AUSTRALIAN RESEARCH COUNCIL
Discovery Early Career Researcher Award
Application for Funding Commencing in 2022

DE

Project ID: DE220100095

First Investigator: Dr Kerry Nice

Admin Org: The University of Melbourne

Total number of sheets contained in this Application: 48

Part A - Administrative Summary (DE220100095)

A1. Application Title

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

Maximising cooling through urban planning using 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	Monash University, The University of Melbourne

A3. Organisation Participant Summary

(Add the Administering Organisation 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))

This project aims to protect urban areas from extreme heat, the most dangerous Australian natural hazard, through the cooling benefits of blue-green infrastructure (vegetation and water features). This is significant because despite the evidence that the use of these features can be an effective method of urban cooling, it has long been too difficult for urban planners to assess and maximise the benefits of their inclusions in urban designs. This project will work with industry stakeholders and ensure they have the tools needed to design urban heat mitigation and adaptation strategies using these features. The benefits will be more heat resilient urban areas and identification of areas of high vulnerability requiring immediate attention.

A5. List the objectives of the proposed project

(List each objective separately by clicking 'Add answer' to add the next objective. This information will be used for future reporting purposes if this application is funded, including reporting on these objectives in the final report. Objectives are pre-populated into the final report template. (Up to 500 characters, approximately 70 words per objective))

Objective

To consult with key stakeholders, especially water companies, and co-design this research project, mapping out the tools and results that will be of highest value to enable their design processes to maximise the human thermal comfort benefits of using blue-green infrastructure in urban areas.

Objective

To collect observations needed to understand the underlying processes driving the cooling benefits of a wide range of blue-green infrastructure features.

Objective

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

Objective

To integrate all the results from this project into a city-scale modelling platform to be used by urban planners to design and test urban heat mitigation strategies based on blue-green infrastructure.

Part B - Classifications and Other Statistical Information (DE220100095)

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

Yes

Science and Research Priority	Practical Research Challenge
Environmental change	Resilient urban, rural and regional infrastructure.

B2. Field of Research (FoR)

(Select up to three classification codes that relate to the DECRA candidate's application. Note that the percentages must total 100.)

Code	Percentage
120507 - Urban Analysis and Development	75
080110 - Simulation and Modelling	25

B3. Socio-Economic Objective (SEO-08)

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

Code	Percentage
970105 - Expanding Knowledge in the Environmental Sciences	50
920407 - Health Protection and/or Disaster Response	25
960301 - Climate Change Adaptation Measures	25

B4. Interdisciplinary Research

(This is a 'Yes' or 'No' question. If you select 'Yes' two additional questions will be enabled:
1. Specify the ways in which the research is interdisciplinary by selecting one or more of the options below.
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' two additional questions will be enabled:
1. Specify the nature of the proposed international collaboration by selecting one or more of the options below.
2. Specify the countries which are involved in the international collaboration.)

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
Face to face meetings

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 PhD, 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

2

Number of Research Student Places (FTE) - Honours

0

Part C - Project Eligibility (DE220100095)

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 the 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

If yes, provide the Funded Project ID(s)

Briefly explain how funding this project would not duplicate Australian Government funding or overlap with existing projects. (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 you answer 'Yes' provide the application ID(s) and briefly explain why more than one application 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 and, should all applications be successful, how they will be managed to avoid duplication of Australian Government funding. (Up to 2000 Characters, approximately 285 words)

Part D - Project Description (DE220100095)

D1. 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:
Maximising cooling through urban planning using blue-green infrastructure

PROJECT AIMS AND BACKGROUND

Extreme heat events cause more deaths in Australia than any other natural hazard[11], with risk disproportionately borne by the elderly and the very young[51]. Future climate projections warn of more frequent, severe, and long-lasting heatwaves[27] and exposure to dangerous levels of heat stress increasing by a factor of 5-10 by 2080[12]. Risks are further multiplied by the design of cities[14, 35] that result in increased heat loads in urban areas. Urban energy balances have been altered in several ways[53]. Anthropogenic heat from buildings and transport and reduced shading through diminishing tree canopy cover result in larger amounts of net energy at street level. Meanwhile, the conversion of vegetated to impervious surfaces and reductions of available water in cities shift the urban energy balance away from latent heat (water evaporation) towards increased sensible heat (heat that can be felt) and heat storage in urban surfaces.

Strategies, especially those that utilise blue-green infrastructure (BGI)[52, 2, 24, 45] such as increased vegetation cover, water features, and water practices (rain gardens, misting systems, or pavement watering), are available to mitigate heat. These strategies are ideally considered during the planning of future development, before these decisions are hardened into the built form for decades to come. Benefits can also be realised by an analysis of existing areas to find problem areas and incorporating BGI through remedial redesign. Both cases are best addressed using modelling tools, but as will be detailed below, these tools are currently insufficient for this task. **This leads to two project aims. The first is to improve existing models so that they are suitable to model a full range of BGI features and their human thermal comfort benefits. The second is to integrate these models into an accessible platform to simplify the analysis and use of modelled results. This project will provide high value tools to a wide range of users including urban planners and policy makers, enabling them to analyse and redesign urban areas to maximise the cooling benefits of BGI, something that has long been out of their reach.**

Performing human thermal comfort modelling of urban areas has many challenges. To capture all the influences of urban geometry and materials on human thermal comfort, especially the influences on mean radiant temperature[30] (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) and should account for the influence of vegetation and water features. However, while there are many urban models, there are few modelling options available at an appropriate scale and especially models that account for all the elements of vegetation impacts and urban hydrology or that can explicitly calculate parameters needed to calculate human thermal comfort. Some of the available urban models include ENVI-met[6], VTUF-3D[48], SOLWEIG/UMEP[34], PALM[16], canyon air temperature (CAT)[20], and OTC3D[44]. Other models offer lower resolution local-scaled (grid resolution greater than 1km) modelling (TARGET[3] and SURFEX[37]) or of a single point averaged across an entire (often idealised) urban canyon (TEB[36], TEB-Veg and TEB-Tree[33, 56], RayMan[39]/SkyHelios[38], and Urban Tethys-Chloris (UT&C)[40]). 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 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

