1 Introduction: 1783 – A Year of Wonders

On 4 June 1783, the residents of Annonay in southern France gathered to witness the launch of the first hot-air balloon. With their invention, the MONTGOLFIER brothers had kick-started a new epoch; that of air travel. The orbicular silhouettes of hot-air balloons and hydrogen balloons, which took to the sky that same year, would not remain the only reason Europeans looked skyward that summer. A strange dry fog with a sulfuric odor appeared, as if from nowhere, and blanketed Europe, stretching as far as North America, Asia, and North Africa. This ominous mist lasted for several months, throughout the summer and into the autumn of 1783. It turned the sun blood-red and robbed its rays of their strength. An apparent increase in the frequency of thunderstorms, earthquakes, and other unusual phenomena coincided with this enduring fog. In 1784, reflecting on this marvelous period, the French writer Louis-Sébastien MERCIER (1740–1814) dubbed 1783 a year of wonders (*l'année des merveilles*).[1] Indeed, 1783 played host to many anomalies that did make it extraordinary – even for a year situated within the Little Ice Age (1250/1300–1850).[2]

What was causing this upheaval of the elements? Many Europeans thought about this question. These wonders were documented in newspaper reports, weather diaries, publications of learned societies, scholarly monographs, and private communications of the period. The fact that these phenomena were widely discussed and reflected upon is indicative of the great interest contemporaries had in them.[3] Emotions concerning these events ranged from giddy excitement to existential fear. Was all this a sign of an impending disaster? Could the natural sciences shed light on these phenomena? Speculation ran wild. The summer of 1783 was sweltering; was this the root of the problem? Could extraordinary events have an ordinary explanation? Were the earthquakes in Calabria to blame? Was the inclemency an expression of a much larger natural event that was taking place? The then-recent invention and installation of lightning rods prompted many to suggest that they were to blame. Could the emergence of a new, smoking island off the coast of Iceland have anything to do with it all? Was the tumultuous weather in any way related to the apparent eruptions of Gleichberg and Cottaberg, two mountains of volcanic origin in the German Territories?[4] Many even strove to connect a meteor, seen scorching a trail across the upper atmosphere, to these terrestrial events.

1 MERCIER 1784: 406.

2 DEMARÉE 2006: 878–879; GLASER 2008: 238; PAYNE 2010: 2–3.

3 A contemporary, in the context of this book, means a person living at the time of the discussed event, unless otherwise stated.

4 The official name of the German Territories is the Holy Roman Empire of the German Nation; in this book, I refer to it as the German Territories for the sake of brevity.

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While Europeans on the continent debated these ideas, Icelanders in the so-called Fire Districts had begun to fight for their very survival. Between 8 June 1783 and 7 February 1784, a 27-kilometer-long fissure, which would eventually consist of 140 craters and cones, tore through the highlands of south-central Iceland. This event produced the largest volume of lava of any volcanic eruption on the planet in the last millennium. It triggered the worst disaster in Icelandic history: one-fifth of the population perished in the aftermath, succumbing to disease or starvation. Volcanic ash and gases poisoned the fields and the waters, killing livestock and fish, the very things Icelanders depended upon.

This particular volcanic eruption came to have many names; in Icelandic, it is mainly referred to as *Skaftáreldar*, meaning "Skaftá Fires," after the Skaftá, the riverbed in which its lava flowed.[5] The Laki fissure itself is called *Lakagígar* in Icelandic, meaning "Laki craters."[6] The Icelandic people remember the eruption for its devastating consequence, which they call *móðuharðindin*, the famine of the mist. Internationally, the eruption of the Laki fissure is most often referred to as the "Laki eruption," the tradition I will follow. Mount Laki, the mountain at the center of the Laki fissure, did not erupt in 1783.[7] Scholars now agree that the Laki eruption was the cause of the dry fog that later haunted Europe.[8]

Volcanic ash and gases do not respect political borders. The eruption injected massive amounts of sulfur dioxide and other gases into Earth's atmosphere. These gases were transported further afield by the jet stream, strong winds in the upper atmosphere, and formed the dry fog that caused the frisson of excitement in mainland Europe that year. It is possible that the aerosols of the eruption, or even the dry fog itself, reached the Southern Hemisphere.[9] Despite the enormity of the Laki eruption, at the time, the outside world was oblivious.[10]

5 Karlsson 2000b: 178. *Eldar* is the plural form of *eldur* and means "fire"; Bragadóttir 2008: 281. Despite the fact that the suffix *-á* in Skaftá indicates that this is the name of a river, I have nonetheless referred to it as the Skaftá River for the reader's convenience.

6 The word *gígar* is the plural of *gígur*, which means "crater"; Bragadóttir 2008: 456.

7 De Boer, Sanders 2002: 118; Vasold 2004: 603; Witze, Kanipe 2014: 21, 148.

8 Demarée 1997: 879; Thordarson, Self 2003: 1–13.

9 According to a study by Trigo, Vaquero, and Stothers (2010), a Portuguese astronomer, Bento Sanches Dorta, who was based in Rio de Janeiro, witnessed an unusually high number of days with a dry fog or haze from 1784 to 1786; he did not observe this, however, in 1783. It is unlikely that the Laki haze descended upon Brazil a full year after the eruption. While Greenlandic ice cores show a signal of the Laki eruption, Antarctic ice cores do not reveal traces of this eruption. This is to be expected; usually, only strong tropical eruptions leave a signal in the ice of both poles. Gao et al. 2007; Zambri et al. 2019a.

10 For essays on the topic of environmental ignorance, see also Uekötter, Lübken 2014. In the last two decades, an emerging body of scholarship has embraced the history of ignorance in conjunction with the history of knowledge; Zwierlein 2016: 40; Daston 2017; Dürr 2021; Verbugt, Burke 2021: 1.

News of the eruption reached Europe in September 1783, by which time the dry fog had all but disappeared. Another decade would pass until the Icelandic naturalist Sveinn PÁLSSON (1762–1840) discovered the scarred landscape of the fissure, hidden in the remote highlands. Unfortunately, the Danish Natural History Society, the organization that supported his expedition, ran into financial difficulties; this led to an earlier-than-planned termination of his funding. As a result, PÁLSSON's research remained unpublished and – for the most part – unread for almost a century. Thus, the connection between the Laki eruption and the haze in Europe would remain a mystery until the 1880s. In that decade, Norwegian geologist Amund HELLAND (1846–1918) and Icelandic geologist Þorvaldur THORODDSEN (1855–1921) published on the Laki eruption, which – in the context of the colossal eruption of Krakatau in the Dutch East Indies in 1883, and its far-reaching effects – lifted the fog of ignorance.[11] That the unusual weather remained a mystery outside of Iceland for so long is what made this volcanic eruption and its aftermath so fascinating to research.

Contemporaries of the Laki eruption lived in an extraordinary time: a time of invention and uncertainty, trial and sometimes fatal error, a time of ingenuity and superstition. It was, for some, a time of exciting change, but for most, a time of great hardship. In 1783, the American diplomat, inventor, and polymath Benjamin FRANKLIN (1706–1790) wrote a letter to Joseph BANKS (1743–1820), British naturalist, botanist, and the president of the Royal Society of London that offers insight into the state of science in Europe at the time. FRANKLIN was thrilled by the pace of discovery and the resources available for experimentation.

> Furnish'd as all Europe now is with Academies of Science, with nice Instruments and the Spirit of Experiment, the Progress of human Knowledge will be rapid, and Discoveries made of which we have at present no Conception. I begin to be almost sorry I was born so soon since I cannot have the Happiness of knowing what will be known 100 Years hence.[12]

The Enlightenment – an eighteenth-century social and intellectual movement concerning human rationality and autonomy – influenced much of western Europe by 1783.[13] The term means, at its core, to illuminate one's mind. It was a contemporary term used by German philosopher Immanuel KANT (1724–1804) in 1784 when he explained that "the Enlightenment is the human's emancipation from their self-incurred immaturity" through reason.[14] New research into the Enlightenment reveals that it was far from a homogeneous movement; the eighteenth century was a period characterized by complexity and contradiction. The reach of the Enlightenment differed from region to region; in some areas, it began earlier than in others.[15] Many naturalists, amateur

11 HELLAND 1886; THORODDSEN 1914.
12 FRANKLIN 2011: 399, Benjamin FRANKLIN in a letter to Sir Joseph BANKS, Passy, 27 July 1783.
13 D'APRILE, SIEBERS 2008: 13–14; STOLLBERG-RILINGER 2011: 14.
14 ALT 2007: 3; STOLLBERG-RILINGER 2011: 9–10.
15 HOCHADEL 2003: 29; STOLLBERG-RILLINGER 2011: 15.

weather observers, and philosophers of the time were in a good position and well-equipped to observe, record, and interpret the many unique weather phenomena of the year. Several learned societies existed that regularly published their findings, including numerous reports on the strange fog of the summer of 1783.

Previous Scholarship

Ever since Amund HELLAND and Þorvaldur THORODDSEN's work connected the Laki eruption to the dry fog of 1783, several scholars have tasked themselves with the study of the Laki fissure using the new scientific methods available to them. I will elaborate on the discoveries of PÁLSSON, HELLAND, and THORODDSEN and several other scholarly expeditions to Iceland and the Laki fissure in detail in Chapter Four.

Guðmundur G. BÁRÐARSON (1880 –1933) was an Icelandic scientist who, in 1929, recognized that the volcanoes of the Reykjanes Peninsula belonged to distinct volcanic systems. He refers to these systems as *vulkanbaelter* (volcanic belts). Later studies independently reached the same conclusions regarding the overall volcano-tectonic architecture of Iceland.[16] Icelandic geologist Sigurður ÞÓRARINSSON (1912–1983) mentioned the Laki eruption in his 1952 lecture, *The Thousand Years Struggle against Ice and Fire,* and in a subsequent 1956 publication.[17] ÞÓRARINSSON's work on the Laki eruption intensified from the 1960s to the 1980s; he contributed much to the event's re-emergence from the dustbin of history. ÞÓRARINSSON researched physical descriptions of the eruption and its environmental impact. In addition to studying Laki's effects on Iceland, he also worked on the impact of the eruption on the wider world, particularly Scandinavia. ÞÓRARINSSON also described the wide-ranging consequences of the "bluish gray haze or mist" that spread over much of Europe, Asia, and North Africa.[18] Photographs taken by ÞÓRARINSSON show that he visited the Laki fissure in 1938, 1958, 1962, and 1967.[19] In 1979, Icelandic geologist Sveinn JAKOBSSON first argued that the Laki eruption was part of the Grímsvötn system.[20]

In 1965, historian Vilhjálmur BJARNAR published a paper titled "The Laki Eruption and the Famine of the Mist." In the essay, he cites ÞÓRARINSSON's and THORODDSEN's research. His paper asserts that the "same type of mist [as in Iceland] was seen in the air over a large part of the northern hemisphere, [. . .] from Siberia to North America

16 BÁRÐARSON 1929: 187; THORDARSON, LARSEN 2007: 123.

17 ÞÓRARINSSON 1956b.

18 ÞÓRARINSSON 1969. The paper was read at the IAVCEI international symposium on Volcanology in 1968. For his other papers on the Laki eruption, see ÞÓRARINSSON 1953; ÞÓRARINSSON 1979: 150–156; ÞÓRARINSSON 1981: 112–117.

19 ÞÓRARINSSON 1969.

