Catalyst Grant Final Project Report

Project Title: Atmospheric Modeling in Human Health & Climate Change Risk Assessment: Wildfire Smoke Exposures

Project team:

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Summary

In high wildfire activity areas such as California, and increasingly with climate change, it is critical to understand the health impacts of wildfire smoke exposure accurately so that more effective and sustainable actions can be taken to protect public health. Our long-term actionable aim is to better understand the spatiotemporal patterns in people's vulnerability to wildfire smoke exposure, as well as the exposure-health relationship. The purpose of this multi-disciplinary sustainability project is to resolve key technical issues related to atmospheric modeling used to develop environmental exposure metrics for the future planned health and geospatial vulnerability study.

On January 10, 2017, we convened a workshop among our emerging research team to address atmospheric modeling (exposure assessment) issues. This included an in-person visit from Sumi Hoshiko from the California Department of Public Health, and participation via phone by US Environmental Protection Agency's Kirk Baker. This in-depth workshop enhanced an existing multi-disciplinary collaboration among University of Michigan College of Engineering and School of Public Health, Michigan Technology University and University of Colorado faculty and government partners. Disciplinary expertise included atmospheric modelers, forest ecologists, epidemiologists, exposure scientists, and statisticians. A key feature of our structure was the role of Dr. Allison Steiner, who served as an evaluator, providing peer expert feedback on our approach.

Our main scholarly outcome was to resolve technical questions about our atmospheric modeling approach that allowed our team to complete a large (R01) grant proposal to National Institute for Environmental Health Sciences (NIEHS). Our team also presented preliminary data at the Lancet Planetary Health conference in Boston, and we are developing a manuscript for publication.

We also hosted two faculty research seminars on campus to engage students and faculty: Dr. Colleen Reid, Assistant Professor and epidemiologist, University of Colorado in January 2017, and Dr. Shiliang Wu, Associate Professor and atmospheric scientist, Michigan Technology University in April 2017. The recordings are available to the public via the Michigan Lifestage Environmental Exposure and Disease (MLEEaD) webpage. We also engaged students to learn more about public health careers in environmental health. Several graduate students were interested in opportunities for summer internships and future employment with the State of California.

This Catalyst grant occurred at a critical moment for our team formation. The Catalyst grant allowed for in-person interactions that were essential to overcoming the disciplinary language differences. We had time during the welcome dinner, our discussions and on breaks to have in-depth conversations that our conference calls simply don't allow for. This grant was essential to our team's ability to come together across disciplinary and geographic boundaries. Our next step is to obtain research funding that will allow us to complete our epidemiologic study. Achieving the long-term goal of improved understanding of the health impacts of climate change through wildfire smoke exposure and identification of vulnerable communities will enhance mitigation measures and planning which can be used in on-going risk assessment and planning to improve public health, equity, sustainability and preparedness.

Project background and approach

Communication of usable geospatial climate health impact knowledge is vital to transformative action on sustainability and public health protection. In high wildfire activity areas such as California, and increasingly with climate change, it is critical to understand wildfire smoke exposure impacts accurately so that more effective and sustainable public health actions can be taken. Our **long-term actionable aim** is to identify spatiotemporal factors that increase vulnerability of people to wildfire smoke exposure, as well as more accurate specification of the exposure-disease relationship. Our short-term objective is to determine the spatial resolution for atmospheric modeling that is the basis for exposure assessment in a future study. Our research would be directly useful to public actions by our **external partners** from California Department of Public Health and the US Environmental Protection Agency. These agencies require the prediction of communities and subpopulations most at-risk from wildfire smoke to mitigate health effects for the most vulnerable communities. Other studies have used less sophisticated atmospheric modeling or have examined relatively short time frames (single fires) or geographic scales. Our effort will ultimately lead to a grant proposal to assemble a 10-year health and wildfire exposure dataset for the state of California that we will use to explore spatial and temporal exposure-response relationships between cardiopulmonary health and a wide variety of fire patterns and forest types. The **purpose of this proposal** was to take the immediate next step to advance this research to understand technical atmospheric modeling issues to developing environmental exposure metrics for the future health and geospatial vulnerability study.

We convened our team in a research workshop and developed a white paper for discussion as we assemble a larger grant proposal. This in-person interactions will enhance an existing multi-disciplinary collaboration among Michigan Tech faculty atmospheric modelers, forest ecologists, and statisticians with additional expertise from the faculty of the University of Michigan College of Engineering and School of Public Health. We also involved students and faculty by hosting two widely publicized multi-disciplinary sustainability seminars – one by Dr. Colleen Reid, University of Colorado Department of Geography, and two by Dr. Shiliang Wu, Michigan Tech University, Atmospheric Sciences Program (one on North Campus and one on Central Campus). We partnered with established U-M research centers to reach a wide audience, and we amplified the reach by broadcasting recordings nationally as part of the Michigan Public Health Training Center and Michigan Lifestage Environmental Exposure and Disease (MLEEaD) center. These seminars also provided career development and visibility for early career faculty while developing actionable information and links with our external partners.

