

RÉSEAU DE SURVEILLANCE MAMBO

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Context

Noise pollution

MSFD (D11) :

- Impulsive noise
- **Continuous noise**
 - 1/3 octave bands 63 Hz
 - 1/3 octave bands 125 Hz

Risks :

- Masking
- Stress
- Hearing loss, habitat abandonment

Evaluation :

- Model
- Measurement

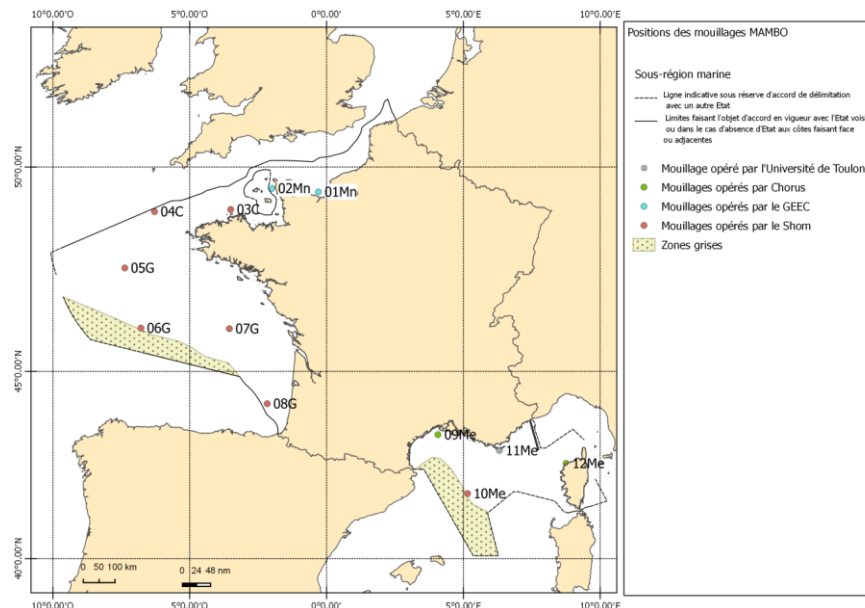


Monitoring

Measurement program

- 11 recording stations (French EEZ) ;
- Close to shipping lane ;
- Presence of marine mammals ;
- Coastal and offshore ;
- Shallow / deep waters (~70 m to 4800 m) ;
- 2 or 4 recorders per station ;
- ~20 000 hours.

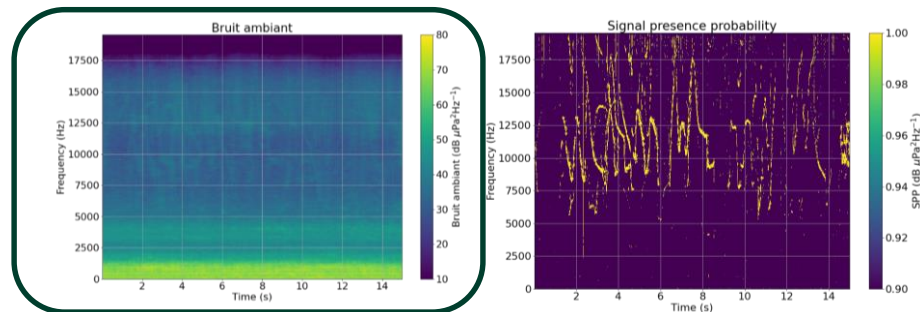
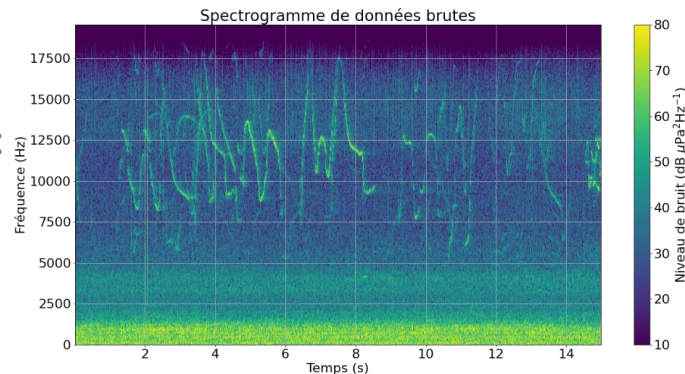
Maintenance is expensive (offshore)
→ reduce sampling to increase autonomy



Ambient noise estimation

Automatic treatment of underwater noise measurement

- Percentile Controlled Recursive Averaging (PCRA) method ;
- The window size is set using the best **stationarity window** of the sample (~10 sec) ;
- Enable to extract the **background noise** ;
- Inform on signal presence probability.



