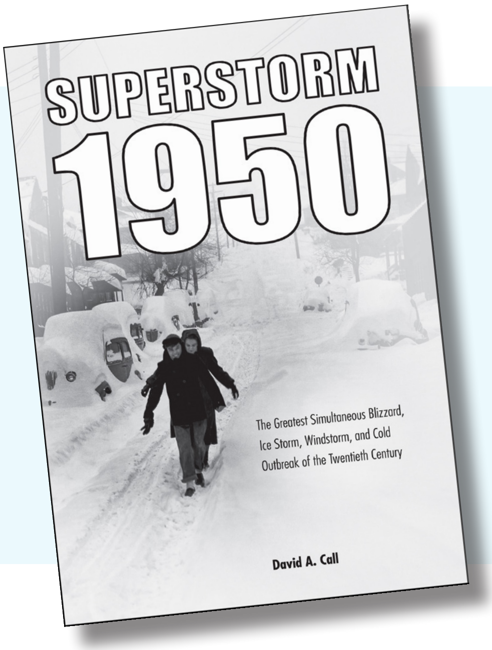
Book review

Ciaran Doolin[1,2]

[1] Meteorological Service of New Zealand (MetService – Te Ratonga Tirorangi), PO Box 722, Wellington, New Zealand
[2] School of Science in Society, Victoria University of Wellington – Te Herenga Waka
Correspondence: ciaran.doolin@metservice.com



David A. Call. 2023.

Superstorm 1950: The Greatest Simultaneous Blizzard, Ice Storm, Windstorm, and Cold Outbreak of the Twentieth Century.

West Lafayette, Indiana: Purdue University Press.
248 pp. 36 illustrations.
ISBN 978 1 6124 9797 6 (paperback) US$25.99.

In late November 1950 much of the eastern United States was impacted by one of the most intense and destructive mid-latitude cyclones of the 20th century. This cyclone, which is often referred to as the Great Appalachian or Thanksgiving storm, brought numerous severe weather hazards including snow, ice, wind, flooding, and cold, with many records being broken. It was the costliest weather disaster when it occurred, and only two storms affecting the mainland since (both hurricanes) have exceeded the loss of life caused by the 1950 cyclone.

David Call is an Associate Professor of Geography and Meteorology at Ball State University. Call teaches courses in meteorology and physical geography, including a storm chasing class in which he takes students on the hunt for tornadoes. His research investigates the impacts of winter weather. In *Superstorm 1950* the author's broad background is brought to bear to produce a study of interest to a wide range of scholars including meteorologists, geographers, historians, emergency managers, and policy makers. Call examines every aspect of the storm, from the meteorological background through the various weather impacts to the present-day significance of the storm.

The first chapter sets the scene by comparing life in the 1950s to 21st century America. Chapter two provides the meteorological background to the storm, while chapters three through eight document in detail the many impacts of the storm, organised according to phenomenon (snow, ice, flooding, etc.). Chapter nine discusses the significance of the storm to the history of science, in particular its impact on the development of numerical weather prediction (NWP). Finally, the last chapter examines the concept of a "superstorm" and speculates on the impacts a comparable storm would have today.

Towards the end of November 1950 an anomalously cold air mass developed over western Canada and began moving southeastwards. On 22 November the cold air started to arrive over the northern Great Plains of the United States. Unimpeded by any mountain ranges, the cold air continued to spread south over the next several days, breaking November records for low temperatures from Ohio down to Florida. The surface analysis in the top left of Fig. 1 depicts the situation on 24 November 1950 of cold air spreading across the central United States following a cold front. Note, the low-pressure system at the northern border of the United States is not the superstorm – the northern low-pressure system filled before the superstorm developed further south.

The low that was subsequently to become Superstorm 1950 first appears on the 1230 UTC 24 November chart (Fig. 1, middle left), with a central pressure just under 1016 mb. Over the next 12 hours the depression deepened (Fig. 1, bottom left). This didn't greatly concern forecasters at the time as the east coast of the United States is a well-known location for cyclone development. Usually, such a depression would move up the coast following the Gulf Stream or out to sea. However, this cyclone surprised both the forecasters and public by moving inland to the northwest.

