

# International Research Center CNRS–USP *Transitions:* Foundations, Achievements and Path Forward

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## Executive Summary

The CNRS–USP International Research Center (IRC) *Transitions* embodies a new era of Franco-Brazilian cooperation. Launched in **October 2023** by the **Centre National de la Recherche Scientifique (CNRS)** and the **University of São Paulo (USP)**, it responds to an urgent global need: producing knowledge capable of guiding the ecological, technological and societal transformations of the twenty-first century. Meanwhile, the initiative inspired the establishment of a **new international funding framework by the São Paulo Research Foundation (FAPESP)**, further consolidating the institutional and structural basis of this long-term partnership.

The IRC unites seven scientific pillars, hundreds of researchers and a growing ecosystem of joint international laboratories, doctoral programs and interdisciplinary initiatives. Its ambition is twofold — to deepen scientific excellence through durable, co-constructed research, and to translate that excellence into tangible contributions for society.

In less than two years, the IRC has already become both a **symbol and an instrument of scientific diplomacy**, linking Europe and Latin America in a shared pursuit of sustainable innovation.

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# 1. Vision and Mission of the IRC CNRS–USP

## 1.1 Genesis and Rationale

The CNRS–USP International Research Center *Transitions* was officially launched in **October 2023**, marking a pivoting point in the evolution of Franco-Brazilian scientific cooperation.

It was jointly founded by the **Centre National de la Recherche Scientifique (CNRS)** and the **University of São Paulo (USP)**, with the conviction that today’s planetary challenges — climate disruption, biodiversity loss, energy transition, digital transformation, and health resilience — cannot be met through disciplinary science alone.

At the occasion of its creation, the **São Paulo Research Foundation (FAPESP)** launched a new international funding instrument entitled “**CIP – Centro Internacional de Pesquisa**” (**International Research Center**), directly inspired by the CNRS–USP initiative. This pioneering program provides targeted support to the IRC through **doctoral and postdoctoral fellowships and funding for the organization of workshops and joint activities**. Importantly, the CIP framework formally recognizes **CNRS researchers residing in the State of São Paulo** and involved in the IRC as eligible beneficiaries of all FAPESP funding instruments, **on an equal footing with USP researchers**.

The IRC is the result of more than **three decades of partnership** between CNRS and USP. Hundreds of joint publications, co-supervised theses, mobility programs, and bilateral projects have progressively built a culture of mutual trust that made this institutional leap possible.

Two International Research Laboratories (IRLs) pioneered the cooperation within the framework of the IRC:

- The **IRL Immune Health** — co-directed by *José Carlos Alves-Filho* (USP) and *Nicolas Riteau* (CNRS) — pioneered collaborative immunology on inflammation and host–pathogen interactions.
- The **IRL Mondes en Transition** — co-directed by *Claudia Perrone Moises* (USP) and *François-Michel Le Tourneau* (CNRS) — created a trans-Atlantic platform addressing democratic, social and ecological transitions.

Their success proved that shared governance and long-term engagement can produce research of international standing and respond to societal needs.

The IRC thus represents both **continuity and rupture**: continuity in scientific excellence and reciprocity; rupture in scale, governance, and ambition. It moves beyond project-based cooperation toward a **mission-oriented institutional framework**, capable of orchestrating scientific ecosystems rather than isolated initiatives, and of turning scientific collaboration into a structural driver of transformation.

## 1.2 Mission and Guiding Principles

The IRC's mission is to **tackle global transitions through interdisciplinary science** that combines curiosity-driven research with social responsibility.

Its scientific architecture spans **seven pillars** covering the full range of contemporary inquiry — from quantum technologies to societal change:

- Humanities and Social Sciences
- Agronomy and Decarbonation
- Biology and Immunology
- Quantum Technologies
- Computational Methodologies and Applications
- Oceans / Atmosphere / Climate
- Ecology and Environment

Each pillar is jointly led by a CNRS and a USP researcher (in some cases could be more than that), ensuring symmetry of leadership, parity of decision-making, and co-ownership of research agendas.

This dual architecture — horizontal by discipline and vertical by cross-cutting mission — forms a **matrix of cooperation** linking fundamental science, applied innovation, and public-policy relevance.

Three guiding principles define the IRC's identity:

- **Interdisciplinarity as a method.** It is not an accessory but a working principle, bridging natural, social, and engineering sciences to design transformational approaches to complexity.
- **Co-construction and reciprocity.** From conception to evaluation, decisions, funding, and outcomes are jointly defined by CNRS and USP communities, ensuring shared visibility and ownership.
- **Transformation through knowledge.** Scientific advances are expected to generate tangible contributions to ecological, technological, and social transitions.

Through these principles, the IRC acts as a **living laboratory of institutional innovation**, translating the idea of “science for society” into operational governance and aligning excellence with impact.

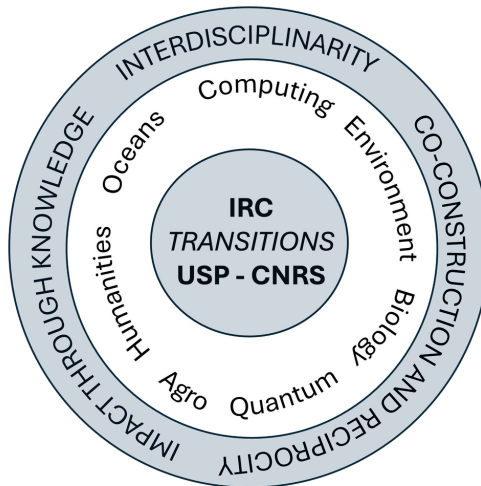


Figure 1: The disciplinary pillars of the USP-CNRS IRC and the guiding principle of the IRC's identity

### 1.3 Architecture and Governance

The structure of the IRC reflects its philosophy. It interconnects **biological, informational, environmental, and quantum sciences** with the **human and social dimensions** of change, fostering continuous dialogue between data, matter, and meaning. Such design encourages a level of cross-fertilization rarely achieved in international cooperation, where theory, experimentation, and application coexist within a single governance framework.

The IRC is overseen by a **Steering Committee** composed of representatives of CNRS and USP — including the CNRS Chief Scientific Officer and USP's Vice-Rector for Research — and advised by an **International Advisory Board** composed of distinguished scholars from Europe and the Americas.

Operational direction is jointly assumed by **Liviu Nicu** (CNRS) and **Fernando Menezes** (USP), ensuring bilateral leadership and continuity between Paris and São Paulo.

Its institutional anchor, the **Maison du CNRS @ USP**, inaugurated in 2023, functions simultaneously as a **diplomatic interface, coworking hub, and training venue**. More than **one thousand participants** have already taken part in workshops, thematic schools, and public events organized there, making the Maison a physical and symbolic embodiment of the IRC's open-science ethos — a space where languages, disciplines, and generations intersect.

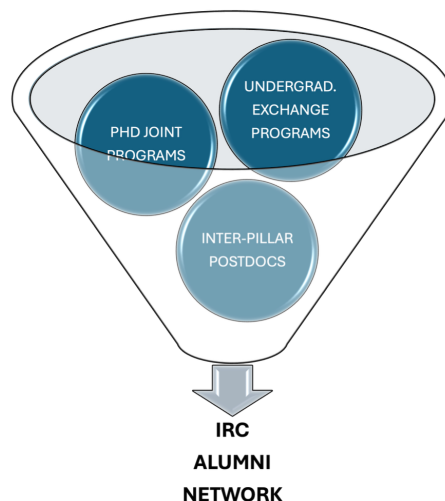
Beyond logistics, this governance model introduces a new form of **co-sovereignty in research**: a shared capacity to decide, invest, and represent, transforming collaboration into a common strategic asset for both institutions.

## 1.4 A Shared Vision for Transformation

The IRC *Transitions* aspires to become a **benchmark for transcontinental, interdisciplinary research**, a South–North engine of innovation linking scientific excellence and societal relevance.

Its long-term roadmap unfolds across four horizons:

- **Consolidation and Expansion.** Strengthen the seven pillars and integrate an eighth — Engineering — by 2026, extending the IRC toward applied technologies, energy, and sustainable materials.
- **Human-Capital Formation.** Develop a continuum of doctoral, post-doctoral, and mobility programs connecting CNRS and USP laboratories and nurturing future scientific leaders.
- **Flagship Interdisciplinary Projects.** Address planetary transitions through emblematic initiatives on sustainable megacities, marine biodiversity, ethical AI, and carbon-neutral agriculture.
- **Science-Policy Interface.** Transform the IRC into a *scientific observatory of transitions*, providing evidence-based knowledge to decision-makers and civil society.



*Figure 2:* Human-capital formation as a continuum between undergraduate mobilities, doctoral and post-doctoral levels

By embedding these ambitions in shared governance, CNRS and USP reaffirm a common conviction: **science co-built across continents can serve as a transformative force**, bridging knowledge and action, North and South, present and future.

The IRC thus carries a dual responsibility — to produce excellence and to orient that excellence toward the sustainable transformation of societies.

## 1.5 The IRC within the CNRS Global Network

Created in **October 2023**, the CNRS–USP IRC *Transitions* belongs to the **global network of CNRS International Research Centers (IRCs)** — a strategic initiative launched in 2021 to reinforce long-term partnerships with leading universities worldwide.

As of early 2026, the CNRS counts **seven IRCs**:

*France–Arizona for Global Grand Challenges* (University of Arizona, 2021)

*Science and Technology of Transformation* (Imperial College London, 2022)

*CNRS–uTokyo* (University of Tokyo, 2022)

*Discovery* (University of Chicago, 2023)

*Transitions* (University of São Paulo, 2023)

*Innovations for a Sustainable Planet* (University of Sherbrooke, 2024)

*IRC with the University of the Witwatersrand* (South Africa, signed December 2025)

Together, these seven IRCs form a **constellation of excellence and shared responsibility**, designed to confront planetary challenges — from climate change and biodiversity loss to energy transition and global health.

Each operates as a **joint governance and co-funding platform**, pooling infrastructures, strategies, and human capital between the CNRS and its partner universities.

Within this constellation, the CNRS–USP IRC *Transitions* holds a **distinctive position** as the **first IRC created in the Global South** and the **only one established in Latin America**. It anchors the CNRS's presence in a region of global significance for biodiversity, decarbonation, and social innovation, symbolizing a new form of **bi-hemispheric cooperation** bridging Europe and South America.

Its focus on societal, environmental, and technological transformations gives it a transversal role within the CNRS network, connecting human and natural sciences and linking the Northern and Southern hemispheres through shared agendas.

## 2. The Transformative Impact of the IRC

### 2.1 A Structural Evolution in Cooperation

The creation of the CNRS–USP International Research Center *Transitions* marks a genuine **paradigm shift** in Franco-Brazilian cooperation.

What began as a constellation of bilateral projects has evolved into a **permanent ecosystem**, integrating research, training and innovation under shared governance.

For the first time, an institutional framework links the world's largest European research

organization and Latin America's leading university through a jointly managed strategic structure, endowed with its own visibility, governance and capacity for action.

Between 2023 and 2025, this transformation has already yielded tangible outcomes: more than **fifteen bilateral workshops**, **forty joint publications**, and **two editions of the CNRS–USP PhD Joint Program**.

These achievements have been supported by a co-funding platform from CNRS, USP and FAPESP amounting to **over eight million euros** for the period 2023–2028.

This new scale of cooperation goes beyond traditional project calls: it aligns long-term priorities, leverages complementary infrastructures, and situates bilateral science at the heart of both institutions' strategic roadmaps.

In that sense, the IRC represents the **operational arm of a shared vision**. For the CNRS, it contributes to the *Contrat d'objectifs, de moyens et de performance 2024–2028*, which emphasizes interdisciplinarity, international structuring and scientific diplomacy. For USP, it reinforces the axes of its *Strategic Research Plan 2022–2030*, devoted to sustainability, digital transformation and social inclusion.

