Big data, climate risks, and risk management: The keys to adaptation

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CONTEXT

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The amount of data collected by machines to record and report on climate conditions and the occurrence of climate events has grown tremendously. These data require the implementation of new practices for assessing and managing physical climate risks within companies.

Climate change spreads through the business value chain, affecting business volume and profitability or causing business interruptions. Significant changes in average temperatures and precipitation can impact sales or prices. Floods or storms can cause destruction of factories, warehouses or logistics platforms. With climate change, the magnitude and frequency of events are increasing.

Faced with the pace, variety and volume of these data, the primary challenge for companies is being able to identify the appropriate information and to establish a relevant climate risk assessment report. For each company, an appropriate measurement of the physical climate risks to which the company is exposed requires an individual measure that is local, global and consistent with the nature and geographical distribution of the company's activities.

This white paper discusses the main challenges of assessing physical climate risk in view of the increasing volume and diversity of climate data.

I. 'CLIMATE' BIG DATA

Climate data management is not just about larger storage capacity or about collecting information through a list of platforms providing a multitude of climate indicators across the globe (NOAA, Copernicus, and so on). The four basic characteristics of Big Data - volume, variety, velocity and veracity - enable understanding the reasons why.

A wide variety and a large quantity of frequently published climate data is not only unworkable with standard IT tools, but also incompatible with the very nature of a company's business, regardless of its sector. The indicators required to manage the performance of a company are not readily available in standard formats. Optimal collection of climate data therefore requires an upstream analysis to identify the physical climate risks whose frequency of occurrence and severity are relevant to the company.

The evolving nature of climate data, both in terms of definitions and format, can also be a real challenge for risk managers. Examples include the changing methodologies used to assess a seasonal normal, or the fine distinction between a climate anomaly, climate variability, and climate trend, or measuring data from 6:00 a.m. to 6:00 a.m. or from midnight to midnight.

Therefore, attempting to collect all available climate information to assess physical risks is both counterproductive and unsuccessful for an organization. Instead, the context in which a climate data set is intended to be used should be the starting point for an effective data collection strategy by a risk manager.

I.a Coverage, Quality and Access

Climate data management is not the only task faced by risk managers who have to deal with the entire range of risks affecting the company (internal and external risks). They are therefore dealing with data scalability issues on multiple levels. For this reason, climate data collection and analysis should be integrated within existing practices.

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When building physical climate risk metrics[1], the major issue is ironically that there is a lack of data that can be integrated and analyzed. While there is an abundance of 'raw' data, there is little 'workable' data. In addition, risk mapping instruments require a fresh look. Conventional risk analyses based on sequencing do not necessarily capture all aspects (direct and indirect) of physical climate risks. Innovative performance management tools are needed. In this respect, risk and compliance governance (GRC) platforms should provide valuable guidance for the integration and the management of physical climate risks within the company.

At the moment, these platforms are not in a position to play their enabling role. They need to deploy standardized and appropriate instruments for the quantification of physical climate risks. These tools are not yet fully available. In addition, in order for this quantification to be useful, risk managers need to have access to climate metrics that are aligned with the internal performance management tools and practices.

These climate metrics should also capture the full range of physical climate risks affecting the company. Presently, there is no standardized definition of physical climate risk metrics. Solutions for the assessment of the climate vulnerability of a company are also not standardized. Implementing such solutions requires the identification of the types of physical climate risks involved within the company, the sequencing of these risks and the assessment of their impacts on all the dimensions of the company (supply chain, value chain, sales volumes, productivity, and so on.).

The task is challenging, particularly as companies will now be required to report on their climate exposure, their environmental impact, and on their ability to achieve net zero targets.

I.b Volume, velocity, variety and veracity

Weatherisus has identified a transitional stage from which the company begins to be constrained in its risk management and in the steering of its performance.

These constraints are not identical from sector to sector but are all related to the four characteristics of Big Data (the four Vs). Here are some examples drawn from the different consulting missions carried out so far by Weatherisus:

[1] EFRAG, 2020.

