

STRONGER CLIMATE RESILIENCE WITH INSURANCE

ROBERT ERHARDT, JESSE BELL, BRIAN BLANTON, FRANK NUTTER, MEGAN ROBINSON, AND RICHARD SMITH

On the connection between climate change and insurance, Evan Mills wrote in *Science* that “insurance is a form of adaptive capacity” (Mills 2005). Well-functioning insurance markets price risk appropriately, and thereby encourage risk reduction. And so, a natural question to ask is this: to what extent can the insurance industry further promote climate adaptation? To address this question, researchers representing the climate science, insurance, and climate adaptation communities gathered at the Nexus of Climate Data, Insurance, and Adaptive Capacity, in November 2018. The goal was to look specifically at the intersection of these three research communities and identify new research paths for how insurance can lead to greater climate change adaptation.

The concept for the workshop grew out of the one-year research program on the Mathematical and Statistical Methods for Climate and Earth System organized in 2017–18 by the Statistical and Applied

THE NEXUS OF CLIMATE DATA, INSURANCE, AND ADAPTIVE CAPACITY

WHAT: Fifty-seven active researchers from climate science, insurance and reinsurance, and climate change adaptation discussed the intersection of these three research communities and developed actionable research paths forward for the insurance industry to lead climate adaptation.

WHEN: 8–9 November 2018

WHERE: Asheville, North Carolina

Mathematical Sciences Institute (SAMSI) in Research Triangle Park, North Carolina. Authors Erhardt, Bell, Blanton, and Smith were members of the program working group on risk and coastal hazards, which was formed to address active scientific questions in the measurement of climate risk, with particular attention to flooding. Those research discussions led to the idea of an interdisciplinary workshop exploring the connections between climate change and the ways in which the insurance industry could promote or better facilitate adaptation and resilience through well-designed insurance products and markets. The organizers added Frank Nutter, president of the Reinsurance Association of America, and Megan Robinson, chief operating officer of The Collider, a global innovation center for climate entrepreneurs in Asheville, North Carolina (<https://thecollider.org/>), to gain better perspective from the insurance and climate adaptation communities. The organizers then identified and invited prominent speakers from across the research areas in roughly equal proportion. A central consideration was to identify those who could speak to all of the varied audiences present.

AFFILIATIONS: ERHARDT—Wake Forest University, Winston-Salem, North Carolina; BELL—University of Nebraska Medical Center, Omaha, Nebraska; BLANTON—Renaissance Computing Institute, Chapel Hill, North Carolina; NUTTER—Reinsurance Association of America, Washington, D.C.; ROBINSON—The Collider, Asheville, North Carolina; SMITH—University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

CORRESPONDING AUTHOR: Robert Erhardt, erhardrj@wfu.edu

DOI:10.1175/BAMS-D-19-0073.1

A supplement to this article is available online (10.1175/BAMS-D-19-0073.2)

In final form 31 March 2019

©2019 American Meteorological Society

For information regarding reuse of this content and general copyright information, consult the [AMS Copyright Policy](#).

THE INVITED SPEAKERS. Three of the speakers were from government agencies. Derek Arndt, chief of climate monitoring at National Oceanic and Atmospheric Administration (NOAA)/National Centers for Environmental Information (NCEI), spoke about freely available sources of climate data and information and introduced the supporting role NOAA/NCEI can play. Jennifer Jurado, chief resilience officer of Broward County, Florida, described efforts to fuse scientific projections with the government approval process for flood control in Florida, going well beyond standards and maps set by the Federal Emergency Management Agency (FEMA). Finally, Adam Smith, from NOAA/NCEI, described the billion-dollar weather and climate disasters database and the increasing trends in these disasters since 1980 (www.ncdc.noaa.gov/billions/).

