

LES PLÉNIÈRES 2010 DU LCPC

Sciences et techniques du **Génie Civil**

JOURNÉES ACOUSTIQUE

Wissembourg – 2 et 3 JUIN 2010

Exploitation de la base de données expérimentales de la "Station de Long Terme" (SLT)



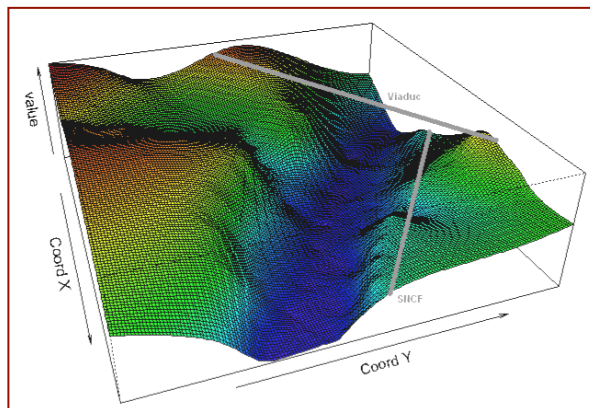
Benoit GAUVREAU – LCPC Nantes (F)
Bernard BONHOMME – LRPC Blois (F)
Hervé POIRIER – CECF Angers (F)

SOMMAIRE

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- B – Présentation générale
- C – Traitement des données
- D – Applications
 - D.1 – Validation des modèles numériques
 - D.2 – Analyse statistique
 - D.3 – Apports pour les travaux normatifs
- E – Conclusions et perspectives

> Societal and scientific motivations

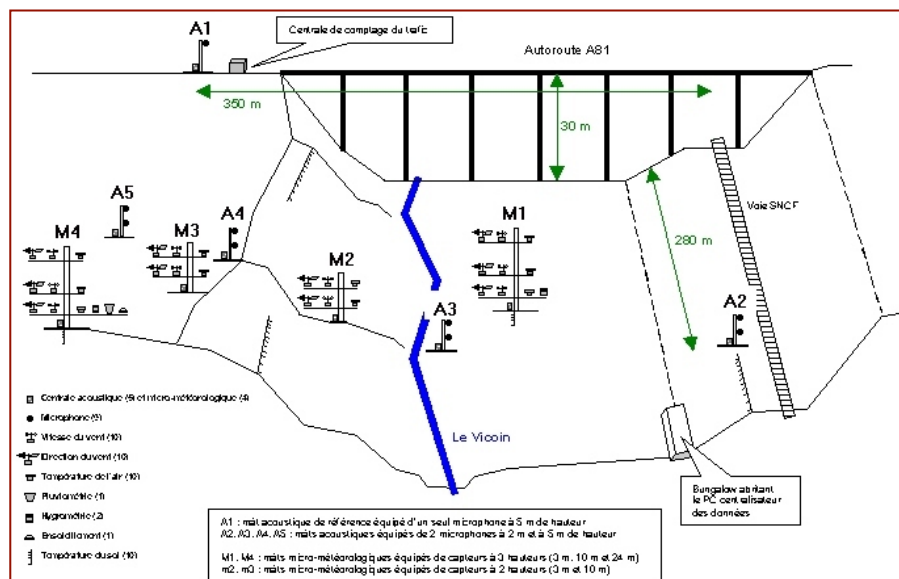
- Wide spreading of long range SPL due to fluctuations of influent parameters
 - (Emission: Sound source characteristics from road traffic)
 - Propagation:
 - Boundaries characteristics: Topography, obstacles, ground impedance, forests, *etc.*
 - Medium characteristics: Mean refraction and atmospheric turbulence (micrometeorology)
- Needs: Quantifying variability and uncertainty of SPL (cartography, impact study, *etc.*)
- Stakes: Estimating space and time representativeness of SPL
- Problematic: Representativeness of propagation conditions (ground and atmosphere)
 - Space representativeness >> Local effect ?
 - Time representativeness >> Long term ?



La SLT, comment ?

> LTMS and LTMS-2 (2007/2008, 319k€HT, 50% Région PdL)

- Localization: Small valley at Saint-Berthevin (F, 53) – Sound sources: Road and railway traffic
- Data acquisition: 24h/24h (« monitoring ») since 2002, 10 seconds average samples
- 5 acoustical masts (2m and 5m measurement heights) – L_{eq10s} – Global (A) + 1/3 octave bands [100Hz;4kHz]
- 4 meteo towers (3m, 10m and 25m measurement heights) – Wind speed and direction, ventilated air temperature
- 4 ultrasonic 3D anemometers (on M1 and M4, 3m and 10m measurements heights) + cloud cover monitoring
- Impedance monitoring (M3/A4, every 4h) + soil water and temperature monitoring + various additional sensors
- Road traffic characteristics: Time, lane, silhouette and speed (for each vehicle pass-by)
- Data synchronization, concatenation and transfer *via* web site (CECP Angers) + validation/filtering (LRPC Blois)



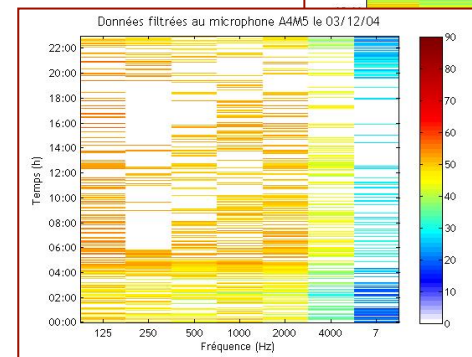
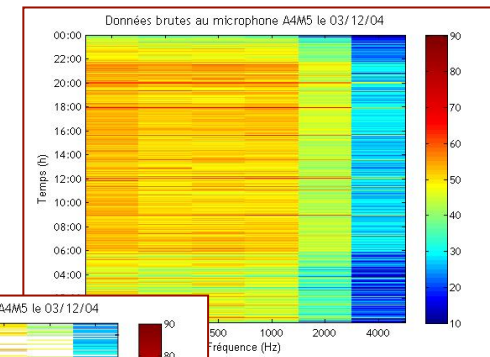
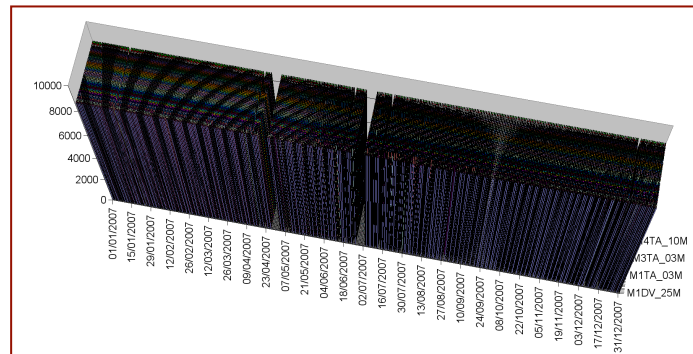
> Post-processing on LTMS databases

■ Road Traffic

- Raw database: 1 sample / vehicle (time, lane, silhouette and speed)
- Post-processed database: 10sec assessment (N_VL, N_PL, V_VL, V_PL for each 4 lanes)

■ Meteo conditions

- Sensors dysfunctions
- Transfer problems
- Data validation/filtering
- Example for 2007:



- $L_{eq15min}$
 - Metrological and/or transfer problems
 - S/N ratio
 - Parasitical sound events (animals, trains, etc.)
 - Data validation/filtering
 - Example for 2004/12/03:

Map

À

Mode avancé

?

Mes lieux favoris | Lieux remarquables

?

