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Using Statistical and Machine Learning Models with Remotely Sensed Data to Estimate PM2.5 in the San Francisco Bay Area

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Abstract Text:

Ambient fine particulate matter ($PM_{2.5}$) is associated with significant adverse health impacts. Continuous, high quality and high resolution $PM_{2.5}$ data has the potential to be greatly useful in public health research and mitigation efforts, but $PM_{2.5}$ monitors are few and unevenly distributed over the landscape. In California, this is of particular concern because catastrophic wildfires have caused and are projected to continue causing episodes of very high levels of $PM_{2.5}$. Previous studies have shown the potential for Aerosol Optical Depth (AOD), meteorological data, emissions, and land cover/land use (LCLU) data to estimate $PM_{2.5}$ using a variety of models. However, the most recent research has yet to be applied in the San Francisco Bay Area, where high density episodes of $PM_{2.5}$ were observed in 2017 and 2018. In addition, few studies have taken advantage of flexible and powerful machine learning algorithms to estimate $PM_{2.5}$ levels, especially considering the variety of parameters known to improve such models. This study aims to apply the state of the art $PM_{2.5}$ estimation techniques, including a proven two-stage model trained on AOD, meteorological, and LCLU data, and compare it to promising ML algorithms including random forests, and gradient boosted decision trees. We envision that this approach will lead to greatly improved estimation of $PM_{2.5}$ in California, and that more flexible ML techniques will allow for improved results when predicting extreme $PM_{2.5}$ events, such as resulting from a wildfire, which are particularly important for public health research.

Plain-Language Summary:
The adverse health effects associated with fine particulate matter ($PM_{2.5}$) are well documented, but monitors are few and far between. Having continuous, fine resolution data would be beneficial for public health research and mitigation efforts, especially in California, where wildfires frequently cause episodes of elevated $PM_{2.5}$. This study uses a variety of data sources, including remotely sensed, emissions, land cover/land use, and meteorological data. We compare the performance of a variety of models to estimate the $PM_{2.5}$ in areas where there are no monitors. We predict that flexible machine learning algorithms will perform better than traditional statistical methods, especially when estimating outliers in $PM_{2.5}$ levels as caused by a wildfire.

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