CLIMAAX
climate ready regions

Deliverable Phase 1 – Climate risk assessment

ATLAS project

REGION HAUTS-DE-FRANCE

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Document Information

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Brief Description	3 workflows implemented for deliverables 1 and 2: Analysis of different relevant risks within the region, focusing as a priority on the following risk workflows: river floods, coastal floods, extreme precipitation
Project name	ATLAS – Adaptation for Territories and Long-term Actions against climate Shift
Country	FRANCE
Region/Municipality	Region Hauts-de-France
Leading Institution	Region Hauts-de-France
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5.0	…		Final version to be submitted

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Abbreviations and acronyms

Abbreviation / acronym	Description
COP	Parties conference
EAIP	Approximate envelope of potential floods
ECRIN	Environment Climate – Research and INnovation
EPCI	Public establishment of intermunicipal cooperation
GEMAPI	Management of aquatic environments and flood prevention
GREC	Regional group of experts on climate
PAPI	Flood prevention action program
PCAET	Territorial climate-air-energy plan
PGRI	Flood risk management plan
PPR	Risk prevention plan
PPRI	Flood risk prevention plan
PNACC	National Climate Change Adaptation Plan
SAGE	Water development and management scheme
SDAGE	Water development and management master plan
SFN	Nature-based solution
SGPE	General secretariat for ecological planning
SRADDET	Regional Plan for Planning, Sustainable Development and Equality of Territories
TRACC	Baseline trajectory of climate change adaptation
TRI	Territories at risk of flooding

Executive summary

This deliverable presents the results of Phase 1 of the ATLAS project, led by the Hauts-de-France Region in partnership with the University of Lille, the AERIS/ICARE data centre, the Hauts-de-France Regional Climate Expert Group, and the POLENERGIE association, within the framework of the Horizon Europe CLIMAAX programme.

The objective of Phase 1 is to implement the common methodology proposed by CLIMAAX for climate risk assessment, by making use of the tools provided and analysing the results obtained.

The risk assessment in the region focused on two main hazards: **heavy rainfall** and **river and coastal flooding**.

This deliverable aims to address the need to improve knowledge of medium-term risks in the region, in particular the intensification of these risks and their possible spatial distribution.

Readers will find the results of the risk analysis for Hauts-de-France based on the CLIMAAX methodology, enriched with already-documented regional data. This approach has made it possible to identify the analyses to be developed in the subsequent phases of the project.

The main conclusions on the assessed risks are as follows:
* **Heavy rainfall**, studied under the RCP 8.5 scenario, shows a significant increase in the frequency of hazardous events in certain areas of the region. The data available in the CLIMAAX model correspond to precipitation volumes over a maximum 24-hour period. This duration is insufficient to explain the flooding that occurred in the winter of 2023–2024 in the northern part of the region.
* **River and coastal flooding**, also studied under the RCP 8.5 scenario, is expected to intensify on several rivers in the region. Fine-scale work is needed to refine analyses for all existing watercourses and to prepare territorial resilience.

The study highlights the main coastal flood-prone areas at risk beyond existing protections. Flooding is increasing in estuaries and spreads to varying degrees into marshes or low-lying areas. Flood depth increases depending on the reference year (2018/2050) and the selected return period. The model does not allow for the identification of coastal erosion risks in cliff areas.

Given the size of the region, Phase 2 will need to develop local-scale risk analyses, prioritising the most exposed areas and taking into account the needs expressed by territorial stakeholders who wish to improve their knowledge and engage in the project.

The stakeholder consultation initiated in Phase 1 indicates both interest in the project and a need for improved understanding of climate change impacts in the region.

The results obtained in Phase 1 confirm the relevance of continuing the analysis of risks related to heavy rainfall and river and coastal flooding, which are expected to intensify in several areas of the region in the medium term. The limitations encountered during this analysis call for a deeper exploration of the available data, with new parameters in particular for the heavy rainfall hazard.

It will also be necessary to continue stakeholder consultation with a larger number of actors, both to increase the availability of fine-scale territorial data, ensure the reliability of the results obtained, and communicate them to the widest possible audience.

1 Introduction

1.1 Background

The Hauts-de-France region covers an area of 31,806 km² in the north of France and comprises five départements: Nord, Pas-de-Calais, Somme, Aisne, and Oise. It shares a border with Belgium. With nearly 6 million inhabitants, it is the second most populous region in metropolitan France.

The Hauts-de-France region is vulnerable to several categories of climate risks. With its geographic specificities- large seafront, lowlands, clay soils etc -, the Hauts-de-France is subject to a high number of climate risks. During the winter 2023-2024, part of the regional territory suffered a significant river flood for 3 months that caused extensive damage to property (housing, economic activities, particularly in the agricultural sector). The cost of these floods was estimated at 640 million euros. The phenomena of stream overflows and marine submersions concern approximately 0.6 million people in the region. 1.5 million persons are concerned by the risks of runoff.

Main objectives of the project

The main objectives of the project are to improve knowledge of the region's future climate risks and to share this information with regional and local decision-makers, territorial stakeholders, and the regional scientific community.
The purpose of this information sharing is to raise awareness of upcoming risks and to promote the implementation of appropriate adaptation strategies and actions, in order to make the regional territory more resilient to climate change.

These objectives are based in particular on:

- The production of maps on the risks and vulnerabilities of the regional territory with a view to publishing them in the next amended or revised Regional Plan for Planning, Sustainable Development and Equality of Territories (SRADDET); The SRADDET, as a land use document, is a strategic, forward-looking and integrative document that is applicable to territories.
- The setting up of an updatable climate database;
- The implementation of educational, awareness-raising and information actions for regional and local decision-makers;
- The development of a regional strategy for adaptation to climate change (improvement of public policies).

The expected benefits of the project are numerous:

- to develop knowledge and consideration of climate risks ;

- to strengthen the strategies and actions already undertaken in certain parts of the territory, and to develop regional and local adaptation strategies and actions ;
- to establish the basis for monitoring data at the regional scale for the various risks studied ;
- to mobilise the scientific community around this work and produce educational materials likely to better inform decision-makers and socio-economic stakeholders in the territory, in order to plan strategies and actions across the entire regional territory.

1.2 Project team

The project is led by the Climate Transition Management unit, in relation with the Geographic Information System and Knowledge Support unit (Région HDF). Two existing employees, an Adaptation Officer and a geomatics specialist, work on the project with support of a consulting firm to ensure consistency of indicators. An agent under a project contract, with skills as a Python developer and geographic information system installation and data science, must be recruited for a duration of 12 months. This agent will be responsible for exploring and analyzing risks of coastal flooding under the supervision of the geographic information service.

As part of a public-public partnership concluded with the Region, researchers from the ECRIN consortium at the University of Lille, responsible for the Regional Expert Group on Climate (GREC), contribute to the project. The AERIS/ICARE data centre, one of the four national atmospheric data centres in France, is housed at the University of Lille. AERIS/ICARE recruited a research engineer to explore and analyze the data made available by Climaax on the risks related to river floods and extreme precipitation.

The team project :

Region:

- Véronique THERRY, Climate Transition Project Officer, Project Coordinator
- Céline LAHAYE, Geomatician

University of Lille:

- Coralie SCHOEMAECKER, Research Officer at the Centre National de la Recherche Scientifique (CNRS /French National Centre for Scientific Research)
- Nicolas PASCAL, Director of the AERIS/ICARE Data and Services Centre
- Robin MIRI, Research Engineer at AERIS/ICARE
- Nathalie WIERRE, Coordinator of the Hauts-de-France Regional Climate Expert Group (GREC) and Liaison Officer with territorial stakeholders for the ECRIN research project

POLENERGIE:

- Hélène BECU, Project Manager

1.3 Outline of the document's structure

This document is organised into five main sections, designed to present the project's context, methodology, results, and future perspectives.

- Executive Summary (~2%) – A one page synthesis presenting the project's objectives, the main results of Phase 1, and key recommendations.
- 1. Introduction (~6%) – Presents the project context, the team, and explains the structure of the document.
- 2. Climate Risk Assessment – Phase 1 (~38%) – The central part of the report, detailing the scoping phase, the risk context, and their assessment. It includes the selection of main hazards, exposure analysis, scenario choice, as well as the results of the workflows on heavy rainfall and river/coastal flooding. It also presents the preliminary findings of the risk assessment (severity, urgency, capacity), followed by monitoring, evaluation, and the Phase 1 work plan.
- 3. Conclusions of Phase 1 – Climate Risk Assessment (~5%) – Summarises the main lessons learned from Phase 1 and their implications for the continuation of the project.
- 4. Proposed Phase 2 and Contribution to Future Phases (~5%) – Describes the planned activities, priority areas, and expected contributions of Phase 2 to the overall project.
- 5. Supporting Documentation and Annexes (~5%) – Lists supplementary documents, data sources, and bibliographic references used in the report.

Preliminary sections (Table of Contents, List of Figures, List of Tables, and List of Abbreviations and Acronyms) facilitate navigation and clarify the terminology used.

2 Climate risk assessment – phase 1

2.1 Scoping

2.1.1 Objectives

The primary objective of the risk assessment for the Hauts-de-France Region is to compile data that will allow for an accessible understanding of the vulnerabilities to which the territory is exposed, with the aim of informing public policies to be proposed in order to make it more resilient.

The implementation of the project should enable us to consolidate data on climate change trends in the region and to increase stakeholders' knowledge on this subject. This will be achieved through the production of educational publications based on the results obtained and the improvement of the "climate change adaptation" component of the SRADDET.
The work to be carried out with stakeholders should lead to knowledge based, on the one hand, on science, and on the other hand, on existing territorial data. Consultations and exchanges with territorial and economic actors will constitute an important stage of the project, both to enrich the data produced, to test the consistency of these data with field experience, and to assess their understanding of the documents produced.
The improvement of knowledge and its dissemination should encourage regional and territorial actors to commit more strongly to adaptation strategies and actions. These will strengthen the

ecological planning work undertaken by State services in the region within the framework of the Conference of the Parties on adaptation in 2025.

The project has focused on risks already identified as the most significant in the region, in view of the proportion of the territory and population exposed: river and coastal flooding, and heavy precipitation.

The constraints we have encountered concern:

- The seasonality of precipitation, which needs to be further examined in the workflow, notably by studying cumulative rainfall over two weeks, in addition to the 24-hour totals currently proposed in the workflow ;
- The definition of risk thresholds for heavy precipitation, which we need to assess by extending stakeholder consultation ;
- Stakeholder participation was initiated during this phase through a presentation of the project and initial results at the annual GREC Hauts-de-France day, a webinar on 17/07/2025, individual interviews (e.g. water agencies, Adopta, etc.), as well as the distribution of an online questionnaire. Nevertheless, during the summer period, mobilization is more difficult. Greater engagement of stakeholders will be undertaken from September onwards. A meeting with socio-economic actors will be organized in the autumn.

2.1.2 Context

In France, the assessment and management of climate risks largely fall under the responsibility of the French State. The latter recently published a third *National Climate Change Adaptation Plan* (PNACC 3), which proposes 51 measures, 14 of which are considered key.

These actions are built around 5 main strategic goals. Crucially, PNACC 3 sets a « reference warming trajectory for climate change adaptation » (TRACC): +4°C by 2100 in France (+2°C by 2030, +2.7°C by 2050, and +4°C by 2100). This path will guide all public organizations.

In the Hauts-de-France region, just like across the country, State officials and operators play a predominant role in climate change adaptation. They do this by : observing and providing data and alert services ; implementing the natural disaster compensation scheme (established by the law of July 13, 1982, which allows for the mobilization of the insurance system) ; defining risk prevention plans, supporting local authorities, and financing natural risk prevention actions by mobilizing a dedicated fund.

<u>Flood Risk Management</u>

The "Floods" Directive provides the framework for flood risk prevention actions. The « Flood Risk Management Plan » (PGRI) is the central planning document : it is developed at the scale of hydrographic districts (in the Hauts-de-France region, two hydrographic districts are concerned : Seine-Normandie and Artois-Picardie), and it frames the prevention actions carried out by local authorities. Local flood risk management strategies have been defined for significant flood risk areas. In this context, « Flood Prevention Action Programs » (PAPI) are implemented.

