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EUropean CLimate and weather Events: Interpretation and Attribution

Deliverable D4.3

Empirical working paper: commercial dimension of attribution products

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1. Executive Summary

Work task 4.3 demonstrates how to "provide […], well verified, well understood assessments" (DOW part B, p.4) from extreme event attribution (EEA) for the insurance industry. It thereby represents a proxy for commercial interests in extreme event attribution. The study builds on an adapted concept for evaluating climate services (see deliverable D4.2 for details), is influenced by the empirical findings of work task (WT) 4.2, and follows a harmonised methodology along the lines of what was proposed in milestone M2.

The review of the literature reveals that extreme weather events have to be considered as key concern to the insurance sector today and even more so in the future. This is often not only consequence of a growth in exposed value, but of climate change. A review of the German and French natural hazard insurance systems reveals that climate change has been debated early on for the insurance sector, but public and private adaptation to changing extreme weather events is widely lacking to date. The review also shows that Baltic Sea storm surges are of key relevance from a general risk-, but not from an insurance perspective. Heat waves, are of relevance to the insurance sector in France, but from a quite narrow perspective: land subsidence associated to prolonged period of droughts. Yet, in France, the state guaranteed insurance against natural catastrophe. This state guarantee may be the most affected by climate change and an associated increase in the probability of extreme weather events. Overall the literature indicates that changing risk patterns, challenging risk assessments, and the evident need for adaptation pose key challenges to the insurance system. This demands a solid information base to take appropriate decisions. Whether or not an information product like extreme event attribution can form part of this base has not been thoroughly addressed in the literature so far and is thereby at the centre of this study.

The empirical findings from the Baltic Sea test case show that all of the interviewees were confident that extreme event attribution could produce important and interesting findings. Nevertheless, this statement was often followed by *'but's* like that EEA does not provide an added value to the existing information, other components of risk are more important, or that it is not applicable in existing business processes. This was not perceived to be the case for all business processes, though. Representatives from the insurance sector could well imagine that EEA would inform strategic decisions, improve risk modelling and premium calculation, and support public awareness-raising and political leverage. Despite of the fact that most of the interviewees were certain that EEA is relevant, no one was convinced that the added value of EEA is currently large enough to pay for it. Being aware of the requirements which could turn extreme event attribution into credible and relevant information products, can help overcome much of the hesitation. Overall, most of the stakeholders did not have a preference for EEA information in near-real time, particularly not if they would only be irregularly available for singular events. They rather wanted solid and reliable information which is attuned to their models and products, fits their viewpoints, and/or the results support existing objectives.

The empirical findings in the greater Paris area test case show that understanding both the regulatory environment and current actuarial practices are the key to analysing the reception of EEA by the French insurance sector. The impact of the regulatory environment is three fold. First, business operations are organised around yearly cycles – their robustness have

to be demonstrated on a yearly basis – which means that climate change is not on the radar screen. Second, insurance against extreme event is compulsory and automatic once covered by building and vehicle insurance packages (that are set by law in their basic configuration). There is little room to influence the insurers activity and the insures behaviour without revamping the regulatory environment. Third, a reform of the current framework is envisioned. On that front EEA may serve at restarting the reform which is currently stalled, it may also be of use in a carefully reformed insurance regulatory framework more attuned to challenges associated to climate change. Current actuarial practices are centred on the use of past events time series. Computing future probabilities, not based stricto-sensu on past long term time series, would be a major cultural shift. This would be justified if EEA clearly points to the fact that the current climate regime is sufficiently different (because of human influence) that it calls for an innovation as radical as EEA. Finally, the Paris case study points to a potential need for EEA being envisioned not on single events, but rather on a class of conjoint event.

2. Project Objectives

With this deliverable, the project has contributed to the achievement of the following objectives (DOW, Section B1.1):

Table 1: Contribution of the deliverable to the achievement of EUCLEIA's objectives.

No.	Objective	Yes	No
1	Derive the requirements that targeted user groups (including regional stakeholders, re-insurance companies, general public/media) have from attribution products and demonstrate the value to these users of the attribution products developed under EUCLEIA.	X	
2	Develop experimental designs and clear ways of framing attribution studies in such a way that attribution products provide a fair reflection of current evidence on attributable risk.	X (for the « framing part »)	
3	Develop the methodology for representing the level of confidence in attribution results so that attribution products can be trusted to inform decision-making.		X
4	Demonstrate the utility of the attribution system on a set of test cases of European weather extremes.	X (for the cases of Baltic Sea storm surges and heat waves/ cold spells in the Greater Paris Area)	
5	Produce traceable and consistent attribution assessments on European climate and weather extremes on a range of timescales; on a fast-track basis in the immediate aftermath of extreme events, on a seasonal basis to our stakeholder groups, and annually to the BAMS attribution supplement.		X

3. Detailed Report

3.1. Introduction

3.1.1. Deliverable 4.2 as it appears in the DOW

In the Description of Work (DoW), Deliverable 4.3 (D4.3) is described as “Empirical Working Paper on commercial dimension of attribution product using the insurance and re-insurance sectors as proxy”. Like the previous deliverables 4.1 and particularly 4.2, the empirical evidence will be drawn from two test cases:

a) German Baltic Sea coast, dealing with the threat of storm surges
b) Greater Paris area, dealing with the climatic extreme of heat waves

Work task 4.3 provides the basis for this analysis. The DoW describes that the “interests and views hold by representatives of the insurance and re-insurance industry” shall be studied in this work task. The target groups therefore comprise insurers in the Baltic Sea Region and the Greater Paris area as well as re-insurances.

3.1.2. Deliverable 4.2 against the background of work package tasks and overall project objectives

At the example of the insurance and re-insurance industry, deliverable 4.3 is meant to demonstrate at the example of one specific target group, i.e. the insurance industry, how to “provide to targeted groups of users, well verified, well understood assessments on the extent to which certain weather-related risks have changed due to human influences on climate”. It thereby represents a proxy for commercial interests in terms of extreme event attribution and to facilitate climate change mitigation and adaptation activities (DoW part B, p. 4).

Due to that, we will be able to contribute to deriving “the requirements that targeted user groups […] have from attribution products and demonstrate the value to these users of the attribution products developed under EUCLEIA” (objective No. 1, Dow part B, p.4) for one of the selected groups of potential users – the insurance sector. This will also include findings which indicate how to frame attribution studies so that they find attention (objective No. 2, Dow part B, p.4). It thereby demonstrates the utility of the attribution system at the example of storm surges in the Baltic Sea and heat waves in the Greater Paris area (objective No. 4, Dow part B, p.4)

For achieving the goals of this work task, we can draw upon the conceptual foundations laid in work tasks 4.1 and 4.2, including risk governance and evaluation approaches in the context of climate services in general and extreme event attribution products in particular. In addition, the empirical findings from the consultation of regional stakeholders in the test cases undertaken in work task 4.2 have facilitated reflecting the findings for the insurance sector against the background of regional stakeholder needs and requirements. In combination with the methodological basis that has been set in Milestone 2, we have been able to formulate an expedient methodology for WT 4.3. This also includes testing the “fake

fact sheet" which was developed as part of Milestone 1 ("*Suitable description of the envisaged product of event attribution*").

3.1.3. Report outline

In the following report, we will first provide an overview of relevant concepts and the contextual background. This comprises a review of the literature about the insurance and re-insurance sector in light of changing risks of extreme weather events as well as information about the insurance sectors in the German Baltic Sea and the Greater Paris test cases. In the subsequent section, the harmonized methodology will be described including details about the interviewing process at HZG and UVSQ. In sections 3.4 and 3.5, the results of the empirical work undertaken at HZG in the German Baltic Sea test case and the results from the Paris test case will be presented. The discussion of results against the background of previous work packages, existing literature and chosen methodology will follow in the final section of the report.

3.2. Literature review – relevant concepts and contextual background

3.2.1. Conceptual basis

Deliverable 4.3 will draw on the conceptual basis provided in D4.1 and D4.2. In D4.1 we argue that risk governance and risk perception approaches as proposed by Renn and his co-authors [see e.g. *Renn*, 2008] indicate *how* information products such as the ones envisaged by EUCLEIA may feed into decision-making processes for risk management, adaptation and mitigation. In 4.2, we refer to concepts explaining *why* scientific (climate) knowledge feeds in stakeholders' decision-making by assessing the factors which influence the perceived usefulness of such information [see e.g. *Cash et al.*, 2002; 2003; McNie 2013; von Storch, Meinke et al. 2011; Krauss and von Storch 2012; Lemos et al. 2014].

3.2.2. The insurance and re-insurance sector in light of changing risks of extreme weather events

Insurances are means to transfer risks of losing assets and livelihoods. Most essential are insurances and re-insurances when the potential financial burden of loss is too large to bear for an individual or entity [*Warner et al.*, 2013]. Statements like that "no one understands risk better than the insurance industry - except, perhaps, the reinsurance industry, the companies that sell insurance to insurers […]" illustrate the large interest in risk-related information of this industry well [The New York Times, 27.08.2013]. Among the 'understood' risks for this industry are also extreme weather events in a changing climate, which are at the centre of interest in EUCLEIA. Extreme weather events commonly cause considerable damages to a large amount of people at a time and thereby lead to so called accumulation loss. Events like hail, winter storms, and heavy rainfall are the most common natural hazards mentioned in the insurances context in Europe. Also less considered hazards like storm surges in the Baltic Sea and heat waves in the Greater Paris area, which are dealt with in the EUCLEIA test cases, are essential to be considered when it comes to a comprehensive view on the "insurance sector as a proxy to commercial interests". Both hazards have caused significant accumulation loss and have affected the life and health of hundred thousands of people in the last decades. Damages from these and other meteorological extremes have increased steadily and it is very likely that this trend continues. This is not only consequence of a growth in value and more property in exposed areas, but it is also caused by climate change.

Climate change was recognised by the insurance industry already at a time when nearly any other entity showed interest in it. The Munich Re was the first big company to warn about global warming as early as in 1973. The re-insurance company observed at that time that flood damages had increased and it feared that a continuation of this trend would threaten its business [*Reguly*, 2013; *Send*, 2015]. Since then, many studies have enforced this fear giving rise to critical and controversial discourses, as for instance, about the future insurability of meteorological extremes [*Send*, 2015]. It has been revealed that the insurance and re-insurance sector has to face significant challenges due to global warming and an increased likelihood and intensity of many extreme weather events all around the globe [*IPCC*, 2014]. According to the Geneva Association, climate change has "effectively caused

a shift towards a 'new normal' for a number of insurance-relevant hazards" [*Geneva Association and others*, 2014]. Key challenges comprise in particular that:

- The risk potential from extreme weather events continues to increase. Events are likely to become more frequent and intense by simultaneously increased values and property holdings in exposed areas. This needs to be factored in existing business models and processes.
- The predictability of extreme events and related impacts will further decrease (e.g. scenarios of multi-hazard occurrences and cascading effects of single events). A paradigm shift from risk analyses based on observation of past trends to predictive, scenario-based approaches is therefore needed.
- The necessity for private and public preparedness is larger than ever. A key challenge for the insurance sector therefore is to raise the public awareness that risks are changing and so is the need for appropriate insurance solutions and individual adaptation actions. A coupling of risk transfer and risk mitigation becomes thereby essential [*Geneva Association*, 2014; *Send*, 2015; *Welp et al.*, 2011].

The insurance sector needs to adapt to these climate change-related challenges. Commonly named measures in the literature are: adapting premiums, limiting insurance coverage for specific extreme events, political leverage, fostering paradigm shifts in risk calculation, establishing new incentive systems to increase clients' adaptation, investing in research on extreme events and climate change, and developing new business models like risk consulting [*Mauelshagen*, 2013; *Surminski et al.*, 2014; *Welp et al.*, 2011].

If "no one understands risk better than [this] industry", as the quote above indicates, investments in appropriate and solid information about climate change-related changes in extreme events seem essential for the insurance and re-insurance sector to face the challenges and grasp potential opportunities. Novel information products describing the changes in the likelihood of extreme events due to anthropogenic changing climate could be part of that.

