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APPLICATION OF PHOTOCHEMICAL GRID MODELS TO IDENTIFY HIGH PRIORITY LOCATIONS FOR HEALTH-BASED COMMUNITY MONITORING NEEDS

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1. INTRODUCTION

Environmental Justice (EJ) is defined by the United States Environmental Protection Agency (USEPA) as both the fair treatment and the meaningful involvement of all people, regardless of race, color, income with respect to the decisions, regulations and policies that result from the implementation of environmental laws. Fair treatment means that no community should bear an undue amount of negative environmental consequences because of economic activities or government actions or policies. Meaningful involvement means that all citizens have a fair opportunity for participation in the process that leads to decisions that have the potential to affect their environment and health (USEPA 2021a). Although EJ issues have been addressed by the USEPA Office of Environmental Justice in Action (OEJ) since its formation in 1992, there is a renewed focus to support communities disproportionally affected by air, water and other types of pollution.

The American Rescue Plan (ARP) legislation signed into law by President Biden in March 2021 (USEPA 2021b) has provided the USEPA with funding to address two major initiatives. The Air quality monitoring and the Environmental justice initiatives. The Air Quality monitoring initiative provides funding to improve ambient air quality monitoring for communities across the United States. The initiative promotes a grant competition for nonprofit community-based organizations; direct awards to air agencies; and mobile monitoring labs for air sensor loan programs. The Environmental Justice initiative funds programs and activities that identify and address disproportionate environmental or public health harms and risks in underserved communities due to COVID-19 and other pollution. For instance, the initiative is has already distributed 2.8 million dollars to 14 EJ programs for outreach to underserved communities and for house intervention programs to improve air quality, among other activities.

Achieving the goals of these initiatives could be advanced more effectively using a data-driven and transparent process to identify disadvantaged communities. The USEPA developed and maintains EJSCREEN (USEPA 2019), an environmental justice mapping and screening tool, with the intent to provide users with a nationally consistent dataset to identify locations that may be candidates for further environmental review. The ARP has allocated $720,000 dollars to enhance the development of EJSCREEN as well as to support other related resources. There are many reasons to have reliable and accurate Environmental Justice screening tools. This information is of interest to communities and other stakeholders and can inform a wide range of research and policy goals. Screening tools can also help ensure that certain areas are not overlooked and receive appropriate consideration and to identify and better support our at-risk communities.

This case study evaluates the sensitivity of EJSCREEN to environmental inputs in order to assess the potential benefits of using EJSCREEN with local datasets for improved decision-making. EJSCREEN's sensitivity to ozone was analyzed by replacing the ozone concentrations in the original EJSCREEN tool with higher resolution modeling data. Although this case study evaluates ozone, some of the conclusions can be applied to many other environmental indicators in the screening tool.

2. MOTIVATION

One motivation of this study was to better understand how EJSCREEN presents the results to

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the public and how inclusion of more accurate local data could affect the results. EJSCREEN combines 11 environmental indicators and 6 demographic indicators displayed in maps and reports. EJSCREEN provides a single interface that helps explore environmental and demographic issues in a consistent manner, but as EPA-acknowledges, it has a series of limitations. First, it is pre-decisional, since the tool is not designed as the basis for agencies to make determinations, regulations, or policies. The screening tool is incomplete because it does not capture all the relevant environmental issues that could affect a community, sometimes this is the result of lack of enough quality data to be integrated in the tool. Finally, the tool has significant uncertainty for index values as they combine the uncertainties of both the demographic and environmental input data.

EJSCREEN's environmental indicators are shown in Table 1 and almost all of them are air-related, either directly or indirectly. This provides multiple opportunities for the air quality modeling community to add value to the screening tool. The most immediate needs are related to improving the quality and spatial resolution of the underlying data driving the tool.