Model	Scale	Spatial	Intensity	Veg.	Temp.	Geometry	Fluxes	Wind	Hydrology
ENVI-met[6]	M	M	H	F	A,S,M,U	C	All	C	W,C,m,M,G,E,P
SOLWEIG[34]	M	M	M	S	M	C	K,L	N	N
PALM[16]	M	M	H	F	A,S,M,U	C	All	C	W,C,m,E,P
OTC3D[44]	M	M	M	N	M,U	C	N,H,E,K,G	E	N
SURFEX[37]	L	M	M	I	A,U	I	All	R	W,C,m,E,P
TEB[36, 33, 56]	L	S	M	I	A,S	I	All	R	W,C,m,E,P
RayMan[39]	M	S	L	S	M	C	K,L	N	N
SkyHelios[38]	M	Se	L	S	M	C	K,L	N	N
UT&C[40]	L	S	M	F	A,S	I	All	R	W,C,m,E,P
SUEWS[28]	L	S	L	I	A,S,So	I	All	N	W,C,m,E,P
BEP-Tree[31]	L	S	M	I	A	I	All	N	N
CAT[20]	M	S	L	N	A	I	All	N	N
VTUF-3D[48]	M	M	M	F	A,S,M,U	C	N,H,E,K,L,G	R	S,m,E
TARGET[3]	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.

modelling techniques to model the entire soil / plant / atmosphere continuum are scarce[55], 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[29, 64, 4]. There are very few observation-based irrigation studies that focus on urban areas[5]. Some agricultural observation-based studies of irrigation[7] 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 quite specialised datasets, ensuring that modelling tools accurately reproduce the underlying mechanisms of cooling using BGI becomes challenging.

A more fundamental problem also presents a barrier to incorporating BGI into urban design. The complexities of operating climate models, analysing the outputs, and assembling the data needed to set them up often proves a challenge. The data challenges include both bringing together suitable local weather data as well as detailed urban morphology parameters. The severity of urban heat stress levels are highly influenced by the types and amounts of different surface types, the layout and orientation of streets, buildings, and vegetation, and sky view factors (determining the net amounts of solar energy available in urban canyons not intercepted by buildings or vegetation). If this information exists, it is likely to be incomplete, non-standardised, and scattered throughout government organisations and different jurisdictions. Developing methods to build these datasets through street view imagery (available from Google as well as other providers) can help fill these gaps. Additional techniques might also be used to create efficiencies in modelling to reduce the computational intensities and make modelling more accessible by clustering urban areas based on their properties (including building and vegetation heights, street widths, street orientation, and fractions of concrete, grass, and other surfaces) and that show similar urban heat thermal performance responses. Because of many of these challenges, consultants working for designers and planners have rarely been able to utilise climate knowledge in urban planning[19] and the complexities of urban climate have complicated the communication of results[54]. **This is the major problem that this project aims to address through a focused collection of observations of BGI features that will be used to upgrade modelling tools and then wrap these tools into a platform that can be easily used by**

planners to utilise BGI as an effective urban cooling strategy.

INVESTIGATOR/CAPABILITY

During my PhD, I developed the Vegetated Temperature of Urban Facets in 3-D (VTUF-3D)[48] 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 The Air-temperature Response to Greenblue-infrastructure Evaluation Tool (TARGET)[3] (with Asst Research Prof. Ashley Broadbent and others), Urban Tethys-Chloris (UT&C)[40] (with Meili Naika and others), and the Monash Simple Climate Model[17] (MSCM) (with A/Prof. Dietmar Dommenget). I have used SOLWEIG / UMEP[34] 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[43]) around the world.

I have published my model development work[48, 3, 40, 17] in Q1 journals, Geoscientific Model Development (SJR Q1 3.18) and Urban Climate (SJR Q1 1.042). These publications demonstrate my range of expertise in designing 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 and the use of urban morphology databases (such as WUDAPT) in urban heat modelling are represented in conference presentations[21, 47] as well as a fully-refereed conference paper[62].

To address the challenge of filling gaps in datasets of urban morphology information, I developed a method through a collaboration with Ariane Middel at Arizona State University and supervised research projects by Masters 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[50] in the Urban Climate journal. My research has evolved beyond urban climates to provide expertise in these additional areas, incorporating other types of urban modelling, 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[61, 63] (SJR Q1 4.205 and SJR Q1 1.356) as well as [49]. This expertise will directly contribute to this project in creating more efficient urban models through identification of urban areas with similar morphology properties and clustering them based on similar urban heat thermal performance responses.

Before returning to university to complete a Masters degree and PhD, I had a 13 year career as a senior level software engineer, working predominately with C++ and Java (the Java 2 Enterprise Edition). The experience I 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. These skills will be important in the development of a platform to bring together the complexity of urban climate heat modelling into urban planning.

Over the last few years, I have quickly developed a sizeable network of Australian and international collaborators. Through my urban climate network, 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, as a developer of two models, in Urban Plumber (multi-site model evaluation project, the next iteration of the Grimmond et al.[23] intercomparison project) led by Mat Lipson (UNSW), Sue Grimmond (Reading) and Martin Best (UK Met Office). 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 2021 International Conference on Urban Climate (ICUC-11) in Sydney, Australia with 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) and Dr. Rahul Goel from Cambridge University. I am a co-investigator in a NHMRC/UKRI awarded grant partnership with Queens University Belfast. I have recently submitted a grant application (modelling urban heat mitigation through stormwater infrastructure) to the Swiss National Science Foundation with João P. Leitão and Peter M. Bach from Eawag (the Swiss Federal Institute of Aquatic Science and

Technology). 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.

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 have developed working relationships with many local and state governments as well as industry partners, in particular, water companies. Currently, I have two PhD students 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[58] 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. A second trial through South Australia Water has been examining the cooling benefits of irrigation at the Adelaide Airport[15, 26]. 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.

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

Existing tools to assess human thermal comfort benefits of BGI are inaccessible to urban planners which means that cities have been and will continue to be developed without this knowledge; urban heat health impacts will be locked in for decades to come. This inaccessibility 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.

In addition, this type of modelling also requires large amounts of data to configure modelling domains. In order to simulate typical present-day average weather conditions, extreme heat days, future typical and/or extreme weather conditions under different climate change projections, or even real-time (next three days) weather forecasts requires data from a large variety of weather sources to drive the models. These include historic observations from the network of the Australian Bureau of Meteorology (BOM) weather stations[1] and global and regional observation reanalysis datasets such as ERA5[25]. Finally, the thermal stress impacts under long term climate change projections can be examined through the use of future weather output from the Coupled Model Intercomparison Project (CMIP5)[60] to interpolate present weather data into future scenarios. This will allow the intensification of future heat exposure to be examined but can also account for shifts in regional weather patterns.

To be accessible to non-expert users, these models cannot require high levels of expertise to set up and run and should be efficient enough to not demand high computing resources. Micro-climate modelling can be computationally expensive. Models such as ENVI-met or PALM can require days to weeks of processing time to complete a simulation of a small area such as a city block (i.e. 500x500m), where other models such as VTUF-3D require 25-50 times less processing time (30-60 minutes for a similar simulation). But even at this level of efficiency, testing many scenarios across a wider local council or city scale will require a large computing investment.

