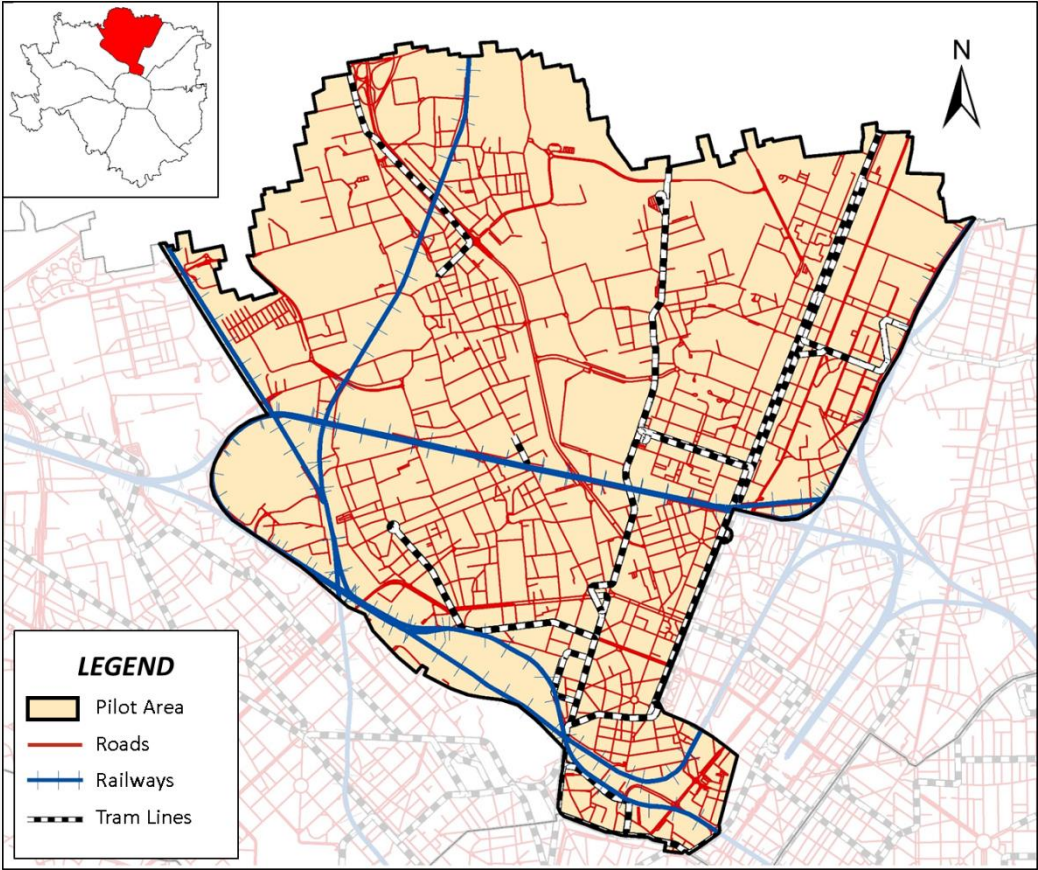




# DEVELOPMENT OF OPTIMIZED ALGORITHMS FOR THE CLASSIFICATION OF NETWORKS OF ROAD STRETCHES INTO HOMOGENEOUS CLUSTERS IN URBAN AREAS

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Alessandro Bisceglie

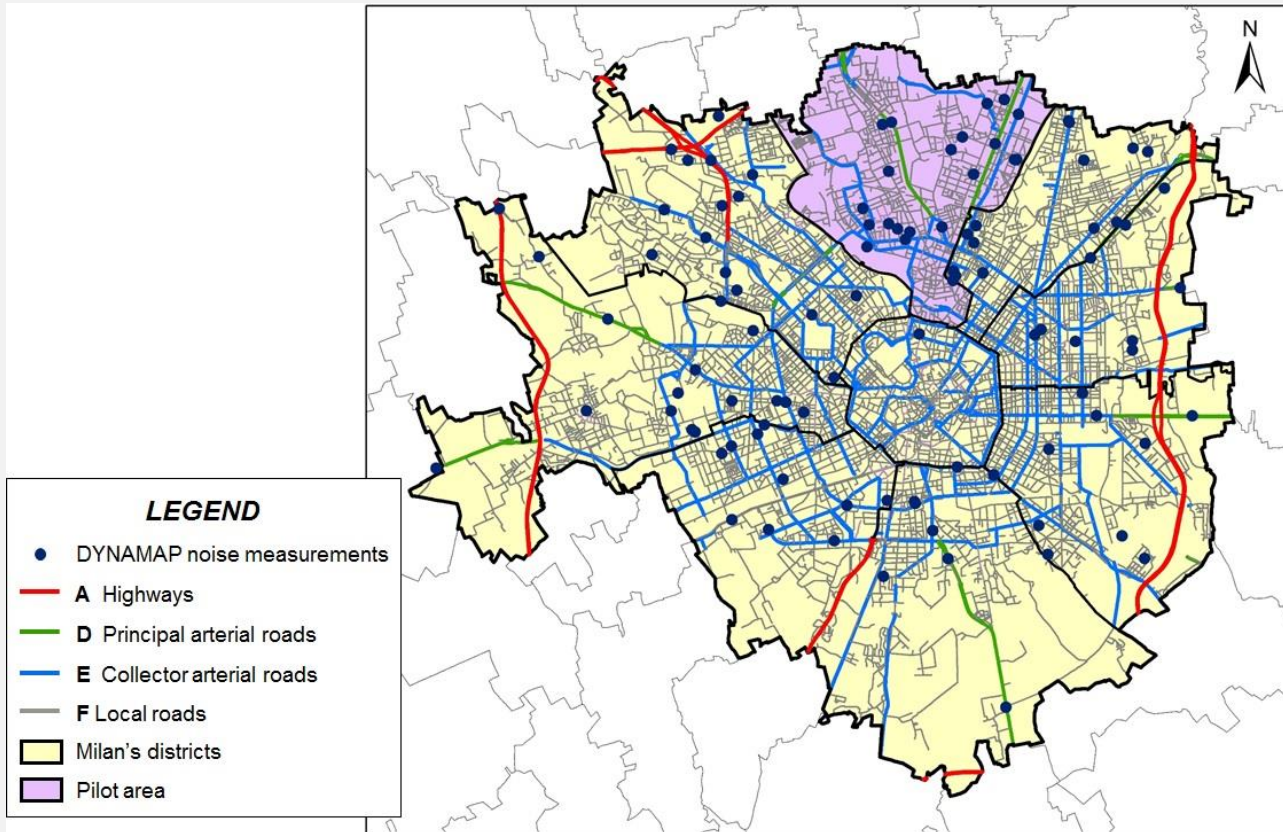
## AREA TO BE MAPPED



2233 road stretches

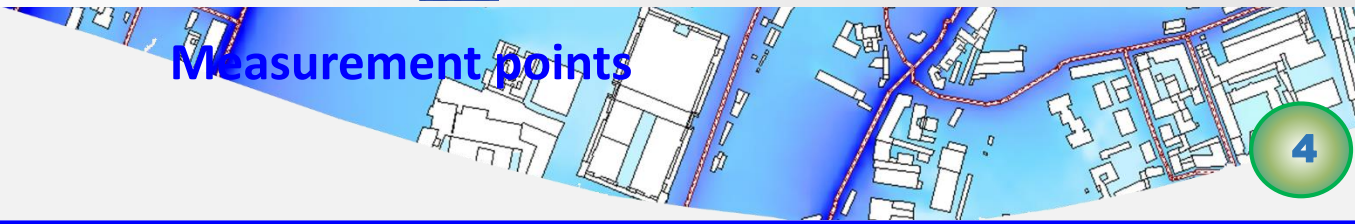
The patterns of traffic flows (and therefore of noise) are very regular and repetitive

The streets can be joined together in a limited number of groups (clusters).  
To verify the homogeneity of the groups is necessary to make on site measurements



