
HAQT deliverable 1-3: Final optimized sensor network in operational use in different environments

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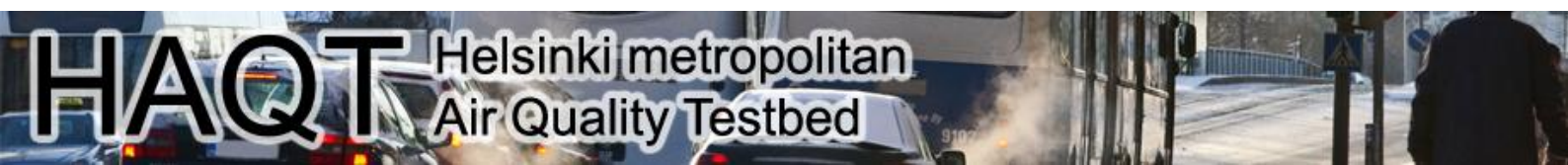
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19/03/2019



Final optimized sensor network in operational use in different environments

The HAQT (Helsinki metropolitan Air Quality Testbed) sensor network was established during autumn 2017. The number of AQ (Air Quality) monitoring stations and HAQT sensor sites was 12 and 15, respectively, in the Helsinki metropolitan area in year 2018 (Fig. 1 and Table 1). All measurement sites are located in the Helsinki metropolitan area which is formed by four cities, i.e. Helsinki, Espoo, Vantaa and Kauniainen. The sensor measurements complement the spatial coverage of air quality monitoring in the area. The sensor sites are located near major streets and roads as well as in small housing areas. Thus, the sites represent the main local pollutant sources, including traffic exhausts, street dust and emissions from small-scale wood combustion in the fire places and sauna stoves. The spatio-temporal variation is especially high for the emissions resulting from street dust and residential wood combustion, and therefore several measurement sites are needed to capture the local variation in air quality. Sensor were not placed at urban or rural background sites, since few air quality monitoring stations already exist in background areas. The spatial variation in pollutant concentration is much lower at background areas than at hotspot sites with poor air quality.

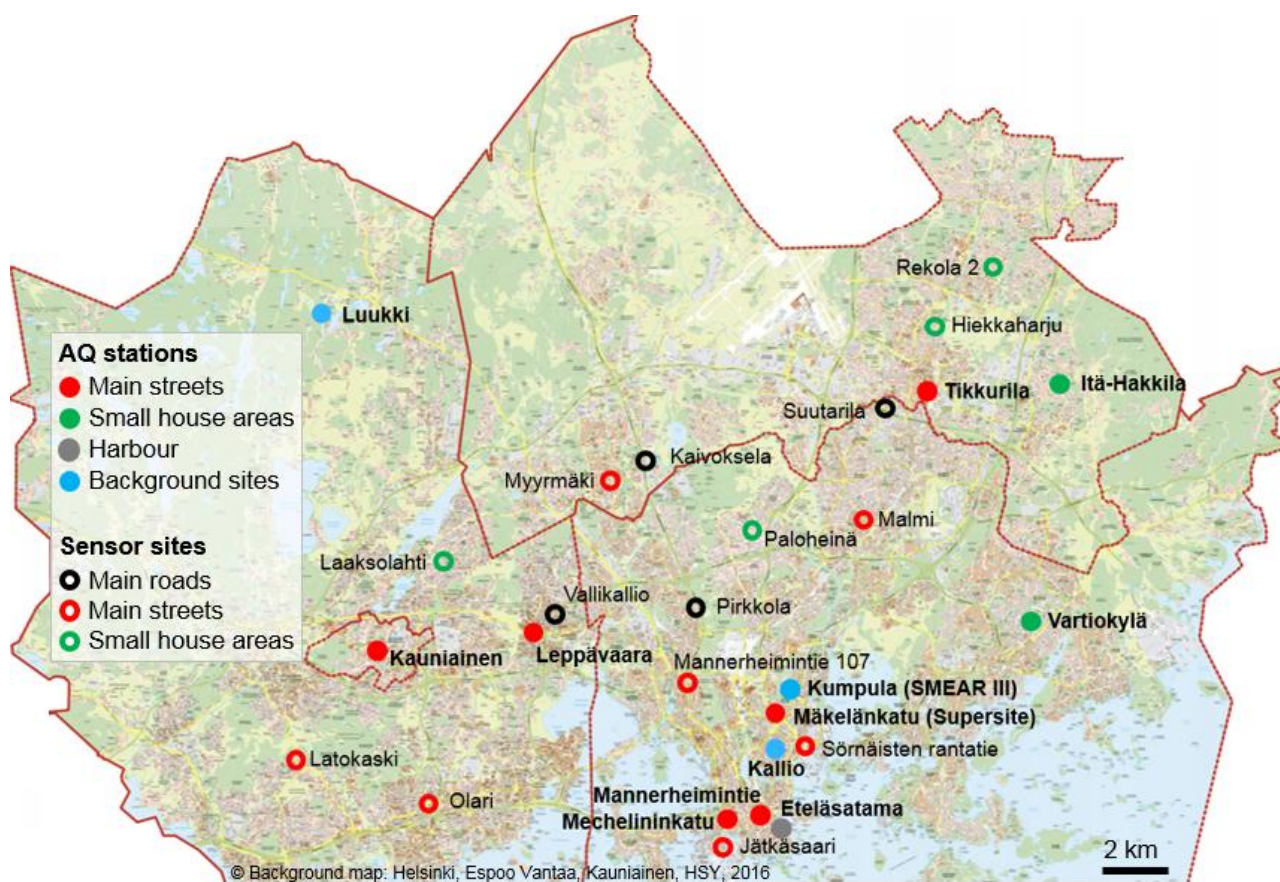


Figure 1. Map of AQ stations and HAQT sensor sites located in the Helsinki metropolitan area in 2018. The Helsinki metropolitan area is formed by the cities of Helsinki, Espoo, Vantaa and Kauniainen and the red lines show the city borders. Supersite station in Mäkelänkatu street canyon and SMEAR III research station in Kumpula urban background area are also depicted.

