

Optimising crop-residue burning PM_{2.5} emission fluxes over the Indo Gangetic Plain using inverse modelling

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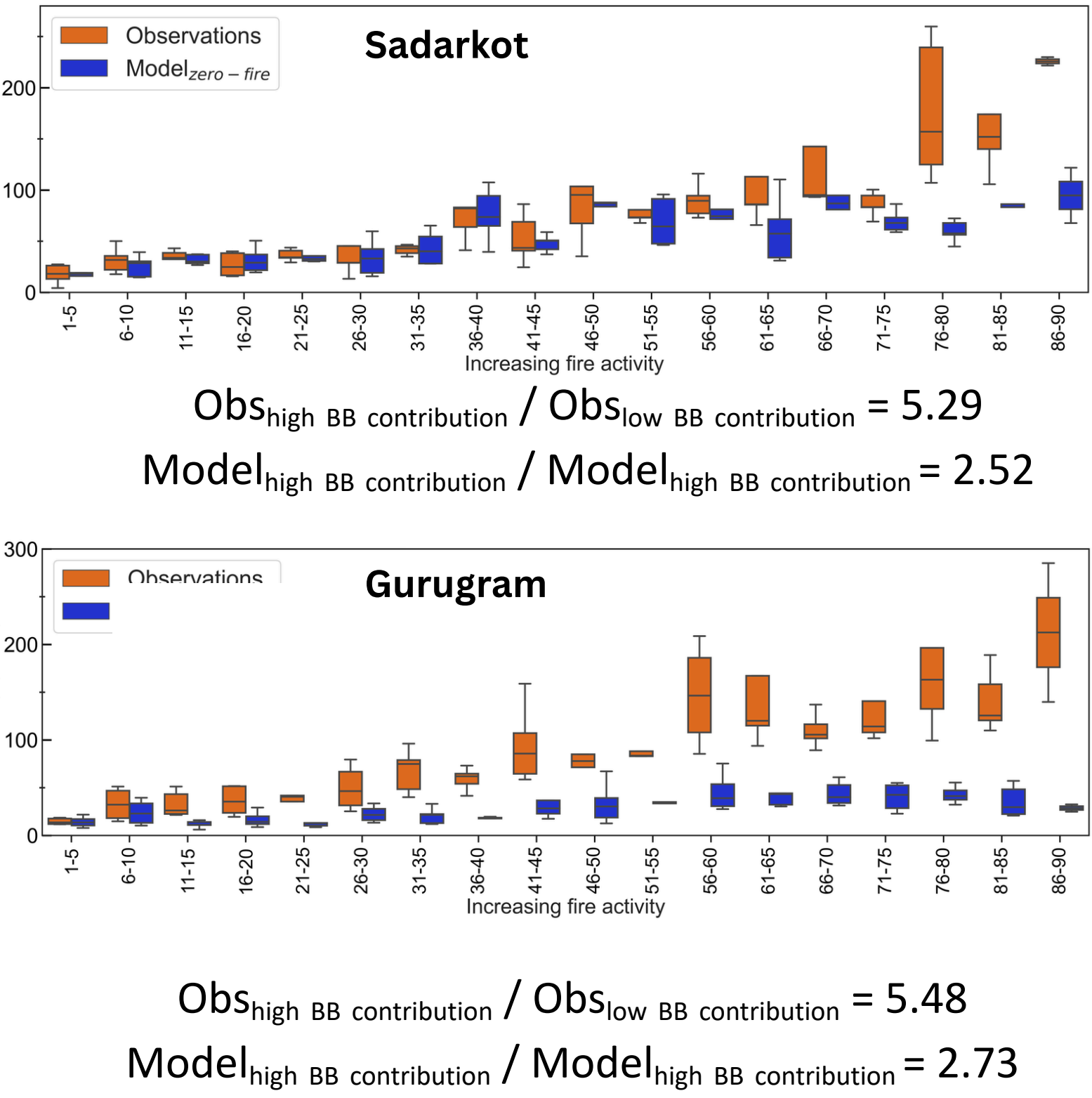
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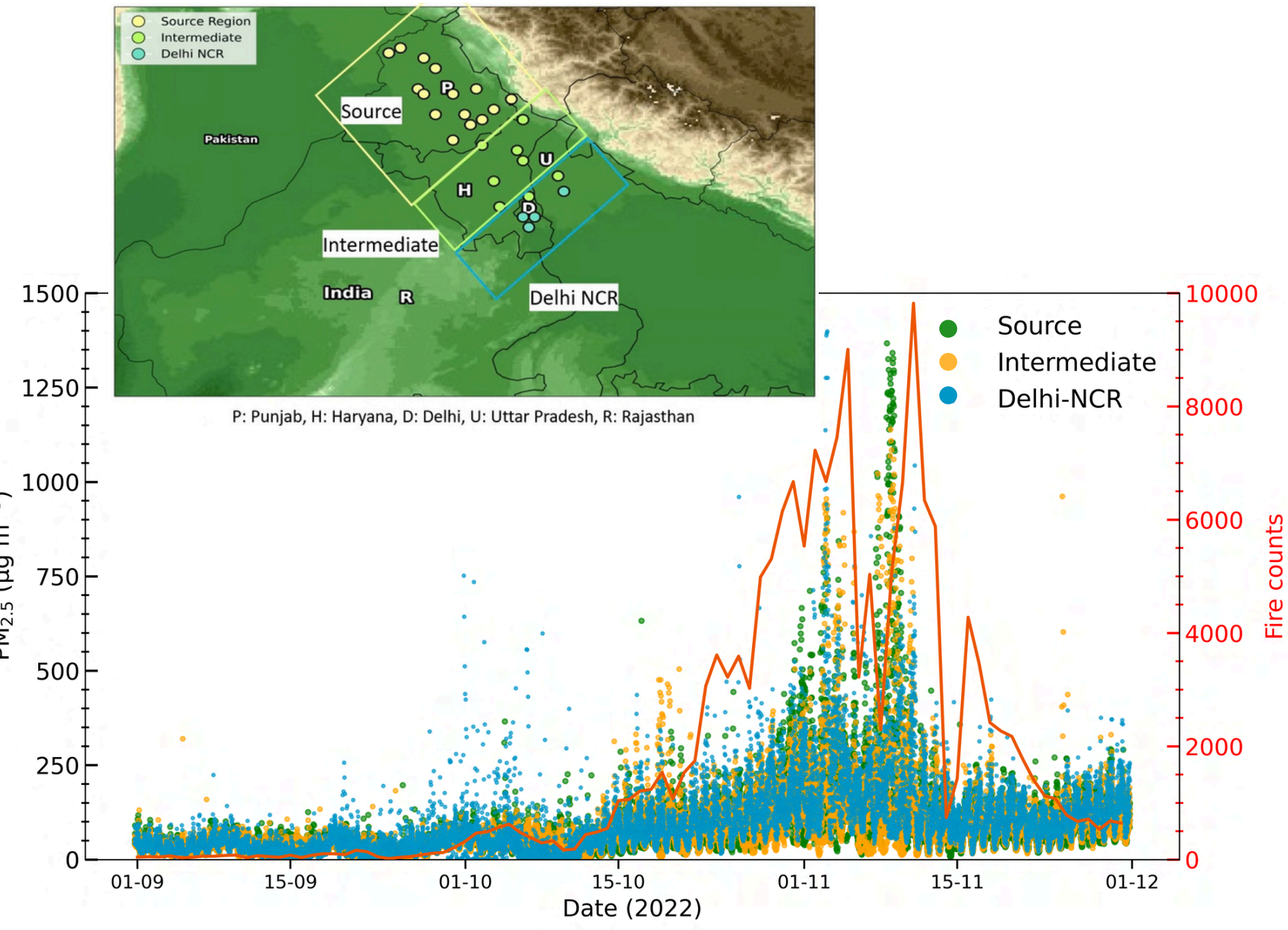
Motivation

