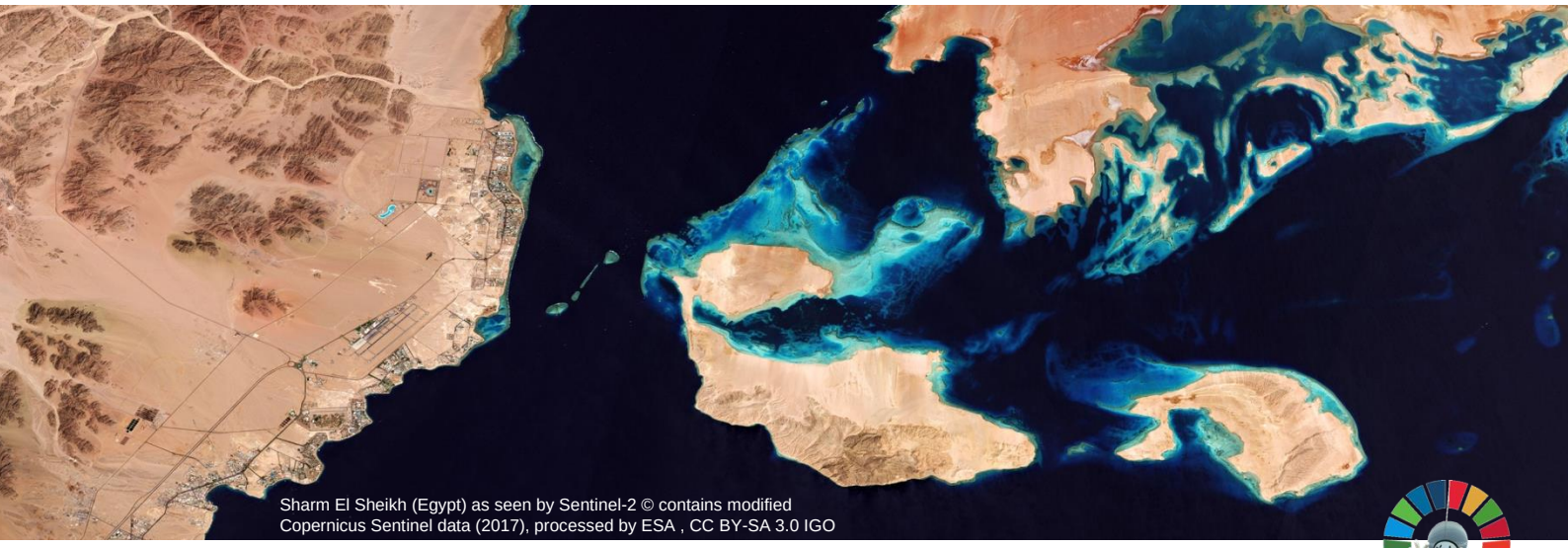


Sharm El Sheikh (Egypt) as seen by Sentinel-2 © contains modified Copernicus Sentinel data (2017), processed by ESA , CC BY-SA 3.0 IGO

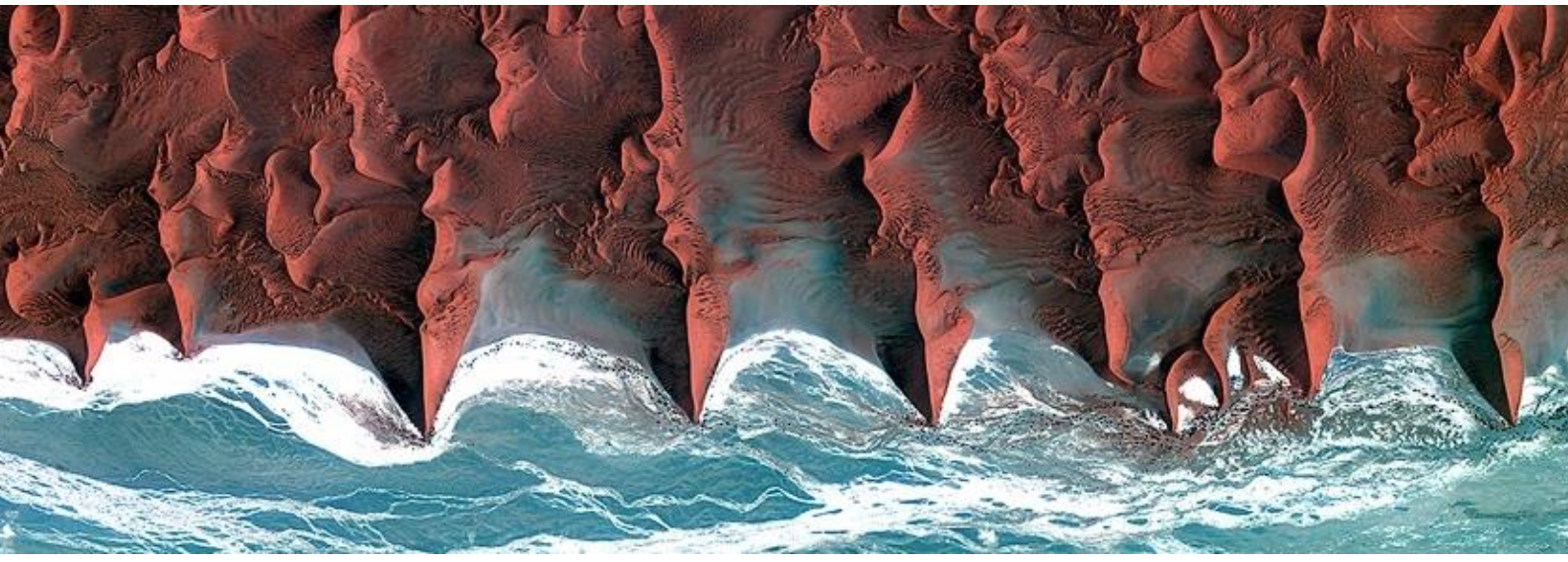
ELYX/SCO

MY TRIP TO SCO

A report by Auriane GIORGALLA

An impact analysis of the SCO (Space for Climate Observatory) project portfolio

July 2023



Namibian desert by Spot 5 © CNES 2006, Distribution Airbus DS

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ACRONYMS

French Space Agency (CNES)

Collecte Localisation Satellites (CLS)

Inter-Organizational Committee (IOC)

Committee on Earth Observation Satellites (CEOS)

Conference of the Parties (COP)

United Nations Framework Convention on Climate Change (UNFCCC)

Departmental Directorate of Territories and the Sea (DDTS)

Intergovernmental Panel on Climate Change (IPCC)

Institute of Research for Development (IRD)

French National Institute for Geographic and Forestry Information (IGN)

Sustainable Development Goals (SDGs)

National Climate Change Adaptation Plan (NCCAP)

Space for Climate Observatory (SCO)

European Union (EU)

United Nations Office for Outer Space Affairs (UNOOSA)

French Biodiversity Office (FBO)

INTRODUCTION

Fragile coastlines and marine environments, coastal erosion, rising sea levels, deforestation, atmospheric emissions, increased frequency of extreme natural disasters such as droughts and heat waves... These are just some of the impacts of climate disruption that are affecting our planet. Recent climate trends, visible in the IPCC reports, illustrate the alarming dynamics of the changes underway. Protecting our environment, controlling the rise in the average temperature of the atmosphere and oceans, and the sudden and flagrant vulnerability of our populations have become the greatest challenges of our century.

