Assessing the Impact of Wildfire Smoke Transport Through Chemical Transport Modeling, Satellite Retrievals, and Ground-Based Observations of Ozone in Rural Nevada

Yi Ji[1], Xiaodan Zhang[1], Abiola S. Lawal[1], Heather Holmes[2], and Cesunica E. Ivey[1]

[1]Department of Civil and Environmental Engineering, University of California, Berkeley; [2]Department of Chemical Engineering, University of Utah

Abstract

This study investigates the impact of the 2013 Rim Fire on ozone levels in rural Nevada, employing analyses using ground-based monitoring data, satellite remote sensing data, and atmospheric modeling. The research focuses on understanding how wildfire smoke affects ozone concentrations in the downwind regions. Findings indicate significant ozone enhancements on smoke days compared to non-smoke days, highlighting the contribution of wildfire emissions to regional air quality deterioration. The study demonstrates that the chemical transport model underestimated ozone levels downwind of wildfire smoke plumes, likely due to uncertainties in emissions estimates. Satellite observations of nitrogen dioxide and formaldehyde underline the link between wildfire emissions and increased ozone production.

Methods

Ground-level Monitoring: Hourly $PM_{2.5}$ and ozone data were collected and obtained by the Nevada Rural Ozone Initiative (NVROI) and EPA AQS monitoring network.

Remote Sensing: Aerosol Optical Depth **(**AOD) measurements were obtained from Moderate Resolution Imaging Spectroradiometer (MODIS) and Aerosol Robotic NETwork (AERONET). Nitrogen dioxide and formaldehyde measurements were obtained from Ozone Monitoring Instrument (OMI).

Atmospheric Modeling: Modeled emission data were obtained from the EPA's Air QUAlity TimE Series (EQUATES) project.

