AUSTRALIAN RESEARCH COUNCIL
Discovery Early Career Researcher Award
Application for Funding Commencing in 2023

DE

Project ID: DE230100402

First Investigator: Dr Kerry Nice

Admin Org: The University of Melbourne

Total number of sheets contained in this Application: 47

Part A - Administrative Summary (DE230100402)

A1. Application Title

(Provide a short title (up to 75 characters, approximately 10 words).)

Achieving urban heat mitigation through blue-green infrastructure

A2. Person Participant Summary

(Add the DECRA candidate participating in this application.)

Number	Name	Participant Type	Current Organisation(s)
1	Dr Kerry Nice	Discovery Early Career Researcher Award	The University of Melbourne

A3. Organisation Participant Summary

(Add the Administering Organisations participating in this application. Refer to the Instructions to Applicants for further information.)

Number	Name	Participant Type
1	The University of Melbourne	Administering Organisation

A4. Application Summary

(Provide an Application Summary (a paragraph of text which is used by the Minister to consider the application), focusing on the aims, significance, expected outcomes and benefits of this project. Write the Application Summary simply, clearly and in plain English. If the application is successful, the Application Summary will be used to give the general community an understanding of the research. Avoid the use of acronyms, quotation marks and upper-case characters. Refer to the Instructions to Applicants for further information (up to 750 characters, approximately 100 words).)

Extreme heat is Australia’s most dangerous natural hazard. This project aims to protect urban areas from extreme heat through the cooling benefits of blue-green infrastructure including vegetation and water features. This is significant because despite evidence that use of these features can be an effective method of urban cooling, we lack detailed observations to understand how to optimise their benefits in urban design. This project aims to provide these observations and use them to build models needed to systematically test scenarios and find optimal urban heat mitigation and adaptation strategies. The benefits will be more heat resilient urban areas and identification of areas of high vulnerability that can benefit from interventions.

A5. List the objectives of the proposed project

(List each objective separately by clicking 'Add answer' to add the next objective (up to 500 characters, approximately 70 words per objective). This information will be used for future reporting purposes if this application is funded.)

Objective

To observe a wide variety of blue-green infrastructure features at a range of spatial and temporal scales necessary to understand the underlying processes driving the cooling benefits.

Objective

To build urban climate modelling tools and show them suitable to model human thermal comfort benefits of blue-green infrastructure and urban water usage.

Objective

To implement co-design principles in the development, implementation and delivery of the findings with key stakeholders, mapping out the tools and results that will be of highest value, allowing them to utilise sophisticated climate science knowledge and integrate with their design processes to maximise the human thermal comfort benefits of using blue-green infrastructure in urban areas.

Objective

Quantify blue-green infrastructure cooling impacts through systematic modelling to discover optimal scenario parameters, design limitations, and ranked priorities to guide redesign efforts to mitigate urban heat.

Part B - Classifications and Other Statistical Information (DE230100402)

B1. Does this application fall within one of the Science and Research Priorities?

Yes

Science and Research Priority	Practical Research Challenge
Environmental change	Options for responding and adapting to the impacts of environmental change on biological systems, urban and rural communities and industry.

B2. Field of Research (FoR-2020)

(Select up to 3 FoR classification codes that relate to the application. Note that the percentages must total 100.)

Code	Percentage
330410 - Urban analysis and development	60
370401 - Computational modelling and simulation in earth sciences	40

B3. Socio-Economic Objective (SEO-2020)

(Select up to 3 SEO classification codes that relate to the application. Note that the percentages must total 100.)

Code	Percentage
280111 - Expanding knowledge in the environmental sciences	50
200406 - Health protection and disaster response	25
190101 - Climate change adaptation measures (excl. ecosystem)	25

B4. Interdisciplinary Research

(This is a 'Yes' or 'No' question. If you select 'Yes' 2 additional questions will be enabled:
1. Specify the ways in which the research is interdisciplinary by selecting one or more of the options below and click 'Add'.
2. Indicate the nature of the interdisciplinary research involved (up to 375 characters, approximately 50 words).)

Does this application involve interdisciplinary research?

No

Specify the ways in which the research is interdisciplinary by selecting one or more of the options below.

Indicate the nature of the interdisciplinary research involved (up to 375 characters, approximately 50 words).

B5. Does the proposed research involve international collaboration?

(This is a 'Yes' or 'No' question. If you select 'Yes' 2 additional questions will be enabled:
1. What is the nature of the proposed international collaboration activities; and
2. If the proposed research involves international collaboration, specify the countries involved.)

Yes

B6. What is the nature of the proposed international collaboration activities?

(Select all options from the drop down list which apply to this application by clicking on the 'Add' button each time an option is selected.)

Correspondence: eg email; telephone; or video-conference
Attendance at and/or hosting of workshop or conference

B7. If the proposed research involves international collaboration, please specify the country/ies involved.

(Commence typing in the search box and select from the drop down list the name of the country/ies of collaborators who will be involved in the proposed project. Note that Australia is not to be listed and is not available to be selected from the drop down list.)

United States of America

B8. How many PhDs, Masters and Honours that will be filled as a result of this project?

(For reporting purposes, the ARC is capturing the number of Research Students that would be involved if the application is funded. Enter the number of all student places (full-time equivalent - FTE) that will be filled as a result of this project, not just those requested in the budget for funding in the application form.)

Number of Research Student Places (FTE) - PhD

0

Number of Research Student Places (FTE) - Masters

1

Number of Research Student Places (FTE) - Honours

2

Part C - Project Eligibility (DE230100402)

C1. Medical Research

(This is a 'Yes' or 'No' question. Does this application contain content which requires a statement to demonstrate that it complies with the eligible research requirements set out in the ARC Medical Research Policy located on the ARC website?)

No

C2. Medical Research Statement

(Justify why this application complies with the eligible research requirements set out in the ARC Medical Research Policy located on the ARC website. Eligibility will be based solely on the information contained in this application. This is your only chance to provide justification, the ARC will not seek further clarification (up to 750 characters, approximately 100 words).)

C3. Current Funding

(Does this application request funding for similar or linked research activities, infrastructure or a project previously funded, or currently being funded, with Australian Government funding (from ARC or elsewhere)? This is a 'Yes' or 'No' question. If 'Yes', provide the Project ID(s) and briefly explain how funding this project would not duplicate Australian Government funding or overlap with existing projects.)

No

Funded Project ID(s)

Detail how this project is different from the previously/currently funded project(s) (up to 2000 characters, approximately 285 words).

C4. Other application(s) for funding

(Are you applying for funding from the Australian Government (ARC or elsewhere) for similar or linked research? This is a 'Yes' or 'No' question. If 'Yes' provide the application ID(s) and briefly explain why more than one application for similar or linked research has been submitted and, should all applications be successful, how they will be managed to avoid duplication of Australian Government funding.)

No

If yes, provide the application ID(s)

Briefly explain why more than one application for similar or linked research has been submitted (up to 2000 characters, approximately 285 words).

Part D - Project Description (DE230100402)

D1. Please confirm that potential risks have been taken into consideration for the proposed project, including the impacts of COVID-19.

(The application form will not validate if 'No' is selected. Please note that if this application is successful a risk management plan will be required to be held by the Administering Organisation before the project starts and any changes in circumstances that affect the proposed research project will be managed as a post award issue by the ARC.)

Yes

D2. Project Description

(Upload a Project Description as detailed in the Instructions to Applicants and in the required format. Ensure that the Project Description responds to the assessment criteria listed in the grant guidelines (up to 10 A4 pages).)

Uploaded PDF file follows on next page.

PROJECT TITLE:
Achieving urban heat mitigation through blue-green infrastructure

PROJECT AIMS AND BACKGROUND

Extreme heat events cause more deaths in Australia than any other natural hazard[8], with risk disproportionately borne by the elderly and the very young[41]. Future climate projections warn of more frequent, severe, and long-lasting heatwaves[24] and exposure to dangerous levels of heat stress increasing by a factor of 5-10 by 2080[9]. Risks are further multiplied by the design of cities[11, 34] that result in increased heat loads in urban areas and increased air temperatures (sometimes up to 10°C for large cities). Urban energy balances (the distributions of energy manifested as heat, stored in surfaces, or reflected back into space) have been altered in several ways[43]. Anthropogenic heat from buildings and transport and reduced shading through diminished tree canopy cover results in larger amounts of net energy experienced by people at street level. Conversion from vegetated to impervious surfaces (e.g. concrete) and reductions of available water in cities is shifting the urban energy balance away from cooling through latent heat (water evaporation) towards increased sensible heat (heat that can be felt) and heat storage in urban surfaces. These factors are commonly understood by urban climate scientists, however consultants working for designers and planners have rarely been able to utilise climate knowledge in urban planning[16] and the complexities of urban climate have complicated the communication of results[44].

The use of water and vegetation has long been recognised as an effective method [11, 1] to mitigate urban temperature extremes using strategies that utilise blue-green infrastructure (BGI)[42, 22, 40] such as increased vegetation cover, water features, and water practices (rain gardens, misting systems, or pavement watering). However as Gao & Santamouris [19] find, research in urban areas is quite rare and at very early stages. In a systematic review of studies quantifying the cooling potential of irrigating urban green spaces **[7]**, only 19 studies were found and the majority were modelling studies or agricultural (and not specifically urban). Of those only seven reported important details such as irrigation amounts. The majority of the studies are of irrigation-induced temperature reductions in agricultural areas. Agricultural studies can provide valuable insights but cannot capture the complexity of highly heterogeneous urban environments.

A lack of high resolution measurements of temperature reductions and cooling mechanisms from irrigation leads to inconsistencies in expected cooling magnitudes between studies and uncertainties in the amounts of water required and optimal strategies to maximise cooling benefits. These gaps have an impact on our understanding of the general principles behind these methods of cooling. To fully incorporate urban cooling strategies into urban planning requires modelling tools and this lack of observations also impedes the design and validation of models that can account for the influences of BGI on human thermal comfort in cities.

To capture all the influences of urban geometry and materials on human thermal comfort, especially the influences on mean radiant temperature[27] (a temperature that accounts for the thermal stresses on a person from both solar exposure and energy/heat radiating from nearby surfaces), modelling needs to be done at a micro-scale (that is, at a grid square or pixel resolution under 1km). BGI is ideally built into planning of future development to maximise potential cooling, before these decisions are concreted into the built form for decades to come. It can also be retrofitted, although with more difficulty, to remediate identified problem areas. Both cases are best addressed using modelling tools, but as will be detailed below, these tools are currently insufficient. BGI cannot be effectively utilised as a urban cooling method without a much better understanding of many of the basic principles behind the cooling.

This leads to two project aims. The first is to quantify the cooling impacts of BGI and to uncover the mechanisms, patterns, and magnitudes behind the cooling by performing a wide range of observations on BGI features. The second is to utilise these observations to improve existing models so that they are suitable to model a full range of BGI features and their human thermal comfort benefits. As a result, this project will provide new insights from fundamental observations of BGI as well as high value tools to a wide range of users including urban planners, consultants, and future researchers, enabling them to analyse and redesign urban areas to maximise the cooling benefits of BGI.

There are many urban models, however there are few modelling options available at a scale that can account for all elements of vegetation impacts and urban hydrology, and that can explicitly calculate parameters needed to calculate human thermal comfort. Some of the available urban models include ENVI-met[5], VTUF-3D**[51]**, SOLWEIG/UMEP[31], PALM[13], canyon air temperature (CAT)[17], and OTC3D[39]. Other models offer lower resolution local-scaled (grid resolution greater than 1km) modelling (TARGET**[4]** and SURFEX[33]) or of a single point averaged across an entire (often idealised) urban canyon (TEB[32], TEB-Veg and TEB-Tree[30, 47], RayMan[36]/SkyHelios[35], and Urban Tethys-Chloris (UT&C)**[37]**). Some of these models (e.g. ENVI-met, PALM) are highly spatially explicit at the cost of high computational burden (and in the case of ENVI-met high licensing costs), or high levels of configuration and

Model	Scale	Spatial	Intensity	Veg.	Temp.	Geometry	Fluxes	Wind	Hydrology
ENVI-met[5]	M	M	H	F	A,S,M,U	C	All	C	W,C,m,M,G,E,P
SOLWEIG[31]	M	M	M	S	M	C	K,L	N	N
PALM[13]	M	M	H	F	A,S,M,U	C	All	C	W,C,m,E,P
OTC3D[39]	M	M	M	N	M,U	C	N,H,E,K,G	E	N
SURFEX[33]	L	M	M	I	A,U	I	All	R	W,C,m,E,P
TEB[32, 30, 47]	L	S	M	I	A,S	I	All	R	W,C,m,E,P
RayMan[36]	M	S	L	S	M	C	K,L	N	N
SkyHelios[35]	M	Se	L	S	M	C	K,L	N	N
UT&C[**37**]	L	S	M	F	A,S	I	All	R	W,C,m,E,P
SUEWS[25]	L	S	L	I	A,S,So	I	All	N	W,C,m,E,P
BEP-Tree[28]	L	S	M	I	A	I	All	N	N
CAT[17]	M	S	L	N	A	I	All	N	N
VTUF-3D[**51**]	M	M	M	F	A,S,M,U	C	N,H,E,K,L,G	R	S,m,E
TARGET[**4**]	L	M	L	I	A,S,M,U	I	N,H,E,K,L,G	R	W,S
VTUF-3D v2	M	M	M	F	A,S,M,U	C	All	R,A	W,C,m,M,G,E,P
TARGET v2	L	M	L	I	A,S,M,U	I	All	R,A	W,C,m,M,G,E,P

Table 1: Comparison of micro and local-scale models, features, and limitations around modelling human thermal comfort and BGI. Modelling scale [**M**icro/**L**ocal], Spatial resolution [**S**ingle point/**Se**ries of points/**M**any points], Computational intensity [**L**ow/**M**edium/**H**igh], Vegetation [**F**ully modelled/**S**hape only/**I**dealised modelling/**N**ot modelled], Temperatures [**A**ir temperature, T_a/**S**urface temperature, T_{surf}/**M**ean radiant temperature,T_{mrt},**U**TCI/**So**il temperature,T_{soil}], Urban geometry [**C**omplex/**S**imple/**I**dealised], Fluxes [**N**et/Sensible (**H**)/Latent(**E**)/Shortwave(**K**)/**L**ongwave/**G**round storage/Anthropogenic(**F**)/**All**(includes N,H,E,K,L,G,F)], Wind [**C**FD/**E**xternal CFD/**R**oughness calculations/**A**dvection/**N**one], Hydrology [**W**ater bodies/**S**imple irrigation/**C**omplex irrigation/Soil **m**oisture/**M**isting/**G**reen wall/**E**vapotranspiration/**P**recipitation/**N**one]. Green highlights indicate necessary model characteristics for BGI and HTC modelling. Yellow highlights indicate useful characteristics. Orange highlights indicate some limitations. Red highlights indicate difficult characteristics.

software expertise (e.g. SURFEX requires modification and compilation of FORTRAN code). Others (e.g. UT&C) rely on simplified parameterisations and an idealised representation of vegetation and urban canyons for producing a detailed time series of the energy balance at the local scale.

