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EUropean CLimate and weather Events: Interpretation and Attribution

Deliverable D4.5

Work package Synthesis report

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1. Executive Summary

Objectives: WP4 assesses the usefulness of a service, which would provide “event attribution” for different potential user groups. It supports achieving the overall EUCLEIA goal to “provide to targeted groups of users, well verified, well understood assessments” and thereby helps closing the gap between stakeholder and public needs on the one side and expectations and ambitions of scientists on the other. To do so, we empirically assess these issues at the example of two case studies dealing with storm surges at the German Baltic Sea Coast (HZG) and heat wave/cold spell in the Greater Paris area (UVSQ). Within these case studies we focus on regional stakeholders, the (re-)insurance sector, the general public, and scientists. The findings and conclusions drawn from these case studies shall provide a basis for deriving conditions for a successful promotion of extreme event attribution.

Theoretical grounds: The study builds, firstly, on concepts of risk governance and risk perception, as proposed in D4.1. This allows conceptualising how stakeholders perceive, understand and articulate extreme event attribution within an overall risk governance context. Secondly, the study makes use of evaluation approaches and concepts explaining the usefulness of scientific climate information and services in an overall decision-making process, as proposed in D4.2 and D4.4. This demonstrates why stakeholders may find extreme event attribution (EEA) useful, shows how to facilitate a successful dissemination, and explains the role of climate services, the media and boundary management between scientists and stakeholders.

Methods applied: The empirical data was acquired by applying a mixed-methods approach which builds on grounded theory (M2). We conducted qualitative interviews, participatory workshops, media analyses, and quantitative surveys. In line with grounded theory, a continuous dialogue between the scientist, existing theories, and the acquired data from the different empirical corpuses was fostered in the selection and design of methods and analysis. The main research questions were in this context:

1. How do stakeholders, the general public, and scientists understand and articulate EEA?
2. Who are potential users and how do they perceive the usefulness of EEA?
3. What makes such information and services useful?
4. How can scientists, climate services, and the media foster fulfilling these requirements to successfully provide a service on extreme event attribution?

Discussion of empirical findings: The expectations of and interactions between stakeholders, public, and scientists are manifold and determine the way how extreme event attribution is or could be perceived, evaluated, and promoted. The empirical data from the case studies reveal that science plays an only minor role in the direct knowledge acquirement of stakeholders and the public. Scientists are most interested in funding opportunities and scientific reward. Interests of stakeholders and the public stay thereby often unknown. The general public and regional stakeholders want above all that science explains complex phenomena and give recommendations for actions. Scientists, however, often hesitate to give these recommendations for action.

The empirical data also show that there is no one set of user groups and that it is more the different fields of work represented in a specific user group which matter. The general public and stakeholders at the regional level mainly referred to awareness-raising activities as

beneficiaries of extreme event attribution; insurance representatives thought that it could feed into strategic decisions and premium calculation. Scientists believe that it can contribute to climate change mitigation and adaptation.

The needs and requirements of regional stakeholders, (re-) insurances, the public, and scientists have shown to be diverse, different and sometimes divergent. For instance, extreme event attribution would arouse interest of insurances if it justified higher prices, for regional stakeholders if it illustrated climate change at the regional level, for the public if it explained the reasons for changes, and for the media if it answered the “weather-blame question”, meaning who is to blame for extreme weather events, preferably with a dramatic signal. A dramatic worst-case scenario is, however, not necessarily what stakeholders want. For many it would rather reduce trust in findings than raise awareness. Trustworthiness is another important requirement which is defined rather differently. For scientists, trusted information has to meet standards of scientific solidity; for insurances, it needs to fulfil internal quality controls; and for regional stakeholders it is trustworthy if received from a trusted knowledge broker. A further example of divergent expectations is what people understand as the “right” timing for publishing information. Insurances and information services want extreme event attribution results to be published in line with their reporting schedule; regional stakeholders only want such information if it is as solid as possible; and the general public wants it as early as possible after an extreme event.

Key conclusions and recommendations for action: Analysing the key requirements of the consulted stakeholders against the background of existing literature on evaluation and climate services facilitated identifying three core criteria to evaluate potential services from extreme event attribution for specific user groups. These are: 1) Clarity and comprehensibility, 2) Context-sensitivity and decision-relevance, 3) Trustworthiness. For a thorough evaluation we need to break these categories down into more specific criteria. These are diverse and cannot be met with a one-size-fits-all service. To derive recommendations for providing a service on extreme event attribution it is therefore inevitable to consult stakeholders and get hold of their specific needs and requirements as it has been done in WP 4. In the following, several recommendations are listed which are relevant to most of the consulted stakeholders, but are certainly not applicable to all groups in the same way. They can still give an indication of aspects which are to be considered.

1. Expedite clarity and comprehensibility:
 - Provide intuitively accessible and understandable information
 - Translate into mother-tongue and every-day language if necessary
 - Find and establish a German translation for the term ‘attribution’
2. Ensure trustworthiness (if certain stakeholder groups are defined)
 - Involve trusted regional and/or sector-specific information services
 - Collaborate with stakeholders to develop user-specific quality control compatible with existing mechanisms
 - Communicate uncertainties & explain study background, data basis and methodologies
3. Facilitate context-sensitivity and decision-relevance:
 - Assess relevant extremes & parameters, i.e. know stakeholders’ exposure, fields of work, data processing and reporting standards
 - Attribute impacts not only hazards, i.e. strengthen ties to the impact modelling community
 - Find appropriate time of availability, i.e. does not necessarily mean as fast as possible

- Ensure continuity, i.e. establish or link up with a long-term operational service.

To put these recommendations into action, scientists can and should interact with stakeholders and knowledge brokers. For WP4, it has been intended to interact with stakeholders before having EEA results at hand. However, an expedient stakeholder dialogue is likely to require enabling knowledge and raising interest first, before tailoring EEA to the needs of stakeholders. This requires an easy access to the overall topic first which is facilitated by presenting understandable information in a first step of stakeholder interaction. Subsequently, relevant topics and questions can be identified and services can be better tailored to the needs of potential users. A stakeholder dialogue is, in the one way or the other, inevitable to ensure legitimate and relevant information. Established cross-sectorial and sector-specific climate services act at the interface of science and practice. Connecting with a network of boundary organisations at European, national, and regional level can accordingly facilitate a continuous dialogue. Against this background, climate services can support putting the above mentioned recommendations into action. This requires that they are in a continuous dialogue with stakeholders and scientists, independent, provide long-term services, are scientifically competent, know how to make science understandable, and are aware of stakeholder needs to create interesting and useful products.

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 4.5 as it appears in the DOW

In the Description of Work (DoW), Deliverable 4.4 (D4.4) is described as “Synthesis report - Promoting attribution products: Conditions for success with stakeholder and recommendations”. It builds on empirical evidence 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 tasks 4.1, 4.2, 4.3 and 4.4 provide the basis for this synthesis report.

