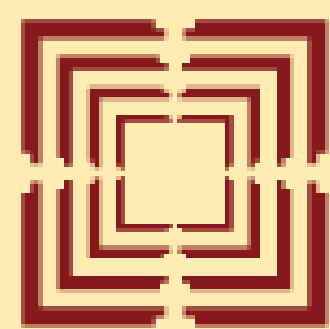


Air quality dynamics in western India through observations and reanalysis

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Introduction

Western Indian cities have been experiencing rapid urbanization and industrialization leading to degradation of regional air quality. While, the fine particulate matter (PM_{2.5}) has been the target for mitigation of air pollution, surface ozone (O₃) has also emerged as a potent super pollutant. Simultaneous occurrence of elevated PM_{2.5} and O₃ develops episodes of compound pollution which can have particularly greater health implications. Quantifying air pollution levels and potential impacts is critical for developing region-specific policy interventions. Additionally, rising frequency of heatwaves is further anticipated to enhance emission of ozone precursors (biogenic VOCs). Nevertheless, long-term systematic observations have been lacking and meteorological versus emissions influences have remained uncertain.

To address the gaps, we have conducted comprehensive analysis combining our in-situ measurements from Ahmedabad University (23°N, 72.6°E), in a semi-arid urban environment of western India, with model results (reanalysis).

Objectives

- To characterize day-to-day and seasonal variability of O₃ and analyze correlations with meteorological parameters.
- To estimate indices indicating O₃ impacts on vegetation and health
- To evaluate the performance of global reanalysis (ERA5, CAMS)
- To investigate the occurrences of compound pollution events

Datasets and Methodology

In-situ measurements:

O₃: Thermo instrument [49i] based on UV light absorption technique

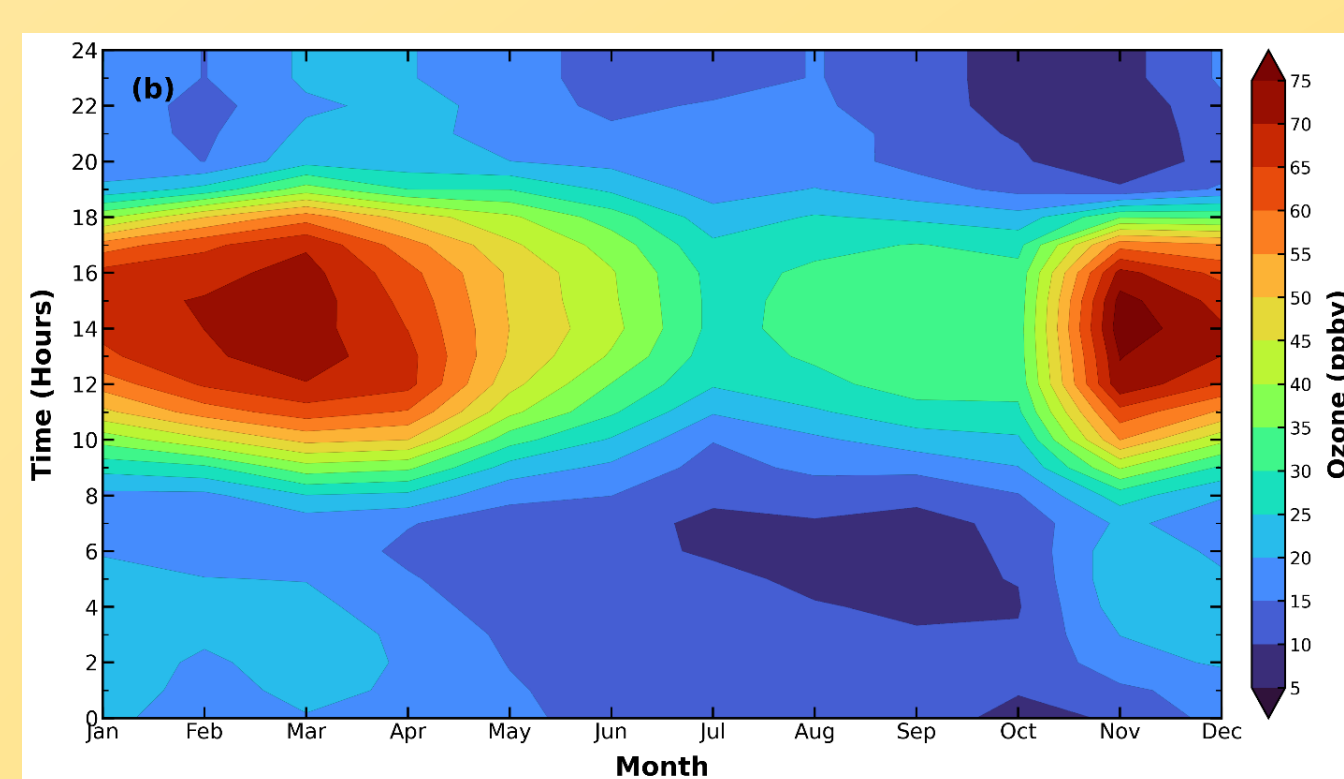
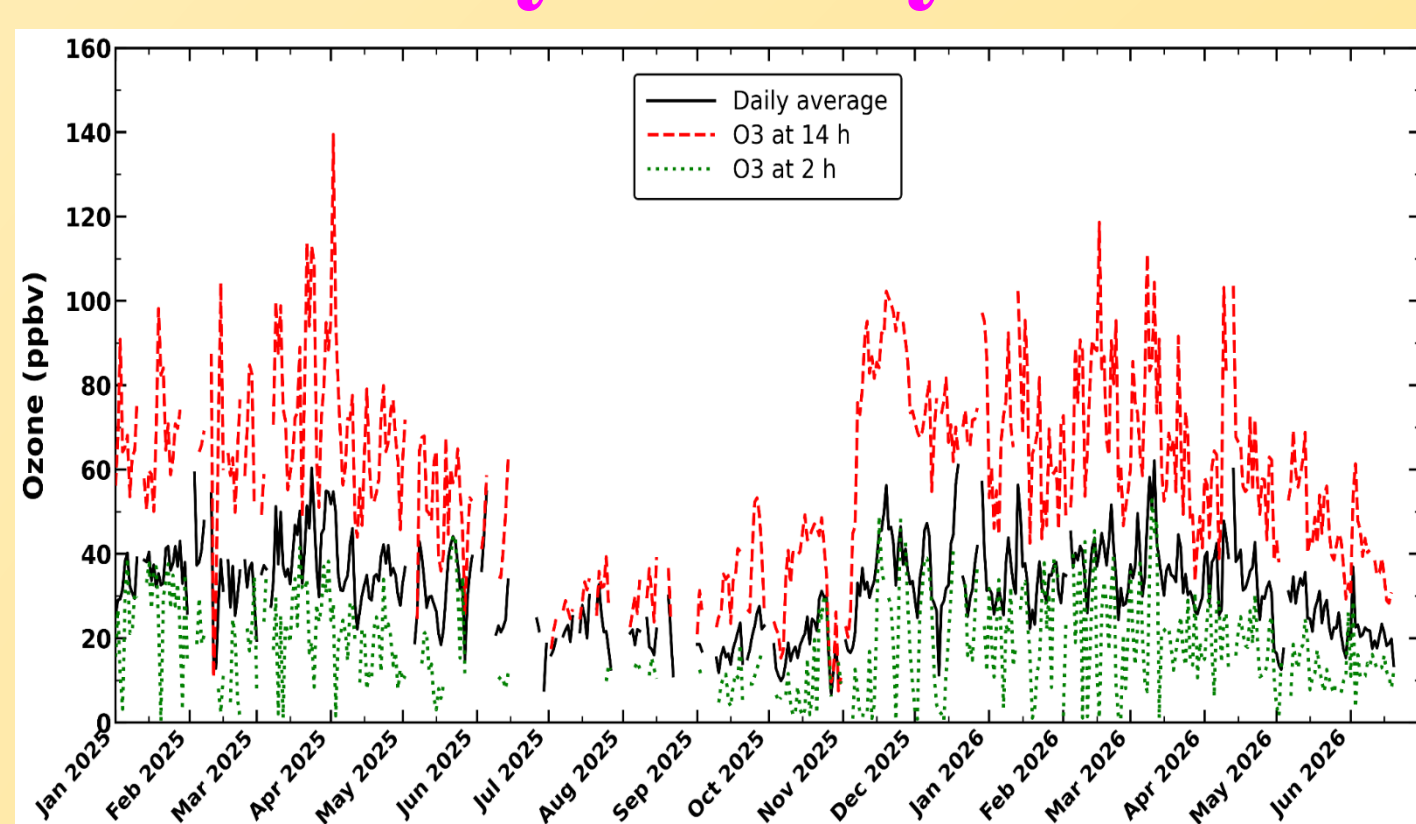
PM_{2.5} – Calibrated low-cost PM sensor-based device was used to measure PM mass concentrations based on light scattering principle



