TAMBORA

THE ERUPTION THAT CHANGED THE WORLD

GILLEN D'ARCY WOOD

PRINCETON UNIVERSITY PRESS
PRINCETON AND OXFORD

To the memory of Bess, Linnell, Monica, and Bessie—
And to Nancy, and a climate-stable future for our children

Copyright ©2014 by Princeton University Press
Published by Princeton University Press, 41 William Street, Princeton, New Jersey 08540
In the United Kingdom: Princeton University Press, 6 Oxford Street, Woodstock, Oxfordshire OX20 1TW

press.princeton.edu

Jacket Art: *Weymouth Bay*, 1816 (oil on canvas), John Constable (1776–1837). Location: The Victoria & Albert Museum, London, UK. Courtesy of The Bridgeman Art Library.

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Library of Congress Cataloging-in-Publication Data
Wood, Gillen D'Arcy.
Tambora : the eruption that changed the world / Gillen D'Arcy Wood.
pages cm
Includes bibliographical references and index.
ISBN 978-0-691-15054-3 (hardcover : acid-free paper) 1. Tambora, Mount (Indonesia)—Eruption, 1815. 2. Weather—Effect of volcanic eruptions on—History—19th century. 3. Volcanoes—Environmental aspects—History—19th century. 4. Climatology—Observations—History—19th century. I. Title.
QC981.8.V65W66 2014
363.34'95—dc23
2013021152

British Library Cataloging-in-Publication Data is available

This book has been composed in Sabon Next LT Pro

Printed on acid-free paper.

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

Gift Idem 6875953

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INTRODUCTION

FRANKENSTEIN'S WEATHER

The War of Independence between Britain and America provisionally ended with the Treaty of Paris in December 1783. But official ratification of the peace accord was delayed for months by a mix of political logistics and persistent bad weather. The makeshift U.S. capital in Annapolis, Maryland, was snowbound, preventing assembly of congressional delegates to ratify the treaty, while storms and ice across the Atlantic slowed communications between the two governments. At last, on May 13, 1784, Benjamin Franklin, wrangling matters in Paris, was able to send the treaty, signed by King George himself, to the Congress.

Even while scrambling to bring the warring parties to terms, Franklin—tireless and mercurial—found time to reflect on the altered climate of 1783–84 that had played such a complicating role in recent events. "There seems to be a region high in the air over all countries where it is always winter," he wrote. But perhaps the "universal fog" and cold that had descended from the atmosphere to blanket all Europe might be attributed to volcanic activity, specifically an eruption in nearby Iceland.[1]

Franklin's "Meteorological Imaginations and Conjectures" amounts to no more than a few pages of disconnected thoughts, scribbled amid a high-stakes diplomatic drama. The paper's unlikely fame as a scientific document rests on its being the first published speculation on the link between volcanism and extreme weather. Franklin hastily sent his

paper on meteorology to Manchester, where the local Philosophical Society had awarded him honorary membership. On December 22, 1784, the president of the society rose to speak on Franklin's behalf. No doubt dismayed at the paper's thinness, he had no choice but to read the "conjectures" of the society's celebrated new member to the crowded assembly. There, in a freezing Manchester public hall, the theory that volcanic eruptions are capable of wreaking climate havoc was given its first public utterance.

No one believed it for a moment. Even as the hall emptied, Franklin's idea had entered the long oblivion of prematurely announced truths. But, of course, he was right. The eruption of the Iceland volcano Laki in June 1783 brought abrupt cooling, crop failures, and misery to Europe the following year, and created dangerously icy conditions for Atlantic shipping. Even so, Laki did not go global. Latitude is critical to the relation between volcanic eruptions and climate. As a high northern volcano, Laki's ejecta did not penetrate the trans-hemispheric currents of the planet's climate system, and its meteorological impacts were confined to the North Atlantic and Europe.

Two hundred years ago, no one—not even Benjamin Franklin—had grasped the potential global impact of volcanic emissions from the *tropics*, where, two decades after Laki, planet Earth's greatest eruption of the millennium took place. When Mount Tambora—located on Sumbawa Island in the East Indies—blew itself up with apocalyptic force in April 1815, no one linked that single, barely reported geological event with the cascading worldwide weather disasters in its three-year wake.