All sensor sites are equipped with Vaisala AQT420 sensor, measuring NO_2 , CO , O_3 , SO_2 , PM_{10} and $\text{PM}_{2.5}$ (Table 1). Furthermore, Pegasor AQ™ Urban sensors, measuring ultrafine particles, are located at 5 HAQT sensor sites (Hiekkaharju, Rekola 2, Paloheinä, Laaksolahti and Pirkkola) and at 5 AQ stations (Itä-Hakkila, Luukki, Kallio, Kumpula and Mäkelänkatu). The detailed descriptions for all 15 HAQT sensor sites are presented at the end of this document. The description of Itä-Hakkila AQ station is also presented in the last page. The

rest of the AQ stations are described in the HAQT project Deliverable 4-1 (Mäkeläncatu supersite station and Kumpula SMEAR III research station) as well as in the air quality reports published by HSY (Luukki and Kallio background stations; Malkki et al., 2018).

Table 1. Characteristics of HAQT sensor sites with Vaisala AQT420 and Pegasor AQ™ Urban sensors and AQ stations in the Helsinki metropolitan area in year 2018.

Site name	Code	City	Site type	Distance to street or road edge (m)	Traffic volume (vehicl. per workday)	Heavy duty traffic (%)	AQT 420	AQ™ Urban
Sensor sites:								
Sörnäisten rantatie	sSÖR	Hki	Main street	7	44 500	4	x	
Mannerheimintie 107	sM107	Hki	Main street	10	30 700	10	x	
Jätkäsaari	sJÄT	Hki	Main street	6	7 600	11	x	
Malmi	sMAL	Hki	Main street	11	7 700	13	x	
Olari	sOLA	Esp	Main street	11	19 800	5	x	
Latokaski	sLAT	Esp	Main street	12	18 000	11	x	
Myrmymäki	sMYY	Van	Main street	2	15 000	11	x	
Pirkkola (VT 3)	sPIR	Hki	Main road	5	50 200	8	x	
Suutarila (Kehä III)	sSUU	Hki	Main road	6	63 900	7	x	
Vallikallio (Kehä I)	sVAL	Esp	Main road	2	81 800	5	x	
Kaivoksela (VT 3)	sKAI	Van	Main road	4	61 100	7	x	x
Paloheinä	sPAL	Hki	Small house area	40	1 300	17	x	x
Laaksolahti	sLAA	Esp	Small house area	5	small*		x	x
Hiekkaharju	sHIE	Van	Small house area	20	small*		x	x
Rekola 2	sREK2	Van	Small house area	5	small*		x	x
AQ stations:								
Mäkeläncatu supersite	MÄK	Hki	Street canyon	1	28 100	11	(x)	x
Kumpula SMEAR III	KUM	Hki	Urban background	150	43 000	13		x
Kallio	KAL	Hki	Urban background	65	6 300	4		x
Luukki	LUU	Esp	Regional background	800	6 500	4		x
Itä-Hakkila	I-HAK	Van	Small-house area	6	2 700	6	x	x
Vartiokylä	VAR	Hki	Small-house area	60	2 400	9		
Mannerheimintie	MAN	Hki	Main street	3	15 900	5		
Mechelininkatu	MEC	Hki	Main street	5	35 500	4		
Leppävaara	LEP	Esp	Main road and street	14	29 300	4		
Kauniainen	KAU	Kau	Main street	8	14 400	4		
Tikkurila	TIK	Van	Main street	10	9 500	5		
Eteläsatama	E-SAT	Hki	Harbour	38	10 200	7		

* Traffic volume is very small, probably less than a few hundred per day.

The locations of 15 sensor site were carefully planned to get optimal information for air quality communication to citizens as well as to authorities that are responsible for air quality actions. The sensor sites were selected based on long-term knowledge obtained from air quality monitoring and research activities in the Helsinki metropolitan area. The utilized background information included;

- AQ monitoring results from numerous sites in Helsinki metropolitan area during last 10-20 years (numerous locations for AQ measurement stations, see Aarnio et al., 2016; hundreds of passive measurements sites for NO₂ between years 2004 and 2017, see www.kartta.hsy.fi)
- Traffic volume and exhaust emission inventory maps for street and road networks
- Locations of tall buildings beside streets and street canyons
- Street and road maintenance areas of different operators for street dust mitigation actions; 1-3) Helsinki city street network divided in three maintenance districts (West, Middle and East), 4) Espoo city street network, 5) Vantaa city street network and 6) the main road network maintained by tenders selected by the Uusimaa ELY centre
- Emissions inventory for residential wood combustion (100 x 100 m spatial resolution)
- Population density maps
- Air quality modelling results for the major local pollution sources (vehicle traffic, small-scale wood combustion, harbours, airport as well as power and heat plants)

The practical steps in establishing the new sensor network included 1) planning of sensor network (representative and unbiased measurement network), 2) searching for suitable sites with electricity supply and placement permit, and 3) installation of sensors to final measurement sites. HSY published a media release in September 2017 to find measurement sites for sensors (<https://www.hsy.fi/fi/tietoa-hsy/uutishuone/2017/Sivut/HSY-etsii-ilmanlaadun-mittauspaikkoja-Onko-kentties-sinun-asuinalueesi-sopiva.aspx>). A few suitable sensor sites were selected to HAQT sensor network based on the suggestions by the volunteers. The rest of the sites were searched and selected by the HSY's air quality experts in co-operation with the environmental authorities of the cities. Electricity is needed at every sensor site, and therefore it is a time-consuming task to find optimal sensor sites from the air quality point of view.

Before installing the AQT420 instruments to the sensor network, all sensors were first compared to reference instruments at HSY's AQ supersite station in Mäkelänkatu street canyon during 3-4-week periods. Based on the comparison results from the supersite station, correction equations were calculated for each AQT420 sensor to obtain maximal accuracy in the sensor network.