By merging the perspectives of both USP and CNRS, the IRC *Transitions* establishes a **co-steered, mission-driven model** of scientific partnership.

## 2.2 From Disciplinary Excellence to Interdisciplinary Convergence

Within its first years, the IRC *Transitions* mobilized more than **two hundred researchers** across its seven pillars. This network has generated a dynamic of convergence that redefines how disciplines interact. Several emblematic examples illustrate this shift:

- **IMMUNE HEALTH international laboratory** – a long-standing CNRS–USP collaboration in biology and immunology that now brings together twenty-five researchers in a new facility to explore inflammation, host–pathogen interactions and immunometabolism through integrated molecular and computational approaches.
- **Worlds in transition international laboratory** – an international research laboratory based on the rich and long-term heritage of the French/Brazilian academic cooperation in Social Sciences and Humanities, encompassing all discipline of this scientific sector in a multidisciplinary approach of social, ecological and economic transitions, with a focus on trans-Atlantic (i.e. Europe/Africa/America) relations.
- **THUS Virtual Lab (Techno-Human Systems of the Future)** – a large-scale interdisciplinary environment uniting sixty researchers from computer science, engineering and cognitive psychology around autonomous systems, sustainable mobility and digital ethics.

Building on these foundations, new cross-pillar initiatives are emerging on **urban ecosystems**, **resilient agricultural landscapes**, **ethics of advanced technologies**, and **marine biodiversity**. These initiatives mark the passage from juxtaposition to **integration**, where scientific questions are defined jointly across disciplines and continents.

The IRC therefore acts as a **matrix of interdisciplinary innovation**: humanities inform environmental challenges; data science enhances public policies related to climate change; immunology intersects with environmental monitoring.

This capacity to articulate complexity — rather than reduce it — is one of the IRC's most visible and transformative outcomes.

## 2.3 A Platform for Talent Circulation and Training

At the heart of the IRC's transformative impact lies its role in **training and talent circulation**. The **CNRS–USP PhD Joint Program**, launched in 2023, embodies this new philosophy of co-construction.

Each selected project associates one CNRS and one USP laboratory under joint supervision and co-funding, thereby institutionalizing reciprocity and continuity.

- **First edition (2024)** – 20 applications, 5 laureates:  
*ICorQuant* (quantum photonics), *MESABI* (agroecology and ecosystem services), *BIOMASP'hD* (urban atmospheric chemistry), *TENDENCY* (artificial intelligence and system safety), *OLRI* (anthropology and heritage studies).
- **Second edition (2025)** – 37 applications, 5 laureates:  
*LiDaMar* (dark matter detection), *BTLA\_TCells* (immunology), *SOCAM* (soil carbon and mangrove ecosystems), *AMACLIM\_PhD* (Amazon hydroclimate), *NSA-EDAFBR* (geography and agro-economics).

Together, these ten doctoral projects illustrate the IRC's role as a **binational incubator of scientific talent**.

They connect disciplines as diverse as physics, biology, archaeology, and social sciences, and form a continuum with the forthcoming **Inter-Pillar Post-Doctoral Program (2025–2026)**. This post-doctoral program will link at least two pillars per project and address cross-cutting topics such as sustainable agriculture, urban resilience, quantum sensing and ethical AI.

Beyond training, these schemes create a community of early-career researchers who are simultaneously **rooted in two scientific cultures**. They learn to navigate multiple languages, funding systems and evaluation frameworks — a decisive skill for the new generation of globally connected scientists.

Through these initiatives, the IRC institutionalizes **mobility, reciprocity and capacity building**, strengthening CNRS–USP cooperation as a model of shared academic sovereignty and trust.

## 2.4 Scientific Diplomacy and Institutional Innovation

The IRC *Transitions* is not only a scientific structure; it is also a **platform for scientific diplomacy**. By uniting Europe's largest research organization and Latin America's leading

university, it provides a visible demonstration that international science can be **co-governed and co-funded** without asymmetry.

Its headquarters — the **Maison du CNRS @ USP** — serves simultaneously as embassy, incubator and forum. It hosts thematic workshops, policy dialogues and public lectures that bring together researchers, students and decision-makers. In less than 2.5 years, it has become a meeting point for the French and Brazilian scientific communities and a gateway to the wider Latin-American network. This framework enables **researcher mobility in both directions**: CNRS scientists from all institutes can spend time in Brazil under the IRC umbrella, while USP teams gain access to European consortia, infrastructures and Horizon Europe opportunities.

Such fluidity paves the way for future International Research Laboratories in Engineering, Quantum Technologies and Environmental Sciences, reinforcing the CNRS's global presence in the Southern hemisphere.

In parallel, the IRC has strengthened institutional links with **FAPESP, CNPq** and **CAPES**, diversifying funding sources and positioning itself within the Brazilian innovation ecosystem.

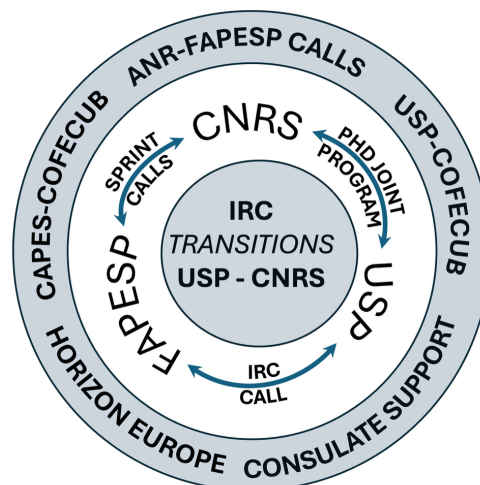


Figure 3: Funding schemes fostering the development of the IRC Transitions.

It also fosters dialogue with ministries and local authorities, translating scientific evidence into public policy recommendations.

In this sense, the IRC has become a **microcosm of the global CNRS network**: a diplomatic, scientific and training interface between continents.

## 2.5 Towards Flagship Projects and Global Leadership

The **Advisory Board** of the IRC and the **First High-Level Meeting held in Paris in 2025** jointly defined the next horizon: to consolidate pillar maturity, define clear milestones, and develop a small number of **flagship projects** capable of structuring the IRC's identity for the coming decade.

Among the emerging directions:

- **Urban sustainability and climate resilience**, linking environmental science, computing, architecture and social innovation;
- **Marine biodiversity and ocean circulation**, integrating biology, oceanography and climate modelling;
- **Just energy and resource transitions**, uniting decarbonation, humanities and data science;
- **Ethics of advanced technologies**, bridging quantum research, AI development and philosophy;
- **Democracy and the research/society interface.**

These initiatives embody the IRC *Transitions'* distinctive capacity to combine disciplinary excellence with institutional agility, and to extend scientific discovery towards tangible contributions to society.

They will serve as exemplars of the center's capacity to produce not only pioneering knowledge, but also new frameworks for organizing that knowledge — more connected, more equitable, and more attuned to the challenges of our time. Through them, the IRC is steadily asserting itself as a **regional and global leader in the science of transitions**, a strategic hub of the CNRS network where scientific excellence, societal well-being and institutional innovation converge.

It shows that Franco-Brazilian cooperation, when institutionalized at scale, can act as a **catalyst for sustainable and inclusive futures**, aligning research, training and diplomacy under a single transformative vision.

### 3. Scientific Contributions by Pillar

The present chapter will detail the **scientific contributions of each pillar**, showing how disciplinary depth and interdisciplinary dialogue converge within the IRC to generate original insights, innovative methods and concrete solutions.

Together, these contributions constitute the living substance of the IRC *Transitions* — a collective enterprise where excellence and engagement advance hand in hand.

#### 3.1 Social Sciences and Humanities: International Research Laboratory Worlds in Transition

USP representative: Cláudia Perrone Moises, Associate professor, Faculty of Law, University of São Paulo

CNRS representative: François-Michel Le Tourneau, directeur de recherche au CNRS

### 3.1.1 Achievements Enabled by the IRC (2023–2025)

The International Research Laboratory Worlds in transition was created in September, 2024 after two years of intense consultation of the French and Brazilian SSH research community in order to draft its core research project, framed around the concept of transition and its use (and misuse) in all fields of Human and Social Sciences. Its foundations, however, are much deeper than this process. France and Brazil have a longstanding dialogue in the areas of Social Sciences and Humanities and many prominent French scholars of the 20<sup>th</sup> century had deep ties with Brazil such as Fernand Braudel, Roger Bastide or Claude Lévi-Strauss, who were part of the “mission universitaire française” during the 1930s, when USP was founded. Since then, the transit of French scholars to Brazil in general and to USP in particular was always intense. In the 2020s<sup>1</sup>, researchers linked with CNRS SHS made about 150 trips annually to Brazil, for a total amount of 2500 work days spent in loco.

On their end, many Brazilian scholars also have had (and have) strong ties with France, especially when those who needed to go to exile during the military dictatorship, such as Fernando Henrique Cardoso, Ignacy Sachs, Josué de Castro or Florestan Fernandes. The relationship was so strong that Michel Foucault, visiting professor at USP in the 1960s and discovering the USP department of Philosophy likened it to “a French overseas philosophy department” so close it was in terms of topics and methods to what was done in France.

The **research project of the IRL** takes the concept of transitions under **five different perspectives**, each being a research axis: (1) Circulations, mobilities and transnational spaces; (2) “building worlds” with linguistic and cultural diversities; (3) inequalities and socio-economic and socio-spatial transitions; (4) mutations of law and democracy; (4) environmental transitions in the Anthropocene. As of early 2026, the laboratory hosts 4 permanent posted researchers (3 CNRS and 1 USP), and about 60 participating or associated members (half from USP, half from France and other Brazilian universities), reflecting the magnitude of the Franco-Brazilian dialogue in SSH.

The community of researchers gathered around the IRL Worlds in transition has been very active and responded to several calls in order to fund the activities inscribed in its work program. Most of the proposals originated in interactions (scientific events, visits, etc.) prompted by the IRL and several were successful such as:

- DURAMA3, a proposal about sustainable development in the Amazon, funded under the ANR/FAPESP call (475 k€ ANR / 2,3 M R\$ FAPESP);
- BLOC “Brazilian response to illegal gold mining in the Amazon”, project funded by the Préfecture de Guyane (25 k€);
- “Voice and politics in the Brazilian indigenous world”, project selected in the 2025 USP/COFECUB call.
- Furthermore, the IRL2034 is associated with several other successful proposals, such as EXTRA “Far-right at the workplace”, selected in the 2025 JCJC ANR call, RESPIRO “Restoring Pyrodiversity in the Cerrado”, Young Researcher project selected by FAPESP, HERMES “Heritages in the making” project selected under the 2024 AMI call.

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<sup>1</sup> Except, of course, for the period of the Coronavirus pandemics.

Aside from this, the Worlds in transition laboratory has been very involved in the organization of scientific events, most of them happening in the Maison du CNRS on the USP campus. Among more than 30 seminars and conferences, we can cite the “Worlds in transition, new fieldwork practices” colloquium, a three-day event held during the “France in Brazil” events season (with support of the Institut Français and FAPESP) or the “Environmental transition: who counts?” workshop supported by the CIP program of the IRC. In total, more than 1,500 persons attended the IRL events in 2025. The laboratory is also a key partner of the annual festival of French-USP activities called “Semanas franco-uspianas”, held each year in late September.

