Delhi Air Pollution Tracker (CJBS–IIT Delhi)

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Context

Delhi's air quality is entering its seasonal decline as winter approaches, with pollution levels rising alarmingly fast. In response, we launch the Delhi Air Pollution Forecast Series – a weekly early-warning tracker focusing on fine particulate matter ($PM_{2.5}$ and PM_{10}), the key pollutants driving health risks. Using time-series forecasting models, the series will project air-quality trajectories up to 14 days ahead, providing credible foresight on imminent pollution trends.

Rapid Decline in Air Quality in October

The National Capital Region (NCR) is already under formal pollution alert as conditions worsen. Authorities activated Stage I of the Graded Response Action Plan (GRAP) on October 14, 2025, when Delhi's Air Quality Index (AQI) first slipped into the "Poor" category (AQI 211)[1]. Within barely a week, pollution levels accelerated into the "Very Poor" range (AQI > 300), a much faster decline than seen in previous autumns. By October 17, parts of the NCR like Ghaziabad were already recording AQI 306 ("very poor"), with Delhi city at AQI 254 ("poor") and poised to worsen[2]. Official forecasts at the time predicted Delhi's air would cross into "very poor" by October 20 – just six days after the first "Poor" readings, a remarkably rapid drop. The combination of local emissions, unfavorable meteorology, and early stubble-burning which has brought this about signals a tougher pollution season ahead.

The trajectory suggested by the forecasts of PM2.5 and PM10 are alarming and strongly suggests that mitigation measures will need to be escalated sooner.

Figure 1. *Forecast PM2.5 concentrations for Delhi hotspots beginning 20 October 2025, showing rapid rise following Diwali day.*

