inter.noise HAMBURG 2016

Comparison of noise indicators in an urban context

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MAIRIE DE PARIS | ADEME Agence de l'Environnement et de la Maîtrise de l'Energie

TOWARDS A QUIETER FUTURE
45th International Congress and Exposition on Noise Control Engineering INTER-NOISE 2016
Hamburg, Germany, August 21-24, 2016

iRSTV FR CNRS 2488 Institut de Recherche en Sciences et Techniques de la Ville | Labex CeLyA Centre Lyonnais d'Acoustique

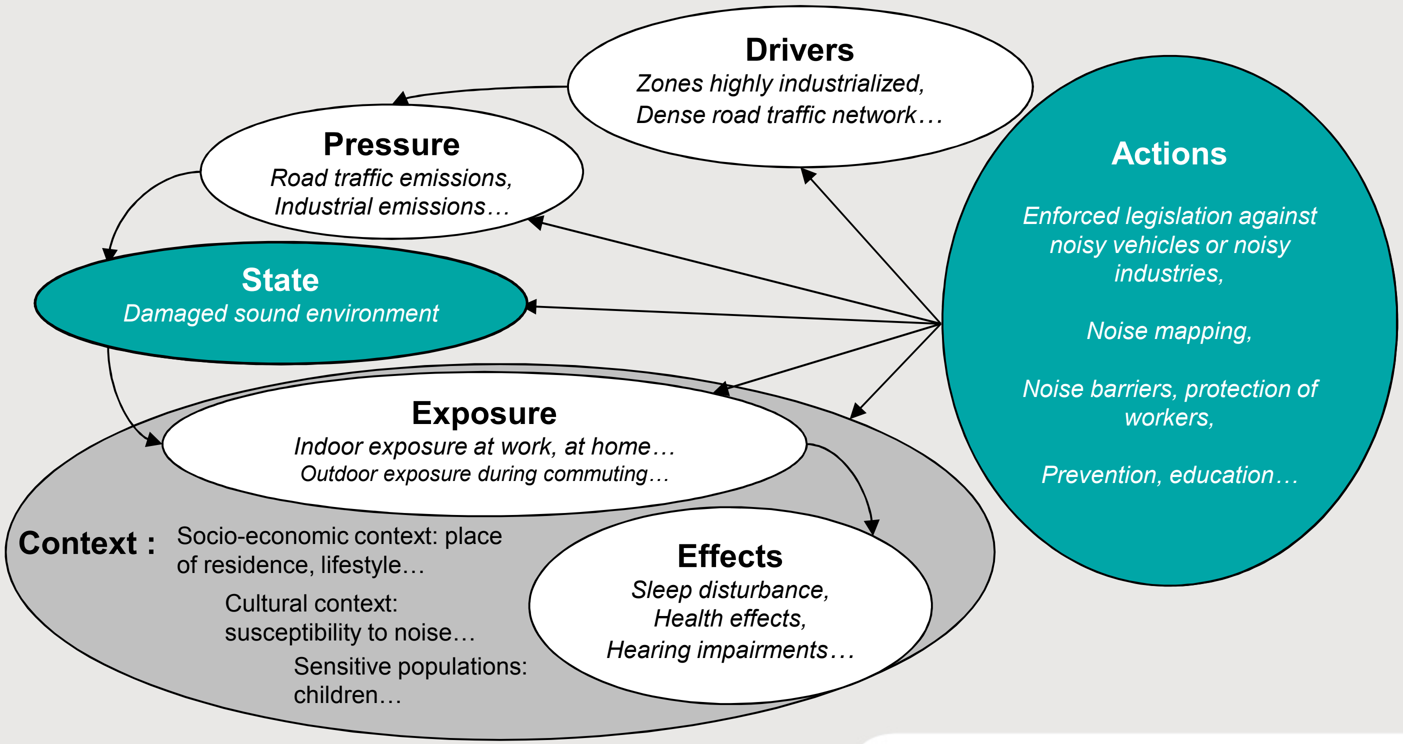
Introduction

- **Urbanization accentuates sound exposure issues**

Need indicators to describe sound environments and evaluate noise mitigation strategies

Introduction

- ## Urbanization accentuates sound exposure issues



Introduction

- **Specificity of the noise pollution:**
  High spatiotemporal variations
  Complexity of human hearing
  Rich spectral content
  Wide variety of sources

- **Comparison of indicators within END 2002/49/CE**
  Long term effects
  L_{den}

