

# MODELLING AND UNDERSTANDING MULTI-TEMPORAL LAND USE CHANGES

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## ABSTRACT:

Understanding temporal urban growth is very crucial to the interpretation of urban morphology and a key challenge for the study of rapid urbanization in contemporary China. Previous land use change modelling approaches only consider the spatial complexity that may be indicated by spatial dependence and landscape fragmentation, ignoring the temporal complexity inherent in the process of urban growth. Multi-temporality is a typical characteristic of urban growth and multi-temporal data availability has been much improved due to great advance in geospatial technology particularly remotely sensed imagery. This paper proposes an innovative application of a machine learning method – Maxent for analysing the urban morphology of a fast growing city –Wuhan, China. Multi-temporal data sets for 1955, 1965, 1993 and 2000 were processed from remotely sensed imagery. The results demonstrate that Maxent is an effective exploratory method and tool for understanding urban morphology.

## 1. INTRODUCTION

Rapid urbanisation has stimulated fast urban growth occurring in Chinese cities and other developing countries. Wuhan, a mega city in Central China, has seen its urban built-up areas grow tenfold between 1955 and 2000 (Cheng and Masser, 2003). Understanding temporal dynamics of urban form and urban land cover/land use is a prerequisite to making appropriate sustainable urban development policies and strategies. Stimulated by rapid advances in geospatial technologies, high-resolution remotely sensed imagery has become widely available and at low cost. Such factors have made monitoring urban growth possible and more successful in developing countries. Moreover, various models have been developed and explored for interpreting, predicting and simulating urban development pattern and processes and assisting the decision support of urban growth management and planning. Among these models, logistic regression, cellular automata and multi agent system methods have received a lot of attention. However, most models are only focused on the spatial complexity of urban growth system, not on temporal complexity. Urban growth is a continuous process, which means that new buildings, roads, and commercial centres emerge temporally accidentally. Multi-temporality is a typical characteristic of urban morphology. Three classic theories of urban morphology were developed in the 1970s: the concentric zone theory, the sector theory and the multiple nuclei theory. These theories have defined morphological factors (e.g. distance to city centre(s), distance to main corridors) which affect urban development patterns. Morphology analysis makes it possible to summarise the changes and trends of the urban spatial structure. For example, we need to establish the dominant morphological factors (e.g. proximity and development density) driving urban growth in multi-temporal periods. Such findings can make a useful contribution to the local knowledge of urban development planning.

The availability of multi-temporal data sets offers great opportunity for measuring and understanding urban

morphology. However, previous studies in urban morphology were focused on the measurement of urban morphology using methods such as fractals, density gradient and landscape matrix. These methods only provide single or multiple indicators for spatially measuring urban morphology, instead of, temporally modelling urban morphology. Multi-temporal spatial modelling is still not well developed in geospatial areas. In this paper, we propose an innovative application of a machine learning method – Maxent, for analysing urban morphology of a fast growing city (Wuhan, China). Multi-temporal data sets are available for 1955, 1965, 1993 and 2000, which were processed from remotely sensed imagery. This research has demonstrated that Maxent is an effective exploratory method and tool in helping understand urban morphology.

## 2. DATA & METHODOLOGY

### 2.1 Data sources and processing

Wuhan is located in Central China on the middle reaches of the Yangtze River. Wuhan municipality, the capital of Hubei province, has a total population of about 8 million over an area of 2000 km<sup>2</sup> in 2007. Wuhan is known as ‘Water City’ (*Liáng chéng*) due to the two rivers (Yangtze and Han rivers) that intersect here, and the surrounding lakes. In previous research (Cheng, 2003), temporal urban growth of Wuhan from 1955 to 2000 has been mapped (see figure 1) based on primary data sources composed of aerial photographs from 1955 (scale 1:25000) and 1965 (scale 1:80000), SPOT Pan/CS images taken in 1986 and 2000, and secondary data sources (e.g. land use map of 1993, topographic maps of 1993, traffic and tourism maps and master plan schemes). Land conversion was detected and classified using the maximum likelihood method (SPOTs) and visual interpretation (photographs).