er une commune

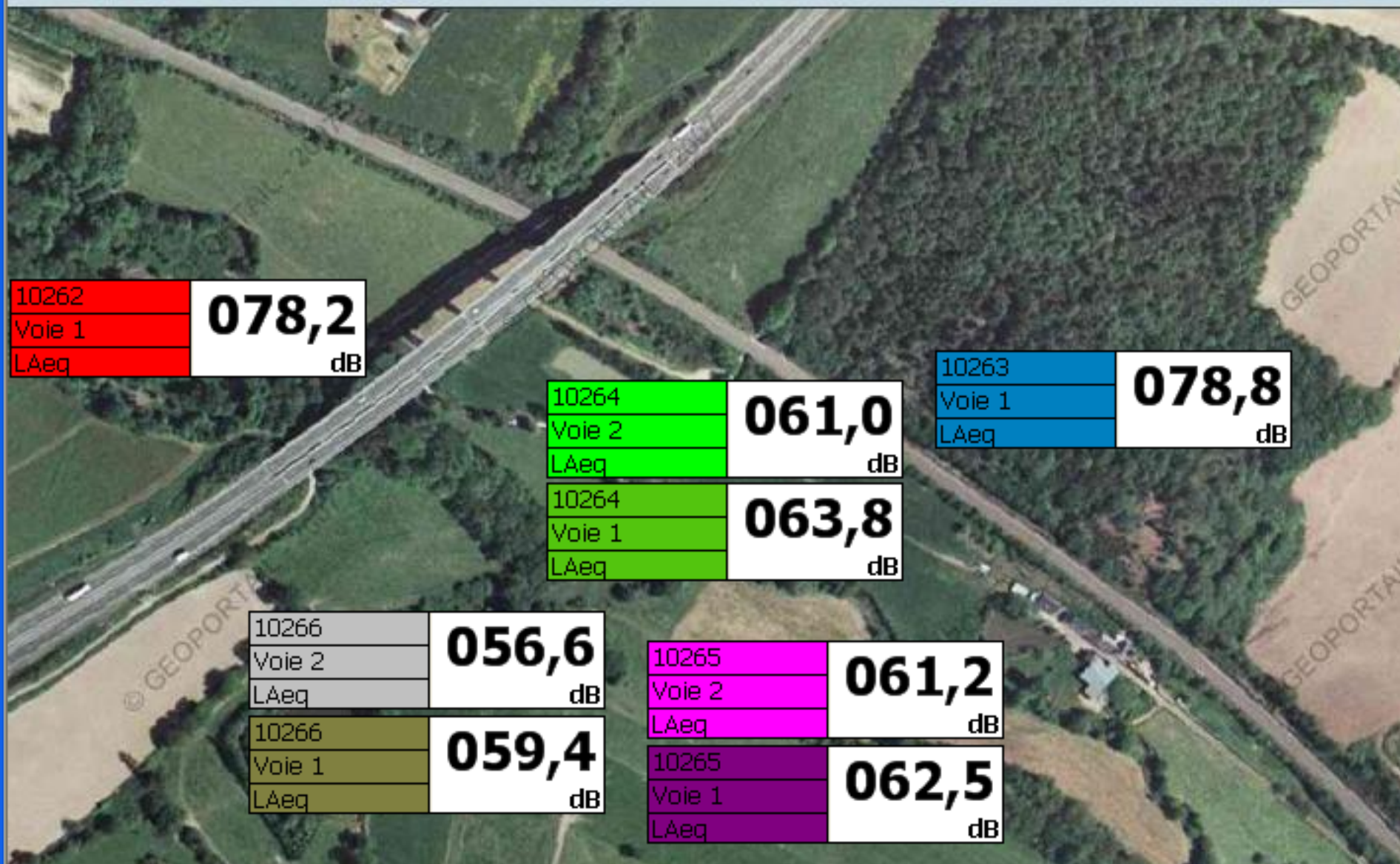
J'y vais

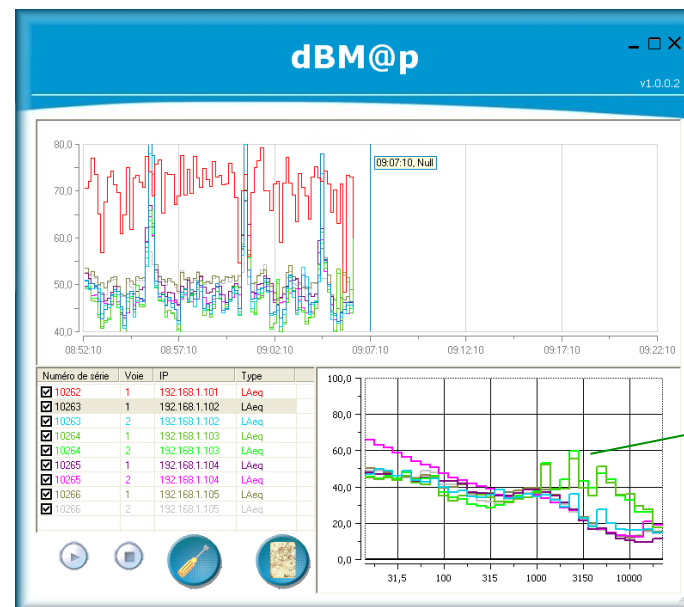
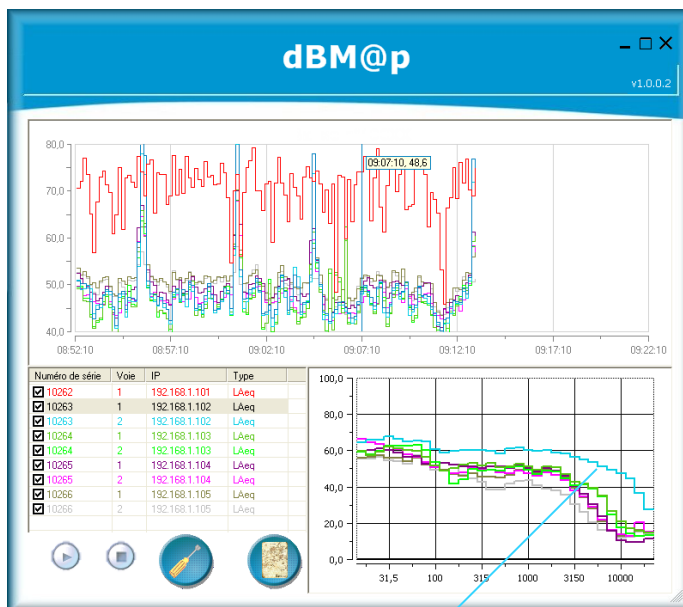
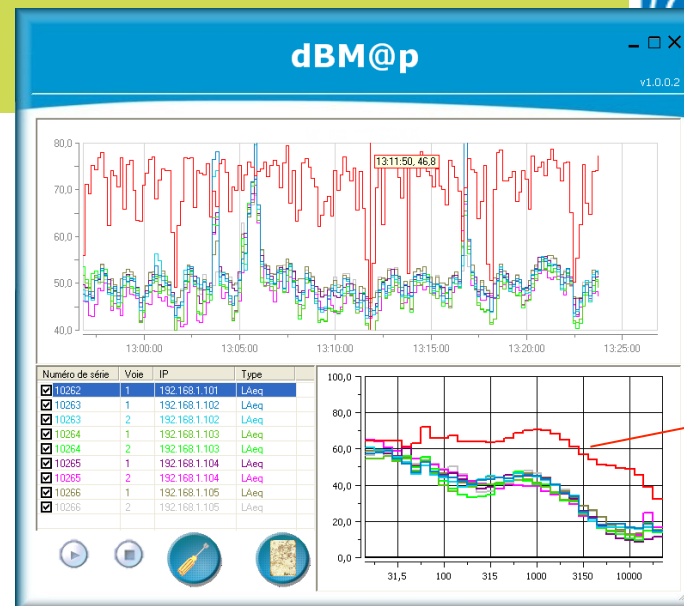
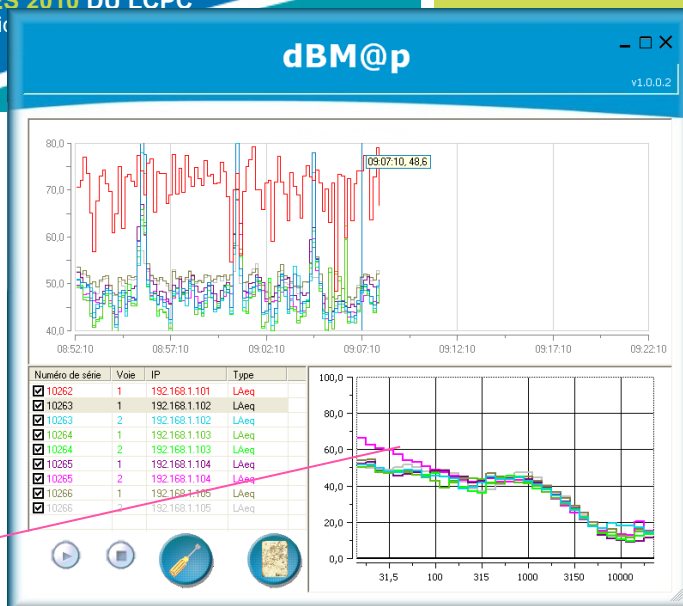
Sélectionnez...

▼



Carte





Bilan pour 2002-2007

Raw database (45Mo/day),
of 10sec samples (2002-2007):
337 630 475 / year = 2 025 782 850

Validation

Validated database (2002-2007),
of 10sec samples = 1 216 387 160

Composition

Validated database (2002-2007),
of 15min samples = 11 399 406

Full lines

- Acoustic (∀ mast, ∀ height, ∀ octave) : **10 (!)**
- Meteo (∀ tower, ∀ height, ∀ parameter) : **69 820**
- Traffic (∀ parameter) : **127 347**

Full lines # - Selection

- A3_2m rel. A1 (A1M5 & A3M2, ∀ octave) : **1 118**
- A3_5m rel. A1 (A1M5 & A3M5, ∀ octave) : **1 293**
- A5_2m rel. A1 (A1M5 & A5M2, ∀ octave) : **1 830**
- A5_5m rel. A1 (A1M5 & A5M5, ∀ octave) : **1 614**
- M1 (DV_10m, VV_i, TA_i, i=3,10,25m) : **99 265**
- M4 (DV_10m, VV_i, TA_i, i=3,10,25m) : **143 144**

Numerical models

PhD P. Aumond
LCPC / MF-CNRM
2008-2011

Full lines # - Selection – Acoustic/meteo combination

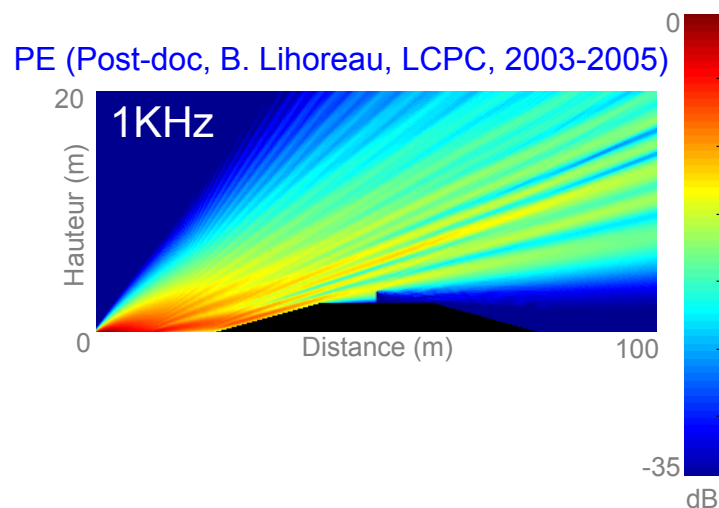
- A3M2 rel. A1 + M1 (valley / 2m) : **370**
- A5M2 rel. A1 + M4 (plateau / 2m) : **1 496**
- A3M5 rel. A1 + M1 (valley / 5m) : **420**
- A5M5 rel. A1 + M4 (plateau / 5m) : **1 310**

Statistical models

PhD O. Leroy
LCPC / EDF-R&D
2007-2010

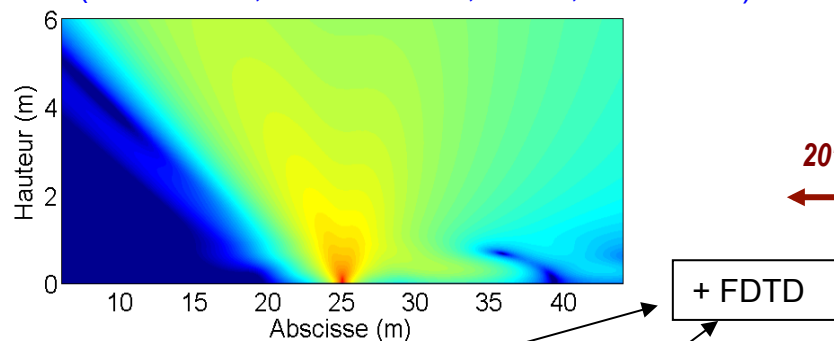
> Application 1: Numerical models validation + coupling

Propagation models



[Lihoreau et al., JASA 2006]

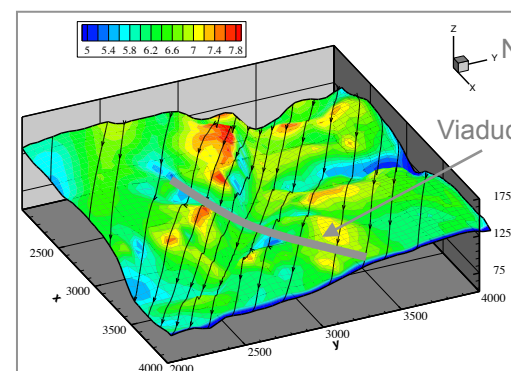
TLM (PhD Thesis, G. Guillaume, LCPC, 2006-2009) + PA



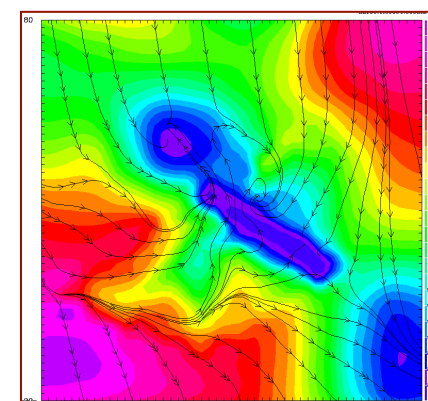
Partnership: RST, EC Lyon, CSTB, LAUM, EDF R&D, etc.

