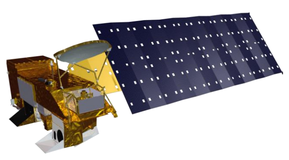
Measuring California Air Quality through the Use of NASA Earth Observations to Identify Spatial, Temporal, and Social Disparities in Particulate Matter Pollution

Abstract

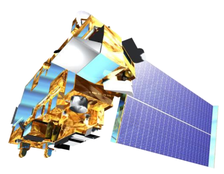
Thirty-five million California residents live in counties where they are more susceptible to contracting an air quality-related health ailment. Particulate matter less than 2.5 μm in size ($PM_{2.5}$) is an important metric of air quality and can cause significant health problems. Despite California's policies targeted at reducing $PM_{2.5}$ and other air pollutants, three major cities experienced increasing levels of $PM_{2.5}$ from 2013 to 2015. California's rapid population growth compounds these air quality problems and stresses the need for air pollution reduction policies. Current air quality remediation and regulations are based off *in situ* air quality monitors; however, these methods do not provide optimal spatial coverage. The NASA DEVELOP project team investigated the advantages of using $PM_{2.5}$ data derived from remote sensing imagery taken from Moderate Resolution Imaging Spectroradiometer (MODIS), Multi-angle Imaging Spectroradiometer (MISR), Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), and Sea-Viewing Wide Field-of-View Sensor (SeaWiFS), to study $PM_{2.5}$ in California from 1998 to 2016. We analyzed trends in $PM_{2.5}$ concentrations over time as well as the spatial distribution of $PM_{2.5}$ relative to socioeconomic factors. With the results of these analyses, the California Air Resources Board will gain a clearer understanding of the spatial and temporal distribution of particulate matter pollution in the state, and which communities are more likely to face heightened health risks from air pollution.

