A Satellite-based Decision Support Tool for Surface PM2.5 Estimates in California

Minghui Diao[1], Frank Freedman[1], Mohammad Al-Hamdan[2], and Jason Vargo[3]

[1]San Jose State University
[2]Universities Space Research Association at NASA/MSFC
[3]California Department of Public Health

November 24, 2022

Abstract

Fine particulate matter smaller than 2.5 micrometers (PM2.5) at the surface presents large health risks to the public. Providing long-term, spatially continuous data set of PM2.5 surface concentrations can support decision making by health departments, air agencies, as well as other stakeholders interested in public health. In this work, a website-based decision support tool will be shown. The tool includes two main parts. The first part is a multi-year, daily, 3-km database for PM2.5 concentrations in California from 2006 to present in both map and tabulate formats. The second part is a daily, 3-km, near real-time update of PM2.5 surface concentrations in California in the last seven days. The near real-time data are generated within 24 hours after the NASA A-train satellite swath. For both products, PM2.5 surface estimates are generated based on a fusion of EPA ground-based monitored data and satellite-derived PM2.5 data from the NASA Aqua/MODIS satellite sensor. This decision support tool can be used to provide quick and easy visualization of certain episodic events (such as California wildfires) on a daily basis. It can also be used to conduct multi-year statistical analysis, such as identifying the higher PM2.5 concentration days above 95th percentile as the days being impacted by wildfires. These datasets and the decision support tool is publicly available and can be accessed via the SJSU HAQAST website: http://www.met.sjsu.edu/weather/HAQAST/home.html

Satellite-based Decision Support Tool for Surface $PM_{2.5}$ Estimates in California

Minghui Diao[(1)], Frank Freedman[(1)], Mohammad Z. Al-Hamdan[(2)], Jason Vargo[(3)]

(1) Dept. Meteorology and Climate Science, San Jose State University, San Jose, CA
(2) Universities Space Research Association at NASA/MSFC
(3) California Department of Public Health

Author contact: Minghui Diao Minghui.Diao@sjsu.edu**, HAQAST website at SJSU:** : http://www.met.sjsu.edu/weather/HAQAST/home.html

AGU Paper Number: GH015-0007A.

Introduction

- Fine particulate matter less than 2.5 micrometers in aerodynamic diameter, known as $PM_{2.5}$, imposes significant adverse impacts to public health.

- A decision-support tool is needed, in order to inform public of the air quality and assist public health sectors, air agencies and other stakeholders during events such as wildfires.

- As a member of the NASA Health and Air Quality Applied Sciences Team (HAQAST), San Jose State University collaborates with NASA USRA and California Department of Public to develop a decision support tool based on NASA MODIS satellite data and EPA ground monitors.

Method and dataset

- In this study, we will present an approach that fuses satellite data (NASA MODIS aerosol optical depth) with ground monitors, to examine $PM_{2.5}$ fields in California at **daily, 3-km resolution**.

- All data and tools developed from this NASA project is publicly available and hosted online by SJSU.

- Satellite data: The NASA Aqua MODIS satellite data provide one observation per day at local time around 1:30 pm. Columnar aerosol optical depth (AOD) concentrations are retrieved from the MODIS data.

- $PM_{2.5}$ – AOD regression: A relationship between columnar AOD and surface $PM_{2.5}$ concentration is derived based on two models – a regression model, and a surfacing model. Sensitivity tests are conducted to evaluate the derived $PM_{2.5}$ against non-FRM monitors (led by Mohammad Al-Hamdan)

- A review paper compares publicly available $PM_{2.5}$ datasets over the continental U.S., led by Minghui Diao (SJSU) and Tracey Holloway (U Wisconsin).

Results

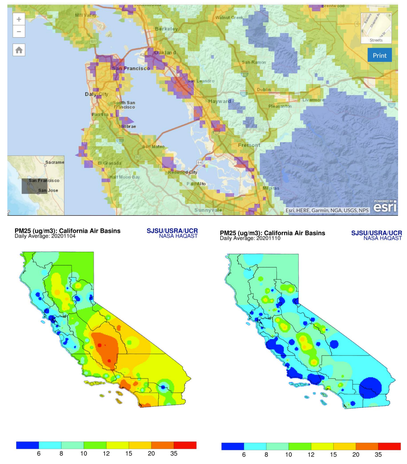
Part 1. Publicly available satellite-derived $PM_{2.5}$ data and tools hosted by SJSU.

1. A Visualization Tool for Viewing Community-Scale PM2.5 in the Bay Area in California
https://www.cloud-research.org/haqast-project

2. Daily Real-Time $PM_{2.5}$ Fields for entire California. Download netcdf or maps.
http://www.met.sjsu.edu/weather/HAQAST/product2.html

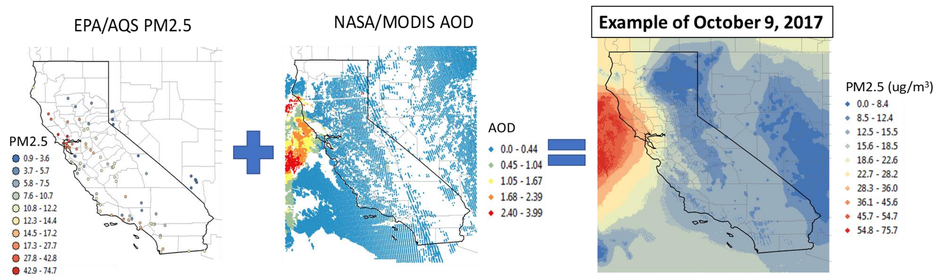
3. Daily $PM_{2.5}$ Fields for entire California (2006 – 2017). Download csv files.
http://www.met.sjsu.edu/weather/HAQAST/product1.html