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Volume

In companies that already collect business-related climate data, the size (in bytes) of a dataset can end up weighing down storage and computing resources. Even if the collection is targeted, climate data sets often exceed the processing capacity of databases that rely on structured query language (SQL), creating a market for so-called "NoSQL"[2] tools. In some cases, this burden can be mitigated by aggregating or compressing the data.

One example of a monitoring task that will experience a significant increase in data volumes is auditing for ESG/CSRD criteria.

Velocity

The pace of the data influx can strain network bandwidth as well as flow analysis. Real-time monitoring of high-frequency data flows during an extreme event or pandemic is an example. Aggravating or recovering climate signals are constrained by the technical limitations of network latency. This results in a high throughput load for any downstream process.

Variety

The variety of climate data structures coming from different sources also affects integration processes[3] (NOAA, Météo France, Met Office, Speedwell Weather, Ubyrisk, DWD, Copernicus, and so on). These various climate data providers all operate in different ways and use different formats.

[2] Varian, 2014.
[3] Halevy et al., 2006; Wu et al., 2022.

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Besides, for the same climate parameter, there are various methods of observation. At Météo France, a difference is made between in situ observations (surface and altitude), radar observations (imagery, antenna towers and wind profiles), satellite observations (infrared radiation) and climatological data (Table 1).

Table 1. The variety of climate data

Observations	Data
In situ	Tri-hourly (SYNOP) Radio soundings by balloon Real-time ground network (hourly or sub-hourly) Snow-meteorological network (snow cover) SHIP and BUOY messages (from ships at sea) Raw data measured at automatic stations (6 min, 1 min)
Radar	Mosaic animation (instantaneous precipitation) Radar reflectivity (instantaneous precipitation in mainland France) Water level accumulation (1 mile) Multi-polarised (30 multi-polarised radars) In polar coordinates Upper air wind profiles
Satellite	Satellite animations (visible radiation, infrared and colour composition)
Climatological	Infra-hours (6 minutes) Climate bulletins Hourly, daily, decadal Decadal agro-meteorological Monthly (values, messages, homogenised) Daily reference Climate normals and records In grid points (daily, decadal) From the simulation model (surface patterns...) By department, station, post, or by episodes Monthly moisture index data for the catnat system

Source : Météo France, https://donneespubliques.meteofrance.fr/?fond=rubrique

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Given this variety of information, all the risk managers have expressed a need for guidance to identify appropriate indicators for their companies. When these indicators are recognized, it is critical to translate the data into operational decision-making materials. The veracity of the climate indicators used is vital for carrying out a relevant analysis of risks and for determining priority action areas.

Veracity

High rates of error in data can affect data validation, integrity and retention processes. For instance, when attempting to maintain the quality of highly detailed and granular climate data (known as grid data), errors can occur. The information is necessarily aggregated, and the accuracy of the integration work is judged by how well the points correspond with each other. The amount of work required to validate these data can grow at an exponential rate as the amount of available data increases[4].

Beyond the type of data used, it is important to consider the complex nature of climate data[5]. In fact, climate data infrastructure requires combining a spatial and a temporal dimension.

Gathering such data, systematically, worldwide, has been a long-standing challenge in terms of data collection and calibration. Meteorologists have worked on this issue since the 1850s. Collecting weather and climate data on a worldwide scale, calibrating them in relation to each other, and ensuring that the measurement instruments used around the globe are somewhat consistent... The production of these large data sets, also known by specialists as the ''data friction issue'', has encountered many hurdles. These hurdles have multiplied in the Big Data era.

Risk managers need to be confident about the quality of the data they use and about the relevance of any resulting indicators. They need to be familiar with all the steps involved in the development of a climate vulnerability diagnosis. This calls for the expertise of specialists in climate data applied to companies.

Given such challenges, how to adapt? The starting point for answering this question is information. It is about what data to collect, how best to manage and use it, and who should have access to it.

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[4] Dong et Srivastava, 2013.
[5] Edwards, 2012 ; Papadopoulos et al., 2022.

