Sur la modélisation et l'estimation du comportement du vivant

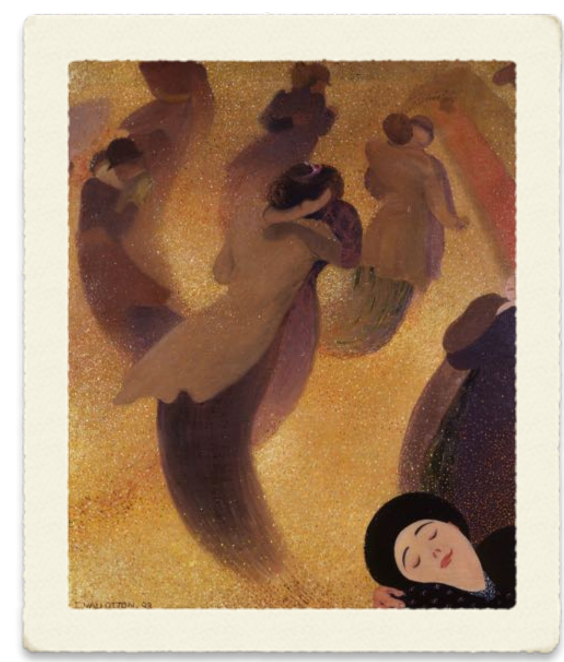
Rosane Ushirobira - **VALSE**

Valse

Analysis of distributed, uncertain and interconnected dynamic systems, with design of estimation and control algorithms

Concepts:

* finite-time/fixed-time/hyper-exponential convergence
* theory of homogeneous systems

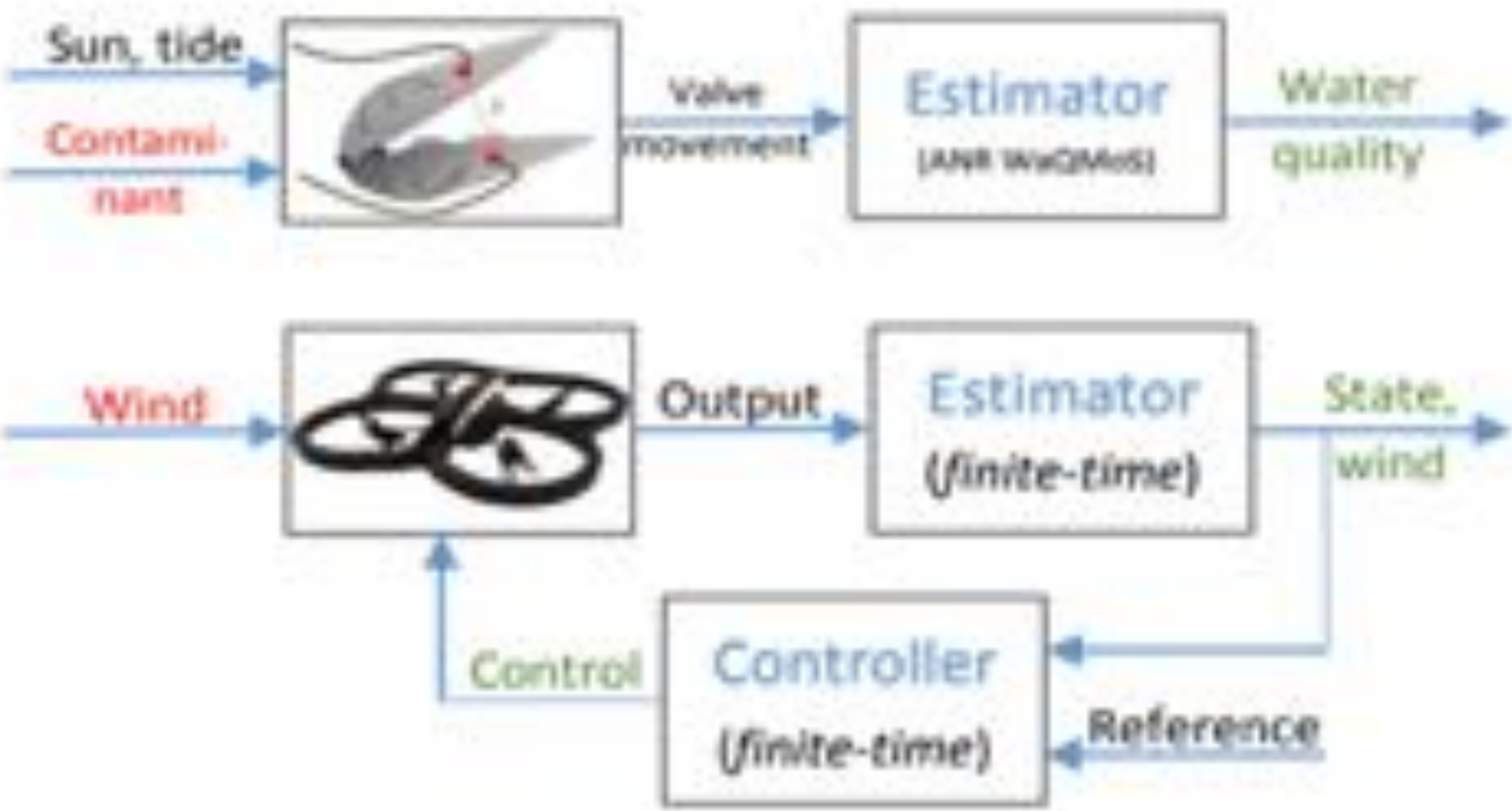


Areas of application:

IoT and cyber-physical systems

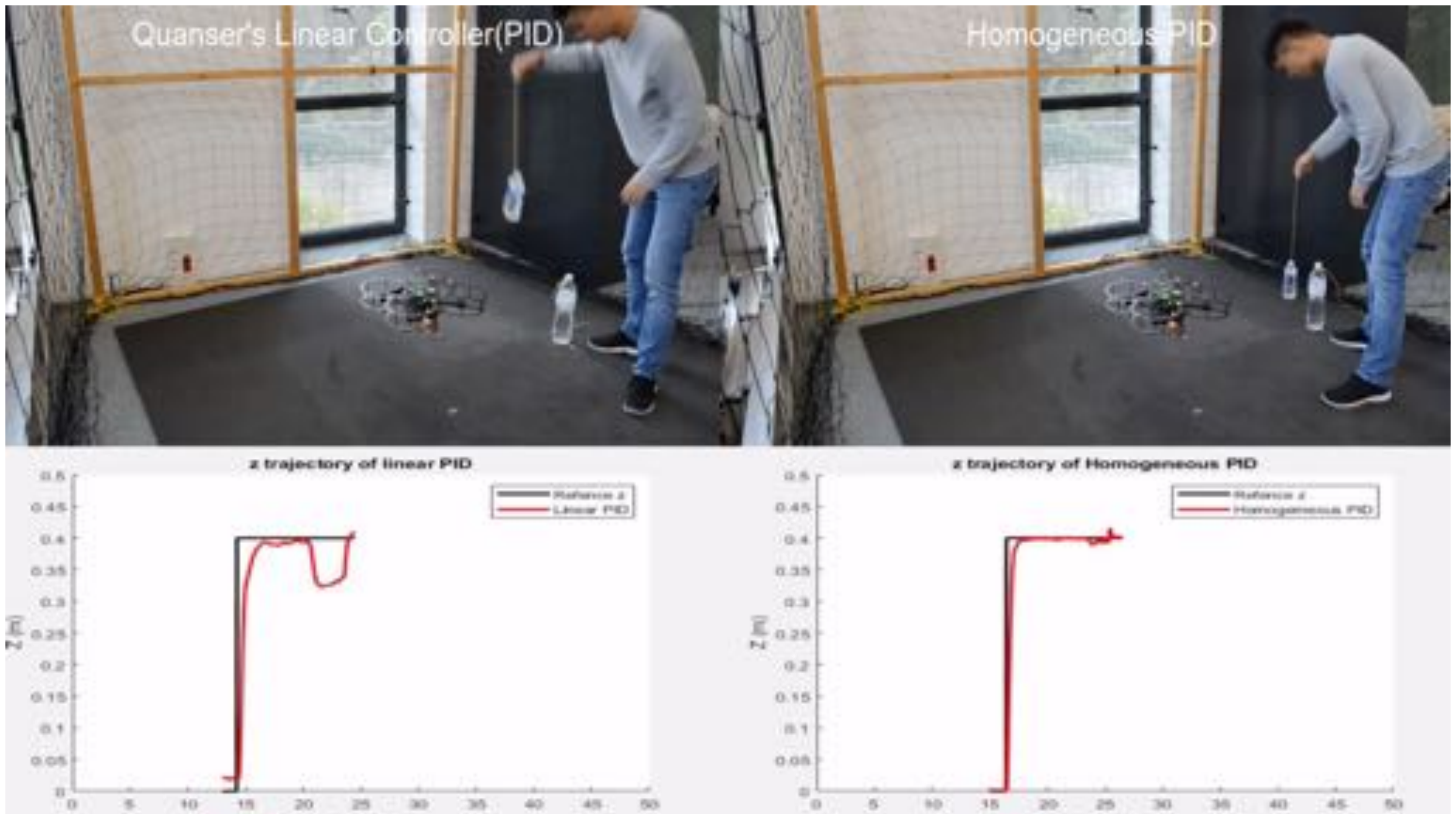
Scientific leader: Denis Efimov

Valse

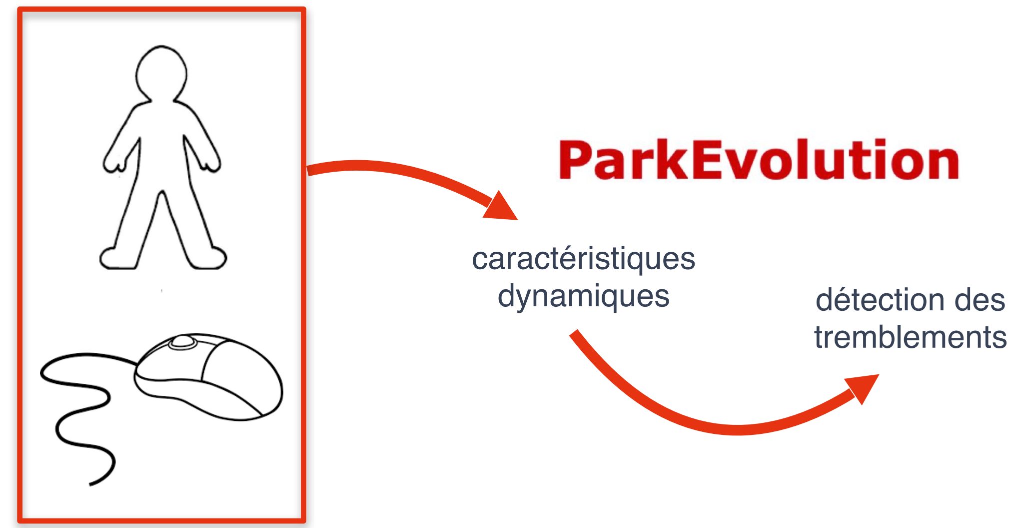


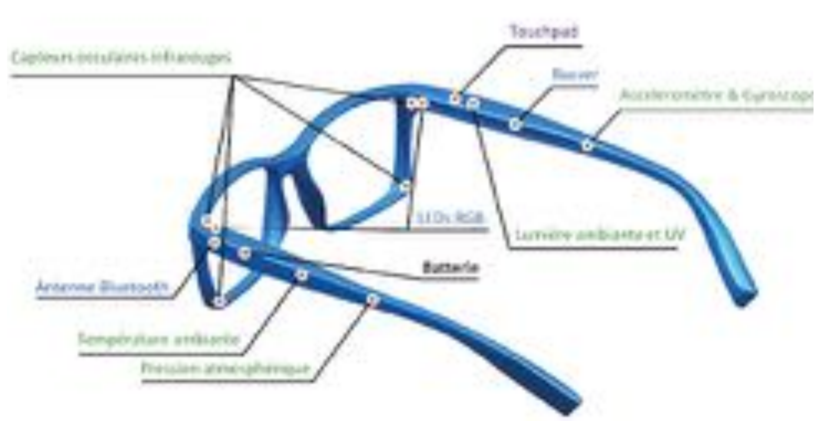
Sun, tide
Contami-nant
Valve movement
Estimator
(ANR WaQMoS)
Water quality
Wind
Output
Estimator
(finite-time)
State, wind
Control
Controller
(finite-time)
Reference