Conditions in the upper troposphere were ripe for rapid subsequent development of the depression. An unusually intense upper cold pool was located over the Ohio Valley, west of the surface depression – a favourable set-up for further development. Furthermore, the polar jet associated with this upper cold pool was located unusually far south for November (over southern Alabama and Georgia) and was unusually strong. In addition, an upper-level ridge over Maine and New Brunswick, located to the west of a surface anticyclone over Labrador, helped to intensify the latter. This intense anticyclone was responsible for blocking the progress of the depression to the northeast, instead directing it northwestwards.

The favourable upper air conditions caused the cyclone to undergo explosive cyclogenesis – to "bomb."[1] By 1230 UTC 25 November (Fig. 1, top right) the cyclone's central pressure had fallen to 992 mb – a drop of 16 mb over the preceding 12 hours and 26 mb over the preceding 24 hours. Meanwhile, Caribou, Maine, under the influence of the anticyclone set a November record for high pressure at 1024 mb. The extreme pressure gradient generated between the high- and low-pressure centres brought hurricane-force winds across the northeastern United States on 25 November.

A new low developed on Saturday morning near Erie, Pennsylvania, and moved west-southwest over Cleveland, Ohio. For a time, this new low coexisted with the existing intense low, but soon it took over as the primary centre. The central pressure of the new depression fell rapidly – though not fast enough to still call it a bomb – while the former bomb low decayed. As the storm drifted further southwest in Ohio it deepened further reaching a minimum of 978 mb over northern Ohio early on 26 November. Dayton, Ohio, set a record for lowest November air pressure at 983.7 mb, less than 24 hours after Caribou reached its November high pressure record.

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By the morning of Sunday 26 November the worst of the storm was over. The cold air had wrapped completely around the low, occluding the warm air; the surface low had moved under the upper-level low, an unfavourable position for further development; and the high-pressure system over Labrador was weakening and moving towards Greenland (see 1230 UTC 26 November chart, Fig. 1, bottom right). Over the next 24 hours the storm filled, and no longer posed a serious threat. However, the cold air persisted, and further light snow and rainfall caused problems. It would be a week before settled, warmer weather returned to the eastern United States.

Superstorm 1950 had a widespread destructive impact across much of the eastern United States. Damage ran into the hundreds of millions of 1950 dollars (equivalent to at least US$1 billion today) and 353 people were killed. To briefly summarise some of these impacts, record-breaking snow affected eastern Ohio, western Pennsylvania, and West Virginia (see Fig. 2); it is the worst snowstorm to have affected the Ohio Valley according to the Regional Snowfall Index. In Pennsylvania, heavy rain caused flooding, especially on the West Branch of the Susquehanna River – this would have been the worst flooding of 1950 had there not been further flooding a week later owing to saturated soil and swollen rivers caused by the superstorm. In west central Pennsylvania, in places like Clearfield and

[1] A "bomb" is a rapidly intensifying mid-latitude cyclone that, according to Fred Sanders' and John Gyakum's (1980) criteria, deepens by at least 24hPa (mb) in 24 hours (at 60°N/S).

