Authors of the Storm

Meteorologists and the Culture of Prediction

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Introduction

Remember, when the weather goes bad, we're in sales, not production.
National Weather Service employee

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The question is not weather but when. Humans are exquisitely sensitive to their ambient environment. We are *Homo meteorologicus*. As Verlyn Klinkenborg puts it, weather is "one of the moral dimensions in which we live."[1] Weather shapes our choices of action. Being planners, we require guides for approaching weather systems. Whenever we desire technical control, we anoint ritual knowledge specialists. Sometimes we demand that the atmosphere be altered. This is the task of rainmakers. For modern societies, prediction is the aim. (Recent attempts to alter the atmosphere have not met with great success or public approval.)[2]

At the heart of weather as an occupational world are those specialists that the public and the state call upon to reveal the future. We ask these workers what to expect in temperature, precipitation, wind, and humidity. We label these workers weather forecasters, or, more formally, operational meteorologists. Most people have their most salient meteorological connection with media figures, charismatic individuals who may or may not have expertise in

meteorology. Too often we ignore those individuals who stand behind these attractive, recognizable, friendly faces.

Prognoses of the future are created and shared, shaped by the contours of group life. Weather knowledge results from the practices of forecasters employed by the National Weather Service, the government agency whose responsibility and claimed expertise includes meteorological prediction.[3] In this, the group life and culture of meteorologists intersect with the organizational demands that are placed on them. I watched as they struggled to create authority in their work life, establishing a right to know. To see how weather forecasts are created and distributed is to understand some of the conditions of *public science,* the making of authoritative, systematic, and empirical claims of the natural environment to a popular audience.[4] In this focus on public science, meteorologists share similar concerns with pharmacists, public health officers, ecologists, agricultural agents, foresters, dieticians, horticulturalists, and even one's family physician.

To understand the doing of weather work, I draw on research from that branch of the social sciences known as science studies. An outsider, I incorporate concerns with worklife, group dynamics, and culture. The underlying claim of science studies is that science—and the knowledge claims that result—is socially organized, not merely a window into truth. That much is valid. Yet, despite our skepticism of confident certainty, scientific claims are based on empirical reality, even though that reality is understood through collective understandings. Some critics unfairly stereotype science studies as a brand of radical doubt and deconstructionism. But anyone who has had a medical procedure, has operated a computer, or has planned a picnic is grateful for the accomplishments of scientists, even when imperfect in their predictions and practices. The salient questions are how these workers come to make the claims they do, how they work to produce these claims, how they feel about those claims, and how they persuade audiences that their claims are plausible.

In this vein I describe how practitioners of one knowledge arena operate. Still, meteorology is not basic science, housed in a university where social control tends to be discreetly hidden. That these practitioners work for the United States government in small offices within a large bureaucracy is critical. In addition, meteorology has relatively low-status in the hierarchy of the sciences, an offspring of the marriage of fluid dynamics physics and earth sciences. None of America's elite Ivy League universities has a department that specializes in meteorology.[5] And the workers that I observed are not oriented to research. These are not professors or Ph.D.s, but, for the most part, men and women with Bachelor

of Science degrees in meteorology, with some M.S. degree holders and a few who lack a college degree. Each local office (of which there are 122) produces two forecasts daily (around 3:30 p.m. and 4:00 a.m.) as well as updates (Nowcasts) for significant precipitation and warnings if severe weather threatens. Practices in local offices are shaped by rules promulgated by headquarters in Washington. I hesitate to term these men and women bureaucrats, given the stigma of the label, but they belong to a bureaucracy with strengths in rationalization and in uniformity of practice.[6]

Most weather forecasts are "good enough." Their accuracy is impressive for the following day's weather, and sufficient to rely upon for two or three days. (I will later have much to say about "accuracy"). These forecasters do more than throw darts at the wind.

Within the broader attempt to understand the conditions of work of these forecasters, I address a set of theoretical issues: (1) how weather forecasting gets done given the bureaucratic obstacles and temporal pressures under which meteorologists operate, (2) how science is defined by these workers and how they situate themselves in relationship to this honorific category, (3) how meteorologists and others depict future events and then justify that depiction, colonizing the future by building on a present and past that they have constructed by means of the machines that they employ, (4) how occupational autonomy maintains itself—in this case embedded in control of language and images—in the face of organizational and technological control, (5) how scientific, predictive accuracy is created through the organizational demands by which forecasts are verified, and (6) how the relationships between these workers and others who stand outside of the boundary of their workplace, including mass media, private companies, and government agents, shape meteorological practice. In each instance, scientific work and one's identity as a scientist are linked to authentic knowledge and legitimacy.