- **New paradigms of urban sound environment analyses**

perceptual effects

new noise sources modelling approaches

holistic evaluations

sounds categorization

interest towards sound events characterization

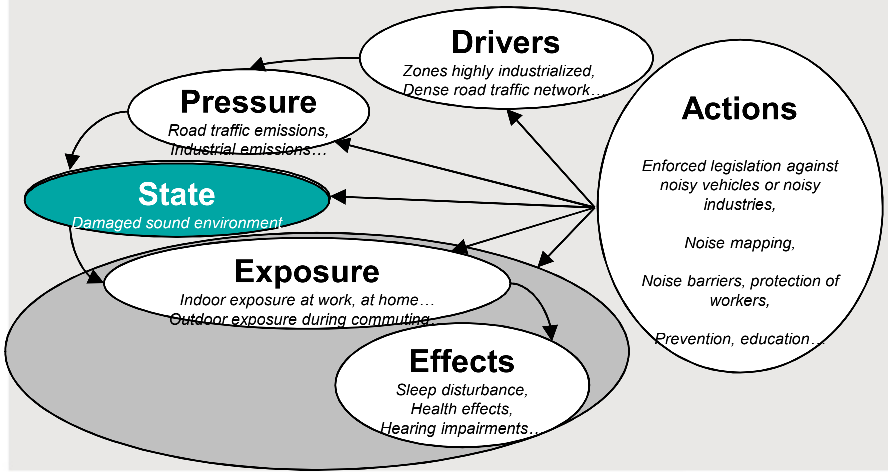
possibility to underline noise levels variations

mobile measurements

Introduction

- **Comparison of indicators based on three criteria:**

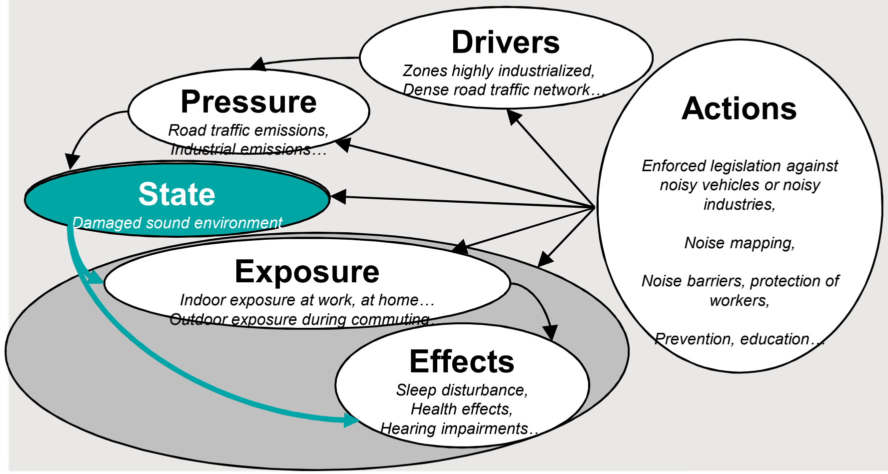
1	Ability to describe and categorize physically urban sound environments
	• *Indicators should capture physical urban sound characteristics* • *Indicators should discriminate two different sound environments*



Introduction

- **Comparison of indicators based on three criteria:**

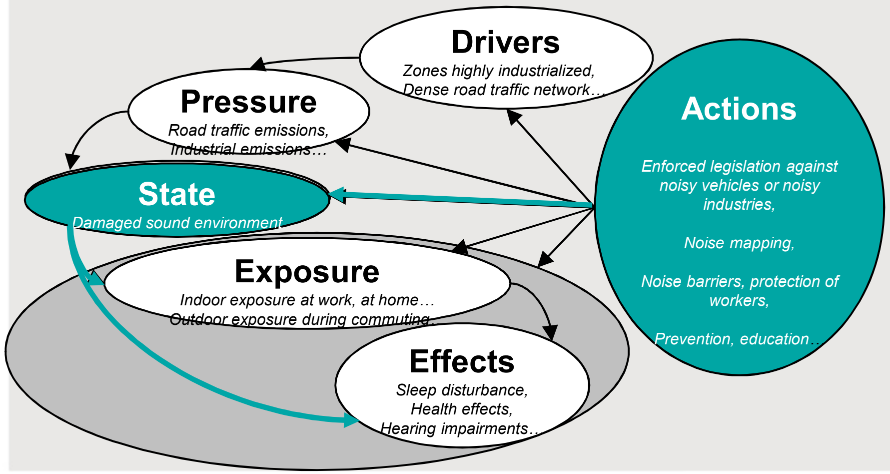
1	Ability to describe and categorize physically urban sound environments
2	Relevance of indicators to describe the perceptive appreciations of urban sound environments
	• *Indicators should correlate with perceptive attributes* • *Indicators should correlate with the presence of sources of interest*