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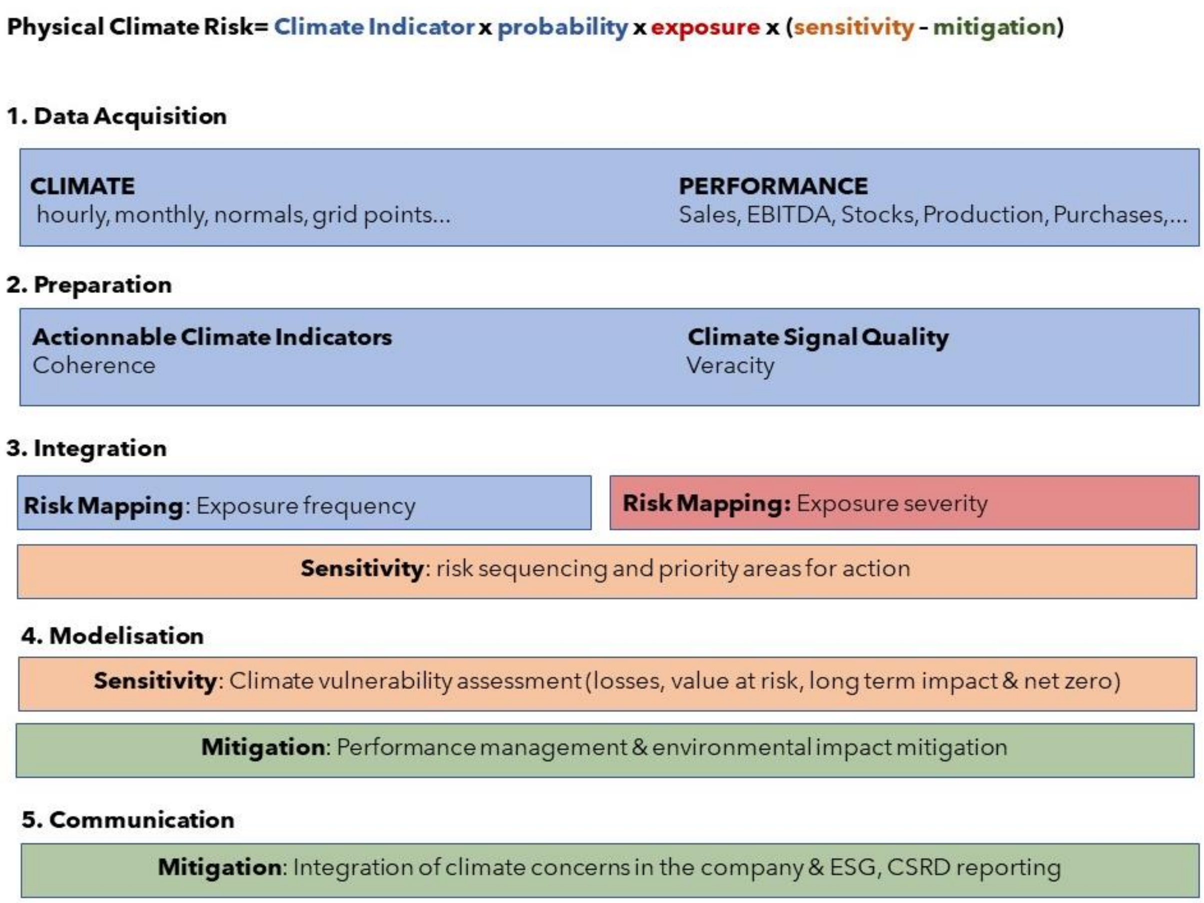
In order to gain a better understanding of these three dimensions (what, how, who) at a company level, it is useful to incorporate them within the big data lifecycle[6] (acquisition, preparation, integration, modelling and then communication of results). The Weatherisus methodology builds on this life cycle (Figure 1).

Figure 1. Weatherisus methodology



[6] Jagadish et al. , 2014.

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II. ACQUISITION

The data collection is aimed at developing a climate risk exposure assessment and implementing an efficient mitigation strategy. It combines climate data and company performance data. The data preparation process allows for the construction of actionable climate indicators. However, this process is only a first step. The next step involves further processing of these data, considering the company's sector of activity on the one hand and its geographic coverage on the other. The management practices and performance management tools of the company are also taken into account.

