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## **The Green Book of the Academy Space, Environment, Risk and Resilience n°2**

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# The Green Book

of the

Academy

*Space, Environment, Risk and Resilience*





**The Green Book of the  
Academy Space, Environment, Risk and Resilience**

N°2 – Edition 2024





UNIVERSITÉ  
CÔTE D'AZUR



Initiative d'Excellence

# The Green Book

of the

Academy

*Space, Environment, Risk and Resilience*

**Edited by**

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N°2 - Edition 2024

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# Preface

The *Academy Space, Environment, Risks and Resilience* focuses on natural, health and anthropogenic hazards and risks. Our goal is to better understand the complexity of the processes involved, characterize their diversity and interconnections, and define their social and environmental links. As such, our objective is to contribute to the development of research that promotes the sustainable well-being of our societies, our environments and, more generally, our ecosystems. In other words, the Academy's domain covers the possible Holocene to Anthropocene transition (a term formalized by Crutzen and Stoermer in the late 90s<sup>1</sup>) that encompasses space, human cultural achievements, political and economic systems and a variety of environmental effects.<sup>2</sup> The research projects united and supported by our Academy are therefore necessarily transdisciplinary in nature, as they address challenging questions about objects or systems that are complex in nature and diversity.

In 2021, the world population reported by the United Nations was 7.877 billion, projected to reach 10.5 billion in the period 2080-90 (perhaps reaching a peak).<sup>3</sup> Along these trends in world demographics, the occurrence of the Anthropocene era (for some authors set arbitrarily to 1784, when J. Watt invented the steam engine) represents the start of a very rapid transformation of the Earth system, driven by humans, away from the glacial-interglacial limit cycle, although this notion is still subject to debate.<sup>4,5</sup> One of the well known consequences is that according to the IPCC (Intergovernmental Panel on Climate Change), the average global surface temperature over the period 2011-2020 is 1.1°C higher than the reference period 1850-1900, and the concentration of greenhouse gases (primarily but not exclusively carbon dioxide) has risen over the same reference period from less than 300 ppm in 1850 (pre-industrial Holocene value) to 410 ppm in 2019.<sup>6</sup>

Logically, **hazards** and **transdisciplinarity** are thus the two main keywords that characterize the work of the *Academy Space, Environment, Risks and Resilience*.

## Hazards

Despite immense progress in understanding the so-called Anthropocene era, much of contemporary Earth is still poorly understood and the complexity of human societies remains, at least in part, a mystery. This represents a challenge, especially for the next generations. How can we hope to achieve global sustainability and understand the intricate relationships between the environment (to be defined) and humans if we do not understand how they behave and interact? Since the sixteenth century, our fundamental knowledge of our place in the Universe has changed enormously. So has our relationship to our environment or so-called "Nature". From the beginning of modern science to the present times our relationship with our environment has dramatically shifted. Progress in anthropology, sociology and natural sciences have driven this shift. Quoting B. Latour, we know that "Galilee's earth could rotate, but it had no tipping point, no planetary boundaries, no critical zones. It had movement, but not behavior. In other words, it was not yet the Earth of the Anthropocene."<sup>7</sup>

A decade ago, the concept of "planetary boundaries" was proposed to help us find our way to global sustainability.<sup>8</sup> "The planetary boundaries framework delineates the biophysical and biochemical systems and processes known to regulate the state of the planet within ranges that are historically known and scientifically likely to maintain the Earth's stability and life-support systems conducive to the human welfare and societal development experienced during the Holocene."<sup>9</sup> Nine planetary boundaries were defined: climate change; ocean acidification; stratospheric ozone depletion; atmospheric aerosol loading; biogeochemical flows (interference with P and N cycles); global freshwater use; land-system change; change in biosphere integrity; and novel (chemical) entities. Exceeding the threshold in any of these systems is likely to drive, or has already driven, humans and Earth into an irreversible situation.

<sup>1</sup> P. J. Crutzen, *Nature* 415:23, 2002

<sup>2</sup> S. L. Lewis, M. A. Maslin, *Nature*, 519 :171, 2015

<sup>3</sup> <https://population.un.org/wpp/>, consulted May 2024

<sup>4</sup> W. Teffen et al. *PNAS*, 115, 8252, 2018

<sup>5</sup> See <http://quaternary.stratigraphy.org/working-groups/anthropocene/> (March 2024) for the rejection of the proposal for an Anthropocene Epoch

<sup>6</sup> IPCC AR6 Synthesis Report (long report), 2023

<sup>7</sup> B. Latour, *Face à Gaïa* Ed; La Découverte, France, 2015, translated by the author

<sup>8</sup> J. Rockström et al. *Ecology and Society* 2009, 14(2): 32

<sup>9</sup> K. Ridgway et al. *Sci. Adv.* 2023, e9, 2548

In addition, most boundaries are interconnected and form an intricate pattern of interrelated hazards. This system of planetary boundaries serves as a guide for humans that Earth is in danger of leaving (or has already left) its Holocene-like state. However, today, societies are still placing an increasing pressure on the planet. Some of the changes caused today will only be seen on evolutionary time scales, while others are already affecting climate and biosphere integrity. The planetary boundary on climate change set the limit of carbon dioxide to 350 ppm. This limit lies within the warming target set by the Paris Agreement (2015) of well below 2°C and preferably 1.5°C in this century.<sup>10</sup> However some authors have suggested the possibility of extreme impacts even at 1.5°C warming or below.<sup>11</sup> In conclusion, our Academy has the duty to initiate and stimulate research projects that will address these vital questions and place science and research at the center of the debate.

### Transdisciplinarity

As noted above, the *Academy Space, Environment, Risk and Resilience* has a core interest in the relations between humans, their societies and their ecosystems. We aim to aggregate and interconnect knowledge from a large panel of disciplines in order to answer complex questions about objects that are complex in nature and diverse. Disciplines may be defined by the conjunction of several criteria such as 1) observable or formalized objects manipulated using methods and procedures, 2) phenomena arising from interaction between these objects and 3) laws to account for phenomena and to predict their operation.<sup>12</sup> Our goal is to foster connections between disciplines and produce a new model with multiple levels and objectives, coordinated to achieve a single goal and answer a complex question. This in our opinion, is transdisciplinarity.<sup>13</sup>

The projects united and supported by our Academy therefore tend to be transdisciplinary in nature. This goes beyond the simple addition of different disciplinary methods and creates new perspectives, because “the stage of interdisciplinary relations may be followed by a higher stage that would be transdisciplinary, that would not only achieve interactions or reciprocities between specialized research, but would situate these links within a total system with no stable boundaries between disciplines.”<sup>14</sup> The main objective is to contribute to a better grasp of the natural and anthropogenic hazards that threaten the Earth and its broader ecosystems, and find ways of coping with their related risks. This large range of interests leads our Academy to merge the natural and social sciences and makes it inherently transdisciplinary. As said earlier, most “planetary boundaries” and hence most hazards are intricate and interconnected, which precludes simplified mono-disciplinary approaches. Hazards must be considered holistically, from biology to Earth sciences, and from chemistry to economics (to give just a few examples), in order to create a new framework where hazards can be described in generalized terms.

To meet our objectives and address environmental and societal issues in line with the United Nations Sustainable Development Goals (SDGs),<sup>15</sup> projects are encouraged to cover a continuum from fundamental observations that lead to scientific understanding, to more applied research on anticipating consequences and risks. We have fostered and supported various types of actions (scientific projects, educational programs, workshops, etc.) organized within five main themes summarized as follows:

- 1- Anthropogenic health and environmental risks
- 2- Natural hazards and their impact on the environment, cities and society
- 3- Energy- and resource-related environmental challenges
- 4- Threats to oceans and coastal areas

This structure corresponds to four clusters of SDGs as shown schematically on the right.

<sup>10</sup> <https://www.diplomatie.gouv.fr/fr/politique-etrangere-de-la-france/climat-et-environnement/la-lutte-contre-les-changements-climatiques/la-conference-de-paris-ou-cop21> consulted May 2024.

<sup>11</sup> D. I. Armstrong McKay, A. Staal, J. F. Abrams, R. Winkelman, B. Sakschewski, S. Loriani, I. Fetzer, S. E. Cornell, J. Rockström, T. M. Lenton, *Science* **2022**, 377, 1171.

<sup>12</sup> M. Boisot, in *L'interdisciplinarité : problèmes d'enseignement et de recherche dans les universités*, p90, **1972**, Paris, OCDE.

<sup>13</sup> There are many ways to define interdisciplinarity and/or transdisciplinarity. See for instance J. H. Bernstein, City University of New York (CUNY), 2015

<sup>14</sup> Jean Piaget, in *L'interdisciplinarité : problèmes d'enseignement et de recherche dans les universités*, p131, **1972**, Paris, OCDE.

<sup>15</sup> <https://sdgs.un.org/fr/goals>, consulted April 2024.

## The Academy's work

In its five years of operation, our Academy has fostered the emergence of innovative transdisciplinary research on the four main themes described above. Three funding mechanisms have been put in place to support this research: *Consortium projects*, *Emerging ideas*, and *Support for scientific outreach*. Notably, during this period our Academy has supported or contributed to 10 Consortium projects, each over a maximum period of 3 years, 27 Emerging ideas and 9 Events and workshops.

The research produced with the support of our Academy is thus rich, diverse and scientifically significant. Furthermore, it has opened the door to new collaborations outside traditional fields of expertise, in France and internationally. As a result, a sense of collective concern has emerged, reflecting the necessity for innovative monitoring, research, and actions at various levels, from individuals to policy-makers, including scientists and public authorities.

We believe that the current synergy between various researchers and institutes of Université Côte d'Azur would never have occurred without the support of our Academy. The transdisciplinary approach we have contributed to foster paves the way for a greater integration of scientific disciplines from the very beginning of project design. To reach this objective, local and national networks need to grow and expand internationally. Synergy and transdisciplinarity are thus keywords in our calls for project proposals.

This book, in its second edition, is organized into chapters corresponding to the four research themes of the Academy, namely Anthropogenic health and environmental risks; Natural hazards and their impact on the environment, cities and society; Energy- and resource- related environmental challenges; Threats to oceans and coastal areas; with an additional chapter for the scientific events and workshops. For each project, a short summary is presented together with its members, budget, possible directions for future development and actions, and its transdisciplinary added value.

We hope that this brief description of these projects will provide the opportunity for new research ideas and collaborations, and more than that, the opportunity for optimism regarding the challenges that are driving research on our so-called Anthropocene era.

Christophe Den Auwer

# SUSTAINABLE DEVELOPMENT GOALS

Anthropogenic health and environmental risks



Natural hazards and their impact on the environment, cities and society



Energy- and resource-related environmental challenges



Threats to oceans and coastal areas







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# Anthropogenic health and environmental risks

Collected in this chapter are projects that are related to SDGs 3, 6 and 13, drawing a clear link between the major health and environmental issues of our present time, interconnecting human beings and Earth. This theme brings together a total of 9 scientific projects: 2 Consortium projects and 7 First projects.

# VIRBT - Foodborne outbreaks and bacteremia associated with *Bacillus thuringiensis* biopesticides: *in vivo* evaluation and modeling of the virulence potential

“ Biopesticides: are natural and organic pesticides really safe? ”

## Academy 3 highlight

*Bacillus thuringiensis* is a bacterium increasingly used as microbial insecticide to fight lepidopteran larvae, a major crop pest. Recently, this bacterium has also been involved in food poisoning and systemic infections, affecting humans, wildlife and the environment indiscriminately. As part of the “One Health” concept, our project tackles the mechanism of virulence of this bacterium using insects, mice and human cell culture and combining medicine, immunology, cell biology, genetics and bioinformatics. It contributes to the topic “Assessment and detection of anthropogenic risks to human health”.

## Scientific domains

Environmental and Human Health  
Biology

## Key words

*Bacillus thuringiensis*  
One Health  
Bioinsecticides  
Agriculture  
Food poisoning

## PI laboratory

ISA - Université Côte d’Azur, CNRS, INRAE

## Partners

C3M - Université Côte d’Azur, Inserm  
CHU de Nice l’Archet - Université Côte d’Azur  
ANSES - Maisons-Alfort

## Total budget

€266,500, including €66,500 from Academy 3

## Start of the project

2022



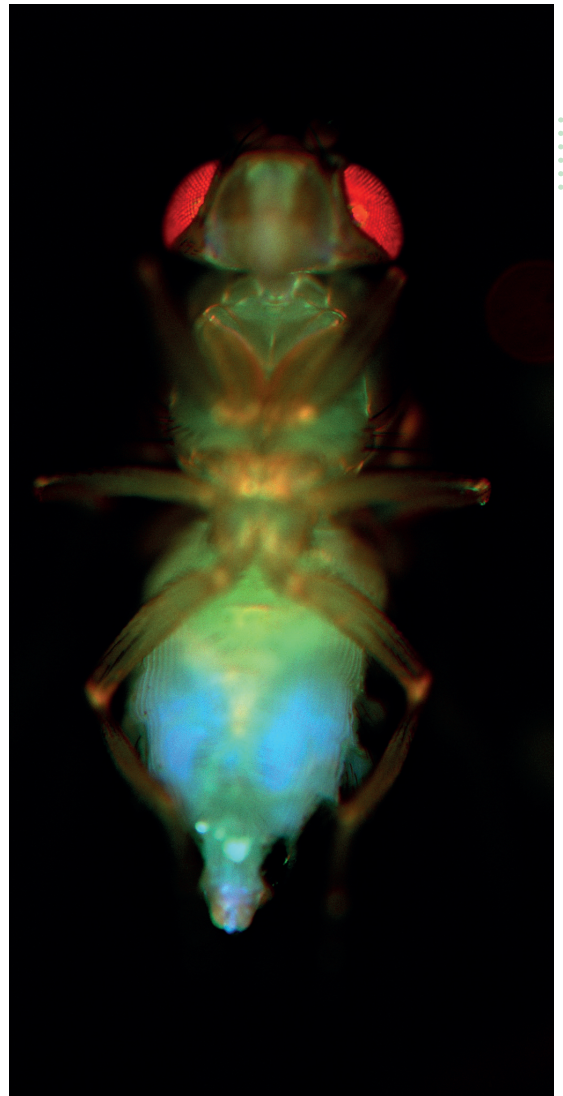
Armel  
Gallet



Laurent  
Boyer



Mathilde  
Bonis



# The project

The use of chemical pesticides is controversial, mainly because of their harmful effects on the environment and human health. The emerging solution is the use of biocontrol agents, also called biopesticides. Like chemical pesticides, biopesticides are used to combat certain organisms considered harmful, but by means of natural substances (plant extracts, pheromones, essential oils, etc.) or organisms (predators such as ladybirds, bacteria, viruses, etc.). These natural pesticides are a good alternative to chemical ones, but not without a risk to human health. The microbial insecticide *Bacillus thuringiensis* (Bt), although an “organic” pesticide, is involved in almost 20% of cases of food poisoning caused by the *Bacillus cereus* group of bacteria to which it belongs (Bonis et al., PLOS One, 2021). Some strains of the *Bacillus cereus* group have also been found responsible for nosocomial diseases (such as septicemia) in weakened individuals (e.g., immunocompromised individuals, the elderly, newborns). So far, we have ignored how this group of bacteria displays its virulence and to what extent the hazard coming from Bt in food originates from agriculture. This is what the consortium of researchers working on the VirBt project is trying to investigate and understand. Focusing on Bt and its effects, biologists from ISA, C3M, Nice CHU and the Laboratory for Food Safety of the ANSES Maisons-Alfort are working together to assess the virulence of Bt strains. They are also investigating the extent to which weakened individuals are prone to Bt infection and more broadly to infection by the *Bacillus cereus* group. To achieve this, three models are being used in the experiments: *Drosophila* (fruit fly), mice and human intestinal cell cultures. *Drosophila* is a well-established model for studying the innate immune system because it presents strong similarities with mammals, including mice and humans. Furthermore, compliance with ethical requirements is ensured by first testing the virulence of many *Bacillus* strains on *Drosophila*, before selecting a limited number of strains and testing them on mice. The data obtained from these models will then be correlated with those recovered from human patient samples. Initial results from tests on *Drosophila* show that Bt storage is most concentrated in the intestinal tract, sporadically leading to diarrhea and intestinal disorders as early as 8 to 24 hours after ingestion.

While Bt strains are the most effective of all pesticides, they are also the ones to which people are most exposed. The survey conducted by ANSES as part of the project highlights this exposure. After collecting and testing 161 fruits and vegetables commercially certified “Organic Agriculture”, almost 50% of the products tested came up positive for Bt. Peppers, tomatoes, apples, cucumbers, aromatic herbs, etc., were all in the same basket! Importantly, no Bt of agricultural origin has been identified in any of the 45 patients analyzed so far with septicemia caused by bacteria from the *Bacillus cereus* group. This observation suggests that Bt used as a microbial pesticide, though present in fruits and vegetables, may be partly responsible for food poisoning but is unlikely to be involved in septicemia in weakened patients.

Research conducted jointly by biologists and public health professionals should lead to the development of tools to assess and detect these Bt strains more easily in food and in the body, and should make it safer to use them in agriculture, since today neither dose limits nor a delay before harvest are imposed.

# How does the project contribute to transdisciplinarity ?



## Cellular Biology - ISA

The BES team is coordinating the VirBt project and bringing its knowledge in organism defense mechanisms against microbes and its skills and expertise in host-pathogen interaction using *Drosophila melanogaster* as host model and *Bacillus thuringiensis* as favorite microbe.



## Food safety - ANSES

The *Bacillus* and *Clostridium* team has been contributing its expertise in *Bacillus* microbiology and genetics to help identify the virulent factors produced by the bacteria.

The team has been communicating the achievements of the VirBt project to the French and European food safety authorities who need to adapt public policies regarding *Bacillus* detection thresholds in foodstuffs.

## Bacteriology - CHU Nice

The Microbiological Laboratory of the Nice l'Archet University Hospital isolated and molecularly characterized the *Bacillus cereus* strains involved in human pathologies, shared them with the BES and MVID teams for virulence studies in *Drosophila* and mice, and performed correlative analyses linking the clinical state of the patients with the level of virulence of the *Bacillus cereus* strain.



## Molecular Medicine

### C3M

The expertise of C3M's MVISD team in mammalian immunity was useful in transposing data obtained in *Drosophila* to the mouse model. The data obtained, along with those from the BES team, were used to assess the levels of virulence of the different *Bacillus cereus* strains.





# ENI-BC+ - Network on non-target effects of biocontrols

“ Non-target effects as a frame of reference to find and assess sustainable strategies for pest and vector management. ”

## Academy 3 highlight

The ENI-BC+ network brings together academic researchers from different disciplines to work toward a common goal: evaluate the anthropogenic impact of *“agriculture and farming on the environment and on society in order to design sustainable pathways”* with the aim of protecting crops, livestock breeding, humans, and the environment.

## Scientific domains

Environmental and Human Health  
Ecotoxicology  
Social Sciences

## Key words

Sustainability  
Agriculture  
Pest-management  
Biocontrol  
One Health

## PI laboratory

ISA - Université Côte d'Azur, CNRS, INRAE

## Partners

GREDEG - Université Côte d'Azur, CNRS  
CBGP - INRAE, Cirad, IRD, Institut Agro Montpellier  
ANSES  
CEFE - Université de Montpellier, CNRS, EPHE, IRD  
EBI - Université de Poitiers, CNRS  
SADAPT - INRAE, AgroParisTech, Université Paris-Saclay  
ECOSYS - INRAE, AgroParisTech, Université Paris-Saclay  
PSH - INRAE  
BABEL - Université de Toulon  
CIRAD  
AgroParisTech  
AGROSCOPE

## Total budget

€30,000 from Academy 3

## Start of the project

2022



Louise Van Oudenhove



# The project

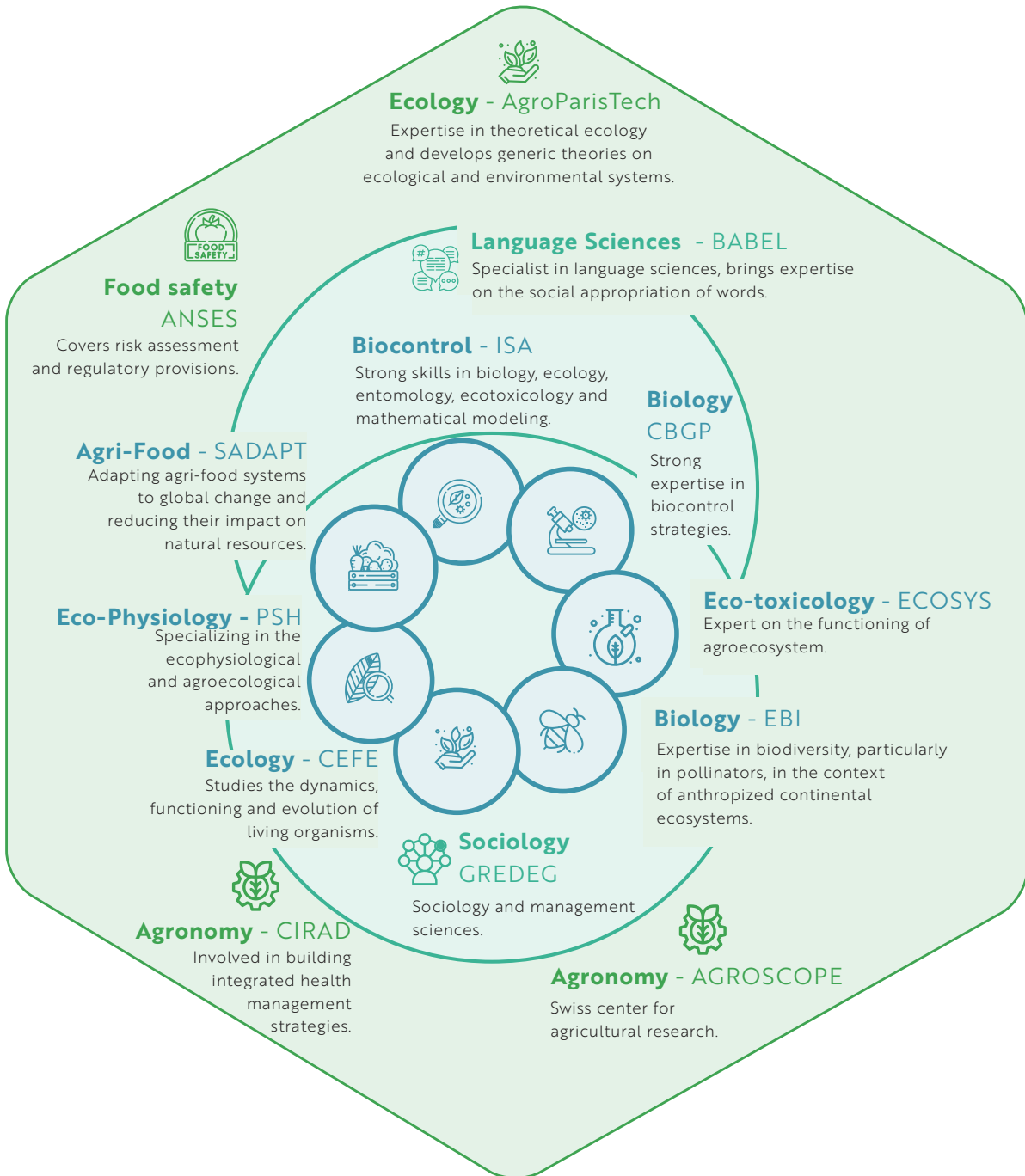
Biocontrol, a word with a wide meaning that covers a multitude of solutions, products and services for crop protection, is promoted by governments, industries and many researchers as the main tool for reducing the use of infamous synthetic pesticides. These are slowly being banned from European agriculture due to their non-target effects on health and the environment. This trend is the outcome of decades of research in developing new concepts and practical solutions, that have now proven their effectiveness. However, the non-target effects of biocontrol solutions have not been studied in depth because it is assumed that because of their biological or environmental origin, they do not have the same negative effects as chemical pesticides. Do biocontrol solutions really have a low environmental persistence and ecotoxicity? Do all the very diverse solutions present similar levels of risks? Could these risks be anticipated and/or avoided? When non-target effects are difficult to anticipate, how should monitoring be implemented after deployment to maximize both safety (for the environment, users and consumers) and the agroecological transition?

In 2020, we initiated a collective investigation of the non-target effects of these biocontrol solutions. A first virtual meeting gathered more than 50 researchers who expressed an interest in the topic. Two main ideas emerged. First, all the biocontrol solutions that deal with the same agricultural issues should be evaluated using the same criteria to provide comparable results. Second, a multidisciplinary approach is mandatory as non-target effects are inherently diverse – ranging from effects on biodiversity to the functioning of human organizations – and their desirability depends on the social group considered. On this basis, it was decided to create the ENI-BC+ research network. Academy 3 helped the community to become more strongly structured and enabled collective research to take shape.

The network aims to promote the study of the non-target effects of crop protection strategies. The ultimate goal is to avoid repeating the mistakes of the past, when synthetic pesticides were deployed, and to provide guidelines for choosing the best biocontrol solutions depending on the context and the region. In concrete terms, the network aims to stimulate the study of the non-target effects of pest and vector management strategies by firstly, federating an interdisciplinary scientific community, secondly, initiating new academic research projects, and thirdly, working collectively on interdisciplinary syntheses and conceptual frameworks. The network covers all the strategies (products, techniques and services) designed to protect crops and livestock breeding and to manage vector-borne diseases. It goes beyond the basic definition of biocontrol and proposes an integrative conception of pest and vector management encompassing plant, animal, human and environmental health. This aspiration is reflected in the acronym of the network: ENI, “Effets Non-Intentionnels”, French for non-target effects, and “BC+”, to designate BioControl strategies and more!

The ENI-BC+ network now includes more than 140 researchers from a wide range of disciplines in the natural and human sciences. These researchers work for different research institutes, universities, technical institutes, and French agencies (ANSES and the Ministry of agriculture and food safety). The network is organized around annual workshops attended by some forty scientists, during which lectures and presentations alternate with group discussions facilitated by collective intelligence tools. These workshops have given rise to research projects on specific issues, as well as two working groups on (1) the identification and categorization of target and non-target effects of pest control levers in agroecosystems, and (2) post-approval monitoring of alternative pest control methods. The ENI-BC+ network is, by its very nature, a collective project that involves many people. Some are more active than others (in the organization team or working groups), but the strength of the network rests on all its participants!

# How does the project contribute to transdisciplinarity ?





Consortium at the 2023 workshop.

## The +

This project has helped to structure and increase the visibility of the ENI-BC+ interdisciplinary research community. It has also led to the production of two collective syntheses on the typology of pest management levers and the characterization of the levels of integration that these levers might affect.

## What's next?

The aim of the ENI-BC+ network is to remain active and keep growing. This interdisciplinary community will be consolidated by the annual workshops which provide the opportunity for academics from different disciplines to focus on common objects and questions. Collective research will be pursued and will probably serve as a basis for upcoming projects. The ENI-BC+ network also aims to expand internationally, with the organization of an international event in 2025.

For more information click here 

# PSYCOMED - Psychiatric disorders and comorbidities caused by pollution in the Mediterranean area

“ Investigating anthropogenic pollutants and psychiatric disorders and comorbidities in the Mediterranean region in a bid to identify possible therapeutic avenues. ”

## Academy 3 highlight

The PsyCoMed project, which proposes to assess the health effects of micro and nanoplastics on human health, falls under the theme “*Assessing and sensing anthropogenic hazards to human health, environments and global changes.*” PsyCoMed brings together neuroscientists, chemists and environmental toxicologists from Université Côte d’Azur laboratories.

## Scientific domains

Neuro-toxicology  
Chemistry  
Environmental and Human Health

## Key words

Pollutants  
Nanoplastics  
Neurological disorders  
Neuroinflammation  
Mediterranean

## PI laboratory

IPMC - Université Côte d’Azur, CNRS, Inserm

## Partners

ICN - Université Côte d’Azur, CNRS  
TIRO-MATOs - Université Côte d’Azur, CEA

## Total budget

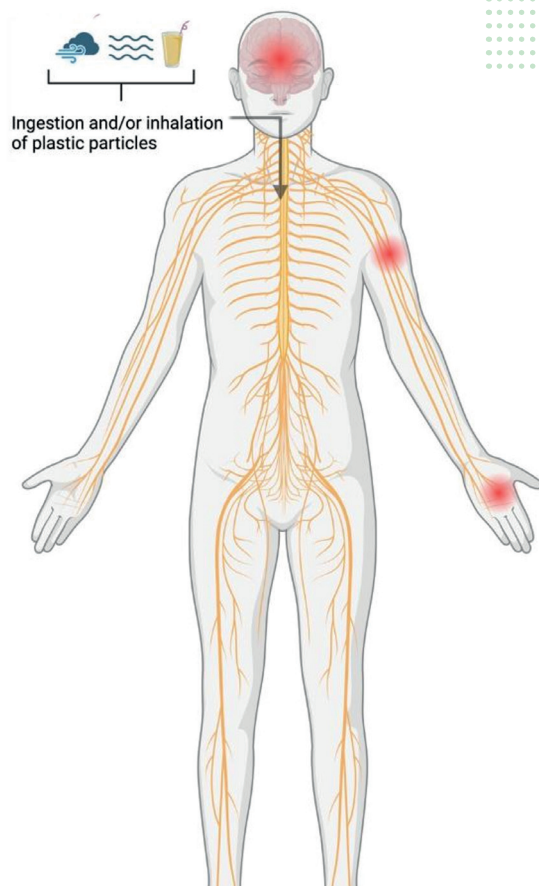
€110,000, including €22,000 from Academy 3



Jacques Noël



Carole Rovere



# The project

The Mediterranean Sea has been identified as one of the seas most affected by marine pollutants of anthropogenic origin in the world. These pollutants represent a growing threat to human health, but their effects on the body are still poorly understood. The PSYchiatric disorders and COMorbidities caused by pollution in the MEDiterranean area (PsyCoMed) project aims to characterize the role of anthropogenic pollutants in the Mediterranean area, with special emphasis on micro and nanoparticles of plastics as a risk factor of neuropsychiatric disorders and associated pathologies, and the role of neuroinflammatory responses in disease progression.

