Domain-oriented services and resources of Polish Infrastructure for Supporting Computational Science in the European Research Space – PLGrid Plus

Application of PL-Grid platform for modeling of the selected acoustic phenomena

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INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Presentation outline

- PLGrid Plus project
- Motivation
- Contribution to Acoustics Domain Grid
  - Noise mapping service
  - Hearing service
- Results

PLGRID PLUS PROJECT

PLGrid Plus Project

- Domain-oriented services and resources of Polish Infrastructure for Supporting Computational Science in the European Research Space
- Most important task is preparation of specific computing environments – so called domain grids i.e., solutions, services and extended infrastructure (including software), tailored to the needs of different groups of scientists.
- 13 groups of users:

  AstroGrid-PL, HEPGrid, Nanotechnologies, **Acoustics**, Life Science, Chemistry and Physics, Ecology, SynchroGrid, Energetics, Bioinformatics, Health, Materials, and Metallurgy.

Domain Grid Acoustics (D1)

- Contribution to Acoustics Domain Grid
  - Tools for sound source and propagation modeling – Noise mapping service
  - Tools for modeling of hearing effects caused by excessive sound level – Hearing service

MOTIVATION

Motivation

- Raising awareness about problem of environmental noise occurrence and its influence on hearing
- Reducing hearing impairments caused by excessive environmental noise
- European Directive 2002/49/EC, published on 18/02/2002, concerns assessment and management of environmental noise
- Noise annoyance

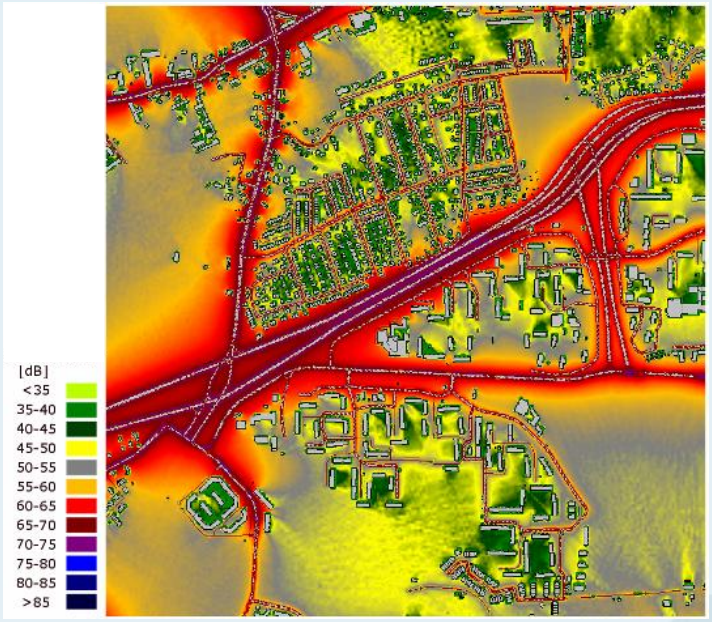
Typical health effects from noise

- Sleep disturbance
- Loss of efficiency of working or learning
- Hypertension
- Increased risk of depression and psychological disorders
- Hearing loss evoked by excessive noise

NOISE MAPPING SERVICE

Noise map

- Noise source description
- Propagation conditions
- Noise indicators: L_{DEN}, L_{NIGHT}

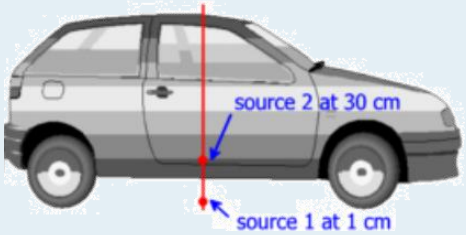


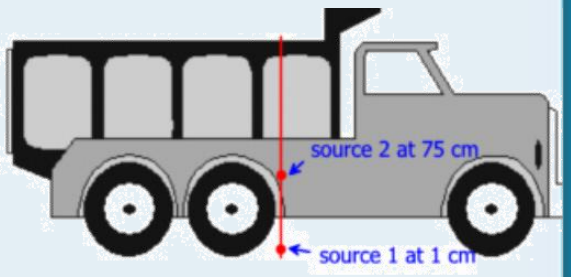
Numerical procedure

Source model → Propagation model → Noise level at the receiver

Source model

- Vehicle model
  - Propulsion noise
  - Rolling noise





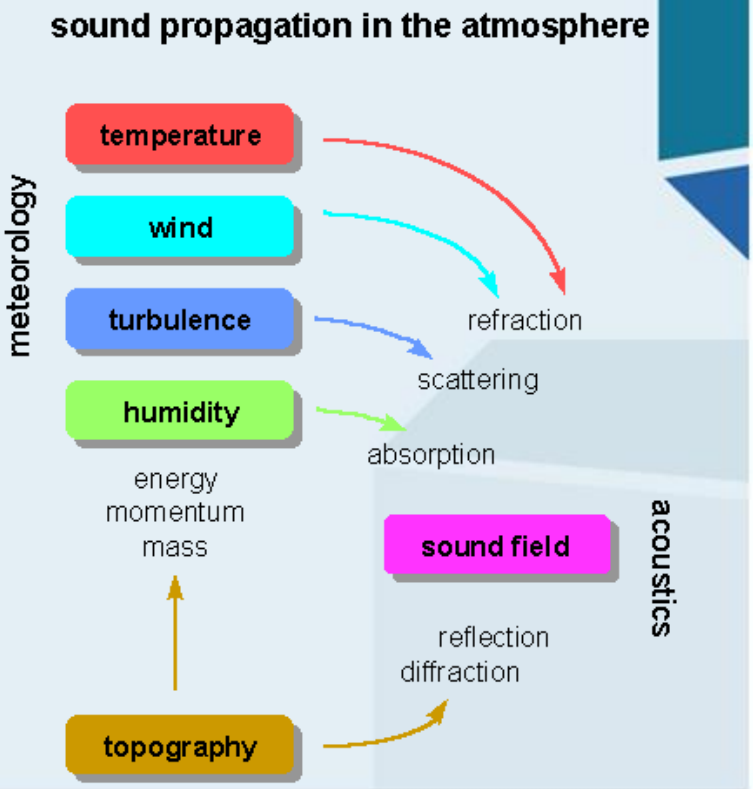
- Traffic model
  - Number of vehicles per hour
  - Road geometry
  - Type of traffic flow
  - Surface type

