

RENCONTRE SCIENTIFIQUE

Radiofréquences et santé :

la recherche face à des technologies
en évolution rapide

23 novembre 2022

Espace Diderot - Paris 12^e

#RadiofrequencesRS

Caractérisation de l'exposition résidentielle aux ondes RF

Projet AMPERE



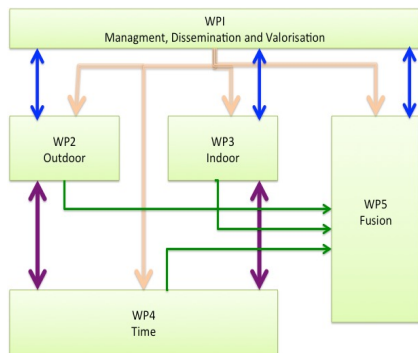
Projet 2016
EST-16-RF-04

Joe Wiart

Holder of Chaire C2M, Telecom Paris,
Institut Polytechnique de Paris



AMPERE project



- The widespread use of **wireless communication systems**, the imminent **deployment of 5G** and the risk perception has highlighted the **need to characterize the residential Electromagnetic Fields Exposure**.
- The AMPERE project proposed by six academic teams, from 4 countries and submitted in 2015, responded to this request.
- The main contributions of the AMPERE project have been:
 - The modeling of the global exposure (UL and DL)
 - The temporal analysis
 - The aggregation of spatial and temporal EMF exposure with geographical data, population distribution, socio-economic data and uses toward EMF mapping building.

Toward RF Exposure Maps based on data fusion

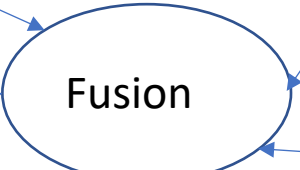


Socio Professional Categories
Type of habitat
Population density

Outdoor assessment and surrogate geostatistical interpolation and modeling (e.g. Kriging)

Indoor assessment and statistical modeling

Temporal Variations



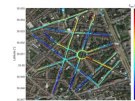
RF MAP OF EXPOSURE



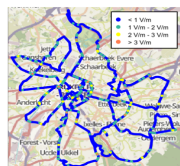
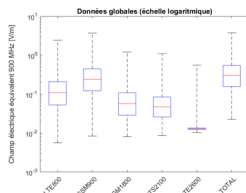
Outdoor drive test measurements in Paris and Brussels. Surrogate modeling.

Challenge: Predict value outside measurement area

Geostatistical tools



Bruxelles



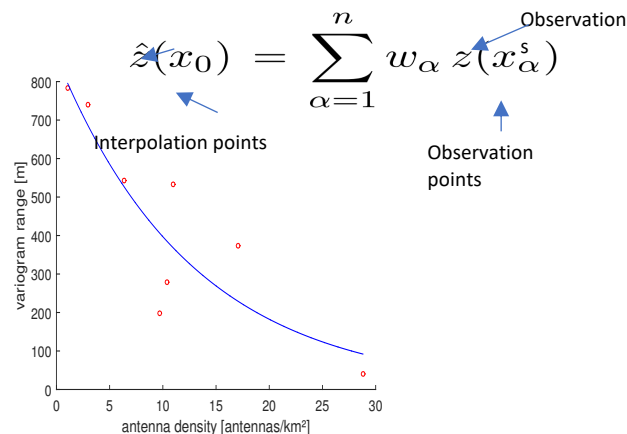
kriging

Experimental variograms

Paris



Freq (MHz)	Moyenne (v/m)	Médiane (v/m)
2600	0,20 v/m	0,14 v/m
2100	0,22 v/m	0,18 v/m
1800	0,29 v/m	0,23 v/m
900	0,28 v/m	0,21 v/m
800	0,27 v/m	0,21 v/m
700	0,13 v/m	0,07 v/m
Total	0,58 v/m	0,44 v/m

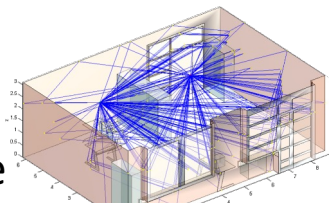


$$E_{\text{equivalent 900}} = \sqrt{\sum_{400 \text{ MHz}}^{2000 \text{ MHz}} \left(\frac{E}{0,2\sqrt{f} [\text{MHz}]} \right)^2 + \sum_{2000 \text{ MHz}}^{300 \text{ GHz}} \left(\frac{6}{9,1} E \right)^2} \text{ [V/m]}$$