Study Area

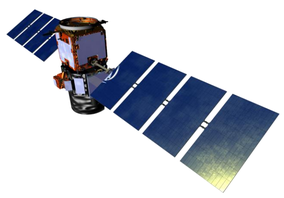
Earth Observations



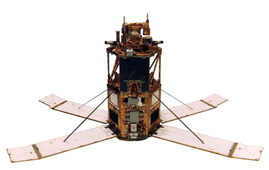
Aqua MODIS



Terra MODIS



CALIPSO CALIOP

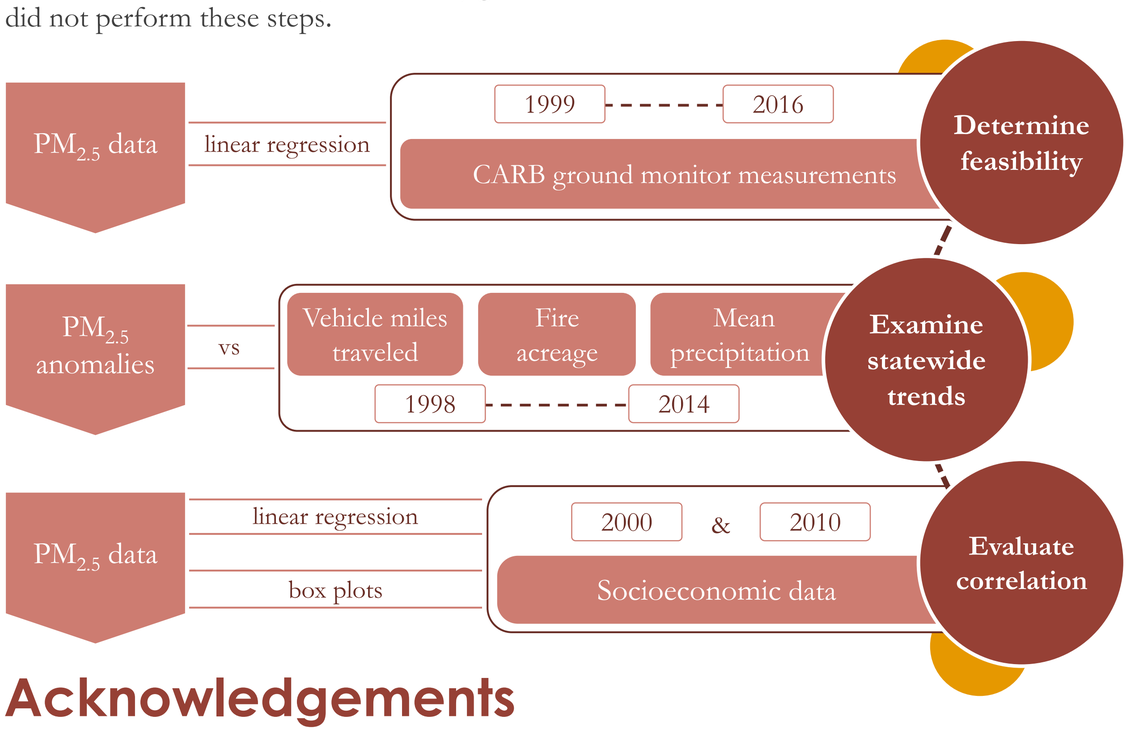


OrbView-2 (SeaStar)

Methodology

$PM_{2.5}$ Data

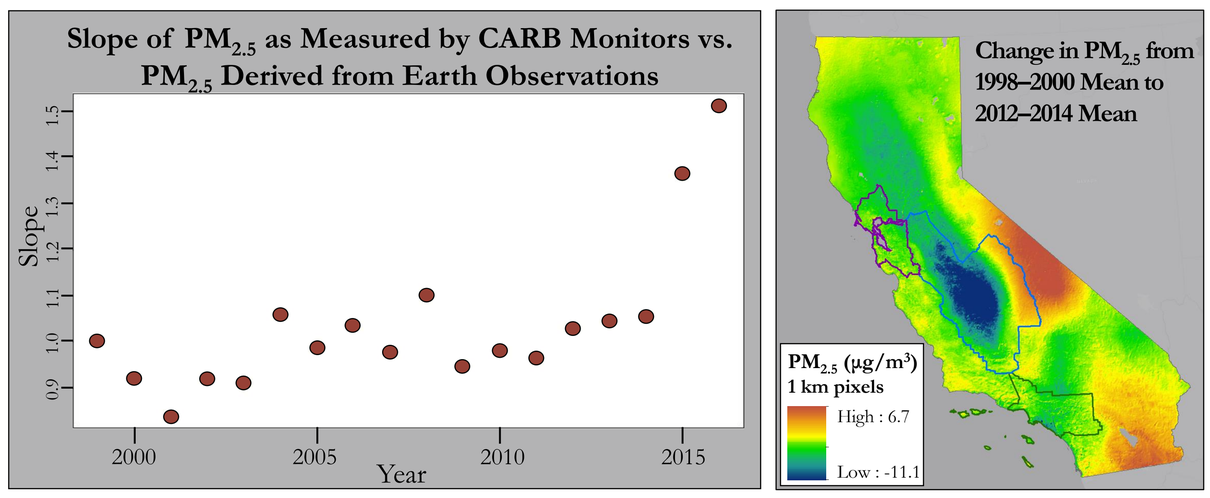
Annual $PM_{2.5}$ averages used in this project were derived by the Dalhousie University Atmospheric Composition Analysis Group (ACAG), who applied a geographically weighted regression to a combination of the above Earth observations, the GEOS-Chem chemical transport model, and Aerosol Robotic Network (AERONET) ground-based observations. The NASA DEVELOP team did not perform these steps.