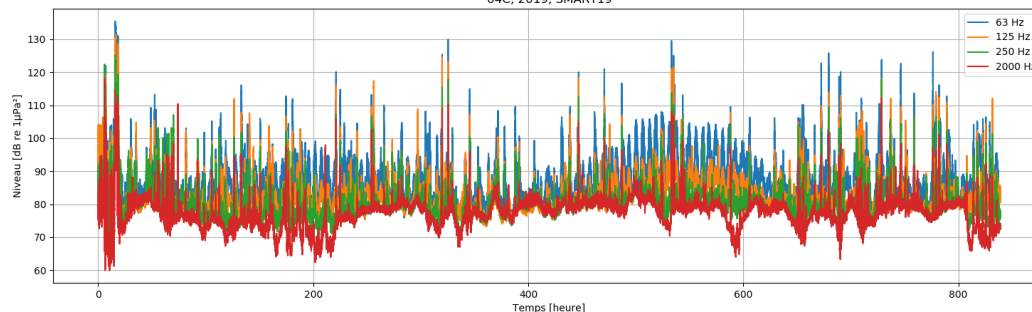
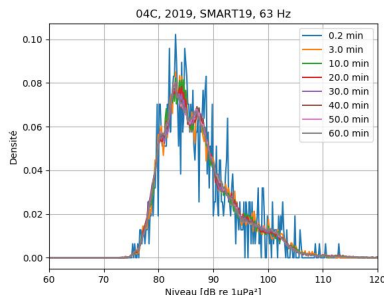
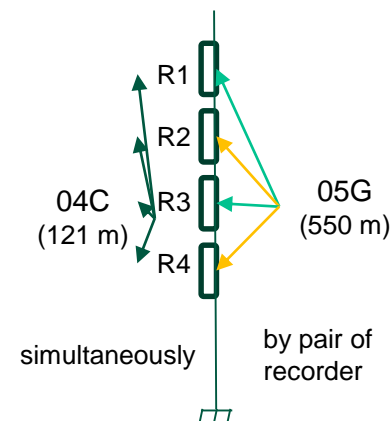
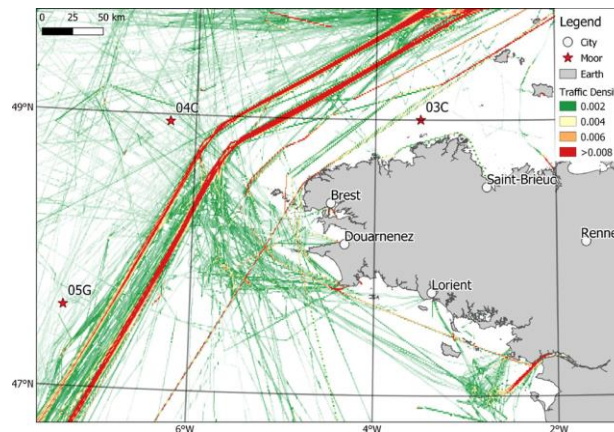
Pihan-Le Bars, H. and Kinda, B. Percentile Controlled Recursive Averaging (PCRA): a novel approach for ambient noise estimation in underwater acoustics. *IEEE Journal of Oceanic Engineering* (accepted)

Selected data

Celtic Sea : Ushant rail

Campagne	Capteur	Immersion (m)	Début (dd/mm/aaaa)	Fin (dd/mm/aaaa)	Durée (jours)	Cycle (min/h)	Durée acq. h
03C 2019	SM19	5	04/09/2019	30/09/2019	26	60	624
	SM1	30	04/09/2019	30/09/2019	26	60	624
04C 2019	SM19	27	07/09/2019	19/10/2019	42	60	1008
	SM1	37	07/09/2019	12/10/2019	35	60	1008
	SM2	54	07/09/2019	30/10/2019	53	60	1008
	SM3	83	07/09/2019	22/10/2019	45	60	1008
05G 2020	SM2	80	20/03/2020	22/05/2020	63	45	1134
	SM3	150	21/01/2020	21/03/2020	60	45	1080
	SM19	300	20/03/2020	18/05/2020	59	45	1062
07G 2020	SM5	20	21/01/2020	20/03/2020	59	45	1062
	SM6	50	19/02/2020	13/04/2020	54	45	972
	SM7	80	21/03/2020	22/05/2020	62	45	1116
05G 2021	SM22	300	21/05/2021	25/07/2021	70	30	840
	SM23	150	11/03/2021	25/03/2021	14	30	160
	SM24	80	16/05/2021	01/08/2021	77	30	924
	SM25	30	16/02/2021	06/05/2021	79	30	948

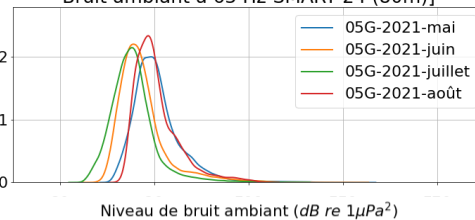
Is the level distribution preserved when downsampling (artificially reduced recording cycles)?



