Modelling the impact of climate change on losses insured under the natural disaster compensation scheme

Modelling and R&D Services
Technical Studies Department
Public Reinsurance Direction - CCR
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Summary

In association with Météo France (France's national meteorological service), CCR conducted detailed modelling work to evaluate the financial impact of climate change on the French natural disaster compensation scheme. This study was realized on the basis of a median scenario of the Intergovernmental Panel on Climate Change (IPCC), which Météo France considers to be scientifically plausible by 2050.

The originality of this study is that it obtains results at a fine spatial scale (25 metres) and a fine time scale (with the use of hourly data).

Area of study

This modelling work concerned metropolitan France and hazards of climatic origin that are included in the natural disasters system: river overflow flooding, surface run-off flooding, storm surge and drought. French overseas territories, which are exposed to hurricanes, have not yet been modelled. For the moment, Météo France's climate simulations concern exclusively metropolitan France.

Methodology

This model was constructed on the basis of the IPCC's median scenario. According to the IPCC's latest report, this climate projection (the RCP 4.5) corresponds to an average increase of 1.4°C in the earth's global temperature during the period [2046-2065] and an average increase of 1.8°C during [2081-2100], in relation to the period 1986-2005. It is consistent with the objectives of COP21 in Paris: to limit the increase in the earth's average temperature to 2°C by 2100.

In order to study the consequences of climate change in metropolitan France, simulations associating the Météo France's climate models and the natural event simulation models developed by CCR were performed for the hazards concerned in the study area.

Two datasets of events were created in this way:

- a dataset of events in the present climate;

- a dataset of events in the 2050 climate conditions according to the IPCC's RCP 4.5 scenario.

The simulation of the impact of these events on a portfolio including all property currently insured on the French market, together with their estimated location, provides an evaluation of the average annual losses and a distribution of the annual losses.

To evaluate the effect of the variation of vulnerability on the increase in costs, above and beyond the effects of climate change in 2050, CCR has constructed a 2050 market portfolio by projecting the present number and value of insured property to 2050.

The choice of the "target" year for the study is fundamentally important. The year 2050 was chosen. Above and beyond climate change and the uncertainties inherent in long-term projections, the question of vulnerability was a stumbling block. This is because there are too many uncertainties in projections of population and of the variation in the values of insured property beyond 35 years.

Main results

Overall, the natural disasters loss experience caused every year by climatic events in metropolitan France should **double by 2050**.

This increase would be mainly related to the change in the **insured values** and their geographical distribution (**around 80% of the forecast increase**).

The results of this study show that **climate change** would also have an impact on the loss experience, since it would explain **around 20%** of the increase that is forecast to occur by 2050.

If, for each hazard, we examine the increase in mean annual losses due to the effect of climate change, apart from the increase in vulnerability, then we obtain the following results:

- Flooding by river overflow and surface run-off: 20% increase mainly related to the increase in events in the Cevennes Mountains area;

- Storm surge: more than 60% increase, mainly related to the increase in sea level (+20 cm by 2050, according to the chosen IPCC scenario);

- Drought: losses would remain constant on the national level, but **major regional disparities are revealed by the study on a fine scale.**

What lessons can be learned from this study for the natural disaster compensation scheme?

These results show a probable notable increase in the cost of the loss experience related to climate events, due to an increase in insured values combined with climate change. Therefore, the question may justifiably be asked whether the natural disaster compensation scheme is able to adapt to this extra cost.

Even if losses compensated in relation to climate risks are destined to increase in the future, the scheme's balance is not fundamentally modified, since premiums would change to reflect changes in insured values, which account for most of the expected increase in the loss experience.

Until now, this natural disaster compensation scheme, which is unique, has proven its effectiveness. It has made it possible to provide compensation for all events that have occurred since more than 30 years ago, including some years that were particularly impacted by natural disasters, such as 1999, 2003 and 2010. These years of exceptional loss experience prove its reliability and show that it could cope with climate change. Some moderate tariff adjustments may prove necessary, but they will be all the more contained if prevention is developed in all its forms and with the participation of all the players involved.

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1 Background and aims of the study

The 21st Conference of the Parties (or COP21) was held in Paris from 30 November to 11 December 2015. It brings together all UN Member States that signed the United Nations Framework Convention on Climate Change (Rio, 1992).

The aim of this Conference was to finalize an agreement that is necessary to combat climate change. There are major stakes involved since the intended agreement must make it possible to limit the increase in temperatures to less than 2°C by 2100, but also to drive a transition to resilient societies and economies that are moderate consumers of carbon and emitters of greenhouse gases.

The possible consequences of climate change require action from every player. Through its expertise and its major role in the management of natural hazards, the Caisse Centrale de Reinsurance (CCR / Central Reinsurance Fund) helps raise awareness among public and private leaders and decision-makers of exposure of societies and geographical areas to climate hazards. As an official partner of COP 21, CCR also aims to promote actions for prevention and adaptation.

For this study, CCR has concentrated on the study of the financial impact of climate scenarios. Since it is not an expert on climate, it joined forces with Météo France to select the scientifically most plausible scenario for the climate in 2050.

1.1 Climate change

The question of climate change is now a central concern of our societies. The last report by the Intergovernmental Panel on Climate Change (IPCC) stresses that this change would probably result in an increase in the number of extreme events in the world, such as heat waves or extremely heavy rainfall. Recent extreme events in southern France in the autumns of 2014 and 2015 are perhaps the first signs of this.

To reach these results, the IPCC chose four different scenarios to try to ascertain future changes in the world's climate. These scenarios are based on the analysis of the variations in greenhouse gas emissions. Thus, if there is no decrease in greenhouse gas emissions, the most pessimistic scenario (RCP 8.5 - Representative Concentration Pathways) would entail an average rise in world temperatures of around 3.7°C by the end of the 21st century in relation to the period 1986-2005. In the most optimistic scenario (RCP 2.6), the rise in temperature would be limited to less than 2°C. The median scenario (RCP 4.5) would entail a rise in world temperatures of between 1.1°C and 2.6°C by the end of the century.

Table 1: The IPCC's Scenarios (Source: IPCC)

Variation in greenhouse gas emissions		Probable variation in temperatures (2046-2065)	Probable variation in temperatures (2081-2100)
RCP 8.5	Scenario with continued increase in greenhouse gas emissions at the present rate. **This is the most pessimistic scenario.**	1.4 to 2.6°C	2.6 to 4.8°C
RCP 6.0	Scenario with stabilisation of emissions before the end of the 21st century at a medium level.	0.8 to 1.8°C	1.4 to 3.1°C
RCP 4.5	Scenario with stabilisation of emissions before the end of the 21st century at a low level.	0.9 to 2.0°C	1.1 to 2.6°C
RCP 2.6	Scenario with very low emissions, with a peak reached before 2050. **This is the most optimistic scenario.**	0.4 to 1.6°C	0.3 to 1.7°C

Climate change would also entail an increase in sea level, notably due to thermal expansion of the oceans and melting of the polar ice-caps. For the RCP 4.5 scenario, this increase would be between 19 and 33 centimetres by 2050 and between 32 and 63 centimetres at the end of the century on a worldwide scale.

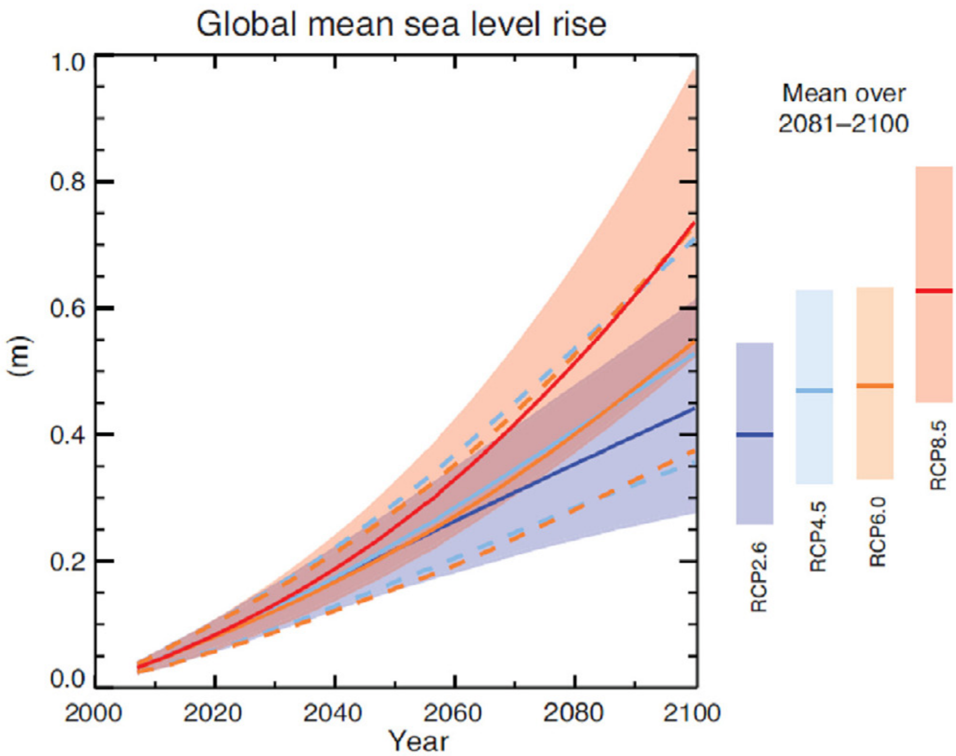


Figure 1. Rise in mean sea level on a worldwide scale (source: IPCC, 2013)

This rise in sea level would have many regional disparities that are still difficult to evaluate. However, it will result in exacerbating the effects of coastal flooding.

