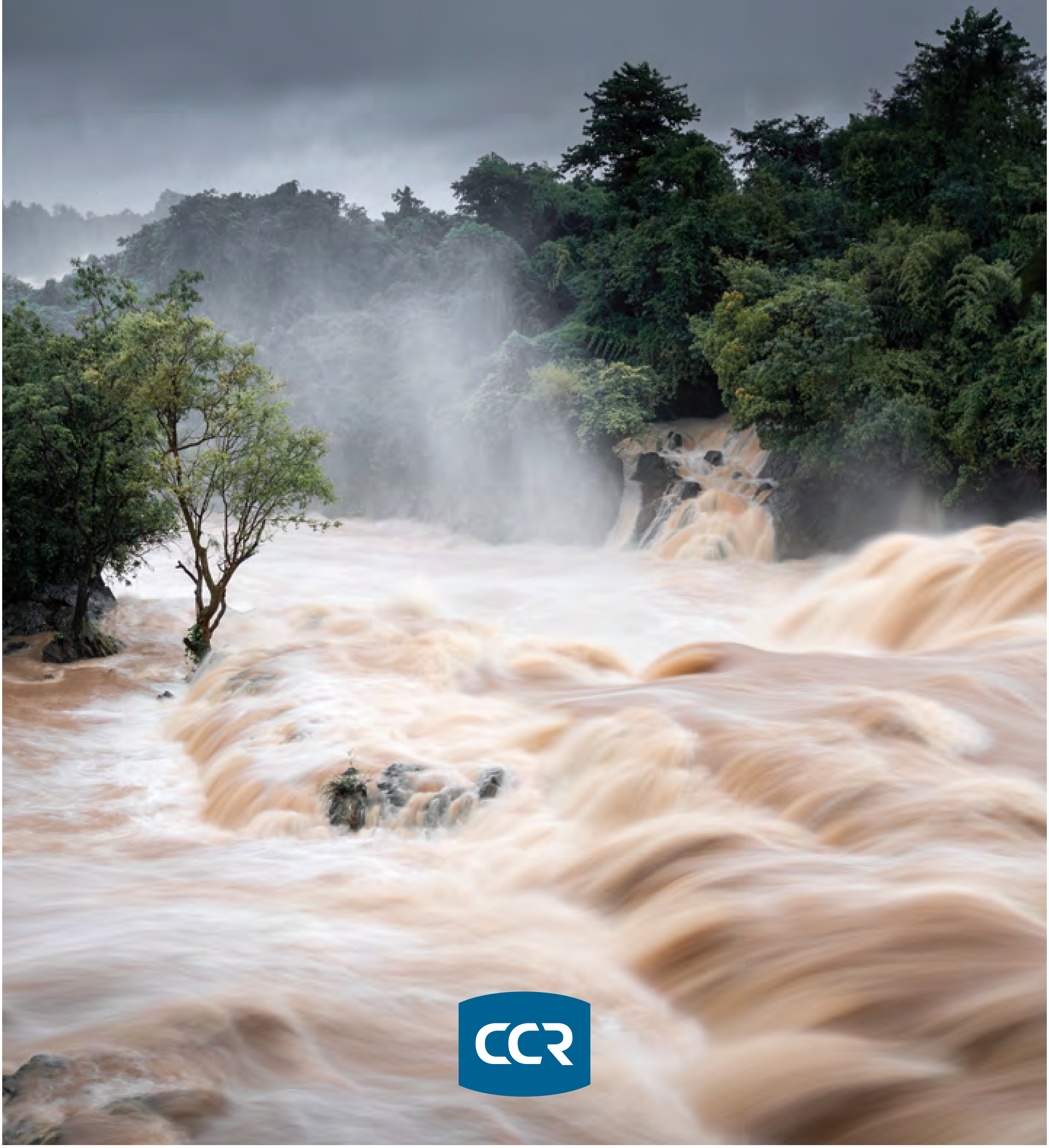
SCIENTIFIC REPORT 2019 CCR



CONTENTS

"THIS SECOND EDITION OF THE CCR'S SCIENTIFIC REPORT TAKES THE FORMAT OF SCIENTIFIC PAPERS CO-WRITTEN WITH OUR PARTNERS."

ANTOINE QUANTIN,
Chief Underwriting Officer - Public Reinsurance and Guaranty Funds

What is the cost of damage caused by an event that has just occurred? What is the distribution of probable losses for the State, for CCR or for an insurance company? What are the uncertainties for those estimations and how to reduce them? What is the obtained benefit of prevention measures implemented or envisaged? What is the expected impact of climate change?

It is a set of issues at the heart of CCR's reinsurance and prevention activities. To respond to these questions it is necessary to develop a fine knowledge of risks, by focusing on collecting and processing data and on the modelling of physical phenomenon, from hazard to damage estimation.

CCR is performing these different tasks since more than 20 years, based on the implementation a team of pluridisplinary experts, on the development of analysis and modelling tools.

Year after year, to reach those objectives, CCR has been associated to renowned scientific partners, at the forefront of which, we can quote Météo-France and the French Geological Survey (BRGM), as well as lot of schools or universities.

In order to highlight this partnership approach, this second edition of the CCR's scientific report, takes the format of scientific papers co-written with our partners. This is the moment for me to thank them for their support in the service of risk knowledge and beyond the resilience of territories and risk prevention. /

2019

RETROSPECTIVE

FEBRUARY 27TH/
PARIS 7°

UNESCO HQ, Operandum project

Operandum project welcomed European projects related to risk prevention and the climate change adaptation topics to make a presentation of their researches and results. The NAIAD project has been presented by focusing on hazard and insured damage modelling.

MARCH 25 – 26TH/
MONTPELLIER

Montpellier, National Conference on Natural Risks (ANRN), AFPCN

Partner of the 2019 ANRN, CCR was the Great Witness – with Météo-France – for climatic questions and participated in round table and participative workshops. The ANRN have notably made it possible to highlight the partnerships between actors in loss prevention and compensation.

MARCH 28TH/
PARIS 15°

AFPCN Workshop, « Extreme events and climate change »

The French Association for Natural Disasters Prevention has organized a workshop dedicated to the impact of climate change on different types of extreme events. CCR intervened in the third part of the day with a thematic on the public policy actions and focusing on "insurances and climate change".

APRIL 2 – 5TH/
CAPE TOWN, SOUTH AFRICA

Actuarial Society of South Africa

The congress of the International Association of Actuaries had for thematic "The Modern Actuary: Challenge, Influence, Lead" with objective to perform a state of the art of knowledge in actuarial science. The R&D research regarding "A quantile mixing approach for the combination of experts' models" have been presented.

APRIL 2ND/
PARIS 9°

French High Committee for National Resilience (HCFDC)

Several times per year, the HCFDC organizes technical round tables. For example, CCR has been invited in April, during the technical talk on "Which strategy of resilience for 2025-2030?". The economic interest of a resilience approach for organization has been discussed.

MAY 13 – 17TH/
MILAN, ITALY

MiCo Milano Congressi, Living Planet Symposium 2019 (ESA)

The conference Living Planet Symposium of the European Spatial Agency is organized every three years. In 2019 the meeting has been organized with the support of the Italian Spatial Agency. The Living Planet Symposium focuses on Earth Observation and provides a contribution to the scientific world and to the overall society. During the different workshops and lectures, ESA, actors involved in the spatial area and the experts in remote sensing demonstrate the capacity of new satellite technologies to transform the traditional area of Earth Observation.

MAY 28-30TH/
LISBON, PORTUGAL

CCB, 4th European Climate Change Adaptation conference (ECCA)

This international meeting gathers all actors involved in climate change and risk reduction topics. The NAIAD project's results have been presented during the session so-called « The insurance value of nature – ecosystem-based solutions to increase the resilience against climate change and natural disasters ».

MAY 26TH/
PARIS 4°

Hôtel de Ville, "Météo & Climat", 16th International Forum of meteorology and climate

The association "Météo & Climat" organizes an unavoidable meeting for the education and the mobilization around climate issues dedicated to both people and professionals. CCR has participated in the participative debate "towards natural disasters, adaptation and prevention to avoid the worst".

MAY 26TH/
PARIS 12°

Salons de l'Aveyron, 10th CCR CAT DAY

Considered as the annual meeting for the French insurance sector, this day is a moment of knowledge exchange on natural disasters and their consequences. This year the thematic "solidarity and responsibility towards catastrophic risks" gathered around 200 participants from the insurance sector, the scientific community and the experts involved in natural disasters. The CCR Cat Nat Award has been delivered to Fanny Benitez for her PhD thesis on the issue "Coping or living with disasters? Adaptive capacities and capabilities in individual and territorial resilience trajectories within the Caribbean space".

JUNE 17TH/
PARIS 14°

Hôtel Marriott Rive Gauche, Institute of Actuaries, 18th Congress of Actuaries

Unavoidable event for the place and for the Institute, the thematic of the congress was, this year, around the climate change issues as actuarial subject. Based on its expertise in the area, CCR participated in the workshop "Climate change impact on the costs of natural disasters by 2050" by presenting the results of the 2018-climate change study and with a special regards on overseas territories.

JUNE 27TH/
BREST

Euro Institut d'Actuariat/ Optimind, Workshops dedicated to diversity and innovation

For the 30 years of EURIA, these days have been organized to highlight the diversity of issues dealt by today's actuaries and the challenges for the future. It was the occasion to present the work on "natural disasters and climate change: what are the issues for the insurance sector and the actuaries ?".

JULY 3RD TO 5TH/
NANTES

Universal Exposure on the Sea XXL, Oceanext 2019

Launched in 2016 by the Coselmar program, the pluridisciplinary and international conference Oceanext of this year was dedicated to the thematic "Building the future of marine and littoral socio-ecosystems". CCR has presented its works on « Evaluation of climate change impact over damages caused by coastal flooding in France ».

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JULY 10TH/
SAN DIEGO, UNITED-STATE

ESRI, International Meeting of ESRI users

During this international meeting of GIS users, CCR received the Special Achievement in GIS Award (SAG) for its expertise in GIS to model natural disasters and for the use of GIS web tools for the diffusion and the valorization of the research.

AUGUST 10 – 16TH/
STATE COLLEGE, PENNSYLVANIA, UNITED-STATES

International Association for Mathematical Geosciences (IAMG)

This 20th IAMG conference gathered scientists working in the area of geomathematics and geo-modelling. The on-going PhD research at CCR have been presented "Regional and exhaustive French seismic catalogues".

SEPTEMBER 10 – 13RD/
NANCY

University of Lorraine, Ring, 30th Ring Meeting

The annual meetings organized by the RING team are the occasion for researchers and students in geology to exchange on their researches through workshops, scientific posters, working groups. The on-going PhD research at CCR have been presented "Stochastic estimation of annual frequencies of main shock in France".

SEPTEMBER 9 – 13RD/
COPENHAGEN, DENMARK

European Conference for Applied Meteorology and Climatology

This annual meeting is dedicated to climate and meteorological issues, with a dedicated topic to agricultural meteorology. The on-going PhD research at CCR have been presented "Impact of climate change on agricultural economic losses in France: modelling drought and frost events in 2050 and their impact on agricultural yield loss rates".

SEPTEMBER 26TH/
PARIS

Fondation Xavier Bernard de l'Académie d'Agriculture

The award of graduation thesis of the Xavier Bernard Fundation is attributed by a commission composed of members of the Fundation, of the Academy Office and experts, and has awarded the graduation thesis of Kapsambelis D., entitled [in French] "Analysis of crop losses at farm level in the context of multi-risk climate insurance in mainland France".

SEPTEMBER 24 – 27TH/
STRASBOURG

French Association of Earthquake Engineering (AFPS), 10th Quadrennial Meeting

Dedicated to a large audience and professionals this meeting gathers oral and poster sessions. This year the thematic was "the society towards seismic risk: knowledge, protection and crisis management". The on-going PhD research at CCR have been presented [in French] "Stochastic generation of seismic catalogues for the French area" and "Earthquake: how to ensure the economic resilience?" and "Calibration of attenuation laws by simulating seismic wave propagation".

OCTOBER 3RD/
PARIS-SACLAY

EDF Lab, Climate Day – knowledge for action

This Climate Day has been organized by the EDF Lab. CCR has been invited to present its R&D activities regarding climate change.

OCTOBER 6 – 9TH/
BORDEAUX

35th Congress of the International Association of Crop Insurers (AIAG)

France is one of the members of the AIAG, this year in Bordeaux more than 400 participants from 40 states participated in the congress of French crop insurers. The main thematic was "Risk Management for Agricultural Production, Climate Volatility and the Role of the Insurance Sector and the State". CCR has shared results on "modelling crop losses towards climatic hazards".

OCTOBER 10TH/
AUBERVILLIERS

ESRI, GIS 2019

For the 2019 ESRI GIS meeting, CCR awarded by the SAG Award, has been invited to demonstrate [in French] "Spatial analysis methods and implementation within the reinsurance sector" and "benefits of satellite imagery in the characterization of floods in France: from hazard mapping to damage estimation".

OCTOBER 16 – 18TH/
NICE

Integrated Disaster Risk Management (IDRIM), 10th IDRIM Conference for a safer world

The CNRS, UMR Espace and AFPCN have organizard the 10th IDRIM Conference dedicated to the resilience of small areas and to the organization of risk management and reduction. CCR was a member of the scientific community and also presented a lecture "Evaluating Financial Impact of Earthquakes for France within the Natural Disasters Compensation Scheme - Benefits from a new modelling tool for both prevention and compensation".

NOVEMBER 21ST/
MARNE-LA-VALLÉE, SHF

SHF Meeting: littoral and climate change

During the SHF Meeting, a seminar dedicated to the littoral and climate change has been organized, CCR has shared results of climate change study "consequences of climate change on insured damage related to marine submersion. Foresight at horizon 2050".

NOVEMBER 28TH/
PARIS 6°

Hôtel de l'Industrie, Météo & Climat, Scientific Meeting

Official partner of the Météo & Climat's Scientific Days, CCR members participated in the 11th meeting on the "Climate change sustainable management of lands and food security" topic.

NOVEMBER 28TH/
LYON

Plan Climat Energie Territorial Grand Lyon, Energy and Climate Meeting

In the frame of the CCR results on the impact of climate change on insured losses in France, the PCETGL has welcomed CCR to participate in the round table "Finances and Climate".

CCR PUBLICATIONS

Cohignac T., and Kazi-Tani N. 2019. "Quantile Mixing and Model Uncertainty Measures." [sub.] https://hal.archives-ouvertes.fr/hal-02405859

Desarthe J. 2019. Les RETEX dans l'histoire : une pratique ancienne dans la gestion des risques. In Proceedings of the Acte du Colloque Géorisque n°8; Montpellier, France, 2019.

Giacona F., Martin B., Eckert N., et Desarthe J. 2019. Une méthodologie de la modélisation en géohistoire : de la chronologie (spatialisée) des événements au fonctionnement du système par la mise en correspondance spatiale et temporelle. *Physio-Géo* 2019, Volume 4.

Gouache C., Bonneau F., Tinard P., et Montel J.-M. 2019 (soumis). Estimation of main shock frequency - magnitude distributions by adapting the inter event time method for low-to-moderate seismicity areas. Application to French mainland.

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Marchal R., Piton G., Lopez-Gunn E., et al. 2019. "The (Re)Insurance Industry's Roles in the Integration of Nature-Based Solutions for Prevention in Disaster Risk Reduction—Insights from a European Survey." Sustainability 11 (22): 6212. https://doi.org/10.3390/su11226212.

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Tourjansky L., Goislot D., et Bauduceau N. 2019. Les Solutions d'adaptation fondées sur la Nature dans la politique de prévention et de gestion des risques et des catastrophes naturels. In Des Solutions fondées sur la Nature pour s'adapter au changement climatique, Rapport de l'Onerc au Premier ministre et au Parlement; Paris, France, 2019; pp. 176–183.

"CCR R&D TEAMS ARE INVOLVED TO PROVIDE A TECHNICAL EXPERTISE TO ONGOING RESEARCHES IN THE INSURANCE SECTOR."

DAVID MONCOULON,
Head of Department R&D
Modelling - Cat & Agriculture

Since 2015, the researches performed by CCR and its partners, especially Météo-France, have demonstrated the increase of economic and insured damages for the next decades on the French national area. This increasing exposure concerns all economic sectors, from damages to assets (dwellings, industries) to crop losses for farmers. It is notably due to the climate evolution and its impact on the frequency and the severity of extremes events and also due to the increase of insured assets located in high risk areas.
The insurance schemes have to change and to adapt themselves to cope with the progression of the claims for the next decades. CCR R&D teams are involved to provide a technical expertise to ongoing researches in the insurance sector and for a better implementation of loss prevention.
Traditional models are evolving towards a multi-hazards approach integrating future climatic scenarios to measure the financial exposure. Then, floods, marine submersion and drought events will be simulated from a common climatic situation. The consequences of those events will be simultaneity studied from this common situation. The consequences will also be studies simultaneity for different areas: agriculture and crop losses, natural disasters and economic damages. This innovative approach will be based on the pursuit of on-going research projects (ANR PICS, TIREX or European project NAIAD) and thesis in collaboration with scientific institutes dedicated to applied researches (INRAE, ENSG, Ecole des Mines, Agrocampus Ouest).
The drought topic becomes notably essential for all economic sectors, due to major events occurred since 2015 and climatic models' projections. The predicted increase of those phenomena require a finest knowledge of this hazard in order to propose adaptive systems and to assess their consequences.
After the Teil's earthquake, the return on experience will increase the knowledge regarding the peril and the modelling of its consequences. In parallel, CCR is developing its own earthquake exposure model in mainland France and in oversea territories and will be able to share the results in the next months.
An emphasis will be done in the next years concerning the development of industrialized models, to project them on new issues (new hazards, new territories), in short delays to respond to the emergence of new subjects for public policies.
The evolution of those models will allow their deployment to realize studies at local scale for organisms in charge of loss prevention, in order to assess, notably, the costs and benefits of the actions implemented. Today, the fine and precise modelling, at different scales, is an effective tool to improve risk knowledge exposure of our territories. Beyond this knowledge, it allows to test hypotheses for adapting prevention and protection policies. /

CLIMATE RISKS

Contributions of satellite imagery to the characterization of floods

Thomas Onfroy[1], Anas Nassih[2]
(1) Department R&D Cat & Agriculture Modelling, CCR. (2) Master
2 IGAST (Geographic Information: Spatial Analysis and Remote Sensing) de l'ENSG (School of Geomatics)

ABSTRACT

In recent years, insurers and reinsurers have been increasingly relying on space technologies to develop their knowledge of risk and to estimate flood-related damage more accurately. This Remote Sensing project demonstrated the potential of EO data and remote sensing methods in characterizing overflow flooding phenomena and estimating insured damage from medium to high resolution satellite imaging data collected by Landsat-8, Sentinel-2, and Sentinel-1. The methods have been applied on three major flood events that occurred in mainland France: Seine and Loire in May-June 2016, Seine and Marne in January-February 2018, and Languedoc in October 2018.