Table 1 presents a comparison of available micro- and local-scaled urban models. Characteristics that are essential for human thermal comfort assessments of BGI are highlighted in green. They should be micro-scaled and provide high spatial resolution. Some models only output a single point, either a single location or one averaged across the entire area. Local scaled modelling provides some insights but there are limitations to the level of understanding they can provide into the factors influencing urban heat. These and other limiting model characteristics are highlighted with orange. Major limitations in modelling BGI are highlighted in red. Ideally, the entire soil/plant/atmosphere continuum must be accounted for in detail, including vegetation and vegetated surfaces, hydrology/water balances, and latent energy fluxes (i.e. the energy due to water evaporation). High computational demand of some models also proves a limitation both for short-term simulations but especially for long-term simulations, which are required to understand the timing between mitigation strategies and extreme heat days. Some characteristics are highlighted in yellow, features that will be useful in modelling the full range of BGI features and some practices intended to reduce thermal stress during heat events (e.g. misting, watering green areas, or pavement-watering). Finally, assessing human thermal comfort requires the ability to predict mean radiant temperatures.

To produce low to medium computational intensity models that are also able to account for the full range of BGI will require some enhancements to existing models. But addressing the limitations in these current modelling tools are hampered by a lack of comprehensive observations to enable model development and validations. Datasets to validate modelling techniques to model the entire soil / plant / atmosphere continuum are scarce[45], particularly observational data related to urban greening and especially at a micro-scale and that account for heat and energy fluxes under a wide range of irrigation scenarios. In addition, no datasets to validate the micro-scaled variations of spatial and temporal distribution of heat and cooling at a neighbourhood scale providing detailed statistics about the amounts, times, and locations of outside water usage (i.e. which household, how many litres used to irrigate, and what hour of the day) are available. Most research around the cooling benefits of irrigation has been conducted through modelling studies[26, 58, 2]. There are very few observation-based irrigation studies that focus on urban areas[3]. Some agricultural observation-based studies of irrigation[6] can provide insights to irrigated urban green areas but lack the complex heterogeneity of urban areas. This scarcity of observations limits our understanding of the full benefits of BGI and without these specialised datasets, ensuring that modelling tools accurately reproduce the underlying mechanisms of cooling using BGI becomes challenging. Without suitable tools, it is difficult for urban designers and planners to explore the full range of benefits BGI can provide. Exploring their designs iteratively during their planning processes through cooling knowledge and simplified tools created during this project allows them to minimise the impacts of their designs on urban heat and heat stress. **This is the major problem that this project aims to address by collecting observations of BGI features, developing modelling tools, then fully exploring the utilisation of BGI as an effective urban cooling strategy.**

INVESTIGATOR/CAPABILITY

I am currently a research fellow at the University of Melbourne in the Transport, Health and Urban Design Research Lab (THUD) in the Melbourne School of Design. My research areas include urban climate modelling and urban analytics and modelling of urban design and transportation systems and their impacts on public health using machine learning and computer vision techniques. I am a chief investigator on a $608,910 (and GBP £479,387) 2020-2023 UKRI/NHMRC grant, a collaboration with Queen's University Belfast. This project builds on my recent Lancet Planetary Health publication **[55]**, utilising neural networks, computer vision techniques, and urban imagery to discover the impacts of urban design on non-communicable disease. I am an investigator on a Swiss National Science Foundation grant along with Dr. João Leitão and Dr. Peter Bach from Eawag (the Swiss Federal Institute of Aquatic Science and Technology), using my TARGET to model urban heat mitigation through stormwater infrastructure.

Finally, I am a Chief Investigator on a $402,000 2021-2023 ARC Discovery project, creating a platform for city-wide modelling of cycling exposure generated from an inventory of cycling infrastructure extracted from satellite imagery through computer vision and machine learning. My role is to supervise and assist the research fellow with the development of a framework to detect urban infrastructure classes in high-resolution unlabelled aerial imagery through self-supervised representative learning and provide a city-wide inventory of cycling infrastructure. This role is complementary to this application as the urban climate modelling will require accurate urban morphology information. Some of this information will be available from urban morphology databases (as discussed below) and through the Geoscape datasets (requested in the budget for this project), but additional parameters and incomplete datasets will require supplementary information extracted from aerial and street view imagery, such as is being done in the Discovery project and a number of my other projects discussed in this application.

Before returning to university to complete a master's degree and PhD, I had a 13 year career as a senior level software engineer, working predominately in C++ and Java (the J2EE Java 2 Enterprise Edition). The experience gained in software design, development, and project management, to create and implement both the user interfaces and the backend functionality for complex business process flows has proven to be highly transferable to climate model development and a research career utilising computer vision techniques, machine learning, and big data.

During my PhD, I developed the **V**egetated **T**emperature of **U**rban **F**acets in **3-D** (VTUF-3D)**[51]** urban micro-climate model to examine the human thermal comfort impacts of street trees and water features (i.e. BGI). Immediately following, I co-developed **T**he **A**ir-temperature **R**esponse to **G**reenblue-infrastructure **E**valuation **T**ool (TARGET)[4] (with Asst Research Prof. Ashley Broadbent and others), **U**rban **T**ethys-**C**hloris (UT&C)**[37]** (with Meili Naika and others), and the **M**onash **S**imple **C**limate **M**odel**[14]** (MSCM) (with A/Prof. Dietmar Dommenget). I have used SOLWEIG / UMEP[31] and TARGET for many thermal comfort modelling consulting projects. VTUF-3D is one of the few models currently available to examine the human thermal comfort impacts of BGI at a micro-climate scale. The source code for VTUF-3D, and my other local-scaled model TARGET, is freely available and currently being used by a number of other urban climate scientists (and consulting groups such as Alluvium[38] and Marsden Jacob) around the world.

I have published my model development work**[51, 4, 37, 14]** in the Q1 journals, Geoscientific Model Development (SJR Q1 3.238) and Urban Climate (SJR Q1 1.151). These publications demonstrate my range of expertise in designing, building, and using local and micro-scale models, models that account for urban surface energy balances and the influence of BGI and the processes of urban hydrology and vegetation physiology. I have conducted research using micro-climate modelling to evaluate human thermal comfort benefits of urban vegetation and water as well as the use of urban morphology databases (such as WUDAPT) in urban heat modelling, works represented in conference presentations**[18, 50]** and a fully-refereed conference paper**[56]**. I am currently participating in a consulting consortium for the Australian Department of Agriculture, Water and the Environment (DAWES) with Prof. Nigel Tapper (Monash) with Dr. Andrew Coutts (Monash), and Dr. Matthias Demuzere (Ruhr-Universität Bochum) utilising the TARGET model to examine health cost impacts of urban heat under future climate scenarios. I am currently collaborating with Aldo Rojas Mondaca from the Pontificia Universidad Católica de Chile to add green roofs and green walls to VTUF-3D.

Through my participation in the CRC for Water Sensitive Cities across its 8 year research program (as well as the precursor project 'Cities as Water Supply Catchments'), I developed working relationships with many local and state governments as well as industry partners, in particular, water companies. Currently, I have two PhD students (one through the University of Melbourne and one through Monash University/Southeast University China) engaged in research in conjunction with South East Water in Melbourne and South Australia Water in Adelaide. In the first project, the Aquarevo housing estate[48] is the site of a number of campaigns to make micro-climate observations (temperatures, humidity, radiation fluxes, wind, and soil moisture and temperatures) of various irrigation strategies as well as the energy balances of misting systems, resulting in one publication **[7]** so far. A second trial through South Australia Water has been examining the cooling benefits of irrigation at the Adelaide Airport[12, 23, 46]. This project will build on this work and collect more data in future observation campaigns, especially examining irrigation of a variety of surface types and the cooling benefits of irrigation at a precinct level.

I developed a method through a collaboration with Asst. Prof. Ariane Middel at Arizona State University and supervised research projects by Master's of IT students using neural networks and computer vision techniques to accurately detect sky pixels in outdoor imagery (and therefore calculate sky view factors from these images). This research was published as an invited first author submission**[53]** in the Urban Climate journal. My use of urban morphology databases to generate local climate zones (LCZ) through a collaboration with Dr. Negin Nazarian, A/Prof. Melissa Hart, and Dr. Mathew Lipson at UNSW has resulted in an AURIN grant application as well as a number of in-preparation articles.

My research has evolved beyond urban climate to provide expertise in additional areas, incorporating other types of urban modelling (including agent based modelling, social network analysis, and clustering and high-dimensional data reductions), and using neural networks and computer vision methods to utilise large imagery data sets. This work involves developing urban and neighbourhood typologies and to cluster similar urban areas based on their urban properties and by health and well-being outcomes. Two of these were published in Q1 journals**[55, 57]** (SJR Q1 4.205 and SJR Q1 1.65) as well as **[52]**. In 2020, I contributed to the THUD research lab's agent based modelling of policy settings, guiding Victoria's roadmap out of COVID-19 stage 4 restrictions**[54]** (also published in a Q1 journal). Overall, as a result of my research and publications, I have achieved a h-index of 7, i10-index of 6, and 192 citations on Google Scholar.

Over the last few years, I developed a sizeable network of Australian and international collaborators. I am currently working with members of the Urban Climate Research Center at Arizona State University, including Asst. Prof. Ariane Middel (specialising in urban heat) and Asst. Research Prof. Ashley Broadbent (urban climate modelling) and Naika Meili (urban ecohydrology) at ETH Zurich and have published 3 papers with them. I am participating in Urban Plumber (multi-site model evaluation project, the next iteration of the Grimmond et al.[21] intercomparison project) led by Mat Lipson (UNSW), Sue Grimmond (Reading) and Martin Best (UK Met Office), evaluating my two models, VTUF-3D and TARGET alongside approximately 30 other models. These intercomparision projects have been important periodic evaluations of the current state of the art in urban modelling and are led by some of the most important figures and research organisations in the urban climate field.

I am an active participant in the UNSW Urban Climate group which forms one of the major research groups within the ARC Centre of Excellence for Climate Extremes. I am currently serving on the Early Career Researcher Engagement Committee for the upcoming 2023 International Conference on Urban Climate (ICUC-11) in Sydney alongside a number of other international ECR urban climate scientists. My frequent attendance at past International Conferences on Urban Climate (ICUC) strengthens my urban climate relationships and has enabled forming new collaborations. In public health and computer vision, I have been collaborating with Dr. James Woodcock (leading public health modelling in the MRC Epidemiology Unit at Cambridge University) and Dr. Rahul Goel (Indian Institute of Technology Delhi). Together, these collaborations connect me to a wide range of expertise across urban climates, climate modelling, urban hydrology, and public health and public health modelling.

In addition to the skills and relationships I bring to this project, my research lab, the Transport, Health and Urban Design Research Lab (THUD) at the University of Melbourne, strongly supports my independent research under the umbrella of urban design and public health. This project provides a unique opportunity to integrate the issue of urban heat and how to create better urban design to mitigate its impacts as a major research area into the lab's areas of expertise.

PROJECT QUALITY AND INNOVATION

Urban planners have access to a wide range of tools to assess their designs across many factors (ArcGIS, Streetmix, Rhino3D, CityEngine, etc.), but a lack of accessible tools to examine urban heat or the ability to integrate heat modelling into their normal processes means that cities will continue to grow larger and denser with little to no consideration to human thermal comfort and urban heat mitigation; urban heat health impacts will be locked in for decades to come.

Even basic guidelines and rules of thumb around urban heat (e.g. increase of tree canopy by x% reduces air temperature by y°C) are currently lacking. In addition, the lack of tools also hampers the analysis of existing areas for locations of high vulnerability and to allow the planning of effective emergency response plans. Testing urban heat mitigation strategies, especially those using BGI features, requires modelling tools that can resolve at a micro-scale the processes driving thermal comfort and be shown suitable to model impacts of BGI, the full soil/plant/atmosphere continuum. Common questions include what locations and which types of vegetation deliver the highest benefits, how much irrigation is needed, or what are the impacts of different types of surfaces. But first to ensure these tools can be made available, more fundamental research needs to be completed, that is high-resolution observations of BGI features to provide the datasets needed to design and test modelling tools.

This project will be delivered through five work packages. These work packages include local and micro-climate **observations** of BGI, upgrading **models** to make them suitable for HTC assessments of BGI, a **co-design** process with industry partners and urban climatologists of the **scenario** analysis process to design scenarios of the greatest value to them, and a **dissemination** process to output the results back through the industry partners (reports and workshops) in addition to the traditional scientific channels (journals and conferences) and plan the next steps for the research to allow widespread adoption of the tools and insights. The overall structure of the project is shown in Figure 1.

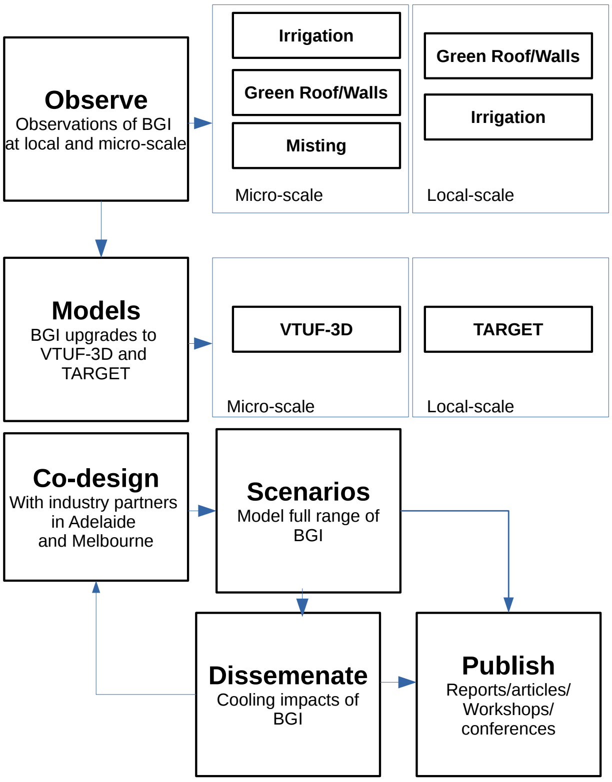

Figure 1: Project work packages and steps to achieve urban human thermal comfort analysis of BGI infrastructure.

