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Climate, weather, and political behavior

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CLIMATE, WEATHER, AND POLITICAL BEHAVIOR

by

Alexander H Cohen

An Abstract

Of a thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy
degree in Political Science in the Graduate College of The University of Iowa

July 2011

Thesis Supervisor: Associate Professor Douglas Dion

This dissertation explores the extent to which weather and climate systematically affect political behavior. The idea that weather (and other elements of the natural world) exercise a fundamental influence on politics has long been a theme in classical and modern political thought. As political science moved from pure description to a more social-scientific form of analysis, scholars became less interested in understanding the impact of climate. If mentioned at all, weather typically is referred to as one of the various elements making up the “error term” in our statistical analyses.

Recent work in the natural and social sciences, however, has suggested there are systematic and important links between weather, climate, and behavior. This work not only inspires a return to a traditional focus of political analysis, but more importantly provides a number of hypotheses to guide our analysis of politics. Inclement weather increases the costs of moving from place to place. Sunlight enhances while extreme temperature depresses mood. Finally, hot weather is associated with enhanced aggression.

These correlates of climate have implications for a variety of subfields across political science, including comparative politics and international relations. This dissertation concentrates primarily, however, on American politics, particularly from a behavioral perspective. I explore behavior in four settings that have been especially important in mainstream studies: Presidential approval; social capital; Election Day voting; and finally elite participation (in the form of abstention on roll call voting). In terms of the first, if (as Zaller argues) a response to a telephone survey indeed entails a summing up of ‘considerations’ regarding an issue rather than expression of a ‘true’ attitude, then it is likely sunlight should stimulate positive responses to questions because it encourages the release of serotonin, which makes people more positive in general. Controlled logistic

regression of sunlight on Presidential approval reveals that, in spring, sunlight boosts approval. The next chapter explores how hot climates and rain may reduce levels of social capital. This is because heat boosts levels of aggression, which should diminish helping behavior, and because rain makes it more difficult to volunteer and associate with other people. Analysis of state-level social capital data and city-level volunteer data provides some evidence that these propositions are correct. The third empirical chapter focuses upon voting on Election Day. While it finds that rain does have a depressive effect upon voting rates among the poor due to raising the costs associated with voting, there is little evidence that vote choice is affected by the weather. The final empirical chapter examines how weather conditions may affect voting rates among members of the United States House of Representatives. OLS regression at the vote-level and logistic regression at the legislator level reveals that in the winter and spring, sunlight boosts voting, while summer humidity depresses voting and heat in winter has a positive effect.

These conclusions are interesting in themselves and meaningfully contribute to contemporary academic discussions. However, they further suggest that analyses of political topics could often be enhanced by reflectively considering the contents of the error term, as this exercise can offer a fresh perspective on current scholarship. Further, this dissertation also suggests that political science (and research in general) could benefit from taking a more comprehensive view of the environmental context of human behavior.

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CERTIFICATE OF APPROVAL

PH.D. THESIS

This is to certify that the Ph. D. thesis of

Alexander H Cohen

has been approved by the Examining Committee for the thesis requirement for the Doctor of Philosophy degree in Political Science at the July 2011 graduation.

Thesis Committee: ___________________________________
Douglas Dion, Thesis Supervisor

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Michael Lewis-Beck

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Douglas Madsen

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Tom Rice

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Heath Spong

… and all over the world/strangers/talk only about the weather.

Tom Waits, Strange Weather

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INTRODUCTION

Orientation. This dissertation is about how weather and climate[1] affect political behavior. The concept is far from novel. Within the tradition of political analysis, it can be traced from Aristotle to the thinkers of the Enlightenment, and, more recently, to a handful of empirical studies. Outside the bounds of political science, it continues to be the subject of rigorous scholarship and scientific debate in many academic and applied realms, including sociology, psychology, psychiatry, economics, and biometeorology. Evidence continually demonstrates that meteorological conditions provoke physiological reactions that can affect mood, constrain actions, and drive conduct. Weather and climate also affect infrastructure and planning. In the aggregate, by influencing how people think, feel, and get from place to place, weather and climate can affect individual-level political behavior[2] in ways interesting to political scientists studying a wide array of topics.

After all, from Anchorage to Alamagordo, weather and climate comprise the backdrop against which political action takes place. Natural conditions surround us and shape the ebb and flow of our day-to-day lives. Consequently, their power in shaping political actions can be pervasive and their mechanisms of influence manifold. There is no escaping it: the habits of carpenters and Congress people alike are inextricably linked to

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[1] The differences between weather and climate will be discussed in the following chapter. For the moment, it is sufficient to note that weather refers to day-to-day meteorological conditions, and that climate refers to long-term weather patterns measured over many years.

[2] Some areas of political science do consider climate and weather, at least tangentially. Studies of war, security, and natural resources tend to consider national or international climate or weather. This dissertation, however, is not especially concerned with how weather and climate affect war, global politics, or natural resources. We know that the sea storm of 1588 marked a turning point in European history, that Napoleon and Hitler should have planned more carefully for the Russian winter, and that oil is an important natural resource. Such relationships have been examined elsewhere and are an acknowledged part of the historical record and security studies. This dissertation is instead focused upon how weather and climate affect frequently studied types of political behavior at the *individual* level. Its goal is to make new contributions to several subjects regularly studied in political science, such as voting behavior, public opinion, and social capital.

cycles of wind, sun, and rain. Some effects are pronounced and others are more subtle. We enjoy good weather and dislike bad weather. We look forward to a warm spring afternoon after a bone-chillingly cold winter, and yearn for a cool breeze and shady skies during an August heat wave. We dread driving in the snow. Weather and climate are constantly shaping what we wear, where we go, and how we get there. Meteorological conditions also affect cardiovascular health, arthritis flare-ups, allergies, respiratory infections, skin diseases, and cancer rates. All of this has important implications for how people navigate the political world.

This introductory chapter outlines some reasons why weather and climate should be studied by political scientists interested in individual-level behavior. To do so, it first discusses the historical roots of the study of weather, climate, and politics. It then speculates as to why such studies fell out of fashion in the 20th Century, points to some properties possessed by weather and climate which make them attractive independent variables for study by political scientists, and discusses a few examples along this vein scattered across the political science literature. Finally, having a made a case that weather and climate are important aspects of humanity's natural environment and could thereby reasonably influence some political activities in a systematic and measurable way, this chapter closes by laying out the structure for the remainder of the dissertation, where hypotheses related to weather, climate, and political behavior will be formulated, explored, and tested.

Weather, Climate, and Politics: An Old Idea. Applying weather and climate to political research is not a new idea. In fact, it is a very old one. Many great minds of the past have thought about how climate and weather might influence political behavior. And while most of these centuries-old deductions have been outright wrong and range from laughable at best to offensive at worst, it is worthwhile to acknowledge this legacy, with the aim of improving upon it by wielding the analytical tools of modern social science.

The Greeks believed that climatic conditions could imbue populations with certain characteristics that affected the practice of politics. Herodotus attributes the success of Egyptian civilization to their excellent health, which is a consequence of an absence of seasonal change (2.77). In *Politics*, Aristotle explains the advance of Greek civilization beyond its neighbors through its temperate climate, which supports a temperate nature among citizens necessary for statebuilding (VII, 7). Cold climates, on the other hand, lead to wild, ungovernable dispositions while hot climates cause servility, and so such places are ill-suited for a *polis.*

Thinkers of the Enlightenment Era also believed that climate influenced behaviors and dispositions in ways that, in the aggregate, determined the spirit of nations and shaped laws. In *The Social Contract,* Rousseau argues that climate is an important determinant of regime type (1947/1752, 3:8). The closer that people live to one another, he argues, the more government will work to promote their interests. In warm climates, few people are required to work the soil, and so populations tend to be spread out, which is conducive to monarchy. Moreover, wealth is more easily produced in warm climates due to the fertility of the soil; this wealth is soaked up by the sovereign's private interests and helps the crown retain power. In mild-to-cool climates, on the other hand, more labor is required to achieve an agricultural surplus, promoting a more densely-packed society, which supports democracy. Further, milder climates tend to inspire liberty because they facilitate free association in public spaces such as town squares, and because people's immediate needs such as shelter and clothing are more easily procured than in harsher climates, which frees both time and energy to think of higher pursuits such as freedom (1947/1752, 3:15).

Montesquieu also discusses interactions between climate and regime type. Hotter climates, he argues, support despotism. First, heat creates agricultural surplus and abundant wealth; this wealth is often spent on purchasing and providing for multiple wives, which are in abundance because female offspring are more likely in hot climates (1989/1748, 16:4). Yet this heat also incites the passion of women, creating household intrigues and necessitating their enclosure from one another, and from the rest of the world; this enclosure system creates despotism in the house, which leads to despotism in government. Slavery, Montesquieu thinks, is also a consequence of climate. Because heat "enervates the strength and courage of men", slavery becomes a popular institution because slaves are easier to manage in heat, which also supports despotic rule (1989/1748, 17:2; 15:7). High temperatures also lead to a general lethargy which prevents nations from acquiring the courage needed to change from traditional ways to more enlightened, democratic principles (1989/1748, 14:4).

Hegel also attributed the characteristics of nations and peoples to temperature. For Hegel, history is understood as a progression of events leading to the ultimate revelation of human freedom (Hegel 1971/1817). As civilizations rise and fall, they contribute to the realization of this freedom. Some cultures advance the collective cognizance of this freedom, while others do not. Temperature is an important element determining whether a culture becomes a contributor to world history. Hegel thus explains central and southern Africa's relative isolation from world history on the basis of heat: contending with extremely high temperatures is so engrossing that it prevents people in these regions from forming nations capable of contributing to global historical processes (Hegel, 1967/1837).

Why the Study of Weather, Climate, and Politics May Have Fallen Out of Fashion (and Some Problems with this Logic). Over a century later, modern political science research seldom considers how weather and climate may pattern individual-level behavior. In general, there is a separation of natural and social science. There are several possible explanations for this. At face value, these objections are sensible ones. However, for the most part, their logic is flawed. This section will review such explanations and gently question their logic.

"Most of the connections between climate, weather, and politics reached by Enlightenment-era thinkers are so obviously incorrect that they border on nonsense. Moreover, the theoretical underpinnings are frequently weak to absurd." None of these claims, as they are presented, would pass muster in a modern social science journal. There is little to no empirical examination of actual relationships beyond the authors' own observations; there are no data, hypotheses, tests, or robustness checks. Instead, the authors merely forward claims built upon uncorroborated opinions about the state of the world. By the standards of modern science, the methods of analysis are thoroughly unsystematic. Alternate explanatory models are not considered. Finally, the theories behind these claims are not supported by any scientific literature. For instance, Montesquieu's argument that heat saps courage comes from the spirit of the times rather than a well-tested and traversed body of scholarship. Modern social science generally regards this sort of slapdash theorizing with great skepticism.

While it is true that the study of weather, climate, and politics conducted by thinkers of the ancient and Enlightenment eras does not measure up to the standards of modern social science, the tools of modern social science can nevertheless readily be applied to exploring similar connections. Put another way, the failures of our predecessors do not doom our efforts to failure. We have at our disposal a very different set of tools than Aristotle, Rousseau, and Montesquieu. The next two points speak to this more specifically.

"Weather and climate are difficult to measure in concrete terms." Weather and climate are inherently difficult to measure. Moreover, measuring weather and climate in a way useful to social scientists requires careful attention to two dimensions. First, the world is vast. To map weather or climate to social phenomena of interest, careful measurements must occur across a large geographical areas. Second, weather is constantly changing, and climate can only be measured over a long span of time. This poses a number of problems to social scientists interested in the subject. A scholar of elections must have the foresight to measure weather conditions on the day that elections are held, a scholar of legislative behavior might want to map rain to the times of major legislative votes, and a student of social movements of the 1960s may want climate measurements from that period. To be useful to social science at-large, then, measurements of meteorological conditions must be made extremely frequently in order to generate a record useful to a large number of social scientists doing work across various temporal and geographic contexts. Such measures must be made via standardized methods and equipment.

While these measurement issues may have been problematic a hundred years ago, they no longer apply. For one, weather is quite easily quantifiable; dozens of weather elements including temperature, sunlight, cloud height, wind velocity, atmospheric pressure, humidity, and dew point can be measured in concrete terms using rather equipment that is far from elaborate. Second, excellent weather and climate data is available at the click of a mouse. In the United States, for over fifty years, the U.S. Government (via the National Oceanic and Atmospheric Agency and the National Climatic Data Center) has overseen the recording of hourly weather observations across over 1,000 locations in the continental states. This data is standardized, subjected to strict quality controls, regularly updated, accessible via the Internet, free to people logging in at an educational institution, and stored in formats that enable simple merging into existing datasets.

“Our understanding of how weather influences human behavior is anecdotal, and this not the stuff that social science is built on.” Many people will acknowledge that they enjoy a bright spring morning or that hot weather makes them angry, but if such beliefs are not tested in some sort of formal scientific setting, they remain part of folklore and should be regarded with skepticism by social scientists. Indeed, this is a great failing of Hegel and company: these philosophers conjure theories about weather and human behavior from the wisdom of the times rather than from a body of careful scholarly dialogue.

Fortunately, science has advanced considerably since the days of the aforementioned philosophers, and—if one is willing to step outside the safety of political science journals—one does not need to look very hard to find myriad articles in reputable outlets documenting specific links between weather, climate, and human behavior. A hefty chunk of this literature is focused on relationships that could have implications for political behavior. For instance, criminologists examine how temperature leads to rioting, which could suggest a link between heat and political violence. The bulk of this relevant work is discussed in detail in the following chapter. For now, the point is that scholars from other research programs have subjected relationships between weather, climate, and behavior to scrupulous tests and rigorous debate, and this provides political scientists who desire to study weather, climate, and political behavior with a rich foundation of extant scientific scholarship from which to construct theories.

"In comparison to other causal factors, weather and climate are relatively unimportant, and so it is inefficient to bother studying them." There is some truth in this particular objection, though it is exaggerated. At no point will this dissertation argue that accounting for weather or climate will fundamentally change how we study any topic within political science. Nothing here suggests that weather and climate represent the primary causal factors in any individual-level political activity. In fact, the effect of weather and climate can often be quite contextual and subtle. Nevertheless, even though the substantive impact of weather may be less than other variables traditionally employed to explain political phenomena, studying these effects can nevertheless inform our understanding of other topics regularly studied by political science.

For instance, in a fully controlled model of roll call voting in the United States House of Representatives, summer humidity tends to suppress the number of total votes cast by about four, though this number increases when unimportant legislation is considered (see Chapter VII). While this is an interesting observation in itself, substantively speaking, it is far from earth-shattering. However, it does have implications for the study of ideological shirking, an important topic that has received considerable attention by serious scholars of legislative behavior (eg, Poole, 2007; Rothenberg & Sanders, 2000a; Cohen and Noll, 1990). Ideological shirking refers to a given legislator abstaining from voting on a bill because their own ideology is at odds with their constituents; because this legislator does not want to vote in a way that might aggravate voters but also strongly disagrees with a given bill, they may abstain rather vote against their constituency or conscience. In order to differentiate shirking from abstentions cast for less strategic reasons, it is useful to explain as much of the variance in voting as possible. Considering the weather helps explain some of this variance, which can improve the accuracy of existing models.

"People react dramatically differently to weather and climate and therefore weather and climate exert a random rather than systematic effect upon human behavior; given this, the effects of weather and climate are so chaotic that they cannot meaningfully be incorporated in social scientific theories. Thus weather and climate are best relegated to the error term." It is true that people are quite different, and that people will not necessarily react in a uniform fashion to weather and climate. Variance across a wide range of personal attributes—many of which are tied into environment, life experiences, and personality—ensures that reactions to weather and climate will never be entirely consistent, even across a homogenous population situated at a fixed geographical coordinate. People are just far too unique for that sort of regularity.

There are four good retorts to this logic. First and foremost, that different individuals may exhibit inconsistent responses to identical weather and climate conditions is a familiar problem to social science. We seek to identify patterns, use those patterns to develop theories that explain the world, but cannot explain everything perfectly. Just as we know that *in general* education tends to lead to a more liberal world view, we acknowledge that there are plenty of exceptions to this rule. So it is perfectly acceptable to craft theories that recognize deviation from the anticipated pattern: *in general*, sunlight bolsters mood and so, in general, sunlight should bolster the likelihood of expressing approval of President Bush (see Chapter V).

Second, the more scientists study the interrelationships between weather, climate, and political behavior, the less chaotic these relationships will seem. So, even though humans are complex and reactions to meteorological conditions may vary, examining this behavior in a thoughtful and analytical manner will help scholarship find order amidst the apparent chaos. If understanding how weather and climate affect political behavior can aid us in explaining politics—and this dissertation will show that they do—then scholars should and can identify clearer patterns. Nothing about the relationship between weather, climate, and human behavior is inherently so complicated that the topic is cannot be studied. Mapping political behavior to meteorological conditions is not always as simple as correlating two variables, but this is the case with many things that political scientists regularly analyze. This dissertation will demonstrate that traditional research methods can overcome the complexity of political behavior and the natural world to test meaningful hypotheses and construct positive statements about concrete relationships. Ties between weather, climate, and politics can be studied just like ideology or turnout, provided that the subject is treated with the same care and seriousness that we apply to other objects of social scientific research.

Third, our genetic makeup exerts powerful pressure towards uniform reactions to weather. Although biology does not mold us into robots who react identically to meteorological stimuli, it does push us towards experiencing conditions in similar ways. This ensures that, in the aggregate, reactions to weather and climate will follow a rough pattern. Our biological composition is a powerful agent of uniformity. Our DNA is remarkably similar, and our reactions to many natural conditions stem from physiological factors that are steeped in millennia of evolutionary processes. For instance, most people do not like extremely hot or cold weather because it causes our core body temperature to fluctuate; this serves an evolutionary purpose because, if we were to get too cold or too hot, we would become ill or die. Of course, there is some variation here, and out shared genetic heritage does not ensure that all people react in exactly the same to all meteorological conditions. Yet it does drive populations towards meaningful patterns of behavior.

Finally, the collectively-experienced nature of weather and climate pushes people towards exhibiting somewhat uniform reactions to conditions. Weather and climate follow us indoors, across borders, and into our dreams—everywhere—and thereby pattern our routine interactions with friends and family. This is particularly visible in conversation: we talk about weather, constantly, because it is intrinsically interesting and because it can drastically affect our short-term plans by impacting clothing selection, travel time, health, and happiness. Weather is perfect fodder for tête-à-têtes with strangers, as it is a safe topic that anyone can discuss (Paolisso, 2003). However, such seemingly innocuous exchanges can also convey huge amounts of information. For instance, when crab fishermen along the Chesapeake Bay gather every morning for coffee, their short discussions of the weather are often explicitly limited to weather predictions and observations, yet these statements are rich with informational subtext about their fortunes, attitudes, outlooks, and even beliefs about God (Paolisso, 2003). Our predisposition to talk about weather and climate, sometimes energetically and at other times casually, both contributes to and reflects the power that natural conditions have over all of our lives; weather and climate are common threads that bind us. As Tom Waits rasps, “the whole world over/strangers/talk only about the weather.” For people across the globe, changes in weather, climate, and seasons provides an important framework for accessing and structuring memory (Harley, 2003, p. 115); it is not uncommon, for instance, to associate important life events with weather conditions at the time, and then use these conditions to calculate dates (“well, last time I had my eyes checked, it was freezing on the way to the optometrist’s office—that was the ice storm of ’06, so I need to get them checked again!”)

At a community, national, and even international level, everyone experiences outdoor conditions. This collective experience is so strong that weather and climate are part of culture and civilization, which both reflects this collective experience and creates uniformity of its own.

The flood myth, a tale of a great deluge unleashed upon man as divine retribution, recurs in the annals kept by dozens of ancient civilizations scattered across the globe. For the monotheistic religions born in the middle east, it is known primarily as the story of Noah; for the polytheistic Babylonians, it was recorded in the Epic of Gilgamesh. In the Shujing, an ancient collection of Chinese texts often collectively called the “book of history," the founder of the first Chinese dynasty, Da Yu, succeeds in staunching a flood that "assailed the heavens" (The Canon of Yao, 1879-1910). The Maharabata, a major Sanskrit epic of ancient India and a cornerstone of Hindu mythology, tells of Manu, who upon the advice of a fish builds a boat atop a mountain, allowing him to survive the great flood and ensuring the survival of mankind. In mythological Greece, Zeus unleashed a horrendous flood as punishment for a cannibal sacrifice; like Noah and Manu, Prometheus' son Deucalion survived the flood and helped repopulate the earth (Apollodorus, 1999). The Norse believed that when the god Odin killed the giant Ymir, so much blood flowed from his wounds that all the other giants were drowned except for Bergelmir and his wife, Sif; naturally, they proceeded to birth a new race of giants (Sturluson, 1964). For the Hopi, Sotukang, the creator, calls a flood to cleanse people of their corruption (Courlander ,1987); for the Inca and Maya, the Great Flood was called by Viracocha and Huracan, respectively (Andrews, 2000; Tedlock, 1996). From the Polynesian islands to Ireland to the Aztecs, the list goes on and on. The power of nature was so awesome to early humankind that it left deep, independent impressions in the traditions of civilizations dotted across the globe, and everywhere, weather and climate were deified and mythologized.

Storms, in particular, have left a cultural imprint so deep that throughout recorded history, people have believed that they signify imbalances in nature and foreshadow monumentous changes in the status quo. This pops up in literature quite frequently. In Shakespeare's *Julius Caesar*, a terrible storm strikes Rome on the eve of the assassination, prompting Casca to say to Cicero, "but never till tonight, never till now/did I go through a tempest dropping fire/Either there is a civil strife in heaven,/or else the world too saucy with the gods/incenses them to send destruction" (I, 3). Author Daphne Du Maurier uses 'unnatural' weather to foreshadow the arrival of swarms of birds that attack a farmhand and their family (this short story was the basis for Hitchcock's film and Steven King's later short story, *The Mist*); the birds are, in turn, symbolic of the rising threat of Communism facing the postwar U.S. during the 1950s (Du Maurier, 1952). The fascination with extreme or unusual conditions has lead to innumerable accounts of aberrant weather. Some are nonfictional, such as Daniel Defoe's 1704 *The Storm,* a chronicle of a terrible storm that racked England in the previous year, or programs on The Weather Channel that provide visuals of natural disasters. Other accounts are stylized, such as Monet's London Series, a series of impressionist paintings blending the fog of London with sooty exhaust of the industrial revolution. Still others, such as the 2004 disaster film *The Day After Tomorrow*, the upcoming *2012*, or Richard Burton's 1955 *The Rains of Ranchipur* are highly fictionalized. Such works demonstrate the continued fascination with weather and climate as powerful agents.

This ethos remains deeply ensconced in the organs of present-day culture. Every February, thousands of Americans gather around a rodent in Pennsylvania as acolytes to a cult leader. *Kitsch* or no, Punxsutawney Phil is covered by every major American media outlet and respected by spell check in Microsoft Word. We ascribe a groundhog with tremendous powers of prognostication over nature because people everywhere anxiously want to know the weather before it happens, as it so significantly affects the rhythm of our days. Groundhog Day is a modern ritual that celebrates the annual transition of winter to spring, but it has analogues across many societies and throughout human history. In contemporary America, many religious holidays are accompanied by symbolism and imagery pertinent to seasons and seasonal change. The Easter celebration of Christ's resurrection occurs as winter dies and warm spring weather brings renewed life to plants, animals, and crops; the First Council of Nicaea set its date as the first Sunday falling after the vernal equinox, and in many places, its celebration is associated with an anthropomorphic rabbit and its prodigious spawn of eggs—symbols of fertility during a time of rebirth. Prior to its adoption by the Church around the 4th Century, Christmas was celebrated by the Romans as *dies natalis solis invicti*[3], or "the birthday of the unconquered sun." Christmas began as a solstice holiday marking the sun's returning power, and today, its observation involves plants such as pine trees and mistletoe: symbols of nature's resilience amidst the darkness of winter. During Halloween, yards and stores are decorated with wheat, pumpkins, gourds, and other colorful products of the last harvests before winter. Such intermingling of religious observation and seasonal symbols, which are evident in cultural contexts around the world, reflects the primordial connection between our spirituality and the weather that surrounds us.

Our intimate relationship with weather and climate sometimes reflects important cultural mores. The British have a long history of obsession with the unpredictable clash of the Atlantic Gulf Stream and air from mainland Europe. This unease, regularly reflected in literature and conversation, reflects an uncertainty of Britain's place in Europe, anxiety towards assimilation of the mainland, and a tenuous desire to remain distinct from Europe at-large (Golinski, 2003). Today, the United Kingdom is one of the few members of the European Union to maintain its own currency. In the Eighteenth Century, throughout Britain, people from many social classes began quantifying and recording daily

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[3] The Romans, in the habit of adopting and adopting the gods of other people that they encountered, worshipped several solar deities under the aegis of 'sol invictus', such as Elah-Gabal, the Syrian sun god, Sol, who was largely Roman in origin, and the Parthian (Persian) god Mithras.

weather conditions; the ‘weather diary’ was a prevalent phenomena in 18th Century England because it reflected the Enlightenment desire to catalogue and master nature or, as Descartes wrote, “[though] we fancy [clouds] to be so high that poets and painters even fashion them into God’s throne… if I explain the nature of clouds in such a way that we will no longer have occasion to wonder at anything that descends from them, we will easily believe that it is similarly possible to find causes of everything that is most admirable above the earth” (Descartes, 2001/1637, p. 263).

This sort of primordial power should not be dismissed lightly; it has not been entirely mastered by modern technology. We heat our homes and huddle beneath umbrellas and hide from tornados in basements, but we cannot blot out weather entirely. And despite our differences as individuals, everyone lives under the sky; this pushes people towards patterned reactions to meteorological conditions, which are both reflected and enhanced by culture.

“Political science is interested in affecting outcomes, and so should be focused upon variables that can be manipulated. Since weather and climate are so exogenous to political behavior, they aren’t worth studying.” Indeed, though weather and climate can both can be affected by pollution via through mechanisms like pollution, heat blooms, and salt in clouds, weather is far more exogenous than many of the processes and energies that inhabit theories of social science.

However, this is actually a quite attractive property. In a discipline where variables tend to influence one another, it is rare that political scientists have the luxury of studying a variable that is largely inoculated from endogeneity issues. Viewed in this light, weather and climate are pleasant explanatory variables to consider.

In summary, the there are several reasons why weather and climate are acceptable explanatory variables for study by political scientists: they can be studied using the tools and conventions of social scientific analysis, they have been measured in a quantitative fashion, a large body of work already explains how they relate to human behavior at-large, they represent an integral part of the word, they are collectively experienced and several forces push people towards reaching towards them in a patterned manner, and they are largely exogenous from human behavior.

Linking the Natural and Social Sciences: Success Stories. Put in a simpler way, Aristotle, Rosseau are writing in a different age. These works share a common assumption: that the natural and social sciences are aligned, and that studying the natural world can inform our understanding of the social one**.** These topics are linked. Yet, to a large extent, this idea became less popular are social science evolved into its more modern incarnation. Yet this idea has enjoyed a resurgence in modern work tying the biological to political sciences.

Three recent studies of weather, climate, and individual-level political behavior illustrate these points nicely: Nelson Polsby's work on explaining Congressional ideology (2004), scholarship on turnout on election day, and Achen and Bartels' invigorating look at droughts (2004). While these sorts of studies are exceptions to the rule, they do show how considering weather and climate can be useful from an analytical perspective.

First, Nelson Polsby (2004) provides an account of how climate and human behavior interacted to impact on the ideological makeup of Congress in the post-World War II era. He argues that the rise of the Republican Party in the postwar south was due to the innovation of affordable air conditioning. Northern retirees, preferring warm southern winters to the chilly frosts of the Midwest and New England, began migrating southward in large numbers as air conditioning permitted them to endure hot southern summers in comfort. At the same time, white-collar workers began settling around cities and building large air-conditioned suburbs. These migrants drove the rise of the Republican south and ended the period of regional Democratic hegemony that stretched back to the Civil War. By considering climate, Polsby constructs and tests a new theory explaining an important aspect of American political history.

In the realm of voter turnout, several recent articles have explored how election day weather can stimulate or depress voting. A French study on weather and voting has demonstrated that while rain decreases turnout, sunshine and higher temperatures boost attendance at the polls (Lakhdar & Dubois, 2006). A similar study of American Presidential voting behavior has also concluded that rain and snow can decrease turnout, and even suggests that inclement weather could have played a decisive role in the presidential campaigns of 1960 and 2000 (Gomez, Hansford, & Krause, 2007).

Finally, Achen and Bartels' (2004) case studies on voting behavior demonstrates that citizens actually punish incumbents for natural disasters beyond the government's control, such as a droughts (or a shark attack), provided that people can construct some sort of narrative connecting the government to a natural disaster such as a drought. This account of how natural conditions can directly affect electoral consequences makes two contributions to political science literature. First, it informs our understanding of voting and, more specifically, retrospective voting by pointing to a previously unnoticed basis for evaluating candidates. It also speaks to the limits of voter rationality.

The Plan for the Book. This study aims to breathe new life into an old yet elegant idea; the underlying research hypothesis here is:

Weather and climate are an integral part of the environment in which human beings practice politics, and therefore weather and climate should affect a wide array of political acts.

Yet unlike Aristotle, Rousseau, or Hegel, this study will apply the tools of modern social science to present and test theoretically sound propositions connecting weather and climate to political behavior of interest to political scientists. So, this is a study of how weather and climate affect contemporary political behavior in ways interesting and relevant to mainstream political science. Probing this relationship further informs the understanding of important and well-studied topics, can aid scholars in deciphering complex interrelationships present in the political world, may prompt researchers to reconsider some nuances of existing theories, and, most importantly, and assists political science in its most fundamental undertaking: describing the world as it is.

The goal, then, is to determine the extent to which climate and weather affect political behavior in several likely contexts, including the realms of public opinion, social capital, electoral behavior, and legislator voting patterns. Investigation takes place almost entirely within the United States. America represents an excellent laboratory for this purpose. Its large land area ensures variation in weather conditions during cross-sectional analysis; on a single day such as Election Day, rain, temperature, humidity, and sunlight can vary quite radically from place to place. The United States is also gifted with an array of climates, such as the arid hot deserts of the southwest, the humid heat of the southeast, the temperate climates of the western coast, and the cloudy skies of the midwest. Many places in the United States experience seasonal change, while others do not, which provides further basis for useful comparisons.

The tone here is admittedly exploratory. Although it is guided by published research, the applied method will be both inductive and deductive. In some cases, relationships between weather, climate, and human behavior are quite well-established in the literature and lead to clear hypotheses. Deductive logic is easy here. For instance, numerous studies in laboratories and in the field have noted a strong connection between heat and aggression; riots and violent crime are vastly more likely to occur on very hot days. For the record, Shakespeare noticed this, too, in Act III, Scene I of *Romeo and Juliet*: “I pray thee, good Mercutio, let's retire: The day is hot, the Capulets abroad/And, if we meet, we shall not scape a brawl.” Here, the theory is clear, which leads easily to hypotheses, such as: areas with hotter climates should exhibit low levels of social capital because the climate there makes people angry. Yet, at other times, the literature does not conjure such lucid theoretical launchpads for analysis. For example, while there is some evidence to suggest that higher barometric pressure may boost mood (Goldstein, 1972), other evidence indicates that higher pressure leads to more emergency psychiatric visits (Schory and Pieczynski, 2003) and the increased frequency of intense headaches (Cull, 1981). There is no clear theoretical signpost regarding barometric pressure from which to lucidly hypothesize, and yet measures of pressure are readily available. In cases such as this, inductive logic is a necessary tool--when the literature furnishes no clear hypothesis, data is analyzed to inform existing scholarship or uncover previously unnoticed relationships. Consequently, while conclusions often very neatly bridge theory to data, sometimes they are weak, contradictory, and difficult to justify.

Such is the nature of exploration. With this in mind, theory, data, methods, analysis, and interpretation are presented as clearly and as cleanly as possible. It is, course, left to the reader to develop their own critique of the arguments presented.

Given the complexity of social and the natural worlds, no single work can grip the entirety of the relationship between weather, climate, and political behavior. To make analysis manageable, several likely political contexts are selected: public opinion, social capital and its indicators, mass public voting behavior, and voting in the U.S. House of Representatives. These areas were chosen because they satisfy several desirable criteria. First, in each context, it is at least plausible that weather or climate ought to affect human behavior. Second, these subjects are neither obscure nor arcane: each area is and continues to be well-studied by political scientists. Finally, in each of these realms, uncovering relationships between weather, climate and political behavior represents a contribution to the existing body of scholarship, as this advances the understanding of the subject in a meaningful way, and has implications for how scholars study and think about that topic.

This dissertation is organized in the following way. Chapter I reviews the literature explaining the mechanisms through which weather and climate influence human behavior in ways relevant to political behavior, and wherever possible generates distinct statements tying weather elements to behavioral tendencies. Chapter II builds on this review by generating specific hypotheses regarding how weather and climate should affect political phenomena of interest to social scientists. Chapter III describes the collection and coding of weather and climate data used in this project. Chapter IV begins empirical analysis by investigating how weather affected the responses to Presidential approval questions on Pew surveys throughout 2005. Chapter V focuses on climate and social capital. Chapter VI deals with weather conditions and electoral behavior. Chapter VII looks at how weather influenced abstentions in the U.S. House of Representatives roll call votes between 1991-2005. The final chapter concludes with a summary of results and some closing remarks.

CHAPTER I. HOW WEATHER AFFECTS PEOPLE

Introduction. While modern political science seldom considers the notion that weather or climate could affect political behavior[4], this idea is far from novel. In fact, signposts pointing towards likely connections exist across the scholarly landscape of other disciplines, including criminology, sociology, biometeorology, psychiatry, psychology, education, marketing, and economics. This literature has uncovered and analyzed multiple significant connections between weather, climate, and human behavior. This chapter focuses on those connections that are relevant to political science.

To best review this immense range of knowledge, this chapter is divided into two parts. The first part considers three rather general points about the weather and climate. The first of these merely lays down some terminological boundaries. The second point explores the mechanisms by which weather and climate affect people. Our physiology directly responds to weather and climate stimuli; however, our self-generated conceptions of weather and climate, and our expectations regarding these, also affect our response to conditions. The third point considers the definition of a ‘nice’ day.

The second part of this chapter is divided into segments, each of which explores a distinct relationship between weather, climate, and human behavior. In the following chapter, these statements will be employed to generate specific, testable hypotheses connecting weather, climate, and variables of interest to contemporary political science. This literature review is by no means holistic. Although this chapter focuses on those areas that have been most closely studied and most naturally translate themselves into political science, other good work on weather, climate, and human behavior certainly

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[4] As noted in the previous chapter, there are exceptions here, such as Polsby’s work on the rise of the Republican Party (2004) and several recent articles on weather and turnout on Election Day.

exists, and much of this could well inform our understanding of politics and its study. This review—much like this dissertation—is just a sampling of ideas.

While most of the literature discussed in this chapter dwells upon theories that have been rather securely established and supported across a wide variety of contexts, some of it is unclear in its findings, and can even be contradictory. Some of this leads quite naturally to hypotheses relevant to political science, but sometimes, the connection between certain weather elements and certain human behaviors is very much unknown, with studies reaching opposite or disparate conclusions—the literature on barometric pressure is particularly confounding in this regard. The goal here is to present both facts and scholarly debates, then (in the next chapter) build theories about political behavior that can be tested. And so while some of these theories will have solid foundations, some will be built on shaky ground. This study is, at times, admittedly exploratory rather than confirmatory, and the author hopes that the reader will approach it with that spirit, as well. First, however, three notes require preliminary discussion. First, there is a distinction between weather and climate. Second, climate and weather are both socially constructed concepts. Finally, the effects of weather on human behavior should be seasonally contingent.

Weather versus Climate. Before proceeding any further, some definitional clarification is necessary. This dissertation will at times concentrate on weather, and at other times focus upon climate. While the two are related, they are not strictly interchangeable, and so it important to be clear about this terminology. *Weather* refers to the day-to-day conditions in the troposphere[5] that are attributable to natural forces. Sunlight and rain are weather conditions; water shooting from an irrigation spigot is not. Changes in weather occur due to changes in temperature and air pressure, which are caused by complex interactions between many natural forces, including solar radiation, the movement of the Earth, geography, and pre-existing weather conditions. However, while weather is overwhelmingly driven by natural forces, it is not entirely immune from human influence. Cities tend to create ‘heat blooms’ caused by exhaust and the reflection of sunlight off concrete. This has a warming effect upon nearby air and contributes to ‘hot’ weather. Statements such as ‘it is snowing in Iowa’ or ‘it’s absurdly cold in Iowa’ are both descriptions of weather conditions. The term ‘weather’ can refer to general conditions (‘what lousy weather we’re having in Iowa’) or a very specific subset of those conditions (‘I really wish the wind wasn’t so cold in Iowa.’)

Over time, fluctuations in day-to-day weather conditions tend to form relatively stable patterns. These long-term characteristics comprise *climate*. Over time, many systems for classifying regional climates have emerged, such as the Köppen system, which averages temperature and precipitation to break the world into ‘dry,’ ‘tropical,’ ‘polar,’ and ‘mid-latitude’ regions (eg, Peel, Finlayson & McMahon, 2007). The easiest way to measure climate is to average weather conditions over a long period of time, though classifications can be far more complex than this. For this purposes of this work, climate takes its simplest meaning: the average weather conditions in a given place over a period of

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[5] The troposphere represents the lowest portion of the Earth’s atmosphere, just below the stratosphere. In the summer, it’s about 11 miles high near the equator and around 4 miles high at the poles, though these figures change slightly as the seasons change. Most plant and animal life lives in the troposphere, though some bacteria does live in the stratosphere. Although the vast majority of weather takes place in the troposphere, there is some air and moisture activity in the stratosphere that can meaningfully be called weather, and which does influence weather in the troposphere is also a small amount of weather in the stratosphere.

time exceeding several years. Table 2.1 gives a survey of climate.

The distinction between these two terms will be useful to keep in mind throughout in the literature review below, and will be absolutely necessary in later chapters, when political science-specific theories are constructed, variables are operationalized, and hypotheses are tested.

Biology, Psychology, and the Social Construction of "Normal" Weather.

Another important point merits preliminary discussion. Human beings are biological organisms residing in an environment. Like all living organisms, we react to stimuli in our environment: we shiver in the cold and may jump at loud noises. Unlike other living organisms, however, we develop ideas about what this environment looks like, which conditions our reception and perception of these stimuli. Some of these ideas are collective ones, and they are ensconced in or carried by other elements of our environment, such as newspapers and popular culture. To understand how weather affects human behavior, we must not only consider the biological basis for reactions to weather, but also how our subjective understanding of our environment can affect these biologically-based reactions and, further, can produce reactions independent of biological ones.

The effect of weather upon human behavior can be disaggregated into two components: a *biological component* and a *subjectively-experienced component.* Biological components are reactions to weather elements triggered by anatomical units operating in the human body. These reactions are often difficult, or even impossible, for an individual to consciously control (try staring at the sun, or avoiding shivering during sub-zero temperatures). Examples include the stimulation of the pineal gland by sunlight and sweating in response to high temperatures.

The subjectively-experienced components of weather are somewhat more difficult to describe. Essential, here, is the acknowledgement that, to an individual, weather is not just the sum of wind speed, temperature, and cloud cover; rather, weather also exists as a psychological construct that is *experienced* by an individual. This experience can have a strong effect on mood and disposition: a 'nice' day makes everything else more pleasant, not only because conditions are well-received by the senses, but because we know from books, movies, and art that 'nice' days are inherently pleasant. Experiencing weather also entails experiencing its effects on one's environment. For instance, while rain is unpleasant in itself, it can also affect networks of infrastructure and alter the costs associated with moving from one place to another, which causes frustration and delays. Weather can also enable or hinder pleasurable outdoor activities, which can have a second-order effect on dispositions. To understand how weather affects us beyond simple biological responses, we should examine how weather, as a psychological construction, is understood by people.

One's understanding of weather is shaped by many factors, including personal experience, news reports, conversations with friends, and national culture (Burroughs, 2003; Glanz, 2003; Meyer, 2000; Knez, 2006). One way to examine the subjective understanding of weather in America is to examine its social construction through language. Language, and how weather is used in language, gives weather meaning (Stehr and von Storch, 1995). And a comprehensive analysis of how people employ 153 descriptive words to describe weather at-large suggests that Americans tend to understand weather along roughly twelve dimensions, which in second-order factor analysis load onto two dimensions: weather often is thought of as normal and good or extreme and bad

(Stewart, 2007). This is an important point; 'good' weather a fair and routine weather, whereas 'bad' weather is extreme or inclement weather. Good weather is described as sunny, tranquil, temperate, warm, or cool; bad weather is described as stormy, wet, cold, hot, humid, or windy.

Importantly, our classification of weather as good or bad is subject to *seasonal* variation. One way to explore this is to focus upon information-senders who play an active role in the social construction of the concept of weather, such as newspapers (Rebetez, 1996). In an examination of nearly ten years of front-page articles appearing in a regional Norwegian newspaper, Meze-Hausken observes that the media's classification of days as 'nice' or 'bad' is dependent upon both time of year and expectations (2007). In the winter, levels of sunshine tend to define the pleasantness of days, because people are tired of cold weather and expect weather to continue to be cold. In the spring, both sunshine and temperatures are important, and the benchmark for a 'nice' temperature is measurably lower than in the summer. In the summer, higher temperatures are required to call a day 'nice'—though, here, we should keep in mind that this is a Norwegian summer, where high temperatures reach the upper 80's. Newspaper coverage of summers in the United States is likely different, as temperatures in many places can reach into the 100's.

I have distinguished here between reactions that are primarily *biological* responses to weather and those that are *subjectively experienced* because this distinction is useful in picking apart the mechanisms by which weather affects people. At the end of the day, we will be unable to identify the proportion of human behavior that is affected by biological reaction to weather, and the proportion that is affected by subjectively experienced components of weather. For instance, sunlight boosts Presidential approval ratings in

Illinois through many channels: it stimulates a gland to release serotonin which consequently boosts mood and fosters optimism, it allows people to go boating, it makes people at the post office smile, and Al Roker puts a big happy sun over Chicago.

Why Weather's Effects Can Vary by Season. That weather is a subjectively experienced and processed construct highlights a third important point: the effects of rain, temperature, and sunlight on human psychology should to some extent vary by season. There are several reasons for this. First, the subjective experience of weather leads people to have temporal expectations and desires for weather that vary seasonally. Spring is when activity peaks: people *want* to go outside and enjoy conditions. We look forward to spring throughout the winter to the point where we have ritualized our hopes into a somewhat bizarre national event focused upon whether or not a groundhog named Phil sees his shadow.

Second, even if we set aside the world of subjectivity and expectations, simple statements like "sunlight always boosts mood" or "warmer temperatures are always good" simply do not align with the empirical record. In some cases, what is preferred in one season is not preferred in another--warmer temperatures in winter may be welcome, but warmer temperatures in summer are not, because they push air temperature well above the comfortable mid-70s range. Also, the magnitude of the effect of some weather conditions vary by seasons. For instance, literature on mood, health, and psychology agrees that sunlight and warming temperatures are particularly important in spring. For example, one empirical study on weather and mood notes: "exposure to higher temperatures predicted increased mood during the spring but had the opposite effect on mood during the summer, especially among participants living in southern climates, where high temperatures are increasingly unpleasant" … and that "there appears to be something uniquely uplifting about warm days in the spring" (Keller et al., 2005, p. 730).

Evidence suggests that, in winter, sunlight is the primary weather condition around which people define how they feel about a day (Meze-Hausken, 2007), a point which is consistent with the seasonal disaffective disorder literature which explains how bright sunlight is vital to supporting mood in winter. Consequently, a general theory stating that 'warmer weather always bolsters mood' would be misleading, since warmer weather in summer does not do so. A general statement such as 'sunlight boosts mood' is more acceptable; however, the medical literature points out that sunlight in the winter is particularly efficacious in boosting mood, and we can easily imagine how sunlight during a summer heat wave is less than welcome. Simple theoretical statements do not suffice because weather, and our relationship to weather, is tied in to the rhythm of the seasons. However, *seasonally-contingent* statements fit the pattern of data much more clearly.

With these preliminary notes in hand, we may promulgate theoretical statements.

Heat Leads to Aggression. The systematic application of weather to behavioral phenomena began with Adolphe Quetelet[6]. Quetelet, who was among the first to import the science of probability and statistics from the realm of astronomy to the world of social problems, was a pioneer of the social sciences. Aware of the overwhelming complexity of human behavior and the impossibility of perfectly explaining it, Quetelet sought to develop statistically-derived laws that undergird human behavior. In *Research on the Propensity for Crime at Different Ages*, Quetelet examines the relationship between statistics from the

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[6] Attempts to disentangle the complex relationship between the weather and human civilization stretch farther back than human recordkeeping. Prior to the accession of 'modern' science, weather was revered, mythologized, and even worshipped. As noted in the introductory chapter, great thinkers like Aristotle, Rousseau, and Hegel considered climate in their work, but by modern standards, this mostly amounts to slapdash theorizing. Quetelet was the first to carefully analyze quantitative data on weather and behavior.

French court system and seasonal patterns in temperature (1833). Ultimately, he drives the 'thermic law of criminality,' a social 'law' in two parts. First, the high temperatures of the summer months incite peoples' passions and drive them to violence, thereby boosting violent crime rates. Second, the need to purchase heating oil and clothing during cold periods accounts for an increase in robberies during the winter months (Quetelet, 1833; Quetelet, 1842). Over the next century, early social scientists tested Quetelet's hypotheses across several contexts and largely agree that Quetelet's law explains variance in violence and robbery across both temporal and geographic spans: robbery is more likely in the winter and in towards the Earth's poles, while violence is more common in the summer and in warmer latitudes (eg, Dexter, 1904; Lombroso, 1911; Cohen, 1941).

More recent research continues to support the thermic law. Of the connection between high temperatures and violent crime, one scholar writes, "apart from the criminological universals of age and gender, it would be difficult to find any factor which is so consistently correlated with violent crime" (Fields, 1992, p. 340). Studies of crime rates in American and European cities have noted that cities in warmer climates tend to exhibit higher violent crime rates[7] than cities in cooler climates, even after controlling for cultural factors such as 'a culture of violence' (Anderson, Anderson, Door, DeNeve, & Flanagan, 2000; Rotton & Frey, 1985; Perry & Simpson, 1987; Michael & Zumpe, 1983; Field, 1992; LeBeau, 1988). Seasonal patterns that accord with Quetelet's research are also apparent (Field, 1992). Many of these studies employ methods far more sophisticated than Quetelet, and operationalize actual recorded temperatures rather than dates or latitude. For the record, it is not just criminals that are affected—experimental work has demonstrated that police officers are more likely to shoot at burglary suspects

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[7] Most typically, assaults, though rape, homicide, and domestic abuse are often included as violent crimes.

under hotter conditions (Vrij, Van Der Steen, & Koppelaar, 1994).

