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Three-level monitoring of downlink 5G EMF exposure in urban and suburban regions at Attica, Greece

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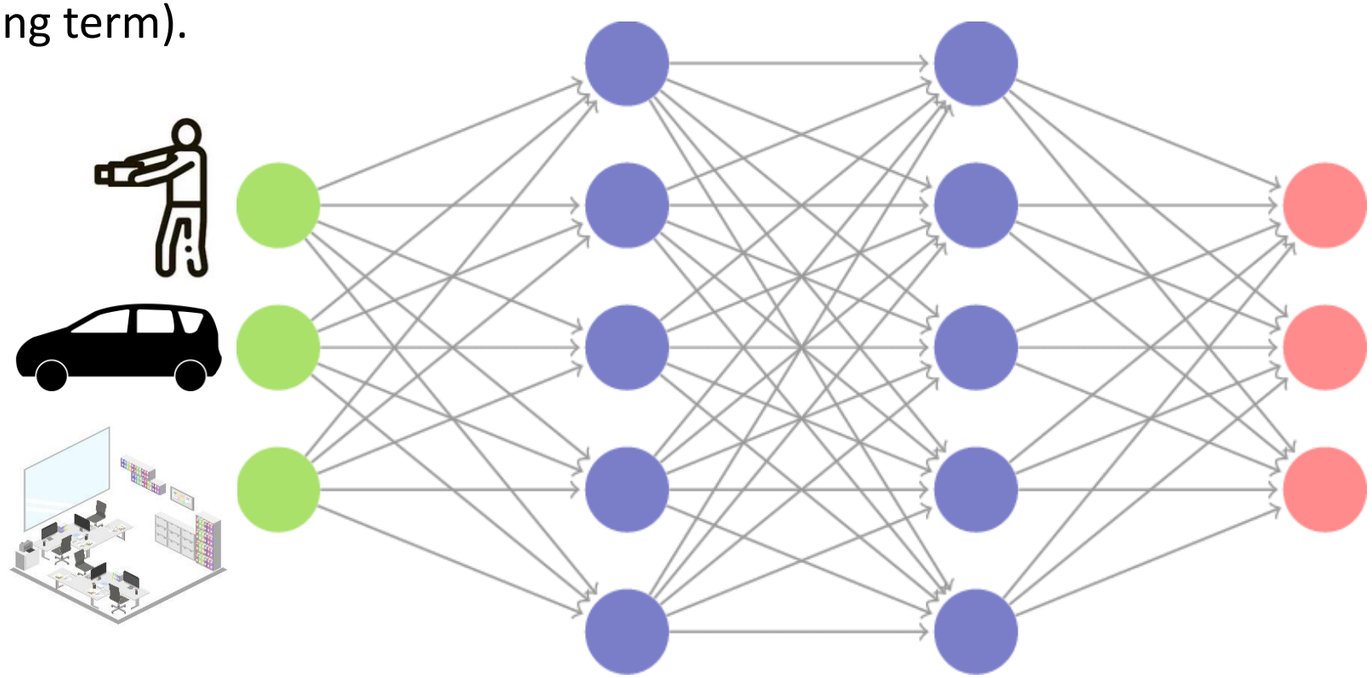
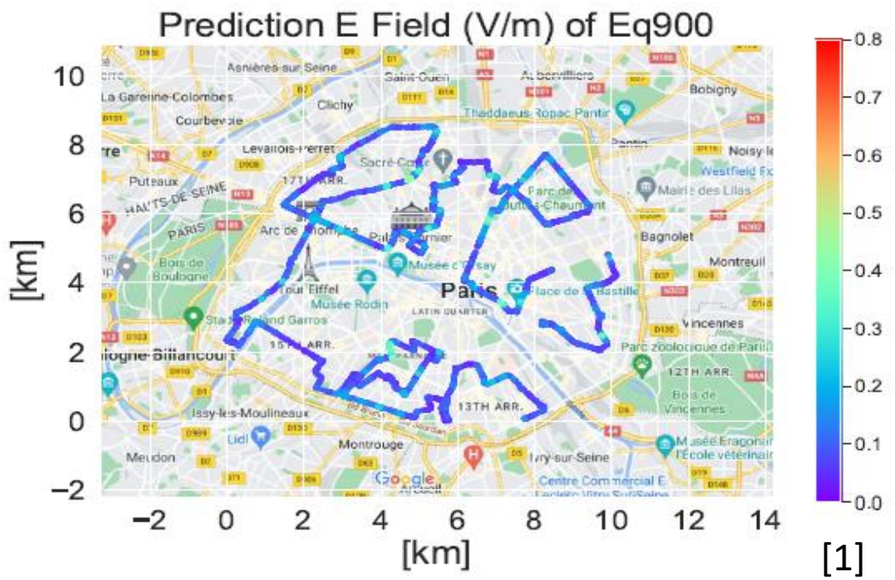
1. Background-Aim