The sensor data will be utilized in air quality fusion modelling (FMI-ENFUSER) to obtain more reliable air quality now- and forecasts. The fusion modelled air quality maps with high spatial resolution (12 x 12 m) and 12 hour forecast are already available at the HSY's air quality map webpages (<https://www.hsy.fi/en/residents/theairyoubreathe/Pages/airqualitymap.aspx>). These maps can also be seen in the info displays of trams and metros. The modelled air quality results (FMI-ENFUSER) are available as open data for further use and applications (<https://ilmatieteenlaitos.fi/avoin-data>). Furthermore, sensor measurement data is also utilized directly without modelling to support street dust mitigation measures, especially during spring time.

References

Aarnio, P., Kousa, A., Malkki, M. 2016. Air quality and factors affecting it in the Helsinki Metropolitan area during 2006 – 2015. Background report for the Air Quality Plan. (in Finnish with an abstract in English) HSY's publications 9/2016. 121 p.

Malkki, M., Loukkola, K., Portin, H. 2018. Air quality in the Helsinki metropolitan area in 2017. (in Finnish with an abstract in English) HSY publications 2/2018. 132 p.

HAQT project Deliverable 4-1. Evaluation of current Kumpula AQ observations and benefits from two close-by supersites in Kumpula and in Mäkelänkatu

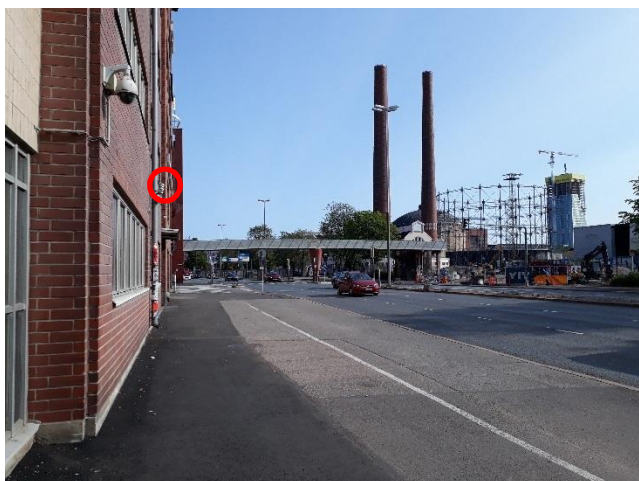
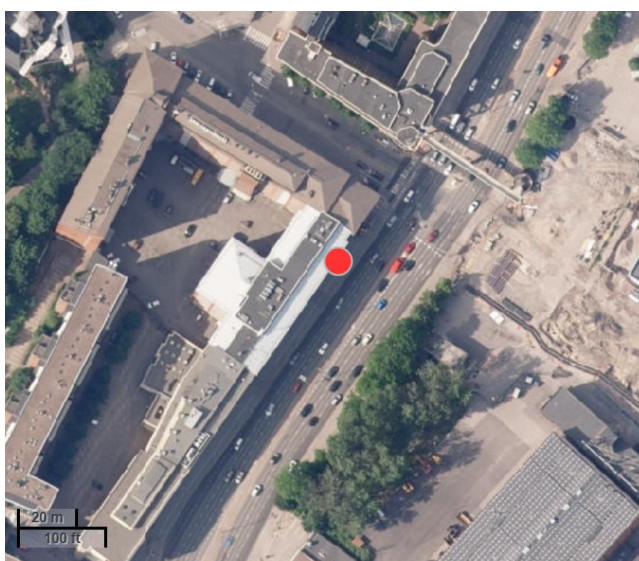
Sörnäisten rantatie (sSÖR)

Name of sensor site	Sörnäisten rantatie
Measurement site type	Traffic, main street
Address and city	Sörnäisten rantatie 27, Helsinki
Coordinates	60.186055, 24.967474
Sampling height	4 m
Distance from street edge	7 m
Measurement devices	Vaisala AQT420

Short description of sampling site and local pollution sources

Sörnäisten rantatie sensor site represents a busy traffic environment in the downtown of Helsinki. The measurement site is located on the wall of a 6-storey building. The sensor site is mainly affected by traffic exhausts and street dust. The distances and traffic characteristics of the nearby traffic streets area as follows;

- Sörnäisten rantatie 7 m, 44 500 vehicles per workday (HDV 4%) and 60 km/h speed limit.
- Junatie 290 m in north (starting point of Itäväylä road) and 24 400 vehicles per workday (HDV 6%) and 60 km/h speed limit.



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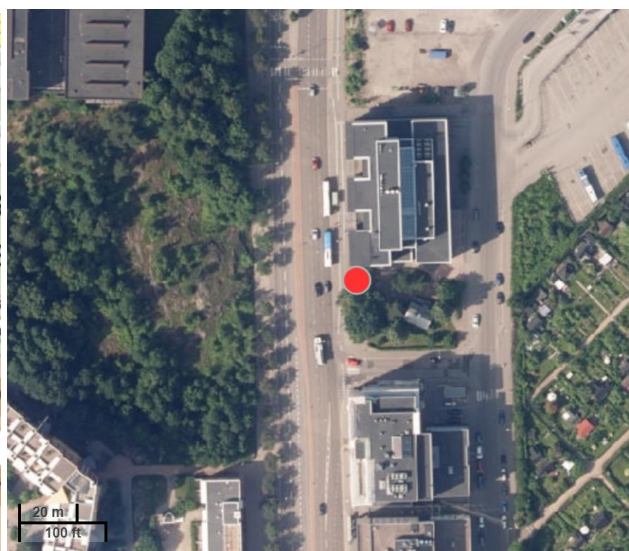
Mannerheimintie 107 (sM107)

Name of sensor site	Mannerheimintie 107
Measurement site type	Traffic, main street
Address and city	Mannerheimintie 107, Helsinki
Coordinates	60.20494, 24.899453
Sampling height	3 m
Distance from street edge	10 m
Measurement devices	Vaisala AQT420

Short description of sampling site and local pollution sources

Mannerheimintie 107 sensor site represents a busy traffic environment in the downtown of Helsinki. The measurement site is located close to the corner on 6-storey building. The sensor site is mainly affected by traffic exhausts and street dust. The distances and traffic characteristics of the nearby traffic streets area as follows;

- Mannerheimintie 10 m, 30 700 vehicles per workday (HDV 10%) and speed limit 50 km/h.
- Hakamäentie 330 m in north and 47 200 vehicles per workday (HDV 9%) and speed limit 60 km/h.



