Voting in the Heat of the Moment: Climate Change Salience and Electoral Behavior

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July 14, 2026

Abstract

We examine the impact of momentary temperature changes on voting behavior in the Brazilian presidential elections from 2010 to 2018, focusing on the candidacy of Marina Silva, a prominent pro-environment politician. Using data on municipality-level voting and daily wet bulb temperature, we find that an increase in temperature on election day relative to its historical mean increases votes for Marina Silva. This effect is driven by the salience of climate change, influencing last-minute voting decisions. Temperature effects are concentrated on election day and the day before, with no impact from earlier pre-election days, highlighting the transient nature of climate salience effects.

JEL: Q54, D72, O13

Keywords: Salience, Climate Change, Voting Behavior.

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1 Introduction

Climate change imposes significant costs on the global economy, and these costs are expected to increase substantially in the future (Dell et al., 2014; Burke et al., 2015; Assunção and Chein, 2016). Avoiding this climate crisis depends on drastically reducing greenhouse gas emissions in the coming decades (Rogelj et al., 2018), which requires complex international cooperation (Nordhaus, 2015; Battaglini and Harstad, 2016; Harstad, 2023; Assunção et al., 2023b). With most of the world living under a democratic system, implementing climate policies and agreements hinges on people demanding such actions through voting.

Gathering votes for pro-environment politicians faces several challenges. Voters need to believe in climate change, understand its issues and costs, and trust that climate policies can effectively mitigate it through the actions of a given politician. This complex chain of thought can create an overflow of information and contribute to worldwide skepticism, especially in a matter where information is costly to acquire and misinformation is widespread (Millner and Ollivier, 2016; Hornsey et al., 2016; Guilbeault et al., 2018; Druckman and McGrath, 2019; Nyhan et al., 2022). Although climate change affects long-term patterns of temperature, people might experience it through weather variations and salient anomalies (Kaufmann et al., 2017; Moore et al., 2019; Choi et al., 2020). Does exposure to abnormally high temperatures affect climate change awareness? If it does, does it increase voters' support for pro-environment politicians?

In this paper, we investigate whether short-term temperature changes affect voting behavior in favor of a pro-environment politician. Our analysis focuses on the three presidential elections in Brazil between 2010 and 2018, where Marina Silva was clearly identified as the pro-environment candidate. Marina Silva is an internationally recognized environmental activist due to her career trajectory and her role as Minister of Environment from 2003 to 2008. We examine the impact of temperature increases on election day on votes for Marina Silva by combining Brazilian voting data at the municipality level for the three election years with daily measures of wet bulb temperature, which is a measure of heat stress that combines temperature and humidity. This panel data allows us to study the impact of temperature changes on election day relative to long-term patterns using a fixed-effects specification.[1]

[1] This identification strategy has been used in economics in different contexts. For example, the impact of variation in temperatures on educational exams (Zivin et al., 2020; Park, 2022), mortality (Deschenes and Moretti, 2009; Heutel et al., 2021), crime (Heilmann et al., 2021), suicide (Burke et al., 2018), and labor productivity (Lai et al., 2023). There is also an extensive literature using weather variation aggregated at much longer periods, for example, yearly temperature on agriculture. See Dell et al. (2014) for a review.

We find that a one standard deviation in temperature on election day increases votes for Marina Silva between 0.6 and 1.3 percentage points. We argue that the mechanism behind this effect is the salience of a changing climate, which leads voters to make a last-minute decision in favor of a pro-environment candidate. This interpretation is consistent with survey evidence showing that a sizable share of the electorate - about 15% - decides their vote either on election day or the day before.[2] Our identification strategy relies on the temperature variation on election day being exogenous to unobservables that would influence votes for Marina Silva. To strengthen our causal claim, we run a placebo test and find that temperature variation on the day after the election has no effect on votes. To rule out alternative explanations, we also show that higher temperatures do not significantly affect turnout, valid votes, or the vote share for the incumbent.

Our results suggest two potentially conflicting perspectives on future voting behavior. As climate change increases weather variability and warmer days (IPCC, 2023), we can expect more people to experience and focus on climate change when voting. However, the effect we capture is short-lived, a common finding in the literature on salience (Bordalo et al., 2022). When including temperatures from days before the election, we find that temperature variations two or three days before the election have no effect on votes for Marina Silva, highlighting the transient nature of climate salience effects.[3]

A growing literature has established empirical evidence of salience in economic choices: e.g., Chetty et al. (2009) and Finkelstein (2009) for taxes, Dertwinkel-Kalt et al. (2017) for consumer demand, and Dessaint and Matray (2017) for choice under risk. See DellaVigna (2009) and Bordalo et al. (2022) for a review. Here, we show how salience can shape behavior in a high-stakes setting involving opinion formation and voter decision-making on a pressing and contentious topic. Related, in a different context, Bines et al. (2025) study the electoral effects of heightened salience of terror threats.

A long-standing literature on voting behavior shows the effects of contextual circumstances close to or on election day (Miller and Krosnick, 1998; Koppell and Steen, 2004; Berger et al., 2008; Shue and Luttmer, 2009; Ajzenman and Durante, 2023). Close to our work, Ajzenman and Durante (2023) show that exposure to information about government performance made salient at the moment of voting affects vote for the incumbent candidate. Here, instead of voters inferring information about the candidates' performance, we show that the salience of an issue on election day affects how voters rank their

[2]Data from a 2014 electoral survey conducted by Datafolha, registered at the Superior Electoral Court under the number BR-01098/2014.

[3]Another concern with extrapolating these results into the future is that people can rapidly shift their reference point of what is understood as a 'normal' temperature (Moore et al., 2019).

priorities when considering their candidate.

On the salience of environmental issues, some studies have documented that, in the US, weather variations are associated with people's beliefs in global warming (Kaufmann et al., 2017; Moore et al., 2019; Egan and Mullin, 2012; Zaval et al., 2014) and support for climate policies increases among those exposed to wildfires in California (Hazlett and Mildenberger, 2020; Coury, 2025). First, we contribute to this literature by using daily high-frequency variation. This allows us to isolate the effect of salience and rule out alternative channels – such as productivity, income, and education – through which temperature could affect voting behavior beyond climate change salience. For instance, Amirapu et al. (2022) and Alfaro (2023) show that cumulative exposure to extreme temperature impacts elections through income reductions. Our approach also rules out channels beyond individual experiences, such as those coming from increased social interactions or media coverage of climate change (Pianta and Sisco, 2020). Therefore, we identify the effect coming from salience beyond any long-run experience.