In addition to driving violent crime rates, high temperatures can lead to civil disturbances such as rioting. This has received considerable scholarly attention due to report of the U.S. Riot Commission of 1968, also known as the Kerner Commission, which was appointed by President Johnson to explore the root causes of three race-related riots: the 1965 Los Angeles Watts Riot, the Chicago Division Street Riots of 1966, and the 1967 Newark Riots. The Watts Riot began during a relatively routine traffic arrest of a black subject by a white highway patrol officer; onlookers gathered, events quickly escalated, and over the next six days 34 people died, 1,032 were injured, and 3,952 were arrested. The Division Street Riots began during the city's first downtown Puerto Rican Parade, as a response to the shooting of a young Puerto Rican man by a white Chicago police officer. Six days of rioting in Newark were sparked by the arrest of a black cabdriver. While the Kerner Commission spent most of its energy exploring the deep-seated racial anxieties undergirding American urban life at the time[8], the Commission did note that the majority of riots occurred on days when the temperature rose over 80 ° F, in heat-wave or near heat-wave conditions. Sociologists and psychologists jumped on this particular piece of the commission's report and subjected the apparent connection between heat and rioting to a variety of tests. Experimental work conducted as a direct response to the Kerner Commission finds that high temperatures lead to aggression in a rather linear fashion, particularly when coupled with insulting information (Palamarek & Rule, 1979). Other experimental work suggests a curvilinear relationship between temperature and rioting (Baron & Ransberger, 1978). However, one subsequent study focusing on violent crime

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[8] The commission famously noted, "our nation is moving toward two societies, one black, one white—separate and unequal."

rates and temperature dismisses the curvilinear theory (Carlsmith & Anderson, 1979).

The mechanism by which high temperatures and violence are connected is not perfectly understood, but two explanations have been offered. First, higher temperatures may lead to greater outdoor activity, which increases the number of potential victims who are vulnerable to attack (Cohen & Felson, 1979). Second: higher temperatures directly increase levels of human aggression because extreme levels of heat cause uncomfortable sensations that resound through both the mind and body (Anderson, 1989; Michael & Zumpe, 1983). These unpleasant sensations can activate the human “fight or flight response,” which—depending on how the pain is understood as well as the presence of absence of other concurrent stimuli—often leads to aggression (Berkowitz, 1993).

Whatever the case, both the literature on riots and violent crimes provide compelling support for Quatelet’s thermic law. This support takes a variety of forms, from experimental work to statistical studies of real-world patterns. Moreover, this research indicates that the relationship between heat and human aggression are by no means limited to assaults and rioting; they affect a wide variety of human behaviors where aggression can occur. For instance, baseball pitchers are more likely to hit batters with a pitch on hot days than on cool days (Reifman, Larrick, & Fein, 1991). Drivers in Phoenix, Arizona, are more likely to honk their horns at hotter temperatures (Kenrick & MacFarlane, 1984). Given that there is a strong relationship between the sociologically and politically relevant variables of rioting and violent crime, and given that the relationship between heat and aggression is not limited to these areas, it is rather surprising that studies have not attempted to tie heat to other important variables of interest. This study aims to fill that gap.

While a large body of literature surrounds the first part of Quetelet's thermic law, the second has been studied with less interest, perhaps because its ramifications are less dramatic than race riots and noontime assaults. However, a wide range of studies suggests that, indeed, cold temperatures are associated with robbery. Most links are apparent in seasonal, but not geographic, terms; while cooler nations do not seem to exhibit systematically higher levels of robbery, robbery does spike as temperatures drop in the wintertime across a multitude of contexts, such as The Netherlands (Van Koppen & Jansen, 1999; Jammers, 1995), Israel (Landau & Fridman, 1993), and Great Britain (Field, 1992). The frequently-advanced explanation comports with Quetelet: the demand for heating fuel and clothing created by winter's chill pushes the disadvantaged towards robberies (Sutherland, 1987; Landau & Fridman, 1993; but see Van Koppen & Jansen, 1999). Cold weather does not incite passions the same way that heat does, and indeed, studies do not show that cold temperatures lead to violent crime. However, experiments have tied colder temperatures to aggression. Yet, in contrast to aggression caused by heat, this aggression was "more instrumental and appropriate to the situation" (Boyanowsky, Calvert, Young, & Brideau, 1981, p. 85).

This smaller body of literature confirms Quetelet's earlier analysis. Cold weather may, in the aggregate, increase economic need by driving heating costs. It also has an independent effect on people, which can stimulate them towards the instrumental application of violence.

Extreme Cold, Heat and Humidity are Uncomfortable. While studies of temperature and crime have been fruitful, they do not comprise the totality of scholarly research on temperature and human behavior. A second, immense, and considerably more general body of literature—one largely separate from the research focused on violence, riots, and robbery—explores how, why, and the extent to which heat and cold pattern human behavior. The goal of these studies has not been to confirm or disconfirm trends in crime or urban unrest, but rather to explain how temperatures affect our dispositions, comfort, health, and lives. And while the results are far less dramatic than the correlation between rioting and heat, this literature explains why very cold or very hot temperatures make us feel outright uncomfortable. This feeling of unease is not insignificant, as it could easily prevent people from engaging in activities (like voting), or make life unpleasant for people engaging in political behavior in ways that affect what they do and say (such as responding to a telephone poll about political beliefs).

Although we are warm-blooded creatures,[9] we find hot or cold temperatures to be uncomfortable. Our bodies can survive in an array of thermal environments, and, over centuries, populations can even evolve features that make life more comfortable for them, given the range of conditions that those populations face. We have also adopted technological and cultural adaptations to help us weather uncomfortable conditions, such as air conditioning, or the *siesta*[10]. However, despite our flexibility, our biological makeup mandates that humans find a range of temperatures to be pleasant or at least acceptable, and that temperatures beyond this range are registered as uncomfortable—and, in the extreme, dangerous. This physiological response is grounded in evolutionary processes that took place over the course of our adaptation to temperate and tropical climates; our definition of a ‘nice’ temperature and our aversion to extremes is so

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[9] Unlike reptiles or fish, we can regulate our body temperatures to adjust to changes in environmental temperature.

[10] An extended mid-day period of rest common in Spain and some South American countries, where people rest during the hottest hours of the day.

second-nature because it is a consequence of our evolution as a biological species. While scholars would be hard-pressed to locate an ‘optimal’ temperature for comfort, one pair of researches suggests that performance on memory-related tasks is optimal at about 72 ° F, and declines at warmer and cooler temperatures (Allen & Fischer, 1978). Others have suggested that mood peaks outdoors at around 67.4 ° F (Keller et al., 2005). Experimental evidence shows that when core body temperatures are raised to above 101 ° F[11] via immersion in hot water tanks, subjects register visible irritability and report themselves to be irritable (Holland, Sayers, Keating, Davis, & Peswani, 1983).

Our physiologically-grounded affinity for temperatures that we perceive to be mild and aversion against temperatures that we believe to be extreme are encapsulated by a term known as ‘thermal comfort’. It is defined as “the condition of mind in which satisfaction is expressed with the thermal environment” (American Society of Heating, Refrigerating, and Air Conditioning Engineers, 1966). While ‘dry-bulb’ temperature—that is, the temperature reading on a mercury thermometer—is an important aspect of thermal comfort, other air conditions contribute to whether we think a day is too hot, too cold, or too mild. Though measurement varies, thermal comfort is generally regarded to have six components: humidity, air velocity, air temperature, radiant temperature, metabolic heat, and clothing insulation. Humidity is especially important, as it has been inversely associated with self-reports of elation, affection, vigor (Sanders & Brizzolara, 1982), concentration, and alertness (Howarth & Hoffman, 1984). It is impossible to measure actual levels of thermal comfort without close observation due to variance in factors such like body size, metabolism, clothing, and the amount of light reflected by nearby objects. However, measurements of temperature, humidity, and wind are readily available, and can

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[11] Well above the normal range of 97 – 99.

be combined into a single measure using a well-established formula. This ‘apparent temperature’ provides a good estimate of what temperature the air ‘feels-like’, and can tell us if people are hot and miserable, freezing and annoyed, or enjoying a temperate day; it is discussed in greater detail in Chapter IV. For now, the important point is this: when people are exposed to very high or very low adjusted temperatures, many will grow irritable, cranky, and uncomfortable.

While this physiologically-based preference for mild temperatures is important, extreme temperatures have other, somewhat less direct effects on human beings. First, outdoor temperatures can regulate levels of outdoor activity; lousy air temperatures can be frustrating and annoying because they prevent people from venturing outside and restrict the range of possible activities (Palutikof, Agnew, & Hoar, 2004; Suminski, Poston, Market, Hyder, & Sara, 2008). While seasonal climatic trends can be annoying (‘oh no, it’s winter in Iowa, time to put the Frisbee away and stay indoors for four months’), heat waves or cold spurts can be even more irritating (‘aw, spring Frisbee was canceled today because it’s 110 F in Iowa City’). Further, lower levels of outdoor activity and physical exercise—which can be a consequence of extreme summer heat or blistering cold—has a depressive effect on human health and, by extension, happiness (United States Department of Health and Human Services, 1996; 2000). Extreme cold can require special proscriptions, such as layers of clothing or water bottles, which add a nuisance to the ebb and flow of everyday life.

Temperatures can have more direct effects on health, as well. Colder temperatures have been associated with higher reported incidences of respiratory infections (Nastos & Matzarakis, 2006) and can cause diseases of the bone and joints such as arthritis to flare up

(Besancenot, 2001; see also McGregor, 2001). Extremely hot temperatures are also associated with cardiac and cardiovascular disease (McGregor, 2001). Humidity is important here, too. Dry conditions are generally associated with better health. Low levels of humidity correspond with low rates of reported incidents of respiratory infections (Nastos & Matzarakis, 2006), as well as depress rheumatism and other diseases of the bones and joints (Besancenot, 2001; McGregor, 2001). Dryness can lead to greater physical activity (Merril, Shields, White, & Druce, 2005), which has a net positive influence on health.

Extremely hot temperatures can pose quite dramatic health risks that are dangerous and threatening. In America, heat waves—sustained periods of extremely high temperatures—can have devastating consequences on health, and account for more deaths than all other natural disasters combined (National Climatic Data Center, 1996; Klinenberg 2002). This is particularly true among the elderly, who are quite vulnerable to health hazards such as heat stroke (Sheridan, 2007). Importantly, heat waves are also *perceived* as dangerous, especially when coupled with heat warnings commonly issued by local National Weather Service bulletins (Kalkstein and Sheridan, 2007; Sheridan, 2007). This can be frustrating and annoying to people.

In summary, this patch of the literature shows that there are a variety of concrete reasons why very high and very low temperatures are associated with discomfort. One level, people have a simple negative physiological reaction to temperatures beyond the mild range. Beyond this, extreme temperatures restrict outdoor activity, which can be frustrating and annoying. Very high or very low temperatures also cause health problems, which lead to discomfort. For all these reasons, people feel and behave differently on days with mild temperatures than on days with more extreme temperatures.

Sunlight Makes People Happy and Prevents Depression. Sunlight is electromagnetic radiation produced by the sun and filtered through the atmosphere[12]. It is closely linked to three important substances present in the human body: serotonin, melatonin, and cortisol. Serotonin is a chemical known as a neurotransmitter, a sort of relay station between the neurons[13] in the brain (as well as some other nerves) and cells located elsewhere in the body (typically, other neurons, muscles, or glands). Nerves talk to other cells through electrical synapse,[14] which is enabled by neurotransmitters like serotonin. Serotonin is a vital link in the pathway through which the brain issues orders: when we are hungry, tired, sexually aroused, or need to vomit, serotonin is carrying messages back and forth between the brain and affected parts of the body. Serotonin also exerts a calming effect on the body as a whole. Problems with serotonin levels, such a deficiency in serotonin production or an inability to receive serotonin, have long been linked to clinical depression and depressed moods (Peirson & Heuchert, 2000; Williams, Stewart-Knox, & Helander, 2006). Many major prescribed antidepressants, such as

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[12] Crudely speaking, it consists of three parts: ultraviolet radiation, which can be harmful to humans, the visible range, which is the portion of radiation that accounts for light, and the infrared range, which produces warmth. The sun fuels nearly all life on earth. Plants convert solar radiation into simple sugars, which are in turn consumed by animals. Gas wastes produced as a byproduct of photosynthesis are a crucial building block of the air we breathe.

[13] Neurons are cells in the central nervous system that send and receive information about stimuli. Heat, cold, and pain are first registered by neurons in the skin. These neurons send this information to the brain or spinal chord, where it is received by neurons located there.

[14] Neurons are connected at points called synapses. Signals are carried from neuron to neuron by electrical charge, which is carried across atoms such as potassium and sodium. An atom consists of a stable nucleus (protons and neutrons), but is surrounded by electrons that can jump between nearby atoms. In a neutral state, an atom consists of the same number of protons and electrons. However, when the number of electrons exceeds the number of protons, an atom is called an ion, and that ion is negatively charged. When the number of protons exceeds the number of electrons, that ion is positively charged. When electrical signals are carried from neuron to neuron, they are carried across channels of potassium and sodium ions which shoot across synapses. When the charge carried by these channels reaches a certain point, the receptor neuron ‘opens’, and the sending neuron dispatches neurostransmitters which ‘activate’ the receiving neuron. This ‘activation’ has different effects, depending upon the type of cell activated.

Prozac, work to boost serotonin levels. Levels of serotonin are directly boosted by the hours of bright sunlight present in a day (Lambert, 2002; Snyder, 2006).

This is because, in the darkness of night, serotonin is synthesized with a certain enzyme[15] and converted to melatonin. This occurs in the hypothalamus, where information about the daily pattern of light and darkness is received from the retina. Melatonin is a hormone responsible for the regulation of circadian cycles, and the synchronization of those cycles to an environmental clock. Melatonin tells our body to relax at night because this is the ‘right’ time for sleep.[16] Melatonin is also a powerful antioxidant, which bolsters the immune system (Mead, 2008). It is secreted by the pineal gland as well as the retina and some portions of the GI tract. This occurs primarily in darkness, and the process of melatonin release is inhibited by light. Because melatonin is synthesized from serotonin, adequate periods of both light and dark are necessary to keep serotonin and melatonin in-balance (Snyder, Borjigin, & Sassone-Corsi, 2006). One biological basis for seasonal affective disorder (SAD) is believed to be the excess of melatonin produced during prolonged periods of winter darkness (Lewy, Sack, Miller, & Hoban, 1980; Rosenthal et al., 1984; Wehr et al., 2001).

Another important substance here is cortisol. Cortisol is the natural form of hydrocortisone, a popular over-the-counter anti-inflammatory and anti-allergy medication. It is secreted by the adrenal gland, and it performs a variety of functions that help maintain homeostasis, or smooth operation of bodily systems. In particular, cortisol works to restore organ operation after periods of stress. Cortisol levels are regulated by our circadian rhythms, and are thus intimately related to the cycle of light and dark.

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[15] 5-hydroxyindole-O-methyltransferase

[16] Humans cannot see well in darkness, and thus evolved simply to sleep the dark time away.

Decreased exposure to sunlight can truncate daily cortisol cycles (Wehr, 1998).

The importance of these three substances and their relationship to cycles of daylight and nightfall form the basis for recent scholarship on seasonal affective disorder (SAD), argues that lower levels of sunlight in the winter lead to a network of symptoms wherein the afflicted feel quite ‘down’ through the duration of the season (Magnusson & Boivin, 2003). The duration of daylight in days between September and May relates to depression, as measured by the Beck Depression Inventory: the longer the day, the less the depression (Molin, Mellerup, Bolwig, Scheike, & Dam, 1995). SAD is often conceptualized as part of a broader pattern of mood fluctuation that troughs during the winter (Harmatz, Well, Overtree, Rosal, & Ockene, 2000). It is associated with memory impairment (Allen & Fischer, 1978; Michalon, 1997) and is particularly prevalent in the north, where cold winters last longer (Kasper, Wehr, Bartko, Gaist, & Rosenthal, 1989). Recent scholarship in the health care community has suggested that exposure to light can significantly reduce the severity of SAD in susceptible individuals. Various studies have recorded considerable success with using artificial sunlight to treat winter SAD (Thalen, Kjellman, Mokrid, & Wetterberg, 1991; 1992; Lam et al., 2006; Glickman, Byrne, Pineda, Hauck, & Brainard, 2006; Kripke, 1998; Stain-Malmgen, Kjellman, & Aberg-Wistedt, 1998), even among those who are not depressed (Leppamaki, Partonen, & Lonnquist, 2002).

Yet although the SAD literature focuses on the length of daylight relative to nighttime as the key causal component of SAD, exposure to bright sunlight during those daylight hours has also been shown to mitigate SAD symptoms (Lambert, 2002). Presumably, this is because exposure to direct sunlight reduces the production of melatonin while stimulating the production of serotonin, which has the effect of boosting overall mood (Peirson & Heuchert, 2000; Williams et al., 2006). Direct exposure to sunlight has other positive effects, as well. Sunlight energizes people, and makes them feel less tired (Denissen, Butalid, Penke, & Van Aken, 2008). There is also specific behavioral evidence that higher levels of actual sunlight contribute to helping behavior, such as tipping well and assisting an interviewer (Cunningham, 1980). People are generally happier and more cheerful when the weather is sunny, and when hours of daylight are longer.[17]

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[17] The literature on SAD suggests that the relationship between sunlight and mood should be straightforward: as levels of sunlight drop due to seasonal change or geographic location, mood should drop accordingly. Yet suicide—perhaps the ultimate expression of depression—peaks in the *springtime*, just as levels of sunlight are increasing. This is an empirical regularity that persists in nearly all nations and across both hemispheres (Dublin, 1963; Lester, 1979; MacMahon, 1993; Bollen, 1983; Maes, Cosyns, Meltze, & Peeters, 1993; Yip, Chao, & Chiu, 2000). Moreover, the risk of spring suicide is substantially larger in countries closer to the tropics, where total hours of daylight are longer (Petridou, Papadopoulos, Frangakis, Skalkidou, & Trichopoulos, 2002). Other studies have shown direct links between exposure to sunlight (independent of hours of daylight) and suicide (Preti, 1997; Souetre et al., 1990). Higher *total* hours of sunlight have been shown to explain decreased suicide rates among countries (Nishimura et al., 2004; Terao, Soeda, Yoshimura, Nakamura, & Iwata, 2002; but see Watson, 2000), while above-average levels of sunshine reduce suicide rates in Sacramento County, California (Tietjen & Kripke, 1994). These findings may seem at-odds with the SAD literature. Some explanations suggest that hours of daylight, rather than sunlight or weather contributes to suicide. This line of reasoning suggests that alterations in circadian rhythms caused by the changing duration of night and day creates instability and disorder in one's natural cycles of rest and activity (see Czeisler et al., 1999; Taillard, Philip, Chastang, Diefenbach, & Bioulac, 2001), which can contribute to suicide. In the seminal work of sociology, *Suicide*, Emile Durkheim expressly rejects both increased heat and sunshine as causal factors of suicide ([1897] 1951). Instead, he focuses on the spike in intense social activity during the spring and summer months: "everything begins to awake; activity is resumed, relations spring up, and interchanges increase" (p. 119). This creates a sensation of a 'new beginnings'; however, when the hopes and aspirations of springtime are not met, suicide can be the result (see also Gabbenesch ,1988). Here, the effect of weather is mediated by social conditions in the aggregate, and the manmade construct of 'spring.' Thus, while the SAD literature suggests that higher levels of sunlight should boost moods and lead to the expression of more 'positive' public opinion, the literature on sunlight and suicide could be read to lead to more confusing predictions. Yet the spike in suicide rates in spring is not necessarily problematic for this assertion, either because the heat of spring and summer leads to increases in *violence* rather than suicide, and/or because the sunlight of spring is coterminous with a swelling of social activity and the subjective construct of 'spring' (which involves obligations and aspirations).

Sunlight Leads to Optimism and Risk-Acceptance. A fascinating and related discussion regarding weather and human behavior can be found in the economics literature, where scholars have examined the role of weather on stock trading[18]. Saunders (1993) has suggested that the amount of sunshine in any given New York day influences stock trading on the NYSE, noting of traders "because they assemble at the same location daily, a strictly local mood variable has the potential to affect this group" (p. 1337). In comparing daily values of sunshine[19] to the Dow Jones Industrial Average and changes in the New York Stock Exchange/American Stock Exchange Index, Saunders observes that people trade more on very nice days (when cloud cover is in the 0-20% range), as opposed to days that are entirely cloudy. The idea that meteorological forces may affect economic phenomena is not a new one; economists have long toyed with the idea that rain may affect stock trading because poor weather reduces shopping and drags down transportation networks (Jevons, 1882) Saunders' conclusions are consistent with experiments in decision-making, which have also shown that positive moods—which can be induced by a sunny day—can cause individuals to overestimate probability of positive outcomes, while negative moods are associated with an overestimation of negative outcomes (Johnson & Tversky, 1983; Isen, 1993; Hockey, Maule, Clough, & Bdzola, 2000; Leith & Baumester, 1996). This idea is particularly prominent in the marketing literature, which frequently suggests inducing a positive mood in customers (via displays, slogans, jingles, etc.) in order to reduce the risk involved in purchasing new products (Blackwell, Miniard, & Engel, 2001; Park, Lennon, & Stoel, 2005).

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[18] I focus here on sunlight. However, other weather phenomena has also been explored by economists. Wind and temperature seem to have an effect on the New Zealand stock market (Keef & Roush, 2002). High temperatures have been associated with apathy, less risky behavior, and hence negative returns (Cao & Wei, 2005).

[19] Taken in Central Park from 1927 – 1960, and LaGuardia field from 1960 – 1989.

Saunders' findings have not been unchallenged. Trombley (1997) revisits his data and accuses him of cherrypicking, noting that dividing clouds into three quantitative ranges (0 – 19.9%, 20% - 99.9%, and 100%) is the only such division that yields a significant relationship between cloud cover and trading. Others have found no such relationship at the stock exchanges in Frankfurt, Madrid, and Istanbul (Kramer & Runde, 1997; Pardo & Valor, 2003; Tufan & Hamarat, 2004). Goetzmann and Zhu (2003) have examined investor behavior in five major U.S. cities over a six-year period, and found no difference between the propensity of individuals to buy or sell stocks on sunny as opposed to cloudy days; however, the authors do note that the daily bid-ask spread for New York widens on cloudy days, and narrows on sunny days, suggesting that sunlight may influence market-makers such as the New York media and floor traders, but not investors.

Loughran and Schultz (2004) agree that orders come to the NYSE from all over the world, and not just New York; thus, measurements of weather in NYC should not affect all investors. Assuming that most trading on publicly-owned companies originates in cities where those firms are headquartered (because all else equal investors both hold and trade substantially more shares in local companies than in other firms [see Coval & Moskowitz, 1999; Grinblatt & Keloharju, 2001]), the authors look at the relationship between the weather in those cities and trading volume of stocks whose companies are headquartered in those cities. Although they find no relationship between local cloud cover and the volume of stocks traded, they note that the trading volume of stocks decreases when blizzards occur in those cities.

Yet other studies have provided compelling support for Saunders claim. Hirshleifer and Shumway (2003) take a comparative approach, and compare daily cloud cover in cities where stock exchanges are located with stock returns in 26 different countries over a fifteen year span. As a control for normal regional and seasonal trends, they subtract the average cloud cover in each location for that week from the observed cloudiness. Both OLS and logistic models confirm that cloudiness has a negative effect on returns. Kamstra, Kramer, and Levi (2003) have focused on the actual hours of sunlight, and found—consistent with scholarship on SAD—that seasonal trends in night and day do explain some variance in market trading, with greater hours of daylight being associated with more trading, even after controlling for other seasonal effects; in a separate paper, Kamstra, Kramer, and Levi (2000) have argued that changes in waking hours associated with daylight savings time have had similar effects. Finally, Chang, Nieh, Yang, and Yang (2005) have argued that stock returns are boosted by sunlight, as well as being repressed by extremely hot and cold temperatures.

Against the backdrop of this dissertation, it is especially significant that sunlight may affect stock returns. Like political behavior, economic behavior is largely driven by human beings seeking positive benefits from the world around them. And like political activities such as voting, protesting, or expressing political beliefs, choosing whether to buy, sell, or hold onto stocks is a rationally-driven aspect of large-scale organized social behavior. Arguably, economic behavior should be *more rational* than many political behaviors, and so a weather-effect does seem even less likely in this environment; this is said with a grain of salt, though, as the author is aware that using the term ‘rational’ in this way (or any way at all) is an invitation for polemic from any number of warring academic camps. Given the parallels between economic and political behavior, the apparent relationship between weather and stock returns suggests that weather and some political behavior ought to be related, as well.

Weather and Infrastructure-Inclement Weather Slows People Down. Another important role weather plays in shaping political phenomena is determining how quickly people can go from place to place. Within the political science tradition, several recent studies have demonstrated convincing links between weather and voting turnout. A French study on weather and voting has demonstrated that while rain decreases turnout, sunshine and higher temperatures boost attendance at the polls (Lakhdar & Dubois 2006). A similar study of American Presidential voting behavior has also concluded that rain and snow can decrease turnout, and even suggests that inclement weather could have played a decisive role in the presidential campaigns of 1960 and 2000 (Gomez, Hansford, & Krause 2007),[20] and point that SES (Almond & Verba 1963; Verba & Nie 1972), rational choice (Downs 1957; Riker & Ordeshook 1968), and mobilization models (Rosenstone & Hansen 1993) agree that the costs of voting are an important element in the decision to vote, and that:

> "uncomfortable weather may make waiting in line a less desirable activity. Roads soaked by rain or perhaps covered by snow may make for a more hazardous journey to the polls. Again, these are not major costs. But for many citizens, the imposition of an additional minor cost may make the difference between voting and abstaining" (Gomez et al., p. 652).

More generally, precipitation can cause the cancellation of planned events and restrict the scope of possible activities, which could well have a depressive effect on attitudes. Such cancellations are interesting to note in their own right: people may, for instance, protest less in places where frequent rain discourages outdoor protesting.

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[20] Knack (1992), however, has found that rain reduced turnout only among those who score low on the NES civic duty index.

Barometric Pressure: A Mixed Record. Barometric pressure, crudely put, is the weight of air. It represents the sum total of the downward pressure exerted by the molecules in air at any given point. Pressure tends to be highest at sea level and weaken as altitude increases. The role that barometric pressure plays in affecting human behavior is difficult to decisively classify for two reasons. First, barometric pressure can also indicate other weather conditions, which makes parsing out the independent effects of pressure, and the effects of concurrent weather conditions, somewhat difficult. Second, its independent effects on human behavior are poorly understood.

Typically, low levels of barometric pressure are associated with cloudy weather and precipitation; higher pressure indicates clearer skies and fairer weather. Areas of high pressure are constantly 'falling' as air molecules descend to the earth's surface. This process tends to warm them, which increases the amount of energy in the air, which enables air to hold moisture more easily, which prevents clouds from forming or rain from falling. This is why higher pressure generally indicates fair and calm weather.

However, this is not always the case. First, if the air near the earth's surface is warm enough, it may cause some air to rise despite overall low pressure; this rising causes the air to cool, which scan form clouds. Second, temperature affects how pressure causes rain and clouds. Warmer temperatures energize electrons in air and allow air molecules to move further apart. While this decreases air pressure by making it less dense, the energy created by heat enables these molecules to bond more easily with water, and thereby to hold in precipitation. Cooler temperatures reduce the overall energy in air, which causes the release of moisture. In general, because air in high pressure areas tends to warm as air settles towards the surface, high pressure usually means fair days, but this is modified by temperature at the surface level. In areas of low pressure, on the other hand, the air rises. As it distances itself from the warmth of the earth's surface, it cools. If the air holds moisture, it will begin to 'sweat' out this moisture as clouds or rain. This is why low pressure generally indicates wet weather. However, this is also dependent on temperature[21]. The interconnectedness between pressure, precipitation, wind, and temperature makes it difficult to parse out the independent effects of barometric pressure from the effects of other weather phenomena.

To add to the confusion, the independent influence of barometric pressure upon human behavior has been poorly visualized. Several claims have been made, but unfortunately, the record here is far from clear (forgive the pun). In the health sciences, scholars have focused on how pressure affects the body, particularly in sufferers of chronic bone and muscle disorders. Yet despite anecdotal patient evidence barometric can affect pain levels, studies aimed at uncovering connections between pressure and suffering in patients with rheumatoid arthritis, fibromyalgia, and edema have arrived at null findings (Blecourt, Knipping, & Voogt, 1993; Noddeland & Winkel, 1988). However, others have pointed out that changes in barometric pressure can indicate pain (McAlindon, Formica, Schmid, & Fletcher, 2007).

Of course, at extremes, the effects of pressure are much clearer. One study on the extremely high levels of pressure experienced by deep sea divers notes that high "barometric pressure produces a narcotic effect on man" (Behnk, Thomas, & Muty, 1935). In mountain climbers ascending to very high altitudes, barometric pressure can create anxiety (Shukitt-Hale, Rauschy, & Foutch, 1990).

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[21] Where two masses of high and low air meet, winds tend to be stronger as they blow in attempts to equalize pressure. If there is moisture in the air, this may develop into a stormfront.

Psychological studies have procured mixed findings, as well. One study has noted that atmospheric pressure has no effect on depression (Molin et al., 1995). Yet others have argued that high levels of barometric pressure are associated with better moods (Goldstein, 1972). Pressure has also been associated with higher emergency psychiatric visits (Schory & Piecznski, 2003). However, lower barometric pressure is related to less intense headaches (Cull, 1981; but see Schulman, Leviton, Slack, Porter, & Graham, 1980).

With respect to politically relevant behavior, the scholarship on barometric pressure does not lead to a particularly clear theoretical statement of how barometric pressure affects people. Amid all of the negative findings, there is some evidence that higher barometric pressure is associated with better moods, though lower pressure could be related to weaker headaches and less anxiety, manifested in lower emergency psychiatric visits. Since barometric data is readily available, it will frequently be analyzed in later chapters, with an eye to contributing to this literature.

Nice Weather Fosters Positive Moods. This section takes a more strictly psychological tack than the previous section, and examines how that 'nice' weather[22] positively impacts mood. Certainly, there is some overlap between this statement and the content of the preceding sections. For instance, very hot temperatures make people uncomfortable, which can worsen moods. Also, the mechanism by which sunlight increases stock trading is mood: sunlight warms moods, stimulating optimism and fostering increased trading. However, the connection between 'nice' weather and positive moods represents a claim distinct from the relationships described previously, and leads to distinct hypotheses regarding political behavior. Consequently, it is examined in great

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[22] Suggestions for concretely measuring this are suggested in the following section.

detail here.

Mood is a concrete concept in the psychology literature. It is “an undirected evaluative mental state which temporarily predisposes a person to interpret and act towards a wide variety of events in ways according with its affective content” (Parkinson, Totterdell, Briner, & Reynolds, 1996). In some ways, mood is similar to emotion: both have an affective component, are frequently expressed (for instance, through tone, posture, or language), and are associated with physiological changes (such as alterations in hormonal production, the function of the immune system, or metabolism) (Larsen, 2000). However, mood is quite distinct from emotion in terms of duration and intensity. Emotions are “responses to specific events localized in time,” while moods are background feelings “not about anything in particular” (Parkinson et al., 1996, p. 14; see also Larsen, 2000). Mood is also less intense than emotions, and is not focused on any particular object (Frijda, 1994; Morris, 1989; Watson & Clark, 1994; Ekman, 1994).

Moods influence individuals by “altering our affective, cognitive, and behavioral responses to a wide array of objects and events” (Morris, 1989, p. 2) and are “the backdrop against which the rest of our psychology gets played out in everyday life” (Larsen, 2000, p. 130). A mood may be described simply as ‘good’ or ‘bad,’ but can also be more specific, such as an angry mood, or a fearful mood. Generally, however, moods are thought of as more general than this, and may be simply described by their positive or negative valence

(Winkielman, Knutson, Paulus, & Trujilo, 2007)[23].

Often, mood affects behavior by influencing it in a way consistent with that mood. This works at many stages of thought. First, people tend to selectively attend to information that is consistent with their present mood (Bower, 1981; 1983). People in good moods tend to pay closer attention to positive attributes of objects, interpret details in a positive light, and retain positive memories of those details later (Erber, 1991; Forgas & Bower, 1987; Clark & Waddell, 1983). Experimental subjects in sad moods will spend more time looking at sad scenes (such as funerals and disasters) than subjects in good moods (Bower, 1983). Further, people in a good mood tend to express greater optimism (Johnson & Tversky, 1983; Wright & Bower, 1992). Fearful moods lead to pessimistic estimates (Lerner & Keltner, 2000). It has also been suggested that good moods lead to greater cooperation (Baron, 1993; Oakley & Jenkins, 1996; but see Forgas, 1998; Hertel, Neuhof, Thuer, & Kert, 2000).

Mood can also strongly influence the recall of memory, prompting individuals to recall memories consistent with their present mood (Bower, 1981; 1983; Lewinsohn & Rosenbaum, 1987). When a positive mood is present, positive material is more likely to be accessed from memory; when a negative mood is present, negative material is more likely to be accessed from memory (Bower, 1983; Kimble, Hansen, Cooper, & Hartman-Bowers, 1992; Natale & Hantas, 1982; Singer & Salovey, 1988; Lewinsohn &

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[23] Some scholars argue that mood and emotion are so similar that they ought to be used interchangeably (Barry & Oliver, 1996). A similar line of reason simply defines mood as a long-lasting emotion (Lazarus, 1994). One empirical study has even shown that self-reported emotion and mood scales are essentially identical (Mayne, 1999). Without maligning such approaches, I retain the more ‘traditional’ distinction between mood and emotion because it is, theoretically speaking, useful here. Weather should not inflict an intense emotional response; in general, people simply don’t have the same level of emotional engagement with cold wind as they do with, say, the discovery that their spouse is unfaithful. Weather is relevant to public opinion response not because it provokes a powerful emotional response, but because it affects background affective states—that is, mood.

Rosenbaum, 1987; Kahn & Isen, 1993). In the language of schema theory, one explanation for this finding is that positive or negative moods stimulate nearby nodes of information encoded with similar affective content. Others have suggested that mood influences judgments not by causing associations, but by eliminating certain cognitions from consideration; this line of reasoning posits, for instance, that negative memories do not directly stimulate negative memories, but rather restrict the retrieval of positive memories (Forgas, 1992; Weiss & Cropanzano, 1996)**.** Experimental evidence here demonstrates that good moods decrease the verbal fluency with which people describe negative future events, while bad moods have a similar effect for positive future events (Hepburn, Barnhofer, & Williams, 2006). Another interesting explanation for the association between mood and the retrieval of affectively similar content is that mood serves as a substitute for information when information is lacking (Schwarz, 1990).

Regardless of the mechanism at work, “the most common and predictable finding is that pleasant moods tend to bias perception, thinking, judgment, memory, and action towards evaluative positive content” (Parkinson et al., 1996, p. 72). Of course, these effects are not deterministic, and “it appears that the nature of the target, features of the judge, and characteristics of the situation, can all have a significant mediating influence on the quality and extent of mood effects on judgments” (Forgas, 1995, p. 40; see also Schwarz & Bless, 1991; Fiedler, 1988). The finding that negative moods cause a similar bias is also consistent. Political psychologist Rose McDermott (2004, p. 695) sums up the universality of this relationship[24]: “These effects reliably take place in a wide variety of domains, including individuals’ recall and evaluation of prospects for the future, the likelihood of bad or good things happening in the future, accepting positive and negative feedback about their personality, explaining successes and failures, and estimating personal skills”

Despite the prevalence of mood congruence, moods can also affect attitudes in directions that oppose expectations. Isen and Levin (1972) demonstrate this *mood incongruence* by showing that although bad moods often decrease the probability of helping another individual, they sometimes cause the opposite to occur because, in helping others, people may relieve their own negative affective states (see also Erber & Erber, 1994; Parrott & Sabini, 1990). Smith and Petty (1995) report that individuals with higher-self esteem tend to do this with greater frequency. The frequency of mood incongruence relative to mood congruence is rather low.

In what psychologists term *mood regulation*, moods are controlled by an individual through both conscious and unconscious channels. Often, people seek to relieve bad moods by turning them into neutral or good moods (Manucia, Baumann, & Cialdini, 1984; Mayer, Salovey, Gomberg-Kaufman, & Blauney, 1991). People may also develop patterns of behavior designed to keep bad moods from appearing in the first place (Larsen,

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[24] Two aspects of the relationship between mood and the expression of beliefs are worth mentioning. First, the self-realization of mood may cancel its effect. Mood may be discounted from an individual’s calculations when that individual realizes that mood is coloring their perceptions and is able to attribute that mood to an irrelevant or irrational cause (Schwarz & Clore, 1988; Schwarz & Bless, 1991). As people realize that their thoughts are being colored by something inconsequential, the influence of their mood may weaken, or even shift back into ‘neutral.’ Such realizations are rare, and although social scientists can engineer them in experimental conditions, nothing about the interview process analyzed in this paper brings respondents’ attention to their mood. Johnson and Tversky add that even when people are aware of the source of their mood, they seldom make the link between their mood and behavior: “although we know that a bounced check my put us in a bad mood, which in turn can make us short tempered, we rarely attribute a refusal to help a friend to a bounced check.” (1983, pg . 30; see also Forgas & Bower, 1987; Erber, 1991; Clark & Waddell, 1983)

2000). ‘Nice’ weather plays a role in mood regulation.

In particular, sunlight seems to bolster mood. Several studies separate from the body of SAD-focused scholarship have shown that sunlight can exert a strong positive impact on mood, which stimulates a positive attitude as well as optimism. Sunlight-induced good moods can stimulate helping behavior (Cunningham, 1980). People tend to describe their lives in a more positive manner on sunny days (Schwarz & Clore, 1983). Sunlight also affects the recall of memories by affecting mood (Parrott & Sabini, 1990). High barometric pressure (Goldstein, 1972) and comfortable temperatures have also been shown to boost mood.

Studies generally agree that ‘nice’ days affect mood through both biological and subjectively-experienced pathways. On one hand, ‘nice’ days have a physiological effect on mood, as mood improves with comfort and exposure to subjectively pleasing weather elements. However, other second-order weather effects should also boost mood; nice days enable pleasurable outdoor activities, signals the absence of inclement weather, and prompts weather forecasters to describe the day as pleasant, all of which contributes to the subjective enjoyment of sunlight, which bolsters mood (Keller et al., 2005; Meze-hausken, 2007).

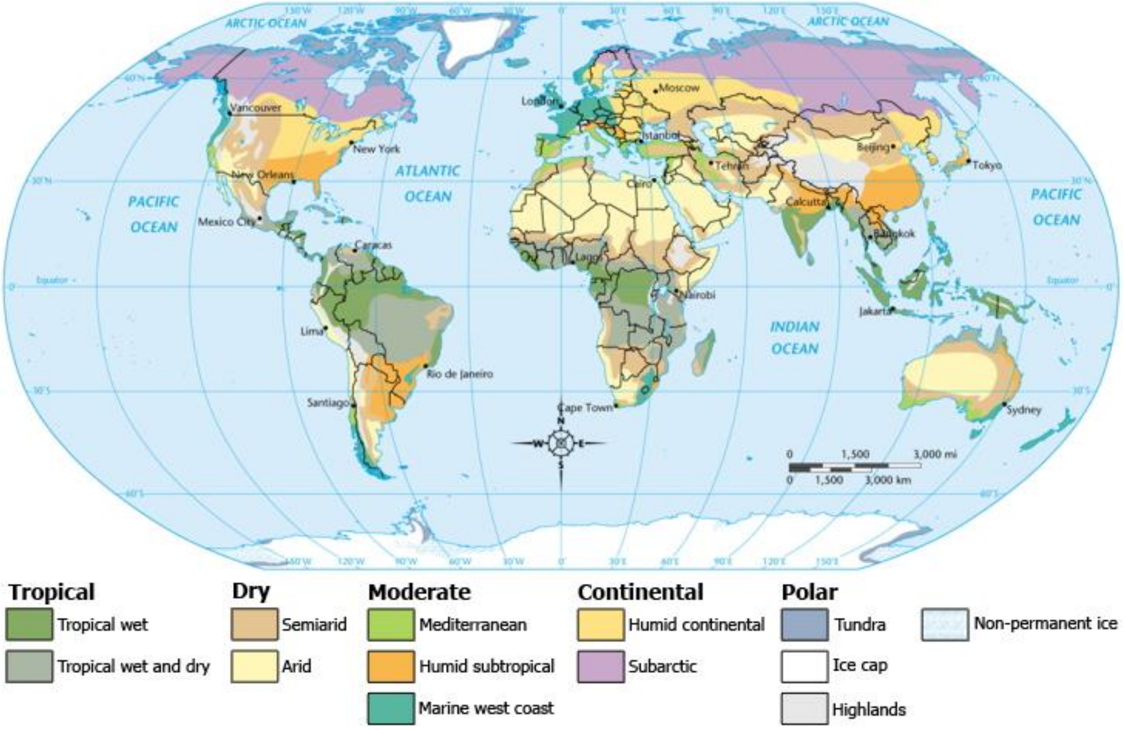
Generally speaking, on nice days, people are in better moods than on poor days, which coul have a pervasive effect on important political behavior.

Nice Weather Leads to the Use of Heuristics. In addition to affecting how people view objects, mood can also affect processing strategies and decision-making (Isen, 1987; Mackie & Worth, 1989). Johnson and Tversky write, “we tend to make judgments that are compatible with our current mood, even when the subject matter is unrelated to the cause of that mood" (1983; p. 30). One consistent finding is that negatives moods appear to increase attention to details while positive moods oblige people to think heuristically (Schwartz & Clore, 1983; Schwarz, 2000) and make use of cues (Worth & Mackie, 1987) and stereotypes (Bodenhausen, 1993). One explanation is that, because people are more familiar with positive affective material than negative material, a good mood clogs a person's cognitive capacity with positive memories and material, which obliges people to rely on heuristics (Schwarz & Clore, 1983; Schwarz, 2000). An alternate view suggests that positive moods imbue people with a sense of security, reducing the need to carefully examine information in their environment (Schwarz, 1990; Bless & Fiedler, 1995). Whatever the case, on nice days, people should be more likely to use heuristics in making decisions than on lousy days.

Summary. Good weather makes people feel good, while lousy weather can make people feel lousy. By affecting mood, health, and activities, weather can lead to more positive or negative behavior. Good weather drives people to evaluate things positively. It makes people more cheerful, helpful, and engaged. Bad weather does the reverse. Of course, it is important to determine what makes a day 'good' or 'lousy.' The literature suggests that sunlight brightens any day, literally and figuratively. Precipitation and inclement weather are viewed negatively. High temperatures and humidity, or extremely cold days, make a day lousy; in addition, hot days tend to make people angry and unhelpful. Finally, these effects should not necessarily be static across the calendar year, and should vary in intensity across seasons. The literature points to warm, sunny days in spring and winter as being particularly uplifting. We should also expect cooler days in summer to be received positively.

The next chapter draws on this information to derive specific hypotheses about how individual weather elements should affect political phenomena in ways interesting to contemporary political science.

Figure 1.1. Sample Climate Map of the World.



CHAPTER II. HOW THE WEATHER SHOULD AFFECT POLITICAL PHENOMENA: HYPOTHESES AND EXPECTATIONS

Orientation. The previous chapter shows how research spanning many fields has shown that weather affects many aspects of human behavior. From crime rates to health to depression, weather is always there, subtly crafting how we interact with our environment and one another. Yet aside from several articles on how weather affects voting turnout, little work has directly study how the weather affects political behavior. In this chapter, I briefly sketch several possible relationships between weather and political phenomena, and provide an overview of findings discussed in later chapters.

The Weather and Public Opinion. Weather should influence how people answer public opinion questions. People should be more optimistic and positive in their answers on ‘nice’ days than on ‘poor’ days. This is consistent with the Zaller and Feldman model of survey response (1992), which posits that people do not have strict, crystal-clear attitudes, but rather considerations regarding issues. These considerations may not be well-organized and may even be contradictory. When searching for an answer to a survey question, a respondent samples considerations via a stochastic process, with more recently considered considerations being more likely to be sampled than those less recently accessed. A weather-induced good mood should increase the likelihood of selecting positive rather than negative considerations, which should make a positive response more likely. Conversely, when weather is poor, people are in bad moods, which increase the likelihood of retrieving considerations with negative evaluative content.

This is consonant with the literature on decision frames, which argues that the decisions of rational individuals are dependent, in part, upon how their decisions are framed (Tversky & Kahneman, 1982; 1986). In survey research, question wording has been shown to cause a powerful framing effect, which affects the sorts of considerations are accessed in memory (Schuman &Presser, 1981; Zaller, 1992). Other examples of framing effects include the level of attention paid to politics (Slothuus, 2008) and one's level of political sophistication (Lau, Smith, &Fiske, 1991; Lau & Schlesinger, 2005; Jackman & Sniderman, 2006) have been identified as factors mitigating framing effects and thereby influencing the process of consideration retrieval. Unlike persuasion, framing does not change beliefs, but rather "passively alter(s the) accessibility of different considerations" (Druckman, 2001, p. 1044) by altering the importance of those considerations (Nelson & Oxley, 1999). While weather is not a framing effect *per se*, it functions in the same way: it does not substantively change opinions, but alters the accessibility of various considerations in a manner congruent with that mood.

This idea also meshes well with recent work by Achen and Bartels (2004). In a paper focused on explaining voting for incumbent candidates, those authors demonstrate that people often blame natural disasters and conditions upon elected politicians. Thus voters sometimes misattribute shark attacks and droughts to office-holders. Achen and Bartels stipulate, however, that for such 'blind retrospection' to take place, voters must be able to construct some sort of story connecting politicians to natural conditions. This chapter suggests that, at least in the case of survey response, that such explicit connections are not necessary, and that people may simply 'blame' and 'reward' incumbents for weather when that weather makes them uncomfortable or happy.

What sort of questions should be affected? Given weather's pervasive effects on mood and disposition, any sort of question asking the respondent to answer in an obviously positive or negative manner should apply. Eight surveys fielded by the Pew Research Center in 2005 offer a good avenue through which to test this idea. Each survey asks whether people approve or disapprove of how George W. Bush is handling the country. Respondents are tied to observations from the nearest piece of weather-sensing equipment, thus providing a unique lens into how weather conditions affect how people answer an important question that taps public opinion.

Chapter V tests several hypotheses about relationships between weather elements and the expression of support for George W. Bush. First, temperature should affect Bush's approval ratings. Specifically, warmer temperatures in winter and spring should have a positive effect. Warmth in the winter is particularly welcome. In the north, it offers an escape from winter's chill, and in the more temperate south, it suggests beautiful days that permit outdoor activity. Warmer temperatures are nice in the spring as well, as they provide relief from colder conditions associated with winter, and hint at still warmer weather to come. Yet in the summer, higher temperatures can be annoying and outright dangerous, and so higher temperatures in the summer should depress the approval of Bush. The theoretical expectations in autumn are less clear. While warmer fall temperatures could well provide a boost to approval ratings because warmth appears to stave off winter's advance, cooler temperatures could also have a positive effect as they provide relief from summer heat. While bivariate analyses suggest that warmer weather in winter, spring, and fall do boost approval of Bush, only the early spring sample survives more careful multivariate analysis. Warmer days in early predict higher approval of Bush, even after controlling for traditional indicators of Presidential approval.

