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Calculation of road and rail noise - A comparison of results obtained with Nord2000, RTN96 and NMT96

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The paper presents a comparison between the Nord2000 calculation method and its two predecessors, the Nordic calculation methods for road and rail noise that were revised in 1996. Sound pressure levels were calculated with Nord2000 and the older methods in both urban and rural surroundings, where the areas were chosen to offer varying challenges for the methods. As much as possible, the methods have used the same input data, search algorithm settings, et cetera, in order to limit the differences in result to what is due to method differences. The results were analyzed with respect to traffic source, type of area, building density, etc. In an overall comparison, the mean difference between Nord2000 and the older methods was relatively small. For example in a city mapping, as a mean Nord2000 gave 0,6 dB lower result than the Nordic road noise calculation method from 1996 (standard deviation 1,9 dB), but the results varied with the conditions.

1 Introduction

Within the Swedish Environmental Protection Agency's programme for health-related environmental monitoring (HÄMI), a survey of noise exposure from road and rail traffic and its health effects at all homes in Sweden is carried out at intervals of approximately five years. Work with the latest of these is currently in its final phase, and one thing that differs from previous surveys is that the noise mapping is being carried out using the Nord2000 calculation method [1]. In Sweden, Nord2000 is the recommended method for calculating noise from road traffic from 2024-06-01 and for calculating noise from rail traffic from 2025-01-01. Prior to that, the Nordic prediction method for road traffic noise from 1996 (RTN96) and the Nordic prediction method for train noise from 1996 (NMT96) were used [2][3]. Although noise metrics and other reference conditions in terms of traffic, weather, etc. have not been changed, the change of calculation method by itself means that calculated levels will not be the same as before.

The initial work on the HÄMI mapping consisted of test calculations for the method development. These tests were expanded with support from the Swedish Transport Administration to also include a comparison between Nord2000 and RTN96/NMT96. The purpose of the comparison is to highlight what kind of differences that can be expected between the methods in different situations.

2 Method

We have chosen to perform a statistical analys of some real-world models in order to get more insight into what mean level differences and associated spread can be expected in common situations. In order for a comparison to give a realistic picture of typically occurring differences, the calculations need to include traffic variations with both large state roads and smaller municipal streets, variations in terrain, different types of building density, from rural areas to cities, and preferably also include some noise screens.

The studied areas were chosen based on the criterion that they can be considered to be representative of commonly occurring calculation situations.

All calculations were carried out using the SoundPLAN software, version 9.1.

3 Studied areas

Façade noise levels were calculated at each floor of residential buildings in four different models, see Figure 1–Figure 4. Road traffic noise was calculated in all four models and rail traffic noise in the two Västerås models and in Brämaregården.

Västerås rural area is an example of very sparely populated area, whereas Västerås city and especially Gothenburg represents densely built areas.

The Brämaregården area, also a densely built area, stands out a bit since almost all of the residential buildings are placed behind noise barriers that protect against noise from the railway and the largest road source.

Apart from Brämaregården, the models were originally developed for mapping with the older Nordic calculation methods and were supplemented with the extra data needed for Nord2000. The Nord2000 emissions, corrections and weather parameters were handled according to recommendations in the Swedish Nord2000 user's guide [4].

The SoundPLAN search ray parameters were selected as in Table 1.

Table 1 SoundPLAN search ray parameters.

Parameter	**Value**
Reflection order	3
Max search radius	2000 m
Max reflection distance, receiver	200 m
Max reflection distance, source	50 m
Allowed tolerance	0,3 dB

