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Developing criteria for a stakeholder-centred evaluation of climate services: the case of extreme event attribution for storm surges at the German Baltic Sea

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Abstract. Science-based knowledge about climate-related hazards is an inevitable part of the knowledge basis needed for many stakeholders' decision-making. Despite continuous advances in climate science, much of this knowledge is perceived to be hardly accessible, understandable, or relevant to stakeholders. One relatively new field where these aspects may become evident is extreme weather event attribution. It has received much attention in science in recent years, but its potential usefulness to stakeholders has rarely been addressed in the literature so far. This study has therefore developed criteria for evaluating potential climate services from a stakeholder perspective, using the example of findings from extreme event attribution. This is illustrated in an empirical mixed-method study about decision-makers dealing with storm surge risks at the German Baltic Sea Coast and (re)insurance sector representatives. The study builds on interviews and workshops with potential users of extreme event attribution. It reveals that there are three main groups of criteria which matter most to the stakeholders in question: 1) trustworthiness, 2) context-sensitivity and decision-relevance, 3) clarity and comprehensibility. Having appropriate evaluation categories, as well as processes to identify stakeholder-specific criteria, will facilitate the inclusion of values, knowledge contexts, and interests. Many stakeholders emphasized that they need a trustworthy knowledge broker who provides decision-oriented information which is intuitively accessible, understandable, and in their mother tongue. Being independent, scientifically competent, and in a continuous dialogue with both scientists and stakeholders, established regional and sector-specific climate services can facilitate the fulfilment of these requirements. A stakeholder-oriented evaluation will thereby help to make climate services more useful to potential user groups – even if a product is not in use yet, as is the case for extreme event attribution products..

Keywords: climate services, extreme weather event attribution, climate change, stakeholder-centered evaluation, science-stakeholder dialogue

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1. Introduction and background

Decision-making in a world of global climate change requires a profound knowledge base which often stems from climate science. This is essential for measures related to mitigation, adaptation or disaster risk reduction. Scientific findings alone will, however, not provide appropriate decision-support that is clearly understood and useful to targeted groups of stakeholders, such as policy-makers, administration, and the private sector. According to the IPCC, "*such support is most effective when it is context-sensitive, taking account of the diversity of different types of decisions, decision processes, and constituencies […]. Boundary organizations, including climate services, play an important role in climate change knowledge transfer and communication, including translation, engagement, and knowledge exchange"* (Jones et al. 2014: 198). These organisations are not only meant to put interests and standards of good scientific conduct at the centre of their work, but they also focus on stakeholder needs and specific requirements (see, e.g., von Storch et al. 2011; McNie 2013; Adams et al. 2015). This is particularly challenging when dealing with novel and complex fields of research which are attached to large uncertainties.

One such field of research is probabilistic extreme event attribution, i.e., research which aims at quantifying the contribution of anthropogenic climate change to specific climate-related extreme events in the recent past. It produces probabilistic statements by simulating the occurrence of extreme weather events tens of thousands of times in two climate representations. One of them simulates the atmosphere and climate as it is today. The other one represents a world without anthropogenic greenhouse gas emissions. This results in two probabilities for an extreme event with characteristics equivalent to the selected case – one probability with and one without the contribution of anthropogenic climate change. Such probabilistic statements are often expressed as return periods of extreme events (see, e.g., Hegerl et al. 2010; Peterson et al. 2013; Herring 2015; Stott et al. 2016).

Extreme event attribution is an expedient example in this case because it has generated large interest among climate scientists in recent years and is expected to complement the set of science-based information for stakeholders' decisions in terms of adaptation and mitigation. It is, however, not clear in how far future research results will be able to meet stakeholder needs. It remains to be seen if such results increase the relevance of understanding stakeholder-based evaluation concepts early on in the process of promoting extreme event attribution. To create appropriate services from such research, it is therefore important to identify potential evaluation criteria that reflect stakeholder needs. For this, we conducted explorative stakeholder consultation in an empirical case study about storm surge risks in the German Baltic Sea region. It deals with questions such as: Which criteria matter to them? How is climate research, in particular regarding extreme event attribution, effectively translated, mediated and communicated by climate service providers? And how can information products, which do not yet exist, be adequately evaluated? To answer these questions, we have identified potential stakeholders and consulted them in interviews and workshops. This has been done using the example of regional stakeholders concerned with storm surges in the German Baltic Sea region as well as with insurance and re-insurance sector representatives. Below, existing concepts for evaluating climate information and related services will be introduced, followed by a description of the methodological basis and a presentation of empirical findings from the case study. In the end, conclusions will be drawn for developing useful climate services from extreme event attribution research.

