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Do Natural Disasters Help the Environment? How Voters Respond and What That Means *

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This paper examines whether voters' experience of extreme weather events such as flooding increases voting in favor of climate protection measures. While the large majority of individuals do not hold consistent opinions on climate issues, we argue that the experience of natural disasters can prime voters on climate change and affect political behavior. Using micro-level geospatial data on natural disasters, we exploit referendum votes in Switzerland, which allows us to obtain a behavioral rather than attitudinal measure of support for policies tackling climate change. Our findings indicate a sizeable effect for pro-climate voting after experiencing a flood: vote-share supporting pro-climate policies can increase by 20%. Our findings contribute to the literature exploring the impact of local conditions on electoral behavior.

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Over the past three decades the salience of environmental issues has increased significantly in the political arena. Considerable progress has been made in addressing a variety of complex and technical problems associated with air and water quality, genetically modified food, and the treatment of waste. However, environmental policies continue to be difficult to implement and sell to voters in both developed and developing countries (Bernauer and McGrath 2016). The disappointing outcomes reached by the global environmental summits held in Johannesburg (2002) and Copenhagen (2009), at which virtually no progress on global warming issues was made, combined with the difficulties encountered in enforcing the Paris Agreement (2015), elucidate such challenges.

Political progress on the climate issue typically requires electoral support, be it in the form of supporting policies put to a direct ballot vote or via supporting politicians who will enact such legislation. The conventional account of retrospective voting assumes that personal experience affects political support (Fiorina 1981). There are two conflicting views of how voters respond to events related to global warming and climate change. An optimistic standpoint is that extreme weather events that are the consequence of global warming are becoming more and more frequent, and hence provide the electorate with gradually increasing and repeating concrete experiences of climate change. This view proposes that an increase in climate-related extreme weather events can serve to shore up support for pro-climate policies. In this view, solutions for climate change will gradually garner majority support as the negative consequences of climate change become more severe and occur more often. The pessimistic view is that voters are not rational but instead short-sighted and do not possess the knowledge and ability to understand these indirect informational updates. Thus, experiencing climate-related extreme weather events does not change voters' expressed political preferences, whether through voting in elections or referendums.

In this paper, we explore whether the occurrence of an exogenous shock, such as

a small local natural disaster, affects political behavior. We assume that the large majority of individuals do not hold consistent opinions on questions of climate change, which are second order in the political debate. Personal experience provides accessible considerations, which increase the salience of the climate issue and lead to the formation of stronger opinions. The mechanism that we explore asks whether experiencing natural disasters primes voters in favor of climate protection. More specifically, we expect that in areas affected by small and local natural disaster events linked to global warming, such as floods, voters who witness destruction become more sensitive to issues related to climate change than those living in areas untouched by disaster. In turn, we hypothesize that areas hit by disasters are more likely to show stronger support for pro-climate policies than disaster-free areas.

To evaluate whether exposure to extreme weather events affects political behavior, we rely on a database of natural disasters and ballot measures related to climate change as well as geographical and geological variables at municipal level. These are small and local events that cause small-to-moderate damage, such as the flooding of one street and adjacent properties with financial damages estimated at below 1 million Swiss Francs (about $1 million). The peculiar features of Swiss direct democracy allow us to exploit behavioral data on repeated voting related to climate change. Thus, we are able to link personal experience of natural disasters to actual political behavior on issues that are closely linked to global warming and climate change. In doing so, we complement previous studies that either test the impact of personal experience on political attitudes that rely only on surveys (Egan and Mullin 2012) or analyze the impact of natural disasters on voting behavior in general elections, during which environmental issues are rarely salient (Bechtel and Hainmueller 2011; Gasper and Reeves 2011).

The results show that there is a causal effect across various estimation strategies and a number of robustness tests. The occurrence of a small and local natural disaster event has a statistically significant positive effect on pro-climate votes. We also explore

effect heterogeneity and show that it is larger in municipalities in which people are more likely to be aware of the climate-extreme weather nexus. But the effect decays over time. After ten months, outcomes in exposed and non-exposed units are indistinguishable. The consequence of exposure on pro-climate votes is not trivial. In baseline model specifications, the pro-climate vote share increases by 6%. Once effect heterogeneity is taken into account, the pro-climate vote-share increases by 20%. Furthermore, we show that exposure to floods has no effect on votes that are orthogonal to climate issues, such as referendums on the European Union. These placebo tests corroborate the validity of our identification strategy and highlight the significance of the main findings.

Finally, we show that natural disasters also have a positive effect on political mobilization, which is another possible mechanism at play. In particular, we find that areas hit by floods have higher turnout in referendums on climate measures compared to unaffected areas. Both mechanisms, meaning the effect of floods on attitudes towards climate change and on mobilization, point to the same key finding: the occurrence of small and local natural disasters affects political behavior and increases support for policies that fight global warming.

These results also contribute to ongoing debates about the value and possibilities of using direct democratic institutions, such as the initiative and referendum. In their recent chapter on popular control, Achen and Bartels (2017) draw a rather bleak picture of the cognitive abilities of voters. Their argument is based on numerous studies showing inconsistent preferences or behavior. One example is the desire for fire protection and the public expenditure on emergency services (p. 83-85). Proponents of the opposite position invoke work by Lupia, specifically his paper on shortcuts and heuristics (Lupia 1994). The results here, in a somewhat glass half-full or half-empty fashion, lead to a more nuanced picture. Voters are able to process complex information, but the average voter holds many considerations. In the short-term the Swiss voter, this analysis suggests, seems to conform more with the optimistic picture drawn by authors like Lupia. But as

the effect decays, the picture approaches a more grim version that might be closer to what Achen and Bartels describe.

