applied sciences

Special Issue Reprint

Advancing Complexity Research in Earth Sciences and Geography

Edited by
Jianbo Gao

mdpi.com/journal/applsci

MDPI

Advancing Complexity Research in Earth Sciences and Geography

Advancing Complexity Research in Earth Sciences and Geography

Editor

Jianbo Gao

MDPI

Basel • Beijing • Wuhan • Barcelona • Belgrade • Novi Sad • Cluj • Manchester

Editor
Jianbo Gao
Faculty of Geographical
Sciences
Beijing Normal University
Beijing, China

Editorial Office
MDPI
St. Alban-Anlage 66
4052 Basel, Switzerland

This is a reprint of articles from the Special Issue published online in the open access journal *Applied Sciences* (ISSN 2076-3417) (available at: https://www.mdpi.com/journal/applsci/special_issues/Earth_Geography).

For citation purposes, cite each article independently as indicated on the article page online and as indicated below:

Lastname, A.A.; Lastname, B.B. Article Title. *Journal Name* **Year**, *Volume Number*, Page Range.

ISBN 978-3-0365-9586-3 (Hbk)
ISBN 978-3-0365-9587-0 (PDF)
doi.org/10.3390/books978-3-0365-9587-0

Contents

applied sciences

MDPI

Editorial

Advancing Complexity Research in Earth Sciences and Geography

Jianbo Gao [1,2]

[1] Center for Geodata and Analysis, Faculty of Geographical Science, Beijing Normal University, Beijing 100875, China; jbgao.pmb@gmail.com
[2] Institute of Automation, Chinese Academy of Sciences, Beijing 100190, China

1. Introduction

Many complex phenomena in earth sciences and geography, including nonlinear fluid motions in the atmosphere, oceans, rivers, and lakes, coastal morpho dynamics, volcanic and seismic activities, the spatiotemporal dynamics of species, human movement trajectory, and city transportation dynamics, among many others, have played significant roles in the creation and development of complexity science, particularly chaos theory and fractal geometry [1]. With big data rapidly accumulating in almost every branch of earth sciences and geography, our increasing understanding of complex systems, and the availability of richer and more powerful methods for modeling complex systems, a golden age for the study of the complexity of the earth and our living environment has emerged. This book arises from a Special Issue of *Applied Sciences* that aimed to systematically examine the many complex phenomena that occur in earth sciences and geography, employing state-of-the-art methods for modeling complex data in order to invigorate research in earth sciences and geography, and to facilitate the further development of complexity science. Altogether, this Special Issue comprises 20 papers, contributed by researchers from all over the world and covering a range of diverse topics, including the encryption of digital elevation models [2], facies heterogeneity [3], the simulation of the snow cover process [4], the exploration of ice elevation change [5], earthquake and seismic activity [6–9], landslide susceptibility [10,11], the effect of reforestation [12], coordination between the supply and demand of ecosystem services [13], indoor positioning [14], public transport flow networks and retail store locations [15], the equality of healthcare facilities [16], recommender systems for e-retail [17], globalization [18], international trade and optimal industrial structure [19], risk analysis [20], and the quantification of political processes [21]. Below, I briefly explain the premise of each work, and when appropriate, highlight what could be further explored in future.

2. Topics Covered in the Book and Future Perspectives

The encryption of digital elevation models (DEMs) is a crucial task in geosciences. In their study, Cheng and Li [2] tackle this issue by integrating a chaos system and a linear prediction technique. While their technique is innovative and interesting, in the future it would be interesting to determine which currently available encryption scheme, including those developed by electrical engineers and computer scientists, operates the best for this purpose.