Indoor exposure

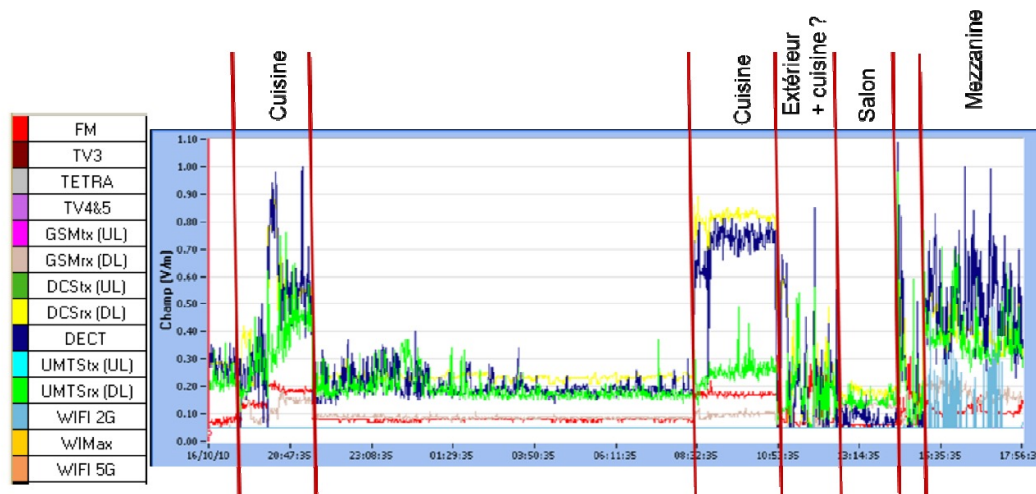
Indoor source

Indoor exposure

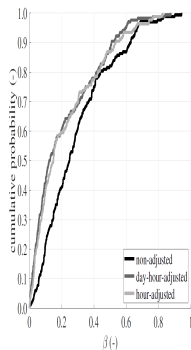


Outdoor Source

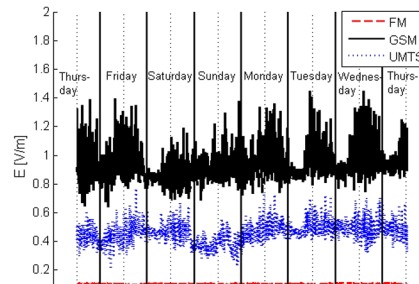
Indoor exposure



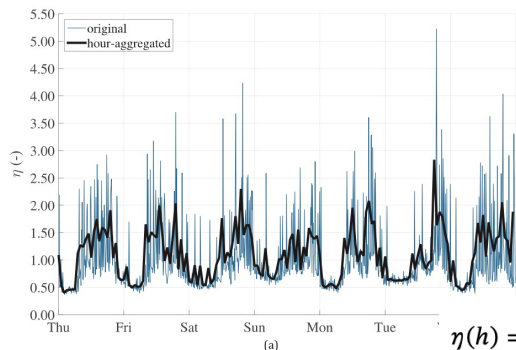
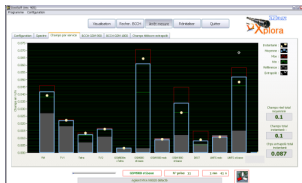
Temporal Measurement



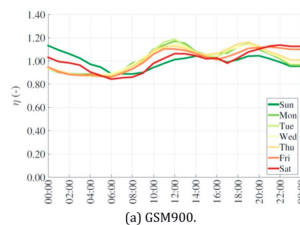
CDF of measurements carried out in Brussels, Paris, UU



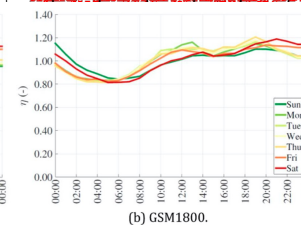
12



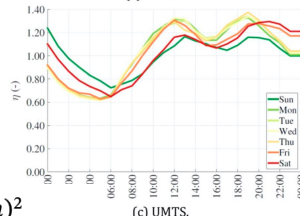
$$\eta(h) = \frac{E(h)^2}{\text{mean}(E(h)^2)}_{h \in d}$$



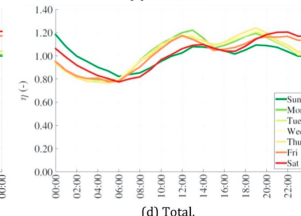
(a) GSM900.



(b) GSM1800.



(c) UMTS.



(d) Total.