20 JAKOBSSON 1979; GUÐMUNDSSON 1989; THORDARSON, SELF 1993: 236.

and from Europe to North Africa."[21] However, this paper mainly analyzes the impact of the eruption and the fog on Iceland and its population. In 1972, climate historian Christian PFISTER conducted an early study that examined the dry fog outside of Iceland with a focus on Switzerland.[22] Historian Otto MÄUSSNEST briefly studied the dry fog's effects on Germany in a 1983 paper.[23]

Volcanology progressed along with the wider field of geology; in the 1970s, glaciologists began to look for traces of volcanic eruptions, particularly sulfur dioxide and tephra, in ice cores drilled from Antarctica and Greenland.[24] This work, in combination with other proxy data, helped volcanologists to date volcanic eruptions more precisely. Generally, the rule is that traces of strong tropical eruptions can be found in ice cores from both poles, whereas traces from high-latitude eruptions can be found in the ice sheets of their respective poles. A very strong sulfate signal from the Laki eruption has been found in Greenland, and a sulfate layer from it has been found in the northeastern Canadian Arctic and Spitsbergen. Tests of ice cores from western China proved inconclusive.[25]

In 1970, climatologist Hubert Horace LAMB invented the dust veil index (DVI), in which a number represents the volume of dust and aerosols released by a volcanic eruption. The output of Krakatau in 1883 was used as a reference value and had a DVI of 1,000. LAMB's paper discusses various past dust veil events, including the one from 1783. Several maps in the paper show how different volcanoes produce different dust veil spreading patterns. LAMB gives the "Laki-Skaptar Jökull" eruption a DVI value of 2,300.[26] Unbeknownst to Europeans at the time, Mount Asama in Japan also erupted in 1783. LAMB estimated that the combined effect of the "two very great eruptions" in Iceland and Japan generated a cooling in the Northern Hemisphere of 1.3 °C.[27] Although the Asama eruption had devastating local consequences, new research conducted after LAMB developed his DVI shows that the Asama eruption did not significantly influence the weather in the Northern Hemisphere.[28]

21 BJARNAR 1965: 415.
22 PFISTER 1972.
23 MÄUSSNEST 1983.
24 CLAUSEN, HAMMER 1988; FIACCO et al. 1994; ZIELINSKI et al. 1994; ZIELINSKI 1995.
25 STOTHERS 1996: 82. Volcanic signals in ice cores: HAMMER 1977; HAMMER, CLAUSEN, DANSGAARD 1981; HAMMER 1984; CLAUSEN, HAMMER 1988; MAYEWSKI et al. 1990; DE ANGELIS, LEGRAND 1994. Volcanic signals in the northeastern Canadian Arctic: KOERNER, FISHER 1982; FISHER, KOERNER 1994. Volcanic signals in Spitsbergen: FUJII et al. 1990. Volcanic signals in western China: THOMPSON 1989; THOMPSON 1990.
26 LAMB 1970: 509 (Laki). This is the combined value of the Laki eruption and the Nýey eruption (here referred to as "Eldeyjar"; for more information on Nýey, see Chapter Three). LAMB (1970: 512) gave the Tambora eruption a DVI of 3,000. See also LAMB 1977; LAMB 1983; LAMB 1985; KELLY, SEAR 1982.
27 LAMB 1995: 297.
28 ZIELINSKI et al. 1994; STOTHERS 1996: 86. The Asama eruption lasted from 9 May to 5 August 1783 and reached a VEI 4; Global Volcanism Program: Asamayama.

In the early 1980s, geologist Tom L. SIMKIN and his colleagues published a catalog of all the known past volcanic eruptions in the world.[29] This catalog uses the volcanic explosivity index (VEI) to categorize these eruptions. The VEI is a logarithmic scale ranging from zero to eight. Apart from VEI 0 to 2, every number represents a tenfold increase in explosivity. Different criteria, such as the volume of erupted ejecta, the height of the eruption cloud, and other observations, influence the classification of a given volcanic eruption. The VEI is not perfect, as all forms of output – for example, ash, lava, and lava bombs – are treated the same and it does not consider sulfur dioxide emissions.[30] A rating of VEI 0 indicates a constant, effusive eruption like Kīlauea on the island of Hawaiʻi, while a rating of VEI 8 indicates a mega-colossal eruption like the Toba event in 72,000 BC.[31] The most recent large eruption was the VEI 7 super-colossal eruption of Tambora in 1815, a volcano in today's Indonesia, which famously caused a year without a summer in 1816 in North America and Europe.[32] This kind of eruption only occurs once or twice per millennium. Eruptions on the scale of the 1991 Pinatubo eruption in the Philippines (VEI 6, colossal) occur every 50 to 100 years. Despite the fact that it released an astonishingly large volume of lava, the Laki eruption ranks low on the index of volcanic explosivity (VEI 4, cataclysmic). This kind of eruption is known as a flood basalt event.[33] Volcanic eruptions can have an impact far beyond their immediate vicinity, with their gases potentially affecting the climate for several years.[34]

In 1983, the Laki eruption had its 200-year anniversary. Many Icelandic scholars from a variety of disciplines contributed to a book on the eruption and its consequences for Iceland. The volume is titled *Skaftáreldar 1783–84: Ritgerðir og Heimildir* (The 1783–1784 Laki Eruption: Essays and Sources). More than 400 pages long, this book features new research on various aspects of the Laki eruption, ranging from geology to society and health. It also includes a collection of transcriptions of primary materials. The book is in Icelandic, with short English-language summaries of each article.[35] Historians Gaston DEMARÉE and Astrid OGILVIE give credit to the Laki eruption's bicentennial for once again piquing the interest of scholars. After 1984, several studies

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29 SIMKIN et al. 1981; NEWHALL, SELF 1982.

30 MILES, GRAINGER, HIGHWOOD 2003. Further estimates of the magnitude and stratospheric sulfur injections for eruptions between 500 BCE and 1900 CE can be found in the eVolv2k database; TOOHEY, SIGL 2017.

31 NEWHALL, SELF 1982; AMBROSE 1998; VOGRIPA: Toba; DE BOER, SANDERS 2002: 258.

32 WOOD 2014; BEHRINGER 2019.

33 SIMKIN et al. 1981: 123; NEWHALL, SELF 1982.

34 Global Volcanism Program: Eyjafjallajökull. For an overview of recent scholarship on the effects of volcanic eruptions on climate, see MARSHALL et al. 2022.

35 GUNNLAUGSSON et al. 1984.

were published on Laki, mostly concerning the eruption itself and its aftermath within Iceland.[36]

In the 1990s, scholars were increasingly inclined to broaden the scope of their research. Many of these studies employed historical sources to reconstruct the eruption's impact on continental Europe, mainly Britain and France, and to reveal how the dry fog was perceived at the time. The first major texts analyzing the effects of the Laki eruption on regions outside of Iceland were written by historian Charles WOOD and physical scientist Sigurður STEINÞÓRSSON in 1992.[37] In 1993, historians Roland RABARTIN and Philippe ROCHER studied the possible impact of the Laki eruption on the French weather and harvest prior to the French Revolution.[38] In 1994, environmental and archaeological scientist John GRATTAN began studying the environmental impact of, and social responses to, the eruption with the help of historical British newspaper reports. Numerous papers throughout the 1990s and 2000s, with various co-authors, such as environmental scientist Daniel CHARMAN, scientist F. Brian PYATT, human geographer Mark BRAYSHAY, geoarchaeologist David GILBERTSON, Earth scientist Michael DURAND, and biogeographer John SADLER, analyzed the effects of Laki's volcanic gases on human health and vegetation in Britain and France.[39] Other work on the dry fog, from 1996 onward, was carried out by scientist Richard STOTHERS and historians Astrid OGILVIE and Gaston DEMARÉE, amongst other scholars.[40]

In their 2003 paper, volcanologists Thorvaldur THORDARSON and Stephen SELF also discuss in great detail the phenomenon they call the "Laki haze" using a variety of historical sources. From these sources, they reconstructed when and where the haze occurred, how high it might have reached, the optical effects it produced, and the heat wave with which it coincided.[41] In 2004, historian of science Manfred VASOLD published a short paper on the Laki eruption, which touches on the dry fog, warm temperatures, and health complaints in the German Territories in the summer of 1783, as well as the cold weather, floods, and ice drifts during the winter of 1783/1784.[42] Historian Oliver HOCHADEL briefly looked at the Laki eruption and the dry fog of 1783 as part of his paper on the introduction of lightning rods to the German Territories.[43] Prior to this book, and apart from GRATTAN's paper on the Gleichberg eruption and THORDARSON and

36 DEMARÉE, OGILVIE, ZHANG 1998. Studies published after 1984: OGILVIE 1986; STOTHERS et al. 1986; WOODS 1993.

37 STEINÞÓRSSON 1992; WOOD 1992.

38 RABARTIN, ROCHER 1993.

39 GRATTAN, CHARMAN 1994; GRATTAN, PYATT 1994; GRATTAN, BRAYSHAY 1995; GRATTAN, BRAYSHAY, SADLER 1998; BRAYSHAY, GRATTAN 1999; GRATTAN, SADLER 1999; GRATTAN, PYATT 1999; GRATTAN, GILBERTSON, DILL 2000; GRATTAN, SADLER 2001; GRATTAN, BRAYSHAY, SCHÜTTENHELM 2002.

40 STOTHERS 1996; DEMARÉE 1997; DEMARÉE, OGILVIE, ZHANG 1998 (comment on STOTHERS 1996); OGILVIE, JÓNSSON 2000; DEMARÉE, OGILVIE 2001.

41 THORDARSON, SELF 2003: 6–25.

42 VASOLD 2004.

43 HOCHADEL 2009: 55–58.

SELF's research on some historical sources from Germany, the papers mentioned above were the only works conducted on the impact of the Laki eruption on the German Territories.[44]

More work on the eruption's consequences for France was carried out by historians Emmanuel LE ROY LADURIE in 2006 and Emmanuel GARNIER in 2009.[45] LE ROY LADURIE describes Laki's effects as rather unspectacular, particularly when compared to Tambora.[46] In 2014, science journalist Alexandra WITZE and science writer Jeff KANIPE published a popular science book called *The Extraordinary Story of Laki, the Volcano that Turned Eighteenth-Century Europe Dark*.[47] This was the first book exclusively dedicated to the history of the Laki eruption. In 2019, literary scholars such as David HIGGINS and David MCCALLAM took a closer look at the Laki eruption.[48] In the 2000s, the aftermath of the Laki eruption was further studied; in particular, scholars evaluated the cold temperatures of the winter of 1783/1784, the flooding of several European rivers, and the ice drifts.[49]

One particular aim of current research is to understand whether the Laki eruption caused a mortality crisis.[50] In 2004, atmospheric scientist Claire WITHAM and volcanologist Clive OPPENHEIMER analyzed mortality rates in England during the eruption; they were drawn to conclude that the eruption probably contributed to extra deaths.[51] In 2011, Earth scientist Sabina MICHNOWICZ further explored this mortality crisis within Great Britain in her thesis. She argues that the data does not point to a surge in mortality that can be linked to the eruption.[52] In 2021, Geoffrey HELLMAN analyzed nearly 1,500 parish registers from England, Wales, the Isle of Man, and Jersey, among others, to ascertain the mortality rate in these places during and after the Laki eruption; his findings suggest that "the Laki eruption was unlikely to have caused a huge surge in the rate of mortality in Britain."[53]

In 2011, volcanologist Anja SCHMIDT modeled how much excess mortality Europe would face in the case of a Laki-style eruption in the present. SCHMIDT assumes that

44 GRATTAN, GILBERTSON, DILL 2000; THORDARSON, SELF 2003.
45 LE ROY LADURIE 2006: 111–122; GARNIER 2009: 72–77.
46 LE ROY LADURIE 2006: 119.
47 WITZE, KANIPE 2014.
48 MCCALLAM 2013; HIGGINS 2019; MCCALLAM 2019.
49 GLASER, HAGEDORN 1990; MUNZAR, ELLEDER, DEUTSCH 2005; DEMARÉE 2006; POLIWODA 2007: 59–84; BRÁZDIL et al. 2010.
50 GRATTAN 1998; DURAND, GRATTAN 1999; DURAND, GRATTAN 2001; GRATTAN, DURAND, SCHÜTTENHELM 2001; GRATTAN, DURAND 2002; GRATTAN, DURAND, TAYLOR 2003; GRATTAN et al. 2003; COURTILLOT 2005; GRATTAN et al. 2005.
51 WITHAM, OPPENHEIMER 2004.
52 MICHNOWICZ 2011.
53 HELLMAN 2021: 239.