A statistical analysis developed (Arora et al., 2025) to disentangle the relative contribution of emissions and meteorology reveals that,

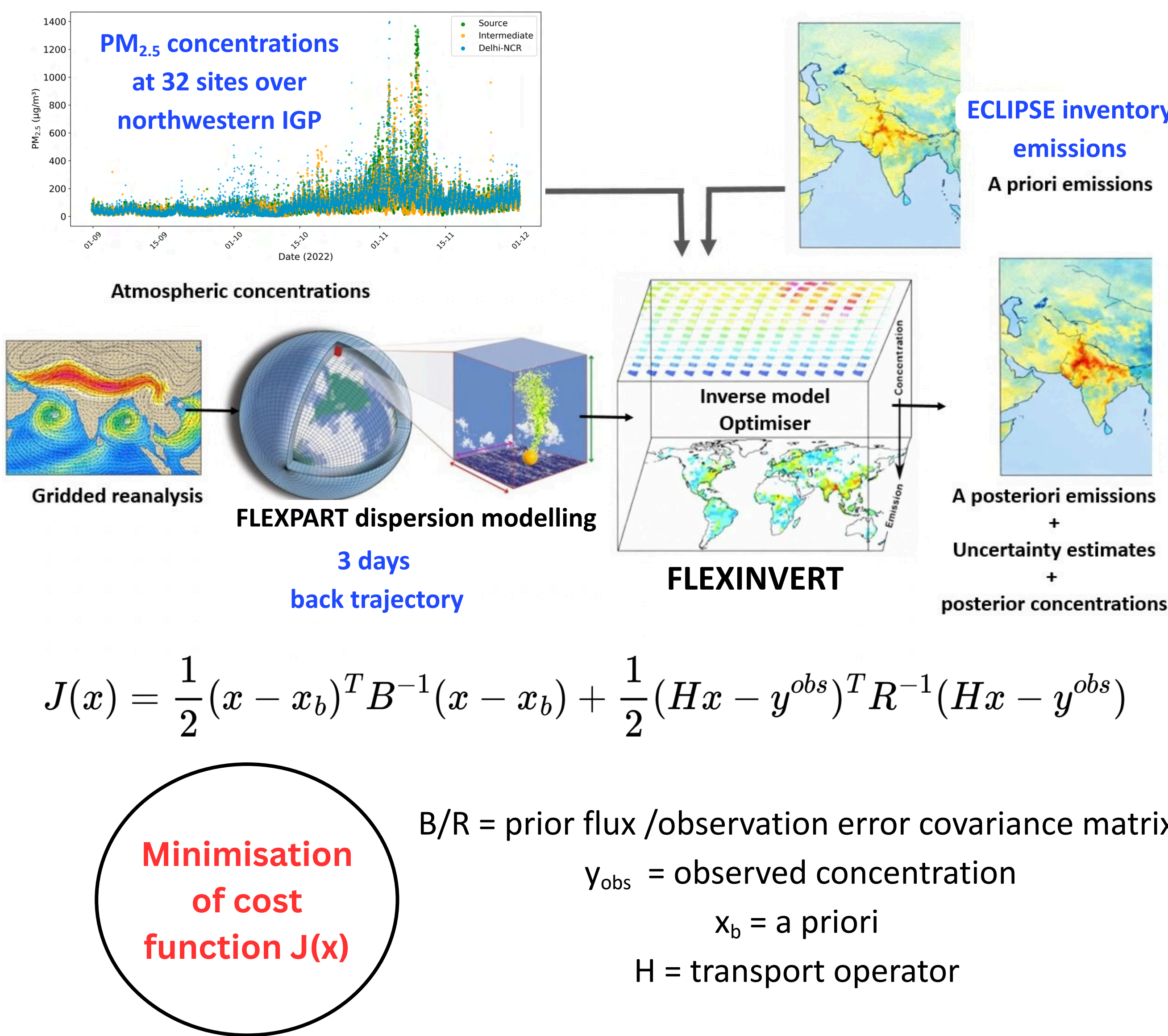
- meteorology can enhance PM_{2.5} concentrations by a factor of ~3, while
- the observed increase exceeds by a factor of ~6, from highest fire contribution to lowest fire contribution periods, thus highlighting the complex interplay between emissions and meteorology in driving PM_{2.5} concentrations over the IGP.



