

Preface

Sand (dust) movement driven by wind force as a natural phenomenon can be seen everywhere in arid desert, farmland, seashore or even broader regions on the earth and other planets including the Mars, Venus, Titan and so on. This kind of aeolian process is usually constituted by three parts including the uplifting from the surface of the earth, atmospheric dispersion, and deposition back to the surface. Whilst wind-blown sand (dust) movement contributes to the formation of the Loess Plateau and the growth of marine fauna and flora, it also causes a series of disasters such as soil nutrient loss, physical damage to farmland, deterioration of air quality, abrasion of engineering facility, etc. These above-mentioned disasters and environmental problems arising from wind-blown sand (dust) movement, to which scholars from many scientific fields other than geographers have paid more and more attention, have always been a governmental as well as a public concern since the 20th century. Despite great achievements have been made in controlling and managing the wind-blown sand hazard in some developed countries, for example, in the United States and Canada, desertification and pollution caused by wind-blown sand movement still remain to be the most serious, most urgent issues in developing countries, especially in China, as the global climate changes.

The transportation of sand (dust) materials by wind force is influenced by a lot of factors: climate, soil type, vegetation cover and soil utilization, to name just a few. Due to its critical dependency, hysteretic nature and high spatial-temporal discontinuity, it is a typical complex natural flow of multi-phases, multi-component media, multi-scale nonlinearity under complex boundaries as well as a comprehensive dynamical system presenting multiple characteristics such as non-linearity, statistical property, diversity, self-similarity, criticality, etc., in which the multi-physics field coupling (wind field, temperature field, wind-blown sand electric field caused by charged sand particles) and multi-processes interaction (atmospheric, ecological, chemical, human activity, and so on) co-exist. Scientific research concerning the transportation of sand (dust) materials by wind force involves issues like multi-scale and multi-field coupling, stochastic and nonlinear process, and complex system, etc., which are also crucial issues confronted by other disciplines. Despite the large amount of progress

achieved through long-period field observations, wind-tunnel experiments and theoretical analysis as well as some famous monographs (i.e. Bagnold, 1941; Greeley and Iversen, 1985; Pye and Tsoar, 1990; Shao, 2000; Zeng, et al., 2006, etc.) published, there is still a long way to travel before we arrive at a comprehensive and profound understanding on the mechanism of sand (dust) movement and form a precise prediction of its real physical process; further still, a lot more obligations need to fulfill before we realize an effective simulation and reproduction of the evolution of wind-blown sand flux and aeolian landforms.

Hence, the research approach which combines experiments, modelling and quantitative analysis, as a predominance of mechanics, is probably to the advantage of a deeper understanding of the physical process and basic rules of wind-blown sand environmental problems. Taking this advantage of mechanics into consideration, my team and I have devoted to the research of several typical issues related to aeolian processes during the past decade from a mechanical perspective. Apart from a summary of recent considerable achievements, this book mainly intends to introduce our recent research on the wind-blown sand movement through theoretical modelling, quantitative analysis and computer simulation. The first chapter of this book briefly introduces the situation of desertification and wind-blown sand disasters in China, especially North-western China. Chapter 2 summarizes the characteristics of the wind field in the atmospheric boundary layer with a particular emphasis on the turbulent property of the wind field. Chapter 3 devotes to the introduction of researches on sand's lifting off the sand bed surface, including the linear and angular velocity of sand particles lifting from the bed, their distribution and the representation of the particle-bed collision process. Chapter 4 is a description of the wind-blown sand electrification and its effect on sand saltation movement. Chapter 5 is dedicated to an analysis of the forces on sand particles and their trajectories, and is also an introduction to the experiment and theoretical prediction of sand transport rate, and in particular, the electric and thermal effect on the development of wind-blown sand flux, as well as the prediction of sand movement and transport intensity under a fluctuating wind field. Chapter 6 and 7 are devoted to the introduction of the formation and evolution of some typical aeolian landforms like ripples and dunes. Chapter 8 presents the mechanical analysis method to estimate the efficiency of sand prevention methods.

This book aims at serving as a reference for researchers and graduate students who major in geo-related sciences, such as physics of wind-blown sand, environmental science, geophysics, atmospheric science, etc., mechanics as well as applied mathematics, broadening the readers' horizon on the latest development of the quantitative research on wind-blown sand

movement and enhancing their competence to apply basic methods in this field. What I strive for is provide some methods and principles which may be helpful to researchers interested in the wind-blown sand movement and other environmental issues via this book, which, on one hand, may help researchers and students of geology and atmospheric science understand what can be absorbed from mechanics to push investigations on wind-blown sand movements in a more rational and quantitative manner and on the other hand, provide researchers and students expertise in mechanics, mathematics, physics and environment-related engineering with a smooth access to the research field of wind-blown sand movement. In this case, both parties mentioned above can unit their efforts to promote an understanding of the mechanism of wind-blown sand (dust) movements and push forward the development of this interdisciplinary research. By the way, with the publication of this book, I would also hope that more and more scholars and experts in the world will pay their attention, further their professional suggestions and actions to aeolian environmental problems in China.

Since the first day I set foot in the field of wind-blown sand movements, I have been inspired by some scholars in Geosciences and atmospheric sciences as follow: Prof. D. A. Gillette of National Oceanic and Atmospheric Administration (USA), Prof. Y. P. Shao of the Institute of Geophysics and Meteorology, University of Cologne, Academician H. L. Sun and D. H. Qin, Dr. P. Cui, Dr. Z. H. Lin, Dr. T. Wang, Dr. J. J. Qu, Dr. Y. Q. Ling, Dr. Z. B. Dong of Chinese Academy of Sciences (CAS) and Academician Y. T. Chen of China Earthquake Administration as well as Dr. X. Y. Zou of Beijing Normal University. Besides, some scholars in Mechanics like Prof. K. Moffat, ex-President of the International Union of Theoretical and Applied Mechanics (IUTAM, 2000-2004), Prof. F. Hussain (Member of the National Academy of Engineering and the Academy of Sciences for the Developing World) of the University of Houston, and several ex-Presidents of the Chinese Society of Theoretical and Applied Mechanics (CSTAM), including Academician Z. M. Zheng, Y. L. Bai, and E. J. Cui, etc., also offered me very important assistance. I would like to take the opportunity to express my gratitude to them. In particular, I would like to appreciate Academician H. Zhou of Tianjin University, Academician Q. C. Zeng of the Institute of Atmospheric Physics, CAS, and Academician J. C. Li, President of CSTAM, who not only provided much important and detailed guidance, but also paid much attention to my research work. All these concern and encouragement have been urging me keep going forward.

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