Work Package 1: **Observe** - *To observe a wide variety of blue-green infrastructure features at a range of spatial and temporal scales necessary to understand the underlying processes driving the cooling benefits.*

Observations will be made of a range of BGI features at local and micro-scales to enable model development of BGI features. BGI features will include misting systems, green roofs and green walls, and irrigation of vegetated surfaces and impervious surfaces.

This work package starts by completing a number of observations that are currently being collected. At a local scale, misting observations have been collected by Greg Ingleton of South Australia Water. A residential cooling project across Adelaide installed misting system at around 100 residences along with thermometers, flow meters, and soil moisture probes. Surveys have been taken quantifying the effectiveness of the cooling and the impacts on their outdoor behaviour and comfort. Also at a local scale, irrigation trials were conducted within the Adelaide Airport, irrigating a 3.5 hectare site and monitoring the air temperature cooling over a multi-year period[12, 23, 46].

Observations at a micro-scale will be captured in 2021-2022, as part of a PhD project, across South East Water's Aquarevo housing estate. Micro-climate and detailed soil property observations (air temperature, humidity, incoming and outgoing shortwave and longwave, wind speed and direction, mean radiant temperature and 3 layers of soil moisture and soil temperature) are to be captured at two sites. The first site is a control site that will be irrigated on a typical suburban schedule. The second site will be irrigated using a number of scenarios, maintaining the soil moisture, emptying rain tanks before rain storms, and irrigating during high heat events. In addition, micro-scaled observations of energy balances, air temperatures and humidity will be observed within a misting system. Trials of turf grass irrigation will also be conducted at the University of Melbourne Burnley campus, providing micro-scaled observations (temperatures, energy balances, soil moisture) with varying amounts and times of irrigation (i.e. no irrigation, 4mm/day, 8mm/day, and 12/mm day). Finally, micro-climate observations will be collected in 2021-2022, as an honours project, of pavement watering at the Monash campus.

While these observations are good starting points for some of the following model development and validation, future observation campaigns will expand on these to ensure the full range of BGI can be modelled.

Micro-scaled green roof observations will be made in the City of Melbourne in conjunction with Dr. Andrea Pianella (University of Melbourne) and A/Prof Sergio Vera (Pontificia Universidad Católica).

Aquarevo will be the site of wider precinct scale observations to observe the cooling effects of outdoor water use. Aquarevo is an ideal site for this as they mandate rainwater capture in rainwater tanks that are also remotely controlled to minimise overflows by releasing water before rainstorms or before heatwaves. In addition, each house is fitted with smart water meters, providing detailed usage measurements for drinking, rainwater, and recycled water. These observations provide a unique opportunity to understand the cooling benefits of irrigation across both micro- and local-scales and provide data essential to ensure that models are correctly modelling the influence of irrigation across these scales. All the observation instruments for the micro-climate sites have been purchased through South East Water's funding of the current PhD project at Aquarevo. Some additional equipment has been requested in this project's budget to fill in observation gaps in the local scaled observations. Travel funding is not required or requested for the Aquarevo or Burnley fieldwork as it is local to the investigator. Funding for travel to setup equipment for Adelaide fieldwork is requested for the first year.

Work Package 2: **Models** - *To build urban climate modelling tools and show them suitable to model human thermal comfort benefits of blue-green infrastructure and urban water usage.*

This work package will focus on utilising existing observational datasets and acquiring additional observations and using them to upgrade the two models I have previously developed (VTUF-3D and TARGET) and perform validations that they are suitable to model the human thermal comfort impacts of a wide range of BGI features and practices. While VTUF-3D, as a micro-scale model, is more suitable for modelling BGI, upgrades will be performed on both models. The code upgrades will be very similar and most can be applied to both. In addition, as TARGET runs about 100 times faster than VTUF-3D, it can be used first during an analysis process to make first-order estimates to guide subsequent, more detailed modelling. The tasks required are as follows:

To add additional surface types, I propose to utilise two existing models to add these missing components. The first is MAESPA[15] which is a soil-plant-atmosphere model that has been previously coupled by myself with the TUF-3D model[29] to create the VTUF-3D**[51]** urban micro-climate model. This coupling provides the hydrology and physiological processes of a single tree, a stand of trees, or vegetated irrigated surface cover (e.g. turf grass) that are currently parameterised in TARGET. To add additional surface types (deep water, swales, misting fountains, porous and/or watered pavements), modules from a second model will be utilised from the Urban Tethys-Chloris (UT&C)**[37]** (co-developed by myself). This model provides a wide range of urban hydrology processes (interception, ponding, vadose zone dynamics, runoff, and soil hydrology) and plant water and biophysical relations. It also allows modelling of many different arrangements of vegetation within the urban canyon including green roofs and green walls. Upgrades will include a simple horizontal advection scheme. These processes are currently neglected for computational reasons. With the addition of this new scheme, wind direction, wind speed, and terrain features will be used to distribute temperature fluxes to nearby grid cells at the end of each timestep. Interfaces need to be created to run both in a modelling engine. This handles processing the urban design information, designing the modelling domain, enabling forcing the different forcing types. Design coupling of the models as online component to regional climate model to allow micro and local-scaled feedback to drive regional changes. An additional change to upgrade VTUF-3D to version 2 is to update the vegetation/hydrology scheme to run online with the model, either through closer coupling with MAESPA[15] or total/partial replacement with modules from UT&C**[37]**.

Work Package 3: **Co-design** - *To implement co-design principles in the development, implementation and delivery of the findings with key stakeholders mapping out the tools and results that will be of highest value.*

In this phase of the project, a co-design process will be conducted with industry partners, particularly with South East Water and South Australia Water. I already have an existing working relationship with both. This process will refine the goals and outcomes for the next phase, the scenario modelling, and ensure the research includes scenarios relevant to their needs. These will include scenarios such as the spatial arrangement of vegetation and interactions with the built form, types and forms of vegetation, irrigation amounts and timing, and targeted cooling through misting and pavement watering. Workshops will be held in Adelaide as well as Melbourne. Workshops in Melbourne will not require additional travel. Quarterly online meetings will continue throughout the project to ensure this engagement remains on track. In the final year, workshops in Adelaide and Melbourne will be used to disseminate the findings and plan future collaborations.

Work Package 4: **Scenarios** *Quantify blue-green infrastructure cooling impacts through systematic modelling.*

This work package will utilise the newly improved modelling tools to systematically test the cooling impacts of BGI. This will uncover optimal scenario parameters, design limitations, and ranked priorities to guide redesign efforts. These interventions might include increasing the street tree canopy cover, modify irrigation rates, or conversion of driveways and other hard surfaces to permeable pavement. Redesigns are iteratively modelled and analysed to converge on the best designs and discover the significant factors impacting urban heat and generate redesigned areas. Additional analysis will add in layers of urban typologies characteristics and demographics to look at the impacts of the heat modelling results on population health.

Work Package 5: **Disseminate** *Share results and methods from the project.*

The final work package in the project will be used to disseminate the methods and results. This will proceed in a number of different ways. The first will happen through the co-design process of Work Package 3 and the ongoing engagement with industry partners, involving follow-up workshops and reports. The second will be through the traditional academic outputs of journal publications, international and domestic conference presentation, and ongoing collaborations with other urban climate researchers. The final method will be to package the tools, model code, and datasets so that they can be easily adopted by a wide base of users including other researchers and consultants. My current models are freely available and open source, this project will continue this tradition and make the outputs of the project available to all.

Honours and masters students will be recruited to complete small discreet projects related to this project, such as observations of individual BGI features (i.e. swales, rain gardens, etc.) and to develop the appropriate models to simulate them. However, their projects will be opportunistic, to widen the full range of BGI features observed and modelled, and are not intended for the critical BGI elements needed to complete the project.

BENEFIT

The fundamental observations of cooling impacts of BGI and the improvements to the models based on these observations this project will deliver considerable benefits for the first time. The observations will provide knowledge about how BGI can cool cities and be best used in heat mitigation strategies. The models will considerably enhance increasingly detailed research to be performed by academic researchers in city science and urban climate. In addition, these modelling tools will help practitioners who need to make immediate decisions about the future design of cities and allow assessments to be made about urban heat mitigation and adaptation strategies using vegetation and the use of water practices. The analysis tools can also be used to examine urban areas for hotspots, areas of high vulnerability, that require immediate attention for remediation to reduce the vulnerability and to provide warning to emergency responders and crisis services for areas that might require extra attention during heat waves. This is work that previously could only be performed using expensive and difficult to obtain observations, often incomplete and captured at only a single point in time.

The 2010s were the hottest decade on record and heatwave occurrences and intensities are projected to be even more frequent in the future. The cost of climate change to society will be especially large in urban areas, while the importance of infrastructure planning and management will grow accordingly. This project, with the aim of contributing to better understanding of urban heat and exploring methods to reducing its impact through data acquisition and model development and validation, will help urban planners and city managers to make better, evidence-based decisions, to design better new cities. It will also support the retrofitting of existing areas and design of new more liveable and climate-safe cities. Climate change will also bring new regional weather patterns and understanding how different areas might perform under these new conditions allows better planning future responses to best protect human health.

The Australian science and research priority of environmental change, and specifically of adaptation to the impacts of environmental change in urban and rural communities is addressed by this project through both the fundamental knowledge generated by this project about the cooling impacts of BGI and through the application of this knowledge to the design (and redesign) of urban areas to maximise these benefits.

The benefits will be achieved over a number of stages. The first benefit is the improved urban climate models. That will happen beginning in the second year and will be enable those benefits to be used by other researchers. This will be integrated into the research of the THUD research lab, as another component in urban design and health.

The second stage of benefits results both after observations have been made and after the modelling assessments are completed. Both will allow this knowledge to be incorporated into design and planning with the industry collaborators. South East Water, Villawood Properties, and Arden Homes have made large investments in designing and building a sustainable and water and energy efficient housing estate and are very interested in being able to showcase the full range of benefits (including cooling using water) to potential customers and to bring sustainable housing into the mainstream in future projects. Finally, after the final delivery of the project, the modelling tools and insights will be available to a wide range of users. Urban planners, consultants, property developers, among others will be able to test how, where, how much, and what kind of BGI can be used in urban areas to maximise the cooling benefits and create heat resilient cities. As Australian cities become hotter and denser, populations become more elderly and vulnerable to heat risks, these tools will become increasingly important to plan and react to these growing challenges.

FEASIBILITY

While developing climate models is complicated and time consuming, my extensive experience in software engineering and human thermal comfort modelling demonstrates that I am the ideal person to develop this project. In addition, many of the micro-climate observations needed for the model development and validation will be provided before and during the first stages of this project through an existing PhD supervised project allowing some of the model development to proceed immediately. Additional local-scaled observations can utilise some of the existing equipment through that research project and through support from South East Water to purchase and install. Additional specialised equipment to supplement these has been requested in the equipment budget in this project. All of these datasets will be unique and have many uses outside of their original projects, especially the ones examining the influence of outdoor irrigation on neighbourhood cooling patterns. These observations have not been possible before, without the detailed water usage data that South East Water can provide through the smart meters they have in place across the neighbourhood. Well designed and unique observation datasets can have a long life and be used in a multitude of other research projects. Coutts et al[10] is a perfect example of such a dataset. Adelaide Airport fieldwork will require travel costs to set up, make observations, and disassemble the equipment while Aquarevo work will be performed locally in Melbourne.

During 2020-2021, fieldwork was able to continue (although with some interruption) during COVID-19 lockdowns in Melbourne, especially after automation and remote monitoring retrofitting enabled unattended fieldwork. In addition, South East Water, as an essential service provider, was able to provide some level of assistance over that period. As future COVID-19 interruptions are possible, future fieldwork will always include contingency plans to continue observations during interrupted periods. Inner-state travel restrictions might require a reformulation of some planned campaigns or to find alternatives in Victoria.

Once the modelling tools are created, they can be used for a wide variety of testing scenarios, both analysis of existing places to find vulnerabilities but also testing new ways to design things. The initial scenario building and analysis process will be focused on Melbourne, Adelaide, and other Australian cities but ultimately the methods and findings are highly transferable to other cities, regions, and countries.

For dissemination, as I have a high professional and academic interest in the ongoing and continual improvements in the modelling tools I have created, they will continue past the end of this project. The code for them will always be available through open repositories (i.e. Github or Bitbucket), made available to the international community of urban climate researchers, and the use and development of them will continue through my academic career.

Industry engagement, especially with the water companies, through consultation and workshops to work through the scenario designs will require travel to Adelaide in the second and third years and travel is included in the budget. However, the rest of the project will be Melbourne based and not require additional travel budget.

At the University of Melbourne, the Transportation, Health and Urban Design Research Lab was created with multi-year seed funding from the university bringing together a large number of researchers from the Faculty around common research themes. This lab provides a very supportive environment for myself and this research. Much of this research can be undertaken in collaboration with other members of this group, and their expertise in research, particularly in the fields of urban analytics, artificial intelligence, and computer vision, is extremely high. Furthermore, the university provides high levels of support to research facilities, including an extensive high performance computing infrastructure (CPU and GPU) with terabytes of available storage. I have gained extensive experience utilising this resource in my research.

Students recruited by the University of Melbourne, masters and honours, are of exceptionally high quality and many of them have provided valuable research to a number of my past projects. For example, the supervision of three Master's of IT final semester research projects have resulted in methods that were integrated into my 2020 Urban Climate sky pixels publication**[53]**. This method of student supervision is an ideal method to provide research experience to Master's students but also to build capacity and gain assistance with development of small discrete portions of this project. However, to mitigate the risk that these projects might produce useful research but that is not directly related to the goals of this project, a modest amount of hours are allocated across the three years for research assistants. In addition, some additional research assistance will be required throughout the project in field work, data analysis and publication preparation.