Given this level of computational intensity, finding efficiencies in the modelling processes are essential to allow wider and more accessible usage of these tools. As local climate zones [59] (LCZ) (a standardised method to describe different urban/rural areas and their mix of building form and surface types in categories such as compact high-rise, open low-rise, sparsely built, etc.) have emerged to provide urban parameters to regional scaled models, this project proposes to extend the LCZ concept and create a new system based on micro climate zones (MCZ)[47]. While LCZs are defined based on clustering common land development patterns, MCZs will be performance based and defined by the thermal response of different urban areas and their mix of urban properties forming distinct clusters. The result of this is to decrease computational requirements by only needing to model representative MCZ areas (at a micro-scale) across a wider area instead of having to model the entire area. In addition, if the simulation is using forcing data with spatial variations (i.e. BOM ACCESS forecasts), these variations can be included in the clustering to ensure they are adequately represented.

A third challenge complicating the accessibility of urban heat modelling is the difficulty in assembling the urban morphology information (including building and vegetation heights and footprints and surface types and properties) needed to model scenarios. An international effort to provide a database of urban parameters, the World Urban Database and Access Portal Tools (WUDAPT)[9], has begun to assemble coarse datasets, initially starting with the generation of LCZs[59] for a number of world cities, and is following a pathway to provide higher resolution data[8]. Some commercial providers supply high resolution GIS layers of building footprints, land cover, and vegetation heights (such as the Geoscape dataset from PSMA in Australia). Many cities (such as Melbourne[10]) have detailed inventories of street trees and building footprints. In Australia, many of these datasets are available on the Australian Urban Research Infrastructure Network (AURIN)[57]. Additionally, information about urban form can be extracted from imagery of cities such as Google Street View or satellite imagery[41, 42, 50] to augment these datasets.

Urban planners have access to a wide range of tools to assess their designs across many factors, 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. The overall goal of this project will be to provide the tools embedded into an accessible platform to overcome these challenges and make this knowledge available to the people who need this information to best plan present and future urban design. This platform will need to be usable by those who are not modelling experts, but only require moderate technical skills and many design questions they want answered.

This project will be delivered through five work packages. These work packages include a **co-design** process with industry partners, micro-climate **observations** of BGI, bringing together **data** and processing methods needed for urban climate modelling, upgrading **models** to make suitable for HTC assessments of BGI, and wrapping all of this work into a **platform** to allow widespread adoption of these tools. The overall structure of these work packages and analysis platform is shown in Figure 1.

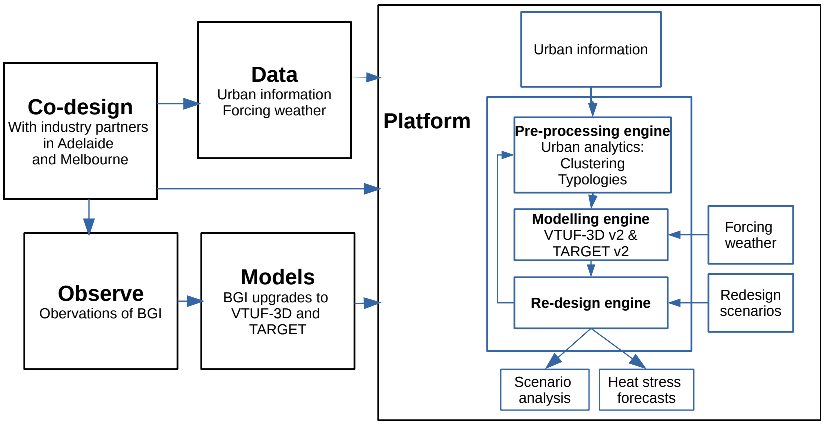

Figure 1: Project work packages and steps leading to urban human thermal comfort analysis platform.

Work Package 1: **Co-design** - *Consult with key stakeholders, especially water companies, to map out the tools and results that will be of highest value to them.*

The first phase of this project will involve a co-design process 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 from the overall research program. Workshops in Adelaide during the first year will be combined with fieldwork travel. 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 conducted to plan and then integrate the platform and tools into their processes.

Work Package 2: **Observe** - *Collect observations to supply missing datasets needed to parametrise and validate the modelling of the impacts on human thermal comfort of a wide range of BGI types and water usage practices.*

Two sets of observations have been or are currently being made to enable model development of BGI features. The first set 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. A second trial has been conducted within the Adelaide Airport, irrigating a 3.5 hectare site and monitoring the micro-climate over a multi-year period. A second set of observations will be captured in 2020-2021, as part of a project from a PhD student I am currently supervising, 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, detailed observations of energy balances, air temperatures and humidity will be observed within a misting system. While both of these datasets are good starting points for some of the following model development and validation, additional data will need to be captured to ensure the full range of BGI can be modelled.

Aquarevo will also 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 sources. 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. Further experiments will capture these same observations for patches of turf (5x5m) with daily irrigation (4mm/day) in early morning, or noon, or continuous, or no irrigation (only rainfall). Other patches will test no irrigation, 4mm/day, 8mm/day, and 12/mm day. 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 neighbourhood scaled observations.

Work Package 3: **Data** - *Process flow for and integration of urban and weather data sources*

Urban data: This work package will assemble a suite of different urban data types, exported from AURIN or WUDAPT, or a process pipeline to convert various types of GIS layers into modelling domain information. These datasets will also be extracted from diverse datasets including Open Street Map, Google Street Map and also from street view and satellite imagery using computer vision and semantic segmentation techniques. Methodology will be devised to combine various sources of urban morphology data from a wide range of providers, including WUDAPT, city inventories, AURIN, and commercial providers into modelling domain input.

For modelling efficiency, a modelling pre-processing step will be devised to define micro-climate zones (MCZ) of representative areas to reduce the amount of areas of a larger modelling domain that need to be individually modelled at a micro-scale. The urban form data can be used as is during the modelling, or can also undergo additional analysis and optimisation. Some parameters necessary for calculating human thermal comfort such as mean radiant temperature can only be properly resolved at a micro-scale, but micro-scaled modelling is computationally expensive. Pre-processing the urban information to find clusters of similar urban typologies can reduce the modelling needed to distinct representative areas for best efficiency.

Weather data: The second task is to assemble a suite of forcing weather types, including past BOM observations, ERA5 present observations, BOM ACCESS forecasts, and CIMP5 future climate change projections, and link them into the modelling engine

Work Package 4: **Models** - *Urban climate modelling tools will be upgraded and shown suitable to model human thermal comfort impacts of BGI and urban water usage.*

Improved data interfaces: The first task is to generate a generic interface to the models to allow a variety of forcing data types (past, present, and future scenarios, including past BOM observations, ERA5 climate reanalysis, BOM ACCESS forecasts, and CIMP5 future climate change projections) to be used and run each within the modelling engine. In the case of TARGET, this will be to adapt the model to be driven with spatial varying weather (compared to having a single weather source driving the entire modelled area). In the case of VTUF-3D, this will be to have instances of VTUF-3D running in parallel in the modelling engine, each with their own weather source. A similar task will be to generate a generic interface to the models to allow the urban design parameters from many different data types to set up the models within the modelling engine.