In its latest cycle of work (2015-2021) [1], the IPCC again highlighted the limited capacity of certain sectors (agriculture, energy, etc.) and of our societies to adapt to the impacts of climate change, particularly in certain regions of the world. Above all, projections for global warming are very pessimistic at a time when it has been shown that, whatever the greenhouse gas emission scenarios, global warming will reach 1.5°C by the early 2030s compared with the pre-industrial era.

That's why experts, scientists, researchers, political decision-makers and civil society are each sounding the alarm in their own way, and making climate change the focus of their actions. At the same time, global climate initiatives are being rolled out. Adaptation, mitigation and anticipation must be the watchwords guiding this dynamic fight against climate change.

In response to climate catastrophes, Earth sciences, meteorology, climatology and Earth Observation have come together to model climate evolutionary processes, deliver ever more precise measurements and warn of extreme environmental phenomena. **Earth Observation** satellites fully demonstrate their added value in terms of surveillance and continuous monitoring of our environment, providing accessible, objective data with high space and temporal resolution. Once processed, this data supports public decision-making and the development of targeted policies (water management, forests, biodiversity, agriculture, carbon, etc.).

Born in 2017 in a geopolitical context rich in climate commitments, **the Space Observatory for Climate** (SCO) fully emerged in 2019 [2].
I traveled to the SCO at a pivotal time in its development, boarding the CNES. I set out to meet the **consortia of players** who make up this engaging alliance. I interviewed 17 players, ranging from project initiators to end-users, as well as a number of others involved in the initiative. An initiative full of projects and tools, which I explored. A look back at the emergence of the SCO, its salient features and a zoom on the SCO France project portfolio. Exploration of the stories behind the commitments of this diverse group of players.

Bijagos Archipelago in Guinea Bissau as seen by Spot6

CHAPTER 1: SCO, AN INITIATIVE BORN OF A RAPIDLY CHANGING GEOPOLITICAL CLIMATIC AND SPACE CONTEXT

1. SCO ALIGNS ITSELF WITH COMMITTED CLIMATE GOVERNANCE

The SCO was born in an international geopolitical climate context rich in commitments and initiatives. It is in line with all these ambitions and has responded to the objectives set at the Rio Earth Summit, the Conferences of the Parties (COPs), the One Planet Summit... A look back at these great moments.

Rio Earth Summit and COPs

June 1992 was one of the first dates to leave its mark on the environmental world. The **Earth Summit in Rio de Janeiro launched** an ambitious plan for global action to **protect the climate and biodiversity** [3]. Under the high patronage of the United Nations, this Conference on Environment and Development was a landmark event, bringing together for the first time such a large number of Heads of State, and placing the concept of **Sustainable Development** at the heart of the debate. It also established the **United Nations Framework Convention on Climate Change** (UNFCCC) [4], responsible for organizing the COPs [5].

Since 1995, these COPs have brought together all the signatory states of the UNFCCC, as well as a wide range of non-governmental players. From the outset, these annual gatherings have had a single objective: to support global efforts to **combat climate change** and to engage the world's governments in this endeavor [6]. Reflecting international climate cooperation, they symbolize the political framework for mobilization and awareness-raising par excellence. The challenge remains to ensure that the ambitions set out in them are genuinely matched by real action.

Two COPs have led to definite progress:

- **COP3** with the signing of the **Kyoto Protocol** in 1997, an international agreement added to the UNFCCC, which called for *developed* countries to reduce their greenhouse gas emissions by 5% between 2008 and 2012, compared with 1990 levels [7]. At the time, it illustrated a certain acceptance of these countries' considerable responsibility for climate change. 20 years after the signing of this Protocol, the spirit of the SCO, particularly at the initiative of France, will continue to focus on concrete action at local level to adapt to and mitigate global warming.
- **COP21**, during which **the Paris Agreement** was adopted in 2015. Keeping global warming below 2°C by 2100, and making every effort to contain it to 1.5°C [8]: this was the goal of the century at a time when the 5e IPCC Report was sounding the alarm about annual temperature rises and future projections.

In this decisive setting for the future of our planet, space has also taken its place. The commitment of space agencies, the deployment of Earth observation satellites, and the development of operational tools, services and applications are just some of the ways in which the *Space Division* is contributing to this major climate effort.

One Planet Summit

From this determinism to rally the entire international community in this common struggle, the **One Planet Summit was** born in 2017, 2 years after the adoption of the Paris Agreement. By presenting itself as a new international framework for discussions on the climate emergency [9], this Summit gave birth to the SCO initiative. Because the Summit led to the emergence of innovative, concrete solutions, 12 transformative climate commitments were born, including the SCO, presented on this occasion by French President E. Macron, supported by CNES, and officially launched in June 2019 at the Salon International de l'Aéronautique et de l'Espace. The conscientious ambition of several space agencies, led by CNES, sees Earth observation data as a real opportunity, enabling global, long-term measurement of our planet's geophysical evolutions and therefore the impacts of climate change.

By taking full advantage of the capabilities of these data (satellite and *in situ*), the **SCO** aims to **promote the development of operational tools** to prevent and measure the consequences of climate change [10]. All this, through various projects.

The SCO and its rich ecosystem

A total of 71 projects from 2020 to 2023. Each of the 71 projects will develop a final tool, generally in the form of a web mapping platform, delivering information and indicators on specific climatic phenomena (water management, biodiversity, extreme events, etc.). All thanks to the complementarity of Earth observation data and socio-economic data. The aim is to help local political decision-makers adapt to the impacts of climate change.

Felt and sensed during my trip to the SCO, the best efforts are made to realize these commitment projects. But by whom? By consortia of players motivated by the meaning and value of these projects. I set out to meet them. They make up the SCO ecosystem. All different, they embody the very essence of SCO: cooperation and partnership. Complementing each other's skills is essential to the success of a SCO project.

Because a project responds to specific needs, a whole chain of partners is involved in the co-construction of project tools. These include **scientists, experts and researchers specializing in remote sensing from space**. Aboard the CNES for

this trip, I was able to grasp their driving role in the development of the SCO tool. Whether working for a space agency or a research laboratory, these scientists provide unique Earth Observation satellite data to monitor a range of climate variables, but not only that. They draw up the keys to understanding the effects of climate disruption, but above all, they are involved in processing the data and designing the algorithms that underpin the operation of the project's final web platform.

But why do we talk about co-constructing a SCO tool? Because, while the scientific part of a SCO project is at the very origin of its existence, the ultimate aim of the tool created is to address an **end-user**, often a **local public decision-maker**. Identified on the basis of project themes, they must be integrated into the production of the indicators and the web platform that displays them. This is essential if such a tool is to be fully appropriated by these public authorities. My trip to the heart of various projects confirmed this: these end-users are mobilized right from the start of a project. Why are they involved? Because they are the ones who define the need, and *ultimately* take the concrete climate measures for their geographic area. If the essence of SCO is to meet a user need, then the user must be at the heart of the project.