# Modelling Changes In Understanding

**Michael Rees**



## **Modelling Changes In Understanding:**

**Understanding and Managing Model Risk** Massimo Morini, 2011-10-20 A guide to the validation and risk management of quantitative models used for pricing and hedging Whereas the majority of quantitative finance books focus on mathematics and risk management books focus on regulatory aspects this book addresses the elements missed by this literature the risks of the models themselves This book starts from regulatory issues but translates them into practical suggestions to reduce the likelihood of model losses basing model risk and validation on market experience and on a wide range of real world examples with a high level of detail and precise operative indications      **Change Management - Models, Perspectives, and Reflections** Jonas Fasth, 2025-05-10 This book challenges the oversimplified recipes that have long dominated the field of change management This book brings together decades of research models perspectives and critical reflections with the aim of helping you think for yourself Through historical overviews different perspectives on change and paradoxes you are invited to explore the real complexity of organizational change not as a checklist to follow but as a process to engage in The book is for managers change leaders HR professionals consultants and students who seek a reflective approach to change Jonas Fasth is a researcher educator and advisor with extensive experience working with change processes in both private and public organizations      *Physically-Based Modelling and Simulation of Climate and Climatic Change* M.E. Schlesinger, 2012-12-06 PREFACE xv LIST OF LECTURERS xix LIST OF PARTICIPANTS xx VOLUME I PART I DESIGN AND DEVELOPMENT OF PHYSICALLY BASED MODELS OF THE ATMOSPHERE Section 1 Introduction GATES W L Climate and the Climate System 3 SIMMONS A J and L BENGTSSON Atmospheric General Circulation Models Their Design and Use for Climate Studies 23 Section 2 Numerical Methods for Large Scale Dynamics ARAKAWA A Finite Difference Methods in Climate Modeling 79 BOURKE W Spectral Methods in Global Climate and Weather Prediction Models 169 Section 3 Parameterization of Subgrid Scale Physical Processes FOUQUART Y Radiative Transfer in Climate Models 223 LAVAL K Land Surface Processes 285 SELLERS P J Y MINTZ Y C SUD and A DALCHER A Brief Description of the Simple Biosphere Model SiB 307 SOMMERIA G Parameterization of the Planetary Boundary Layer in Large Scale Atmospheric Models 331 x TABLE OF CONTENTS TIEDTKE M Parameterization of Cumulus Convection in Large Scale Models 375 SUNDQVIST H Parameterization of Condensation and Associated Clouds in Models for Weather Prediction and General Circulation Simulation 433 PART II DESIGN AND DEVELOPMENT OF PHYSICALLY BASED MODELS OF THE OCEAN AND SEA ICE HAN Y J Modelling and Simulation of the General Circulation of the Ocean 465 HIBLER W D Modelling Sea Ice Thermodynamics and Dynamics in Climate Studies 509 PART III METHODS OF COUPLING ATMOSPHERE OCEAN AND ICE MODELS BRYAN K      **The Social Change Model** Kristan C. Skendall, Daniel T. Ostick, Susan R. Komives, Wendy Wagner, 2017-01-30 A comprehensive guide to using the Social Change Model in all types of curricular and co curricular settings This book is designed to provide leadership educators with a wealth of classroom and workshop activities discussion

and reflection questions assignment suggestions and additional resources such as video clips and supplementary readings It also includes several case studies for students to consider the implications of applying all eight elements of the Social Change Model in a variety of contexts The Social Change Model of Leadership Development upon which the book is based was designed by well known leadership educators and received wide acclaim and use The validity of this model has been established through a number of research studies including the Multi Institutional Study of Leadership Written by leading experts and developers of the Social Change Model who often present and consult on the topic Helps curricular and co curricular leadership educators teach the Social Change Model through individual and group activities reflection questions and discussion questions Walks course or workshop facilitators through the entire process of teaching the content and facilitating and debriefing activities If you re a leadership educator of high school undergraduate or graduate school students The Social Change Model Facilitating Leadership Development is indispensable reading Please note that The Social Change Model Facilitating Leadership Development is intended to be used as a Facilitator s Guide to Leadership for a Better World 2nd Edition 978 1 119 20759 7 in seminars workshops and college classrooms You ll find that while each book can be used on its own the content in both is also designed for use together A link to the home page of Leadership for a Better World can be found below under Related Titles