Literature Review

Our paper builds on two rich streams of literature in social science: personal experience and political attitudes, as well as natural disasters and political behavior. While this literature is too large to review fully here, below we provide a short overview of each stream.

Personal Experience and Political Attitudes

The idea that personal experience matters for political attitudes lies at the core of the economic voting literature (Duch and Stevenson 2006). For voters who are less politically engaged, personal experience represents an easy and cheap way of acquiring information that, in turn, might affect their voting behavior or, more generally, their attitudes. Here, we take advantage of disaster data and referendum results, which allows us to study political behavior and how it is affected when voters are exposed to extreme weather events.

Indeed, several papers link personal experience to attitudes on climate change. Stokes (2016) finds that citizens living in proximity to wind energy projects punish the incumbent government for its climate policy. Brody et al. (2007) note that vulnerability to floods and rising sea levels affects the perception of risk associated with global climate change, whereas temperature has no such impact. Recent papers explore the impact of weather conditions on attitudes towards global warming (Egan and Mullin 2012; Konisky, Hughes, and Kaylor 2015; Li, Johnson, and Zaval 2011; Hazlett and Mildenberger 2017). In particular, Egan and Mullin (2012) find that an unusual increase in local temperatures strengthens belief in global warming. Their estimates indicate the magnitude of such an increase is substantial, though it survives only in the short-term.

While it provides interesting results and compelling insights, we identify three shortcomings in the existing literature. First, although Erikson and Stoker (2011) and Egan and Mullin (2012) are important exceptions, results from previous papers are plagued by the fact that personal experience is not randomly assigned among individuals.

Moreover, previous studies rely on surveys to capture personal experience. This creates several well-documented problems, such as measurement error in self-reporting and political bias in answering questions about personal experience (Bartels 2002; Achen 1975). Without linking attitudes to an exogenous shock that is likely to modify opinions on environmental issues, it is difficult to draw conclusions from survey data based on self-reports.

Finally, and importantly for our paper, previous studies capture attitudes towards global warming by relying on surveys among a non-representative sample of the population (Li, Johnson, and Zaval 2011) or a representative sample (Egan and Mullin 2012). While this approach is surely effective in measuring political attitudes, social scientists are ultimately interested in actual political outcomes. This is particularly important in the case of global warming, where attitudes seem only weakly affected (if at all) by external shocks. By exploring the impact of natural disasters on *actual voting* in referendums, our study is able to show not only if external shocks change political behavior on climate ballot measures, but also how these effects vary across units and time.

Natural Disasters and Political Behavior

There is a compelling literature that links natural disasters to political behavior. The theoretical framework is, again, economic voting: Rational voters reward incumbents not only for delivering positive economic performance in good times, but also for organizing prompt rescue and relief programs in bad times, as in the case of a hurricane or major flood.

This literature is heavily grounded in American politics. In a pioneer study, Abney and Hill (1966) explore voter response to the rescue program after Hurricane Betsy in New Orleans. Chen (2012) shows that disaster relief after the Florida hurricane increased votes for George W. Bush in the 2004 election, but only in Republican precincts. Healy and Malhotra (2009) draw political economy implications from such findings. Since voters reward relief programs, politicians have an incentive to invest in relief aid and under-invest in preparedness measures. Thus, what is an electorally efficient policy turns out to be economically sub-optimal. Finally, Gasper and Reeves (2011) show how the US electorate rewards/punishes the requests/denials for federal assistance.[1]

The take-home message from this literature is two-fold. First, relief programs, if effective, carry a sizable electoral reward for incumbents and their parties. Second, such a reward is usually short-lived, since voters are quick to forget. This second result squares with the literature on blind retrospective voting with the important exception of the recent contribution by Bechtel and Hainmueller (2011). They provide the most sophisticated analysis on the effect of natural disasters on political behavior outside the US and find that voter gratitude lasts longer than claimed by previous studies.

These studies have convincingly shown the importance of natural disasters on voter behavior, treating relief programs as a form of pork barrel spending in bad times.[2] However, there is another channel through which natural disasters might affect (rational) voter behavior. Given that events such as floods are associated with global warming and climate change, voters who have directly experienced a natural disaster might form new opinions on the salience of the climate issue. In turn, changing such opinions might shape voting behavior on issues related to climate change. To the best of our knowledge no

[1]For a recent paper that addresses the impact of natural disaster on economic loss, see Neumayer, Plümper, and Barthel (2014).

[2]While we do not look at the behavior of politicians there is new research indicating that politicians respond to hurricanes in the US with more pro-climate behavior (Gagliarducci, Paserman, and Patacchini 2018).

study has yet explored this channel and this is where we aim to make our contribution to the literature.