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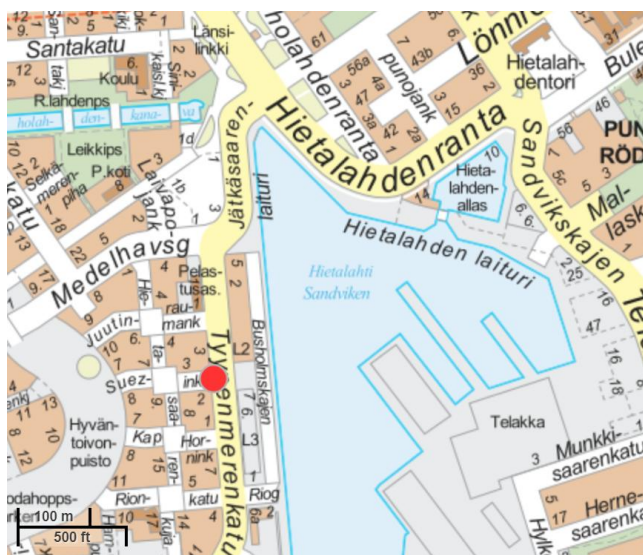
Jätkäsaari (SJÄT)

Name of sensor site	Jätkäsaari
Measurement site type	Traffic, main street
Address and city	Suezinkatu 3, Helsinki
Coordinates	60.158452, 24.921396
Sampling height	3 m
Distance from street edge	9 m
Measurement devices	Vaisala AQT420

Short description of sampling site and local pollution sources

Jätkäsaari sensor site represents a busy traffic environment in the Jätkäsaari district of Helsinki. The measurement site is located on the corner of a 8-storey building. The sensor site is mainly affected by traffic exhausts, street dust and construction work dust as well as ship emissions from Länsisatama harbour. The distances and traffic characteristics of the nearby traffic streets area as follows;

- Tyynenmerenkatu 9 m, 7 600 vehicles per workday (HDV 11%) and 30 km/h speed limit.
- Hietalahdenranta 480 m 25 400 vehicles per workday (HDV 3%) and 40 km/h speed limit.



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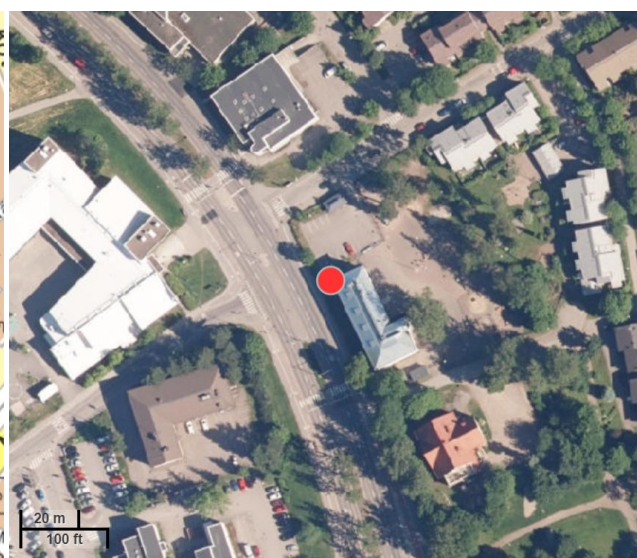
Malmi (sMAL)

Name of sensor site	Malmi
Measurement site type	Traffic, main street
Address and city	Kirkonkyläntie 25
Coordinates	60.255048, 25.002348
Sampling height	4 m
Distance from street edge	11 m
Measurement devices	Vaisala AQT420

Short description of sampling site and local pollution sources

Malmi sensor site represents a busy traffic environment in the Malmi district of Helsinki. The measurement site is located on the corner of a 3-storey building (daycare centre for children). The sensor site is mainly affected by traffic exhausts and street dust. There is also residential wood combustion in nearby detached house areas. The distances and traffic characteristics of the nearby traffic streets area as follows;

- Kirkonkyläntie 11 m, 7 700 vehicles per workday (13 %) and 40 km/h speed limit.



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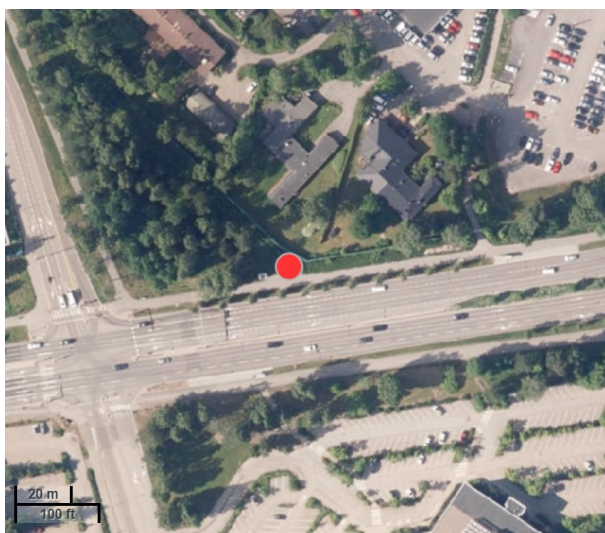
Olari (SOLA)

Name of sensor site	Olari
Measurement site type	Traffic, main street
Address and city	Kuitinmäentie XX, Espoo
Coordinates	60.169993, 24.749385
Sampling height	3 m
Distance from street edge	11 m
Measurement devices	Vaisala AQT420

Short description of sampling site and local pollution sources

Olari sensor site represents a busy traffic environment in the city of Espoo. The sampling site is mainly affected by traffic exhausts and street dust. The distances and traffic characteristics of the nearby traffic lines area as follows;

- Kuitinmäentie street 11 m, 19 800 vehicles per workday (HDV 5%) and speed limit 50 km/h.
- Kilonväylä road (i.e. Ring II road) 200 m and 62 100 vehicles per workday (HDV 4%).
- Uuskartanontie street 67 m and 5 200 vehicles per workday (HDV 7%).