Five of the speakers were academics. Doug Nychka, professor of statistics at Colorado School of Mines and former institute director at the National Center for Atmospheric Research, spoke about climate model projections and their use in statistical analyses. Dan Cooley, professor of statistics at Colorado State University, spoke about the statistics of modeling extreme events as opposed to “typical” events, relying on extreme value theory with attention to paired extreme events. Mitch Roznik, graduate student in agricultural economics at the University of Manitoba, described changes to crop risk and crop insurance in Canada owing to a changing climate. Mathieu Boudreault, associate professor of actuarial science at the Université du Québec à Montréal (UQAM), described a hierarchical modeling approach that fused climate model projections, hydrology, and hydraulics models to study flood risk along a river in Canada. Finally, Jeremy Hess, associate professor of emergency medicine at the University of Washington, described estimating the human health impact of climate change with attention to health and life insurance.

Three speakers represented industry. Roy Wright, president and CEO of the Insurance Institute for Business and Home Safety, former deputy administrator of FEMA, and former director of the National Flood Insurance Program, discussed the use of regulation and building codes to encourage greater climate resilience. Raghuveer Vinukollu, natural catastrophe solutions manager at Munich Re, discussed public-private partnerships to manage flood risk. Steve Kolk, of the Casualty Actuarial Society, introduced the audience to the actuaries’ climate index and the actuaries’ climate risk index.

The workshop itself followed an established organizing strategy from SAMSI. We began with the

plenary talks and then self-selected into breakout discussion groups to address different topics raised in the talks. The chosen topics were 1) how to build a better flood map, 2) the use of climate model projections for insurance, 3) climate mitigation and adaptation, and 4) high-impact possibilities that was warmly named “What keeps you up at night?” Brief summaries of each discussion are included, with extended material on each topic available in the online supplement to this summary (see <https://doi.org/10.1175/BAMS-D-19-0073.2>).

HOW TO BUILD A BETTER FLOOD MAP.

This breakout group broadly addressed current FEMA flood maps in terms of what could be adopted from the commercial sector, including more probabilistic information on flood hazard levels under uncertain environmental conditions. Participants included academic, federal, and industry researchers, with significant input from commercial sector insurance experts. The goal was not to be critical of FEMA practices in map making but rather was more about identifying features of “next generation” flood maps that capture more of the uncertainty of living in or near the floodplain. It was also explicitly recognized that researchers and practitioners have been conducting research and extending applications along these lines, such that improvements to risk characterization vis-a-vis flood maps could be made with relatively little technical effort (as compared to the effort needed to change the federally backed insurance system). The group discussed moving beyond binary measures to probabilistic measures; incorporating land use and projected land use; moving to smoother, finer-scale maps that avoided sharp discontinuities; and how commercial insurance could be the better venue for innovation led by the private sector. These points are each described in further detail in the online supplementary material (<https://doi.org/10.1175/BAMS-D-19-0073.2>).

USE OF CLIMATE MODEL PROJECTIONS IN INSURANCE.

Climate model projections are not widely utilized within the insurance industry, the group acknowledged. Most insurance policies are sufficiently short-term that pricing does not need to consider a changing climate over the policy period. Many insurers lack the technical in-house expertise needed to work with high dimensional climate model output and avoid common misuses of these models. Some regulations, particularly those related to catastrophe models, restrict the use of simulations, projections, or other modeled products (American

Academy of Actuaries 2018). Still, the group found many reasons to view climate model projections as a valuable tool for insurers. Emanuel (2017) stated that the recent Hurricane Harvey rainfall event in Texas has a much higher estimated annual exceedance probability under future climate scenarios than under the past climate. Discussants noted that large scale extreme events like Harvey have tremendous buy-in from the industry, and so restating these risks under future climates is a valuable planning tool. Rerunning observed events under different climate scenarios could allow researchers to quantify the “fraction of attributable risk,” or the fraction of the likelihood of an event that is attributable to a specific causal factor (National Academies of Sciences, Engineering, and Medicine 2016; Lott and Stott 2016). More broadly, the group enumerated nonpricing core functions of insurers that operate on longer time scales, such that a changing climate would impact important decisions. More on this topic can be found in the online supplement (<https://doi.org/10.1175/BAMS-D-19-0073.2>).

