

Vertical profiles of particulate matter concentration using low-cost sensor on-board drone over Delhi, India

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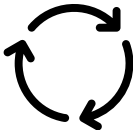
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Presenting author email: ahlawat@tropos.de



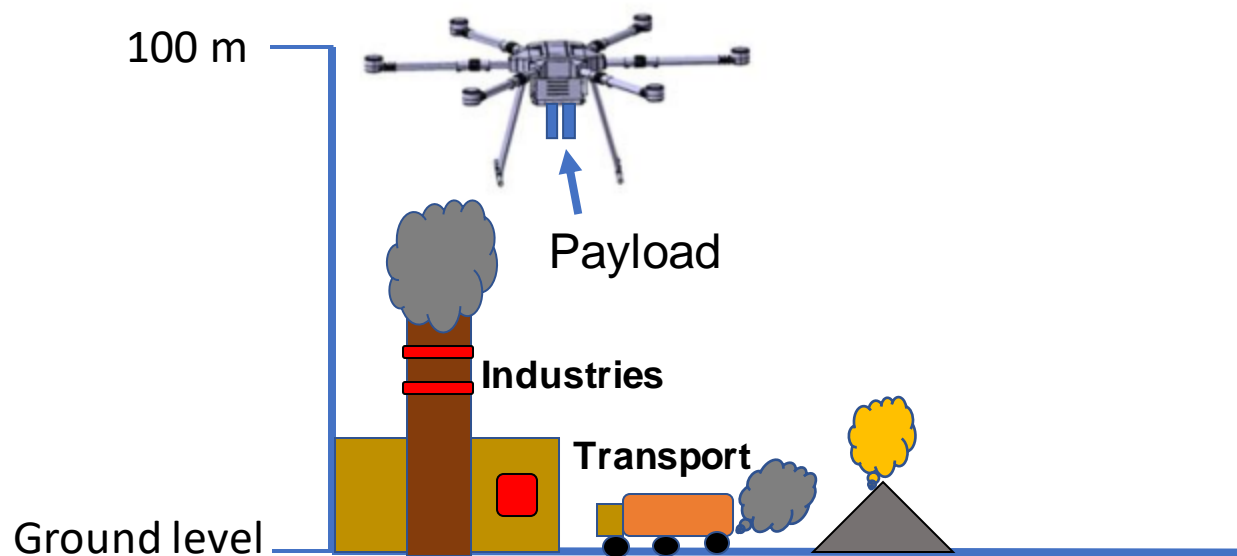
03.05.2024





INTRODUCTION

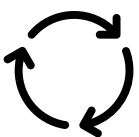
There are a few studies which used ground-based low-cost sensor (LCS) network over Delhi (Jai Prakash et al (2021)).



There is still a significant knowledge gap regarding vertical information of air pollutants over Delhi.