The overall project plan and timeline are shown in Figure 2

COMMUNICATION OF RESULTS

There are a number of peer-reviewed publications planned to result from this project (as well as presented at international conferences including ICUC-11, the AMS General Meeting, and the EGU General Assembly). Papers will result from each of the micro and local scaled observations of misting, green roofs, and irrigation. There will be one article each for the upgrade (v2) of the VTUF-3D and TARGET models, to be likely submitted to the Geoscientific Model De-

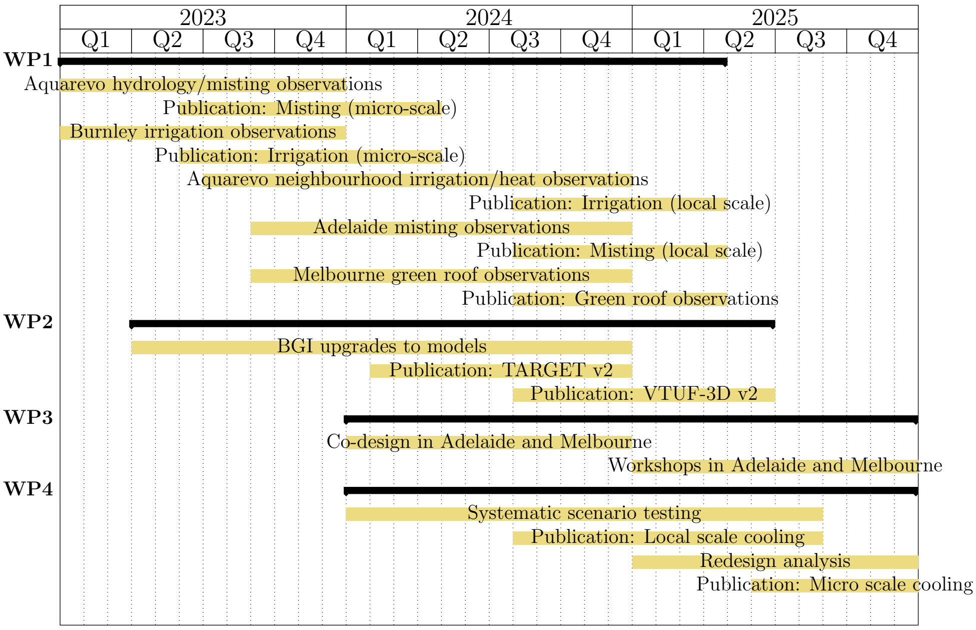

Figure 2: Project timeline.

velopment journal. Two additional papers will result from the modelled systematic assessments of BGI at local scales and micro-scales, describing how to use these distinct types of urban design to deliver the best thermal performance under extreme heat conditions and what mitigation strategies work best to reduce the risk in vulnerable areas.

Reports will be written reporting on the overall findings from the project of development designs and mitigation strategies for the industry partners. A project wrap-up will involve a stakeholder workshop with previous partners (for example the City of Melbourne or the Victoria Department of Environment, Land, Water and Planning) to disseminate these reports and help plan the next stages for the research beyond this project.

Beyond academic outputs, translations of the research for more general audiences will be disseminated through platforms such as The Conversation and the University of Melbourne's Pursuit. For example, my recent publication on identifying urban typologies through through the use of urban imagery and computer vision techniques was featured in Pursuit[**49**] and the Sydney Morning Herald[20].

Finally, the models, their code, and observational datasets will be distributed as open-source bundles will allow other interested users to use and extend the work.

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Morrison. **A global analysis of urban design types and road transport injury: an image processing study**. *Lancet Planetary Health*, 4:32–42, 2020. [56] T. Todorovic, G. London, N. Bertram, O. Sainsbury, M. A. Renouf, **Nice, Kerry A.**, and S. J. Kenway. **Models for water sensitive middle suburban infill development**. In *9th State of Australian Cities National Conference, 30 November - 5 December 2019, Perth, Western Australia*, 2019. [57] J. S. Wijnands, **Nice, Kerry A.**, J. Thompson, H. Zhao, and M. Stevenson. **Streetscape augmentation using generative adversarial networks: insights related to health and wellbeing**. *Sustainable Cities and Society*, 2019. [58] J. Yang and Z.-H. Wang. Optimizing urban irrigation schemes for the trade-off between energy and water consumption. *Energy & Buildings*, 107:335–344, 2015.

D3. Statement by the Administering Organisation

(Provide a statement that addresses the relevant criteria as set out in the grant guidelines (upload a PDF of up to 3 A4 pages).)

Uploaded PDF file follows on next page.

Professor James McCluskey AO
Deputy Vice-Chancellor (Research)

THE UNIVERSITY OF MELBOURNE

28 January 2022
Chief Executive Officer
Australian Research Council

Attention: Chief Executive Officer,

Re: DE230100402, Dr Kerry Nice, *Achieving urban heat mitigation through blue-green infrastructure*

The University of Melbourne strongly supports Dr Kerry Nice's DECRA award application, *Achieving urban heat mitigation through blue-green infrastructure*. This project focuses on crucial issues central to the future function and health of Australian cities and their growing populations. Urban heat is of high concern in urban areas and a large health risk, particularly to vulnerable populations such as the very young and the elderly.

Dr Nice completed his PhD in science in March 2017. His PhD project was to design and develop the urban climate model VTUF-3D. This was the first model, with low computational demands, to examine the human thermal comfort impacts at a micro-scale of blue and green infrastructure (BGI), such as vegetation and water features. The impact of this work has been significant and the knowledge and experience from his PhD research has led to co-development of three additional climate models to enable research into urban heat mitigation utilising BGI features at both micro-scales (street scaled) and local-scale (neighbourhood scaled).

Dr Nice's research into urban climate modelling has led to publications in top academic journals including Geoscientific Model Development and Urban Climate. In addition, his research into the applications of machine learning methods to examine the health impacts of urban design has been published in journals such as The Lancet Planetary Health, Computer-Aided Civil and Infrastructure Engineering, and Sustainable Cities and Society. Highlighting his rapid trajectory, in the last 4 years only, he has published 14 peer-reviewed articles while in the last 8 years, he has presented at 9 international conferences and 7 national conferences, three of them by invitation. He was also invited by Cambridge University to present his research methodologies at a computer vision and health workshop, leading to an ongoing collaboration with key public health researchers from Cambridge University. The urban climate modelling methodologies in these studies are directly aligned with Dr Nice's proposed DECRA research, while the computer vision and machine learning methods will play a large supporting role. Further, his publication track record in top academic journals in a wide variety of domains, exemplifies his knowledge of transportation, public health, urban design and machine learning. This demonstrates Dr Nice's capacity to undertake the proposed research program, requiring expertise in all these domains.

Prior to his current appointment as a Research Fellow at the University, Dr Nice held positions as a senior software engineer in publishing and other sectors for 13 years. This provided him with a high level of expertise in computer languages and software design. It also provided him with project management skills to scope, design, implement and deliver large multi-year multi-site projects as well as providing ongoing maintenance, support, and enhancements to support the customer base's growing and changing needs.

Dr Nice’s proposed project themes relating to the nexus of urban design and public health aligns with The University of Melbourne’s Advancing Melbourne strategy, particularly with the Discovery priorities to attract and nurture the best researchers from around the world and to advance reseearch success through cross-

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disciplinary partnerships and research translation. Further, Dr Nice's project aligns with the Faculty of Architecture, Building and Planning's investment in its Transport, Health and Urban Design research lab (THUD). THUD is chaired by NHMRC Research Fellow, Professor Mark Stevenson, Professor of Urban Design and Population Health. THUD has been specifically established to bring together researchers from across the University and encourage interdisciplinary collaboration to understand the links between urban design and public health outcomes including urban heat. Given the multi-disciplinary nature of the proposed DECRA project and the aforementioned existing research lab with a similar research focus, the THUD lab at the University of Melbourne will be the best fit for this research project on issues spanning health and urban design. The Faculty's continued support of THUD offers Dr Nice an ideal environment to build research collaborations with other Senior Researchers on the impacts of future city design. It has already achieved success with a Lancet Series in 2016 and a recent publication in The Lancet Planetary Health in 2020 on the global relationships between urban design and transport injuries, in which Dr Nice was a co-author. Given the achievements of the lab so far, the proposed DECRA project is likely to make further contributions to the Australian Government's National Science and Research Priorities on 'Environmental change' and 'Resilient urban, rural, and regional infrastructure.

At THUD, Dr Nice will be supported through close collaborations with leading researchers who, together, will form the University-based component of an advisory group for the proposed project. These researchers include Professor Mark Stevenson, Dr Jason Thompson, and Dr Sachith Seneviratne, who are highly experienced in investigating complex urban issues using machine learning methods and open-source imagery data sources. This indicates delivery of the proposed DECRA project will be enhanced by day-to-day interactions with leading academic researchers in the lab.

Dr Nice will not only be supported by the University and Faculty through exposure to this high-quality research environment but through practical means. This includes provision of equipment, office and meeting space, computing hardware and software, access to additional academic and practical training (e.g., media training), and opportunity to apply for numerous internal travel and early career project grants. Further, the University will provide access to their centralised, state-of-the-art general-purpose GPU high-performance computing infrastructure for the development of the urban climate modelling platform required in the proposed DECRA project. The University of Melbourne will also provide opportunities for dissemination of Dr Nice's work through its on-line 'Pursuit' magazine and through coverage on the lab's website to reach target audiences, as well as opportunities for commercialisation through its Business Development Unit. If successful, the University is committed to providing Dr Nice with project establishment grant support of $50,000. This establishment grant will be used to purchase enviromental sensors necessary for the observations to be made as part of work package 1. Salary top-up of $195,894 at level B6 for the period of the award is also offered. Over-all, this amounts to a total of $245,894 over the period of the award. This is in addition to standard, competitive early career funding support offered to Dr Nice through the Faculty of Architecture, Building and Planning for conference travel and registration costs.

The DECRA award presents a significant opportunity for Dr Nice to extend work that was first envisaged and explored during his PhD. The micro-climate observations of the cooling benefits of irrigation that will be collected in the project will enable significant improvements to his climate models and serve as a valuable resource to other researchers on how to best utilise BGI features as an urban heat mitigation strategy. The increased sophistication of these models will enable increasingly detailed research to be performed by academic researchers in city science and urban climate. The tools will also allow assessments to be made about urban heat mitigation and adaptation strategies using vegetation and the use of water practices. The analysis tools can also be used to examine urban areas for hotspots, areas of high vulnerability, that require immediate attention for remediation to reduce the vulnerability and to provide warning to emergency responders and crisis services for areas that might require extra attention during heat waves. The DECRA resources and award period provide a tangible opportunity for Dr Nice to establish an independent research team and modelling program that can solve significant problems facing contemporary Australian and international society.

Dr Nice's track record in acquiring competitive funding for his research is testament to his ability to conceive and deliver these innovative projects and is indicative of the significant potential of his research. Up to this point, his research has attracted $1,207,910 in funding, primarily from sources external to the University. The DECRA will further enhance his competitiveness for future national and international competitive scientific grants including the AURIN High Impact Project he has recently applied for. The university is committed to supporting Dr Nice through its research strategy and has recently moved him to a continuing research-based position. If this application is successful, upon its completion Dr Nice will be supported in this continuing position, subject to appropriate performance during the Fellowship and in line with faculty teaching and research priorities. The resources to undertake this DECRA project will establish Dr Nice as an international leader on the use of BGI features to promote urban cooling.

Dr Nice is a highly productive and high-quality early career researcher. He has demonstrated an ability to produce new scientific advances, published in top academic journals, which have led to evidence-supported research impact. The research proposed in his DECRA award application is innovative, impactful, and aligns with the goals of the University of Melbourne. We have no hesitation in committing to support Dr Nice in his pursuit of a DECRA award.

Yours sincerely,

Professor James McCluskey AO FAA FAHMS
Deputy Vice-Chancellor (Research) and
Redmond Barry Distinguished Professor
The University of Melbourne

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Part E - Project Cost (DE230100402)

E1. What is the proposed budget for your project?

(There are rules around what funds can be requested from the ARC. You must adhere to the scheme specific requirements listed in the grant guidelines. Refer to the Instructions to Applicants for detailed instructions on how to fill out the budget section.)

Total requested budget: $462,285

Year 1

Description	ARC	Admin Org
	Cash	Cash
Total	150,085	98,871
Personnel	127,906	48,871
Dr Kerry Nice (Discovery Early Career Researcher Award)	108,106	48,871
Research Asst Grade 2, @ $66/hr	19,800	
Travel	7,680	
International conference	7,680	
Field Research	10,499	50,000
Adelaide Fieldwork	2,128	
2x CNR4-L10m net radiometer for energy balance observations of mising systems at Aquarevo and Adelaide		26,540
50X LoRa sensor nodes for Aquarevo neighbourhood observations	8,371	23,460
Other	4,000	
Open access publication fees	4,000	

Year 2

Description	ARC	Admin Org
	Cash	Cash
Total	157,094	54,346
Personnel	124,606	54,346
Dr Kerry Nice (Discovery Early Career Researcher Award)	108,106	54,346
Research Asst Grade 2, @ $66/hr	16,500	
Travel	15,360	
International conference	15,360	
Field Research	2,128	
Adelaide Fieldwork	2,128	
Other	15,000	
PSMA Geoscape urban data set	7,000	
Open access publication fees	8,000	

Year 3

Description	ARC	Admin Org

	Cash	Cash
Total	155,106	59,825
Personnel	137,806	59,825
Dr Kerry Nice (Discovery Early Career Researcher Award)	108,106	59,825
Research Asst Grade 2, @ $66/hr	29,700	
Travel	7,680	
International conference	7,680	
Field Research	1,620	
Adelaide industry workshop	1,620	
Other	8,000	
Open access publication fees	8,000	

E2. Justification of non-salary funding requested from the ARC

(Fully justify each budget item requested in terms of need and cost. Use the same headings as in the Description column in the Budget Table of this application (upload a PDF of up to 4 A4 pages and within the required format).)
Budget Justification

Uploaded PDF file follows on next page.

