| Table of contents | 4.5 The instrumental measurement of |
|---|---|
| | the weather 98 |
| Preface 8 | 4.5.1 A breeding ground for innovations |
| Abbreviations 10 | 4.5.2 The establishment of meteorological |
| | networks |
| - Introduction | 4.6 A fundamental break 103 |
| 1. Introduction | 4.6.1 The rise of scientific meteorology and |
| 1.1 The switch to rapid warming – a new | climatology |
| comparative basis in climate history 14 | 4.6.2 The exclusion of extreme events |
| 1.2 Two scientific cultures 15 | 4.7 Summary and conclusion 107 |
| 1.3 Common ground 20 | |
| 1.4 The climate system 23 | |
| 1.5 The global energy balance – | 5. Reconstructing past climate 109 |
| driver of the climate system 26 | 5.1 Introduction 110 |
| 1.6 What determined the Holocene energy | 5.2 Evidence from archives of nature 110 |
| and temperature fluctuations? 27 | 5.2.1 Signal detection and dating |
| 1.7 Circulation, energy and mass exchange - | 5.2.2 Trees never forget |
| basic elements of climate dynamics 29 | 5.2.3 Mud with a long-term memory |
| 1.8 Forcing disturbances and internal variability | 5.2.4 Ice cores – long frozen climate calendars |
| generate climate change 33 | |
| 1.9 The structure of the book 38 | 5.2.5 Stalagmites – an archive growing drop |
| | by drop |
| ä. ·) 1 | 5.2.6 Glaciers and treelines - synthetic integra- |
| 2. Ötzi's wake-up call 41 | tors of climate change |
| 2.1 Introduction 42 | 5.3 Evidence from archives of societies 122 |
| 2.2 Facing a Neolithic mummy 42 | 5.3.1 A puzzle with missing pieces |
| Insert 2A: The most thoroughly investigated body | 5.3.2 How glaciers became pictures |
| in the world | 5.3.3 The blessings of historical administrations |
| 2.3 Ötzi's last hike 44 | 5.3.4 The summer half-year in the light of vine |
| Insert 2B: The longer-term climatic background | growing |
| 2.4 Ötzi and the mid-Holocene transition to | 5.3.5 Cultural responses to climatic stress |
| | 5.4 Numbers out of words - the concept of |
| cooler climate 51 | indices 133 |
| 2.5 Conclusion 55 | 5.5 Outlook to Chapters 6 to 8 136 |
| | |
| 3. The long arm of Tambora 57 | 6. European climate - present and past |
| 3.1 Introduction 58 | |
| 3.2 Dark night at midday 58 | 6.1 The European topography at a glance 138 |
| 3.3 A global weather chaos 60 | 6.2 Spatial overview of current European |
| Insert 3A: Disaster alert in a mountain valley | climate 139 |
| 3.4 Europe's last subsistence crisis 65 | 6.3 A 1000-year long overview 144 |
| | 6.4 A 1000 year-long simulation 149 |
| 3.5 Contrasting vulnerabilities 68 | |
| 3.6 Too many hunger refugees 73 | - The III by diesel Desir J |
| Insert 3B: The birth of Frankenstein and Dracula | 7. The High Medieval Period |
| 3.7 Conclusion 77 | 1000 to 1300 AD 15 |
| | 7.1 Introduction and guide to source references 152 |
| 4. From weather narratives to climate science 79 | 7.2 A warm peak around 1000 AD 153 |
| 4.1 Introduction 80 | Insert 7A: Vikings on a voyage of discovery - from |
| 4.2 An animated environment 81 | Iceland to the New World |
| 4.3 Developing weather chronicles 83 | 7.3 The 11th century 156 |
| 4.3.1 The Graeco-Arabic legacy | 7.3.1 Winters from 1000 to 1099 |
| 4.3.2 The 12th-century Renaissance | Insert 7B: The Road to Canossa - pure fiction: |
| 4.3.3 Reporting under clerical control | 7.3.2 Summers from 1000 to 1099 |
| 4.3.4 Outstanding weather chroniclers | 7.3.2 General climatic conditions in the 11th |