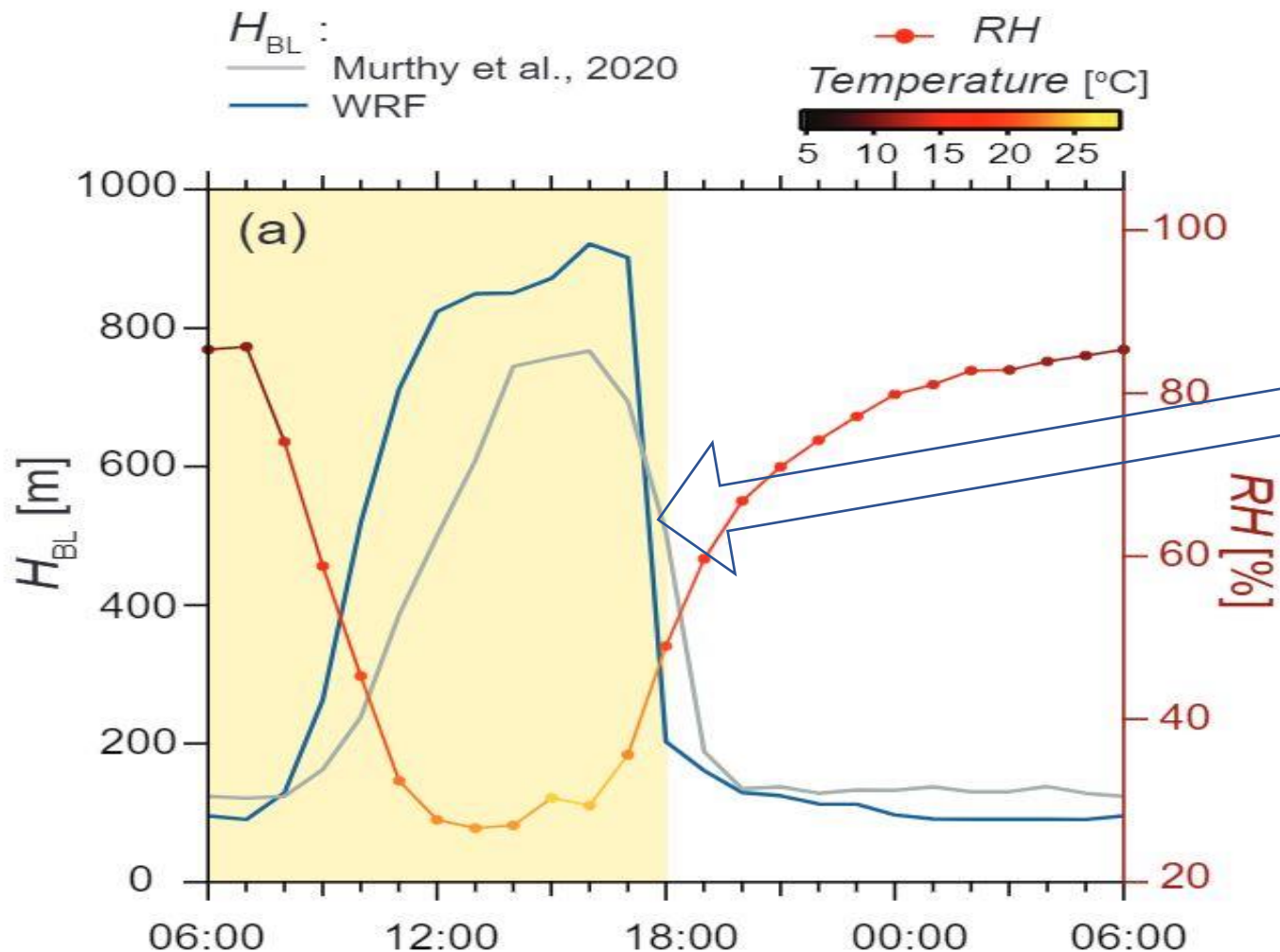
Model validations are barely conducted at such altitudes

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INTRODUCTION

Typical Planetary Boundary Layer in Delhi during February and March



Planetary boundary layer height (HBL) modeled by the WRF model (blue) and measured by Ceilometer from Murthy et al. (2020)

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Drone Campaign 2021, Delhi, India

