

EVE GRUNTFEST

WEATHER AND SOCIETY

TOWARD INTEGRATED APPROACHES



WILEY Blackwell

Weather and Society

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Eve Gruntfest

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Editorial Office

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Acknowledgments

This book began as an effort to support and amplify two ambitious efforts that were passionately dedicated to changing the way that the social sciences and atmospheric sciences collaborate to improve weather forecasting effectiveness, reduce the number of lives lost to severe weather, and to develop a cadre of hybrid socio-meteorologists. The two main efforts toward these goals were the WAS*IS movement (Weather and Society * Integrated Studies) and the SSWIM or Social Science Woven into Meteorology program. When funding for both of these programs ended and I faced the prospect that this textbook would need to be historical and not totally optimistic, progress on this book slowed. The book retains a cautiously optimistic tone even though a close examination in 2017 reveals that atmospheric scientists, without a clear understanding of or appreciation for social science, are doing most of the talking at the intersection of weather and society and there are only a handful of examples of woven collaborations between atmospheric scientists and social scientists.

My graduate school mentor and advisor, Dr. Gilbert F. White, inspired me. Gilbert's brilliance had powerful policy implications for natural hazard mitigation at the local, state, federal, and international levels, and his tireless persistent dedication to bringing all stakeholders, researchers, and students together for decision making kept me focused on getting this book finished. I began my career studying the behavior of people during the 1976 Big Thompson flood in Colorado (Gruntfest, 1977) and the flash flood research led to a broader passion for understanding flash floods and warnings nationally and internationally (Gruntfest and Handmer, 2001). Forty years later, I am still highly motivated and engaged with ways to improve flash flood warnings.

Completing this book required lots of help. I appreciate the feedback and support throughout my career and in the creation of this book of Sandrine Anquetin, Rachael Ballard, Chip Benight, Julia Becker, Eric Beteille, Enrica Caporali, Francesca Carli, Kim Carsell, Julie Demuth, Gina Eosco, Micky Glantz, Neil Gordon, John Handmer, Mary Hayden, Bob Henson, Stephanie Hoekstra, Bill Hooke, David Johnston, Ilan Kelman, Matt Kelsch, Kim Klockow, Emily Laidlaw, Linda Layne, Heather Lazrus, Cedar League, Diana Liverman, Celine Lutoff, Brenda Mackie, Vinodhini Mathiyalagan, Beth Mitchneck, Burrell Montz, Rebecca Morss, Ellen Nelson, Amy Nichols, Lori Peek, Brenda Philips, Andrea Ray, Valerie Ritterbusch, Paola Salio, Celeste Saulo, Lucy Sayer, Fiona Seymour, Andrea Schumacher, Russ Schumacher, Hatim Sharif, Marshall Shepherd, Bill Siembieda, Priya Subbrayal, Bella Talbot and Molly Wingate. My dearest friends, Sarah Christensen, Fanette Pollack, Andrea Herrera, Karen Breunig Hine, Claire Sheridan, and Marc Weber, relentlessly encouraged me to finish this project.

The book is dedicated to the formal and informal WAS*ISers who continue to attempt to weave social science into the fabric of the weather enterprise. I hope this book provides a jumping off point for additions and modifications by new brave generation of scholars, practitioners and charismatic policy entrepreneurs including Simone Balog, Kenny Blumenfeld, Dereka Carroll-Smith, Julia Chasco, Renee Curry, Greg Dobson, Tanja Fransen, Jen Henderson, Eric Holthaus, Rebecca Jennings, Aisha Owusu, Amber Silver Nelson, Daniel Nietfeld, Justin Nobel, Vahid Rahmani, Isabelle Ruin, Jason Samenow, Jen Spinney, Galetia Terti, Chris Uejio, and Charlie Woodrum. These scholars and others are tirelessly leading efforts to integrate social science into atmospheric science, despite limited formal credit for this work from their employers or advisors.

