

ANNUAL REPORT 2024

Project name: In situ monitoring of water quality in Cuban bays: creating and promoting the use of scientific tools

Project — In situ monitoring of water quality in Cuban bays: creating and promoting the use of scientific tools

Participating institutions

- University of Havana (UH)
- Université Libre de Bruxelles (Belgium)

Cooperating institutions

- Center for Environmental Research and Transport Management (CIMAB)
- ESPOLETA Tecnologías (SME)

Other collaborating institutions

- José Antonio Echeverría Technological University of Havana (Cujae)
- Geocuba
- Havana Bay State Management Group
- Université Catholique de Louvain (Belgium)

Project coordinators

Cuban side: Dr. C. Ernesto Altshuler Álvarez

Foreign side: Dr. Denis Terwagne

Participants — Dr. Geydis Fundora Nevot, Dr. Florence Degavre, Dr. Stamatios Nicolis, Dr. Alexandre Campo, MSc. Lázaro Martínez Ortiz, Eng. Alex Rivera Rivera, MSc. Luis Abel Rodríguez de Torner, Dr. Aramis Rivera Denis, Eng. Orestes Chávez Linares.

Duration — Five years

General objective — To provide the Cuban scientific-social ecosystem with a set of tools that enables in situ monitoring of water-quality parameters in Cuban bays, in a sustainable way and connected to local communities.

Specific objectives

- Design and build a wave channel at the Faculty of Physics, UH
- Design and build a buoy prototype
- Set up a server with a website to receive data from the buoys and from the community
- Train the corresponding human resources

Fulfillment of the tasks planned for the project's first year



Fig. 1 — Fab Academy students of the Université Libre de Bruxelles (ULB), first semester of 2024.



Fig. 2 — Prototype of an "autonomous" buoy built by project participants, fitted with sensors and capable of wireless communication via the LoRa protocol.

PhD students Eng. Alex Manuel Rivera Rivera and MSc. Luis Abel Rodríguez De Torner had the opportunity to take part in their first academic stay at the Université Libre de Bruxelles during the January–June 2024 period, where they attended the international "Fab Academy" course. This program focuses on digital fabrication and prototype design, giving students the tools needed to carry out innovative projects. As a result of their training — and after successfully passing all of the course's credits — both students developed and defended their final-project prototypes. Eng. Alex Manuel Rivera Rivera presented a weather buoy, a device designed to measure and record meteorological data in real time, contributing to the collection of information crucial for bay studies. MSc. Luis Abel Rodríguez de Torner, meanwhile, worked on building a small wave channel that simulates sea conditions and allows the study of wave behavior; this channel serves as a prototype for the larger one to be built at the University of Havana under the project. The experience in Brussels gave them a solid foundation to continue their studies and contribute to advancing knowledge in engineering and meteorology within the goals of the ARES project.

After the Cuban PhD candidates returned from the Fab Academy, they continued working intensively on developing the buoy. Efforts specifically focused on optimizing the stability and reliability of the wireless communication link, as well as improving the buoy's energy efficiency to gain greater autonomy. To address this challenge, several strategies were implemented, such as adjustments to the buoy's physical design to improve its flotation system, aiming to minimize unwanted movement that could affect data collection. On the wireless-communication side, extensive tests were run to ensure data transmission remains constant and secure — essential not only for real-time monitoring but also to ensure the collected data stays accessible without interruption; different libraries and manufacturers are being explored that could offer greater resistance to external interference and a stable connection even under adverse conditions. Energy efficiency is another fundamental pillar in the buoy's development; to maximize autonomy, different energy sources are being evaluated, including renewable options such as solar panels.

Following an initial visit to Geocuba (coordinated through engineer José A. Amado-Ojito), the buoys currently used in Havana Bay were examined and evaluated. It was concluded that the best strategy is for our monitoring system to be attached to those existing buoys, taking advantage of their appropriate size, their seabed-anchoring system, and the fact that they are authorized, operational devices. This has been a strategic decision of great importance that should notably ease the implementation of the project's objectives.



Fig. 3a — Group photo of the workshop "Introducing scientific tools for the in situ monitoring of water quality in

Cuban bays" (UH, March 12, 2024).



Fig. 3b — Group photo of the workshop "Coordinating the first in situ trials of smart buoys" ("Espoleta Tecnologías," November 20, 2024).

Over the course of the year, two workshops associated with the project were held, as planned. The first took place on March 12, 2024 at the University of Havana, and the second on November 20, 2024 at the SME "Espoleta Tecnologías." The first was attended by all parties involved on the Cuban side: members of the University of Havana, of "Espoleta Tecnologías," of Geocuba, of the "Havana Bay" State Group, of bay pilots, of representatives from several Havana Bay communities, of CIMAB members, and others. That workshop featured broad presentations on the project's objectives and modes of collaboration between institutions, which allowed for valuable coordination. The second workshop, by contrast, brought together a smaller representation of the institutions involved, since its purpose was to pin down the place and time for the first action of installing sensors, solar cells, and a LoRa transmitter on one of the buoys actually in service in Havana Bay.

A varied range of outreach work associated with the project was also carried out during the year. For example, an extensive feature on the activities carried out in 2024 was presented on the program "Observatorio Científico," broadcast on Cuban TV for the first time on August 7, 2024, featuring two of the PhD students as well as Dr. Geydis Fundora, of FLACSO (University of Havana). Also during 2024, both Luis Abel and Alex supervised the work of teams of pre-university students during the "2024 Summer School" organized by the Faculty of Physics of the University of Havana, from July 15 to 20, 2024. The projects proposed to the students covered electronics elements involved in building the buoys, as well as the study of a small wave channel built at the same institution. These projects served as a vehicle for raising young people's awareness of the project's themes.

In the social sciences, an exploratory study was carried out on the cognitive, motivational, and attitudinal changes among scientific, business, community, and government actors, based on their participation in the project's first workshop, yielding interesting preliminary results that could point to future strategies once the project reaches a more advanced technical stage. The project was presented at the 4th Mesoamerican Forum on Climate Change and Risk Management (October 22–25, 2024, Havana).

Throughout the year, intensive work went into selecting and purchasing material resources to be shipped to Cuba (digital fabrication machines, tools, computer systems, maintenance materials, etc.), as well as preparing the corresponding import documents and authorizations, where specialist Marianela Constantén Macías (University of Havana) and her small team played a key role. It should be noted that this process has been very arduous, due to the purchasing formalities required by the Université Libre de Bruxelles and the complexities of local import formalities. While a container awaits authorization to sail to Cuba from Brussels, materials needed to build the wave channel are

already in transit from China, along with another group of items from Panama. Corresponding details can be found in the attached documents.

As a relative shortfall against the work plan, it could be said that far fewer visits than scheduled took place, both by Belgian colleagues to Cuba and by Cuban colleagues to Belgium — a situation we expect to reverse next year, as the project reaches a more mature stage. In any case, this was offset by constant video-conference exchanges between the Belgian and Cuban counterparts.

Dr. Ernesto Altshuler

Project coordinator, Cuban side

January 7, 2024



Fig. 4 — Stills from the program "Observatorio científico," broadcast by Cubavisión on August 7, 2024. From left to right: Dr. Geydis Fundora, MSc. Luis Abel Rodríguez, and Eng. Alex Manuel Rivera.



Fig. 5 — PhD candidate Alex Manuel Rivera instructs pre-university students on an electronics task during the 2024 Summer School (July 15–20, 2024).