CLIMATE MITIGATION AND ADAPTATION.

An early insight of this group was that insurers speak of mitigating losses from climate change, since they are addressing consequences of climate change, but the climate science community often terms their activity adaptation: scientist Mills (2005) termed insurance adaptive capacity, not mitigative capacity. To the climate science community, mitigation is stopping or slowing the climate change itself. This discussion on terminology extended more broadly and suggested the value of jointly authored papers across research communities. The group also spent considerable time considering the costs of action versus the costs of inaction, noting that many of the costs of inaction will ultimately be shouldered by the insurance industry. Among the four breakout discussion groups, this one also addressed most directly the unique role that reinsurance plays, owing to the massive financial resources it has available, the long-term outlook it naturally possesses, and its position as the “insurer of last resort” within private industry. (More on this group can be found in the online supplement at <https://doi.org/10.1175/BAMS-D-19-0073.1>).

WHAT KEEPS YOU UP AT NIGHT? This group was charged with identifying problems that did not fit into any standard category but that could nevertheless be very troublesome in trying to develop a comprehensive approach to climate and insurance risk. The group attracted a wide range of participants,

which immediately shed light on the challenge of translating and disseminating research results and needs across communities. The group suggested that jointly authored papers with authors spanning multiple groups were one strong remedy. Climate model projections again came up in discussion, this time regarding the mismatch in time scales and validation tools used by climate model producers with the desired time scales and validation preferred by potential users within the insurance industry. In short, climate models are produced over long time scales and validated in terms of large-spatial-scale trends, but insurers often need reliable climate projections at a much finer spatial and temporal scale. The group also discussed extreme insurance consequences arising from an interaction of several (possibly nonextreme) causes, with Mora et al. (2017) receiving attention for highlighting the combined causal effects of heat and humidity that lead to extreme heatwaves. The group was particularly interested in questions of attribution of extremes, along with appropriate risk measures for extremes from a financial risk management perspective, and some related papers discussed were Bindoff et al. (2013), Acerbi and Tasche (2002), and Artzner et al. (1999). Each of these topics, along with additional points raised, is further described in the supplement.

MOVING FORWARD. The four groups tackled different questions but came upon similar themes throughout discussion: appropriate databases, best practices, time scales, research priorities, terminology, and government regulation were universally discussed. Each community has a distinct perspective to share, but each also has an opportunity to better incorporate external perspectives into its future research development.

A major takeaway from the workshop was the broad interest in more jointly authored papers combining authors from across different research communities. Not only would this help disseminate results across communities and also clear up misunderstandings in priorities, terminology, limitations, and so forth, but these partnerships would also seed the formation of next generation tools and research. For example, scientific agencies have existing databases such as the Spatial Hazard Events and Losses Database for the United States (SHELDUS); phase 5 of the Coupled Model Intercomparison Project (CMIP5); or the NOAA/NCEI databases, and jointly authored papers can highlight current best practices and data access. But the relationships forged through joint authorship can also inform future development of

next generation data products with respect to the terminology, time scale, priority, and validation needs of this new class of end users. It is easy to imagine how jointly authored papers would lead to greater insights for every research community present at the workshop.

ACKNOWLEDGMENTS. Funding for this workshop was provided by the National Science Foundation (NSF 1824394).