4. Daily Real-Time $PM_{2.5}$ Fields (East San Jose, CA). Download netcdf or maps.
http://www.met.sjsu.edu/weather/HAQAST/dispersion1.html

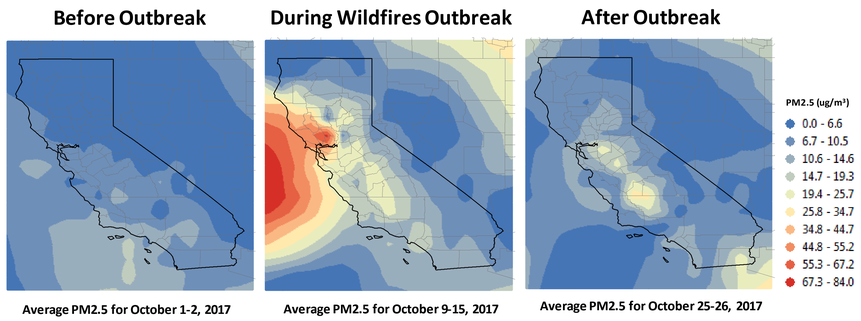


All free for download. Available in both maps and tables.

Part 2. Application of satellite data in analysis of California wildfire 2017.



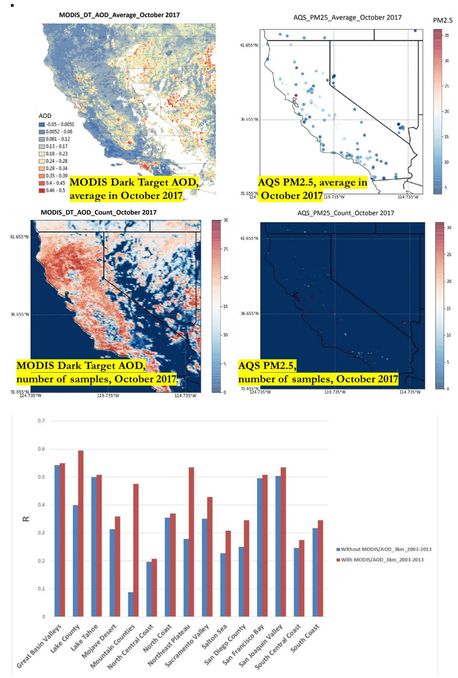
We used spatial/geostatistical surfacing algorithms, which combine data from 3-km, daily NASA Aqua MODIS satellite AOD data (Dark Target product) and EPA ground monitors to provide daily estimates of PM2.5 on a 3-km grid (surface). The surfacing and regression algorithms were explained in Al-Hamdan et al. (2009, JAWMA).



Average PM2.5 for October 1-2, 2017 | Average PM2.5 for October 9-15, 2017 | Average PM2.5 for October 25-26, 2017

Using the daily, 3-km $PM_{2.5}$ surface concentration derived from NASA satellites and ground monitors, we can track the evolution of wildfire emissions before and after the Northern California wildfire outbreak during October 9 – 15, 2017.

Part 3. Advantages of fusing satellite and ground monitor PM2.5 data.



1. Satellite data can help to fill in missing gaps in ground monitor data, especially for rural areas.

2. Satellite data can be "trained" to represent the ground monitor data more accurately by improving the regression model of aerosol optical depth (AOD) – $PM_{2.5}$.

3. The figure on the bottom shows R values for the comparison between satellite-informed $PM_{2.5}$ and the $PM_{2.5}$ reported by non-FRM monitors. Comparing $PM_{2.5}$ data with or without satellite information, the evaluation shows the improvement/value added to the multiple regression model (R improvement) by including the MODIS/AOD in the multiple regression model.

Conclusions and future work

- As a key deliverable of our NASA project, the SJSU/USRA team have developed a method that fuses satellite AOD information with EPA ground monitor data, to derive surface $PM_{2.5}$ data for California.

- This PM2.5 data set in California is available on daily, 3-km resolution, and is currently updated at near real-time (within 24 hours of the satellite swath time). This data set is free for download on the website hosted by SJSU: http://www.met.sjsu.edu/weather/HAQAST/home.html

- These satellite-informed $PM_{2.5}$ surface data in California have been shared with several stakeholders, including California Department of Public Health, CARB, BAAQMD, etc. This decision-support tool can be used to evaluate near real-time wildfire emissions in California during the wildfire season.

- For future work, we aim to advance this decision support tool into higher resolution – 1 km scale for the entire state of California. The information will be updated within 24 hours of the satellite swath, and be shared with stakeholders and the public for air pollution alert and advice.

Acknowledgments

- M. Diao, F. Freedman and M.Z. Al-Hamdan are funded by NASA grant NNX16AQ91G.

References

- Diao M., Holloway, T. et al. Methods, availability, and applications of $PM_{2.5}$ exposure estimates derived from ground measurements, models, and satellite datasets, Journal of Air & Waste Management Association (JAMWA), 2019.
- Freedman, F. et al. Spatial Particulate Fields during High Winds in the Imperial Valley, California Atmosphere, 11, 88, 2020.
- O'Neill, S., Diao, M. et al. Wildfire Emissions of PM2.5 in Northern California 2017: Data, Methods, Tools and Intercomparisons, JA&WMA, the Third International Smoke Symposium (ISS3) Special Issue, in review, 2020.
- Al-Hamdan, M. Z. et al. Development and validation of improved PM2.5 models for public health applications using remotely sensed aerosol and meteorological data, Environmental Monitoring and Assessment, 2020.