Micrometeorological models

Submésos (PhD Thesis, T. Pénelon, EC Nantes, 1997-2000)



Mésos-nH (PhD Thesis, P. Aumond, LCPC/CNRM, 2008-2011)



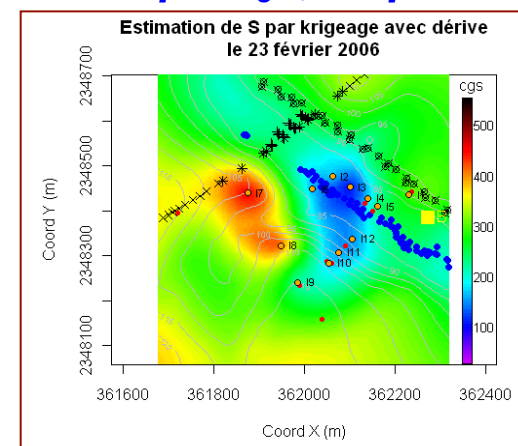
2010 / 2011

Partnership: EC Nantes, ISL, INRA, Météo-France (CNRM), etc.

> Application 2: Statistical exploration

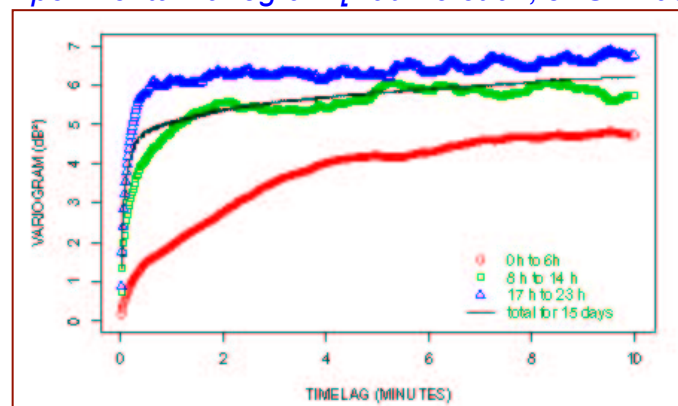
- **Space and time representativeness**
 - Short-term vs Long-term
 - Regional scale vs Local scale
 - Geostatistics
- **Classification**
 - Variability and uncertainty
 - Relative influence of ground/meteo parameters
 - Multidimensional analysis

*Estimation of σ with kriging method
[Bellanger, 2010]*

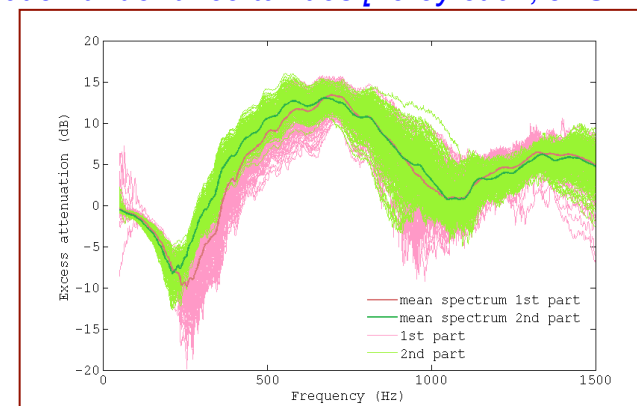


PhD Thesis (LCPC / EDF R&D):

Experimental variogram [Baume et al., JASA 2009]



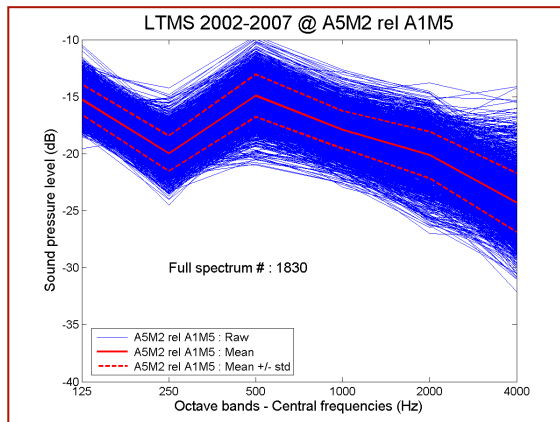
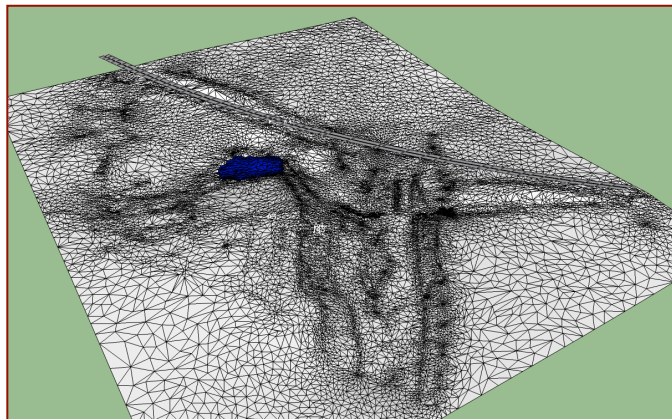
Calibration under uncertainties [Leroy et al., JASA 2010 ?]



Partnership: RST, EDF R&D, École des Mines de Paris (Centre de Géostatistique), etc.

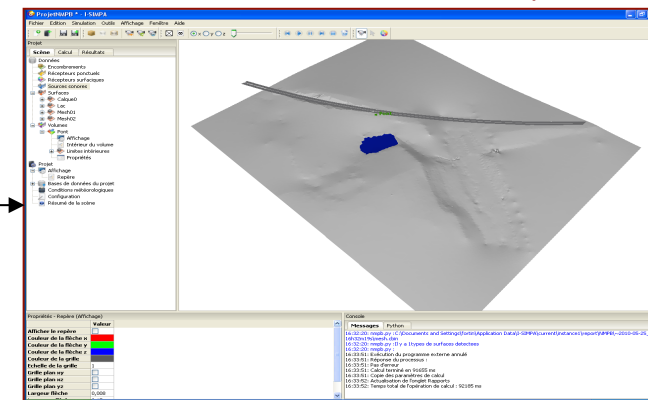
> sous MeshLab

- Importation MNT (source : LRPC Blois)
- Réchantillonnage (40000 pts > 10000 pts)
- Saisie des plateformes du viaduc



> sous I-Simpa (N. Fortin & J Picaut)

- Saisie des sources (linéiques)
- Saisie des récepteurs (mâts)
- Caractéristiques de sol (lac, rivière)
- Plan de calculs sur G / σ (script Python)



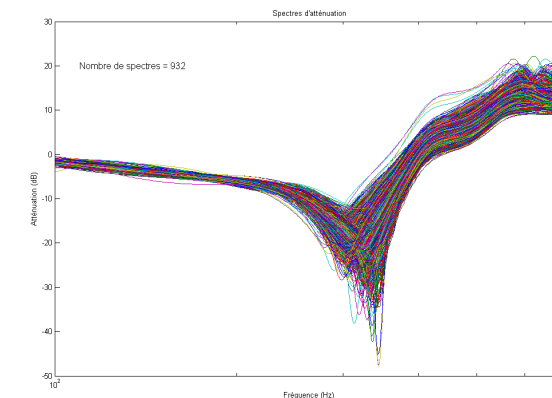
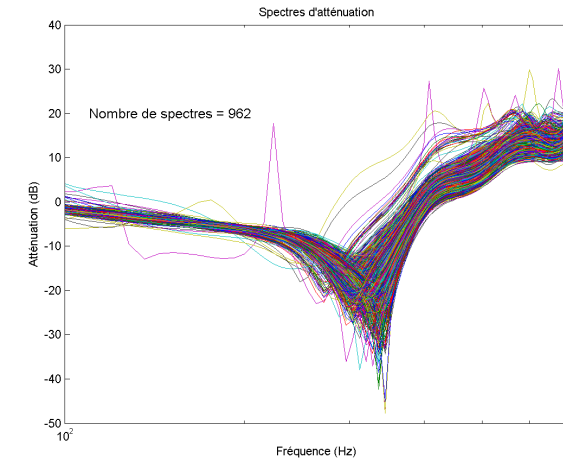
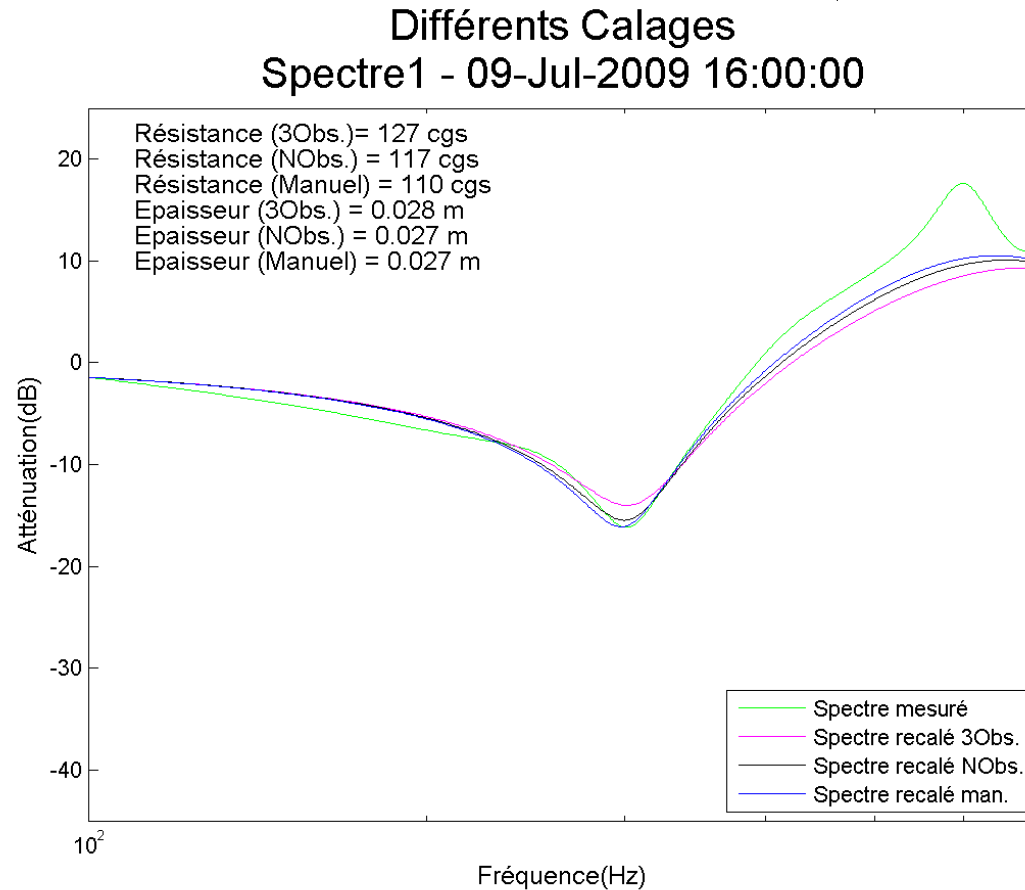
Noyau de calcul :
NMPB2008
(LRS.exe)

CUU

Thèse O. Leroy
(LCPC/EDF R&D)



> Monitoring impédance : stage R. Rouffaud (Univ du Maine, 2010)



- > Influence des observables (hygro + temp sol, hygro+ temp air, humectation, etc.) ?
- > Influence du modèle de calage automatique (D&B, Z&K, H&B, etc.) ? >> Campagne exp SNCF / ECL
- > Quel algorithme/méthode pour la fonction coût (minima locaux/globaux) ?

