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► To cite this version:

Aglaé Jézéquel, Pascal Yiou, Jean-Paul Vanderlinden. Comparing scientists and delegates perspectives on the use of extreme event attribution for loss and damage. *Weather and Climate Extremes*, 2019, 26, pp.100231. <10.1016/j.wace.2019.100231>. <hal-03263533>

HAL Id: hal-03263533

<https://hal.science/hal-03263533v1>

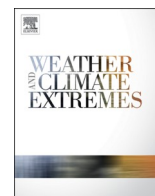
Submitted on 18 Jun 2021

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Comparing scientists and delegates perspectives on the use of extreme event attribution for loss and damage

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ABSTRACT

The Paris agreement recognizes “the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events”. Hence, it raises the question of discriminating extreme events between those influenced and not influenced by climate change. Extreme event attribution (EEA) is the ensemble of scientific ways to interpret and answer the question “was this event influenced by climate change”. The relevance of EEA for climate negotiations was debated before the adoption of the Paris Agreement and is still discussed in post Paris Agreement literature. To inform this debate, we propose a phenomenological approach based on interviews. Parker et al. (2017) analyzed interviews from a mix of loss and damage stakeholders at COP 19, and highlighted a variety of opinions regarding the relevance of EEA for loss and damage. We propose to go further by focusing on two distinct groups of stakeholders: EEA scientists and loss and damage delegates (or their advisers). We find that delegates perceive EEA as a useful tool for awareness raising. We outline a number of hurdles raised by both groups, which may hinder EEA to be part of a practical loss and damage mechanism.

1. Introduction

In November 2013, at COP19, Filipino head negotiator Yeb Saño delivered a poignant speech¹ to denounce the inaction in international climate negotiations while the Philippines was devastated in the wake of super Typhoon Haiyan: “To anyone who continues to deny the reality that is climate change, I dare you to get off your ivory tower and away from the comfort of your armchair. [...] you may want to pay a visit to the Philippines right now.” He pointed out the role of anthropogenic climate change in the occurrence of this disaster: “We must stop calling events like these as natural disasters. [...] It is not natural when science already tells us that global warming will induce more intense storms.” Through the example of typhoon Haiyan, he was specifically promoting the inclusion of *loss and damage* within the work of the United Nations Framework Convention on Climate Change (UNFCCC): “if we have failed to meet the objective of the Convention, we have to confront the issue of loss and damage. Loss and damage from climate change is a reality today across the world.”; “We call on this COP to pursue work [...] until the promise of the establishment of a loss and damage mechanism has been fulfilled”. A little more than a month before Yeb Saño’s speech however, the Intergovernmental Panel on Climate Change

(IPCC) published a report stating that there was low confidence on the attribution of changes in tropical cyclones to anthropogenic activities (Bindoff et al., 2013). More recently, Wehner et al. (2019) have found that two different methodologies of attribution of Haiyan’s intensity lead to opposite results, showing that the influence of anthropogenic emissions on individual tropical cyclones is still a complicated scientific question. The gap between Yeb Saño’s speech and scientific evidence challenges the importance of the *attributability* of extreme events — i.e. the technical possibility to attribute them — in regards to the key messages some of the actors need to deliver. More specifically, this questions the place of extreme event attribution (EEA), the science studying the influence of climate change on specific events, in the context of climate change negotiations, and more precisely of loss and damage negotiations.

Loss and damage in the context of the UNFCCC is hard to comprehend because it does not have a consensual definition. Since Yeb Saño’s speech, loss and damage has gained traction in the negotiation (Mace and Verheyen, 2016; Vanhala and Hestbaek, 2016) despite an ambiguous framework and a lack of clear definition (“The reason loss and damage was easy was that nobody knows what it means yet” (Vanhala and Hestbaek, 2016)). Boyd et al. (2017) investigate the different

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¹ <http://www.climatechangenews.com/2013/11/11/its-time-to-stop-this-madness-philippines-plea-at-un-climate-talks/>.

<https://doi.org/10.1016/j.wace.2019.100231>

Received 25 October 2018; Received in revised form 26 August 2019; Accepted 21 September 2019

Available online 15 October 2019

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meanings of loss and damage through interviews with thirty-eight key stakeholders, conducted before COP21. They identify four perspectives. The *Adaptation and Mitigation perspective* considers loss and damage as all the impacts of anthropogenic climate change that the Convention as a whole aims to avoid. In this perspective, there is no need for an additional loss and damage mechanism, as the goal of mitigation and adaptation is precisely to avert and minimize loss and damage. The *Risk Management perspective* links loss and damage to ongoing efforts in disaster risk reduction (DRR). The *Limits to Adaptation perspective* presents loss and damage as the residual impacts of climate change which were not avoided through mitigation and go beyond the possibilities of adaptation. The *Existential perspective* is centered on the need to address the inevitable harm the most vulnerable populations already face because of climate change. Figure 1c of [Boyd et al. \(2017\)](#) shows how these typologies are adopted by different groups of interest within climate negotiations. The Paris agreement and its accompanying decision reflect well the dividing lines between Annex I² and non-Annex I³ countries regarding loss and damage. On the one hand, the inclusion of loss and damage in the Paris agreement in a paragraph separated from adaptation was considered a victory for developing countries (Article 8 of the [UNFCCC \(2015\)](#)). On the other hand, developed countries, the US in particular, conditioned their acceptance of the agreement on the explicit exclusion of compensation and liability. As stated in paragraph 51 of the accompanying decision to the Paris agreement ([CP.21, 2015](#)), the conference of Parties: “agrees that Article 8 of the Agreement does not involve or provide a basis for any liability or compensation”.