MEASUREMENTS: Collecting data available in *different countries* from **in situ measurements (indoor/outdoor)** and **deployed monitoring networks** using distributed E-field sensors and performing **drive test measurements** to complement these data and citizen science data (mobile app).
PARAMETERS: exposure vs. time and technology (new (5G) and emerging (beyond 5G))
ANALYSIS: ANN architectures that combine measurements with communication network information available in open data (location and azimuth of the antenna) to **create RF maps using AI**.
OUTCOME: Building **'live' breathing maps of RF fields**, i.e., the spatial distribution that changes with time (short and long term).





[1]

The presented work is within the frame of SEAWave WP1: Exposures from 5G vs. 2G-4G Cellular Networks
Task 1.1: monitoring of downlink exposure induced by network infrastructure

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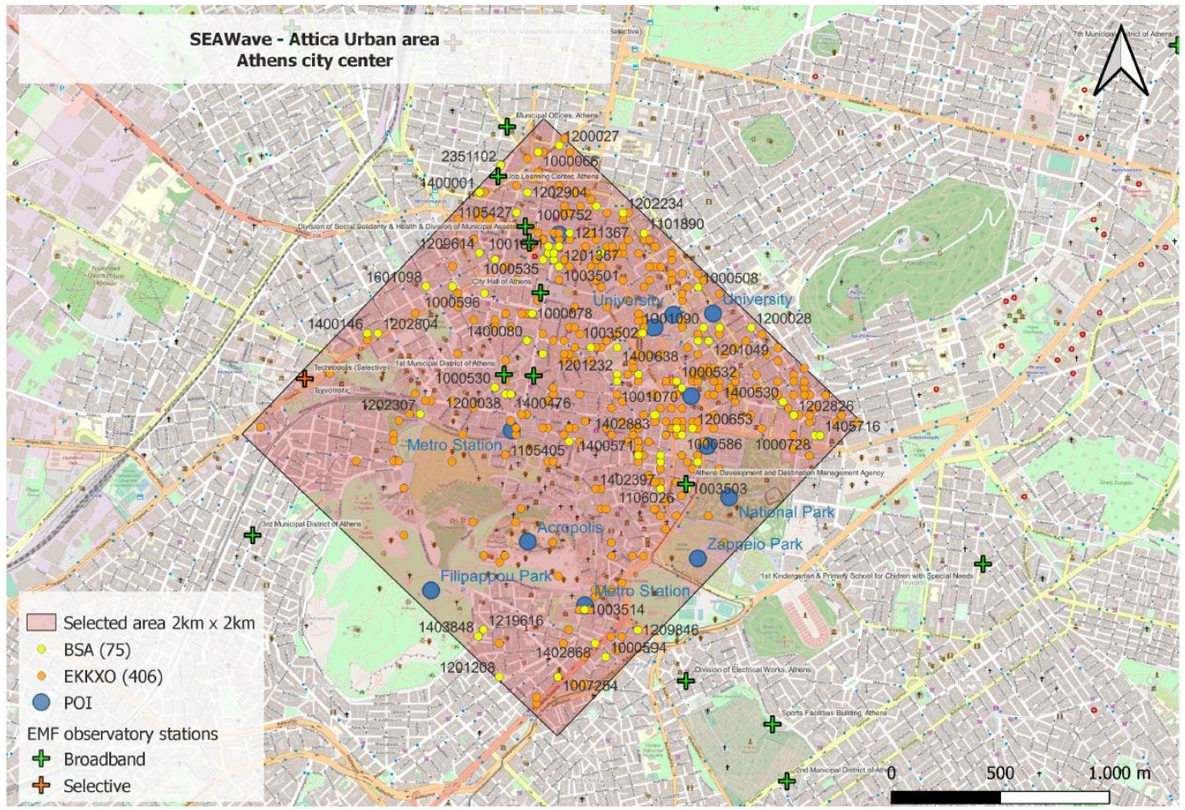
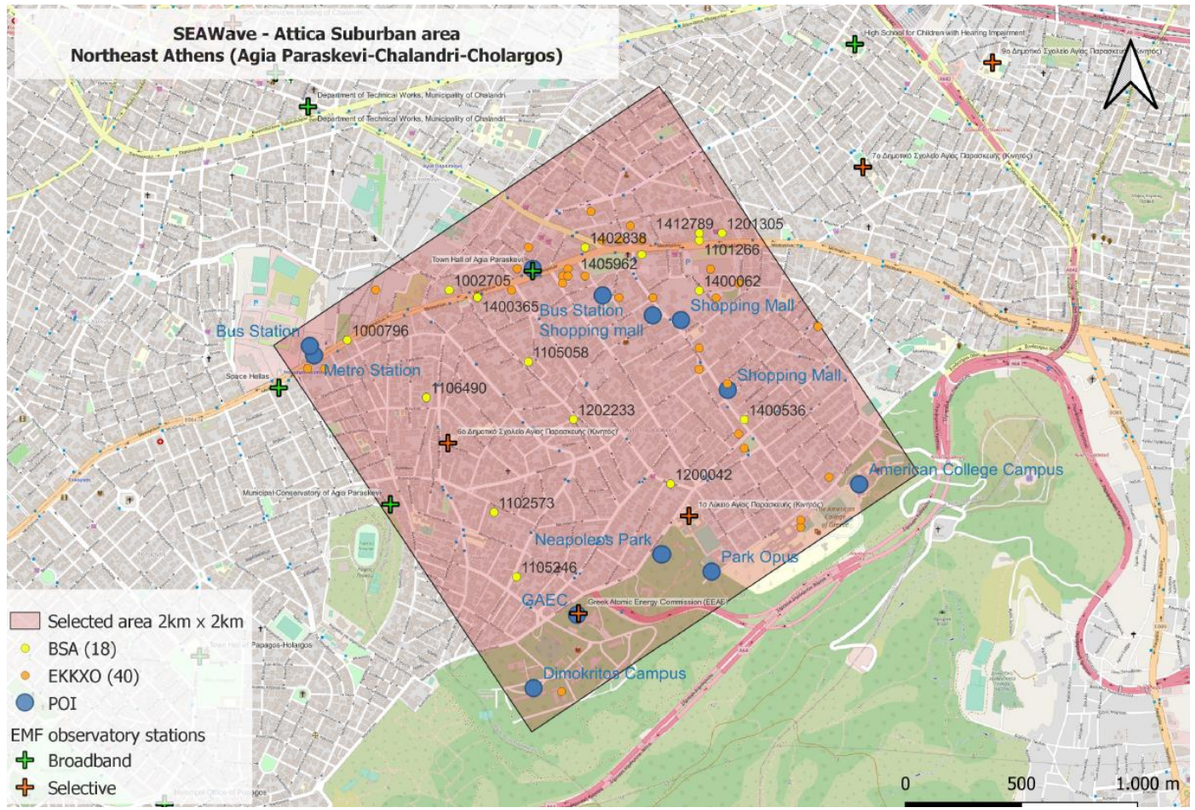
2. Materials & Methods (selected regions)