3.1.2. Deliverable 4.5 against the background of overall project objectives

The synthesis report is meant to provide a discussion of the findings in the previous work packages and derive recommendations for reaching the overall EUCLEIA goal 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” (DoW part B, p. 4). The previous work tasks have all displayed “the requirements that targeted user groups [namely the regional stakeholders, insurance representatives, scientists and the general public] [...] 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). This includes findings which indicate how to frame attribution studies so that they find attention (objective No. 2, Dow part B, p.4). It 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). We can draw upon the conceptual foundations laid in work tasks 4.1, 4.2, and 4.4, including risk governance, decision-making and evaluation approaches in the context of climate services in general and extreme event attribution products in particular.

Overall, this deliverable helps deriving conditions for a successful development and dissemination of potential EUCLEIA findings by considering the interplay of different requirements from stakeholders, scientists and the general public. This synthesis will provide a basis to create appropriate EUCLEIA products and climate services from extreme event attribution science for regional decision-makers, the general public, and the media. It can help manage expectations of the non-scientific community, create credible and practice-relevant information, and develop effective dissemination strategies. In the end, this can facilitate integration into existing climate services, like regional climate offices, sector-specific information providers, and the European climate service Copernicus. In this way, an important cornerstone for raising the motivation to implement individual climate change mitigation and adaptation activities can be laid.

3.1.3. Report outline

In the following, we will first introduce the main concepts and the contextual background derived from existing literature. It served as basis to develop methodologies for empirical research, provided a better understanding of underlying structures and processes, and facilitated discussing the empirical findings against existing literature. In the next section 3.3, we describe the methods used to obtain empirical data for the two case studies. It refers to the qualitative interviews, group discussions, surveys, and media analyses conducted in WP4. Sections 3.3 and 3.4 delineate central findings from the case studies in the Baltic Sea region and in the Greater Paris area. This comprises results describing the general understanding of extreme event attribution, potential user groups and interests, and stakeholder requirements regarding potential EUCLEIA products and services. From these findings, we derive key recommendations on how to identify relevant evaluation criteria, facilitate fulfilling underlying requirements regarding information and services, and thereby help promote EUCLEIA products. In section 3.6 we draw common conclusions from the discussion of both case studies' findings. Chapter 4 will then present the main challenges, limitations, and lessons learned from our work conducted in WP4. In chapter 5, the main links built during the three project years will be summed up.

3.2. Literature review – relevant concepts and contextual background

3.2.1. Conceptual basis presented in D4.1, D4.2 and D4.4

Risk governance and risk perception concepts as proposed in D4.1 and D4.4 (partly cited from D4.4)

In Deliverable 4.1 (D4.1), risk perception and risk governance research is introduced as overall conceptual framing for the stakeholder consultation undertaken in WP4. We build on Renn and his co-authors' [see e.g. *Renn, 2008*] conceptual framing of risk perception and governance to grasp stakeholder understanding, needs and requirements with respect to extreme event attribution services. Along these lines, we define risk governance as all “structures and processes for collective decision making” regarding risks [*Renn, 2008*] (see D4.1 for more details). Renn [2008] also proposes an integrative framework for risk perception which we anticipated to facilitate conceptualising how the general public and stakeholders perceive, understand and articulate extreme event attribution within an overall risk governance context. To gain a more detailed and focused view on how risk perception actually feeds into governance, we propose in D4.4 concepts which explain when larger risk awareness leads to a motivation to take action. We thereby refer to Grothmann and Patt [2005] who propose that the motivation to act is not only influenced by the perception of climate change-related hazards, but also the perception of one's own capabilities to apply appropriate actions. Both cognitive processes are mainly determined by social discourse on climate change, reliance on public adaptation, risk experience appraisal and cognitive biases and heuristics. Extreme event attribution information can feed into most of these external social factors [APA, 2009; Engels et al., 2016; Hornsey et al., 2016; *Grothmann and Patt, 2005*; Kane et al., 2014]. To understand, how knowledge about climate change is most likely to influence cognitive processes, we propose in D4.1 that the social articulation of Extreme Event Attribution, related needs, and their specific requirements which are manifestations of evidence-, material-, and value-based claims (see D4.1 and D4.4 for more details).

Concepts explaining the usefulness of scientific (climate) knowledge in stakeholders' decision-making as proposed in D4.2 (cited from D4.4)

In Deliverable 4.2 (D4.2), we propose a conceptual framing which complements the concepts proposed in D4.1 and D4.4. In particular, to understand why stakeholders may find scientific information useful and why they are able to access and apply gained knowledge. We argue that Cash et al.'s [*Cash et al., 2003; Cash et al., 2002*] criteria for assessing information and information services can provide a valuable basis to do so. Along these lines, information is most likely to influence the risk perception and thereby also decision-making if the boundaries between knowledge and action are managed in ways “that simultaneously enhance [their] salience, credibility, and legitimacy [...]” [*Cash et al. 2003*]. To grasp how to fulfil these requirements we also draw on von Storch, Meinke, et al. [2011] who claim that it is essential to assess and understand “regional experiences, memories and values [...]”; present information in an understandable manner, consider relevant region-specific impacts, and embed scientific findings in the overall political and societal decision-making context [von *Storch et al., 2011*]. Pielke emphasises in this context that a responsible scientist should function as an “honest broker” who is able to explain complex processes and research results and facilitate identifying expedient ‘solutions’ also in case of high

uncertainties [Pielke, 2007]. Several scholars like von Storch [2009], Krauss and von Storch [2012], or Bray and Martinez [2011] argue that a mutual science-stakeholder dialogue has increasingly gained importance to live up to these requirements. This is an answer to a so-called 'post-normal situation' which is characterised by interest-lead science. Several authors argue in this context that there is a need to focus on more than just scientificity, methodological profoundness, or scientific validity to make science more 'useful'. It is essential to consider its relevance to decision-making and its social acceptance [Bray and Martinez, 2015; von Storch, 2009]. Scientists alone can rarely fulfil stakeholder requirements. Various climate services have therefore emerged which set grounds for making science more useful and are therefore also important to be considered in developing EUCLEIA products.

3.2.2. Contextual background presented in D4.1, D4.2, D4.3, D4.4

Potential users of an EEA operational system (partly cited from D4.2, D4.3 and D4.4)

Among scientists extreme event attribution has received increasingly attention in recent years. It is on the one hand highly debated among scientists, but is on the other hand increasingly represented in high-ranking journals and on scientific conferences. It is believed to be able to serve the perpetual and plain-old interest in the cause of extreme weather [Banholzer et al., 2014; Hulme, 2014; Trenberth et al., 2015]. Nowadays, it is no longer god or evil spirits who are most commonly held responsible for nature's capriciousness, but climate change. Particularly after extreme events or at times of major climate negotiations like 2015 in Paris, people want to know whether anthropogenic climate change caused recent extreme events (see e.g. *New York Times*, 2016-08-01; Al-Dabbagh, 2016).