➔ *Central hypothesis: Suitable products of extreme event attribution are able to meet commercial interests of the insurance sector*

Along these lines, EUCLEIA considers the insurance and re-insurance sector as potential user of extreme event attribution products and thereby a proxy for commercial interests in general. This will be illustrated at the example of the two test cases of storm surge risks in the German Baltic Sea region and heat wave risks in the Greater Paris area. In the following, the insurance sectors in both test cases will be outlined to understand the specific challenges and elaborate hypothesis on the potential need for extreme event attribution and its relevance to meeting commercial interests of the insurance sector.

3.2.3. The insurance sector in the German Baltic Sea test case

Germany has a system of free market natural hazard insurance with ad-hoc governmental relief programs. This means that natural hazard-related damages are, on the one hand, insured by private insurance companies as supplement to basic loss insurance for building or house/apartment content of private sector entities and individuals. On the other hand, there are cases, when the German Federal Government compensates for some of the

losses with relief programs, mainly after larger extreme events. Prominent examples of ad-hoc relief programs in Germany were the large river floods in 2002 and 2013. However, the circumstances which allow such programs and the extent to which different individuals and entities receive support, is not regulated under German federal legislation to date [*Keskitalo et al.*, 2014; *Porrini and Schwarze*, 2014]. Insurance companies demand from the government at federal and state level beside a better predictability of such decisions, also tax benefits for and public investments in natural hazard protection and precaution measures [*Keskitalo et al.*, 2014]. If there was solid proof that floods like the ones in 2002 and 2013 - popularly known as *once-in-a-century events* - happen once every decade in a changing climate, it should be inevitable that legally binding regulations for such instances exist and it should provide incentives to foster public and private adaptation.

➔ *Hypothesis (added value): Extreme Event Attribution can strengthen the motivation to issue regulations at the national and federal state level (particularly in the aftermath of an extreme event) if it reveals that this historically very rare event has become a common event today. The insurance sector would benefit from a higher predictability of legal decisions, more governmental support for risk mitigation actions, and higher demand for natural hazard insurances.*

Regulations and the prevalence of natural hazard insurances in Germany are different depending on the federal state [*Keskitalo et al.*, 2014; *Porrini and Schwarze*, 2014]. In most of the states, some natural hazard induced damages to houses and its content were, historically, included in a voluntary insurance which covered fire, storms, and hail. Since 1992, people were able to also include an optional, more comprehensive natural hazard insurance scheme for an extra premium, the so called "*Elementarschadenversicherung*". It covers damages from floods, earthquakes, landslides, subsidence, avalanches, and volcanic eruptions. Exceptions to this development were the federal state of Baden Württemberg and the former German Democratic Republic. Up to the beginning of the 1990s, a system of mandatory natural hazard insurance for buildings existed in these regions [*Arendt*, 2013; *Seifert et al.*, 2013]. In consequence, the market coverage for natural hazard insurances is still considerably higher there than in the rest of Germany. The share of buildings which is insured for natural hazard-related damages is, for instance, as high as 95% in Baden Württemberg and as low as 15% in Bremen. On average in Germany, the number of people holding an *'Elementarschadenversicherung'* has increased continuously in recent years from less than 20% in 2002 to 38% in 2015 [*GDV*, 2015a, 2015b]. Schleswig-Holstein and Mecklenburg-Vorpommern, the Federal States at the Baltic Sea coast, still show comparably low shares, however. In 2013, only 15% respectively 21% of the buildings were insured for natural hazards [*GDV*, 2013a]. Large extreme events in recent years, like the storms Christian and Xaver in 2013 which caused large damages in these regions, might be one reason why the natural hazard insurance coverage went up by 3 respectively 2 percentage points.

The generally rather low rate of natural hazard insurance coverage in Germany is partly caused by a comparably low risk perception. A representative survey of the GDV (German Insurance Association) revealed that 90% of the German population thinks that the likelihood of them being affected by natural hazards is low [*GDV*, 2013b]. This does not only reduce the demand for natural hazard insurances, but also fosters adverse selection, according to Arendt et al. [2013]. This means that mainly house owners in risk-prone areas buy natural hazard insurances, whereas people in low risk areas are less likely to do so. This will

increase premiums and will in turn reduce the incentives of less affected households even more.

Risk perception in terms of meteorological events is likely to increase as the occurrence of extreme events increases in light of climate change. Not only does the confidence in detection of changes increase, but also the belief that these changes can be attributed to human activities. A representative survey initiated by the AXA insurance group revealed that Germany is the European country with the highest rate of respondents (87%) who believe that human activities are the main cause of climate change [*AXA Konzern AG*, 2012]. A study of the German Federal Environment Agency (UBA), however, pointed out that insurance clients are still not sufficiently aware of the nexus between insurances, natural hazard-related damages and climate change [*Hoffmann and Welp*, 2011]. Stott et al. [2013] argue that Extreme Event Attribution can be "the essential bridge between monitoring and prediction services**,** that puts recent weather and climate conditions into a longer term context and relates what has just happened to likely future of such an event happening". It might therefore be means to overcome the lack of awareness and increase risk perception of insurance clients.

➔ *Hypothesis (added value): Extreme Event Attribution might be able raise the awareness of the population that extreme events like the floods in 2013 are more likely today than in the past and can thereby increase the motivation to enter into a natural hazard insurance contract. The insurance sector would benefit from an increased demand for natural hazard insurances and a lower risk of adverse selection.*

In addition to low risk perception, many people seem to think that their house is not insurable against, for instance, flooding. A look into the German Flood Zoning System ZÜRS, however, shows that 99% of all houses *are* insurable [*AXA Konzern AG*, 2012]at lower costs than most people expect [*GDV*, 2013b]. Moreover, many people seem to think that the state will pay for losses after major disasters happen. As outlined before, it is, however, not regulated under German federal legislation which conditions justify a relief program and it is commonly the case that payments are only received if a prove of non-insurability is at hand [*AXA Konzern AG*]. Storm surges were not insurable for a long time. Since a couple of years, possibilities to be insured for it exist so that non-insurability holds now true for an only small share of the population. Overall, it seems that various misperceptions are widespread and influential.

From the insurer's perspective, it is not only an increase in demand for natural hazard insurances that is of importance, but a reduction of the risks. Storm surges and flood risks are, for instance, determined by public water and flood management. Keskitalo et al. [2014] found, in this context, that a widespread lack of awareness of these institutions hampered taking effective measures. The level of awareness as well as technical capacities among public water administration is unevenly distributed between the ones who were affected by floods in the past and the ones who were not. Among the latter, there seems to be a larger reluctance to collaborate with the insurance industry and less effective measures taken. Similarly, also the risk perception and capacities of the population is found to be lower if no major event happened in the recent past, as is the case for storm surges at the Baltic Sea. Extreme Event Attribution might show that anthropogenic climate change has increased the

chances of being hit by an extreme event, like the floods in Passau in 2013, also right on the doorstep of the ones who were not affected by such an extreme before.

➔ *Hypothesis (added value):* *Extreme Event Attribution can raise awareness of public and private actors which have not been affected by extreme events in the recent past, as is the case for Baltic Sea storm surges. The insurance sector would benefit from an increased demand for natural hazard insurances and better cooperation with public authorities.*

The federal states have tried to raise the overall share of insurance coverage and private risk mitigation measures with public campaigns for natural hazard insurances. 8 out of 16 Federal States have initiated such programs – the federal states at the Baltic Sea coast were not among these, however. The storyline of an increased risk of extreme events due to climate change has been used in most of these campaigns - also by taking extreme events of the recent past as an indication for a changing climate. The campaign of Saxony "Das Wetter spielt verrückt. Sachsen sorgt vor[1]" states in the official brochure that "the extreme weather events of the recent past reveal clearly that climate change does also not spare Saxony" linking it amongst others to the floods at the river Elbe in 2002 and the tornado in Großenhain in 2010 [*Freistaat Sachsen*, 2012]. Lower Saxony has a campaign called „Klimarisiko sehen – elementar versichern" also using recent extreme events as prove of climate change. The first lines in the brochure are as follows "Storm Kyrill or summer floods at the river Elbe: extreme weather events have increased in the recent past. Scientists trace this back to climate change" [*Niedersächsisches Ministerium für Umwelt*, 2012]. Also insurance companies increasingly engage in climate initiatives or issue awareness-raising campaigns. To do so, they make use of the extreme weather events and climate change nexus. The General Cologne Re, for instance, titled in a report "Flood catastrophes - signifiers of climate change?" already back in 2002 [*General Cologne Re*, 2002]. The Axa Insurance Group states in one of their brochures "Climate- and weather experts are in agreement: Due to a changing climate, also Germany will have to experience more extreme weather events and natural catastrophes. A powerful example was the flooding in wide areas all over Germany in early summer 2013" [*AXA Konzern AG*]. These examples illustrate that the extreme weather event and climate change nexus which can be manifested by extreme event attribution is used in public relations activities relevant to the insurance sector already today– yet mostly only if it supports the assumption that climate change increases the risks of extreme weather events and without referring to extreme event attribution or having solid scientific proof.

➔ *Hypothesis (fields of application):* *Extreme Event Attribution can add to public campaigns and political leverage if it illustrates the necessity to take action. The insurance sector would benefit from an increased demand for natural hazard insurances.*

Despite of the awareness-raising efforts, the share of houses which is covered by an 'Elementarschadenversicherung' is still low in many regions of Germany, also at the Baltic Sea Coast. One of the reasons may be the fact that the natural hazards which are considered as insurable "Elementarschaden" are of minor importance in Northern Germany (e.g. earth quakes, landslides, avalanches, and volcanic eruptions), whereas storm surge, a potential extreme event in this region, is not covered by the majority of natural hazard

[1] The weather acts up. Saxony gets prepared for it.

insurances. There are only two private insurance companies which provide an insurance scheme for storm surge-related damages, IAS and Itzehoer insurances.

This can be explained by the general insurability problem of *low-probability high-impact events (*Kron, 2009 cited in [*Seifert et al.*, 2013]*).* Events like storm surges are rare, but characterized by high accumulation loss, meaning that a large amount of people is affected after a single event. This is most likely in regions where value concentration is high and coastal protection measures are sparse. Both are the case at the Baltic Sea coast. Moreover, the risk group is comparably small meaning that there are only few people who are exposed to Baltic Sea storm surges and therefore interested in insuring related damages [*DKKV*]. A further barrier of implementing storm surge insurance schemes is the fact that risk modelling and premium calculation is very challenging. Arendt et al. [2013] argue that these are typical conditions leading to an adverse selection at the supply side of the market, meaning that insurance companies are reluctant to provide appropriate means of risk transfer in areas where the need for it is high. If insurances could prove that climate change has significantly increased storm surge hazards, it might raise public acceptance and provide legitimacy for not offering storm surge insurances schemes in exposed areas or asking high premiums.

➔ *Hypothesis (fields of application): Extreme Event Attribution can influence the motivation to provide storm surge insurances in exposed areas and/or raise premiums. The insurance sector would benefit in strategic decisions from a legitimization of higher premiums or of not providing storm surge insurance schemes.*

A precise definition of risk is essential to calculate risk. The Swiss Re model of storm surge risk requires, for instance, information about the hazard, i.e. “Where, how often, and with what intensity do events occur?”, vulnerability, i.e. ”What is the extent of damage at a given event intensity?”, the value distribution, i.e. ”Where are the various types of insured objects located and how high is their value?” and the insurance conditions, i.e. “What are the conditions of the insurance coverage?” [*Gaslikova et al.*, 2011]. For rare extreme events, like in the Baltic Sea case where very severe storm surges occurred only a few times in history, such assessments are particularly difficult. The Itzehoer Insurance, one of the insurance companies offering storm surge coverage, assumes that statistically “a storm surge is to be expected every 14 to 15 years at the North Sea Coast and merely every 41 years at the Baltic Sea coast [SHZ, 26.09.2014]. This means that information about vulnerability characteristics cannot or only marginally be based on observations, have to rely on models, and are attached to large uncertainties. Both the Itzehoer Insurance and IAS had to rise to this challenge to implement their insurance scheme for storm surge risks. The Itzehoer Insurance developed a storm surge model in cooperation with Aon Benfield. Based on hundreds of thousands of scenarios in a probability based model, they plan with an average of 95 million Euro storm surge damages per year and a 0.5 percent probability of a storm surge event with damages of over two billion Euro [Die Welt, 20.01.2012].