This shows the distribution of forces in the SCO, where everyone is the bearer of a solution. There's another player in the ecosystem, not always, but for a wide range of projects: service providers. Why should this be the case? To act as a link between scientific research and the end-user, when this link is not provided directly by the scientists themselves. How do they actually take this final step towards the user? By transforming space data into readable and comprehensible information for these users, public decision-makers who are not *space* specialists. These service operators then participate in the deployment of the project's web platform, a veritable service and decision-making tool. The innovative solutions provided by these private companies are one of the keys to successfully scaling up. To forge this cooperation specific to the SCO, ensure that tools can easily be tailored to other areas facing similar issues, seal the international alliance and serve international ambitions, this ecosystem of players, under the coordination of UNOOSA, established the **SCO International Charter** in September 2022.

2. COMMITTED SPACE GOVERNANCE, SCO ALIGNED

A trip to the SCO is both a journey into adapting to climate change and into the world of space. Its originality lies in its focus on the local, on a geographic area. So that space data can serve local climate action.

My various encounters have led me to players in the space landscape and its governance. I took part in a number of space and applications events, in which the SCO is involved. Among them, the launch of the French Satellite Applications Plan [11].

Here's a look back at the elements that also structure the SCO.

Earth observation satellites and space programs are the very resources of SCO. From the *Sentinels* family of the Copernicus or Pleiades programs, to SPOT or Landsat, the data provided by these satellites is one of the main pillars in the development of a SCO product. By zooming on specific areas, SCO projects give concrete expression to the use and application of satellite data to meet the specific challenges of climate change in our various geographic areas.

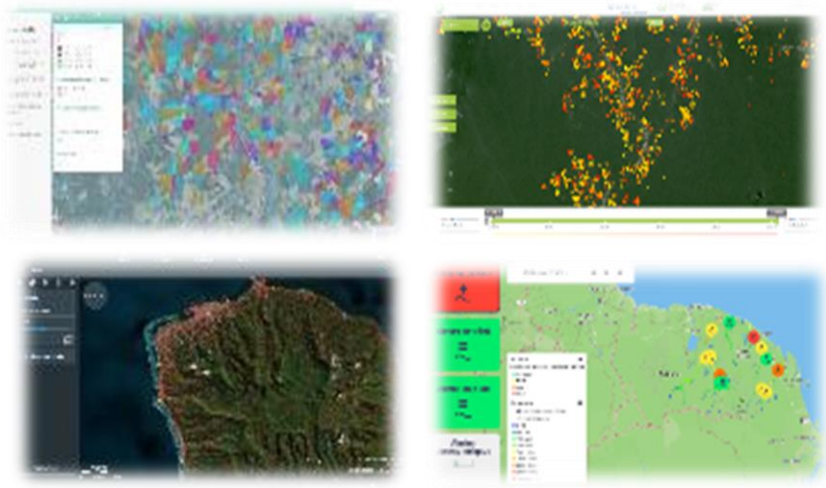
The SCO benefits from this global space landscape to build its own.

In this space journey that structures the SCO, there are these satellites, but not only. There are other space initiatives among which the SCO takes its place. Like the Satellite Applications Plan. In fact, my time at the SCO led me in the footsteps of the launch of this Plan for the period 2023-2027, steered by the Commissariat Général au Développement Durable of the French Ministère de la Transition Ecologique et de la Cohésion des Territoires. The aim of the Plan is to facilitate the appropriation of space applications by French public authorities in charge of the environment. To attend this launch was to see a fully-represented SCO which, through its projects, is giving concrete expression to the Plan's key objectives, on a regional scale.

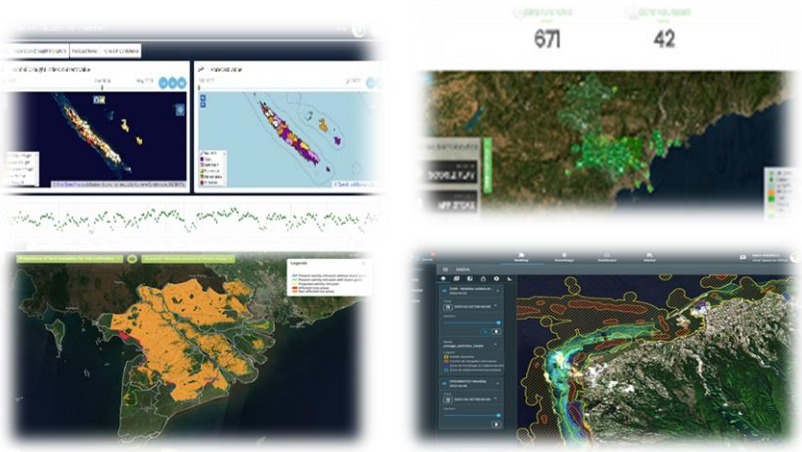
Finally, my exploration of the space environment in which SCO operates reveals the need to develop applications. In this case, those linked to Earth observation and climate phenomena. Applications which, like the SCO, are anchored in the "*use of data*", where the end-user, the public decision-maker, must be a real player. Because these tools provide them with precise, objective, real-time information on issues as varied as adapting to extreme events and managing water, forests, soils and biodiversity...

In connection with these applications and space initiatives such as the SCO, I naturally grasped the key issue that was becoming increasingly apparent: NewSpace. See my last section, "*Conclusion and outlook*", to understand what's behind it.

And then I continued on my way to SCO and approached SCO France...



CHAPTER 2: SCO FRANCE, THE INTERNATIONAL SCO POWERHOUSE



My journey through SCO continued, where I met SCO France. A local implementation of the international initiative, SCO France is leading the way. The way to deploy projects led by French players on 5 continents, using satellite data to help decision-makers adapt to climate change. So I put my magnifying glass on this national SCO and its projects; projects uniting a community of motivated and committed players, who opened their doors to me for a chat.

1. SCO FRANCE, A TOOLBOX FOR CLIMATE ACTION

61 projects, including 18 completed ones, in 28 countries, on 10 themes, and involving over 300 partner institutions. Here are the hallmarks of this *locomotive* alliance. As the French focal point, CNES plays a key role in ensuring the link between the SCO International and the national version, but not only. The French Space Center also plays this central role through the Inter-Organizational Committee (IOC), the steering body for SCO France [12]. Comprising 22 French public institutions (ADEME, IRD, CEREMA, INRAe, IGN...), the IOC guides the strategic orientations of SCO France, and guided us to Rouen in Normandy for its July 2023 meeting. Hosted by CEREMA Normandie-Centre [13], the IOC members got together. It was a unique opportunity to spend part of my trip at the SCO, exchanging views with the players and dealing with climate change issues at the Normandy level.

61 projects, 1 issue that unites them: adapting to the effects of climate change. It's clear that the SCO's hallmark of success lies in these famous projects, their complementarity and their quality. That's why, since 2020, SCO France has adopted a valuable mechanism: the Call for Projects, launched once a year.

A call for projects means a labeling committee (on which IOC members sit), responsible for studying and evaluating project applications according to precise criteria.

Developing a tool, a platform or a web portal that is operational at the end of the project and that explicitly meets the needs of a geographic area and an end user is none other than the heart of the SCO, and is therefore at the top of our list of criteria. Making the right use of satellite data, environmental data and socio-economic data to address a specific climatic issue is a natural SCO criterion. The originality of a SCO project also lies in its ability to federate an ecosystem of scientific players, researchers, service providers and public decision-makers. This cooperation is essential, and everyone must contribute something to the SCO project. The key is to obtain the SCO label for your project.