**Modelling the Impact of Climate Change on Water Resources** C. Fai Fung, Ana Lopez, Mark New, 2011-07-05 The quantitative assessment of the impact of climate change on water availability and water resources management requires knowledge of climate hydro geo logical and water resources models and particularly the relationships between each of them This book brings together world experts on each of these aspects distilling each complex topic into concise and easy to understand chapters in which both the uses and limitations of modelling are explored The book concludes with a set of case studies using real life examples to illustrate the steps required and the problems that can be faced in assessing the potential impacts of climate change on water resource systems For students scientists engineers and decision makers alike this book provides an invaluable and critical look at the information that is provided by climate models and the ways it is used in modelling water systems A key focus is the exploration of how uncertainties may accrue at each stage of an impacts assessment and the reliability of the resulting information The book is a practical guide to understanding the opportunities and pitfalls in the quantitative assessment of climate change impacts and adaptation in the water resource sector

**Identification of Change Patterns for the Generation of Models of Work-as-Done using Eye-tracking** Arenius, Marcus, 2017-01-01 In this PhD a method was developed to identify systematic patterns of change in visual attention allocation change patterns The change patterns were then integrated into the Functional Resonance Analysis Method FRAM for the generation of models of work as done The change patterns were validated against known changes in visual attention allocation due to shifts in functions of work as done in several eye tracking studies three simulator studies one field study and one experimental study In total approx 50 hours of eye tracking data was analyzed The results of the method were validated

quantitatively and qualitatively In the quantitative validation the changes in visual attention allocation due to changes in functions were covered with a mean deviation of approx 13 seconds averaged over all datasets 2% deviation relative to the recording lengths In the qualitative validation the change patterns produced were found to be plausible for the evaluated studies Finally it was demonstrated how the change patterns can be integrated into FRAM and potentially contribute to the understanding of emergent effects in industries with high levels of automation

**Twenty-one Mental Models That Can Change Policing** Renée J. Mitchell, 2021-09-16 This book goes beyond other police leadership books to teach practitioners how to think about policing in a structured way that synthesizes criminological theory statistics research design applied research and what works and what doesn't in policing into Mental Models A Mental Model is a representation of how something works Using a Mental Model framework to simplify complex concepts readers will take away an in depth understanding of how cognitive biases affect our ability to understand and interpret data what empirical research says about effective police interventions how statistical data should be structured for management meetings and how to evaluate interventions for efficiency and effectiveness While evidence based practice is critical to advancing the police profession it is limited in scope and is only part of what is necessary to support sustainable change in policing Policing requires a scientifically based framework to understand and interpret data in a way that minimizes cognitive bias to allow for better responses to complex problems Data and research have advanced so rapidly in the last several decades that it is difficult for even the most ambitious of police leaders to keep pace The Twenty one Mental Models were synthesized to create a framework for any police public or community leader to better understand how cognitive bias contributes to misunderstanding data and gives the reader the tools to overcome those biases to better serve their communities The book is intended for a wide range of audiences including law enforcement and community leaders scholars and policy experts who specialize in policing students of criminal justice organizations and management reporters and journalists individuals who aspire to police careers and citizen consumers of information about policing Anyone who is going to make decisions about their communities based on data has a responsibility to be numerate and this book Twenty one Mental Models That Can Change Policing A Framework For Using Data and Research For Overcoming Cognitive Bias will help you become just that

