

SOURCE-TO-SINK FLUXES IN UNDISTURBED COLD ENVIRONMENTS

Amplified climate change and ecological sensitivity of polar and cold climate environments are key global environment issues. Understanding how projected climate change will alter surface environments in these regions is only possible when present-day source-to-sink fluxes can be quantified.

The book provides the first global synthesis and integrated analysis of environmental drivers and quantitative rates of solute and sedimentary fluxes in cold environments, and the likely impact of projected climate change. The focus on largely undisturbed cold environments allows ongoing climate change effects to be detected and, moreover, distinguished from anthropogenic impacts. A novel approach for coordinated and integrative process geomorphic research is introduced to enable better comparison between studies.

This highly topical and multidisciplinary book, which includes case studies covering Arctic, Antarctic, and alpine environments, will be of interest to graduate students and researchers in the fields of geomorphology, sedimentology, and global environmental change.

ACHIM A. BEYLICH is a senior research scientist at the Geological Survey of Norway, Trondheim. He has also held an Associate Professor position at the Norwegian University of Science and Technology (NTNU) in Trondheim. Dr. Beylich has more than 20 years of experience in field- and laboratory-based quantitative process geomorphic research in cold climate environments in Iceland, Sweden, Finland, Norway, Canada, Russia, and the German Alps. He initiated the SEDIBUD (Sediment Budgets in Cold Environments) working group of the International Association of Geomorphologists (IAG), which he has chaired and led since 2005.

JOHN C. DIXON is professor of Geosciences at the University of Arkansas, USA. His principal research interests lie in the area of landscape evolution in cold and warm dry climates and, in particular, the role of chemical processes in soil and regolith formation. Professor Dixon has worked in Swedish Lapland, Alaska, the Rocky Mountains, southern Australia, and southern Norway and has published over 100 refereed journal articles and book chapters.

ZBIGNIEW ZWOLIŃSKI is a professor at the Institute of Geoecology and Geoinformation at Adam Mickiewicz University in Poznań, Poland. His main research interests include fluvial geomorphology and sedimentology, GIScience, geodiversity, and global changes. He conducts research on desert landforms as well as landforms in tropical and Polar Regions and has participated in many summer expeditions to the High Arctic (Spitsbergen, Iceland) and Antarctica (King George Island).

Cambridge University Press
978-1-107-06822-3 - Source-to-Sink Fluxes in Undisturbed Cold Environments
Edited by Achim A. Beylich, John C. Dixon and Zbigniew Zwoliński
Frontmatter
[More information](#)

Cambridge University Press
978-1-107-06822-3 - Source-to-Sink Fluxes in Undisturbed Cold Environments
Edited by Achim A. Beylich, John C. Dixon and Zbigniew Zwoliński
Frontmatter
[More information](#)

Source-to-Sink Fluxes in Undisturbed
Cold Environments

Edited by

ACHIM A. BEYLICH
Trondheim, Norway

JOHN C. DIXON
Fayetteville, Arkansas, USA

ZBIGNIEW ZWOLIŃSKI
Poznań, Poland



CAMBRIDGE
UNIVERSITY PRESS

Cambridge University Press
978-1-107-06822-3 - Source-to-Sink Fluxes in Undisturbed Cold Environments
Edited by Achim A. Beylich, John C. Dixon and Zbigniew Zwoliński
Frontmatter
[More information](#)

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

Cambridge University Press is part of the University of Cambridge.
It furthers the University’s mission by disseminating knowledge in the pursuit of
education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781107068223

© Cambridge University Press 2016

This publication is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without the written
permission of Cambridge University Press.

