A Primer on Air Quality Monitoring

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UrbanEmissions (UEinfo) was founded in 2007 with the vision to be a repository of information, research, and analysis related to air pollution.

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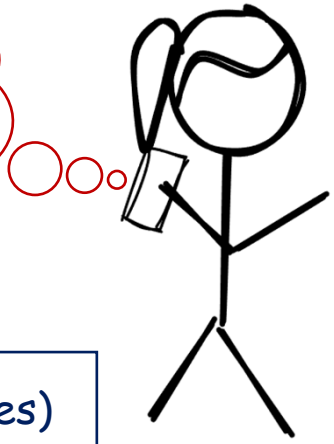
If we increase the number of monitoring stations in a city, does it reduce air pollution?

No, increasing monitoring efforts does not reduce air pollution.

Monitoring is a diagnostic tool to assess levels of air pollution.

Monitoring increases our understanding of air pollution trends (spatially and temporally) and provides a direction to address the problem.

Why do we assume that monitoring pollution will lead to better air quality?



Policy makers and (sometimes) media cite the monitoring activity as an integral part of a pollution control strategy.

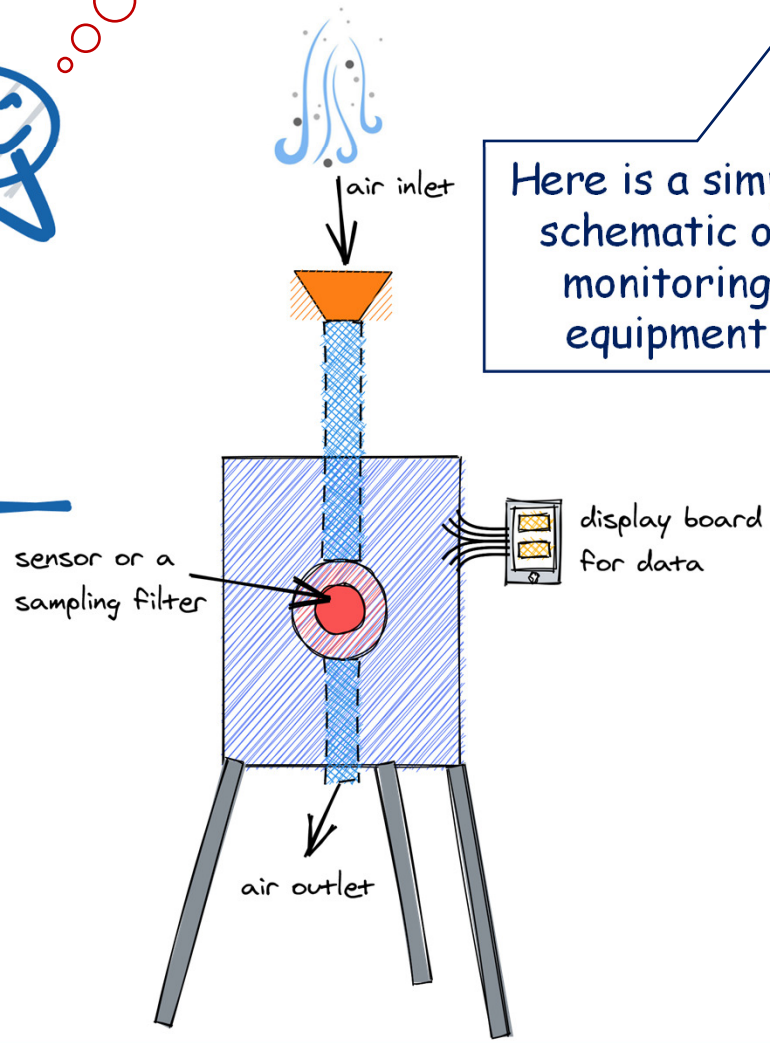
"The mobile air quality monitoring unit will be capable of real-time sampling, analysis and control of air pollution from sources.."
Hindustan Times (2016)

Media statements like these, could be misconstrued as saying

"..while the monitoring equipment is making rounds in the city, the unit is also reducing air pollution.

How does an air quality monitoring station work?