The other half of the 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[18] which is a soil-plant-atmosphere model that has been previously coupled by myself with the TUF-3D model[32] to create the VTUF-3D[48] 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 (i.e. turf) 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)[40]

(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[18] or total/partial replacement with modules from UT&C[40].

Work Package 5: **Platform**

This work package brings together all the work packages into a single ready to use platform. It consists of a number of modules (engines) to complete different parts of the process flow. The first engine is the pre-processing engine to enable integration of micro- and local-climate modelling into city-scale analysis. It brings together the data sources from Work Package 3 and prepares them for submission to the (second) modelling engine. The modelling engine handles the logistics of running the models and storing the results.

The third engine, the analysis/redesign engine allows analysis on two levels. The first is to provide analysis of the results and methods to compare the results from different scenarios. The second is to enable redesigned scenarios to be iteratively built and recalculated. This will allow setting scenario parameters, design limitations, and ranked priorities to guide redesign efforts. There will be options to manually redesign areas and test the results. These interventions might include increasing the street tree canopy cover, modify irrigation rates, or conversion of driveways and other hard surfaces to permeable pavement. Redesigned areas 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 allow adding in layers of urban typologies characteristics and demographics to look at the impacts of the heat modelling results on population health.

The final task in this work package is to develop a site that can be used to demonstrate the platform. This will involve packaging the tools and platform into a bundle (such as Docker or Flatpak) so that it can easily be deployed across generic cloud computing servers.

BENEFIT

The improvements to the models and the analysis platform built around them in this project will deliver benefits on two levels. Their increased sophistication will enable increasingly detailed research to be performed by academic researchers in city science and urban climate. In addition, the platform built around these tools will bring these sophisticated tools to practitioners who need to make immediate decisions about the future design of cities. 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. 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 was 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 benefits will be achieved over a number of stages. The first benefit is the improved urban climate models. That will happen after the first year and those 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 after integrating the tools into the platform following the second year. This will enable working on case studies with industry collaborators. For example, 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. Finally, after the final delivery of the project, the entire platform 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 investigator capability 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.[13] 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.

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. This project will design a platform that can be used for demonstration purposes, initially configured for Melbourne and other Australian cities, a ‘living laboratory’, but is also a platform that is transferable to other cities, regions, and countries beyond the end of the project. The funding for these expenses have been requested in the budget for the final year. As I have a high professional and academic interest in the ongoing and continual improvements in the modelling tools I have created, they and the platform they will integrated into 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. Funding has been requested in the budget for urban data costs. Licensing the PSMA Geoscape data will provide the baseline data needed to analyse all the Australian cities in their present form while the Google Street View data will allow the analysis to be expanded to many other locations.

Although the platform will be designed to be user-friendly, some industry engagement, especially with the water companies, through consultation and workshops to work through the documentation process, training, and integration into their design processes in the final year. Travel to Adelaide is included in the budget for this while the rest of the project will be Melbourne based.

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.

Master’s students recruited by the university are generally 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[50]. 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 data analysis and publication preparation.

The overall project plan and timeline are shown in Figure 2

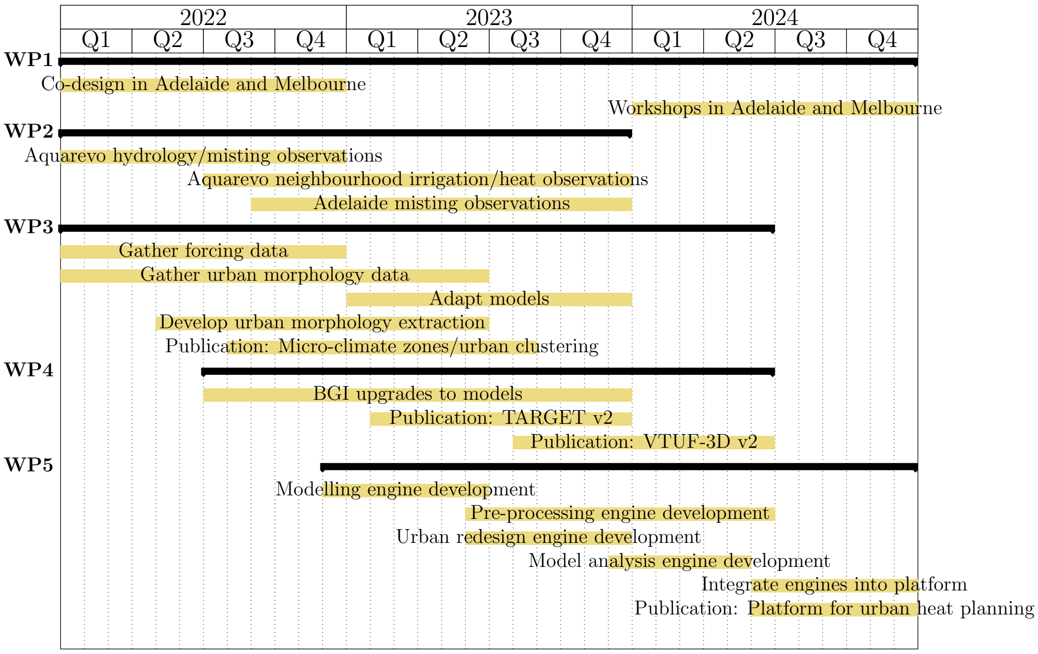

Figure 2: Project timeline.

COMMUNICATION OF RESULTS

There are four 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). 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 Development journal. Another publication will describe the extension of the local climate zone concept into micro-climate zones and how the clustering of those enables and increases the efficiency of doing micro-climate modelling of large areas. It will also describe how to use these distinct types of urban design to identify which types deliver the best thermal performance under extreme heat conditions and what mitigation strategies work best to reduce the risk in vulnerable areas. A further publication will introduce the urban human thermal comfort platform to the urban planning community and perform case studies demonstrating its utility in testing development designs and mitigation strategies. This 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 test and utilise the platform for some of their current projects. Training documentation and case study results will also be delivered through reports targeted to each of these organisations.

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[46] and the Sydney Morning Herald[22]. The platform itself will be demonstrated on an open website as part of this project to allow some testing and experimentation by end users and integrated with industry partners through the project end workshops. The platform will be an open-source bundle will allow other interested users to deploy the platform on their own servers.

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D2. Statement by the Administering Organisation

(Provide a Statement that addresses the relevant criteria as set out in the grant guidelines. The Statement must be signed by the Deputy Vice-Chancellor (Research) or equivalent. (Upload a PDF of up to three A4 pages))

Uploaded PDF file follows on next page.