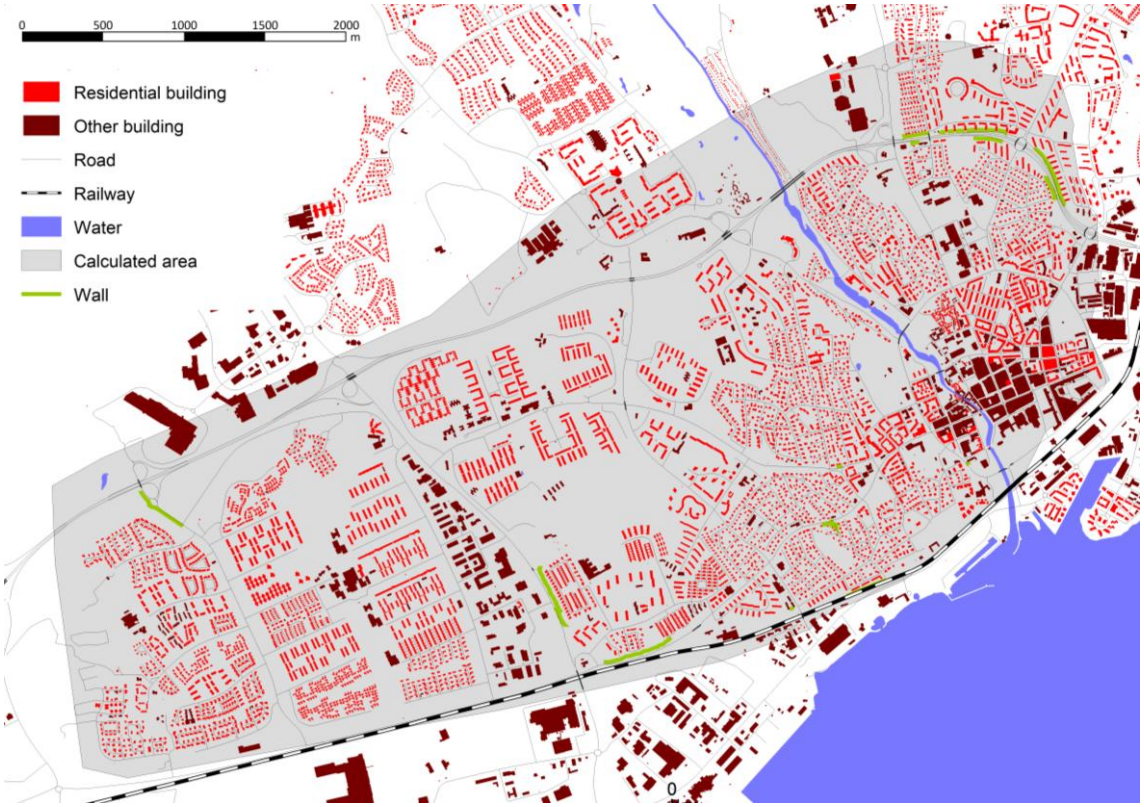

Figure 1: The Västerås city model. The size of the calculated area is 1700 Ha.