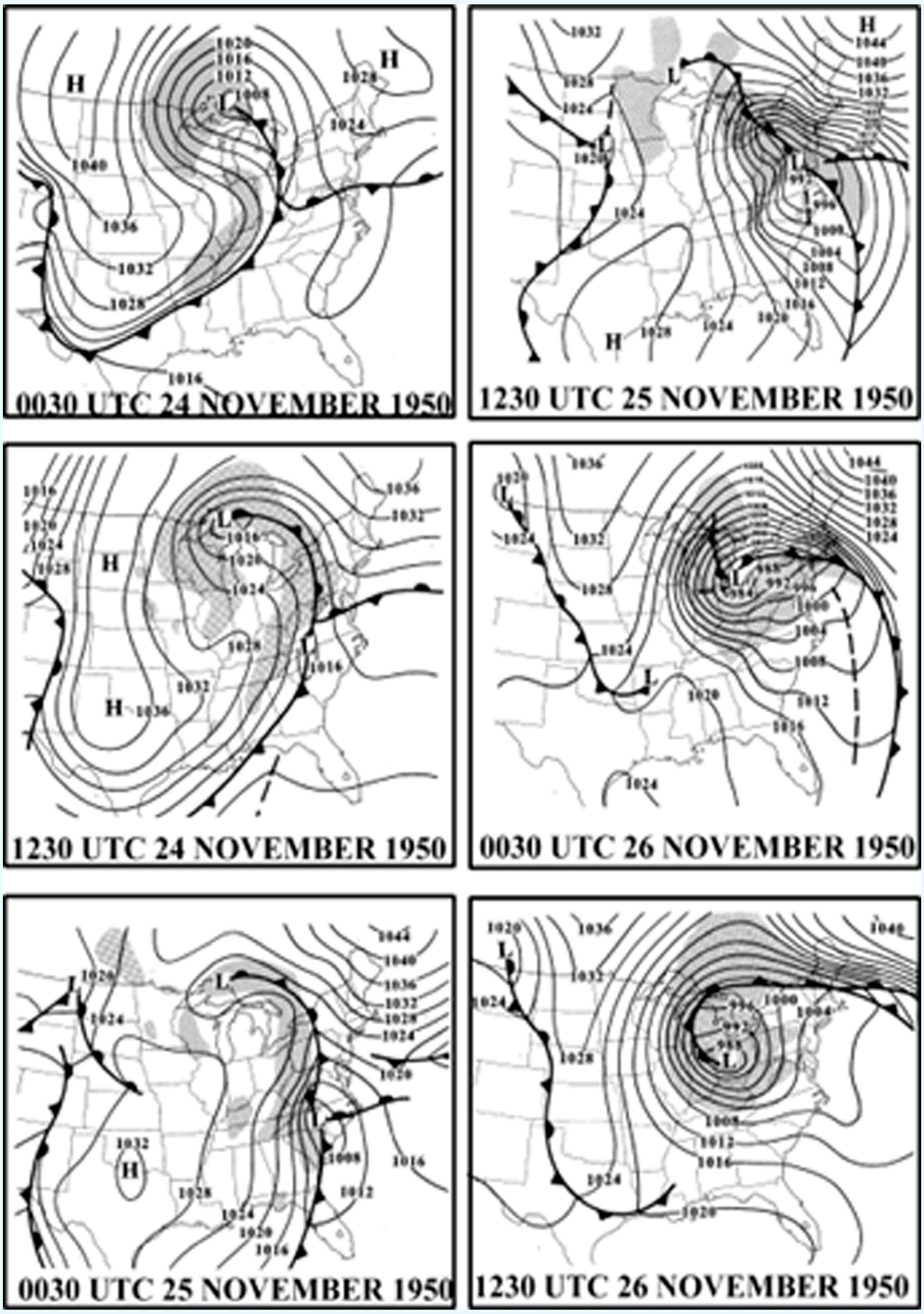

Figure 1: Surface analyses of Superstorm 1950. The storm first appears on the 1230 UTC 24 November chart (middle left), located just south of the triple point between the cold, warm, and occluded fronts. The depression rapidly deepens and moves to the northwest. Typically, cyclones progress up the east coast or out to sea, but in this case an intense anticyclone to the northeast blocked the superstorm's progress, forcing it inland. From Kocin and Uccellini (2004, p. 348). (© American Meteorological Society. Used with permission.)