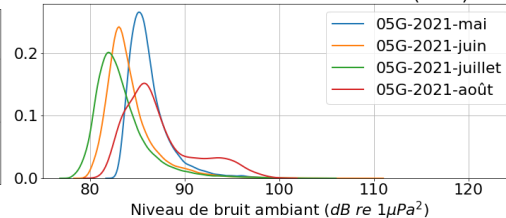
Duty cycle

Densité de probabilité (DDP)

Bruit ambiant à 63 Hz-SMART 24 (80m)



Bruit ambiant à 125 Hz-SMART 24 (80m)



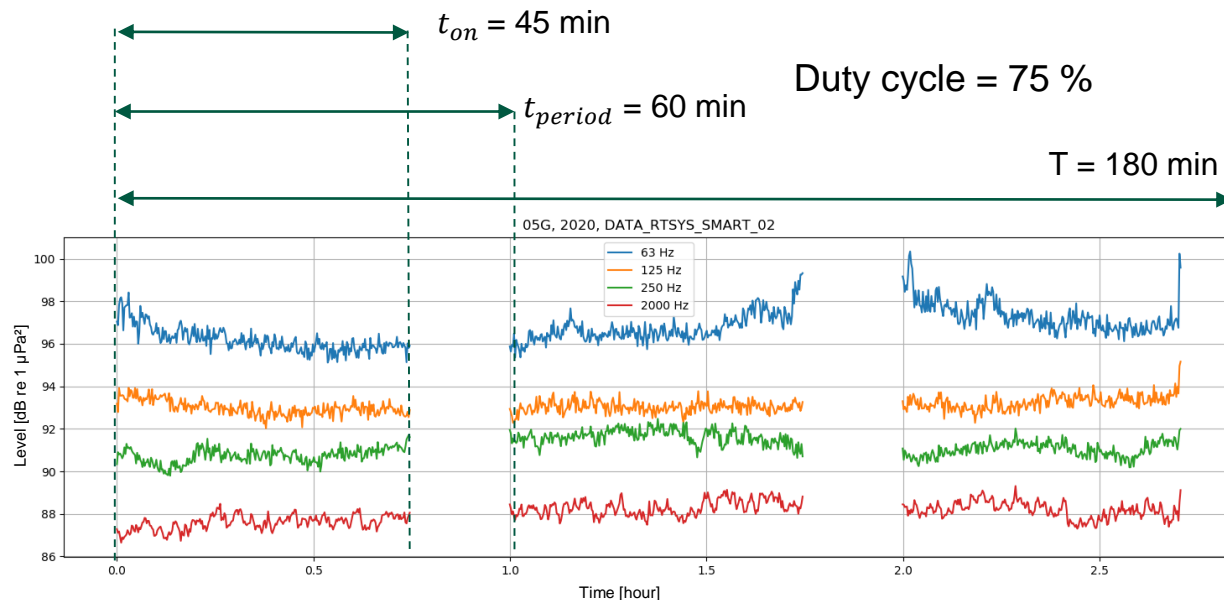
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Parameters

- T : recording period
- t_{on} : recording duration
- t_{period} : duty cycle period
- Duty cycle = t_{on} / t_{period} %

Working hypothesis

- $T_{reference}$ = 30 days
 - Probabilistic model
 - Distribution monthly dependant



Method

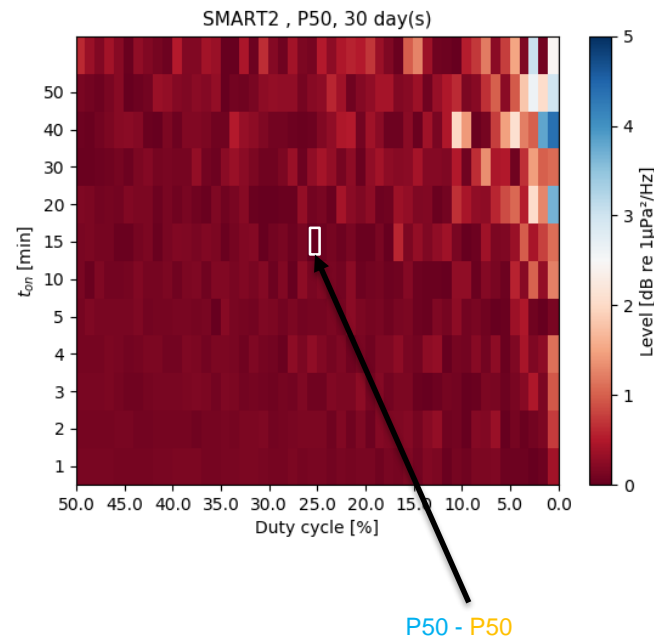
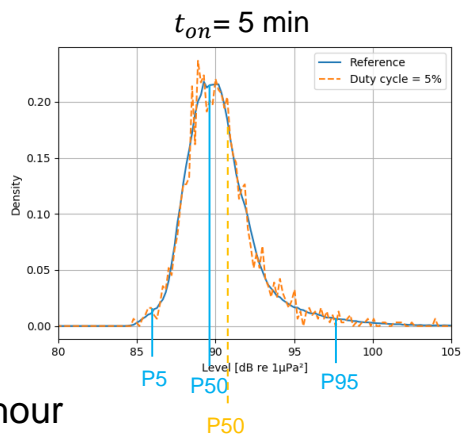
Error estimation

