SIMMER Workshop:

Integrated Models
For Heat-Health Decision Making

Linking Complex Science to Policy for Heat-Health Decision Making

Meeting Summary Report

Toronto, Canada
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EXECUTIVE SUMMARY

The System for Integrated Modeling of Metropolitan Extreme Heat Risk (SIMMER) is a NASA-funded study led by the U.S. National Center for Atmospheric Research that integrates spatial information about extreme heat vulnerability and climate adaptation planning. SIMMER integrates information about current and future exposure to heat based on local and regional climate modeling; the impact of land use and building characteristics on heat exposure; social and physical factors that affect population vulnerability to heat; and the relationship between heat exposure, sensitivity, adaptive capacity, and heat-health impacts.

Key scientists, researchers and stakeholders met on October 24th and October 25th, 2013 in Toronto (Canada) to explore how SIMMER could inform local extreme heat preparedness and climate change adaptation. The workshop featured seven sessions including multidisciplinary presentations, case study discussions and a breakout discussion. Participants in the SIMMER workshop discussed the efforts of Canadian and American research organizations and government agencies that conduct heat health research. Each session featured different aspects of heat-related vulnerability including the user perspective on decision making to prevent heat-health impacts, explanation of the complex models used in the SIMMER project, explanation of other models used by Canadian researchers and most importantly, discussion of how the SIMMER model can be integrated into the existing Canadian research and be applied to cities such as Toronto.

Key themes that emerged from the workshop included strategies to ensure that knowledge and information learned from the SIMMER project are used and applied by decision makers and public health professionals. Identifying similarities in research approaches, exchanging knowledge to develop an integrated heat system approach, and understanding where collaboration across government, research organizations, and agencies can overcome gaps in the research were also discussed throughout the workshop.

Workshop participants recognize that the transfer of the SIMMER model to Toronto begins with strategic communications and collaborations between agencies, governments and organizations. Various short- and long-term methods of integrating SIMMER into public health preparedness and response tools were identified. However, many rely on data availability and sharing across agencies. It was suggested that research and operational activities being held in preparation to the 2015 Pan American Games in Toronto might be an appropriate venue to test the transferability of the SIMMER project. This event would act as a major driver in keeping knowledge transfer on time, provide a large-scale case study to test the validity of the model and showcase the research and partnerships between government, research organizations, and agencies.

This report serves as a summary assessment of the workshop and will initiate the discussions needed to transfer the SIMMER project to Toronto.

WORKSHOP THEME & OBJECTIVES

This workshop brought together key U.S. and Canadian climate and health scientists with climate and heat-health policy stakeholders from Toronto and government agencies across Ontario and Canada to:

- Explore how integrated models such as SIMMER could be used to inform extreme heat preparedness and climate adaptation policy, considering operational and policy needs of users;
- Build capacity and connections to support integrated heat impact modelling for Toronto and beyond;
- Explore the transferability of the SIMMER methodology (using Toronto as a demonstrated example);
- Share knowledge and expertise in the fields of urban climate modelling and societal vulnerability;
- Foster new connections among climate, health and heat vulnerability researchers and policymakers.

The workshop was divided into five sessions and a breakout discussion over one and a half days. The goals of the workshop were to share the processes, challenges, and lessons learned from the SIMMER project and transfer the knowledge from Houston, TX (study site of the SIMMER project) to Toronto and beyond. Sessions focused on the following:

- Learning from local-level users of extreme-heat-related information about their experiences and needs;
- Learning from scientists who have been working on integrating the components of SIMMER;
- Learning about Houston's plans for using SIMMER outputs;
- Participating in discussions to help identify the key policy questions for SIMMER-type models, describe critical elements and outputs of such models, and consider feasibility, needs, and next steps for adapting these models to broad municipal use;
- Learning about Canadian research and policy work that could inform integrated heat-health models; and
- Exploring feasibility of transferring the SIMMER approach using Toronto as a demonstrated example: discussing data availability and needs, incorporating user perspectives, considering capacity and resource issues, and identifying next steps.

WORKSHOP CONTENT

Session 1: User perspectives on making decisions to prevent heat-health impacts

The goal of this session was to highlight the needs of decision makers trying to use complex science in a policy development or decision-making environment.

1.1 Learning from Community Pilots on Building Resilience to Extreme Heat

Abderrahmane Yagouti, Health Canada (HC)

Health Canada's Heat Resiliency Initiative revealed some valuable lessons learned in supporting adaptation to heat and the health risk for Canadians. HC is supporting resiliency to heat by identifying the needs and gaps in knowledge of heat and health science, helping health professionals to better advise, diagnose and treat their clients and encouraging them to share knowledge of heat risks, expanding heat alert and response systems in at-risk communities, and promoting heat-health awareness to individuals and communities through partnerships and networks. Data needs and gaps were discussed through three examples of projects supported by HC: the harmonization of heat alert and response systems in Ontario, heat-health vulnerability assessments and urban heat island effects in Canada.

Next Steps:
Further research into defining and implementing a harmonized heat alert and response system in Ontario would establish a consistent and evidence-based approach to issuing heat alerts. This could be supported by a heat health vulnerability assessment for various geographic levels that would allow the identification of vulnerable populations and promote the reduction of individual and community risks. Lastly, identification of urban heat islands with the intent of suggesting adaptation and mitigation of the effects would prove beneficial.

Requirements for Next Steps:
Each of the next steps identified above requires an increase in data sharing and collaboration between organizations. Public health surveillance and local health outcomes are required to understand how the burden of illness related to heat in Ontario differs across urban and rural landscapes. Additionally, development of user-friendly tools would support decision makers to understand vulnerability of populations, socio-economic deprivation, and environmental impacts of urban heat islands.

Discussion:
Additional discussion focused on the feasibility of involving the Provincial Government to intervene with government-operated long-term care facilities to ensure that building codes require the use of air conditioning units. This may be more effective than the actions taken by individual municipalities.

1.2 Experiences from the U.S. Centers for Disease Control: Linking complex science to policy for heat-health decision making

Shubhayu Saha, U.S. Centers for Disease Control (U.S. CDC)

The Climate and Health Program at the U.S. CDC has developed a program 'Building Resilience Against Climate Effects' (BRACE) that focuses on collecting information from climate model projections, assessing vulnerabilities associated with environmental exposures projected to increase, projecting the disease burden attributable to those exposures, and assessing public health interventions that would help communities adapt to and prevent adverse health outcomes. This comprehensive plan is expected to guide decision making within the health agencies, as well as offer important information for other sectors to integrate health co-benefits across climate adaptation and/or mitigation policies.

Next Steps:
To move away from a reactive response to heat-related illness, a proactive approach of translating and linking scientific climate change information to best inform health departments and decision makers is important. Tools to support and build capacity to prepare for climate change are an essential component in the preparation for climate change impacts, including a heat-health system that uses a baseline risk assessment to predict future impacts, identifies communities and areas vulnerable to extreme heat, and informs planning and implementing of health interventions to prevent adverse health outcomes.

Requirements for Next Steps:
Developing systems and tools that detect and respond to current and emerging health threats is important for preventing heat-related illness in a context of climate change. Data sharing and collaboration across physical and social sciences research can aid in this proactive approach and support the adaptation of climate change by linking heat exposure and health. Specifically, educating the public about health intervention strategies and recognizing the symptoms to prevent heat illness in vulnerable populations are important steps.