For regulating when insurance covers damages, defining the extreme weather event is important. IAS defines a storm surge as follows: “*Als Sturmflut (Storm Tide) bezeichnet man die Überflutung von trockenem Land durch akuten Anstieg von Flutwellen in Küstengebieten, in Buchten oder Binnengewässer mit Verbindung zum Ozean oder Meer, infolge eines Sturms oder Unwetters mit einer Windstärke von mindestens 8 Beaufort (Bft), wobei das Wasser die lokale Durchschnittshöhe für Hochwasser an der Nordsee um mindestens 1,5*

Meter und den mittleren Meeresspiegel an der Ostsee um mindestens 1 Meter übersteigt. Dabei gilt, dass der Meeresspiegel nicht unbedingt die Höhe eines Dammes übersteigen muss, um Schaden anzurichten. Eine Sturmflut muss vom Bundesamt für Seeschifffahrt und Hydrographie (BSH) festgestellt werden[1]" [*IAS*, 2014].

Risk modelling provides the foundation for premium calculation. IAS state in their terms of contract that premiums are based on the distance to the sea, the name of the water body (North Sea, Baltic Sea, River), existing private and public measures (dikes, retaining wall, retention basin, backflow trap), and the claims history [*IAS*, 2015]. The Itzehoer Insurance states that storm frequency, wind speeds, tidal sea levels and wave heights are included in their model and considered against the background of the existing coastal protection system [Die Welt, 20.01.2012]. For extremely rare events like storm surges it may not be possible to use observation data. Model data based on past observations may, as stated in the previous section, not be sufficiently able to represent current and future risks. Extreme event attribution can provide return periods of extreme events which occurred in the recent past.

➔ *Hypothesis (field of application): EEA can improve risk modelling and premium calculation. The insurance and re-insurance sector would benefit from more appropriate premiums and would thereby reduce business risks.*

Specific requirements of the insurance sector with respect to extreme event attribution have not been studied extensively so far, particularly not for the case of the German insurance industry. Stott and Walton [2013] have included the insurance industry in their study assessing stakeholder needs in terms of extreme event attribution. A workshop of theirs which included representatives of the insurance sector indicates some specific requirements which might also be of interest to this test case. They found that long-term developments and specific patterns of an event are more relevant to insurers than assessing single events. The nature and type of extreme event assessed also played a role to the people in the workshop. In addition, the tolerance of uncertainty seems very low in this sector causing hesitation of the participants to use data with uncertainty levels as high as in case of EEA.

➔ *Hypothesis (requirements): Stakeholders from the insurance sector require extreme event attribution products which are available over a long time period, for specific extremes, and which are attached to small uncertainties.*

Another requirement can be drawn from an analysis of existing insurance campaigns and reports. The literature review shows that climate change scenarios for the insurance sector are linked more to the associated damages than to meteorological parameters. The German Insurance Association states, for instance, in its report on climate change scenarios for the insurance sector in Germany that "flood damages which occur today every 50 years and cause damages of around 750 million Euro could become double as expensive" in 2100 under the IPCC A1B Scenario [*Gerstengarbe*, 2011].

[1] Storm Tides are known as a flooding of dry land because of acute rise of tidal waves in coastal areas, bays or inland waters linked to the ocean or sea as consequence of a storm or thunder-storm with minimum wind speeds of 8 Beaufort (Bft), whereby the water level has to exceed the local average high tide level by at least 1.5 meters at the North Sea and 1 meter at the Baltic Sea coast. The sea level does not necessarily have to exceed the height of a dike to cause damages. A storm tide has to be announced as such by the Federal Maritime and Hydrographic Agency (BSH).

➔ *<u>Hypothesis (requirements):</u> Extreme Event Attribution raises larger interest if it is linked to impacts and damages of extreme events.*

An in-depth study and identification of potential users of extreme event attribution within the insurance industry is not available to date. Stott and Walton [2013] provide some insights in this respect. They found that the representatives from the insurance sector could imagine including such information into contracts and long-term planning. The literature of insurance-related aspects in terms of natural hazards and climate change analysed above has led to hypotheses which point out that extreme event attribution can provide an added value to risk assessment, strategic planning, public awareness campaigns, marketing and sales activities.

➔ *<u>Hypothesis – stakeholder groups:</u> There is a range of stakeholder groups within the insurance industry which is able to make use of Extreme Event Attribution products. Decision-makers in insurances and re-insurances as well as in associations are among these. This comprises local insurance agents as well as people holding positions in the central departments of strategic planning, public relations, marketing, and statistics.*

3.2.4. The insurance sector in the Greater Paris test case

Insurance in France is a highly regulated public-private hybrid sector. Natural risks in France (outside of agricultural risks) are covered by private insurance contracts for risks considered as insurable and covered by a publicly owned reinsurance firm, totally guaranteed by the government, for events falling under the definition of natural catastrophes. Building and vehicle insurance contracts contain compulsory natural catastrophe coverage, involving a 6 % premium on auto insurance and and a 12% premium on building insurance, these extra premium funding the state owned reinsurance firm, as a part of a natural catastrophe insurance regime. This hybrid coverage is part of the French insurance law. Most consequences of extreme meteorological event are covered under the public regime, named "Regime des catastrophes naturelles" (RCN, Natural Catastrophe Regime). High building and vehicle insurance penetration rate (above 98%) leads to high natural catastrophe coverage which is often presented as a French specificity [*Magnan*, 1995, *Schwarze et al.,* 2011]. Table 2 below present key meteorological risk and their associated coverage.

Table 2: Natural risks insurance regime for risks associated to extreme meteorological events in continental France (Adapted from *Grislain-Letrèmy and Peinturier* [2010])

Hazard	Covered by insurance contract	Covered through RCN (eligibility conditions see in text below)
Damages considered as "insurable" under the French insurance regime		
Hail, Snow, Freezing, Wind (in their impacts on roofs)	Through specific "Storm, hail, snow roof damages" contracts	No (with exception of the impacts of wind for storms that are identified as natural catastrophes see below)
Damages that may be considered as "insurable" or as "non insurable" under the French insurance regime		
Water infiltration associated to the joint effect of rain and wind	Water damage insurance contract	Yes
Subsidence associated to droughts impacting buildings	Non existent	Yes
Floods (all)	Rare, some companies do offer flood coverage but the penetration rate is low	Yes

The focus of the greater Paris area are heat waves. Yet, in terms of insurance and reinsurance, the only consequence of heatwaves that is covered is subsidence associated to droughts and its impact on buildings. This represented 41 % of the claims made within the "RCN" in France in 2011 [*Collet*, 2012, "Assurance : la réforme du régime catastrophes naturelles est finalisée," Actuenvironement, March 12]. Furthermore, this is not covered by insurance contracts. We have thus extended our analysis to other climate risks.

The RCN has several features the are of importance within the context of extreme event attribution. First its general guiding principle are quite constraining. Secondly, the conditions under which an event is identified as a natural catastrophe, thus triggering the indemnification of victims' through their insurance, are central. Thirdly, the funding of the reinsurance scheme and the condition under which it may remain sustainable, even in the face of potentially increasing risks, must be understood.

The RCN guiding principles are two-folds; insurance against natural catastrophe is compulsory and is based on national solidarity [*Deboudt,* 2010]. These two principle are translated by (a) an obligation to contribute to the RCN regime for all persons and structures that are insured and (b) by a fixed premium, proportional to the value of the insurance contract, regardless of exposure or vulnerability to natural risks [*Dumas et al.,* 2005]. These features are the subject of a quite vibrant debate as both seem to create a situation where no incentives exist for the insured party to reduce exposure or vulnerability to natural catastrophe. This creates a potential moral hazard [*Nussbaum*, 2008, *Poussin et al, 2013*,]. A reform of RCN, geared at addressing this moral hazard, is currently envisioned. It is, according to the industry, unfortunately stalled [*Vadjoux*, 2015, La question d'une réforme catnat toujours en suspens, News assurance pro, April 9].

➔ *Hypothesis (added value): Extreme event attribution can strengthen the motivation to reform the RCN by identifying specific type/class of meteorological events associated to exposure patterns justifying the adjustment of premiums*

The second dimension that is of interest in the framework of extreme event attribution lies in the definition of natural catastrophe. Within the French insurance law natural catastrophes are events generating "direct material damages that are not insurable and that have as a determining factor the abnormal intensity of a natural event and when usual prevention practices could not be taken in order to avoid these damages". This definition is not in itself very precise. By law every specific event need to go through process in order to be recognized as a natural catastrophe. This process consists of an initial declaration by local authorities (mayors) to the prefect (head of the département, representing the national government). The département prepares a file comprising the documentation of the event that is then submitted to an interministerial committee which emits its opinion on the event. For some meteorological events (rainfall associated to flash floods) this includes an analysis as to whether the event has a return period of ten years or above [*Douvinet and Vinet*, 2014], yet the quality of the science that is mobilized is regularly contested [*Dumas et al.,* 2005].

➔ *Hypothesis (application): Fast track Extreme Event Attribution may be in a position to analyse, in real time, the actual return period, in a way that is seen as robust and considered devoid of political consideration.*

This opinion from the inter-ministerial committee and the associated file is then transmitted to the ministers (interior, economy, environment and budget) for final decision as to whether the event may be considered a natural catastrophe or not. The final decision is then published in the Official Journal of the French Republic. This process is often criticized as not being sufficiently transparent. It has the potential to create uncertainty for the insures on one hand. On the other hand, the remittance of the reinsurance company is dependent upon convoluted political processes which may have very little to do with the nature of the event itself. The reform of RCN that is envisioned includes a rationalization of this process to insure better predictability both for the insurer and insures.

➔ *Hypothesis (application): Fast track extreme event attribution may contribute to the definition and identification of event that should trigger the RCN, extreme event attribution would thus contribute to a rationalization of RCN.*

The third dimension that is important in the context of extreme event attribution is the concerns that have expressed in terms of the long term financial health of the state owned reinsurance firm (CCR). Repeated concerns have been expressed both without [*Dumas et al.,* 2005] and with climate change [*Nussbaum*, 2008].

➔ *Hypothesis (application): extreme event attribution by assessing the evolution of probabilities in real time can contribute to a robust analysis of the mid to long term financial viability of the state owned reinsurance firm within the RCN.*

Beyond the specifics associated with the RCN, much of the analysis and hypothesis presented of the German case study deserve to explored within the French insurance system.

3.3. Methodology and materials

Having reviewed key literature conveys a first idea about potential user groups, fields of application, as well as added value and requirements of the insurance and re-insurance sector in terms of extreme event attribution. Empirical extreme event-specific studies which provide a more solid, specific and detailed understanding are still lacking, however. The following section will elaborate on ways of empirically assessing stakeholder needs for potential EUCLEIA products and will describe the methods used for this study. As proposed in the DOWs of the EUCLEIA project, this empirical study is undertaken in two test cases: Storm surges at the German Baltic Sea coast and heat weaves and cold spells in the greater Paris area. More details about the harmonized methodology developed for this work package can be found in Milestone 2 (M2) of the EUCLEIA project. In this milestone, we identify content-related foci, outline the leading questions, and aligned the methodology with the conceptual framework developed in WT 4.1.

3.3.1. Qualitative interviews with key stakeholders and related analyses conducted by HZG and UVSQ

Qualitative interviews were chosen because they are known to be better able to provide an in-depth understanding of viewpoints, needs, and specific requirements than quantitative methods (see M2 for more details about reasons to conduct qualitative interviews in the given research context). For the sampling of interviewees we selected key stakeholder groups within the insurance sector. The selection was based on insights gained in WT4.2 and the literature review of this report (see “hypothesis – stakeholder groups” in the previous section). It comprises the following groups clustered in two categories:

a) Institution type
   - Insurances (with and without storm surge insurance scheme, in Germany, undifferentiated in France)
   - Re-insurances
   - Associations
b) Fields of work
   - strategic planning,
   - risk assessment and premium calculation,
   - press and public relations
   - marketing and sales

In addition to those, we found during the interviewing that also information service providers are important actors in the insurance industry to be considered.

