Localisation de drones par antennerie acoustique en milieu maritime : premiers résultats et perspectives (Projet DGA_Rapid : ALARM) Essais au SESDA

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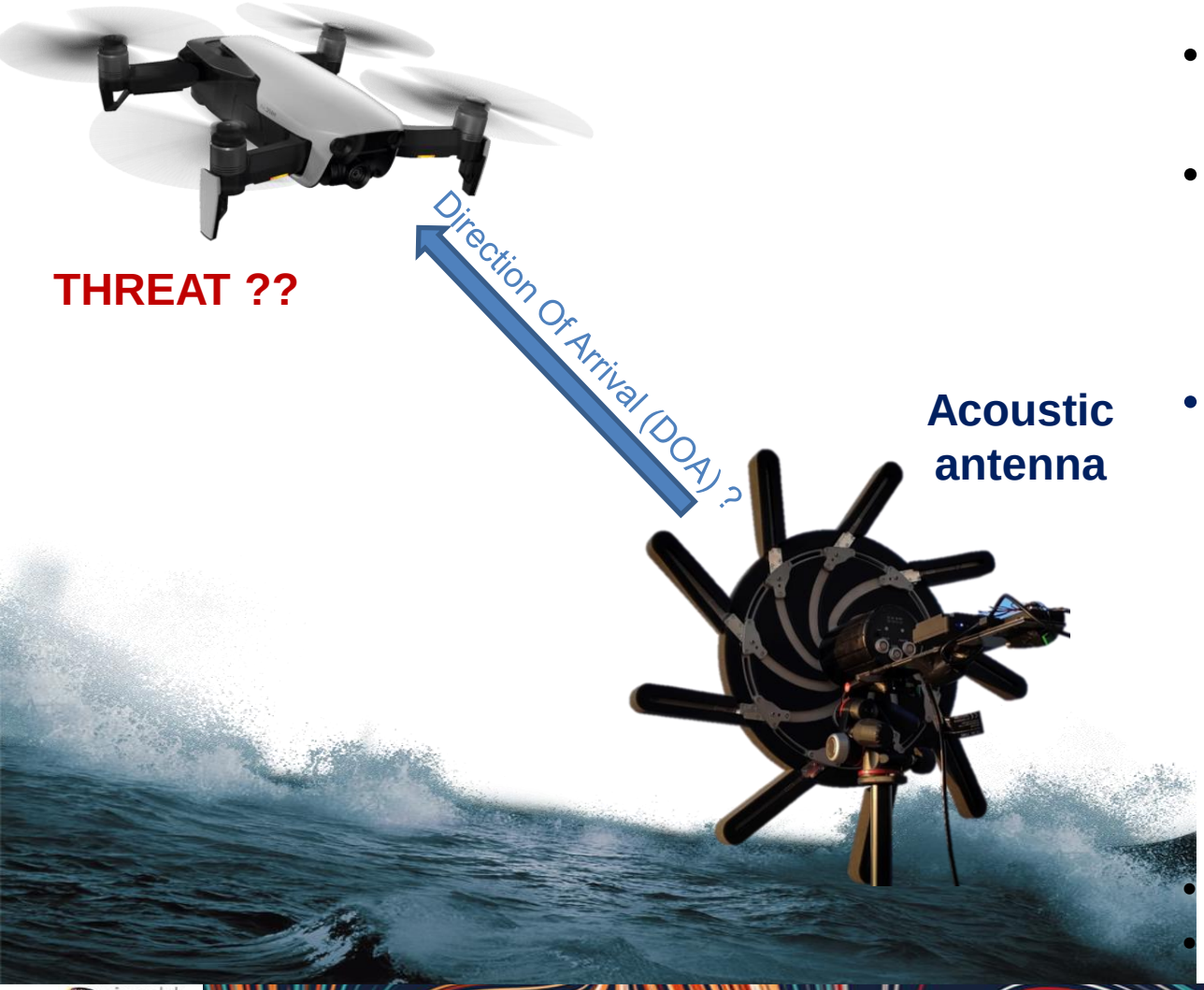
Context: UAV acoustic localization in a maritime environment



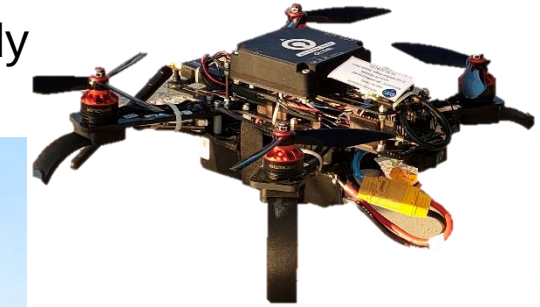
- UAV = threat (Pb).
- Counter UAV = priority
  - → Existing technologies: optics, radar, radio-freq.
  - → New Challenge : Acoustics
- **Acoustic methods :**
  - **Advantages:**
    - → Work at night or in a foggy environment
    - → Deal with autonomous targets
    - → Identification possible
  - **Drawback:**
    - → sensitive to ambient noise
- Literature is not complete.
- **Experiment conducted in a maritime environment**