Floods and Attitudes Toward Climate Change

How do people form opinions on environmental issues? The overarching assumption of our conceptual framework is that individuals possess multiple and often conflicting opinions on many political questions (Zaller and Feldman 1992). The environment is a second-order issue for the large majority of people and ranks low among the policies that decide elections in virtually every democratic country. According to the annual Credit Suisse Worry Barometer, the environment was not even among the top five worries of Swiss voters in 2017.[3]

So how do people transform diverse considerations into closed-ended responses in a survey or referendum on an environmental issue? We argue that people make social judgments based on the information that is most salient or available to them. Indeed, several scholars have previously claimed that individuals are often overly influenced by a single dominant consideration or explanation (Shelley and Fiske 1978; Tversky and Kahneman 1982; Rudolph and Kuhn 2018). More specifically, we argue that personal experience serves as a focal point to form opinions on specific political issues over which people hold different considerations. The idea that personal experience matters for political attitudes lies at the core of the economic voting literature (Duch and Stevenson 2006). For voters who are less politically engaged, personal experience represents an easy and cheap way of acquiring information, which, in turn, might affect their voting behavior.

In sum, we argue: 1) that a large majority of individuals do not hold consistent opinions on climate change, which has not been particularly salient politically; 2) personal

[3]See `https://www.credit-suisse.com/ch/de/about-us/responsibility/dialogue/sorgenbarometer.html` - accessed August 13, 2018.

experiences provide accessible considerations, which increase the salience of climate change and lead to the formation of opinions; 3) experiencing natural disasters that are related to global warming primes voters in relation to climate change.[4] Building on this conceptual framework, we put forward the following testable hypothesis:

Municipalities hit by natural disasters, the occurrence of which may be linked to global warming, are more likely to vote in favor of strict climate protection than municipalities that do not undergo the same experience.

Data

We test our hypotheses on Switzerland for three main reasons. First, the Swiss case provides reoccurring votes on a wide array of issues and also specifically votes on climate measures (see e.g. Kriesi 2005; Leemann 2015). This provides us with *behavioral* data and since referendums are single-issue votes, they allow us to isolate the effect of natural disasters on climate issues from other concerns. Hence, we can test the effect of natural disasters on a second-order issue such as climate change policies (Stadelmann-Steffen 2011). With federal or local elections, testing our hypotheses would be problematic, given that voters care about a variety of policies, a condition which may act as a confounder, and do not exclusively cast their votes based on the climate issue. In other words, using referendums minimizes the measurement error.

Second, Switzerland experienced a large number of smaller and local natural disasters during the period under investigation. In conjunction with frequent referendums on climate-related measures, this offers the opportunity to identify the behavioral effect

[4]We run an original survey on 929 Swiss citizens in January 2020 and ask: "Floods, mudslides or debris flows occur once in while. When you see how a community is hit by such an event, do you sometimes wonder what the cause is? If so, what do you think?". Figure A1 in the appendix shows that about 60% of respondents mention climate change as their response.

rather than just a change in surveyed attitudes. Third, Switzerland has gathered very good data on natural hazard events, easing statistical analyses. For instance, the Swiss Federal Research Institute has been collecting data on flood and natural disaster events since 1972 (Hilker, Badoux, and Hegg 2009).

The major database we rely on is maintained by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) which collects all reports in local, regional, or national newspapers of damage caused by debris flows, floods, or landslides (WSL 2012; Andres et al. 2013). The database goes back to 1995 and we use all entries from 1995 to 2010. This data allows us to measure the natural disaster events at municipal level.

A Behavioral Measure of Climate Change Attitudes

For the behavioral measure we focus on voting behavior of villages on ballot measures related to climate change.[5] We identify a number of ballot issues that can be labeled as environmental issues.[6] But not all environmental votes are linked to climate change or global warming.

To select specific votes, we rely on the official government information brochures that are sent to each citizen before a vote on a referendum or initiative.[7] In each brochure we search for the following keywords to identify votes that can be connected to climate

[5]This is akin to the political behavior literature that analyzes aggregated attitudes and preferences rather than the individual responses. While the individual voter may often not appear very coherent, stable, or responsive to new circumstances, the aggregate voter typically displays all of these characteristics (see e.g. Page and Shapiro 1992; Erikson, MacKuen, and Stimson 2002).

[6]There is no strategic launching as a response to a flooding event. Given the rules and regulations governing the collection of signatures and the parliamentary debate, the process takes too long to make it possible to observe natural disaster events and then start collecting signatures. Given that the effect is not as long-lasting, strategic timing can be ruled out.

[7]The brochure contains a neutral general description of the specific measure, the main arguments of the government, and the main arguments of the opposing side. An example for one of the votes used here can be found at https://bit.ly/3fGlez5.

change: *emissions*, *climate*, *air pollution*, *exhaust emissions*, *global warming*, *greenhouse*, and *fuel consumption*.[8] Based on this there are nine ballot proposals for which emissions and climate change mattered.

One vote is not included: the 2003 twin-initiative to abandon nuclear power. In this campaign the center and center-right parties were fighting against a nuclear ban, while the left and the ecological groups supported the ban. This is a highly unusual case because the groups supporting stronger protection of the climate wanted to ban nuclear power while the usual non-environmentalist groups (center, center-right, and the government) embraced climate protection in their argument.[9] While both sides used the climate argument it was more prominent in the government's position. The problem is that voting for or against the issue is not a clear measure of pro-climate behavior.

Nevertheless, including the 2003 twin-initiative does not change the general inferences – while effect size is somewhat smaller, all significance tests yield the same outcome. This provides us with eight ballot measures from 1998 up to 2009 (see Table A11 for a full list of all votes used). Finally, the government comprises an oversized coalition of the four or five largest parties, which typically represent 80% or more of the citizens. Citizens usually vote four times a year and their vote is based on party recommendations or policy preferences. It is not unusual for a vote not to pass, and therefore the government does not resign in such cases (Kriesi 2005).