with long-term exposure to PM 2.5, particulate matter smaller than 2.5 micrometers, an additional 142,000 people in Europe would perish from cardiopulmonary diseases.[54]

Volcanology changed in the 1990s when satellites began to monitor the atmosphere from space and observe changes in atmospheric chemistry over time. The VEI 6 volcanic eruption of Pinatubo in Philippines was observed by satellite, as was the spread of its volcanic gases into the atmosphere: this provided further proof that ash and gases ejected by volcanic eruptions can have far-reaching global impacts that influence the climate.[55] In 2000, climate modeler Alan ROBOCK published a paper on the mechanisms of volcanic eruptions and how they affect the climate, mainly based on observations of recent eruptions such as Mount St. Helens in 1980, El Chichón in 1982, and Mount Pinatubo in 1991. He asserts that volcanic eruptions that release large amounts of sulfur dioxide are now known to have the potential to perturb the climate significantly.[56] Other relevant scholarly works on the impact of volcanic eruptions on the atmosphere include published papers by Clive OPPENHEIMER, Jelle Zeilinga DE BOER, Donald T. SANDERS, and Haraldur SIGURÐSSON.[57]

Thor THORDARSON and scientists Ármann HÖSKULDSSON and Guðrún LARSEN have contributed to the breadth of knowledge of Icelandic volcanism.[58] New methods and technologies have produced new insights into eruption sequences and effusion rates. THORDARSON and Stephen SELF have come to a different conclusion than Sigurður ÞÓRARINSSON.[59] Initially, flood basalt events did not figure much into the debate regarding the possible effects of volcanic eruptions on climate. It was not until the 1990s that further research on them changed the discourse.[60] It was now accepted that numerous eruptive episodes during one flood basalt event could release large amounts of sulfur from basaltic magma that can result in sulfuric aerosols (H_2SO_4) staying in the atmosphere for months to years.[61] In 1993, THORDARSON and SELF reconstructed the different eruptive episodes of the Laki eruption, estimated the output of gases, tephra, and lava, and even considered the environmental impact beyond Iceland.[62]

At present, several satellites orbit Earth, taking images, observing weather patterns, measuring gas concentrations, and much more. Scholars know that at any

54 SCHMIDT et al. 2011; LOUGHLIN et al. 2012; SCHMIDT 2013: 114.

55 MCCORMICK, THOMASON, TREPTE 1995; SELF et al. 1996; PAYNE 2010; GRATTAN, DURAND, TAYLOR 2003: 401–402.

56 ROBOCK 2000; OMAN 2006b.

57 SIGURÐSSON 1999; DE BOER, SANDERS 2002; OPPENHEIMER, PYLE, BARCLAY 2003; ROBOCK, OPPENHEIMER 2003; FRANCIS, OPPENHEIMER 2004; OPPENHEIMER 2011.

58 THORDARSON 1990; THORDARSON 1995; THORDARSON et al. 1996; THORDARSON, SELF 2003; THORDARSON, LARSEN 2007; THORDARSON, HÖSKULDSSON 2008; THORDARSON, HÖSKULDSSON 2014.

59 ÞÓRARINSSON 1969; THORDARSON, SELF 1993: 234.

60 THORDARSON, SELF 1993: 234; SELF et al. 1996; SELF, THORDARSON, KESZTHELYI 1997; THORDARSON 2005: 205.

61 THORDARSON et al. 1996; THORDARSON 2005: 205.

62 THORDARSON, SELF 1993: 258–261.

given time, there are around 40 volcanic eruptions taking place on planet Earth. Currently [January 2023], the Smithsonian Institution's Global Volcanism Program lists 44 eruptions as ongoing.[63] Most of these eruptions do not make the news, as they are small, occur in remote areas, and are detectable only by satellite. Volcanic eruptions have the potential to wreak havoc, especially when they occur near inhabited areas. The direct consequences of these eruptions, such as lava flows, ashfall, pyroclastic flows, and gases that pollute the air, can be devastating. That said, large and explosive volcanic eruptions are relatively rare.

Over the past two decades, climate modelers have studied the Laki eruption in detail. The first models of the atmospheric impact of Laki were conducted in 2003 by atmospheric scientist David S. STEVENSON, atmospheric physicist Ellie J. HIGHWOOD, and Thor THORDARSON.[64] Further modeling followed in 2005 and 2006. Environmental scientist Luke OMAN's work mainly focuses on the impact of high-latitude eruptions on monsoonal rains and the Nile River floods.[65] Anja SCHMIDT and her colleagues also modeled the climate impact of the Laki eruption.[66]

Whether a volcanic eruption has long or short-term effects on the weather depends on several factors. These include the latitude, time of year, and, most importantly, how much sulfur dioxide is released and how high the volcano injects it into the atmosphere (Figure 1).[67] Today we know that volcanic gases in the lower part of the atmosphere (the troposphere) have severe consequences at ground level lasting a few weeks to months. In contrast, volcanic gases in the upper part of the atmosphere (the stratosphere) can alter the climate for up to a few years, a process called climate forcing.[68] If sulfur dioxide reaches the stratosphere, it undergoes oxidization and becomes sulfuric acid aerosol particles. These microscopic particles reflect incoming solar radiation back into space and cause a cooling of the troposphere (known as the albedo effect or volcanic forcing).[69]

63 Global Volcanism Program: "Current Eruptions"; Global Volcanism Program: "How Many Volcanoes Are There?"

64 HIGHWOOD, STEVENSON 2003; STEVENSON et al. 2003; THORDARSON et al. 2003a.

65 CHENET, FLUTEAU, COURTILLOT 2005; OMAN et al. 2005; OMAN et al. 2006a; OMAN et al. 2006b.

66 SCHMIDT et al. 2010; SCHMIDT et al. 2012: This study states that 120 Tg of sulfur dioxide were released to the upper troposphere/lower stratosphere, which was followed by three years of below-average temperatures. The climate modeling conducted by this study suggests that the radiative effects produced by the eruption lasted long enough to contribute to the winter cooling. A question that remains is why the summer of 1783 was so warm. On this matter, also see COLE-DAI et al. 2014 (comment on SCHMIDT et al. 2012); SCHMIDT et al. 2014b (response to comment by COLE-DAI et al. 2012); SCHMIDT et al. 2016.

67 KRAVITZ, ROBOCK 2011; WITZE, KANIPE 2014: 131–132.

68 GRATTAN, PYATT 1999; PAYNE 2010: 4.

69 ROBOCK 2000: 191–193; GRATTAN, SADLER 2001: 141; GRATTAN, BRAYSHAY, SCHÜTTENHELM 2002: 88; OPPENHEIMER 2011: 44–46; COOPER et al. 2018: 239.

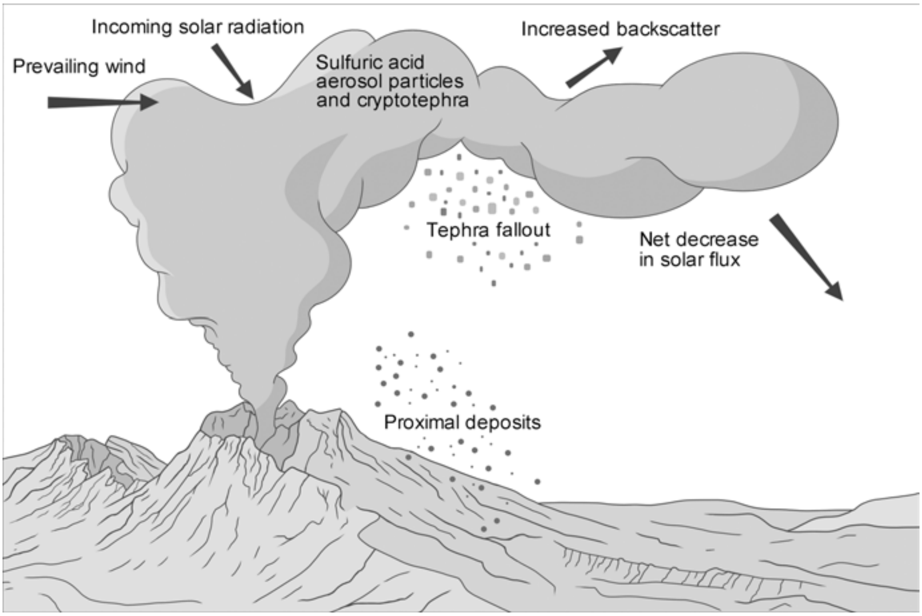

Figure 1: Volcanic outputs injected into the atmosphere.[70]

In Iceland, the stratosphere begins at only nine to 13 kilometers above sea level, as opposed to approximately 18 kilometers in the tropics.[71] To this day, scientists still debate whether the gases released by the Laki eruption reached the stratosphere or only the troposphere.[72] Evidence suggests that they only reached the troposphere: the gases appeared above Europe within a week and were mostly washed out by precipitation within three to four months. Additionally, ice core drillings in Greenland show sulfur particles for 1783 but not for 1784.[73] These points, together with the fact that the gases' effects were noticeable at ground level, all suggest they only reached the troposphere.[74] Although THORDARSON and SELF have done much work reconstructing the volume of sulfur dioxide released by the different eruptive phases, the resulting figures

70 For more information and details on the copyright for all of the illustrations, see the list of illustrations at the end of this book.

71 THORDARSON et al. 1996: 207; WITZE, KANIPE 2014: 130.

72 The following scholars argue that the volcanic gases reached the stratosphere: SCARTH 1999: 113; OMAN et al. 2006b: 1; GLASER 2008: 234; OPPENHEIMER 2011: 276; SCHMIDT et al. 2012; WITZE, KANIPE 2014: 134. Brian ZAMBRI et al. argue that most of the aerosols had dissipated by May 1784 (2019a: 6753). These scholars argue that only the troposphere was reached: WOOD 1992: 70–71; GRATTAN, BRAYSHAY 1995: 2; STOTHERS 1996: 79; GRATTAN, SADLER 2001: 138; GRATTAN, BRAYSHAY, SCHÜTTENHELM 2002: 88; GRATTAN, DURAND, TAYLOR 2003: 402.

73 WOOD 1992: 70–71.

74 GRATTAN, BRAYSHAY, SCHÜTTENHELM 2002: 92.

are still uncertain. David STEVENSON and Luke OMAN estimate the uncertainty to be up to 20 percent.[75] Future models might need to adjust these volumes.[76]

The winter of 1783/1784 was 3 °C below the mean (1778–1782), and cooling could be observed from 1784 to 1786; the overall temperature suppression for Europe is estimated to have been between 1° and 2 °C.[77] In contrast, the summer of 1783 was unusually warm: the temperatures in July 1783 in western Europe were almost 3 °C above the mean. Climate models have shown that volcanic cooling should have occurred during that summer. In general, volcanic eruptions increase the albedo effect, as they lead to a decrease in the solar radiation that is absorbed by Earth.[78]

Atmospheric circulation alters heat distribution and causes spatial variation in volcano-related cooling of the planet. Although the Laki eruption likely caused cooling over the year, western European historical sources describe drought and soaring temperatures during the summer.[79] Several temperature reconstructions also confirm this warm weather.[80] For a long time, this puzzled scientists. GRATTAN and SADLER have proposed that the sulfuric gases emitted created a greenhouse effect, which led to higher temperatures.[81] Other studies have subsequently shown that this greenhouse effect was relatively small and probably could not explain the warm temperatures.[82] THORDARSON and SELF argue that the warm summer was due to climate variability.[83]

The latest climate modeling work carried out by Brian ZAMBRI and his colleagues seems to confirm THORDARSON and SELF's hypothesis: a high-pressure system located over northern Europe created atmospheric blocking and caused the heat wave of July 1783. The hot air remained in northern and western Europe, whereas cold polar air traveled to eastern Europe and the Middle East. The Laki eruption caused a phenomenon called hemispherically asymmetric volcanic forcing, which disturbed normal weather patterns

75 STEVENSON et al. 2003; OMAN 2006b.

76 ZAMBRI et al. 2019b: 6787.

77 LAMB 1970; ANGELL, KORSHOVER 1985; BRIFFA et al. 1998; PÍSEK, BRÁZDIL 2006.

78 HANSEN, WAND, LACIS 1978; GRATTAN, SADLER 1999: 162; OMAN et al. 2006b; OPPENHEIMER 2011: 282–283; ZAMBRI et al. 2019b: 6777.