The management of aquatic environments and flood prevention (GEMAPI) has been a responsibility entrusted to inter-municipalities (metropolitan areas, urban communities, agglomeration communities, communities of communes) by decentralization laws No. 2014-58 of January 27, 2014, and No. 2015-991 of August 7, 2015, since January 1, 2018.

The "flood prevention" component of GEMAPI primarily consists of actions such as "watershed development" and "defense against floods and the sea," without precluding other actions. For instance, proper maintenance of watercourses helps ensure that the consequences of a flood are not exacerbated by the presence of debris. The "coastal" component of GEMAPI includes coastline management. These inter-municipalities can delegate their GEMAPI responsibilities to mixed syndicates, which are generally structures tasked with watercourse management and flood control.

Water Agencies and Planning

Furthermore, Water Agencies, public establishments under the Ministry responsible for Ecology and Sustainable Development, at the watershed level, are tasked with developing « Water Development and Management Master Plans » (SDAGE), established by the Water Law of 1992. These planning documents set out, for six years, the guidelines for achieving the objectives of "good water status."

Within this framework, these agencies develop multi-year programs outlining the main challenges:

- Preserve and restore the ecological functionality of aquatic ecosystems and wetlands.
- Ensure quality and quantity of drinking water.
- Use natural functioning of environments to prevent and limit the negative effects of floods.
- Protect coastal and marine environments.
- Implement public actions consistent with the water policies.

SDAGEs are locally translated into Water Development and Management Schemes (SAGE). Urban planning documents developed by inter-municipalities or communes are required to be compatible with SDAGEs and SAGEs.

Regional Role and Vulnerabilities

The region's expertise contributes to economic development and sustainable land use. Since the Energy Transition for Green Growth law of August 17, 2015, each region in France plays a leading role in biodiversity and climate.

Since the new territorial organization of the Republic law of August 7, 2015, the Region has been in charge of a planning document setting out the guidelines for the territory, the Regional Plan for Development, Sustainable Development, and Equality of Territories (SRADDET). The SRADDET, as a land use document, is a strategic, forward-looking, and integrative document that is nonetheless applicable to certain levels of the community. Its legal scope is reflected in the consideration of its objectives and compatibility with the rules of its regulation in local planning documents and territorial climate-air energy plans (PCAET). The main climate vulnerabilities in the region have been identified. These data need to be spatially refined and modeled in the future.

The Hauts-de-France Region also manages the European Regional Development Fund 2021-2027. In this context, it supports climate change adaptation projects through 4 sub-objectives: combating inland floods due to river overflow or rising groundwater ; adapting coastal territories to natural risks of flooding, submersion, and coastal erosion ; preventing the risks of cavity collapse ; and adapting urban and rural territories to climate change (actions to combat runoff in urban or rural areas, protecting catchment areas from pollution, balanced use of water resources, and developing drinking water savings). The region may co-finance these projects.

Moreover, the Region leads a consultation body called the Parliament of the Hauts-de-France Sea in which the adaptation of the coastline to coastal risks is taken into account.

Since the beginning of the year 2025, the Region also supports local businesses in their adaptation to climate change through the device called Booster Transformation REV3. This device aims to help regional companies in their transformation towards a sustainable and decarbonized development model through the support of experts and educational resources.

Current Challenges and Future Planning

In this regulatory context and distribution of roles and responsibilities, State services fulfill a crucial mission of assessing climate hazards, impacts, and risks in the region. The « Central reinsurance fund » complements this assessment with publications (cf. appendix). The significant volume and duration of rainfall observed particularly in the Pas-de-Calais department from November 2023 to January 2024, after a particularly dry period, caused floods of several rivers, leading to numerous impacts in the affected areas on homes, industries, transport networks (roads and railways), agricultural plots, and access to education.

The Hauts-de-France Region is involved in consultation bodies and may be called upon to (co-) finance actions. A roadmap on regional water policy is currently being developed and should be presented to regional elected officials for validation in autumn 2025.

Forecasts in the Hauts-de-France region show that with an RCP 8.5 scenario, as recommended by Météo France in the DRIAS platform for the region, risks related to increased rainfall could grow during certain seasons.

For these reasons, the extreme precipitation and riverine flood workflows were selected in the regional application for the Climaax call for projects based on the RCP 8.5 scenario.

The Hauts-de-France Region has a 190 km coastline, partly subject to coastal erosion and submersion risk. It is essential that we can assess the risks associated with sea-level rise and coastal flooding. The Atlas project has therefore chosen the "Coastal floods" workflow, according to the RCP 4.5 scenario, which is close to the reference trajectory adopted in PNACC 3.

ATLAS Project and Vulnerability Assessment

As a key objective of the ATLAS project is to improve the SRADDET, and this planning document covers the horizon of 2050, we have chosen to explore and analyze all these risks in the medium term, as defined by Climaax, from 2041-2060.

Within the framework of PNACC 3, State services in the region are currently conducting a survey of local climate vulnerabilities and actions implemented in the territories.

The preferred scale of work is that of the departmental territory, with the aim of facilitating the mobilization of all communal blocs and local elected officials.

This work is based on organizing "Parties Conferences" starting in September 2025 in each department of the Region.

The operational implementation of the approach involves establishing a dialogue with local authorities, particularly EPCIs (Public Establishments for Inter-municipal Cooperation) and communes, on the subject of climate change adaptation, using the methods and decision-making tools of the national General Secretariat for Ecological Planning (SGPE).

Through a didactic appropriation of all the effects of climate change and the TRACC, the approach aims to co-construct, between the departmental State administration and local authorities, a tangible and prioritized vision of adaptation challenges and to highlight the specific needs of each

EPCI regarding adaptation. The mapping exercise consists of "cross-referencing" the probable effects of climate change by 2050 with the social, economic, and environmental sensitivity factors of each territory. The third step involves aggregating adaptation actions within the framework of the regional ecological planning roadmap. For the first step of the approach, the deliverable is expected to consist of:

- A selection of adaptation priorities to be debated in phase 2, derived from the cross-referencing prioritized by the territorial State administration and local authorities.
- A concise qualitative analysis explaining the prioritization choices made.

The partners of the Atlas project will follow the results of this process, which will enrich the data to be analyzed during the project's second phase, both in terms of observed vulnerabilities and actions proposed by territorial actors. The results of these consultations can guide us in phase 3 during the comparative tests of data obtained by Climaax, data refined in phase 2, and data held by local territories.

The outcome of the prioritizations established during the COP (Conference of Parties) in the region will help us to evaluate adaptation actions already envisioned and additional adaptation actions that could be suggested.

2.1.3 Participation and risk ownership

In partnership with the Département du Nord, winner of the GREEN 59 project, we presented the initial results obtained from exploring the workflows selected in the projects during a regional day held on 1 July by the Hauts-de-France Regional Climate Expert Group (GREC HdF), a partner in the ATLAS project. The GREC HdF is part of the national network of GRECs (https://www.cnfcg.fr/index.php/grec-en).

Around one hundred participants attended the presentations that day. The audience was made up of academic representatives, territorial and economic stakeholders, and State services.

To strengthen communication about the GREEN 59 and ATLAS projects and encourage territorial stakeholders to take part, a webinar was held on 17 July 2025. The invitation to this webinar included a link to a questionnaire aimed at gathering stakeholders' views on the risks to which each territory is exposed, the data they have available, the alert thresholds, and the adaptation actions already undertaken (https://docs.google.com/document/d/1qKfD3XGOpLcUF9hmPMJCxFx5ZD3slIEO/edit)

Given the summer period, 17 people took part in this webinar, but the information was circulated to around one hundred stakeholders in the region.

In July, we received about ten responses to the questionnaire, which is why we will circulate it again starting in September. The main results obtained from the distributed questionnaire are as follows: all respondents are interested in the ATLAS and/or GREEN 59 projects, depending on their location. All of them have integrated the issue of climate change and its impacts within their organization, but just over 40% do not have data enabling them to analyze past events related to the risks to which they are exposed, and more than 91% have not worked on risk thresholds.

The main risks and hazards addressed or experienced by respondents are: heatwaves, drought, extreme precipitation, and river flooding (coastal areas are not represented among the respondents). Respondents' risk analyses focus on vulnerability and changes in biodiversity, in addition to socio-economic risks and impacts on infrastructure and equipment. The issue of insurability of damages is still very little taken into account, particularly by actors representing territories.

On 16 July, the scientific committee composed of researchers specialized in the workflows selected in the two projects was convened. The initial results obtained were presented to them.

Composition of the University of Lille expert committee:

- Nicolas PASCAL, Director, AERIS/ICARE Data and Services Center UAR 2877, specialized in database management, processing, and visualization tools
- Robin MIRI, Research Engineer, AERIS/ICARE Data and Services Center UAR 2877, specialized in database management, processing, and visualization tools
- Coralie SCHOEMAECKER, Director of Research, coordination of expertise
- Nathalie WIERRE, Research Engineer, supporting stakeholder interactions
- Gabriel BILLON, Professor, Head of the Environmental Physical Chemistry team at the Laboratory of Spectroscopy for Interactions, Reactivity and the Environment (LASIR)
- Nicolas SPILMONT, University Professor, Laboratory of Oceanology and Geosciences, UMR 8187 LOG – CNRS – University of Lille – University of the Littoral Côte d'Opale – Institute of Research for Development, specialized in intertidal and estuarine ecology
- Olivier COHEN, Laboratory of Oceanology and Geosciences, UMR 8187 LOG – CNRS – University of Lille – University of the Littoral Côte d'Opale – Institute of Research for Development, specialized in current and recent coastal dynamics
- Guillaume PENIDE, Lecturer-Researcher, Laboratory of Atmospheric Optics, University of Lille
- Claire ALARY, Institut Mines-Télécom IMT – University of Lille, Lecturer-Researcher, specialized in Environmental Geosciences
- Jérôme RIEDI, University Professor, Laboratory of Atmospheric Optics, UMR 8518 – CNRS – University of Lille, expert in Remote Sensing / Atmospheric Observation / Cloud Physics
- François LECONTE, Lecturer-Researcher, University of Lorraine, specialized in urban adaptation to climate change
- Luc DAUCHET, Senior Lecturer and Hospital Practitioner / INSERM U1167 Rid-AGE / University of Lille
- Caroline NORRANT, Senior Lecturer, ULR Territories, Cities, Environment and Society, University of Lille

The main comments from the members of this committee were as follows:

- Regarding precipitation risk, a question was raised about the uncertainty margins associated with the model. The RCP 8.5 scenario is the one that provides quantitatively visible changes in the evolution of precipitation in the region. The value of exploring the long-term model to better assess the impacts of climate change in the region was highlighted.
- During the first meeting of the scientific committee on 16 July, questions raised about the interpretation of the results led us to modify the presentation used during the 17 July webinar with territorial stakeholders, in order to make the graphs relating to event return periods easier to understand.
- We were advised to make use of the EXPLORE 2 data on the evolution of temperatures and precipitation. Led at the national level by State operators, the EXPLORE 2 project aims to update knowledge on the impact of climate change on hydrology based on the latest IPCC publications, and to support territorial stakeholders in understanding and using these results to adapt their water resource management strategies.

- It emerged that the workflows did not allow for the direct processing of runoff risks linked to changing precipitation patterns.

Following these meetings, the project team plans to organize new gatherings starting in September 2025 to increase the collection of stakeholder data.

Research into territories benefiting from Flood Prevention Action Plans (PAPI) also enabled us to find local data on the risks studied, the alert thresholds identified in the territories, and the adaptation actions planned or implemented.