2. Concepts for evaluating climate information and related services

In order to understand why stakeholders may find science-based information like extreme event attribution results relevant to their decision-making and to ensure that they are able to take up this knowledge, key stakeholder requirements are to be identified. One way of assessing such needs is proposed by Cash et al. (2003). They identify ways or criteria for assessing information and information services. It is argued that information is most likely to influence decision-making if the boundaries between knowledge and action are managed in ways that enhance, at the same time, their salience, credibility, and legitimacy. Salience refers to "the relevance of information for an actor's decision choices, or for the choices that affect a given stakeholder"; credibility involves "the scientific adequacy of the technical evidence and arguments"; legitimacy reflects the idea that research has considered stakeholders' needs and interests. This is often based on a judgement about who has participated in what way in knowledge production, assessment and dissemination (Cash et al. 2002, 2003).

Pielke (2007) argues, 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 the identifying of expedient "solutions", including in cases of high uncertainty. Policy-makers, on the other hand, should only pose scientifically solvable problems to scientists and not make them provide the most accepted or appropriate "solution" to problems (see also von Storch 2010). McNie (2013) found that climate science has to be not only credible and trusted, but is most salient to users if it is contextual and well understood. In that way, it will be able to feed into decision-making and enhance adaptation efforts. Von Storch et al. (2011) further argue that scientific knowledge about climate change may only influence society's risk perception if it fulfils a number of key requirements; i.e.:

- "regional experiences, memories and values have to be understood and analysed";
- information needs to be presented in an understandable manner;
- scientific findings should be targeted towards relevant region-specific impacts;
- scientists should rather than convey an illusion of static and universal truths, embed this in the overall political and societal decision-making context.

The requirements named by Pielke (2007), McNie (2013) and von Storch et al. (2011) seem to reflect the criteria which were described as important by Cash et al. (2003) and add a more specific understanding to Cash's criteria in terms of climate-related knowledge for regional decision-makers. Accordingly, salience can be ensured by providing understandable information, targeted particularly to region-specific impacts to facilitate the identification of expedient solutions; credibility is more likely to be achieved if scientists honestly communicate uncertainties and dynamics; legitimacy is reflected in the requirement for a consideration of regional stakeholders' perspectives. Legitimacy can also counteract another common problem for creating knowledge that is useful for decision-making, i.e., the problem that neither the users nor the producers of knowledge "own the problem" of producing usable knowledge (Dilling, Lemos 2011).

Due to this, an institution is needed which makes producing useful and applicable knowledge related to "its problem" and also feels responsible for it. Such an institution is needed to enhance salience, credibility and

legitimacy, according to Cash et al. (2003). They argue in this context that we need institutional mechanisms which enable and foster communication, translation and mediation across related boundaries between knowledge and action. These can be, according to Dilling and Lemos (2011), information brokers, collaborative group processes, organization-internal or embedded capacities, and boundary organisations. Climate service providers can thereby function as so-called boundary managers by standing in a mutual dialogue with stakeholders, the general public, and knowledge producers.

Meinke (2017) points out the importance of evaluating regional climate services and highlights the significance of involving stakeholders in such evaluations. In a participatory approach which builds on personal interviews with stakeholders, Meinke (2017) identifies three main evaluation categories. She argues that climate services need to ensure credibility, relevance and appropriateness of climate information for regional stakeholders. Credibility means that the communicated climate information should include scientific proof, be transparent in terms of methods, and build on expert knowledge. Relevance refers to a consideration of matters of scale, social integration and practical implications. Appropriateness stands for ensuring a communication of comprehensible climate information, an easy access to filtered information and the availability of long-term interpersonal relations to climate service providers.

