

# Noise mapping based on participative measurements with a smartphone

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# Introduction

- **(Effect of) Noise in Europe:**

*“Excessive noise seriously harms human health and interferes with people’s daily activities at school, at work, at home and during leisure time. It can disturb sleep, cause cardiovascular and psychophysiological effects, reduce performance and provoke annoyance responses and changes in social behaviour.”*

- **European Environmental Noise directive 2002/49/EC**

*“define a common approach intended to avoid, prevent or reduce on a prioritised basis the harmful effects, including annoyance, due to the exposure to environmental noise”*



# Introduction

- **Noise mapping:**

- To identify noise pollution
- To propose action plans to reduce noise
- To communicate with citizens



- **Methods:**

- **Modelling** of noise emission and propagation (NMPB, CNOSSOS, ISO 9613...)
- **Measuring** real noise in urban areas (noise observatories): need a large amount of “qualified” data.



# Introduction

- **Alternative approach:**

*Develop a participative approach based on collaborative noise maps using smartphones (i.e. citizens) for a massive acquisition of noise data in urban environment*

G. Guillaume et al, « Noise mapping based on participative measurements ». *Noise Mapping* 3, n° 1 (2016): 140–156. doi:10.1515/noise-2016-0011.

- Made by specialists in Geomatics and in Acoustics
- Citizen both producer and consumer of data
- Build a qualified noise database
- Produce “real” and relevant noise maps
- **Share database and noise maps with communities**



# Summary

- Introduction
- General overview
- NoiseCapture application
- Spatial Data Infrastructure (SDI)
- Processing data
- Conclusion & prospects



# General overview

## NoiseCapture Android App



G. Guillaume et al,  
*Noise Mapping 3*,  
n° 1 (2016): 140–  
156.  
doi:10.1515/noise-  
2016-0011.

## OnoMap SDI



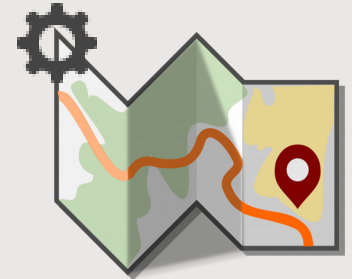
E. Bocher et al, *OGRS  
2016* Perugia, Italie:  
PeerJ Preprints, 2016.  
doi:<https://doi.org/10.7287/peerj.preprints.2273v2>.

## Raw database

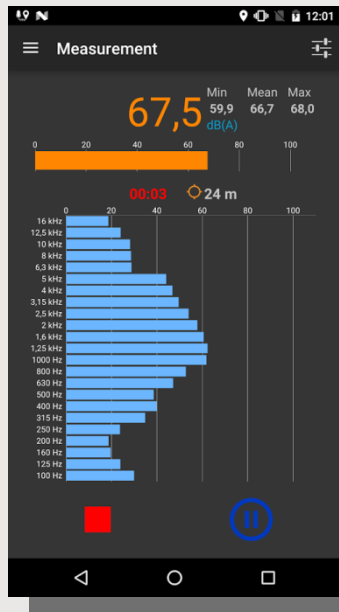
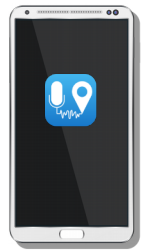


E. Bocher et al,  
« Collaborative noise  
data collected from  
smartphones », *Data in  
Brief* (2017, to be  
published)