Table 1. Environmental indicators included in EJSCREEN

Indicator	Key Medium
Ozone	Air
Particulate Matter ($PM_{2.5}$)	
NATA[1] Air Toxics Cancer Risk	
NATA Respiratory Hazard Index	
NATA Diesel PM (DPM)	
Lead Paint	Dust/Lead Paint
Traffic Proximity and Volume	Air/Other
Proximity to RMP[2] Sites	Waste/Water/Air
Proximity to TSDFs[3]	
Proximity to NPL[4] Sites	
Wastewater Discharge	Water

[1] National-Scale Air Toxics Assessment
[2] Risk Management Plan
[3] Treatment, Storage or Disposal Facilities
[4] National Priorities List

3. METHODOLOGY

EJSCREEN relies on the concept of the EJ index to combine demographic and environmental information. The raw EJ index is calculated for each census block group for a given region or nationally and is the result of the multiplication of each of the variables shown Equation 1.

$$\text{EJ Index} = \text{Environmental Indicator} \times (\text{DI Block Group} - \text{DI US}) \times \text{Census Block Group Population} \quad (1)$$

The population is the number of people that live on a given census block group. The demographic index (DI) is the average of the percent minority and the percent low-income people within each census block group as shown in Equation 2.

$$\text{Demographic Index} = (\%\text{ minority} + \%\text{low income})/2 \quad (2)$$

The second term in Equation 1 is the difference between the demographic index calculated for the target census block group with the demographic index calculated for the entire US. The environmental indicator in Equation 1 refers to any of the indicators included in Table 1. In the case of the ozone EJ index, the environmental indicator are the ozone concentrations in units of ppb. The raw index values themselves are hard to interpret and the USEPA provides the final index as population weighted percentiles.

A case study that focuses on the ozone EJ index is presented here. The underlying ozone concentrations data in EJSCREEN was replaced with finer resolution and more current modeling output to observe the potential changes on the ozone EJ index. In this study we applied previous State Implementation Plan [SIP] modeling results, which had demonstrated acceptable model performance. State- or area-specific modeling data may have more accurate emissions than older or national-scale modeling data. Additionally, for this case study, the state-specific modeling results were available for 4-kilometer (km) grid resolution, a higher spatial resolution than the default 12km grid data used in EJSCREEN. The state-specific dataset was implemented with source apportionment information that can provide critical insights related to what emissions sectors are contributing to impacts. This can guide decision makers not only to select those areas with the highest priority for further analysis, such as community monitoring, but also the pollutants of importance to a given area.

This proof-of-concept study uses an existing modeling platform with emissions projected for the year 2023 (RAQC 2021). This dataset focuses on the ozone season in Colorado and therefore only spans the summer months. This study only considers updates to the ozone data instead of Particulate Matter (PM); however, it is noted that

PM is a very important driver for health impacts and should be consider on any assessment. Modeling output was processed to obtain the highest values on each grid cell for the 8-hour daily ozone maximum. The updated ozone concentrations from the state-specific modeling were then used to replace the EJSCREEN default ozone concentrations and the ozone EJ Index was recalculated following Equation (1). Finally, the raw index values were ranked and presented in terms of population weighted percentiles to directly compare to EJSCREEN. This method demonstrates the ability to leverage existing modeling data to support environmental justice priorities. This process can also provide added value and benefits for existing modeling data beyond their original purpose. Although our case study focuses on Colorado, the methodology can be applied to other regions in the country.

4. RESULTS

Figure 1 shows a comparison between the original ozone EJ index as obtained by default from EJSCREEN on the top, while the bottom panel shows the index with the results using the state-specific 4km data. Although ozone concentrations were updated for the entire state of Colorado, Figure 1 shows a zoomed-in area that encompasses the Denver metropolitan area, north is generally at the top of the figures, and the Colorado the Rocky Mountains are located west of the urban corridor, at the left of the figures. Figure 1 illustrates that there are no significant differences to the ozone EJ Index between the national default data and the state-specific updates. Only a few blocks show visible changes, but in general the change is subtle.

