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Climate summits and protests have a strong impact on climate change media coverage in Germany

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Media inform the public, thereby influencing societal debates and political decisions. Despite climate change's importance, drivers of media attention to climate change remain differently understood. Here we assess how different sociopolitical and extreme weather events affect climate change media coverage, both immediately and in the weeks following the event. To this end, we construct a data set of over 90,000 climate change articles published in nine major German newspapers over the past three decades and apply fixed effects panel regressions to control for confounders. We find that United Nations Climate Change Conferences affect coverage most strongly and most persistently. Climate protests incite climate coverage that extends well beyond the reporting on the event itself, whereas many articles on weather extremes do not mention climate change. The influence of all events has risen over time, increasing the media prominence of climate change.

Anthropogenic climate change is one of the greatest challenges facing humanity[1]. Public perception of climate change is crucial for the implementation of mitigation and adaptation measures. Due to competition for votes in democracies, the opinion of the average voter has a significant influence on public policy[2]. For example, it has been shown that the adoption of renewable energy policies in Europe has been accelerated by a shift in public opinion towards prioritising the environment[3].

Media play an important role in informing the public, hence shaping public perception of climate change[4]. Two principal aspects are crucial for the public perception of climate change via news coverage: the way climate change is portrayed in articles, and the frequency with which articles about climate change are published. First, readers' concern tends to increase when climate change is presented as a pervasive issue that affects the reader personally[5,6]. For example, it has been shown that coverage of health-related climate impacts can increase public engagement[7] and lead to higher levels of support for climate change mitigation and adaptation[8]. Second, increases in climate change coverage are associated with heightened public concern, as theory posits[9–11] and empirical studies show[4,12].

Besides its influence on public opinion, there is also evidence that media coverage of climate change affects human behaviour, such as mobility choices[13] or investment decisions[14,15]. In light of rapid, anthropogenic climate change[1], the question of what drives media coverage of climate change and for how long is hence more relevant than ever.

Previous work suggests that sociopolitical events such as the United Nations (UN) Climate Change conference (Conference of the Parties; COP), the largest global conference on climate policy[16–20], and domestic extreme weather events[18,21–23] increase climate change media coverage. In a cross-national study for Australia, Germany and India, Schäfer et al.[24] found that extreme weather events influence climate change coverage only in Germany, whereas other events, for example the UN Climate Change Conference, significantly influence coverage in all three countries.

However, it remains unclear which events draw most attention to the topic of climate change, both in the short- and in the longer term. This leaves a gap in our understanding of the mechanisms and dynamics of climate change media coverage, in the following defined as the percentage of newspaper articles that address climate change. To close this gap, we have assembled a novel data set, encapsulating approximately 9 million print and online articles published in nine major and diverse newspapers in Germany over the course of the last three decades. We focus on Germany as one of the world's largest emitters of greenhouse gases[25]. Journalistic news media, e.g. online and print newspapers, are a particularly important source of information on climate change in Germany[26]. 36% of the Germans inform themselves about the topic at least once per week via daily print newspapers. 39% use online news platforms like Google News, which cover news articles from multiple journalistic news media companies[27].

Building on this new data set, we statistically analyse the immediate and cumulative effect of different types of climate-related events on climate

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change media coverage. Specifically, we analyse the effect of the following event types: domestic heat waves and extreme rainfall events that affect a critical number of people, the introduction of new climate laws in Germany, climate change-related protests, publications of the Intergovernmental Panel on Climate Change (IPCC), COPs, and G7/G8 summits. We focus on these event types because of their societal importance and their direct link to climate change. Furthermore, they have occurred repeatedly in the period 1990-2021, enabling a time series-based analysis. Altogether, this set of events encompasses the public (protests), academic (IPCC publications) and—both, the domestic and international—policy spheres (climate laws, COPs, G7/G8 summits). It accounts for two types of weather extremes (heat waves and extreme rainfall) of high relevance for Germany that have been found to increase in intensity and frequency due to climate change[1,28,29].

We investigate media reporting between 1990 and 2021 by analysing print and online articles from a diverse set of regional and national newspapers, which have daily and weekly publication rhythms, as well as readerships with different sociocultural backgrounds. Utilising a dictionary-based approach, we identify more than 90,000 articles on climate change out of nine million published articles. For each newspaper outlet, we estimate the weekly percentage of articles addressing climate change, having aggregated the number of articles published in daily publishing newspaper outlets to the weekly level (see Supplementary Fig. S1).

Newspaper coverage and event data are aggregated at the weekly level, enabling us to disentangle the effects of different event types and to capture the dynamics of the media response over multiple weeks. To assess the events' immediate, extended and - in case of the socioeconomic events - possible preceding effects on within newspaper outlet changes in climate change coverage, we employ a distributed-lag fixed-effects panel regression model. This approach allows us to account for unobserved constant differences across newspaper outlets, common annual shocks such as the Covid19-pandemic and overall time trends such as changes in general climate awareness, enhancing the identification of plausibly causal effects of event occurrences on media coverage of climate change. We further control for potential confounders such as extreme weather events abroad, or elections (see Methods for detail).

Results

UN Climate Change Conferences draw most attention to climate change

We find robust evidence that both, climate-related sociopolitical and domestic extreme weather events lead to more climate change coverage in German newspapers (Fig. 1; Supplementary Table S1+S2; Supplementary Fig. S2). However, the effects' magnitude and duration differ across event types. COPs have the most pronounced and persistent impact on coverage of climate change. We find a significant impact from one week before the event to three weeks after. The impact is largest in the first two weeks ($l = 0$ and $l = 1$), in line with COPs' typical two-week duration. In the week of the conference start, COPs increase climate coverage by (0.80 ± 0.13) p.p. and in all five weeks combined the accumulated effect is (2.6 ± 0.26) p.p. In the context of the average weekly climate change coverage across the whole observation period, 1.56%, COPs increase climate change coverage by about 51% on average in the week of the conference start. IPCC publications and extreme rainfall events have the second-highest influence on climate change coverage. IPCC publications significantly increase climate change coverage