It is therefore imperative to discuss the type of data which is most relevant to capture the physical climate risks impacting the company. This work must be supported by the core indicators used for performance management by the governance policy and body.

II.a Detail

To avoid missing important details during the collection phase, it is important to take a holistic approach: planning a procedure to expand the collection of data from the start will allow for greater efficiency. This is particularly relevant as initial results obtained during the integration and modelling steps frequently push for further exploration.

Blind spots that were not covered by the initial data collection can also appear as reporting requirements evolve (CSRD). Vigilance is also required in order to prevent sampling blindness, where the climate phenomena considered to be the most valuable may hide others that are equally important but that have not been included at first.

Finer sampling frequencies do not necessarily cure sampling blindness. For this reason, the data acquisition step is very important: risk managers' expertise needs to be combined with that of climate data specialists.

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II.b Granularity

When the most relevant data have been identified, the question of granularity is next. Granularity defines the level and techniques of data aggregation. There are advantages and disadvantages associated to each level of aggregation selected. Aggregation is a first transformation of data. Therefore, to reduce costs and collection effort, there is some incentive to collect the information at the highest possible resolution and then to provide aggregated and/or filtered summaries. It is indeed easier to discard information than to recreate it, just as it is easier to avoid going into too much detail.

The choices made here will have a direct consequence on the quality of the climate signal. This is because the information content of a climate dataset can be readily degraded as downstream processes filter and aggregate the data. The documentation of the provenance of the data, of the context that led to its collection, as well as the key metadata associated with the data can also be lost over time. The link to the original context which made the data valuable could be lost[7].

This content may also grow over time, as other data sources are added[8]. Hence, it is particularly important to carefully prepare for the subsequent storage and integration of the data at the time of data entry.

III. PREPARATION

Following collection, the data is transformed into actionable indicators for risk managers. The primary goal is to build up a list of climate indicators consistent with company performance management practices.

III.a Company-level scaling

Quality of the indicators, especially of the climate signal, is a key concern during this step. Inaccurate signals can lead to incorrect analyses and poor decisions[9]. Additionally, as the volume of climate data increases, so does the burden of data preparation[10].

[7] Buneman et Tan, 2007.
[8] Zhao et al., 2004.
[9] Osborne, 2012.
[10] Dasu et Johnson, 2003.

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There are tools for automatic data cleaning[11], quality assessment[12] and integration[13]. They have to be adapted to be used with climate data. Again, risk managers require support from specialists in climate data applied to companies.

III.b Preserving climate signal quality

Given these challenges, some companies might be tempted to bypass the accuracy of climate information with greenwashing practices or fraudulent declarations. The growing awareness of the issue of climate change not only makes such practices irrelevant, but also harmful to a company's image.

In-depth work on the quality of climate data as well as comprehensive studies of the climate exposure in all its dimensions allows to better account for the efforts the company makes. Transparent and effective communication on the quality of the data avoids relegating climate to an additional contingency. It shows the professionalism and commitment of the company to contemporary stakes.

IV. INTEGRATION, MODELLING AND COMMUNICATION

Analysis is a key component in the development of a climate risk assessment. Risk managers already have toolkits[14] for evaluating the different risks impacting the company. Risk maps are one of those tools. Physical climate risk measures remain to be integrated into these methods. In fact, physical climate risks should be combined with all the other categories of risks.

In this manner, risk managers can take ownership of the climate risk assessment report. They can adjust and even innovate in order to keep the analysis relevant to their business and to market practices. Integration is therefore crucial as it fosters appropriation.

[11] Rahm et Do, 2000.
[12] Pipino et al, 2000.
[13] Bernstein et Haas, 2008; Esmaiel et al., 2022.
[14] Stefana et al., 2022.

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IV.a Risk mapping

The analysis of physical climate data risks applicable to companies is still in its infancy. Consequently, the development of risk maps integrating these risks is also at an early stage. Weatherisus developed a methodology for processing and analyzing these risks, which is based on the frequency and severity of events. These different risk categories cover both the internal and external environment of the company.

