LCPC Laboratoire Central des Ponts et Chaussées

Réseau Scientifique et Technique de l'Equipement

1949 • 2009 LCPC 60 ans d'innovation

LES PLÉNIÈRES 2009 DU LCPC

Sciences et techniques du **Génie Civil**

JOURNÉES ACOUSTIQUE

BATZ-SUR-MER – 10 et 11 JUIN 2009

Limites et perspectives des modèles de propagation acoustique

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Section Acoustique Routière et Urbaine

Background

- Societal background:
  - **INSEE (2002): 54% of the french population is annoyed by noise**
    from: Agence de l'Environnement et de la Maîtrise de l'Énergie (ADEME)
  - **IFEN (2007): money that is spent to reduce noise increase of 6.2% each year since 1990, of which the half is due to transportation noise**
    from: Commission des Comptes et de l'Économie de l'Environnement (CCEE)

Background

- Regulation background:
  - **France: « Noise » law (Loi « Bruit ») n° 92-1444 (december 31, 1992) regulating sound emission and noise levels**
  - **European directive 2002/49/CE (June 25, 2002) on strategic noise mapping**
  - **French method NMPB 2008 (NF S 31-133) on the calculation of outdoor sound propagation**

What is *approximately* taken into account

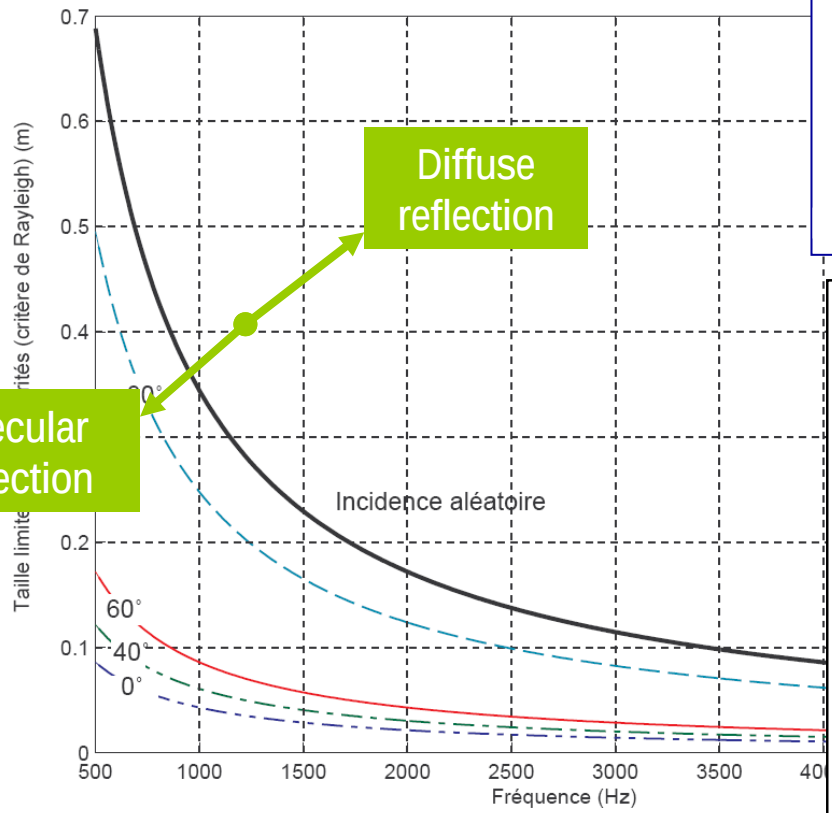
- Physical phenomena of sound propagation:
  - **Direct field** ★ ★ ★ ★ ★
  - **Specular reflection** ★ ★ ★ ★
  - **Diffuse reflection** ★ could be, but not really done
  - **Scattering** ★ ★ ★ building edges
  - **Geometrical dispersion** ★ ★ ★ ★ ★
  - **Atmospheric absorption** ★ ★ ★ ★ ★
  - **Ground effect** ★ ★ homogeous ground or 1 discontinuity
  - **Meteorological** ★ celerity gradient for open field (not urban)

What *should be* taken into account

- Physical phenomena of sound propagation:
  - **Diffuse reflection by building façades**
  - **Diffusion by fitting objects in streets**
  - **Specific meteorological effects in urban areas**
  - **Interferential effects in streets**