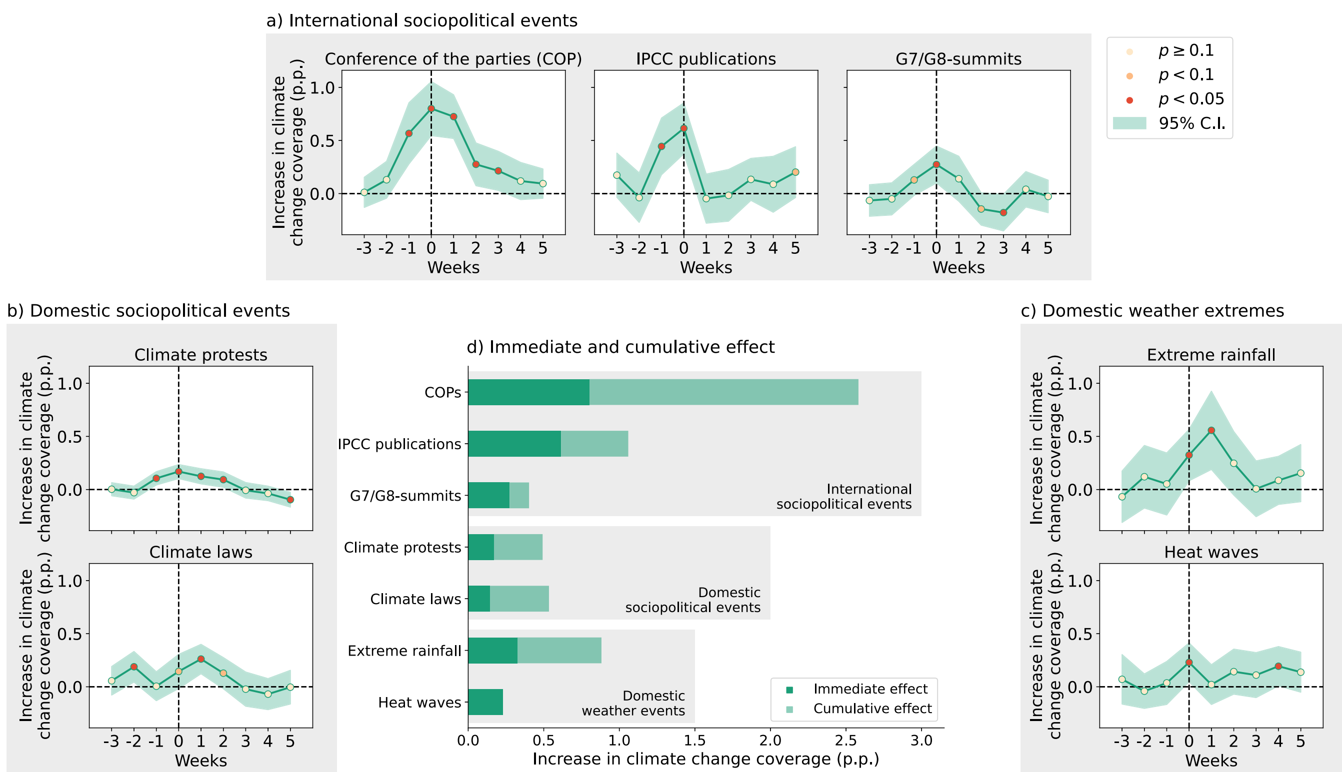

Fig. 1 | Effect of climate-related sociopolitical and extreme weather events on climate change coverage in German newspapers. Temporal evolution of the effect of different event types on climate change media coverage from three weeks before to five weeks after the event, where week zero ($l = 0$) is the week of the event's occurrence (**a**–**c**). The effect sizes are expressed as percentage point (p.p.) changes in the share of articles discussing climate change. For example, assuming that climate change coverage is 1.56% (the average value across the whole time period), an increase of 0.4 p.p. corresponds to 26% more coverage of climate change. The colours of the dots indicate the level of statistical significance of the estimated effect (red: $p < 0.05$, orange: $p < 0.1$, beige: $p \geq 0.1$). Green shaded areas (**a**–**c**) denote the 95% confidence intervals with standard errors clustered at the newspaper outlet-month interaction level. Additionally, each event type's immediate and cumulative effect on climate change media coverage is provided (**d**), where the immediate effect is defined as the effect in week $l = 0$, when the event occurs, and the cumulative effect is defined as the total effect over all consecutive, statistically significant weeks (see Methods). The regression coefficients, standard errors and their significance are given in Supplementary Table S1.

for two weeks by (1.1 ± 0.18) p.p. ((0.61 ± 0.12) p.p. in week zero). Similarly, extreme rainfall events lead to more climate change coverage for two weeks. The effect is strongest one week after the events' occurrence, likely indicating that the extent of the damage caused becomes fully apparent only then. The cumulative effect is (0.88 ± 0.23) p.p. In contrast, heat waves have a relatively small and short impact on climate change coverage, increasing it by on average (0.23 ± 0.09) p.p. in the week of the event. Noticeable, this is about a quarter of the influence of extreme rainfall, contrasting with the fact that heat waves are the deadliest extreme weather events in Germany[30]. In subsequent weeks, no further significant effect of heat waves on climate change media coverage can be detected. The only exception is the fourth week $l = 4$, where we find a significant positive effect. This may be due to retrospective reporting on possible temperature records during the heat waves. With regard to domestic sociopolitical events (Fig. 1b), we find that climate-related protests and new climate laws increase coverage in the week of the event by (0.17 ± 0.03) p.p. and (0.14 ± 0.08) p.p., respectively. Climate protests have a statistically significant impact on climate change coverage for four weeks in total. They thus have the second most persistent effect of all the events analysed. Accumulated, these weeks lead to an increase in climate change coverage of (0.49 ± 0.07) p.p. For climate change legislation, we find a statistically significant positive effect on climate change coverage one week after ($l = 1$) and two weeks before ($l = -2$) the decision of the parliament or council, and a slightly significant effect ($p < 0.1$) in the week of the decision ($l = 0$). The complex legislative process in Germany, characterised by several stages, each of which could potentially lead to increased media coverage, could explain this result. The cumulative effect over all four weeks is (0.53 ± 0.13) p.p. Finally, G7/G8 summits significantly increase climate change coverage by (0.27 ± 0.09) p.p. in the week in which the events take place and have a slightly significant positive effect (0.13 ± 0.08) p.p. on climate change coverage in the week before ($l = -1$). In the second and third week ($l = 2$ and $l = 3$) after the summits, climate change coverage decreases, possibly because reporting on other topics discussed during the summits dominates in the media. However, this effect is only weakly significant, $p < 0.1$.

Our results are robust to using alternative definitions of extreme weather events, COPs, climate legislation, and climate protests (Supplementary Note 2.1). In addition, we test the influence of single events on our results and find consistency when single events are systematically omitted (see Supplementary Note 2.2). Furthermore, the results are robust to reducing or extending the number of lags included in the analysis (Supplementary Note 2.3), to considering different keywords for defining climate change coverage (Supplementary Note 2.4), to alternative time trend controls (Supplementary Note 2.5), to additionally controlling for seasonal differences (Supplementary Note 2.6), to separately analysing daily and weekly publishing newspapers (Supplementary Note 2.7), to the exclusion of climate protests and laws (Supplementary Note 2.8), to the removal of duplicated news articles (Supplementary Note 2.9), and to alternative international weather controls (Supplementary Note 2.10).

Climate protests and IPCC publications amplify climate change coverage

Having identified disparities in the duration and intensity of the impact of weather extremes and sociopolitical events on climate-related media coverage, we explore possible explanations for these discrepancies. For events that do not draw as much attention to climate change, the explanation is either that there is comparably little overall reporting on that event type or that there is coverage but that these articles do not mention climate change. To empirically assess this, we determine the share of all articles that report on an event itself (referred to as event-specific coverage) and estimate the effect the event had on event-specific news coverage. For example, we assess how much extreme rainfall events drive coverage of extreme rainfall. For each event type, we then compare the event's impact on climate change coverage to the event-specific coverage. Specifically, we introduce the climate attention ratio (CAR) which is defined as the effect of the event on climate change coverage divided by its effect on event-specific coverage. Values greater than one indicate that an event type leads to climate change coverage beyond event-specific coverage, i.e. it motivates articles about climate change that do not mention the event itself. By contrast, values smaller than one indicate that this event type leads to less climate change coverage than event-specific coverage. Put differently, not all articles about that event mention climate change. The main results of this analysis are shown in Figs. 2 and 3.