Experiment @ SESDA (Toulon Harbor)

- **Aims:**
  - ➔ Study the ambient noise without UAVs
  - ➔ Study UAVs acoustical characteristics
  - ➔ Measure the performance of acoustic localization method

DJI Phantom Pro 4
1,4 kg

- **Real Environment:** Coastline with rocks, strong backwash, windy condition (but sunny…)



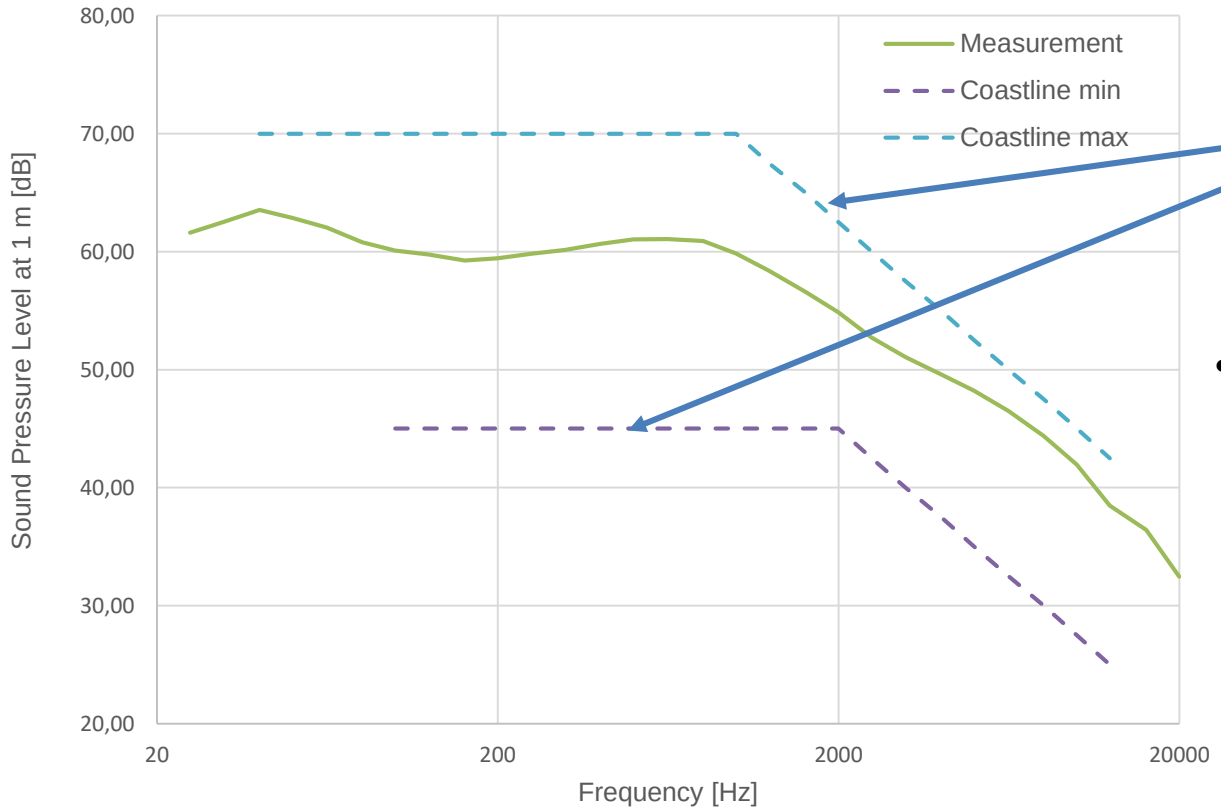
BM42
1,2 kg
gipsa-lab
Robotex

SoundCamera
81 microphones
MEMS
MicrodB

Parrot Anafi
320 g

Study the Ambient Noise without UAVs

Aim = compare background noise and the UAV
to identify the frequency band of interest