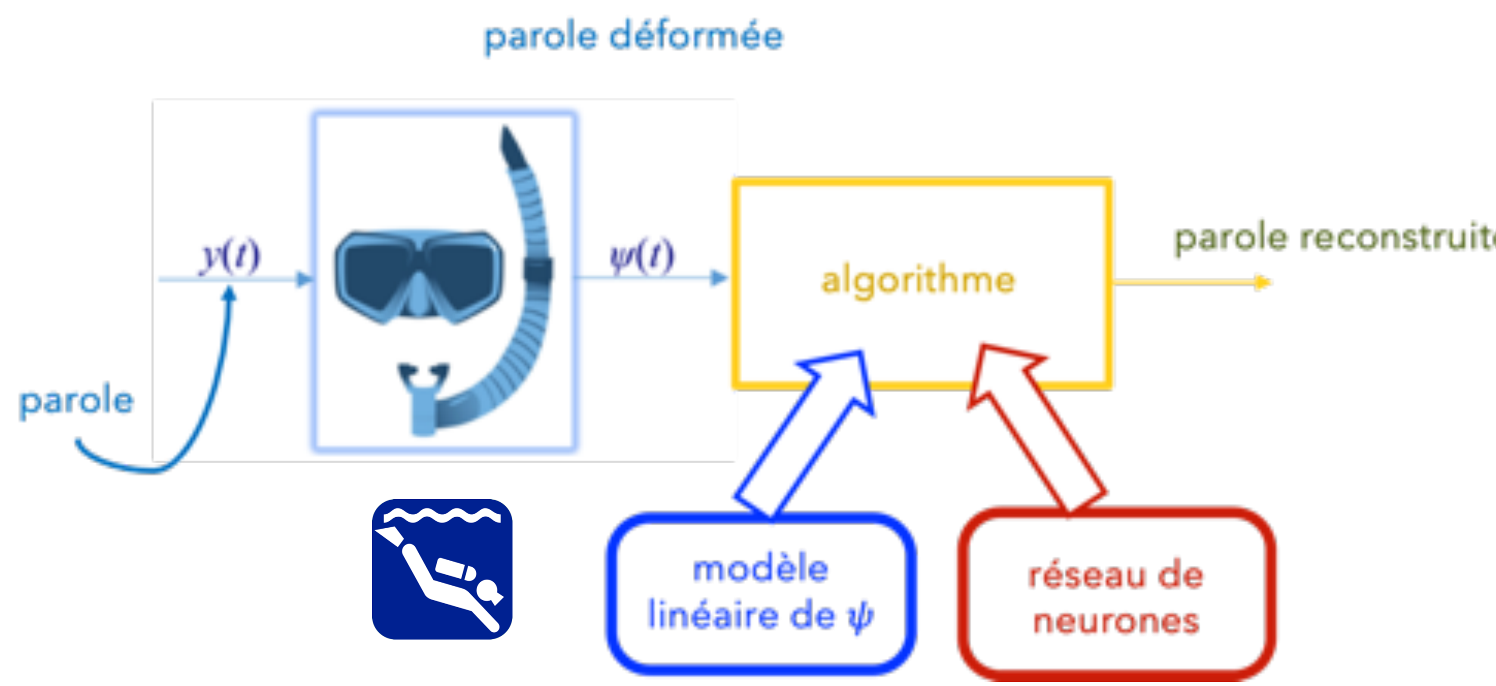
Drones, blimp, robots & cars



Robust adaptive filtering for the living



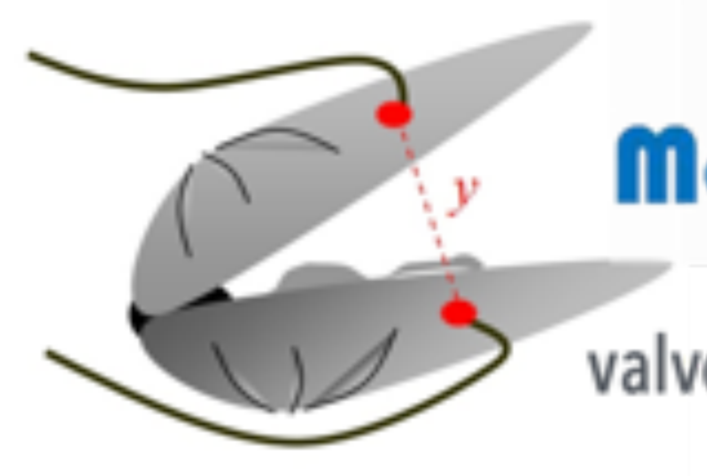




Oysters behavior

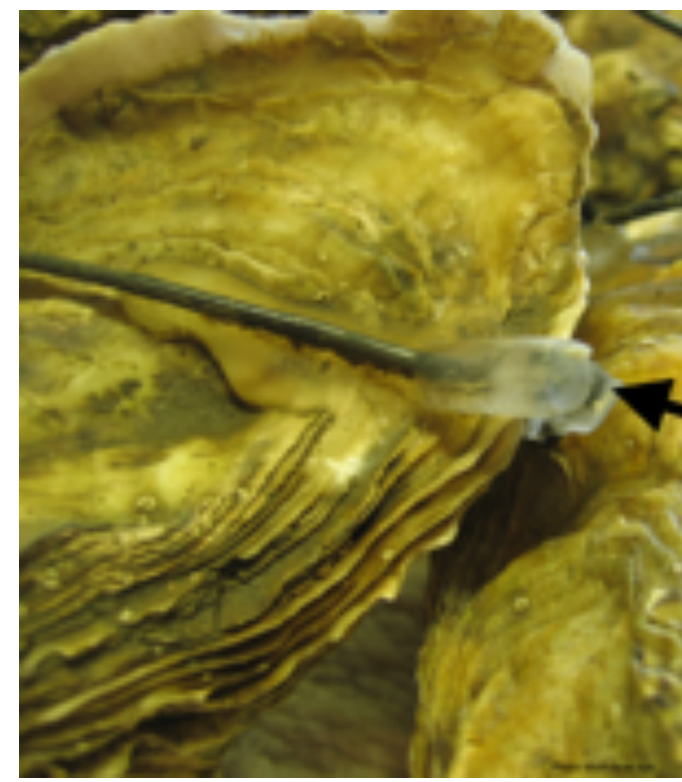
Modeling bivalves biological rhythm

biosensor → monitoring water quality



MolluScan eye

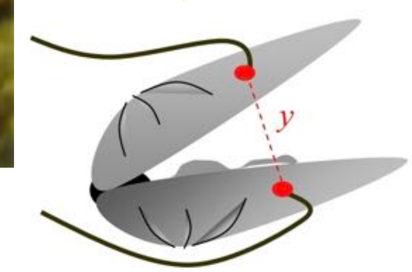
valvometry high frequency
non invasive

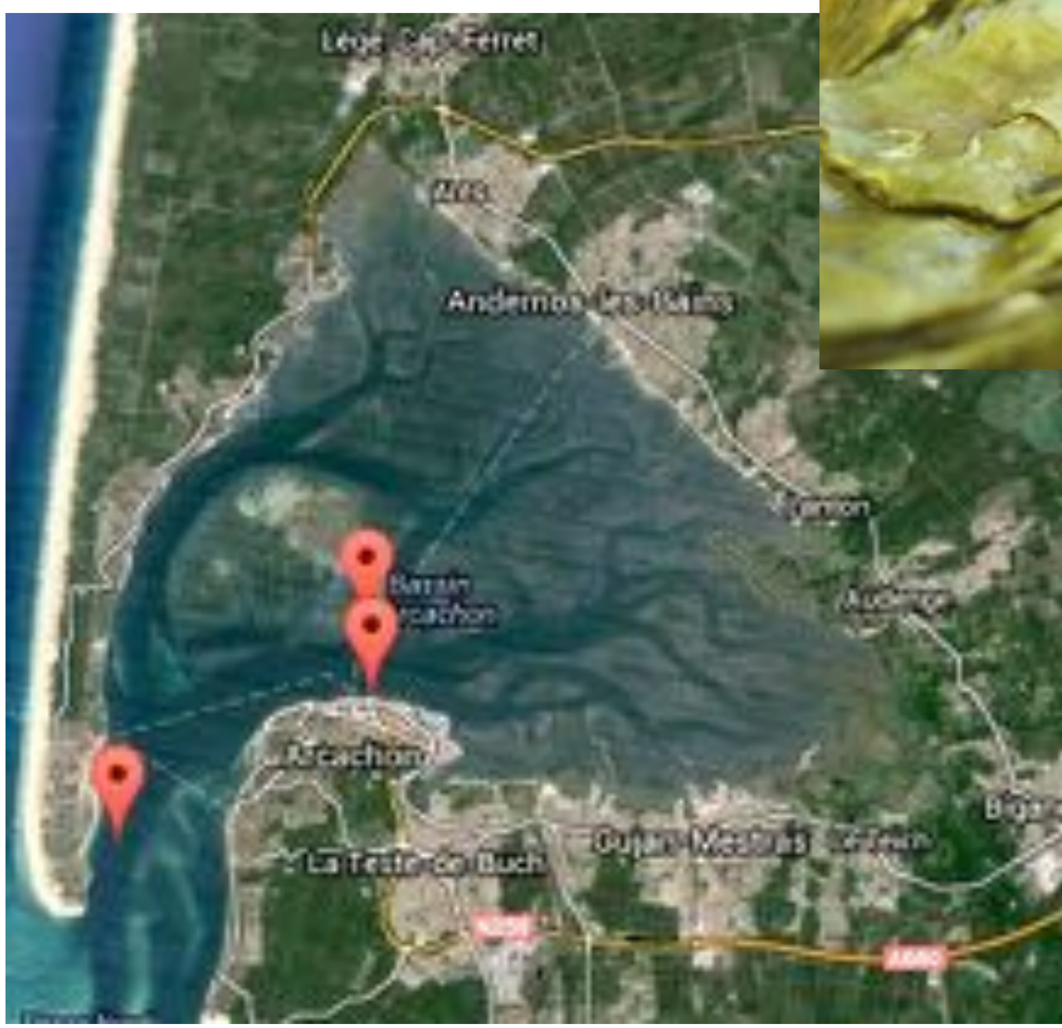