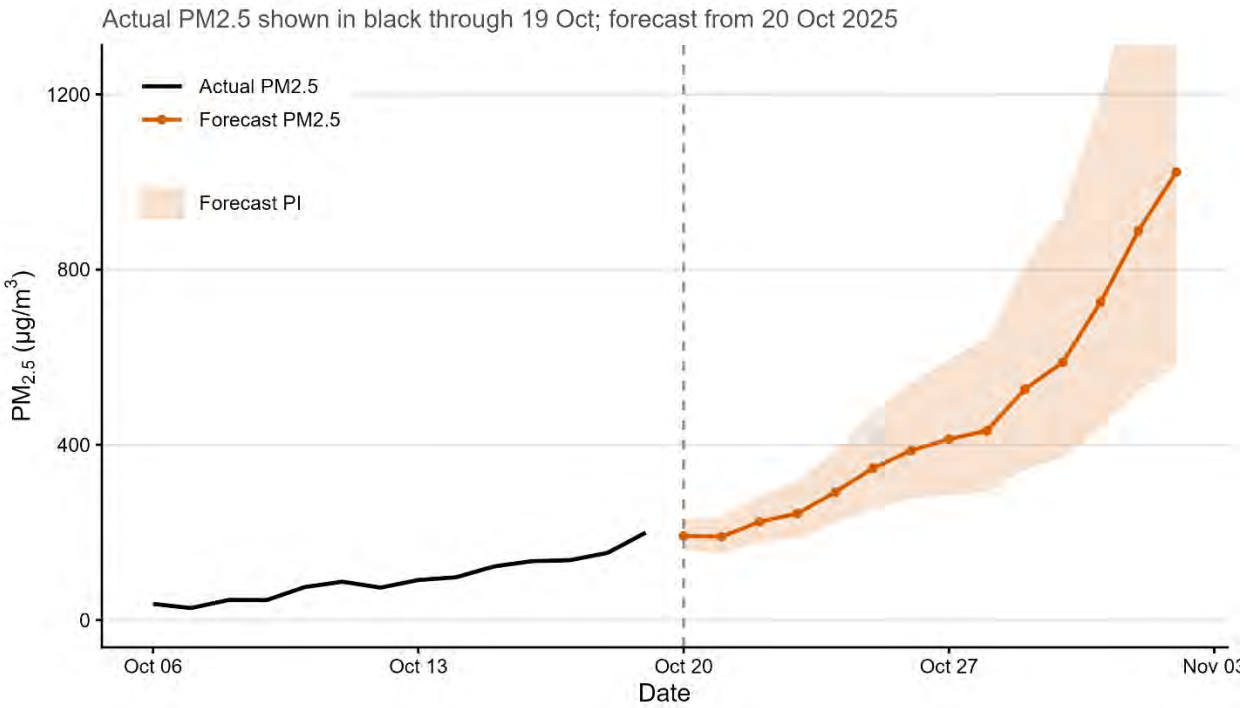
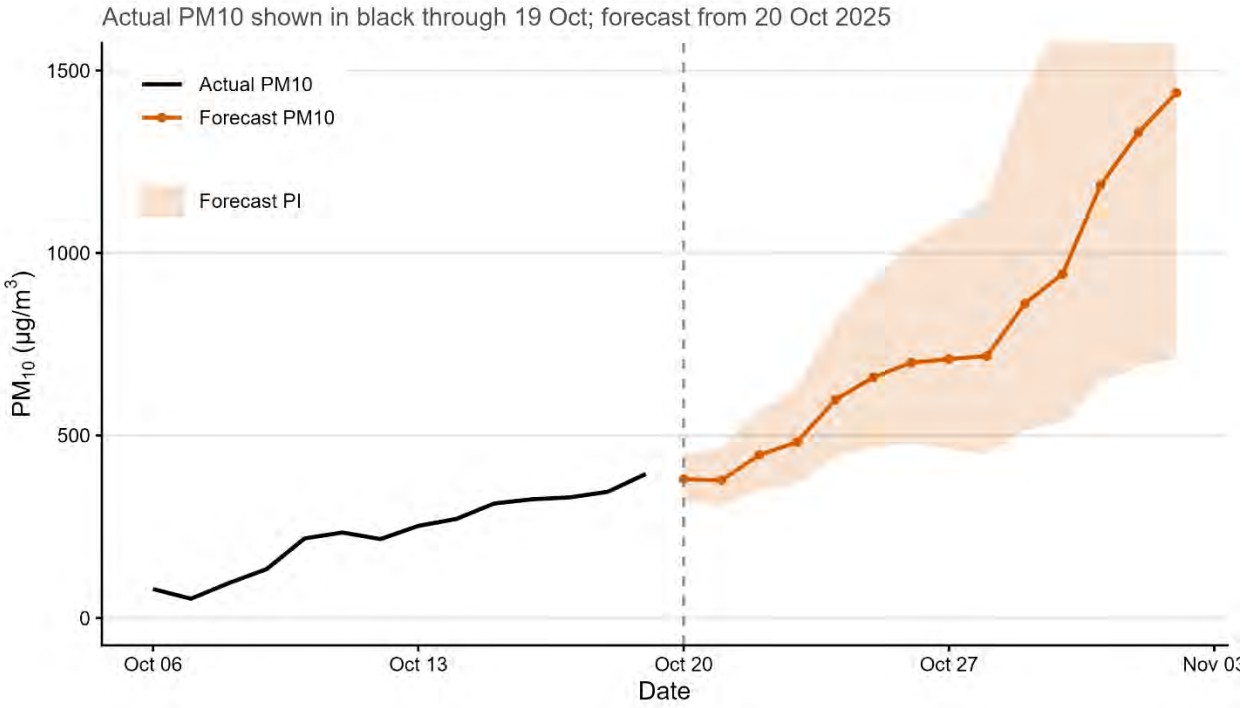


Figure 2. *Forecast PM10 concentrations for Delhi hotspots beginning 20 October 2025.*



The forecasts for the fortnight following Diwali 2025 point to a sharp and early escalation in particulate matter concentrations across Delhi. The steepness of the forecast trajectory suggests that the city could experience *Severe plus* air quality conditions much sooner than in the recent past. In contrast to 2023 and 2024—when PM2.5 levels stabilised or even eased after Diwali—the model now anticipates a continued and accelerated rise through the final week of October.

The early warnings from this forecast series are intended to enable anticipatory action — addressing rising pollution before it escalates to catastrophic levels**,** thereby helping to prevent such levels from being reached in the first place. If the predicted rise materialises, waiting for observed AQI values to breach critical thresholds would leave too little time for an effective response. The forecasts therefore strengthen the case for earlier deployment of measures**,** tighter coordination with agricultural-burning surveillance, and intensified public-health communication to reduce exposure risks. The model's historical accuracy in capturing both stable and rising post-Diwali patterns (see below) lends credibility to these warnings.

Should strong interventions (or favourable weather) reduce emissions or improve dispersion, a downward deviation from the forecast would be a positive outcome.

