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 advertise-

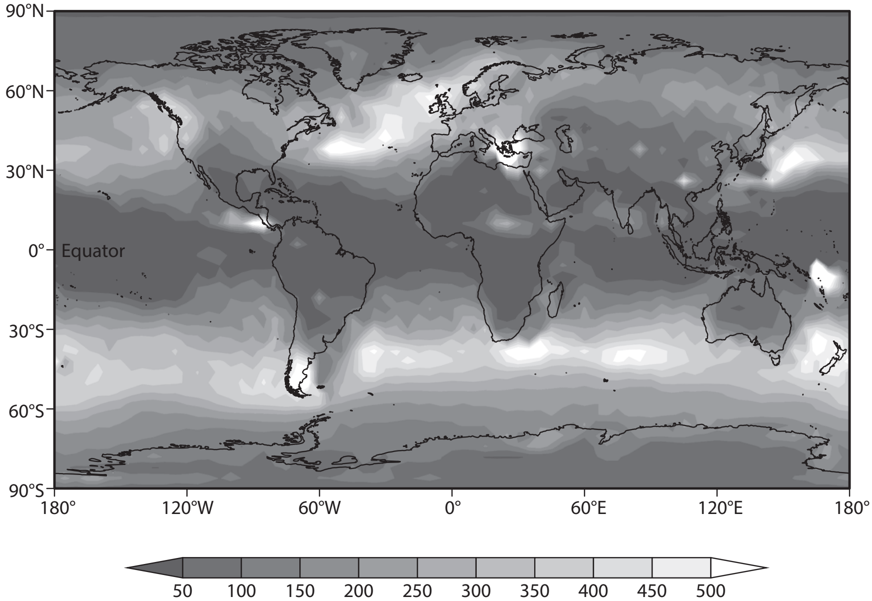

FIGURE 0.1. This 2007 model of Tambora's sulfate cloud shows its global reach, with a band of high aerosol concentration at mid- to high latitudes in both hemispheres, notably over the North Atlantic and Western Europe. This model situates the volcanic cloud in the stratosphere, 24–32 kilometers above 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).

ment 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]

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

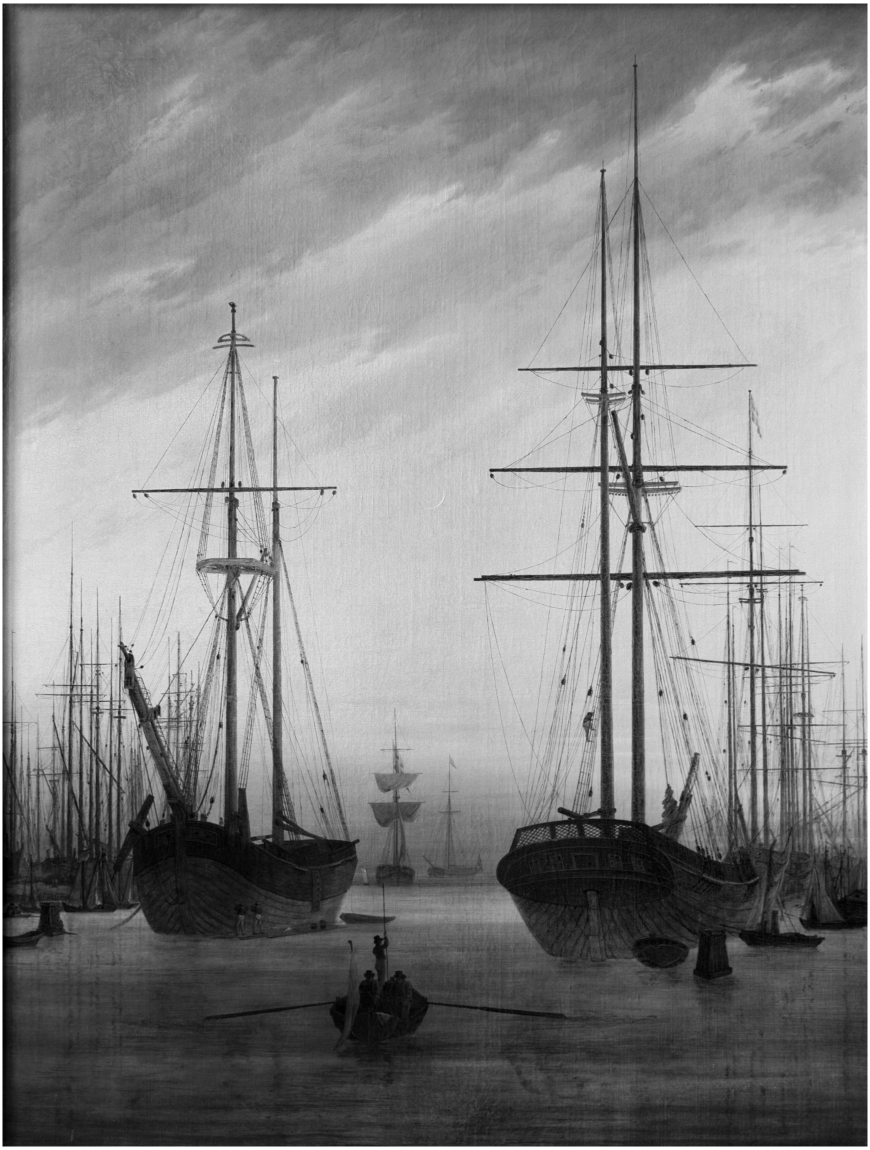

FIGURE 0.2. Caspar David Friedrich, *Ships in the Harbor* (1816). Sanssouci Palace, Potsdam. (© Erich Lessing/Art Resource, NY).

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

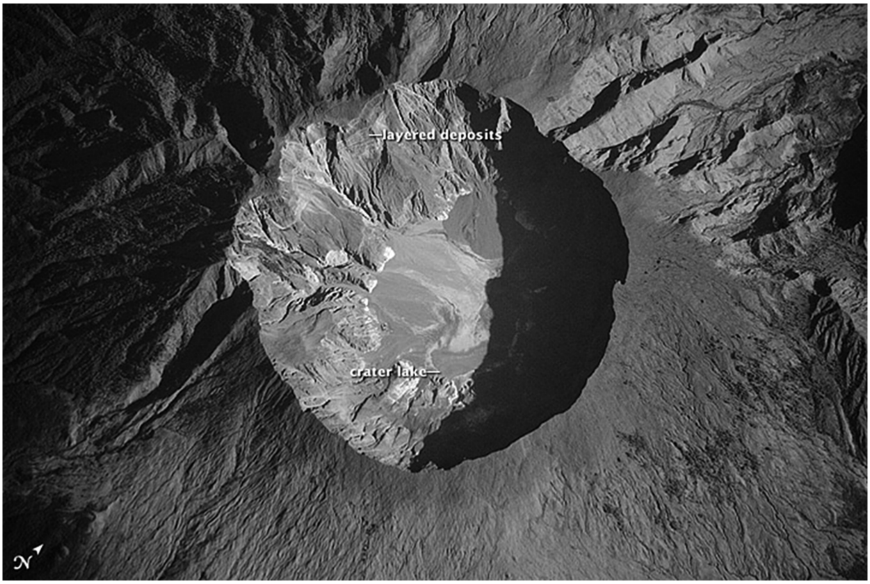

FIGURE 0.4. An aerial view of Tambora's caldera taken from the International Space Station shows its terrific, lunar-like dimensions. (NASA).

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.