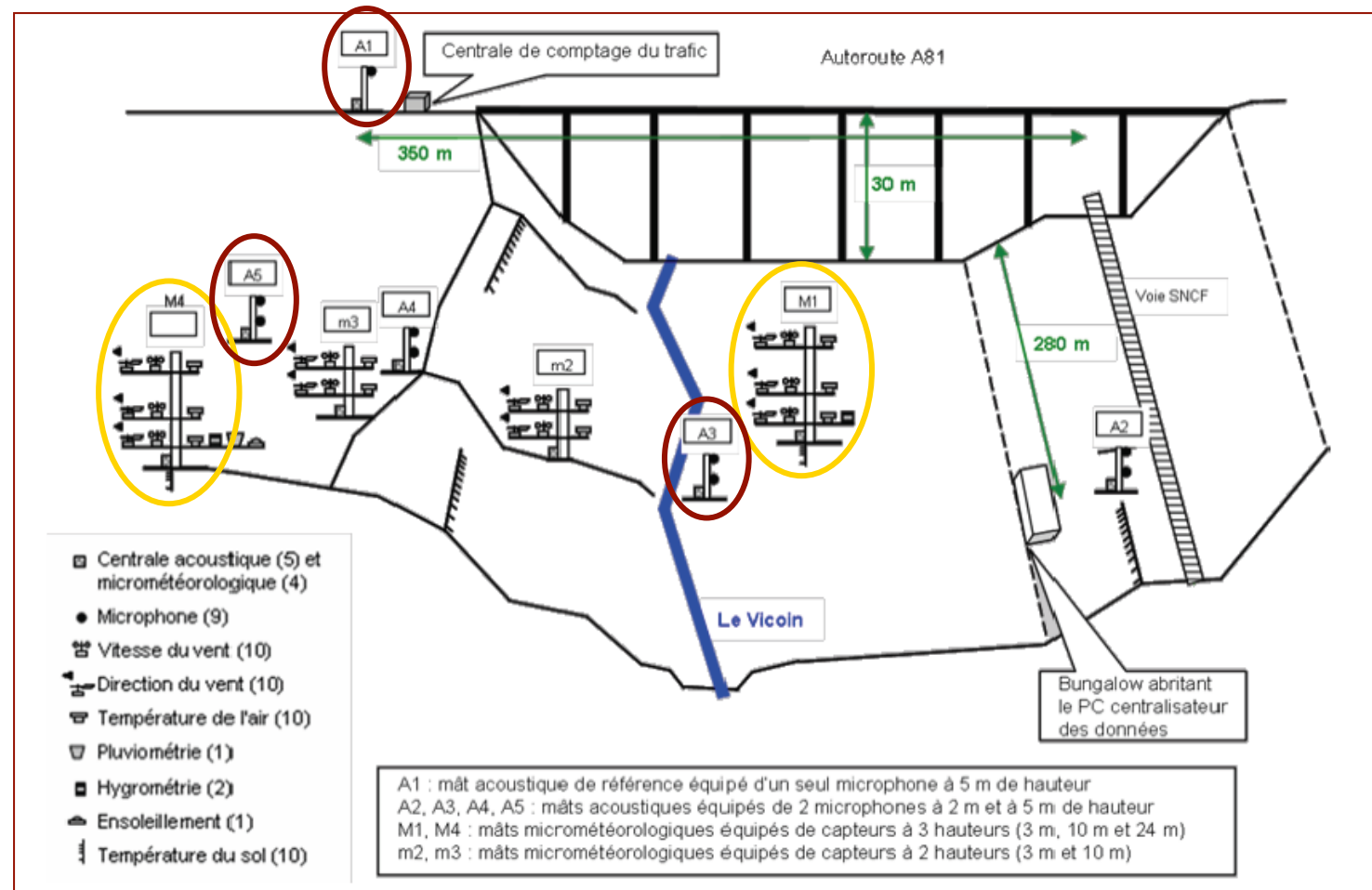
- > Selection of period: 2002-2007 (6 years)
- > Selection of variables:

Meteo:

- M1 & M4
- 3m, 10m, 25m
- WS, WD, T

Acoustics :

- H=2m & 5m
- A1, A3 & A5
- Att_5 = A5-A1
- Att_3 = A3-A1

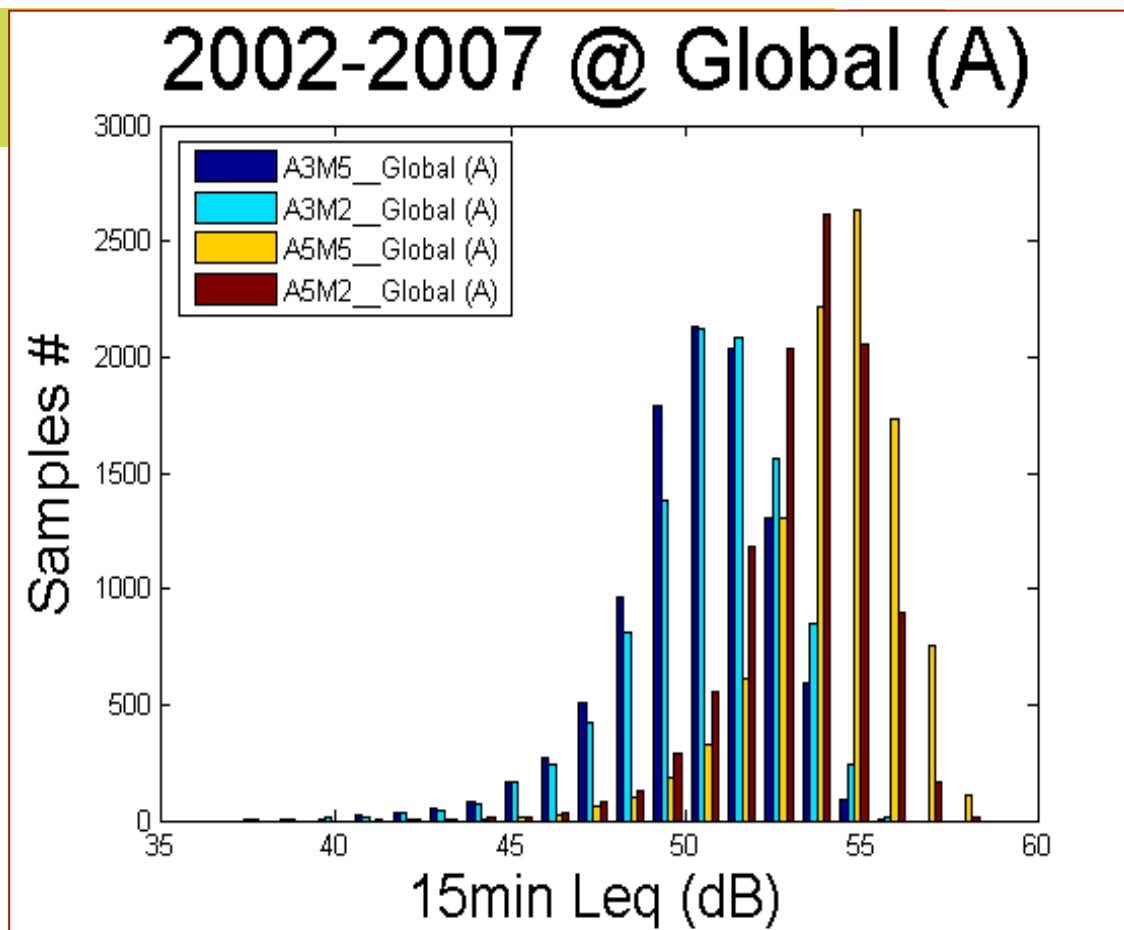


Space and time representativeness

- > Leq_{15min}
- > A3 // A5
- > 2m // 5m
- > Global(A)
- > 10 092 "full" lines

Comments :

- Influence of the microphone
localization...
- ... and influence of the microphone
height...
- ...on *mean* and *std* values !
- Observations for Global(A)...
- ... but significant discrepancies
between frequencies (octave bands)