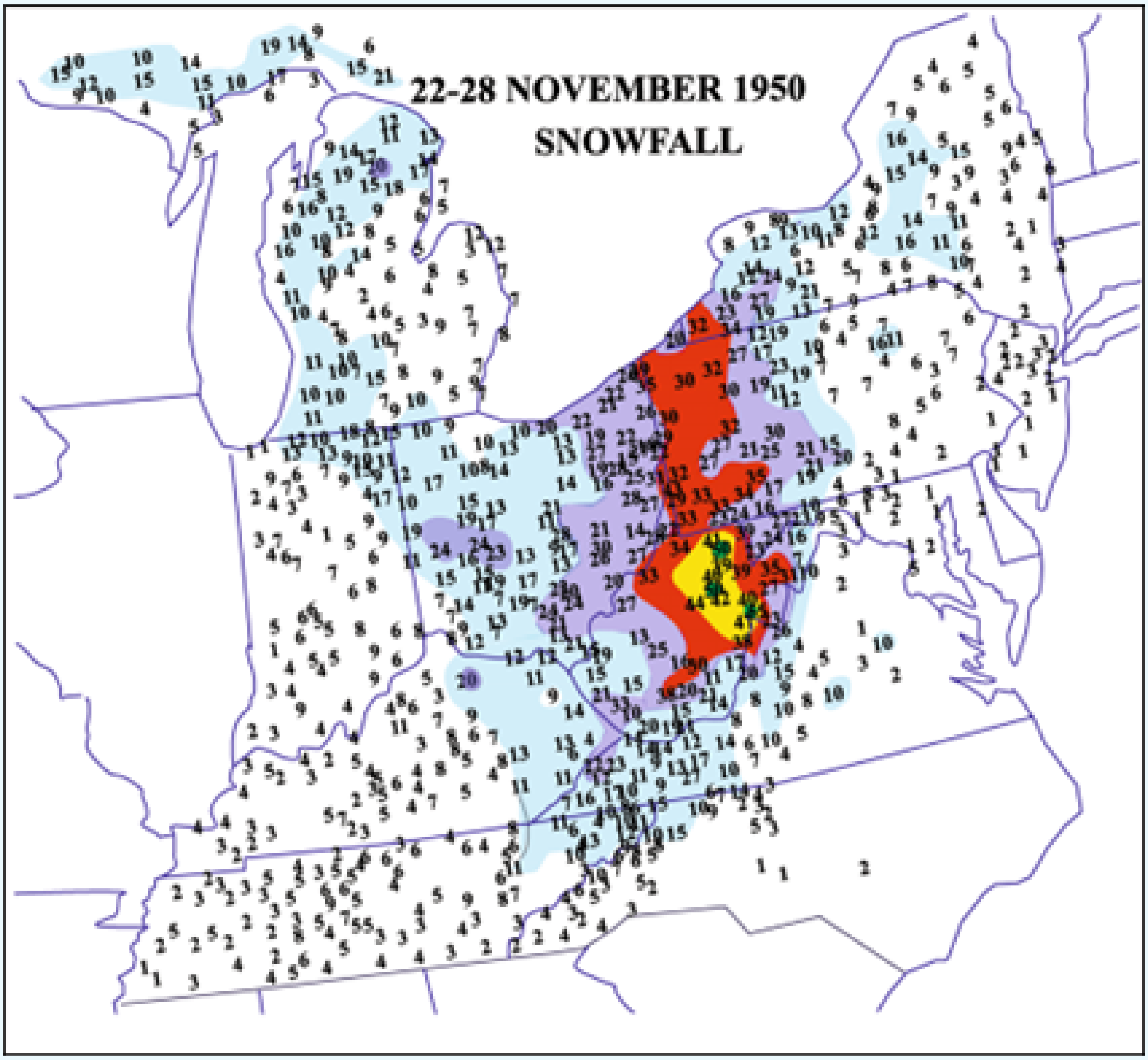

Figure 2: Cumulative snowfall (in.) across the northeastern United States for 22-28 November 1950. Coloured shading represents increments of 10in. (25cm) for amounts of 10in. (25cm) and greater. The heaviest snowfall (red, yellow, and green) occurred in eastern Ohio, western Pennsylvania, and West Virginia. From Kocin and Uccellini (2004, p. 347). (© American Meteorological Society. Used with permission.)

Altoona, precipitation fell as freezing rain, which destroyed the electricity grid. Finally, the windstorm in the northeast was widespread and severe. The destruction wrought by the wind was compared to the Great Hurricane of 1938 with many areas experiencing gusts to hurricane strength.