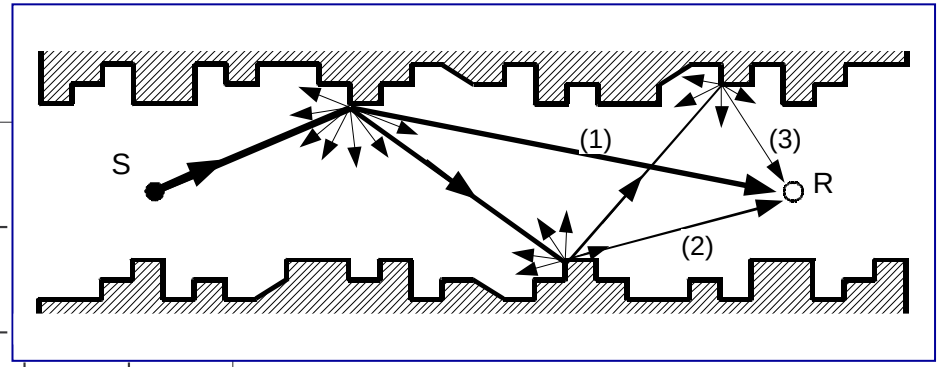
Diffuse reflection by building façades

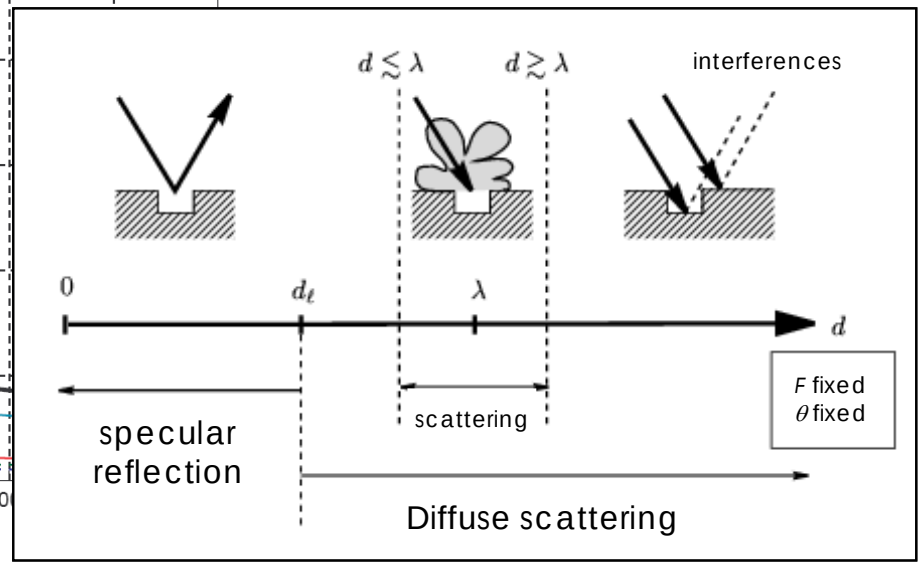
Diffuse reflection



Diffuse reflection

Specular reflection



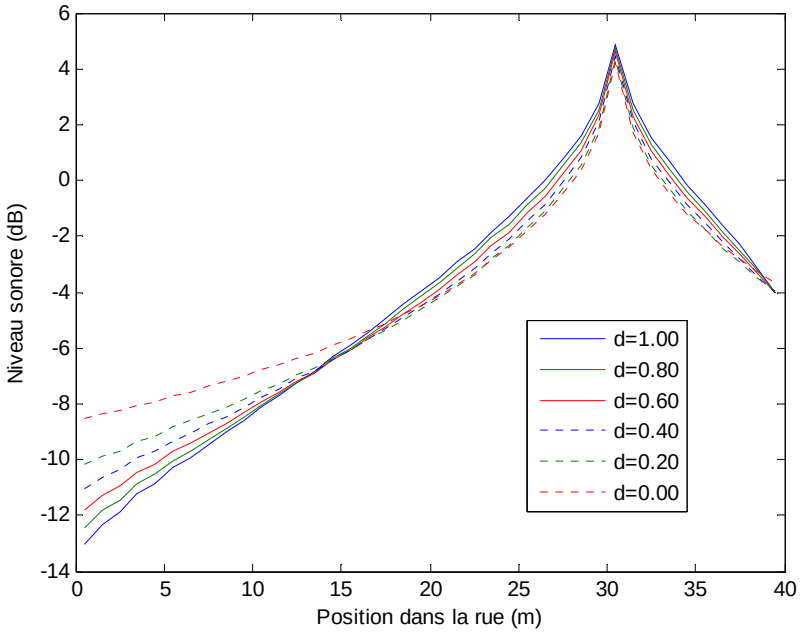


Diffuse reflection

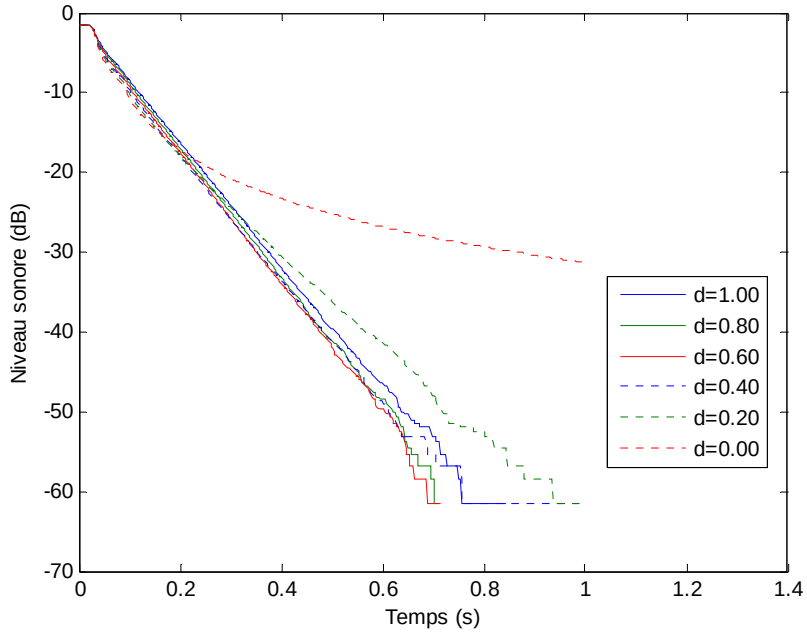
Sound propagation in a street (40m long x 8m width x 8m high)

with partially diffusely reflecting boundaries: from 100% (diffuse, d=1) to 0% (specular, d=0)

Sound attenuation dB=f(position in the street)



Sound decay dB=f(time)