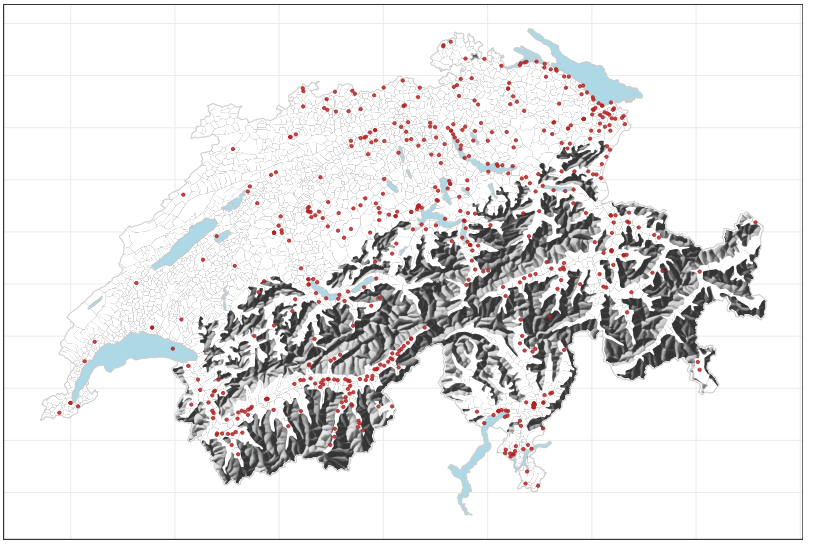
[8]The German version of the information brochures was used and these are the original keywords: Emissionen, Klima, Luftverschmutzung, Schadstoffausstoss, globale Erwärmung, Treibhausgase, und Treibstoffverbrauch.

[9]The argument of non-environmentalists is that abandoning nuclear power would make Switzerland dependent on electricity that is partly produced in German coal-fired steam stations. Hence, relying more on this production method would increase emissions.

Measuring Exposure

The natural disaster data gathered by the WSL includes all publicly recorded natural disaster events. Data collection is based on more than one thousand newspapers and magazines. The database identifies three different principal events: floods and debris flows, rockfall, and landslides. We focus on medium and large events during the period 1995 to 2010 (Hilker, Badoux, and Hegg 2009). These are events that cause an estimated damage of 400,000 CHF (about $400,000 or €340,000) or more.

Figure 1. Map of Swiss Municipalities Natural Disaster Events (1995-2010)



Notes: Natural disaster events (WSL, 2012). Red dots show events that occurred twelve months or fewer prior to a vote related to climate change.

In Figure 1 all events are plotted. The red dots show the natural disaster events that took place within the twelve months preceding a national environmental vote that was climate-related. We use this cut-off since it allows for long effect decay. We also show later in this paper that twelve months after a natural disaster there is no longer a difference

between affected and non-affected municipalities (see Table 4).

These events are not independent of the topography. From Figure 1 it can be seen that there is an impressive clustering in flat areas along lakes and at the bottom of valleys. This is because floods and mudslides usually occur along rivers and lakes or at the bottom of hills and mountains (e.g. Eng, Milly, and Tasker 2007).

Our unit of analysis is municipality votes. We are able to rely on more than 2,800 municipalities for each vote. Our key variable is exposure and captures whether a municipality has been hit by a flood in the twelve months prior to a specific vote. For each vote we include all treated and control municipalities for which data is available.

Additional Data Sources

Apart from the municipality-level ballot outcomes and the disaster database, we also collected electoral results by municipality for all federal elections during the period (BfS 2013). In addition, we gathered numerous geographic and geological variables for all municipalities. Two noteworthy clusters of variables are, first, the surface type in which we have detailed information of how much area in a municipality is underbrush, artificial (houses, lawns, parks), wetland areas, water (lakes or rivers), or forests (Swisstopo 2013). The second relevant part is annual rainfall data per municipality from 1995 to 2011 (MeteoSwiss 2013).

Identifying the Effect

If weather and exposure to natural disaster events occurred completely at random, it would be possible to simply compare the means of the yes vote share per municipality, and this would provide the average treatment effect on the treated (ATT) where treatment is exposure to a disaster. However, there are good reasons to believe that natural disasters do not occur completely at random. Villages at the bottom of a valley or at a lakeshore

are more likely to be affected (e.g. Eng, Milly, and Tasker 2007). If well-educated people tend to live in lakeside municipalities and hold views on climate change that differ from the general population, the estimate would be biased.

We use two different strategies to estimate the effect of natural disaster events. We first rely on a difference-in-differences estimator and then use entropy balancing to avoid functional form constraints. In what follows, we first present the difference-in-differences results based on various models with numerous control variables (Models I-III). To do so, we use fixed effects for individual votes and individual municipalities. The variable measuring exposure is coded as a "1" if the municipality-vote observation was affected by a flood in the preceding twelve months, and 0 otherwise. The effect of exposure is then the difference-in-differences estimate.

To corroborate our results, we also rely on entropy balancing to estimate the ATT with no functional form assumptions (Model IV). Importantly, the entropy balancing balances out observables but not unobservables. Here we can rely on an additional measure to confront this problem. We have a risk measure (of being affected by a local natural disaster) for each municipality and can add this to the analyses. In addition, we provide a number of robustness tests to strengthen confidence in the empirical results. This triangular estimation process, together with various robustness tests, provides confidence that the causal effect is actually uncovered.