Within weeks, Tambora's stratospheric ash cloud had circled the planet at the equator, from where it embarked on a slow-moving sabotage of the global climate system at all latitudes. Five months after the eruption, in September 1815, meteorological enthusiast Thomas Forster observed strange, spectacular sunsets over Tunbridge Wells near London. "Fair dry day," he wrote in his weather diary—but "at sunset a fine red blush marked by diverging red and blue bars."[2] Artists across Europe took note of the changed atmosphere. William Turner drew vivid red skyscapes that, in their coloristic abstraction, seem like an advertisement for the future of art. Meanwhile, from his studio on Greifswald Harbor in Germany, Caspar David Friedrich painted a sky with a chromic density that—one scientific study has found—corresponds to the "optical aerosol depth" of the colossal volcanic eruption that year.[3]

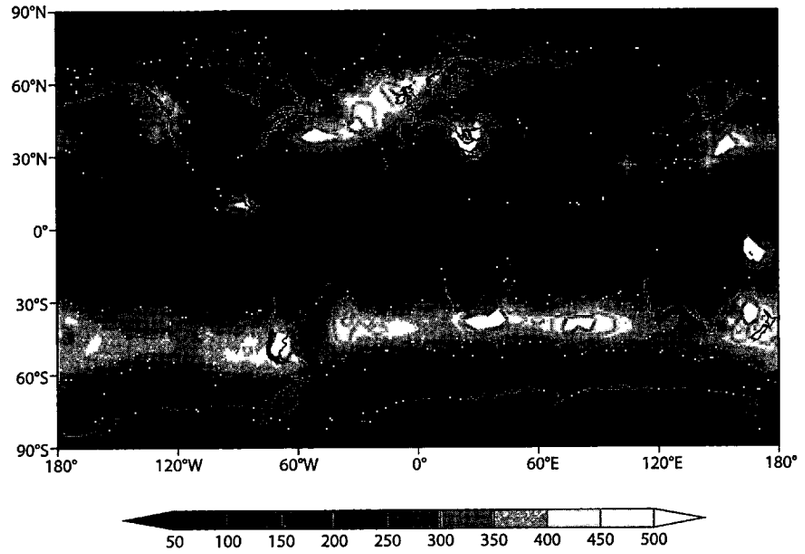


FIGURE 0.1. This 2007 model of Tambora's sulfate cloud shows its global reach, with a band of high aerosol concentration at mid- to high latitudes in both hemispheres, notably over the North Atlantic and Western Europe. This model situates the volcanic cloud in the stratosphere, 24–32 kilometers above the Earth. (Chaochao Gao, "Atmospheric Volcanic Loading Derived from Bipolar Ice Cores: Accounting for the Spatial Distribution of Volcanic Deposition," *Journal of Geophysical Research* 112 [2007]: D09109; © American Geophysical Union).

Forster, Turner, and Friedrich—all committed skywatchers—saw the imprint of major atmospheric changes in the North Atlantic. But neither Forster's London sky "on fire" in September 1815 nor the nearly three years of destructive global cooling that ensued inspired anyone to the realization that a faraway volcanic eruption had caused it all. Not until the Cold War—and the development of meteorological instruments to measure nuclear fallout—did scientists begin study of the atmospheric residency of volcanic aerosols. The sun-blocking dust veil

