Urban Physics

7S0X0, 2020-2021 Quartile 3

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www.tue.nl/buildingacoustics

Urban Acoustics

Week 2 Metrics of Urban Acoustics

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Overview Urban Acoustics

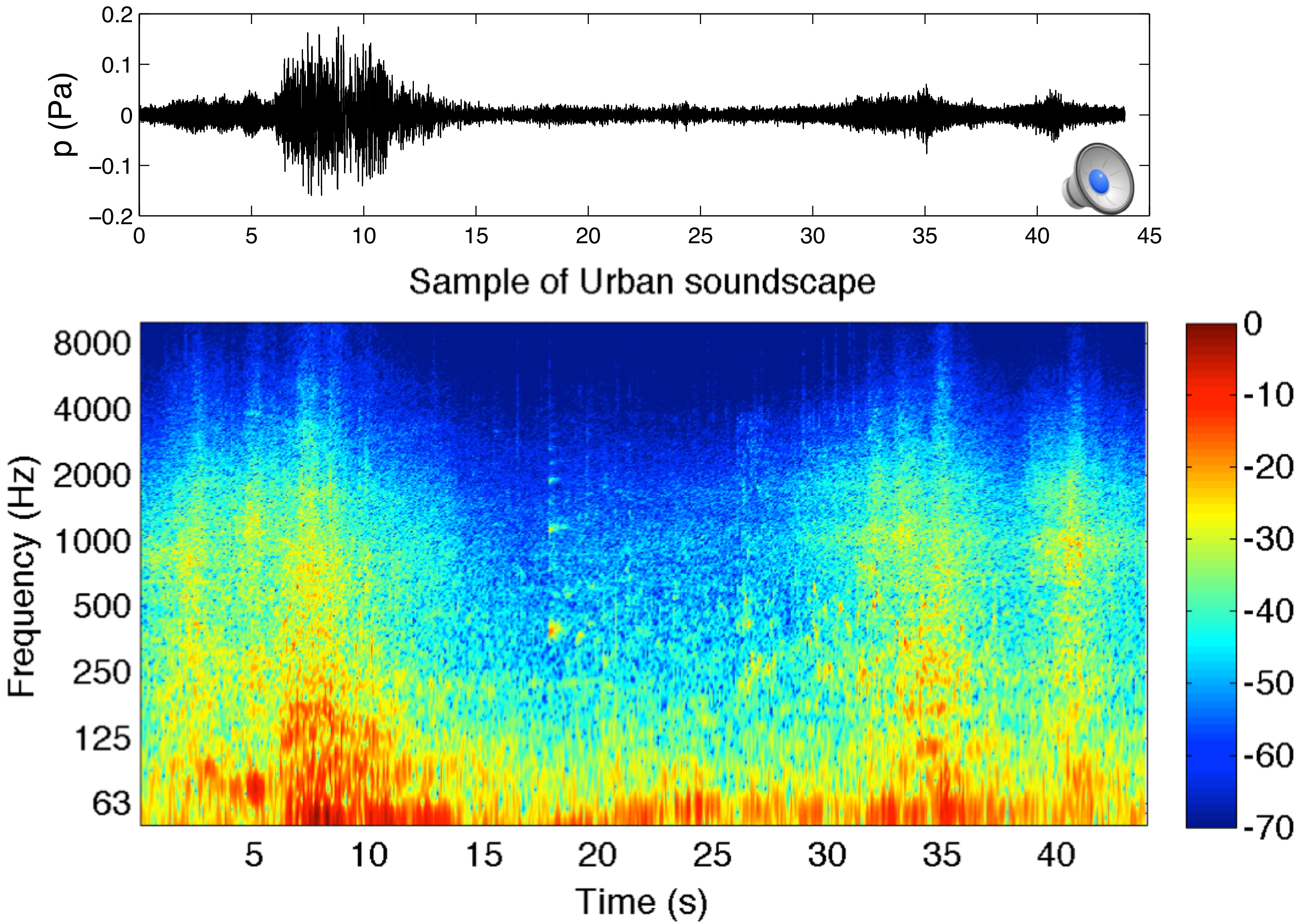
Week	Subject
1	Effects of noise, acoustics quantities
2	Metrics of urban acoustics
3	Sources of sound
4	Effects on noise propagation
5	Urban noise control
6	Computing urban acoustics, I
7	Computing urban acoustics, II
8	Presentation of assignment