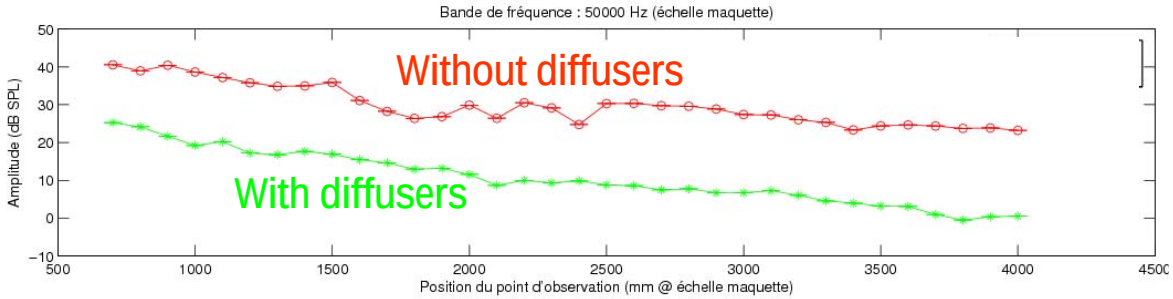


Diffuse reflection

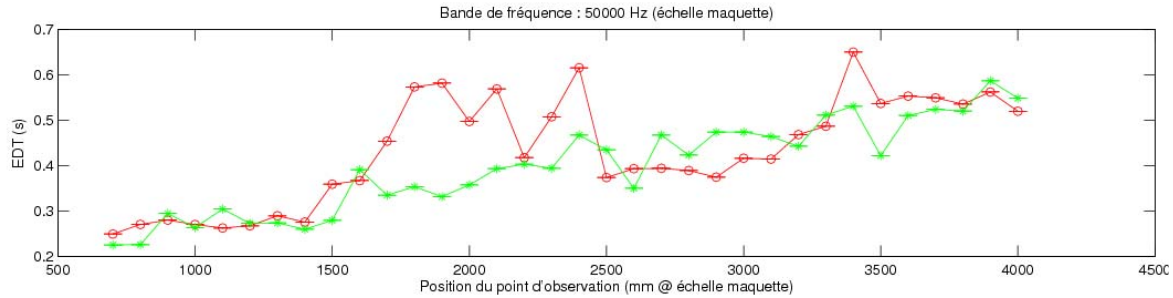
1/10 Scale model measurements (4m long x 0.4m width x 0.7m high)

with (30% of the façade area) and without acoustic diffusers (5000Hz FS)

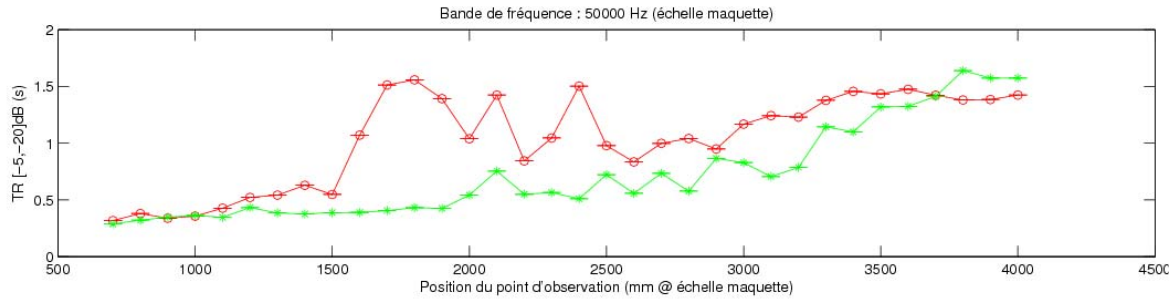
SL (dB)



EDT (s)



RT15 (s)



Diffuse reflection

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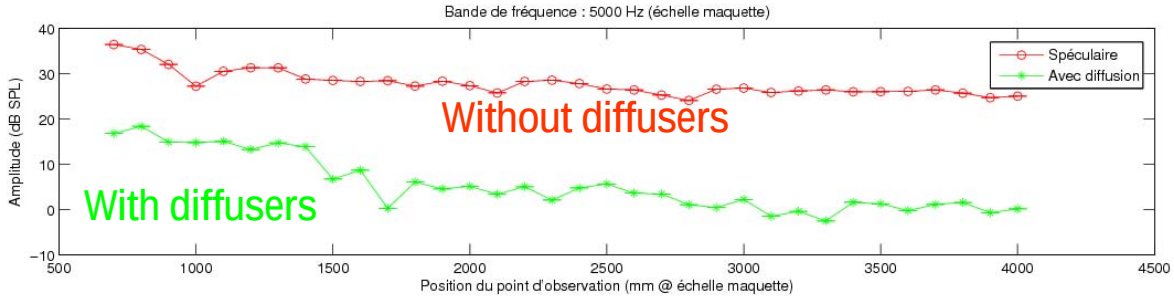

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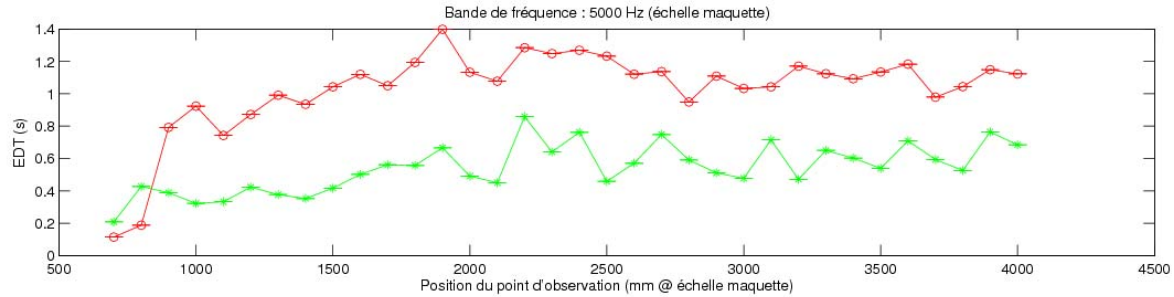
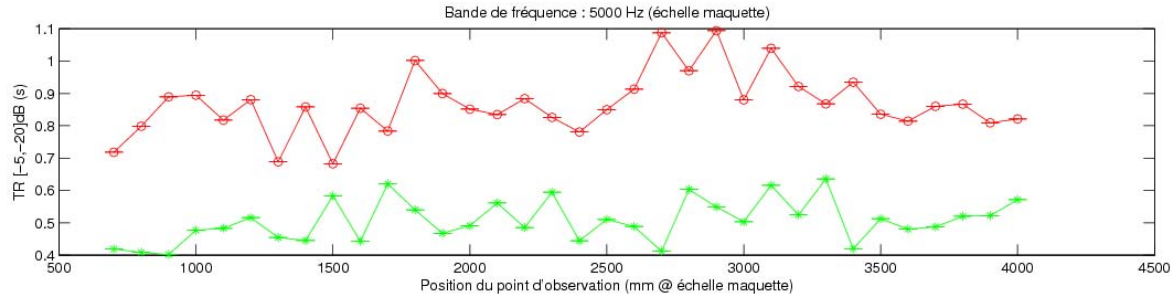


