Advances in Global Change Research 55

Stefan Brönnimann

Climatic Changes Since 1700

Springer

Advances in Global Change Research

Volume 55

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ISSN 1574-0919 ISSN 2215-1621 (electronic)
Advances in Global Change Research
ISBN 978-3-319-19041-9 ISBN 978-3-319-19042-6 (eBook)
DOI 10.1007/978-3-319-19042-6

Library of Congress Control Number: 2015953015

Springer Cham Heidelberg New York Dordrecht London

Cover Illustration: © Morphart / fotolia

Printed on acid-free paper

Springer International Publishing AG Switzerland is part of Springer Science+Business Media (www.springer.com)

Preface

The Earth's climate is undergoing profound changes that will affect the future of our economies and societies. "The key to learning about the future lies in the past" is a common saying. Indeed, by studying past changes in climate, scientists can learn how the climate system works, test their models, and develop theories. At the same time, past climates exert a fascination for scientists as well as the public. They form a background for legends and are part of our culture.

When the existence of ice ages in ancient times was discovered in the nineteenth century, this stimulated both public imagination and scientific research:

> "The belief that it [the weather] has improved or worsened in the course of time quite persistently holds up. There is hardly any human being, even the most common, who has not tried, owing to the experiences of his life, to attribute the eternally changing, chaotic, unpredictable character of the weather with some law. [...] In the Ice Age, however, all miracles of this weather seem to unite. Something like an age-old fear of our ancestors seems to come to life again: of a global winter that destroyed everything. At the same time one believes that whoever solved the secret of the Ice Age would have to understand the magic of today's weather." (translated from p. 13 of Bölsche 1919)

A century later, this quote from a popular scientific booklet appears almost visionary as many climate theories, including the CO_2 greenhouse effect, are rooted in the ice age problem.

The debate on the ice age theory was particularly lively at the end of the nineteenth century. A leading figure in this debate was Eduard Brückner[1] (see Fig. 1), who co-published a standard textbook on ice ages ("Die Alpen im Eiszeitalter", 1909). Brückner also was a pioneer in the study of climatic changes on multidecadal time scales and their effects on society (von Storch and Stehr 2000). In 1890—at that time Brückner was a professor of Geography at the University of Bern—he published a book entitled "Klima-Schwankungen seit 1700" ("Climatic

[1] Eduard Brückner, 1862–1927, was a German geographer and climatologist. He was professor at the University of Bern from 1888 to 1904, then in Halle and from 1906 on in Vienna (see Stehr and von Storch 2000).

Fig. 1 Photo of Eduard Brückner (provided by the Institute of Geography, University of Bern)

Changes Since 1700") that was influential for generations of climatologists. In this landmark publication, several chapters of which were translated by Stehr and von Storch (2000), Brückner promoted the view of climatic fluctuations (against the conception of a stable climate or slow, progressive change) and proposed a 35-year cycle of global climate (see Sect. 4.1.2). He based his work on meteorological or hydrological observations, documentary evidence as well as indirect evidence or "proxy data", as we would say today. Brückner, likewise, considered studies of past climate to be a key to the future and, most importantly, saw their societal relevance:

> "There are numerous hypotheses and theories about climate change. Quite naturally they have caught the public attention, as any proof of past climatic change points to the possibility of future climate change, which inevitably will have significant implications for global economics." (translated from p. 3 in Brückner 1890)

Over a century later, the field of palaeoclimatology is undergoing profound changes. First, progress in analytical and sampling techniques as well as a better understanding of climate proxies has led to a wealth of information. Second, increased modelling capabilities and computing power has enabled us to address palaeoclimatological problems with full-fledged computer models. Third, powerful techniques such as data assimilation have been introduced to palaeoclimatology. Together with increasingly refined research questions in the light of global climate change, this technical progress has caused a constant reinvention and revaluation of historical data and approaches, accompanied by strong efforts in data recovery.

These developments are about to change our view of the past, specifically of the past ca. 300 years—the period studied by Brückner. This period is of particular interest because the radiative forcings changed considerably during this period.

The intention of this book, which is entitled "Climatic Changes Since 1700" in honour of Brückner's book, is to discuss mechanisms behind interannual-to-multidecadal climate variability and to analyse climatic changes since 1700 in light

of new tools and data. The book shows *how* we can learn from climatic changes during the past 300 years and *what* we have learned from these changes. It does not replace a textbook, even though it is based on one of my courses and can be used in a lecture hall. There are excellent textbooks on climate and climatic changes, which are referenced at the appropriate places. It is also not a review of climate and climatic changes, which would be an impossible undertaking. Excellent reviews exist for individual topics, and for a comprehensive assessment of the literature, the reader is referred to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2013).