Overview Urban Acoustics

Le = Lecture, Tu = tutorial, Pr = presentation

Week		
1	Lectures	
2	Lecture + Tutorial exercises week 1&2	
3	Lecture + Tutorial exercises week 3	
4	Lecture + Tutorial exercises week 4	Assignment explanation
5	Lecture + Tutorial exercises week 5	
6	Lecture + Tutorial exercises week 6	~~Intermediate test~~
7	Lecture + Tutorial exercises week 7	
8	Presentations	

Road traffic noise



Indicator or metric

A noise indicator or metric

- Used to reduce a large volume of information about a noise situation into a single number system
- Designed to make the information easy to handle, but still provides accurate information about the noise environment
- Used to assess the extent of harmful effects due to traffic noise
- Depending on the type of noise, and relevant legislation in a country, the indicator can take many different forms.

Various metrics

L_{eq}	Equivalent sound pressure level
L_{Aeq}	A-weighted Equivalent sound pressure level
L_x	Percentile levels
L_{night}	Night level
L_{den}	Day, evening, night level

L_{max} and $L_{min:}$ maximum and minimum level

SEL	Sound exposure level
EPNL	Effective perceived noise level
L	Loudness

Categories of time-varying noise

Categories of time-varying noise

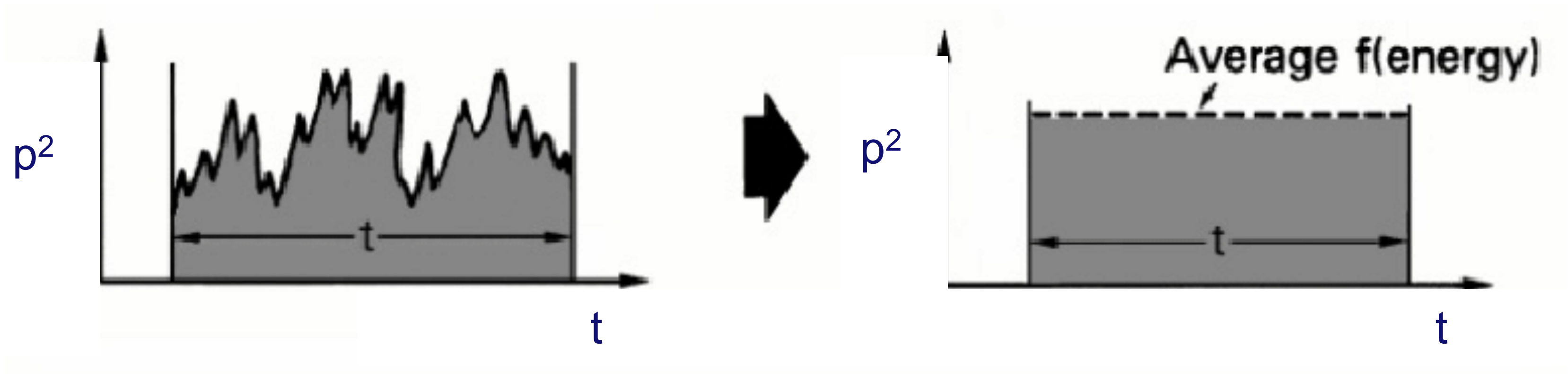
- Continuous noise
- Intermittent noise
- Impulsive noise