As for publications, since the laboratory was created in the Fall of 2024, most are forthcoming. However, researchers posted in the IRL have sustained their publication rhythm and here are 5 examples:

- Capone (2025)<sup>2</sup>, which centers around the key questions of restitutions and reparations of slavery;
- Le Tourneau (2025)<sup>3</sup>, which develops a critical analysis of the possibilities of sustainable bioeconomy in the Amazon;
- Badin and Bardet (2025)<sup>4</sup>, which accounts of an indicator system for the ecological transition developed in partnership between France and Brazil;
- Paugam (2025)<sup>5</sup>, which is the Brazilian revised edition of an important book in the social theory of relationships and affects;
- Velloso and Zeron (2025)<sup>6</sup>, by two associated researchers of the IRL, which develops a new analysis of slavery of native people in the Andes.

The IRL is very attentive to the training of PhD and post-doctoral students, for those young talents are the future of the dialogue between France and Brazil, and CNRS and USP, in the area of SSH. For this reason, the IRL sponsored responses to the Joint PhD call, with a success in 2025 for the “New scales of agribusiness” project (2026 edition results are not known). Training of PhD students and young researchers is also a key issue for the USP/COFECUB “Voice and politics in the Brazilian indigenous world” in which we participate, and we hope to host several post-doc researchers funded by the IRC, either under the supervision of the IRL permanent researchers or through the URBANGREENOPT proposal in response to the IRC inter-pillar post-doc call.

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<sup>2</sup> Capone, S. 2025, « L’Acervo Nosso Sagrado ou la restitution comme réparation de l’esclavage et du racisme structurel au Brésil », Paris, Patrimoines : revue de l’Institut national du patrimoine, 20, pp. 57-62.

<sup>3</sup> Le Tourneau, F.M. 2025, «Economia baseada em produtos da biodiversidade amazônica na Amazônia brasileira: dimensão, geografia e gargalos», *Confins* [Online], 68 | 2025, <http://journals.openedition.org/confins/64128>; DOI: <https://doi.org/10.4000/14nlc>

<sup>4</sup> Badin A.-L. and Bardet F., 2025, "Un forum étudiant d’indicateurs de la transition écologique pour refaire le monde", *JESES*, Vol. 2 No 1 (2025); <https://jeeses.org/article/view/154>

<sup>5</sup> Paugam, S., 2025, *A sociedade em laços. Teoria do vínculo social*, Rio de Janeiro, Ateliê de Humanidades Editorial, 2025, 836 p.

<sup>6</sup> Velloso, Gustavo; De Moura Ribeiro Zeron, Carlos Alberto. Os mundos da escravidão ameríndia e o gradiente multidirecional das modalidades de trabalho nas Américas da Época Moderna. *Revista de História*, São Paulo, n. 184, p. 1–29, 2025. DOI: 10.11606/issn.2316-9141.rh.2025.234129

The IRL interacts with existing IRP or IRN since its creation, especially the IRN TRACS “Transatlantic cultures”. As of 2025, the laboratory is also involved in two new projects selected in the 2025 CNRS IRN/IRP call: IRP VIA-TEAMS “The real voices of artificial intelligence”, and IRN DICA “International law and the Anthropocene”. The creation or reinforcement of networks of researchers around the IRL is supported by the hosting of short or medium-term mobilities, especially within the CNRS-SHS SMI program (3 laureates in 2025), but also by other mechanisms. In 2025, approximately 12 researchers visited the IRL and it is expected that this number will grow in 2026.

The IRL is also active in the inter-IRC dialogue promoted by CNRS. Common topics and interests have been identified already with the CNRS/University of Arizona IRC and an exploratory dialogue with the CNRS/Witwaterstand University IRC will be initiated in 2026. Possibilities with CNRS/University of Chicago around literature and languages, and with CNRS/Sheerbrooke University (Indigenous questions) are also considered.

### 3.1.2 Transformative impact of the IRC in the pillar

By promoting a new impulse and giving new tools, the creation of the IRC has changed the scale, depth, or nature of SSH collaborations between France and Brazil and especially between USP and CNRS researchers. If the funds provided within the FAPESP funding facility were useful, it is much more, at this stage, the physical infrastructure and the IRL offices which have been determinant in this respect. The Maison du CNRS is now well identified by the community as a meeting point and a place where high-level scientific discussions are held, as well as a meeting hub with officials and researchers from most of French universities and research units. What the IRC and IRL are permitting is the institutionalization of networks which were previously much more centered around personal ties, giving them a potential to survive after the academic career of the researchers who initiated them ends.

The IRC and the IRL were also instrumental in promoting a broader interdisciplinarity, within the realm of Social Sciences and Humanities and also with other scientific domains. For the first part, the non-disciplinary definition of the IRL research axes has permitted a blend of disciplines within each, resulting in an improved dialogue and the elaboration of multi or interdisciplinary proposals such as DURAMAZ3. For the second part, aside regular interactions with passing colleagues and delegations, the most efficient device has been the inter-pillar post-doc call, which allowed a rich dialogue around the construction of a proposal joining five pillars and centered on developing a multi-perspective approach of green urban infrastructures in the São Paulo metropolitan area.

### 3.1.3 What would not have been possible without the IRC

Most of the results described above would not have been achieved without the impulse and the visibility that the IRC gave to our initiatives. The IRC served as a catalyst, and also it opened new possibilities of dialogue with the inter-IRC perspective. Last, the IRC materialized a whole universe of relationships which were latent but which found a new concrete expression in the Maison du CNRS.

### 3.1.4 Future directions and disruptive ideas (2025–2035)

For the 2025-2035 period, the IRL will seek short (1-2 year), medium (4-6 years) and long term (10 years) directions and objectives.

In the short run, the laboratory needs to consolidate its promising start. This implies consolidating its base of associated members, keeping it around 60-80 persons and adjusting the structure to encompass emerging topics (literature, philosophy, energy transition, etc.). Attention will also be given to the theoretical support of the laboratory, which needs to refine its approach of transition and transition theories. A regular lab seminary will be implemented for this purpose in early 2026. Innovation at this stage will be centered around the inter-SSH dialogue within the laboratory and the development of new multidisciplinary approaches of the concept of transition.

Medium-term objectives are to strengthen the laboratory as a place of reference in the USP campus. In order to achieve this, a high volume of scientific events will be maintained, and we expect to host as many visits as feasible within the funds allocated by the different partners and those of existing calls the IRL researchers can access. It is expected at this stage that the proposals funded in 2025 or 2026 be mature enough to produce or have produced a high number of publications. Innovation in the horizon will be centered around the identification of new topics or scientific interdisciplinary subfields and the writing of big proposals for UE calls. Examples of these innovative fields are: inclusion of native students and native languages in higher education; use and limits of big data to support public statistics; green infrastructures, etc.

In the long run, the objective of the IRL is twofold. First, it is to succeed in institutionalizing its existence (whatever the administrative form it might take) as a reference center in the way centers like CEMCA in Mexico or IFEA in the Andes have. Second, it is to develop interfaces with the other sectors either of the CNRS/USP IRC or with other French-Brazilian centers such as the INRAE IRC, the Pasteur/USP center, the forthcoming IRD/UNICAMP Migration studies center, etc., so as to expand activities and maintain the pluri/multi/interdisciplinar focus which is fundamental aspect of the IRC since its creation. Innovation at this stage will be focused on identifying new trends in SSH in a context where AI technologies and methodological hybridizations between ‘hard’ and ‘soft’ science will probably increase dramatically.

## 3.2 Biology/Immunology: International Research laboratory Immune Health

**USP representative:** Prof. José Carlos Alves-Filho (Faculty of Medicine of Ribeirão Preto (FMRP-USP, Director of the International Research Laboratory IRL2029 “Immune Health” CNRS-USP)

**CNRS representative:** Dr. Nicolas Riteau (CNRS Biology, co-director of the International Research Laboratory IRL2029 “Immune Health” CNRS-USP)

### 3.2.1 Achievements Enabled by the IRC (2023–2025)

The emergence of the IRC aligned perfectly with the launch of the International Research Laboratory IRL2029 “Immune Health”. Both initiatives were conceived in parallel and mutually reinforced each other: the IRC provided a broader level of institutional legitimacy and extended funding opportunities while the IRL supported the installation of a permanent CNRS scientific within the FMRP-USP.

The IRC has supported the development of our activities in several important ways, including the initiation of our research program at FMRP-USP and the establishment of new collaborations. This support has been instrumental in creating the conditions for joint projects and future funding opportunities.

**Increasing the visibility** of our IRL thanks to our participation to a series of events, both in Brazil and France:

- 2025 Pasteur Global Health in tropical Regions, São Paulo, Brazil
- 2025 FAPESP-sponsored Brazil-France Health Workshop, Toulouse, France
- 2025 High Level Meeting IRC CNRS-USP, Paris, France
- 2024 Seminar on Ocean Innovation and Transformative Technologies, São Paulo, Brazil
- 2024 FAPESP-sponsored Brazil-France Health Workshop, São Paulo, Brazil

Collectively, these high-level participations significantly enhanced the international visibility of the IRL “Immune Health,” strengthened its institutional positioning within the CNRS-USP partnership, and contributed to establishing the Biology/Immunology pillar as a recognized interface for Franco-Brazilian scientific exchange.

**Offering logistical support** to organize the institutional inauguration of the IRL:

The inauguration of our IRL “Immune Health,” held on 29 November 2024 in Ribeirão Preto, was made possible thanks to the decisive logistical and institutional support of the IRC. The IRC’s involvement was essential to ensure the successful organization of this event, the presence of high-level CNRS, USP, and international representatives, and the strong scientific and institutional visibility that marked the official launch of the IRL within the CNRS-USP partnership.

**Offering financial support** to organize a major scientific event:

The IRC provided essential financial support for the organization of the First IMMUNE HEALTH Symposium, which took place on 6-7 October 2025 in Ribeirão Preto. This flagship event, co-organized by CNRS and USP, brought together ten invited CNRS scientists from leading French laboratories alongside with 10 researchers from USP Ribeirão Preto and USP São Paulo. The IRC’s contribution has been instrumental in securing international travel, logistics, and the coordination of scientific activities, ensuring high-level participation and strong visibility for the Biology/Immunology pillar. This support enabled the creation of a

major Franco-Brazilian connection dedicated to inflammation, immunology, and translational lung research, an event that would not have been feasible at this scale without the IRC framework.

### Providing Fellowships:

- A four-year PhD fellowship (2025-2029) attributed thanks to the IRC to Yago Gonçalves de Azevedo for his project *Self-nucleic acid sensing in hypersensitivity pneumonitis* (FAPESP process number 2025/10685-8, total budget: 340.992 R\$). Thesis director: Nicolas Riteau
- A three-year PhD sponsored by the PhD joint program (2025-2028). This project has been granted within the USP-CNRS Collaboration Program and brings together Prof. Dr. Jose Carlos F. Alves Filho (USP) and Dr. Renaud Lesourne and Dr. Loïc Dupré (Infinity Toulouse) for the project *“Modulatory function of the immune checkpoint BTLA in effector and regulatory T cells in the context of autoimmunity and cancer”*
- A two-year Post doc (2026-2027) (in process of recruitment) to Nicolas Riteau for the project *“Crosstalk Between the IL-17A Axis and STING Signaling in the Pathogenesis of Gastroesophageal Reflux Disease”* (FAPESP process number 2025/01171-0, total budget: 344.418 R\$).

By enabling the recruitment and long-term support of doctoral and postdoctoral fellows, the IRC plays a foundational and irreplaceable role in building the scientific workforce of the Biology/Immunology pillar, securing the sustainability of the IRL “Immune Health,” and establishing a robust Franco–Brazilian training ecosystem capable of driving high-impact research at the international level.