$$L_{W,m,i} = L'_{W,m,i} + 10\log\left(\frac{Q_m v_0}{1000 Q_0 v_{eq,m}}\right)$$

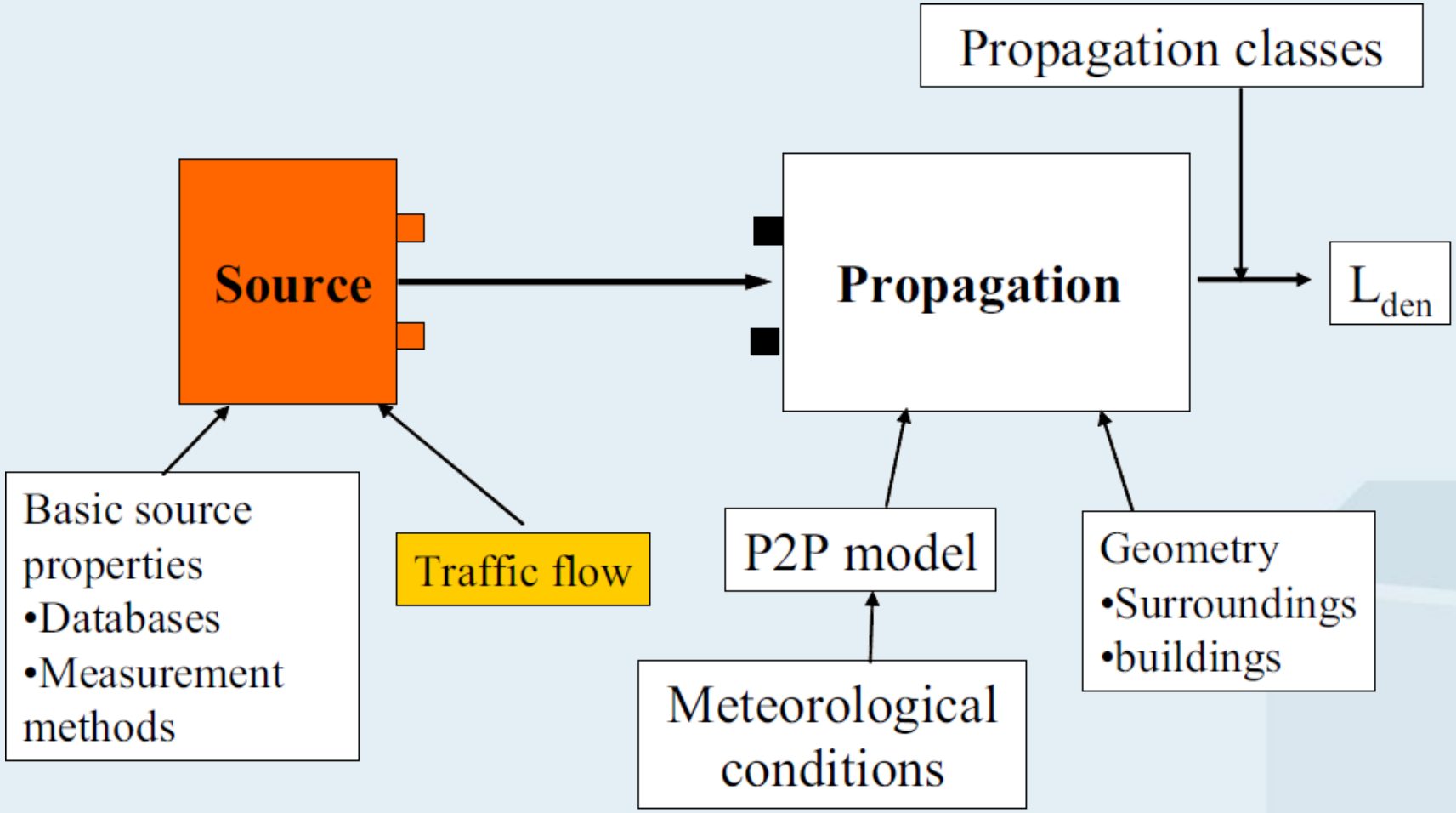
Propagation factors

$$L_{Eq1h,i,n} = L_{W,i} - A_{div} - A_{atm,i} - A_{refl,i} - A_{sc,i} - A_{E,i}$$

$L_{W,i}$ – sound power level of source,
A_{div} – the attenuation due to geometrical spreading,
$A_{atm,i}$ – the attenuation due to atmospheric absorption,
$A_{refl,i}$ – the attenuation due to energy loss during reflection,
$A_{sc,i}$ – the attenuation due to scattering,
$A_{E,i}$ – excess attenuation due to ground reflections and diffraction effects,
i – frequency index.