We wrote personal invitation emails to representatives in each of the above listed institutions and fields. Stakeholders who were considered to be interested and needed to cover the whole range of selected stakeholder groups were also contacted via telephone. To increase the respondent rate and chance to talk with interested, relevant and knowledgeable people, we used in addition to an internet-based research, snowball sampling. When an interview appointment was rejected and during each of the conducted interview, we asked to be referred to other potentially interested and interesting stakeholders.

Table 3: List of contacted stakeholders and interview appointments, German and French case studies

Stakeholder group	Contacted (Germany)	Interview appointment (Germany)	Contacted (France)	Interview appointment (France)
Insurances	30	4	18	5
Strategic planning	*4*	*2*	*2*	*1*[1]
Risk assessment and premium calculation	*5*	*2*	*4*	*2*
Press and public relations	*5*	*0*	*5*	*0*
Local and regional sales agents	*15*	*0*	*6*	*2*
Other/general info address	*1*	*0*	*0*	*0*
Re-insurances, including the state owned French reinsurance firm involved in the coverage offered by the RCN.	10	4	4	2
Strategic planning	*4*	*3*[2]	*3*	*1*
Risk assessment and premium calculation	*6*	*1*	*1*	*1*
Public relation	*(1)*	*(1)*[3]	*1*	*0*
Association	5	2[4]	3	2
Strategic planning	*1*	*1*	*2*	*2*
Press and public relations	*2*	*0*	*0*	*0*
Natural hazards and climate change statistics	*1*	*1*	*0*	*0*
Other/general info address	*1*	*0*	*0*	*0*
Information and data services	5	2[5]	1	0[1]
Total	**50**	**12**	**25**	**9**

For the German case study, we contacted 50 people in total and made appointments with 12 people (see table 3 for a list of contacted stakeholders). The response rate was lowest for local and regional sales agents. No one replied to the invitation email, the ones that were called denied an interview and commonly referred us to the central press department. Also the press and public relations departments denied interview appointments. They rather referred us to risk assessment and statistics departments. The response rate was highest when being personally referred to a stakeholder - 9 out of 12 interview appointments were made with people who we were referred to. In the end, we conducted 9 interviews with 11 stakeholders from the following institutions: two insurances with storm surge scheme and two without storm surge scheme, two re-insurances (one of them was a foundation linked to a re-insurance), the German Insurance Association, as well as information and data services. The interviews were conducted between September and November 2015. Seven people were interviewed face-to-face, four via the telephone.

[1] An appointement could not be achieved before deadline of deliverable, interview will be conducted in February 2016

[2] One of the interviews was with stakeholders from a foundation established and linked to a re-insurance. They represented on the one hand a more association/foundation perspective; on the other hand, also a re-insurance point of view given that one of the interviewees was in the re-insurance for a very long time period and was still closely linked to the re-insurance. In the following analysis, the differentiation between the perspectives will be made individually for each statement depending on the context.

[3] The representatives from the re-insurance foundation were also involved in public relations activities

[4] The two interviewees from the German Insurance Association were interviewed at the same time

[5] One of the interview appointments was cancelled, but a new appointment is possible at a later stage.

For the French case study, we contacted 25 people, we obtained 9 appointments in time for the deliverable, two more interview will be conducted for later stages of the work. Positive responses were closely associated to personal referrals. Public relation officers denied interviews, but directed us to strategic planners/senior management.

The results from WT 4.2 about needs and requirements of regional stakeholders as well as the literature review helped identifying guiding questions for the interviews. They include general topics also covered in previous interviews with regional stakeholders (see D4.2 and M2) as well as more insurance-sector specific questions (see text box 1 for a list of guiding questions and M2 for more details about the linkages to the concept and foci of the WP). The guidelines were re-considered and adjusted before each interview to cover institution- and interviewee-specific aspects. The interviews were conducted in an open and flexible way with little interference from the interviewer. They lasted between 30 and 140 minutes in Germany, between 28 and 45 minutes in France. In Germany, 8 interviews were audio-recorded, one interview was documented by taking detailed notes. In France all interview were audio recorded.

Textbox 1: Guideline for the in-depth interviews with representatives from the insurance and re-insurance sector

I. Introduction

1. *Interviewer:* Northern German Climate Office (in Germany only), EUCLEIA project, goals of the interview
2. *Interviewee:* Institution/company, department, professional/academic background, fields of work

II. Role of extreme event and climate information / services

1. Reasons for providing insurance schemes for storm surge-related damages (incl. details about risk assessment and marketing) → *for the German case study only; for insurances and associations, more specific in the discussion with insurances who cover storm surge hazards*
2. Relevance of climate change and related information needs → *mainly for insurances, information service provider and association, if time also for re-insurers*
    a. Priority of climate change in the insurance industry
    b. Fields of work where climate change and related information play a role
    c. Relevance of climate change and related information in terms of extreme event/storm surge risks and insurances → *for insurances, information service provider and association*

III. Definition and potential relevance of extreme event attribution

3. Explanation of extreme event attribution → *if a more specific information than in the beginning is required*
4. Opinion about the do-ability of extreme event attribution
5. General interest in extreme event attribution (why, which fields of application) → *more specific information about the applicability only if people have an idea of where or how they could apply it; fields listed below are to be mentioned only after the interviewee gave an answer to the general question and only if the respective field is relevant to the jobs or expertise of the interviewee*
    a. risk assessment and premium calculation
    b. strategic planning
    c. awareness-raising and political leverage
    d. marketing and sales

IV. Quality criteria/evaluation of climate, coastal and extreme event attribution information

1. Criteria making information useful and pertinent to their work
2. Relevance of criteria like: solidity, credibility, time of availability, appropriate definitions of extreme events, regular availability, geographic scale, level of complexity, kind of results → *only to be named after the interviewee answered to the previous question exhaustively and only if the criteria which have not been named before*
3. Appropriate sources, marketing and financing of extreme event attribution products → *only if people have an idea of where or how they could apply it*

The recorded interviews were transcribed, coded and analysed along the lines of qualitative content analysis (see Milestone 2 for more details). Like in WT 4.2, we have built on grounded theory in the analysis. An iterative dialogue between us as scientists, the theoretical presumptions (see D4.1 for more details), and the data and conclusions drawn from the interviews, helped developing a coding system for the data analysis. The analysis could thereby be adjusted to the specific research context and allows drawing conclusions with respect to empirical findings as well as underlying theories and concepts [see *Glaser and Strauss*, 1998; *Mayring*, 2000].

3.4. Results Part 1: Results of the empirical work undertaken at HZG

3.4.1. General understanding and interest in EEA

The **general understanding and conversancy** in terms of extreme event attribution (EEA) varied across the interviewed stakeholder groups. All interviewees from re-insurances (RI-1[1], RI-2, RI-Fa[2]) and the natural hazard statistician in the insurance association (I-ASb[3]) were aware of EEA research and related concepts. The interviewees engaged in strategic planning (with modelling background, though) have named examples of studies and scientists (RI-2, RI-Fa), specific EEA differentiations and/or terms like 'fraction of risk' (RI-2). This indicates that they not only heard about EEA, but have also dealt with it before. Representatives from direct insurances, the data service and the association, in contrast, told to have merely heard about EEA before (I-SP[4], DI-2[5]) or were not aware of this field of research at all (I-ASa, DI-1, DI-3, DI-4).

All of the interviewees found that extreme event attribution may produce **interesting** findings[6]. Particularly people from the re-insurance sector showed explicit interest in EEA research during the interview (RI-1, RI-2, RI-Fa). Representatives from the re-insurance sector (RI-1, RI-2), the association (I-ASb), the information/data service (I-SP) and one risk modeller of a direct insurance (DI-2) were interested to be further involved in EUCLEIA. They thought that it could convey a better understanding of the insurance system in a changing climate and provide a more differentiated picture of the various facets of changing damage profiles (I-ASa/b). It would demonstrate the extent of damage that climate change can cause (DI-4). A representative of an association opined

"for me the most convincing would be that you could say: This is what happened! Look at it! This is not a singular instance […]. These are our regions which can be hit and there is no indication that you, who have not been hit today, may not be hit tomorrow" (I-ASb).

On that note, EEA was perceived to be of interest not only to them and to the insurance industry in general, but to the overall societal debate about climate change (RI-2, RI-Fa). The head of the re-insurance foundation, for instance, said that extreme event attribution is undisputedly of large importance, even if there are no concrete fields of application to date. It is something that can advance the whole debate about climate change.

However, the expression of interest was often followed by a *'but'*. The interviewees told, for example, that EEA would be **interesting, but** that it would not provide an added value to the existing information (RI-F, RI-1, RI-2, DI-2, DI-3). A risk modeller of a re-insurance explained,

[1] RI-n: Interviews with re-insurance representatives
[2] RI-F: Interview with re-insurance foundation; a: head of the foundation; b: project manager
[3] I-AS: Interview with German Insurance Association; a: head of damages department; b: natural hazard research and statistics
[4] I-SP: Interview with data- and information service
[5] DI-n: Interviews with direct insurances (with and without storm surge coverage)
[6] One interview did not address extreme event-related aspects. The interviewee was involved in strategic planning of a direct insurance company not offering storm surge schemes and did not think that he could answer questions related to EEA. Instead the interview focused on the relevance of climate change and the reasoning behind offering storm surge insurances.

in this respect, that premiums have to be paid to affected people no matter if the extreme event was caused by human activities or not (RI-1). Others mentioned that statistics in general only have a marginal influence compared with personal experiences of hazard-related damages (DI-4, RI-F). Another common argument was that other aspects would be more essential and thereby outweighing the potential relevance of EEA by far, like scenarios of future extreme events and decadal projections (RI-1), return periods of damages (DI-2, DI-4), or the anthropogenic contribution to exposure and vulnerability changes (RI-2, DI-2). One interviewee from a re-insurance was, moreover, sceptic and concerned that too large an attention on extreme event attribution would put hazard mitigation by large emitters and not risk mitigation or adaptation of *all* actors at the centre of political debates (RI-2). He argues that it is dangerous

> *"[…] if we take the attribution story into the loss-and-damage debate to claim that a fraction of attributable risk of 30 percent means that we have to pay for 30 percent of the impacts/damages of an event in Kiribati or somewhere else from some kind of international mechanism […]. I think we have to look at the interfaces and ask whether it is not rather exposure which has increased by more than 30 percent in the same time period. And maybe all of that is not home-made in the sense of an event occurring […] it is a societal problem and this has a lot to do with own initiative […]. To put it in other words, if we talk about attribution, we should also talk about risk being a product of hazard, exposure and vulnerability. All of these factors change over time" (RI-2).*

In addition to these *'buts'*, several people reasoned that it is not possible to integrate EEA information into key business processes and/or that this information is not relevant to them (I-AS, RI-F, RI-1, RI-2, DI-2, DI-3). This was mentioned to be due to aspects like a general lack of interest in future problems (DI-3), a short-term oriented perspective of insurances and re-insurances (DI-2, RI-Fb), and because of the fact that it does not matter to the market who caused the natural hazard-related damages (RI-Fb) (see section 3.4.2 for more specific reasons why EEA is or is not of relevance to certain fields of work).

3.4.2. Potential fields of application

None of the interviewees has used or needed extreme event attribution information in the past. All of them mentioned potential fields of application for them or others when discussing EEA, however. Extreme event attribution information was imagined to be able to inform **strategic decisions** (RI-F, DI-2, DI-3, DI-4, I-ASb). It was assumed to be able to illustrate whether some events are expected to be more frequent and show what you have to be prepared for. EEA was therefore thought to be able to provide a basis for discussions in the foundation council (RI-F) or executive board (DI-2, DI-4). It could, for example, influence a debate about the general insurability of specific hazards in a region, particularly in the aftermath of a large and recent event (DI-3). This was an issue that was acknowledged particularly in the context of Baltic Sea storm surges. Being a low-probability-high-impact-event with a relatively small number of potential clients was an often mentioned problem in terms of general insurability (DI-1, DI-2, DI-3, DI-4, I-AS).