Brief analysis is conducted on another dependent variable: party ID. While for many people party ID is set relatively early in life, some Americans do not possess strong affiliation to either party. Warmer weather in spring may push these people to more readily identify with one major party, as opposed to identifying themselves as Independents. Warmer days in spring tend to push people to identifying more readily with the Republican Party, as opposed to as Independents, even after restricting multivariate analysis to regional subsamples.

Sunlight should also affect whether people approve or disapprove of Bush. The simplest hypothesis here is that sunlight should unilaterally stimulate approval of Bush because it makes people more cheerful and optimistic about everything. However, the literature suggests that sunlight during the months of winter and spring have the strongest effect on human behavior; consequently, sunlight should have a particularly pointed impact during these months. This proposition is supported, at least in part: sunlight in the spring exerts a substantive and statistically significant positive impact upon approval of Bush, even after controlling for other individual-level correlates of approval, and very strict controls for regional geography. However, there is little evidence that sunlight matters in the winter. It stands to reason that sunlight should have a positive effect in the fall, as well, but no supportive evidence is uncovered. Finally, while sunlight could have a comparatively weak stimulating effect during the summer, such an effect could well be canceled out by the unpleasant heat generated by sunlight amid an already hot period. As it happens, in the summer, lower levels of sunlight also boost levels of approval. There is some evidence to suggest that this occurs due to how it interacts with the summer heat.

Finally, it is worthwhile to explore the relationship between public opinion and some weather variables that are less prominent in the literature. Ceiling height, horizontal visibility, and precipitation in clouds each measure sky conditions in a different way. Lower ceiling height, greater visibility, and more precipitation in clouds should each have a negative effect on public opinion, as they render a day more gloomy. There is some limited evidence that the amount of precipitation in clouds does reduce approval. Barometric pressure also has a negative effect on approval ratings, most clearly in the late spring, summer, and early fall months, perhaps because low barometric pressure tends to indicate cooler days, which in the summer should be quite pleasant. Finally, in summer, people who reside regions with fewer daylight hours tend to approve more of Bush, because shorter days offer a reprieve from the summer heat.

Both theory and test results indicate that the effects of weather on public opinion fluctuate over the course of the calendar year. The next chapter looks at patterns of behavior that are much broader than these discrete effects. Consequently, Chapter VI operationalizes measures of climate rather than weather to test for relationships between natural conditions and indicators of social capital.

The Weather and Social Capital. Another area where weather should exert a measurable impact upon human behavior is in the realm of social capital. Social capital, a product of social networks, group membership, and intrapersonal ties, is often characterized by relationships of trust and reciprocity between people (Coleman, 1982; Putnam, 2000).[25] It is a feeling of interconnectedness embodied in informal and formal associations. In most cases, social capital is viewed as a positive public good that enables cooperation and collective action.[26] It is indicated, among other things, by political

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[25] Social capital, which has become an important topic in sociology and political science over the last decade, has been given many definitions over the years, none of which is viewed as necessarily definitive.

[26] However, some have argued that excessive amounts of exclusive social capital--or social capital that bonds people of similar ethnic, religious, or racial groups to together while excluding relationships beyond those primary groups--can be a bad thing (eg, Berman, 1997).

participation, feelings of efficacy, positive feelings about government, social trust, volunteering, and low crime rates. It has even been associated with improved mental and physical health (Browning & Cagney, 2002). While no single 'cause' of social capital exists, many scholars have noted the importance of individual relationships and informal and formal group membership at the local, community level in stimulating the creation of social trust, community involvement, and more tolerant attitudes (eg, Putnam, 2000).

Climate could well be part of this process. Broadly speaking, climate should affect people in two ways relevant to social capital. First, climatic conditions should produce direct psychological effects that bear on associational behavior. For instance, hot and humid days should make people crabby, which should depress their desire to help one another. Effects upon infrastructure are also relevant. Inclement weather and extreme temperatures should force people indoors, which could limit the potential for face-to-face interaction in parks or on the street. Bad weather should also hinder citizens' ability and desire to venture to volunteer stations. Thus, social capital should be lower in places where rain is frequent and temperatures are extreme.

There are many indicators of social capital, and so the domain for potential tests of this proposition is substantial. Investigation is restricted to three relevant areas. First, the level of correlation between state-level measures of social capital and statewide weather conditions are examined. Second, analysis focuses upon the relationship between the climate of major and mid-size American cities and volunteer rates between 2004-2007. Finally, this dissertation briefly returns to the realm of survey research to explore how weather affects the expression of social trust and attitudes towards government. This differs from the previous tests on weather and public opinion because, here, we are interested on climate's effects on attitudes relating to social capital, rather than the current weather's influence on survey response. Thus, key weather variables will represent *typical* weather conditions for that respondent's location, rather than the weather at the time of the call.

The literature on weather and human behavior leads to several hypotheses about social capital, its indicators, and climate. First, because sunlight makes people happier and more helpful, it seems likely that sunlight ought to boost levels of social capital. We should expect, then, that sunlight should boost indicators of social capital by stimulating people to associate with and help one another, and placing them in an optimistic frame of mind. However, there is also some evidence that depression can actually stimulate people to help one another, as the act of helping is often intended to alleviate personal depression. As it happens, analysis of volunteer rates in major and midsize American cities reveals that sunlight actually has a *negative* effect on volunteer rates.

Another important point in the literature is that oppressive heat and humidity make people irritable, mean, and violent. Heat also increases violent crime, a correlate of low social capital (Putnam, 2000). High temperatures, then, should exert a negative influence on many of the indicators of social capital. Further, in places where summer heat grows dangerous (for the elderly in particular), people face stronger incentives to avoid traveling to volunteer locations. There is quite consistent evidence that cities in cooler climates enjoy higher levels of volunteering.

Finally, rain and snow should push people to remain indoors. This, in turn, should make people more likely to volunteer, talk to one another on the street, associate with one another, and join informal groups. Inclement weather has also been shown to be upsetting to people. Both of these facts suggest that precipitation should be negatively related to social capital and its indicators. Data at both the state and the city level demonstrate that precipitation has a decidedly negative effect on social capital, its indicators, and volunteer rates in cities.

Barometric pressure--a measure that is readily available for analysis but for which the literature does not produce any clear theoretical expectation with respect to human behavior--emerges as a positive predictor of social capital and many of its indicators. It also seems likely that both horizontal visibility and ceiling height should have a positive effect on social capital, as positive values on these conditions should correspond with less gloomy conditions. No support is found for this particular proposition.

While no scholarly work has explored the relationship between climate and social capital, the following chapter backtracks into more traversed scholarly territory. Chapter VII examines how weather affects turnout on election day as well as vote choice. The former proposition has been explored elsewhere, but only using a comparatively limited number of weather conditions. The second has been entirely untouched.

The Weather and Voting Behavior. Weather could affect voting behavior in two ways: it could affect turnout at the polls, and could influence vote choice.

The first proposition is far from novel. Scholars of turnout have long noted that in choosing to enter a voting booth, voters make calculations regarding the costs and benefits of casting a ballot. While the benefits include the estimated probability of that vote mattering and the fulfillment of a sense of civic duty (Downs, 1957; Riker & Ordeshook, 1968), costs include time, money lost from taking off from work, and transportation expenses (Almond & Verba, 1963; Verba & Nie, 1972; Rosenstone & Hansen, 1993).

Weather is simply another cost used in calculating the payoff for voting: by making the journey to the polls longer, less comfortable, and more annoying, lousy weather should increase the overall cost of voting and reduce the likelihood that an individual will vote. As Gomez et al (2007) note:

> "uncomfortable weather may make waiting in line a less desirable activity. Roads soaked by rain or perhaps covered by snow may make for a more hazardous journey to the polls. Again, these are not major costs. But for many citizens, the imposition of an additional minor cost may make the difference between voting and abstaining" (p. 652).

There is some empirical support for this idea. Prior work has demonstrated that turnout in U.S. Presidential elections has been suppressed by precipitation, and that rain may have played a decisive role in the presidential campaigns of 1960 and 2000 because it disadvantaged Democratic voters (Gomez, et al., 2007). A French study on weather and voting has demonstrated that while rain decreases turnout, sunshine and higher temperatures boost attendance at the polls because those conditions make days more pleasant, and thereby encourage people to make the journey to the polls (Lakhdar & Dubois, 2006). However, an earlier study found no relationship between rain and turnout, except among those who scored low on the NES civic duty indicator (Knack, 1994), suggesting that weather's effect is perhaps strongest among those who receive the weakest psychological payoffs for serving as dutiful democratic citizens and voting.

In Chapter VII, survey data collected after the 2004 American Presidential is used to test the proposition that weather elements influence turnout. Precipitation should have a decidedly negative effect. The French study demonstrates that sunlight has a positive influence on turnout, and so it seems likely that this should also hold in the American context (Lakhdar & Dubois, 2006). However, possible connections between turnout and other weather elements are tenuous at best. Because warmer temperatures, high horizontal visibility, and high ceiling height should all make a late November day more pleasant, it is possible that these conditions should boost turnout; however, these conditions should have such a minor effect upon the costs associated with voting (unlike rain) that it is quite possible that they have no effect at all. Once again, there is no clear expectation regarding barometric pressure.

Findings are interesting. Among the general population, there is little connection between precipitation and turnout, though this may be due to how precipitation is measured in the NSRDB, and the limited time period over which tests are conducted. However, it does appear that those with lower income are less likely to vote on days where any quantity of rain appears. Strangely, both temperature and sunlight seem to be negatively related to turnout, perhaps because warmer and sunnier weather actually pushes people *away* from the polls, as these conditions facilitate pleasurable outdoor activities. There is some evidence to suggest that sunlight's effect is more pronounced among those who possess weaker incentives to vote in the first place those who lack strong party identifications.

Second, weather could affect vote choice in Presidential elections. Nice weather could push voters to vote against the incumbent candidate. This is consonant with theories of retrospective voting, which explain votes for or against incumbent candidates represents referenda on their terms (Key, 1966; Fiorina, 1981). Moreover, Achen and Bartels (2002) have argued that sometimes voters 'blame' incumbent candidates for natural conditions like droughts, so long as voters are able to construct some sort of story connecting politicians with weather. This chapter agrees in principle, but deviates from Achen and Bartels in suggesting that this tie need not be so explicit. When the weather is nice, voters should feel more warmly toward the incumbent candidate and his term, and which should increase the probability of voting for that candidate. This effect should be strongest--and perhaps limited to--those who have weaker pre-existing dispositions towards the candidate, such as Independents, and those whose votes have very low saliency, such as those who do not live in a battleground state. Analysis locates very little support for the proposition that weather influences vote voice, though lower barometric pressure does appear to be related to an increased likelihood of voting for Bush.

If weather conditions can affect voting turnout among ordinary citizens by influencing the costs and benefits associated with casting a ballot, then it is conceivable that the likelihood of voting at the elite level may be affected by weather, as well. Consequently, chapter VIII explores the extent to which weather affects abstentions in roll call votes held in the U.S. House of Representatives.

The Weather and Turnout at the Elite Level. Understanding the relationship between legislators and their constituents is fundamental to understanding representative democracy. To this end, political scientists have focused their energies on analyzing voting patterns in legislatures. One important issue confronted by this scholarship is whether representatives ‘shirk’, or deliberately deviate from their constituents’ preferences. This literature has explored shirking in two areas. First, studies have explored if legislators’ ideological positions change as electoral consequences vanish during the term preceding retirement. This work on ‘ideological shirking’ tends to look for shifts in the pattern of vote choices or interest group ratings as retirement approaches (eg, Figlio, 1995; Poole & Romer, 1997; Poole, 2007, Rothenberg & Sanders, 2000a; 2000b; Lawrence, 2007). Second, scholars have questioned whether legislators engage in ‘participatory shirking’ by deliberately abstaining on some legislation rather than assuming a position unpopular with their constituents. Cohen and Noll noticed such strategic use of abstentions in their case study of votes on the Clinch River Breeder Reactor (1990). More recently, Rothenberg and Sanders (2000b) have argued that such shirking is evident in the last six months of the Congressional term among retiring members (see also Figlio, 1995), an argument that has since been subjected to a methodological critique (Carson, Crespin, Jenkins, & Wielen, 2004; for a rejoinder, see Rothenberg & Sanders, 2004). This chapter seeks to inform, in a rather ancillary fashion, both strands of scholarship by proposing another quantifiable determinant of abstention in U.S. House votes: weather.

Specifically, the proportion of abstentions should increase during inclement weather, broiling summer D.C. days, and freezing winter conditions. Due to D.C.’s climate, during the winter and spring, sunlight should boost voting; in the fall and winter, the obverse should be true. It is also possible, though unlikely, that high horizontal visibility and ceiling height may decrease abstentions, as these days are comparatively nice. However, because these conditions have such a minor impact on the cost of traveling to the Capitol, these make rather unlikely candidates for weather effects. No real theoretical expectation exists with respect to barometric pressure. Finally, due to how especially uncomfortable humidity can be during D.C. summers, this chapter tests is humidity has an independent effect on abstentions.

Weather should affect abstentions because, just like John Q. Public on Election Day, legislators must weigh the costs and benefits of voting before saying yea, nay, or not bothering to vote in the first place. Research has shown that Congresspeople do face physical costs associated with attending session, and that these costs can affect the likelihood that they will vote in a contest. For instance, politicians whose home districts are farther from Washington, D.C. tend to vote less often because they face higher transportation costs and longer times in transit (Rothenberg & Sanders, 1999). Even though the trip from offices to the Capitol Building is a short one, representatives may opt to sit out votes when conditions are uncomfortable enough to add to costs of voting. Of course, such an effect should be vastly more likely when votes are unimportant, and the outcome is a foregone conclusion.

However, there are good reasons why legislators may not be as easily distracted from their duties as ordinary citizens are on election day. Professional politicians know that their decisions will be scrutinized and publicized, and because frequent abstention can be equated with a dereliction of duty, failing to vote can be painful liability in November (Rothenberg and Sanders 2000). Moreover, the distance between the Capital Building and Congressional offices is not particularly far, and the journey is an easy one to make. Finally, Representatives may simply be more conscientious in their duties than the average voter, and may therefore be undeterred by uncomfortable weather.

Determining if weather conditions affect abstentions has some implications for the literature on legislative behavior because abstentions, in themselves, are a variable of interest. While many abstentions can occur because representatives are sick, forgetful, lazy, or attending to business in their home districts, abstentions can also be a tactical tool employed by Congresspeople when constituent interests conflict with their own beliefs or motives. For instance, when a member of Congress faces a vote on a bill that they or some prominent campaign contributors strongly dislike, but which is supported by their constituency, that Congressperson may abstain rather than openly provoke their base of support by taking an oppositional stance. Alternately, a Congressperson may be pressured by party leadership to vote in a bloc against legislation viewed favorably in her home district; this legislator may opt to abstain rather than have a nay vote recorded, which could provide ammunition for an opponent during in the upcoming campaign season.

The behavior of avoiding representing constituent interest by simply declining to attend Congressional meetings when certain legislation is up for a vote is called shirking (Lott, 1987; 1990). In this view, abstentions can be a tactical tool employed by representatives who must balance constituent interests with their own (Cohen & Noll, 1991). However, while abstaining can be shirking, it is not necessarily shirking. Not all abstentions are strategic: some are mistakes, others are the product of laziness, and others may stem from delayed flights or family emergencies. Understanding when abstentions are tactical or more innocent behavior has important implications for this literature. Thus, determining when and if weather is a cause of abstaining can provide an analytic lens to aid in distinguishing between tactical shirking and simple laziness.

This proposition will first be tested by examining the correlation between weather conditions and all roll call votes cast in the U.S. House of Representatives across the 102nd and 108th Congresses (1991-2005). While month-by-month bivariate results are far from compelling, multivariate analysis conducted at both the vote level and the individual level suggest that weather does matter, although its substantive effects are quite minor. Sunlight in the winter and spring has a positive impact on voting. In the summer, humidity has a depressive effect, and in the winter, higher temperatures boost voting.

Summary. This chapter has outlined a number of hypotheses regarding weather and climate, and how they might affect variables of interest to political scientists. Table 3.1 offers an overview of expectations, organized by weather or climate element. The following chapter provides a detailed explanation of how the weather and climate conditions discussed in this chapter are actually measured.

Table 3.1. Hypotheses Regarding Weather, Climate, and Political Variables of Interest.

	Sunlight	Temperature	Precipitation	Barometric Pressure	Ceiling Height	Horizontal Visibility
Public Opinion - Approving of Bush	Winter, Spring: ++ Fall: + Summer: 0	Winter, Spring: ++ Fall: 0 Summer: --	--	0	+	+
Social Capital	++	--	--	0	+	+
Turnout	++	0	--	0	+	+
Vote Choice - Incumbent Voting	++	+	--	0	+	+
Elite Voting - Choosing to Vote on Legislation	Winter, Spring: + Fall, Summer: -	Winter, Spring: ++ Fall, Summer: --	--	0	+	+

++ = strong, clear positive relationship anticipated

+ = positive relationship seems likely.

0 = both a positive or negative relationship is plausible.

- = negative relationship seems likely.

-- = strong, clear negative relationship anticipated.

CHAPTER III. WEATHER AND CLIMATE DATA

Orientation. This chapter offers a detailed explanation of how weather conditions are quantified and recorded. It also describes the variables used in later analyses, and describes how weather elements are related to one another. The first section describes the data sources utilized in this project. The second section discusses specific variables.

The NSRDB. Much of the weather data used in this project comes from the National Solar Radiation Database, 1991-2005 update. The NSRDB was developed and published by the national Renewable Energy Laboratory (NREL), which is a laboratory operated by the United States Department of Energy. The NSRDB is ultimately a collaborative project between several institutions and agencies, including the National Aeronautics and Space Administration (NASA), the National Climatic Data Center, the Northeast Regional Climate Center, SUNY at Albany, the University of Oregon, the University of Wisconsin, and Solar Consulting Services, a private firm.

It is an integrated database consisting of hourly measures of solar radiation, as well as weather elements such as rain, cloudiness, wind speed, and temperature. This data largely comes from two distinct sources: the NCDC's GIS database, and the NREL's Supplemental Cloud Project. Both are described in Table 4.1.

The NCDC Data. Measures of all weather elements other than sunlight are drawn directly from the data provided by the National Climatic Data Center. The NCDC is a subdivision of the National Environmental Satellite, Data and Information Service (NESDIS), which is a subdivision of the National Oceanic and Atmospheric Administration (NOAA), which is a subdivision of the Department of Commerce. From the NCDC website:

> “The National Climatic Data Center (NCDC) is the world's largest active archive of weather data. Our mission is to provide access and stewardship to the Nation's resource of global climate and weather related data and information, and assess and monitor climate variation and change. This effort requires the acquisition, quality control, processing, summarization, dissemination, and preservation of a vast array of climatological data generated by the national and international meteorological services. NCDC's mission is global in nature and provides the U.S. climate representative to the World Meteorological Organization, the World Data Center System, and other international scientific programs. NCDC also operates the World Data Center for Meteorology, Asheville.”

NCDC data represents the official government archive of the United States’ weather. The information provided to the public is extensive, and includes hourly measures of weather conditions for thousands of sites across the United States, direct access to NEXRAD imaging, datasets focused on extreme weather phenomena, verbal summaries of state climates, documentation of climate change over the course of the postwar era, forecasting, and even data on the fluctuating demand for heating fuel. Most of this information is free to people affiliated with educational or government institutions.

The NCDC data used by the project come from the Global Integrated Surface (GIS) database, which contains extensive records of weather conditions at 20,000 sites across the world, with records sometimes stretching back to 1900. Observations pertaining to the United States are collected at observation stations situated throughout the surface of the North American continent, nearby islands, and buoys floating in oceans and lakes. About 1,000 of these stations belong to the Automated Surface Observing System (ASOS), a collaborative project between the NWS (another division of NOAA), the Federal Aviation Administration, and the Department of Defense. These automated stations use equipment such as rain gauges and ceilometers to collect information on weather elements. Because the ASOS was initially designed to facilitate safer air travel, automated stations are generally located near airports. Another source of data for the GIS is the Cooperative Observer Program (COOP) in which roughly 11,400 individuals and institutions provide routine weather observations by monitoring NWS-calibrated equipment. The NWS maintains very strict and careful standards over data collection in the COOP network. All COOP stations are subject to regular inspections and all COOP data is subjected to extensive quality-control. Some marine data is provided by the NWS's National Data Buoy Center, which maintains about 100 buoys and 60 land-based coastal observation stations (C-MAN stations). The United States Navy and even ships in transit contribute to the GIS as well. Generally speaking, data at automated and manned stations is collected hourly, though at non-automated stations there is some variation. Weather elements documented include cloud coverage, wind speed, wind direction, temperature, precipitation amount, precipitation duration, and atmospheric pressure. Those observations taken since the Second World War are regarded as quite reliable; they constitute the official record of the United States government and are regularly used throughout academia and industries alike.

The NREL Supplemental Cloud Project. While all weather measurements aside from solar data are merged into the NSRDB from the GIS database, measurements of sunlight are produced directly by the NREL, under the aegis of the NCDC's Supplemental Cloud Project. Due to changes in how levels of sunlight and cloudiness were measured in the mid-1990's, directly measured figures of sunlight are now quite scarce. Prior to the mid 1990's, the NCDC relied on humans to record cloudiness and sunlight. However, with the introduction of the Automated Surface Observing System (ASOS), human observations were phased out in favor of machine observations. Problematically, however, the ASOS could only measure levels of cloud cover beneath 12,000 feet, and thus were so unreliable for reflecting actual levels of sunlight that they were dropped from the cumulative NCDC dataset entirely. Consequently, the NREL commissioned the NSRDB 1991-2005 update to remedy this gap in the meteorological record. With the help of the NCDC's ASOS Supplemental Cloud Product (Graumann 2003) and the Meteorological-Statistical (METSTAT) Model (Maxwell 1998), NREL researchers used satellite imagery in conjunction with extremely limited surface-level solar and cloud observations to assess levels of sunlight for several hundred sites across the United States. It is important to note that these figures are in some cases simulated or interpolated, and may even make use of random tables to fill in missing data. Ideally, sunlight would always be measured from ground-based observation stations; unfortunately, these account for only 1% of the total observations in the dataset, which would keep sample sizes tiny and prevent the estimation of many models using truly national samples.

The end product of all of this collection is a series of enormous data files that provide hourly meteorological observations for almost 1,400 across the continental United States for fourteen years. This level of accuracy is helpful, as it enables us to pinpoint how sunny an election day was in Missoula, Montana in 1990, or whether it is hot or temperate when a telephone respondent in Birmingham, AL reports approving of Bush’s handling of his job as president. In some cases, though, we will be more interested in the climate of a given place, rather than the specific weather conditions at a given point in time. For instance, in determining whether Putnam’s index of social capital is affected by temperature, climatic measures of statewide temperatures are needed, since social capital is not a discrete action (like survey response or voting) that can be pinpointed to a specific place and time. Climate data is found in the NREL's Typical Meteorological Year Database.

The NREL's Typical Meteorological Year Database. The Typical Meteorological Year Database, which typifies conditions at a specific location over a long period of time. The TMY database contains hourly observations for every site contained in the NSRDB, but does not distinguish between years. TMY data follow natural diurnal and seasonal variations to represent a year of typical climatic conditions for a location. In some cases, these typical years are constructed from data contained in the 1991-2005 NSRDB; however, in the case of over a hundred stations where longer histories are available, typical years are constructed from data collected between 1976-2005. In order to build the TMY database, a computer algorithm was instructed to look at the entire population of data for a given site in a given month, and then select the most typical month for that site. The process is repeated for each month, thereby generating a typical year which consists of the most typical months for the period of record. More information about this process is available at http://www.nrel.gov/docs/fy08osti/43156.pdf.

Having discussed the data in general, specific variables may now be described.

Temperature Measures. The measure of temperature used in this analysis is *apparent temperature*, which is an index of several conditions that, collectively, generate the temperature that outdoor conditions actually 'feel like'. The basic component is *dry-bulb temperature.* This represents the temperature of air, as measured by an outdoor thermometer which has been shielded from both solar radiation (sunlight) and moisture (condensation). Dry-bulb temperature is the ambient temperature of the air before calculating humidity, wind, and sunlight. This is measured in Fahrenheit.

Apparent temperature is a better measure because it represents an approximation of 'thermal comfort,' which is often used in measuring the amount of thermal stress produced by air. It is defined as "the condition of mind in which satisfaction is expressed with the thermal environment" (ASHRAE, 1966). Thermal comfort is modified, to some extent, by 'mechanical comfort,' which is determined by the movement of air (American Society of Civil Engineers, 2004; Blocken & Carmeliet, 2004). Though measurement varies, thermal comfort is generally regarded to have six components: humidity, air velocity, air temperature, radiant temperature, metabolic heat, and clothing insulation. Measuring actual levels of thermal comfort is impossible without close observation due to variance in factors such as body size, metabolism, clothing, and the amount of light reflected by nearby objects.

The apparent temperature measure used in this dissertation takes three factors into account: humidity, wind, and dry-bulb temperatures. This composite measure of thermal comfort is preferable to dry bulb temperature or humidity alone because studies have shown that people tend to experience air comfort holistically, and have difficulty attributing their comfort to specific components of the air around them (Givoni et al., 2003; Stathopoulos et al., 2004). For instance, it is difficult for people to consciously sense humidity unless it is at an extreme level or accompanied by a high temperature (Nikolopoulou & Lykoudis, 2006). Scaling dry bulb temperature, humidity, and wind together creates a variable with more meaningful implications for behavior than its three constituent variables taken individually.

Humidity represents the amount of water vapor in the air, relative to how much water vapor that the air can hold. When air heats up, such as on a warm day, its capacity for carrying moisture increases, which is why humidity is most acutely felt during the hot summer months. When the air is saturated with water vapor, moisture clogs skin pores, which prevents the body from baling heat by secreting sweat. In conjunction with already elevated summer temperatures, this can raise core body temperatures above a comfortable range and causes a hot, unpleasant feeling. Humidity can also cause water to ‘pool’ on the surface of objects, such as clothes and jewelry, which can render these things sticky. However, humidity is not especially important to human comfort at colder temperatures. First, levels of humidity at cold temperatures tend to be low because air requires energy to support moisture, and the air has less such energy when it is cold. Second, any effect that humidity has at lower temperatures is strongly overwhelmed by the chilling power of wind. However, as the dry-bulb temperature falls, humidity ceases to affect apparent temperature. At colder levels, wind chill begins to reduce apparent temperature, a process that grows more and more drastic as dry-bulb temperature drops and wind speed increases (Stathopoulos et al, 2004; Westerberg et al, 2006). To measure apparent temperature, then, a variable with three zones is created. Beneath 50° F, wind chill is used. Between 50° and 67°, the simple dry bulb temperature coincides with the apparent temperature. And above 67° F, the heat index is used (see Steadman, 1984)[27].

Sunlight. As discussed above, solar data is collected directly by the NSRDB using a modified version of the METSTAT model (Maxwell, 1998). Essentially, this is an algorithm that generates estimates of sunlight. To do so, it must take many surface and atmospheric factors into account. Snow depth, days-since-last-snowfall, present weather,

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[27] This heat index (HI) variable looks like this: when temperature is below 50 degrees, HI = 35.74 + 0.6215T - $35.75V^{0.16}$ + $0.4275TV^{0.16}$**,** where V is the wind speed in miles per hour and T is the dry bulb temperature in Fahrenheit. When temperature is above 67 degrees, HI = -42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 6.83783x10-3T2 - 5.481717x10-2R2 + 1.22874x10-3T2R + 8.5282x10-4TR2 - 1.99x10-6T2R2, Where T is the ambient dry bulb temperature (°F) and R is the relative humidity expressed as an percentage. Otherwise, temperature is simply the dry bulb temperature in degrees Fahrenheit.

and atmospheric pressure were collected from the NCDC GIS dataset. Solar geometry--the position of the sun relative to a point on the Earth's surface--is commonly available.

Aerosols, which are fine particles of solid matter suspended in a gas, were estimated by combining surface sun photometry with satellite data from NASA's Multi-Angle Imaging SpectroRadiometer (MISR) and Moderate Resolution Imaging Spectroradiometer (MODIS). These measurements of aerosols were initially encoded in spectral terms, and are converted to broadband data. These estimates were used to create measures of monthly aerosol levels at locations across the country. Gaps were interpolated then adjusted for elevation. Values between July 11, 1991 to December 31, 1994 were corrected for the excessive amount of ash pumped into the atmosphere by the Mount Pinatubo explosion.

The METSTAT model also takes ozone into account. Ozone (O_3) is an allotrope, or alternate form, of O_2, the pure form of oxygen. A layer of ozone situated in the upper atmosphere prevents dangerous ultraviolet light from reaching Earth's surface by filtering out photons[28] with shorter wavelengths. Ozone levels vary as a direct result of pollutants, but also due to seasonal patterns related to shifts in weather, vegetation, and wildlife. Ozone levels are taken from daily satellite observations from the Total Ozone Mapping Scanner (TOMS), which offers a resolution of 1° in latitude and 1.25° in longitude. Missing data are replaced with long-term means.

Atmospheric water vapor--the amount of water in a column extending from the earth's surface to the top of the atmosphere--is drawn from the North American Regional

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[28] Physicists call photons 'elementary particles' because they are the basic 'unit' of electromagnetic radiation. Put crudely, photons are units of light.

Reanalysis (NARR), produced by the National Centers for Environmental Prediction (NCEP). This data came from three sources: radiosondes, which is whether sensing equipment placed in weather balloons, dropsondes, measurement equipment dropped from airplanes, and infrared radiance data from the Television Infrared Observation Satellite Operational Vertical Sounder-1B satellite. This offers measures of water vapor every three hours to a 32 kilometer grid. NREL used GIS to move this gridded data to each of its sites, then interpolated hourly observations to affix water vapor measures to each site.

Finally, cloud data came from two sources: ASOS stations and the NCDC ASOS Supplemental Cloud Product. ASOS stations detect clouds up to 12,000 feet in the sky through the use of ceilometers; the Supplemental Project recorded cloud cover above that height through the use of satellite imagery. The final measure of sky coverage is expressed by the equation Sky Cover = 100 - [(100 - clouds beneath 12,000 ft) x (100 - clouds above 12,000)] / 100.

The METSTAT model uses all of this data to generate hourly means of sunlight for a given location. When necessary, data was interpolated; interpolated data was subject to temporal limits, typically five hours. The METSTAT model also varies certain operational parameters to simulate hourly changes in conditions. This, when combined with limitations in equipment accuracy as well as interpolated data at many layers in the process, produces an estimate of actual conditions that is, ideally, close to measured data, but is not identical to ground-based observations. As a check on accuracy, the NREL collected measured data from several sites nationwide, and found that the METSTAT estimates were reasonably accurate.

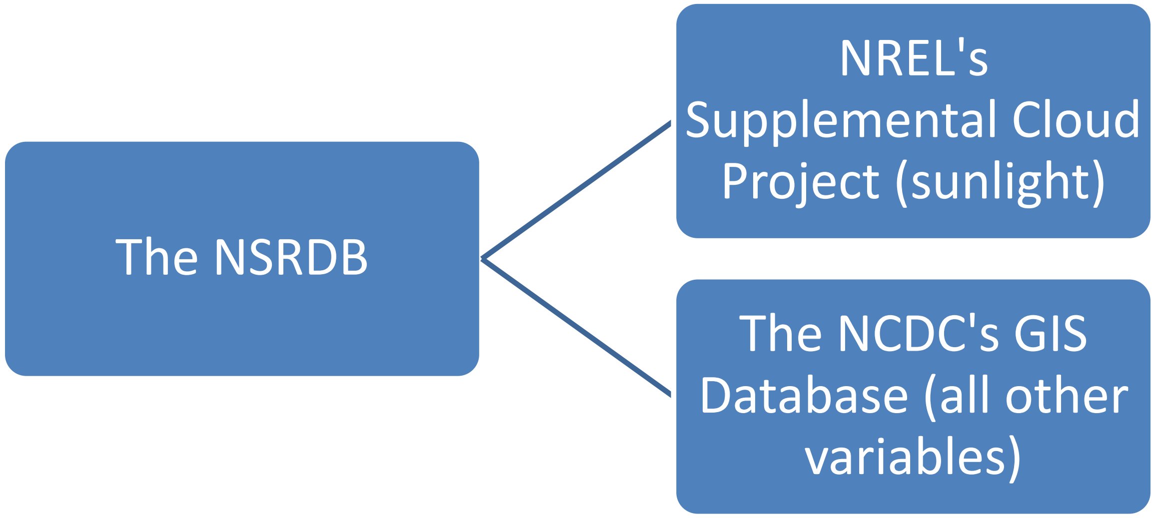
This method produces three different measures of sunlight: *direct sunlight, diffuse sunlight*, and a combined measure of *direct and diffuse sunlight*. Direct sunlight is a measure of the amount of unscattered sunlight that reaches the surface of the earth--in other words, the amount of sunlight that, over the course of the day, makes its way to land uninterrupted by clouds, fog, or mist. This measure takes the amount of ash in the atmosphere and the distance between the ASOS station and the sun into account. Diffuse sunlight, on the other hand, measures the amount of sunlight that actually penetrates any clouds in the sky; thus, having *no* diffuse sunlight could actually correspond to a nice day, because all sunlight experienced during that day is direct. However, looking at diffuse and direct sunlight together is a more useful measure, as this measures the scattered sunlight that penetrates clouds *with* the sunlight that makes it way uninterrupted to earth by shooting between existing clouds or simply shining when clouds are not present.

Other Weather Variables. Other weather variables are also used in analysis. *Barometric pressure*, crudely put, is the weight of air. It represents the sum total of the downward pressure exerted by the molecules in air at any given point. This is measured in milibars. *Ceiling height* measures the height of the lowest flying cloud in the sky. *Precipitable water in atmosphere* is a measurement of how much water that may eventually fall to earth (precipitable water) is contained in a single column stretching from the earth’s surface to the upper reaches of the atmosphere. While this variable does not perfectly predict to rain levels, higher values suggest rain or impending rain, reflect the duration and severity of such rain, and lead to weather forecasts predicting rain. High values on this measure can also indicate the presence of dark, looming clouds. *Horizontal visibility* measures the distance to the farthest discernable object on the horizon--in other words, this captures how far someone can see. Visibility and ceiling height are measured in meters, and precipitation in clouds is measured in millimeters. All of this data is contained in the NSRDB, where it was taken from the NCDC's GIS.

Finally, *day length* is measured as the amount of minutes between sunrise and sunset. Sunrise is defined as the moment when the sun reaches .8333 degrees above the horizon and sunset is defined as the moment when the sun reaches .8333 degrees below the horizon. .8333 is used as opposed to zero to account for refraction. These calculations were made using a spreadsheet provided by the NOAA that outputs sunrise and sundown times for a given input of latitude and longitude.

A Note on Coding. There are many ways to code this raw data; those approaches are not attempted because they ran a distinct danger of molding results to match expectations. Sunlight, for instance, can be recrafted into a variable coded 2 if the day is extremely sunny, 1 if the day is in the middle, and 0 if it is very bleak. Such an approach could be justified because there is substantial support in the literature for the notion that people tend to experience days as 'nice' and 'not nice;' by this logic, really nice and really lousy days affect mood, but moving between a slightly-more-sunny-than-average day to a slightly-less-sunny-than-average day may not. But deciding where to draw cutpoints in ordinal variables can be tricky, and with no guidelines pointing towards where such variables should be divided, all analysis is performed utilizing original, absolute values for weather effects.

Figure 3.1. The NSRDB.



CHAPTER IV. WEATHER AND THE SURVEY RESPONSE

Orientation. Does weather affect responses to certain questions fielded in public opinion questionnaires? The literature suggests that it should. If nice days make people more optimistic, happy, and healthy, then they should also lead people to respond to questions in an optimistic and positive way. As previously argued, this is consistent with the Zaller and Feldman (1992) model of survey response, in which people do not have strict attitudes, but rather considerations regarding issues. While weather does not substantively change opinions, it does affect mood, which should alter the accessibility of various considerations in a manner congruent with that mood. People should be more optimistic and positive in their answers on ‘nice’ days than on ‘poor’ days. This chapter tests the relationship between weather and answers to a question asked across eight Pew surveys administered in 2005: whether or not a respondent approves of Bush’s handling of his job as President.

Hypotheses in Brief. First and foremost, because our subjective expectations of weather vary as the seasons change, these hypotheses should be sensitive to seasonal changes.[29] The two most studied variables are temperature and sunlight. In the summer, warmer temperatures should reduce approval, because hot weather depresses levels of outdoor activity, and tends to make people aggressive and unhappy. In the spring, however, warmer temperatures promote good mood and stimulate activity. Likewise, in autumn, warmer temperatures should lead to more positive evaluations, as colder weather signals the onset of winter and drives people indoors. Where there is little published evidence that warmer temperatures in winter boost mood, we can tentatively hypothesize that in winter, warmer temperatures should be associated with more positive responses.

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[29] Hypotheses are discussed in greater detail in chapter III.

Sunlight, on the other hand, should have a positive effect on people year-round. While there is substantial evidence that sunlight ought to have a strong effect in winter--when people are essentially sunlight deprived due to the constrictive hours of winter--there is no reason to believe that sunlight is unimportant outside of winter. There is some specific evidence that sunlight should boost mood in spring, and it seems reasonable to hypothesize that this effect should extend to summer and fall as well.

While sunlight and temperature are certainly the most studied relevant weather elements here, three other weather variables are amenable to analysis. The first is horizontal visibility, a measure of how far one can see in a horizontal line. On a hazy or foggy day, horizontal visibility is lower. Ceiling height represents the height of the lowest cloud in the sky. Very low ceiling height would suggest fog. Finally, precipitation in atmosphere is a measure of how much water exists in the atmosphere in a single vertical column extending from the surface of the Earth to the top of the atmosphere. While this variable does not directly equate to rain levels, higher values suggest rain or impending rain, reflect the duration and severity of such rain, and lead to weather forecasts predicting rain. When these variables take on large values, approval of Bush should fall substantially. For one, dark and foggy days aren’t pleasant. They can also negatively impact planning: the threat of rain can cancel softball games. Fog also stresses infrastructure because it can be dangerous for drivers, which is annoying in its own right and can cause traffic delays. Finally, fog, dark clouds, rain, and the threat of rain can disrupt outdoor activity by making it less pleasant.

Another important variable that describes weather is atmospheric pressure, sometimes called barometric pressure. Typically, low levels of barometric pressure are associated with cloudy weather and precipitation; higher levels are associated with clearer skies. Some work has linked high barometric pressure with better moods, but others have noted that it can coincide with higher emergency psychiatric visits, and more intense, frequent headaches. The theoretical expectation here is not especially strong in either direction, but since the data is available and easy to analyze, it's worth looking at.

Finally, the literature on SAD suggests that the longer daylight lasts, the happier people are. This is a fairly straightforward proposition to test here; length of day is measured simply as the amount of time between sunrise and sunset.

Survey Data. Survey data comes from surveys fielded by the Pew Research Center. One question is particularly useful: a simple question asking whether respondents approve of President Bush's handling of his job. This is the most suitable choice for three reasons. First, it does not require respondents to think particularly hard and therefore may tap background feelings such as mood. Second, it offers an obviously positive and negative dimension. Finally, this question is asked in an identical fashion throughout the year.

In total, 8 surveys are used from 2005 (the last year of the NREL study): February, March, May, June, July, September, October, and December. These samples can be divided categorically to align with seasonal change: Late Winter/Early Spring (February/March), when winter first loosens its fist, late Spring (May), when temperatures in many places begin to rise above pleasant spring levels, summer (June/July), when sweltering heat is often the norm, fall (September/October), when summer heat slakes and winter begins to once again rear its head, and early winter (December), when temperatures reach their lowest levels. It is true, of course, that many parts of the country (particularly southern latitudes and the Pacific coast) do not experience the same range of seasonal change as other parts of America. This problem is most pronounced in considering the hypotheses that relate to temperature. However, in most cases, the differing intensities of the seasons should not affect the direction of anticipated relationships between weather conditions and survey response. Neither Texan nor New Yorker enjoys a 104 degree day in July, and while -20 degrees in Bangor, Maine may not be as uncomfortable as a forty-five degree day in Birmingham, research suggests that residents of both cities would certainly desire things to bit warmer. And from Lake of the Woods, Minnesota to Key West, Florida pleasant spring days tend to be warmer days. If anything, this could cause some noise in obtained estimates and cause difficulty in estimating statistically significant coefficients on weather variables, which should increase confidence in any significant results that are obtained.

Each respondent who provides a ZIP code is tied to the nearest piece of weather sensing equipment. This produces a national sample of 10,130 cases. The mean distance between respondent and weather station is 18 miles, and only a handful of cases include distances greater than 60 miles.

Some Problems. In many cases, survey response represents a least-likely case for weather to affect political behavior. Most people do not spend much time outside on an average day. There are exceptions, of course: a homeowner may garden, a husband may shovel the driveway then organize the garage, a National Parks employ may spend all his time patrolling trails, and an undergrad may whittle away the afternoon hours playing Frisbee. But sometimes routine dictates most time is spend indoors: a respondent wakes up, drives to work as an orderly at a hospital, eats lunch in the cafeteria, drives home, and watches television until she is called by industrious social scientists seeking her opinion on Bush’s handling of the country. Aside from the brief period of time spent walking to and from her car, this woman hasn’t been exposed to the elements--and, if her car is parked in a garage attached to the hospital via a skyway, and her car is stored in a covered garage at home, she really isn’t outside much at all. Of course, while driving to work she is exposed to sunlight and, while the car acclimates itself to the temperature outside via air conditioning or heat, she experiences temperature (provided that her car isn’t equipped with an automatic starter, of course). She may also live in an apartment with big windows, or in an office where the windows are always kept open unless it is very cold. Then again, she may not. We also don’t know if she has heating or air conditioning.

People live all sorts of different lives, and so we have no guarantee that a respondent has even been outside, or even knows what the weather outside is. In some cases, by virtue of their sleeping patterns and occupation, respondents may not experience even a sliver of weather conditions. But at the very least, I think, people do receive meaningful snapshots of the weather outside over the course of a day. A housewife washing dishes may look longingly at her yard as she puts pots away. A busy businessman takes out the trash and grabs the mail at the end of his driveway. An alcoholic makes his daily trip to the liquor store. A live-in babysitter scrapes the dirty ice off the kids’ shoes as they come home from school. And so on. Most people do experience weather to at least a limited extent. And even these brief impressions should be reflected in mood. And while this does pose some problems for the theory and for analysis, it makes any significant results all the more compelling. It also may help explain some noise in estimates: some patterns emerge at levels of statistical significance that hover around .1. Some people just aren't exposed to the outdoors as much as others, so we ought to expect some noise in estimates and even correlations.

A second problem concerns the timing of calls and how weather is measured. For these analyses, the *average* weather over the course of the day is used to represent weather. The hourly observations of weather conditions are added up and averaged for each day[30]. This presents an obvious problem: what happens when a respondent answers the phone at 10:00 am? By this metric, the 'weather' for that phone call almost entirely consists of weather that has not yet happened. The obvious solution would be to tie that respondent to the weather outside his window at the moment he picked up the phone. This is quite possible. While many datasets--Pew included--do not provide the timing of phone calls in publicly-available data because such information is, for almost all scholarly purposes, extraneous, it is sometimes available from survey administrators and principal investigators, and weather data is recorded hourly.

There are two problems with such an approach. First, using precise times for weather conditions focuses only on the weather for a single hour, which may not be a fair representation of weather for that day. For instance, a single gust of wind could make it seem that an Ohio man is living in a hurricane, while a lone break in a week of solid black clouds would lead to believe that a New Yorker is eating breakfast in a tropical paradise.

Second, while there are certainly some cases where using the average weather over the course of the day is somewhat inaccurate and does not adequately capture the complex relationship between individuals' moods or how weather affects their answers to questions, there is no clear argument justifying why using weather at the moment of the survey call is a *more* accurate approach. In fact, since we lack realistic measures of when, exactly,

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[30] Defined as the complete hours between sunup and sundown.

people were last outside, the average weather for a given day may just be as good a measure as any. Further, people make plans around what the weather will be, and are no doubt influenced by the morning weatherman's forecast of gloom or brightness. Even for phone calls in the morning, the future weather may still matter. The literature simply doesn't provide a realistic cue regarding how long the effects of weather persist after having been outside (which we can't determine in the first place), or the varying intensity of weather's effects based on time of day; there is no equation explaining that 'the weather three hours ago matters *x* amount and the weather two hours ago matters *y* amount and so on…' An average measure of weather is empirically meaningful and smoothes out some of the hour-by-hour fluctuations that could cause improper inferences and, moreover, the literature suggests that average conditions are acceptable because a nice *day* affects survey response, not a nice *moment*.[31]

Finally, there are certainly some cases where respondent ZIP codes are not correctly coded. Some of this may be data entry error on the part of surveyors, but I suspect that some people simply give incorrect answers for any number of personal reasons (my father, for instance, habitually lies by a single digit when the clerk at Radio Shack asks for his ZIP code, for no other reason than to spite the corporate establishment). Almost fifty given respondent ZIP codes (out of about 11,000) could not be merged with weather data because those ZIP codes do not exist.

Although these problems are worth noting and should cause some noise in estimates, they should also increase our confidence in any significant results that are obtained. A relationship between weather and public opinion represents a sort of

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[31] Though, for the record, nice moments seem to matter, too. In a seminar paper written in spring 2008, I found that the weather at the exact moment of a phone call affected survey response.

least-likely case for a connection between weather and political behavior. The theoretical case that weather affects voting, for instance, is easier to swallow, since people must go outside to reach the polls. However, tying weather to public opinion is rocky terrain at best. And while this makes uncovering a relationship difficult, results here should increase our confidence in results in other areas.

A Seasonal Approach. As with many things, weather's effects are conditional upon temporal context. In looking at the relationship between temperature and approval, we have clear seasonal expectations: warmer weather in the winter, spring, and fall, and cooler weather in the summer, should boost approval. And although sunlight should matter year round, the magnitude of this effects should vary with the seasons. After all, there is focused evidence in the literature that sunlight has a strikingly positive effect, in particular, in the winter and spring. Visibility and barometric pressure should be much less context-dependent; however, since little work has been done in this area, it is worthwhile to test seasonal effects as well. Consequently, the following analysis is conducted on both yearlong samples, as well as seasonal samples.

Temperature and Approval of Bush. Warmer temperatures in winter, spring, and fall, as well as cooler temperatures in summer, should boost approval of Bush. In the winter, warmer temperatures should offer respite from uncomfortable chilliness, stimulate outdoor activities in warmer climates, and move the mean temperature towards more pleasant levels. The spring, warmth is associated with winter's retreat, permits pleasurable outdoor activities, and even in warmer climates, leads to spectacularly pleasant days. In summer, however, heat can cause dangerous and unpleasant conditions, and should depress approval ratings.