The research was linked to on-going mission of our engaged partners at the California Department of Public Health, assuring the translation of findings to science-based action. California Department of Public Health's research supports the Senate Bill 375 Sustainable Communities and Climate Protection

Act which governs the State's climate action goals. They support this on-going research to directly examine wildland fire smoke exposures and the associated health effects and to identify vulnerable populations and communities, via geospatial analyses such as Cal EnviroScreen, and our long-term aims could inform these decision tools. California Department of Public Health is in a position to utilize the data produced from this research to make decisions about public health surveillance and mitigation efforts for vulnerable communities. They are committed to support the activities in this proposal and have dedicated staff time to the effort. Further, our research has broader national applications. Understanding and quantifying the connections between climate change and health is a priority for the Centers for Disease Control's Building Resilience Against Climate Effects (BRACE) framework, in which both Michigan and California and many other states (including members of our research team) participate.

Findings

While some air pollutants are ubiquitous and well mixed across large areas covered by air quality monitors, wildland fire smoke can be locally concentrated and occur in remote areas with few monitoring stations. Use of routine air quality monitoring network data for wildfire smoke exposure therefore may not fully capture the extent of impacts or impacts in particular areas and times that were not monitored. One solution to this problem to determine exposure using atmospheric modeling techniques (Figure 1). Sophisticated atmospheric models provide estimates of primary and secondary pollutants over an entire region and time period without gaps. Further, models have the capability to differentiate the impact of wildfire from other sources of pollution which provides more specific relationships between wildfire air quality and health impacts that are not possible with ambient data alone. However, these models each have strengths and limitations. Our project was to review options and create a research proposal. Previously, our team successfully modeled emissions in southern California with another less sophisticated model.

During our research workshop of our newly broadened team worked through reviewer comments on a previously submitted grant, including the selection of atmospheric modeling (using GEOS-Chem and Community Multiscale Air Quality (CMAQ)) and other aspects of model resolution issues.

Using a full chemistry atmospheric model can overcome barriers to the measurement of health effects attributable to wildfire-specific pollutants. To approximate exposure to wildfire smoke pollutants, most studies use air quality monitor networks or satellite remote sensing-based measures. The former are generally too sparse to feasibly interpolate over large remote regions and the latter do not necessarily reflect surface conditions (Preisler et al. 2015). Further, neither of these methods distinguishes between wildfire-specific pollutants and those from any other source (e.g., transportation). This is important because (1) the source of fine particulate matter ($PM_{2.5}$) affects its chemical composition, which in turn can affect the health responses (Chung et al. 2014; Naeher et al. 2007; Wegesser, Pinkerton, and Last 2009), and (2) the health effects of wildfire-related ozone exposure are largely unstudied (Reid et al. 2016). Air quality modeling methods, while requiring interdisciplinary expertise and additional efforts, can provide estimates of the pollutant levels that are solely sourced from wildfires. This is essential for determining the fraction of health effects directly attributable to wildfire activity and for making predictions about the public health impacts of increasing wildfire activity due to climate change (Spracklen et al. 2009; Westerling et al. 2006). These methods have been used routinely in risk assessment for PM and to address measurement error in exposure assessments from in situ-based approaches. However, geospatial mapping of wildfire smoke exposure using a coupled emissions-transport model has seldom been used (Liu et al. 2015 identified only 6 of the 61 studies that used modeling methods); and the methods have not been applied to a broad study domain to link to observed human health effects.

However, GEOS-Chem and CMAQ have not been widely used to model wildfire emissions. Successful air quality modeling requires careful choice of model resolution and extensive model evaluation with available air quality monitoring data (Chen et al. 2014; Friberg et al. 2016). The CMAQ model has been used to estimate health impacts from PM2.5 based on multiple annual simulations with and without wildland fire (Rappold et al, 2017; Fann et al, 2017). Recently CMAQ was specifically evaluated for skill in representing ozone (O_3) and $PM_{2.5}$ impacts from specific wildland fires and showed some over-estimation tendency for O3 and both over and under-estimation for $PM_{2.5}$ impacts (Baker et al, 2016). Ideally, other modeling systems will be evaluated similarly against routine and special field study data in the future to improve confidence in predictions. Our main output from this grant was a larger grant proposal, and we proposed to rely on the CMAQ modeling platform. In developing that proposal, we acknowledged the strengths and limitations and expected opportunities to understand and refine the modeling platform more fully. We hope to communicate our findings via a publication in the peer reviewed literature.