Noise model

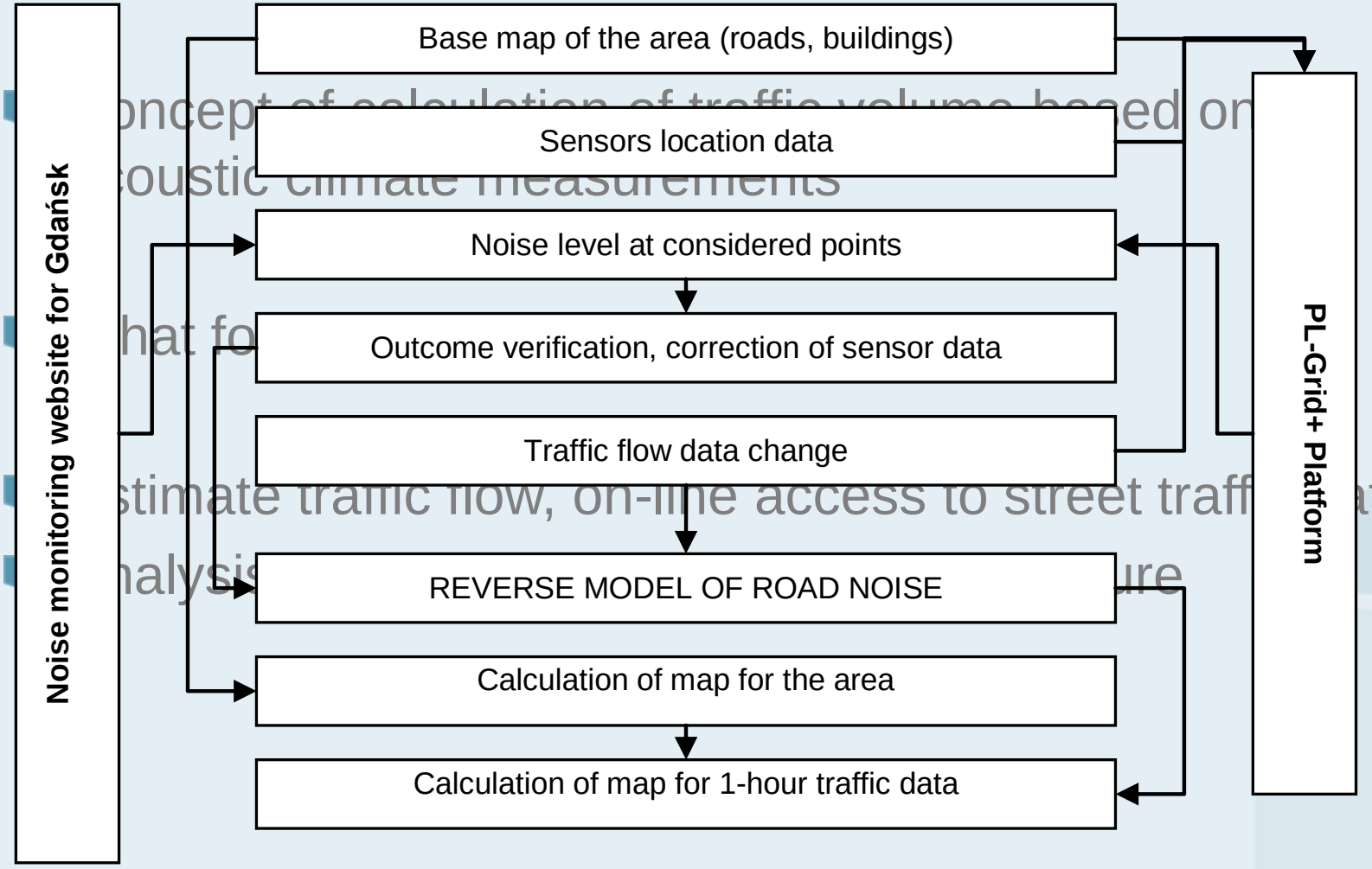

Propagation classes
Source
Propagation
L_{den}
Basic source properties
•Databases
•Measurement methods
Traffic flow
P2P model
Meteorological conditions
Geometry
•Surroundings
•buildings

Use cases

Noise maping service

- Simulation of acoustic climate in urban area based on data provided by user. Offline mode.
- Dynamically updated map of road noise, based on pre-calculated propagation paths and dynamically changed road traffic data (number of vehicles, speed). Noise maps can be updated fast.
- Estimation of traffic volume based on measurement of noise using reverse model. The outcome is provided in a form of dynamic noise map.