Two other types of experts were consulted between 11 and 21 July:

- The *Regional Directorate for the Environment, Planning and Housing* (DREAL**)**, a State service in the region. This meeting allowed us to review the Conference of the Parties (COP) approach to adaptation undertaken in the territories, and the expertise gathered to inventory the effects of climate change based on existing cartographic data.
- The *Water and Biodiversity Directorate of the Hauts-de-France Region*, which manages regional policies in the field of water (support for river management unions, roadmap project to be presented to regional elected officials in the autumn) and the climate change adaptation objective included in the FEDER implementation document. This meeting provided access to numerous data sources relating to coastal and river flood risks.

2.2 Risk Exploration

2.2.1 Screen risks (selection of main hazards)

The Hauts-de-France region is exposed to several natural hazards : river and coastal flooding, clay shrink–swell, heatwaves, drought, and wildfires. Based on an initial inventory of local climate data and historical incidents, the following hazards have been identified as particularly significant:

- Heavy precipitation
- River and coastal flooding

Data obtained from Copernicus indicate a future increase in precipitation in the region (see annex 4). The data are modelled at the scale of France, which, at the national level, shows significant spatial differences in precipitation trends. The evolution of precipitation modelled for Belgium, a country bordering Hauts-de-France, appeared to us to be more representative of the results to be taken into account for the region.

Examination of the NASA Sea Level Projection Tool shows that the difference between RCP scenarios (4.5 vs 8.5) results in a continuous rise in sea level, about 20 cm higher by 2100 under the RCP 8.5 scenario compared with RCP 4.5. An acceleration in sea level rise from 2080 onwards is observable under the RCP 8.5 scenario.

The projected increase in sea level is roughly similar for the ports of Dunkirk, Calais, and Boulogne-sur-Mer under both scenarios and across all time horizons examined; it is slightly higher for the port of Dieppe, located just south of the Picardy coastline of the Hauts-de-France region. (See annex 3).

2.2.1.1 Workflow selection

2.2.1.2 Workflow #1 : Heavy Rainfall

As part of the PNACC3, Météo France has modelled the climatic hazards for France. Regarding the rainfall risks for the Hauts-de-France region, it recommends taking into account the RCP 8.5 scenario. We have therefore chosen this scenario to explore this workflow. This data is supported by the exploration of Copernicus.

2.2.1.3 Workflow #2 : River and coastal flood

In its 2024 report, the Central reinsurance fund indicates that 2.2 million people are exposed to the risk of all types of flooding.

The floods that affected part of the regional territory (the départements of Nord and Pas-de-Calais) during the winter of 2023–2024 left a strong impression on the inhabitants and decision-makers of the region. These were preceded by other significant events, such as the flooding of the Somme Valley in 2001 and of the Oise Valley, with historically significant flood levels in 1993 and 1995.

In its 2022 publication "*Tour d'horizon*", the Regional Climate Observatory states that floods — such as river overflows, mudslides, surface runoff, and groundwater rise — represent the number one natural hazard in Hauts-de-France. Their main causes are linked to land-use planning (soil sealing, stormwater management, etc.) and the physical characteristics of the environment. By affecting precipitation patterns, climate change increases both the frequency and the intensity of this risk.

2.2.2 Choose Scenario

To study the risk related to river floods, we considered the RCP 8.5 scenario, consistent with the choice of the scenario chosen for exploring the risk related to heavy rainfall.

The hazards and risk assessment related to marine flooding were explored with the default RCP proposed by Climaax, namely scenario RCP 8.5 with return periods of 5, 10, 50, 100, and 250 years to estimate the damages.

The maritime frontage of the Hauts-de-France region concentrates a high density of activities within a limited geographical area. This situation generates strong pressures on natural environments, as well as conflicts over the use of and access to resources (land, water resources, etc.).

To address these human, industrial, and tourist pressures, the challenges are multiple: decarbonising industry, seeking a balance between economic development and the preservation of natural environments, anticipating societal and tourism-related changes, and meeting future needs for labour and training.

The territory appears particularly vulnerable to the impacts of climate change.

Due to its topography, the coastline of Hauts-de-France is especially exposed to the risk of marine submersion, and the stakes in this area are significant (industry, agriculture, tourism, housing, infrastructure, natural environments, etc.). Out of the total population of the Hauts-de-France region (6 million inhabitants, including around 1 million in the wider coastal area), an estimated 450,000 people live in the Potentially Floodable Area (EAIP) for marine submersion.

Industrial development projects announced for the Dunkirk area (polder of the Flemish maritime plain) in the coming years are expected to lead to changes in local demographics. The vulnerability of the territory could increase as a result, due to the exposure of industrial facilities, associated infrastructure, and the population located in flood-prone areas.

Sea level rise, along with the recurrence and intensity of winter storms, will further increase this vulnerability.

Beyond the threats to the safety of people and property, the natural hazards affecting the regional coastline have indirect effects on the attractiveness of coastal areas. The vulnerability of coastal sectors to natural hazards can increase local land pressure but also lead to a loss of value for certain exposed properties, particularly since the recent provisions of the Climate and Resilience Law.

These climate change-related risks must be considered alongside the socio-economic issues and specific characteristics of the wider coastal area.

The aging of the population raises economic and quality-of-life challenges (development of the silver economy, decline in the working-age population, adaptation of housing, etc.). The coastline is expected to be particularly affected by a sharper decline in the population under 65, while the proportion of those over 65 would increase significantly. The latter would represent 29.7% of the population of the wider coastal area in 2040 (296,600 inhabitants), an increase of 10 percentage points compared to 2018, when they accounted for 19.8%.

Employment in the wider coastal area is characterised by an over-representation of jobs in agriculture and fishing (3.2% compared to 2.1%), and in industry (16.6% compared to 13.7%).

The share of activities oriented towards external markets is significant: it reaches 9.4% compared to just over 5% in the region and in France as a whole, with the presence of industrial activities (steelmaking, metallurgy, etc.) that are sometimes highly energy-intensive and emit greenhouse gases.

The wider coastal area is also characterised by its port activity (a quarter of global maritime traffic passes through the Strait of Dover) and its energy production (Gravelines nuclear power plant, soon to host two EPR reactors; Loon-Plage LNG terminal; Dunkirk offshore wind farm project; potential for marine renewable energy, etc.).

Tourism is also a driver of the territory: tourist numbers have been increasing since 2020. To address the effects of climate change, which can lead to fluctuating tourist flows, the region and its coastline are focusing on the development of sustainable and local tourism.

2.3 Risk Analysis

2.3.1 Workflow #2 Heavy Rainfall

Table 2-1 Data overview Heavy Rainfall workflow

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
EURO-CORDEX from the Climate Data Store: two different 30-year frames (1976-2005 and 2041-2070 timeframes RCP 8.5)	-	-	*Evolutions of critical impact based threshold in terms of return period & intensity*

2.3.1.1 Hazard assessment

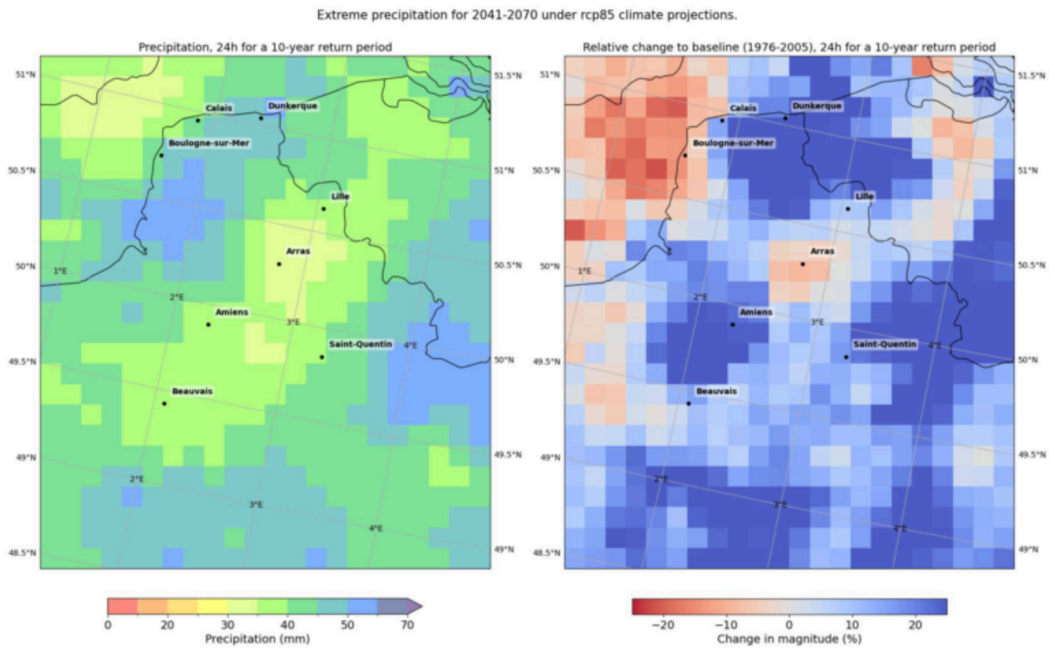

Figure 2-1 (left) Heavy rainfall hazards over the Hauts-de-France region, for a return a return period of 10 years in the 2041-2071 period in mm/24h (right) Heavy rainfall hazards relative change (in %) between projected period (2041-2071) and baseline period (1976-2005) for a return period of 10 years over the Hauts-de-France region

The assessment of heavy rainfall hazards shows that, for the same rainfall intensity, the return period will be shorter in the RCP 8.5 scenario for the medium-term period (2041–2070) compared to the 1975–2006 period in certain areas of the region: the north of the Pas-de-Calais and Nord departments, the south of the Somme department, the north of the Oise department, as well as almost the entire Aisne department. In these areas, 24-hour rainfall totals (in mm) could be more than 20% higher compared to the 1976–2005 period, for a 10-year return period. A near doubling of the frequency of heavy rainfall events is observed under the medium-term RCP 8.5 scenario compared to the 1976–2005 period, for the same rainfall intensity of 50 mm in 24 hours.

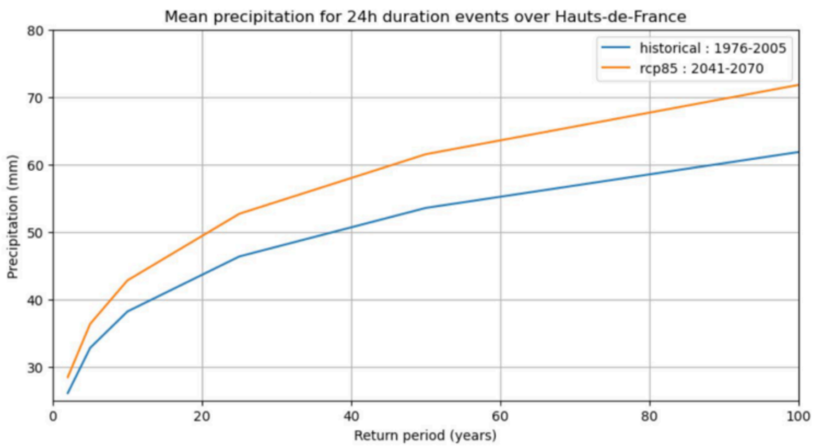

Figure 2-2 Mean precipitation extremes over the Hauts-de-France region in function of the return period, for projected period (2041-2071) in the RCP 8.5 scenario, and for historical period (1976-2005)

The intensification of rainfall increases the risk of runoff, which in turn amplifies the risk of flooding. Runoff, which is by nature diffuse across the territory and greatest on impermeable surfaces, is not taken into account by the models. On cultivated agricultural plots, runoff creates a risk of mudflows. Certain areas of the region are subject to a high or medium hazard of soil erosion (see annex 1: soil erosion map).

In its 2024 report, the "Caisse Centrale de Réassurance"(*Central Reinsurance Fund*) indicates that, for the region, runoff phenomena affect 11% of the regional territory's surface area and that 1.5 million inhabitants are exposed to flooding from runoff, including 700,000 directly.

2.3.1.2 Risk assessment

Risk assessment is carried out using a cumulative rainfall threshold set at 40 mm/24 h for the entire Hauts-de-France region.