Our use of voting data allows us to assess the impact of environmental change's salience beyond stated beliefs. For instance, Egan and Mullin (2012) and Zaval et al. (2014) show that short-term temperature fluctuations affect beliefs about global warming. Instead, we show how today´s temperature impacts individuals' actions, ruling out survey reporting issues such as framing/wording effects, social desirability, expressive responding, or hypothetical bias. Other papers have examined the effects of local conditions on Google search volume for global warming (e.g., Herrnstadt and Muehlegger (2014) and Choi et al. (2020)). Here we focus on political attitudes measured by voting behavior. This outcome is particularly relevant because climate policies must be implemented through the political system, making voting behavior the key aspect influencing climate policies.

Our analysis spans three elections featuring a presidential candidate who has been consistently identified as an environmentalist. Consequently, it avoids the need to classify candidates as pro- or anti-environmental policies, which could introduce significant nonclassical measurement errors. For instance, Hoffmann et al. (2022) classifies "Green Parties" to assess the impact of weather anomalies on votes in the European Parliament election on a cross-country estimation.

Importantly, our paper focuses on a developing country.[4] Lessons learned from developed countries about environmental salience (Egan and Mullin, 2012; Zaval et al., 2014; Hazlett and Mildenberger, 2020; Hoffmann et al., 2022) may not directly apply to poorer

[4] Amirapu et al. (2022) is a notable exception that studies long-term effects for India.

countries. Indeed, correlations between climate change risk and socioeconomic variables vary widely between high and low-income nations (Fasolin et al., 2023), highlighting that public perception and support of climate policies are likely heterogeneous across different countries. Considering that most of the future emissions increases will originate in developing countries (Shukla et al., 2019; Wolfram et al., 2012), reducing emissions and mitigating global warming depend on these countries' ability to implement environmental policies. Thus, it is crucial to understand if – and how – environmental matters influence voters' choice of representatives in developing countries.

Our findings are also obtained from a particularly relevant setting. Environmental policies in Brazil significantly impact global climate change mitigation efforts due to the Amazon Rainforest. The Amazon stores the equivalent of five years of global CO_2 emissions (Baccini et al., 2012). Increasing deforestation in the Amazon threatens to push it towards a tipping point (Flores et al., 2024), potentially releasing most of its carbon stock and undermining efforts to limit global warming to stay below 1.5°C. While the international community can exert pressure on Brazil to protect the Amazon (Harstad, 2024; Araujo et al., 2024b), ultimately, its preservation depends on the actions of elected Brazilian officials and, consequently, on Brazilian constituents.

The remainder of this paper is structured as follows. Section 2 presents background information on Marina Silva and her candidacies. Section 3 describes the data used in our analysis. Section 4 describes our empirical strategy and presents the results. Section 5 concludes.

2 Marina Silva and the Environmental Agenda in Brazil

Maria Osmarina Marina da Silva Vaz de Lima, known as Marina Silva, is by far the most prominent pro-environment leader in Brazil. She was born in 1958 in a rubber plantation in the Brazilian state of Acre. This state is the cradle of the Brazilian environmental movement that began with the rubber cycle in the Amazon. Rubber was a major driver of the Amazon's economy in the late 19th century and was also the cause of conflicts between Brazil and Bolivia that culminated in the annexation of the state of Acre to Brazil. Also born in a rubber plantation in Acre, Francisco Alves Mendes Filho, or Chico Mendes, is a crucial figure connecting the rubber cycle and the environmental movement. Chico Mendes was a pioneering environmental activist, known internationally for his efforts to protect the forest and the rubber tappers. Marina Silva and Chico Mendes collaborated for many years as union leaders and environmentalists.

In 1988, Marina Silva was elected councilwoman for Rio Branco (Acre state's capital); the same year, Chico Mendes was assassinated on the orders of farmers because of his activism. In 1990, Marina Silva was elected state deputy, and four years later, she became a senator. During her first mandate as a senator, she actively opposed the illegal exploitation of mahogany, a valuable Amazonian timber.[5] After being re-elected as a senator, she became Minister of Environment in 2003. During her tenure, the Brazilian Institute of Environment and Renewable Natural Resources (Ibama) enforced strict regulations on mahogany extraction. The seized timber funded socio-environmental projects through the Dema Fund, named after the murdered activist Ademir Federicci.[6] Mahogany extraction was subsequently tied to sustainable practices.[7]

It was also during her administration that Marina Silva implemented the most successful plan to curb deforestation in the Amazon, bringing deforestation rates down by 80% (Burgess et al., 2019; Bragança and Dahis, 2022; Assunção et al., 2023a). In 2006, the Public Forest Management Law was enacted, creating the Brazilian Forest Service to supervise the concession of public forests for the sustainable exploration of timber and other forest products.[8] In 2007, she created the Chico Mendes Institute of Biodiversity Conservation (ICMBio) inside the Ministry of Environment, responsible for managing the Brazilian protected areas, which corresponds to 18% of the national territory.

In 2008, Marina Silva resigned from office as Minister of Environment because she strongly opposed the construction of the Belo Monte dam located in the Amazon. Belo Monte is the fourth largest hydropower plant in the world and accumulates records of negative consequences, such as deforestation (Costa et al., 2024), violence (Schmutz, 2023), and violations of human rights.[9]

Marina Silva dedicated her career to the environmental agenda as a councilwoman, state deputy, senator, and minister. It was no different when she started running for the presidential elections.

In 2010, she ran in her first presidential election as a candidate of the *Partido Verde* (Green Party).[10] In her government program, she committed to investing in renewable energy,

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[5] www.folha.uol.com.br/fsp/1995/10/14/brasil/31.html

[6] www.fundodema.org.br

[7] For more details of the mahogany economy in Brazil, see Chimeli and Boyd (2010); Chimeli and Soares (2017); Araujo et al. (2024a).

[8] www.planalto.gov.br/ccivil_03/_Ato2004-2006/2006/Lei/L11284.htm

[9] For example, see the precautionary measure 382-10 of the Inter-American Commission on Human Rights of the Organization of American States.