Discussion:
Additional discussion raised the importance of citizens understanding climate change, extreme weather, and the effects of extreme heat. It is important that the general public understands the difference between climate change and extreme heat vulnerabilities, which is why climate education is important. Long-term policy development is dependent on scientific research that includes supporting improved understanding of heat risk among the general public.

1.3 Planning for health impacts of heat in Toronto

Stephanie Gower, Toronto Public Health

Toronto Public Health engages in research, advocacy, and policy development to increase resilience to extreme heat in Toronto. Actions and planning for extreme heat can occur at various timescales: immediate response, seasonal, and long term. With the number of hot days in Toronto expected to increase, collaboration and partnership across multiple agencies will be vital to reduce heat vulnerability in the City.

Next Steps:
Suggested steps include the harmonization of heat alert calls across health units, education that informs the general public about the effects of climate change on health, and further research to help prepare for extended heat alerts, particularly where heat is combined with other factors that increase vulnerability.

Requirements for Next Steps:
By collaborating with the appropriate partners, health and equity considerations can be mainstreamed into climate adaptation planning. For example, collaboration with Toronto's Urban Forestry division has resulted in Toronto Public Health's heat vulnerability maps playing a role in decisions about where to plant trees across Toronto. It was noted that resilient infrastructure supports better health outcomes.

Discussion:
Climate model simulations suggest that the number of very hot days in Toronto is expected to increase. Concerns were raised over the greater demand for public health services (including services related to extreme heat) during the summer months when more staff are on vacation. In situations of extended heat events, the strain on public resources to conduct heat response may become an issue. In this case, health units may not have adequate capacity to maintain sufficient level or heat response activities. . In the event that a heat emergency is declared, Toronto Public Health would collaborate with other agencies such as Toronto's Office for Emergency Management. Furthermore, when the number of heat-alert calls increase, message fatigue becomes an issue. This reinforces the need for a harmonized heat alert call, but acknowledges that the heat alert may require updating as the population adapts to the changing weather.

Collaboration between different levels of government can also inform policy. While the federal government may not have detailed information about what resources are most needed by each specific health unit, a local-level government agency that interacts with the public could inform and advocate the direction of resources more effectively.

Session 2: Integrating innovative work – the SIMMER components

The goal of this session was to showcase innovative research components of SIMMER.

Each presentation in this session focused on novel approaches to help inform policies to reduce heat-related health impacts and how the model could be transferred to Toronto and other cities.

2.1 Representing urban areas and heat stress in global climate models (CESM)

Keith Oleson, National Center for Atmospheric Research (NCAR)

Dr. Oleson discussed the development of Community Land Model Urban (CLMU) that considers urban environments such as building materials and urban density types in the climate model. This presentation stressed the need for climate models to consider more than temperature when attempting to understand heat stress. The SIMMER model considers air temperature, humidity, and various heat indices to develop a thorough understanding of the urban heat island effect on human comfort.

Next Steps:
To get an accurate assessment of heat stress and urban heat island effect, the SIMMER model requires climate models that consider more than temperature. Research indicates that heat stress needs to move away from singular measures of temperature and move towards a physiological response of humans to extreme heat. This presentation also reinforces the need for a universal thermal climate index that specifically indicates how heat stress is measured.

Requirements of Next Steps:
For SIMMER to be effective in measuring heat-related illness in other cities, the climate model portion of SIMMER must be supported by data that considers the physiological response of humans to extreme heat. If the Universal Thermal Climate Index is chosen as the approach for estimating heat stress, then temperature, radiation, humidity, wind, and physiological measures will be required for input in the model for each city.

Discussion:
Discussion was raised about the measurement of heat stress in soldiers from the military. The SIMMER project includes one of the same heat indices as the U.S. Military research: the "Wet Bulb Globe Temperature." This index considers temperature, humidity, wind speed and visible (sunlight); and infrared radiation however for the SIMMER project, the radiation component was not considered. The Universal Thermal Climate Index, a physiologically based heat/cold stress metric, is also being explored in the SIMMER project.

Further, it is important to consider that the typical healthy adults' physiological response to heat stress would not be the main focus of the model as more vulnerable demographics would take precedence. This could add complexity to the model as different categories of vulnerable populations should be considered.

2.2 High-resolution simulations of the urban heat island

Andy Monaghan, National Center for Atmospheric Research (NCAR)

This presentation explored the modeling of land surface temperature used in the SIMMER project. The NCAR team conducted various experiments to simulate temperature variability over a 10-year period for Greater Houston. Testing was conducted using an offline (i.e., uncoupled) version of a land surface model to perform eight experiments to explore how temperature was affected by increasingly complex representations of urban morphology. The simulations were validated with MODIS satellite imagery and observations from weather stations.

Next Steps:
The model simulations will be configured and run for the Greater Toronto Area using a high-resolution land use dataset provided by Ryerson University.

Requirements of Next Steps:
The Toronto land use dataset was processed by Ryerson to various resolutions and has been provided to NCAR for use in the simulations. Collaboration with Ryerson University to complete the simulations is needed.

Discussion:
Modeling the effects of irrigation was considered as a limitation of the vegetation component because evaporation is underestimated. Simulating irrigation and vegetation moisture at the city level is difficult due to lack of information about watering practices. Methods to adapt to heat are being explored to determine if changes in vegetation, such as tree planting or reduction of grass cover can be reflected in the model. This lends itself to scenario testing where physical and social factors are changed in the model to determine if there is a change in outcome.

2.3 Developing parameterizations to simulate alternative urban systems in climate models

Johannes Feddema, Department of Geography, University of Kansas

This presentation focused on defining urban characteristics and inputs into models as they relate to heat stress. There are differences in thermal properties across urban areas, specifically building heights, building density, thermal conductivity, heat capacity and vegetation that affect simulated climate modeling outcomes. Further, the models must consider the time of day and the surrounding geographic features, such as bodies of water that cool the area. This is important when considering the transferability of the SIMMER model to Toronto and beyond as the building construction types in particular may drastically change the outcome of the model.

Next Steps:
Further research is required to explore how small modifications made to the urban land cover and building properties might change the outcomes of the climate modeling. This is an important component, as it would support policy and decision making.

Requirements of Next Steps:
Additional research and modeling efforts are necessary for the implementation of green roofs and the effects of seasonality changes with respect to vegetation and tree canopy. These modifications must be considered in the model when transferring the approach to Toronto.

Discussion:
The timeline for releasing these findings was discussed to determine when this research could support policy changes. Ultimately, the timing is dependent on political climate and context, given that these models require funding. Additionally, modeling requires careful consideration about the processes needed to capture small single adaptation changes. For example, the model is capable of examining the tree canopy of a forest but is not nearly as accurate when considering the tree canopy over a sidewalk in an urban setting. Complexities are increased when the model must consider seasonality changes to tree coverage.

2.4 Knowledge, attitudes and practices related to heat vulnerability: Results from a household survey in Houston, TX

Mary Hayden, National Center for Atmospheric Research (NCAR)

To better understand the demographics and adaptive capacity of populations vulnerable to heat, a household survey was conducted in Houston, Texas. The survey identified non-home owners, African American and Hispanic/Latinos, those with incomes less than $20,000 per year, unemployed and those in poor health to be most vulnerable to heat stress. Additionally, findings indicate that these populations have little or no knowledge of the symptoms of heat stress, nor do they know where the closest cooling center is. Often, financial barriers restricted the use of an air conditioner at home, where they felt the greatest number of participants reported symptoms of heat stress. Additionally, a stakeholder survey was conducted, and the results showed consensus that heat stress would become an increasing issue in the future and populations with underlying medical conditions, senior citizens, and minorities were at an increased risk.