First published 2016

Printed in the United Kingdom by TJ International Ltd. Padstow Cornwall

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication data

Names: Beylich, Achim A., editor.
Title: Source-to-sink fluxes in undisturbed cold environments / edited by
Achim A. Beylich, Trondheim, Norway, John C. Dixon, Fayetteville, U.S.A.,
Zbigniew Zwoliński, Poznan, Poland.
Description: Cambridge ; New York : Cambridge University Press, 2016. |
Includes bibliographical references and index.
Identifiers: LCCN 2016000904 | ISBN 9781107068223 (hard back : alk. paper)
Subjects: LCSH: Sediment transport–Polar regions. | Sedimentation and
deposition–Cold regions. | Geomorphology–Polar regions.
Classification: LCC GB1399.6 .S68 2016 | DDC 551.3/040911–dc23 LC record available at <https://lcn.loc.gov/2016000904>
ISBN 978-1-107-06822-3 Hardback
Cambridge University Press has no responsibility for the persistence or accuracy
of URLs for external or third-party internet websites referred to in this publication,
and does not guarantee that any content on such websites is, or will remain,
accurate or appropriate.

Contents

<i>List of contributors</i>	<i>page</i> vii	
<i>Preface</i>	xi	
Part I: Solute and sedimentary fluxes and budgets in changing cold climate environments	1	
1 Introduction to the theme	3	
ACHIM A. BEYLICH		
2 The I.A.G./A.I.G. SEDIBUD (Sediment Budgets in Cold Environments) program	5	
ACHIM A. BEYLICH		
Part II: Climate change in cold environments and general implications for contemporary solute and sedimentary fluxes	11	
3 The changing cryosphere – implications for solute and sedimentary fluxes in cold climate environments	13	
IVAR BERTHLING AND BERND ETZELMÜLLER		
4 Changes in vegetation cover and implications for solute and sedimentary fluxes in cold climate environments	30	
ULF MOLAU		
Part III: Solute and sedimentary fluxes in subarctic and Arctic environments	37	
5 Contemporary solute and sedimentary fluxes in Arctic and subarctic environments: current knowledge	39	
JOHN C. DIXON		
6 The use of dendrogeomorphology to recognize the spatiotemporal distribution of snow avalanches in Northern Iceland – case studies from Dalsmynni, Ljósavatnsskarð, and Fnjóskadalur	52	
ARMELLE DECAULNE, ÓLAFUR EGGERTSSON, AND THORSTEINN SÆMUNDSSON		
7 A contemporary assessment of sediment and solute transfers in Kärkevagge, Swedish Lapland	67	
JOHN C. DIXON		
8 Hillslope processes and related sediment fluxes on a fine-grained scree slope of Eastern Canada	79	
DANIEL GERMAIN AND BERNARD HÉTU		
9 Sediment and solute transport from Greenland	96	
BENT HASHOLT		
10 Measurements of bedload flux in a high Arctic environment	116	
WALDEMAR KOCIUBA		
11 Solute and particulate fluxes in catchments in Spitsbergen	133	
GRZEGORZ RACHLEWICZ, GRAŻYNA SZPIKOWSKA, JÓZEF SZPIKOWSKI, AND ZBIGNIEW ZWOLIŃSKI		
12 Sediment and solute fluxes at the Igarka field site, Russian subarctic	144	
NIKITA I. TANANAEV		
13 Variability and controls of solute and sedimentary fluxes in subarctic and Arctic environments	154	
JOHN C. DIXON		

