Satellite-Based Mapping of $PM_{2.5}$ for Kanpur

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Regulatory air pollution monitoring in India is mostly limited to urban areas. Without a dense network of monitors, it is difficult to capture the fine spatial variations of $PM_{2.5}$, one of the major pollutants with severe implications for human health.

Using satellite-based products to estimate $PM_{2.5}$ can help generate high-resolution gridded spatial maps at a significantly lower cost. These spatial maps can be useful for policymakers, urban planners and developers, and health researchers. They can also be instrumental in guiding clean air action plan for the city.

A study by the Center for Study of Science, Technology and Policy (CSTEP) mapped high-resolution daily $PM_{2.5}$ for the calendar year 2019 over the Kanpur Dehat and Kanpur Nagar districts. The study, which used satellite data and ground data collected from monitoring stations, also identified $PM_{2.5}$ hotspots and examined the rural-urban contrast in $PM_{2.5}$.

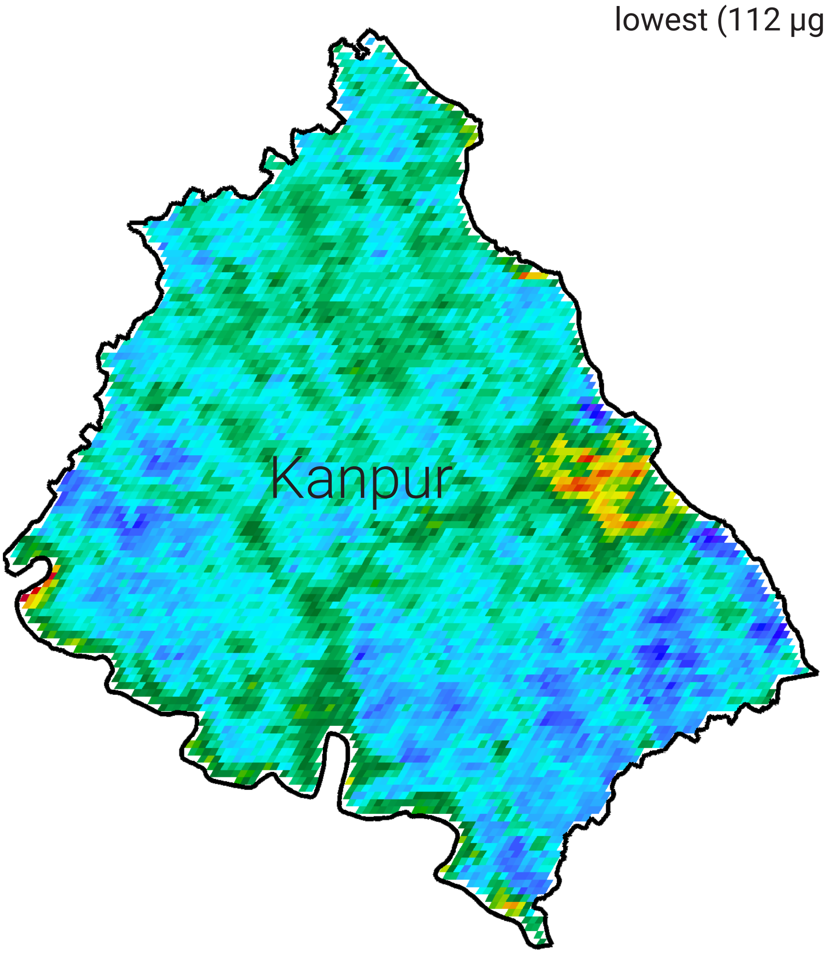
Key insights

1

Across Kanpur Dehat and Kanpur Nagar districts, the annual mean $PM_{2.5}$ ranged between 95 and 130 µg m^{-3} with the highest value over Kanpur city.

2

Spatially averaged annual mean $PM_{2.5}$ value for Kanpur city was 115 µg m^{-3} with Zone 1 recording the highest (122 µg m^{-3}) and Zone 2 the lowest (112 µg m^{-3}).



3

The annual mean $PM_{2.5}$ over all of rural and urban Kanpur exceeded the national annual standard (40 µg m^{-3}).

4

Seasonally, winter recorded the highest $PM_{2.5}$ (141 µg m^{-3}) followed by post-monsoon (138 µg m^{-3}), summer (81 µg m^{-3}), and monsoon (71 µg m^{-3}).

5

All six zones of Kanpur city except parts of Zone 2 and Zone 6 were identified as hotspot areas.

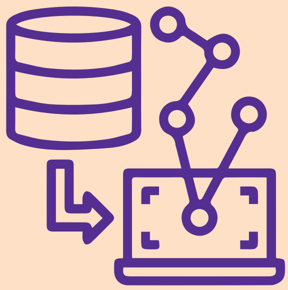
6

The urban area was characterised by the highest mean $PM_{2.5}$ (114 µg m^{-3}), followed by peri-urban (112 µg m^{-3}), rural (108 µg m^{-3}), and uninhabited (107 µg m^{-3}) areas.

