

## Impact case study (REF3)

<b>Institution:</b> University of Oxford		
<b>Unit of Assessment:</b> 14 – Geography and Environmental Studies		
<b>Title of case study:</b> Angry Weather: Changing public discourse and meteorological services for extreme weather attribution		
<b>Period when the underpinning research was undertaken:</b> 2014-Dec 2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b> Friederike Otto	<b>Role(s) (e.g. job title):</b> Associate Professor, Environmental Change Institute	<b>Period(s) employed by submitting HEI:</b> 2011 to present
<b>Period when the claimed impact occurred:</b> 2014 to Dec 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> N		
<b>1. Summary of the impact</b> (indicative maximum 100 words)		
<p>The World Weather Attribution (WWA) project, founded in 2014 and co-led by Friederike Otto, has significantly advanced the science of attributing extreme weather events to anthropogenic climate change. Attribution can now be completed in real-time – that is, within a few days – where this previously took months or longer. This acceleration of attribution science has sharply increased media attention and changed public understandings of changes in the weather and climate. The higher public profile of extreme weather events, as well as the WWA's research and methods, have also encouraged and enabled European meteorological institutions to develop their own weather attribution service.</p>		
<b>2. Underpinning research</b> (indicative maximum 500 words)		
<p>While methods to attribute extreme weather to climate change have existed for decades, the World Weather Attribution (WWA) project has dramatically shrunk the timescale over which attribution is completed. WWA has been co-led by Otto and hosted at the University of Oxford's Environmental Change Institute since its inception in 2014. Together with colleagues at the UK Met Office, the Royal Netherlands Meteorological Institute (KNMI), the University of Princeton and several other organisations, Otto has developed a method to identify the role of anthropogenic climate change in the likelihood and intensity of extreme weather events in real-time [R1]. Attribution of extreme events is now established as an independent (albeit small) branch of climate science [R1, R2].</p> <p>The WWA project includes theoretical work on the framing of the attribution question [e.g. R3], methodological development [e.g. R4], and creation and maintenance of the infrastructure to run very large ensembles of climate models on the home computers of non-academic volunteers. The WWA methodology entails risk-based probabilistic event attribution [R2]. The basic idea is to simulate possible weather in the present climate (with anthropogenic climate change) and possible weather under preindustrial or counterfactual climatic conditions, and compare the probability of the extreme event occurring in both worlds [R4]. The WWA researchers always use a multi-method approach, combining observational data, analysis of different climate models and on-site reports. Using this approach, the researchers seek to come to one of the four possible outcomes of an attribution study [R2]:</p> <ol style="list-style-type: none"> <li>1. The event has been made more likely/intense by human-induced climate change;</li> <li>2. The event has been made less likely/intense;</li> <li>3. The likelihood/intensity has been unaltered; or</li> <li>4. No robust conclusions can be drawn with the current available models and observations.</li> </ol> <p>The WWA team used the European heatwave of 2015 as its first case. The second case – the 2015-16 Storm Desmond in the UK – showed that that the storm was 40% more likely to have occurred as a result of climate change. This finding was announced in December 2015 at a press conference at the global COP21 climate conference in Paris. The study was later extended and</p>		

published in *Environmental Research Letters* [R4]. The US National Academy of Sciences commissioned a report in late 2015 on the status of research into extreme weather attribution, which aimed to clarify whether events can be attributed, and if so, what types of events – and which methods are suitable. The report confirmed that the WWA work can be applied to various forms of extreme weather, and recommended that scientists use the method that the team had developed and refined.

In her book *Wütendes Wetter* [R2], Otto discusses “dozens” of attribution studies in which she has been involved as lead or co-researcher. These have analysed the role of climate change in heatwaves (e.g. in India’s state of Andhra Pradesh, 2015 and city of Phalodi, 2016), cold spells (e.g. Southeast Europe, early 2017), extreme rainfall (e.g. Louisiana, 2016 and again in 2017 when Hurricane Harvey struck), and drought (e.g. São Paulo State, 2014). As shown below, some of these studies attracted widespread attention beyond academia. This occurred, for instance, for studies of Hurricane Harvey, where the increased rainfall rather than the actual hurricane was the real disaster [R5], and the heatwave in Southern Europe in the summer of 2019 [R6]. The latter demonstrated that anthropogenic climate change had increased the odds of a similar heatwave occurring by a factor of three since 1950.