Introduction

- ## Comparison of indicators based on three criteria:

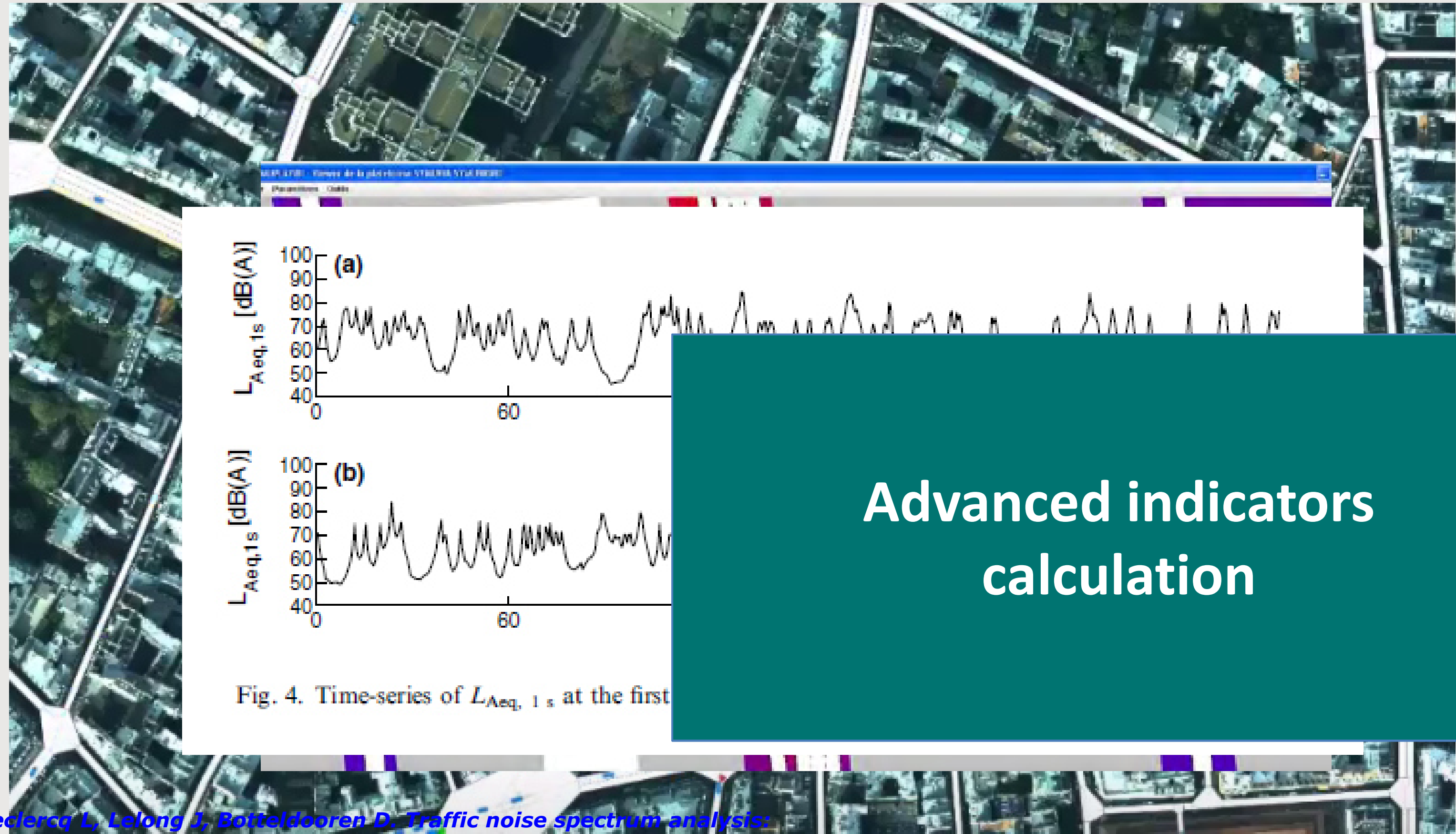
1	Ability to describe and categorize physically urban sound environments
2	Relevance of indicators to describe the perceptive appreciations of urban sound environments
3	Ability of indicators to be estimated through classical or more advanced traffic noise estimation models
	• *Indicators should be possible to estimate* • *Indicators should be sensitive to mitigation strategies*



a parte…

③ Ability of indicators to be estimated through classical or more advanced traffic noise estimation models