Several scientists, including von Storch (2009), Krauss et al. (2012) and Bray and Martinez (2015), argue that this mutual science-stakeholder dialogue has increasingly gained importance and has been the answer to a so-called "post-normal situation". In a "post-normal situation", it is no longer only scientificity, methodological profoundness, or scientific validity that is sufficient for making science "useful", but its relevance to decision-making and its social acceptance (von Storch 2009; Bray, Martinez 2015). Scientifically legitimized knowledge is, according to von Storch et al. (2015), just one knowledge type which competes with other forms of knowledge. The IPCC chapter on decision-making highlights that knowledge transfer is a negotiation process which needs to consider diverse, sometimes divergent forms of knowledge (Jones et al. 2014: 198). Lemos et al. (2014) and Kirchhoff et al. (2013) argue in this respect that the usability of new knowledge, including from science, depends on its interaction with the types of knowledge that are in use on the stakeholder's part at that moment. In order to produce "useful" information, science therefore needs to comprehend these "other" knowledges, and vice versa (von Storch et al. 2015). Understanding general public and stakeholder needs on the one hand and scientists' perspectives and capabilities on the other is thereby also the basis for enhancing salience, credibility, and legitimacy, balancing the trade-offs between these criteria, and making an advantage of the evident complementarities.

How extreme event attribution research is effectively translated, mediated and communicated by boundary managers like climate service providers has not been studied so far. This is also the case for questions like: *"How important are different evaluation criteria to potential user groups? And how can specific requirements linked to these criteria be best met – even though such information has not yet been used?"* have not been addressed so far in extreme event attribution literature, and only rarely in evaluation literature. We therefore try to answer these questions by looking at the cases of representatives of the insurance sector and regional stakeholders dealing with storm surge risks in the German Baltic Sea region.

3. Material and methods

To gain an understanding of different stakeholders' perspectives on climate information – in particular from extreme event attribution – and grasp its relevance to their decision-making, we conducted an empirical case study. It is meant to reveal in how far the literature discussed above facilitates the evaluating of novel information products like those from extreme event attribution. This case study shall facilitate the development of expedient criteria for evaluating climate services. It builds on the example of climate services for the general risk context of storm surges in the German Baltic Sea region. Even though people, infrastructure, and landscape are at risk of storm surges in this region, these risks are commonly not recognised as such. The fact that there were no storm surge events with extreme impacts in recent decades could be a reason for this. The last storm surges with major consequences occurred in 1872 (Bork, Müller-Navarra 2009) and 1913 (von Storch et al. 2014; Wagner et al. 2016). The largest storm surges, accordingly, occurred in times when anthropogenic climate change did not play a role. Nevertheless, these examples prove that storm surges with higher water levels than those which were experienced in the past century are possible. Anthropogenic climate change may or may not change the likelihood of such extreme events. Regardless of this, exposed actors and institutions should be prepared for storm surges like those in 1872 and 1913. Several studies show, however, that many of them do not seem sufficiently prepared for such storm surges (see e.g, Koerth, Sterr 2012; UBA 2012; Schröder 2013). Appropriate climate services from sci-

ence, like extreme event attribution, could help in raising awareness and the motivation to react.

The empirical case study follows principles of Grounded Theory, meaning that 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. Following the principles of qualitative research, we conducted personal interviews and a workshop with regional stakeholders in the German Baltic Sea region and representatives of the insurance- and re-insurance sector at a more supra-regional level. The interviews lasted between 30 minutes and 2 hours and were conducted face-to-face. The focus group workshop was facilitated by the researchers and followed the principles of qualitative and participatory approaches.

The sample of regional stakeholders was intended to represent a variety of important sectors and institutions engaged in coastal storm surge risk management. We selected institutions with an evident need for regional climate information given current socio-economic problems related to storm surges and climate change. The interviewees were mainly found by snowball sampling, meaning that we were referred to them by other interviewees or people of our pre-existing network (Biernacki, Waldorf 1981: 141). The selected stakeholders work in civil society organisations, public administration, education and the private sector in four regions along the Baltic Sea coast. They are engaged in spatial planning, nature protection, climate change mitigation, coastal protection, ports and emergency management. In total, nine personal interviews[1] and one workshop were conducted with regional stakeholders. Another ten personal and telephone interviews with representatives of the insurance- and re-insurance sector in Germany and Switzerland were additionally undertaken. This sample included representatives from insurance companies, re-insurance companies, an association, a foundation, and a data service. The interviewees worked in strategic planning, risk assessment, marketing and sales.

The interviewing framework for both the interviews and workshop with regional stakeholders and the interviews with (re-) insurance representatives involved guiding, and not predetermined, questions. This means that the formulation, detail, and order of questions were adapted to the interviewee's background, the interviewing situation, and the information gathered during the interview. Overall, the guiding questions covered the general role of regional climate services, the definition and potential relevance of extreme event attribution-related information, and quality criteria which determine the value of climate and extreme event attribution-related information.