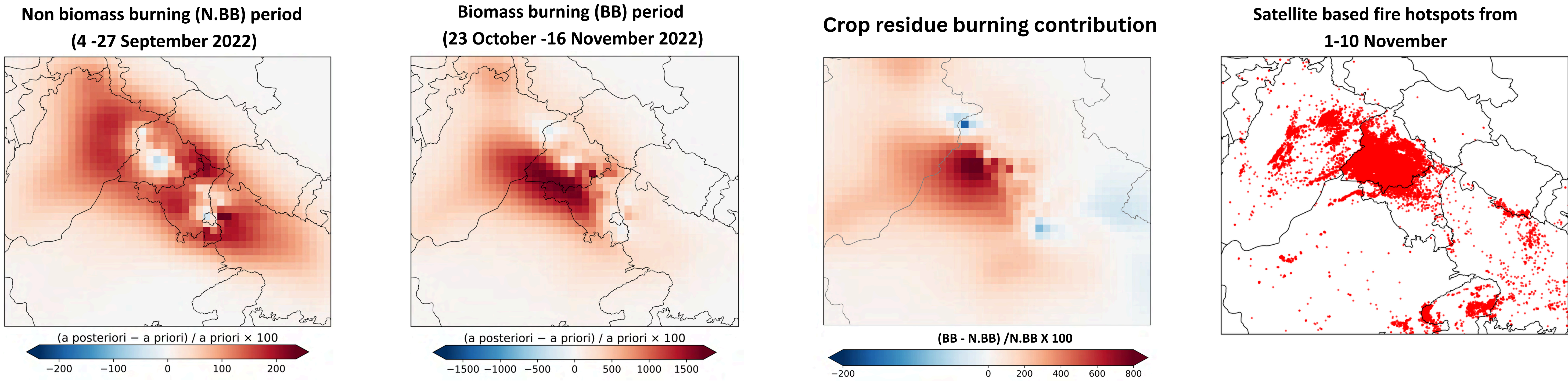
- PM_{2.5} surface mass concentrations are elevated across IGP during periods of intense crop-residue burning (CRB).
- Establishing a probable causal relationship between fire activity and surface PM_{2.5} concentrations is challenging, as CRB occurs simultaneously with stagnant meteorological conditions.
- 32 ground-based PM_{2.5} monitoring sites are located across the northwestern Indo-Gangetic Plain (IGP), and of which 27 were used in the inversion.



