Burns Obscured - How do Rapid Wildfire Growth Conducive Weather Conditions Affect the Timing of our Observations?

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INTRODUCTION

Rapid-growth wildfires disproportionately contribute to loss of life and destruction of property (Balch et al., 2024). Periods of rapid growth are often associated with severe weather conditions (Murphy and Mass, in press). As such, further improving our understanding of fire-associated weather is crucial if we are to mitigate future destruction. To this end, temporally and spatially accurate ascription of fire growth is important. Here, we evaluate an aerosol index product to investigate if, when, and how smoke degrades our ability to soundly interpret meteorological influence on periods of rapid wildfire growth.

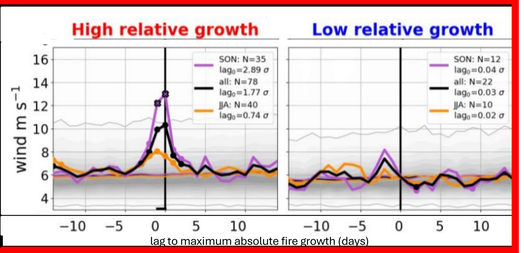


Figure 1. *Adapted from* Murphy and Mass, in press. *Composite time-evolutions of seasonal (Summer, JJA—orange, Autumn, SON—purple) and annual (black) wind (y-axis) during high- and low-relative growth events from FIRED. All fires in top 100 by absolute single-day growth.*

METHODS

We compare eight years of aerosol index data from NASA's Ozone Map Profiler Suite (OMPS) (Torres 2019) to the Fire Events Data Suite (FEDS) fire growth dataset for California wildfires (Chen et al., 2022).

- The top-100 FEDS fires by 12-hourly acreage growth are evaluated
- Aerosol index residue is a daytime value derived from Lambertian equivalent reflectivity. It represents the difference of the logs of the ratios of observed and calculated radiance at two wavelengths (here, 340 and 378.5 nm)
- We re-gridded aerosol index data to a 0.1° grid using a gaussian re-gridder, and then sliced 3° x 3° around each's fire single-day maximum growth polygon centroid to capture large areas of smoke
- We created composite plots by averaging…
- …the 3° x 3° grids across fires in several ways, choosing 10m ERA5 wind gusts as a threshold to subdivide the set of fires, after already separating them by season
- Relative growth (adapted from Murphy and Mass, in press) also worked as a dividing metric to a lesser extent (not shown). As displayed in Figure 1, strong winds bear a significant influence on wildfire growth across both seasons we consider (Murphy and Mass, in press)

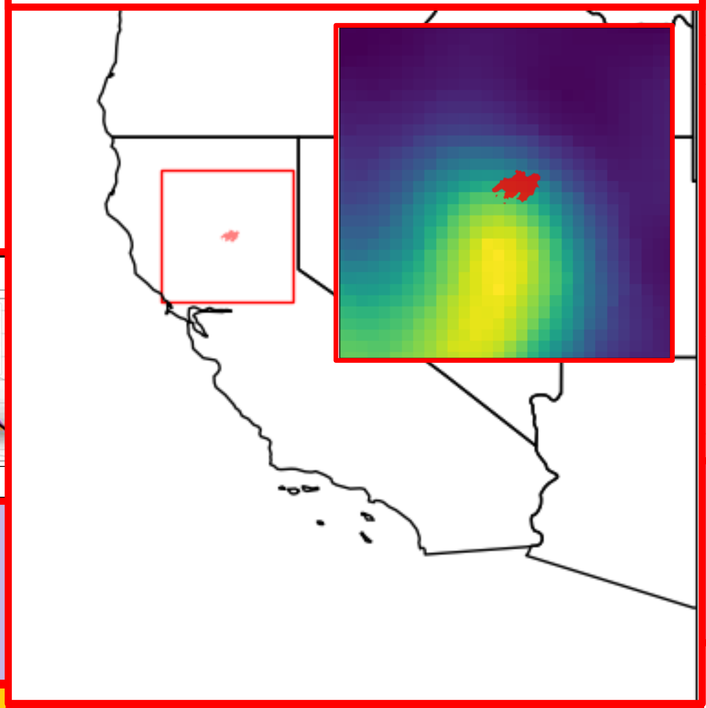


Figure 2. *Aerosol index residue over a 3° x 3° degree box encompassing the 2018 Camp Fire (red) on 9 November 2018.*

RESULTS

During periods of rapid wildfire growth, obscuration via smoke and aerosols varies with season, fire relative growth, and magnitude of wind gusts (Figure 3).

Fires occurring during summer tended to have smoke centered close over the new fire growth (gusts below 14 ms^{-1}, Figure 3a) or displaced to the east (gusts above 14 ms^{-1}, Figure 3b). Fires occurring in autumn generally displayed a higher aerosol index with smoke centered slightly northwest of the single-day growth centroid (gusts below 14 ms^{-1}, Figure 3c), or to the southwest (gusts above 14 ms^{-1}, Figure 3d). Similar patterns, but with lower magnitudes of aerosol index, occurred over days before fire growth maxima (Figure 4).