**Modelling urban spatial change: a review of international and South African modelling initiatives** Chris Wray, 2013-08-30 Urban growth and land use change models have the potential to become important tools for urban spatial planning and management Before embarking on any modelling however GCRO felt it was important to take note of and critically assess lessons to be learnt from international experience and scholarship on spatial modelling as well as a number of South African experiments that model future urban development In 2012 GCRO initiated preliminary research into current international and South African modelling trends through a desktop study and telephone email and personal interviews This Occasional paper sets out to investigate what urban spatial change modelling research is currently being undertaken

internationally and within South Africa At the international level urban modelling research since 2000 is reviewed according to five main categories land use transportation LUT cellular automata urban system dynamics agent based models ABMs and spatial economics econometric models SE EMs Within South Africa urban modelling initiatives are categorised differently and include a broader range of urban modelling techniques Typologies used include provincial government modelling initiatives in Gauteng municipal government modelling initiatives other government funded modelling research and academic modelling research The various modelling initiatives described are by no means a comprehensive review of all urban spatial change modelling projects in South Africa but provide a broad indication of the types of urban spatial change modelling underway Importantly the models may form the basis for more accurate and sophisticated urban modelling projects in the future The paper concludes by identifying key urban modelling opportunities and challenges for short to long term planning in the GCR and South Africa

**Exploring Maternal-Fetal Pharmacology Through PBPK Modeling Approaches** André Dallmann, Johannes Nicolaas Van Den Anker, 2022-06-06 [A Review and Assessment of Land-use Change Models](#), 2002

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*Land Use Cover Datasets and Validation Tools* David García-Álvarez, María Teresa Camacho Olmedo, Martin Paegelow, Jean François Mas, 2022-06-16 This open access book represents a comprehensive review of

available land use cover data and techniques to validate and analyze this type of spatial information The book provides the basic theory needed to understand the progress of LUCC mapping modeling validation practice It makes accessible to any interested user most of the research community's methods and techniques to validate LUC maps and models Besides this book is enriched with practical exercises to be applied with QGIS The book includes a description of relevant global and supra national LUC datasets currently available Finally the book provides the user with all the information required to manage and download these datasets

*Business Models and Firm Internationalisation* Christian Nielsen, Svetla T. Marinova, Marin A. Marinov, 2021-12-21 Internationalisation has been a binding request for firms dealing with the challenges of the present day realities Extant international business publications have recently begun to point out the relationship between the notions of business model and internationalisation yet the field needs considerably more attention The core aim of this book is to provide a comprehensive analysis of the ways in which business models and internationalisation impact one another in the process of initiating and expanding international business activities The analysis makes it feasible to detect the core issues of the interdependences between business models and internationalisation to facilitate management decision making and implementation of pertinent firm internationalisation incorporating the application of appropriate business models In this book the business model is applied to explore the specifics and aspects of firm internationalisation processes Innovating the business model is analysed as a persuasive means for augmenting the propensities of firms to internationalise The book enriches the comprehension of the significance of business model innovation as an enabler of firm internationalisation in view that it shows in what manners business model innovation facilitates firm internationalisation The book chapters address a broad range of issues encompassing the general roles of business model in firm internationalisation the relationships between digital business models and platforms on one side and firm internationalisation on another how business models determine the internationalisation of services firms the interplay between business models and firm internationalisation in specific contexts It will therefore be of interest to researchers academics and advanced students in the fields of international business and management

**Perspectives and Implications for the Development of Information Infrastructures** Constantinides, Panos, 2012-05-31 In the same way that infrastructures such as transportation electricity sewage and water supply are widely assumed to be integrators of urban spaces information infrastructures are assumed to be integrators of information spaces With the advent of Web 2.0 and new types of information infrastructures such as online social networks and smart mobile platforms a more in depth understanding of the various rights to access use develop and modify information infrastructure resources is necessary *Perspectives and Implications for the Development of Information Infrastructures* aims at addressing this need by offering a fresh new perspective on information infrastructure development It achieves this by drawing on and adapting theory that was initially developed to study natural resource commons arrangements such as inshore fisheries forests irrigation systems and pastures while placing great emphasis on the

complex problems and social dilemmas that often arise in the negotiations

**Models of Change in Medieval Textual Culture** Jonatan Pettersson, Anna Blennow, 2024-08-07 Handbook Of Climate Change And Agroecosystems: The Agricultural Model Intercomparison And Improvement Project (Agmip) Integrated Crop And Economic Assessments — Joint Publication With Asa, Cssa, And Sssa (In 2 Parts) Daniel Hillel, Cynthia Rosenzweig, 2015-02-13