Toward Global exposure via fusion data

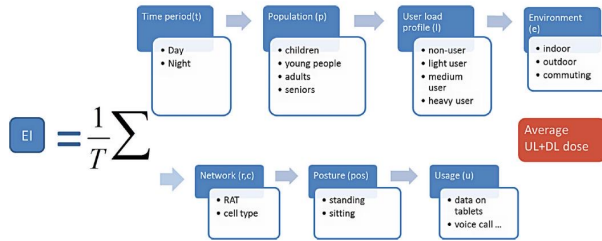
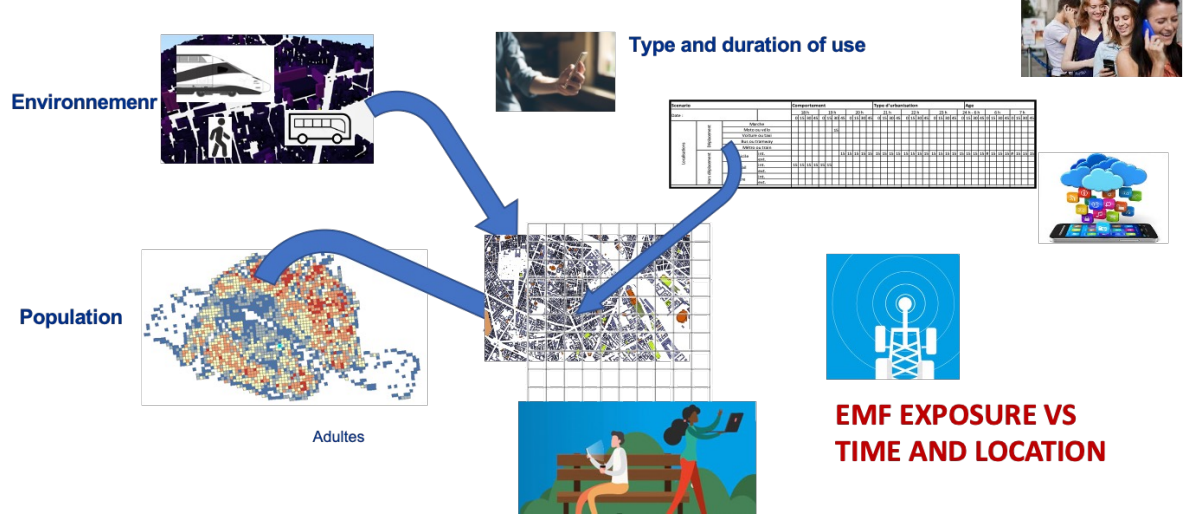


Fig. 1. EI chain of exposure.

Global exposure based on LEXNET concept



What has been learnt from AMPERE

- Global (UL and DL) exposure is needed to assess the residential Electromagnetic Fields Exposure.
- Indoor Exposure assessment using deterministic method is complex, statistical methods have to be used
- Surrogate models can be used where measurements are not easy to perform
- Fusion data matching usage and exposure can be used to assess the residential Electromagnetic Fields Exposure.

European projects Seawave and Goliat will improve the monitoring approaches using IA

Spot Measurements



Drive test measurements



Sensors Networks measurements



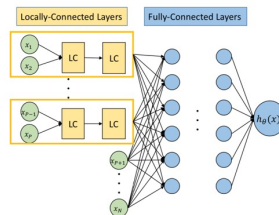
Trace mobile measurements



Wireless networks cities structures



IA



SEAWave

GOLIAT

Centre international de Recherche sur le Cancer

Organisation mondiale de la Santé



anses

Publications

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- Chiaramello E, Parazzini M, Fiocchi S, Ravazzani P, Wiart (2017) J. Assessment of Fetal Exposure to 4G LTE Tablet in Realistic Scenarios: Effect of Position, Gestational Age and Frequency, IEEE Journal of Electromagnetics, RF, and Microwaves in Medicine and Biology, 2017, 1(1): 26-33).
- Chiaramello E, Parazzini M, Fiocchi S, Ravazzani P, Wiart J (2018). Stochastic Dosimetry based on Low Rank Tensor Approximations for the Assessment of Children Exposure to WLAN Source, IEEE Journal of Electromagnetics, RF, and Microwaves in Medicine and Biology, 2018, 2(2): 131-137
- Chobineh, A., Huang, Y., Mazloun, T., Conil, E., and Wiart, J. Statistical model of the human RF exposure in small cells environment. Annals of Telecommunications (2018)
- S. Aerts, J. Wiart; L. Martens; W. Joseph, "Assessment of Long-Term Spatio-Temporal Radiofrequency Electromagnetic Field Exposure", Environmental Research, vol. 161, pp. 136-143, 2018.
- S Azzi, Y Huang, B Sudret, J Wiart. Surrogate modelling of Stochastic Function - Application to Numerical Electromagnetic Dosimetry. International Journal for Uncertainty Quantification 2019 - 9 (4)
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- Chiaramello E, Bonato M, Fiocchi S, Tognola G, Parazzini M, Ravazzani P, Wiart J. Radio frequency electromagnetic fields exposure assessment in indoor environments: A review, International Journal of Environmental Research and Public Health, 2019, 16(6): 955
- Chiaramello E, Plets D, Fiocchi S, Bonato M, Tognola G, Parazzini M, Le Brusquet L, Martens L, Joseph W, Ravazzani P. Innovative Stochastic modelling of Residential Exposure to Radio Frequency Electromagnetic Field Sources, submitted to IEEE Journal of Electromagnetics, RF, and Microwaves in Medicine and Biology, on February 2, 2020
- S. Wang and J. Wiart Sensor aided EMF Exposure Assessments in Urban Environment using Artificial Neural Networks . International Journal of Environmental Research and Public Health, 2020
- C. Regrain, J. Caudeville 1,3, R. de Sèze, M. Guedda, A Chobineh Ph. de Doncker, L. Petrillo, E Chiaramello , M Parazzini , W Joseph, S Aerts, A Huss and Joe Wiart Design of an integrated platform for mapping residential exposure to Rf-EMF sources submitted to International Journal of Environmental Research and Public Health, 2020

Conclusion



Dans la confusion trouver la simplicité
De la discorde faire jaillir l'harmonie
Au milieu de la difficulté se trouve l'opportunité

Albert Einstein,
Trois règles de travail