

Environmental Science and Engineering

Series editors

Ulrich Förstner, Hamburg, Germany

Wim H. Rulkens, Wageningen, The Netherlands

Wim Salomons, Haren, The Netherlands

More information about this series at <http://www.springer.com/series/7487>

Gulnura Issanova · Jilili Abuduwaili

Aeolian Processes as Dust Storms in the Deserts of Central Asia and Kazakhstan

 Springer

Gulnura Issanova
Research Centre of Ecology
and Environment of Central
Asia (Almaty)
State Key Laboratory of Desert
and Oasis Ecology, Xinjiang
Institute of Ecology and Geography,
Chinese Academy of Sciences
Urumqi
China

Jilili Abuduwaili
Research Centre of Ecology
and Environment of Central
Asia (Almaty)
State Key Laboratory of Desert
and Oasis Ecology, Xinjiang
Institute of Ecology and Geography,
Chinese Academy of Sciences
Urumqi
China

and

U.U. Uspanov Kazakh Research Institute
of Soil Science and Agrochemistry
Almaty
Kazakhstan

ISSN 1863-5520 ISSN 1863-5539 (electronic)
Environmental Science and Engineering
ISBN 978-981-10-3189-2 ISBN 978-981-10-3190-8 (eBook)
DOI 10.1007/978-981-10-3190-8

Library of Congress Control Number: 2016957700

© Springer Nature Singapore Pte Ltd. 2017

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.

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

*The original version of the book was revised:
The book title has been updated.
The Erratum to the book is available at
DOI [10.1007/978-981-10-3190-8_8](https://doi.org/10.1007/978-981-10-3190-8_8)*

Preface

This book considers and contains research results on aeolian processes as dust and sand storms in the deserts of Central Asia and Kazakhstan. Dust and sand storms are a common natural phenomenon in the arid and semi-arid regions of Central Asia and Kazakhstan, especially in its southern parts where the land is covered by a great variety of deserts, which are a powerful source of mineral and salt aerosols.

Aeolian processes as storms are important in arid environment such as deserts. Desert covers >40% of the territory of Central Asia. These deserts are characterized by large areas and empty expanses of sand. The sandy deserts of Central Asia are bordered by the green plains of the Central Asian steppe in the north and abutted by soaring mountain ranges that border with Iran, Afghanistan, and China in the south and east.

Deserts occupy much of Kazakhstan and almost all of Uzbekistan and Turkmenistan. The deserts of Kazakhstan mostly cover lowlands and extend from the eastern coast of the Caspian Sea to the piedmonts of the Tien-Shan Mountain.

Central Asian deserts—particularly the sandy northern desert in central Kazakhstan and the southern desert, which covers Turkmenistan, Uzbekistan, and southern Kazakhstan—have a great diversity of natural conditions.

Desert areas are major source areas of dust- and sand-storm activities. Storms are particularly dangerous for the environment because they have a great impact on soil conditions. Thus, the study of aeolian processes as dust and sand storms in the sandy deserts of Central Asia and Kazakhstan has great importance toward aiding in the prediction and monitoring of storms and their movement patterns.

The aim of the study is the detection of dust, sand, and salt storm sources and determining their causes based on the consideration and analysis of numerous cartographic materials, data from weather stations, and satellite-monitoring materials, thereby providing an accurate picture of the distribution and frequency of storms over the deserts of the Central Asia and Kazakhstan. In addition, we also aimed to conduct a quantitative assessment of sand and dust transport during the process of deflation and thus determine the mobile-sand process in the deserts of Central Asia and Kazakhstan.

Consideration of the interesting topic of dust- and sand-storm distribution in the deserts of Central Asia and Kazakhstan, as well as the identification of powerful sources of dust- and sand-storm origin, is important and required to determine their role in soil deflation and desertification. Information and published scientific materials on dust and sand storms in Central Asia are quite limited, and especially rarely do such publications appear in English-language peer-reviewed journals. Therefore, this publication will fill a gap in our knowledge of aeolian processes as dust and sand storms in arid or desert areas of Central Asia and Kazakhstan.