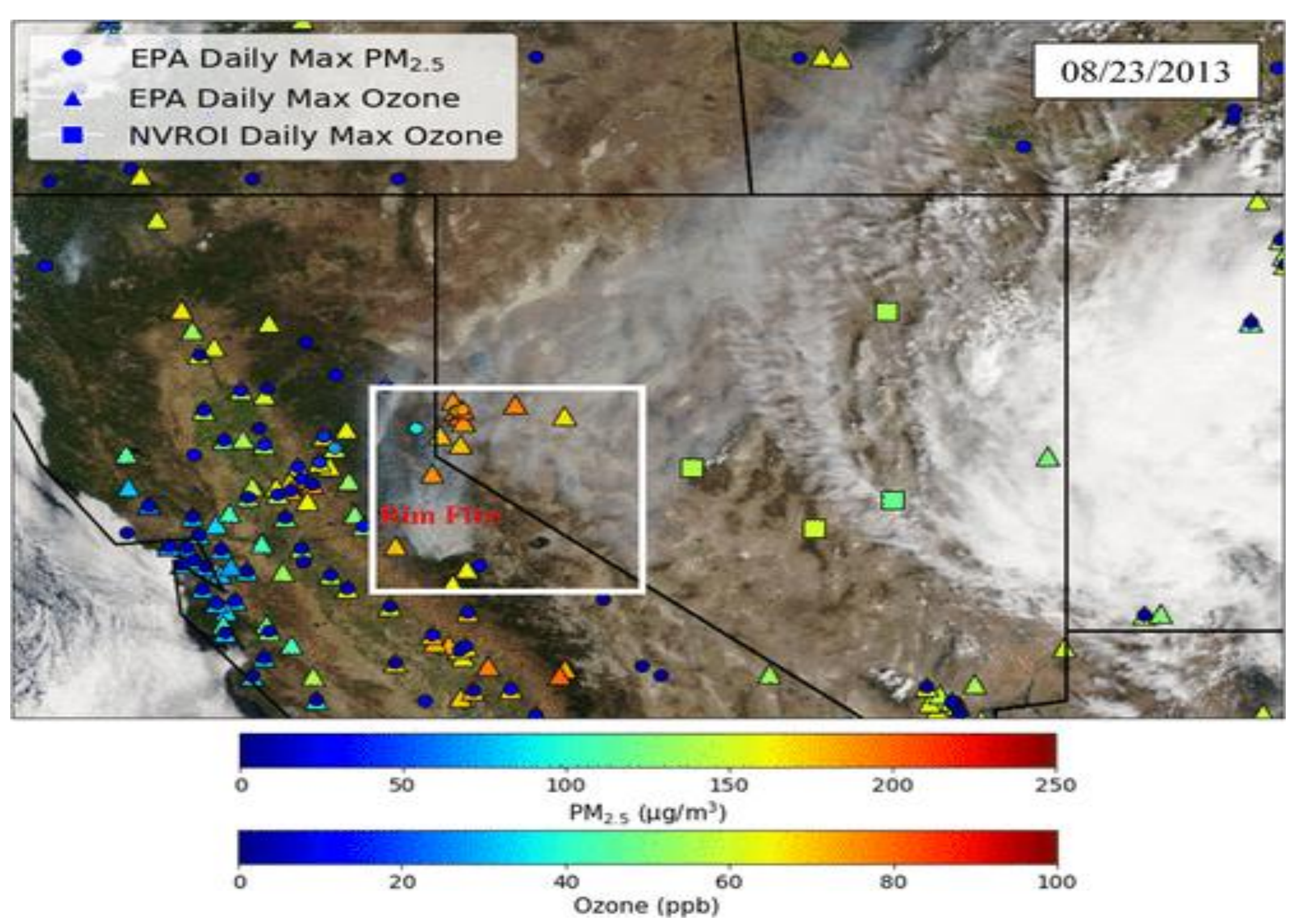

Figure 1. Spatial distribution of daily maximum $PM_{2.5}$ and ozone concentrations across California and Nevada on August 1, 2013, a non-smoke day.