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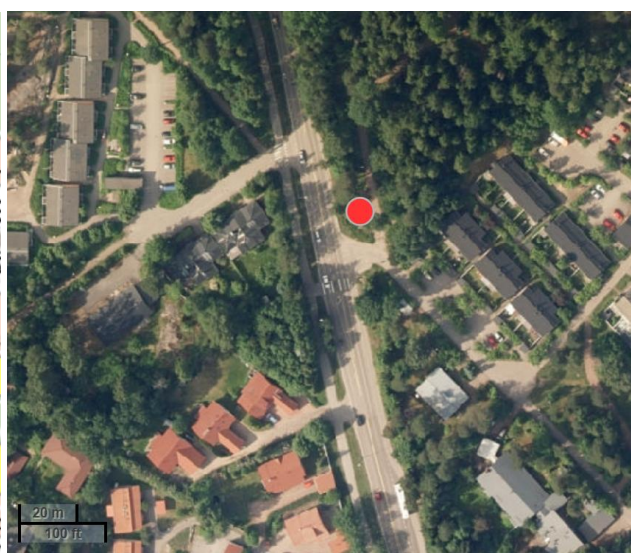
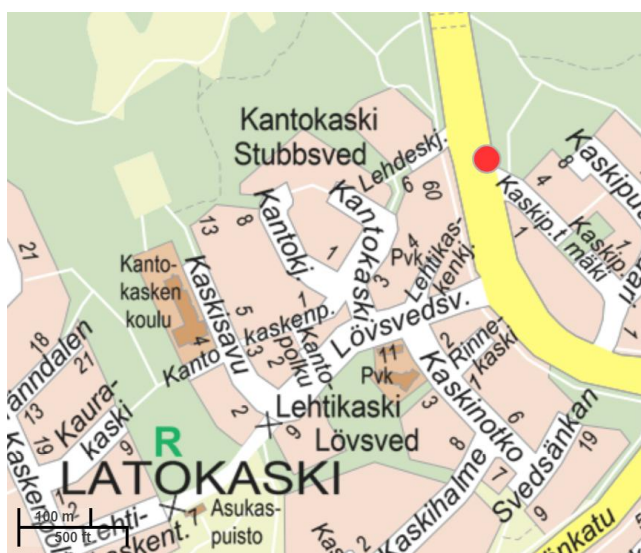
Latokaski (sLAT)

Name of sensor site	Latokaski
Measurement site type	Traffic, main street
Address and city	Finnoontie 67, Espoo
Coordinates	60.182725, 24.670396
Sampling height	3 m
Distance from street edge	12 m
Measurement devices	Vaisala AQT420

Short description of sampling site and local pollution sources

Latokaski sensor site represents a traffic environment in the Latokaski district of Espoo. The measurement site is located beside Finnoontie street. The sensor site is mainly affected by traffic exhausts and street dust. There is also residential wood combustion in nearby detached house areas. The distances and traffic characteristics of the nearby traffic streets area as follows;

- Finnoontie 12 m, 18 100 vehicles per workday (HDV 11%) and 50 km/h speed limit.



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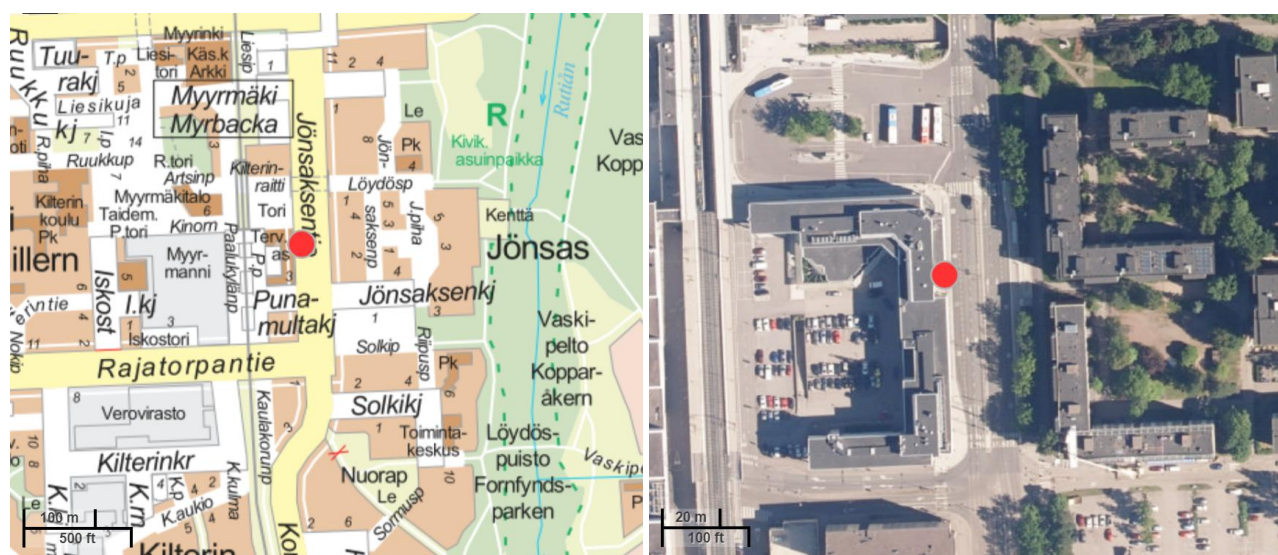
Myyrmäki (sMYY)

Name of sensor site	Myyrmäki
Measurement site type	Traffic, main street
Address and city	Jönsaksentie 4, Vantaa
Coordinates	60.260775, 24.856364
Sampling height	4 m
Distance from street edge	2 m
Measurement devices	Vaisala AQT420

Short description of sampling site and local pollution sources

Myyrmäki sensor site represents a busy traffic environment in the Myyrmäki district of Vantaa. The measurement site is located near a bus stop on the wall of a 4-storey building. There are also 5-storey buildings on the other side of Jönsaksentie street, which reduces dilution of pollutants. The sensor site is mainly affected by traffic exhausts and street dust. The distances and traffic characteristics of the nearby traffic streets area as follows;

- Jönsaksentie 2 m, 15 000 vehicles per workday (HDV ~11%, estimate based on nearby Vaskivuorentie) and 40 km/h speed limit.