[1] These personal stakeholder interviews also serve as basis for Meinke's (2017) analysis. Her paper focuses on the evaluation of climate services for regional stakeholders in general, while our paper looks at the case of climate services from extreme event attribution for regional stakeholders and insurance and re-insurance sector representatives.

4. Discussion of results: understanding stakeholder requirements as a basis for identifying appropriate evaluation criteria

Credibility concerns ranked prominently among the requirements of the consulted stakeholders, particularly among planners of large and expensive infrastructures. This means that, for them, if a new piece of information, such as that from extreme event attribution, is to be applied, it needs to be reliable and credible:

"Yes, well if it were certain [whether climate change caused it or not], people would not be able to discuss it anymore, they would have to face the topic… and if it is uncertain then everyone who does not want to hear it starts thinking again, well, this is scenario x, but what if we assume scenario y – then they would not take it as a fact, but as speculation."

The relevance of credibility requirements coincides with what other literature concerned with stakeholder needs in terms of climate science (see, e.g., McNie 2013; Meinke 2017) and extreme event attribution research (see, e.g., Stott, Walton 2013) has found. In this context, it was important to people that stakeholders received their information from a trusted, reliable and independent institution – this would be even more the case for novel information like that from extreme event attribution. An urban planner working in public administration said the following:

"I believe that if [we/our institution] alone come up with such ideas, we would stand on rather difficult ground; if there were all the relevant technical/scientific institutes, like Helmholtz, this would be the alternative, then it would also be easier for [us/our institution] to argue and get into planning."

Talking about their previous experience with applied climate and extreme event information products revealed that strengthening the trust of the considered stakeholders requires long-term relationships and interaction. Having a trusted knowledge broker appears to be more important if stakeholders are not scientifically expert in climate science, as is the case for many of the consulted regional stakeholders in the German Baltic Sea region. The inter-

views and workshop have shown that established regional and sector-specific climate services can help ensure that information is trustworthy – particularly if they have proven to be aware of the requirements stakeholders have in terms of credibility. In the case of regional stakeholders in northern Germany concerned with Baltic Sea storm surges, this was most commonly mentioned in the context of public awareness-raising and communal spatial planning activities.

It was also perceived to be important that the institution providing climate services act independently of scientific, private-sector, and political interests in order for the reliability of novel climate information people are not familiar with to be seen as credible. The interviewees required that a diverse set of the most relevant scientific research is considered, compared, and evaluated according to established quality standards. Insurance sector representatives demanded this in respect of automated quality tests, preferably according to their own quality standards.

The interviews and workshop further show that climate information should not only be attached to small statistical uncertainties, but that stakeholders want plausible results. An interviewee in emergency management illustrates this as follows:

"It is not always conducive to come up with the worst-case scenario. That could also backfire and rather reduce risk awareness because you are denounced as a worst-case prophet."

The insurance representatives and regional stakeholders in the German Baltic Sea region wanted realistic information grounded on a solid methodology. This emphasizes the necessity to openly and intelligibly communicate the associated uncertainties of extreme event attribution results and explain the study background, data basis and the underlying methodologies. Accordingly, it seems that the consulted stakeholders demand an "honest broker", as has also been suggested in previous studies (Pielke 2007; von Storch et al. 2011; Meinke 2017). This was most commonly mentioned in the context of public awareness-raising and communal spatial planning activities.

The consulted stakeholders also expressed their need for someone to translate and contextualise scientific research in an understandable, context- and target-group specific manner. City or commune administrations, for instance, articulated that they need a kind of "scout" who provides information which is filtered and bundled. For the considered stakeholders, it is very time consuming and difficult to acquire the most appropriate data or information from the multitude available. Depending on the decision-context, such a bundle may or may not include extreme event attribution results. A spatial planner who is interested in conducting an urban vulnerability assessment explained this as follows:

"And it seems to be no problem that there is still a lack of information. […] It is more of a problem […] that you are overwhelmed by the mass [of information] (laughs) […] You would not believe how much scientific literature I have on this topic. And this is about the region – it is only one segment. So, if I dealt with it more thoroughly […], you wouldn't see me anymore from under the whole mountain of brochures and books and whatever else is somehow relevant."