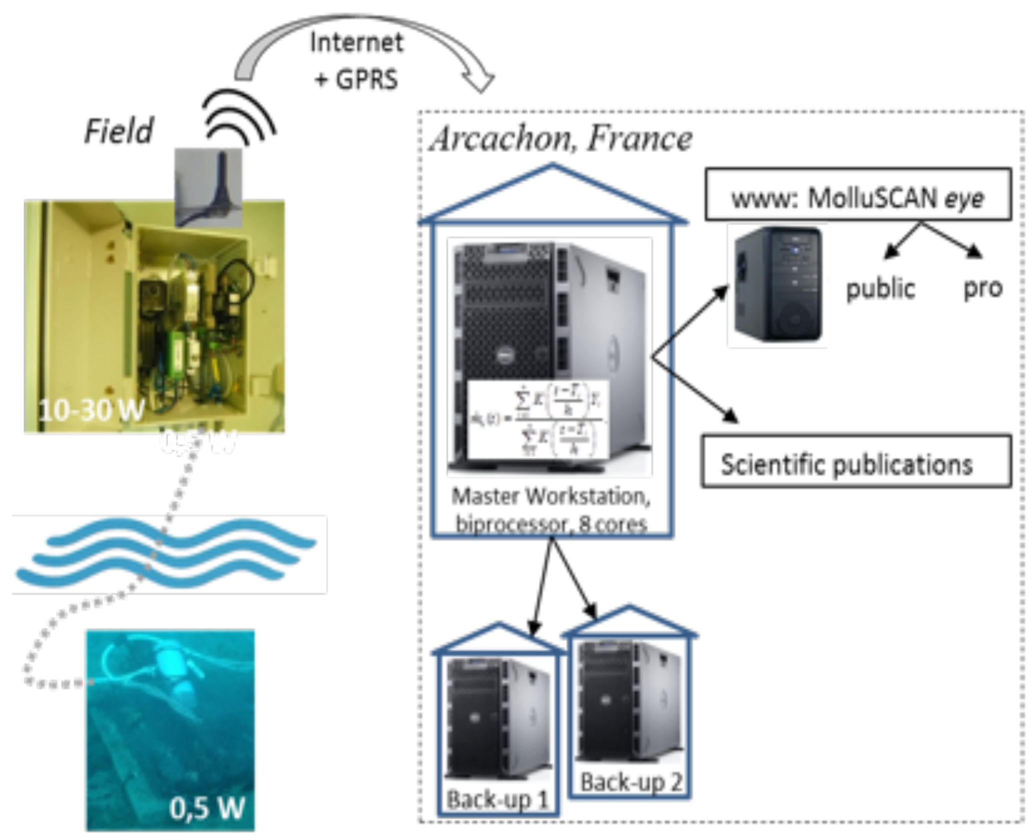
Valse & EA-EPOC CNRS Bordeaux

Experimental setup

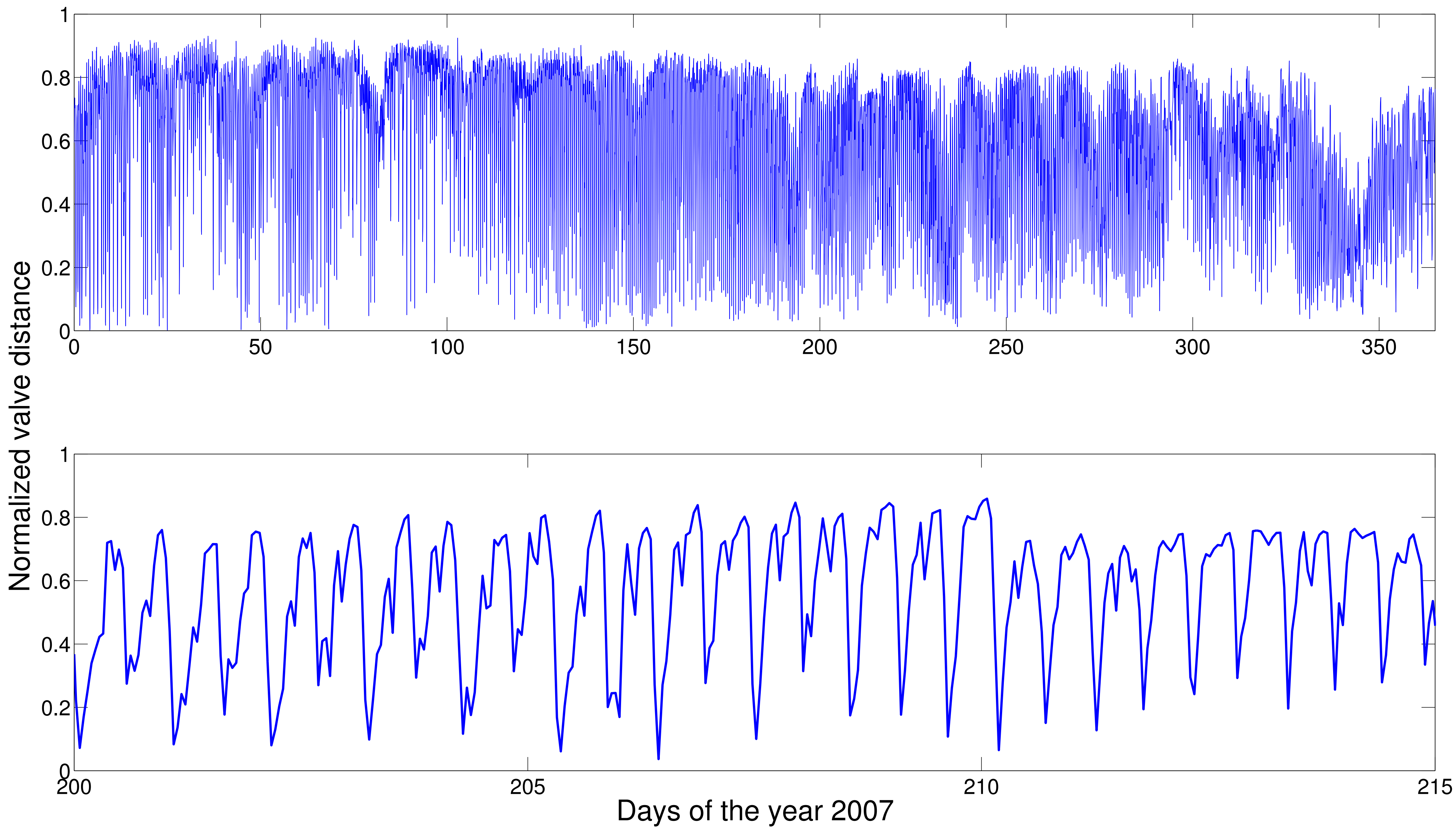
light coils glued on the valves







Data

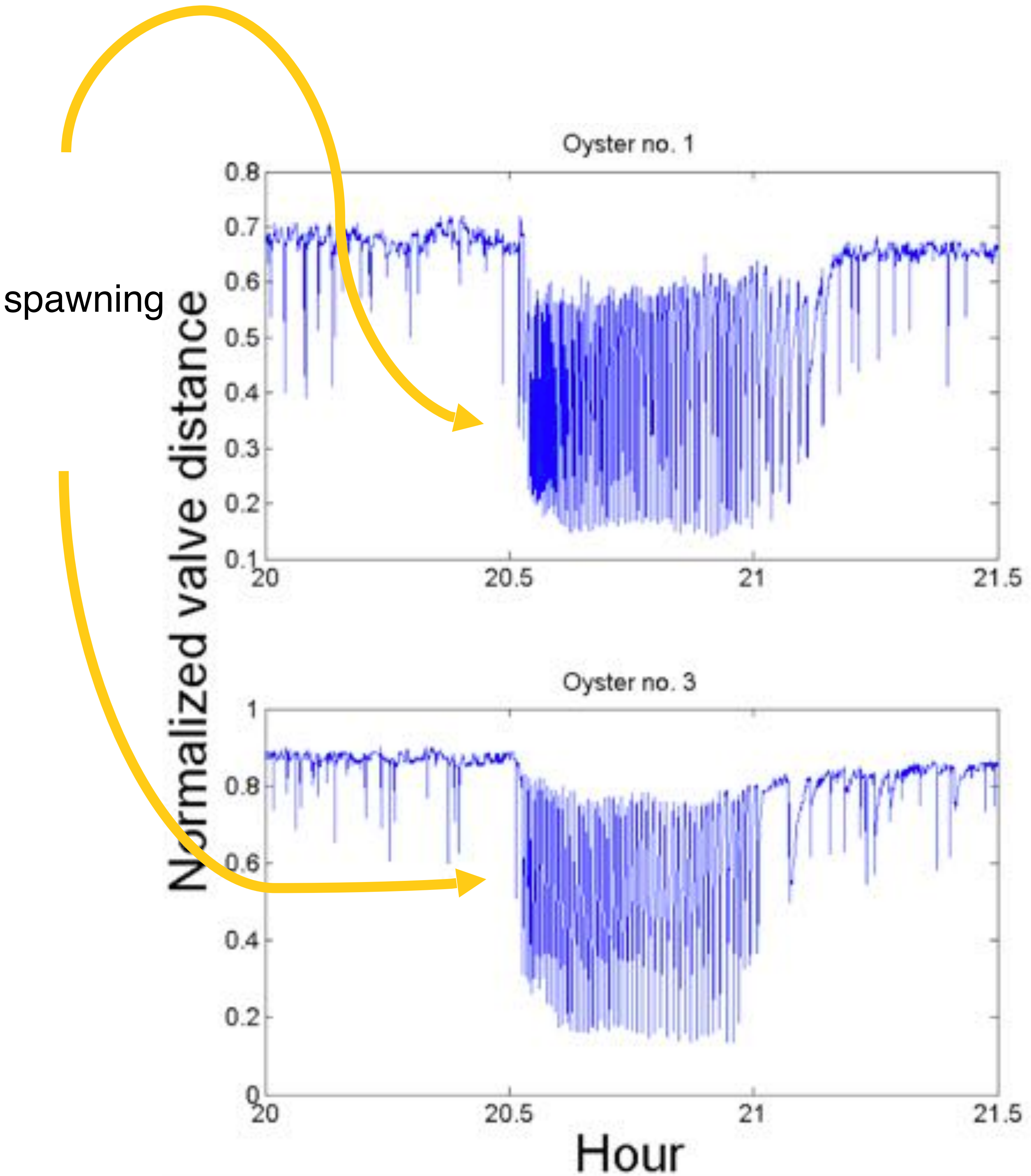


1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
Normalized valve distance
1
0.8
0.6
0.4
0.2
0
200
205
210
215
Days of the year 2007

Oysters as biosensors

- oysters can be used as biosensors for environmental monitoring