The highest CARs are found for climate protests ($CAR = 3.34$), meaning that protests generate more than three times as many articles on climate change than on the protests themselves. Furthermore, we find CAR values larger than one for IPCC publications ($CAR = 1.31$) and climate legislation ($CAR = 1.73$). However, the complex legislative process makes the latter result difficult to interpret. In contrast, we find low CARs for extreme weather events, $CAR = 0.62$ for extreme rainfall and $CAR = 0.18$ for heat waves, implying that a large amount of coverage deals exclusively with the event itself without addressing climate change. G7/G8 summits also show a low CAR ($CAR = 0.17$), consistent with the fact that climate change is only one of several topics discussed during these summits. Finally, for COPs we find that both climate change coverage and conference-specific coverage increase similarly ($CAR = 1.03$). Even though it is intuitive that articles about the conference mention climate change, this also means that COPs - unlike IPCC publications - generally do not draw attention to the general topic of climate change that extends beyond reporting on the COPs themselves. Our results are robust to considering different keywords for defining event-specific coverage (Supplementary Note 2.11). To further exclude the possibility that flood events confound the effect of extreme rainfall, explicit controls for flood events unrelated to extreme rainfall are included in the model (see Supplementary Note 2.12 for model specification without controls).

Effect of all event types on climate attention has strongly increased in the last decade

The third part of our analysis provides evidence that the impact of climate-related sociopolitical events and weather extremes on climate change coverage has increased over time, implying that climate change has become a more prominent topic in the media. Specifically, we divide the observation period into three decades, namely 1992-2001, 2002-2011, and 2012-2021, and conduct our analysis separately for each decade. The corresponding results are shown in Fig. 4 and Supplementary Table S3.

For COPs we find that they have led to more climate reporting in all three decades. However, the effect is approximately three times larger in the last period, (1.4 ± 0.3) p.p., compared to the first, (0.56 ± 0.14) p.p., and second, (0.51 ± 0.12) p.p., decades. Notably, COPs are the only events that show a statistically significant positive effect in the first decade. For IPCC reports, for example, we do not find any significant effect on climate change coverage during the first decade, nor on event-specific coverage, possibly due to the novelty of IPCC reports. During the intermediate and last decade, IPCC publications however elevate climate change coverage by (0.80 ± 0.19) p.p. and by (1.14 ± 0.23) p.p., respectively. Their impact on event-specific coverage is consistently smaller, which implies that in both decades, IPCC publications have motivated articles about climate change that did not explicitly address the publications themselves (CAR of 2.09 in the second and of 1.61 in the third decade, Supplementary Fig. S3).

For G7/G8 summits, we observe a similar trend of larger effect sizes in more recent decades. The summits boost coverage by (0.79 ± 0.18) p.p. during the latest decade. During the intermediate decade, we do not identify any statistically significant influence. In contrast, for the decade 1992-2001, the effect is negative, (−0.18 ± 0.08) p.p., indicating a decrease in climate change coverage during G7/G8-summits, possibly because other topics discussed at the summit crowded out the coverage of climate change. In line with this, the effect on event-specific coverage is comparably high across all three decades. Climate protests exhibit a statistically significant positive effect in the last decade, (0.15 ± 0.04) p.p., whereas the effect is much smaller in the second decade, (0.09 ± 0.04) p.p. This fits to the emergence of Fridays for Future and other climate protest movements in more recent years. In

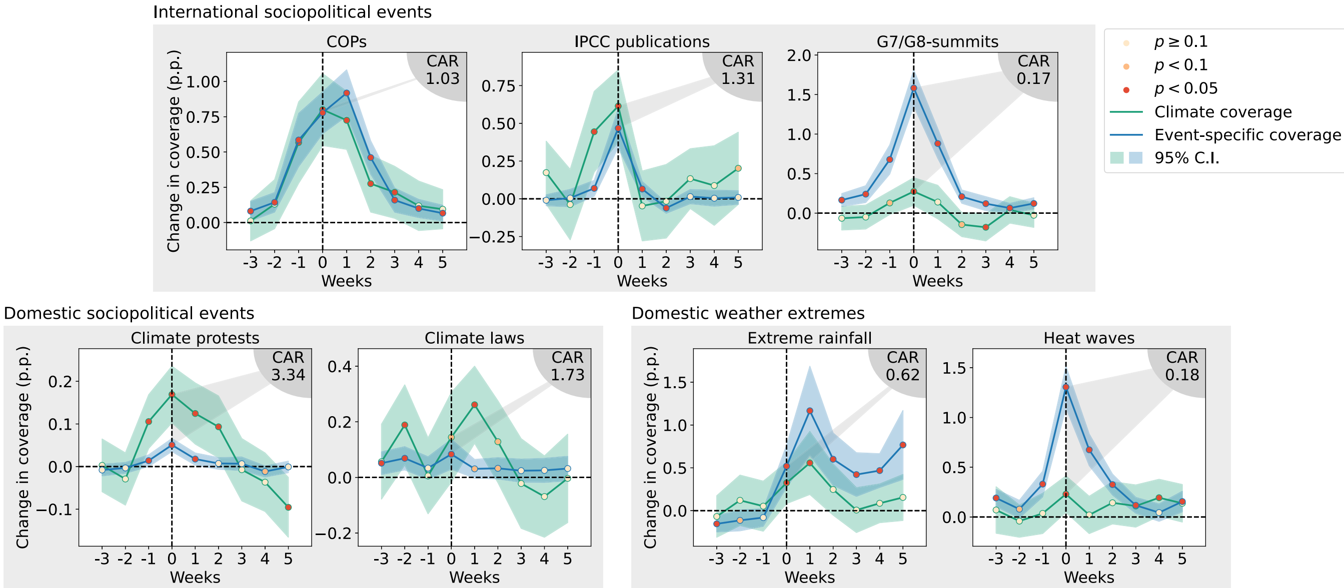

Fig. 2 | The event types' effect on climate change coverage versus their effect on event-specific coverage. The effect of all event types on climate change coverage (green) and event-specific coverage (blue) over time from three weeks before to five weeks after the event, where week zero, $l = 0$, is when the event occurred. The climate attention ratio (CAR) is given in grey quarter circles as the ratio between the event type's effect on climate coverage and its effect on event-specific coverage in the week of the event ($l = 0$). CAR greater than one indicates that an event type leads to climate change coverage beyond reporting on the event itself, whereas values less than one mean that climate change coverage is less than event-specific coverage. The effect sizes are expressed as percentage point changes in the share of the respective articles. Green and blue shaded areas indicate the 95% confidence intervals, with standard errors clustered at the newspaper outlet-month interaction level. The colour of the dots denotes the level of statistical significance of the estimated effect (red: $p < 0.05$, orange: $p < 0.1$, beige: $p \geq 0.1$).

