

ERMES plenary 2023

Day2 - Air Quality and Remote Sensing

Tuesday 28th November 2023



UNIVERSITY OF LEEDS

First comprehensive analysis of data in the new CARES RS database

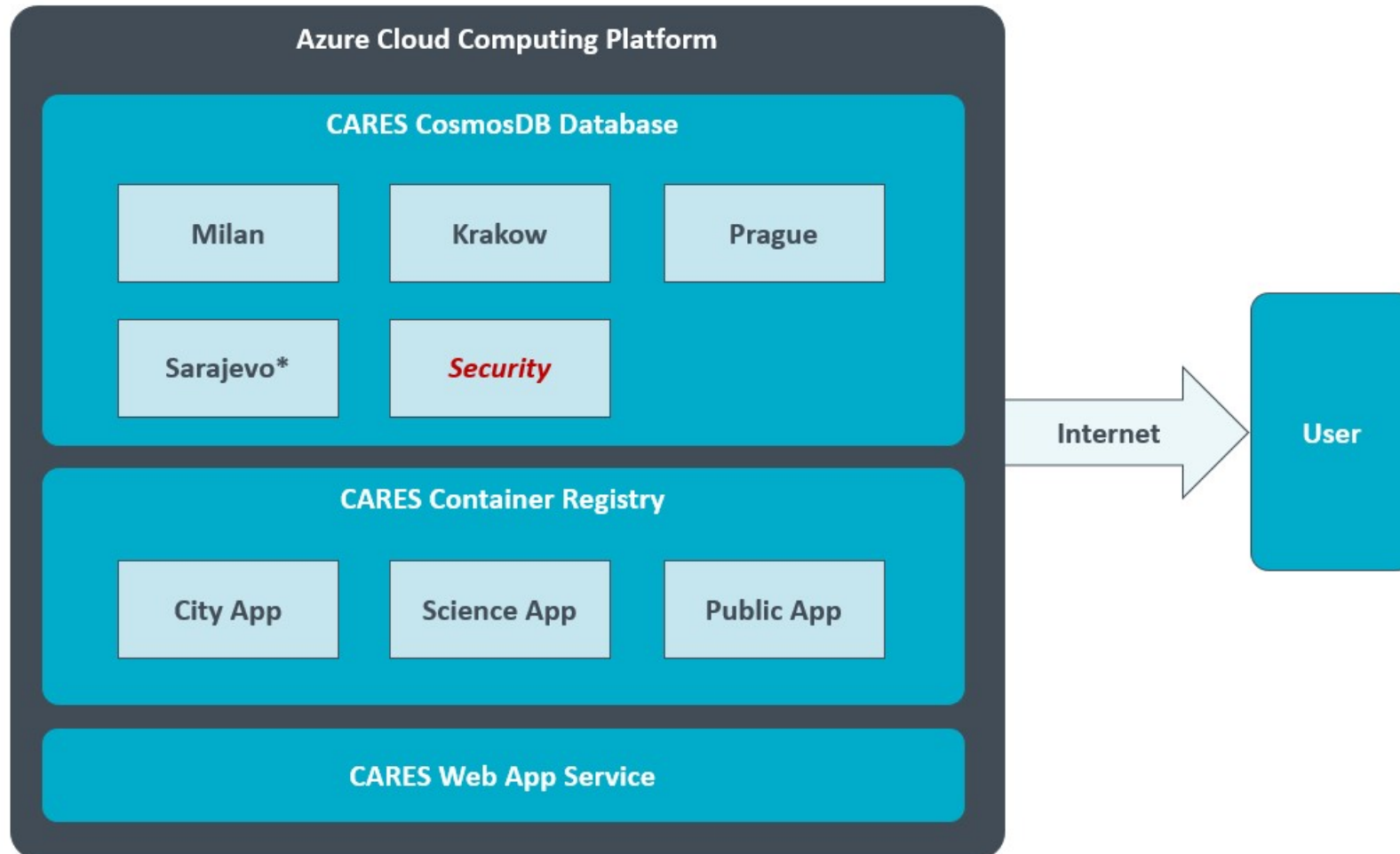


James TATE, Chris RUSHTON & Dr Zhuoqian YANG (Southwest Jiaotong University, CH)

Institute for Transport Studies (ITS), University of Leeds, UK

Email: j.e.tate@its.leeds.ac.uk

Twitter / X: [drjamestate](https://twitter.com/drjamestate)



Web-App: interact with the latest EU vehicle emission remote sensing data:
<https://cares-public-app.azurewebsites.net>