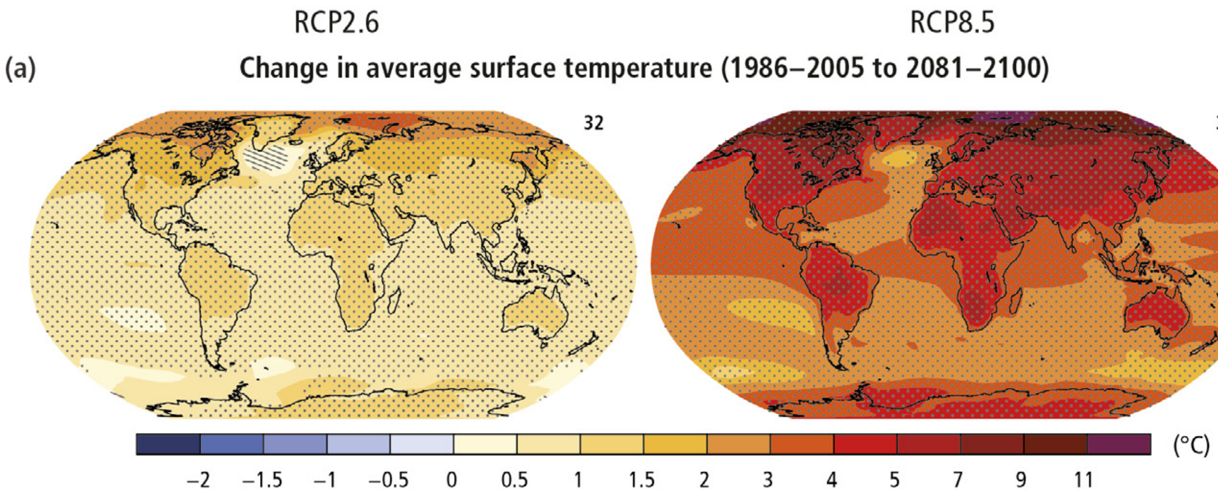


Figure 2. Évolution de la température moyenne en surface (source IPCC, 2013)

On the scale of France, the last report by the l'ONERC[1] on France's climate in the 21st century highlights an increase in temperatures which, with the most extreme scenario (RCP 8.5), could reach 3.6°C in winter and 5.3°C in summer at the end of the century.

According to the ONERC, this warming could go hand-in-hand with an increase in the duration of droughts and of heat waves. There would also be more numerous, larger scale extreme rainfall events. For France's overseas *Départements*, the projections suggest that it is probable that the frequency of hurricanes would reduce or remain the same by the end of the century; however, they would become more intense at the same time.

1 ONERC: Observatoire National sur les Effects du Warming Climatique (National Observatory of the Effects of Climate Warming)

1.2 Natural disaster compensation scheme and hazards covered

In France, the natural disaster compensation scheme (referred to hereinafter as the natural disaster scheme), which is in operation since 1982, has been through a certain number of changes, but its main principles have remained constant:

- a system based on a public-private partnership;
- a principle of mutual support between the insured parties, whatever their level of exposure to the natural events;
- State participation, in the form of an unlimited guarantee for the natural disaster scheme, via non-mandatory public reinsurance proposed by CCR;
- activation of the natural disaster insurance scheme for relatively frequent events, such as the thres hold of the ten-year return period for flooding.

The Act dated 13 July 1982 does not include a list of hazards covered, and it does not specify the hazards that are excluded. Article 1 of this Act only describes what are considered to be the effects of a natural disaster, viz., «non-insurable direct material damage of which the determining cause is the abnormal intensity of a natural agent».

In practice, the hazards that are currently within the scope of application of the scheme are as follows:

- flooding (surface run-off, river overflow, rising groundwater, dam burst caused by a natural pheno menon);
- landslides and mudslides;
- earthquakes;
- land movements (including drought);
- subsidence due to underground cavities and marl pits (except mines);
- storm surge and wave impact;
- avalanches;
- large-scale hurricanes (with an average wind speed of more than 145 km/h for 10 minutes or 215 km/h in gusts).

This list is not exhaustive. Figure 3 shows the variation in amounts of compensation paid under the natural disaster scheme during the period 1990-2013, updated by incorporating the variation in insured values.

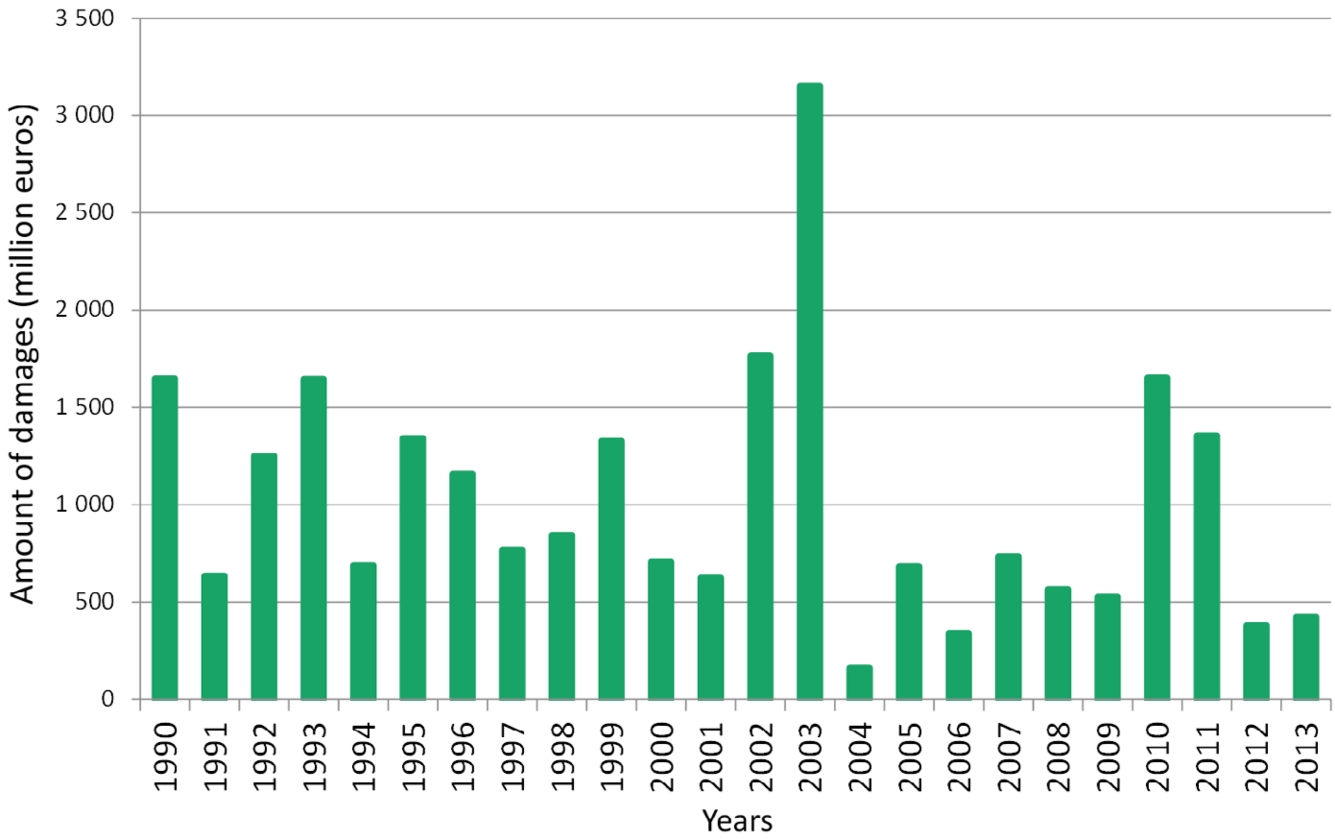


Figure 3. Estimation of final amount of compensation updated in € 2014

There are peaks that correspond to a combination of extreme events (for example, exceptional drought and flooding of the River Rhone in 2003), but, at this stage, there is no visible notable upward (or downward) trend. But will this observation remain true in the future?

1.3 Aim of the project

Over a number of years CCR has developed its own models for analysing the impact of natural disasters: 2003 for flooding hazard, 2005 for drought hazard, and 2011 for storm surge. These models have two objectives:

- measure the costs of natural events shortly after they occur, in order to estimate the financial impact for insurance companies, for CCR and also, as a last resort, for the State;

- analyse the exposure of private or professional property to potential natural events in a uniform manner throughout the whole of metropolitan France and its overseas territories covered by the scheme.

To meet the first objective, so-called determinist models were developed to estimate the consequences of an event on the basis of its physical characteristics (hazard) and the characteristics of the insured property (vulnerability).

To appreciate the second objective, probabilistic models are implemented. They consist in simulating the consequences, not of one event, but of a very large number of fictive events, associated with a probability of occurrence.

To do this, we must construct a dataset of realistic climate events. Until now, these datasets of events were constructed to reflect present or recent climatic conditions (in the last 30 or 40 years).

In order to study the consequences of climate change, we have created two datasets of events for this study:

- a dataset of events with the present climate;

- a dataset of events in the climatic conditions of 2050 according to the IPCC's RCP 4.5 scenario.

Therefore, the study highlights the variations of exposure to natural hazards due to climate change.

The simulation of the impact of these datasets on a portfolio including all properties currently insured in the French market provides an evaluation of the mean annual losses and a distribution of the annual losses according to their return periods.

In order to evaluate the effect of the variation in vulnerability above and beyond the effects of climate change in 2050, we have constructed a 2050 market portfolio by projecting the present number and value of insured properties to 2050.

2 Method

2.1 CCR modelling work and scientific partnerships

In order to implement its modelling work, CCR is associated with scientific partners who are references in each of the fields of climate hazards:

- Météo France and CNRM (Centre National de Recherches Météorologiques) for modelling climate, flooding, drought and hurricanes;

- the BRGM (Bureau de recherches géologiques et minières) for modelling drought and coastal floo ding;

- IRSTEA (Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture) for flood modelling.

Modelling of the impact of climate risks is constructed as shown in the diagram below.