Depending on the chosen perspective, the attributability of weather-related impacts is not always necessary to deal with loss and damage ([Warner and van der Geest, 2013](#)). However, it is expected that the UNFCCC should deal with impacts that can be related to climate change. The lack of clear definition of loss and damage has not prevented a number of authors from discussing the relevance of EEA to inform climate negotiations, and eventually loss and damage in particular. Before loss and damage became a hot topic in the negotiations, [Allen \(2003\)](#), [Allen and Lord \(2004\)](#), and [Allen et al. \(2007\)](#) had already discussed the potential of attribution of extreme events to allow wronged citizens to appeal for compensation and liability. In fact, the perceived social need to attribute extreme weather impacts to climate change was the motivation stated by Allen to start investigating the scientific prospects of attributing specific damaging extreme events. He considers this solution as “apolitical” ([Allen, 2003](#)), in stark contrast with the political battles led within the UNFCCC.

[Hulme et al. \(2011\)](#) alert against the potential use of weather event attribution for the allocation of adaptation funding (note that when their article was published, loss and damage was only emerging in negotiations). They highlight three main problems behind the idea that adaptation funding should go to the impacts that have been directly related to anthropogenic climate change through attribution. This position was defended by [Pall et al. \(2011\)](#) and [Hoegh-Guldberg et al. \(2011\)](#). First, EEA often relies on models to estimate changes of probability between worlds with and without climate change. Given that the choice of the model can lead to different results (e.g. [Hauser et al. \(2017\)](#)), there can be “subjectivity” in EEA results, which “may simply open up new spaces for political contestation, but now hidden in the language of science” ([Hulme et al., 2011](#)) ([Surminski and Lopez \(2015\)](#) raise a similar issue). [Jézéquel et al. \(2018\)](#); [Angéil et al. \(2017\)](#) also discuss other subjective choices that may lead to fairly different results, depending on the framing of the study (e.g. the definition of the event). Second, as of today, EEA studies conducted to date mostly measure changes in hazards, not in risks (there are however an increasing number of exceptions, e.g. [Schaller et al. \(2016\)](#); [Mitchell et al. \(2016\)](#)). It hence falls short of

assessing potential changes in risks related to changes in exposure or vulnerability, and is still far from dealing with the political, social and ethical components of impacts. In line with this point, [Huggel et al. \(2013, 2015\)](#) argue that EEA has to expand from just the evaluation of changes in *hazards* to changes in *risks* to be relevant to international climate policy. Third, [Hulme et al. \(2011\)](#) argue that the allocation of funds through attributability frames adaptation in a compensatory way rather than on building capacity with respect to vulnerability.

With the establishment of loss and damage as a major topic in the run-up to the Paris agreement and afterwards, scientists started to highlight the issue of linking impacts and anthropogenic climate change. Following the adoption of the Warsaw International Mechanism for Loss and Damage (WIM), [James et al. \(2014\)](#) explain that “From a scientific perspective, [...] the first challenge in implementing the WIM would be to estimate where and when loss and damage can be attributed to anthropogenic climate change”, which calls for detection and attribution and EEA information. They point out that this potential scientific input has been largely neglected in negotiations. They are concerned “that a body of scientific evidence is growing, which is highly relevant to the WIM, yet is seen as a distraction from the negotiations” and call for better communications between scientists and policy makers through co-construction of scientific questions between both groups (see also [Parker et al. \(2015\)](#)).

In parallel, the growth of EEA as a scientific topic has fostered more general discussions on the motivation of scientists to pursue EEA, and on the identification of potential users. The use of EEA results as material to back up a liability case, possibly in the context of UNFCCC loss and damage, is among the four motivations proposed by [Hulme \(2014\)](#). [Stott and Walton \(2013\)](#) do not mention loss and damage as a potential domain of application, while [Sippel et al. \(2015\)](#) do mention this application. The interesting issue is that both EEA and loss and damage have been growing concurrently, and that a part of the scientific community has established a link between the two topics.

The literature contains different views on the role that EEA can play to inform loss and damage. [Thompson and Otto \(2015\)](#) argue that EEA is a necessary scientific input to provide restorative justice, which would be a basis for “healthy long-term international relations.” Beyond monetary compensation, it would be a way for big emitters to acknowledge their part in impacts suffered by the most vulnerable countries, and this acknowledgement would be a first step in the making of amends. [Mace and Verheyen \(2016\)](#) argue that the establishment of a scientific link between emissions and specific impacts puts policy makers in a position where it is more advantageous for them to take action collectively in the UNFCCC than to risk being brought before a court of law. [Verchick \(2018\)](#) adopts a similar point of view. He values EEA because of the “unavoidable moral duty to know what’s going on”. EEA results could provide “substantial leverage” to push for ambitious mitigation, adaptation and loss and damage policy. [James et al. \(2019\)](#) discuss four possible “ways attribution science could be applied to support actions to address losses and damages”: catalyzing action, providing evidence for liability and compensation, informing the distribution of adaptation or loss and damage funding, and, analyzing drivers of loss and damage to inform practical actions to avert, minimize, and address losses and damages. They deem the latter to be the most promising.