REFERENCES

- Acerbi, C., and D. Tasche, 2002: Expected shortfall: A natural coherent alternative to value at risk. *Econ. Notes*, **31**, 379–388, <https://doi.org/10.1111/1468-0300.00091>.
- American Academy of Actuaries, 2018: *Use of Catastrophe Model Output*. American Academy of Actuaries, 44 pp., www.actuary.org/files/publications/Catastrophe_Modeling_Monograph_07.25.2018.pdf.
- Artzner, P., F. Delbaen, J.-M. Eber, and D. Heath, 1999: Coherent measures of risk. *Math. Fin.*, **9**, 203–228, <https://doi.org/10.1111/1467-9965.00068>.
- Bindoff, N. L., and Coauthors, 2013: Detection and attribution of climate change: from global to regional. *Climate Change 2013: The Physical Science Basis*. T. F. Stocker et al., Eds., Cambridge University Press, 867–952, <https://doi.org/10.1017/CBO9781107415324.022>.
- Emanuel, K., 2017: Assessing the present and future probability of Hurricane Harvey’s rainfall. *Proc. Natl. Acad. Sci. USA*, **114**, 12681–12684, <https://doi.org/10.1073/pnas.1716222114>.
- Lott, F. C., and P. A. Stott, 2016: Evaluating simulated fraction of attributable risk using climate observations. *J. Climate*, **29**, 4565–4575, <https://doi.org/10.1175/JCLI-D-15-0566.1>.
- Mills, E., 2005: Insurance in a climate of change. *Science*, **309**, 1040–1044, <https://doi.org/10.1126/science.1112121>.
- Mora, C., and Coauthors, 2017: Global risk of deadly heat. *Nat. Climate Change*, **7**, 501–507, <https://doi.org/10.1038/nclimate3322>.
- National Academies of Sciences, Engineering, and Medicine. 2016: *Attribution of Extreme Weather Events in the Context of Climate Change*. National Academies Press, 186 pp.

Weather in the Courtroom Memoirs from a Career in Forensic Meteorology

William H. Haggard

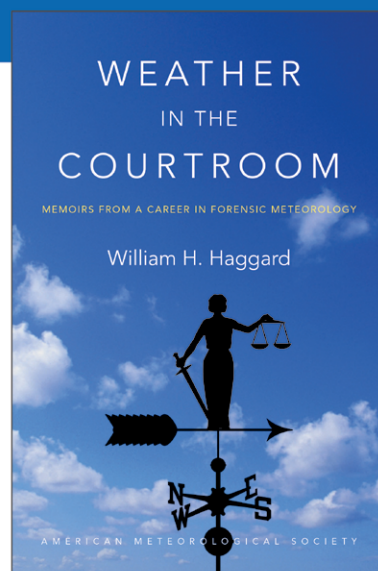
From a pioneering forensic meteorologist...

The inside scoop on legendary litigations where the weather may—or may not—have played a crucial role, including:

- The disappearance of an Alaskan congressman’s airplane in 1972
- The collapse of Tampa Bay’s Skyway Bridge in 1980
- The crash of Delta Flight 191 in Dallas/Fort Worth in 1985

William H. Haggard is former director of the NCDC and AMS certified consulting meteorologist (CCM), fellow, and honorary member.

© 2016, paperback, 240 pages
ISBN 13: 978-1-940033-95-2
List price: \$30 AMS Member price: \$20



AMS BOOKS
RESEARCH APPLICATIONS HISTORY
bookstore.ametsoc.org

STRONGER CLIMATE RESILIENCE WITH INSURANCE

ROBERT ERHARDT, JESSE BELL, BRIAN BLANTON, FRANK NUTTER, MEGAN ROBINSON, AND RICHARD SMITH

This document is a supplement to “Stronger Climate Resilience with Insurance,” Robert Erhardt, Jesse Bell, Brian Blanton, Frank Nutter, Megan Robinson, and Richard Smith (*Bull. Amer. Meteor. Soc.*, **100**, 1549–1552) • ©2019 American Meteorological Society • Corresponding author: Robert Erhardt, erhardrj@wfu.edu • DOI:10.1175/BAMS-D-19-0073.2

HOW TO BUILD A BETTER FLOOD MAP.