This choice was motivated by the evaluation of the orange alert thresholds established by Météo-France (a national public institution that collects and provides meteorological data and works on climate projections). These alert thresholds, which vary, are generally between 40 mm/24 h and 60 mm/24 h (as shown in Figure 2-3), which reinforced our decision to adopt 40 mm/24 h as the risk threshold for the entire region. Further work will be undertaken in subsequent phases to refine this value by consulting stakeholders and local actors in order to obtain more localised and relevant risk thresholds.

Figure 2-3 Météo France communication on Facebook to warn concerning an orange vigilance alert on heavy rainfall, corresponding to a precipitation level of 40 to 60 mm/24h

Figure source : https://www.facebook.com/photo/?fbid=1176011384558165&set=a.482685020557475&locale=fr_FR

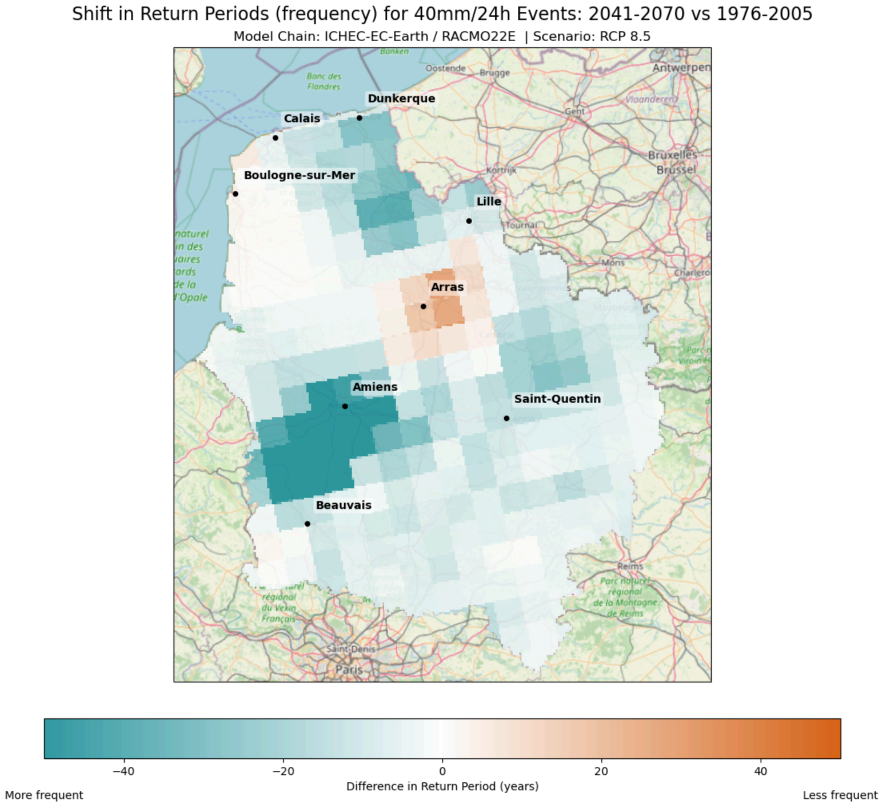

Figure 2-4 Shift in return periods of raining events exceeding 40 mm/24h in the Hauts-de-France region, between the historic period (1976-2005) and the projected period (2041-2071) in the RCP 8.5 scenario

The risk assessment shows a significant increase in the frequency of hazardous events in the departments of Somme and Oise, in parts of the Nord and Pas-de-Calais departments, and in Aisne. The areas of the region are unevenly affected: in the Arrageois area (Arras) in particular, and along the north-western coast of Pas-de-Calais (north of the city of Boulogne-sur-Mer), the frequency of hazardous events decreases.

The data available in the models provided by Climaax correspond to the volume of precipitation over a maximum period of 24 hours. In the region, such 24-hour precipitation totals—or totals over a few hours—are comparable to intense rainfall from thunderstorm-type events, such as those experienced again in various municipalities in July 2025. These intense rainfalls over a few hours cause flooding that affects homes, infrastructure, and roads, but which recedes quickly. Such flooding can be caused by stormwater network overflows.

This model is not sufficient to explain the precipitation events observed during the winter of 2023/2024.

The floods observed in the region during the winter of 2023/2024 were linked to a large cumulative rainfall over a period of several days or even several tens of days. The maximum daily values observed in several affected municipalities did not exceed the 10-year or 50-year reference daily precipitation totals (see Figure 2.5). However, the cumulative precipitation over 15 days exceeded the 50-year or 100-year reference return periods, depending on the municipalities affected (see Figure 2.6 below).

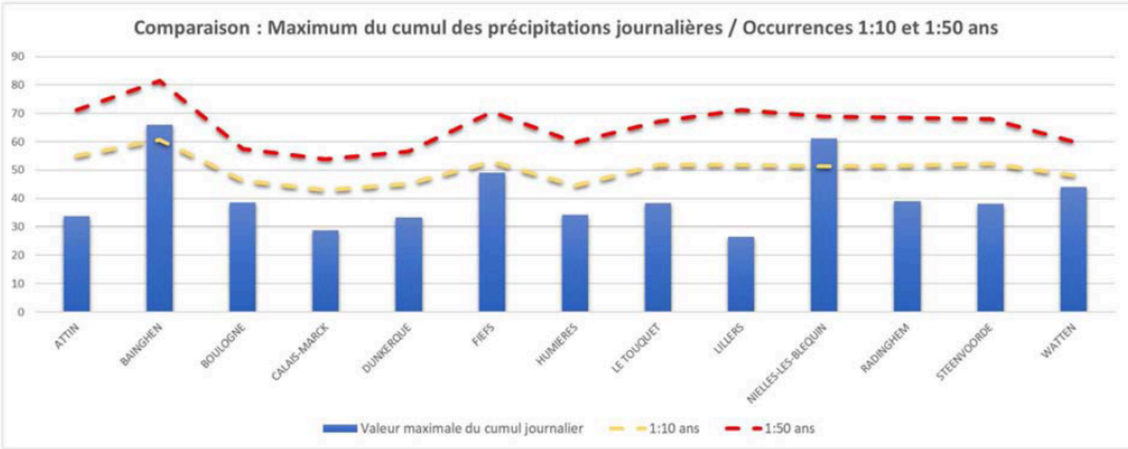

Figure 2-5 : Comparison of daily maximum cumulative precipitation from November 2023 to January 2024 with 10-year and 50-year reference values across various stations in the Pas-de-Calais and Nord departments. (Palhol et al., 2024)
Figure source : Meteo France data, treated by the mission (Palhol et al., 2024)

These floods caused extensive damage to homes and industries, led to agricultural losses, and disrupted transport services, with certain roads rendered impassable for several days, interrupting access to educational institutions.

In addition, floods can be caused by groundwater rise (e.g., the case of the Somme Valley). The JRC model does not account for flood risks from groundwater rise; however, this issue needs to be explored further by engaging a hydrology expert during the second phase of the project.

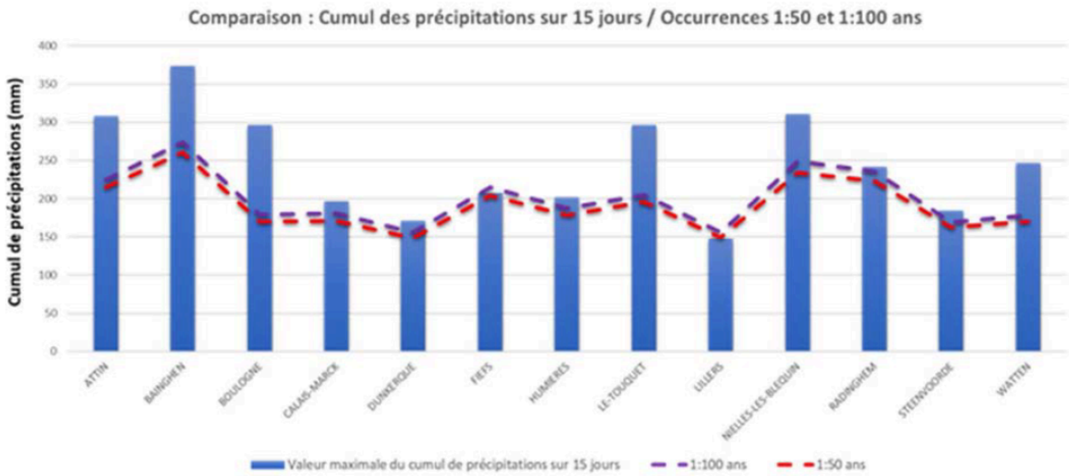

Figure 2-6 : Comparison of maximum cumulative precipitation on 15 days from during winter 2023-2024 with 50-year and 100-year reference values across various stations in the Pas-de-Calais and Nord departments. (Palhol et al., 2024)
Source : Météo France data, treated by the mission (Palhol et al., 2024)

The seasonality of precipitation is important for anticipating the types of risks. For example: summer thunderstorms over a short period (a few hours) on dry soil, or rainfall over several days observed in autumn or winter in the region. The assessment of this seasonality by the available models will need to be supplemented in phase 2.

2.3.2 Workflow #2 River and coastal flooding

Table 2-2 Data overview workflow #2

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
JRC high-resolution river flood maps (RP:10, 50,100, 500 years) *Aqueduct flood dataset (RP:100, 250, 500 years, for 1980 & 2050 in RCP 8.5)*	*JRC damage curves for land use (LUISA)*	*LUISA land cover* *Open street map*	*Flood damage maps (economic damage estimates million €)*
MERIT-DEM floodmaps (RP: 2, 5, 10, 50, 100, 250) RCP 8.5	*JRC damage curves for land use (LUISA)*	*LUISA land cover* *Open street map*	*Coastal flood risk* *Flood damage maps (economic damage estimates million €)*

2.3.2.1 Hazard assessment

2.3.2.1.1 River flood

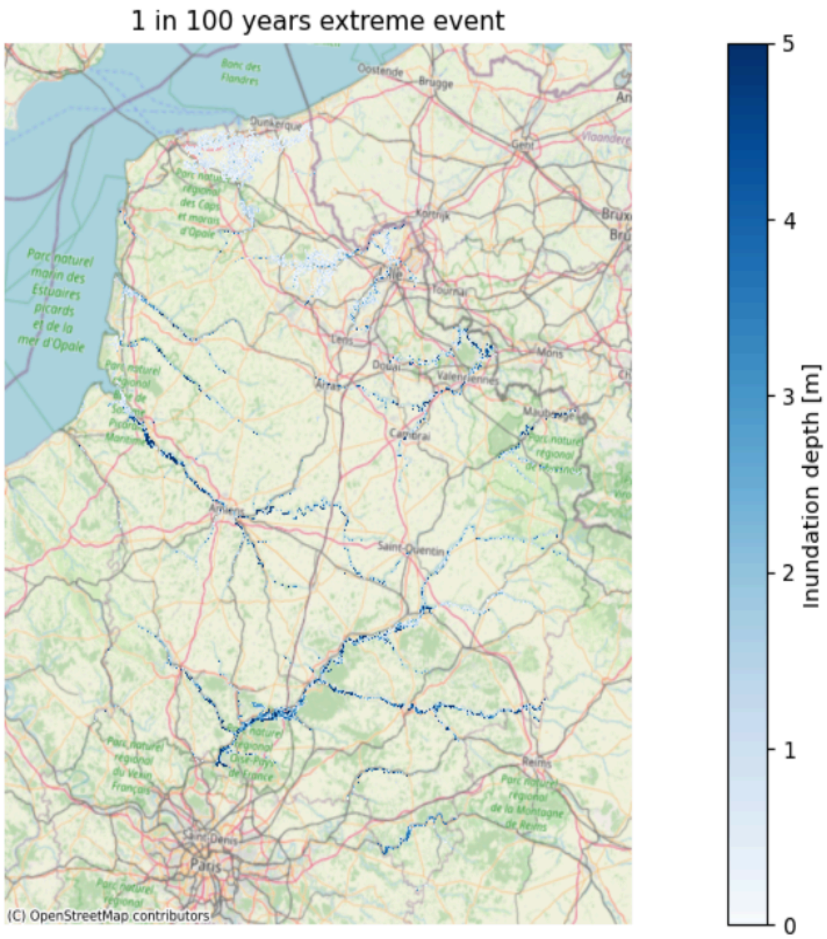

Figure 2-7 : River floodmap overview for a return period of 100 years, dataset : JRC high resolution

As shown in Figure 2-7, the size of the study area makes large-scale analysis of the results challenging, highlighting the need to work at more local scales.