Many attribution scholars have claimed that extreme event attribution is fundamental to decision-making of various stakeholder groups [Hegerl et al., 2010; James et al., 2014]. Stott et al. [2013] identify four major groups of EEA service users based on their experiences from case studies where EEA attempts have previously been made. These are: the general public, the legal sector, actors engaged in climate change adaptation, and the geo-engineering sector. In other studies, also the insurance sector and the media have been named as potential users of EEA information [Hulme, 2014; James et al., 2014; Stott and Walton, 2013]. In the adaptation debate, it is for instance, argued that extreme event attribution information would not only enhance the justification for taking action and facilitate more effective resource distribution, but would also improve planning and implementation of climate adaptation [Stott et al., 2013; Stott and Walton, 2013]. For the insurance sector, it was found that changing risk patterns, challenging risk assessments, and the evident need for adaptation pose key climate change-related challenges to the insurance system. This demands a solid information base to take appropriate decisions which could be complemented by extreme event attribution information.

The designation of these sectors and their potential needs mainly builds upon EEA studies which have been undertaken so far, in particular on studies about the contribution of anthropogenic climate change to extreme events like heat waves, cold spells, heavy rainfall or flooding - mainly in the UK and the US. The identification of potential users has, however, not been reflected against the background of context-, hazard-, or region-specific factors. Potential users of EEA in the context of, for example, storm surges at the German Baltic Sea Coast or heat waves in a region like Greater Paris might well be substantially different to

those interested in EEA for flooding in the UK. WP4 looks at various potential user groups in two test cases of different regions, hazards and contexts (see table 1 and 2 in M2). It is therefore able to shed light on such aspects while at the same time allowing for identification of potential regularities.

Stakeholder-specific needs as discussed in the literature (partly cited from D4.2)

The review of extreme event attribution literature reveals that the **credibility** of results is a major concern and yet there is little known about stakeholder perspectives on it. Most people dealing with climate change and extreme events seem to think that it is not possible to attribute specific events to anthropogenic climate change. This is assumed to be caused by the facts that there is yet little information available about the contribution of anthropogenic climate change to specific extreme events and that the information which is provided is often contradictory and highly uncertain [Stott and Walton, 2013]. Hulme argues that extreme event attribution information which lacks credibility may “open up new spaces for political contestation, but now hidden in the language of science” [Hulme, 2011]. These are arguments which can be found in the context of most climate change related debates [see e.g. Koerth and Sterr, 2012; Patt and Weber, 2013]. Also **salience** is indirectly acknowledged as relevant criterion in extreme event attribution studies. Stott and Walton [2013], for instance, state that the relevance and interest in such information is largest during or right after an extreme event. This might even compensate for the larger uncertainties which are to be expected if results have to be produced timely. They also argue, that such information should be available on a regular basis similar to weather forecasting services. Moreover, the results themselves seem to influence the relevance of information about the anthropogenic forcing of extreme events. Adam, for instance, argues that lawyers would only get interested in such information if the contribution of climate change would be large enough [Adam, 2011]. The review of the literature has further shown that **legitimacy** is a rarely named criterion in extreme event attribution studies. According to Stott and Walton [2013], most extreme event attribution studies have not met the requirement of producing research results in consultation with relevant stakeholders, i.e. they have not explicitly considered legitimacy concerns in their research. Scientific rigour and innovative research methodologies have been at the centre of interest instead. Thompson and Otto [2015] somehow touch this question by considering the ethical and normative dimension of EEA within the context of loss and damage.

How extreme event attribution research is effectively translated, mediated and communicated by boundary managers like climate service providers has not yet been studied. And also questions like: “How important are these criteria to different stakeholder groups? In how far influence quality judgements of extreme event attribution risk perception? And how do these perceptions feed into governance processes for climate change mitigation and adaptation?” have not been addressed so far in extreme event attribution literature more thoroughly. Answering these questions, however, builds cornerstones for identifying and understanding conditions of successful EUCLEIA services as intended in this deliverable and in the EUCLEIA project in general. The EUCLEIA project has thereby committed itself to move beyond the current state of the art by “engaging with targeted groups of stakeholders in a systematic and comprehensive fashion from start to finish of the project” and therefore intends to put also legitimacy criteria to the fore. In the following chapter, we will present the applied methodologies to do so and to find out about stakeholder-specific needs and requirements.

3.3. Methodology and materials

In WP 4, we have decided to apply a multitude of methods in a mixed-method design and have followed a grounded theory approach. In Table 1, we summarise the applied methods in the different work tasks. For more details about the methodological reasoning and field research methods see Deliverables 4.1, 4.2, 4.3 and 4.4 as well as Milestone 2. One of the more fundamental challenges was to harmonize, as much as possible, the methodologies used in both case studies. This was challenging at three levels. First, storm surges and heat waves impacts the population and the stakeholders differently. They occupy different spaces in the memory and are treated differently by private and public interests. Second, when surveying human subjects, culture does matter. Once methods are harmonized, pre-tests are conducted in order to ascertain whether the method, as designed, is applicable in a specific setting. This led to changes in methods at the margins. Finally, when interacting with human subject current context matters. For instance, the fact the COP21 had been held in Paris, did influence the answers obtained in the greater Paris area. These variations had to be taken into account both at the data collection level and at the data analysis and interpretation levels. This tension between harmonization and local specifics led to the mix of methods and approaches that are presented in the table below:

HZG	UVSQ	WT
1. Media analyses: reporting on Baltic Sea storm surges <ul style="list-style-type: none"> Regional print media Four storm surges (>1.5m), 64 articles 	1. Media analyses: reporting on heat waves / cold spells (D4.1) <ul style="list-style-type: none"> Regional print media Winter 1953-4; summer 2003 	4.1
2. Interviews with German speaking scientists <ul style="list-style-type: none"> working at least partly on attribution / climate service / storm surges 8 interviews 	2. Interviews with EUCLEIA scientists <ul style="list-style-type: none"> 11 interviews (out of a total of 48 EUCLEIA scientists) 	4.1
3. Survey of mayors <ul style="list-style-type: none"> 1109 personal invitation letters 165 answers = 15% response rate 		4.1
4. Interview with regional stakeholders <ul style="list-style-type: none"> 9 interviews with stakeholders from: civil society organisations and education, public and private sector actors 	3. Interviews with regional stakeholders <ul style="list-style-type: none"> 7 interviews with stakeholders from: civil society, administration, public-private partnerships and private sector actors 	4.2
5. Focus group workshop <ul style="list-style-type: none"> 12 participants - regional public and private sector stakeholders 	4. Focus group workshop (WT4.1, 4.2) <ul style="list-style-type: none"> 6 participants from public bodies engaged in health and climate change planning 8 participants from local governance bodies or involved in services related to local governance and land use planning. 	4.2
6. Interviews with representatives of the insurance and re-insurance sector <ul style="list-style-type: none"> 9 interviews with stakeholders from direct insurances, re-insurances, sector-specific information services, and association 	5. Interviews with representatives of the insurance and re-insurance sector <ul style="list-style-type: none"> 11 interviews with stakeholders from direct insurances, re-insurances, sector-specific information services, and association 	4.3