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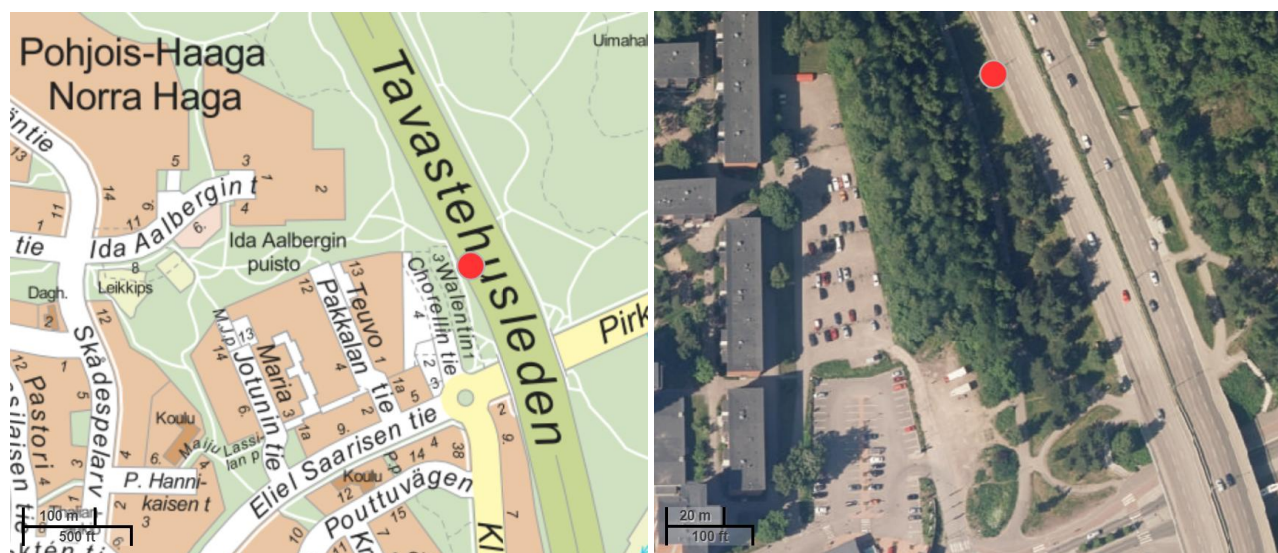
Pirkkola VT 3 (sPIR)

Name of sensor site	Pirkkola VT 3
Measurement site type	Traffic, main road
Address and city	Hämeenlinnanväylä, Helsinki
Coordinates	60.2293599, 24.9050744
Sampling height	4.4 m
Distance from street edge	5 m
Measurement devices	Vaisala AQT420

Short description of sampling site and local pollution sources

Pirkkola VT3 sensor site represents a very busy traffic environment beside a major road in Helsinki. The AQ sensor is located at a road weather station beside Hämeenlinnanväylä (road number VT3). The sensor site is mainly affected by traffic exhausts and street dust. The distances and traffic characteristics of the Hämeenlinnanväylä road is as follows;

- Hämeenlinnanväylä 5 m, 50 200 vehicles per workday (HDV 8%) and 80 km/h speed limit.



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Suutarila Kehä III (sSUU)

Name of sensor site	Suutarila Kehä III
Measurement site type	Traffic, main road
Address and city	Kehä III, Helsinki
Coordinates	60.284818, 25.0158029
Sampling height	4.3
Distance from street edge	6 m
Measurement devices	Vaisala AQT420

Short description of sampling site and local pollution sources

Suutarila Kehä III sensor site represents a very busy traffic environment beside a major road in Helsinki. The AQ sensor is located at a road weather station beside Kehä III (Ring road III). The sensor site is mainly affected by traffic exhausts and street dust. The distances and traffic characteristics of the Kehä III road is as follows;

- Kehä III 6 m, 63 900 vehicles per workday (HDV 7%) and 80 km/h speed limit.



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Vallikallio Kehä I (sVAL)

Name of sensor site	Vallikallio Kehä I
Measurement site type	Traffic, main road
Address and city	Kehä I, Espoo
Coordinates	60.226536, 24.8252184
Sampling height	5 m
Distance from street edge	2 m
Measurement devices	Vaisala AQT420

Short description of sampling site and local pollution sources

Vallikallio Kehä I sensor site represents a very busy traffic environment beside a major road in Espoo. The AQ sensor is located at a road weather station beside Kehä I road (Ring road I). The sensor site is mainly affected by traffic exhausts and street dust. The distances and traffic characteristics of the Kehä I road are as follows;

- Kehä I 2 m, 81 800 vehicles per workday (HDV 5%) and 60 km/h speed limit.