vi	<i>Contents</i>	
Part IV: Solute and sedimentary fluxes in sub-Antarctic and Antarctic environments	161	
14 Environmental impact on contemporary solute and sedimentary fluxes in Antarctica: current knowledge ZBIGNIEW ZWOLIŃSKI, SERGEY BOLTRAMOVICH, MAREK KEJNA, ALEXANDER LASTOCHKIN, AND ANDREY ZHIROV	163	22 Suspended sediment dynamics in the proglacial zone of the rapidly retreating Castle Creek Glacier, British Columbia, Canada TIM A. STOTT, MIKE S. LEGGAT, PHILIP N. OWENS, BARRY J. FORRESTER, STEPHEN J. DÉRY, AND BRIAN MENOUNOS 313
15 Solute and solid cascade system in the Antarctic oases ZBIGNIEW ZWOLIŃSKI	183	23 Sedimentary fluxes in Himalaya MONIQUE FORT 326
16 Environmental controls on sediment composition and particle fluxes over the Antarctic continental shelf ENRIQUE ISLA	199	24 Rates of slope and channel processes in the Reintal valley, Bavarian Alps DAVID MORCHE, MICHAEL KRAUTBLATTER, TOBIAS HECKMANN, FLORIAN HAAS, AND JOACHIM GÖTZ 351
17 Solute and sedimentary fluxes on King George Island ZBIGNIEW ZWOLIŃSKI, MAREK KEJNA, GRZEGORZ RACHLEWICZ, IRENEUSZ SOBOTA, AND JÓZEF SZPIKOWSKI	213	25 Comparative analysis of sediment routing in two different alpine catchments JOHANNES STANGL, ERIC RASCHER, AND OLIVER SASS 364
18 Dynamics of the Antarctica ice cap ALEXANDER N. LASTOCHKIN	238	26 Controls and variability of solute and sedimentary fluxes in alpine/mountain environments ACHIM A. BEYLICH 378
19 Solute and sediment fluxes from rivers and streams in the McMurdo Dry Valleys, Antarctica WILLIAM BERRY LYONS, KATHLEEN A. WELCH, JOSEPH S. LEVY, ANDREW G. FOUNTAIN, AND DIANE M. MCKNIGHT	260	Part VI: Quantitative analysis of solute and sedimentary fluxes in cold climate environments 383
Part V: Solute and sedimentary fluxes in alpine/mountain environments	273	
20 Chemical denudation in partly glacierized mountain catchments of the fjord landscape in western Norway: contemporary rates, environmental controls, and possible effects of climate change ACHIM A. BEYLICH AND KATJA LAUTE	275	27 Environmental drivers, spatial variability, and rates of chemical and mechanical fluvial denudation in selected glacierized and nonglacierized cold climate catchment geosystems: from coordinated field data generation to integration and modeling ACHIM A. BEYLICH 385
21 Sediment delivery from headwater slope systems and relief development in steep mountain valleys in western Norway KATJA LAUTE AND ACHIM A. BEYLICH	293	28 Summary of key findings from Arctic, Antarctic, and mountain environments ACHIM A. BEYLICH, JOHN C. DIXON, AND ZBIGNIEW ZWOLIŃSKI 398
		<i>Index</i> 401

Contributors

IVAR BERTHLING
Department of Geography, Norwegian
University of Science and Technology (NTNU),
Trondheim, Norway

ACHIM A. BEYLICH
Geo-Environment Division, Geological Survey
of Norway (NGU), Trondheim, Norway

SERGEY BOLTRAMOVICH
Institute of Earth Sciences, St. Petersburg
State University, St. Petersburg, Russia

ARMELLE DECAULNE
Le Centre national de la recherche scientifique
(CNRS), University of Nantes, Nantes, France

STEPHEN J. DÉRY
Environmental Science and Environmental Engineer-
ing Program, University of Northern British Columbia,
Prince George, British Columbia, Canada

JOHN C. DIXON
Department of Geosciences, University of Arkansas,
Fayetteville, Arkansas, U.S.A.

ÓLAFUR EGGERTSSON
Research Branch, Icelandic Forest Service,
Reykjavik, Iceland

BERND ETZELMÜLLER
Department of Geosciences, University of Oslo,
Oslo, Norway

BARRY J. FORRESTER
Faculty of Education, Health & Community,
Liverpool John Moores University, Liverpool,
United Kingdom

MONIQUE FORT
Laboratoire de géographie PRODIG, Paris Diderot
University, Paris 7, Paris, France

ANDREW G. FOUNTAIN
Department of Geology, Portland State University,
Portland, Oregon, U.S.A.