Another field mentioned by the interviewees was **risk modelling**. A risk modelling expert at a re-insurance mentioned that EEA might be of interest to *model development* (RI-1). He argued that long time series are decisive for risk assessment and that, against this background, changing return periods due to greenhouse gas emissions might be of relevance as well. Nevertheless, risk models are developed only every 10 years and updates

of the models are made every five years on average so that information on long time periods is needed rather rarely, according to this interviewee (RI-1). He could also not imagine that someone would pay for such information because they are not inevitable for model development (ibid.). The natural hazard data service portal of this re-insurance provides *hazard/extreme event footprints*. The interviewed risk modeller from this re-insurer thought that extreme event attribution information might feed into these footprints because it links historical/past events with future climate change (ibid.). Other interviewees imagined that extreme event attribution could be factored into investment decisions (I-ASb) or related net-present value calculations (RI-2). An interviewee from a re-insurance used the example of the construction of a dam in the city of Hull in England – where a model of theirs facilitates comparing the net present values of costs and benefits. He argues that *"this will allow taking robust and maybe even resilient decisions. […] and this is where also attribution – or rather detection – can play a role […]"* (RI-2).

Several interviewees also found that extreme event attribution could feed into existing **impact models** (RI-2, I-SP, I-ASb). In this context, a renowned data and information service which provides extreme event footprints to the insurance and re-insurance industry was named as being potentially interested in extreme event attribution information. This company collects damage data from insurances and re-insurances for several European countries and provides meteorological event details and damage estimations after extreme events (for wind storms also before the event) (RI-1). In an interview with a representative of this service provider, it was shown that his company has not considered EEA yet, but he could think of fields of application. He cared to imagine that it would allow statements like

„ [It is] market consensus [that storm] Lothar had a market damage of ten billion [Euro] for the whole of Germany and had accordingly a 30-year return period. Now – with information from your project - it would be possible to say that this return period would be 30 years without and 20 years with climate change[1]" (I-SP).

Return period calculations are, however, made by others, according to this interviewee. He mentioned that „AIR[2], RMS, Eqecat und the Impact Forecasting of Aon Benfield[3] subscribe to their data service and use the data to improve their own models" (I-SP). He therefore thought that these companies might be interested in EEA and might be able to develop return periods or likelihoods of damages with and without climate change based on EEA (ibid.).

Risk assessments and statistics like the one above have, respectively can have, influence on **premium setting**. Smaller return periods would in that sense justify higher prices of re-insurance coverage for certain hazards, according to some of the interviewees involved in premium calculation (RI-2, DI-4) and others not directly involved in it (I-SP, RI-F, I-AS). A representative from a data service explained that a re-insurer could say

"I provide coverage tailored to an event like Lothar for you, but I have to assume that such events happen more often [than in the past]; it happens every 20 years, and not only every 30 years. You

[1] Despite of the fact that he transposed numbers in this statement, he understood the concept of EEA well.
[2] To also include this group of potential users in our sample, we contacted an employee at AIR worldwide to which we were referred to. An appointment was made, but was cancelled on short notice. A new appointment was not possible to date, but could be made for next year.
[3] We contacted Aon Benfield and asked for an interview, but did not receive a response. They are therefore not included in our sample.

have to pay 50 percent more […]. A 30-year event would be double as large, it could cost 20 billion"(I-SP).

This quote makes clear that extreme event attribution is able to provide justification for higher prices if it provides the "right" results.

An interviewee from a large re-insurer said in this context that "*information [like from extreme event attribution] about return periods is very important, but so are scenarios*" (RI-1). The head of a direct insurer told along the same lines that extreme event attribution could also influence the price setting of direct insurance coverage (DI-3, DI-4). Another interviewee from a direct insurance, in contrast, told that the process of change is too slow to be considered. He explains that *"[…] in 2012, we introduced the last product onto the market; the next one will be out in 2016 – in this period, there will not be much of a climate change, no?"* (DI-2). Climate change which is a process that can be detected only over decadal time periods is therefore not assumed to be compatible with existing models.

In general, extreme event attribution was understood to be of less relevance to the premium setting of direct insurances than of re-insurances (DI-4). For direct insurance companies, such information seemed to rather be of relevance to control and negotiate their re-insurance coverage. These are commonly coupled to return periods of hazards and related damages. A statistician in a direct insurance told that if they knew that the likelihood has increased for storms like Christian where

"we are getting close to the limits of our current re-insurance coverage and we would observe that the re-insurance asks for ever higher premiums, we would start doing our own calculations to estimate if it wouldn't be possible to get cheaper re-insurance coverage, raise the damage excess, increase the contract run-time – although it is very common that we make one year contracts" (DI-4).

A representative from a re-insurance argued on this note that they might make use of scientific information like EEA in their negotiations and communication with re-insurance clients, i.e. also direct insurances (RI-1). To his knowledge, clients have not asked for specific data in this respect, however. They rather ask for scenarios or mere changes in return periods of damages (ibid.).

In addition, the interviewees mentioned that extreme event attribution could be of use in **press, marketing and public relations** activities (I-ASa/b, RI-Fa, RI-2, DI-2, DI-3, DI-4). Information about the contribution of climate change to recent extreme events can raise awareness and provide another prove to make "*climate change an accepted future risk*", only if extreme event attribution points in the "right" direction, though (RI-Fa). It shows that climate change is a problem to us here and already today (I-ASb) which causes a discernible human impact (RI-2). This is due to the fact that EEA is linked to events which were actually experienced in the recent past (DI-4) - events that people can remember and which are less abstract than a one degree change in temperature (DI-3, I-ASa/b). This might make a good argument for climate change which is more differentiated than the "*everything is getting worse*" statement and could therefore counteract the accusation of alarmism (I-ASb). This seems important to create trust which is decisive as insurance marketing *"is all about trust of the clients […] because they might not buy the insurance otherwise"* like the head of a re-insurance foundation argued (RI-Fa). Despite of the added value extreme event attribution can provide for public relations, the interviewees also mentioned a range of downsides to it. A representative from the association argued that it mostly comes down to the question

whether it is possible to catch the attention of the media. He told that *"[…] some things are important, they are decisive - and still - they will not be echoed by the media […] even if I market them perfectly well" (I-ASb).* On that note, it was argued that numbers like probabilities will never be as powerful as pictures (DI-4. I-ASa). Another common argument was that extreme event attribution is too sophisticated to provide a real added value. The representative of the re-insurance foundations illustrated this as follows: *"I would again just say – well, dear farmer, you can see that things have changed, you have experienced more droughts (…) and this has been confirmed by science, by the way"* (RI-Fa).

The relevance of EEA for direct **sales activities of local insurance agents** was rarely mentioned. Only an employee of an association told that it could serve as an argument in a sales talk (I-ASa). The other interviewees did either not mention it or explicitly negated the relevance of EEA for direct sales (DI-2, I-ASa/b). An interviewee from a direct insurance, for example, told that *"I cannot imagine, how an insurance agent would sit down and sell a household or natural hazard insurance based on climate change"* (DI-2). He was also concerned that if it would be included in direct sales, that *"this would add up to a lot of sciolism, and this would then, I think, become confused and adventurous"* (ibid.) because local sales agents have to sell all sorts of insurances and would, in most cases, not be expert enough to convey such information correctly.

The interviewees also mentioned that extreme event attribution could help influence **political processes** (I-AS, RI-Fa/b, RI-2). This was only mentioned by stakeholders from the association and the re-insurances (I-AS, RI-2, RI-F); the representatives from the direct insurances did not think that political leverage is part of their mandate (DI-1, DI-2, DI-3). A stakeholder who is engaged in several political processes thought that EEA could have *"a large influence, a really large influence because the role of climate change is still a big matter of beliefs"* (RI-Fa). According to an interviewee from the insurance association, it could be of use in the debate with insurance control regarding solvability requirements for the insurance sector. He told that *"one could, for instance, show that certain trends are not as bad as it is currently assumed so that [an insurer] would need less risk capital at some point"* (I-ASa). The interviewees directly and indirectly involved in international negotiation processes also highlighted extreme event attribution's potential to influence international processes like the climate negotiations and the liability debate about whether industrial countries or large emitters have to pay for disaster relief or long-term adaptation (RI-Fa/b, RI-2). In this respect, examples like the legal disputes between Inuit and large emitters, NGOs and the Dutch state, or the case of Kiruna were mentioned (RI-2, RI-Fa). The head of the re-insurance foundation also mentioned the Green Climate Fund and ideas of developing a climate change-related catastrophe fund in this context. He told that these mechanisms would be

> *"exactly about attribution of climate change and that this is […] still the big bottle neck because nature produces large storms and then it is all about the question 'can we take from the climate fund, because we have proof that the storm which occurred is caused by climate change' […] this is an incredibly large group of clients which – if you are planning long-term oriented – could provide a basis for developing a whole business model. You could say 'we offer you a service where you can retrieve information about where climate change is included with a high level of certainty in order to allocate financial means right" (RI-Fa).*

3.4.3. User requirements with respect to climate, coastal and extreme event attribution information

The requirements of the consulted stakeholders with respect to potential extreme event attribution products were diverse and more or less concrete depending on the background of the interviewees. Stakeholders who have dealt with EEA before, were able to give more specific requirements with respect to extreme event attribution in comparison to others who had already difficulties to figure if or where they would be able to include such findings into their work. The latter have, however, named more concrete requirements for climate and coastal information which were commonly used. Some of these requests are likely to be of relevance in the context of extreme event attribution as well. In the following, we will therefore not only refer to quality criteria named in the context of EEA, but also to the ones that were mentioned in the context of other coastal, climate change- and extreme event-related sets of information.

A very important criterion was ***credibility*** – both for extreme event attribution and other sorts of information. The **level of uncertainty** was of particular importance in this context. It was mentioned by most of the interviewees in the context of either EEA (RI-F, I-SP, DI-2) or climate and coastal information in general (I-SP, I-ASa/b, DI-2). The reliability and solidity of the underlying **methodology or research process** was decisive for several interviewees to ensure credibility for a product like EEA, i.e. findings building on a scientific (RI-Fa), independent and neutral (RI-Fa, DI-3), solid (I-ASb), and/or peer-reviewed process (RI-Fa, I-ASa). The discussions about climate and coastal information needs showed that this requires, in general, a good quality of the research infrastructure and personnel (RI-Fa), realistic assumptions (DI-4), and a continuous sector-wide exchange (DI-3). The head of a re-insurance foundation further argued that information from extreme event attribution would be more credible, if it had undergone an IPCC-like practice where findings are reviewed by a multitude of authors and agreed on in a political process. In this way, EEA could turn into consolidated knowledge which is more likely to influence decision-making (RI-Fa).

Credibility has also been related to the need for information which builds on a **reliable data basis**. A representative from a data service for the insurance sector emphasised that *"real"* data is essential in this respect (I-SP). This data service has therefore mainly built on observational data. He emphasised that *"it is the past which has real persuasive power. Because this is what you experienced, no?".* A natural hazard statistician of an association reasoned that it is also important to select a solid and appropriate climate model in order to create a reliable data basis and that event attribution for heat waves would, for instance, be more credible than for storms where already detection is problematic (I-ASb). The interviewees further emphasised that extreme event attribution products would be credible if they produced **plausible results and explanations**. In this context, it was mentioned several times that it is decisive to refrain from making use of incredible extremes. Alarmism as emotional sales argument is often understood as such and will therefore rather have a negative influence on clients' investment decisions than the other way round (I-ASa, DI-3). It was claimed that it is also important to give plausible explanations for making information from EEA more credible (DI-3, I-ASb).