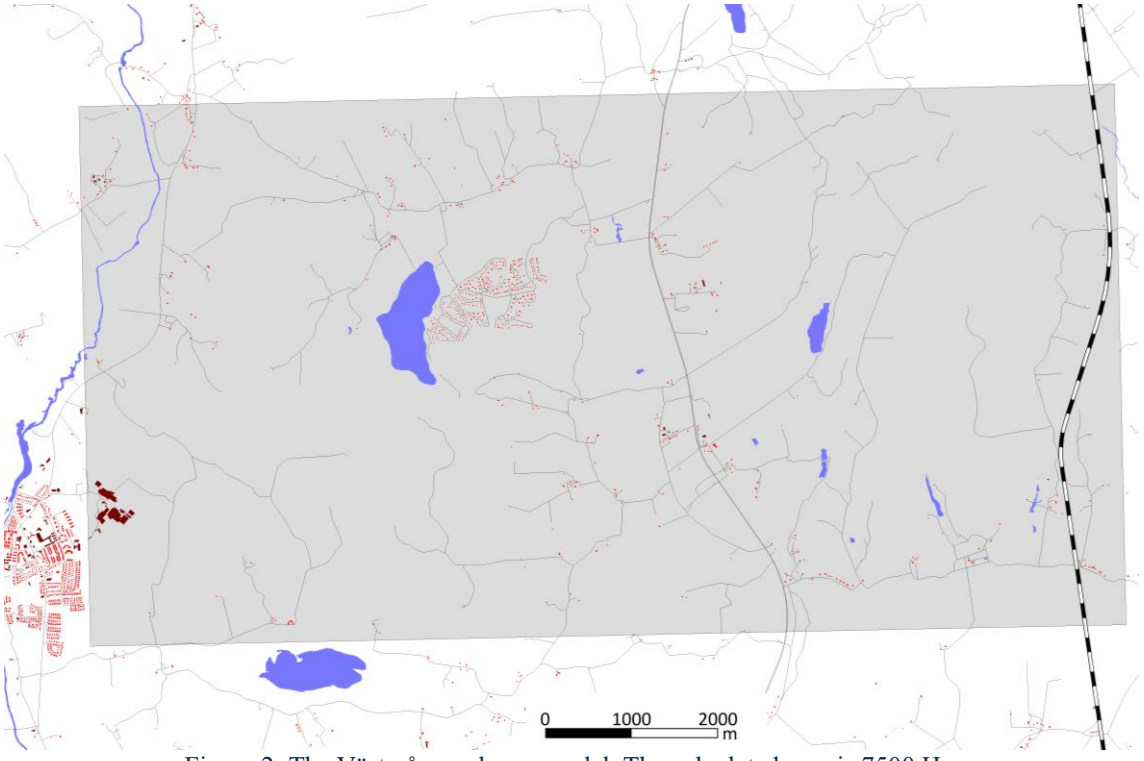

Figure 2: The Västerås rural area model. The calculated area is 7500 Ha.

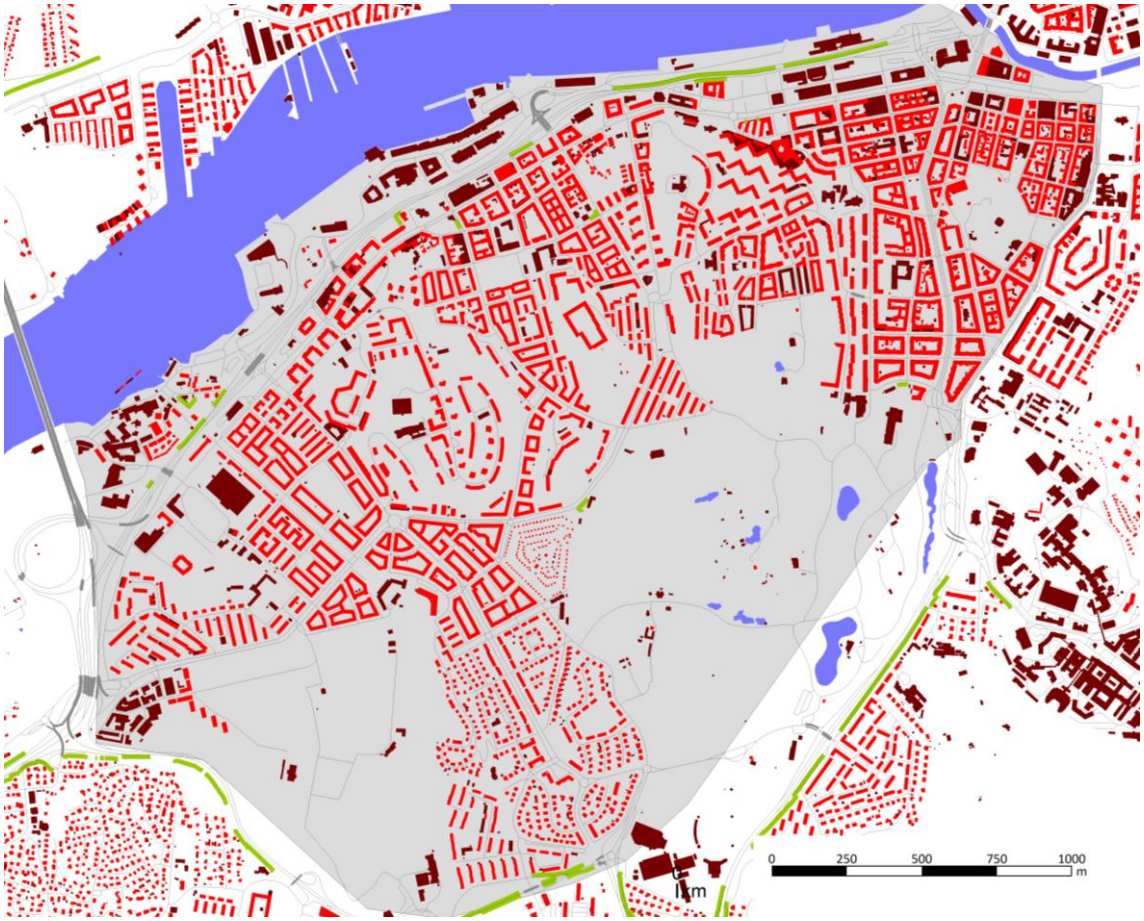

Figure 3: The Gothenburg model. The calculated area is 685 Ha.