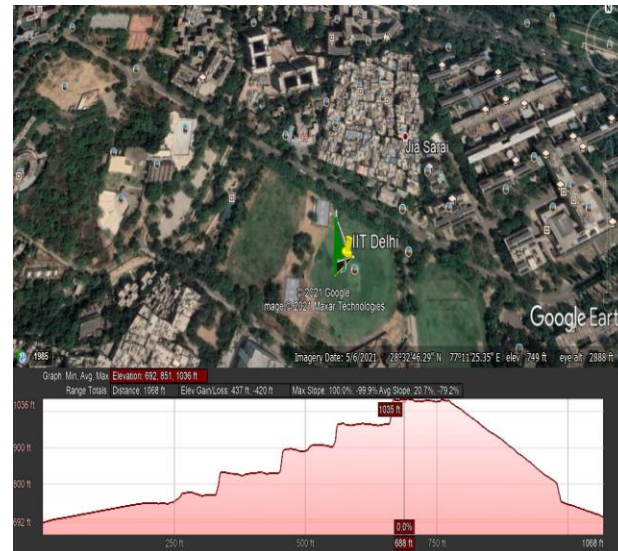
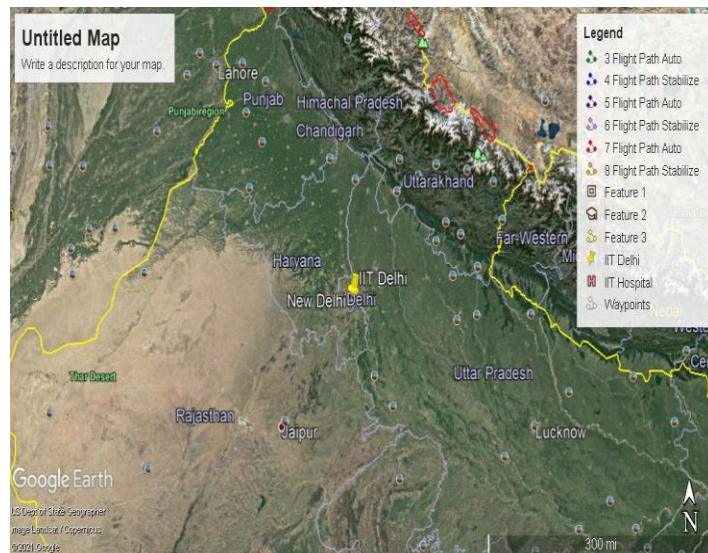
- Drone campaign (11 – 23 March 2021) IIT Delhi (28.5457° N, 77.1928° E)

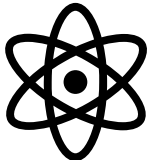
Objective-1: Inter-comparison Campaign

- Inter-comparison of PM monitor with E-BAM instruments at 15 m height.

