GEOS-CF Model Assessment of $PM_{2.5}$ During Wildfires: Inferring the Impact of $PM_{2.5}$ Exposure on Adverse Respiratory & Cardiovascular Conditions

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Take Home Message

- NASA Goddard's Earth Observing System Composition Forecast (GEOS-CF) model produces global forecasts of atmospheric pollutants such as O_3, NO_2, $PM_{2.5}$ in near real-time. This project demonstrates one of the model applications for inferring estimated health impacts during severe air quality events.
- In this study we evaluated how the change in $PM_{2.5}$ level concentration impacts an individual's respiratory and cardiovascular health as well as their daily activities.
- This work demonstrates that NASA's observations and models are now detailed enough to assess the impact of wildfires on air quality and human health.
- Based upon the estimated health impact results from BenMAP we can make the broad assumptions that individual's (i.e. children and the elderly) respiratory and cardiovascular health was greatly affected due to the 2017 wildfire events in Washington and California.

Methods

GEOS-CF simulated $PM_{2.5}$ applied to a human health assessment model, BenMAP (The Environmental Benefits Mapping and Analysis Program, version 1.4.8), estimates the impact on adverse respiratory health conditions due to $PM_{2.5}$ exposure from wildfires.

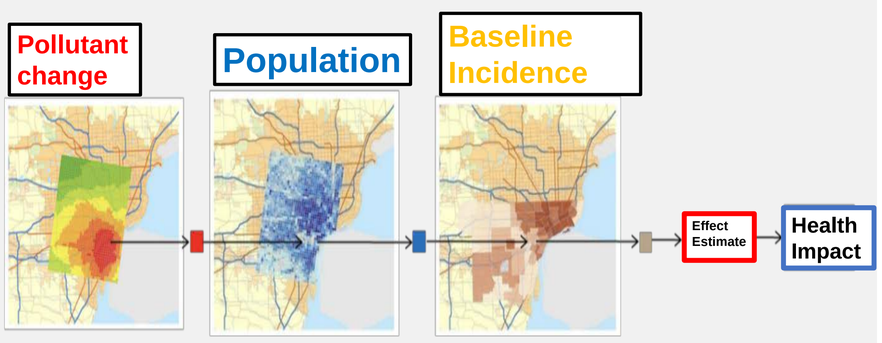


Figure 1: BenMAP calculates the health impact estimate based upon the change in pollutant concentration and exposed population; which refers to the number of individuals impacted by the change in pollutant concentrations.

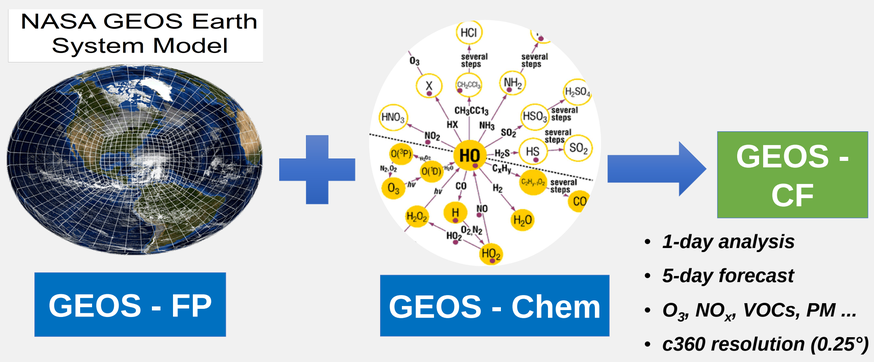


Figure 2: The GEOS -FP weather model combined with the detailed chemistry from GEOS-Chem produces the GEOS-CF system, which is able to provide a 5 day forecast for various chemical species across the globe. GEOS-CF includes NO2 and O3 and the same type of study can be extended to these constituents.

