
Geography of the Physical Environment

The *Geography of the Physical Environment* book series provides a platform for scientific contributions in the field of Physical Geography and its sub-disciplines. It publishes a broad portfolio of scientific books covering case studies, theoretical and applied approaches as well as novel developments and techniques in the field. The scope is not limited to a certain spatial scale and can cover local and regional to continental and global facets. Books with strong regional focus should be well illustrated including significant maps and meaningful figures to be potentially used as field guides and standard references for the respective area.

The series appeals to scientists and students in the field of geography as well as regional scientists, landscape planners, policy makers, and everyone interested in wide-ranging aspects of modern Physical Geography. Peer-reviewed research monographs, edited volumes, advance and undergraduate level textbooks, and conference proceedings covering the major topics in Physical Geography are included in the series. Submissions to the Book Series are also invited on the theme 'The Physical Geography of...', with a relevant subtitle of the author's/editor's choice.

More information about this series at <http://www.springer.com/series/15117>

Tobias Heckmann · David Morche
Editors

Geomorphology of Proglacial Systems

Landform and Sediment Dynamics
in Recently Deglaciaded Alpine
Landscapes



Springer

Editors

Tobias Heckmann
Physical Geography
Catholic University of
Eichstätt-Ingolstadt
Eichstätt, Germany

David Morche
Environmental Authority
of Saalekreis District
Merseburg, Germany

ISSN 2366-8865 ISSN 2366-8873 (electronic)
Geography of the Physical Environment
ISBN 978-3-319-94182-0 ISBN 978-3-319-94184-4 (eBook)
<https://doi.org/10.1007/978-3-319-94184-4>

Library of Congress Control Number: 2018950204

© Springer Nature Switzerland AG 2019

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Cover image by Sonja Weber, München

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Contents

1	Introduction	1
	Tobias Heckmann, David Morche and Michael Becht	
Part I Proglacial Areas, Glaciers and Ground Ice		
2	Glacier Changes Since the Little Ice Age.	23
	Frank Paul and Tobias Bolch	
3	An Inventory of Proglacial Systems in Austria, Switzerland and Across Patagonia	43
	Jonathan Carrivick, Tobias Heckmann, Mauro Fischer and Bethan Davies	
4	Debris-Covered Glaciers	59
	Elisabeth Mayr and Wilfried Hagg	
5	Closing the Balances of Ice, Water and Sediment Fluxes Through the Terminus of Gepatschferner	73
	Martin Stocker-Waldhuber and Michael Kuhn	
6	(Ground) Ice in the Proglacial Zone.	85
	Isabelle Gärtner-Roer and Alexander Bast	
7	Periglacial Morphodynamics in the Upper Kaunertal.	99
	Jana-Marie Dusik, Matthias Leopold and Florian Haas	
Part II Hillslope Processes in the Proglacial Zone		
8	Rock Slope Instability in the Proglacial Zone: State of the Art	119
	Samuel T. McColl and Daniel Draebing	
9	Rockfall at Proglacial Rockwalls—A Case Study from the Kaunertal, Austria	143
	Lucas Vehling, Joachim Rohn and Michael Moser	
10	Glacial Sediment Stores and Their Reworking	157
	Philip R. Porter, Martin J. Smart and Tristram D. L. Irvine-Fynn	
11	Slope Wash, Gully Erosion and Debris Flows on Lateral Moraines in the Upper Kaunertal, Austria	177
	Jana-Marie Dusik, Fabian Neugirg and Florian Haas	

Part III Proglacial Rivers and Lakes

- 12 Sediment Transport in Proglacial Rivers** 199
Luca Mao, Francesco Comiti, Ricardo Carrillo
and Daniele Penna
- 13 Fluvial Sediment Transport in the Proglacial Fagge River,
Kaunertal, Austria** 219
David Morche, Henning Baewert, Anne Schuchardt,
Matthias Faust, Martin Weber and Taimur Khan
- 14 Proglacial Lakes in High Mountain Environments** 231
Jan-Christoph Otto

Part IV Proglacial Sediment Cascades and Budgets

- 15 Sediment Budgets in High-Mountain Areas:
Review and Challenges** 251
Ludwig Hilger and Achim A. Beylich
- 16 Sediment Connectivity in Proglacial Areas** 271
Marco Cavalli, Tobias Heckmann and Lorenzo Marchi
- 17 A Sediment Budget of the Upper Kaunertal** 289
Ludwig Hilger, Jana-Marie Dusik, Tobias Heckmann,
Florian Haas, Philipp Glira, Norbert Pfeifer, Lucas Vehling,
Joachim Rohn, David Morche, Henning Baewert,
Martin Stocker-Waldhuber, Michael Kuhn and Michael Becht

Part V The Role of Soil, Vegetation and Morphodynamics in the Evolution of Proglacial Systems

- 18 The Uncalm Development of Proglacial Soils
in the European Alps Since 1850** 315
Arnaud J. A. M. Temme
- 19 Vegetation Succession and Biogeomorphic Interactions
in Glacier Forelands** 327
Jana Eichel

Author Index 351

Subject Index 353