Reference estimation :

- T (time period) : 30 days
- Frequency : 1/3 octave band 63 Hz
- Percentile : P50
- Duty cycle : 100%
- Sensor reference : SMART2

We will vary :

- T : 1, 7, 14 and 30 day(s)
- t_{on} (recording duration) : 1 min – 1 hour
- Duty cycle : 50% to 0,1%



Error estimation

Recording period

Fixed parameters

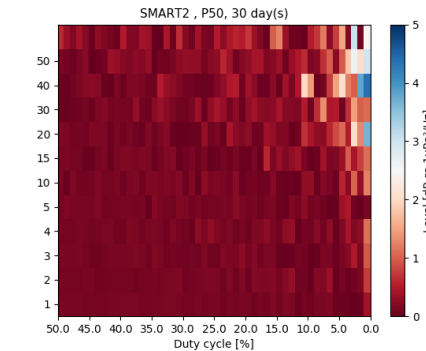
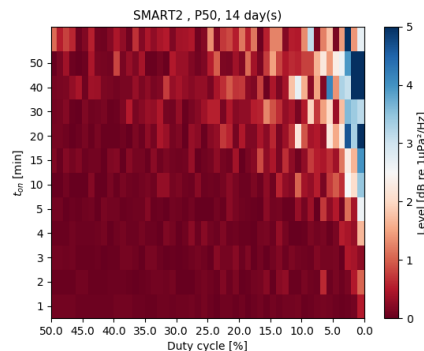
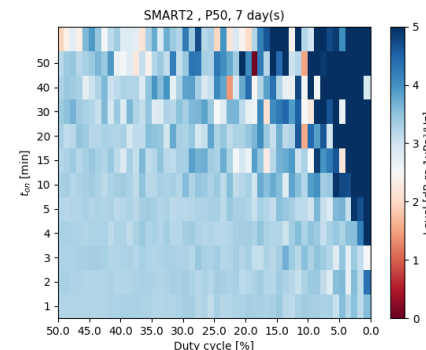
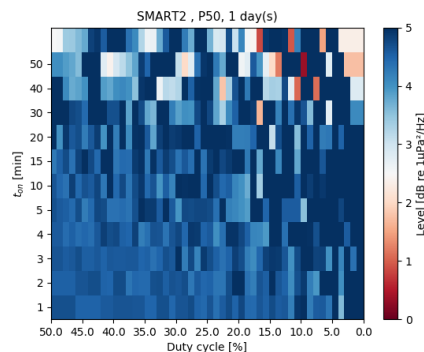
- Sensor : SMART2
- Frequency : 1/3 octave band 63 Hz
- Percentile : P50

Variable

- T (time period) : 1, 7, 14 and 30 day(s)

→ Median value is affected if T is not long enough (14 days appear enough here).

→ Duty cycle > 10% is recommended



Error estimation

Frequency

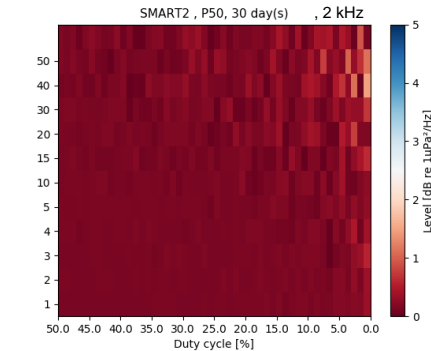
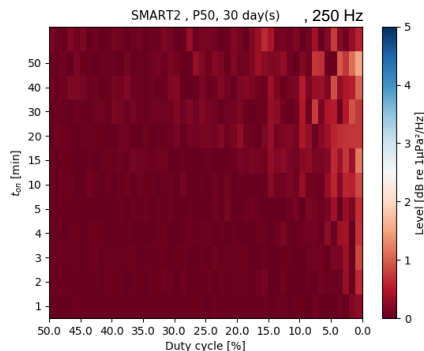
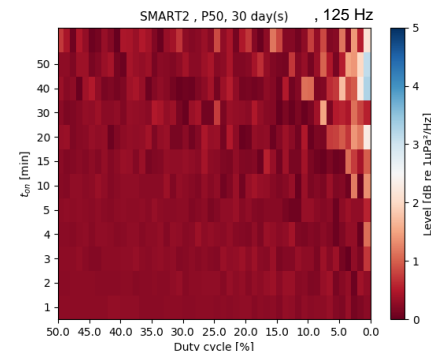
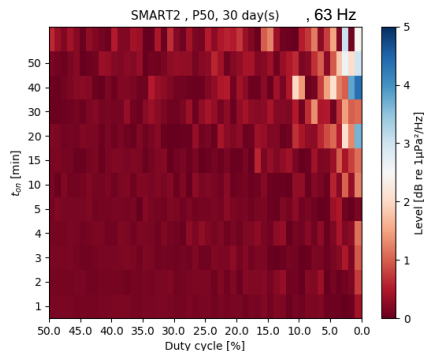
Fixed parameters