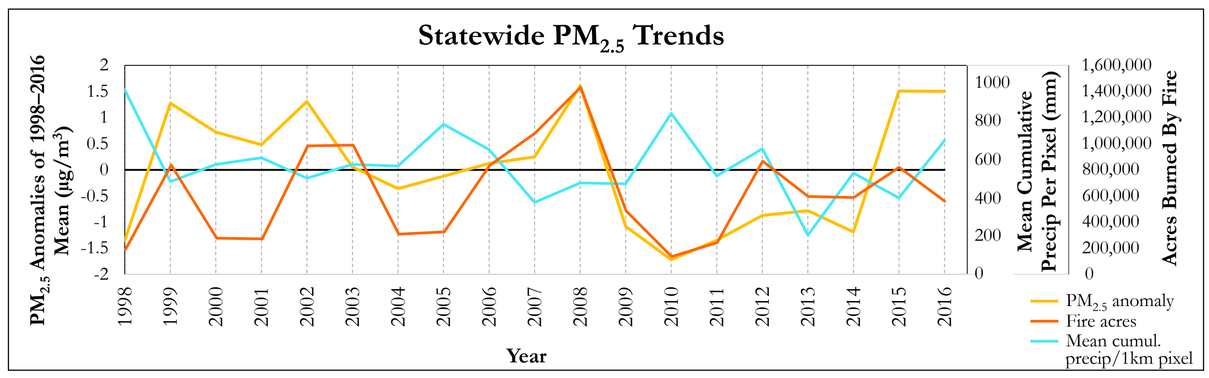


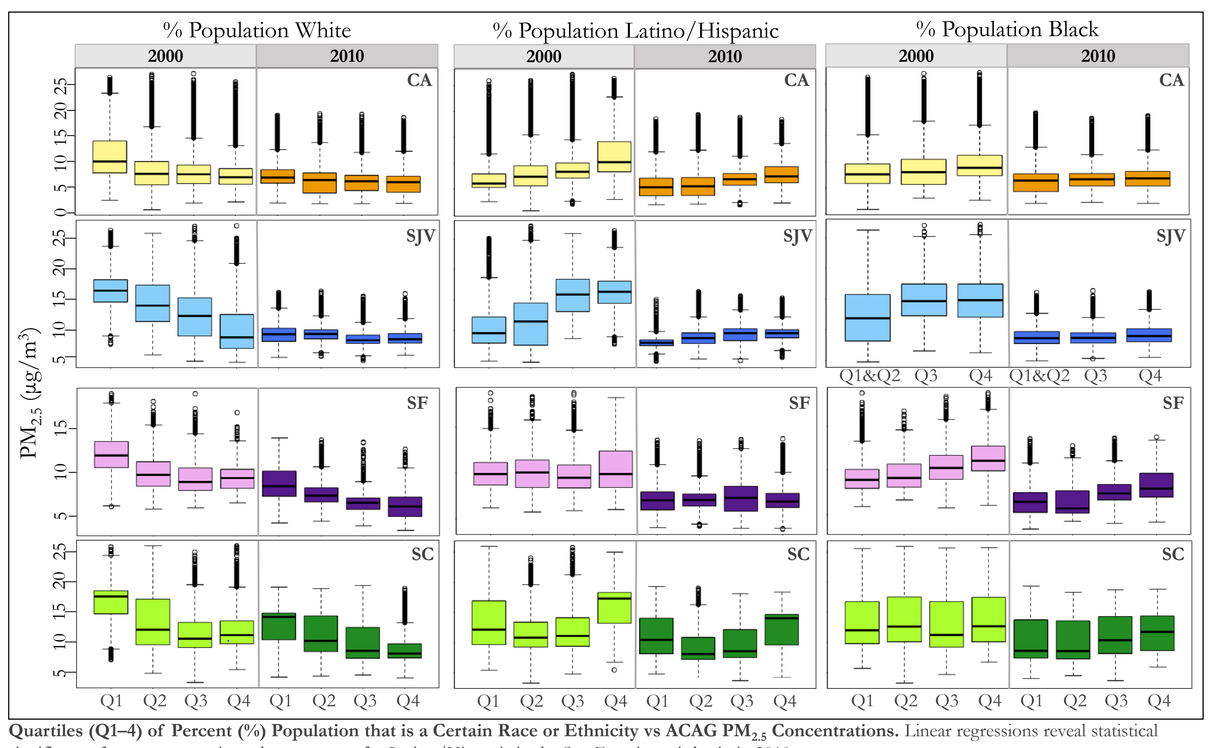
Objectives

- **Determine** the feasibility of using a satellite-derived dataset to represent $PM_{2.5}$ in California
- **Examine** statewide spatial and temporal trends in $PM_{2.5}$ concentration
- **Evaluate** the correlation between satellite-derived $PM_{2.5}$ and socioeconomic factors

Results







Quartiles (Q1–4) of Percent (%) Population that is a Certain Race or Ethnicity vs ACAG $PM_{2.5}$ Concentrations. Linear regressions reveal statistical significance for every group in each year except for Latino/Hispanic in the San Francisco air basin in 2010.

Conclusions

- While the ACAG $PM_{2.5}$ data product adequately represents long-term exposure and large-scale spatial processes, the dataset's coarse annual average temporal resolution may fail to capture all $PM_{2.5}$-related health risks.
- Recent California air quality policies and regulations may be factors contributing to overall declines in $PM_{2.5}$, while precipitation, fire, and transportation patterns likely contribute to the inter-annual variability in the San Francisco, San Joaquin Valley, and South Coast air basins.
- Low-income communities, especially those with higher percentages of minority populations, are more likely to experience greater annual mean $PM_{2.5}$ concentrations.

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