During my trip to SCO, all these players opened their doors to me to share their experience. But while on board the CNES, other players also shared their stories of strong commitment with me: the referents of SCO projects at the CNES. As the author of a cooperative cross-disciplinary dialogue, the referent accompanies, enhances and supports. Accompanies the consortium of players through the various stages of the project. Promotes the project on a scientific and industrial level. Supports the progress of project content and deliverables. The spirit of sharing and commitment that makes sense is what drives this community of SCO players. In the end, they gave me a taste of their own journey.

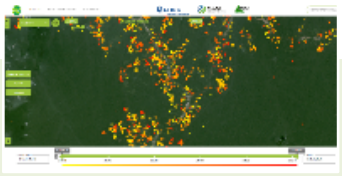
A look back at these projects, explored during my trip. This portfolio of 61 projects was expressed as a union of 2 models, a union of 2 categories of projects that co-exist, complementary and a real necessity for the SCO:

- The existence of *science as a service* **projects**, where the platforms deployed are *open-source*. At the heart of this type of project are research laboratories.
- The existence of **projects promoting the development of a service** (*software as a service*), where the platforms deployed are reserved access, where a business model is asserting itself. At the heart of this type of project are the service providers.

2. SCO PROJECTS: CONCRETE SOLUTIONS TO LOCAL PROBLEMS

One of the highlights of my SCO journey was my excursion through the SCO France projects (funded by CNES or other French organizations, but which may be located in other countries). The itinerary I chose led me to navigate between several climate themes, each of which is home to its share of SCO projects. But going a step further, I've come to see these as veritable *toolboxes* - the boxes represented by the themes, the tools by the projects - where policy-makers can come and find what they want, according to their needs, to the issues it addresses.

A) SCO and Land Use, a faithful and operational history



1- *SCO, forests and TropiSCO*

Climate change and soils: little heard of in this form in the history of global warming, but in fact a major factor in the climate system. Highly impacted, soils play a crucial role in the adaptation to climate change by hosting vegetation, natural parks, green spaces or forest environments, vital resources for our planet [14].

And it was here, on the issue of forests, that I began my journey to explore the "*Land Use*" toolbox. Because yes, the ecosystem benefits provided by forests are numerous, being one of the planet's largest carbon sinks as well as a major habitat for our global biodiversity. Monitoring and protecting them has become an imperative. TropiSCO was present at this major event [15].

TropiSCO, the cornerstone of the project portfolio, is helping to achieve one of the world's greatest objectives: combating global deforestation. The aim of this major project is to visualize tropical deforestation and its evolution via an online platform using Sentinel-1 images. As we all know, the area most affected by deforestation is the Amazon, but Africa and South-East Asia have also been hard hit [16].

This virtual journey into the heart of the forest enabled us to grasp the significant environmental and political spin-offs of this project. These results would not have been possible without the collaboration of CNES, the startup GlobEO and the CESBIO laboratory, each of which contributed part of the solution. These solutions include the algorithm, the production of the maps, the development of a web platform that can be easily exploited by users, and the provision of expertise and funding. Open, accessible free of charge, easy to use and promoting scientific research, the TropiSCO platform is of great use to local players in these areas, to local NGOs and also to fire controllers, who see it as "*extremely useful*".

Thanks to data, statistics and maps updated on a weekly basis, these public players are able to relay "*alert*" information to the general public whenever they deem it necessary. And as we can see from the TropiSCO tool, this goes further than simply visualizing lost forest areas. TropiSCO also helps to deal with illegal logging or species trafficking, and above all. In fact, I have observed razed areas showing how they were being used to grow other crops at the expense of millions of destroyed trees, which are essential in the fight against climate change.

Finally, TropiSCO fully embodies several high-level international initiatives, in this case the commitments made at the One Forest Summit in 2023 [17].

2- SCO, territorial dynamics and CHOVE-CHUVA

The journey through TropiSCO inevitably made me think of Brazil, so I went up there, learning that deforestation was also being dealt with there. While TropiSCO is currently focusing on the Guiana Basin in South America, the **CHOVE-CHUVA** project has set down roots in Brazil, more specifically in the state of Mato Grosso [18].

On a more global scale, it tracks territorial transformations throughout this geographical area, which is heavily affected by "soil" issues. By "territorial transformations", we mean all the dynamics of land use change, whether in terms of forest cover, water resources or the agricultural environment. The tool deployed in this project observes these variables in order to support the region in the positive transformation of its soils. In keeping with the SCO's original approach, the tool highlights climatic indicators thanks in large part to satellite data. Sentinel-2 and Landsat are at the "*rendez-vous*". I've seen it, I've learned it, I've understood it: the collaborative dimension is at the heart of the project's success. Research laboratories abound, including CNRS, CIRAD and the University of Rennes, supported by Alkante, a company specializing in web tool development and monitoring. But another category of players is also involved: citizens. Indeed, during my trip, the project's partners reaffirmed that the tool must be aimed at as many people as possible. So, adding citizen data to space data has taken on its full meaning in terms of adapting to and mitigating the effects of climate change. For the time being, we need to continue questioning end-users, public decision-makers, land-use planners and citizens alike. The aim is to get an even clearer picture of the benefits of this tool.

3- The SCO, wasteland and SCOFrichesAgricoles

Back to France, still on the subject of land use, with its many challenges. The country, like many others, is facing the problem of wasteland. These are areas that must not be ignored, as they give rise to concerns about fire, environmental and health risks.

A member of **SCOFrichesAgricoles** [19] opened the door for me to talk about this project currently under development. An operational lever for the resilience of the Occitanie region, agricultural wasteland needs to be upgraded and requalified while respecting its various functions. Since 2014, as required by the Law for the Future of

Agriculture and Forestry (LFAF), regulatory obligations have been introduced to carry out an inventory of wasteland [20].

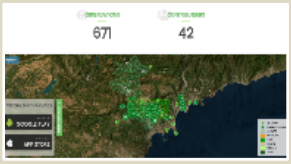
With this in mind, the role of satellite data has become increasingly important. SCOFrichesAgricoles has taken advantage of this major opportunity. How has it done so? By creating several tools, including an algorithm to identify agricultural wasteland using Sentinel-1 and 2, Spot 6 and 7 and Pleiades data.

In the story of the players' commitment, I sensed their motivation, where deep down, several challenges animate them: fighting against the great climate disruption but also participating in the production of the inventory of wastelands at regional level through this project, for 2024. Contact with decision-makers and local players is also at the heart of the SCO project, and I've really grasped it. That's why this project is developing a decision-support application with the clear aim of supporting public players, giving concrete form to public policy and, above all, identifying needs.

A first box which, through the tools on offer, brought to light the multiple challenges of another theme, that of agriculture. So I took a trip. A journey through 2 projects that reveal what the SCO can achieve in agricultural and climate action.

B) SCO and Agriculture, supporting the ecological transition

1- *SCO, the olive tree and SCOlive*



Olive-growing, a threatened heritage and subject to the effects of climate change. This is the reality observed by our olive growers, particularly in Mediterranean countries. In France, in the *Pays de Grasse*, a consortium of stakeholders has been formed to promote the **SCOlive** project [21] and take up 2 challenges:

- Restore and preserve the rich heritage of the olive tree.
- Develop a collaborative olive tree observatory.