The survey revealed compound vulnerability based on knowledge gaps, economic barriers, and issues of poor health for vulnerable populations.

Next Steps:
The transferability of these survey findings is important when considering how to best reach vulnerable populations in all urban areas. Although Toronto and other cities may not have the same demographic composition as Houston, the methods to educate stakeholders so that they effectively connect with vulnerable populations may be similar.

Requirements of Next Steps:
According to the survey results, survey participants were either not receiving or not processing the messages from stakeholders as to how best deal with heat stress. Information sessions for front-line workers would be beneficial to help disseminate informed advice to vulnerable groups. Comparison of demographic trends between Houston and Toronto would be beneficial to determine if the knowledge gaps, socioeconomic barriers, and poor health issues were consistent.

Discussion:
One of the responses from the Houston stakeholder survey spurred discussion about the accessibility to facilities such as public toilets. This flaw in planning causes people to drink less water at large events and can induce heat stress. Additional discussion questioned whether the physiological response to heat stress was consistent in all demographic groups across the U.S. and whether access to health care may influence physiological response.

2.5 Statistical methods for connecting health, heat stress, and vulnerability in urban populations

Steve Sain, National Center for Atmospheric Research (NCAR)

This presentation identified how to incorporate mortality, risk, demographics, satellite imagery, and health outcomes into a hierarchical statistical model that indicates health, heat stress and vulnerability. This is a challenge given health impacts are distributed unevenly across the spatial domain.

Next Steps:
The hierarchical model requires input data for testing. Additionally, research indicating how well the model deals with extended heat waves and lag effects is important. The impacts of such extended heat alerts on measures such as mortality would then require further analysis.

Requirements of Next Steps:
This approach encourages a harmonized heat alert system that can be input to the statistical model and tested in various urban cities. Further research and discussion is needed to determine what the harmonized heat alert system might include. When considering the transferability of this model to be tested on cities such as Toronto, the availability of comparable data must be considered.

Discussion:
This presentation spurred discussion about the need for and the added complexities of defining a heat-alert threshold. For example, in this research, emergency 911 calls related to heat stress were made before an official heat alert was called in Houston. This may indicate that the existing threshold is higher than residents feel is ”too hot.” This relates back to the need to consider physiological response to heat in the harmonized heat alert system.

Session 3: Integrating Innovative Canadian Research

The goal of this session was to showcase innovative research that could support an integrated model in Toronto

3.1 Future weather and climate modeling in Toronto and the significance of the results for public health

Christopher Morgan, City of Toronto

Dr. Morgan identified the need for Toronto to take a new approach to modeling climatic data by shifting the focus from predicting the future averages-of-climate data to predicting the future of extreme weather. According to the current heat thresholds, the number of heat-alert days is expected to increase in Toronto but spatially this will not occur uniformly. The new approach takes into consideration local influences of water bodies, smog, and historical climate data to determine the future of extreme weather. This approach accounts for downtown canyons holding heat, air pollution, and adaptation approaches to deal with extreme heat in the city.

Next Steps:
Collaborations across several levels of government are needed to support adaptation measures in urban planning and urban design. Further, preparation for an increase in the demand of public resources is needed to support the vulnerable. The need for increased monitoring stations has been discussed to capture urban pollution, which influences heat stress.

Requirements of Next Steps:
Comparison between this approach and the models developed for SIMMER is required to support transferability of knowledge and findings. Heat adaptation strategies for downtown cores with regard to heat canyons can be addressed by modeling to help ventilate areas that trap heat. Adaptation will require collaborative input and policy development with urban planners. Further, increased monitoring stations (other than the Pearson Airport monitors) are needed to capture a greater area of air quality and heat risk.

Discussion:
Increased monitoring would support heat stress research for urban cities beyond Toronto as well. However, it was discussed that, historically, air quality has been improving in Ontario and could be less of a concern than projected extreme heat. Further, the more open design of urban canyons to promote greater ambient ventilation between buildings and improve dispersion of heat and pollution is important for future city planning. However, this would require significant contributions and collaborations with urban planners.

3.2 Extreme ambient temperatures and emergency room visits: a time series study in Toronto, Canada

Eric Lavigne, Public Health Agency of Canada (PHAC)

This presentation examined climate change and extreme ambient temperatures from an epidemiological approach and discussed how epidemiology can best inform policy. Research examined the association between extreme ambient temperatures and emergency room visits for cardiorespiratory diseases among vulnerable groups in Toronto. Findings indicated that higher temperatures were associated with increased risk for children and older adults, and those with existing medical conditions.

Next Steps:
Further research is required at the individual level to better understand the demographic characteristics that increase vulnerability to extreme heat. However, these findings still support public health decision makers to consider the impacts on vulnerable populations. Additionally, incorporation of more complex climate data, mortality rates, air-conditioning usage and the impacts of heat waves on pregnancy and birth outcomes would be of interest.

Requirements of Next Steps:
This work would also benefit from collaboration on climate modeling to inform heat stress thresholds.

Discussion:
Further research ideas for examining the combined effect of other weather hazards and heat on health were discussed.

3.3 Urban modeling capabilities at Environment Canada

Sylvie Leroyer, Environment Canada (EC)

Dr. Leroyer discussed the development of an urban meteorology prediction system in preparation of the 2015 Pan American Games and beyond. Although the approach focuses on providing short-term forecasts of weather variables, similar inputs as considered in the SIMMER project are included in the model such as canyon effects of the urban land cover and building properties to indicate surface temperatures and vegetation cover at the country level.

Next Steps:
This research approach has the capacity to be used in real-time forecasting once the model is validated and could be used after Pan AM Games for weather forecasting at very high resolution (down to 1 km and 250 m) over major cities such as Montreal, Vancouver, and Toronto.

Requirements of Next Steps:
A more sophisticated heat stress index at the street level is needed as model output that could be used to support heat alert and response systems.

Discussion:
There is an interest in modeling data over a 10-year time period using an offline (i.e., uncoupled) model simulations so that health impact studies can be conducted. The age of buildings would be useful to help improve the quality of the model outputs.

3.4 Toronto's Heat Vulnerability Maps: A planning tool for hot weather response and climate change adaptation

Claus Rinner, Department of Geography, Ryerson University; Stephanie Gower, Toronto Public Health

The Toronto Heat Vulnerability Index includes exposure and sensitivity components that capture a number of specific indicators including surface temperature, shading, high-rise buildings, population density, and demographics relating to age, immigration status, education, and income. Toronto Public Health (TPH) has frequently used it as a communications and advocacy tool. This index has also been used by Toronto Urban Forestry to prioritize "greening" across the city and has been uploaded into a web map for public access.

Next Steps:

TPH would like to develop guidance to support users of the maps in understanding and applying the information to support heat and adaptation planning. TPH may consider updating the maps with more recent data; this will require reformulating the heat vulnerability index since some of the data used in the original index is no longer collected by Census Canada.

Requirements of Next Steps:

Carrying out these next steps may benefit from improved understanding of who the key users of the maps currently are and how they are using them. Maintaining communication with agencies currently developing heat vulnerability products and integrated models will support development of this improved understanding.

Discussion:

Collaboration across city departments is important for considering various aspects of heat-health vulnerability. Participants suggested collaborating with public transit (Toronto Transit Commission) to offer complimentary transportation on hot days. This would help vulnerable populations reach cooling centers. Although TPH has explored the free transit idea previously with limited success, the agency is interested in exploring innovative ideas about ways to apply the heat vulnerability maps.