The quality and credibility of information have often been associated with the **source of information**. Several interviewees, particularly from the association, the data service, and the re-insurance foundation – all of whom are a source of information for other stakeholders

in the sector themselves – emphasised the relevance of having credible and reliable sources of information. The head of a re-insurance foundation suggested that extreme event attribution would be more credible and therefore more likely to be used, if it came from an established and reliable EEA platform like a weather service. He further reasoned that it would also receive more attention and credibility if it had been approved by an advisory board and in particular if it had been picked up by the IPCC. The IPCC is for him a kind of "*ideal construct"* which acts as a clearing house ensuring that certain information is relevant and solid (RI-Fa). Stakeholders of an association and the head of a direct insurance thought that many people would be more wary of information released by the insurance industry than by public institutions like the German Weather Service (DWD). They told that this was one reason why they have increasingly banked on cooperation project with science. In that way, they are also able to control the process, ensure a considerate handling of sensible insurance data, and can better understand the data and findings which are produced (I-ASb, DI-3).

Even if extreme event attribution information is credible, it still needs to fulfil certain criteria to be ***relevant*** to the work that people are doing, before it is applied. In this respect, it is decisive to select a sufficiently interesting and relevant **type of extreme event**. The data service, for instance, focuses on wind storms and flooding; similarly do direct insurances and the data portals of re-insurances only cover selected extreme events. In the interviews, storms and floods were the most commonly mentioned extreme events[1]. Among these, the floods in 2002 and 2013 (I-AS, DI-2, DI-4) as well as the storms Xaver and Christian in 2013 (DI-4, I-SP) were the events which have been referred to the most. Heat waves seemed of little or no relevance for direct insurances because they are not considered in damage-related insurance schemes. Storm surges were also rarely named as examples, particularly not the ones at the Baltic Sea coast. Even representatives of the direct insurances which introduced storm surge coverage in the last years did not refer to Baltic Sea storm surge examples, if not being specifically asked for it. This appeared to be related to the fact that these events have not been covered by insurance schemes in the past. Moreover, it seemed to be caused by the fact that these events occurred rarely and were not extreme in their impacts.

On that note, it appeared to be important that the selected event is an **'extreme'** extreme event. An interviewee from a direct insurance told "*what is newsworthy today, may not be tomorrow. And this is why you have to stick to the 'extreme events', because it is these which stay in mind, no?*" (DI-3). 'Extreme' is thereby mostly linked to extreme consequences and not to extreme meteorological characteristics. This aspect has been mentioned to better catch the attention of the media and thereby raise concerns of the population or potential clients. It was therefore considered important for public awareness-raising of the insurance association and for marketing of storm surge insurances by a direct insurer (I-AS, DI-3).

Along the same lines, also the **regional focus** determines the relevance of information to the work of the interviewees. The data service, for instance, only offers data on Central and Northern European countries (I-SP); the German Insurance association is mainly interested in data about Germany (I-AS); and the direct insurances have regional foci within Germany (DI-1, DI-2). A risk modeller of a re-insurance company further mentioned that it is essential

[1] This refers not only to the discussions around extreme event attribution requirements, but to any situation, where an extreme event was mentioned or taken to illustrate something.

to have spatially inclusive and comprehensive data and this at least country-wide for their world-wide data portal. He exemplified this as follows:

> *"it would not make any sense if we had data only on the federal state of Schleswig-Holstein – in this respect, our tool has too low a resolution and we would be able to address a very small range of customers only, i.e. the ones located in Northern Germany" (RI-1).*

With this in mind, it appears also important to know which **spatial resolution** is needed by a stakeholder in order to make extreme event attribution information useful. A representative of a data service mentioned that *"spatial resolution is always a matter of what it is used for"* (I-SP) and opined that:

> *"the typical modeller would say: the higher the resolution, the better – preferably at the […] address level. I am not so sure if it is really 'the higher, the better'. Sometimes you can miss the forest for the trees. I think that modellers in my industry often hide behind big resolution and miss the greater picture" (I-SP).*

A modeller of a large re-insurance said on that note that *"in an ideal world, we would have high resolution climate simulations"* (RI-2). Moreover, it was mentioned that there are restrictions from the competition authority. They do not allow the data services to disseminate data in any kind of high resolution (I-SP, I-AS). In Germany and Switzerland, it is allowed to disseminate market data at the two-digit post-code level only. This is different for hazard-related data. For them, the restrictions arise from the model capacities (I-SP). In the insurance sector, CRESTA[1]-level is the most common metric to describe the level of spatial resolution. In Germany this is linked to the 5-digit post-code system (I-SP, I-AS, DI-4). The resolution requirements are in some cases hazard-dependent. For example, for wind storms, two-digit post-code/CRESTA-level is sufficient, whereas maps representing floods or storm surges need higher resolution data (I-SP).

Similarly, also the **meteorological parameters and the definition of extremes** appeared to be of importance when developing a relevant extreme event attribution information product. The data service representative told that they selected events according to specific criteria for a research project to create a historical storm event database. This might also be of relevance when it comes to selecting extreme events for an EEA analysis. He explained

> *"first of all, we received lists of events from Munich Re and Swiss Re where damages were recorded by them, events which were in the newspaper, simply the ones with a certain relevance to the insurance sector. We have maybe 50 events from them for this time period. […] For the others, we used an approximation, i.e. the affected population. Many of the 6000 possible events took place over the Northern Atlantic, or over uninhabited land. These might be interesting from a meteorological viewpoint, but not for us because they did not cause any damage. […] We then selected the largest 200 events. […] There exists a multitude of ways how to do that. We decided for a very pragmatic and fast manner […]. We took the Top-200 […] from an insurance perspective"(I-SP).*

The cooperation with research was perceived to be an interesting and informative process. The interviewee told that *"the fact that 'insured damages' is the selection criterion is still difficult to understand for people with a science background because they wear different glasses" (I-SP)*. For the data and information service directly after extreme events, they only

[1] CRESTA (Catastrophe Risk Evaluation and Standardizing Target Accumulations) has been established by the large re-insurance companies to create a globally uniform system for assessing risks or damages from natural hazards.

select, record, and report on events which cause a damage of over 200 Million Euro (ibid.). Extreme event attribution would therefore be only relevant for events which exceed this threshold. The data service provider and the re-insurance data portal also present pre-selected parameters for each event or hazard in a standardised way. For a EUCLEIA product it is important to be aware of these indicators to be able to integrate extreme event attribution findings in existing standardised formats, impact models, or mapping tools. The data service, for instance, provides maps on gust speeds in m/s per CRESTA zone, or inundation height for maximum flood extent maps available in GIS shape format; the storm model of a direct insurance includes return periods of maximum wind speeds (DI-4).

A stakeholder from a large re-insurance further emphasized that extreme event attribution is *not* relevant for their natural hazard data portal, if it was available for a single event only. They would need a whole **event set**. He proposed in an email after the interview that,

> *"It could be interesting, if we were able to rely on a whole event set, i.e. all historical events in a time period of for example 50 years, to estimate the change in likelihood due to climate change. Even the analysis of an out-take of the event set, could provide insights" (RI-1).*

The actual **result of an EEA analysis** was of importance to some of the interviewees as well. Some told that it would be better if there was clear indication of a climate change signal, while it may be the contrary in a different context. To reduce solvability requirements of the insurance control authority, it would be helpful to receive findings which show that climate change has not increased the likelihood of a specific extreme event; whereas an employee responsible for climate change adaptation in an insurance company would rather need information showing that the likelihood increased to strengthen his argument for adaptation in the allocation of financial means (I-GDVa). An interviewee from a direct insurance also argued that extreme event attribution could only be of use to marketing and sales if it revealed that a historically very rare event has become an event with intervals far below a lifetime. Only then would it show people that they might be affected by an extreme themselves. This could thereby serve as argument for buying natural hazard insurance coverage (DI-4).

Several interviewees also argued that it is in some respects essential to provide information which is **understandable and intuitively accessible**. A representative from an association, for instance, reasoned that this is important particularly in a policy-making context. He told, *"we experienced that politics searches for simple answers. It picks up things, only if you can provide easy answers"* (I-Asa). Understandable information was also perceived to be important in sales activities. A meteorologist at a direct insurance expressed, in this respect, that *"[…] it starts with return periods which are not understood – and I know our sales processes and people a bit – they know our products of course, but to the left or right from this happens relatively little"* (DI-2). The head of an insurance company argued along these lines that, from a client's perspective, it is important to be able to say *"'that makes sense, I understand that. And yes, if this is the case then we can do it that way'. All these large, complex studies in the scientific journals […] are for the normal user simply too difficult […]"* (DI-3). The head of a re-insurance foundation which cares for outreach and educational work further argued that you do not need new and highly complex information. It appeals the most to people at a public event or presentation, if you convey the information in a way that even children can understand it (RI-Fa).

All interviewees referred repeatedly to the **relevance of return periods**. It is for instance important for insurances in order to know over how many years peaks or extremes have to be spread financially. This allows calculating how to buffer these events or how much re-insurance might be needed (DI-4; DI-2). Return periods have in contrast also been understood as a source of misunderstanding, particularly in outreach activities. A meteorologist of a direct insurance explained *"I always bite my tongue when I mentioned return periods. […] because then I again and again hear, 'well, now [after having experienced a 100 year event] we will not have this for another 100 years'" (DI-2).* Return periods appeared to be particularly critical when being longer than a person's life time. A statistician of a direct insurance said that if it exceeds 30 or 50 years *"people will mentally tick it off and say, this does not affect me"* (DI-3). For events like Baltic Sea storm surges, which occur only rarely, he claimed that it would be better to use probabilities of occurrence or the general change in likelihood (ibid.).

The interviews also revealed the relevance of linking information like the ones from extreme event attribution to **concrete implications**. A representative of an association told that it is essential for outreach activities to convey direct, next-door and immediate concerns arising from event attribution. In the communication with the private sector it is according to this interviewee essential to clearly show

> *"what is the added value of it for our company? […] where can it be directly applied in management decisions? […] in an insurance company I have to deal with capital and investment questions […] or, my products can be better sold, placed, offered at a lower price, produced easier [with this information]"* (I-ASa).

In this respect, the stakeholders mentioned several times that extreme event attribution would be most useful if it was **linked to impacts and damages**. The head of a direct insurance, for instance, told that extreme event attribution would be of larger relevance to him if you were able to link it to impacts in order to allow answering questions like *"had it exceeded the dike? by how much? what amount? […] how long had the event lasted? […] how long had the dike been able to withstand? and what had happened then?"* (DI-3). In this respect, several interviewees claimed that it would be more useful if the results could be linked to monetary damages. A natural hazard statistician of an association exemplified

> *"let's take hail […] we had a total damage of 3.1 billion Euro in 2013 […], but without climate change it would only be 2.5 billion or 2 billion. This would be very important for us to judge what is likely to happen within the next years."* (I-ASb).

His colleague further opined that *"the monetarization of the impacts is essential. If you don't do that, the topic will always just stay on a very abstract level" (I-ASa).*

Access and user rights of potential extreme event attribution products were also addressed by some of the interviewees. A representative of an association claimed that it is important to provide products at a reasonable and competitive price and ensure that property rights are clarified. It is therefore important to do price sensitivity analysis beforehand to see if potential users are willing to pay a cost-covering price. This will ensure also continuity of an extreme event attribution service, according to this stakeholder (I-ASa). The representative from the natural hazard data portal of a re-insurance told that *"it is always a big issue"* to ensure that the official rights to disseminate the data to their clients are available. He also considered

that it could be a competitive advantage to receive exclusive rights, i.e. to be the only data service being able to provide such information to their clients.

The **time of availability** was also discussed in the interviews. For media and outreach activities it was perceived to be important to have information available shortly after an event happened (I-ASb; DI-3). *"After an event, there is a time window of only a few months when people are responsive and willing to take fundamental decisions"* (I-ASb). Others, like the head of a re-insurance foundation did not see the added value of having EEA information in near-real time for public outreach activities. He explained that if there was a super storm and it had been possible to say *"[…] by the way, we have 14 percent climate change attribution. Then the governor would tell you, yes, but I have to manage the storm now first"* (RI-Fa). For the data service provider who disseminates extreme event footprints according to a fixed reporting schedule, it was argued that it is important to have extreme event attribution at the same time as their reports are being issued, i.e. a couple of days, six weeks, three months, six months, and twelve months after the event. For their storm catalogue, which is done only once, a near-real time availability of EEA reports would not be important (I-AS).