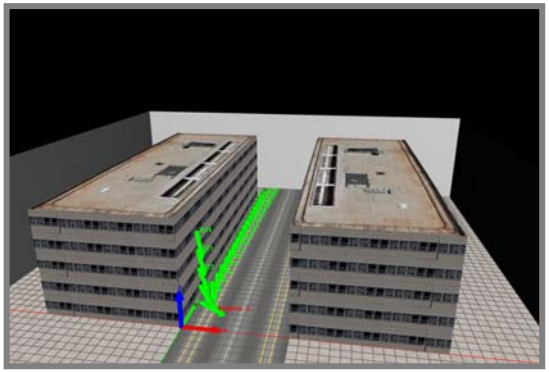
RT15 (s)



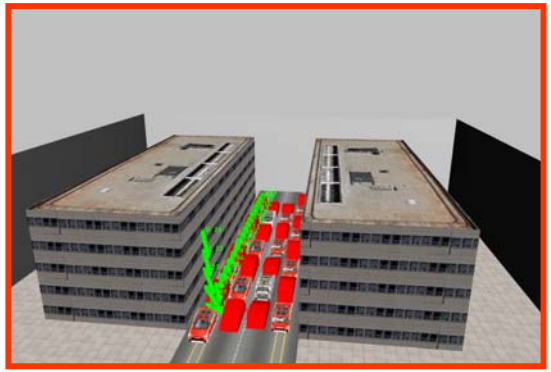
Diffusion by fitting objects in streets

Diffusion by fitting objects

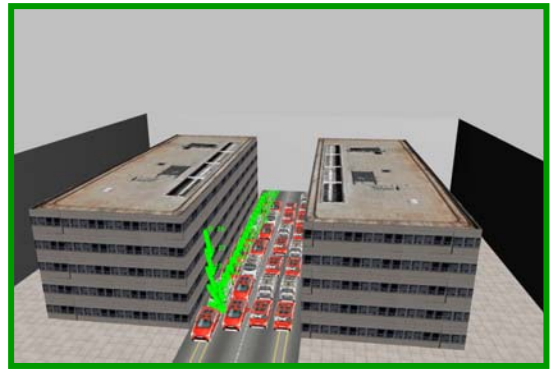
Empty street: reference



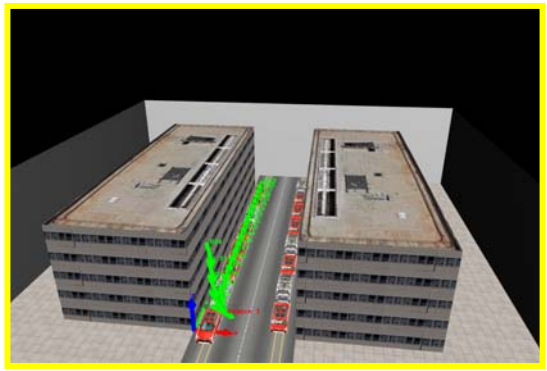
Fitting: 14 cars



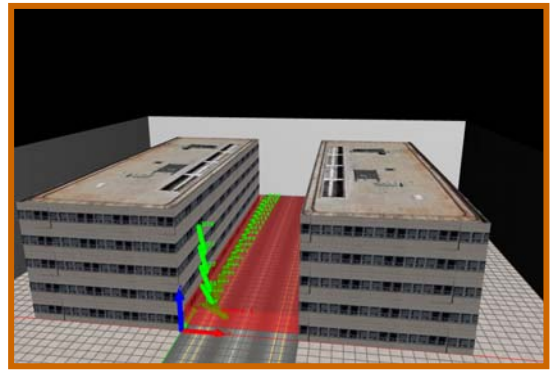
Fitting: 30 cars



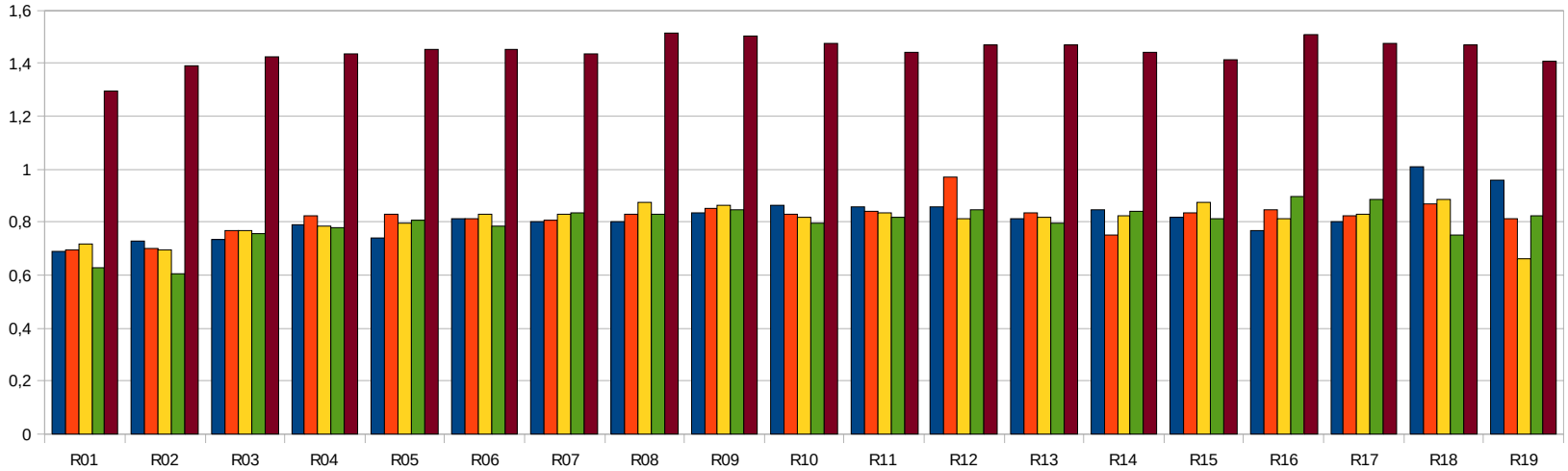
Fitting: 16 cars

