Comparison of 3 engineering methods for outdoor sound propagation

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Introduction

The target of the CNOSSOS-EU project is to specify common prediction methods for the implementation of the 2002/49/EC directive (END) [4]. A major milestone was achieved in this project with the release of the CNOSSOS-EU JRC Reference Report [6] whose chapter on sound propagation for terrestrial sources is based on the French standard NF S 31-133:2011 (NMPB 2008) [3, 5] for road, railway and industrial noise. Although NMPB was deemed a good trade-off between quality of specification, flexibility, computation time and required input data compared to ISO 9613-2 [1] and Harmonoise as defined in [7], the question of accuracy of these methods remains to be addressed before choosing which method is to become the common noise noise prediction for terrestrial noise sources for the implementation of the END. Here accuracy means agreement with experiment.

The purpose of this paper is to compare the current candidate CNOSSOS-EU propagation model with its two challengers from the point of view of trueness and precision, as defined in [2]. In short, trueness (resp. precision) corresponds to the bias (resp. standard-deviation) between prediction and experiment. The paper is organised as follows: the methodology of comparison is outlined in the first section and the results are presented in the second section.

Methodology

The methodology was set up in order to ensure a comparison everything else being equal, and to check the prediction against validated experimental data.

Protocol

The reference frame is defined by [6]. The modeling of a site (topography, position of receivers, discretization of source-lines), the path finding between each source and each receiver, and the calculation of attenuations have been performed with the same test software for all models. This test software handles calls to the following point-to-point software libraries:

- Harmonoise P2P release 2.020 from CSTB
- ISO 9613-2 from CSTB
- Reference library for NMPB 2008 from SETRA[1]

Ground is described by a ground factor G for ISO 9613-2 and NMPB and by an air flow resistivity σ for Harmonoise. Only hard ($G = 0$, $\sigma = 300\ kNsm^{-4}$) and soft grounds ($G = 1$, $\sigma = 20000\ kNsm^{-4}$) are considered. For Harmonoise and NMPB, two meteorological conditions have been assumed: homogeneous and downward-refraction conditions (linear sound speed profile at $0.07s^{-1}$). Source height is set to 0.05 m as in [6]. An equidistant discretization of source lines was used with 5 m step. Attenuations are computed for 1/3 octave bands from 100 Hz to 5 kHz for NMPB and Harmonoise and for octave bands from 125 Hz to 4 kHz for ISO 9613-2.

[1] http://www.setra.developpement-durable.gouv.fr/les-bibliotheques-logicielles-de-a5604.html

Sites

For the comparison, experimental data have been drawn from campaigns carried out during the validation of the NMPB model, and during the Harmonoise project. They cover typical road configurations and the major acoustic phenomena: almost flat terrain: La Crau (FR - Harmonoise); with embankment: Molsheim North, Molsheim South and Mulhouse; elevated platform with noise barrier: Unna (DE - Harmonoise); viaduct over a valley: Saint Omer; road platform on one side of a valley: Massiac. Over the different sites, the maximum propagation distance ranges from 270 to 550 m. Receiver heights are either 2 or 5 m above ground. The typical (meteorological/acoustical) monitoring period is two weeks.

Results

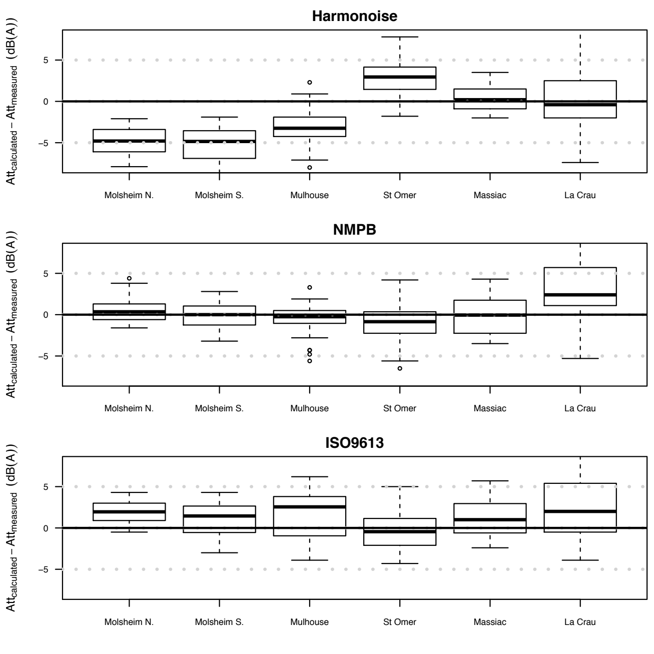

Figure 1: Deviations between calculated and measured attenuations site by site.

For each model the deviations between calculated and measured attenuations were calculated for all receiver locations. Data from Unna have not been used due to missing information.

The following statistical analysis is performed on 291 mid-term measurements estimated either during day time (6h-22h) or night time (22h-6h). For each mid-term period a probability of occurence of downward refraction conditions is computed. The results site by site are shown in Figure 1.