### 3. References to the research (indicative maximum of six references)

**R1:** Otto, F.E.L. (2017) Attribution of weather and climate events. *Annual Review of Environment and Resources* 42: 627-646. <http://doi.org/10.1146/annurev-environ-102016-060847> [output type: D]

**R2:** Otto, F. (2019) *Wütendes Wetter: Auf der Suche nach den Schuldigen für Hitzewellen, Hochwasser und Stürme*. Berlin: Ullstein. ISBN: 13 9783843720908. English version: Otto, F. (2020) *Angry Weather: Heat Waves, Floods, Storms, and the New Science of Climate Change*. Vancouver/Berkley: Greystone Books. ISBN: 9781771646147. [Available upon request] [output type: A]

**R3:** Otto, F.E.L., van Oldenborgh, G.J., Eden, J., Stott, P.A., Karoly, D.J. and Allen, M.R. (2016) The attribution question. *Nature Climate Change* 6: 813-816, <https://doi.org/10.1038/nclimate3089> [output type: D]

**R4:** Otto, F.E.L., Van der Wiel, K., van Oldenborgh, G.J., Philip, S., Kew, D.F., Uhe, P. and Cullen, H. (2018) Climate change increases the probability of heavy rains in Northern England/Southern Scotland like those of storm Desmond—a real-time event attribution revisited. *Environmental Research Letters* 13(2): 024006. <http://doi.org/10.1088/1748-9326/aa9663> [output type: D]

**R5:** Van Oldenborgh, G.J., Van der Wiel, K., Sebastian, A., Singh, R., Arrighi, J., Otto, F., Haustein, K., Li, S., Vecchi, G. and Cullen, H. (2017) Attribution of extreme rainfall from Hurricane Harvey, August 2017. *Environmental Research Letters* 12(2): 124009. <http://doi.org/10.1088/1748-9326/aa9ef2> [output type: D]

**R6:** Kew, D.F., Philip, S.Y., van Oldenborgh, G.J., Otto, F.E.L., Vautard, R. and van der Schrier, G. (2019) The exceptional summer heat wave in Southern Europe 2017. *Bulletin of the American Meteorological Society* 100(1), Special Supplement, S49-S53. <http://doi.org/10.1175/BAMS-D-18-0109.1> [output type: D]

**Funded by:** European Centre for Medium-Range Weather Forecasts – Overall Co-I & PI of Oxford strand: Otto, *Prototypes of extreme events and attribution service* (part of *Copernicus Climate Change Service*, CS3) (01 October 2018-present) GBP158,728; Climate Central – Co-I: Otto, *World Weather Attribution* (June 2014-March 2017) GBP210,733; PI: Otto, Phase 2, *World Weather Attribution* (April 2017 – March 2019) GBP413,923.

### 4. Details of the impact (indicative maximum 750 words)

The research of the WWA team at the University of Oxford has attracted high and increasing levels of media attention since 2014. This has changed public understandings of changes in the weather and climate, by allowing journalists to make evidence-based claims about their interrelations. The

research also enables national meteorological institutions in Europe to develop their own weather attribution service.

### Changing the understanding of weather events in public discourse

Since 2014, Otto and the University of Oxford team have seen **media interest** in their work **rise sharply**. Data from media monitor agency Meltwater show articles discussing their work or including comments from research team members increased more than 40 times at the global level, from 60 in 2014 and 180 in 2015 to 596 in 2017 and 2,605 in 2019 [E1]. The articles have been published across the world. While in 2015, 2017 and 2019 most were published in the USA, UK, Germany and France, WWA activity has also been referenced in countries as diverse as Vietnam (17 articles in 2017, 52 in 2019), India (7 in 2015, 13 in 2017, 74 in 2019), South Africa (8 in 2015, 2 in 2017, 53 in 2019) and Brazil (26 in 2017 and 88 in 2019) [E1]. These articles are published in outlets across the political spectrum. In the UK it was not only *The Guardian* (1 article on Storm Desmond in 2015, 5 in 2017 and 10 in 2019) that reported on WWA research from the University of Oxford or invited Otto and team to comment; the frontrunner was the *Daily Mail Online/Mail on Sunday* combination (3 articles in 2017, 43 in 2019) [E1].

The Strategic Communications Manager for Climate Impacts at the European Climate Foundation (ECF) – an international organisation promoting European leadership in climate change mitigation – corroborates the strong media interest in the WWA research by Otto and colleagues. ECF collaborated with Otto and colleagues in communicating the results of attribution studies on the June 2019 heatwave in Europe, January 2020 bushfires in Australia and July 2020 heatwave in Siberia to global media. The ECF's Strategic Communication Manager writes that: “[a]ccording to our analysis of Meltwater data, the studies were covered in 1,921, 1,587 and 1,525 news articles, respectively. This puts them among the most widely covered climate science studies in 2019 or 2020” [E2].