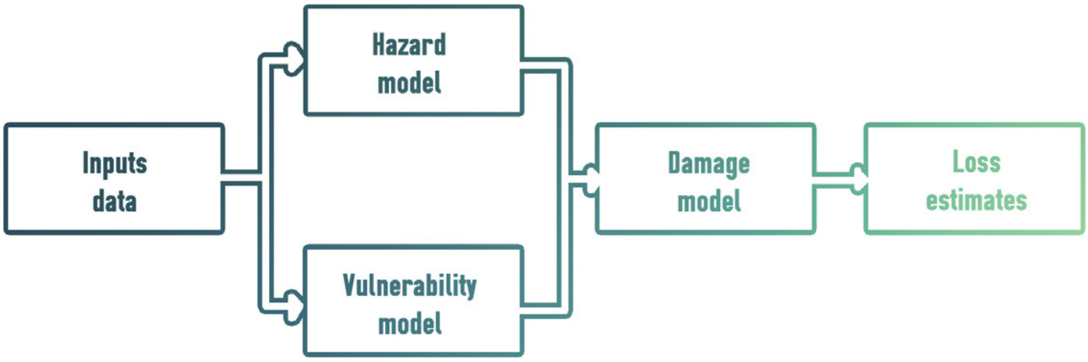


Figure 4. Diagram of models of impact of natural disasters developed by CCR

A hazard model, based on climatic and geographical input data, estimates the areas affected by a disaster such as river overflow flooding and surface run-off flooding, storm surge or geotechnical drought. This hazard model is constructed differently for each hazard.

Using a database of insurance policies and natural disaster claims, the vulnerability model locates the insured property in the geographical area and lists their characteristics, such as the nature of the property (house, building or apartment), the type of risk (private or professional) and its form of occupation (owner-occupier, tenant, joint property owner).

By crossing the hazard (whether it corresponds to a real or a fictive event) with vulnerability, it is possible to estimate the amount of insurance losses. This estimation is performed within the model of losses for each insured item of property. The model of losses takes four factors into account: the probability that the property will suffer loss, the associated rate of destruction, the probability that a natural disaster is officially declared in the commune [town or municipal district] and, lastly, the insured value of the property. The first three variables were calibrated and are calculated in a different way for each hazard. In the end, the estimated costs for each insured item of property are totalled on different scales (commune or municipal district, Département [equivalent of the British county], or France) and can be calculated for different portfolios corresponding to the insurance market or to the insurance companies.

2.1.1 The flood hazard model

The flood model developed by CCR (Moncoulon et al., 2014) is made up of two complementary models. The first is a surface run-off model. On the basis of the rainfall measurements obtained from the ARPEGE[2] model, it calculates the water volumes that flow on the surface and under the surface of the ground. This run-off model takes into account topography, but also land use, in order to reproduce the behaviour of impermeabilised areas.

The river overflow model is used to estimate the flow rate of the main water courses and their overflow during an extreme event. This overflow is based on the spread of water on a digital model of ground, describing the topography of the impacted area.

These two models are complementary and each have their own importance, since the CCR's loss experience data has shown that a large proportion of damage to property is not located in the overflow area of the main water courses, but perhaps caused by secondary water courses or by run-off.

2.1.2 The storm surge hazard model

Severe weather events create meteorological conditions that drive up the water level, creating a storm surge. This storm surge could result in coastal flooding if it occurred during high tides. The modelling system developed by CCR (Naulin et al., submitted) benefited from collaboration with the BRGM and is based on the combination of three models.

The first is the TELEMAC-2D hydrodynamic model (Hervouet et al., 1996) which is used to simulate the tide and the rise in sea level caused by a weather event. It uses wind speed and atmospheric pressure data obtained from the ARPEGE model. Waves, which may contribute considerably to coastal flooding, are simulated with the TOMAWAC model (Guillou & Chapalain, 2011), supplied by outputs from the TELEMAC-2D model. Lastly, the seawater levels resulting from the tide, the storm surge and the breaking of waves are propagated on land by a flooding model.

In addition to the variation in climate, the warming of seas and the melting of polar ice caps could have a direct effect on sea level. This could rise by as much as 20 cm by 2050 in relation to the mean sea level in 2015. In order to measure the impact of this rise, simulations of events with the 2050 climate were modified by increasing the sea level by 20 cm.

In this study, the study of storm surge only concerns the Atlantic coastline for which ARPEGE modelling operations were performed as a priority.

2 ARPEGE : (http://www.cnrm.meteo.fr/spip.php?article121)

2.1.3 The drought hazard model

Geotechnical drought – or clay shrinkage-swelling – is a hazard caused by climate factors, due to an anomaly in the precipitation regime but with a factor of predisposition if there is any clay that may cause ground movements that affect foundations and structures of constructions.

In order to characterise the impact of this hazard, CCR has developed a model that cross-references vulnerability data such as the exact location of risks, the estimation of their insured value or the history of drought losses experienced under the natural disaster scheme. The model also takes into account hazard data characterising both the soil using the clay shrinkage-swelling hazard maps produced by the BRGM office and the climate by an index of soil wetness. As part of our study, soil wetness data was produced by Météo France for the two sets of present climate and future climate simulations.

2.2 Modelling climate change

The modelling system developed for estimating the potential impacts of climate change by 2050 is based on the use of Météo France climate scenarios for supplying hazard and damage models developed by CCR.

As part of IPCC activities, Météo France has implemented its global ARPEGE CLIMAT model for each of the trajectories of variation in greenhouse gas concentrations (RCP: Representative Concentration Pathways) to produce simulations up to 2100 for the whole world. Work is also being done to scale models down to the regional level (the CORDEX[3] programme).

For CCR's needs, Météo France configured ARPEGE CLIMAT in order to refine calculations in a region of interest, with 31 vertical levels for two simulations of 200 years in hourly time increments and with 20 km resolution in Europe, for a constant present climate (around 2000) and future climate (around 2050).

The hypothesis chosen for simulation of the 2050 future climate is RCP 4.5 (solar radiation forcing of +4.5W/m2 in 2100) which follows a progression that stabilises without excess by 2100, with a rate of 660 ppm CO2 equivalent, which corresponds to a mean increase of 1.8°C in 2100 in relation to the present mean temperature. **This variation scenario is consistent with the objectives targeted during COP21 in Paris.**

The choice of the "target" year for the study is fundamentally important. The year 2050 was chosen. Above and beyond climate change and the uncertainties inherent in long-term projections, the question of vulnerability was a stumbling block. This is because there are too many uncertainties in projections of population and of the variation in the values of insured property beyond 35 years. The data obtained from these simulations was used to supply CCR impact models for risks of flooding and storm surge in France. For drought risk, Météo France provided simulation data for its ISBA[4], model, configured with uniform clay soil content. The soil wetness index (SWI) characterising the water content of soils was produced with daily time increments.

ISBA simulates exchanges of water and energy between the soil and the atmosphere. The version used has three strata of soil (surface, roots area and deep area) and two temperatures (overall surface temperature of the soil-vegetation continuum and deep temperature). ISBA simulates all flows of water with the atmosphere (interception, evaporation and transpiration) and with the ground (precipitation run-off and drainage in the ground). Its time increment is 5 minutes. ISBA Uniforme is configured for a uniform representation of the texture of soils and vegetation in France in the surface diagram, to identify climate forcing on the scale of the plot of land.

3 CORDEX: Coordinated Regional Climate Downscaling Experiment (www.cordex.org)
4 ISBA: Interaction Sol Biosphère Atmosphere (Interaction Ground Biosphere Atmosphere)

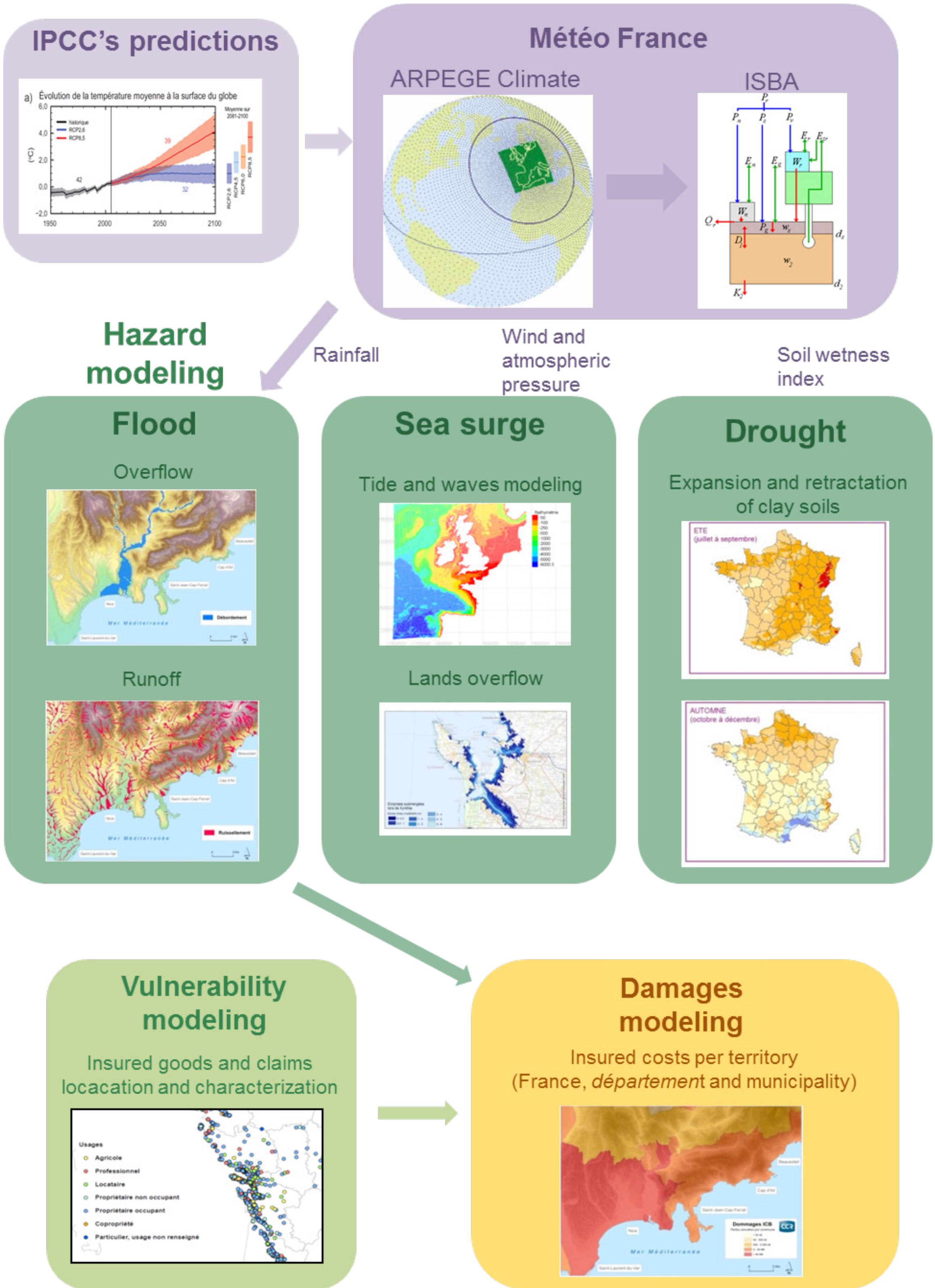


Figure 5. Modelling system put in place for the study of the impact of climate change

