**Session: S05**
**Dosimetry 3 (Measurements)**
**Tuesday September 28, 2021 • 09:45 - 11:00**
**Einstein**
**Chairs: Marco Zahner & Wout Joseph**

**S05-1 [09:45]**

**Assessing exposure to low frequency magnetic fields in a broad frequency range using fft-based personal exposimeters: The issue of spectral noise**

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***Keywords: Dosimetry (measurements), ELF/LF, Work in Progress***
***Presented by: Jens Kuhne***

The exposure of the general public to low frequency magnetic fields can be assessed using body worn personal exposimeters (PEM). In Germany, a large study with 1952 participants in Bavaria has been conducted 1996/1997 with PEM capable of measuring magnetic fields at two distinct frequencies, namely 16.7 and 50 Hz [Brix et al, 2001]. In order to update this low frequency exposure data and to generate data that is representative for the German population a new study is planned.

In this study a new generation of FFT-Based PEM that allow to simultaneously cover a broad frequency range from DC to 1 kHz with a spectral resolution of 1 Hz will be used. However, broadband spectral noise of the PEM strongly dominates the sum exposure calculated over the whole frequency range, which renders such data useless in case of the typical everyday low exposures. Peak detection algorithms that select sharp signal peaks for evaluation of the summed exposure can help to overcome this problem. However, these algorithms often depend on the chosen parameters for peak detection and might lead to an underestimation of total exposure in case of undetected small or broadened peaks.

Here, an alternative approach for evaluating the total magnetic field exposure across the whole frequency range is presented. The approach is based on the estimation of the spectral noise distribution and allows for spectral integration of the data over the whole frequency range.

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**S05-2 [10:00]**

**What has been the impact of Covid-19 on the environmental exposure to RF-EMF?**

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***Keywords: Dosimetry (measurements), RF/Microwaves, Work in Progress***
***Presented by: Sam Aerts***

Mid-March 2020, nation-wide lockdowns were instated in several European countries to reduce the spread of the COVID-19 pandemic. In this study, the impact of these lockdowns on the environmental radiofrequency (RF) electromagnetic field (EMF) exposure is investigated, using data from EMF monitoring networks in four European countries: Belgium, France, Greece, and Spain. It was generally observed that sensors positioned in a distinct type of microenvironment (e.g. residential) measured EMF exposure patterns that followed the mobility trends of that microenvironment. However, this correlation also depended on the frequency band and the country.

## Introduction

In several European countries, strict lockdowns were instated between mid-March and the beginning of May 2020 (and again later that year) in order to contain the spread of COVID-19. Mobility trends captured by Google [1] and Apple [2] visualize this abrupt change in our society by a steep decrease in mobility in almost any microenvironment other than residential areas. In this study, the impact of this lockdown on the environmental radiofrequency (RF) electromagnetic field (EMF) exposure is investigated, using measurement data from sensor networks and monitoring stations in Belgium [3,4], France [5], Greece [6,7] and Spain [8,9]. In this abstract, a number of results of the ongoing analysis are presented.

## Materials & Methods

### *RF-EMF Monitoring Networks*

The considered RF-EMF monitoring networks consisted of: (a) in Belgium four multi-frequency RF sensors in an area of 0.1 $km^2$ in the city centre of Antwerp [3,4]; (b) in France in total 31 wideband RF sensors (in 2020) in four cities (Paris, Nantes, Bordeaux, and Marseilles) [5]; in Greece 165 monitoring stations all over the country [6,7]; and finally in Spain five multi-frequency RF sensors in the city centre of Santander [8,9].

The city centres of Santander and Antwerp are similar, in that they comprise residential areas, shops and offices in mid-height buildings. The wideband sensor and monitoring station locations in France and Greece varied.