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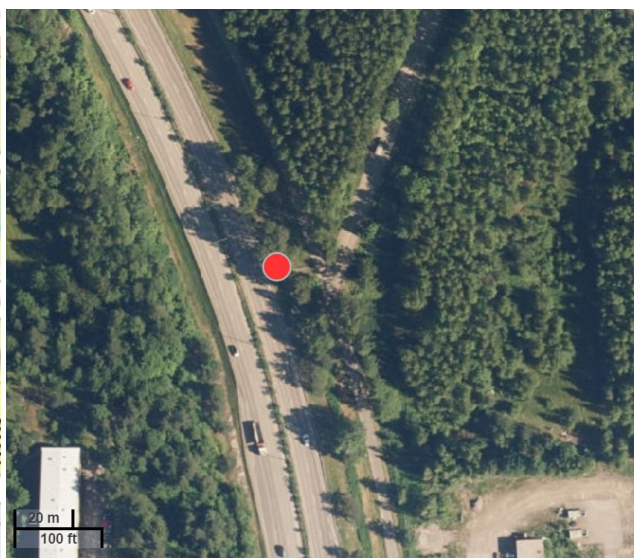
Kaivoksela VT 3 (sKAI)

Name of sensor site	Kaivoksela VT 3
Measurement site type	Traffic, main road
Address and city	Hämeenlinnanväylä, Vantaa
Coordinates	60.271927, 24.874481
Sampling height	3.7 m
Distance from street edge	4 m
Measurement devices	Vaisala AQT420, Pegasor AQ TM Urban

Short description of sampling site and local pollution sources

Kaivoksela VT3 sensor site represents a very busy traffic environment beside a major road in Vantaa. The AQ sensor is located at Vaisala's road weather test station beside Hämeenlinnanväylä (road number VT3). The sensor site is mainly affected by traffic exhausts and street dust. The distances and traffic characteristics of the Hämeenlinnanväylä road are as follows;

- Hämeenlinnanväylä 4 m, 61 100 vehicles per workday (HDV 7%) and 80 km/h speed limit.



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Paloheinä (sPAL)

Name of sensor site	Paloheinä
Measurement site type	Small-house area
Address and city	Paloheinäntie 17, Helsinki
Coordinates	60.250057, 24.93943
Sampling height	2 m
Distance from street edge	40 m
Measurement devices	Vaisala AQT420, Pegasor AQ TM Urban

Short description of sampling site and local pollution sources

Paloheinä sensor site represents a small-house area in Helsinki. The measurement site is located on a yard and surrounded by detached houses. The site is mainly affected by emissions from wood combustion in fire places. The emissions from traffic may also increase NO₂ and PM₁₀ concentration. The distances and traffic characteristics of the nearby streets are as follows;

- Paloheinäntie 40 m, 1 300 vehicles per workday (HDV 17%) and 40 km/h speed limit.
- Tuusulanväylä 490 m, 90 300 vehicles per workday (HDV 8%) and 80 km/h speed limit.



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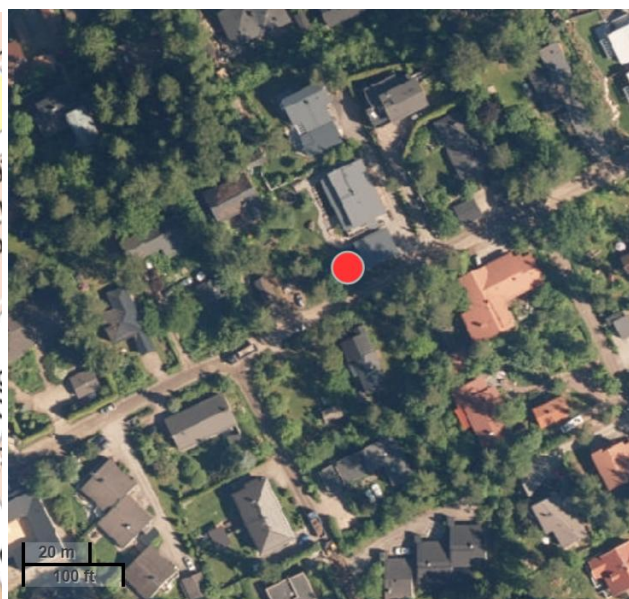
Laaksolahti (sLAA)

Name of sensor site	Laaksolahti
Measurement site type	Small-house area
Address and city	Huvilamäki 2, Espoo
Coordinates	60.249171, 24.761835
Sampling height	2 m
Distance from street edge	5 m
Measurement devices	Vaisala AQT420, Pegasor AQ TM Urban

Short description of sampling site and local pollution sources

Laaksolahti sensor site represents a small-house area in Espoo. The measurement site is located on a yard and surrounded by detached houses. The site is mainly affected by emissions from wood combustion in fire places. There were also construction works near the measurement site that probably increased PM₁₀ and NO₂ concentrations. The distances and traffic characteristics of the nearby street is as follows;

- Huvilamäki 5 m, traffic volume is very small, probably less than a few hundred per day.
- Pitkäjärventie 130 m, 7000 vehicles per workday (HDV 7%).



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Hiekkaharju (SHIE)

Name of sensor site	Hiekkaharju
Measurement site type	Small-house area
Address and city	Metsätähdentie 15
Coordinates	60.307368, 25.046366
Sampling height	2 m
Distance from street edge	20 m
Measurement devices	Vaisala AQT420, Pegasor AQ TM Urban and PM ₁₀ sampling for PAH analysis

Short description of sampling site and local pollution sources

Hiekkaharju sensor site represents a small-house area in Vantaa. The measurement site is located on a yard and surrounded by detached houses. The site is mainly affected by emissions from wood combustion in fire places. The distances and traffic characteristics of the nearby street is as follows;

- Metsätähdentie 20 m, traffic volume is very small, probably less than a few hundred per day.
- Talkootie 370 m, 4 000 vehicles per workday (HDV 8%) and 40 km/h speed limit.