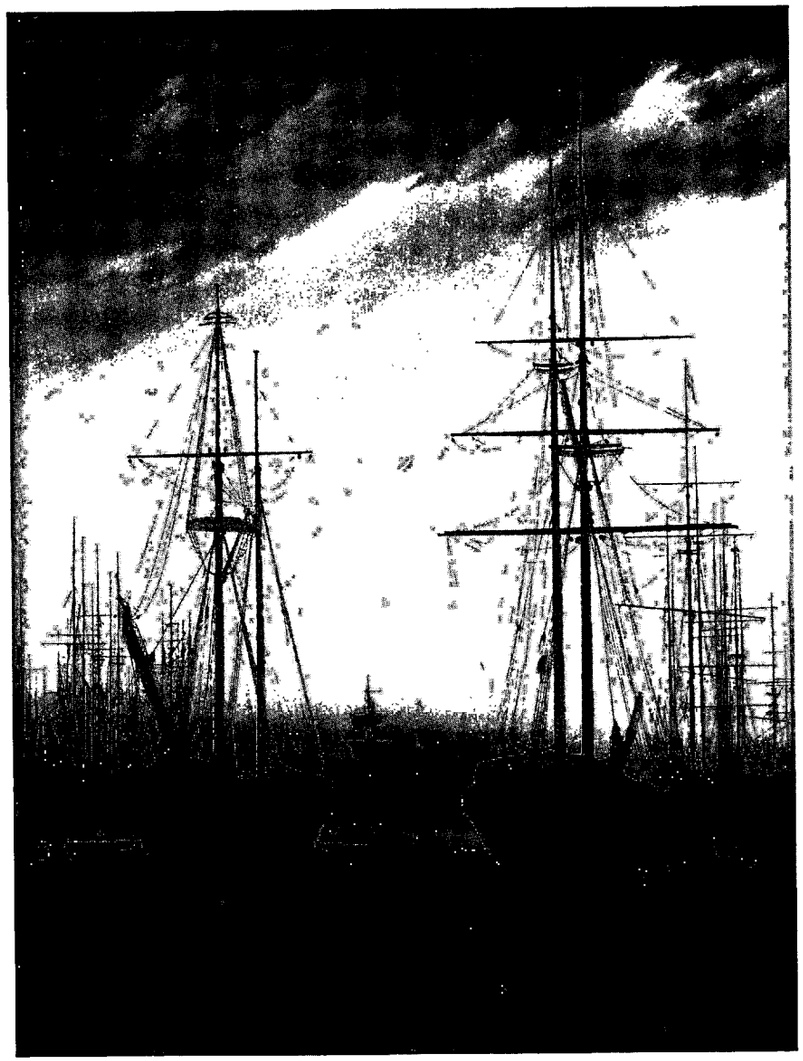


FIGURE 0.2. Caspar David Friedrich, *Ships in the Harbor* (1816). Sanssouci Palace, Potsdam. (© Erich Lessing/Art Resource, NY).

of a major eruption, it was concluded, might linger above the earth for up to three years. Two centuries after Franklin's first tentative speculations, the geophysical chain linking volcanism and climate could at last be proven.

I dwell on this point for good reason. The formidable, occasionally mind-bending challenge in writing this book has been to trace cataclysmic world events the cause of which the historical actors themselves were ignorant. Generations of historians since have done little better. The Tamboran climate emergency followed hard upon the devastations of the Napoleonic Wars and has always remained in the shadows of that epochal conflict. Out of sight and out of mind, Tambora was the volcanic stealth bomber of the early nineteenth-century. Be it the retching cholera victim in Calcutta, the starving peasant children of Yunnan or County Tyrone, the hopeful explorer of a Northwest Passage through the Arctic Ocean, or the bankrupt land speculator in Baltimore, the world's residents were oblivious to the volcanic drivings of their fate. Equally challenging for me as an environmental historian has been to capture the physically remote relation between cause and effect in measuring Tambora's impact on the global commons of the nineteenth century. Volcanic strife traveled great distances and via obscure agents. But it is only by tracing such "teleconnections"—a guiding principle of today's climate and ecological sciences—that the *worldwide* tragedy of Tambora can be rescued from its two-century oblivion.

Climate change is hard to see and no less difficult to imagine. After a day's climb through the dense forests of Sumbawa Island, drenched in tropical rains, I almost didn't succeed in seeing at firsthand the great Tambora's evacuated peak. Then, at daybreak on the second morning, the clouds suddenly lifted, and we were able to complete our ascent along the treeless ridges. Nearing the summit, we clambered over flat pool tables of tan, serrated rock and left our boot prints in the black volcanic sand. Almost without warning, we found ourselves at the rim of a great inverted dome of earth, with sheer rock walls leading down to a pearl-green lake a kilometer below. My camera whirred as puff-clouds of sulfur performed lazy inversions in the still, separate universe



FIGURE 0.3. Tambora's caldera. The morning this photograph was taken (March 3, 2011), the mountain rumbled and the odor of sulfur was palpable. A few weeks later, the volcano began belching ash and smoke. By September that year, Indonesian seismologists had ordered evacuation of the surrounding area. Volcanologists do not expect an imminent eruption, however, on account of the geologically recent 1815 event. (Author photo).

of Tambora's yawning caldera. Its six-kilometer diameter might as well have been a thousand. My swimming eyes performed no better than my camera in taking measure of the volcano's unhealed intestinal canyon, let alone in imagining its once pristine peak a mile above me in what was now open sky. Sleepless and damp in our tents the night before, we had felt rumblings from deep in the earth. Now, we smelled the distinct odor of sulfur in the morning air. Looking down for a moment to recover my senses, I realized I was standing on a sponge-like rock that, but a blink before in geological time, had been adrift among the brewing magma of Tambora's subterranean chamber.