Table 4.1 displays bivariate correlations between two measures of temperature and survey response. The first is the simple *dry-bulb temperature* in Fahrenheit, just like a thermometer reading. The second variable, *apparent temperature*, represents what the air 'feels-like.' It is modified version of the dry-bulb temperature that takes humidity and wind taken into account[32]. The dependent variable is coded 1 if the respondent answers 'approve' to this question: "Do you approve or disapprove of the way George W. Bush is handling his job as president?"[33]

Both variables relate to approval in quite consistent ways. In February, March, May, and September, higher temperatures are correlated with greater approval of Bush. This suggests that, as anticipated, warm days during spring and autumn tend to have positive effects on mood and therefore survey response. However, in late autumn, early winter, and summer, no statistically significant relationship between temperature and approval of Bush emerges. While there is little in the literature to suggest that extreme cold in winter would depress mood, it is surprising that summer heat does not stifle approval ratings. Perhaps air conditioning simply counteracts the effect of extreme heat in the summer, and that on very hot days--those that should depress mood--people simply stay in the cool indoors. In the winter, heating may have a similar neutralizing effect on weather conditions, as people remain indoors to avoid blistering cold. Alternately, temperature in the summer and winter may not matter because people expect to be hot and cold during those seasons, and so they are unbothered by extreme conditions.

On the other hand, in spring and autumn, people have less reason to retreat indoors,

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[32] See Chapter IV.

[33] If the respondent does not supply an answer, he probing question is asked: "Overall do you approve or disapprove of the way George W. Bush is handling his job as president?" Again, approval is scored as a 1 and disapproval is scores as a 0.

and tend to expect more pleasant days. In spring, people expect and enjoy the sensations of winter receding: windows are opened, winter coats are exiled to closets, and public parks explode with activity. In autumn, people cling to summer's retreating warmth, so as temperatures begin to fall and winter starts creeping in, warm days are again appreciated. Public places may turn off their heating and cooling systems during these transition months, as well. Of course, the substantive impact of the statistically significant correlations is quite minimal, but this is in concert with our theory--a nice day ought to push some people to respond one way or another, rather than single-handedly determining their response.

Of course, these are just correlations, and more careful exploration is needed. Table 4.2 presents multivariate analysis of the relationship between apparent temperature and approval of Bush. Several traditional predictors of Presidential approval are included in this model as controls. *Age* represents the respondent's age. *Income* is an ordinal variable corresponding to total family income in 2003, before taxes[34]. *Education* is an ordinal variable that represents the last grade that the respondent completed[35]. *Nonwhite* is a dummy variable coded '1' if the respondent does not identify themselves as white. *Ideology* is an ordinal variable with lower values corresponding to greater conservativism[36]. *Church attendance* denotes the frequency with which a respondent

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[34] Income is coded as follows: 1 = Less than $10,000; 2 = $10,000 to under $20,000; 3 = $20,000 to under $30,000; 4 = $30,000 to under $40,000; 5 = $40,000 to under $50,000; 6 = $50,000 to under $75,000; 7 = $75,000 to under $100,000; 8 = $100,000 to under $150,000; 9 = $150,000 or more.

[35] Education is coded as follows: 1 = None, or grade 1-8; 2 = High school incomplete (Grades 9-11); 3 = High school graduate (Grade 12 or GED certificate); 4 = Business, Technical, or vocational school AFTER high school; 5 = Some college, no 4-year degree; 6 = College graduate (B.S., B.A., or other 4-year degree); 7 = Post-graduate training or professional schooling after college (e.g., toward a master's Degree or Ph.D.; law or medical school)

[36] Ideology is coded as follows: 1 = Very Conservative; 2 = Conservative; 3 = Moderate; 4 = Liberal; 5 = Very Liberal.

attends church, with lower values corresponding to greater attendance[37] and *Democrat* and *Republicans* are dummy variables corresponding to the self-identification of partisanship ('Independent' is the omitted category.)[38]

Results here differ from the bivariate analysis. Temperature does not influence the likelihood of approving of Bush in late spring or early fall. One explanation for the disparity between the multivariate and bivariate results is that temperature is merely picking up regional patterns in partisanship. Generally speaking, the south is more Republican and the north is more Democratic, and so latitude is significantly related to being a Republican (but not a Democrat).[39] At the same time, it is warmer in the south and cooler in the north. Temperature, then, is to some extent coterminous with existing patterns of party identification, which would cause a significant bivariate relationship to fade in multivariate analysis that controls for Party ID. Turning back to Table 4.2, the significant bivariate correlation between temperature and approval of Bush in the yearlong sample seems to confirm this suspicion: looking at the year as a whole, warmth is correlated with approval of Bush.

A roundabout way to test if temperature is simply picking up regional patterns in partisanship is to drop party ID from the regression equation. In fall, dropping party ID from the equation does not result in a statistically significant coefficient on temperature. But in spring, however, running the identical regression from Table 4.2 without Party ID does produce a significant coefficient on temperature. Yet if regional controls or simple

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[37] Question wording and coding: Aside from weddings and funerals, how often do you attend religious services... more than once a week (1), once a week (2), once or twice a month (3), a few times a year (4), seldom (5), or never (6)?

[38] Those with 'no preference' or who respond with 'other' are placed in the omitted category, independent.

[39] Correlation is -.05, statistically significant.

latitude are substituted for party ID, temperature again fades to insignificance, suggesting that the bivariate relationship is a spurious one, produced by the close relationship between geography and regional patterns of partisanship[40].

In late spring, however, even after controlling for partisanship, the adjusted temperature is a statistically significant predictor of approval of Bush[41]. This suggests that spring thaw makes people happy, and that escape from the clutches of winter boosts mood--and, thus, Presidential approval. But what about those sections of the country that never really experience the chill of winter? It is reasonable to hypothesize that people living in the southern portions of the country should be less likely to be affected by this warming effect in spring, since their winters have not been particularly cold, and their spring may actually be too hot! Indeed, Table 4.3 demonstrates that this is the case: south of 36" (the Mason-Dixon line), temperature has no affect on approval of Bush; north of this line, it does.

The substantive impact of temperature on approval is predictably modest. Table 4.4 presents the predicted probabilities of approving of Bush for Democrats, Republicans, and Independents. A ten degree increase in temperature makes an average Democrat 1.2% more likely to approve of Bush, all else constant. Moving from the lowest daily apparent temperature (-14˚ F) to the highest one (75˚ F) causes a 11.2% change in approval. In Republicans, the effect is similar: an increase of ten points in temperature leads to a 1.5% increase in the probability of approving, while going from the minimum temperature to the maximum one causes a 9% change. Finally, among independents, this effect is

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[40] If party ID is dropped from the early spring analysis and replaced with dummy variables corresponding to region or latitude, the test statistic remains significant.

[41] Substituting simple temperature instead of the apparent temperature variable produces a substantively similar outcome.

markedly more pronounced, likely because many independents lack deeply entrenched beliefs about Bush and are more readily swayed by the weather. For the average independent, ten degrees of warming boosts the likelihood of supporting Bush by 2.4%, with a net increase of 19% when moving from the coldest temperature to the warmest one (see also Figure 4.1).

One potential objection to this finding is that weather variables are merely picking up *other* sorts of regional variations. By this line of reasoning, colder temperatures correspond to lower approval of Bush not only because there are more Democrats in the far north, but because the political culture becomes more liberal in the north, as well. In my view, controlling for party ID, ideology, and other socio-demographic variables has been sufficient vigilance against the emergence of spurious statistical relationships, since ideology and party ID represent controls for geographic patterns such as 'northern liberalism,' albeit at an individual level. Adding geographic controls is not an improvement in the model, as any geographic control is necessarily coterminous with temperature, and dropping these into the model tends to create enormous multicollinearity issues.

However, it's worthwhile to see if the apparent relationship between weather and survey response survives a still stricter test that includes controls for geographic location. Several approaches are plausible, such as including regional dummy variables, simple latitude, or state-level dummy variables, or splitting the sample into subsamples. The first three approaches produce models with uncentered VIFs on the key independent variable above 50, while the final approach drastically reduces both sample size and variation in the key independent variable. Nevertheless, it's worth noting that following these methods generally produces an insignificant test statistic[42].

Temperature and Party ID: Secondary Analysis. If we set aside the absence of geographic controls in the model, it does appear that warmer weather in spring affects approval of Bush--in particular, in the north. If pleasant weather in spring positively influences this type of survey response, it stands to reason that it could affect others. Could something as fundamental as, say, party ID fall prey to seasonal weather effects? It seems possible. Although we have long known that, for many Americans, partisanship is something established early in life that remains relatively immutable, we also know that some people are not strong partisans. These people should be more likely to be susceptible to weather effects. Because they lack strong affective feelings toward the major parties, when asked if they are a “Democrat, or Republican, or what”, they may generally respond as Independents, reflecting their apathy towards the two major parties. However, on a nice day, they may feel warmer towards their preferred party, and answer accordingly. Even though a machinist in Bridgeport, Connecticut may lean towards the Democratic Party, the strength of this feeling is so minor that he could not honestly call himself a Democrat, or even a leaner[43]. But it is reasonable to hypothesize that a nice day--in this case, a lovely spring afternoon after a cold winter--could warm his feelings up a bit, pushing him to state that he identifies with his preferred party, even though he is not wholly within the Democrat fold.

In bivariate analysis conducted on the early spring subsample, being an Independent relative to all other categories (in other words, a dummy variable coded ‘1’ if

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[42] In some cases, significant results are still obtained, particularly in the season-by-season analysis. However, levels of statistical significance hover around $p < .1$.

[43] Throughout this analysis, leaners--those who in a follow-up to the initial Party ID question reveal that they lean either Republican or Democratic--are included in the main Democrat and Republican categories.

the respondent is independent) is negatively and significantly related to apparent temperature. Of course, this could merely reflect geographic patterns of partisanship, so multivariate analysis is needed. The first column in Table 4.4 demonstrates that, in a controlled logistic regression, this relationship persists: as it gets colder outside, the probability of being an Independent relative to all other categories decreases. The next two columns restrict the sample to Independents and Democrats, and to Independents and Republicans, which reveals that this movement is focused on Republicans: as it gets warmer, the probability of being a Republican rather than an Independent increases.

Of course, this could simply reflect geographic patterns of partisanship: independents may simply be clustered in the north. Although latitude is significantly and positively related to being an independent, the strength of the correlation is only .03. Nevertheless, this objection does seem valid, particularly when you consider the prevalence of independents in places like Vermont and Minnesota (then again, consider California). To confront this objection head-on, Table 4 also offers these estimations restricted to regional samples. The results are consistent. In the Midwest, South, and West, the colder it gets, the more likely people are to call themselves Independents, relative to Republicans, all else constant. In the northeast subsample, however, apparent temperate is not a significant predictor of being an independent relative to a Republican.

An interesting question naturally follows: why does warm weather in the spring push Independents to identify as Republicans, without inducing Independents to call themselves Democrats? It’s difficult to say. Very speculatively, it may be related to the Republican Party being the party in power in 2004--on nice days, people feel better about everything, including the people running the government, and so Independents loosely leaning towards the Republican Party may express more loyalty on these days. On the other hand, Independents sympathetic to the Democratic Party may feel better about the people running the country, which does nothing to push them towards the Democratic side of the aisle.

Temperature and Survey Response--Summary. Analysis in this section has uncovered a single link between temperature and survey response: warm days in spring boosted approval of President Bush. This was anticipated by theory. However, other hypotheses generated by a review of the weather literature stumbled entirely. First, cold days in winter do not affect what people say. Yet this is not particularly surprising, as there is little specific discussion in the literature about cold weather and unhappiness (the winter depression literature is focused on light and sunlight). However, given the strong relationships between summer heat, aggression, unhealthiness, and irritability, it is somewhat surprising that the sticky heat of summer does not adversely affect survey response. Perhaps, since people expect uncomfortably hot weather, they can simply hide in air conditioning on extremely hot days, just as they can stay heated during winter. On the other hand, warming days in spring are such a pleasant events people choose to go outside, and thus this weather actually makes them happier and more optimistic, which is in turn reflected in survey response.

Sunlight and Approval of Bush. We turn next to the relationship between sunlight and survey response. The literature is clear here: sunlight makes people happy, healthy, and even humored. Sunlight, then, should push people towards more positive evaluations of Bush. However, as it turns out, the relationship between sunlight and survey response is slightly more nuanced than this simple theory predicts.

Table 4.5 shows that in March, June, July, and September, sunlight is a statistically significant correlate of approval of Bush. Of the three measures of sunlight kept by the NSRDB, two are significant during each of these months: the cumulative measure of both diffuse and direct sunlight, and direct sunlight. Diffuse sunlight in itself is insignificant in all but one case. This is not surprising given what these measures represent. Direct sunlight is a measure of the amount of unscattered sunlight that reaches the surface of the earth--in other words, the amount of sunlight that, over the course of the day, makes its way to land uninterrupted by clouds, fog, or mist. Diffuse sunlight, on the other hand, measures the amount of sunlight that actually penetrates any clouds in the sky; thus, having *no* diffuse sunlight could actually correspond to a nice day, because all sunlight experienced during that day is direct. Yet an identical reading could also correspond to an abysmal day. The lack of statistical significance on this variable, then, is not troubling. However, looking at diffuse and direct sunlight together is a quite valid measure, as this records the scattered sunlight that penetrates clouds *with* the sunlight that makes it way uninterrupted to earth.

Interestingly, the direction of the relationship changes as the seasons change, which explains why the bivariate relationship between sunlight and approval is insignificant in the national sample. In March and September, sunlight is associated with higher levels of approval. In summer, however, more sunlight pushes people in a negative direction. This is relatively straightforward to interpret. In spring, as people climb out of the cold gloom of winter and shed their winter coats for short-sleeved shirts, sunlight represents an energizing promise of warmer weather to come. Moreover, sunlight in spring pushes up temperatures, another welcome change from three months of winter. However, as the heat and humidity of summer set in, the sun becomes an enemy. Here, sunlight is associated with higher temperatures, which leads to discomfort and lower approval ratings, whereas the shade of the clouds makes the day more pleasant. In fall, there is a shift back in the other direction: as temperatures fall and cooler winter winds sweep in, sunlight again makes the outdoors more pleasant.

Of course, these relationships should be subjected to multivariate analysis. In fall, the relationship between sunlight and approval of Bush does not survive such a test. However, the positive relationships in spring and early winter, as well as the negative relationship in summer, remain apparent in controlled logistic regressions, shown in Tables 4.6 and 4.7.

As was the case with the previous analysis, it is necessary to confront the contention that the significant relationships between sunlight and approval in the spring and summer could be spurious due to geographic patterns that have nothing to do with weather, and are not otherwise uncontrolled for in the model. Here, such a case is even weaker for two reasons. First, given how the sign on the sunlight variable changes across seasons, it is impossible to argue that ‘the South is warmer and sunnier, and people approve of Bush more in the South, therefore sunlight is only positively related to approval because the South is sunny.’ Second, even if one ignores the fact that sunlight depresses approval in summer, this line of reasoning falters still further when one considers that sunlight simply doesn’t follow the same geographic patterns as temperature. While liberalness does increasingly prevail as temperature decreases, no such pattern ties sunlight to ideology or party ID. This is illustrated in Figure 4.2, which summarizes of annual sunlight levels across the United States. The Bible Belt simply isn’t very sunny. Rather, the southwestern deserts receive the most intense sunlight, with slightly lower levels that radiate outward, across California, into western Texas, and up into northern Rockies. Idaho, Wyoming, and South Dakota generally receive more sunlight than the Louisiana, Mississippi, or Georgia. The liberal Pacific northwest, despite being along the same latitude as the northeast, is much sunnier. Patterns of *average* sunlight simply don't map as easily onto the distribution of national partisanship, ideology, or political culture.

Nevertheless, regional controls are also inserted into this model, in the form of both simple latitude and regional dummies. As a still stricter test (and, in my view, an overly-strict test), regional controls, latitude, and dummies for each state are included in a single model. Estimates are displayed in Tables 4.6 and 4.7, and results are extraordinarily consistent: sunlight in spring pushes people to approve of Bush, while sunlight in summer has the opposite effect, even after controlling for demographic factors, party ID, ideology, and geographic position measured three distinct ways! Of course, sometimes the levels of statistical significance slip into the $p<.1$ range, but given some of the hazards of measurements entailed in aggregating daily weather variables, tying them to geospatially specific respondents, not knowing whether or not given respondents have even been outside, and placing them in a models with so many variables that vehemently suck out all sorts of regional variance (and create multicollinearity), this is to be expected.

Figures 4.3 and 4.4 display the predicted probabilities of approving of Bush generated by these models. As with temperature and survey response, the relationship between Presidential approval and sunlight is not substantively overwhelming. However, its effect is not negligible, either. The most strenuously controlled model predicts that, in the spring, moving from the cloudiest day to the sunniest day increases the probability of approving of Bush by about 9%. The same model in the summer sample predicts that a respondent living at the cloudiest location is about 12% less likely to approve of Bush than a respondent living at the sunniest location, all else equal. Figures 4.3 and 4.4 show that these effects are consistent across Democrats, Republicans, Independents, and the entire population, though the effect upon Republicans is marginally weaker than it is across the other categories. Democrats are more affected than Republicans, but less so than Independents, whose probabilities change the most as sunlight changes. This makes sense: most Independents have weaker affective dispositions toward Bush than Republicans or Democrats, and so they ought to be more susceptible to weather effects. In the language of Zaller and Feldman (1992), Democrats and Republicans have a number of pre-existing considerations regarding the President. When these respondents sample their considerations in order to provide a response, feelings about Bush are numerous and salient, both outnumbering and overpowering considerations stimulated by weather conditions. On the other hand, many Independents are Independents because they lack strong affective ties to the political world, and thus draw from a rather shallow well of considerations pertaining to Bush; in this environment, positive considerations induced by a sunny day are more likely to sway question response.

Day Length and Approval: A Second Test. The previous tests demonstrate that more sunlight in the summer depresses approval ratings, and that more sunlight in the late spring boosts it. This measure of sunlight takes represents the average amount of solar radiation that reaches the earth’s surface between sunup and sundown, and is therefore a measure of how sunny a day is, regardless of day length. The literature on SAD suggests that the *length* of daylight should affect human behavior, as well. This is measured simply as the number of minutes between sunrise and sunset[44]. Testing if this variable has an effect on approval is both a test of whether the SAD hypothesis applies in this context, and a check on the previous finding of how sunlight affects approval.

While there is no apparent relationship between the length of days and survey response in the bivariate analyses, two significant relationships pop up in multivariate regression, which are shown in Table 4.8. Over the course of the year, longer days appear to increase approval--which is precisely what we should expect, given that longer days tend are associated with better mood and happier attitudes. However, when only focused on the summer, it appears that shorter days boost approval, likely because these days are cooler than longer summer days.[45] This comports well with the previous finding sunlight negatively impacts approval in the summer. However, because the bivariate relationship is insignificant, this outcome should be regarded with skepticism, and so we should be cautious in asserting that the length of daylight affects survey response.

Sunlight and Heat: A Second Check. If summer sunlight is negatively related to approval for Bush because sun in the summer indicates heat, then adding heat to the model while interacting sunlight with heat should reverse the sign on the sunlight variable. This would draw out the variation in estimation caused by sunlight and heat mattering *together*, leaving heat and sunlight's independent effects. Unfortunately, in the summer dataset, this approach does not yield significant test statistics on any of the weather variables. However, in the pooled dataset, the results are interesting. Results are shown in Table 4.8. Once the interactive effects of sunlight and temperature are meted out of the model,

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[44] Calculated by latitude/longitudinal position by a spreadsheet provided by the NOAA.

[45] Unfortunately, because length of day bears a linear relationship to latitude, regional variables are extremely problematic, as they produce uncentered VIFs on the key independent variable in excess of 200.

sunlight has a *positive* influence on approval year-round.

However, sunlight and temperature occurring together has a negative effect. At first glance, this is troublesome: during winter and spring, sunlight and temperature should boost approval, especially when they occur together. However, neither sunlight nor temperature have emerged as predictors of Presidential approval in our strictest winter models. What remains is a positive relationship between sunlight and heat and approval during the spring, and a negative relationship between sunlight and approval in the summer. There are, then, strong countervailing forces working on the positive relationship evident in the spring: heat and sun together can make people uncomfortable both in southern latitudes, which can be hot year-round, as well as throughout the country in the summer months. Looking at the year as a whole, this effect may outweigh the role that heat and sunlight play in boosting mood in the spring. Nevertheless, neither the weather variables nor their interaction consistently emerge as statistically significant in season-specific models, and so this particular point remains supposition. Yet Table 4.9 does illustrate an interesting and important point: once the interactive effect of heat and sunlight are controlled, sunlight exerts a *positive* effect on approval, year-round.

Visibility, Precipitation, and Approval. The literature on weather and human behavior has led to clear hypotheses about how temperature and sunlight might affect approval ratings, some of which have been supported in this chapter. However, other, less-closely scrutinized weather conditions are amenable to analysis. Three such variables are horizontal visibility, ceiling height, and precipitable water in the atmosphere. Horizontal visibility measures the distance to the farthest discernable object on the horizon--in other words, this captures how far someone can see. Lower horizontal visibility corresponds to low-lying clouds or foggy conditions. Greater horizontal visibility could well correspond with lower Presidential approval, since foggy or hazy conditions limit sunlight, and are gloomy in themselves. Another such measure is ceiling height, which measures the height of the lowest flying cloud in the sky. There is really no theoretical expectation here, although it does seem conceivable that, since lower-flying clouds are fog, ceiling height could be negatively correlated with approval. Finally, precipitable water in the atmosphere is a measurement of how much moisture would fall to earth if all the moisture in a single beam stretching from the earth to the atmosphere would fall in one moment. A high score on this variable can indicate full, ponderous, dark clouds, suggests rain or at least the probability of rain, and can reflect humidity. A low score would correspond to clear skies, or skies with white clouds, and a clearer forecast. This variable should also be negatively related to approval.

Bivariate relationships are shown in Table 4.10. Horizontal visibility is only statistically correlated with approval in march. This relationship is not apparent when controls are introduced. Ceiling height is also unrelated to approval. In February, March, and July, however, precipitable water in the atmosphere actually leads to *greater* approval of Bush.

This is a strange outcome, and is difficult to interpret. Multivariate analysis suggests that these significant bivariate relationships are flukes. When inserted into a logistic regression, precipitable water in the atmosphere is a statistically significant predictor of approval the yearlong sample, but is never significant in the season-by-season analysis. Yet when the national sample is sliced into seasonal or regional subsets, or any sort of geographical control is placed in the model, statistical significance wanes. Since this relationship does not fare well in strict multivariate analysis, it is reasonable to set it aside, and move on.

Barometric Pressure and Approval. Finally, we turn to barometric pressure, which represents the total weight of air at a given point. Generating hypotheses about how barometric pressure can affect public opinion has been problematic because the literature on the subject does not lead to especially clear theoretical expectations, and because barometric pressure can indicate other weather conditions. Lower pressure has been associated with poorer moods, while higher pressure is associated with weaker and less frequent headaches. Pressure also indicates other weather conditions, but in a far from deterministic fashion, which significantly complicates matters.

In bivariate analysis, shown in Table 4.11, a statistically significant negative relationship emerges between barometric pressure and approval. This appears in the yearlong sample, as well as February, May, June, July, and September. In multivariate analysis, this relationship persists. Estimates are displayed in Table 4.12. In the yearlong sample, higher barometric pressure reduces the likelihood of approving of Bush, even after regional controls are inserted into the model. This is also the case in late spring, summer, and fall. To preserve space, regional controls are not shown here, but results using either latitude or regional dummies are consistent. It is difficult to say why barometric pressure has this effect on survey response. It could be because lower levels of pressure are associate with less headaches (Cull, 1981), which could boost approval. Alternately, or perhaps concurrently, the effect of pressure may revolve around how it affects other weather conditions. In the summer, high levels of barometric pressure generally indicate clearer days and less shady, and so the negative relationship between pressure and approval evident in the summer months may reflect the cooling effect of low pressure. This test, then, may well provide further support for a recurring finding: cooler and shadier days in the summer boost approval ratings.

However, this is problematic for two reasons. First, pressure is tricky in that it does not deterministically affect temperature and cloud cover. Where there is a *tendency* in the summer months for lower pressure to lead to cooler temperatures and shadier days, this is not necessarily case. Second, barometric pressure is also negatively related to approval in the late spring and the autumn, and it is unlikely that this is because barometric pressure is cooling conditions during those seasons, since earlier findings suggest that people prefer warmth and sunlight during these times.

It is possible, then, that this finding offers some confirmation of the argument that lower levels of barometric pressure reduce headaches and psychiatric emergencies. Yet, in later chapters, higher levels of barometric pressure seem to stimulate more positive behavior. Unfortunately, it is difficult to move beyond speculation on the subject here. Nevertheless, the data suggest that there *is* a relationship between barometric pressure and Presidential approval.

Summary and Implications. If we restrict findings only to relationships that are apparent in both bivariate and multivariate analyses, and those findings that survive strict multivariate tests with regional controls, the data tell us that, in some cases, weather does affect survey response. Yet this effect varies as the calendar moves. In the spring, warmer temperatures and more sunlight boosts approval of Bush. In the summer, less sunlight bolsters approval. And through much of the year, low barometric pressure stimulates approval. These particular effects remain statistically significant even after we control for region; in some cases, they survive the inclusion of latitude, regional dummies, and dummies for each state, all in the same model. Of course, there are other interesting relationships in the data--however, these are the strongest and most consistent.

While the substantive impact of sunlight and temperature in no way overrides, say, party ID or education, the effect is not tiny, either. For instance, Table 4.13 shows that moving from the darkest to the sunniest day in March increases the likelihood of approving of Bush 22.3%; this effect is commensurate with the 25.7% increase in likelihood of approval exhibited as church attendance changes from its minimum to its maximum value. Identifying with the Republican party (relative to the Democratic party) impacts the likelihood of approval about four times more than a minimum to maximum shift in sunlight. However, this 'sunlight effect' is not trivial: it has a greater effect on the likelihood of approval than a similar shift in the race variable (being nonwhite as opposed to white. A similar pattern is evident in December.

But weather doesn't always matter. Looking at all the analysis above, it's quite clear that relationships are most apparent in spring and summer, much less so in fall, and almost never apparent in winter. Neither a lousy or nice day in winter or fall appear to have much effect on what people say. However, in the spring--as people in most places emerge from the long winter cold--nice days stimulate positive response. In this summer, when people crave shade, weather continues to exert a clear effect.

Why this disparity between summer and winter? It's difficult to say for certain, but it likely has to do with the extent to which people go outside--or, at least, *expect* to go outside. People are most affected by weather when they go outside (Keller et al., 2005). And the spring is when outdoor activity peaks: sporting leagues open, parks are flooded with people, families venture to public pools, and people start building new decks. Days are longer, leaving more time for outdoor leisure activities--or, outdoor errands. A cold day in spring annoys people who want to play Frisbee, and it makes the game less pleasant for those who do. In winter and fall, however, activity is winding down. As leaves fall, cold winds pick up, and night grows longer and longer, people follow Nature's pattern and retreat indoors. Just as people expect spring to be nice, people expect winter to be lousy, and aren't uplifted by a uniquely nice winter day because they just aren't planning on going outside, and because they know that winter isn't finished yet. For that matter, they aren't bothered by a disgusting winter day, either. Finally, the disparity between summer and winter could well relate to the limited breadth of the country that experiences winter. In the south and along the western coast, the winter months are not especially unpleasant, and so neither sunlight nor warmth may be especially appreciated. The situation in the northeast and the interior is quite the opposite. However, everyone experiences uncomfortable summers--it can become stiflingly hot even in Maine, but it never becomes cold in Key West.

So, sunlight and temperature matter at certain points during the year. However, many things *don't* matter at all. For one, incorporating the average temperatures for a given location into analysis almost always produces statistically insignificant results. Weather, not climate, affects survey response. Further, weather's effects on people do not appear to be in any way contingent upon typical weather conditions. The difference between the observed weather conditions at a given place and time and the average weather conditions for that place and date doesn't have a measureable effect on approval. While a cool day in summer unilaterally increase approval rates, an *unusually* cool day for a given location does not appear to have a significant impact. A farmer outside of Baton Rouge enjoys a cool summer day just the same as a farmer outside of Nampa, Idaho. A woman in New York who experiences a 70 degree day in December is no more likely to approve of Bush than her sister in Los Angeles. Taking the differentials between typical conditions and observed conditions into account does not produce significant results at any level.

This is surprising given that weather is, to some extent, subjectively experienced, and research suggests that people build their understanding of 'good' and 'bad' weather based on their surroundings. Nevertheless, analysis here suggests that absolute measures for temperature and sunlight are what matter, suggesting that the perception of 'good' weather isn't particularly attuned to regional climate. Alternately, there may also be some measurement issues at work. In cases where the NREL does not have good, consistent weather records, it does not generate average weather measures. Many stations that generate accurate 2005 measures have not been consistently open for a decade, and thus for these stations, no average measures exist. Consequently, some respondents are tied with average conditions associated with stations that are significantly further away than the stations that measure observed conditions. Yet the difference is fairly minor, as the average distance between respondent and stations providing climatic data is just 12 miles further than the distance between respondents and the nearest stations providing observed data.

There is also no evidence that rain affects survey response.

As a whole, results here are interesting. They suggest that, under certain circumstances, weather matters. Although statistical significance on key variables is not always incontrovertibly strong, some variables survive extremely tough cross-sectional tests. These results, then, are quite remarkable, since the claim that weather affects public opinion leads us down a road marked with measurement issues that ought to confound analysis. Weather is complex, and there are a lot of problems with meaningfully condensing it into a quantitative dataset comparable with survey data. Remember that the weather data is aggregated over the course of the day, yet we do not know the timing of the phone call. We also don't know how long people have been outside on a given day, or if they have even looked out of the window. People are tied to the nearest weather station, which is, on average, about 30 miles away. People do not always truthfully enter their ZIP codes, and the ZIP codes given may be improperly entered. Despite all of these problems, in some cases, weather matters!

These findings offer commentary of Achen and Bartels' (2004) work on blind retrospection. Those authors find that voters punish incumbents for things that are well out of their control, such as shark attacks and droughts, provided that people can construct some sort of narrative that attributes undesirable natural conditions to incumbents. Shark attacks and droughts upset voters because they are unpleasant, and because they exist in a part of the public sphere that government should be able to do something about. Shark attacks could be prevented through judicious government and floods can be handled by hired engineers (or so peoples' logic goes). This chapter agrees with the first part of Achen and Bartels' theory: people do appear to punish Bush for things well out of his control. However, there is little evidence here that such blind retrospection requires respondents to construct any sort of narrative tying an incumbent to natural conditions. In the realm of public opinion, people appear to exhibit knee-jerk reactions to unpleasant weather; there is no explicit connection between Bush and cloudiness floating through popular culture, as was the case after the Jersey Shore shark attacks around the turn of the Century. This analysis, then, suggests that people are even more myopic than Achen and Bartels' voters.

These results also suggest a route to subtly manipulating presidential approval ratings, and a key to diffusing such potential machinations. While this is admittedly a stretch, it is not entirely inconceivable that organizations pushing their own agendas could mold the expression of public opinion by timing surveys to correspond with particularly sunny or cloudy weather in the winter or spring. If this were the case (and the author does not mean to suggest that it is), understanding the nature of this 'sunlight-effect' would be crucial to diffusing such unscrupulous efforts.

The avenue for further research in this area is broad. Sunlight could well influence other sorts of questions, which could be the subject for interesting scholarship. Other weather conditions, such as temperature and precipitation, could also conceivably affect public opinion. It would also be interesting to explore how weather and public opinion interact in different geographic contexts. Sunlight likely has a stronger effect in more light-deprived that cling to the extreme northern and southern reaches of the hemisphere. Sunlight could play a more powerful role in shaping public opinion in agrarian nations, where citizens are less sheltered from the elements and generally spend more time outside.

The results here tell an interesting story that is not at all at odds with the methods and theories of conventional social science analysis. Sunlight affects Presidential approval in winter and spring, albeit in a rather modest fashion. This conclusion could well give researchers pause to consider other environmental variables that could potentially influence phenomena of interest to social scientists, even if they sit just a bit off the beaten path.

Table 4.1. Bivariate Correlations Between Temperature and Approval of Bush, 2005.

	Yearlong	February	March	May	June	July	September	October	December
Temp	0.0176*	0.0788**	0.0984****	0.0765***	-0.0045	0.0055	0.0848*	0.034	0.0094
App. Temp	0.0169*	0.0836***	0.0901***	0.0743***	-0.0045	0.0091	0.0884***	0.0233	-0.0013

Note: Dependent Variable is 0 when respondent disapproves of Bush, and 1 when respondent approves.

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.2. Logistic Regressions of Apparent Temperature on Approval of Bush, 2005.

	Early Winter (Dec.)	Late Winter/Early Spring (Feb., Mar.)	Late Spring (May)	Summer (June, July)	Autumn (Sep., Oct.)
Adjusted Temperature	.0035 (.004)	.007** (.003)	.0097 (.007)	.0046 (.008)	.0064 (.005)
Age	-.0008 (.005)	-.0106*** (.007)	-.0164*** (.005)	-.0134**** (.004)	-.0101*** (.004)
Education	-.0452 (.055)	-.0241 (.04)	-.1645*** (.058)	-.0979** (.041)	-.0471 (.041)
Nonwhite	-.8216*** (.241)	-.7262**** (.169)	-1.439**** (.270)	-.58*** (.169)	-.8321**** (.172)
Income	-.011 (.039)	.0334 (.029)	.0870** (.042)	.0124 (.029)	.0314 (.029)
Ideology	-.7527*** (.097)	-.5387 **** (.071)	-.7541**** (.103)	-.5664**** (.074)	-.7344**** (.073)
Church Attendance	-.1240** (.051)	-.1304*** (.038)	-.1392*** (.053)	-.1741**** (.039)	-.1228*** (.037)
Democrat	-1.8289**** (.214)	-1.34**** (.132)	-1.579**** (.196)	-1.172**** (.137)	-1.4933**** (.147)
Republican	1.401**** (.182)	2.169**** (.159)	1.7497**** (.211)	2.322**** (.159)	1.9343**** (.141)
Constant	2.56**** (.517)	2.101**** (.372)	3.2036**** (.693)	2.6067*** (.756)	2.2238**** (.509)
N	1117	2159	1103	2161	2268
p>chi2	0	0	0	0	0
Pseudo-R2	0.3483	0.3579	0.3876	0.3758	0.3712

Note: Dependent Variable is 0 when respondent disapproves of Bush, and 1 when respondent approves.

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.3. Logistic Regression of Adjusted Temperature on Approval of Bush, North and South of 36th Parallel.

	Early Spring (Feb., Mar.), North of the 36 Parallel	Early Spring (Feb., Mar.), South of the 36 Parallel
Adjusted Temperature	.001** (.004)	-.01267 (.01)
Age	-.0059 (.004)	-.0082 (.006)
Education	-.0768* (.045)	-.0615 (.069)
Nonwhite	-.6932*** (.214)	-.895*** (.269)
Income	.0418 (.033)	.0165 (.052)
Ideology	-.6256**** (.086)	-.367*** (.127)
Church Attendance	-.1671**** (.044)	-.2277**** (.063)
Democrat	-1.4764**** (.156)	-1.4034**** (.227)
Republican	2.2287**** (.181)	2.7706**** (.297)
Constant	.6216 (.3789)	2.1422*** (.76)
N	1478	750
p>chi2	0	0
Pseudo-R2	0.3131	0.3918

Note: Dependent Variable is 0 when respondent disapproves of Bush, and 1 when respondent approves.

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.4. Logistic Regressions of Temperature on Being an Independent, Spring.

	Full Sample	Independents and Democrats Only	Independents and Republicans Only	Independents and Republicans, Northeast	Independents and Republicans, Midwest	Independents and Republicans, South	Independents and Republicans, West
Adjusted Temperature	-.0088*** (.003)	-.0037 (.003)	-.0165**** (.004)	.0158 (.014)	-.048**** (.011)	-.0183** (.008)	-.02711*** (.011)
Age	-.0134**** (.003)	-.0196**** (.004)	-.0113*** (.004)	-.0236** (.011)	-.0077213 (.009)	-.0047 (.007)	-.0121* (.007)
Education	.0067 (.038)	.0282 (.043)	.0189 (.048)	-.1026 (.114)	-.0531 (.104)	.0479 (.08)	.0710 (.088)
Nonwhite	-.2 (.159)	-.8574**** (.169)	.6513*** (.241)	.5489 (.58)	2.0222*** (.835)	.5867 (.379)	.2109 (.325)
Income	-.0382 (.027)	.0254 (.032)	-.1172*** (.035)	.06036 (.082)	-.1295* (.074)	-.165*** (.059)	-.0957 (.058)
Ideology	.1831*** (.062)	-.334**** (.075)	1.0415**** (.101)	1.0588**** (.24)	1.1589**** (.219)	1.0815**** (.177)	.2083 (.135)
Church Attendance	.1094*** (.036)	.066 (.042)	.1850**** (.0462)	.2264** (.112)	.2433** (.102)	.1244 (.08)	.0806 (.078)
Constant	-1.212**** (.337)	1.1715 (.392)	-2.21**** (.447)	-3.1074** (1.243)	-1.6832* (.9)	-2.2553*** (.812)	-.2622 (.83)
N	2280	1194	1173	204	296	445	433
p>chi2	0	0	0	0	0	0	0
Pseudo-R2	.0285	.0470	.179	.1871	.2209	.1689	.044

Note: Dependent Variable is 1 when a respondent identifies themselves as an Independent, and 0 otherwise.

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.5. Bivariate Correlations between Sunlight and Approval of Bush.

	Yearlong	February	March	May	June	July	September	October	December
Diffuse and Direct Sunlight	0.0966	0.0024	0.0812***	0.0118	-0.0659**	-0.0737***	0.0665**	0.0296	0.0093***
Direct Sunlight	-0.0016	-0.0132	0.0567**	0.0124	-0.0612**	-0.0638**	0.0816***	0.0181	-0.0119
Diffuse Sunlight	-0.005	0.0382	0.0028	-0.01	0.0274	-0.0116	-0.0954****	0.0369	-.0012

Note: Dependent Variable is 0 when respondent disapproves of Bush, and 1 when respondent approves.

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.6. Logistic Regressions of Sunlight on Approval of Bush, Early Spring.

	Early Spring	Early Spring, With Latitude	Early Spring, With Regional Dummies	Early Spring, With State Dummies
Diffuse and Direct Sunlight	.0019** (.001)	.0011** (.001)	.001* (.001)	001* (.000)
Age	-.0109*** (.004)	-.011*** (.004)	-.0110*** (.004)	-.0121** (.003)
Education	-.0177 (.04)	-.0185 (.04)	-.01946 (.04)	-.01** (.041)
Nonwhite	-.7049**** (.169)	-.7341*** (.17)	-.7567**** (.171)	-.781*** (.177)
Income	.0356 (.029)	.0349 (.029)	.0326 (.029)	.0247 (.029)
Ideology	-.5428**** (.071)	-.5397**** (.071)	-.5354**** (.072)	-.545**** (.073)
Church Attendance	-.1311*** (.038)	-.1287*** (.038)	-.1292*** (.039)	-.1372**** (.038)
Democrat	-1.3346**** (.132)	-1.3458**** (.133)	-1.3517**** (.133)	-1.386**** (.139)
Republican	2.19**** (.158)	2.1747**** (.159)	2.18**** (.159)	2.262**** (.164)
Midwest			-.1977 (.178)	20.691**** (1.408)
Northeast			-.0503 (.186)	20.2286**** (1.719)
South			.2164 (.168)	19.947**** (1.546)
Latitude		-.0207* (.012)		.0593 (.048)
State Dummies				(not shown)
Constant	2.0107**** (.384)	2.8517*** (.624)	2.0849**** (.414)	-.324 (2.3)
N	2160	2160	2160	2156
p > Chi	0	0	0	0
pseudo-R2	.3576	0.3586	0.3602	.3768
Change in Predicted Probability of Dependent Variable = 1 as Temperature or Sunlight Increases from Min to Max, all else constant	.1319	.113	.102	.94

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.7. Logistic Regressions of Sunlight on Approval of Bush, Summer and Winter.

	Summer	Summer, With Latitude	Summer, with Regional Dummies	Summer, with State Dummies	Winter
Diffuse and Direct Sunlight	-.001** (.001)	-.0008* (.000)	-.001** (.000)	-.0009* (.000)	.0012* (.001)
Age	-.0136** (.004)	-.0130**** (.004)	-.0132**** (.004)	-.0123** (.004)	-.0003 (.005)
Education	-.0937** (.042)	-.0894** (.042)	-.0929** (.042)	-.0947** (.043)	-.0443 (.056)
Nonwhite	-.56782*** (.168)	-.5883*** (.17)	-.5933**** (.169)	-.5507*** (.176)	-.815*** (.239)
Income	.0112 (.029)	.0096 (.0291651	.0095 (.029)	.0194 (.03)	-.010 (.039)
Ideology	-.566**** (.074)	-.5686**** (.074)	-.5689**** (.074)	-.5728**** (.076)	-.7519**** (.098)
Church Attendance	-.1710**** (.039)	-.159**** (.039)	-.1645**** (.039)	-.1586**** (.041)	-.1208** (.051)
Democrat	-1.1824**** (.137)	-1.1929**** (.138)	-1.1918**** (.137)	-1.2049**** (.143)	-1.8502**** (.214)
Republican	2.3156**** (.158)	2.3129**** (.159)	2.3117**** (.158)	2.3747**** (.143)	1.4005**** (.182)
Midwest		-.0241 (.187)		-1.0678 (2.001)	
Northeast		-.0251 (.19)		-1.2506 (1.452)	
South		.2825 (.173)		.119 (1.873)	
Latitude			-.026** (.019)	-.0545 (.049)	
State Dummies				(not shown)	
Constant	3.39**** (.412)	3.154**** (.472)	4.3619**** (.607)	8.2539 (2.451)	2.3331**** (.535)
N	2168	2168	2168	2167	1119
p > Chi	0	0	0	0	0
pseudo-R2	.3765	.3785	0.3781	.3937	.3494
Change in Predicted Probability of Dependent Variable = 1 as Temperature or Sunlight Increases from Min to Max, all else constant	-.1476	-.123	-.148	-.142	-.1206

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.8. Logistic Regressions of Hours of Sunlight on Approval of Bush.

	Yearlong Sample	Summer
Daylight Hours	.0008*** (.001)	-.0046** (.002)
Age	-.0108**** (.002)	-.0136**** (.004)
Education	-.0672*** (.02)	-.0969** (.041)
Nonwhite	-.793**** (.085)	-.5962**** (.169)
Income	.0316** (.014)	.0116 (.029)
Ideology	-.6596**** (.036)	-.5731**** (.074)
Church Attendance	-.1363**** (.019)	-.1714**** (.039)
Democrat	-1.391**** (.069)	-1.1845**** (.137)
Republican	1.9713**** (.073)	2.3005**** (.156)
Constant	2.2641**** (.26)	6.0035**** (1.5)
N	8821	2168
P > chi 2	0	0
Pseudo - R2	.3625	.3762

Note: Dependent Variable is 1 when a respondent approves of the way President Bush is handling the country, and 0 otherwise.

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.9. Logistic Regressions of Sunlight, Heat, and Their Interaction on Approval of Bush, Pooled Sample.

	With Regional Dummies as Control Variables	With Latitude as a Control Variable	With Regional Controls and Latitude as Control Variables
Diffuse and Direct Sunlight	.0011* (.000)	.0013* (.001)	.001* (.000)
Adjusted Temperature	.0047 (.003)	.0061* (.003)	.005 (.003)
Sunlight x Temperature	-.000* (.000)	-.0000** (.000)	-.000* (.000)
Age	-.0103**** (.002)	-.0106*** (.002)	-.010**** (.002)
Education	-.065*** (.02)	-.0664**** (.02)	-.065*** (.020)
Nonwhite	-.832**** (.086)	-.8284**** (.086)	-.832**** (.086)
Income	.0319** (.014)	.03** (.014)	.031** (.014)
Ideology	-.65**** (.036)	-.6538**** (.036)	-.65**** (.036)
Church Attendance	-.127**** (.019)	-.133**** (.019)	-.127**** (.019)
Democrat	-1.3962**** (.069)	-1.392**** (.069)	-1.3953**** (.036)
Republican	1.9777**** (.07 3)	1.97**** (.069)	1.9767**** (.073)
Midwest	-.078 (.09)		-.076 (.092)
Northeast	-.1273 (.092)		-.1255 (.094)
South	.2674*** (.082)		.2625*** (.094)
Latitude		-.0244**** (.006)	-.000 (.009)
Constant	2.3695 (.455)	3.3623**** (.373)	2.4068 (.455)
N	8808	8808	8808
p > Chi	0	0	0
pseudo-R2	.3651	.3638	.3651

Note: Dependent Variable is 1 when a respondent approves of how Bush is handling his job as President, and 0 otherwise.

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.10. Bivariate Correlations between Visibility and Precipitation and Approval of Bush.

	Yearlong	Feb.	Mar.	May	June	July	Sep.	Oct.	December
Horizontal Visibility	-0.0082	.0082	-0.049*	-0.0323	-0.0343	0.0345	0.0215	0.0117	-0.0216
Ceiling Height	-0.0065	0.0091	0.0172	-.0125	-0.0117	-0.0168	0.0277	-0.0023	-0.0228
Precipitable Water in the Atmosphere	0.0131	.0628**	0.0620**	0.0119	0.0327	0.0487*	-0.0013	0.0106	0.0361

Note: Dependent Variable is 1 when a respondent approves of how Bush is handling his job as President, and 0 otherwise.

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.11. Bivariate Correlations Between Barometric Pressure and Approval of Bush.

	Yearlong	Feb.	March	May	June	July	Sept.	Dec.
Barometric Pressure	-0.0656****	-0.0487*	-0.0263	-0.0732***	-0.0983*	-0.0769***	-0.1297****	-0.0388

Note: Dependent Variable is 1 when a respondent approves of how Bush is handling his job as President, and 0 otherwise.

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.12. Logistic Regressions of Barometric Pressure on Approval of Bush.

	Yearlong	Yearlong with Regional Controls	Late Winter/Early Spring (Feb., Mar.)	Late Spring (May)	Summer (June, July)	Autumn (Sep., Oct.)	Early Winter (Dec.)
Barometric Pressure	-.0021*** (.001)	-.0031**** (.001)	.0008 (.001)	-.0035* (.002)	-.0033** (.001)	-.0036** (.001)	-.0004 (.002)
Age	-.0109**** (.002)	-.0106**** (.002)	-.0105*** (.004)	-.0163*** (.005)	-.014**** (.004)	-.0098*** (.004)	-.001 (.005)
Education	-.06759*** (.020)	-.0647*** (.02)	-.0182 (.039)	-.1767*** (.058)	-.1047*** (.042)	-.0412 (.041)	-.044 (.055)
Nonwhite	-.7787**** (.085)	-.8101**** (.086)	-.6951**** (.169)	-1.368**** (.271)	-.5351*** (.17)	-.7939**** (.172)	-.7959*** (.238)
Income	.0342** (.014)	.0374** (.014)	.0334 (.029)	.0937* (.042)	.0189 (.029)	.0321 (.029)	-.0070 (.039)
Ideology	-.6572**** (.036)	-.6503**** (.036)	-.547**** (.071)	-.7661**** (.104)	-.5549**** (.075)	-.7406**** (.073)	-.7512**** (.097)
Church Attendance	-.1361**** (.019)	-.124**** (.019)	-.1264**** (.038)	-.1362*** (.053)	-.1827**** (.039)	-.1186*** (.037)	-.1209** (.051)
Democrat	-1.3794**** (.069)	-1.3918**** (.069)	-1.3333**** (.132)	-1.5365**** (.196)	-1.1886**** (.138)	-1.4733**** (.147)	-1.8299**** (.213)
Republican	1.9686**** (.073)	1.9672**** (.073)	2.1824**** (.158)	1.788**** (.211)	2.2997**** (.158)	1.9361**** (.141)	1.4026**** (.182)
Midwest		.0016 (.091)					
Northeast		.0208 (.099)					
South		.3993**** (.087)					
Constant	4.8457**** (.732)	5.565**** (.778)	1.5462 (1.5086)	7.2573**** (1.987)	6.1954**** (1.484)	6.2113**** (1.506)	3.0185 (2.085)
N	8796	8796	2157	1100	2156	2264	1119
p>chi2	0	0	0	0	0	0	0
Pseudo-R2	0.3622	.3657	.3558	.3874	.3773	.3716	.3475

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 4.13. Discrete Changes in Predicted Probabilities of Approving of Bush Across All Independent Variables as Sunlight Changes from Its Minimum to Maximum Value.