- Sensor : SMART2
- Percentile : 50
- T (time period) : 30 days

Variable

- Frequency : 1/3 octave bands 63, 125, 250 and 2000 Hz

→ Same impact on all frequency bands



Error estimation

Percentile

Fixed parameters

- Sensor : SMART2
- Frequency : 1/3 octave band 63 Hz
- T (time period) : 30 days

Variable

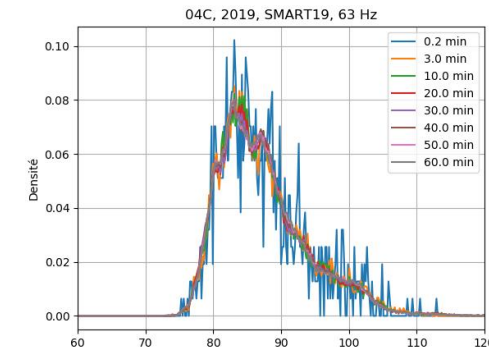
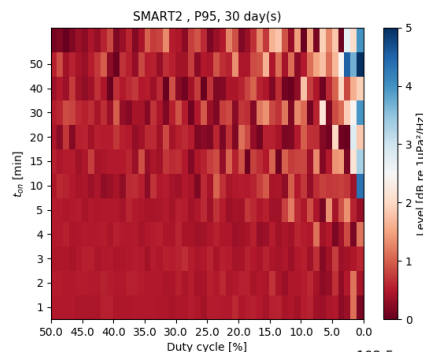
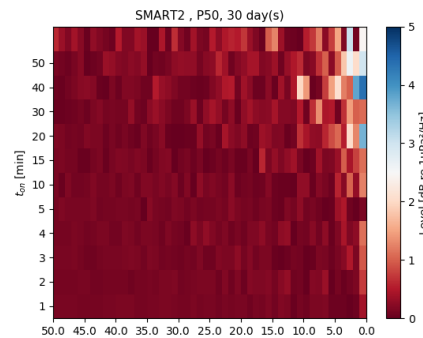
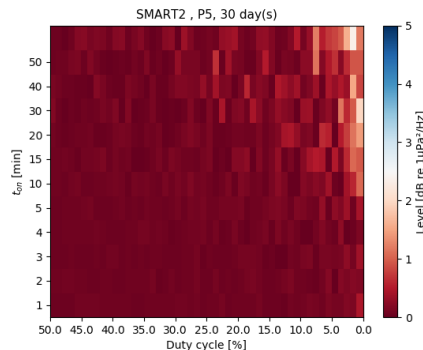
- Percentile : 5, 50 and 95

→ P95 more impacted : presence of ships

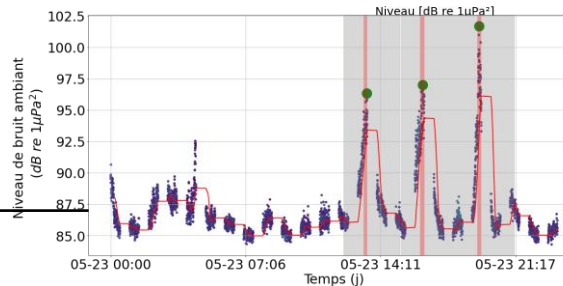
→ affected percentile depends on soundscape

→ < 2 dB re 1 μPa^2

Cécile Perrier de la Bathie, Analyse statistique du bruit ambiant sous-marin et de l'impact de l'environnement sur ce dernier à l'échelle de la sous-région marine Gascogne.



Heavy tail



Représentation du signal journalier (Niveau de bruit ambiant en fonction du temps)

Campagne	Capteur	Immersion (m)	Debut (dd/mm/aaaa)	Fin (dd/mm/aaaa)	Durée (jours)	Cycle (min/h)	Durée acq. h
04C 2019	SM19	27	07/09/2019	19/10/2019	42	60	1008
	SM1	37	07/09/2019	12/10/2019	35	60	1008
	SM2	54	07/09/2019	30/10/2019	53	60	1008
	SM3	83	07/09/2019	22/10/2019	45	60	1008