79 THORDARSON, SELF 1993; JACOBY, WORKMAN, D'ARRIGO 1999: 1365.

80 MANLEY 1974; KINGTON 1980; KINGTON 1988; PARKER, LEGG, FOLLAND 1992; LUTERBACHER et al. 2004. Notable exceptions were temperature reconstructions based on maximum latewood density in tree rings from Sämtland in Sweden that showed a cool summer (TINGLEY, HUYBERS 2013; LUTERBACHER et al. 2016; ANCHUKAITIS et al. 2017). EDWARDS et al. (2022) have shown that the acidity of the Laki haze likely created anatomical anomalies in the trees, which means that these tree rings are not suitable for reading the temperature for the summer of 1783; KLEEMANN 2022b.

81 GRATTAN, SADLER 1999: 141, 164; GRATTAN, SADLER 2001.

82 HIGHWOOD, STEVENSON 2003.

83 THORDARSON, SELF 2003.

in the Northern Hemisphere. During the summer of 1783, temperatures were hotter than usual in some areas of the Northern Hemisphere, such as western and northern Europe, and colder than usual in other areas, such as Alaska and northwest Siberia.[84] The close connection between the high-pressure system and the heat seems to be corroborated by the fact that with the dispersion of the high-pressure system, temperatures in western Europe returned to normal.[85] Without the Laki eruption, the heat wave would likely have been even more intense than it was.[86] Thus, in the case of a future Laki-style event, Europe should expect cooling rather than warming.

Another topic of debate in the scientific literature is why the winter of 1783/1784 was so cold. Better multi-proxy records exist for summer temperatures; analyses of tree rings, among the other archives of nature, offer this high-resolution data. Winter temperature records are mainly based on early instrument readings and written documents.[87] The written records are in good agreement that the winter of 1783/1784 was severely cold. Did the Laki eruption cause this freezing winter? A previous study by paleoclimatologist Rosanne D'ARRIGO and colleagues in 2011 suggests that the severely cold winter of 1783/1784 was due to natural climate variability in the shape of a positive El Niño-Southern Oscillation (ENSO) phase and a negative phase of the North Atlantic Oscillation (NAO). They argue that these conditions randomly arose at that time. The same conditions occurred in 2009/2010 and caused an anomalously cold winter in Europe and eastern North America.[88] While ENSO is a variation in wind and sea surface temperatures over the central and eastern Pacific with worldwide teleconnections, the NAO is a fluctuation of sea level pressure between the Icelandic Low and the Azores High. ZAMBRI and his colleagues argue, based on their climate models, that the Laki eruption actually precipitated a positive ENSO phase. This finding is corroborated by results from a study undertaken by climate modeler Francesco PAUSATA and his team: they argue that a southward shift of the Intertropical Convergence Zone (ITCZ) in the aftermath of a high-latitude volcanic eruption leads to a positive ENSO phase, particularly if La Niña or neutral ENSO conditions are present at the time of the eruption.[89] However, there is some debate about how long the ENSO event around the time of the Laki eruption lasted.[90]

Scientists have proposed a connection between Icelandic volcanic eruptions and fluctuations in the Nile River floods. Fluctuations certainly took place in 1783 and

84 ZAMBRI et al. 2019b: 6771, 6777–6778.
85 GRATTAN, SADLER 1999: 169.
86 ZAMBRI et al. 2019b: 6771, 6777–6778.
87 FRANKE et al. 2017.
88 D'ARRIGO et al. 2011.
89 PAUSATA et al. 2015; PAUSATA et al. 2016; ZAMBRI et al. 2019b: 6787.
90 D'ARRIGO et al. 2011; DAMODARAN et al. 2018: 521–522; GROVE 2007.

1784.[91] As described above, climate models have shown that the asymmetric cooling in the Northern Hemisphere created a southward shift of the ITCZ. Thus, there was a decrease in precipitation in the tropics; the June eruption, therefore, influenced the monsoonal rains that would usually occur around that time of the year and so triggered droughts in India and eastern Africa. This led to a low Nile River flow in 1783, which resulted in famine in Egypt.[92]

Natural scientists have studied volcanic eruptions worldwide and have established valuable chronologies, which are updated with the availability of data from more precise dating of ice cores.[93] In 2015, glaciologist Michael SIGL and his colleagues re-dated volcanic signals in Greenland and Antarctica's ice cores from the past 2,500 years with the help of multi-proxy records (Figure 2). In particular, spikes of radiocarbon in tree rings caused by extraterrestrial events between 774/775 CE and 993/994 CE serve as precise time markers around the globe.[94]

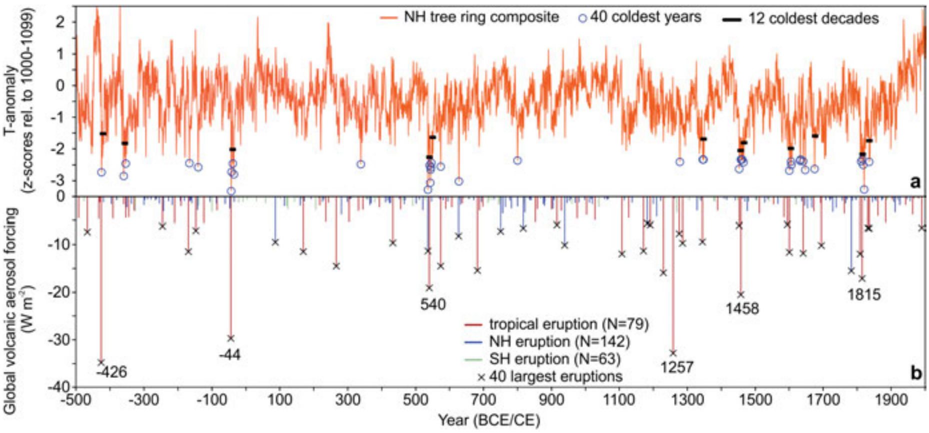

Figure 2: Northern Hemisphere temperature variations (above) and global volcanic aerosol forcing (below), 500 BCE to 2000 CE.

For a long time, in the natural sciences, many volcanologists presumed that tropical eruptions were more likely to have a significant global impact than high-latitude eruptions. High-latitude eruptions were generally believed to be less explosive and, therefore, less likely to eject volcanic gases high enough to reach the stratosphere and have long-lasting climatic impacts (Figure 3). As a consequence, high-latitude eruptions remained

91 OMAN et al. 2006a; MANNING et al. 2017; MIKHAIL 2015; MIKHAIL 2017; ZAMBRI et al. 2019b: 6787.

92 PAUSATA et al. 2016; ZAMBRI et al. 2019b: 6787. On the connections between ENSO and the Nile River, see BELL 1970; ORTLIEB 2004.

93 SIMKIN et al. 1981; Global Volcanism Program.

94 SIGL et al. 2015: 543–544.

comparatively neglected. However, recent studies show that high-latitude eruptions can "have significant impacts on global circulation on seasonal to annual timescales."[95] The Laki eruption is a notable example because of the enormous volumes of lava and sulfur dioxide it produced over several months.[96] The study mentioned above by SIGL and others notes that the Laki eruption was the largest non-tropical eruption in the Northern Hemisphere and the eighth-largest volcanic eruption in the world within the past 2,500 years. It resulted in a summer temperature in Europe and the Arctic that was 0.97 °C below the 1961 to 1990 average.[97] Other volcanoes in the high latitudes that could have potentially significant eruptions can be found in Alaska and Kamchatka in the Northern Hemisphere and Antarctica in the Southern Hemisphere.[98]

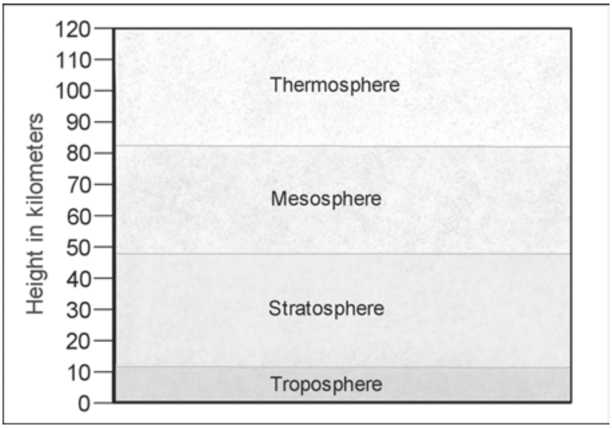

Figure 3: The different layers of the atmosphere.

The Laki eruption is significant because it was the first flood basalt event witnessed and well-documented by humans.[99] In the 2010s, there were other flood basalt events, albeit smaller than the Laki eruption (VEI 4, covering 600 square kilometers), such as the 2014/2015 Holuhraun eruption at nearby Bárðarbunga (VEI 0, covering 82 square kilometers), and the 2018 eruption at Kīlauea in Hawai'i (VEI 3, covering 36 square kilometers).[100] In the 2020s, the first fissure eruptions in Iceland were in 2021 at Geldingadalir and 2022 at

95 ZAMBRI et al. 2019a.

96 SCHNEIDER, AMMANN, OTTO-LIESNER 2009; OPPENHEIMER 2011: 269–270.

97 SIGL et al. 2015, Extended Data Table 4: Large volcanic eruptions during the past 2,500 years. Although the volcanoes that caused the 426 BCE and the 1230 CE eruptions are not known, it is known that they were tropical due to their bipolar deposits in the ice cores.

98 OMAN et al. 2005; PAUSATA et al. 2015.

99 THORDARSON 2003: 1.

100 USGS: "Preliminary Summary of Kīlauea Volcano's 2018 Lower East Rift Zone Eruption and Summit Collapse," 2018; Global Volcanism Program: Kīlauea; Global Volcanism Program: Bárðarbunga.

Fagradalsfjall on the Reykjanes Peninsula.[101] Obtaining a better understanding of historical and present-day flood basalt eruptions helps geologists in their study of large igneous provinces in deep geological time, such as the Deccan Traps in India (500,000 square kilometers).[102]

Research Focus

While this book starts in deep geological time with the formation of the Iceland mantle plume, possibly as far back as 130 million years ago, and ends with an outlook on the future of Icelandic volcanism in a warming world, the main focus is the summer of 1783. During that time, contemporaries in many parts of the Northern Hemisphere experienced the dry fog by seeing, smelling, and even tasting it. Although the Laki haze is the principal topic of this book, earthquakes, blood-red sunsets, severe thunderstorms, and meteors will also be discussed.