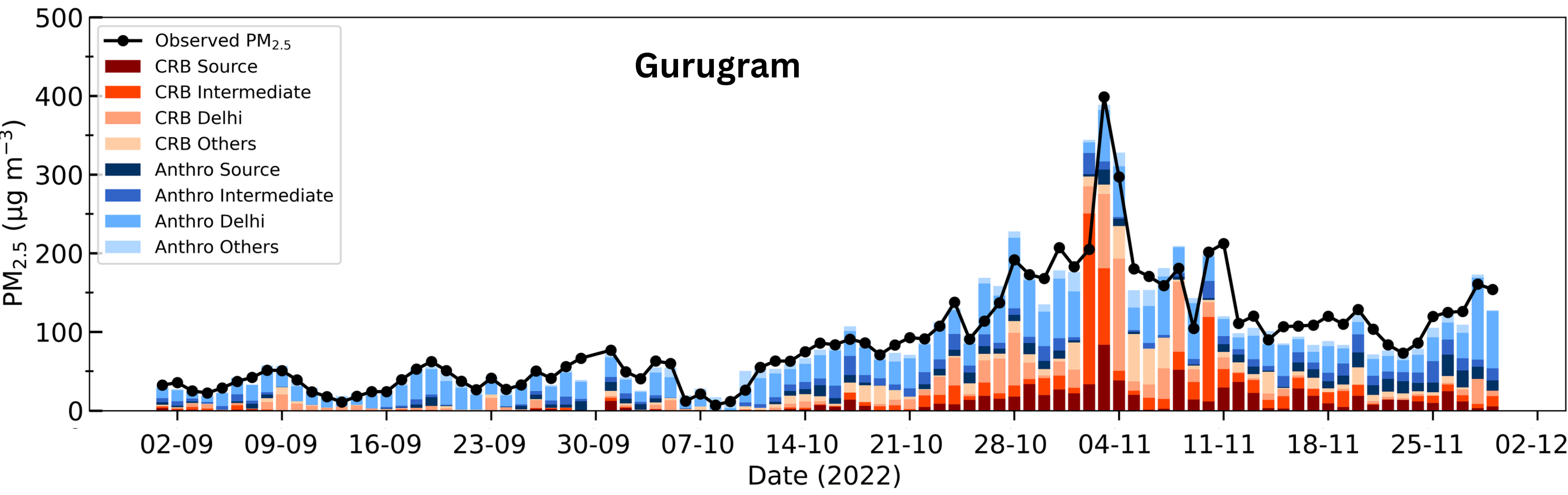
Data and methodology



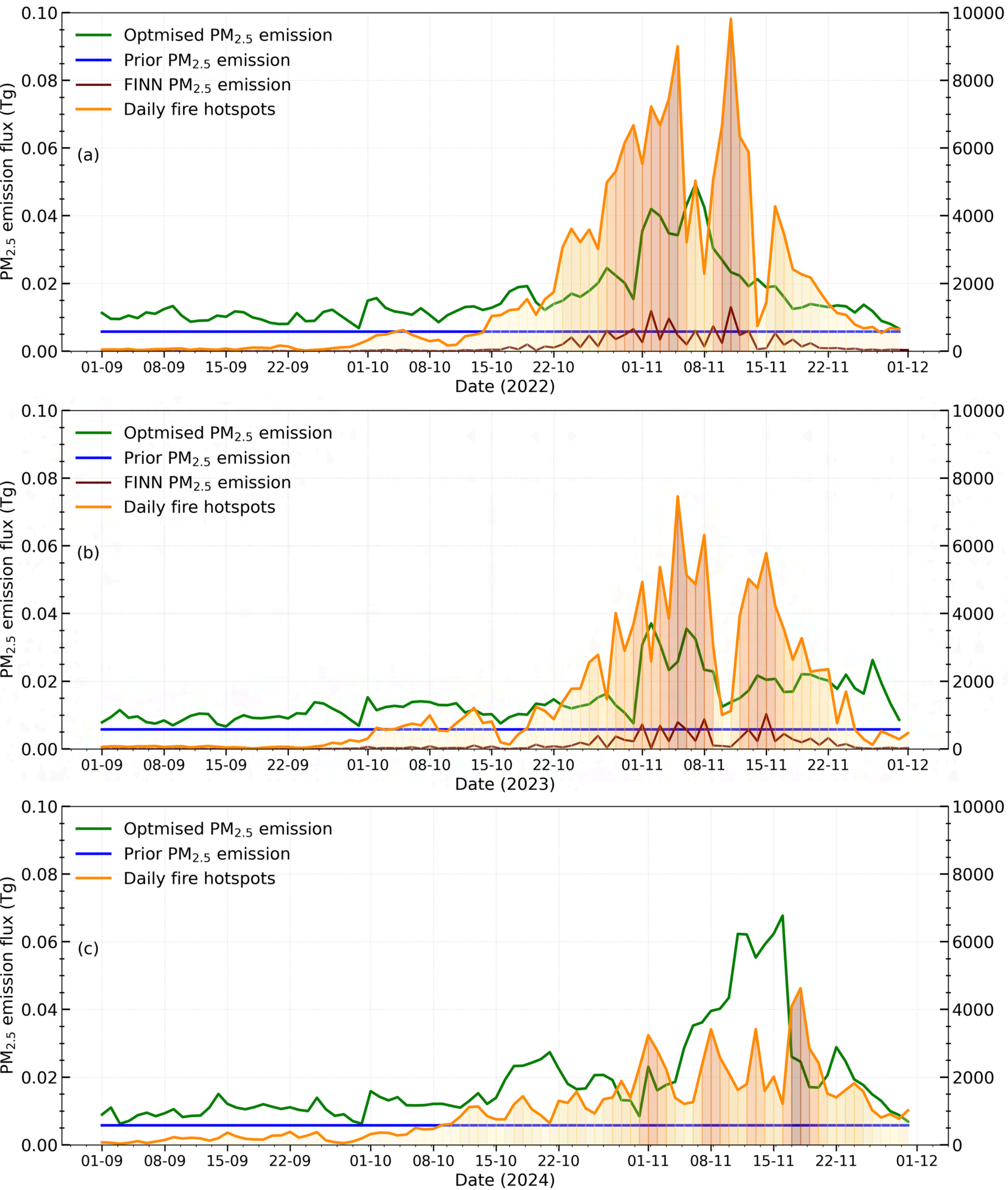
Spatial distribution of optimised PM_{2.5} emission fluxes (2022)