Error estimation

Sensor : 04C station

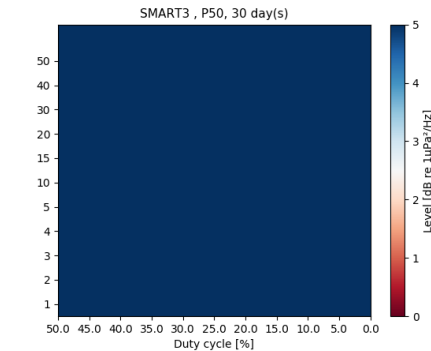
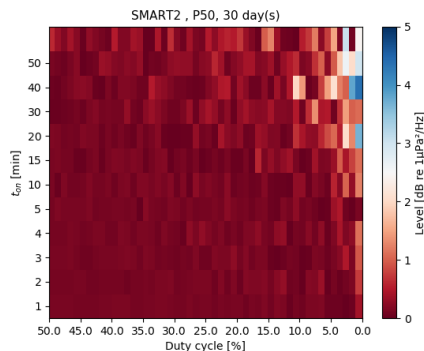
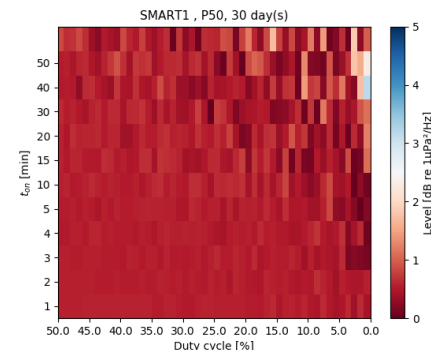
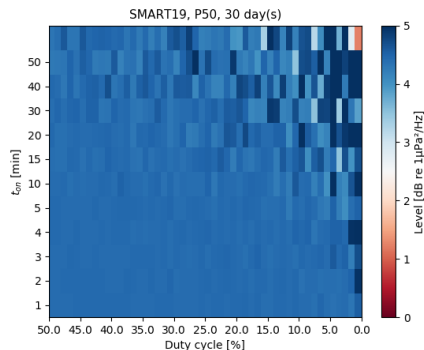
Fixed parameters

- Percentile : 50
- Frequency : 1/3 octave bands 63 Hz
- T (time period) : 30 days
- Sensor_ref : SMART 2

Variable

- Sensor : SMART19, 1, 3

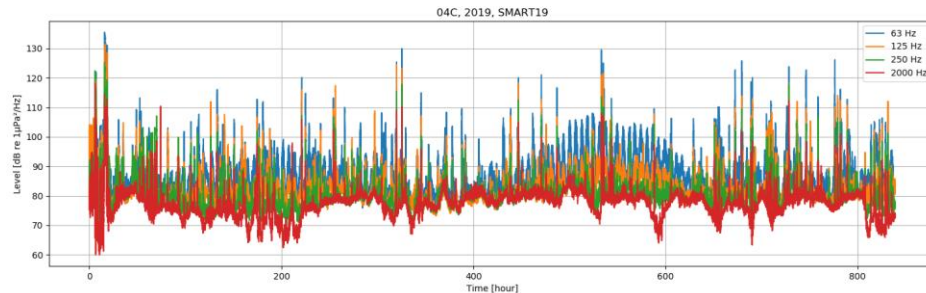
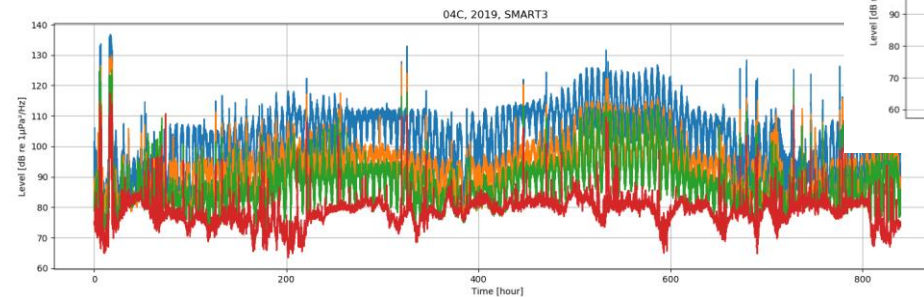
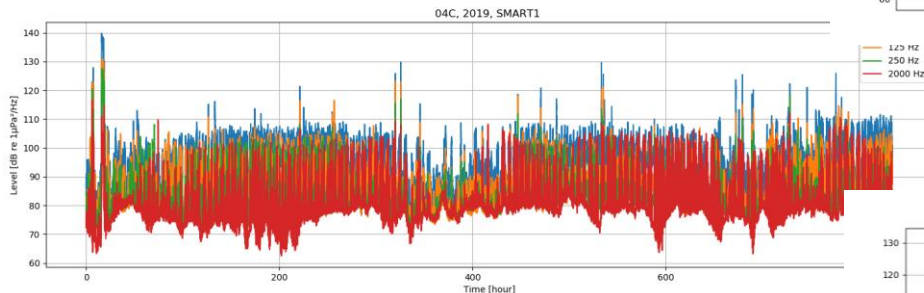
→ necessity to monitor on the water column