Background Information

Health Endpoint	Metric	Author	Year	Age Range (years)	Location
Acute Myocardial Infarction Nonfatal	D24 Hour Mean	Pope et al.	2006	0 to 99	Greater Salt Lake city, Utah
Acute Respiratory Symptoms: Minor Restricted Activity Days	D24 Hour Mean	Ostro & Rothfield	1989	18 to 64	Nationwide
Asthma Exacerbation: Cough	D24 Hour Mean	Mar et al.; Ostro et al.	2004; 2001	6 to 18	Spokane, WA; Los Angeles, CA
Asthma Exacerbation: Shortness of Breath	D24 Hour Mean	Mar et al.; Ostro et al.	2004; 2001	6 to 18	Spokane, WA; Los Angeles, CA
Asthma Exacerbation: Wheeze	D24 Hour Mean	Ostro et al.	2001	6 to 18	Los Angeles, CA
Emergency Room Visits: Asthma	D24 Hour Mean	Mar et al.	2010	0 to 99	Greater Takoma, WA
Hospital Admissions: All Cardiovascular (less Myocardial Infarctions)	D24 Hour Mean	Zanobetti et al.	2009	65 to 99	26 U.S. communities
Hospital Admissions: All Respiratory	D24 Hour Mean	Zanobetti et al.	2009	65 to 99	26 U.S. communities
Mortality	Annual	Krewski et al.	2009	30 to 99	116 U.S. cities
Work Loss Days	D24 Hour Mean	Ostro	1987	18 to 64	Nationwide

Table 1: The epidemiological studies described in the table were used in the health impact function to estimate which health endpoints produced the largest health impact estimate due to the change in $PM_{2.5}$ model concentrations.

Location of Wildfire Events	Wildfire event Scenario (dates)	Background Scenario (dates)	Delta of $PM_{2.5}$ Concentration* $(\mu g/m^3)$
Washington State	7/30/2017-8/15/2017	8/16/2017-8/30/2017	18.0
Northern California	10/01/2017-10/15/2017	10/16/2017-10/30/2017	2.3
Southern California	12/04/2017-12/24/2017	12/24/2017-01/12/2018	4.0

Table 2: The wildfire event scenario dates evaluates the $PM_{2.5}$ levels prior to and during the wildfires and the background scenario evaluates the $PM_{2.5}$ levels after the wildfire. The delta represents the change in GEOS-CF $PM_{2.5}$ model concentrations between the baseline and background scenario. The largest delta value was calculated for the Washington wildfire events.

GEOS-CF Model concentration vs. Observational studies

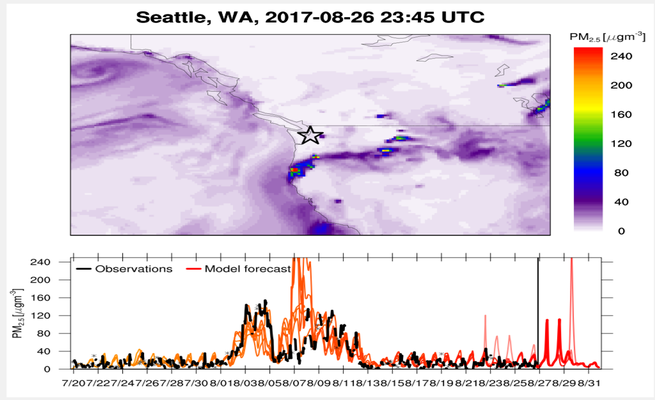
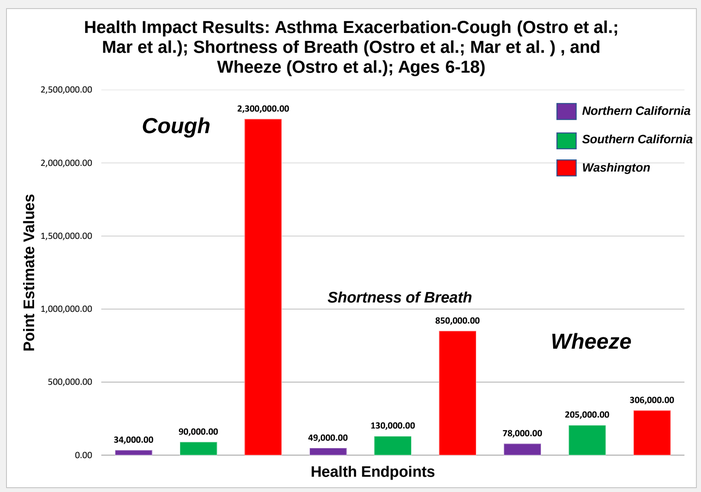


Figure 3: PM2.5 concentrations simulated by GEOS-CF agree well with independent observations (i.e. openAQ) for the August 2017 Seattle, Washington wildfires. GEOS-CF uses satellite observations to constrain fire emissions (i.e. QFED-the Quick fire emissions dataset).