Measures used to check the homogeneity of the groups: n. 103

Measurement points



SITO	Dist. bordo carreggiata (m)	h fonometro (m)	GIORNO	CLASSE	06.00-07.00 07.00-08.00 08.00-09.00 09.00-10.00 10.00-11.00 11.00-12.00 12.00-13.00 13.00-14.00 14.00-15.00 15.00-16.00 16.00-17.00 17.00-18.00 1												
					06.00-07.00	07.00-08.00	08.00-09.00	09.00-10.00	10.00-11.00	11.00-12.00	12.00-13.00	13.00-14.00	14.00-15.00	15.00-16.00	16.00-17.00	17.00-18.00	
27	Garegnano	0,5	2,5	da giovedì 17/5/2012	F2	55,0	62,3	62,2	60,0	59,1	58,3	60,0	64,5	58,6	58,8	60,0	60,8
28	Suzzani	0,5	2,5	da martedì 2/10/2012	F0	65,6	68,0	68,2	68,5	67,8	68,3	69,9	67,5	67,1	66,9	67,3	67,3
	Suzzani	0,5	2,5		F0	66,3	68,4	68,3	67,4	67,1	66,6	70,5	67,2	67,6	68,0	67,8	68,2
	Suzzani	0,5	2,5		F0	66,0	68,1	68,1	68,7	69,4	68,7	69,0	67,4	68,9	67,4	66,9	68,3
	Suzzani	0,5	2,5		F0	66,5	67,5	69,0	67,6	67,7	67,0	67,2	67,7	67,4	67,6	67,2	
	Suzzani	0,5	2,5		F0	66,8	68,1	69,6	67,7	67,6	68,3	73,0	67,2	67,2	67,4	69,0	67,7
	Suzzani	0,5	2,5		F0	65,9	68,5	68,9	68,3	68,3	69,8	68,0	68,0	68,5	69,1	67,4	71,1
29	Meleri	10	4	da giovedì 25/10/2012	F2	45,7	50,9	56,0	51,1	48,2	49,5	53,3	51,3	48,2	49,8	52,2	50,4
	Meleri	10	4		F2	51,5	59,9	61,3	57,2	51,8	53,4	55,5	50,3	50,1	56,7	57,6	49,8
30	Ugoni	5	4	da lunedì 29/10/2012	E2	59,7	62,2	62,4	61,3	61,0	61,4	61,0	64,4	61,2	61,1	61,5	61,4
	Ugoni	5	4		E2	59,2	61,6	60,4	68,5	61,0	60,6	59,9	60,0	60,3	60,2	61,0	61,9
	Ugoni	5	4		E2	59,6	62,0	63,5	62,0	60,8	60,1	59,8	60,2	60,1	60,1	60,9	61,4
	Ugoni	5	4		E2	58,8	61,6	62,0	60,6	59,4	60,3	60,0	60,3	59,9	60,2	60,6	60,9
31	Iseo	3	4	da mercoledì 21/11/2012	F3	55,1	58,8	62,4	61,6	59,0	57,7	59,4	59,6	59,2	61,9	61,4	59,9
	Iseo	3	4		F3	56,0	57,7	60,3	58,8	58,1	58,2	57,6	61,5	58,6	61,7	62,0	59,7
32	Suzzani	15	5	da mercoledì 21/11/2012	F0	56,9	60,0	60,8	60,7	61,2	60,3	59,9	60,5	60,1	61,0	60,7	59,9
	Suzzani	15	5		F0	57,1	60,0	60,5	60,1	60,7	62,3	62,2	60,6	61,0	60,9	61,1	60,8
33	Novara	4	4	da mercoledì 21/11/2012	E2	67,6	69,7	70,2	69,8	69,1	69,4	69,4	69,9	69,5	70,0	70,8	69,3
	Novara	4	4		E2	68,4	70,7	71,4	70,4	69,8	69,4	70,2	70,9	70,9	69,8	69,3	69,1
	Novara	4	4		E2	69,3	72,5	70,7	71,1	70,1	70,0	69,6	69,6	69,7	69,5	70,9	68,8
	Novara	4	4		E2	67,9	70,0	70,8	70,2	69,3	69,2	70,0	70,6	70,1	69,1	69,9	69,1
34	A8-A9	7	4	da lunedì 11/4/2013	A	75,7	78,3	78,7	78,6	77,8	77,9	78,1	78,1	77,9	78,2	78,0	76,8
	A8-A9	7	4		A	74,7	77,2	77,5	77,0	76,9	76,7	76,6	76,7	76,9	77,3	77,1	77,1
	A8-A9	7	4		A	74,4	77,6	77,5	77,2	76,4	76,3	76,5	76,7	77,3	76,9	76,9	77,1
35	il Moro	2	4	da giovedì 6/2/2013	F0	71,3	72,6	73,1	72,8	72,3	72,3	72,2	71,8	72,0	71,7	70,5	70,5
	il Moro	2	4		F0	57,0	76,5	71,4	57,1	58,0	56,5	58,1	61,2	53,7	54,4	55,7	54,5
	il Moro	2	4		F0	59,5	63,4	58,3	56,7	53,4	55,3	54,3	59,9	53,0	54,3	54,6	56,7
	il Moro	2	4		F0	58,4	63,6	59,3	57,7	56,0	56,9	60,8	65,4	68,3	55,8	59,8	57,5

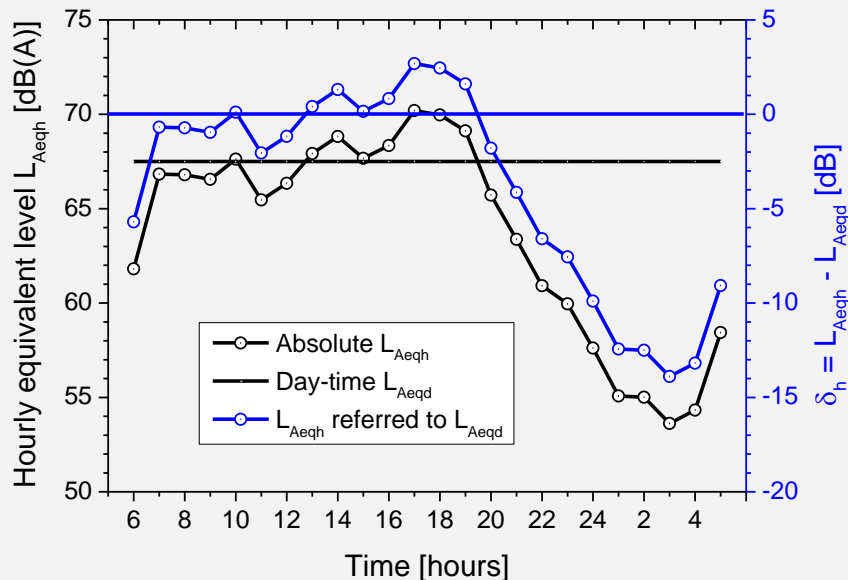
Examples of hourly noise levels obtained by measurements



## Parameter use for roads comparison

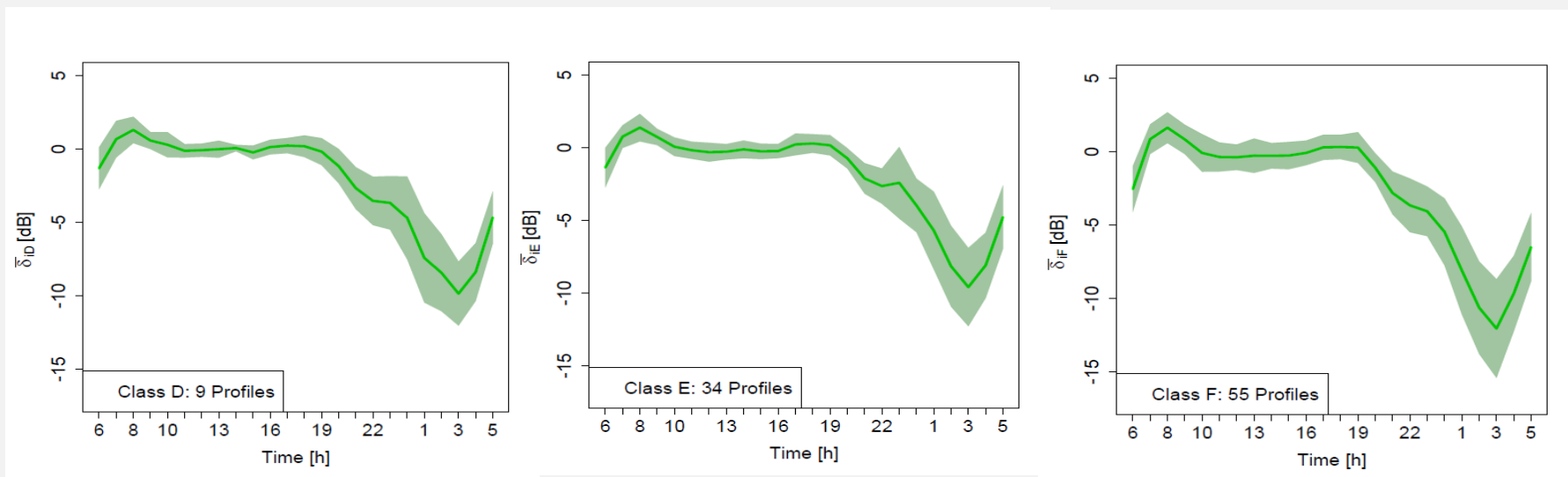
Each  $j$ -th value of the temporal series was referred to the corresponding daytime  $L_{Aeqdj}$  (06-22 h) taken as reference level, that is for each hour the following parameter  $\delta_{ij}$  was computed:

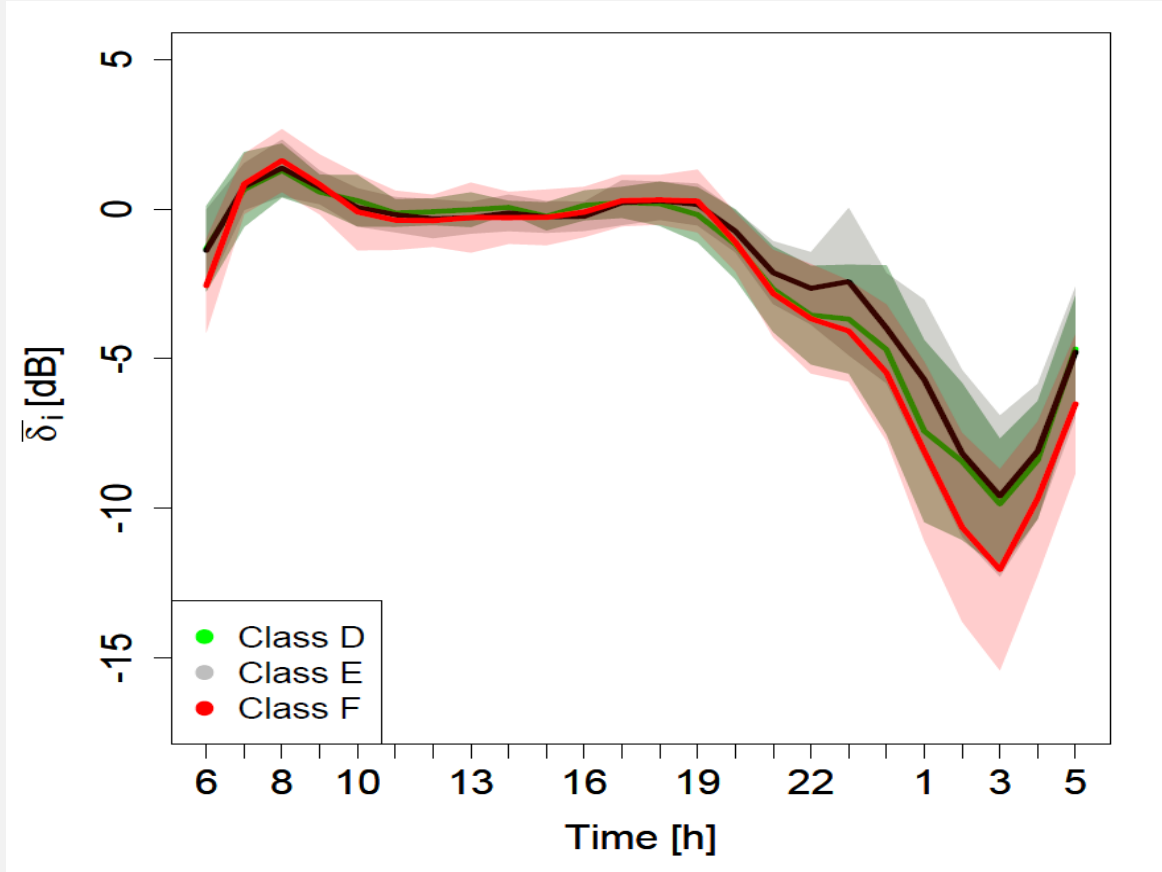
$$\delta_{ij} = L_{Aeqh_{ij}} - L_{Aeqd_{j}} \quad [\text{dB}] \quad (i= 1, \dots, 103)$$