Multiple sources [E2-E8] indicate that the increased media interest in the research by Otto and colleagues has enabled a **qualitative change in public understandings** of the relationship between climate change and weather events. The Environment Editor of *The Guardian* explains that [E3]:

“[o]ne of the questions frequently asked about climate change is did it cause a specific extreme weather event? For a long time, the answer was by necessity frustratingly vague and qualitative - global heating increases the chance of extreme weather and might increase its severity. The science of real-time attribution, pioneered by Friederike Otto and colleagues and building on the earlier work of Myles Allen, has transformed this. It enables numerical answers to the question, giving clarity and impact to the findings. Crucially, it also does this rapidly, meaning that statements on the influence of climate change on extreme weather events can be reported while those events remain relevant to the news media. It has enabled journalists to state plainly that the climate crisis is making extreme weather worse, and is therefore having real world impacts. Climate change therefore goes from being a threat to a reality. I have little doubt that this transformation has been a significant part of the rising understanding and concern about climate change and rising action.”

The ECF's Strategic Communications Manager for Climate Impacts adds that the research by Otto and colleagues has been [E2]:

“extremely valuable in increasing public, media and political understanding of the relationship between human-caused climate change and well-known extreme events. Over a short period, media coverage – particularly in Europe – shifted from saying it is not possible to connect particular events with climate change to recognising that such statements are scientifically justifiable.”

Otto and colleagues' research has also enhanced the scientific basis for collective action to address climate change. A review of *Wütendes Wetter* [R2] in Germany's leading centre-right, liberal-conservative newspaper *Frankfurter Allgemeine Zeitung* (circulation in print: >230,000 in 2019) explains that the methodological innovations that have accelerated attribution research, for which “Otto ... was a driving force ... from the start”, offer “the decisive arguments in today's sharp climate protests for action” [E4, translated]. They have enabled “a completely new line of evidence” where “correlations have now become computer-generated causalities ... Suddenly you can

search for the fingerprint of climate change after every extreme weather [event]. Science has now gone from assessor to key witness for the prosecution. The question of blame for the global climate crisis can now be tackled with mathematical means” [E4].

Others have drawn similar conclusions. The ECF’s Strategic Communications Manager states that: “[b]y demonstrating recent consequences of greenhouse gas emissions, in a scientifically robust manner, Dr Otto and colleagues provided further evidence of the urgency of rapid action, which helped galvanise public concern, media pressure and political action” by national government in particular [E2]. Meanwhile, in a *Fox News* article from 2017 on the summer heatwave in Southern Europe that year, the Director of the Red Cross Red Crescent Climate Center (which provides research for national Red Cross/Crescent agencies) confirms that “the new study [later published as R6] should be a wake-up call to policymakers in Europe about the need to prepare for hotter summers” [E5].

Otto’s research and engagement has also influenced and reinforced the actions of political actors in Germany. *Wütendes Wetter* [R2] has been particularly influential. It was ranked 3<sup>rd</sup> on the authoritative non-fiction ranking produced jointly by *Deutschlandfunk Kultur*, ZDF (the German BBC2) and *Die Zeit* (influential weekly magazine, circulation >500,000 in 2018) in mid-2019 [E6]. The media prominence of R2 and Otto’s wider engagement influenced the **Heat Action Plan** proposed by two *Bundestag* [Parliament] members of *Die Grünen* [Green Party] in July 2019 and again in July/August 2020. In it Germany’s Green Party calls for more action and financial support from the Federal Government to, for example, provide better information about heatwave risks to citizens and offer a right to reduced working hours during heatwaves for those working outside. The office of one of the Greens’ co-leaders has confirmed that Otto’s work has played a significant part in the thinking behind the plan [E7, translated and emphasis added]:

“I am happy to confirm that your [i.e. Otto’s] research - including your media work (most recently on the Siberian heat wave) - has an **impact on our political discussion**. Your studies in attribution research are perceived by us as a warning to have climate protection more rapidly and are generally very helpful in the communication of science-based policy change. The need for a common, coordinated heat action plan has become clearer.”

Moreover, in a podcast interview with Otto in the summer of 2020, Germany’s then Federal Minister of the Environment, Nature Conservation and Nuclear Safety indicates that *Wütendes Wetter* [confirmed her belief that the EU (chaired by Germany in July-December 2020) should become more proactive in climate change mitigation and adaptation [E8].