The book is mainly addressed to scientists and researchers whose research has been focused on storm and land-degradation and -desertification studies as well as students and planners. It is intended to be a source of information and inspiration for all readers who feel responsible for initiating the sustainable development and sustainable use of natural resources in Central Asian countries. We are hopeful that readers will gain some useful information and inspiration from this book for their own work. We believe that this publication provides a great contribution to our knowledge about the nature of dust and sand storms, the causes of their origin, and the environmental issues they create.

Almaty, Kazakhstan/Urumsqi, China
Urumsqi, China

Gulnura Issanova
Jilili Abuduwaili

Content and Structure of the Book

This book summarises the outcomes of research results and recent studies related to dust and sand storms occurring in Central Asia and Kazakhstan. The book has seven individual chapters as follows. Chapter 1, “Introduction and Status of Storms in Central Asia and their Environmental Problems,” provides an overview of issues related to dust and sand storms, land degradation and desertification, shrinking lakes in Central Asia and their environmental changes, the relationship between dust storms and desertification process, as well as data sources on storms and research methods. The chapter contains six sections that analyze the current status of environmental issues brought by dust and sand storms. Chapter 2, “Natural Conditions of Central Asia and Land-Cover Changes”, provides information about climate conditions and weather processes in Central Asia, the natural geographical division of deserts in Central Asia and Kazakhstan, as well as land and soil resources and changes in soil and vegetation cover. Chapter 3—“Spatial and Temporal Distribution of Storms in Central Asia and Kazakhstan,” contains six sections providing information on the spatial and temporal distribution of storms and the variance of dust deposition in Central Asia, temporal changes in the frequency and intensity of storms in Kazakhstan, and atmospheric parameters influencing dust transport. Chapter 4, “Relationship Between Storms and Land Degradation,” contains three sections considering and analyzing the relationship between storms and land degradation. It provides information about natural and geographical conditions (topography, soils, vegetation) serving as sources of sand storms, the land-degradation process produced by wind erosion created by storms, and a comparative analysis of storm sources using temporal remote-sensing data along with ground-monitoring data. Chapter 5, “Dust Storms in Central Asia and Kazakhstan: Regional Division, Frequency and Seasonal Distribution,” contains eight sections that consider and describe the main sources of dust storms in Kazakhstan and Central Asia as well as their seasonal distribution, duration, and frequency. It provides information about main dust-storm sources in the Aral Sea basin including the Pre-Aral Karakum, Kyzylkum, and Aralkum deserts, other sources such as the Southern Pre-Balkhash and Naryn deserts, the seasonal distribution, duration, and frequency of storms, the relationship between storm origin

and soil texture with favorable plant community, and visual identification of dust-storm sources based on satellite images. Chapter 6, “Aeolian Transport of Dust and Sand in the Deserts of Kazakhstan,” contains five sections that give a quantitative assessment of dust and sand transport during deflation and thus determines the mobile-sand process in the deserts of Kazakhstan. It offers quantitative information on the transport of dust and sand in the deserts of Kazakhstan (the Aralkum, Southern Pre-Balkhash, and Naryn deserts) as well as the direction of dust transport, the size of sand particles, and physical–statistical modelling of dust- and sand-transport processes. Chapter 7, “Conclusions”.

Acknowledgements

Many people and scientists have supported and provided the basis for this book. We are heartily thankful to professor and academician at the National Academy of Sciences of Kazakhstan, Medeu Akhmetkal (worthy director at the Institute of Geography, Kazakhstan), for the providing some necessary materials for researching and writing this valuable monograph and his comprehensive support.

Many profound thanks and sincere gratitude goes to my mentor, Prof. Dr. Zheken Mamutov, whose guidance, mentorship, encouragement, and advice immensely helped accomplish this noble task.

We owe special thanks to Murat Kassenov whose help made this work possible for me by providing the raw necessary data for the analysis part and, in addition, for valuable advice and brotherly support.