Flood maps are geospatial depictions of flood hazard. Ultimately, maps guide insurance policy underwriting decisions. Residential property flood insurance is provided through the National Flood Insurance Program (NFIP), administered by the Federal Emergency Management Agency (FEMA). Premium rates for a specific property are determined by the flood hazard zone for that property on a regulatory flood map. Due to federal regulatory constraints on FEMA, the resulting maps are effectively “binary” in the sense that a property either is or is not in a flood hazard zone. The maps also represent “current conditions” of land use, hazard assessment, and floodplain management practices, without the ability to consider long-term uncertainties.

The group discussed how current federal map making practices do not allow for a more graded characterization of risk levels, effectively preventing FEMA maps from conveying “future” risk levels under uncertain conditions. For example, in the coastal context, it seems unlikely that current conditions should persist into map products that are used for future rate setting as well as longer-term community planning. Evolving hurricane trends, encroachment of sea levels upland, and projections of coastal population density and development could change future risk. This would not matter much in residential flood insurance *if* updates to FEMA maps were more frequent (effectively keeping up with changing development and environmental trends) and if policy durations were sufficiently short.

However, since map updating is both expensive and time consuming, more probabilistic information in flood maps could permit a more risk-graded approach to rate setting and better facilitate long-term community and municipal planning.

A more comprehensive approach to risk mapping may require more dynamic, computer-based maps rather than the static zone-based FEMA map format. The commercial (i.e., private) insurance industry experiences could be almost immediately leveraged. Commercial insurance coverage can be accessed by both residential and commercial property owners, and mapping has considerably more leeway in factoring in potential sources of uncertainty that drive the long-term underlying risk. In particular, risk scoring develops a more comprehensive risk profile at finer spatial and probabilistic levels, achieving more risk-based and smoothly varying rates and avoiding the “in versus out” issue with current federal maps. Geographic and topographic features of specific properties could be easily incorporated, based on existing datasets, allowing a much finer “structure specific” granularity. This includes rapid updating of impermeable surface extents, civil infrastructure (waterway damming and diversion), and scenario-based climate impacts on risk levels.

The commercial insurance sector’s innovation in risk characterization may lie in their more direct exposure, as compared to the U.S. government’s backing of the NFIP and its ability to operate at long-standing loss (claims have exceeded premium revenues since

2006). They have a much larger incentive to understand long-term rate pricing.

Additional topics discussed included how to convey complex, multidimensional risk concepts in a visual, map-based context; social/behavioral aspects of risk communication; statistical methods and related advancements for incorporating climate science-derived uncertainties into risk models and maps; and how temporal aspects of risk can be characterized and presented in map form.

THE USE OF CLIMATE MODEL PROJECTIONS IN INSURANCE.

Most insurance products are sold on annual time scales, and therefore climate model projections are of limited direct value for pricing insurance contracts. However, companies operate on longer time scales for decisions such as capital investment and new product development. One discussant noted that, in insurance, the further you are from pricing, the more quantifying climate risk becomes relevant. The reinsurers in the group commented that their industry seeks long-term partnerships with companies on a scale of decades, which requires a demonstration of financial strength and planning for that period.

Discussion focused on a recent paper by Emanuel (2017), which stated that the Hurricane Harvey rainfall event in Texas has an estimated annual exceedance probability of 1% under the 1981–2000 climate but an estimated 18% exceedance probability under the 2081–2100 climate described by an ensemble of phase 5 of the Coupled Model Intercomparison Project (CMIP5) climate models under the representative concentration pathway (RCP) 8.5 scenario. Catastrophic weather events such as Hurricane Harvey attract tremendous “buy in” from the insurance and reinsurance industries, and so recasting them under different climate scenarios was seen as a useful scientific exercise. This should be repeated across different perils (windstorm, drought, flood, etc.). Companies could combine those results with internal estimates of their own future exposures and conduct stress tests. One discussant noted a statement like “the wind portion of hurricane costs are expected to outstrip population growth in Florida by X%” would make some waves in the insurance and corporate communities. Medders (2017) writes that “indeed, insurers do not need to take ‘climate change,’ per se, into account at all. If probable loss, frequency, and/or severity are changing, they do not have to be labeled as climate changes for insurers to respond appropriately.” Rerunning observed events under different climate scenarios could allow researchers

to quantify the “fraction of attributable risk,” or the fraction of the likelihood of an event that is attributable to a specific causal factor (National Academies of Sciences, Engineering, and Medicine 2016).