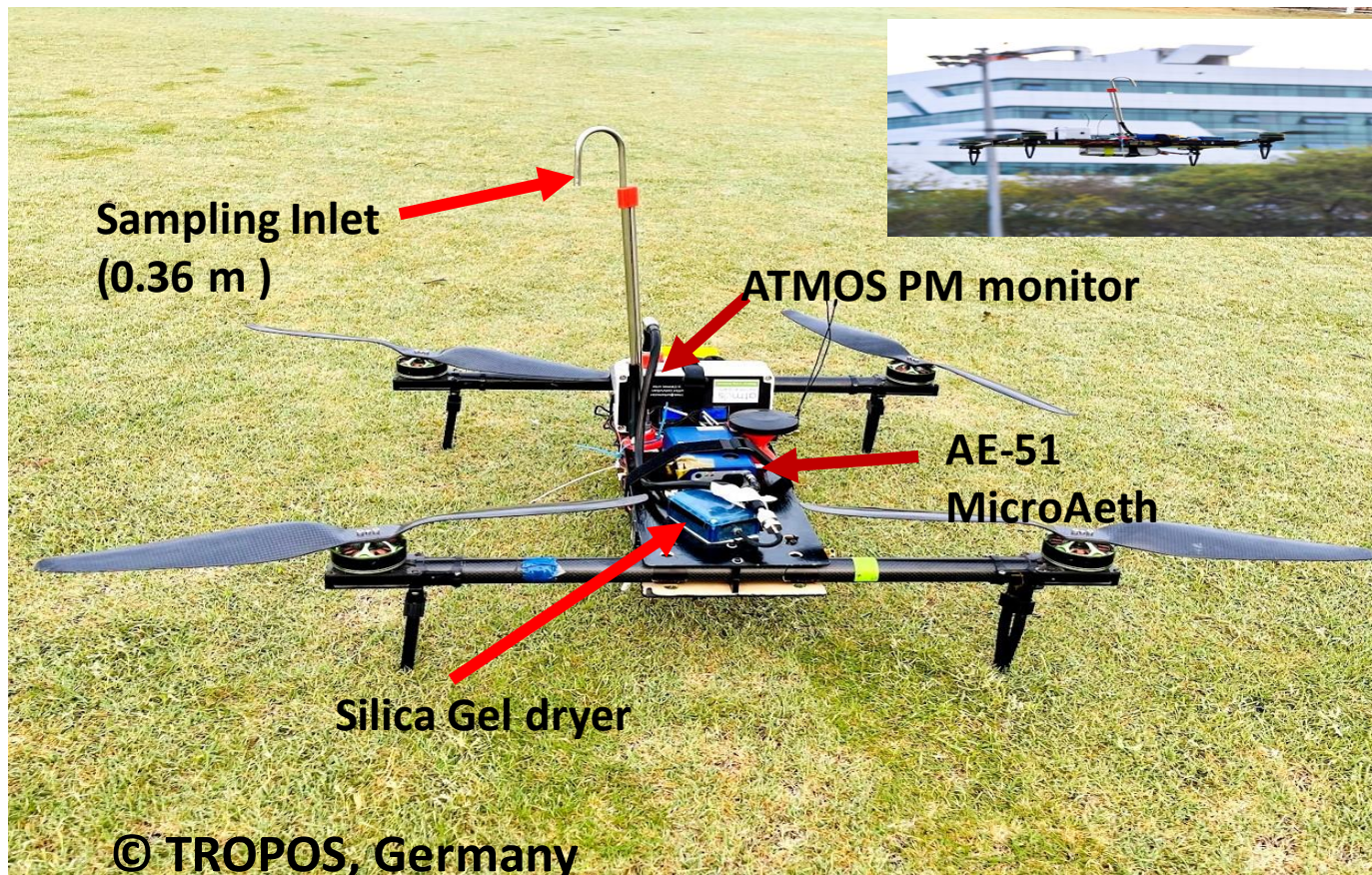
Objective-2: Drone Field Campaign

- Vertical and temporal profiles of pollutants i.e. PM using PM Monitor within 100 m a.g.l.
- Vertical variations of air pollutants concentration on Hazy and Non- hazy mornings.





Drone-setup for Delhi campaign



Drone Specifications

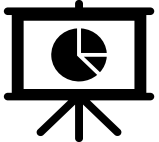
- **Propeller** : 18X5.5 (18 inches diameter 5.5 inches Pitch)
- **Battery** : 10 AH 25 Volt Lithium Polymer
- **Payload** : 1 Kg
- **Endurance Time**: 15 min
- **Flight Controller** : PixHawk 2.4, GPS
- **Radio Link** : 433 MHz (Switchable Power up to 1 Watt)

Payload Specifications

- **ATMOS PM Monitor** for measurement of PM_1 , $PM_{2.5}$ and PM_{10}
- **AE-51** for eBC measurement
- **Temperature & humidity sensors** (HYT 939)

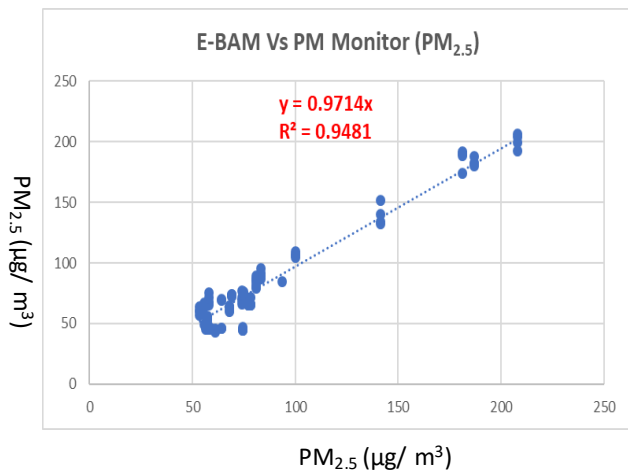
Ajit Ahlawat et al., 2024 (In preparation); Measurement of ambient air pollutants concentration using drone set-up at Delhi