In Belgium and Spain, the sensors comprised four single polarized antennas which measured the frequency bands 900 MHz, 1800 MHz, 2100 MHz, and 2400 MHz [3,4,8,9]. Whereas the latter is mostly used by Wireless Fidelity (Wi-Fi), the other bands can be used by either one of (or combination of) the $2^{nd}$ through $4^{th}$ generation mobile telecommunications technologies Global system for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS), and Long Term Evolution (LTE). The sampling speeds were 1s and 5min respectively in Belgium and Spain. In Spain, the 900 MHz and 1800 MHz frequency bands are jointly used for voice (GSM) and data (UMTS and LTE), whereas the 2100 MHz band is only used for data-based technologies (UMTS and LTE). Moreover, in the city of Santander there is a remarkable number of Internet of Things (IoT) devices using 802.15.4 communications (in particular ZigBee) and sharing the 2400 MHz band with Wi-Fi. In Belgium, on the other hand, besides Wi-Fi in the 2400 MHz band, 900 MHz is used by both GSM and UMTS, 1800 MHz solely by LTE, and 2100 MHz solely by UMTS.

In France, wideband three-axis antennas were used, capturing the total field strength between 80 MHz and 6 GHz [5]. Whereas in Greece, monitoring stations can provide both wideband measurements, as well as measurements in specific narrower frequency bands, the results presented here are only from wideband measurements in the frequency range 100 kHz to 7 GHz [6,7].

### *Mobility Trends Data*

Data on the mobility trends during 2020 were made available by Google [1], using as baseline (= 0) the median value, for the corresponding day of the week, during the five-week period Jan 3 to Feb 6, 2020, and Apple [2], with baseline (= 100) 13 Jan 2020. Whereas Google monitored the visits to places, aggregated in six microenvironments (retail & recreation, grocery & pharmacy, parks, transit stations, workplaces, and residential), Apple tracked the number of directions requests in its Maps app for either walking, driving, or transit. Furthermore, the spatial resolution of the data sets depends on the country and the region (e.g. in Belgium, the Google mobility data is available for the province of Antwerp and the Apple mobility data for the city of Antwerp).

### *RF-EMF Exposure Metric*

To analyse the correlation with the mobility data, the RF-EMF exposure (in terms of power density S, in $W/m^2$) measured by each sensor node (and per frequency band) was averaged per day and then normalized to a baseline. The normalized exposure is denoted by s (in %).The baseline depended on the considered measurement period. For example, $s_{2020}$ represents the daily power density variation from the annual average power density measured over 2020, hence the baseline (= 0) is the average exposure level over 2020.

## Results

### *Correlation with mobility data from Google and Apple*

Figure 1 shows the 2020 daily power density variation $s_{2020}$ in residential areas in Greece, together with the Google daily mobility variation for residential areas with respect to the reference period in the beginning of the year (before the lockdown). From this, the correlation between the wideband RF-EMF exposure and the mobility is quite clear (r = 0.72), although the variations in the RF-EMF exposure are smaller than for the mobility data (in the first lockdown: +20% in RF-EMF exposure versus +35% in residential mobility). Similar results were found for residential areas in France (not shown here). However, sensors or monitoring stations in mixed areas did not exhibit a correlation with any of the Google microenvironments.

In addition, in Antwerp, it was observed that the correlation with mobility was the highest for the 1800 MHz band (not shown here), which is used solely by LTE. Furthermore, even though the sensors were geographically close, based on the measurements in this band it could be deduced that some were in different microenvironment than others.

### *Comparison to 2019*

In Figure 2 the situation in Spain 2020 during the first lockdown, between 14 March and 18 June 2020 (along with different relaxations towards the end), was highlighted and compared to the same period in 2019. Here, the baseline to calculate $s_{2020}$ and $s_{2019}$ was the average over 2020 and over 2019, respectively.

In 2019, which represents the normal situation, the exposure was rather flat during this period, until the start of the summer. Mid-June, there was an increase of 20% compared to the yearly average of the RF exposure in the 900 and 2100 MHz bands.

In 2020, there is a sudden decrease in exposure in both 900 and 2100 MHz bands as soon as the lockdown was instated. In this period, the 1800 MHz band showed the least difference compared to 2019. From then on, the exposure in the 900, 1800, and 2100 MHz bands stayed relatively low until July, which saw a large increase, probably due to the return of foreign tourists. There was also a large peak in the 2400 MHz just before the lockdown and a few smaller ones between mid-May and the beginning of June. However, their origin is unknown.

Similar results were observed in Belgium (predominantly in the 1800 MHz band) and Greece (both not shown here).