Results

Rim Fire Air Pollution Enhancement

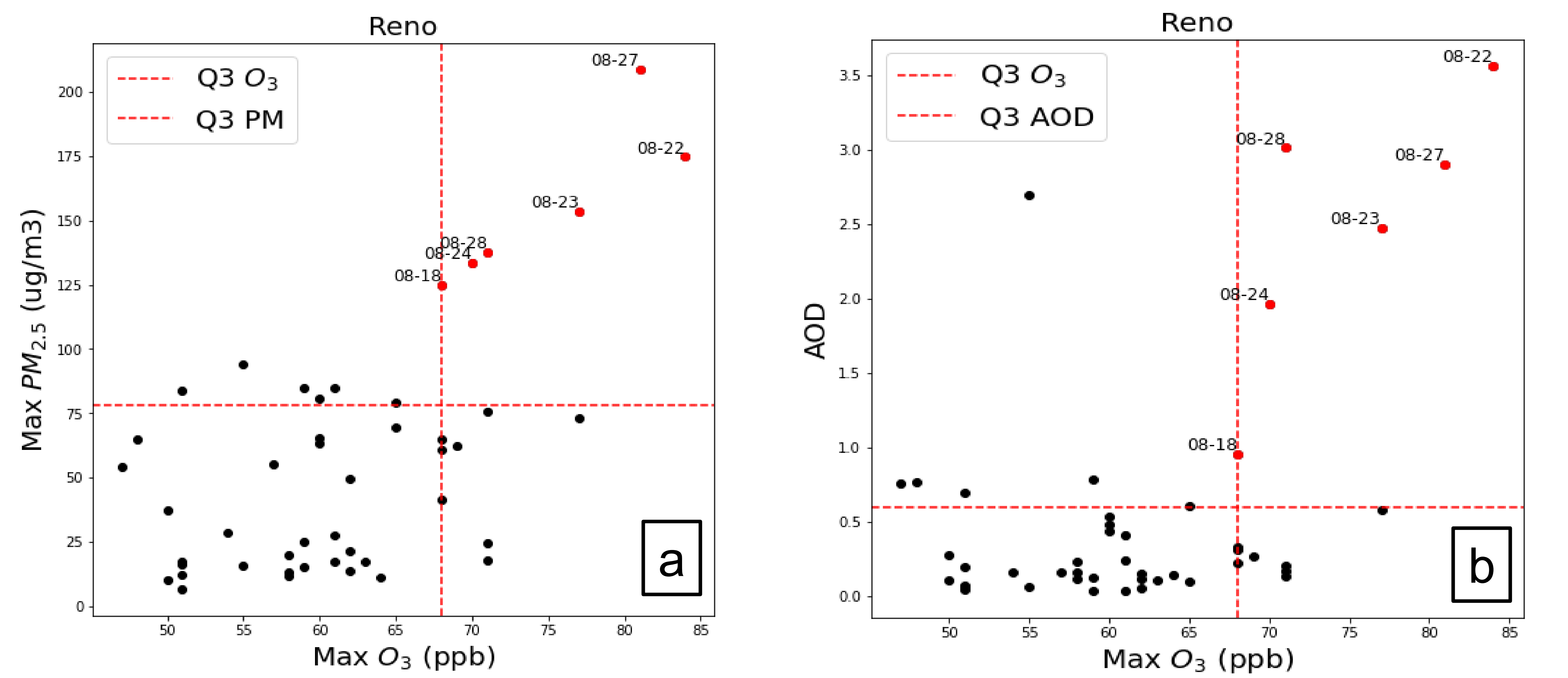

Figure 2. (a) Scatter plot showing the relationship between daily maximum ozone and daily maximum $PM_{2.5}$. (b) Scatter plot showing the relationship between daily maximum ozone and daily maximum AERONET AOD. Red dashed lines indicate the third quartile threshold for ozone and AOD. Red dots represent smoke days. Black dots represent non-smoke days.

CMAQ Underestimates Fire-Driven $PM_{2.5}$ Levels in Reno, NV

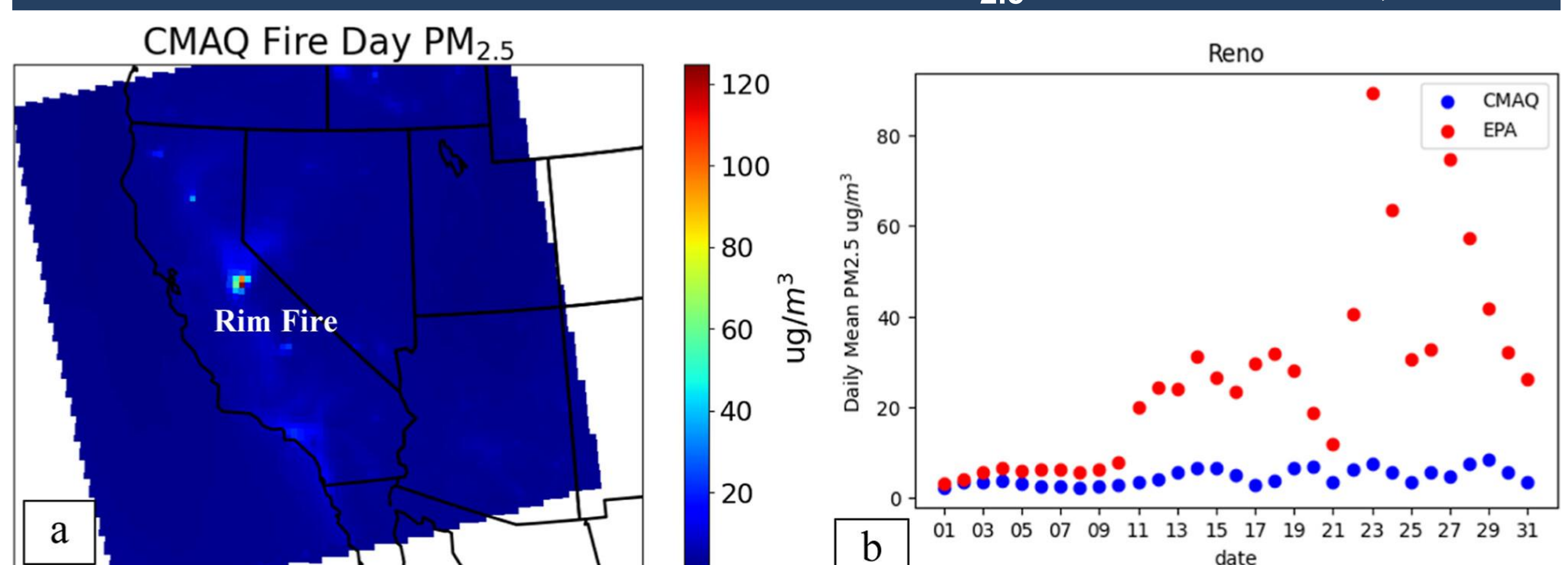

Figure 3. (a) Map of average daily mean $PM_{2.5}$ concentration during fire days (August 23-27) from CMAQ. (b) Time-series comparison of maximum daily $PM_{2.5}$ concentrations (in µg/m³) for August 2013 between model predictions (blue) and ground-level observations (red).