Through a multi-scale (from molecular to clinical science) and multi-modal (from mechanistic to behavioral approaches) study, PsyCoMed will correlate the effects of pollutants on psychiatric symptoms with alterations of inflammatory pathways in preclinical animal models exposed to pollutants. We aim to investigate neural mechanisms underlying these pathological changes in *in cellulo* and *in vivo* models. Funding from Academy 3 is covering the cost of a master's research internship at the Institute of Molecular and Cellular Pharmacology of Université Côte d'Azur. The project aims to study inflammation and toxicity resulting from prolonged exposure to plastic nanoparticles. We are studying the key organs involved in pollutant collection, elimination and metabolism in these preclinical models.

It is essential to characterize the impact of environmental plastic pollution on the human body, as it has been shown that the inflammation resulting from pollution can act on the central nervous system, causing psychiatric illness and comorbid chronic pain.

## The +

This project examines the effects of plastic pollution and plasticizer additives on mental health at a time when such pollution is taking on considerable proportions in the Mediterranean sea. Knowledge of the neurological mechanisms involved in the harmful effects of these pollutants should help limit their effects and inform public decision-makers about the risks.

## What's next?

The research partners of this project are SMEs that use naturally occurring substances with anti-inflammatory properties to reduce the toxic effects of environmental pollutants. We will test these natural substances on preclinical models to assess their positive effects on the neurological disorders induced by nanoplastic particles and exposure to plasticizer additives.

For more information click here 

# CRYSMASS - Cry toxins used in genetically modified crops: Mode of action and unintended effects

“ Are the toxins in *Bacillus thuringiensis* (Bt) biopesticides and in genetically modified crops safe for human health and the environment? ”

## Academy 3 highlight

This multidisciplinary project combines genetics, powerful biochemical tools, electronic microscopy and cellular/physiological approaches to assess and characterize the potential negative effects of the ingestion of *Bacillus thuringiensis* (Bt) toxins. It contributes to the topic “*Risk assessment of biocontrol agents and genetically modified crops on human health and the environment.*”

## Scientific domains

Environmental and Human Health  
Biology

## Key words

Biopesticide  
Cry toxins  
Risk assessment  
*Bacillus thuringiensis kurstaki* (Btk)

## PI laboratory

ISA - Université Côte d’Azur, CNRS, INRAE

## Partner

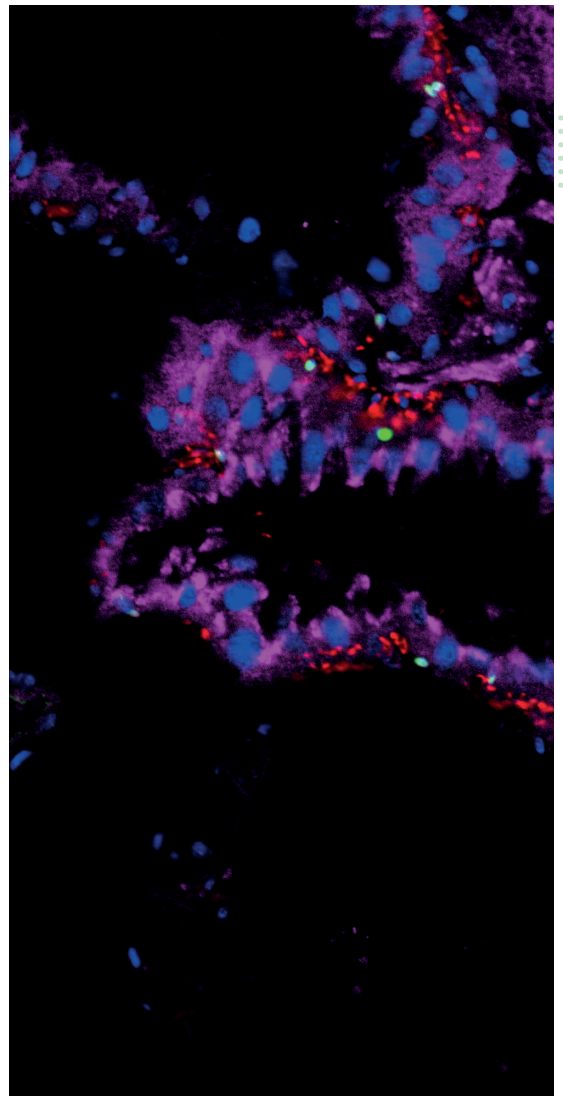
CCMA - Université Côte d’Azur

## Total budget

€5,000 from Academy 3



Nathalie  
Zucchini-Pascal



# The project

In the future, agriculture's main challenge will be to increase crop production to feed the world's growing population in a safe and sustainable manner. Between 20 and 40% of the world's agricultural production is lost annually due to disease and pests. Synthetic pesticides have been extensively used but need to be limited because of their well-established negative impact on the environment and human health. Of all the strategies available, biopesticides offer a promising alternative means of pest management. Considered environmentally friendly, *Bacillus thuringiensis kurstaki* (Btk) is a bacterium that specifically targets pests by producing Cry toxins. It could be used as a sprayable pesticide or in genetically modified (GM) crops to express these toxins and make them resistant to the threat of lepidopteran larvae, one of the world's most harmful pests. In targeted insect larvae, Cry toxins are thought to create pores that disrupt the gut epithelial membranes by interacting with specific receptors that are absent in non-targeted organisms. These pores allow the pathogen to enter the hemocoel, thereby killing the insect by sepsis in two or three days. Despite increased use of these genetically modified crops and *Bt* biopesticides, only a few studies have described the unintended effects of Cry toxins on non-target organisms. This project aims to characterize the impact of Cry toxin ingestion on *Drosophila melanogaster*, a powerful model for studying unintended effects. We had previously demonstrated that Cry toxin ingestion by adult *Drosophila* induces disruptions of the midgut homeostasis, leading to massive differentiation of intestinal stem cells into enteroendocrine cells instead of enterocytes. We suspected that this change in cell fate could be the consequence of an interaction between Cry toxins and cellular or extra-cellular proteins. We therefore combined immunoprecipitation with liquid chromatography-tandem mass spectrometry (IP-LC-MS/MS) to characterize the Cry toxin interactome in the *Drosophila* gut. Based on the results obtained, we focused on the role of the Cry-toxin interaction network in disrupting gut homeostasis. We achieved this by 1) using genetic approaches to make *Drosophila* strains gain or lose the function of identified midgut Cry-interactant, 2) defining the cellular and molecular processes disturbed by these complexes and 3) studying the fate of Cry toxins in the gut by localizing them at the tissue, cellular and subcellular levels in the *Drosophila* gut. Our results revealed that the interaction of Cry with two gut proteins is responsible for the diversion of ISC cell fate. Our work will be of major importance in understanding the mode of action of Cry toxins and will contribute to optimizing new strains that are less harmful for the environment and health without loss of effectiveness on devastating species.

## The +

This study is the first to characterize the mode of action of Cry toxins in the gut of non-target species. Results obtained will contribute to improving the assessment of the risks of biocontrol agents and GM crops for human health and the environment and avoid reproducing past pesticide disappointments.

## What's next?

This study will continue as a part of a larger project that aims to characterize the binding sequences of Cry toxins with intestinal proteins responsible for the disturbance of many cellular and molecular processes, in an attempt to suppress unintended effects while maintaining insecticidal properties against target lepidopterans.

For more information click here 

# SKIN - Proof of concept: potential migration of plastic additives through human skin

“ Can additives of plastics migrate through human skin? ”

## Academy 3 highlight

This project falls under the topic “Assessing and sensing anthropogenic hazards to human health, environments and global changes.” We have been investigating potential future solutions to decrease the health risk of plastic additives by observing additive migration through the skin, gaining a scientific understanding of the process and anticipating its consequences and hazards.

## Scientific domains

Chemistry  
Biology  
Human Health

## Key words

Plastics  
Additives  
Migration  
Human skin

## PI laboratory

CEMEF - Mines-Paris, CNRS

## Partners

ICN - Université Côte d'Azur, CNRS  
PKDerm

## Total budget

€7,000 from Academy 3



Patrick Navard



# The project

Everyone is currently aware that plastics contain additives that may be harmful. These additives, organic molecules mixed with polymers to enhance their properties, have raised concerns. Over 2,400 of them have been found to be potentially harmful for the environment and human health. Only one research article has been published showing that additives can migrate into human skin. The objective of this project is to re-explore the issue by placing a piece of plastic in contact with human skin. The originality of this work is the full control of the composition of the plastic. A low-density polyethylene was chosen because it is one of the most common plastic materials. Five very common additives (at 1% concentration) were added to polyethylene in an internal mixer, then shaped into discs. The additives were two primary antioxidants (Irganox 1010: sterically hindered primary phenolic; Irganox 1076: sterically hindered primary phenolic), one secondary antioxidant of phosphite class (Irgafos 168) and two UV protectors (UV 326: hydroxyphenyl benzotriazole class; Chimassorb 81: 2-hydroxy-benzophenone class). The size of the plastic disc was compatible with Franz diffusion cells and the disc was placed in contact with human skin at 37°C for 24 hours. After 24 hours, the skin that had been in contact with the plastic disc was removed and it was investigated whether the additives present in the plastic disk were present in the skin. To measure this, the additives were extracted from the skin and analyzed using HPLC-MS. The results show the presence of additives in all extracts and confirm their ability to penetrate the skin tissue in the short term. Additives with low mass and high lipophilicity had the highest concentration in the skin.

It was found that about 0.8 % of the additives migrated into the skin from the PE disc within 24 hours. This may be explained by the fact that polyethylene contains a non-crystalline fraction which is highly mobile, since its glass transition temperature (-100°C) is well below body temperature.

This an essential finding, since humans are always in contact with plastic materials touching their skin. This study has provided valuable insights into the potential health risks associated with prolonged skin interaction with plastic materials, particularly for people who handle them extensively. The use of both physico-chemical and biological methods shows the multidisciplinary nature of the project.

## The +

The project demonstrated that common additives of low molar mass found in everyday polyethylene products can migrate through human skin upon contact.

## What's next?

The innovative aspect of the SKIN project is its demonstration that additives found in plastics migrate through human skin. This work was performed using a home-compounded polyethylene plastic disk. The next steps will be to look at additive penetration in the skin using commercial products such as clothes, computer mice or steering wheels.

For more information click here 

# SENTOS - Environmental stress and bone tissue

“ Exploring the molecular mechanisms in bone cells exposed to heavy metal (uranium). ”

## Academy 3 highlight

The study of the biological mechanisms involved in chronic exposure of bone tissue to low doses of uranium corresponds to the focal area of interest *"Assessment and detection of anthropogenic risks to human health, environments and global change"* by helping us better understand and assess the effects of this natural and anthropogenic toxicant on human health.

## Scientific domains

Biology  
Health Risks

## Key words

Chronic exposure  
Bone cells  
Uranium

## PI laboratory

TIRO-MATOs - *Université Côte d'Azur, CEA*

## Partner

ICN - *Université Côte d'Azur, CNRS*

## Total budget

€250,000, €7,000 from Academy 3



Georges Carle



# The project

Our bones are complex and extremely dynamic organs, continuously remodeled (resorption and construction) throughout our lives. Their natural remodeling can be affected by unfavorable environmental conditions or chronic exposure to an external compound, in this case uranium, a radioelement naturally present in the soil or drinking water. This remodeling is the work of different cell types whose activities are closely coordinated: osteoclasts, responsible for resorption of the bone matrix, osteoblasts, responsible for construction of this matrix, and osteocytes, which act as coordinators relaying the information between the other two cell types. The research team working on the SEntOs project is seeking to shed light on the effects of natural, moderate daily exposure to uranium, and to determine its impact on bone cell mechanisms. In order to explore these mechanisms, an internship supported by Academy 3 has focused specifically on modifications to the bone matrix generated in the presence of uranium, using a cell culture protocol and *in vitro* uranium exposure.

The unique feature of the project is its protocol, in which exposure of the bone matrix to uranium is chronic and moderate: ten days of exposure to two micromoles of uranium. At the end of this period, two effects could be observed: mineralization of the matrix by osteoblasts slowed down, and the component cells of osteoclasts were reduced. Experiments show that bones rebuild more slowly, and bone matrix resorption is slower, potentially disturbing bone tissue remodeling and leading to bone fragility. Over time, bones capture a number of toxic compounds and heavy metals, including uranium. The project has shown that the metal is more concentrated in areas of active remodeling and will therefore be trapped when the new matrix is built, only to be released again when the old matrix is resorbed. Uranium thus becomes trapped in the bones through this molecular cycle, which the team calls "the uranium cycle" linked to the environmental memory of bone cells.

To further understand this process, RT-PCR and Western blot analyses were performed to identify and confirm the genes and proteins affected by uranium exposure. Some proteins present in the matrix were over-expressed, while others were under-expressed compared with control conditions.

In the next stages of the project, the consequences of these differences in expression on bone molecular mechanisms will be investigated.

## The +

This study uses a novel approach to examine the effects of natural exposure to a heavy metal (uranium) on bone formation. The project implemented a complete, reproducible protocol supported by two ANR projects (2016 & 2023).

## What's next?

After the first French National Research Agency (ANR) grant in 2016, the project team recently obtained a second grant in 2023 from the ANR, which allows this promising project to continue and gain momentum. Two doctoral fellows have already completed part of the project, and further internships are planned to generate and analyze new results.

For more information click here 

# NEUROPOL - Unraveling the impact of endocrine disruptors on human brain development

“ How do endocrine disruptors alter human brain development and contribute to the pathophysiology of neurodevelopmental disorders? ”

## Academy 3 highlight

Current human activities are increasingly unbalancing the environment and multiplying the sources of exposure to endocrine disruptors (EDs) that are difficult to control. Understanding their effects on human brain development and their implication in neurodevelopmental disorders is essential for future policymaking and for preventing the "risks of EDs to human health and ecosystems in the context of 'One Health'."

## Scientific domains

Biology  
Health risks

## Key words

Endocrine Disruptors  
Human neurodevelopment  
Organoids  
One Health  
Neurodevelopmental disorders

## PI laboratory

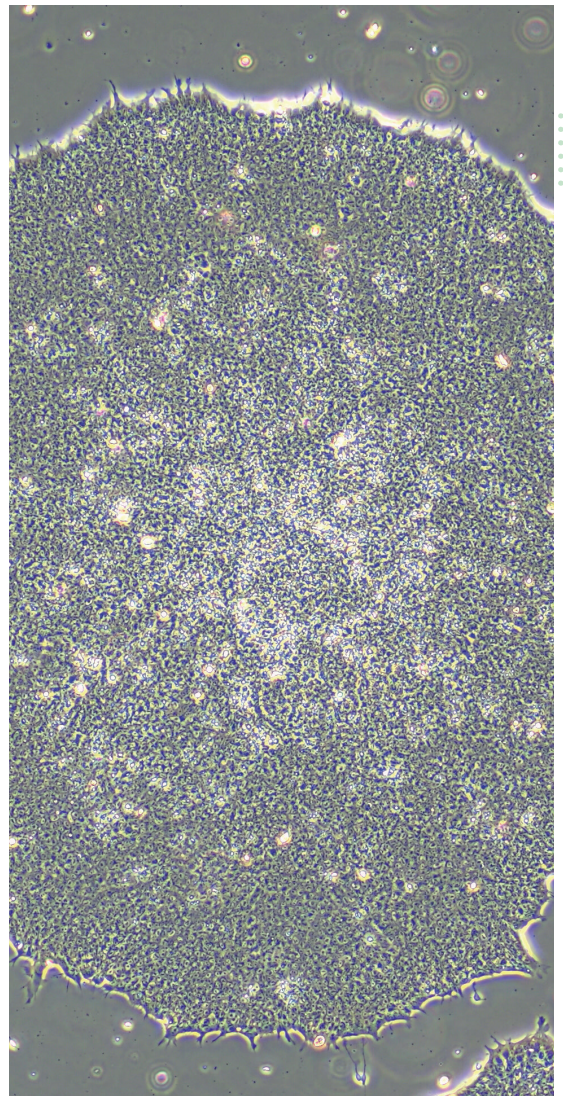
IPMC - Université Côte d'Azur, CNRS, Inserm

## Total budget

€96,989, including €12,989 from Academy 3



Olfa Khalfallah



# The project

The Neuropol project was initiated in 2022 in line with the Cytopol project led by Nicolas Glaichenhaus in 2020. Both projects aim to determine the impact of our environment on human health. In particular, the objective is to investigate the links between the emergence of cognitive and behavioral disorders known as neurodevelopmental disorders (NDDs), in young children and their prenatal exposure to endocrine disruptors (EDs). EDs are pollutants present everywhere in our daily lives (food, food packaging, cosmetics, detergents, pesticides, etc.). This is being accomplished in two stages: first, by conducting epidemiological studies based on population groups called cohorts through questionnaires and biological analyses and second, by analyzing the impact and toxicity of these disruptors on cellular models of human neurodevelopment. Epidemiological studies have shown a link between exposure to EDs during pregnancy and cognitive and behavioral disorders in young children, such as autism spectrum disorders. Thus, this project aims to assess the danger and toxicity of EDs by using "cerebral organoids" as models. These organoids have proven to be valuable and relevant tools for studying human brain development and neurodevelopmental disorders associated with behavioral issues.

By culturing and differentiating human pluripotent stem cells (iPSCs) in three dimensions, the team has successfully generated "cerebral organoids" that reproduce the organization and complex multicellular interactions of the brain cortex, the center of "higher cerebral functions" in humans (reasoning, decision-making, emotions, memory, attention). These functions are often impaired in behavioral disorders.

This model is used to study the effect of various EDs, either individually or in cocktail, at different doses, on the formation of the fetal brain during pregnancy and the subsequent development of NDDs. This study demonstrates that exposure to bisphenol A alters cerebral organoid development and induces disorganization of brain structure, demonstrating the harmful effects of this molecule on human neurodevelopment.

By understanding the effects of EDs on human brain organoids, this project aims to provide reliable and robust scientific data on the effect of these molecules on children's mental health. This work is intended to ensure better regulation of the use of these pollutants and guide the industrial design of the daily products that contain them. The project targets not only industry stakeholders but also civil society, which needs to be aware of the scientific evidence regarding the dangers and toxicity of these pollutants that the project will uncover.

## The +

The project proposes a reliable and replicable model: human brain organoids and an unprecedented study of the "cocktail effect" of pollutants and endocrine disruptors.

## What's next?

Funding has been requested from ANSES to continue the project. Phase one has been successfully completed and phase two is currently underway. A doctoral project in Molecular and Cellular Interactions ("Role of interleukin 6 in human neurodevelopment: implication in autism spectrum disorders," by Guillaume Cinquanta) is also in progress.

For more information click here 



# BATHUBOW - Evaluating whether chronic food intake of *Bacillus thuringiensis* biopesticides promotes bowel

“ Our project is investigating the unintended effects of the most widely used microbial pesticide in agriculture, which is based on spores of the bacterium *Bacillus thuringiensis*. ”

## Academy 3 highlight

The BATHUBOW project will help determine whether health measures are needed to prevent consumer exposure, such as longer pre-harvest intervals or thorough washing of fruits and vegetables. It assesses the “risks of agricultural products and practices to both biodiversity and human health” and is therefore in line with Academy 3 priorities.

## Scientific domains

Environmental and Human Health  
Biology

## Key words

*Bacillus thuringiensis*  
Gut inflammation  
*Drosophila*  
Mouse

## PI laboratory

ISA - Université Côte d’Azur, CNRS, INRAE

## Partner

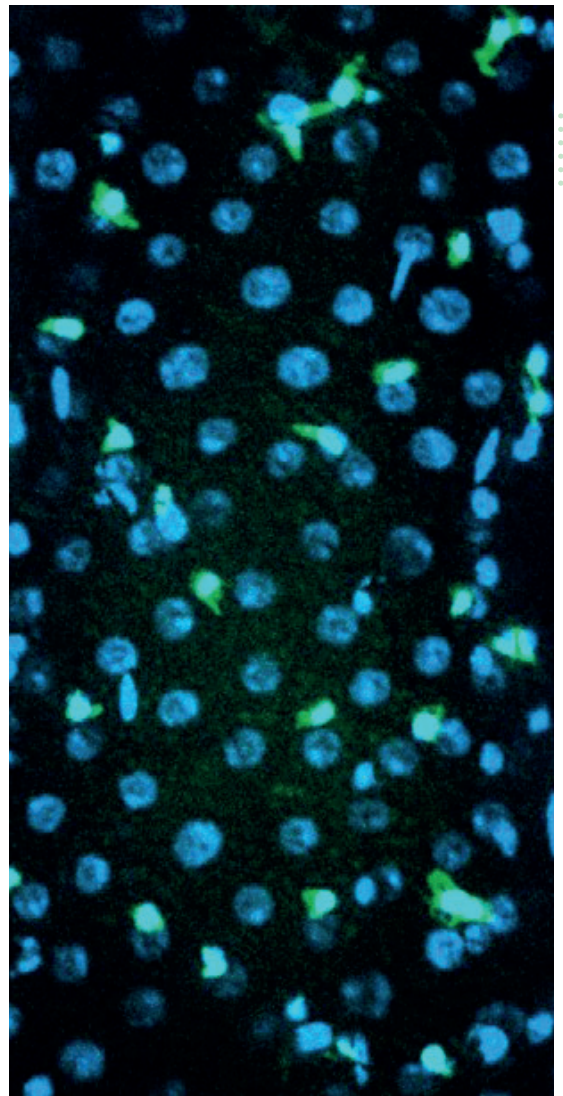
Institut Pasteur

## Total budget

€865,000, including €6,000 from Academy 3



Raphaël Rousset



# The project

*Bacillus thuringiensis* (*Bt*), a spore-forming Gram-positive bacterium, is the leading microbial pesticide used in both organic and conventional agriculture, making it the second most widely used pesticide in the world. Commercial *Bt* pesticides, which consist of *Bt* spores that produce entomopathogenic toxins (called Cry toxins), kill target pests after ingestion by destroying their intestinal epithelium. Although studies have shown that *Bt* spores and toxins are not acutely toxic for non-target organisms over a short period of time, the potential adverse effects of chronic ingestion have not been studied. It is now established that the microbial population colonizing the intestine plays a central role in the development of potential inflammatory bowel diseases (IBD) and cancer. In addition, *Bt* belongs to the *Bacillus cereus* group, which is responsible for many foodborne outbreaks in humans. To our knowledge, no study has examined the impact of *Bt* product consumption on IBD and bowel cancers. The aim of our project is to assess whether chronic ingestion of *Bt* pesticides promotes or aggravates intestinal diseases. We have been using *Drosophila melanogaster*, a non-target organism of *Bt* and a valuable model for studying the impact of *Bt* pesticides on insects, which are known to be important for environmental health. In addition, the conservation of intestinal physiology between *Drosophila* and vertebrates will facilitate the transfer of knowledge to the mouse, which is a preclinical model.

We have developed a simple, direct protocol for chronic ingestion of *Bt* spores that mimics natural dietary exposure to an agricultural dose. Our results show that long-term consumption of *Bt*-contaminated food, even at low doses, significantly reduces the lifespan of *Drosophila*. Our findings demonstrate that *Bt* spores affect gut morphology, promote dysplasia, alter septate junctions and enhance epithelial permeability. They also show that *Bacillus* spores germinate in the gut and that the number of vegetative cells remains constant. Additionally, we observed increased levels of inflammatory signaling pathways and reactive oxygen species. Overall, our results indicate that chronic consumption of *Bt* spores promotes inflammation and oxidative stress, leading to premature aging of the gut and early lethality in *Drosophila*.

## The +

Extended to non-target insects, which account for 85% of animal biodiversity, our study suggests that highly persistent *Bt* spores may have unintended long-term effects on the environment.

## What's next?

Based on our results, we will extend this study to include at-risk individuals who are predisposed to, or develop, intestinal inflammation (IBD) or tumors and may be even more sensitive to *Bt*. We will also translate our findings to the mouse model. To this end, we have developed a collaboration with Benoit Chassaing's team (Institut Pasteur), whose members are experts in mucosal microbiota in chronic inflammatory diseases and have studied them using the mouse model.

For more information [click here](#) 

# NICE-AIR - Mapping air pollution in the Nice metropolitan area with mobile monitoring devices

“ Discover how cutting-edge mobile monitoring is transforming our understanding of air quality in Nice. ”

## Academy 3 highlight

By improving the spatial resolution of air quality data and linking pollution exposure to health outcomes in various local projects, the initiative directly supports the topic of ensuring healthy lives. It allows for a more accurate assessment of the effects of air pollution on health in Nice. Therefore, NICE-AIR also contributes to *“make cities and human settlements inclusive, safe, resilient, and sustainable.”*

## Scientific domains

Environmental and Human Health  
Health Risks

## Key words

Exposome  
Air pollution  
Health  
Epidemiology

## PI laboratory

TIRO-MATOs - Université Côte d'Azur, CEA

## Partners

ESPACE - Université Côte d'Azur, CNRS, AMU, AU  
AtmoSud - Région Sud Provence-Alpes-Côte d'Azur  
University of Utrecht

## Total budget

€15,000, including €5,000 from Academy 3



Sonia Dagnino



# The project

Air pollution is a major public health concern, particularly in urban environments where the concentration of pollutants can vary significantly over short distances. Traditional methods for monitoring air quality, though effective, offer limited spatial resolution and provide a general picture that can overlook the nuanced variations of urban pollution landscapes. The advent of mobile air quality monitoring carried out by a vehicle equipped with sophisticated air quality sensors, marks a decisive advance in environmental health research. This initiative, conducted under the European EXPANSE project, aims to deploy this innovative technology in the city of Nice (France) to gather detailed data on a range of pollutants, including black carbon, NO<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub>, and ultrafine particles. In 2024-2025, this project will conduct comprehensive measurement campaigns across the Nice metropolitan area to map air pollution with an unprecedented level of detail. By integrating this granular data with ongoing health research projects within the city, the project seeks to elucidate the complex relationship between air pollution exposure and health outcomes. The findings of this research will not only improve our understanding of urban air quality dynamics but also inform public health strategies and policies, by providing the tools needed to create healthier and more sustainable urban environments. It will ultimately contribute to the well-being of the urban population. The future developments of this project are aimed at significantly advancing environmental health research. In addition to mapping air pollution across the urban area of Nice, the aim will be to establish a direct link between high-resolution air pollution data and local cohorts for exposome-based studies. This integration should provide a deeper understanding of how specific pollutants influence health outcomes and make it possible for researchers to dissect the complex interplay between environmental factors and disease at an unprecedented level of detail.

## The +

The key highlight of this project is an innovative mobile Air Quality Monitoring device that captures detailed pollution data across the urban landscape of Nice, France. High spatial resolution brings an unprecedented level of detail to air pollution mapping, down to sub-street levels, which cannot be provided by traditional, fixed, monitoring stations.

## What's next?

By providing a more nuanced view of exposure risks within varied urban environments, the project aims to make a vital contribution to the development of targeted public health interventions and policies. These advances will not only improve the accuracy of exposome research, but also offer a blueprint for cities worldwide to better safeguard the health of their residents against the insidious effects of air pollution.

For more information click here 





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# Cities, societies and natural hazards

This chapter encompasses SDGs 11, 12 and 13. It deals with research projects linking Earth sciences and social sciences, aiming to identify impacts at different scales. This theme includes 9 research projects : 3 Consortium projects and 6 First projects.

# FORESEE - Floods and Other extreme Rain Events in South-East France and Italy

“ Extreme rainfall events are increasing in frequency and require new approaches to mitigate and manage their devastating impacts. ”

## Academy 3 highlight

Foresee addresses large scale flooding, “a natural hazard that impacts the environment” and an increasing number of cities and societies throughout the world as rainfall events grow in intensity and as a greater number of the world’s people settle in alluvial plains exposed to floods.

## Scientific domains

Geography  
Environmental Sciences  
Social sciences

## Key words

Floods  
Participative democracy  
Natural hazards  
Land use

## Laboratory PI

CEREMA  
SMIAGE  
CARF  
University of Genoa

## Partners

ESPACE - *Université Côte d’Azur, CNRS, AMU, AU*  
SKEMA Business School – *Sophia-Antipolis*  
GREDEG - *Université Côte d’Azur, CNRS*

## Total budget

€63,000, including €42,700 from Academy 3

## Start of the project

2021



Dennis  
Fox



Margot  
Chapuis



Ana  
Pizzutti



# The project

Deadly storms struck south-east France in 2015 and again in 2020 causing close to 40 cumulative fatalities and several hundred million euros in damage. The 2015 event hit the urbanized coastal catchments of Cannes and Biot, while the 2020 event, greater in magnitude, occurred in the Alpine valleys of the Vésubie and the Roya. Both events generated historic rainfall depths and discharges. The objective of the Foresee project is to identify lessons that could be learned from these major events in order to better manage extreme rainfall events in the future.

The project addresses four main themes: 1) the vulnerability of linear networks; 2) the human response to extremes; 3) landscape changes; and 4) urbanization and flood risk.

Electrical and communication lines are buried under roads, so when a road is damaged by bank erosion or a landslide, power and communication are automatically cut. Similarly, these services are concentrated at focal points on bridges, which means that a bridge rupture inevitably cuts power and communication, including to transmitter pylons, putting even cell phones out of service. A first step in improving post-event resilience is to identify vulnerable sections of the road (for example, alluvial deposits close to the channel or meander convexities, or steep thalwegs prone to mass movements intersecting the road network) and plan for alternative routes. These measures include the upkeep of secondary dirt roads and train routes and maintenance of electrical generators and emergency communication devices in mountain municipalities to ensure better preparedness. Perhaps most importantly, smaller isolated hamlets and families need to be trained in disaster preparedness, so they can be self-sufficient for at least three days (food, water, medicine, heating, etc.) while waiting for rescue workers to arrive.