[10] In Brazil, Marina Silva is the leading figure representing the environmental agenda. *The Green Party* has obtained little electoral support, except for the 2010 presidential campaign, when Marina Silva ran as

creating a national system to cope with climate change and natural disasters, ratifying Indigenous territories, and intensifying policies that promote the sustainable economic use of biodiversity and forest products. She notes: “Brazil must lead the international effort to implement the conventions derived from Rio-92, especially the fight against climate change [...] (pg. 30, translated by the authors)".[11]

Marina Silva was again a candidate in the following presidential election in 2014, this time by the *Partido Socialista Brasileiro* (Brazilian Socialist Party). In her 2014 government program, she made stronger claims regarding climate change than in 2010. She proposes the creation of a National Climate Change Committee, the implementation of “Growth and Development Strategy for the Decarbonization of the Economy" with a “Brazilian Market of Emissions Reductions". She also highlighted the importance of investing in renewable energy and monitoring systems to curb deforestation.[12]

In 2010 and 2014, Marina Silva ended the first round of the presidential election in third place, with 19% and 21% of the valid votes, respectively. In both elections, the winning candidate was Dilma Roussef, running by the *Partido dos Trabalhadores* (Workers' Party).

Marina Silva disputed her last presidential race in 2018. In this election, she ran as a candidate of the party *Rede Sustentabilidade* (Sustainability Network). Her 2018 government program explicitly committed to the Nationally Determined Contribution of emissions reduction, to a long-term plan to achieve net zero emissions by 2050, and to zero deforestation by 2030. It also proposed to incorporate the decarbonization of the economy under the Brazilian tax system, with the implementation of carbon taxes.[13] Different from her campaigns in 2010 and 2014, Marina Silva was less successful in 2018, securing only 1% of the valid votes in the first round of this highly polarized election that ended up electing Jair Bolsonaro from the *Partido Liberal* (Liberal Party).

Marina Silva did not run in the following election. In 2023, she came back as the Minister of Environment and Climate Change.

its candidate. In the 2014 presidential election, the party received only 0.6% of the valid votes, and in 2018 it supported Marina Silva's campaign without fielding its own candidate. Currently, the *Green Party* holds no governorships or Senate seats and only a small fraction of federal deputies (1%), mayors (0.2%), and city councilors (0.8%).

[11] Marina Silva's 2010 complete campaign program is available at: divulgacandcontas.tse.jus.br/dados/2010/14417/BR/BR/1/280000000001/proposta.pdf.

[12] Marina Silva's 2014 complete campaign program is available at: divulgacandcontas.tse.jus.br/dados/2014/680/BR/BR/1/280000000121/proposta_governo1408744539964.pdf.

[13] Marina Silva's 2018 complete campaign program is available at: static.poder360.com.br/2018/08/MS18_Diretrizes-do-Programa.pdf.

External Validation of the Environmental Candidate Classification

A key feature of our empirical setting is the presence of a presidential candidate who is widely associated with environmental protection policies. In the Brazilian context, Marina Silva is commonly perceived as the leading political figure advocating environmental conservation and climate policy. While this association is well known among Brazilian voters and observers, it may be less obvious to international readers.

To provide an external validation of this classification, we conducted a simple exercise using large language models (LLMs). We asked four widely used LLMs the following prompt:

> "Which Brazilian public figure is most widely associated with advocating strong environmental or climate protection policies? Answer with one name and a short explanation."

Importantly, the prompt does not mention Marina Silva, elections, or the context of our study. Instead, it asks the model to identify the Brazilian public figure most associated with environmental advocacy.

All four LLMs independently identified Marina Silva as the most prominent Brazilian political figure associated with environmental protection. The answers consistently highlighted her long-standing environmental activism, her role in the Amazon environmental movement, and her tenure as Brazil's Minister of Environment.

The responses were as follows:

ChatGPT 5.3: The Brazilian public figure most widely associated with strong environmental and climate protection policies is **Marina Silva**.

Explanation: Marina Silva is a longtime environmental activist and politician who gained national and international recognition for defending the Amazon rainforest and advocating sustainable development. She served as Brazil's Minister of the Environment (2003–2008) under President Luiz Inácio Lula da Silva, during which Brazil achieved significant reductions in Amazon deforestation. She has also run for president multiple times and remains one of the most prominent voices for climate protection and environmental conservation in Brazil.

Gemini 3: Marina Silva

As the current Minister of Environment and Climate Change and a lifelong activist from the Amazon, Marina Silva is the definitive face of Brazil's green agenda. She is internationally lauded for spearheading the PPCDAm (Action Plan for the Prevention and Control of Deforestation in the Legal Amazon), a policy framework that achieved historic reductions in forest loss, and for her persistent efforts to integrate climate resilience into every level of Brazilian public policy.

Claude 4.6: Marina Silva

A former rubber tapper from the Amazon, Marina Silva served as Brazil's Minister of the Environment under President Lula (2003–2008), achieving dramatic reductions in Amazon deforestation. She returned to the same role in 2023. She has also run for president multiple times, making climate and environmental protection the centerpiece of her campaigns. Internationally recognized, she is widely regarded as Brazil's most prominent voice for environmental and climate policy.

Grok 4: Marina Silva

She is Brazil's Minister of Environment and Climate Change (serving again since 2023 under President Lula), a lifelong Amazon defender and activist who has led major reductions in deforestation, established key conservation policies and funds like the Amazon Fund, and is widely recognized internationally (e.g., Goldman Prize, UN Champion of the Earth, Time 100) as the country's foremost advocate for strong environmental protection and climate action. While historical figures like Chico Mendes are iconic, Marina Silva is the most prominent living public figure directly tied to ongoing national and global climate policies.

Although LLMs are not a substitute for formal survey evidence, their responses reflect the associations that emerge from large corpora of publicly available information, including news coverage, academic discussions, and historical records. The consistency of the responses across models provides additional support for the interpretation that Marina Silva is broadly recognized as the Brazilian political figure most closely associated with environmental and climate protection policies.

This validation exercise reinforces our classification of Marina Silva as the pro-environment candidate in the Brazilian presidential elections analyzed in this paper.