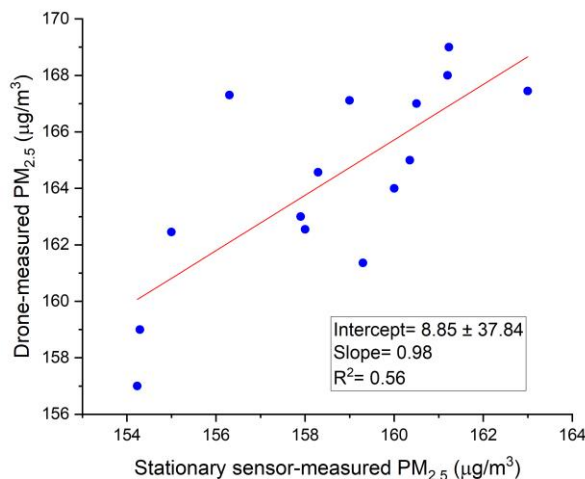
RESULTS 1/3

Inter-comparison of PM Monitor with E-BAM

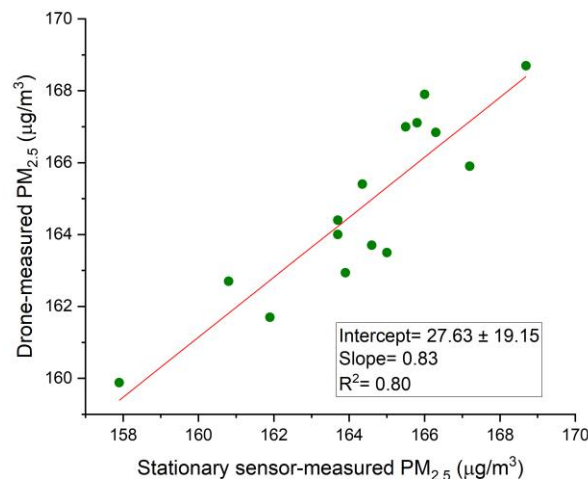


- The LCS performance comparison revealed higher correlation ($R^2 = 0.94$) when compared against BAM at ground.

