j)} + 4\,\Delta l\,\frac{\ln(10)}{20}} $$



Celerity (wind, temperature)

$\Delta p - 1/\mathbf{c_{eff}(x,y,z,t)}\; d^2p/dt^2 = 0$

$$ {}_t\eta_{(i,j)} = 4\left[\left(\frac{c_0}{{}_t c_{\mathrm{eff}(i,j)}}\right)^2 - 1\right] $$

$\mathbf{c_{eff}}$ *under wind effects depends on wave direction propagation !*

$\mathbf{c_{eff}} = c_0 + \|\vec{u}\|.\cos\alpha$

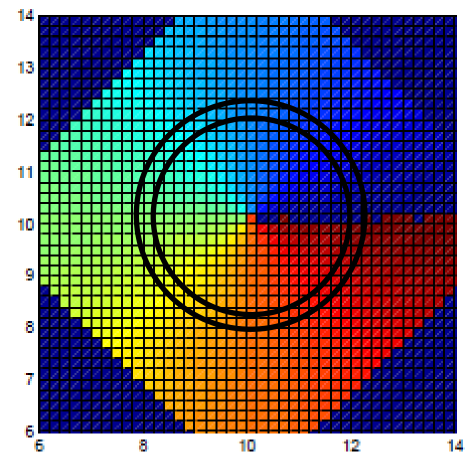
How to get the wave front direction ?

G. Dutilleux, « Applicability of TLM to wind turbine noise prediction » , 2nd International Meeting on Wind Turbine Noise, Lyon, 2007