Others are less enthusiastic (although not as critical as [Hulme et al. \(2011\)](#)). [Wallimann-Helmer \(2015\)](#) remarks that not all loss and damage results from climate change, some is related to natural variability. The type of responsibility differs between these two cases. EEA could help to distinguish which impacts would fall under corrective liability or remedial responsibility. However, he also asserts that corrective liability (related to attributable events) should be a secondary concern in regards to remedial responsibilities because loss and damage approaches are prospective in nature, and because it would be inappropriate to compensate only the attributable fraction of loss and damage. This makes the utility of EEA only secondary. [Surminski and Lopez \(2015\)](#)

² Annex I countries are developed countries, who are historically the biggest emitters. Full list of Annex I countries: <https://tinyurl.com/ybp3udkd>.

³ Full list of non Annex I countries: <https://tinyurl.com/y7bvd2c7>.

criticize the idea that EEA could support the compensation of loss and damage, because this could “distract from the importance of recognizing risk in its totality” by focusing only on hazards. [Boran and Heath \(2016\)](#) argue that given the history and processes of the UNFCCC, the normative frame based on compensation and liability is bound to fail. They propose an alternative “risk-pooling logic” in which EEA would strengthen insurance mechanisms. [Huggel et al. \(2016\)](#) discuss the type of climate information needed to feed different normative principles of justice. They show that a compensation process based on attribution results would not be feasible with the current level of confidence in scientific evidence. In particular, they reveal an inequity in the scientific potential to attribute events depending on the region and the type of impact. This inequity is caused by the uneven quality of observational records. [Huggel et al. \(2016\)](#) hence argue that vulnerable countries are also those for which attributability is the lowest. This inequity is of practical nature and should, however, be tempered for some extreme events based on theoretical considerations. For example, temperature variability is lower in low latitudes than in high latitudes, leading to a higher signal-to-noise ratio in tropical regions, where the most vulnerable countries are generally located (e.g. [Wallace et al. \(2015\)](#); [Hawkins and Sutton \(2012\)](#); [Giorgi and Bi \(2009\)](#)). [Lusk \(2017\)](#) discusses the social utility of event attribution, and concludes that the best social fit for EEA would be loss and damage. He however points out that EEA is not the only way to address loss and damage and that there is no certainty that it will ever be used in the UNFCCC arena. [Roberts and Pelling \(2018\)](#) argue that although it could be useful, EEA should not be a pre-requisite as there are still many scientific challenges to deal with on the way to operationalization, which they feel should not be allowed to hinder efficient and rapid loss and damage action. They argue that support should be given foremost to the most vulnerable, rather than the most attributable.

The variety of perspectives regarding the relevance of EEA for loss and damage calls for input from the involved stakeholders. [Parker et al. \(2017\)](#) were the first to analyze stakeholders perceptions of event attribution in the context of loss and damage. They conducted interviews of a panel of 31 stakeholders involved in loss and damage between November 2013 and July 2014. They focused on two questions: how much is known about probabilistic event attribution, and how probabilistic event attribution might inform loss and damage. They concluded that there was little awareness of EEA between stakeholders, and that they had divergent perspectives on its potential use. The 31 stakeholders interviewed by [Parker et al. \(2017\)](#) were a mix of NGOs, social scientists, governmental and intergovernmental organizations, climate scientists and private sector representatives. The lack of agreement they found may be related to this diversity. The goal of this paper is to investigate if and how EEA could feed the loss and damage negotiations through the combination of two corpora of interviews: one exclusively with EEA scientists, and one exclusively with loss and damage delegates and their advisers. This was also an opportunity to update the results of [Parker et al. \(2017\)](#) post Paris agreement. Indeed, one of the essential conclusions from the literature is that the ways in which EEA could inform loss and damage very much depends on the author's definition of loss and damage. The explicit exclusion of compensation and liability from loss and damage in the decision accompanying the Paris agreement may have changed the perspectives of stakeholders. We detail hereafter the methodology we followed to conduct and analyze the perspectives of both stakeholders groups on loss and damage and extreme event attribution. Then, we present the results of this analysis. Finally, we discuss the implications of these results for the potential uses of EEA in the context of loss and damage.

2. Material and methods

This paper adopts a phenomenological approach to the study of the science policy interface. Its objective is thus to contribute to the “understanding [of] unique individuals and their meanings and interactions with others and the environment” ([Lopez and Willis, 2004](#)). This

approach allows exploratory analysis of the issues at hand. It minimizes the shaping of our analysis along the line of pre-established hypothesis regarding loss and damage and EEA. By not imposing a theoretical framework to our inquiry, we could explore the “appearances of things, or things as they appear in our experience, or the ways we experience things, thus the meanings things have in our experience” [Smith, defining phenomenology, 2018]. We conducted this exploration accepting that the relative youth of both the loss and damage debate and EEA would lead us to results associated to the emergence of the field. This means that our relative freedom from prejudice may also, in this case, somehow limit the interpretive frames that we actually encountered. This is a risk that we felt justifiable in the light of our research objectives which included capturing the variety of perspectives regarding the relevance of EEA for loss and damage.

Our study is based on two corpora of semi-structured interviews from two different groups of individuals. The first corpus consists of nine climate scientists working on Extreme Event Attribution (EEA), and the second of twelve delegates and affiliates working on loss and damage. Saturation has been used as the primary guiding principle for sample size (see [Mason \(2010\)](#)). A sample is saturated when adding new data (in this case, conducting other interviews) does not provide new information. Saturation has been verified through the repeated removal of each and every corpus individual from the corpora and checking that this procedure did not influence the results. The small sample size may be explained by the relative homogeneity and small size of the target populations, the focused nature of our inquiry and the saliency of the issue at hand for the interviewee (for a description of the populations see below). The information power of our small samples may find its source in our narrow study aim – the issues we are exploring here are quite focused ([Malterud et al., 2016](#)). For context, [Creswell \(1998\)](#) identifies a minimum sample size of five for interview-based phenomenological studies, while [Morse \(1994\)](#) identifies this minimum as being six.