### 3.2.2 Transformative Impact of the IRC in the Pillar

The creation of the IRC coincided with the launch of the IRL2029 “Immune Health,” providing timely institutional support during the establishment of the Biology/Immunology pillar. This alignment helped facilitate the installation of Dr. Nicolas Riteau’s research activity at FMRP-USP, including support for recruiting the team’s first postdoctoral fellow, which was important to initiate laboratory work and structure the group’s early development. The IRC also played a decisive role in fostering new collaborations across CNRS and USP teams, notably through IRC-supported events such as the IMMUNE HEALTH Symposium (6-7 October 2025), which proved critical for stimulating new scientific interactions. These exchanges generated promising joint projects and the preliminary data necessary to be competitive in highly selective international grant applications, including upcoming calls from the French ANR.

Several concrete collaborations of IRL-affiliated USP professors emerged directly from these IRC-enabled interactions (non-exhaustive list):

- José Carlos Alves-Filho (FMRP-USP) ↔ Véronique Adoue (Infinity, Toulouse)
- José Carlos Alves-Filho (FMRP-USP) ↔ Romain Roncagalli (CIML, Marseille)

- Nicolas Riteau (IRL Immune Health, Ribeirão Preto) ↔ Vanja Sisirak (Immunoconcept, Bordeaux)
- Sandra Fukada (FCFRP-USP) ↔ Julien Marie (CRCL, Lyon)
- Tathiane Malta (FMRP-USP) ↔ Sylvie Guerder (Infinity, Toulouse)

Beyond these new scientific links, the IRC is also supportive of the preparation of a CNRS-sponsored International Research Network (IRN) proposal dedicated to T cell biology. The coordinated Franco-Brazilian exchanges and the institutional visibility provided by the IRC will be essential to consolidate this initiative and mobilize leading teams on both sides.

In addition, thanks to logistical support from the IRC, Tathiane Malta went to Toulouse in June 2025. Her interactions with local scientists were productive and led to a collaboration with the CRCT in Toulouse and the joint submission of a grant proposal to the ARC Foundation under the ARC-SIGN'IT 2026 call, entitled "*Identification of key modulators of therapeutic response in recurrent glioblastoma treated with hypofractionated irradiation and immunotherapy: Insights from the STERIMGLI Clinical Trial.*" This project will be conducted in collaboration with the laboratory of Prof. Elizabeth Moyal at CRCT Toulouse.

Altogether, these elements illustrate how the IRC has facilitated collaborations, enabled early research capacity at FMRP-USP, and created new strategic opportunities that would not have emerged in the same way without its support.

### 3.2.3 What Would Not Have Been Possible Without the IRC

As outlined earlier, several major achievements arose specifically due to the IRC framework: A strong support of the IRC that helped the early installation of Nicolas Riteau and provided critical guidance for the development of the "Immune Health":

- The organization of a high-visibility scientific event and the ability to attract French delegations to Brazil.
- The recruitment of both PhD students and Post-doctoral fellows to the IRL.

Taken together, these achievements demonstrate that the IRC was not merely a facilitating instrument but a central structural driver of the Biology/Immunology pillar, enabling progress of the IRL "Immune Health," the emergence of durable Franco-Brazilian collaborations, the organization of high-visibility international events, and the consolidation of a new generation of doctoral and postdoctoral researchers-outcomes that would not have been attainable at this scale, pace, or level of integration without the IRC framework.

### 3.2.4 Future Directions and Disruptive Ideas (2025–2035)

The Biology/Immunology pillar aims to build a transformative 10-year agenda, positioning the CNRS-USP alliance as an internationally recognized hub in inflammation, immunoregulation, immune-mediated diseases and beyond. This ambitious long-term vision

builds on the consolidation of the IRL “Immune Health” and seeks to anticipate major scientific, technological, and societal challenges in health and life sciences.

### **Biology pillar**

- Improve our attractiveness and capacity to host short-term (weeks to months) and long-term (multi-year) stays of French scientists, fostering sustained scientific immersion and knowledge transfer.
- Facilitate the nucleation of new research axes within the Biology/Immunology pillar, enabling the emergence of innovative projects driven by investigator mobility, exploratory funding, and cross-laboratory synergies.

### **Interdisciplinary bridges**

While scientifically and technically challenging, the Biology pillar will actively promote cross-disciplinary interactions, notably through the Inter-Pillars Postdoctoral Program, by supporting fellowships designed to connect immunology with complementary scientific domains, for instance:

- Computing and data sciences: AI-enhanced immune profiling, digital pathology, multi-omics integration, and spatial data analysis.
- Humanities and Social Sciences: societal and ethical dimensions of immunotherapies and cell therapies; integration of Indigenous and traditional knowledge related to inflammation, infection, and healing; community perceptions of zoonoses and emerging viral epidemics.
- Ecology and Environment: interactions between climate change, environmental pollution, and immune-mediated diseases; health impacts of environmental stressors.
- Oceans, Climate, and Atmosphere: identification of bioactive compounds from marine microorganisms, biodiversity-driven immune modulation, and environmental exposure-immune system interactions.

Over the 2025-2035 period, the strategic ambition is to consolidate the Biology/Immunology pillar as the primary Franco-Brazilian reference hub combining excellence in fundamental research, translational approaches, and advanced training. Beyond bilateral cooperation, the pillar is designed to serve as a structuring anchor for CNRS activities in Latin America, capable of attracting international talent, catalyzing large-scale collaborative programs, and positioning the CNRS-USP alliance as a key contributor to global research efforts addressing immune-mediated diseases, emerging health challenges and beyond.

## **3.3 Quantum Technologies**

USP representative : Paulo Nussenzveig (Physics Institute, USP)

CNRS representative : Robin Kaiser (DR CNRS, Inphyni, Nice)

### 3.3.1 Achievements enabled by the IRC (2023–2025)

The quantum pillar of this IRC is in its initial phase, but it is based on a very long tradition of scientific collaboration between France and Brazil in the fields of quantum optics and laser/atomic physics. Most of the recent joint activities have been concentrated in the cold atomic physics context. The main achievements enabled by the IRC so far have been in building broader connections towards joint activities in quantum technologies, mainly in the following areas:

- Quantum turbulence: experiments, simulations and theory
- Cooperative atom-photon interactions: experiments, simulations and theory
- Atom clocks

The major workshops, schools, or scientific events that have been held in the past years allowing the prefiguration of the pillar are the following:

- *Coscali series of workshops (Porquerolles-France 2007, 2013, 2019, 2021, 2022, 2024; Fernando de Noronha-Brazil 2018, 2024, Ubatuba-Brazil 2016, Peyresq-France 2025).* This series of workshops had been initiated by an EU project (with the Brazilian group as a non-beneficiary partner) and it is now well established with high level speakers from all countries (beyond France and Brazil).
- *Cold atom schools (Sao Carlos 2010, Sao Paulo 2017, 2019, 2023, 2025).* This school became a regular event (once every second year), with organizers from Brazil and France, and takes place at ICTP-SAIFR in Sao Paulo.

The cold atom activity in Sao Carlos (including V. Bagnato, P. Courteille, R. Bachelard and R. Teixeira) has a strong collaboration with the cold atom group in Nice (M. Hugbart, R. Kaiser), the wave turbulence expert in Nice (S. Nazrenko) and the Villeteuse group (H. Perrin), which is started in the 90. This has led to many common publications, with in particular:

- *PNAS : matter wave speckle and quantum turbulence (PNAS 114, 12691 (2017)):* the group in Sao Carlos has been the pioneer in turbulence with Bose Einstein condensates. A mapping on optical speckle has been done in collaboration with the Nice group.
- *PRL on cooperative scattering (Phys. Rev. Lett. 126, 103604 (2021)):* the experimental expertise of the Nice group on cooperative atom-light interactions (in particular Dicke subradiance) has been supported by a long-standing theory effort by the Sao Carlos group. Dicke super- and subradiance are now being explored by many groups for the potential application in quantum technology (memory, computation).
- *PRL on photon blockade with ground state atoms (Phys. Rev. Lett. 125, 073601 (2020)):* based on the joint expertise on Dicke super- and subradiance, a new proposal to allow for photon blockade (not requiring Rydberg atoms with their specific limitations, despite the fantastic potential) has emerged from the continuous collaboration between the two groups, illustrating the importance of long term sustained collaborations
- *PRL on Anderson Localisation (Phys. Rev. Lett 122, 183401 (2019)):* the Nice group has initiated a decade-long effort on Anderson localization of light in three dimensions, using cold atoms as scattering medium. Signatures of Anderson localization of light

are crucial ingredients for this effort and this paper provides a novel signature, based on photon correlations.

- *PRL on turbulence in quantum fluids (Phys. Rev. Lett. 134, 023401 (2025))*: triggered by networks including different researchers without prior collaborations (in particular the EU RISE project “Halt”) a world leader on wave turbulence (now based in Nice) has started a collaboration with the Sao Carlos group, who has pioneered turbulence studies with ultracold atoms combining their expertise.

Several PhD cotutelles have been implemented between USP, UFSCAR and Nice university (F. Cottier, M. Bicassi, J. Vitor). Beyond these formal aspects, many students from Sao Carlos have visited the groups in France and vice versa. Even if those informal visits did not all result in scientific publications, one should not underestimate the impact of such visits on the future generations of scientists.

### 3.3.2 Transformative Impact of the IRC in the Pillar

**The Coscali/QualiCo event in 2025, in Peyresq**, had participation from Brazilian and French researchers from different groups, relevant to the quantum pillar of the IRC, who were supported by the IRC. With ~30 participants from France and Brazil, this workshop has allowed both to strengthen existing collaborations and to set the ground for new collaborations. The website of this meeting is on <https://sites.google.com/ufscar.br/romain/events/qualico-2025>. Two main suggested actions arose:

- Visits of French scientists – to explore possibilities for IRLs in the Quantum Pillar, several French researchers (from both CNRS and Universities) expressed interest in follow-up exploration. A two-week visit in the different laboratories in state of Sao Paulo (and maybe the state of Rio de Janeiro) appears to be an efficient and necessary first step. Three French researchers have already been selected to visit, either in early February or in May 2026.
- French-Brazilian school - One well known efficient investment in future collaborations is the involvement of younger researchers, more mobile and planting the seed for future collaborations. During the Peyresq workshop, we identified potential organizers for a French-Brazilian school for PhD students and postdocs on the topic related to the quantum pillar in the spring of 2027.

The quantum pillar of this IRC is building on past collaborations, initially focused on those that are currently active, including bilateral (ANR, Fapesp, Capes-Cofecub) and multilateral collaborations (STIC-AmSud “Atoms, photons, and their interactions” , EU ETN “Colopt”, EU RISE “HALT”).

The IRC has allowed joint PhD programs consolidating existing collaborations between groups in France and Brazil. Following an IRP organized meeting in Peryresq in 2025, the IRC supports the visits of 3 French scientists in 2026, allowing them to get an overview of the

scientific expertise in Sao Paulo state, with the midterm goal of identifying a potential director of an IRL to be created.

Also, a joint school on quantum technologies, to be organized in Sao Paulo state in 2027 has been put forward and is under evaluation for funding by the IRC. The goal is to attract many French and Brazilian students to attend that school with lectures from both countries covering all aspects of quantum technologies with the potential to be developed in the IRC framework.

The IRC thus plays a crucial role for the consolidation of existing research collaborations in quantum science. At present, the effort is focused on collaborations between groups in France and Sao Paulo (with groups at USP but also with support from Fapesp, thus including all universities in Sao Paulo). The broader aim of this effort should include all groups in Brazil (such as in Recife, Rio de Janeiro, Belo Horizonte, Maceio, Natal, and others) and even in other countries in South America (Uruguay, Argentina, Chile, Colombia) with existing research expertise in quantum technology and past, ongoing or planned collaborations with French groups.

### 3.3.3 What would not have been possible without the IRC

The IRC has allowed for the joint PhD program, where students with their main affiliation in one country will spend several months in the partner country, thus fostering the active collaboration between the involved groups.

The IRC supports the visitor program which will allow scientists from France without past collaborations with Brazilian groups to meet the researchers in Brazil, laying the foundation for novel collaborations to start.