2.3 Predicted vulnerability by 2050

In order to better grasp the consequences of climate change on our societies, it is important to take into account the variation in vulnerability by 2050. Indeed, the consequences of population growth and territorial dynamics will have direct consequences on the exposure of insured values. In order to better grasp the consequences of climate change on our societies, it is important to take into account the variation in vulnerability by 2050. Indeed, the consequences of population growth and territorial dynamics will have direct consequences on the exposure of insured values.

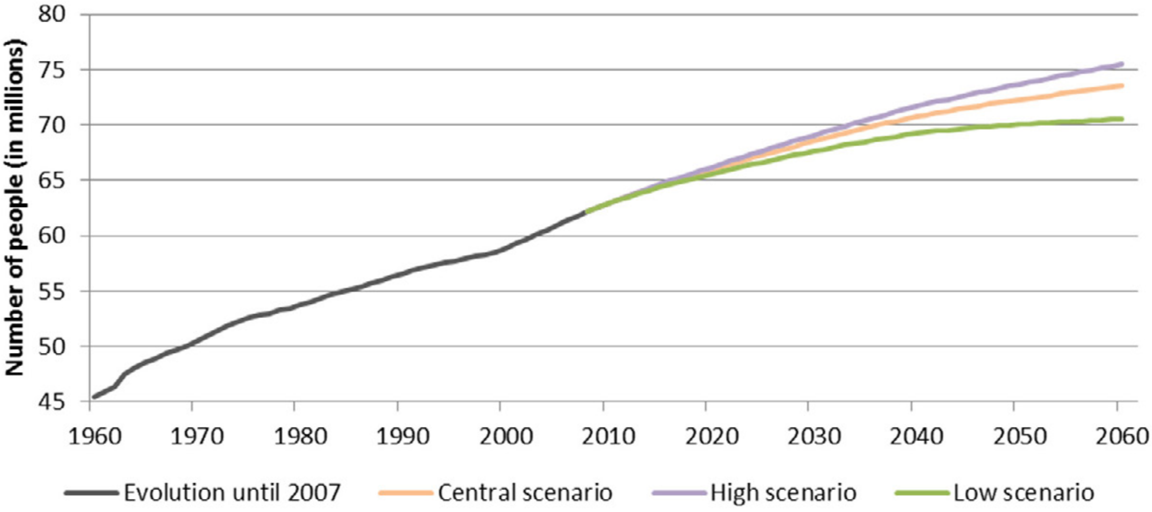


Figure 6. Projections of population variation according to INSEE's scenarios

Consequently, the number of exposed properties that may be affected by a natural event will also increase. To better anticipate the cost of future natural disasters, CCR has developed a methodology to estimate the number and values of insured items of property in 2050.

On the basis of INSEE's projections, it was possible to estimate the number of insured items of property by 2050. At the same time, a projection of values of insured property was produced from historical data.

Market portfolio	Variation between 2015 & 2050
Numbers of risks	+ 11.7%
Insured values	+ 72.3%

Table 2: Variation of the market portfolio between 2015 and 2050 for metropolitan France

Therefore the number of risks would increase from nearly 51 million in 2015 to almost 57 million in 2050, i.e., an increase of 11.7%. The insured values would grow by more than 72%. However, the distribution of this evolution in France's various Départements shows major disparities from one area to another (as shown in the map below).

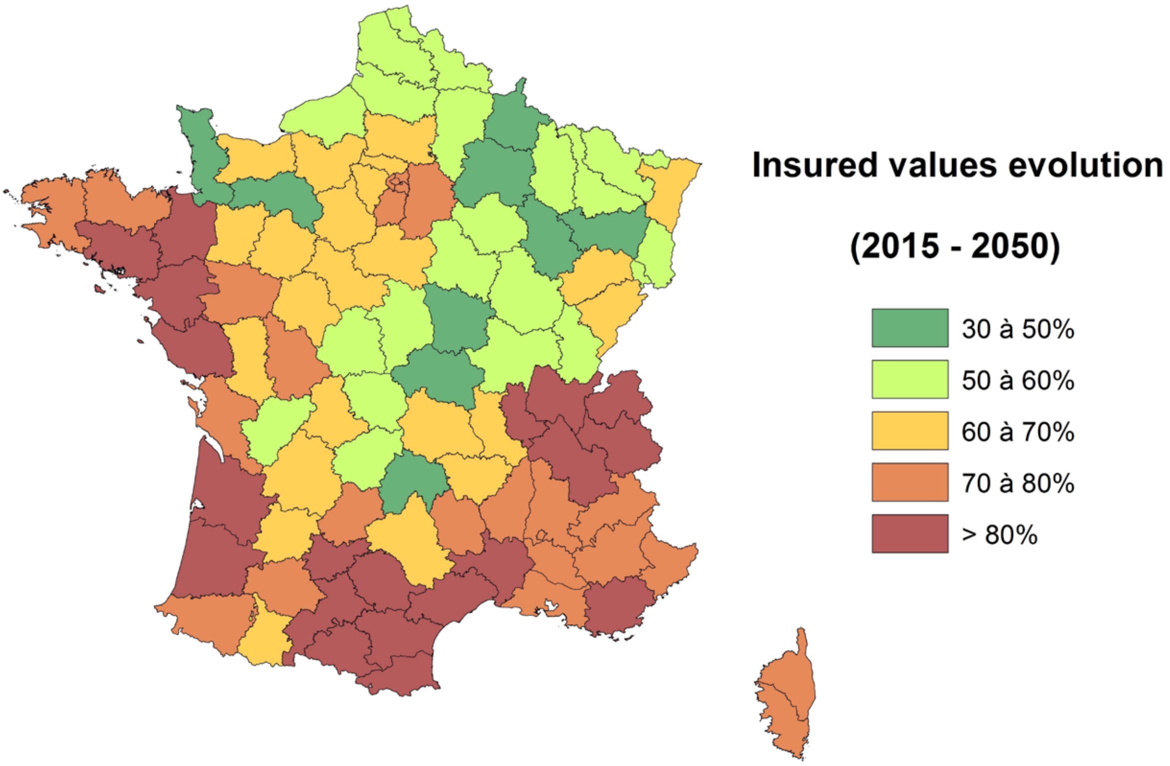


Figure 7. Map of the variation in insured values by Département between 2015 and 2050

The expected increase in insured values for the Atlantic and Mediterranean areas and in the south-west of France corresponds to a continuation of the dynamics observed today. The variation in insured values in these areas is greater than 70%, or even 80%. In the areas marked by a decrease in population, the insured values nevertheless increase, but to a lesser degree; thus the north-east quarter of France has a more moderate increase.

3 Results

3.1 Flooding

Climate scenarios of flooding for mainland France are modelled on the basis of hourly precipitations:

- for a period of 3 days in around one hundred small catchment areas;

- for a period of 10 days in fifteen large catchment areas.

The modelling takes into account surface run-off and overflow of water courses. The map in Figure 8 shows the variation in exposure to run-off between today and 2050.

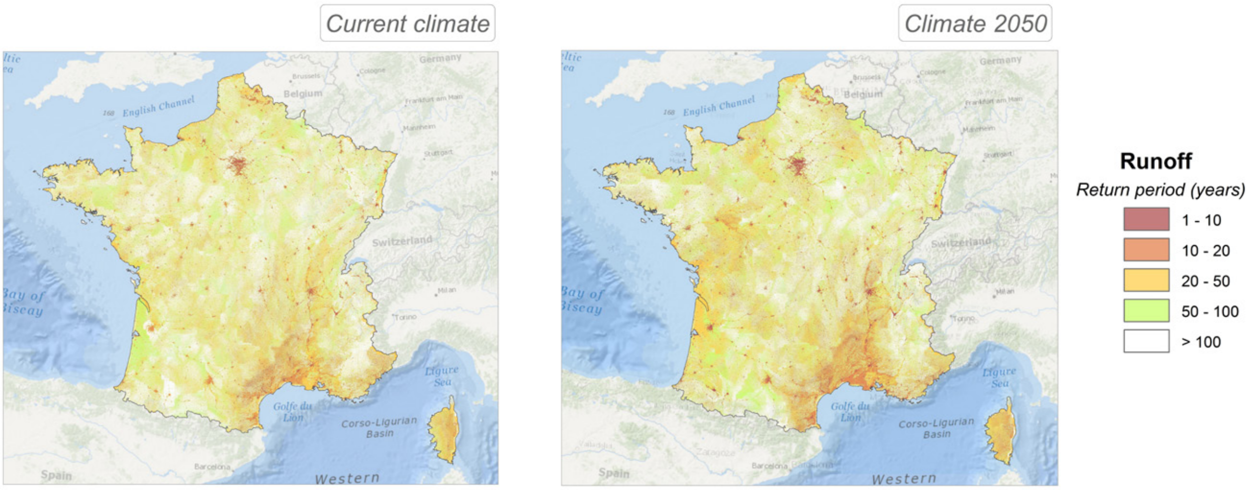


Figure 8. Variation of the frequency of run-off hazard modelled by CCR between 2015 and 2050

The increase in exposure in the South-East region and more specifically in the Rhone Valley is particularly marked. Météo France simulations show a significant increase in the heaviest precipitation in aggregate totals for 72-hour periods in this region.