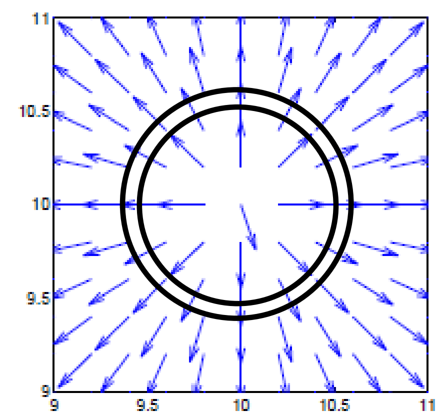
Wave propagation

Direction

$$\langle \vec{I} \rangle_\lambda = \langle p^* \vec{v} \rangle_\lambda$$



Direction of propagation

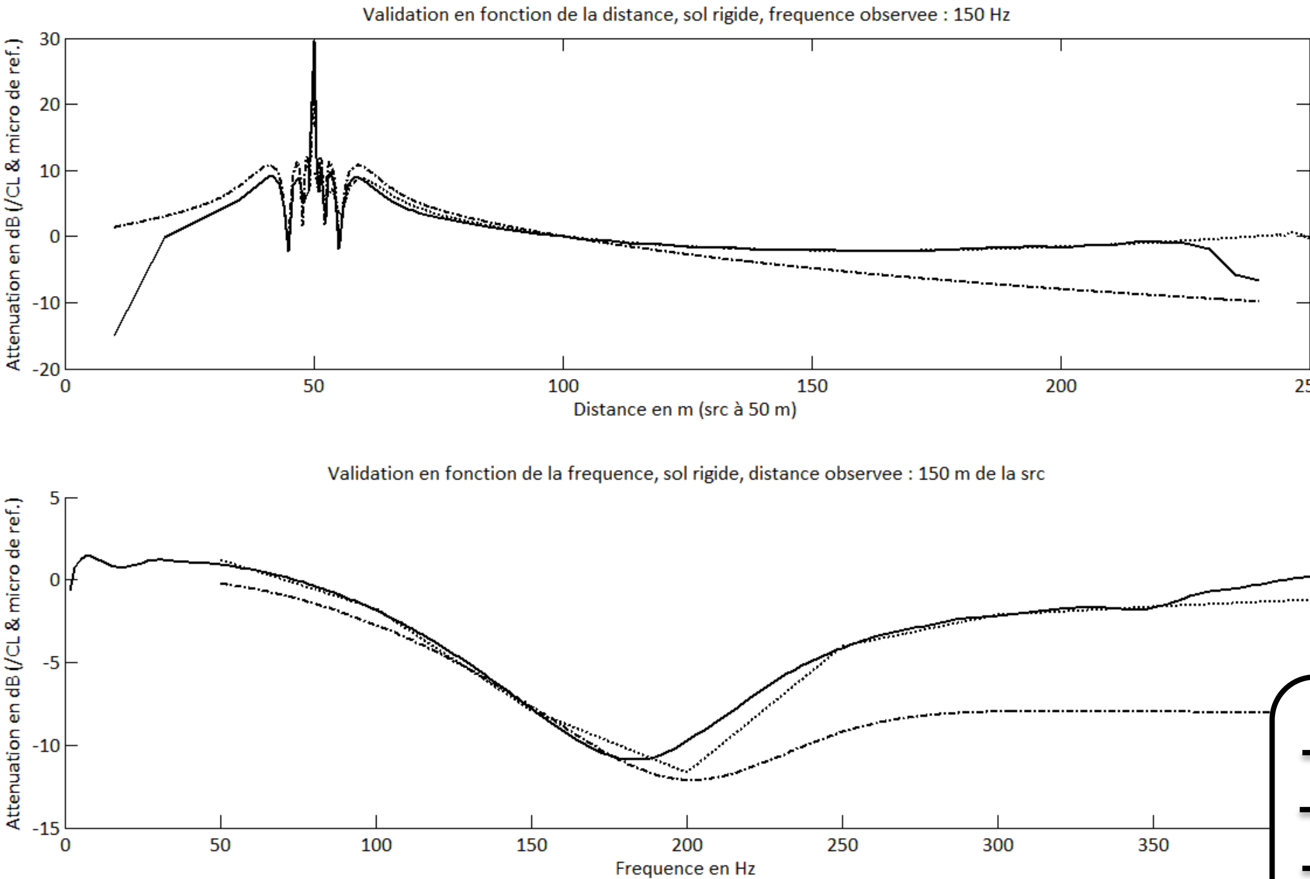


Valid for Long Range Sound Propagation :

- Far field
- Non stationnary field
- Non diffuse soundscape

G. Dutilleux, « Applicability of TLM to wind turbine noise prediction » , 2nd International Meeting on Wind Turbine Noise, Lyon, 2007

Take into account meteorology



Wind vertical gradient
$0.2\ m.s^{-1}.m^{-1}$

Domain size = 250 m*70 m
Source height = 2,025 m
Resolution tlm = 0,05 m
Sol herbeux : 100cgs (Miki)

- · - analytic (hom.)
— TLM
---- PE

Atmospheric model

Meso-NH

MESO-NH

Meso-scale

Atmospheric research model of the french community (Meteo France)

After some developements:

Realistic and accurate results

http://mesonh.aero.obs-mip.fr/

Case of study

Presentation

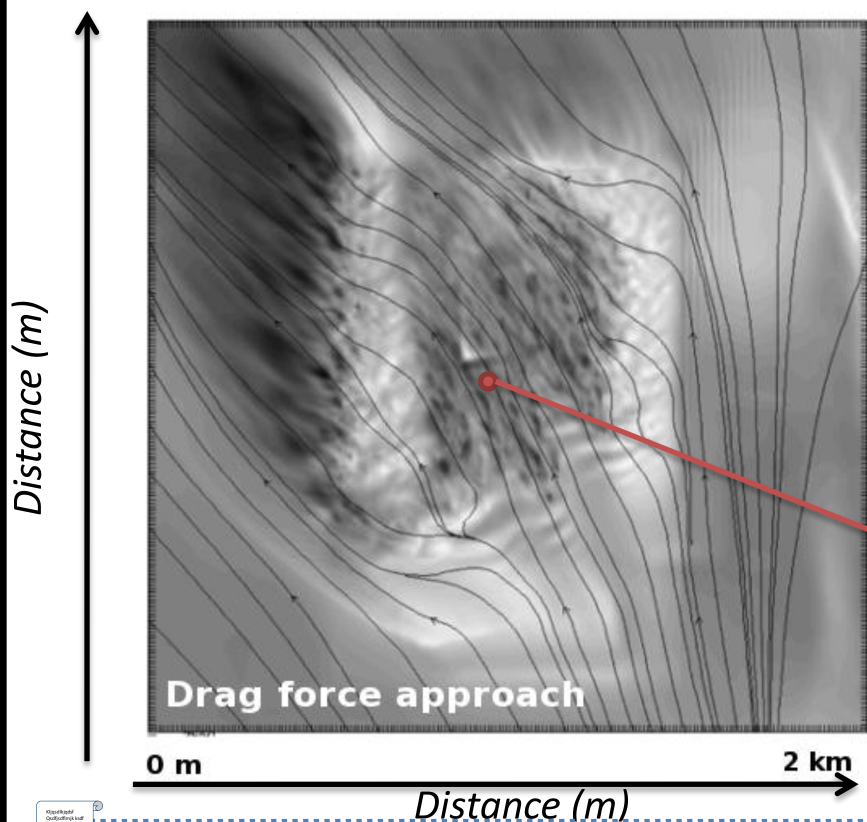
- Flat ground
- Stationnary source
- Observations period: 3 months
- Important measure systems
- Close to a national meteo station