3 Data

Voters, votes, and turnout. Brazil's presidential election system functions on a two-round system under majority rule. The president is elected by direct popular vote. If no candidate secures more than 50% of the valid votes in the first round, a second round is held between the two most-voted candidates in the first round. Elections occur every four years. Voting is compulsory for citizens aged 18 to 70. Citizens who do not vote become ineligible for certain public services until they pay a fine. The first round happens on the first Sunday of October. The second round, if needed, takes place the following month. We focus on the first round when we observe votes for Marina Silva. On average, 11 candidates have contended at each presidential election from 2010 to 2018.

Voting data is from the Brazilian Superior Electoral Court. We gather data for the first round of presidential elections in 2010, 2014, and 2018 at the Brazilian municipality level. The voting data consists of the total electorate, votes for Marina Silva (and other candidates), invalid votes (null and blank), and turnout.

Temperature. We use the wet bulb temperature as our main explanatory variable because it better reflects human heat stress. The human body needs to keep its temperature within a very specific range in order to survive. When temperatures are high, the human body starts to sweat as a strategy of thermoregulation. However, for the sweat to dissipate the heat and cool down the body, it needs to evaporate. A health hazard begins when the sweat cannot evaporate as easily. For example, when the relative humidity of the ambient is close to 100%, the air is fully saturated with water vapor, and sweat cannot evaporate. In this scenario, the human body keeps accumulating energy, which increases its temperature, potentially leading to death.

The wet bulb temperature is a combination of temperature and relative humidity that describes the capacity of the human body to regulate its temperature. It is, therefore, a more precise measure of heat stress for the human body and discomfort. To calculate the wet bulb temperature, we collect daily data with a resolution of approximately 10km on relative humidity and maximum temperature for Brazilian municipalities around and on election dates (Xavier et al., 2022). We then compute a municipal average of the daily wet bulb temperature using Stull's formula (Stull, 2011). We compute daily temperatures on and around the election day for 2010, 2014, and 2018; we also compute a historical average from 1962 to 2018. Figure 1 shows wet-bulb temperature deviations from the average on and around the election day.[14] Table 1 below summarizes the main variables used in this

[14]When building the wet bulb temperature, we exclude two Brazilian municipalities from our sample: Fernando de Noronha and Bombinhas. Fernando de Noronha is an island 350 km away from the Brazilian coast in the Northeast region. Bombinhas is a small peninsula in the South region for which interpolation procedures to convert ground station data to raster data do not work properly. These two municipalities represent only 0.01% [28,225/203,080,756] of the Brazilian population according to the last Demographic Census.

paper.

Figure A.1 in the Appendix illustrates the relationship between dry-bulb temperature, humidity, and wet-bulb temperature. At a relative humidity of 70% — which corresponds to the average level in Brazil in October — a dry-bulb temperature of 29°C is equivalent to a wet-bulb temperature of 25°C.

Table 1: Descriptive Statistics

Variable	Mean	SD	Max	Min
Vote Share (Marina Silva)	0.08	0.08	0.74	0.00
Turnout / Voters	0.80	0.06	0.96	0.48
Vote Share (Incumbent)	0.50	0.19	0.95	0.04
Null and Blank / Turnout	0.09	0.03	0.23	0.02
Wet Bulb Temperature (T_{mt})	23.66	4.64	33.25	9.92
$T_{mt} - \bar{T}_m$	0.00	2.08	6.34	-6.47
$\bar{T}_m$	23.66	4.14	32.74	11.58

Notes: This table shows descriptive statistics of the main variables we use. $\bar{T}_m$ is the municipality average of wet bulb temperatures across election days.

Additional data. We merge the temperature and humidity data with Brazilian municipalities using the 2010 municipality mesh from the Brazilian Institute of Geography and Statistics (IBGE). To include controls in our specifications, we use data from the Demographic Census of 2010, also from IBGE, on the share of women in the population, income per capita, and the share of the population with a college degree.

4 Results

4.1 Temperature and votes

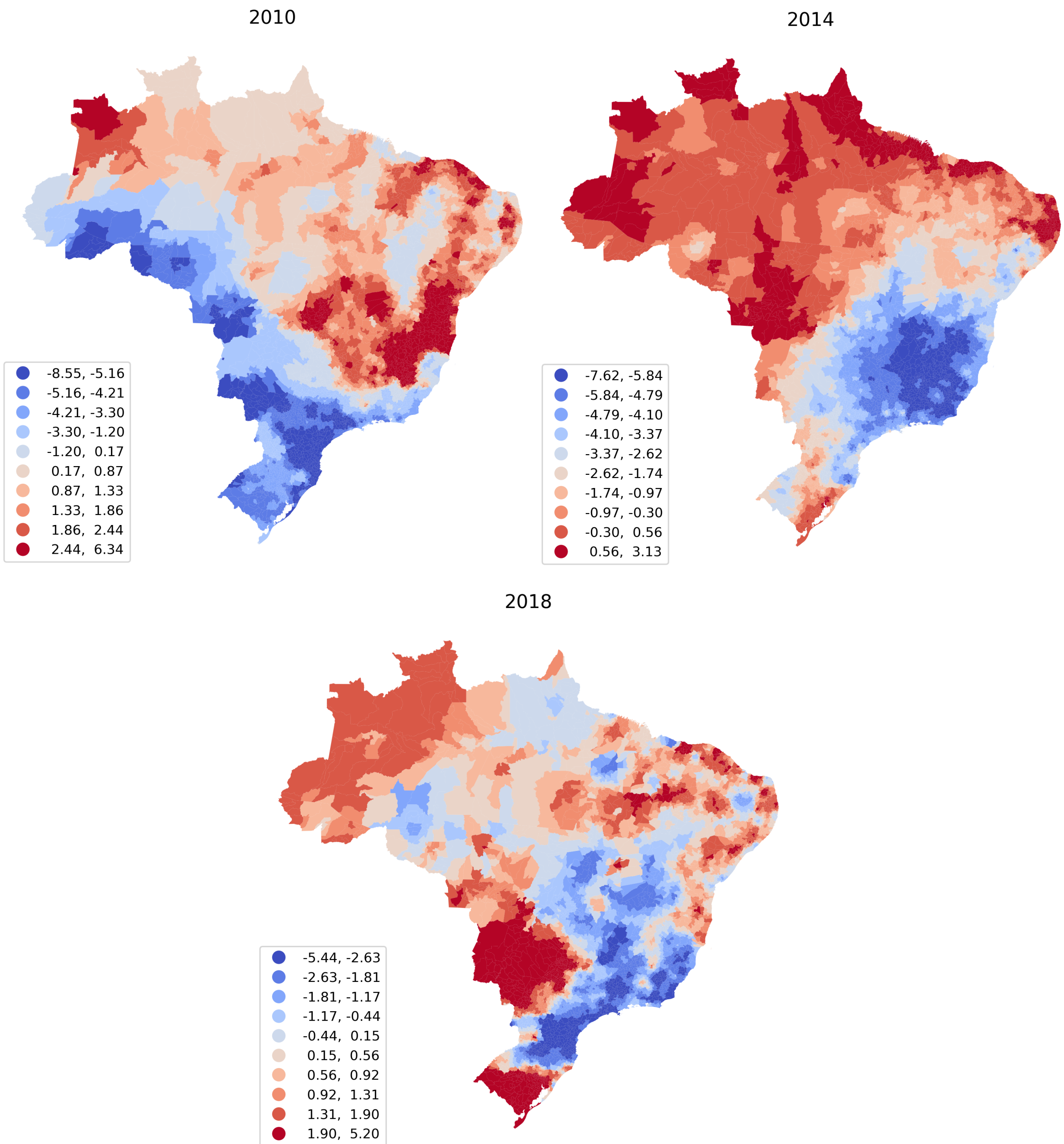
Our main empirical specification is given by the following equation:

$$y_{mt} = \beta \Delta T_{mt} + X_m \gamma_t + \alpha_t + \alpha_m + \varepsilon_{mt}, \tag{1}$$

where y_{mt} denotes the share of valid votes for Marina Silva in municipality m and year t; ΔT_{mt} denotes the deviation of wet bulb temperature (relative to the historical mean) on the election day in municipality m and year t;[15] α_m and α_t are municipality and year fixed

[15] $\Delta T_{mt} = T_{mt} - \bar{T}_m$, and $\bar{T}_m$ is the wet bulb temperature calculated using the historical average temperature and humidity during the first week of October from 1962 to 2018.

Figure 1: Temperature shocks



Notes: This figure shows, for each municipality-year, deviations of temperature on election day from the historical average (1962-2018). Different colors in the legend and on the map represent deciles within the year.

effects; X_m are controls that include the share of women in the population, the share of college graduates, and income per capita measured by the 2010 Demographic Census; we include income and education as controls, given that awareness of climate change varies significantly across them (Dechezleprêtre et al., 2025). Additionally, we control for the share of women in the population, as women may be more likely to support female candidates in elections (Schwarz and Coppock, 2022); the parameters γ_t allow these variables to be interacted with year fixed effects. We are interested in the β parameter, the effect of increasing temperature on election day on the vote share of Marina Silva. Given the municipality fixed effect (α_m), the parameter β captures the effect of a variation in the wet bulb temperature along a long-run average on votes.

The identification assumption is that the deviation on temperature *on the election day* is not correlated with unobservables that are important to explain votes for Marina Silva. This identification strategy has been used in different contexts (Deschenes and Moretti, 2009; Zivin et al., 2020; Heutel et al., 2021; Heilmann et al., 2021; Park, 2022; Burke et al., 2018; Lai et al., 2023) and relies on the argument that daily temperature variation is an unexpected shock. High-frequency temperature variation on the election day – always a Sunday – combined with placebos and robustness checks allows us to rule out alternative channels in our setting, such as productivity, income, and education, through which temperature could affect voting behavior beyond climate change salience. Standard errors account for heteroskedasticity and spatial autocorrelation (Conley, 1999). In our main specification, the threshold of Conley (1999)'s standard errors is 40km. This is the average distance of a municipality seat to its ten closest neighboring municipalities.

Table 2 shows the results of estimating Equation (1). The estimated coefficient is positive, meaning a higher temperature causes an increase in votes for Marina Silva. This result is robust across a range of specifications, controlling for education, income, and the share of women in the population interacted with year fixed effects.

Table 2: Temperature Deviation on Vote Share

	Marina Silva's Vote Share						
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔT	0.001*	0.003***	0.003***	0.003***	0.004***	0.003**	0.003***
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0007)	(0.001)	(0.0008)
$\Delta T + 1$							-0.0001
							(0.0007)
munic (5,562)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
College		Yes	Yes	Yes	Yes	Yes	Yes
Income			Yes	Yes	Yes	Yes	Yes
Women				Yes	Yes	Yes	Yes
Excl.2018					Yes		
Trend						Yes	
# year	3	3	3	3	2	3	3
Observations	16,686	16,686	16,686	16,686	11,124	16,686	16,686
R^2	0.75	0.79	0.81	0.81	0.82	0.85	0.81
Within R^2	0.002	0.19	0.24	0.25	0.10	0.42	0.25

Notes: This table shows the results of the regression of Marina Silva's vote share on the deviation of wet-bulb temperature (relative to the historical average) on election day and the following day. All specifications include municipality and year fixed effects. Standard errors are based on Conley (1999)'s to account for spatial correlation. The threshold of Conley (1999)'s standard errors is 40km. This is the average distance of a municipality's seat to its ten closest neighboring municipalities. Figure A.2 in the Appendix shows the robustness of our estimates for different thresholds. *p<.1; **p<.05; ***p<.01.

In our preferred specification in column (4), an increase of $1C^\circ$ in temperature leads to an increase of 0.3 percentage points in votes for Marina Silva. Given that this is only information received on election day, this effect represents a large change in constituents' willingness to vote for Marina Silva. We can compare our estimated magnitudes with those in the literature. Ajzenman and Durante (2023) find that voting in a school with bad infrastructure sway votes against the previous mayor between 0.2 - 0.6 percentage points. Our results indicate that one standard deviation in temperature (σ^T) increases Marina Silva's vote share by 1.3 percentage points $[\beta \times \sigma^T = 0.003 \times 4.63]$. An alternative way of studying this magnitude is to compute the standard deviation of temperature for each municipality (σ^T_m) and take their average $(\mathbb{E}\sigma^T_m)$ as a way of capturing more of the conditional temporal variation. Then, a typical variation in temperature leads to 0.6 percentage points higher vote share for Marina Silva $[\beta \times \mathbb{E}\sigma^T_m = 0.003 \times 2.20]$, which is remarkably close to the effect estimated by Ajzenman and Durante (2023).