Storm Alex in 2020 was not only devastating for the landscape, it was also psychologically traumatic for the people of the valleys. The estimated return period ranged from hundreds to thousands of years, and many residents needed psychological counseling to deal with post-traumatic stress. More positively, the devastation opened new possibilities for the Alpine population to redefine its future. Local governments supported and encouraged the emergence of new bottom-up economic development projects by organizing public hearings, which followed a long wave of mutual support (food, clothing, housing, etc.) initiated in the immediate aftermath of the storm. The post-crisis atmosphere was therefore one of empowerment at the local scale.

As regards landscape changes, hundreds of mass movements, large and small, occurred on the upper slopes of catchment areas. Studies therefore attempted to define the topographic conditions favorable to landslides, which included the aspect and inclination of slopes and their vertical and horizontal curvature based on different threshold conditions. This work was challenging because of the complexity of the phenomenon and the intermediate grey zone between a classic landslide and torrential flows in shallow thalwegs, where sediment movement was initiated by gravitational and runoff forces. Mass movements were initiated in two ways: 1) Slope undercutting close to the river bed and channels that widened in places by several dozen meters as torrential flows cut into soft alluvial deposits; and 2) Loading on steep south-facing upper slopes where precipitation in October normally falls as snow but was rainfall because of the warmer temperatures during Storm Alex. Once in the channel, land mass from the slopes lowered flow velocity and led to massive deposits. In Saint Martin Vésubie for example, the town's sports complex (tennis courts and football stadium) was buried beneath a 12-meter deposit of coarse cobbles and gravel. Sediment transport dynamics in the main river channels will be affected by the new sediment distribution conditions for decades to come.

Finally, a small-scale analysis of urban development was conducted in three near-coastal catchment areas to map changes in building over a 30 year-period (1990-2020). Thousands of individual buildings were extracted from the IGN BD-TOPO database while others were digitized on screen. Urbanization growth rates were highest in the first decade and slowed over time. Three flood events (mild, moderate, extreme) were simulated to estimate the impact of urbanization on peak discharge and the number and surface area of flooded buildings for each decade. Peak discharge increased over time with all events, but the overall increase in flood risk was due more to the construction of new buildings in the flood plain than to greater peak discharge. Risk management laws appear to have been partially effective in reducing the rate of construction close to the channel starting in 2014, but further from the stream, where only extreme events can cause damage, building growth rates were fastest. In these areas, the land was further from the river channel but still relatively flat so easy to build on and close to the main road network. Most of the new large buildings close to the channel had been built with features to reduce flood damage, such as elevated floors.

## How does the project contribute to transdisciplinarity ?



### Economy and European Laws SKEMA and GREDEG

They contribute by enlightening the researchers on how the phases are managed and organized, the role of coordination and governance, and the underlying mechanisms that activate regional resilience.



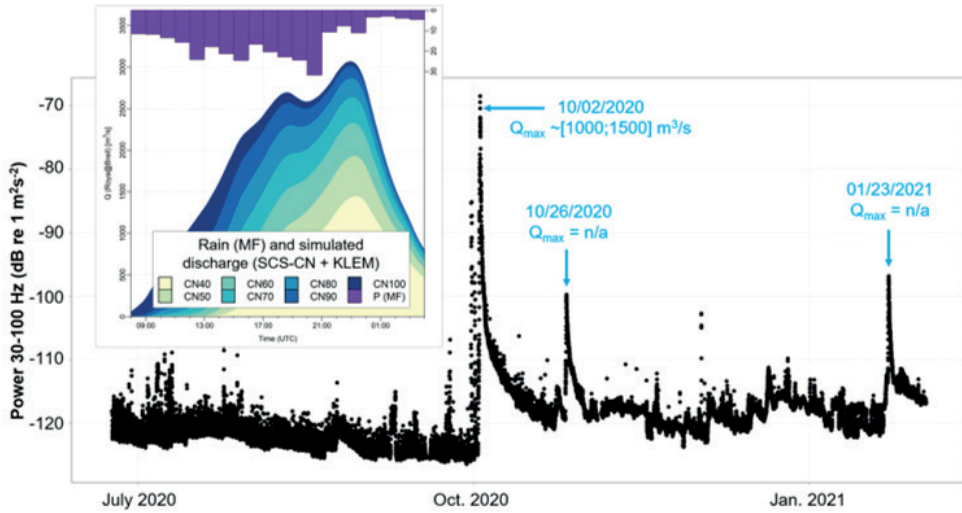
### Geography ESPACE

In addition to coordinating the project, ESPACE investigated how extreme events can induce landscape-scale changes whose consequences can be mitigated or aggravated by local planning strategies.

### Geology - CEREMA

Cerema's focus is on analyzing the impact of the storm on landslides and bank erosion, combining geological and geomorphological research with GIS processing. The aim is to provide local stakeholders with input data for managing future extreme weather events.





Seismic signal from storm Alex on Oct. 02, 2020 and associated hydrological modeling at Breil-sur-Roya.

## The +

Several measures highlighted in the FORESEE project show that developing alternative strategies to reduce dependence on main roads, central electricity and the usual communication services can be developed and maintained as part of an ongoing strategy of preparedness well in advance of a major event.

## What's next?

Network resilience analyses should be carried out before a major event occurs to ensure better preparedness when it hits. The project is exploring the possibility of using machine learning algorithms to predict the combined impact of climate and land cover changes. Some of this work will impact future zoning rules, such as the 'Zéro Artificialisation Nette (ZAN)' laws which seek to freeze urban growth in the coming decades in France in order to protect natural and agricultural land cover.

For more information click here 

# NDMH - Natural Disasters and Mental Health: Rebuilding territories and repairing the living

“ This project assesses the consequences on mental health of a major natural disaster such as Storm Alex in October, 2020, and the consequences of the reconstruction of the area. ”

## Academy 3 highlight

The project addresses the theme of “*natural hazards and impacts on environments, cities and societies*” and uses an interdisciplinary approach that brings together researchers in public health, economics, environment and artificial intelligence.

## Scientific domains

Human Health  
Social Sciences  
Economics

## Key words

Storm Alex  
Natural disasters  
Mental health  
Psychiatry effects

## PI laboratory

GREDEG - Université Côte d'Azur, CNRS

## Partners

UR2CA - Université Côte d'Azur, CHU de Nice, INRIA  
CoBtek - Université Côte d'Azur, INRIA  
RETINES - Université Côte d'Azur

## Total budget

€57,000 from Academy 3

## Start of the project

2023



Thomas Jobert



Christian Pradier



# The project

On October 2 and 3, 2020, three valleys in the Alpes-Maritimes department were hit by Storm Alex, which caused damage that was considered the most extensive in mainland France since the Second World War.

We can assume that such a catastrophic event was traumatic for the population (notably causing post-traumatic stress states), and that it led to an increase in medical visits, increased consumption of psychotropic medication, and so forth. We can also wonder whether the effects of rebuilding the region led to an economic rebound that had a positive impact on the mental health of the residents of the valleys.

The main originality of this project was to adopt a population-based approach to assess the impact of this disaster on the mental health of valley residents. We therefore did not analyze individuals, but areas – municipalities or IRIS (Ilots Regroupées pour l'Information Statistique, the smallest administrative unit in France) – and studied the aggregate consumption of mental health-related care (consumption of psychotropic medication, medical visits, appointments with psychiatrists, etc.).

We collected aggregated data at the level of the geographic area of the municipality or IRIS. This data came from the CPAM (Caisse Primaire d'Assurance Maladie, the French health insurance system) for medical data, from Insee (National Institute of Statistics and Economic Studies) for socioeconomic data, and from Géorisques (public information portal) for data related to environmental or industrial risks.

To measure the consequences of Storm Alex on the population, we have been using three alternative methods:

- The difference-in-differences method is applied to the consumption of mental health-related care for each municipality affected by Storm Alex.
- An econometric approach is used to empirically determine the socioeconomic or environmental determinants of mental health, with the objective of identifying distinct clusters.
- Qualitative surveys are being conducted with mayors of municipalities impacted by Storm Alex.

The first year of the project was mainly devoted to database construction and analysis:

i) checking data consistency; ii) identifying population problems which were measured by the census data and found to be significantly higher in the municipalities of the Vésubie and La Roya valleys due to the prevalence of second homes; iii) developing a multidimensional indicator of social poverty; and iv) conducting a descriptive analysis of mental health care consumption in the Alpes-Maritimes department.

A first analysis was carried out using the difference-in-differences method. This method consists in comparing changes in mental health status between two groups: a first group composed of residents of the municipalities in the affected valleys and a second group (the control group) composed of all the residents of the department (the population of the valleys represents less than 0.01% of the department's population, so its behavior should not influence the control group).

Mental health was approximated by the proportion of people insured under the general medical scheme who had been reimbursed at least six times for psychotropic medication in a given year. The choice of this proxy can be explained by the absence of community medicine data linking a diagnosis with the prescription of psychotropic medication. The decision to include all psychotropic medication made it possible to work with a higher number of healthcare reimbursements.

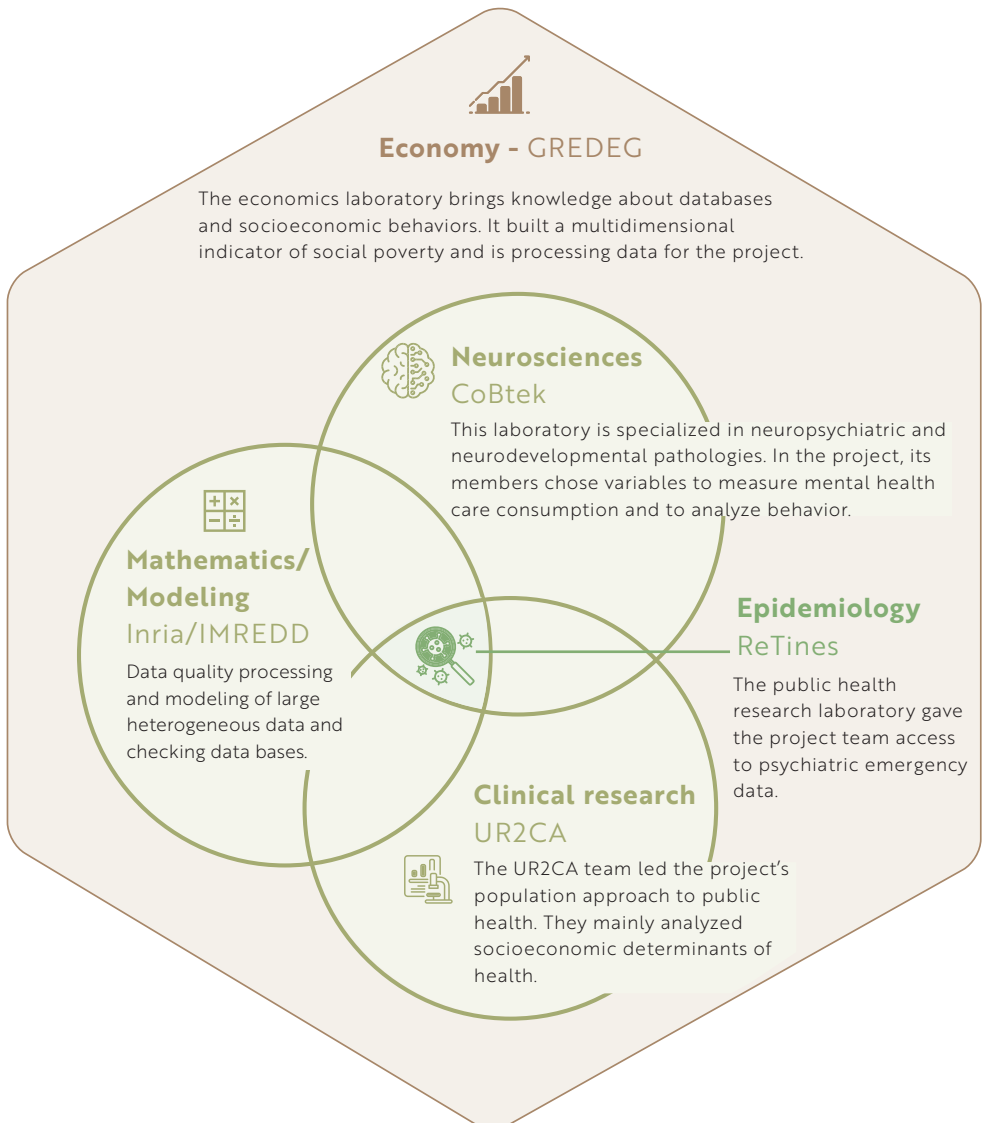
In 2020, two major events influenced mental health: the COVID-19 lockdown and Storm Alex. Since Storm Alex occurred in October 2020, the choice of six reimbursements (at least one every 28 days) means that in 2020, we could not yet measure the effects of Storm Alex in terms of reimbursement of psychotropic medication.

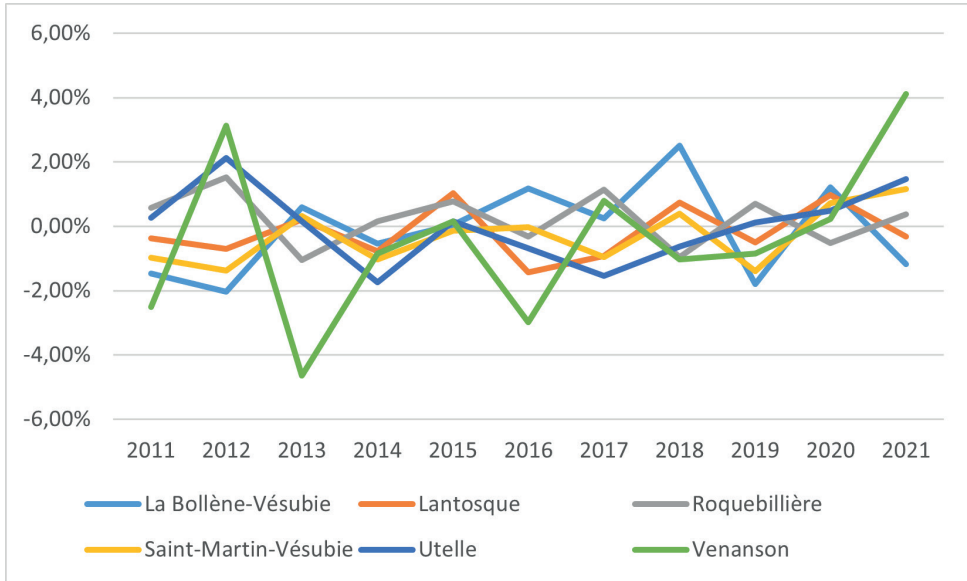
The difference-in-differences method applied to the year 2020 allowed us to measure the specific effect of the lockdown in the valley municipalities compared to the rest of the department.

By applying the difference-in-differences method to the year 2021, we measured the effect of Storm Alex on the municipalities in the valleys compared to the rest of the department which was not impacted by the storm.

We were not able to identify an increase in 2021 in the consumption of mental health-related care by residents of the municipalities impacted by the storm. This result could be explained by the hypothesis that the most traumatized residents left the area.

## How does the project contribute to transdisciplinarity ?





Indicator of difference-in-differences in the use of psychotropic medication. Vésubie

### The +

Storm Alex did not cause any significant variation in mental health treatment in the Alpes-Maritimes department. The study shows that it remains challenging to develop quantitative indicators at the IRIS (neighborhood) level of data characterizing exposure to environmental risks.

### What's next?

Based on our results, the project will focus on the effects of rebuilding in the area on population flows and economic activity. Population variations for each municipality (household, business) will be calculated using the FILOSOFI database (Insee). Changes in household habits should provide information on future demographic movement.

For more information click here 



# StS-Sealex - Source-to-sink sediment transfers and management of hydro-sediment fluxes after Storm Alex in the Roya catchment

“ Searching for Storm Alex and previous extreme events in a land-to-sea approach. ”

## Academy 3 highlight

The StS-SEALEX project aims at “better constraining the natural hazards related to storms and flash floods” and providing recommendations to institutional stakeholders on risk mitigation and land use.

## Scientific domains

Earth Sciences  
Geography  
Social sciences

## Key words

ALEX storm  
Sediment Transfer  
Extreme events  
Land-to-sea continuum  
Risk mitigation

## Laboratory PI

Géoazur - Université Côte d'Azur, CNRS, OCA, IRD  
ESPACE - Université Côte d'Azur, CNRS, AMU, AU  
CEPAM - Université Côte d'Azur, CNRS

## Partners

OFB  
IMT Mines Alès  
Université Paris Cité

## Total budget

€132,100, including €41,300 from Academy 3

## Start of the project

2024



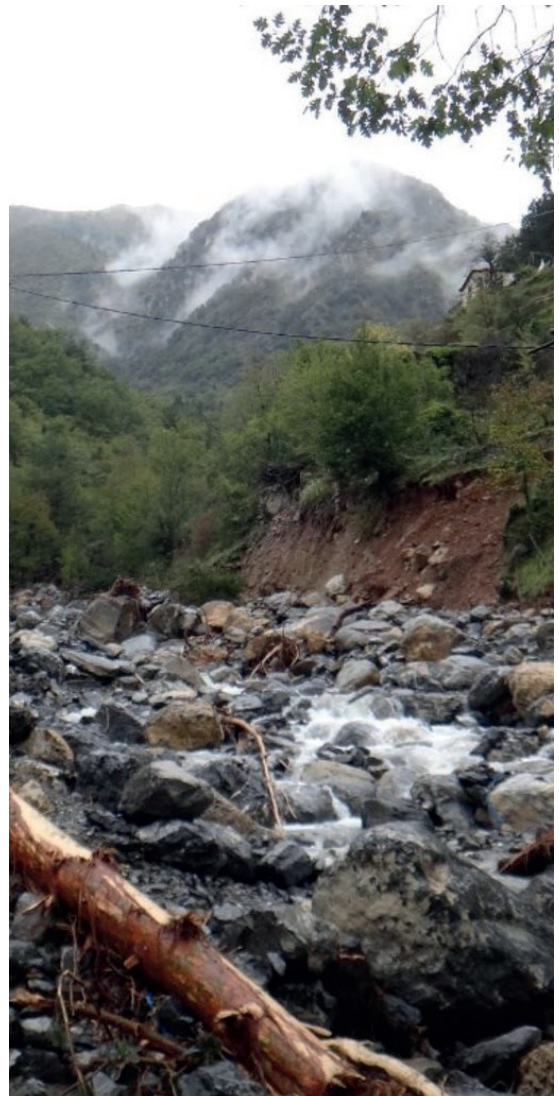
Sébastien Migeon



Margot Chapuis



Louise Purdue



# The project

Understanding flood phenomena and characterizing their frequency and impact on populations are major challenges, particularly in the context of climate change. In the Mediterranean Riviera, torrential flooding is caused by exceptional events characterized by intense rainfall, which is accentuated in the catchment areas by steep slopes, narrow valley floors and shallow soils. The large quantities of sediments eroded and carried away during heavy and sudden rainfall make these events particularly hazardous and damaging for the populations of the hinterland. In the context of climate change, such intense rainfall events are expected to become more frequent and even more intense. In the Southern Alps, torrential events of this kind can take place on a regional scale, as illustrated by the floods of June 1957, November 1994, and May 2008, or can concentrate in a few subcatchments (e.g., December 2006, June 2010 and October 2015). The case that interests the StS-Sealex project is Storm Alex, which affected France and more specifically the Alps-Maritime department on October 2 and 3, 2020. The storm generated record levels of rainfall, flooding, erosion and deposition, and landslides and debris flows in the Roya, Vésubie and Tinée valleys: the rainfall return period was estimated to be up to 1,000 years in the Roya. The catastrophic consequences of this storm both in terms of human casualties and damage to infrastructure, have revealed the high vulnerability of this particular area, located between the Mediterranean Sea and the Alps, as well as scientific gaps in terms of fundamental and operational knowledge.

The project aims to better understand the processes of water and sediment transfer at the catchment scale along the land-to-sea continuum over the long term, and to look at how land use and policies affect sediment fluxes. The objective is threefold: 1) to better understand Storm Alex by identifying and analyzing the morphologies and deposits left on land and at sea, and by quantifying erosion rates and sediment transfers between land and sea; 2) to find out how often these events happen by looking at the deposits in the continental and marine sediment archives and then to characterize the link between land use changes and sediment fluxes; and 3) to analyze the impact of government policies on land use and sediment management.

The study focuses on the two catchment areas most affected by Storm Alex (Roya and Vésubie valleys), which provide perfect case studies for the land-to-sea approach thanks to their physiographic characteristics (short river network and proximity to the sea).

To achieve the objectives of the project, an innovative interdisciplinary approach was proposed, combining several fields of expertise in environmental and human sciences, including marine geology (submarine geomorphology and long-term marine records of extreme events), geoarchaeology (agrarian geomorphology and long-term continental records of extreme events), fluvial geomorphology (source-to-sink sediment transfers at catchment scale, sediment management), biogeography (hillslope afforestation and land use change vs. sediment yields to the river network), and socio-ecology (how to build a shared narrative about land planning, sediment use and management). Each field is providing state-of-the-art insights that will be combined at different spatial and temporal scales along the land-to-sea continuum, to gain a deeper understanding of such extreme events and to better integrate their consequences in sustainable land management planning guidelines.

# How does the project contribute to transdisciplinarity ?

## Earth Science GEOAZUR

Submarine geomorphology (bathymetry, seismic profiles) to identify the sediment accumulation left at sea by Storm Alex; sedimentology to characterize the signature of past extreme events in the sediment cores.



## Geography - ESPACE

Fluvial geomorphology to characterize sediment fluxes, and biogeography to characterize vegetation dynamics, at different time and spatial scales; landscape management; and retro- and prospective climate change.



## Geoarchaeology - CEPAM

Fluvial and agrarian geoarchaeology to characterize long-term continental records of extreme events and understand climate change consequences from a retrospective perspective.



## Environmental management - OFB

Fluvial geomorphology for sustainable environmental management of landscapes and waterbodies, in order to limit human impact, restore environments and anticipate climate change consequences.



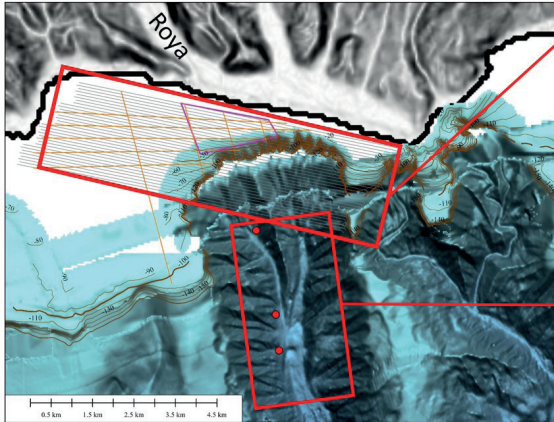
## Geomatics - Université Paris Cité

Geomatics for integrated spatial analysis of environmental dynamics.



## Environmental Sociology - IMT Mines Alès

Environmental sociology to understand socio-ecological dynamics regarding land-use planning, aiming at defining a desirable future through the development of a shared narrative within the inhabited area.



### On the continental shelf

Bathymetric survey to map the most recent deposits

Camera dragged close to the bottom, to assess and map grain size of sediment deposits

Sediment tracking experiment undertaken before storm Alex in the river channel: particle detection

### In the Royo canyon

Marine sediment core's collection to confirm the absence of record of storm Alex in sediment deposits

**Key steps in the marine survey along the morphological continuum between the Royo River channel and its submarine canyon.**

## The +

The project is combining a land-to-sea approach applied at several spatio-temporal scales and focused on an exceptional rainfall event, with an innovative interdisciplinary approach that spans marine geology, geoarchaeology, fluvial geomorphology, biogeography and socio-ecology.

## What's next?

This project is creating a new synergy between the partners and will benefit from the contribution of new results obtained from fieldwork and an oceanographic campaign.

For more information click here 



# ARCHEOSISMOTEIL - Archaeoseismology in the Teil area

“ Recording historical earthquakes and the seismic resilience of medieval buildings in Ardèche, France. ”

## Academy 3 highlight

The Archeosismoteil project is at the intersection of seismology and archaeology: archaeoseismology. The project is addressing one of the main themes of the Academy: to better “*identify and evaluate natural hazards and their impact on the environment, cities and societies*” by making cities and human settlements inclusive, safe, resilient and sustainable.

## Scientific domains

Earth Sciences  
Archaeology  
Seismic Risks

## Key words

Historical seismicity  
Ambient vibrations  
Historic buildings  
Seismic risks and hazards

## Laboratory PI

CEREMA  
Géoazur - Université Côte d'Azur, CNRS, OCA, IRD

## Partners

ISTerre - CNRS, UGA, USMB, IRD, UGE  
OCA - Université Côte d'Azur  
IRD  
INGEMMET

## Total budget

€100,000, including €4,500 from Academy 3



Diego Mercerat



# The project

The project is part of a larger research initiative focusing on geology and seismology in the Cevennes region, the project: Faults, Ruptures and Earthquakes and strong Motion in the region of Le Teil, a village in Ardèche, France, located near the La Rouvière fault. This project, which started in 2021 and has been running for three years, aims to study the rheology and seismic hazard of the La Rouvière fault. The sudden activity of this fault is responsible for the magnitude 4.9 earthquake that struck this region on November 11, 2019. The project covers several scientific fields: geology, geomorphology, paleoseismology and archaeoseismology. Financed by the Academy, its aim is to make an inventory of historical earthquakes and monitor the seismic resilience of medieval buildings in the region of Le Teil. The study has been planned in three phases:

- An inventory of historical earthquakes in the region and the buildings still standing as witnesses to these events.
- An on-site study around the buildings to characterize the dynamic response of the structures.
- Modeling of ground motions and their consequences on old buildings.

Among the historical buildings identified, five were studied: the chapel of St Jean Baptiste de Rac, the chapel of St Blaise de Montboucher sur Jabron, the old village of Allan, the Château de St Thomé and the château de Rochemaure. The study of these historical structures provides details of their seismic behavior: amplifications, vibration frequencies, cracking zones, etc. The information gathered with the help of an M2 intern, once modeled, will be synthesized in a database and used for the preservation of historical monuments. The development of a database of the vibration modes and frequencies of monuments in the region will make it possible to anticipate their reactions and their seismic vulnerability. The Fremteil project is coming to an end and the consortium of laboratories involved is preparing to report on the progress made and their recommendations before outlining the next steps of their studies.

## The +

This innovative project helped quantify past seismic reactions of historical structures in Ardèche with the aim of providing recommendations for anticipating and preventing damage caused by earthquakes. This method can be replicated for other sites.

## What's next?

The project team aims to continue its research by submitting an ANR project. In the field of earthquake-resistant construction, Diego Mercerat (Cerema-Geoazur) and Andy Combey (IRD-Geoazur) wish to carry out a comparative study of the resistance and resilience of buildings and masonry in Peru (Inca) and in Ardèche, France to the shocks experienced.

For more information click here 

# AmbientVariation - Ambient vibration testing and vulnerability assessment of Inca and colonial buildings in the city of Cusco, Peru

“ Understanding and protecting the Peruvian built heritage using non-invasive passive seismic methods and remote sensing tools. ”

## Academy 3 highlight

The objective of the project is to better assess seismic risks in Cusco and determine the significance of this research for the resilience of growing cities such as Cusco, which contributes to a better understanding of *“natural hazards and their impact on cities and societies.”*

## Scientific domains

Earth Sciences  
Archaeology  
Seismic Risks

## Key words

Ambient vibrations  
Architectural analysis  
Seismic vulnerability  
Structural health monitoring  
Peruvian heritage

## PI laboratory

Géoazur - Université Côte d'Azur, CNRS, OCA, IRD

## Partners

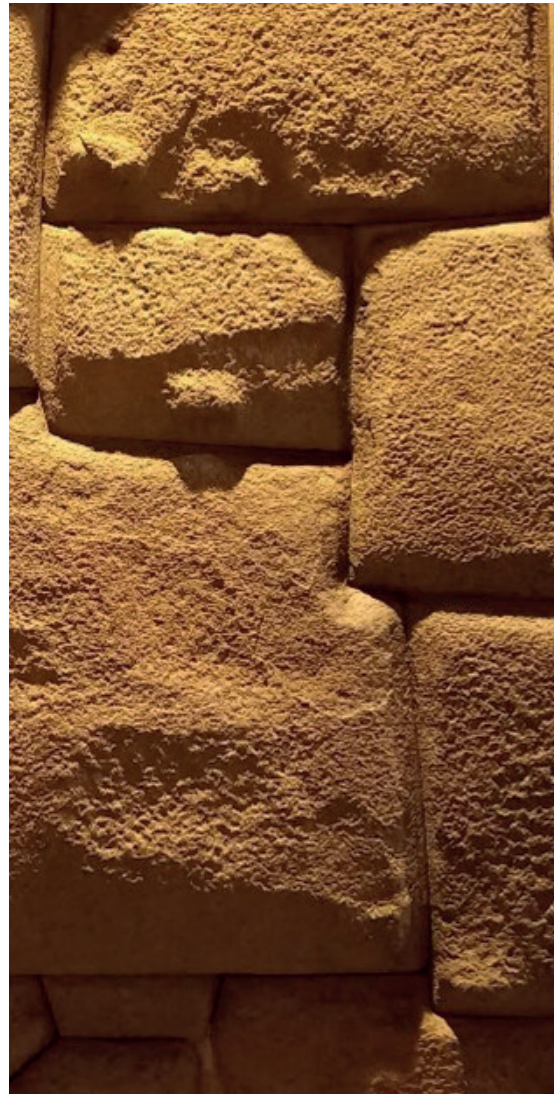
CEREMA  
IRD  
INGEMMET

## Total budget

€13,600, including €6,300 from Academy 3



Andy Combey



# The project

The Cusco region is known worldwide for its Inca and colonial built heritage, which makes it a major touristic and economic center in Peru. However, the area is crossed by a large active fault system that may threaten its growth. Considering the violence of historical earthquakes (1650, 1950, 1986), it is essential to develop non-invasive methods to evaluate and mitigate the impact of future events on cultural assets. Unfortunately, the use of passive seismic techniques to characterize the dynamic behavior of heritage buildings is still uncommon in South America and notably in Peru.