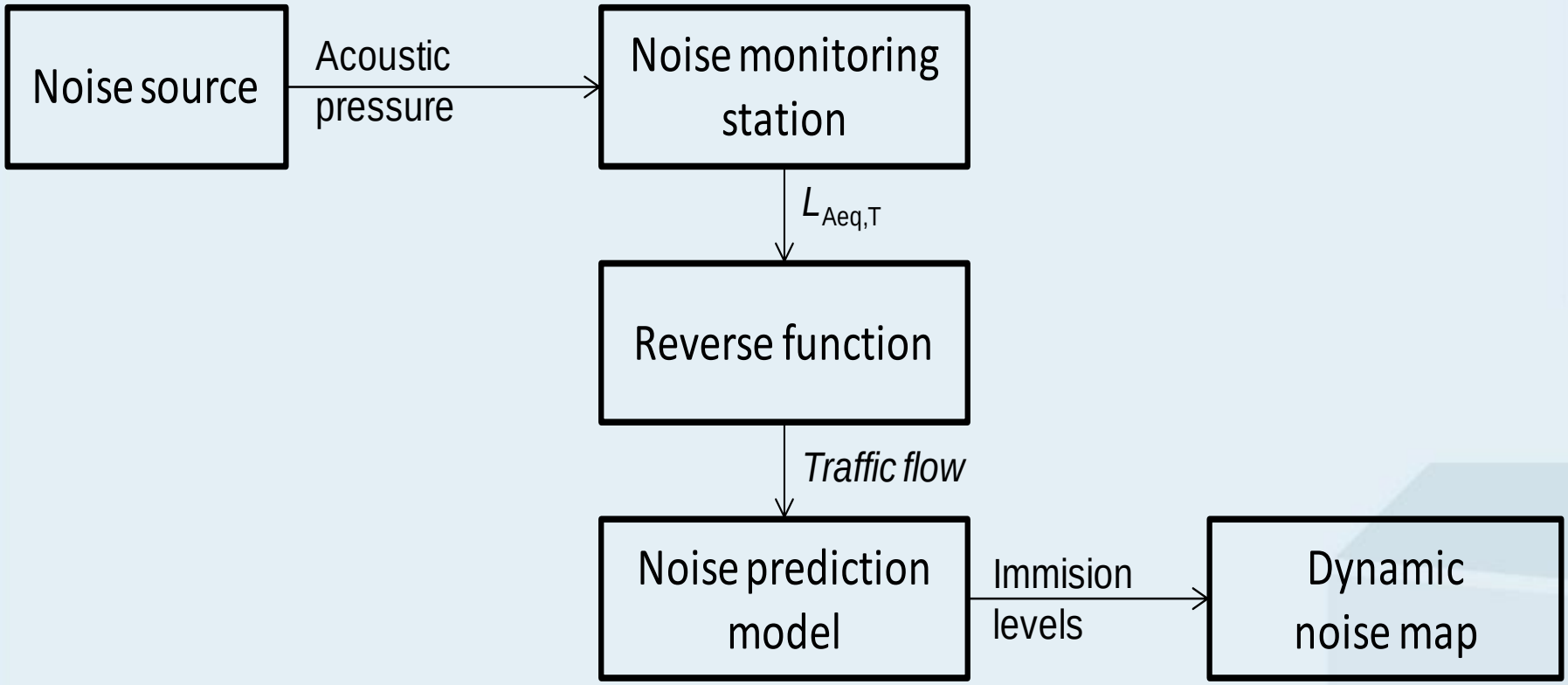
Dynamic noise map



Map of noise sensors

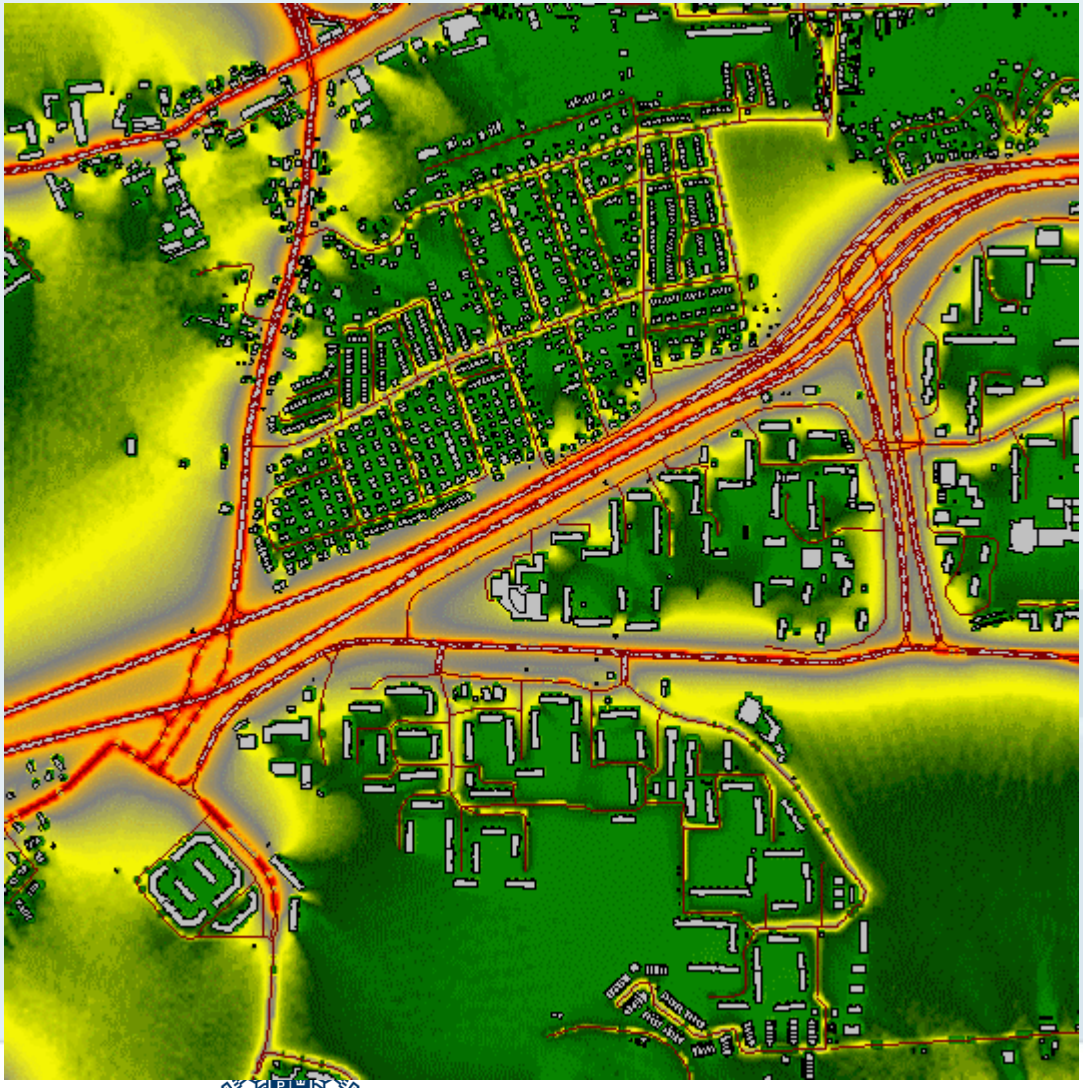
Example of measurement sensor

Reverse model



Dynamic noise map

00:00-00:59

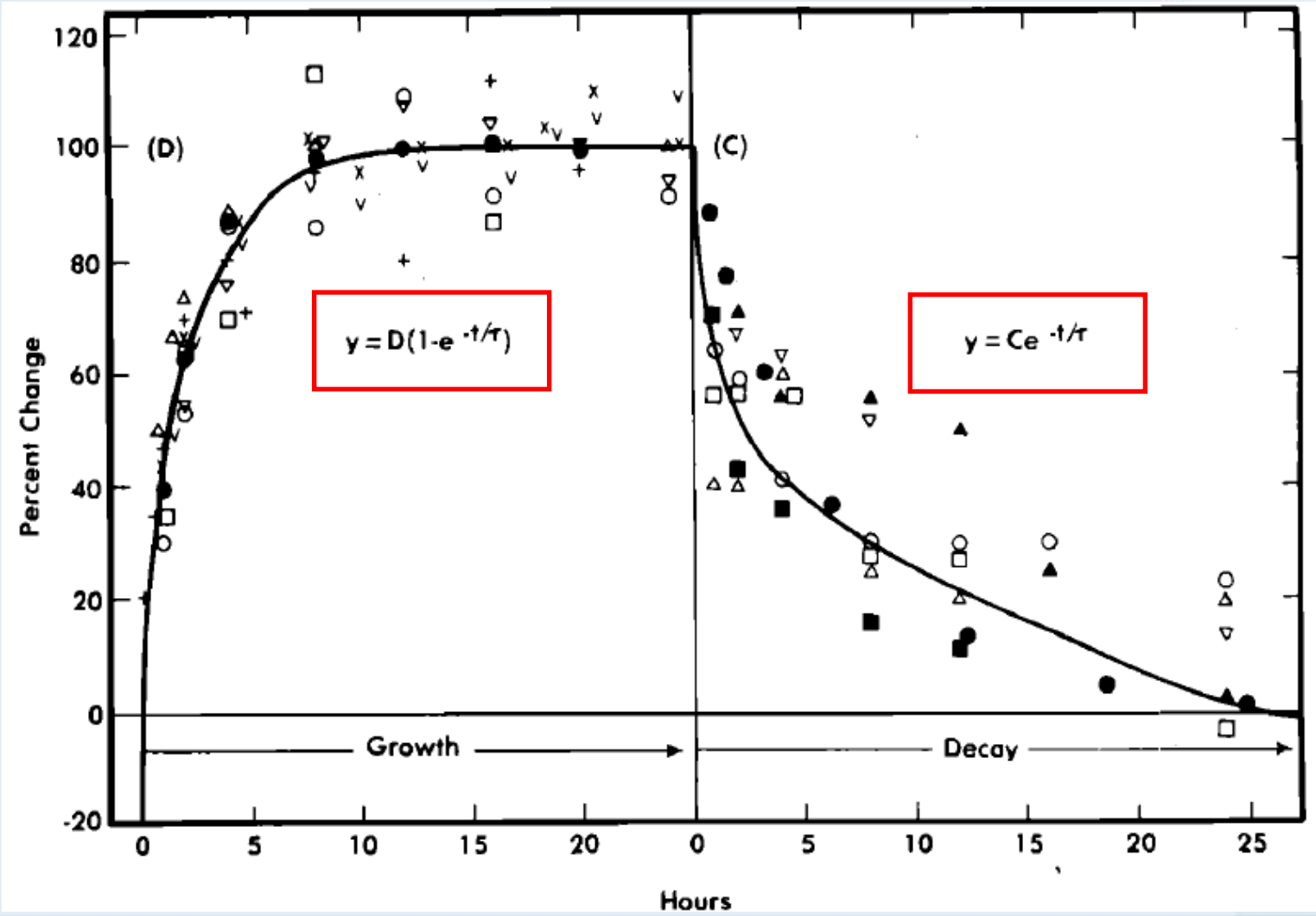


HEARING SERVICE