Example of the normalization of the 24 h profile of the hourly  $L_{Aeqh}$

Aggregation of the noise levels trend for the different road class D,E,F (defined by italian classification)

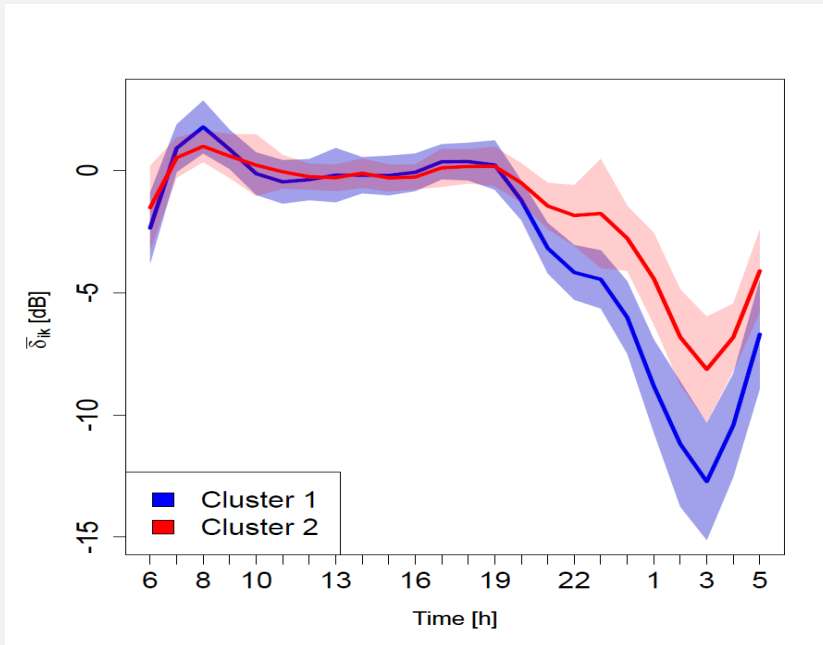




Global view of the three trends: doesn't appear a clear subdivision

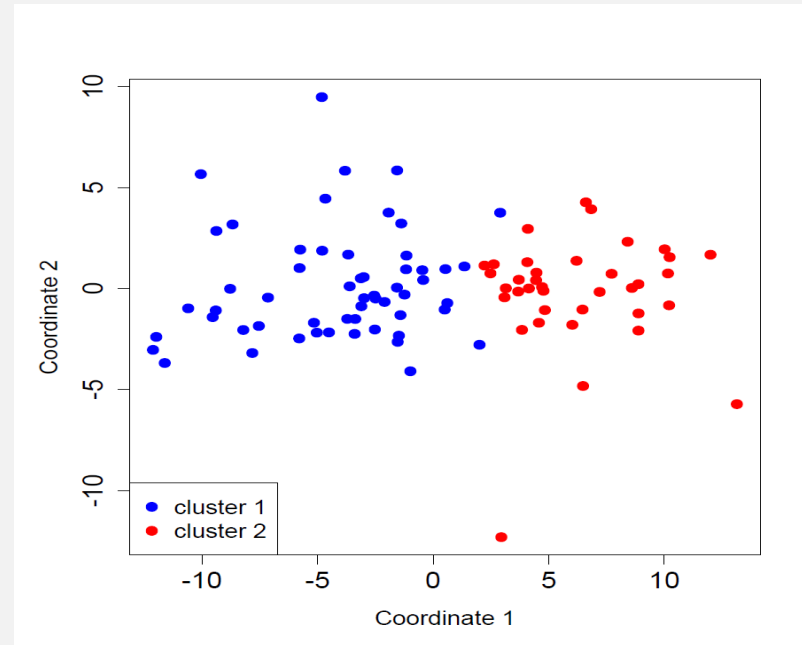


## Cluster analysis of hourly noise profile



By means cluster analysis we obtain two clusters clearly distinct

## MDS Cluster



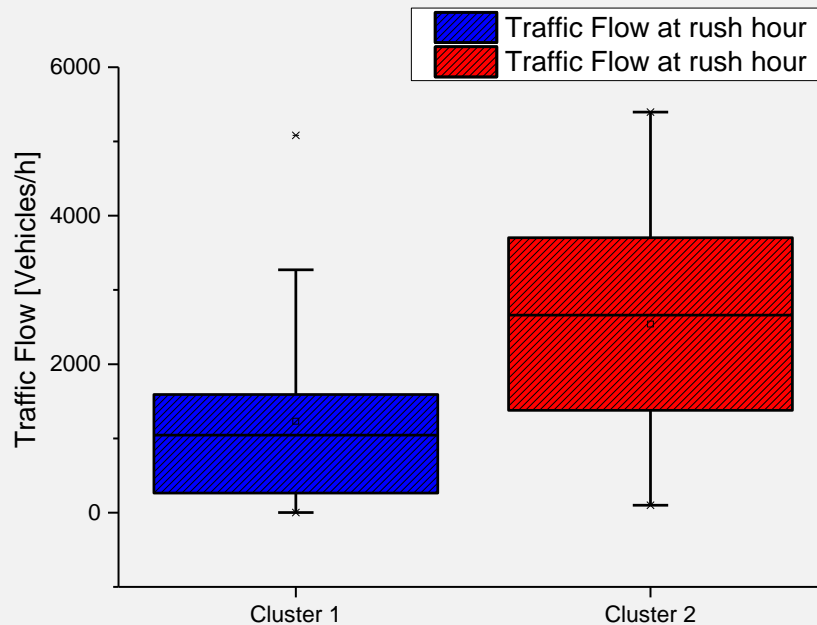
The Multi-Dimensional Scaling (MDS) applied to the data provides a visual representation of the pattern of proximities among the data. The distinction among clusters, marked by different colors, is rather good.



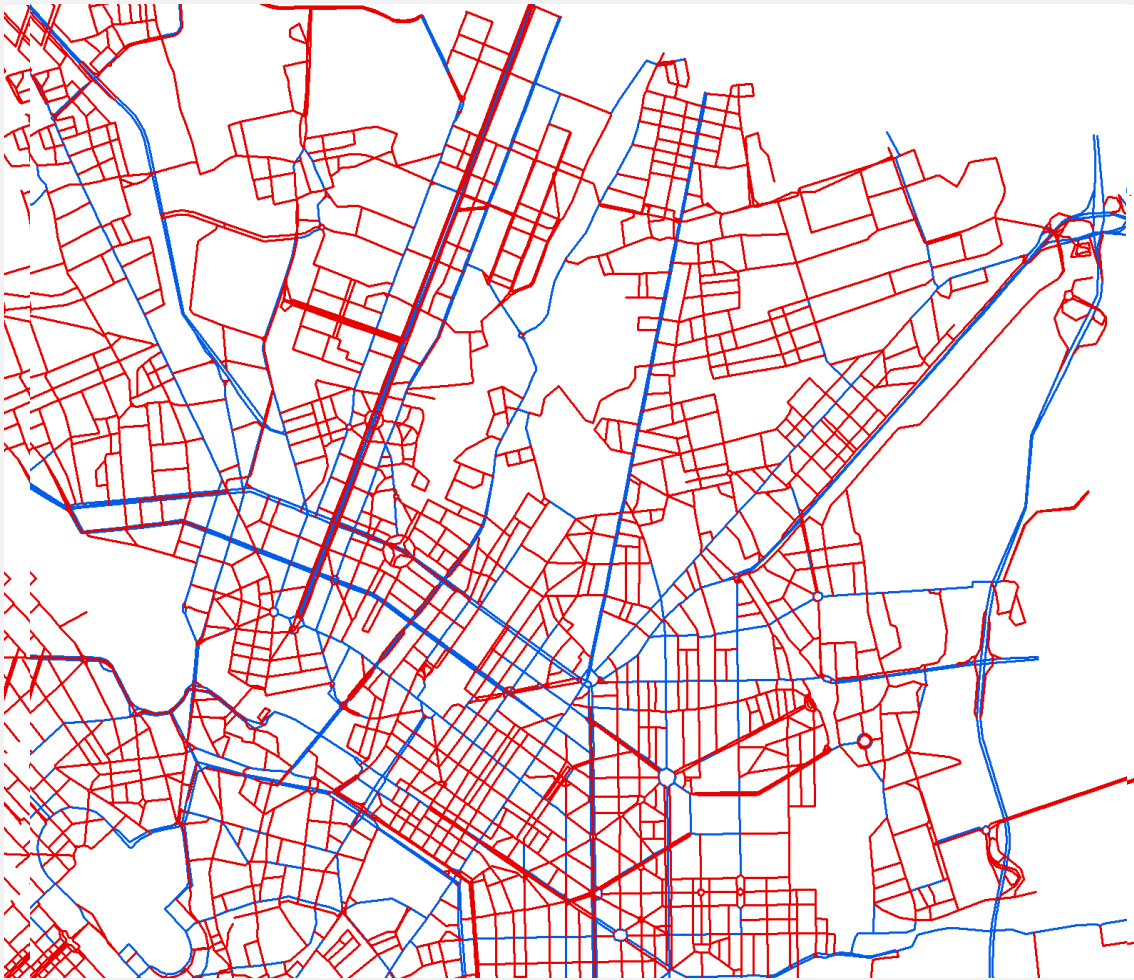
Numerosità	CLASSI			TOT
	D	E	F	
<b>Cluster 1</b>	5	12	43	60
	8%	20%	72%	
<b>Cluster 2</b>	4	18	13	35
	11%	51%	37%	
<b>TOT</b>	9	30	56	95

Distribution of the different road classes D,E,F in the two clusters

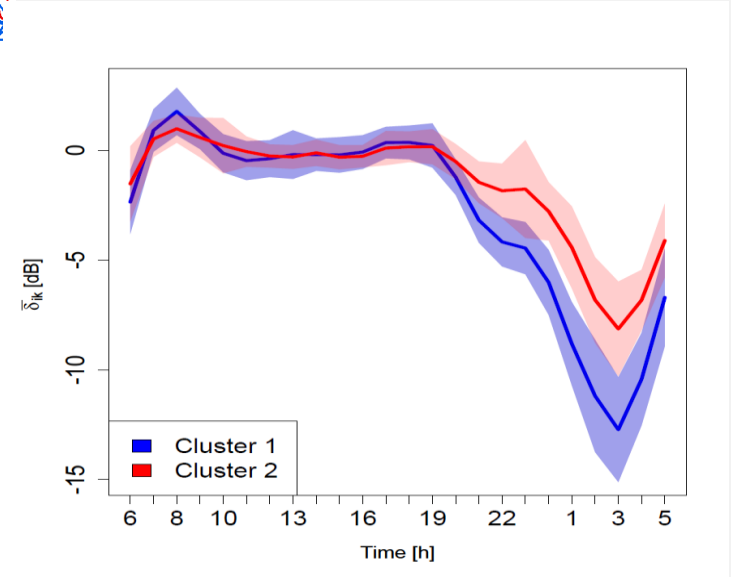
Identification of a non-acoustic parameter for the attribution of a non-monitored road to a cluster.  
Rush hour obtained from the traffic model.