The 2022 Summer highlighted once again the exposure of companies to climate risks, the challenges of anticipating these risks, and the need to assess their causes and consequences. The current energy crisis underlines even further the importance of climate risks. Today, it has never been more relevant to develop and adopt meaningful climate risk management tools.

These tools must be meaningful, as they aim to capture the complete sequences of risks with robust and representative data. They also need to be adaptable, as it is no longer enough to learn from experience. It is also about being prepared for what can happen in the future.

Figure 2 shows an example of a risk map developed by Weatherisus. This map shows the probability of occurrence of a risk (frequency) and its severity. The different quadrants of this map help to define priority risks. Priority risks are those which cannot be avoided because of their potentially devastating impact. These are risks for which an action plan, involving operational or financial mitigation measures, are required.

A risk map is above all a strategic management tool. With a risk map, the risk manager draws up an action plan which will address the risks identified as the most important. Thresholds of importance are fixed according to the company's ability to cope with the risks, and according to the guidelines set by the governance policy and body.

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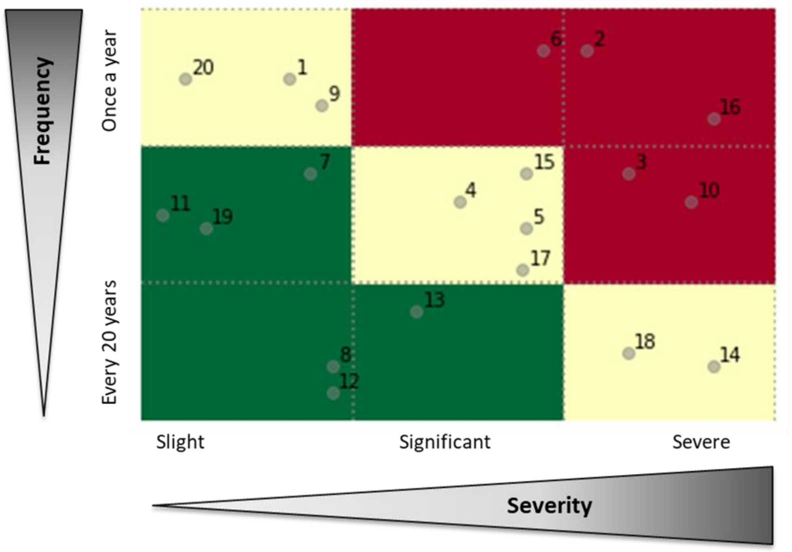
Figure 2. Risk mapping



These thresholds of importance are company-specific. The development of appropriate instruments for the management of physical climate risks requires considering the priorities of the company in respect of these thresholds (figure 2, red areas in terms of severity and frequency). These choices have a direct impact on the climate risk assessment. They also provide a benchmark for gauging the organization's ability to deal with the risks faced.

Thus, this is not just a matter of being able to quantify the impact of the risk and its probability of occurrence. Rather, it is also required, on the basis of the strategic management defined by the company, to suggest solutions at the appropriate moment and to activate the correct levers. Here, being able to sequence a risk is critical. By identifying the cause of an event and understanding how it spreads within the company, we can comply with the specifications set by the governance. Sequencing also offers the opportunity to prevent recurring events.

IV.b Mitigation

Risk mapping and sequencing constitute the first steps of a climate risk assessment. Modelling, which is also part of the process of identifying the categories of risk to be prioritized within the company, makes it possible to quantify the consequences of these risks (potential losses, maximum historical losses, Value at Risk, and so on.).

This is where the connection between climate indicators and company performance becomes tangible. Models used to make this connection are usually based on conventional econometrics. However, with Big data, these causal analysis approaches have been challenged.

The reason is that with more data, more models are required, and more results are produced. The boom in available results has opened up a multitude of possibilities. What are the best solutions when faced with this avalanche of quantitative information, all supported by data identified upstream as solid and consistent for the company?

This is probably the biggest challenge that risk managers and climate scientists will have to face in the coming years: the issue of combinatorial explosion of results. This proliferation generates a huge potential for data mining through artificial intelligence and machine learning.

The right processing approaches still need to be identified in order to avoid false discoveries. Indeed, 'climate' Big data involves the use of new solutions[15]. These solutions must be both relevant and reliable. It is not just a matter of using faster hardware.