$L_{eq,T}$ Equivalent sound pressure level

$L_{eq,T}$ Continuous steady sound level that would have the same total acoustic energy as the fluctuating noise measured over the same period of time

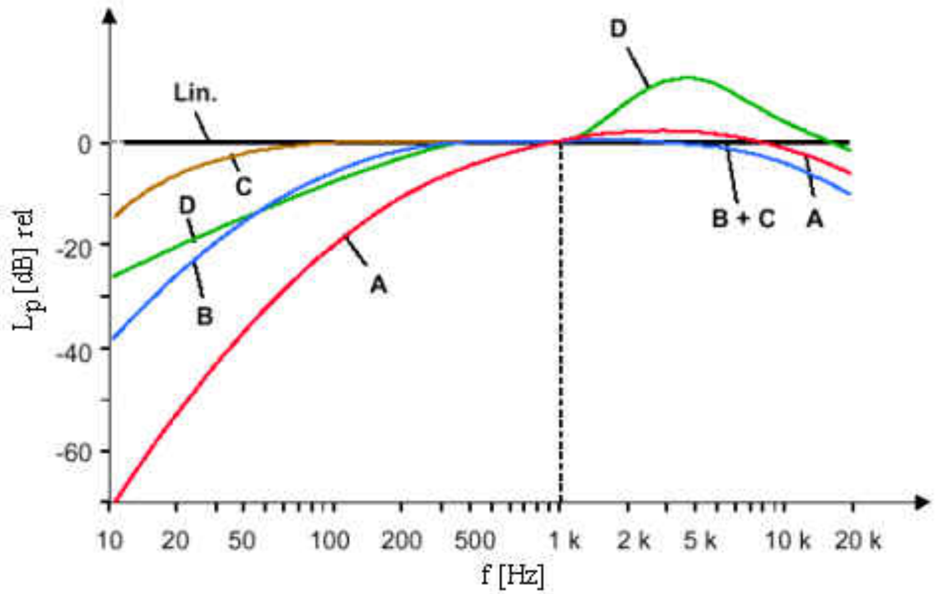
$$L_{eq,T} = 10\log_{10}\left(\frac{\frac{1}{T}\int_0^T p^2(t)\,dt}{p_0^2}\right) \quad [\mathrm{dB}]$$

T = measurement time [s]



$$L_{A,eq,T} = 10\log_{10}\left(\sum_{m=1}^{m=M} 10^{\frac{L_{eq,T,m}+W_m}{10}}\right) \quad [\mathrm{dB}]$$

m = 1/1 octave band index [-]
M = number of 1/1 octave bands [-]
W_m = A - weighting [-]



$L_{A,eq}$ example

- $L_{A,eq,1}$ 1 minute 80 dB(A)
- $L_{A,eq,2}$ 6 seconds 90 dB(A)
- $L_{A,eq,3}$ 2 minute 77 dB(A)

$$L_{eq,T} = 10\log_{10}\left(\frac{p_{eff,T}^2}{p_0^2}\right) \quad \rightarrow \quad \frac{p_{eff,T}^2}{p_0^2} = 10^{\frac{L_{A,eq,1}}{10}}$$

$$L_{A,eq} = 10\log_{10}\left(\frac{1}{3.1}\left[1\times 10^{\frac{L_{A,eq,1}}{10}} + 0.1\times 10^{\frac{L_{A,eq,2}}{10}} + 2\times 10^{\frac{L_{A,eq,3}}{10}}\right]\right)$$

$$= 79{,}9 \quad [\mathrm{dB}]$$

Statistical indicators L_x

L_x represents the noise level exceeded for x% of the time.