Continuity of potential extreme event attribution services was also considered to be important in order to increase the applicability. A representative of an association was concerned that it would be problematic if *"you discovered something great, but after three years, five years it runs out and will be stopped. […] if it should really influence insurance companies, then there will naturally be the question 'will I also have this service in five years from now?"* (I-ASb). A risk modeller for the natural hazard data portal of a re-insurance argued in this context that it is important to have regular updates of the information that is fed into the data base (RI-1).

The head of a re-insurance foundation further anticipated that the insurance industry might be more willing to pay if extreme event attribution was an **operational service** in a way that "*you could click on a button and say: Mumbai, these floods have a 30 percent climate attribution*" (RI-Fa). A representative from the German insurance association anticipated that extreme event attribution could or should become a service which ensures to produce accepted, relevant and reliable information with clarified user rights. If the operational service becomes known for this, it will turn into an established source of useful information.

3.5. Results Part 2: Results of the empirical work undertaken at UVSQ

3.5.1. General understanding and interest in EEA

In general terms most interviewees had a clear understanding of probabilistic extreme event attribution as an end product. Most interviewees were, or still are, involved in risk/premium analysis. Complex probabilistic statements are, or were, part of their education and professional practice. Furthermore, their position made them have a clear understanding of the polysemy of the concept of extreme. They were quite clear that changes in probabilities on the "hazard" side of risk was as interesting as changes in the consequences, mediated through vulnerability and exposure.

A, predictable, exception to this were the local sales agents. They seemed to relay a quite dominant idea (see deliverable 4.1) that attribution of a single event is simply impossible. Yet, once examples were given [*Stott et al*, 2004, *Rahmstorf and Coumou*, 2011], and the core concept understood, these expressed doubt as to whether such statements would be robust and verifiable. For these interviewees the interview proceeded under the hypothesis that probabilistic extreme event attribution is indeed possible and progressing.

Most interviewees reacted immediately to the concept of extreme event attribution by highlighting the challenge of including consideration associated to climate change for the insurance sector in France. Most, if not all, the business decisions of the insurance and re-insurance sector in France is influenced by its regulatory framework. This regulatory framework is centred on yearly cycles. Guarantee funds, viability, premiums, have to be reassessed every year using relatively traditional actuarial techniques based on past time series (be they observed or generated by models calibrated on past time series). This has, according to most interviewees, prevented the insurance sector in France to consider climate change as pertinent to their business, or at least to the operational side of their business. Risk being recomputed every year, the climate change signal is believed to be embeddable in a yearly review, yet put in a long term, past, perspective. Two respondents stressed the fact that such an approach is viable with slow pace, progressive changes. A major and brutal shift in probabilities would not be captured by traditional actuarial techniques. In such a case extreme event attribution might be critical in identifying such a shift and its anthropogenic origin, thus contributing to the long term solidity of the sector.

Some interviewees, mostly but not only, on the strategic planning side of things did stress that extreme event attribution may, today, be mostly useful for long term planning as opposed to the day to day operation of their business. Some added that climate change leads to many, poorly informed, "coffee machine" talks, and that robust, probabilistic, assessments of the potential impacts of climate change on the sector would clearly enhance the corporate culture and the ability for insurance persons, at all levels, to face a changing (or not) future.

As heat waves are not really within the realm of intervention for the French insurance and reinsurance sectors, we furthered the enquiry into the relative potential interest of specific extremes. Extremes in temperature (heat waves and cold waves) were seen as indirectly interesting. Heat waves, understood by interviewees as highly correlated to dry spells, were seen as important for the national state owned reinsurance firms as they cover drought

induced subsidence and the damage that subsidence may induce on buildings. Yet it is not generally speaking seen as a priority. Cold spells are interesting in an even more indirect fashion. Cold spells are associated with pipe-freezing which in turn may induce water damage, which are covered by insurance companies as part of the building insurance, which all insurance companies, in France, are obliged to offer and which have an extremely high penetration rate (98% explained by conditions on rentals and mortgage contracts). Cold spells, combined with precipitation are also seen as somehow important in case of heavy snowfall and associated risks of roof collapses. Extreme temperatures event attribution did not seem to be understood as showing a high interest. Extremes in precipitations and associated floods, were seen as generating a higher level of interest. Extreme winds, either inland or associated with storm surges on the coast, were also seen as very salient by insurers and reinsurers alike. The evolution of of their probabilities is or should be of concern.

3.5.2. Potential fields of application

A first level enquiry in terms of potential application that was suggested to the interviewees was the potential contribution of extreme event attribution for market development. Due to the nature of French insurance law, and the fact that most insurance packages that include a meteorological dimension in the risks covered have a high penetration rate, all respondents stressed the fact that the issue was not one of market growth. Insurance sales force and insurers saw the central challenge as one of market share. They did not express that extreme event attribution, and the increased awareness that it may raise, could in any way increase their market share.

Using extreme event attribution in order to foster risk reducing behaviour for insures is seen by some interviewees as potentially beneficial. Yet, interviewees from insurance companies and members of local salesforce felt that communication toward insures to promote individual centred risk mitigation strategies is currently poorly developed, at least for meteorological events. Yet insurers (not local retailers) felt that, if awareness raising was developed for risks where meteorology plays a role, then extreme event attribution could reinforce the message, particularly in situation involving long term investments (structural work on dwellings for instance). Furthermore, representatives of the sector's association stressed the fact that insurance in France may not have an important impact on individual household behaviour regarding extreme meteorological events. As extreme event coverage is automatically included in their insurance contracts (see section 3.2.4 above), insures are de facto covered, whatever their behaviour. Yet for institutional insures (cities, private companies) awareness raising combined with potential increases in premium may play a role in their behaviour. Yet currently premium increases are not possible due to the regulatory framework. Part of the reform that has been considered was to allow for such an increase in premium. Extreme event attribution, if such a reform goes forward, may contribute, to safer behaviour.

Extreme event attribution is seen as having a higher potential in order to allow for long term planning. Most respondent stressed the fact that beyond day to day operation, centred on yearly cycles, the long term sustainability of the insurance is directly dependant upon its ability to project itself in longer time horizon. In this context insurer and reinsurance do

invest in research and development in which extreme event attribution could play a role, at least for companies having a portfolio where meteorology plays a significant role.

Using extreme event attribution, particularly robustly assessed shifts in probabilities, for risk assessment is seen as having a high potential. Respondents felt that this would not be technically challenging but would induce a quite important cultural shift. Currently most techniques rely on data calibrated on time series of past events. They felt that extreme event attribution might allow for the development of future probabilities in order to assess risks and premiums. A respondent stressed the fact that such an approach would be fundamental in case of rapid shifts in probabilities (see 3.5.1 above). A respondent from the insurance sector stressed the fact that having information on future probabilities might put them in a better position to negotiate with their reinsurers.

Extreme event attribution is seen as having a role in the definition of the regulatory environment. First, it may encourage the systematization of mid term planning, provided that it demonstrates that relying on long term time series is not reliable anymore. Furthermore, and this is salient in France, it may help at pushing a revision of the RCN, which is already felt in dire need of a reform. If an increase of the frequency of extreme events is robustly demonstrated, it may push for a more flexible regime, more attuned to the actual risk key insures are facing.

3.5.3. User requirements with respect to extreme event attribution information

Before moving on to the requirement associated with extreme event attribution, interviewee from insurance firm felt important to explain more precisely the diversity of climate service provider they are dealing with. While most have in house services, they do use information provided by the national French meteorological office (mostly data), by their reinsurance brokers (assessment of potential cost of events with a low return period) and by risk assessor who themselves use climate models integrated to exposure, vulnerability and damage models – integrated models. These relationships, and the associated trust building, is seen as an important part if running their insurance business. They do have experience in relying on climate services, and in most case they did refer to these experience when being precise as to their requirements.

For most interviewee the first and foremost criterion is data quality and comparability across geographical context and through time. This central requirement translates itself into the need not to assess one single event, but rather to be able to access extreme event attribution to classes of events, in different places and at different times. Most interviewee did not feel that “one shot” extreme event attribution were worth much in their activities. As a corollary insurers and reinsurers pointed strongly to the necessity to have standardized procedures with standardized outputs. The geographical dimension was important as well, they felt that somehow in order to segment markets geographically, outputs (series), should be mapped at scales that make sense for their business operations.

Two insurers expressed strongly the need to develop “open source” models and that this requirement should apply to extreme event attribution as well. They expressed that extreme event attribution should allow for exchange around and on the tools that are used. They expressed the need to develop communities of model users – of extreme event attribution users. This points to the fact that they envision extreme event attribution as an operational

tool, made available, not as an ongoing research activity focusing on key events through "one shot" developments. Ideally, at least for insurers and reinsurers, such extreme event attribution, should be integrated into wider modeling platforms that would include vulnerability, exposure and impacts.

In terms of knowledge production, many expressed that such a tool as extreme event attribution should be produced by (public) scientists, well trusted, and managed with the insurance and reinsurance industry – yet not hired directly by these. Insurers and reinsurers expressed that an information such as extreme event attribution should be seen as a public good, or as a public dataset allowing the industry itself to fund more refined analysis.

Finally, and this was widely expressed, for insurers and more importantly reinsurers hazards associated to meteorological events are mostly conjoint. Damages occur often when two extremes occur sequentially of simultaneously (cold + precipitation, long dry spell + intense rainfall, wind + rain etc.). These respondents expressed that the "extreme event" that could be of interest in an attribution exercise should ideally be specified in terms of several meteorological variables, not as a single one.

3.6. Discussion and Conclusion

3.6.1. Potential user groups and their understanding of EEA

The stakeholder consultation shows that *"a suitable product of extreme event attribution is able to meet commercial interests"* of the insurance sector (see chapter 3.2.3). An engagement process building on in-depth interviews with various groups of stakeholders has provided a profound basis for this analysis. It proved to be expedient, in this context, to base the stakeholder typology on a literature review and continuously advance it in the course of the interview process (see chapter 3.3.1). It provided a foundation to confirm the hypothesis derived from the literature review that "[…] *decision-makers in insurances and re-insurances as well as in associations […]"* would be interested in EEA (see chapter 3.2.3). Beside these, the interviews show that also data and information service providers for the insurance sector are an important stakeholder group worthwhile considering.

The statement that "no one *understands risk* better than the insurance industry - except, perhaps, the reinsurance industry" [The New York Times, 27.08.2013] was particularly visible when comparing the interviews with insurance representatives with the ones with regional stakeholders. The consulted stakeholders from the insurance sector are indeed very knowledgeable in terms of 'risk' and therefore often more acquainted with aspects related to extreme event attribution than the regional stakeholders consulted in WT4.2 (see D4.2, 3.6.1). It also seems to hold true that re-insurances have an even more profound understanding of risk than direct insurances have. The interest in *risk-related information* was generally high. Nevertheless, for the interviewees risk comprises more than just the causation of changes in the hazard patterns which are at the centre of EUCLEIA. Most of the interviewees were more interested in the vulnerability and exposure side of risk indicating how important it is to embed EUCLEIA results into the overall risk context and impact modelling (see chapter 3.4.1). This coincides with what was found in the media analyses (see D4.1, p. 62) and for the regional stakeholders in WP4.2 (sees D4.2, 3.6.1). Similar to what was mentioned in the literature, winter storms, hail and heavy rainfall were the most relevant extremes to the interviewees; storm surges at the Baltic Sea, and heat waves in the greater Paris area, which are at the centre of this case study played merely a minor role. In a world where climate change has "effectively caused a shift towards a 'new normal' for a number of insurance-relevant hazards" [*Geneva Association and others*, 2014], interest in climate change was supposed to be essential to insurances and re-insurances (see section 3.4.1). Nevertheless, it was, in contrast to re-insurances, of only minor importance to direct insurances. A potential user group that emerged from the French case study consists of individual and structures involved in the design and implementation of the RCN (association, state owned reinsurers and civil servants).