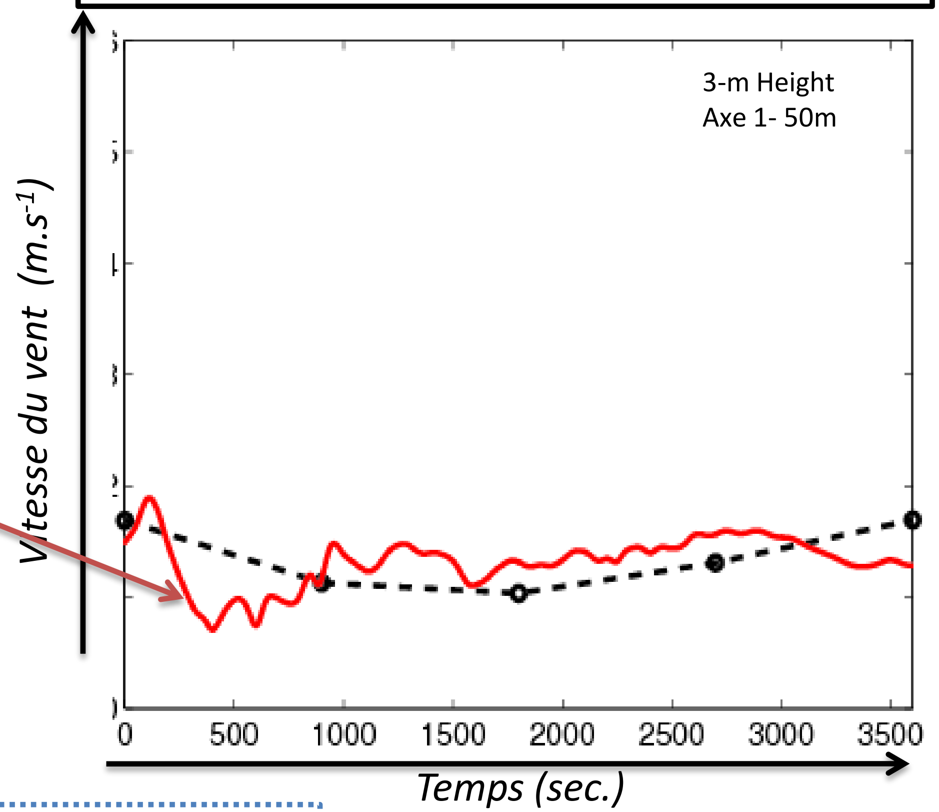
Experimental campaign:
Lannemezan 2005

F. Junker et al., « *Meteorological classification for environmental acoustics* >> - ICA 2007

Meso-NH

Results example

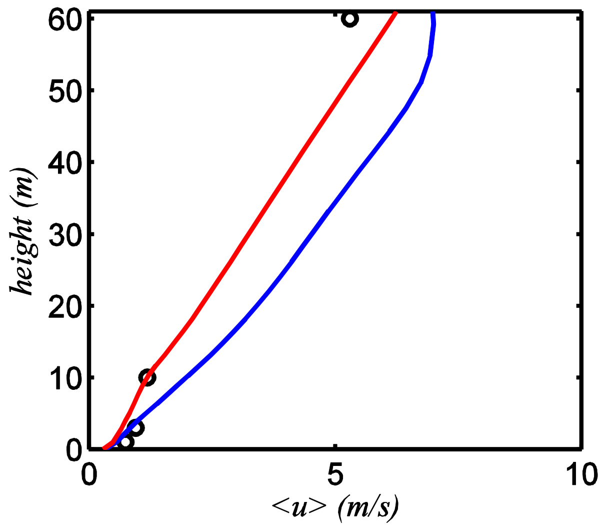




P. Aumond et al. *"Large-Eddy Simulations on the Effects of Drag Force of Trees: A real case study"* - 19th Symposium on Boundary Layers and Turbulence, 2010