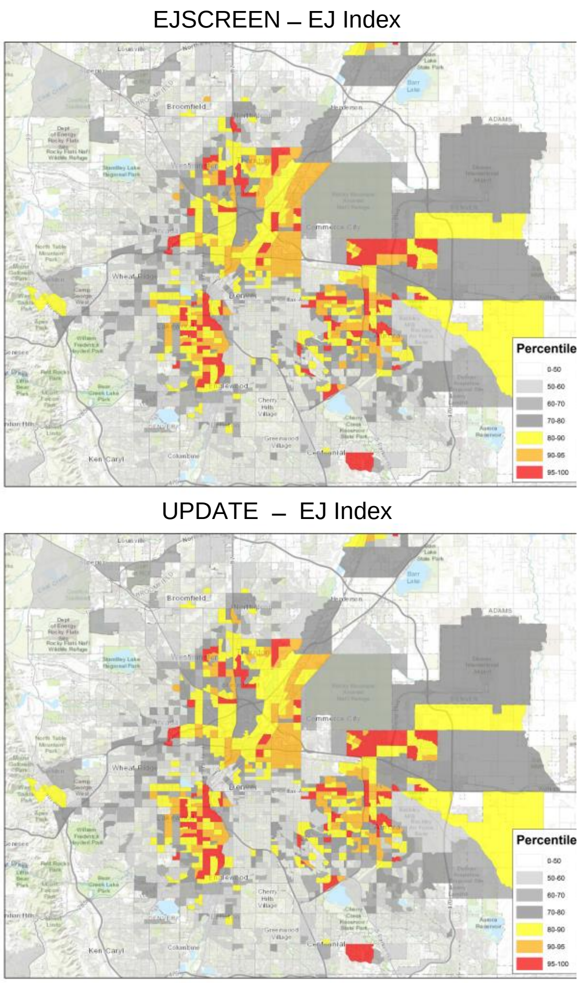


Figure 1. Ozone EJ Index comparison between original EJSCREEN (top) and updated data (bottom).

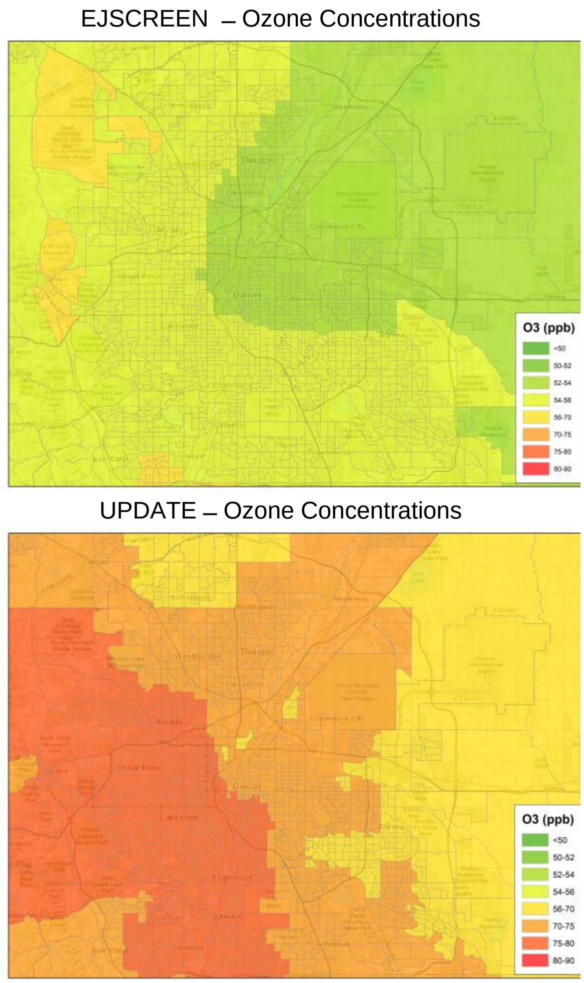
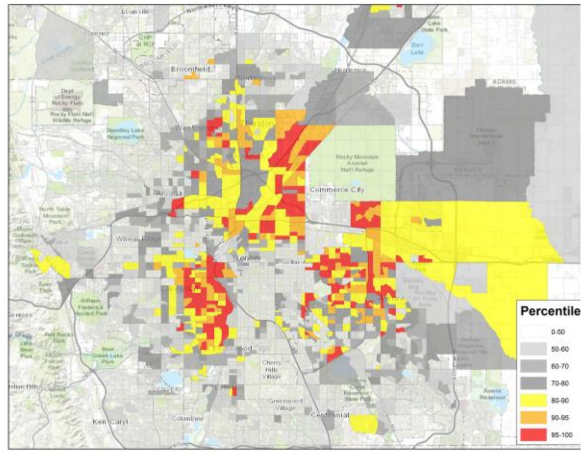


Figure 2. Ozone concentrations comparison between original EJSCREEN (top) and updated data (bottom).