We thank Dr. Oleg Semenov as a great scientist in the field of dust- and sand-storm physics for providing some basic and essential materials to accomplish this uphill task.

Separate thanks go to Dr. Azamat Kaldybayev for technical support in GIS mapping for some chapters of the book.

We sincerely to thank all of the researchers and scientists—in particular Dr. Orlovsky Leah, Prof. Christian Opp, Dr. Michael Groll, Dr. Indoitu, and Dr. Micklin—performing dust-storm research, conservationists, practitioners, friends, and colleagues and well-wishers who had provided precious help on many different occasions during the writing of this book by sharing their scientific articles, reports, reviews, experiences, critiques, suggestions, and ideas, all of which became part of this book.

Thanks are also due for the external reviewers and Editors—Ulrich Forstner, Wim H. Rulkens, Wim Salomons, whose constructive criticism and suggestions helped improve the book.

The authors thank all the contributors for their support and engagement. Separate thanks go to D’Silva, Loyola, Meiyazhagan Divya and Mohammed Ali.

Thanks also to our good friends worldwide and confederate for their continued facilitation, support, and love.

Lastly, I sincerely thank my mother, Zeinep Issanova, and father, Tolegen Issanov as well as my sisters and brothers who always prayed for my good health and success.

This research was funded and supported by the National Natural Science Foundation of China (U1603242; 41471098). International Science and Technology Cooperation Program of China (2010DFA92720; 2012DF70110), and the Foundation State Key Laboratory of Desert and Oasis Ecology, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences.

Contents

1 Introduction and Status of Storms in Central Asia and their Environmental Problems	1
1.1 Background of Research on Storms in Central Asia and Kazakhstan	1
1.2 Sand and Dust Storms in Central Asia and Kazakhstan	3
1.3 Land-Degradation and Desertification Processes in Central Asian Countries	4
1.4 Shrinking Lakes in Central Asia Plus Dry Regional Environmental Changes	11
1.5 Sand and Dust Storms and Desertification in Central Asia	18
1.6 Data Sources on Storms and Research Methods	20
References	23
2 Natural Conditions of Central Asia and Land-Cover Changes	29
2.1 Natural Geographical Division of Deserts in Central Asia and Kazakhstan	29
2.2 Climate Conditions and Weather Process in Central Asian Deserts	34
2.3 Land Resources (Soil Cover) and Changes in Vegetation Cover and Climate	43
References	48
3 Spatial and Temporal Distribution of Storms in Central Asia and Kazakhstan	51
3.1 Spatial and Temporal Distribution of Storms in Central Asia and Kazakhstan	51
3.2 Spatial and Temporal Variance of Dust Deposition in Central Asia	53
3.3 Temporal Changes of Storms Regarding Frequency and Intensity in Kazakhstan	60
3.4 Typical Regional Climate and Weather Process (Wind Regime) in Kazakhstan	61

3.5	Atmospheric Parameters Influencing Dust Transport in Central Asia	64
3.6	Analysis of Dust-Storm Trends in Central Asia	66
	References	68
4	Relationship Between Storms and Land Degradation.	71
4.1	Sources of Natural and Geographical (Topography, Soils, Vegetation) Storm Conditions	71
4.2	Storm-Produced Wind Erosion and Land-Degradation Processes . . .	73
4.3	Sand-Storm Outbreaks (Sources) Based on Temporal Remote-Sensing Data Combined with Ground-Monitoring Data . . .	75
	References	84
5	Dust Storms in Central Asia and Kazakhstan: Regional Division, Frequency and Seasonal Distribution	87
5.1	Main Dust Storm Sources in the Aral Sea Basin: Pre-Aral Karakum, Kyzylkum, and Aralkum Deserts	87
5.2	Southern Pre-Balkhash Desert Region Is the Source of Dust and Sand Storms	92
5.3	Sources of Dust and Sand Storm in the Naryn Desert	93
5.4	Visual Identification of Dust-Storm Sources Based on Satellite Images	98
5.5	Strong and Very Strong Dust Storms Within Kazakhstan	98
5.6	Seasonal Distribution and Frequency of Dust Storms in Central Asia and Kazakhstan	101
5.7	Duration and Diurnal Pattern of Dust Storms in Central Asian Deserts	103
5.8	The Relationship Between Dust-Storm Origin and Soil Texture . . .	107
	References	108
6	Aeolian Transport of Dust and Sand in the Deserts of Kazakhstan. . .	111
6.1	Physical–Statistical Modelling of Dust- and Sand-Transport Process	111
6.2	Aeolian Transport of Dust and Sand in the Aralkum Desert	114
6.3	Variability in the Time of Intensive Deflation Processes and Dust-Transport Direction in the Aral Sea Region	116
6.4	Dust and Sand Transport, Dominant Wind Direction, and Size of Sand Particles in the Southern Pre-Balkhash Deserts . . .	120
6.5	Aeolian Transport of Dust and Sand in the Naryn Desert (Northern Caspian Plain)	122
	References	126
7	Conclusions	129
	Bibliography	132
	Erratum to: Aeolian Processes as Dust Storms in the Deserts of Central Asia and Kazakhstan	E1

