Estimating spatiotemporal trends in wildfire smoke concentrations in the western United States

The United States (US) has seen significant improvements in seasonal air quality over the past several decades. However, particulate air quality in summer over the majority of the western US has seen little improvement in recent decades. Particulate matter with diameters < 2.5 microns (PM$_{2.5}$) is a large component of ambient air quality that is associated with negative health effects and visibility degradation. Wildfires are a major summer source of PM$_{2.5}$ in the western US. While anthropogenic-related sources of PM$_{2.5}$ have decreased across the US, wildfires have increased in both frequency and burn area since the 1980s. It is currently uncertain 1) how this increase in wildfires has impacted seasonal air quality trends and 2) how the health effects of wildfire-emitted PM$_{2.5}$ may differ from anthropogenic-sourced PM$_{2.5}$. We do not directly address the latter uncertainty, but rather focus on improving smoke-exposure estimates which are a critical, yet challenging, component to understanding the health effects of wildfire-emitted PM$_{2.5}$.

We use a combination of satellite estimates, surface observations, and chemical transport models to distinguish wildfire smoke PM$_{2.5}$ from non-wildfire-smoke PM$_{2.5}$ during summer in the US. We update the record of seasonal trends in PM$_{2.5}$ observed at surface monitors to the most recent decade and provide the first estimates of trends in wildfire smoke-specific PM$_{2.5}$. We find continued decreases in total-PM$_{2.5}$ in most seasons and regions of the US. In summer in heavily fire-impacted regions of the western US we find non-decreasing total-PM$_{2.5}$ while wildfire smoke-specific PM$_{2.5}$ has increased and non-wildfire-smoke PM$_{2.5}$ has decreased.

We expand the application of blended smoke exposure models, which use multiple data sources as input variables (e.g. satellite-derived aerosol optical depth, chemical transport models, etc.), to the full western US. These models have previously only been applied on an individual state basis. We also incorporate a novel dataset into the model, Facebook posts, which have been shown to correlate well with surface PM$_{2.5}$ concentrations during the western US wildfire season. We find the blended smoke exposure model performs well across the western US ($R^2 = 0.66$). However, the Facebook dataset is well correlated with interpolated surface monitors (another input variable) and thus does not significantly improve the blended smoke-exposure estimates.