## Conclusions

In this study, the impact of the COVID-19 on the environmental exposure to radiofrequency (RF) electromagnetic fields (EMF) is being investigated, using data from EMF monitoring networks in four European countries (Belgium, France, Greece, and Spain). From the preliminary results, it was generally observed that when a sensor was positioned in a distinct type of microenvironment (e.g. residential), the temporal EMF exposure captured by that sensor seemed to follow the mobility trends in that microenvironment, but to a lesser extent. This means that the RF-EMF exposure generally increased in residential areas, and decreased in retail and recreational areas. The observed exposure trends (e.g. a decrease during the first lockdown) were more clear in frequency bands used predominantly for mobile data (LTE). Although the differences in the sensors and the small sample size make it difficult to draw general conclusions between the four countries, this study clearly shows the overall usefulness of RF-EMF monitoring networks.

## Acknowledgment

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Innoveren & Ondernemen) and installed in cooperation with the City of Antwerp. The sensors in France are funded and deployed by EXEM (Toulouse, France) [5]. S. Aerts is a post-doctoral fellow of UGent-BOF (Universiteit Gent – Bijzonder Onderzoeksfonds). The contribution of the University of Cantabria is supported by the Spanish Government (MINECO-FEDER) under the project FIERCE (RTI2018-093475-AI00).

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**Figures**

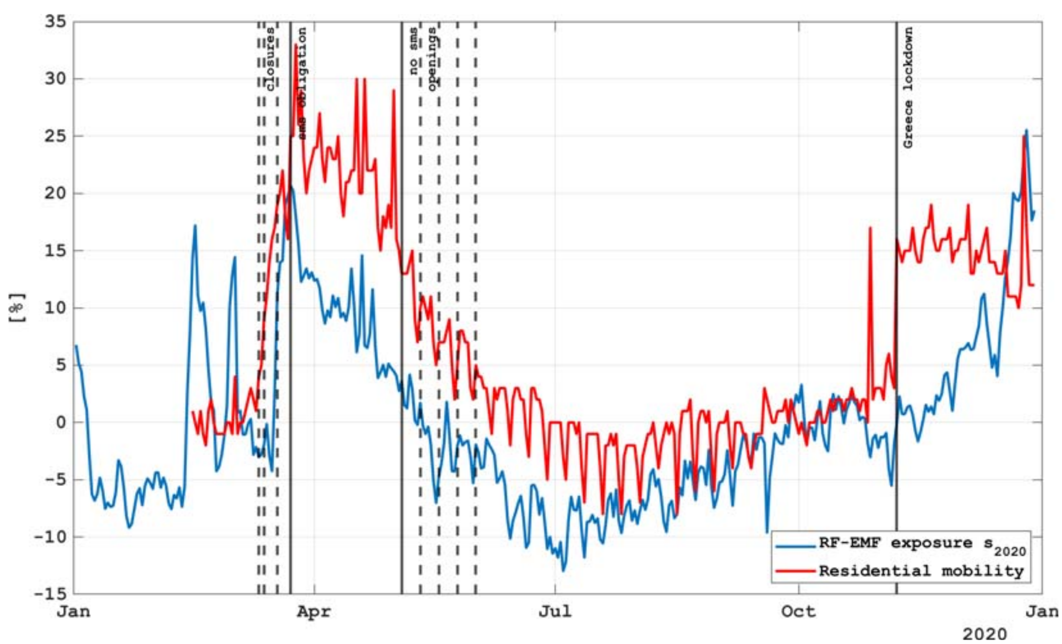


Figure 1. The figure shows the daily power density variation $s_{2020}$ from the annual average power density of 2020 in residential areas in Greece, together with the Google daily mobility variation for residential areas with respect to the reference period in the beginning of the year (before lockdown). The power density was averaged over 51 monitoring stations in residential areas around Greece. In March 2020 first the schools (11 March), then the restaurants and malls (13 March), and finally the retail closed (18 March).Between 23 March and 4 May, SMSs were obligated to obtain a lockdown movement permit. Starting 11 May 2020, the country started opening up again, before going back in lockdown on 7 Nov 2020.