| 4.4 Systematic weather reporting 90 | century |
| 4.4.1 The significance of astrometeorology | 7.4 The 12th century 160 |
| | |
| 4.4.2 Weather reports from the world's oceans | 7.4.1 Winters from 1100 to 1199 |
| 4.4.3 Outstanding weather diarists | 7.4.2 Summers from 1100 to 1199 |
| | 7.4.3 General climatic conditions in the 12th |
| | century |

| 7.5 | The 13th century 164 | | 8.6.2 Springs from 1700 to 1799 | |
|---|---|-------|---|--|
| | 7.5.1 Winters from 1200 to 1299 | | 8.6.3 Summers from 1700 to 1799 | |
| | 7.5.2 Springs from 1200 to 1299 | | Insert 8I: Five months of volcanic haze over | |
| | 7.5.3 Summers from 1200 to 1299 | | Europe | |
| | Insert 7C: Olive trees in Cologne | | 8.6.4 Autumns from 1700 to 1799 | |
| | 7.5.4 General climatic conditions | | 8.6.5 Annual temperatures from 1700 to 1799 | |
| | in the 13th century | | 8.6.6 General climatic conditions in the 18th | |
| | | | century | |
| | | | The record-breaking cold 19th century 230 | |
| The Boreal Little Ice Age and the Short | | | 8.7.1 Introduction | |
| Twentieth Century 171 | | | 8.7.2 Winters from 1800 to 1899 | |
| 8.1 | Introduction 172 | | Insert 8J: Events and sporting activities | |
| | The fateful 14th century 173 | | on the ice | |
| | 8.2.1 Winters from 1300 to 1399 | _+ | 8.7.3 Springs from 1800 to 1899 | |
| | 8.2.2 Springs from 1300 to 1399 | | 8.7.4 Summers from 1800 to 1899 | |
| | 8.2.3 Summers from 1300 to 1399 | | 8.7.5 Autumns from 1800 to 1899 | |
| | Insert 8A: The millennium flood of July 1342 | | 8.7.6 Annual temperatures from 1800 to 1899 | |
| | 8.2.4 General climatic conditions | | 8.7.7 General climatic conditions in | |
| | in the 14th century | | the 19th century | |
| | Insert 8B: The Flowered Alp Saga | 8.8 | The slow-warming 20th century 238 | |
| 8.3 | The frosty 15th century 182 | | 8.8.1 Winters from 1900 to 1999 | |
| | 8.3.1 Winters from 1400 to 1499 | | Insert 8K: Winter 1963 - the last memory | |
| | 8.3.2 Springs from 1400 to 1499 | | of the Little Ice Age | |
| | Insert 8C: Wolves in Paris | | 8.8.2 Springs from 1900 to 1999 | |
| | 8.3.3 The 14-month-long heat and drought | | 8.8.3 Summers from 1900 to 1999 | |
| | in 1473 to 1474 | | 8.8.4 Autumns from 1900 to 1999 | |
| | Insert 8D: Characteristics of outstanding hot | | 8.8.5 Annual temperatures from 1900 to 1999 | |
| | and dry European summers | | 8.8.6 General climatic conditions in the Short | |
| | 8.3.4 Summers from 1400 to 1499 | | Twentieth Century | |
| | 8.3.5 Autumns from 1400 to 1499 | 8.9 | Annual temperatures from 1500 to 1999 246 | |
| | 8.3.6 General climatic conditions | | | |
| | in the 15th century | | | |
| 8.4 | The two-faced 16th century 193 | 9. We | ather, climate, and the human world 24 | |
| | 8.4.1 Winters from 1500 to 1599 | 9.1 | Introduction 248 | |
| | 8.4.2 Springs from 1500 to 1599 | | Population size as a new focus 250 | |
| | 8.4.3 Summers from 1500 to 1599 | | The medieval demographic greenhouse 254 | |
| | 8.4.4 The 11-month-long heat and drought in | | Setback and stagnation 263 | |
| | 1540 | | Insert 9A: Biological warfare and the Black Death | |
| | 8.4.5 Autumns from 1500 to 1599 | | Insert 9B: Forging the Hammer of Witches | |
| | Insert 8E: The fate of the Spanish Armada | 9.5 | The two-faced 16th century 271 | |
| | 8.4.6 Annual temperatures from 1500 to 1599 | | Insert 9C: The age of witch hunts 1570-1630 | |