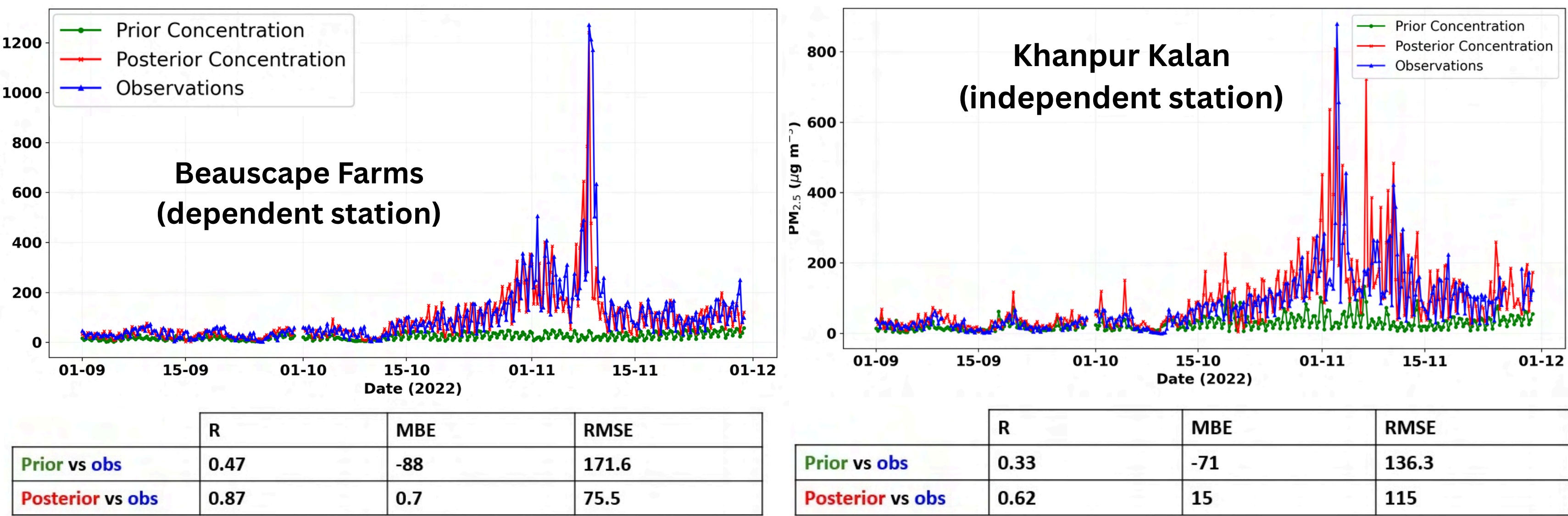
Source contribution to PM_{2.5} at Delhi NCR site



Top-down vs bottom-up emissions vs satellite based fire hotspot



Model evaluation : prior vs posterior vs observations



Key results

- During BB, the largest enhancements occur over Punjab and Haryana agricultural states which spatially, coinciding with fire hotspots implying that enhancement is due to CRB.
- At representative Delhi NCR sites, during a major pollution episode (2-4 November), CRB from Punjab and Haryana contributes up to ~50-60% of total PM_{2.5}, with an additional ~15-25% coming from local CRB within Delhi NCR.
- Compared to 2022, optimised fluxes are highest in 2024, despite satellite-detected fire counts are nearly 50% lower in 2024, suggesting that satellites fail to detect the true extent of fire activity.
- Bottom-up BB emissions underestimate optimised fluxes by a factor of 2-7.