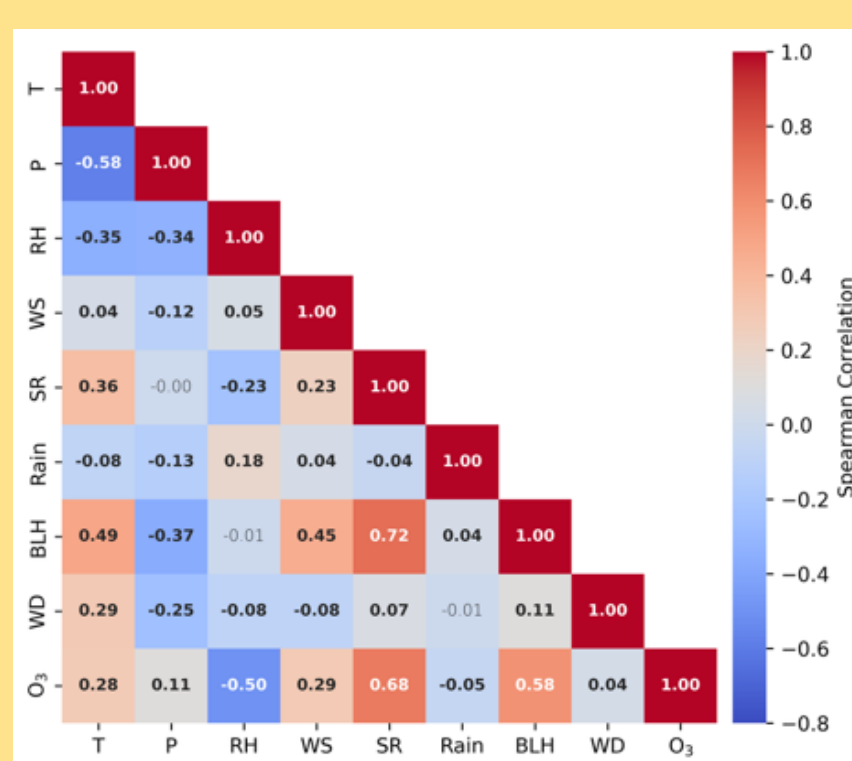
Global reanalysis: ERA5 and CAMS from ECMWF, UK