2.1. Selection of interviewees

We targeted two populations from the general group of stakeholders involved in loss and damage, which was already studied by [Parker et al. \(2017\)](#) and [Boyd et al. \(2017\)](#). The first population consists of climate scientists working on EEA. The science of EEA originated in 2003 ([Allen, 2003](#)). This community continues to expand and now includes researchers from most of the Annex I countries and China. We can consider that our target population consists of scientists participating in the European project EUCLEIA (EUropean CLimate and weather Events: Interpretation and Attribution), and/or in the IDAG (International ad hoc Detection and Attribution Group), and/or who wrote an article about EEA, for example in one of the special issues of the BAMS (Bulletin of the American Meteorological Society) explaining the events of the previous year. Most groups working on EEA have coauthored articles with other groups.

The first corpus, consisting of nine climate scientists, was selected based on their publications and involvement in EEA research. They all came from different laboratories based in Europe, North and South America. An effort was made to cover different types of methodologies. Five of them were interviewed during the IMSC (International Meeting on Statistical Climatology, held in Canmore, Canada, in June 2016). Two others were interviewed in person on other occasions and the last two via skype, between June 2016 and January 2017. The nine interviewees included eight men and one woman. Five have a background in physics and four in statistics. We chose to only interview holders of a PhD and with a permanent position as they were perceived to be more likely to be in contact with stakeholders outside the world of research. For an emerging science like EEA – which is being conducted by young scientists – this is a limitation of our sample. Another limitation of our sample may be its gender imbalance that does not represent the EEA community in its gender diversity. Yet we see no reason for neither the nature of the position occupied (permanent vs non-permanent) nor the

gender of scientists to change the nature of our results.

The second targeted population consists of people closely involved in the loss and damage negotiation process. The targeted group was the 20 members of the Warsaw Implementation Mechanism (WIM) executive committee (Excom) and/or the persons who participated in the closed-to-observers negotiations on loss and damage at COP22. This second group includes less than 50 persons, as not all delegations are present for the negotiations on loss and damage, which is still a rather small (but highly political) topic within the UNFCCC. This population is gender balanced and evenly distributed between Annex I and non-Annex I countries.

For the second corpus, the sample consists of twelve interviewees involved in the loss and damage negotiations. Eight were Parties delegates, including five members of the WIM Excom. Amongst the twelve interviewees, three were Annex I countries delegates. Three others were advisers to delegates, all to non Annex I countries. Five interviewees were delegates from non-Annex I countries. In addition, one interviewee was a member of the UNFCCC secretariat. This corpus is hence unbalanced in favor of non-Annex I countries. This is related to a certain reluctance of Annex I countries delegates to participate to these interviews. We were only able to interview European Annex I delegates, which may have introduced a bias in our results. It would have been interesting to identify the negotiation blocs to which respondents belonged, but this would have made it impossible to maintain the anonymity of respondents. The twelve interviewees included seven men and five women.

The first target of these interviews was members of the WIM Excom whom we contacted before COP22. Starting with those who accepted, we asked each interviewee to recommend others, following a snowball sampling technique. Seven interviews were conducted at COP22 in Marrakesh in 2016, and five others were done via skype afterwards. Due to the political nature of the topic, some of the persons we contacted were unwilling to accept an interview (especially members of Annex I countries).

2.2. Interview procedure

We conducted semi-structured interviews. Confidentiality was respected by following the Chatham House rules, as agreed with the interviewees before the beginning of the interview. The climate scientists were asked to define extreme events, detection and attribution, and extreme event attribution, what was their personal contribution to EEA, how they came to work on it, why they were interested in it, what their criteria were to consider that an EEA exercise they engaged in was successful, whether they were in contact with potential users, if yes what were their expectations and if not why not, whether they considered EEA to be useful, and in what manner, and how they imagined the future of EEA. Two questions were specifically on loss and damage; whether they knew about it, and the role they thought EEA could play regarding loss and damage. If they did not know about loss and damage beforehand, we provided an explanation to them using the limits to adaptation perspective (Boyd et al., 2017). We chose this definition for the sake of simplicity, and because we feel it is the most faithful to the historical development of loss and damage in the UNFCCC. This choice may however have introduced a bias in the interviews.

The delegates and affiliates were asked to state their personal definition of loss and damage, what was the state of loss and damage during/after COP22, what was their role regarding loss and damage, how they would define extreme weather events and measure their impacts in the context of the Paris agreement, why did the WIM Excom define an action area about slow onset events and not about extreme weather events, how they imagined the implementation of loss and damage, what is the role of science in loss and damage, whether they work with scientists and about the future of loss and damage. Four questions were specifically on EEA. We asked them how an extreme weather event would be attributed to climate change in the context of loss and damage, what

they thought of the attribution of individual extreme weather events, what would be their ideal contribution from climate science on the attribution of extreme weather events and how they would deal with the events for which the uncertainties are too high for science to attribute them to climate change.

The questions related to slow onset events vary a bit from one interview to the other because we specifically asked the members of the Excom why there was an action area about slow onset events and none about extreme weather events while we could not ask the same question to people who were not part of the process of defining those action areas. We asked them how they understood the place of both slow onset events and extreme weather events in the negotiations.