[urban] Athens city center | BSA+SCA~100



[suburban] Agia Paraskevi- Chalandri-Cholargos | BSA+SCA~15

BSA: Base station Antenna
SCA - EKKXO: small cell antenna installations, usually mounted on commercial signs, balconies and generally at low heights (classed as E2, E10, E100, E+)
POI: Points of interest (public buildings, metro stations, shopping malls, etc.)
EMF observatory stations (NOEF): broadband | selective

Region	Municipalities	Surface (km^2)	No of residents (2021)	BSA+SCA density (antennas/km^2)
A. Attica urban	Athens	39.0	637,798	~120
B. Attica suburban	Agia Paraskevi	7.9	62,147	~14.5
	Chalandri	10.8	77,102	
	Papagou-Holargos	8.6	45,266	

2 x 2 km^2

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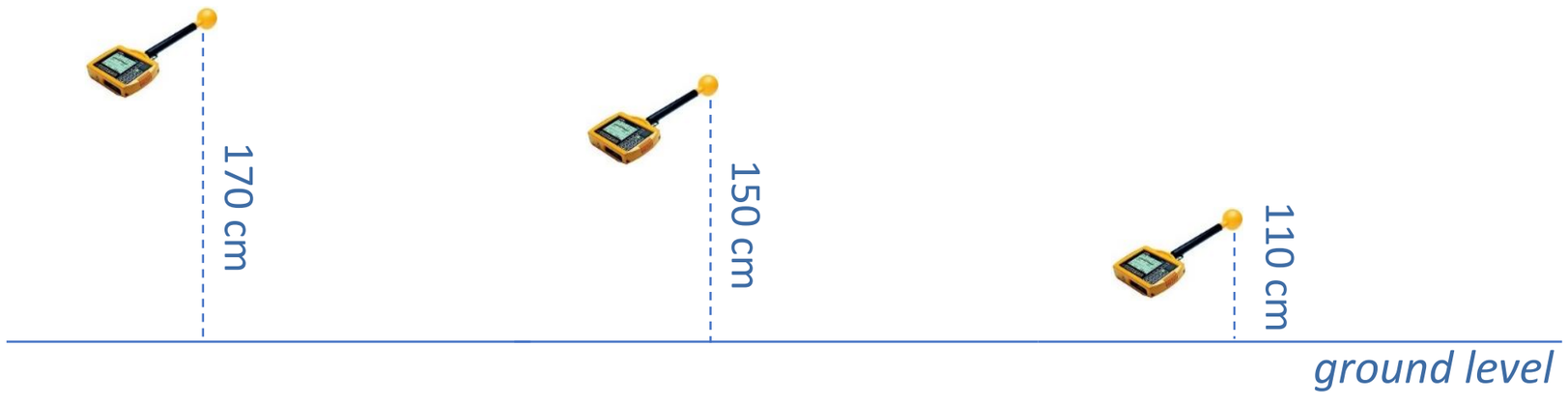
2. Materials & Methods (in situ measurements)

- ✓ SRM-3006 [Narda] with two E-field antennas **[27 MHz – 3 GHz, 420 MHz – 6 GHz]**
- ✓ **DL measurements** for each provider in Greece
- ✓ **Broadband** inspection of the site in order to specify the local maximum values
- ✓ **Frequency selective measurements** at three successive heights: **110, 150, 170 cm,** where the averaged E-field value **over 6 minutes duration** is saved
- ✓ Spectrum analysis for **FR1 3.4-3.8 GHz**
- ✓ 5G coverage (>86% in Greece)[5G Observatory]



In situ

200 measurement points

100 points in urban

100 points in suburban

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2. Materials & Methods (drive tests & indoors)

Drive tests

1 urban (3 times)

1 suburban (3 times)

N_{temp} = 2

urban: 40 km route

suburban: 40 km route

- ✓ Tektronix RSA 306B, Narda SRM 3006
- ✓ Spectrum analysis: **F_{min}: 750 MHz, F_{max}: 3.8 GHz (Tektronix, SRM-3006), RBW: 2-3 MHz,** MR (measurement range): depending on the region
- ✓ The height of the SRM probe from the metallic car roof is approximately **50 cm**
- ✓ The height of the SRM probe from the ground level is approximately **2 m**