These are broad issues, with implications that extend to other spheres of social life. Meteorologists, despite their seemingly specialized and esoteric work, face many of the same challenges of autonomy, prediction, and evaluation as other workers.

A Student of the Air

Having claimed generalization, the craft of meteorology is also specialized and unique. This is an occupation that an outsider, a naive sociologist, with only a junior high school course in earth science and a high school course in physics could not fully master, no matter how many

hours watching the Weather Channel and the antics of Al Roker and Willard Scott. At best, in the terms of Harry Collins and Robert Evans,[7] I acquired *interactive expertise,* able to converse about basic meteorological concerns and to translate them to others.

To conduct an ethnography of a technical field requires immersion in a specialized, complex, and jargon-filled world: a world of machines and their tenders. The primary challenge for untrained outsiders who examine workers is to learn enough to understand without learning too much, so that one can perceive the world with distant eyes. I explain relevant meteorological terms to assist readers without expertise in meteorology, as terms like vorticity, bow echoes, vil, zulu time, and mesoscale need clarification, even as I avoid still more technical terms. The American Meteorological Society–sponsored *Glossary of Meteorology* (2d ed.) weighs in at 855 pages, with 45 terms beginning with "z" alone. Some of the discourse is specialized, but informal talk also is common, such as "boxology," "knobology," a "dead pattern," or "flip-floppiness." My favorite was when forecasters told me that there was "no weather," meaning, of course, no likelihood of severe weather, disappointing for those who like the challenge of forecasting. Specialized acronyms like ETA, AWIPS, CWA, CAPE, AFD, NCEP, or DAPM are hardly transparent, even when spelled out.[8] At various meetings I found the range of acronyms and other specialized terms daunting and sometimes felt like an anxious pre-med who had spent too long partying. Acronyms, characteristic of the sciences,[9] are so evident that employees of the National Oceanic and Atmospheric Administration joke that the acronym NOAA stands for the National Organization for the Advancement of Acronyms (or, sometimes, for No Organization At All) or imagine the fantasy Bureau of Atmospheric Research Forecasters or BARF (Field notes). Sociology has a deserved reputation for jargon,[10] but, having been a sociologist for decades, I view *our* terms as transparent as air itself.

As in all occupations, metaphors abound in meteorology, transforming technical, scientific concepts into profane talk: clouds as sugar cones, pinwheels, castles, and beaver tails. Storms are popcorn, zappers, meatballs, and slop.[11] Radar images can be likened to a toilet bowl, Pac-Man, a beast, a bow, a battle,[12] or the Spanish Armada (Field notes). Weather naturalizes the social,[13] as society colonizes the meteorological. Physical features are given agency and motivation, and, thus, temperatures struggle to rise, rain wants to freeze, and storms shoot their wad (Field notes). In this, we see *nature's autonomy,* the belief that the sky has a mind of its own. We easily slide from claims of causation to claims of intention. Meteorological talk is a mix of images ripped from American culture and

the local occupational subculture: talk that the public can understand and comment upon and talk that requires specialized training.

I was fortunate in finding patient teachers. Several forecasters, both older hands, the lead (or senior) forecasters, and younger journeymen (or general) forecasters assisted me on my travels toward meteorological literacy.[14] I recall one occasion in which I sat with Stan for his shift, and he patiently and carefully explained that high pressure was usually associated with "good" weather with the exception of so-called "dirty highs." He pointed to the synoptic (hemispheric) scale weather patterns, pointing to the ridges and troughs that tended to keep weather patterns stable over the winter months, explaining why regions often have extended periods of higher or lower than normal weather. Further, he indicated the pressure gradients (pictured as lines on a map of the height of air pressure), explaining that "the tighter the bars, the more weather." Being a careless consumer of two-dimensional weather maps, I had not realized how important that third dimension of height was in determining weather conditions: weather is not simply temperature and rainfall marching across the nation from Montana to Maine. Air, I was told, is like water, and the sky is "like an ocean" because of its waves and its properties of fluid dynamics (Field notes). The metaphor seemed useful to these workers and eventually to me. The key rule in meteorology is that "warm air rises and cold air sinks," emphasizing the three dimensional domain of the air. Further, as I was told many times, the critical fourth dimension of *time* affects weather systems.