 # remote sensing
 # flooding
 # insurance claims
 # insurance indicators

INTRODUCTION

Nowadays, remote sensing is a valuable tool for mapping and monitoring natural disasters, especially flood events. It is an earth observation discipline based on the measurement of electromagnetic radiation emitted or reflected by surface targets (soil, water, vegetation, buildings, and so on…) in the visible light or in the invisible spectrum such as near or mid-infrared light.
Optical satellites acquire images of earth's surface by receiving different wavelengths of the electromagnetic spectrum emitted from a surface using an on-board multi-spectral sensor. Most of today's optical and radar satellites are able to cover very large areas: up to 400 km for Sentinel-1 radar satellites, 185 km for Landsat-8 (NASA/USGS) and 290 km for Sentinel-2 (ESA). Satellite imagery data can be used to monitor floods in real time or a few days after their occurrence[1].
However, during a flood event, the multi-spectral data at medium (20-30m), high (5-10m) or very high (< 1m) resolutions are often altered by the presence of clouds that prevent direct observation of the ground.
Their use can be unreliable or even impossible in case of total cloudiness, whereas radar satellites, on the other hand, can observe earth surface and floods through clouds, day and night.
In 2019, CCR wanted to implement reliable remote sensing methods that would enable the use of these imaging data, in particular through the involvement of an end-of-studies project of the Master Degree IGAST of the School of Geomatics.
The purpose of this research was to compare the results of hydrological modelling with the flooded areas observed by remote sensing. Medium-to-high resolution satellite imagery data (Landsat-8, Sentinel-2 and Sentinel-1 from 30 to 10 m resolu-

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Contributions of satellite imagery to the characterization of floods

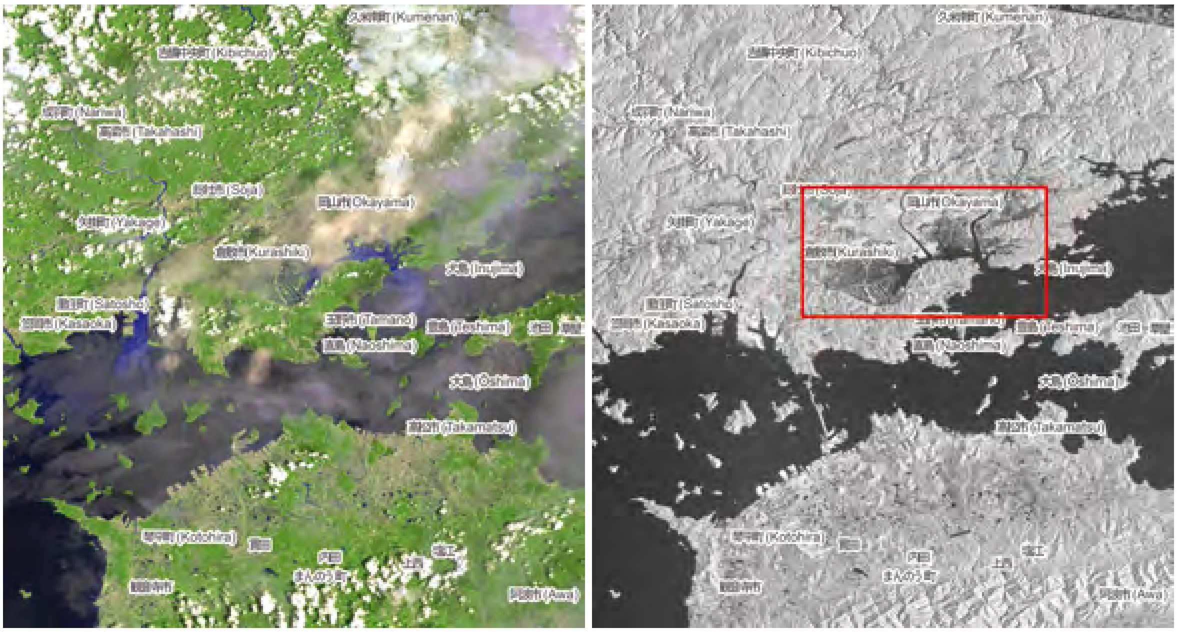


Figure 1 - Floods observed on multispectral imagery on the left (© NASA/USGS Landsat-8, 2018) and on radar imagery on the right (© ESA Copernicus Sentinel-1, 2018).

> tion) for three major events occurring in the metropolitan area from 2016 to 2018 were studied: Seine and Loire flooding in May and June 2016, Seine and Marne flooding in January and February 2018, and Languedoc flooding in October 2018. Since the end of 2017, the processing and post-event analysis of satellite imagery data has made it possible to provide innovative elements for the validation of the overflow flooding model's results.

METHODOLOGY

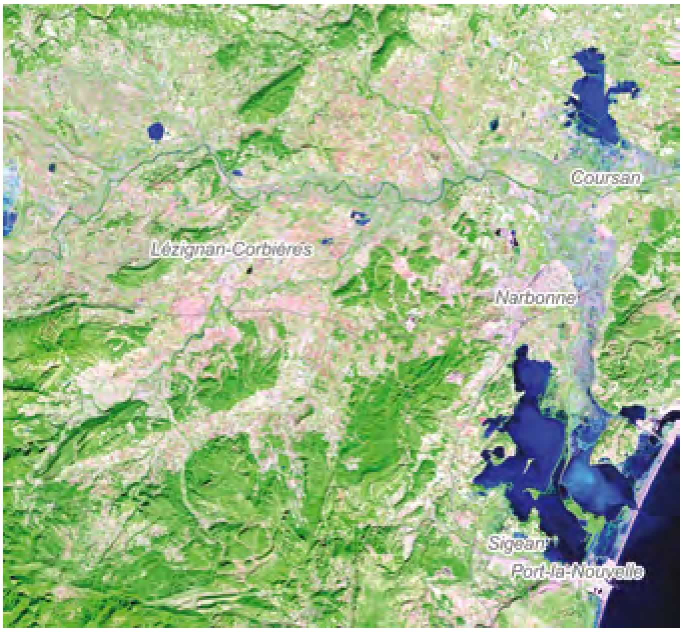
Radar satellites have the ability to acquire images of earth's surface in whatever weather conditions. This is due to the ability of radar waves to operate outside the visible spectrum and to pass through the cloud layer both day and night.

Moreover, the radar waves have the ability to penetrate the first centimeters of the ground, notably then the ground is waterlogged. It makes it possible, under certain conditions, to distinguish flooded areas from non-water areas and to provide detailed information during the active phase of the flood. Radar waves are sensitive to the roughness of the surface encountered[2]: roughness areas such as buildings and relief crests for example, have an important radar reflectivity and appear in light tones. On the contrary, smooth surfaces appear in dark tones, which is the case for flooded areas. Raw radar images are processed using remote sensing software ESA SNAP. A radiometric threshold is defined to distinguish water surfaces from non-water surfaces[3] (Figure 1).

For multi-spectral imagery, the methods used differs. Flooded areas are detected by mathematical operations between the different spectral bands of the satellite. The results are spectral indices such as the MNDWI (Modified Normalised Difference Water Index[4], Figure 2).

In order to improve the characterization of flooded areas from multi-spectral data, a supervised classification using a Random Forest algorithm was used. The classification relied on four main classes: water, soil, vegetation and wetland areas. Validation of the results was performed using a confusion matrix. This method was applied for Languedoc 2018 floods on Landsat-8 images acquired eight days after the event. Soils still waterlogged a week after the flood allowed the detection of flood leads.

Radar imagery data can be also used in dense urban areas following a method based on interferometric coherence[5].



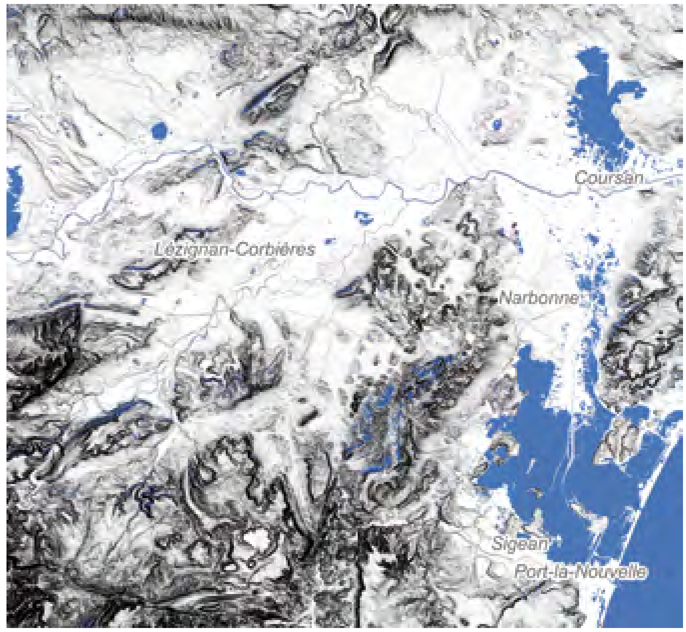


Figure 2 - Extraction of flooded areas from the optical image (© ESA Copernicus Sentinel-2, 2018) with MNDWI index (Languedoc 2018)

In the most urbanized areas, interferometric coherence makes it possible to define the buildings flooded during an event[6]. This method establishes cross-correlation between two radar images: one just before and one during the flood[7]. The buildings have a very stable coherence value in normal times (near 1). During a flood, the coherence value of the building decreases (between 0.5 and 0.6). It is the decrease in the coherence value which allows, a priori, to distinguish flooded buildings from non-flooded ones.
However, the coherence values of the vegetation or other types of land-use next to buildings can also decrease between the two periods observed on the images. To avoid false alarms, the European settlement map foot spatial layer was used to mask the other types of land-use and to retain only buildings, the only object of interest in the interferometric coherence method.
In order to be considered in the damage simulation, the flooded areas from imagery have to be extracted in terms of water heights. Thus, from a Digital Terrain Model (IGN's DTM at 25m resolution), the water heights resulting from overflow observed by remote sensing are obtained through automated geomatics processing in a Model Builder workflow (Esri ArcGIS®). This tool crosses-reference input data (DTM, hydrography, major river beds, etc.) with the flooding areas resulting from remote sensing.

RESULTS

The application of remote sensing methods to the three studied events resulted in overflow hazard maps and water heights resulting from GIS post-processing of the observed areas.
For optical imagery, the MNDWI index was selected because it allows a finer and more efficient delineation of water surfaces. The Random Forest classification proved very effective in defining the distribution of the flooded areas within the major river bed from the learning areas integrated in the algorithm.
In the assessment of a supervised classification from a confusion matrix, when the Kappa index[8] is between 60% and 80%, the classification is considered as viable and the results can be exploited. In this case, the Kappa index obtained was 96.2%, with an overall accuracy of 97.7%. The results of the classified image are satisfactory and usable.
The results of the method based on interferometric coherence on building >

Contributions of satellite imagery to the characterization of floods

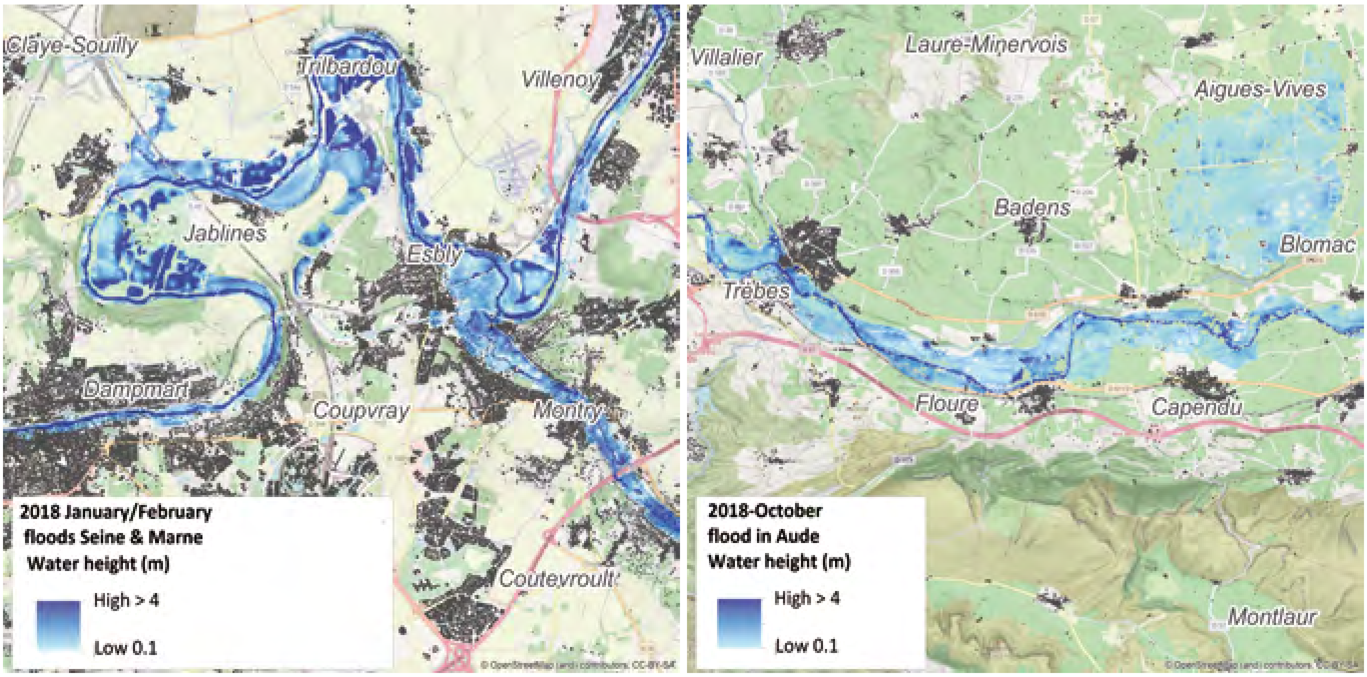


Figure 3 - Results of water heights extraction on the Marne (Seine and Marne 2018) and Aude (Languedoc 2018) (background: OpenStreetMap®)

allowed a very good detection of flooded buildings. The result were validated by comparing it with claims data for the 2016 and 2018 events.

The next steps were to compare areas obtained by remote sensing with CCR's overflow hazard simulations. The remote sensing results were also overlaid on insured claims. The number of claims recorded within remote sensing hazard is higher for the three studied events, but it is by combining the two types of hazards that a greater number of claims are identified. The false alarms are fewer in the remote sensing hazard area. The following insurance indicators were calculated:

- Probability of Detection (POD): percentage of claims in the hazard area out of the total number of claims;
- Probability of False Detection or false alarms (POFD): percentage of insurance contracts located in the hazard area but not damaged;
- True Skill Score (TSS): POD subtracted to the POFD. This score allows to measure the effectiveness of hazard modelling.

For example, for the Seine-Loire 2016 event, the POD increases from 69% with the CCR model to 86.9% with remote sensing alone and to 95.4% by combining the two types of hazards. The POFD does not incur any degradation.

The cost of simulated damage according to the two types of hazards are of the same order of magnitude for the Languedoc 2018 event, which can be explained by the similarity of flooded areas. On the contrary for Seine & Marne 2018 and Seine & Loire 2016 there is a difference in terms of damage assessment. The difference is due to variation of area and of water heights between the two hazards. It is especially at the communal level that the cost of damage may vary according to the selected hazard.

CONCLUSION

The added value of satellite imagery, as a complement to classic models, concerning the characterization of overflow hazard was demonstrated on three major floods occurred between 2016 and 2018. Diverse methods and data were used according to the operating conditions of satellite images. Nevertheless, the remote sensing methods display some limits that may affect the quality of the results:

- the use of a threshold for the multispec-

THE PARTNER

In 2019, Anas Nassih student in the Master degree IGAST of the ENSG worked on a remote sensing project at CCR. The Master 2 IGAST is co-accredited by the University Paris-Est Marne-la-Vallée (UPEM) and the School of Geomatics (ENSG) which provide courses in remote sensing and analysis of geographical data.

tral indexes (optical) or for the radiometric thresholding (radar) may generate uncertainty in the classification between wet and dry areas;
- the unavailability of images the day or in the day following the flooding;
- the use of interferometric coherence between images acquired at different dates and for which terrain condition may have changed (e.g. state of vegetation, presence/absence of vehicles, and so on...)

Nevertheless, these methods improve hazard zoning and damage estimation. They have now been implemented in the process of post-event damage estimation. /

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CITATION

Onfroy et al., Contributions of satellite imagery in the characterization of floods. In Scientific Report CCR 2019 ; CCR, Paris, France, 2020, pp. 09-13.

Modelling urban runoff

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ABSTRACT

Flood modelling has been at the heart of the CCR R&D activities for more than 15 years. The flood model is used to simulate hazard and to estimate losses in case a natural disaster occurs. A probabilistic version of the model is developed in parallel to assess the flood risk exposure of ceding companies and of the State. The impact model of river overflow and runoff phenomena is regularly updated. CCR's expertise has shown that a significant part of the flood losses are due to surface runoff. In order to continuously improve flood modelling, CCR takes advantage of multiple partnerships with Météo-France, of real-time alerts provided by the company Predict, and of Sertit and ESA satellite imagery. Furthermore, the model contributes to on-going research projects, adaptations are added for case studies (e.g. Cost-Benefit Analyses) or to respond to requests from territorial authorities.

 # floods
 # runoff hazard
 # catastrophe loss model
 # claims
 # public stakeholders
 # prevention

INTRODUCTION

Modelling overflow and runoff hazards has been at the heart of CCR's Research and Development activities for more than 15 years[1]. It is an operational model to characterize flood and to simulate real events. This model, regularly updated, is calibrated on a selection of historical events occurred in France from 1999. For the events that have not occurred but are probable, a probabilistic model based on a catalogue of fictive events is developed to measure the financial flood exposure of the State, of CCR, and of insurance companies.

Thanks to the large number of flood events simulated since the implementation of the model, and based on its continuous improvement, CCR has acquired an expertise in estimates of flood damage. This knowledge of water-related risks has demonstrated that a large part of the flood losses is not only due to overflow hazard but also to urban runoff.

In 2019, the flood model was used several times for real-time event monitoring, notably during the October, November and December floods in Occitanie, in the South-East and in the South-West of France. The model was also applied and improved for projects realized for insurance companies, for research projects like the ANR (PICS) and H2020 (NAIAD), and for studies dedicated to local authorities.

METHODOLOGY

The runoff model simulates surface water flows at any point on the territory when the intensity of rainfalls exceeds the infiltration and the soils' water retention capacity. It is performed for all catchments and ungauged water courses. Then, surface flows are distributed on the slopes of the Digital Terrain Model (IGN DTM-25 m resolution). In addition, the runoff model is also based on input data such as rainfall and land-use types (Figure1).
For the simulation of real events, the precipitation data are acquired from the Météo-France library for all rain gauge stations available and Antilope images. Meteorological parameters used by the model are daily rainfall, hourly rainfall and PET (Potential Evapo-Transpiration) representing the theoretical amount of water that evaporates from the soil or is transpired by vegetation.
The probabilistic runoff model relies on a catalogue of thousand fictive events simulated and based on rainfall data from the Météo-France climate model, ARPEGE-Climat.
Land-use types described in the Corine Land Cover database at a 250 m resolution are used in the runoff model to characterize the flows and infiltration on different types of surfaces. For each land-use type (among 8 main types) roughness values are especially defined.
In addition to its use for real-time event monitoring, the runoff model can be adapted to carry out studies and analysis of exposure to water-related risks on a finer scale, on a targeted area, a community, or on small catchments for example. That is the case for the experimental flood risk study performed for the Bièvre catchment (Val-de-Marne) led in partnership with the Paris Region Institute (IPR)[1]. Detailed land-use data on the area (MOS) provided by IPR and sewage system networks provided by the Val-de-Marne Department of Environmental and Sanitation Services have been integrated in the flood model.
Moreover, to respond to requests from local and regional public authorities, the runoff model, on the perimeter of intervention of these actors, has been improved in order to produce the runoff intensity in cubic meters per second for different return periods.
Furthermore, CCR's rainfall-flow model is highlighted in the context of research projects. For example, in the study of flood events on two demonstration sites in France, the October 2015 flood event on the Brague catchment and the 2014-flood events on the Lez catchment. The insured losses due to the flood events have been analysed in the frame of the European project called NAIAD (cf. NAIAD article p.18). A large part of the insured damage are due to runoff in these flood events. Methodological changes have been done in the model to take into account local issues in terms of hazards and according to the availability of detailed local data. Considering the area of studied catchments, the model has been modified to calculate the slopes by overlaying hourly water levels to the DTM. Also, in the urban area, a fictive pluvial sewage systems has been modelled to consider the absorption of decennial hourly rainfall by underground sewage systems.
Finally, the model is also used for internal R&D projects. As shown by the research on the consequences of climate change on overseas territories, in partnership with Météo-France anw d RiskWeatherTech (cf. Oversea article p.43). The runoff model has been transposed to oversea territories to be used in the same manner as for the metropolitan area. New input data including a DTM, a division into sub-catchments and land-use have been integrated. The rainfall data are coming from the 400 fictive years at current climate extracted from Météo-France ARPEGE-Climat model.

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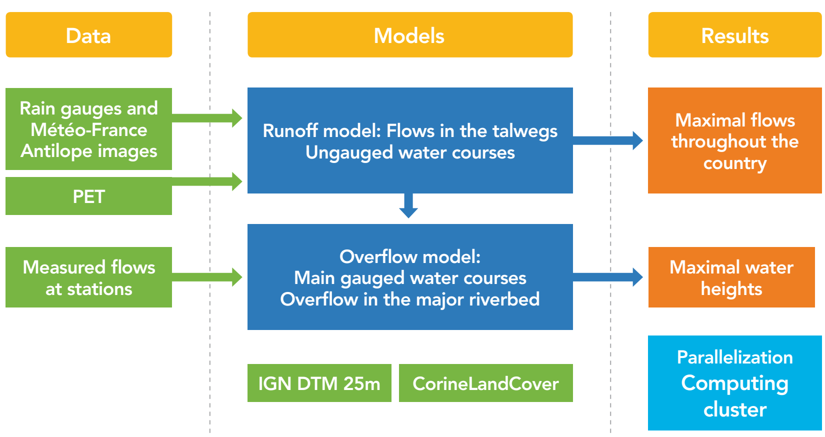

Figure 1 - Functional scheme of the flood model

Modelling urban runoff

RESULTS

For all ungauged water courses and for each catchment, the runoff model reproduces surface flows from rainfall data, and outputs, for each mesh of the DTM, a value of the maximal flow reached during the event. Thus, the flows are distributed on the DTM slopes and converging downstream towards the talwegs.
The operational results related to the climatic events are hazard maps modelling local floods. For example, the result of the simulation of the december 2019 flood that occurred in the South-East of France, in Bielle in the Pyrénées-Atlantiques region (Figure 2).
As regards the simulation of probable events, a catalogue of one thousand fictive event provides a distribution of maximal runoff flows for the entire territory. This allows to estimate hazard intensity on each DTM mesh for a given return period. The frequency of the phenomenon appears higher in waterproofed areas than in the areas covered by vegetation (Figure 3).
The study realized on the Bièvre catchment is based on an improvement of the input data quality for the flood model (surface occupation data and sewage systems) participate in the implementation of an infra-community exposure index combining flood risk due to surface flows modelled by CCR and flood risk due to upwelling from sewage systems (Figure 4). This index highlights the areas most exposed to water-related hazards. The result has been linked and validated by geolocalized claims that have been calculated for each 250m-mesh, with an important number of claims (107/177) in the “high” risk class.
Concerning the local authorities’ requests regarding an improvement of their knowledge of their exposure to urban runoff, the maps classifying the runoff according to four classes of intensity have been shared for each return periods. The mean annual losses modelled for the flood hazard in the frame of the Nat Cat scheme and aggregated at the community level have also been studied and shared with the stakeholders.