Forecasting Approach: Time-Series Growth Curve Model

While the core air pollution models simulate weather and chemistry, the forecasting framework in this series takes a phenomenological time-series approach. We employ an ensemble of statistical models to capture patterns in the observed pollution data and adapt to real-time trends. The primary model – a Time Series Growth Curve (TSGC) model – is based on methods developed in Harvey & Kattuman (2021). It uses a state-space formulation to decompose the pollutant time series into underlying growth trends, seasonal components, and noise, updating its estimates continuously via Kalman filtering. This data-driven model "learns" the trajectory of $PM_{2.5}$/PM_{10} from recent observations and projects it forward, adjusting quickly if the trend shifts (for example, due to a policy intervention or a weather change). Such growth-curve models proved their adaptability in forecasting COVID-19 waves, where focusing on the growth rate of cases helped guide timely responses. In air quality forecasting, this translates to closely tracking the rise (or fall) in pollution concentrations and detecting turning points as early as possible.

By design, the TSGC and companion statistical models emphasize rapid updates, uncertainty quantification, and interpretability over longer-range physical simulation. Each day, new data from Delhi's continuous monitoring (hourly PM readings from Central Pollution Control Board stations) and meteorological indicators (e.g. wind speed, mixing height from sources like ERA5 reanalysis) are analysed, and the forecasts are adjusted accordingly. The approach is empirical – it does not explicitly model complex atmospheric chemistry or transport – but this simplicity allows it to respond to the latest conditions and present probabilistic ranges for expected pollution levels. Over the 14-day horizon, forecast uncertainty naturally grows, especially if

major shifts occur (such as a rain spell cleaning the air, or emergency measures cutting emissions). The model is therefore re-calibrated frequently to incorporate any such changes.

Crucially, this statistical forecast is intended to complement the high-resolution mechanistic models. The India Meteorological Department (IMD) and Indian Institute of Tropical Meteorology (IITM) run advanced chemistry-transport models – SILAM and WRF-Chem – which simulate pollutant dispersion using weather forecasts and emissions inventories. These models provide granular 3–10-day forecasts and underpin the official Air Quality Early Warning System. Our time-series framework is not a replacement for these; rather, it offers a parallel, fast-turnaround tool that focuses on recent data trends. For example, if unexpected pollution spikes or dips occur, the statistical model can incorporate them immediately, whereas physical models might take longer to adjust due to computation and input update lags. The goal is to marry the strengths of both approaches: detailed physics-based understanding from WRF-Chem/SILAM, and real-time adaptive forecasting from the growth-curve ensemble.

Proactive Air-Quality Management

The 14-day forecast window is deliberately chosen to empower policymakers and regulatory bodies to act ahead of time. Instead of reacting only to present or past pollution levels, authorities can use forward insight to initiate mitigative steps *before* conditions reach emergency thresholds. Anticipatory action, guided by forecasts rather than only real-time monitors, is exactly what Delhi's updated GRAP framework envisions. It shifts the strategy from a reactive response (waiting for air quality to turn "Severe" for three days before intervening) to a proactive mode where advance notice prompts preventive measures.

For public health authorities, a two-week pollution outlook also aids risk communication and emergency preparedness. Healthcare systems can brace for higher respiratory case load if a severe smog episode is forecast. Schools and employers can plan advisories or temporary closures if hazardous air quality looms. And the general public, through media reports, can be alerted to take protective measures (limiting outdoor exposure, using N95 masks, etc.) on bad-air days that are expected. As experts note, reliable forecasts are crucial for guiding citizens' precautions and enabling officials to enact short-term pollution curbs that save lives. By providing a credible heads-up on pollution spikes, this forecast series aims to reduce the surprise factor of sudden smog and facilitate a smoother activation of responses – from GRAP escalations to health advisories – that minimize human exposure during the worst days.

It's important to stress that these forecasts represent probable trajectories under current conditions. If strong interventions take place or anomalous weather (unexpected rain) occurs, actual pollution levels will deviate from the forecast. The forecasts are to be continuously cross-checked with most up-to-date air quality observations, and the models recalibrated as new data arrives. The value of the system lies in its ability to forewarn and prompt early action, but it will always be used in tandem with real-time AQI updates and expert judgement. These forecasts provide a risk outlook guiding adaptation to observed conditions.

Coverage of the Inaugural Forecast and Hotspot Focus

This first issue of the Delhi Air Pollution Forecast Series zeroes in on several known pollution hotpots around the capital: Anand Vihar, ITO, Jahangirpuri, Punjabi Bagh, RK Puram, and Wazirpur. These areas consistently rank among the highest in Delhi's pollution charts and are bellwethers for citywide air quality problems. By tracking these locations, the report provides insight into worst-case conditions where intervention is most urgently needed. For example, on October 16–17, Anand Vihar recorded an AQI of 360 and Wazirpur 352[15], both deep in the "Very Poor" category and the highest in the city at that time. Such figures highlight why these areas demand special attention: they are the first to deteriorate and often reach hazardous levels of PM concentration.