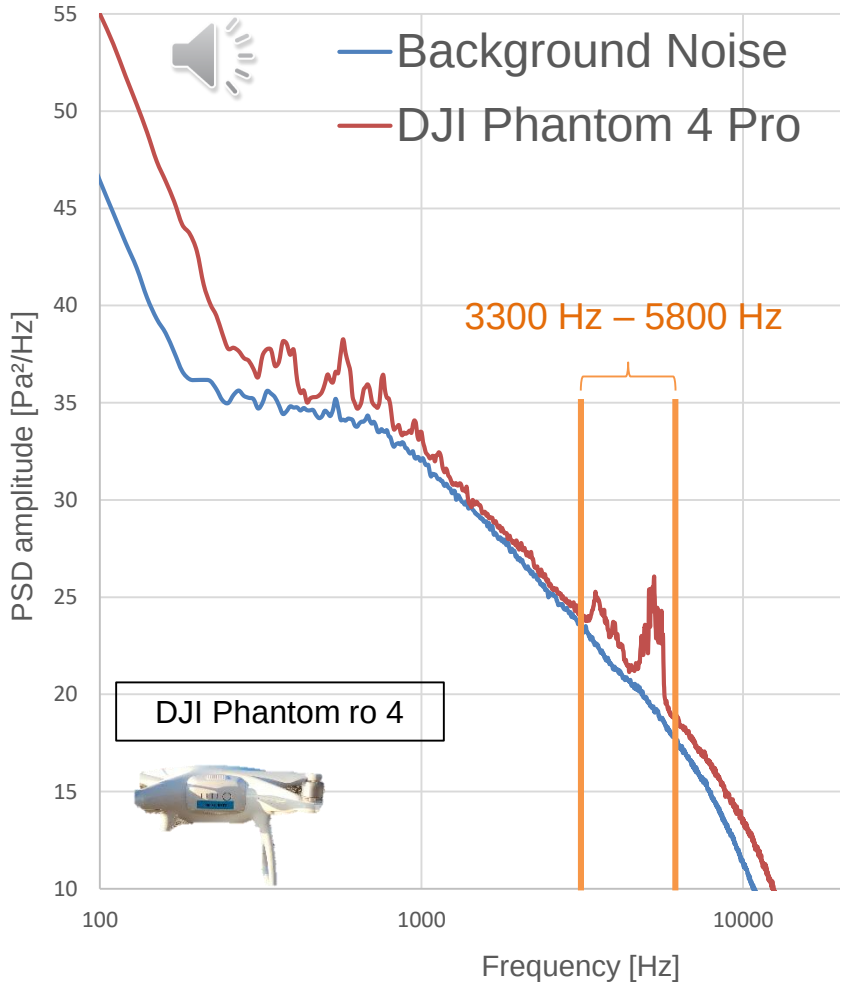


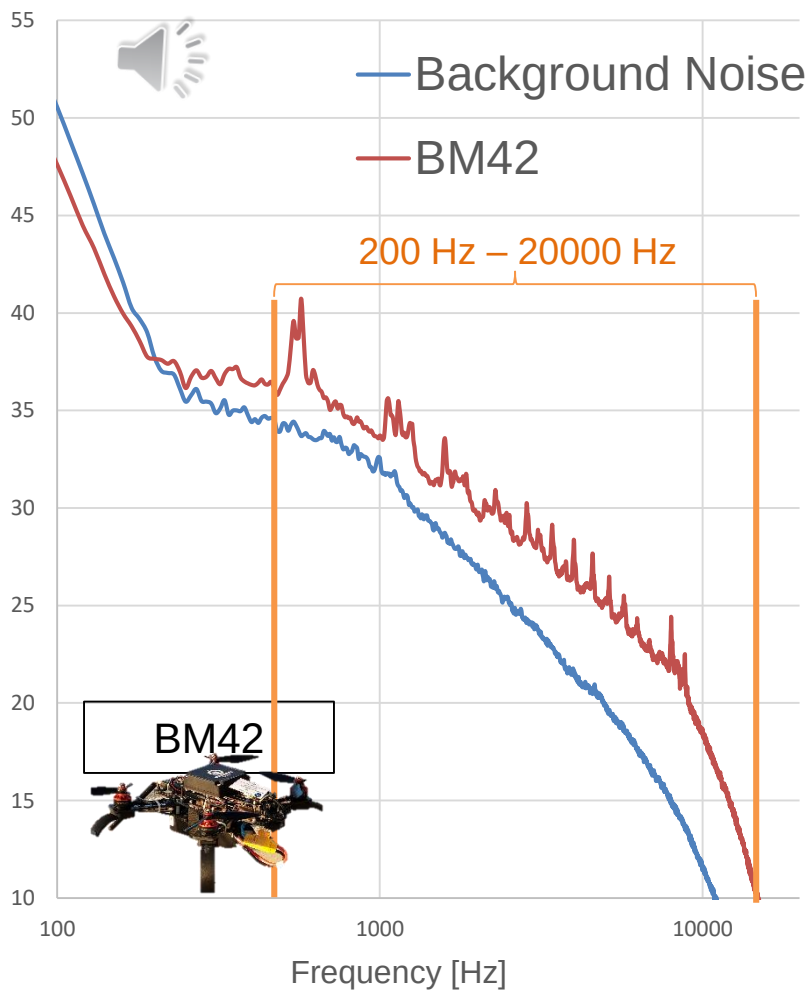
Real sonometer
@(position toulon)