We chose not to directly ask the delegates whether they knew about EEA or not in order to gauge how they would interpret our questions, and whether they would bring up EEA results by themselves. We also wanted to give them leeway to describe the type of attribution science they would like without describing pre-existing methodologies.

All the interviews were recorded with the consent of the interviewees and later transcribed for the analysis. We only used a part of the questions of both corpora for the analysis presented in this paper. The first corpus has also been used in (Jézéquel et al., 2018). The questions of the second corpus regarding the definition of loss and damage have been explored by other researchers using their own corpus of interviews and we considered we had nothing new to add on that topic (Boyd et al., 2017).

2.3. Data analysis

The interview transcripts were analyzed using a qualitative, iterative, inductive, phenomenological approach, in three steps. First, we identified nine themes covering the content of the interviews: the definition of extreme weather events by climate scientists, and by delegates, the definition of impacts by delegates, delegates knowledge of the influence of anthropogenic climate change on extreme weather events, delegates knowledge of EEA, the perspective on EEA for loss and damage of climate scientists, and of delegates, delegates perspective on the difference between slow onset events and extreme weather events, and delegates perspectives on uncertainties regarding the attribution of some extreme weather events to anthropogenic climate change. The second step was to select the excerpts of interviews related to each of those themes. The third step was to build the tables presented in the supplementary material from those excerpts.

3. Results

3.1. Delegates knowledge of EEA and scientists knowledge of loss and damage

Two years before the 2015 Paris Agreement, stakeholders involved in loss and damage had various, and often incorrect knowledge of EEA (Parker et al., 2017). A year after the Paris Agreement, despite calls (James et al., 2014) and initiatives (Parker et al., 2016) from scientists for better communication with stakeholders, our survey shows that the diagnostic stays the same. Table 1 summarizes the understanding of twelve delegates and affiliates on both the general influence of anthropogenic climate change on extreme events and EEA. Less than half had prior awareness of EEA. The understanding of both the challenges and the concepts associated with EEA vary between interviewees. The general understanding of how extreme weather events are affected and will be affected by climate change also differs between delegates. Most declare that climate change affects the severity and the frequency of extreme events, without discriminating between regions of the world and types of events. The Intergovernmental Panel on Climate Change (IPCC) establishes this variability in the influence of anthropogenic climate change on different types of events and in different regions in its last assessment report (Bindoff et al., 2013) and specifically in its special

Table 1

Delegates' knowledge of the relationship between extreme weather events and anthropogenic climate change. Complete quotes supporting this table are available in the supplementary material (Table 4 and 5).

	Influence of anthropogenic climate change (ACC) on extreme weather events (EWE)	Knowledge of extreme event attribution (EEA)
D1	ACC contributes to existing EWE, but does not induce totally new weather events.	– “Difficult to say that one event in its entirety is attributable to climate change.” – Has not heard about EEA.
D2	ACC increases the severity, intensity and frequency of extreme events.	– It is possible to calculate the difference in magnitude or in probability caused by ACC for a specific EWE within a matter of days. – Has heard of EEA.
D3	ACC increases the unpredictability of EWE. Explicit reference to IPCC.	– Impossible to attribute one event to ACC – Has heard about EEA. – EEA is “a way to say whether CC is 30% or 20%, it is very technical.”
D4	ACC increases the frequency, and the intensity of EWE	Has not heard about EEA. Outside of field of expertise.
D5	ACC increases the frequency, the impacts and the magnitude of EWE. Explicit reference to IPCC.	– Has not heard about EEA. – Attributing one storm to ACC is “impossible, non scientific even.”
D6	ACC explains the occurrence of extreme events like hurricanes. The refusal to link EWE to ACC comes from political reasons, not from science.	– Has not heard about EEA. – Does not understand the need for EEA because the science is “easy”.
D7	No specific statement.	– Has heard about EEA.
D8	ACC increases the frequency, and the severity of extreme events. ACC is not the only driver of EWE.	Refuses to answer the question. Outside of field of expertise
D9	The frequency, the severity and the location of current EWE are a result of ACC. ACC is not the only driver of EWE.	– Has heard about EEA. – There are other factors than ACC in EWE.
D10	No specific statement.	Refuses to answer the question. Outside of field of expertise
D11	The influence of ACC on EWE depends on the type of events and on the region studied. Explicit reference to IPCC.	– “it's difficult to attribute just one event to climate change, scientifically.” – Has not heard about EEA.
D12	ACC increases the number of EWE. ACC is not the only driver of EWE.	– EEA is difficult because of “climate variability”. – Has heard about EEA. – Even if we cannot “fully” attribute, we may attribute a part of the event to ACC.

report on extreme events (Seneviratne et al., 2012). This shows that those research findings have not yet been assimilated by all the negotiators.

Similarly, only a minority of EEA scientists interviewed in this study had previously heard of loss and damage (Table 2). This indicates that a very small part of the EEA community actively considers how EEA results might inform loss and damage. Both topics are quite complex to comprehend for the other group. EEA is, as stated by one of the delegates, “very technical” (D3). Loss and damage is a political concept that has been integrated in the negotiations without a clear definition (Boyd et al., 2017). This might not evolve in the future, since this fuzziness is the result of a compromise between the positions of Annex I and non-Annex I countries (Vanhala and Hestbaek, 2016). The understanding gap between the EEA and the loss and damage communities currently makes it difficult for EEA to be integrated into the loss and damage negotiations. More communication between the two groups would be a necessary condition for EEA to be used in the context of climate negotiations (James et al., 2014).