The attribution will be made considering the threshold of 1850 V/h



**Cluster 1 + Cluster 2**



The whole roads network is divided between the two clusters

After the separation of the roads in the two clusters, which will be the pattern of each road, during the mapping?

The one provided by 24 low cost monitoring stations, installed in one of the two clusters.

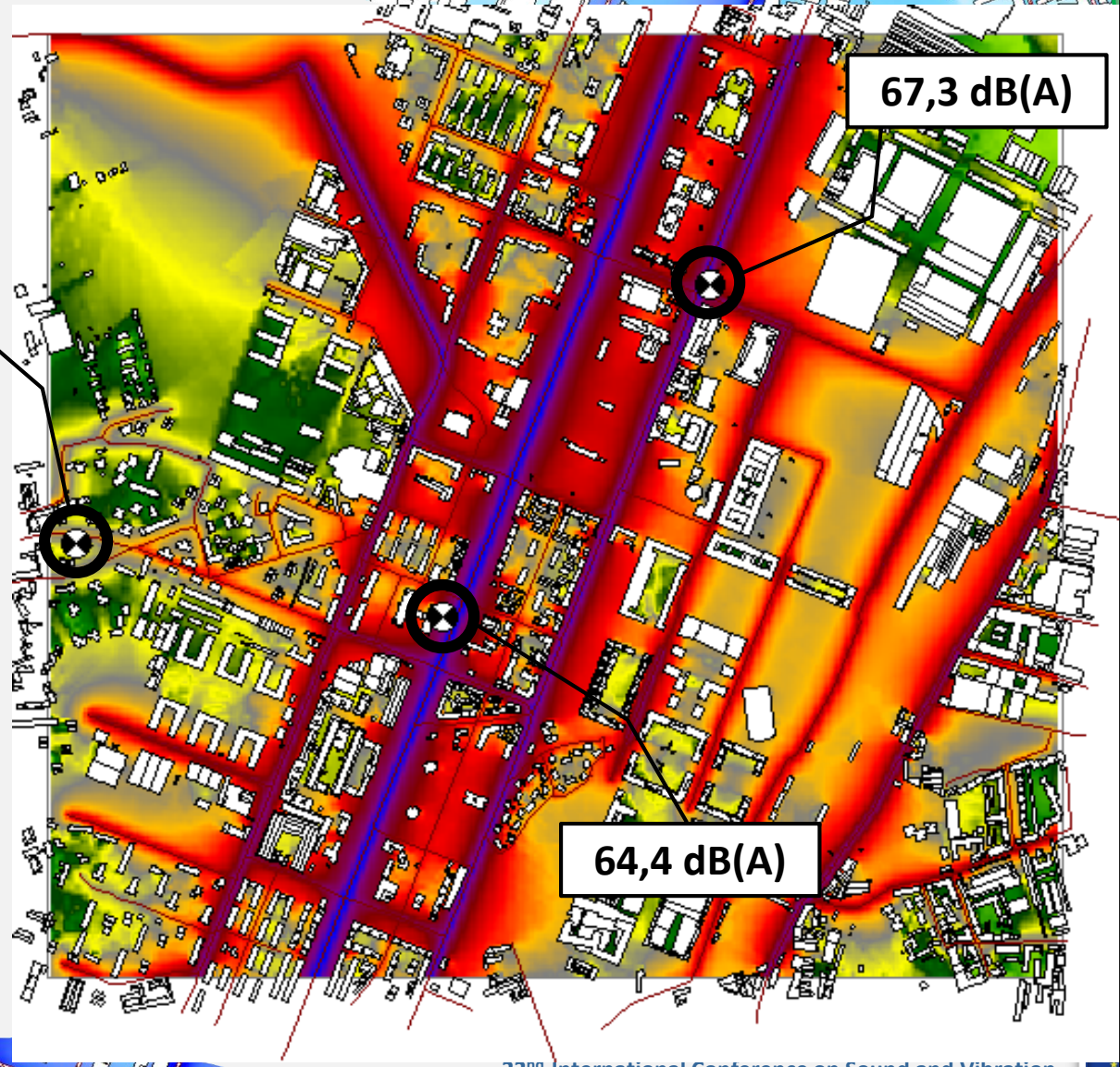
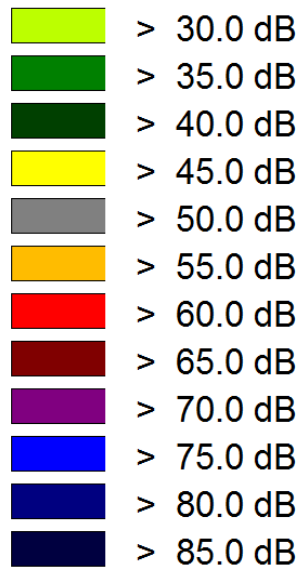
Starting from two basic maps (one for each cluster of roads), will be possible to get their hourly update. Subsequently, every hour, the two maps will be added together.

06:00

52,9 dB(A)

67,3 dB(A)

64,4 dB(A)

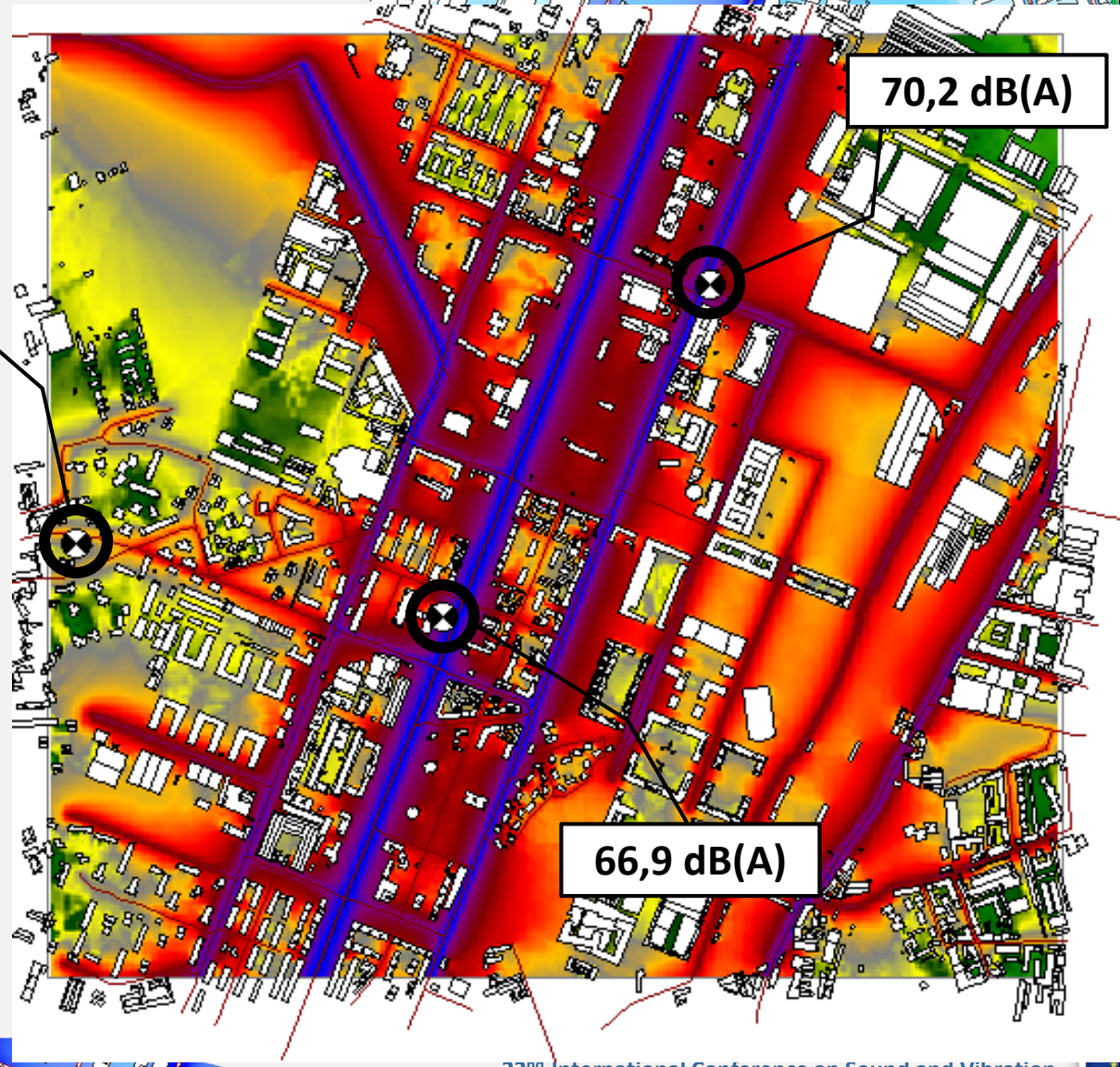
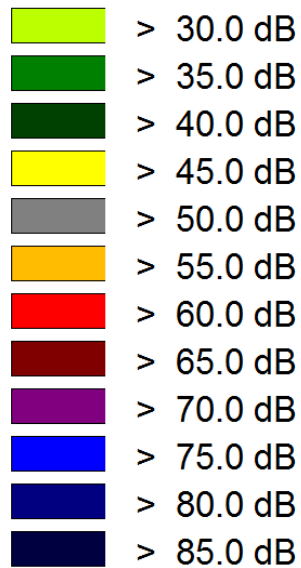


07:00

55,6 dB(A)

70,2 dB(A)

66,9 dB(A)