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- Gruntfest, E and J Handmer (eds) (2001) *Coping With Flash Floods* Kluwer

Preface

This textbook is the culmination of four decades of collaborations to meet the challenges of natural hazard mitigation. My own contributions came from the social science and societal impacts perspectives. I hope the publication of this book formally marks the end of the era of social science as merely an “add-on” to meteorology.

Until 2005, my expectations for genuine integration of social science into meteorological research and practice were low. I was content to know that at least the words “social science” or “societal impacts” were being considered. I was pleased to be invited to workshops, conferences, short courses, and meetings to be a social conscience. When the presentations went over well, I would be invited back for a similar presentation the following year. Meteorologists would agree that someone should do the social science related to meteorology but no one in particular was volunteering.

I gave dozens of invited talks all over the world. The talks were usually scheduled at the end of a session or a course. While societal impacts and the “so what” part of forecasting and new technologies were acknowledged, the commitment to addressing more than the physical science and engineering was superficial. There was no funding or actual integration of social scientists on research teams. My presentations were not an integrated part of larger research and practice for the physical scientists and engineers in the classes. I always happily fulfilled my role as an add-on social scientist to whatever was the main course, workshop, or conference topic. An egregious example was when I was invited to Germany to provide societal impacts dimensions to the 10-year Mescoscale Alpine Programme (<http://www.map.meteoswiss.ch/>). Only after a decade of

research did the team invite in a few social scientists to provide the “so what” part of the massive experiment. Looking back on my career, preparing to retire from my position as a geography professor, I recognized that, as an add-on social scientist, my work had not made changes in how atmosphere science was being conducted.

Now my expectations for the integration of atmospheric science and the social sciences are higher. The roots of WAS *IS and this textbook can be traced to visiting scientist opportunities I had to work with atmospheric science teams at the National Center for Atmospheric Research (NCAR) and at the Cooperative Institute for Research in the Atmosphere at Colorado State University in Fort Collins, Colorado in the 1990s and early 2000s. I picked up some of their language and concerns of atmospheric scientists that led to grant writing collaborations. In 2012 and 2013, I was invited to serve as a program officer at the National Science Foundation in the Atmospheric and Geospace Division of the Geosciences Directorate. That appointment is one demonstrable piece of evidence among many that there has been movement for the atmospheric sciences to formally appreciate what a social scientist can offer.

So it is with this renewed encouragement that this book lays some groundwork for further integration of social science with atmospheric science. This is just a beginning. Once these two kinds of scientists learn to truly work together, then the real business can begin of more accurately and effectively explaining weather events so that people can respond appropriately and in time.

1

The Need for Integrated Approaches to Weather and Society

1.1 Rationale for This Book

What do you do when you see a weather alert—SEVERE WEATHER EXPECTED? If you are a driver or a passenger in a car, do you pay any attention? Do you change your behavior or do you keep moving forward without any change in your plans? Does your answer depend on where you are heading or how pressing your obligations are? If the alert specifically mentioned icy conditions ahead or wet roadways, would that information be more useful? Would you seek additional weather information? If so, where would you get that information?

Every day and everywhere, people talk about and deal with the weather. They consider the forecasts and the potential weather impacts. The discussions and actions are often place-specific and revolve around what is normal or abnormal for a particular place or region. Conversations about weather range from appreciation of the mild conditions that foster the enjoyment of outside activities to awe and sadness about catastrophic impacts of tornadoes, hurricanes, droughts, and floods. But the question of how to best educate and inform people about weather impacts remains. Some recent weather books for a more general audience that take on this challenge include *The Weather Machine* by Andrew Blum (2017), *Thunder and Lightning: Weather Past, Present, Future* by Lauren Redniss (2015), *The Weather of the Future Heat Waves, Extreme Storms, and Other Scenes from a Climate-Changed Planet* by Dr. Heidi Cullen (2010), and *Weather on the Air: A History of Broadcast Meteorology* by Robert Henson (2010b).