L_{10} measure for intermittent noise

L_{90} measure for background noise

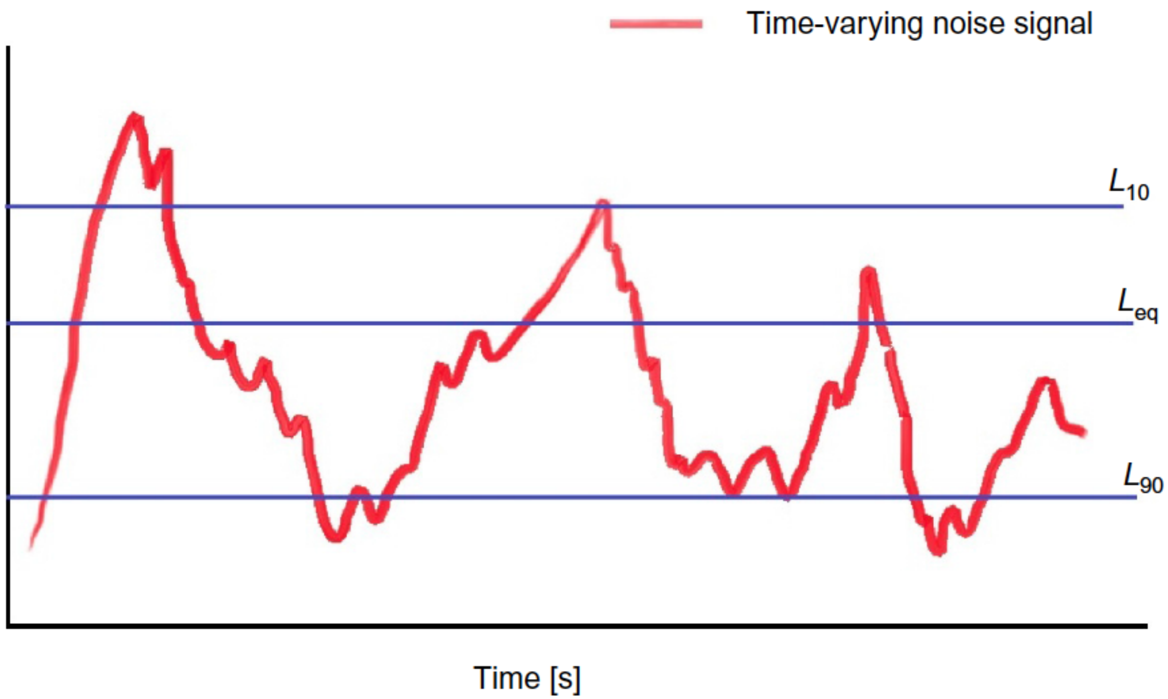
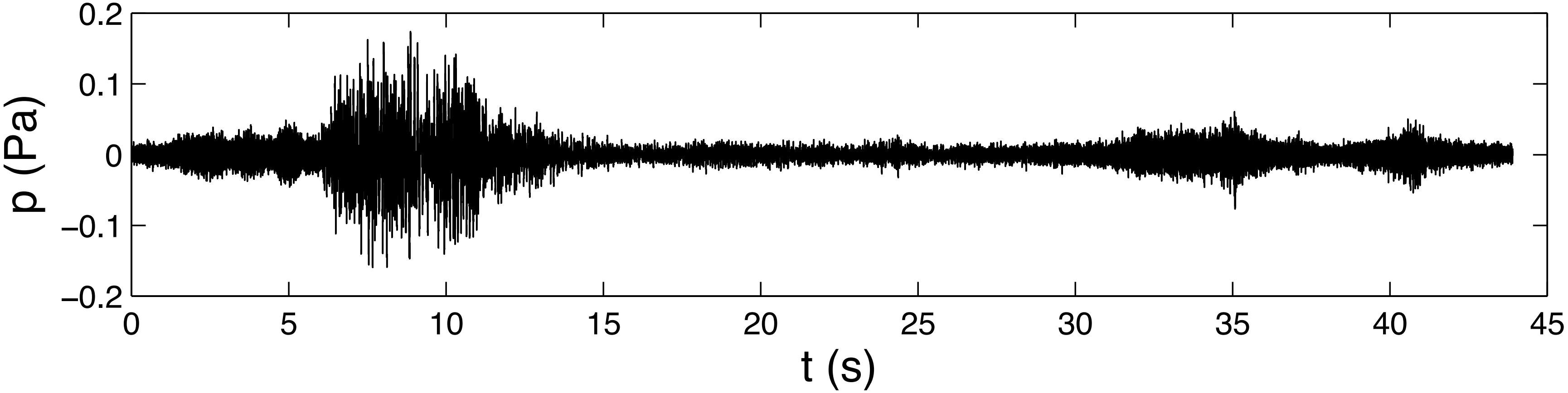