Delegates also generally consider the knowledge on extreme weather events to be greater than that on slow onset events (see Table 8 in the

Table 2

Answers of the climate scientists regarding the possible use of EEA for L&D. Complete quotes supporting this table are available in the supplementary material (Tables 6).

	Knew L&D	Which role do you think EEA could play regarding loss and damage (L&D) ?
C1	No	Maybe useful for liability but complicated: – acceptability of the science by a court. – failure to mitigate vs failure to adapt.
C2	Yes	Uncomfortable with the idea: – the science is not robust enough yet. – the robustness/attributability depends of the types of events and of the region: unfairness in attributability.
C3	No	Useful to determine what should be compensated. The way to implement is still mysterious.
C4	Yes	Confused: – would be necessary to evaluate what is related to climate change. – justice problem regarding the geographical distribution of attributability. – compensation and liability are explicitly removed from the Paris agreement.
C5	Yes	Useful to determine what should be compensated.
C6	No	Not convinced: – the real problem is to find ways to mitigate. – problem of reproducibility of the science with just one planet. – could slow decision making.
C7	Yes	Does not think it will play a major role for L&D. 2 possible other options: – EEA for quantitative risk assessment (part of L&D and adaptation, has nothing to do with liability). – indirect influence on L&D through liability cases outside of the UNFCCC.
C8	No	Not convinced of the use of EEA for L&D: – uncertainty. – non-linearity of the impacts. – apportionment of the blame between emitters.
C9	No	Against the use of EEA for L&D: – all the money would go to the lawyers. – non-linearity of the impacts. – complexity of choosing between different ways to count. – international help should be based on resources, not on attributability.

Supplementary material). Slow onset events include “sea level rise, increasing temperatures, ocean acidification, glacial retreat and related impacts, salinization, land and forest degradation, loss of biodiversity and desertification” (CP.16, 2010). However, the scientific understanding of how climate change affects some extreme events remains lower than for slow onset events (James et al., 2014). We found two reasons in the interviews to explain this discrepancy. First, the IPCC released a special report on extreme events in 2012 (Seneviratne et al., 2012), which led delegates to consider the “issue [of the influence of climate change on extreme events being] fairly well covered” (D11). This perception of the delegates is surprising, since the IPCC assessments also deal with slow-onset events like sea level rise or ocean acidification (e.g. Bindoff et al. (2013)). Second, although anthropogenic climate change may have an influence on extreme events, they have happened before. Stakeholders have historical experience dealing with them and there are already many ways to address their impacts. For example, D2 states that “the rapid onset events like floods, hurricanes, and event droughts, are well-known phenomena that occurred naturally before human-induced climate change.”

3.2. Potential uses for EEA in loss and damage

In order to better understand how EEA could inform loss and damage, we interrogated the delegates on their vision of EEA in relation to loss and damage and the climate scientists on their vision of loss and damage in relation to EEA. Their answers are summarized in Tables 2 and 3. A significant part of the climate scientists are not convinced of the

potential usefulness of EEA for loss and damage and a few delegates think that EEA could be ill-used and dangerous. Most of the delegates, especially those from non-Annex I countries, agree that EEA could be useful to some extent. They think that EEA could help to raise awareness among policy makers on the fact that the impacts of climate change are already being observed. EEA could also act as a basis to put pressure on Annex I countries to meet their responsibilities. James et al. (2019) identify this potential use for EEA as catalyst. The use of EEA to inform loss and damage has been historically discussed in relation with problems of compensation, liability and distribution of adaptation funding (James et al., 2019). The accompanying decision to the Paris agreement explicitly states that Article 8 does not provide any basis for compensation and liability, making it unclear whether these applications of EEA remain relevant, and should still be discussed. Nevertheless, our interviewees gave us perspectives on EEA as a potential scientific basis for such types of hypothetical mechanisms. Our analysis of the interviews revealed six serious technical and ethical hurdles.

Climate scientists are sometimes uncomfortable with the use of their results given the current state of EEA, which is still a relatively new branch of climate science, and lacks robustness in some cases. For instance, subject C2 would be “uncomfortable [...] if you would use our current methodology to make any statements about it and describe dangerous events.” C8 also points out the inherent uncertainties of EEA results. This worry is related to the robustness of the current methodologies (Hulme et al., 2011). Indeed, to this day, there are examples of EEA case studies leading to quantitatively, and sometimes qualitatively, varying results about the same event, depending on the methodology and model used (Angéil et al., 2017; Hauser et al., 2017). If EEA results were to inform loss and damage negotiations, they would need to be robust, so that other EEA studies could not contradict them.

Another technical problem resides in the differences in our capacity to attribute different kinds of events in different regions (e.g. C2, C4 and C9). Some events are easier to attribute than others: it is simpler to get robust results for heat-related events than for precipitation, and attributing storms and hurricanes (on Extreme Weather Events and Attribution, 2016) is a still an unresolved challenge. Additionally, EEA studies

in particular and climate sciences in general are more robust when they rely on long observational records, which tend to be more widely available in Annex I countries than non-Annex I countries. This is particularly true for African countries (Huggel et al., 2016). Therefore, the most vulnerable countries are also those for which scientists are less likely to have the data needed to attribute an extreme event to anthropogenic climate change. Furthermore, the current UNFCCC mandate addresses loss and damage “in developing countries that are particularly vulnerable to the adverse effects of climate change” (CP.19, 2013). These two concerns remain valid for any of the potential uses of EEA identified by James et al. (2019).