About the Authors



Gulnura Issanova holds a doctorate degree in Natural Sciences and is an associate professor, scientist, and researcher at U.U. Usmanov Kazakh Research Institute of Soil Science and Agrochemistry and a scientific secretary at the Research Centre of Ecology and Environment of Central Asia (Almaty), Kazakhstan. She studied at the Al-Farabi Kazakh National University for bachelor's degree (B.Sc.) and master's (M.Sc.) degrees in Physical Geography and for her doctoral degree graduated from Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, China.

Her research interest is focused on problems of soil degradation and desertification, in particular the role of dust and sand storms in the processes of land and soil degradation and desertification. She participates regularly in the International Scientific Activities (Conference, Forum, and Symposium) on Environmental Problems as well as writes papers on the subject and takes part in local and international projects.

Gulnura Issanova has published many papers in international peer-reviewed journals with high level and wrote a handbook, "How to Write Scientific Papers for International Peer-Reviewed Journals."

She is a co-author of the monograph, "Overview of Central Asian Environments" (in Chinese) and the handbook *Methodical Handbook on Interpretation of Saline Soils* (in four languages: Kazakh, Russian, English, and Chinese). Gulnura Issanova became a Laureat of the International Award "Springer Top Author" and awarded in the Nomination "Springer Young Scientist Awards" for high publication activity in scientific journals published by Springer Nature, 2016.



Jilili Abuduwaili is a professor and deputy director at the Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences (China) and an executive director of the Research Center of Ecology and Environment of Central Asia (Almaty). He holds a doctoral degree from the Lomonosov Moscow State University, Russia.

He is a member of a council of the China Natural Resources Society and the Xinjiang Geographical Society as well as a deputy chairman of the Xinjiang Natural Resources Society.

Jilili Abuduwaili is an associate editor of the *Journal of Arid Land* and editor-in-chief of the journals *Arid Land Geography* and *Arid Land Research* (both in Uyghur language). He is also an editorial board member of the journals *Arid Ecosystem* and *Soil Science and Agrochemistry* (Почвоведение и агрохимия). He is a Supervisor for postgraduate students. Since 2015, he has been a foreign academician at the Academy of Agriculture of Kazakhstan.

His main fields of work and expertise are in the areas of natural resources and environments, ecological safety, lake environments, disaster, and landscape changes in arid lands.

Jilili Abuduwaili has built international cooperation in research between Russia and Central Asian countries. He has published more than 200 papers in international and domestic journals and 7 books: *Lakes and Salt Dust Storms in Arid Lands* (in Chinese), *Overview of Central Asian Environments* (in Chinese), *Climate Change Effects to the Ecological System in TianShan Mountains* (in Russian), *Natural Geography of Kyrgyzstan* (in Russian), *Water Resources and Utilization in Uzbekistan* (in Russian), *Arid Soil in Kazakhstan: Current States and Utilization* (in Russian), *Salt Dust Storms: Special Disaster in Arid Lands* (in Uyghur).