As noted before, the 2018 presidential election was highly polarized already in the first round. As a consequence, Marina Silva received only 1% of the valid votes. As 2018 was such a unique election, column (5) in Table 2 presents a robustness exercise where we use only data of the 2010 and 2014 elections. The estimate of temperature on vote share is very similar to the one where we include 2018. If anything, the estimate without 2018 is larger than in our preferred specification.

Some regions may be warming more than others during our study period and this trend can be correlated with unobservables. We account for this by allowing heterogeneous municipal trends by adding individual slopes for each municipality $(\gamma_m \times t)$ to Equation (1), that is, the interaction of the municipality fixed effect with the continuous time (year) variable. This is a saturated specification that is only possible because we have panel data spanning three years of presidential elections. Still, column (6) in Table 2 shows that the result remains the same and that heterogeneous trends are not driving the results.

In our baseline specification, we estimate the linear effects of temperature rather than the non-linear effects, such as those occurring above a particular temperature threshold. The reason is that we want to capture individuals' perceptions that the temperature is higher than usual, even if it is not extremely hot. Therefore, we are precisely interested in any temporal variation in the wet bulb temperature. Reassuringly, Appendix Figure A.2 shows that effects are quite stable for different intervals of the wet bulb temperature distribution. Finally, our results are robust to setting different thresholds for the spatial correlation (Appendix Figure A.3).

Placebo. One implication of our proposed mechanism is that temperature after the election day should not affect votes for Marina Silva. This offers a placebo strategy to test for the existence of unobservable components we may not be accounting for. To test it, we modify Equation (1) to include the temperature of the day after the election. Since we have a high temporal correlation in the wet bulb temperature (close to 0.9), we must also include the temperature on the election day to avoid omitted variable bias. We therefore estimate:

$$y_{mt,day=0} = \beta \Delta T_{mt,day=0} + \tilde{\beta} \Delta T_{mt,day=+1} + X_m \gamma_t + \alpha_t + \alpha_m + \varepsilon_{mt}, \tag{2}$$

where $day = 0$ denotes election day and $day = +1$ denotes the day after the election. The results are presented in column (7) of Table 2. The coefficient of the election-day temperature remains remarkably close to the ones estimated without the lead temperature. Moreover, the effect of temperature on the day after the election is highly statistically in-significant and an order of magnitude smaller than the effect on the election day. The standard error of our parameter of interest increases, which is expected since we are adding an irrelevant variable to our specification ($\Delta T_{mt,day=+1}$), which is highly correlated with the variable of interest ($\Delta T_{mt,day=0}$).

Turnout. One source of concern is that temperatures could affect turnout heterogeneously among voters, and that somehow a lower/higher turnout could benefit Marina Silva. Column (2) in Table 3 shows the result of estimating Equation (1) using turnout share instead of Marina Silva's vote share. The estimated effect has a low statistical significance and the effect is an order of magnitude smaller than the effects estimated in Table 2. This suggests that temperature has zero or a very limited effect on turnout. We interpret this result as evidence that turnout is not the driving force behind changes in votes.[16]

Voting against the incumbent? One mechanism we want to rule out is the possibility that higher temperatures decrease votes for the incumbent and that these votes are, for some reason, transferred to Marina Silva.[17] In the 2010 and 2014 presidential elections, the Workers' Party (*Partido dos Trabalhadores* - PT) was clearly the incumbent.[18] In 2010, Luiz Inácio Lula da Silva was finishing his second term. In 2014, Dilma Rousseff, also from PT, was running for re-election. However, because of Dilma Rousseff's impeachment in 2016, it is less clear who should be considered the incumbent in the 2018 election. After the impeachment, Michel Temer — Dilma Rousseff's vice-president and a member of the Brazilian Democratic Movement Party (*Movimento Democrático Brasileiro* - MDB), assumed the presidency. Both PT and MDB then fielded their own candidates in 2018, making both parties effectively incumbents.

For this reason, we consider PT as the incumbent in 2010 and 2014 and both PT and MDB as incumbents in 2018. Column (3) in Table 3 shows the result of estimating Equation (1) using the share of votes for the incumbent as the dependent variable. The estimate is not statistically significant. If anything, higher temperatures have a very small positive effect.

[16] A large literature explores the determinants of turnout focused on the US (e.g., Hansford and Gomez, 2010; Gomez et al., 2007; Fujiwara et al., 2016). As voting is mandatory in Brazil, it is no surprise that we did not find a significant effect.

[17] One potential mechanism is that temperature is associated with temperament/sentiment (Baylis et al., 2018; Baylis, 2020), although, again, we cannot reason why this would benefit Marina Silva.

[18] In the Brazilian political system, it is not straightforward to define incumbents. The party coalition system is a prominent feature of the electoral process, especially in presidential elections. Given the country's numerous political parties, this system is essential for consolidating support and enhancing electoral success. Parties within a coalition agree to back a single presidential candidate, share campaign resources, and coordinate strategies to increase visibility and reach. This approach helps secure a larger share of the electorate by combining the support bases of different parties and reduces vote fragmentation. Post-election, coalition parties often receive key positions in the administration, ensuring legislative support and stability.

We interpret this as evidence that our estimated effect is not some mechanical transfer of votes against the incumbent. For completeness, columns (4) and (5) show that the positive effect of temperature on votes for Marina Silva comes from the other 15 political parties, regardless of their political leaning.

Valid votes. An additional source of concern is that higher temperatures may cause inattention, which might somehow benefit Marina Silva. Although we cannot reason why inattention would benefit Marina Silva specifically, we can test this hypothesis directly. In column (6) of Table 3, we present the estimate of Equation (1) using null and blank vote share instead of vote for Marina Silva. We find no effect of temperatures on valid votes, which is not consistent with the inattention story.