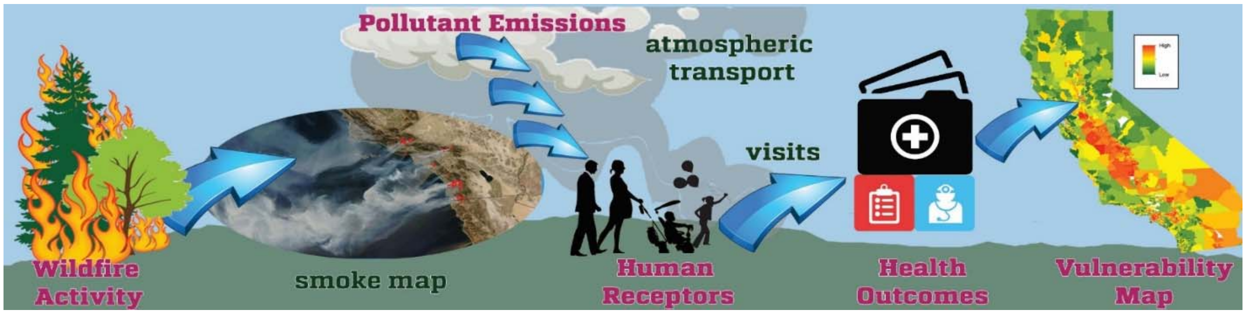


Figure 1: *Conceptual overview for studying associations between wildfire smoke and health for mapping vulnerability.*

Outputs

Our team accomplished our main objective for the Catalyst grant, which allowed our team to complete an R01 grant submission to National Institute for Environmental Health Sciences (NIEHS) for an opportunity to pursue our research (February 2017). To accomplish this, on January 10, 2017, we convened a workshop among our emerging research team including an in-person visit from our government partner, California Department of Public Health's Sumi Hoshiko, to address atmospheric modeling (exposure assessment) issues. Dr. Kirk Baker, US Environmental Protection Agency (EPA) Office of Research and Development, participated by phone. This in-depth workshop enhanced an existing multi-disciplinary collaboration among University of Michigan College of Engineering and School of Public Health faculty, Michigan Tech faculty (atmospheric modeler, forest ecologist, and geospatial analyst), government atmospheric modelers, and statisticians with additional epidemiologic expertise from the faculty of the University of Colorado. U-M's Dr. Allison Steiner served as an evaluator, providing peer expert feedback on our approach which was instrumental in our team's ability to reach closure on our approach which allowed us to move ahead with our grant proposal. Our main outcome was to resolve technical questions about atmospheric modeling approach that allowed our team to complete a R01 grant proposal to NIEHS.

This grant was essential to our team's ability to come together across disciplinary and geographic boundaries. In-person interactions were essential to overcoming the disciplinary language differences. We had time during our discussions and on breaks to have nuanced and in-depth scholarly conversations that our conference calls simply don't allow for. In addition, we used the welcome dinner and other parts of the visit to be sure that early career investigators had a chance to meet more senior faculty for career development and visibility.

Side-by-side with the research workshop, we took advantage of the presence of nationally recognized experts to involve students and faculty with two additional events: a career talk and a research workshop. First, Ms. Sumi Hoshiko met with 7 students, and three practitioners (including a local public health manager) over lunch to discuss the California Department of Public Health and her career path. Several SPH students were interested in opportunities for summer internships and future employment.

Secondly, we hosted a widely publicized multi-disciplinary sustainability seminar by Dr. Colleen Reid, University of Colorado Department of Geography. Over 40 attendees participated in person (we exceeded our proposed goal). This included many students. The seminar was recorded and is available via the Michigan Public Health Training Center training portal and the Michigan Lifestage Environmental

Exposure and Disease (MLEEaD) website. The seminar was promoted on social media by SPH and the Graham Institute to current students, faculty and staff as well as to SPH alumni networks.

Additionally, on April 18,2017, Dr. Shiliang Wu, Michigan Tech University, Atmospheric Sciences Program, presented two seminars because of the geographic split on U-M campus of College of Engineering on north campus and School of Public Health (SPH) on central campus. Dr. Wu presented a special research seminar on North Campus at CLaSP and at the SPH at our Environmental Epidemiology seminar to engage many students with his research ideas. The recordings are available to the public via the Michigan Lifestage Environmental Exposure and Disease (MLEEaD) webpage.

Our team also advances scholarship through presentations and plans for publishing a manuscript in the peer reviewed literature. We were delighted to have the opportunity to present our research aims to the advisory board for the Graham Institute on April 13th and to receive feedback and ideas. We presented preliminary data at the Lancet Planetary Health conference in Boston. We also engaged students to learn more about public health careers in environmental health. Several graduate students were interested in opportunities for summer internships and future employment with the State of California.