“Extreme weather is costly. From 2008 to 2013, alone, the price tag of extreme weather events in the U.S was \$309 billion. These costs are soaring even as forecasts improve” (Samenow, 2015a,b). Perhaps the most impressive gains in accurately predicting severe weather have been in hurricane forecasting. In the 1980s when the National Hurricane Center tried to predict where a hurricane would hit three days in advance of landfall, it missed by an average of 350 miles. If Hurricane Isaac, which made its unpredictable path through the Gulf of Mexico in August 2012, had occurred in the late 1980s, the center might have projected landfall anywhere from Houston to Tallahassee, canceling thousands of business deals, flights and picnics in between—and damaging the reputation of the National Hurricane Center when the hurricane zeroed in hundreds of miles away. By 2012 the average miss was only about 100 miles (Silver, 2012).

However, even with more accurate predictions, there are severe events that seem to surprise people. More than two feet of rain caused extreme flooding of Baton Rouge, LA in August 2016. The flood killed 13 people, displaced tens of thousands of others, caused an estimated \$8.7 billion in damage and destroyed 60,000 houses. More than 73,000 households across 20 parishes were approved for Federal Emergency Management Agency aid for the flooding that is considered to have 1000-year recurrence interval. Linking this extreme event and others to human caused climate change is a lively discussion (Ball, 2016; Mooney, 2016). Should these extreme floods have “names” to help forecasters inform the public about their unusual severity (Shepherd, 2016a; Schroeder *et al.*, 2016)?

Some people have an intense interest in weather details. People who are planning an outside wedding on a particular June day, or who are planning a winter vacation to Florida, or, who are farmers worried how “hard” a predicted freeze will be and its potential impact on their orange groves are particularly weather-aware. Many, but not all, people have a serious, deep interest in weather and meteorological phenomena and they pay close attention to forecasts, warnings, and their own experience.

People use official forecasts from meteorologists, observations from weather stations, and many personal idiosyncratic ways to predict and understand the weather and weather forecasts. Many people rely on environmental cues to tell them whether a storm is coming or if the rainstorm will produce flooding. Some rely on sophisticated scientific and technological tools. Others rely on a combination of sources including low and high technology data.

Some people have little confidence in official forecasts, preferring to “look out the window” or rely on folk methods, “gut readings,” or previous experience. Increasingly, more people look at their phones to see radar images of storms moving across town or to listen to the latest official warning from a trusted television meteorologist or the National Weather Service (NWS). Some people consider the continuum of weather from bad to good. What is considered “good” weather? The characterization is related to season and locale. The improvements in forecasting have changed how and when people respond to a major blizzard in 2016 compared to people in 1888.

Research Spotlight Box: Forecasts are Improving Dramatically Impacts of Blizzards in the Nineteenth Century Were Devastating Compared with Impacts in 2016

Imagine that you were a farmer in the Northern Great Plains of the United States on January 12, 1888. You were out in the fields feeding your cattle and then you were getting your children ready for school. The weather was mild. In the afternoon, as school was letting out, the temperature dropped 30 degrees and a major blizzard caused blinding snow and cold winds. More than 100 children died on their way home because they were unprepared for the severe snowstorm that occurred (Laskin, 2004). There were no forecasts of that storm that has been named the “Children’s Blizzard.” More than a total of 500 people were killed as a result of that “surprise” storm. There were no “means of monitoring the upper atmosphere, no satellites, no radar, no wireless communications with ships at sea, and no computer models for forecasting the weather” (Moran, 2012:2).