	March	December
Sunlight	.2231***	0.1385*
Age	-.2667**	-0.0108
Education	-.0200	-0.1068
Nonwhite	-.1441**	-0.2084****
Church Attendance	.2578****	0.1399**
Income	-.0595	-0.0147
Ideology	-.4769****	-0.5954****
Democrat	-.3540****	-0.4053****
Republican	.4398****	0.3497****
Latitude	-.1369	-0.1869**
Longitude	.0363	-0.1063

Note: Dependent Variable is 0 when respondent disapproves of Bush, and 1 when respondent approves.

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Figure 4.1 - Predicted Probability of Approving of Bush as Temperature Increases, Early Spring, North of 36th Parallel.

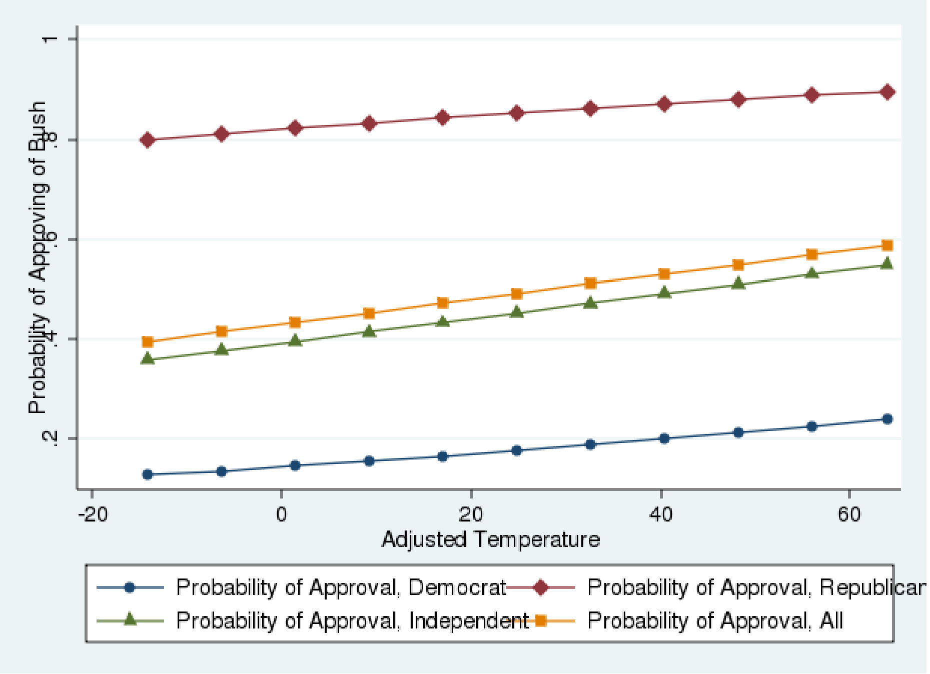


Figure 4.2: Measures of Annual Solar Radiation (Source: NREL).

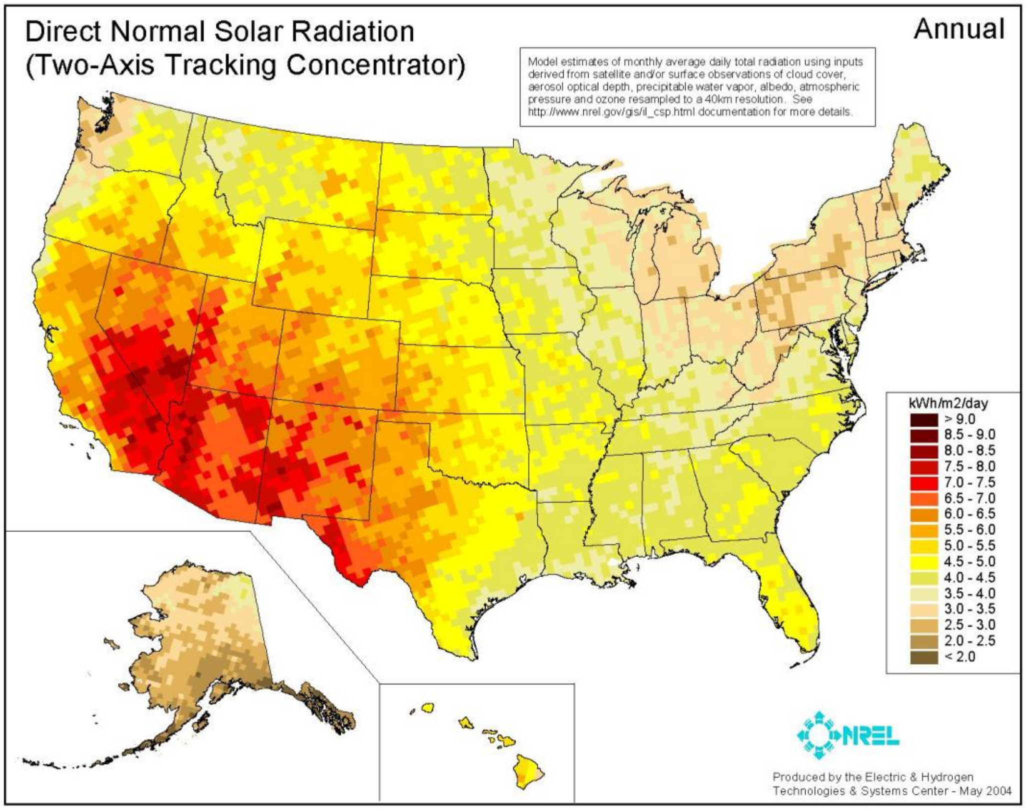


Figure 4.3: Predicted Probabilities of Approving of Bush and Sunlight, Spring.

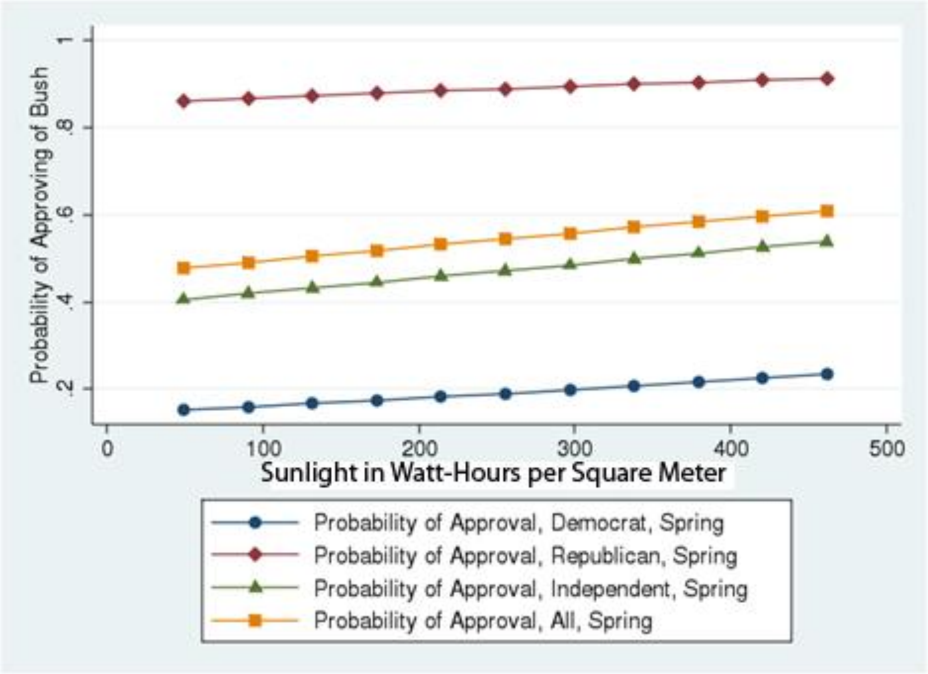
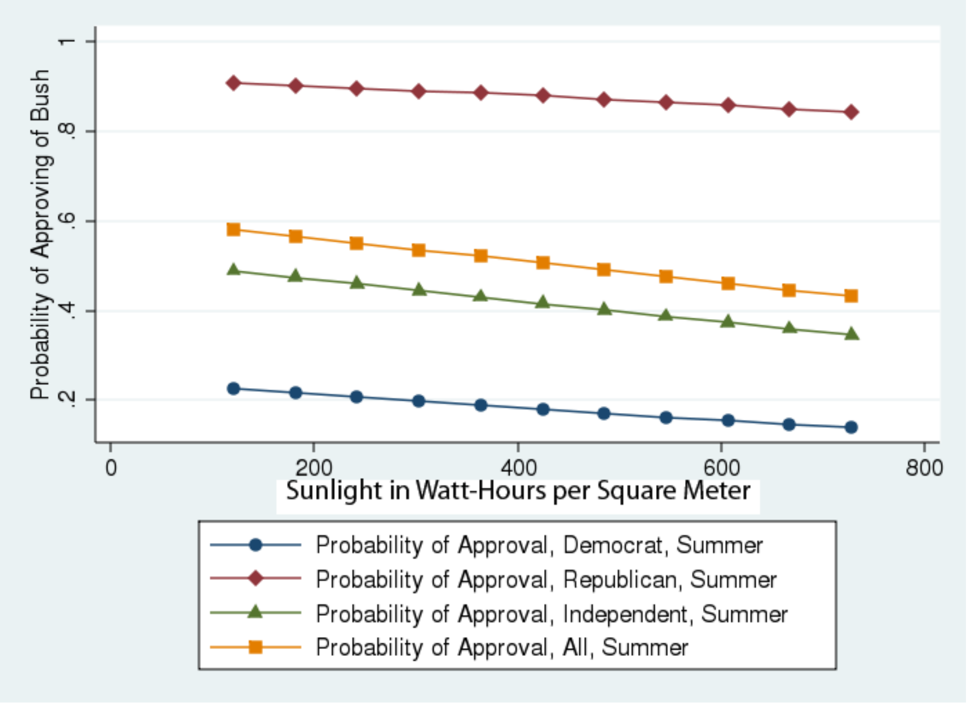


Figure 4.4: Predicted Probabilities of Approving of Bush and Sunlight, Summer.



CHAPTER V: CLIMATE, WEATHER, AND SOCIAL CAPITAL

Weather and Social Capital: An Introduction. Social capital, which generally refers to the sense of social connectedness gained from trusting interpersonal connections characterized by reciprocity, is an important force in maintaining a successful, healthy, and tolerant democracy (Ladd, 1999; Putnam, 2000; Skocpol, 2003). Some have argued that social capital is rooted in individual interactions and associations at the community level. These roots may well be watered by the weather. Behavioral and psychological research has shown that weather can substantially affect interpersonal relations and communication by making people happy, irritable, or helpful. Further, climate has been shown to affect health and crime rates, which also relate to social capital. The goal of this chapter is to investigate, first in broad strokes then with an eye to detail, the extent to which weather influences the indicators and indices of social capital.

Climatic Data. While the previous chapter focused on whether a sunny day increased the probability of someone approving of Bush *on that day*, we are more interested in whether sunny *places* exhibit higher levels of social capital than cloudier places. Observed weather conditions on any given day aren’t relevant to the measures of social capital that collected for this study. Certainly, sunlight and nice temperatures may encourage people to volunteer outside at a local park. However, the data sources used do not specify the date on which this volunteering took place[46]. Instead, we know the frequency with which a survey respondent has volunteered over the course of the year, or volunteer figures in the aggregate. The indicators of social capital employed herein, such as

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[46] Though, it is quite likely that this data exists somewhere. It would be interesting to correlate weather conditions with actually occurrences of indoor and outdoor volunteering. This would certainly help explain the mechanisms by which weather affects social capital and its indicators. However, such a micro-level data was not collected and used in this analysis.

trust, volunteering, and discussing politics, are not singular actions that can be tracked with the precision of one's stated approval of Bush. Attitudes about trust or tolerance should be influenced by long-term weather trends, as well.[47] Consequently, climatic conditions are considered in this chapter; quantitative measures come from the NREL's Typical Meteorological Year 1991-2005 dataset, an explanation of which is available in Chapter IV.

Hypotheses in Brief[48]. After looking at the general pattern of data which suggests that social capital to some extent overlaps weather conditions on the American map, tests will be conducted in three distinct areas. First, we will turn to Robert Putnam's seminal *Bowling Alone* to explore the extent to which weather relates to Putnam's statewide index of social capital. Second, we will shift units of analysis to compare weather with volunteer rates in major and mid-size American cities.

The most theoretically relevant weather variables are, again, sunlight and temperature. In addition to boosting personal health and decreasing depression, sunlight can make people more friendly, helpful, and optimistic. Sunnier places should exhibit higher measures of social capital, higher volunteer numbers, and the more positive expression of relevant attitudes like social trust, tolerance, and support for government. Both the amount of sun that reaches the earth as well as the number of hours of daylight should exert this positive influence.

Warmer temperatures, on the other hand, should have a negative effect on social

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[47] When measured via survey research, these should also be subject to short-term fluctuations based on the weather at the time of the phone call, as discussed in the previous chapter. Here, though, the focus is on more enduring trends that affect community interaction, rather than sunlight's twist on mood and question response. Further, short-term affects have already been examined, and so in this chapter, they are set aside in favor of exploring the link between climate and the responses to survey questions that pertain to social capital.

[48] This is discussed in greater detail in chapter III.

capital and its indicators, as heat tends to boost crime, encourage aggression, and make people feel miserable. Thus, places that experience warmer weather should score poorly on social capital indices, have fewer volunteers, and host populations that express low trust in others, intolerant views, and weak support for government institutions, relative to cities situated in cooler climates.

Precipitation should have a negative effect on social capital, volunteer rates, and the expression of trusting and helpful attitudes for two reasons. First, rain can indicate the absence of sunlight, which should exert negative effects on mood and helping behavior. Second, rain and snow make it more difficult for people to get from place to place, which should hamper all sorts of communitarian efforts, from volunteering to visiting friends. In the worst case, events are canceled due to inclement weather.

Finally, the relationship between barometric pressure and social capital, volunteering, and communitarian attitudes will be examined. The literature offers no clear signpost about the relationship between pressure and human behavior. High pressure has been associated with better moods, while low pressure may relieve headaches. To complicate matters, pressure can be conditionally related with other weather conditions: in the summer, for instance, high pressure can, but does not always, suggest cooler, cloudier days. Yet pressure’s tendency to reflect other weather conditions is hardly deterministic. Consequently, the theoretical link between pressure and behavior is rather weak. Nevertheless, barometric pressure is a readily available variable, and is subjected to analysis.

The Argument In Brief and Hypotheses. In *Bowling Alone* (2000), Robert Putnam uses a weather analogy to explain the map of social capital in the United States:

> “Geographically speaking, the national social-capital 'barometric map' is fairly straightforward. The primary 'high-pressure' zone is centered over the headwaters of the Mississippi and Missouri Rivers and extends east and west along the Canadian border. The primary 'low-pressure' area is centered over the Mississippi Delta and extends outward in rising concentric circles through the former Confederacy.” (p. 292)

Putnam goes on to note that Alexis de Tocqueville noticed the same pattern, and quotes:

> “‘As one goes farther south [from New England], one finds a less active municipal life; the has fewer officials, rights, and duties; the population does not exercise such a direct influence on affairs; the town meetings are less frequent and deal with fewer matters. For this reason, the power of the elected official is comparatively greater and that of the voter less; municipal spirit is less wide awake and less strong …’” (p. 292-3)

Putnam expressly states that explaining these differences is a “task for another day” (p. 292), but does suggest that correlation between states of the Confederacy and low social capital is striking, and that the legacy of slavery is a likely cause. Indeed, as Figure 5.1 shows, there is a clear geographic pattern to social capital. It is weakest in the south, and strongest in the patch of states situated to the west of the Great Lakes, and New England. And as Figures 5.2 and 5.3 demonstrate, this rather curiously parallels a map of temperatures throughout America.

The literature on temperature and human behavior demonstrates that people are generally more aggressive and less friendly to one another as heat and humidity increase. If this is the case, then people residing in hotter places should, by virtue of the discomfort endured during hot and sticky days should, be less trusting and less willing to connect with one another than residents of colder regions. Further, high temperatures—particularly during the boiling summer—decrease the safety and pleasantness of moving from place to place, and so should reduce the frequency of casual interactions on places like streets and public parks. It should also stifle the desire to venture outdoors and volunteer. In short, social capital should be lower in places where it routinely quite hot. Comparing Putnam's social capital map with the climate maps in Figures 5.2 and 5.3 show that the areas with the highest social capital—the Canadian border west of the Great Lakes and New England—are colder places. Except for Nevada, none of the states low social capital states fall in the 'cold' temperature zone shown in Figure 5.2, and with the exception of California, Arizona and Nevada, all the states registering the hottest temperatures exhibit quite low levels of social capital. Nevada is an interesting case, because although most of the state enjoys somewhat temperate climate, the key population centers of Reno and Las Vegas are located in hot regions, which could explain its low score. The Californian climate, on the other hand, is split neatly in half: it enjoys temperate marine temperatures along the heavily-populated coast, but more oppressive heat in the interior, and around San Diego. Figure 5.4, which shows the volunteer rates in major and mid-size American cities, shows that volunteerism in California is lowest in the hot interior, and along the southern coast.

Figure 5.5 provides another look at levels of civic community in U.S. states, this time using more recent data from the Census Population Survey. Seven of the nine states registering the lowest levels of civic life fit snugly within the band of 'hot climate.' Four of these states (Texas, Louisiana, Georgia and Florida) are members of the old Confederacy. However, three other states that are quite hot yet do not share the same cultural or historical legacy—California, Nevada, and Hawaii—also suffer from low levels of civic life. The remainder of southern and southwestern states—that is, those beneath the Mason-Dixon line on both sides of the Mississippi—are situated in the second-to-lowest tier of civic life, with a single exception: Oklahoma. No state in the top category of civic life is found within the band of hot climate, and Missouri is the only state registering high levels of civic life to fall within the region of mixed climate.

Of course, aggregate measures of social capital and civic community can be misleading, because it—like weather—is not necessarily uniformly distributed across the state. Another way to tease out this relationship is to look at volunteer rates in major cities. Figure 5.4, which documents the percentage of citizens that volunteer in several dozen American cities, displays a consistent pattern. In 28 of the 70 (40%) of the cities south of the Mason-Dixon (and including northern California, which shares a similar climate), less than 25% of citizens volunteered once in 2007-2008; compare this to only 9 of 81 (12%) cities in the cooler, northern regions, which show such low numbers. On the other hand, 57 of these 81 northern cities (70%) register volunteer rates in excess of 30%, while only 11 of the 70 southern cities (15%) have such high rates.

Doubtless, there are other factors at work here. For one, the legacy of slavery, the Civil War, and racial segregation in the states of the former Confederacy certainly has a depressive effect. Further, many hot southern states like Arizona have experienced positive population growth in recent years, and people should be less apt to volunteer in communities where they are less grounded.

Yet although these causal factors certainly have some explanatory power, temperature will be part of the story. As a robustness check, consider the hypothesis that social capital is related to temperature in a different historical and cultural context. Figure

5.6 displays Putnam's measures for civic community in Italy; they are drawn from his landmark 1994 work, *Making Democracy Work*[49]. Figures 5.7 and 5.8, document average temperatures in July and January, respectively. Southern Italy, Sardinia, and Sicily do appear to experience hotter summers than the north. The clear exception to this pattern is the broad scythe of hot temperatures jutting into northern Italy from the Adriatic; indeed, Milan, Rome, Florence, and Venice all experience uncomfortably hot summers, just like their southern-Italian counterparts. But civic community is built over the course of decades rather than a single season, and Figure 5.8 tells the second part of the story: winter cools northern Italy considerably more than it cools southern Italy. While summers may be hot in many places in northern Italy, the transitions to and from winter tend to keep southern Italy much hotter than the north. Perhaps, then, the heat of southern Italy—rather than just an unfortunate history—explains poor communitarian spirit and government inefficiency there.

These uncontrolled comparisons suggest a relationship between heat and social capital. Other variables are worth considering. It is conceivable that sunlight should have a positive influence on social capital and its indicators because sunlight makes people happy and helpful. However, a comparison between maps of social capital or volunteer rates and average yearly sunlight (Figure 5.9) is unconvincing. The sunniest region of the country is the southwestern region; many of the Arizonan, New Mexican, Californian, and Nevadan cities in this bright band exhibit low levels of volunteering and social capital. The states of the old Confederacy are considerably sunnier than New England, yet these states suffer from lower volunteer rates or social capital scores than their northern

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[49] A predecessor to *Bowling Alone*, *Making Democracy Work* chronicles how social capital is positively correlated with more efficient governance, public health, and public happiness.

counterparts. The only area where the pattern remotely fits is the north-central and north-western states, which enjoy high levels of social capital and sunlight; however, the brightness here is pale in comparison to that in the southwest, where social capital is markedly lower.

A relationship between rain and social capital does appear to be a distant possibility, at least at a glance. Figure 5.10 maps annual precipitation throughout the United States. The lowest social capital area--the south--is also the wettest. This makes sense, since rain indicates both cloudy skies, as well as impediments to travel that would render volunteering a less desirable activity. However, throughout the rest of the country, no clear pattern is evident. Nevada, one of the driest states, also suffers from low social capital, and the high social-capital states are situated near the middle on the rain scale.

While a glance at the broad pattern of data does not indicate that sunlight and social capital are related, it does suggest that rain and social capital could be weakly related, and that lower temperatures may be related to social capital and its indicators. In the next three sections, these relationships are examined in three areas: Putnam’s measures of social capital and its components from *Bowling Alone*, volunteer rates in large and midsize American cities, and survey data from the 2006 Social Capital Community Survey.

Weather and Social Capital at the Statewide Level. In his landmark work, *Bowling Alone*, Robert Putnam argues that the decline of American associational life and interpersonal trust experienced throughout the postwar era is linked to declining feelings of trust in government, political efficacy, and political participation (2000). In crafting this argument, he quantifies social capital at a statewide level using an index that he calls ‘The Comprehensive Social Capital Index,’ which contains fourteen components that measure associational life, attitudes between people, trust, and political participation. If weather is indeed related to social capital, then weather conditions should correlate with this index and its component indicators.

The unit of the analysis here is the state, which poses some problems for our weather variables. In the analysis of public opinion, respondents were tied to the nearest piece of weather-sensing equipment. However, Putnam's measures of social capital and its indicators are statewide, and weather stations measure weather at discrete points, rather than across a wide area. To obtain statewide weather measures, two approaches seem plausible, and due to the nature of available data, each is employed to create weather variables. First, wherever possible, weather conditions across the state are aggregated into a single measure[50]. The National Atmospheric and Oceanic Administration provides average statewide temperature (in degrees Fahrenheit)[51] and precipitation in inches[52] by month for all 48 contiguous states. This average reflects data stretching back to 1895 and aggregates station-level observations to the state levels using procedures outlined in Karl, Diaz, Young, and Wendland (1986). The figures from 1980-2000 are summed across each month, added together, and then divided by twelve, providing *Average Temperature Over Twenty Years* and *Average Precipitation Over Twenty Years*[53].

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[50] Following a procedure outlined in Karl and Koss, 1984.

[51] These are dry bulb temperatures, and not adjusted temperatures. Because the NOAA's method for aggregating temperatures into a single statewide variable is more precise than using a single station near the middle of the state, these dry bulb temperatures are likely more accurate than using the adjusted temperature obtained from any single weather station. If the average yearly adjusted temperature from the weather station closest to the geographic middle of the state is substituted for the NOAA's measure, results are substantively similar.

[52] It is worth noting that these measures of weather are taken over a 24-hour period, rather than merely daylight hours, which is the period over which most variables extracted from the NREL files are aggregated

For each state, *Average Yearlong Direct and Diffuse Sunlight* (how sunny a state is, on average) *Average Yearlong Barometric Pressure* (the average barometric pressure in a state), and *Minutes in Day on the Solstice*[54] are taken from the piece of weather sensing equipment closest to the geographic midpoint of the state[55]. The TMY database is used to generate the first two variables, and so these variables reflect long-term climatological trends at the state level. The last variable was manually calculated using a spreadsheet provided by the NOAA. Using weather stations situated in the center of states is a far from perfect approach, and it is unfortunate that the NOAA does not aggregate all measures of weather to the state level as it does with temperature and precipitation.

Putnam provides us with a comprehensive index of social capital, as well as fourteen indicator variables. Table 5.1 offers bivariate correlations between weather variables and some of Putnam's more prominent measures. The *Comprehensive Social Capital Index II* represents Putnam's final measure for statewide social capital. It is the average of the standardized scores of its fourteen component measures[56]. *Mean Number*

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[53] This time period was collected because it most neatly maps over the time span over which Putnam's measures were collected. Replacing the twenty-year average with longer or shorter averages obtain substantively and statistically similar results.

[54] Measured as the number of minutes between sunrise and sunset on the Winter Solstice, at the location of the weather station nearest to the city. Sunrise is defined as the moment when the sun reaches .8333 degrees above the horizon and sunset is defined as the moment when the sun reaches .8333 degrees below the horizon. .8333 is used as opposed to zero to account for refraction. The solstice is used to measure length of daylight because aggregating minutes of daylight over the course of a year would have been needlessly time-consuming. Put another way, to measure how long the sun is in the sky, one day is as good as any other. Substituting minutes in any other day during the year produces near-identical results.

[55] For each station, hourly observations are aggregated into daily observations, which are in turn averaged.

of Group Memberships is drawn from the General Social Survey (GSS) , and represents the average number of groups to which respondents in a given state belong. *Organizations per capita* is how many nonprofit organizations exist per 1,000 in population, as designated by 501(c)(3) of the Internal Revenue Code[57]**.** *Civic and Social Orgs* represents the quantity of these organizations per every 100,000 in a state[58]. *Mean Presidential Turnout* is the aggregate turnout in the 1988 and 1992 Presidential elections[59].

As Table 5.1 shows, with two exceptions, all the weather variables are negatively and significantly correlated to each of these measures. Two of these relationships are signed in the anticipated direction: both precipitation and warmth appear to hinder social capital, communitarian life, and presidential turnout. Yet, surprisingly, sunlight and daylight are both negatively related to social capital and its indicators. Sunny days, and longer days, appear to have a depressive effect. Finally, barometric pressure is negatively correlated with these measures. The theoretical signpost here has never been clearly inked. Lower pressure can indicate with cooler days but also precipitation, but has been linked with a weakening of headache symptoms in chronic sufferers. Of course, all of this is merely at the bivariate level, and should be noted with skepticism until multivariate analyses are conducted later in this chapter.

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[56] From *Bowling Alone*: "Of the ninety-one possible bivariate correlations among these fourteen indicators, eighty-eight are statistically significant in the proper direction at the .05 level of better, and none are in the wrong direction The mean intercorrelation across the ninety-one is r = .56. The concordance is impressive, given that the underlying data come from three independent survey archives and three different government agencies. The summary index is simply the average of the standardized scores on the fourteen compoenent measures. To maximize the number of cases, we computed this average even for those few cases in which data were missing on as many as five of the underlying fourteen indicators; this procedure enabled us to include all states except Alaska and Hawaii in our analysis. Effectively, this index is identical to the factor score from a principal components analysis of the fourteen component variables (487).

[57] *Non-Profit Almanac* (1989).

[58] County Business Patterns (1977-92). This is a publication of the United States Department of Commerce.

[59] From the U.S. Census Bureau.

Putnam also looks at interpersonal behavior and attitudes relevant to communitarian life. Each of these variables represents individual responses to survey questions, which are averaged across each state. *Time Spent Visiting Friends* is the extent to which people in a state agree with the statement “I spend a lot of time visiting friends,” measured as on a six-point agree or disagree scale, where disagree represents the highest category[60]. *Feelings About Honesty* represents how much people in a state agree with the statement “most people are honest,” measured on the same six-point scale[61]. *Interpersonal Trust* is the average of whether people in a state agree with the statement “most people can be trusted” (coded 1), or if they believe that they “can’t be too careful” (coded 0)[62]. *Times Volunteered* is the average number of times state residents say that they did volunteer work in the previous year[63].

Although the pattern in Table 5.2 is less consistent than the pattern in Table 5.1, results are quite similar. For the most part, sunlight, temperature, precipitation, and day length are negatively and significantly related to the dependent variables. However, the fit is somewhat weaker than that observed in Table 5.1. Barometric pressure only reaches statistical significance on one of these variables. The relationship between weather and how much time people feel that they spend visiting friends is nonexistent in two cases, and dubious in two others (p<.1). The amount of times that people entertain one another appears to only be related to sunlight and day length. Once again, any definitive

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[60] DDB Needham Life Style archive, 1975-98.

[61] DDB Needham Life Style archive, 1975-98.

[62] General Social Survey, 1974-76.

[63] DDB Needham Life Style archive, 1975-98.

conclusions should be reserved until multivariate analyses are conducted in the next section.

The final components in Putnam's social capital index are measurements of how involved people are in community organizations and civil society. *Number of Club Meetings Attended* is the number of club meetings individuals attended in the previous year, averaged across each state[64]. *Community Projects* represents the average number of community projects state citizens worked on in the previous year[65]. *Committee Service* is the percent of state residents who served on some sort of committee attached to an official organization[66]. *Officer Service* is the percent of state residents who served as an officer in an official organization[67]. *Town or School Meeting Attendance* represents the percentage of state residents who attended town or school meetings[68]. *Times Entertained* is the number of times people say that have hosted others at their house in the previous year[69]. Bivariate relationships are shown in Table 5.3.

While sunlight does not significantly relate to any of these measures, many of the other negative relationships persist. Cooler states experience more committee service, officer service, and meeting attendance. Precipitation reduces the number of club meetings attended, service on committees, service as officers in organization, and

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[64] DDB Needham Life Style archive, 1975-98.

[65] DDB Needham Life Style archive, 1975-98.

[66] Roper Social and Political Trends archive, 1974-94.

[67] Roper Social and Political Trends archive, 1974-94.

[68] Roper Social and Political Trends archive, 1974-94.

[69] DDB Needham Life Style archive, 1975-98.

attendance at town and school meetings. States that experience shorter days exhibit more of all of the measured activities.

Of course, these are simply bivariate correlations, and although they are suggestive, caution should be exercised in extracting any definitive conclusions from them. In particular, we should be wary of the north-south distribution of social capital, as this maps rather well onto both the distribution of temperatures as well as day length, both of which grow larger as one travels south. Moreover, the rainiest portion of the country is the deep south, which is also suffers from a dearth of social capital. Weather and social capital may relate to one another simply because they are distributed in a similar manner across alike geographical spaces. Therefore, in order to determine if these relationships indeed exist with any certainty, it is necessary to conduct multivariate analyses that control for other potential causes of social capital.

Statewide Social Capital: A Multivariate Model. A solid statewide multivariate model predicting social capital and its indicators should first take into account socio-demographic characteristics that affect citizens' desire and capacity to volunteer their time, join informal organizations, and associate with one another, which in turn should affect their attitudes about one another. Because densely populated cities can foster anonymity between residents and can hinder the cultivation of social capital (Sampson et al., 1999), *Percent Rural* is measured as the percent of state residents who do not reside in an urban area or an urban cluster[70]. Scholars such as Rodney Hero (1998) have pointed out that racial diversity tends to diminish social cohesion and can exert a negative influence on social capital, and so *Percent White* represents the percent of the

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[70] As defined by the 2000 U.S. Census. Source: U.S. Census Bureau, "Census 2000 Summary File 1 (SF 1) 100-Percent Data" using American FactFinder, accessed August 26, 2009 (related Internet site <http://factfinder.census.gov>).

state population that identifies itself as entirely white[71]. Next, people who own their own homes ought to feel a greater investment in their communities, and so should volunteer in greater numbers and with greater dedication, as well as feel warmer towards their neighbors (Rupashinga et al., 2006; Sampson et al., 1999; DiPasquale & Glaeser, 1999). *Percent Homes Owned* reflects the percentage of homes that are occupied by their owners[72]. Further, since those who had lived in communities longer should exhibit stronger attachment to them, *Percent In Same Residence, 5 Years* measures the percent of the state's population over the age of five who have remained in the same residence for more than five years[73]. Those with fewer monetary resources ought to have less discretionary time for community involvement, and so *Median Household Income* is recorded in dollars.[74] Because education forges personal resources that lower the cost of becoming involved in community (Wilson, 2000; Musick, 1999), and because communities with greater levels of education have more resources available to create infrastructure and organizations amenable to those who wish to become more involved in civic affairs, *Percent High School Graduate* and *Percent College Graduate* measure the percentage of adults in a state over the age of 25 who have graduated high school and obtained a 4-year college degree, respectively[75].

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[71] U.S. Census Bureau, "Census 2000 Summary File 1 (SF 1) 100-Percent Data" using American FactFinder, accessed August 26, 2009 (related Internet site <http://factfinder.census.gov>).

[72] Ibid.

[73] U.S. Census Burau, "Census 2000 Summary File 3 (SF 3) - Sample Data", using American FactFinder, accessed August 26, 2009.

[74] Ibid.

[75] Ibid.

Another important element mediating the relationship between individuals and their level of involvement in community affairs and related attitudes is the political culture that surrounds them. According to Daniel Elazar, political culture is “the particular pattern of orientation to political action in which each political system is imbedded” (1966, pp. 84-5). It can have many effects, such as defining how people see their government, determining what people expect from their government, influencing certain people or groups to participate in politics, and affecting policy outcomes. Political culture, then, could affect measures of social capital because it affects, in part, the mood of civil society in which interpersonal interactions, group membership, and civic involvement take place. One important statewide scale of political culture was developed by Ira Sharkansky (1969), which quantifies earlier work by Elazar (1966).

Drawing on public studies, state history, official statements, voting data, newspapers, and field work, Elazar classified states along a continuum of Moralist-Individualist-Traditionalist. In a Moralist political culture, citizens believe that participation is a duty, bureaucracy should be extensive and helpful, government should regularly intervene in civil affairs for the good of the community, and that social programs that benefit everyone are good things. Individualist political cultures tend to believe that people should participate in politics for personal advantage, view bureaucracy as both a potential help and hindrance to private affairs, desire to strike a balance between government intervention in the commonwealth and the private sector’s right to operate on its own, and that new government programs should only exist as an extension of individual interest. In Traditionalist cultures, participation is reserved for the elite, bureaucracy is resisted as it checks elite power, government intervention in the community is used only to preserve existing leadership, and new government programs should exist only to protect the ruling elite. In the context of social capital, we should expect states with Moralist political cultures to exhibit higher rates of social capital, states with Traditionalist political cultures to have lower rates, and Individualist states to fall somewhere in between. Sharkansky (1969) places states on a quantitative Moralist-Individualist-Traditionalist continuum, which he examines in-depth to show that it has strong empirical utility. Moralist political culture have low scores, and Traditionalist political cultures have high scores. This scale becomes *Political Culture*.

There are some problems with this measure. For one, if weather is related to social capital, then weather could also be related to political culture. If weather affects how people feel about one another and hence social capital, it should also affect how they feel about authority or government, and thereby political culture. Nevertheless, there is little harm in subjecting this hypothesis to the strictest test possible. Moreover, bivariate correlations between weather conditions and political culture are statistically insignificant.

Finally, since Putnam himself notes that the legacy of the American Civil War may relate to lower social capital in the south, *Former Confederacy* is a dummy variable coded 1 if a given state was a member of the Confederate States of America.

Null Results: Statewide Social Capital, Sunlight, and Temperature. Multivariate analysis using average yearly direct and diffuse sunlight, hours in the day on the date of the solstice, and the average temperature over twenty years fail to demonstrate any link between these measures of weather and statewide measures of social capital.

Regressions run on each component in Putnam's index also produce null results[76]. This suggests that there is no relationship between these weather measures and social capital at the state level.

However, null results here could be related to the somewhat clumsy way these weather variables line up with statewide social capital measures. The average temperature over twenty years variable represents an aggregation of conditions across the entire state; although measures of social capital are aggregated from survey respondents across the state, these respondents may be concentrated in specific geographic areas, and thus the temperature variable may reflect variation across large portions of the state that are unoccupied by respondents. For instance, the range of temperatures in a state like California is large, and the final twenty year average is an aggregation of lower temperatures along the coast and in the mountains, middling temperatures deeper in the state's interior, and high temperatures in the southwestern desert. Yet the bulk of respondents reside along the heavily populated coast, and few reside in the desert. Likewise, the population of Nevada is centered largely on Las Vegas, where the weather is hot; however, the vast majority of northern Nevada is actually rather temperate. So, while the aggregation of temperature across entire states produces a statewide average, that statewide average may not represent the 'average' weather that affects survey respondents. The failure to produce a significant test statistic here may be because the average statewide temperature poorly reflects how the distribution of actual temperature lines up with

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[76] There are two exceptions: in a multivariate model, sunlight does appear to positively influence interpersonal trust and feelings about honesty. However, these are significant at only $p>.1$, and these are the only categories for which sunlight is significant. Further, the sign is opposite that obtained in the bivariate analysis.

population. Perhaps, in the future, this effect could be mitigated by weighting weather by population.

While this sort of measurement issue is a possible explanation for this null finding, it is not especially convincing for two reasons. First, this uneven alignment between independent variables and respondent locations is true of all the statewide contextual variables. Further, rain--which is aggregated across states in precisely the same measure as temperature--is a significant predictor of all sorts of statewide measures of social capital, and so explaining away the insignificant coefficient here as a measurement issue is quite problematic. Nevertheless, it is important to note that later, city-specific analysis skirts this problem by using more discrete measures centered upon much smaller geospatial areas, and there temperature does significantly affect volunteer rates.

Sunlight, however, falls prey to a much clearer measurement issue: measures of statewide sunlight are taken from the centermost weather station in each state. This was necessary, as the NOAA does not provide statewide aggregations of weather beyond precipitation and temperature. Insignificance here may be due simply to the fact that most survey respondents live far from these stations, or because these states are very large and this measure thereby fails to accurately represent statewide weather. However, these shortcomings in measurement are not meant to obscure the finding here: at a statewide, multivariate level, there is no evidence that the average yearly temperature, average yearly sunlight, or day length on the day of the solstice bear any relationship to social capital or its indicators. This could indicate that these bivariate correlations are statistically significant only because sunlight and temperature reflect geographic patterns in social capital, and have no independent effect on their own.

Barometric Pressure. The multivariate examination of the effect of barometric pressure on social capital is more enlightening, and shown in Table 5.4. Average yearly barometric pressure has a positive effect on social capital. It also boosts the propensity for people to host others at their home, the degree of trust felt between citizens, and the number of nonprofit organizations in a given state. The substantive impact is significant. The model predicts that moving from the state with the lowest barometric pressure (Colorado, where high altitudes reduce the total weight of air) to the state with the highest barometric pressure (Delaware) causes a bump in the social capital scale of .57, which is a 17% increase, all else constant. Likewise, it predicts that after controlling for other causal factors, people in Delaware should entertain people in their homes on just about three more occasions than their cousins in the west and are 12% more likely to trust one another. The net effect on nonprofit organizations is much less impressive; all else constant, moving from Colorado to Delaware boosts the number of these organizations by.3.

The important question is, of course, is why barometric pressure should have this effect. As noted in Chapter II, the scholarly record on barometric pressure is a mixed bag of contradictory and null findings, most of which bear on muscle pain, joint pain, and edema. While some have argued that lower levels of barometric pressure may relieve headaches and reduce the number of emergency visits to psychiatric clinicians, Goldstein (1972) does argue that higher barometric pressure is related to better moods. This particular relationship is supported by the multivariate analysis here.

A somewhat more compelling explanation revolves around how barometric pressure relates to rain. Low levels of barometric pressure often indicate wetter weather, because at lower levels of pressure, air cools and expands, which causes it to lose energy and release precipitation. So, generally speaking, as barometric pressure increases, rain is less likely. So, high levels of barometric pressure here may boost social capital because they indicate less rain over the course of a year, a point which meshes happily with the finding that the 20-year average of rainfall has a negative effect upon statewide social capital (see next section).

However, three facts cast a shadow of doubt onto this finding. First, barometric pressure is negatively signed in the bivariate correlations, and the sign flips at the multivariate level. This is suspicious, to say the least. Second, barometric pressure is negatively related to approving of Bush: where pressure is higher, people were less likely to say that they approved of the President, all else constant. The relationship here in the inverse: barometric pressure boosts mood and leads to positive behavior, rather than depressing it. Third, in the city-level analysis, barometric pressure does not emerge as a statistically significant predictor of volunteer rates at the multivariate level Yet rain is negatively related to social capital. Yet, with all of that said, at a state level, this result does survive a very well-controlled model.

Precipitation. Likewise, in the multivariate analysis displayed in Table 6.5, rain remains negatively related to the social capital index, the mean number of group memberships in a state, committee service, and the amount of time people spend visiting friends. The model predicts that the effects of moving from the wettest state over twenty years (Mississippi) to the driest state (Nevada) is substantial, boosting the score on the social capital scale by 25%, increasing the mean number of group memberships in a state by about one, and making people nearly 4% more likely to have served on a committee. The effect of diminishing rain on the amount of time spent visiting friends is more difficult to interpret because the dependent variable is a six-point scale; moving from the maximum value for rain to the minimum value for rain decreases the score by .2. The statistical significance of these relationship falls within quite reasonable bounds. Finally, it's worth noting that this finding is also apparent at the city-level, where analysis is conducted later in this chapter--precipitable water in the atmosphere reduces volunteer rates, as well.

There is very little in the literature to suggest that precipitation exerts a direct effect on mood beyond its coincidence with clouds. There is an indirect link, however--people do not like to have their schedules changed by inclement weather. It is annoying, upsetting, and can reduce mood, which could reduce the desire to associate with others or to volunteer (Goldstein, 1972). Another important effect of precipitation is its influence on infrastructure. Precipitation clogs roads, delays flights, floods streams, and ices highways. Not only is this common sense, but within the discipline of political science, scholars of voting behavior have noted how rain visibly reduces turnout (Gomez et al, 2007).

The draining effect precipitation exerts upon travel could well be the reason why rain negatively impacts social capital. On rainy or snowy days, volunteers may be unable to travel to meetings or volunteer stations, and even if they *can* make the trip, the inclement weather could be seen as sufficiently dangerous or inconvenient to keep these potential volunteers at home. From the standpoint of volunteer and community organizations, inclement weather reduces the opportunities for others to volunteer or attend meetings because many organizations cancel events when dangerous weather appears. Your local Elks' Club does not want to be responsible for your elderly father sliding into a guardrail during a rainstorm. When volunteering and involvement in community organizations is more costly, the opportunities for committee service or holding official positions drops accordingly. Finally, informal socialization should drop too, both as a byproduct of weakened civil society, and because it's rather rude to expect the Rydbergs to come over for tea during Hurricane James.

Statewide Analysis: A Summary. This analysis of weather and statewide measures of social capital offers a good jumping-off point for further investigation. First, the promising bivariate relationships between sunlight, day length, and temperature turn null in multivariate analysis. While this could be a product of how weather variables are measured, it could also suggest that at the bivariate level, many correlations between weather and social capital and its indicators are merely picking up on geographic patterns of social capital, rather than the effect of weather. A second test will sidestep these statewide measurement issues by testing if city volunteer rates are affected by these variables. As it turns out, at the city level, lower temperatures stimulate approval, while day length actually suppresses it.

Multivariate analysis of the statewide data confirm two relationships. First, higher barometric pressure leads to greater social capital. This an interesting finding, although it is difficult to place it in the literature, as links between barometric pressure and behavior are rare. Finally, in accordance with theory, rain suppresses social capital, most likely because it makes it more difficult for people to travel from place to place, and causes the cancellation of events.

Weather and Social Capital at the City Level. To correct for some measurement problems inherent to aggregating weather to a statewide level, and to check for consistency with the statewide multivariate analysis, it is useful to change levels of analysis. In this section, analysis is focused on the state to the city level.

A Closer Look: Volunteer Rates and Weather. A look at Figures 5.3 and 5.4 indicates that, in broad strokes, cities situated in warmer climates tend to exhibit lower volunteer rates than cities in the cooler north. There is little evidence that sunlight has such an effect.

One way to more carefully test the proposition that weather affects social capital is to correlate weather conditions with volunteer rates in American cities. Data on volunteering is provided by the Corporation for National and Community Service, which calculates a three-year moving average of the percentage of people who performed unpaid volunteer activities for or through an organization at any point during the previous year in major and mid-size American cities[77]; this three-year average covers 2005, 2006, and 2007, and represents volunteer rates for 2007. Solar radiation and temperature cloud data comes from the National Renewable Energy Laboratory's Typical Meteorological Year Database[78]. Due to how precipitation is coded in the NREL dataset, it was impossible to extract precipitation measures for individual stations. Instead, the amount of precipitable water in clouds is used when analyzing city and individual level data. This is a decent proxy for precipitation. A high value can indicate precipitation, a heightened possibility of precipitation, and dark, gloomy skies--in the aggregate, averaged over the course of a year,

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[77] This is calculated from the Census and Population Survey, Volunteer Supplement, which is taken in September. Individuals aged 16 and over are considered. More information is available at www.volunteeringinamerica.gov, or more specifically at http://www.volunteeringinamerica.gov/about/faq.cfm. Cities are regarded as Metropolitan Statistical Areas (MSAs) or NECMAs (New England County Metropolitan Areas). The definition is outlined by the U.S. Office of Management and Budget and used by the Census. For information, see http://www.whitehouse.gov/omb/bulletins/b03-04.html. In some cases, however, component communities are hewn from MSAs (eg, Riverside from LA). In multivariate analysis of these few cases, MSA-level data or NECMA-level data is used to create control variables.

[78] The TMY database, which contains hourly observations of a typical meteorological year, was trimmed down to produce a single, yearly value for each variable at each site. Hourly observations taken during hours of daylight were averaged over the course of this 'typical year' to create the final variables used here.

it is comparable to actual precipitation levels, though substantively more difficult to interpret than measured rainfall or snowfall. The hours of sunlight at the solstice were calculated manually using a spreadsheet provided by the NOAA. The combined measure of direct and diffuse sunlight, as well as adjusted temperature, are used to represent average yearly sunlight and temperature, respectively. Two other potentially relevant variables are also included: barometric pressure and the amount of precipitation in clouds, both of which seemed to negatively relate to measures of approval of Bush[79]. Bivariate correlations with significance levels are displayed in Table 5.6 below.