On several occasions I was walked through the process of making a forecast, shown the information that the meteorologist examines in shaping a decision: imagining a funnel from the global meteorological community to the single forecaster on the hot seat. This information included forecast models, radar pictures, data from upper air balloons or aircraft, satellite images, and ground readings, as well as the forecast that had been distributed twelve hours previously. The amount of information was staggering, but, as in all such cases, those threatened with cognitive overload—such as air traffic controllers or medical students[15]—rely on communal heuristics, including pattern recognition skills, to determine which of these data are relevant. Forecasters have personal preferences, offices establish norms, and different weather conditions, including seasonal effects, give especial weight to particular types of data. Information is not created equally in the process of forecasting.

I began this research in January 2001 and continued until June 2002 with the exception of a convention of the National Weather Association that I attended in October 2002. The research was largely focused on the

Chicago (Romeoville, Illinois) office of the National Weather Service,[16] where I spent January 2001 until April 2002, present for three days a week for the first six months and approximately once a week for the remainder of the research. Since this time various procedures and rules have changed, but my account is based on that moment of weather service history.

The Chicago office is one of the oldest offices in the National Weather Service, dating to 1871. It once had forecast responsibility for much of the Midwest, but reorganizations that created a network of state and local offices removed this authority, leaving few more responsibilities than most other offices. But this distinguished history is important in understanding the emphasis on autonomy found in the office culture, an emphasis that has remained constant over decades. The office, once situated on the campus of the University of Chicago, is now located in a small suburb near Joliet, Illinois, but the main measurement point is situated at O'Hare Airport. Because it is assumed that most weather systems move from west to east, and often from south to north, many weather service offices are located to the southwest of large cities, as is the case in Chicago.

The Chicago office currently has the forecasting and warning responsibility for 23 counties in and around the Chicagoland metropolitan area, including Rockford and five counties in Indiana. During most of my observation, the Chicago office had a staff of twenty-four, including ten operational forecasters, an intern, three "hydrometeorological technicians" or HMTs (in charge of distributing the radio broadcast and gathering data), a science and operations officer (the SOO, pronounced Sue), a data acquisition program manager (the DAPM, "dap'm"), a public information officer or warning coordination meteorologist (the WCM, alternatively "wick'm" or "W-C-M"), a technology officer, two technicians, a port officer, a hydrologist, the Meteorologist-in-Charge (the MIC, "M-I-C"), and the administrative assistant (once the secretary). At the Chicago office, the administrative assistant, like most in the service, was female, as was the intern and the port officer. The others, including all the forecasters, were male. The two technicians and one of the lead forecasters were African American. The Chicago office is fairly representative of the National Weather Service in being dominated by white males, particularly in the higher status positions. The NWS does emphasize diversity, rhetorically and, as best I could tell, sincerely, but the combination of the job market, the stresses of shift work, and the image of who constitutes a proper meteorologist contribute to hiring patterns.

The other two offices at which I observed were similar: one had two female forecasters and the other had a Hispanic male forecaster, but diversity was limited in those (less urban) settings. Each of these offices

had approximately the same number of employees in approximately the same job classifications. The Belvedere office was located in a rural area between the two moderately large cities that constituted their CWA (or County Warning Area). Belvedere is an established office and, like the Chicago office, once had responsibility for its state until the NWS created a network of offices with more compact areas of responsibility. The Belvedere office was established in the 1970s at the time that the National Weather Service decided to organize forecast offices by state. Forecasts for its area had once been issued by the Chicago office, but over three decades, Belvedere and other state offices became treated as older offices, even if they lacked all of the sense of tradition (and entitlement) of the Chicago office.

The Flowerland office, in contrast, was a spin-up office, established in the mid-1990s, part of the move toward decentralization. In contrast to Chicago and Belvedere, most of the lead forecasters were relatively young. The office did not have the same level of tradition, or as strong a culture, as the two other offices. I observed at the Belvedere and Flowerland offices ten days each, getting to know their routines, comparing and contrasting their practices and culture with that in Chicago.