By basing our models on detailed data from these locations (drawn from CPCB's network of continuous ambient air quality stations), we aim to capture the upper bound of pollution trends in the NCR. Meteorological inputs – such as wind patterns and temperature are integrated from sources like the ERA5 satellite-reanalysis to account for how weather will affect each hotspot's pollution over the coming fortnight. While the forecasts currently cover only these six key areas, they serve as a representative early warning for the broader region: if Anand Vihar or Punjabi Bagh are forecast to see a sharp spike in PM2.5, it likely heralds worsening air across Delhi unless localized factors are at play. In future updates, we plan to expand the regional coverage (bringing more areas and surrounding towns into the forecast fold), but the hotspot-centric approach in this inaugural report ensures we don't miss the critical signals from the worst-affected zones.

Forecast Accuracy

Diwali is a crucially important festival. It is generally associated in discussion with elevated particulate concentrations due to a combination of fireworks, festive mobility, and winter onset. To assess how well our forecasting model captures post-Diwali dynamics, we carried out a heuristic validation exercise: forecasting from the Diwali day onwards for the past three years — 2022, 2023, and 2024 (figures below). In 2023 and 2024, the period immediately following Diwali showed no further acceleration in particulate levels, while in 2022, pollution continued to climb in the days after the festival. The model reproduced these contrasting trajectories with reasonable accuracy, successfully tracking both the stable post-Diwali plateaus and the more sustained 2022 increase. The current 2025 forecast, which begins on Diwali day, indicates a potentially sharper and faster rise in PM2.5 concentrations than in the previous two years, signalling the need for heightened vigilance and early mitigation.

Next Steps

This first weekly forecast bulletin underscores the message that Delhi's winter pollution season is off to an earlier and faster worsening than in years past. By marrying statistical growth-curve models with on-ground data, the Delhi Air Pollution Forecast Series strives to be a reliable

early-warning tool for all stakeholders – from government agencies coordinating emergency responses to journalists informing the public on what lies ahead. The approach is innovative in its focus on adaptive forecasting and is meant to augment (not replace) the sophisticated physical models already guiding policy. Together, these tools can offer a more complete picture: high-detail simulations from IMD/IITM for understanding spread, and agile forecasts from this series for staying one step ahead of emerging pollution spikes.

Moving forward, subsequent bulletins in this series will:

- Expand regional coverage – incorporating forecasts for a wider set of locations across Delhi and NCR, to ensure all major areas are included in the early-warning system.
- Expand pollutant coverage – beyond $PM_{2.5}$ and PM_{10}, we plan to include forecasts for other critical pollutants as data allows, giving a more comprehensive outlook on air quality.
- Evaluate forecast accuracy – assessing how well the forecasts perform against actual observed AQI outcomes, in order to refine the models and quantify confidence levels for decision-makers.
- Evaluate the efficacy of GRAP measures – examining, as the season progresses, how the different stages of the Graded Response Action Plan are influencing pollution trajectories (e.g., do Stage II or III interventions noticeably bend the curve downward?) and providing feedback on what strategies work best.

Sources: Central Pollution Control Board (CPCB) continuous air quality data; ERA5 meteorological reanalysis; Forecast model methodology based on Harvey & Kattuman (2021)