Session 4a: What's the whole package? Integrating complex heat-health information for decision makers

The goal of this session was to show how models such as SIMMER help users navigate large amounts of complex scientific evidence, sophisticated modeling, and statistics to help inform decision making

4.1 Reducing vulnerability to Extreme Heat: Science-Policy Interface

Olga Wilhelmi, National Center for Atmospheric Research (NCAR)

The SIMMER research aimed to understand and characterize current and future vulnerability of urban populations to extreme heat. It also sought to reduce negative heat-stress-induced health outcomes and ultimately produce solution-oriented research that informs policy. It is important to identify gaps in the existing research and understand how the needs of the vulnerable populations are changing.

Next Steps:

One of the outcomes of the SIMMER project is an interactive GIS-based tool. An extreme heat vulnerability GIS application is being developed and made available for the Houston stakeholders with features and spatial data. The tool would allow exploring and querying various heat-health datasets for analysis. This approach could bridge the knowledge gap between decision makers and a complex model like SIMMER by making the data accessible and easier to understand and implement. The goal of the tool is to spatially link heat-risk factors and solutions for risk reduction at a neighborhood scale.

Requirements of Next Steps:

Informed policy and decision making should include partnerships with community service-level organizations that support the vulnerable populations.

Discussion:

The system is an ArcGIS Online-based platform that is familiar to most GIS users and has a simple interactive interface making it accessible to the public if necessary.

4.2 Real time data monitoring for improved public health situational awareness: ACES and PHIMS

Kieran Moore, Kingston, Frontenac and Lennox & Addington Public Health (KFL&A PH)

This presentation focused on the use in Ontario of two user-friendly tools named Public Health Information Management System (PHIMS) and Acute Care Enhanced Surveillance Acute Care Enhanced Surveillance (ACES). PHIMS is a GIS-based tool that provides environmental and social determinants of health to local and regional senior management and public health professionals in Ontario. ACES is a valuable source of information designed to enhance situational awareness and provides real-time health outcomes (morbidity) to participating Ontario Health Units.

Next Steps:
Integrating historical information with real-time weather and health data could be helpful during heat stress situations. Climate data would be useful in a variety of ongoing health situations as well as power grid, transportation data.

Requirements of Next Steps:
Collaborations and data sharing would help enhance these tools and allow for a system that assists in more dimensions than health or heat-stress assessments.

Discussion:
ACES has historical data capacity for existing hospitals, but in some regions, the data are not available because new hospitals may come on board.

4.3 Public health end users' info needs about heat waves

Pierre Gosselin, Institut National de Santé Publique du Québec (INSPQ)

This presentation focused on the use of a GIS-based tool called System of surveillance and prevention of extreme meteorological events impacts on public health (SUPREME) in Quebec. In collaboration with Environment Canada and local universities, INSPQ led a research project that helped to identify heat health thresholds by region, based on the relationship between excess mortality and extreme heat. This allowed for the development of alert levels by region throughout the province and lead to the development of the SUPREME tool. This tool allows for a better understanding of vulnerable populations and provides real-time health outcomes to monitor health impacts during extreme heat events. SUPREME is designed to support prioritization and prevention interventions, particularly during emergencies.

Next Steps:

SUPREME showcases the integration of several sources of information into a unique platform that could be used to support decision making. Lessons learned and integration approaches can be shared between governments including user training of the portal, integrating data, and assessing vulnerability in real time.

Requirements of Next Steps:

SUPREME relies upon Census data from Statistics Canada to support the vulnerability assessment. However, the quality of data collected from 2011 Census data might not be representative at fine-scale geography. Other means of attaining data are necessary to capture vulnerability within a community.

Session 4b: Discussion

The goal of this session was to synthesize the main themes from Day One and discuss future challenges and opportunities.

Vidya Anderson, Ontario Ministry of Health and Long-Term Care (MOHLTC)

Ms. Anderson provided comments on the presentations from Day One of the workshop and identified common themes, overlaps in research, and key steps to move forward with transferring SIMMER to Toronto. Presenting the various research methods of modeling and assessing vulnerability to heat-health impacts provides opportunities for collaboration and knowledge transfer to help prevent heat-related illness. However, these presentations are not reflective of the current capacity to conduct research and advanced modeling in more rural areas across the province.

In Ontario, Toronto has taken the greatest initiative to model and understand heat stress. However for other municipalities, capacity, expertise and coordinated response to heat remain ongoing challenges. This is especially true for small health units that may not have the resources to begin investigating climate change impacts and environmental health hazards. That being said, there are still issues in existing heat-health research because of gaps between what the users want and what the existing models offer. The models currently measure heat stress at various thresholds and regions but it is unclear whether there is a difference in risk for urban and rural populations. Therefore, it is unclear whether the approaches can be generalized or transferred between communities, given the differences in model input requirements.

For this reason, a suggested outcome of this workshop is to continue efforts to build a harmonized heat-alert system in consultation with Ontario Health Units. Such a system could rely on a standard set of heat-vulnerability indicators for both a national and local scale. At the national level, a specific heat-alert system would rely on a set of key indicators of heat vulnerability. The local-scale harmonized heat-alert system would employ the same indicators, but consider local specificities of heat stress such as availability of services in that municipality. This approach would provide a consistent definition of what a heat alert means and as a result, avoid message confusion and fatigue.

Once a model was developed, a demonstration of the heat alert models and presentation of the outcomes may demonstrate a cost and resource saving for municipalities. This would appeal to the small health units that express concern over the expense and lack of resources available. At that time, integration of survey data would be a useful addition to models so that before-and-after assessments of heat stress can be measured.

The reliability of Statistics Canada's 2011 Census is a concern to the implementation of a harmonized heat-alert system. However, research into alternative proxy indicators of vulnerability could be acquired by such sources as banks and hospitals, as suggested by one participant. Furthermore, the availability of air-quality monitoring data at the national level may need to be assumed until more sensors are implemented.

Session 5: Summary and Transferability of SIMMER

The goal of this session was to identify opportunities and needs that are specific to Toronto and may inform the transfer of SIMMER to Toronto or future research efforts.

5.1 Discussion on transferability

Olga Wilhelmi, National Center for Atmospheric Research (NCAR)

This session revisited the discussions from Day 1 with a clear focus on the transfer of SIMMER from Houston to Toronto. Toronto can be viewed as the pilot project for transferring the model before considering expansion to other cities. Consensus among the group suggests that the transfer of SIMMER should start with data and modeling information that already exist in Toronto. Some immediate to short-term goals to start the SIMMER transfer include:

- Take inventory of relevant SIMMER data that already have been collected or modeled in Toronto;
- Define audience: how are they using heat-health information ;
- Apply SIMMER methodology to Toronto;
- Explore possibility of incorporating existing modeling data into PHIMS to support the real-time data analysis; and
- Overlay heat information through SUPREME to identify very specific areas in the community for targeting efforts. This could be a target for focusing modeling and other research efforts.

Intermediate goals and potential projects include:

- The need for a predictive short-term component. Would provide public health units with more time to prepare and mobilize. SIMMER could be developed into an operational tool. Real-time data helps with immediate planning and intervention but the longer-term piece would feed into broader planning and larger systemic structural changes.
- Forecast the changing demographic with particular interest in growing population of seniors (therefore growing vulnerable populations).