The project partners are fully aware that the olive tree is a "*biological marker*": all its transformations and evolutions bear witness to the impacts of climate disruption. As on my adventure with CHOVE-CHUVA, I saw the citizen as being at the heart of the project and the observatory. It's a philosophy rooted in this trip to the SCO. Indeed, this observatory is fed by Copernicus, Sentinel 2 and 3 data, Pleiades data, scientific environmental data and citizen data that act as ground truth.

But what kind of olive tree observations are we talking about? Where are they hosted and who are they for? These were the questions I asked myself. The partners answered them, and the ACRI-ST project leader expressed his views.

From the collaboration between scientists and citizens, the information obtained mainly concerns the location of olive trees, their level of maturity, their phytosanitary status and the monitoring of the appearance of diseases harmful to the development of the olive tree [22].

To facilitate the harvesting of data rather than olives, the project is based on a mobile application that can be downloaded to smartphones, where the maps resulting from the observations are freely available to users of the application. These users themselves play an active part in the project, by contributing field data to the application. Among them are private citizens who harvest, olive growers, nurserymen, horticulturists and, in our case, the *Communauté d'Agglomération du Pays de Grasse*, which communicates the project to the public, highlighting the environmental, cultural and socio-economic role of the olive tree.

This SCO project inaugurates the model of participatory science, where it has been shown that the use of such an application is dynamic as soon as the user sees an interest in the results and contributes to its deployment. This is the case with SCOlive, where all the players mentioned above contribute and benefit from the information

they need, such as the evolution of diseases according to climatic conditions, the quality of production, etc.

Finally, information that enables them to assess and anticipate. Anticipate to adopt the best possible treatments for olive trees and adapt.

On this trip, I felt a very strong passion, revealing that adapting to climate change could go hand in hand with preserving an entire cultural, historical and social heritage. The SCO reveals this. It also revealed it through the **VIMESCO-Rice** project on rice-growing in Vietnam [23].

2- SCO, crop irrigation and Space4irrig

My agricultural trip led me to field crops, which are also strongly affected by climate change. But above all, they are impacted by the increase in drought decrees in France. Here's a look back at a project that combines agriculture and water resource issues: **Space4Irrig** [24]. This project complements existing tools in the "Agriculture" thematic box, in particular those of the successful **MEO-Climate** project [25].

As the project leader, in close collaboration with CESBIO, CNES and several Chambers of Agriculture, the start-up MEOSS opened the doors to Space4Irrig and its deployed tool, MEO-Irrigation. It then opened the doors to the collaborative dynamic within the project, where the complementary nature of everyone's skills ensured the success of this SCO project.

The birth of the project fully anchored its legitimacy in the response to needs expressed by specific users. Prior to the project's inception, users such as farmers and water managers had already expressed a number of needs in terms of water and crop irrigation. These were very high-resolution needs, so that the most appropriate measures could be taken. Since 2022, these needs and requests for solutions have exploded in the face of increasing drought. At the same time, CESBIO's scientific work on irrigated agricultural surfaces was increasing. All that remained was to take the final step between scientific research and end-users. MEOSS did just that. Thanks to its expertise in creating value-added services from satellite data.

But what does this last step actually mean in practical terms? Quite simply, the final product is the MEO-Irrigation tool, an online mapping platform that provides useful information to precisely identified farmers and local authorities.

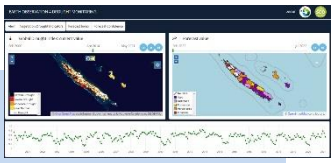
A true climate service, the platform allows users to visualize Sentinel-1 and Sentinel-2 images in a way they can understand:

- Maps showing irrigated and non-irrigated plots.
- Maps classifying crop types.
- Indicators of water demand and quality.

A significant spin-off: after presenting the MEO-Irrigation demonstrator to a number of "potential customers", 12 are now user-testers, and satisfaction questionnaires have been sent to them. As we can see, being as close as possible to the user's needs is the essence of a SCO project. And connections to the online demonstrator have continued to grow. Space4Irrig's next step is to commercialize its service.

Although this trip was classified as "agricultural", it also initiated a new stage in my trip, that of water resource management. Crop irrigation issues naturally raise the question of drought. We're heading for a new thematic box that provides us with tools for dealing with water issues.

C) SCO and water management, a priority



1- SCO, the drought phenomenon and EO4DroughtMonitoring

Space4Irrig naturally led me to pursue this closely related project: **EO4DroughtMonitoring** [26]. Because yes, some of the tools (projects) I explore in one thematic box can intersect with tools in other boxes. In this way, I've fully rediscovered the dynamics of adaptation to climate change, where a large number of phenomena are interdependent. Agriculture, drought and water resource management illustrate this intrinsic link.

For this project, I set sail for New Caledonia, hosted by geo-solutions provider INSIGHT. Discover a SCO project that delivers a tool for adapting to a major global threat: drought.

Lack of rain for part of the year, rising temperatures, dry soils, adverse impacts on agriculture and water resources: these are the challenges facing New Caledonia. A panel of stakeholders (INSIGHT, Météo-France, IRD, CNES, Agence Rurale, etc.) came together to design a tool for characterizing, monitoring and forecasting drought. All based on Earth Observation data. Like its neighboring project, EO4DroughtMonitoring placed the response to user needs at the heart of its objectives. A clearly identified main user: The *Agence Rurale*. As a public structure, it needs precise information on the state of drought, as it plays a role in granting aid to farmers when they are subject to these climatic hazards.

During my meeting with INSIGHT, in charge of deploying the web platform, I got a sense of what guides their day-to-day activity, namely the principle of creating "*decision support tools*". In this case, a decision-making aid not only for the *Agence Rurale*, but also for farmers and local public institutions. The aim: to help them better manage their crops.

Benefiting from a demonstration of the online platform, I enter indicators and information that are readable for users who are not specialists in spatial remote sensing:

- Characterize the intensity of drought periods.
- Anticipate future hydrological seasons.
- Combine meteorological information on rainfall and satellite data on vegetation condition, temperature and humidity to monitor and forecast droughts, and therefore the action to be taken.

INSIGHT's aim is to make the tool as durable as possible, and to extend it to French Polynesia, Wallis & Futuna and Vanuatu. But that's not all, as INSIGHT proudly confided to me: a collaboration is currently underway

with the MEOSS company from the Space4Irrig project, to explore the possibility of cross-fertilizing information between projects.

And even more, I'm witnessing the birth of a new SCO project, **EO4AgriWater**, accredited in 2023, with a clear objective: to merge, on a platform, water resource indicators based on knowledge of irrigated agricultural areas and drought conditions [27]. Here, too, the impact of the SCO is striking: the existence of 2 separate projects paving the way for this new project.

My journey at SCO into the world of water didn't stop with cultures. I travelled to other horizons. Among them, dams and monitoring river conditions.

2- SCO, hydraulic dams and Stock Water

The availability of water resources: a major issue on which **Stock Water** has focused through the strategic instrument of the dam [28]. A geopolitical and strategic challenge for political decision-makers at a time when water and its availability are vital, in human, environmental and economic terms. Here again, this stage through the dams of France, Spain, India, Laos, Burkina Faso and Tunisia echoes my previous point on drought. Faced with droughts and heatwaves, storing water has become an invaluable tool. The Stock Water tool provides the solution.