Figure 4: The model of Brämaregården, a district in Gothenburg. Calculated area 22 Ha.

3.1 Railway emission

In 2023, a set of new Swedish Nord2000 train emission data was produced in a large measurement campaign [5]. These new emissions differ to some extent to older emission data used by NMT96 [3][6][7]. Especially the emission data for freight trains show quite large differences at certain speeds, cf. Figure 5.

In the Brämaregården calculation the railway traffic consists of freight trains only, running at 40 km/h. At 40 km/h, the 2023 emission data is ca 3,5 dB lower than the old data. On the other hand, in the Västerås city and rural models, where railway traffic is a mix of the train types in Figure 5, freight trains are mainly running at 100 km/h, where the 2023 emission is ca 3 dB higher than the old data.

Due to that, extra comparisons were made in which the Nord2000 rail emissions were based on the same data as the NMT96 emissions. In that way it is possible to see to which extent the differences are caused by different emissions or by differences in the methods.

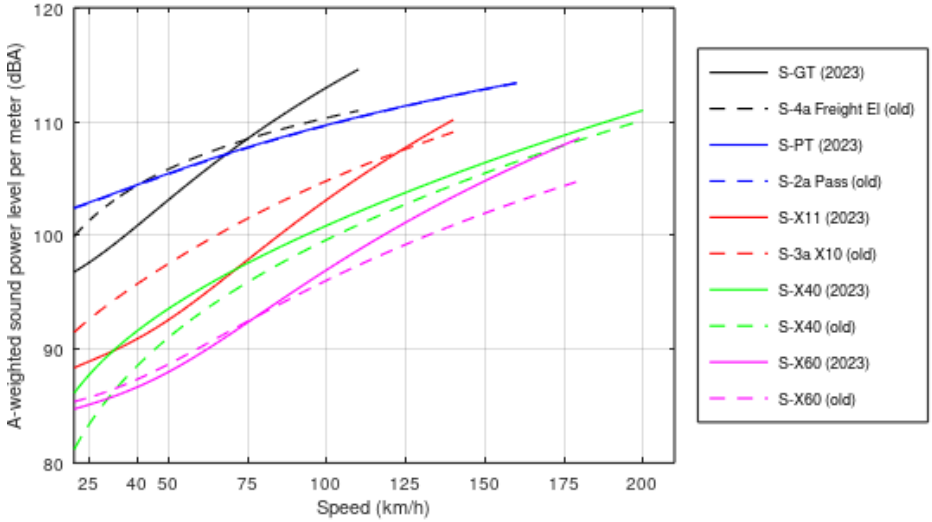

Figure 5: Comparison some of the emission data measured in 2023 with older measurements. Solid lines are 2023 data and dashed lines are old data. Black lines are freight trains, blue lines are locomotive driven passenger trains, red lines are X11 trains, green lines are X40 trains, and mangenta lines are X60 trains.

4 Results

Levels were calculated as L_{Aeq24h} and L_{AFmax}. For road traffic L_{AFmax} represents the sixth noisiest passage during night (22-06), and for rail traffic L_{AFmax} represents a passage of the noisiest train type, which in the presented cases have been calculated for the freight trains. The results are presented as the difference ΔL between a result calculated with Nord2000 and a result obtained with RTN96 or NMT96. That is ΔL = Nord2000–RTN96 or ΔL = Nord2000–NMT96.

As the lowest levels are likely to contain great uncertainties (for example receivers positioned in heavily shielded positions of closed inner yards), and also are less interesting in assessments (when comparing to limits, or when evaluating exposure according to the CNOSSOS-EU that disregards levels below the median value), equivalent levels below 45 dBA (35 dBA in the rural area) and maximum levels below 60 dBA (55 dBA in the rural area) were filtered out prior to the analysis.

Table 2 contains a summary of the results.

Table 2: Sound level differences ΔL as mean values and standard deviations in the studied areas.