Symuvia, Vissim, Paramics



Advanced indicators calculation

Can A, Leclercq L, Lelong J, Botteldooren D. Traffic noise spectrum analysis: Dynamic modeling vs. Experimental observations, Applied Acoustics. 2010; 71(8): 764-770.
De Coensel, B. De muer, T. Yperman, I. Botteldoren, D. The influence of traffic flow dynamics on urban soundscape, Applied Acoustics, 2005, 66, 175-194

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2. Relevance of indicators to describe the perceptive appreciations of urban sound environments
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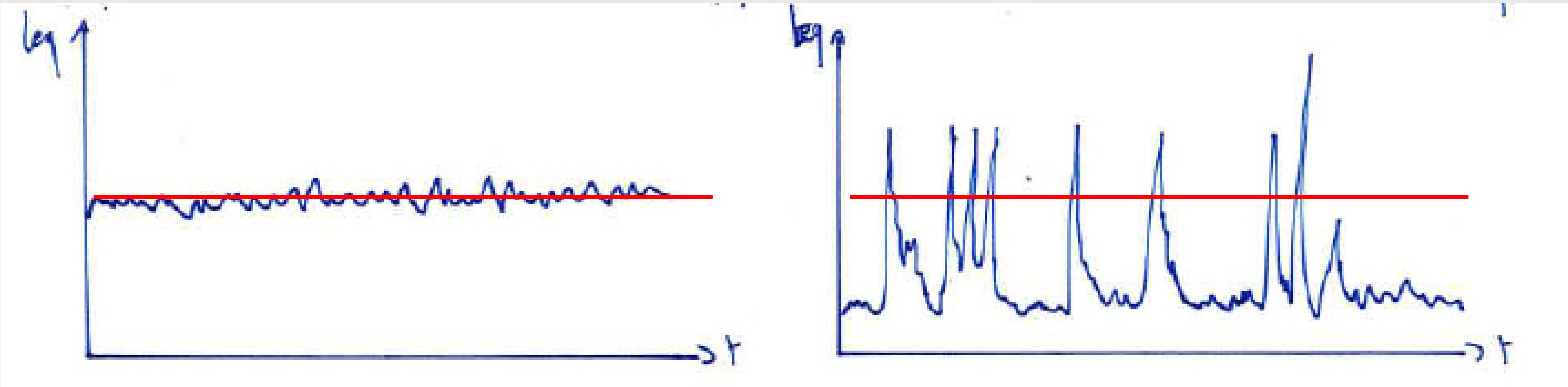
- **Today:**
  Scan of some indicators following these three criteria

Classical energetic indicators

- L_{eq}, L_{Aeq}



Same value regardless the temporal structure
Highly impacted by noise peaks ☹

Classical energetic indicators

		Physical descriptive power	Perceptive descriptive power
Energetic Indicators	L_{eq}	☹ Highly impacted by noise peaks [4] ☹ Hides the sound levels dynamics [7] ☹ Same L_{eq} value whatever the sound variation are [15]	☺Correlated to long term health effects [3]
	L_{Aeq}	☹ A-weigthing often criticized for underestimating low frequencies at sound levels encountered in cities	☹ A-weigthing does not fulfil perceptive requirements [23]