Given the small sample size (116), the level of statistical significance on these variables is remarkable. The first finding stands out as strange: lower levels of sunlight correspond to higher levels of volunteering. This runs contrary to expectation, as sunlight tends to reduce depression and makes people more cheerful and happy. It is worth noting that this relationship is not at all apparent in multivariate analysis. However, the total amount of daylight hours[80] experienced by cities--a variable that does not account for cloud cover--also negatively correlates with volunteer rates. To say the least, this is a confusing result.

Yet two other variables do conform to theoretical expectations. As expected, cities in cooler climates enjoy higher levels of volunteering, presumably because lower

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[79] Unfortunately, due to limits of time and computer processing power, two previously used variables--ceiling height and horizontal visibility--were excluded from this analysis.

[80] Measured as the number of minutes between sunrise and sunset on the Winter Solstice, at the location of the weather station nearest to the city. Sunrise is defined as the moment when the sun reaches .8333 degrees above the horizon and sunset is defined as the moment when the sun reaches .8333 degrees below the horizon. .8333 is used as opposed to zero to account for refraction. The solstice is used to measure length of daylight because aggregating minutes of daylight over the course of a year would have been needlessly time-consuming. Put another way, to measure how long the sun is in the sky, one day is as good as any other. Substituting minutes in any other day during the year produces near-identical results.

amounts of uncomfortably hot weather motivate people to help one another, and permit easier travel to volunteering stations during the summer months. Further, the average amount of precipitable water in the atmosphere is negatively related to volunteering. This is unsurprising, as higher levels of precipitable water not only indicate higher levels of cloud cover, but also darker, gloomy clouds, impending rain, and precipitation. Figures 5.11, 5.12, and 5.13 are scatterplots of these relationship with lines of best fit and confidence intervals.

Finally, barometric pressure is significantly and negatively related to volunteering. Just as greater pressure leads to disapproval of Bush, it also seems to keep people from helping one another. While higher barometric pressure is associated with better moods, it has also been tied to headaches. High barometric pressure can, but does not always, suggest clearer skies, a point which puts this finding in concord with the strange negative relationship between sunlight and volunteering. Yet this is inconsistent with the finding that raininess depresses volunteering, as lower levels of barometric pressure usually indicate rain. However, because the theoretical expectations regarding barometric pressure are somewhat unclear in the first place, and because the coefficient on this variable is insignificant in multivariate analysis, this finding should be interpreted with a note of skepticism.

Of course, a look at the volunteering maps earlier in this chapter suggest that, in general, the north enjoys higher levels of social capital and volunteer activity, a relationship that could suggest that these correlations with weather are spurious. Putnam himself suggested that the legacy of the Confederacy may have had lingering effects throughout the south, and arguments about regional patterns to political culture are not uncommon. In order to ensure that the relationship between weather and volunteering is not an artifact of regional culture, multivariate analysis is conducted, using several traditional predictors of civic volunteer rates. This model contains several variables that have been shown to be important predictors of volunteering. Because people who own homes in their home communities have a greater financial stake in their communities, they ought to volunteer in greater numbers, and so *Owner Occupied Housing* is included (Rupashinga, Goetz, & Freshwater, 2006; Sampson, Morenoff, & Earls, 1999). It represents the percentage of homes that are occupied by their owners[81]. On the other hand, cities with many multiple-unit housing structures tend to attract more transient populations, which does little to cultivate personal attachment to the community (The Corporation for National and Community Service, 2007). A city with large numbers of single-unit structures suggests a more settled population, and should exhibit a higher level of volunteering. *Multi-Unit Structures* are measured by the percentage of housing in a city that contain more than one living unit.[82] High population density can decrease volunteering by fostering anonymity between residents (Sampson et al., 1999), and so *population density* is measured as the number of persons per square mile of land[83]. Demographic factors are also important in determining volunteer rates. Education creates personal resources that make the act of volunteering easier, and raise demand for one's volunteer skills (Musick, 1999; Wilson, 2000). Consequently, communities with greater

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[81] U.S. Census Bureau, American Community Survey. DP-2. Selected Housing Characteristics: 2006. Accessed using American FactFinder, accessed February 14, 2008.

[82] U.S. Census Bureau, DP-2. (2006). Selected housing characteristics: 2006. *American Community Survey*. Accessed using American FactFinder, accessed February 14, 2008 (related Internet site <http://factfinder.census.gov>).

[83] Information on geography drawn from U.S. Census Bureau. (2000). 2000 summary population and housing characteristics, series PHC-1. *Census of Population and Housing*.
Population from "Annual Estimates of the Population for Counties: April 1, 2000 to July 1, 2007, published March 27, 2008 (related Internet site<http://www.census.gov/popest/counties/CO-EST2007-01.html>).

levels of education possess greater civic resources for volunteering (Brady, Verba, & Schlozman, 1995; Verba, Schlozman, Brady, & Nie, 1993). *High School Graduates* measures the percentage of the population who hold a high school degree, and *College Graduates* measures the percentage of the population who hold a four-year college degree[84]. Because people living in poverty have less discretionary time for volunteering, may feel sidelined from mainstream civic society (Brehm & Rahn, 1997; Browning & Cagney, 2002; Sampson et al., 1999), and may be less likely to be targeted for mobilization (Spring, Dietz & Grimm, 2007). *Poverty* is included as a measure of the percentage of people in a community whose income lies beneath the poverty line[85]. Because some have argued that volunteering is more likely where people perceive one another to be similar, *Racial Diversity* is measured as the percent of the population that is white[86]. Finally, because nonprofits create opportunities for volunteering by mobilizing people, advertising opportunities, and encouraging action (The Corporation for National and Community Service, 2007), *Number of Small Nonprofits* and *Number of Large Nonprofits* provide per capita measurements of the presence of these organizations. Results are offered in Table 5.7 below.

All three variables remain statistically significant in multivariate analysis. First, both temperature has a negative effect on the percentage of people who volunteer, even after controlling for other factors that determine volunteer rates. While the difference

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[84] U.S. Census Bureau. (2006). DP-2: Selected social characteristics in the United States: 2006. *American Community Survey*. Also, U.S. Census Bureau. (2006). DP-3: Selected economic characteristics: 2006. *American Community Survey*. Accessed using American FactFinder, accessed February 14, 2008 (related Internet site <http://factfinder.census.gov>).

[85] See above. The amount of family income necessary to be considered beneath the poverty line varies by family income.

[86] See above. The amount of family income necessary to be considered beneath the poverty line varies by family income.

between cities in warmer climates and cooler climates is far from dramatic, the model predicts that a twenty-degree drop in the annual adjusted temperature should depress volunteer rates by about 3.5%. According to the model, we should see a 7.3% higher volunteer rate in the coldest city (Fargo, ND, with an annual adjusted temperature of 38.6° F) than the hottest city (Phoenix, AZ, which experiences an annual adjusted temperature of 79.94° F). For this pair of cities, the model quite on the mark--the volunteer rates in Fargo and Phoenix are 31.7% and 22.6%, respectively, and the actual difference between the two is 8.3%. While temperature is far from the single most important factor affecting whether or not people volunteer, it is nevertheless a nontrivial contributor.

The effect of dark, watery clouds is considerably more subtle. Although the regression coefficient on this variable is large, the variable takes a minimum of .87 (in Ogden, Utah) and a maximum value of 3.43 (in Cape Coral, Florida). Thus, holding else constant, the model predicts that the city with whitest clouds, clearest skies, and lowest precipitation should enjoy a volunteer rate of about 1% more than the city most stricken by wet, dark clouds and precipitation year-round. This aligns well with findings at the state level, where rain had a negative effect on social capital.

Finally, the minutes between sunrise and sunset during the winter solstice continue to depress volunteer rates. The maximum value here is 631 minutes (in Miami, FL, where 14.5% volunteer) and the minimum is 506 minutes (in both Spokane and Seattle, WA, where 33.5% and 35.5% volunteer). Shorter days remain significantly related to volunteering. This is surprising for two reasons. First, shorter days correspond to lower levels of sunlight, which ought to encourage volunteer activity by boosting mood and stimulating helpfulness. So, in places where the days are shorter, people should be, on average, more depressed than in places that experience longer periods of sunlight. This has been the focal point of important research on alcoholism, depression, and suicide in northern latitudes, as well as Seasonal Affective Disorder. Yet light-related depression here seems to stimulate volunteering. Second, shorter days should make people more tired, since greater nighttime hours inhibit the production of serotonin and stimulate the release of melotonin, which in the balance, should make people more lethargic and, potentially, less likely to expend their energy for the benefit of others. This finding, then, poses a problem for a central theoretical expectation from the weather literature: sunlight should stimulate 'positive' behavior.

Yet, the previous analysis of sunlight on the approval of Bush does not suggest this at all. Although sunlight was a statistically significant predictor of approval, this was only the case in the spring and fall, when warm temperatures offer relief from retreating or encroaching winter winds, and permit outdoor activity. In the summer, low levels of sunlight stimulated approval. In the analysis of the public opinion data, then, sunlight mattered, but not because it made people happy. It affected approval rates because it was tied in with expectations regarding the change of seasons: an affinity for winter changing into summer, a desire for cooler summer days, and a preference for a warm autumn resistant to the encroaching winter cold. Here, too, the relationship between sunlight and volunteering is not as simple as 'sunlight makes people happy and so they are nicer.' Perhaps here, too, the relationship is more complicated.

A lack of sunlight may actually stimulate helpful behavior because it *depresses* people. We do know that sunlight causes positive moods, both through direct exposure (going outside and being under the sun makes people happy) and by providing daylight (people are happier when days are longer). According to the theory of mood congruence, this should make people behave in a positive manner. However, sometimes, moods can affect attitudes in directions that oppose expectations; Isen and Levin (1972) demonstrate this *mood incongruence* by showing that although bad moods often decrease the probability of helping another individual, they sometimes cause the opposite to occur because, in helping others, people may relieve their own negative affective states (see also Erber &Erber, 1994; Parrott & Sabini, 1990). Smith and Petty (1995) report that individuals with higher-self esteem tend to do this with greater frequency. Thus, volunteer rates may be lower in areas with less minutes of sunlight because people are more depressed in those areas, and opt to volunteer in order to relieve their depression.

Seasonal analysis of the direct and diffuse sunlight offers some limited support for this proposition. In the aggregate, the average amount of measured sunlight over the course of the year has no significant effect on volunteering. However, during certain months, when a monthly measure for sunlight is substituted for the yearly measure, sunlight emerges as a statistically significant negative predictor of volunteer rates. This occurs in the months of October, December, January, and February--in the winter, when seasonal rates of depression are already highest due to reduced minutes of daylight. During this bleak time, cities that experience still bleaker, darker weather tend to exhibit higher levels of volunteering, perhaps because people struggling with SAD volunteer their services in an unconscious effort to alleviate their own feelings.

One possible problem with this explanation is evident in the other findings regarding weather and social capital. In the statewide data, higher pressure (which may boost mood) and less rain (which should also boost mood) are associated with more social capital. Weather conditions that lead to good moods do, in fact, lead to good moods. Yet, in the city data, longer night, which should lead to depression, stimulates volunteering[87]. If good moods enhance social capital elsewhere, how can the depression invoked by cloudy days depress volunteer rates? Speculatively, the answer may lie in the difference between mood and depression. Certainly, the two can be related, in that depressed people tend to exhibit more dour moods. However, mood is ephemeral--it is the background feeling that affects most everything that people do. Depression, on the other hand, is physiological in nature, and relates to, among other things, the biological balance of serotonin and neurotonin in the human body. Of course, this causes people to have more negative moods. So, barometric pressure and dryness can boost volunteer ratings because they boost *mood* which bolsters helping behavior, while the absence of sunlight stimulates *depression*, which does depress mood, but also provokes people to volunteer in an attempt to improve their disposition. If this is the case, why should moods stimulated by SAD respond differently to moods stimulated more directly by weather conditions? Unfortunately, there is no clear answer in the literature.

These findings lead to a second interesting question: if sunlight depresses volunteer rates, shouldn't the amount of precipitation in clouds boost volunteer rates? After all, a high score on the precipitable water variable corresponds to very low levels of sunlight, which should stimulate volunteering. Yet this is not the case: precipitable water depresses volunteering, just as rain depresses social capital in the statewide data. Though it's difficult to arrive at a definitive answer, it is important to note that this measure of precipitable water captures more than just the gloominess of clouds. When this value is

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[87] We can set aside the finding that cooler temperatures stimulate volunteering, as this is tied in with heat's relationship with aggression, rather than strictly mood.

high, rain tends to be more frequent, and even when it is not raining, it tends to loom more ominously on the horizon. The effect of inclement weather on volunteering is independent of sunlight's psychological effects for three reasons. First, quite speculatively, rain may well have its own depressive effect, one that is independent of sunlight and provokes a different psychological response[88]. A second explanation (which is more grounded in literature) is that precipitation and the threat of precipitation can disrupt plan and restrict options for behavior, which is mentally agitating. Finally, precipitation interferes with city infrastructure to a far greater degree than levels of sunlight, since snow, rain, or the threat of either can clog roadways, create transit delays, and require the acquisition of special clothing and umbrellas. Rain, then, and the threat of rain may keep people from volunteering not only because they are in poor, frustrated moods, but because it's simply less convenient to venture away from home to help others. Further, it may actually cause the cancelation of outdoor events or, in the case of extreme cases, indoor ones, as well. Finally, recall that rain is a negative predictor of social capital and its indicators in the statewide tests, which adds considerable validity to the same finding at the city level.

One Problem: Political Culture. To this point, results from the forgoing analysis seem reasonably strong. However, including Elazar's measure of political culture as a control variable strongly diminishes the statistical significance of weather variables. While this may suggest that weather variables are merely picking up regional variation related to political culture, two alternate explanations are possible. First, these are state-level measures of political culture, and placing them in a city-level model may well be inappropriate. The political culture across cities within the same state may not be the

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[88] However, no study of which I am aware has come to this conclusion.

same. Consider, for instance, Jacksonville and Palm Beach, or San Francisco and Los Angeles, or Cincinnati and Cleveland. Alternately, it may be that weather is endogenous to political culture, a suspicion supported by the very high bivariate correlations between the two measures.

A Note on Other Seasonal effects. These analyses are conducted using average temperatures over the course of a year as the key independent variables, and so they beg the question: do seasonal weather effects matter? While monthly volunteer data is not available, typical monthly weather is, and it permits more careful examination of how seasonal climate conditions affect volunteer rates in the aggregate. It seems possible that extremely cold winters should have a negative effect, and sunlight in spring should have a positive effect. As it happens, looking at seasonal data tends to produce statistically insignificant test statistics. However, while winter temperatures do not seem to matter, cooler spring, summer, and fall temperatures continue to have positive effects on volunteering.

Conclusion. This chapter has presented reasonable evidence that, indeed, weather has an effect upon social capital and its indicators. At the state level, precipitation has a negative effect on social capital, and at the city-level, it appears that cooler, drier weather has a positive effect upon volunteering.

Table 5.1. Bivariate Correlations Between Putnam’s Social Capital Measures and Weather.

	Comprehensive social capital index II (N=48)	Mean Number of Group Memberships (N=40)	Organizations Per Capita, 1989 (N=48)	Civic and Social Orgs Per 1000 pop, 1977-1992 (N=48)	Mean Pres'l Turnout, 1988 & 1992 (N=48)
Average Yearlong Diffuse and Direct Sunlight	-0.4328***	-0.1944	-0.4616**	-0.3838***	-0.5183***
Average Temperature Over Twenty Years	-0.4292**	-0.4004**	-0.3827***	-0.3665**	-0.4650****
Average Yearlong Barometric Pressure	-0.2462*	-0.5098****	-0.2838*	-0.2838*	-0.2352
Average Precipitation Over Twenty Years	-0.4805****	-0.6670****	-0.3745***	-0.4142***	-0.3269**
Length of Day, Solstice (Center of State)	-0.7651****	-0.5868****	-0.7003****	-0.6533****	-0.7678****

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 5.2. Bivariate Correlations Between Communitarian Attitudes and Behavior and Weather.

	Time Spent Visiting Friends (N=48)	Feelings About Honesty (N=48)	Interpersonal Trust (N=41)	Times Entertained (N=48)
Average Yearlong Diffuse and Direct Sunlight	-0.2518*	-0.4112**	-0.4240***	-0.5446****
Average Temperature Over Twenty Years	-0.1938	-0.4358***	-0.4692***	-0.2023
Average Yearlong Barometric Pressure	-0.0672	-0.3300**	-0.2290	0.1590
Average Precipitation Over Twenty Years	-0.2689*	-0.4793****	-0.5235****	-0.0533
Length of Day, Solstice (Center of State)	-0.3668**	-0.7508****	-0.7180****	-0.6230****

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 5.3. Bivariate Correlations Between Community Involvement and Weather.

	Number of Club Meetings Attended (N=43)	Community Projects (N=48)	Committee Service (N=43)	Officer Service (N=43)	Town or School Meeting Attendance (N=43)	Times Volunteered (N=48)
Average Yearlong Diffuse and Direct Sunlight	0.0138	-0.1901	-0.1751	-0.1956	0.0138	-0.0713
Average Temperature Over Twenty Years	-0.2545	-0.2153	-0.3186**	-0.2824*	-0.2545*	-0.3434**
Average Yearlong Barometric Pressure	-0.4045***	-0.1128	-0.3306**	-0.2958*	-0.4045***	-0.3027**
Average Precipitation Over Twenty Years	-0.5507****	-0.2046	-0.5720****	-0.5076****	-0.5507*	-0.4730****
Length of Day, Solstice (Center of State)	-0.4451***	-0.3737***	-0.5250****	-0.5174****	-0.4451****	-0.4341***

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001

Table 5.4. Multivariate Regressions of Barometric Pressure on Social Capital and Selected Indicators.

	Social Capital Index	Times Entertained	Interpersonal Trust	Organizations per capita, 1989
Avg. Yearly Barometric Pressure	0.0028** (.002)	0.0082*** (.002)	.0006** (.000)	0.0019* (.001)
Percent Rural	0.6689* (.628)	-0.9994 (1.327)	.0224 (.112)	1.6327*** (.465)
Percent White	0.98 (.303)	2.4737 (1.981)	.2713 (.160)	0.1246 (.694)
Percent Homes Owned	-3.5317** (.167)	-6.8644* (3.524)	-.07065** (.34)	-4.448 (2.392)
Percent in Same House, 5 Years	-0.0974 (1.459)	3.6601 (3.082)	-.2109 (.403)	-1.3663 (1.08)
Median Household Income	-0.0001*** (.000)	0*** (.000)	.000*** (.000)	0** (.000)
Percent High School Graduate	15.4173**** (.000)	13.4597** (5.284)	2.042**** (.438)	6.1045*** (1.851)
Percent College Graduate	4.9246** (2.182)	3.5227 (4.611)	.1888 (.480)	5.3149*** (1.616)
Political Culture	-0.0000 (.000)	0 (.000)	.000**** (.000)	0 (.905)
Confederacy	-0.2918 (.155)	-0.7382* (.424)	-.0418 (.035)	-0.4469*** (.148)
Constant	-12.4496**** (2.056)	-5.4646 (4.344)	-1.2645** (.4642)	-2.3155 (1.522)
Increase in Value Moving from Min to Max Pressure	.57 (17% of scale)	2.66	12%	.3
N	47	47	40	47
R2	.8403	.6789	.8154	.7829
prob>F	0	0	0	0

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001; Standard Errors in Parentheses

Table 5.5. Multivariate Regressions of Precipitation on Social Capital and Selected Indicators.

	Social Capital Index	Mean Number of Group Memberships	Committee Service	Time Spent Visiting Friends
Average Precipitation Over Twenty Years	-0.1831** (.081)	-0.2388*** (.068)	-0.0086** (.004)	-0.049** (.022)
Percent Rural	.8842 (.621)	-0.1028 (.578)	0.0517 (.032)	0.0806 (.169)
Percent White	1.6767* (.947)	0.1858 (.769)	0.1087** (.046)	0.0031 (.257)
Percent Homes Owned	-3.5671** (1.651)	0.0519 (1.612)	-0.1493* (.087)	-0.8001* (.449)
Percent in Same House, 5 Years	3.7615 (1.5618)	3.1247** (1.341)	-0.108 (.082)	1.1998*** (.424)
Median Household Income	-.000* (.000)	-0.000 (.000)	0.000 (.000)	-0.000* (.000)
Percent High School Graduate	12.3112**** (2.559)	4.123* (2.055)	0.3247** (.123)	1.891** (.695)
Percent College Graduate	3.8193* (2.128)	1.8896 (2.396)	-0.1746 (.134)	0.1766 (.578)
Political Culture	0.000 (.000)	0.000 (.000)	0.000 (.000)	0.00 (.000)
Confederacy	0.1577 (.228)	0.2592 (.188)	0.0144 (.011)	0.1212* (.062)
Constant	-10.486**** (1.6924)	-2.2195 (1.586)	-0.0941 (.096)	1.8289**** (.459)
Increase in Value Moving from Min to Max Precipitation	.8 or 25% of scale	1.046	.0377	.2129
N	40	39	43	47
R2	.8217	.5985	.7703	.5412
prob>F	0	.0013	0	.0006

* = p < .1, ** = p < .05, *** = p < . 01, **** = p < .001; Standard Errors in Parentheses

Table 5.6. Bivariate Correlations Between Weather and Volunteer Rates In American Cities.

Diffuse and Direct Sunlight	-.2727***
Hours of Sunlight (Solstice)	-.4155****
Adjusted Temperature	-.4374***
Precipitation in Clouds	-.3165****
Barometric Pressure	-.3170****

N = 116

* = p < .1, ** = p < .05, *** = p < .01, **** = p < .001

Table 5.7. Regressions of Weather on Volunteer Rates in Major and Mid-Size American Cities.

Adjusted Temperature (F)	-0.1787** (.072)		
Precipitable Water in Clouds (cms)		-1.7358* (.98)	
Minutes of Daylight (winter solstice)			-.005** (.021)
Owner Occupied Households (%)	.0741 (.141)	.126 (.15)	.138 (.145)
Multiunit Households (%)	.1696* (.01)	.1642 (.104)	.176* (.099)
People Per Square Mile	-.0029** (.002)	-.0021 (.001)	-.0025* (.001)
High School Degree (%)	.3954** (.058)	.5642*** (.191)	.4074** (.203)
College Degree (%)	.357**** (.115)	.2982** (.116)	.3709*** (.115)
Poverty (% beneath poverty line)	.2078 (.24)	.2608 (.243)	.2615 (.239)
Racial Diversity (% white)	.123 (.738)	.152 (.637)	.148 (.812)
Large Nonprofits (per 100 people)	-.7476 (.724)	-.1855 (.678)	-.637 (.706)
Small Nonprofits (per 100 people)	.2951 (.37)	.3884 (.375)	.3317 (.369)
Confederacy	-.261 (1.934)	-.3778 (1.462)	-.0996 (1.583)
Constant	-20.49 (.347)	-45.841 (18.235)	-6.7304 (25.1)
N	116	116	116
P>F	0	0	0
R2	.457	.442	.458

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001; Standard Errors in Parentheses.

Figure 5.1- Social Capital in the United States.

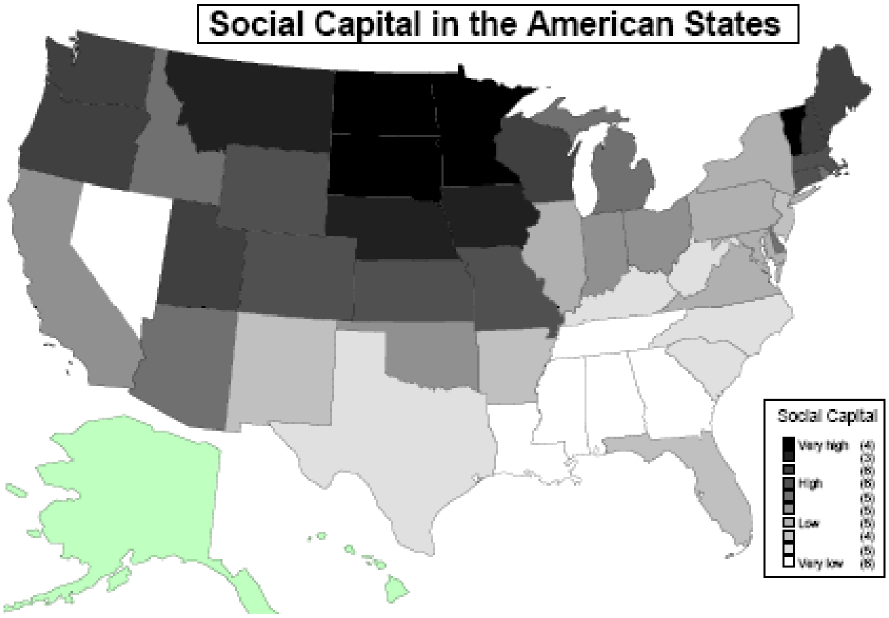


Figure 5.2- Climate in the United States, NCDC.

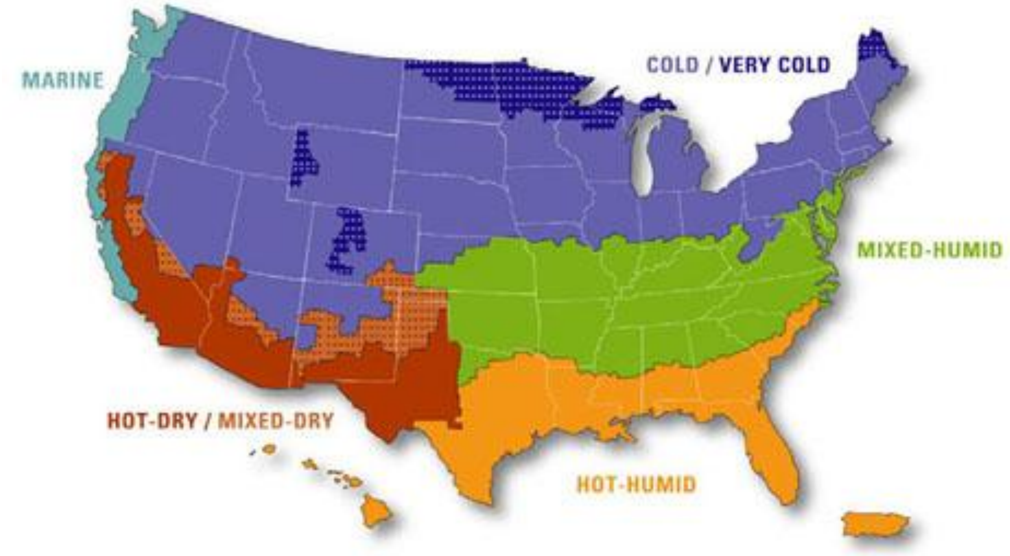


Figure 5.3. Average U.S. Temperature According to NCDC.

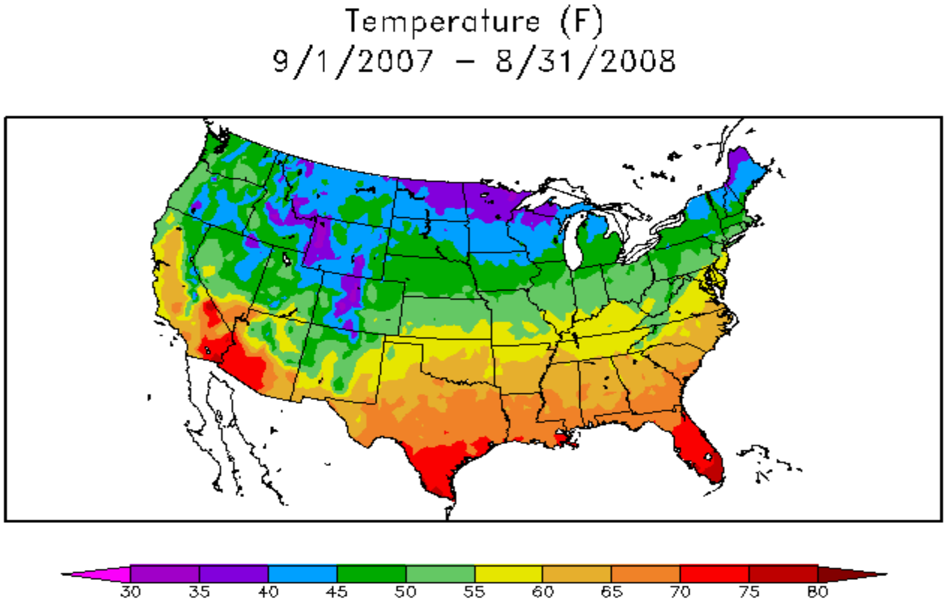


Figure 5.4- Volunteer Rates in Major and Mid-Size American Cities.

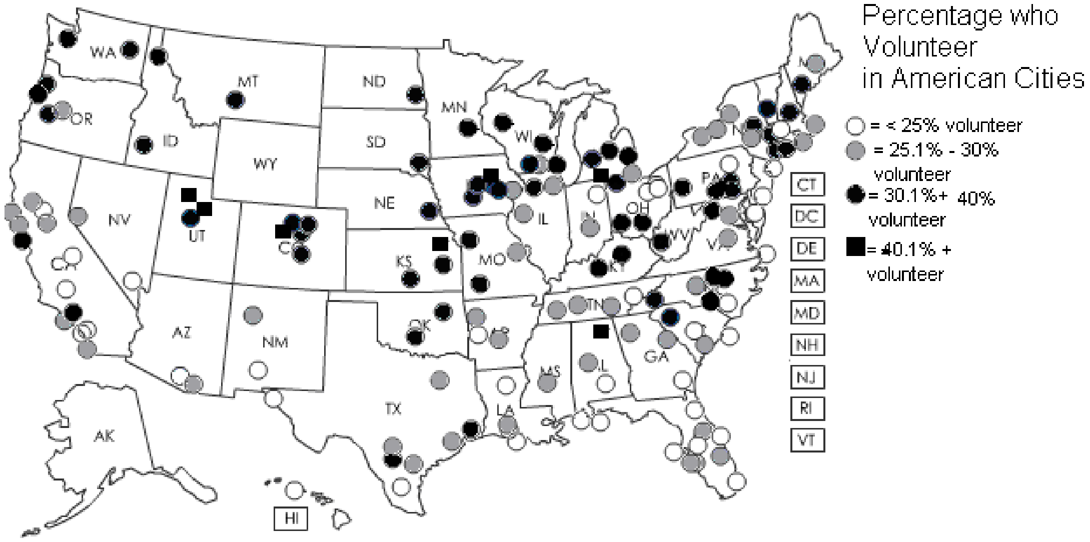
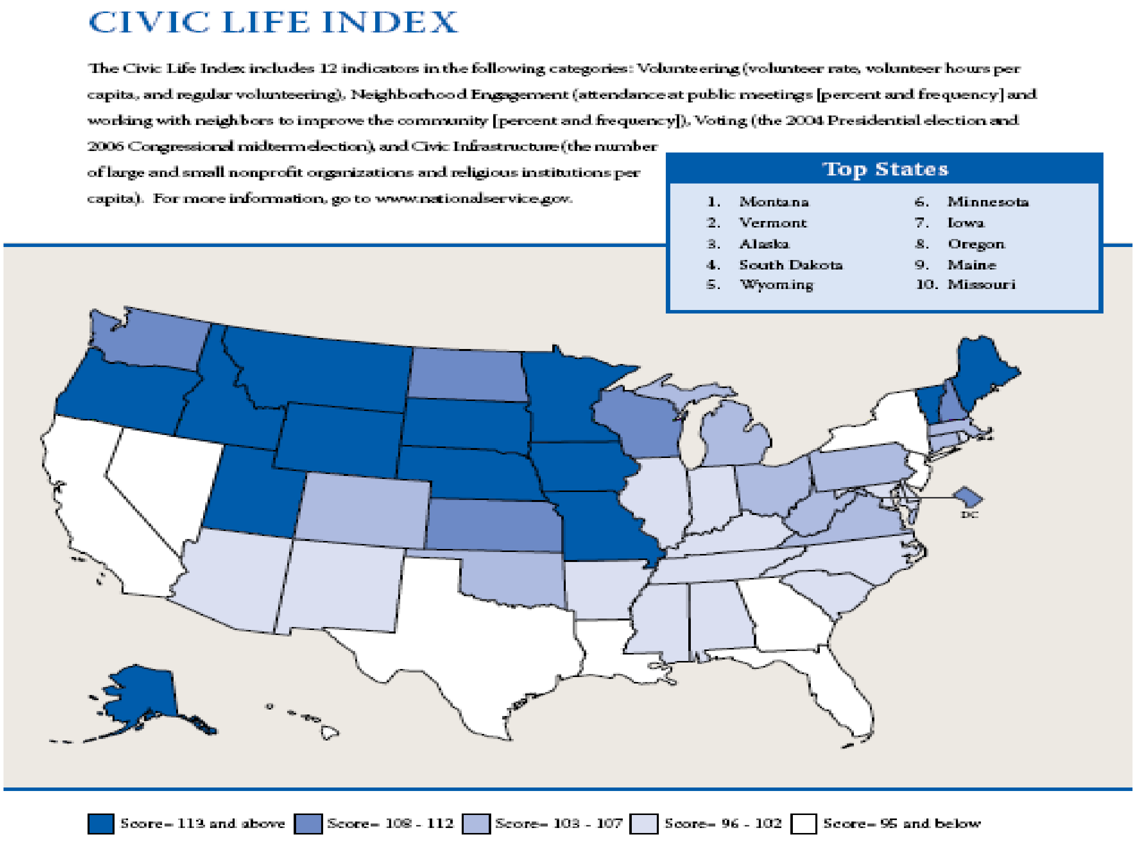


Figure 5.5- Civic Life in the United States.



CIVIC LIFE INDEX

The Civic Life Index includes 12 indicators in the following categories: Volunteering (volunteer rate, volunteer hours per capita, and regular volunteering), Neighborhood Engagement (attendance at public meetings [percent and frequency] and working with neighbors to improve the community [percent and frequency]), Voting (the 2004 Presidential election and 2006 Congressional midterm election), and Civic Infrastructure (the number of large and small nonprofit organizations and religious institutions per capita). For more information, go to www.nationalservice.gov.

Top States

1. Montana
2. Vermont
3. Alaska
4. South Dakota
5. Wyoming
6. Minnesota
7. Iowa
8. Oregon
9. Maine
10. Missouri

Figure 5.6- Civic Community in Italy.

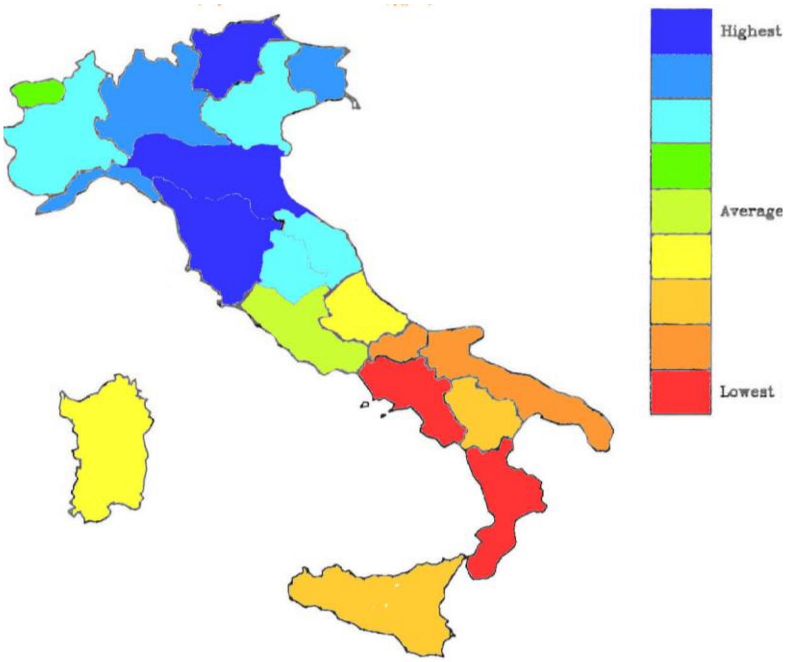


Figure 5.7- Summer Temperatures in Italy.

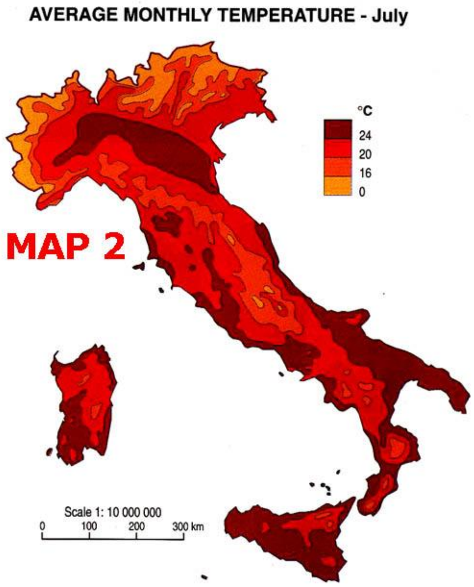


Figure 5.8- Winter Temperatures in Italy.

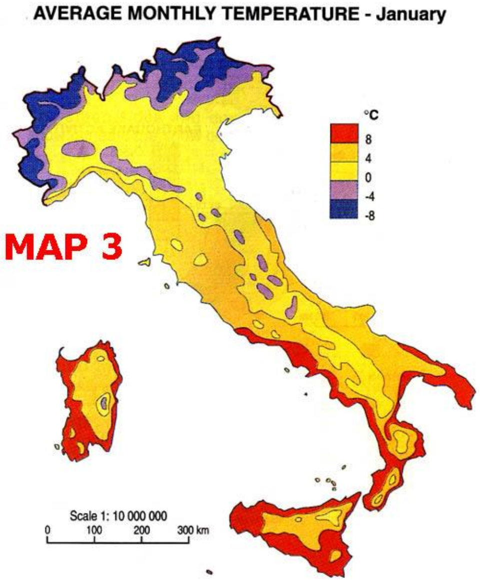


Figure 5.9. Average Annual Solar Radiation, United States.

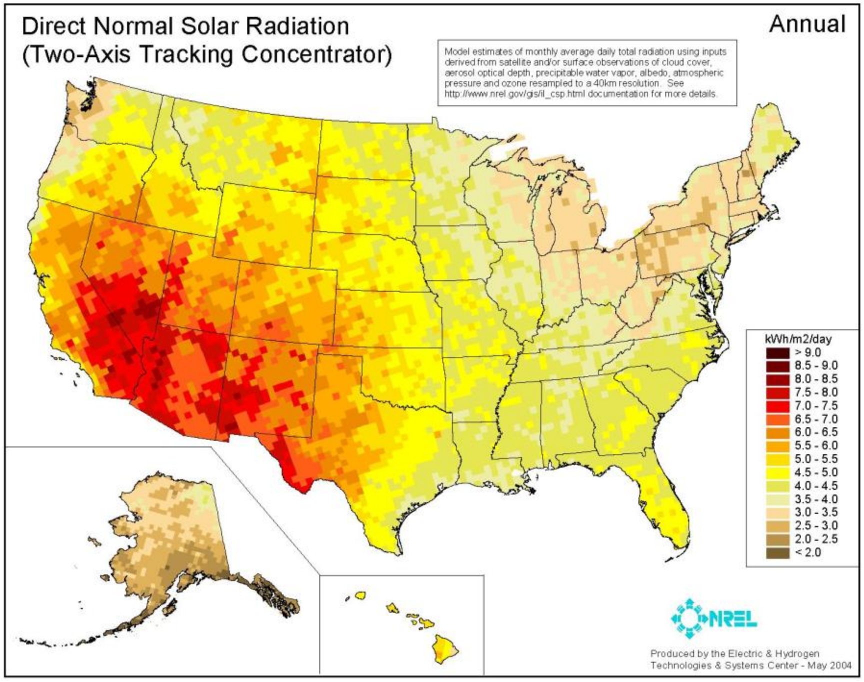
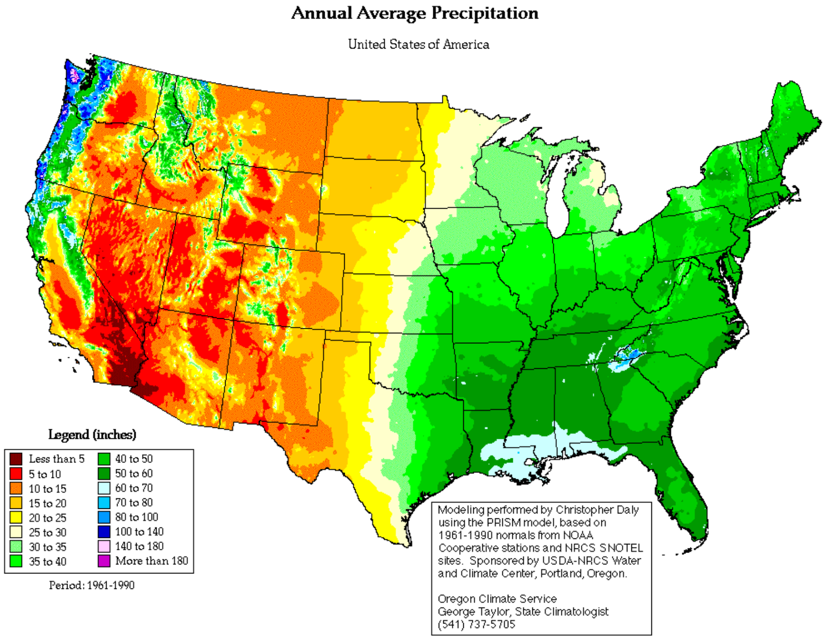


Figure 5.10. Average Annual Precipitation, United States.



Modeling performed by Christopher Daly using the PRISM model, based on 1961-1990 normals from NOAA Cooperative stations and NRCS SNOTEL sites. Sponsored by USDA-NRCS Water and Climate Center, Portland, Oregon.

Oregon Climate Service
George Taylor, State Climatologist
(541) 737-5705

Figure 5.11. Scatterplot of Volunteer Rates and Minutes of Daylight, Winter Solstice.

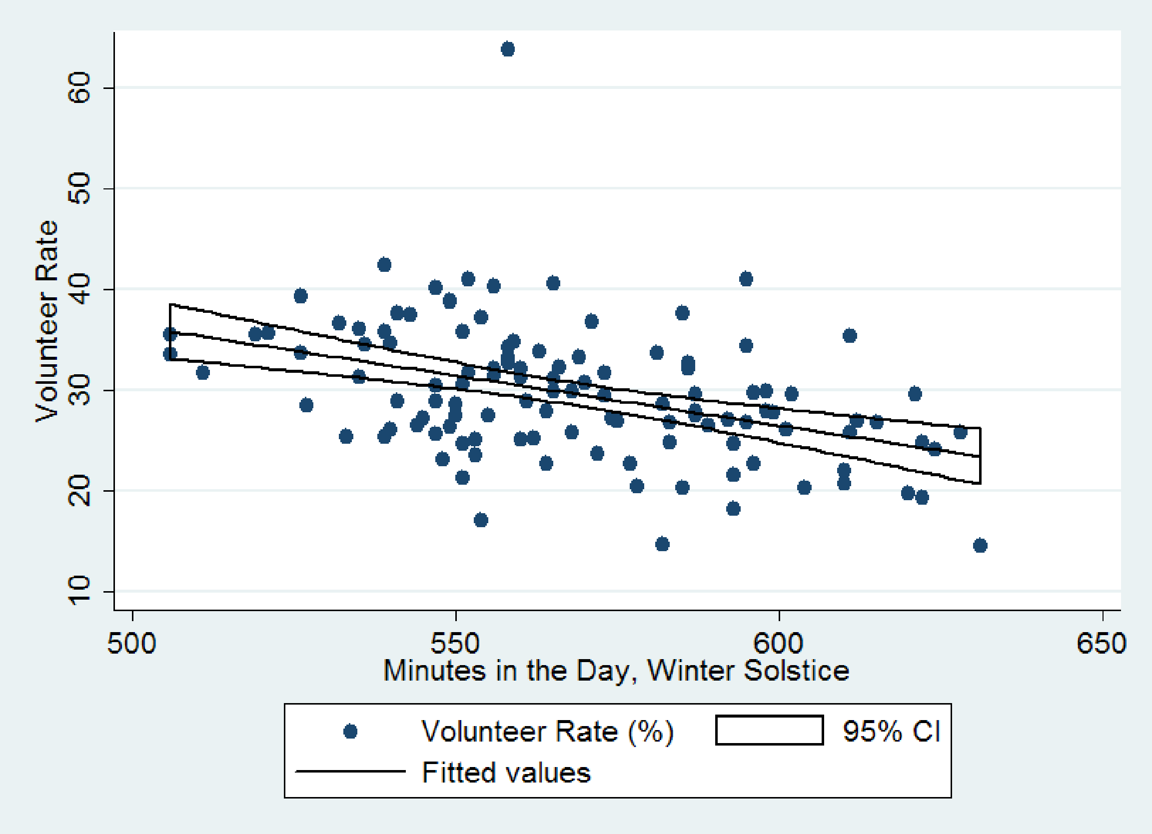


Figure 5.12. Scatterplot of Volunteer Rates and Average Yearly Adjusted Temperatures in Major American Cities.