The IRC has triggered the proposal of a joint summer school aimed at French and Brazilian students on quantum technologies.

### 3.3.4 Future directions and disruptive ideas (2025–2035)

Beyond the well-established cold atom and quantum optics expertise, condensed matter and hybrid systems will be explored based on existing expertise in Brazilian groups. USP has just committed to a significant investment from its own budget for the development of quantum technologies. One priority will be to complement support for three young investigators with awards from FAPESP. They are pursuing research in quantum information processing with trapped ions, quantum communications (QKD and quantum networks) with structured light, and quantum transduction using superconducting circuits.

Quantum sensing is a promising technology, in which higher applied maturity (TRL) can be achieved on a shorter time scale. Exploring end users with particular relevance for Brazil will

be scrutinized with attention. Materials science and engineering will be crucial in these efforts.

Interdisciplinary projects include quantum astrophysics (with existing collaboration between a group in Nice and Rio de Janeiro and initial contacts at IAG in Sao Paulo).

Quantum (or quantum-inspired) sensing for applications in agriculture is a very promising avenue for future research. Gravimeters are already a subject of research at USP and France. One of the three researchers who plans to visit USP in 2026 works in this domain. Discussions were already initiated to explore frequency-comb spectroscopy for the detection of greenhouse gas emissions, in collaboration with the decarbonation pillar.

Novel quantum protocols (e.g. on photon blockade or photon correlations) are being discussed and proposed, following non-standard tracks of research.

Novel protocols for quantum sensing (and potentially quantum or quantum inspired simulations) are of strategic importance and will be explored in the framework of this IRC. Quantum communication and cryptography is a well identified strategic technology, with expertise existing in both France and Brazil. Satellite based intercontinental quantum communication between Brazil and France should be a strategic ambition.

Finding quantum light emitters in space would open a new window to the universe. This involves an interdisciplinary effort and the access to large telescopes in the southern hemisphere. Observation time on such facilities is often extremely difficult to obtain and might have country specific restrictions. Brazil has privileged access to some of them, which is a strategic opportunity to exploit.

### 3.4 Computing Methodologies: Techno-Human Systems of the Future

USP Representative: Alfredo Goldman (Professor at IME USP), and Jaime Simão Sichman (Professor at POLI USP) – CNRS Representative: Afonso Ferreira (Europe scientific advisor at CNRS)

Affiliations: University of São Paulo (USP), Centre National de la Recherche Scientifique (CNRS)

#### 3.4.1 Achievements enabled by the IRC (2023–2025)

The Computing Methodologies pillar, operating under the Techno-Human Systems of the Future (THUS) framework, has achieved significant scientific and structural milestones since the International Research Center (IRC) was established in 2023. The pillar is organized into **four highly collaborative teams: CHAINS, SYNERGY, MEGALOPOLIS, and UNBIAS**. These teams have collectively redefined how digital systems interact with human environments, focusing on sustainability, safety, and governance.

A cornerstone of these achievements has been the series of THUS annual workshops. The inaugural 2023 workshop at Inova USP established the cooperation agreement, while the 2024 session at the CNRS headquarters in Paris deepened the technical alignment. The 2025 workshop, held at the Maison du CNRS on the USP campus, was particularly notable, featuring high-level engagement from FAPESP and industrial partners such as Dassault Systèmes and SiDi. This event facilitated key discussions on intelligent modeling for hybrid twins of cities and regulatory compliance, allowing the teams to move from theoretical foundations to actionable action points.

Scientifically, the **CHAINS** team has pioneered a sustainability-driven perspective on software supply chain (SSC) analysis. By conceptualizing SSCs as dynamic, multi-dimensional ecosystems, they have addressed how energy consumption and sustainability metrics interact with security and project vitality. This work has been disseminated at premier venues, including the 10th International Workshop on Green and Sustainable Software (GREENS'26), co-located with the International Conference on Software Engineering (ICSE).

The **UNBIAS** team has advanced the field of intelligent agency through a neuro-symbolic system for assessing argument quality using the Minimal Dialectical Quality (MDQ) criterion. On the other hand, their work in the Industry 4.0 domain, supported by the FAPESP-ANR NAIMAN project, uses autonomous agents to manage industrial processes through explicit normative representation, ensuring that agent behavior remains transparent and intelligible to human operators.

In the realm of autonomous systems, the **SYNERGY** team has made major strides in the safety and resilience of unmanned aerial vehicles (UAVs) and air taxis. They developed scalable deep learning models using tensor decompositions and introduced the Executable Digital Twin (EDT) approach to update system dynamics in real-time. Their contributions include real-time anomaly detection for identifying cyberattacks such as GPS spoofing and jamming, thereby ensuring the reliability of AI-based systems in dynamic environments.

Simultaneously, the **MEGALOPOLIS** team has focused on Urban Digital Twins (UDTs), proposing a multi-dimensional architecture that prioritizes frugality. Their Bounded-Boundary Search (BBS) scheduling algorithm has demonstrated the potential to reduce non-renewable energy usage in urban simulations by up to 99.98%. A major technical success was the development of a carbon footprint plugin for the SimGrid/Batsim simulator, which has since been integrated into the core open-source distribution of SimGrid, providing a global tool for validating the environmental efficiency of urban management strategies.

Talent development has been a central achievement of the pillar, with numerous joint PhDs and personnel exchanges. Notable talents include eleven undergraduate and graduate students. These initiatives have solidified a robust human resource pipeline that bridges the two nations' scientific communities.

The following emblematic publications, selected from dozens of publications, highlight the scientific depth of the pillar:

- Sunyé, G., Eler, M., Cordeiro, D., Le Calvar, T., de Carvalho, V. R., Gouveia de Amorim, F. K., & Morandini, M. (2026). CHAINS – Collaborative hub for advancing innovative and sustainable software supply chains. In: *Proceedings of the 10th International Workshop on Green and Sustainable Software (GREENS '26)*. [to appear]. Description: This paper outlines the CHAINS proposal, integrating quality aspects such as energy consumption and security into the software supply chain model.
- Yan, E.; Nardin, L.G; Boissier, O.; Sichman, J.S. (2025). A Regulation Adaptation Model for Multi-Agent Systems. In *Proceedings of the 28th European Conference on Artificial Intelligence, 25-30 October 2025, Bologna, Italy*. IOS Press. Description: In this work, we propose a general regulation adaptation model for MAS and a method that uses constitutive and regulative norms to govern the execution of the regulation adaptation capabilities.
- Geronel, R.S., Santos, J.C., & Da Silva, M.M. Executable digital twin for a flexible robotic link. *J Braz. Soc. Mech. Sci. Eng.* 47, 600 (2025). Description: This paper applies Executable Digital Twins (EDTs) to exchange data from physical and virtual representations in real-time, achieving a 38% attenuation of undesired flexible dynamics.
- Ferrão, I., Oliveira, A., Marçal, V., Dezan, C., Espes, D., & Castelo Branco, K. (2024). Smart self-diagnosis method for GPS attacks and safety faults in UAVs. In: *2024 International Conference on Unmanned Aircraft Systems (ICUAS)*. Description: This paper proposes an intelligent real-time self-diagnosis method for UAVs capable of identifying operational faults and GPS spoofing using machine learning.
- Cordeiro, D., Song, J., Braghetto, K., Kon, F., & Amblard, F. (2025). Urban Digital Twins for Megalopolises: Requirements, Challenges, and Opportunities. In: *Anais do I Workshop em Engenharia de Software para Gêmeos Digitais*, (pp. 7-16). Porto Alegre: SBC. doi:10.5753/sedt.2025.14274. Description: This paper examines the technical challenges of deploying UDTs at the scale of megacities, proposing a framework based on scalability, interoperability, and carbon-responsible computing.
- Saraiva, G., Vasconcelos, M., Bruschi, S., Carastan-Santos, D., & Cordeiro, D. (2025). Estimating CO2 emissions of distributed applications and platforms with SimGrid\_Batsim. In: *Anais do XXVI Simpósio em Sistemas Computacionais de Alto Desempenho*, (pp. 109-120). Porto Alegre: SBC. doi:10.5753/sscad.2025.15853. Description: This work presents a carbon footprint plugin for the SimGrid simulator, enabling the calculation of CO2 emissions based on energy consumption and regional carbon intensity.

### 3.4.2 Transformative impact of the IRC on the pillar

The IRC has fundamentally altered the scale and nature of scientific collaboration within the Computing Methodologies pillar. Before the IRC, many of these groups collaborated on a project-by-project basis; the IRC has provided a permanent structure that fosters long-term, transversal research. A primary example of this transformation is the MEGALOPOLIS team, which expanded from an initial group of 13 members to a massive network of 42 researchers, incorporating new partners from the Université de Rennes and INSA Toulouse. This growth demonstrates how the IRC acts as a catalyst for attracting external interest and expanding the breadth of scientific inquiry. The IRC has moved the collaboration beyond

simple paper co-authorship toward a structural model of co-direction and shared infrastructure.

Interdisciplinarity has also become a core feature of the pillar's work. By linking experts in software engineering, artificial intelligence, automation, and urban planning, the IRC has enabled the teams to address "system-level" questions that would be impossible to tackle in isolation. For instance, the CHAINS team now integrates technical dimensions of software with environmental and social factors, while the UNBIAS team has successfully bridged the gap between normative agents and the practical requirements of Industry 4.0. The creation of these inter-pillar links has changed the types of scientific questions being addressed, moving from narrow technical problems to holistic challenges involving human-centric systems and urban governance. Furthermore, the IRC has granted teams better access to resources and infrastructures, such as the software archives of the Software Heritage project and the advanced simulation capabilities of SimGrid, now enhanced by the pillar's own sustainability contributions.

### 3.4.3 What would not have been possible without the IRC

The existence of the IRC provided the essential scientific and institutional backbone for several high-impact developments. The integrated software supply chain model proposed by CHAINS is a direct result of joint workshops where international experts in energy, security, and quality could align their research agendas in person. Without the IRC's financial and organizational support for these workshops, particularly the physical meetings in São Paulo and Paris, this multi-dimensional model would likely have remained fragmented. Similarly, the structural support for mobility was crucial; in particular, the success of PhD exchanges was directly facilitated by the IRC framework. These missions allowed researchers to utilize local infrastructures: in the case of the UNBIAS team, theoretical models were validated in a real-world setting: the Fábrica do Futuro located at USP.

The MEGALOPOLIS team's ability to submit massive joint proposals to the ANR and other international funding bodies is another outcome of the IRC's consolidating effect. The institutional weight of the IRC has provided a level of visibility that small, independent projects cannot achieve. In the SYNERGY team, the establishment of formal PhD co-directions and the frequency of researcher visits between Brazil and France have created a level of trust and continuity that project-based funding alone cannot sustain.

In essence, the IRC transformed a series of disconnected scientific interests into a coherent, strategically aligned pillar capable of competing on the global stage for large-scale funding and international talent.

### 3.4.4 Future directions and disruptive ideas (2025–2035)

Looking toward the 2025–2035 decade, the Computing Methodologies pillar aims for a "sky is the limit" approach to techno-human systems.

The CHAINS team envisions becoming a global hub for software supply chain research, providing the definitive datasets that other international projects will use to analyze security and energy consumption. This roadmap includes the development of automated tools for sustainable software configuration that can adapt in real-time to the carbon intensity of the global grid.

The UNBIAS team plans to expand its agent argumentation and norm-based regulation frameworks into critical cross-domain applications, specifically targeting environmental monitoring and medical decision-support systems. They aim to build a computational infrastructure where autonomous agents can assist human experts in making transparent, ethical decisions in high-stakes environments.