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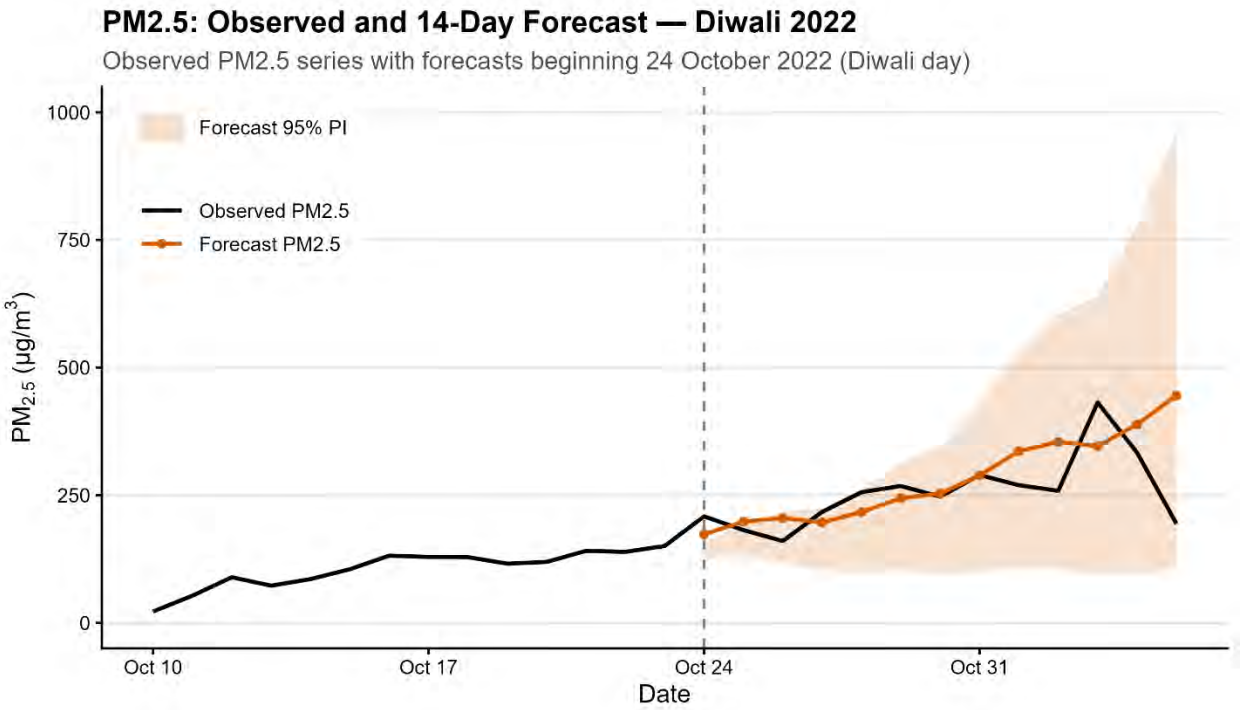
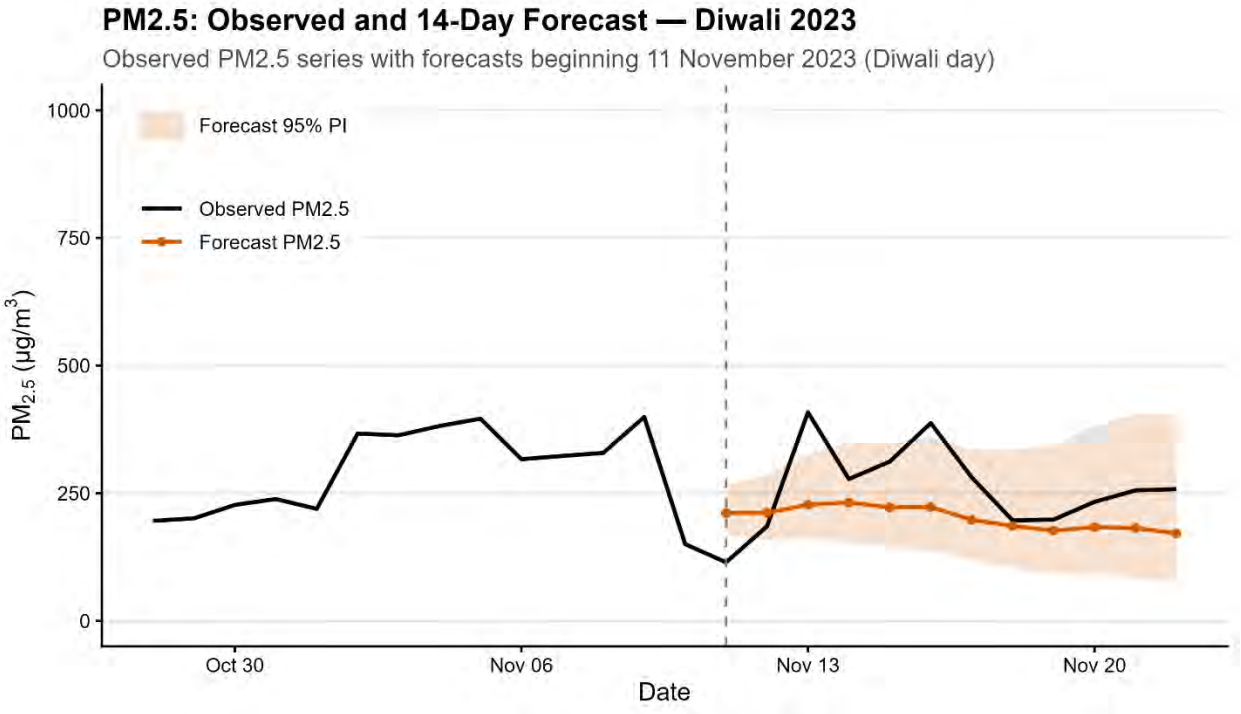
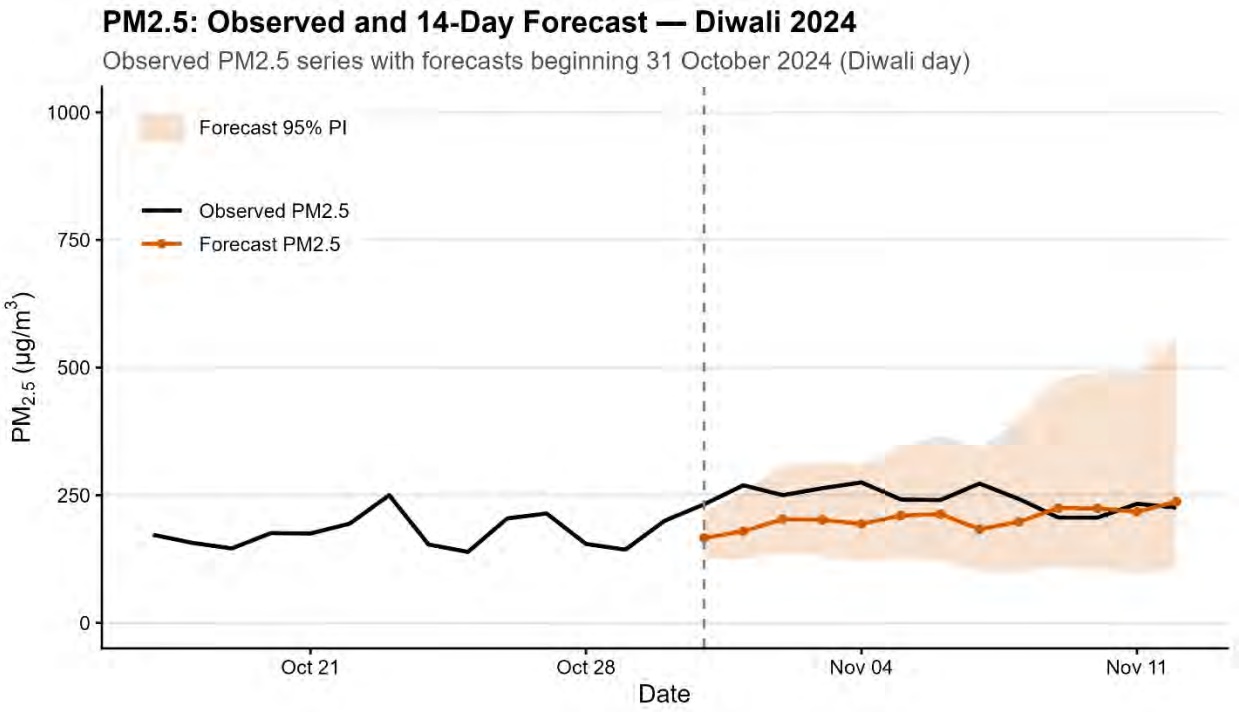
Appendix


PM2.5: Observed and 14-Day Forecast — Diwali 2022
Observed PM2.5 series with forecasts beginning 24 October 2022 (Diwali day)
Forecast 95% PI
Observed PM2.5
Forecast PM2.5
1000
750
500
250
0
PM2.5 (µg/m3)
Oct 10
Oct 17
Oct 24
Oct 31
Date


PM2.5: Observed and 14-Day Forecast — Diwali 2023
Observed PM2.5 series with forecasts beginning 11 November 2023 (Diwali day)
Forecast 95% PI
Observed PM2.5
Forecast PM2.5
1000
750
500
250
0
PM2.5 (µg/m3)
Oct 30
Nov 06
Nov 13
Nov 20
Date


PM2.5: Observed and 14-Day Forecast — Diwali 2024
Observed PM2.5 series with forecasts beginning 31 October 2024 (Diwali day)
Forecast 95% PI
Observed PM2.5
Forecast PM2.5
1000
750
500
250
0
PM2.5 (µg/m3)
Oct 21
Oct 28
Nov 04
Nov 11
Date