Meso-NH

Results examples



. 15 min averaged experiments and model fields

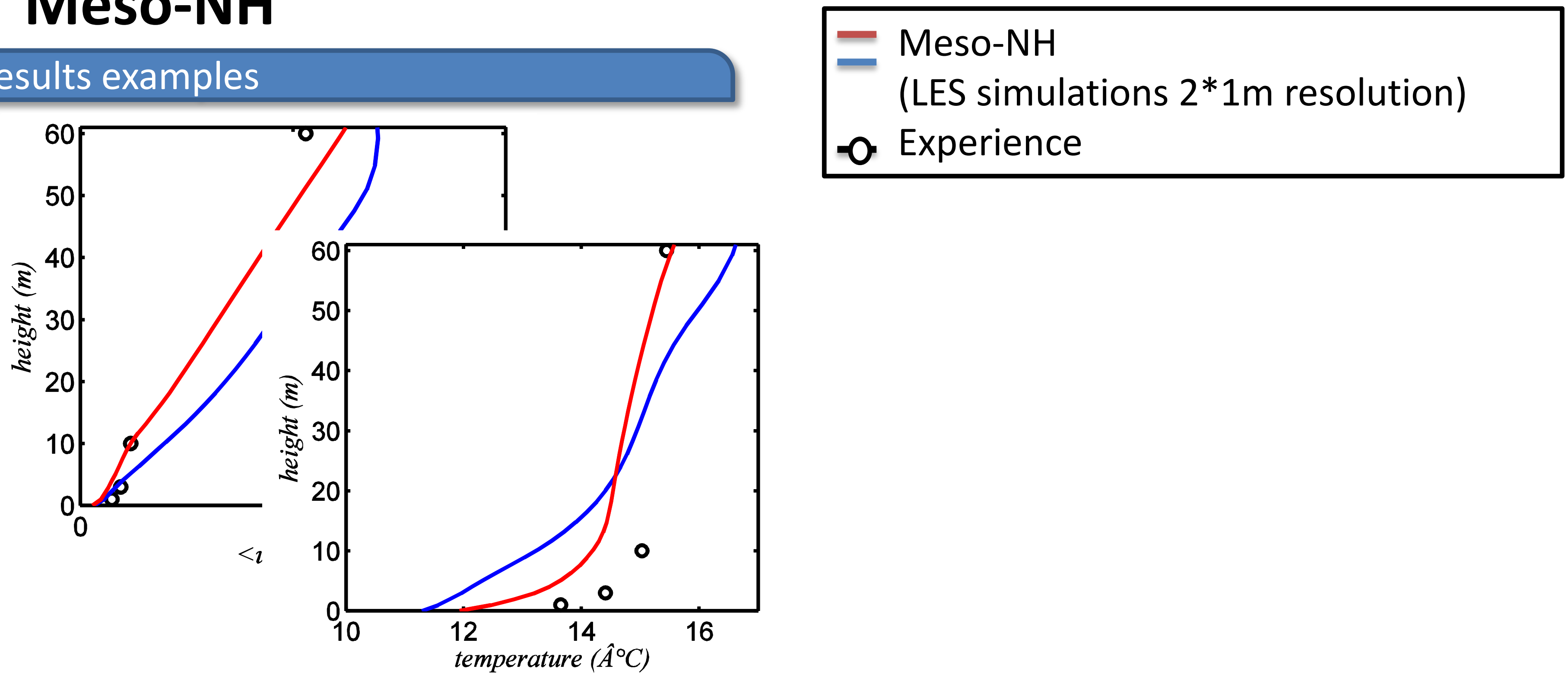
. Space averaging over the experimental zone (300m*300m)

. LES simulations 2*1m resolution

P. Aumond et al. *“Large-Eddy Simulations on the Effects of Drag Force of Trees: A real case study”* - 19th Symposium on Boundary Layers and Turbulence, 2010

Meso-NH

Results examples



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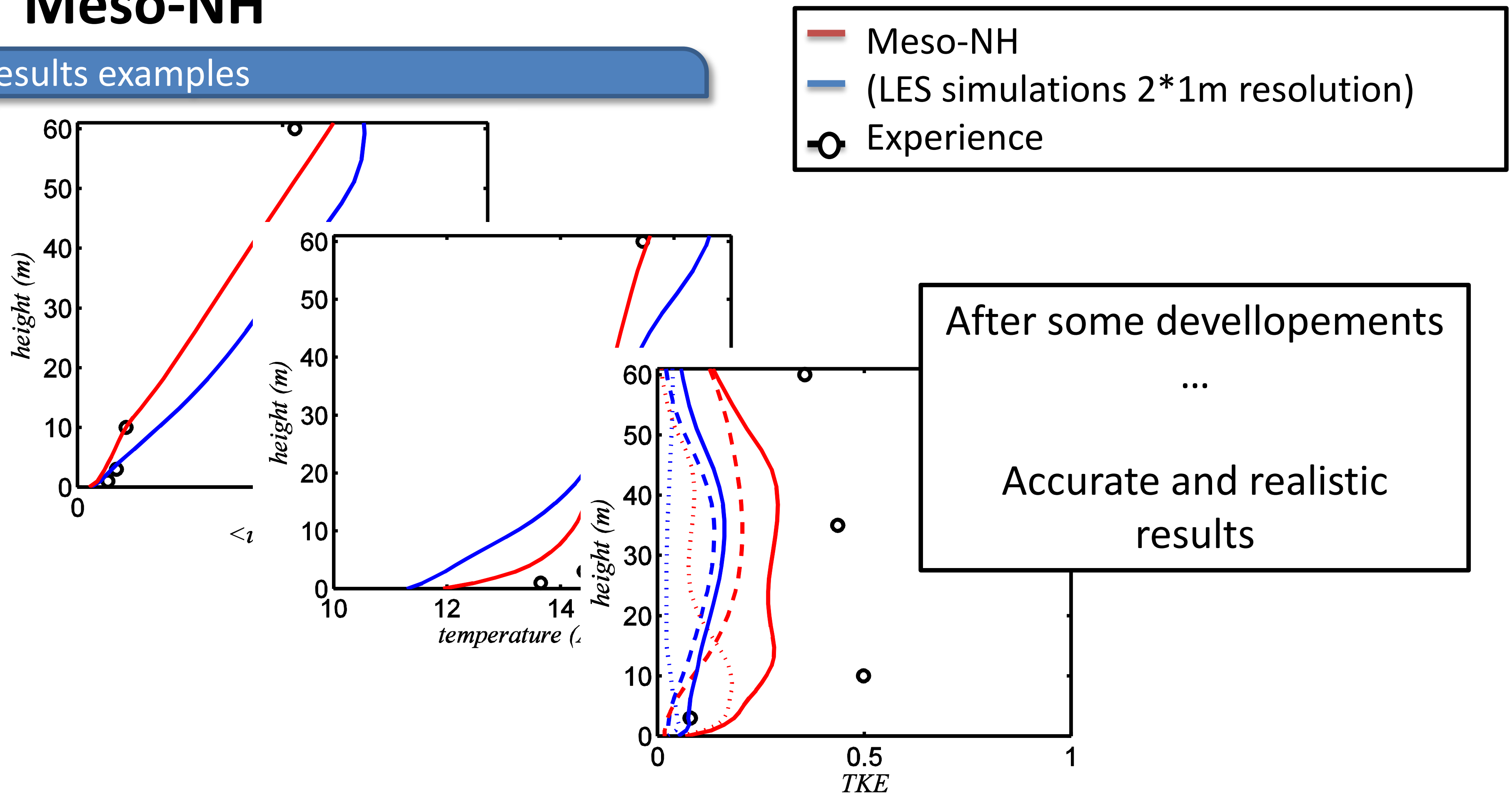
Meso-NH

