Exploring the use of phenocams and satellite data to better inform the pasture phenology and aerobiology of allergenic grass pollen in eastern Australia

by Yuxia Liu

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

under the supervision of

Distinguished Professor Alfredo Huete (principal supervisor)

Doctor Qiaoyun Xie (co-supervisor)

University of Technology Sydney

Faculty of Science

School of Life Science

November 2021

CERTIFICATE OF AUTHORSHIP

I, Yuxia Liu, declare that this thesis is submitted in fulfilment of the requirements for the award of the degree of Doctor of Philosophy, in the Faculty of Science 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 the International Research Scholarship and President's Scholarship funded by University of Technology Sydney. Also, this research is supported by an Australian Government Research Training Program.

Production Note:
Signature: Signature removed prior to publication.

Date: 15 / 11 / 2021

To my parents.

I love you.

To Professor Alfredo Huete, and Doctor Qiaoyun Xie.

For their endless support and encouragement.

Acknowledgements

I would like to express my sincere thanks to my supervisor panel, Professor Alfredo Huete, and Doctor Qiaoyun Xie. They have taught me the true meaning of scientific research and shown me how to think and do as a real researcher. Although their (he) comments made me doubt myself deeply sometimes, I really would like to say: Thank you. It was those difficult moments that have moulded me into the person I am today. Thank you, Alfredo and Qiaoyun, for everything. They always understood the challenges that I experienced, and they always cheered me up in their own ways. I also would like to say thanks for Qiaoyun (extra), cause of her yummy foods (cheese cake, tiramisu, muffin, steamed bun … and those empty wine bottles …). I feel very lucky to be their student. I am very sure I will miss these four years someday.

Next, I would like to express my thanks to all my groupmates. Especially, Song Leng, Sicong Gao and Ha Nguyen. Thanks for their efforts to set up phenocams that were used in this thesis. I also thank Beth Addison-Smith in the Queensland University of Technology to maintain the Phenocam sites. The use of the Sentinel-2 grass map would not have been possible without the modelling and ongoing assistance of several people: Mr Abolfazl Abdollahi and Professor Biswajeet Pradhan in FEIT of University of Technology Sydney (UTS). I also would like to express my sincere thanks to Ms Shannon Hawkins, the research officer in the Faculty of Science, UTS. My PhD journey would not have been such smooth without her supports in terms of administrative affairs.

Finally, I would like to say thanks to my friends in Sydney and my parents. My life away from home would not have been so smooth and sweet without my friends' support and accompany.

Thank you, mom and dad. Thank you for giving life and endless love to me.

Ponder the path of your feet then all your ways will be sure.

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Abstract

Phenological studies of grassland/ pastures have attracted increased attention for their sensitivity to climate change with associated impacts on allergenic pollen release and public health. Allergenic pollen exposure is expected to increase with global warming following extended grass growing and grass pollen seasons and the prevalence of allergic diseases in Australia is among the highest globally. The primary aims of this thesis were to integrate phenocam and satellite imagery with pollen concentration data, over subtropical to temperate grassland sites in Australia, in order to address critical knowledge gaps in our understanding of the ecological drivers of grass pollen aerobiology.

Phenocams were used to investigate the diurnal and daily greenness variations across solar zenith angles, solar intensity, and direct/ diffuse sky conditions. This information was used to develop an optimised daily compositing methodology. Next, I successfully registered a 3×3 window of Sentinel-2 pixels at 10 m resolution with the phenocam measurement footprint to conduct upscaling analyses. The relationships between Sentinel-2 Enhanced Vegetation Index (EVI) and phenocam green chromatic coordinate (GCC) index were strong and independent of the time of year and grass phenophases. This enabled the more sparse temporal sampling of Sentinel-2 greenness to be converted to daily values.

Relationships between seasonal grass pollen concentrations and phenocam GCC and satellite EVI phenology were also strong with pollen concentration peaks in phase with grass greenness peaks, including multiple sub-seasonal pollen and greenness peaks. The grass greenness amplitudes, a surrogate of biomass, were found to be correlated with total pollen concentrations. Finally, I investigated grass pollen sources at more detailed, 10 m resolution, by generating a neural net grass map, from the Sentinel-2 sensor. This enabled urban, peri-urban and regional grass sources to be quantified based on distance and orientation to the pollen sampler, providing new insights for pollen forecasting. This thesis highlights the ability of near-surface and satellite remote sensing to achieve more accurate grassland/ pasture phenology to improve upon the understanding of ecologically relevant factors for grass pollen aerobiology in Australia.