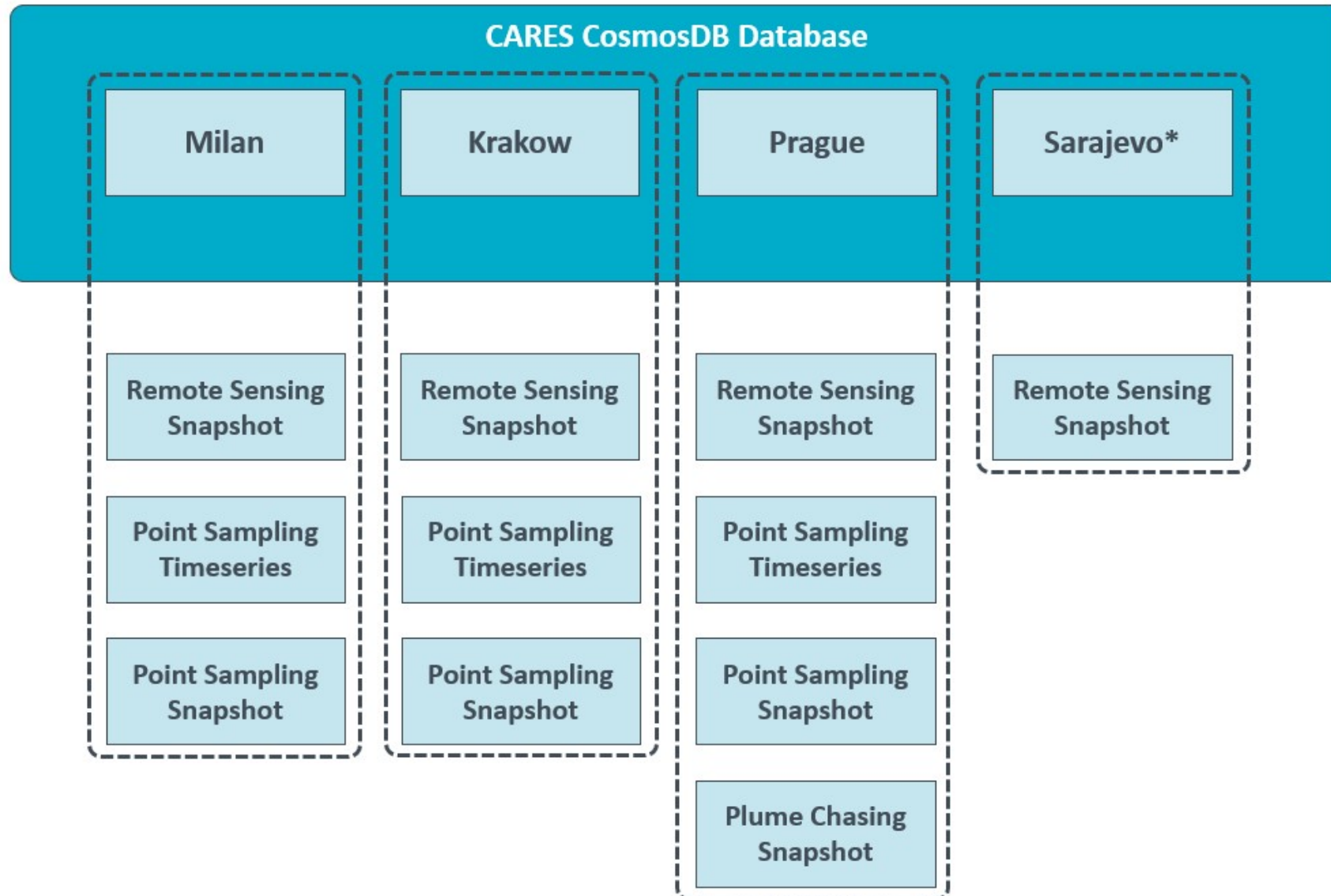
CARES DATABASE

CITY AIR REMOTE EMISSION SENSING

Data architecture



UNIVERSITY OF LEEDS





CARES DATABASE

CITY AIR REMOTE EMISSION SENSING

Data registry

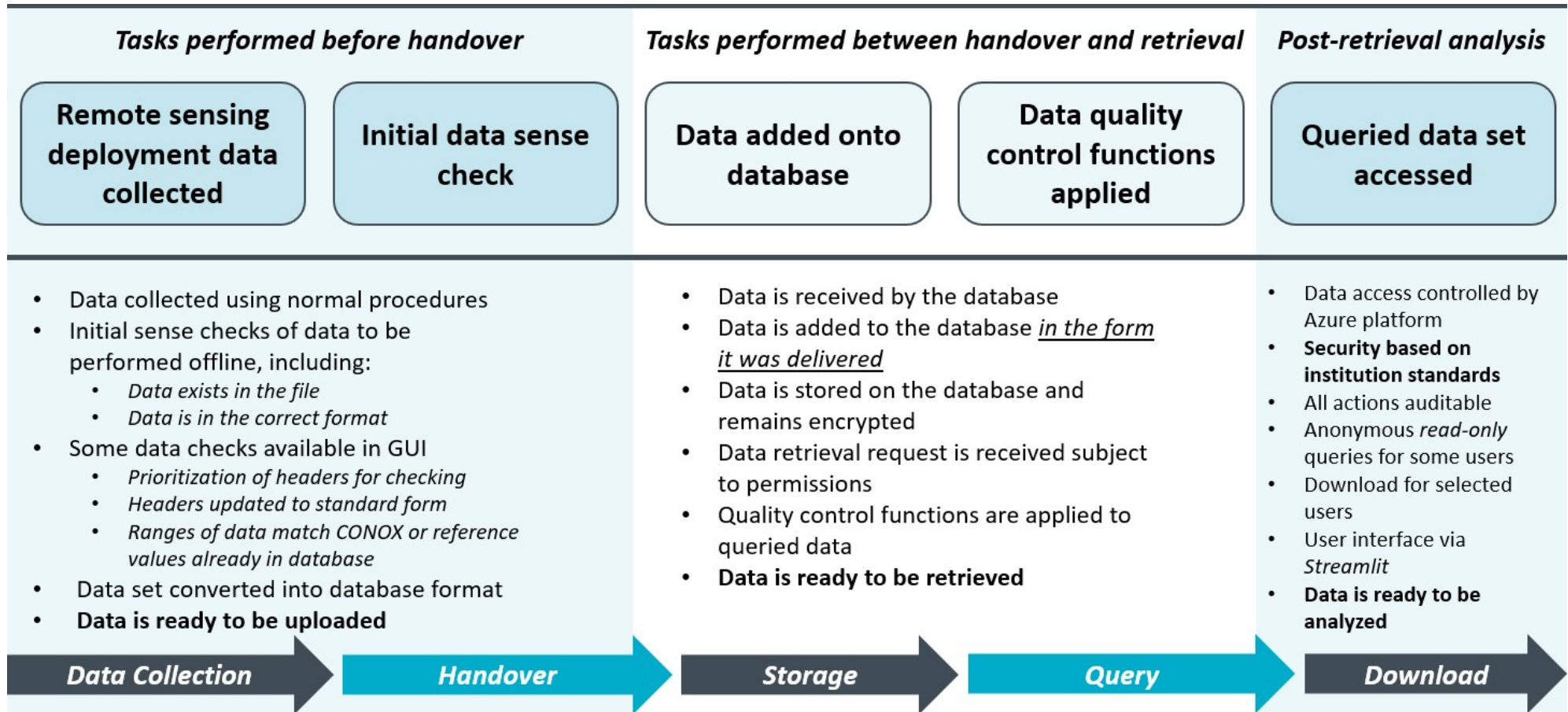


UNIVERSITY OF LEEDS

DEMONSTRATION CITY (WP3) or other	INSTRUMENT (see Key)	MEASUREMENTS (number)
MILAN	PS	10,852
	RS	35,568
PRAGUE	RS	120,611
	PS	10,658
	PC	3,374
KRAKOW	RS	128,883
	PS	6,162
Sarajevo*	RS	25,079
CARES TOTAL		341,187
CONOX		1,840,659
REMOVES Project	RS HEAT	150,684
	RS OPUS	130,667
TOTAL	All	2,463,197

NEW 2023
Switzerland
(Zurich) RS (Opus)
measurements
(now open data)
n = 37k

KEY: RS - commercial Remote Sensing, PS - Point Sampling, PC - Plume Chasing



Web-App: interact with the latest EU vehicle emission remote sensing data:

<https://cares-public-app.azurewebsites.net>

See conference paper on Minerva: Rushton, C., Tate, J., Callaghan, M., Knoll, M., Sjodin, A. 2023. A modern, flexible cloud-based database and computing service for storing & analysing vehicle emission measurements. Transport & Air Pollution Conference, September 2023.