We proposed to carry out the first diagnosis and assessment of the vulnerability of Inca and colonial buildings in the city of Cusco, listed as a UNESCO World Heritage site since 1983, by implementing both an architectural analysis and an ambient vibration-based survey. While the in-situ inspection of the buildings involves detailed documentation of the architecture (e.g., photogrammetry) and a damage/repairs survey (construction history), the ambient vibration tests provide relevant data about the dynamic response of the structures and their structural health. The research also includes soil/rock response tests to understand the main characteristics of the superficial geological layers of the Cusco Basin and identify potential amplification phenomena of the seismic waves (site effects). By combining several disciplines that have contributed to the study of past earthquakes (architecture, tectonics, seismic engineering), this interdisciplinary project aims to investigate the seismic behavior of different types of historical structures in Cusco and their relative vulnerability to earthquakes. The overall objective is to enhance the preservation strategies of the Andean cultural heritage and update regional and national Disaster Risk Management plans.

## The +

In this project, low-cost but powerful three-component seismographs will be installed for the first time and over the long term in heritage buildings in Cusco. The experiment will provide unprecedented information about the main factors affecting the dynamic response of local historical masonry.

## What's next?

Based on our results, the project will be extended to a greater number of historical buildings in the Cusco region, including world-renowned sites such as Machu Picchu. The methods developed could help devise innovative and automated approaches to monitoring the structural health of heritage buildings. In addition, the ambient vibration data collected will serve for more robust numerical modeling of allegedly seismic-resistant Inca stone architecture.

For more information click here 

# AFSTORM - After the storm: Studying a natural disaster from an anthropological perspective

“ Nothing is more anthropological than a “natural” disaster! ”

## Academy 3 highlight

The project aims at understanding how human communities deal with the risk of flooding and at studying how they adapt to living in such a context of “*natural hazards and their impact on local societies.*”

## Scientific domains

Social Sciences  
Anthropology

## Key words

Storm Alex  
Disaster  
Flooding  
Vulnerability  
Memory

## Laboratory PI

LAPCOS - Université Côte d'Azur

## Total budget

€3,222, including €2,922 from Academy 3



Quentin Megret



# The project

In a context of climate change, flooding is one of the main threats that human communities face around the world. This is particularly true in the coastal department of Alpes-Maritimes, where Mediterranean episodes with potentially severe consequences regularly occur. The project AFSTORM studies the multiple social and cultural consequences of Storm Alex, which was a major disaster in the Cote d'Azur's hinterland. The project seeks to understand the reconstruction and resilience process in affected valley societies and studies how people adapt their ways of living and thinking after this type of event.

In the first part of the project, personal stories and different social perceptions of the disaster were collected. As ethnologists, the project members conducted informal interviews and participated in the daily life of the residents to understand their viewpoints.

The study is organized around three main points. The first is the memory of the disaster. The objective is to get closer to the individuals who experienced the storm and to record their experiences. After a period of media coverage and shock, it is essential to understand how a memory of the event is being formed. The aim is to grasp the different ways of "telling" this catastrophe in the present time. The initial results show that individual stories gradually become part of a collective narrative, forming a local memory of the event.

The second point relates to knowledge, skills, and expertise (KSEs). Studying the KSEs mobilized by the residents during the various phases following the storm has enabled us to understand how this event disrupted everyday social practices and how people adapted to cope with this exceptional context. Results from the field show that local people did not wait for government services to rebuild and take ownership of their environment. "Homemade" structures were set up immediately after the storm (a "makeshift" zip line, for example, was installed with a bow and fishing line to re-establish communication with people isolated by the river).

The final point concerns exploration of issues relating to "living" and "rebuilding" after the disaster. After the storm, several dynamics emerged among the residents: some left the valleys, others stayed and went back to their usual routine with a more or less acute ecological awareness. Storm Alex, and more generally "natural" disasters, are unique laboratories for studying transition processes in a context of climate change. The data collected are still being cross-referenced to provide a more detailed analysis of these reconstruction mechanisms.

## The +

The project highlights the links between the natural aspects of a disaster and its social and cultural dimensions, thereby demonstrating the importance of recent events as "natural" disasters.

## What's next?

The next step is to compare the results of the project with those obtained from other "natural" disasters. Based on the data collected, a paper detailing the entire ethnological study of Storm Alex has been written and will soon be published.

For more information click here 



# FLODHEA - FLOods and Drought Hazards in East Africa

“ Investigating past and present major hydrological events and soil vulnerability in Djibouti to help prevent and mitigate the impact of floods and drought events in East Africa. ”

## Academy 3 highlight

The Flodhea Project aims to provide the knowledge and tools to prevent and mitigate flood and drought hazards in East Africa, notably in Djibouti. It aligns with the transdisciplinary theme of the Academy by focusing on *“hazard observation, understanding, and risk anticipation.”* These efforts directly support UN SDGs 3, 6, and 13, emphasizing health, clean water access, and climate action.

## Scientific domains

Earth and Environmental Sciences  
Natural Risks

## Key words

Climate Change  
Flood Hazards  
Drought Hazards  
Soil Vulnerability  
Cities and societies

## Laboratory PI

Géoazur - Université Côte d'Azur, CNRS, OCA,  
IRD  
CERD - Djibouti

## Partner

University of Addis Ababa

## Total budget

€4,500 from Academy 3



Carlo Mogni



# The project

In recent years, East Africa has experienced rapid climate warming, particularly in Djibouti, leading to heightened risks of floods and droughts. These changes have disrupted the region's hydrological cycle, resulting in more intense flash-flood events and increased scarcity of rainfall during the long monsoonal season, which pose serious threats to food production systems and water resources. The Flodhea Project is taking the first steps to address these challenges by estimating the impact of anomalous floods and extreme dry periods on water resources and soil development in Djibouti's semi-arid regions.

The project has three main objectives:

- Observation and measurement in shallow aquifers: This involves monitoring changes in groundwater levels during floods and droughts. Specialized sensors have been installed in agricultural pits and rivers to measure water level, temperature, and conductivity every 30 minutes for at least a year. This data will provide valuable insights into how hydro-climatic events affect groundwater resources.
- Palaeohydrological evolution: The project aims to understand hydrological changes in the region over the last 10,000 years. By studying river incision rates, we can estimate the intensity and timing of past extreme flooding periods. This historical data will be useful in the future for building predictive models of flood hazards in Djibouti.
- Soil cover degradation: The study aims to monitor soil systems to understand their pedological development, degradation, and vulnerability. Using sedimentological and geochemical techniques such as total organic carbon analysis, elemental geochemistry, and lithium isotopes on clay minerals, the project will reconstruct the history of soil cover degradation in semi-arid regions, specifically focusing on the Lake Abhe basin and the Day National Forest in Djibouti.

The project's outputs will contribute to better understanding and predicting future flood risks and droughts in Djibouti. By collaborating with local agricultural stakeholders, the project seeks to develop sustainable management responses to climate change and ensure the long-term resilience of semi-arid regions. Overall, the Flodhea Project aims to address the urgent challenges posed by climate change in East Africa and contribute to the sustainable development of the region.

## The +

The Flodhea Project is investigating the impact of rapid climate warming in East Africa, notably in Djibouti, where floods and droughts are becoming more frequent. It focuses on assessing how these extreme events affect water resources and soil development in semi-arid regions.

## What's next?

The Flodhea project should grow into a comprehensive program for addressing the region's pressing environmental challenges (in all East African countries, including Ethiopia, Uganda, and Kenya). Its results will serve as valuable inputs for developing numerical predictive models that will serve firstly, for collectively managing responses to floods and drought hazards in partnership with local institutions and NGOs, and secondly, for formulating sustainable development strategies in collaboration with local research centers in Djibouti.

For more information click here 



# MONITORINCA - Long-term monitoring of the dynamic response of cultural heritage monuments in Cusco, Peru

“ Listening to Inca and Colonial buildings to determine their seismic vulnerability. ”

## Academy 3 highlight

By monitoring historic monuments in Cusco, Peru, the MonitorInca project is measuring the vulnerability and the resilience of these structures to “*evaluate the impact of natural hazards on the environment, cities and societies,*” in partnership with INGEMMET Peru, the Geological, Mining and Metallurgical Institute of Peru.

## Scientific domains

Earth Sciences  
Archaeology  
Seismic Risks

## Key words

Ambient vibration testing  
Time series analysis  
Structural engineering  
Structural dynamics

## Laboratory PI

CEREMA  
Géoazur - Université Côte d'Azur, CNRS, OCA, IRD

## Partners

INRIA - Sophia-Antipolis  
IRD  
INGEMMET  
EURECOM - Sophia-Antipolis

## Total budget

€7,000 from Academy 3



Diego Mercerat



Andy Combey



# The project

The Cusco region in Peru, which is the cradle of Inca civilization (fifteenth–sixteenth centuries) and Andean Baroque (seventeenth–eighteenth centuries), has an exceptional density of archaeological and historical buildings. Because of their centuries-old history and the diversity of materials and construction techniques used, the dynamic behavior and structural integrity of these complex engineering systems remain difficult to understand. Non-invasive, “passive” seismic methods, such as the analysis of ambient vibrations, have demonstrated their relevance for characterizing the dynamic response of structures and historic monuments. While Operational Modal Analysis using short-term instrumentation is booming today, long-term monitoring of the behavior of structures, that requires heavier logistical and scientific investment, is still not widespread, particularly in the Andes. In the Cusco region, a large network of active faults represents a threat to the population and its heritage (earthquakes occurred in 1650 and 1950). In addition, greatly changing weather conditions and rapid urbanization of the region are threatening the resilience of the structures. It is therefore essential to estimate over the long term the impact of these various factors (seismic, environmental and human) on the response of historical buildings and to evaluate the diversity of processes at work. Continuing the postdoctoral research of A. Combey (IRD-Géoazur) and the long-term instrumentation of the first two buildings in Cusco, the project aims to broaden the spectrum of the approach to other historical buildings (Incas and colonial) and to offer logistical, scientific and financial guarantees for the sustainability of this long-term monitoring system.

Using an interdisciplinary approach that brings together geophysicists, architects, civil engineers and data scientists, the data collected should lead to a better assessment of the processes of damage and aging of structures and improve numerical simulations in the event of strong earthquakes.

## The +

The project has demonstrated the potential of artificial intelligence (AI) to create a dynamic response model for cultural heritage buildings and measure the impact of different stresses, such as changes in environmental parameters, catastrophic climatic events, anthropic vibrations and earthquakes.

## What's next?

The next step will be to apply the project's techniques to other ancient masonry buildings in the Cusco area and in other countries. The comparison of different construction techniques may provide insights into ancient civilizations' knowledge of catastrophic phenomena. It will lead to the proposal of a Structural Health Monitoring system to assess damage in cultural heritage sites using non-invasive techniques.

For more information click here 

# STFAR - The Teil earthquake and fluid circulation in the active fault of La Rouvière

“ Understanding the relationship between long-term and active fault history by studying mineral crystallization and fluid circulation. ”



Christophe Matonti

## Academy 3 highlight

The level of destruction caused by the Le Teil earthquake was the worst in mainland France since 1967. The scientific and societal interest of this earthquake, which occurred in an area with very high stakes, has led to several research projects studying the *“active fault over the long term and the consequences for infrastructures and the population.”*

## Scientific domains

Earth Sciences  
Seismic Risks

## Key words

Faults  
Microstructures  
Geochemistry  
Earthquake

## PI laboratory

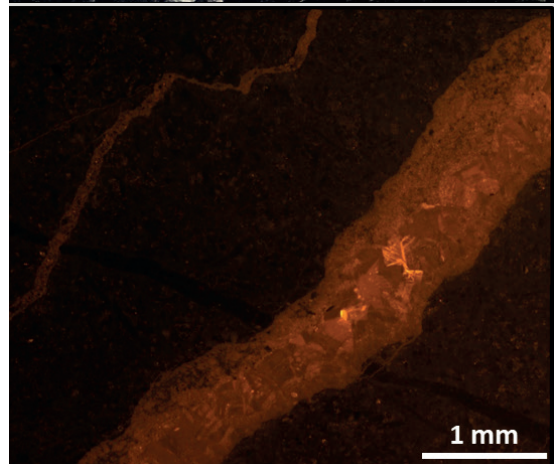
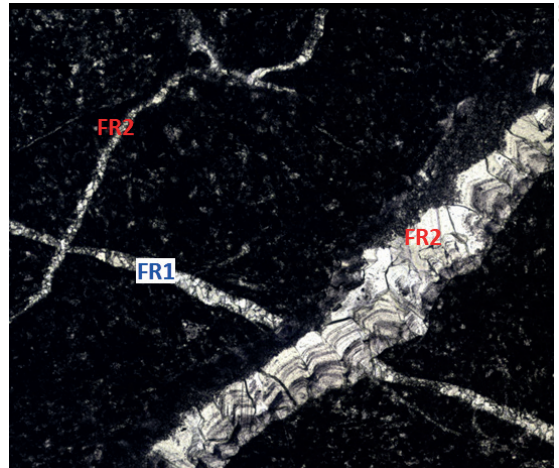
Géoazur - Université Côte d'Azur, CNRS, OCA, IRD

## Partner

GeoRessources - Université de Lorraine

## Total budget

€7,000 from Academy 3



# The project

On November 11, 2019, an earthquake of moment magnitude 4.9 occurred near the town of Le Teil (Ardèche, France). Despite its moderate magnitude, the earthquake caused considerable damage near a dense urban area (Montelimar) and two currently operating nuclear plants (Cruas and Tricastin). It was also rather unexpected, as this area had not been identified previously as a high seismic hazard zone. The earthquake therefore represents a major means of raising awareness of seismic risk in mainland France, and as such, Geoazur's geologists and seismologists are playing a major role in analyzing it.

The La Rouvière fault has been identified as responsible for the earthquake. The associated rupture at the surface runs along 4.5 km, with a hypocenter located at very shallow depth (~1 km). This provides a unique opportunity to analyze the relationship between geological attributes of the active fault and the seismological parameters of the earthquake.

The major question we are trying to address in this project is how such a significant earthquake was able to nucleate inside rather soft clay-rich rocks, at such a shallow depth. For this purpose, we are analyzing samples retrieved from a borehole drilled at about 30-meter depth through the La Rouvière fault. These samples are used to characterize the microstructures of fault-zone polyphasing (as calcite veins or pyrite minerals). Each generation contains information on all the episodes of deformation along this fault and on the origin of the fluids involved in the deformation/mineralization.

As part of this project, we have been able to complete the geochemical analysis of these minerals, measuring stable isotope ratios of Carbon and Oxygen using an ion microprobe instrument located in the Géoressources lab (Nancy). With these isotope ratios, we can determine the origin (shallow or deep) of the fluid circulating through the fault during these mineralization phases. We can also trace the evolution of fault permeability, which is an important parameter to better understand what triggered (human-induced or naturally) the Le Teil earthquake.

## The +

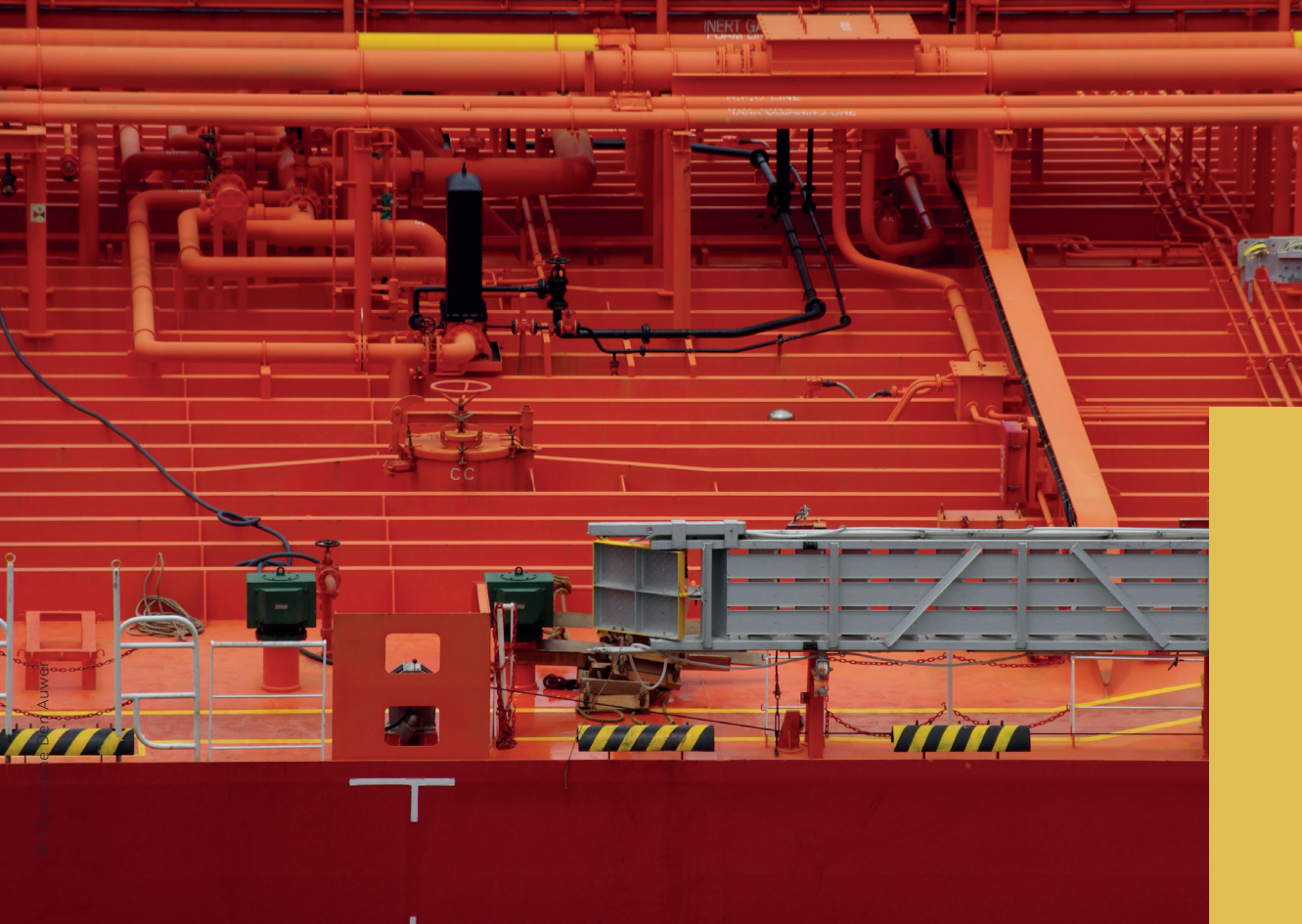
The project combines the study of the microstructures of mineralized veins and the geochemistry of crystallizations in post-earthquake active fault samples. The relationship between long-term deformation and active faulting is also being analyzed on a fault in a stable intracontinental domain.

## What's next?

The studies carried out on the samples from this first borehole drilled through the La Rouvière fault will enable us to calibrate our analyses for the rest of the project. This will involve drilling, for the first time in the world, at hypocentral depth, in other words in the zone where the seismic rupture started in 2019.

For more information click here 





# Environmental challenges related to energy and resources

The energy and resource theme is linked to SDGs 7, 12 and 15. It aims to provide innovative scientific outputs and explore circular economy and sustainable use of our planet's natural resources. This theme is composed of 9 projects : 2 Consortium projects and 7 First projects.

# TEFOR - Territorial food system resilience

“ Meeting the challenges and dealing with the realities of tomorrow’s agriculture by co-constructing scenarios for feeding people locally. ”

## Academy 3 highlight

The project seeks to improve agricultural resilience within the Alpes-Maritimes department by building local food systems with farmers in an interdisciplinary way. It also uses a participatory approach to discuss “*environmental challenges related to food resources*” with local actors.

## Scientific domains

Agriculture  
Economics  
Social Sciences

## Key words

Food system resilience  
Land-use  
Initiatives  
Modeling  
Participatory approach

## Laboratory PI

GREDEG - Université Côte d’Azur, CNRS  
ISA - Université Côte d’Azur, CNRS, INRAE  
ESPACE - Université Côte d’Azur, CNRS, AMU, AU  
OTECCA - Université Côte d’Azur

## Partners

ISAGA  
CIHEAM BARI  
CIAS - University of Wisconsin

## Total budget

€168,300, including €105,800 from Academy 3

## Start of the project

2022



Nathalie Lazaric



Karine Emsellem



Christine Poncet



Pedro Lopez Merino



# The project

Ongoing health, climate and geopolitical crises have shown the vulnerability of our food systems and the need for a transition to more resilient, self-sufficient local food systems. Given its extremely low level of food self-sufficiency (an estimated 2% of the food consumed is produced locally), the Alpes-Maritimes department is facing a real challenge in this regard, despite its past agricultural and culinary tradition. At the same time, strong initiatives have been developed by citizens, farmers and decision-makers to reverse this trend and restore a certain level of local agriculture. The department has launched six official local food projects, and a host of initiatives to help new farmers set up and create local sales channels for their products. In addition, the presence of a relatively wealthy fraction of the population that can afford comparatively more expensive products potentially justifies the development of a local market.

The Tefor (Territorial Food Systems Resilience) project seeks to gain a better understanding of the levers and obstacles to this transition. An interdisciplinary team comprising two geographers from the ESPACE laboratory, three economists from GREDEG, an agronomist from ISA and an expert in collaborative methods from OTECCA are working towards the same goal: the co-construction of scenarios for tomorrow's agriculture. The area studied is the Cap Azur Metropolitan Cluster, located at the western end of the department, and home to approximately 400,000 people. Its history shows a clear division between a highly populated coastal area where agricultural land has been lost to urbanization, and a rural hinterland where land has been left fallow or preserved for extensive livestock farming (including for recreational purposes). Today, the challenge is to understand how such an area can feed itself and attain a higher level of local self-sufficiency. This can only be achieved by collaborating with different disciplines and actors.

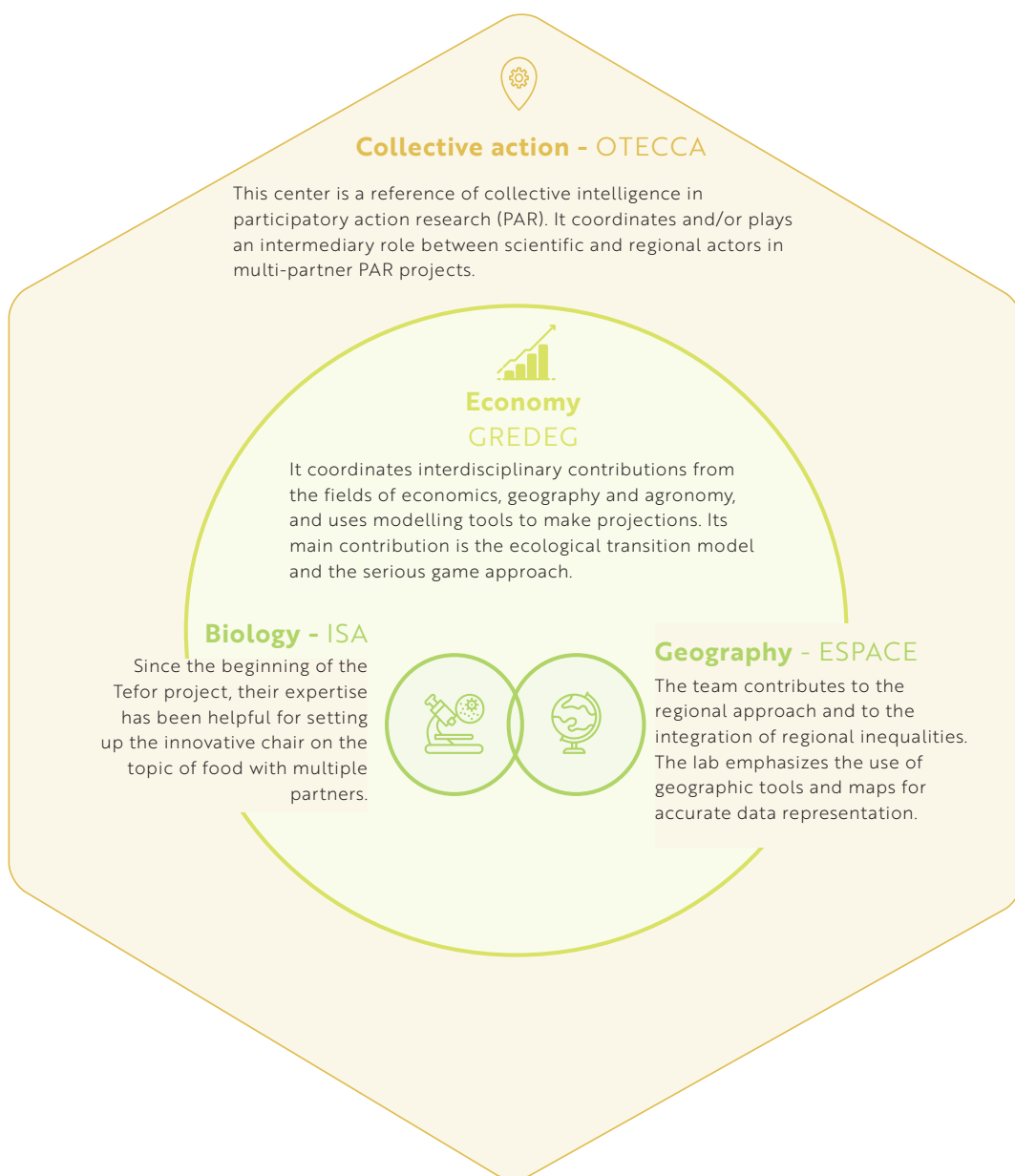
The project team, led by Nathalie Lazaric from GREDEG, first carried out an analysis of the area to characterize current food systems and their development over the past 150 years, and to identify the obstacles and tipping points towards territorial resilience. This involved joining discussions regarding Territorial Food Plans with the communities concerned, and studying data from different sources including the national agricultural census to spatially characterize the agricultural landscape and its evolution. The project has also made it possible to identify, study and unify some of the main innovative agricultural initiatives within the area.

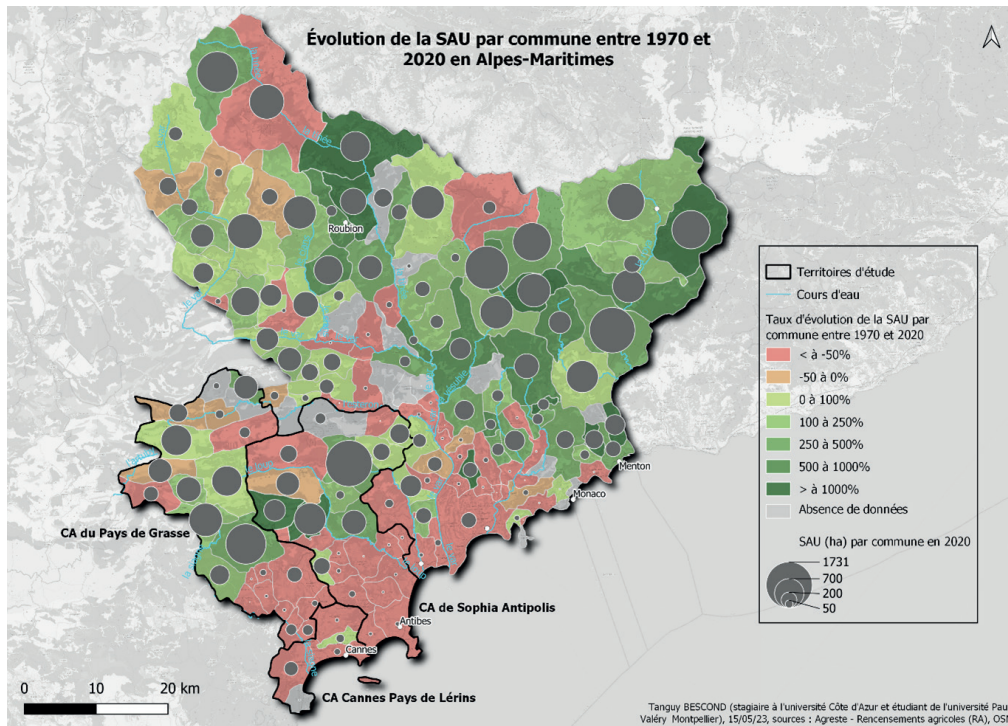
The initiatives under study highlight an important phenomenon of diversification of the economic models implemented by farmers, and this may offer a pathway towards a locally resilient agriculture. At present, Tefor is focusing on studying how the combination of traditional farming with the production of energy by photovoltaic greenhouses can create synergies between food and energy production. The hypothesis is that this could provide a more stable income for farmers and create a partnership with industry and could help fund longer-term projects.

An additional outcome is the production of agent-based models to explain the process and potential scenarios for reintroducing agriculture in the area. We have developed a first model that focuses on economic variables (chiefly, variations in farmers' income) to explore how this might influence the future of the agrifood system. In addition, ongoing interdisciplinary work is seeking to extend the model to include spatial dimensions, with the objective of studying where and what type of production is possible in a given area.

Ultimately, the Tefor project aims to design tools to assist public decision-makers and local stakeholders in developing local food resilience, notably by creating a serious game to be used in participatory workshops. This "gamification" should help the stakeholders (local actors, farmers, citizens) take a new turn while also highlighting the different possible pathways of transition.

# How does the project contribute to transdisciplinarity ?





Changes in the agricultural surface by commune between 1970 and 2020 in the Alpes-Maritimes.

## The +

The Tefor project aims to identify transformative initiatives that can re-direct the course of a region. It is an intermediate milestone that should lead to the development of a chair partnership project on the topic of agriculture and food with the aim of including all the stakeholders in research, development, innovation and funding at the regional level. Through its transdisciplinary approach and the use of serious games, it also contributes to the field of participatory research.

## What's next?

Based on the first results, the project will be pursued in many ways: the economic model will be extended to include spatial considerations, a training session will be organized on participatory action research methods, a serious game will be designed to help understand possible transition scenarios to be developed, a comparison will be made with other regions, Cap Azur will be included in the observatory of agroecological transitions, and a new research project will be set up to continue the work.