FIGURE 2.10 The L_{eq} level compared with statistical levels.

Murphy, E., & King, E. (2014). *Environmental noise pollution: Noise mapping, public health, and policy.* Newnes.

Analysis of urban traffic noise signal

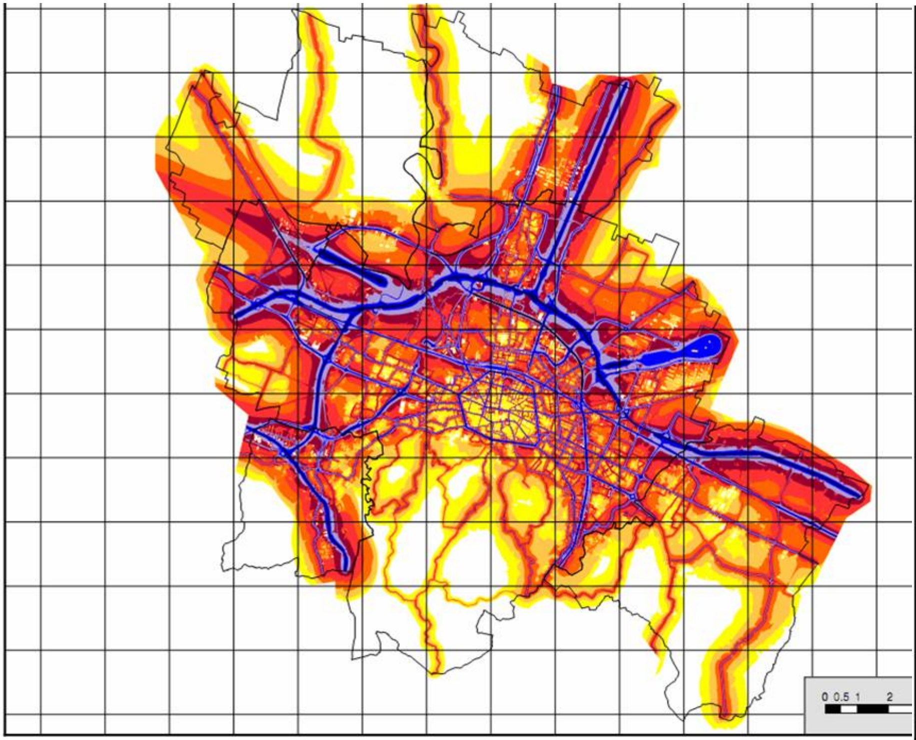


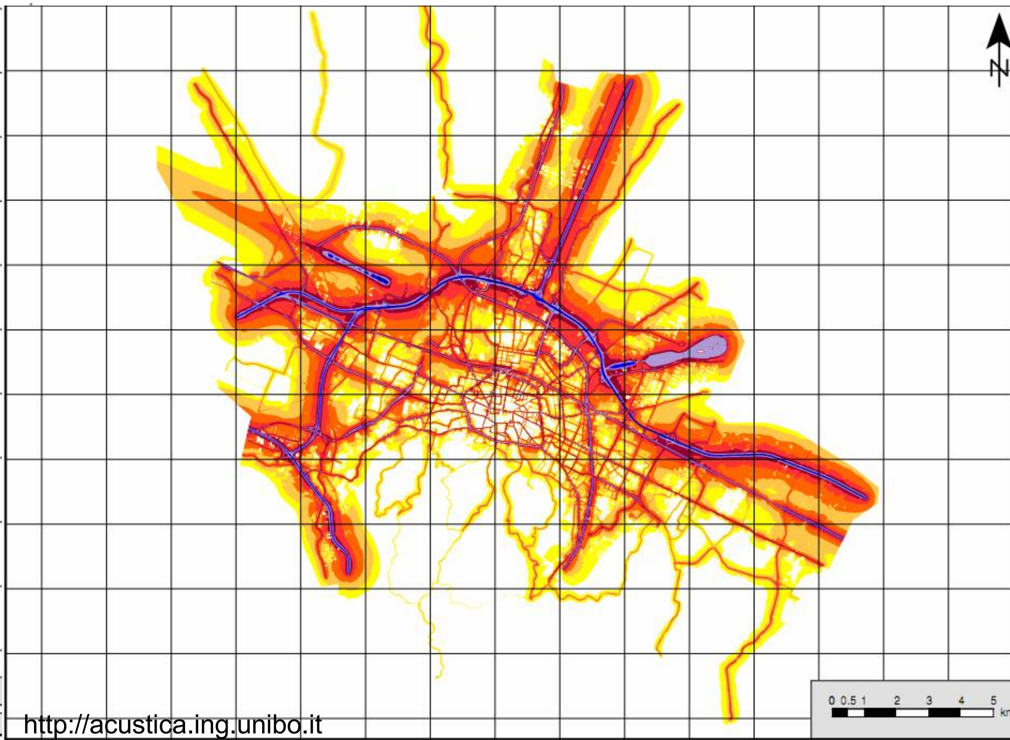
END indicators

END developed two universal noise indicators to be used for the development of strategic noise maps across the EU, derivatives of the $L_{eq,T}$ indicator

L_{den} Day, evening, night level, related **overall annoyance**

L_{night} Night level, related to **sleep disturbance**





http://acustica.ing.unibo.it

L_{den} and L_{night}

- L_{den} energetic average over day, evening and night levels
- Include penalties for evening and night
- Including A-weighting

$$L_{den} = 10\log_{10}\left(\frac{1}{24}\left[12.10^{\frac{L_{day}}{10}} + 4.10^{\frac{L_{evening}+5}{10}} + 8.10^{\frac{L_{night}+10}{10}}\right]\right)$$

- L_{day} A-weighted long-term average day-time noise level (between the hours of 07:00 and 19:00 measured) over 1 year
- $L_{evening}$A-weighted long-term average evening-time noise level (between the hours of 19:00 and 23:00) measured over 1 year and
- L_{night} A-weighted long-term average night-time noise level (between the hours of 23:00 and 07:00) measured over 1 year