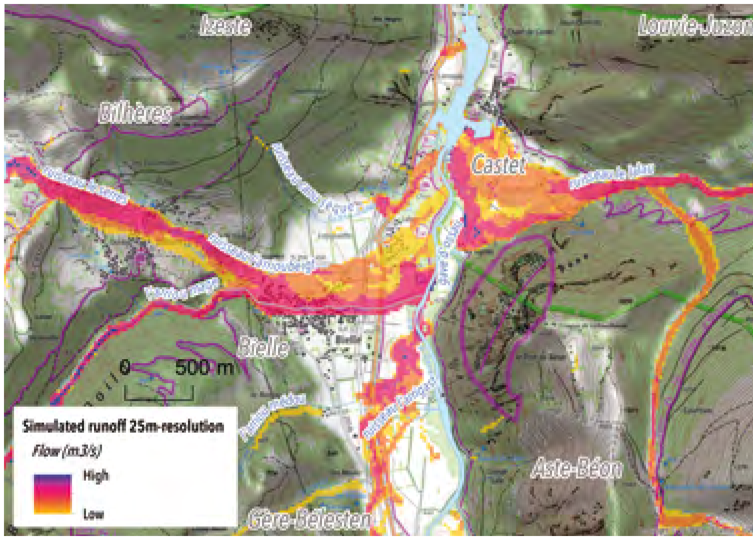

Figure 2 - December 2019 flash flood in Bielle (Pyrénées Atlantiques), CCR runoff model.

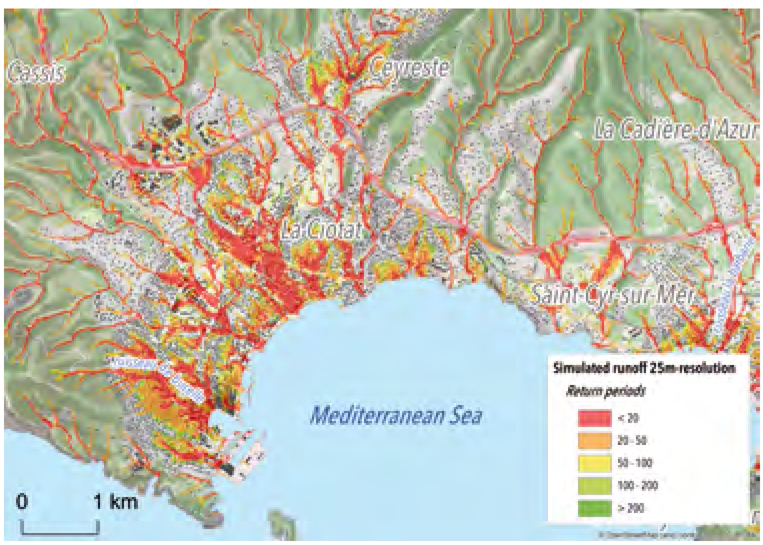

Figure 3 - Probabilistic runoff in the la Ciotat area (Bouches-Du-Rhône).

CONCLUSION

The model simulates occurred events and estimates the amount of insured damages due to both overflow and runoff floods. The model is operational both when a natural disaster occurs or for specific studies in the frame of research projects or requests from local authorities. Finest local input data can easily be integrated in the model, which limits uncertainty due to the quality or the accuracy of data.
The development of studies in the form of partnerships contributes to reinforcing risk knowledge on urban runoff and can be used to foster damage prevention policies. /

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Moncoulon et al., Modelling urban runoff. In Scientific Report CCR 2019 ; CCR, Paris, France, 2020, pp. 14-17.

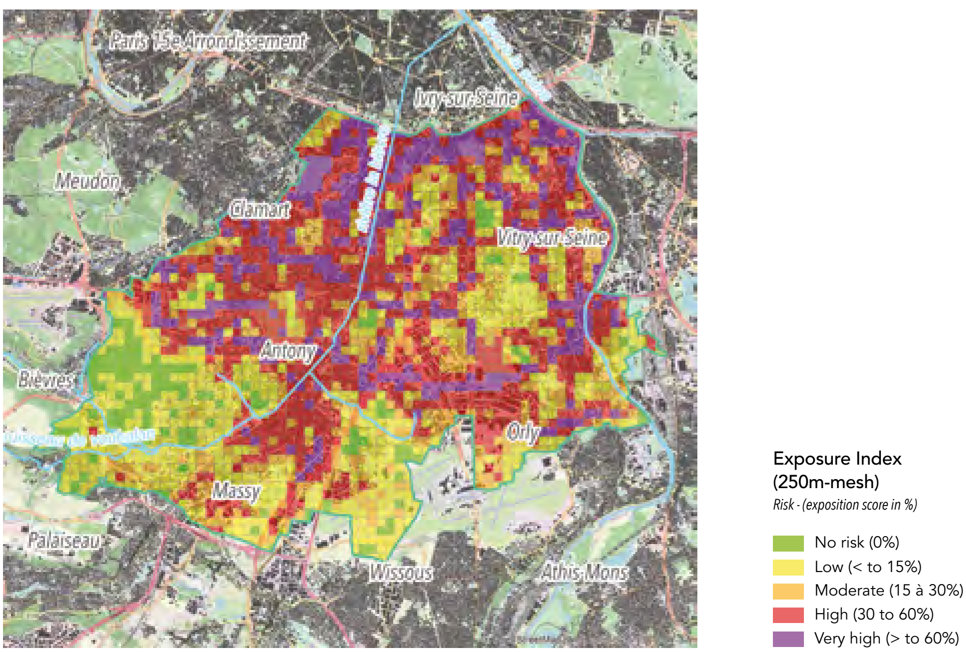

Figure 4 - Exposure index to water-related risks aggregated at a 250m-resolution mesh (Bièvre catchment, Val-de-Marne)[2].

Nature-based solutions: the European project H2020 NAIAD

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ABSTRACT

The Brague river is one of the demonstration sites of the H2020 European project NAIAD: Nature Insurance Value: Assessment and Demonstration (2016-2019). The approach relies on the assessment of overflow and runoff hazard, considering locally-adapted data, with the objective of modelling avoided damage of the implementation of nature-based solutions. The consequences of the climate change at horizon 2050 on insured damages were also explored.

flood model
damage model
nature-based solutions
preventive measures
insured damage
climate change

INTRODUCTION

The European project Horizon 2020 NAIAD (Nature Insurance Value: Assessment and Demonstration (2016-2019)) gathers 23 European partners, including four French partners: the French Geological Survey (BRGM), INRAE, University of Nice and CCR. The objective is to assess and to demonstrate the effectiveness of nature-based solutions (NBS) to reduce water-related hazards (floods and droughts). CCR intervenes principally on hazard modelling issues, on assessing vulnerability and both current and potentially avoided damage related to the implementation of NBS. The project is based on demonstration sites (DEMOs) in Europe, and two in France: the Lez catchment in Montpellier (Hérault) and the Brague catchment in Antibes (Alpes-Maritimes). This article focuses only on the Brague DEMO. The Brague river is 21 km long located in the Mediterranean area and it is characterizes by destructive and potentially murderer flash floods. The studied event is the October 2015 Cevenol event which took the lives of 20 people and the insured damages were estimated at €M 520 (non-auto) by CCR. The flood risk varies according to the localization in the catchment: the low land area is more exposed to overflow flooding from Brague river and its tributaries, while the upper land is exposed to urban runoff. In that context, the assessment of grey or NBS preventive measures is necessary. This assessment concerns both the avoided damage and the landscape, the environmental and the socio-economic co-benefits.
A fine comprehension of hazards and their consequences in terms of insured damage has motivated the collaboration between INRAE and CCR. The INRAE expertise has been applied on modelling overflow hazard and on the use of damage curves recommended by the French Ministry of Ecological and Solidarity Transition (MTES in French). CCR has adapted its runoff model and its insurance damage curves to perform specific analysis for the Brague catchment. The assurance value of NBS has been estimated in terms of mean annual avoided damage; the co-benefits generated by the implementation of these measures has been assessed in parallel[1].

METHODOLOGY

The runoff hazard has been modelled for the entire catchment. The approach is based on the CCR flood model[2] with a resolution of 25m (see: Runoff article). Concerning the information about the characteristics and the localization of the October 2015 claims, the data has been extracted from the CCR historical claims portfolio and targeting only residential homeowners. The climate change modelling has been based on the results of the CCR and Météo-France 2018 study[3].

In addition to this large scale analysis, the overflow hazard has been finest re-analysed on the low land where the most important damages have been recorded. INRAE has used the 2D-numerical model Iber[4] to estimate water heights and flows at 2 m resolution. A recent LIDAR survey has been used to rebuild the geometry of the valley and the surveys of the earth's topography have been digitalized to determinate the river bathymetry and the geometry of numerous bridges and hydraulic structures located on the river and its tributaries. The BD Carto® and BD Topo® data from the IGN have been used to integrate all the buildings and roads within the model, and the land-use data have been checked and revised to model the varying ground roughness. The two major floods, October 2015 and November 2011 have been well documented in recent reports and have been used to numerically reconstitute these events and to calibrate the model. More than 400 geolocalized flood leads reached by the floods have been used to ensure reasonableness of the calculated water levels (Figure 1).

Then the SHYREG[5] method has been applied to calculate the flood events with a given probability of occurrence under current and future climate scenarios (RCP 4.5 >

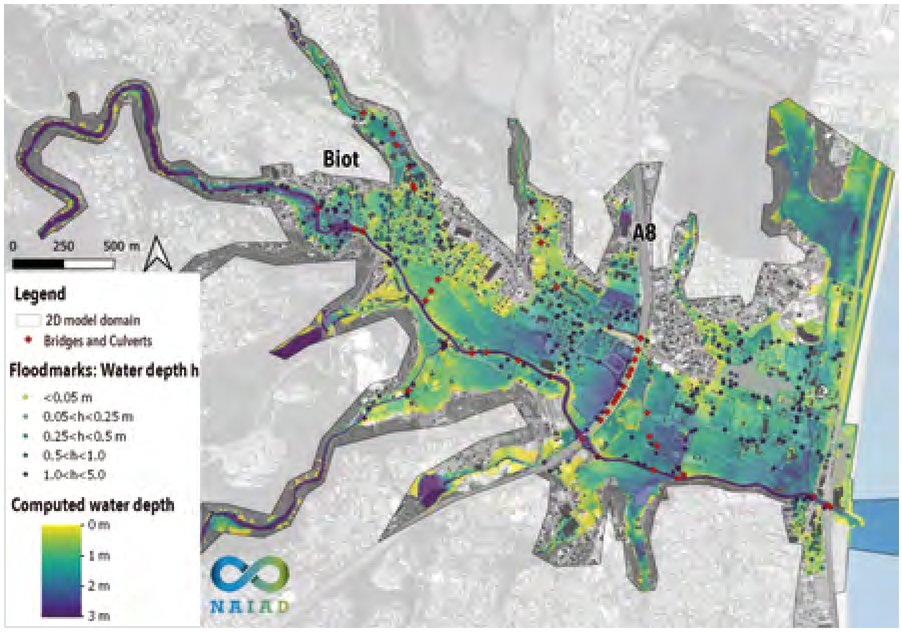


Figure 1 - Modelling results of simulated water heights compared to floodmarks collected during the 2015-flood.

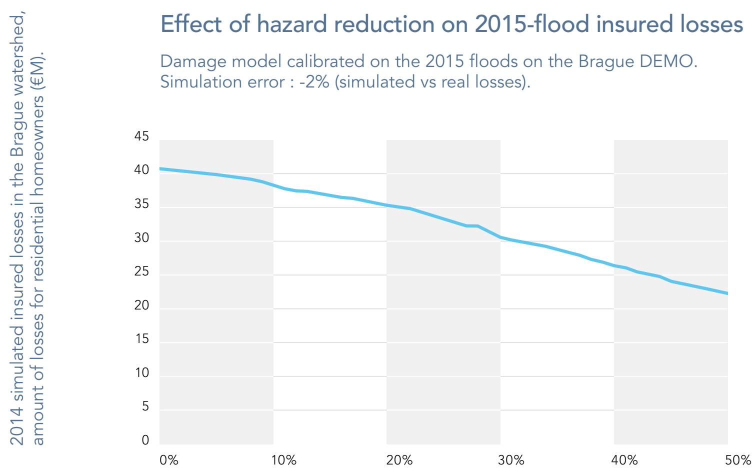
> and 8.5 of IPCC). It has also been used in current and future land-use scenarios or in the presence of conventional protective measures (retention dams) or NBS.
The MTES has developed standardized and national damage curves systematically used to carry out cost-benefit analysis for the Barnier funds grants to flood protection projects[6]. Damage curves are functions highlighting the relation between measured damages (rebuilding costs) and hazard intensities (water heights or flows).
These average curves have been compared to the observed damage and alternative approaches developed by CCR. The calibration of damage curves is based on the use of insured claims data and applied both on runoff and overflow hazard, according to the hazard intensity of Iber model. Then, the damage curves have been crossed with hazard modelling from the study on the consequences of climate change on insured losses in France[3].

RESULTS

The accuracy for flood levels is ±25 cm for the calibration event (Oct. 2015) and fewer for the validation event (Nov. 2011).
- For water heights comprised between 1,5 and 3,5 m (Iber model 2m-resolution), the destruction rate is around 30% of the insured value. It was also found that areas with water heights of less than 20 cm are generally not affected. It is only from such a height that the storm sewage system are completely saturated and the water reaches the power grids which significantly increasing the damages;
- For runoff of 2,5 m^3/s 25 m-resolution, the mean destruction rate are around 15% of the insured value. This major loss is notably correlated to the exceptional intensity of the 2015-flood event whereby numerous tributaries of the Brague catchment have generated floods near or above a 100 year flood[7]. The joint occurrence of these magnitudes is even rarer.
The more or less chaotic aspect of the flows in the peri-urban area of the lower Brague valley is partially reproduced by the hydraulic models implemented. The uncertainty related to the flows or to the logjam have limited the accuracy regarding the modelled water heights.
After the assessment of current risk exposure, it has been possible to assess the effectiveness of preventive measures. For example, regarding the runoff hazard, an analysis has been performed by looking at the relation between runoff flows reduction and consequences on damages whatever the implemented protective measures. Without hazard reduction, damages are estimated for the residential homeowners of €M 4 for the Oct. 2015 event on the catchment. A decrease of 20% of runoff flows may reduce damage to €M 3,5 either 12% (Graph below)

Effect of hazard reduction on 2015-flood insured losses

Damage model calibrated on the 2015 floods on the Brague DEMO.
Simulation error : -2% (simulated vs real losses).



% Hazard reduction rate applied to the runoff flow (m^3/s) at the insurance policy scale before damage calculation - 0 represents no hazard reduction.

THE PARTNER

INRAE (previously IRSTEA) and CCR are partners since 10 years including 3 years within the NAIAD project (2016-2019). The two partners are sharing their knowledge regarding both hazards modelling and assessment of insured damages. A lot of deliverables available on line underline the researches performed within NAIAD, visit www.naiad2020.eu In 2020, IRSTEA and INRA merged to become INRAE.

At the low land scale, the NBS scenario of restoration of the river's hydraulic and ecological corridor "giving-room-to-the-river" has been integrated in Iber model in order to estimate avoided damage due to the implementation. According to the estimates and the use of CGDD and CCR damage curves, the mean annual avoided damage could reached k€ 200-700, either 30% of current mean annual damages. This without considering protective measures to reduce runoff hazards that have to be designed locally. Improving the quality of natural environments, the landscape, the quality of life and the economic dynamics of the valley are all co-benefits that have been difficult to estimate precisely but which could be evaluated at several million euros per year[2]. The runoff from the many vallons overlooking the lower valley also limits the effectiveness of any project that is limited to exclusive river management. This highlights the need to pool the approaches and measures envisaged: to reduce runoff as much as possible and facilitate the flows of unavoidable runoff.

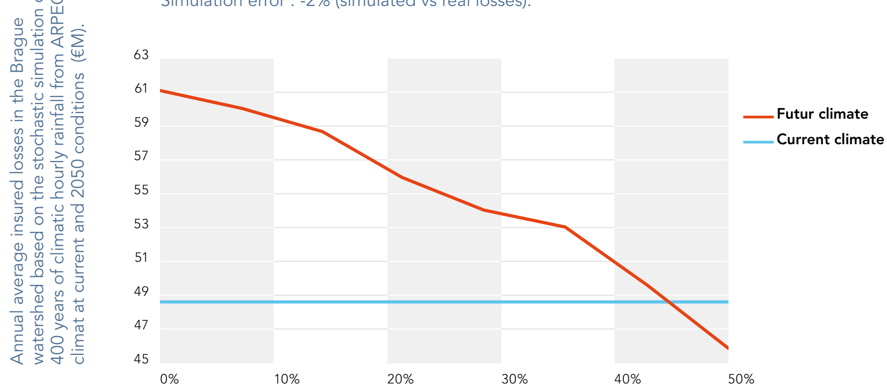
The calibrated damage curves on the October 2015-flood event have been integrated in the damage model to estimate the cost of flooding at current and future climate. The curves have been validated by comparing the real costs of the October 2015 losses with the estimate cost for the intensity levels modelled for this event (less than 2%). At current climate, the mean annual damages are estimated at €M 48,7 for residential homeowners only. The estimates tend to €M 61 at horizon 2050 for the IPCC RCP 8.5 scenario, either an increase of 25% without taking into account the increase of vulnerability. The model indicate a potentially increase of the frequency of extreme events and related losses. Thus, to limit the consequences of climate change on insured losses, a hazard reduction of 45% may be required to maintain the losses at the current level, which is already considered locally as unbearable (Graph below).

CONCLUSION

This in-depth and complementary analysis of overflow and urban runoff hazards has improved risk knowledge on insured damage, on the assessment of avoided damage and on the co-benefits resulting from NBS that could be implemented in the Brague catchment. According to the estimates, the mean annual avoided damage could reach 30% with the implementation of preventive measures based on overflow hazard, without taking into account runoff reduction. Generally speaking, in order to have a real impact on hazard and damage reduction, prevention policies using NBS have to be ambitious. The result of this study may >

Required hazard reduction to maintain future damage at BAU level

Damage model calibrated on the 2015 floods on the Brague DEMO.
Simulation error : -2% (simulated vs real losses).



% Hazard reduction rate applied to the runoff flow (m³/s) at the insurance policy scale before damage calculation - 0 represents no hazard reduction.

Nature-based solutions: the European project H2020 NAIAD

> participate to orientate local stakeholders involved in loss prevention through the use of cost-benefit and multicriteria analysis. The losses can be reduced, but the residual risk is always there, taking into account uncertainty related to the hazards and to the climate change. /

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NAIAD

THE NAIAD PROJECT

The NAIAD project is financed by the European Commission under the H2020 Research and Innovation program, under the subvention N° 730497. It gathers 23 european partners, including 4 French partners (BRGM, INRAE, Université de Nice et CCR) and it is coordinated by the Duero Hydraulogical Confederation (Spain). The research project is applied on nine demonstration sites accross eleven european countries with different scales: from urban neighbouhood in Rotterdam to the Danube catchment for example.

CITATION

Marchal et al., Nature-based solutions: the European project H2020 NAIAD.
In Scientific Report CCR 2019 ; CCR, Paris, France, 2020, pp. 18-22.

Propagating uncertainties in the marine submersion model

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ABSTRACT

Determining the sources of uncertainty in a model constitutes a major stage in order to assess the variability of its results and to improve the simulation's quality. An on-going PhD, carried out in partnership with ESME and the BRGM-Orléans, currently focuses on the analysis of uncertainties in an estimation model of the impacts of marine submersions. The developed methodology is based on the implementation of a meta-model from an initial physical model, with the objective of performing a large number of simulations in a minimum of time. A first implementation of the tool has been applied on the Boucholeurs area located in Charente-Maritime, and a sensitivity analysis of marine forcing has been conducted. The adjusted meta-model reproduces the physical model's results in a satisfactory way. The meta-model was subsequently used to perform a sensitivity analysis using a methodology based on Sobol's indices. The consistency of the results makes it possible to validate the developed methodology, which will be later extended to all the parameters of the model. Finally, this methodology can also be used to combine models in order to improve the model's predictive capabilities.