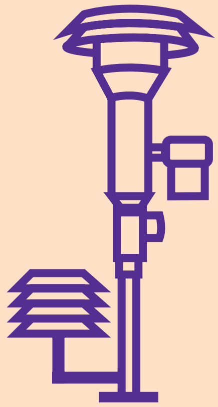
7

Representative regulatory measurements in non-urban areas of Kanpur will help understand the pollution dynamics and sources better.

How it works?



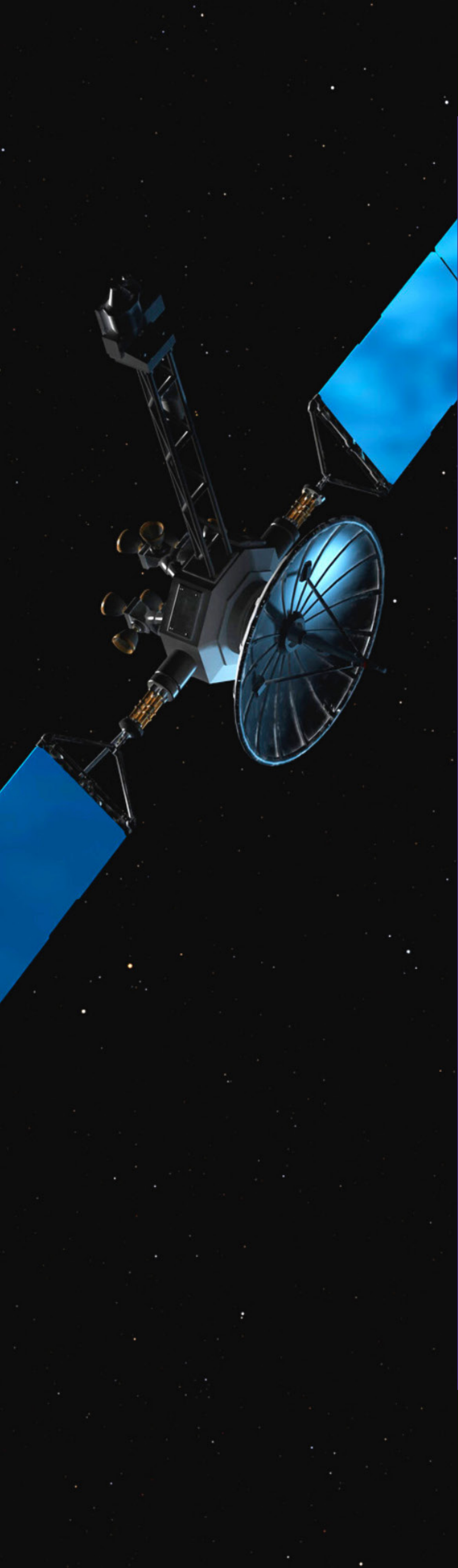
This approach effectively utilises public datasets to build advanced statistical or artificial intelligence models for predicting $PM_{2.5}$ from satellite products.



Representative air pollution monitoring station in non-urban areas of Kanpur will provide accurate local data useful for model building and validation.

As satellite provides daily near global data, spatial $PM_{2.5}$ also can be estimated at daily scale.

Statistical tools can be applied on spatial maps to identify $PM_{2.5}$ hotspots in and around Kanpur.



Benefits

- Satellite-based maps can help in accurate estimation of population-weighted exposure.
- These maps will be useful in understanding the urban, peri-urban, and rural air-pollution levels.
- For policymakers, these maps can be useful in strategising region/season-specific mitigation measures instead of umbrella activities.
- Pollution maps can be helpful in identifying the locations for future regulatory monitoring stations and hybrid (a combination of high-end and low-cost sensors) monitoring networks.

Barriers

- Infrastructural demands (such as uninterrupted power supply, building, etc.) for pollution monitoring set up could be a challenge in the non-urban areas.
- Availability of skilled manpower in non-urban areas to manage the monitoring equipment.

Annexure

We trained a linear mixed effects model using the continuous ambient air quality monitoring $PM_{2.5}$, satellite aerosol optical depth, reanalysis meteorological parameters, and land use proxies. Spatial (at 1 km x 1 km resolution) daily mean $PM_{2.5}$ were predicted using the trained model over the Kanpur Dehat and Kanpur Nagar districts. The model is extensively validated using 10-fold and leave-one-out cross validation exercises. $PM_{2.5}$ hotspots were identified based on Gi* index. The rural, peri-urban, urban and uninhabited settlements pixels were identified using Global Human Settlement Layer data. Major limitations of this approach include the non-availability of satellite aerosol optical depth (AOD, which contains information on the aerosol abundance) during cloudy days and the lack of non-urban $PM_{2.5}$ measurements.

Season classification is as follows: January and February months constituted Winter; March, April, and May constituted Summer; June, July, August, and September constituted Monsoon; October, November, and December constituted Post-monsoon.

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