Item Requested	Year 1 Cost (AUD)	Justification
Personnel		
Research Asst Grade 2, 300 hours @ $66/hr	$19,800	In the first year, assistance will be required with a number of tasks. The first is the data collection and data processing from the observations. The second is collection of relevant academic literature and manuscript formatting according to journal guidelines for the two publications planned in the first year. The RA will need to have a good understanding of modelling and climate. For this reason, all research assistance requested for this project is at Grade 2.
Travel		
International conference, accommodation, 7 nights @ $250/night	$1,750	conference discussing misting and irrigation observations. The aim is to present this at the annual meeting of the American Meteorological Society or the general assembly of the European Geoscience Union. International accommodation estimates are based on the University's Price Guide for international hotel rates at Frequently Requested Destinations.
International conference, per diem, 7 days @ 70% of $240/day	$1,680	Per diem rates are requested at the standard 'Category 5' ATO rate for CI Nice to cover meals and incidentals.
International conference, return economy airfare	$2,500	Presentation of findings at an international climate conference discussing misting and irrigation observations. The aim is to present this at the annual meeting of the American Meteorological Society or the general assembly of the European Geoscience Union. Airfare estimates are based on the University's Price Guide for international flights.
International conference, registration fee	$1,750	Registration fee required to attend and present at year 1 'International conference', as detailed above.
Field Research		
Adelaide Fieldwork year 1, Flights to Adelaide	$350	Fieldwork will be performed in Adelaide in conjunction with South Australia Water to perform micro-climate observations of the impacts of irrigation and misting systems. This fieldwork fits into Work Package 1, the observations. Airfare estimates are based on the University's Price Guide for domestic flights to Adelaide.
Adelaide Fieldwork year 1, accommodation, 7 nights	$1,099	This estimate for domestic accommodation is based on the standard ATO rate for accommodation in Adelaide.
Adelaide Fieldwork year 1, per diem, 7 days	$679	Per diem rates are requested at 70% of the standard ATO rate for domestic travel, covering CI Nice' meals and incidentals.
50X LoRa sensor nodes for Aquarevo neighbourhood observations	$8,371	LoRa sensor nodes with 1 x humidity sensor ($26), 2 x soil moisture sensors ($57), 2 x soil temperature sensors ($67), 1 x ambient temperature sensor ($24), 1 x ambient light intensity sensor ($9), and solar radiation shield ($132) (and batteries, cables, boxes, and power boards) to observe neighbourhood scale cooling during Aquarevo fieldwork. This equipment is required for Work Package 1 and will allow high resolution observations to be made across this neighbourhood and determine how the outside irrigation of each individual household provides localised cooling. Each node will be assembled based on existing sensor nodes designed by South East Water currently being used at a small scale in Aquarevo. Each node costs about $640 and uses a variety of parts from Digikey and Jaycar. The full cost of this equipment is split across E2 and E3, partially utilising University of Melbourne grant establishment funding.

Other		
Open access publication fees	$4,000	Fees related to one publication in a highly reputable academic journal in Year 1, in order to meet ARC requirements for publishing research findings as Open Access. Besides meeting ARC requirements, Open Access publications are important for disseminating the findings of this research beyond academic audiences.
	Year 2	
Personnel		
Research Asst Grade 2, 250 hours @ $66/hr	$16,500	Assistance will be required with a number of tasks. The first is the data collection and data processing from the observations. The second is collection of relevant academic literature and manuscript formatting according to journal guidelines for the three publications planned in the second year. Finally, the modelling will require collection of urban morphology information, scenario creation, and data analysis. The RA will need to have a good understanding of modelling and climate. For this reason, all research assistance requested for this project is at Grade 2.
Travel		
International conference 1, return economy airfare	$2,500	Presentation of findings at an international climate conference discussing green roof observations. The aim is to present this at the annual meeting of the American Meteorological Society or the general assembly of the European Geoscience Union. Airfare estimates are based on the University's Price Guide for international flights.
International conference 1, accommodation, 7 nights @ $250/night	$1,750	Presentation of findings at an international climate conference discussing green roof observations. The aim is to present this at the annual meeting of the American Meteorological Society or the general assembly of the European Geoscience Union. International accommodation estimates are based on the University's Price Guide for international hotel rates at Frequently Requested Destinations.
International conference 1, per diem, 7 days @ 70% of $240/day	$1,680	Per diem rates are requested at the standard ‘Category 5’ ATO rate for CI Nice to cover meals and incidentals.
International conference 2, return economy airfare	$2,500	Presentation of findings at an international climate conference discussing local scale misting and irrigation impacts. The aim is to present this at the annual meeting of the American Meteorological Society or the general assembly of the European Geoscience Union. Airfare estimates are based on the University’s Price Guide for international flights.
International conference 2, accommodation, 7 nights @ $250/night	$1,750	International accommodation estimates are based on the University’s Price Guide for international hotel rates at Frequently Requested Destinations.
International conference 2, per diem, 7 days @ 70% of $240/day	$1,680	Per diem rates are requested at the standard ‘Category 5’ ATO rate for CI Nice to cover meals and incidentals.
International conference 1, registration fee	$1,750	Registration fee required to attend and present at year 2 'International conference 1', as detailed above.
International conference 2, registration fee	$1,750	Registration fee required to attend and present at year 2 'International conference 2', as detailed above.
Field Research		

Adelaide Fieldwork year 2, accommodation, 7 nights	$1,099	This estimate for domestic accommodation is based on the standard ATO rate for accommodation in Adelaide.
Adelaide Fieldwork year 2, per diem, 7 days	$679	Per diem rates are requested at the standard ATO rate for domestic travel, covering CI Nice' meals and incidentals.
Adelaide Fieldwork year 2, Flights to Adelaide	$350	Fieldwork will be performed in Adelaide in conjunction with South Australia Water to perform micro-climate observations of the impacts of irrigation and misting systems. This fieldwork fits in work package 1, making observations of BGI. Airfare estimates are based on the University's Price Guide for domestic flights to Adelaide.
Other		
Open access publication fees	$8,000	Fees related to two publications in highly reputable academic journals in Year 2, in order to meet ARC requirements for publishing research findings as Open Access. Besides meeting ARC requirements, Open Access publications are important for disseminating the findings of this research beyond academic audiences.
PSMA Geoscape urban data set	$7,000	Licensing the PSMA Geoscape data will provide the baseline data needed to analyse all the Australian cities in their present form. The scenario generation in work package 4 requires urban morphology information to build and run the scenarios and to analyse each city. This information includes building heights and locations, tree heights and locations and detailed maps of land use and surface types across each urban area.
	Year 3	
Personnel		
Research Asst Grade 2, 450 hours @ $66/hr	$29,700	Assistance will be required with a number of tasks. The first is collection of relevant academic literature and manuscript formatting according to journal guidelines for the two publications planned in the second year. Second, the modelling will require collection of urban morphology information, scenario creation, and data analysis. Finally, assistance will be required in setting up workshops. The RA will need to have a good understanding of modelling and climate. For this reason, all research assistance requested for this project is at Grade 2.
Travel		
International conference 1, return economy airfare	$2,500	Presentation of findings at an international urban planning or geography conference detailing the new improvements to the VTUF-3D model. The aim is to present this at the annual meeting of the American Association of Geographers. Airfare estimates are based on the University's Price Guide for international flights.
International conference 1, accommodation, 7 nights @ $250/night	$1,750	Presentation of findings at an international urban planning or geography conference detailing the new improvements to the VTUF-3D model The aim is to present this at the annual meeting of the American Association of Geographers. International accommodation estimates are based on the University's Price Guide for international hotel rates at Frequently Requested Destinations.
International conference 1, per diem, 7 days @ 70% of $240/day	$1,680	Per diem rates are requested at the standard 'Category 5' ATO rate for CI Nice to cover meals and incidentals.
International conference 1, registration fee	$1,750	Registration fee required to attend and present at year 3 'International conference 1', as detailed above.
Field Research		

		to bring the results of the fieldwork and bring the usage of the modelling platform into SA Water's urban cooling strategies. This workshop fits in both work package 3, co-design of scenarios and work package 5, the dissemiation of observation results to industry partners. Airfare estimates are based on the University's Price Guide for domestic flights to Adelaide.
Industry workshop-Adelaide, flights	$350	
Industry workshop-Adelaide, accommodation, 5 days	$785	This estimate for domestic accommodation is based on the standard ATO rate for accommodation in Adelaide.
Industry workshop-Adelaide, per diem, 5 days	$485	Per diem rates are requested at the standard ATO rate for domestic travel, covering CI Nice' meals and incidentals.
Other		
Open access publication fees	$8,000	Fees related to two publications in highly reputable academic journals in Year 3, in order to meet ARC requirements for publishing research findings as Open Access. Besides meeting ARC requirements, Open Access publications are important for disseminating the findings of this research beyond academic audiences.

E3. Details of non-ARC contributions

(Provide an explanation of how non-ARC contributions will support the proposed project. Use the same headings as in the Description column in the above Budget Table of this application (upload a PDF of up to 2 A4 pages and within the required format).)

Details of non-ARC Contributions

Uploaded PDF file follows on next page.

E3Jusifications

Item Requested	Cost (AUD)	Justification
Year 1		
Personnel		
Dr Kerry Nice	$48,871	The University of Melbourne provides funding support to cover remaining salary and overhead costs. The DECRA candidate time commitment to this project is 0.8.
Field Research		
2x CNR4-L10m net radiometer for energy balance observations of mising systems at Aquarevo and Adelaide	$26,540	Two (for control and experimental sites) net radiometers are required for energy balance observations of misting systems at Aquarevo and Adelaide. These energy balance observations are an essential component to validate modelling tools and fits into work package 1, the micro-scaled observations of BGI. This cost is covered by the University of Melbourne $50,000 project establishment grant.
50X LoRa sensor nodes for Aquarevo neighbourhood observations	$23,460	LoRa sensor nodes with 1 x humidity sensor, 2 x soil moisture sensors, 2 x soil temperature sensors, 1 x ambient temperature sensor and 1 x ambient light intensity sensor to observe neighbourhood scale cooling during Aquarevo fieldwork. This cost is partially split between ARC funding and the University of Melbourne $50,000 project establishment grant.
Year 2		
Personnel		
Dr Kerry Nice	$54,346	The University of Melbourne provides funding support to cover remaining salary and overhead costs. The DECRA candidate time commitment to this project is 0.8.
Year 3		
Personnel		
Dr Kerry Nice	$59,825	The University of Melbourne provides funding support to cover remaining salary and overhead costs. The DECRA candidate time commitment to this project is 0.8.

Part F - Participant Details including ROPE (Dr Kerry Nice)

F1. Personal Details

(To update any Personal Details, click on the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the DECRA candidate's profile.
Note: The date of birth, country of birth, citizenship, material personal interests and Indigenous status section will not appear in the PDF version of the form and will not be visible to assessors.
Data may be shared with other Commonwealth Entities.
All information contained in Part F is visible to the Administering Organisation on this application.)

Participation Type

Discovery Early Career Researcher Award

Title

Dr

First Name

Kerry

Middle Name

Alan

Family Name

Nice

Citizenship

Australia

Australian Permanent Resident

N/A

Australian Temporary Resident

N/A

F2. Current country of residence

(If the DECRA candidate is not an Australian citizen, they must obtain a legal right to work and reside in Australia.)

Australia

F5. Qualifications

(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the DECRA candidate's profile.)

Conferral Date	AQF Level	Degree/Award Title	Discipline/Field	Awarding Organisation	Country of Award
08/03/2017	Doctoral Degree	Doctor of Philosophy	Science	Monash University	Australia

13/10/2011	Masters Degree	Master of Enviroment and Sustainability	Geography	Monash University	Australia
31/05/1990	Bachelor Degree	Bachelor degree	English and Film Studies	University of Colorado at Boulder	United States of America

F6. Research Load (non-ARC Grants and Research)

(Provide details of research funding from non-ARC sources (in Australia and overseas). For research funding from non-ARC sources, list all projects/applications/awards/fellowships awarded or requests submitted involving the DECRA candidate for funding for the years 2022 to 2026 inclusive.)

Uploaded PDF file follows on next page.

Description (All named investigators on any application or grant/fellowship in which the DECRA candidate is involved, project title, source of support, scheme and round)	**Same Research Area** (Yes/No)	**Support Status** (Requested/Current/Past)	**Application Project ID** (for NHMRC applications only)	**2022** $'000	**2023** $'000	**2024** $'000	**2025** $'000	**2026** $'000
Dr Kerry Nice, University of Melbourne, 'DECRA Establishment Grant', 2023.	Yes	R			50			
Dr Ruth Hunter, Dr N Anderson, Professor G Ellis,Dr L Garcia, Dr R Hunter, Professor F Kee, Dr K Nice, Professor M Stevenson, Dr J Thompson, 'A vision of healthy urban design for NCD prevention', NHMRC UKRI 20/23	Yes	C	1194959	202	202			
Dr. Negin Nazarian, Prof. Chris Pettit, A/Prof. Melissa Hart, Dr. Kerry Nice, Dr. Sachith Seneviratne, AURIN High Impact Projects 2022, "Climate Resilient and Just Cities: Data for Research and Practice"	Yes	R		89	60			

F7. What will the DECRA candidate's time commitment be to research activities related to this project?

(It is a requirement for DECRA candidate to work a minimum of 0.8 full-time equivalent (FTE) of their time on research activities related to the DECRA. Enter your time commitment to this project as a full-time equivalent (FTE). Note that an FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)

0.8

F8. Eligibility - Currently held ARC Projects

(This information is auto-populated. If you have any concerns with the information recorded here, please contact your Administering Organisation's Research Office.)

Identifier	Investigators	Admin Organisation	Project Title	Funding	End Date	Final Report Due Date	Final Report Status
DP210102089	Dr Ben Beck ; Prof Christopher Pettit ; Dr Meead Saberi ; Dr Simone Zarpelon Leao ; Dr Kerry Nice ; Prof Tarek Sayed ; Prof Trisalyn Nelson ; A/Prof Meghan Winters	Monash University	Sustainable mobility: city-wide exposure modelling to advance bicycling	$422,000	31/12/2023	31/12/2024	Draft

F9. Eligibility - Relevant Qualification

(Please select the qualification which is most relevant to the application.)

Degree/Award Title	Awarding Organisation	Conferral Date
Doctor of Philosophy	Monash University	08/03/2017

F10. Are you utilising the one-year eligibility extension due to COVID-19?

(Researchers who were in their final year of eligibility for DE22 and chose not to apply in that round can utilise the automatic one-year extension to apply in this round (DE23).)
This is a Yes/No question – select Yes or No

No

F11. Eligibility - Has the DECRA candidate been granted an extension by the Administering Organisation, to the eligibility period due to a significant career interruption as outlined in the grant guidelines?

(If the DECRA candidate's qualification relevant to this application (listed in Question F9) was awarded prior to 1 March 2017 and they have had a significant career interruption (as listed in the grant guidelines), the DECRA candidate will need to seek an extension to the eligibility period through their Deputy Vice-Chancellor (Research).)

No

F12. Eligibility - Select the category of career interruption claimed (more than one may be selected)

(Choose all types of career interruptions which have been claimed in the application for extension to the DECRA candidate's qualification as certified by the Deputy Vice-Chancellor (Research) or equivalent.
Select a type of interruption and click 'Add'.)

F13. Eligibility - What is the total period of extension that the DECRA candidate has claimed?

(Select the period of time which most closely equals the total period of extension claimed.)

F14. Eligibility - Current Research Fellowship or Award funded by other Australian Government agencies

(Do not list Fellowships and Awards granted by the ARC. Only list Fellowships and Awards from other agencies.)
Does the DECRA candidate hold a current Research Fellowship or Award funded by other Australian Government agencies?