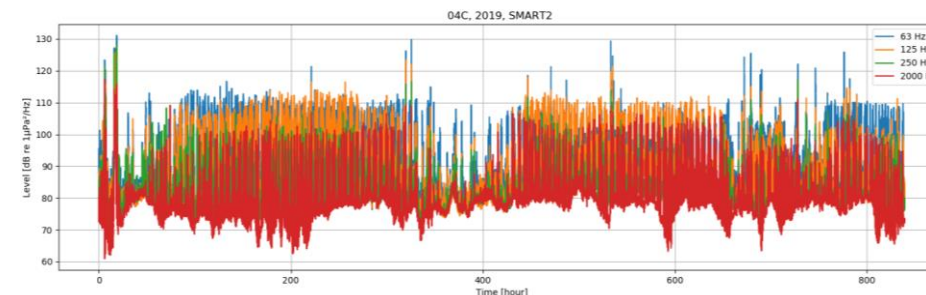
Campagne	Capteur	Immersion (m)	Debut (dd/mm/aaaa)	Fin (dd/mm/aaaa)	Durée (jours)	Cycle (min/h)	Durée acq. h
04C 2019	SM19	27	07/09/2019	19/10/2019	42	60	1008
	SM1	37	07/09/2019	12/10/2019	35	60	1008
	SM2	54	07/09/2019	30/10/2019	53	60	1008
	SM3	83	07/09/2019	22/10/2019	45	60	1008

Error estimation

Sensor : 04C station



Flow noise from tidal current
→ to remove



Mooring mechanic self-noise

Campagne	Capteur	Immersion (m)	Debut (dd/mm/aaaa)	Fin (dd/mm/aaaa)	Durée (jours)	Cycle (min/h)	Durée acq. h
05G 2020	SM2	80	20/03/2020	22/05/2020	63	45	1134
	SM3	150	21/01/2020	21/03/2020	60	45	1080
	SM19	300	20/03/2020	18/05/2020	59	45	1062

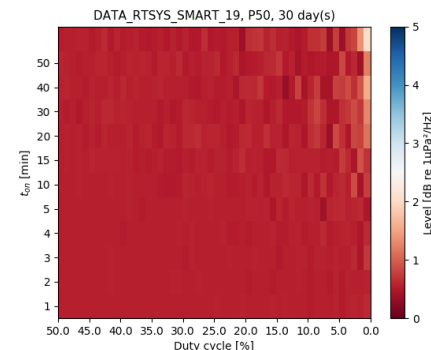
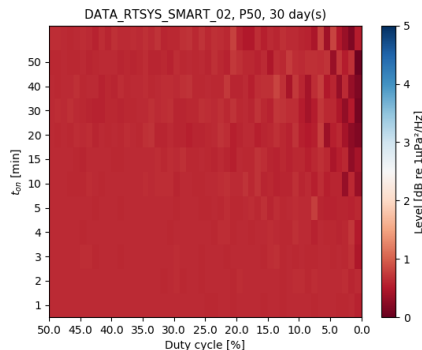
Error estimation

Sensor : 05G station

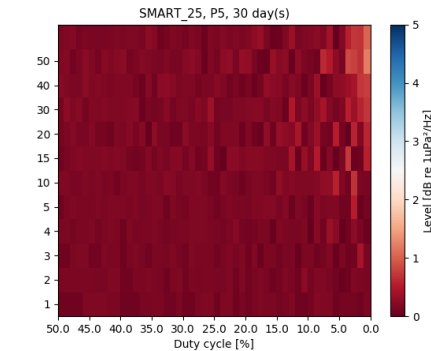
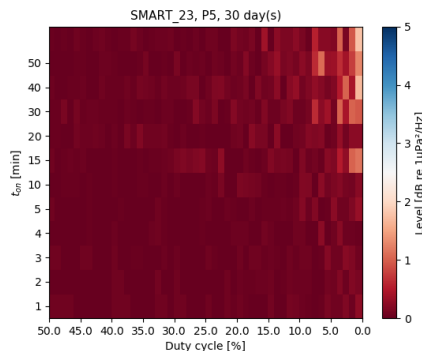
Fixed parameters

- Percentile : 50
- Frequency : 1/3 octave bands 63 Hz
- T (time period) : 30 days
- Sensor reference : SMART 2 (2020)
- Sensor reference : SMART 19 (2021)

→ T (time period) : 14 days enough for 05G, 2021



05G, 2020



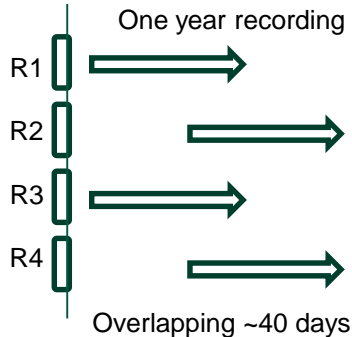
05G, 2021

05G 2021	SM22	300	21/05/2021	25/07/2021	70	30	840
	SM23	150	11/03/2021	25/03/2021	14	30	160
	SM24	80	16/05/2021	01/08/2021	77	30	924
	SM25	30	16/02/2021	06/05/2021	79	30	948