Results and Discussions

1. Day-to-day and seasonal characteristics

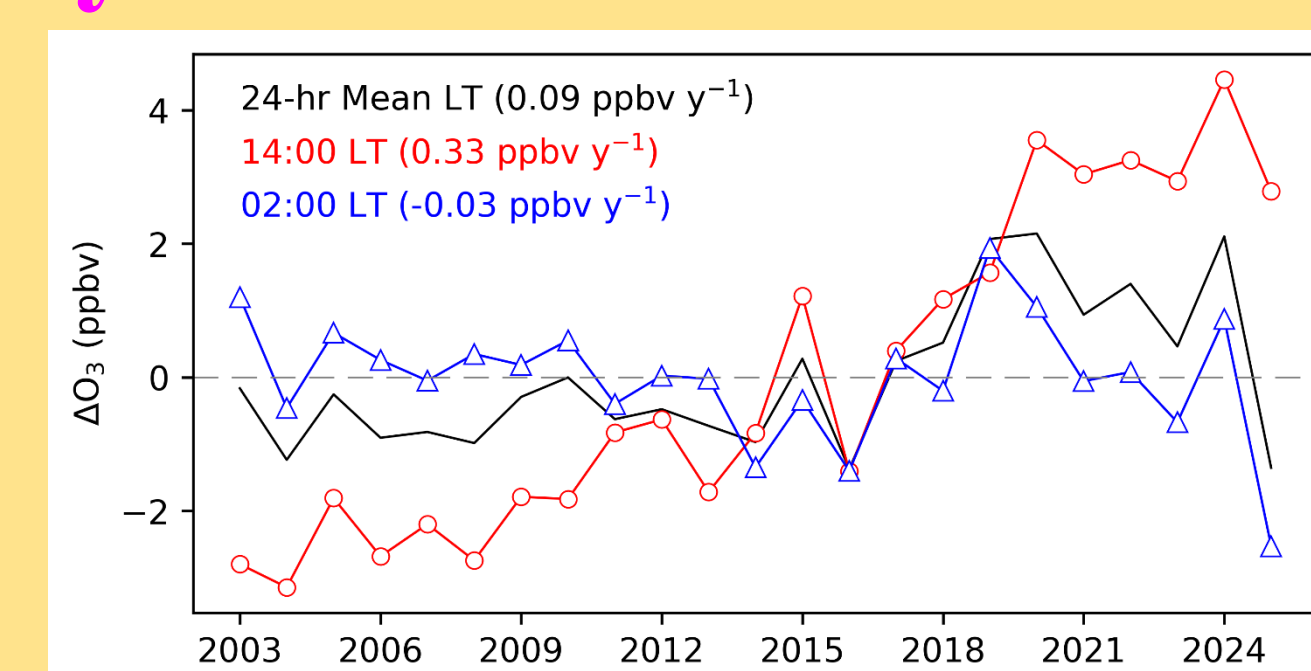


- Noontime O₃ shows large day-to-day and seasonal variability. Seasonal cycle is unique here as O₃ peaks during post-monsoon & winter.
- O₃ variations are strongly correlated with solar radiation, humidity, and BLH.
- Western India receives pollution outflow from IGP region during winter, whereas, local pollution contributes more during April-May.