 # sensitivity analysis
 # applied mathematics
 # extreme events
 # uncertainty analysis
 # spatial statistics

INTRODUCTION

Estimates of impact models generate lot of uncertainties. Concerning the marine submersion model developed by CCR, the uncertainties are related to the input data such as the offshore marine forcing (waves and water level) or the altitude of the Digital Terrain Model (DTM). Other uncertainties are related to the model's parameters such as the soil roughness. In that context, a PhD in applied mathematics, focusing on analysis of uncertainties in the marine submersion model, has been launched in October 2017, in partnership with BRGM (French Geological Survey) and School Mines Saint-Etienne. The objective is to identify and to rank sources of uncertainties in order to prioritize the functionalities that can be improved in the model.
The Sensitivity Analysis (SA) methods enable this identification and this ranking to be carried out, notably by the definition of sensitivity indices measuring the influence of one or more model inputs, on the variability of the outputs.
One of the most widely used indices is the Sobol[1] index which is based on the output variance decomposition. However, two issues are raised with the calculation of this index. The first is that its estimate require a large number of model simulations of the order of 103. Nonetheless, getting that many simulations can take several days >

Propagating uncertainties in the marine submersion model

a: Case study location

b: Parameterization of temporal forcing

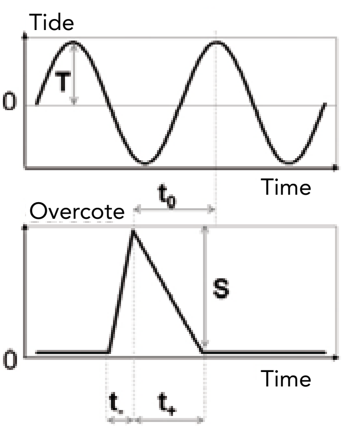

Figure 1 - Case study location (a) and schematic representation of the tested parameters (b).

> or even weeks. The second issue is that the model output, consisting of the maximum water heights simulated during an event, is a spatial data with strong irregularities. To overcome the first problem, it is possible to build a substitution model, so-called meta-model. Methods are available, such as linear regression, Gaussian Process Regression (GPR), etc. However, independently of the meta-modelling methods, the second problem remains. Thus, a method has been implemented to build a meta-model taking into account spatial properties of the observed maps. Once the meta-model developed, it is possible to obtain a sufficient number of simulations to estimate Sobol indices. The issue of spatial data also arises for SA. Like for the meta-model, analyzing each and every localization of the map will be very long in terms of computing time and not relevant. Moreover, it is interesting to synthetize the influence of one or more inputs on the whole predicted water level map into a single index. A specific index has been developed for this case study.

METHODOLOGY

To implement the method, the selected case study is the Boucholeurs area (*Charente-Maritime*). This area is located on the French Atlantic coast near La Rochelle and was severely damaged during Xynthia storm in 2010. An initial analysis has been realized focusing on the impact of marine forcing parameters on the flooded area and the associated water heights.
Figure 1 illustrates the five considered variables: tidal amplitude (T), atmospheric overcote (S), phasing between the overcote and tide (t0), rise time (t) and the fall time of marine overcote (t+). Finally, the model forcing is composed of the sum of the tide and the marine overcote. This forcing has been used as input of CCR[2] and BRGM (adapted from Lazure et al. (2008)[3], see details in Rohmer et al., (2018)[5]) overflow models. 500 calibration events have been simulated by model by varying these 5 parameters. Once these events have been simulated, a meta-model has been calibrated on each of the models and a sensitivity analysis has been realized.

Meta-model calibration

The meta-modelling objective is to replace a physical model, costly in computing time, by a mathematical model, which is much faster, to test a large number of potential variations of the initial model.
The meta-model is a mathematical function that will estimate the outputs of the impact model for input data set based on the observation of a limited number of model simulations. In the case of spatial outputs, a classic approach consists in:
- **{1}** summarize the calibration maps in a limited number of variables (between 1 or 10 variables) by Principal Component Analysis (PCA);
- **{2}** develop a meta-model (linear regression, GPR, neural network etc.) for each of the variables;
- **{3}** for a new set inputs data, predict these variables using the meta-model developed in the **step {2}**;
- **{4}** generating the map associated with these predicted variables, which corresponds to the estimate of maximum water heights during an event.

However, in practice, the **step {1}** is hardly applicable considering the map extent. Moreover, the PCA does not take into account the spatial dependence between the different locations and the regularity of the maps. To alleviate these disadvantages, a modification of the **step {1}** has been done by using a functional wavelet based PCA. The functional PCA means

performing a classical PCA, not on locations, but on wavelet coefficients. The wavelet-based decomposition makes it possible to consider the spatial structure of the maps by studying the frequencies of water heights and their locations.
To validate the model, a cross-method is implemented. The sample of observations is divided into 10 sub-samples each consisting of 50 simulations. The outputs of each sample are compared with those obtained by calibrating one meta-model on the 9 others. The relevance of the models is quantified using the RMSE criterion (Root Mean Square Error). Figure 2 shows the map of mean errors obtained by the classic PCA and the functional PCA. The errors are not homogeneity distributed. A comparison of the error distributions shown in Figure 3 demonstrates that wavelet-based functional PCA method with predictive capability is slightly better than the standard PCA. Moreover, the method is 5 times faster than the standard one: this is due to the fact that the PCA has been applied on fewer variables. On average, the error is 35cm for the functional PCA-based method. This error is higher by a few cases when irregularities of the terrain lead to significant simulation errors. Nevertheless, it is still acceptable when compared to the errors that a DTM have.

Sensitivity analysis

Once the meta-model implemented, it is possible to obtain as many as simulations as necessary in order to estimate Sobel indices and thus to achieve SA. Sobol index is one of the most commonly used sensitivity index, allowing the assignment of an indicator of the influence of one or more model inputs on the variability of the model output. The closer the index is to 1, the more influence the parameter has. The influence of the parameters can

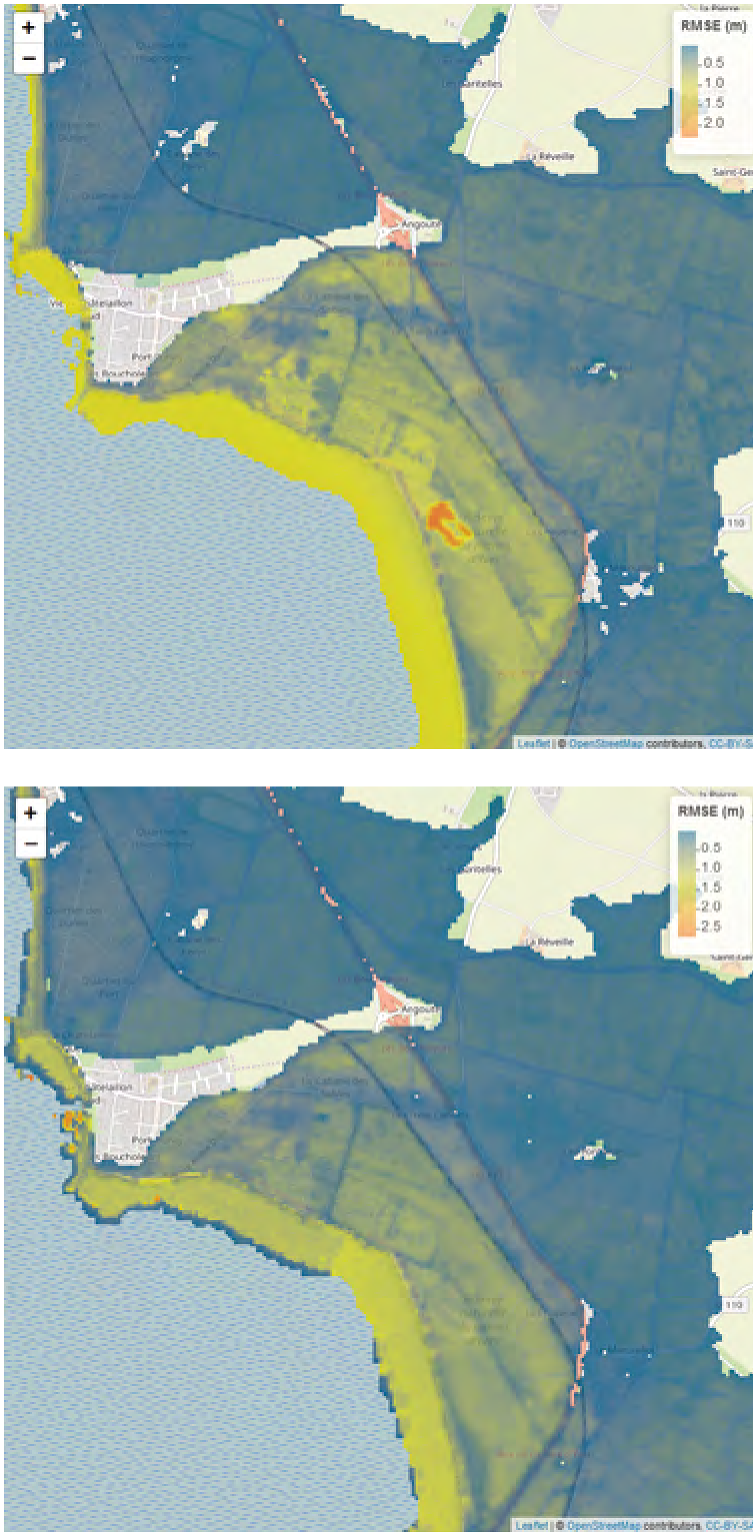

Figure 2 - Representation of the RMSE maps obtained with classic PCA (above) and functional PCA (below).

Propagating uncertainties in the marine submersion model

Histogram of the RMSE maps

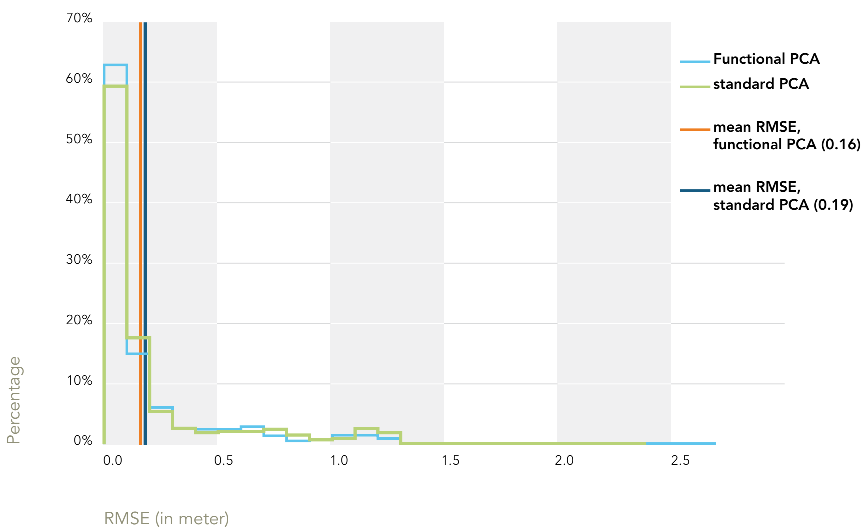

Figure 3 - Comparison of the RMSE criteria distributions between classic PCA and functional PCA.

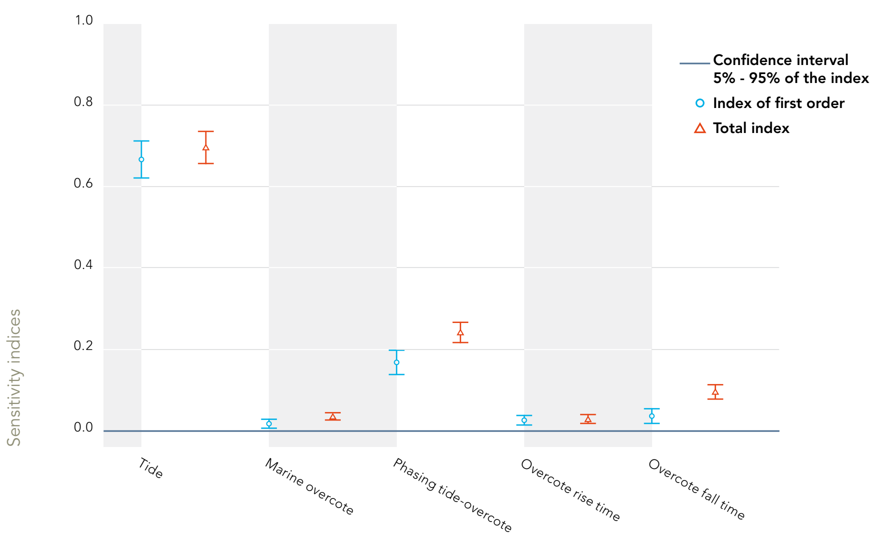

Figure 4 - Sensitivity indices obtained for each input of the model.

> thus be ranked in descending order of index values. An adaptation of this index has been carried out on the basis on the work of Lamboni et al. (2011)[4].
Figure 4 shows the calculated indices for each variable. The first order indices are the value of the input's influence alone, while the total indices are the value of the input's influence in interaction with the other inputs of the model. Tidal amplitude seems to be the most influential parameter with about 70% of influence alone. The second influential parameter is the phasing between the marine overcote and the tide (t0). This one seems to have more influence in interaction with other inputs (about 25% of total influence). Finally the less important parameters, in the decreasing order of influence, seem to be the rise and fall time of the marine overcote (equivalent influence) and the marine overcote. This result could be explained by the fact that even if a marine overcote may be important, if it is out of phase with the tide, it does not generates marine submersion risk.

CONCLUSION

The work carried out focused on the sensitivity analysis of a flood model, generating spatialized outputs. In order to obtain the number of simulations needed to perform the sensitivity analysis, a meta-model based on wavelet-based functional PCA has been implemented, then a sensitivity index adapted to spatial data set has been defined. It has been demonstrated that developed the meta-modelling method has a predictive capability, that is not only better, but also 5 times faster than the standard PCA method. The sensitivity index obtained in the end make it possible to rank the marine forcing parameters according to their importance. For

THE PARTNERS

The thesis is cofinanced and framed by BRGM, ARMINES and CCR. ARMINES is a contractual research association. It is linked, by agreements approved by the State, to its partner schools, the most important of which are MINES ParisTech and the School of Mines's network. The thesis is attached to the School of Mines Saint-Etienne. The BRGM is a public institution of industrial and commercial nature. One of its expertise is in the field of geosciences area applied to coastal oceanography and marine submersion.

the next steps of the PhD, it is envisaged to study the influence of other sources of uncertainties such as the soil roughness or the presence of hydraulic connections, such as nozzles allowing water to pass through. However, the additional difficulty is that some of these parameters appear as qualitative variables and should be therefore considered as such. Finally, it is possible to achieve several configurations of the flood models by changing the DTM for example. This is why a work on combination of models, using the notion of meta-model, has been launched in order to improve the output of the coastal flooding model. /

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Modelling the geotechnical drought

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ABSTRACT

CCR has been modelling the impact of drought/rehydration of soils phenomena of soils causing major disorders on buildings and especially houses. This hazard is the second most costly (36% of the total) since the implementation of the natural disaster compensation scheme in 1982. The model benefits both from the work of Météo-France in the hydro-meteorological modelling of atmosphere-soil interactions and from the CCR's feedback on past events thanks to the characterization of claims. New meteorological criteria, hereafter homogeneous for the whole year and evaluated for each of the four seasons, have also been implemented this year together with a new methodology for generating stochastic events.

geotechnical drought model
insured damage
hydro-meteorological modelling
natural disasters

INTRODUCTION

The geotechnical drought, shrinking-swelling clay (SSC) resulting from cyclic episodes of drying and rehydration of the first few meters of soil. It has to be distinguish from agricultural drought and hydrological drought. It is one of the most costly and one of the most complex hazard to understand within the French natural disasters compensation scheme (Nat Cat scheme). The SSC drought represents more than 36% of the global losses excepted automobiles on the period 1982-2019 in France[1]. The CCR position into the Nat Cat scheme, reinforces the development of its expertise in the natural disasters areas and notably for modelling SSC drought. Nowadays, the development of a physical model of characterization of soil movements at the foundation level is still a research topic (cf. symposiums SEC 2008 & 2015, projets ARGIC 1 & 2).
CCR has elaborated a simulation model of the impact of droughts, real or fictive. It is based on meteorological indexes (Météo-France Soil Wetness Index – SWI), geological indexes (SSC hazard map from BRGM), and characteristics on policy and claims collected by CCR alongside its ceding companies.
In 2019, new recognition criteria for this peril has been implemented. An important phase of evaluation of these new criteria has taken place and the work carried out has made it possible to integrate the updating of the model for the representation

of physical processes related to water in the soil (SIM2 for Safran-Surfex-Modcou by Météo-France). A common approach for all drought typologies, on the overall year, has been proposed by ensuring fairness in the treatment of future droughts.

METHODOLOGY

Global principles of the model

The SSC drought impact assessment model relies on statistical approach. For a given drought event, first it is a question of estimating by regression, the probability that a community formulate a request for drought recognition. This probability is assessed both regarding historical requests performed by communities since 1989, the date on which the peril was fully considered by the Interministerial Commission Nat Cat and different indexes translating the intensity of the phenomenon on divers periods of the year[2]. These indexes could be, for example, averages on certain periods of the year, or absolute minimum of soil wetness for key periods, such a summer. Then, the probability of claim for each policy and the destruction ratio in case of loss is assessed. To be noted that buildings and their foundations all react differently and the local conditions (slope, orientation, altitude or presence of vegetation) do not have the same influence on the damage.

Finally, beyond the evaluation of the impact of drought for a given event, the model has, in its so-called probabilistic version, a stochastic generator of droughts that are physical plausible but have not yet occurred.

Derivated from works realized during a PhD leaded by CCR and University of La Rochelle[3], this model generates stochastic drought events integrating historical soils wetness data. It is based on

Ratio to the 10-years SWI uniform normal
Maps of trimester averages by Safran mesh

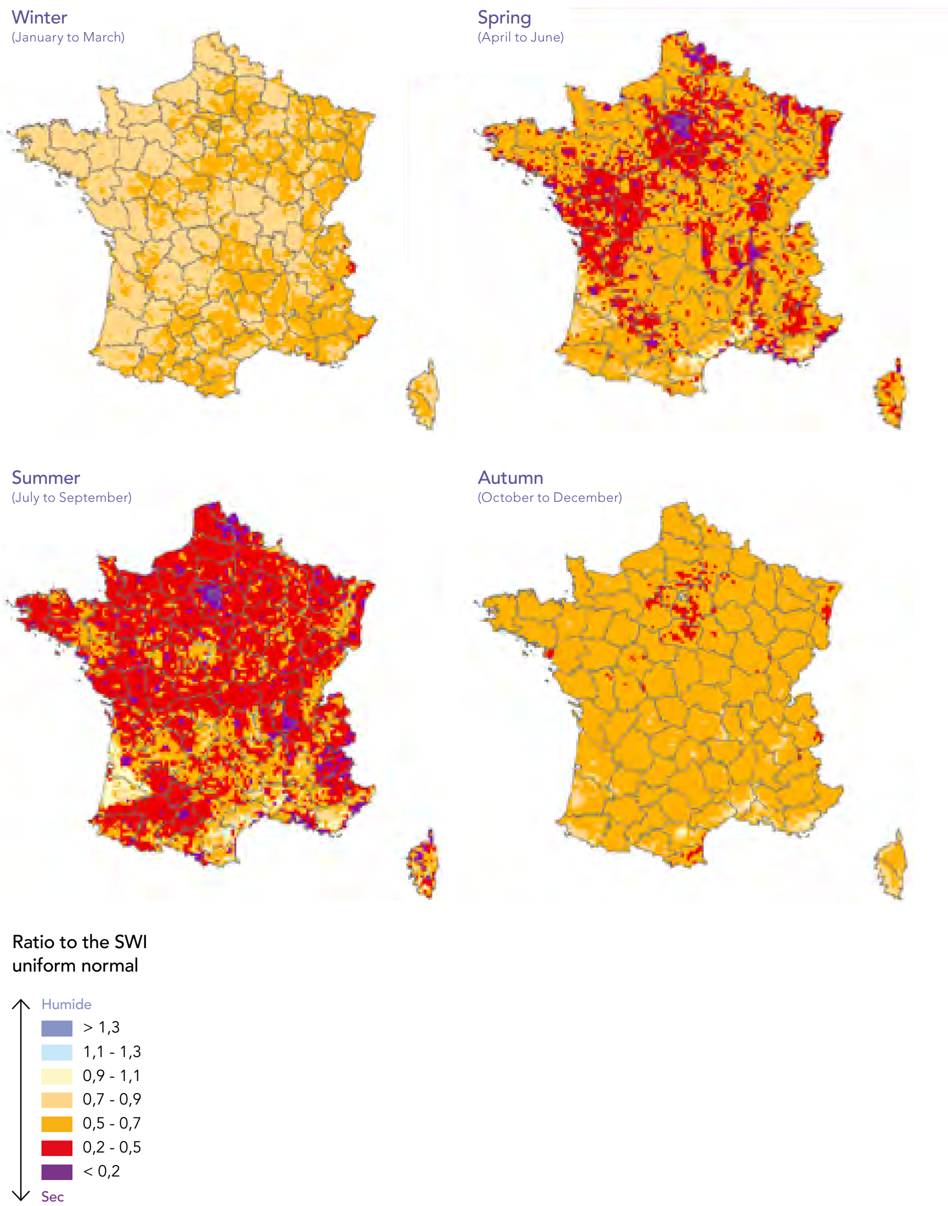

Figure 1 - Map of the compared to the normal, by season, of the 10-year uniform SWI from the CCR stochastic generator for 10 000 fictive drought years.