Table 3: Temperature Deviation on Vote Share and Turnout

Model:	Vote Share (Marina Silva) (1)	Turnout / Voters (2)	Vote Share (Incumbent) (3)	Vote Share (Others - Left) (4)	Vote Share (Others - Right) (5)	(Null and Blank) / Turnout (6)
ΔT	0.003***	0.0004*	0.0002	-0.001**	-0.002**	0.0002
	(0.0006)	(0.0002)	(0.0006)	(0.0006)	(0.0008)	(0.0001)
munic (5,562)	Yes	Yes	Yes	Yes	Yes	Yes
year (3)	Yes	Yes	Yes	Yes	Yes	Yes
College	Yes	Yes	Yes	Yes	Yes	Yes
Income	Yes	Yes	Yes	Yes	Yes	Yes
Women	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,686	16,686	16,686	16,686	16,686	16,686
R^2	0.81	0.82	0.93	0.94	0.94	0.79
Within R^2	0.25	0.07	0.20	0.36	0.44	0.30

Notes: This table shows the results for the regression of vote shares for different outcomes on deviation of wet-bulb temperature (relative to the historical average) on the election day. Column (1) presentes baseline results for Marina Silva's vote share. Incumbent includes PT and MDB. Others Left include: PDT, PSTU, REDE, PCB, PCO, PSB, PV and PSOL. This list excludes PT (incumbent party) and Marina Silva's parties (PV in 2010, PSB in 2014, and REDE in 2018). Others Right include: PODE, PSC, PSL, PSDC, PRTB, NOVO, PATRI, PPL, and PSDB. This list excludes MDB (incumbent party). All specifications include municipality and year fixed effects. Standard errors are based on Conley (1999)'s to account for spatial correlation. The threshold of Conley (1999)'s standard errors is 40km. This is the average distance of a municipality seat to its ten closest neighboring municipalities. *p<.1; **p<.05; ***p<.01.

4.2 (Very) Short-lived Effects

It is reasonable to ask whether higher temperatures on days before the election can also have an effect on voting behavior. The main concern with testing this hypothesis is that the further we go from the election day to add lags, the more likely it is that we will be capturing something completely unrelated to salience. Indeed, temperature deviations from weeks/months/years before the election day may be related to a range of different mechanisms going from mortality and crime to productivity/earnings (Zivin et al., 2020; Heutel et al., 2021; Heilmann et al., 2021; Park, 2022; Lai et al., 2023). Given this caveat, we can stretch our time window a few days and estimate a dynamic specification to understand how important the temperature on election day is relative to the temperature on previous days:

$$y_{mt,day=0} = \sum_{day=-3}^{+1} \beta_{day} \Delta T_{mt,day} + X_m \gamma_t + \alpha_t + \alpha_m + \varepsilon_{mt}, \tag{3}$$

where $day = 0$ denotes election day and $day = -x$ indicates x days before the election.

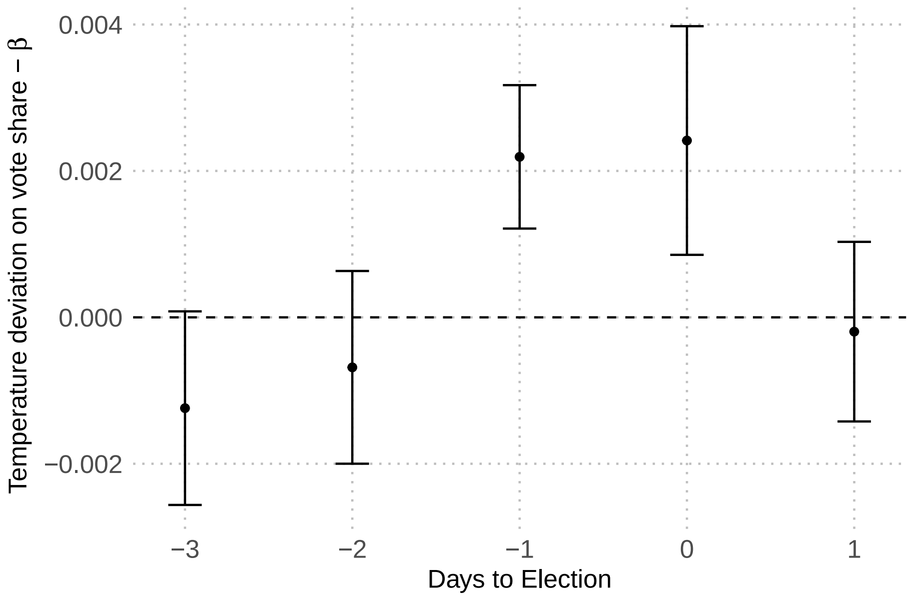
Figure 2 displays the estimates of this equation, adding lags for three days. This specification is very saturated due to the high temporal correlation of the temperature data (close to 0.9). However, even in this specification, the effect of the election-day temperature remains stable and significant. Moreover, the estimate for the day before is also statistically significant and has a similar magnitude to those presented in Table 2. However, the effect of temperature two or three days before the election disappears, indicating that the salience effect on voters is very transient. Overall, this finding connects with the short-lived effects of salience largely explored in the literature (Bordalo et al., 2022).

Furthermore, Figure 2 also shows the placebo estimates for $T_{mt,day=+1}$ presented in a similar way as in Column (7) of Table 2. Combined, these placebo results are evidence that daily temperature variations are not capturing some unobservable factor that affects votes for Marina Silva and strengthen our claim that the mechanism behind our results is of salience of climate change.

5 Conclusion

Our study demonstrates the significant effect of short-term temperature changes on voting behavior in favor of a pro-environment candidate in Brazil. By studying three rounds of presidential elections, we found that higher temperatures on election day increased votes for Marina Silva, a well-known pro-environment candidate. Specifically, an increase of one standard deviation in temperature raises vote share for Marina Silva between 0.6 and 1.3 percentage points. This effect highlights the salience of immediate weather conditions in shaping voter decisions, suggesting that climate variability can play an important role in individuals' perceptions about climate change and, subsequently, in electoral outcomes.

Figure 2: Temperature Deviation on Marina Silva's Vote Share (with lags)



Notes: This Figure shows the effect of temperature deviation (relative to the historical mean) on Marina Silva's vote share. Specification includes municipality and year fixed effects, income per capita, share of college, and share of women interacted with year dummies. Standard errors are based on Conley (1999) with a distance threshold of 40 km to allow for spatial and temporal correlation of the error terms.

Our results are robust to a series of specifications, samples and placebo exercises.