Conclusion

Autonomy

RTSYS



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- T (recording period) : 1 year
- t_{on} (recording duration) : 15 minutes
- t_{period} (duty cycle period) : 1 hour
- Duty cycle = 25 %



Illustration de l'enregistreur avec le kit de montage

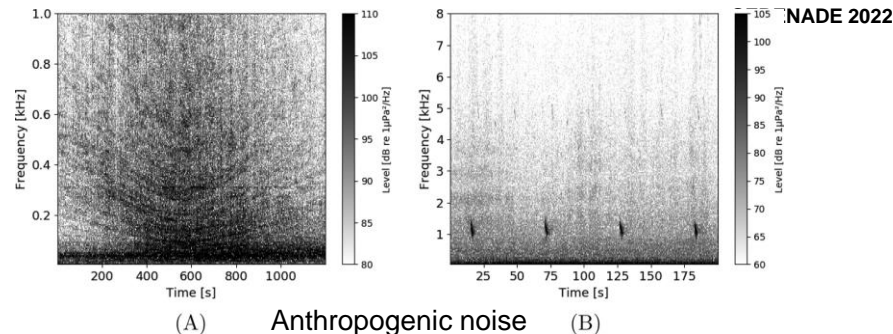
Table 1: Battery life in hybrid mode for 1,210 mm RESEA

Configuration			Duty cycles and configuration examples							
Sampling rate	Recording frequency		100 % continuous recording	75 % 45 min ON 15 min OFF	50 % 30 min ON 30 min OFF	40 % 24 min ON 36 min OFF	30 % 45 min ON 15 min OFF	25 % 45 min ON 15 min OFF	17 % 45 min ON 15 min OFF	10 % 45 min ON 15 min OFF
			Total autonomy endurance							
54 Li SOC12 Batteries	39 kHz	3 Hz – 15 kHz	44	60	89	111	133	199	266	440
	78 kHz	3 Hz – 20 kHz	43	57	86	107	128	160	256	430
	312 kHz	3 Hz – 150 kHz	35	47	47	88	106	153	206	350
54 Alkaline Battery*	39 kHz	3 Hz – 15 kHz	15	21	21	36	45	63	93	150
	78 kHz	3 Hz – 20 kHz	15	18	27	36	42	60	90	150
	312 kHz	3 Hz – 150 kHz	12	18	27	33	39	48	72	120

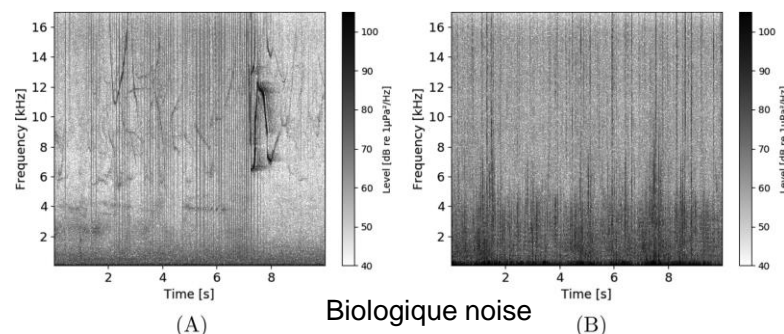
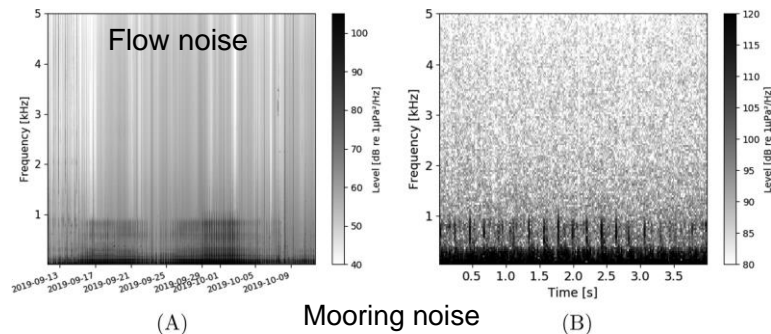
Perspectives

Underwater soundscape is rich :

→ What duty cycle to detect other components ?



$$r = \underbrace{s_{sea} + s_{traffic}}_{\text{ambient noise}} + \underbrace{A_{tide}(s_{flow} + s_{moor})}_{\text{pseudo-noise}} + \underbrace{\delta_{sonar}s_{sonar} + \delta_{bio}s_{bio}}_{\text{transient-noise}} + \underbrace{\delta_{ship}s_{ship} + \delta_{meteo}s_{meteo}}_{\text{other additive noise}}$$





Thank you