Health Impact Results



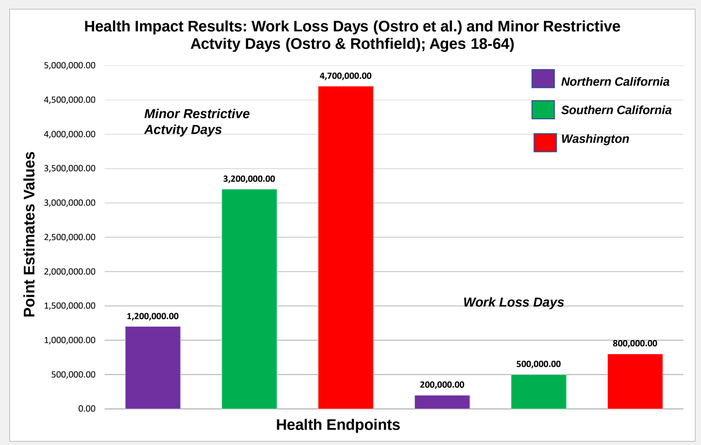


Figure 4: The bar graphs above show that the 2017 Washington state wildfire produces the highest health impact estimates for each health endpoint (i.e. asthma exacerbation, work loss days, and minor restrictive activity days) compared to the California wildfire events.

Location of Wildfire Events	Health Endpoint	Percentage of (Exposed) Population Impacted (%)
Washington State	Asthma Exacerbation: Cough	53
	Asthma Exacerbation: Shortness of Breath	68
	Asthma Exacerbation: Wheeze	25
	Work Loss Days	16
	Minor Restrictive Activity Days	97
Northern California	Asthma Exacerbation: Cough	1.5
	Asthma Exacerbation: Shortness of Breath	2.1
	Asthma Exacerbation: Wheeze	3.3
	Work Loss Days	2.4
	Minor Restrictive Activity Days	15
Southern California	Asthma Exacerbation: Cough	2.2
	Asthma Exacerbation: Shortness of Breath	3.2
	Asthma Exacerbation: Wheeze	5
	Work Loss Days	21
	Minor Restrictive Activity Days	3.5

Table 3: The chart above shows the percentage of the total amount of individuals impacted by the specific health impact during a severe wildfire event based upon the BenMAP health impact estimate results.

Spatial Maps: Health Impact Results, Exposed Population (County Level)& Average $PM_{2.5}$

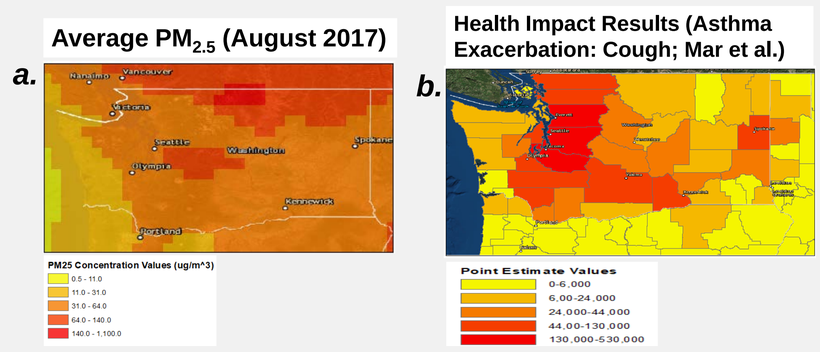


Figure 5: (a.) displays the August's monthly average GEOS-CF model $PM_{2.5}$ concentrations values in the Washington area **(b. and c.)** the county distribution for the cough symptom for the asthma exacerbation health impact estimates and the corresponding exposed population density of the areas in Washington. Based upon the BenMAP result shown in the maps one can assume that individuals with the pre-existing condition of asthma in Seattle were heavily impacted by the wildfire events.