Long-term goals and projects to build on the SIMMER research include:

- Take a bottom-up approach to collect data from people and ask them to help us to figure things out rather than dictating the data and tools to them. Get people involved, perhaps in a crowd-sourcing type of activity for gathering information.
    - Ask people to text temperatures using their cell phones to measure temperature.
    - Health Canada and Toronto Public Health are partnering in developing an app on weather and health but currently, there isn't a component where we gather information from users.
- The Urban Heat Island phenomenon is currently outdoor information but the models are getting better at indoor temperature gauging. It's important to know what the indoor temperatures are because health issues may be linked to indoor rather than outdoor heat.

- Incorporate the adaptation that populations will make to "new normal" in future. This may reveal a decrease in demand for health services
  - People will have to adapt to rapidly changing conditions. Investigate whether we are expecting too much adaptation outside certain thresholds

Other comments

- Incorporate existing modeling data into PHIMS for real-time data analysis.

Session 6: Case studies

6.1 Heat monitoring during Pam Am and opportunities for integration with SIMMER

Dave Henderson, Environment Canada; Abderrahmane Yagouti, Health Canada

This presentation focused on extensive new heat data that will be collected during the Pan Am games to be held in Toronto in 2015. This data collection and the associated research and collaborations may offer an opportunity to accelerate and facilitate the transfer of SIMMER to Toronto. Climate data will be collected by Environment Canada from 60 locations in Games area and could be shared with the NCAR team to test the validation of the SIMMER project. Highlighting the SIMMER project and partnership can trigger conversations with Emergency Management Services, Telehealth Ontario, and other government health organizations to further integrate the model.

Discussion:
Participants suggested the incorporation of other risk factors in the analysis such as obesity, poverty, and level of vulnerability as well as incorporation of physiologically-based metrics to measure heat stress. Additional discussion focused on the legacy of the SIMMER project and ensuring that the lessons learned were not lost. A suggestion of applying the SIMMER project to the 2015 Pan American games would keep the transferability on a schedule and act as a platform for testing the validity of the Toronto model.

Another approach to consider in future collaborations when preserving the legacy of the SIMMER project is to incorporate SIMMER outcomes into PHIMS and explore the possibility of expansion at the provincial level. Such an application may include the development of a general model to examine vulnerability for other extreme-weather events such as flooding.

6.2 Toronto's climate adaptation information needs

Dave Macleod, Environment and Energy Division, City of Toronto

This presentation focused on the criticality of the energy sector's role in supporting resilience during extreme-weather events and how climate information and projection of extremes could support the energy utility sector. Mr. Macleod discussed the impact of extreme weather events and the public -health risk tolerance to major power disruptions, and specifically among vulnerable populations.

Next Steps:

Based on limited knowledge of the current status of the energy sector, concerns have been identified that the means to support vulnerable populations during times of need are put at risk during extreme weather events. It was suggested that climate modelers and energy divisions collaborate and expand communications to discuss the feasibility of monitoring systems that forecast potentially catastrophic weather events.

Breakout Session

The breakout session divided participants into two groups: one to discuss the social vulnerability perspective of SIMMER and the other to discuss the environmental modeling perspective of SIMMER. Each group was asked to explore the following questions:

1.) What are the specific needs and gaps (data, policy) to support the SIMMER transfer?
2.) What is the most appropriate mechanism or methodology to transfer the model?
3.) What are the challenges that may stop/block us?
4.) What are appropriate timelines, opportunities for partnerships, and proposals for funding (and any other next steps that should be taken)?

Breakout group 1: Social vulnerability perspective

1.) What are the specific needs and gaps (data, policy) impeding the SIMMER transfer?

Participants in the group felt that identifying the audience who would use the model in Toronto was a "need" to support the successful transfer of SIMMER. If the model attracted the attention of the general public (which was not the initial user target), some of the more vulnerable populations may not have access to this tool.

The data needs from SIMMER are likely similar to those of the heat vulnerability work. Heat-related 911 call data and mortality data might not be possible to share if it is too specific; however, the Toronto Emergency Services group might have better data now, given the switch to electronic medical records. Additionally, socioeconomic data are linked to where people live, but this may be different from heat exposure. If the transferability of SIMMER is kept within Toronto, it is likely all the data needs will be met.

2.) What is the most appropriate mechanism or methodology to transfer the model?

This user data would inform long-term planning of the model and would dictate the most appropriate mechanism to transfer the model. The group felt that technology should be used to disseminate information with an emphasis on a multimedia approach. If the intended audience was the general public, a challenge include the "digital divide" in which vulnerable populations may not necessarily have access to smart phone devices with internet capability. However, the cell phone could be an appropriate device to disseminate SIMMER information. Notifications could be pushed to devices based on GPS capabilities that would issue a heat alert. If the data were disseminated through the internet, a publically available link could be used with password-protected data for stakeholders to access. Future consideration includes the use of postal codes to disseminate information so as not to rely on electronic forms of information that may exclude vulnerable populations.

3.) What are the challenges that may stop/block us?

The digital divide may pose to be a problem in the future if the dissemination of data is focused on the public. Not all vulnerable populations have access to cell phones with internet access; therefore, this approach may be problematic. However, a move towards collaboration with weather broadcasters to provide health information alongside the alert has potential. However, this leads to another potential challenge of information overload on the population. There may be reluctance to sign up for additional information. An alternative is building resiliency by working with communities and connecting with fire services to reach vulnerable populations on the ground level. This could tie in well with the Pan AM games where volunteer fire services assist the vulnerable populations surrounding the stations.

4.) What are appropriate timelines, opportunities for partnerships, and proposals for funding (and any other next steps that should be taken)?

The time scale was discussed with a short-term, mid-term and long-term use of the information. SIMMER was originally developed as a mid to long-term and even longer-term planning tool. Once the model was transferred, the heat-vulnerability maps could be compared to the SIMMER model output to determine whether the results align. If the results were consistent, the model could then be simplified and applied to other communities using more basic indicators than those used in the Toronto map.

Moving forward with the transfer of SIMMER from a social vulnerability perspective should start by developing data-sharing agreements. The inventory of Houston and Toronto data can then be considered side by side. If the data-sharing agreements pose as a problem then alternative methods will need to be considered.

Breakout group 2: Environmental modeling perspective

1.) What are the specific needs and gaps (data, policy) impeding the SIMMER transfer?

Participants agreed that while climate data remain relatively easy to obtain, collect, and process, there are still gaps in observational data at the urban scale. However, the needs of the stakeholders were not clear in terms of climate information available from SIMMER. The lack of information on stakeholder needs makes it difficult to identify a delivery mechanism of SIMMER results.

2.) What is the most appropriate mechanism or methodology to transfer the model?

The challenges of transferring of the methodology are assembling the various required databases and then applying the statistical methodology to calculate mortality-relative risks associated to Toronto census blocks. The approach could reflect a traditional statistical or expert-driven application, depending on stakeholder needs. It is also important to develop guidelines on the use of the SIMMER project.

3.) What are the challenges that may stop/block us?

Data agreements on sharing health data may be a major obstacle to applying the SIMMER statistical component as well as updating the data into the future. These data constraints lead to concerns over the ability of long-term funding to keep a SIMMER-like system running once the initial set-up is complete. Additionally, concerns about updating social datasets may prove difficult. Participants suggested the idea of forming private-sector partnerships with banks, insurance companies, etc., which have troves of social proxy data that could be shared.