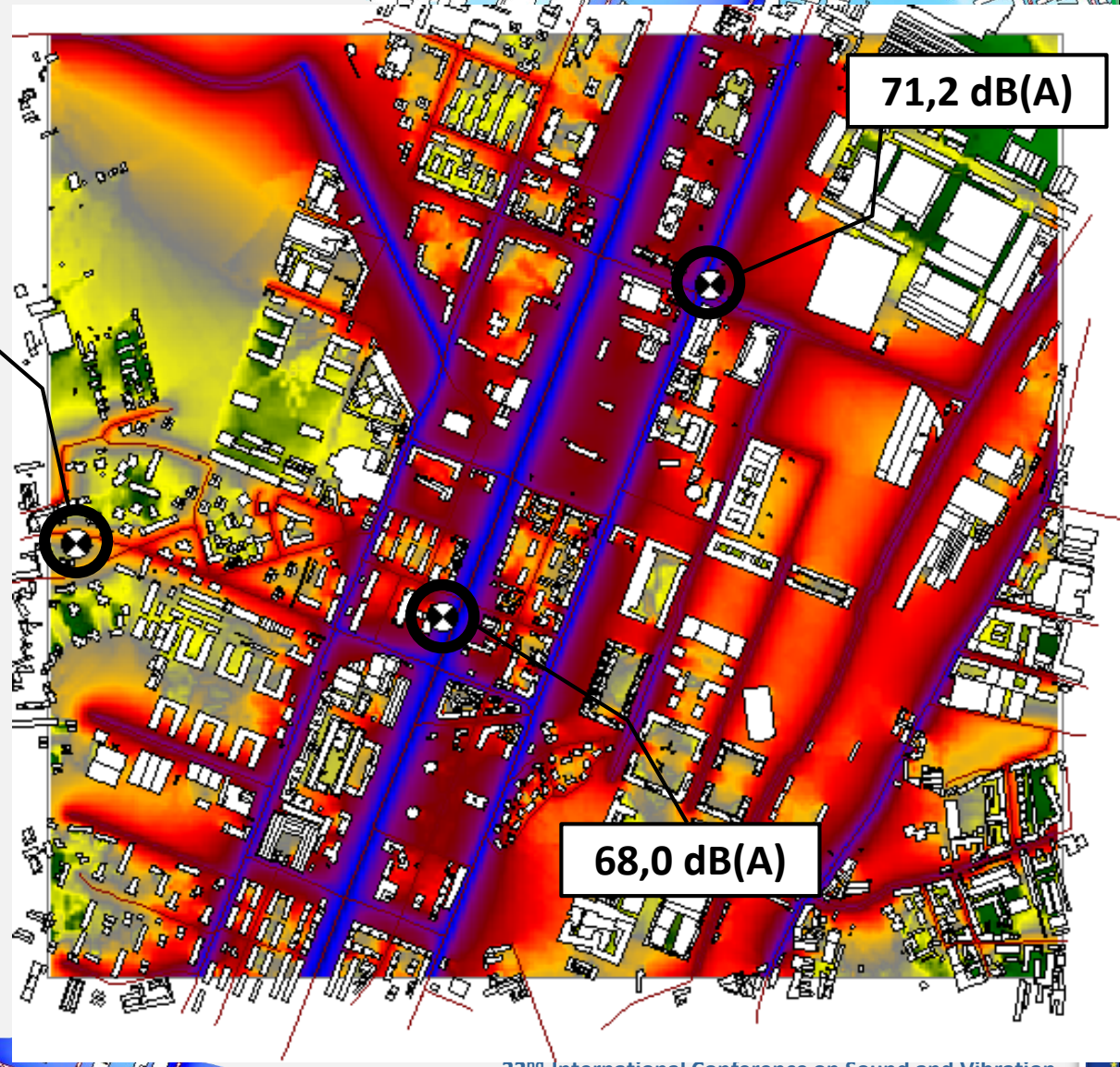
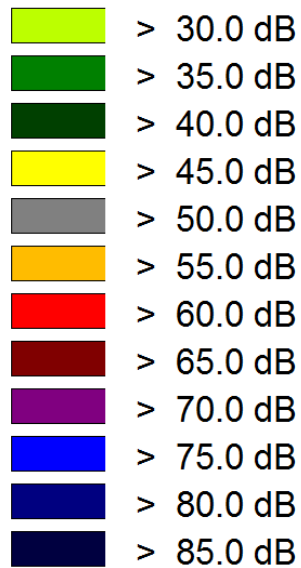


08:00

57,2 dB(A)

71,2 dB(A)

68,0 dB(A)

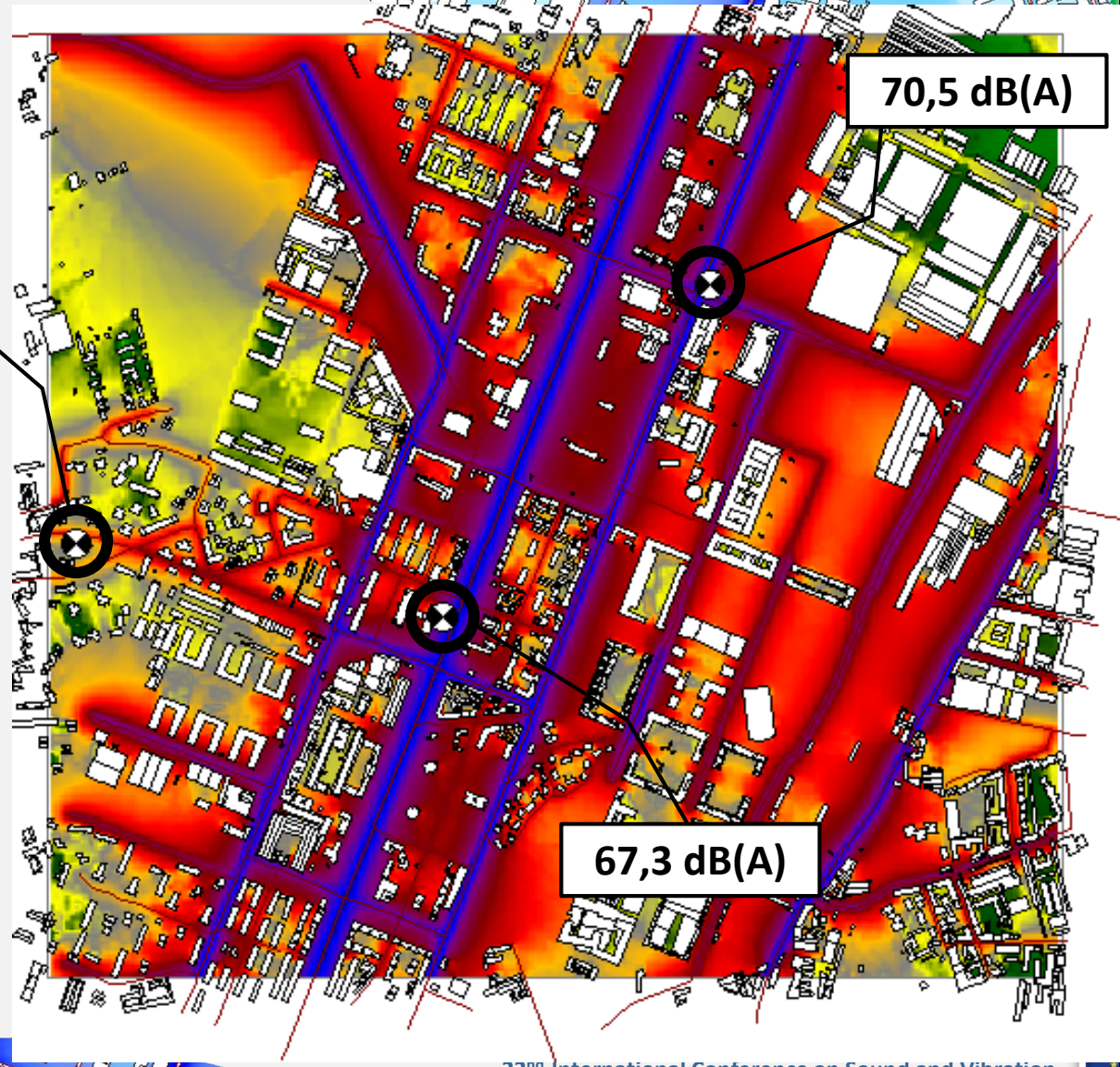
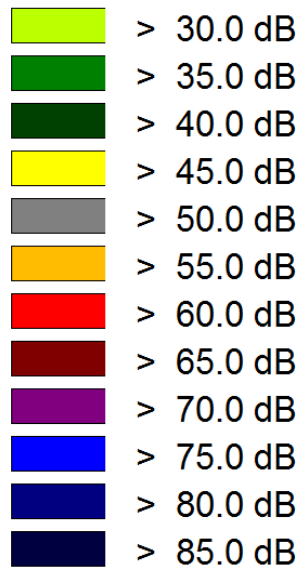


09:00

58,2 dB(A)

70,5 dB(A)

67,3 dB(A)