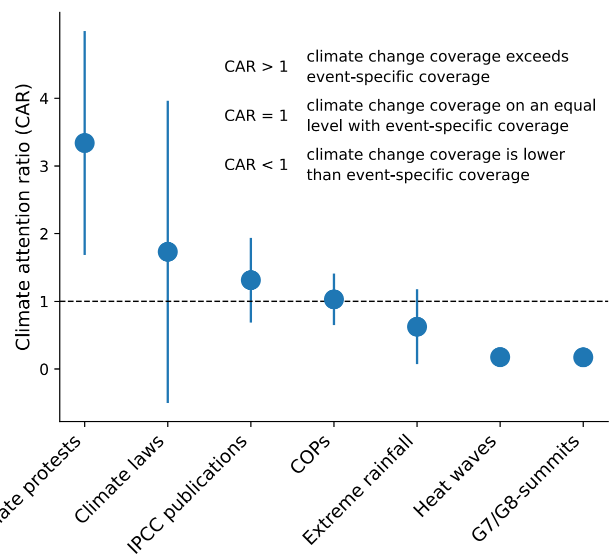

Fig. 3 | Climate attention ratio (CAR) of climate-related sociopolitical and domestic extreme weather events. The climate attention ratio (CAR) is given as the ratio between an event type's effect on climate coverage and its effect on event-specific coverage in the week of the event ($l = 0$). Values greater than one indicate events that increase climate change coverage beyond event-specific coverage, and values less than one indicate events where climate change coverage is less than event-specific coverage. The 95% confidence intervals of the estimates are shown as bars.

both decades, the effect exceeds the impact on protest-related coverage. In the earliest decade, the small number of recorded climate protests ($n = 1$) does not allow us to estimate a reliable effect on coverage (see Supplementary Table S4). For climate laws, we find a significant effect on climate change coverage during the last decade, (0.27 ± 0.12) p.p. This result corresponds to the large number of climate laws that were introduced in this decade ($n = 46$) compared to the other decades ($n = 22$ and $n = 4$). Consistently, we find elevated levels of law-specific coverage in this decade. Furthermore, we measure a slightly significant effect on law-specific coverage for the second decade, but cannot detect a significant effect on climate change coverage. This suggests that the relevant laws were discussed in the media, but were not always portrayed as climate change-related (*CAR* < 1, compare Supplementary Fig. S3). Extreme rainfall events have a positive effect on climate change coverage in the last two decades. In the period from 2012 to 2021, rainfall events increase coverage by (0.79 ± 0.34) p.p., whereas in the second decade the effect is only (0.63 ± 0.14), p.p. In contrast, for the period 1990-2001, we find a slightly significant negative effect of (-0.25 ± 0.14) p.p. However, in this decade we measure a positive significant effect on the overall coverage of extreme rainfall. This indicates that the dominance of extreme rainfall coverage not related to climate change crowded out climate change coverage. In other words, articles about extreme rainfall events did not only not mention climate change but also made it less likely that other articles about climate change were published in the same week. Heat waves exert a statistically significant influence on climate change coverage in the latest decade (0.26 ± 0.13) p.p., whereas no significant effects are found for the other decades. On the contrary, we find for all three decades a significant positive effect on heat-related coverage. Hence, heat waves are discussed in the media during the full observation period but only since 2012 they also draw significantly attention to climate change. This fits to the emergence of the field of attribution science, which assesses how much more likely and intense specific extreme weather events have become due to anthropogenic warming. The strong increase in the number of attribution studies since 2014 coincides with the increase in the effect size of weather extremes on climate change coverage in the last decade (Supplementary Fig. S4). Yet, there are still articles in that period about heat waves that do not mention climate change at all (*CAR* < 1, compare Supplementary Fig. S3).

Discussion

This study estimates the impact of various climate-related events on the coverage of climate change in nine German newspapers, revealing three main findings. First, we provide evidence that COPs draw most overall attention to climate change. This ties in with previous research findings that

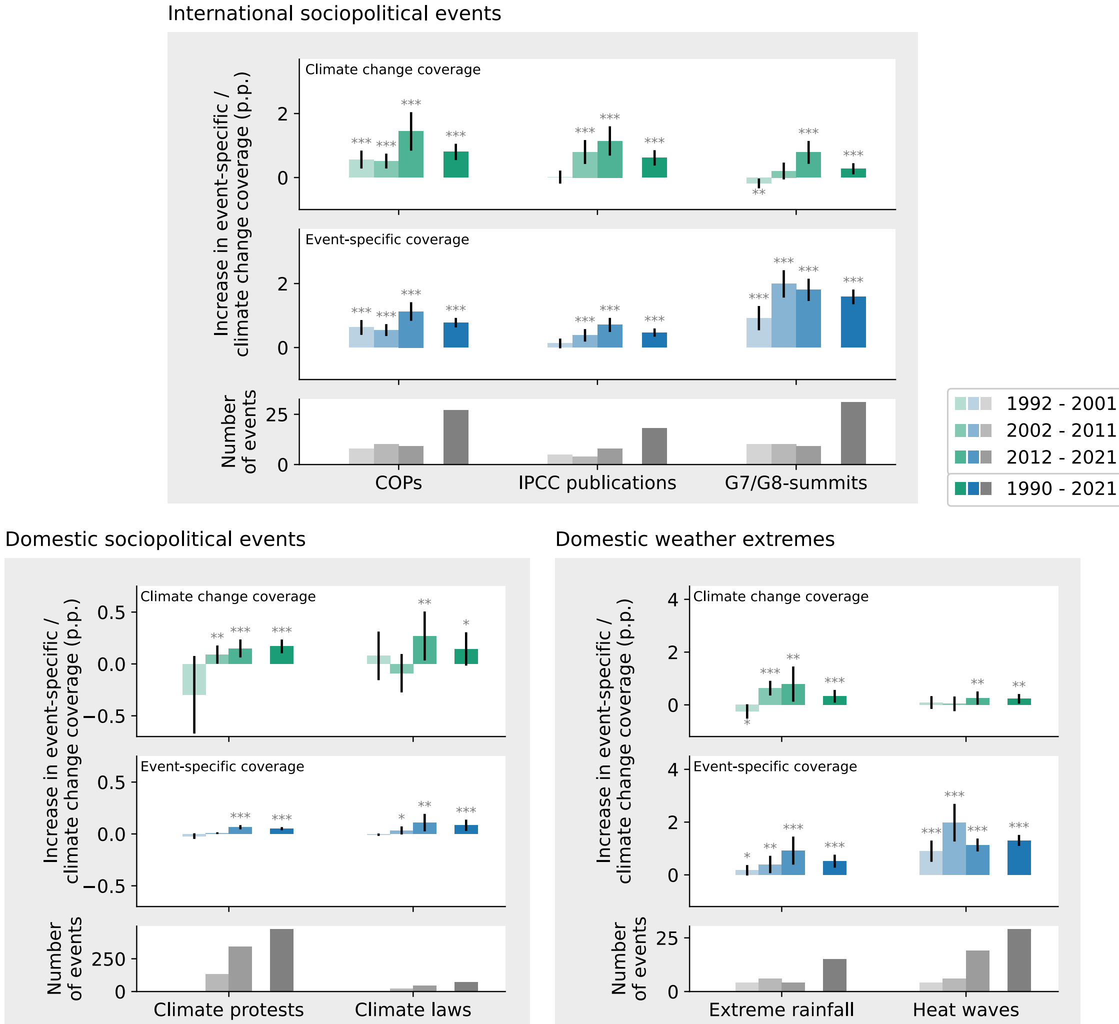

Fig. 4 | Evolution of the effect of different climate-related events on climate change and event-specific coverage over three decades. The effect on climate change coverage (green) and event-specific coverage (blue) in the week of the event ($l = 0$), assessed separately for each decade, 1992-2001, 2002-2011, 2012-2021, and the full observation period 1990-2021 (indicated by light to dark shades). Effect sizes are expressed as percentage point changes in the share of the respective articles. The 95% confidence intervals of the estimates are shown as bars, with standard errors clustered at the newspaper outlet-month interaction level. The number of events per decade and over the entire observation period is shown in the histograms below. The level of statistical significance is indicated as follows: $^{***}p < 0.001$, $^{**}p < 0.05$, $^{*}p < 0.1$.