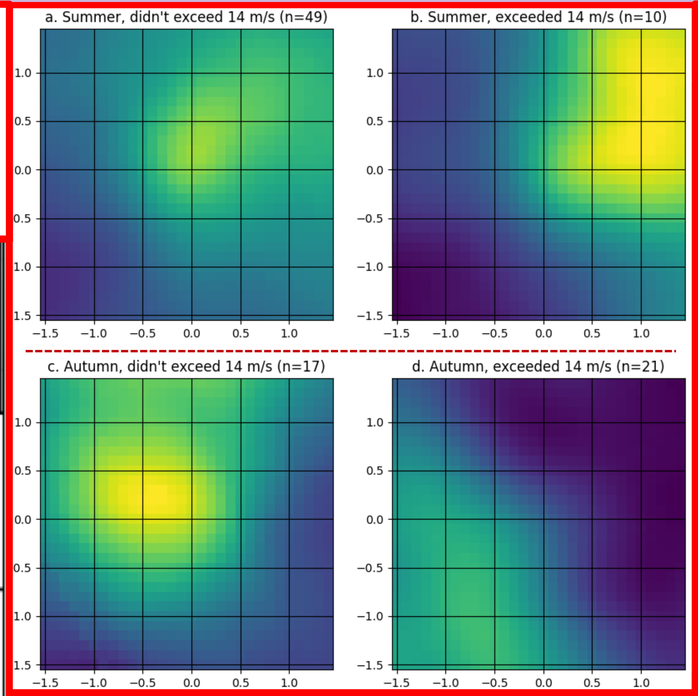


Figure 3. *Composite plots for fires which exhibited maximum growth during summer (a,b) and autumn (c,d), and which occurred within 12 hours of near-surface wind gusts that exceeded 14 m s^{-1} (b,d) or did not exceed 14 m s^{-1} (a,c). Aerosol index magnitude varies between the summer and autumn plots. Summer maximum value (yellow) ~ 2.2. Autumn maximum value (yellow) ~ 4.5.*

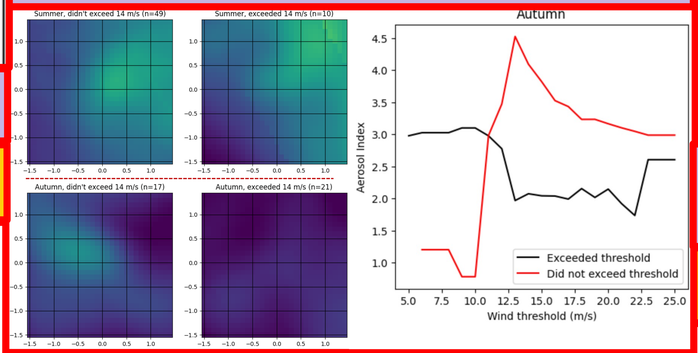


Figure 4. *Repeated process from Figure 3, using aerosol index from the day directly preceding maximum growth.*

Figure 5. *Average aerosol index over a 0.2° x 0.2° slice, for fires whose wind gusts did (black) or did not (red) exceed wind gust thresholds (x axis).*

In autumn, as winds increase, fires may become more observable, but very high winds may again lead to increased aerosols, again reducing observability (Figure 5). The greatest difference between aerosol indexes over the fire growth centroid occurred when splitting fires by a preceding wind gust threshold of 14 ms^{-1}.

CONCLUSIONS

The results of this study add to an under-researched area of fire meteorology – the investigation of whether and to what extent atmospheric aerosols may impact the veracity of wildfire remote sensing, especially considering rapid-growth fires. **During periods of rapid growth, high aerosol index, and thus obscuration of fires, varies with season and meteorological conditions**. These values do not appear to strongly affect the ability of the VIIRS active fire detections (FEDS) to resolve relative peaks in fire growth (Figures 3,4). However**, such obscuration could conceivably impact the observability of fire from other platforms.**

Several avenues for future research exist, including:

- Development of an improved relative fire growth metric given only twice daily measurements
- Reproduction of this project using a reliable, higher resolution aerosol/cloud product (or development of a product)
- Reproduction of this project, with comparisons to the MODIS-derived FIRED dataset (Balch et al., 2020) used in Murphy and Mass, in press
- Evaluation of a larger timespan of aerosol data preceding and following maximum fire growth

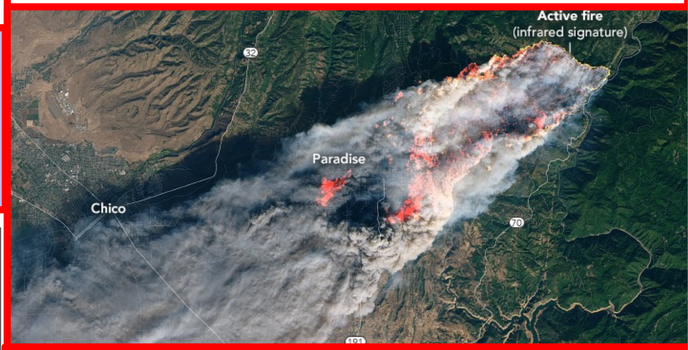


Figure 6. *The Camp Fire, as captured by NASA/USGS Landsat on 8 November, 2018 (California Department of Forestry and Fire Protection, 2018)*

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