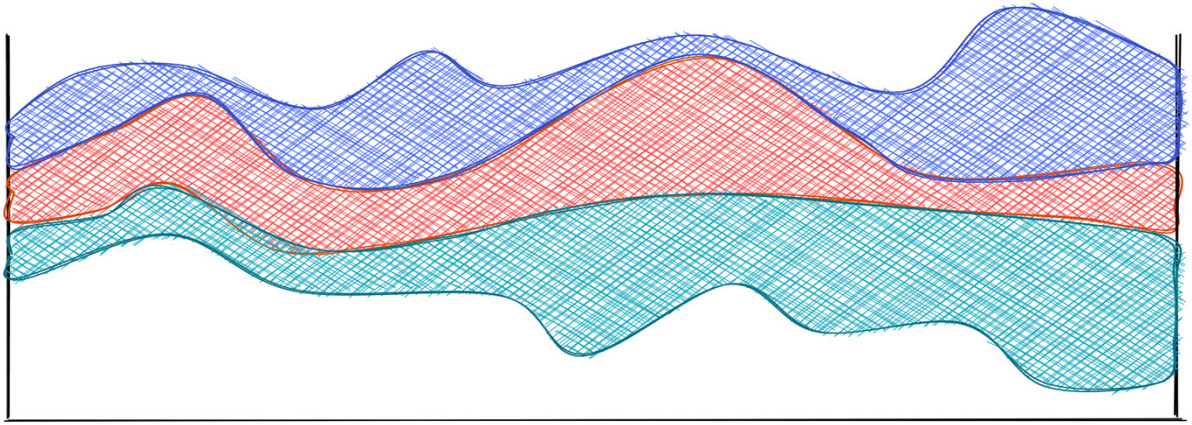
Here is a simple schematic of monitoring equipment



How do we define air pollution monitoring and the data?

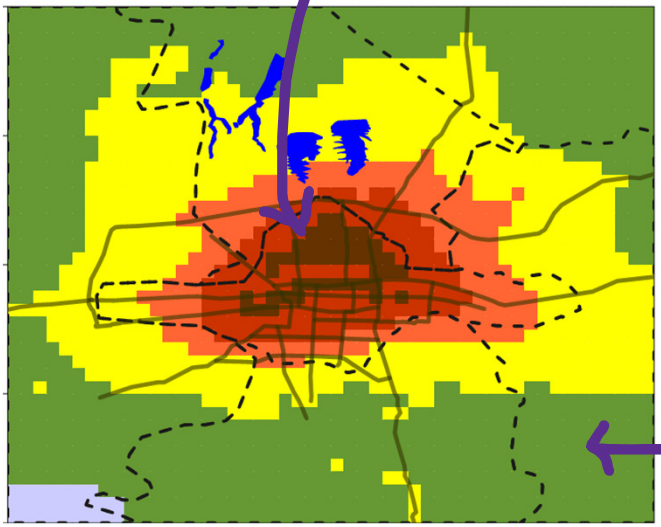
Monitoring is an exercise to measure air pollution levels in an area or at a source.

Data over a long term allows us to tease out diurnal and seasonal patterns that support formulating and auditing a pollution control plan.



These patterns also include spatial differences in pollution, such as which part of the city (or a region) are more polluted or experience better air quality.