<p>7. In-depth interviews with the general public</p> <ul style="list-style-type: none"> 5 interviews (with 8 people) with representatives of the general public and civil society 	<p>6. In-depth interviews with journalists</p> <ul style="list-style-type: none"> 15 interviews with journalists. 	4.4
<p>8. Telephone survey of the general public</p> <ul style="list-style-type: none"> Telephone-based pre-tests with 13 people randomly selected from the official telephone registry Survey of 630 households living at the Baltic Sea coast (subcontracted) 	<p>7. Telephone survey of the general public</p> <ul style="list-style-type: none"> Telephone pretest with 5 people, volunteers identified in a pool of students Survey of 903 households living in the greater Paris area (subcontracted). 	4.4
<p>9. Media analysis: German-speaking national online newspapers</p> <ul style="list-style-type: none"> reporting after heavy rainfall event in 2016 articles on extreme event attribution 	<p>8. Media analysis: French-speaking newspapers</p> <ul style="list-style-type: none"> reporting after heavy rainfall event in 2016 with a focus on the treatment of the attribution question/ 	

3.4. Recommendations derived from the Baltic Sea case (HZG) and the Greater Paris Area case (UVSQ)

3.4.1. Understanding of extreme event attribution and its implications for developing extreme event attribution services

An understanding of how stakeholders conceptualise and articulate extreme event attribution facilitates identifying the specific needs and requirements of decision-makers. It is thereby important to understand the sometimes similar, sometimes divergent interests and perceptions of various stakeholder groups to find ways of making them more compatible with each other. This can strengthen the motivation to take actions by each of the stakeholder groups. So far, there are only very few studies which assess the degree to which scientists and different stakeholder groups differ in their perceptions of climate change, particularly not against the background of extreme event attribution research (cited from D4.2 and D4.4).

The interviews with German-speaking climate and attribution scientists in the first year of EUCLEIA reveal that attribution is defined as the assignment of a certain cause to a statistically detected deviation from the norm. Event-Attribution, in contrast, is understood to answer the question if and to what extent a single extreme event is caused by anthropogenic climate change. It was perceived to be more elusive than attribution in general and could therefore only be explained after consideration and the mental reconstruction of their everyday work. Extreme event attribution is perceived as extraordinarily complicated, since extreme events are rare events making it difficult to be assessed with statistical methods. Furthermore, the interviewed scientists in Germany articulate “Detection and Attribution” and “Extreme Event Attribution” solely in English language. German language is not used as primary communication language and there seems no larger need for a good translation into their national language. This can be framed as an eloquent speechlessness (*see D4.1 for more details*).

Similar to the interviewed scientists, regional stakeholders, in France and in Germany, assumed that EEA is a highly complex scientific endeavour without knowing more details about the science behind it, though. In general, most of the interviewees never used or even heard of the possibility of EEA before. This seemed to cause a lack of understanding and misunderstandings of EEA. After explaining – using mock attribution statement and reports - the kind of results expected from EUCLEIA, most people seemed to understand the general idea behind EEA. Methodological details and potential results have been perceived to be rather abstract and complex, however. And stakeholders commonly misunderstood EEA, particularly as being equivalent to detection and attribution, or as being able to predict future extreme event characteristics or consequences rather than referring to the anthropogenic causation of singular past events. These aspects and difficulties might hold true not only for the considered stakeholders, but for most other stakeholders at a regional level who are far from being expert on EEA-related topics. The fact that there is no appropriate term for attribution in German language further complicated discussions and the articulation of EEA needs and requirements. This is one aspect which arises from the fact that scientific debates and publications related to climate change are almost entirely in English and rarely German or French. This eloquent speechlessness of German scientists may significantly inhibit awareness-raising and civic participation (*see D4.1, 4.2, and 4.3 for more details*). The

consulted stakeholders from the insurance sector (WT4.3) are, compared with the interviewed stakeholders at the regional level (consulted in WT4.2), more knowledgeable in terms of 'risk' and therefore often more acquainted with aspects related to extreme event attribution. Re-insurances have in this context an even more profound understanding of risk, as an interpretive frame for EEA, than direct insurances (see D4.3).

Furthermore, the general public, regional stakeholders as well as insurance sector representatives were rather sceptical that EEA is actually possible or is able to produce reliable results. This reflects the opinion of many climate scientists not directly involved in extreme event attribution science (see D4.2, 4.3 and 4.4). Stott and his co-authors [Stott *et al.*, 2013, see chapter 3.2.1] argue that the scepticism towards EEA might also be caused by the fact that uncertain and contradictory information about EEA has been provided in the past. Indeed, several media articles which posed the "weather-blame question" mentioned that it is not possible to attribute a single event to climate change. Considering that there is still a rather small number of articles asking this question or referring to climate change at all, this might play a minor role than expected. We have not observed that the general public and the consulted stakeholders in the Baltic Sea region are aware of any contradictory information in case of extreme event attribution. In fact, they have rarely heard of EEA-related information before (see chapter 3.4.1).

Recommendation (Strengthening awareness and knowledge of EEA): *A suitable product of EEA for regional stakeholders should be explicit with respect to what an EEA system as developed in EUCLEIA is, mention how it is different from related concepts, and explain these aspects in an understandable way.*

Recommendation (Establish understandable EEA terminology/language): *The scientific community needs to formulate and establish a mother-tongue terminology of extreme event attribution to be able to translate scientific language into mother-tongue and every-day language.*

3.4.2. Potential user groups & interests in extreme event attribution

In the extreme event attribution-related literature, it is argued that the results of extreme event attribution are fundamental to decision-making and raise large interest among stakeholders [see e.g. Hulme, 2014; Stott and Walton, 2013]. Commonly named potential user groups are: the general public, the legal sector, actors engaged in climate change adaptation, the geo-engineering sector, the insurance sector, and the general public [Stott *et al.* 2013; Hulme, 2014; James *et al.*, 2014; Stott and Walton, 2013]. Out of these sectors suggested, in fact, only insurances, national media, and the general public are identified to be potential users of extreme event attribution in this case study.

The empirical results of the German Baltic Sea case study show that there is a **general interest** in EEA when asking stakeholders explicitly. Among the representatives from the (re-) insurance sector, the interest in extreme event attribution appeared to be large. This reflects their generally high interest and understanding of risk in comparison with regional stakeholders. Most regional stakeholders told that it is generally interesting. When asking the mayors at the German Baltic Sea coast explicitly about their interest in potential findings of event attribution more than 80% stated that they would find it useful. A similarly high share of the general public thought that EEA is interesting. Considering that only very few

interviewees of the general public named climate-related issues to be among their main interests, people may rarely search actively for climate information. It is therefore very likely that such information will not reach most of the public – even if they find EEA results interesting. And if people coincidentally encounter EEA-based information, it seems to provide little added value for rendering the risk perception of the consulted stakeholders compared with the existing information. Particularly regional stakeholders seem to think that it is good and enough to know *that* climate change is man-made and that there is no need to know whether a specific event is man-made or not. It was often stated that it is interesting, but not really relevant to their work. The survey of mayors shows that only 2% ask for the physical basis of extreme events. This might, however, be owed to the fact that there are no such information available yet and they are not on the radar screen of most stakeholders.