The three methods have a non zero bias. The difference between biases is statistically significant: NMPB=0.6 (95 %CI=$[0.3, 1.0]$), Harmonoise=-0.6 (95 %CI=$[-1.0, -0.2]$), ISO9613=1.3 (95 %CI=$[1.0, 1.6]$) (See Figure 2). Harmonoise / NMPB and Harmonoise / ISO9613 have significantly different dispersions. On the contrary the dispersions ISO/NMPB are not significantly different. From the cumulated distribution of deviations shown in Figure 3 it can be seen than 40% of deviations are lower than 2 dB pour Harmonoise, 45% for ISO9613-2 and 60% for NMPB.

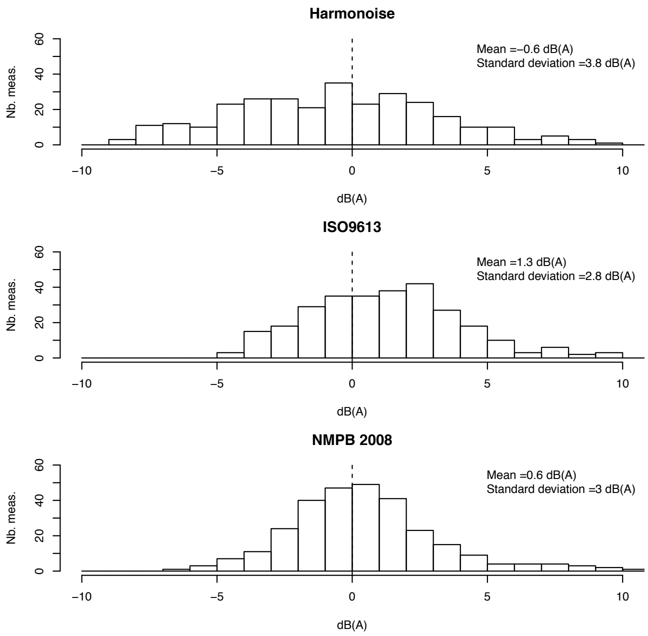

Figure 2: Distributions of deviations between calculated and measured attenuations for the different methods.

Conclusion

This comparison between Harmonoise, ISO 9613-2 and NMPB 2008 has been carried on road traffic noise test cases. A limited, yet arguably representative, set of interurban configurations has been considered. The comparison was carried out everything else being equal wherever it was possible, thanks to a common testing software platform. The comparison is made on mid-term attenuations with respect to a reference receiver.

In general, the tested methods perform reasonably well with respect to trueness in dB(A).

It appears that Harmonoise does not perform better than

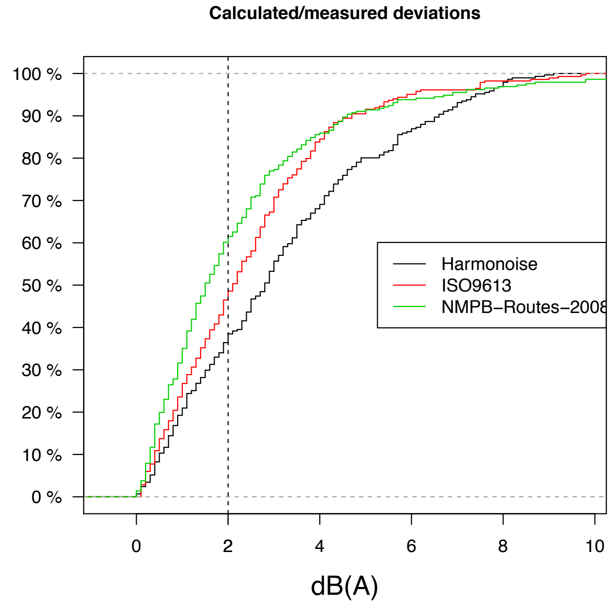

Figure 3: Cumulated distribution functions of deviations between calculated and measured attenuations for the different methods.

simpler methods. A possible explanation is that this method is more sensitive to input data. Expecting more detailed input data in strategic noise maps than in the test cases considered here is not realistic.

References

[1] ISO 9613-2 Acoustics - attenuation of sound during propagation outdoors - Part 2: General method of calculation, 1996.

[2] JCGM 100:2008 evaluation of measurement data — guide to the expression of uncertainty in measurement, September 2008.

[3] NF S 31-133 : Acoustics - Outdoor noise - Calculation of sound levels, February 2011.

[4] European Community. Directive 2002/49/EC of the european parliament and of the council of 25 june 2002 relating to the assessment and management of environmental noise, June 2002.

[5] Jérôme Defrance, Michel Bérengier, Guillaume Dutilleux, Fabrice Junker, Benoit Gauvreau, and David Ecotière et al. *Road noise prediction 2 -Noise propagation computation method including meteorological effects (NMPB 2008)*. Sétra, June 2009.

[6] Stylianos Kephalopoulos, Marco Paviotti, and Fabienne Anfosso-Lédée. Common noise assessment methods in Europe (CNOSSOS-EU). Technical Report EUR 25379 EN, JRC, Ispra, August 2012.

[7] Dirk van Maercke and Jérôme Defrance. Development of an analytical model for outdoor sound propagation within the Harmonoise project. *Acta Acustica united with Acustica*, 93:201–212, 2007.