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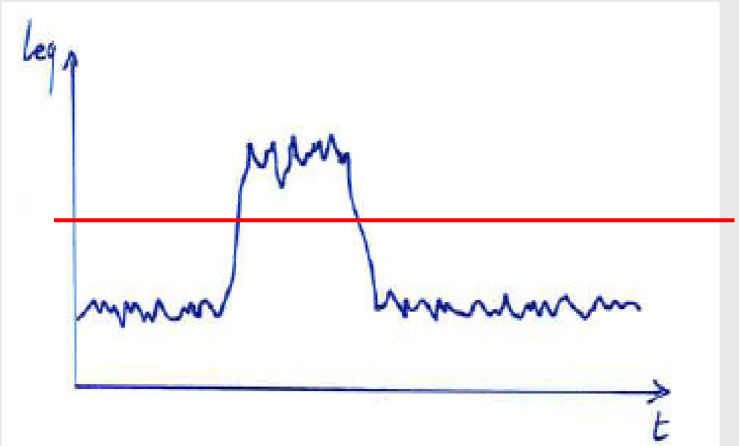
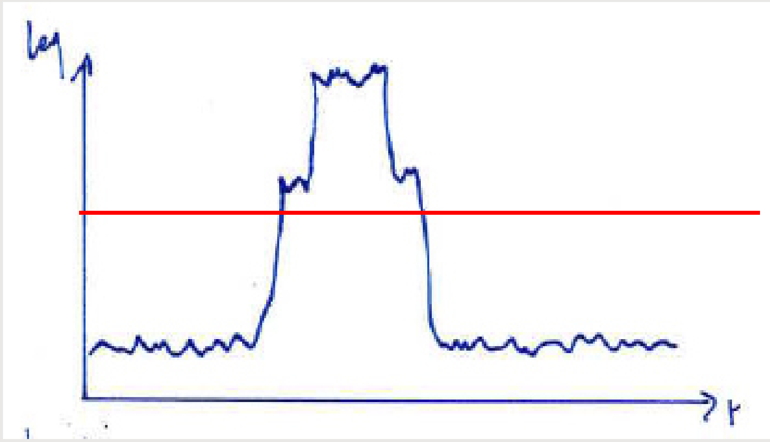
😐 Is a real L_{Aeq} estimated by static models?

Percentile indicators

- L_{10}, L_{50}, L_{90}

Describe the dynamic range of sound levels ☺





But :
- on homogeneous periods
- one only point of the distribution
- fail to characterize the rhythm of sound variations 😐

Percentile indicators

		Physical descriptive power
statistical indicators	L_{90}	☺ Describes background noise [50] 😐 Low range of variation in urban context
	L_{50}, $L_{50,A}$	☺ Good for discriminating sound environments [15]
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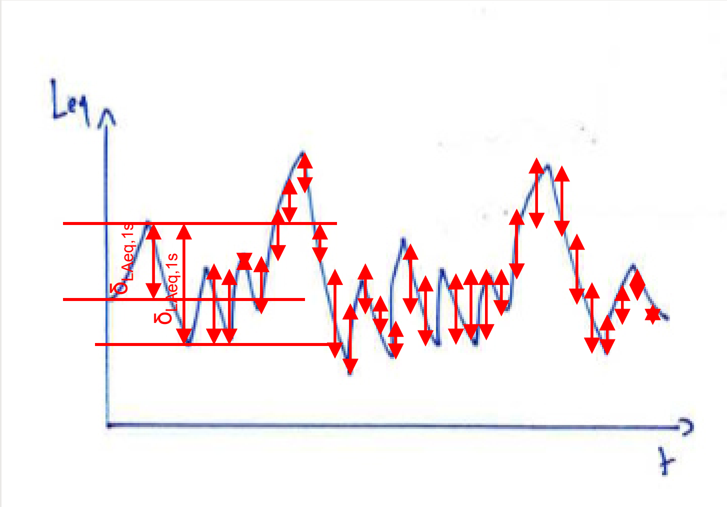
Noise variations indicators

		Physical descriptive power
Noise variations indicators	L_{10}-L_{90}, L_5-L_{95}	☺ Describes the amplitude of noise variation (Boulevard vs irregular traffic street)
	$\sigma_{LAeq,1s}$	☺ Describes the width of the sound levels distribution ☺ Good for discriminating sound environments [15] 😐 Assumes a normal distribution of $L_{Aeq,1s}$ values
	$\delta_{LAeq,1s}$	😐 Discrimination of traffic situation based on 1-s dynamics [51], although its discriminative power is not proved
	Slope of 1s-fft	☺ Discrimination of road traffic situations [11]