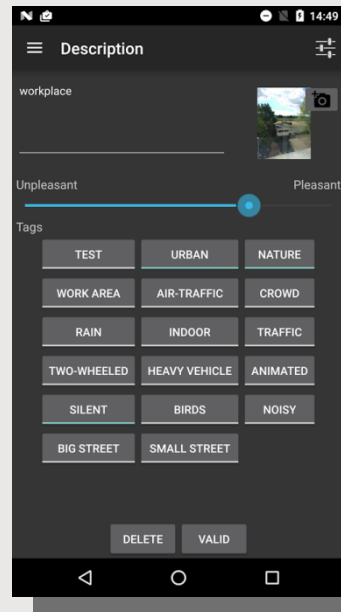
## Noise maps



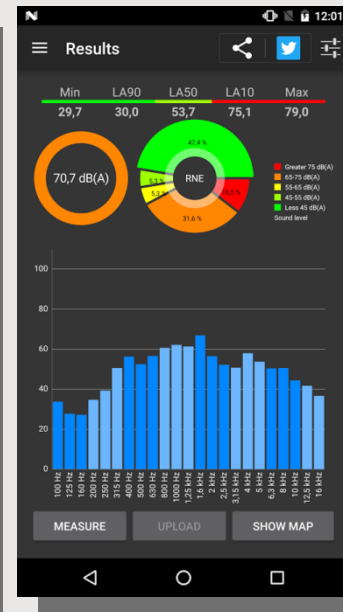
# NoiseCapture Android App



Measurement



Description



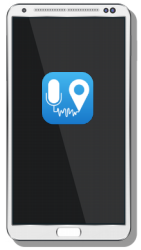
Indicators



Visualization



# NoiseCapture Android App



- **Audio restrictions** (SHOULD / MUST since Android 4.3)
  - Format:
    - Linear PCM, 16-bit
  - Sampling rates (Hz):
    - 8000, 11025, 16000, (22500), 44100, (48000)
  - Frequency response:
    - $\pm 3$  dB, from 100 Hz to 4000 Hz
  - Amplitude response:
    - 30 dB range from -18 dB to +12 dB @ 90 dB SPL
  - Total harmonic distortion:
    - less than 1% for 1000 Hz at 90 dB SPL

[https://source.android.com/compatibility/5.1/android-5.1-cdd#5\\_4\\_audio\\_recording](https://source.android.com/compatibility/5.1/android-5.1-cdd#5_4_audio_recording)

Smartphones and Apps accuracy: see Kardous & Shaw, JASA 135(4) and JASA 140(4)