Indoors

44 points and 67 metro stations

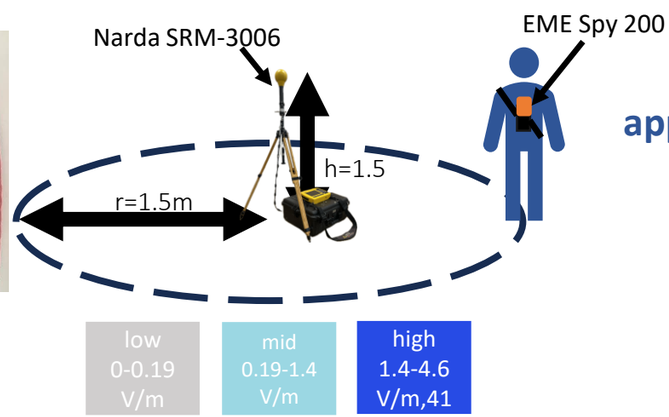
N_{temp} = 2

POIs: 111

metro stations (Attica): 67

POIs
- Train/Metro station
- Moving train/bus/tram
- Shopping malls
- Public buildings
- University buildings
- Residential apartments

- ✓ **EME Spy 200 [MVG]** put in cross-body bag in front of the user's chest
- ✓ **measurement every 4 sec**
- ✓ mobile phone on flight mode, slow walking pace, each measurement lasts for **10-30 min**



applied correction factor α

$$\alpha = \frac{E_{srm}}{E_{spy}}$$

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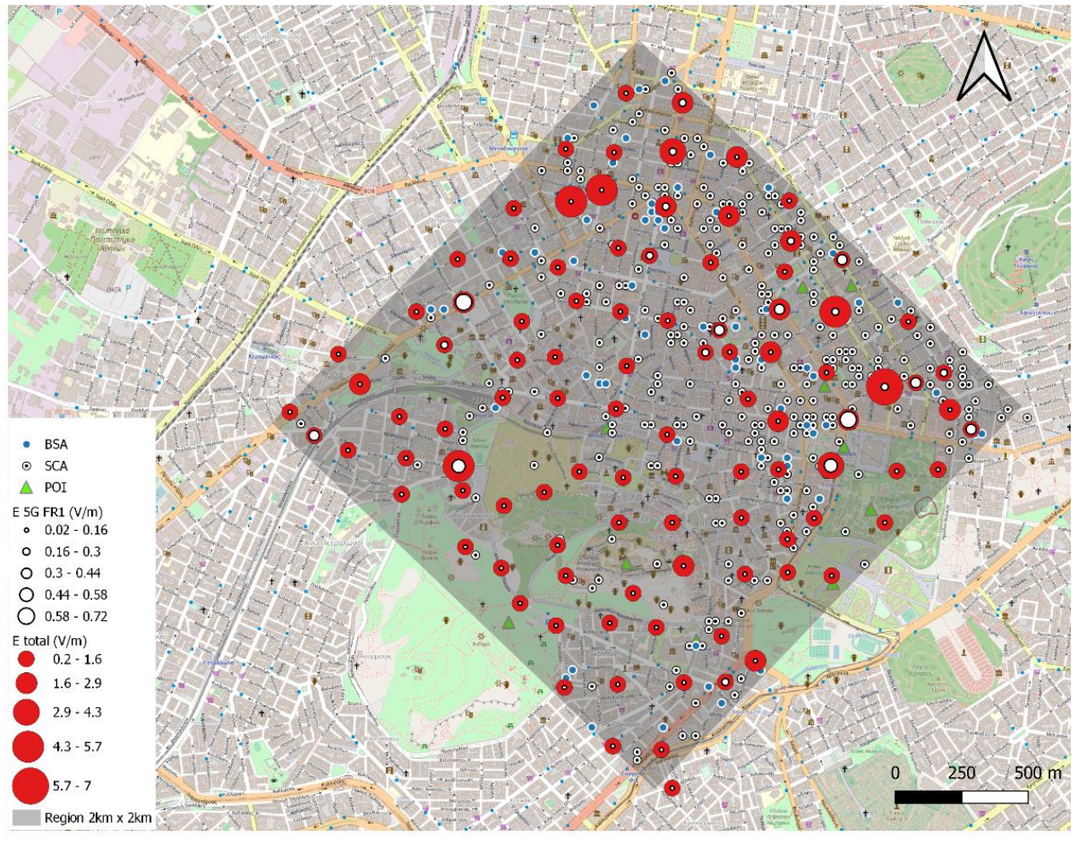
3. Results (in situ measurements)