- abnormal behavior may trigger pollution alarm
- spawning behavior is abnormal, as a deviation from normal behavior
- particular rhythmic behavior during reproduction to expel eggs
- spawning observation is important in domains like aquaculture, ecology, etc.
- detection process is manual until now

Oysters spawning



- a series of rapid contractions and relaxation
- regularity in rhythm and consistency in amplitude
- duration 30 - 40 minutes with short relaxation period
- simultaneous spawning in the population
- fluctuation in the velocity

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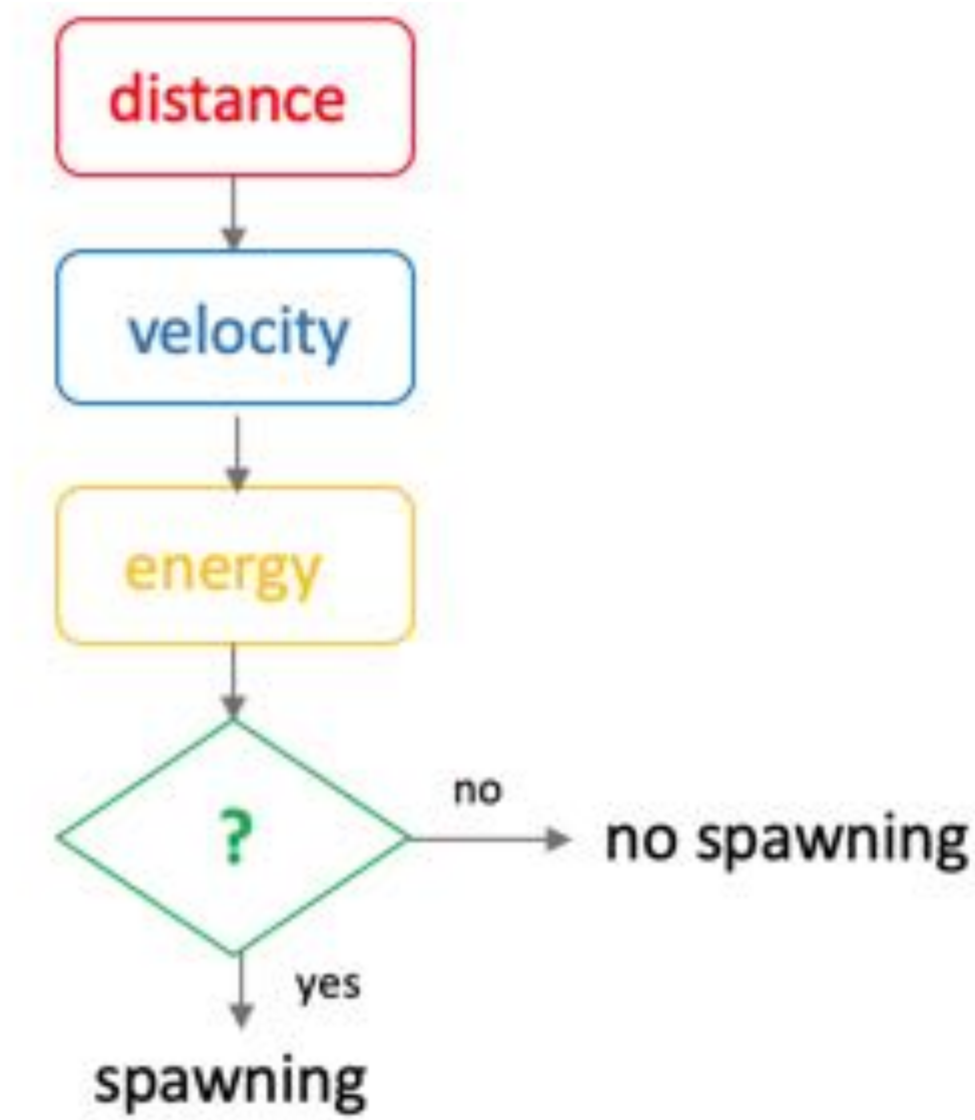
Spawning detection algorithm

1. calculate velocity
2. calculate energy from velocity
3. pass the energy signal through a low-pass filter
4. compare the filtered signal with some pre-defined threshold
5. spawning or no-spawning decision