No

F15. Eligibility - Project Relinquishment or Application Withdrawal

(ARC grant guidelines specify the limits on the number of applications and projects per DECRA candidate. This question will be activated where a DECRA candidate will exceed ARC project limits at the grant opportunity closing date, if this application is successful. While the application can be submitted, project limits must be met under the grant guidelines before the project can start. Project limits can be met by relinquishing existing active project(s), or relinquishing role(s) on existing active projects, or withdrawing application(s) that would exceed the project limits. This does not need to occur until all applications are announced.)

F16. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years

(To update any details in this table, click on the 'Manage Employment Details' link in this question. Note this will open in a new browser tab. 'Refresh' the application page when returning to the form to capture changes made to the DECRA candidate's profile.)

Description	Department	Contract Type	Employment Type	Start Date	End Date	Organisation
Research Fellow	Faculty of Architecture, Building and Planning	Contract	Full Time	14/11/2016	31/12/2022	The University of Melbourne
Research Fellow	School of Earth Atmosphere and Environment	Contract	Part Time	01/04/2019	31/12/2020	Monash University
Research Fellow	School of Earth Atmosphere and Environment	Contract	Part Time	14/06/2017	31/12/2018	Monash University
Research Assistant	School of Earth, Atmosphere and Environment	Contract	Part Time	01/06/2012	01/10/2016	Monash University

Doctoral Researcher	School of Earth, Atmosphere and Environment	Contract	Full Time	01/04/2012	01/08/2016	Monash University
Practical session teaching/lecturing	School of Earth, Atmosphere and Environment	Contract	Part Time	01/08/2013	01/11/2015	Monash University
Research Assistant	School of Mathematical Science	Contract	Part Time	01/04/2012	01/04/2013	Monash University
Environmental Science Assistant	School of Geography & Environmental Science	Contract	Part Time	01/08/2011	27/04/2012	Monash University

F17. Research Opportunity and Performance Evidence (ROPE) - Career Interruptions

(You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section.)

Has the DECRA candidate experienced a significant interruption that has impacted on research opportunity?

No

F18. Research Opportunity and Performance Evidence (ROPE) - Details of the DECRA candidate's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application

(Provide details of the DECRA candidate's circumstances and opportunities. This should not include information presented in the following questions (upload a PDF of up to 5 A4 pages).)

Uploaded PDF file follows on next page.

F18-ROPE-Details of the participant's academic career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application

Amount of Time as an Active Researcher

I was awarded my PhD on urban micro-climate modelling from the School of Earth, Atmosphere and Environment at Monash University in March 2017. I have been an active researcher (at 1.0 FTE) for 4 years and 10 months post-PhD without interruption.

Research Opportunities

- Academic career

Following a 13 year industry career as a senior and consulting level software engineer (most significantly 8 years at LexisNexis/Reed Elsevier), I returned to university. This previous career has proven highly transferable to my academic research career. It gave me a high level of expertise in software development and design and proficiency in many computer languages (including C++, Python, FORTRAN, and especially Java). I also gained years of experience in project development and management, guiding multi-year projects, developed by globally distributed teams, and delivered to multiple business units around the global. This experience has been directly transferable to managing large research programs, working with remote collaborators, and supervising students.

My post graduate academic career started at the School of Earth, Atmosphere & Environment at Monash University. My master's final semester research project was an observational and modelling study examining the micro-climate of mixed urban and parkland environments which led to engagement by the CRC for Water Sensitive Cities to write a report recommending (but not finding an existing) micro-climate model suitable for thermal comfort impact assessments of water sensitive urban design (especially urban vegetation and water features). My PhD at Monash University followed from this, designing and building this (missing) model. The models VTUF-3D and TARGET and publications (F20, ten best #1 and 6) resulted from this PhD research and subsequent collaborations with other researchers at Monash. I also designed and built the user interface for the Monash Simple Climate Model (MSCM) with A/Prof. Dietmar Dommenget (F20, refereed articles #6). This web-based interface (F20, additional research outputs #14) is a teaching tool that allows students to interactively study the interactions of physical processes in the global climate system through the results of more than a 1000 different model experiments of the Globally Resolved Energy Balance (GREB) model.

My post-doctoral career, at times, has been split (50/50) between two research fellow positions (funded separately) but that encompass research areas that both use modelling and computational techniques to examine urban areas for health impacts. One of these position was a 2 year 0.5 FTE research contract (subcontracted through the University of Melbourne) as a Research Fellow and urban climate modelling scientist with Monash University and the CRC for Water Sensitive Cities. My achievements in urban climate model development, even at an early research career stage, have led to recognition as an expert in vegetation and human thermal comfort modelling, leading to this external funding from the CRC for Water Sensitive Cities to further develop this work and consult with local and state government. This role was split between 40% research, 40% tool development, and 20% consulting.

The research portion was largely devoted to assessments of urban heat outcomes for different urban infill development scenarios. I designed and performed an urban heat analysis of a number of different green field development scenarios in Sunbury for the CRC, especially considering water sensitive (and climate sensitive) urban design. This resulted in a report for the CRC, "Estimating the economic benefits of Urban Heat Island mitigation Biophysical Aspects" (F20, additional research outputs #8). Additional modelling analysis of infill development typologies in a number of Australian cities resulted in three additional reports, the 'Infill Performance Evaluation Framework', the 'Knutsford Urban Heat Modelling Report', and the 'Salisbury case study final report: water sensitive outcomes for infill development'. Finally, I wrote the report 'Managing urban heat in water sensitive cities: research and policy responses' to summarise the heat mitigation research of the CRC over its eight year program. These reports are additional research outputs #1-5.

The tool development was devoted to continued development of my urban climate models VTUF-3D and TARGET and their integration with the CRC's scenario planning support tool. I also used this opportunity to improve the performance and usability of my climate models. This is important as some (although very few) models can quantify the human thermal benefits of urban green and blue space, especially accounting for cooling effects of vegetation and water evaporation, but often the complexity of configuring, running, and interpreting modelling means this knowledge is out of reach for most potential users.

The consulting included urban heat modelling for state and local government, often joint projects with consulting companies such as GHD. For example, projects resulted in contributions of urban heat assessments to the Urban Ecology Strategy for Fishermans Bend for the Victoria Department of Environment, Land, Water & Planning (DELWP) and serving on the science panel for the development of the Cool Suburbs Tool[1] for the Western Sydney Regional Organisation of Councils (WSROC). Additional projects include a microclimate assessment for the ACT government and assessments of future heat vulnerability for the Queensland DES/QFES.

- Current role

My current position is as a Research Fellow (100% research) with the Transport, Heath, and Urban Design (THUD) Research Lab in the Faculty of Architecture, Building, and Planning at the University of Melbourne. This involves research using innovative technologies (artificial intelligence, big data analysis, agent-based modelling, computer vision techniques as well as more traditional statistical methods) to examine multiple aspects of urban areas such as transport networks, urban features, and urban heat and impacts on public health. Building on my PhD research and the position with the CRC, this position incorporates a wide range of disciplines and applies the development and application of modelling to public heath problems. For example, modelling was applied to a wide range of applications, including modelling of the COVID-19 roadmap for Victoria, creating inventories of cycling infrastructure from remote sensing images, and assessing the impacts of global cities typologies on road injuries. In addition, my software development skills and computer vision technical knowledge has proven highly beneficial to undertaking research across multiple disciplines, leading to new innovations in quantifying health impacts of urban design and transportation infrastructure. This has led to my role as a key contributor to the research lab.

My initial task in THUD was to organise and write an ARC Linkage application, ‘A Multi-criteria Design Platform to Facilitate Active School Journeys’, quantifying thermal comfort, topography, street network connectivity, traffic risk, and pollution levels. I was not a named participant but the application was submitted in December 2017 (and resubmitted and funded in 2020). I co-developed the neural network clustering and analysis technique used in the lab’s recent Lancet Planetary Health publication. This allowed the identification of city types from map segments from the 1700 largest global cities at higher risk of road trauma. This method was expanded in a more recent publication (with myself as first author) in Urban Science to also include street view imagery and satellite imagery to derive urban typologies. Also, in conjunction with other lab collaborators, I developed a method to identify neighbourhood typologies (‘block typologies’) using self organising maps to cluster metrics extracted from map segments. All three of these projects were used as the base methodology for our lab’s current $1.3 million NHMRC/UKRI research project. My contribution to the lab is also represented in many of the 11 journal publications I co-authored with the lab in the last 4 years.

My expertise in urban heat modelling and computer vision techniques have led to me being sought out to participate as a chief investigator on a $422,000 ARC Discovery (fully detailed below) to create cycling risk exposure models from satellite and street view imagery and from Strava data and traffic cameras. I am also a co-investigator on an awarded 453,764 CHF Swiss National Science Foundation grant ‘Heat-Down: Integrated modelling of stormwater and urban heat for cooling cities’ headed by Dr. João P. Leitão (Eawag) and Dr. Peter M. Bach (ETH Zurich) based on my TARGET model. I have also built on an ongoing collaboration with the UNSW City Futures Research Centre with a recently submitted application for the AURIN High Impact Projects 2021, ‘Climate Resilient and Just Cities: Data for Research and Practice’ led by Dr. Negin Nazarian.

At the University of Melbourne, Prof. Mark Stevenson (professor of Urban Transport and Public Health and NHMRC Research Fellow) supervises my other position and along with other members of the lab (especially Dr. Jason Thompson, the senior research fellow in the lab) provides valuable mentoring. Through my academic career, I have been fortunate to receive excellent mentoring and career guidance. My PhD was supervised by Emeritus Prof. Nigel Tapper (Monash University; current president of The International Association for Urban Climate) and Dr. Andrew Coutts (Monash University; a leading urban climate researcher). Prof. Tapper remains a frequent collaborator and co-supervisor of honours and PhD students.

Research Achievements and Contributions

- How my research has led to advances in knowledge in the field. How will my achievements contribute to the application:

As an early-career researcher, I have quickly built a large body of work. These research achievements include a number of urban climate models able to examine urban heat mitigation strategies at local and micro-scales and make predictions of human thermal stress. These models have been adopted by other researchers and consultants. My knowledge about modelling and model development has led to being included in research projects and grant applications to further develop these models and contribute to the development of other models. In addition, methods that I have developed using computer vision techniques to cluster similar types of urban areas and examine the links of the design to public health outcomes and have formed the basis of successful grant applications and research papers. These

[1] https://wsroc.com.au/projects/project-turn-down-the-heat

techniques and the results from them (especially those around urban heat) are currently being utilised by state and local governments to formulate appropriate public health measures.

After my industry career and PhD candidacy, I have focused on building and improving my track record as a researcher. Despite having completed my PhD by thesis and as a result my research has only started to be published in 2018, when comparing with other researchers in urban climate modelling and model development at similar stages of their careers, my publication output compares favourably (Figure 1). When comparing citation counts, my record shows a rapidly rising trajectory in the last four years (in Google Scholar, 13 in 2019, 60 in 2020, 99 in 2021, and 7 from the first few weeks of 2022), but it should also be considered that citations take a number of years to accumulate.

The first stage of my academic career has been in urban climate modelling, the topic of my PhD. The model I developed in my PhD, VTUF-3D continues to be one of the few models able to assess the cooling impacts of urban vegetation at a micro-scale, and has led to further collaborations and model development as well as a large engagement. My PhD thesis, from which the journal article was developed, has had over 2,000 reads. Three additional climate models, TARGET, UT&C, and MSCM-DB, have been co-developed through collaborations. In a collaboration (F20, top 10 #8), have explored the state of the art in modelling (including my VTUF-3D model) outdoor mean radiant temperatures, a key parameter for predicting heat stress, and found circumstances where VTUF-3D and ENVI-met successfully model this parameter and where they encounter challenges.

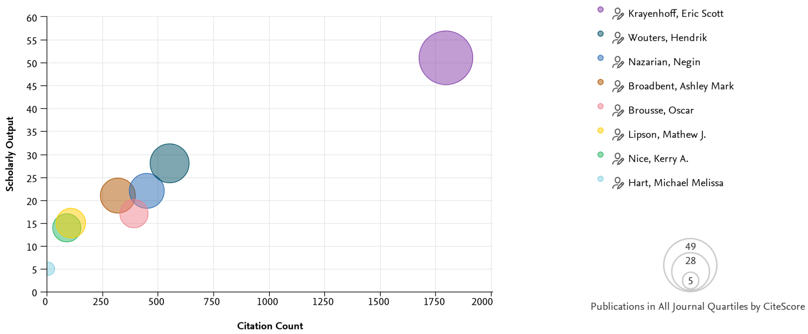

Figure 1: Benchmarking of my publication output in top 10% journals (by CiteScore percentile) compared to well-regarded researchers in urban climate modelling and model development at similar stages of their careers. Y-axis: All types of publications included. Bubble size: CiteScore percentile (from 2011 onward) (Source: Elsevier SciVal).

My recent paper in Sustainable Cities and Society, 'Estimating the cooling potential of irrigating green spaces' is directly related to this DECRA application. In addition, my research in urban heat has also included wider multidisciplinary applications of (and a framework around) water usage and urban design on both urban heat and other issues of urban liveability that were presented at the State of Australian Cities conference (#2 below). I have utilised computer vision techniques in support of urban climate modelling. This led to a method to more accurately detect sky pixels (a preliminary step in calculating sky view factors) using a range of urban imagery types (F20, top 10 #4). I presented methods to utilise urban morphology databases (such as WUDAPT) in conjunction with micro-climate modelling to target heat mitigation strategies and the beginning steps to discover and define micro-climate zones at the European Geosciences Union conference EGU2020 (#3 below). This has been expanded to an (in-progress) collaboration with researchers at UNSW to isolate the impacts of urban form and fabric from geography on heat mitigation strategies.

While my expertise in urban climate and urban climate modelling have the most direct link to the successful delivery of this project, much of my recent research has involved the use of artificial intelligence and machine learning. These techniques can be applied to urban climate questions as well. The $30,000 2020 Melbourne Energy Institute grant resulted in a study (currently in review with Atmospheric Pollution Research) using XGBoost to quantify the effects of human activity (reduced during COVID-19) on key pollutants (NO_2, $PM_{2.5}$, PM_{10}, and O_3) across 700 global cities. Other research has included using neural networks to cluster the largest 1700 global cities using millions of maps and examine the impact of urban design types on road trauma, as well as adding additional imagery types (satellite and street view) to the maps to construct urban typologies based on features discovered in the imagery. I've used other types of artificial intelligence, generative adversarial networks, to transform street level and satellite imagery from areas with poor health outcomes into new imagery, providing insights into the urban factors leading to these poor outcomes. Finally, I have used deep autoencoder extracted features from satellite imagery of all the intersections in Australia to identify safe intersection design.