← A3M5 (A) : M=50.3 dB(A), Std=2.2 dB(A) →

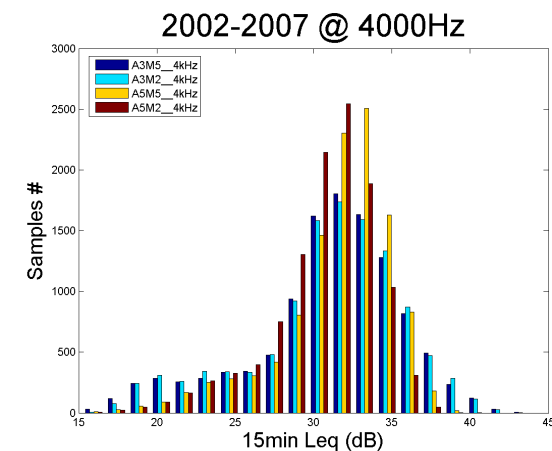
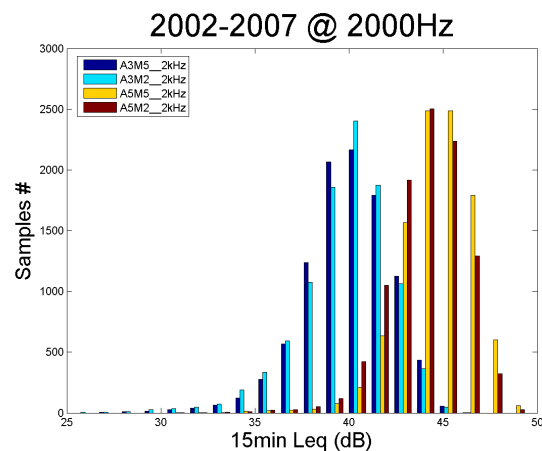
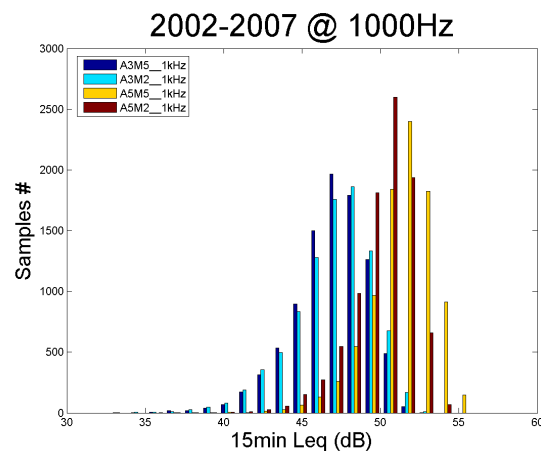
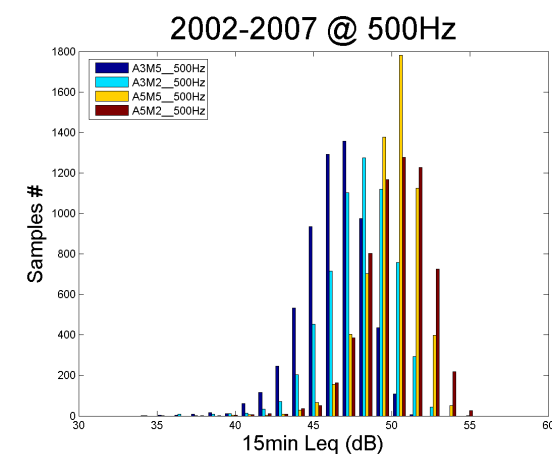
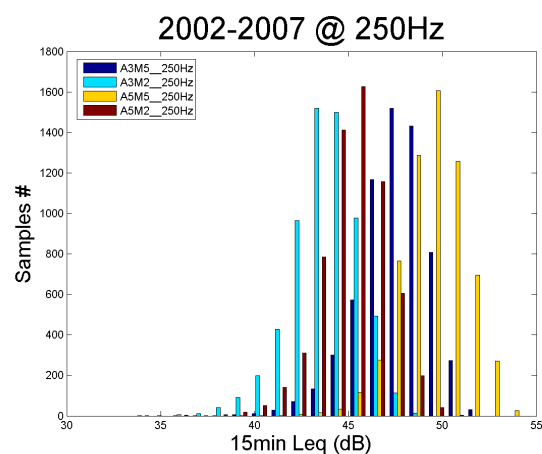
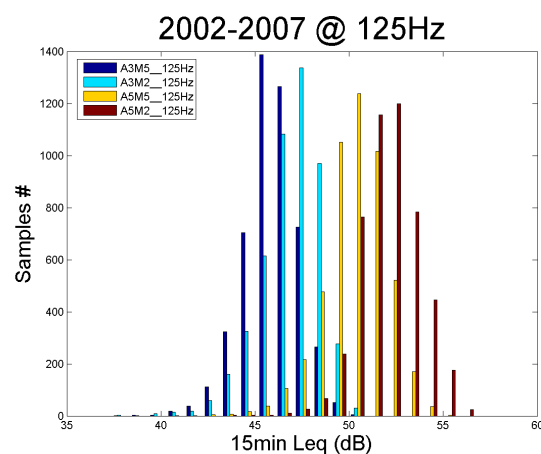
← A3M2 (A) : M=50.7 dB(A), Std=2.3 dB(A) →

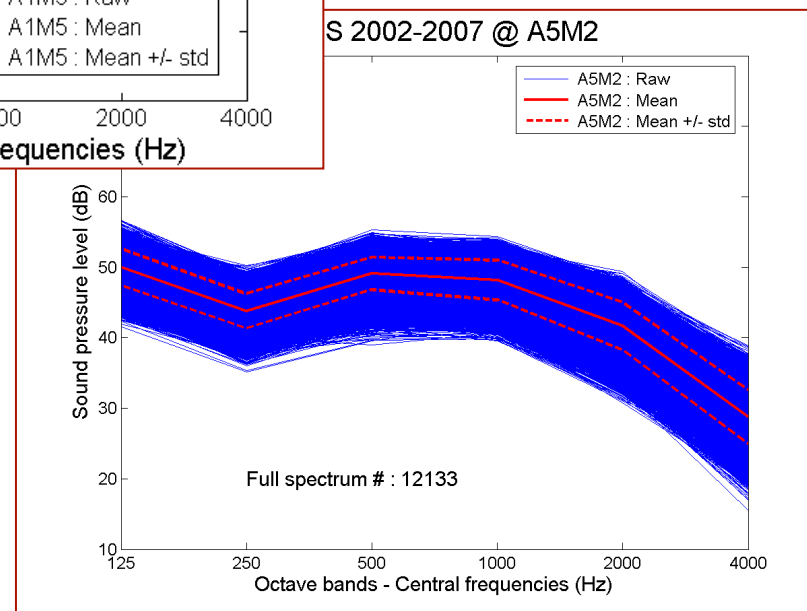
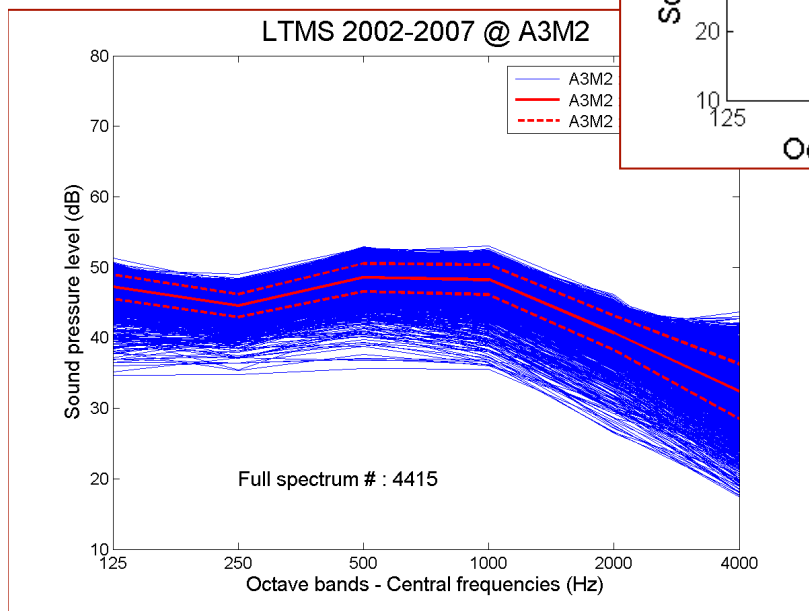
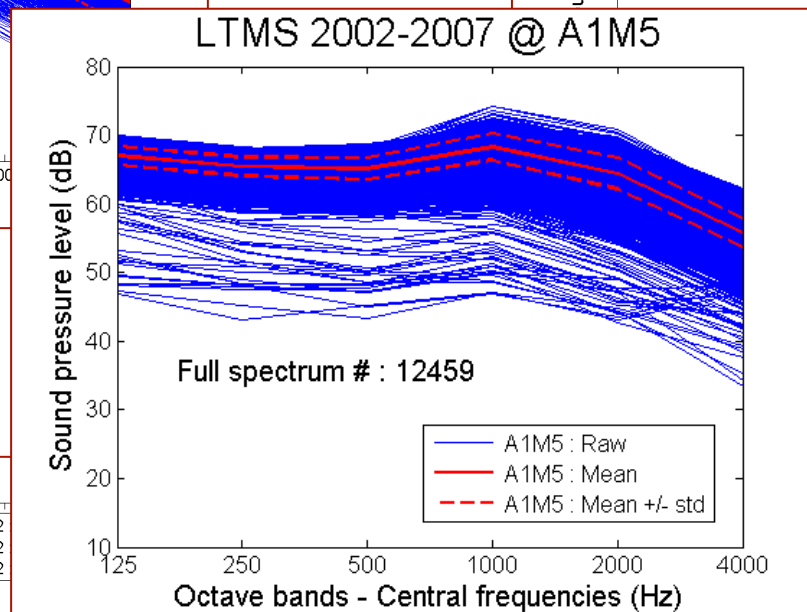
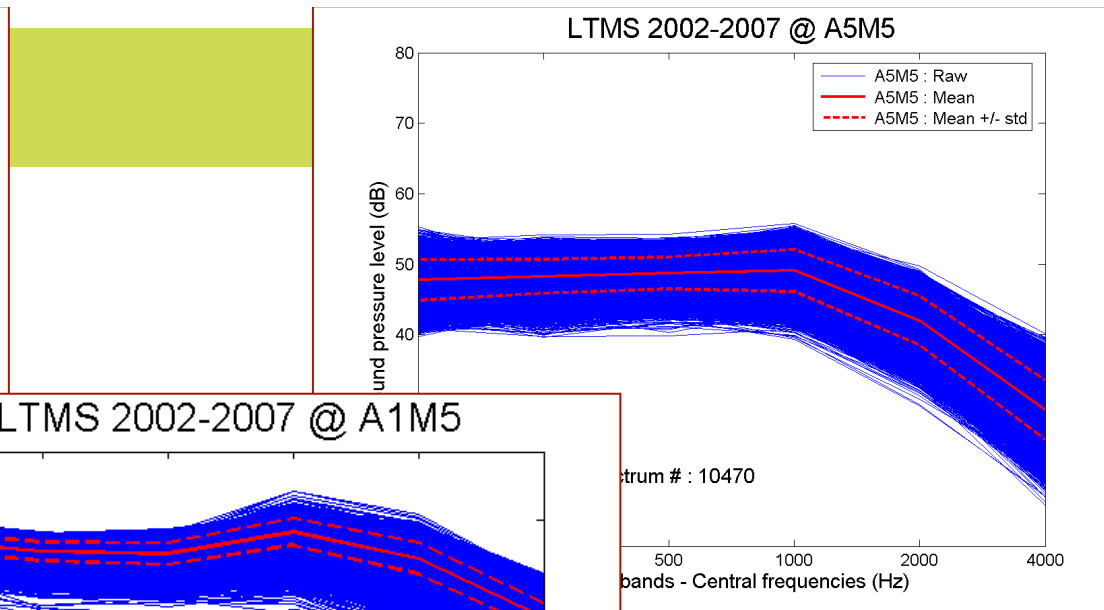
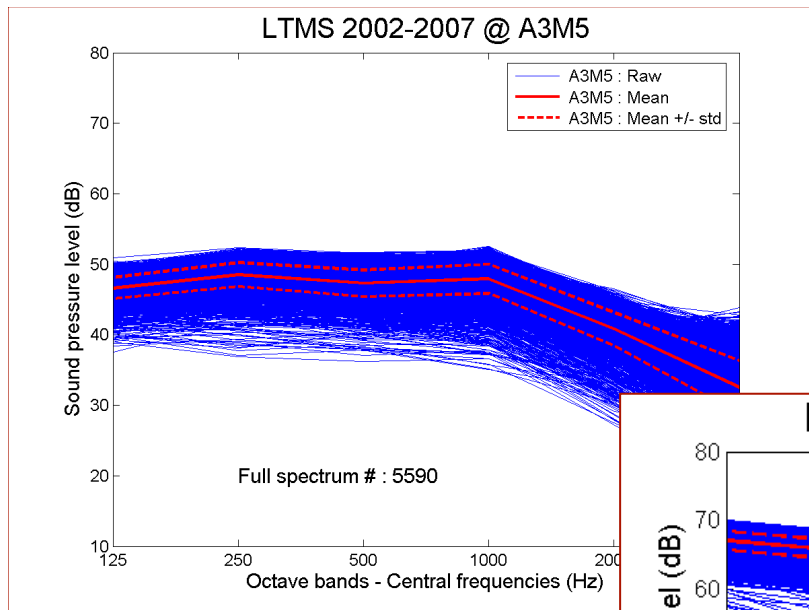
← A5M5 (A) : M=54.1 dB(A), Std=1.9 dB(A) →