In terms of damage, the effect of the flooding hazard alone represents an increase of 20% of mean annual losses. According to the Météo France simulations, this reflects the effects of the RCP 4.5 scenario and of the overall increase in precipitations. It is mainly in small catchment areas that the impact of the climate scenario is the most marked, due to run-off. In fact, the effect of lowland floods is not as marked.

In regions of southern France, the increase of the run-off hazard goes hand-in-hand with the growth in vulnerability, leading to a much greater increase in exposure than the national average.

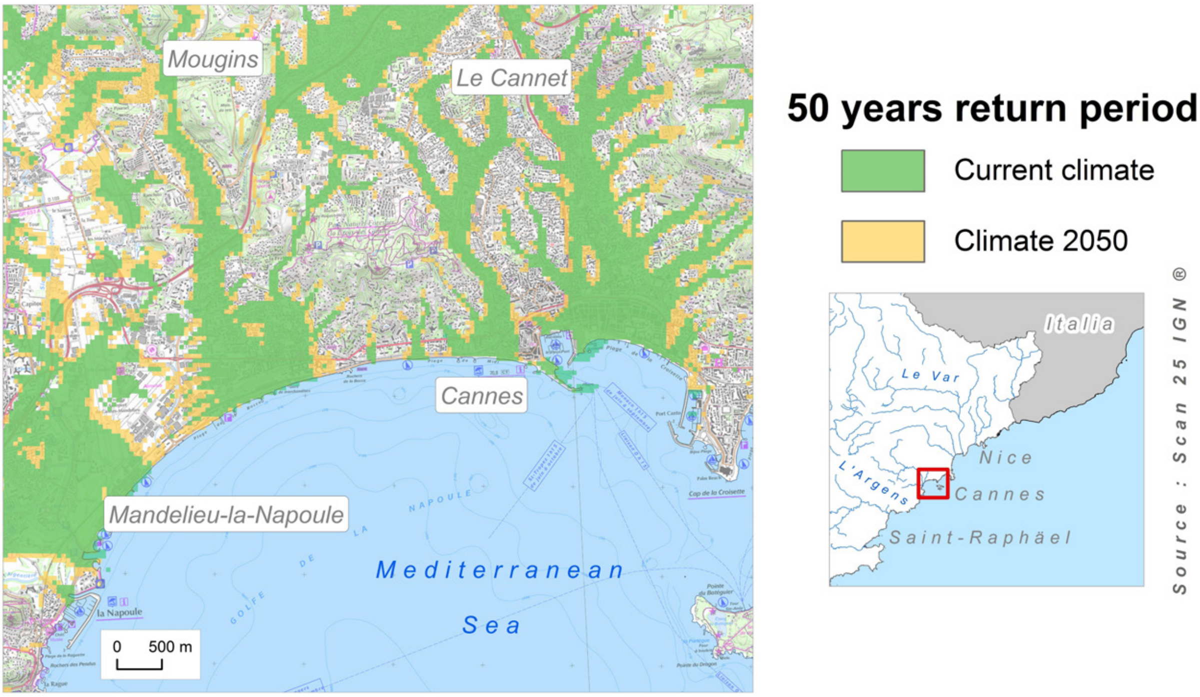


Figure 9. Variation in distribution of areas exposed to run-off for a return period of 50 years in the French Riviera between 2015 and 2050

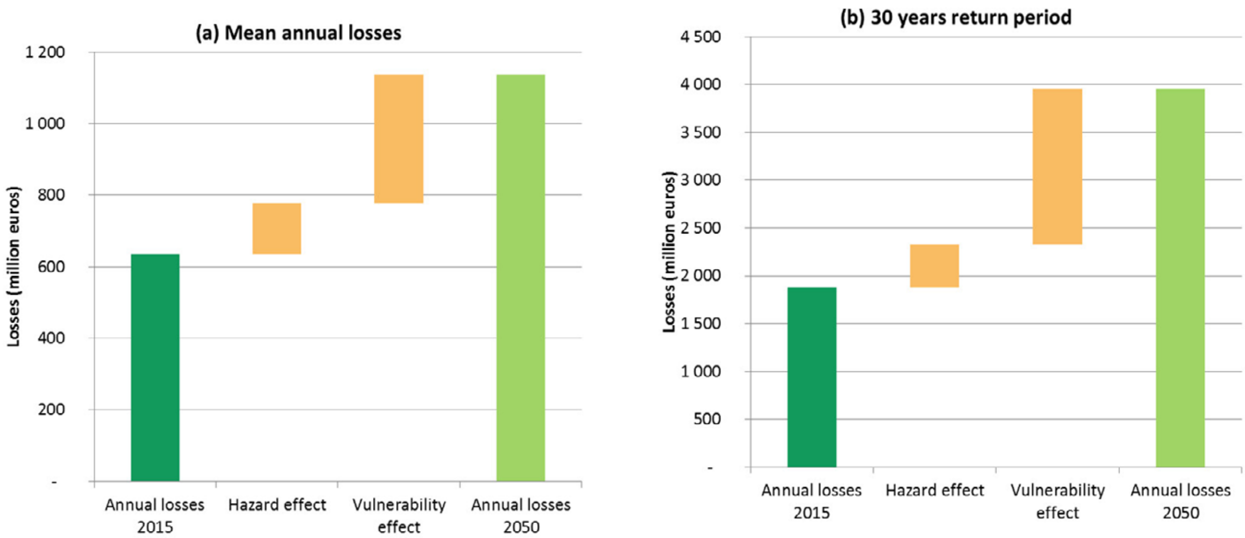


Figure 10. Flooding - variation in annual mean losses (a) and losses in a 30-year return period (b) between 2015 and 2050 broken down between the effects of the hazard and of vulnerability – RCP 4.5 scenario

3.2 Storm surge

Three aspects of exposure of the Atlantic coastline by 2050 were studied: the effect of the variation in climate, the impact of the rise of sea level, and the variation in vulnerability.

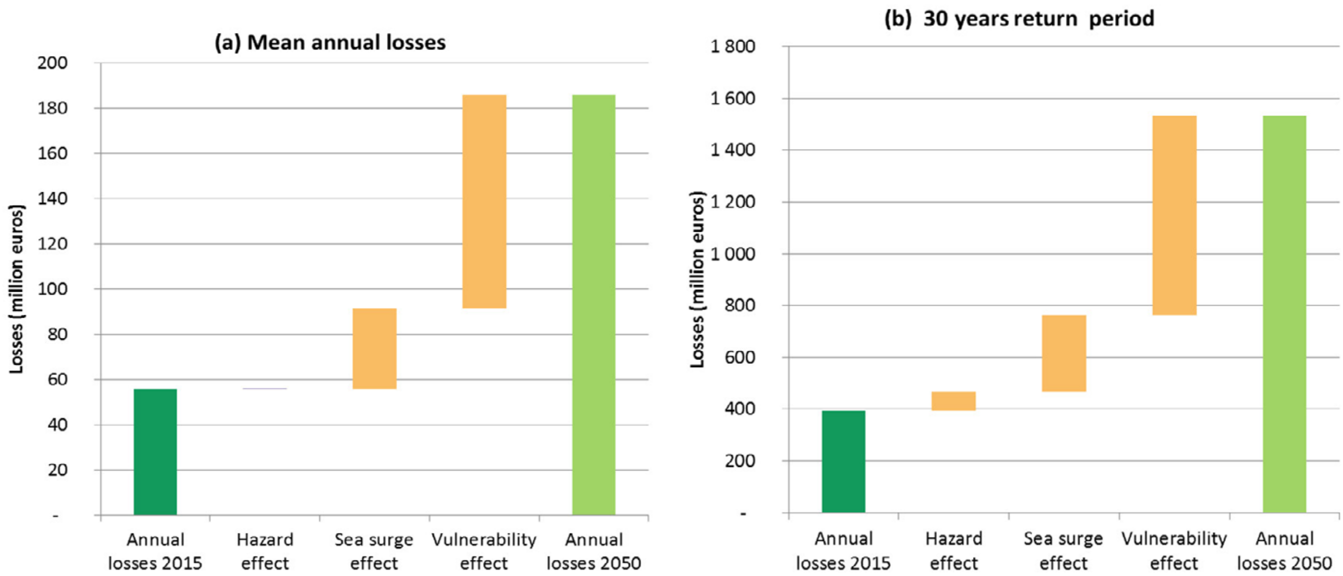


Figure 11. Storm surge - estimation of mean annual costs (a) and of costs associated with a 30-year return period (b) according to scenarios tested for costal flooding– RCP 4.5 scenario

As regards climate variation, the results presented in Figure 11 do not show clear trends towards an increase in the intensity and frequency of coastal flooding by 2050. In fact, the mean annual loss with unchanged vulnerability is stable between 2015 and 2050. At the same time, the most extreme years (with a return period greater than 30 years) would cost more.