Even if those technical challenges were addressed and the science were able to calculate the attributable part of any extreme event impact, there would still be political hurdles in the attribution of responsibility. Interviewees from both corpora raised the problem of the apportionment of responsibility based on emissions (C8 and D5). The apportionment of the emissions and their related responsibilities is not only an EEA problem but has been a constant issue since the beginning of the negotiations. There are different ways to calculate the contribution of a country to global emissions depending on the components of anthropogenic forcings (CO₂ only, different greenhouse gases, land-use changes, etc.), the start year of the emissions, the year the impacts of climate change are evaluated, whether one should account for emissions within a territory, or for consumption-based emissions, or for emissions per capita, or for the total emissions of a country, and the indicator of climate change (e.g. global mean surface temperature) (Skeie et al., 2017). Otto et al. (2017) propose a mechanism to apportion the attributable part of the impacts of an extreme event between emitters. They show that emission apportioning choices impact responsibility distribution. Although there can be multiple scientific ways to apportion contributions to anthropogenic climate change, the choice between different methods and the translation of these contributions into responsibilities is an ethical, rather than scientific issue. Without agreement in the UNFCCC on how to apportion anthropogenic emissions responsibilities, we can question whether this problem will be solved in the context of a hypothetical loss and damage implementation mechanism based on EEA.

Ahead of this, there are also subjective choices to make in the framing of an EEA case study (Jézéquel et al., 2018), which have led to a debate on the most useful framing to stakeholders (Lloyd and Oreskes, 2018). Different framing options lead to answering different questions regarding the influence of climate change on individual extreme events. The subjective choices that scientists have to make depend on the goal of the study. Hence consultation with the relevant stakeholders is necessary, in order to answer their questions (Otto et al., 2016) (also see Table 1 in the supplementary material). However, loss and damage delegates are probably not the stakeholders who are best suited to the task. Indeed, a key choice in any EEA study is the precise definition (duration and region) of the event that is to be studied, which is a subjective choice that quantitatively impacts the results (Cattiaux and Ribes, 2018). When asked how they would define extreme weather events and their impacts, delegates typically answered that this type of technical question was outside their field of expertise (see Tables 2 and 3 in the supplementary material). This shows that we are still far from a fruitful conversation between both groups that would ensure the event is defined in a way that is both meaningful to the stakeholder and feasible within the confines of available models, observational data and knowledge.

Another responsibility dilemma lies between the responsibility related to the failure to mitigate and the responsibility related to the failure to adapt, which are often held by different parties (C1, D1, D3, D11). This relates in part to a point raised by Hulme et al. (2011) that EEA could only be useful if it attributed changes in impacts, not changes in hazards. Only a few EEA case studies tackle impacts (Mitchell et al., 2016; Schaller et al., 2016). There is still a long way to go before attributing the large variety of economic and non-economic losses. In

Table 3

Answers of the delegates regarding the possible use of EEA for L&D. Complete quotes supporting this table are available in the supplementary material (Table 7).

	Relevance of EEA for L&D
D1	EEA could be useful for awareness raising for mitigation. EEA could be dangerous: – if framed in the compensatory way (ethical problem of accepting that you cause impacts on other countries and get away with it with money). – problem of maladaptation vs lack of mitigation.
D2	EEA could be useful: – for understanding of the role of climate change on extreme events. – but it is a “second order problem”.
D3	EEA could be dangerous: – it puts the light on climate change while there are other drivers of impacts.
D4	EEA could be useful: – to determine what is L&D. – to raise awareness among policy makers.
D5	EEA could be dangerous: – apportionment of responsibility between emitters is not easy. – only the mediatized events would be addressed. – paying only for the attributable part is morally wrong.
D6	Does not understand the need for EEA because the science is “easy”.
D7	EEA has potential in a forward looking framing.
D8	EEA is useful to put pressure on big emitters to take their responsibilities towards vulnerable countries.
D9	EEA is useful to put pressure on big emitters to take their responsibilities towards vulnerable countries.
D10	EEA is useful because it is the only way to measure the contribution of anthropogenic climate change to an event.
D11	EEA is important to discriminate what part of the impacts is related to ACC and what comes from maladaptation.
D12	EEA is useful to raise awareness among policy makers.

particular, dealing with (possibly by quantifying) cultural and non-economic losses poses operational and ethical problems (Wrathall et al., 2013). This point is important because the observed increase in damages related to natural disasters has been shown to be largely due to an increase in exposure and vulnerability rather than an increase in hazards [e.g. Visser et al. (2014)].

Delegates may point out that EEA could lead to a situation where a loss and damage mechanism would only pay for the attributable part of the event (e.g., D5). This is especially troublesome when considering that impacts are not linear (C8 and C9): “a lot of these things involve a threshold [...] the straw that breaks the camel’s back, the non linearities become extraordinarily difficult to deal with.” (C9). This is illustrated by D2 when recounting the impacts of the Haiyan typhoon in 2013. “Philippines is well adapted to typhoons. [...] Haiyan came, they got the warning, they went to the shelters, they died in the shelters. Haiyan was a super typhoon. The shelters were not built to withstand a super typhoon.”