Professor James McCluskey AO
Deputy Vice-Chancellor (Research)

THE UNIVERSITY OF MELBOURNE

16 November 2020

Professor Sue Thomas
Chief Executive Officer
Australian Research Council

Dear Professor Thomas,

Re: DE220100095, Dr Kerry Nice, *Maximising cooling through urban planning using blue-green infrastructure*

The University of Melbourne strongly supports Dr Kerry Nice's DECRA award application, 'Maximising cooling through urban planning using 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. During his PhD, he designed and developed the Vegetated Temperature of Urban Facets in 3-D model (VTUF-3D), the first urban climate 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. This led to co-development of two additional climate models to enable research into urban heat mitigation utilising BGI features. The impact of this work has been significant, and a number of these models have since been adopted for urban heat modelling by consulting groups including Alluvium, Edge Environment, and E2DESIGNLAB as well as the CRC for Water Sensitive Cities.

Dr Nice's research into urban climate modelling has led to publications in top Q1 academic journals including Geoscientific Model Development (SJR 3.18, the leading journal for geophysical modelling development) and Urban Climate (SJR 1.04, a central journal for the urban climate discipline). In addition, his research into the applications of machine learning methods to examine the health impacts of urban design has been published in journals including The Lancet Planetary Health (SJR 4.21), Computer-Aided Civil and Infrastructure Engineering (SJR 1.87), and Sustainable Cities and Society (SJR 1.36, covering resilient city design). Highlighting his rapid trajectory, in the last 3 years only, he has published 13 peer-reviewed articles (3 as 1st author and 3 as 2nd). In the last 8 years, he presented at 8 international conferences and 7 national conferences, three by invitation. He was also invited by Cambridge University to present his research methodologies at a computer vision and health workshop, leading to ongoing collaborations with top Cambridge University public health researchers. 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 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 and demonstrates his capacity to undertake the proposed research program, requiring expertise across many domains.

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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 two of The University of Melbourne’s three strategic ‘Grand challenges’: ‘fostering of population health and wellbeing’, and ‘supporting sustainability and resilience’. The project is also related to research priorities in University of Melbourne's Advancing Melbourne strategy to bring together "different disciplines and partners together to ensure multiple ways of understanding complex questions" and 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. 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 was 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, the THUD lab at the University of Melbourne will be the best fit for this research project that spans health and urban design and offers Dr Nice an ideal environment to build research collaborations with other senior researchers on the impacts of future city design. The lab 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.

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 Jasper Wijnands, 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. Mark Stevenson provides extensive mentoring and career advice. In addition, Prof. Nigel Tapper (Monash University; current president of The International Association for Urban Climate), his former PhD supervisor, remains a frequent collaborator and mentor.

Dr Nice will be supported by the University and Faculty through exposure to this high-quality research environment and access to state-of-the-art GPU high-performance computing infrastructure essential for this project. The University also provides opportunities for dissemination of Dr Nice’s work through its on-line ‘Pursuit’ magazine and coverage on the lab’s website, and 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. Salary top-up of $142,212 at Level B2-B4 for the period of the award is also offered. Over-all, this amounts to a total of $192,212 over the period of the award. This is in

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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 observations of the cooling benefits of irrigation collected in the project will enable significant improvements to his climate models and will be a valuable resource to other researchers on how to best utilise BGI features for urban heat mitigation. The increased sophistication of these models will enable detailed research to be performed by academic researchers in city science and urban climate. In addition, the platform built around these tools will bring these sophisticated tools to practitioners who need to make immediate decisions about the future design of cities. The analysis tools can also be used to scan urban areas for hotspots, areas of high vulnerability requiring urgent 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 innovative projects and is indicative of the significant potential of his research. Up to this point, his research has attracted $785,910 in funding, primarily from sources external to the University, including the UKRI/NHMRC and a research contract with the CRC for Water Sensitive Cities. The DECRA will further enhance his competitiveness for future national and international competitive scientific grants including ARC Discovery and NHMRC Ideas schemes he has recently applied for. During his employment, the University will continue to provide all support to Dr Nice as the full potential of his research program is realised. 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 (DE220100095)

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: $448,863

Year 1

Description	ARC	Admin Org
	Cash	Cash
Total	152,788	83,837
Personnel	112,671	42,047
Dr Kerry Nice (Discovery Early Career Researcher Award)	106,194	42,047
Research Asst Grade 2, 100 hours @ $64.77/hr	6,477	
Travel	3,171	4,250
International conference, year 1	3,171	4,250
Field Research	2,115	
Adelaide Fieldwork, year 1	2,115	
Equipment	31,831	26,540
2x CNR4-L10m net radiometer for energy balance observations of misting systems at Aquarevo and Adelaide		26,540
50X LoRa sensor nodes for Aquarevo neighbourhood scale observations at Aquarevo	31,831	
Other	3,000	11,000
PSMA Geoscape urban data set		7,000
Open access publication fees		4,000
Google Street View imagery (through web portal)	2,000	
Web site hosting	1,000	

Year 2

Description	ARC	Admin Org
	Cash	Cash
Total	153,895	47,614
Personnel	119,148	47,404
Dr Kerry Nice (Discovery Early Career Researcher Award)	106,194	47,404
Research Asst Grade 2, 200 hours @ $64.77/hr	12,954	
Travel	14,632	210
International conference 1, year 2	7,211	210
International conference 2, year 2	7,421	
Field Research	2,115	
Adelaide Fieldwork year 2	2,115	

Other	18,000	
Open access publication fees	8,000	
Consultant (web software development)	7,000	
Google Street View imagery (through web portal)	2,000	
Web site hosting	1,000	

Year 3

Description	ARC	Admin Org
	Cash	Cash
Total	142,180	60,761
Personnel	119,148	52,761
Dr Kerry Nice (Discovery Early Career Researcher Award)	106,194	52,761
Research Asst Grade 2, 200 hours @ $64.77/hr	12,954	
Travel	9,032	
International conference 1, year 3	7,421	
Industry workshop Adelaide, Year 3	1,611	
Other	14,000	8,000
Open access publication fees		8,000
Consultant (web software development)	11,000	
Google Street View imagery (through web portal)	2,000	
Web site hosting	1,000	

E2. Justification of 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 above Budget Table of this application. (Upload a PDF of up to four A4 pages and within the required format))

Budget Justification

Uploaded PDF file follows on next page.