More polluted centre

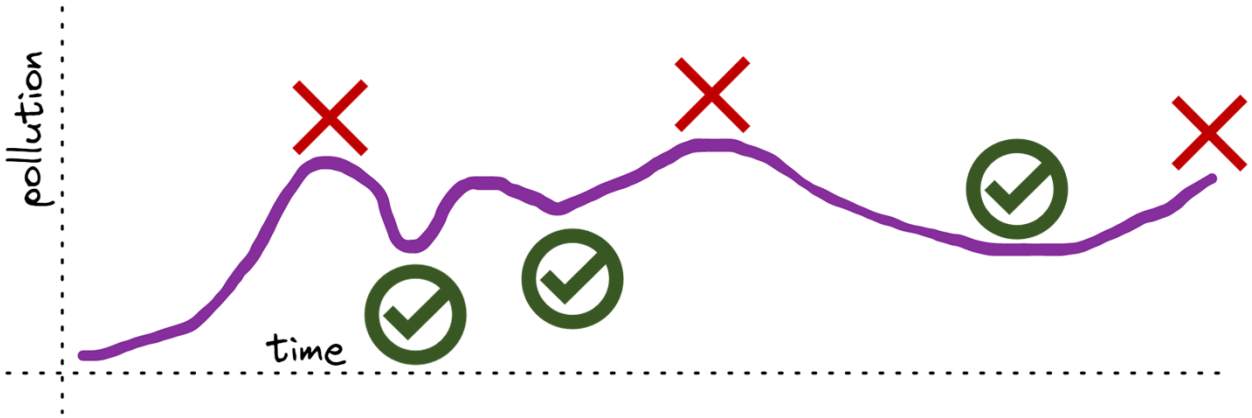


Cleaner outskirts

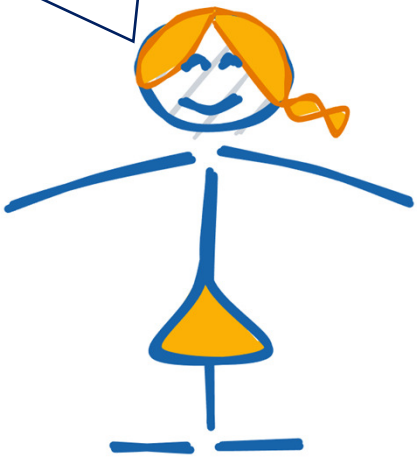
Using these data trends, we can conclude if our efforts for improving air quality are successful.

If yes, then by how much.

If not, do we need to try other options or be more aggressive in our current efforts.



So, while air pollution monitoring itself does not reduce air pollution, the process gives us information on….



.. how much is the pollution?

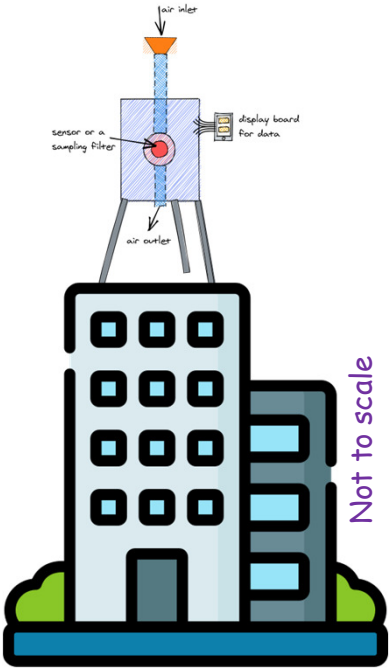
.. where is the pollution?

.. when is the pollution?

What are the different types of monitoring?

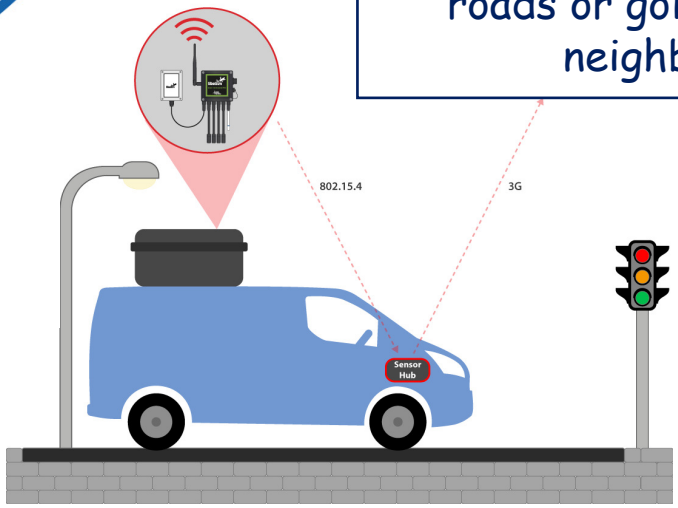
Here are some examples

Most common practice is "**Static Monitoring**" where data is collected only from one location for long periods of time.

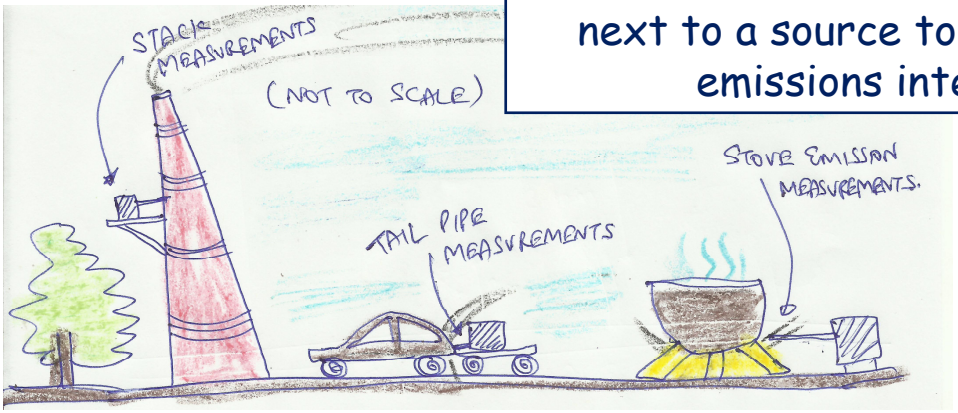


Not to scale

We have "**Mobile Monitoring**", where data is collected in a moving vehicle, either on the roads or going around in a neighborhood.