Results examples



After some devellopements

…

Accurate and realistic results

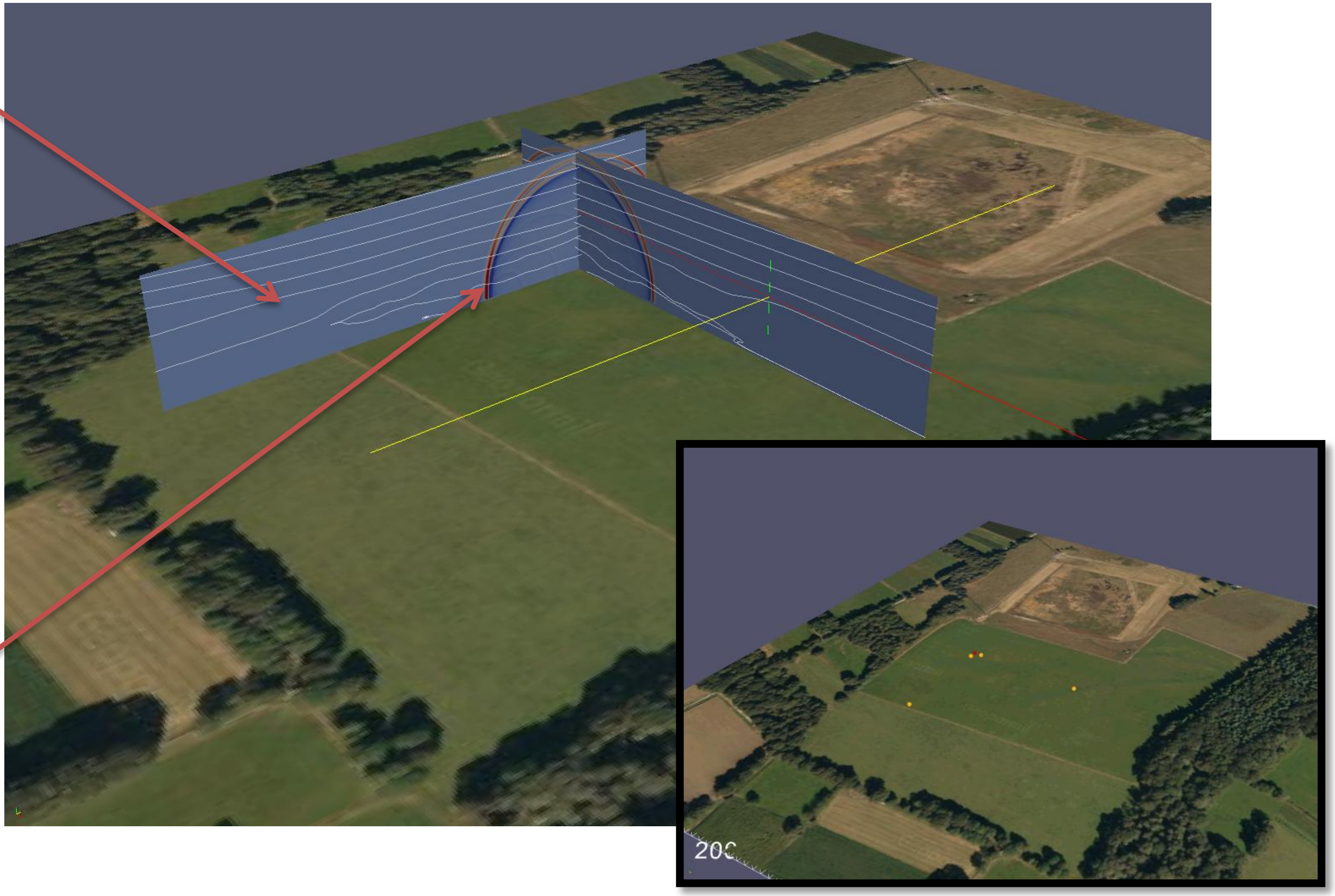
P. Aumond et al. *“Large-Eddy Simulations on the Effects of Drag Force of Trees: A real case study”* - 19th Symposium on Boundary Layers and Turbulence, 2010