National Weather Service local offices operate 24/7/365. In normal circumstances, at least two forecasters will be on duty in the office, although occasionally only a single meteorologist was present. Of course, no matter how energetic an observer, I could not hope to be a constant presence. However, in Chicago I observed two midnight shifts and at various points in the research observed every hour of the day and night. I came to be a fixture at the Chicago office, invited to parties and other outings. This was not as true in the other offices, where I was welcomed and instructed, but remained marginal.

In addition to these three offices, I also visited two National Weather Service centers. In order to explore decision making under pressure I spent two weeks at the Storm Prediction Center in Norman, Oklahoma, that shares space with the National Severe Storms Laboratory, a research center that is not part of the National Weather Service. Both organizations are affiliated with the prestigious meteorology department at the University of Oklahoma.[17] Like the local offices, the SPC is a small organization with a staff of approximately three dozen, mostly males. At the time I visited there were no female forecasters and one African American.

Like local offices, the Storm Prediction Center is a 24/7/365 operation, but with the mandate of putting out watches for severe weather, primarily for tornadoes and severe thunderstorms.[18] The SPC is particularly active from spring to fall with less activity in the winter months.

While the SPC ostensibly covers the entire continental United States, most tornadoes occur in the Midwest ("Tornado Alley") and throughout the Southeast.

While the tracks of large-scale weather events, such as hurricanes and major snowstorms, can be predicted with some measure of confidence, the advent of smaller-scale events, like tornadoes, are more problematic.[19] It was only in 1948 that the first warning was issued for a tornado that miraculously hit Tinker Air Force Base outside of Oklahoma City, Oklahoma, just as predicted.[20] For many years government forecasters were forbidden to use the word "tornado," for fear that it might create panic, placing it in a euphemistic netherworld with such linguistically problematic terms as "cancer" and "pregnancy." The first severe weather unit was established in 1952 and became the Severe Local Storms Warning Service the following year. In 1997, the office moved to Norman, Oklahoma, changing its name to the Storm Prediction Center.[21]

During my research I learned that it was not only observed data that allowed forecasters to make predictions, but "models." These models are extensive and elaborated sets of equations, based on theoretical assumptions about the nature of weather systems. They constitute the theory through which data are made available for forecasters to create predictions. Because weather systems are vastly complex and because meteorological theories are imprecise, these models are imperfect estimators. Weather is a chaotic system that is unlikely to be perfectly modeled. Models are expert systems, created by those with the authority to know, but with inexact information.[22] The importance of models to operational forecasting led me to spend five days at the Environmental Modelling Center (EMC) in Camp Springs, Maryland, and at the Hydrometeorological Prediction Center in the same building, the center that forecasts significant precipitation.

I conducted face-to-face taped interviews at each of these locations. These interviews lasted from one to three hours and were bolstered with extensive discussions throughout the year. I interviewed eighteen employees at the Chicago office, including all the forecasters and meteorological technicians. This was supplemented by two interviews at Belvedere and two interviews at Flowerland. I also conducted three briefer interviews at the Storm Prediction Center and four at the Environmental Modeling Center.

I attended a four-day conference of the National Weather Association in Fort Worth, Texas. In contrast to the more academic American Meteorological Society, the NWA is a mix of academics, mostly those

focused on descriptive meteorology, government forecasters, meteorologists working for private concerns, and broadcast meteorologists. The NWA split from the AMS in the mid-1970s, feeling that the AMS had little interest in issues of "operational meteorology." I also read several meteorology textbooks (beginning appropriately with *Weather for Dummies*[23]) and a large number of magazines and journals devoted to weather (notably *Weatherwise,* a bimonthly aimed at weather enthusiasts with a circulation of about 20,000, and the *Bulletin of the American Meteorological Society*), as well as more academic articles that touched on issues connected to the sociology of prediction or the history of meteorology.

As noted in the preface, I was welcomed in the meteorological community with considerable warmth. Weather forecasters, like those in many other occupations, feel underappreciated. Meteorologists, lawyers, cooks, butlers, butchers, police, politicians, and sanitation workers feel with some justice that their publics do not appreciate the conditions and constraints under which they labor, and this vexation provides an opening for ethnographers; observers are to be shown the "truth" of their plight. They wish us to describe their virtues and commitment. We do not always do as our informants wish, but this is their hope.