L_{den} and L_{night}

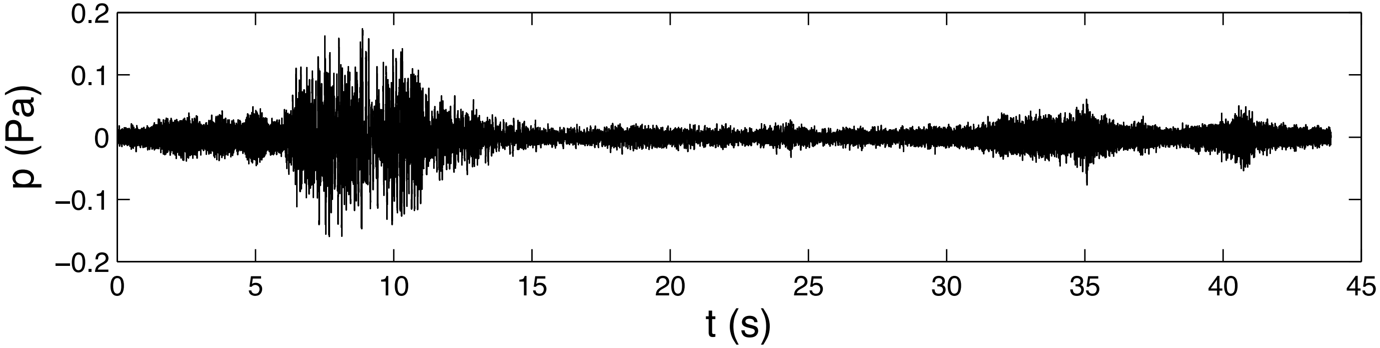
Problems with L_{den} and L_{night}

They represent long-term average levels, unsuitable to assess short-term situations, which are often the source of noise complaints to authorities.

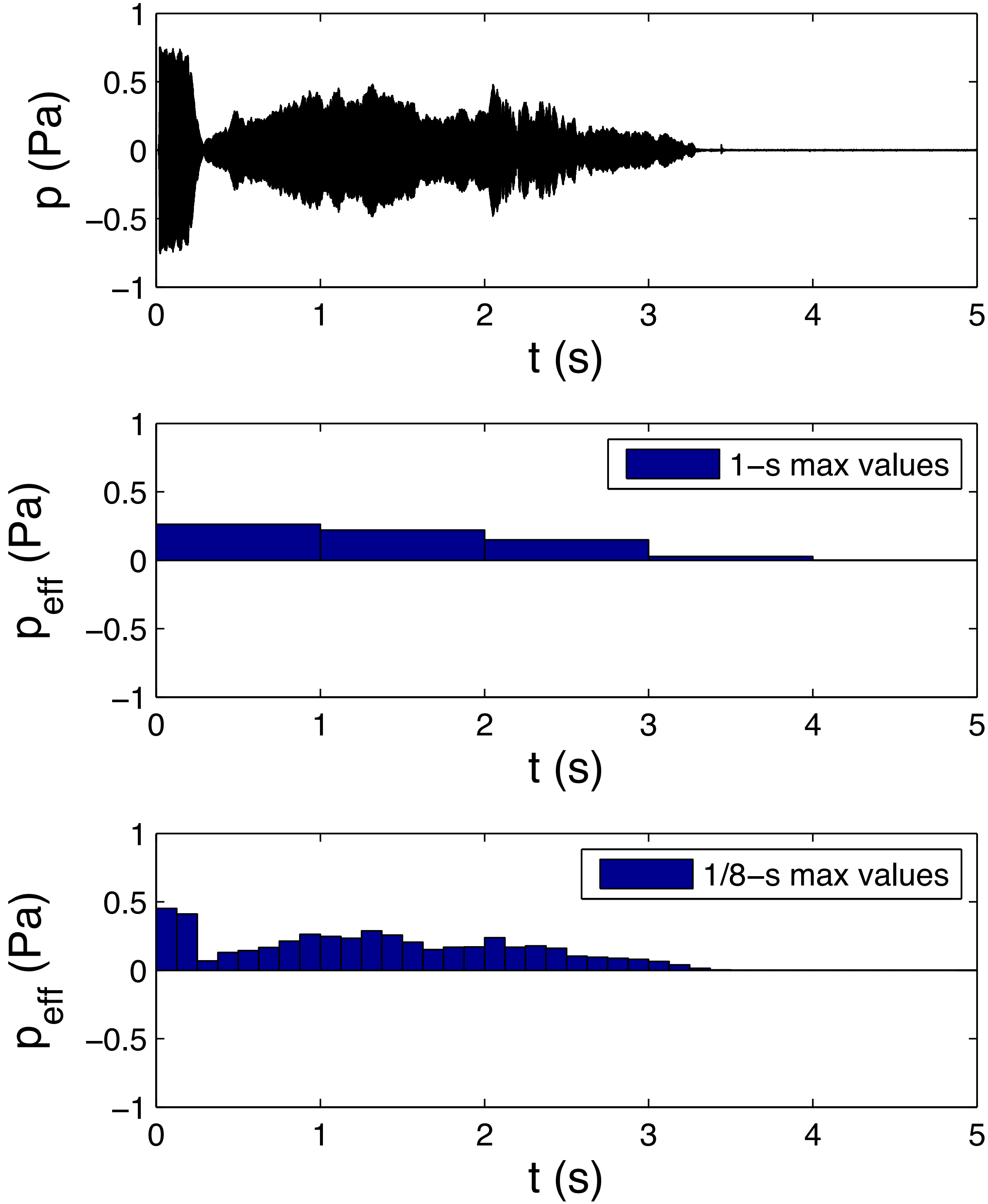
Examples of when these indicators might be **inappropriate** include when the noise source under consideration operates for only a small proportion of time, the noise contains strong tonal components or the noise has an impulsive character.