### Developing a new prototype for meteorological service provision in Germany

The increased understanding of the relationship between extreme weather and anthropogenic climate change has placed new demands on meteorological services in European countries, including Germany. In addition to predicting the weather, they are also increasingly expected to explain to the government, business, the media and the public if weather events are linked to climate change. The Head of Climate and Environmental Advice of the German Weather Service (DWD) confirms that:

“[t]he analysis and evaluation of extreme events is [now] a central topic of DWD research and advice in the field of climate services, since user inquiries have increased significantly in recent years due to the increased damage caused by extreme weather. [...] Out of self-interest, but also due to increased inquiries, the DWD started to deal with the topic of attribution in 2017.” [E9, translated]

As a result of both her research and media coverage in Germany of *Wütendes Wetter*, DWD invited Otto to its headquarters in Offenbach in January 2018, and “this meeting was the starting point for a close collaboration with you [i.e., Otto] and your research group” [E9]. This collaboration evolved into a capacity-building project called ‘Prototype Extreme Events and Attribution Service’ (2018-2021) within the European Copernicus Climate Change Service (C3S) – an EU service that supports climate adaptation and mitigation through information provision. The project was awarded to the WWA team with Otto as co-lead and four national weather services – the DWD alongside the UK’s Met Office, KNMI and Meteo France – by the European Centre for Medium-Range Weather Forecasts (ECMWF). The ECMWF is an independent intergovernmental organisation that implements C3S and provides weather predictions to EU Member States and



commercial customers worldwide. ECMWF wanted to create a “prototype extreme events and attribution service” [E10]. It anticipates that this prototype will eventually develop into an **attribution service** for national weather services in Europe, public bodies concerned with climate change impacts, commercial entities (e.g. in insurance), and outreach to the general public [E10, emphasis added]. Despite the early stage of the new service, The DWD Head Of Climate and Environmental Advice has similar expectations, and recognises benefits that are already occurring:

“according to our assessment, the project will lead to a new operational climate service that is very helpful for our role. The direct participation in the project allows the DWD the necessary knowledge transfer in order to be able to expand the national climate service portfolio of the DWD in Germany to include the attribution of weather-related extreme events in the next few years.” [E9, translated]

By October 2020, working with DWD and the three other weather services, the WWA team had: a) developed protocols on attribution, communication and data use; b) put in place a framework for quality assurance about real-time attribution on practical, methodological and scientific levels; and c) enhanced attribution capabilities through 3 pieces of educational material, 3 fact sheets and 2 demonstration cases of high temperature and high precipitation events on a dedicated website [E11]. The DWD’s Head of Climate and Environmental Advice confirms that “[o]ur task in this [project] is to test the system that you [Otto] have co-developed for practical suitability from the perspective of an operational user” [E9, translated]. Their interest is not only in the scientific methods and analysis steps but also in the “external communication of [attribution] results” [E9, translated]. Their Head of Climate and Environmental Advice considers the “very cooperative and technically very valuable” collaboration with Otto “a very important element in the DWD’s expanding portfolio of operational climate services that, in the future, will enable the DWD to offer evidence-based answers to questions about the role of climate change in extreme events” [E9, translated]. Otto’s own commitment to innovative scientific analysis alongside public communication has thus become a central part of DWD’s mission.

#### 5. Sources to corroborate the impact (indicative maximum of 10 references)

**E1:** Data on written coverage of WWA research in online media for 2014-2019, downloaded from Meltwater’s website, 12-19 October 2020. [Data available in full upon request]

**E2:** Letter: Strategic Communications Manager for Climate Impacts at the European Climate Foundation (2021) Testimonial letter, 19 January.

**E3:** E-mail: The Guardian Environment Editor (2020) Testimonial statement, 22 October.

**E4:** Newspaper article: Frankfurter Allgemeine Zeitung (2019) Die Spürhunde des Klimawandels, 19 July 2019.

**E5:** Website news item: Fox News Channel (2017) Climate change may spell hotter summers for southern Europe. *Fox News Channel*, 27 September 2017.

**E6:** Media article: Deutschlandfunk Kultur (2019) Die 10 besten Sachbücher im Juli und August, 26 June 2019.

**E7:** E-mail: Office of Die Grünen co-leader (2020) Testimonial, 21 August.

**E8:** Transcript from podcast: Bundesumweltministerin (2020) Folgen des Klimawandels und Maßnahmen zur Anpassung, interview with Otto.

**E9:** Letter: Head of Climate and Environmental Advice, Climate and Environment Division, German Weather Service (DWD) (2020) Testimonial letter, 9 December.

**E10:** ECMWF (2019) United Kingdom-Reading: Research and development services and related consultancy services – 2019/S 102-247355: Contract Notice.

**E11:** KNMI (2020) Quarterly Report 03-2020: C3S\_62\_KNMI - Prototype extreme events and attribution service.