Identifying the Impact of Floods on Climate Behavior: Difference-in-Differences

A first attempt to identify the impact of a natural disaster event on voting behavior is to compare municipalities hit by a landslide or flood with those not affected. In this very first step we rely on a difference-in-differences estimator.Model I only includes municipality-level party vote-shares, Model II includes a number of geographic and surface-related variables as well as rainfall data, and Model III includes all covariates.

We include three categories of variables to take the impact of a natural disaster event on voting behavior into account: vote share for parties (as a proxy of the ideological structure of a municipality), rainfall (almost always precedes a natural disaster event), and a number of variables describing the surface. The surface is relevant to how quickly rainfall can be absorbed and thus municipalities with large agricultural spaces, and hence a strong farming element, could differ from those with largely uncultivated spaces that tend to be more oriented towards tourism. Across all models the difference-in-differences estimator is shown in the top line (labeled as *flooded*).

TABLE 1 *Voting and Weather (OLS)*

	Model I	Model II	Model III
EXPOSURE			
Flooded	0.86^{**}	1.28^{***}	1.19^{***}
	(0.42)	(0.42)	(0.42)
Vote Shares	✓	✗	✓
Precipitation	✗	✓	✓
Surface	✗	✓	✓
Fixed Effects			
Votes	✓	✓	✓
Municipality	✓	✓	✓
R^2	0.82	0.84	0.85
Adj. R^2	0.80	0.82	0.82
Num. obs.	21024	18320	17934
RMSE	8.18	7.62	7.61

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$, full table with all estimated coefficients is presented in the appendix (Table A1)

The outcome variable in every model is the yes vote in percentage points in a municipality. The explanatory variable of interest is exposure: whether or not a municipality was affected by a natural disaster event in the twelve months preceding a vote. All models indicate that there is a positive and significant effect. Depending on

the model specification, this effect is somewhere between 0.9%-points and 1.3%-points. As mentioned above, the estimated coefficients will only be causal estimates under rare circumstances. The next subsection relies on an alternative identification strategy to produce an estimate of the impact of exposure to a natural disaster event on environmental votes related to climate change.

Identifying the Impact of Floods on Climate Behavior: Matching via Entropy Balancing

Recent contributions to the empiricist's toolbox, namely genetic matching algorithms (Sekhon 2011) and entropy balancing (Hainmueller 2012), enable the retention of the full sample of treated observations while still estimating the ATT. We rely on entropy balancing as it directly achieves balance on our covariates rather than searching for weights for the nearest neighbor and also because it is computationally far less demanding and much faster. Finally, previous Monte Carlo simulations indicate that it performs superior to alternatives.

Entropy balancing enables researchers to find the optimal sets of weights that produce a perfectly balanced sample with respect to exposure. This in turn allows for the estimation of ATT. Two sets of variables are included: first, the political parties, which reflect the political and ideological structure of the municipality and second, an array of geographic and climatic variables - steepness, surface structure, and rainfall.[10] One problem is that balance is only achieved on observables. In this application a known *unobservable* is the actual risk of a municipality of being affected.

We know that natural disaster events are random within municipalities that share the same risk of being affected. Ideally, we would have a perfect measure of risk and could just compare exposed and non-exposed cases with similar risk measures. While we were

[10]We also included binary indicators for each ballot to ensure that we have perfect balance on the ballots. This is important as each vote has a different overall yes share.

TABLE 2 *ATT Based on Entropy Balancing (Model IV)*

		Matched Sample	$p-$val			
	ATT	**+2.33**	**0.00**			
	s.e.	**0.72**				
	Before Matching			After Matching		Balance
	$D = 1$	$D = 0$	t-test	$D = 1$	$D = 0$	$t-test$
Flooding Risk	0.68	0.29	0.00	0.68	0.68	✓
Surface: % No vegetation	8.46	3.38	0.00	8.46	8.46	✓
Surface: % Water	3.69	1.63	0.00	3.69	3.69	✓
Surface: % Grass	31.72	44.68	0.00	31.72	31.72	✓
Surface: % Artificial	17.51	13.16	0.00	17.51	17.51	✓
Altitude (in m)	602.68	584.16	0.21	602.68	602.68	✓
Rainfall (per sqkm)	1.31	2.43	0.00	1.31	1.31	✓
Steepness in %	15.29	9.59	0.00	15.29	15.29	✓
Social Democrats (%)	19.47	18.56	0.04	19.47	19.47	✓
Christian Democrats (%)	23.64	16.68	0.00	23.64	23.64	✓
Greens (%)	5.03	5.65	0.02	5.03	5.03	✓
Liberals (%)	18.32	18.28	0.94	18.32	18.32	✓
Swiss People's Party (%)	25.01	27.60	0.00	25.01	25.01	✓

working on this project, the Federal Office for the Environment (FONE) concluded a program known as "Aquaprotect." Together with one of the largest reinsurers (SwissRe), the FONE created a flood model and provided risk estimations. The model is based on grids that are 25 by 25 meters. Based on this data, we compute a risk measure for every municipality by estimating the areas that are flood-prone within the next 50 years. In the appendix we provide an example of the flood risk and an actual flood in the municipality of Uerkheim; the accuracy of the measure is striking (see Figure A2). While this measure cannot be a perfect measure, it is the closest we can get to the actual true risk of being affected.