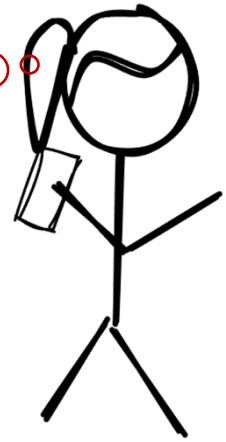


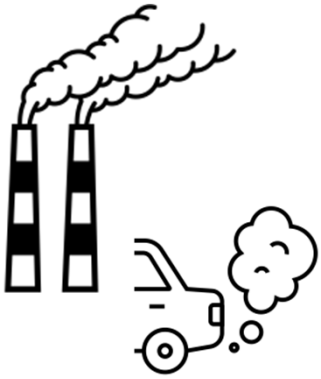
And we have "**Emissions Monitoring**" where data is collected immediately next to a source to measure its emissions intensity.



What is the difference between emissions and concentrations?

This is a very important question





Emissions is the amount of pollutant directly emitted at a source (like a vehicle tailpipe, industrial chimney, or a pile of openly burning garbage).

Typical unit: kg/day or kg/kg-fuel

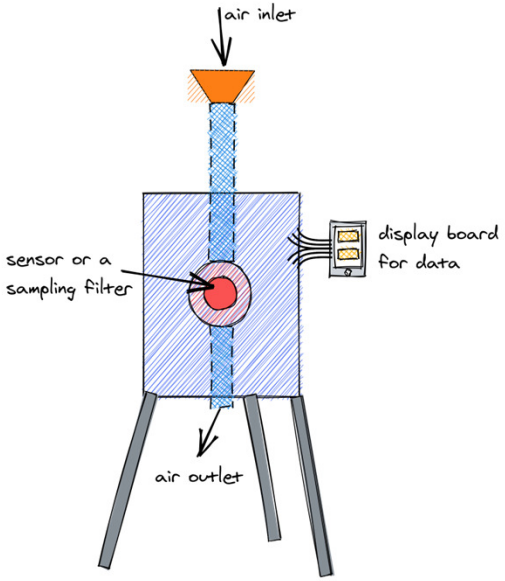
Concentration is the amount of pollutant present in a unit volume of ambient air that we are breathing.

Typical unit: $\mu g/m^3$ or ppm

What are the common practices of ambient monitoring?

There are two ways with some operational differences.

Both are useful and necessary for understanding pollution trends.



Manual

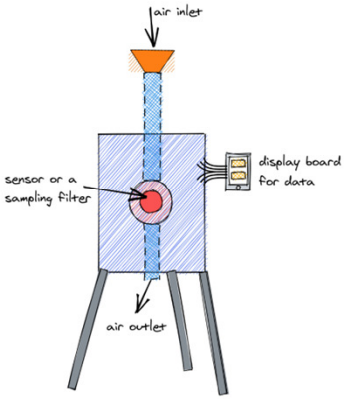
&

Continuous

How the process of manual ambient monitoring works

I have to conduct maintenance regularly to get reliable data

This process can take 1-2 days from sample collection to data release



Take the filters to the lab for gravimetric and chemical analysis

Record the results

and archive them.

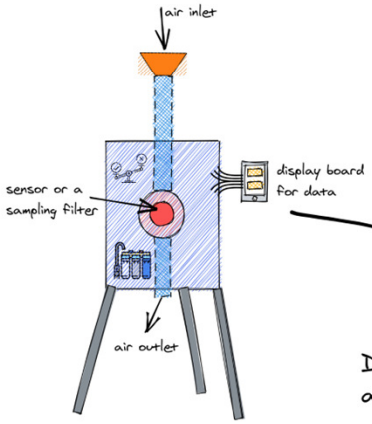
Data release

Samples are collected every day or once in 2-3 days. Only one data point per collection period.