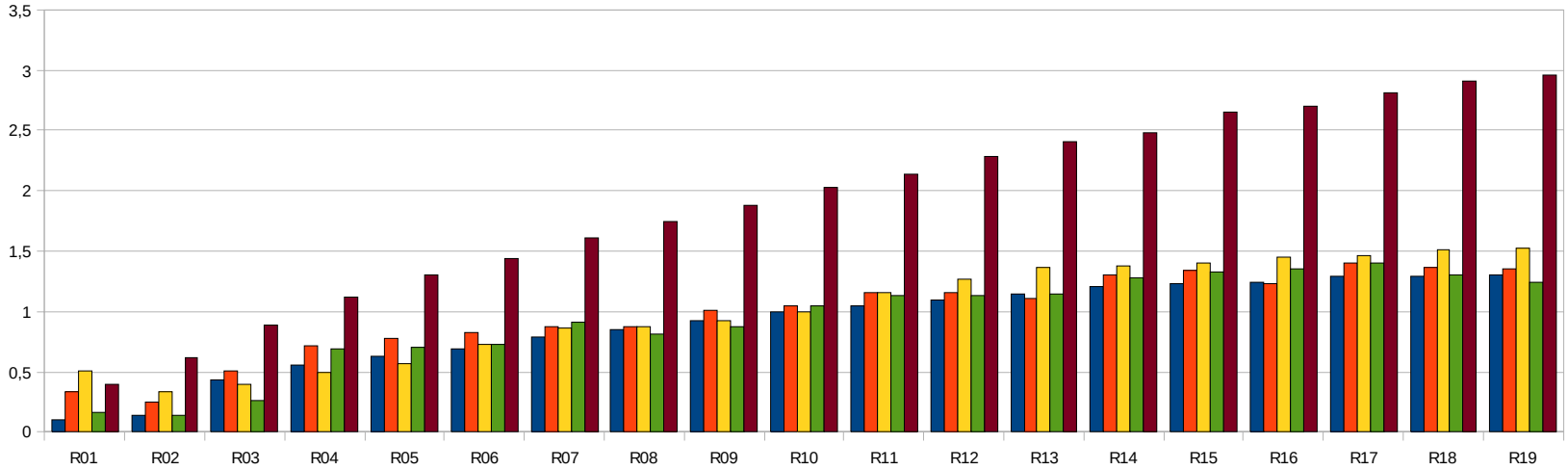


Statistical fitting (λ=6m,α=0)

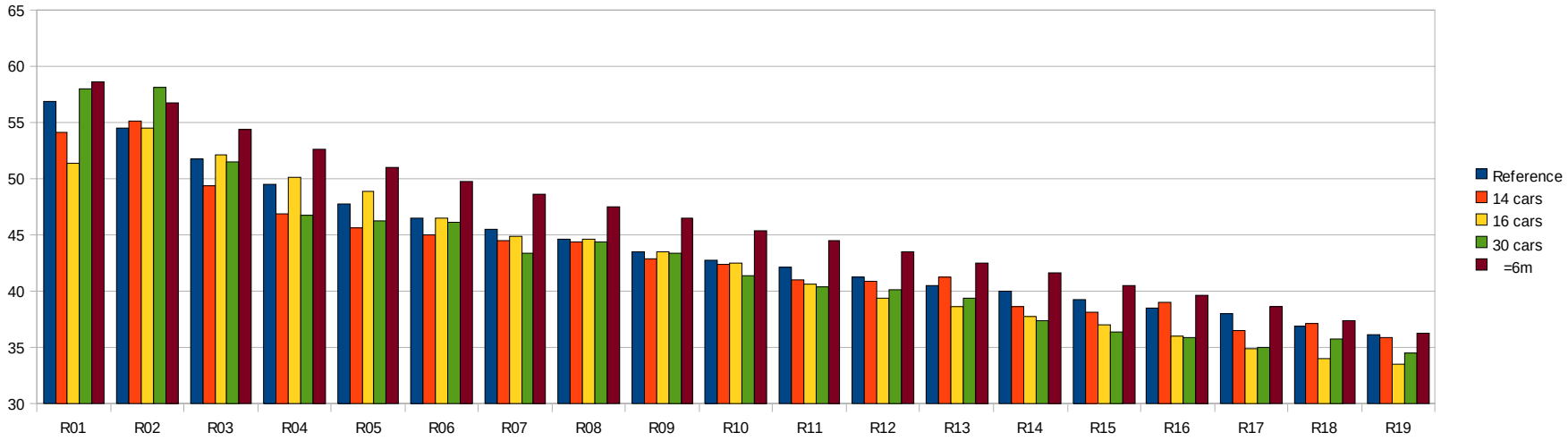


Diffusion by fitting objects





Diffusion by fitting objects



Conclusions:

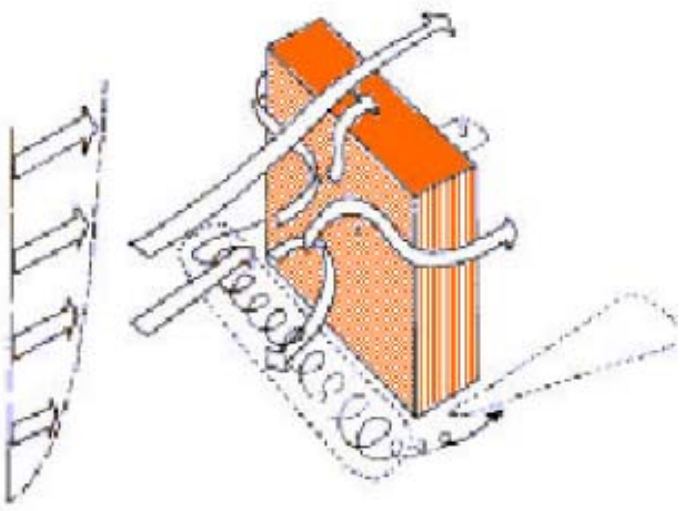
- small effect for fitting objects with specular reflection (local effect?)
- important effect of statistical diffusion (increase of SL, RT, EDT)
- need more detailled studies (OPALHA project in progress)