COPs increase climate change coverage in Germany and other countries[16,24,31]. It adds to that literature by showing that this effect is more pronounced and persistent than that of other climate-related events.

Second, we show that IPCC publications and climate protests amplify climate coverage beyond the reporting on the respective event itself (measured as climate attention ratio, $CAR > 1$). These events incite an event-independent discussion on climate change, e.g. journalists write articles on climate-related topics without explicitly addressing these events. By contrast, many articles on weather extremes do not mention climate change ($CAR < 1$). These articles are likely to focus on the consequences rather than the causes of the extreme event. In addition, ambiguity as to whether the event in question is truly related to climate change may contribute to not discussing climate change as a possible cause. In line with that, we find greater CAR values for more recent years when more attribution studies became available (Supplementary Fig. S4). Further, we even find a mechanism of suppression for events with $CAR < 0$, e.g. G7/G8-summits and extreme rainfall events in the 1990s. These events then reduced climate change attention, plausibly as a result of a competing effect between coverage of the event itself and coverage of climate change topics.

Third, we show that the effect of all investigated event types on climate change coverage has increased over the last three decades, rendering climate change a more prominent topic in the media. There are three main factors that could account for this trend. First, in line with a general societal trend in Germany[32], journalists might have become more aware of climate change. Consistently, we find a trend towards increased climate change coverage in the climate attention time series (Supplementary Fig. S1). Second, with anthropogenic climate change accelerating, extreme weather events such as heat waves have become more frequent and intense, and climate protests have become more popular[1,33]. The strengthened intensity of events may have led to a general increase in attention towards them, thus an elevated event-specific coverage, including an elevated climate change coverage. We observe this trend for most events studied, except for heat waves and G7/G8-summits (Fig. 4). Third, journalists' attention might have been drawn to climate change through climate change-related events or through climate change claiming a more prominent space in established events (G7/G8 summits). As a consequence, the perceived link between climate change and the respective events may have intensified, leading to increased reporting on climate change and an increase in CAR. We observe this trend for many events studied, in particular for G7/G8-summits (Supplementary Fig. S3).

There are several limitations that should be acknowledged. First, it is important to note that our analysis focuses on a subset of nine German newspapers, and - even though the mix of newspapers is diverse, spanning daily and weekly, regional and supraregional as well as more conservative and more liberal newspaper outlets - this selection does not necessarily represent all newspapers in Germany. The purpose of this study, however, is not to identify coverage drivers that universally impact all newspapers in the country. Instead, we aim to examine the coverage provided by newspaper outlets that cumulatively reach well over 12 million people, a substantial portion of newspaper consumers[34]. The fact that we find similar patterns and results across all the newspapers analysed (see Supplementary Note 2.7) strengthens our confidence that our findings are not exclusive to the selected newspapers. The question of whether and to what extent these findings also hold for other countries is an interesting avenue for future research. Previous studies suggest different thematic emphases in climate reporting[24,31]. It should also be noted that, in addition to newspapers, television is an important source of information on climate change[35,36]. An assessment of whether our results are generalisable in the sense that they also hold for climate change coverage on television presents another promising avenue for future research.

Second, the dictionary-based approach used in this study is a commonly applied[24,37–39] but not perfect approach. It identifies all articles comprising at least one of our climate change-related keywords (Supplementary Table S5). Accordingly, this yields a set of climate change articles that potentially encompasses both extremes: articles that mention climate change only in a peripheral way, e.g. only in the last sentence, and articles that treat climate change as the main topic. This could potentially overestimate coverage of climate change. Similarly, articles that address climate change but use none of our keywords are not classified as climate-related, which could lead to an underestimation of climate change coverage. By carefully selecting the keywords, we have tried to minimise this source of error. In addition, we systematically analysed variants of the dictionaries and re-ran our analysis (see Supplementary Note 2.4). The results are robust to these changes in keywords. In both cases, we do not expect a possible over- or underestimation of climate change coverage to bias our results, as our study focuses primarily on comparing coverage of different event types as well as changes in coverage over time rather than their absolute number.

Third, while quantifying the number of articles that address climate change, we do not assess the sentiment of the articles. As a consequence, we do not know whether the increases in climate change coverage we observe include more or less climate scepticism, for example. A further interesting avenue for future research could hence be to analyse not only the effect of different events on climate change coverage as such, but also on the content and sentiment of the articles.

Finally, we focus on seven event types because of their clear link to climate change and their high societal relevance and control for other plausible climate-related events. There are however further possible drivers of climate change media coverage such as, for example, other types of extreme weather events, movies on climate change or new scientific publications. Exploring possible other drivers of climate change coverage presents another promising avenue for future research.

Methods

Climate change and event-specific coverage

News data. We conduct our analysis using articles published online or in print, between 1990 and 2021 in nine prominent German newspapers. The articles are collected from the newspaper outlets' webpages using an automated scraping procedure. The selected newspapers are Berliner Morgenpost, Focus, Hamburger Abendblatt, Handelsblatt, Der Spiegel, Tagesspiegel, Die Tageszeitung (taz), Die Welt, and Die Zeit. Supplementary Table S6 provides detailed information about the newspapers. This selection is compiled to cover a diverse range of regional and national media outlets, with daily and weekly publication frequencies and readerships with diverse sociocultural backgrounds[40]. Collectively, these nine newspapers have a readership exceeding 12 million people[34]. We do not consider special issues, e.g. anniversary issues. Their long-term planned thematic orientation contrasts with the timely reporting of the regular issues and would therefore introduce noise into the analysis. The main analysis is robust to the exclusion of duplicate articles, i.e. articles that are at least 95% identical (Supplementary Note 2.9). As each article is separately published in the newspaper outlet's archive, we assume the duplicates not to be due to errors in the database but to editorial decisions and thus retain them for the main analysis.

Dictionary-based approach. To identify climate-related articles, we adopt a dictionary-based approach, following previous studies[24,37–39], whereby we consider all articles containing at least one climate change-related term. The complete list of climate terms used in our analysis can be found in Supplementary Table S5. This dictionary on climate change was created using dictionaries from previous studies[24,31], which were successively expanded to include additional terms on climate change identified through sample reading of mismatched articles. In total, this yields 90,515 climate change-related articles across all newspapers.

To identify event-specific articles, we proceed analogously to our approach for identifying climate-related articles but use event-specific dictionaries (Supplementary Table S7). For instance, for heat waves, we select articles specifically addressing heat-related subjects, i.e. articles that contain at least one heat-related keyword. In the specific case of reporting on climate protests, we select articles that contain the name of an initiative and additionally at least one protest-related and one climate-related keyword. For coverage of heat waves and extreme rainfall events, articles that contain country names except 'Germany' are excluded, to separate coverage of domestic events from that of international events which could occur concurrently (see Supplementary Note 1.1). This procedure is conservative in that an article that covers both the domestic and a concurrent international extreme weather event is excluded. Keeping these articles in our data set increases the effect size of event-specific coverage and decreases the respective CAR value (Supplementary Fig. S5).

Finally, we determine the total number of all published articles by counting those articles that contain at least one stop word, such as definite or indefinite articles (e.g. 'a', 'an', 'the' etc.). The list of terms used for this purpose can be found in Supplementary Table S8. This approach ensures that non-text postings such as picture series, caricatures, or cartoons are filtered out. In total, we count 8,664,773 published articles across all nine newspaper outlets.