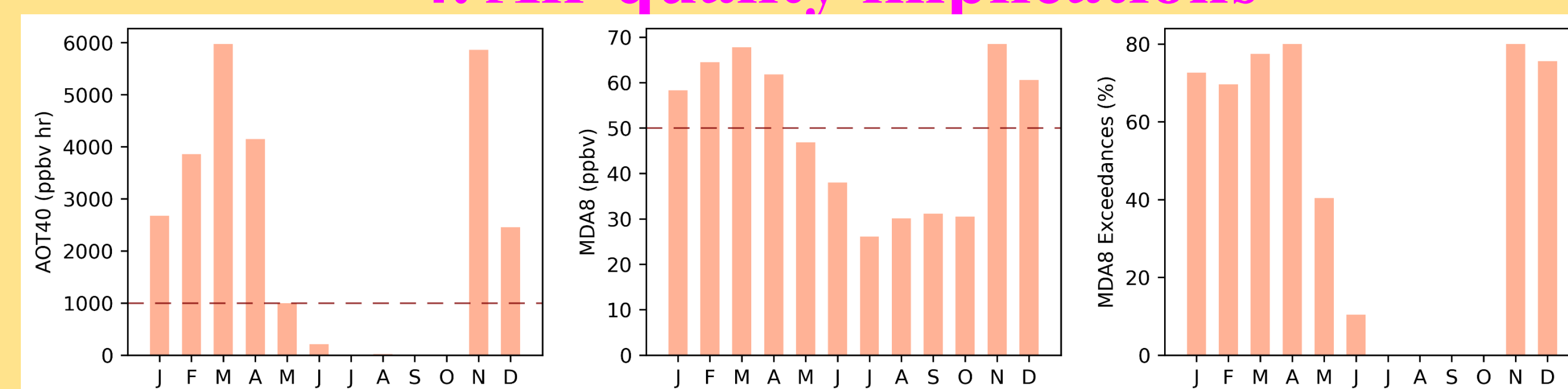


2. Trend Analysis

- CAMS data has been used to derive long-term trends in O₃.
- Noontime O₃ shows a significant increasing trend (0.33 ppbv y⁻¹) while nighttime O₃ show insignificant decline (-0.03 ppbv y⁻¹)