Model	Traffic source	Sound level	mv (dB)	std (dB)
Västerås city	road	Leq	-0,6	1,9
		Lmax	-0,6	2,3
	rail	Leq	2,8	3,4
		Lmax	2,5	3,8
Västerås city, Nord2000 emission based on same (old) data as NMT96	rail	Leq	0,3	3,0
		Lmax	-0,3	3,3
Västerås rural area	road	Leq	0,2	2,4
		Lmax	3,0	1,9
	rail	Leq	3,9	3,2
		Lmax	3,7	4,0
Västerås rural area, Nord2000 emission based on same (old) data as NMT96	rail	Leq	0,6	3,6
		Lmax	0,7	3,9
Gothenburg	road	Leq	-1,1	1,4
		Lmax	2,4	2,7
Brämaregården	road	Leq	-1,9	1,6
		Lmax	-1,9	2,7
	rail	Leq	-6,0	2,4
		Lmax	-6,1	3,0
Brämaregården, Nord2000 emission based on same (old) data as NMT96	rail	Leq	-3,3	3,1
		Lmax	-3,4	3,5

4.1 Results in some detail from Västerås city

In Figure 6–Figure 11 ΔL results from comparisons in the Västerås city model are presented. Left plots show the actual differences as dots, where the x-value is the corresponding level calculated with Nord2000, and the y-value is the level difference ΔL. Mean values and ± one standard deviation are marked for each decile. The histogram to the right represents the same data set as the left plot, with statistics indicated above the histogram.

In Figure 12 ΔL is plotted against building density.

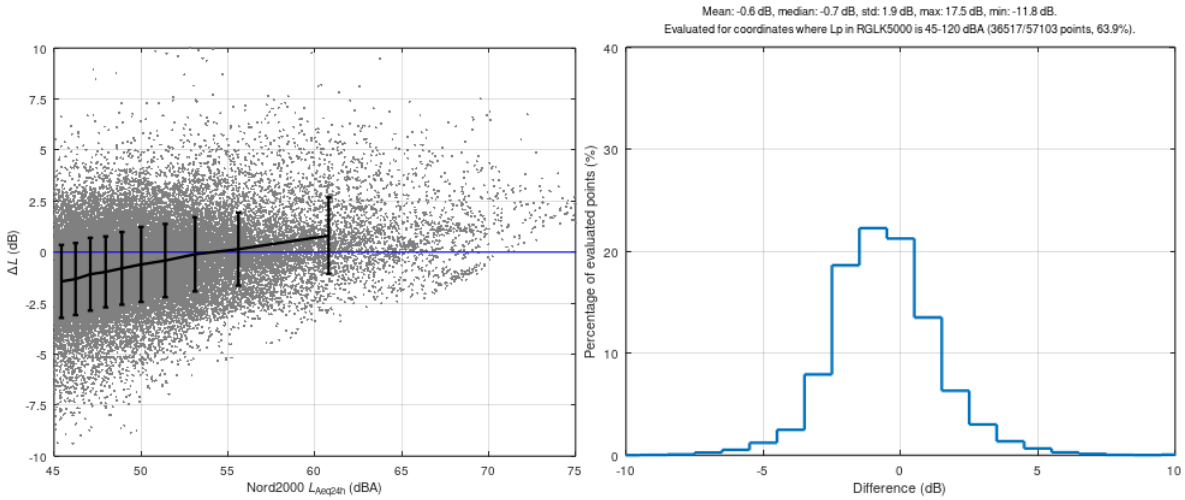

Figure 6: Road traffic, L_{Aeq24h}.