| | 8.4.7 General climatic conditions in | 9.6 | A cornucopia of innovations 277 | |
| | the 16th century | | 9.6.1 A new momentum in demographic growth | |
| 8.5 | The volatile 17th century 207 | | 9.6.2 Enforcing quarantine | |
| | 8.5.1 Winters from 1600 to 1699 | | 9.6.3 Modernising agriculture | |
| | 8.5.2 Springs from 1600 to 1699 | 9.7 | Severe famines and overcoming them 281 | |
| | 8.5.3 Summers from 1600 to 1699 | | 9.7.1 Hunger and climate variability | |
| | Insert 8F: The most devastating inferno | | 9.7.2 Impacts of climate variability | |
| | in peacetime | | 9.7.3 The millennium famine of 1195 to 1197 | |
| | 8.5.4 Autumns from 1600 to 1699 | | 9.7.4 13th-century famines | |
| | 8.5.5 Annual temperatures from 1600 to 1699 | | 9.7.5 The Great European Famine of 1315–17 | |
| | 8.5.6 General climatic conditions in the 17th | | 9.7.6 The deadly frost famine of 1437–38 | |
| | century | | 9.7.7 The Malthusian Famine of 1569-74 | |
| | Insert 8G: Why the Greenland whales | | 9.7.8 The perennial crisis of 1585–1601 | |
| | survived | | 9.7.9 Famines during the 17th and | |
| 86 | The quiet 18th century 219 | | early 18th centuries | |
| 0.0 | 8.6.1 Winters from 1700 to 1799 | | 9.7.10 Subsistence crises and famines in the late | |
| | Insert 8H: Sudden Stratospheric Warming | | 18th and 19th centuries | |
| | and the Big Chill of 1709 | 0.8 | Summary and conclusion 294 | |
| | and the Dig Onth of 1/09 | 9.0 | outilitiary and conclusion 294 | |

| | 10.1 | The se | easonally resolved climate of the period | |
|-----|--------|----------|--|---|
| | | | to 1989 AD 298 | |
| | | 10.1.1 | Introduction | |
| | | 10.1.2 | The evolution of seasonal temperatures | |
| | | | prior to the Recent Warming Period (RWP) | |
| | | 10.1.3 | Forcing factors and the longer-term picture | |
| | | 10.1.4 | Seasonal overview of past millennium | |
| | | | climate The transitions from the IIMP to the | |
| | | 10.1.5 | The transitions from the HMP to the BLIA and from the STC to the RWP | |
| | 10.2 | Glacie | r fluctuations 309 | |
| | | | ne fluctuations 314 | |
| | - | | te and human affairs 315 | |
| | 10.4 | Cililia | te and marrain arrains 313 | |
| | Tues. | | into-monid-washin | _ |
| 11. | Fron | n slow- | going to rapid warming 31 | 9 |
| | 11.1 | Trappe | ed in the greenhouse: From early | |
| | | detect | ion to full manifestation 320 | |
| | | 11.1.1 | Introduction | |
| | | 11.1.2 | Scientific pioneers and early alerters | |
| | | 11.1.3 | The greenhouse debate reaches the | |
| | | | international level | |
| | | 11.1.4 | The greenhouse controversy | |
| | 11.2 | The "1 | 950s Syndrome" 328 | |
| | 11.3 | The su | dden transition to sustained | |
| | | warmi | ng 334 | |
| | | 11.3.1 | The Recent Warm Period (RWP) | |
| | | 11.3.2 | Future climate scenarios | |
| | 11.4 | The re | turn of vulnerability 340 | |
| | | | | |
| An | nex | | | 9 |
| Enc | dnote | s | | C |
| Ref | erend | ces | | 9 |
| | | | | • |
| nd | lex | | | 9 |
| | | | | |
| Γha | anks t | to the s | ponsors 39 | 7 |
| | | | | |
| | | ppend | | |
| | | | ı; Wanner, Heinz (2021). Climate | |
| | | , | urope - the Last Thousand Years. | |
| | | | ris.148155 | |
| | - | | inibe.ch/id/eprint/148155 | |
| | | | for Winter | |
| | | | for Spring | |
| | | | for Summer | |
| | | | or Table 1 to 3 | |
| ľab | le 4 C | entenn | ial sums of Pfister-Indices 1000-1999 | |
| | | | | |
| | | | | |

10. European climate over the last millennium ... 297