Our project is generating new ideas based on the enthusiasm for continuing to work together as a team. From this enthusiasm, for example, a subgroup on our team presented a poster "Approaches and challenges to connecting exposure to air pollution from wildland fire emissions to cardiopulmonary health outcomes" to a national climate and health meeting sponsored by the Lancet journal at Harvard University, called Planetary Health. (MTRI generously provided the travel funding for conference attendance.) We are continuing to make progress on a manuscript for publication based on the white paper developed for this grant.

Outcomes

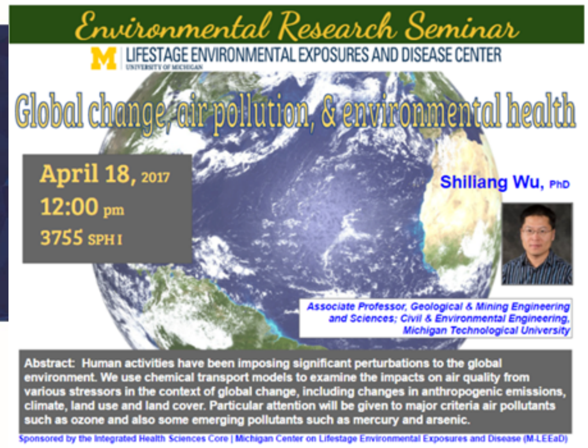
We increased the understanding of faculty, students and staff about the connection between atmospheric concentrations of pollutants from wildland fire smoke and human health. Research seminar participants could name one thing they learned from the seminar, and it has stimulated discussion on campus about the connections between climate change and human health.

Our project also created connections among members of the research team that is allowing us to explore additional ways to work together to pursue this research and other scholarship. As this research continues, we anticipate that over the long-term, we will increase our knowledge and advance sustainability.

Other information (optional)

We had some success engaging with social media (Twitter) to advertise our seminars. We appreciate the Graham Institute's assistance with amplifying the messages to reach a broader audience.


CLaSP Special Seminar
CLIMATE AND SPACE SCIENCES AND ENGINEERING
Monday, April 17, 10:00 a.m.
Donahue Room, rm 2422
Professor Shiliang Wu
of Michigan Tech
"GLASP: Global Arsenic Pollution"
Professor Wu will discuss the source-receptor relationships of environmental pollutants such as arsenic and mercury, and the importance of international cooperation in addressing these toxins. Please join us!
Space Research Building
University of Michigan - North Campus
2455 Hayward Drive, Ann Arbor


Environmental Research Seminar
LIFESTAGE ENVIRONMENTAL EXPOSURES AND DISEASE CENTER
Global change, air pollution, & environmental health
April 18, 2017
12:00 pm
3755 SPH I
Shiliang Wu, PhD
Associate Professor, Geological & Mining Engineering and Sciences; Civil & Environmental Engineering, Michigan Technological University
Abstract: Human activities have been imposing significant perturbations to the global environment. We use chemical transport models to examine the impacts on air quality from various stressors in the context of global change, including changes in anthropogenic emissions, climate, land use and land cover. Particular attention will be given to major criteria air pollutants such as ozone and also some emerging pollutants such as mercury and arsenic.
Sponsored by the Integrated Health Sciences Core | Michigan Center on Lifestage Environmental Exposures and Disease (M-LEEaD)


MICHIGAN
Public Health Training Center
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TRAININGS onsite & online
COLLABORA projects
Health Effects Of The 2008 Northern California Wildfires
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Online
Availability Open
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Cost No Charge
Credit None available.
DESCRIPTION
COURSE DETAILS
INSTRUCTORS
Course Details
Objectives
• Discuss evidence of climate change-related health effects regarding smoke inhalation
• Identify geospatial and temporal analysis techniques used in an epidemiological study
Sponsors
The Michigan Public Health Training Center was pleased to support the recording of this lecture. The seminar series is provided by the UM Graham Sustainability Institute, MLEEaD Center, and Michigan Tech Research Institute.

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References

French, N.H., K. Anthony, K. Baker, M. Billmire, S. Hoshiko, J. Hutchinson, J. Johnson, P.D. Koman, B. Koziol, V. Limaye, J. McCarty, R. C. Owen, C. Reid, B. Thelen, S. Wu. Approaches and challenges to connecting exposure to air pollution from wildland fire emissions to health outcomes. Planetary Health and GeoHealth Annual Meeting, Boston, MA, April 29, 2017

French, NH, M Billmire, JT Dvonch, S Hoshiko, J Hutchninson, PD Koman, MS O'Neill, CE Reid, A Steiner, BJ Thelen, S Wu. Modeling Wildland Fire Smoke Exposure for Quantifying Human Health Associations (*First draft prepared)* (after first author, authors listed alphabetically)