For more information click here



# CASHOO - Electromigration to remove phosphate and ammonium ions from an aquaculture pond by adsorption

“ Do intensive shrimp farming activities impact shrimp and human health? Search for ecological and economic pathways. ”

## Academy 3 highlight

The project falls under the theme “*Assessment and detection of anthropogenic risks on human health, environment, and global changes,*” by focusing on the consequences of intensive shrimp farming on shrimp and human health (shrimp consumption). It also addresses the management of pollution risks associated with intensive farming practices in coastal areas in Vietnam.

## Scientific domains

Environmental and Human Health  
Material Sciences  
Aquaculture

## Key words

Electrokinetic  
Electromigration modeling  
Depollution  
Food pollution

## Laboratory PI

INPHYNI - *Université Côte d’Azur, CNRS*  
ICN - *Université Côte d’Azur, CNRS*

## Partner

Ho Chi Minh City University of Natural Resources and Environment

## Total budget

€37,000 from Academy 3

## Start of the project

2023



Charlotte Hurel



Hervé Michel



# The project

In Vietnam, aquaculture activities represent a significant part of agricultural activity. Many aquaculture farms practice intensive shrimp farming for local and international consumption. Since 2010, the emergence of acute hepatopancreatic necrosis disease (AHPND) caused by the bacterium *Vibrio parahaemolyticus* has led to a worrying increase in shrimp mortality. The measures implemented to fight the proliferation of this bacterium initially focused on conventional approaches such as disinfecting ponds or using antibiotics, but these practices gradually led to an increase in the resistance of pathogenic bacteria. Meanwhile, analyses of farming water quality have shown that phosphate and ammonium levels are difficult to control and increase over time due to inputs from (1) shrimp feed and (2) waste produced by the shrimp themselves (excrement, animal carcasses, etc.). Water pollution by phosphates and ammonium is an environmental problem because it promotes eutrophication, leading to oxygen depletion and ultimately species extinction. To combat water pollution by phosphates and ammonium, different regulations have been introduced to limit their use and promote sustainable agricultural practices. To better manage the concentration of ammonium and phosphates in shrimp farming ponds, two options are possible: (1) use filters to adsorb ammonium and phosphates (these filters, based on activated carbon, are generally very expensive), (2) regularly renew the water in the ponds. Given the depletion of water resources worldwide, the second option should be avoided as much as possible.

The objective of this project is to investigate an alternative, ecological, and cost-efficient treatment capable of simultaneously containing both chemical pollution and the proliferation of pathogenic bacteria in a shrimp farming pond. To achieve this, non-pathogenic bacteria will be used as probiotic agents, combined with a solid adsorbent naturally present in Vietnam, with the aim of (1) limiting the growth of pathogenic bacteria and (2) immobilizing phosphate and ammonium ions by adsorption to limit water pollution. Electrokinetic principles will be applied to promote water filtration through the solid adsorbent and thus improve the effectiveness of probiotic treatment and immobilize pollutant ions. Preliminary work conducted in the laboratory has revealed that the addition of natural zeolite combined with the bacterium *Bacillus subtilis* (*B. subtilis*) to the water in shrimp farming ponds significantly improves shrimp health. This improvement appears to be correlated, among other factors, with a decrease in phosphate and ammonium levels in the water (these ions are likely trapped on the surface of the zeolite) and a reduction in the activity of the bacterium *Vibrio parahaemolyticus*.

The different phases of the project include: 1) characterizing the physico-chemical surface properties of natural zeolite both with and without *B. subtilis*; 2) investigating the physico-chemical interactions between zeolite (natural and with *B. subtilis*) and ammonium and phosphate ions in static mode (batch experiments); and 3) studying the migration of ammonium and phosphate ions under the influence of an electric field applied to electrodes placed at both ends of a miniature pond (an electrokinetic cell representing the shrimp farming environment), and their trapping by placing porous zeolite filters (natural and with the presence of *B. subtilis*) on either side of the pond.

Several disciplines are involved in the project, including physics, chemistry, and biology, with the ultimate goal of offering shrimp farmers an ecological and cost-efficient approach to managing their farming ponds.

# How does the project contribute to transdisciplinarity ?



## Biology

Ho Chi Minh City University of Natural Resources and Environment, Vietnam

The Vietnamese laboratory will contribute its expertise in the methods of enhancing the surface of zeolite by adding *B. subtilis* and evaluating the effectiveness of the treatment on their development.



## Physics - INPHYNI

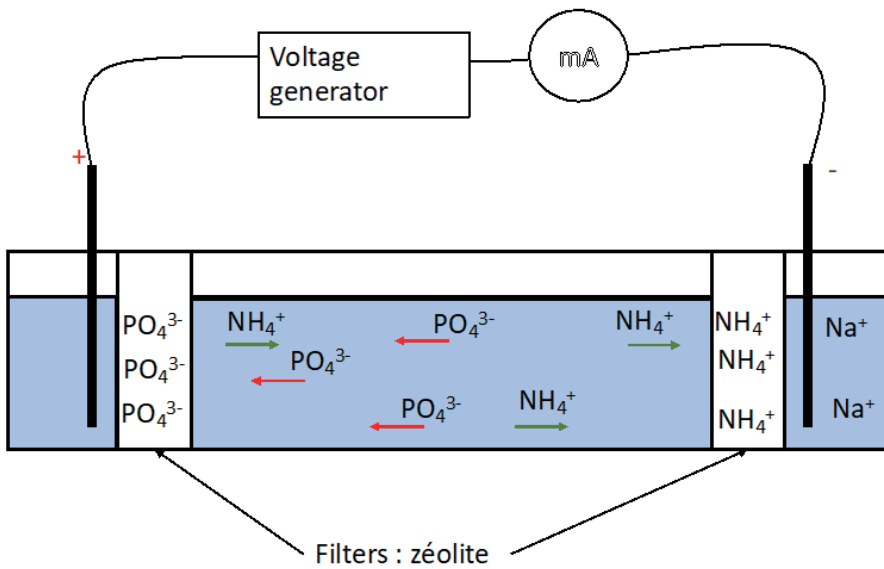
INPHYNI will contribute its expertise in characterizing the surface properties of zeolite, assessing interactions with pollutants, and modeling.



## Chemistry - ICN

ICN will bring its expertise in highlighting the redox phenomena occurring in various compartments of the cell and in choosing the nature of the electrodes to be used.

**CASHOO**



Scheme of electromigration cell used at laboratory scale.

## The +

The Cashoo project proposes a comprehensive approach to promote the implementation of a local and sustainable solution that addresses an environmental issue that could have repercussions on animal and human health and bring societal changes in farming practices in Vietnam.

## What's next?

From laboratory scale to real production scale, adaptation of technologies will be necessary. Then, the project will investigate a scaleup of the treatment approach in real conditions of shrimp farming. An ecological and economic approach to manage farming ponds in Vietnam will be pursued.

For more information click here 

# AURACLE - Autonomy and food resilience through short-chain supply in cities: contributions from geo-foresight

“ Understanding and assessing short food chains supplying the city of Nice in a multitemporal perspective. ”

## Academy 3 highlight

In a context where the contemporary agri-food model associated with long conventional supply chains predominates, understanding the alternative organization of supply chains based on proximity opens the way to further investigations in connection with the *“agri-food transition and challenges related to energy.”*

## Scientific domains

Agriculture  
Geography  
Social Sciences

## Key words

Short and local circuits  
Food re-territorialization  
Food sovereignty  
Geo-foresight

## PI laboratory

ESPACE - Université Côte d'Azur, CNRS, AMU, AU

## Total budget

€5,915 from Academy 3



Stéphane Bouissou



# The project

The Auracle project was started in 2022 with doctoral research conducted by Juliette Benedetti. It is part of a wider research project aimed at understanding the dynamics of re-territorialization of food systems through the consultation with all the actors of the food chains: production, distribution and consumption. The project focuses on short food and proximity circuits in the city of Nice, in the Alpes-Maritimes department. The objective is to deploy geo-prospecting tools to identify the dynamics of agriculture and the potential for maintaining short and local food supply chains in a context of democratization of long supply chains. Ultimately, this project will define prospective scenarios for food sovereignty in the Nice area. With the support of Academy 3, we were able to collect and analyze data drawn from interviews with distributors in consumption and production areas. Three types of supply chains were identified in the first phase of the project:

- Short and local supply chains, within a region, in which typical regional products circulate, and which allow a good flow of information from producer to customer.
- Local supply chains, also within a region.
- “Short and local stages” with products processed locally but produced anywhere in the world.

The project team around Stéphane Bouissou and Juliette Benedetti will then focus on the last phase of the project: the co-construction of geo-prospective scenarios for food sovereignty in the Nice area.

## The +

The project team quickly created a dense, complete and usable database, and as a result, an intern/doctoral team was set up: this multi-partner research experience was rewarding for all sides: both as regards the amount of data collected in record time and the analysis of the results.

## What's next?

Based on the prospective scenarios for the region assessed by the work on short food chains, the project will identify the potential for maintaining these short food chains in the region. This work will help to assess which agricultural spaces will be more vulnerable in the 10 years to come.

For more information [click here](#) 



# NAFTA - New nitride alloy for tandem solar cells

“ The increasing demand for energy implies the development of new technologies, preferably in the renewable field, but these technologies should be earth-friendly and use abundant elements. ”

## Academy 3 highlight

The NAFTA project is directly related to the topic “*Environmental challenges related to energy and resources*” as its main objective is to develop a top cell based on indium-free, earth-abundant and non-toxic nitride, namely the  $(Zn_{1-x}Mg_x)_3N_2$  alloy compatible with the c-Si technology used in tandem solar cells.

## Scientific domains

Materials Sciences  
Energy

## Key words

Nanotechnologies  
Sustainable energy  
Tandem solar cells  
Earth-abundant element-based material

## PI laboratory

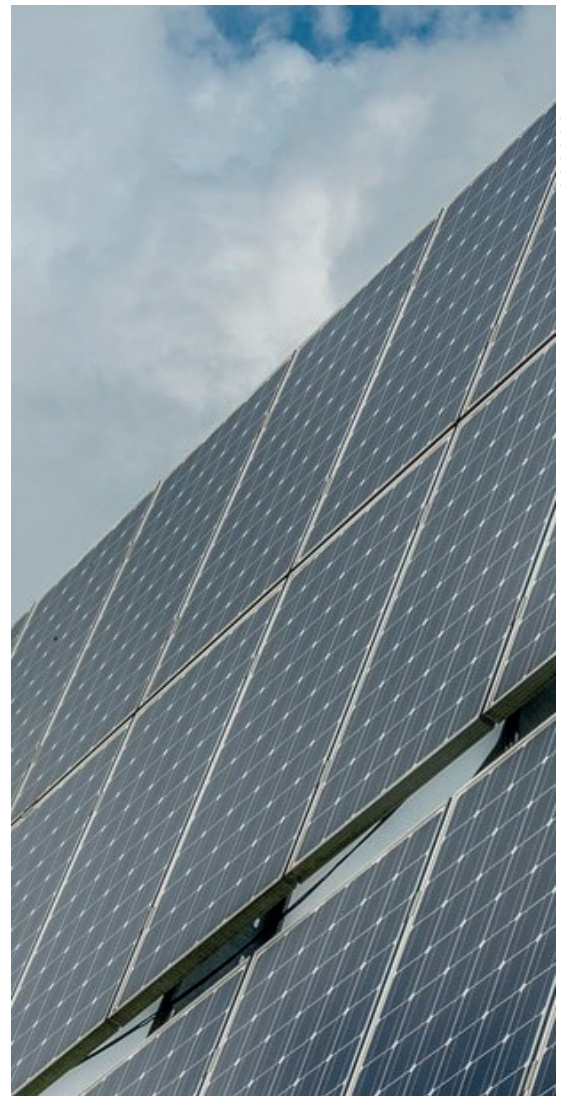
CRHEA - Université Côte d'Azur, CNRS

## Total budget

€3,600 from Academy 3



Hélène Rotella



# The project

With the growing demand for energy due to the population increase, there is a crucial need for sustainable energy resources. This is driving demand for renewable energy sources such as solar energy and is the key factor in the development of photovoltaic (PV) energy. However, PV panels are often made from materials whose elements are considered scarce on the planet, such as indium, or toxic, such as lead. The Nafta project proposes to develop a top cell based on indium-free, earth-abundant and non-toxic nitride, namely the  $(\text{Zn}1 - \text{xMgx})\text{3N}2$  alloy compatible with the c-Si technology used in tandem solar cells, one of the most promising technologies for high-efficiency PV panels. We have optimized the growth conditions of the  $(\text{Zn}1 - \text{xMgx})\text{3N}2$  layer to obtain a material with an optimum band gap of 1.7 eV on the MgO(100) substrate using the molecular beam epitaxy growth method. In the case of the II-nitride system, this non-equilibrium technique has the advantage of allowing the growth of alloys with a wide range of compositions without significant degradation of crystalline quality. This technique was used to produce a series of samples covering the entire composition range from  $\text{Zn}3\text{N}2$  to  $\text{Mg}3\text{N}2$  compounds. The quality of the material was studied by X-ray diffraction, which showed a monocrystalline epitaxy of the  $(\text{Zn}1 - \text{xMgx})\text{3N}2$  layers with satisfactory quality. The term "monocrystalline epitaxial" means that all the crystalline grains in the layer adopt a single orientation and their atomic arrangement is linked to that of the substrate. Using a home-made absorption device developed during the project, measurement of the optical band gap of the samples showed that we achieve the ideal value of 1.7 eV for a nominal composition of ~20% Mg.

## The +

The  $(\text{Zn}1 - \text{xMgx})\text{3N}2$  alloy, composed of earth-abundant and non-toxic elements, has an optical band gap that can be adjusted from 1 eV to 2.9 eV depending on the Mg content. This allows it to achieve the ideal band gap of 1.7 eV, and easily be combined as a top cell with a c-Si cell in a tandem solar cell using the molecular beam epitaxy growth method.

## What's next?

The project will continue thanks to ANR funding (ANR NITA) under the name: Earth-abundant Nitride for tandem solar cells. The future of the project will be to have a strong societal impact through the development of a low-cost green energy source that makes it possible to reduce dependency on fossil fuels currently used.

For more information click here 

# EDUDELO - Groundwater detection and sustainable aquifer management in Cameroon

“ Exploration and sustainable management of water reservoirs: Quantifying the impact of climate change on water reserves through the installation of weather stations and humidity sensors. ”

## Academy 3 highlight

“Environmental challenges related to water exploration” and its sustainable management are at the center of this project, which focuses on local monitoring by meteorological stations to quantify climate change and its impact on water reserves.

## Scientific domains

Earth Sciences  
Hydrology

## Key words

Electrical data  
Education  
Weather stations  
Groundwater monitoring  
Sustainable management

## PI laboratory

Géoazur - Université Côte d'Azur, CNRS, OCA, IRD

## Partner

University of Yaoundé 1

## Total budget

€10,000, including €5,000 from Academy 3



Alessandra  
Ribodetti



Lionel Mbida  
Yem



# The project

With a dense network of perennial rivers fed by abundant rainfall over much of the country and for most of the year, Cameroon has abundant surface water resources. However, a large proportion of the rural population is dependent on groundwater, and in many rural areas demand for surface water exceeds supply during the dry season. One of the many problems associated with water access and management is the lack of information about the underground environment and the extent of groundwater and aquifers. Geophysical tomography measurements carried out on the ground surface and drilling by the team of technicians from LABOGENIE and GEOBASE, have identified some aquifers. However, a certain amount of data has not yet been exploited due to a lack of tools.

This project aims to continue underground exploration to monitor the aquifers and has identified three main avenues to be explored: 1) a scientific component to improve the processing of available data in conjunction with AEP, and the new Saba (Sanaga Basin Aquifers) and Granite (Groundwater Targets) projects at the University of Yaoundé, in addition to selecting exploration sites with the possibility of deploying weather stations and soil moisture sensors on site to quantify the impact of climate change on groundwater; 2) a socioeconomic component to protect, exploit and sustainably manage this precious resource; and 3) an educational component (Edu-Delo). The aim of the Edu-Delo project is to create a "test site" observatory. We want to develop an educational project in hydrology, by creating a network of sensors connected to a database, from a few months to a few years, depending on the objectives. The use of three weather stations combined with groundwater pressure sensors could be the first step in creating a permanent hydrological network.

The station's network of sensors could estimate the amount of water that infiltrates during periods of rain and the evapotranspiration on that surface. Support for this equipment as a school project gives a strong partnership dimension to this hypothetical network and creates a synergy of interests. The project not only has a research dimension, but also an ambitious educational component based on teachers identified before the installation. Hydrology will be addressed in school through themes related to the management of primary resources.

Water management is, of course, the main focus of the project. Linked to specific meteorological events, but also to longer-term climatic trends, its study should allow more or less broad themes to emerge. The monitoring of groundwater through its return to the surface (of interest for the installation of Reefnet-type water level sensors in the absence of existing data) or its storage (by geophysical imaging) may be an ambitious first area of research currently funded in the region. The database developed would be managed by local university staff. Following the example of EduMed-Obs at Geoazur, we will create an open "data center" and use existing tools to provide easy access to the data. The main mission of the project will be to increase the visibility and outreach of the research team's work in hydrogeological observation, and disseminate it to the public (science and citizens) and especially to schoolchildren (science and research).

## The +

The Edu-Delo project addresses several issues:

- 1) The environmental challenge of data processing for groundwater exploration and sustainable management;
- 2) Local monitoring through meteorological stations to quantify climate change and its impact on groundwater resources; and
- 3) "Educational" actions following the example of EduMed-Obs of Geoazur to involve students and civil society.

## What's next?

This project plans to create educational material about hydrology, an observatory, and a hydrogeological database. The Edu-Delo educational component and the interface providing easy access to research and educational data on sustainable water management will be implemented in 2024-2025. To support its actions in the longer term, the project is expected to strengthen partnerships with regional authorities involved in water management.

For more information [click here](#) 



# REBIRTH - Ecological resilience and biodiversity of tropical rainforests after the cessation of human activities

“ How human activities and climate have shaped Central American tropical forests over the past millennia. ”

## Academy 3 highlight

The Rebirth project seeks to determine the extent of “*past climatic and anthropogenic risks to Central American rainforests*” and, conversely, the role of environmental changes in the Southern Maya Lowland cities.

## Scientific domains

Archaeology  
Environmental Sciences

## Key words

Tropical forests  
Maya society  
Anthracology  
Environmental risk and resilience

## PI laboratory

CEPAM - Université Côte d’Azur, CNRS

## Partners

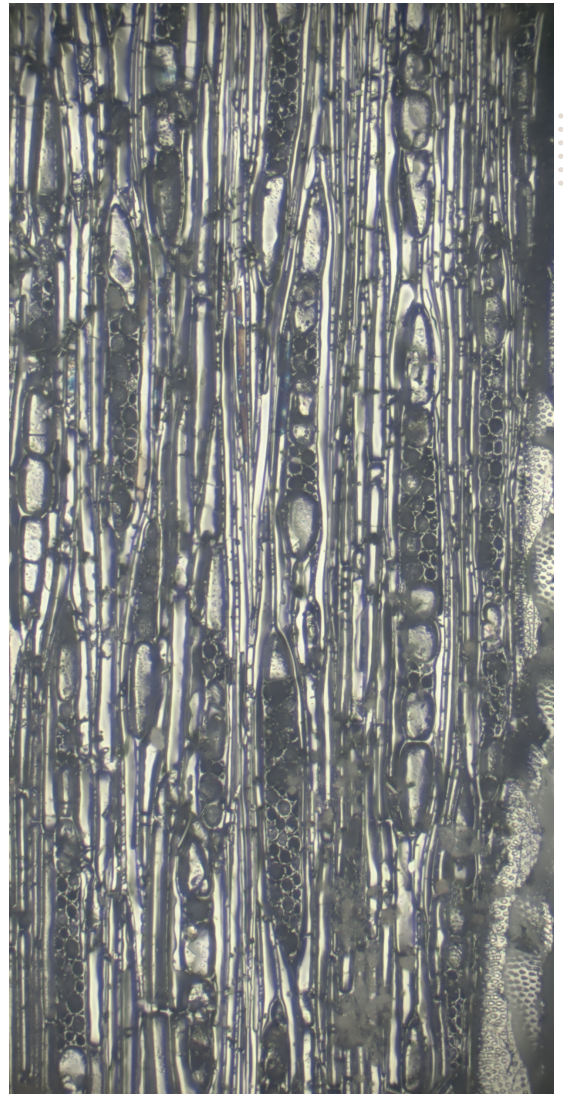
ArchAM - CNRS, Université Paris 1  
MSHE - CNRS, UBFC  
University of Toronto  
University San Carlos of Guatemala  
CEMCA

## Total budget

€7,000 from Academy 3



Lydie Dussol



# The project

The rainforests of southern Mexico and Central America are a biodiversity hotspot severely threatened by modern agriculture, urban expansion and climate change. In the past, these forests were already impacted by human activities, with the expansion of Classic Maya cities between AD 250 and 1000 causing unprecedented deforestation in the lowlands of the Yucatan Peninsula. Available paleoecological data (fossil pollen) indicate that forest regeneration was relatively rapid, in the region of 80 to 260 years, after the Maya deserted the region following the collapse of their government during the Terminal Classic period (AD 800-1000). However, while pollen archives provide information on the relative extent of forests, we still have a poor understanding of how their floristic composition and physiognomy changed as a result of anthropogenic modifications. Besides, these forests were probably also affected by a generally drier climate and severe drought episodes during the Late Holocene that are confirmed by paleoclimatic studies.

In this context, the Rebirth project aims to understand the impact of human activities on the dynamics and reforestation processes of tropical rainforests in the past. Several Maya sites in the Department of Alta Verapaz, Guatemala, have been excavated since 2016 as part of the Raxruhá-Cancuén Regional Archaeological Project. This region straddles the southern Maya lowlands and the highlands, where data are rare on the paleoenvironment during the pre-Columbian period, unlike the central and northern lowlands, which are much better documented. The Alta Verapaz sites offer archaeological contexts, both in urban centers and in caves, that cover a long period of occupation, from the foundation of the cities to their political demise and abandonment by the Maya. The anthracological study of these contexts – the study of archaeological wood charcoal – will allow us to reconstruct the evolution of the forest cover during the Classic period and beyond. Anthracology has proved its worth in other parts of the world for reconstructing paleoenvironments. However, this approach has never been used systematically in the southern Maya lowlands. The research questions this project will address are the following: What was the impact of regional droughts and human activities on local forests during the Classic period? To what extent were forests cleared and disturbed at the end of the first millennium AD? How did the forests recover after the Maya abandoned the region? In the global context of climate change and adaptation of human societies, this project will provide new data for anticipating the long-term effects of climate and human modifications on the biodiversity of neotropical rainforests.

## The +

The project used a century-long approach to study the environmental resilience of tropical forests. It had a strong interdisciplinary dimension that involved both archaeology and paleoecology. Finally, it implemented a novel approach which allowed direct comparison between changes in forest cover and socio-political mutations.

## What's next?

The southern lowlands are a grey zone in the socio-ecological history of the Maya area. Further anthracological studies at other sites, in particular in the major city of Cancuén, will provide a more complete picture of the co-evolution of societies, forests and climate during the last two millennia. These data will be supplemented by a regional paleoecological and paleoclimate approach involving the coring of lakes and wetlands for pollen analysis, the study of paleo-fires, geochronology and geochemistry.

For more information click here 



UNIVERSITY OF  
TORONTO



# VAPOREE - Valorization of industrial by-products into porous materials for energy and environmental applications

“ Water purification using industrial waste: when waste recovery and green chemistry serve the circular economy. ”

## Academy 3 highlight

This project contributes to the Academy 3 theme “*Environmental challenges related to energy and resources*” by proposing to use biomass waste from the cosmetics/fragrance industry to produce energy, and by developing a method for the chemical and organic depollution of water through absorbent materials.

## Scientific domains

Material Sciences  
Environmental chemistry

## Key words

Waste recycling  
Hydrochars  
Adsorption  
Pollution control  
Circular economy

## PI laboratory

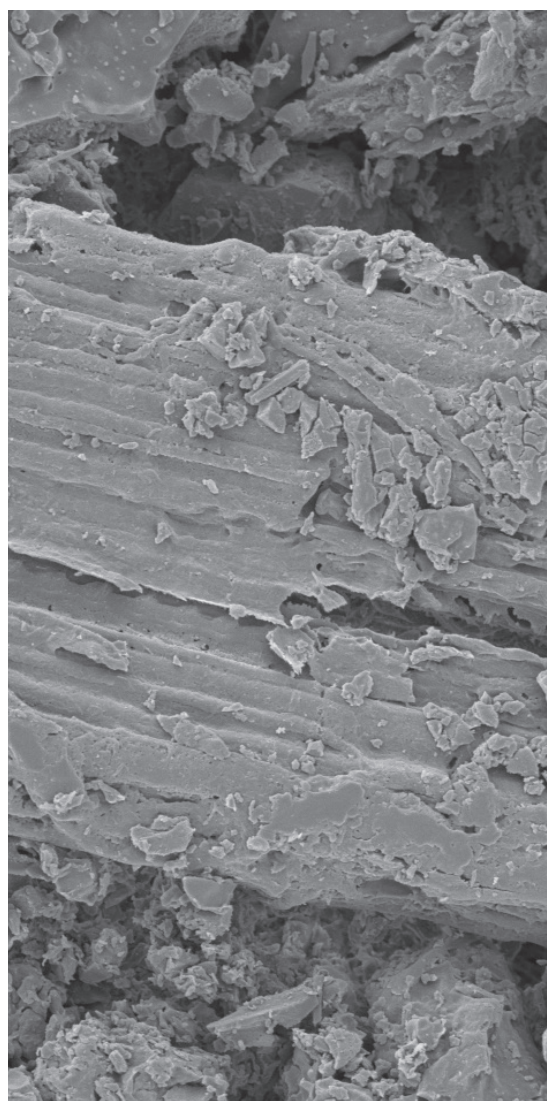
INPHYNI - *Université Côte d’Azur, CNRS*

## Total budget

€43,500, including €7,000 from Academy 3



Charlotte  
Hurel



# The project

Waste recycling is a major economic and ecological challenge for today's society. It helps to limit the depletion of natural resources and also limits waste volumes and encourages the transition from a linear to a circular economy. Against this backdrop, the Vaporee project led by Charlotte Hurel is investigating ways of recycling industrial waste, with the aim of obtaining porous adsorbent materials (known as hydrochars). Once transformed, recycled industrial waste can be used for environmental or energy applications. To achieve this objective, the research team acquired a TRISTAR II specific surface and mesoporosity analyzer, an instrument used for calculating the adsorbent potential of a material, a crucial piece of data when it comes to water decontamination. The project focuses more particularly on a waste product from the cosmetics/perfume industry: lavender waste. After the essential oils have been extracted by the industry, lavender waste is recovered, heated until carbonaceous materials are obtained, then tested using a specific surface area analyzer. Perfect control of heating time and temperature is essential to successfully prepare the perfect adsorbent material. These parameters vary from one material to another, and are particularly important for lavender. The entire material production chain is optimized for energy consumption, in line with the Vaporee project's sustainable development approach. After treatment, and given the material's remarkable adsorption capacities, there are two possible recycling options:

- The first would be to compact the material into pellets ready for combustion for domestic heating.
- The second would be to use it as a depolluting material to clean water contaminated by heavy metals, antibiotics or organic matter.

Compaction and adsorption tests carried out on materials derived from lavender waste have been highly convincing. It is now up to industry to commercialize the cost-efficient and environmentally-friendly materials developed by the Vaporee project.

## The +

The Vaporee project focuses on the values of the circular economy by recycling industrial waste from the Côte d'Azur region.

It goes even further, proposing innovative depolluting solutions using this waste.

## What's next?

Based on the first results, the project team will be looking at other materials for testing and recycling. More specifically, in 2024, the laboratory will host a doctoral student who will study depollution systems applied to Vietnamese aquaculture.

For more information [click here](#) 

# NR2P3 - Nuclear risk and radio-isotopes, from public perception to new policies

“ How do European students really feel about nuclear power? ”

## Academy 3 highlight

Nuclear power could play a key role in replacing fossil fuels and becoming part of the future energy mix. But the desirability of nuclear power is perceived differently in different countries. This project focuses on the perception of nuclear risk by university students as this important societal question regarding “*challenges related to energy*” is less studied than other risks.

## Scientific domains

Social Sciences  
Energy

## Key words

Nuclear Risk  
Perception  
European universities

## PI laboratory

ESPACE - *Université Côte d’Azur, CNRS, AMU, AU*

## Partners

ICN - *Université Côte d’Azur, CNRS*  
TIRO-MATOs - *Université Côte d’Azur, CEA*

## Total budget

€43,500, including €7,000 from Academy 3



Sandra Perez



# The project

In an effort to reduce greenhouse gas (GHG) emissions, many countries around the world are planning to shift to more sustainable forms of energy. Nuclear energy is expected to play a key role in replacing fossil fuels, or at least to be an essential option in the future energy mix. However, the use of nuclear power is controversial among younger people, who prefer the development of solar and wind power. Assessing young people's perception of nuclear risk is the subject of the NR2P3 project: "Nuclear Risk and Radioisotopes, from Public Perception to New Policies." While a previous survey (NR2P2) focused on two target populations, experts vs. non-experts, in this new survey a single social group was selected: students who responded to a questionnaire sent to the Ulysseus network of universities. While information is readily available about the different energy policies pursued at international level, less is known about how they are perceived by the general public. The initial fieldwork for this study was carried out in eight European countries: Austria, Finland, France, Germany, Italy, Montenegro, Slovenia and Spain. The questionnaire did not achieve the desired level of representativeness for some countries. Nevertheless, it allowed us to explore the different energy contexts, which was an important part of our study. We received 1,015 incomplete responses and 726 complete responses, and decided to focus only on the latter. The first argument in favor of nuclear power (53.4%) concerned the climate and the fact that nuclear power is a low-carbon energy and therefore necessary to combat greenhouse gas emissions. Arguments against the development of nuclear power focused on the concept of risk and the problem of radioactive waste, which were highlighted in the responses, together with the more recent argument that it is impossible to continue to produce nuclear power in a world with an increasingly uncertain climate (the issue of reactor cooling). In terms of perceived nuclear risks, the nuclear threat came first (380 students). The current geopolitical context, notably Russia's war in Ukraine, might have influenced this perception. Overall, the responses show a desire for citizen participation in energy decision-making. All the responses reflected the students' interest in participating in the nuclear debate.