Superstorm 1950 was poorly forecast. Call argues that a bust forecast was probably unavoidable given that in 1950 meteorological science was in a juvenile stage of development, and there were few upper air observations and little data over the oceans and polar regions. He does note, however, that there was an analogue storm, the 1913 White Hurricane, which forecasters could have drawn upon in their prognoses. In the end, he argues, even if the storm had been well predicted:

> it is unlikely that the forecasts would have been heeded. Weather forecasts in 1950 were given nowhere near the credence of those today. And even if the forecasts had been heeded, the magnitude of the weather was so extreme that government officials could not have done much to prepare (p. 33).

Arguably, today, courtesy of the great advances in meteorological theory, remote sensing, and NWP, meteorologists and emergency management officials are faced with the reverse problem: the public has become so accustomed to reliable, timely warnings that there is a tendency to view weather as less of a hazard than it has been for previous generations. While improvements in forecasting have allowed the public to prepare for storms well in advance, society remains vulnerable to severe weather.

Chapters three through eight, which make up just over half the book, examine in detail the effects of the storm, namely snow, freezing rain, flooding, wind, and cold temperatures. All but one of these chapters are relevant to New Zealand's experience of mid-latitude cyclones – chapter five is on freezing rain, which is an extremely rare phenomenon in any of the populated parts of New Zealand. Of the effects studied, the flooding and wind damage could be said to be of similar magnitude to severe storms in New Zealand history – though it should be noted that in the last 100 years our most destructive storms tended to be ex-tropical cyclones (e.g., the 1936 storm, the 1968 Wahine storm, the 1988 Cyclone Bola, and the 2023 Cyclone Gabrielle), whereas Superstorm 1950 was a classical frontal wave. Although New Zealand also experiences disruptive snow and cold with outbreaks from the Southern Ocean (e.g., the 2006 snowstorm, 2011 polar outbreak), these events are typically more severe in the United States owing to the continental character of their climate.

In cataloguing the many different impacts of the superstorm, Call is sensitive to the uneven way in which the storm's effects were experienced. Race, gender, and class shaped peoples' experience of the storm. African Americans, especially in the South, were overrepresented in the fatalities from the storm; poverty among African Americans was extremely high in 1950 and many died from exposure owing to inadequate heating in their dwellings or in fires started by faulty heating systems. Men were also overrepresented in fatality statistics; many died from heart attacks triggered by overexertion while attempting to clear fallen snow.

As is often the case during natural disasters, there were many stories of survival, self-sacrifice, and community spirit. Call also weaves into the narrative some more light-hearted anecdotes. For example, in Wheeling, West Virginia, a bottled gas dealer enjoyed 15 minutes of local and national fame when he offered the use of his home-made flamethrower to melt snow. The city manager gave the experiment his blessing and the flame throwing went ahead. The experiment was a flop: only a small area about the size of a newspaper was successfully melted. More successful, however, were the efforts of electricity workers in Pennsylvania. Desperate to free their lines from the burden of accumulated ice, they took to short-circuiting sections of the lines – the heat generated from shorting they hoped would melt the ice. This apparently worked for all but the most elevated sections of the lines.

I must say I found these chapters dry and hard going at times. The author seems to have relied heavily on newspaper reportage in working up his narrative of the effects of the storm. There is nothing wrong with this per se, but I was left wondering if the story could not have been rendered livelier through quotations from first-hand accounts of people affected by the storm. In the end, these reservations may simply be attributable to my professional interests – meteorology and history of science. Geographers and emergency managers, for example, might find these sections of the book more engaging. Social historians, on the other hand, are likely to be underwhelmed.

The final two chapters I found much more interesting. Chapter nine examines the impact of Superstorm 1950 on the history of meteorological science.