The literature review in D4.2 reveals that some EEA scientists argue that extreme event attribution could be fundamental to decision-making and raise large interest among stakeholders [see e.g. *Hulme*, 2014; *Stott and Walton*, 2013]. In D4.1, we refer to Renn [2008] in this context and put up the assumption that EEA allows for a better understanding of the extreme event, renders risk perception and feeds into all processes of risk governance. Similar to what we found for regional decision-makers consulted in WP4.2, this

was not really the case. The interviewees were all well-aware of the fact that also some extreme events are likely to change due to anthropogenic climate change. This was a major reason why EEA might rarely change the perception of risk substantially.

3.6.2. Fields of application and commercial benefits from extreme event attribution

In the literature review, we identify various potential fields of application, including: strategic decisions, risk modelling, premium setting, marketing, public campaigns, and political leverage. To get a better idea, why EEA might matter to these fields and to appreciate whether there are others which are overlooked so far, we decided to not only focus on the potential need for EEA, but also on the general relevance of climate and extreme event information. Understanding the overall mandate, background and objectives of the stakeholders facilitated unrevealing perspectives which are also relevant for EEA, a field of research which is complex, still rather abstract and which people are not acquainted with.

Some interviewees confirmed that EEA could "*inform strategic decisions*" and might be useful for debates in the management or foundation board. It would thereby certainly not be the only piece of information which triggers strategic decisions, but could well contribute to it. Furthermore, in the French case EEA was seen as showing potential to strengthen the motivation for RCN reform. In the Baltic Sea case, it was not mentioned, though, that EEA would provide an argument for introducing storm surge insurances as hypothesised. A legitimization of higher premiums was named as potential commercial benefit, yet the regulatory framework, as in France, may prevent from being able to capture such benefits. In the German and French case, representatives from direct insurances have furthermore assumed that EEA could help negotiate premiums of the re-insurances. Overall, in the German case extreme event attribution seems to be able to provide justification for higher prices, pay less, or help make larger profits, if it provides the "right" results - possibly also when uncertainties are high. If it does prove the opposite – namely that climate change has no influence on extreme events – the insurance representatives are able to simply ignore the information. This brings up an essential question, i.e. how solid have findings got to be, before they are made public and can thereby be utilised to meet commercial interests.

Whether or not EEA can "*improve risk modelling and premium calculation"* so that the insurance sector could *"benefit from more appropriate premiums and would thereby reduce business risks*" (see section 3.2.3) was controversially debated, particularly by interviewees in the German case study. It was explained that EEA could contribute to model development, hazard or extreme event footprints, net-present-value calculations, or impact models and thereby influence premium setting. The interviewees consulted in the German case study were, however, not certain whether it would actually be able to improve risk modelling and premium setting significantly and thereby provide commercial benefits from better risk estimates or more appropriate premiums. Others argued that it is merely past or present return periods which matter to their models and not the anthropogenic contribution to it. None of the stakeholders in Germany/Switzerland argued that the added value of EEA for risk modelling is currently large enough to pay for it. In France responses were less clear cut, interviewee expressed the fact that that the inclusion of EEA in models would be culturally challenging and that the industry might consider buying services attuned to their specific needs.

The interviewees engaged in public relations and awareness-raising conditionally confirmed the hypothesis that "*Extreme Event Attribution can add to public campaigns and political leverage because it illustrates the necessity to take action. The insurance sector would benefit from an increased demand for natural hazard insurances".* Some stakeholders imagined that EEA could contribute to existing *public campaigns*. They did not mention, though, that it would notably increase the awareness of the "nexus between insurances, natural hazard-related damages, and climate change" [see chapter 3.2.3; Hoffmann and Welp, 2011]. The interviewees in the German case study further argued that the success of campaigns does commonly not depend on single numbers and that EEA would therefore, if at all, only marginally contribute to increase the demand for natural hazard insurances. Political leverage played a larger role at the international level, and less so nationally or regionally. Commercial interests in EEA are therefore rather linked to enhancing the international influence of re-insurances on climate negotiations than to raising the demand for direct insurances or the political commitment for the insurance sector in Germany as assumed in the literature (see section 3.2.3). In the context of a highly regulated insurance market, the commercial benefit of EEA may be seen as providing leverage on policymakers for reform of the market allowing for more flexibility both for insurers and reinsurers.

The hypothesis that also local insurance agents could benefit from EEA in their sales activities was not confirmed by the interviews. This finding, however, is only based on interviews with people either not directly involved in local sales activities (Germany) or in a situation where the market is already saturated (France). The perspective of local agents themselves could either not be integrated in the analysis because they did not answer our requests or denied an interview appointment (Germany) or because sales agents were more concerned with market share than with market development (see chapter 3.3.1 and above, Deboudt, 2010).

3.6.3. Stakeholder requirements to develop useful extreme event attribution products

The stakeholder engagement reveals a multitude of requirements for making extreme event attribution a useful information product. Given that none of the interviewees actually applies extreme event attribution information yet, it was sometimes difficult to get concrete insights on potentially relevant requirements. It was therefore important to embed the interviews in an overall climate service context, and not only focus on extreme event attribution (see also D4.2 where a similar conclusion was drawn). The stakeholder engagement shows that the most commonly stated requirements are linked to either salience or credibility concerns. These categories represent two of the three quality criteria for information services identified by Cash et al. [2002, 2003] (see D4.2, section 3.2.1 for more details about the concept). Legitimacy, which was proposed as third category, has rarely been mentioned – as was also the case for the consulted regional stakeholders in the Baltic Sea region (see D4.2). Nevertheless, legitimacy is essential given that it is often a necessary condition to produce credible and relevant information and is therefore nested in most other requirements.

The hypothesis that "*Stakeholders from the insurance sector require extreme event attribution products […] which are attached to small uncertainties"* was confirmed by the interviews. Credibility concerns were essential for the consulted stakeholders in the insurance sector. This coincides with what has been found in D4.2 for regional stakeholders

and by other EEA studies [see e.g. Stott and Walton 2013 in section 3.2.1] as well as in the literature concerned with the evaluation of climate information [see e.g. McNie 2013, Storch et al. 2011]. The stakeholder consultation in WP 4.3 is able to show that credibility is linked to more than just the "level of uncertainty" and indicates what credibility means to the people The interviewees mentioned in this respect that credibility depends on the reliability of the underlying research process, the solidity of the data basis, the plausibility of results and explanations, and the trustworthiness of the source of information. It is accordingly linked to similar criteria as was the case for regional stakeholders (see D4.2, section 3.2.1).

Also the hypothesis that "*Extreme Event Attribution raises larger interest if it is linked to impacts and damages of extreme events"* and that *"Stakeholders from the insurance sector require extreme event attribution products which are available over a long time period, for specific extremes […]"* seemed to hold true, at least for some of the consulted stakeholders. The interview process reveals that these criteria are just some of a multitude of different requirements which turn information like EEA into information relevant to the work people are doing. Further requirements were linked to the regional focus, spatial resolution, type of extreme event, selected meteorological parameters, ways of defining extremes, the availability of a whole event set, the actual result of the analysis, an understandable and intuitively accessible presentation of findings, the availability of return periods, conveyance of concrete implications, forms of access and user rights, the time of availability, continuity and operationalization of a service. Accordingly, these criteria are widely different from the ones commonly mentioned by regional stakeholders or ranked differently in the set of identified criteria. The study furthermore reveals why each of these criteria is of relevance, what they actually mean for the stakeholders, and how they facilitate feeding in different fields of work.

Overall, most of the stakeholders did not have a preference for EEA information in near-real time, particularly not if they would only be irregularly available for singular events. They rather wanted solid and reliable information which is attuned to their models and products, fits their viewpoints and/or the results support their existing objectives.

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4. Lessons Learnt

The methodology and empirical findings in WT4.3 demonstrate key lessons to be learned for the following work task 4.4 where the general public will be polled by a representative telephone survey in order to comprehend their interests in information from extreme event attribution.

In WT 4.3 we decided to conduct in-depth interviews. They served both exploratory and explanatory purposes. Extreme event attribution is a novel information product and there is only little known about potential interests of insurers in EEA to date, particularly not in the selected case studies. In-depth interviews were therefore important means to get insights and explanations why certain things matter to the stakeholders and others not. As already argued in D4.2, in-depth interviews might also be expedient for WT4.4. Before conducting a quantitative survey, as intended, we need to know what to focus on and how to formulate which questions in an understandable way. The complexity and unacquaintedness of the public in terms of EEA is particularly critical to a telephone survey, as planned in WT4.4. It is therefore indispensable to design the questionnaire thoroughly, test it carefully, and train the interviewers well.

Similar to the selection of interviewees in WT 4.2, we developed a stakeholder typology which is based on a literature review and has been continuously advanced in the course of the interview process. The interviews did in this context not only help identifying interested institutions and people in charge, but were used for snowball sampling. Being referred from one representative of the insurance sector to another certainly raised the likelihood of receiving an appointment for interviews. For the survey of the general public, however, a stratified random sampling might be more expedient given the larger basic population.

It proved to be important to embed the stakeholder engagement not only in the context of extreme event attribution, but into the overall context of climate and extreme event information. In this way, it was possible to understand the general background, mandate and objectives of the interviewees and transfer findings on general climate and extreme event information to extreme event attribution. This was most important for the representatives from the direct insurances which were not expert on extreme event or climate change-related topics. The interviews with re-insurances focused more on extreme event attribution because the consulted stakeholders were more acquainted with the concept of EEA and had a better idea of how and where to apply such information. In the general public, the number of people who do not deal with climate and extreme event information in their daily life is most likely larger than among regional stakeholders or people from the insurance sector. It is therefore essential to explain extreme event attribution well and embed it in the overall context of climate and extreme event information.

Both WT4.2 and WT4.3 reveal that needs and requirements are diverse and vary across stakeholder groups, particularly relevance-related criteria. So far, we defined “needs” mainly by referring to the applicability in different fields of professional work. This will be different when considering the general public in WT4.4. We will proceed from the professional to the private sphere where perceptions are linked to a very different set of goals. It is therefore important to explore these goals and understand why climate change and extreme events matter to them and how information on these can change their risk perception and behaviour. The general public is in this respect likely to be less aware of the fact that the

chances of being affected by an extreme event could be altered by anthropogenic climate change already today. EEA may therefore have a more significant influence on their perception and governance of risk than it has on the stakeholders considered in WT4.2 and 4.3. Renn's [2008] concept of risk perception and governance might thereby provide a good basis to assess the usefulness of extreme event attribution.

Beyond the lessons learned above, the French case study added the dimension of the regulatory environment. The quite importantly regulated French insurance market has not been designed to handle emerging natural catastrophes or relatively rapid changes in probabilities. This leads to a situation that a radical innovation as EEA may see its development hindered because it addresses an issue that was not envisioned by the regulator. As such, EEA does not only have the potential to reinforce the insurance as an economic sector, it has also the potential to contribute to a message in terms of the need for a better attuned and more reactive regulatory environment.

5. Links built

In work package 4.3 several links with EUCLEIA partners were built or strengthened. The WP4 partners had a meeting in Paris in November 2015 and aligned the methodology of both test cases in work task 4.3. The cooperation between WP3 and WP4 was further strengthened in the course of this work task. There were several WP3-WP4 telephone conferences and personal meetings; WP4 members participated at a WP3 workshop with the stakeholder user panel in Paris in July; and WP4 members connected several interested interviewees from the insurance sector with the WP3 colleague and the stakeholder user panel. In WT 4.3, also the links to the test cases have been enforced. There exists a close cooperation and continuous exchange with the scientists involved in the WP7 test case of Baltic Sea storm surges. Links with the other test cases were made at a WP7 meeting in Amsterdam in November, where WP4 contributed their insights from the consultation of regional and insurance stakeholders to the definition of extreme events for the test cases. For the Paris case study, WP6 scientists assisted WP4 researchers in the identification of interviewee.