In this research I was informed: "You know the weather service is filled with weirdos," "you know we're all crazy," "it's a good thing you're not a psychologist," "have you found anyone who is certifiable?" "have you found out we're a bunch of sociopaths?" and a reference to "the madness of meteorology" (Field notes). Over the course of three decades, examining eight research sites, I have learned that one commonality among groups is the half-jocular claim of "insanity." I have playfully termed this *Fine's Law of Shared Madness*. These informants do not literally mean that they are mad but that they share subcultural eccentricities that those outside of their domain do not appreciate. Here, too, workers made the claim that the public assessments of their work and how this work should be done was at odds with their informal practices, necessary because of constraints and from a desire to have emotionally satisfying employment, a point emphasized by Everett Hughes, that pioneer in the sociology of work.[24]

With few exceptions I was accepted readily, not only in the attempt to teach me the business. One meteorologist asked me to complete a weather map for him, drawing lines between points of common pressure and similar dewpoints. Another permitted me to "play" on his computer when he wasn't busy. Once after I made a presentation to the Chicago chapter of American Meteorological Society, several forecasters brought

in a cake with icing that read "Gary Just Fine." I was touched. I was also the subject of joking, both in my presence and absence. At times the forecasters claimed to arrange severe weather for my benefit. At one point they laughed that whenever I showed up, severe weather vanished—an outcome that caused mixed feelings as severe weather was emotionally enriching in contrast to mundane tasks.

Only occasionally were indications of (joking) suspicion evident, mostly at Belvedere and Flowerland, where, when I was taking notes, forecasters commented that "He's working for General Kelly [then head of the weather service]. Make him a double agent," or "Are you still spying on us?"[25] I suppose that there was some truth here, in that as a result of my presentation at the Chicago chapter of the American Meteorological Society, I was invited to present my thoughts at a Corporate Board meeting of the NWS in Washington. I accepted with some trepidation, but the invitation was made after my research was completed at the local offices and at the Storm Prediction Center, and during my research week at the modeling center. This lecture, and its outcome, with the talk shared with every science officer at each local office, proved helpful for establishing my credentials.

At various times I was tested, mostly in regard to shift work. Would I observe midnights? I did—twice—but these men had to do seven midnight shifts in sequence, an emotional and physiological strain. As one forecaster put it: "You have to work seven days on mids, and then we'll take you seriously. Unless you do, you're just passing through . . . Then we know you are worth keeping" (Field notes). He even attempted to entice me with the revelation that on their last night they have dancing girls and beer. However, his skepticism was just; I was only passing through. But they were kind enough to accept a tourist.

The History and Memory of Weather

Because of its impact on human activity, weather has long been part of human interest and social discourse. Animals of all species respond to weather conditions, and humans are no different. It is estimated that 90 percent of the American public check weather forecasts on a daily basis.[26]

Aristotle[27] is perhaps the first great weather analyst in his essay "Meteorologica," but he was surely not the first to speculate about the skies. By the eighteenth century, it was a common pastime for European and American amateur scientists (notably Thomas Jefferson) to inscribe weather conditions in diaries. Famed English naturalist Gilbert White kept detailed

weather records for the village of Selborne for four decades.[28] Discussion abounded about the origins of meteorological phenomena, clouds among them.[29]

However, it soon became evident that the study of weather is not something an individual, no matter how conscientious, could do in isolation. Although meteorology is an observational science (only rarely experimental), it is a networked science. Much of the essential work, particularly in predicting weather, requires a network of observers. During the nineteenth century, proposals were advanced to map the movement of weather systems systematically. In the United States this mapping occurred under the auspices of the newly established Smithsonian Institution.[30]

Eventually, in 1870, the federal government created a national reporting system under the Army Signal Corps, an organization with observers already spread across the nation,[31] recognizing the linkage of technology with the military. Weather forecasting subsequently moved from the Department of War to the Department of Agriculture and more recently to the Department of Commerce, nicely indicating the changing importance of forecasting to various institutional spheres—defense, agriculture, and industry. The National Weather Service is one of the most visible government agency and one of the most respected, used by President Bush as a model of how government agencies should work. Currently the National Weather Service (formerly the U.S. Weather Bureau) is a part of the National Oceanic and Atmospheric Administration (NOAA).[32] Revealing continuity with its earliest institutional formulation, the NWS head is a retired Air Force general as was his predecessor (the head of NOAA during this period was an admiral). These leaders are felt to have superior management and organizational skills, but they are always called "General" or "Admiral," underlining their military connections. A considerable number of meteorologists had once been forecasters in the armed services.