At the Institute for Advanced Study in Princeton, New Jersey, meteorologist Jule Charney and mathematician John von Neumann were leading the Meteorology Project to undertake NWP by computer for the first time in history. While waiting for their own navy-funded computer to be built at Princeton, the Meteorology Project travelled to Aberdeen, Maryland, in March 1950 to use the army's Electronic Numerical Integrator and Computer (ENIAC) to conduct their initial NWP efforts. The scientists were pleased with their initial experiments and encouraged for the future. Seven months later the superstorm occurred. The scientists at Princeton were affected by the superstorm, with winds at nearby Trenton gusting over 100 mph (161 km/h), causing extensive damage and knocking out power to much of the town and university. The unusual severity and track of the storm, as well as the fact it was poorly forecast, inspired the modellers to use it as a key case study to test their models. If their early NWP models could predict this storm, so the modellers' logic went, then surely they could predict more garden-variety weather systems. Norm Phillips, another Meteorology Project member, developed a simple two-level model building on Charney's work. In 1951 he tested this by hand-calculating values for Superstorm 1950 – this was the first time the storm was used to test a model. The results, published in *Journal of Meteorology,* were mixed and Phillips recommended introducing another vertical level and modifying some assumptions.

By 1952 the Princeton computer was up and running, offering vastly superior performance to the ENIAC. In 1953 Charney and Phillips published a paper outlining how a two-and-a-half-dimensional model outclassed a two-dimensional model for Superstorm 1950. A year later Charney showed a three-level model improved the forecasting of the magnitude of the superstorm, though the location was still wrong. In 1958 Phillips used a model with a stream function to forecast the superstorm. The model was a great success; Phillip's two-layer model, focused on wind fields rather than temperatures, was a major improvement on the traditional geostrophic approach. Later in life, Phillips credited his and Charney's work modelling the superstorm as leading to the formation of the Joint Numerical Weather Prediction Unit (JNWPU) in 1954. The JNWPU was a collaboration between the United States Weather Bureau, air force, and navy. They began issuing forecasts in 1955, although these were not of a usable quality. However, by 1958 computer models were successfully able to forecast future weather. Superstorm 1950 was used by the modelling community as a key case study to test their models for the next 50 years.

The other interesting dimension to Superstorm 1950's role in the history of science was its contribution to storm surge modelling. In the 1960s N. Arthur Pore and William S. Richardson at the National Weather Service's (NWS) Techniques Development Laboratory began developing storm surge models using the superstorm as a test case. Superstorm 1950 was of value because of its unusual intensity and track. Winds that generated the storm surge came from the east/southeast instead of from the more typical northeast direction; the timing of the storm coincided with a spring tide; and the intensity of the storm generated record high tides along the northeastern coastline.

Call's concluding remarks of this chapter neatly capture that fascinating interplay of chance, social necessity, and ingenuity which so often lies at the heart of periods of rapid progress in science:

> The weather disruptions caused by Superstorm 1950 were severe, but generally short-lived. The storm, however, lived on within meteorology. Its fortuitous timing meant that it played a large role in developing and perfecting meteorologists' and computers' understanding of the atmosphere … Ultimately, while Superstorm 1950 killed hundreds and caused hundreds of millions of dollars in damage, countless lives and dollars have been saved since then due to the improved accuracy of weather forecasts. The quality of these forecasts is directly attributable to this storm (p. 176).

The final chapter of the book examines how changes in society since 1950 have modified the effects of cyclones of similar severity to Superstorm 1950. Call notes that while progress has been made in improving race relations, reducing poverty, and addressing gender inequity, the effects of a similarly severe storm would still be felt unevenly across society. Although technological changes have increased societal resilience in some areas, society remains susceptible to several hazards. Improvements in automobile technology and snow removal equipment has reduced their susceptibility to stalling and other mechanical failures. Tires have also improved making for better traction on snowy surfaces. Flood protection systems have reduced the risks of riverine flood damage. Record cold would be less of a hazard to life due to public education around carbon monoxide poisoning and better home insulation and heating systems. Tremendous improvement in forecasting has also greatly reduced disruption caused by severe storms by allowing the public and emergency managers to prepare for various weather impacts well in advance. On the other hand, society remains vulnerable to ice storm damage, if not more vulnerable given the greater dependence on electricity today. Coastal flooding would also likely be worse due to a combination of explosive growth of the coastal population and property values, sea level rises associated with climate change, and the loss of coastal wetlands. Wind damage would probably be similar in terms of physical effects, but greater in cost due to increases in property values. Crop damage would also be worse in terms of costs because of the increase in crop yields.