Since the weighted sample is balanced, the ATT is the difference in the means of exposed and non-exposed observations. Table 2 shows the estimate as well as the covariates and balance statistics. Entropy balancing produces a set of weights for each observation and the ATT is estimated by regressing the pro-climate vote share on the variable measuring exposure while using weights.

The estimate is 2.33 percentage points, indicating that if a municipality was affected by a natural disaster in the twelve months preceding a ballot vote, it will on average cast a higher yes vote. This estimate is somewhat larger than the estimated coefficients in models I, II, and III in Table 1. The ATT is 2.33 percentage points; since the average support for pro-climate environmental ballots lies at 42.2% in our sample, a treated municipality will on average cast about 6% more yes votes. In the next subsection we reexamine this effect and explore whether it varies by the structure of the affected municipalities and whether the time elapsed between vote and natural disaster matters. After that we conclude the empirical section with a number of robustness tests.

Exploring Effect Heterogeneity

So far, we have estimated an average effect. But it is most likely not the case that this estimate is really constant over all exposed observations (Gerber and Green 2012, p.285). In this subsection we explore effect heterogeneity. First, we look at how the effect varies across different types of municipalities – specifically, whether the educational structure of a municipality is correlated with the effect size. Second, we look at how long-lasting the effect is over time and whether or not it fades out.

Heterogeneity Across Space. The effect is the average increase in yes votes per municipality when they are hit by a natural disaster event. The assumed underlying mechanism is that people already hold views about the causes of climate change (Beiser-McGrath and Huber 2018). When people are affected immediately, their climate change consideration is activated (Zaller and Feldman 1992). This will in turn affects the decision of some individuals, but not all.

One way to validate our assumption is to see if the effect is higher where people are more likely to know that there is a relationship between climate change and extreme weather phenomena. In municipalities with more people who believe that climate change

is man-made, the effect is expected to be larger than in those municipalities where fewer believe in the human impact on climate change. Without precise ideological measures for municipalities or a measure of how many people believe in climate change or know how CO_2 is related to climate change, we have to use a proxy. We do not have sufficiently detailed survey data to estimate this knowledge for each municipality in Switzerland, but we do have detailed educational data. We use education – specifically, share of inhabitants with a tertiary degree – to proxy for this awareness. That is, we assume that educated people know that CO_2 is related to climate change and that climate change is related to floods.

We present here three additive models, whereas Model VI presents the interaction effect. The outcome variable is the yes-share in a municipality. To estimate the relationship between a municipality's share of well-educated citizens and the size of the exposure effect, we estimate a weighted linear regression – as in the standard set-up (see Table 2 for more details on the entropy balancing) – with the pro-climate yes-vote share as outcome. But rather than just including the exposure dummy we now also include the share of well-educated citizens and the interaction.

TABLE 3 *Heterogeneity Across Municipalities*

	Model IV	Model V	Model VI
Constant	25.29^{***}	17.93^{***}	19.46^{***}
	(0.24)	(0.84)	(0.57)
Exposure	2.33^{***}	2.56^{***}	−0.96
	(0.72)	(0.70)	(1.87)
Tertiary Education Share		55.77^{***}	44.15^{***}
		(6.11)	(3.69)
Exposure × Tertiary Education Share			27.11^{*}
			(14.34)
Deviance	3613860.72	3439087.49	3428971.32
Dispersion	201.97	192.20	191.64
Num. obs.	17894	17894	17894

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

In Table 3 we present the original result based on entropy balancing (Model IV).

In Model VI the interaction effect is integrated. We run a weighted regression with weights that achieve perfect balance between the exposed and non-exposed group (Hainmueller 2012). The estimated parameter is significant and positive, indicating that for municipalities with a higher share of well-educated citizens the effect is larger. For municipalities where there are no well-educated citizens at all the effect is indistinguishable from 0. The left panel in Figure 2 presents a visualization of this conditionality. These results are consistent with the mechanism based on floods activating the climate change consideration.

Heterogeneity in Time. The effect of being exposed was estimated by categorizing certain municipalities as exposed and others as non-exposed. We defined an exposed municipality as one affected by a natural disaster event in the twelve months leading up to a ballot vote. Here, we explore whether the time lag between event and vote is related to the size of the effect.

TABLE 4 *Elapsed Time and Treatment Intensity*

	Model IV	Model VIII
Constant	25.29^{***}	25.29^{***}
	(0.24)	(0.24)
Exposure	2.33^{***}	9.43^{***}
	(0.72)	(2.19)
Time betw. Flood and Vote		-0.99^{***}
		(0.26)
Deviance	3613860.72	3532605.00
Dispersion	201.97	197.43
Num. obs.	17894	17894

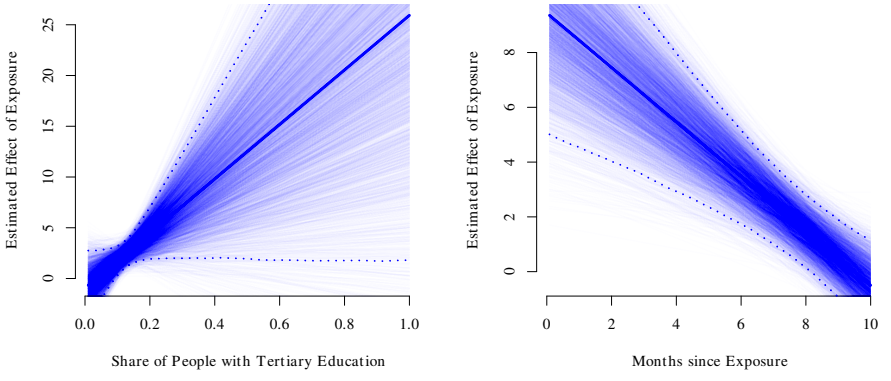
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

To explore any such systematic effect heterogeneity, we use the *balanced sample* from the entropy balancing and regress the vote outcome on exposure and elapsed time since exposure. The first model (model IV) only includes a binary indicator whether or not a municipality was exposed. This is the ATT based on entropy balancing since it is the difference in means with optimal weights. The estimated ATT is presented in Table 2.