Flash forward to 2017. Forecasts of any major blizzard are made days in advance. As a storm gets closer the forecasts become more precise with probabilities of certain amounts of snow or high wind speeds. Satellites, that orbit the earth continuously, monitor a storm’s developing movements, radar locates snow bands sweeping onshore and observational data from the surface and upper atmosphere feed into sophisticated numerical weather forecast models running on supercomputers. Winter storm watches and warnings are issued by the National Weather Service (NWS). Some schools announce snow days before the first snowflake falls. People go to supermarkets to stock up on bread, water and batteries. National Oceanic and Atmospheric

Administration's (NOAA's) *four-day* predictions for hurricane track have become as reliable as our two-day predictions were prior to 1995. In 2015, *five-day* temperature forecasts have the same level of accuracy that *three-day* forecasts had 20 years ago. NWS tornado warning lead times have more than doubled over the past two decades, to an average of 13 minutes (Sullivan, 2013:6).

Unlike 100 years ago, school superintendents use many resources, including local social networks, official government websites, private meteorologists, webcams and other resources to help support their decisions of whether to keep schools open or to close early because of existing or predicted “severe” weather. Recent research efforts summarize the various information sources leaders of school districts use. Their decisions have enormous consequences for public safety (Balog, 2013; Call and Coleman, 2012; Hoekstra, 2012; Montz *et al.*, 2014).

In 2017, many atmospheric scientists with classical training in meteorology recognize that improved forecasting is not the most serious challenge to reducing losses from severe weather, the biggest challenges arise from predicting human behavior in response to these weather events or forecasts. These scientists appreciate that the severity of weather's impact has at least as much to do with the capability of the population at-risk to reduce its own vulnerability as it does with the strength of winds, the height of a storm surge, the high temperatures, the depth of flood waters, or the strength of a tornado. A perfect flash flood warning will not affect the behavior of everyone who hears it. People are aware of the risks of driving across flooded roads and know there are warnings in effect but sometimes they HAVE to get somewhere—to work or to pick up the kids. Or, maybe they want to test whether their truck can successfully forge flooded roads (League, 2009; Ruin, 2008). Social scientists can help assure that the forecasts reach the vulnerable people and increase the likelihood that vulnerable people take the appropriate actions in the time they have before the severe weather impact. “An excellent weather forecast, if not properly communicated and acted upon, is of practically no value” (Samenow, 2015a).

This book is the first textbook to share an understanding of how social scientists are working on weather-related problems. It is not exhaustive or comprehensive in its coverage of all the studies at the intersection of weather and society, but it is representative of the

range of scholarship that has been completed and is underway. Many new people are getting involved in this work, so there are simply too many research and operations projects to cover in one book. Also, every day presents us with more flash floods, droughts, tornadoes, or snowstorms to learn about and from.

This book provides an overview and is meant to serve as an introduction to the emerging field of socio-meteorology. It highlights historic and contemporary collaborative efforts between social scientists and meteorologists at the intersection of weather and society. This book explores the leading edge of weather research that addresses the impacts of forecasts and warnings. It is a 2018 snapshot of a quickly changing landscape where the characters are changing from primarily governmental and academic partners to a dynamic mixture of governmental agencies, academics, and private companies. This book addresses the numerous calls for widening the community at the intersection of weather and society. It provides a first exposure that can broaden academic programs in meteorology, hydrology, environmental studies, geography, natural hazards, anthropology, communication, economics, and sociology across the globe where there is a growing appreciation of more interdisciplinary and multi-disciplinary approaches to answering questions about how to reduce the negative impacts of weather. It offers an overview of the growing body of literature that tries to solve problems related to weather and society.

Weather and Society: Toward Integrated Approaches is written for anyone who wants to learn about how to think about integrating social science and atmospheric science. This book starts to address the needs of a growing community of people who want to learn about how the social sciences can contribute to solving problems at the intersection of weather and society. Tackling these complex problems, including reducing losses from weather events, calls for interdisciplinary cooperation and multi-disciplinary approaches. In 2014, the American Meteorological Society (AMS) Board on Societal Impacts adopted a professional guidance statement aimed at strengthening social sciences in the weather-climate enterprise (<http://www2.ametsoc.org/stac/index.cfm/boards/board-on-societal-impacts/>).