An environmental history of a volcanic eruption of a certain magnitude – one that impacted several different countries – ought to be international. Several planetary events play a role in the story of the Laki eruption: from a newly emerging island in the North Atlantic to earthquakes in Calabria and a volcanic eruption in faraway Indonesia. The main focus, however, will be on Europe, specifically the German Territories. Previous research on Laki's effects has focused on Great Britain, France, the Low Countries, the Czech Lands, Alaska, and the Ottoman Empire.[103] Historians Otto Mäussnest, Manfred Vasold, and Oliver Hochadel have touched upon the German Territories, but there remains a lot to be uncovered.[104] Thus, in this book, I demonstrate that the German Territories – which I define as a geographic area based on language – was a region very much affected by the Laki eruption. At times, the Laki haze was present in the German Territories in concentrations strong enough to wither vegetation and cause sore eyes, throats, and breathing difficulties.

Studying a geographic region as vast and diverse as the German Territories in the eighteenth century reveals that the effects of, and reactions to, the dry fog varied substantially. At different points, naturalists and the media would intervene in an attempt to circumvent panic in the general public. The discourse between naturalists, editors, and the public was international. Theories, ideas, and findings were shared and commented on across Europe. For this reason, my book includes not only German primary sources but also British, Danish, Dutch, French, Italian, and Icelandic sources. I use

101 Veðurstofa Íslands: "Fagradalsfjall Eruption," 2021; Global Volcanism Program: Krýsuvík-Trölladyngja.
102 Thordarson et al. 2003b: 34; Park 2010: 12; Mather, Schmidt 2021: 104.
103 Michnowicz 2011 (England); Hellman 2021 (Wales, Jersey, Isle of Man); Courtillot 2005; Grattan et al. 2005 (France); Demarée 1997 (Low Countries); Brázdil et al. 2017 (Czech Lands); Jacoby, Workman, D'Arrigo 1999 (Alaska); Mikhail 2015 (Egypt).
104 Mäussnest 1983; Vasold 2004; Hochadel 2009.

discourse analysis hermeneutically to examine these contemporary debates about the Laki eruption and the subsequent haze that played out in newspapers and scientific publications, such as monographs and journals of learned societies.

When writing disaster history, the recurrence period of a given event must be established so that reasonable assumptions can be made about when it will happen again. In order to mitigate the potential hazards of a future eruption, knowledge of recurrence periods is crucial. Scientists have determined that a Laki-sized volcanic eruption in Iceland is statistically probable every 200 to 500 years. It has been almost 250 years since the Laki eruption occurred; although the exact timing of the next flood basalt event is unclear, it is safe to say that one will happen again. Can volcanologists, policymakers, public health officials, and the modern global community learn from the events of 1783?

In this book, I explore a number of research questions, including the following. What impact did the Laki eruption have on people in Iceland and the Northern Hemisphere? Moreover, how did the people in 1783 react – physically, emotionally, and intellectually – to the Laki haze? How did naturalists explain the phenomena that they were witnessing? What made the Laki eruption and its effects so extraordinary? What is the Laki eruption's overall legacy, and when did scholars connect the dry fog to the eruption?

Methods

Environmental History

The story of the Laki eruption and its legacy represents one part of this book's contribution to the growing field of environmental history. Historians in this field have the opportunity to work on documented volcanic eruptions from antiquity to modern times.[105] The 1815 Tambora eruption, which has a minor part in the story, was the largest eruption in the last 500 years.[106] The eruption of Krakatau in 1883 plays a significant role in this story due to its occurrence after the invention of telegraphy.[107] Before this point in time, technological limitations meant that, in some parts of the world, an eruption's emissions were visible long before news of the event arrived.

Why should one study a volcanic eruption as a matter of environmental history? This question deserves a nuanced answer. Volcanic eruptions are an ideal subject of study in the field of environmental history because – depending on their explosivity and output of lava and gas – they can have dire local and significant distant effects.

105 Gunn 2000; Jones 2000; Thüsen 2008; White 2011; Cocco 2012; Rudwick 2014; Bauch 2015; Guerra 2015; Ebert 2016; Bauch 2017; Wozniak 2017; Manning et al. 2017; Newfield 2018; Wozniak 2020.

106 Wood 2014; Krämer 2015; Pfister, White 2018a; Behringer 2019.

107 Winchester 2005.

Their immediate and direct physical consequences, such as lava flow, can potentially change a landscape. Far-reaching gases can adversely affect human health and even cause death; they also affect the vegetation and the well-being of animals. Beyond human health, volcanic ejecta can affect weather and circulation patterns. Obviously, volcanic eruptions affect nature as well as society.[108]

According to historian John McNeill, environmental historians "write history as if nature existed. And they recognize that the natural world is not merely the backdrop to human events but evolves in its own right, both of its own accord and in response to human action."[109] Historian Reinhold Reith defines environmental history as the study of the interactions between humans and nature.[110] Nature can be understood as the natural and anthropogenic environment.[111] It is a cultural construct; in reality, it is constantly changing, even without anthropogenic influences. Historian J. Donald Hughes has identified three themes of environmental history: the first is the influence of environmental factors on human history; the second is the changes in the environment caused by human actions; and the third is the history of what humans think about the environment.[112] Although all three themes play a role in this book, the first and third themes are strongly represented here. In this book, I analyze the influence of a volcanic eruption, an environmental factor, on human history.

For a long time, historians did not consider nature, climate, or weather in their research. Environmental history is changing this paradigm. In the 1970s, the Club of Rome illustrated the limits of growth; consequently, environment, ecology, and conservation have become topics of public debate.[113] In the United States, environmental history emerged in the 1970s and gradually reached other countries and continents. Today, it is perhaps the fastest-growing field of history.[114] Only in the 2010s did climate and weather become leading themes in environmental history: this upward trend was fueled, in part, by the growing concern about anthropogenic climate change and the availability of high-resolution data from paleoclimatological reconstructions.[115] Volcanic eruptions, like the climate, are agents of change; they do not determine people's actions but rather change the number and kind of choices they have.[116]

Volcanic eruptions have far-reaching consequences that pay no heed to political boundaries; in this regard, the study of historical eruptions is quintessentially environmental history. Whereas "traditional" history focuses mainly on the modern nation-state,

108 Flannery 2007: 15.
109 McNeill 2010: 346.
110 Reith 2011: 3.
111 Mauelshagen 2010: 20.
112 Hughes 2006: 3–8; Reith 2011: 1–4.
113 Reith 2011: 1.
114 McNeill 2010: 349–357, 364.
115 Pfister, White, Mauelshagen 2018: 10.
116 Degroot 2018a: 16.

environmental history is transnational and is therefore well-suited for this study.[117] John McNeill suggests that there are two potential routes for environmental history in the future: one is imitation (of previous work), and the other one is interdisciplinarity.[118] For this book, I have chosen the latter. Interdisciplinarity is a hallmark and great asset of environmental history because it allows for the examination of a historical topic from different and previously unexplored angles.[119]

Climate History and the Little Ice Age

In the nineteenth century, knowledge of the ice ages and the new concept of deep geological time, rather than biblical timescales, changed the long-held belief that the climates of the past had been stable.[120] Even seemingly small climatic fluctuations of 1 °C can have severe consequences, as is now becoming evident.[121] Up until the 1960s, historians had, for the most part, ignored evidence produced by the physical sciences regarding climate change in historical times. Climate history pioneers such as Emmanuel Le Roy Ladurie, Hubert H. Lamb, and Christian Pfister deviated from this long-held tendency in the 1960s and 1970s.[122]

Climate historians use approaches of historical climatology to reconstruct the climates of the human past; they treat climate and weather as something that has always influenced the "human experience."[123] They analyze historical documents to study societal, cultural, and economic vulnerability in the face of climatic changes and extreme weather. In addition, they also reconstruct a history of knowledge of the climate.[124] Because of the "shifting-baselines" problem, in many cases, climatic variability can best be understood by reconstructing climates of the past.[125] In the 1980s, climate historians started to contribute to the understanding of climate change by using a historical perspective.[126] Rudolf Brázdil, Christian Pfister, Heinz Wanner, Hans von Storch, and Jürg Luterbacher have identified three topics in the field: first, the reconstruction of patterns of climate, weather, and climate-related nature-induced disasters; second, the study of

117 McNeill 2010: 359.
118 McNeill 2010: 365.
119 Kleemann 2019b.
120 Mauelshagen 2010: 16–26.
121 Degroot 2018a: 8.
122 Lamb 1972; Manley 1974; Pfister 1975; Pfister 1984; Richards 2003: 64–65; Le Roy Ladurie 2006. Emmanuel Le Roy Ladurie published his book in French in 1967 and it was translated into English in 1971. However, only in the 2000s did Le Roy Ladurie find that seasonal or annual changes in the climate could affect history; Pfister et al. 2018: 283.
123 Pfister, White, Mauelshagen 2018: 19–20.
124 Mauelshagen 2010: 19–20.
125 Degroot 2018a: 2.
126 Pfister, White, Mauelshagen 2018: 11.

the vulnerability of societies in the past; and third, the exploration of discourses on weather and climate.[127]

Generally, the weather is what one experiences and can be measured with thermometers and other instruments. The climate, on the other hand, is the average weather calculated statistically over at least 30 years.[128] Climate scientist Michael GLANTZ puts it in a nutshell: "Climate is what you expect. Weather is what you get."[129] Climate change, therefore, alters the average weather and, with it, the frequency and severity of extreme weather events. However, extreme weather events can occur in any climate and are not necessarily caused by climate change.[130]

Climate historians mainly work with the "archives of society," which are historical records that include logbooks, chronicles, or weather diaries with information on harvests, floods, or snowfall. Natural scientists work with the "archives of nature," such as tree rings, ice cores, lake sediments, and stalagmites, to reconstruct past climates.[131] The proxy data retrieved from the archives of nature have advantages and disadvantages and can provide different resolutions, which means they reveal decadal, annual, or seasonal information.[132] In the last two decades, interdisciplinary collaborations between historians and natural scientists have become more common. These collaborations are not without their problems, such as the disparate terminology within each field.[133] Combining the archives of society and the archives of nature is advantageous in that scholars can easily cross-check the reliability of their findings.[134]

Many early climate history studies focused on crisis, disaster, and collapse, but newly emerging scholarship in the field focuses on resilience, adaptation, and complexity.[135] Just as there is no disaster without society, there is also no climate that is bad per se. Even during periods that would seem at first glance to be disadvantageous across the board, there were winners and losers.[136] Many factors influence human thought and behavior; climate alone does not directly result in human action. Instead, interactions between societies and their environments are complex and manifold.[137]

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127 BRÁZDIL et al. 2005: 366.
128 FLANNERY 2007: 20; MAUELSHAGEN 2010: 7–8.
129 GLANTZ 1996: 1.
130 DEGROOT 2018a: 1, 15.
131 MAUELSHAGEN 2017; BRÖNNIMANN, PFISTER, WHITE 2018; CAMUFFO 2018; PFISTER 2018a; PFISTER 2018b; PFISTER, WHITE 2018b.
132 MAUELSHAGEN 2010: 38–42.
133 PAULING, LUTERBACHER, WANNER 2003; BRÁZDIL et al. 2005; MCNEILL 2010, 364; HALDON et al. 2018; KLEEMANN 2019b: 38–40; WHITE et al. 2022.
134 GLASER 2001: 13.
135 DEGROOT 2018b; SÖRLIN, LANE 2013; WHITE, PFISTER, MAUELSHAGEN 2018; MCCORMICK 2019; STRUNZ, MARSELLE, SCHRÖTER 2019; BAUCH, SCHENK 2020: 1; DEGROOT et al. 2021; DEGROOT et al. 2022.
136 This has recently been illustrated in great detail by Dagomar DEGROOT (2018a) with the example of the Dutch, who thrived during the coldest periods of the Little Ice Age.
137 MAUELSHAGEN 2010: 21–22.

