Jacklyn Vo
February 16, 2021
Writing 159A

Assignment 3: Analytic summary of a peer reviewed IMRAD article

Liu, J. C., Mickley, L. J., Sulprizio, M. P., Dominici, F., Yue, X., Ebisu, K., Anderson, G. B., Khan, R., Bravo, M. A., & Bell, M. L. (2016). Particulate Air Pollution from Wildfires in the Western US under Climate Change. Climatic change, 138(3), 655–666. https://doi.org/10.1007/s10584-016-1762-6.

Introduction

As anthropogenic climate change persists, the severity and frequency of wildfires and their smoke waves are predicted to exacerbate in the western US (Liu et al., 2016). Not only are fires devastating to an area's landscape and infrastructure, they can also be dangerous to those inhaling its air pollutants in surrounding regions. Fires emit toxic levels of $PM_{2.5}$ during a short time span and disperse in the atmosphere relatively quickly, depending on meteorological variables. Two consecutive days or more with high fire specific $PM_{2.5}$ are defined as "smoke waves". $PM_{2.5}$ is a mixture of fine solid and liquid particles with diameters of 2.5 micrometers and smaller. The inhalation of high concentrations of fire associated $PM_{2.5}$ is correlated with heightened health outcomes of respiratory morbidity, asthma, and chronic obstructive pulmonary disease (COPD). Although there is substantial research on the health effects of all-source $PM_{2.5}$ exposures, research on estimating the amount of $PM_{2.5}$ emitted by fires are limited. This could be because smoke waves are short-term events that are difficult to correlate with potential latent health effects. This paper examines modeling projections that aim to quantify how much $PM_{2.5}$ is currently associated with wildfires and how much is predicted to be released as the fire are predicted to intensify.

Methods

To quantify fire-specific $PM_{2.5}$ concentrations, Liu et al. (2016) used a 3-dimensional (3D) chemical transport model, GEOS-Chem, and fire prediction models to estimate $PM_{2.5}$ levels associated with wildfires, in the present day (2004–2009) and future (2046–2051), in 561 western US counties. The GEOS-Chem model is a global chemistry model that solves for the temporal and spatial evolution of both anthropogenic and wildfire aerosols. The GEOS-Chem model was run three times with the NASA Global Modeling and Assimilation Office Goddard Earth Observing System (GEOS-5) horizontal resolution of 0.5°x0.667° for present time and 4° x 5° for future conditions. The model calculated 24-hour $PM_{2.5}$ averages and was simulated under the following initial conditions: 1) $PM_{2.5}$ concentrations from all present-day sources 2) $PM_{2.5}$ concentrations from non-fire sources 3) $PM_{2.5}$ concentrations from all future sources. To differentiate between how much $PM_{2.5}$ is directly from wildfires, boundary conditions consisted of simulations with and without fire emissions. This model included black carbon and primary organic particles and was validated by daily and seasonal ground-based and aircraft measurements. Additionally, fire prediction models, incorporated in the GEOS-Chem model, used observed area burned, meteorological variables, and the effects of elevation, population, fuel load, and Santa Ana winds to measure fire emissions. After the model was run, the authors incorporated the EPA Population Projections and 2005 US census tract to estimate the amount of people in a county. This multi-model approach estimated the $PM_{2.5}$ concentrations associated with wildfires in 561 western US counties.

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Results

Liu et al.'s (2016) GEOS-Chem model found that the average fire- $PM_{2.5}$ concentrations will increase about 160% from 0.69 $\mu g/m^3$ (2004-2009) to 1.13 $\mu g/m^3$ (2046–2051). Under future climate change conditions, these elevated $PM_{2.5}$ levels are spatially heterogeneously associated with an increase in smoke waves of 0.98 smoke waves per year to 1.53 smoke waves per year. The authors estimated that there are at least 82 million people are going to experience a 57% increase in frequency and 31% increase in intensity of smoke waves.