Without de-humidifier

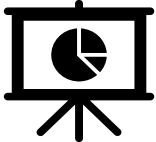


With de-humidifier

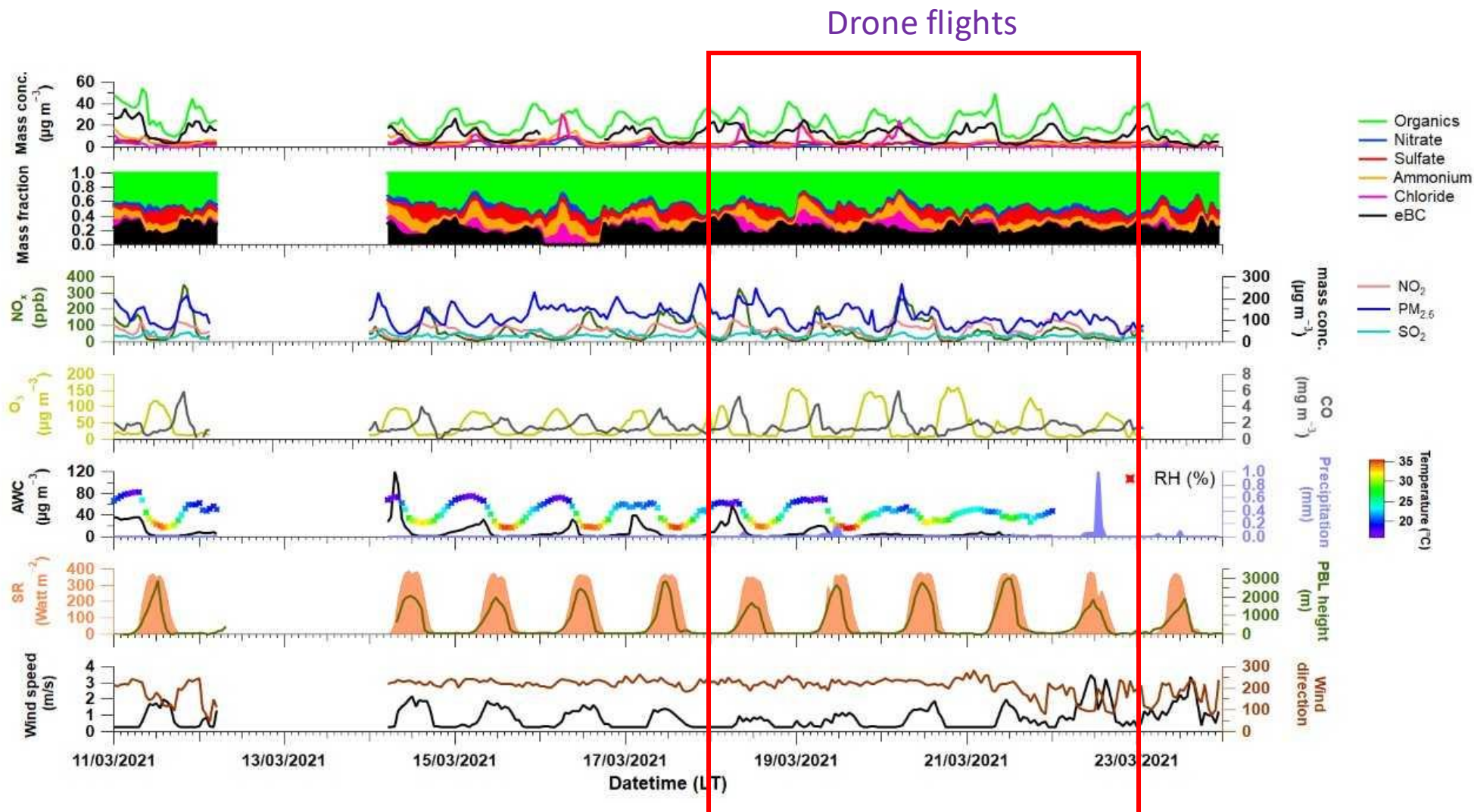


- The LCS on-board drone performance significantly enhances by incorporating the silica gel de-humidifier in front of the sensor with better correlation ($R^2 = 0.80$) when compared without the de-humidifier.



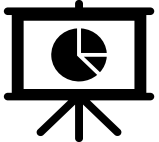