## The +

Although surveys on the perception of nuclear risk are not new, it remains important to understand the similarities and differences in European students' perceptions of nuclear risk. This gives us a better understanding of the variability due notably to each country's national energy policies and its geopolitical context.

## What's next?

The next step is to ensure a better representation of European universities to obtain a more representative panel of students. The questionnaire should be redistributed to the Ulysseus university network.

For more information [click here](#) 



# Qual&H2ONiA - Quality of water resources in New Caledonia

“ How can the geology, physicochemical factors and the content in suspended particulate matter impact water quality in a tropical environment (New Caledonia). ”

## Academy 3 highlight

By assessing water quality and defining future standards for New Caledonia, this project will ensure “*sustainable management of water and healthy lives for all*”. It also proposes recommendations to protect and promote sustainable use of terrestrial ecosystems.

## Scientific domains

Environmental chemistry  
Hydrology

## Key words

Water quality and resources  
Sustainable management  
Contamination  
Metals  
Risk

## PI laboratory

Géoazur - Université Côte d'Azur, CNRS, OCA, IRD

## Partners

ISEA - Université de la Nouvelle Calédonie  
IPREM - CNRS, UPPA

## Total budget

€203,100, including €6,500 from Academy 3



Aurélie  
Barats



# The project

In New Caledonia, 61% of surface water is used to supply drinking water and 24% of water resources come from ultramafic geological formations. Ultramafic rocks are extensively exploited in open-cast mines because they are rich in metals such as nickel, chromium, and cobalt. The quality of water resources is vulnerable and does not always comply with the drinking water guidelines defined by the World Health Organization. For instance, concentrations of arsenic and chromium in the dissolved phase of water can exceed these standards. The quality of water resources is also threatened by the presence of suspended particulate matters (SPM) in river water, which can be enriched with potentially toxic elements (PTEs), such as metals or metalloids. The quantity of SPM in water depends on natural processes and human activities, such as erosion due to the semi-tropical climate, soil denudation caused by invasive species or fires, and mining activities. PTEs contained in SPM can be released in the dissolved phase of water. The physico-chemical conditions of the water, such as temperature, pH, and the amount of dissolved oxygen, as well as the chemical composition of SPM, directly affect the solid/liquid transfer of PTEs and these phenomena can deteriorate water quality. Available data on water quality typically pertains to the dissolved phase of water and mainly in ultramafic catchment areas. This project proposes an innovative approach that takes into account both the geological diversity of the island and the presence of SPM transported by river water. Our study aims to characterize the quality of surface water in New Caledonia from rivers that drain the two main geological formations: ultramafic and volcano-sedimentary substrates (particularly the volcano-sedimentary catchment areas which have received little attention to date). Reference concentrations in surface water will be determined for nickel, cobalt, chromium, iron, manganese, and arsenic. These data will be useful for differentiating natural background levels from anthropogenic contributions. The results will also serve to establish environmental quality standards specific to New Caledonia. This study will also examine PTE reactivity and more particularly their transfer from the particulate phase to the dissolved phase of water. The physico-chemical conditions that contribute to these solid/liquid transfers and subsequently, possible degradation of water resources, will be defined.

## The +

This innovative method will simplify sampling protocols. The preservation, storage and shipments of dried filters instead of liters of water will be easier (less heavy and bulky). The new development of laser ablation-ICPMS will allow rapid, quantitative and direct analyses of water particles collected on filters.

## What's next?

The project also aims to strengthen collaborative research with the University of Nouméa by proposing a simplified methodological approach to address an essential question of societal interest. The differentiation between the natural levels of contaminants (heavy metals) and the anthropogenic levels will lead to better regulation policies.

For more information click here 







© Christophe Den Auwer

# Threats on oceans and coastal areas

This chapter, addressing oceans and coastal issues, is linked to SDGs 14 and 15. It promotes the emergence of projects that identify various sources of pressures on oceans and coastal areas and that propose nature-based solutions. This theme brings together a total of 9 scientific projects: 2 Consortium projects and 7 First projects.

# MARE - Integrated management of marine resources, application to the Nice Marine Protected Area

“ The French Riviera coastal socio-ecosystems: towards sustainable management of marine resources. ”



Cécile Sabourault

## Academy 3 highlight

The MARE project brings together experts from many fields to analyze the “*interactions between human activities and Mediterranean marine ecosystems*” on the French Riviera. It provides new monitoring tools and data on both marine biodiversity and economic activities that should help to understand how this socio-ecosystem functions, and to move towards appropriate sustainable management of human activities, in the context of a new Marine Protected Area that will be created in the Bay of Nice.

## Scientific domains

Environmental Sciences  
Marine ecology

## Key words

Socio-ecosystems  
Marine Protected Areas  
Sustainable Management  
Marine Resources

## PI laboratory

ECOSEAS - Université Côte d’Azur, CNRS

## Partners

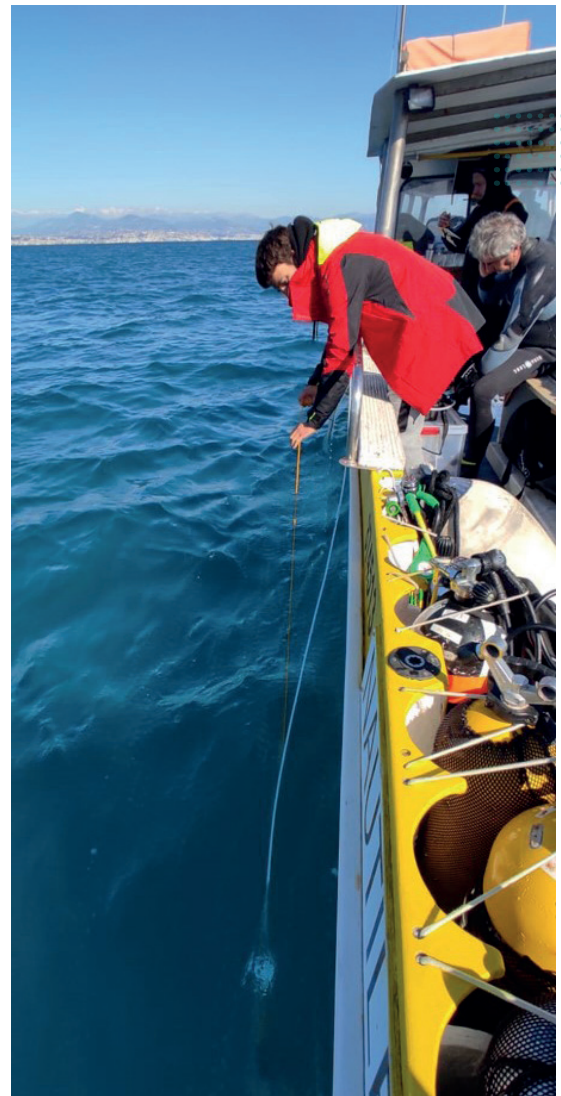
GREDEG - Université Côte d’Azur, CNRS  
ICN - Université Côte d’Azur, CNRS  
I3S - Université Côte d’Azur, CNRS, Inria  
LJAD - Université Côte d’Azur, CNRS  
LADIE - Université Côte d’Azur  
ITCA - Université Côte d’Azur  
UNA - Costa Rica  
COIBA AIP  
UniGe - Italie

## Total budget

€438,000, including €88,000 from Academy 3

## Start of the project

2022



# The project

The Mediterranean basin is one of the world's biodiversity hotspots, with numerous endemic marine species. However, the Mediterranean Sea is faced with long-standing and significant anthropogenic pressures and is threatened by global climate change. It is therefore of great importance to 1) study human-environment interactions (the coastal socio-ecosystem) and 2) protect marine biodiversity through the creation of Marine Protected Areas (MPAs). MPAs are delimited maritime areas that meet the objectives of protecting/restoring marine biodiversity and promoting the sustainable management of maritime activities (fishing, sustainable recreational and tourist activities, shipping). An MPA is thus a complex system and a living lab whose creation and monitoring necessarily require an integrated transdisciplinary approach. The Nice Côte d'Azur Metropole is engaged in the creation of a new MPA in the Bay of Nice and has invited experts from Université Côte d'Azur to participate. In this context, the MARE project aims at developing new monitoring tools and knowledge for local authorities and MPA managers.

The effectiveness and benefits of MPAs and their management are usually assessed using Underwater Visual Census (UVC) techniques (scuba-diving), which are costly in terms of human resources and time. In the first task of the project, we have developed new methodologies using environmental DNA (eDNA) metabarcoding and artificial intelligence to monitor fish communities inside and outside MPAs of the Northwestern Mediterranean Sea. The eDNA protocol involves sampling both surface and bottom seawater and enables the detection of numerous fish species. Analysis of videos from UVC is performed automatically with the help of a Deep Learning (DL) algorithm. Results demonstrate the efficiency of both eDNA and DL methods for monitoring marine coastal ecosystems, providing reliable complementary tools to traditional visual methods (UVC). We also investigated whether the metabolomic footprint could reflect the health of marine organisms, especially marine forests (macroalgae). The second task of the project was dedicated to developing new sustainable food resources, and to study acceptance and behavioral changes associated with them. This was done through surveys to measure people's willingness to modify certain eating habits, and the dual impact on both socioeconomic issues and biodiversity conservation. The third task of the project focuses on developing appropriate socioeconomic indicators to assess the effectiveness of the management of urban and non-urban MPAs. First, socioeconomic activities within the Nice coastal area were mapped to serve as baseline before creating the MPA. Socioeconomic monitoring will provide vital information on the distribution and intensity of potentially threatening activities within the MPA, as well as an evaluation of the economic costs and benefits of the MPA for different economic activities. Beside these surveys, the aim is to increase the participation and engagement of all stakeholders (commercial fishing, shipping traffic, whale-watching and recreational fishing, tourism) through constant dialogue and communication.

Overall, the outcomes of the MARE project are to facilitate the creation and improve the monitoring of urban MPAs (including Nice) and establish a management plan to promote the sustainable management of marine resources.

# How does the project contribute to transdisciplinarity ?



## International and European Law

LADIE

Researchers from LADIE are providing expertise in international and European laws pertaining to the sea and maritime activities, which is a critical field for Marine Protected Areas and how they are governed.



## Marine Ecology

ECOSEAS

ECOSEAS biologists are contributing to the Marine Protected Areas by working on the best available nature-based solutions.

## Tourism - ITCA

ITCA scientists will be analyzing tourism and leisure uses of the French Riviera using questionnaires and big data techniques.

## Chemistry - ICN

The health status of marine organisms is assessed in part by mapping the molecules they produce. These molecules are identified using analytical chemistry methods, thanks to the expertise of ICN researchers.

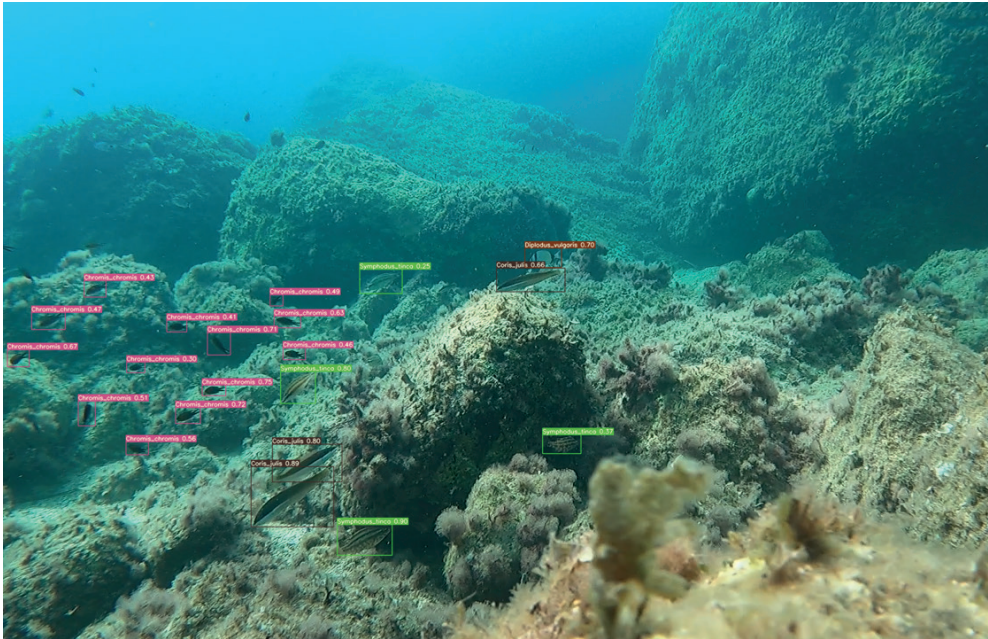
## Economics - GREDEG

The GREDEG team is examining behavioral change, focusing on adaptation strategies to face climate change, by combining qualitative and quantitative approaches. These methods are applied to the sustainable consumption of Mediterranean fish and to habit changes.

## Data mining - MAASAI-INRIA

Monitoring the health status of marine ecosystems, using techniques based on Artificial Intelligence. This is particularly the case for monitoring fish populations in Marine Protected Areas, for which a deep learning algorithm has been developed by the MAASAI team to recognize fish species.

MARE



Development of a new monitoring protocols to assess the biodiversity in Marine Protected Areas.

## The +

The MARE project addresses an important challenge in the current international context, which is to develop MPAs for at least 30% of the Ocean by 2030. The forthcoming UN Ocean Conference to be held in Nice will be an extraordinary opportunity to present the newly created French Riviera MPAs.

## What's next?

The MARE project has successfully launched pilot studies (eDNA, BiodivAI) and developed new methods that could be used by the National Biodiversity Strategy of the French Biodiversity Agency (Water Framework Directive). The project brings together scientists from different fields of expertise on the theme of coastal marine socio-ecosystems and will lead to other interdisciplinary research projects, such as new international collaborative projects with colleagues from Italy and Costa Rica.

For more information click here 

# BENTOX+ - The role of benthic communities in the production and transfer of marine microalgal toxins: environmental, health and economic considerations

“ A transdisciplinary “Ocean One Health” approach bridging marine biodiversity conservation, food safety, human health and wellbeing, and the blue economy to address harmful algal blooms in the Mediterranean Sea. ”

## Academy 3 highlight

The problem of harmful algal blooms in marine environments, especially those generating toxins, spans environmental concerns, human and animal health impacts, food safety threats, and socioeconomic repercussions. It falls within the scope of Threats to oceans and coastal areas (SDG 14), and also intersects with broader themes of “*anthropogenic health and environmental risks*” (SDG 2, 3, 13).

## Scientific domains

Ecotoxicology  
Chemistry  
Socioeconomics

## Key words

Biotoxins  
Food safety  
Blue Economy  
Biodiversity  
Sustainable development

## Laboratory PI

ECOSEAS - Université Côte d’Azur, CNRS  
ICN - Université Côte d’Azur, CNRS  
IRCAN - Université Côte d’Azur, CNRS, Inserm

## Partners

LOV – IMEV - CNRS, Sorbonne Université  
Centre Scientifique de Monaco  
Plan Bleu - UNEP  
Università di Genova

## Total budget

€214,000, including €104,000 from Academy 3

## Start of the project

2023



M-Yasmine  
Dechraoui  
Bottein



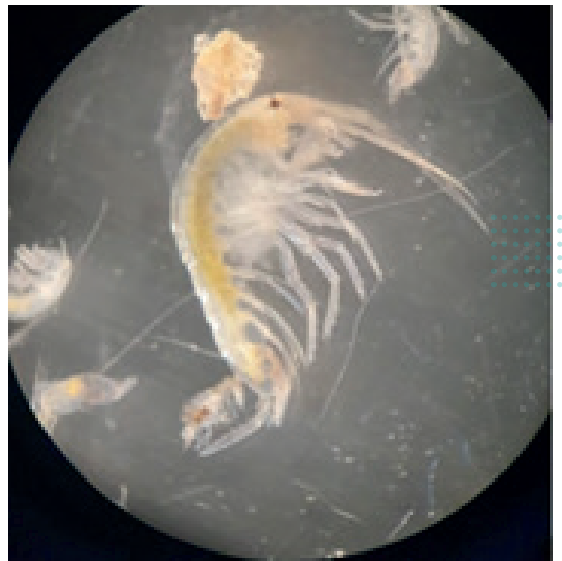
Maeva  
Dufies



Mohamed  
Mehiri



Gilles  
Pages



# The project

Countries worldwide are facing, directly or indirectly, issues with harmful algal blooms (HABs, naturally occurring proliferations of microscopic algae) that result in adverse effects on the environment as well as on animal and human health. Major HAB events lead to mass mortalities of marine organisms, aquaculture and fisheries closures, beach closures, food contamination with biotoxins above safety levels or human intoxications (IOC Global Harmful Algal Bloom Status Report, 2021), resulting in significant economic losses in the tourism, fishing and aquaculture sectors.

In the Mediterranean, HAB events have increased over the last 30 years, and those in benthic systems are particularly concerning. They mainly involve the toxic species *Ostreopsis cf. ovata*, which reappears every year, covering macroalgal communities and rocky shores and evolving into mucilaginous floating aggregates that can cause massive mortalities of marine organisms and human illnesses through skin contact and inhalation of aerosols. Additionally, other benthic species belonging to the genus *Gambierdiscus* are seen as emerging threats in the Mediterranean. Widespread in tropical coral reefs, these dinoflagellates produce potent neurotoxins that accumulate in fish and are responsible for ciguatera, the most common form of food poisoning from correctly preserved fish worldwide.

In both the Mediterranean and tropical coral reef areas, abrupt changes associated with global change (multiple stressors directly linked to climate and human activities, including coastal urbanization, tourism, overfishing, water quality, etc.) are leading to significant habitat deterioration (known as “regime shift”) and are suspected to play a significant role in the emergence and toxicity of toxic microalgae. In these deteriorated habitats, toxic benthic microalgae appear to thrive. However, the mechanisms and ecological conditions that foster cell growth, along with facilitating toxin production and transfer in these altered habitats remain to be elucidated.

The BENTOX+ project aims to establish a research program at UniCA to address these knowledge gaps. It adopts a “One Health” transdisciplinary approach, applied within the context of a Blue Economy. Our approach involves ecology, toxicology, ecotoxicology and chemistry, as well as socioeconomics, and fosters partnerships among scientists from different disciplines, intergovernmental agencies and program representatives, in addition to public health professionals and natural coastal managers.

More precisely, by exploring the ecological factors influencing toxic algae growth, assessing health risks, and estimating economic impacts, the project’s objectives are to enhance marine ecosystem understanding, develop management tools, and promote sustainable practices.

- **Ecology, Ecotoxicology, Chemistry:** Exploration of the enigmatic influence of marine benthic community assemblages on algal toxin dynamics. Assessing *Ostreopsis* toxin levels and effects along the food chain in preserved and degraded habitats, through sample extraction, metabolite analysis, and toxicity testing on laboratory animal and cellular models.
- **Toxicology:** Evaluation of seafood contamination and the resulting environmental and human health risks, through the establishment of a Mediterranean network on HABs and a review of available data on HAB and associated biotoxin occurrences.
- **Socioeconomic Evaluation:** Analysis of the economic cost of direct and indirect impacts of HABs.

# How does the project contribute to transdisciplinarity ?



## Socioeconomics

### Plan Bleu

Plan Bleu is promoting the conservation and sustainable management of marine and coastal resources in the Mediterranean, by providing scientific analysis and policy recommendations to governments and stakeholders.



## Toxicology

### IRCAN

Dedicated to research in cancer biology, the IRCAN team will provide the expertise to assess the toxicity of isolated metabolites using advanced in vitro methodologies.



## Ecotoxicology

### ECOSEAS

The ECOSEAS team is developing a deeper understanding of marine ecosystems, fostering their conservation and management within the context of sustainable development, while promoting awareness through communication and education.



## Chemistry - ICN

The ICN team specializes in researching natural compounds, investigating their properties and applications using mass spectrometry. Collaboration with IRCAN and ECOSEAS is essential for precise identification and toxicological characterization of isolated compounds.

**BENTOX+**



**Field sampling of harmful benthic algae using artificial substrate along the Côte d'Azur on the French Mediterranean coast.**

## The +

The project stands out by its transdisciplinary One Health methodology to address harmful algal blooms. It involves rigorous field and laboratory investigations with comprehensive socioeconomic analysis, and fosters partnerships between academics and stakeholders.

## What's next?

Once we have characterized benthic assemblages and identified key organisms introducing toxins to the food web of the Mediterranean Sea, we will then seek to transpose this approach to the Pacific region and develop models to better predict toxin transfer and better manage foodborne poisoning.

For more information [click here](#) 

# CORA(i)L - Revisiting coral health monitoring: from AI-based image recognition to next-generation reef monitoring

“ AI-based image recognition for next-generation monitoring of coral reef health. ”

## Academy 3 highlight

CORA(i)L is an ambitious, interdisciplinary, and international project that will change the approach used for coral reef health monitoring by providing “*new tools for coral reef conservation and restoration programs*” involving local communities and stakeholders.

## Scientific domains

Marine ecology  
Environmental Sciences

## Key words

Reef building coral ecophysiology  
Coral Reef health  
Artificial Intelligence  
Citizen Science Program  
Tourism

## PI laboratory

IRCAN - Université Côte d'Azur, CNRS, Inserm

## Partners

MSI - Université Côte d'Azur  
ITCA - Université Côte d'Azur  
URMIS - Université Côte d'Azur, Université Paris-Cité, CNRS, IRD  
CRIOBE – Université de Perpignan, CNRS, EPHE-PSL  
University of Papua  
Udayana University  
Kahi Kai  
Coral Triangle Center  
Misool Foundation

## Total budget

€97,500, including €47,500 from Academy 3

## Start of the project

2024



Eric  
Röttinger



Eric  
Gilson



# The project

Coral reefs are unique marine ecosystems, famous for their incredible diversity and undeniable beauty. Coral reefs are a key factor in tourism, and are exceptionally beneficial to humans and society as a source of high-protein food and therapeutic compounds useful for human health and well-being. However, coral reef ecosystems are in immediate danger due to climate change and anthropogenic activities. It is therefore imperative to adopt innovative scientific approaches and provide sustainable solutions to the challenges of coral preservation in the face of global change.

Coral health, like human health, is complex and multifactorial, making it difficult to describe it based on a single variable. Currently, a reference diagnosis of coral health is still lacking. WHO defines health as multifactorial and “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”. In addition, it has been proposed that age, culture, and personal potential, should be included in the definition of health. Taking all these elements into account and transposing it to coral colonies, we began to re-examine coral health as a multifactorial process considering environmental, physical, and social factors subdivided into nine attributes related to coral health that can be easily recognized in an image of a coral colony.

We designed a photo acquisition protocol and developed a large corpus of coral photos (13,000+) combining those taken during the Tara-Pacific expedition (2016-2018, and others taken since then in Moorea (French Polynesia), Papua Barat (Indonesia) and Raja Ampat Selatan (Indonesia). This dataset was used to develop, as part of an interdisciplinary and collaborative effort, an artificial intelligence (AI) tool that can detect in a matter of seconds the nine characteristics linked to the health of thousands of coral colonies. This method not only saves time and is non-invasive, but more importantly, the efficiency of this AI tool is comparable to the manual annotations carried out by two different annotators.

Now that we have formulated a multifactorial definition of coral health and developed a novel AI tool to extract health attributes from coral images, we are in a unique position not only to gain fundamental new insight into how global change affects the health of corals and coral reefs, but also to provide new opportunities for their rapid and (cost)-effective monitoring in the context of conservation and restoration actions.

With this in mind, CORA(i)L has set three specific goals:

- 1) Determine coral health trajectories in longitudinal studies by linking visual health attributes and molecular data to individual coral fate (bleaching, resilience, mortality) via the development of a database containing the AI-based tool for image analysis.
- 2) Determine whether combinations of health attributes from multiple coral colonies within a coral reef site can be used to diagnose its state (polluted, damaged, pristine, restoration, recreational diving). This will be done by acquiring site-specific transect images and subsequently analyzing them using AI.
- 3) Implement a citizen science program for real-time monitoring of coral reef health by launching a survey to determine the willingness of dive centers to participate in a pilot program that will be implemented in volunteer dive centers.

CORA(i)L is an ambitious, interdisciplinary project, based on innovative tools, that will change the approach used to determine the effects of global change/warming on coral health and will introduce new conservation and restoration programs involving local communities and stakeholders. A citizen science program is also being developed thanks to a database and web interface that allows coral colony photographs to be uploaded and automatically annotated by AI. Finally, as global change and the threat to coral reefs are a topical societal challenge, we have initiated, in collaboration with non-profits and NGOs, the development of outreach material (articles for the general public, photo exhibitions, games, etc.).

# How does the project contribute to transdisciplinarity ?



**URMIS**  
Expert in tourism practices, notably in Pacific regions. ITCA and the tourism faculty of the Udayana university (Denpasar, Bali, Indonesia) will closely collaborate in developing and analyzing the survey of dive tourists in Bali.



**IRCAN**

Expert in human health (EG), coral biology and physiology (ER & EG) but also in molecular and cellular biology (ER & EG).

## University of Papua (Indonesia)

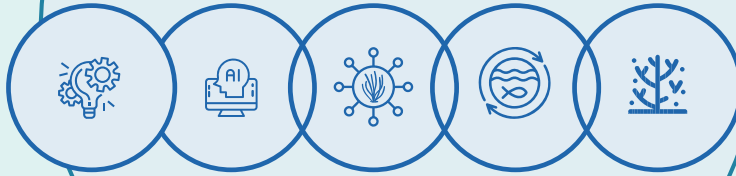
Expert in ecological connectivity, coral preservation and restoration. Will provide ecological, socioeconomic and sociocultural knowledge as well as logistic assistance for the field studies.

## Non-profit organization

Field work and outreach projects

## CRIOBE

Expert in coral ecophysiology, coral preservation and restoration. Will provide datasets that will be used for image extraction and AI analyses, is participating in field work and data interpretation.



**MSI**

Informatics and AI specialist. IRCAN & MSI have developed the AI tool that will be further developed and implemented in the proposed database and used for image analysis.

## Udayana University (Indonesia)

Expert in marine ecology and computation. Will provide ecological knowledge as well as logistic assistance for the field studies.



## Udayana University (Indonesia)

Will exchange with URMIS to develop and analyze the surveys of Balinese dive centers and to study the possibility of transferring the CORA(i)L model.

# CORA(i)L



Field work in Misool, Raja Ampat (Indonesia) for the CORA(i)L project.

## The +

CORA(i)L is an ambitious, interdisciplinary, and international project combining academic and non-profit partners that will change the approach for monitoring coral health and provide new tools for conservation and restoration programs involving local communities and stakeholders.

## What's next?

The project has only recently been funded, but its ultimate goal is twofold: 1) to gain an up-to-date and fundamental understanding of coral and coral reef health; and 2) to develop a next-generation citizen science reef monitoring program to obtain real-time data that can be used for reef preservation, restoration and management.

For more information click here 



# AC-DC - Accretion-controlled deformation cycles along the Hellenic subduction zone

“ Plate tectonics remains full of secrets: the AC-DC project aims to unravel the secrets hidden in Greek rocks from the past. ”

## Academy 3 highlight

Field and laboratory outcomes from the AC-DC project will shed light on the “*threat of the hidden, and often overlooked, basal-accretion process,*” which contributes to the tectonic and topographic signals being monitored daily along a large number of active subduction zones worldwide.

## Scientific domains

Earth Sciences  
Marine Geosciences

## Key words

Tectonics  
Petrology  
Subduction  
Metamorphism

## PI laboratory

Géoazur - Université Côte d'Azur, CNRS, OCA, IRD

## Partners

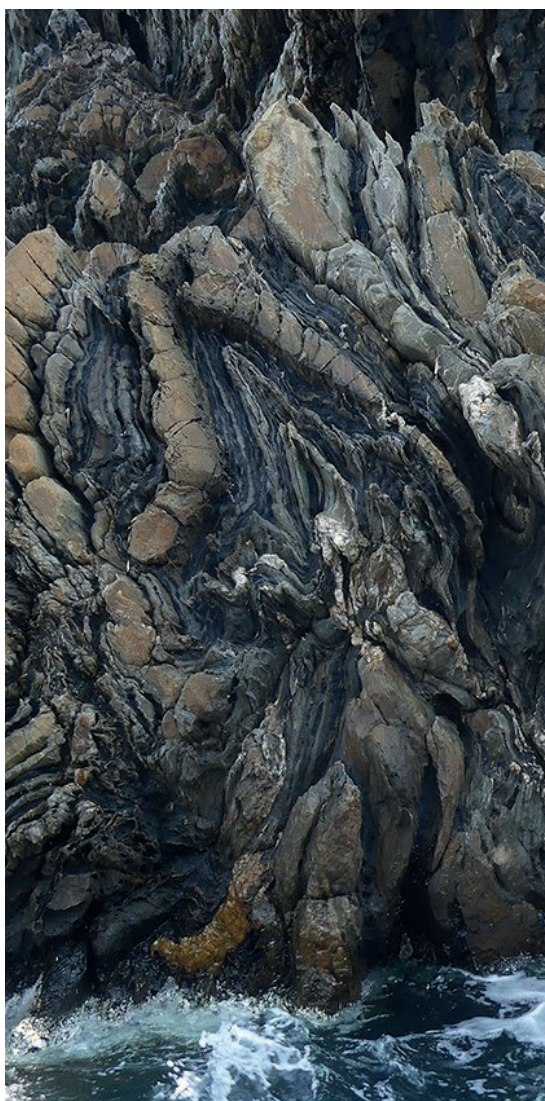
ISTeP - Sorbonne Université, CNRS  
LGL-TPE - UCNL, ENS de Lyon, UJM, CNRS  
GFZ Potsdam  
University of Athens

## Total budget

€6,988 from Academy 3



Armel Menant



# The project

At the interfaces of tectonic plates, and more precisely in subduction zones where one lithosphere sinks below another, rocks move and undergo deformations that can generate very large earthquakes. These events are intimately linked to the mechanical coupling of the plate interface and is linked to the nature and the quantity of material buried under the Earth's mantle.