To understand the reasons behind the small changes in the EJ Index, the underlying data was further analyzed. Figure 2 shows a comparison of the ozone concentration data between the original EJSCREEN data and the state-specific 4-km modeling data. Figure 2 shows that ozone concentrations in the national default EJSCREEN are constant across the Denver metro area and exhibit less spatial variability compared to the state-specific 4km data. The figure also shows that the ozone concentrations are systematically much lower for the original EJSCREEN data. Notice that the census blocks groups have similar population counts but different population densities, which is generally makes the blocks' area very different. For those census blocks groups with a large area, the current EJSCREEN may not capture important spatial gradients of the environmental indicators within each block.

Figure 3 shows a comparison of the Demographic index compared to the ozone index, from the original EJSCREEN. This figure illustrates that there is a high spatial correlation between both fields. The raw EJ index values were also inspected, and we found that the updated values increase relative to the original EJSCREEN dataset, but importantly they show the same spatial correlation with the demographic index. As mentioned above, the index is presented in population weighted percentiles, notice that this effectively preserves the same ranking irrespective of the ozone inputs, leaving the ozone index mostly unchanged. Figure 3 indicates that the demographic index is in fact the main driver in the ozone index, and this has important implications for the suitability of the screening tool for its intended purpose.

EJSCREEN – Demographic Index



EJSCREEN – Ozone EJ Index

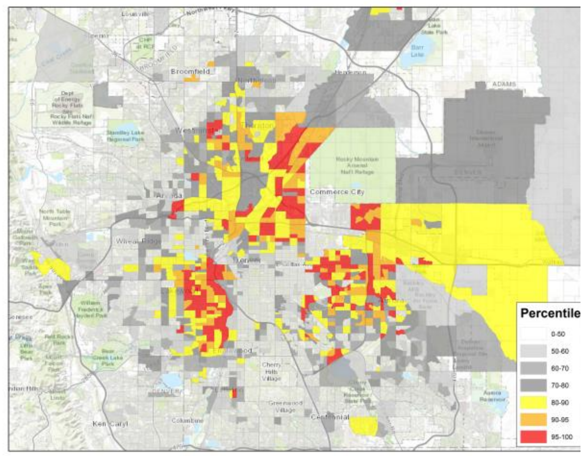


Figure 3. Comparison between EJSCREEN Demographic Index (top) and ozone EJ Index (bottom).

5. DISCUSSION

This study replaced the ozone concentrations in the original EJSCREEN tool with higher resolution data from recent SIP modeling. We found that updating the ozone concentrations had only a small effect in the final ozone EJ index expressed as a percentile. It was found that the ozone EJ index is in fact most sensitive to the demographic index, which is a consequence of expressing the results as a percentile. If EJSCREEN is not sensitive to changes in air pollution levels, then its results will not change, and air quality related mitigation strategies will not show any impacts or changes for those populations disproportionately affected by air pollution. If the results are not truly representative of environmental burdens, then areas that are heavily burdened may not receive the appropriate resources needed for further investigation and mitigation.

One recommendation from this study is to revise the EJSCREEN methodology to produce results that enable users to assess the minority and low-income populations pollutant burdens. We recognize that EJSCREEN is a screening tool; however, it is important that the tool be sensitive to the environmental indicator fields to provide representative information about the relative differences in pollutant burdens across various communities.

Recommendations for future work include several potential areas for further analysis. It is important to understand if the findings for the ozone EJ index also apply to all other environmental indicators. It is recommended that a thorough sensitivity analysis for all environmental indicators currently included in EJSCREEN be conducted. It is recommended that the suitability of different metrics for each of the environmental indicators be evaluated, for instance the effects of using 1-hour ozone maximum instead of the highest 8-hour daily average. Finally, it is recommended that EJSCREEN be adapted to enable users the selection of available input to leverage the full power of existing, state and local information, such as modeling with source apportionment results.

6. REFERENCES

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USEPA, 2021b. American Rescue Plan. Accessed October 2021, https://www.epa.gov/arp