Velocity estimation

Velocity is the first order derivative of distance signal

Three numerical differentiators:

1. algebraic differentiator
2. non-homogeneous high-order sliding mode differentiator
3. homogeneous finite-time differentiator

Algebraic differentiator

For a real valued signal y, analytic on some interval I, the first-order derivative estimate is

$$\widehat{\dot{y}} = \int_0^T \frac{6}{T^3}(T - 2\tau)\; y(t - \tau)\; \mathrm{d}\tau$$

where T is the window length

Non-homogeneous high-order sliding mode

Consider the following unknown noisy signal

$$\tilde{y}(t) = y(t) + v(t)$$

where v is some bounded measurement noise

Consider

$$\dot{x}_1(t) = -\alpha\sqrt{|x_1(t) - \tilde{y}(t)|}\,\mathrm{sgn}(x_1(t) - \tilde{y}(t)) + x_2(t)$$

$$\dot{x}_2(t) = -\beta\ \mathrm{sgn}(x_1(t) - \tilde{y}(t)) - \chi\ \mathrm{sgn}(x_2(t)) - x_2(t)$$

where $\alpha > 0$ and $\chi \geq 0$ are tuning parameters with $\beta > \chi$

x_1 is the estimate of y and x_2 is the estimate of $\dot{y}$

Homogeneous finite-time

For a real valued signal y, consider

$$\dot{x}_1(t) = x_2(t) - k_1\lceil x_1(t) - y(t)\rfloor^{\alpha}$$
$$\dot{x}_2(t) = -k_2\lceil x_1(t) - y(t)\rfloor^{2\alpha-1}$$

where $k_1, k_2, \alpha > 0$ are tuning parameters

x_1 is the estimate of y and x_2 is the estimate of $\dot{y}$

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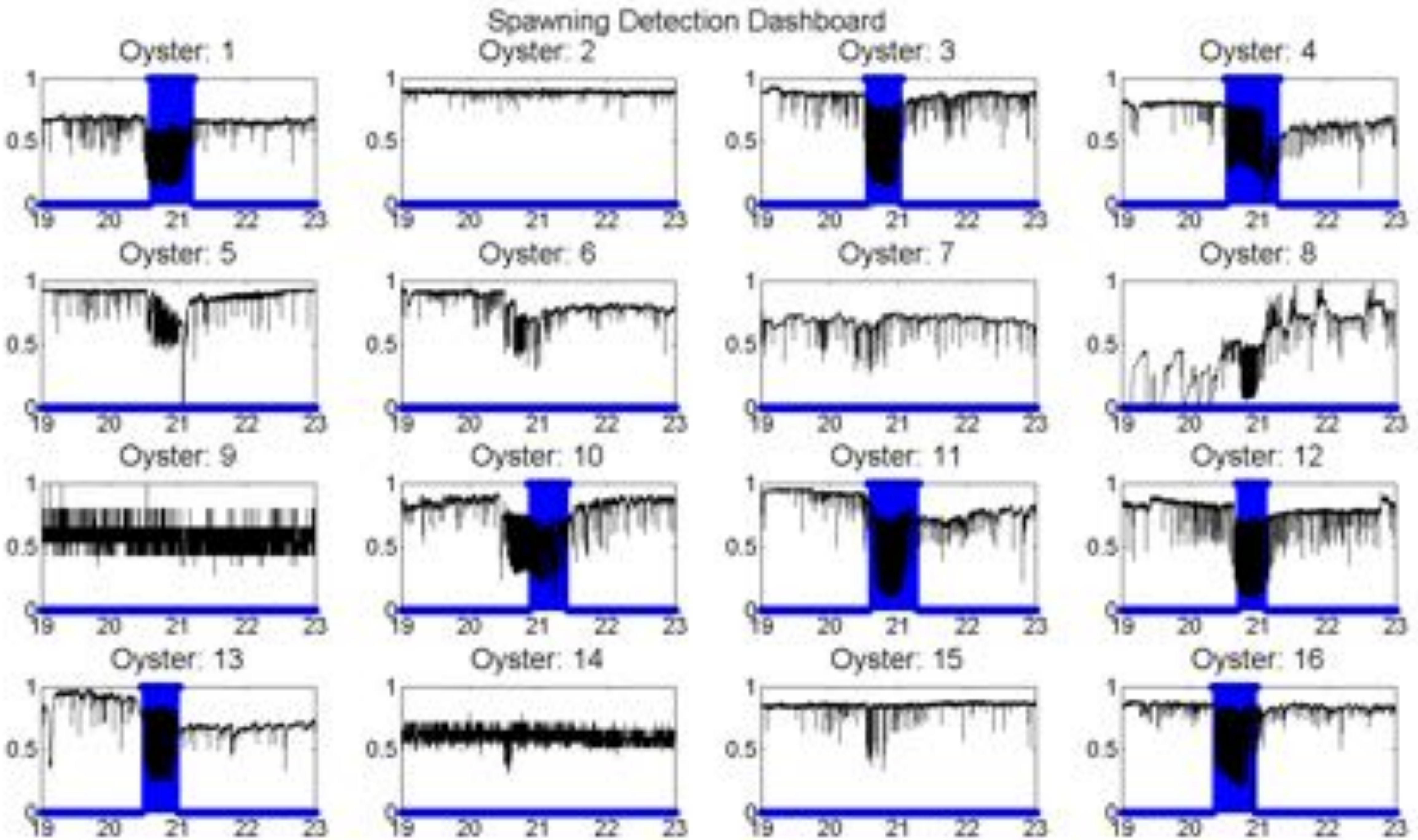
Spawning detection