The National Weather Service employs approximately 4,800 workers, including 2,400 meteorologists, located in 122 local offices, 13 river forecast centers and 9 national centers, including the Tropical (Hurricane) Prediction Center in Miami, the Storm Prediction Center in Norman, Oklahoma, and the Aviation Weather Center in Kansas City. The 2004 operating budget of the agency was $824 million. Over the course of a year, local offices issue approximately 50,000 weather warnings.[33]

The organization changed dramatically in the mid-1990s. Before that time, each state had a forecast office with several smaller offices to gather information and to warn of local severe weather. In the change

the weather service established a network of offices serving comparable geographical areas, organized by county (the CWA or County Warning Area). As a result, the number of offices issuing forecasts more than doubled, leading to considerable hiring. These new offices were termed "spin-up" or "start-up" offices, and the older offices, such as Chicago, resentful at being "spun-down," often assumed that these forecasters were not as experienced (surely true) and less competent (more doubtful). While changes in technology, including the role of computers for data analysis and word processing, decreased the size of the organization, the new offices provided for additional staff.

This constitutes a brief version of the institutional history of weather forecasting. As Diane Vaughan emphasizes in her analysis of the National Aeronautics and Space Administration, *The Challenger Launch Decision,* organizations exist *in* history, embedded in institutional environments, and they exist *as* history, products of accumulated experiences.[34] I was impressed when forecasters recalled particular meteorological happenings, referring to them casually by the date that they occurred.[35] Weather records become important in typifying events, but the events themselves are significant as pegs for collective memory:

> Don notes that today is March 27, and he comments to Vic: "Eleven years ago we were issuing tornado warnings. It was just about now [3:30 p.m.] that a tornado warning was going out for southern Cook County, Lamont." (Field notes)
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> I was observing on a February day in which a sharp drop in temperature occurred (from 55 degrees to 38 degrees). Don started talking about April 6, 1972, telling us that the temperature dropped from 80 degrees to 19 degrees over thirty-six hours with five inches of snow. Don adds, "My wife would say, 'though he remembers those things, but he forgets his car keys.' I say I used up all my memory. There's little left." (Field notes)
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> At the SPC a forecaster tells me on April 27, 2002, "The Tulsa tornado was like this. Very late to clear out, and then F4." Another adds, "We still think about April 8, 1999, May 4, 1999. This could be a day like that. This is a big day. We've got four or five supercells just where we want them." The first forecaster says that there may be tornado watches until 7:00 a.m. the next

> morning, and he mentions a killer tornado in Cincinnati at 5:30 a.m. in 1999. (Field notes)

The importance of such recall was emphasized by one forecaster who recounted a tornado from fifty years previous, comparing it to the current situation. His point was that "no one saw [the earlier one] coming," and he wanted to make sure that this didn't happen again.[36] These are instances of occupational collective memory, a form of socially shared cognition,[37]common to all work communities. They belong both to individuals and to groups. Together the *office remembers* a wide range of events, and these events serve as benchmarks for judging current events by what had occurred previously. These memories justify the occupational claims of intuitive knowledge, separating these workers from those for whom weather is but a passing fancy.