One issue raised was the regulatory considerations for use of an ensemble of multiple climate models to capture model uncertainty. The American Academy of Actuaries (2018) report on catastrophe models notes that “a company submitting a rate filing for residential property insurance in the state of Florida that relies on the results of a hurricane model is limited to those models that have been found acceptable by the [Florida Commission on Hurricane Loss Projection Methodology].” Prominent companies in the area of catastrophe modeling should lead the way on petitioning regulators to recognize the value of full climate model ensembles.

The group ended with discussion on the development of what might be termed “best practices” for the use of climate model data within the insurance and reinsurance industries. Examples could include reports along the lines of the American Academy of Actuaries (2018) report on how catastrophe models intersect with actuarial standards of practice.

CLIMATE MITIGATION AND ADAPTATION.

The first point of discussion focused on the differences in terminology across fields. For example, in the realm of climate change, mitigation generally refers to strategies that reduce greenhouse gas emissions, whereas other fields tend to think of mitigation as an effort to reduce costs from an individual event (such as a flood or fire). Typically, work dealing with the effects of climate change is called adaptation and has parallels with mitigation or risk management. Insurance is a form of financial risk mitigation or climate adaptation, depending on the point of view.

The next point discussed was the costs associated with mitigation efforts to combat climate change, which can be large; however, the costs of not mitigating climate change may be larger. Many of these costs will be absorbed by the insurance companies and distributed to their policyholders. More work is needed to understand these potential costs and how mitigation efforts will reduce fees associated with policyholders. Communication efforts will also be important to deal with these issues and should address how to properly provide this information to policyholders. It is also important to understand if there is a tipping point when policyholders will no longer tolerate increasing fees.

The discussion ended on international reinsurance companies. Lack of response to climate change

by the insurance industry may eventually fall to the reinsurance companies to address.

WHAT KEEPS YOU UP AT NIGHT? A major concern was translating research results from one group of consumers to another: between academia and the insurance industry or between either of those and the general public. The first of those issues could be addressed by a concerted effort for joint papers between the two groups of researchers, and hope was expressed that this workshop could lead to a few outcomes of that type. As for communication with the general public (including politicians and media), the group did not have any magic bullet solution but all were agreed on the importance of both groups of researchers making more effort to do this.

Climate models were naturally a focus of discussion as well, with several members noting the disconnect between the products typically produced by climate models and the kinds of results the insurance industry really needs. One issue is the time scale for the model projections themselves: typical climate model results look at a 30-year or end-of-century timeframe but the insurance industry operates on a year-to-year basis. Changes over much shorter time periods need to be studied. Another concern was the auditing of climate models for use in the insurance industry: climate models are tested for their ability to reproduce observed climate over large time and space scales (e.g., 30-yr global-average temperatures) but much less on the short-term small-scale extreme events that are of greatest concern. Despite much recent work on extreme events (National Academy of Sciences 2016), the time- and space-scale aspects have not been adequately addressed.

One participant was particularly concerned about questions of attribution and liability. He drew an analogy with the asbestos industry, where the source of damage is well defined and there were relatively few manufacturers to blame for it. In contrast, there are many different polluters responsible for climate change and attributing a specific negative outcome to a specific source is almost impossible. The field of detection and attribution (Bindoff et al. 2013) is in principle available to answer questions of this nature but in practice has rarely been applied at the level of individual causes and effects.

Another participant was concerned about the possibility of climate stresses resulting in war. It was noted that National Research Council (2013) had looked at issues of this nature but was inconclusive.