L_{max} and L_{min}

L_{max} and L_{min} maximum and minimum sound level measured over the measurement period. They are measured either over the fast (1/8 s) or slow time constant (1s)



L_{max} and L_{min}



SEL

The Sound Exposure Level (SEL) of a noise event is the constant level which, if maintained for only 1 second, would contain the same A-weighted noise energy as the actual event itself.

The SEL is often used in railway noise assessments allowing an easy comparison of different train types

http://info.acoustiblok.com

EPNL

Effective Perceived Noise Level (EPNL)

Common noise metric used when assessing aircraft noise

This metric takes into account the observer's response to the disturbing effect of pure tones such as whines or screeches and the duration of a single noise event. Three basic physical properties of sound pressure must be measured to determine the EPNL: the sound level, frequency and time variation

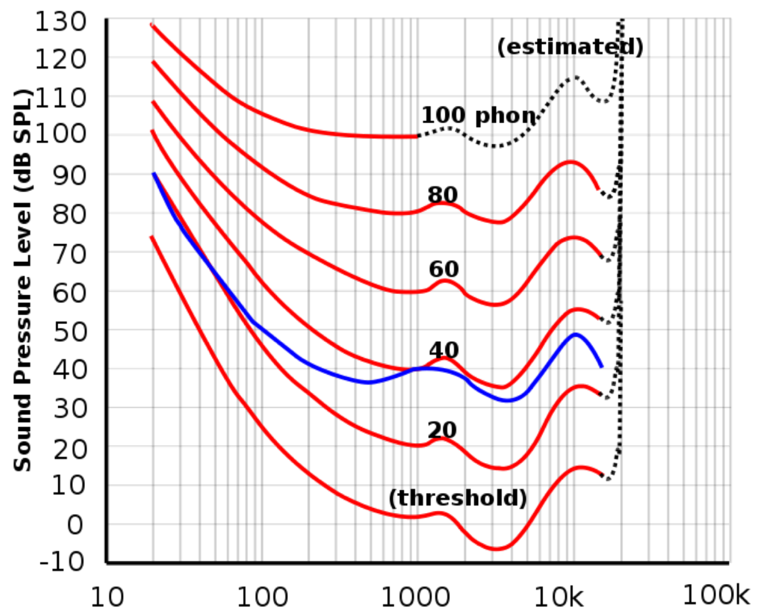
https://www.youtube.com/watch?v=HfahbCEb9U0

Loudness

L Loudness: “that attribute of auditory sensation in terms of which sounds can be ordered on a scale extending from quiet to loud".

American National Standards Institute, "American national psychoacoustical terminology" S3.20, 1973, American Standards Association.

Filters such as A-weighting attempt to adjust sound measurements to correspond to loudness as perceived by the typical human. However, loudness perception is a much more complex process than A-weighting.



Equal-loudness contours (red) (from ISO 226:2003 revisi
Original ISO standard shown (blue) for 40-phons