Several factors influence climate; for instance, volcanic eruptions that release large amounts of sulfur dioxide into the atmosphere can warm the stratosphere but cool the surface, resulting in global cooling. Particularly devastating are double eruptions, two or more large volcanic eruptions within the space of a few years.[138] Fluctuations in the sun's activity, in particular so-called sunspot minima, can also produce a cooling effect.[139] Other factors that influence climate include changes in atmospheric and oceanic circulation patterns and orbital deviations, such as the Milanković cycles.[140] Even small temperature fluctuations can create feedback loops: a decrease in temperature creates more snow and sea ice, which increases the Earth's albedo effect.[141]

Throughout the Common Era, there have been several climatic oscillations, including the Late Antique Little Ice Age (410–775/536–660), the Medieval Climatic Anomaly (900–1400), the Little Ice Age (1250/1300–1850), and, with the onset of the industrial revolution in around 1750, anthropogenic climate change.[142] Coincidentally, James WATT introduced his improvements to the steam engine, considered one of the starting points of the Anthropocene, in 1784, the year after the Laki eruption. His engines burned fossil fuels and released carbon dioxide into the atmosphere, traces of which can still be found in air bubbles trapped in the ice of Greenland and Antarctica.[143]

In 1939, geologist François MATTHES coined the term "little ice age" for a period of glacial surges that occurred in the late Holocene. It was *little* compared to the *large* ice ages prior to the Holocene.[144] Glaciologist Jean M. GROVE points out that the term refers explicitly to glacier advances, not the temperature.[145] The appellation is slightly misleading as it suggests a world of ice and snow, but scientists and historians alike use it.[146] Several climate historians have carried out work on the Little Ice Age, a

138 ROBOCK 2000; COLE-DAI 2010; SCHMIDT, ROBOCK 2015.

139 EDDY 1976.

140 MAUELSHAGEN 2010: 12–15. The Milanković cycles are the deviations of the Earth's orbital path, its tilt on its axis, and its axial precession, all of which affect the long-term climate.

141 GROVE 2000; ZHONG et al. 2010; MILLER et al. 2012; SIGL et al. 2015; STOFFEL et al. 2015; DEGROOT 2018a: 23.

142 Different scholars offer different definitions of when these anomalies started and ended: MANN 2002; MATTHEWS, BRIFFA 2005; MILLER et al. 2012; WHITE 2014. All of these anomalies were relevant for Europe. However, not all of these anomalies can be found in all regions around the world – with the exception of modern global warming; NEUKOM, STEIGER, GÓMEZ-NAVARRO 2019. Nevertheless, during the Little Ice Age, significant glacial surges occurred in Alaska, central Europe, and Tibet between 1300 and 1850; PFISTER et al. 2018: 268.

143 MENELY 2012: 479.

144 MATTHES 1949; KRÜGER 2008; PFISTER et al. 2018: 268.

145 GROVE 2001.

146 JONES, BRIFFA 2001; REITH 2001: 77; BÜNTGEN, HELLMANN 2014; KELLY, Ó GRÁDA 2014. For a detailed history and discussion of the term, see OGILVIE, JÓNSSON 2000.

period characterized by variable weather with extremes in both directions.[147] Overall, it was a cold climatic regime.[148] Several minima occurred throughout the Little Ice Age, during which temperatures were significantly lower than the average for this period. The most notable minima were the Spörer Minimum (1450–1530), the Grindelwald Fluctuation (1560–1628), the Maunder Minimum (1645–1720), and the Dalton Minimum. The latter lasted from roughly 1760 to 1850 and therefore covered the period of the Laki eruption.[149] Historian Wolfgang BEHRINGER argues that the 1780s saw a density of extreme weather events, the likes of which had not occurred since the Maunder Minimum.[150]

Disaster History

Humankind has always endured setbacks. As we have seen above, historians have only recently begun to study nature-induced disasters in human history. Whereas climate change occurs over a relatively long time, disasters often strike suddenly, unexpectedly, and with brute force. Previously, humans were considered "the only or decisive actor of history."[151] Historians in the field of historical disaster research challenge this view.

As anthropologist Anthony OLIVER-SMITH puts it, "Disasters occur at the intersection of nature and culture and illustrate, often dramatically, the mutuality of each in the constitution of the other."[152] The presence of a society, or people, is required for a force of nature to be considered a disaster. Thus, the idea of a "natural disaster" is a social construct.[153] Historians Dieter GROH, Michael KEMPE, and Franz MAUELSHAGEN suggest that every nature-induced disaster is based upon an extreme natural event; however, not every extreme natural event is considered a disaster.[154] In the last 30

147 FAGAN 2000; BEHRINGER, LEHMANN, PFISTER 2005; PFISTER, BRÁZDIL 2006; GLASER 2008; BEHRINGER 2011.
148 FAGAN 2000: 48; DEGROOT 2018a: 22–49; PFISTER et al. 2018: 269.
149 DEGROOT 2018a: 31–41: These minima are named after the researchers who discovered them: astronomer Gustav SPÖRER (1822–1895) discovered a period of low sunspot numbers from historical observations; the Grindelwald Fluctuation is named after a glacier near a Swiss village of the same name; astronomer Edward MAUNDER (1851–1928) discovered a low in sunspot numbers from historical observations for the given period; meteorologist John DALTON (1766–1844) discovered a period of lower-than-average temperatures. The dating of these minima is not set in stone: different scholars give slightly different start and end dates. PFISTER et al. (2018: 269) give 1790 and 1820 as the start and end dates of the Dalton Minimum.
150 BEHRINGER 2011: 214.
151 KEMPE, ROHR 2003: 123 (quote), 123–124.
152 OLIVER-SMITH 2002: 24.
153 KEMPE, ROHR 2003: 124; JUNEJA, MAUELSHAGEN 2007: 2, 14.
154 GROH, KEMPE, MAUELSHAGEN 2003: 15; MAUELSHAGEN 2010: 19, 96, 117–118.

years, historians have begun to understand that disasters have to be regarded as physical *and* socio-cultural events.[155]

The *móðuharðindin* – the famine of the mist – was a disaster for the Icelanders; a fifth of the population perished, and it took decades to recover. The Laki eruption had wide-reaching effects across the Northern Hemisphere and might have caused increased mortality in Europe. Even imagined phenomena that coincided with the eruption, conjured up by people being swept up in the excitement, caused surprise and fear and stimulated the need for explanations. Responses to imagined phenomena were not unlike those shown in the face of real disasters.

Historian Matthias GEORGI studied the English media of 1750. His research shows that in the aftermath of two earthquakes precisely one month apart, news spread of a third earthquake. This third earthquake was imagined. Londoners' reactions to it were real, with many leaving the city to seek refuge. GEORGI shows that although these imagined disasters only affected the lives of the "victims" for a few short days, they still influenced knowledge production. In many ways, 1750 in Britain was comparable to 1783 in Europe: publications, especially newspapers, attempted to spread calm. Despite the media's best efforts, their reports did not always have the intended effect.[156]

Today, the lines between disaster, catastrophe, and calamity are often blurred.[157] The term "natural disaster" is a modern one. The word "disaster" has an astrological origin and means "ill-starred." In 1783, the word of choice was "revolution," which also has an astrological-astronomical origin. Revolution was initially used to describe the rotation of a celestial body on its axis.[158] As early as the sixteenth century, the word "catastrophe," meaning a sudden (down)turn, entered the English language. In the late eighteenth century, "revolution" became synonymous with "catastrophe." Both were used to describe violent geological events, such as volcanic eruptions or earthquakes. A revolution was defined as a "large, important change that is accompanied by unusual events, be it in nature, political relations, or the sciences."[159] Naturalists in 1783 used the word "revolution" to describe what they believed to be an imminent disaster that announced itself with the Laki haze, the blood-red sun, and the many earthquakes. Historian Guido POLIWODA discovered that in 1784, the term "catastrophe" was used for the first time in print by the *Zürcher Zeitung*, a Swiss newspaper, to describe the flooding events throughout Europe earlier that year.[160]

155 MAUCH 2009: 5; PFISTER et al. 2010: 283.
156 GEORGI 2009: 15–16, 21, 68–69.
157 IRWIN, SMITH 2020: 98–99.
158 GROH, KEMPE, MAUELSHAGEN 2003: 16–18; WEBER 2015: 11.
159 "Revolution" in KRÜNITZ 1813, vol. 123: 186. "[. . .] eine große, wichtige, von ungewöhnlichen Ereignissen begleitete Veränderung, sey es in der Natur, in den politischen Beziehungen, in den Wissenschaften, etc." See also RIGBY 2015: 16–17.
160 POLIWODA 2007: 30.

History of Science

The Laki eruption struck when the Enlightenment was in full swing; the dry fog and all the other accompanying phenomena proved intriguing subjects of research.[161] Much of the work on the environmental history of the Little Ice Age period has focused on disasters, which has produced a skewed representation of the period.[162] Historian Simon SCHAFFER states that disasters were not more prevalent in the eighteenth century than in other periods; however, the people of this time were "uniquely fitted" to appreciate the meaning of the spectacles of nature.[163]

The Enlightenment was an epoch of change in Europe and elsewhere; it offered the chance to look at the world through a different lens. Thinkers of the time were sometimes at odds with the various local and Church authorities: this clash produced ideas and notions that were far from homogenous. The scientific curiosity of the contemporaries in 1783 – undoubtedly sparked by the Enlightenment – generated an exceptional wealth of primary sources about that fateful summer. Unusual weather has the potential to trigger emotions such as fascination and fear in human beings; these sources provide numerous examples of both.

In 1783, naturalists strove to engage with their environment in a meaningful way. It was apparent that gathering objective data was the principal way, and perhaps the only way, to develop satisfying explanations that addressed the phenomena they were witnessing. With some tried and tested instruments and some exciting recent inventions at their disposal, these naturalists played their part in the unfolding drama of scientific discovery. The tools of their trade included uncontroversial hardware, such as the thermometer, and exciting, high technology, such as the hot-air balloon. Findings were much discussed in learned societies and scholarly journals.

Three topics in the scientific realm stand above all others when investigating the summer of 1783: meteorology, air-travel via hot-air and hydrogen balloons, and electricity. Meteorological networks began to employ standardized equipment; the data produced could be compared and contrasted and served as a foundation for better hypothesizing.[164] Hot-air balloons allowed those who dared to see the world from a different perspective and, while they were at it, measure all sorts of phenomena from places that were previously impossible to reach.[165] And, of course, then there was the lightning rod; hitherto, it would have been inconceivable to even think about capturing

161 STOLLBERG-RILINGER 2011: 256.

162 LÜBKEN 2004; REITH 2011: 91.

163 SCHAFFER 1983: 16.

164 GOLINSKI 1999.

165 DE SYON 2002: 7–13; LYNN 2010; THÉBAUD-SORGER 2013.

electricity and rendering it harmless. But in 1783, it became a tantalizing possibility that this could become commonplace; the only resistance to this was a reluctant public.[166]

Deep Geological Time

In his definition of environmental history, John McNeill states, "More than most varieties of history, environmental history is an interdisciplinary project."[167] Interdisciplinarity is the merging of two or more disciplines, which are not merely combined but draw from one another to influence the research outcome. The idea behind interdisciplinarity is to pave new ground by thinking across traditional boundaries. In this book, I take this idea to heart: while environmental history and climate history are interdisciplinary fields already, this study also combines history with geology. After all, it was Iceland's unique geology that formed the Laki fissure and therefore caused its far-reaching physical and intellectual consequences, including the long-lived missed connection.

The book title, *A Mist Connection*, suggests that the *fog* produced by the eruption and interchangeably called *haze* or *mist* was a *connecting phenomenon*; the entirety of the European continent was burdened, at least to some extent, by its presence. Indeed, those who sought to unravel the mystery of the fog's origin *missed*, or rather overlooked, its connection to the Laki eruption. The potential insights that could be garnered by co-opting knowledge and practices from the field of geology and applying them to environmental history are, as yet, unappreciated; this is another missed connection. *A Mist Connection* also utilizes the approaches and methods of climate history, disaster studies, discourse analysis, and history of science. Environmental history is an ideal home for this topic as it is an interdisciplinary field that accommodates this novel approach.