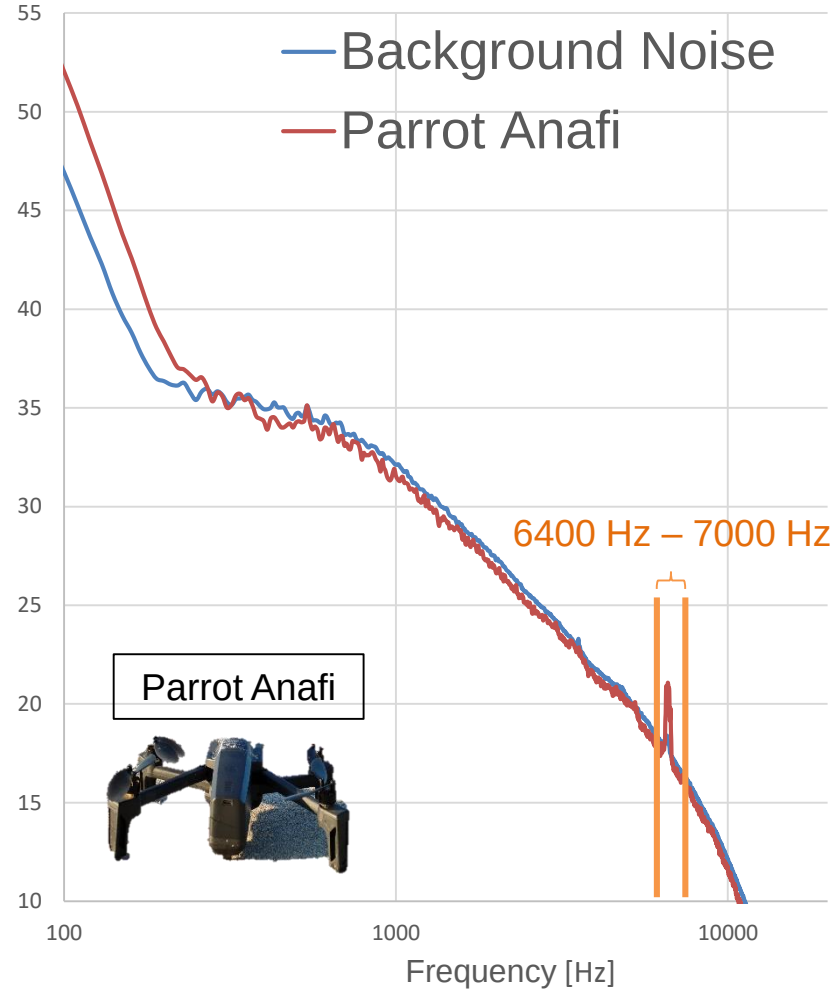
- Ambient noise = wideband with -20 dB/decade from 1kHz

1/3rd octave band analysis of the measured coastline

Spectral analysis – UAVs @20m from antenna

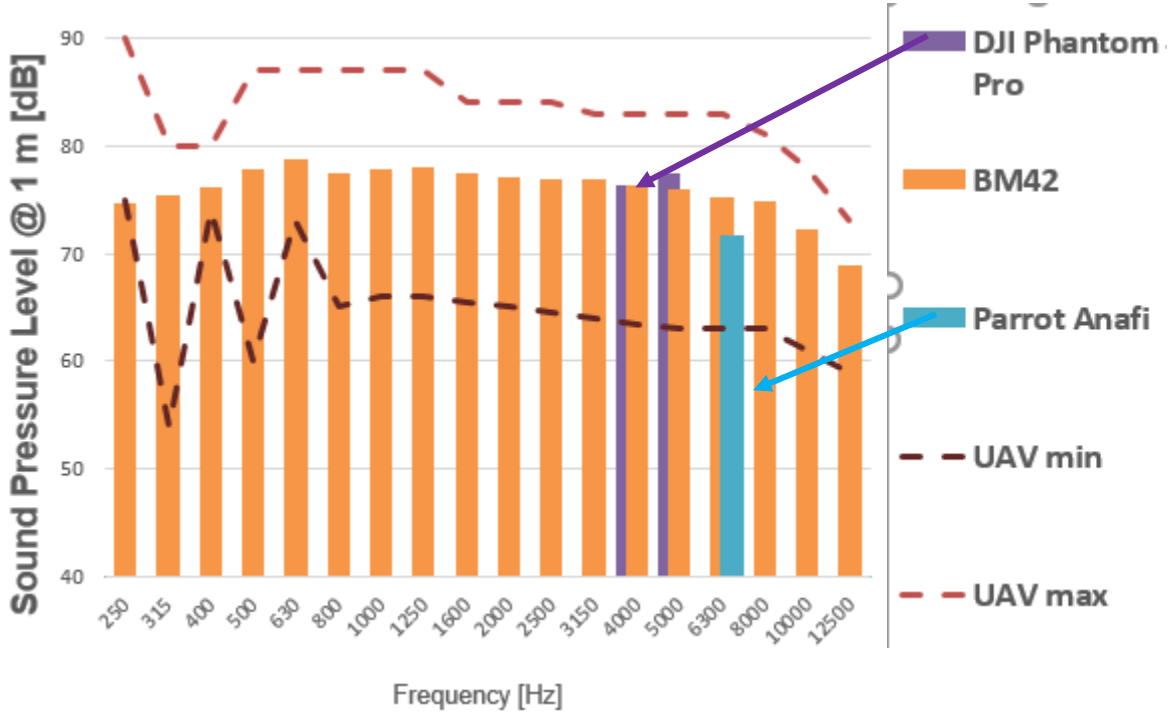






Power Spectrum Density of UAVs signal compared to ambient noise

Spectral analysis – UAVs



1/3rd octave band analysis of the UAVs signal

In a maritime environment, UAV localization frequencies: $(3\ kHz\ to\ 7\ kHz)$

Frequency bands of interest:

	BM42	DJI Phantom 4 Pro	Parrot Anafi
Frequency band of interest	0.2 – 20 kHz	3.3 – 5.8 KHz	6.4 – 7 KHz

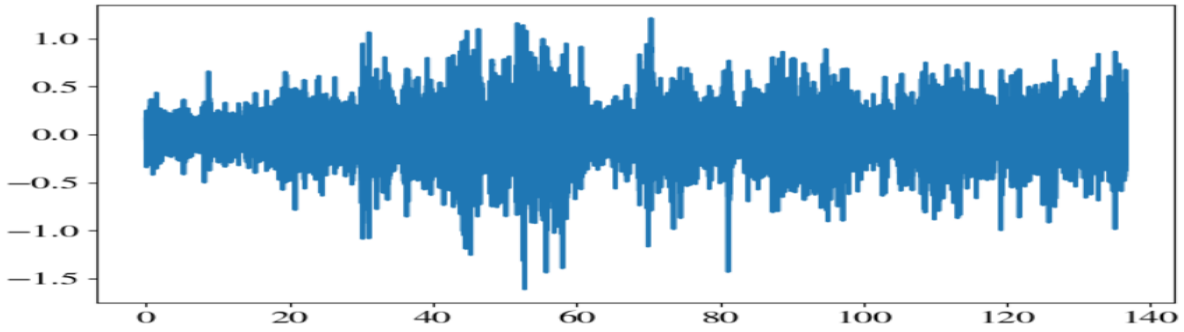
UAV localization result in a maritime environment

- Aim = measure the performance of our method by estimating the **detection range D_r for each UAV**

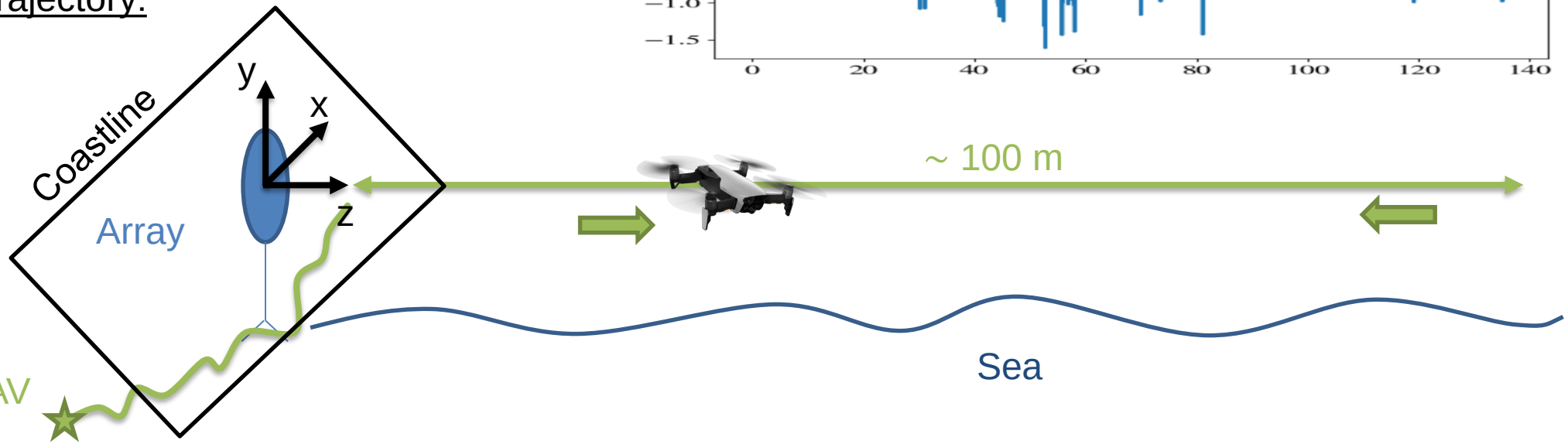
Localization method:

- Plane wave model
- Recorded signals cut into sequences of 0.2 s
- Localization method : **narrowband MUSIC manually set**