Gazing out across that dizzying crater, I felt no better equipped than pioneer meteorologist Thomas Forster in 1815 to grasp the catastrophic

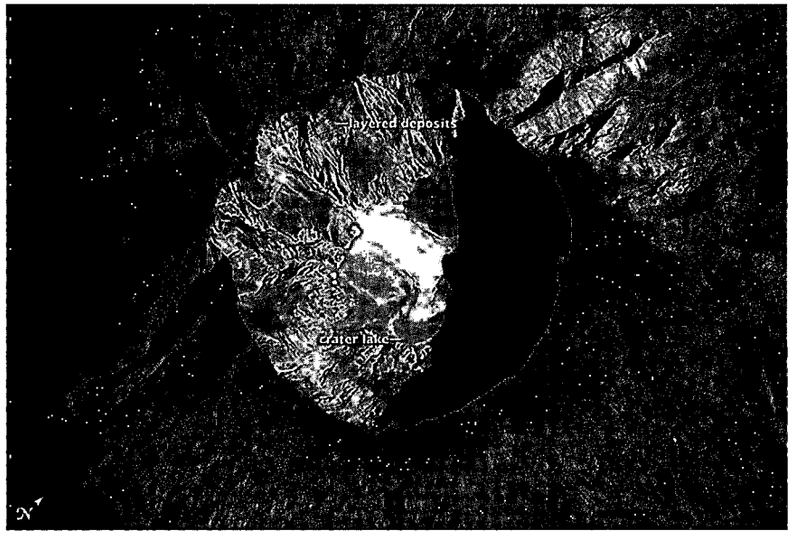


FIGURE 0.4. An aerial view of Tambora's caldera taken from the International Space Station shows its terrific, lunar-like dimensions. (NASA).

impact of a single mountain's explosion on the history of the modern world. It was a calm sunrise. The straits of Teluk Saleh to the south came into view over the treetops, its postcard blue waters dotted with islands in the milky sunlight. Stretching behind us, the forests of the Sanggar peninsula appeared at perfect peace. Did an event of world-changing violence truly happen here? Like the shivering audience in that Manchester hall two centuries ago, trying to make sense of Franklin's ramblings about cold weather and an Iceland volcano, I could hardly believe in Tambora's global reach.

It has taken five years of research into the science of volcanism and climate, collaboration with scholars across many disciplines, and much dogged detective work to remake that morning's ascent of Tambora in my imagination: to articulate, in book-length form, the years-long impact of the massive 1815 eruption on the world in the critical period after the Napoleonic Wars. Unlike Benjamin Franklin and Thomas Forster, I have had the advantage of modern scientific instruments and data through which to "see" the otherwise invisible teleconnections linking

tropical eruptions, climate change, and human affairs. Climbing Tambora, by this route, one could not mistake its greatness.

Tambora belongs to a dense volcanic cluster along the Sunda arc of the Indonesian archipelago. This east-west ridge of volcanoes is a segment, in turn, of the much larger Ring of Fire, a hemisphere-girdling string of volcanic mountains bordering the Pacific Ocean from the southern tip of Chile, to Mount St. Helens in Washington State, to picturesque Mount Fuji in Japan, to Tambora's near neighbor Krakatau, due to explode into global fame in 1883. Along its almost 40,000 kilometers length, the Ring of Fire boasts lofty, cone-topped volcanoes located exclusively on coastlines and islands. Tambora sits some 330 kilometers north of a tectonic ridge in the trans-Pacific Ring of Fire known as the Java Trench, which marks a curvilinear course south of the islands of Sumbawa and its neighbors Lombok and Sumba.

After perhaps a thousand years' dormancy, Tambora's devastating evacuation and collapse in April 1815 required only a few days. It was the concentrated energy of this event that was to have the greatest human impact. By shooting its contents into the stratosphere with such biblical force, Tambora ensured its volcanic gases reached sufficient height to seriously disable the seasonal rhythms of the global climate system, throwing human communities worldwide into chaos. The sun-dimming stratospheric aerosols produced by Tambora's eruption in 1815 spawned the most devastating, sustained period of extreme weather seen on our planet in perhaps thousands of years.

A dramatic story unto itself. But a more urgent motivation has driven my history of Tambora. The great Sumbawan volcano is the *most recent* volcanic eruption to have had a dramatic impact on global climate. Considered on a geological timescale, Tambora stands almost insistently near to us, begging to be studied. On the eve of Tambora's bicentenary and facing multiplying extreme weather crises of our own, its eruption looms as the richest case study we have for understanding how abrupt shifts in climate affect human societies on global scales and decadal time frames. The Tambora climate emergency of 1815–18 offers us a rare, clear window onto a world convulsed by weather extremes, with human communities everywhere struggling to adapt to sudden,

radical shifts in temperatures and rainfall, and a flow-on tsunami of famine, disease, dislocation, and unrest.