Another challenge to transferring the SIMMER methodology is the choice of the Pan American Games, which would likely be the catalyst and funding mechanism for the initial set-up of SIMMER. This event may be too anomalous to work well within the SIMMER framework, which does not deal with large events. Participants questioned the ability of SIMMER to predict vulnerability for mass gatherings typical of sporting events like the Games. It was suggested that a hybrid model for both long and short-term climate prediction may be an option to take advantage of the SIMMER project and EC activities for Pan Am Games.

4.) What are appropriate timelines, opportunities for partnerships, and proposals for funding (and any other next steps that should be taken)?

If the Pan Am Games were to be the trial run for SIMMER, the appropriate timeline for implementation must allow a stable version of SIMMER to be up-and-running prior to 2015. Other opportunities for partnerships might come from the private sector (insurance companies and banks), who may be able to address the need for regularly updated social data. More investigations on these partnerships are needed. Participants discussed the potential of taking an "all hazards" approach for adaption and expand SIMMER for a variety of risk assessment projects.

LESSONS LEARNED AND MOVING FORWARD

Take Away Message from Session 1

This session focused on linking complex science outcomes to policy development and decision-making through examples and initiatives related to adaptation to climate change and extreme heat. The session addressed one of the objectives of the workshop, which aimed to explore how integrated models such as SIMMER could inform extreme-heat preparedness and climate-adaptation policy. Participants agreed that the most effective approach for allocating resources and benefitting from research projects such as SIMMER is through collaboration across government and research organizations. This collaboration would also support the development of a harmonized heat-alert system that would encourage further research and support education of the general public. Health intervention strategy planning would help support increased resiliency against heat stress. Further, participants identified that there are different time scales for decision making as well as different audiences. The time scales to consider include short-term response, seasonal, and long-term adaption. The audience or users of tools to support heat-health decision making can vary between the public, organizations, or government, which affects the strategic planning approach.

Take Away Message from Session 2

The presentations in this section focused on the technical advances and novel approaches in the SIMMER project. It addressed the second goal of the workshop, which aimed at sharing knowledge and expertise in climate modeling and social vulnerability. Many of the presentations provided valid arguments on the need for a harmonized heat-alert system, heat thresholds, and research to support physiological response to heat. Specifically, presenters reinforced the need for SIMMER implementation to integrate climate modeling data, social science, and health impacts to understand the complexities of heat vulnerability and response. Collaborations are necessary to integrate model components and to understand the transferability of the system over jurisdictions. Adjustments to the model may be necessary for transferability across cities, given available input data. For example, adjustments to SIMMER have already been observed in the ongoing integration of remote sensing imagery of Toronto into the existing SIMMER land-use surface-temperature variability modeling.

Take Away Message from Session 3

This session focused on the modeling efforts that have been conducted using Toronto data to understand vulnerabilities to heat. This work includes innovative downscaled climate modeling for future extreme heat in Toronto, new research on heat and ER visits, and high-resolution weather forecasting models. Toronto Public Health led development of a heat-vulnerability map for the city, which integrated evidence of risk factors for heat vulnerability with data about heat exposure and knowledge of local populations. The session addressed one of the goals of the workshop, which aimed at sharing knowledge and expertise in climate modeling and social vulnerability. These modeling efforts could be more productive if they were coordinated and better integrated, similar to what is being done in the SIMMER project.

Take Away Message from Session 4a

The discussion during this session focused on the importance of presenting the research findings from complex science in a manner that can be understood by policy and decision makers. It is important to consider the end-user audience who will be using these applications. Decision makers do not need complicated tools to understand vulnerability when simple indicators are sufficient. This session explored how integrated models such as SIMMER could be used to inform extreme heat preparedness and climate adaptation policy, which addresses a key goal of the workshop. The applications discussed (SIMMER GIS-based tool; PHIMS or SUPREME) are great platforms to disseminate heat-related information and can be considered as a prototype when SIMMER is ultimately transferred to Toronto and beyond. These applications may engender wider partnerships and collaborations among heath and vulnerability/risk research. SIMMER is more oriented to long-term season and strategic planning, while PHIMS supports intermediate responses.

Take Away Message from Session 4b

This session provided a recap of the presentations from day one of the workshop. The discussion focused on identifying potential gaps between what users wanted and what the existing models offered; if the approaches could be generalized or transferred for use in other communities; discussing the next steps and potential opportunities for collaboration in which SIMMER can be used; and identifying whether there is a need for guidelines municipalities could follow related to integrating or tailoring the models to particular areas. This session successfully addressed the goal of the workshop that aimed to build capacity and connections that support integrated heat-impact modeling for Toronto and beyond.

Discussants identified the importance of understanding the limited capacity to which individual and multi-tier public health units are capable of managing climate change and environmental health hazard issues. Participants acknowledged that the limited resources of small public health units might pose a barrier to integrating SIMMER. However, incentives to participate include the potential of existing overlapping research models across health units that are collecting the same key pieces of information required for SIMMER integration. There is also a need to understand how the existing heat-health vulnerability tools are being used, which may ensure that SIMMER can be used effectively in health units and beyond.

Lastly, it was suggested that the Environment Canada model presented in session 3.3 is a potential base model that can support consistent climate modeling across Canada.

Take Away Message from Session 5

The presentations in this section focused on ways to successfully begin the transfer of SIMMER to Toronto. Short-term and long-term goals and projects were listed.

Participants agreed that the transfer should begin with relatively small tasks but aim to transfer knowledge with the mid goal of supporting the Pan AM Games in 2015.

Take Away Message from Session 6

This session capitalized on the discussion from session 5 and successfully addressed one of the goals of the workshop that aimed to foster new connections among climate, health, and heat-vulnerability researchers and policy makers. The Pan Am Games event was suggested as a medium-term goal to showcase the SIMMER research project, the successful partnerships, and transfer of a complex model to support decision makers and policy. Key elements from the breakout sessions include the need to identify an audience and user of SIMMER, the need to research the complexities in data sharing agreements across health units, jurisdictions and beyond, and identifying the most appropriate partnerships necessary to fully integrate and successfully integrate SIMMER.

APPENDIX A – Agenda

8:15-8:30 **Registration**
8:30-8:45 **Welcome** – Kate Bassil (Toronto Public Health) and Jim Frehs (Health Canada)
8:45-9:15 **Introductions**

9:15-10:30 **Session 1: User perspectives on making decisions to prevent heat-health impacts**
Goal: To identify the needs of decision makers trying to use complex science in a policy development or decision-making environment
Chair: Kate Bassil

Abder Yagouti, Health Canada - Learning from Community Pilots on Building Resilience to Extreme Heat
Shubhayu Saha, U.S. CDC - Experiences from the U.S. Centers for Disease Control (by WebEX)
Stephanie Gower, Toronto Public Health - Planning for health impacts of heat in Toronto

Discussion

10:30-10:45 Break

10:45-12:30 **Session 2: Integrating Innovative work – the SIMMER components**
Goal: to showcase innovative research components of SIMMER **Chair: Olga Wilhelmi**

Keith Oleson (NCAR) - Representing urban areas and heat stress in global climate models
Andy Monaghan (NCAR) - High resolution simulations of the urban heat island
Johannes Feddema (University of Kansas) – Developing parameterizations to simulate alternative urban systems in climate models
Mary Hayden (NCAR) - Knowledge, attitudes and practices related to heat vulnerability: Results from a household survey in Houston, TX
Steve Sain (NCAR) – Statistical methods for connecting health, heat stress, and vulnerability in urban populations