Coupling

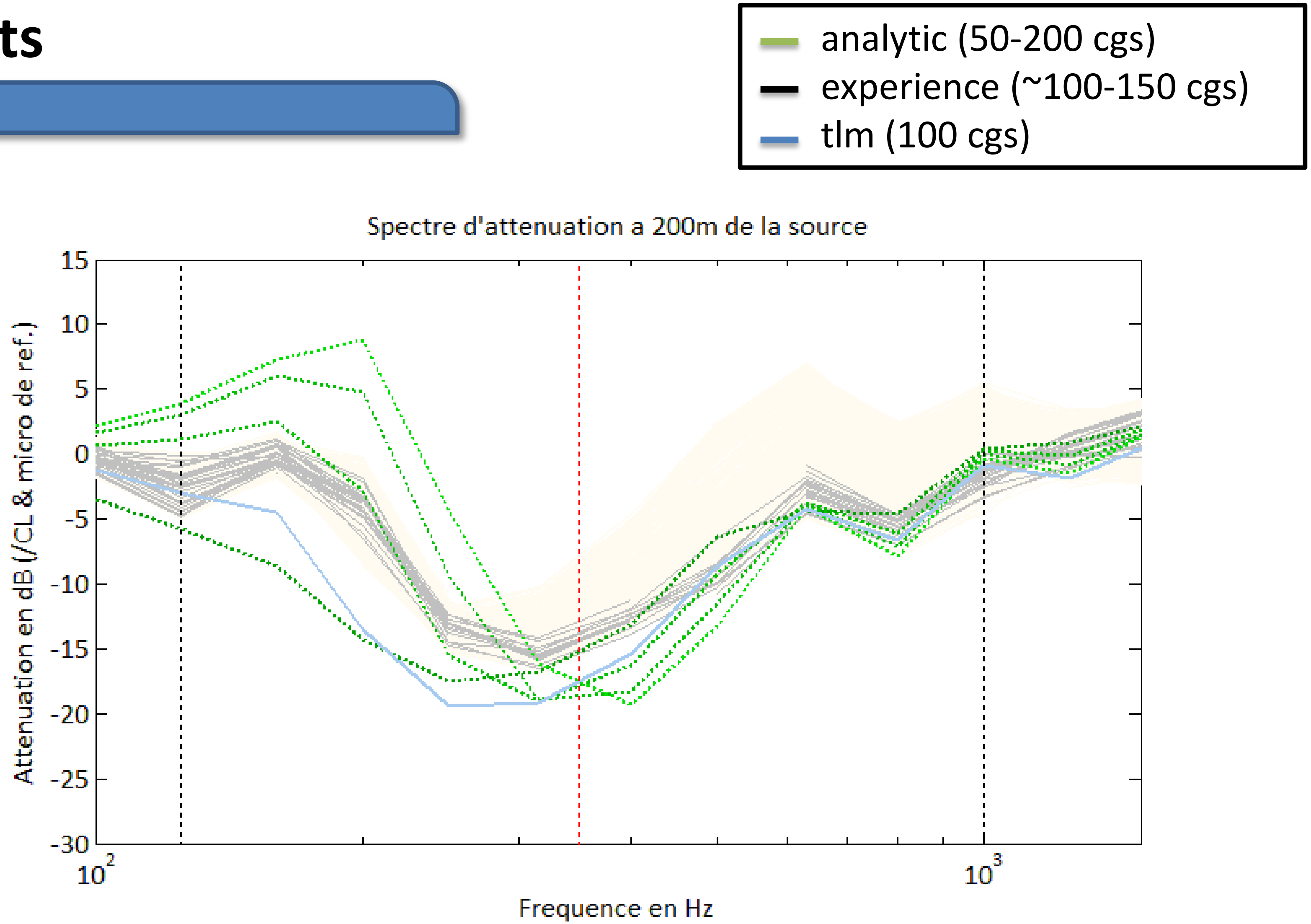
Presentation

Frozen meteorological conditions

2D wave propagation

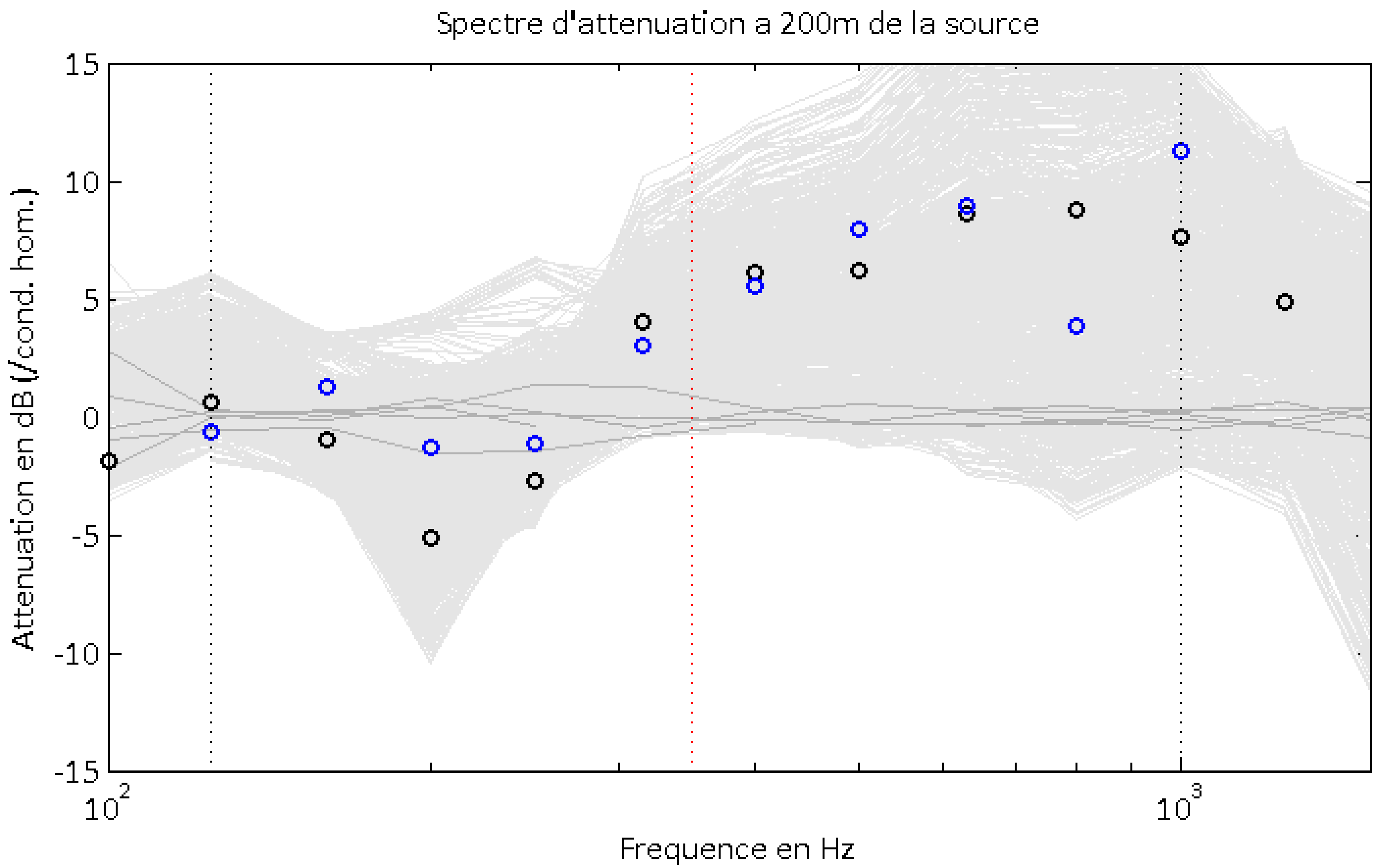


Results


analytic (50-200 cgs)
experience (~100-150 cgs)
tlm (100 cgs)
Spectre d'attenuation a 200m de la source
Attenuation en dB (/CL & micro de ref.)
15
10
5
0
-5
-10
-15
-20
-25
-30
10^2
10^3
Frequence en Hz

Results

— experience (tout *clair*, hom. *foncé*)
○ experience (16-06-2005)
○ tlm (16-06-2005)