In their study, Jamil et al. [3] study facies heterogeneity in the West Crocker Formation of Sabah in northwest Borneo. By using the lithological characteristics, bed geometry, sedimentary textures and structures of individual beds, they categorize the rock units into nine sedimentary lithofacies: five sandstone lithofacies (S1–S5), one hybrid bed facies (H), two siltstone facies (Si1 and Si2), and one shale or mudstone facies (M). These facies were then grouped into four facies associations (FA1–FA4), which were further interpreted as lobe axis (FA1), lobe off-axis (FA2), lobe fringe (FA3), and distal fringe to interlope (FA4) facies associations. In future, it would be interesting to determine whether this approach may be applicable for the determination of the distribution of lobes and their sub-seismic, multiscale

Citation: Gao, J. Advancing Complexity Research in Earth Sciences and Geography. *Appl. Sci.* **2023**, *13*, 12275. https://doi.org/10.3390/app132212275

Received: 8 November 2023
Accepted: 10 November 2023
Published: 13 November 2023

complexities, for the purpose of characterizing the potential hydrocarbon intervals in deep-marine sand-shale systems around the globe.

The accurate simulation of the snow cover process is of great significance to the study of climate change and the water cycle. In their study, Gao et al. [4] use the China Meteorological Forcing Dataset (CMFD) and ERA-Interim as driving data to simulate the dynamic changes in the snow depth and snow water equivalent (SWE) in the Irtysh River Basin from 2000 to 2018 using the Noah-MP land surface model; they compare the simulation results with the gridded dataset of snow depth at Chinese meteorological stations (GDSD), the long-term series of the daily snow depth dataset in China (LSD), and China's daily snow depth and snow water equivalent products (CSS). The authors find that the rainfall and snowfall (SNF) scheme mainly affects the snow accumulation process, while the surface layer drag coefficient (SFC), snow/soil temperature time (STC), and snow surface albedo (ALB) schemes mainly affect the melting process.

Hitziger et al. [5] provide a fascinating account of a series of geodetic expeditions conducted in order to explore ice elevation change based on GNSS measurements along the Korth-Traverse in Southern Greenland. The efforts made by the researchers in these expeditions are truly inspirational.

In the cluster of papers on earthquakes and seismic activity, Cucci et al. [6] make efforts to compile all of the information available regarding the M6.3 earthquake that occurred in southern Lazio (Central Italy) in 1654, the strongest seismic event to have ever occurred in the area, in order to provide reliable landmarks with which to identify its seismic source. Alaei et al. [7] propose a 2D pseudo-viscoelastic time-domain full-waveform inversion approach for the seismic imaging of complex velocity structures. Hamdache et al. [8] employ a stochastic model entitled the restricted epidemic-type aftershock sequence (RETAS) to examine the similarities/differences in the three aftershock sequences that occurred in Al Hoceima, Morocco, in May 1994 (Mw 6.0), February 2004 (Mw 6.4) and January 2016 (Mw 6.3). In addition, in their study, Edigbue et al. [9] develop a combined local and global optimization approach for jointly inverting two-dimensional direct current resistivity (DCR) and seismic refraction (SR) data for the purpose of reliably estimating the corresponding physical model parameters.

On the issue of landslide susceptibility, in their study, Martinello et al. [10] first evaluate the reliability of regional landslide susceptibility models obtained by exploiting inhomogeneously collected inventories for calibration. They find that models appearing to perform well on a large scale may actually perform very poorly on a local scale. Then, they choose the Torto River Basin (Central-Northern Sicily, Italy) as an example, and propose a technique with which to overcome the limitations of Public Landslide Inventories in order to assess landslide susceptibility more reliably [11]. The assessment of landslide susceptibility is certainly of enormous practical importance. It would be interesting to observe whether some salient patterns or regularities can be found in the measured landslide data so that the assessment of landslide susceptibility is not solely data-driven, but also has a sound theoretical foundation.