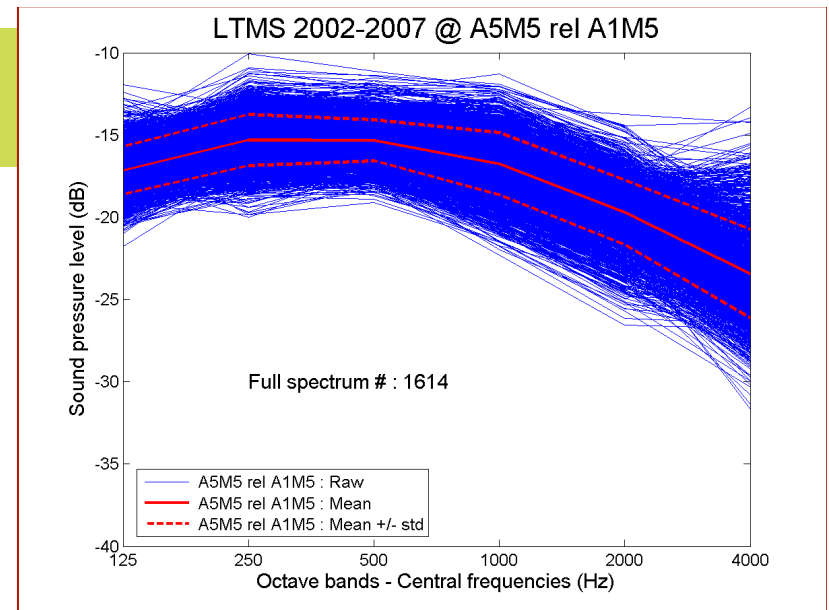
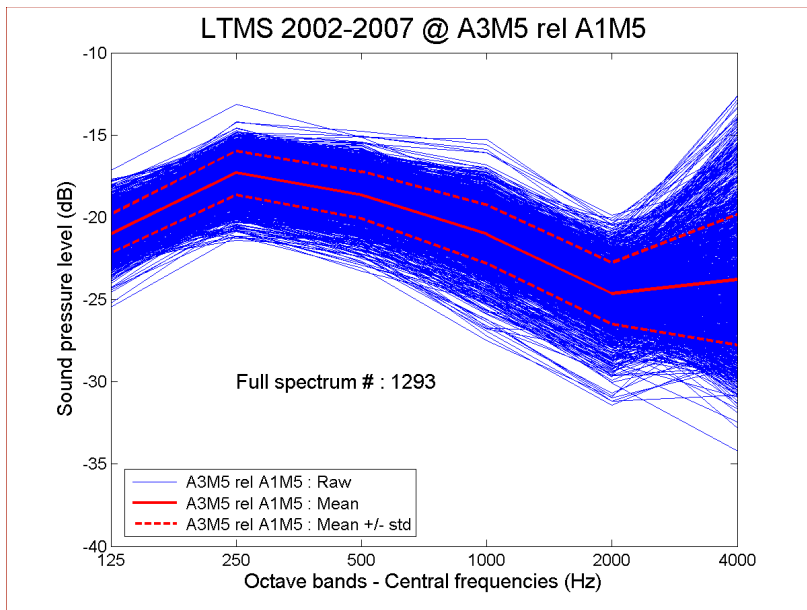
← A5M2 (A) : M=53.2 dB(A), Std=1.9 dB(A) →

Space and time representativeness

- > Leq_{15min}
- > A3 // A5
- > 2m // 5m
- > Octave bands





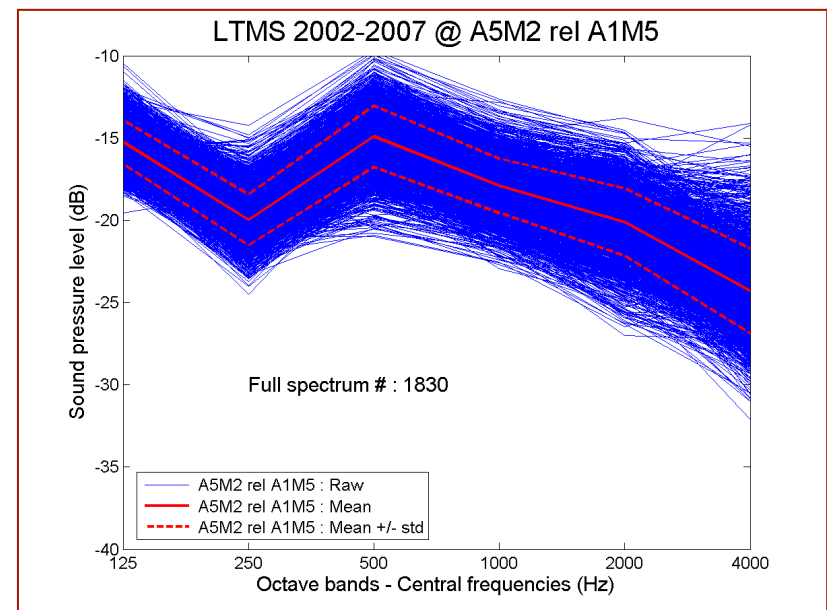
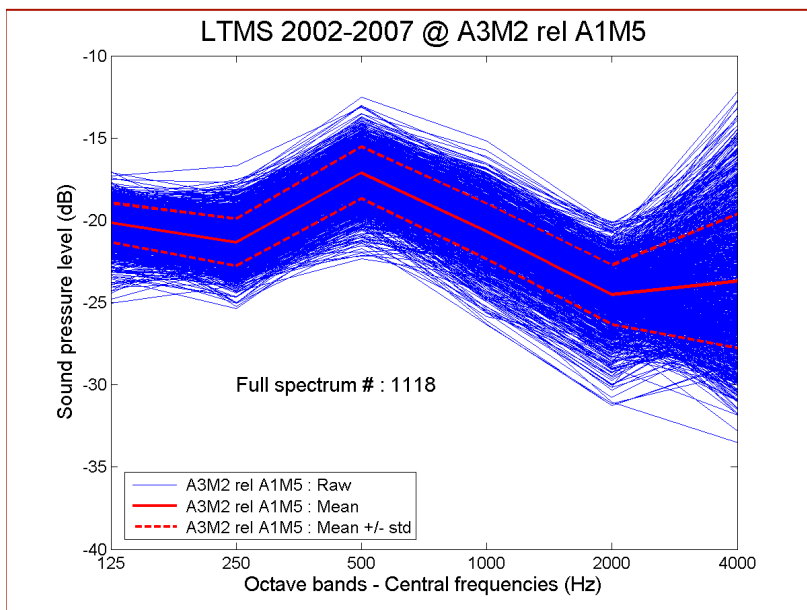


Niveaux sonores relatifs au microphone de référence (A1)

> effets propagatifs (excess att.)

> comparaison avec méthode RLT

> GT AFNOR (31-110, 31-185)



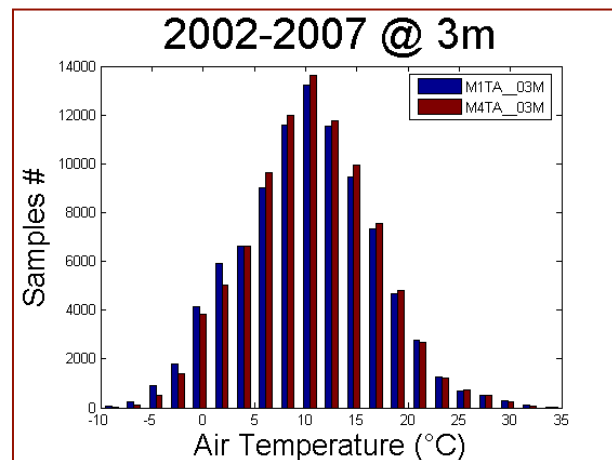
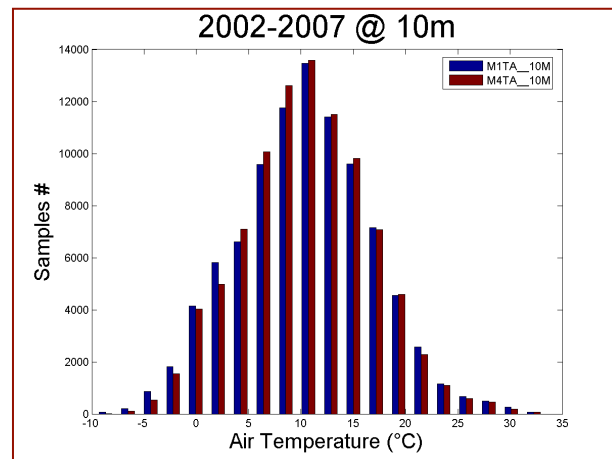
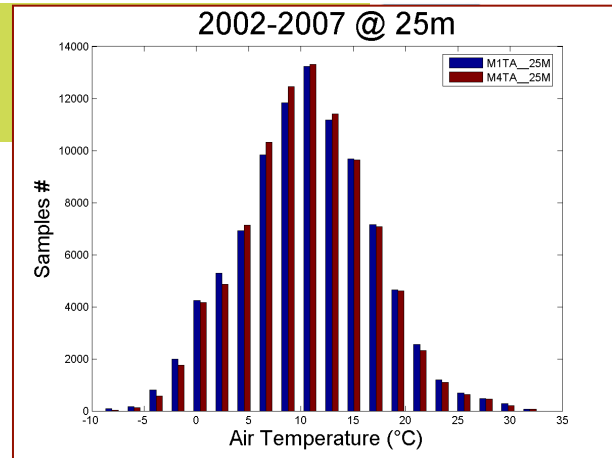
Température