This illustrates that if new information from extreme event attribution is to be applied, trusted, and known, the "scout" who regularly provides climate services to the stakeholders needs to be aware of it. This was discussed in the context of public awareness-raising for storm surge risks as well as in the general context of communal spatial planning activities. Scientists therefore need to connect with established and trusted institutions and provide convincing arguments proving the reliability and relevance of extreme event attribution information.

Moreover, if climate information like that from extreme event attribution is to be integrated into existing information needs in the stakeholders' fields of work, it needs to be bundled and contextualized. This is very time consuming and difficult for scientists. Again, a broker at the interface between science and stakeholders can facilitate the fulfilment of such requirements. Being aware of specific stakeholder needs, he can transform information, like that from extreme event attribution, into products available in the right spatial resolution, time scale, region, parameter, etc. This may also comprise data re-formatting or processing.

Often, it has been required that data or information be directly linked to local or regional problems, that concrete impacts are illustrated, and that direct business, political or social implications are explained. This reflects the requirement of linking climate information to region-specific impacts, identified by von Storch et al. (2011). Extreme event attribution, as well as other climate information, is therefore likely to be filtered, provided that stakeholders or knowledge brokers do not see the direct relevance of the information to their work. In communication with the private sector, it is, according to a representative of an insurance association, essential to clearly show the business implications of extreme event attribution if it is to be applied. He explains this as follows:

"[you need to demonstrate] 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 more easily [with this information]."

Linking probabilistic extreme event attribution statements to losses and damage which occurred due to an extreme event were in this context also perceived to illustrate the relevance of such information. If extreme event attribution results are to be applied, they should be part of more integrative statements, where anthropogenic climate change is one of the factors explaining shifts in impact.

A requirement mentioned by many of the interviewees and workshop participants was that information needs to be understandable, more specifically, it should not be too complex, but instead intuitively accessible, descriptive, or in native language. Extreme event attribution is a field of research which is complex and abstract, where technical or statistical terms and parameters are unknown. This is already the case for numerous climate scientists, and even more so for stakeholders which are scientifically not expert in climate research. In addition, there is no German term for Attribution yet established, making it even more difficult to convey and promote such findings. These aspects were, for instance, perceived to be a major reason why an information product like that from extreme event attribution would not be applied in sales activities for direct insurance. A meteorologist in an insurance company expressed, in this respect, that:

"[…] it starts with return periods that 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 of this, relatively little happens."

Intelligibility was an aspect which was most commonly named in the context of civic participation and public awareness-raising. One interviewee engaged in regional coastal protection expressed the need for comprehensible information in the context of his own work:

"Well (…) one could say, just read the IPCC. No? Hundreds of scientists wrote it, just read this through. Yes (…) you can do this. But I do not understand it, which is (…), on the one hand, down to the fact that I do not speak English fluently, and on the other hand, even if I could do so, I would not understand it due to the technical vocabulary."

The abovementioned requirements are naturally not always compatible with each other. Regional and sector-specific climate services are able to balance conflicting requirements. Credibility concerns, for instance, often conflict with the requirement of the timely provision of data. The time of availability is a commonly mentioned criterion in the extreme event attribution literature, which is often identified as highly relevant for ensuring the usefulness of such information or related services (see, e.g., Stott, Walton 2013). This is why great efforts are currently put into developing an operational near-real time extreme event attribution service (see, e.g., Climate Central 2015). For media and outreach activities it was, for instance, perceived to be important to have information available shortly after an event occurred. A representative of the German Insurance Association explains:

"After an event, there is a time window of only a few months when people are responsive and willing to take fundamental decisions."

However, it is a requirement which seems of great interest to only some stakeholder groups. The consulted regional stakeholders at the German Baltic Sea coast did not attach greater relevance to the time of availability. This might be linked to the specific background of the stakeholders, who are mainly concerned with long-term preparedness or continuous awareness-raising campaigns. They argue, for instance, that a memorable extreme event can also serve as an illustrative example after a longer period of time and does therefore not need to be published right after an event. Providing a climate service based on extreme event attribution should, for these stakeholders, therefore include information at a later time, but with smaller uncertainties than vice versa.

Communication of scientific climate-related information is a key function of climate service providers. Several people stated that it is important to ensure a reliable and continuous communication of findings in order to establish that this information feeds on a regular basis into people's work. One interviewee explains the relevance of continuity as follows:

"[…] and, other than that, it is also important to ensure a certain continuity of such information, that you have regular contact, so that the topic is not eaten up by daily routines. But that it receives a certain value/priority."