CARES Project

Measurements 2021/2022/2023

<https://cares-project.eu/>



RS ANALYSIS

Identifying high-chance HIGH EMITTERS



UNIVERSITY OF LEEDS

MEASUREMENTS: 2021 / 2022 / 2023

Campaign	Site	Year	Dates	Device	Measurements (<i>n</i>)	Measurements-diesel car (<i>n</i>)
Switzerland	Zurich	2021	May 29-Jun11	Heat	150683	17363
Switzerland	TBC	2021	Apr 26-Jun17	Opus	130666	20588
Italy	Milan	2021	Sept 23-Oct8	Heat	35568	7954
Poland	Krakow	2021	Nov 30-Dec10	Opus	128883	43852
Czech Republic	Prague	2022	Sept 5-23	Opus	120611	48459
Bosnia and Herzegovina	Sarajevo	2022	Jun 28-Jul1	Opus	25079	11920
Switzerland	Zurich	2023	2023	Opus	36566	14371

Rushton, C., Tate, J., Shepherd, S. 2021. A novel method for comparing passenger car fleets and identifying high-chance gross emitting vehicles using kerbside remote sensing data. *Science of the Total Environment*, 2021, 750, 142088. DOI: 10.1016/j.scitotenv.2020.142088

Yang, Z., Tate, J., Rushton, C., Morganti, E., Shepherd, S.P. 2022. Detecting candidate high NO_x emitting light commercial vehicles using vehicle emission remote sensing. *Science of the Total Environment*, 2022, 823, 153699. DOI: 10.1016/j.scitotenv.2022.153699

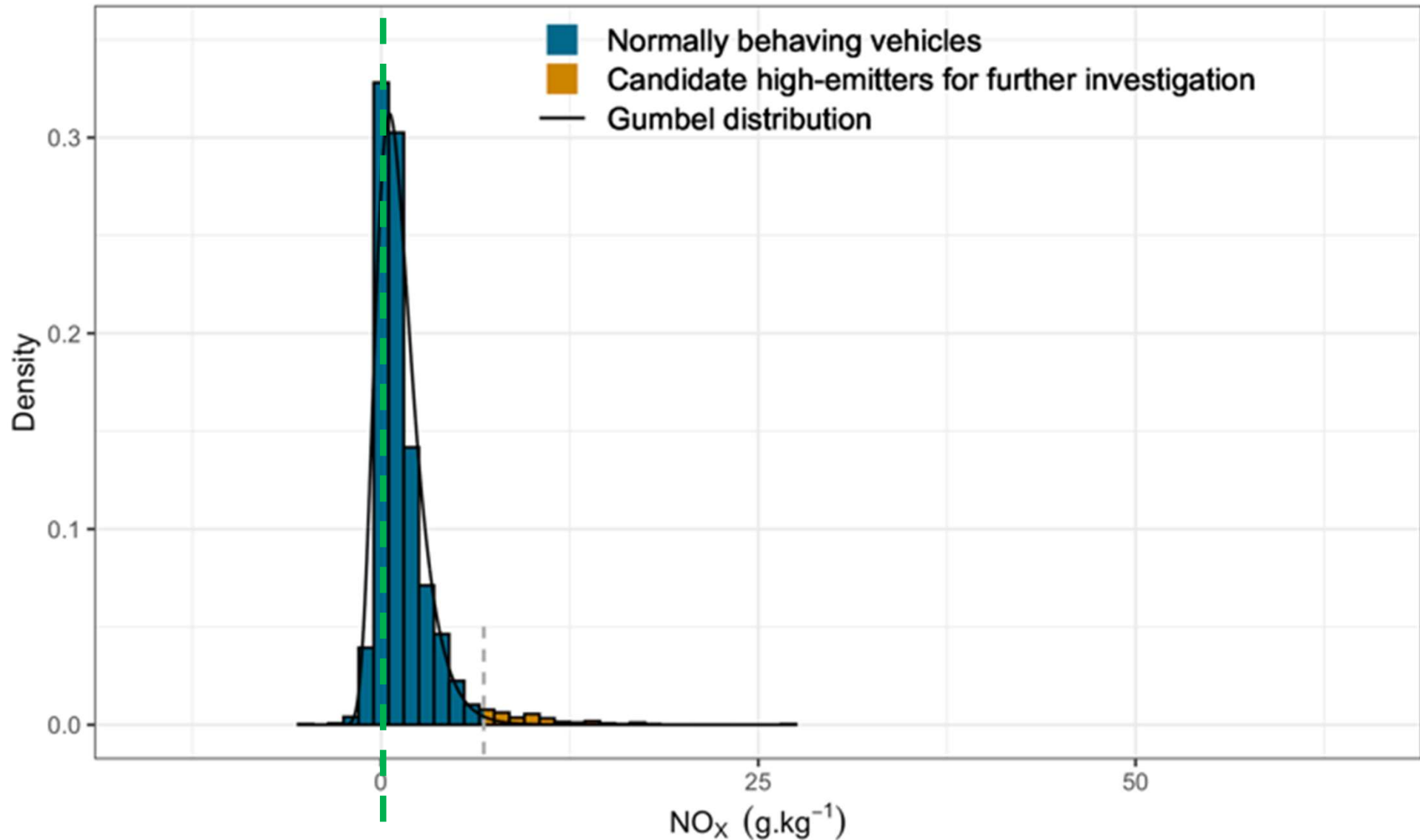
METHOD

Identifying high-chance HIGH EMITTERS



UNIVERSITY OF LEEDS

swiss-heat Euro 6d_temp



Location Value \underline{a} 'typical emission rate' Scale parameter \underline{b} 'dispersion' of the data

METHOD

Identifying high-chance HIGH EMITTERS



UNIVERSITY OF LEEDS

Algorithm for identifying the 'off-model' (high chance high-emitting) vehicles:

Step 1: Apply the Gumbel / Laplace distribution to the whole fleet F_{100}

Step 2: Calculate R_2 value of the observed and theoretical quantiles for fleet F_{100}

Step 3: Cut the fleet at each integer percentile starting from 99, apply the Gumbel distribution to F_i , $i = 99, 98, \dots, 1$