Figure 2-8 presents the river flood map for 10-year and 50-year return periods, zoomed in on the Oise River at Chauny. This scale of analysis is more suitable for working on territorial resilience.

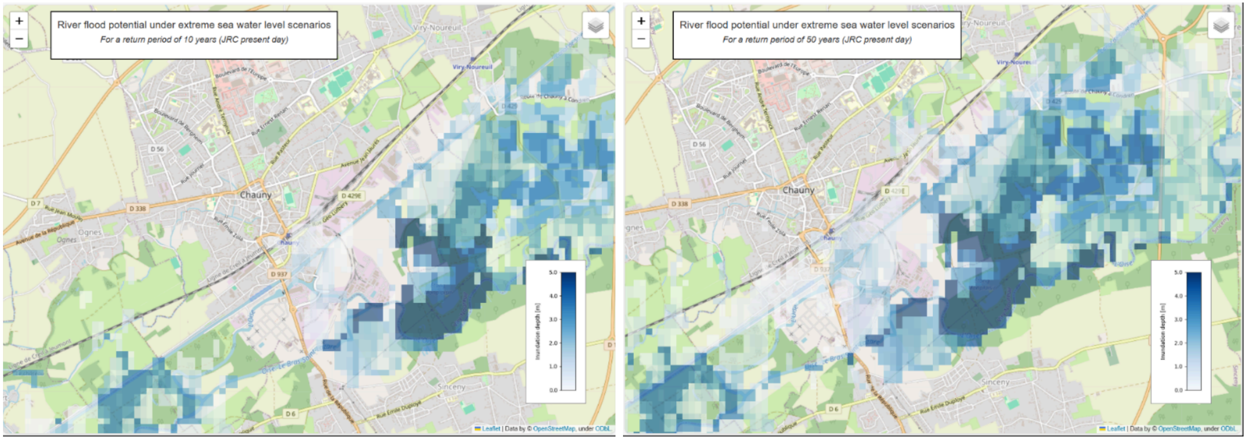

Figure 2-8 : River floodmaps examples around the Saint-Quentin canal and Oise river, for 10 years and 50 years return periods, dataset : JRC high resolution

When working at this scale in particular, marked differences and inconsistencies began to emerge between the JRC high-resolution datasets and Aqueduct.

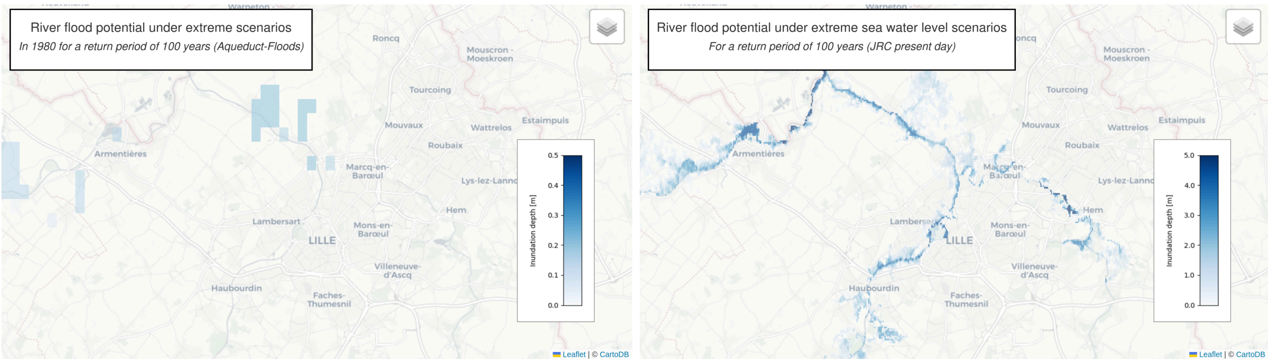

Figure 2-9 : River floodmaps examples around Lille, for a return period of 100 years, datasets : (left) Aqueduct floods, (right) JRC high resolution

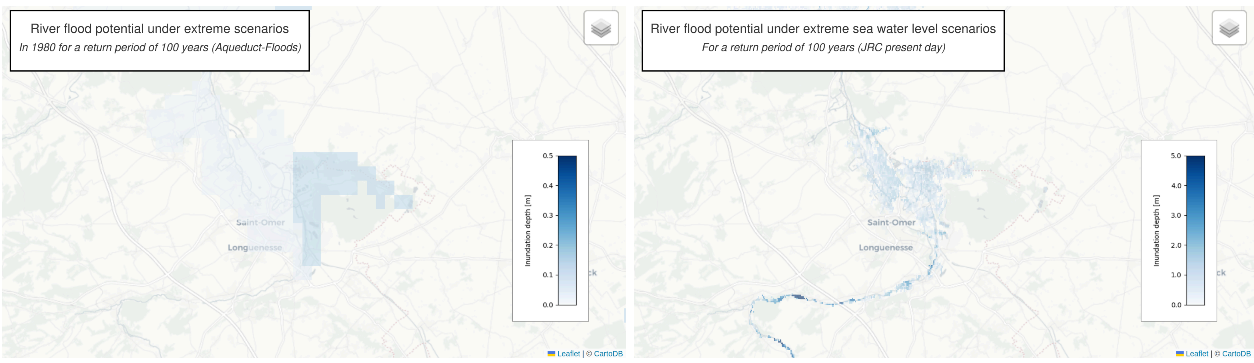

Figure 2-10 : River floodmaps examples around Saint-Omer, for a return period of 100 years, datasets : (left) Aqueduct floods, (right) JRC high resolution

Significant differences were observed between the results of the JRC and Aqueduct models, both in terms of the areas covered and the estimated flood depths, as shown in Figures 2-9 and 2-10.

In the Lille area (Figure 2-9), crossed by the Deûle River, the JRC model predicts the presence of flood-prone areas for a 100-year return period—areas that are not considered flood-prone by the Aqueduct model for the same return period. Conversely, east of Saint-Omer, for the same return period, certain areas are predicted as flood-prone by the Aqueduct model but not by the JRC model.

More broadly, in the polder area, the JRC model anticipates flood-prone zones with average flood depths between 50 cm and 1 m, whereas Aqueduct model predictions for the same area and return period do not exceed 20 cm.
This finding can be generalised to the entire territory, where flood levels estimated by the JRC model are significantly higher than those estimated by the Aqueduct model.

Nevertheless, the hazard assessment still shows that large areas of the territory are subject to flooding in both the JRC high-resolution model and the Aqueduct model. Furthermore, according to the Aqueduct model results, more and more areas are expected to be flooded in the future, with higher flood depths for similar return periods, as shown in Figure 2-11 below. However, this trend is not uniform across the entire region, particularly in the south-west, where Aqueduct model projections indicate a decrease in flood depths.

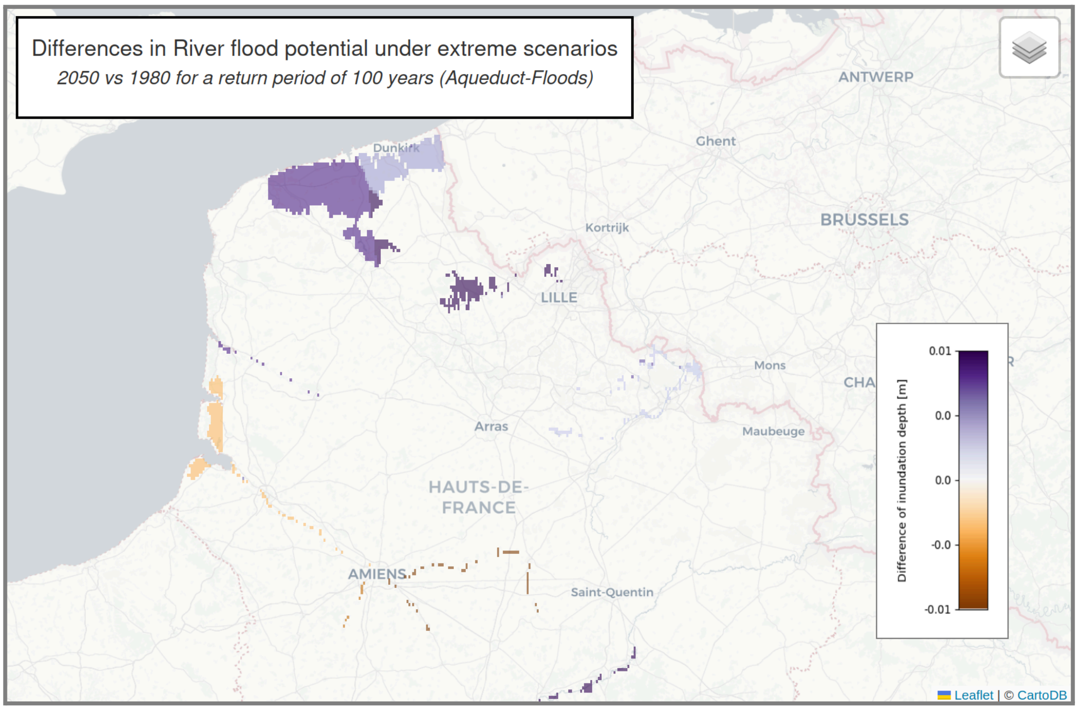

Figure 2-11 : River floodmaps differences between historical period (1980) and projected period (2050), for a return period of 100 years, datasets : Aqueduct floods

2.3.2.1.1 Coastal Flood

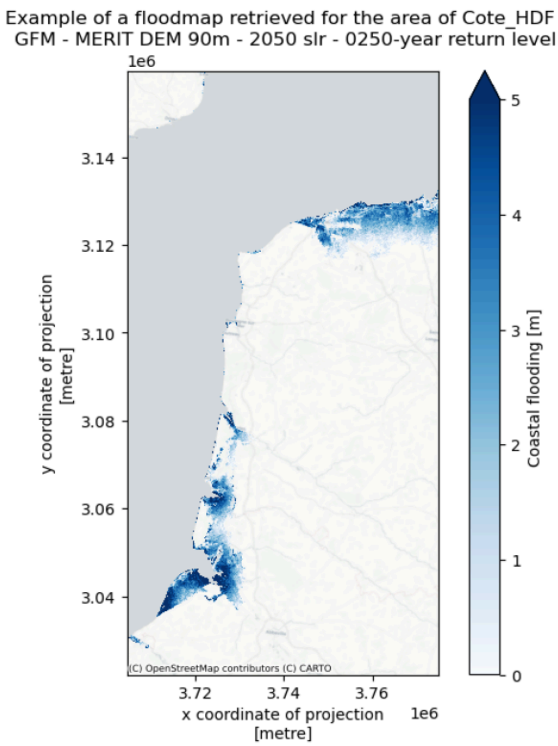

Figure 2-12 : Coastal floodmap example, for a return period of 250 years in 2050, in the Hauts-de-France region, datasets : MERIT-DEM