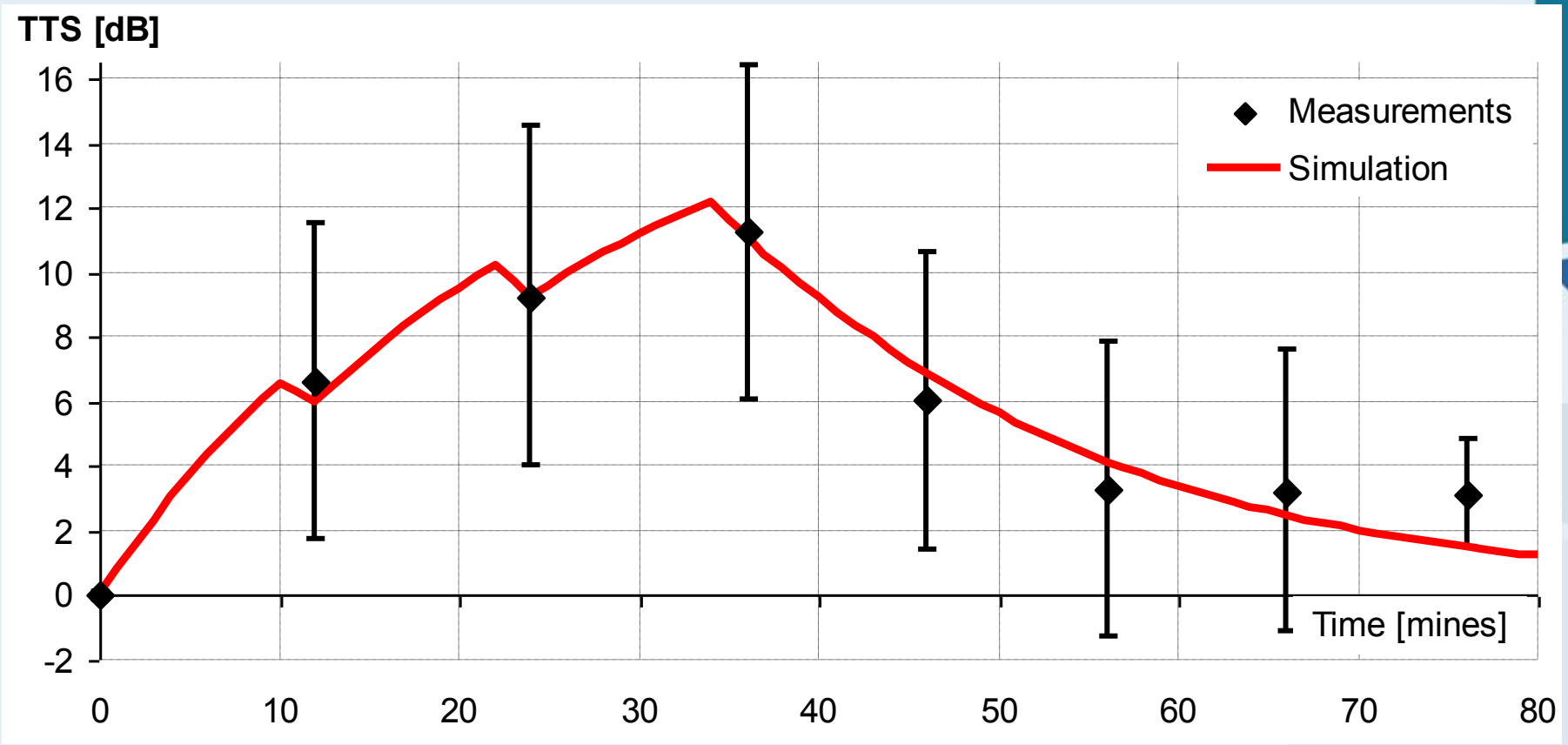
Psychoacoustical noise dosimeter

- Today's methods of hearing impairment risk evaluation are mostly based on the equal energy hypothesis
- The time characteristic of noise is ignored while the main emphasis is put to the equivalent noise level
- The new way of assessment of noise-induced harmful effects on human hearing system
- It based on some psychoacoustical properties of the human hearing system and, at the same time, on evaluation of the time and frequency characteristics of noise