Step 4: Calculate R_2 value of observed and theoretical quantiles for fleet F_i ($F_{99}, F_{98}, \dots, F_1$)

Step 5: Repeat steps 3–4 until there is no vehicle left in the fleet

Step 6: Create a dot plot of the cutting percentiles vs. the R_2 values

Step 7: Sub-fleet with the maximum R_2 value is regarded as the 'on-model' vehicle subset, and the fit parameters for the 'on-model' vehicles are the best description of the normally behaving vehicles in the whole fleet; the rest of the vehicles that do not follow Gumbel distribution are regarded as 'off-model' vehicles

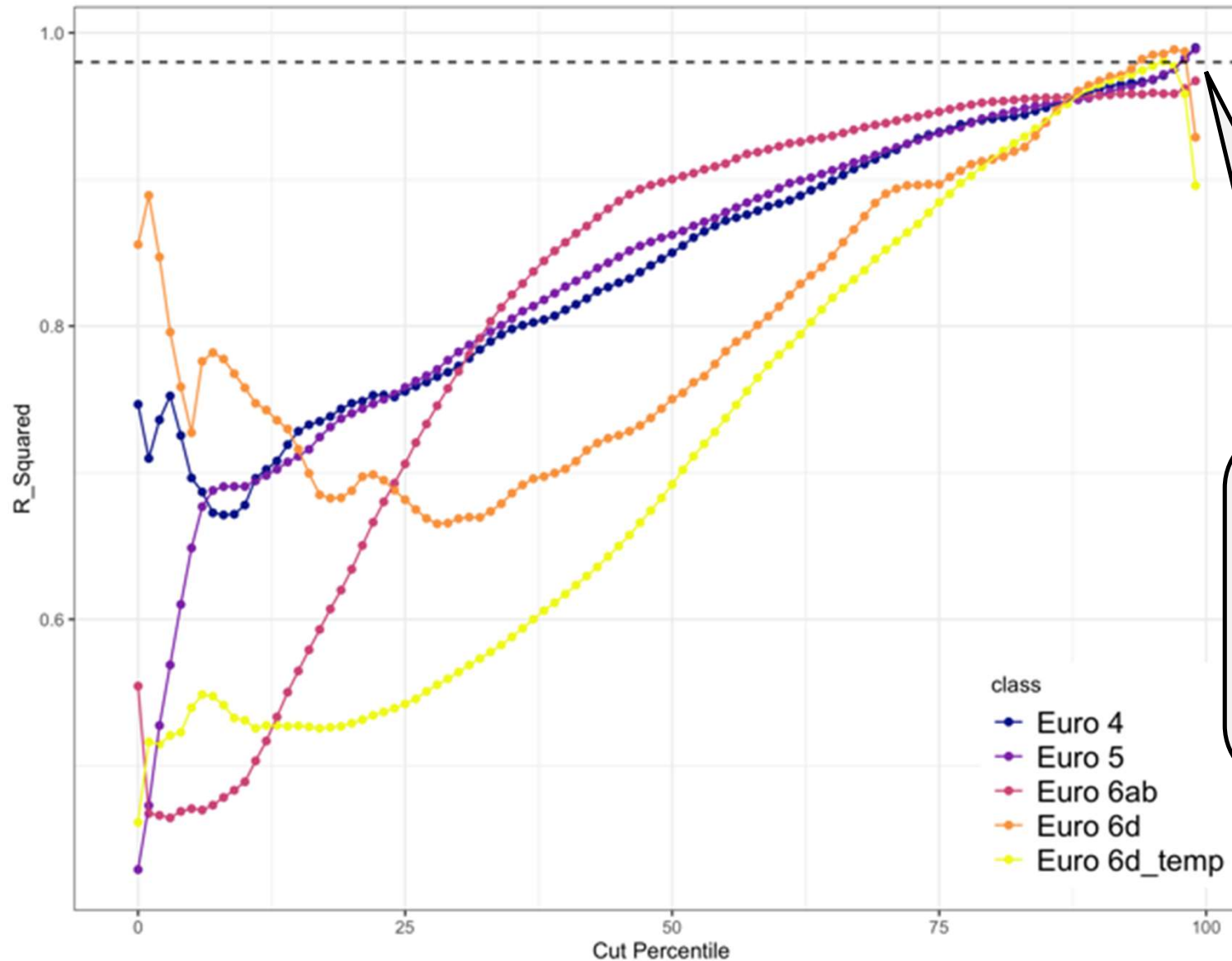
METHOD

Identifying high-chance HIGH EMITTERS



UNIVERSITY OF LEEDS

swiss-heat 2021



***Euro 6d-TEMP
high-emitter
share ≈ 3%***

RESULTS

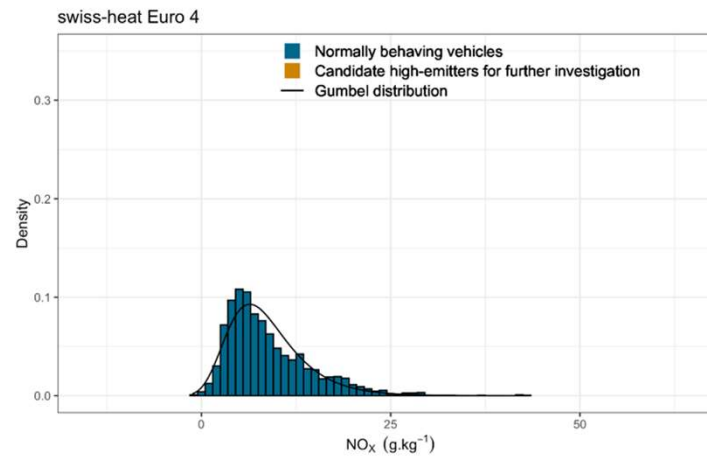
Identifying high-chance HIGH EMITTERS



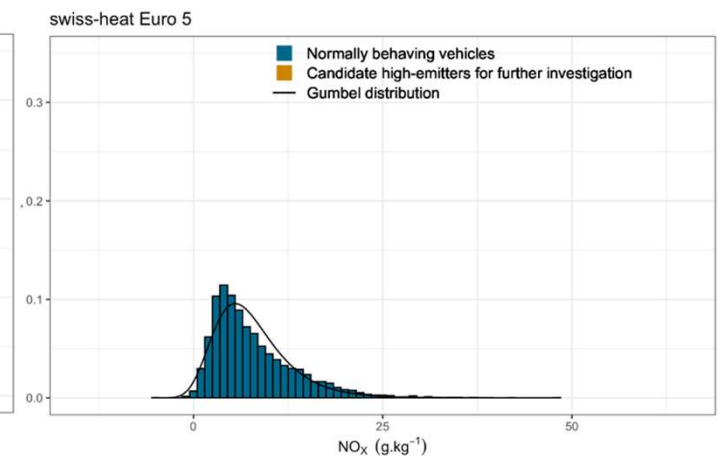
UNIVERSITY OF LEEDS

Switzerland-Heat May-Jun 2021

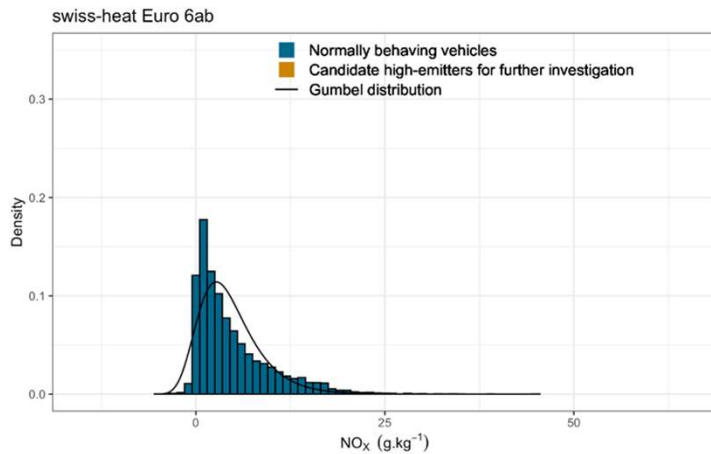
Euro 4



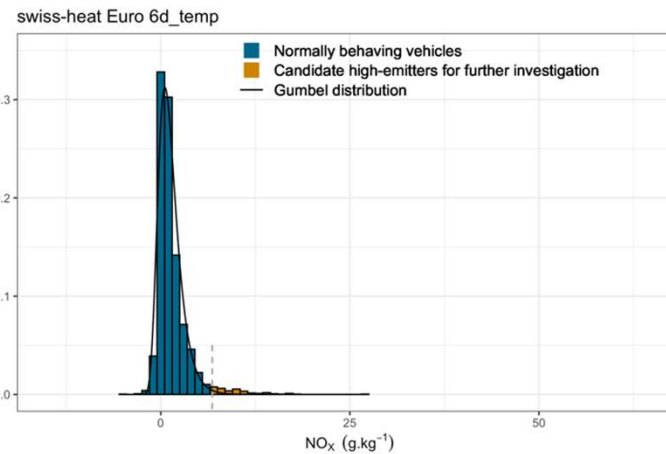
Euro 5



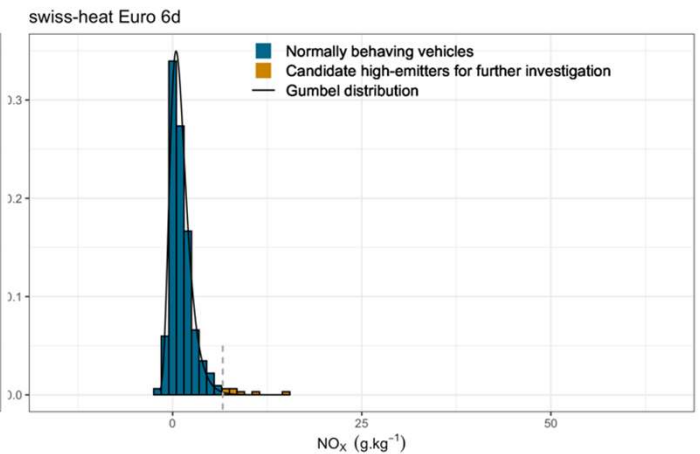
Euro 6a/b



Euro 6d-TEMP



Euro 6d



RESULTS

Identifying high-chance HIGH EMITTERS