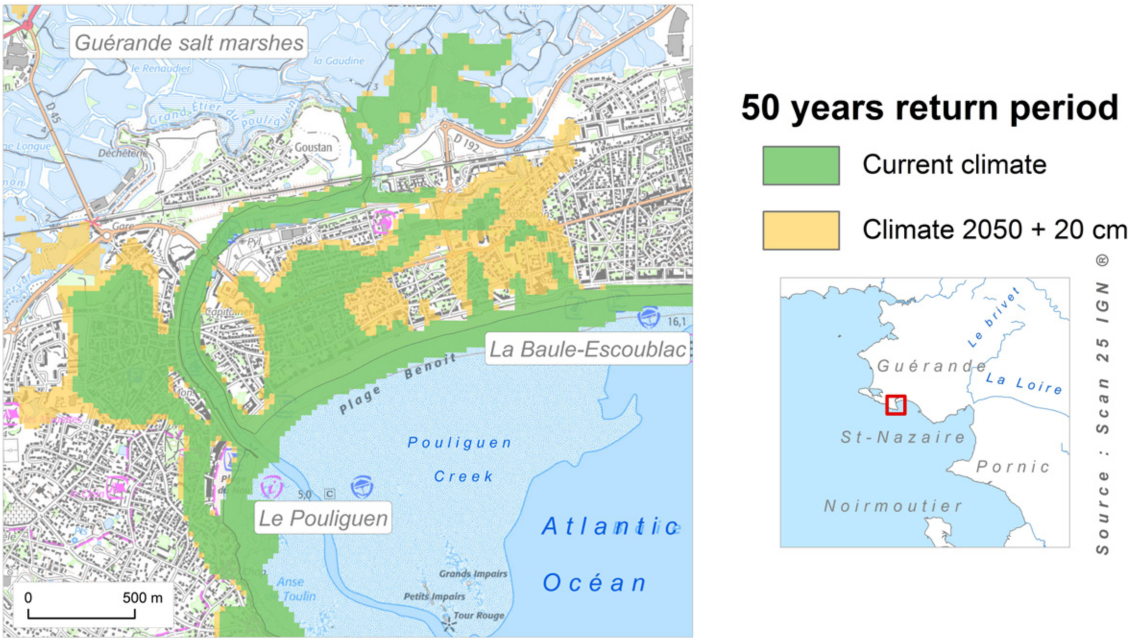


Figure 12. Illustration of fifty-year hazard in the Baie du Pouliguen area of France

However, the impact of the rise in sea level is much more visible. In fact, there is a significant increase in damage after a 20 cm rise in sea level, both in terms of average and for a 30-year return period. This is particularly true in areas of low relief. As illustrated in Figure 12, a 20 cm increase in the level of water leads to a considerable extension of flooded areas for one same return period.

However, the greatest effect in terms of estimated costs in 2050 is due to the variation in vulnerability. The results presented in Figure 11 show a very strong increase in losses, both in terms of annual average and for a 30-year return period. This increase is caused by two factors: the increase in insured values and the increase in population. This increase in vulnerability, which is particularly marked in Départements of western France, as shown in Figure 7, could have very marked repercussions on the cost of coastal flooding in 2050.

3.3 Drought

Figure 13 shows the variations in terms of soil moisture, quarterly averaged, which could be induced by a climate change as characterised in the context of our study. During the winter period, the overall trend is a slight drying-up of soils in the eastern half of France. In spring, only the south-eastern part would experience drying-up of soils while a large western half of France is much wetter. In summer, France appears to be divided in two between the north and south, with wetter soils in the north and drier in the south. Lastly, the autumn period does not exhibit any notable variation in soil moisture.

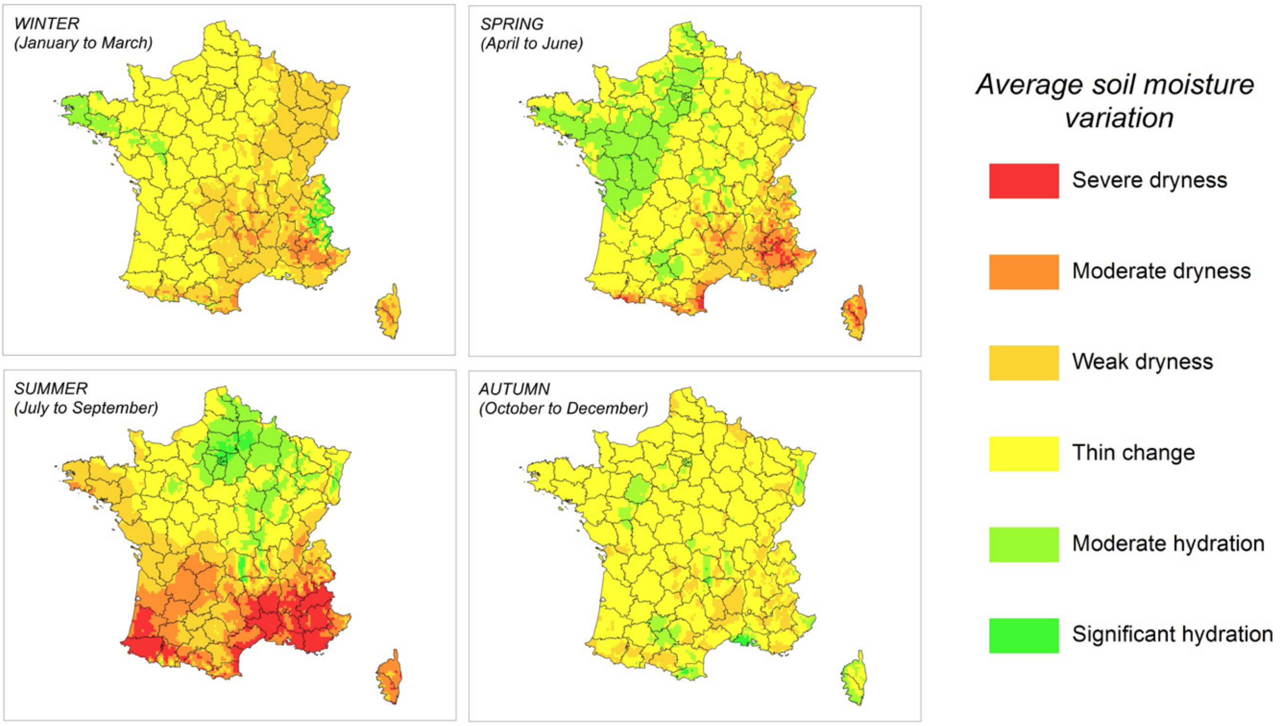


Figure 13. Variation in soil moisture averaged by quarter as part of the modelled climate scenario

The insurance costs borne by the natural disaster scheme could increase by 2050 with an annual average of ~114% (Figure 14). This significant increase is mainly due to the vulnerability evolution and in particular to the estimated insured values of houses, which are almost exclusively the only line of business affected by drought.

For houses, the variation in insured values is estimated at +97% by 2050 for France mainland and up to +136% in some specific areas. The intensification of the drought hazard in the context of climate change would only account for 3.1% of the increase of mean annual losses on the scale of France mainland. However, leaving aside the variation in vulnerability, there are major regional contrasts (Figure 15): the southern half of France is clearly more exposed to future drought, particularly in the areas around the Pyrenees and the Alps.

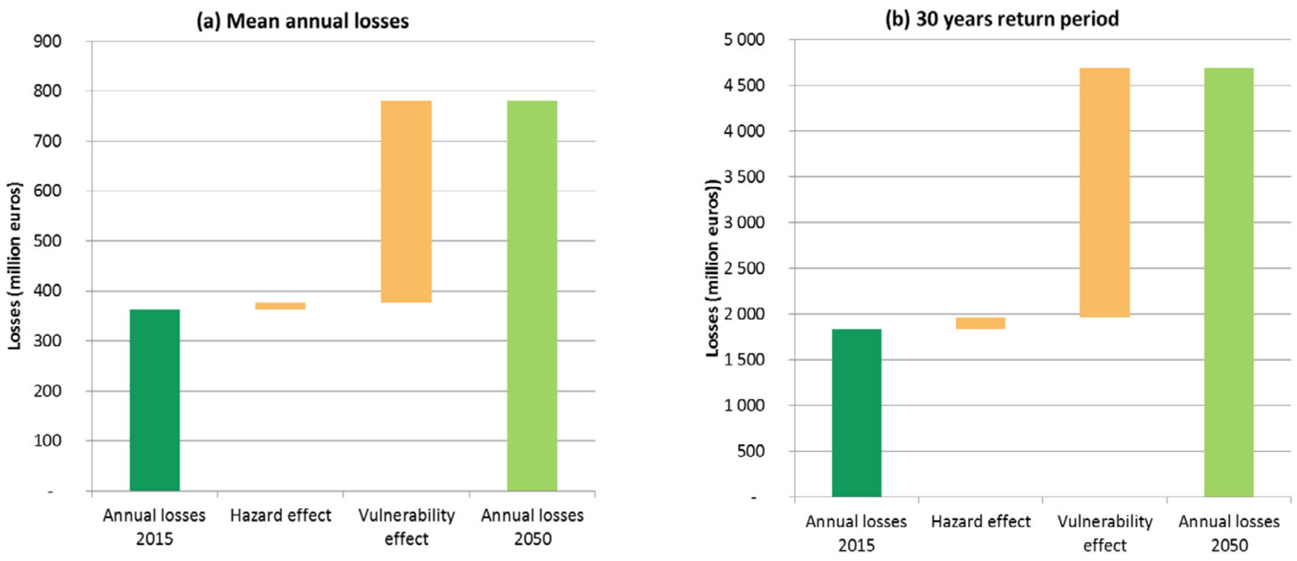


Figure 14. Variation in mean annual losses (a) and 30-year losses (b) for drought – RCP 4.5 scenario