Space and time representativeness

- > Air temperature
- > M1 // M4
- > 3m // 10m // 25m
- > 92 271 “full” lines

Comments :

- Same behavior $\forall$ M_i and $\forall$ height...
- ... but vertical profiles between M1 and M4 can be significantly different for some samples !
- Example: No wind + sunny >> river effect (plateau/vallée)

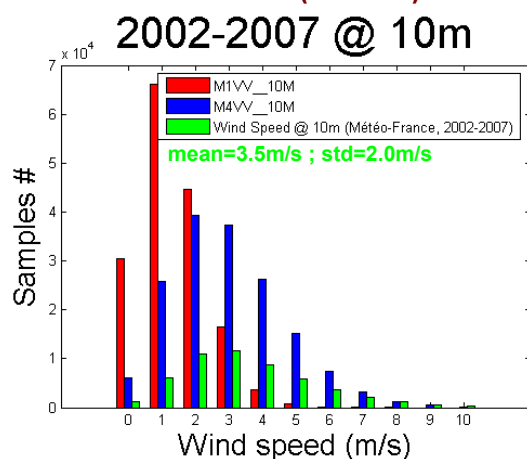


Vitesse du vent

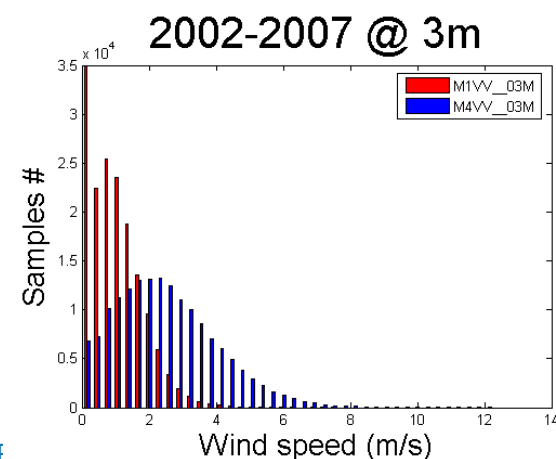
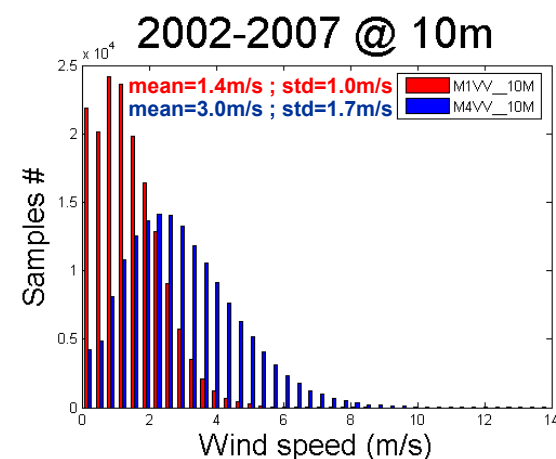
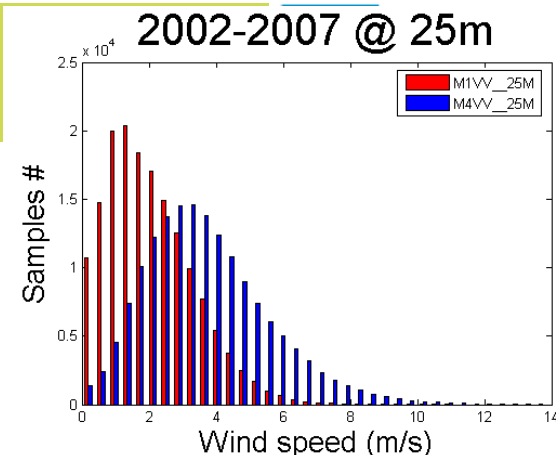
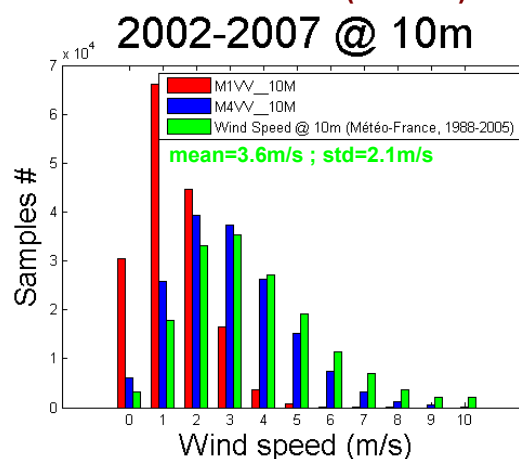
Space and time representativeness

- > Wind speed
- > M1 // M4
- > 3m // 10m // 25m
- > 162 225 “full lines”

> + MF 2002-2007 (horaire)



> + MF 1988-2005 (horaire)

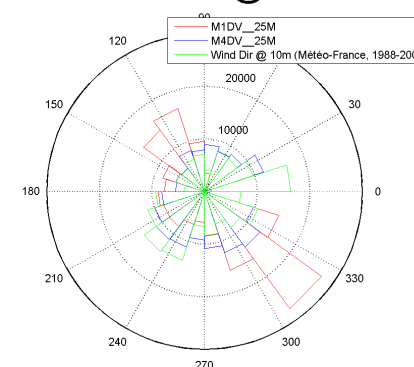


Comments :

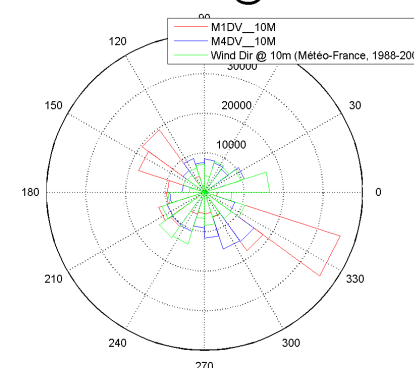
- Different behavior regarding height...
- ... but more noticeable for M1 (local effect)...
- ... leading to significantly different vertical profiles...
- ... and different SPL predictions ?

Direction du vent

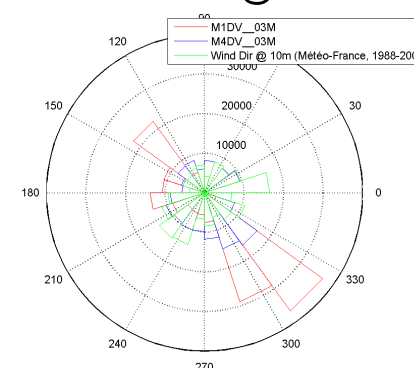
2002-2007 @ 25m



2002-2007 @ 10m



2002-2007 @ 3m



Space and time representativeness

- > Wind direction
- > M1 // M4
- > 3m // 10m // 25m
- > 168 374 “full” lines
- > + comparison with Météo-France measurements,
10km South-East from LTMS, hourly data, 10m high,
2002-2007 period (6 years)
- > idem, 1988-2007 period (20 years)

Comments :

- M1: Canyon effect for wind direction
- M4: Also a slight “site effect” (regarding M-F data)
- M1 // M4 // M-F: Influence on SPL predictions ?

Meteo conditions: From wind and temperature observables...

> no atmospheric turbulence

$$n(r, \theta, z) \cong n(z) = \frac{c(z)}{c_0} = \frac{\langle c(z) \rangle}{c_0} + \mu$$

> mean refraction (e.g. 15min samples)

$$\langle c(z) \rangle = \sqrt{\gamma \cdot R \cdot \langle T(z) \rangle} + \langle V(z) \rangle \cdot \cos \theta$$

> Hyp: log shaped vertical profiles for wind and temperature

$$\langle T(z) \rangle = a_T \cdot \ln \left(1 + \frac{z}{z_0} \right) + T_0$$

$$\langle V(z) \rangle = a_V \cdot \ln \left(1 + \frac{z}{z_0} \right)$$

... to influent parameters a_{Tp} and a_{Vp}

> relative influence of wind/temperature effects

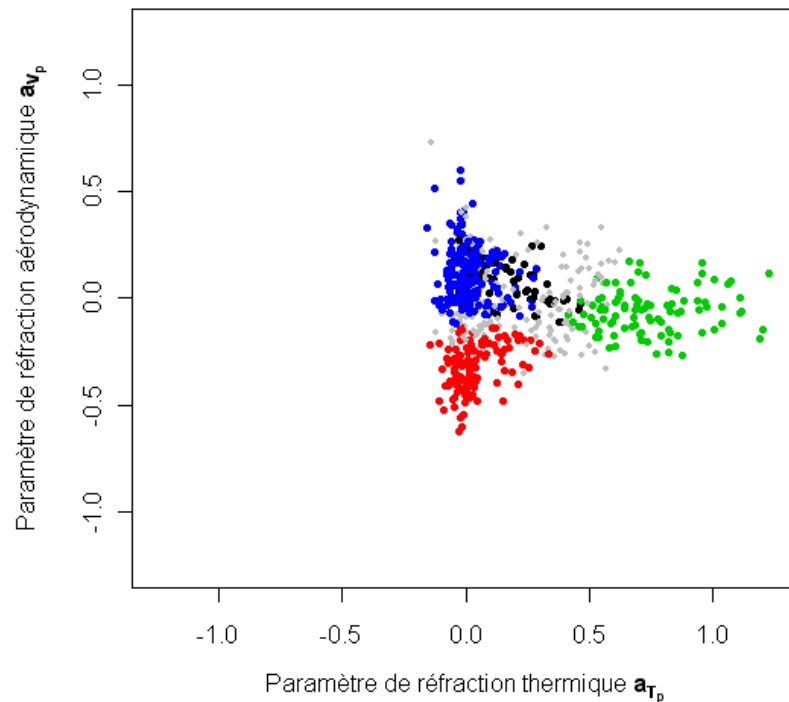
> Mean refraction parameters

$$\frac{\partial \langle c(z) \rangle}{\partial z} \approx \frac{1}{2} \cdot \frac{\gamma \cdot R}{c_0} \cdot \frac{\partial \langle T(z) \rangle}{\partial z} + \frac{\partial \langle V(z) \rangle}{\partial z} \cdot \cos \alpha$$