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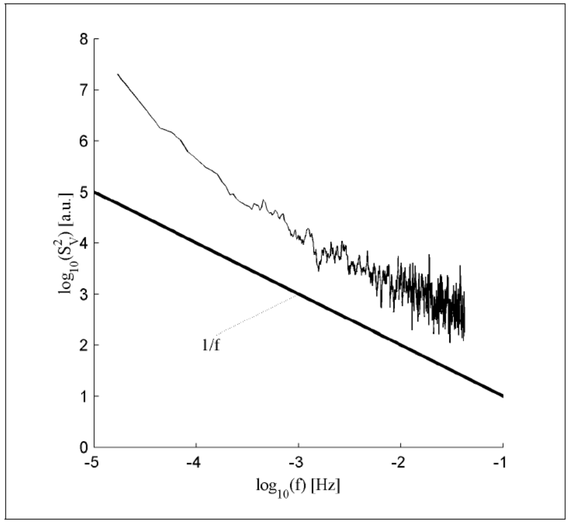
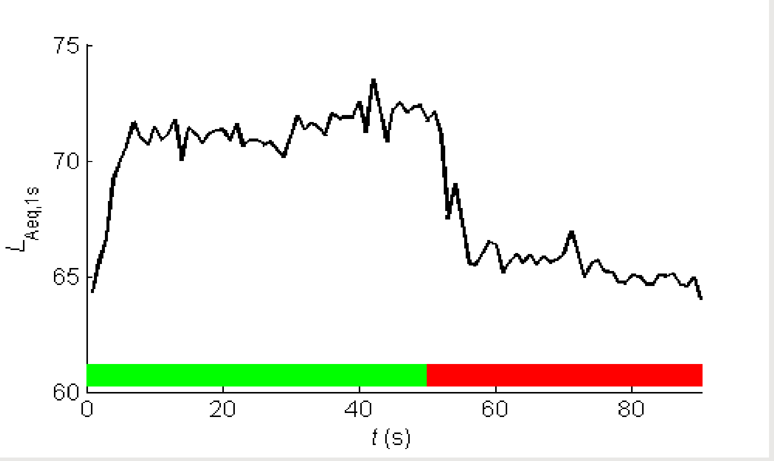


De Coensel, B. Botteldoren, D., De Muer, T. 1/f noise in rural and urban soundscape, Acta Acustica united with Acustica, vol. 89 (2003) 287 – 295, 2003,

Noise variations indicators

- **Specific urban noise indicators :**

  Mean noise pattern, variations around it
  ($N_{Lmax>80}$, $N_{lmin>60}$, $L_{max/cycle}$, *etc.)*



Very precise picture of sound variations ☺
But : dedicated to sound environments with cadenced rhythm 😐

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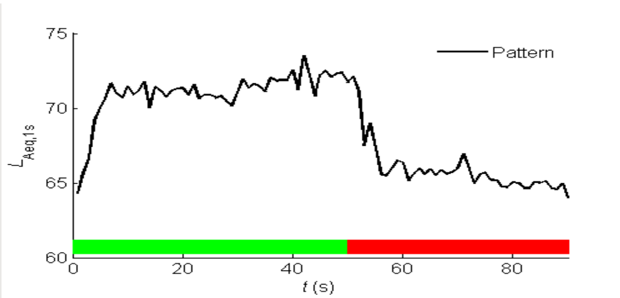

Spectrum indicators

		Physical descriptive power
Spectrum indicators	SGC	☺ Good for discriminating sound environments based on their spectral content [15]. ☹ Highly unstable.
	$TFSD_{mean,4kHz}$	☹ Never investigated
	$TFSD_{mean,500Hz}$	☹ Never investigated
	L_f, with f frequency of interest	☺ Related to road traffic time of presence (f=65 Hz,125 Hz) [34] ☺ Good for discriminating sound environments frequency content [13] ☹ Spectrum described through a large number of indicators

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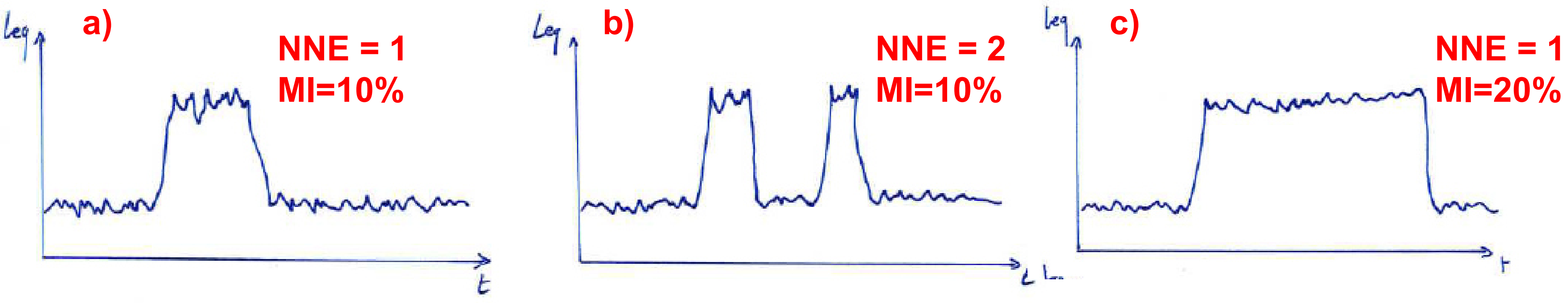
Sound recognition in urban environments should produce new indicators ☺