Even though it flies in the face of formal scientific analysis, there is a strong belief in the importance of pattern recognition, particularly among older forecasters.[38] The emphasis on pattern recognition transforms meteorology into something akin to art, a personalistic and elusive process of interpretation, a domain of authenticity that is beyond the abilities or even understanding of outsiders. As geographer Mark Monmonier recounts in his incisive *Air Apparent:* "A storm's origins and subsequent movement could reveal its destination, but because weather is quirky, the forecaster remained alert for a sudden acceleration or shift in direction. This strategy worked much of the time, and what he learned from one storm, he filed away in mind and map to help predict others."[39] Attempts at *weather typing,*[40] creating a catalog of storm patterns, have been less than totally successful in that storms do not recreate their predecessors. The importance of microclimates and the chaos embedded in the system militates against rule-based knowledge. Thus, an informal system grounded on experience, incorporating the nuances of the atmosphere, is thought to improve forecasting over formal processes. Moreover, the emphasis on experience and pattern recognition provides forecasters with autonomy, carved from the domain of machines and models. This creates control over uncertainty, while simultaneously providing older forecasters with interpersonal authority. For example, one forecaster in Chicago contrasted the experience in his office with the absence of knowledge he saw in the newer, spin-up offices: "You don't have people who have been there 25, 30 years, who have seen everything. You have a lot of people who have been out for three to five years. You need more rules. We've had the experience in forecasting." "Seeing everything" is critical to meteorological authority. Said another, "That's

why [the Flowerland office] is so wacky. They don't have the experience." (Field notes). As Neil Stuart, a workshop speaker at the National Weather Association meeting, asserted: "Use your own knowledge of past events. That's an important part of forecasting. That's part of pattern recognition" (Field notes). Another forecaster suggested that traditional career mobility in the National Weather Service requiring one to move from office to office to be promoted was counterproductive in preventing forecasters from gaining experience-based authentic knowledge of local weather.

These claims of intuitive knowledge, linked to group interaction, belong not only to the domain of meteorology, but to much scientific work and to other occupations that claim specialized knowledge. Memory and experience are central to the process by which scientific predictions are created. Both the organization and individual workers are embedded in history. Organizational forms—here the collective responsibility for forecasting and the creation of new spin-up offices—can either contribute to collective memory or retard it.

The Plan of the Book

As one focuses on any solid subject, it rapidly dissolves into a mosaic. Topics overlay each other like fish scales. Even with a focus—how small-group life affects work practices, occupational identity, and organizational culture—issues emerge that expand one's focus.

To select a single theme, not perfectly descriptive, I claim to examine the *production of the future.* By this I emphasize that the special domain of the weather *forecaster* is to *predict* what will happen in the future, establishing and drawing on the past, and then to communicate with a public so that others can act on these predictions. Forecasters focus not on the present or the past, but claim that they see the future. This future can only be known because of the establishment of what has gone before. The production of the future depends on the production of the past and present. In this weather forecasters share a prospective orientation with physicians, stock market analysts, political pollsters, tipsters, policymakers, commodity brokers, currency traders, economists, military strategists, acquisitions editors, fortune tellers, and parents. They think of themselves not as men and women of the here and now, but of the later, and this shapes how they interpret what they do and who they are, even if the later depends on what has been made of the here and now. In the case of weather forecasters, later may be a few minutes or days away (a close future), but it is a future on which people rely. Each chapter, but

especially the third, addresses the problem of how to announce what is not here yet in light of what is and has been happening.

I set the stage by examining the practices of meteorological life. Chapter 1, "On the Floor," starts from the analysis of worklife to describe how forecasts are produced in real time. I examine the constraints of life in a meteorological office, both its routines and the emotional and temporal intensity when severe weather threatens. Because of the possibility of destructive weather, meteorology is a 24/7/365 occupation, placing enormous strain on workers, while investing them with authority. Their work entails keeping records of the past and communicating present conditions, but this is transformed into advice for the future.

The second chapter, "A Cult of 'Science,'" explores the *routine accomplishments* of these college graduates. Meteorology is classified as a "science," but what does this mean? It is, for the most part, not an experimental science, even in university settings, but it is more than descriptive in its prospective orientation. Meteorology is theoretical in that the creation of models is a professional goal. Yet, the practice involves generating predictions on the basis of current theory.

Science is at the heart of occupational identity within this government bureaucracy. Is the work scientific, not in an objective sense, but in terms of identity management and professional ideology? The concept of *scientist* is an honorific, and there is a push to claim that mantle. Yet, simultaneously these workers have culturally derived ideas about what science consists of,[41] and many are uncertain that this is what they do. Further, they are members of a discipline in which there are collective professional stakes, including authority, resources, and jobs. As a result, forecasters are ambivalent about whether they are scientists. The attitudes to science are also revealed in the ambivalence toward technology and equipment. Does the material inscription of the world provide autonomy or remove it? If machines have agency, as some claim, how do workers adjust to this reality? Can technology provide the authenticity that is central to the creation of a modern self?