Validation. The classification of both, climate change coverage and event-specific coverage is validated by manually reviewing samples of articles (Supplementary Note 1.2). Going beyond manual validation, the results are robust to systematically omitting single keywords from the climate change-related dictionary and robust against the expansion of the dictionary to include additional climate change-related terms (Supplementary Note 2.4).

Aggregation to week-level. In order to consistently measure climate change coverage as well as event-specific coverage across different newspaper outlets, we account for variations in publication frequencies between daily and weekly newspaper outlets. For daily publishing newspaper outlets, we aggregate their articles to weekly intervals, referred to as w, which span Monday to Sunday. As for weekly newspapers, we preserve their original publication rhythm without imposing a fixed Monday-to-Sunday week format. For example, if a newspaper outlet publishes on a weekly basis every Thursday, a week w for that newspaper outlet begins on Friday and ends on the following Thursday.

Climate change coverage measure. For each week w and newspaper outlet j, we define climate change coverage $CC_{j,w}$ as the proportion of climate-related articles. This measure is obtained by normalising the number of climate-related articles in a given week with the total number of articles published in the same week. The normalisation corrects for differences in the number of newspaper pages that climate change-related topics have to share with other topics within a newspaper outlet. The resulting time series are shown in Supplementary Fig. S1. The average weekly climate change coverage across all newspaper outlets is $(1.56 \pm 0.02)\%$, where the margin of error is given as the standard error of the mean. We identify the lowest average coverage, $(0.66 \pm 0.03)\%$, for the newspaper outlet 'Hamburger Abendblatt' and the highest average coverage, $(2.79 \pm 0.09)\%$ for the newspaper outlet 'Die Zeit'. For some newspapers, articles are not continuously available; for example, articles published by 'Die Zeit' from 2006 to 2008 are missing. In periods with missing data, the respective newspaper was excluded from the analysis.

Event-specific coverage measure. Analogous to the definition of climate change coverage, for each week w and newspaper outlet j we define event-specific coverage $EC_{j,w}$ as the proportion of event-specific articles among the total number of articles published in the same week.

Climate-related sociopolitical events

To examine the influence of various sociopolitical events on climate change media coverage, we collect data from multiple sources spanning the period from 1990 to 2021. We gather data about UN Climate Change conferences, G7/G8 summits, climate change legislation in Germany, publications of the Intergovernmental Panel on Climate Change (IPCC) and climate protests. Details on these event types and on the data are provided in Supplementary Note 1.3.

Binary measures for sociopolitical events. The collected data are transformed into binary vectors for further analysis. The vector C_w denotes the presence of climate conferences (COPs), taking a value of 1 in the first week of a COP and 0 in all other weeks. Similarly, the vector G_w signifies the occurrence of G7/G8 summits and is assigned a value of 1 during the weeks when a summit took place. The vector L_w represents climate laws, with entries set to 1 in the weeks when climate-related laws were passed by the German federal parliament (Bundestag) or the federal council (Bundesrat). The vector I_w captures the release of IPCC reports, taking a value of 1 in the week of publication and 0 otherwise. Lastly, the vector M_w indicates climate protests, being assigned a value of 1 in weeks when at least one initiative issued a press release regarding a climate protest.

Extreme weather measures

Extreme weather events are increasing in frequency and intensity due to climate change and can have severe humanitarian and economic impacts, discussed in the media. One example is the flooding in Western Germany in 2021, which resulted from heavy rainfall that was made up to 19% more intense because of climate change[41], devastating entire villages and regions[42]. Another example are the repeated heat waves from May to October 2022 that led to an estimated excess mortality of about 4500 people in Germany[30]. We here focus on extreme rainfall and heat events, both of which have been shown to cause huge humanitarian and economic costs[43–45]. To examine their effect on climate change coverage, we apply a percentile-based threshold approach for measuring heat waves and extreme rainfall events in Germany and abroad. Additionally, we control for further extreme weather events.

Data sources. All climate data used are obtained from ERA5-Land, the fifth generation European Centre for Medium-Range Weather Forecasts global climate and weather reanalysis data set[46]. Our main climate variables of interest are daily maximum temperature and daily total rainfall, from which we derive heat waves and extreme rainfall events. Data are used from 1961 to 2021 on a $0.50° \times 0.50°$ grid.

To assess the population share affected by extreme weather, we use yearly population data from ISIMIP, the Inter-Sectoral Impact Model Intercomparison Project, particularly its third simulation round ISIMIP3a[47], which adopted the data from the History database of the Global Environment (Hyde)[48]. The original data from Hyde are provided on a $1/12° \times 1/12°$ grid and have been interpolated by ISIMIP to a $0.50° \times 0.50°$ grid. We use the interpolated annual population data, on ISIMIP's $0.50° \times 0.05°$ grid, for the years 1990 to 2021.

Heat waves. Heat waves can be measured in many ways, and a variety of heat wave metrics have been proposed[49]. Calculating heat waves relative to climatological baselines based on percentile-based thresholds is a method used in many studies[49–51] as well as by the German Meteorological Service (DWD)[52]. We adopt the heat wave definition of the DWD, since heat waves classified by the DWD are usually also discussed in German media. Individually for each grid cell, we define a threshold value for each day of the year - corresponding to the 97th, 98th, 99th, 99.5th, 99.9th, and 99.99th percentile of the historical distribution (1961–1990) of daily maximum temperature in a 31-day window (the selected day and 15 days before and after). If the daily maximum temperature $T_{d,c}$ in a given grid cell c is above the grid-cell specific temperature threshold and additionally above 28 °C for three consecutive days or more, a heat wave is present, i.e. $HW_{c,d} = 1$ for grid cell c and all consecutive hot days d. The heat wave thresholds for which we identify the strongest and most significant effects on climate change media coverage are $HW(98th)$ for events in Germany, with the percentile noted in brackets, and $HW(99.9th)$ for events abroad. The results are qualitatively robust to small changes of the used thresholds (see Supplementary Figs. S6 and S16).

Extreme rainfall. Similar to heat waves, extreme rainfall is frequently defined relative to climatological baseline values based on percentile thresholds[43,53–55]. We follow this approach and calculate, individually for each grid cell, threshold values - corresponding to the 97th, 98th, 99th, 99.5th, 99.9th, and 99.99th percentile of the historical distribution (1961-2021) of daily total rainfall. If total rainfall $P_{c,d}$ at day d and in the grid cell c is above this grid-cell specific threshold, an extreme rainfall event is present, i.e. $PR_{c,d} = 1$. The extreme rainfall threshold for which we identify the strongest and most significant effects on climate change media coverage is $PR(99.99th)$ for events in Germany, with the percentile noted in brackets. The results are qualitatively robust to small changes in the used thresholds (see Supplementary Fig. S6). In some countries, rainfall is unevenly distributed over the seasons, however seasonal effects, e.g. due to rainy seasons, are not corrected for in this threshold definition. Therefore, alternatively to the percentiles using the full historic distribution, we calculate the percentile values within 31-day, 61-day and 91-day windows, centred around the day of interest and use these alternative threshold definitions to calculate extreme rainfall events abroad. The extreme event threshold for which we identify the strongest and most significant effects on climate change media coverage is $PR(99.9th, 31d)$, with the $99.9th$ percentile determined in 31-day windows. The results are qualitatively robust to small changes of the used thresholds (see Supplementary Fig. S17).

