

Influences of Rainfall Pattern Changes on  
Vegetation Dynamics of Savanna Ecosystems  
in Australia under Climate Change

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A thesis submitted in fulfilment of the requirements for the degree  
of  
Doctor of Philosophy

Faculty of Science  
University of Technology Sydney

April 2020

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## Certificate of Authorship

I, Jie He, declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Life Sciences/Faculty of Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by an Australian Government Research Training Program.

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Date: 9/4/2020

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## Acknowledgements

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This project was funded by a joint scholarship of China Scholarship Council (CSC) and University of Technology Sydney (UTS). I appreciate this treasured opportunity for me to experience a four years Ph.D. study in science. I will memorize those days in my entire life, and devote myself to the career I love in the future.

Foremost, I would like to thank my principal supervisor Professor Qiang Yu and my co-supervisor Professor Alfredo Huete for their continuous guidance and generous supports during my past four years. I thank Professor Qiang Yu provided me the opportunity at the beginning of this Ph.D. application, and he always encouraged me and supported my thoughts. When wandering in my research topic, I felt hesitated and depressed, but I can always acquire strength and confidence after discussion with Professor Qiang Yu. I hardly achieved the current outcome without his belief in me. I am very grateful to my principal supervisor. I also thank Professor Alfredo Huete. He extended my horizon by introducing remote sensing to my domain and provided a new viewpoint on my study topic. The helpful environment and academic atmosphere in Alfredo's group benefited my growth a lot. I feel very grateful for his kindness and helps.

I thank Dr. James Clevely at UTS, and he gave me a lot of valuable suggestions for my research topic. He encouraged and confirmed my efforts to strengthen my confidence in my research. I also appreciate Professor Yongqiang Zhang in the Commonwealth Scientific and Industrial Research Organisation (CSIRO), who friendly invited me to study in Canberra, and I can have an opportunity for further cooperation. I am also grateful to Dr. Deli Liu and his group in the NSW Department of Primary Industries (DPI). They not only provided insight into agriculture works in Australia but also provided

meteorological data in Australia, which is essential for my research. I am also grateful to Professor Lei Cheng, who works at Wuhan University currently. Thanks to his encouragement and suggestions on my research and. Lastly, I appreciate the Energy and Water Exchange initiative (OzEWEX) Climate and Water Summer Institute, especially Professor Albert van Dijk, organizing the summer school of climate and water in Canberra and providing me a chance to have a deep cooperative study for two months. I really appreciate this memorable time to change my life. Also, thanks to my team members in summer school, Tian Hu and Tengjiao Liu. Cooperation and sharing a happy time with them are enjoyable and worthy.

I also appreciate my friends during my Ph.D. study, who altruistically offered their time for helping me and motivating me, including Dr. Xuanlong Ma, Dr. Zunyi Xie, Dr. Hao Shi, Dr. Bin Wang, Dr. Xunhe Zhang, Dr. Xueling Li, Dr. Nguyen Ngoc Tran, Dr. Jianxiu Shen, Dr. Qinggaozi Zhu, Dr. Leandro Giovannini, Dr. Paras Sidiqi, Sicong Gao, Wenjie Zhang, Rong Gan, Song Leng, Puyu Feng, Mingxi Zhang, Ekena Rangel Pinage, Hong Zhang, Jiaqi Dong, Marita Gambino.

I am grateful to administrative staff in the School of Life Sciences, Faculty of Science, Graduate Research School and IT support team at UTS. I deeply appreciate their effective and warming helps through all these years.

I want to thank my supportive families for teeming with endless love. Their unconditional love inspires and motivates me to devote myself to my career continuously. With their accompanying, I can continue to devote into my career. There is no doubt I can hardly obtain current achievements without them. I love you, my lovely families. I want to share all my moments of happiness and glory with you. Last, I want to thank the people who I loved and loved me. May you all be happy and healthy!

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## Abstract

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Climate change has significantly influenced the global hydrological processes with rising temperature and elevated CO<sub>2</sub>. Rainfall is the most active factor to influence the terrestrial ecosystems, especially with frequent heavy rainfall events in recent decades. Although much research has addressed the relationship between rainfall and vegetation under climate change, the impacts of rainfall pattern changes on terrestrial ecosystems have still not been stated clearly. In this project, we attempted to explore the mechanism of how rainfall pattern changes driving vegetation dynamics of savanna ecosystems in Northern Territory, Australia, where a well-known rainfall gradient is located and provides a natural laboratory for climatic analysis. To investigate rainfall pattern changes, we diagnosed the long-term rainfall pattern changes by analyzing trend, periodicity, abrupt change, and extreme rainfall events based on long-term rain gauge data, describing rainfall conditions over the sub-continent. The findings supported the view that rainfall pattern has significantly changed and especially occurred after the 1970s, illustrated by showing more frequent hydroextremes. We explored the sensitivity of vegetation phenology to rainfall variations from the wet coastal regions to the dry inland regions over different savanna vegetation biomes by retrieving phenological metrics from MODIS enhanced vegetation index (EVI). Results revealed maximum EVI was the most appropriate proxy to represent vegetation growth status and also be sensitive to rainfall variations, even if the sensitivity declined in water sufficient regions. Afterwards, we demonstrated the dominating roles of rainfall patterns in driving vegetation dynamics by evaluating the relative importance between maximum EVI and three decomposed rainfall pattern components, namely, intensity, duration, and frequency. Surprisingly, we noticed the roles of three factors varied along with rainfall gradient, and frequency become the most dominating factor in controlling vegetation dynamics in semi-arid and semi-humid regions. Eventually, we

extended our research from ground rain gauge measurements to TRMM satellite precipitation observations to investigate the spatiotemporal variations of rainfall patterns and its influences. We found savanna biomes in semi-humid regions responded to rainfall changes mostly, and the relative importance of rainfall pattern component followed the consistent spatial regime, which has been illustrated by meteorological data. In summary, this study contributes to the deeper understanding of the roles of rainfall pattern changes in dominating vegetation dynamics under different rainfall conditions, and the findings benefit projection and modelling to mitigate the impacts of climate change.

**Keywords:** Rainfall pattern changes, vegetation dynamics, savanna ecosystems, climate change, Northern Territory, Australia