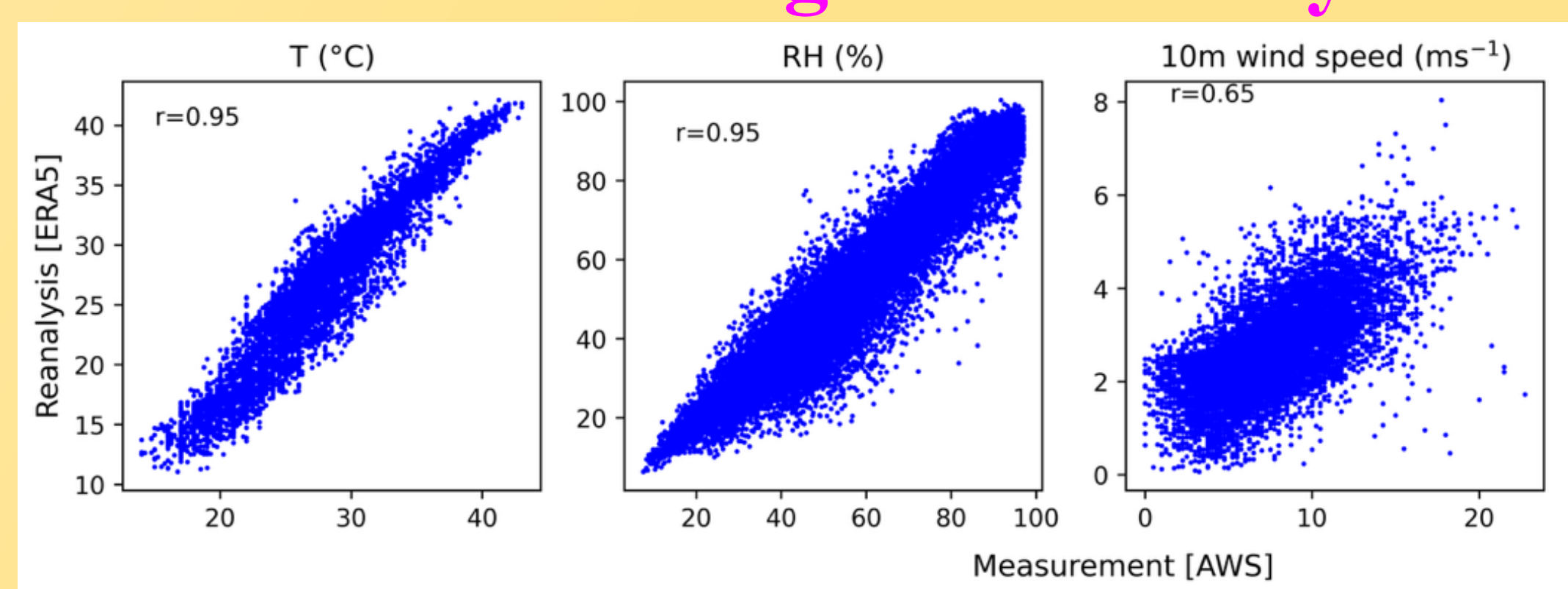


4. Air quality implications

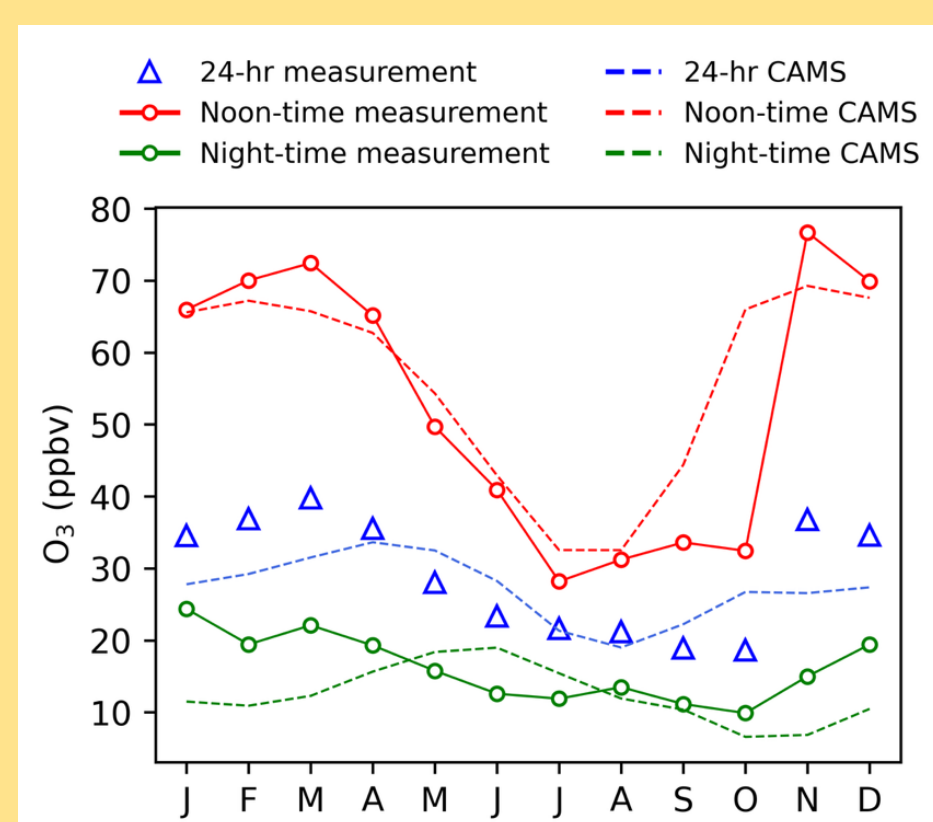


- AOT40 (Accumulated O₃ above Threshold of 40 ppbv) is systematically higher (2500-6000) during October-April suggesting impacts on vegetation.
- MDA8 (Maximum Daily 8-h Average O₃) is also in exceedance of the 50 ppbv threshold. 70-80% of the days during winter & late post-monsoon experience MDA8 exceedance indicating impacts on public health.