The SYNERGY team is dedicated to facilitating a seamless shift toward adaptive human-agent interaction. Their visionary goals include the development of low-complexity, data-driven modeling strategies that allow high-performance AI to run on resource-constrained hardware without losing accuracy. They also seek to solve the "safe reinforcement learning" challenge, providing stability and robustness guarantees for dynamical systems controlled by AI. A major focus will be on trustworthy decision support and assistive systems that meet individual-specific requirements for users with disabilities, ensuring that the technology of the future remains inclusive and reliable.

The MEGALOPOLIS team envisions a paradigm shift in urban governance through the deployment of "Carbon Responsible" Urban Digital Twins. Their roadmap includes a disruptive Adaptive Simulation Engine capable of toggling between high-fidelity models and lightweight AI surrogates based on real-time energy availability, a "follow-the-sun" strategy for urban management. By validating these technologies in the massive ecosystem of São Paulo, they aim to establish a new, sustainable standard for Smart Cities in the Global South. This ambitious plan will integrate heterogeneous data, from mobility patterns to social inequality indicators, into a unified decision-support system that serves urban climate justice.

Through the Inter-Pillars Postdoctoral Program and continued collaboration with industry leaders like Dassault Systèmes, the THUS pillar will continue to lead the development of innovative platforms that bridge high-performance computing with the urgent needs of human society.

### 3.5 Ocean-Atmosphere-Climate

USP representatives and affiliations

Alexander TURRA, UNESCO Chair for Ocean Sustainability, Oceanographic Institute and Advanced Studies Institute, University of São Paulo

Rachel Ifanger ALBRECHT, Department of Atmospheric Sciences, University of São Paulo

CNRS representatives and affiliations

Sabrina SPEICH, Laboratoire de Météorologie Dynamique, Department of Geosciences, Ecole Normale Supérieure

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### 3.5.1 Achievements enabled by the IRC (2023–2025)

The 2023–2025 period marks a transformative phase for this pillar, defined by a decisive strategic pivot in early 2025. Under the IRC's governance, the pillar expanded its remit to integrate the Atmospheric and Climate sciences with its existing oceanic foundations. The transition was formalized through a joint vision developed by newly appointed co-coordinators from both fields and researchers from both USP and CNRS. By consolidating a "core group" of more than 30 lead researchers into a single strategic framework (among more than 100 researchers engaged from both institutions), the IRC has ensured that the pillar is well-equipped to tackle complex interactions among the oceans, atmosphere, and climate. Strategic governance was solidified during high-level meetings in São Paulo (April 2025), where the pillar began developing specific metrics and milestones to monitor progress and ensure alignment with the IRC's mission.

To ensure this 2025 pivot gained immediate traction, the IRC served as a primary convener, notably through the May 2025 Online Workshop, which mobilized 48 researchers to define shared research questions and lay a foundation for a broader community of students and postdocs. To consolidate the medium-term (2026-2030) plan, an in-person workshop with approximately 25 participants is planned to take place in Paris from March 23–26, 2026. Finally, the pillar has successfully projected this integrated vision onto the global stage through active participation in the United Nations Ocean Conference (2025), the Franco-USPIANA Week, and COP30.

Scientific efforts are currently focused on high-caliber collaborative research, exemplified by a recently accepted paper in the *Bulletin of the American Meteorological Society*, a top-tier flagship journal renowned for publishing large-scale, high-impact international projects. The article, titled 'The BIOMASP+ project on biosphere-atmosphere exchanges and their impact on air pollution in the subtropical megacity of São Paulo,' is the product of a robust CNRS-USP partnership. This collaboration is strategically anchored in the IRC through a PhD Joint Programme and an International Research Project (IRP), providing a foundational five-year mobility framework for the consortium's research teams. Beyond its atmospheric focus, the megacity research serves as a primary driver of transdisciplinary synergy within the IRC. The study of urban environments is identified as a major inter-pillar initiative, bridging the topics of the Environment, Informatics (digital twins), and Humanities.

Similarly, recent advances of the IRP "Saravá," which focus on South Atlantic Paleoceanography and Paleoclimatology, were published in the *Quaternary Science Reviews*, exemplifying a bilateral partnership supported by a joint PhD and a recent submission to the 2025-2026 FAPESP-ANR call.

Talent integration remains a cornerstone of the pillar's success. Short-term (two-week) mobility at the IRC is planned, for example, in 2026, to integrate Artificial Intelligence into micropaleontological climate reconstruction, a collaboration between CEREGE and IO-USP. The core of the exchange rests on the five-year frameworks provided by IRPs, of which the pillar currently has two (SARAVA and BIOMASP+), which provide the institutional stability

necessary for continuous researcher exchange. These frameworks support high-impact initiatives such as the joint PhD program (AMACLIM). This institutional branding has created a powerful "IRC effect," facilitating information sharing, collaboration, successful joint applications for high-level funding, including FAPESP-SPRINT and ANR-FAPESP (AMACLIM), and securing the resources necessary for high-impact research.

### 3.5.2 Transformative impact of the IRC on the pillar

The IRC has fundamentally redefined the nature of USP-CNRS collaboration by shifting from a model of fragmented, bilateral laboratory ties to a coordinated, institutional ecosystem. For this nascent pillar, the IRC provided a critical structural framework that allowed activities to scale beyond the historical boundaries of individual projects.

By establishing a joint strategic vision, the pillar has created the legitimacy needed to move beyond traditional disciplinary approaches toward interdisciplinary and transdisciplinary initiatives, building on existing collaborations (e.g., Drivers of past changes in South Atlantic Circulation and tropical South American climate, SARAVAL; Cycle of Convection, from Lightning activity and Oxide emission to Particle formation and Subsiding transport, CyCLOPS; South Atlantic Meridional Overturning Circulation, SAMOC; The Franco-Brazilian BIOMASP+ project, BIOMASP+; Aerosol observation over Brazil and impacts, AEROBI), while also seeding new opportunities for joint research. This institutional presence is what makes a programmatic expansion into topics such as megacities, renewable energies, or the ocean-biodiversity-climate nexus possible; it provides the stability and network required to create and sustain initiatives that exceed the scope of conventional bilateral agreements, expanding the opportunities created by funding agencies such as FAPESP (e.g., Program for the South Atlantic and Antarctica).

Because the IRC exists, the ocean-atmosphere-climate consortium can operate with a "core group" of synchronized expertise and a shared roadmap for infrastructure and mobility. This shift in scale ensures that the pillar is not merely a collection of scientists but a high-momentum strategic hub capable of long-term scientific leadership to deliver robust scientific and societal contributions.

The impact of the pillar is an ongoing endeavor, and its outputs and outcomes depend on the joint creation of a strategic vision and timely actions that add value to the existing collaboration. This work occurs within challenging frameworks, such as the ocean-atmosphere-climate nexus and the varied interfaces it has with other pillars of the IRC Transitions and other CNRS IRLs and IRCs worldwide. This demands sufficient time to engage research groups and reimagine their work through more audacious and strategic approaches, leading to stronger collaborations and contributions. The opportunity provided by the IRC to identify existing initiatives and to map and engage researchers from USP and CNRS was fundamental to supporting the co-creation of a systemic approach to face contemporary societal challenges. This is where the pillar stands today, creating high expectations for its first in-person workshop, which will focus on the joint elaboration of its medium-term plan.

### 3.5.3 What would not have been possible without the IRC

The Ocean, Atmosphere, and Climate pillar was proposed within the IRC as a new and needed approach to address emerging international issues and challenges, including high-level bilateral Brazil-French commitments such as the “Nice to Belém declaration,” signed at the United Nations Conference in Nice in June 2025. It was created based on existing activities of a group of researchers at USP and CNRS who were already collaborating. It was proposed to map the existing and potential initiatives that could contribute to forging a strategy to implement the IRC Transitions.

Without the IRC, the pillar would not exist, and the joint efforts to connect the science of the nexus of ocean, atmosphere, and climate to the perspective of sustainable development would not be catalyzed. In other words, this means that a core group of coordinators from different areas of knowledge would not be nominated to strategically design a process to identify and engage researchers and initiatives, and to support USP and CNRS in pursuing this mission. Without the IRC, the coordination of this relevant heuristic process would not be possible.

In practice, the IRC promoted:

- the development of a strategic view of the ocean-atmosphere-climate nexus, based on the contour parameters outlined in the assessment report;
- the identification of ongoing and potential collaborations between USP and CNRS researchers;
- it has fostered interaction and the sharing of experiences among researchers with ongoing collaborations;
- the dissemination of information on key funding opportunities, whether directly or indirectly linked to the IRC; and,
- the joint development of the pillar medium-term strategy.

Although the pillar is still in its infancy, it already shows clear evidence of its potential long-term impact on science and on the transition to a more sustainable future.

### 3.5.4 Future directions and disruptive ideas (2025–2035)

The medium-to-long-term trajectory of the Ocean-Atmosphere-Climate pillar is built on shifting from observational studies to predictive and solution-oriented Earth-system science. By 2035, the pillar aims to have moved beyond individual collaborations to a consolidated international research ecosystem.

The core scientific focus will expand to encompass Earth system transitions and tipping points, with a specific emphasis on the Atlantic Meridional Overturning Circulation (AMOC) and its impacts across spatial and temporal scales, as well as a refined characterization of biosphere-atmosphere coupling in the Amazon basin—currently under pressure from deforestation and climate change. A key disruptive priority is the investigation of the Land-Ocean Aquatic Continuum, linking the Amazon’s hydrological cycle to deep-ocean feedback loops. Furthermore, research on the transition toward next-generation clean cities will use

the São Paulo megacity (MASP) as a primary natural laboratory to study the interaction of biogenic and anthropogenic emissions on air quality degradation.

A primary objective is to increase the Operational Readiness Level of the pillar by ensuring that shared platforms and equipment—such as research vessels, flux towers, and balloon-borne sensors—are consistently available to the binational community. A central ambition is to create a Data Center for the exchange and exploration of new data domains, including the upper atmosphere and the deep ocean. Methodologically, the pillar will pioneer the use of Informatics (Digital Twins) to create real-time simulations of urban-atmosphere-biosphere (ocean) interactions, bridging the gap between microseconds of matter flux and multi-year climate scales. To achieve this, the pillar is cocreating its medium-term strategy (2026–2030) with the research community identified and engaged during its initial phase (2024–2025), which will be further unfolded into its long-term strategic ambitions (see below).

### **Joint elaboration of the medium-term strategy (2026–2030)**

The collaborative development of the medium-term strategy began with an online workshop in 2025 and will be finalized at the first in-person meeting in Paris in March 2026. This meeting will consolidate ongoing discussions to identify the pillar’s primary contributions (i.e., its research agenda) and define its strategic goals and targets for 2030. Additionally, the strategy will establish the pillar’s structure and governance, outlining the processes and routines needed to support coordination and research activities. Alongside strengthening scientific cooperation—such as by disseminating funding calls—the coordination team will continue to map existing partnerships, foster new synergies, and promote inter- and transdisciplinary research.

### **Consolidation of long-term strategic ambitions (2030–2035)**

The pillar has defined clear milestones for institutional growth:

- consolidation of International Research Laboratories (IRL): By 2030, the pillar aims to have at least one or two fully structured IRLs, integrating existing initiatives such as the IRL IFAECI to strengthen the regional network;
- São Paulo School of Advanced Science (SPSAS): We will establish a recurring program of high-level training, with planned schools on Microplastics (2026), Observations (2027), and Transformative Solutions (2027);
- interpillar Synergies: we will support joint projects that intersect with the Environment and Humanities pillars to provide Policy Briefs and scientific pathways for environmental agencies.

Our long-term ambition is to move beyond academic publications to provide clear guidance for funding and environmental agencies. By attracting private investment and fostering transdisciplinary research, the pillar will transition from studying climate problems to providing science-grounded, transformative solutions for societal resilience. This includes expanding research efforts across the entire Brazilian territory and using coastal studies as a pathway to mitigate environmental impacts for society.