For three years following Tambora's explosion, to be alive, almost anywhere in the world, meant to be hungry. In New England, 1816 was nicknamed the "Year without a Summer" or "Eighteen-Hundred-and-Froze-to-Death." Germans called 1817 the "Year of the Beggar." Across the globe, harvests perished in frost and drought or were washed away by flooding rains. Villagers in Vermont survived on hedgehogs and boiled nettles, while the peasants of Yunnan in China sucked on white clay. Summer tourists traveling in France mistook beggars crowding the roads for armies on the march.

One such group of English tourists, at their lakeside villa near Geneva, passed the cold, crop-killing days by the fire exchanging ghost stories. Mary Shelley's storm-lashed novel *Frankenstein* bears the imprint of the Tambora summer of 1816, and her literary coterie—which included the poets Percy Shelley and Lord Byron—will serve as our occasional tour guides through the suffering worldscape of 1815–18. As one literary historian has observed, "there was never a more documented group of people" than Mary Shelley's circle of friends and lovers. The paper trail of impressions they left of the late 1810s will lead us back again and again to Tambora.[4]

In the early nineteenth century, the overwhelming majority of the world's population were subject (unlike Dr. Frankenstein) to the unforgiving regime of nature: most people depended on subsistence agriculture, living precariously from harvest to harvest. When crops worldwide failed in 1816, and again the next year, starving rural legions from Indonesia to Ireland swarmed out of the countryside to market towns to beg for alms or sell their children in exchange for food. Famine-friendly diseases, cholera and typhus, stalked the globe from India to Italy, while the price of bread and rice, the world's staple foods, skyrocketed with no relief in sight.

Across a European continent ravaged by the Napoleonic Wars, tens of thousands of demobilized veterans found themselves unable to feed their families. They gave vent to their desperation in town-square riots

and military-style campaigns of arson, while governments everywhere feared revolution. Human tragedies rarely unfold without blessings to some. During this prolonged global dearth that ended only with the bumper harvests of 1818, farmers in Russia and the American western frontier flourished as never before, selling their grain at stratospheric prices to desperate buyers in the Atlantic trade zone. But for most people, worldwide, this was "the worst of times."

Tambora's aftermath, particularly the "Year without a Summer," 1816, is rich in folklore and continues to be the subject of popular histories. But these accounts are confined to 1816 and to Tambora's impacts in Europe and North America.[5] None has engaged seriously with the robust and ever-increasing scientific literature on Tambora, volcanism, and global climate change. I learned about Mount Tambora in an atmospheric science seminar, not from a history book, and my first exhilarated thought was it was high time historians caught up with the climatologists on Tambora. This book, through all the byways of its creation, remains the product of that initial inspiration. *Tambora* is the first study of this iconic period to marry a volcanological account of the 1815 eruption with both the folklore of the "Year without a Summer" and the full range of biophysical sciences relevant to climate change. It is the first to treat the Tambora event not as the natural disaster of a single year, 1816, but as a three-year episode of drastic climate change whose downstream effects can be traced long into the nineteenth century.

I focus here on the human story of Tambora's aftermath, while my engagement with the detailed discussion of the volcano to be found in recent scientific literature allows me to tell that story on multiple spatial scales, from the molecular to the global. My emphasis, from the point of view of method, is less on nature's impact on history—far less a crude environmental determinism—but on Tambora as a case study in the fragile interdependence of human and natural systems. Put another way, this book considers the disparate human communities of 1815–18—and the climatic zones to which they were adapted—as a single, anthro-ecological world system on which Tambora acted as a massive, traumatic perturbation. After April 1815, many human societies were "changed, changed utterly"—to borrow from the poet

W. B. Yeats—altered, in radical ways, from their pre-eruption state. I have not traveled, in my fieldwork and research, to all continents. In some areas of the globe—notably Africa, Australia, and Latin America—the contemporary data are thin or archives nonexistent. But *Tambora* offers a rich and unique travelogue nonetheless, traversing the hemispheres to trace this epochal eruption's shaping hand on human history.