The empirical results of the Greater Paris area case study show that, when explained in details, **EEA is deemed interesting**. Yet **this interest is closely connected to benefits associated to the attribution exercise rather than to attribution of a single event per se**. Regional stakeholders have interest in a better evaluation of return periods on order to dimension infrastructure and prepare land use plans. The insurance and reinsurance sectors see interest in obtaining mid to long term probability density functions in order to engage into better informed strategic planning.

The attention of regional stakeholders and the general public is clearly linked to media attention. Particularly public interest is naturally linked to **media reporting** and vice versa. In the literature on extreme event attribution, it is often stated that the ‘extreme weather blame’ question is the most commonly asked question to climate scientists by media representatives [Hulme 2014; Stott and Walton 2013]. The analysis of the regional press coverage after Baltic Sea storm surges undertaken in this case study, in contrast, reveals that reporting is mainly damage driven, physical conditions and climate change play only a minor role, and there is no article attributing a storm surge to anthropogenic climate change. This indicates that there is little interest in event attribution for Baltic Sea storm surges in the regional press and that it might therefore be difficult to convey such results (see D4.1). For other extreme events and for national or international press coverage the general interest might be higher. The national media in Germany, for instance, did report about Extreme Event Attribution findings after the latest BAMS report was published and after the latest heavy precipitation in Germany the weather-blame question was asked by numerous newspapers (see D4.4). Similarly, the analysis of the national press coverage of the heat (2003) and cold waves (1953-54) in the greater Paris area, as well as the analysis of the 2016 river floods, indicates a limited interest in climate and meteorological centred causal statements. Consequences dominates, this is even more so once damage and casualties are known. Attribution’s content, and associated expectations, seem to change in nature as the extreme event progresses in time (see D4.2 and D4.4).

The specific needs and requirements of different stakeholder groups depend on the **fields of work such** information can be used for. For the daily work of the interviewees, extreme event attribution was rarely perceived to provide an added value. It was not mentioned to be relevant to risk assessment, adaptation planning, or international negotiations. These are commonly mentioned potential user groups in the EEA literature, however. The survey of the general public in the Baltic Sea region reveals in this respect that it is most useful to public awareness-raising and political leverage. The survey of the general public in the greater Paris shows that people are most interested in EEA as a source of political leverage. In

Germany, the survey of mayors reveals in this context that extreme event attribution could be used particularly for enforcing action, planning, and for making sense. The regional stakeholders mentioned that extreme event attribution information could be most useful to the general public climate change discourses and to stakeholders engaged in awareness-raising. For the representatives of the (re-)insurance sector, extreme event attribution was mentioned to be particularly interesting to inform strategic decisions, risk and premium calculation. The latter was controversially debated, though. Generally, 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.

Recommendation (identification of target groups): *It is essential to know not only who potential stakeholders are, but particularly in which way extreme event attribution could be applied. Only when being aware of this, is it possible to tailor services derived from extreme event attribution to the often very stakeholder-specific needs and thereby raise the chances of providing useful information.*

3.4.3. Stakeholder requirements to potential EUCLEIA information

Similar to what has been found by other studies related to EEA [see e.g. *Stott and Walton 2013* in section 3.2.1] and climate information needs [see e.g. *McNie, 2013*], **trustworthiness** plays an important role for all considered stakeholder groups in Baltic Sea region. In most of the extreme event attribution studies dealing with stakeholder needs explicit criteria for trustworthiness are not empirically assessed. This case study shows that trustworthiness includes that the level of uncertainty is known and tolerable, the methodology is found to be solid, and the results plausible. Among the regional stakeholders concerned with German Baltic Sea storm surges, it was particularly the planners of large and expensive infrastructure which were interested in receiving credible information. Regional stakeholders rather demand an “honest broker” who is transparent with respect to uncertainties and the underlying methodologies as proposed by for instance *Pielke [2007]* and *von Storch, Meinke et al. [2011]* than receiving information which mass-advertise with the largest scientific rigour. In contrast to regional stakeholders, insurance sector representatives apply their own automated quality tests to ensure that information is credible. The consulted stakeholders rather wanted to receive information from a trusted and reliable institution. This was particularly important for stakeholders who are not scientifically expert in climate change-related issues.

Throughout the two case studies, re-insurances and insurances build on established and trusted information sources. The interviewed regional stakeholder and the representatives of the insurance sector wanted independent information sources and required that a diverse set of the most relevant scientific research is considered, compared, and evaluated according to established quality standards. This was particularly important for insurances and spatial/infrastructure planning. Only few of the consulted regional stakeholders in the German Baltic Sea region and even less representatives from the insurance sector mentioned that they trust and use information from the mainstream media. The surveys reveal that these are, however, the most important source of information for mayors and the general public at the German Baltic Sea coast, and for the general public in France when it comes to climate change. In this context, the survey shows that the general public has, in fact, a larger interest in receiving information as fast as possible than as reliable as possible.

Recommendation (strengthening of trust in science): *Most important seems to be an active involvement of already established and trusted regional and sector-specific climate services in the dissemination of extreme event attribution findings.*

Recommendation (strengthening of trust in results): *Openly and understandably communicate attached uncertainties and explain the study background, data basis and the underlying methodologies.*

Recommendation (strengthening of trust in results): *Collaborate with (re-)insurances to develop individual sector-specific quality control mechanisms which are compatible with existing mechanisms.*

Our work in WP4 also shows that stakeholders require **context-sensitivity**, meaning impact-, problem-, or decision-oriented products and services. City or commune administrations employees concerned with Baltic Sea storm surges and climate change, for instance, expressed their need for a kind of “scout” who filters and bundles the available information according to their specific needs. If an agency compiles, for example, a vulnerability assessment, they are challenged by the multitude of available information on each of the potential vulnerability components and/or cannot find appropriate local information. For all of the stakeholder groups considered in both case studies, it was important that data or information is directly linked to local, regional, or business-related problems; that concrete impacts are illustrated; and that direct business, political or social implications are explained. Linking, for example, probabilistic EEA statements to losses and damages which occurred due to an extreme event were perceived to be more relevant than stand-alone statements about the contribution of anthropogenic climate change to extreme events. If stakeholders do not see the direct relevance of EEA information to their work, it is likely to be filtered out and stays widely unrecognized.

Recommendation (providing tailored information): *If climate information like extreme event attribution is to be integrated in existing work processes, they need to be available in the “right” spatial resolution, time scale, region, parameter, etc. To be aware of what the “right” means, we need to identify stakeholder-specific needs for different fields of work.*

Winter storms, hail and heavy rainfall were the most relevant extremes to the interviewees from the (re-)insurances; storm surges at the German Baltic Sea coast, which are at the centre of this case study, played merely a minor role for them. In case of regional decision-makers, the interest in specific hazards largely depends on the responsibilities of the interviewee and the hazard they feel most exposed to. A coastal protection agency is, not very surprisingly, more interested in storm surges than heat waves or hail; whereas a spatial planner might be more interested in heavy rainfall because this is the hazard their region is exposed to the most. The media and the general public seem most interested in the hazards which cause the largest damages.