>

> spatial-temporal correlations for all points of the metropolitan area (Figure 1). The model generates a catalogue of N events to estimate mean annual losses or losses for longer return periods, 100-year type at the community level for example.

New methodology for generating the catalogue of stochastic droughts

The stochastic drought generator creates events, for the year N, taking into account tendency, seasonality and spatial-temporal correlation observed in the past[2]. Then, the variables are applied following the historical known uniform SWI data for year N-1. Thus, the uniform SWI modelled will be lower, reflecting a significant drought, the more the last known drought will be; the reciprocal being also true. De facto, a significant variability of mean annual losses and the 200-year losses generated from the stochastic generator is observed according to the initialization conditions of the generator. In retrospect, the difference between the simulated years and the real years could in some cases be significant if extremes wetness or drought occurred at the end of autumn period.
In 2019, in order to stabilize the drought foresight, a new methodology of generating a catalogue of stochastics events has been implemented in the model. The final catalogue of 10 000 fictive events, translating the actualized vision of the peril, is henceforth developed taking randomly each event across 10 stochastic catalogue whose the year of initialization of uniform real SWI varies, each of these "sub-catalogues" contains 10 000 events.
A map of the ratio to normal, by seasons, of the ten-year uniform SWI from CCR stochastic generator for 10 000 fictive years of drought is presented in Figure 1. The current tendency corresponds to dry spring periods, notably for a large quarter North-East, including Île-de-France and Rhône valley; the occurrence of autumn drought is not excluded, as the example of the 2018-drought.

Uploading Nat Cat recognition criteria

In order to improve and to simplify Nat Cat recognition criteria, members of the Interministerial Commission have work during 2019 on the evolution of the criteria.

I. Criteria linked to soil characteristic

Differential ground movements are generated by drought's cycles and soil rehydration damage buildings located in soils whose composition is sensitive to this phenomenon. Soil shrinkage in the dehydration phase or swelling in the rehydration phase is important in soils characterized by the important presence of certain types of clays.
The first criteria historically implemented by the Commission consisted in checking the presence of soils sensitive to the phenomenon on the community area requiring Nat Cat recognition. This criteria of quantitative order allowed to determine the predisposition of the superficial soils of a community to be sensitive to the phenomenon. This criteria assessing the predisposition to the peril is maintained as it is and combined with a meteorological criteria translating the trigger factor.

II. Meteorological criteria

Before the evolution of the criteria, there were two meteorological ones with alternative or cumulative sub-criteria. The objective was to characterize the level of superficial soil wetness over several periods of a year.
These criteria had disparities because the level of soil wetness was studied on three periods of unequal duration: over a total year, at spring (April/May/June) and during the summer (July/August/September). Moreover, the parameter allowing to characterize the level of soil wetness were different for each of the analyzed periods: level of water reserve, period of reference, frequency or duration of return of the observed humidity level.
Thus, the new criteria have been defined thanks to the progresses implemented in the hydrometeorological modelling chain realized by Météo-France (Figure 2).
The calculation of drought criteria relies on this modelling chain, so-called SIM (Safran-Surfex-Modcou). The inputs are the surface observations coming from Météo-France observation networks. The water content of the first two meters of soil is modelled according to the soil geological characteristic, vegetation type and its evolution.
The new SIM modelling allows a better representation of physical processes regulating water in the soil[4]. The update of the digital terrain model is translated by the redefinition of the altitude of some geographic mesh. Finally, the integration of the incident infrared radiation has been improved.

RESULTS

The hydrometeorological modelling chain has been improved, in complement to the introduction of new criteria. These modifications have impacts on the number of community potentially eligible to Nat Cat recognition for SSC drought. The proposed criteria have been applied on the drought events of the last decade. Then, the geographic mesh and communities "virtually recognized" with the new criteria have been compared to the ones recognized by using the previous criteria. After some adjustments, it was decided that in order to be recognized as a Nat Cat for a given season, the level of surface soil moisture observed for that

THE PARTNER

Météo-France as the national meteorological and climatological service conducts works, studies and researches on climate and its future evolution, particularly on drought, and manages a climatological database for France. Météo-France is an essential source of information and expertise for the successful accomplishment of the CCR's missions. Since 2013, Météo-France and CCR have maintained a partnership that will be renewed in 2019.

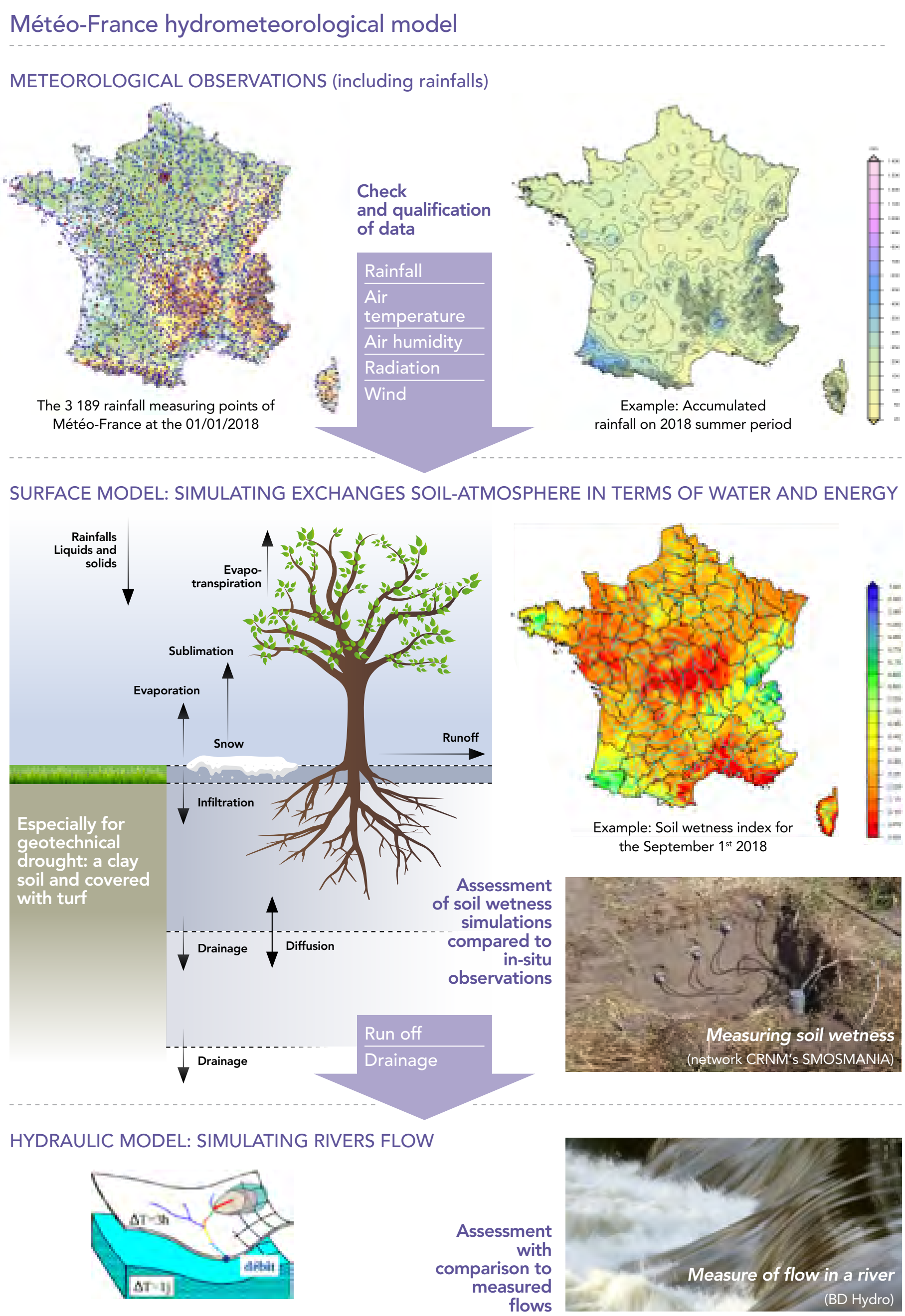

Figure 2 - Météo-France SIM hydrometeorological modelling chain characteristics[5]

season must be the 1st or the 2nd lowest for the past 50 years.
The recognitions are determined by trimester: each recognized community is for 1, 2, 3 or 4 trimesters of the year, corresponding to the seasons, according to the content of the demand which is analyzed by trimester. Finally, data taken into account to calculate the rank are data by sliding trimester, for example for the 2018 winter trimester, the eligibility is assessed on the three sliding trimesters:
- 1/ [November 2017, December 2017, January 2018]
- 2/ [December 2017, January 2018, February 2018]
- 3/ [January 2018, February 2018, March 2018].

CONCLUSION

The annual generation of the CCR catalogue of stochastic drought events now allows to integrate more possible cases of drought by taking into account the observed annual variability over the last decade. This has improved the quantification of the extreme events, while insuring, year after year, a stable average view that will better reflect, in medium term, the potential trends related to climate change.
The implementation of new criteria leads to:
- The use of the last scientific knowledge on hazard and to mobilize the most performing Météo-France hydrometeorological modelling tools;
- The adoption of the most relevant geotechnical and meteorological criteria to characterized the intensity of a shrinking-swelling clay events while insuring that they are understandable;
- The better characterize shrinking-swelling clay events for autumn and winter periods. >

Modelling the geotechnical drought

> These new criteria allow an important reduction of instructions delays for communities' applications, thanks to the adoption of the meteorological criteria that no longer requires a full year's technical data to be compiled for implementation. Globally, the assessment model developed by CCR allows to estimate losses for the Nat Cat scheme concerning real droughts like the 2019 one or droughts that are physically plausible but have not yet occurred. This vision of the territories exposure is shared with insurance companies, partners, and local stakeholders and also meets regulatory requirements such as Solvency 2./

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Tinard et al., Modelling the geotechnical drought. In Rapport Scientifique CCR 2019 ; CCR, Paris, France, 2020, pp. 28-32.

GEOLOGICAL HAZARDS

Measuring seismic exposure

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ABSTRACT

In order to avoid the issue of the lack of large seismic recorded data in France (mainland and Lesser Antilles), a probabilistic earthquakes generator is built. Over a chosen period, this generator creates seismic scenarios that contain generated earthquakes on French territories. These earthquakes did not happen in the past but are plausible. Finally, a better estimation of the seismic hazard (peak ground acceleration) is found thanks to simulations of waves propagation.

earthquake hazard
generator
probabilistic
waves propagation
France

INTRODUCTION

In France, earthquake events are uncommon and since the implementation of the Nat Cat scheme in 1982 (1990 for overseas territories), these events represent only one per cent of the cumulated sinistrality. Nevertheless, damaging earthquakes occurred in the past, in the Antilles or in the mainland area. For example, Basel (1356), Bagnères-de-Bigorre (1660), Martinique (1839), Guadeloupe (1843), Ligure (1887) or again Lambesc (1909).

Among the global seismic data available, seismic catalogues are the most used. The later gather all instrumental earthquakes, whose tremors were recorded by the monitoring network (since 1960), and/or historic earthquakes, whose tremors have been experienced and witnessed by the population (before 1960). The main issue is that mainland France the French Antilles have different paradoxes concerning seismic catalogues:

- In the Antilles: major damaging earthquakes occur more often than in metropolitan France (lowest return periods) but the temporal depth of seismic observation is very low (< 200 years);
- In mainland France: even if the historical data are available over the 14th century (≈ 700 years of data), return periods of catastrophic earthquakes (high magnitudes) are very high and requires largest data bases.

METHODOLOGY

Then, the idea is to create, with sparse available data, a probabilistic generator of earthquakes in mainland France and in the French Antilles area. By using notably, uncertainty related to the magnitude (liked to the energy) of past events, different scenarios of earthquakes are automatically generated on these areas.

These scenarios are all different of the past-observed seismicity and all unique but probable. The probabilistic term designs the fact that all seismic scenarios generated have the same probability of occurrence, even if they are different in terms of phenomenology and consequences. Moreover, by selecting high generation periods, it is possible to reach magnitudes associated to very high return periods (> 1,000 years). Thus, with these new fictive databases (Figure 1), it is easier to estimate the French seismic hazard than with the initial small databases.

To do so, a filter method[1] is applied on incomplete initial data in order to conserve only exhaustive data. Once the data are filtered, they are analyzed thanks to the lag time method[2], in other words the time between two successive earthquakes. Based on the lag time, the ratio of independent earthquakes is calculated. This ratio is used in the estimation of the frequencies. The latter are used to generate fictive scenarios of independent earthquakes. Nevertheless, due to few available data for high magnitude earthquakes, the appropriateness of the proportions of independent earthquakes is low for the latter. Then an improvement of the lag time method has been implemented in order to provide more viability and stability in the estimates of the proportion of independent earthquakes[3].

RESULTS

Simulations have been realized over an observation period of 100,000 years in order to ensure the generation of the highest earthquakes. Due to the initial data and methods used[2,1], the minimal magnitude of generated earthquakes is 5 on the Caribbean area and 5.5 for the mainland France. Considering that one of the Nat Cat recognition criteria is a magnitude greater or equal to 5. Taking into account all simulated seismic scenarios, the average number of earthquakes' magnitude over or equal to:
- 5 is of 312,000 for the Antilles;
- 5.5 is of 6,670 for mainland France.

So, there is in average 3 earthquakes of magnitude greater or equal to 5 every year in the Antilles. Similarly, there is in average an earthquake of magnitude greater or equal to 5.5 every 15-years in mainland France.

CONCLUSION

This innovative approach highlighted in this article is based on the implementation of lag time method and its adaptation to seismic data of low-to-medium seismic zones, such as mainland France and the Antilles. This approach avoids the use

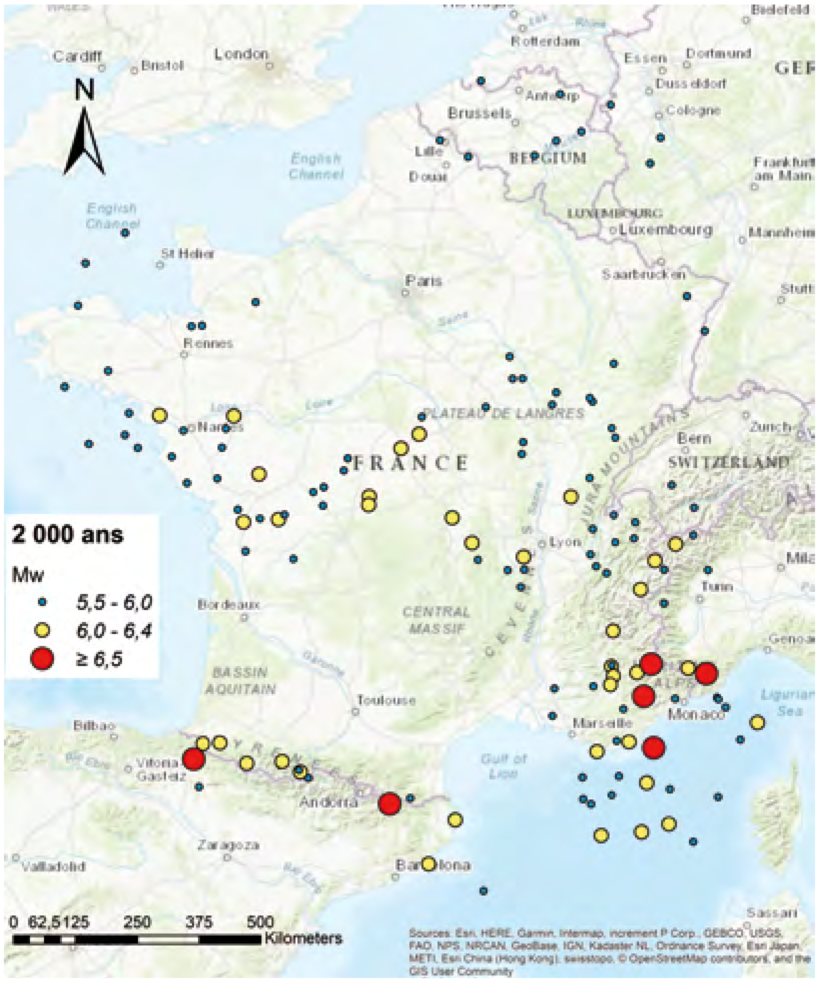

Figure 1 - Representation of 2,000 seismic fictive years, among the 100,000 years generated for mainland France. Only earthquake of magnitude greater or equal to 5.5 are represented.

>

> of some largely used methodologies to estimate seismic hazard but introducing strong bias and uncertainty. The generator provides a large quantity of probable seismic data comparing to real ones. For example, in mainland France, real data gathers only 57 earthquakes with a magnitude greater or equal to 5.5 whereas in a simulation of 100,000 years the generator gathers an average of 6,670 earthquakes. Finally, from the different scenarios, it is necessary to calculate the seismic hazard associated to each of generated earthquakes in the scenarios. The earthquake hazard corresponds to the peak ground acceleration (m/s²) generated by each earthquake. To calculate this hazard, ground motion prediction equations (GMPE) are used. It is equations taking into account different parameters such as the distance from the observation point to the earthquake, the magnitude, the soil type (rock, soft ground, and hard ground), earthquake depth etc. (Figure 2 left). These GMPE are easily applicable on a large scale and quick to calculate. Nevertheless, there are a large quantity of laws[3]. It is then complex to make a choice. Moreover, these laws are physically simple and have some limits (Figure 2 centre). This is why the results of the most applicable laws to the French area (i,e: calibrated with Italian data for mainland france) are compared to the results of simulations of seismic waves propagation (Figure 2 right[4]). The latter are physically more realistic because they more accurately translate the propagation of seismic waves on the ground (Figure 2 left). Nevertheless, it is impossible to perform these simulations at the national scale because of important calculation power constraints. Thus, the results are considered as references are used to calibrate attenuation laws at the local scale (30 x 30 x 30 km). Finally weights are attributed to each of the GMPE depending on how close are these results with the simulations ones. This is an on-going work./

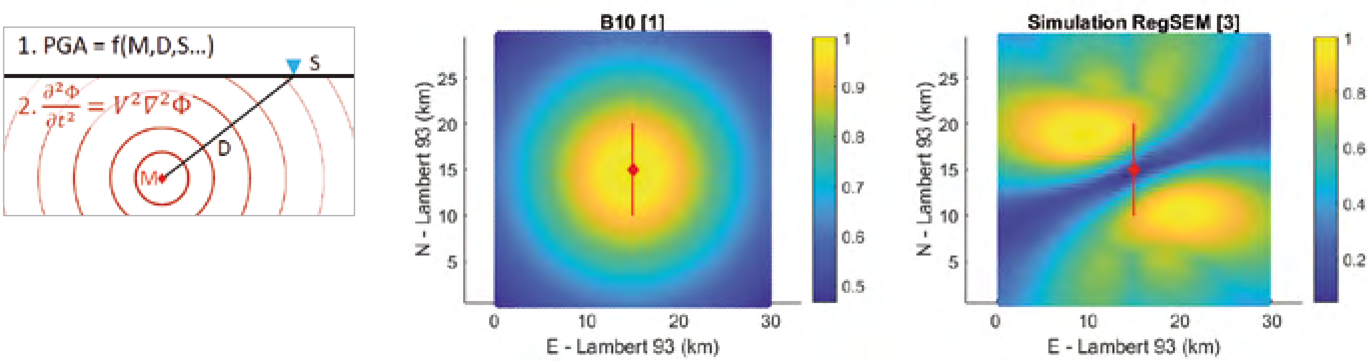

Figure 2 - Left: there are two ways to calculate seismic hazard (soil acceleration) that an earthquake (M) generates at an observation point (S) in surface: attenuation laws (1) and simulations of seismic waves propagation (2).

Centre and right: Comparison of seismic hazard through attenuation law (in the centre[5]) and a simulations of seismic waves propagation (on the right[4])

THE PARTNERS

The scientific association for applied geology (ASGA) is a 1901 law charity. It has been created the May 24th 1955 and its objectives are to develop education and research in the earth science topics. ASGA supports and manages the RING (Research for Integrative Numerical Geology) project since 1989. This project is supported by an international consortium gathering 14 industrial sponsors, including CCR since 2018, and more than 140 academics. The consortium managed by ASGA is linked to the GeoRessources laboratory and leaned to the National School of Geology (ENSG) within the University of Lorraine.

