US Trends in Wildfire Smoke derived from NOAA's Hazard Mapping System Smoke Product and Airport Data from 2010-2020

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Abstract

The scale of wildfires and their associated smoke plumes have increased in the last four decades and have exacerbated the health risks for people living within wildfire-prone areas. While satellite imagery enables us to monitor the location, abundance, and severity of smoke, datasets such as NOAA's Hazard Mapping System (HMS) smoke product are unvalidated and may not reflect ground-level smoke conditions. We propose that airports monitoring the presence of smoke may offer a localized constraint on satellite smoke products. Our research aims to validate NOAA's HMS product by comparing how well the HMS smoke data agree with NOAA's Integrated Surface Database (ISD) of local, hourly airport data from 2010 to 2020 across the US. Our spatial and temporal analysis shows that the trend in the number of smoke days is similar between the two datasets. HMS smoke plumes are qualitatively categorized into 3 densities: light, medium, and heavy. Particularly, HMS smoke plumes with "medium or heavy" densities have the strongest correlation of r = 0.60 and a mean absolute error of 0.73. We observe the greatest difference in the airport and HMS-derived mean smoke days across the west and east coast, especially in California's Central Valley and eastern Washington. However, there is a very weak correlation of r = 0.17 between surface-level mean smoke days and from HMS "heavy, medium, or light" density smoke days. Further, using all HMS smoke densities tend to overestimate the trends in and magnitude of smoke days. Based on these results, NOAA's HMS product is somewhat consistent with trends observed at airports, but caution should be used in assuming equivalence with surface conditions in research investigating wildfire smoke and its consequences for public health.

US Trends in Wildfire Smoke Derived from Satellite and Airport Data from 2010-2020

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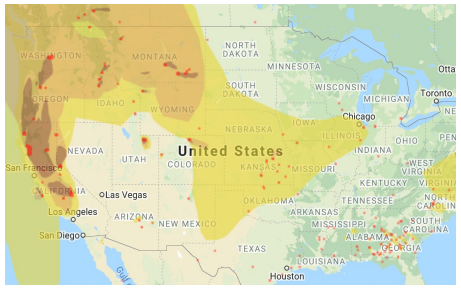
Key Questions

1. How well do satellite-derived HMS smoke days align with airport smoke days?
2. What are the **spatial and temporal patterns** associated with smoke days for NOAA HMS and ISD airport data?

Background

- To better understand recent increases in the scale of wildfire and the effects of associated smoke plumes, **NOAA's Hazard Mapping System (HMS) smoke product** can be a proxy for ground-level smoke extent and severity



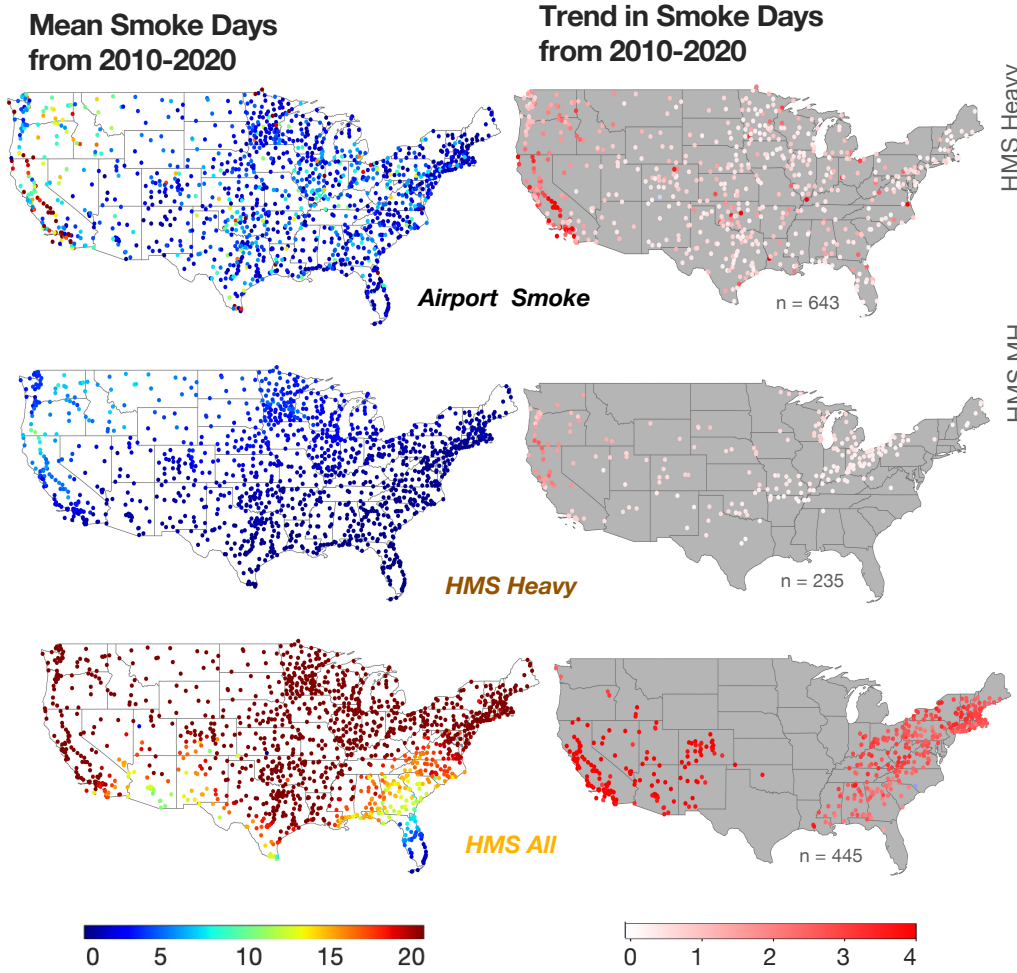
globalfires.earthengine.app/view/hms-smoke