Haghtalab et al. [12] examine the impacts of potential tropical reforestation on surface energy and moisture budgets, including precipitation and temperature. Using WRF.V3.9 (weather research and forecast model), they find that forest rehabilitation across the Amazon Basin can make the atmosphere cooler, with more moisture and latent heat (LH), especially between May and November. Choosing a large watershed area with a number of counties, Zhang et al. [13] employ the coupling coordination degree model (CCDM) and examine the coordination between supply and demand in ecosystem services (ESs), including crop production, water retention, soil conservation, carbon sequestration, and outdoor recreation. Within their study area, they find that different regions could be classified into four distinct types: extreme incoordination, moderate incoordination, reluctant coordination, and moderate coordination. As one could readily expect, a mountain ecosystem belongs to the first category, where the ES supply is much greater than the demand. This study is based on data collected in 2000 and 2020. It would be interesting to observe

how the degree of coordination between supply and demand in ESs continuously varies with time.

In their study, Xu et al. [14] develop a real-time Bluetooth low-energy (BLE)/pedestrian dead-reckoning (PDR) integrated system for enhanced indoor positioning. The system is based on constructing a robust vector that is responsible for changing the observation covariance matrix of the extended Kalman filter (EKF). This is achieved by detecting the gross error at different granularities. Focusing on three weighted centrality indices in the networks of public transport flows, namely degree, betweenness, and closeness, Liao et al. [15] find that supermarkets, convenience stores, electronics stores, and specialty stores have the highest weighted degree value. In contrast, building material stores and shopping malls have the lowest weighted closeness and weighted betweenness values, respectively. In their study, Tao et al. [16] develop a hierarchical maximal accessibility equality model to examine the equality of accessibility to healthcare services in Shenzhen, China. In addition, Huang and Liu [17] propose a more accurate personalized recommendation system for e-retailers that is also computationally more efficient. While all this research is fascinating, it would be desirable to see whether the results of these studies can be applied in practice and make a profound impact on society.

Globalization is often understood in terms of an increase in human mobility with time, an increase in the number of multinational corporations with time, as well as an increase in connectedness over time, enabled by increasingly powerful communication and information technologies. Considering this, Sun et al. [18] propose an alternative globalization index, which is a valuable addition to the globalization indices proposed previously [22–25]. One can readily see that with this kind of reasoning, globalization will generally increase with time, despite being at times disrupted by some global catastrophe, such as the COVID-19 pandemic. However, it is difficult to simultaneously understand anti-globalization with regard to this concept. In future, it would be vital to develop an approach that can simultaneously understand globalization and anti-globalization, so that superior strategies can be developed to ensure that globalization benefits more people and countries.

Analyzing massive international trade data from 1991 to 2019, Liu and Gao [19] find that deviations from normality for the distribution of revealed comparative advantage (RCA) are strongly negatively correlated with the logarithm of GDP and the Economic Complexity Index (ECI). In particular, the correlation between this deviation and GDP is stronger than that between ECI and GDP post 2008. These results suggest that this deviation may serve as an excellent new index with which to quantify the economic complexity and economic performance of a country. It would be interesting to use the entropy maximization principle to gain further insights into the approach.

With extreme weather and natural disasters occurring more frequently, risk analysis and mitigation have become increasingly crucial. Rising to this challenge, Bilotta et al. [20] provide formal mathematical expressions for hazard, the exposure of hazard, vulnerability, risk, and the mitigation of risk. It remains to be seen how these expressions can actually be computed in various scenarios of real-world importance. In future, it is perhaps even more vital to pay greater attention to insurance in countries where the insurance industry lags the development of economy, since without the proper development of the insurance industry, risk analysis cannot make a real impact. Here, of course, an important issue is to properly quantify the term "lag".

When dedicating this Special Issue of *Applied Sciences* to the study of complexity in earth sciences and geography, it is assumed that a significant fraction of researchers and students in the relevant fields understand the basics of complexity science. But however significant this fraction is, there will still be many researchers and students who require help in order to catch up with the recent developments in complexity science. This book thus includes a review article by Gao and Xu [21], which first provides a tutorial introduction to complex systems and emergence, then presents two multiscale approaches that may be useful for analyzing complex temporal dynamics in earth sciences and geography, and