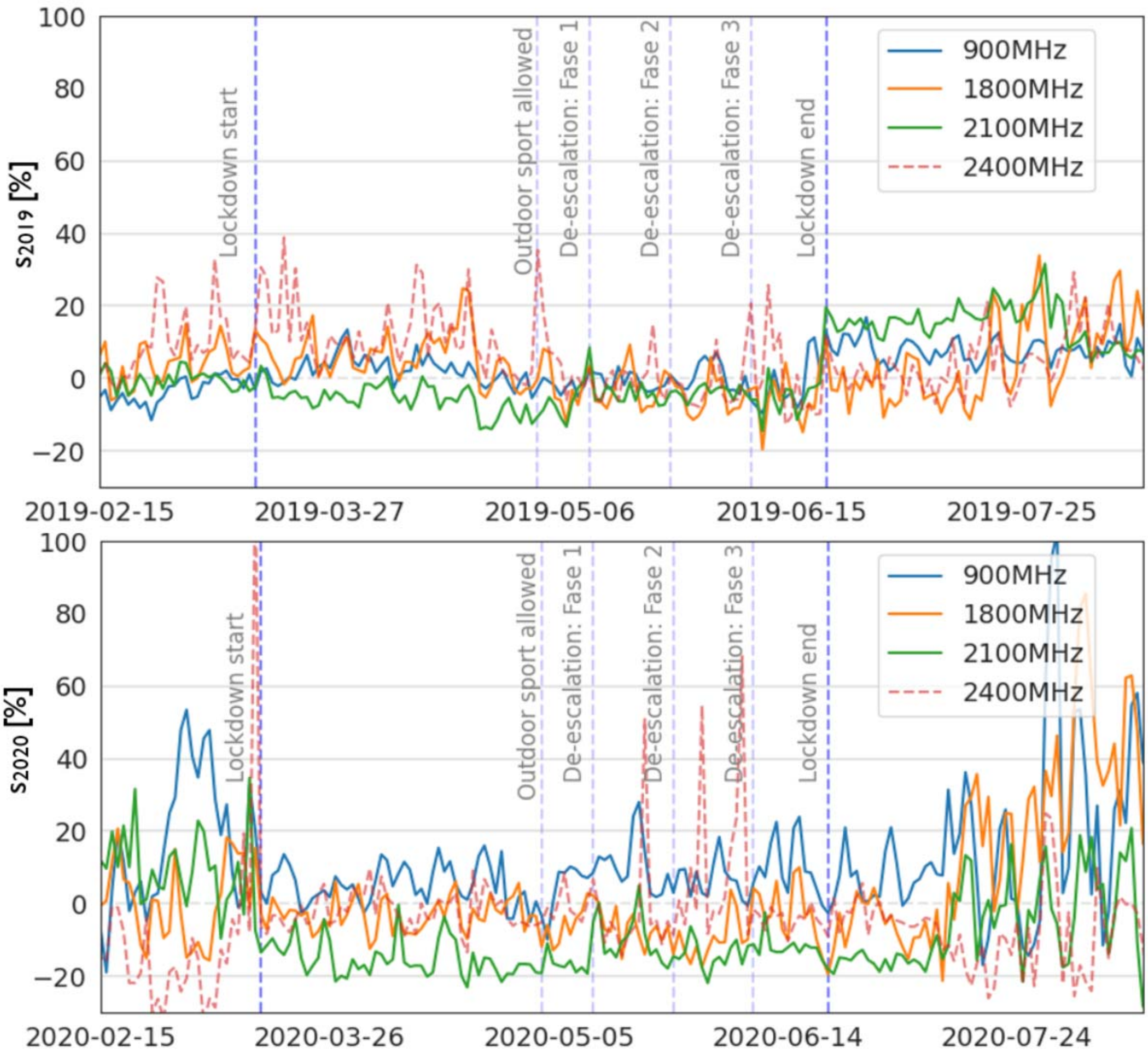


Figure 2. Comparison of the daily power density variations in four frequency bands from the annual average power density of 2019 ($s_{2019}$) and 2020 ($s_{2020}$) in Santander, Spain, with (for both years) indication of the dates of the start of the COVID-19 lockdown (in 2020) and the subsequent relaxations leading to the end of the lockdown. The power density was averaged over the five RF-EMF sensors in the city.

**S05-3 [10:15]**

**Development of a web-based assessment tool for occupational magnetic field exposure in the vicinity of resistance spot welding devices**


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## Abstract Collection