Across Asia, for example—whose Tambora story has never been told—the volcano's effects were arguably the most devastating of all. A celebrated ancient genre of Chinese verse is called Poetry of the Seven Sorrows. In a Seven Sorrows poem, the poet dramatizes the five bodily senses under assault, overlaid with the twin mental afflictions of injustice and bitterness: seven sorrows in all. The original work in the genre, from the third century, tells of a man forced by civil war from his home, a kind of Chinese Dante. The sorrowful poet, Wang Can, sees lines of corpses from the road and encounters an anguished woman who has abandoned her child in the barren fields. She cannot feed it, but she loiters nearby, listening to its cries. As we will see in chapter 5, the ancient poetic mode of Seven Sorrows enjoyed a renaissance in China in the Tambora period of 1815–18 because it captured so well the human suffering wrought by three successive years of climatic breakdown. A forgotten Chinese poet named Li Yuyang, it turns out, spoke as movingly as anyone for the weather-devastated world of the late 1810s.

The accounts of environmental breakdown and human tragedy left by survivors such as Li Yuyang must stand in for countless histories of individual and community trauma from the Tambora period that are lost forever. In the aftermath of a mega-disaster such as Tambora, the paucity of victim narratives itself tells us something both of the scale of the cataclysm and who bore the brunt of it: the poor and illiterate peasant millions of the early nineteenth-century world. Just as my vision failed me confronted by the dizzying vortices of Tambora's vast caldera, so a complete panoramic view of the human crises it spawned lies out of reach. But with an eye committed to a twenty-first-century way of seeing—to tracing the complex teleconnections between earth, sky, and the fate of human beings—the haywire story of a two-centuries-old global climate crisis may at last be properly told and with it our own fate, in cautionary ways, foretold.

developed into the metropolitan-based manufacturing society Jefferson foresaw with such clear-eyed loathing. After 1820, climate change likewise faded from the transatlantic conversation. The United States did not need a moderate climate—or the promise of one—to attract investment and build industries in the new era. Undergirding this industrial development, a modern financial system evolved that, for the most part, insulated ordinary Americans from the vicissitudes of weather and crop yields.[63]

One consequence of the long decline of American rural life has been a profound climate illiteracy among the political class, which reflects that of the citizenry at large. So the American public was ill-prepared when, in the mid-1980s—two hundred years after Jefferson's famous dinner with the Comte de Buffon—climate change returned as a live issue in American politics. As in the age of Jefferson, climate change continues to be a subject peculiarly fired with controversy, passion, and no small amount of ignorance. Twenty-first-century Americans, like their predecessors in the early republic, take climate very personally. As this chapter has shown, climate pessimism has never been popular in the United States, whose citizens long ago embraced Jefferson's sunny optimism at the expense of the icy prognoses of the Comte de Buffon. To suggest that the American climate is bad or getting worse is, in this historical sense, unpatriotic.

But patriotic or not, Buffonian climate pessimism now enjoys its modern revival, in drag, as global warming. The twenty-first-century climate emergency, as we all know, involves not lack of heat but too much, while higher volumes of water vapor destabilize the carbon-charged atmosphere. A new era of Frankenstein's weather—heat waves, droughts, wild storms, and floods—are increasingly part of the fabric of American life. Cascading extreme weather events, of ever-greater size and frequency, now loom as a serious threat to the agriculture and prosperity of the nation—its Jeffersonian core. No longer an historical footnote, climate pessimism has returned in full, bounding and ferocious, like the dog who will have its day at last.

EPILOGUE

ET IN EXTREMIS EGO

So near to us in geological time, 1815–18 was—in human terms—a remote age of small farms and horses. Railroads and steamships lay a few decades in the future, the mass-produced automobile a century away. Cocooned within our own advanced food and transport infrastructure in the developed world, it is easy to lose sight of the significance of animal mortality on a preindustrial world. The cold conditions and lack of grain in Europe during the 1816–18 climate crisis meant untold losses in livestock and the death of countless thousands of horses. The decimation of Europe's preindustrial transport system prompted one young German nobleman, Karl von Drais, to tinker with alternative modes of locomotion. The result: a "velocipede," a crude prototype of the modern bicycle.[1]

This historical vignette from the Tambora period tells us three things. First, that this book has contained almost nothing on the perhaps irrecoverable history of Tambora's impact on the world's animal and biotic populations. Second, that the downstream effects of an ecological crisis on the scale of Tambora evolve over many decades (a commercial, mass-produced bicycle wasn't developed until the 1890s). And third, that these long-term impacts of drastic climate deterioration are felt not only in the physical world—in human and animal suffering—but in the world of ideas and technology, where sudden environmental dislocations act as an extraordinary stimulant.