In addition, my record of publication in high impact journals have also given me an understanding of complex review processes and required engagement in international-level debates. The Computer-Aided Civil and Infrastructure Engineering publication required satisfying 10 reviewers. The Lancet Planetary Health publication, with a multi-year review process and an excess of 10 reviewers, proved even more challenging. Numerous editorials are published in public health about the need to develop and utilise new techniques and multi-disciplinary approaches, but actually submitting this work requires overcoming large amounts of resistance to moving beyond what has always been done.

I have presented my research at 8 international conferences and 7 national conferences with 3 of those as invited talks. My research has also been featured in 5 collaborative presentations at 5 international conferences (1 as an invited talk).

The following conference presentations and conference papers are most strongly related to this DECRA application (i.e. climate model development, human thermal comfort modelling, and the collection of urban morphology information through databases and extraction from urban imagery).

1. Gál, C. V and **Nice, K. A.** Mean radiant temperature modeling outdoors: A comparison of three approaches, in *100th Annual Meeting of the American Meteorological Society (AMS) jointly with the 15th Symposium on the Urban Environment*, 2020.
2. Todorovic, Tatjana, London, Geoffrey, Bertram, Nigel, Sainsbury, Oscar, Renouf, Marguerite A, **Nice, Kerry A** and Kenway, Steven J. 2019. Models for water sensitive middle suburban infill development, in *9th State of Australian Cities National Conference, 30 November - 5 December 2019, Perth, Western Australia*. doi: 10.25916/5efa774bda643.
3. **Nice, K. A.**, Targeted urban heat mitigation strategies using urban morphology databases and micro-climate modelling to examine the urban heat profile. *EGU General Assembly 2020*.

Further other research outputs support my expertise in urban climates, urban typology clustering and urban analytics.

4. **Nice, K. A.**, Climate science context around urban cooling. In: *4th Water Sensitive Cities Conference 2019, Brisbane*. **Invited talk.**
5. **Nice, K. A.**, Urban Greening for improved human thermal comfort. In: *202020 Vision, The Green Light Tour, 2018, Adelaide*. **Invited talk.**
6. **Nice, K. A.**, Designing liveable cities through heat mitigation: tools to translate knowledge into design. In: *3rd Water Sensitive Cities Conference, 2017, Perth.* **Invited talk.**
7. **Nice, K.A.**, The Nature of Human Settlement: Building an understanding of high performance city design. In: *UrbanSys2019/2019 Conference on Complex Systems, Singapore.*

I have developed a strong collaborative network (within my universities, Australia, and internationally), and developed a strong research direction based on modelling and quantifying urban systems. This rapid upward trajectory has been strongly enabled by a previous long career in industry and software engineering that required the ability to develop and organise large projects, solve problems, and build the tools necessary to deliver results. This combination of extensive experience in computing techniques with deep urban climate and urban climate modelling development knowledge demonstrate that I am the ideal researcher to undertake and deliver this project.

- Invited keynote and speaker addresses:

I have presented my research at 8 international and 7 (3 invited, #4, #5, and #6 above) national conferences since 2012. Three of these have been at the International Conference on Urban Climate (ICUC), the leading conference for urban climate. Two of these ICUC talks were about my VTUF-3D model and one was about using computer vision techniques and Google Street View to discover urban morphology parameters (namely sky view factors). Two recent international conference presentations have been on the topic of deriving urban typologies through big data urban imagery datasets and machine learning and computer vision. I have given three invited presentations on the topics of urban heat and designing heat mitigation strategies at the 3rd and 4th Water Sensitive Cities Conferences in Perth and Brisbane and in the 202020 Vision Green Light Tour in Adelaide (202020 Vision is now Greener Spaces Better Places). I have also been invited to present five guest lectures at Monash University and the University of Melbourne on the topic of urban climate modelling and the urban heat benefits of water sensitive urban design.

- Research income:

I have secured AUD $1,207,910, GBP £479,387, and 453,764 CHF in research income through competitive grants over the last five years. This demonstrates my capacity to secure funding across a wide range of research areas in collaboration with other Australian and international researchers and delivering publications and reports from these projects.

- In 2016 I was awarded the $10,000 Graham Treloar Early Career Researcher Fellowship (The University of Melbourne Faculty of Architecture, Building and Planning) for the development of the project ‘Urban canyon mean radiant temperatures predictions through mining Google Street View imagery and neural network machine learning’. The outcome from this project was published in career-best publication #4.

- I am a Co-Investigator on the AUD $608,910 (and GBP £479,387) 2020-2023 UKRI/NHMRC grant 1194959, ‘A Vision of Healthy Urban Design for NCD Prevention’. The methodology for this grant utilises neural networks and computer vision techniques to process large amounts of urban imagery to assess the impacts of urban design on non-communicable disease (NCD). This is a collaborative project between researchers at the University of Melbourne and Queen’s University Belfast.

- I secured a $137,000 research contract with the CRC for Water Sensitive Cities as a specialist cohort in urban heat modelling. This contract was solicited by the CRC to provide urban heat expertise to the final two years of the CRC research program and provides two years of 0.5 FTE funding over 2019-2020. This funding has provided opportunities both to advance my model development work and work in collaboration with industry partners and local and state governments to develop urban heat mitigation strategies (as detailed in the benefits section below).

- I am a Chief Investigator on a $30,000 2020 Melbourne Energy Institute grant on 'The effects of COVID-19 on reduced transport and emissions for global city typologies'.

- I am a Chief Investigator on the $402,000 2021-2023 ARC Discovery DP210102089 'Sustainable mobility: city-wide exposure modelling to advance bicycling' grant headed by Dr Ben Beck (Monash University). This grant utilises my expertise in computer vision and machine learning to extract an inventory of cycling infrastructure from satellite and street view imagery. These inventories will be used to develop a platform for city-wide modelling of cycling exposure that can be applied globally.

- I am a Partner Investigator on a 453,764 CHF 2021 Swiss National Science Foundation Project ID 200021_201029, 'Heat-Down: Integrated modelling of stormwater and urban heat for cooling cities'. My urban climate model, TARGET, will be upgraded and utilised to investigate heat mitigation strategies enabled by the use of stormwater.

- Research supervision, mentoring and advice:

Student supervision of topics closely related to this project has provided experience in micro-climate observations of cooling through BGI features. I am currently co-supervising two PhD students in conjunction with Prof. Nigel Tapper (Monash) and A/Prof. Stephen Livesley (Melbourne). The student at Monash University/Southeast University is observing and modelling the cooling potential of irrigation of the runway buffer areas at Adelaide Airport. Another student at the University of Melbourne is looking at the cooling potential and energy balances of misting systems and irrigation of turf grass and trees. I am supervising one Honours student at Monash in conjunction with Prof. Nigel Tapper and Prof. Julie Arblaster, who will be modifying VTUF-3D to include the ability to model impervious surfaces watering based on an observation campaign.

I have also supervised the final capstone research projects for 11 Masters of IT (MIT) students at the University of Melbourne. Methods from 3 of these MIT projects were incorporated into the Urban Climate paper, listed above. In addition, methods from one other MIT project is currently being incorporated into a health/computer vision collaboration with researchers from Cambridge University. Finally, I have been invited to participate in 3 PhD review panels for the urban climate discipline.

- Benefits outside academia:

My expertise in urban heat modelling has been utilised in a number of government consultations and planning reports in 2019-2021. I am currently consulting with the Department of Agriculture, Water and the Environment (DAWES) for the project 'Health cost impacts of urban heat amelioration through integrated water cycle management (IWCM) measures', a consortium through Marsden Jacob with a modelling team led by Prof. Nigel Tapper (Monash) with Dr. Andrew Coutts, and Dr. Matthias Demuzere (RUB) and a health team led by Prof. Peng Bi (University of Adelaide). Past projects include serving on the science advisory panel for Western Sydney Regional Organisation of Councils (WSROC) Cool Suburbs Rating and Accreditation tool, providing modelling and urban heat analysis for the Queensland Department of Environment and Science (DES), reports for urban heat impacts of infill development for South Australia (Salisbury, an Adelaide suburb) and Western Australia (the Perth suburb of Kutsford), urban heat assessments for the Fishermans Bend Urban Ecology Strategy for the Victorian government, and project work for the ACT government's micro-climate urban heat strategies.

- Other professional activities:

I maintain memberships in the European Geosciences Union (EGU), The Australian Meteorological and Oceanographic Society (AMOS), The International Association for Urban Climate (ICUC), and the Complex Systems Society (CSS).

Article Referee Activities: In the past 5 years, I have performed 45 peer reviews for 17 leading climate and urban design journals, including Urban Climate, Theoretical and Applied Climatology, Sustainable Cities and Society, Environmental Science & Technology, Environment and Planning B, Scientific Reports, Science of the Total Environment, Landscape and Urban Planning and am on the review board for Atmosphere.

F19. Research Opportunity and Performance Evidence (ROPE) - Research Outputs Context

(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the DECRA candidate's discipline/s. The information should help assessors understand the context of the DECRA candidate's research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in their field; specific indicators of recognition within their field such as first authorship/citations, or significance of non-traditional research outputs.
If preprints or comparable resources are cited, these should be explicitly identified in the reference list by including [PREPRINT OR COMPARABLE] after the reference. The reference should include a DOI, URL or equivalent, version number where available and/or date of access, as applicable (up to 3,750 characters, approximately 500 words).)

I currently have published 15 journal articles (3 as first author and 3 as second author) and 3 refereed full-length conference papers. In the four years that I have been publishing (since 2018), I have already accumulated 192 citations in Google Scholar and a h-index of 7. My citations are increasing rapidly, with 99 of them occurring in 2021. The article on my VTUF-3D model is my most cited work. I have 7 reports written for the CRC for Water Sensitive Cities and 1 book chapter. My publication output compares favourably (as shown in F18) to a selection of other highly respected urban climate researchers at similar or later career stages.

My research crosses a number of different disciplines, urban climates, climate modelling, artificial intelligence, computer vision, urban analytics, urban design, and public health. For all the fields I have published in, authorship conventions are similar, ordered by contribution level, with the first author leading the effort, the second and third authors generally also making large contributions, and the final author supervising. Sole authorship is rare because of the collaborations and inter-disciplinary research required in these areas.

There are a wide variety of climate journals but Urban Climate (SJR Q1 1.151) is the central journal for urban climate. Geoscientific Model Development (SJR Q1 3.238) is a leading journal modelling and simulation, especially geophysical modelling development. Author lists can include 5-10 authors as model development is an incremental process and next generation models generally build on the work of previous models.

The computer vision and artificial intelligence fields publish predominately in conference proceedings, but applied research is more often published in domain specific journals. My other research outside of urban climates generally crosses multiple disciplines and is published in interdisciplinary orientated journals. Lancet Planetary Health (SJR Q1 4.205) is a highly ranked interdisciplinary journal covering global health issues. Sustainable Cities and Society (SJR Q1 1.65) focuses on multi-disciplinary research into designing resilient cities. Q1 journal Environment and Planning B focuses on state of the art analytical methods for urban planning and design. Computer-Aided Civil and Infrastructure Engineering (Q1 SJR 2.77) focuses on the the use of computer science in aid of engineering.

Many papers have attracted attention. Five received an Altmetric Attention Score of 10 or higher. Seven are over 5. The Lancet Planetary Health paper has a score of 165, the streetscape augmentation paper has reached 20, and the Urban Science paper 17.

Conferences in my various disciplines are either a combination of abstract submission and presentation or abstract submission, presentation, and then a fully peer-reviewed article in the proceedings. I have participated in both types. A peer-reviewed article resulted from three, the American Meteorological Society, the State of Australian Cities, and Digital Image Computing conferences.

Other research outputs from my career are made up of modelling code (the four models I have developed or co-developed) distributed through online public repositories. DOI numbers can be assigned to attract citations when the code is used by others, but in practice the code is rarely given recognition on its own and are only cited in other's academic work via the publications describing their development. Usage or adoption by consultants or other non-academic users will generally receive no public recognition.

F20. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including 10 Career-Best Research Outputs

(Provide a list of research outputs marking those that are most relevant to this application categorised under the following headings: 10 career-best research outputs; Authored books; Edited books; Book chapters; Refereed Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs and preprints or comparable resources). CVs and theses should not be included in this list. The

DECRA candidate's 10 career-best research outputs should not be repeated under subsequent headings. (Up to 100 research outputs))

Research Outputs Listing

Generated research output document follows on the next page

Ten Career-Best Research Outputs

[1] * Kerry A. Nice, Andrew M. Coutts & Nigel J. Tapper 2018, 'Development of the VTUF-3D v1.0 urban micro-climate model to support assessment of urban vegetation influences on human thermal comfort', *Urban Climate*, vol. 24, pp. 1052–1076, doi:10.1016/j.uclim.2017.12.008 (Refereed Journal Article)

[2] Jason Thompson, Mark Stevenson, Jasper S Wijnands, Kerry A Nice, Gideon DPA Aschwanden, Jeremy Silver, Mark Nieuwenhuijsen, Peter Rayner, Robyn Schofield, Rohit Hariharan & Christopher N Morrison 2020, 'A global analysis of urban design types and road transport injury: an image processing study', *The Lancet Planetary Health*, vol. 4, no. 1, pp. e32–e42, doi:10.1016/s2542-5196(19)30263-3 (Refereed Journal Article)

[3] * Nice, Kerry A, Thompson, Jason, Wijnands, Jasper S, Aschwanden, Gideon D P A & Stevenson, Mark 2020, 'The "Paris-end" of Town? Deriving Urban Typologies Using Three Imagery Types', *Urban Science*, vol. 4, pp. 27, doi:10.3390/urbansci4020027 (Refereed Journal Article)

[4] * Kerry A. Nice, Jasper S. Wijnands, Ariane Middel, Jingcheng Wang, Yiming Qiu, Nan Zhao, Jason Thompson, Gideon D.P.A. Aschwanden, Haifeng Zhao & Mark Stevenson 2020, 'Sky pixel detection in outdoor imagery using an adaptive algorithm and machine learning', *Urban Climate*, vol. 31, pp. 100572, doi:10.1016/j.uclim.2019.100572 (Refereed Journal Article)

[5] * Wijnands, Jasper S., Zhao, Haifeng, Nice, Kerry A., Thompson, Jason, Scully, Katherine, Guo, Jingqiu, Stevenson, Mark 2020, 'Identifying safe intersection design through unsupervised feature extraction from satellite imagery', *Computer-Aided Civil and Infrastructure Engineering* (Refereed Journal Article)