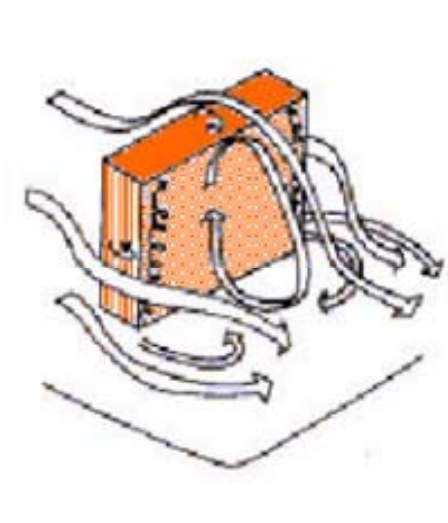
Specific meteorological effects in urban areas

Meteorological effects

- Meteorological effect in streets?
  - Thermal effects:
    - Heat turbulences
    - Celerity gradient : vertical and transversal
  - Aerodynamic effects:
    - Wind: « canyon » effect
    - Turbulences around buildings

Ögren and Forssén (2004)
Renterghem *et al.* (2004)
Heimann (2007)





Effects (in french) :
- de coin
- de tourbillon amont
- de sillage
- de rouleau aval
- de trou
- de barre
- de liaison
- Wise
- Venturi
- de canalisation
- de maille (ou de cour)

Meteorological effects

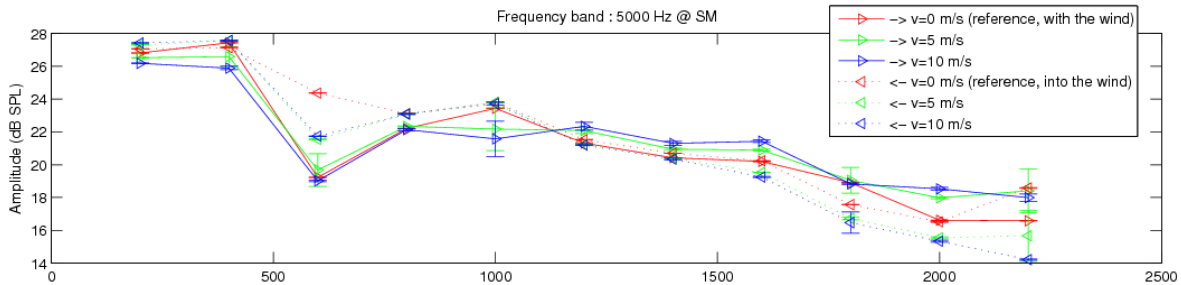
1/20 Scale model measurements (EM2PAU project)

(2.4m long x 0.35m width x 0.52m high)

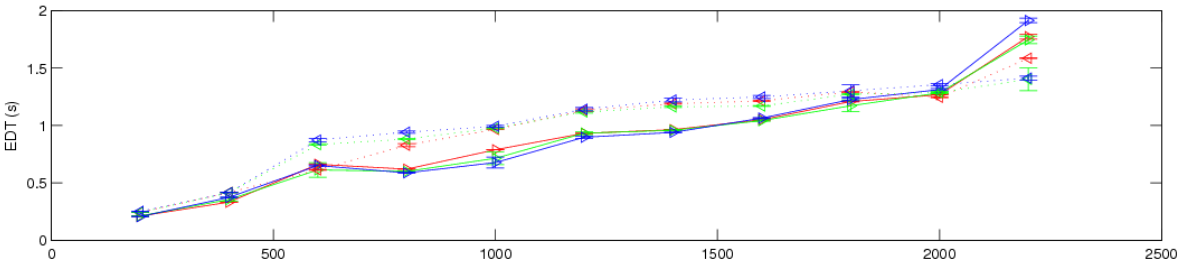
500Hz FS

Measurements in a PIV. Collaboration with the LMF (ECN)

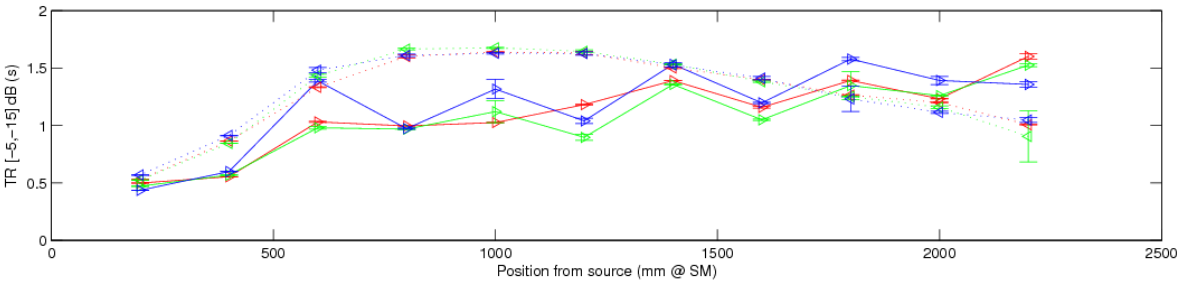
SL (dB)



EDT (s)



RT10 (s)

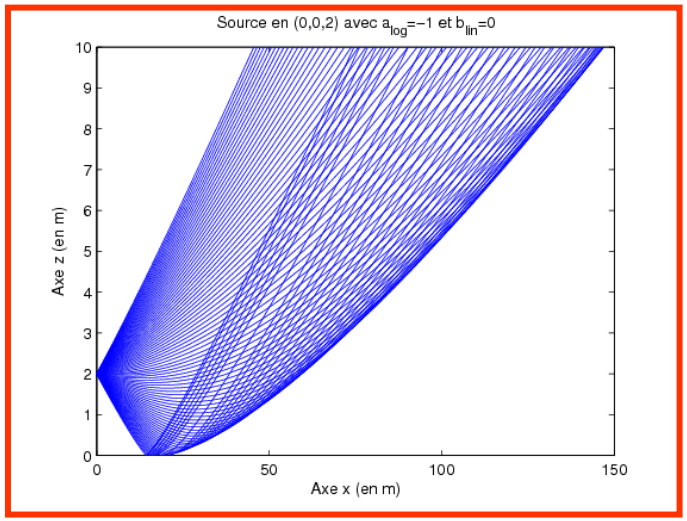


Meteorological effects

« Upward » configuration:

Celerity gradient log-lin

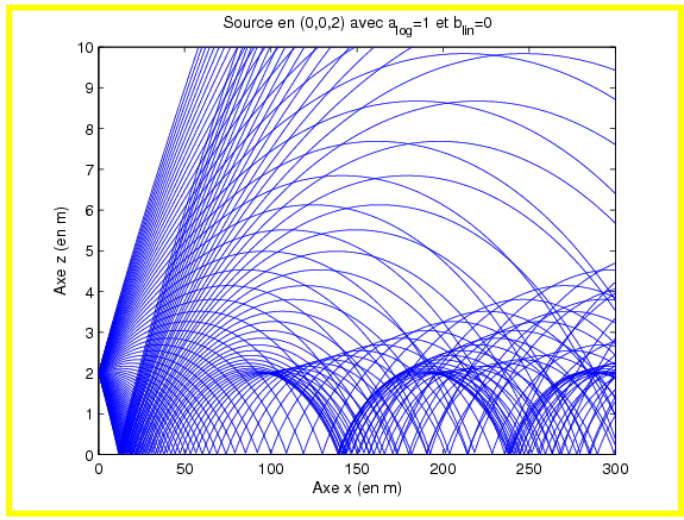
Particles path curved to the sky



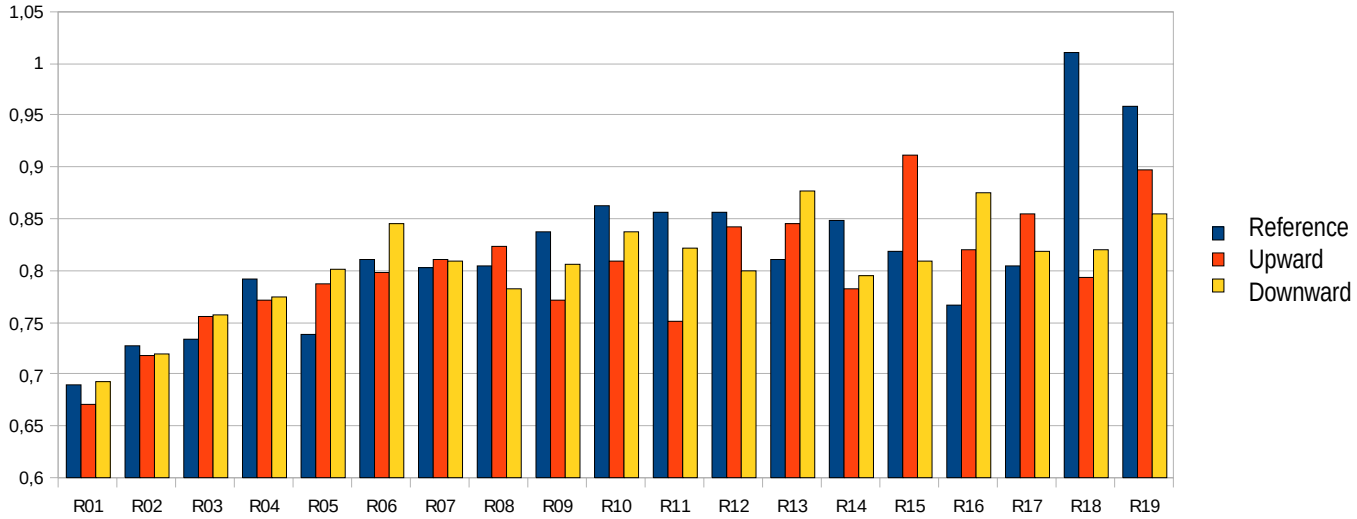
« Downward » configuration:

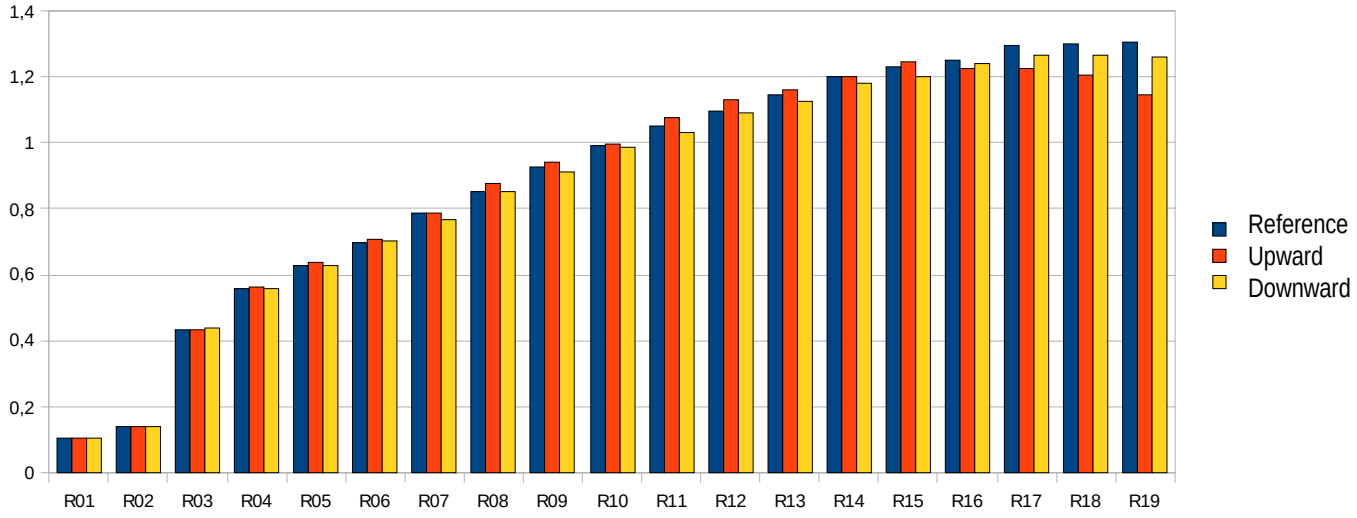
Celerity gradient log-lin

Particles path curved to the ground

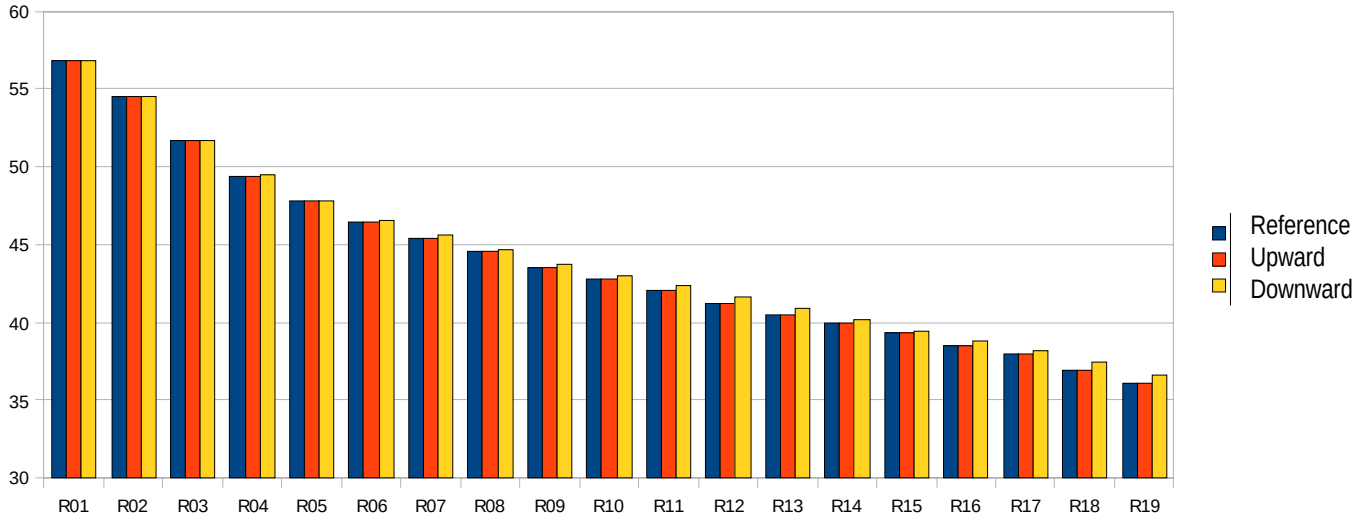


Meteorological effects





Meteorological effects



Conclusions:

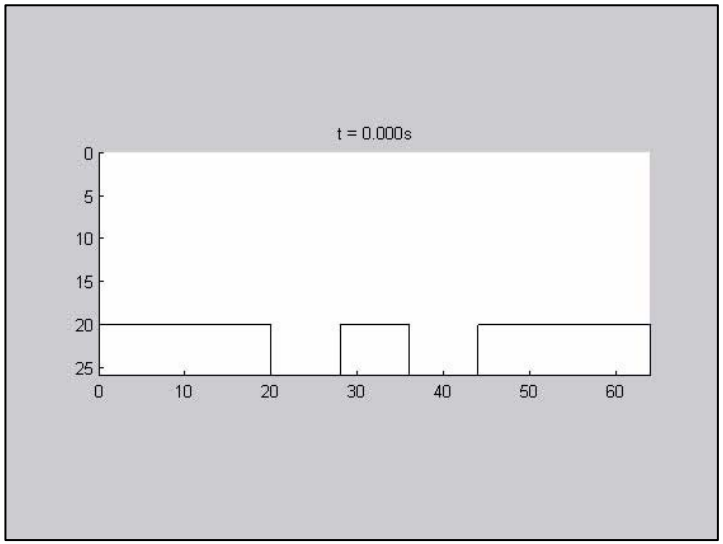
- not visible on SL; small effect on RT (10%), but arbitrary hypothesis…
- need more experimental and numerical studies (EM2PAU project in progress)

Interferential effects in street

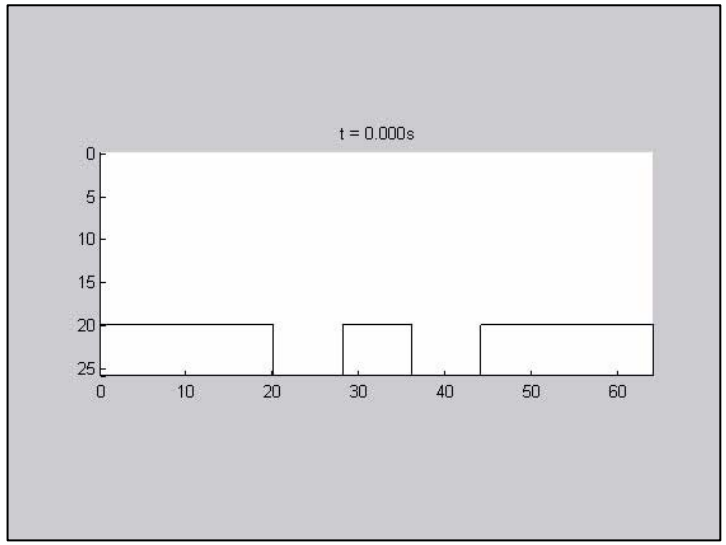
Interferential effects

- Effects of:
  - Roof impedance ★ never taken into account
  - Facade impedance ★ never taken into account

What is the real effect? Illustration (TLM simulation, 100Hz)



Façades with perfect reflection



Façades with porous material

Conclusion

- Physical phenomena of sound propagation:
  - **Diffuse reflection by building façades**
    - **Numerical simulations: real effect**
    - **Measurements: real effect**
  - **Diffusion by fitting objects**
    - **Numerical simulations: not pertinent (OPALHA Project…)**
    - **Measurements: OPALHA Project…**
  - **Meteorological effects**
    - **Numerical simulations: not pertinent (arbitrary simulation)**
    - **Measurements: not pertinent (EM2PAU project…)**
  - **Interferential effects in streets**
    - **Numerical simulations: pertinent (VegDUD Project…)**