The eruption of Mount Tambora in 1815 was a natural disaster with a long dragon-like tail. As a geological act of global climate sabotage, its explosion was responsible, in ways direct and indirect, for a Shakespearean shelf's worth of human tragedies: from transcontinental famines, to a global cholera epidemic, to an exponential growth in the Chinese opium trade, to the first "great" depression in U.S. history. But there are parallel stories of human progress also arising from the Tambora crisis. Among those examined in this book have been the first speculative steps toward Ice Age theory; a golden age of Arctic literature, science, and navigation (despite the body count); a great leap forward in the sciences of agriculture and meteorology (the first weather map!); and the tentative emergence of a modern, liberal idea of the state, in which government's responsibilities expanded, in the minds of many, to include the welfare of its citizens in times of crisis. In terms of progressive idea generation, we can only wish that our current climate emergency will do the same, that the pressures of painful adaptation to increasing extreme weather conditions will produce grand solutions to climate change itself. And soon.

Many such solutions have already been proposed, one of which bears directly on the subject of this book, namely geo-engineered moderation of the world's warming climate. Since Nobel Prize–winning earth scientist Paul Crutzen brought new publicity to the idea in a 2006 article, a flurry of scientific papers has considered the possibility of imitating the cooling impact of volcanic eruptions on global temperature by artificially injecting massive volumes of sulfate aerosols into the stratosphere.[2]

Evidence for the extraordinary folly of this idea is to be found on every page of this book. How ironic if a series of Tambora-sized eruptions were—by some dubious miracle of international cooperation—to be authorized, and we were to relive the weather chaos of 1815–18 not as a natural disaster but a staged volcanic catastrophe (à la Surrey Gardens) of our own making? On the other hand, for a technology-rich civilization addicted to photoshop realities and spectacular special effects—and little versed in the teleconnections of climate and human society—a supersized artificial volcano blast might make for an appropriate climax . . . or finale. But in such cynical reflections, as King Lear warns us, "madness lies."

Further complicating the project of artificial aerosol cooling is recent evidence that naturally occurring volcanic eruptions are already having an intermittent chilling effect on the impacts of man-made global warming. Even four relatively minor eruptions in the 2000–2010 period—in Indonesia, Ecuador, Papua New Guinea, and Montserrat—increased the stratospheric aerosol load sufficient to offset man-made warming by 25%.[3] Unfortunately, however, there is no volcanic solution—natural or artificial—to twenty-first-century climate change, since volcanoes explode unpredictably, while human carbon emissions remain on an inexorable upward trajectory.

• • •

A celebrated seventeenth-century painting by the landscapist Nicolas Poussin shows shepherds of antiquity in an idyllic rural setting under temperate blue skies, clustered about a stone tomb. They are pondering the enigmatic inscription on the tomb, which reads "Et in Arcadia Ego." Death appears to be saying: "I am with you here, even in paradise." The virile shepherds and a beautiful, well-dressed woman look on the mausoleum with curiosity and respect—and a healthy dose of disbelief. But life is so good here! they seem to say. The painting portrays the inevitability of death even as it celebrates, in loving rendering of the Arcadian landscape, the equable, life-sustaining climate that vitalized human civilization in the Mediterranean for thousands of years. Scientists call it the Holocene—the roughly twelve millennia of temperature stability since the last glacial epoch during which human agriculture flourished and with it human arts and culture. The cultural wealth of our Holocene legacy is embodied in Poussin's exquisite painting itself, even as its serene atmosphere offers us a window onto a now vanished climatological past.

It was also Paul Crutzen, would-be climate engineer, who popularized the term "Anthropocene" to distinguish the benevolent Holocene of Poussin's Arcadia from our modern fossil-fuel era. The



FIGURE E.1. Nicolas Poussin's *Shepherds of Arcadia* (1637–38), better known as *Et in Arcadia Ego* after the inscription barely legible on the tomb. Poussin's exact message in his painting—is he emphasizing the reality of death or the pleasures of Arcadia?—has been a debate point among art historians for centuries. In our century of climate change, the "choice" between these interpretations captures perfectly the situation facing global humanity. (© Musée du Louvre/Art Resource, New York.)

Anthropocene designates the age of accelerated urban-industrial development and population increase since 1750 that has wrought ever-increasing changes on the Earth's biosphere, and witnessed the contamination and depletion of its natural resources.[4] Where the deep time modulations of geology or Darwinian natural selection might be said to have long ruled unchallenged, we are now at the point, Crutzen and others have argued, where human beings have assumed the principal levers of control over biophysical conditions on planet Earth.