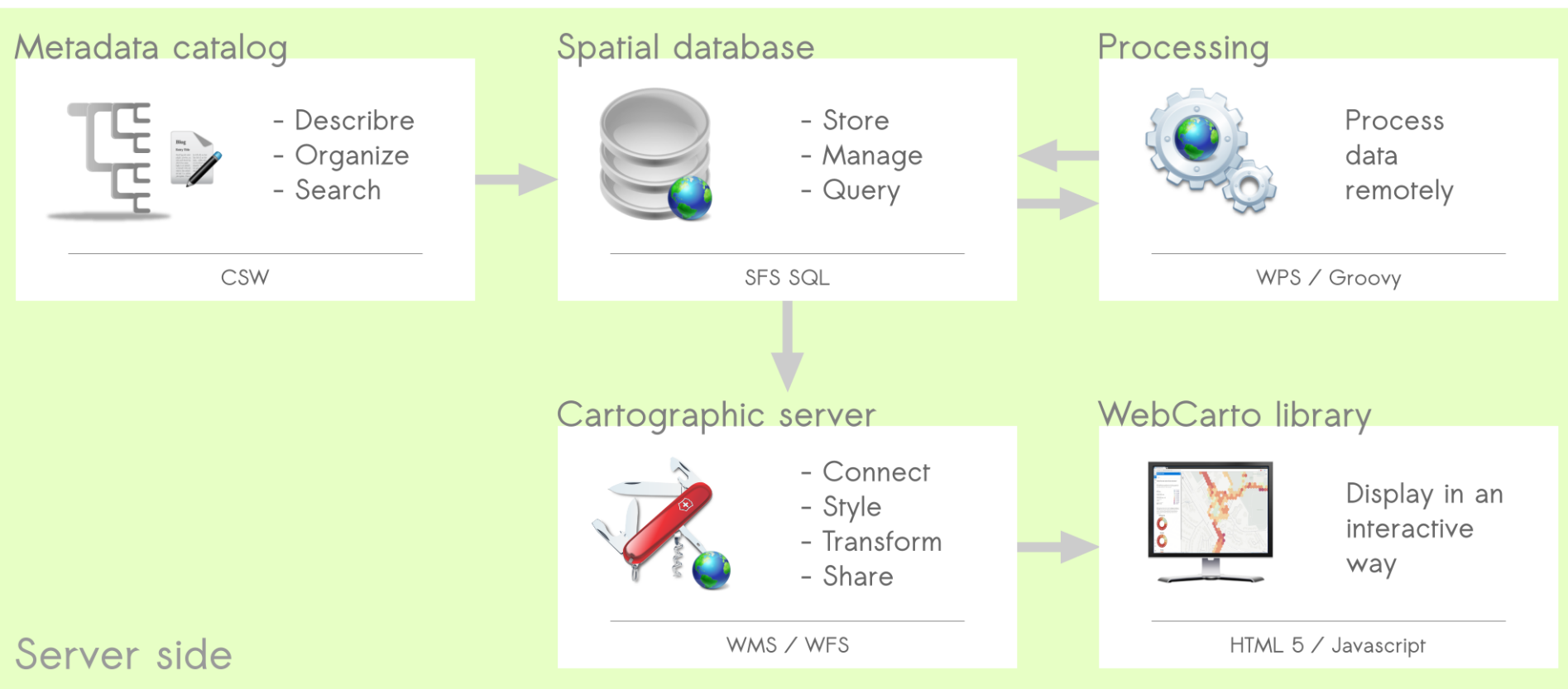
# NoiseCapture Android App



- **Audio measurement**
  - Noise reduction processing disabled
  - Automatic gain control disabled
  - Respect of the audio input sensitivity 90dB@1000Hz
- **Audio processing**
  - No audio recording (anonymised data, privacy policy)
  - FFT analysis (short@1s & fast@125ms)
  - Calibration with a reference device
  - Noise indicators calculation: LAeq, LA%, spectrum



# OnoMap SDI



## Server side

E. Bocher et al. « OnoM@p : A Spatial Data Infrastructure Dedicated to Noise Monitoring Based on Volunteers Measurements ». In *OGRS 2016*, 11. Perugia, Italie: PeerJ Preprints, 2016.  
doi:<https://doi.org/10.7287/peerj.preprints.2273v2>.



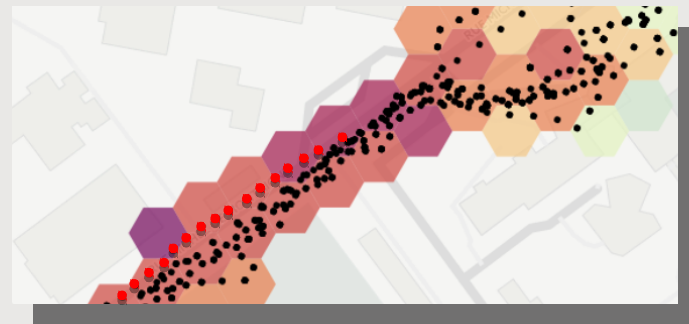
# Raw database (online: <http://data.noise-planet.org/noisecapture/>)



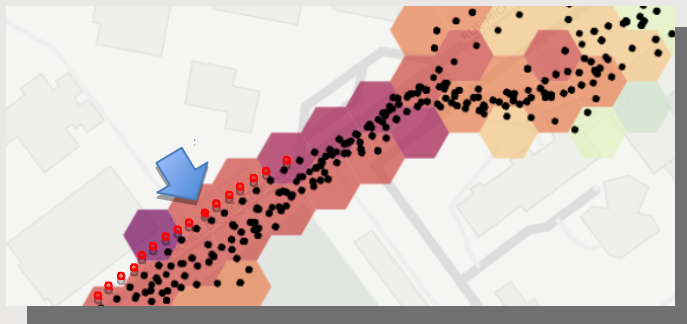
## 3 GeoJSON files

```
{  
  "type": "Feature",  
  "geometry": {  
    "type": "Point",  
    "coordinates": [125.6, 10.1]  
  },  
  "properties": {  
    "name": "Dinagat Islands"  
  }  
}
```