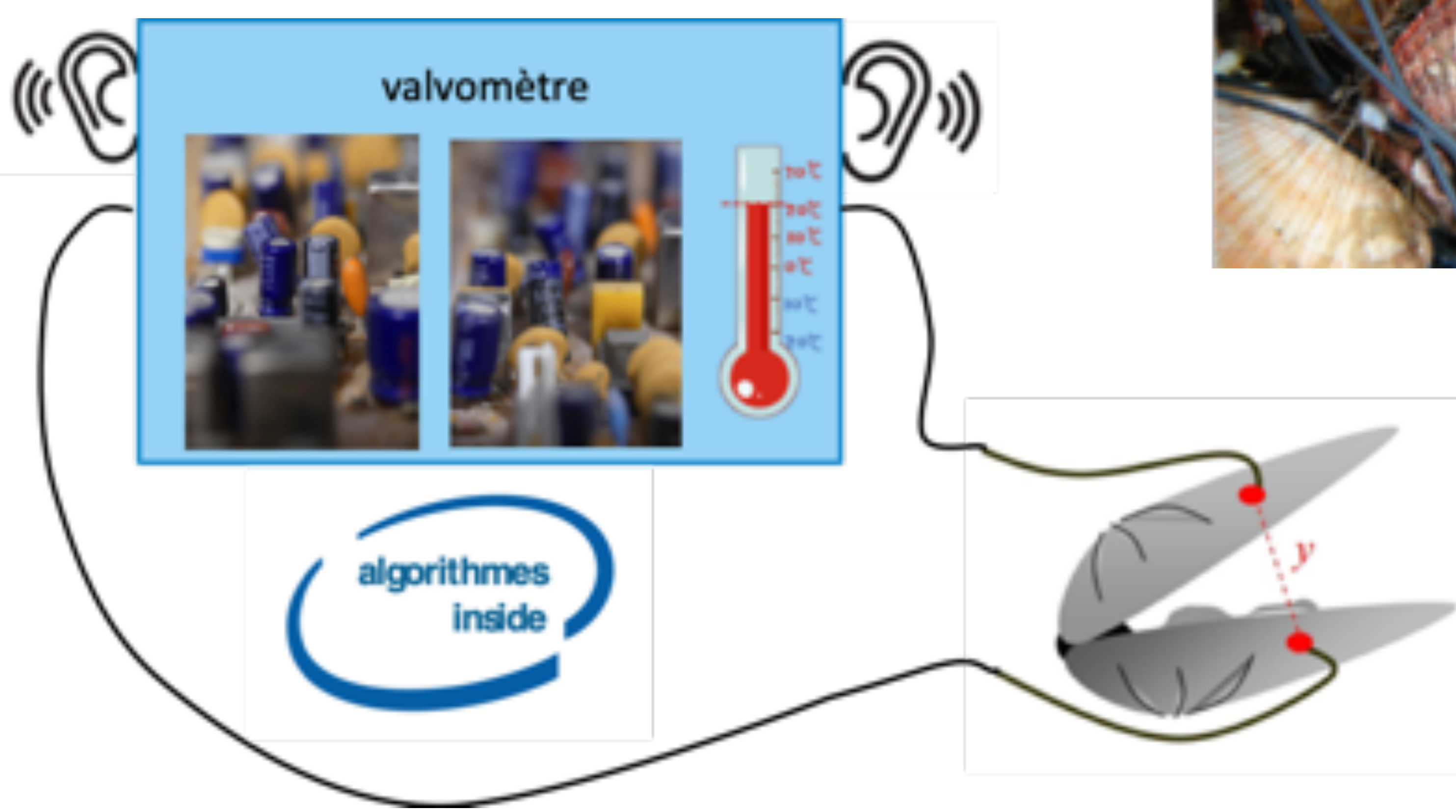


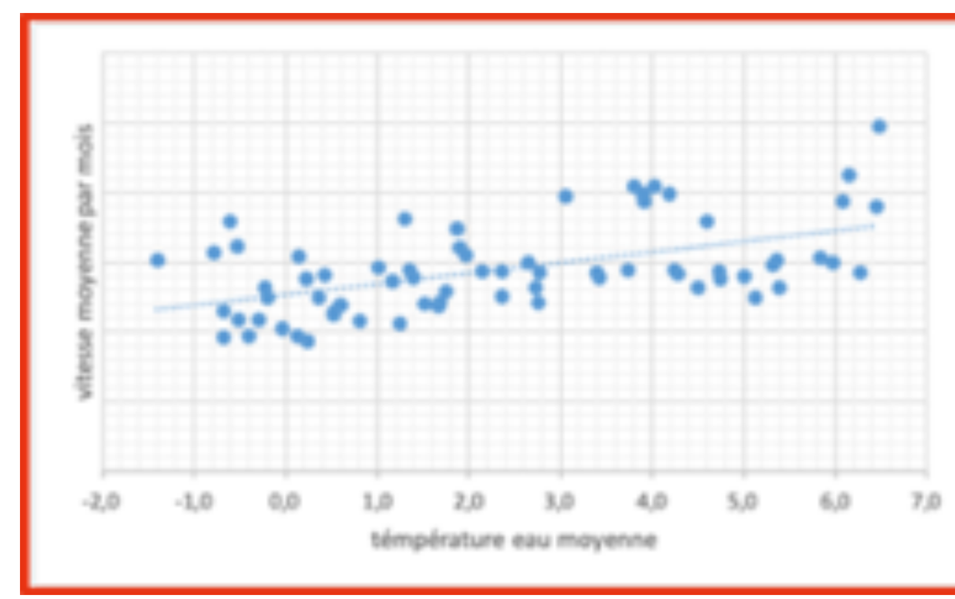
Bivalves behavior

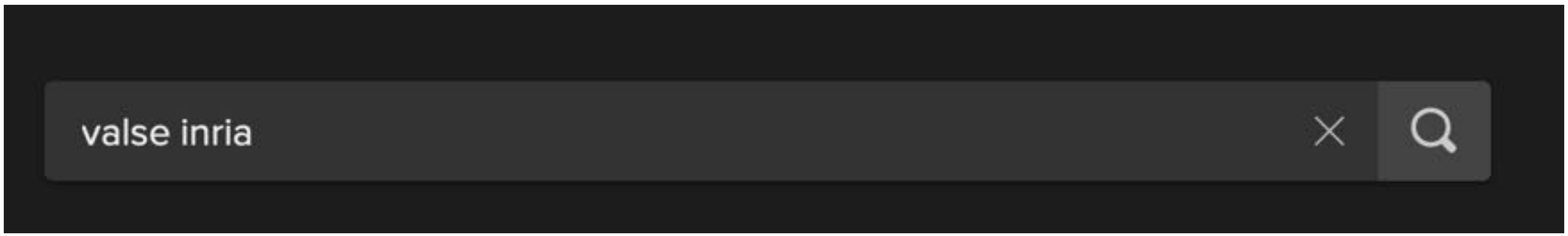
Analyzing climate change consequences

Svalbard

Clamys Islandica







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