Ozone Precursors from the Rim Fire

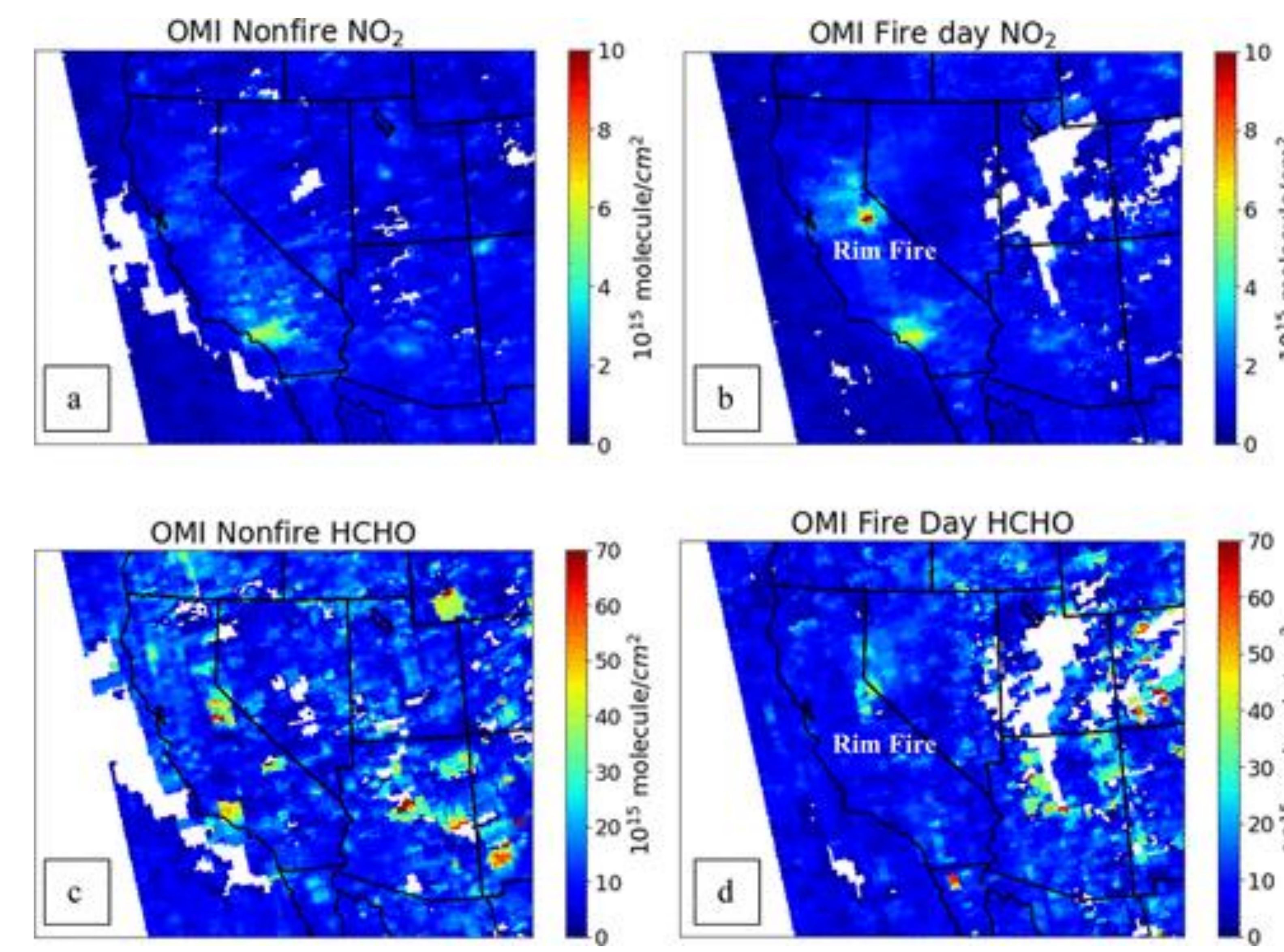

Figure 4. (a-d) Satellite-derived concentrations of nitrogen dioxide (NO_2) and formaldehyde (HCHO) from the OMI on both non-fire and fire days.

Conclusion

- The spatial and temporal distribution of the Rim Fire's smoke plumes, as illustrated by ground measurements and satellite data, demonstrated extensive transport and dispersion affecting air quality over large areas.
- We found discrepancies between CMAQ and the observed $PM_{2.5}$ concentration, with the CMAQ model generally underestimating $PM_{2.5}$ levels during the Rim Fire event.
- Satellite observations of NO_2 and HCHO showed that higher concentrations of these pollutants were detected in areas affected by the Rim Fire, supporting the link between wildfire emissions and increased ozone production through photochemical reactions.

Reference

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