Conclusions / perspectives

- **Meso-NH**
- **TLM validation :**
  - **Num. : meteo + ground**
  - **Exp. : Good agreement with Lannemezan 2005 data 400 - 800 Hz**

- **Extended validation with more experimental samples**
- **Use this model to study more complex situation…**
  - **LTMS**
  - **Urban modelling**

Perspectives

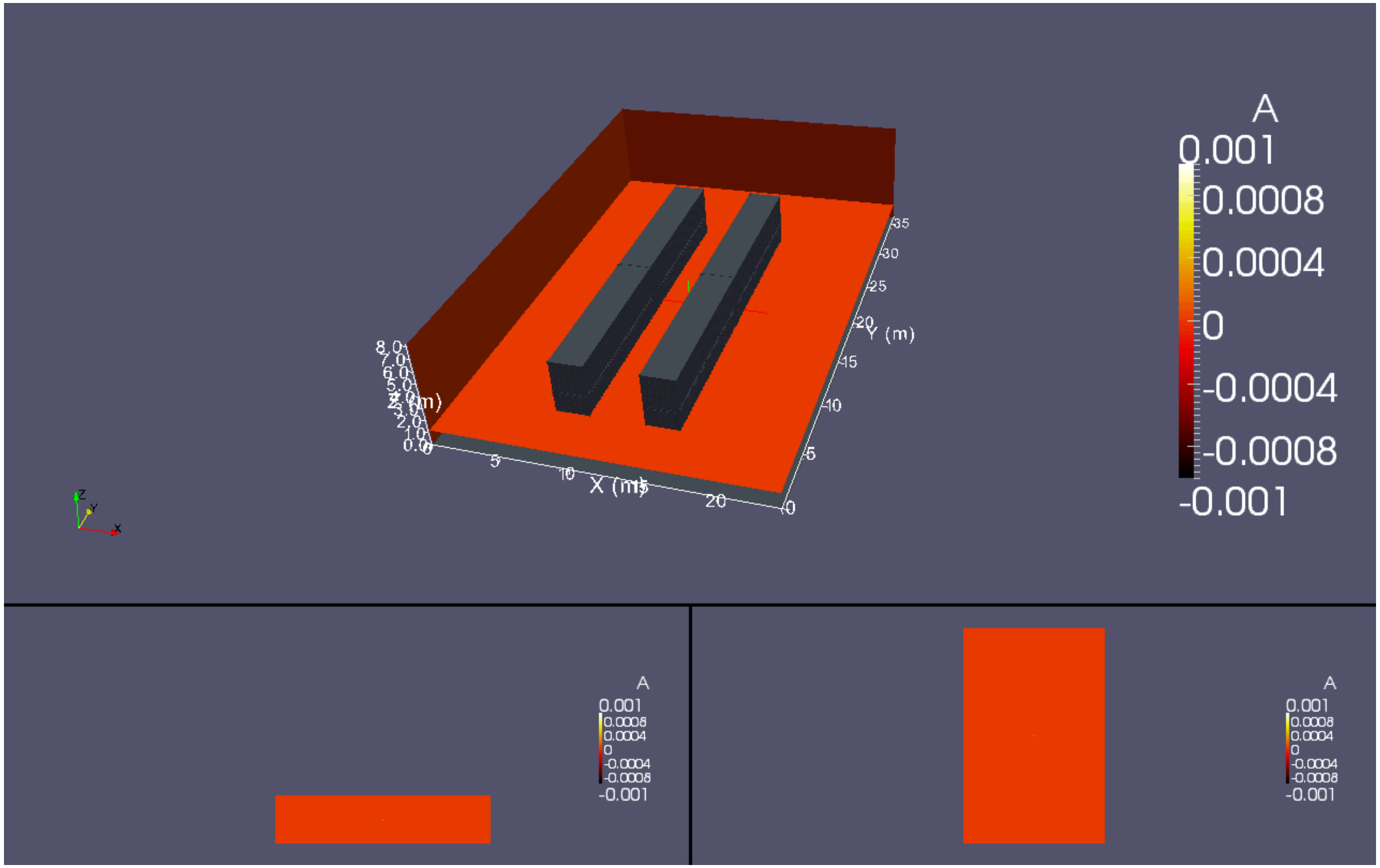
LTMS

- Complex topography
- Real sources (highway, railroad, …)
- Monitoring meteo/acoustic aquisition over several years (since 2002)

Experimental campaign:
Long Term Monitoring Station

http://www.lcpc.fr/english/presentation-209/human-and-financial-resources/lcpc-exceptional-testing-229/

Urban modelling



Thank you
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Questions ?

Pierre Aumond
3rd year PhD-Thesis

17th may 2011

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« […] our observations this day prove the very great effect which upward refraction has on the distances at which sounds can be heard. »

Pr. O. Reynolds & Pr. Stokes - 1876