Spatial aggregation. The weather extremes are aggregated spatially using a regional population-weighted average at the country level for events occurring in Germany, and at the level of world regions as defined by the IPCC[56] for international events. These world regions encompass North America, Central and South America, Antarctica, Africa, Europe, Asia, Australasia, and Small Islands. The utilisation of this intermediate aggregation level offers advantages compared to both, global (worldwide) and local (country-level) aggregation approaches. In contrast to the first, it takes into account regional variations and acknowledges the specific characteristics that define an extreme event within different geographical areas. Compared to the second approach, selectivity is maintained by placing the events in question into a broader context of weather extremes in the world regions and finally selecting only the most relevant ones. Shapefiles for these regions are obtained from the Database of Global Administrative Areas (GADM) and for the world regions from the IPCC Multi-MIP Climate Change Atlas[57]. The weather extreme measures are weighted by population using yearly population data from ISIMIP on an

0.50° x 0.50° grid, yielding a measure of the share of people affected by heat waves and extreme rainfall, respectively. For all grid cells c where an event occurs, the number of people $P_{c,y(d)}$ living in these cells during the corresponding year $y(d)$ is accumulated and normalised by the total population living in the respective region r, i.e. in Germany or an IPCC world region.

$$HW_{r,d} = \frac{1}{P_{r,y(d)}} \sum_{c \in r} HW_{c,d} \cdot P_{c,y(d)}, \tag{1}$$

$$PR_{r,d} = \frac{1}{P_{r,y(d)}} \sum_{c \in r} PR_{c,d} \cdot P_{c,y(d)}. \tag{2}$$

Temporal aggregation. We aggregate extreme weather events to weeks w that match the weekly aggregation of the newspapers. For each week w, we determine the maximum daily share of people affected.

$$HW_{r,w} = max(\{HW_{r,d} | d \in w\}), \tag{3}$$

$$PR_{r,w} = max(\{PR_{r,d} | d \in w\}). \tag{4}$$

Domestic extreme events. For extreme events that occur within Germany, binary vectors are formed, which are 1 if we measure an event and 0 if we do not. In the main analysis, only the 25% of the events that affect the most people are included, i.e. events above the 75th percentile of the distribution of $HW_{r=de,w}$ and $PR_{r=de,w}$, respectively. In doing so, we focus on large events, i.e. events that affected many people and thus potentially had a strong humanitarian impact. Formalised, this reads

$$HG_w = \begin{cases} 1 & \text{if } HW_{r=de,w} > HW(75\%), \\ 0 & \text{else,} \end{cases} \tag{5}$$

$$PG_w = \begin{cases} 1 & \text{if } PR_{r=de,w} > PR(75\%), \\ 0 & \text{else,} \end{cases} \tag{6}$$

with $HW(75\%)$ and $PR(75\%)$ the respective 75th percentiles. Results are qualitatively robust to using other percentile thresholds (see Supplementary Fig. S6). In total, we measure 29 weeks that are affected by domestic heat waves and 14 weeks that are affected by domestic extreme rainfall events in our observation period from 1990 to 2021.

Control variables

Besides the selected extreme weather and sociopolitical events, there are several other events that can potentially influence climate change coverage, such as the release of movies about climate change or the awarding of Nobel Prizes related to climate change. Using topic modelling, a machine learning technique, we conduct a systematic analysis of all articles addressing climate change and identified a number of further events that have influenced climate change coverage besides those introduced so far (see Supplementary Note 1.4). We include these events as statistical control variables in our analysis. A full list of all events, their dates as well as the period we control for is provided in Supplementary Table S17.

Sociopolitical events as controls. The sociopolitical events we control for in our main model specification include all German and European elections, key European policy decisions, climate-related Nobel Prizes, the awarding of the Oscar for the film 'An Inconvenient Truth', the Climatic Research Unit email controversy known as 'Climategate', the US withdrawal from the Paris climate agreement, the solar valley bankruptcy and further events. To control for these, we include a dummy variable $CT_{i,w}$, which is 1 in weeks w when such an event i occurs and 0 otherwise.

International extreme heat and rainfall. For international extreme events, we create, analogous to domestic events, binary vectors for heat waves and extreme rainfall that cover the respective event types in all IPCC world regions, excluding Germany. In the main analysis, the 1% of events that affected most people in the respective world region r are included, i.e. events above the 99th percentile of the distribution of $HW_{r,w}$ and $PR_{r,w}$, respectively. Due to the high frequency of international extreme events, the inclusion of a larger share of events is not suitable for our analysis; individual events could then no longer be distinguished. For each week, the variables are equal to 1 if there is an extreme event in any of the IPCC regions and 0 otherwise. Formalised, this reads

$$HA_w = \begin{cases} 1 & \text{if } HW_{r,w} > HW(99\%)_r \text{ in any } r, \\ 0 & \text{else,} \end{cases} \tag{7}$$

$$PA_w = \begin{cases} 1 & \text{if } PR_{r,w} > PR(99\%)_r \text{ in any } r, \\ 0 & \text{else,} \end{cases} \tag{8}$$

with $HW(99\%)_r$ and $PR(99\%)_r$ the respective 99th percentile of the corresponding distribution. In total, we measure 266 weeks that are affected by international heat waves and 1150 weeks that are affected by international extreme rainfall events in our observation period from 1990 to 2021.

Further extreme weather events. To statistically control for potential confounding effects of extreme weather events and hazards other than extreme heat and rainfall, we consider all domestic and international wildfires, storms, and floods given in the international disasters database EM-DAT[58]. EM-DAT, maintained by the Centre for Research on the Epidemiology of Disasters (CRED), is a global database that systematically records and collates information on various natural and technological disasters. We utilise data pertaining to wildfires, storms and flood events spanning the period from 1990 to 2021, assessed on a monthly basis and encompassing occurrences from diverse regions worldwide.

To ensure that floods caused by extreme rainfall are not counted twice, i.e. by our extreme rainfall measure and the flood control, we exclude flood records categorised as 'Flash flood', since they are defined to be caused by 'Heavy or excessive rainfall' and flood records that are explicitly marked as originating from 'Heavy rain' or 'Torrential rainfall'. For months with storm events (extra-tropical storms or tropical cyclones) we control with the binary vector ST_m and for months with floods with FLO_m. Wildfires in EM-DAT usually last multiple months. We only control for the last month, i.e. the binary vector $WF_m = 1$ in that last month m, assuming that in this month media coverage is largest as the full extent of the damage can be seen. Solely for the Australian wildfires 2019/2020, we control for the last two months, motivated by their extraordinary strength which led to repeated media coverage.

Empirical strategy

We use fixed-effects panel regression models with distributed lags to estimate the effects of the different extreme weather and sociopolitical events on climate change coverage, $CC_{j,w}$, and on event-specific coverage, $EC_{j,w}$. This approach exploits variability in the occurrence of heat, extreme rainfall, climate-related protest, the publication of IPCC reports, and other non-weather-related variables from one week to the next to assess their impact on within-newspaper outlet changes in climate change coverage. As such, it allows us to account for unobserved confounding factors, strengthening the identification of plausibly causal effects of the different drivers on climate change media coverage[59–61].