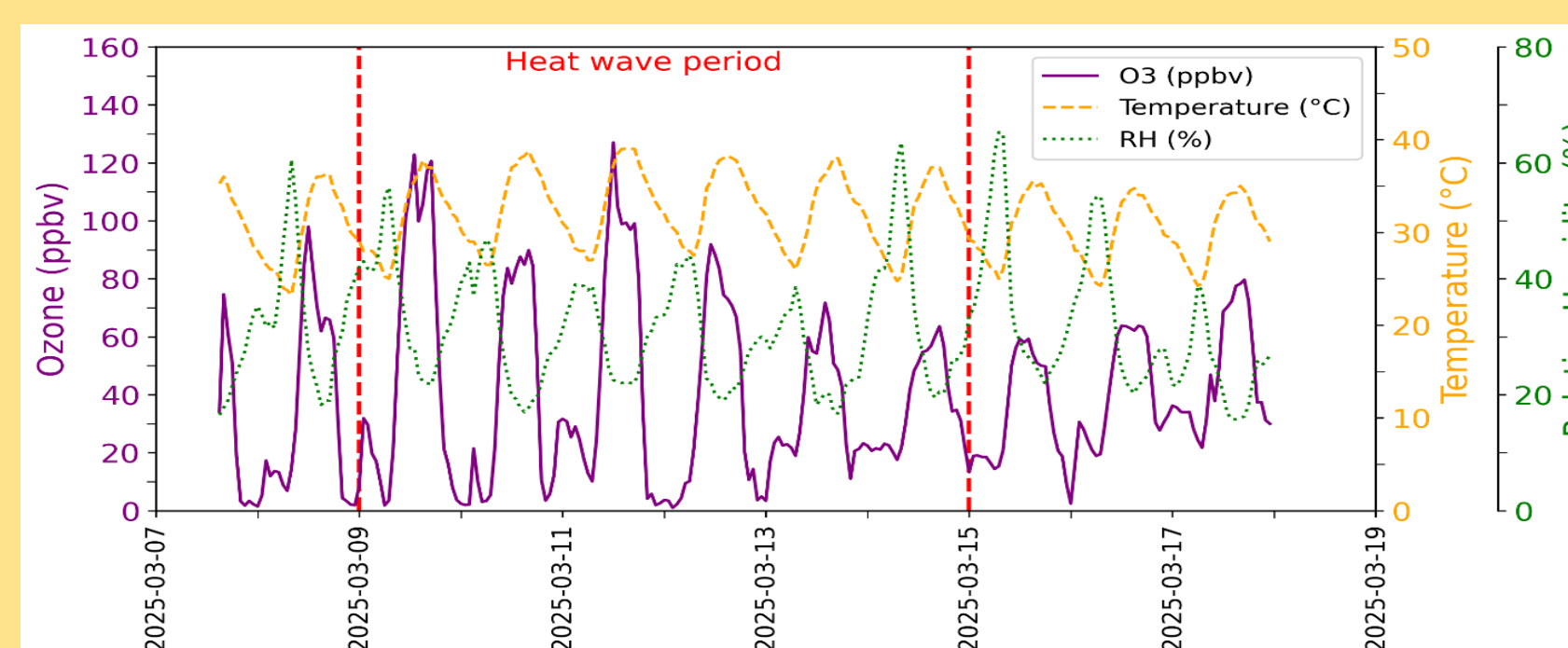
3. Evaluation of global reanalysis



- ERA5 reproduces the observed meteorological variability very well.
- CAMS captures the magnitude as well as variability in O₃ over western India, in contrast to other regions in India where the model is reported to overestimate O₃.



5. Extreme event and Compound pollution



- Sustained elevated O₃ ~ 100 ppbv were observed during March 2025 heatwave, indicating accelerated regional photochemistry.
- Concurrent rise in O₃ (as well as PM_{2.5}) can have greater health implications.

Month	Compound pollution days (%)
Jan	81.7
Feb	57.1
Mar	23.7
Apr	6.8
May	6.5
Jun	0
Jul	0
Aug	0
Sep	4.3
Oct	0
Nov	82.8
Dec	92.7

Summary and Conclusions

- Continuous observations of O₃ and related parameters are conducted over an urban environment (Ahmedabad) in western India. O₃ seasonality is unique with winter and late post-monsoon peak, attributed to pollution outflow from IGP.
- AOT40 and MDA8 exceed the thresholds indicating substantial impacts on public health and vegetation.
- CAMS model captures O₃ levels (as well as seasonality) over western India, in contrast to northern India where model is reported to overestimate O₃ levels.
- Because of unique wintertime high O₃, when aerosol levels may also be higher, this region is seen to be more vulnerable to compound pollution events.

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References

- Y. Dahima and A. Vaishya, 2025, Indoor air quality assessment using low-cost sensors, impact of outdoors; Air Quality Atmosphere & Health, doi.org/10.1007/s11869-025-01843-z.
- Y. Dahima, T. Sarangi, Y. Patel, L. K. Sahu, N. Ojha and A. Vaishya, "Calibration and Performance Evaluation of Low-Cost Air Quality Sensors in an Urban Environment of Western India," in IEEE Sensors Letters, vol. 10, no. 2, pp. 1-4, Feb. 2026, Art no. 6001404, doi: 10.1109/LSSENS.2026.3650975.