How the process of continuous ambient monitoring works

I have to conduct maintenance regularly to get reliable data and the unit also has internal QA/QC checks

This process only takes 15 minutes from sample collection to data release



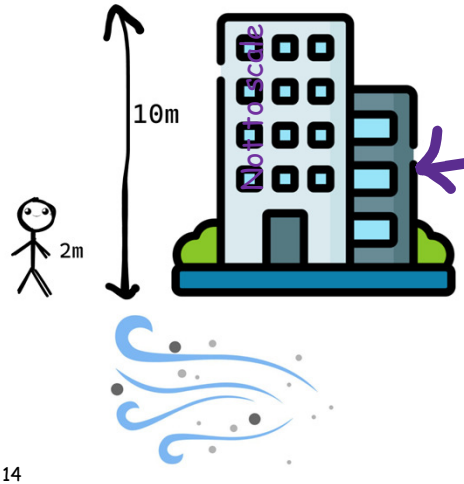
Data records are archived immediately

After QA/QC checks immediately available for release

Data is available at an optimal temporal resolution of 1 minute to 1 hour.

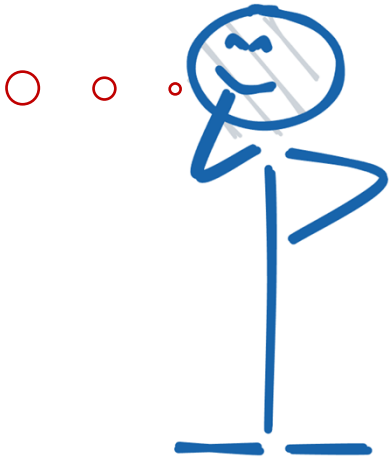
Is there an ideal height for ambient air monitoring?

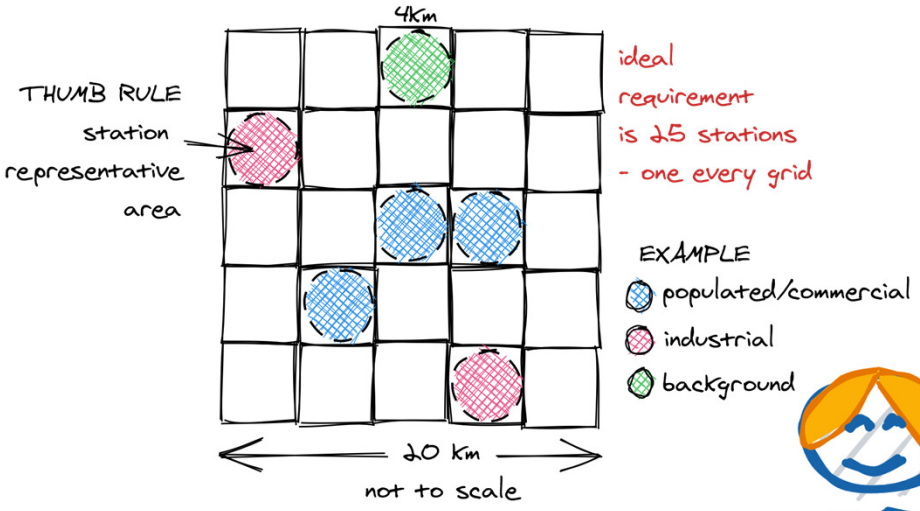
Yes, for ambient measurements, all the air under ~10m is considered as representative of all the sources in the vicinity (including pollution coming from long distance).



This height is expected to represent all the sources contributing at this location and not be biased by any specific source (e.g., measurements near ground, can lead to overestimation of pollution due to vehicle exhaust).

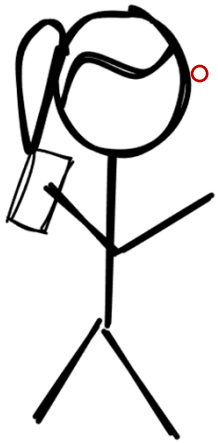
How do you select the monitoring locations?





If locations are not selected representatively, the monitoring data will have biases.

To minimize these biases, protocol suggests multiple locations representing all areas and activities in a city.

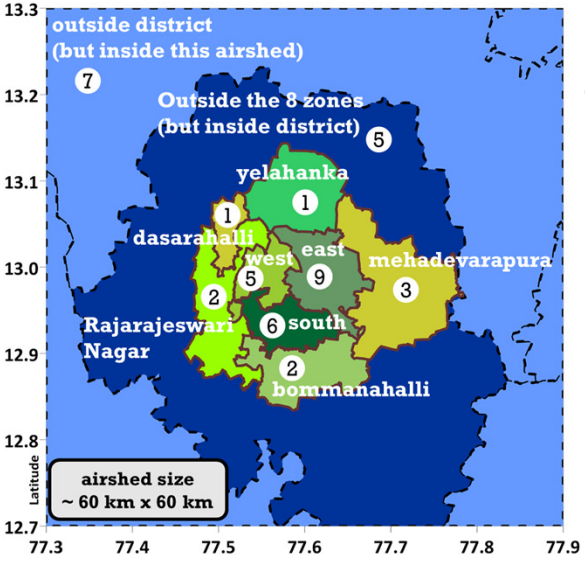


Are there any rules for how many monitors must be installed?