Top agricultural scientists from around the world have taken up the challenge of sustainable agriculture with the specific focus on integrating agronomic climatological biophysical and socio economic perspectives and processes Every chapter of the Handbook contributes to addressing the growing food security challenges facing the world Foreword by Jeffrey Sachs Director of the Earth Institute at Columbia University Climate effects on agriculture are of increasing concern in both the scientific and policy communities because of the growing population and the greater uncertainty in the weather during growing seasons Changes in production are directly linked to variations in temperature and precipitation during the growing season and often to the offseason changes in weather because of soil water storage to replenish the soil profile This is not an isolated problem but one of worldwide interest because each country has concerns about their food security The Agricultural Model Intercomparison and Improvement Project AgMIP was developed to evaluate agricultural models and intercompare their ability to predict climate impacts In sub Saharan Africa and South Asia South America and East Asia AgMIP regional research teams RRTs are conducting integrated assessments to improve understanding of agricultural impacts of climate change including biophysical and economic impacts at national and regional scales Other AgMIP initiatives include global gridded modeling data and information technology IT tool development simulation of crop pests and diseases site based crop climate sensitivity studies and aggregation and scaling

*Measuring and modelling soil carbon stocks and stock changes in livestock production systems - A scoping analysis for the LEAP work stream on soil carbon stock changes* Food and Agriculture Organization of the United Nations, 2019-01-14 In order to build consensus on methods to measure and model soil carbon stocks and stock changes the Steering Committee of the Livestock Environmental Assessment and Performance LEAP Partnership mandated a task force to develop this scoping analysis and pave the way towards the formation of the LEAP Technical Advisory Group on soil carbon stock changes Soil carbon sequestration and storage in grasslands offers a significant potential to compensate for GHG emissions from livestock but the lack of consensus on the appropriate methodologies to account for soil carbon stock changes hinders robust and standardized assessments In this report we reviewed several published soil organic carbon SOC models and evaluated their aptitude to combine them with life cycle assessments LCAs Among contentious issues the most relevant are a the lack of universal models b the uneven data availability comparability and quality between countries and regions and c the difficulty to match measurable SOC fractions with those determined by the models Taking this into account a tiered approach is proposed according to the availability of original data to run the models The use of IPCC carbon C accounting system appears to be the simplest approach suitable to



countries with scarcity of original C data Conversely more complex models such as Century Parton 1987 1988 or Roth C Smith 1998 are likely to perform better and give less uncertainty when original input data are easily available

**The M3C Model of Cooperative Contextual Change** Biscaccianti, Williams, Esposito, 2011-05 Alessandro Biscaccianti Mark Esposito and Lloyd C Williams have come together to write a modern new textbook on the theory of contextual change presenting original ideas tested and ready to implement in their highly informative book The M3C Model of Cooperative Contextual Change The authors posit that to increase effectiveness of change it s necessary to introduce dynamic stability into a system The whole organization and each individual should have a sense of security and M3C can become the vehicle for this change One especially new element is the contextual drivership method which integrates leadership and management into organizational practices and processes that assure opportunity and capacity for success among employees So if you re ready to increase action coordination proactively anticipate possible issues enhance information sharing and become willing to look for solutions instead of focusing on problems pick up The M3C Model of Cooperative Contextual Change for some brand new insight

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**Demystifying Climate Models** Andrew Gettelman, Richard B. Rood, 2016-04-09 This book demystifies the models we use to simulate present and future climates allowing readers to better understand how to use climate model results In order to predict the future trajectory of the Earth s climate climate system simulation models are necessary When and how do we trust climate model predictions The book offers a framework for answering this question It provides readers with a basic primer on climate and climate change and offers non technical explanations for how climate models are constructed why they are uncertain and what level of confidence we should place in them It presents current results and the key uncertainties concerning them Uncertainty is not a weakness but understanding uncertainty is a strength and a key part of using any model including climate models Case studies of how climate model output has been used and how it might be used in the future are provided The ultimate goal of this book is to promote a better understanding of the structure and uncertainties of climate models among users including scientists engineers and policymakers

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