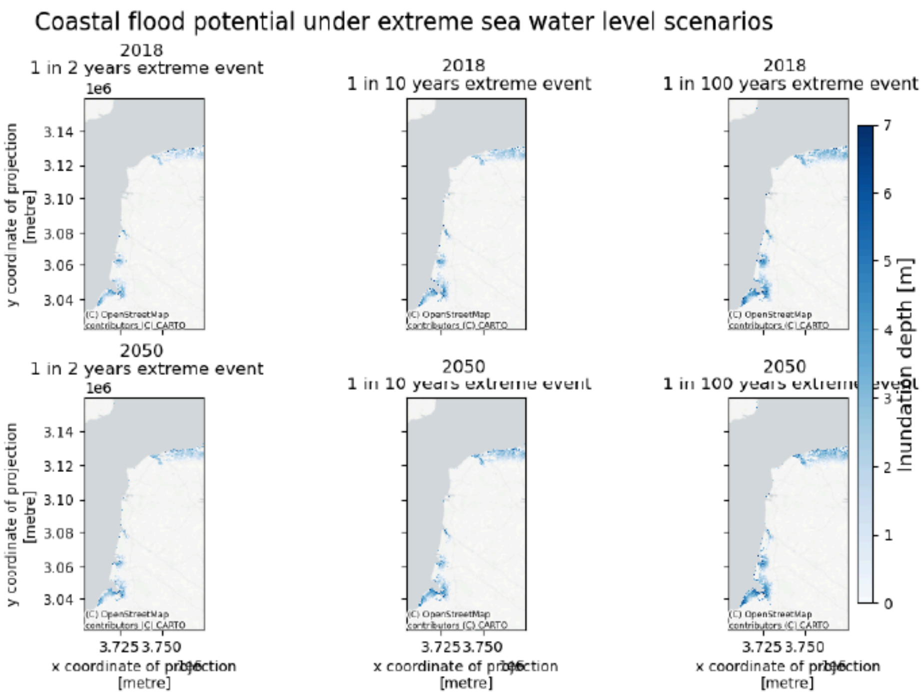

Figure 2-13 : Coastal floodmaps, for different return periods in 2018 (upper row) and 2050 (lower row), in the Hauts-de-France region, datasets : MERIT-DEM

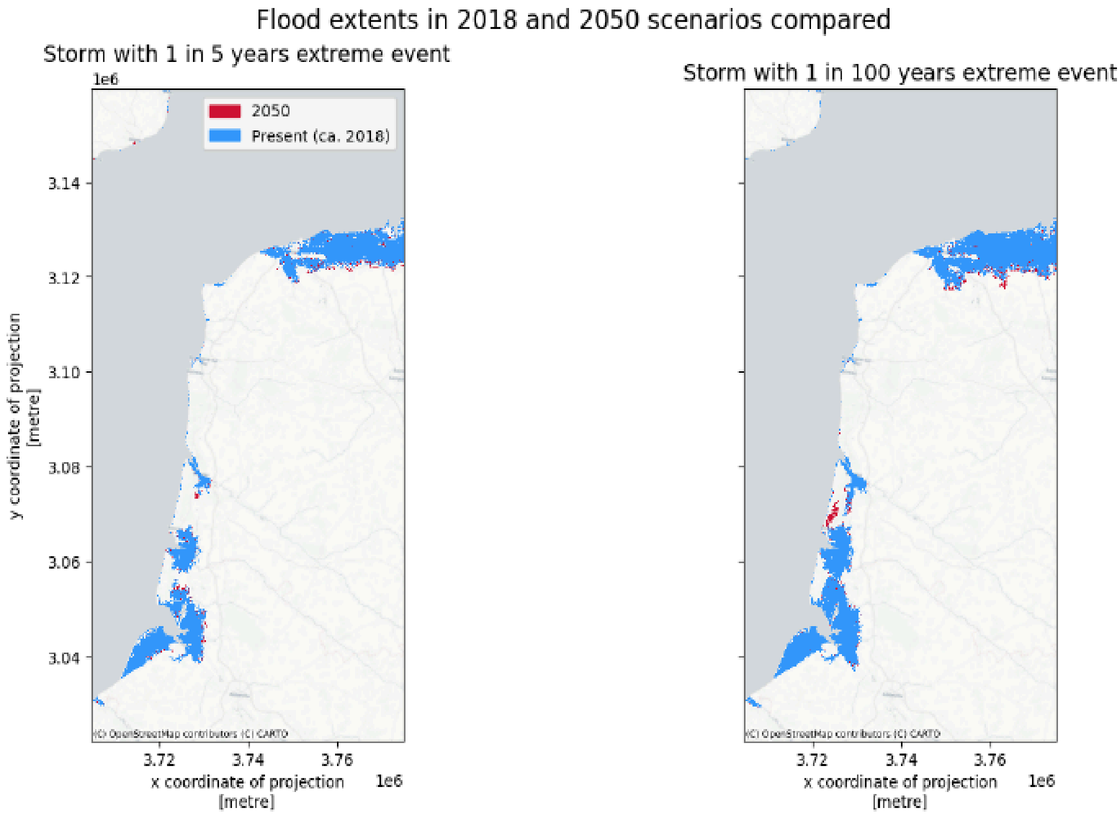

Figure 2-14 : Differences of flushable areas between 2018 and 2050, for a 5 years return period (left) and a 100 years return period (right) in the Hauts-de-France region, datasets : MERIT-DEM

Coastal flood hazard maps highlight the need to work at a fine scale in order to visualise the spatial worsening of differences in flood depth linked to sea level rise, depending on the return periods.

Flooding intensifies in estuaries and spreads to varying degrees in marsh areas or low-lying zones. Flood depths increase according to the reference year (2018/2050) and the selected return period.

Reference maps of potential flooding between 2018 and 2050 reveal newly flooded areas, depending on the selected return periods.

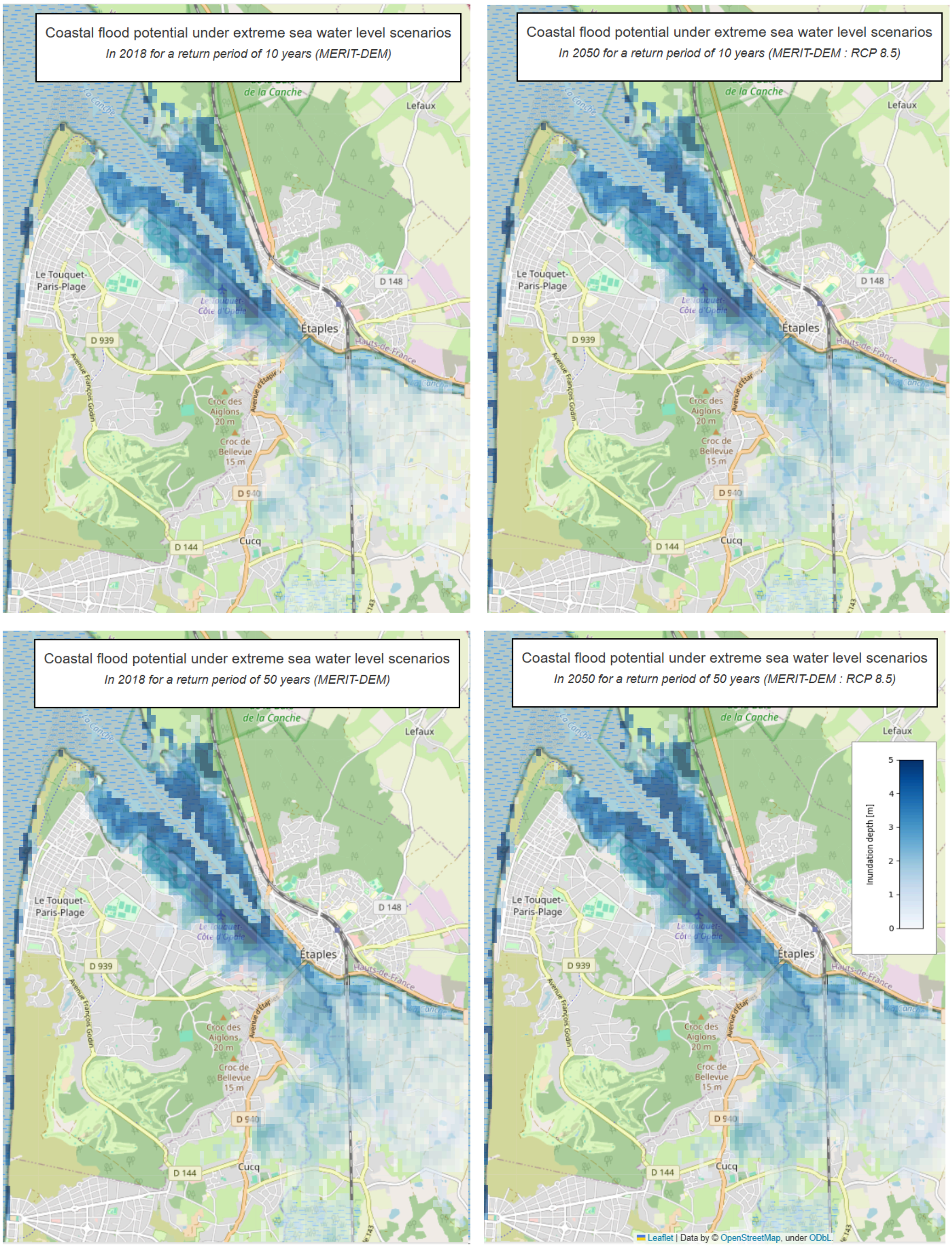

Figure 2-15 : Floodmaps, for a 10 years return period (upper row) and a 50 years return period (lower row) in 2018 (left side) and 2050 (right side) in the Hauts-de-France region, datasets : MERIT-DEM

Limitation: Coastal erosion in cliff areas is not taken into account by the model, which only covers topographic areas exposed to marine submersion: low-lying areas, coastal marshes, and polders. The model does not take coastal protection measures into consideration. For example, the model predicts regular flooding in the polder area (flood-prone zone with a 2-year return period), whereas in reality, the protections and topography mean that the area is only very rarely flooded thanks to the protection systems in place (pumps, sluices, etc.).

2.3.2.2 Risk assessment

2.3.2.2.1 River flood

Using the LUISA database and the associated damage curves, the economic impact of flood events can be computed for the Hauts-de-France region. Figure 2-16 shows an example of this output, around the city of Pont-Sainte Maxence in the Oise department, for different return periods, using the JRC high resolution dataset.

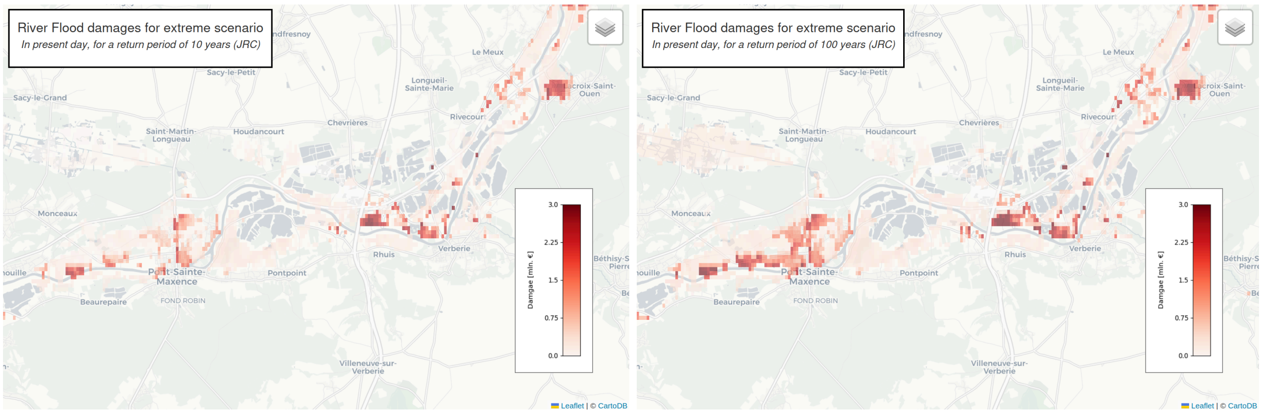

Figure 2-16 : Damage estimation from LUISA dataset and JRC high resolution floodmaps for 10 years return period (left) and 100 years return period (right) near the city of Pont-Sainte Maxence

This method provides an initial estimate of the costs generated by river flooding in the Hauts-de-France region, which constitutes an essential resource for forecasting such events and their evolution. However, given the large differences between the flood maps produced by the JRC and Aqueduct models, as well as the fact that the Aqueduct model covers only a very small proportion of the rivers present in the study area, this analysis was initially carried out using only the results from the JRC model. As a result, estimates of river flood damages are available only for the historical period. That said, by analysing the differences between present and future flood maps in the Aqueduct model (as shown in Figure 2-17 below), we can infer which rivers are likely to experience an increase in these impacts (as demonstrated here by an increase in flood depth between 1980 and 2050), or a decrease.
In the second phase, the focus will be on identifying complementary datasets to Aqueduct in order to strengthen the reliability of the projected flood maps for 2050, and thus carry out the risk assessment for that period.