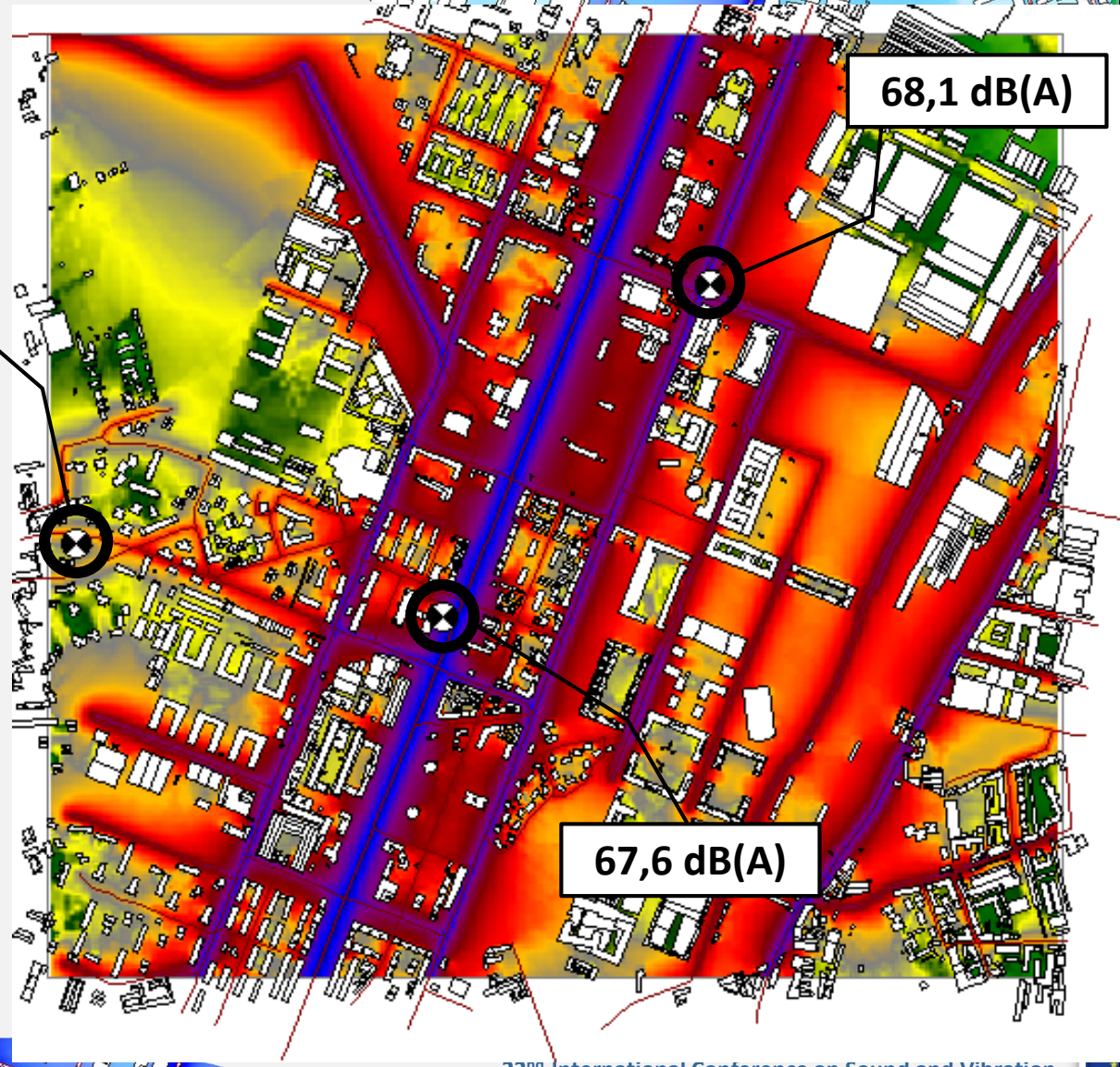
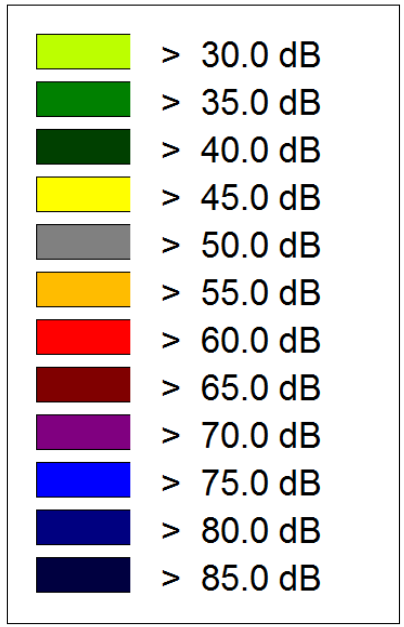


10:00

56,4 dB(A)

68,1 dB(A)

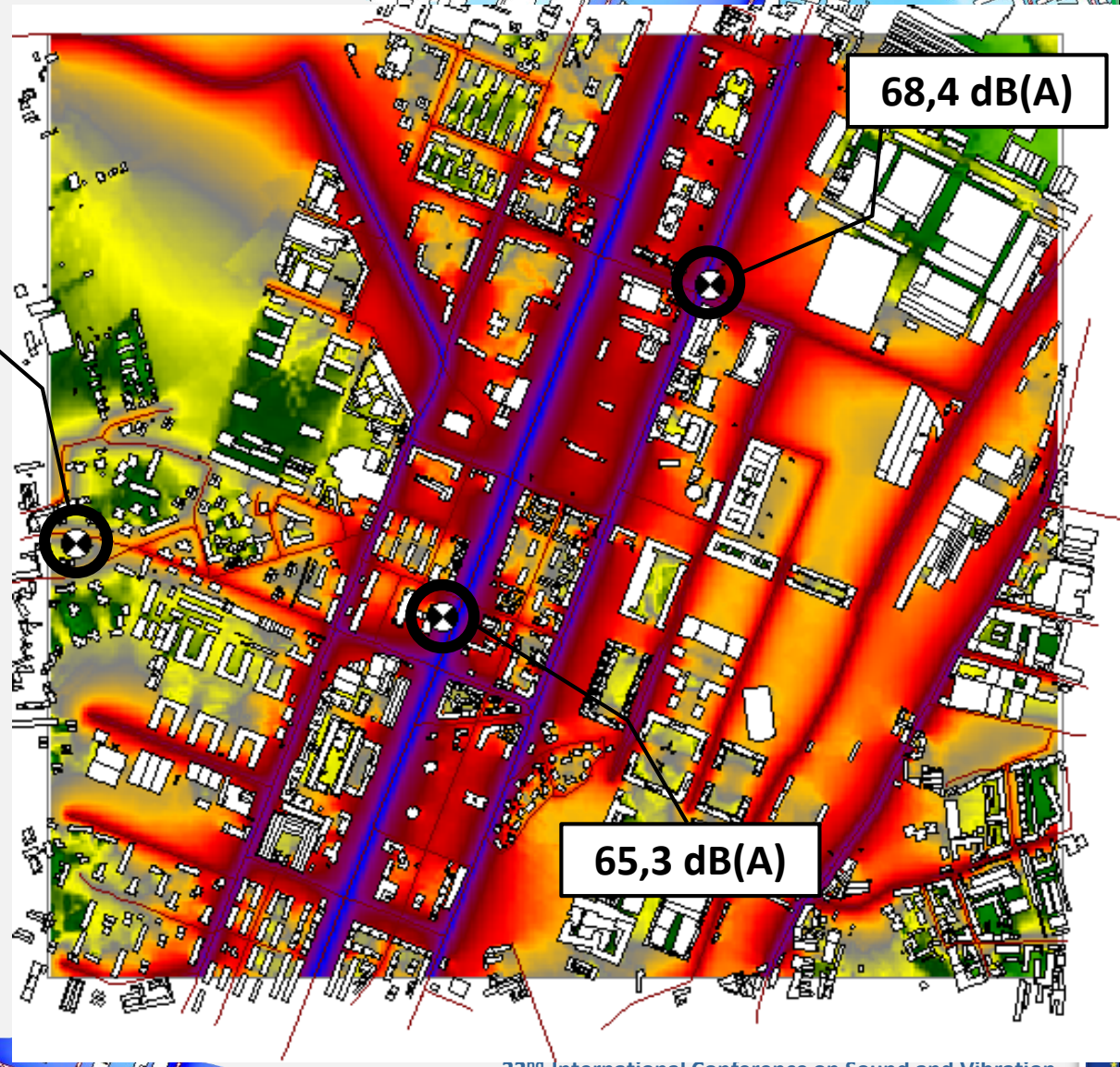
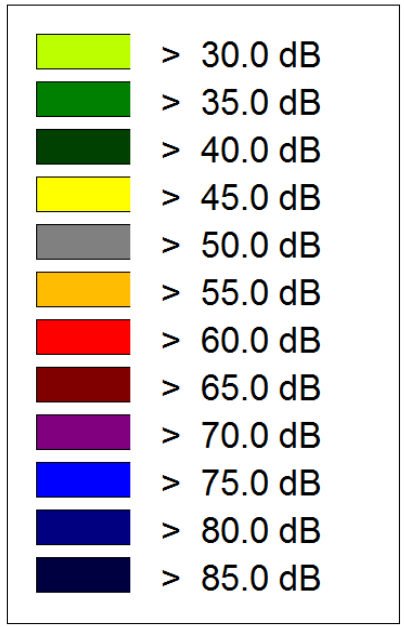
67,6 dB(A)



11:00

54,5 dB(A)

68,4 dB(A)



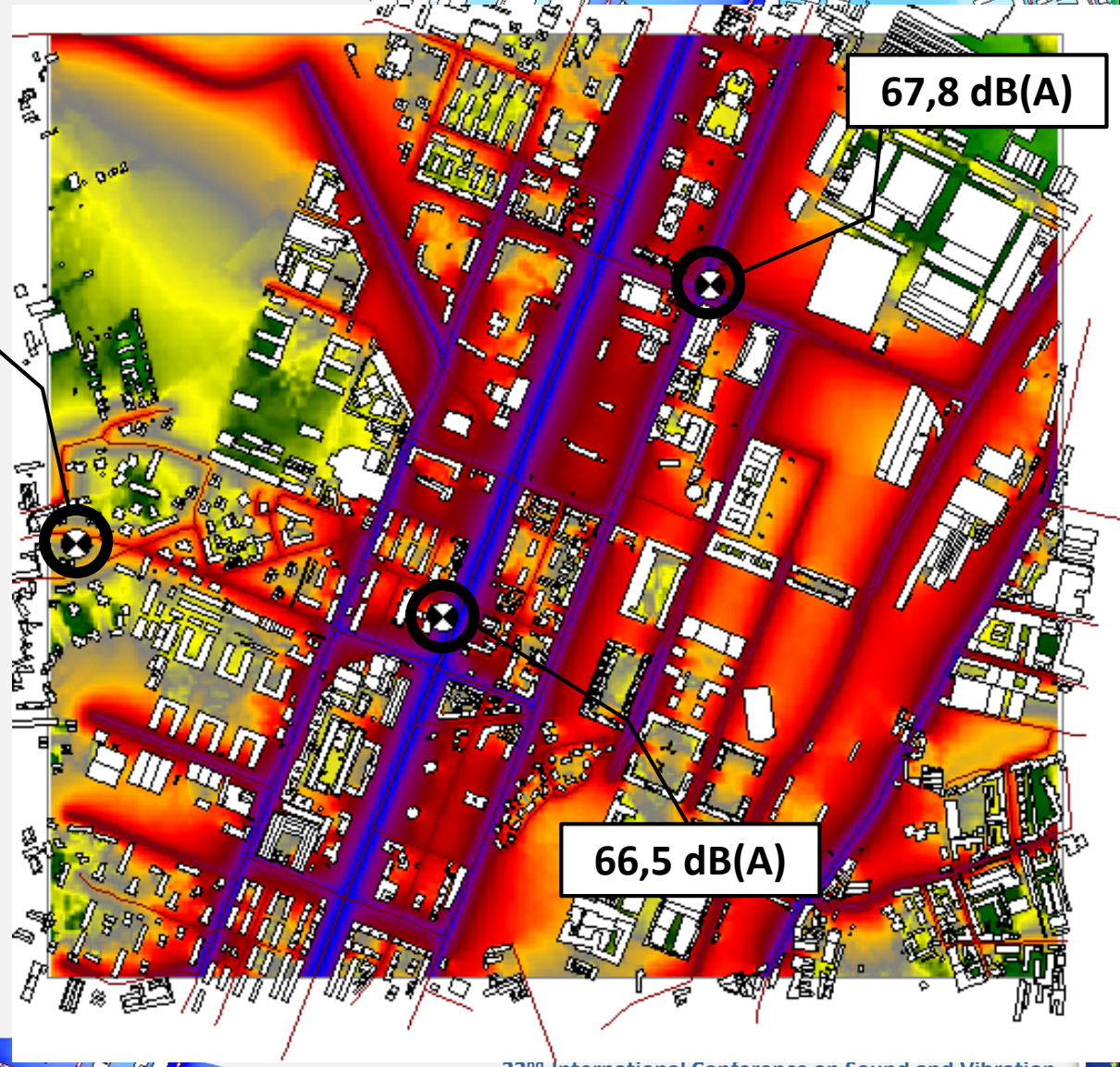
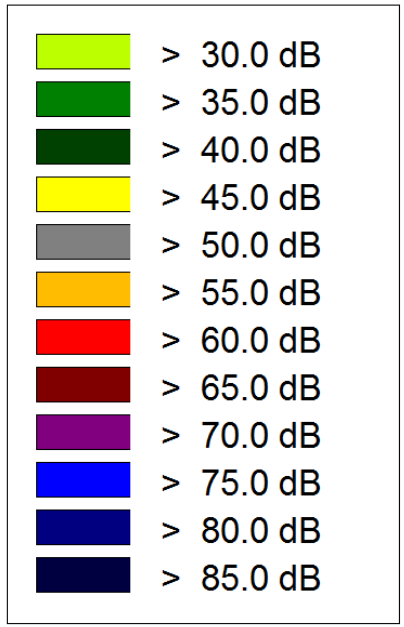
65,3 dB(A)