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

Year 1		
Item Requested	Cost	Justification
Personnel		
Research Asst Grade 2, 100 hours @ $65/hr	$6,477	For the creation of publication 1, research assistance is required for the collection of relevant academic literature and manuscript formatting according to journal guidelines. The RA will need to have a good understanding of modelling and climate. Additional tasks required are to begin collating forcing data and urban morphology information. For this reason, all research assistance requested for this project is at Grade 2. These tasks will require about 2 weeks of work part-time over 3-4 months.
Travel		
International conference, accommodation, 7 nights @ $250/night	$1,750	Presentation of findings of publication 1 at an international climate conference discussing the new version of the VTUF-3D model. 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 @ $203/day	$1,421	Per diem rates are requested at 70% of the standard 'Category 5' ATO rate for CI Nice to cover meals and incidentals.
Field Research		
Adelaide Fieldwork year 1, Flights to Adelaide	$350	Fieldwork will be performed in Adelaide at Adelaide Airport and in other locations in Adelaide in conjunction with South Australia Water to perform micro-climate observations of the impacts of irrigation and misting systems for Work Package 2. Travel will also be combined with the co-design workshop as part of Work Package 1. Airfare estimates are based on the University's Price Guide for domestic flights to Adelaide. CI Nice will be the sole traveller for this fieldwork and all that follows through the rest of the project.
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	$666	Per diem rates are requested at 70% of the standard ATO rate for domestic travel, covering CI Nice's meals and incidentals.
Equipment		
50X LoRa sensor nodes for Aquarevo neighbourhood observations	$31,831	LoRa sensor nodes with 1x humidity sensor, 2x soil moisture sensors, 2x soil temperature sensors, 1x ambient temperature sensor and 1x ambient light intensity sensor to observe neighbourhood scale cooling during Aquarevo fieldwork. This quantity of sensor nodes are required to provide adequate coverage across the Aquarevo neighbourhood to see the micro-climate impacts of irrigation. These nodes are hand assembled using relatively inexpensive components (from Digi-Key and Jaycar). At a material cost of $640 per node, they are extremely cost effective in comparison to equipment used in more traditional observation campaigns where the cost (thousands per node) have made this level of detailed observations previously impossible.
Maintenance		
Other		
Google Street View imagery (through web	$2,000	Google charges a fixed fee of USD 0.007 for each image downloaded using the Street View Static API. Downloading 40,000 locations (6 images

portal)		required for a 360 panorama) will allow sampling of Melbourne at a 400x400 meter resolution.
Web site hosting	$1,000	As the a key project output will be a web-based application, high quality commercial grade hosting is required. This is costed at $1000/yr for years 1, 2, and 3.

Year 2		
Item Requested	Cost	Justification
Personnel		
Research Asst Grade 2, 200 hours @ $65/hr	$12,954	For the creation of publication 2 and 3, research assistance is required for the collection of relevant academic literature and manuscript formatting according to journal guidelines. The RA will need to have a good understanding of modelling and climate and urban analytics. Additional tasks required are to continue collating forcing data and urban morphology information and to begin downloading Google Street View imagery. For this reason, all research assistance requested for this project is at Grade 2. These tasks will require about 4 weeks of work part-time over 6 months.
Travel		
International conference 1, return economy airfare	$2,500	Presentation of findings of publication 2 at an international climate conference discussing the new version of the TARGET model. 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 of publication 2 at an international climate conference discussing the new version of the TARGET model. 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 @ $203/day	$1,421	Per diem rates are requested at 70% of the standard ‘Category 5’ ATO rate for CI Nice to cover meals and incidentals.
International conference 1, registration fee	$1,540	Registration fee required to attend and present at year 2 'International conference 1', as detailed above. The full $1750 cost is split between the ARC and the Administering Organisation.
International conference 2, return economy airfare	$2,500	Presentation of findings of publication 3 at an international climate conference discussing the micro-climate zone and urban typology clustering. 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 @ $203/day	$1,421	Per diem rates are requested at 70% of the standard ‘Category 5’ ATO rate for CI Nice to cover meals and incidentals.
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	$666	Per diem rates are requested at 70% of the standard ATO rate for domestic travel, covering CI Nice's meals and incidentals.
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 from Work Package 2. Travel will also be combined with the co-design process and stakeholder engagement as part of Work Package 1. Airfare estimates are based on the University's Price Guide for domestic flights to Adelaide.
Equipment		
Maintenance		
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. As an example, Geoscientific Model Development fees are €93 per page, so the total fees for a 25 page article are approximately AUD $4000.
Google Street View imagery (through web portal)	$2,000	Google charges a fixed fee of USD 0.007 for each image downloaded using the Street View Static API. Downloading 40,000 locations (6 images required for a 360 panorama) will allow sampling of Sydney at a 400x400 meter resolution.
Consultant (web software development)	$7,000	A web software developer (costed at $100/hr) will be required to develop a user-friendly web interface to the analysis platform, a key output from Work Package 5. This work will begin in year 2 based on the requirements gathered during the co-design process and involve 70 hours of development work. This platform will allow stakeholders to conduct tests and gain an understanding of the system. It will allow other interested parties to discover, explore, and adopt the system beyond the end of the project.
Web site hosting	$1,000	As the a key project output will be a web-based application, high quality commercial grade hosting is required. This is costed at $1000/yr for years 1, 2, and 3.

Year 3		
Item Requested	Cost	Justification
Personnel		
Research Asst Grade 2, 200 hours @ $65/hr	$12,954	For the creation of publication 4, research assistance is required for the collection of relevant academic literature and manuscript formatting according to journal guidelines. The RA will need to have a good understanding of modelling and climate and urban analytics. Additional tasks required are to complete downloading Google Street View imagery and assist with the setup of the platform. For this reason, all research assistance requested for this project is at Grade 2. These tasks will require about 4 weeks of work part-time over 6 months.
Travel		

International conference 1, return economy airfare	$2,500	Presentation of findings of publication 4 at an international urban planning or geography conference detailing the benefits of the completed platform for urban heat analysis and incorporation into urban planning. 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 of publication 4 at an international urban planning or geography conference detailing the benefits of the completed platform for urban heat analysis and incorporation into urban planning. 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 @ $203/day	$2,030	Per diem rates are requested at 70% of 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.
Industry workshop-Adelaide, flights	$350	This workshop will be conducted with South Australia Water to bring the results of the fieldwork and bring the usage of the modelling platform into SA Water's urban cooling strategies. Airfare estimates are based on the University's Price Guide for domestic flights to Adelaide.
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	$476	Per diem rates are requested at 70% of the standard ATO rate for domestic travel, covering CI Nice's meals and incidentals.
Field Research		
Equipment		
Maintenance		
Other		
Google Street View imagery (through web portal)	$2,000	Google charges a fixed fee of USD 0.007 for each image downloaded using the Street View Static API. Downloading 40,000 locations (6 images required for a 360 panorama) will allow sampling of Perth and Adelaide at a 400x400 meter resolution.
Consultant (web software development)	$11,000	A web software developer (costed at $100/hr) will be required to complete the user-friendly web interface to the analysis platform. This will finish the work started in year 2 and complete the user interface to the underlying modelling and analysis tools and involve 110 hours of development work.
Web site hosting	$1,000	As the a key project output will be a web-based application, high quality commercial grade hosting is required. This is costed at $1000/yr for years 1, 2, and 3.