Providing the groundwork for new ways for meteorologists and others to approach their own disciplinary and interdisciplinary challenges, this textbook complements courses offered by various professional societies and professional associations including the National Hydrologic Warning Council (www.hydrologicwarning.org),

the American Meteorological Society (www.ametsoc.org), the Association of State Floodplain Managers (www.floods.org), the International Association of Emergency Managers (www.iaem.com), COMET (www.comet.ucar.edu), and other professional groups that have online and in-person certification courses. All of these groups are seeking ways to incorporate lessons from social science to improve warnings, interagency communication, interdisciplinary partnerships, public and private relationships, and others.

Meteorology textbooks cover a wide range of atmospheric physics principles and applications. They do not emphasize societal impacts of weather or results of social science research studies related to weather. They often use case studies of extreme historical events with an emphasis on the meteorological characteristics such as wind speeds, amount of precipitation, or hail size, but atmospheric science textbooks do not include chapters on how people are affected by the weather or how research by social scientists can reduce vulnerability to severe weather or increase understanding of weather forecasts.

What people do when facing severe weather or when warnings are issued is a central topic of this book. This book provides various considerations of how the NWS is changing the ways its forecasts and warning products are issued to respond to the weather information needs of decision makers including school administrators, emergency managers, ranchers, transportation departments, and others. The discussion of “warnings” in traditional meteorology textbooks covers the products issued by the NWS and mentions briefly the recommended public behavior that the warnings should influence, but there is no impacts section, social science, or societal impacts section (Moran, 2012).

Weather and Society: Toward Integrated Approaches starts with the ways social scientists and others are learning about how people behave in severe weather. This book takes a 30,000-foot or 10,000-foot view of the issues at the intersection of weather and society. It provides a big picture of the societal impacts of weather and how social scientists can and do collaborate with meteorologists to address weather challenges that require combined atmospheric and societal approaches. It is written for an audience that recognizes the importance of bringing the applied aspects, or the “so what” factors, together with the more physical science of forecasts.

This book builds on the growing recognition from academia, government, the private sector, and the non-governmental sector that when meteorologists and social scientists work together, they provide results

and products that are greater than the sum of their individual parts. Many early career physical and social scientists and engineers interested in weather seek to learn about concepts, tools, questions, and policies related to more than one discipline, but most academic departments, especially in meteorology and hydrology, are too narrow to allow much leeway for electives outside of their narrowly defined discipline.

Since 2000 the integrated atmospheric-social science community has relied on informal social media networks that have risen in popularity and proved their usefulness. As of 2018, these social networks include Facebook, Twitter, NWS chats, and blogs as the main sources of data and information, since more standard, classical sources tend to remain quite narrow in their uni-dimensional or uni-disciplinary approaches. It is time for a more formal and organized approach.

This book includes new perspectives from a wide variety of specialties that are taking into account the societal impacts of weather and developing new ways of thinking about forecast verification. It means stepping into new points of view and being open minded to new ways of seeing weather and its impacts. It presents ideas that are being developed by a community of scholars and practitioners dedicated to changing the stove-piped culture of current scientific disciplines. This community is devoted to new problem-solving approaches and is willing to take the time necessary to learn the languages and perspectives of people from different backgrounds and disciplines. This book uses case studies to highlight the complexity and multi-dimensional aspects of some of the most pressing problems at the intersection of weather and society. The book shows how different social scientists have framed and represented their integrated work. Using many figures from recent publications and presentations provides the “look and feel” of how integrated work is conducted and reported.

Weather and Society: Toward Integrated Approaches has seven main goals:

- 1) To create an environment where scientists and teachers can develop materials for stand-alone meteorology or weather-society courses or to supplement current materials with a social science dimension;
- 2) To provide the groundwork for conducting interdisciplinary work by learning new strategies and addressing typical challenges;
- 3) To expose the readers to various social sciences, the methods they use, and the ways they share their data;