Emergence indicators

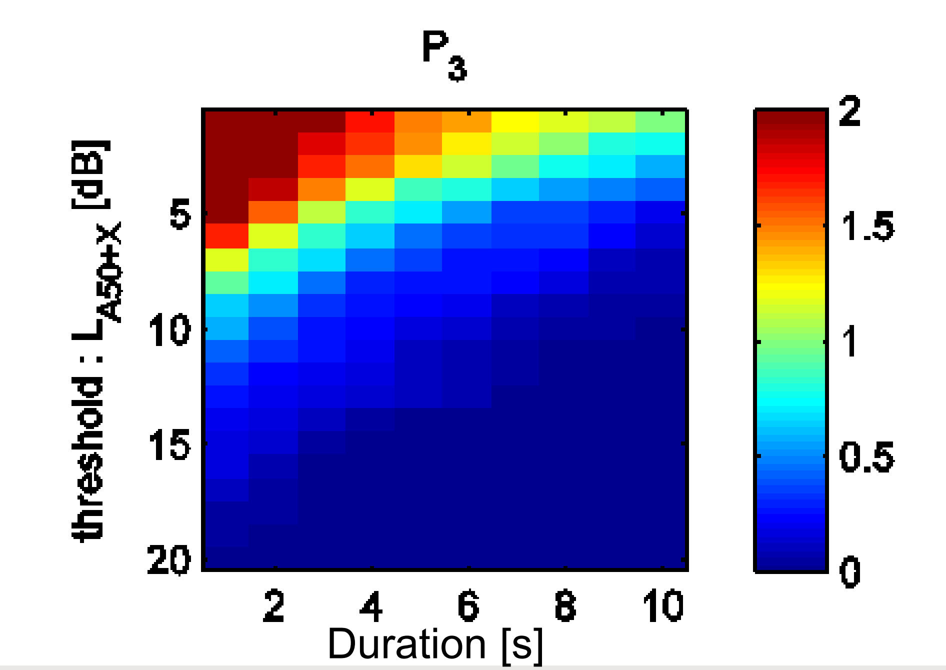
- **Number of Noise Events (NNE) and Mask Index (MI) :**
  Threshold : fixed value (i.e.70), or adaptative (L_{Aeq+10}, L_{10+10}) ☺
  Designed to measure either noisy or quiet periods



But : partial view of the emergences 😐

Emergence indicators

- **Map of emergences :**



Complete but complex…

☺ ☹

Can A, Guillaume G, Gauvreau B. Noise indicators to diagnose urban sound environments at multiple spatial scales. Acta Acust unit Acust. 2015;101:964-74

Emergence indicators

		Physical descriptive power
Emergences indicators	$L_{1,A}$,	☺ Good for discriminating sound environments based on emergences [8]
	$MI_{LA50+10}$	☺ Good for discriminating sound environments based on emergences [8]
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	CF	☺ Good for discriminating sound environments [13] ☹ Based on max values so no repeatable measurements
	$N_{Lmax>80}$	☺ Good for discriminating sound environments in the vicinity of traffic signals [7]
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Discussion

- **Difficulty to highlight an optimal set of indicators for characterizing and evaluating urban sound environments**
- **High correlations between indicators add some partiality in the choices made**

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- **High correlations between indicators add some partiality in the choices made**

- **Categorization and indicators number reduction**

Aims to reduce the number of indicators based on r

- **Different set of indicators for a similar relevance**

Tells which indicators are meaningless to use co-joi

Example of set of indicators :

- Torija et al., JASA (2013): CF, $L_{eq,25Hz}$, $L_{eq,31.5Hz}$, $L_{eq,125Hz}$ $L_{eq,5kHz}$, $L_{eq,10kHz}$, $L_{eq,16kHz}$ and $L_{eq,20kHz}$, statistical indicat
- Can et al. AAA (2015): $L_{50,A}$, $\sigma_{LAeq,1s}$, SGC, + $L_{1,A}$, MI_{LA50}