Suburban (Agia Paraskevi-Chalandri-Cholargos)

E-field total [0.09-4 V/m]

E-field @ RF1 3.5 GHz [0.03-0.8 V/m]



Urban (Athens city center)

E-field total [0.2-7 V/m]

E-field @ RF1 3.5 GHz [0.02-0.72 V/m]

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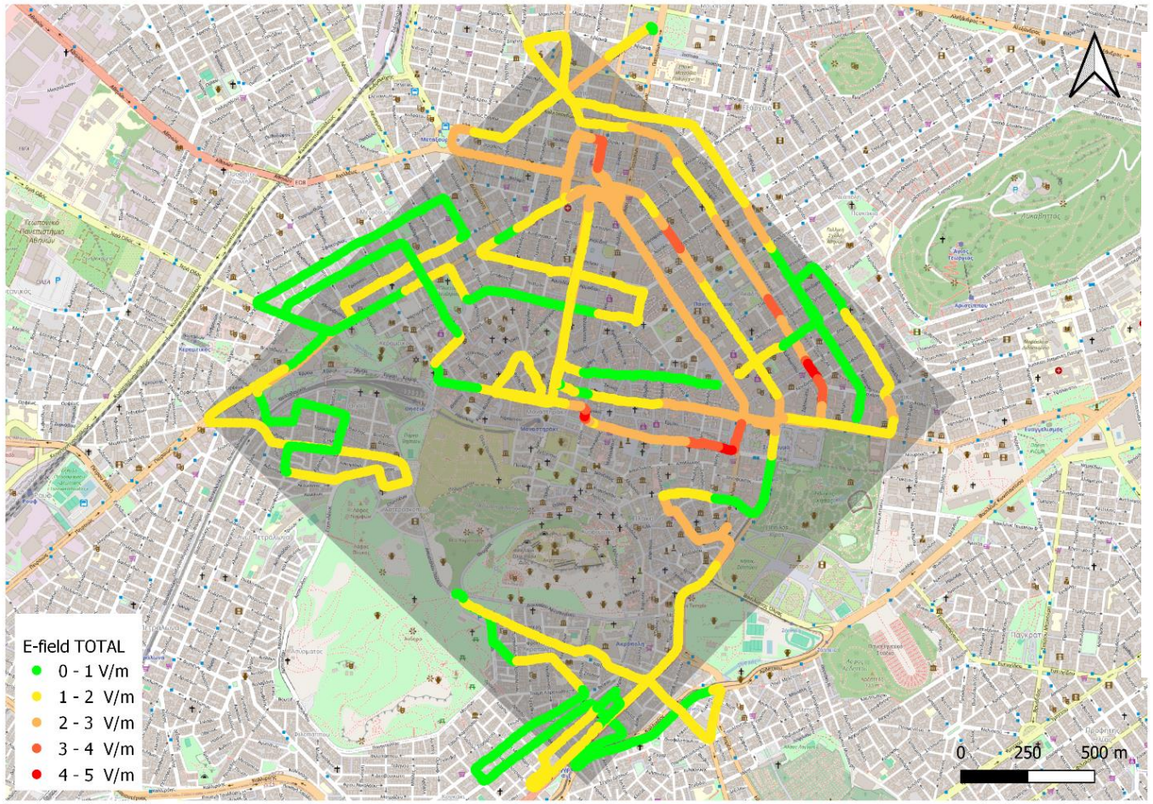
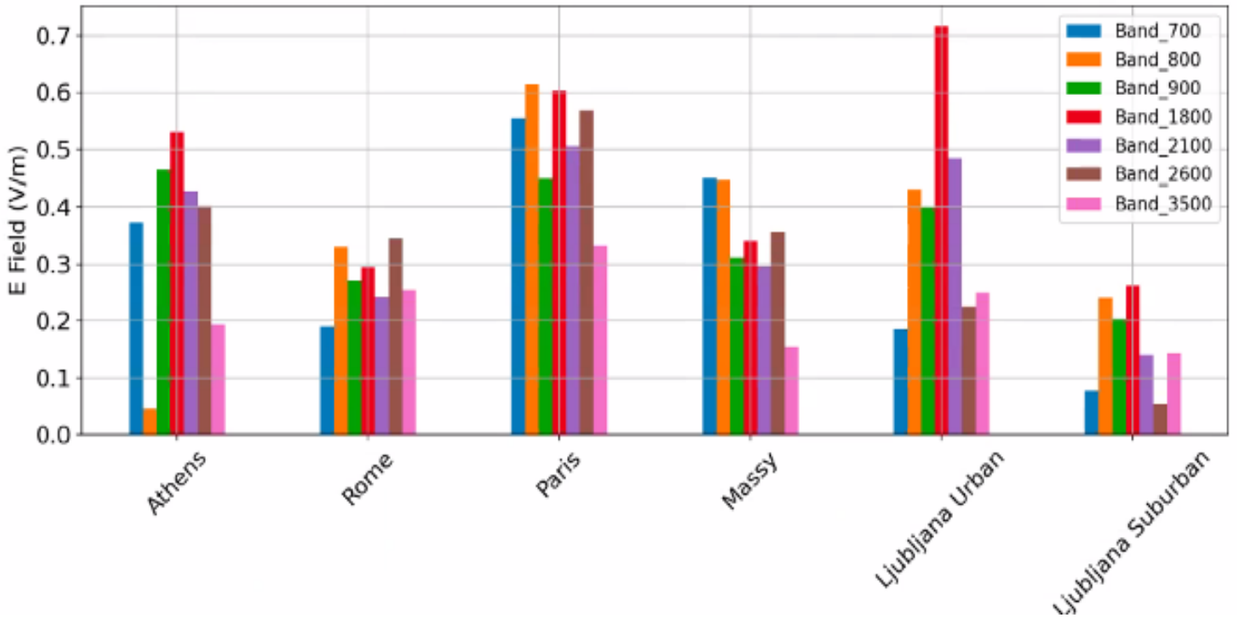
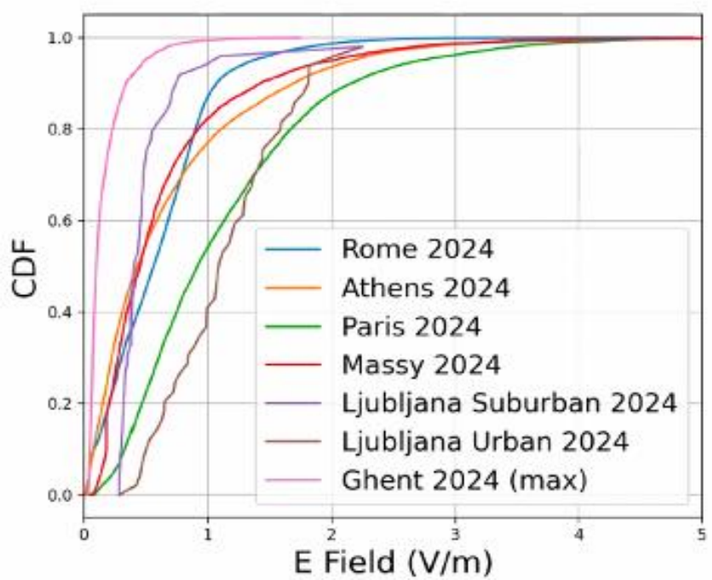
3. Results (drive test)



Athens (~40 km, weekday, morning)