Discussion: Q & A

12:30-1:15 Lunch

1:15-2:40 **Session 3: Integrating Innovative Canadian Research**
Goal: To showcase innovative research that could support an integrated model in Toronto
Chair: Simon Pellerin
Christopher Morgan, City of Toronto - Future Weather and Climate Modelling in Toronto and the Significance of the Results for Public Health
Eric Lavigne, Public Health Agency of Canada - Extreme ambient temperatures and emergency room visits: a time series study in Toronto, Canada
Sylvie Leroyer, Environment Canada – Urban Modeling Capabilities at Environment Canada
Claus Rinner and Stephanie Gower – Toronto's Heat Vulnerability Maps: A Planning Tool for Hot Weather Response and Climate Change Adaptation

Discussion: Q & A

2:40-3:00 Break

3:00-4:00 Session 4a: What's the whole package? Integrating complex heat-health information for decision makers

Goal: to show how models such as SIMMER helps users wade through large amounts of complex scientific evidence, sophisticated modelling and statistics to help inform decision-making. **Chair: Jim Frehs**

Olga Wilhelmi (NCAR) – Reducing Vulnerability to Extreme Heat: Science-Policy Interface
Kieran Moore (KFL&A Public Health) – Real-time data monitoring for improved Public Health situational awareness: ACES and PHIMS
Pierre Gosselin (INSPPQ) – Public health end users' info needs around heat waves (by WebEX)

4:00 – 4:45 Session 4b: Discussion

Format: Discussant responds to material presented throughout the day, leading to a group discussion

Vidya Anderson (Ontario Ministry of Health and Long-Term Care) – Discussant

Example questions for discussion:

- Are there gaps between what users want and what these models offer?
- Could these approaches be generalized or transferred so as to be useful to other communities?
- What are the next steps, alignments, and opportunities for collaboration?
- Is there a need for guidelines for municipalities related to integrated models? How to focus?

4:45-5:00 Wrap-up Day 1: Jim Frehs (Health Canada) and Kate Bassil (Toronto Public Health)

SIMMER Day 2: Transferability Example: "SIMMER Houston" -> "SIMMER Toronto"

9:00-9:30 Session 1: Summary and Transferability of SIMMER

Goal: Describe what the transfer of SIMMER from Houston to Toronto would look like, given needs of Toronto

Heather Hart (Ryerson University) – 5 minute recap of Day 1 key themes/points

Olga Wilhelmi (Chair) - Discussion on transferability

Facilitated discussion: Revisit discussions from Day 1 with a clear focus on Houston to Toronto transfer. Eg., General frameworks, Important data, scales (spatial, temporal), How to put information together, (such as statistical model or a set of indicators)

9:30 – 10:15 Session 2: Case studies

Goal: To understand opportunities and needs that are specific to Toronto and may inform the transfer of SIMMER to Toronto or future research efforts

Dave Henderson *(Environment Canada)* ***and Abder Yagouti*** (Health Canada) - Heat monitoring during Pan Am and opportunities for integration with SIMMER

Dave Macleod (City of Toronto) – Toronto's climate adaptation information needs

10:15 – 10:30 Break

10:30- 11:30 Breakout sessions

Each group will discuss the following questions:

1. What are the specific needs and gaps (data, policy) to support the SIMMER transfer?
2. What is the most appropriate mechanism or methodology to transfer the model?
3. What are the challenges that may stop/block us?
4. What are appropriate timelines, opportunities for partnerships, and proposals for funding (and any other next steps that should be taken)?

11:30 – 12:00 Report back & discussion

12:00-12:15 Closing Remarks: Olga Wilhelmi (NCAR) and Stephanie Gower (Toronto Public Health)

The workshop is being co-hosted by Toronto Public Health, Health Canada, Ryerson University, and the U.S. National Centre for Atmospheric Research (NCAR). Many thanks to Environment Canada for significant contributions to the workshop planning.

APPENDIX B – Speakers, Chair and Discussant Bios

Vidya Anderson
Vidya Anderson is a Senior Policy Advisor with the Ministry of Health and Long-Term Care. She is the policy lead for the environmental health hazards file and is leading the development of provincial environmental health climate change strategy. Vidya has worked in various ministries across the Ontario Public Service including the Ministry of the Environment and the Ministry of Municipal Affairs and Housing. She holds a Master's degree in Environmental Studies in urban planning and is currently working on her PhD in Environmental Science with a focus on climate change and human health impacts.

Kate Bassil
Kate Bassil is a manager in the Healthy Public Policy Directorate at Toronto Public Health. She holds a PhD in Epidemiology from the Dalla Lana School of Public Health.

Jim Frehs
Jim Frehs is the Manager of the Climate Change and Health Office within the Safe Environments Directorate at Health Canada. He leads a team of researchers and analysts focused on assisting the health and emergency management sectors prepare, and individual Canadians prepare and adapt to the impacts associated with a changing climate. Jim has a Masters degree in economics and has over 25 years' experience in the federal government on environmental, sustainability, resource development and climate change policies.

Johannes Feddema
Johan Feddema is climatologist in the Department of Geography at the University of Kansas. His primary research focus is on incorporating human land surface impacts within climate models. He has helped develop models and datasets to parameterize these processes in the NCAR Community Earth System Model.

Stephanie Gower
Stephanie Gower conducts research and policy development as a member of the Healthy Public Policy Team at Toronto Public Health. She received her PhD in Health Studies from the University of Waterloo, and holds a status appointment at the Dalla Lana School of Public Health in Toronto. Her current work supporting a healthier Toronto focuses on health impacts of air pollution and climate change and on issues related to active transportation and the built environment.

Pierre Gosselin
Pierre Gosselin was trained in family medicine (Laval U.) and environmental health (U.of California at Berkeley). He currently works mostly at the Quebec Public Health Institute (INSPQ), where he coordinates the joint Ouranos-INSPQ research program

in climate change and health, and the Health component of the Quebec Action Plan on Climate Change (2007-2012 and now 2013-2020).

Heather Hart
Heather Hart is a graduate student in the Masters of Spatial Analysis program at Ryerson University. Heather specializes in analytics, leveraging spatial data to support decision making and geovisualization. She focuses on finding ways to bridge the gap between geographic information systems and health sciences.

Mary Hayden
Mary Hayden (NCAR) is a behavioral scientist working on weather, climate and health related linkages. She received her PhD in Health and Behavioral Sciences in 2003 from the University of Colorado and is adjunct faculty at the University of Colorado School of Public Health as well as a Guest Researcher with the U.S. Centers for Disease Control and Prevention. Her primary research emphasis is on the human behavioral component of climate-sensitive health and disease issues, including community participatory research and the characterization of population vulnerability to weather and climate related health threats.

Dave Henderson
Dave Henderson currently holds the position of Senior Advisor for Health and Air Quality Services for the Meteorological Service of Canada Environment Canada. He was the lead Environment Canada architect behind the development of the Air Quality Health Index and has current responsibility for policy and stakeholder engagement associated with the implementation of the index and its ongoing improvement. He also coordinated MSC activities on heat forecasting/alerting and responsible for the health services portfolio associated with the upcoming Pan Am Games in 2015.

Eric Lavigne
Eric Lavigne holds a PhD and MSc in epidemiology from University Laval and is an Adjunct Professor at the University of Ottawa. He has been working for the Public Health Agency of Canada since 2008. He is currently working as an epidemiologist with the Environmental Issues Division at the Public Health Agency of Canada. His expertise is in environmental epidemiology and cancer epidemiology.