The AC-DC project aims to unravel the dynamics of these huge mass fluxes by determining the succession of deep accretion events at convergent margins, through a reconstruction of the tectonic and metamorphic history of the rocks that crop out in the Neapoli region in Greece. This little-studied area in southern Peloponnese is a key zone where basal accretion processes are suspected to be still active at depth, making this area an ideal target to link past and present times. The exposed high-pressure/low-temperature metamorphic rocks, which rose vertically to the surface after plunging to a depth of 50 km over 20 million years ago, provide valuable evidence of fossil deformation and the pressure and temperature conditions that characterize the deep interface of subduction zones.

Armel Menant and a master's student went out into the field to identify, map and sample these rocks (also called "metasediments") for in-depth analysis in the laboratory. By studying the wealth of history imbued in these rocks (deformation, structure, mineral transformations, etc.), the aim is to gain a complete picture of the periodic occurrence of deep mass transfer events. These key constraints on the deep subduction dynamics at long timescales pave the way for investigating their consequences on our environment at shorter timescales (seismic hazard, evolution of coastal zones).

Thin sections of the rocks are still being studied and will soon reveal all their secrets.

## The +

The Southern Peloponnese is one of the few places on Earth where underground phenomena between two converging plates can be investigated through the study of exceptionally preserved rocks brought vertically to the surface without a significant deformation overprint.

## What's next?

The project has now been awarded funding to allow a PhD student to continue studying the rocks and attempt to identify the timing and depth of deformation. A digital reproduction of the lateral evolution of the rocks via 3D modeling is planned. This will enable better visualization of lateral variations of mass fluxes in relation to crustal and mantelic processes governing the geodynamic evolution of this subduction zone.

For more information click here 

# COREXPLORE - Development of innovative marine invertebrate culture systems for functional experimentation on stress response and the impact of the marine environment on human health

“ Innovative functional exploration of corals to decipher the biological impact of environmental changes. ”

## Academy 3 highlight

COREXPLORE provides an innovative means to determine, at the molecular level, the “effect of climate change, threats on corals and marine organisms,” that is, observing the origin of the phenomena. These data also serve as baseline for assessing the impact of global changes, including anthropogenic hazards, on the marine environment and on human health, that is, understanding the process at a mechanistic level.

## Scientific domains

Marine ecology  
Environmental Sciences

## Key words

Experimental platform  
Cnidarians  
Corals  
Climate change  
Telomere analysis

## PI laboratory

IRCAN - Université Côte d’Azur, CNRS, Inserm

## Total budget

€8,000 from Academy 3



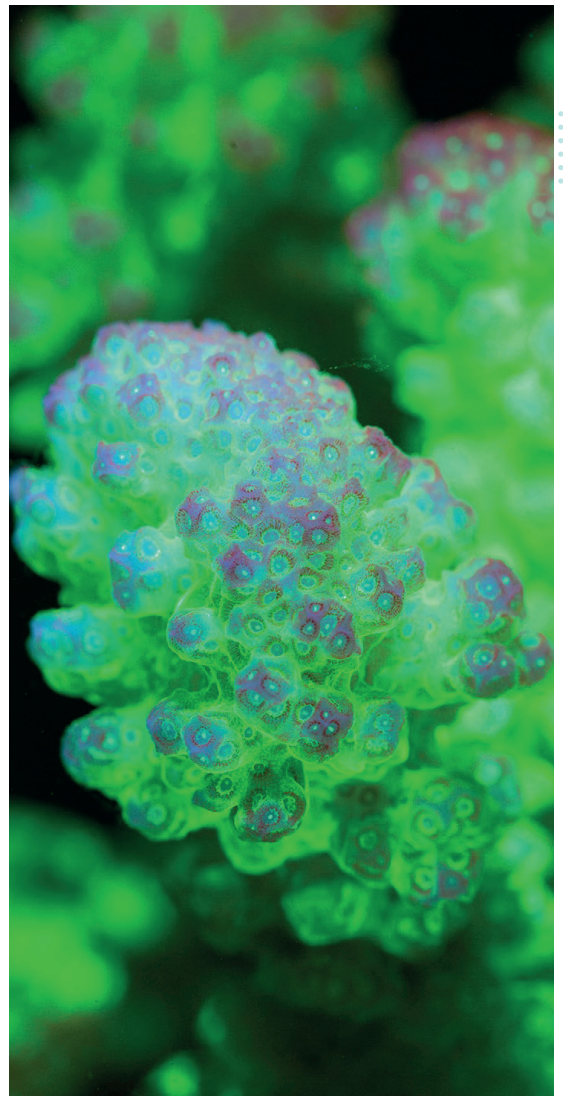
Eric  
Röttinger



Aldine  
Amiel



Eric  
Gilson



# The project

The first, core technical objective of the project was the implementation of new experimental equipment in a marine invertebrate facility, ANTIAGE. Overcoming the technical challenges of controlling temperature conditions in various large-volume marine aquariums that share the same water circuit was a primary goal of the project.

The second, scientific objective was to perform controlled heat-stress experiments on corals to assess their effects on telomere length (TL). Telomeres are the extremities of linear chromosomes that are essential to maintain genome stability, control cellular homeostasis and determine disease susceptibility. While telomere-length variation has been mostly associated with the aging process in humans, a few studies in mammalian animals have shown that deviations from the optimal temperature can also change telomere length. It is well known that heat waves can have major consequences for corals, inducing a bleaching event during which photo-symbiotic algae are expelled by the animal, eventually leading to its death. Interestingly, our analyses of the reef coral sampled across the Pacific Ocean during the Tara-Pacific expedition suggest that the way telomeres are regulated by seasonal temperature is different between two coral species that share the same habitat but diverge in their longevity and stress resistance: the short-lived, stress-sensitive branched coral *Pocillopora* spp and the long-lived, stress-resistant massive coral *Porites* spp. While the TL appears longer in higher temperatures for *Pocillopora* spp, no correlation between TL and temperature was observed in *Porites* spp.

In order to test the effects of thermal variations on TL under laboratory conditions, we acclimatized *Porites* and *Pocillopora* coral colonies in the maintenance system of the facility for several weeks, then transferred them into the experimental system. The conditions used were defined by the range of temperatures measured during the Tara-Pacific expedition and mimicking cold (20°C, 23°C), normal (26°C) and warm (30°C) conditions. The first results obtained from this experiment show a trend towards longer TL after one month in the high temperature aquarium (30°C) for *Pocillopora* colonies as was observed across the Pacific for this type of coral.

## The +

We were able to 1) further develop and improve a unique marine invertebrate facility for functional exploration of stress resistance and longevity of cnidarians (corals, sea anemones) and 2) validate under laboratory conditions, observations made in the field at the Pacific Ocean scale.

## What's next?

Combining the wealth of data obtained from the Tara-Pacific expedition, not only on TL but also other -omics data, with the data obtained from the laboratory experiments and from another cnidarian system that is suitable for genetic functional exploration within the ANTIAGE facility, the next step of the project will be to decipher the molecular mechanisms that drive the telomere-temperature relationship in cnidarians (corals, sea anemones).

For more information click here 



# DEEP\_BLUE - Diving to understand the Mediterranean's largest tsunamigenic earthquake of the twentieth century: the 1956 Amorgos earthquake, in Greece

“ On the trail of past great tsunamis: Study off the coast of Greece to understand the origin of the Amorgos earthquake and its tsunami. ”

## Academy 3 highlight

This project intends to better understand the “*seismic and tsunami hazards of the Eastern Mediterranean*” by shedding light on one of the largest seismic and tsunami events of the past two centuries.

## Scientific domains

Earth Sciences  
Seismic Risks  
Marine Geosciences

## Key words

Tsunami  
Earthquake  
Telluric hazard  
Underwater geomorphology  
Submarine Faults

## PI laboratory

Géoazur - Université Côte d'Azur, CNRS, OCA, IRD

## Partners

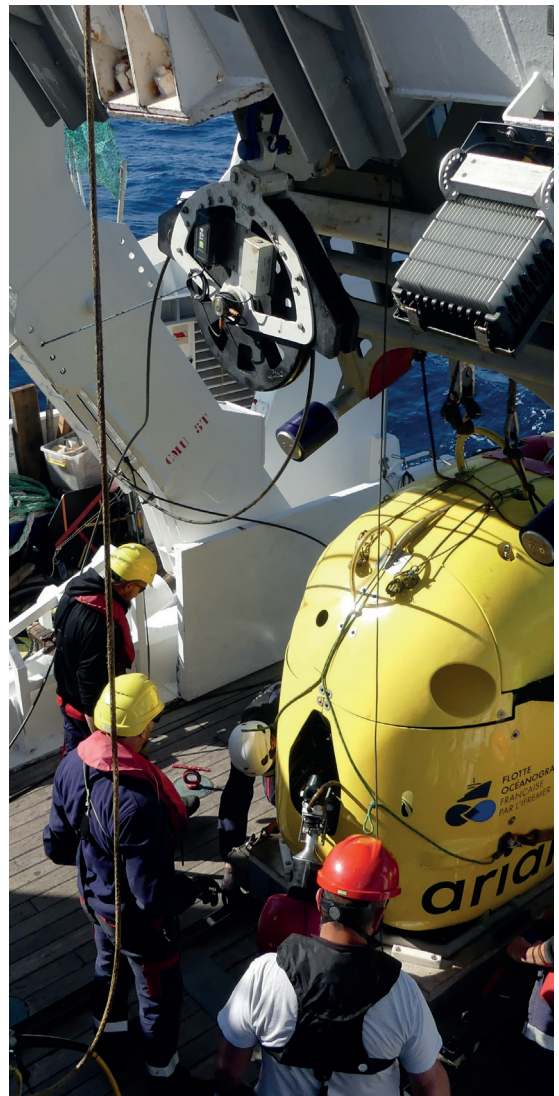
ENS-PSL  
IPGP - Université Paris-Cité  
EPOC - Université de Bordeaux, CNRS, Bordeaux INP, EPHE - PSL  
National and Kapadostrian University of Athens  
University of Girona

## Total budget

€48,000, including €7,000 from Academy 3



Frédérique  
Leclerc



# The project

Based on current knowledge, we can identify four main phenomena that trigger tsunamis: the occurrence of an earthquake along a submarine fault (the most common cause), an underwater volcanic eruption, an underwater landslide, or, very rarely, the fall of a meteorite. While European historical records mention the occurrence of large tsunamis and detail their impacts on Mediterranean civilizations, the causes of many of them are still unknown. Today, the development of underwater vehicles allows us to research the sources of these tsunamis by observing the seafloor.

A study, conducted by the team from 2013 to 2017 on the fault responsible for the 2004 Saintes tsunami in the Caribbean, highlighted long-lasting traces of past underwater deformation generated by fault slip. While traces of seismic events occurring on land disappear rapidly due to erosion, deformation of the seabed persists longer. It is therefore possible to observe old deformations on the seabed, and thus determine the source of historical tsunamis. The DEEP\_BLUE project stems from this observation.

This project aims to understand one of the largest European earthquakes in the last two centuries. On July 9, 1956, off Greece's coast between Santorini and Amorgos, an earthquake greater than magnitude 7 caused the twentieth century's largest tsunami in the Mediterranean Sea. Seismometers were scarce, leading to uncertainty in localizing the quake and fault. Identifying this fault is crucial for assessing seismic and tsunami risks in this tourist region, which hosts more than two million visitors each year.

Previous studies identified three potentially ruptured faults near the earthquake's epicenter. But the characteristics of the tsunami waves, which spread to the Turkish and mainland Greek coasts, suggested there were multiple triggers: seafloor movements generated by fault slip during the earthquake and large underwater landslides.

Two missions conducted on the Research Vessel Europe (French Oceanographic Fleet) shed light on these events. During the AMORGOS-22 cruise, a submarine was used to acquire very fine bathymetric data of the three faults, which are essential for identifying ruptures and escarpments on the seafloor. In 2023, the AMORGOS-23 mission, supported by DEEP\_BLUE, conducted seven dives with an HROV (Hybrid Remotely Operated Vehicle) equipped with cameras, aiming to observe the seabed and find traces of these events.

Observations confirmed that one of these faults did indeed recently slip. Since the HROV has a limited field of vision, the video data was subsequently processed by photogrammetry to reconstruct in 3D the outcrops that show evidence of this recent seabed rupture. The slip could be quantified and corresponds to a deformation of about ten metres. Sediment cores were also sampled by the HROV to confirm the age of this rupture and to associate these deformations with the 1956 earthquake. This discovery thus challenges the hypothesis that two sources are needed to generate the tsunami, in favor of a single massive underwater rupture of the fault, which could have generated the observed waves.

## The +

The results of the two oceanographic campaigns, supported by the DEEP\_BLUE project, confirmed that in certain contexts underwater terrains evolve very slowly, thereby making them excellent environments in which to trace the origins of large tsunamis dating back several decades.

## What's next?

Tsunami simulations based on the results obtained will help dispel doubts about the real cause of this extreme event. Research in paleoseismology and the use of new tools in this field could provide a better understanding of tsunami hazard and risk in the Mediterranean. The ANR AMORGOS project, proposed as a continuation of DEEP\_BLUE, will address these issues.

For more information click here 



# MARFOR-SPOT - Applying new technologies in combination with traditional field mapping to assess the conservation status of marine forests in the French Riviera's last biodiversity hotspot

“ What's left in the last hotspot of marine forest in the French Riviera? ”

## Academy 3 highlight

MarFor-SPOT will *"increase current knowledge of the ecological status of marine forests"* and will allow us to detect and better understand the effects of anthropogenic and natural stressors threatening this essential coastal habitat.

## Scientific domains

Marine ecology  
Environmental Sciences

## Key words

Mediterranean Marine forests  
Conservation  
Aerial surveys  
Anthropogenic and natural stressors  
Microalgal forest conservation

## PI laboratory

ECOSEAS - Université Côte d'Azur, CNRS

## Partners

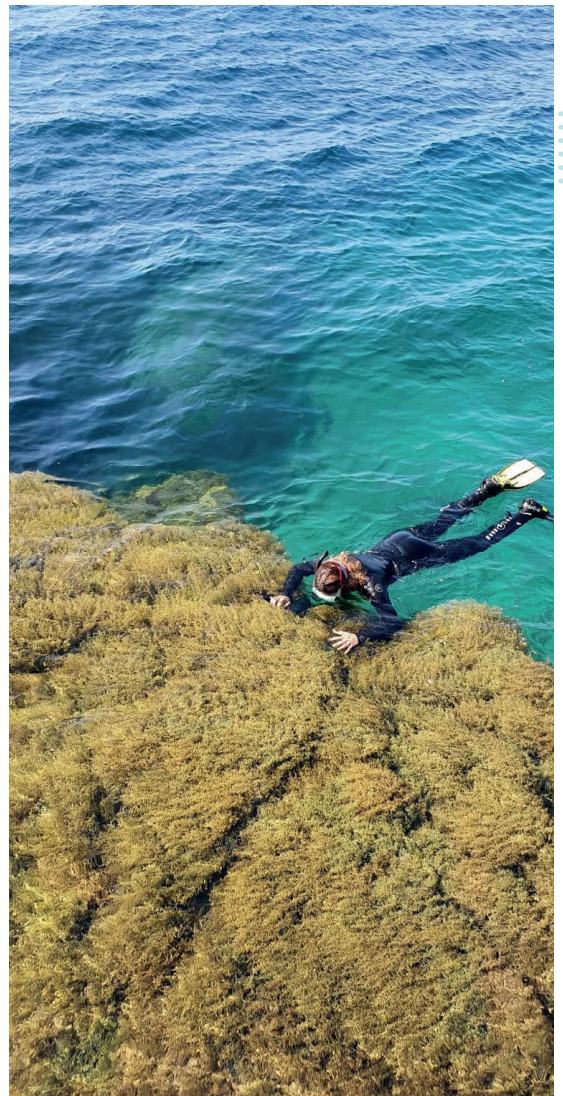
CEAB-CSIC  
CoNISMa

## Total budget

€5,876 from Academy 3



Jana Verdura



# The project

MarFor-SPOT is a project focused on the conservation of macroalgal forests, key marine ecosystems. Macroalgal forests of *Cystoseira sensu lato* are some of the most productive and biodiverse ecosystems in the Mediterranean Sea. For this reason, most *Cystoseira* species have been included in different conservation priority lists. Due to anthropogenic and natural stressors, such as pollution, habitat destruction and climate change, marine forests have been largely lost or have been poorly preserved in many areas of the Mediterranean Sea, including the French Riviera. However, their distribution, ecology, conservation status, and the stressors potentially affecting them are still poorly known. In recent decades, severe decline of *Cystoseira* species has been reported in the French Riviera. In 2022, we mapped the shallow *Cystoseira* populations along the coastline of Saint Honorat Island, (Natura2000 Site). We found 13 *Cystoseira* species, highlighting that Saint Honorat is an unexpected biodiversity hotspot in the French Riviera, a highly urbanized region. Some of the species were not previously documented and can no longer be found in other parts of the region. We combined traditional visual census with aerial surveys (drones), to obtain high-resolution georeferenced images that will be used for future monitoring of these important habitats. Drawing on this data, MarFor-SPOT aims at 1) improving the existing distributional and ecological data, 2) evaluating the effects of anthropogenic stressors, and 3) providing management tools for conservation and restoration actions based on new technologies. As performed in Saint Honorat, detailed traditional visual census and aerial surveys will be performed in Saint Marguerite Island and the continental zones of Cap d'Antibes and Cap Ferrat (two different Natura2000 Sites), to provide an accurate baseline map of *Cystoseira* distribution and conservation status. Given the Mediterranean Sea's vulnerability to climate change, temperature loggers will be deployed in some populations to assess the effects of climate change.

Results obtained in MarFor-SPOT will provide important information on the distribution of *Cystoseira* species (mapping), their conservation status (anthropogenic stressors) and their sensitivity to climate change (temperature loggers). All this information will represent a baseline for setting up long-term monitoring that will allow a better understanding of the effects of anthropogenic stressors on these essential coastal habitats. The interdisciplinary nature of this project lies in its combination of biology, ecology, geospatial science, traditional methodologies, and new technologies, which allows for a comprehensive approach to study Mediterranean biodiversity and its response to various stressors.

## The +

The project allowed us to map shallow *Cystoseira sensu lato* populations. It provided aerial and georeferenced images of the most ecologically relevant populations in addition to seawater temperatures (hourly records) for the most ecologically relevant populations.

## What's next?

MarFor-SPOT will provide ecological and cartographic information (collected in GIS software) that can be included in a national observation network and databases. This information will represent a baseline for setting up long-term monitoring of the ecological status of the studied habitats. These surveys are crucial to detect and understand population changes driven by current and future hazards and thus to design strategies for optimal management and conservation.

For more information click here 

# SUPER-MOUV - Deformation and fluid circulation associated with the Pedernales earthquake

“ Improving understanding of the relationship between fluid circulation and the occurrence of big earthquakes. ”



François Michaud

## Academy 3 highlight

Our project brings together geologists, geophysicists and geochemists to contribute to the “*understanding of natural hazards in Ecuador (earthquakes and submarine landslides)*” and highlight their potential impacts on environments, cities and societies.

## Scientific domains

Earth Sciences  
Seismic Risks  
Marine Geosciences

## Key words

Earthquake  
Fluids  
Education  
Subduction  
Natural hazards

## PI laboratory

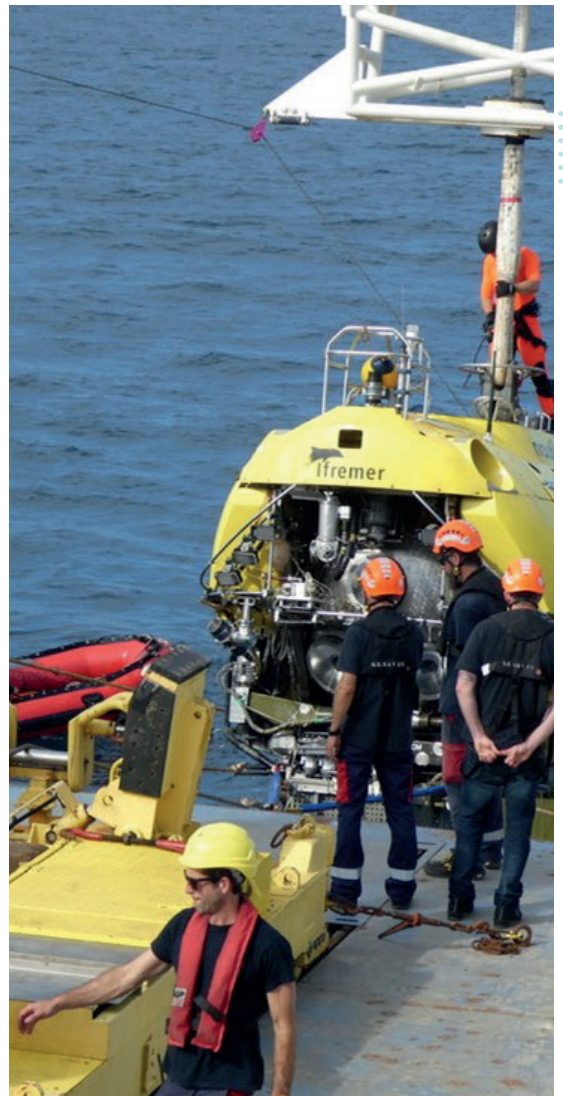
Géoazur - Université Côte d’Azur, CNRS, OCA, IRD

## Partners

ISTeP - Sorbonne Université, CNRS  
IMEV - CNRS, Sorbonne Université  
Ifremer  
GET - CNRS, IRD, UPS, CNES  
Grande Chancellerie de la Légion d’honneur  
EPN Ecuador  
INOCAR Ecuador

## Total budget

€127,000, including €7,000 from Academy 3



# The project

In April 2016, a magnitude Mw 7.8 earthquake occurred on the subduction fault offshore Pedernales in Ecuador and caused hundreds of fatalities and millions of dollars in damage. The Ecuadorian coastline is subject to a high seismic hazard, with earthquakes of magnitude greater than 7 affecting an increasingly populated coastline.

Previously, the only recorded seismic event of this magnitude was in 1979, before the deployment of the Ecuadorian seismological network. The terrestrial observations (GPS, seismometers, accelerometers) of the Pedernales earthquake and its aftershocks provided unprecedented detail and highlighted mechanisms of strain accumulation and release that were much more complex than predicted by simple seismic cycle models. For example, geodetical observations showed the existence of aseismic slip (not felt by the population) on the edge of the area affected by seismic slip.

The SUPER-MOUV (Sub-seafloor effects of the Pedernales Earthquake Rupture, Ecuador and associated vertical MOUVements) project is based on data acquired during a marine campaign. During this cruise (January– February 2024) we collected subsurface data with the Research Vessel Pourquoi Pas? and the submarine Nautile: multibeam bathymetry, sediment cores, heat flux measurements, seafloor observations and fluid sampling. These data will enable us to correlate the deformation, fluid seepage distribution, heat-flow anomalies and origin depth of fluids with lateral variations in the slip mode (seismic versus aseismic) and aftershock distribution. The findings should answer questions such as: Are there any correlations between areas affected by different slip modes and particular characteristics of the fault contact (geometry, fluid overpressure) or of the upper plate (degree of fracturing, fluid migration, local modification of heat flux)? Are the changes in slip mode reflected in the deformation of the seafloor, the sedimentary instabilities and the nature and location of fluid seepage?

In addition, marine biologists will investigate the composition of fluid seepages in the Ecuadorian subduction zone and their potential influence on local marine fauna.

During the marine campaign, a secondary school teacher on board the research vessel led discussions and exchanges with classes, thereby establishing a link between research and secondary school teaching. Videoconferences were organized to give pupils the chance to talk to researchers, find out what life is like on board a research vessel, discover the jobs involved and learn about the issues involved in recycling waste on board a ship.

## The +

One of the objectives of the SUPER campaign was to characterize and sample the distribution of fluid vents on the seafloor in order to understand their role in the slip modes of the Ecuador subduction fault and their effect on local marine fauna. The project is the continuation of the HIPER campaign which imaged these fluids at depth. During the campaign, secondary school students were able to observe the scientific operations with the support of a teacher.

## What's next?

The results of this project may contribute to the debate on the possibility of monitoring fluid seepage along subduction zones. It will be essential in the future to measure the geophysical, geochemical and biological parameters of oceanic ridges on a continuous basis.

For more information click here 

# PEEWAN - Deciphering the deep-marine sedimentary archive of past extreme events east of Taiwan

“ An oceanographic cruise collected seafloor data that will help understand the occurrence and cyclic nature of extreme typhoons, earthquakes and tsunamis offshore Taiwan. ”

## Academy 3 highlight

This marine sedimentological and geophysical exploration aims at reconstructing the time series of extreme telluric and climatic events occurring on- and offshore Taiwan. The forthcoming results have strong implications for *“limiting the natural hazards on coastal societies”*.

## Scientific domains

Earth Sciences  
Seismic Risk  
Marine Geosciences

## Key words

Paleo-seismology  
Earthquake  
Typhoon  
Tsunami  
Turbidite

## PI laboratory

Géoazur - Université Côte d'Azur, CNRS, OCA, IRD

## Partners

Geo-Ocean – CNRS, Ifremer, UBO, UBS  
National Central University

## Total budget

€6,940 from Academy 3



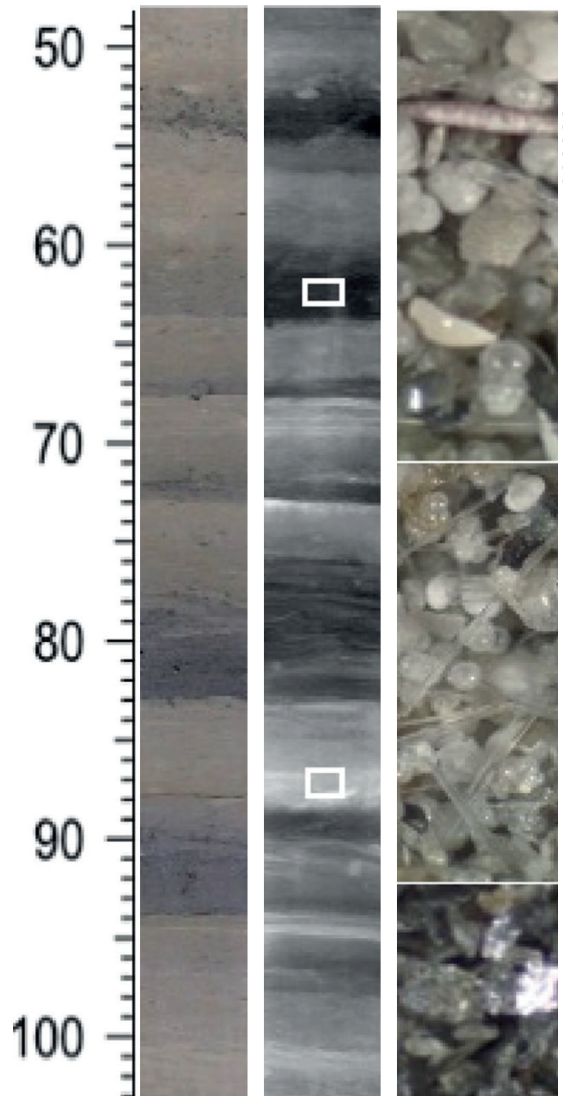
Gueorgui Ratzov



Marie Revel



Cédric Turel



# The project

The island of Taiwan is located in a unique geodynamical context characterized by intense seismicity, with over 23 earthquakes of magnitude  $M_w > 7$  in the last century, onshore or offshore. Additionally, Taiwan's climate is mainly influenced by the East Asian monsoon, which plays a dominant role in local rainfall. Directly located within "Typhoon Alley", Taiwan is impacted by three to four typhoons each year. These events generate heavy and potentially devastating rainfalls and landslides. For instance, 2,700 mm of rainfall accumulated in 24 hours during typhoon Morakot in 2008 (compared with ~600mm during Storm Alex in 2020 in Roya and Tinée, one of the biggest historical events in France).

By definition, extreme events are rare, and instrumental and historical records are too limited. It is therefore essential to establish time series of several thousands of years (or more), first, to constrain the recurrence and intensity of such events; second, to better understand the factors that control them in the long term; and third, ultimately draw up predictive models of these natural hazards and improve the prevention of the associated risks.

Deciphering the geological record is thus necessary to establish long time series. Due to the high level of erosion on the island, the geological traces of these events on land are limited or incomplete. In contrast, in the marine realm, where deposition prevails, traces of such events are very well preserved. Catastrophic events generate submarine landslides and turbidity currents whose deposits (turbidites) contrast with the slow background sedimentation; they are identifiable and datable by marine sedimentary cores. Detailed analysis of the sedimentary sequences and their contents can be used to trace the source areas, and to discriminate between triggering factors such as large earthquakes, tsunami wave washout, or exceptional floods caused by typhoons.

## The +

The project used a transdisciplinary approach that involved studying both natural hazards and threats to the oceans and coastal areas.

## What's next?

After the preliminary results were obtained, the opportunity was given to our UniCA PhD student to spend two months conducting research in the Taiwanese partner lab. Depending on the final results, we will discuss the possibility of submitting a bilateral ANR PRCI proposal.

For more information click here 



# PROMAB - Profiling marine biofilms

“ Unveiling the secret lives of microorganisms and their impact on ocean ecosystems through a revolutionary look at marine biofilms. ”

## Academy 3 highlight

This project contributes to the “*conservation and sustainable use of oceans, seas and marine resources*” for sustainable development. It aims at considering urgent measures to combat climate change and its impacts and ensure the availability and sustainable management of water and better monitoring of wastewater treatment.