I will show that at various points of the story, the theories and conclusions of the contemporaries were, at times, far off the mark and, at times, incredibly close to the truth. With an understanding of geological mechanisms, it is possible to separate fact from fiction. If one is to understand conclusions drawn in 1783, one needs an understanding of geology as they understood it then and as we do today.

Geology was a young discipline in 1783. The Swiss naturalist Jean-André Deluc first used the word *geology* in 1778.[168] The idea that the Earth was around 6,000 years old was still commonplace; seashells found far from the oceans seemed to be evidence of the biblical Flood. With new methods and technologies, geologists began to understand that the Earth was much older than they had thought. The notion of deep geological time developed during the 1780s. Geologists James Hutton and Abraham

166 Hochadel 2003.
167 McNeill 2010: 348.
168 Deluc 1778–1780.

Gottlob WERNER, on opposite sides of the "Plutonist vs. Neptunist" debate, contributed tremendously to the understanding of this concept. They believed that Earth was not formed by a few catastrophes over a few thousand years but through processes that took place over extremely long periods of time.[169]

Philosopher Robert FRODEMAN compares HUTTON and WERNER's role in the discovery of deep geological time to the role astronomer Nicolaus COPERNICUS played in the human understanding of extraterrestrial space. FRODEMAN also emphasizes that the idea of deep time, and the change it brought about, is often underappreciated.[170] Over the next two and a half centuries, geology changed: almost every new generation discovered that the Earth was even older than the last generation had estimated until radiocarbon dating in the early twentieth century revealed that the planet was 4.56 billion years old.[171] Geologists must think in deep geological time, which is hard to comprehend for almost anybody who is not an Earth scientist.

This particular environmental history will start in deep geological time, with the formation of the Iceland mantle plume 130 million years ago. Using this unique timescale, I have incorporated other vital aspects of the story, including the convergence of the mantle plume and the Mid-Atlantic Ridge. The necessary precursors to the narrative happen within this time frame; this is an exceptionally long period for a study of history but a relatively short one for geology. It is about the length of a Wilson cycle, a model that describes the breakup of a continent, the subsequent opening and closing of an ocean basin, and the forming of a new continent.[172] Iceland's volcanism is unique due to its location at the converging point of a subaerial mid-oceanic ridge and a mantle plume. Ever since settlers first set foot on Iceland in the late ninth century, the "fires" in their new country became apparent, as did their potentially devastating effects.

In deep geological time, events like the Laki eruption are common. Colossal flood basalt events gave rise to large igneous provinces, the remnants of which are dotted around the globe. Even if our frame of reference is only the Holocene (about the last 11,700 years), the Laki eruption pales in comparison to larger flood basalt events such as those produced by the Katla and Bárðarbunga volcanic systems. This eruptive style was virtually unknown in 1783; today, armed with extensive data, perhaps we can prepare ourselves for a future event on the scale of Laki or larger.

History is part of the humanities and geology is part of the natural sciences. In environmental history, a combination of the two allows for precisely the kind of interdisciplinary approach needed to ask and answer new questions. Indeed, history and geology have much in common. For most historians and geologists, it is impossible to

169 GROTZINGER, JORDAN 2017: 192.

170 FRODEMAN 1995: 960. For the context of this debate, see also GOULD 1987; RUDWICK 2008; RUDWICK 2014.

171 RUDWICK 2005: 250–253.

172 GROTZINGER, JORDAN 2017: 262–267.

make direct observations of the events and processes that they study. Perhaps these events took place deep inside Earth and occurred over the course of millions of years, impossible to witness, or maybe they are veiled by the passage of time, an even greater impediment to observation. Both disciplines use a hermeneutic process: as historians work with written documents, geologists may work with outcrops, for example. Just as an image or a piece of text needs interpreting, so too does an outcrop. Due to the time that has elapsed between the event we study and the present, sometimes not all the data we need is available; both historians and geologists have to fill the gaps with knowledge and reasonable assumptions. While historians assume that humans in the past thought, felt, and acted as we would today – albeit within their historical context – geologists assume that the geological processes of the past were similar to those that can be observed in the present; this is called the principle of *uniformitarianism*.[173]

Teleconnections

In order to study transcultural relationships, historians have previously worked with concepts such as "entangled histories," *histoire croisée*, and connected histories. More recently, historians have adopted the concept of "teleconnections."[174] The term *teleconnection* comes from meteorology; it refers to the synchronicity of weather phenomena in different parts of the globe. The term was first used in 1935. It is often used in the context of atmospheric oscillations that have global effects, such as El Niño-Southern Oscillation.[175] Prior to the discovery of teleconnections, there was a missing link in the understanding of different climate patterns around the globe.[176] The concept of teleconnections first emerged in the late nineteenth century and was systematically verified by statistical analysis in the early twentieth century.[177]

In the early twenty-first century, the concept of societal teleconnections emerged.[178] Geographer Susanne MOSER and oceanographer Juliette FINZI HART assert, "[s]ocietal teleconnections link activities, trends, and disruptions across large distances, such that locations spatially separated from the locus of an event can experience a variety of impacts from it nevertheless." The idea is "to uncover distal vulnerabilities via a distinct

173 FRODEMAN 1995: 960–966; GROTZINGER, JORDAN 2017: 8.
174 BEHRINGER 2017: 27–28.
175 ANGSTRÖM 1935; GLANTZ 1996: 40–41.
176 BRIDGMAN, OLIVER 2006: 25–27.
177 BAUCH, SCHENK 2020: 17. For a more detailed history of the discovery of teleconnections, see GROVE 1997.
178 LIEBERMAN 2003–2009; ADGER, EAKIN, WINKELS 2009; CAMPBELL 2016; BAUCH, SCHENK 2020: 17.

focus on the connection itself."[179] The term is used in the study of the "direct and indirect causal links between historical phenomena of climatic and societal change."[180] Of course, the consequences of natural events vary; their impact depends on their scale and the societal and political circumstances of the affected region.[181] Did similar events happen before? What time of year did the incident take place? It would be deterministic to assume that climate directly leads history; however, the weather is still an important factor.[182] Climate is complex; many factors play a role. In the context of this interdisciplinary study, both physical and societal teleconnections triggered by the Laki eruption are relevant.

Teleconnections explain the time lag between events and their physical manifestations.[183] While the Laki eruption commenced on 8 June 1783, the dry fog it produced settled above Europe mid-month at the earliest. The climatic effects of the Laki eruption, a topic of much debate to this day, took more time to develop. The winter of 1783/1784 was severely cold, and several abnormal seasons followed. It took until 1787 for the weather to normalize. Some of the societal reverberations, in particular those that occurred after the realization of a connection between the eruption and the dry fog, took much longer to come about: some 100 years.

The concept of teleconnections also aids the interdisciplinary approach of environmental history, as it makes for more viable connections between concerned fields. Volcanic eruptions and their effects, like the realm of climate in general, are often abstract and difficult for laypeople to grasp. Nevertheless, we can find information hinting at these teleconnections in sources from 1783 and the following years.

Sources

The main sources for this book are an autobiography, official reports, newspapers, scientific publications, weather diaries, and travelogues. As is often the case, unusual or extreme weather is better documented than "normal" weather.[184] In some German newspapers from mid-July 1783, almost every report dealt with an extreme weather event.[185] Newspaper reports, scientific publications, and letters help reconstruct the phenomena of 1783, contemporary perceptions of them, and historical populations' ideas on the possible origins of said phenomena.

179 Moser, Finzi Hart 2015: 15.
180 Bauch, Schenk 2020: 17.
181 Hoffmann 2020: 281.
182 Fagan 2000: xiv.
183 Hoffmann 2020: 283–284.
184 Pfister 1999: 16–17; Fagan 2000: 51; Greyerz 2009: 42.
185 Examples are the issues of the *Königlich Privilegirte Zeitung* dated 17 July and 19 July 1783, both of which have numerous articles relating to the weather.

My sources for the eruption itself are chiefly the English translations of the autobiography and "fire treatise" of Jón STEINGRÍMSSON (1728–1791), a Lutheran pastor in Kirkjubæjarklaustur, who observed the fiery columns of the eruption, the lava flows, and the effects of the eruption's ejecta on the vegetation and population first-hand. His "fire treatise," also called an *eldrit* in Icelandic, is a report about the eruption and its aftermath and has strong religious overtones. The other sources are by two Icelandic authors, Sæmundur Magnússon HÓLM (1749–1821) and Magnús STEPHENSEN (1762–1833): the former is a collection of letters and the latter is a report detailing observations made while on duty in Iceland for the Danish Crown.[186]

The invention of the printed newspaper, which Wolfgang BEHRINGER calls one of the most important media revolutions, occurred shortly after the so-called postal revolution. This created a perfect synergistic moment: news could now be printed more readily and distributed more efficiently.[187] Johann CAROLUS, a writer and former correspondent, established the first printed newspaper in Strasbourg in 1605.[188] Over the next two centuries, postal networks and roads improved, which meant, for instance, that the travel time of news between Hamburg and Augsburg was reduced from 30 days in 1615 to only five days by 1800.[189] The postal routes also dictated the order of the stories in newspapers: periodicals of the time printed news in the order that they received the reports. This meant the most important stories were not necessarily on the front page. Printed newspapers served three main purposes: first, to advertise and initiate trade and economic relationships; second, to maintain the political system; and third, to spread scholarly findings.[190] Newspapers also documented military successes and failures, diplomatic negotiations, theater, and other cultural affairs, as well as weather events and disasters.[191] A story would be printed simply if the editor considered it newsworthy.[192] As historian Margot LINDEMANN reminds us, the newspaper was often no more than a cobbled-together collection of news and rumors.[193]

In the German Territories, the number of newspapers quadrupled to 200 between 1700 and 1800, with a particularly sharp increase in the last 25 years of that period.[194] Some of these ran daily, others only once a week. The frequency of the postal routes

186 STEINGRÍMSSON 1998; STEINGRÍMSSON 2002; HÓLM 1784a; HÓLM 1784b; STEPHENSEN 1785; STEPHENSEN, EGGERS 1786. For other Icelandic sources written around the time of the eruption, see THORDARSON et al. 2003b; GUNNARSDÓTTIR 2022.

187 For more information on this "media revolution," see BEHRINGER 2003: 680; BEHRINGER 2010: 51.

188 ARNDT, KÖRBER 2010: 20; WEBER 2005. For more information on the early days of the newspapers, see BEHRINGER 2005; MAUELSHAGEN 2005.

189 BEHRINGER 2003: 664.

190 WILKE 2010: 62.

191 BLOME 2010: 207.

192 STÖBER 2002: 159–160; ARNDT, KÖRBER 2010: 6.

193 LINDEMANN 1969: 34.

194 STEIN 2006: 222.

determined the frequency of newspaper publications: that is, if they received mail daily, they could publish daily.[195]

A few newspapers, such as the *Hamburgischer Unpartheyischer Correspondent* and the *Mercure de France*, were read in different regions and countries.[196] LINDEMANN states that the *Hamburgischer Unpartheyischer Correspondent* was, in fact, the most widely-read newspaper in Europe at the time. In 1789, each issue was printed 30,000 times. It was highly regarded because of its generally reliable reports. Because of this, it served as the news source for several other newspapers that did not have their own correspondents.[197] In 1783, newspapers primarily consisted of letters from anonymous correspondents: usually, the only information provided was where and when they had written the letter. The role of the newspaper correspondent has been misunderstood for a long time; it was assumed they worked on behalf of an authority and it has only recently become understood that financial incentives were motivating factors.[198]

In many territories, the state imposed a substantial degree of local censorship on newspapers; this meant that periodicals often forbore printing local news in favor of stories from other regions to avoid conflict with authorities.[199] To gather as much information as possible about different regions in the German Territories, I analyzed newspapers from Hamburg (*Hamburgischer Unpartheyischer Correspondent*), Berlin (*Königlich Privilegirte Zeitung, Berlinische Nachrichten*), Munich (*Münchner Zeitung*), Augsburg (*Augsburgische Postzeitung*), Göttingen (*Göttingische Anzeigen von gelehrten Sachen*), Breslau (*Schlesische Privilegirte Zeitung*), and others from Dessau, Hanau, and Vienna.[200] In addition to German newspapers, I also worked with British, French, and American periodicals.