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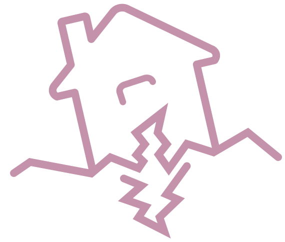
Measuring earthquakes' consequences



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ABSTRACT

Based on a multi-year partnership initiated in 2014, BRGM and CCR finalized in 2019 a model for assessing the impact of earthquakes in France taking into account the French specificities of both the hazard and the vulnerability of buildings. The effects of lithological and topographic sites were evaluated. The vulnerability of the buildings according to the local typologies of construction were characterized as well for mainland France and its overseas territories for dwellings, malls or the industrial zones. Finally, an assessment of the overall uncertainty related to the many parameters of the model is being finalized.

 # seismic risk
 # vulnerability
 # stochastic
 # PSHA
 # uncertainty

INTRODUCTION

In the framework of their agreement established in 2014, BRGM and CCR has set up a collaborative research partnership aimed at:
- Improve multi-perils vulnerability expertise and the transformation of these vulnerabilities into economic approach;
- Establish homogenous and coherent mapping of earthquake risk – probabilistic exposure vision – in financial terms through the characterization of hazard, vulnerability, damage and insured losses;
- Estimate physical vulnerability and insured losses for the main building typologies: dwellings, shops, agricultural and industrial buildings.

For the earthquakes, this approach is developed through departmental damage scenarios in order to assess financial consequences on buildings for a given seismic source. The financial consequences assessment is performed only on insured losses in the framework of the French natural disaster compensation scheme.

A complete model from hazard to damages, through vulnerability, has been developed in the last years. In 2019, the developments have made it possible to finalize the work on all territories covered by the Nat Cat scheme (excluding Wallis-et-Futuna) for all types of insured assets: housings, shops, industries, agricultural buildings.

This hazard/vulnerability/damage is integrated in a largest tool including a stochastic earthquake generator developed during a PhD thesis financed by CCR (cf: article GOUACHE p.34) and an assessment tool of the uncertainty propagation along the modelling chain.

METHODOLOGY

The hazard component of the model is fed by the stochastic generator developed by CCR, the 2019 joint BRGM-CCR research focused on i) the characterization of lithological and topographical sites effects and ii) the characterization of overseas assets for the new areas included in 2019 in the

model. The 2019 methodology is in coherence with the one previously used for the BRGM-CCR works on other areas[1,2,3,4].
The characterization of lithological and topographical sites effects is an important step in the assessment of seismic risk. In the probabilistic studies of seismic hazard (PSHA), soil accelerations (PGA translating the effect of surface seismic waves) are always expressed for an ideal case so-called "at the rock" in order to present a global harmonization of studies; it is notably the case of the French regulatory seismic hazard map.
But this "at the rock" hazard do not highlights the soil nature effect and the topographic conditions that may locally amplify seismic waves. For example, topographic resurgences or hills act as seismic wave guides or traps that increase the amplitude of seismic waves and potential damage to buildings on the surface. Similarly, soft soils such as alluvial basins made of recent sediments (in the geological sense), still soft and less structured may amplify seismic waves and have the same consequences that marked topographies. In practice, in the most unfavorable cases, amplification coefficients until 3 are estimated in both mainland France and oversea territories.
Another key point in the studies performed by BRGM and CCR consists in the fine characterization of building vulnerability and the estimate of the stock of French buildings in the different estimated vulnerability classes.
The assessment of earthquake consequences, inspired of RISK-EU[5] methods, describes the probable distribution of the state of damage to buildings under a giver seismic solicitation according their vulnerability index.
At a macroscopic scale, this research is performed by estimating for each type of risks (housings, collective building, in-

Industrial Type	RISK-UE typology														
	W	S1	S2	S5	S4	S3	RC1	RC2	RC3.1	RC5	RC6	M4	M5	M3.4	MH
IND1	3	29	13	2	2	15	0	14	7	1	0	4	2	8	0
IND2	4	14	8	22	1	18	0	16	1	1	0	2	0	13	0
IND3	1	18	8	3	3	20	0	22	0	2	0	2	0	13	0
IND4	2	24	12	7	2	13	0	16	0	2	0	3	0	20	0
IND5	0	21	5	5	0	3	0	35	2	10	2	15	0	2	0
IND6	32	3	2	10	0	18	0	8	7	0	0	0	0	13	7
Total per typology	42	109	48	49	8	87	0	111	17	16	2	26	8	70	7
Distribution according the types (%)	7	18.2	8	8.2	1.3	14.5	0	18.5	2.8	2.7	0.3	4.3	1.3	11.7	1.2
	7	50.2					24.3					18.5			

Table 1 : Example of class of vulnerability repartition (in colunms) according to the industrial activities typology IND1 to IND6 for a French area exposed to earthquake risk.

Type	Vi	Description
Individual houses type 1 to 4	0.447 to 0.527	Wood structure
Small collective building type 1and 2	0.547	Wood structure
Small collective building type 3	0.722	Posts/beams system with unreinforced masonry infill walls – Irregular structures (load-bearing system or irregular infill or flexible level)
Small collective building type 4	0.562	Posts/beams system with unreinforced masonry infill walls – Irregular structures (load-bearing system or irregular infill or flexible level)

Table 2 : Estimate of the central vulnerability index (Vi) for Saint-Pierre-et-Miquelon buildings; distribution of index is also assessed.

Units	Number of parameters	Description
Hazard and phenomenon	9	CCR stochastic catalogue, depth, azimut, dip, rift dimensions, Gutenbert-Ritcher's law parameters, attenuation law
Vulnerability and damage	20	Amplification factors for soil classes, intensity-acceleration conversion law, sigma of the conversion law, vulnerability indices for building classes
Losses	13	Destruction rate of considered building types (housings, apartments, collective buildings, shops, industries)

Table 3 : Description of considered parameters in the experience plan, for studying uncertainty propagation.

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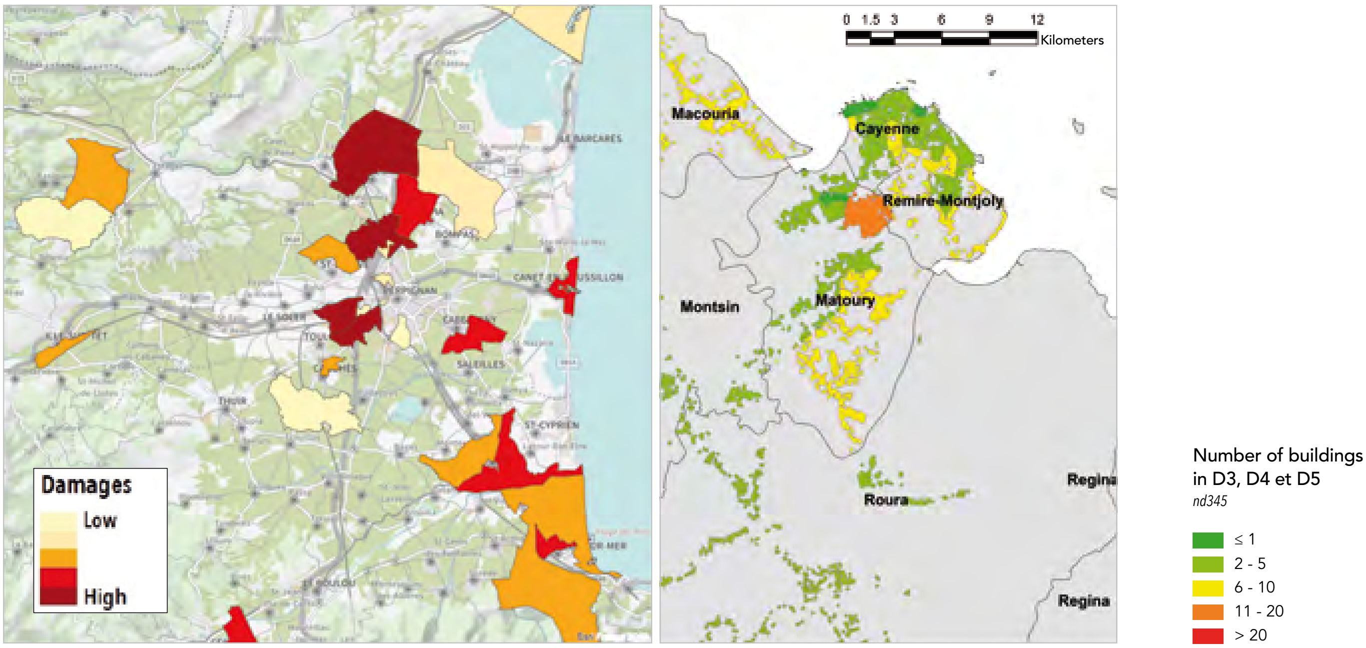

Figure 1 – On the left, damages on building in Guyana and on the right, damages to industrial risks around Perpignan. Loss estimates under seismic solicitation equal to the regulatory earthquake hazard.

dustries etc.), the stock repartition according to the different class of vulnerability (Table 1), then by attributing to each class a probable interval of vulnerability indices (Table 2) based on structural engineering knowledge.

Finally, concerning the uncertainty propagation along the modelling chain, a specific tool has been developed by coupling the CCR earthquake stochastic generator, the BRGM "Armagedom batch" unit to assess damage[6,7] and the CCR damage/costs conversion unit. Forty-two continued or categorical variables are available in the different model units. An experience plan of 1 million of lines and 42 columns have been generated, for each of the 42 million input a random value has been estimated through a Latin hypercube sampling. The idea is to use the whole processing chain by using the variability allowed for each of the 42 parameters of the model (Table 3) and then to estimate both the weight of each parameter in the global uncertainty and to propose a law translating the global model uncertainty. Based on this approach, an estimate of the Sobol indices is applied to the whole calculated losses (at the mainland France or specific urban area scales) to quantify the relative weight of uncertainty linked to each considered parameters. At this step, major methodological developments have been realized and the assessment is done for the hazard, vulnerability and damage units. Uncertainty related to the loss estimates will be soon integrated and the whole research will be communicated in 2020.

RESULTS

The results of the different scenarios have been exposed during national and international congresses in 2019, and the papers are available online (AFPS Strasbourg September 2019 and IDRiM Nice October 2019). To illustrate, the results are presented for the damage assessment on residential building, for an oversea territory and on industrial risks in the southeastern part of Pyrenees, the both under seismic solicitation linked to the regulatory earthquake hazard and after the application of lithologic and topographic site effects.

Globally, the finalized research allows to estimate the earthquake impact in overall French territory related to the French na-

THE PARTNER

The BRGM, French Geological Survey, is public establishment of an industrial and commercial nature, its objective is to understand geological phenomenon and associated risks, in order to produce and share high quality data necessary to loss prevention, within a framework of support for public policy on risk reduction and management. The BRGM is labelled Institut Carnot since 2011 awarding the excellence of research performed in partenariat with socio-economic actors, especially to respond to the enterprises needs such as CCR ones.

tural disasters insurance scheme excluding Wallis-et-Futuna.

The model is notably used to assess the consequences of the ongoing seismic crisis since mid-2018 in Mayotte or for the recent Teil earthquake in Ardèche the November 11th 2019.

CONCLUSION

If the characterization of buildings vulnerability and the lithologic and topographic site effects are now completed and allow more precise the loss estimate of any earthquake occurring in mainland France or in the overseas territories, the uncertainty propagation and its quantification in the overall earthquake estimate might be finalized in early 2020.

More detailed studies on most exposed areas, the integration of new scientific data gathered during different tasks or a resolution entry on industrial risk in seismic zones are also envisaged./

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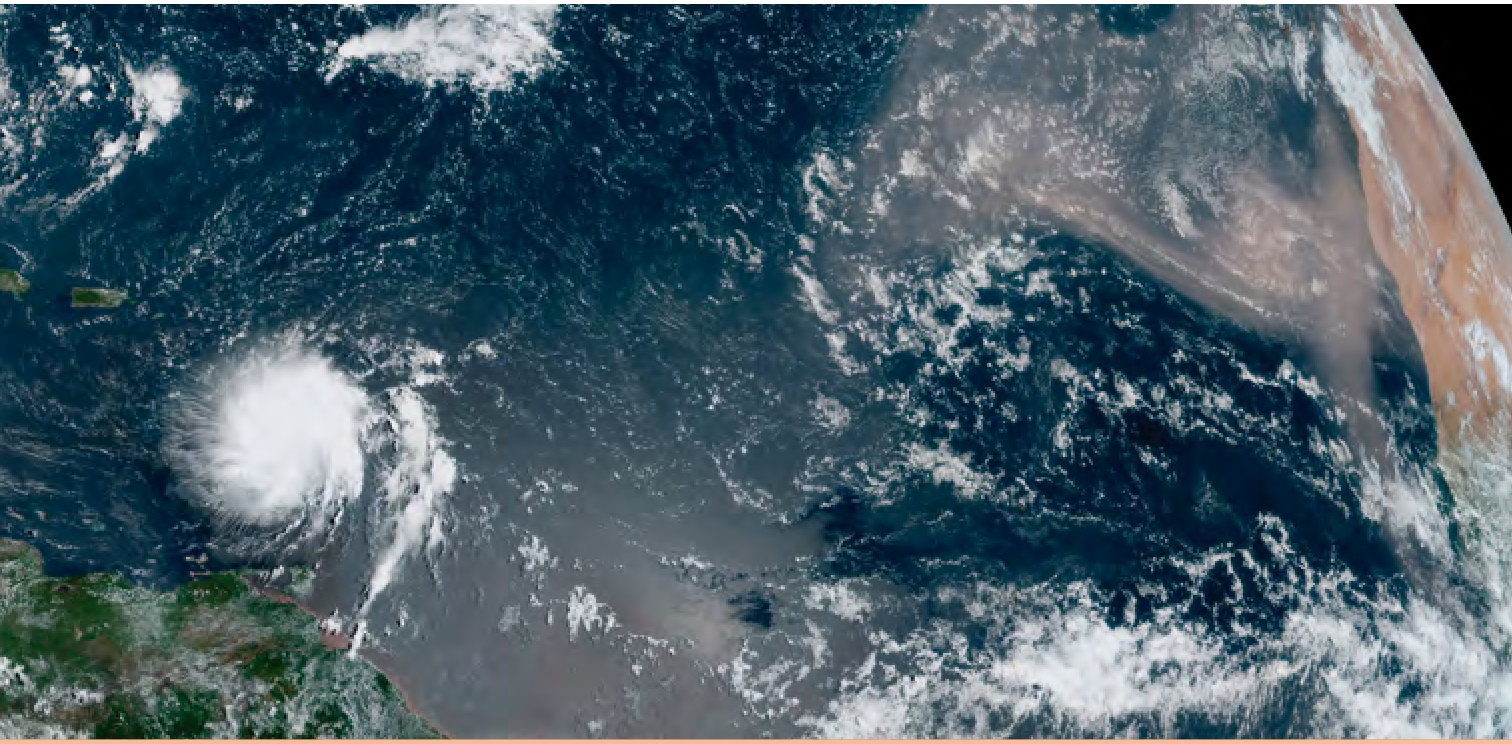
CLIMATE CHANGE



Modelling climate change impacts on oversea territories

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ABSTRACT

After an initial study on the modelling of consequences of climate change on the cost of natural disasters in France by 2050, Météo-France and CCR worked in 2019 on the evolution of cyclonic risk in overseas territories by 2050. These scientific works are helping to improve knowledge of the exposure of overseas territories to this risk by mapping the areas exposed to perils due to cyclones. This study can be used to set up prevention measures adapted to local issues.

hurricanes
cyclones
overseas territories
climate change
insured damages
floods
cyclonic winds
marine submersion
loss prevention

INTRODUCTION

Oversea territories are exposed to unpredictable and destructive climate hazard: the tropical cyclones. The history of these islands and their economic activities must be read in light of those events generating catastrophic consequences. By understanding their histories, it is possible to reconstitute a chronology of the main events, based on the description of their consequences, written within the ship's logbooks or in the journals of ancient governors[1]. This look into the past demonstrates the regularity of the events' occurrence and the cyclical character of periods of high intensity. After several decades qualified as calm, no major events, namely category 4 or 5 hurricanes have damaged oversea territories since Hugo in 1989. In September 2017 two category 5 hurricanes, Irma and Maria have crossed the Lesser Antilles. The first, Irma, has crossed the Norther Lesser Antilles destroying Saint-Barthélemy and Saint-Martin, and generating insured damages estimated today at more than €bn 2 (global economic losses are not totally assessed). The second, Maria, due to its trajectory has caused much less damage, outside southern Guadeloupe and northern Martinique, which were affected by very intense rainfall. Consecutive damages due to cyclonic winds are taken into account since the Orientation Law on oversea territories of the December 13th 2000, by the French natural disasters insurance scheme, if they reached the threshold of 145 km/h in average or 210 km/h in maximum burst speed.

These two successive events into one cyclonic season, have remind the exposure of these territories. Lot of questions have been raised: how often such events occur? What would have been their consequences if they had crossed areas such as Guadeloupe, Martinique or even Réunion island? Will their numbers increase with climate change? Can loss prevention be used to deal with it?
To respond to these questions, CCR, Météo-France and RiskWeatherTech[2,3] associated themselves to model the consequence of climate change on the insured damages in oversea territories. The modelling chain starts at Météo-France with the use of the ARPEGE-Climat model, a global climate change and prediction model and with the use of the ALADIN-Climat regional >

> model, then follows at RiskWeatherTech by a downscaling process using WRF model and finishes at CCR by the damage assessment. These works are based on the most pessimistic IPCC's scenario, the Representative Concentration Pathway (RCP) 8.5. The interest of this research is in the multi-perils character of cyclones which generates three types of hazards: cyclonic winds, intense rainfall generating flash floods and runoff phenomena and marine submersions associated to breaking waves and oceanic overcote. The results of these works provide a solid scientific basis to guide policy decisions for climate change prevention and adaptation.

METHODOLOGY

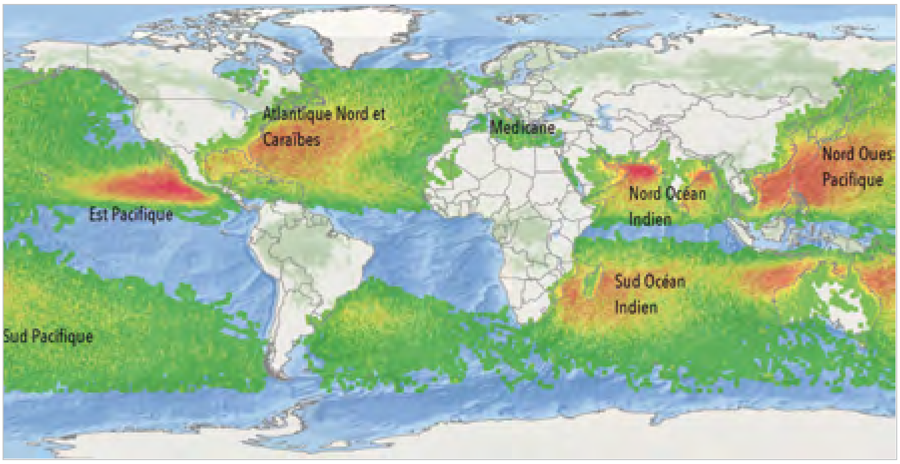
A cyclone, namely a tropical depression, is formed in specific thermic conditions which are a water temperature around 28-29°C in the first sixty meters. These conditions occur generally at the end of the summer, from June to October for Lesser Antilles and from November to April for Réunion island. The rarity of these phenomena requires a look back over a long historical period to estimate the return period of the cyclones. Nevertheless, on oversea areas, the low historical depth of rainfall and wind speeds data measured at meteorological stations cannot make possible to characterize extreme cyclones. Assuming a stable climate over the past 400 years, it is possible to estimate the return period of a cyclone according to its power. The strength is classified by the Saffir-Simpson scale created in 1970 to categorize events according to their consequences and to the wind speeds[4]. To estimate the evolution of the return periods of wind gust events greater than 22 m/s, another database has been used: CORDEX-CAM (Central America). Then, frequencies have been modified according to the conclusions of the CORDEX study to determine the evolution of wind gust between the periods [1980-2005] and [2035-2065].
Currently, the relation between the climate change and the cyclone formation is unfamiliar within the scientific community. Hypothesis may be conflicting concerning the effect of the water temperature, of the CO_2 rate and of the humidity of the air in the middle atmosphere[5]. The applied methodology relies on the global numerical model ARPGE-Climat of Météo-France to produce simulations of cyclonic trajectory occurrence over three catalogues of 400 fictive years. Among the simulated years, a detector of cyclone, so-called "tracker" locates tropical storms and follows their movements in the ARPEGE-Climat' results.
Once the events are detected, the most interesting are selected, namely those that may damage Lesser Antilles islands or Réunion island, then a downscale finest modelling is performed. It is based on ALADIN (Météo-France) and WRF (RiskWeatherTech) models. It is necessary to take into account islands' topography which affects both wind speed and rainfall.
Once this first step is performed, the CCR hazard and damage models are applied. The inputs are the ALADIN or WRF data (hourly rainfall, wind gusts, atmospheric pressure) and the model calculates flood areas, submerged by the sea or affected by wind gusts for each cyclone. This constitute the global insured costs of a cyclone. CCR has simulated about thirty extreme events among those touching the islands.

