

Automation of Environmental Monitoring in Patagonia: Progress of OHMi Patagonia - Bahía Exploradores

Lemunao Sabina^{1,2,3*}, Salazar-Burrows Alejandro^{1,2,3,4}, Godoy Raquel^{1,2}, Carrasco Rodrigo^{1,5}, Aranda Benjamín^{1,2,3}, Qüense Jorge^{1,2,3}, Covacich Sol^{1,5}

- ¹ Estación Patagonia de Investigaciones Interdisciplinarias UC, Pontificia Universidad Católica de Chile, Santiago, Chile.
- ² Observatoire homme-milieux International Patagonia-Bahia Exploradores (OHM-i), Labex DRIHM (Programme Investissements d’avenir: ANR-11-LABX-0010), INEE-CNRS, Paris, France.
- ³ Instituto de Geografía, Facultad de Historia, Geografía y Ciencia Política, Pontificia Universidad Católica de Chile, Santiago, Chile.
- ⁴ Centro de Investigación en Ecosistemas de la Patagonia (CIEP), Proyecto PATSER ANID RFOF0002, Coyhaique, Chile.
- ⁵ Facultad de Ingeniería, Pontificia Universidad Católica de Chile, Santiago, Chile.

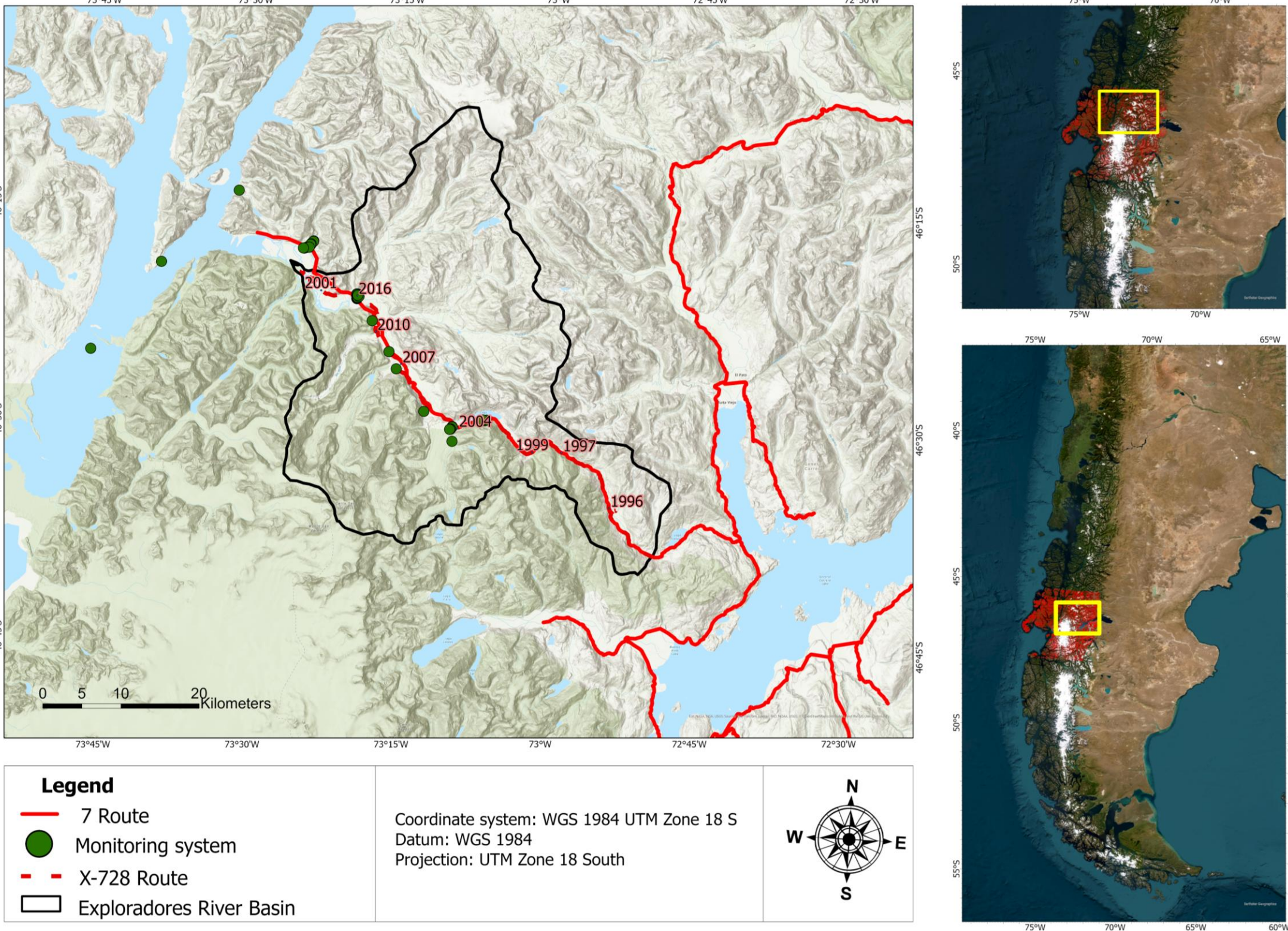
Abstract

Patagonia, and in particular the territory where the International Human-Environment Observatory (OHMi) Patagonia-Bahía Exploradores is located, represents an area of high socio-territorial relevance. This space is characterized by its relatively pristine condition, formed by periglacial ecosystems, temperate forests and southern maritime environments, under the combined influence of the Northern Ice Field and the South Pacific. These unique conditions, together with the emerging threats derived from the growing anthropization of the area and the impact of climate change, make this territory a key natural laboratory for the study of socio-territorial transformations.

In this scenario, the Observatory has promoted the development of an automated environmental monitoring system in remote areas, aimed at facilitating the collection, processing and analysis of data in almost real time. This system connects environmental sensors in the field to a central port, from where data is transmitted to a cloud infrastructure developed with Microsoft, consisting of platforms such as Azure and Power BI. This robust observation network, which articulates data science tools with a collaborative production logic, strengthens the monitoring of critical ecosystems in a key region for the study of global change.