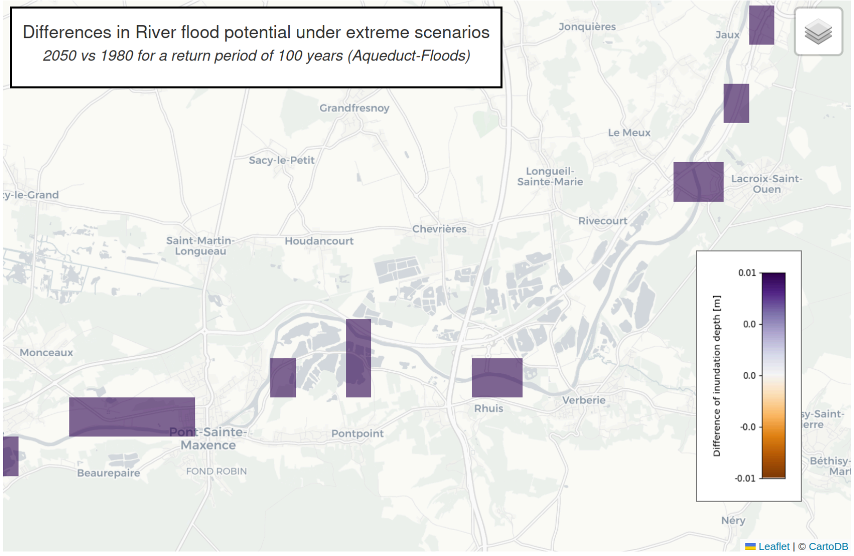

Figure 2-17 : Differences in river floodmaps between 2018 and 2050 for a return period of 100 years near the city of Pont-Sainte Maxence, dataset : Aqueduct-Floods

However, in the JRC model, the small rivers in the polder area located between the cities of Calais, Dunkirk, and Saint-Omer are not well represented in terms of river flood risk.
Furthermore, it appears that groundwater rise phenomena are also not simulated in the JRC model (Dottori et al., 2022). Yet this phenomenon is widespread in the region and plays a major role in amplifying flooding events, particularly in autumn and winter during continuous rainfall episodes that saturate the soils with water (Palhol et al., 2024). This characteristic leads to an underestimation of flood risk, especially in this area (e.g., the Aa River basin, 665 km² with 120 km of waterways), which nevertheless experienced exceptional flooding during the winter of 2023-2024, as illustrated in the map below.

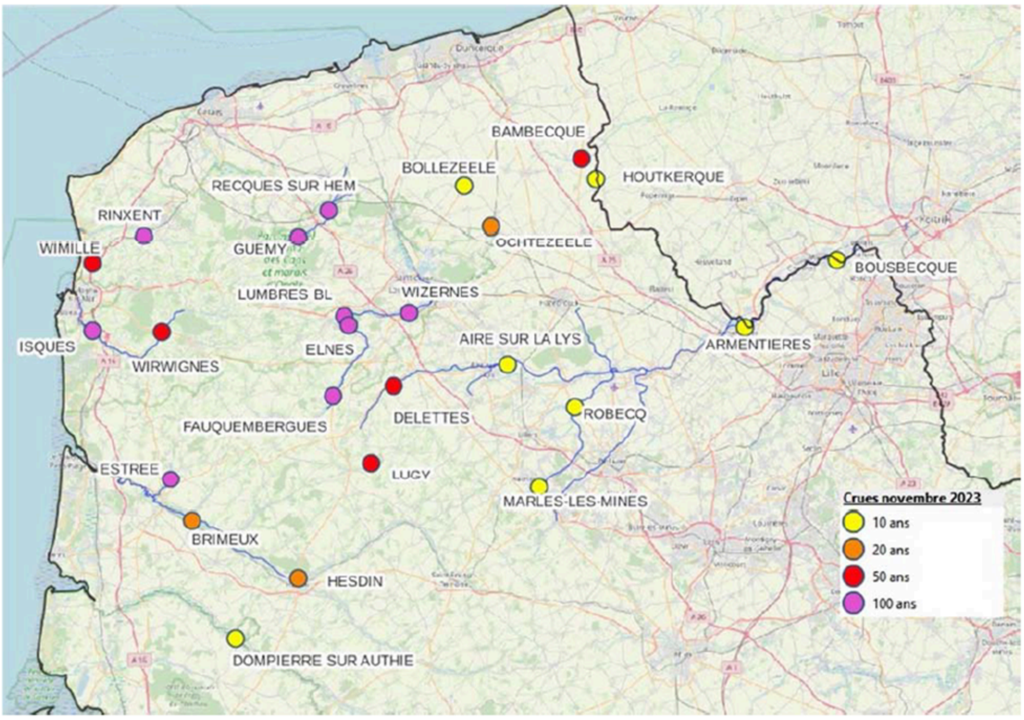

Figure 2-18 : Return periods of November 2023 floods on the main measurement stations of the Hauts-de-France region

Source: Support mission to the Prefect of the Hauts-de-France region to strengthen the resilience of areas affected by flooding – April 2024 – General Inspectorate of the Environment and Sustainable Development (IEGDD), General Inspectorate of Administration (IGA) and General Council for Food, Agriculture and Rural Areas (CGAAER). See appendix

2.3.2.2.2 Coastal flood

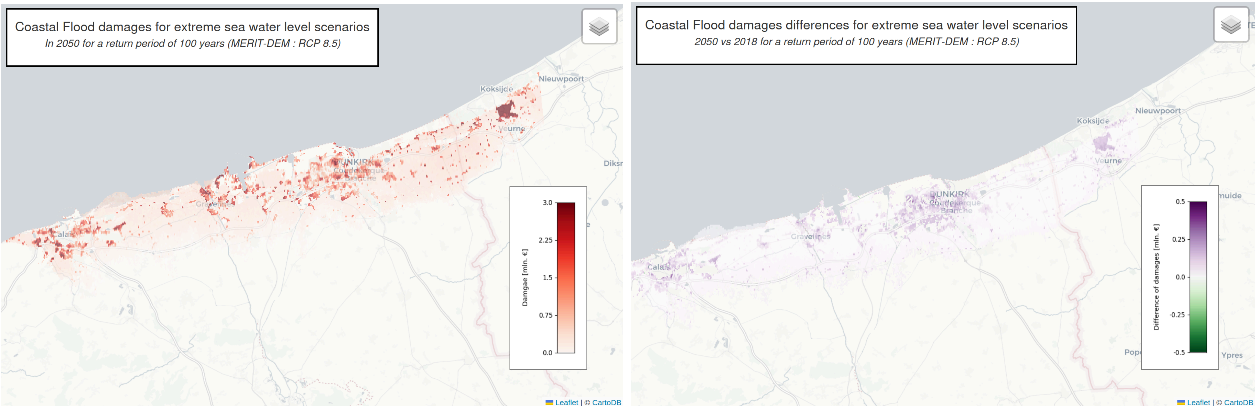

Figure 2-19 : Coastal flood damage estimation in 2050 (left side) and difference between the damages in 2050 and in 2018 (right side) for a return period of 100 years in the Northern coast of Hauts-de-France, dataset : MERIT-DEM (floodmaps) and LUISA (damage curves & land use data)

Figure 2-19 shows the estimated damages caused by a coastal flooding event with a 100-year return period by 2050, as well as the difference compared with the historical period. These estimates are valuable for localities as they provide an overview of the future risks associated with coastal flooding events, as well as identifying which buildings are most vulnerable to this type of event.

However, certain limitations can be identified in this analysis: coastal protection measures are not taken into account in the MERIT-DEM model, which drastically overestimates the extent of flooding, particularly in the polder area. Although this area lies below sea level, it is nevertheless very rarely subject to coastal flooding events thanks to the protection systems in place and the topography of the land.

Ecosystem degradation is also not considered in the damage estimates; only the impact on built infrastructure and agriculture is monetarily assessed. Likewise, the salinisation of agricultural land does not appear to be taken into account, nor does the risk of saltwater intrusion, which can affect the availability of drinking water.

2.4 Preliminary Key Risk Assessment Findings

2.4.1 Severity

Successive floods that struck part of the Hauts-de-France region during the winter of 2023-2024 were of exceptional severity, setting records in terms of duration and extent, with an estimated cost of €640 million. These events caused significant damage to homes, businesses, and transport infrastructure. In Blendecques, an entire neighbourhood had to be demolished due to irreversible damage (homes purchased by the State), and schools were relocated.

The PPRI map (below) shows that a large part of the region is exposed to flood risk. To address this risk, certain areas are identified and mapped (TRI, PAPI, PPR). In these areas, projects and developments are already being implemented to better manage water and reduce risks. Organisations such as the Syndicat Mixte Interdépartemental des Wateringues and the Syndicat Mixte du Grand Littoral Picard are actively working on these issues, and PAPI programmes (Flood prevention action program), such as the one "from the Bresle estuary to the Authie estuary," are currently under review.

Regarding coastal erosion and marine submersion, we are already witnessing a loss of natural areas and ecological changes.

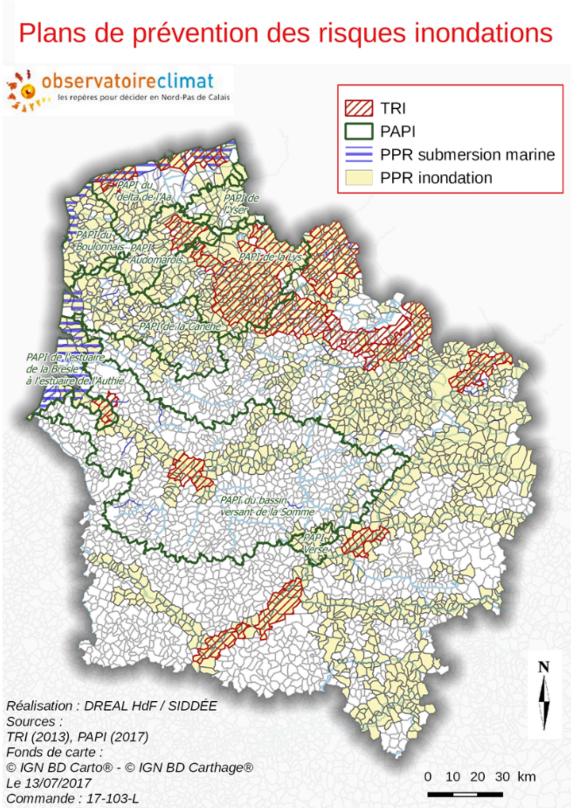

Figure 2-20 : Map of the PPRI (Plan de Prévention des Risques Inondations) in the Hauts de France region
Source : DREAL HdF/SIDDÉE, TRI (2013), PAPI (2017)

2.4.2 Urgency

The urgency of risk management is clear, as the region is regularly affected by flooding. Autumn and winter are the most impacted seasons, with variations in intensity from year to year, though intense rainfall can also occur in other seasons.

As for the intensification of precipitation, results from the Workflow show that the northern parts of the Pas-de-Calais and Nord departments, the Aisne department, the southern Somme, and the northern Oise will be increasingly affected. The departments of the region are also unevenly impacted by the evolution of this risk (e.g., an increase in frequency in the south of the Somme and the north of the Oise, and a decrease in rainfall events in the Arras area).

Models indicate that for a 10-year return period, climate hazards are already changing in the near future. The territory is exposed to sudden events (rain, storms, thunderstorms) as well as slow-onset events (sea-level rise). The risk will inevitably grow, and a large part of the coastline is already affected by the combination of these risks (sea-level rise + more frequent rainfall + inland flooding), particularly in polder areas.