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Spectrum indicators	SGC	☺ Good for discriminating sound environments based on their spectral content [15]. ☹ Highly unstable.	😐 No consensus concerning the perceptive effects	😐 Estimated with Dynamic modelling
	$TFSD_{mean,4kHz}$	☹ Never investigated	☺ Related to perceived birds time of presence [34] ☹ Only appears in one paper	☹ No current model allows its estimation
	$TFSD_{mean,500Hz}$	☹ Never investigated	☺ Related to perceived voices time of presence [34] ☹ Only appears in one paper	☹ No current model allows its estimation
	L_f, with f frequency of interest	☺ Related to road traffic time of presence (f=65 Hz,125 Hz) [34] ☺ Good for discriminating sound environments frequency content [13] ☹ Spectrum described through a large number of indicators	☺ Low frequencies and tonal components increase annoyance [20,21]	😐 Estimated with Dynamic modelling
Emergences indicators	$L_{1,A}$,	☺ Good for discriminating sound environments based on emergences [8]	☹ Never investigated	😐 Estimated with Dynamic modelling
	$MI_{LA50+10}$	☺ Good for discriminating sound environments based on emergences [8]	☹ Never investigated	😐 Estimated with Dynamic modelling
	$MI_{LLF50+15}$	☺ Good for discriminating sound environments based on emergences [8]	☹ Never investigated	😐 Estimated with Dynamic modelling
	CF	☺ Good for discriminating sound environments [13] ☹ Based on max values so no repeatable measurements	☹ Never investigated	☹ No current model allows its estimation
	$N_{L_{max}>80}$	☺ Good for discriminating sound environments in the vicinity of traffic signals [7]	☹ Never investigated	😐 Really specific to urban corridors
	$N_{L_{95}>65}$	☺ Good for discriminating sound environments in the vicinity of traffic signals [7]	☹ Never investigated	😐 Really specific to urban corridors

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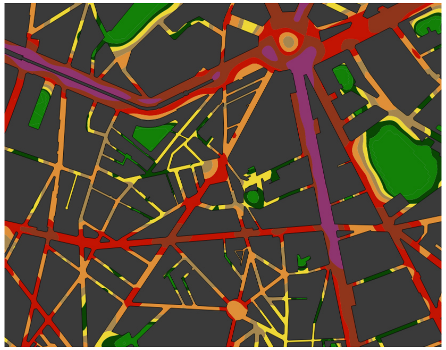
Static road traffic modeling



- L_{Aeq} — *Not best indicator for sound pleasantness*
  Discriminates poorly sound environments

Dynamic road traffic modeling

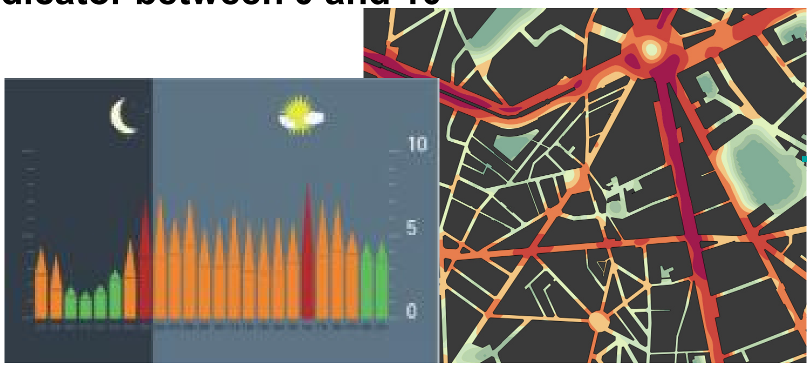
- *Energetic dimension:* ~~L_{Aeq}~~ L_{50}
- *Temporal dimension:* $\sigma_{LAeq,1s}$, L_{10}-L_{90} — *Useful in categorization context* / *No consensus concerning perceptive effects*
- *Spectral dimension:* ~~SGC~~ — *Useful in categorization context* / *Not often mentioned as relevant in the perception context*

  L_{125Hz}
  Sound sources indicators: TFSD — *Sources not taken into account in current modeling*
- *Emergences indicators:* L_{A1}, $MI_{LA50+10}$, $MI_{LL50+15}$

Drawback: too complex for communication

→ **Aggregate into a single dimensionless indicator between 0 and 10**

Ex :
Grafic Project,
Sound Pleasantness map



→ **Spatial indicators for exposure assessment**

inter.noise
HAMBURG 2016

Thank you for your attention

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