DANIEL GERMAIN
Département de géographie, University
of Quebec at Montréal, Montréal, Quebec, Canada

JOACHIM GÖTZ
Department of Geography and Geology,
University of Salzburg, Salzburg, Austria

FLORIAN HAAS
Physical Geography, Catholic University
of Eichstätt-Ingolstadt, Eichstätt, Germany

BENT HASHOLT
Department of Geosciences and Natural Resource
Management, University of Copenhagen, Copen-
hagen, Denmark

TOBIAS HECKMANN
Physical Geography, Catholic University
of Eichstätt-Ingolstadt, Eichstätt, Germany

BERNARD HÉTU
Département de biologie, chimie et géographie,
University of Quebec at Rimouski, Rimouski,
Quebec, Canada

ENRIQUE ISLA
Institut de Ciencies del Mar-CSIC, Barcelona,
Spain

MAREK KEJNA
Faculty of Earth Sciences, Nicolaus Copernicus
University, Toruń, Poland

WALDEMAR KOCIUBA
Institute of Earth Sciences, Maria Curie-Skłodowska
University, Lublin, Poland

MICHAEL KRAUTBLATTER
Chair of Landslide Research, Technical
University of Munich, Munich, Germany

ALEXANDER N. LASTOCHKIN
Institute of Earth Sciences, St. Petersburg
State University, St. Petersburg, Russia

KATJA LAUTE
Geo-Environment Division, Geological
Survey of Norway (NGU), Trondheim, Norway

MIKE S. LEGGAT
Environmental Science and Environmental
Engineering Program, University of Northern
British Columbia, Prince George, British
Columbia, Canada

JOSEPH S. LEVY
Department of Geological Sciences, University
of Texas at Austin, Austin, Texas, U.S.A.

WILLIAM BERRY LYONS
School of Earth Sciences, Ohio State University,
Columbus, Ohio, U.S.A.

DIANE M. MCKNIGHT
Institute of Arctic and Alpine Research,
University of Colorado, Boulder,
Colorado, U.S.A.

BRIAN MENOUNOS
Geography Program and Natural Resources
and Environmental Studies Institute, University of
Northern British Columbia, Prince George, British
Columbia, Canada

ULF MOLAU
Department of Biological & Environmental Sciences,
University of Gothenburg, Göteborg, Sweden

DAVID MORCHE
Institute for Geosciences and Geography, Martin
Luther University Halle-Wittenberg, Halle (Saale),
Germany

PHILIP N. OWENS
Environmental Science and Environmental Engineer-
ing Program, University of Northern British Columbia,
Prince George, British Columbia, Canada

GRZEGORZ RACHLEWICZ
Institute of Geoecology and Geoinformation, Adam
Mickiewicz University, Poznań, Poland

ERIC RASCHER
Department of Geography and Regional Science,
University of Graz, Graz, Austria

THORSTEINN SÆMUNDSSON
Institute of Earth Sciences, University of Iceland,
Reykjavik, Iceland

OLIVER SASS
Department of Geography and Regional Science,
University of Graz, Graz, Austria

IRENEUSZ SOBOTA
Faculty of Earth Sciences, Nicolaus Copernicus
University, Toruń, Poland

JOHANNES STANGL
Department of Geography and Regional Science,
University of Graz, Graz, Austria

TIM A. STOTT
Faculty of Education, Health & Community, Liverpool
John Moores University, Liverpool, United Kingdom

Cambridge University Press
978-1-107-06822-3 - Source-to-Sink Fluxes in Undisturbed Cold Environments
Edited by Achim A. Beylich, John C. Dixon and Zbigniew Zwoliński
Frontmatter
[More information](#)