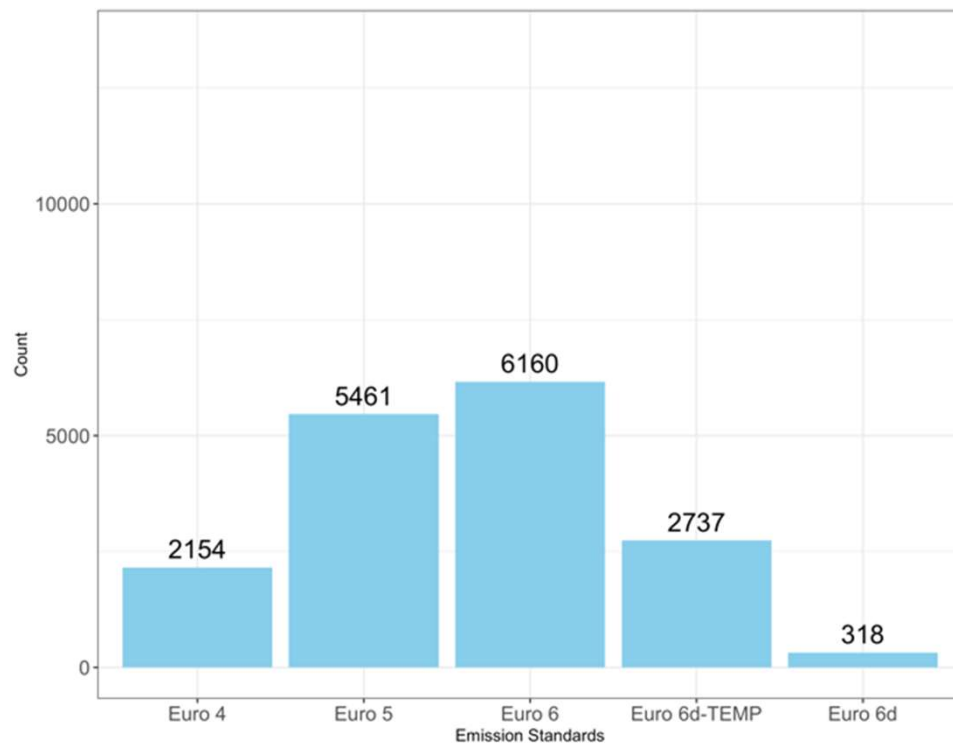


UNIVERSITY OF LEEDS

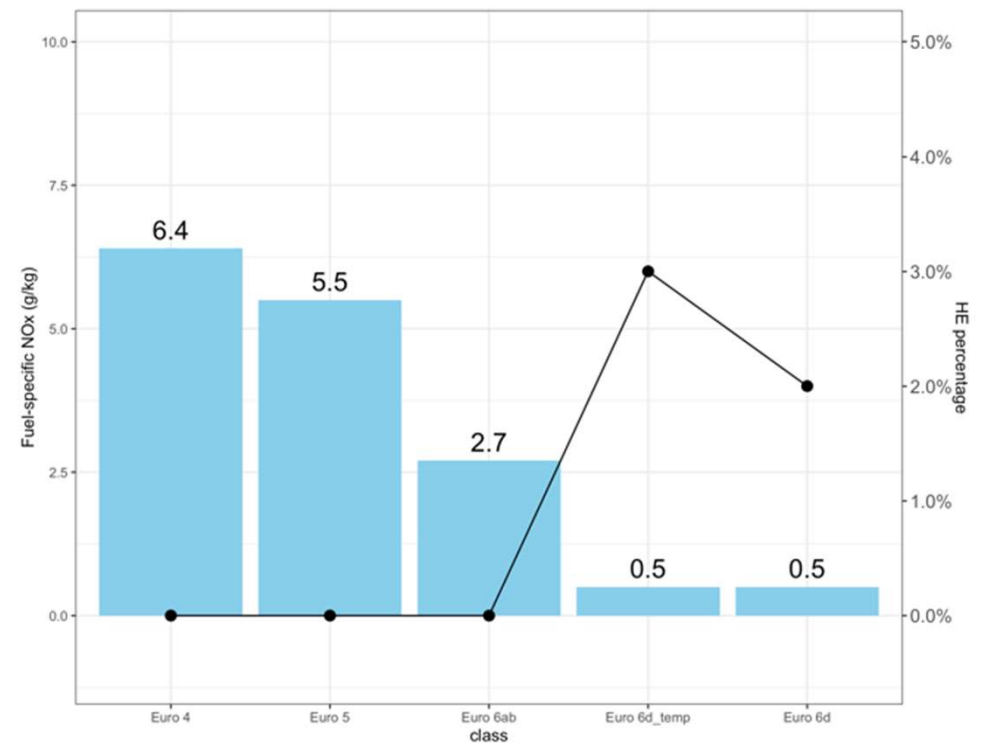
Switzerland-Heat

May-Jun 2021

Measurements



Location Value (LV) & % High-Emitter (HE)



RESULTS

Identifying high-chance HIGH EMITTERS

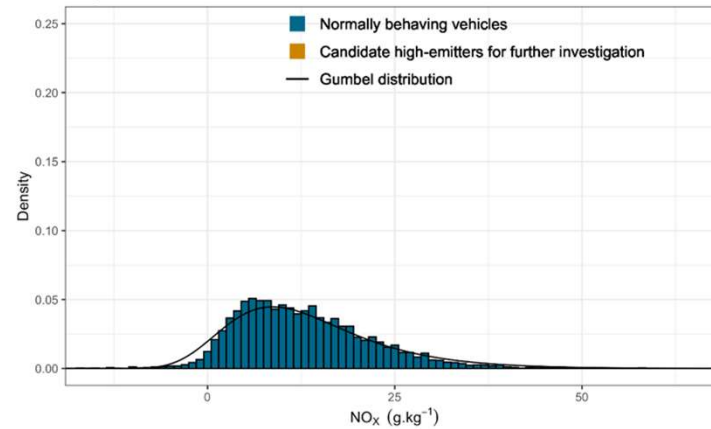


UNIVERSITY OF LEEDS

Czech-Rep
Prague
Sept-2022

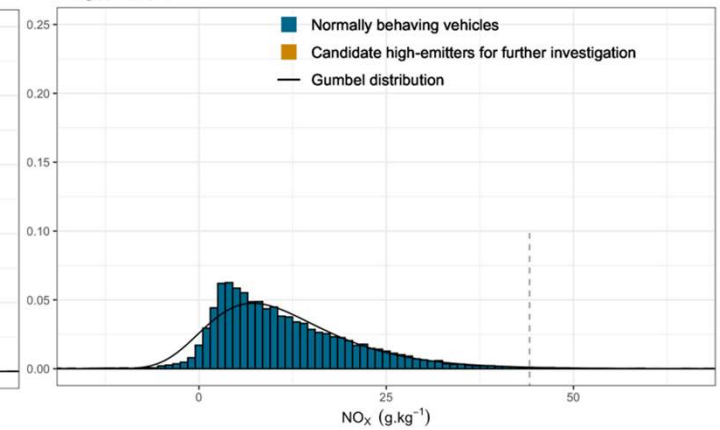
Euro 4

Prague Euro 4



Euro 5

Prague Euro 5



RESULTS

Identifying high-chance HIGH EMITTERS

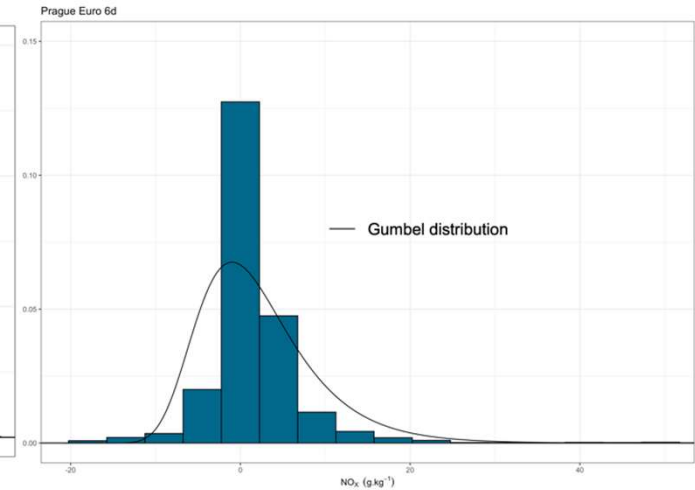
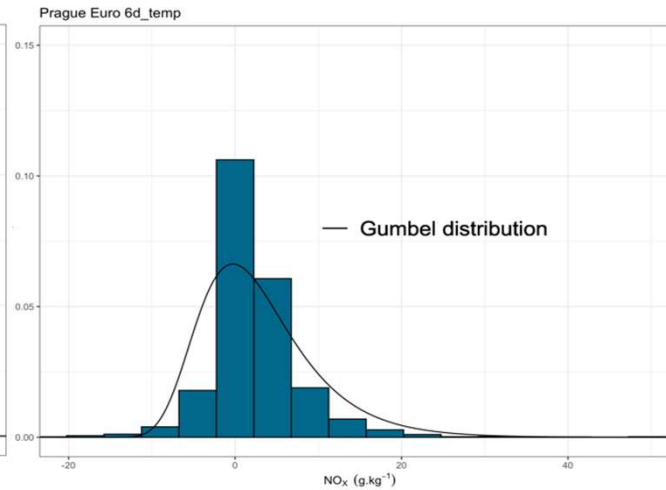
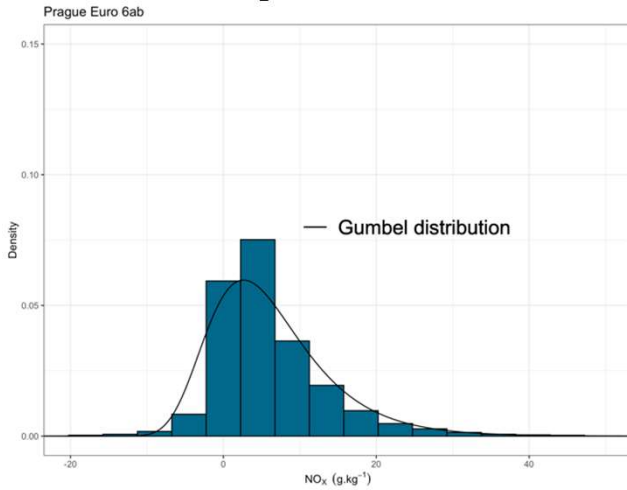