(1) « Coordinated Regional Downscaling Experiment » coordinated by the World Climate Research Programme.

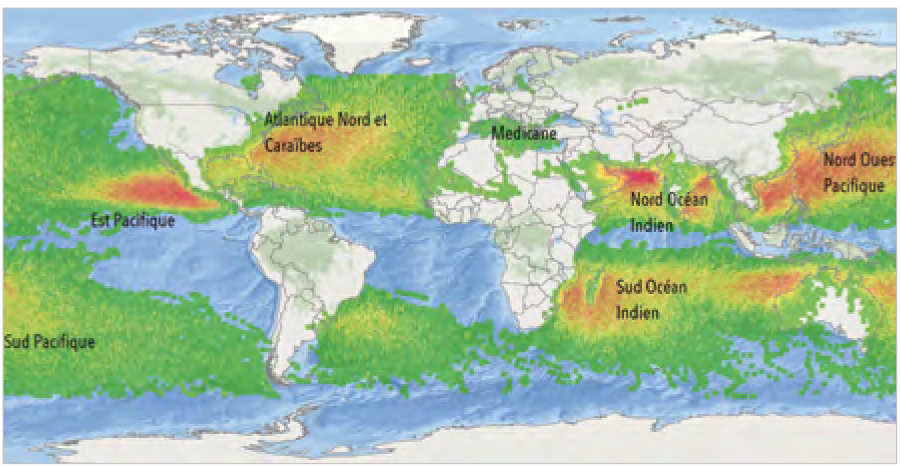
THE PARTNERS

Météo-France as the national meteorological and climatological service conducts work, studies and research on climate and its future evolution, through the development of two global models ARPEGE and ALADIN-Climat. Since 2013, Météo-France and CCR maintain a partnership that has be renewed in 2019. RiskWeatherTech is a society specialized in climate risk modelling and has used the WRF model for fine scale modelling and the CORDEX data for the research on the cyclones' frequencies.

Climate modelling today



Horizon 2050



Number of cyclones
per mesh of 10 km

1	7-10
2	11-20
3-4	21-50
5-6	50-121

Figure 1 - Comparison of cyclones' trajectories between the different scenarios
(sources: ARPEGE-Climat Météo-France simulations: 400 years of simulation at constant climate).

RESULTS

Concerning cyclonic trajectories, it can be compared between the different scenarios (Figure 1). In total, at current climate 31 872 cyclones are simulated against 26 714 cyclones at climate 2050 RCP 8.5. The comparison of the two maps highlights the decrease number of hurricanes in the Caribbean area and a movement of trajectories to the north by 2050. As for the CORDEX simulations, the results are diverging according to the models. For the Guadeloupe, all CORDEX-CAM models highlight an increase of the event frequencies from + 17% to + 68%. For the Martinique and the Réunion island, the results are more contrasted with an evolution comprised between – 35% and + 51% for the Martinique and – 18% to + 26% for the Réunion island.
The results of this research are coherent with the synthesis of the IPCC[6] results indicating a global decrease of the number of cyclonic systems (– 6% à – 34%) and an increase of extreme cyclones (4 and 5 categories) and associated rainfall.
Indeed, the sea water constituting the cyclones' fuel will be warmer farthest north of Atlantic north and farthest south of Indian Ocean, which may allow these phenomena to take longer and stronger trajectories.
In terms of oversea territories' exposure, an analysis has been performed by associating the frequency of extreme events and insured damages on hazards resulting from cyclones. Oversea territories' exposure is demonstrated and was therefore largely underestimated so far in existing damage models. Thus, the average cost of category 5 hurricanes is estimated to €bn 6.8 in the Guadeloupe (with extremes until €bn19.1), to €bn 4.9 in the Martinique (until €bn 18) and to €bn 5.2 in

>

> the Reunion island (until €bn 21.9). At horizon 2050, the results demonstrate that the sinistrality will increase by 20% on oversea territories due to the increase of the average frequency of cyclones (according to CORDEX) and to the sea level rise. Today, the frequency occurrence of a category 5 event is near a centennial frequency for these islands. Then, it is possible to compare it to a possible major Seine flood in Paris which may generate direct damages (excluding business interruption) estimated between €bn 8.8 and 23.9[7]. Regarding average costs and maximums simulated, a category 5 cyclone on the oversea territories may have a financial impact of similar magnitude. The occurrence of that type of event, in particular on the Guadeloupe, would therefore pose a greater risk on these areas.

CONCLUSION

This collaborative research performed by CCR, Météo-France and RiskWeatherTech highlights the consequences of extreme cyclonic events and assesses the vulnerability of exposed territories. It provides a better understanding of the effect of climate change on those events, by distinguishing the impact of climate change on the intensity of those events and the randomness of their trajectories. Concerning categories 4 and 5 cyclones, it is important to reasoning by cyclonic basins, the evolutions are very different according to the local climatic context. Modelling the impacts of wind, marine submersions and floods on the Antilles and on the Reunion island on a fine scale provides a mapping of areas exposed to extreme events (at current climate and at climate 2050). The maps can be used to implement locally-adapted protective measures by taking into account the overall associated hazards with the occurrence of a cyclone. /

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Modelling crop losses at horizon 2050

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ABSTRACT

Extreme climatic events like drought (2003, 2011, 2018) and excess of water (2001, 2016) severely impact crop yield in metropolitan France. Therefore, the objective of this paper is to develop a model that links one meteorological index to crop yield losses with focus on extreme events. A new index, DOWKI (Drought and Overwhelmed Key Indicator) based on a water balance, on departmental scale, and correlated to crop yield losses has been developed. Stochastic simulations of the DOWKI are used to estimate crop yield losses frequency and intensity due to extreme drought and excess of water.

extreme events
agriculture
modelling
climate change
crop yield losses

INTRODUCTION

Extreme climatic events have large consequences on agricultural crops yields[1]. In France, the 2003-drought has generated crop losses corresponding to a 20% drop in the expected yield for field crops, 25% to 30% for fruit and more than 50% for fodder[2,3]. These extreme climatic events are repeated and in 2018 a major drought has generated large losses on grassland production, notably in North-East of France. Other types of extreme events impact crop production, such as exceptional excess of water of May-June 2016 in the half North of France, have generated yield reductions by 50%. In climate change context, it is important to increase risk exposure knowledge of the main crops in order to adapt public policies about risk management and loss prevention. In this frame, the Minister for Agriculture and Food has launched last September an enlarged consultation on climate risk management, in which CCR is participating to provide input on crop exposure. A research project is underway as part of a PhD thesis, in partnership between CCR, AgroCampus Ouest and Météo-France. The objective is to model the consequences of climate change by 2050 on extreme of drought and water excess events and their consequences on the main crop productions in France. The research will also focus on the role of the insurance sector and its sustainability by 2050. This article focuses on the development of a model for estimating the frequency and the intensity of yield losses on the main crop productions (cereals and grasslands). This methodology relies on the creation of a new climatic index calculated from the meteorological data: the DOWKI (Drought and Overwhelmed Key Indicator). This index is based on the water balance calculation and correlated to crop losses[4]. The implementation of a stochastic model allows to predict the frequency and the intensity of crop losses due to extreme climatic events.

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Modelling crop losses at horizon 2050

METHODOLOGY

The first climate model developed relies on the combination between a hazard model and a damage model. The first corresponds to the creation of a new index (DOWKI) representing extreme drought and water excess events. The damage model estimates a crop loss for a given index value. The climate model is coupled to a stochastic approach in order to calculate the probability of occurrence of an extreme event and its impact in terms of crop yield losses.
Meteorological input data comes from Météo-France stations, with a station per department. It is the rainfall data (P) and 10-days evapotranspiration data (ETP), available from 1989 to the present day. The yield data used comes from the public database AGRESTE[1], with a yield per crop, per department and per year from 1989 to 2018. The yield crop losses for the year n is calculated regarding a reference yield which corresponds to an Olympic average of yields over the last five years; this is the methodology used in the case of climatic multi-risk insurance.
The DOWKI is based on the cumulated difference between P and ETP calculated for each decade. The index relies only on climatic data and does not require calibration: its unique calibration parameter is the period of crop vulnerability over which is calculated. Next, it is declined over two shapes to represent drought and water excess events.

(1) http://agreste.agriculture.gouv.fr/page-d-accueil/article/agreste-donnees-en-ligne

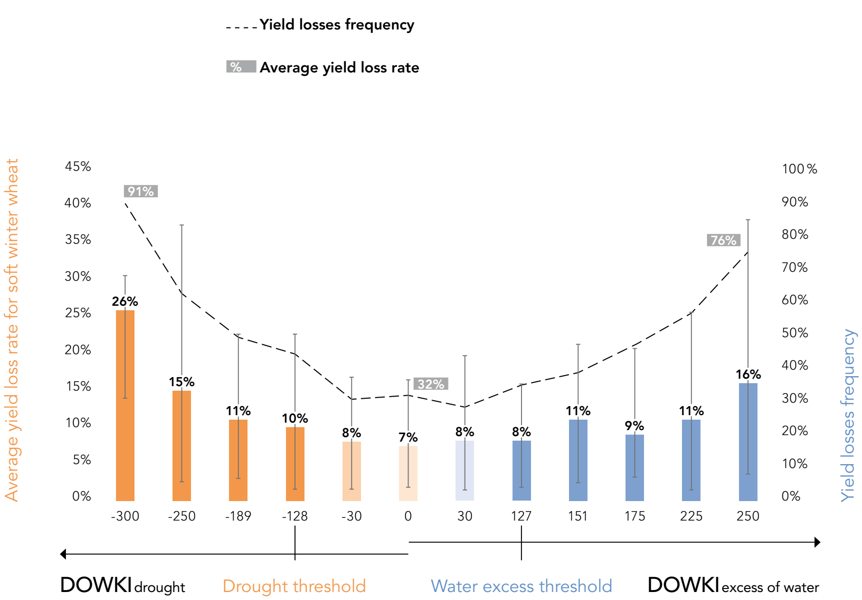

Figure 1 - Damage functions for soft winter wheat: yield loss frequencies, percentiles [10-90] and average yield loss rate according to DOWKI values.

An experimental plan has been realized to optimize index parameters: the period of crop vulnerability, the respective thresholds for the two perils from which we consider that the index well represents extreme events and the number of departments affected by the hazard, to represent systemic events. This experimental plan consists in 2 880 simulations per culture. Model validation criteria rely, among others, on the computation of the global average error for the two types of perils, per department and per event.
The calibration of the index on the crop losses is realized on a historic of 30 years per indices classes. For each class, the distribution of observed crop yield losses and the frequency of occurrence of a claim are calculated (Figure 1).
The stochastic model of index value simulations uses a Gaussian copulas method to simulate a large number of events with an intensity spatially correlated. To do so, the copulas are computed from the correlation matrix for DOWKI calculated on the departments. The adjustments of marginal laws on historic data translate the frequency resulting from copulas in intensity. The marginal distributions are calculated by using a normal distribution for the $DOWKI_{drought}$ (a K-S test has been done to check that the index follows a normal law) and a bootsrap for the $DOWKI_{excess\ of\ water}$.

RESULTS

The damage frequencies are calculated for DOWKI extreme values. For the soft winter wheat, on metropolitan France, we observe a probability of 91% to have a yield loss when the DOWKI value is under or equal to – 300 for a drought, and a probability of 76% when the DOWKI is above to 250 for excess of water. Thus, the created index has a strong capacity

THE PARTNERS

The unit Mixed Research « SMART-LERECO » has been officially created the January 1st 2017, in the continuity of a scientific project which gathered economists from the UMR SMART of Rennes and the UR LERECO of Nantes. This UMR gathers today sixty people (around thrity researchers and professors-researchers) from the EcoSocio INRAE department and Agrocampus Ouest.

to predict extreme yield losses occurrence for the two perils (Figure 1). For an extreme year such as 2003, the most damaged departments correspond to the departments with the most extreme DOWKI values as illustrated by Figure 2 for grasslands and soft winter wheat. Figure 3 (p. 50) illustrates the distribution of 5 000 simulated years of yield losses of soft winter wheat due to drought in some France's departments. For each distribution, the percentage of null losses has been calculated. We observe that the departments of a same climatic region (for example the Cher (18) and Eure-et-Loire (28) departments, or the Gers (31) and Haute-Garonne (32) departments) have similar results. The extreme event frequencies seem to be rarer for Hérault (34) but yield anomalies are higher when a disaster occurs. The lowest proportion of surfaces producing wheat in South of France may explain notably the larger volatility of the results.

CONCLUSIONS

This research proposes a new climatic index, based only on meteorological data, to predict crop yield anomalies due to extreme drought and water excess events. The calibration and the validation of the index allows to realize stochastic simulations of crop yield losses in the current climate conditions. The global objective of this research is to predict the impact of climate change on the risk exposure of farms. To do so, the index will be projected at current and future climate (2050) according to the Météo-France ARPEGE-Climat model (mesh of 8*8 km on France[5]). The simulations will rely on 400 years of current climate and 400 years of future climate. It will estimate frequencies and intensities of extreme events at horizon

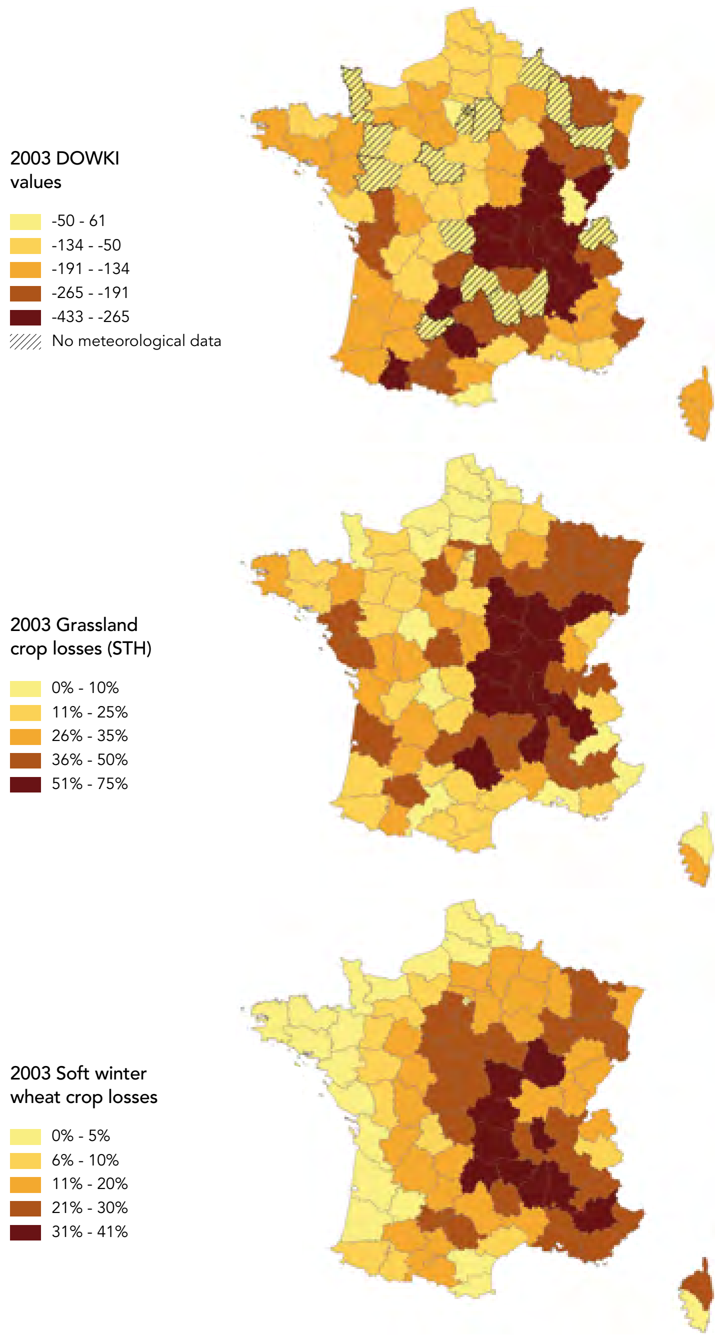

Figure 2 - DOWKI values for year 2003 and yield loss rates for grasslands and soft winter wheat.

Modelling crop losses at horizon 2050

> 2050, and thus the crop risk exposure. It will be then possible to anticipate the impact of the application of public policy conditions such as the climatic multi-risk insurance./

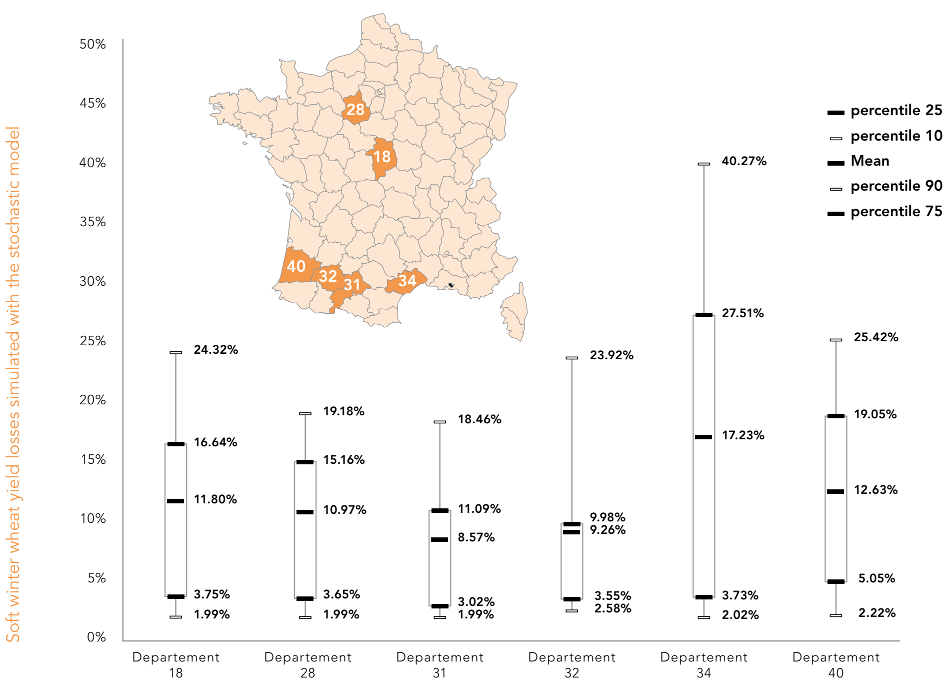

Figure 3 - Soft winter wheat yield losses simulated with the stochastic model.
The department 34 is characterized by a mediterranean climate,
the departments 31, 32 et 40 exemplify the oceanic climate and the departments
18 and 28 exemplify the degradated oceanic climate North.

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CITATION

Kapsambelis et al., Modelling crop losses at horizon 2050. In Rapport Scientifique CCR 2019 ; CCR, Paris, France 2020, pp. 47-50.

DATA SCIENCE

Quantile mixing and model uncertainty measures

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ABSTRACT

In this paper, a new methodology is introduced for combining two models, which are given in the form of two probability distributions. Convex combinations of quantile functions is used, with weights depending on the quantile level. The weights are choosen by comparing, for each quantile level, a given measure of model uncertainty calculated for the two probability distributions that we intend to combine. This methodology is particularly useful in insurance and reinsurance of natural disasters, for which there are various physical models available, along with historical data. Our procedure is applied to a real portfolio of insurance losses, and it is demonstrated that the model uncertainty measures have a similar behavior on the set of various insurance losses considered.

\# model combination
\# model uncertainty
\# quantiles
\# risk management
\# catastrophe models

INTRODUCTION

The subjects of this collaboration with Nabil Kazi-Tani researcher within the laboratory SAF of the Financial Science and Insurances Institute are related to actuarial issues encountered by CCR in the context of its internal company model.
A mathematical theory allowing the mix of two models (two distributions of probabilities) modelling the same phenomenon (for example natural disasters claims) has been developed. This method combines two models based on the calculation of model's uncertainty to extract the best of each model. The operational interest of this technic resides in an implementation without any parameter. It is 100% based on data. This method is used by CCR to mix CAT models obtained by historical approach and by approach based on the physical aspects of the CAT hazard. However, it can be used for all types of applications where the two models coexist. These researches have been published within the French Actuarial Bulletin (BFA in French), and entitled: Quantile Mixing and Model Uncertainty Measures, https://hal.archives-ouvertes.fr/hal-02405859

METHODOLOGY

Within different practical situations, it is possible to have numerous models for a same phenomenon. The main question is to know how to choose among those models, or how to combine them to obtain optimal decisions. There is a large literature on models combination[1,2,3,4,5] : one of the main methodology is the linear pool, which consists in taking a linear combination of each model's results[6]. A standard assumption is to consider that the output of each model is given in the form of a probability measure. Most of the literature on linear polling deals with convex combinations of the densities provided by the models or of the Cumulative Distribution Function[7]. In this paper, probability measures are mixed by combining convex combinations of quantile functions. Indeed, quantile functions, like densities or CDF, characterize the distribution of a random variable. A method is also provided to select the weights to be applied on each level of quantile based on model uncertainty measurements. The criteria introduced in this paper, to choose the weights, are based on model uncertainty measurements. Then it provides high weights for the historical model quantile for frequent events and high weights for the CAT model quantile for rare and extreme events.