Main empirical specification to assess effects on climate change media coverage. In our main model, we assess potential prior and posterior effects of the different events on climate change coverage $CC_{j,w}$, by including three lead-weeks and five lag-weeks. We test for different numbers of lags and leads and find climate attention triggered by the respective events to decay to zero before and after that time. Results for week $l = 0$ show to be robust under variations of the number of lags as well as without lags (see Supplementary Note 2.3). Further, we include newspaper outlet, ν_j, and year, η_y, fixed effects. Newspaper outlet-fixed effects flexibly account for unobserved, time-invariant differences between newspaper outlets, such as different baseline climate change coverage or differing climate change awareness between editorial teams. Year fixed effects account for unobserved, spatially invariant annual changes in both climate measures and the article share owing to newspaper outlet-overlapping phenomena such as the El Niño-Southern Oscillation, pandemics, or changes in sociopolitical climate awareness. Lastly, following previous literature[62–64], we apply Chebyshev polynomials, $T_{i,w}$, of degree $i = 0, \ldots, 4$ to capture spurious correlations due to common time trends. Recursively, the Chebyshev polynomials are given by

$$T_{i,w} = 2w \cdot T_{i-1,w} - T_{i-2,w}, \tag{9}$$

with $T_{0,w} = 1$ and $T_{1,w} = w$. Polynomials up to the order of $i = 4$ are sufficient to obtain robust results (see Supplementary Note 2.5).

As independent variables, we include binary vectors of domestic weather extremes HG_w, PG_w, using the $HW(98th)$ heat wave specification and the $PR(99.99th)$ extreme rainfall specification. These have been shown to give strong statistically significant effects across a range of models with different thresholds. Further independent variables in the main specification of the model are the binary vectors for sociopolitical events, I_w, C_w, G_w, L_w, M_w. Finally, we explicitly control for international weather extremes, i.e. heat waves, extreme rainfall events, wildfires, floods, and storms and for additional sociopolitical events. The main econometric specification reads:

Empirical specification to assess event-specific coverage. In addition to our main panel regression model, which relates extreme weather and sociopolitical events with climate change coverage, we measure the events' influence on event-specific coverage, $EC_{j,w}$. For each event type, we use a separate model that includes newspaper outlet fixed effects, ν_j, year fixed effects, η_y, and Chebyshev polynomials, $T_{i,w}$, up to order four. The dependent variable is the event-specific coverage $EC_{j,w}$. The independent variable is the respective binary event vector, e.g. C_w for COPs. Contrary to the main model specification, we do not include any further controls, as we do not expect $EC_{j,w}$ to be sensitive to other climate-related events. Only in the model for extreme rainfall events, we additionally control for flood events, unrelated to extreme rainfall, in order to exclude potential confounding effects. Analogously to the main model specification, errors are clustered at the newspaper outlet-month interaction level. The model specification for COPs reads for example:

$$\underbrace{EC_{j,w}}_{\substack{\text{COP}-\text{specific}\\ \text{media coverage}\\ \text{(article share)}}} = \sum_{l=-3}^{5} \underbrace{\alpha_l C_{w+l}}_{\text{COPs}} + \underbrace{\sum_{i=0}^{4} \tau_{j,i} T_{i,w}}_{\substack{\text{Chebyshev}\\ \text{polynomials}}} + \underbrace{\eta_y + \nu_j}_{\text{fixed effects}} + \epsilon_{j,w}\,. \tag{11}$$

The relation between the event's effect on event-specific coverage and its effect on climate change coverage is quantified by the climate attention ratio (CAR). CAR is defined as the ratio between the event type's effect on climate coverage and its effect on event-specific coverage in the week of the event ($l = 0$). CAR greater than one indicates that an event type leads to climate change coverage beyond reporting on the event itself. Using the example of COPs, CAR is defined as $CAR = \gamma_{l=0}/\alpha_{l=0}$, with $\gamma_{l=0}$, the effect of COPs on climate change coverage estimated with the main econometric model (Eq. (10)) and $\alpha_{l=0}$ the effect of COPs on event-specific coverage, estimated with our second model specification (Eq. (11)).

$$\begin{aligned}
\underbrace{CC_{j,w}}_{\substack{\text{climate change}\\ \text{media coverage}\\ \text{(article share)}}} = \sum_{l=-3}^{5} \Bigg[& \underbrace{\alpha_l HG_{w+l} + \beta_l PG_{w+l}}_{\substack{\text{domestic heat waves \&}\\ \text{extreme rainfall}}} + \underbrace{\gamma_l C_{w+l}}_{\text{COPs}} + \underbrace{\delta_l G_{w+l}}_{\substack{\text{G7/G8}\\ \text{summits}}} + \underbrace{\zeta_l I_{w+l}}_{\text{IPCC}} + \underbrace{\theta_l L_{w+l}}_{\text{laws}} + \underbrace{\kappa_l M_{w+l}}_{\text{protests}} \Bigg] \\
& + \underbrace{\varphi_1 HA_w + \varphi_2 PA_w}_{\substack{\text{international heat waves \&}\\ \text{extreme rainfall}}} + \underbrace{\varphi_3 WF_m}_{\text{wildfires}} + \underbrace{\varphi_4 ST_m}_{\text{storms}} + \underbrace{\varphi_5 FLO_m}_{\text{floods}} + \underbrace{\sum_i \lambda_i CT_{i,w}}_{\substack{\text{controls for}\\ \text{elections, nobel}\\ \text{prize, etc.}}} \\
& + \underbrace{\sum_{i=0}^{4} \tau_{j,i} T_{i,w}}_{\substack{\text{Chebyshev}\\ \text{polynomials}}} + \underbrace{\eta_y + \nu_j}_{\text{fixed effects}} + \epsilon_{j,w},
\end{aligned} \tag{10}$$

with j, m, y being the newspaper outlet, month, and year respectively and $\epsilon_{j,w}$ the newspaper outlet-week error term. Errors are clustered at the newspaper outlet-month interaction level. For each of the nine newspaper outlets, this gives 384 clusters, corresponding to the months in the 32-year observation period. This approach flexibly accounts for possible correlation of regression errors within newspaper outlets and months, that might exist due to coverage shocks at the month level, e.g. from sports events, as well as from newspaper outlet-specific properties such as higher variability in climate change coverage. The coefficients of interest are α_l, β_l, γ_l, δ_l, ζ_l, θ_l, κ_l. These are the marginal effects that denote the percentage point change in climate change media coverage in weeks when an event was measured ($l = 0$) as well as up to three weeks before the event, $l \in [-3, -1]$, and up to five weeks thereafter, $l \in [1, 5]$. Moreover, the cumulative marginal effect is defined as the sum of all statistically significant consecutive weeks, e.g. the cumulative effect of IPCC publications is given by $\sum_{l=-1,0} \zeta_l$, where $l = -1$ and $l = 0$ are the significant weeks and ζ_l is the respective estimated marginal effect.

Data availability

In compliance with the newspapers' terms of service restrictions and due to copyright, the news data will not be shared in a public repository. ERA5 climate data are publicly available at https://www.ecmwf.int/en/era5-land. The GADM data on administrative boundaries are publicly available at https://gadm.org/. The data on the legislative process are publicly available at https://dip.bundestag.de/. EM-DAT disaster data are publicly available at https://www.emdat.be/. ISIMIP3a population data are publicly available at https://data.isimip.org/10.48364/ISIMIP.822480.2

Code availability

The code to reproduce the analysis is available at the public repository for this publication: https://doi.org/10.5281/zenodo.10869157.

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