List of contributors ix

GRAŻYNA SZPIKOWSKA Geoecological Station, Adam Mickiewicz University, Grzmiąca, Poland	KATHLEEN A. WELCH Byrd Polar Research Center, Ohio State University, Columbus, Ohio, U.S.A.
JÓZEF SZPIKOWSKI Institute of Geoecology and Geoinformation, Adam Mickiewicz University, Poznań, Poland	ANDREY ZHIROV Institute of Earth Sciences, St. Petersburg State University, St. Petersburg, Russia
NIKITA I. TANANAEV Igarka Geocryology Laboratory, Siberian Branch, Russian Academy of Sciences, Igarka, Krasnoyarsk Krai, Russia	ZBIGNIEW ZWOLIŃSKI Institute of Geoecology and Geoinformation, Adam Mickiewicz University, Poznań, Poland

Cambridge University Press
978-1-107-06822-3 - Source-to-Sink Fluxes in Undisturbed Cold Environments
Edited by Achim A. Beylich, John C. Dixon and Zbigniew Zwoliński
Frontmatter
[More information](#)

Preface

Amplified climate change and ecological sensitivity of largely undisturbed polar and high-altitude cold climate environments have been highlighted as key global environmental issues. The effects of projected climate change will change surface environments in cold regions and alter the fluxes of sediments, nutrients, and solutes, but the absence of quantitative data and coordinated geomorphic process monitoring, analysis, and modeling to understand the sensitivity of the Earth surface environment in these largely undisturbed environments is acute.

This book, *Source-to-Sink Fluxes in Undisturbed Cold Environments*, addresses this key knowledge gap and aims at an integrated analysis of environmental drivers and rates of contemporary solute and sedimentary fluxes in cold climate catchment geosystems. It summarizes and synthesizes achievements of the International Association of Geomorphologists' (I.A.G./A.I.G.) SEDIBUD (Sediment Budgets in Cold Environments) program which has been active over the last eleven years, since 2005. In the focus of the book are selected examples of natural and largely undisturbed catchment geosystems (SEDIBUD key test sites) from different characteristic cold climate environments worldwide. The book is not aiming at a geographical survey or inventory of these environments. The key focus is on the quantitative analysis and understanding of environmental controls and rates of contemporary solute and sedimentary fluxes in defined cold climate catchment geosystems. Referring to the issue of glacial environments versus cold environments both glacierized and nonglacierized catchment geosystems are investigated.

For reaching a global cover of different cold climate environments the book is, after providing an introductory part, "Solute and sedimentary fluxes and budgets in changing cold climate environments" (Part I) and a general part, "Climate change in cold

environments and general implications for contemporary solute and sedimentary fluxes" (Part II), dealing in different defined book parts with "Solute and sedimentary fluxes in sub-Arctic and Arctic environments" (Part III), "Solute and sedimentary fluxes in sub-Antarctic and Antarctic environments" (Part IV), and "Solute and sedimentary fluxes in alpine/mountain environments" (Part V). In Part VI, "Quantitative analysis of solute and sedimentary fluxes in cold climate environments," the key findings from the previous book parts are summarized and main conclusions are drawn. In addition, comparable datasets on contemporary solute and sedimentary fluxes and yields generated during coordinated research efforts in different selected cold climate catchment geosystems are integrated with the key goals to (1) identify the main environmental drivers and rates of contemporary solute and sedimentary fluxes, (2) explain the spatial variability of contemporary solute and sedimentary fluxes and yields found across different cold climate environments, and (3) assess possible effects of projected climate change on solute and sedimentary fluxes in these cold climate environments.

All chapters of this SEDIBUD synthesis book went through a peer-review process, and the completion of this book would not have been possible without the valuable help of numerous peer reviewers. We would like to thank all these anonymous reviewers for their important work and contributions. In addition, we would like to express our special thanks to Professor Dr. Olav Slaymaker (Vancouver, Canada), who provided essential scientific advice throughout the duration of the SEDIFLUX and SEDIBUD programs and during the process of preparing this book.

**Achim A. Beylich, John C. Dixon,
and Zbigniew Zwoliński**