Several of these challenges apply to the application of EEA for a liability or compensation mechanism, or for apportionment of responsibility. The interviewees responses are therefore in agreement with James et al. (2019) in the challenges of using EEA for liability of compensation. However, this does not preclude the use of attribution for raising awareness and catalyzing action, or for understanding the drivers of risk to inform UNFCCC loss and damage activities. It also does not preclude the use of EEA outside of UNFCCC activities. Delegates (as well as C7) identify the disaster risk reduction community as the relevant stakeholders regarding technical issues on natural disasters. Hence, this community is more likely to grasp the concepts and limits of EEA and to integrate its results into their work. There have also been recent arguments for (Marjanac and Patton, 2018) and against (Lusk, 2017) the use of EEA for liability purposes in courts outside of the UNFCCC jurisdiction. Whether EEA will be needed in those contexts remains to be explored by social scientists and jurists in a separate analysis of each stakeholder group’s needs (Sippel et al., 2015).

4. Discussion and conclusion

At first sight, the introduction of loss and damage “associated with the adverse effects of climate change, including extreme weather events” (UNFCCC, 2015) calls for a tool to determine which extreme weather events are effectively related to climate change. However EEA does not blend in most of the political and ethical discussions surrounding loss and damage within the UNFCCC, especially when it comes to attributing responsibilities. Six hurdles delegates and scientists associate with the use of EEA for loss and damage emerge from the analysis of the interviews we present here. The first two hurdles are technical: the lack of confidence in EEA results, and the challenges associated with the attribution of events in the most vulnerable countries. Four other hurdles regard the attribution of responsibility that could ensue from EEA results. This could lead to politically complicated (possibly impossible) choices: the apportionment of responsibilities between emitters, the definition of the extreme events, the apportionment of responsibilities between those who failed to mitigate and those who failed to adapt, and the risk of only dealing with the attributable part of an event.

The relationship between EEA and loss and damage sheds light on the relationship between science and negotiations within the UNFCCC. For comparison, we can take the example of the 2 °C threshold, which is an example of co-construction between science and policy within the UNFCCC (Randalls, 2010; Aykut and Dahan, 2011; Cointe et al., 2011). At COP15 in Copenhagen, the choice of a long term goal was at stake. Two options were a fixed global temperature threshold of 2 °C above the pre-industrial temperature, which made it into the final decision, and a fixed amount of emissions. Cointe et al. (2011) analyze the reasons for the success of the 2 °C threshold. One of the main points they develop is that “it is less accurate and less clearly measurable than concentrations, which affords it an ambiguity that is very useful in the negotiation

process: we can point relatively precisely to the moment when 450 ppm of atmospheric CO₂ are to be expected, but much less precisely to the moment when the average global temperature will have risen 2 °C above the pre-industrial baseline.” Flexibility and fuzziness are essential for the political process. Policy is not rational, it thrives on “constructive ambiguity” (Geden, 2016). The example of EEA is representative of the difficulty for scientists to grasp the type of scientific information to which the UNFCCC is porous. As Geden (2018) puts it: “climate researchers need to understand processes and incentives in policy making and politics to communicate effectively.”

Despite the difficulties regarding the use of EEA within the UNFCCC, the fact that loss and damage is supposed to deal with events related to climate change remains legitimate. Aykut et al. (2017) introduced the concept of a *globalization of the climate problem*, meaning “the inclusion of new issues and actors into the climate regime”. Through a compilation of articles on specific topics based on the ethnographic analysis of COP21, they show how climate change negotiations integrate other international policy topics, which are not necessarily directly linked to climate, like fossil-fuel regulation (Aykut and Castro, 2017), or security and migration (Maertens and Baillat, 2017). Loss and damage (at least the part on extreme weather events) include disaster risk reduction issues in the COPs. The integration of disaster risk reduction within COPs presents two main advantages. It profits from the general momentum and media coverage of the climate arena, which is huge compared to traditional disaster risk reduction forums (e.g. the Sendai protocol, which is cited by a few of the interviewed delegates). It also opens the possibility of a shift of responsibilities in case of disasters. As D8 formulates it: “One of the important things about the climate change convention and the international climate change regime is that there is a responsibility in the convention for Parties, for developed country parties, to finance adaptation and resilience building. Whereas in all of the other international arenas that are related the responsibility falls on the country itself.” Another interesting point is that the original loss and damage proposal only included loss and damage associated with sea level rise (Vanuatu, 1991). We do not have the material to treat this question, but it would be interesting to investigate when and how extreme weather events (and the associated disaster risk reduction issues) were included in the UNFCCC loss and damage. This could help to understand which groups are behind this inclusion of disaster risk reduction within the UNFCCC.

The analysis presented in this article confronts the perspectives of two groups of stakeholders on the potential inclusion of EEA results in a loss and damage process: EEA scientists and loss and damage delegates. A third major stakeholder group was not included in this study: the NGOs. This is an important limitation of the results presented there. Indeed, this group plays a key part in the climate regime both within and without the UNFCCC arena (e.g. de Moor et al. (2017) on the role of climate activists and Morena (2017) on the role of philanthropies at COP21). Interviews with NGO representatives would be needed to understand whether they would find EEA results useful, and for what purposes they would find it to be useful (e.g. awareness raising, lobbying).

Declaration of competing interestCOI

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have

followed the regulations of our institutions concerning intellectual property.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). She is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

Acknowledgements

This work was supported by the ERC grant no. 338965-A2C2. We thank Vivian Dépoues, Hélène Guillemot, Aurélien Ribes and Emily Williams for their feedback on this study. We thank Rachel James and Francis Zwiers for their constructive reviews.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.wace.2019.100231>.

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