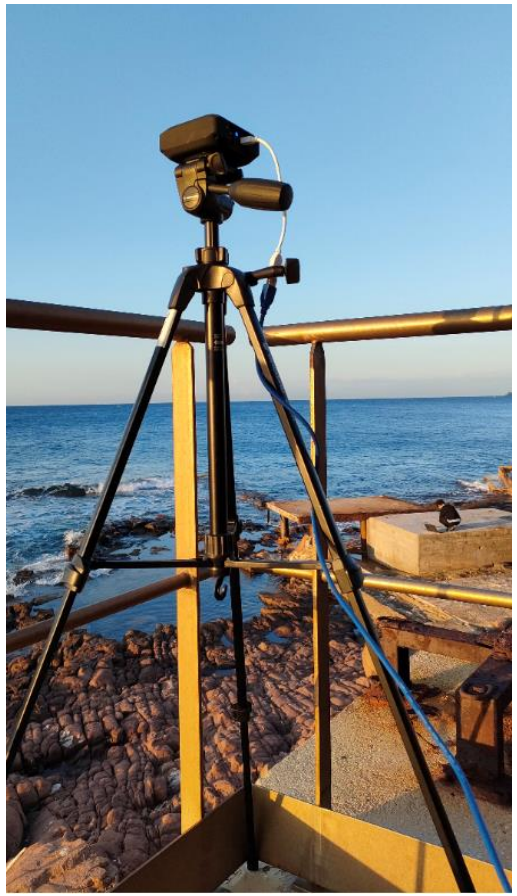
- Direction-of-arrival $(\theta_{max}, \varphi_{\max})$ = maximum of the MUSIC map



UAV trajectory:



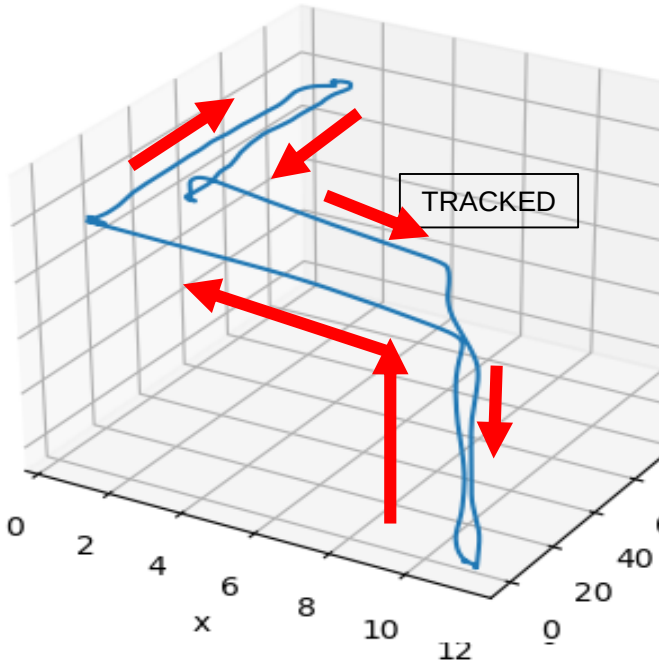
UAV Localization result in a maritime environment