[6] * Ashley M. Broadbent, Andrew M. Coutts, Kerry A. Nice, Matthias Demuzere, E. Scott Krayenhoff, Nigel J. Tapper & Hendrik Wouters 2019, 'The Air-temperature Response to Green/blue-infrastructure Evaluation Tool (TARGET v1.0): an efficient and user-friendly model of city cooling', *Geoscientific Model Development*, vol. 12, no. 2, pp. 785–803, doi:10.5194/gmd-12-785-2019 (Refereed Journal Article)

[7] * Jasper S. Wijnands, Kerry A. Nice, Jason Thompson, Haifeng Zhao & Mark Stevenson 2019, 'Streetscape augmentation using generative adversarial networks: Insights related to health and wellbeing', *Sustainable Cities and Society*, vol. 49, pp. 101602, doi:10.1016/j.scs.2019.101602 (Refereed Journal Article)

[8] * Gál, Csilla V & Nice, Kerry A. 2020, 'Mean radiant temperature modeling outdoors: A comparison of three approaches', *100th Annual Meeting of the American Meteorological Society (AMS) jointly with the 15th Symposium on the Urban Environment* (Fully Refereed Conference Proceeding)

[9] * Naika Meili, Gabriele Manoli, Paolo Burlando, Elie Bou-Zeid, Winston T. L. Chow, Andrew M. Coutts, Edoardo Daly, Kerry A. Nice, Matthias Roth, Nigel J. Tapper, Erik Velasco, Enrique R. Vivoni & Simone Fatichi 2020, 'An urban ecohydrological model to quantify the effect of vegetation on urban climate and hydrology (UT&C v1.0)', *Geoscientific Model Development*, vol. 13, no. 1, pp. 335–362, doi:10.5194/gmd-13-335-2020 (Refereed Journal Article)

[10] * Pui Kwan Cheung, Stephen J. Livesley & Kerry A. Nice 2021, 'Estimating the cooling potential of irrigating green spaces in 100 global cities with arid, temperate or continental climates', vol. 71, pp. 102974, doi:10.1016/j.scs.2021.102974 (Refereed Journal Article)

Book Chapters

[1] Haifeng Zhao, Jasper S. Wijnands, Kerry A. Nice, Jason Thompson, Gideon D. P. A. Aschwanden, Mark Stevenson & Jingqiu Guo 2019, 'Unsupervised Deep Learning to Explore Streetscape Factors Associated with Urban Cyclist Safety', *Smart Innovation, Systems and Technologies*, Springer Singapore, pp. 155–164, doi:10.1007/978-981-13-8683-1_16

Refereed Journal Articles

[1] Thompson, Jason, McClure, Rod, Blakely, Tony, Wilson, Nick, Baker, Michael G., Sa, Thiago Herick De, Nice, Kerry, Wijnands, Jasper, Aschwanden, Gideon, Cruz, Camilo & Stevenson, Mark 2022, 'Modelling SARS-CoV-2 disease progression in Australia and New Zealand: an account of an agent-based approach to support public health decision-making', *Australian and New Zealand Journal of Public Health*

[2] Mark Stevenson, Jason Thompson, Jasper S. Wijnands, Kerry Nice, Gideon Aschwanden & Haifeng Zhao 2019, 'Opportunities to reduce road traffic injury: new insights from the study of urban areas', *International Journal of Injury Control and Safety Promotion*, pp. 1–7, doi:10.1080/17457300.2019.1704790

[3] Gideon DPA Aschwanden, Jasper S Wijnands, Jason Thompson, Kerry A Nice, Haifeng Zhao & Mark Stevenson 2019, 'Learning to walk: Modeling transportation mode choice distribution through neural networks', *Environment and Planning B: Urban Analytics and City Science*, pp. 239980831986257, doi:10.1177/2399808319862571

[4] Jasper S. Wijnands, Jason Thompson, Kerry A. Nice, Gideon D. P. A. Aschwanden & Mark Stevenson 2019, 'Real-time monitoring of driver drowsiness on mobile platforms using 3D neural networks', *Neural Computing and Applications*, doi:10.1007/s00521-019-04506-0

[5] Haifeng Zhao, Jasper Wijnands, Kerry Nice, Jason Thompson, Gideon Aschwanden, Jingqiu Guo & Mark Stevenson 2019, 'Reducing Cyclist Crashes by Assessing the Road Environment: An Application of Google Imagery and Machine Learning', *Journal of Transport & Health*, vol. 14, pp. 100698, doi:10.1016/j.jth.2019.100698

[6] * Dietmar Dommenget, Kerry Nice, Tobias Bayr, Dieter Kasang, Christian Stassen & Michael Rezny 2019, 'The Monash Simple Climate Model experiments (MSCM-DB v1.0): an interactive database of mean climate, climate change, and scenario simulations', *Geoscientific Model Development*, vol. 12, no. 6, pp. 2155–2179, doi:10.5194/gmd-12-2155-2019

Fully Refereed Conference Proceedings

[1] * Todorovic, Tatjana, London, Geoffrey, Bertram, Nigel, Sainsbury, Oscar, Renouf, Marguerite A, Nice, Kerry A & Kenway, Steven J. 2019, 'Models for water sensitive middle suburban infill development', *9th State of Australian Cities National Conference, 30 November - 5 December 2019, Perth, Western Australia*, doi:10.25916/5efa774bda643

[2] * Nice, K.A. & Isaac, P. 2012, 'The micro-climate of a mixed urban parkland environment', *WSUD 2012 - 7th International Conference on Water Sensitive Urban Design: Building the Water Sensitive Community, Final Program and Abstract Book*

[3] * Seneviratne, Sachith, Nice, Kerry A., Wijnands, Jasper, Thompson, Jason & Stevenson, Mark 29 N, 'Self-supervision, Remote Sensing and Abstraction: Representation Learning across 3 million locations', *Digital Image Computing: Techniques and Applications 2021*

Additional Research Outputs

[1] * Nice, Kerry 2021, 'Managing urban heat in water sensitive cities: research and policy responses'

[2] * Zhu, Y, Nice, K & Eadie, M 2020, 'Knutsford Urban Heat Modelling Report', Water Sensitive Cities Institute, Melbourne, Australia

[3] * Renouf, M. A., Kenway, S. J., Bertram, N., London, G., Sainsbury, O., Todorovic, T., Nice, K.A., Surendran, S. & Moravej, M. 2020, 'Water Sensitive Outcomes for Infill Development: Salisbury Case Study Performance Analysis Report'

[4] * Renouf, MA, Kenway, SJ, Bertram, N, London, G, Todorovic, T, Sainsbury, O, Nice, K, Moravej, M & Sochacka, B 2020, 'Water Sensitive Outcomes for Infill Development: Infill Performance Evaluation Framework. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities'

[5] * Renouf, Marguerite A., Kenway, Steven J., Bertram, Nigel, London, Geoffrey, Sainsbury, Oscar, Todorovic, Tatjana, Nice, Kerry A., Surendran, Shenbagameenal (Meena) & Moravej, Mojtaba 2020, 'Salisbury case study final report: water sensitive outcomes for infill development', pp. 1–73

[6] * Kerry Nice & Ashley Broadbent 2020, 'Targeted urban heat mitigation strategies using urban morphology databases and micro-climate modelling to examine the urban heat profile', doi:10.5194/egusphere-egu2020-12795

[7] * Nice, Kerry & Wijnands, Jasper 2019, 'Dataset for: Sky pixel detection in outdoor imagery using an adaptive algorithm and machine learning.', doi:https://doi.org/10.5281/zenodo.2562396

[8] * Tapper, Nigel, Lloyd, Sara, Mcarthur, Jane, Nice, Kerry & Jacobs, Stephanie 2019, 'Estimating the economic benefits of Urban Heat Island mitigation – Biophysical Aspects'

[9] * Broadbent, Ashley, Coutts, Andrew, Nice, Kerry, Demuzere, Matthias, Krayenhoff, E. Scott, Tapper, Nigel & Woulters, Hendrik 2018, 'Target-Java v1.0 source code', doi:https://doi.org/10.5281/zenodo.1310138

[10] * Kerry Nice 2018, 'Development, validation, and demonstration of the VTUF-3D v1.0 urban micro-climate model to support assessments of urban vegetation influences on human thermal comfort', doi:10.31237/osf.io/d769f

[11] * Nice, Kerry 2017, 'mothlight/VTUF-3D: VTUF-3D initial release source code', doi:10.5281/zenodo.260064

[12] * Coutts, Andrew, Demuzere, Matthias, Tapper, Nigel, Daly, Edoardo, Beringer, Jason, Nury, Sultana, Broadbent, Ashley, Harris, Richard, Gebert, Luke & Nice, Kerry A. 2014, 'Impacts of harvesting solutions and water sensitive urban design on evapotranspiration: Green cities and microclimate'

[13] * Nice, K 2012, 'Urban climate model selection for modelling WSUD features. ', Cities as Water Supply Catchments, Project 3: Green Cities and Micro-climate.

[14] * Dommenget, Dietmar, Blöhdorn, Janine, Bayr, Tobias, Rezny, Michael, Nice, Kerry, Stassen, Christian, Schweitzer, Martin, Vitt, Tobias, Diezel, Jan Markus, Luthardt, Hans & Kasang, Dieter, 'Monash Simple Climate Model', doi:https://monash.edu/research/simple-climate-model/mscm/

[15] Ben Beck, Christopher Pettit, Meghan Winters, Trisalyn Nelson, Hai Vu, Kerry Nice, Sachith Seneviratne & Meead Saberi 2021, 'Association between network characteristics and bicycle ridership across a large metropolitan region', doi:10.31219/osf.io/39ke6 [PREPRINT OR COMPARABLE]

[16] Ben Beck, Meghan Winters, Trisalyn Nelson, Christopher Pettit, Meead Saberi, Jason Thompson, Sachith Seneviratne, Kerry A Nice, Simone Zarpelon-Leao & Mark Stevenson 2021, 'Developing urban biking typologies: quantifying the complex interactions of bicycle ridership, bicycle network and built environment characteristics', doi:10.31235/osf.io/8w7bg [PREPRINT OR COMPARABLE]

[17] Nice, Kerry A., Aschwanden, Gideon D.P.A., Wijnands, Jasper S., Thompson, Jason, Zhao, Haifeng & Stevenson, Mark 2019, 'The Nature of Human Settlement: Building an understanding of high performance city design.', arXiv [PREPRINT OR COMPARABLE]

[18] Thompson, Jason, McClure, Roderick, Blakely, Tony, Wilson, Nick, Baker, Michael, de Sa, Thaigo Herick, Nice, Kerry, Wijnands, Jasper S., Aschwanden, Gideon, Cruz-Gambardella, Camilo & Stevenson, Mark 2020, 'The estimated likelihood of eliminating the SARS-CoV-2 pandemic in Australia and New Zealand under current public health policy settings: an agent-based-SEIR modelling approach.', SSRN [PREPRINT OR COMPARABLE]

Certification

Certification by the Deputy/Pro Vice-Chancellor (Research) or their delegate or equivalent in the Administering Organisation

I certify that—

- I have read, understood and complied with the *Grant Guidelines for the Discovery Program (2021 edition)*, (grant guidelines) and, to the best of my knowledge all details provided in this application form and in any supporting documentation are true and complete in accordance with the grant guidelines.
- Proper enquiries have been made and I am satisfied that the Discovery Early Career Researcher Award (DECRA) candidate listed in this application meets the requirements specified in the grant guidelines, including having been awarded a PhD on or after 1 March 2017. Where the DECRA candidate has allowable career interruptions, sufficient evidence has been provided to the Administering Organisation and based on this evidence, I certify that the candidate has an award of PhD date together with an allowable period of career interruption (as listed in the grant guidelines) that would be commensurate with an award of PhD date on or after 1 March 2017.
- Where the DECRA candidate holds a research higher degree, that is not a PhD, sufficient evidence has been provided to the Administering Organisation and based on this evidence, I certify that the candidate's qualification meets the level 10 criteria of the *Australian Qualifications Framework Second Edition*.
- I certify that where a DECRA candidate has more than one PhD, the earliest PhD has been selected and meets the eligibility requirements, including having been awarded a PhD on or after 1 March 2017.
- Upon request from the ARC, this organisation will provide evidence to support a career interruption justification in relation to the PhD award date.
- The ARC reserves the right to audit any evidence on which an application is based.
- I will notify the ARC if there are changes to the DECRA candidate after the submission of this application.
- The listed participants are responsible for the authorship and intellectual content of this application, and has appropriately cited sources and acknowledged significant contributions to this application.
- To the best of my knowledge, all personal material interests and Conflicts of Interest relating to parties involved in or associated with this application have been disclosed to the Administering Organisation, and, if the application is successful, I agree to manage all Conflicts of Interest relating to this application in accordance with the *Australian Code for the Responsible Conduct of Research* (2018), the *ARC Conflict of Interest and Confidentiality Policy* located on the ARC website and any relevant successor documents.
- I have obtained the agreement, attested to by written evidence, of all the relevant persons and organisations necessary to allow the project to proceed. This written evidence has been retained and will be provided to the ARC if requested.
- I have obtained the certification of all organisations contributing to the project (CEO or their delegate) that they support the project, will contribute the resources outlined in the application, have complied with the grant guidelines and will abide by the relevant Commonwealth grant agreement, including the requirement to enter arrangements for intellectual property.
- The application, including all parties involved in or associated with this application, has undergone due diligence to assess risks from foreign interference in line with the *Guidelines to Counter Foreign Interference in the Australian University Sector (2019)* developed by the University Foreign Interference Taskforce.
- This application complies with the eligible research requirements set out in the *ARC Medical Research Policy*, located on the ARC website.
- This application does not request funding for the same research activities, infrastructure or project previously funded or currently being funded through any other Commonwealth funding.
- If this application is successful, I am prepared to have the project carried out as set out in this application and agree to abide by the terms and conditions of the grant guidelines and the relevant Commonwealth grant agreement.
- The project can be accommodated within the general facilities of this organisation and if applicable, within the facilities of other relevant organisations specified in this application and sufficient working and office space is available for any proposed additional staff.

- All funds for this project will only be spent for the purpose for which they are provided.
- The project will not be permitted to commence until there is an ethics plan in place to ensure that the appropriate clearances or other statutory requirements will be met before the part/s of the project that require those clearances commence.
- I consent, on behalf of all the parties, to this application being referred to third parties, including to overseas parties, who will remain anonymous, for assessment purposes.
- I consent, on behalf of all the parties, to this application being provided to third parties for the purposes of assessment for potential other funding opportunities.
- I consent, on behalf of all the parties, to the ARC copying, modifying and otherwise dealing with information contained in this application for the purpose of conducting the funding round.
- To the best of my knowledge, the Privacy Notice appearing at the top of this form has been drawn to the attention of the DECRA candidate whose personal details have been provided in the Participant section of the application.