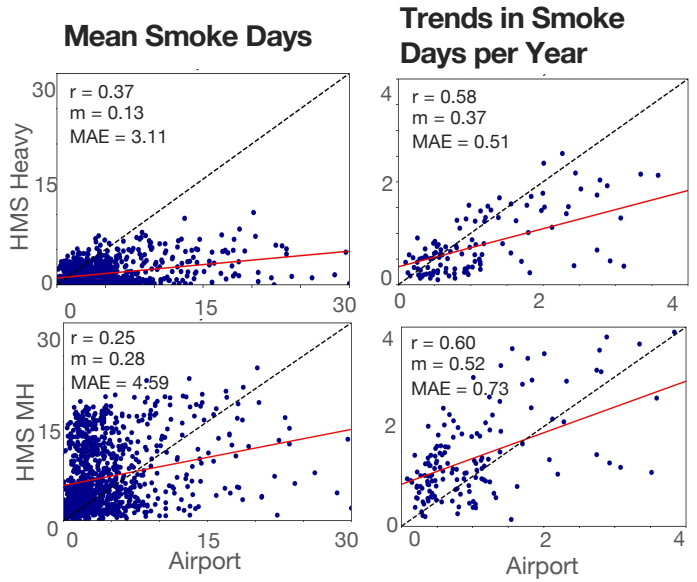
HMS is categorized into **light, medium, or heavy** smoke dependent on density

Light	(0-10 μg/m^3)
Medium	(10-21 μg/m^3)
Heavy	(21-32 μg/m^3)

- However, **NOAA HMS is unvalidated** and may not reflect smoke conditions at the surface.
- **NOAA's Integrated Surface Database (ISD)** of airport data monitors the hourly presence of smoke plumes and can act as localized sources of ground-truth data.
- We define NOAA HMS categories into **three definitions** to assess smoke plume accuracy
  1. **HMS Heavy**
  2. **HMS Heavy or Medium (HMS MH)**
  3. **HMS Heavy, Medium, or Light (HMS All)**

Results





- HMS Heavy has greater skew towards mean airport smoke days than HMS MH
- HMS MH has stronger correlation with airport data
- Greater overall average of smoke days and an increasing trend in the number of smoke days
- The number of smoke days per year increases by as much as 2-4 days at some sites
- HMS Heavy **generally underestimates** the mean smoke days over 2010-2020, while HMS All tends to **overestimate** the mean smoke days

Conclusions and Future Work

- NOAA's HMS product is **somewhat consistent** with airport smoke observations. Specific HMS categories may be more accurate for smoke day detection in some states and time periods
- The observed **increases in smoke days** in the HMS product reveal the impact of changing wildfire activity on U.S. air quality
- Future research should reconstruct smoke periods pre-2007 to provide a more holistic view of how smoke changes over time