Recommendation (assessing relevant extremes): *Identifying the most relevant hazard and parameters to be assessed requires an awareness of how ‘relevant’ or ‘extreme’ is defined by each stakeholder. It is thereby essential to understand stakeholders’ exposure, fields of work, as well as established data processing and reporting standards.*

For the interviewees from the (re-)insurance industry as well as for regional stakeholders and policy-makers at the German Baltic Sea coast, risk comprises more than just the causation

of changes in the hazard patterns which are at the centre of EUCLEIA. This reflects the requirement of linking climate information to region-specific impacts identified in the literature on climate services in general [see e.g. von Storch, Meinke et al. 2011]. They seem more interested in the causation of impacts, exposure and vulnerability than the mere hazard-side of risk. The survey of mayors, for instance, reveals that more than 18% ask for more information about the regional and local impacts of climate change. The analysis of the press coverage presented in D4.1 shows that the regional press mainly reported on damages after larger storm surges and that there seems less interest in natural hazard-based explanations. This indicates that also the media might be more interested in a combined hazard-, vulnerability-, and exposure-based attribution, particularly when linked to impacts of extreme events. Judging the contribution of climate change in combination with the relevance of vulnerability-related drivers might also counteract that EEA numbers add to the climate deterministic account and are misused for downplaying socio-economic drivers of natural disasters.

Recommendation (attributing impacts not only hazards): *It is important to strengthen the ties to the impact modelling community. If EEA results are to raise interest and are to be used and not misused, they should be part of more integrative statements where anthropogenic climate change is one of the factor explaining shifts in impacts (e.g. extreme event attribution in combination with causation of vulnerability and exposure).*

Also the **kind of results produced** by EEA mattered to the consulted insurance representatives and regional stakeholders. Similar to Adam's [2011] argument for EEA in litigations, some stakeholders found that EEA-based results should not be communicated if they do not indicate a significant contribution of anthropogenic climate change because it might strengthen climate skepticism. For some regional stakeholders in the German Baltic Sea region, such results were believed to counteract awareness-raising activities and inhibit political leverage for mitigation and adaptation. For insurance representatives such results cannot be used for marketing and sales of natural hazard insurance schemes and allocation of financial means to subsidize such schemes (see D4.3). On the other hand, results which do not show signs of climate change might reduce solvability requirements of the insurance control authority.

In the EEA literature which deals with stakeholder needs, the time of availability was named as key criterion determining the salience of EEA for stakeholders [Stott et al., 2013]. This is confirmed by what the general public requires. In the survey, near to 75% of the Baltic sea interviewee demanded that EEA results should be published as fast as possible after an event; compared with only 17% who wanted that results are published only when they are as solid as possible. For the greater Paris area, these number are 42% and 34% respectively.

In contrast to this, the consulted stakeholders in the Baltic Sea and in the Paris case studies did not attach larger relevance to the time of availability – neither the regional stakeholders, nor the insurance sector representatives. This might be linked to the specific background of the stakeholders. The consulted regional stakeholders are mainly concerned with long-term preparedness or continuous awareness-raising campaigns. They state that an extreme event will stay in peoples mind for a long time and does therefore also serve as a good example in future. Rather than having information as fast as possible, regional stakeholders wanted information which is as reliable as possible (see D4.2). Insurance representatives, in contrast, attached a bit of a larger attention to the time of availability. For media and

outreach activities, receiving information timely after an event it has been perceived to be an advantage to receive information as fast as possible. Also insurance data and information services which have fixed reporting schedules after an event might be interested in timely information. Overall, however, the reliability of the results was perceived to be of larger importance to the representatives of the insurance sector (see D4.3).

Recommendation (finding appropriate time of availability): A suitable product of EEA for the considered stakeholder groups should rather produce information at a later time, but with smaller uncertainties than vice versa. For the general public the findings should, in contrast, be available as soon as possible after an event – meaning that it is necessary to further strengthen research on fast-track analyses if media and public attention is to be raised.

Recommendation (finding appropriate time of availability): *It is important to be aware of existing reporting schedules and internal processes – in this case of insurance sector institutions. Providing extreme event attribution findings at the most appropriate time facilitates the application of results. Most appropriate timing does thereby not necessarily mean receiving information as fast as possible.*

For insurance sector representatives, also continuity in the provision of findings was of large importance. To include new information into regularly issued information services, it is important that this information is not only available once in a while, but after each major event. Besides being aware of the reporting schedules and internal processes, it is therefore important to be aware of how ‘major’ extreme events are defined in each institution. Becoming an established long-term operational service which is known for providing relevant and reliable information with clarified user rights would be one way of being used.

Recommendation (ensuring continuity): *A suitable product of EEA should be produced regularly after each event relevant to the stakeholder. Establish a long-term operational service for extreme event attribution or integrate it in established climate services.*

Of large importance is also **clarity and comprehensibility** of extreme event attribution information. This was a commonly named requirement making information applicable and useful by the consulted stakeholders. IPCC-like reports and scientific papers are essential for experts, but lay people struggle with the length, language, and scientific complexity of such information. Many of the stakeholders, particularly at the regional level, are neither trained in climate sciences and have difficulties understanding complex issues in a foreign language, nor do they have the time to get more proficient in these regards. For both regional stakeholders concerned with Baltic Sea storm surges, regional stakeholder concerned with heat waves in Paris, and insurance representatives, understandable and intuitively accessible information was highly important in the awareness-raising context. Moreover, understandable information was meant to be able to feed into direct sales activities and political leverage for the insurance sector.

Recommendation (ensuring comprehensibility): *Provide scientific extreme event attribution results which are intuitively accessible and understandable.*

Recommendation (ensuring comprehensibility): *Translate scientific extreme event attribution results into mother-tongue and every-day language.*

3.4.4. Promoting extreme event attribution by creating useful climate services

In science, funding is increasingly bound to ensuring legitimacy and social significance of research projects. Most of the interviewed German-speaking climate scientists, and some, yet a clear minority, of the interviewed attribution scientists, have, however, expressed that they have not thought about the links of their research to socially oriented problem themselves. It seems that many scientists still pose their personal utility first by prioritising aspects like funding opportunities and marketing advantages. The customers and their possible interests regarding climate information stay widely unrecognized. The assumed stakeholder utility is therefore often reflecting producers'/scientists' utility. A larger survey of international climate scientists undertaken by Bray and von Storch in 2016 shows that the surveyed scientist believe that science should rather deliver facts than policies [Bray and von Storch, 2016]. On the other hand, the general public and many stakeholders (particularly mayors and regional decision-makers at the Baltic Sea coast) believe that policies and recommendations for actions is what science should be doing most importantly. The interviewed German-speaking climate scientists are, in this respect, often concerned that their scientific results are either trivialized or dramatized depending on the media interest in order to create information interesting, understandable and relevant to the public. Against this background, a stakeholder dialogue is inevitable. This is a process which can start from two sides. On the one hand, it is expedient to start with enabling knowledge and raise interest in climate change-related topics. To do so it is particularly important to present information in an understandable and intuitively accessible way. Starting from there, it is then possible to initiate a dialogue with stakeholders and tailor this information more specifically to the needs of interested target groups. On the other hand, one can start with getting into a dialogue with pre-defined stakeholder groups and enquire their needs in terms of a climate information product like from EEA first. In EUCLEIA we decided for the second approach given that there are no results to be presented yet. This is, however, only a pre-assessment which may and probably should merely be the starting point of a process as proposed before once actual results are available.