In model VIII (Table 4) we also include the amount of time that has elapsed between the natural disaster event and the vote taking place. Since the time variable is set to 0 for non-exposed units, this is the equivalent of the interaction of time and exposure. The interesting result here is that the more time that lapses between, for example, a flood and a climate sensitive vote, the smaller the effect becomes. After ten months there is no statistical difference from an untreated unit.[11] indicating that after ten months these two (hypothetical) municipalities are indistinguishable. This is illustrated in the right panel in Figure 2 and shows the decay of the effect over time.

We present here only the simplest functional form, but the results also hold up when using the logarithm or other assumptions of decay. All these functional forms indicate that the greater the passage of time between a natural disaster and a vote, the smaller the effect.

Figure 2. Illustration of Marginal Effects



Notes: Pseudo-Bayesian approach for uncertainty generation via sampling from the posterior distribution. Dashed line shows 95% confidence interval.

[11]Even on an α level of 0.1, the confidence interval of the difference between an exposed and non-exposed unit after ten months is covering 0. The lower bound is −.92 and the upper bound is +1.89,

If all municipalities were affected by flooding in the week prior to a referendum, we would on average see a yes share that is 9.4 percentage points higher. This would change the outcome of at least one vote in our sample (that on *Subsidy for renewable energies*). On average, the votes in this analysis have a vote-share of about 42.2% for the pro-climate position. Hence, the effect increases the yes-vote share by roughly 20%.

Floods and Mobilization

We argue that exposure to a natural disaster event affects the political behavior of citizens. The conceptual framework above is based on citizens holding conflicting considerations when it comes to climate change. Exposure then affects the salience of pro-climate considerations and leads to a higher share of yes votes. Another, very closely connected, way in which exposure can affect the yes share is by affecting who turns out to vote.

Previous research has shown that the bulk of the Swiss electorate is constituted by selective voters in referendums (Sciarini et al. 2016). Indeed, roughly 80% of voters have participated in at least one of thirty successive direct democracy votes between 2003 and 2014 (Sciarini et al. 2016). This is in contrast to the argument put forward by Gomez, Hansford, and Krause (2007) and Hansford and Gomez (2010), since the floods take place months before the day of the ballot vote. But, similarly to these studies, it also relies on differential effect on turnout for people inclined to vote in favor of climate protection.

How could natural disasters affect turnout? Here, prior work by Kriesi (2005, p. 115-121) points to two aspects that are relevant. First, by providing tangible examples of the negative effect of global warming, natural disasters increase the probability that people discuss climate change and share concerns about global warming. In turn, this increases the political salience at the local level, which in turn should increase local turnout.[12]

[12]For instance, virtually every Swiss voter was aware of and participated in the referendum on the accession to the EU market in 1992 (turnout rate of 80%), since the

Second, floods, which produce damage that is highly visible to the local population, help to raise voters' political awareness on climate change, which in turn increases turnout in referendums locally. In the appendix we show that floods have a positive effect on turnout and this effect holds across our main model specifications (see **??**).

The main question is whether or not natural disaster events can help the climate. There are two ways that natural disasters could affect support for climate-related ballots. First, voters who participate and do not have clear attitudes will vote in more climate-friendly ways after experiencing a local natural disaster. Second, voters who are close to indifferent about whether to participate in a vote actually turn out after witnessing a local natural disaster. While our data's strength is that it captures actual behavior, its weakness is that one cannot actually adjudicate between these two mechanisms.

Robustness Checks

We present here a number of robustness checks related to our main analysis. The checks are formulated in the following subsections, and the actual tables are relegated to the appendix. We carry out four additional robustness tests. First, we create an exposure variable for units that were affected right *after* a vote. This allows us to illustrate that our main findings are neither spurious nor due they reflect an anticipatory effect. Second, we estimate identical models on three environmental votes that were unrelated to climate change. Third, we reestimate the same models on votes related to Switzerland's relationship to the European Union. Forth, we include a measure for whether a municipality was close to an affected municipality. Across all models we find consistent results.

issue was perceived as being of utmost importance for the country (Kriesi et al. 1993). Participation was about twice as large as regular participation rates.

Future Exposure

The first robustness check relies on an alternative exposure variable - municipalities are coded as treated if they experienced a local natural disaster in the twelve months *after* a vote. In the *lead* variable, a municipality is not counted as treated if it was hit *before* a vote but we code it as treated if it was hit *after* a vote. Since the disaster event is actually *after* the vote, there should be no effect. This allows a first check of the robustness of our findings. In a second step we can also add the regular exposure variable and rule out anticipatory effects (Malani and Reif 2015). If we find a significant effect for the lead variable, that would suggest the presence of anticipation which would (partly) refute our argument. We do not find any significant *lead* effect of natural disasters on pro-climate political behavior across all models (see Table A3 and Table A4). Importantly, the coefficient of our exposure variable remain positive and significant. This increases the credibility of the presented results.