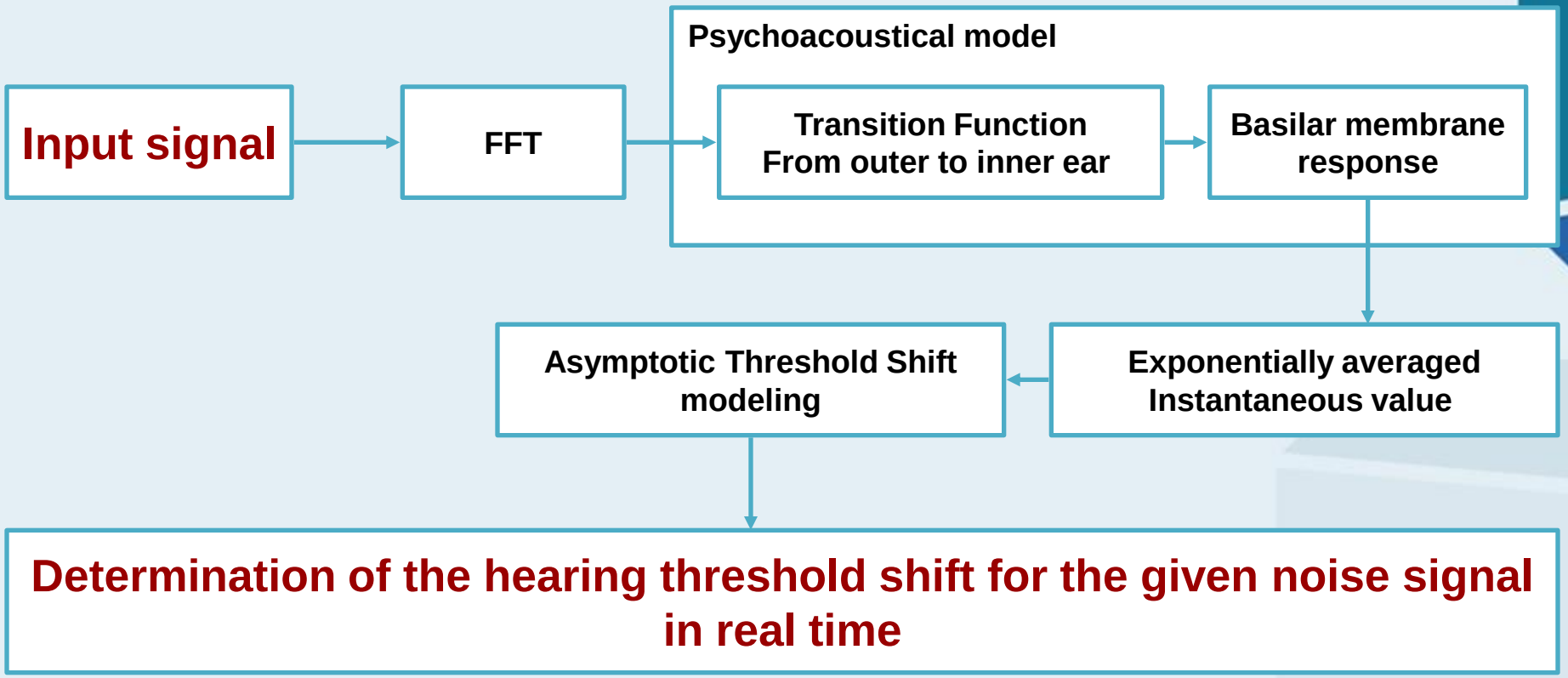
Psychoacoustical noise dosimeter



The results obtained in the laboratory - hearing



Psychoacoustical noise dosimeter



Use cases for developed services

- Calculation of the auditory effects induced in hearing system during the exposure. User should deliver the sound recording for considered acoustic and exposure conditions. (Hearing)
- The user define the properties of noise exposure such as sound level (in dB(A)) and time (in minutes) of exposure, the spectrum of noise is calculated based on recorded sound sample. (Hearing)
- During calculation of the noise immission levels, the maximum TTS values for every point are obtained. The calculated sound immission in 1/3 octave bands provides a base for estimate of TTS of hearing using an advanced model. (Noise mapping + Hearing)

SIMULATION OF OUTDOOR CONCERT

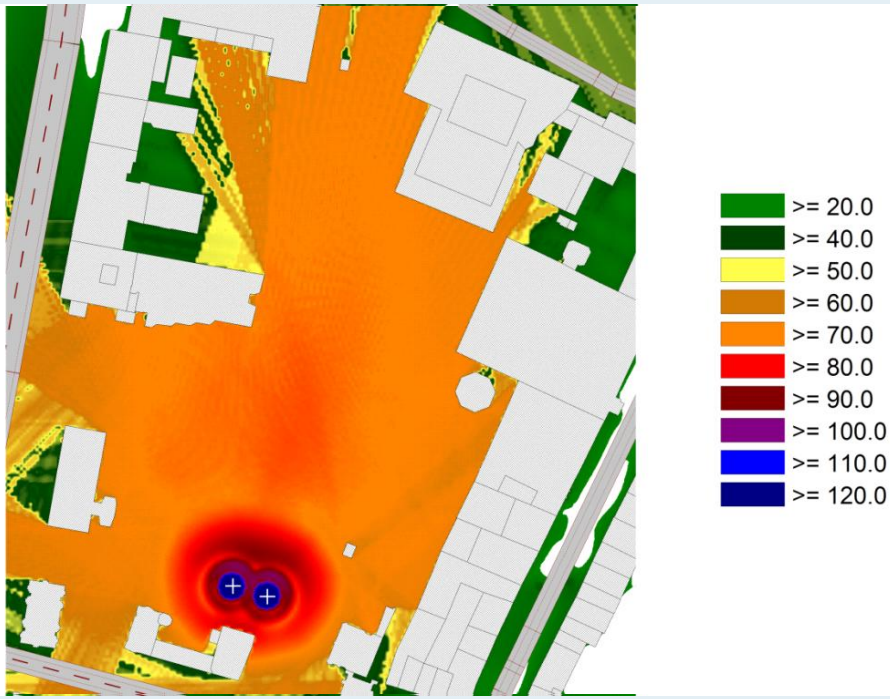
Maps of noise an hearing threat

- A noise-induced temporary threshold shift simulation during outdoor concert at the city square was made
- Auditory area: about 100×130 meters
- Point sources
  - Energy given in 1/3 octave bands
  - Detailed source directivity
- Noise map and hearing threat map