This is why many companies prefer econometrically based approaches. These methods allow an accurate assessment of impacts with, for example, value at risk, which is a basic tool for performance management.

The tools provided by artificial intelligence and, more generally, machine learning are however not without interest. They are not so different from the techniques used by econometricians[16]. Firstly, they enable relevant sortings to be carried out when confronted with a proliferation of results. They also enable future projections to be established[17], which is vital for net-zero strategies.

On this basis, a central focus of Weatherisus consists in providing tailored solutions, i.e., the most appropriate and yet the simplest ones for managing the performance as set by the governance policy.

[15] Fan et al., 2014 et Domingos, 2012.
[16] Lopéz de Prado, 2020.
[17] Zahedi et al., 2022.

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Finally, there is the issue of reporting results. Now driven by European directives (ESG, CSRD), reporting is mandatory for companies with more than 250 employees, or which meet specific turnover or total assets thresholds. For many reasons, this is an extremely sensitive issue for companies.

Publishing openly or selectively sharing information on their climate exposure and net-zero commitments is a transparency signal to investors. Because it is now mandatory, companies will have to take a more proactive approach to the input, processing, and output of climate information. Companies will turn this information into derived artefacts using various analytical processes and will distribute them to target user groups (risk scorecards for public or industrial use, interactive or static visualization tools for research and decision-making support, etc.).

This is a heavy duty that engages the reliability and reputation of companies. The privacy of some information is an additional concern.

Many solutions already exist to prevent the disclosure of strategic information, such as removing key fields, 'blurring' data (i.e., adding noise) and 'bucketing' data (i.e., replacing detailed attributes with broader categories).

In the age of Big Data, these practices are, however, not enough. The re-identification of anonymized information back to its true owners, for instance through linkage attacks using other data sources, may often defeat these age-old techniques[18].

The communication of statistics derived from confidential data is a complex issue, which must take into account the competitive advantages, legal constraints, and technical capabilities of companies. Potential competitors who could compromise the shared information must also be considered.

[18] Emam et al, 2011.

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About WEATHERISUS

Weatherisus SAS provides clients with advice and support in climate risk management, climate risk assessment reports, and parametric financial hedging solutions in the form of insurance or financial products.

Founded in 2019 by a team of experienced corporate risk managers and climate scientists, Weatherisus operates from Angers and London and draws on extensive R&D experience, proprietary analysis methodologies and algorithms, applied and proven experience in climate risk management, and leading risk takers, insurers and reinsurers.

Weatherisus SAS is a financial intermediary regulated by ORIAS in Europe and the FCA in the UK.

Weatherisus was co-incubated by Angers Technopole and Atlanpole, members of the French Tech.

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About the author

Miia Chabot is a professor at the Essca School of Management. She holds a PhD in Economics and Finance (2006) and a State Habilitation for Supervising Doctoral Research (2014). Her courses focus on data analytics, programming in R and Python applied to management, economics and finance. She also teaches portfolio management and market finance using tools such as Bloomberg or Reuters. A book on Python programming applied to concrete business situations, based on her various teaching experiences, is forthcoming from De Boeck Supérieur.

Her research work focuses on climate variability, physical risk management, systemic risks and contagion networks of climate and financial risks.

She has published more than twenty research articles, and has supervised thesis work on corporate fraud (PhD Ecricome). She is currently co-supervising a thesis at Ensam on the exposure of companies to climate variability. Her most recent articles have been published in the Revue Économique, Finance or the Journal of Business Research.

Member of the IFABS scientific committee since 2017, she hosted the association's conference organized for the first time in France, on the Essca campus in Angers in 2019 (Reinventing banking and sustainable finance in a context of low interest rates, climate change, TCFD, AI and Fintech).

In addition to these activities, she has carried out various consulting missions. After a first contract with CGI-UK (Logica) for the European Space Agency (ESA), she performed various missions within private and public companies. Today, she is supporting Weatherisus in its research and development. The projects she is working on aim to help companies understand their exposure to climate change and physical risks, and to choose a relevant operational and financial strategy.

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