12:00

57,2 dB(A)

67,8 dB(A)

66,5 dB(A)

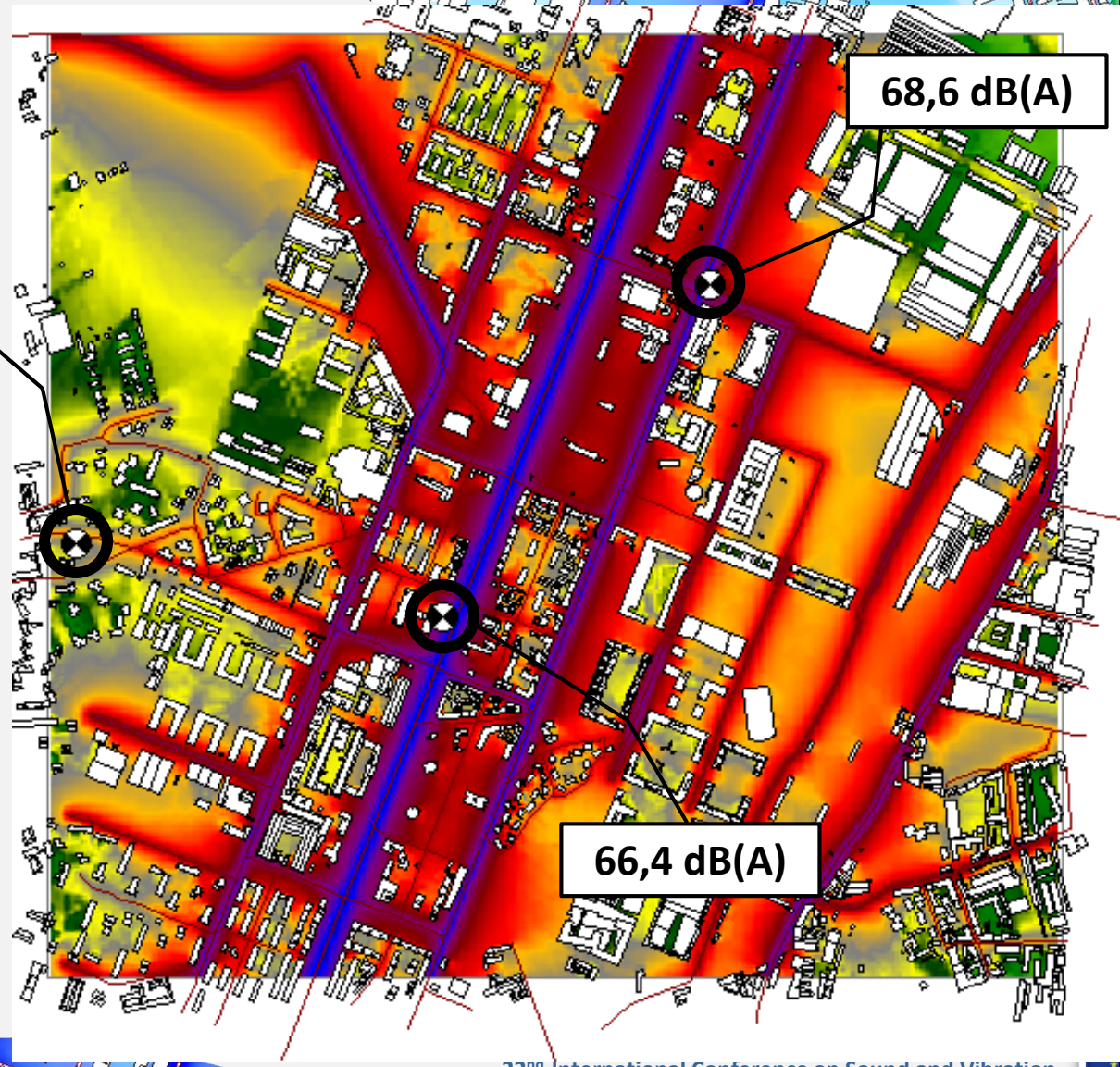
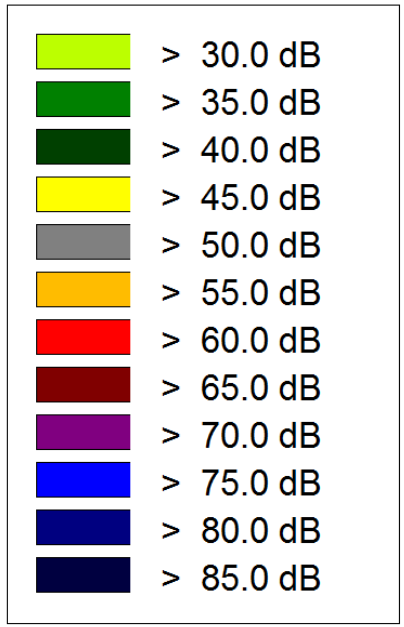


13:00

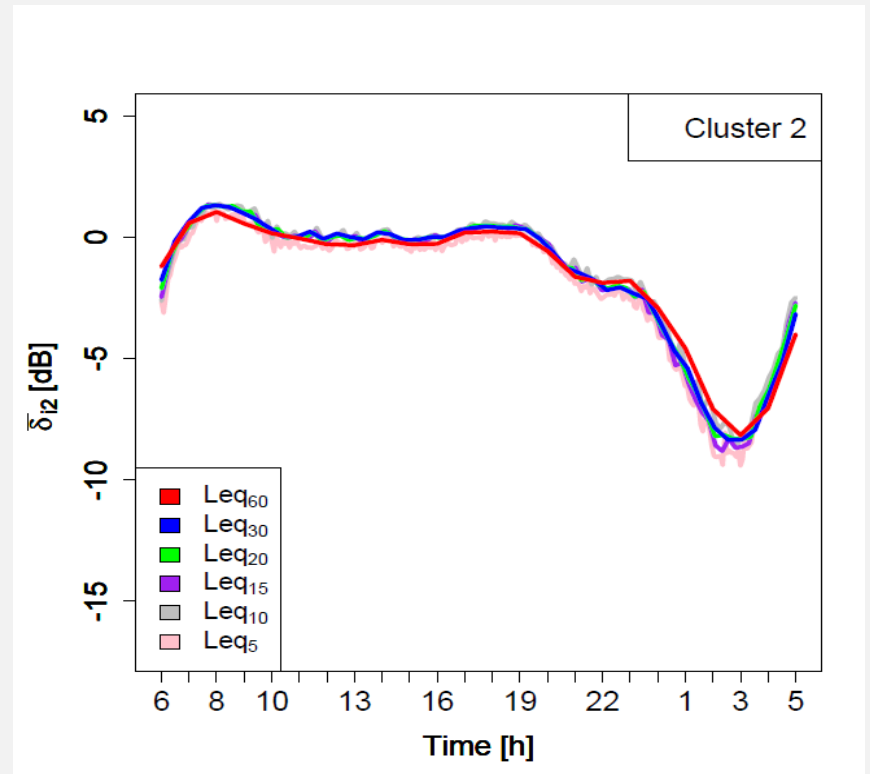
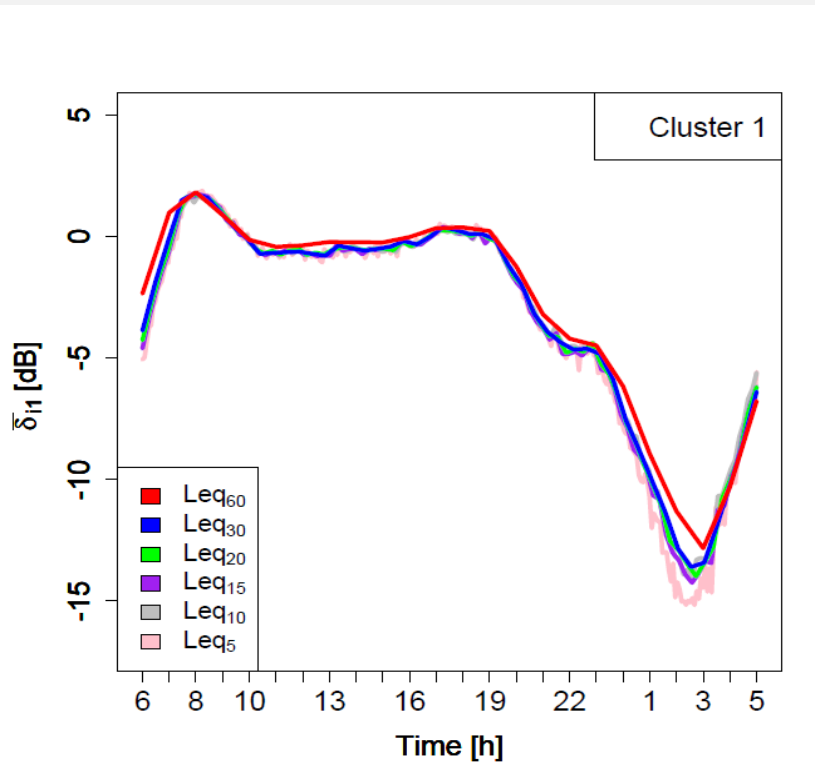
54,9 dB(A)