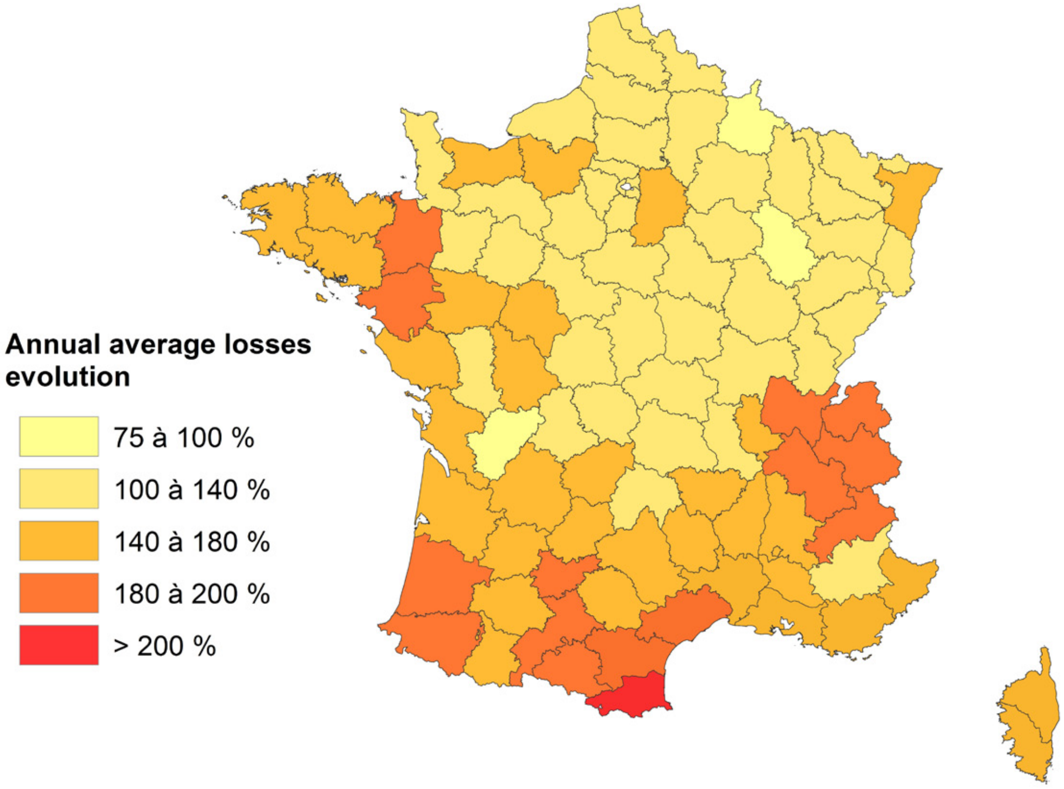


Figure 15. Variation in mean annual losses by Département for drought

The regions most affected by drought are located in southern France. In this region, we also model an increase in floods. These results are not incompatible, since the heavy precipitation occurs during short periods (a few days) and, on the other hand, drought lasts for longer periods.

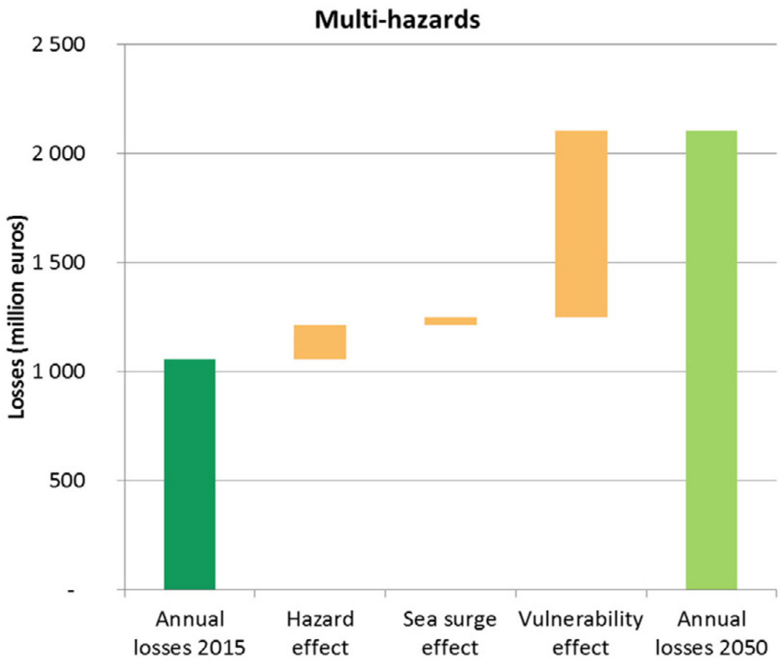
3.4 Results for multi-hazards

One of the specific features of the natural disaster scheme is that it covers many hazards of climatic origin: flooding by river overflow and by surface run-off, rising water table levels, storm surge, hurricanes, drought, etc.

Most existing natural disaster models are developed for a specific hazard/geographic area. To obtain results for several hazards, it is usually accepted that a hypothesis of independence is devised in order to total annual losses in a random manner.

The originality of the approach presented here is that it models the impacts of the three hazards that are studied on the basis of a single set of climate data obtained from the Météo France model. As a result, the occurrence of events is a response to climatic conditions that are common to the hazards.

The graph in Figure 16 shows the accumulated effect of the hazard, of the rise in sea level and of the vulnerability for the three modelled hazards. The principal factor of increase in mean annual losses for the three climate risks is the increase in vulnerability.



Variation in mean annual losses totalled for the three modelled hazards – RCP 4.5 scenario

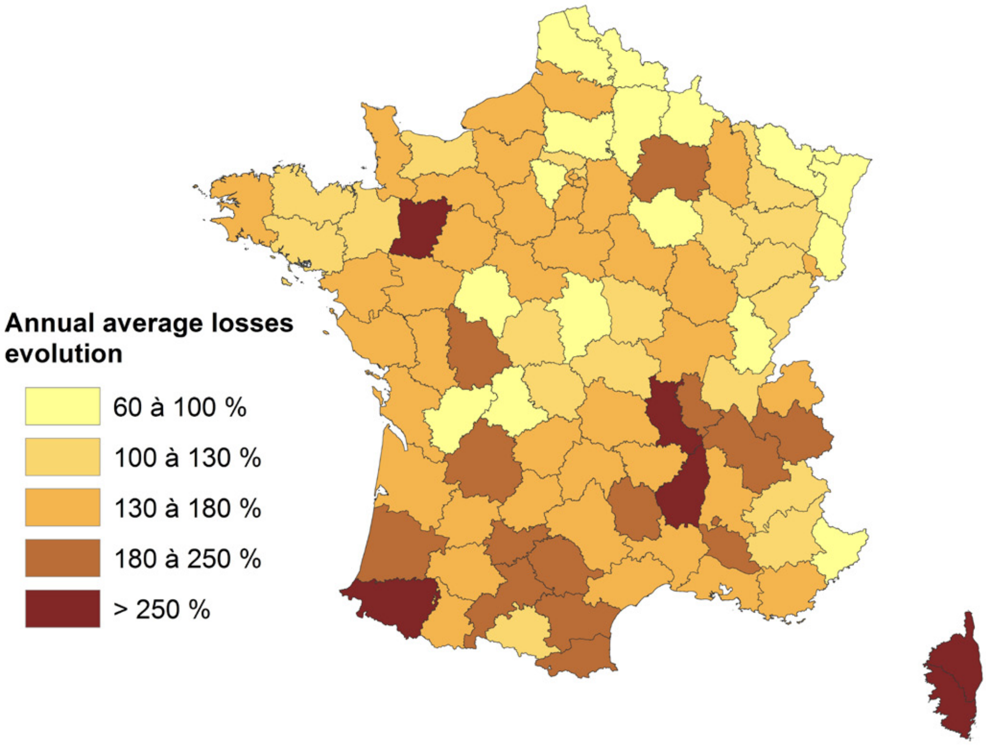


Figure 17. Variation in mean annual losses totalled for the three modelled hazards

3.5 Effect of geographical distribution of insured property in 2050

On the basis of the modelling results, we studied the variation in geographical distribution of values between 2015 and 2050.

Figure 18 shows, for the different perils, the proportion of the increase in mean annual losses that is explained by insured values increase and the proportion resulting from the geographical distribution of population. These results reflect the increase in population and in the number of professional risks in the exposed areas.

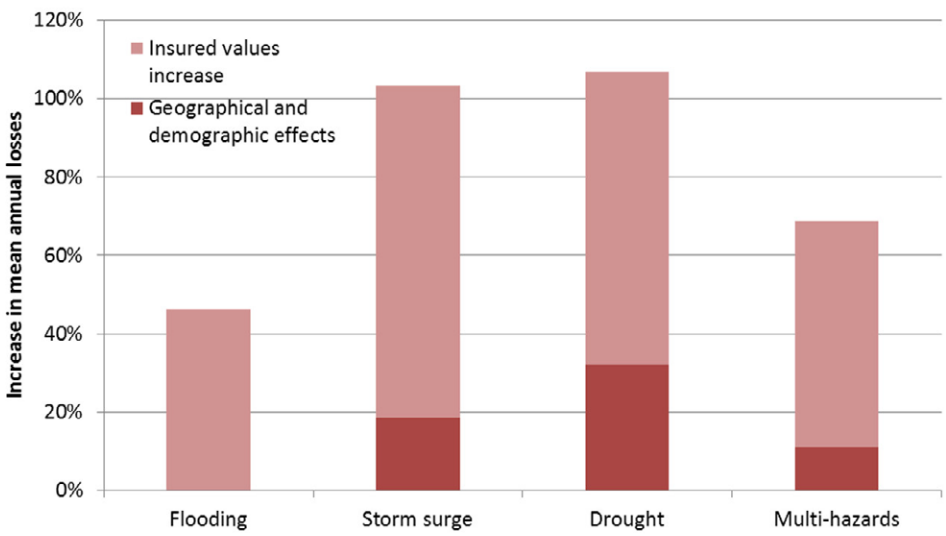


Figure 18. Effect of geographical distribution of insured property on mean annual losses according to simulated climate risks

The variation in geographical distribution of property has especially had an impact on drought and storm surge hazards. In fact, the increase in insured values is especially concentrated in coastal areas and in southern France, which are greatly affected by these two hazards. As regards flooding, the geographical variations in insured values offset each other across the country as a whole.

4 Conclusion and future prospects

The work completed by CCR, in association with Météo France, to evaluate the financial impact of climate change on the natural disaster scheme on the basis of the IPCC's RCP4.5 scenario has led to the identification of the initial trends.