## 3.6 Ecology & Environment

USP representative: Jean Paul Metzger (Institute of Biosciences and Institute of Advanced Studies, University of São Paulo)

CNRS representative: Jérôme Chave (CNRS Directeur de Recherche and Deputy Director of the Center for Research on Biodiversity and the Environment); Former representative: Gilles Pinay from the National Institute of Ecology and Environment (INEE).

### 3.6.1 Achievements enabled by the IRC (2023–2025)

Since its creation, the *Environment and Sustainability pillar* of the IRC (CNRS–USP) has played a decisive role in *structuring a research community*, enabling not only scientific coordination but also the collective formulation of a shared mission, vision, and set of values that now orient the development of its activities.

One of the most significant achievements enabled by the IRC was the emergence of a **shared scientific identity**, fostered through sustained dialogue among French and Brazilian researchers during two major workshops held in São Paulo (25–26 March 2024) and Rennes (30 September–4 October 2024). These workshops brought together approximately 20 researchers from seven CNRS laboratories and seven USP institutes, spanning a wide range of thematic areas and research groups. They functioned as genuine spaces of co-construction, enabling participants to move beyond simple thematic proximity toward a collectively articulated set of priorities, roles, and intended societal impacts.

Through these interactions, the pillar collectively defined its **mission**: to promote cutting-edge, collaborative research at the interface of climate and biodiversity sciences, while strengthening long-term Franco–Brazilian cooperation and fostering the training of early-career researchers within an international and network-based environment. This mission reflects a shift from fragmented/individual collaborations toward a durable research ecosystem, explicitly oriented toward global socio-ecological challenges.

In parallel, the workshops enabled the articulation of a forward-looking **vision**, centered on contributing to more just and resilient societies capable of responding to climate change and biodiversity loss. This vision emphasizes not only ecological resilience, but also biodiversity conservation and restoration, the strategic deployment of nature-based solutions, and more harmonious coexistence among human, non-human, and more-than-human entities. Importantly, this vision emerged from comparative reflections across Brazilian and French contexts, highlighting shared challenges but also contextual specificities.

A further achievement was the explicit formulation of **core values** guiding the pillar's development. These include commitments to social and environmental justice, ethical and participatory scientific practices, diversity and inclusion, and a non-colonial approach to knowledge production and international collaboration. Far from being declarative, these values already shape concrete choices, such as the emphasis on participatory approaches,

attention to uneven vulnerabilities, and reflexivity regarding power asymmetries in North–South research partnerships.

Scientifically, these shared foundations translated into the identification of **two major research challenges**:

- (1) climate justice in the face of extreme events and socio-ecosystem vulnerabilities; and
- (2) cross-scale and transboundary approaches to socio-ecological polycrises.

#### *Challenge 1 - Towards Climate Justice in the Face of Extreme Events and Socio-Ecosystem Vulnerabilities*

The frequency and intensity of extreme events—such as droughts, heat waves, floods, ecosystem dieback, pollution crises, rapid land-use change, and mass mortality events—have increased markedly in recent decades, placing growing pressure on socio-ecological systems and testing their resilience and adaptive capacity. These events are not only climatic in nature but also emerge from complex interactions among environmental, ecological, and social processes, often amplified by human activities such as urbanization, deforestation, and pollution. Importantly, their impacts are unevenly distributed, with lower-income and marginalized populations disproportionately exposed and affected, underscoring the need for a climate justice–oriented response.

This axis treats extreme events as a wicked problem, requiring integrated, interdisciplinary approaches that explicitly consider the interdependence between climate dynamics, biodiversity, ecosystems, and social systems, as well as strong regional and contextual variability. Climate justice is understood here as the incorporation of distributive, procedural, and recognition-based justice principles into climate mitigation and adaptation efforts, supported by inclusive and representative data and monitoring systems.

Key objectives include understanding the processes that lead to extreme events and their intensification over time, identifying trends that may redefine what becomes the “new normal,” assessing patterns of vulnerability across populations and territories, and developing participatory approaches that engage relevant actors in the co-production of knowledge and solutions. The axis mobilizes complementary tools such as in situ and remote observations, modeling, and multi-scale indicators of vulnerability and adaptive capacity. Expected outcomes include spatialized assessments of extreme events and their impacts on socio-ecological systems, monitoring frameworks, and integrative indices designed to support climate justice–oriented decision-making.

#### *Challenge 2: Cross-Scale and Transboundary Approaches to Address Socio-Ecological Polycrises*

Environmental challenges increasingly manifest as interconnected polycrises, in which ecological degradation, climate change, and biodiversity loss interact with economic, social, and political systems, affecting the full range of ecosystem services. These challenges unfold across multiple spatial, temporal, and institutional scales, requiring responses that account for complex feedbacks between global drivers, national policies, and local actions.

This axis focuses on understanding how environmental policies and conservation actions are designed, implemented, monitored, and scaled across levels, including the challenges of scaling down policy objectives to local contexts and scaling up successful local practices. Addressing these dynamics requires analytical approaches capable of capturing cross-scale interactions, non-linear responses, and trade-offs across ecological and social systems, as well as governance arrangements that support coordination across jurisdictions and sectors while explicitly incorporating principles of environmental and climate justice.

By integrating natural and social sciences and promoting transdisciplinary collaboration, this axis emphasizes the role of stakeholders' knowledge, perceptions, and practices in shaping responses to socio-ecological polycrises. It explores participatory and co-production approaches that enhance legitimacy, social engagement, and adaptive capacity, with the ultimate goal of identifying governance and institutional configurations that enable effective conservation outcomes, strengthen nature's contributions to people, and promote environmental justice in multilevel and transboundary contexts.

The IRC also enabled the translation of these challenges into **concrete research initiatives**, including the preparation of a large ANR–FAPESP proposal on heat waves across urban, coastal, and forest systems, and the subsequent development of an inter-pillar postdoctoral project, entitled "*Challenges of Urban Greening Optimization to Promote a Transition towards More Sustainable and Resilient Megalopolises: An Integrative Perspective*" (URBANGREENOPT). Even when not selected, these collective efforts consolidated the group, tested integrative methodologies, and clarified future directions. Finally, the IRC has supported the early **integration of training, mobility, and international networking** into the pillar's activities, laying the foundations for long-term talent development and scientific leadership.

### 3.6.2 Transformative impact of the IRC in the pillar

The IRC has transformed the *Environment and Sustainability pillar* by enabling a shift from fragmented collaborations to a more **coordinated and collectively governed research framework**.

At a structural level, the IRC provided the conditions for researchers from diverse disciplines and institutions to engage in sustained dialogue, leading to the co-construction of mission, vision, and values that now serve as a common reference point. This has fundamentally altered the nature of collaboration, fostering trust, intellectual openness, and a willingness to engage with complex questions related to justice, inequality, and power. During this initial phase, members of the Environment and Sustainability pillar have expressed interest in engaging in two ongoing International Research Network (IRN) initiatives:

- an IRN led by Damien Arvor (Directeur de Recherche, Université de Rennes) on Land Use and Land Cover Changes in Mato Grosso;
- an IRN led by Julia Hidalgo (Maison de la Recherche, Université Toulouse Jean Jaurès) on " Living in the Cities of the Future: Urban Worlds in Transition and the

## Reconfiguration of Actor Systems Around Projects for Livable, Sustainable, and/or Smart Cities".

The IRC also **changed the scale and ambition of scientific questions** addressed by the pillar. Rather than focusing on isolated environmental processes, research is now framed around integrated socio-ecological systems, extreme events as systemic stressors, and the interactions between climate change, biodiversity loss, and governance across scales. **Interdisciplinarity** has become a core operating principle, embedded from the formulation of research questions to methodological choices. The pillar actively integrates natural sciences, social sciences, and legal and governance perspectives, enabling richer analyses of vulnerability, adaptation, and resilience.

Moreover, the IRC has facilitated **cross-pillar fertilization**, particularly with the Decarbonation, Human and Social Sciences, Computer Science, and Earth, Atmosphere and Ocean pillars. These interactions have expanded access to new tools (such as digital twins), conceptual frameworks, and funding instruments, reshaping both the content and feasibility of the pillar's agenda.

In essence, the IRC has increased collaboration, making it more strategic, reflexive, and transformative.

### 3.6.3 What would not have been possible without the IRC

Without the IRC, several key developments would likely not have emerged, or would have remained fragmented and short-lived.

Most importantly, the collective articulation of mission, vision, and values would have been difficult to achieve outside a stable institutional framework encouraging long-term engagement. The IRC provided both the legitimacy and the temporal horizon necessary for researchers to invest in foundational discussions that go beyond immediate project outputs. The identification of climate justice and socio-ecological polycrises as unifying challenges also emerged directly from IRC-enabled workshops. Without this framework, research efforts would likely have remained disciplinary and disconnected, limiting their capacity to address complex, real-world problems.

Similarly, the development of ambitious, integrative projects—such as the ANR–FAPESP proposal and URBANGREENOPT—depended on the organizational support, coordination capacity, and cross-pillar connectivity provided by the IRC.

The early embedding of training, mobility, and leadership development into the pillar's strategy is another distinctive feature made possible by the IRC, which encourages thinking beyond individual careers toward the long-term sustainability of the research community itself.

### 3.6.4 Future directions and disruptive ideas (2025–2035)

Building on its consolidating phase, the *Environment and Sustainability pillar* envisions a future marked by scientific ambition, ethical engagement, and international visibility. Mission, vision, and values will continue to guide the development of research activities, ensuring coherence between scientific excellence and societal relevance. A central priority will be the consolidation of *extreme events* as a unifying analytical lens, linking climate dynamics, biodiversity responses, governance failures, and social inequalities across multiple environments and scales.

Urban socio-ecological systems, particularly in megacities of the Global South, will serve as key laboratories for testing *nature-based solutions*, *climate adaptation strategies*, and *innovative financing mechanisms*. The development of *digital twins* is envisioned as a disruptive platform for integrating data, modeling scenarios, and engaging stakeholders in decision-making processes.

The pillar also aims to strengthen its role in *cross-scale and transboundary governance research*, contributing to international debates on climate justice, biodiversity policy, and sustainability transitions. Strategic positioning within international networks and assessments will be actively pursued.

Interdisciplinary and inter-pillar collaboration will be further deepened through joint doctoral and postdoctoral schemes, enabling a new generation of researchers to operate fluently across disciplinary and national boundaries.

Ultimately, the long-term ambition is for the pillar to evolve into a globally recognized, agenda-setting platform, capable of shaping both scientific discourse and policy responses to socio-ecological crises over the coming decade.

## 3.7 Agro/Decarbonation

### 3.7.1 Scope and Scientific Positioning

The Agro/Decarbonization pillar addresses the role of agricultural systems in climate change mitigation and adaptation, with a particular focus on **carbon dynamics within soil–plant–animal–atmosphere interactions**.

Its scientific positioning lies at the interface between agronomy, soil science, ecology, sustainable land management, and socioeconomics, aiming to reconcile agricultural productivity with biodiversity conservation and climate objectives.

By revisiting food production systems in the context of the **UN Sustainable Development Goals**, the pillar contributes to identifying pathways toward low-carbon, resilient agricultural systems in tropical environments.

### 3.7.2 Key Achievements Enabled by the Agro Pillar

The main achievement enabled by the IRC within the Agro/Decarbonization pillar was the organization of a **binational and interdisciplinary workshop** held on **November 4–6, 2024**, at the “*Luiz de Queiroz*” College of Agriculture (Esalq/USP).

This event provided a unique framework for bringing together scientists from leading French and Brazilian institutions to discuss **carbon dynamics in agriculture and decarbonization strategies**.