In addition to belonging to an occupation, these workers are also members of small groups that like all groups develop a microculture or idioculture.[42] Offices are social systems with robust cultures—as experiments in the cultural organization of scientific practice and culture. They reflect the fact that all structure and culture are tied to local conditions: a sociology of localism.

In the third chapter, "Futurework," I explore the production of the future. How do meteorologists create forecasts to contain uncertainty? Meteorologists rely on gathered data in conjunction with models that

provide a theoretical infrastructure. This affects the data to be collected. But if this was all that was necessary, forecasters would not be needed, so humans carve out a domain of personal expertise, selecting among alternate models, doubting the adequacy of data, and then adding their own experience. Armed with data, theory and experience, the organization provides legitimacy that is crucial for the presentation of these public predictions. Meteorologists, like other *future workers,* are authorized to predict by their sponsors. They are mandated to colonize the future.

Occupational autonomy, a frequent theme of those who examine work, is tied to organizational and group dynamics. Meteorologists wish to feel that they are constructing the forecast as authored. During my research, a period of intense technological change in the creation of forecasts, much of their autonomy involved control over language. I title chapter 4 "Writing on the Winds." Writing involves professional impression management and serves as the point of contact between forecasters and their publics. While I was observing, local forecasters faced major changes in work practices, threatening their identity, or so they felt. Headquarters was instituting a computerized forecast system, a system that largely removed the authority for writing a forecast from meteorologists. This change, allegedly providing workers with more time for meteorological analysis, caused great concern. Who has the authority to determine how weather is to be communicated? How is autonomy structured? How does this affect forms of coordination among forecasters and offices? I examine the literary battles of meteorologists, both as they were played out in the National Weather Service and as they were played out in particular offices as the culture of writing was being negotiated.

The fifth chapter, "Ground Truth," analyzes the organizational problem of scientific truth, tied again to the dynamics of group culture. The creation of models of truth has been emphasized in science studies, notably in Steven Shapin's *A Social History of Truth*.[43] But Shapin's analysis is fundamentally normative, examining the rules of truth-telling as set by society. In contrast, I treat verification as an interactional achievement. Forecasters make claims about what the future will bring, but these claims need to be accepted by others.

On what basis do we claim accuracy, how is this linked to our claims of authentic knowledge, and what are the practical issues in making these assessments? How correct must a forecast be? What is the line between right and wrong?[44] If a forecaster claims a 30 percent chance of rain, is the claim correct if it rains or if it doesn't? Does a high temperature of 52 justify the forecast, if the predicted high was 54? 60? 70?

Does a prediction of five inches of snow count, if eight inches fall? Verification is central to organizational control and the personal identity of meteorologists, but it is also a cultural phenomenon. As a government agency, the NWS feels a powerful push toward accountability. It must develop techniques that allow workers to evaluate how well they are doing, but these techniques are collective choices. Weather forecasts are responsive to group concerns; they are social constructions. This does not mean that forecasts are random—hardly so—but that they are tied to how particular communities define competence.

The sixth chapter, "A Public Science," addresses the reality that meteorologists have multiple audiences to satisfy and from which they want esteem. I use the label *public science* to refer to domains of scientific practice, like meteorology, that operate within the public sphere and with a primarily public audience. As members of the meteorologist's public, even if their assessments are translated and tweaked by the media, we rely upon their forecasts, and complain bitterly or drily when we feel that they have got it wrong. That these workers are tied to an organization, embedded in a governmental structure, affects prediction. Further, the system of media, commerce, and public interest suggests that each audience has expectations and demands. Private sources do not like government meteorologists to push too far into their domains, diverting profits and undercutting their claims of expertise. Government forecasters want to communicate to their public, but often this communication is mediated and shaped by others with their own economic and professional agendas.

The final chapter, "Weather Wise," addresses broad theoretical concerns and points to connections between this ethnographic investigation and other studies of scientific and work processes. I discuss core concepts of work, science, prediction, autonomy, truth, and public knowledge, hoping to generalize from this particular and peculiar case to other domains of science, of culture, and of work.