Introduction

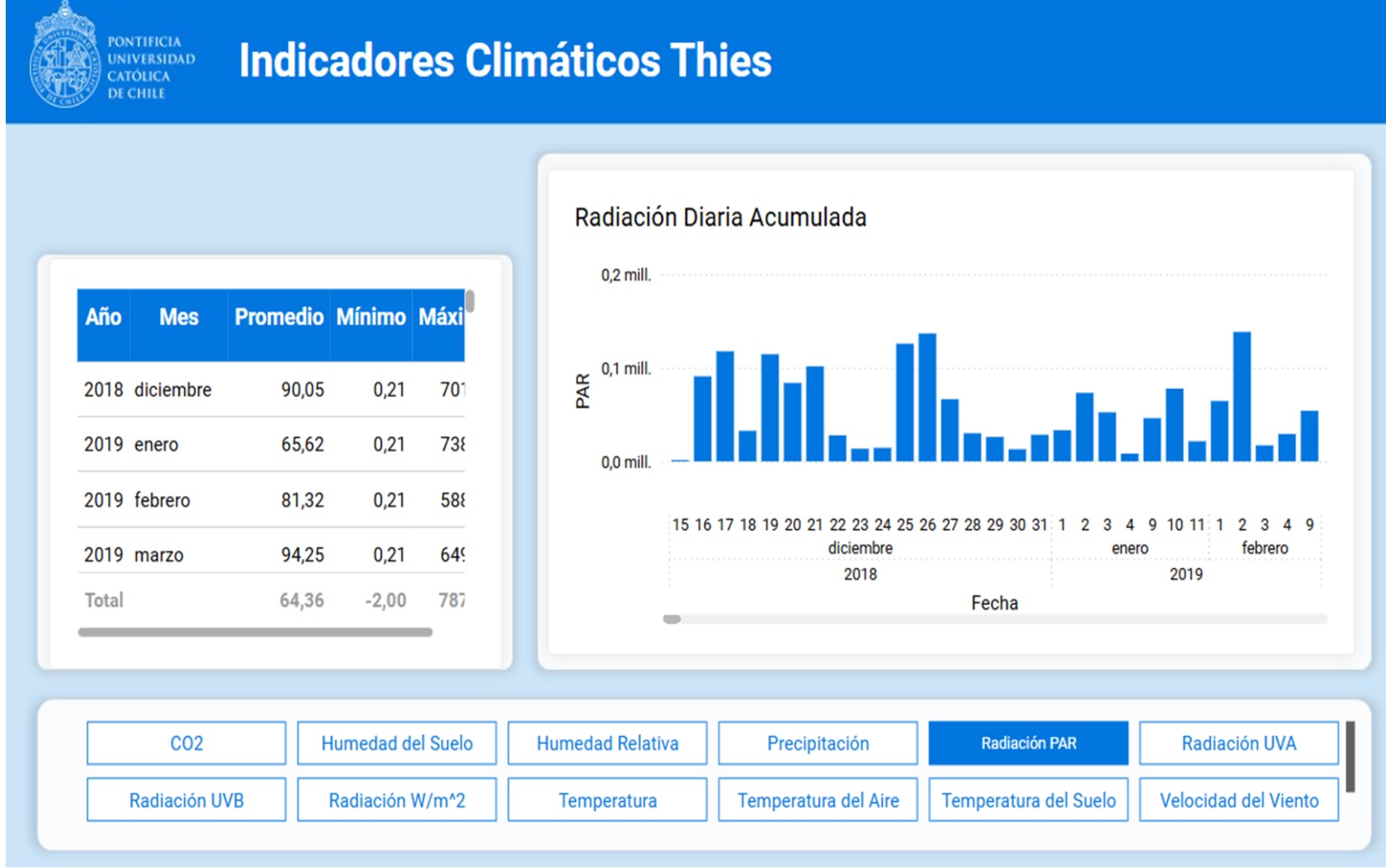
Western Patagonia and, in particular, the area covered by the International OHMi Patagonia-Bahía Exploradores, constitutes a natural laboratory of high socio-territorial relevance. Its periglacial ecosystems, temperate forests and southern marine environments, under the influence of the Northern Ice Field and the South Pacific, make it unique and vulnerable to emerging threats such as anthropization and climate change. In this context, it becomes essential to implement long-term environmental observation systems to understand the ecological transformations underway, in which OHMi has promoted the development of an automated environmental monitoring system in the area.



Objectives

- Strengthen the capacity to monitor critical ecosystems in the face of transformations induced by global change.
- Establish an automated system for the capture and processing of environmental data in near-real time in isolated areas.
- Ensure that data governance aligns with the objectives of researchers and the Station.
- Align the platform with FAIR objectives to help foster research and interconnectivity, and ensure traceability, quality and accessibility of environmental data for scientific use.

Dashboard



Conclusions

Automated environmental monitoring is advancing in the construction of a robust network that integrates technology, data science and institutional collaboration. This system allows transforming the complexity of the territory into accessible and validated data, fundamental to lay the foundations for an open, reproducible science with concrete territorial impact. In addition, future integration with international monitoring networks will strengthen scientific cooperation, facilitate the exchange of information and generate shared knowledge on a global scale, thus enhancing the capacity to respond to the environmental threats of these unique natural laboratories.