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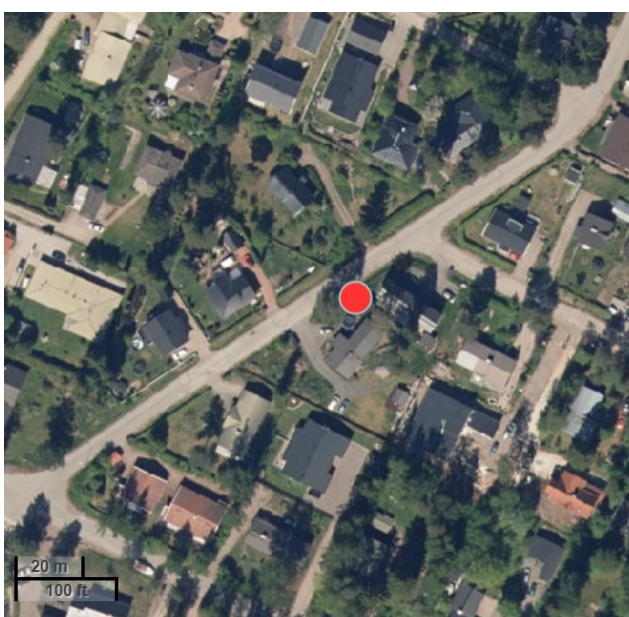
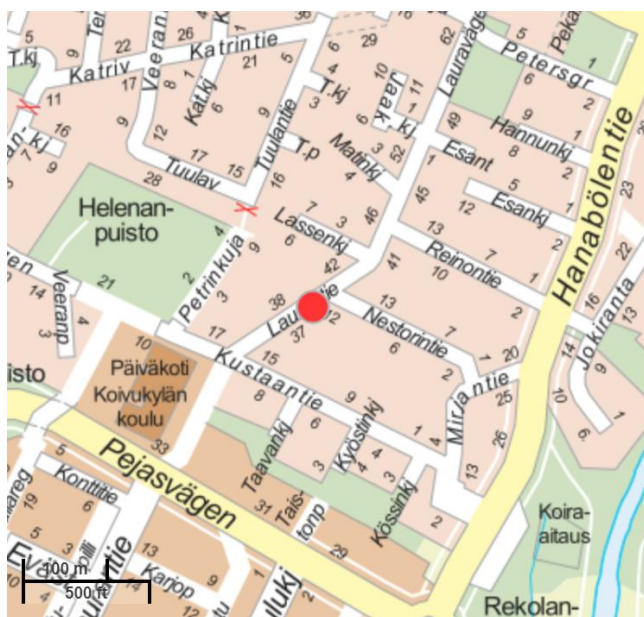
Rekola 2 (sREK2)

Name of sensor site	Rekola 2
Measurement site type	Small-house area
Address and city	Laurantie 37, Vantaa
Coordinates	60.3257876, 25.0800486
Sampling height	2 m
Distance from street edge	5 m
Measurement devices	Vaisala AQT420, Pegasor AQ™ Urban

Short description of sampling site and local pollution sources

Rekola 2 sensor site represents a small-house area in Vantaa. The measurement site is located on a yard and surrounded by detached houses. The site is mainly affected by emissions from wood combustion in fire places. The distances and traffic characteristics of the nearby streets are as follows;

- Laurantie 5 m, traffic volume is very small, probably less than a few hundred per day.
- Peijaksentie 260 m, 5 600 vehicles per workday (HDV 9%) and 40 km/h speed limit.
- Hanabölentie 280 m, 2 400 vehicles per workday (HDV 7%) and 40 km/h speed limit.



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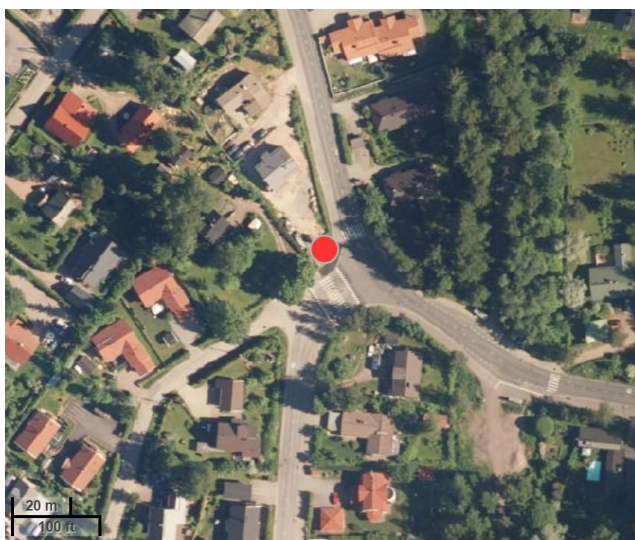
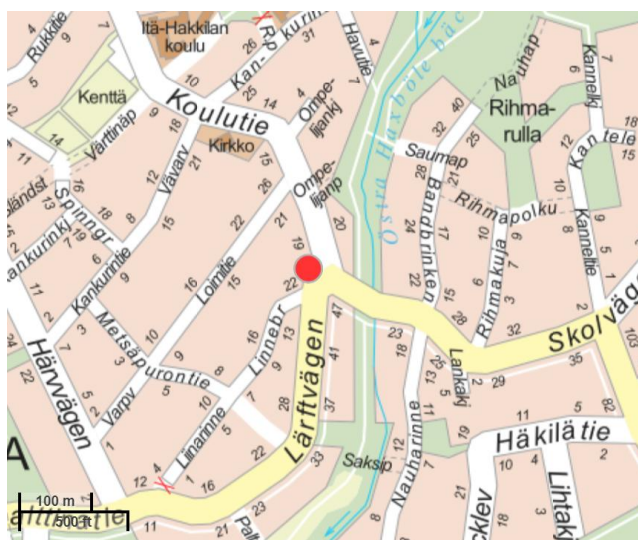
Itä-Hakkila air quality station (I-HAK)

Name of air quality station	Itä-Hakkila
Measurement site type	Small-house area
Address and city	Liinarinne 22, Vantaa
Coordinates	60.291729, 25.112837
Sampling height	4 m
Distance from street edge	6 m
Measurement devices	Vaisala AQ420 and Pegasor AQ TM Urban sensors; Reference level instruments (NO ₂ , NO, PM _{2.5}) and PM ₁₀ sampling for PAH analysis

Short description of sampling site and local pollution sources

Itä-Hakkila air quality station site represents a small-house area in Helsinki. The measurement site is located beside a small street (Koulutie) and surrounded by detached houses. The site is mainly affected by emissions from wood combustion in fire places as well as emissions from traffic. The distances and traffic characteristics of the nearby streets are as follows;

- Koulutie 6 m, ~2 700 vehicles per workday (estimate from year 2008; HDV ~6% estimate based on Palttintie) and 40 km/h speed limit.
- Palttintie 5 m, 1 200 vehicles per workday (HDV 6%) and 40 km/h speed limit.



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