68,6 dB(A)

66,4 dB(A)



## Comparison among mean profiles with different temporal discretization

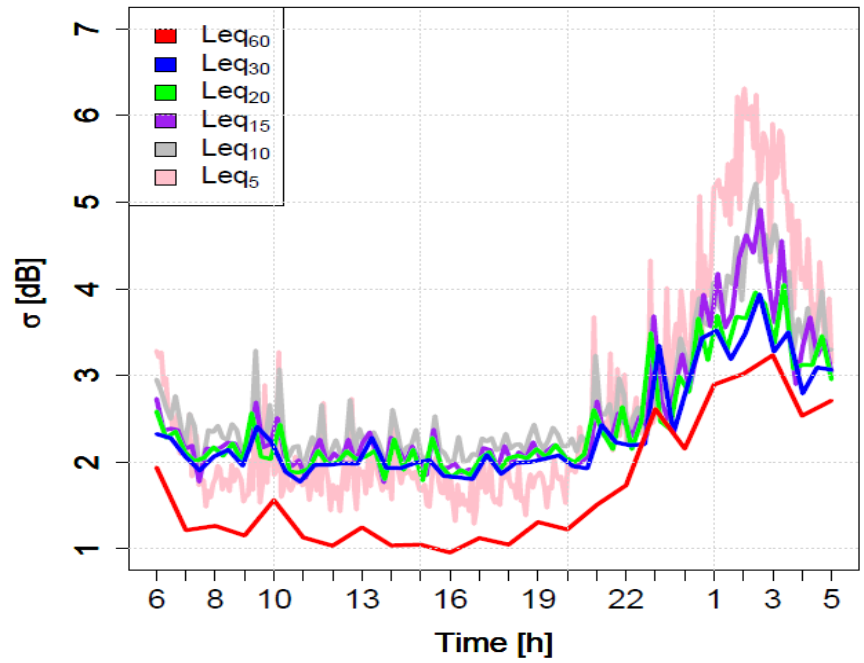


Good stability of noise profiles for all temporal resolution.

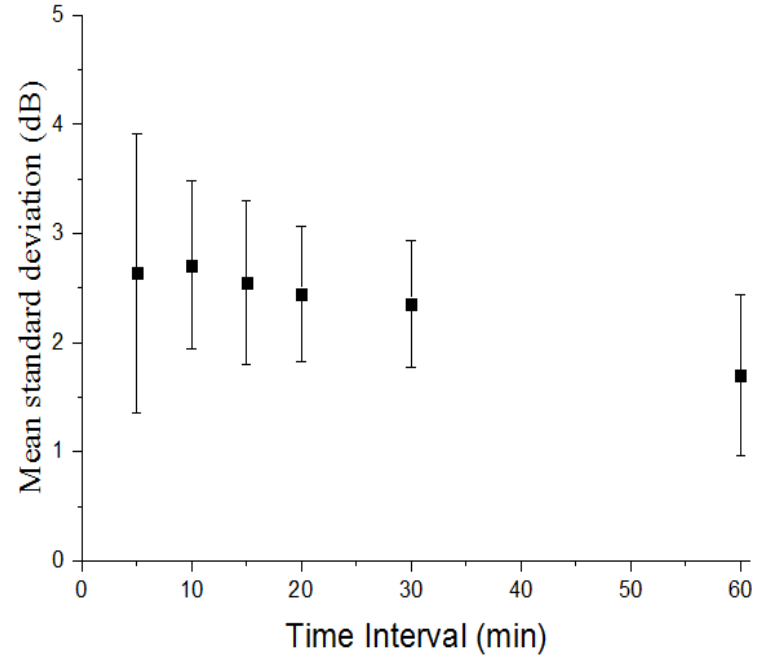
## Variation of the road composition within the cluster 1 for different integration time

CLUSTER 1	60 min	30 min	20 min	15 min	10 min	5 min
	D1	D1	D1	D1	D1	D1
	D3	D3	D3	D3	D3	D3
	D5	D5	D5	D5	D5	D5
	D6	D6	D6	D6	D6	D6
	D7	D7	D7	D7	D7	D7
	E1	E1	E1	E1	E1	E1
	E10	E10	E10	E10	E10	E10
	E11	E11	E11	E11	E11	E11
					E12	
E13	E13	E13	E13	E13	E13	
E19		E19	E19	E19	E19	
E20	E20	E20	E20	E20	E20	
				E21		
E22	E22	E22		E22	E22	
E23	E23	E23	E23	E23	E23	
				E24		
E25	E25	E25	E25	E25	E25	
E27				E27		
E5	E5	E5	E5	E5	E5	
E7	E7	E7	E7	E7	E7	
E21	E21	E21	E21	E21	E21	
	E22	E22	E22	E22	E22	
F10	F10	F10	F10	F10	F10	
				F1		
F11	F11	F11	F11	F11	F11	
F12	F12	F12	F12	F12	F12	
F13	F13	F13	F13	F13	F13	
F14	F14	F14	F14	F14	F14	
F16		F16		F16	F16	
F2	F2	F2	F2	F2	F2	
F21	F21	F21	F21	F21	F21	
F22	F22	F22	F22	F22	F22	
				F23		
F24	F24	F24	F24	F24	F24	

CLUSTER 1	60 min	30 min	20 min	15 min	10 min	5 min
	F26	F26	F26	F26	F26	F26
	F27	F27	F27	F27	F27	F27
					F28	
	F29	F29	F29	F29	F29	
	F3	F3	F3	F3	F3	F3
	F30	F30	F30	F30	F30	F30
	F32	F32	F32	F32	F32	F32
						F33
	F34	F34	F34	F34	F34	F34
F36	F36	F36	F36	F36	F36	
F37	F37	F37	F37	F37	F37	
F38	F38	F38	F38	F38	F38	
F39				F39		
F4					F4	
F40	F40	F40	F40	F40	F40	
F41	F41	F41	F41	F41	F41	
F43	F43	F43	F43	F43	F43	
			F44	F44	F44	
F45	F45	F45	F45	F45	F45	
F46	F46	F46	F46	F46	F46	
F48	F48	F48	F48	F48	F48	
F49	F49	F49	F49	F49	F49	
F5					F5	
F50	F50	F50	F50	F50	F50	
F51	F51	F51	F51	F51	F51	
F52	F52	F52	F52	F52	F52	
F54	F54	F54	F54	F54	F54	
F55	F55	F55	F55	F55	F55	
F56	F56	F56	F56	F56	F56	
F57	F57	F57	F57	F57	F57	
F6	F6	F6	F6	F6	F6	
F7	F7	F7	F7	F7	F7	
F8	F8	F8	F8	F8	F8	
F9a				F9a		
F9b	F9b	F9b	F9b	F9b	F9b	
TOT	60	54	56	55	66	59

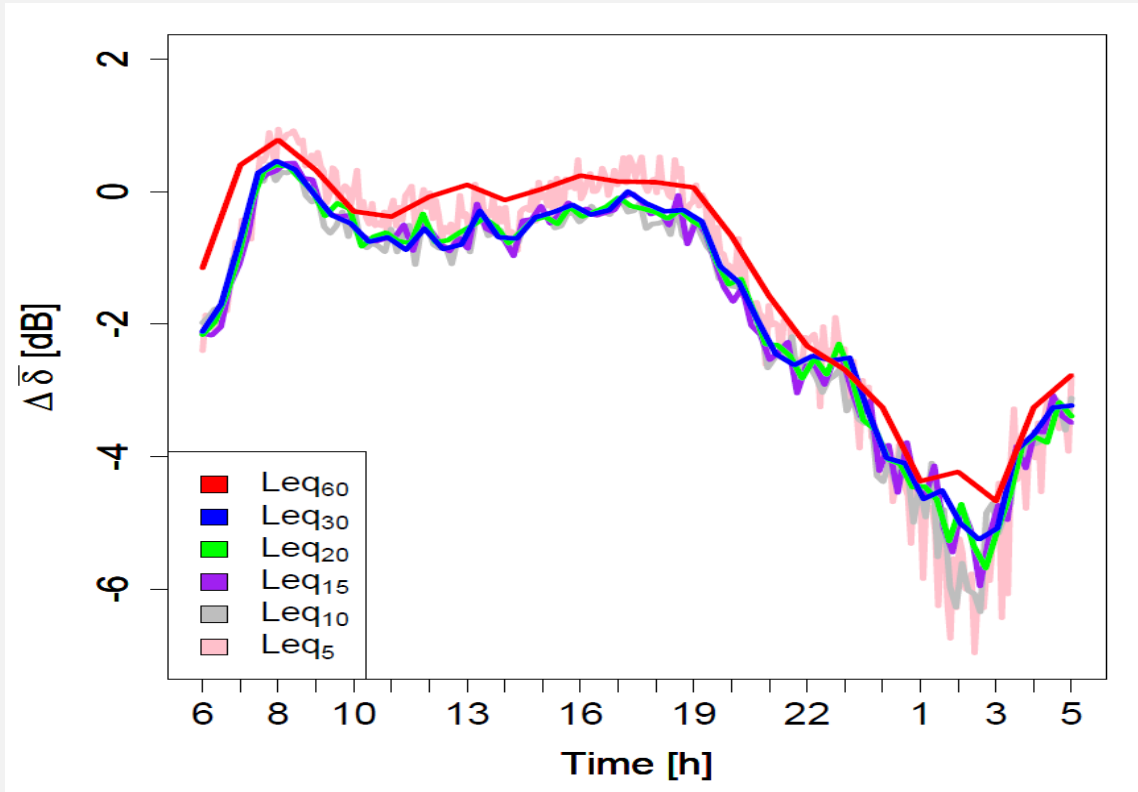


Associated errors to each time interval



Average errors associated to each time interval





Maximum error associated with a wrong attribution of a road to one of the two clusters