RESULTS 2/3



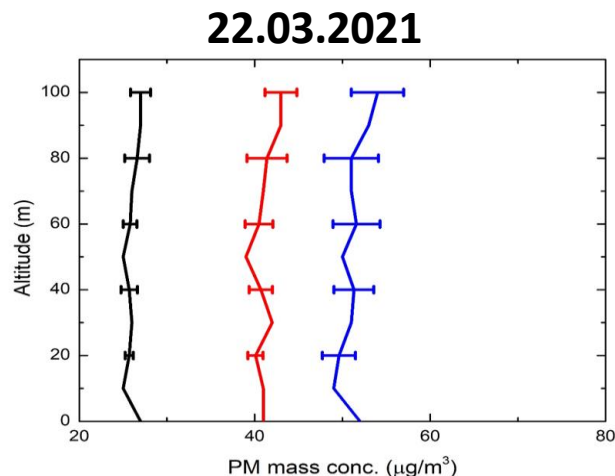
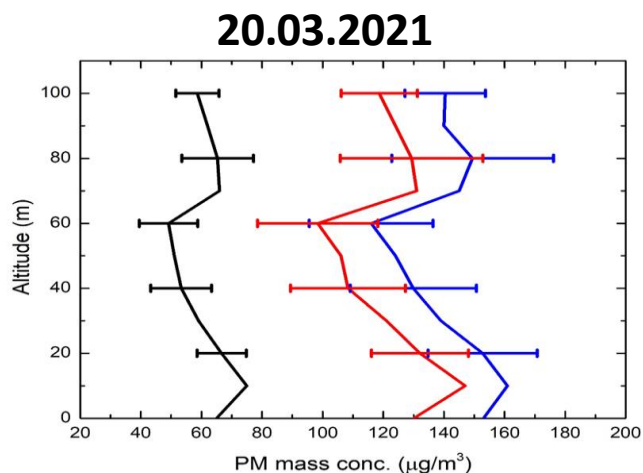
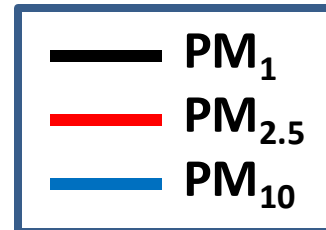
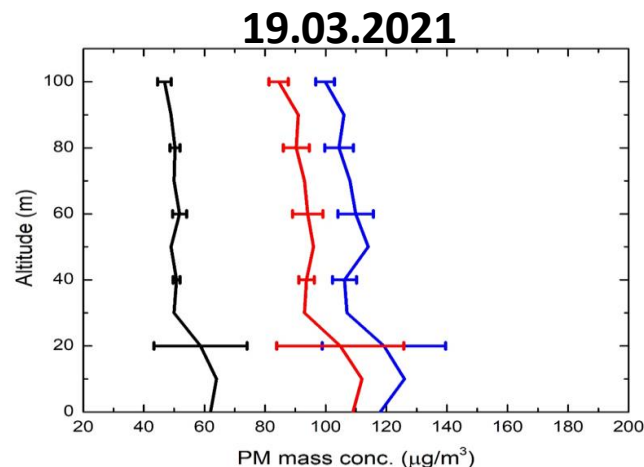
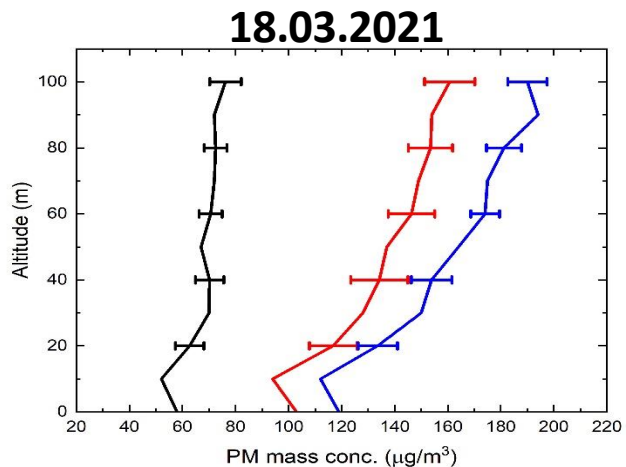
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Ground-based chemical composition, $\text{PM}_{2.5}$, gases conc., and meteorological parameters