Overall, the natural disasters loss experience in metropolitan France caused every year by the main climate events covered by the natural disaster scheme should **double by 2050**.

This increase is mainly related to the change in the **insured values** and their geographical distribution (**around 80% of the forecast increase**).

The results of this study show that **climate change** would also have an impact on the loss experience, since it would explain **around 20%** of the increase that is forecast to occur by 2050.

If, for each hazard, we examine the increase in mean annual losses due to the effect of climate change, apart from the increase in vulnerability, then we obtain the following results:

- Flooding by river overflow and surface run-off: 20% increase, mainly related to the increase in events in the Cevennes Mountains area;
- Storm surge: more than 60% increase, mainly related to the rise in sea level (+20 cm by 2050, according to the chosen IPCC scenario);
- Drought: losses would remain constant on the national level, but major regional disparities are revealed by the study on a fine scale.

Currently, the study of storm surge only concerns the Atlantic coast. Subsequently, it will be necessary to extend modelling to the Mediterranean coast.

From a methodological viewpoint, for the first time, this project combined an overall large-scale climate model with several models of impacts that operate with very fine spatial resolution.

The choice of the "target" year for the study is fundamentally important. The year 2050 was chosen. Above and beyond climate change and the uncertainties inherent in long-term projections, the question of vulnerability was a stumbling block. This is because there are too many uncertainties in projections of population and of the variation in the values of insured property beyond 35 years.

The choice of the scenario is also a key point. On the advice of Météo France, CCR opted for a median scenario (the RCP 4.5), optimistically envisaging a positive effect of negotiations currently in progress concerning climate.

The simulated number of years remains a preponderant factor of the stability of results. The average is sensitive to the number of years, but is more sensitive to the extreme values (ten-year losses, fifty-year losses, etc.). In our case, the 200 years of climate are important, but may be insufficient to represent accurately the most extreme possible events.

Therefore this study will continue in 2016, taking into account a larger number of simulated years as well as other climate scenarios.

The model does not take into consideration the variation in preventive measures and the organisation of risk prevention plans in the future. Therefore this study is based on constant protection works.

Once the contribution of climate simulations are clearly evaluated, we may widen the already available database in several directions:

- extension of simulations already performed with the same configuration of the model: an extension of the simulations already performed would widen the sample of extreme events with more variety in configurations of atmospheric conditions;

- production of an additional simulation with the RCP6.0 hypothesis of climate variation incorpora ting more severe radiation forcing (+6.0W/m2 in 2100);

- implementation of a new version of ARPEGE Climat, including prognostic physics, to better repre sent cloud cover and convection, with 91 levels of vertical resolution and 12 km of horizontal resolu tion for Europe.

The operational use of the data provided by the simulations can be developed by supplying the (non-uniform) ISBA model for producing new parameters that are indicators of the risks of agricultural drought, such as potential evapotranspiration and water reserves in the soil.

What lessons can be learned from this study for the natural disaster compensation scheme?

These results show a probable notable increase in the cost of loss experience related to climate events, due to an increase in insured values combined with climate change. The question can justifiably be asked whether the natural disaster compensation scheme is able to adapt to this extra cost.

Even if losses compensated with respect to climate risk are destined to increase in the future, the scheme's balance is not fundamentally modified since premiums will change to reflect changes in insured values, which account for most of the expected increase in loss experience.

Until now, this natural disaster compensation scheme, which is unique, has proven its effectiveness. It has made it possible to provide compensation for all events that have occurred since more than 30 years ago, including some years that were particularly impacted by natural disasters, such as 1999, 2003 and 2010. These years of exceptional loss experience prove its reliability and show that it could cope with climate change. Some moderate tariff adjustments may prove necessary, but they will be all the more contained if prevention is developed in all its forms and with the participation of all the players involved.

References

Guillou N., Chapalain G., 2011 : *Effects of the coupling between TELEMAC2D and TOMAWAC on SISYPHE modelling in the outer Seine estuary*. Presented at the XVIIIth TELEMAC & MASCARET User Club, p. 51–58

Hervouet J.-M., Van Haren L., Electricité de France, 1996 : *TELEMAC-2D Version 3.0 principle note*. Rapport EDF HE-4394052B, Chatou, p. 1-98

IPCC Climate Change, 2013 : *The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 p.

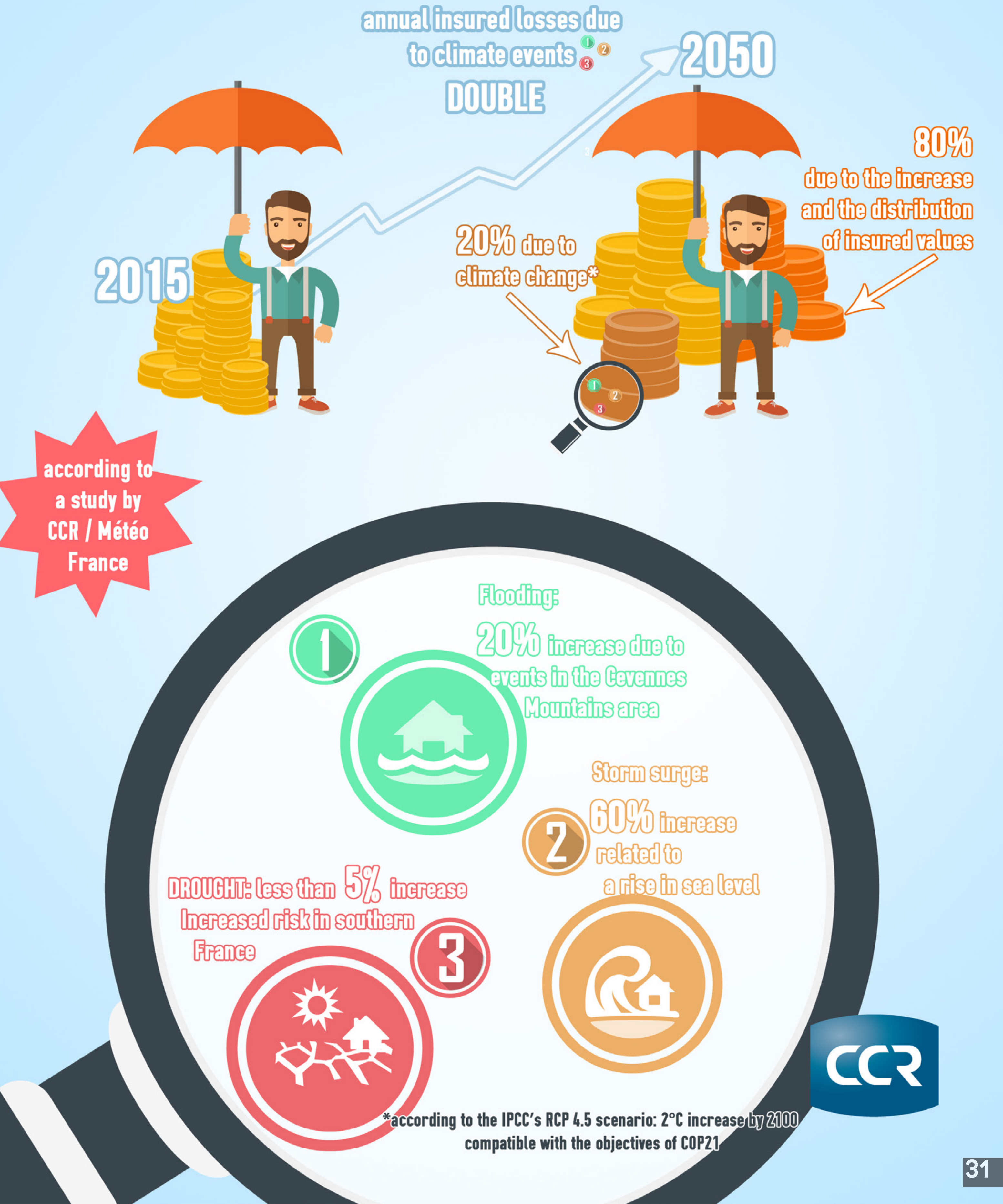
Moncoulon, D., Labat, D., Ardon, J., Leblois, E., Onfroy, T., Poulard, C., Aji, S., Rémy, A., Quantin, A., 2014 : *Analysis of the French insurance market exposure to floods: a stochastic model combining river overflow and surface runoff*. Natural Hazards and Earth System Science 14, p. 2469–2485

Naulin J.-P., Moncoulon D., Le Roy S., Pedreros R., Idier D., Oliveros C., 2015 : *Estimation of insurance related losses resulting from coastal flooding in France.* Natural Hazards and Earth System Sciences Discussion., 3, p. 2811-2846

ONERC, 2014 : *Le climat de la France*, Volume 4. Scénarios régionalisés : édition 2014 pour la métropole et les régions d'Outre-Mer, 64 p.

ONERC, 2015 : *Le climat de la France*, Volume 5. Changement climatique et niveau de la mer : de la planète aux côtes françaises, 70 p.

FINANCIAL IMPACT OF CLIMATE CHANGE
on the French natural disaster compensation scheme



Notes

Production of the study

Study coordinators

David Moncoulon (CCR)
dmoncoulon@ccr.fr

Martine Veysseire (Météo France)
martine.veysseire@meteo.fr

Project team

Jean-Philippe Naulin (modelling of storm surge), Pierre Tinard (modelling of drought), Zi-Xiang Wang (modelling of floods)
Jérémy Desarthe, Chadi Hajji (projections of vulnerability in 2050)
Fabienne Régimbeau (ISBA Météo France modelling)
Thomas Onfroy (Geomatics - cartography)

Press Contact

Isabelle Delval
idelval@ccr.fr
Tél : +33 (0) 1 44 35 37 01

www.ccr.fr

@CCR_Reassurance

CCR Réassurance

CCR ™
Caisse Centrale de Réassurance
157 boulevard Haussmann 75008 Paris - France
Tél. : +33 1 44 35 31 00 - www.ccr.fr
SA au capital de 60 000 000 € - 388 202 533 RCS Paris