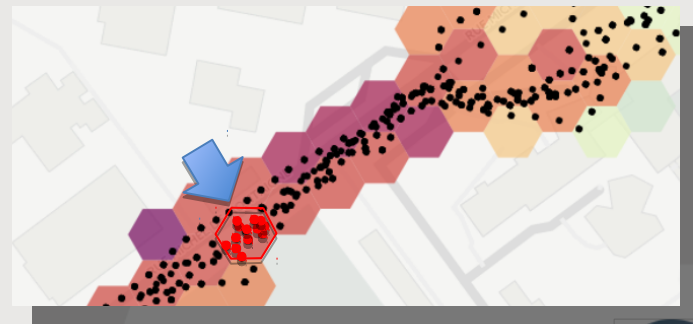
### \*.tracks.geojson



### \*.points.geojson



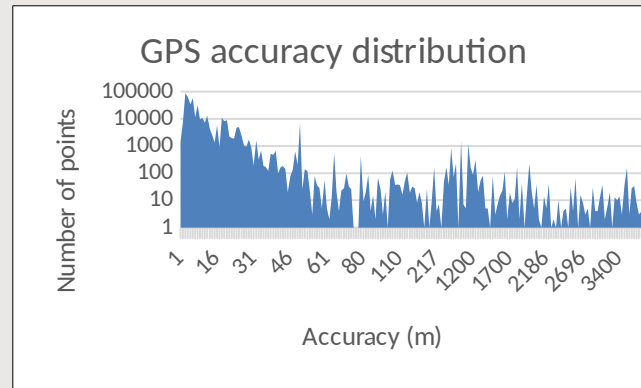
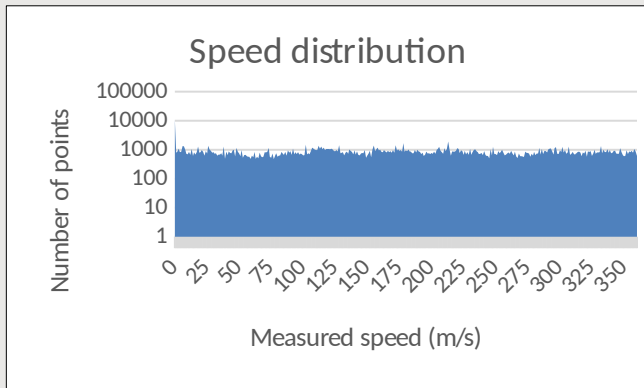
### \*.areas.geojson



# Raw database



## Be careful on the relevance of data

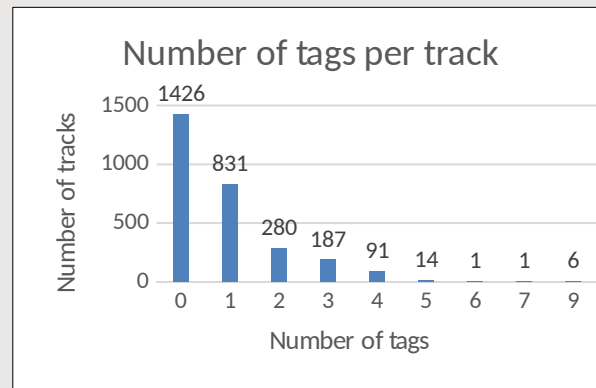
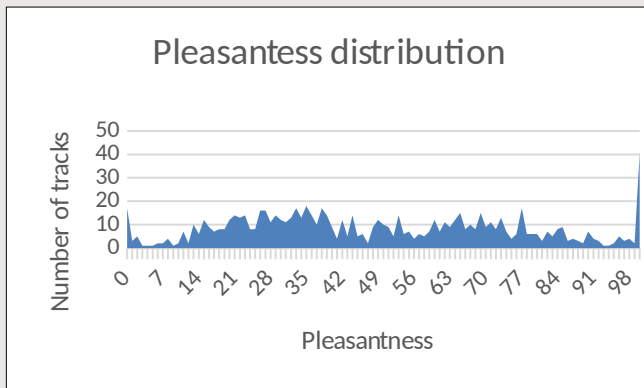