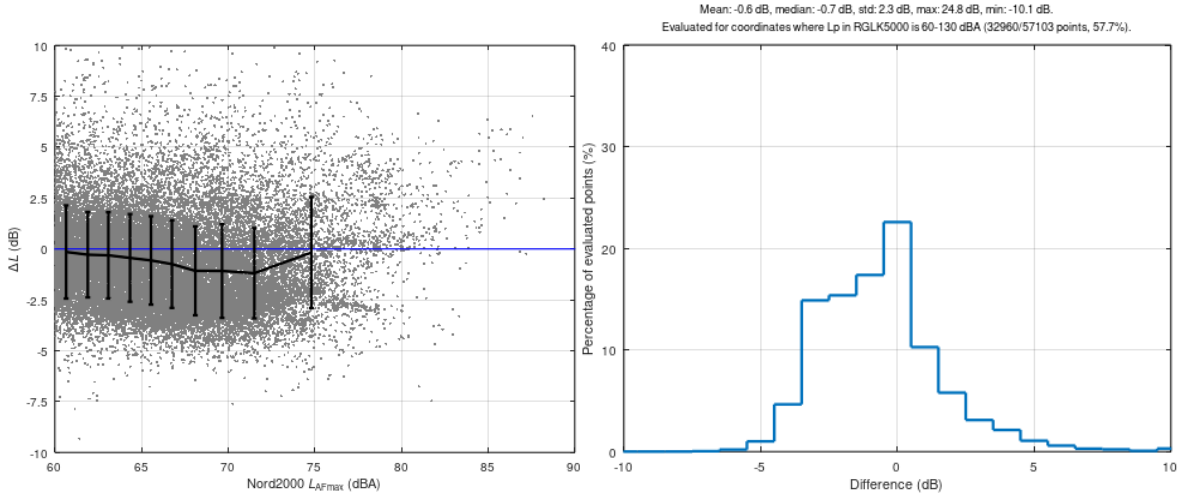

Figure 7: Road traffic, $L_{AFmax6e}$.

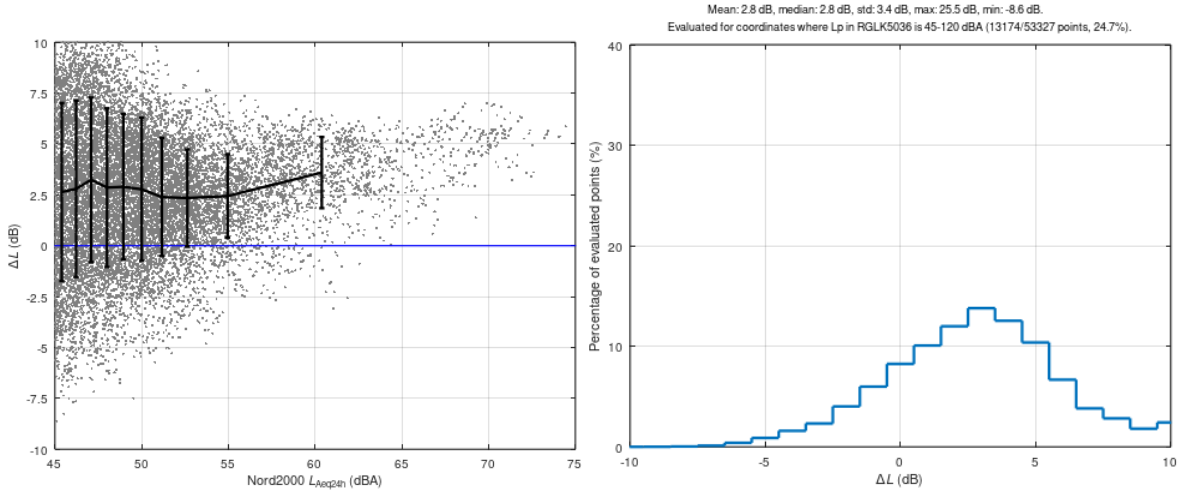

Figure 8: Railway traffic, L_{Aeq24h}. Nord2000 using the new 2023 emission data.