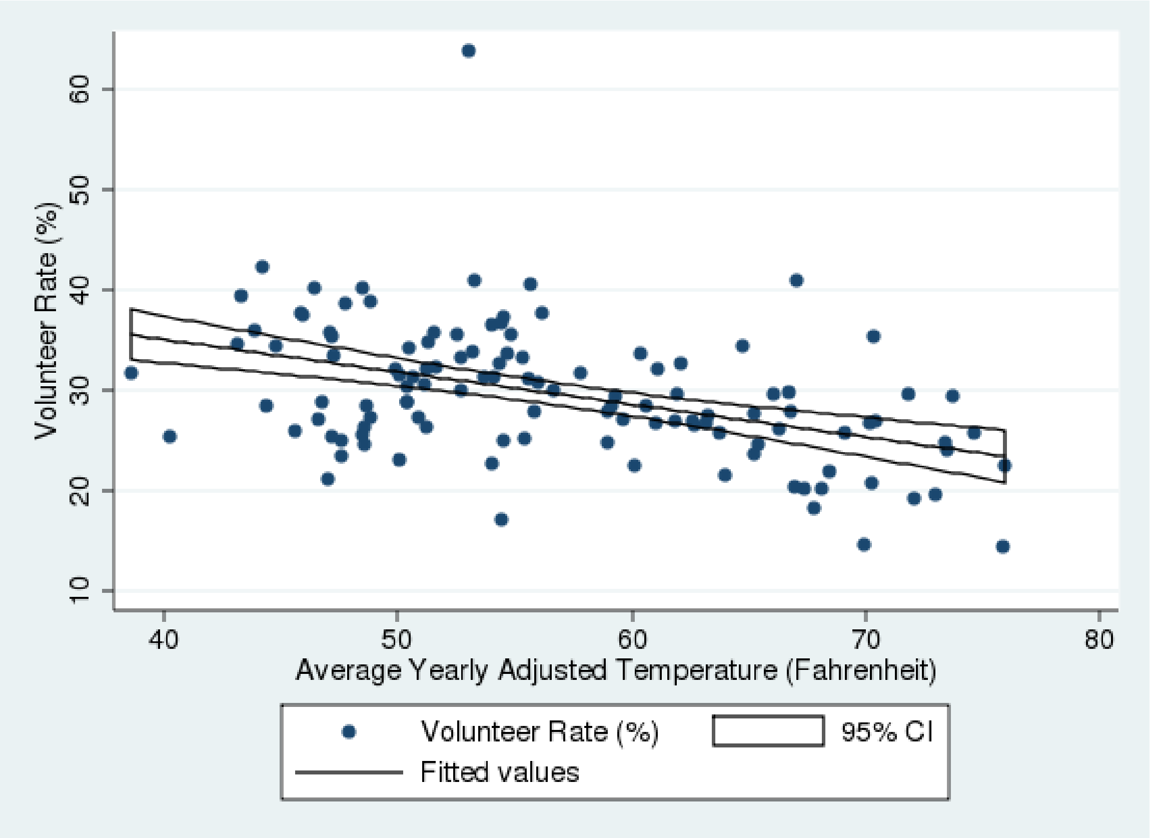
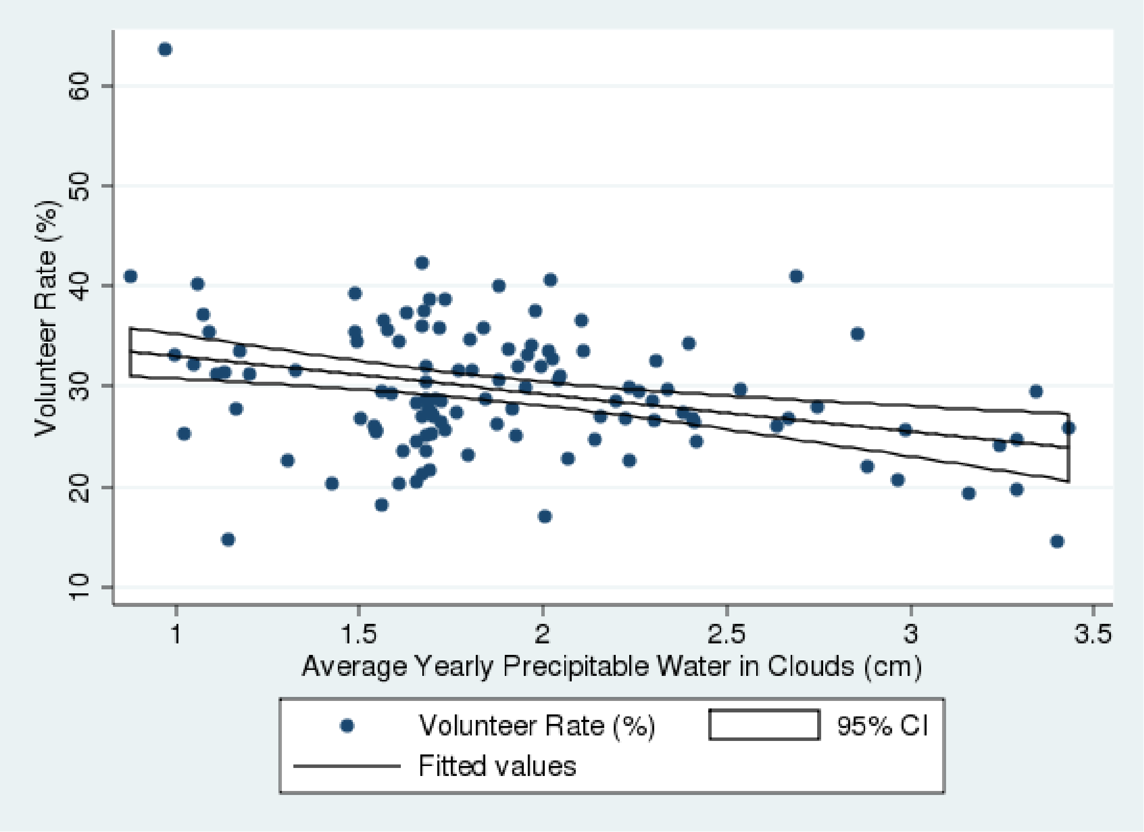


Figure 5.13. Scatterplot of Volunteer Rates and Average Precipitable Water in Clouds in Major American Cities.



CHAPTER VI. WEATHER AND VOTING BEHAVIOR

The Weather and Voting Behavior. Weather should affect voting behavior in two ways. First, by altering the costs associated with journeying to the polls, weather should affect turnout rates. Inclement weather should stymie turnout, and nice weather should make the journey to the polls less trying, and thus increase turnout. Second, if a vote for an incumbent Presidential candidate is indeed a referenda on his previous term, then nicer weather should increase incumbent vote shares because such weather boosts mood, fosters optimism, and leads to warmer evaluations of a wide array of objects.

These relationships will be tested across a series of 2005 surveys conducted by the Pew Research Center, in which respondents were asked whether they voted in the 2004 Presidential election. Although turnout data is drawn from survey data, the following analyses are a study of turnout, not survey response. The latter exercise was conducted in Chapter IV, which found that some weather conditions affected the probability of approving of the sitting President. Given that, one might be led to suggest that weather would affect whether or not people say that they have voted. Yet this is not the question at hand. Moreover, such a claim is unlikely to be upheld, as the nature of this particular question is quite different from the Presidential approval question. When asked if he or she approves of Bush, a respondent must express ‘attitude’ which, for many individuals, is not necessarily clearly or permanently formed, and is thus subject to the influence of mediating factors like the weather outside. Yet asking a respondent if they voted is asking them to recall a single, concrete action that either did or did not take place; the response should not be affected by weather. This chapter asks whether the weather near the respondent‘s location on November 2, 2004 influenced whether they voted and how they voted; the notion that weather outside their home on the date of the survey somehow affected their response is not considered.

As a check upon any positive results obtained, the effects of weather upon county-level turnout data across several recent Californian elections will also be analyzed.

The Weather and Turnout: Hypotheses. First, because rain increases the cost of getting to polling place, more precipitation should reduce the likelihood of respondents reporting that they voted in the 2004 Presidential election. This relationship has been noted in two studies on the subject (Gomez et al., 2007; Lakdar & Dubois, 2006); however, another study has found no relationship between turnout and voting, except among those scoring low on the NES civic duty indicator (Knack, 1992). Unfortunately, due to how the NSRDB codes weather data, actual levels of precipitation are not available for this analysis. The NSRDB was chosen as the source of weather data for this project because, in addition to being the only reliable source for sunlight data, it is a single dataset containing measurements on all weather variables at precise hourly intervals, streamlining the process of merging weather data to specific geospatial locations. Unfortunately, while most hourly weather observations can easily be merged into a single daily measurement by averaging them across hours of daylight, rain is coded in an awkward fashion. It appears as two fields: rain depth, and the period of time over which this depth is measured. Rain observations can occur hourly, bi-hourly, or at uneven intervals. Sometimes, the same quantity of rain is measured multiple times. Here is an example. At 1:00 pm, the dataset may record 1 mm of rain over the previous 1 hour. At 2:00 pm, it records no rain measured over the previous 1 hour. However, at 3:00 pm, it records 2 mm of rain over the previous 3 hours, measuring 1 mm of rain between 2-3, and the 1mm of rain at 1:00, which was already counted at 1:00! This pattern makes it very difficult to simply aggregate rain over the course of a day.

Two measures are used instead. The first is precipitable water in the atmosphere, which measures the amount of moisture that would fall to earth if all the moisture contained a single vertical column stretching from the ground to space were to descend as precipitation. This is far from a perfect proxy. While a high value should generally correlate with rain and a low value with dry conditions, it is possible for the sky to be very wet without rainfall. Thus, this measure of precipitable water in the atmosphere corresponds roughly with conditions, without predicting them absolutely. However, unlike a simple of rainfall, this high values on this variable also tend to indicate gloomy, foreboding skies. A second, more straightforward measure is also extracted from the precipitation data contained in the NSRDB: a dummy variable coded '1' if any rain fell on election day[89].

The role of temperature is somewhat more difficult to predict, as both extremely cold and extremely hot days should depress turnout because these days are so uncomfortable. However, few polling places experienced extremely hot conditions on November 2, 2004. 99% of surveyed voters live in places that were cooler than 80 F[90]on election day, 80% live in places cooler than 70 F, and 50% live in places where the adjusted temperature was beneath 60 F. Looking at the country as a whole, then, most voters faced cool or at least temperate conditions (see Figure 7.1 for a visual illustration). Given that the 'ideal' temperature is generally placed in the 70's (Allen & Fischer, 1978), warmer

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[89] This variable is coded '1' if, at any point in the day, weather sensing equipment picked up precipitation greater than 1 mm.

[90] Adjusted temperature, as opposed to the dry bulb temperature.

days were 'nicer' days in nearly all locations in America on election day, 2004. The prevalence of cool temperatures and the absence of truly hot temperatures complements the experience of late autumn, when winter's encroaching chill is rather undesirable, warmer daytime temperatures offer a pleasant contrast to cooler nighttime air, and, in many parts of the country, daytime warmth permits last chances at pleasurable outdoor activities. Because warmer temperatures on November 2, 2004 indicated nicer autumn days, we can hypothesize that warmer temperatures should have a positive influence on turnout. This hypothesis was supported in the French study of weather and electoral behavior (Lakhdar & Dubois 2006).

Predicting the role of sunlight is easier. Sunlight makes people happy and cheerful, and makes time outside pleasant--provided, of course, temperatures are not extremely hot. On a scorching day in Phoenix, for instance, sunlight could make traveling to the polls dangerous and uncomfortable. Fortunately for this analysis, no respondents lived in locations registering scorching temperatures during the election of 2004. Consequently, sunlight should boost the likelihood that a respondent voted in the 2004 contest. This was also a finding of the French study (Lakhdar & Dubois, 2006).

Other weather variables are available for analysis. Lower levels of horizontal visibility, which correspond with low-flying clouds and in the extreme case can correspond with fog, should decrease turnout. Low ceiling height, which also corresponds with low-flying clouds, could conceivably reduce turnout. Finally, barometric pressure--which has a strong relationship to social capital and its indicators, and also affects survey response--could also affect turnout. Admittedly, these are long theoretical stretches, but since the data can be readily analyzed it's worth looking into.

Of course, weather may not affect all people equally. Weather's effects should be more pronounced among those who possess weaker incentives to vote in the first place. For those without strong political convictions or for whom elections are substantively meaningless, lousy weather could be the difference between casting a meaningless vote and staying at home to watch Spongebob with the kids. This includes voters who face noncompetitive elections, or those who lack strong party identifications. Further, weather's effects should be more acutely felt among those who pay higher costs for voting, such as the poorer citizens for whom transportation costs and time off of work are most costly. Finally, since Gomez et al. (2007) point out that rain tends to benefit Democrats, it is worthwhile to test if Democrats are more affected by weather than Republicans.

Data. Weather data, once again, comes from the NSRDB. Voting data comes from a series of seven Pew Research Center polls fielded in 2005, in which respondents were asked whether or not they voted in the 2004 Presidential contest, and which candidate they voted for.

The Multivariate Model. The hypothesized relationships are tested in a multivariate model that controls for other factors that could conceivably affect an individual's likelihood of voting. Since older Americans tend to vote with greater frequency (Miller & Shanks, 1996), *age* is represented as an interval measure. *Sex* as a dummy variable coded '1' if the respondent is male. Following the intuition that those with greater material and mental resources ought to participate more (eg, Almond & Verba, 1963; Brady et al., 1995; Rosenstone & Hansen, 1993), *education* and *income* are represented in ordinal scales where higher values correspond with higher scores in each category. Given that beliefs and identity can powerfully mobilize people to vote, (Campbell, Converse, Miller, & Stokes, 1960; Miller & Shanks, 1996) *ideology* is represented as an ordinal scale where high values correspond with liberalness, and *Democrat* and *Republican* are coded '1' if respondents identify themselves with either party (leaners and Independents represent the omitted category). *Religious Attendance* is coded as an ordinal variable where lower values correspond with greater attendance at houses of worship. Because there is considerable evidence that minorities tend to participate less because they feel as though contemporary politics is exclusionary and may lack information about how the political process works (Burns, Schlozman, & Verba, 2001), *nonwhite* is coded as a dummy variable.

In addition to controlling for individual-level factors, the model takes the competitiveness of statewide electoral contests into account. Competitive elections stimulate turnout through two channels: they create the perception that one's vote matters, and they encourage mobilization by candidates and political parties (Cox & Munger, 1989; Rosenstone & Hansen, 1993). Competitiveness is represented through three dummy variables. First, *battleground state* is coded '1' if the respondent lives in a state that was won by Bush or Gore by less than 3% of the popular vote in 2000[91]. Second, *competitive Senate race* is coded '1' if the respondent lives in a state in which a Senator was elected by less than a 5% margin.[92] Finally, *competitive gubernatorial race* is coded '1' if the respondent lives in a state where the governor's race was decided by less than a 5% margin.[93] Unfortunately, because the only geographic information attached to

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[91] Washington, Oregon, Nevada, Arizona, Colorado, New Mexico, Minnesota, Iowa, Wisconsin, Missouri, Arkansas, Louisiana, Florida, Michigan, Ohio, Pennsylvania, Delaware, West Virginia, New Hampshire, Maine.

[92] Florida, Kentucky, Louisiana, North Carolina, South Dakota.

[93] Missouri, Montana, New Hampshire, Washington.

respondents in the Pew dataset is ZIP code, it was impossible to determine whether they lived in a House district that was competitive. Although some ZIP codes do fall neatly within House district lines, approximately 15% cross these lines, and in these cases, it would be impossible to determine in which district a given respondent resides. In order to control for competitive House races, these multiple-district ZIP codes would have to be excluded from analysis; since the bulk of these multiple-district ZIP codes fall within major cities, this would eliminate most urban respondents.

Several geographic controls are included. *South*, *midwest*, and *northeast* represent dummy variables corresponding to region, with the west as the omitted category[94]. *Latitude* and *longitude* are also used as second geographic controls for robustness, as are dummy variables for each state. Finally, cases from Oregon are discarded because Oregon permits voting only by mail, and so weather should have no effect on the likelihood of voting on election day in Oregon.

The dependent variables are hourly weather conditions averaged across all hours of full daylight, as recorded by the weather station nearest to the respondent's location. Unfortunately, we have no way of knowing whether a respondent moved between election day and the administration of the Pew polls, and so this may cause some minor error in estimates. Only those cases where the distance between the respondent and the nearest weather station is less than 40 miles are analyzed.

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[94] South: Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. Midwest: Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, South Dakota, and Wisconsin. Northeast: Connecticut, DC, Massachusetts, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. West: Arizona, California, Colorado, Idaho, Montana, North Dakota, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming.

Rain and Turnout. The claim that rain affects turnout is part of conventional wisdom, and has been studied by several scholars within the tradition of political science. However, even at the bivariate level, there is no statistically significant relationship between either precipitable water in the atmosphere or the dummy variable indicating rain and turnout. Given the extent to which the subject has been studied, this is surprising. This result cannot be written off due to a lack of variation in the dependent variable: November 2 was a rainy day in many parts of the country. Figure 6.2 shows that at 7:00 am on election day, a band of rain ran from southeastern Texas, across Arkansas, and up into the Midwest. Smaller spats of precipitation hovered over northeastern Texas, Washington state, and Minnesota. Figure 6.3 provides a view on the following morning, which enables us to see the movement of the rain: while the rain in the Midwest rolled northeast into Canada, some rain remained fixed in the skies above the south. Figure 6.4 provides a survey of the total rain between 7:00am on November 2 and 7:00am on November 3; although some of this rain occurred after the close of polls and is not reflected in the dataset, it does show the general northeastern movement of rain during election. Parts of southeast, midwest, and northeast were rainy on election day, while broad swaths of the country were not.

It is possible that the disparity between this finding and that of Gomez et al. (2007) may be one of data and methodology. The dependent variables in this analysis were 1) precipitable water in the atmosphere, which is far from a perfect proxy for rainfall and 2) a dummy indicating whether rain was at all present. Gomez et al. use actual rainfall levels, GIS technology, and pooled election data across multiple Presidential elections. While it is possible to use NOAA data to more accurately measure rainfall, this would require generating a new, cumbersome dataset from the NOAA servers and merging it with respondent data, which is a very time-consuming process, and unfortunately outside the scope of this project.

Nevertheless, the rainfall dummy is a valid and meaningful measure, and it is surprising that the presence of rain has no effect on turnout. Its statistical insignificance lends support to one study of rain and voting behavior which found no relationship between rainfall and voting (Knack, 1992). However, Knack does note that those who score lowest on the NES civic duty indicator *are* negatively affected by rain. While rainfall may not discourage those strongly believe that voting is their civic duty, it may by sufficiently annoying to repel those who care very little. Gomez et al. (2007) strike a similar chord in finding that rain disproportionately benefits Republicans because Democrats often rely on the support of poor communities, whose comparative lack of resources renders voting a more ‘expensive’ act than it is for wealthier people. In both cases, election day rain is part of a larger equation, wherein those who possess weaker incentives to vote or pay higher costs for voting are more affected by rain than others.

This provides a strong theoretical reason to test whether rain affects the probability of voting among certain subpopulations of the respondent pool. First, party identification could affect how rain affects turnout. Gomez et al. (2007) have suggested that Democrats tend to be more affected by rain. Further, Independents, who often face weaker incentives to vote given that they have weaker identification with the major-party candidates, could also be more affected than the general population. However, at both the bivariate and multivariate level, splitting the sample by party identification produces insignificant test statistics on both measures of rainfall. Once again, this study finds no support for the case of Gomez et al. (2007).

Second, respondents who live in states wherein elections are entirely noncompetitive face very weak incentives to vote in the first place, and so these people could be more easily discouraged by rain than the general population. There is no support for this at either the bivariate or multivariate level.

Finally, those who possess less material resources should also be more deterred by the increased costs posed by rain than the general population. For the poor and even the lower middle-class, taking time off of work to vote or paying for transportation to the voting booth can be a substantial hardship, one that is compounded by inclement weather. Rain can substantially increase transportation times, which can make voting more much difficult for those who cannot scarcely afford to duck out of work during even optimal conditions. And for those who must carefully balance bus fares or gas mileage against food or child care costs, rain eliminates the options of walking or riding a bicycle to polling places. Table 6.1 provides bivariate correlations between both rain variables and voting across several low income levels. While the measure of precipitable water in the atmosphere is not significantly related to voting, the dummy variable does negatively correlate with the probability of voting across several low and middle-low income categories. The correlation is strongest at -.1 in the lowest income group (those who make less than $10,000 a year), and grows weaker to -.055 when the sample size is increased to include all those who make less than $20,000 a year, and weakens further to -.044 when all those who make less than $30,000 a year are considered. If any wealthier groups are considered, the relationship ceases to be statistically significant.

As Tables 6.2, 6.3, and 6.4 show, the negative relationship between rain and turnout persists in multivariate analyses. Each of these tables lists three models. The first is a base model with regional dummy variables to draw out patterns of geographic variation that may have nothing to do with weather. The second model includes both latitude and longitude as further controls against the emergence of a spurious relationship between voting and geographic patterns that happen to coincide with rainfall. The final model adds a dummy variable for each state as a still stricter test. In each case, the result is the same: the presence of rain on election day lowers the probability of voting among three overlapping categories: those who make less than $10,000 a year, those who make less than $20,000 a year, and those who make less than $30,000 a year. Not surprisingly, the magnitude of rain's effect shrinks as the sample size expands to encompass progressively wealthier group. For those who make less than $10,000, rain decreases the probability of voting by 13.2%. When those with incomes lower than $20,000 are considered, rain's effect decreases to a 5.4% reduction in the probability of voting. Finally, those who earn less than $30,000 a year are 4.8% less likely to vote if it rains on election day.

This finding is consonant with the literature in many respects, yet it does not fully comport with other findings. It agrees with Knack (1992), who found no general relationship between rain and turnout. However, Knack did note that rain depressed turnout among those scoring lowest on the NES civic duty indicator, many of whom undoubtedly fall in these low income brackets. Unlike Gomez et al. (2007), there is no evidence that rain exerts a general depressive effect on turnout, though this may well be due to the different operationalization of rain employed by those authors, as well as their different methods. Yet, like Gomez et al, these findings do suggest that rain should indeed help Republicans, as it stifles the participation of poorer Americans, who tend to be Democrats.

Temperature, Sunlight, and Turnout. Because November 2, 2004 was a cool or at least temperate day throughout most of the United States (again, refer to Figure 6.1), sunlight and warmer temperatures should have exerted a positive influence on turnout by making the trip to the voting booth more pleasant. However, the bivariate analysis shown in Table 6.5. tells a different story entirely: as temperature and sunlight increased, the probability of voting decreased.

This relationship persists in the fully specified model, shown in Table 6.6[95]. The model predicts that moving from the minimum average daily temperature (8.8° F, in Manhattan, Kansas) to the maximum (87.47° F, in Brunswick, Georgia) decreases the probability of voting by about 6.7%, all else constant. An increase of 10° F decreases the probability of voting by about .6%. Likewise, the model predicts that a respondent in the least sunny city (Seattle-Tacoma, Washington) is about 2% more likely to vote than the respondent in the most sunny city (Deming, New Mexico).

These findings run contrary to the specified hypotheses, which posited that sunlight and warmer temperatures would boost turnout by reducing the cost of traveling to the polling booths. Instead, nicer days lead to a decrease in turnout. Perhaps, then, sunlight and temperature do not affect the costs of going to polling places in the same way that rain does. It is clear that rain depresses turnout by making the trip to vote more difficult and lengthy. On the other hand, while sunlight and temperature may make the trip less

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[95] Results obtained using longitude and latitude as control variables are substantively similar to those making use of regional dummy variables as geographic controls. To preserve space these results are not shown. Including latitude along *with* regional dummies does not result in a significant test statistic on weather variables; however, these models are imbued with a high level of multicollinearity, with uncentered VIFs on several variables that exceed 80.

pleasant and, for some very elderly or sick citizens, slightly more dangerous, these conditions do not slicken roadways, obscure visibility, and slow mass transit the same way that rain does. However, more sunlight and higher temperatures on election day may make *other* activities more pleasant, thereby reducing turnout. Perhaps, on nice autumn days, potential voters opt to spend their limited time off work walking their dog through the park, raking leaves in the front yard, or playing organized sports. While this is admittedly speculation, it would explain the significant negative relationships observed in Table 6.7.

Those who possess weaker incentives to vote in the first place should be more readily seduced away from the polls by the opportunities offered by pleasurable weather. Voters who face noncompetitive elections and Independents fall into this category. However, if the sample is divided to consider only those states that do not have competitive elections at the Senatorial, gubernatorial, or Presidential level, the model estimates a statistically insignificant regression coefficient on the weather variables. There is, then, no evidence to suggest that voters who face noncompetitive elections are less likely to be distracted by warmth and sunlight on election day. However, as days grow sunnier (but not warmer), Independents are indeed less likely to vote than the general population. Among the general population, the model predicts that a shift from the minimum to maximum value of sunlight results in a 2% reduction in the probability of voting. However, as the last column in Table 6.6 shows, the model predicts that Independents are 4% less likely to vote in the sunniest location, relative to the cloudiest location, all else constant.

Ceiling Height, Horizontal Visibility, Barometric Pressure. The weather variables that remain are a potpourri of conditions for which it was difficult to generate clear theoretical expectations. The bivariate correlations in Table 6.7 neither barometric pressure nor horizontal visibility appear to affect turnout. However, ceiling height is negatively correlated--the lower the clouds were on election day, the lower the likelihood of voting. As Table 6.8 shows, this outcome survives multivariate analysis with various geographic controls placed in the models. It is somewhat challenging to explain this finding, but whatever the case, lower-flying clouds on election day appear to depress turnout.

Weather and Turnout-An Aggregate Level Analysis of Californian Elections, 1998-2004. One way to check the results of the preceding individual-level analysis is to shift the level of analysis to see if findings continue to hold. County-level turnout figures from recent California elections are well-suited for this purpose for two reasons. First, the large size of California permits significant variation in weather conditions. Temperature, sunlight, and ceiling height vary substantially across the state on election day. Second, weather conditions that create ‘nice’ days in much of the United States in November should also contribute to ‘nice’ days in California. It is true that Californians do not drown in heat like south Floridians, and they do not shiver in the afternoon like Vermonters. However, although conditions are somewhat warmer and more pleasant than the national average, much of California is quite cool in November, which is fits the pattern across much of the United States. Across the four regular November elections and the single special October election between 1998 and 2004, the average daily Californian temperature ranged from 26° F to 87° F, with a mean around 62° F and a standard deviation of 7.5° F. In the national sample analyzed in the previous section, average daily temperatures ranged from 8° F to 87° F, with a mean of 58.5° F and a standard deviation of 12.34. While the Californian November is not an exact replica of weather throughout the United States, it is reasonably close. This is important for two reasons. First, inferences drawn from Californian data can be generalized to the national level. Second, the same weather conditions that make days 'nice' in most of the United States also make days 'nice' in California. As with the national sample, sunlight and warmth should generally boost mood in California because these conditions move temperature towards the 70's, which has been regarded as the 'optimal' temperature for mood (Keller, 1972). If sunlight and warmth are again negatively related to turnout, it would suggest that nicer days depress turnout because people opt to do more pleasurable things instead, such as going to the beach, or hiking.

Turnout data for each of California's 58 counties is furnished by the office of the Californian Secretary of State[96]. County-level information includes the number of registered voters, voters voting in person, and voters voting absentee. Because absentee voters are unaffected by election day weather, the turnout figure used here is calculated using the following formula:

Number of voters voting in person / (number of registered voters - number of absentee voters).

This yields a percentage figure indicating the proportion of registered voters capable of voting in person who trekked to the polls on election day. Five Californian elections are considered: the 1998, 2000, 2002, and 2004 November elections, as well as the October 2003 special election. Each county was tied to the nearest piece of weather

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[96] http://www.sos.ca.gov/elections/elections_elections.htm.

sensing equipment, and thereby associated with proximal weather at each election date.[97] Bivariate correlations between weather and turnout is shown in Table 6.9.

Findings here differ from those obtained in the survey analysis in several respects. First, sunlight does not significantly correlate with turnout, providing no corroboration the individual-level finding that sunlight depresses turnout. This could be because California is, on average, sunnier than the United States at large. Second, though ceiling height is significantly related to turnout, the relationship is positive, while it was negatively related to the probability of voting at the individual-level. This is a difficult twist to interpret. Third, barometric pressure emerges a significant negative correlate of turnout, which is a new observation, but one that comports well with the previously-noted relationship between temperature and turnout. Lower pressure often corresponds with cooler temperatures, so in this case, the correlation between lower turnout and lower pressure may indicate people refraining from voting because days are nicer and other activities are more desirable.

These bivariates converge with the individual-analyses at two points. First, rain does not affect Californian turnout, at least across the general population. Second, cooler temperatures are negatively related to turnout. This, again, indicates that turnout drops on nicer, warmer days in autumn, which suggests that voters are drawn from the polls by the possibility for more pleasurable outdoor activities, such as going to the beach, or hiking.

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[97] The latitudinal/longitudinal coordinates for counties were provided by the U.S. Census Bureau. The coordinates used were population centroids for each county, which indicates the geographical 'midpoint' for population in each county. While the population centroid is distinct from a geographic centroid, it is better for this purpose because it follows population more closely, and thus gives a better indication of the weather affecting most people in a given county. See http://www.census.gov/geo/www/cenpop/county/coucntr06.html

As a further test of the apparent bivariate relationship between temperature and turnout, an admittedly small multivariate model is constructed to predict turnout at the county level. The model contains three control variables. First, because minority populations often vote in lower numbers due to feelings of exclusion from the political system and a lack of resources or mobilizing institutions (Burns et al., 2001), *percent white* indicates the percentage of county population that considers itself white[98]. Because those with more resources are more likely to vote (Almond &Verba, 1963; Brady et al., 1995; Rosenstone &Hansen , 1993), *percent college graduate* and *median household income* are included[99]. Multivariate results are displayed in Table 7.10.

In the full sample, and in 1998, 2000, and 2002, lower temperatures indicate higher turnout. This supports the results of the individual-level analysis: on nicer, warmer days in the autumn, voters cast their ballots in fewer numbers than on cooler, less pleasant days. Further, consider the bivariate relationship between weather variables and the percentage of registered voters voting at precincts[100] across three March primaries held in California in 2000, 2002, and 2004, displayed in Table 7.10. Air temperature during these three March elections slightly cooler than conditions in autumn: across all the county-level observations across these elections, the average adjusted temperature was 52° F, with a minimum of 24° F, a maximum of 69.1° F, and a standard deviation of 9°. As during the autumn, then, higher temperatures correspond with nicer days. And, as table 7.11 shows, temperature is again negatively correlated with turnout among registered voters. So, too,

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[98] Based on estimates provided by the U.S. Department of the Census County Quickfacts Database. Data from 2008.

[99] Both variables are furnished by the U.S. Department of the Census County Quickfacts Database. Educational data drawn from 2000 Census. Median household income collected in 2007.

[100] As before, absentee voters are subtracted from the total number of registered voters before calculating turnout at the precinct.

is barometric pressure, which often indicates cooler temperatures. Again, this suggests that warmer, nicer days distract voters from the polling booth. This relationship persists in the multivariate model, displayed in Table 7.12.

Weather and Turnout: Summary. Weather affects turnout. The poor are significantly less likely to vote on rainy days than on clear days. By increasing travel times and slowing mass transit, rain raises the cost of voting by increasing the time needed to cast a ballot; for those without the economic freedom to take off work or the means to pay for extra child care, this increase in time can be enough to keep them from voting. Moreover, even if the increased travel time associated with rain is set aside, precipitation prevents voters from walking to polls and obliging them to take an automobile or public transit to voting locations. For those with less material resources than the general population, such increases in the material cost of voting are, in some cases, sufficient to prevent voting at all. Sunlight and temperature also affect turnout. On nicer days, people are less likely to vote. Presumably, this is because nice days in the autumn inspire people to outdoor activities instead of the stuffy confines of their local high school gymnasium or community center.

Weather and Vote Choice: Hypotheses. Theories of retrospective voting posit that votes in Presidential elections are referenda upon incumbent's terms. Because voters who are in better moods may well evaluate incumbent performance in a more positive light than those having a lousy day, the presence of weather conditions that bolster mood should increase the likelihood that a respondent voted for Bush. Consequently, respondents living in places that were sunny, warm, and dry on election day should report voting for Bush more than respondents living in places that were cloudy, cold, and wet. While there are no clear theoretical expectations regarding the role of ceiling height, horizontal visibility, and barometric pressure on vote choice, these relationships will also be subjected to analysis.

Of course, it is quite reasonable to argue that, since voting is such an important act, voters are not swayed in their position by short-term fluctuations in mood. In particular, those with strong pre-existing political dispositions--those who identify themselves as Democrats and Republicans--could well be inoculated against weather effects. Independents, on the other hand, should be particularly susceptible to weather's influence on their vote choice, as many enter the voting booth with weaker positive and negative affective ties to the candidates. Further, those who reside in states where the Presidential election was not competitive--effectively, people who knew that their votes would not count--should also be more susceptible to weather effects.

Weather and Vote Choice: Analysis. As a starting point, Table 7.13 lists bivariate correlations between weather conditions and vote choice. The dependent variable here is coded 1 if the respondent voted for Bush, and 0 if the respondent voted for Kerry or a third party candidate. This analysis was replicated using alternate variable, coded 1 if the respondent voted for Bush, and 0 if the respondent voted for Kerry, and the results were substantively the same. Throughout the following analyses, these two variables operate in a very similar fashion and produce alike results, and so only results obtained using the former measure are shown.

Temperature positively and significantly correlates with voting for Bush in both the general sample and among independents only, though the magnitude of the relationship is small. However, this relationship is not apparent in multivariate analysis, suggesting that temperature here is merely picking up the higher rate of votes for Bush throughout the South, and his weaker performance in the northeast and Pacific northwest. Sunlight appears related to vote choice only in non-battleground states, and even this does not survive bivariate analysis. Both rain and precipitable water in the atmosphere are positively correlated with voting for Bush, a point which comports well with the claim that rain ought to benefit Republicans because it keeps generally lower-income Democrats from the polls. However, neither of these variables are able to survive multivariate analysis, either. Horizontal visibility is not significant at all, and only one correlation involving ceiling height registers as significant, and this also perishes when placed aside control variables. Finally, Barometric pressure is negatively related to voting for Bush among both the general population, and among independents.

While this relationship between pressure and approval does not survive a multivariate test in the general sample, it does continue to be negatively and significantly related to voting for Bush in the Independent-only sample, even after several geographic controls are placed in the model (see Table 7.14). Unfortunately, the literature does not offer much direction in explaining this relationship. However, it is possible to eliminate one potential explanation: because low levels of barometric pressure often (but do not always) indicate precipitation, including a dummy coded 1 when any rain fell near respondents on election day out variation in the dependent variable due solely to precipitation. The negative relationship persists despite this variable, suggesting that the depressive effect of barometric pressure on voting for Bush is not related to its correlation with rainfall.

Higher levels of barometric pressure have been tied to better moods. Yet, if this was the mechanism by which pressure influenced vote choice among independents *and* the theory of retrospective voting largely held in this instance, we would see increases barometric pressure boost the probability of voting for Bush rather than depressing it. High barometric pressure has also been tied to more frequent and severe headaches, and a greater frequency of emergency psychiatric episodes. To argue that headaches wrought by barometric pressure drove Independents to vote less for Bush is a far stretch indeed.

Likewise, the suggestion that psychosis boosted votes for Bush is likewise empirically silly--though, for liberals who watched the 2004 election returns with dismay, it is an intuitively plausible notion. Unfortunately, making sense of these particular findings is difficult at the moment, and could well be a worthy target of further research.

Weather and Vote Choice: Summary. The data here is fairly clear: the average weather over the course of election day appears to have no effect upon whether people voted for the incumbent candidate, even if the sample is split to include only those with the weakest partisan ties (Independents) and those for whom the Presidential vote was, strategically speaking, a meaningless act (residents of battleground states). Alternate models constructed to explore if weather affects vote choice fall similarly flat. For instance, a multivariate test of whether weather affects the choice to vote for a third-party candidate yields insignificant test statistics on independent variables of interest.

In many ways, this is not an especially surprising outcome. Voting is a far from random act. Those who choose to go to the polls often take strong preconceived attitudes, thoughts, and evaluations into the voting booth, and are unlikely to be swayed in such an important decision by minor shifts in mood. Moreover, in a Presidential election year, quite a bit of information is about the major-party candidates is supplied to voters, and though this data may not be accurately received, translated, or remembered, very few voters flip a mental coin before checking the both next to ‘President of the United States.’ Unlike answering a survey questions asking respondents how Bush well is running the country, voting is a premeditated act with clear ramifications, and is thus far less prey to weather’s influence.

Table 6.1. Bivariate Correlations between Turnout Across Income Groups and Measures of Precipitation.

	Income < $10,000 (N=639)	Income < $20,000 (N=1668)	Income < $30,000 (N=2915)	Income < $40,000 (N=4193)
Precipitable Water in the Atmosphere	-.008	-.0113	.0078	.0082
Rain Dummy	-.1**	-.055**	-.044**	-.0137

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Table 6.2. Logits of Rain on Voting Among Those Who Make Less Than $10,000 Per Year.

	Income < $10,000, Regional Controls	Income < $10,000, Regional Controls with Latitude/Longitude	Income < $10,000, Regional Controls, Latitude/Longitude, with Fixed Effects
Rain Dummy	-.6111*** (.221)	-.5679** (.224)	-.9046*** (.273)
Sex	.1251 (.224)	.1538 (.227)	.047 (.26)
Age	.0155** (.006)	.016*** (.006)	.0211*** (.007)
Education	.362**** (.075)	.3619**** (.075)	.4644**** (..088)
Religious Attendance	-.2999**** (.068)	-.319**** (.07)	-.406**** (.083)
Ideology	-.0782 (.104)	-.0566 (.106)	-.1193 (.123)
Republican	1.5558**** (.367)	1.5459**** (.367)	1.7387**** (.416)
Democrat	1.0176**** (.237)	1.0489**** (.241)	1.2211**** (.277)
Nonwhite	-.235 (.25)	-.3096 (.253)	-.4743 (.291)
South	-.1388 (.347)	-.7949 (.677)	-4.2153 (3.4165)
Midwest	.2205 (.342)	.2188 (.624)	.8033 (3.082)
Northeast	.0549 (.374)	-.0722 (.838)	-19.8958*** (6.1602)
Latitude		-.0954** (.038)	-.2478** (.1088)
Longitude		.0121 (.03)	.02 (.0793)
State Dummies			(not shown)
Competitive Senate Race	-.1273 (.391)	-.3475 (.414)	-16.7349* (9.313)
Competitive Gubernatorial Race	.0279 (.491)	.5371 (.564)	2.5386 (2.179)
Battleground State	.165 (.257)	.1428 (.259)	-19.4575** (8.891)
Constant	-.638 (.731)	4.308 (3.0104)	30.86261 (--)
Change in p(vote) as Rain Dummy Changes from 0 to 1	-13.2%	-12.2%	(could not be estimated)
N	489	489	471
Pseudo-R2:	.1731	.1835	.2643
p>chi2	0.0000	.000	.000

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Table 6.3. Logits of Rain on Voting Among Those Who Make Less Than $20,000 Per Year.

	Income < $20,000, Regional Controls	Income < $20,000, Regional Controls with Latitude/Longitude	Income < $20,000, Regional Controls, Latitude/Longitude, with Fixed Effects
Rain Dummy	-.2641* (.135)	-.258* (.136)	-.4205*** (.153)
Sex	.1797 (.137)	.1812 (.14)	.1563 (.144)
Age	.018**** (.004)	.0179**** (.004)	.0187**** (.004)
Education	.3583**** (.048)	.3599**** (.049)	.3712**** (.051)
Religious Attendance	-.2468**** (.041)	-.2451**** (.041)	-.2692**** (.044)
Ideology	-.0947 (.068)	-.1021 (.069)	-.099 (.073)
Republican	.9381**** (.19)	.9376**** (.191)	1.0487**** (.19)
Democrat	1.055**** (.152)	1.0524**** (.152)	1.1***** (.152)
Nonwhite	-.401** (.159)	-.3994** (.16)	-.4834*** (.17)
South	.0699 (.204)	-.2493 (.425)	-1.5444 (2.174)
Midwest	.4147 (.216)	.0728 (.394)	-.4392 (1.696)
Northeast	.1087 (.222)	-.3812 (.529)	(dropped)
Latitude		.003 (.022)	-.1047* (.058)
Longitude		.0121 (.012)	.0181 (.046)
State Dummies			(not shown)
Competitive Senate Race	.0872 (.236)	.0218 (.251)	1.4554 (1.263)
Competitive Gubernatorial Race	.2929 (.306)	.3391 (.339)	-.8485 (2.824)
Battleground State	.1407 (.159)	.1315 (.16)	.2849 (2.018)
Constant	-1.1845 (.46)	.1107 (1.914)	5.6931 (4.873)
Change in p(vote) as Rain Dummy Changes from 0 to 1	-5.4%	-5.2%	(could not be estimated)
N	1299	1299	1280
Pseudo-R2:	.1552	.1599	.1911
p>chi2	.000	.000	.000

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Table 6.4. Logits of Rain on Voting, Among Those Who Make Less Than $30,000 Per Year.

	Income < $30,000, Regional Controls	Income < $30,000, Regional Controls with Latitude/Longitude	Income < $30,000, Regional Controls, Latitude/Longitude, with Fixed Effects
Rain Dummy	-.2664** (.105)	-.2683** (.105)	-.4061**** (.116)
Sex	.12 (.105)	.1158 (.105)	.1307 (.108)
Age	.0264**** (.003)	.0263**** (.003)	.027**** (.003)
Education	.3646**** (.038)	.3664**** (.038)	.3708**** (.039)
Religious Attendance	-.1896**** (.033)	-.1896**** (.033)	-.1986**** (.039)
Ideology	-.0341 (.055)	-.0374 (.055)	-.0364 (.057)
Republican	1.0416**** (.146)	1.0471**** (.146)	1.067**** (.151)
Democrat	1.0123**** (.119)	1.0131**** (.119)	1.035**** (.124)
Nonwhite	-.2623** (.127)	-.2642** (.128)	-.3062** (.133)
South	.1925 (.159)	-.1563 (.326)	-3.022** (1.32)
Midwest	.4724*** (.167)	.055 (.303)	-1.4356 (1.264)
Northeast	.3022* (.168)	-.294 (.408)	(dropped)
Latitude		.009 (.017)	-.0986** (.044)
Longitude		.0143 (.01)	-.0412 (.034)
State Dummies			(not shown)
Competitive Senate Race	.1509 (.189)	.0816 (.203)	4.9493** (2.005)
Competitive Gubernatorial Race	.1659 (.24)	.1942 (.262)	-1.576 (1.442)
Battleground State	.0488 (.124)	.0411 (.124)	3.6392* (1.9114)
Constant	-1.826**** (.361)	-.507 (1.478)	-2.1362 (3.598)
Change in p(vote) as Rain Dummy Changes from 0 to 1	-4.8%	-4.8%	(could not be estimated)
N	2321	2321	2293
Pseudo-R2:	.1578	.1589	.1816
p>chi2	.000	.000	.000

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Table 6.5. Bivariate Correlations Between Adjusted Temperature, Sunlight, and Whether or Not Respondents Voted in the 2004 Presidential Election.

	Voted?
Adjusted Temperature	-0.0474****
Direct and Diffuse Sunlight	-.0262***

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Table 6.6. Logits of Sunlight and Temperature on Choosing to Vote, 2004 Presidential Election.

	Temperature	Sunlight	Sunlight, Independents Only
Adjusted Temperature	-0.008** (.004)	--	--
Direct and Diffuse Sunlight	--	-0.0001** (.000)	-0.0014*** (.000)
Sex	0.04 (.067)	0.0538 (.065)	0.0977 (.098)
Age	0.0358**** (.002)	0.0359**** (.002)	0.0348**** (.003)
Education	0.3938**** (.023)	0.3929**** (.023)	0.398**** (.033)
Religious Attendance	-0.1679**** (.022)	-0.1717**** (.021)	-0.1628**** (.031)
Income	0.1426**** (.016)	0.151**** (.016)	0.1775**** (.023)
Ideology	-0.0627* (.038)	-0.0422 (.037)	-0.0867 (.054)
Republican	0.9013**** (.088)	0.8964**** (.087)	--
Democrat	0.8075**** (.078)	0.821**** (.077)	--
Nonwhite	-0.2147** (.086)	-0.2293**** (.084)	-0.4629**** (.124)
South	0.2183** (.106)	0.017 (.113)	-0.0455 (.168)
Midwest	0.2767** (.113)	0.125 (.14)	-0.04085 (.203)
Northeast	0.0003 (.103)	-0.1294 (.121)	-0.1739 (.177)
Competitive Senate Race	-0.0433 (.122)	-0.055 (.121)	-0.0306 (.187)
Competitive Governor's Race	0.2612 (.166)	0.0971 (.175)	0.0148 (.247)
Battleground State	0.2087*** (.08)	0.2342*** (.079)	0.307** (.119)
Constant	-1.9778**** (.312)	-2.2489**** (.263)	-2.063**** (.379)
Change in p(vote) as weather variable changes from min to max	-6.7%	-2%	-4%
N	8216	8513	2923
Pseudo-R2	.1778	0.1804	.1821
p>chi2	0	0	0

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001;

Standard Errors in Parentheses; Dependent Variable = 1 if R. Voted.

Tables 6.7. Bivariate Correlations Between Miscellaneous Weather Variables and Turnout.

	Voted?
Barometric Pressure	-.0114
Horizontal Visibility	-.0094
Ceiling Height	-.0330****

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Table 6.8. Logistic Regression of Ceiling Height on the Probability of Voting.

	With Regional Dummies	With Lat. and Long.	With Dummies and Lat. and Lon.
Direct and Diffuse Sunlight	-.0000***	-.0000****	-.0000***
	(.000)	(.000)	(.000)
Sex	.0386	.0402	.0354
	(.067)	(.067)	(.067)
Age	.0358****	.0356****	.0358****
	(.002)	(.002)	(.002)
Education	.3926****	.393****	.3934****
	(.023)	(.023)	(.023)
Religious Attendance	-.1691****	-.1736****	-.1687****
	(.022)	(.021)	(.022)
Income	.1446****	.1429****	.1455****
	(.016)	(.016)	(.016)
Ideology	-.0598	-.0623*	-.0597
	(.038)	(.038)	(.038)
Republican	.9005****	9051****	.9091****
	(.088)	(.088)	(.088)
Democrat	.7966****	.7979****	.7993****
	(.078)	(.079)	(.078)
Nonwhite	-.2261***	-.2171**	-.2192**
	(.085)	(.086)	(.086)
South	-.0374		-.2062
	(.121)		(.253)
Midwest	.04804		-.2665
	(.145)		(.25)
Northeast	-.1841		-.5947**
	(.125)		(.309)
Latitude		.0134	.0201*
		(.008)	(.011)
Longitude		-.0027	.0077
		(.003)	(.007)
Competitive Senate Race	-.0652	.0478	-.05508
	(.12)	(.122)	(.129)
Competitive Governor's Race	.1302	.04188	.0347
	(.175)	(.176)	(.183)
Battleground State	.2446	.2559***	.2521***
	(.080)	(.074)	(.081)
Constant	-2.1438****	-2.9182****	-1.9882*
	(.258)	(.49)	(1.0597)
Change in p(vote) as ceiling height changes from min to max	-3.4%	-3.5%	-3.70%
N	8246	8246	8246
Pseudo-R2	.177	.177	.1785
p>chi2	.000	.000	.000

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Table 6.9. Bivariate Correlations Between Weather and Turnout in Autumn Elections in California, 1998-2004

Direct and Diffuse Sunlight	-.1001
Adjusted Temperature	-.2385****
Rain Dummy	.0328
Ceiling Height	0.2898****
Horizontal Visibility	.0718
Barometric Pressure	-0.1623****

* = p < .1, ** p < .05, *** = p < .01,
**** = p < .001.

Table 6.10. OLS Regressions of Temperature on County-Level Turnout in California, Autumn Elections.

	Full Sample	1998	2000	2002	2004
Adjusted Temperature	-.0032**** (.000)	-.0026** (.001)	-.0032** (.001)	-.0088**** (.002)	-.0025 (.003)
Percent White	.0019** (.000)	.0023** (.001)	.0018* (.001)	.0013 (.001)	.002* (.001)
Percent College Graduate	.0018 (.001)	.0008 (.002)	.0017 (.002)	.0004 (.001)	.0032 (.002)
Median Houshold Income	.000 (.000)	.000 (.000)	.000 (.000)	-.000 (.000)	.000 (.000)
Constant	.5744**** (.105)	.4339*** (.139)	.6194**** (.137)	.9089**** (.19)	.6177*** (.227)
N	236	46	48	49	48
p>F	.0001	.0659	.0301	.0031	.1133
R-Squared	.0976	.1894	.2161	.2348	.1561

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001

Standard Errors in Parentheses.