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 two A4 pages and within the required format))

Details of Non-ARC Contributions

Uploaded PDF file follows on next page.

E3 – Details of non-ARC contributions
Note: unless otherwise specified, funding is via a University of Melbourne $50,000 DECRA establishment grant.

Year 1		
Item Requested	Cost	Justification
Personnel		
Dr. Kerry Nice	$42,047	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.
Travel		
International conference, return economy airfare	$2,500	Presentation of findings of publication 1 at an international climate conference discussing the new version of the VTUF-3D model. 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. *This amount will be contributed via a Faculty staff conference travel support grant; it is additional to the $192,212 the University is contributing in salary support and establishment grants.
International conference, registration fee	$1,750	Registration fee required to attend and present at year 1 'International conference', as detailed above. *This amount will be contributed via a Faculty staff conference travel support grant; it is additional to the $192,212 the University is contributing in salary support and establishment grants.
Equipment		
2x CNR4-L10m net radiometer for energy balance observations of mising systems at Aquarevo and Adelaide	$26,540	Two (one each for control and experimental sites) net radiometers are required for energy balance observations of misting systems at Aquarevo and Adelaide. These are critical pieces of equipment to developing a full understanding of how the misting drives shifts in energy fluxes and the impact those have on how much, the duration, and extent of cooling that can be realised through misting systems.
Other		
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.
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. See E2 year 2 for example fees.

Year 2		
Item Requested	Cost	Justification
Personnel		
Dr. Kerry Nice	$47,404	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.
Travel		

International conference 1, registration fee	$210	Registration fee required to attend and present at year 2 'International conference 1', as detailed above. *This amount will be contributed via a Faculty staff conference travel support grant; it is additional to the $192,212 the University is contributing in salary support and establishment grants. The full $1750 cost is split between the ARC and the Administering Organisation.
Other		

Year 3		
Item Requested	Cost	Justification
Personnel		
Dr. Kerry Nice	$52,761	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.
Travel		
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. See E2 year 2 for example fees.

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 participant'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

Second Name

Alan

Family Name

Nice

F2. Current country of residence

(If the DECRA candidate is a Foreign National, 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 that participant for funding for the years 2021 to 2025 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)	**2021** $'000	**2022** $'000	**2023** $'000	**2024** $'000	**2025** $'000
Dr Kerry Nice, University of Melbourne, 'DECRA Establishment Grant', 2022.	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	202		
Dr Ben Beck, Prof Christopher Pettit, Dr Meead Saberi Kalaee, Prof Mark Stevenson, Dr Simone Zarpelon Leao, Dr Kerry Nice, Prof Tarek Sayed, Assoc	Yes	R	2002025		347	306	162	133

Prof Meghan Winters, Prof Trisalyn Nelson, 'Pathways to health: advancing bicycling as an active mode of transport', NHRMC 2020 Ideas Grants									

F7. 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.)

F8. 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.
)*

0.8

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. 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 2016 and they have had a significant career interruption (as listed in the grant guidelines), the participant will need to seek an extension to the eligibility period through their Deputy Vice-Chancellor (Research).)

No

F11. Eligibility - Select the category of career interruption claimed (more than one may be selected)

*(Choose all types of career interruptions which have been claimed and granted by the DECRA candidate's Deputy Vice-Chancellor (Research).
Select a type of interruption and click 'Add'.)*

F12. 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.)

F13. 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

F14. Eligibility - Project Relinquishment or Application Withdrawal

(ARC grant guidelines specify the limits on the number of applications and projects per named participant. This question will be activated where a DECRA candidate will exceed ARC project limits, if this application is successful.

In this case, 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.)

F15. 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	31/12/2021	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
PhD Thesis	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

F16. 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

F17. 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 career and opportunities. This should not include information presented in the following questions. (Upload a PDF of up to five A4 pages))

Uploaded PDF file follows on next page.

F17-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 3 years and 7 months post-PhD without interruption.

Research Opportunities

Academic career

Following a 13 year industry career as a senior 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 resources located around the world, and delivered to multiple business sites across the global company locations, experience directly transferable to managing large research programs, working with remote collaborators, and supervising students.

My academic career started at the School of Geography 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, leading to engagement by the CRC for Water Sensitive Cities to write a report recommending a suitable micro-climate model to model the thermal comfort impacts of water sensitive urban design (especially urban vegetation and water features). My PhD at Monash University then followed from this, designing and building such a model. VTUF-3D and later TARGET resulted from this PhD research and subsequent collaborations with other researchers at Monash. I also designed and built the user interface for the Monash University Simple Climate Model (MSCM) with A/Prof. Dietmar Dommenget. This web-based interface (F19, additional research outputs #13) 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.

Current roles

My post-doctoral career has been split (50/50) between two research fellow positions (funded separately) that encompass two research areas that use modelling and computational techniques to examine urban areas for health impacts. The first position is as a Research Fellow (research only and currently at 0.5 FTE) 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 and the contribution of urban design on public health.

My second position is 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, 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 is split between 20% consulting, 40% research, and 40% tool development. The research portion has largely been 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" (F19, additional research outputs #5). The tool development is 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, as 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. These skills are directly transferable to the expertise needed to deliver this DECRA project. The consulting has 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 for the Western Sydney Regional Organisation of Councils (WSROC).

While these two positions sit in different disciplines, they overlap in the development and use of modelling and techniques to examine urban areas and the health impacts of urban design issues. In addition, my software development skills and computer vision technical knowledge has highly beneficial to undertaking research in a wide range of disciplines including urban analytics, 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 Transport, Heath, and Urban Design Research Lab (THUD). 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 topography, street network connectivity, traffic risk, pollution levels, and thermal comfort. 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 recently awarded $1.3 million NHMRC/UKRI research grant. My contribution to the lab is also represented in many of the 9 journal publications I co-authored with the lab in the last 3 years.

My expertise in urban heat modelling and computer vision techniques have led to me being sought out to participate as a co-investigator on the recently awarded $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 have also been sought out for a submitted (in-review) grant application NHMRC Ideas application 2002025 'Pathways to health: advancing bicycling as an active mode of transport' headed by Dr Ben Beck (Monash University). I am also a co-investigator on a (submitted) Swiss National Science Foundation grant application '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). These are in addition to awarded grants detailed in the section below.

Through my academic career, I have been fortunate to receive excellent mentoring and career guidance. My PhD was supervised by 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 also supervises one of my current positions. 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.