The workshop, entitled “**Carbon dynamics in the soil–plant–animal–atmosphere interactions**”, aimed to integrate research groups and resources from both countries in order to strengthen existing collaborations and lay the foundations for a **robust international research proposal** targeting future funding opportunities.

It was organized by the **Center for Carbon Research in Tropical Agriculture (CCARBON/USP)**, with the support of **FAPESP** and the **Consulate General of France in São Paulo**, and was held in a hybrid format to maximize international participation.

### 3.7.3 Interdisciplinary and International Dimension

The discussions adopted a strongly interdisciplinary approach, bringing together researchers in **agronomy, conservation biology, sustainable development, land management, and socioeconomics**.

The scientific exchanges focused on climate adaptation, greenhouse gas emissions, carbon sequestration, sustainable agricultural practices, and their socioeconomic implications. The workshop mobilized a broad institutional ecosystem.

On the Brazilian side, CCARBON/USP was represented by its directors **Carlos Eduardo Cerri, Maurício Cherubin, and Tiago Osório Ferreira**, together with several researchers and technical staff involved in both scientific and organizational activities. The CNRS was represented by **Elisa Bruni** and **Liviu Nicu**, reflecting its interdisciplinary engagement across scientific domains.

French participation also included researchers from **CIRAD** and **INRAE**, two major institutions active in sustainable agriculture, biodiversity preservation, climate resilience, and land-use strategies.

The opening session benefited from the participation of **Prof. Thaís Vieira** (Dean of Esalq/USP and member of CCARBON’s International Scientific Advisory Board) and **Prof. Fernando Menezes de Almeida** (Administrative Director of FAPESP), highlighting the institutional relevance of the initiative.

### 3.7.4 Main Scientific Outputs

#### *Conference Paper*

One of the two main outputs of the Agro/Decarbonization pillar is a **conference paper** consolidating the key discussions and shared insights generated during the workshop. This document serves as a reference for future collaborations in sustainable agriculture and carbon management, emphasizing adaptation and mitigation strategies in tropical systems.

The paper synthesizes interdisciplinary perspectives on carbon sequestration mechanisms, land management changes, and the resilience of agricultural systems to climate stress. Interactive sessions, including flash talks and thematic group discussions, facilitated knowledge exchange and helped identify **priority research directions**, particularly in sustainable land use, data modeling, and carbon monitoring techniques.

By doing so, the conference paper contributes to broader international debates on sustainable agriculture and aligns with global frameworks such as the **Paris Agreement**.

#### *Draft of a Long-term Research Proposal*

The second major output is the development of a **draft research proposal** for a long-term collaborative project in sustainable agriculture and carbon management. This proposal aims to establish a structured framework for continued cooperation between Brazilian and French institutions, focusing on **soil health, carbon dynamics, and climate-resilient agricultural systems** in tropical environments.

Building on Brazil's significant potential for carbon sequestration, the proposal emphasizes sustainable agricultural and agroforestry practices as key levers for mitigation. It outlines a multidisciplinary scientific agenda spanning agriculture and forestry, including research on integrated agroforestry systems, soil recovery and conservation, climate-resilient cropping systems, and advanced carbon and biodiversity monitoring.

The initiative seeks to generate impacts both at the scientific level and in terms of climate adaptation, food security, and environmental conservation.

### 3.7.5 Perspectives and Structural Evolution of the Pillar

Looking ahead, researchers involved in the Agro/Decarbonization pillar have identified strong scientific convergence with the **Ecology & Environment** pillar.

Future perspectives therefore point toward a **progressive fusion of the two pillars**, reflecting shared research themes such as **nature-based solutions**, climate change adaptation and mitigation, and ecosystem resilience.

This structural evolution is expected to strengthen interdisciplinarity within the IRC and to provide a more integrated framework for addressing environmental and agricultural transitions in tropical regions.

## 4. Scientific Horizons 2026–2030

### 4.1.1 Structuring Scientific Convergence in a Multi-Polar World

Following its creation in October 2023 and its initial consolidation phase, the IRC CNRS–USP *Transitions* now enters a strategic period in which its scientific ambition must translate into **coherent, visible and durable trajectories**.

Beyond disciplinary excellence, the central challenge for the coming decade is to **organize scientific convergence** around shared questions that cannot be addressed by isolated fields, institutions or regions.

The horizons presented below are intentionally formulated at a **supra-pillar and inter-pillar level**. They aim to articulate scientific challenges, organizational instruments and international leverage, while remaining grounded in the operational realities of the IRC.

### 4.1.2 Short-term horizon (2025–2027): Structuring Convergence and Readability

In the short term, the priority is to move from coexistence of excellent disciplinary dynamics to **organized scientific convergence** around clearly identified challenges. Three cross-cutting scientific issues emerge as structuring drivers across the IRC:

- **Interdependencies between environmental change and health**, including ecosystem degradation, exposure pathways, and social vulnerability;
- **Sustainable transformation of socio-technical systems**, spanning food systems, urban environments, energy transitions and resource use;
- **Data, modeling and complexity**, as transversal enablers to understand, simulate and govern non-linear systems across disciplines;
- **Democracy and science with and for society** as today's context see increasing questioning of science and a crisis of democratic regimes, which must be responded.

Rather than creating new thematic silos, the objective is to **use these issues as convergence vectors**, enabling communities from different pillars to articulate shared research questions and methodologies.

Operationally, this phase relies on:

- the **CNRS–USP PhD Joint Program** as a primary instrument to seed interdisciplinary research trajectories at an early stage;
- the **Inter-Pillar Postdoctoral Program** to position young researchers explicitly at the interfaces between communities;
- targeted support from the **FAPESP CIP – Centro Internacional de Pesquisa**, notably for doctoral and postdoctoral fellowships and the organization of convergence workshops and thematic schools.

At this horizon, inter-IRC interactions should begin in a **focused and pragmatic manner**, prioritizing collaboration with the **IRC in Arizona** and the **IRC in the Witwatersrand**, which share comparable scientific cultures and thematic proximities.

Initial joint activities may include co-organized workshops, shared doctoral or postdoctoral mentoring schemes, and exploratory exchanges aimed at identifying common scientific denominators.

The goal of this phase is clarity: **clear scientific narratives, clear instruments, and clear interfaces**, both internally and externally.

#### 4.1.3 Medium-term horizon (2027–2030): Flagships and Inter-IRC Amplification

The medium-term horizon should mark a decisive shift toward **structuring impact at scale**. Building on the convergence dynamics initiated earlier, the IRC should progressively formalize **two to four flagship scientific trajectories**, explicitly inter-pillar and mission-oriented.

These flagships should:

- address global challenges where Europe and Latin America share strong complementarities (e.g. environmental resilience, health–environment–society interfaces, responsible digital and technological transitions);
- mobilize multiple pillars in a coordinated manner, while maintaining disciplinary depth;
- serve as focal points for international funding, visibility and institutional alignment.

At this stage, inter-IRC cooperation becomes a **strategic lever** rather than an exploratory activity.

Joint initiatives with the IRCs in **Arizona and Witwatersrand** could evolve into co-led flagships, allowing the IRC CNRS–USP to participate in **tri-continental scientific configurations** linking Europe, Latin America, North America and Africa.

This horizon should mobilize:

- European and binational funding schemes (ANR, Horizon Europe, COFUND-type instruments),

- CNRS structuring tools such as **International Research Networks (IRN)**,
- coordinated funding strategies combining CNRS, USP and FAPESP resources.

The ambition is for the IRC to become a **credible platform for large-scale scientific initiatives**, capable of federating communities beyond bilateral cooperation while retaining strong institutional anchoring.

#### 4.1.4 Long-term horizon (2030–2035): A Bi-Hemispheric and Multi-IRC Reference Hub

In the long term, the IRC CNRS–USP *Transitions* should consolidate its position as a **bi-hemispheric reference hub** for interdisciplinary research on transitions, fully embedded within a networked ecosystem of IRCs.

Scientifically, this implies:

- the capacity to anticipate emerging questions at the intersection of environment, health, technology and society;
- the development of integrated research frameworks combining natural sciences, engineering, data sciences and humanities;
- sustained contributions to global scientific and policy debates on sustainability and resilience.

Institutionally, the IRC is expected to:

- play a structuring role within the **CNRS network of International Research Centers**, through long-term inter-IRC alliances and shared flagships;
- act as a **gateway between Europe and Latin America**, while participating in broader multi-regional configurations;
- serve as a training ground for future scientific leaders capable of navigating complex international and interdisciplinary environments.

At this horizon, success will be measured less by individual outputs than by the IRC's ability to **shape scientific ecosystems**, influence agendas, and ensure continuity across generations and governance cycles.

Across all three horizons, the core ambition of the IRC remains unchanged: to **create durable conditions for convergence, amplification and transformation**, without substituting disciplinary communities or imposing artificial structures. By aligning scientific ambition with realistic instruments and progressive inter-IRC integration, the IRC CNRS–USP *Transitions* is positioned to evolve into a **long-term structuring actor of global scientific cooperation**, firmly anchored in both institutional excellence and societal relevance.

## 5. Conclusion: A Shared Future

The IRC CNRS–USP *Transitions* was conceived as more than a new cooperation instrument. From its inception, it has been designed as a **shared scientific space**, capable of transcending institutional boundaries, disciplinary silos and geographical distances in order to address the major challenges of our time.

Two years after its creation, the IRC has demonstrated its relevance and viability. It has successfully brought together world-class institutions, mobilized diverse scientific communities, launched concrete training and mobility programs, and fostered a new culture of interdisciplinary and international collaboration. These achievements confirm that the IRC is not an abstract concept, but a **functional and productive framework**, rooted in scientific excellence and institutional trust.

At the same time, the IRC has reached a critical moment in its trajectory. The challenge ahead is no longer to prove its existence, but to **secure its long-term impact**. This requires clarity of purpose, selective ambition, and the ability to transform scientific momentum into structured, visible and durable outcomes. The Scientific Horizons outlined in this Report provide a roadmap for this next phase, emphasizing convergence, flagship initiatives and progressive integration within the global network of International Research Centers.

For the forthcoming leaderships of CNRS and USP, the IRC CNRS–USP *Transitions* represents a **strategic asset**. It offers a stable, credible and forward-looking platform for international cooperation, aligned with both institutions' missions and values. It also provides a unique opportunity to position the CNRS–USP partnership at the forefront of global scientific debates, while contributing to the training of future generations of researchers capable of navigating complex, interdisciplinary and international environments.

A central element in this collective trajectory is the **Maison du CNRS at the University of São Paulo**, which has rapidly become a cornerstone of the IRC's daily life and scientific culture. More than a hosting facility, the Maison du CNRS functions as a **shared intellectual space**, where researchers from different disciplines, institutions and countries work side by side, exchange ideas informally, and co-construct scientific initiatives. By providing a physical environment that encourages proximity, dialogue and experimentation, it has significantly contributed to breaking down disciplinary and institutional barriers. The Maison also plays a key role in aggregating the IRC community around common scientific events, workshops and training activities, giving tangible form to interdisciplinarity. The decision of the USP leadership to create and support this space reflects a **clear strategic vision** and an acute understanding of how physical infrastructures can catalyze scientific convergence. In this respect, the Maison du CNRS stands as a flagship of the CNRS–USP partnership and a source of shared institutional pride.

Looking forward, the success of the IRC will depend on its capacity to remain faithful to its founding principles while adapting to evolving scientific, institutional and geopolitical contexts. By combining excellence with openness, structure with flexibility, and ambition with realism, the IRC CNRS–USP *Transitions* is well positioned to evolve from a pioneering initiative into a **long-term reference model of bi-hemispheric scientific cooperation**.

This White Paper is therefore both a milestone and an invitation: a milestone marking what has already been collectively achieved, and an invitation to continue building, together, a shared scientific future grounded in trust, responsibility and global engagement.