Discussion

The GEOS-Chem model may underestimate the amount of wildfire specific $PM_{2.5}$ under climate change conditions. This is because the fire prediction model does not include how fire suppression and changes in vegetation may lead to an increased probability of large fires. To minimize uncertainty, modelers increased confidence by only incorporating median area burned projections found in the fire prediction model. The authors emphasize the need for expanded monitoring to both rural and urban regions to better estimate $PM_{2.5}$ concentrations in fire-prone areas. Atmospheric chemical transport models can be biased due to limitations on emissions and meteorology inputs. However, these models can be effective tools in studying the impacts of fire specific pollutants on ambient air quality and population

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Article Analysis

1. ***Is the topic of the paper somewhat original?***
   The paper topic is unique in the way that air quality impacts associated with wildfires are not commonly modeled. Usually, air quality is examined with the perspective of health and air quality effects. Although this paper is concerned with the health of people living in the western United States, the researchers are most interested in quantifying the magnitude in which air quality is predicted to change as climate change persists and which regions will be most affected. This paper topic is also original in the sense that it was only recently that humans have been concerned with air quality from wildfires... let alone connecting the dots with wildfires and climate change.

2. ***Who sponsored the study?***
   The study was sponsored by the National Institute of Health (NIH), National Institute of Environmental Health Sciences (NIEHS), and the Yale Institute for Biospheric Studies (YIBS). The study was supported by multiple contributors within the NIH and NIEHS. The NIH/NIEHS is part of the U.S. Department of Health and Human Services and are one of the largest biomedical and environmental health research centers in the world (NIH, n.d.). YIBS is Yale's environmental science research center, including departments in public health, environmental studies, biology, and anthropology (YIBS, 2016). Because the study was funded by renowned institutions, I believe the study is credible and valuable. These programs are also dedicated to research that aims to improve the health of the general public, so bias is limited. If the study was done by a think tank, it would be less credible, and readers should be skeptical of the results.

3. ***What was the aim of the study? What hypothesis did the researchers test? Are the conclusions reached important to you and others?***
   The aim of the study is to quantify how much particulate matter (PM2.5) was generated by wildfires in the western United States counties in 2004–2009 and 2046–2051. The study questions how the air quality was affected in 2004–2009 and how air quality will change under global warming conditions. Furthermore, which communities will be most affected by increasing PM2.5 conditions? The researchers tested to what extent is PM2.5 associated with fires a risk to western US counties and which locations are most and least at risk. These conclusions are important to me and the general public because this study presents areas that will be considered higher risk of increasing PM2.5 concentrations in the near future. Inhaling high concentrations of PM2.5 is of health concern to the general public, particularly children, adults, and those with respiratory illnesses. This study informs public health officials and policy makers about potential air quality scenarios they need to consider when planning for climate change. Quantifying the magnitude of change and identifying locations most affected are crucial steps in learning about climate change and mitigating the effects of air pollution on our communities.

4. ***Do the Results section and Methods section match?***
   The methods the modelers used are appropriate for the results received. The methods section corresponds with how the researchers came up with their results for the air quality intensities and parameters; however, the authors do not provide much information on

how they got the number of individuals expected to experience smoke waves. Although the modelers do not provide readers with a clear calculation of how they concluded these values, they provide us with supplementary information that we could refer to if we wanted to see the data table. Despite not clarifying this calculation in the methods, the paper is still credible because they provide us the dataset and everything else is transparent. The results expand to discuss which locations, the magnitude, and vulnerable populations will be most affected.

5. ***Are both P values and confidence intervals reported?***
   P values and confidence intervals are reported in the results section and supplementary material of the study. The parameters, smoke wave frequency, intensity, length, and length of smoke wave season, for the future scenario compared to present day have a p value of less than 0.01. This means that the study experienced statistically significant results, observing increased values for each parameter. In the Supplementary Material, the confidence intervals are reported in a chart with the PM2.5 levels. Providing these p values and confidence interviews enhance the reliability and transparency of the study, elevating the reader's trust in the researchers' work.

6. ***Have the authors discussed possible limitations of the study?***
   The authors clearly write that climate models have limitations. Some of the limitations include only including limited emission and meteorological processes, inaccurate probability of fire, and computational expenses. The model also underestimates the amount of PM2.5 associated with wildfires because it is difficult to model the probability increased wildfires. Uncertainty analyses are done to quantify the variabilities of the input and estimate the reliability of the model. The researchers also prioritized certain processes, using their expertise discretion, to develop the most robust and accurate model.

7. ***Do the study's findings have practical importance, regardless of whether they have statistical significance?***
   This study is important and have been well cited because it evaluates a growing area of interest: air quality in regard to anthropogenic climate change induced wildfires. Regardless of the statistical significance, the study presents an area of concern for health professionals, urban planners, policy makers, and the general public. Anthropogenic climate change is a widely accepted concept that has multi-faceted effects and examining all aspects of this issue is vital for protecting the health of humans and environment.

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