The book aims at readers interested in climatology and climatic changes, particularly graduate students in geography or climate sciences but also palaeoclimatologists, palaeoecologists, historians or other scientists interested in climatic changes. It starts with an introduction and a chapter on data and methods used in climatology and palaeoclimatology—an area in which our research group is strongly engaged. The chapter also introduces key data sets and some main concepts used in the later parts of the book. The third chapter introduces the most important mechanisms causing climatic changes on interannual-to-multidecadal time scales. These first chapters of the book will appeal to less-advanced readers as they start at a rather basic level. However, it is important, in my view, to discuss past climate changes by building upon a solid background in climatological methods and climate physics.

The fourth and main chapter of the book discusses major climatic variations since 1700, some of which are important in their own right, while others exemplify cases that are typical or characteristic for a certain period. Rather than to review the literature on these events, one main goal of this book is to reproduce and interpret these variations in the new data sets and the new approaches introduced in the second chapter. These analyses, though imperfect and preliminary, serve the purpose of illustrating what palaeoclimatology can do. The book concludes with a summary.

The choice of topics and of climatic events included in this book is not objective or comprehensive—this would be beyond my expertise. The selection of climatic events, data sets and models is therefore strongly biased by the work of our research group, and it has a focus on Europe and Switzerland. The book thus conveys a personal view of how and why the climate developed over the past 300 years; it does not do justice to all the excellent work that has been done by others in the field.

Bern, Switzerland Stefan Brönnimann
August 2015

Acknowledgements

This book is the result of a number of projects in which I was fortunate to participate over the past decade. These projects were funded by the Swiss National Science Foundation (my SNF professorship, NCCR Climate project PALVAREXIII, research projects EVALUATE and TWIST and sinergia projects FUPSOL and FUPSOL 2), COST Action "Home", the EC FP7 projects ERA-CLIM and ERA-CLIM 2, ERC grant TITAN, MeteoSwiss, the cogito foundation, the Bretscher Stiftung, the Holderbank and Janggen-Poehn Foundations, and ETH Zurich. The CLIMANDES project made me draw simple schematic figures. Computing time was provided by the Swiss Supercomputer Centre CSCS. I also acknowledge the great support of the Oeschger Centre for Climate Change Research at the University of Bern and of the IT staff at our Institute: Basilio Ferrante and Andrey Martynov.

The book uses many data sets that are based on long-term efforts of numerous individuals and institutions such as NCEP/NCAR, the European Centre for Medium-Range Weather Forecast (ECMWF), NOAA/CIRES CDC, NASA, the Hadley Centre of the UK Met Office, the Climatic Research Unit of the University of East Anglia, Norwich, MeteoSwiss and many others.

The photos displayed in Figs. 2.2, 2.5, 2.6, 2.11, 2.27 and 5.3 are from Andrea Kaiser.

I would like to thank those who made the research possible, collaborated in the projects, hosted me during various stays or administered the projects. I thank Monique Stewart for language editing and Céline Dizerens, Matthias Röthlisberger and Yuri Brugnara for formatting. Finally, my greatest thanks goes to all those who performed the actual research on which this book is based, all of the Masters and Ph.D. students and the scientists whose results constitute the progress in our field and all colleagues and scientists with whom I have had the pleasure to work with: Rob Allan, Julien Anet, Florian Arfeuille, Renate Auchmann, Jürg Beer, Tom Bodenmann, Petra Breitenmoser, Philip Brohan, Yuri Brugnara, Marcel Bühler, Gilbert P. Compo, Silke Dierer, Tracy Ewen, Andreas Fischer, Doris Folini, David Frank, Jörg Franke, Andrea Grant, Thomas Griesser, Martin Grosjean,

Jenny Grütter, Gertrude Hirsch Hadorn, Ena Hirschi, Dogushan Kilic, Matthias Röthlisberger, Matthias Rutishauser, Stefan Hunziker, Martin Jacques-Coper, Sina Lenggenhager, Jürg Luterbacher, Brigitte Müller, Stefan Muthers, Raphael Neukom, Thomas Peter, Christoph Raible, Marco Rohrer, Olivia Romppainen, Eugene Rozanov, Margit Schwikowski, Alexander Stickler, Constantin Streit, Peter Stucki, Christian Vogler, Esther Volken, Heinz Wanner, Richard Wartenburger, Martin Wegmann, Helmut Weissert, Martin Wild, Sebastian Wolfinger, Heinz Zumbühl and many others.

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