Finally, Call argues for the adoption of the term "Superstorm" to describe intense mid-latitude cyclones. He motivates the use of this term by discussing the challenges of communicating Hurricane Sandy in 2012. When Sandy transitioned from a hurricane to a mid-latitude cyclone, the NWS began referring to it as "post-tropical storm Sandy" and forecasting responsibilities were handed over from the National Hurricane Center to the Hydrometeorological Prediction Center, an office more than 1000 miles away. The "post-tropical" label was one largely unknown to non-meteorologists. Call argues that while the public understand hurricanes are serious storms, according to the NWS label

Sandy was no longer a hurricane, yet it was still a severe storm of which the public needed to be vigilant. To add to the confusion, the Federal Emergency Management Agency continued to refer to it as Hurricane Sandy after the system had transitioned, which was technically incorrect and potentially misleading as the heavy snow that accompanied Sandy is not an impact normally associated in the public imagination with a hurricane.

These communication challenges around former tropical cyclones echo the experience of New Zealand meteorologists. MetService has cycled through a range of labels over the years – e.g., "ex-tropical cyclone," "former tropical cyclone." Today the practice is to refer to transitioned tropical cyclones as "Cyclone …," simply dropping the term "tropical" from the name. Call makes the case for the term "Superstorm" as a way of clarifying the communication of severe post-tropical storms as well as for severe depressions that develop in the mid-latitudes. He proposes a general definition of a "Superstorm" as:

> a midlatitude cyclone that causes record conditions in multiple disparate meteorological hazards over a large area. Superstorms also cause significant societal impacts via loss of life, destruction of property, or general disruption (p. 185).

He goes on to discuss more specific criteria for a storm to meet the threshold of a superstorm. These are somewhat American centric and would require reinterpretation were they to be applied to the New Zealand region.

Call's advocacy of the term "Superstorm" to clarify communication of severe mid-latitude cyclones should be situated within a broader debate about the best practice for communicating severe weather in the 21st century. An approach gaining currency amongst hydrometeorological organisations around the world, with support and encouragement from the World Meteorological Organization, is "impact-based forecasts/warnings," which are typically conveyed graphically with the inclusion of colour to indicate impact severity. Advocates for impact-based forecasts/warnings argue that traditional hazard-based forecasts/warnings often fail to adequately communicate to the public the risks associated with weather hazards as they focus on phenomenon intensity (e.g., X mm of rain per hour) rather than the societal impacts of the phenomenon (e.g., flooding of a state highway during rush hour). MetService has begun to move in the direction of impact-based warnings through the introduction of formal colour-codes in its Warning System in 2019. Warnings are categorised into Orange or Red "depending on the expected severity and impact of the event," with Red being reserved for only the most severe/impactful storms (MetService, 2023). Arguably, even before the introduction of these new warning categories MetService was already taking an impact-based approach by adhering to slightly different warning criteria for various phenomena across different regions based on known regional weather vulnerabilities (e.g., lower wind thresholds for northeast winds in Auckland, lower rain thresholds in Southland and eastern Otago). This is a growing area of research internationally as well as in New Zealand (for a New Zealand study see Potter et al. 2021).

Overall, I enjoyed this book. It is a valuable addition to the literature on historical storms. The study is multifaceted, which ought to make it of interest to a diverse range of readers. I personally got the most out of early chapter dealing with the meteorological background, and the last two chapters which discussed, respectively, the significance of the storm to the history of science and to present-day efforts in meteorology, science communication, and emergency management to respond to superstorms. I found the middle chapters less stimulating, but as noted above this may simply reflect my professional background. With severe storms becoming increasingly the norm in a warming climate, Call's thoroughly researched, eminently readable study is a timely contribution which ought to be read by scientists, policy makers, and anyone else who is grappling with the pressing questions of New Zealand's – and the world's – future climate.

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