Placebo Test: Environmental Votes Not Related to Climate Change

An additional robustness test can be performed by reestimating our models on other environmental votes. During the period studied, three other votes were held that were related to the environment but not climate. Two votes in 2003 were on nuclear power plants (one demanded a ban on new nuclear power plants and the other demanded the slow phasing-out of nuclear power) and one vote in 2008 sought to ban military fighter jet training in recreation areas due to noise. The discussion surrounding the two nuclear power plants was based on arguments about the safety of nuclear power (implying support for a ban of nuclear power plants) and the economic costs of such a ban (implying opposition to the ban). The two main arguments against the ban were the loss of jobs and expected price hikes (Blaser et al. 2003). All three votes were strongly supported by the Green party but climate change arguments were not a relevant part of the debate on the

pro or on the contra side.

We reestimated the effect with both strategies (difference-in-differences and entropy balancing) and show the results in the appendix (see Table A5 and Table A6). We estimate the models on data from these three votes which are not related to climate change. All estimated effects are not distinguishable from 0, as we would expect.

Placebo Test: Non-Environmental Votes

The final robustness test relies on seven votes about the relationship between the European Union and Switzerland. These votes are unrelated to climate change and represent yet another way of assessing the robustness of the results. These votes also tap into the second dimension but represent a more salient issue (Linder and Mueller 2017; Kriesi et al. 2005). We re-estimate the models and find across all specifications no effect (see Table A8 and Table A9). This further increases the confidence in the main findings.

Surrounding Municipalities

A an additional robustness check involves adding information on other municipalities that are close to the flooding events. We add a covariate that captures whether a municipality is close to an affected municipality and use different cutoffs: 2, 4, and 8 km. The substantive results do not change as the estimates remain virtually unchanged. We present this analysis in Table A10 and the original estimates remain unchanged.

Summary of Empirical Results

The last couple of sections show that across a number of different empirical models there is a clear positive effect – the pro-climate voting share is significantly higher in municipalities recently affected by local extreme weather events. This effect also changes depending on time or educational structure, as expected. The robustness section serves to

increase confidence in the identified effect here. It does so by showing that the effect is not found when coding future events as past events or when relying on votes where there should not be an effect.

The effect sizes in models I-VI are moderate as the average effect is averaged over the events in the data. But in model VIII we estimate the decay of the effect and see that an event a week before a vote increases the yes-vote share by 9.4 percentage points, which is a sizable effect that would have changed the outcome of at least one of the votes under consideration here. In addition, the pro-climate vote share is on average 42.2%, which implies that being affected right before a vote will increase the yes vote share by about 20%.

The argument here is that these small and local events serve as information and make more salient the pro-climate consideration when the individual decides on how to or whether to cast a ballot. Apart from the effect decay, there is also a second verification that must hold. Municipalities with a higher share of people likely to hold the consideration at all should show a larger effect. To test this, we model the effect size as a function of the share of population with a tertiary education. We find again a strong correlation. Based on a model, we can compare the expected effect of a municipality where 7% have a tertiary degree (tenth percentile) with another where that share is at 22% (ninetieth percentile). The effect increases by 4 percentage points. This is a large effect. Overall, the estimation shows a robust causal effect and the correlations of effect size and two theoretically motivated variables support the argument. Voter behavior is affected by living in an area recently hit by a local extreme weather event.

Conclusion

This paper started out with the question of whether popular support for climate protection is likely to increase with the rate of extreme weather events. Based on geo-coded data

on small and local natural disasters, we measure the behavioral effect. We show that municipalities affected before a ballot vote display significantly higher vote shares. But the effect size is dependent on how close in time these events occur and how many people may even hold such considerations.

The results have direct implications for climate policy and also speak to debates about the efficiency of direct democratic institutions. The decay of the effect within a year is sobering as it is unlikely that the current increase in extreme weather is sufficient to bring about a substantial political change within the electorate. At the same time, these results show that there is a window of opportunity after such small and local events during which voters are more sensitive to questions of climate change. One immediate question coming out of this is how pro-climate organizations can seize this window of opportunity.

Based on prior theoretical models of beliefs regarding climate change and its consequences, we also explore effect heterogeneity as a function of education to proxy for the awareness of the climate change and extreme weather mechanism. These results are more encouraging for environmental groups. If the proxy variable actually captures knowledge of the link between climate change and extreme weather, one direct implication is to further educate the public. The effect size is extremely strong.

Finally, our paper speaks to the question of voter competence and whether average citizens use direct democratic institutions in a coherent way (Achen and Bartels 2017). The results support the argument that citizens' behavior changes in the expected direction after they experience a local event. While it is possible to judge whether beliefs are correct or not, we cannot do the same in a liberal democracy with attitudes or behavior. However, one can investigate whether there is consistent behavior showing that informational updates affect the behavior of at least *some* citizens. Of interest here is the heterogeneity in the effect. The effect is driven in part by the ability to link, for example, local flooding with climate change. In municipalities with a higher share of well-educated citizens the increase in pro-climate voting is most pronounced. At the same time, these effects fade

out over time. This shows that there is consistency in behavior but this does not apply to the entire citizenry and is limited to the aftermath of events.

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