Many participants were concerned that academic research on climate extremes was failing to address

the issues likely to be of greatest concern to the insurance industry. One concern, expressed in different language by several participants, was that extreme climatic events are not necessarily caused by a single variable: there may be several variables that are not individually especially extreme but whose combination could have extreme consequences. One example was modeling the effect of hurricanes: extreme losses could arise from several causes such as extreme winds, storm surges, or precipitation, and it is really the combination of these and how they affect property damage that is of concern. The Spatial Hazard Events and Losses Database for the United States (SHELDUS; <https://cemhs.asu.edu/sheldus>) covers many natural hazards such as thunderstorms, hurricanes, floods, wildfires, and tornados and detailed information about the date, location, and losses from each event. This dataset is not widely known by academic researchers. Another example is stress from extreme heatwaves where it is known that the most extreme consequences arise from a combination of heat and humidity and neither one on its own (Mora et al. 2017). Another concern was clustering: the combined effect of several extreme events possibly occurring during a short time interval and having more extreme consequences in combination than any one on its own. As a mathematical question, this issue has been studied by specialists on extreme value theory (Leadbetter et al. 1983), but practical statistical work on extreme events often focuses on the single most extreme event and neglects this aspect of the problem. Extreme risk management requires different risk measures than the common ones of extreme quantiles or return values. This issue has been known for a number of years in the financial risk field, resulting in measures such as conditional value at risk (also known as expected shortfall) as an alternative to traditional value at risk, which is based on quantiles (Acerbi and Tasche 2002; Artzner et al. 1999).

The final issue discussed within this group was the use of new data sources. The data available from the National Centers for Environmental Information (www.ncei.noaa.gov/) now total 36 PB and are growing all the time, but many researchers do not know it's there, how to get it, or what to do with it. We need new tools for visualization and data summarization to help people understand and navigate such large datasets.

REFERENCES

Acerbi, C., and D. Tasche, 2002: Expected shortfall: A natural coherent alternative to value at risk. *Econ.*

- Notes*, **31**, 379–388, <https://doi.org/10.1111/1468-0300.00091>.
- American Academy of Actuaries, 2018: *Use of Catastrophe Model Output*. American Academy of Actuaries, 44 pp., www.actuary.org/files/publications/Catastrophe_Modeling_Monograph_07.25.2018.pdf.
- Artzner, P., F. Delbaen, J.-M. Eber, and D. Heath, 1999: Coherent measures of risk. *Math. Fin.*, **9**, 203–228, <https://doi.org/10.1111/1467-9965.00068>.
- Bindoff, N. L., and Coauthors, 2013: Detection and attribution of climate change: from global to regional. *Climate Change 2013: The Physical Science Basis*. T. F. Stocker et al., Eds., Cambridge University Press, 867–952, <https://doi.org/10.1017/CBO9781107415324.022>.
- Emanuel, K., 2017: Assessing the present and future probability of Hurricane Harvey’s rainfall. *Proc. Natl. Acad. Sci. USA*, **114**, 12 681–12 684, <https://doi.org/10.1073/pnas.1716222114>.
- Leadbetter, M. R., G. Lindgren, and H. Rootzen, 1983: *Extremes and Related Properties of Random Sequences and Processes*. Springer Verlag, 336 pp.
- Medders, L., 2017: Climate change impacts on insurance in Florida. *Florida’s Climate: Changes, Variations, & Impacts*, Florida Climate Institute, 179–207, <https://doi.org/10.17125/fci2017.ch06>.
- Mora, C., and Coauthors, 2017: Global risk of deadly heat. *Nat. Climate Change*, **7**, 501–507, <https://doi.org/10.1038/nclimate3322>.
- National Academies of Sciences, Engineering, and Medicine. 2016: *Attribution of Extreme Weather Events in the Context of Climate Change*. National Academies Press, 186 pp.
- National Research Council, 2013: *Climate and Social Stress: Implications for Security Analysis*. National Academies Press, <https://doi.org/10.17226/14682>.