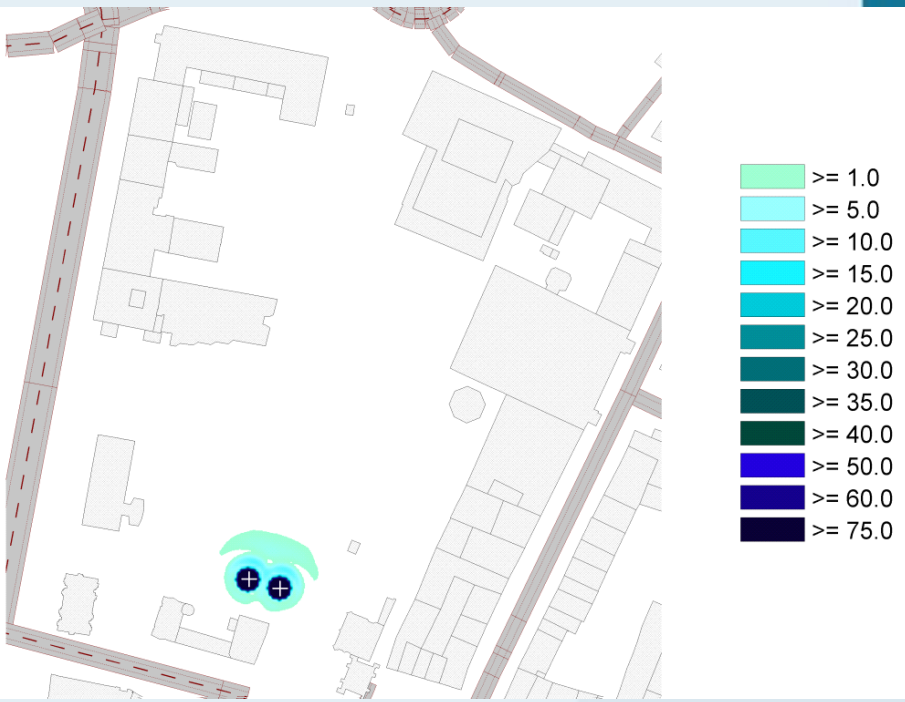
Noise maps for point sources

Sum: 250 Hz to 10000 Hz

Sound level (L_{Aeq})

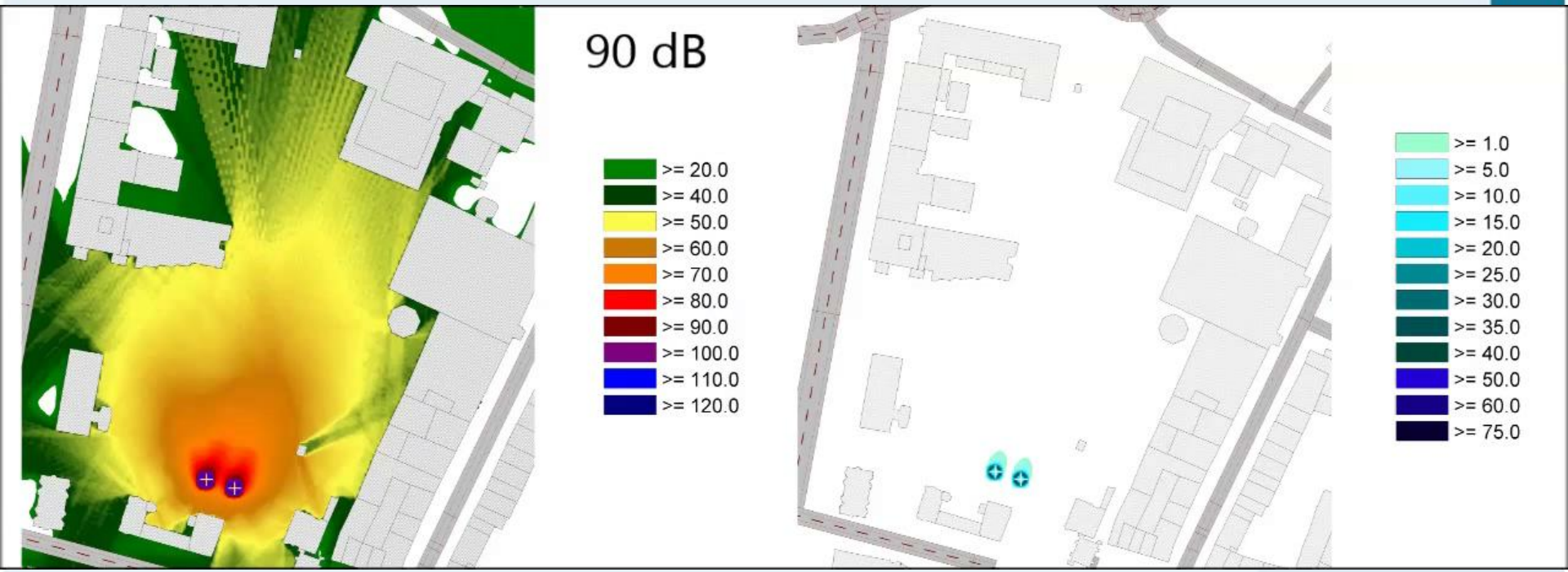


Temporary threshold shift (TTS_{max})



Noise maps for point sources

L_{Aeq} and TTS_{max}, variable source level



CONCLUSIONS

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- The concept and the results of the dynamic noise mapping were introduced
- The analysis of auditory effects caused by the outdoor concert was presented
- The results were obtained by means of supercomputing PL-Grid Infrastructure and developed algorithms of outdoor sound propagation and psychoacoustical noise dosimeter
- Provided services may help to predict the annoyance of the outdoor acoustic events or to protect hearing of the audience
- Application of developed services in education

Acknowledgements

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