RESULTS 3/3

Vertical profiles of particulate matter during different days





SUMMARY

- The LCS performance comparison revealed higher correlation ($R^2 = 0.94$) when compared against BAM at ground.
- The LCS on-board drone performance significantly enhances by incorporating the silica gel de-humidifier in front of the sensor with better correlation ($R^2 = 0.80$) when compared without the de-humidifier.
- The results indicate that incorporating LCS into innovative platforms (drones) is feasible, potentially offering more finely detailed data in vertical dimension.

➤ Upcoming plans

- Vertical profiles of particle number size distribution (PNSD).
- To include more parameters such as NO_x , O_3 , CO etc.

Last day of drone campaign



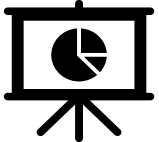
Comments or questions: ✉ ahlawat@tropos.de



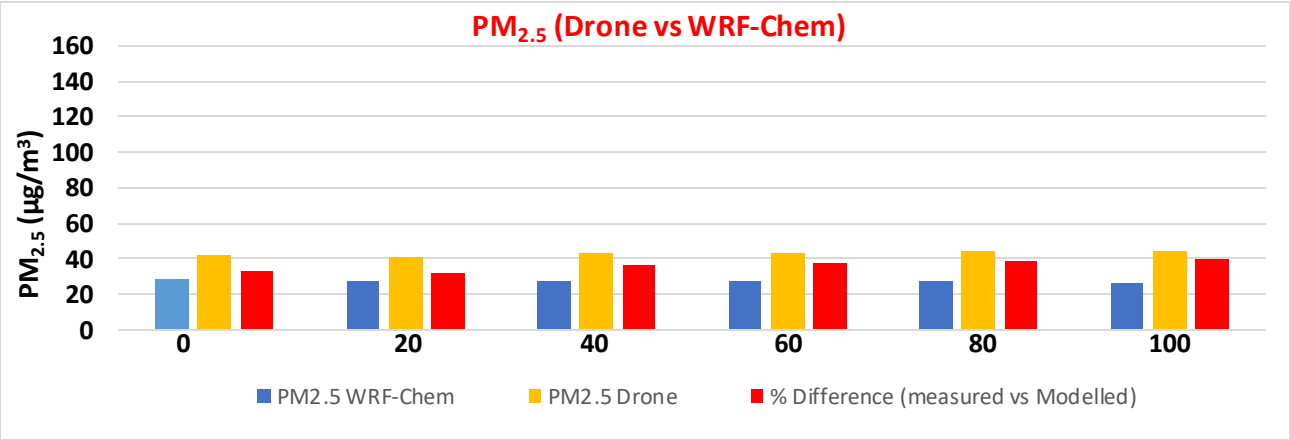
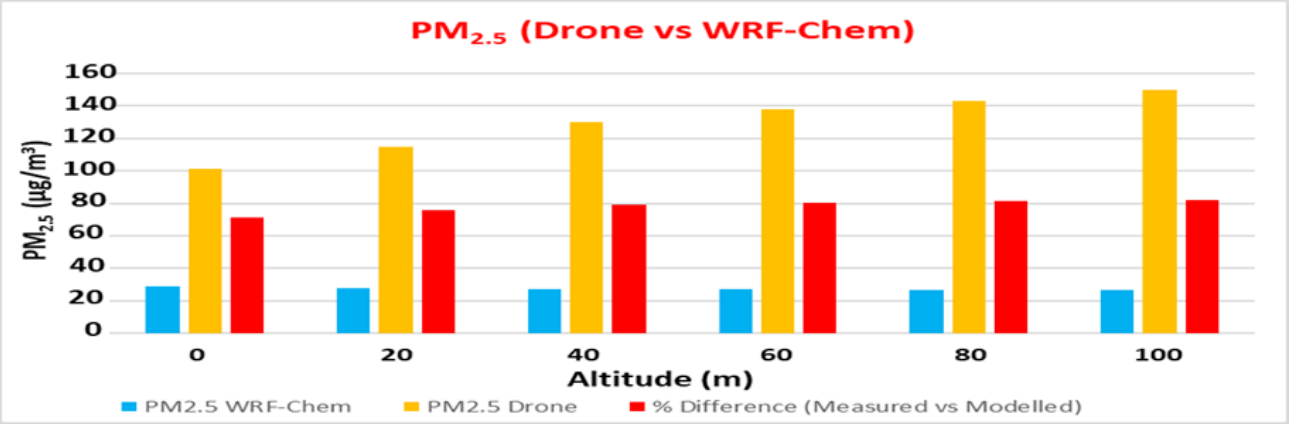
Back-up Slides

Delhi's meteorology and pollution sources in March

- Delhi, the capital city of India—considered to be one of the most populated and polluted cities in the world—experiences very diverse climatic conditions. March is relatively warm than winter months i.e. Nov-Feb (with average diurnal temperatures of 16–35 °C) and humid (average diurnal RH of 20–70%).
- Even during March we observe frequent inversions, the boundary layer depth is around 100-200 m, especially during early morning hours before sunrise, when the temperature reaches its minimum. Besides the winter season, even in March Delhi experiences high aerosol mass burdens attributed to local emissions and regional transport during night-time and early mornings due to haze formation.
- IIT Delhi is surrounded by small- and medium-scale industries within a 15 km vicinity, dealing with metal processing, paper production, plastic and medicine manufacturing, e-waste handling and recycling, medical waste management, dumping sites management and so on, which cause emissions of various toxic gases and pollutants into the atmosphere of Delhi.
- This waste mainly constitutes diverse trash, but a common and abundant component is mixed plastic from food wrappers and e-waste. Large numbers of informal and unorganized units for e-waste handling and recycling, and metal processing, are prevalent across Delhi.
- E-waste handling units aim to retrieve copper, silver and gold from printed circuit boards, cables, scrap plastics and batteries with processes that use acids and open burning. The metal processing industries use acids for pickling and polishing purposes.



RESULTS



The results showed large underestimation in PM_{2.5} mass concentration (81%) at 100 m altitude during hazy morning while almost half (40%) was observed at 100m altitude during non-hazy morning.



Vertical profiles of PM and eBC mass concentration (Hazy Morning), 18.03.2021