Work carried out as part of the COP has classified potential flood risks as a "high priority," particularly in the wateringues sector (a polder area between the cities of Calais, Dunkirk, and Saint-Omer), along the Somme—especially near Abbeville—in the Lille metropolitan area with an arc between Béthune and Valenciennes, and in low-lying coastal areas. State services classify the risk of marine submersion as a high priority: the entire regional coastline is concerned, with a very high priority given to the Aa delta polder (450,000 inhabitants, Grand Port Maritime of Dunkirk, industries, Gravelines nuclear power plant, cross-border coherence, etc.) and a high priority for the Bas-champ sectors within the Somme/Authie river basins.

2.4.3 Capacity

For coastal risks, protective works have existed for decades. Forward-looking studies are underway or being updated. Adaptation strategies are currently being developed; however, these projects will be large-scale and present challenges for the authorities in terms of spatial reorganisation, costs (investment and maintenance), and consultation/negotiation between local decision-makers, as well as with the population and businesses, regarding the possible relocation of existing buildings.

“Nature-based adaptation solutions” (NbS) are being tested in certain areas of the regional territory, for example near Cayeux-sur-Mer, in collaboration with the departments and the Coastal Conservatory. Natural flood expansion zones and river re-meandering have been implemented in some locations to combat flooding.

The map below shows that significant works have been undertaken in the areas affected by the winter 2023-2024 floods.

In addition to the investments already made or planned, discussions are underway to improve governance of these issues and strengthen the coherence of actions taken by the various organisations involved. State services plan to develop a resilience plan with the following objectives:

- Understand climate phenomena
- Improve knowledge of hazards
- Envision the future of the territory and collectively build resilience roadmaps involving consultation with elected officials, farmers, and residents.

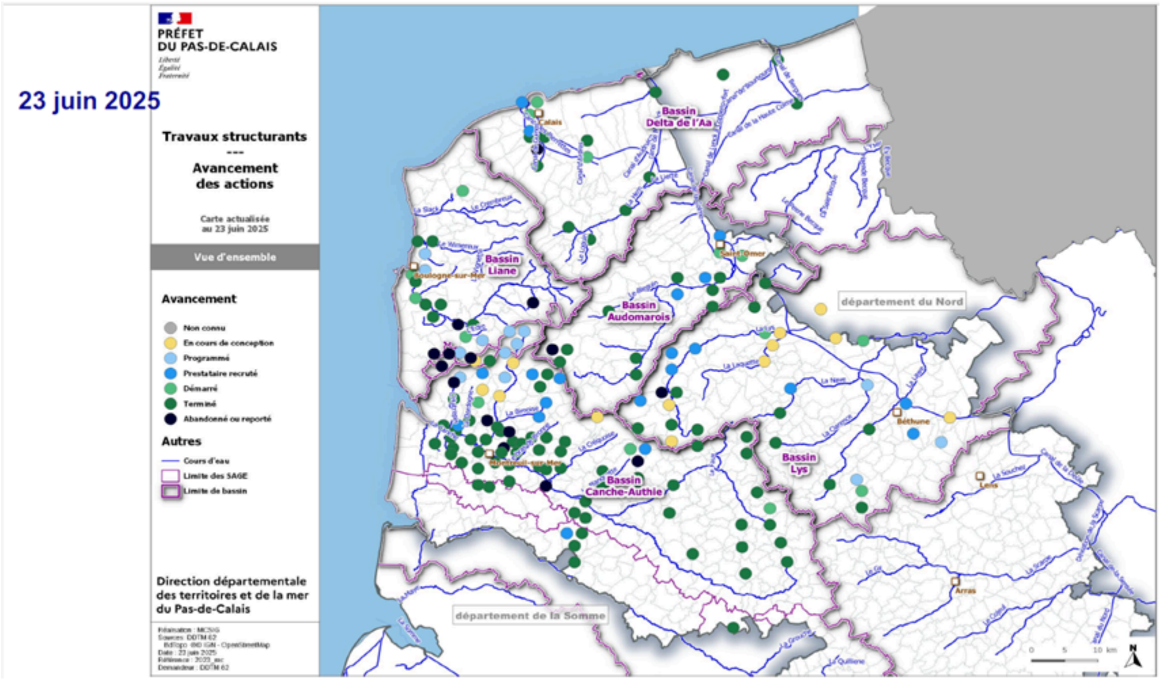

Figure 2-21 : Illustration of the planned or completed works carried out as part of the Monitoring Committee established in the Nord and Pas-de-Calais departments by State services following the winter 2023–2024 floods.

Regarding inland flood risks, there is an inequality between territories in their ability to undertake risk-management actions. Rural municipalities or inter-municipal bodies responsible for GEMAPI (*Gestion des Milieux Aquatiques et Prévention des Inondations*) and stormwater management have fewer financial and technical resources to define and implement the necessary investments to adapt to increasing pluvial and flood risks.

The management of alert systems also falls under the responsibility of municipalities or EPCIs (*Établissements Publics de Coopération Intercommunale*) through municipal or inter-municipal safeguard plans. These plans are mandatory for certain municipalities if natural or technological risks are identified, or if they are covered by a specific intervention plan, but many municipalities have fallen behind in developing them.

2.5 Preliminary Monitoring and Evaluation

The results obtained from the models in the explored workflows have reinforced our decision to focus on heavy rainfall and coastal and river flooding. These results show an increase in the corresponding climate hazards in the medium term, which must be anticipated in order to build adaptation strategies whose translation into actions and implementation will take time.

Initial consultations with stakeholders show their interest in the project and an expectation from certain territories to improve their knowledge of risks. We have questions about the consistency of the results obtained with the JRC and Aqueduct models for river flooding and plan to explore this further in phase 2 of the project. Experts consulted during the first phase alerted us to the absence of runoff consideration in the workflows and to the uncertainty margins generated by the models.

Coastal topography is a determining factor in the results of the coastal flooding workflow: the worsening of the risk appears on the maps only in low-lying areas or estuaries.

We have observed several limitations in the models proposed by Climaax for all workflows. These limitations encourage us to collect existing local data in the region so that the project's final results are as accurate as possible. We will need to ensure the accuracy of the results when communicating them so that they are considered credible and accepted by regional decision-makers and stakeholders.

The second phase should allow us to take ownership of the local diagnostics and modelling carried out in the most exposed areas in order to refine the data at a fine scale. The continuation of COP work in the second half of 2025 should also enable us to refine the diagnosis in the different territories of the region and to identify the priority adaptation actions put forward by local stakeholders.

We consider stakeholder consultation and the inventory of existing data to be very important in order to produce reliable results on climate change in the region, which will make it possible to provide educational information to decision-makers and local actors.

2.6 Work plan

During the first phase of the project, we began compiling an inventory of data and strategic plans related to the coastal and river flooding workflow. In the second phase, we will need to continue this inventory, particularly in consultation with territorial stakeholders. This consultation has been initiated but must be strengthened. It should enable us to better understand the alert thresholds identified in the territories. We plan to examine the results produced by the models by modifying certain parameters (e.g., duration of heavy rainfall over a period longer than 24 hours).

In addition to the university researchers whose consultation began during phase 1, we plan in phase 2 to involve State operators who have expertise in climate data. We also wish to draw on the expertise of a hydrologist to further investigate the issue of accounting for groundwater rise risk in the JRC model. This remains an important matter to address for floods observed in particular on the Somme River, whose cause is partly linked to the phenomenon of groundwater rise.

We will work to ensure consistency between the data collected and the data observed through the models provided by Climaax. Depending on the territorial stakeholders we are able to mobilise, we will refine the scale of the data obtained and organise working seminars to share knowledge and initiate or continue reflection on local adaptation strategies useful for the resilience of these territories.

All results obtained in phase 2 will be the subject of educational publications aimed at raising awareness among regional actors and decision-makers about the evolution of climate impacts in the region and the actions that can be taken to mitigate them, particularly in the field of spatial planning.

We will set up an updatable climate database within the geographic information service, which can be used to produce maps and information useful to the territories.

Phase 3 should allow us to work with a few volunteer territories to disseminate the project results locally and deepen consultations with local stakeholders, with a view to promoting the co-construction of adaptation strategies and projects.

We will also work to identify how these results can be incorporated into the SRADDET (Regional Plan for Planning, Sustainable Development and Equality of Territories) to better inform regional and local decision-makers about the evolution of climate change and flood risks.

We will examine how to continue work on the heavy rainfall workflow, if possible over longer periods of several days, so that it is adapted to observed historical data, linking it with models available to experts.

3 Conclusions Phase 1- Climate risk assessment

It is important to note that the results and conclusions presented here are valid only within the framework of the simulations carried out and according to the scenarios selected. A significantly different or faster evolution of the climate system than currently simulated (for example, and particularly for the Hauts-de-France region, a greater and faster slowdown of the AMOC – van Westen et al., 2025; Roquet et al., 2025) would obviously affect the validity of the results.

The exploration and analysis of the workflows selected in the project have made it possible to visualise the evolution of coastal and river flood risks and heavy rainfall over a 24-hour period and their geographical distribution.

Given the models used for the river flooding workflow, which concerns large river basins, floods potentially caused by watercourses in the north of the Nord and Pas-de-Calais departments are underestimated.

The coastal flooding workflow makes it possible to visualise the risks of marine submersion in the coastal areas potentially most exposed: polder areas in the north of the region, between the cities of Calais, Dunkirk, and Saint-Omer, and the low-lying areas of the Picardy coast. The model does not take into account the risks of coastal erosion in cliff areas, even though retreat is observed in some parts of the region (e.g., the Deux Caps site, the town of Ault). This workflow can only be run with RCP 8.5, the most pessimistic scenario, whereas scenario 4.5—close to the national reference trajectory of the 3rd National Climate Change Adaptation Plan (PNACC) TRACC—would seem more appropriate in light of research carried out by regional scientists.

For both workflows, we need to work at very fine scales to assess the expected changes.

The workflow dedicated to assessing heavy rainfall risks makes it possible to understand the evolution of heavy rainfall over a maximum period of 24 hours. This model is insufficient to explain the floods that affected the Nord and especially the Pas-de-Calais departments during the winter of 2023-2024. These floods were in fact caused not by daily rainfall exceeding in millimetres the decadal or 50-year maxima of the reference periods, but by the accumulation of rainfall volumes over several weeks following a relatively dry period. To better assess the evolution of this risk, seasonal data would also be useful.

Key performance indicators
The results of the first phase confirm the anticipated future intensification of coastal and river flood risks (increased depths of potential flooding, newly flooded areas in the medium term, excluding protections). In some areas of the regional territory, strategies and action plans are being implemented or updated to reduce their consequences, particularly on buildings and human activities (e.g., agriculture). The heavy rainfall workflow, using the RCP 8.5 scenario and Copernicus data based on the national reference trajectory of the 3rd National Climate Change Adaptation Plan, also confirms a foreseeable increase in heavy rainfall, but some territories in the region will be more exposed than others.

4 Progress evaluation and contribution to future phases

Table 4-1 Overview key performance indicators

Key performance indicators	*Progress*
Heavy rainfall	Completed
River and coastal floods	Completed

Table 4-2 Overview milestones

Milestones	*Progress*
Public-public subcontracting agreement between Region and Lille University	In the process of signing at the University of Lille
Preparation, publication and selection of the contract for assistance to the project	Postponed
Inventory of all regional climate data spread across sites and sources	In progress
Publication of posts on the linkedIn accounts	Document prepared and partially distributed
Workshop at Barcelona	Participation and realization of the poster

Supporting documentation

List of annexes

- 1. Map of soil erosion in Hauts-de-France
- 2. Regional map of the main rivers
- 3. Results of the NASA consultation Sea level projection tool
- 4. Data results from the consultation of Copernicus Interactive Climate Atlas
- 5. Territorial stakeholder consultation questionnaire

5 References

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