The Anthropocene came often to my mind as I sailed through open Arctic waters in the summer of 2012, on my intermittent global quest to retrace, in sublunary fashion, the course of Tambora's volcanic plume from the tropics to the poles. On a journey of some 2,500 nautical miles from the west coast of Greenland to northwestern Canada, our sturdy

Russian arctic vessel encountered a solitary thin film of sea ice.[5] The cruise ships and oil companies had already moved in, while the few polar bears we saw prowled along sandy beaches. I had come to see The Arctic!—but was already too late. This was not the smooth-running air-conditioner of our Holocene planet as I should have found it but a new Arctic altogether—the doomed-to-be-ice-free Arctic of the Anthropocene. When the summer ice does disappear altogether—a decade or two from now—the Arctic will be an open sea for the first time in a million years. Lounging on deck in a light cotton jacket, it was difficult to imagine the terrible privations of Ross or Franklin's crews in these waters: beset for years, frostbitten, starving. But for the flowering Arctic tundra on the shore, we might have been cruising the Hudson or the Rhine. "Et in Arcadia ego," I thought.

Because if death is always with us, according to Poussin—even in sunny, serene Arcadia— how much more true is this of a weather world in extremis, such as the Tambora-driven hell of 1815–18? The global death toll from Tambora was likely in the millions—or tens of millions if we include the worldwide cholera epidemic its eruption almost certainly triggered. Reflecting on Tambora's three-year extreme weather regime of the early nineteenth century, we cannot predict what the mortality rates of our own extended climate emergency will be in the Anthropocene age. Advanced infrastructure, technology, and communications guarantee first-world citizens far greater resilience against weather disasters than that available to the global peasantry of 1815–18. On the other hand, the unsustainable consumption rates of the West and high population growth in developing countries increase humanity's vulnerability overall. Already, the stresses on human food, water, and public health systems worldwide from a changing climate are immense and dangerously unpredictable.

Whatever the historical variables separating 1815 and 2015, the Tambora case study allows us, at the very least, to appreciate the scale of the current threat to human civilization. If a three-year climate change event in the early 1800s was capable of such destruction and of shaping human affairs to the extent I have described in this book, then the future impacts of multidecadal climate change must be truly off the

charts. It's difficult to think of any aspect of our lives and societies that won't be transformed in the coming decades, and for the worse.

Tambora's history, then, like Mary Shelley's *Frankenstein*, ultimately tells a cautionary tale. Both warn against the technological hubris of our modernity through figures of intense and widespread suffering. "All men hate the wretched," laments the Creature, Shelley's literary projection of the homeless, starving poor of Europe in Tambora's aftermath.[6] Two centuries on, the global ranks of the wretched are set to increase exponentially in coming decades at the hands of our own climate "Frankenstein," a monster who feeds on carbon waste and grows more violent by the year. Failure to draw down the carbon emissions and rampant deforestation that drive climate change brings us ever closer to the traumatized world of 1815–18 writ large. Imagine, if you can bear it, the "Seven Sorrows" of Tambora scaled to a planet of ten billion, and lasting for centuries. While the cautionary tale of Tambora's eruption has here been told at last, to write a history of the global climate breakdown of our early third millennium—with its relentless attrition of human well-being across all latitudes—might be beyond the capacity of any future historian, whose chaotic world it is.

ACKNOWLEDGMENTS

My grateful thanks, first of all, to my editor at Princeton, Ingrid Gnerlich, for her enthusiastic support for this project. She never flinched from the challenge of our highwire crossing between the sciences and humanities and has been a consistent and generous advocate. If our interdisciplinary ambitions have been realized here, others at Princeton University Press likewise share in that success, including Alison Kalett, Eric Henney, Debbie Tegarden, and Jennifer Backer—consummate professionals all.

At the outset of my Tambora research, indispensable help in grappling with the scientific literature on Tambora came from climatologist and Intergovernmental Panel on Climate Change (IPCC) coauthor Don Wuebbles and his graduate student Darienne Curio-Sanchez. Other scientists in the fields of volcanology and climatology provided illumination at crucial points, including Michael Schlesinger, Stephen Self, Bob Rauber, and anonymous readers at Princeton University Press. The guidance of all the above was vital for a humanist entering into the sometimes difficult terrains (and atmospheres) of the physical sciences.

The mostly unglamorous detective work required to bring the global *Tambora* story to light involved tracking down a vast range of nineteenth-century sources across multiple continents. This could not have been done without the magnificent library at the University of Illinois at my disposal and a host of expert staff. I wish to thank, in particular, Shuyong Jiang of the Asian Library, Adam Doskey in the Rare Book Room, and the staff of the Interlibrary Loan Office who dealt