Dependent Variable = 1 if R. Voted.

Table 6.11. Bivariate Correlations Between Weather and Turnout in Spring Elections in California, 1998-2004

Direct and Diffuse Sunlight	-0.0086
Adjusted Temperature	-.2955****
Rain Dummy	.0342
Ceiling Height	-.0438
Horizontal Visibility	-.0393
Barometric Pressure	-.3464****

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Standard errors in parentheses.

Dependent variable = 1 if respondent voted.

Table 6.12. OLS Regressions of Weather on Turnout in Spring Elections in California.

	Full Sample	2000	2002	2004
Adjusted Temperature	-0.003**** (.000)	-.0037**** (.000)	-.007**** (.002)	-.0021* (.001)
Percent White	0.0009 (.000)	.0002 (.001)	.0008 (.001)	.002* (.001)
Percent College Graduate	-0.0034 (.002)	-.0056** (.003)	-.0006 (.004)	-.0021 (.003)
Median Household Income	0.0000 (.000)	.000** (.000)	-.000 (.000)	.000 (.000)
Constant	0.4834**** (.108)	.6528**** (.106)	.6802**** (.171)	.2673* (.138)
N	147	50	48	49
P > F	.0026	.0002	.0032	.1010
R-Squared	.1079	.384	.3026	.1514

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Standard Errors in Parentheses.

Dependent Variable = 1 if R. Voted.

Table 6.13. Bivariate Correlations Between Weather and Voting for Bush.

	Voted for Bush = 1, Others = 0, Full Sample	Voted for Bush = 1, Others = 0, Independents Only	Voted for Bush = 1, Others = 0, Non-Battleground States Only
Adjusted Temperature	.0285***	.0435**	-.0171
Direct and Diffuse Sunlight	-0.0113	-.0386	-.0238**
Precipitable Water in Atmosphere	.0191*	.0525***	.0032
Rain Dummy	.0267**	.0317	-.0105
Barometric Pressure	-.0712****	-.049**	.0061
Horizontal Visibility	-.0117	-.0263	-.0155
Ceiling Height	-.0039	-.0221	-.0246**

* = p < .1, ** p < .05, *** = p < .01**** = p < .001.

Table 6.14. Logistic Regressions of Barometric Pressure on Voting for Bush (1), Relative to All Other Candidates (0), 2004 Presidential Election, Amongst Independents.

	Barometric Pressure	Barometric Pressure with Regional Dummies	Barometric Pressure with Latitude and Longitude	Barometric Pressure with All Geographic Variables
Barometric Pressure	-.0027** (.001)	-.0029** (.002)	-.0025* (.001)	-.0039*** (.001)
Rain Dummy	.0868 (.103)	.0808 (.104)	.1069 (.104)	.0741 (.105)
Sex	.0507 (.104)	.0607 (.105)	.0611 (.105)	.0692 (.105)
Age	-.0073** (.003)	-.0064** (.003)	-.0068** (.003)	-.0061* (.003)
Education	-.1547**** (.038)	-.15737**** (.038)	-.1612**** (.038)	-.1564**** (.039)
Religious Attendance	-.187**** (.033)	-.1761**** (.034)	-.187**** (.033)	-.173**** (.034)
Income	.0361 (.027)	.0398 (.027)	.0379 (.027)	.0379 (.027)
Ideology	-1.1278**** (.077)	-1.1208**** (.077)	-1.1236**** (.077)	-1.117**** (.077)
South		.2859* (.156)		1.1718*** (.354)
Northeast		-.1455 (.171)		1.0645** (.449)
Midwest		-.0393 (.156)		.7602** (.316)
Latitude			.0243** (.011)	.0018 (.016)
Longitude			-.0041 (.004)	-.0277*** (.009)
Constant	7.3843**** (1.315)	7.3856**** (1.314)	7.7058**** (1.599)	5.0422*** (1.766)
N	1920	1920	1920	1920
p>chi2	0	0	0	0
pseudo-R2	.1544	.1584	.1570	.1616
Probability of Voting for Bush as Pressure Changes from Maximum to Minimum	16.5%	17.48%	15.2%	23.3%

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Figure 6.1. Maximum and Minimum Dry Bulb Temperatures on Election Day, 2004.

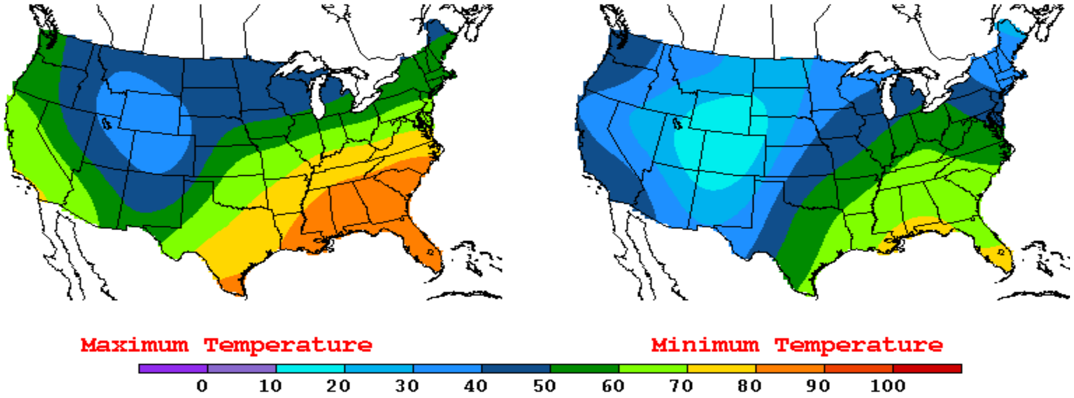
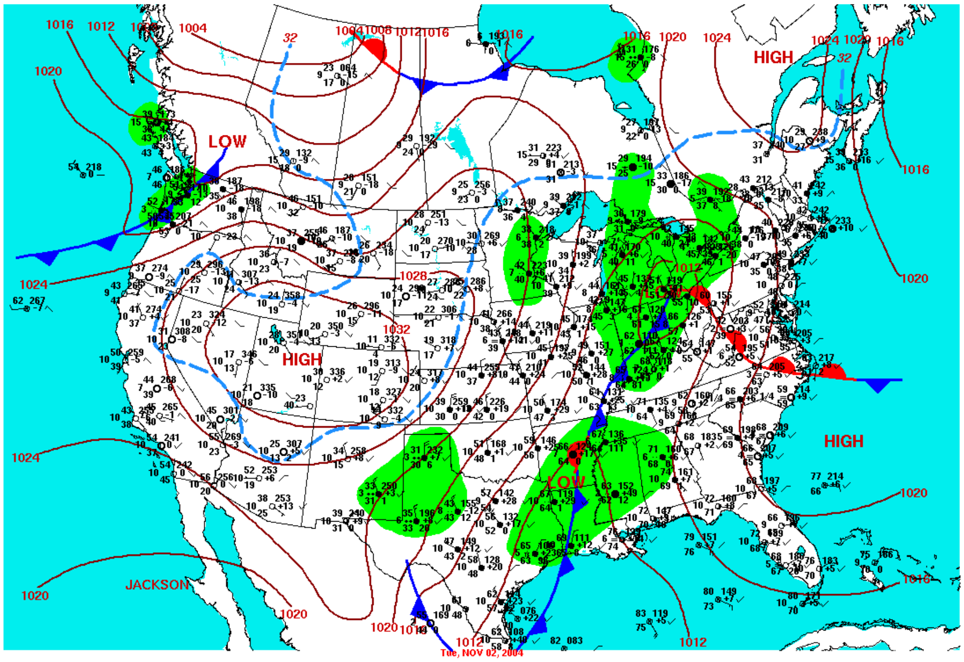


Figure 6.2. Precipitation on November 2, 2004.



Surface Weather Map and Station Weather at 7:00 A.M. E.S.T.

Figure 6.3. Precipitation on November 3, 2004.

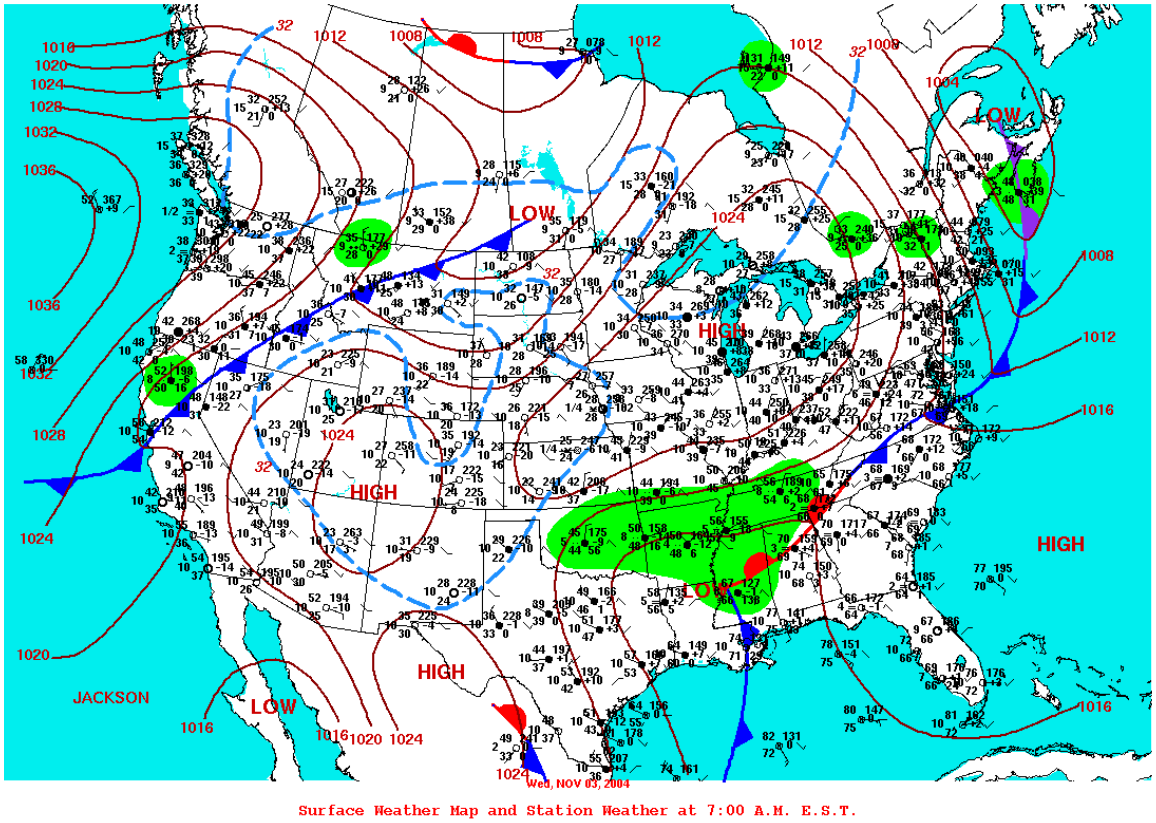
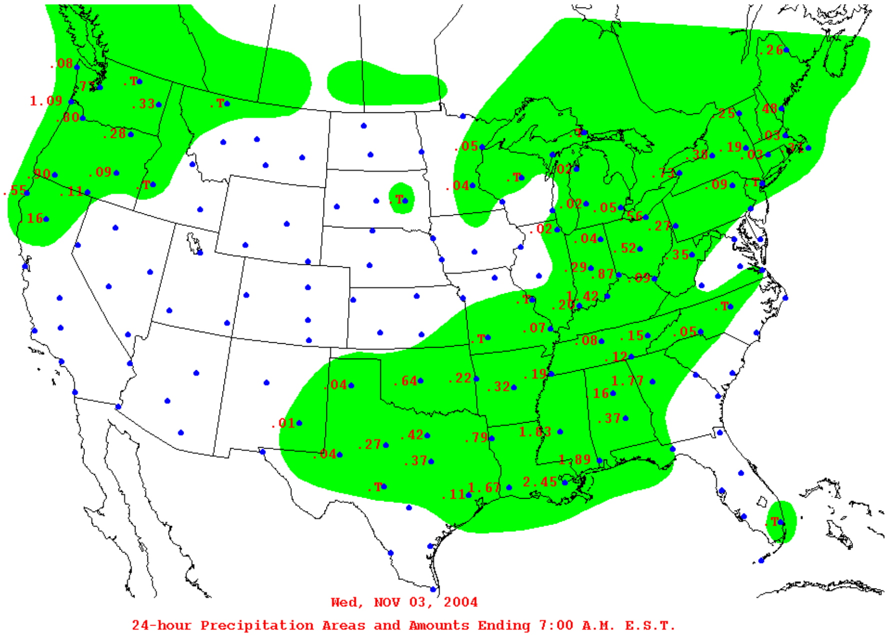


Figure 6.4. 24-hour Precipitation Between 7:00 am, November 2, 2004 and 7:00 am, November 3, 2004.



CHAPTER VII. WEATHER AND VOTING AT THE ELITE LEVEL

Overview. If weather can affect the voting patterns of ordinary citizens by altering the costs associated with venturing to the polls, then perhaps weather can also affect elite behavior by altering the costs of certain activities, such as voting on the passage of legislation. In the context of the United States, this would be indicated by greater abstention in Congressional roll call votes held on unpleasant days. After all, just like John Q. Public, elites are people who may simply prefer to remain indoors during an especially torrential downpour, or on a dangerously hot day. Of course, this effect would be most pronounced when the expected benefits from voting would be minimal, such as when a bill is already assured passage by a wide margin, or public attention is not focused upon the outcome. On the other hand, though, elites face a very different array of incentives than the average American voter, and so they may well be immune from weather effects. Most legislators have ambition for further elected office or, at the least, re-election, and so may dutifully vote in order to maintain the image of a hard-working representative of the people. Party discipline should encourage voting, as party leaders may threaten political retribution if representatives do not lend their voice to roll calls. Even setting politics aside, many elected representatives may feel driven to consistently vote on the basis of ideological beliefs or a sense of duty, regardless of the weather. Determining if weather conditions affect abstentions can help distinguish between the act of non-voting and tactical abstentions lodged to avoid voting against constituent interest, otherwise known as ‘shirking.’

Data and Hypotheses. Records of Congressional roll-call votes and legislator behavior is readily available thanks to the work of Poole and Rosenthal[101] (1997; 2007). Analysis is restricted to votes in the United States House of Representatives between 1991 and 2004, covering the 102nd - 108th Congresses. If weather does affect roll call voting, then the number of votes cast in the House should decrease on days when weather is uncomfortable. Because the criteria for a day being uncomfortable changes with the seasons, the role of some weather conditions should be seasonally contingent. In the summer, lower temperatures and cloudy skies should boost voting, as these days offer House members reprieve from the oppressive heat of D.C. summers. In the winter, sunshine should encourage attendance and voting, as these conditions provide some relief from winter's chill. In the spring, when people look forward to summer and enjoy the escape from the icy grip of winter, sunlight should boost roll call voting, as well. In the fall, however, expectations are mixed. On one hand, sunlight could have a positive effect on voting, as these conditions offer protection from the encroaching chill of winter. However, cool, sunless autumn days could also be particularly well-received, as these days provide particularly welcome relief from the disgustingly hot and humid D.C. summers.

Humidity, which is particularly unpleasant in the District of Columbia (which was founded upon a swamp), should reduce roll call voting during spring, summer, and fall because it amplifies the effects of hot days by causing condensation on the skin, reducing the body's ability to sweat and thereby increasing internal temperatures. During the heat of summers, humidity is also uncomfortable in its own right, as it causes a general sense of stickiness. In the winter, humidity generally corresponds to bleak and overcast days. Humidity in winter also increases the thermal conductivity of air, which means that the

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[101] An expansive repository exists at www.voteview.com.

human body loses heat more rapidly. So, humidity and voting should also be negatively related during the winter months.

In the summer, however, horizontal visibility could be positively related to voting, as shade may be well-received during the stifling summer heat. Finally, although there are no clear theoretical expectations regarding the role of barometric pressure or ceiling height, these variables are readily available for analysis and will be examined. Precipitation and the amount of precipitable water in the atmosphere should increase abstentions year-round, as rain or snow obviously increases the cost of heading to the Capitol. Throughout winter, spring, and fall, horizontal visibility should be positively related to voting, as lower values on this variable indicate dismal, low-flying clouds and hazy days.

Of course, weather may only matter, or may affect voting to a greater degree, when the expected benefit from voting is quite low. This would be the case when the result of a vote is already a foregone conclusion. In this case, a legislator's vote may be unimportant to the party leadership because the legislator's vote will not be pivotal. Bills that pass by a wide margin are often unimportant or procedural in nature, and so legislators with ideological convictions may sit these out on unpleasant days. Finally, many uncontested bills are less-scrutinized by the public, media, and PACs, and so taking a non-position by abstaining may not cost anything. Consequently, weather's effects should be more acutely felt--or, perhaps, solely felt--when the legislation passes by a huge margin.

Roll Call Votes and Weather at the Vote Level, Bivariate Analysis. The most straightforward way to test for a relationship between abstaining and weather is to examine the bivariate relationship between the number of roll call votes cast on a given bill and the weather on that day. While some weather elements like rain should have consistent directional effects year-round, sunlight and humidity play different roles as the seasons change. Consequently, relationships are examined on a month-by-month basis. While this approach is admittedly scattershot, it does offer a wide view of the field.

Correlations between weather conditions and roll call voting for every vote held between 1991 and 2004 are shown in Table 7.1. In most cases, results are not especially encouraging. Many weather variables drop in and out of statistical significance multiple times over the course of the year, and in many cases, the sign frequently flips in seemingly illogical ways, suggesting that many of these relationships are merely spurious ones. However, some hypothesized relationships do emerge. Multivariate analyses will be useful in highlighting genuine relationships, but for the moment, analysis will focus on bivariate findings.

In February and March, more sunlight is associated with higher rates of voting in the House. This makes sense: in the cool days of late winter and early spring, sunlight should make the trip to the House more pleasant. However, this is not apparent in the early winter months of December and January, though perhaps this may relate to the small sample sizes in those months that surround the holiday season. More troubling is the fact that sunlight in October is negatively and significantly related to voting, which is difficult to rationalize. If warm days in spring make the walk to the Capital more pleasant, then warm days in autumn ought to have the same effect. Sunlight is also positively related to voting in August, which--given the stifling heat of D.C. summers--is odd to say the least.

Humidity is negatively related to voting in most months, though this relationship is statistically significant in only five. In the first three months of the year, lower levels of humidity are correlated with more voting. This is intuitively appealing, because high humidity at low temperatures indicates colder, cloudier days where the increased thermal conductivity of air causes human bodies tend to bail out heat, which should keep Congresspeople indoors. The negative relationship in August also fits with theory: humidity on hot days is uncomfortable and should depress voting by driving people to the safety of air conditioning. However, the relationship between humidity and voting is insignificant and signed in the wrong direction throughout summer, which is when this relationship should be most apparent. The positive relationship in October is also difficult to explain.

With one exception, the relationship between barometric pressure and voting is insignificant. In the first three months of the year, both ceiling height and horizontal visibility are positively and significantly related to voting. These relationships fit well with theory. Higher ceiling height should generally indicate clearer days, since its maximum value indicates the absence of clouds. During these months, clearer days are sunnier and therefore nicer, which should reduce the costs associated with attending session, a point supported by the positive and significant relationship between sunlight and attendance in February and March. Low amounts of horizontal visibility correspond with overcast or even foggy days, which should be particularly distressing in the winter.

Finally, the rain dummy variable and the amount of precipitable water in the atmosphere often relate to voting in the anticipated manner. Precipitable water is negatively and significantly related to voting in six months. However, it is positively related to voting in two. It should be remembered, though, that although this variable is a reasonable proxy for rain, it does not necessarily indicate rain, and can co-indicate other conditions such as overcast skies and changing winds. The rain dummy is, thankfully, more straightforward. In five months of the year, voting in the House is negatively related to precipitation. Two of these months, January and February, are winter months, when nearly all precipitation is snow. March is also generally snowy, suggesting that snow, as opposed to rain, may have a particularly negative effect on voting. While a thunderstorm can be kept at bay by an umbrella, substantial snowfall requires a snowjacket as well as boots. When snow accumulates on the ground, it poses a considerable danger to expensive clothing, especially when combined with salt. The costs for venturing to the Capital on snowy days, then, may be higher than on rainy days. Further, in these three months, precipitable water in the atmosphere is also negatively and significantly related to voting, which should increase confidence in the observation that snowy days tend to coincide with weaker attendance at roll call votes. Although precipitation does not appear to be related to turnout in December, this month is host to the fewest number of observations, and also represents a special case, as many legislators go home for the holidays and, every other year, some have been voted out of office. These two mechanisms certainly exert powerful downward pressures on voting and, given the small sample size, could thereby mask weather effects.

It was hypothesized that these relationships should be more acutely felt when only unimportant roll call votes are considered. It is also possible that, under such conditions, other relationships may emerge as statistically significant. After all, while a snowy day may only keep a few Congresspeople from politically important, high-profile votes, many more may opt to stay warm and dry when the issue at stake is a bill renaming the

Washington Opera the National Opera[102]. Table 7.2 presents bivariate correlations between weather and the total number of votes for every roll call vote in the House between 1991-2005, but only considers roll call votes where the vote passed by a margin greater than 100. The outcome of these votes was, most certainly, a foregone conclusion for all involved. Of course, while Congresspeople face somewhat weaker incentives to vote on these bills than those bills where their votes could conceivably affect the outcome, House members do have some incentives to vote on these bills, such as building a voting record in favor or against a particular issue, swapping votes with political allies, satisfying party leaders, fulfilling a sense of duty, appearing busy to constituents at home, satisfying constituents to increase the likelihood of re-election, serving special interests with political clout, or supporting their own ideological beliefs. These votes represent about 60% of House business during the time period considered, and so the changed sample size provides a modest check against spurious findings.

With a few exceptions, bivariate correlations between weather and voting on nonpivotal pieces of legislation are not much different from those drawn from the general population of bills. While, as anticipated, the magnitude of statistically significant correlations generally increases, this is not always the case. The correlation between weather and voting achieves new statistical significance in certain months, but significance is lost in others. Mostly, the results remain as confusing and non-compelling as the previous lot. Three results, however, are worth noting. First, the correlation between

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[102] Public Law 106-42: Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, The Washington Opera, organized under the laws of the District of Columbia, is designated as the `National Opera.' Any reference in a law, map, regulation, document, paper or other record of the United States to the Washington Opera referred to in section 1 shall be deemed to be a reference to the `National Opera'.

horizontal visibility and voting remains positive and significant in four months, and picks up statistical significance in a fifth month, September. This continues to suggest that, sometimes, overcast days filled with low-flying clouds may suppress voting. Second, the confusing positive correlations between percipitable water in the atmosphere and voting vanish, and what remains is a uniformly negative relation across three winter months and September. Finally, in the five months of the year where the rain dummy is significantly related to voting, the correlation uniformly increases in magnitude, further suggesting that snowy days depress voting in Congressional roll call votes.

Roll Call Votes and Weather at the Vote Level, Multivariate Analysis. The bivariate picture of the relationship between weather and roll call votes is somewhat scattered and, at points, both contradictory and confusing. Testing this relationship in a multivariate model could help iron out some of these odd wrinkles in the data. In their work in analyzing the causes of abstention in Congress, Rothenberg and Sanders (2000a; 2000b) provide an excellent base model for predicting abstentions and roll call votes, and the following model follows their work, with a few modifications.

Legislators often possess stronger incentives to vote when that vote will be closely decided. First, the instrumental utility of legislators’ votes rises when their votes are more likely to affect the outcome, as is the case during closer contests (eg, Downs, 1957). Second, such close votes often emerge as high-profile conflicts due to their hotly contested nature, and the public, media, and interest groups may watch these votes more carefully than less conflictual one. In these cases, legislators may face greater costs for abstaining or garner more benefits by voting than when the issue at stake is, for instance, a bill designating a Chicago area post office be renamed the Roberto Clemente Post Office[103]. Finally, when a vote is expected to be close, party leaders may put pressure on legislators to vote rather than remain in their offices or in their home districts. Thus, the *closeness* of a vote is measured as 1 - |total yea votes - total nay votes|, where higher values indicate a closer vote.

Because many legislators opt to travel to their home districts on the weekends, Monday and Friday generally see lower attendance at roll call votes. *Midweek* is coded 1 on Tuesday, Wednesday, and Thursday, and otherwise coded 0. Days where more votes are held should naturally see higher attendance, as well, as the desire to vote upon more important pieces of legislation should have spillover effects upon less important pieces of legislation bundled on the same day. *Votes in a Day* corresponds to the total number of votes held on a given day. Because House members must campaign for re-election with increasing energy and time as election day approaches, legislators should vote less as election day approaches. *Term Day*, therefore, is coded as the number of days since the beginning of a Congressional term[104]. Finally, votes where party unity is strong should have a positive effect on voting, as party leaders work to encourage turnout and punish those who do not tow the party line (eg, Rohde, 1991). *Party Unity* is a dummy variable coded '1' on a roll-call vote where a majority of Democrats vote in opposition to a majority of Republicans.

These variables enable a multivariate test of the relationships suggested in the

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[103] Public Law 106-123. Begun and held at the City of Washington on Monday, the twenty-fourth day of January, two thousand An Act To redesignate the facility of the United States Postal Service located at 2339 North California Avenue in Chicago, Illinois, as the `Roberto Clemente Post Office'.

[104] This coding scheme continues in the two months after election day but before the start of a new term. Even though election day has passed, the holidays, post-election fatigue, the few votes that are held during this period, and the number of Representatives who were not re-elected should continue to suppress roll call voting.

bivariate data. First, in February and March, sunlight was positively and significantly correlated with voting. This relationship was positive, but not significant, in April and May, all of which is consistent with the claim that sunnier weather in the winter and spring should boost voting by reducing the costs associated with walking to the Capital Building. The negative significant correlations later in the year were more difficult to interpret, but as it happens, these do not recur in multivariate analysis. Table 7.3 displays results of OLS regressions of sunlight on voting during the winter and spring months. In both spring and winter, the coefficient on sunlight is significant and positive. During these seasons, after controlling for other causal factors, more votes were recorded on sunny days. However, the substantive impact is of sunlight is modest. The model predicts that a change from the minimum observed sunlight in winter to the maximum observed value increases the number of votes by 4.33. The effect of sunlight in spring is still weaker, as a shift from the minimum observed sunlight to the maximum observed level only increases the number of votes by about 1.6.

Multivariate analysis of adjusted temperature and relative humidity is quite interesting. First, most of the confusing results apparent in the bivariate results vanish. However, two new findings emerge, suggesting that the relationship between voting and these weather conditions is suppressed by other factors at the bivariate level. Once other important determinants of voting are controlled for, relative humidity appears to matter more than the bivariate snapshot suggests. When these factors are accounted for, two relationships emerge that are quite in concert with theory. These are also displayed in Table 7.3. First, relative humidity appears to have a significantly negative impact in the summer. Sticky, sweltering summer days in D.C. are particularly unpleasant, and in some cases are sufficient to keep Representatives in their offices. A change from the maximum to the minimum value causes a decrease of just about four votes, all else constant.

The remaining weather variables--horizontal visibility, ceiling height, precipitable water in the atmosphere, and the rain dummy variable--do not emerge as significant predictors of roll call votes in multivariate analysis on the full sample of votes cast between 1991-2004. However, when the sample size is restricted to include only those votes which pass by a wide margin, horizontal visibility and precipitation do significantly affect voting. Table 7.4 displays these outcomes, which are reasonably consistent with the bivariate analysis. Horizontal visibility matters in winter, spring, and summer; after holding other causal factors constant, moving from the minimum to maximum value on this variable leads the model to predict about 9 more votes in winter, 4.3 votes in spring, and about 8.7 votes in summer. Finally, the model predicts that the presence of snow in winter reduces the number of votes cast by about 5.4, all else constant.

Roll Call Votes and Weather at the Legislator Level, Multivariate Analysis. As a further check on these findings, multivariate analysis is shifted to the individual-level, where the unit of analysis is Congress-legislator-bill. This permits the integration of several individual-level control variables into the model. Again, I borrow heavily from Rothenberg and Sanders (2000a; 2000b). First, the relationship between legislator’s ideological preferences and bill content can affect the decision to abstain. The direction of this relationship is somewhat difficult to predict, as two possible relationships seem likely. First, Representatives could be more likely to vote when the ideology of a bill is very far from their own preferences, as they ‘target’ bills that they do not like. In this case, there would be a positive relationship between distance and voting. On the other hand, Representatives may vote more when they like legislation, which would suggest a negative relationship between abstaining and distance. Of course, it is quite possible that both forces act concurrently which perhaps explains the insignificant test statistic sometimes obtained on this variable in the multivariate analysis that follows. Whatever the case, *Ideological Distance* represents the distance between the 1) legislator's score on the first dimension of Poole and Rosenthal's Common Space DW-NOMINATE Scores and 2) the midpoint of the bill ideology on this same first dimension, as estimated by Poole and Rosenthal (Poole and Rosenthal 1997; 2007). This variable is equal to |legislator's score - bill midpoint|.

Another important individual level variable is the *distance to home state*. Because legislators must spend some time at home with their constituencies, those who must travel greater distances should spend more time away from Washington, D.C. This variable represents the distance between Washington, D.C., and the coordinates of the population centroid of each legislator's home state[105]. Finally, legislators face weaker incentives to vote when their voting record is unlikely to be used against them in the future. No politician wants to campaign against an opponent that can charge them with dereliction of duty, and so Representatives who run for re-election or run for higher political office should vote more than those who intend retire from the political arena. *Retiring* is coded '1' if a legislator did not seek re-election to any office at the close of a term, or at any time within two years thereafter[106]. All variables used in the previous analysis are also included.

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[105] As provided by 2000 Census, U.S. Department of the Census. Distances were calculated using a standard formula for calculating distances between latitudinal/longitudinal coordinates; see www.nhc.noaa.gov/gccalc.shtml for a an easy-to-use online calculator.

Several relationships continue to survive this stricter test. They are displayed in Table 7.5. Sunlight is negatively and significantly related to the likelihood of voting on the spring and winter, confirming once again that sunlight during these colder seasons has a positive effect on roll call voting. Humidity in the summer is positively related to abstaining. Horizontal visibility (not shown) also remains positively related to voting in winter, summer, and fall. Substantively speaking, however, these models are problematic on two counts. First, the change in the predicted probabilities of abstaining as weather variables travel from their minimum to maximum values is fairly small, at less than 1% in the largest case (see bottom rows of Table 7.5). This is fairly in line with estimates obtained in the OLS regressions of roll call votes: even dramatic changes in weather conditions have quite minor effects on voting patterns, a point that is not unsurprising given the powerful set of incentives legislators face to vote. Second, the strikingly low R-squared scores demonstrate that the estimated equations scarcely fit the data. However, when taken with the OLS regressions in Tables 7.3 and 7.4, these results do provide support for the presence of some weak relationships between weather and voting at the elite level in the United States House of Representatives.

The Weather and Voting at the Elite Level: Conclusions. In the balance, the analysis presented in this chapter provides some support for the proposition that weather affects roll call voting in Congress, so long as we are sensitive to two important factors. First, the effect of weather is contingent upon expectations of ‘normal’ weather, which changes from season to season; consequently, temporal context must be considered in assessing weather affects. Second, weather’s influence tends to be less evident when contested legislation is considered. In some cases, weather only matters when the domain

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[106] Biographies are available at the Directory of U.S. Congress; bioguide.congress.gov.

of cases is restricted to less-contested legislation. This latter point is not shocking. Votes that pass by a wide margin represent contests where the incentives for voting are somewhat weaker than those involving more divisive pieces of legislation. Therefore, such votes are more susceptible to the increased costs of travel imposed by weather.

After all, like John Q. Public on Election Day, Representatives are human beings. In choosing whether or not to vote on legislation before the House of Representatives, legislators make calculations based upon costs and benefits. One minor cost in this equation are conditions outside. Because it can render even a brief trip to the Capitol Building quite unpleasant, conditions have a slight but perceptible negative effect upon voting in House roll call votes.

In addition to being intrinsically interesting, these findings speak to how we think about legislators and their behavior. As politicians who practice their craft on a national stage, House members must juggle personal ambitions, constituent service, a public persona, friendship with powerful interests, electoral concerns, fundraising, and intraparty politics. Consequently, the choice to vote can be the end-product of a complicated series of political calculations. However, despite the often highly sophisticated nature of this calculus, legislators occasionally succumb to simpler, entirely non-political motivations. Many of these are idiosyncratic or impossible to measure, but weather is not. It is universally experienced and easily quantified.

These results are far from changing how political scientists study voting in the U.S. House. Considering the modest model fits embodied in the R-squared statistics, and the rather small substantive differences predicted by the models, it is safe to conclude that the magnitude of weather effects is far from overwhelming. Weather is less important in determining voting than the day of the week, or the time until election, or party unity. Nevertheless, while weather does not single-handedly settle votes, it does appear to affect voting in a measureable and meaningful way.

Table 7.1. Bivariate Correlations Between the Number of Votes on Roll Call Votes and Weather in Washington, D.C., (January 1, 1991- December 31, 2004).

	January	February	March	April	May	June	July	August	September	October	Nov.	Dec.
Sunlight	-0.0064	.1020**	.0747**	.0707	-.003	-.0375	.0252	.2442****	-.0451	-.0941***	-.0703	-.1926
Humidity	-.2615****	-.2215****	-.0601*	-.0238	.0269	-.0027	-.0325	-.3032****	-.0269	.1579****	.014	.0346
Barometric Pressure	.0065	.0228	.02	-.0497	-.0503	.0445	.0118	.1153*	-.0543	.0425	.0092	.0692
Horizontal Visibility	.3375****	.1368***	.1046**	-.0665	-.0249	-.0097	-.035	-.0877	.0529	.006	.1114**	.0034
Ceiling Height	.1924**	.1025**	.0743**	.0719	-.0132	-.0621**	-.0128	.2046***	-.0349	-.0604*	-.0538	-.2241**
Precipitable Water in the Atmosphere	-.2195***	-.2093****	-.0329	-.1169**	.0851***	.0448	-.0524*	-.1112*	-.1464****	.0747**	.0063	.1442
Rain Dummy	-.1396*	-.1084**	-.0765**	-.0575	.034	.0267	-.0749***	-.2013***	-.0412	.0796**	.0422	.0325
N	177	404	808	430	923	1336	1276	245	838	813	527	122

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Table 7.2. Bivariate Correlations Between the Number of Votes on Roll Call Votes and Weather in Washington, D.C., (January 1, 1991- December 31, 2004), Votes Passed by a 100 Vote Margin Only.

	January	February	March	April	May	June	July	August	September	October	Nov.	Dec.
Sunlight	-.0493	.1422**	.1151**	.0152	.0015	-.0395	.0227	.1957**	-.0656	-.0847*	-.1055*	-.1287
Humidity	-.2242**	-.3038****	-.1118**	.0402	.0182	-.0251	-.0295	-.2597***	.0055	.1647****	.0267	.112
Barometric Pressure	-.0622	-.0634	.0077	-.1489**	-.0959**	.0570	-.0079	.1666*	-.0147	.111**	.0029	.0218
Horizontal Visibility	.3739****	.2892****	.1872****	-.0524	-.018	.0440	.0122	.0091	.0901**	-.0173	.1614***	.0298
Ceiling Height	.1473	.1874***	.1039**	.0224	-.0033	-.0764**	-.0213	.1627*	-.0154	-.0574	-.0585	-.1269
Precipitable Water in the Atmosphere	-.2961***	-.3336****	-.0891*	-.0869	.0552	.0373	.0544	-.0637	-.1580****	.056	.0153	.2161
Rain Dummy	-.2076*	-.2349***	-.1369***	.0341	.0387	.0528	-.0883**	-0.2102**	-.0236	.0528	.043	-.0198
N	98	225	482	268	541	787	724	119	533	511	320	69

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001.

Table 7.3. OLS Regression of Sunlight, Humidity, and Temperature on Roll Call Votes in U.S. House of Representatives, Washington, D.C., (1991- 2004).

	Winter	Spring	Summer
Direct and Diffuse Sunlight	0.0104** (.005)	.00282* (.001)	
Relative Humidity			-5.733*** (1.962)
Closeness	0.0142**** (.003)	.01574**** (.002)	.0112**** (.002)
Midweek	11.0191**** (1.5022)	17.7805**** (.937)	18.2585**** (.715)
Votes in a Day	1.6384**** (.156)	.5876**** (.074)	.5864**** (.062)
Term Day	-0.0211**** (.003)	-.0132**** (.001)	-.0098**** (.001)
Party Unity	5.5705**** (1.115)	2.6546**** (.491)	4.2483**** (.527)
Constant	395.475**** (2.4823)	399.3903**** (1.164)	402.2639**** (1.546)
N	703	2161	2857
P > F	.0	.00	0.0000
R-Squared	.3268	.2555	0.2840

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001

Standard Errors are robust.

Table 7.4. OLS Regression of Horizontal Visibility and Rain on Roll Call Votes in U.S. House of Representatives, Votes Passed by a Wide Margin Only, Washington, D.C., (1991- 2004).

	Winter	Summer	Fall	Winter
Horizontal Visibility	.0002*** (.000)	.0001** (.000)	.0002*** (.000)	
Rain Dummy				-5.4181* (2.982)
Closeness	.0012 (.007)	.0034 (.003)	-.0011 (.004)	.0064 (.008)
Midweek	15.0865**** (2.132)	22.0345**** (.971)	16.0069**** (1.122)	15.4854**** (2.569)
Votes in a Day	1.9056**** (.216)	.6781**** (.081)	.4449**** (.105)	1.8054**** (.268)
Term Day	-.0251**** (.004)	-.011**** (.002)	-.0304**** (.003)	-.0257**** (.004)
Party Unity	3.7388** (1.692)	5.3226**** (.715)	6.7909**** (.927)	5.2039*** (1.716)
Constant	385.6314**** (3.953)	390.3367**** (1.978)	399.4126**** (2.387)	392.3666**** (3.9177)
N	392	1630	1364	361
P>F	0	0	0	0
R-squared	.3937	.3462	.2958	.3726

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001

Standard Errors are robust.

Table 7.5. Logistic Regressions of Weather on Whether or Not Representatives Abstained (1=yes, 0=no) by Bill, Washington, D.C., (1991- 2004).

	Winter	Spring	Summer	Winter
Sunlight	-.0002*** (.000)	-0.0001**** (.000)		
Relative Humidity			0.2992**** (.034)	
Adjusted Temperature				-0.0044**** (.000)
Closeness	.0005*** (.000)	-0.0005**** (.000)	-0.0000 (.000)	0.0005*** (.000)
Midweek	-.4891**** (.023)	-0.7482**** (.015)	-0.7883**** (.01)	-0.478**** (.023)
Votes in a Day	-.0002**** (.000)	-0.000**** (.000)	-0.0000**** (.000)	-0.0002**** (.000)
Term Day	.0011**** (.000)	0.0009**** (.000)	0.0006**** (.000)	0.0011**** (.000)
Party Unity	-.4409**** (.044)	-0.1629**** (.023)	-0.2176**** (.016)	-0.4557**** (.044)
Ideological Distance	.0326 (.032)	0.113**** (.018)	0.0799**** (.015)	0.03 (.032)
Distance to Home State	.0002**** (.000)	0.0000**** (.000)	0.0000*** (.000)	0.0002**** (.000)
Retiring	.6692**** (.03)	0.8201**** (.017)	0.8918**** (.014)	0.6698**** (.029)
Constant	-2.2371**** (.065)	-2.6476**** (.034)	-2.6419**** (.032)	-2.143**** (.067)
Change in predicted probability of abstaining as value of weather variable changes from min to max.	-0.0035	-0.0032	0.007	-.0107
N	304,444	936,053	1,239,992	304,444
p > chi	0	0	0	0
Pseudo-R2	0.0357	0.0215	.0312	.0359

* = p < .1, ** p < .05, *** = p < .01, **** = p < .001

Standard Errors are robust.

CONCLUSION

Overview. This concluding chapter is structured in three pieces. First, it will summarize the empirical findings of this dissertation. It will review the general finding—that weather and climate matter—as well as the topic-specific findings. Second, it will discuss the broader implications of these findings, with respect to our understanding of human behavior and our understanding of political science. Finally, it suggests avenues for further research on this topic.

Summary of General Findings. Put simply, weather and climate systematically affect political behavior in measurable and somewhat predictable ways. As has been stated, within the legacy of political analysis, this is not a new idea--it can be traced from Aristotle to the thinkers of the Enlightenment. While the mechanisms of influence are widespread, weather and climate generally drives political behavior by affecting mood, constraining actions, driving conduct, and affecting infrastructure and planning. In the aggregate, by influencing how people think, feel, and get from place to place, weather and climate affects individual-level political behavior in ways interesting to political scientists studying a wide array of topics.

Summary of Specific Findings. More specifically, the empirical analysis presented here has produced several novel findings. Although the attendant theories and implications have been discussed in the preceding chapters, the concrete conclusions are worth briefly restating here.

In the realm of public opinion, spring sunlight and warmth boost approval of the sitting President. In the summer, weaker levels of sunlight seem to stimulate approval. These effects are statistically significant in models that include multiple geographic controls, and so we should be reasonably confident in these results. And while the substantive impact of sunlight is far from overwhelming, the ‘sunlight effect’ is measurable.

Further, it appears that climate has an effect upon social capital and its indicators. At the state level, precipitation has a negative effect on social capital, and at the city-level, it appears that cooler, drier weather has a positive effect upon volunteering.

Weather also affects turnout on election day. In particular, rain has a depressive effect upon voting rates among the poor. Warmer, sunnier days depress voting, presumably because people opt to enjoy themselves outside rather than punch holes in a closed voting booth. However, there is little evidence that vote choice is affected by weather.

Finally, weather also affects abstentions in the U.S. House of Representatives by reducing the costs associated with traveling to Congress, particularly when only unimportant legislation is considered. In the winter and spring, sunlight boosts voting. In the summer, humidity has a negative effect upon voting. And, finally, in the winter, higher temperatures stimulate voting.

Implications for Political Science. The inclusion of weather and climate as independent variables in models contained herein is not meant to suggest that extant models have been horribly lacking without them, nor are the positive results here intended to ridicule the practice and profession of political science. Further, the substantive importance of these variables is limited: at no place in the chapters here does the examination of weather and climate fundamentally change how we think about any subject. However, nevertheless, this *is* political science: a study of conventional political behavior that utilizes a familiar methodology in order to make meaningful claims about political phenomena of interest to contemporary scholars.

That said, this dissertation does raise some general points about how we think about political science that, at the very least, are worth considering. Of course, many political scientists might find the discussion of these points insulting as they are so self-evident and already an integral part of research. However, academic subfields and competing paradigms can breed methodological epistemism, and few political scientists would admit that they are doing everything perfectly at all times (and those that are probably aren't)! These implications, then, may be useful either as interesting perspectives or friendly talking points—not as a didactic pronouncement of how to fix an unbroken discipline or an excoriation any particular approach.

First, political scientists should be reminded that political science did not start with Almond, Downs, and Converse. There is an older intellectual tradition, and that tradition holds some lost wisdom. In this case, the thinkers of the Enlightenment—and those that came before them—believed that weather and climate strongly drove social behavior. This is perspective, as shown here, hold some merit. Of course, our forerunners did not have it wholly correct (Hegel's racism is especially concerning), and so we should not blindly follow precedent. And, granted, the advent of modern statistics and methodology enables us to examine ideas in a more formal fashion than was previously possible. Yet this, too, carries bias, though it is a different sort than that of our progenitors. We should not allow the austere attraction of clean statistics and crisply printed Cambridge journals to lull us into a feeling of absolute mastery of understanding: sometimes, the old 'crude' thinkers have it right, in bits, and we do knowledge a disservice by forgetting this. Of course, we can't know everything, and we don't know everything. Yet we should aspire to know as much as we can, given our tools and the limits of human understanding. This requires studying the past as well as the present, and looking back as well as forward.

This research also suggests that exploring the error term can be a useful enterprise. Several undergraduate and graduate textbooks—dimly recalled, now, due to their being consumed at 4 am after the infusion of dangerous levels of caffeine—explain the error term as containing things that can't be measured, like weather. Yet weather *can* be measured, and plucking it from the error term yields real scholarly gains. As we know, the error term is not immutable. It can always be further deconstructed, and while this is not always useful, *thinking* about this deconstruction in a less-than-conventional way can be very helpful.

Political scientists, then, should not be afraid of thinking outside the box and exploring ideas with immense intuitive appeal but for which the means and method of systematic study may not be immediately clear. This is where new, interesting, and important ideas are born. While there is of course immense analytical utility in cleaving closely to established debates, replicating results with a slightly transmuted variable, or hammering home a controversial point, science is also the act of *creation*. While we don't create reality we do create ideas, and to do so, scientists must sometimes take long risks and be unafraid of following interesting ideas even if those ideas do not seem immediately salable. Unfortunately (and arguably), the profession, its job market, and the decomposition of the tenure system does not necessarily support this approach. But certainly a middle-ground can be achieved. New ideas, after all, turn the wheels of history (though this dissertation certainly does not).

Finally, political science and its labor force should take pause to look outside the office window. Scientists cannot live ensconced in a world of STATA, publications, and CVs. While contributing to established discourse is a vital enterprise, good science can also spring from drawing from the rhythms of everyday life, and using these direct observations to explore new avenues in political science. Consider the immortal words of Schattschneider: “watch the crowd.” This a profound and simple observation about a colloquial experience that, by analogy, provides a memorable portrait of a powerful idea that is now integral to our understanding of power and politics. While it is impossible to prove, one has to imagine that Schattschneider would not have been driven to pen those words if he had never seen a fight! The point here is that the world in which we live our day-to-day lives is intimately connected with the political one, and serious scholarship can, occasion, benefit from embracing this connection. Human beings are live in complex environments filled with measurable stimuli that could conceivably affect politics; many of these stimuli are quite apparent in our day-to-day lives. Political scientists should be open to drawing upon these self-apparent truths, studying them in a scientific fashion, and connecting them to politics.

Implications Regarding Rationality. It is no secret that humans are not purely self-interested maximizers. Indeed, such a strawlike construction of the rational-choice model likely raises the hackles of most serious scholars, regardless of paradigmatic preference. Rational-choice does not allege perfection and could certainly allow for weather by simply defining self-interest as including both ‘long-term strategic goals’ as well as ‘short-term relief from psychological stresses caused by the immediate environment,’ impulses which are no less rational if we take a broad view of human preferences. This dissertation embraces such a view. It also suggests that stricter constructions of rational-choice ought to allow for environmental and contextual effects such as weather. One could argue *ad naseum* regarding whether such allowances are ‘rational’ or whether rational models ought to pay head to ‘irrational’ effects, and solving such a dilemma is probably both impossible and painful. The point, though, is that weather does subtly and unconsciously affect our calculations, and this is something that informs our understanding of rationality, and why people do what they do.

However, with all of that said, there is a strong vindication of the rational-choice paradigm here—or, at the very least, this dissertation does demonstrate the relative supremacy of traditional determinants of political behavior. Comparatively speaking, in terms of predictive accuracy, the improvement offered by considering weather and climate is generally substantively minor.

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