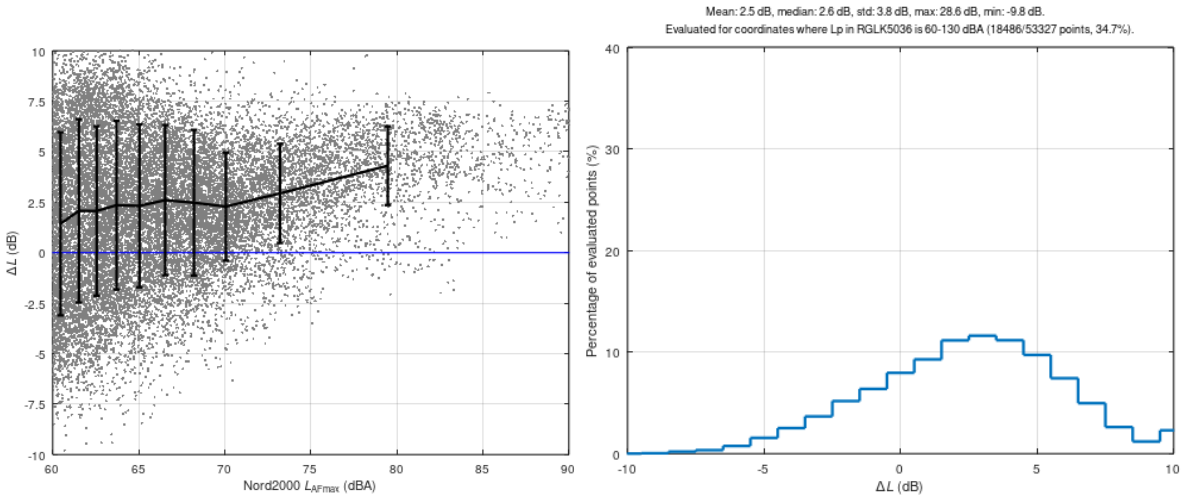

Figure 9: Rail traffic, L_{AFmax}. Nord2000 using the new 2023 emission data.

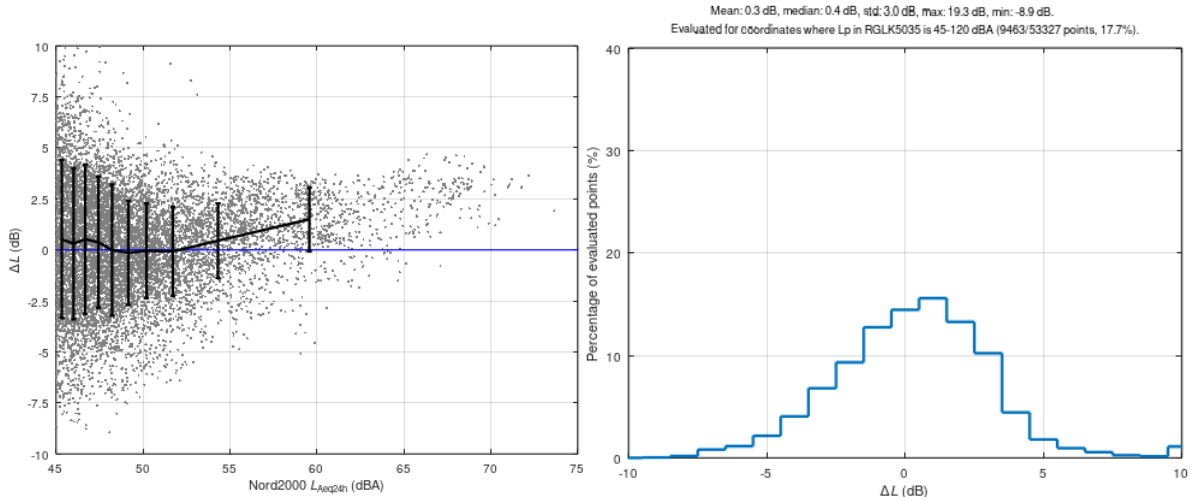

Figure 10: Rail traffic, L_{Aeq24h}. Nord2000 using emission based on same old data as is used with NMT96.

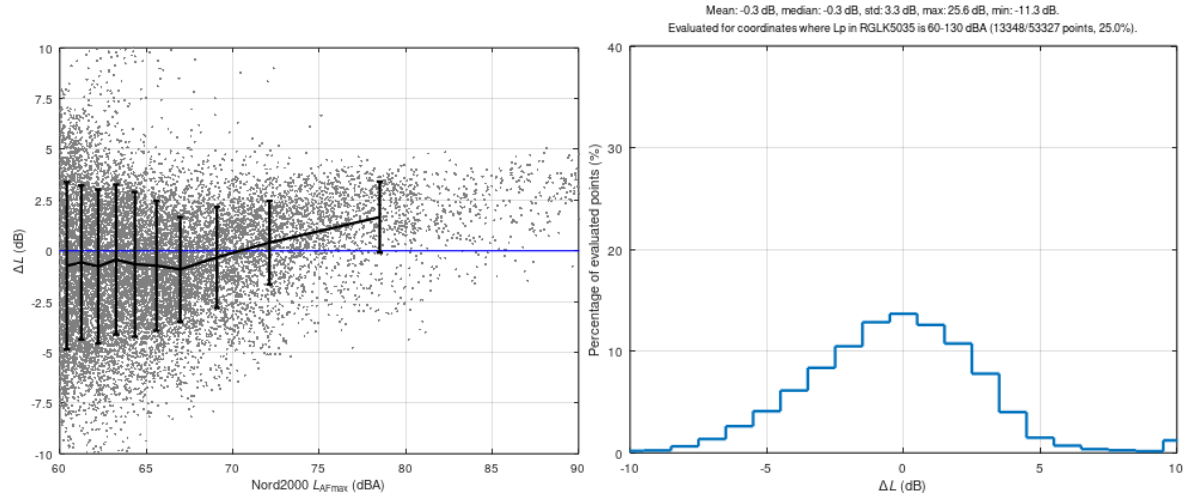

Figure 11: Rail traffic, L_{AFmax}. Nord2000 using emission based on same old data as is used with NMT96