Tracks  
**2 837**

Points  
**470 869**

Points with speed  
**116 004 (27%)**

## Information provided by the user

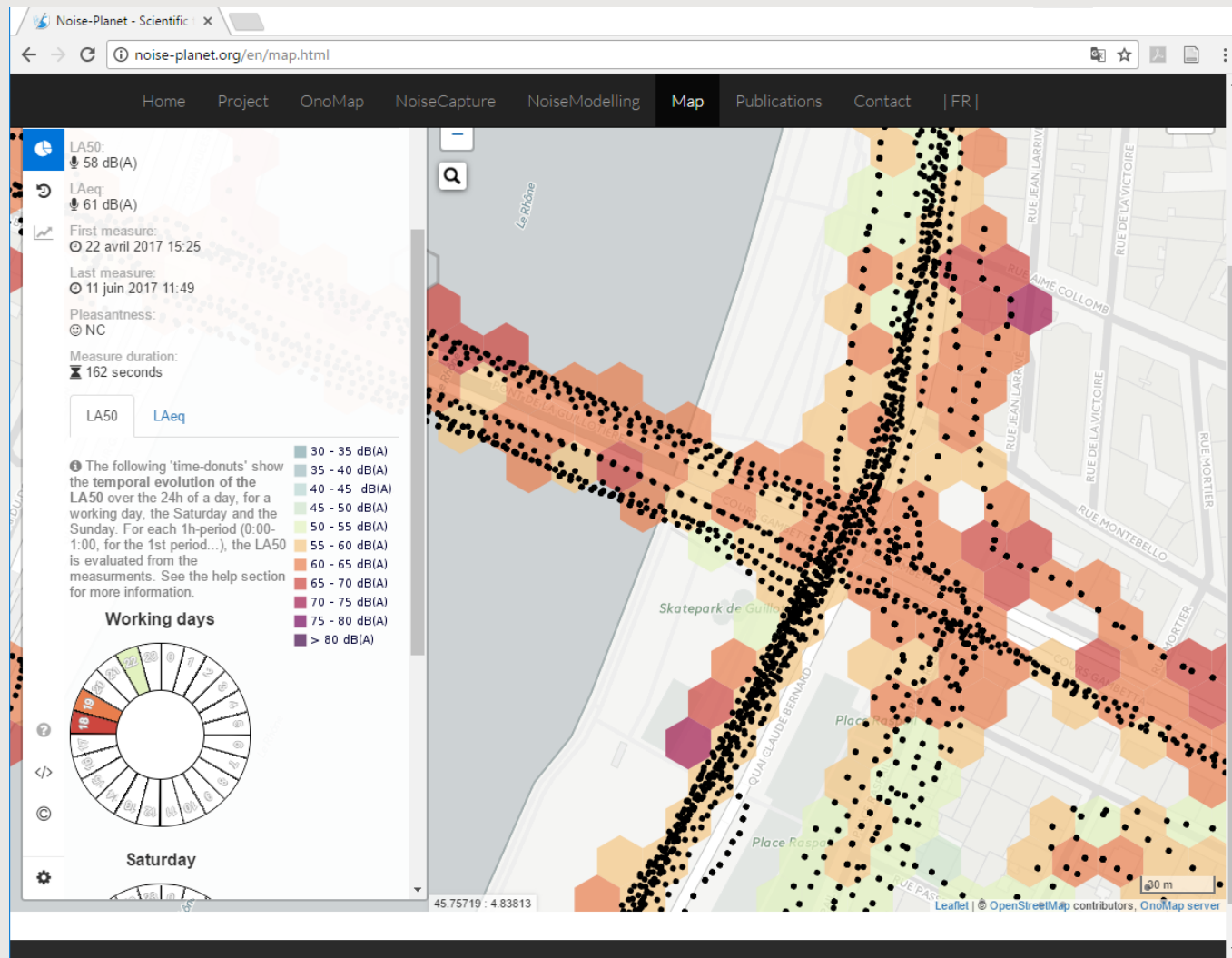
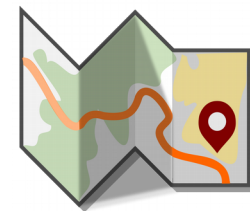