Recommendation (ensuring legitimate and relevant EEA results): *EEA information needs to be legitimate and socially relevant. It is important to engage potential users and to be aware of their needs and requirements. Scientists do not think that it is up to them to take on this role. It is therefore important to link up with existing independent climate service providers managing the interface between science and practice.*

Climate services are perceived to provide a link to societal relevance according to many of the interviewed German-speaking scientists. In this context, some of the interviewed scientists understand climate service as a long-term dialogue between science and actors, enabling a joint generation of decision-relevant knowledge. Others perceive it as one-directional information transfer from science to public. Both viewpoints are also reflected in the survey of international climate scientists by Bray and von Storch [2016]. This one-directional function of translating scientific findings for stakeholders and the public is also revealed in the opinion about climate services of the interviewed stakeholders - particularly the regional stakeholders in the Baltic Sea region (see D4.2 and D4.3).

Recommendation (being aware of stakeholders' and scientists' needs): *Connect with climate services. They are at the interface between science and practice which ensures that both stakeholder needs and requirements of scientists are acknowledged.*

Despite of this, many scientists, the public and stakeholders are not aware of the specific products offered by climate services [see D4.1, D4.2, D4.3, D4.4 and *Bray and von Storch, 2016*]. Particularly the general public and regional decision-makers concerned with Baltic Sea storm surges therefore rarely make use of existing services (see D4.2, and D4.4). This is not primarily linked to the fact that climate services cannot or do not meet the needs of various actor groups. In the general public, it is often rather linked to the fact that there is a general lack of interest in environmental and climate-related issues. This inhibits searching actively for climate information (see D4.4). Insurances make mainly use of established sector-specific information services (see D4.3); regional decision-makers want a climate service with regional representation and person of contact; the general public and mayors in the Baltic Sea region mainly draws upon the mainstream media and known internet platforms for informing themselves about climate change (see D4.2 and D4.3, D4.4).

Recommendation (link up with relevant information sources): *Be aware of stakeholders' common sources of information and link up with these sources.*

Recommendation (cooperate with established climate services): *Promote extreme event attribution through cooperation with a network of climate services at European, national, and regional level which includes both cross-sectorial and sector-specific institutions.*

The requirements in terms of climate services were often related to credibility concerns. Regional stakeholders in the Baltic Sea wanted information from a trusted and independent 'information scout' who delivers information which conforms to state of the art science (see D4.2). Insurances emphasised in this respect that information needs to undergo solid quality control mechanisms which apply to their standards and processes (see D4.3). The German-speaking scientists wish a neutral climate service conveying the current state of climate research into the public (see D4.1).

Recommendation (independence of knowledge broker): *The institution providing information should be independent and should consider, compare, and evaluate the most relevant scientific research (for some stakeholders: according to established quality standards).*

Recommendation (competence of knowledge broker): *The institution/person disseminating such findings needs to be aware of the current state of the art and should have a substantial preconception of climate research. Trainings of journalists and scientific cooperation with climate services may help strengthening the necessary competences.*

Recommendation (long-term services): *To strengthen trust in science, long-term relationships and interaction is perceived to be essential.*

Particularly regional decision-makers in the Baltic Sea region wish for someone who translates scientific findings into understandable, intuitively accessible, and mother-tongue language. This is even more so for novel and complex information like from EEA.

Recommendation (understandable EEA results): *Linking up with climate services and other knowledge brokers can facilitate making complex information like EEA understandable without losing seriousness and credibility along the way.*

All consulted stakeholder groups and the general public in the Baltic Sea case study want contextualized information. Regional stakeholders ask particularly for region-specific and local information, while insurances want sector- and business-relevant information instead of ready-made one-size-fits-all products.

Recommendation (contextualized EEA results): *Cooperating with established sector-specific and regional information services can help creating individual parameterisable and context-sensitive products.*

Overall, it is essential to facilitate a communication of legitimate, applicable and socially relevant EUCLEIA results, by at the same time ensuring that the delivered information meets scientists' pledge for a dissemination of neutral, solid, and reliable information. Scientists are often not aware of stakeholder needs and do not feel responsible for fulfilling their requirements; Stakeholders, on the other hand, have divergent, sometimes hardly viable expectations regarding scientific findings. It is therefore important to link up with independent institutions that are at the interface and in a long-term dialogue with both science and practice.

3.5 Conclusion, Challenges, Limitations, and Lessons Learnt

The work undertaken in WP4 has demonstrated critical lessons to be learned for future consultation processes. First and foremost, it has shown that it is inevitable to build upon a continuous context-specific stakeholder consultation process and proactive engagement. Only in that way, is it possible to make implicit expectations explicit and derive implications for a successful promotion of extreme event attribution (EEA) information.

Within the consultation process, a major challenge emerged from the fact that extreme event attribution is a relatively **new field of research** which has, so far, not been acknowledged by most stakeholders and knowledge brokers. In this regard, it would have been useful to have concrete event attribution results at hand for the consultation process. However, there are no EEA results available to date which depict the contribution of greenhouse gases to Baltic Sea storm surges. WP7 intended to attribute Baltic Sea storm surges and heat waves in Paris to anthropogenic climate change. This would have provided an opportunity to present actual region-specific EEA results to stakeholders and the public. Given that these test cases have only started their work in the second half of the project, the results have only been available when the stakeholder consultation was already over. The fake fact sheets were meant to be used as an illustration of how EEA results could look like. According to the DOWs they were therefore planned to be designed already at the outset of the project as part of M1. They have, however, shown to be no appropriate substitute for actual results. On the one hand, there is the risk that the fact sheets are taken for real and may therefore give the impression that EEA information for Baltic Sea storm surges are already available and that they deliver the designated results. On the other hand, designing a hypothetical report for stakeholders and the public without having actual results yet and without having talked to a single potential user was an endeavour beside the question. Having tried to use it in stakeholder workshops revealed that it was, for instance, rather the scepticism regarding the unrealistic nature of the climate change scenario than concrete requirements regarding EEA which have been expressed. We have therefore decided to continuously design and modify the "fake fact sheets" as we go along in the stakeholder engagement process. In that way, it was not possible and not intended to directly involve hypothetical EEA statements in the

engagement process, but we had a product in the end which is able to facilitate further stakeholder dialogues once actual results are available.

Being a relatively new field of research, science has rarely or insufficiently addressed needs of potential user groups, e.g. without empirical evidence, by only looking at a rather narrow set of potential users, or without considering the region- or hazard-specific context. We therefore decided to address this issue with empirical case studies considering various potential user groups in two hazard-specific regions and for different hazards. Given that there has little research been undertaken in this area so far, we also decided to make use of a mixed-methods approach, starting with explorative qualitative research and complementing it with qualitative and quantitative explanatory methods. Also a grounded theory approach helped approaching this topic more adequately. It builds on the grounds of a continuous dialogue between the researcher, existing theories, and the acquired data. This facilitated the selection and design of data collection and analysis.