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 three urban climate models able to examine urban heat mitigation strategies and make predictions of human thermal stress at a local and micro-scale. 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. These 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 two years, 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

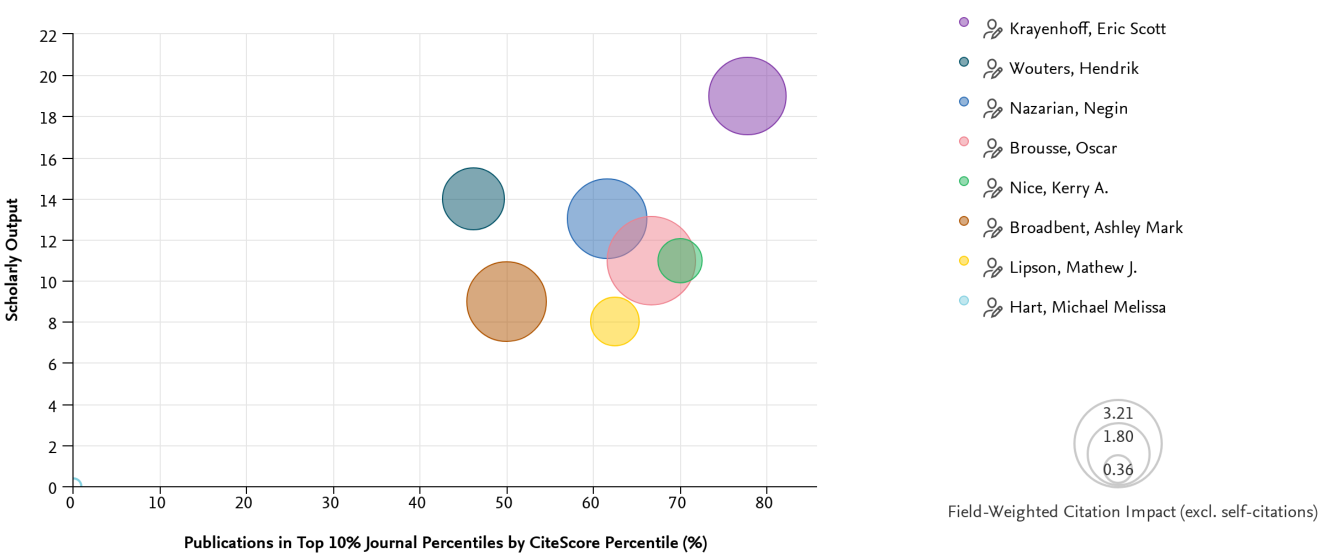

Figure 1: Benchmarking of my publication output in top 10% journals (by CiteScore percentile) compared to well-regarded researchers in urban climate modelling and model development at similar stages of their careers. (Source: Elsevier SciVal).

developed in my PhD, VTUF-3D remains 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 1,305 reads. Three additional climate models, TARGET, UT&C, and MSCM-DB, have been co-developed through collaborations. In a collaboration, 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), presented at the American Meteorology Society annual conference, and found the circumstances where VTUF-3D and ENVI-met successfully model this parameter and where they encounter challenges.

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. 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). Each of the proceeding provide key pieces of expertise for the successful completion of the work packages in this project.

While my expertise in computer vision techniques have the most direct link the successful delivery of this project, specifically the tasks around generation of urban morphology information in Work Package 3, Work Package 5 will require the use of many types of analytical methods, including artificial intelligence and machine learning. My research has also includes work in those areas through my use of artificial intelligence to examine urban systems. These have 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 and GBP £479,387 in research income through competitive grants over the last four 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.

Research supervision, mentoring and advice:

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 is observing and modelling the cooling potential of irrigation of the runway buffer areas at Adelaide Airport. The other student at the University of Melbourne is looking at the cooling potential and energy balances of misting systems and other active irrigation techniques in outdoor areas. 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 Graham Treloar Early Career Researcher Fellowship outputs, 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 2019-2020. These 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 finally 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 4 years, I have performed 30 peer reviews for 13 leading climate and urban design journals, including Urban Climate, Theoretical and Applied Climatology, Atmosphere, Sustainable Cities and Society, Environment and Planning B, and Building Simulation.

F18. 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. (Up to 3,750 characters, approximately 500 words))

I currently have published 13 journal articles (3 as first author and 3 as second author) and 2 refereed full-length conference papers. In the two years that I have been publishing (since 2018), I have already accumulated 73 citations in Google Scholar and a h-index of 4. My citations are increasing rapidly, with 47 of them occurring in 2020. The article on my VTUF-3D model is my most cited work. I have 5 reports written for the CRC for Water Sensitive Cities and 1 book chapter. My publication output compares favourably (as shown in an Elsevier SciVal analysis detailed in Section F17) to a selection of other respected urban climate researchers at similar 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. Authorship is generally 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 the effort. Sole authorship is less typical 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 1.042) has become the central journal for this discipline since 2012. Publications on climate modelling can be found across all these journals but Geoscientific Model Development (SJR Q1 3.18) is the leading journal specifically for 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 generally publish predominately in conference proceedings, but applied research using these techniques are more often published in domain specific journals. In my case, as my other research outside of urban climate field generally crosses multiple disciplines, I have published in interdisciplinary orientated journals. The Lancet family of journals are top tier in medicine and health, and the Lancet Planetary Health (SJR Q1 4.205) is a highly ranked interdisciplinary journal covering global health issues. Sustainable Cities and Society (SJR Q1 1.356) focuses on multi-disciplinary research into designing resilient cities. The Q1 journal Environment and Planning B focuses on state of the art analytical methods for urban planning and design.

Many of these papers have attracted attention. Four papers received an Altmetric Attention Score of 10 or higher. Seven are over 5. The Lancet Planetary Health paper has a score over 169, including coverage by four different news outlets and the Urban Science paper has reached 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 two, the American Meteorological Society and the State of Australian Cities 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.

F19. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including Ten Career-Best Research Outputs

(Provide a list of research outputs relevant to this application categorised under the following headings: Ten 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). CVs and theses should not be included in this list. The DECRA candidate's ten career-best research outputs should not be repeated

under subsequent headings. (Up to 100 research outputs)
Do not include or refer to pre-prints in your application.)
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] * 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 (Fully Refereed Conference Proceeding)

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] 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

[2] 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

[3] 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

[4] 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

[5] * 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

Additional Research Outputs

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

[2] * 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'

[3] * 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

[4] * 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

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

[6] * 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

[7] Nice, Kerry & Wijnands, Jasper 2018, 'Melbourne Google Street View imagery dataset', doi:https://doi.org/10.5281/zenodo.1256252

[8] * 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

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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 (2019 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 2016. 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 2016.
- 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 2016.
- 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.
- 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.