The head of a re-insurance foundation anticipated in this context that the insurance industry might be more willing to pay if extreme event attribution was an opera-

tional service in a way *that "you could click on a button and say: Mumbai, these floods have a 30 percent climate attribution."*

Many stakeholders in the German Baltic Sea region found that information should be communicated personally either by a presentation or through consulting. This was perceived to be most important to city and commune administrations who want to raise awareness either among the public or internally within an institution. It was argued that personal communication is better able to convey the understanding of complex issues because people can receive a thoroughly selected set of relevant information and can ask context-specific questions. In addition, web tools and reports were frequently mentioned. A climate service which consists of a standalone data portal for extreme event attribution information may not be sufficient to fulfil such requirements.

Overall, climate services from extreme event attribution need to be trustworthy, decision-relevant, and comprehensible. To fulfil these requirements, trusted regional and/or sector-specific information services need to be involved in transferring knowledge from extreme event attribution. These services should be provided as a long-term operational service and/or integrated within established climate services. Climate service institutions need to collaborate with stakeholders to be aware of their exposure, fields of work, data processing, quality control and reporting standards. This is the foundation for developing trusted, user-specific and understandable climate services.

5. Conclusion

Overall, our analysis of user requirements in terms of extreme event attribution and climate services in general indicates that the considered stakeholders want understandable information and products tailored to their specific concerns and received from a trusted knowledge broker or information scout. This represents three main groups of criteria which appear to matter most to the considered stakeholders in our case study. These principal criteria may not only serve for evaluating potential extreme event attribution information and services for stakeholders in the German Baltic Sea region, but may also be an expedient basis for judging the quality of science-based climate information in other contexts. The identified groups of stakeholder-based criteria are: 1) trustworthiness; 2) context-sensitivity, 3) clarity and comprehensibility. Trustworthiness refers to the fact that the level of uncertainty is known and tolerable, the methodology is found to be solid and the results plausible. Trustworthiness does hereby, however, not primarily emphasise *"scientific adequacy of the technical evidence and arguments"* (see, e.g., the credibility definition of Cash et al. 2003). We want, rather, to highlight the notion of trust, particularly trust in the institution or person who communicates scientific findings. Many stakeholders accordingly wish to put someone else – a trustworthy knowledge broker – in charge of ensuring scientific adequacy, rather than being responsible themselves. Context-sensitivity refers to aspects like having the "right" scale, measure and timing, i.e., similar to the criteria that Cash et al. (2003) proposed in terms of salience. More specifically, such information should be impact-, problem-, or decision-oriented (see also Pielke 2007; von Storch et al. 2011 who argue along similar lines; McNie 2013). Clarity and comprehensibility – the third group of criteria – underline the importance of providing scientific results in a way that makes them intuitively accessible and understood by a targeted group of users. Mother tongue and non-scientific language, as well as appropriate graphic representations, are thereby important fundamentals of clarity and comprehensibility (see also Meinke 2017 who understands comprehensibility as one of the dimensions of appropriateness).

Regional and sector-specific climate services aim to meet all these requirements to facilitate decision-making in a world of climate change. They are perceived to be independent knowledge brokers who contextualize and translate scientific findings and act as a quality control body. Regional and sector-specific climate services should function as an information platform and are appreciated for communicating findings from science in a personal, pro-active, interactive, credible, and understandable way. Along these lines, climate services can collaborate and link up with relevant institutions which deliver climate-related information, e.g., conduct training for the media. It is essential for such services that there is therefore a continuous dialogue between the service providers and scientists and stakeholders. Interaction with producers, potential users and other providers of information facilitates networking and also creates and provides legitimate knowledge, i.e., unbiased and produced with consideration for stakeholders' divergent values, knowledge contexts, and interests (see, e.g., Cash et al. 2003). Legitimate knowledge production demands for an understanding of stakeholder needs from scientists and an understanding on the side of stakeholders in terms of what science can/should provide. We argue that legitimacy is nested within trustworthiness, context-sensitivity and comprehensibility, rather than being a category of quality criteria of its own, as Cash et al. (2003) propose. Regional and sector-specific climate service providers can serve as an interface for creating this necessary mutual understanding. If climate

services at international, European and national level want to improve their dissemination of climate information at the local and regional level, it is therefore expedient to link up with regional climate service providers.

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