SUMMARY OF THE APPROACH

Mixing quantiles

Assuming that the models to be combined are given in the form of two probability measures μ et γ. Let Q_μ et Q_γ be the quantile functions respectively associated to the measures μ et γ.

The function Q is defined by:

$$Q(u)=\lambda(u)Q_\mu\,(u)+[1\text{-}\lambda(u)]Q_\nu\,(u)$$

Where

$\lambda:[0,1]\to[0,1]$, a weight function.

This type of quantile function combination has been suggested by Granger Nobel Price of Economy[4].

In order to determine this weight function λ, it is compared to the model uncertainty related to μ et γ.

Model uncertainty

Definition of the absolute uncertainty of the selected model (cf P. Barrieu[1]):

$$AM(X_0) = \frac{\overline{\rho(L)} - \rho(X_0)}{\overline{\rho(L)}}$$

Where:

L : a given set of probability distributions;

X_0 : a random variable with a reference distribution;

ρ : a given risk measure;

$\overline{\rho(L)} = \sup_{X\varepsilon L}\rho(X)$.

Quantile mixing and model uncertainty measures

> Proposition
Si $\rho = \mathrm{VaR}_\alpha$ (ie., the selected risk measure is VaR of α level), while the model uncertainty defined below is calculated with the formula:

$$\mathrm{AM}(X_0,L)(\alpha) = \begin{cases} 1 - \dfrac{\rho(X_0)}{\mu + \sigma\sqrt{\dfrac{\alpha}{1-\alpha}}} & \text{si } \alpha^* \leq \alpha < 1 \\ 1 - (1-\alpha)\dfrac{\rho(X_0)}{\mu} & \text{otherwise} \end{cases}$$

Where:

μ: the moment of order 1 of X_0
σ: standard deviation of X_0
$$\alpha^* = \frac{\mu^2}{\mu^2 + \alpha^2}$$

Thus, the weight function selected, is the one given the higher weight to the model with the lowest uncertainty. This function is built on the overall uncertainty measurements for all models (all modelling on all insurance portfolios in that particular case):

$$\lambda(u) = \frac{1}{n}\sum_{i=1}^{n} 1_{\{\alpha_i \leq u\}}$$

Where α_i, the quantile representing the uncertainty related to the model μ is lower than the one associated to the model ν.

Then $\lambda(u)$ represents the proportion of models with a lowest uncertainty for the level of risk u (for the u quantile).

ILLUSTRATIONS

The Figure page 55 illustrates the results obtained by this method. For low return periods, a higher weight is given to the model based on historical approach (the model's error is lower). On the contrary, for high return periods, a higher weight is given to models based on physical approach (CAT models). The model obtained by this process is called a hybrid model.

CONCLUSION

These methods of mixing models are particularly useful for insurance and reinsurance of natural disasters, using different available physical models and historical data. Classical methods used allow to calculate some quantities (for example the tail) from the two models (classical method of credibility). The developed method allows to extent those calculations to the entire distribution of claims and not only to a quantity characterizing the distribution.

Thus, the obtained distribution of the claims synthetizes the better risk knowledge from available models. This claims distribution is then used for numerous applications such as the pricing, the reserve calculation, the internal model and all applications requiring a precise knowledge of the CAT claims./

THE PARTNER

Since 3 years, CCR collaborates with Nabil Kazi-Tani, professor-researcher within the SAF Laboratory of the Financial Science and Insurances Institute (ISFA in Lyon, France).

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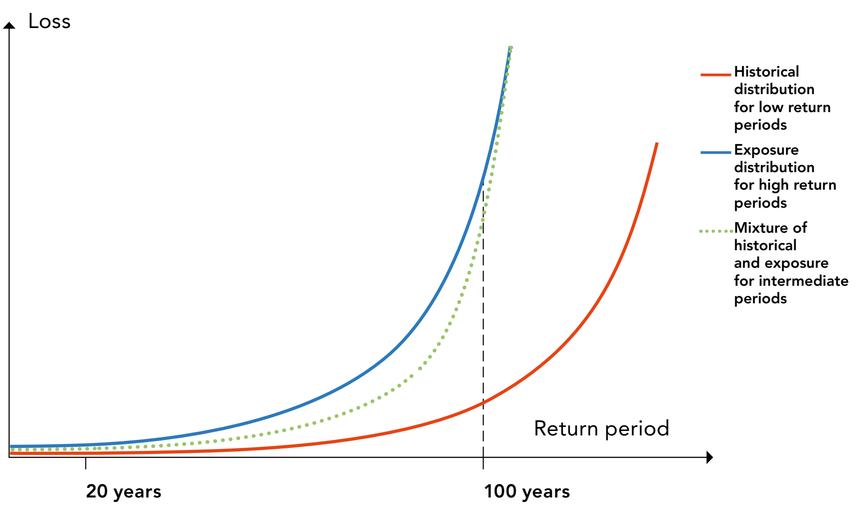
Hybrid modelling of natural hazard disaster



Modelling insured values

Luc Rongiéras[1], Hans Wackernagel[1], Émilie Chautru[1], Georges Farah[2]
(1) Mines PARISTECH (2) Department Data Science & Actuariat, CCR

ABSTRACT

Insured values depend on spatial location and on many factors that are not necessarily available in insurers' databases. The goal of this work is to estimate insured values following two different approaches, one using geostatistics and the other using Bayesian statistics. New sources of data, outside from the insurance world, may be exploited.

geostatistic
bayesian
entropy
mixed models

INTRODUCTION

In relation with its public reinsurance activities in France, CCR leads since numerous years works aimed at improving risk knowledge and the vulnerability of exposed areas by collecting data as part of its contractual relations with insurers (ceding companies). Data, available at geocoded address, integrate sometimes information on the insured values. Nevertheless, this information is not always viable and some data may be missing. Data is voluminous, some databases contain several hundred million lines.

A PhD thesis aimed to improve the algorithm for estimating insured value has been launched in December 2018, in the frame of a collaboration between CCR and Mines PARISTECH. The objective of these researches is to propose approaches providing solutions to the insured values modelling, in the context of the French natural disaster insurance scheme and for all types of risks (residential or professional). The insured values are defined as the maximal indemnity to restore an insured property to its original condition after its total destruction.

The amount is decomposed into 3 parts:

- The content value insured: the overall physically moveable goods contained within the insured property;
- The building value insured: non-moveable goods;
- The insured value of business interruption: if the property is used for professional activities, this value is predefined in a policy contract and should make it possible to compensate for the loss of revenues resulting from the non-use of the asset and to cover fixed costs during the period of business interruption.

The assessment of insured values is an essential prerequisite for modelling natural disasters, and for the quantification of insurance issues. The study focuses on the development of geostatistics and Bayesian methods in order to estimate the three parts of the amount and to identify related uncertainty easily integrated into different analysis.

METHODOLOGY & WORK IN PROCESS

The first main difficulty in this PhD is the absence of general formula defined to calculate insured values. If it is relatively easy to target the potentially most influent variables (i.e, the cost of the materials, of their transports, manpower, the surface are of the building, its geographical location), within the numerous number of

THE PARTNER

The PhD is cofinanced and framed by Mines PARISTECH and CCR.
The spatial character of insured values can be modelled by the geostatistic theory, created by Georges Matheron. At the end of the day, the geostatistic is taught at the Higher National School of Mines, Paris and stay a central research activity of the Centre of Geostatistics of Mines PARISTECH.

variables, but it can be very complex to propose an insured value model using the overall variables and for the different types of insured risks.
Ceding companies provide geolocalized data to CCR, the estimation of insured values can be available as calculated by themselves. In addition to the problems related to the presence of anomalies or the simple absence of data, another difficulty arises: there is no general formula for calculating the insured values, each ceding company provides its own estimated values. Thus, the insured values can be heterogeneous and do not correspond to the exact reality, it is only estimates based on variable methods across ceding companies. The quantification of uncertainties related to the estimation of these values has to be considered in this PhD.
Data provided by ceding companies allow the evaluation of potential explanatory variables of insured values, notably the location, the asset characteristics and their uses. These variables will play a major role in the development of the approach.
The data are more or less precisely geolocalized, one of the first implemented approach is related to the geostatistic area[1,2]. Alternatively, a classic statistic approach is currently developed. This involves considering the estimates of insured values provided by ceding companies as a noisy signal, using a Bayesian approach[3,4,5]. The objective is to choice a model appropriated to the noise, taking advantage of all available information, in order to produce a realistic modelling of the insured value of any assets. The choice of the model is supervised by the experts' knowledge on the insurance sector. >

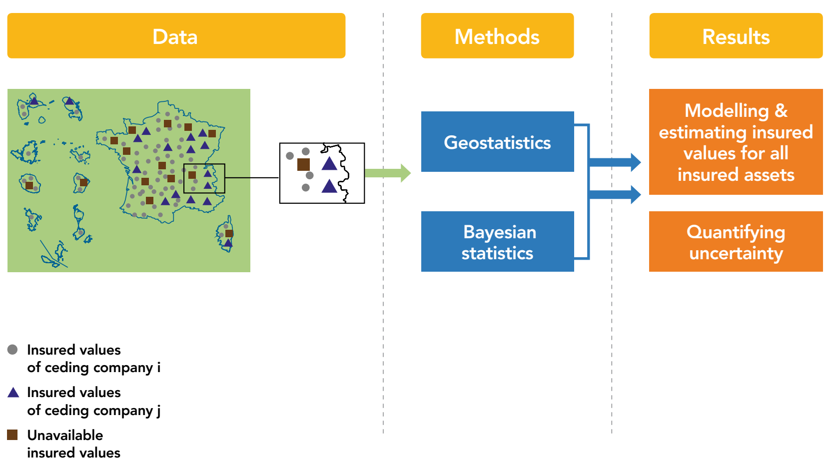


Figure 1 - Methodology implemented during the PhD.

CONCLUSION

These works propose two methodological approaches to analyse the issue of insured values calculation for all types of insured assets. The deployment of these on-going works allows to select one, geostatistics and/or the other, Bayesian, taking into account positive and negative aspects of each, the pertinence in the context and needs of CCR and the speed of execution. The operational interest of these works lies in the improvement of the precision of the risk knowledge concerning the exposure of CCR, State and insurance companies. As this PhD progresses, new sources of data, not coming from the insurance world, can be exploited (i.e., databases of notaries, BD Topo® etc.). /

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CITATION

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Using the text-mining in reinsurance

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ABSTRACT

By collaborating with REACFIN, CCR has automated some of its processes thanks to text-mining. Information is extracted from PDF documents or scans within 5 minutes as an average time, whereas it may have lasted several hours before. This automation highly contributes to improve the data quality. What as success!

text-mining
natural disasters decrees
agricultural calamities
numerical text format
data cleaning
data mining

INTRODUCTION

At the heart of the French natural hazards insurance scheme, CCR proposes public reinsurance coverages to insurance companies operating in the French market. The natural disasters decrees are resulting from the Interministerial Commission's notices which studies the requests for recognition files by prefects after the occurrence of an exceptional event. The lists of communities recognized by Nat Cat decree are published in the Official Journal. Then, it unlocks the CCR intervention to reinsure insurance companies in the frame of the natural disasters guarantee. CCR is also in charge of the accounting and financial management of public funds on the behalf of the State, including the National Funds for Managing Agricultural Risks (FNGRA in French). The agricultural calamities scheme compensates farmers for crop losses or funds losses due to the occurrence of an exceptional climatic event recognized by a ministerial decree.
In the objective of process optimization to analyze natural disaster decrees and agricultural calamities, CCR has used in 2018 and 2019 the text-mining tool. Those decrees are .pdf documents or images and manual processing may generates mistakes. The development of the text-mining approach is justified by its capacity to extract information from textual documents and to structure it for further analysis. This project relies on an agile partnership with the REACFIN company expert in natural language process and in the development of automatic textual analysis methods to analyze unstructured data.
After a proof of concept (POC) performed in 2018 on a sample of documents, a pilot has been implemented in 2019. The objectives are the optimization of the analysis of recurrent and time-consuming tasks; the reduction of operational risks links to manual processing; and the user support in its activity by making at its disposal decision making tools, which saves time then the user can concentrate itself on its core business and on quality control tasks.

METHODOLOGY

The first step was to understand the different steps of the analysis performed manually and the decrees' contents. The two types of decrees have been studied as source of textual data. The natural disasters decrees (Figure 1) are .pdf files with a numerical text format and with a standardize structure. It gathers information on the natural disaster recognitions for one or more communities. The name of the communities, the number of deductible modulation, the favorable or unfavo-

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Using the text-mining in reinsurance

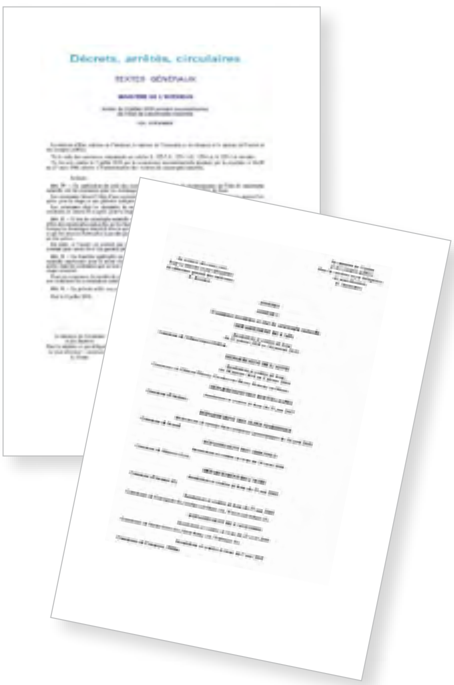

Figure 1 - Example of PDF documents used for the automatic text analysis – the natural disasters decrees (in French).

rable decision and the NOR code constituted of 12 alphanumerical characters etc. are structured identically for each decree. The decrees are downloaded from the *Légifrance* database[1]. A sample of 100 decrees published between 2014 and 2018 has been used in the study. The agricultural calamities decrees are black and white image (PDF format), containing information on the decrees or on their compensation. These decrees are non-publicly accessible documents, *de facto* it could not be shared hereafter. These decrees are scans of poor quality (eroded text). A sample of 79 decrees have been used in the study.
In a second time, the text-mining methods have been developed and implemented. After the download of the documents, the data are cleaned to transform the .pdf or the scan into textual content through the use of the package pdftotext. To do so, an optical character recognition (OCR, with the package Tesseact) is applied on the different areas of the document, it transforms an image into a text automatically.

NOR code (numerotation of official French texts)	Date of the commission	Date of the decree	Date of the publication within the Official Journal
INTE1818802A	July 3rd 2018	July 9th 2018	July 27th 2018

Decision label	Department name	Peril name	Start of the peril	End of the peril	Community name	INSEE code	Deductible modulation
Favourable	Aisne	Floods and mud flows	Mai 22^{sd} 2018		Nouvron-Vingré	02562	(2)
Favourable	Aisne	Floods and mud flows	Mai 24th 2018		Holnon	02382	(1)

Figure 2 – Example of the results obtained after an analysis of a natural disasters decree.

The text areas are then analyzed by a supervised learning (recursive neural networks) in order to associate each area to a relative class with a given subject (package Scikit-Learn). Based on the identified subject, the algorithm extracts from each area the information and proceeds to quality control and check before structuring the data into a database.

RESULTS

Detection rates exceeded 99% for natural disasters decrees, the processing time for a multi-pages decree is less than one second. Regarding agricultural calamities decrees, detection rates are around 95%, which is a very good result taking into account the low quality of the data. The processing time is around 20 seconds in average, with 19 seconds for the OCR part. In practice, real detection rates are of 100%, because the tool suggests a result to the user, and the later can modify it or validate it.
The tool has been put into production for the two types of decrees: the natural disasters decrees in June 2019 and the agricultural calamities in September 2019. The return on experience on natural disasters decrees was very positive: the average duration of a decree analysis was reduced to 5 minutes whatever the number of communities to be analyzed, before this duration was of 45 minutes in average and could take up to several hours for multi-page decrees. The main benefit has been to replace the manual process by an automatic upload with a suggestion of possible anomalies, which has largely accelerate the processing time while reducing the risk of mistakes.
Concerning the agricultural calamities decrees, the lack of setback time to perform a return on experience.

CONCLUSION

Thanks to the text-mining approach, CCR has automatized recurrent and time-consuming tasks, while the user can process the information more quickly and in a more reliable way, and the user has the possibility to focus itself on tasks with a higher added value and to create new ones. The new data are more reliable, CCR has improved the quality of the data within its information system. The collaboration with REACFIN has been positive, future collaborations and synergies are under development, in particular on issues related to data science or artificial intelligence, in order to improve the productivity and the quality. /

CITATION

Couloumy et al., Using the text-mining in reinsurance. In Rapport Scientifique CCR 2019 ; CCR, Paris, France, 2020, pp. 59-61.

(1) www.legifrance.gouv.fr

CCR CAT NAT AWARD

Inaugurated in 2015, CCR Cat Nat Award awards an innovative and original PhD thesis dedicated to improve knowledge on natural disasters and its implementation within the insurance and loss prevention areas. The CCR Cat Nat Award is open at the European level and open to research area in the area of geosciences, economic and social sciences. The Award is open to nominees who submitted or supported a PhD between the January 1st and December 31st 2020.

2019
Fanny BENITEZ, [in French]
"Coping or living with disasters? Adaptive capacities and capabilities in individual and territorial resilience trajectories within the Caribbean space".

2018
Kenji FUJIKI, [in French]
"Prospective study of the social impacts of a major flood in the Ile-de-France region. Socio-spatial disparities in the care of Paris Region populations in crisis and post-crisis situations: a mapped and quantified analysis of household needs, from evacuation to reconstruction".

2017
Elif ORAL, [in French]
"Multi-dimensional modelling of the propagation of seismic waves in linear and non-linear environment".

2016
Vanessa MULOT, [in French]
"Marine submersions: new issues, new legal practices".

2015
Camille ANDRÉ, [in French]
"Damage analysis of marine submersions and assessment of residential costs from insurance data".

The winner is designated by a panel composed of academics, research experts, insurers, and CCR staffs. In 2019 the panel was presided by M. Alberto Monti, Professor of Comparative Law at IUSS Pavia and member of the Head Council of the OCDE on the financial management of natural disasters.

The winner receives a monetary compensation and is welcomed to make a presentation of its research results during the annual CCR Cat meeting and had the possibility of meet actors of the insurance industry and of the prevention areas. The PhD thesis is shared on the CCR website and the winners are offered the opportunity to write a scientific paper within the annual scientific report.

We thank all the nominees and the winners for their contributions in these emerging research areas and we hope that the readers will have as much as pleasure as we have to read and discover these research.

The 2019 Award went to Fanny Benitez for a research within the Caribbean area (Martinitique, Guadeloupe, Haïti) focusing on "Coping or living with disasters? Adaptive capacities and capabilities in individual and territorial resilience trajectories within the Caribbean space"./

Video summary
https://www.ccr.fr/journee-ccr-cat/videos

For more information
prixccrcat@ccr.fr

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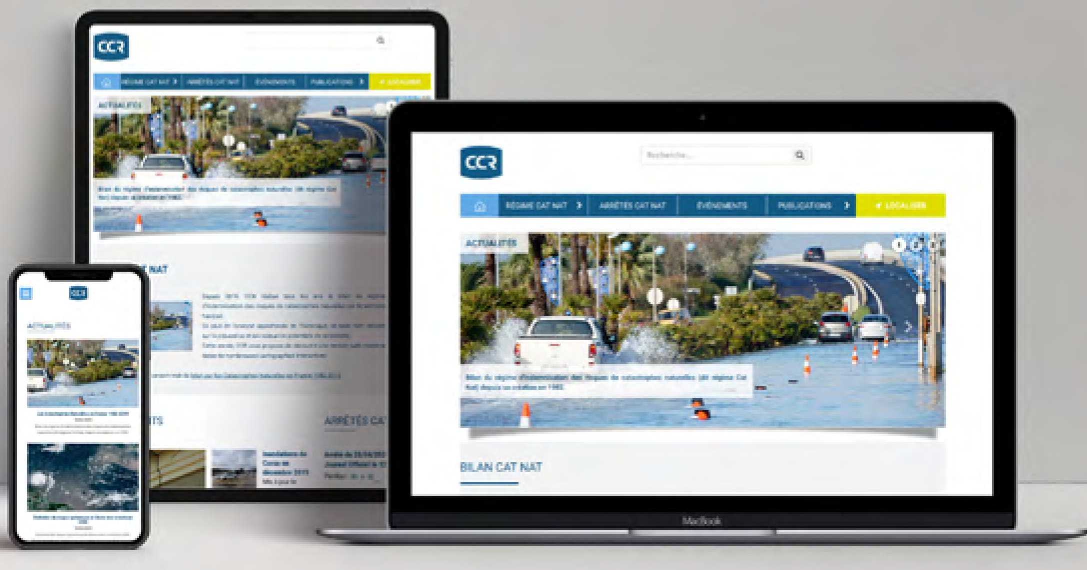

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