Monitoring and measuring the volume of water stored in reservoirs and the rate at which dams are filled with water on a global scale: this is what the Stock Water web platform has made possible in several countries. Significant results have been observed. Thanks to a combination of Sentinel-1 and 2 images and *in situ* measurements, 110 reservoirs have been and continue to be monitored for several parameters: water surface over the reservoir area, water volume and filling rate... A SCO project that is already showing positive results, with uncertainties of less than 8% in France and Spain, for example, for filling rate measurements.

The decision to launch this project speaks for itself, as it fills a gap: the difficulty of access to information on hydraulic dam stocks by regional decision-makers and national governments. Stock Water responds to this by offering a global, open solution in which any country wishing to do so can join the project and benefit from the tool.

Above all, this stage of my trip really highlighted the fundamental nature of the methodology employed.

Built by a consortium of mainly research laboratories, this is a project that promotes

science. It has sought to validate its methodology, with a view to generalizing it. It aims to continue the operational deployment of the tool and its adaptability to water resource management in an alarming climate context.

3- SCO, rivers and Ophyse

Embarking on SCO with CNES also means traveling to French Guiana. Not just to our launch base. It's a journey to the whole of French Guiana, including its rivers, which play a major climatic, economic and political role. Here, a panel of partners with enhanced hydrological skills have set down their luggage, or rather, their tools. Through one project: **Ophyse**. Their motivation for involvement: to improve the monitoring of these river waters using space, to assess the impact of climate change on the evolution of these rivers, and to predict the hydrological state of Guyana's watersheds in real time [29]. Together, they have deployed a tool designed for public authorities in charge of water issues, public associations and security authorities. I found, in it, SCO's aims: to adapt to global warming, anticipate measures and even alert populations in real time.

Along the way, I came across these committed partners. Among them, HydroMatters, a company specializing in space hydrology, or in other words, the production of hydrological (water) information from satellite data. The Departmental Directorate of Territories and the Sea (DDTS), responsible for maintaining French Guiana's hydrological network. The Guiana Water Authority and the International Water Office wishing to benefit from hydro data.

The mobilization of these players has a clear political impact. Particularly in terms of the appropriation of information from the Ophyse tool by these basin managers. Even more, I've noted the far-reaching environmental and climatic impacts. Based on fundamental research, this project has provided an analytical perspective on variables that have not yet been fully explored in this region: precipitation on rivers, flow, water level...

But above and beyond the tool's contribution to the objective of adapting to climate change, the journey involved in this project and the presentation of its final phase within the SCO framework raised the question of its position. It's a project that ultimately promotes scientific research, science open to all, and the sharing of knowledge and results with as many people as possible.

A journey on water that raised new issues: those of preserving biodiversity. Including marine and wetland biodiversity. But also the biodiversity of alpine and polar geographic areas. Let's take a look at this SCO thematic box of promising tools.

D) SCO and biodiversity, the imperative to preserve

1- SCO, coastal and lagoon areas, and TAHATAI

"The questions posed by users are very pragmatic and have to do with knowledge of marine biodiversity and coastal areas for the rational management of geographic areas", says BLUECHAM when I go to question them about the SCO **TAHATAI** project, where they are at the heart of it [30].

French Polynesia. Going in the footsteps of this major project. The project is now up and running and continues to be deployed throughout Polynesia and the Pacific States. Improving coastal governance, monitoring the state of the lagoon and marine resources: these are the overall objectives that the project players (IRD, BLUECHAM, MRD, CSIRO, CNES...) set themselves to achieve through this project. And they have achieved them. What did they achieve? By developing and inserting a whole series of digital resources and indicators on a digital platform named Qëhnelö, operational and deployed by BLUECHAM, for the Government of French Polynesia and more specifically, the Marine Resources Department (MRD).

This is made possible by the collection and processing of a wide range of data, from satellites, the field and socio-economic information. BLUECHAM explains this and insists on the importance of one dimension: that of having met the MRD's needs. The players have highlighted these needs, and I wanted to understand them clearly and grasp their capacity for success.

The platform has succeeded in this objective, and now offers:

- Alert the MRD to changes in the coastline and lagoons caused by climate change, or to alarming aspects (phytoplankton blooms, presence of a boat in a prohibited zone, etc.).
- Visualize indicators and maps on aspects as important as water quality, maritime traffic, the pressure of human activities in the lagoons and on the coast, such as infrastructure construction...
- Identify vulnerable areas for better adaptation.
- Enable MRD to download the data it needs as required.

- To soon provide the MRD with an updated dashboard for better zone planning.
- Accompany the MRD in the use of the Qëhnelö platform to ensure full appropriation of its multiple functionalities.

As we can see, and this is another of SCO's added values, this is a project that touches on and meets even broader needs than preserving marine biodiversity. It goes even further. It allows us to identify the different uses of these areas, as well as the impact of human activity (the location of a boat, the deterioration of vegetation, etc.). These impacts are decisive for biodiversity and are therefore fundamental for the Polynesian authorities so that they can anticipate measures and best establish their marine spatial planning.

I explored this project at length during my trip, where it was also striking to grasp the business model behind it. Because it's a real service delivered by BLUECHAM, the company has created "Qëhnelö Tokens". A very special currency that users must use to access the platform's applications. And it has the added advantage of simplifying any costs involved.

The project partners have not said their last word. The project continues under its new name: **TAHATAI NEO** [31] ...

Developing products to protect biodiversity in water environments: SCO has also made this possible in France, in the Mediterranean basin, with its **AIon Wetlands** project [32]. This project focuses on monitoring wetlands, which are home to a high level of biodiversity.

Finally, these projects embody many of the ambitions set out at the last COP15 Biodiversity, held in Montreal, Canada in December 2022 [33].

2- SCO, alpine and polar zones, and CARTOVEGE

Because biodiversity is not just marine, it is also terrestrial. In the heart of the *Terres Australes Françaises* (TAF), I travelled through the **CARTOVEGE** project. This SCO project is also at the service of international climate action [34]. Because the players involved have reaffirmed that climate and biodiversity are inseparable. The SCO project also responds to a key objective of COP15: biodiversity conservation.

Transforming data into a decision-making tool, where knowledge and methodology are shared, where science is accessible: this is the philosophy behind this project, which concerns the preservation of the flora and habitats of the Austral Islands and the Crozet and Kerguelen archipelagos. All of which are UNESCO World Heritage Sites.

Places where rising temperatures are having a major impact on biodiversity and natural

habitats. My interview with one of the project's stakeholders also reveals the threats posed by the increasing arrival of invasive species, both plant and animal, on these lands. These are real threats to biodiversity that the managers of the French Southern Territories National Nature Reserve have to face up to. The main user of the tool deployed in this project.

Through CARTOVEGE, the University of Rennes 1, CNRS, INRAE, the Polar Institute and FBO are answering a major question: *how is climate change affecting biodiversity in the polar regions, and how can it be preserved?* The answer lies in the tool they have developed, which enables:

- To establish a typology of the habitats and vegetation of these archipelagos, in collaboration with the Nature Reserve: an essential preliminary classification to see the distribution of species and their distribution on the island.
- To develop vegetation model mapping: a fundamental tool for obtaining data on the biodiversity of these archipelagos and for predicting changes that may affect vegetation.