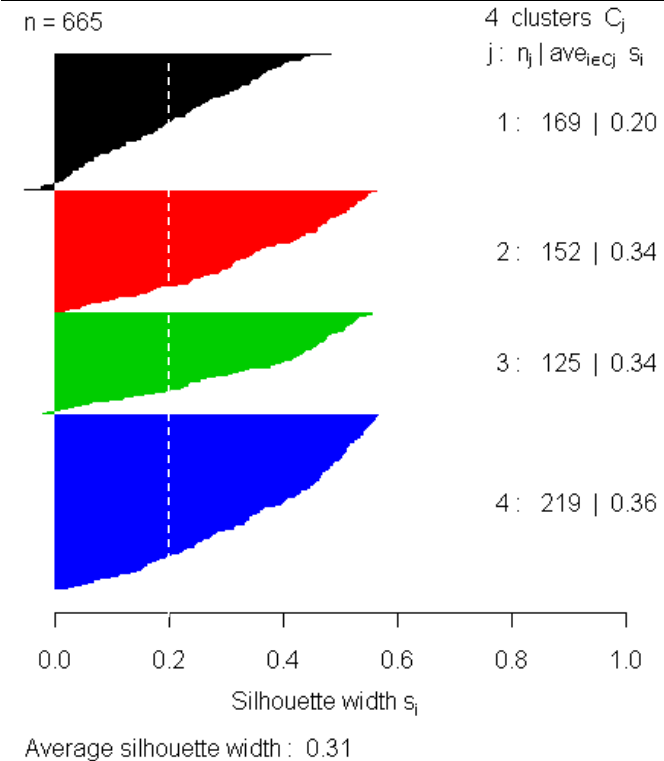
$$\frac{\partial \langle c(z) \rangle}{\partial z} \approx \frac{1}{z} \left\{ \underbrace{\frac{1}{2} \cdot \frac{\gamma \cdot R}{c_0} \cdot a_T}_{a_{Tp}} + \underbrace{a_V \cdot \cos \alpha}_{a_{Vp}} \right\}$$

Stage M. Bellanger (Univ. de Nantes, 2009) : algorithme des « k-means »

nuage de points en M1



Graphique des silhouettes

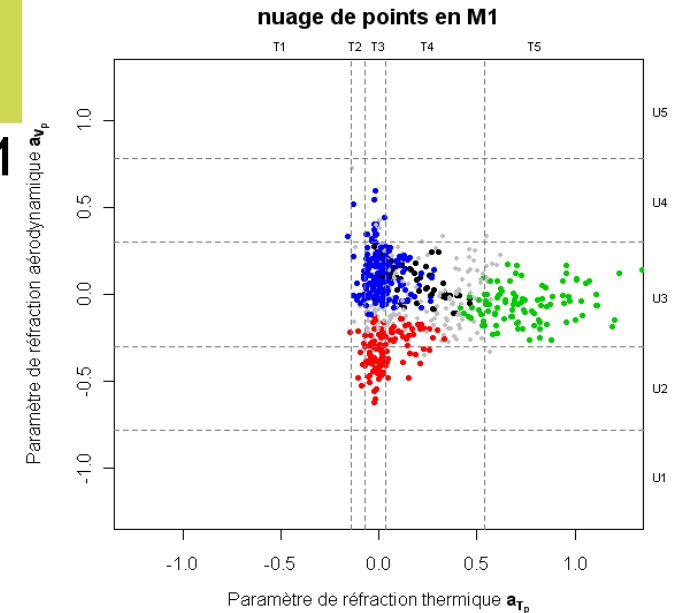


Classification

Classification...

- > Multidimensional analysis ("k-means")
- > H=5m (idem H=2m)
- > 6 variables: a_{vp} , a_{tp} , A3_250_5m, A3_1k_5m, A5_250_5m, A5_1k_5m
- > Meteo plane (a_{tp} & a_{vp})
- > 665 "full" lines

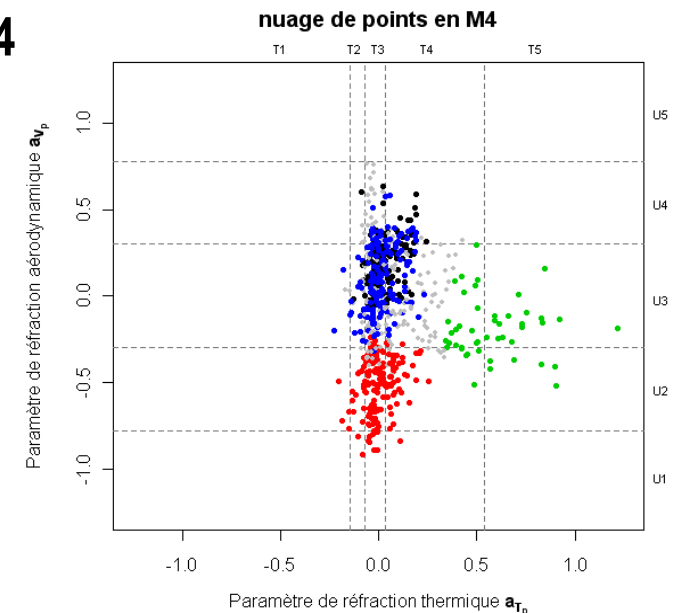
... using M1

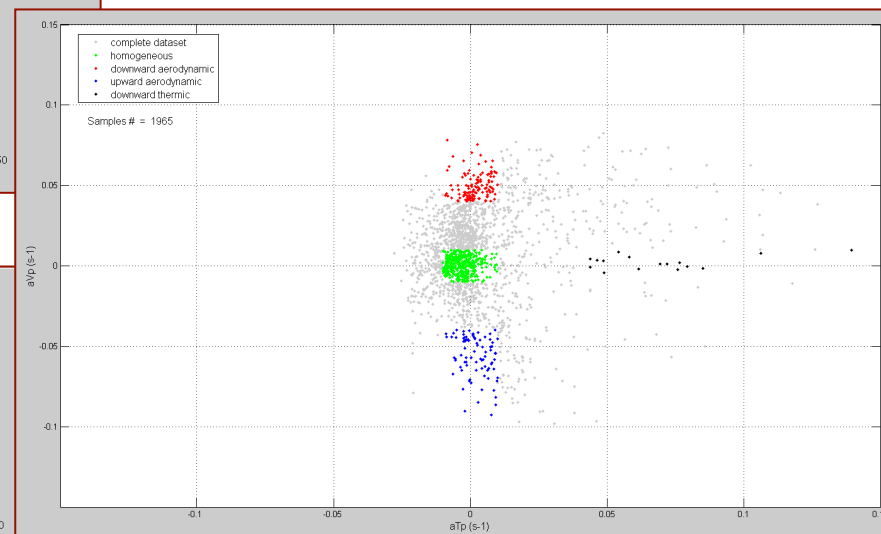
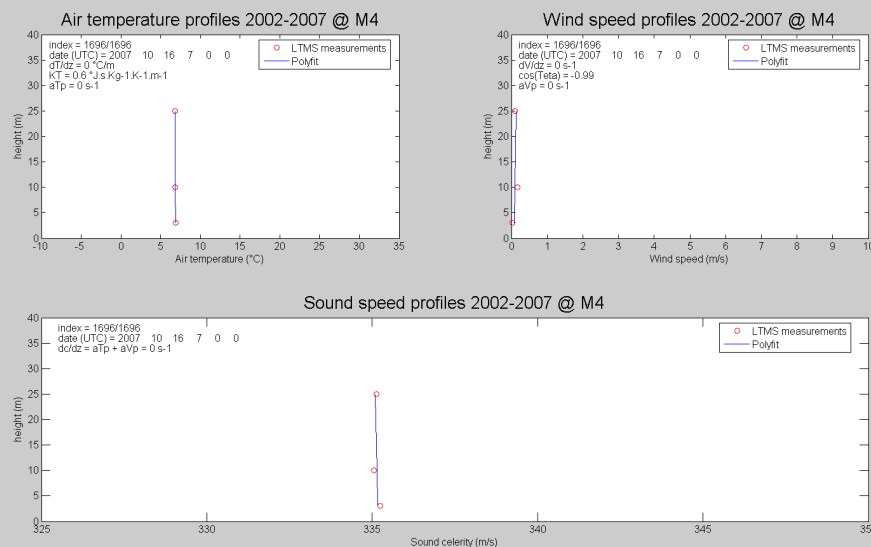
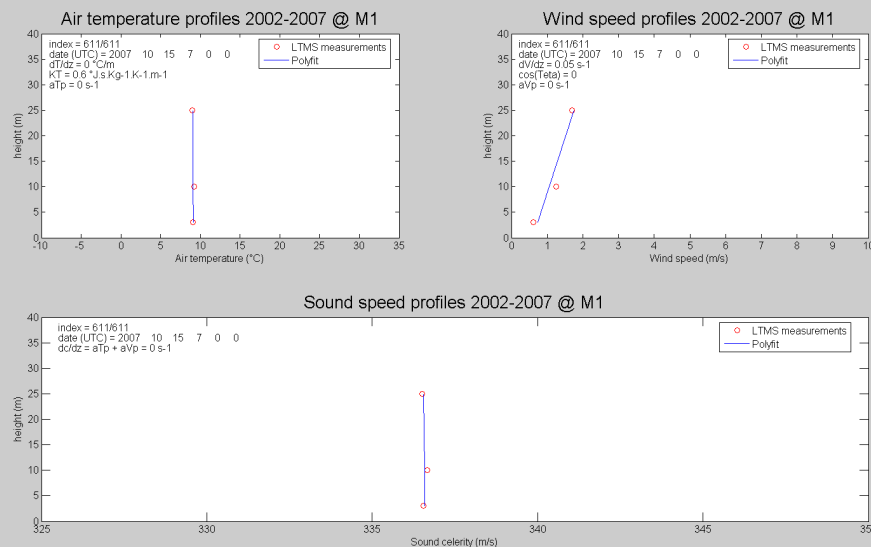


Comments :

- The choice of meteo tower have a significant impact on the classification of propagation conditions (W & T)
- Long-term measurements are condensed in a small region of UiTi (or WiSi) tables
- Some UiTi (or WiSi) classes are either over or under estimated
- >> the UiTi (or WiSi) classes need to be revised
- >> révision partie météo NF S 31-110
- >> Projet EMMA (Financement ADEME ?)

... using M4





More information on the LTMS:

<http://www.lcpc.fr/en/presentation/moyens/slt/index.dml>

Coming soon, the LTMS database in free access on the LCPC web site:

<http://www.lcpc.fr/en/produits>