Athens compared to other European cities





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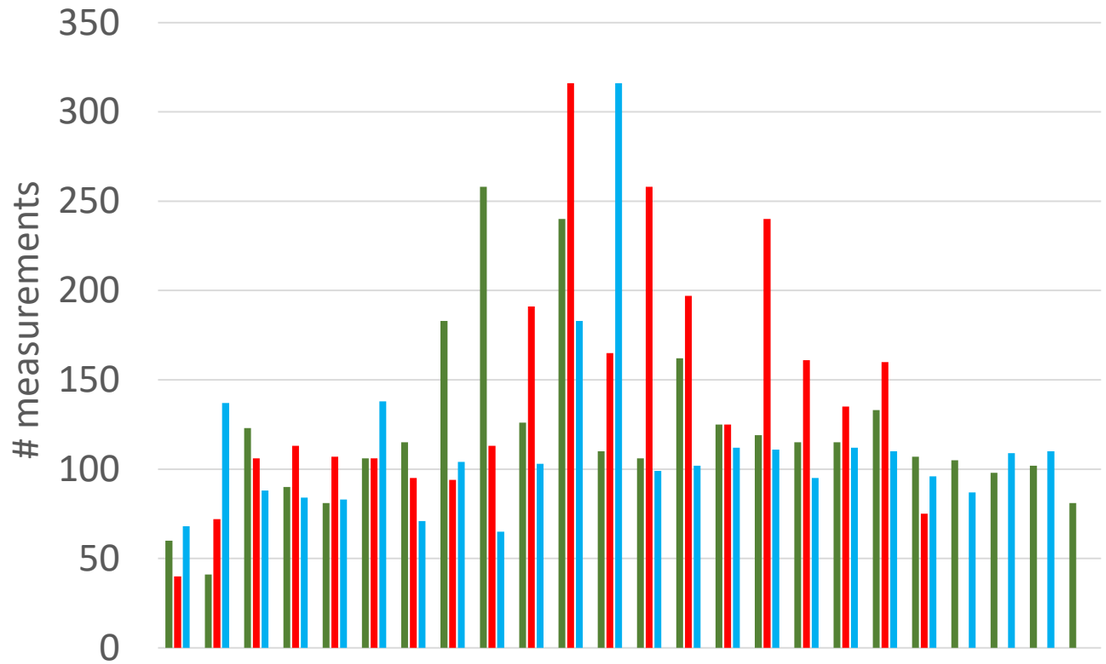
3. Results (indoors)

Line 1 (green)
24 stations
moving train

Line 2 (red)
20 stations
moving train

Line 3 (blue)
23 stations
moving train



$$E_{rms} = \sqrt{\frac{\sum_{i=1}^{N} E_i^2}{N}}$$

Summary of rms E-field (V/m) values at each line/stations or moving train at frequencies of mobile telecommunication services

line/case	N	duration (min)	791-821 MHz (DL)	925-960 MHz (DL)	1805-1880 MHz (DL)	2110-2170 MHz (DL)	2620-2690 MHz (DL)	3300-3900 MHz
1/stations	2901	193.4	0.422	1.814	1.558	0.721	0.290	0.122
1/moving train	1460	97.3	0.245	0.778	0.859	0.539	0.261	0.210
2/stations	2869	191.3	0.111	1.480	0.605	0.389	0.048	0.025
2/moving train	619	41.3	0.017	0.507	0.215	0.225	0.026	0.020
3/stations	2583	172.2	0.034	1.510	0.515	0.104	0.044	0.025
3/moving train	1276	85.1	0.014	3.390	0.543	0.178	0.031	0.020

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4. Conclusions

- ❑ Non significant 5G NR FR1 contribution to total E-field
- ❑ Differences in exposure levels at urban/suburban regions are directly connected to the population/antennas density/5G users
- ❑ Results from comparative drive tests in Attica are in compliance with other European cities
- ❑ Results in Athens metro dependent on the network planning and the small cell antennas' sites
- ❑ Indoor measurements: Issues to be studied in detail (by standers, moving train,…)

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5. References

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