Thanks to this tool, which is still being deployed, Reserve managers will soon have all the information they need to monitor habitat dynamics and manage this precious heritage in the best possible way. *Rendez-vous* in **CARTOVEGE 2** for an extension of the project to other islands in the Terres Australes...

It's important to know that SCO's biodiversity projects don't stop there! But I continued on my way to explore a new toolbox, and not the least: one that offers tools for adapting to extreme events. Events that are multiplying with the onset of global warming. Here is a look at some SCO tools of this major theme.

E) SCO and extreme events, essential tools

1- SCO, flood risk and Flaude

I cast off in the direction of a fully advanced project, which today is proving to be a structuring tool for the SCO: **Flaude** and its web tool FORO [35]. It was born in the wake of the severe flooding that hit France in 2018, and the Occitanie region in particular. The impact of climate change can no longer be ignored. And by everyone. But especially by the public decision-makers who deploy action plans in their geographic areas.

So, I set off to meet the Aude Departmental Directorate for Territories and the Sea (DDTS), as well as CNES players, to understand the impact of the project in terms of *political* appropriation of the tool, but also its environmental and economic impact.

In this project, I grasped the agility of a public-private partnership that delivered convincing results. CNES, Météo-France, Toulouse 2 University, SGEvt, DDTS... All complementary in their positioning, they helped FORO emerge as a tool to meet the specific needs of the Aude DDTS and today, to extend the sale of the FORO service to other local authorities, notably in the Mediterranean Arc. *But what were the needs then?*

- Gain a better understanding of the impact of local flooding.
- A better understanding of the phenomenon of intense runoff.
- Better anticipate and above all prepare for future extreme hydrometeorological events.

The partners responded by integrating a series of indicators linked to the risk of extreme precipitation and runoff into FORO. The impact is major: more than 30 local authorities, agglomerations and chambers of agriculture are registered on FORO, more than 10 use it on a daily basis or have even integrated it into their territorial plan, and interest in using the service by other local authorities continues to grow. The DDTS confirms that FORO can really help a chamber of agriculture, for example. In keeping with the spirit of SCO, and in response to a user need, these public agents are fully mobilized in the collection of data and information to be inserted into FORO. By establishing field verifications, for example, following satellite image detections (Pleiades, Sentinel-1 and 2...).

Finally, it was through meeting other project players that I grasped a global concept, born elsewhere, which in fact applies here on a territory-wide scale through Flaude: that of *Recovery Observatory* (or *Observatoire du Relèvemen,, de la Résilience*). Created in 2016 by CEOS and co-chaired by CNES, with the involvement of other partners, this Observatory was born following Hurricane Mathieu, which hit Haiti that year [36]. It is a perfect illustration of the benefits of satellite imagery for post-disaster recovery. The

parallel is clear with the Flaude project, where the aim was initially to create a post-flood observatory on the Aude.

2- SCO, cyclonic and submersion risks: GADE LAPLI, BAND-SOS and Littoscope

This journey through the *'Flood'* tool also brought me closer to another of the company's projects, deployed in Haiti: **GADE LAPLI** [37]. Yes, as we all know, Haiti is one of the countries most vulnerable to extreme disasters, including heavy rainfall, cyclones and floods. I had the opportunity to attend a demonstration of the tool developed by Predict Services, which provides Haitian authorities and civil protection agencies with a whole range of information on rainfall, flood-prone areas, and so on.

On a similar issue, let's head for the Bengal Delta. This is an area hard hit by cyclonic flooding. A series of researchers (IRD, Arizona State University, Ohio State University...) stopped off there to understand the hydrodynamics of these tropical geographic areas and develop a SCO project: **BAND-SOS** [38]. Yes, when I left to interview the IRD, I really grasped the urgent need to deploy products to deal with the consequences of cyclones in this region. A need accentuated by the region's vulnerability:

- The delta's altitude: very low in relation to sea level.
- Weak coastal infrastructure.
- High population density.

Through the platform they have developed, these researchers wanted to answer one question: *what is the submersion hazard, how can it be assessed and how will it evolve with climate change?* And BAND-SOS provides the answer: thanks to its system capable of digitally forecasting, in real time, the probability of flooding and submersion between 36 and 38 hours before the arrival of a cyclone. This forecast is made possible by Sentinel-2 imagery, which tracks the evolution of rising water levels and provides access to the relief of intertidal areas, coupled with socio-economic data on vulnerability, provided in particular by the Bangladeshi authorities.

Authorities who, as we shall see from the theme '*Adapting to extreme disasters*', are the primary users of such tools. Here, the Bangladesh Flood Forecasting and Warning Centre is at the center. Why is this? Because these forecasts enable them to adapt and anticipate. Anticipate operations to protect and evacuate populations, before they are hit by the cyclone. Adapt by developing long-term policies to deal with the famous "*submersion hazard*", so as to be more resilient in the face of these major events.

At the time of my meeting with IRD, who spoke to me about this project, no cyclone had occurred since the platform was delivered (which is good news☺), so it's difficult to assess its post-cyclonic impacts at this stage.

Because the history of submersions is so striking, I ended this journey with another SCO tool, indispensable for dealing with these extreme disasters caused by climate change: **Littoscope**. A project to help manage coastal and marine flooding in the face of climate change [39]. Where? France. Submergence hazards are not confined to tropical regions. With rising sea and ocean levels, the south of France is also affected by this phenomenon. Meet CLS, the service operator for this project. During this new meeting, I once again perceived the major environmental impacts that this project could have. These impacts can be measured by the platform's ability to :

- Measuring the risk of an area, such as Gâvres or Palavas-les-Flots, being submerged in the near future.
- Deliver maps on these risks, but also on land-use elements to anticipate them.

In short, this journey through all these projects shows how each of them, in a complementary way, gives concrete expression to international efforts to adapt to extreme natural disasters.

F) SCO and urban adaptation, a major challenge

And then I explored a final SCO toolbox, that of adapting cities to the effects of climate change. As we all know, cities and large metropolises are increasingly faced with an alarming phenomenon: heat waves and heatwaves. At a time of increasing urban population density, the need for liveable cities and successful thermal management is fundamental. The SCO is tackling this issue, with the aim of adapting cities to heat peaks and identifying the vulnerability of these environments. Thanks to satellite imagery.

In particular, I looked at 2 projects, 2 tools. Intimately linked to this major challenge. **Thermocity** is one of them [40]. Using thermal images, thermography: this is the originality of this SCO project, where I met a player. *But what needs do these images meet?* The person involved in this project answers my question. These images can be used to identify thermal anomalies and hot spots, in buildings for example. Urban heat islands can also be characterized. Even more, other very high space resolution data have been integrated into the tool, enabling vegetation to be closely studied. Yes, vegetation can be thermally efficient.

The aim was to enable decision-makers in major metropolitan areas to make the tool their own, after expressing their needs and expectations, so as to implement their planning policies even more effectively. The *political* impact has been significant. The Strasbourg metropolis has expressed its views. The tool and space imagery have made a real contribution, notably to the development of the inter-communal Local Urban Plan. Tracking changes over time and having data available at regular intervals is invaluable for decision-makers, as the metropolis confirms.

It's true that one of the major limitations of the project today is the space resolution of thermal images, and those involved are well aware of this. But the arrival of a new mission could well revolutionize thermal observation...