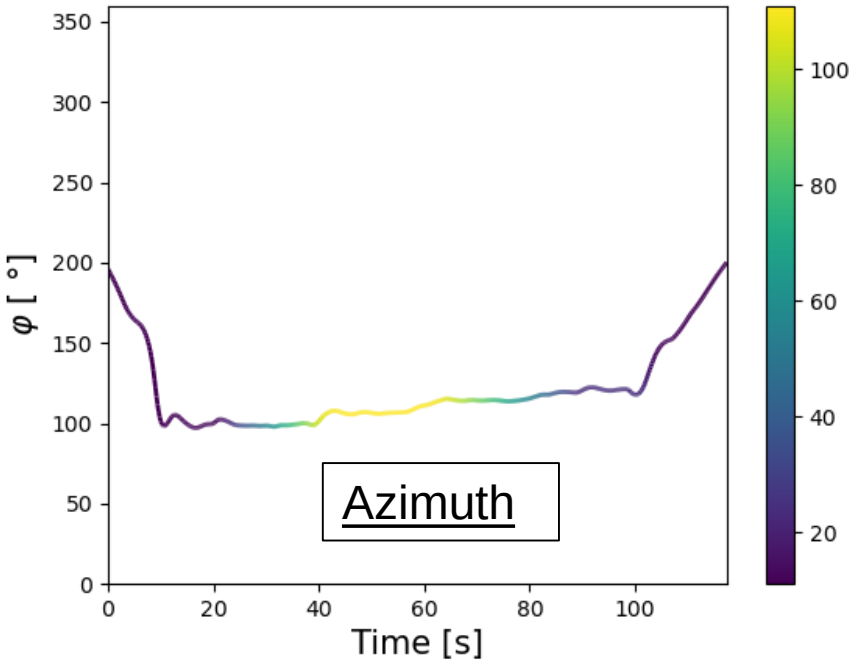


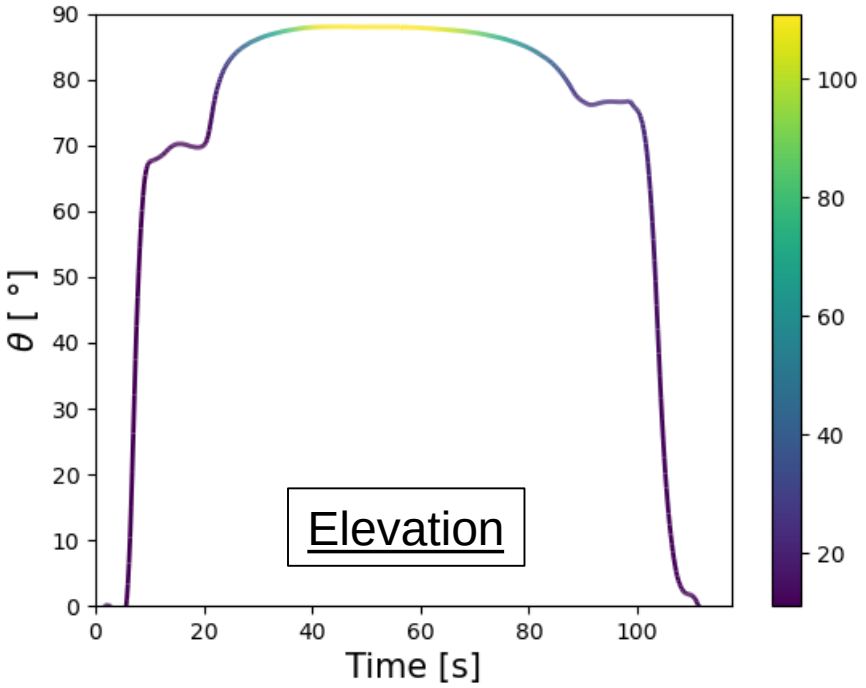
UAV Localization result in a maritime environment

Ground truth = tracked trajectory of the UAVs relatively to the array position

GPS Tracking:



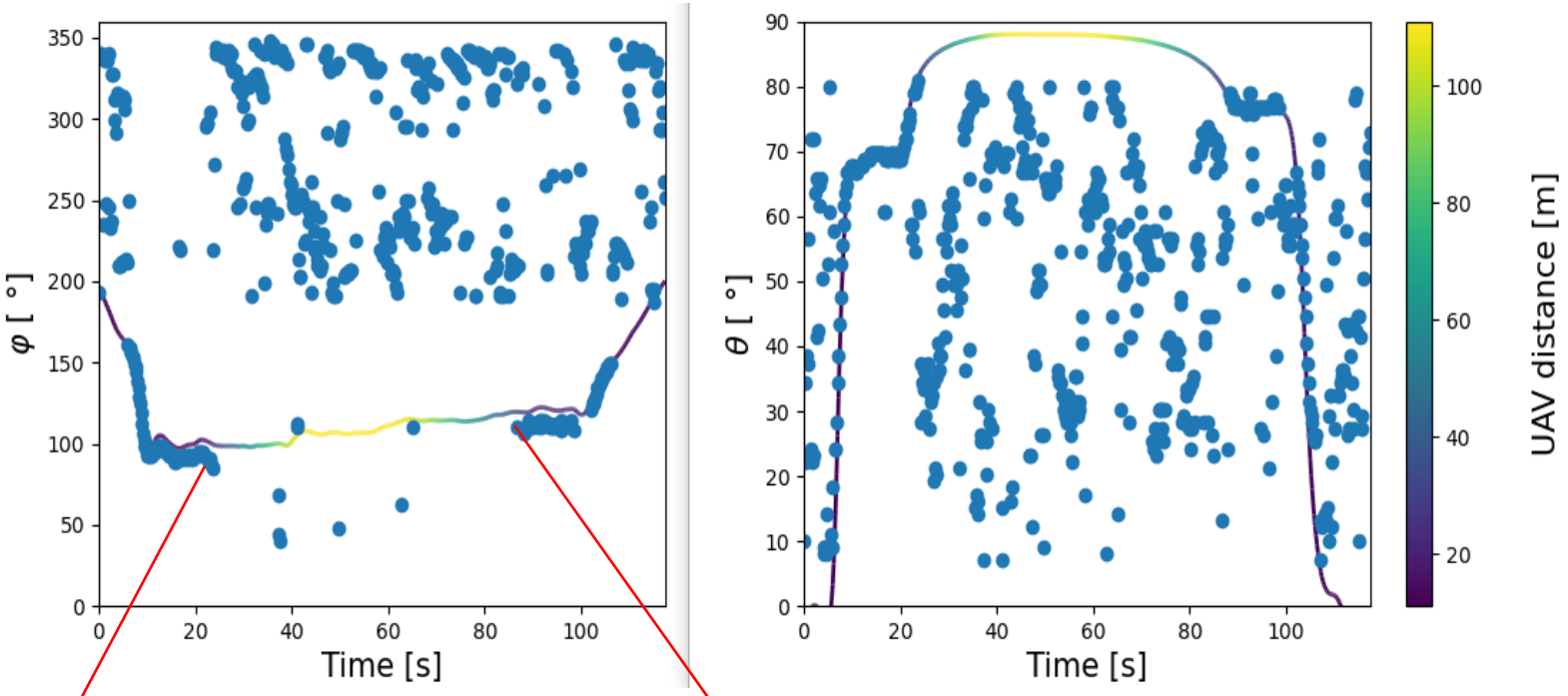




UAV localization result in a maritime environment

Output exemple:

BM42



D_r = 24 m / SNR = -2.20 dB

D_r = 29 m / SNR = -3.84 dB

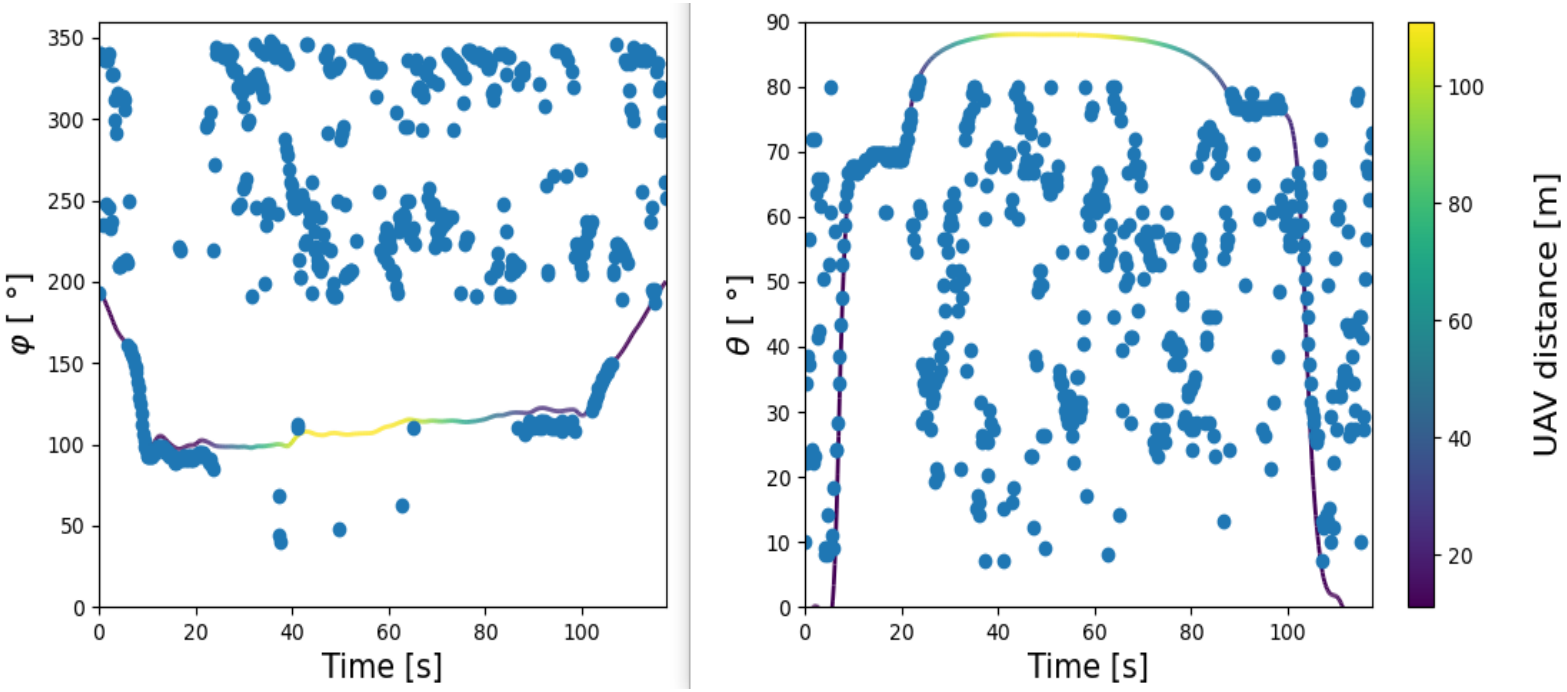
Experimental Results:

	Maximum Detection Range [m]	SNR [dB]
BM42	29	-3.84
DJI Phantom Pro 4	54.9	-7.77
Parrot Anafi	29	-7.07

UAV localization and focalisation

Output exemple:

BM42



Experimental Results:

After localisation we can applied a « focus processing » to evaluate performance

Before

After

Conclusion

- **Characterization of the maritime environment (with state-of-art and experiment)**
  - Wideband with decrease in high frequency (>1kHz)
  - **Loud environment (equivalent of haevy urban environment)**
    ➔ Challenging environment

- **Definition of the frequency bands of interest (to perform the localization method)**
  - Frequency band of interest : ($3\ kHz\ to\ 7\ kHz$)

- **UAV localization in a maritime environment results:**
  - **<u>UAV correctly localized from 20 m to 50 m (corresponding SNR to -2.2 dB to -7.7dB)</u>**

    - **Improvements pespectives**

      - Temporal data unprocessed to filter the ambiant noise
      - Narrowband localization
      - Number of sources present to localize manually set

      ➔

      1. Denoise the temporal data recorded by the array
      2. Perform a wideband DOA estimation
      3. Automatically estimate the number of sources