Tracks with pleasantness  
**1 972 (70%)**

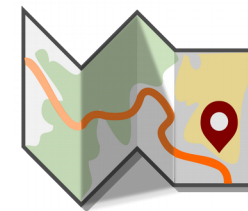
Tracks with tags  
**1 411 (50%)**



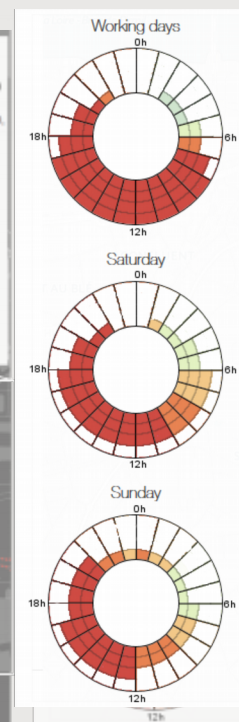
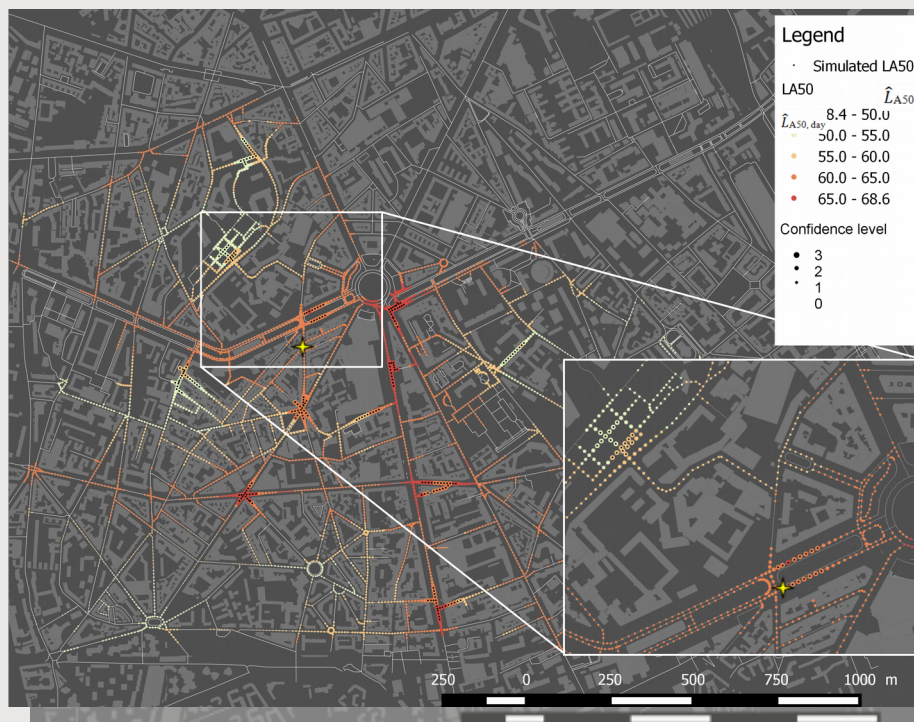
# Noise maps (first level: no filtering)



# Noise maps (second level)



Interpolated  $\hat{L}_{A50,day}$  sound levels map. The dots size represents the confidence level and the small black dots represent the location of the  $\hat{L}_{A50}$



Daily Average Noise Pattern statistically estimated at the location symbolized by the yellow star, and the associated level of confidence

See P. Aumond et al, *Acoustic mapping based on measurements: space and time interpolation*, Internoise 2017, Hong Kong