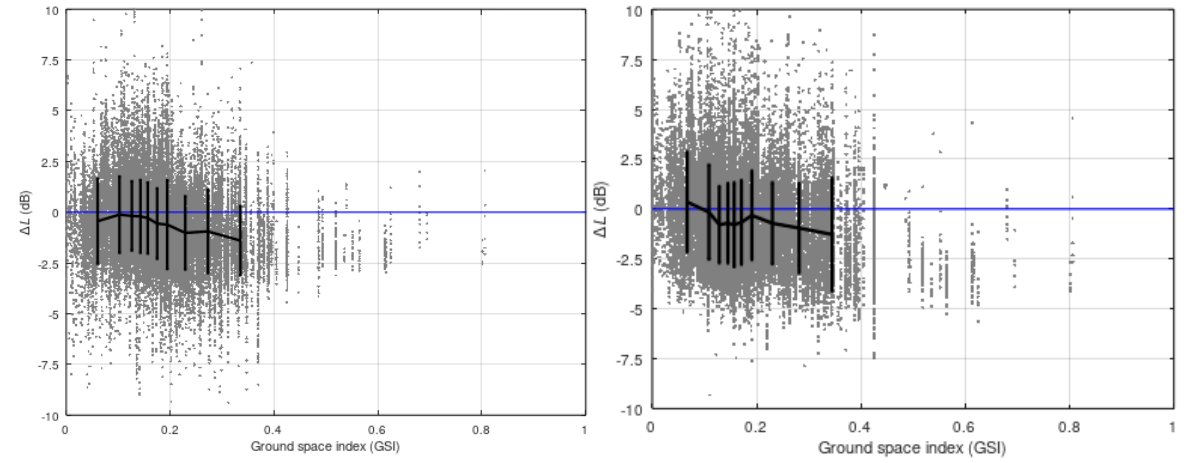

Figure 12: Road traffic, level difference versus ground space index. Left plot is for L_{Aeq24h} and right plot for $L_{AFmax6e}$. GSI is a measure of the ratio of a building's ground-level footprint to the total plot area.

Discussion

Depending on given conditions such as traffic, buildings, terrain and ground absorption, Nord2000 can produce equal, lower or higher noise level than its predecessors. Such sound level differences may be caused by source model differences, or that the methods make use of different source strengths, especially when it comes to railway traffic. But level differences may also be due to the different approaches of the propagation methods to handle ground effect, diffraction, refraction, etc.

Nevertheless, in connection with previous comparisons between Nord2000 and RTN96/NMT96 [8][9], when calculating in accordance to the recommendations for weather parameters etc. in [4], it has been possible to discern three things:

- there is a tendency that NMT96 and RTN96 values are lower than Nord2000 when propagating close to soft ground,
- and a tendency that NMT96 values are higher than Nord2000 when propagating over hard ground.
- There seems also to be a tendency that screened values calculated with Nord2000 are somewhat lower than when calculated with RTN96/NMT96.

However, the current comparisons exhibit rather large standard deviations, from $\sigma = 1{,}4$ to $\sigma = 4{,}0$ dB, corresponding to 95% confidence intervals of ±2,8 dB and ±8,0 dB respectively. In other words, it is not always as simple as the rules of thumb might suggest.

The largest general difference is found for railway traffic in Brämaregården, where ΔL is as low as -6 dB (Nord2000 values are lower than NMT96). A part of the explanation here is that the 2023 freight train emission data is ca 3,5 dB lower than the old freight train emission. As sound propagates over hard ground, we can also expect NMT96 to calculate higher levels than Nord2000. Finaly, the traffic source is screened, both from the screen itself, but it is also shielded by the dense building blocks, which also tends to give lover values with Nord2000.

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