## Scientific domains

Environmental Sciences  
Marine ecology  
Engineering

## Key words

Marine ecosystems  
Biofilm diversity  
Bioindicators  
Ecological quality  
Ecotoxicology

## PI laboratory

ECOSEAS - *Université Côte d'Azur, CNRS*

## Partners

ICN - *Université Côte d'Azur, CNRS*  
IMREDD - *Université Côte d'Azur*

## Total budget

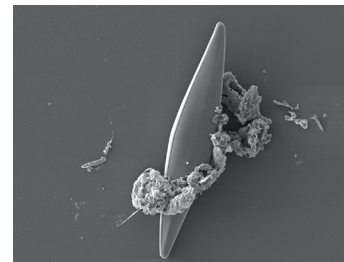
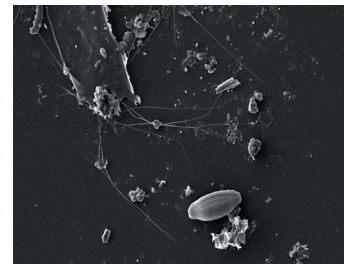
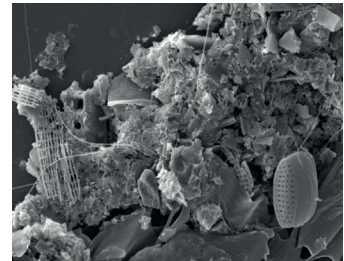
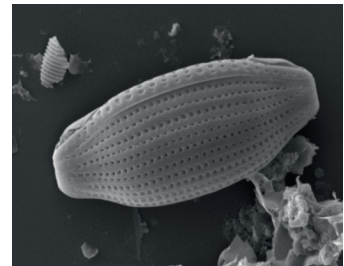
€6,900 from Academy 3



Christine  
Risso



Cécile  
Sabourault



# The project

Marine biofilms are widespread in the marine environment, and the microbial diversity in these biofilms is substantially higher than previously believed. Recent studies indicate that 40 to 80% of all living bacteria and archaea on Earth form biofilms. Notably, both biotic surfaces, including animals, and abiotic surfaces immersed in seawater can become rapidly colonized by microorganisms in less than a day. Biofilms also develop at the seafloor interface and at the sea surface. These marine biofilms include a wide variety of microorganisms, such as bacteria, archaea, diatoms, fungi, unicellular and multicellular eukaryotes, viruses and extracellular vesicles. Biofilms serve as living substrates for successive colonization by multicellular eukaryotes, and they are, therefore, key elements in the development of marine trophic networks. Marine biofilms often play essential ecological roles in ecosystems. They can produce diverse bioactive compounds to adapt to changing environmental conditions. These chemical cues can influence biofilm formation, assembly and maturation, consequently determining whether biofilms promote or inhibit the recruitment of marine larvae. Microorganisms within natural marine biofilms also engage in complex social interactions. Cooperative behaviors give biofilm microorganisms advantages over their free-living counterparts, while competition plays a vital role in shaping the community structure. For example, the release of antibiotics and toxins is a common strategy for competing microbial species. A better understanding of how environmental changes affect microbial community structures and biofilm functions, and how biofilms influence the initial colonization of marine benthos will provide critical knowledge about the interaction between the environment, biofilms, benthic ecosystems, fish health and fish communities. The first step and main objective of the PROMAB project is to characterize biofilm formation using 3D-printed Autonomous Reef Monitoring Structures (ARMS). Marine microbial diversity and the functional role of microorganisms (profiling of microbial proteome) within benthic biofilms have been assessed by shotgun proteomics. The kinetics of biofilm formation has been studied on two different sites of Côte d'Azur shores: one within the Port Canto in Cannes (exposed to anthropogenic activities) and one within the Lérins Marine Protected Area ("pristine" conditions). Scientific experiments have been conducted by ECOSEAS, in collaboration with the 3D printing platform (IMREDD) and the microscopy platform (CCMA). Identification of microorganisms has been carried out by proteotyping using tandem mass spectrometry

## The +

The main strength of the PROMAB project lies in its comprehensive approach to understanding marine biofilms and their ecological significance, both through innovative methodologies and interdisciplinary collaboration. Furthermore, by studying the kinetics of biofilm formation in two contrasting environments PROMAB should provide insights into the interaction between marine biofilms, environmental factors and benthic ecosystems.

## What's next?

The expected results will be used to submit a proposal for an ANR grant as part of a broader project encompassing the study of ecosystems and fish-associated microbiota. This project will be launched with UniCA partners (ICN and IMREDD), national partners (PSL) and international partners (UniGe and UNITO).

For more information click here 





© Christophe, Den Auwer

## Scientific events

In addition to research projects, the Academy promotes various scientific events and workshops. Organised by the Academy itself, thematic days and fall seminars, once per year, are leading the Academy's dissemination policy with a strong emphasis on transdisciplinarity.

# Thematic Day n°1 : RISKS, RESILIENCE, SOCIETY



## Academy 3 highlight

Co-organized by Academy 3 and the French National Research Institute for Sustainable Development (IRD) at Parc Phoenix in Nice, this day brought together experts from various backgrounds and gathered more than 70 people to discuss major societal issues.

## Date and location

December 3, 2021, 9 am to 12 pm – Nice

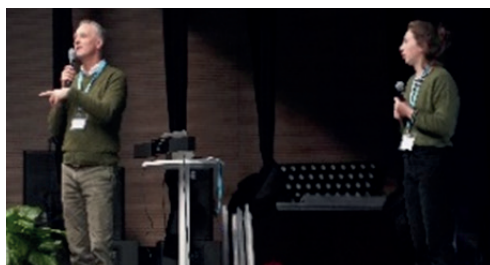
## Scientific domains

Economy · Ecology · Chemistry · Physics · Social sciences · Geography · Health

## The program

- Migration and environment: a complex reality – Flore Gubert (LEDA - IRD)
- The role of climate change and deforestation in the emergence of infectious diseases – Rodolphe Gozlan (ISEM - IRD)
- Risks and benefits of water on a uranium territory; the need to cross knowledge – Gilles Montavon (Subatech - IMT Atlantique)
- Soil erosion and sediment connectivity in the Anthropocene – Olivier Cerdan (BRGM)
- Spatial imaging: examples of applications – Gwendoline Blanchet (Cnes)
- What opportunities are there for the environmental sciences to integrate the concept of sustainability? – Olivier Dangles (CEFE - IRD)

# Thematic Day n°2 : HYDROSPHERE



## Academy 3 highlight

Researchers, students, and university staff were able to discuss the hydrosphere, a fundamental area of sustainability. The various presentations addressed the Hydrosphere in all its forms, raising awareness of the issues associated with it, and showing the key role that education plays in its protection.

## Date and location

January 30, 2023, 9 am to 5 pm – Nice

## Scientific domains

Geography · Economy · Marine Ecology · Glaciology · Law

## The program

- The Mediterranean as an area of cooperation: the Plan Bleu's action – François Guerquin (Plan Bleu – UNEP)
- Water landscapes: from representations to perception – Adèle Beaufiles (GEOLAB, Université de Limoges)
- Maritime spaces and interfaces – Eric Rottinger and Christophe Mocquet (IFR MARRES, Université Côte d'Azur)
- For mountain glaciers, every tenth of a degree counts – Fabien Maussion (ACINN – Université d'Innsbruck)
- Influence of climate change on mountain water resources in the Andes and Alps – Thomas Condom (Climat-Cryosphère-Hydrosphère - IGE, IRD)
- Legal approach: Thoughts on the legal status of the clouds – Grégoire Leray (CERDP - Université Côte d'Azur)

# Thematic Day n°3 : EXPOSURE & POLLUTION

UNIVERSITÉ  
CÔTE D'AZUR

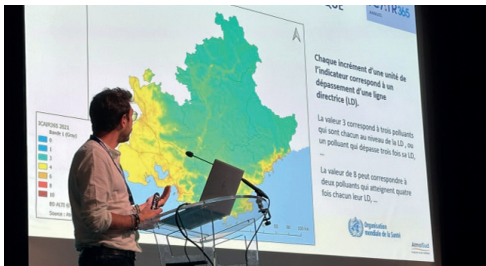


Institut de Recherche  
pour le Développement  
FRANCE

JOURNÉE THÉMATIQUE  
de l'Académie "Espace, Environnement, Risques et Résilience"

## EXPOSITION & POLLUTION

27 Mai 2024  
Parc Phoenix, Nice



### Academy 3 highlight

The Academy 3 scientific community gathered to discuss the themes of exposure and pollution in all its forms. The day brought together 80 participants, including experts who came to share their knowledge at the event.

### Date and location

May 27, 2024, 9 am to 4 pm – Nice

### Scientific domains

Biology · Health · Environmental Chemistry ·  
Sociology · Ecology · Risk

## The program

- The exposome - Definition and issues – Bruno Le Bizec (Exposome France, Laberca – ONIRIS, INRAE)
- Fukushima reconstruction policy – Cécile Asanuma-Brice (Mitate Lab - CNRS Japan)
- Cadmium transfer from soil to agricultural plants and its impact on health – Géraldine Sarret (ISTerre – Université Grenoble Alpes, IRD)
- Marine pollution and health – Hervé Raps (CSM)
- Air pollution: measuring exposure – Sonia Dagnino TIRO-MATOs - Université Côte d'Azur, CEA) and Maithé Rosier (AtmoSud – Région Sud Provence-Alpes-Côte d'Azur)

# First Opening Seminar – 2023



## Academy 3 highlight

The seminar featured contributions from four leading researchers in fields related to the Academy's themes, with a focus on transdisciplinarity. The seminar welcomed 80 participants and the presentations gave rise to a lively exchange between the audience and the speakers.

## Date and location

October 13, 2023, 9 am to 12 pm – Nice

## Scientific domains

Economy · Biology · Oceanography · Health · Law

## The program

- Biodiversity negotiations - wilderness and biotechnologies – Catherine Aubertin (IRD)
- Early exposure to air pollution, co-exposures, and child development – Johanna Lepeule (IAB, Université Grenoble Alpes)
- When underwater volcanoes create oases of life in ocean deserts and sequester CO<sub>2</sub> – Sophie Bonnet (MIO, IRD)
- Conference of the Parties on climate Change: role and workings – Julien Dellaux and Jean-Christophe Martin (LADIE, Université Côte d'Azur)

# Second Opening Seminar – 2024



## Academy 3 highlight

Our annual interdisciplinary seminar brought together earth sciences, chemistry and geoengineering. The event was interspersed with poetic interludes on the themes of environment and ocean: a good way to introduce our 70 participants to the idea of bringing together scientific fields and mixing science with art.

## Date and location

September 27, 2024, 9 am to 12 pm – Nice

## Scientific domains

Education · Geoengineering · Energy · Ocean · Poetry

## The program

- Involving secondary school students in an oceanographic campaign – Faustine Gendron (Maison d'Éducation de la Légion d'Honneur)
- Geoengineering: beliefs, promises and risks of climate change – Marine De Guglielmo Weber (IRSEM)
- Electrochemical energy storage and batteries: implications for the ecological transition – Lorenzo Stievano (ICGM)
- Poetry and Environment interludes : 'Bain de mer' - Lou Nils (La Poémerie)

## R3C - Second Radiochemistry Radiation Meeting

### Event summary

In 2022, the Human and Environmental Radiochemistry group of the Nice Institute of Chemistry (ICN) organized the Second French Radiochemistry Radiation Meeting (R3C). The Radiochemistry Radiation Meeting brought together approximately one hundred participants from academic and industrial laboratories involved in nuclear activities in France.

### Date and location

From August 31 to September 2, 2022 - Nice

### Scientific domains

Chemistry · Radiochemistry

### PI and laboratory

Gaëlle CREFF, Aurélie JEANSON  
ICN - Université Côte d'Azur, CNRS

### Academy 3 contribution

€600 from Academy 3

**R<sup>3</sup>C 2022** Institut de Chimie de Nice  
**2<sup>es</sup> Rencontres Rayonnement Radio-Chimie**  
31 Août-2 Septembre 2022  
Parc Phoenix, Nice

Contact et inscriptions :  
R3C-organisation@univ-cotedazur.fr  
<https://r3c-nice2022.cnrs.fr/>

ICN Institut de Chimie de Nice  
<https://r3c-nice2022.cnrs.fr/>

Events supported by the Academy

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## UNESCO - Sound Week – 2023

### Event summary

UNESCO Sound Week was held in January 2023 around five sound-related themes with a cross-disciplinary approach. Its aim was to encourage medical, scientific and societal research into sound and health through a week of conferences, workshops and artistic performances. This event takes place every year in several cities in France.

### Date and location

From January 16 to 29, 2023 – Nice

### Scientific domains

Biology · Humanities

### PI and laboratory

Renaud DAVID  
CHU de Nice - Université Côte d'Azur

### Academy 3 contribution

€2,700 from Academy 3

**LA SEMAINE DU SON DE L'UNESCO**  
20<sup>ème</sup> édition | SAVOIR ÉCOUTER, SAVOIR SE PARLER  
DU 16 AU 29 JANVIER 2023  
PARTOUT EN FRANCE

CHU de Nice  
<https://www.lasemaineduson.org/>

## BAW - Brain Awareness Week 2023

### Event summary

The aim of this international event was to raise public awareness of the importance of brain research. It was an opportunity for numerous researchers to meet the public, share with them the advances made in neuroscience research laboratories, and present the issues relating to our knowledge of the brain and the implications for our society.

### Date and location

From March 13 to 19, 2023 – Nice

### Scientific domains

Biology · Neurosciences

### PI and laboratory

Carole ROVERE

IPMC - Université Côte d'Azur, CNRS, Inserm

### Academy 3 contribution

€700 from Academy 3



<https://www.semaineducerveau.fr/>

## MOMI 2023 & MOMI 2024 - The World of Industrial Mathematics

### Event summary

MOMI is a two-day workshop on applied and industrial mathematics. The focus in 2023 was on the Smart Environment and in 2024 on Models and Modeling. These two events were organized to allow young researchers to discover the link between the industrial world and applied mathematics and become familiar with approaches used and the companies involved. The events were mainly aimed at and conducted by PhD students

### Date and location

From April 3 to 4, 2023 and from April 8 to 9, 2024 – Sophia-Antipolis

### Scientific domains

Mathematics · Informatics

### PI and laboratory

Bernard SANDOUNO and Haydar JAMMOUL

INRIA - Sophia-Antipolis

### Academy 3 contribution

€2,000 from Academy 3



<https://phd-seminars-sam.inria.fr/momi2023-le-monde-des-mathematiques-industrielles-smart-environment/>

# Ecological transition, sustainable and responsible consumption 2022 – Anthropocene, Collapsology & Environmental Justice 2023 – Nature’s new challenges for responsible consumption 2024

## Event summary

Over the three editions of this workshop, discussions focused on the new challenges of nature for responsible consumption. The various speakers approached this theme through the prism of their own areas of expertise, such as economy, sociology or ecology. The multidisciplinary nature of the days stimulated debate on ecology collapse, responsible consumption of food and energy and even on our emotions linked to these problems.

## Date and location

June 8, 2022; June 16, 2023; and June 27 to 28, 2024 – Nice

## Scientific domains

Economics and management sciences · Political Sciences and law · Humanities · Environmental sciences for agriculture

## PI and laboratories

Damien BAZIN  
GREDEG – Université Côte d’Azur, CNRS ;  
Mantiaba COULIBALY  
GRM - Université Côte d’Azur

## Academy 3 contribution

€3,500 from Academy 3



<https://mshs.univ-cotedazur.fr/workshop-nature-et-emotions>

## MACF - The Carbon Border Adjustment Mechanism

## Event summary

This scientific day analyzed the Carbon Border Adjustment Mechanism, a new European Union legal instrument that will help implement the Paris Agreement on the European continent, from the perspective of legal experts and economists. The scientific ambition of this initiative was twofold: first, to clarify how this particularly complex mechanism works, and second, to put the mechanism into perspective within the European and international legal systems.

## Date and location

June 16, 2023 – Nice

## Scientific domains

Political Sciences and Law

## PI and laboratory

Nicolas PIGEON  
LADIE - Université Côte d’Azur

## Academy 3 contribution

€2,000 from Academy 3



<https://mshs.univ-cotedazur.fr/journee-detude-mecanisme-europeen-dajustement-carbone-aux-frontieres>

# MARALEX - Maralpine watersheds in the face of change: Storm Alex, climate change and anthropogenic pressures

## Event summary

A group of 50 participants criss-crossed the mountainous watersheds of the Alpes-Maritimes and Mercantour to understand the hydro-climatological processes that led to the devastating damage caused by Storm Alex in October 2020. The discussions explored the specific features of the hydro-sedimentary context of southern Alps watersheds and highlighted the wealth of partnerships and development initiatives being carried out in the region.

## Date and location

From July 11 to 13, 2023 – Vésubie and Roya valleys, Alpes-Maritimes

## Scientific domains

Humanities, Earth and Space Sciences

## PI and laboratory

Margot CHAPUIS  
ESPACE - *Université Côte d'Azur, CNRS, AMU, AU*

## Academy 3 contribution

€3,000 from Academy 3



<https://umrespace.hypotheses.org/3128>

# ISMEC - International Symposium on Thermodynamics of Metal Complexes

## Event summary

ISMEC is the annual congress of the International Group for the Thermodynamics of Metal Complexes, an open group in which researchers meet freely to share ideas and perspectives, and promote research and best practices in the field of thermodynamics of metal complexes. The scientific program focused on the most recent advances in thermodynamics and kinetics of coordination processes, covering the fields of analytical, biomedical, environmental, inorganic and physical chemistry.

## Date and location

June 10 to 13, 2024 – Nice

## Scientific domains

Radiochemistry

## PI and laboratory

Maria-Rosa BECCIA  
ICN - *Université Côte d'Azur, CNRS*

## Academy 3 contribution

€2,000 from Academy 3



<https://ismec2024.sciencesconf.org/>

## Summit meetings - the Mercantour and climate change

### Event summary

These meetings aimed to raise public awareness of the issues surrounding climate change in our region, and more specifically in the Mercantour mountain range. They involved two days of immersive hikes in the Mercantour mountains, and included meetings between the public, researchers and mountain specialists, who shared their knowledge of climate change and its impact on the environment.

### Date and location

June 7 to 8, 2024 – Estenc

### Scientific domains

Earth and Environmental Sciences, Geology

### PI and laboratory

Philippe CHARVIS

Géoazur - Université Côte d'Azur, CNRS, OCA, IRD

### Academy 3 contribution

€1,900 from Academy 3



## SNE2024 - 46<sup>th</sup> Symposium of the Neuroendocrinology Society

### Event summary

The aim of this international event was to raise public awareness of the importance of neuroscience and, in particular, neuroendocrinology research. It was an opportunity for numerous researchers from France and Canada to meet the public, with plenary lectures given by well-known experts, symposia on recent advances in the field, and oral and poster sessions dedicated mainly to young researchers.

### Date and location

September 16 to 19, 2024 – Nice

### Scientific domains

Biology, Neuroendocrinology

### PI and laboratory

Carole Rovere

IPMC - Université Côte d'Azur, CNRS, Inserm

### Academy 3 contribution

€1,000 from Academy 3



<https://www.sne2024nice.com/>

# DIRECTORY Laboratories

| Acronym               | Laboratory Name'  |
|-----------------------|---|
| AgroParisTech         | AgroParisTech - <i>Université Paris Saclay</i>  |
| AGROSCOPE             | AGROSCOPE - <i>Confédération Suisse</i>   |
| ANSES                 | Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail  |
| ArchAm                | Archéologie des Amériques - <i>CNRS, Université Paris 1 Panthéon-Sorbonne</i>   |
| BABEL                 | Langages, Littératures, Civilisations et Sociétés - <i>Université de Toulon</i>   |
| Benephyt              | Plateforme pour la biodiversité du Grand Est  |
| C3M                   | Mediterranean Center for Molecular Medicine - <i>Université Côte d'Azur, Inserm</i>   |
| CARF                  | Communauté d'agglomération de la Riviera française  |
| CBGP                  | Centre de Biologie pour la Gestion des Populations - <i>INRAE, Cirad, IRD, Institut Agro Montpellier</i>  |
| CCMA                  | Joint Center for Applied Microscopy - <i>Université Côte d'Azur</i>   |
| CEAB-CSIC             | Centre d'Estudis Avançats de Blanes - Consejo Superior de Investigaciones Científicas, Madrid   |
| CEFE                  | Centre d'Ecologie Fonctionnelle et Evolutive - <i>Université de Montpellier, CNRS, EPHE, IRD</i>  |
| CEMCA                 | Center for Mexican and Central American Studies - Mexico  |
| CEMEF                 | Centre de Mise En Forme de Matériaux - <i>Mines-Paris, CNRS</i>   |
| CEPAM                 | Culture and Environment, Prehistory, Antiquity and the Middle Ages - <i>Université Côte d'Azur, CNRS</i>  |
| CERD                  | Centre d'étude et des Recherches de Djibouti  |
| Cerema                | Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement   |
| CHU de Nice           | Nice University Hospital - <i>Université Côte d'Azur</i>  |
| CIAS                  | Center for Integrated Agricultural Systems - <i>University of Wisconsin, Madison</i>  |
| CIHEM BARI            | Centre International de Hautes Etudes Méditerranéennes de Bari  |
| CIRAD                 | Centre de coopération Internationale en Recherche Agronomique pour le Développement   |
| CoBTek                | Cognition Behavior Technology - <i>Université Côte d'Azur, INRIA</i>  |
| COIBA AIP             | Coiba Scientific Station - Panama   |
| CoNISMa               | Consorzio Nazionale Interuniversitario per le Scienze del Mare  |
| Coral Triangle Center | Coral Triangle Center - Non Profit Organisation   |
| CRHEA                 | Research Center for Heteroepitaxy and its Applications - <i>Université Côte d'Azur, CNRS</i>  |
| CRIOBE                | Centre de Recherches Insulaires et Observatoire de l'Environnement - <i>CNRS, Université de Perpignan Via Domitia, Ecole Pratique des Hautes Etudes d'Université Paris Sciences &amp; Lettres</i> |
| CSM                   | Centre Scientifique de Monaco   |
| EBI                   | Écologie et Biologie des Interactions - <i>Université de Poitiers, CNRS</i>   |
| ECOSEAS               | Ecology and Conservation Science for Sustainable Seas - <i>Université Côte d'Azur, CNRS</i>   |
| ECOSYS                | Écologie fonctionnelle et écotoxicologie des agroécosystèmes - <i>INRAE, AgroParisTech, Université Paris-Saclay</i>   |
| ENS                   | École Normale Supérieure - <i>Université Paris Sciences &amp; Lettres</i>   |
| EPN                   | Escuela Politécnica Nacional - Ecuador  |
| EPOC                  | Environnements et Paléoenvironnements Océaniques et Continentaux - <i>Université de Bordeaux, CNRS, Ecole Pratique des Hautes Etudes, Institut Polytechnique de Bordeaux</i>                      |
| ESPACE                | Laboratory for the Study of Spatial Structures, Adaptation Processes and Changes - <i>Université Côte d'Azur, CNRS, AMU, AU</i>   |
| EURECOM               | École d'ingénieur - Sophia-Antipolis  |
| EXPANSE Project       | European research project on the Urban Exposome   |
| Géoazur               | Géoazur - <i>Université Côte d'Azur, CNRS, OCA, IRD</i>   |
| Geo-Ocean             | Geo-Ocean - <i>CNRS, Ifremer, Université de Bretagne Occidentale, Université Bretagne Sud</i>   |
| GeoRessources         | GeoRessources - <i>Université de Lorraine</i>   |
| GET                   | Géosciences Environnement Toulouse - <i>CNRS, IRD, Université Toulouse III Paul Sabatier, CNES</i>  |
| GREDEG                | Research Group in Law, Economics, and Management - <i>Université Côte d'Azur, CNRS</i>  |

# DIRECTORY Laboratories

| Acronym           | Laboratory Name'   |
|-------------------|--|
| GRM               | Management Research Group - <i>Université Côte d'Azur</i>  |
| I3S               | Sophia Antipolis Laboratory for Computer Science, Signals and Systems - <i>Université Côte d'Azur, CNRS, Inria</i>   |
| IBV               | Valrose Institute of Biology - <i>Université Côte d'Azur, CNRS, Inserm</i>   |
| ICGM              | Institut Charles Gerhardt Montpellier  |
| ICN               | Nice Institute of Chemistry - <i>Université Côte d'Azur, CNRS</i>  |
| IMEV              | Institut de la Mer de Villefranche - <i>CNRS, Sorbonne Université</i>  |
| IMREDD            | Mediterranean Institute of Risk, Environment and Sustainable Development - <i>Université Côte d'Azur</i>   |
| IMT               | Institut Mines-Télécom - <i>Mines Alès</i>   |
| INGEMMET          | Instituto Geológico, Minero y Metalúrgico - Peru   |
| INOCAR            | Ecuadoran Oceanographic Institute of the Naval Forces  |
| INPHYNI           | Nice Institute of Physics - <i>Université Côte d'Azur, CNRS</i>  |
| INRIA             | National Institute for Research in Digital Science and Technology - Sophia-Antipolis   |
| Institut Cochin   | Institut Cochin - <i>Inserm, CNRS, Université Paris-Cité</i>   |
| Institut Pasteur  | Institut Pasteur - Paris   |
| IPGP              | Institut de physique du globe de Paris - <i>Université Paris-Cité</i>  |
| IPMC              | Institute of Molecular and Cellular Pharmacology - <i>Université Côte d'Azur, CNRS, Inserm</i>   |
| IPREM             | Institut des sciences analytiques et de physico-chimie pour l'environnement et les matériaux - <i>CNRS, Université de Pau et des Pays de l'Adour</i>                                   |
| IRCAN             | Institute for Research on Cancer and Aging in Nice - <i>Université Côte d'Azur, CNRS, Inserm</i>   |
| IRD               | French National Research Institute for Sustainable Development   |
| IRSEM             | Institut de Recherche Stratégique de l'Ecole Militaire   |
| ISA               | Sophia Agrobiotech Institute - <i>Université Côte d'Azur, CNRS, INRAE</i>  |
| ISAGA             | International Simulation and Gaming Association  |
| ISEA              | Institut des Sciences Exactes et Appliquées - <i>Université de Nouvelle-Calédonie, Nouméa</i>  |
| ISTeP             | Institut des Sciences de la Terre de Paris - <i>Sorbonne Université, CNRS</i>  |
| ISTerre           | Institut des Sciences de la Terre - <i>CNRS, UGA, USMB, IRD, UGE</i>   |
| ITCA              | Institut du Tourisme Côte d'Azur - <i>Université Côte d'Azur</i>   |
| Kahi Kai          | Kahi Kai-Connect the ocean - <i>Non Profit Organisation</i>  |
| LADIE             | Laboratory of International and European Law - <i>Université Côte d'Azur</i>   |
| LAPCOS            | Laboratory of Anthropology, Cognition and Social Psychology - <i>Université Côte d'Azur</i>  |
| LGL-TPE           | Laboratoire de Géologie de Lyon - Terre Planètes Environnement - <i>Université Claude Bernard Lyon 1, Ecole Normale Supérieure de Lyon, Université Jean Monnet Saint-Étienne, CNRS</i> |
| LJAD              | Jean Alexandre Dieudonné Laboratory - <i>Université Côte d'Azur, CNRS</i>  |
| LOV-IMEV          | Laboratoire d'Océanographie de Villefranche - <i>Institut de la Mer de Villefranche - CNRS, Sorbonne Université</i>  |
| Misool Foundation | Misool Foundation - Indonesia  |
| MSHE              | Maison des Sciences de l'Homme et de l'Environnement Claude-Nicolas Ledoux - <i>CNRS, Université Bourgogne Franche-Comté</i>   |
| MSI               | Center for Modeling, Simulation and Interactions - <i>Université Côte d'Azur</i>   |
| OCA               | Côte d'Azur Observatory - <i>Université Côte d'Azur</i>  |
| OFB               | Office Français de la Biodiversité   |
| OTECCA            | Observatory for Socio-Ecological Transition on the Côte d'Azur - <i>Université Côte d'Azur</i>   |
| PKDerm            | PKDerm - Grasse BIOTECH  |

# DIRECTORY Laboratories

| Acronym    | Laboratory Name'  |
|------------|---|
| Plan Bleu  | Observatoire de l'Environnement et du Développement Durable - Centre d'Activités Régionales du Plan d'Action pour la Méditerranée du Programme des Nations Unies pour l'Environnement |
| PSH        | Plantes et Systèmes de culture Horticoles - INRAE   |
| RETINES    | Risks, Epidemiology, Territories, Information, Education And Health - Université Côte d'Azur  |
| SAD-APT    | Science Action Développement - Activités Produits Territoires - INRAE, AgroParisTech, Université Paris-Saclay   |
| SKEMA      | SKEMA Business School - Sophia-Antipolis  |
| SMIAGE     | Syndicat Mixte pour les Inondations, l'Aménagement et la Gestion de l'Eau maralpin  |
| The Florey | The Florey Institute of Neuroscience and Mental Health - Australia  |
| TIRO-MATOs | Carriers, Imaging And Radiotherapy In Oncology - Biological Mechanisms Of Bone Tissue Alterations - Université Côte d'Azur, CEA   |
| UR2CA      | Côte d'Azur Clinical Research Unit - Université Côte d'Azur, CHU de Nice  |
| URMIS      | Migration and Society Research Unit - Université Côte d'Azur, Université Paris-Cité, CNRS, IRD  |
| WATCHFROG  | Laboratoire indépendant dédié à l'identification des perturbateurs endocriniens - France  |



## **Partner universities**

### **Cameroon**

University of Yaoundé I

### **Costa Rica**

Universidad Nacional de Costa Rica (UNA)

### **Ethiopia**

University of Addis Ababa

### **Egypt**

Alexandria University

### **France**

Université Bourgogne Franche-Comté

Université Bretagne Sud

Université Claude Bernard Lyon 1

Université de Bordeaux

Université de Bretagne Occidentale

Université de Lorraine

Université de Montpellier

Université de Nouvelle-Calédonie

Université de Pau et des Pays de l'Adour

Université de Perpignan Via Domitia

Université de Poitiers

Université de Toulon

Université Jean Monnet Saint-Étienne

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### **Malta**

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Université Cadi Ayyad

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Initiative d'Excellence

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All other national organisations



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