UNIVERSITY OF LEEDS

Euro 6a/b

Euro 6d-TEMP

Euro 6d

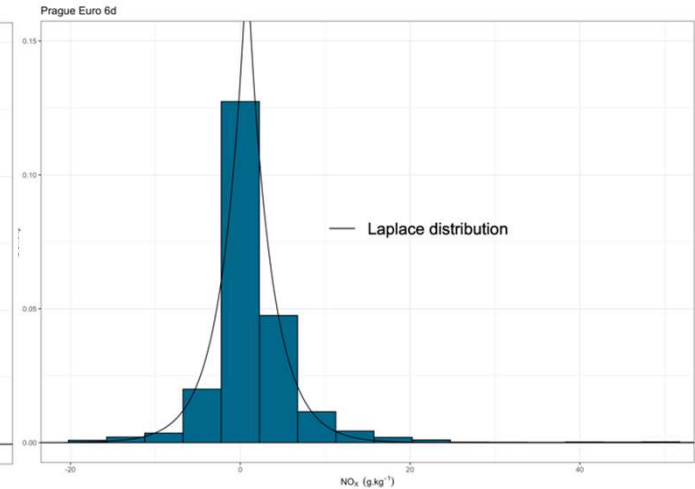
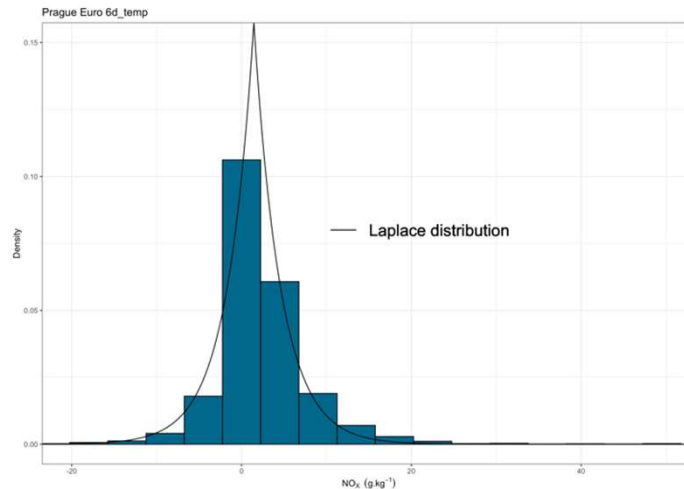