The implications of our findings are twofold. On the one hand, individuals' experiences can not only create awareness about climate change but also affect political attitudes. As climate change continues to intensify weather variability and extreme temperature events, we can expect heightened public awareness and concern about environmental issues, potentially leading to greater electoral support for pro-environment candidates. On the other hand, the ephemeral nature of the observed effects raises concerns about the sustainability of such electoral impacts. Voters' responses to climate salience appear to be short-lived, emphasizing the need for continuous and consistent engagement on environmental issues to maintain public support for long-term climate policies.

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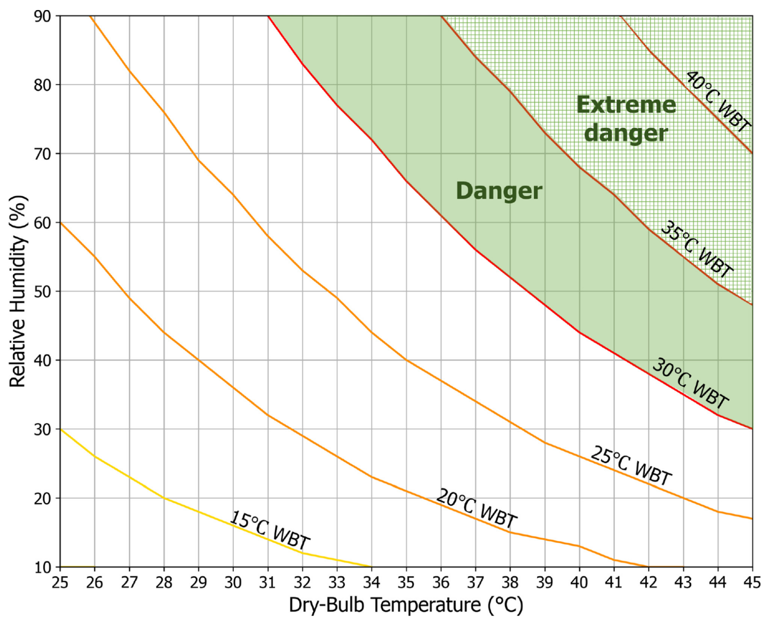
A Appendix

A.1 Translating dry-bulb to wet-bulb

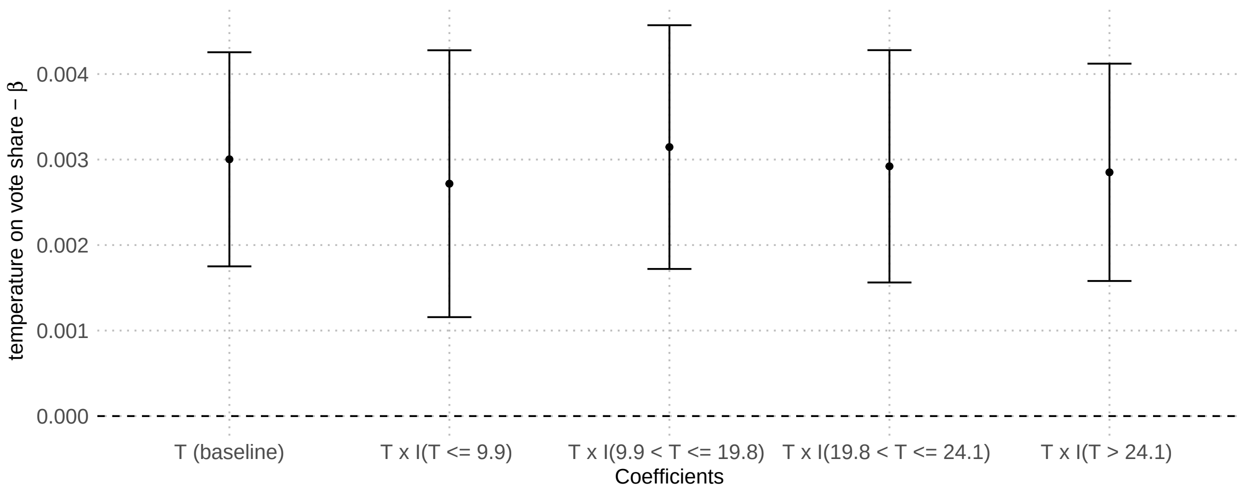
Figure A.1: Dry-bulb, humidity, and wet-bulb



Notes: This figure is from Hong (2025). It shows the equivalence from dry-bulb to wet-bulb temperature.

A.2 Non-Linear Temperature Effects

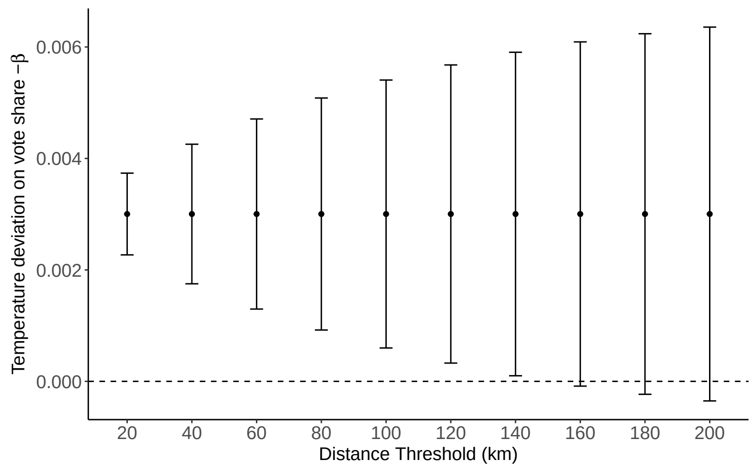
Figure A.2: Confidence Intervals (95%) for the Effect of Temperature on Votes, by Temperature Ranges (Quartiles)



Notes: This figure shows the estimates and 95% confidence intervals for the non-linear effects of temperature on votes. The first bar displays our preferred estimates (column (4) of Table 2). The remaining four bars present estimates from a similar model, but with the wet bulb temperature interacted with dummies that indicate which quartile of the wet bulb distribution each observation belongs to.

A.3 Robustness to Alternative Distance Thresholds

Figure A.3: Confidence Intervals (95%) for the Effect of Temperature Deviation on Votes Using Alternative Conley (1999) Distance Thresholds



Notes: This figure shows the robustness of the effect of temperature deviation (relative to the historical mean) on votes, considering alternative distance thresholds to compute Conley standard errors. Estimates were obtained using our preferred specification - column (4) of table 2.