The novelty of the research field was, furthermore, one of the reasons why most stakeholders and the general public were not **acquainted with the concept of EEA**. This made it very difficult for the consulted stakeholders to identify potential fields of application for EEA and express specific and concrete requirements to EEA information or services. In addition, some of the identified fields of application may, indeed, not be relevant and several expectations may rather be owed to a misunderstanding of or a lack of knowledge about EEA. To overcome this problem, it is important not to ask for extreme event attribution in isolation from the general context of climate information and services. When asking people about their needs and requirements with respect to information which are already being used, they are able to express their expectations more easily and concretely. This can, on the one hand, serve as a door-opener for asking for potential services from extreme event attribution. On the other hand, requirements regarding general climate information can provide important implications for requirements regarding EEA.

Also owed to the fact that it is a relatively new field of research, there is **no established set of users of EEA** which can serve as a basis for identifying relevant stakeholder groups. Against this background, it was helpful to conduct a stakeholder mapping which builds on a presumption of potential user groups by being at the same time not limited to this set. It appeared to be expedient to specify and modify the stakeholder mapping in the course of the interviewing period. The information received in the interviews helped adapting the stakeholder mapping and identifying people in charge. In this way, we have identified a case-specific set of users which may certainly be different from other hazard-, geographic-, or institutional settings. Even though many things may only hold true for the specific cases of Baltic Sea storm surges in Germany and heat waves in Paris, this case-specific identification process may be more relevant to creating useful EEA services than trying to identify a context-independent set of potential users and requirements as it has been done in most of the existing literature so far.

An important lesson learned is the real need to face **stakeholder fatigue** when conducting climate research. Mobilizing individuals for interviews and workshops becomes increasingly challenging. This seems urgent if we want stakeholders to be closely associated with the development of climate services. To increase the chances, we selected a large set of potential users, addressed each stakeholder individually, and commonly proceeded according to snowball sampling where interviewees referred us to other potential

interviewees. In addition, we made use of existing networks and long-term relationships with stakeholders. The efforts made in the course of WP4 are steps in the right direction but may not be sufficient to entirely overcome this problem.

The **novel, complex and abstract** nature of EEA as well as the fact that there is no German term for attribution complicated the interaction with stakeholders and the general public notably. During the qualitative interviews and workshops and particularly during the quantitative telephone survey, it was difficult to convey what EEA is and counteract misunderstandings. In the telephone survey of the general public, where people are rarely acquainted with related topics and where room for explanation is restricted, it was of particular importance to focus on or how to formulate questions in a way that they are understandable to everyone. We therefore conducted qualitative interviews and a set of questionnaire-based telephone pre-tests for designing an appropriate questionnaire.

Overall, we have achieved a unique and extremely innovative overview of the diverse and sometimes divergent needs and requirements of a broad range of user groups comprising beside the general public, the media and scientists also stakeholders from politics, public administration, civil society, associations, and the private sector. We have in this respect identified and covered some of the most relevant sectors who could make use of EEA information in the case of Baltic Sea storm surges and heat waves in the Greater Paris area. Nevertheless, this is just a first step towards an in-depth understanding on how to provide targeted groups of users, well verified, well understood assessments and thereby close the gap between stakeholder needs and scientists' expectations. Specific requirements with respect to extreme event attribution were, for example, addressed but did, at times, not receive enough attention in the engagement process. This was principally the case due to the explorative character of the interviews, the diverse stakeholder interests represented in the workshop and survey, and the hypothetical nature of extreme event attribution results. To derive specific conditions for a successful promotion of EUCLEIA findings several questions need to be answered in more depth when actual results are available and at the example of one specific target group; e.g.: how and why are probabilistic EEA statements understood? What are threshold values of an anthropogenic contribution making an EEA finding useful? When and why should EEA findings be linked to the impacts of extreme events? What level of uncertainty is tolerable? Which communication channels can be used in what way? What role should climate service providers play in an operational EEA system?

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4. Contributions to conferences and publications

Contributions to conferences and project-external workshops

Contributor	Title	Contribution type	Conference	Date and Location
Jean-Paul Vanderlinden , Hans von Storch, Insa Meinke, Maria Schwab, Nabil Touili	Framing Extreme Event Attribution from the Bottom up – an Enquiry into the Social Representations of key stakeholders, of the Press and of Climate Scientists	Presentation	Our Common Future Under Climate Change	Paris, July 2015
Maria Schwab , Insa Meinke	Learning cities in a changing climate - stakeholder perspectives on Extreme Event Attribution in the context of Baltic Sea Storm Surges	Presentation	German Congress for Geography	Berlin, 2.10.2015
Maria Schwab , Insa Meinke	Assessing stakeholder needs to develop useful climate services from extreme event attribution	Poster	INQUIMUS Workshop – Challenges in Q2 methodologies	Bolzano, Italy, 28.-29.10.2015
Maria Schwab , Insa Meinke	Assessing stakeholder needs to develop useful climate services from extreme event attribution	Poster	Innovations in Climate Services	Netherlands, 2.-4.11.2015
Jean-Paul Vanderlinden	A sampler of what social scientists may do with meteorological extremes, and with climate scientists	Presentation	Course of the “Statistical and mathematical tools for the study of climate extremes	Cargese, November 9-13, 2015
Jean-Paul Vanderlinden	Analysing the social construction of extremes through the mass media, Exercise developed for the “Statistical and mathematical tools for the study of climate extremes	Presentation	Course of the “Statistical and mathematical tools for the study of climate extremes	Cargese, November 9-13, 2015
Maria Schwab , Insa Meinke, Hans von Storch, Jean-Paul Vanderlinden, Nabil Touili	Exploring regional stakeholder needs and requirements in terms of Extreme Weather Event Attribution		AGU	San Francisco, 14-18.12.2015

Publications

Authors	Year	Title	Journal	Status
van Oldenborgh, G. J., D. B. Stephenson, A. Sterl, R. Vautord, P. Yiou, S. S. Drijfhout, H. von Storch and H. van den Dool	2015	Drivers of the 2013/14 winter floods in the UK	Nature Climate Change, 5, 490–491	published

Stott, P. A., N. Christidis, F. Otto, Y. Sun, J.-P. Vanderlinden, G. J. van Oldenborgh, R. Vautard, H. von Storch, P. Walton, P. Yiou, F. Zwiers	2015	Attribution of extreme climate events	WIRES Climate Change	published
Schwab, M., Meinke, I., Vanderlinden, JP, von Storch, H.		Regional decision-makers as potential users of Extreme Weather Event Attribution - case studies from the German Baltic Sea coast and the Greater Paris area	Weather and Climate Extremes	Submitted
Schwab, M., Meinke, I., von Storch, H.		Developing criteria for a stakeholder-centred evaluation of climate services at the example of Extreme Event Attribution for storm surges at the German Baltic Sea	Climatic Change	submitted