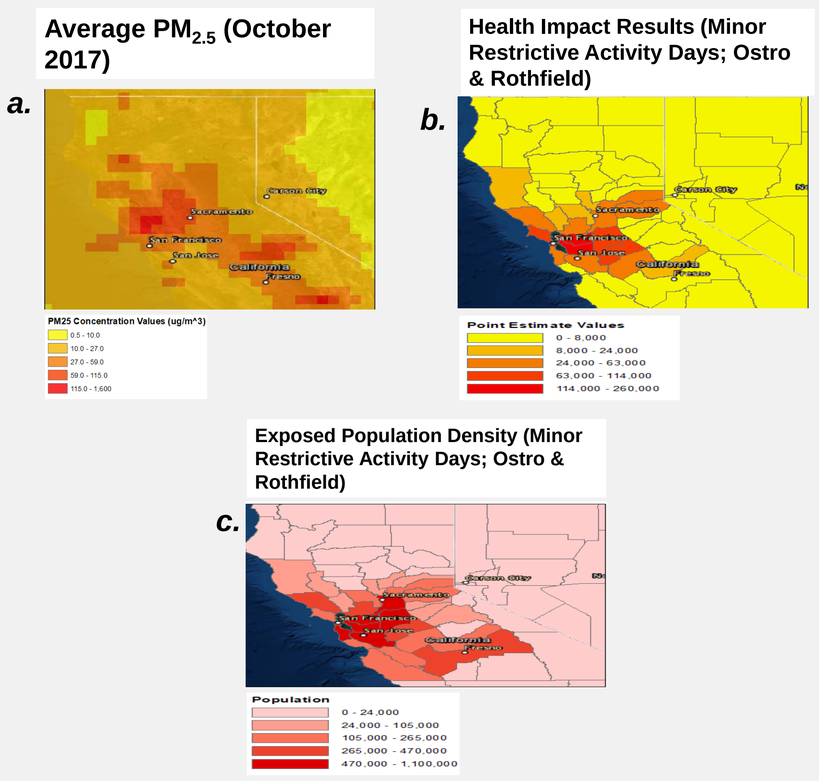


Figure 6: (a.) displays the October's monthly average GEOS-CF model $PM_{2.5}$ concentrations values throughout the Northern California area **(b. and c.)** the county distribution for the minor restrictive activity days health impact estimates and the corresponding exposed population density of the areas in Northern California. BenMAP's health impact estimate results infer that individuals located in the San Francisco/San Jose area daily activities were impacted due to wildfires.

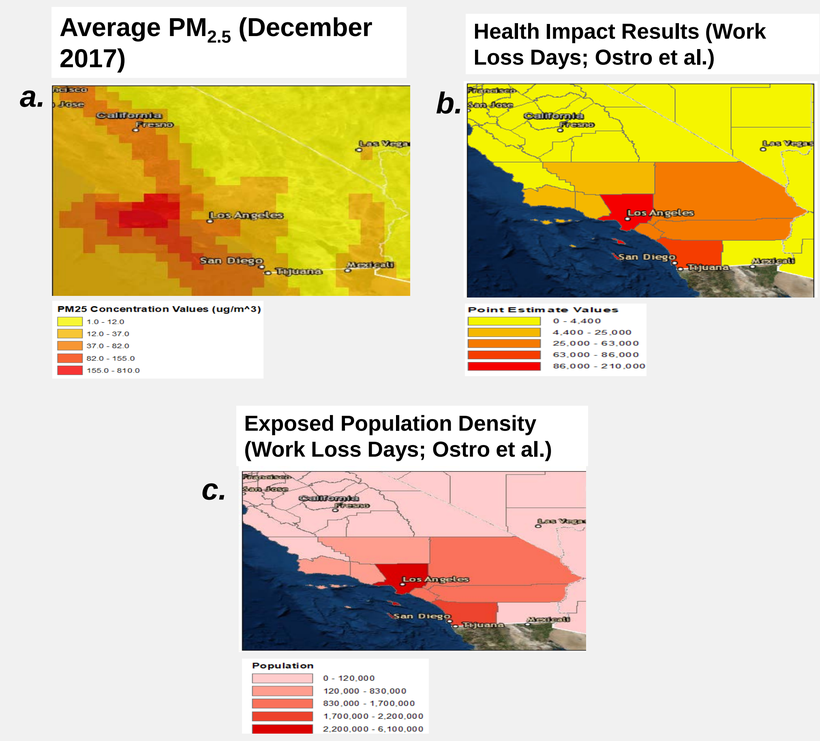


Figure 7: (a.) displays the December's monthly average GEOS-CF model $PM_{2.5}$ concentrations values in the Southern California area **(b. and c.)** the county distribution for the work loss days health impact estimates and the corresponding exposed population density of the areas in Southern California. BenMAP's health impact estimate results infer that individuals located in the Los Angeles were unable to attend work due to wildfires.

Conclusions

- GEOS-CF can be used to perform analysis and predictions for $PM_{2.5}$ concentrations during severe air quality events (i.e. wildfires).
- According to the BenMAP results it can be assumed that the 2017 wildfire events in Washington did impact individual's respiratory health and daily activities.
- The simulated change in PM2.5 from the wildfires was likely not large enough to impact severe-outcome health endpoints such as emergency room visits, hospital admissions, and mortality.
- The health impact results showed a minimal effect on individual's cardiovascular health.

Future Work

- Evaluate severe air quality events across the globe (i.e. India) using the GEOS-CF model
- Observe the resulting health impact estimates due to the 2018 wildfire events

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National Aeronautics and Space Administration