A study conducted by historian Jürgen WILKE revealed that the *Berlinische Nachrichten* did not print any local news in 1736. By contrast, 60 years later, in 1796, local news made up ten percent of the paper. Over this period, most newspaper articles recounted news from other countries, often southern European countries; reports from the German Territories accounted for between one-fifth and one-third of all news. His study also showed that between 1736 and 1796, about half of the reports that appeared in the *Berlinische Nachrichten* also appeared in the *Hamburgischer Unpartheyischer Correspondent* or vice versa.[201]

195 BEHRINGER 2003: 667.

196 STOLLBERG-RILINGER 2011: 142.

197 LINDEMANN 1969: 163; STEIN 2006: 222.

198 ARNDT, KÖRBER 2010: 20.

199 See also LINDEMANN (1969: 111–123), to learn how different, larger territories dealt with censorship in the seventeenth and eighteenth centuries.

200 The newspapers from Hamburg and Berlin can be found on microfilm at the Staats- und Universitätsbibliothek Hamburg and the newspaper department of the Staatsbibliothek zu Berlin. All other newspapers have been digitized for the relevant years and can be found through ANNO and DigiPress.

201 WILKE 2002: 84.

At the end of the eighteenth century, the German Territories had an estimated 27.5 million inhabitants.[202] The sheer number of newspapers in that region prompts the question: who could read them? Literacy rates, which varied widely across Europe, substantially increased within the German Territories throughout the eighteenth century. Some territories introduced compulsory school attendance. Reading and writing were taught by family members, in the community, and through the Church. Lending libraries had been around since 1750 in the German Territories, 1717 in Switzerland, 1725 in England, and 1759 in France.[203] It is safe to assume that most people in cities – home to about 20 percent of the population – had access to newspapers. There is proof that handypersons and servants who worked in stately homes could read.[204] Generally, it was men rather than women who could read and write, as well as people from the upper classes; more people to the west of the Stralsund-Dresden line were literate than to the east.[205]

Newspapers were interested in selling as many copies as possible. Even as early as the seventeenth century, most had become interested in expanding their readership beyond the intellectual elite by targeting the "common man." Thus, by the mid-eighteenth century, newspapers were no longer the exclusive domain of the educated.[206] Even so, in 1783, newspapers often used technical terms that were not necessarily meant to be understood by everybody, perhaps in order to suggest authority.[207] Newspapers were not only accessible to the literate: often, they were read aloud within the family home, in coffeehouses, or in reading societies.[208] Verbal exchanges remained the most common form of communication in the early modern city.[209] Historian Peter STEIN estimates that in the 1780s, 300,000 German-language newspaper issues were printed weekly, reaching approximately three million readers (or listeners).[210]

The naturalists who influenced the journalistic and scientific discourse had different backgrounds; however, they shared the ideals of the Enlightenment.[211] Reasoned argument, the search for truth, and empirical evidence became of the utmost importance. In 1783 and the following years, many naturalists published papers about the different phenomena they witnessed and offered explanations. Scientific monographs were aimed at scholars and general audiences alike; some books directly addressed their readers. In contrast, articles in the journals of learned societies were written for a scholarly readership; these learned societies often financed themselves through

202 HARTMANN 1995: 348.
203 ENGELSING 1973; STEIN 2006: 267–270.
204 ARNDT, KÖRBER 2010: 18. The size of the readership was estimated by WELKE (1981: 163–166).
205 FRANÇOIS 1989: 407–413.
206 BÖNING 2010: 236–237.
207 GEORGI 2009: 68–69.
208 PUSCHNER 2002: 194; STEIN 2006: 265.
209 GEORGI 2009: 71.
210 STEIN 2006: 222; LINDEMANN 1969: 124.
211 BRIESE 1998: 15.

subscriptions to their journals. Scientific publications tended to be much more detailed than newspaper reports.[212]

Scientific books and articles were generally published in the common language – German in the German Territories, French in France, English in Britain, etc. This was part of the media revolution of the eighteenth century: in 1740, in the German Territories, Latin books made up 28 percent of the total number of published texts; in 1800, they made up only four percent of the total.[213] Neither newspapers nor scientific publications existed in a vacuum; frequently, they addressed one another. Often, newspapers referred to scientific findings and commented on them. Similarly, in some scientific publications, naturalists referenced rumors they had read in the newspaper and tried to correct inaccuracies.

One significant outlier in this trend was the *Ephemerides* of the Societas Meteorologica Palatina, a highly technical publication compiled and published two years after the data was gathered. Its Latin text made it clear that it was written for a highly educated and sophisticated readership. As the Society gathered its data from a network of around 30 weather stations in several countries, it made sense for its publication to use an international language. The *Ephemerides* also used many symbols that were not necessarily self-explanatory. During the summer of 1783, the Mannheim observatory, headquarters of the Societas Meteorologica Palatina, published a statement about the nature of the dry fog in several newspapers. That they chose to take such action underlines how urgently the readership of the newspapers wanted explanations for the unusual weather.[214]

This book mainly relies on weather diaries to reconstruct the summer and winter weather in Great Britain and North America. In the United States, almanacs were popular; here, the observer could record the daily weather and any other occurrences. Most weather observers described the weather simply, with words such as “fair” or “rainy.” They also noted the readings from the instruments they had at hand, often thermometers, barometers, and hygrometers. Instrument readings from this time should be taken with a grain of salt, as the practices for using them had not yet been standardized. Temperatures were measured inside or outside, in the sun or the shade, without reference. Sometimes weather observers remarked upon the unreliability of their instruments and their frustration with them, such as when British naturalist Gilbert WHITE (1720–1793), in the winter of 1784/1785, complained that his thermometers were not up to the task of measuring the extreme cold.[215]

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212 BARDILI 1783; FISCHER 1784.

213 MIX 2005: 283.

214 Münchner Zeitung, 10 July 1783: 422; Berlinische Nachrichten, 19 July 1783: 670: Report from the Mannheim observatory, 6 July 1783.

215 Gilbert WHITE, “The Naturalist’s Journal,” 1784, Add MS 31849, British Library, London, UK. Gilbert WHITE kept a diary for several years and, by means of close phenological observations, tried to decipher nature’s pattern each year in order to “domesticat[e] climatic chaos into diaries of ecological self-awareness,” as eco-critic Heidi SCOTT (2009) puts it.

I also conducted archival research in the United Kingdom and the United States to reconstruct the weather of 1783 and the following years. This subset of my study has three purposes. The first is to establish whether the dry fog appeared in North America, as Benjamin FRANKLIN famously claimed.[216] A few mentions of fog can be found in the sources from the United States for the summer of 1783; however, the fact that these are not further remarked upon is indicative of them being occurrences of "normal" fog. In contrast, sources from three Moravian settlements in Labrador, in today's Canada, reveal that the dry fog was visible there; it was perceived as a "smoke" that lingered for several months. The second is to reconstruct the weather during the summer in Great Britain, where the dry fog was also present. The third purpose is to analyze the winter climate in both regions, as both primary and secondary literature indicate that the winter was exceptionally cold in North America and Europe.

Travelogues were reports written by naturalists and private persons traveling to other countries. Often, they were aimed at a general audience. Iceland was an exotic destination and many were interested in reading about the "land of fire and ice." These travelogues included tales of the people, the landscape, and personal achievements, such as summiting Mount Hekla. Even the travelogues in the direct aftermath of the Laki eruption, which served the purpose of collecting information for the Danish king rather than entertaining readers, were translated into other European languages. Of particular importance for this book are the travelogues and other scientific articles authored by Sveinn PÁLSSON, Þorvaldur THORODDSEN, and Amund HELLAND. They play key roles in connecting the Laki eruption to the dry fog in Europe.[217]

Unless otherwise stated, I have translated all the quotes from the sources; the non-English texts can be found in the footnotes. Spelling in the original source texts differs from twenty-first-century spelling. The various newspaper reports and scientific publications are expressions of individuals, which reflect the complexity, plurality, and contradictions of the eighteenth century. This compilation of different responses to the dry fog helps to paint a picture of the collective atmosphere at the time.

Structure

This book has three distinct parts. In Chapter Two, I explore Iceland's geological formation and its volcanic activity during the Holocene. This chapter aims to illustrate the Icelanders' experience with volcanism from when they first set foot on the island until the late eighteenth century. Furthermore, I describe the Laki eruption itself and its consequences for Iceland. How did the people cope with this eruption? Given their

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216 FRANKLIN 1785: 357–361.

217 PÁLSSON 1793a; PÁLSSON 1793b; PÁLSSON 1945; PÁLSSON 2004; THORODDSEN 1879; THORODDSEN 1925; HELLAND 1881; HELLAND 1882; HELLAND 1884; HELLAND 1886.

almost 900-year history in Iceland, could they have been prepared? What makes the Laki eruption so unique? For the most part, the sections on the geology and the history of Iceland are based on English-language secondary literature.

Leaving Iceland behind and effectively following the Laki eruption's gases where they lead us, in Chapter Three, I study the various real and imagined consequences of the eruption outside of Iceland, focusing on Europe, where the dry fog was most intense and lasted the longest. I first describe the various phenomena visible during 1783, including those unrelated to the Laki eruption. Naturalists at the time considered all the phenomena to be interconnected; therefore, an awareness of them is crucial to understand the story. After detailing the phenomena, I analyze how naturalists from different disciplines interpreted them. Influenced by the Enlightenment, the natural sciences experienced a transformation after 1750. Many disciplines became more specialized, and some were newly established. This period laid the foundation for the modern disciplines as we know them today. The main focus of this chapter is the summer of 1783, during which most of the Laki eruption's effects were observable. Toward the end, I briefly look at the cold winters that followed. The main research questions here are: what impact did Laki have on the Northern Hemisphere? How were the dry fog and other phenomena perceived? What explanation strategies were developed?

In Chapter Four, I trace the legacy of the Laki eruption. Legacy, in this case, means something transmitted from the past. The Laki eruption serves as a fascinating opportunity to trace the knowledge production of a meteorological and geological event that originated in a remote and sparsely populated country in the North Atlantic from the late eighteenth century to the present. In 1783, the discipline of geology had to compete against other spheres of knowledge and was itself characterized by internal disagreement. In this chapter, I study naturalists' and geologists' travelogues and letters, along with diaries from participants in European expeditions to Iceland between the 1790s and the early twentieth century. The principal question in this chapter is: when was the Laki eruption connected to the dry fog of 1783? Thus, I also analyze scientific publications that were compiled and published in the aftermath of the Krakatau eruption in 1883.

In Chapter Five, I make concluding remarks on my research and offer an outlook on the substantial changes that the fields of volcanism and geology have gone through since the Laki eruption. One such change was the widespread acceptance of the theory of plate tectonics in the late 1960s; this led to a major paradigm shift in geological theory. At present, the theory of plate tectonics explains most of the geological phenomena around the world, from earthquakes to volcanic eruptions.[218] Finally, I trace the perceptions of the Laki eruption in the present and discuss what scholars know about it today, what we have yet to discover, and how Icelandic volcanism will change in a period of anthropogenic climate change

218 McKenzie, Parker 1967; Morgan 1968. Xavier le Pichon (1991) reconstructs what happened to the discipline of geology between 1967 and 1968.