GUMBEL

Czech-Rep
Prague
Sept-2022

Euro 6d-TEMP

Euro 6d



LAPLACE

RESULTS

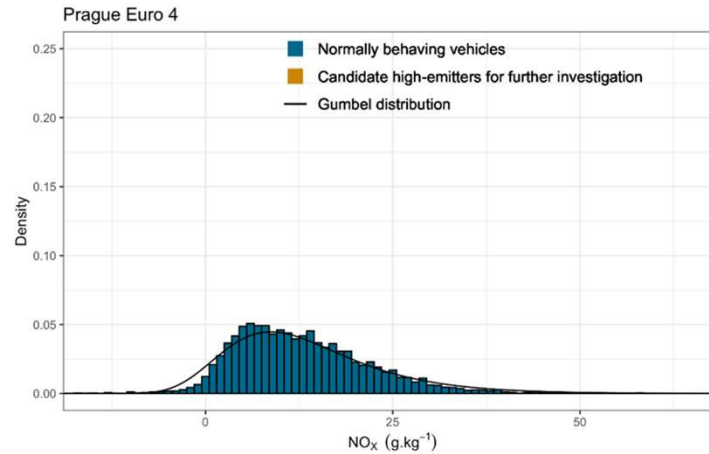
Identifying high-chance HIGH EMITTERS



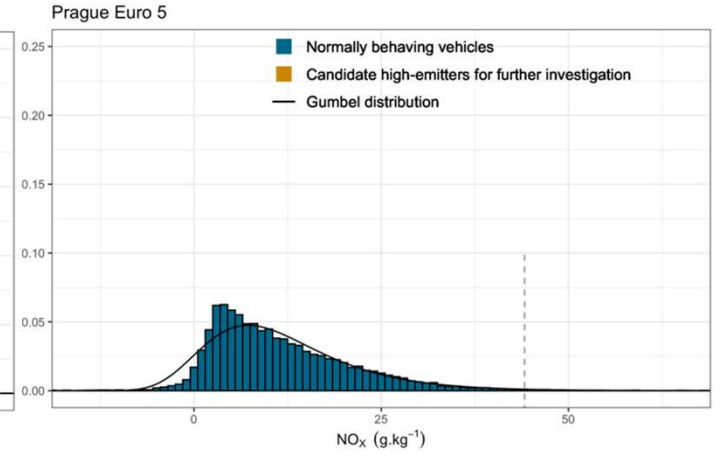
UNIVERSITY OF LEEDS

Czech-Rep
Prague
Sept-2022

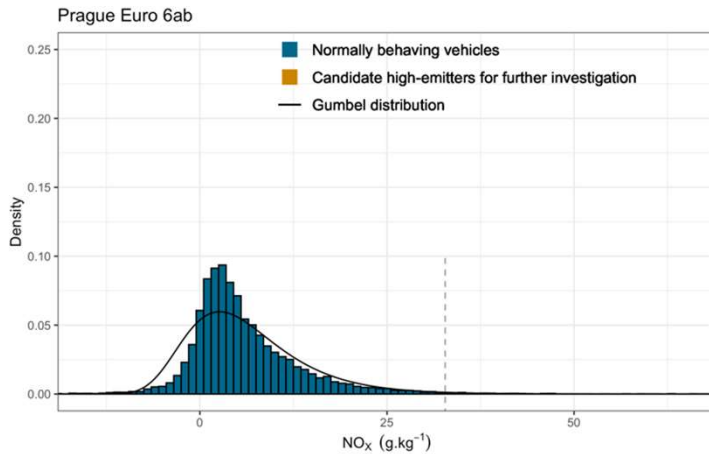
Euro 4



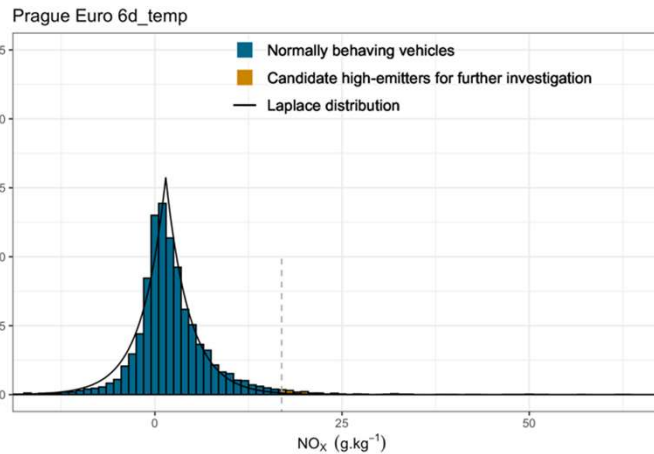
Euro 5



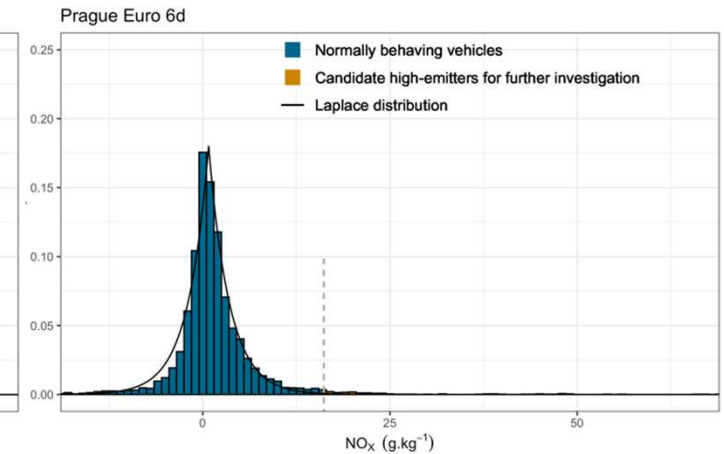
Euro 6a/b



Euro 6d-TEMP



Euro 6d



RS ANALYSIS

Identifying high-chance HIGH EMITTERS



UNIVERSITY OF LEEDS

	Country	City	Year	Device	E4	E5	E6a/b	E6d-T	E6d
Location (g/kg)	Switzerland	Zurich	2021	Heat	6.4	5.5	2.7	0.5	0.5
	Switzerland	Zurich	2021	Opus	3.3	3.7	1.3	0.6	0.5
	Italy	Milan	2021	Heat	7.2	7.4	3.2	0.5	0.1
	Poland	Krakow	2021	Opus	9.6	8.6	2.2	0.6	0.4
	Czech-Rep	Prague	2022	Opus	8.7	7.2	2.6	1.4	0.8
	Switzerland	Zurich	2023	Opus	12.3	11.0	4.2	1.1	0.6
Scale (g/kg)	Switzerland	Zurich	2021	Heat	4.0	3.9	3.2	1.2	1.1
	Switzerland	Zurich	2021	Opus	5.2	5.5	4.3	2.2	2.0
	Italy	Milan	2021	Heat	5.9	5.7	3.4	1.3	1.0
	Poland	Krakow	2021	Opus	8.3	8.4	5.2	2.0	2.1
	Czech-Rep	Prague	2022	Opus	8.2	7.7	6.2	3.2	2.8
	Switzerland	Zurich	2023	Opus	8.2	9.1	5.5	3.0	3.0

RS ANALYSIS

Identifying high-chance HIGH EMITTERS



UNIVERSITY OF LEEDS

	Country	City	Year	Device	E4	E5	E6a/b	E6d-T	E6d
% High-Emitter (HE)	Switzerland	Zurich	2021	Heat	0	0	0	3	2
	Switzerland	Zurich	2021	Opus	2	2	4	9	13
	Italy	Milan	2021	Heat	0	0	7	5	4
	Poland	Krakow	2021	Opus	1	1	4	10	5
	Czech-Rep	Prague	2022	Opus	0	1	1	2	2
	Switzerland	Zurich	2023	Opus	0	0	5	2	1
% HE contribution	Switzerland	Zurich	2021	Heat	--	--	--	22	16
	Switzerland	Zurich	2021	Opus	17	16	36	60	62
	Italy	Milan	2021	Heat	--	--	25	35	43
	Poland	Krakow	2021	Opus	7	7	28	48	61
	Czech-Rep	Prague	2022	Opus	--	5	7	15	28
	Switzerland	Zurich	2023	Opus	--	--	23	16	10

ON-GOING RESEARCH

Identifying high-chance HIGH EMITTERS



UNIVERSITY OF LEEDS

ANALYSIS:

- ADD Sarajevo 2022 data
- Further quality checks on the latest Switzerland 2023 data >> CARES database
- Review individual site characteristics, environmental conditions & emission results
- Replicate analysis for PETROL passenger cars
- Identify ‘common’ high emitting vehicle models (Marque, Model, Euro/Fuel type)
 - Vehicle ‘families’, engine codes & ‘alliances’ (uCAREs project)
- Prepare paper: Science of the Total Environment

DATABASE:

- Welcome **NEW** datasets
- Zurich data now “open” >> *open-CARES-App*
- Extend functionality e.g. a deterioration function
 - where mileage information is available e.g. Switzerland 2023 (small sample)