Résumé

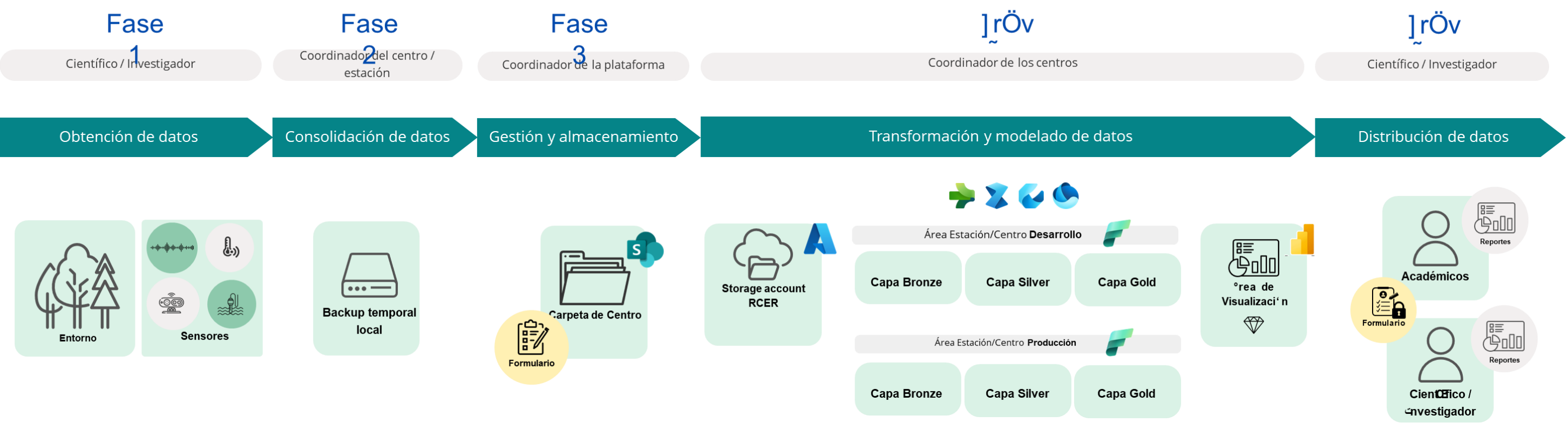
La Patagonie, et en particulier le territoire où se trouve l'Observatoire international homme-environnement (OHMi) Patagonia-Bahía Exploradores, représente une zone d'une grande importance socio-territoriale. Cet espace se caractérise par son état relativement vierge, formé d'écosystèmes périglaciaires, de forêts tempérées et d'environnements maritimes méridionaux, sous l'influence combinée du champ de glace septentrional et du Pacifique Sud. Ces conditions uniques, ainsi que les menaces émergentes liées à l'anthropisation croissante de la zone et à l'impact du changement climatique, font de ce territoire un laboratoire naturel essentiel pour l'étude des transformations socio-territoriales.

Dans ce contexte, l'Observatoire a encouragé le développement d'un système automatisé de surveillance environnementale dans les zones reculées, visant à faciliter la collecte, le traitement et l'analyse des données en temps quasi réel. Ce système relie les capteurs environnementaux sur le terrain à un port central, d'où les données sont transmises à une infrastructure en nuage développée avec Microsoft, composée de plateformes telles qu'Azure et Power Bi. Ce réseau d'observation robuste, qui articule des outils de science des données avec une logique de production collaborative, renforce la surveillance des écosystèmes critiques dans une région clé pour l'étude du changement global.

Methodology

The automation system is composed of different sensors for constant monitoring of environmental variables in the Exploradores Valley, Western Patagonia. The system allows the automatic upload of data captured in the field by hydrometric and meteorological sensors, camera traps and audio recorders, through a Raspberry Pi with internet access. For this purpose, infrastructure has been installed to upload the data to the cloud storage in its raw form, functioning as a backup and starting point for further processing (Bronze layer). Then, this data is cleaned, transformed and modeled in a development environment (Silver layer), using tools such as Azure and Data Factory. Finally, the data validated by the Observatory team are published in a production environment (Gold layer) through interactive dashboards in Power BI, facilitating their visualization and analysis by researchers.

Data pipeline



Preliminary results

- Installation and operation of multi-parameter sensor stations in remote areas.
- Develop a local data orchestration system to ensure data quality and safety, as well as manage station operation parameters.
- Initial configuration of automatic data flows from the field to the cloud.
- Development and production environments for data modeling.
- Partial integration with collaborative tools for visualization and reporting.
- Articulation with the UC Regional Centers and Stations Network as a replicable model.