Sylvie Leroyer
Sylvie Leroyer is a research scientist at Environment Canada (RPN-E) involved in the development of an integrated system for urban meteorology prediction over the Toronto metropolitan area in the context of the Pan/Parapan Am 2015 games. Shehas obtained her PhD degree in France and has worked six years on urban and land surface modeling projects with McGill University and Environment Canada.

Dave Macleod
David Macleod is a Senior Environmental Specialist in the City of Toronto's Environment & Energy Division. He was responsible for the formation of the City's

climate adaptation strategy and the Toronto region's WeatherWise Partnership, a multi-sectoral group of infrastructure owners that seeks to enhance extreme weather resilience. Recently he has been most instrumental in catalyzing the Ontario electrical sector on climate change adaptation. Currently David is facilitating 15 City organizations in reporting to City Council on extreme weather vulnerabilities of the city and corresponding adaptation actions.

Andy Monaghan
Andy Monaghan is an atmospheric scientist at UCAR's National Center for Atmospheric Research in Boulder, Colorado. His research interests include a broad range of interdisciplinary regional climate topics, with an emphasis on climate-sensitive health and disease issues.

Kieran Moore
Kieran Moore is an Associate Professor and the Associate Medical Officer of Health at KFLA Public Health in Kingston. He is the lead for Research and Informatics at KFLA. His team creates and manages real time surveillance capability for Public Health in Ontario. The Acute Care Enhanced Surveillance system (ACES) currently links 24 health units with over 90 acute care partners in real time to provide situational awareness for public health emergencies. The Public Health Information Management System (PHIMS) monitors environmental data integrated into a geospatial portal linked to population data.

Christopher Morgan
Christopher Morgan joined the former City of Toronto as a senior environmental planner and science advisor in 1989. He has been the Program Manager responsible for air quality assessment across Toronto within the Environment & Energy Office since 2008, and in that role also works closely with Toronto Public Health. Dr. Morgan is currently responsible for such areas of applied research as: the City's local air quality research program, climate change assessment and evaluation program and research to support sustainable energy planning, sustainable transportation planning, GHG reduction target compliance, Toronto's Green Development Standards and adaptive site and building design standards regarding future weather, air quality and energy conservation.

Keith Oleson
Keith Oleson is a Project Scientist in the Terrestrial Sciences Section of NCAR's Climate and Global Dynamics Division. His current research interests are 1) urban modeling; 2) land use and land cover change; 3) the hydrological cycle in land surface models. He also supports the development, testing, evaluation, and documentation of the Community Land Model in the Community Earth System Model.

Simon Pellerin, Environment Canada
Simon Pellerin is Acting Chief of High Impact Weather National Laboratory Unit at Environment Canada. He holds a Master's degree in Atmospheric Science from the

Université du Québec à Montréal and a Bachelor's degree in Physical Sciences from the Université de Montréal.

Claus Rinner
Claus Rinner is an associate professor and program director of the Master of Spatial Analysis (MSA) in the Department of Geography at Ryerson University. His research aims to improve geographic visualization, participatory mapping, and spatial decision support tools with applications in public health, social policy, and environmental planning.

Shubhayu Saha, U.S. Center for Disease Control
Shubhayu Saha is a health scientist with the Climate and Health program at the Centers for Disease Control and Prevention (CDC). Part of his research involves spatiotemporally linking environmental exposures (like heat, precipitation, pollen) with health outcomes to assess the epidemiologic risk associated with those exposures. He also conducts cost-effectiveness analysis of community-level health intervention strategies. He joined CDC as a Prevention Effectiveness Fellow after completing his Ph.D. in Environmental Economics from North Carolina State University. He was awarded a National Science Foundation Dissertation fellowship to support his research on socio-economic determinants of deforestation in the Amazon. He currently participates in the United States Global Change Research Program (USGCRP) coordinating research and tool development relevant to climate and health. He is a member of the International Health Economics Association, International Society of Environmental Epidemiology and American Meteorological Society.

Stephan Sain
Stephan R. Sain is a scientist and statistician in NCAR's Institute for Mathematics Applied to Geosciences where he heads the Geophysical Statistics Project

Olga Wilhelmi
Olga Wilhelmi is a geographer at the National Center for Atmospheric Research in Boulder, Colorado and the principal investigator of the SIMMER project. Her research interests focus on understanding societal risk, vulnerability and adaptive capacity to extreme weather events and climate change.

Abderrahmane Yagouti
Abderrahmane Yagouti is a senior analyst at the climate change and health office of Health Canada, he has been leading and involved in several research projects on heat health impacts and supporting communities implement heat alert and response systems.

APPENDIX C - Presentations

All presentations from the workshop can be accessed at:
http://ral.ucar.edu/csap/events/heat-health-decision-making

APPENDIX D – Participants (alphabetical)

Name	Title	Organization	Email
Abderrahmane Yagouti	Senior Analyst	Health Canada	abderrahmane.yagouti@hc-sc.gc.ca
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Christopher Moran	Program Manager	City of Toronto	cmorgan1@toronto.ca
Claus Rinner	Associate Professor	Ryerson University	crinner@ryerson.ca
Dave Henderson	Senior. Policy Analyst	Environment Canada	Dave.Henderson@ec.gc.ca
David Green	Lead for Emerging Science and Services	National Oceanic and Atmospheric Association	david.green@noaa.gov
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Eric Lavigne	Epidemiologist	Public Health Agency of Canada	eric.lavigne@phac-aspc.gc.ca
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Heather Hart	Master's Candidate	Ryerson University	hhart@ryerson.ca
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Jim Frehs	Manager	Health Canada	jim.frehs@hc-sc.gc.ca
Jonannes Feddema	Climatologist	Department of Geography	feddema@ku.edu
Kate Bassil	Manager	City of Toronto - Toronto Public Health	kbassil@toronto.ca
Keith Oleson	Project Scientist	National Center for Atmospheric Research	oleson@ucar.edu
Kevin Behan	Deputy Director	Clean Air Partnership	kbehan@cleanairpartnership.org
Kieran Moore	Associate Medical Officer of Health	Kingston, Frontenac, Lennox & Addington Public Health	kieran.moore@kflapublichealth.ca

Mary Hayden	Behavioral Scientist	National Center for Atmospheric Research	mhayden@ucar.edu
Olga Wilhelmi	Project Scientist	National Center for Atmospheric Research	olgaw@ucar.edu
Pierre Gosselin	Program Coordinator	Institut Nationale de la Santé Publique du Québec	pierre.gosselin@inspq.qc.ca
Richard Foty	Epidemiologist	Public Health Ontario	Richard.Foty@oahpp.ca
Sanjay Khanna	Resident Futurist	Massey College	sanjay.khanna@utoronto.ca
Shubhayu Saha	Health Scientist	U.S. Center for Disease Control	hsf5@cdc.gov
Simon Pellerin	Scientist	Environment Canada	simon.pellerin@ec.gc.ca
Stephan Sain	Statistical Scientist	National Center for Atmospheric Research	ssain@ucar.edu
Stephanie Gower	Research Consultant	City of Toronto – Toronto Public Health	sgower@toronto.ca
Sylvie Leroyer	Research Scientist	Environment Canada	sylvie.leroyer@ec.gc.ca
Vidya Anderson	Senior Policy Advisor	Ministry of Health and Long-Term Care	Vidya.Anderson@ontario.ca