With this in mind, and with a view to adapting to heatwaves in cities, the **SatLCZ** project has also joined in [41]. Segmenting cities into Local Climate Zones (LCZs) to identify the vulnerability of geographic areas to summer heatwaves, using very high-resolution satellite data: this is the methodology developed in SatLCZ, validated, integrated and transposed. Validated in the Lille metropolis, which applied the method after experiencing a severe heatwave in 2019. Transposed to a city in Thailand, proving once again the significant results of a SCO project.

CONCLUSION AND OUTLOOK

This was the end of my journey through the SCO, but it's not the end. Quite the contrary, in fact. It continues to gain momentum, to grow. Its first 4 years, which it celebrates today, in the summer of 2023, have proven this. The increase in the number of SCO projects over time, the successful completion of several of them and the growing number of partners each year are strong markers of this. All that remains now is to pursue this commitment by integrating the new challenges that lie ahead.

Through CNES, I have come to appreciate the role it plays in shaping, organizing and leading this promising alliance. An alliance which, through its projects, responds concretely to the global objectives of adapting to and mitigating climate change. An alliance that uses the complementarity of satellite and *in situ* data to build its projects. An alliance that brings together players from all horizons to shape its tools. An alliance that acts as a figurehead for climate and space policy. And one that also responds directly to several of the 17 Sustainable Development Goals (SDGs) integrated into the United Nations' Agenda 2030.

1. SCO AND APRES-SCO, A PARTNERSHIP THAT NEEDS TO BE DESIGNED TOGETHER

Thinking about the post-SCO era? It means thinking about what will happen to a project when it comes to the end of its SCO contract. Because today, a SCO project lasts an average of 2 years. In my meetings with the players involved, I've grasped this essential dimension, where from the outset of a project, its sustainability and follow-up over time need to be considered. Supporting the continuation of these projects appeared to be a necessity, and all the more so in a context where the philosophy and values of the SCO are those of adapting to the effects of climate change, a long-term effort that must never stop.

2. DIGITAL TWINS AND NEWSPACE: WHAT'S AT STAKE FOR SCO?

Digital twins and NewSpace, 2 challenges for the SCO, highlighted during my trip.

Space industry players are well aware of this, and the digital twin, which is in full development, could provide a new springboard for SCO. If this is not already the case, in light of the FloodDAM-DT project [42]. But what is a digital twin? It's the virtual digital replicability of an object or product, enabling modeling, simulation and projection. Project and understand certain climatic phenomena, for example. Through a digital twin of the Earth. Where might SCO fit in? The future will tell.

NewSpace, on the other hand, is clearly visible, and is a major challenge that the SCO is already thinking about. The rise of a new branch of industry, with the development of nanosatellites in particular, represents a growing challenge for the SCO, as the players keep repeating. Why is this? Because they offer complementary capabilities: very high-resolution, very precise data, acquired in real time and on *a hyper-frequent basis.* The SCO will have to take them into account.

Another aspect of this NewSpace ecosystem, which is already at the heart of the SCO, is the growing presence of private-sector companies, which are and must be fully involved in the dynamics and future of SCO services and products. Finally, the growing demand for solutions for monitoring, adapting and mitigating climate change, a key objective of the SCO, is driving the development and ongoing innovation of this *new space industry*.

Finally, a synergy is emerging between the SCO and the space component of the France 2030 investment plan. The development of partnerships within the framework of this Plan is at the heart of the SCO's prospects.

3. SCO, A TOOL THAT RESPOND TO EUROPEAN AND NATIONAL CLIMATE POLICIES?

This trip was a perfect illustration of the fact that the SCO works in the service of international climate action. Today, continuing the SCO's trajectory also means making a full link with the "*France Nation Verte*" action plan and the development of PNACC 3 (Plan National d'Adaptation au Changement Climatique - National Climate Change Adaptation Plan). How can we do this? By proposing itself as a local adaptation tool. The aim of "*France Nation Verte*" (Green France) is to implement objectives on a territory-by-territory, theme-by-theme basis, and to adapt to local realities by involving all stakeholders in environmental and climate-related decision-making [43]. These are precisely the aspirations of the SCO.

Pursuing the SCO trajectory also means thinking about the link with European climate policies. With the EU's Green Deal roadmap. Because its central pillar is to achieve carbon neutrality by 2050, and one of its environmental priorities is the protection and restoration of biodiversity, this European *Green Deal* and its objectives are in line with the SCO's actions. A SCO that could, in fact, play a full part in this European strategy at territorial level.

Julie Letertre, Copernicus representative to ECMWF at the SCO Congress, spoke of the SCO France projects as "*inspiring and enabling us to identify needs on a French scale*".

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APPENDICES

1. TABLE OF ESTABLISHMENTS SURVEYED

Establishment	Positioning in relation to SCO
CNES - EUROPE & INTERNATIONAL DIVISION	Actor around the SCO
INSTITUTE FOR SUSTAINABLE DEVELOPMENT AND INTERNATIONAL RELATIONS	Actor around the SCO
MINISTRY OF EUROPE AND FOREIGN AFFAIRS	Actor around the SCO
MINISTRY OF HIGHER EDUCATION, RESEARCH AND INNOVATION	Actor around the SCO
MINISTRY OF ECOLOGICAL TRANSITION AND TERRITORIAL COHESION	Actor around the SCO
CNES - STRATEGY DEPARTMENT	SCO project managers
CNES - Hélène DE BOISSEZON	SCO project manager
CNES - Pascale FERRAGE	SCO project managers
CNES - Vincent LONJOU	SCO project managers
CNES - Lab'OT	SCO project managers
BLUECHAM Company	Project sponsor
Company CLS	Project sponsor
SCOP E2L	Project sponsor
INSIGHT Company	Project sponsor
Institute of Research for Development (IRD)	Project sponsor
MEOSS Company	Project sponsor
DDTS Aude	SCO project end-user

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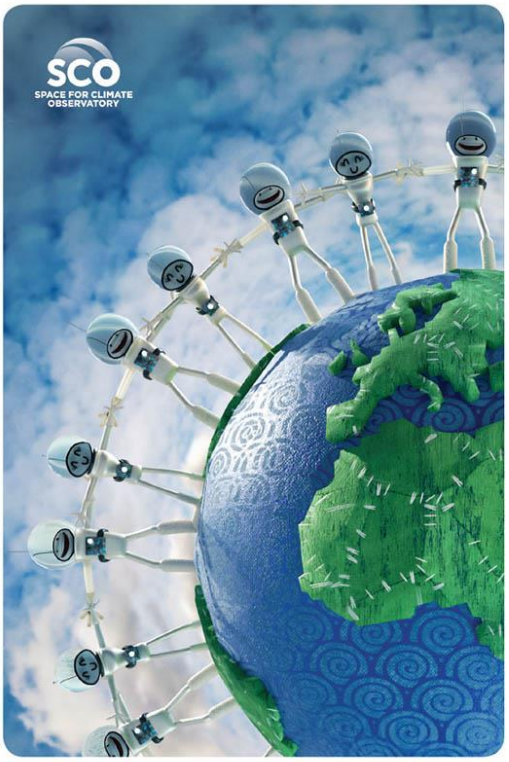
3. SCO BOOKLET - 2020 TO 2022 VINTAGES

Link to the SCO online portfolio: SCO-Portfolio_2022-BD.pdf (spaceclimateobservatory.org)



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