# Conclusion & prospects

- ✓ **A comprehensive and open infrastructure** for producing noise data from smartphones, with a special attention (but perfectible) to the audio-processing
- ✓ **A raw database** for the need of the scientific community in order to produce a relevant evaluation of noise in the environment
- + **Enhancement** of the calibration and audio process
- + Methodologies for **Data Quality Assessment**
- + Production of **noise maps** for a more relevant assessment of the quality of the noise environment
- + Manage **temporal vs spatial** data



# Thank you for your attention



## **More information on the project:**

<http://noise-planet.org/en/index.html>

## **Download NoiseCapture App on Google Play:**

[https://play.google.com/store/apps/details?id=org.noise\\_planet.noisecapture](https://play.google.com/store/apps/details?id=org.noise_planet.noisecapture)

## **Community noise maps:**

<http://noise-planet.org/en/map.html>

## **Download data (per country):**

<http://data.noise-planet.org/en/index.html>

## **Follow the development of NoiseCapture on GitHub platform:**

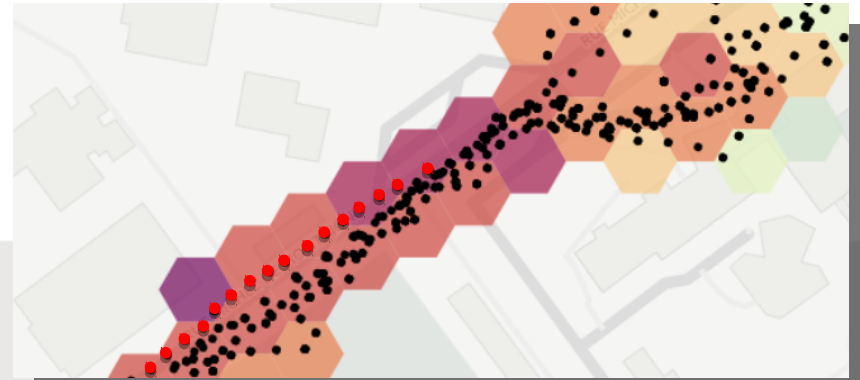
<https://github.com/lfsttar/NoiseCapture>

The EU ENERGIC-OD Project is funded under the ICT Policy Support Program (ICT PSP) as part of the Competitiveness and Innovation Framework Program of the European Community, and supported by the French geographic portal GÉOPAL of the Pays de la Loire region (France).





# Raw database



## \*.tracks.geojson (raw data)

- `time_ISO8601`: start time of measurement in ISO 8601
- `time_epoch`: start time of measurement in UTC
- `pk_track`: database track primary key
- `track_uuid`: track universally unique identifier
- `gain_calibration`: signal gain calibration in dB
- `noise_level`: LAeq along the track
- Tags: user supplied noise tags
- Pleasantness: user supplied pleasantness 0-100



# Raw database



## \*.points.geojson (raw data)

- `pk_track`: track primary key
- `time_ISO8601`: measurement time in ISO 8601
- `time_epoch`: measurement time in UTC
- `time_gps_ISO8601`: GPS measurement time in ISO 8601
- `time_gps_epoch`: GPS measurement time in UTC
- `Noise_level`: LAeq,1s in dB(A)
- `speed`: GPS provided speed (not accurate)
- `Orientation`: GPS provided orientation (not accurate)
- `Accuracy`: GPS localization accuracy in meters



# Raw database



## \*.areas.geojson (pre-process)

- cell\_q: hexagon q coordinate (EPSG:3857- WGS84)
- cell\_r: hexagon r coordinate (EPSG:3857- WGS84)
- La50: LA50 in dB(A)
- laeq: LAeq in dB(A)
- mean\_pleasantness: mean pleasantness
- measure\_count: number of seconds of measurements
- first\_measure\_ISO\_8601: date of the first measurement
- first\_measure\_epoch: date of the first measurement
- last\_measure\_ISO\_8601: date of the last measurement
- last\_measure\_epoch: date of the last measurement
- leq\_profile: 72 hours LAeq levels