Yes, there are some thumb rules.
e.g., India defined the following based on total population (TP) for PM monitoring.

For TP under 100,000 -- 4 units
For TP under 1 million - 4 + 0.6 per 100,000
For TP under 5 million – 7.5 + 0.25 per 100,000
For TP above 5 million - 12 + 0.16 per 100,000

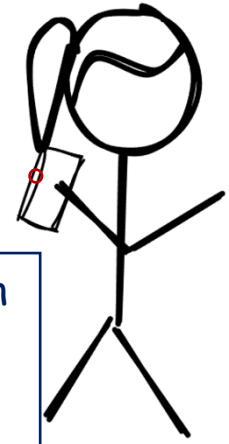
Table source: CPCB, India



For example:
City of Bengaluru requires 41 monitors based on their population and commercial activity information by zones.

Finally, the city's financial, personnel, and operational capacity decides how many monitors are installed.

How to integrate the use of low-cost sensors?

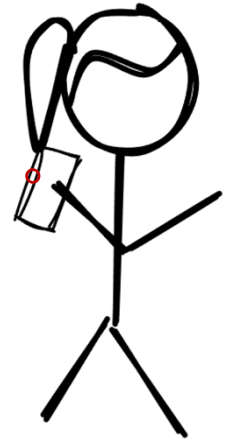


These sensors can create a pollution map faster and cheaper and supplement in expanding regulatory grade monitoring network.

All the units need regular maintenance or replacement, including recurring calibration of results.

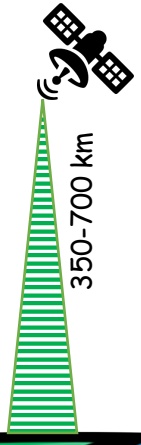
If uncalibrated or used incorrectly, the sensor readings will be biased and will not be accepted by the officials as a representative diagnostic.

How can satellite observations help with ground monitoring?



Satellite observations are columnar – representing everything from the lens of the satellite to the ground.

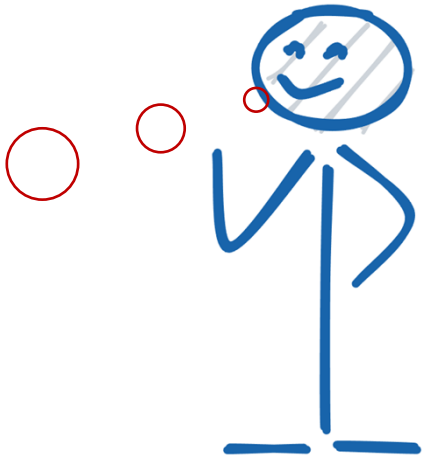
Converting this into surface concentration is a multi-step procedure that involves use of a chemical transport model.



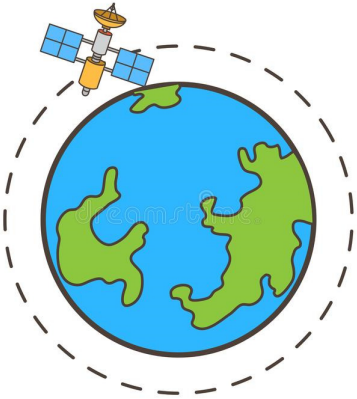
These models depend on detailed emission inventories and meteorological data.

Hence, for accurate estimates from satellite monitoring, data from on-ground monitoring stations and local emission inventories are crucial inputs.

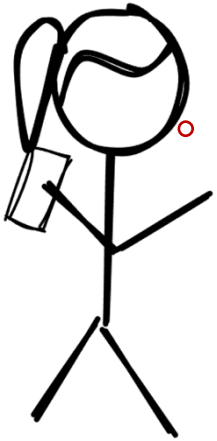
Geostationary satellites are required to build localized models and to support ambient monitoring efforts.



Geostationary satellite, collects data over one location, all the time.



Polar or orbital satellite, collects data around the globe to provide snapshots.



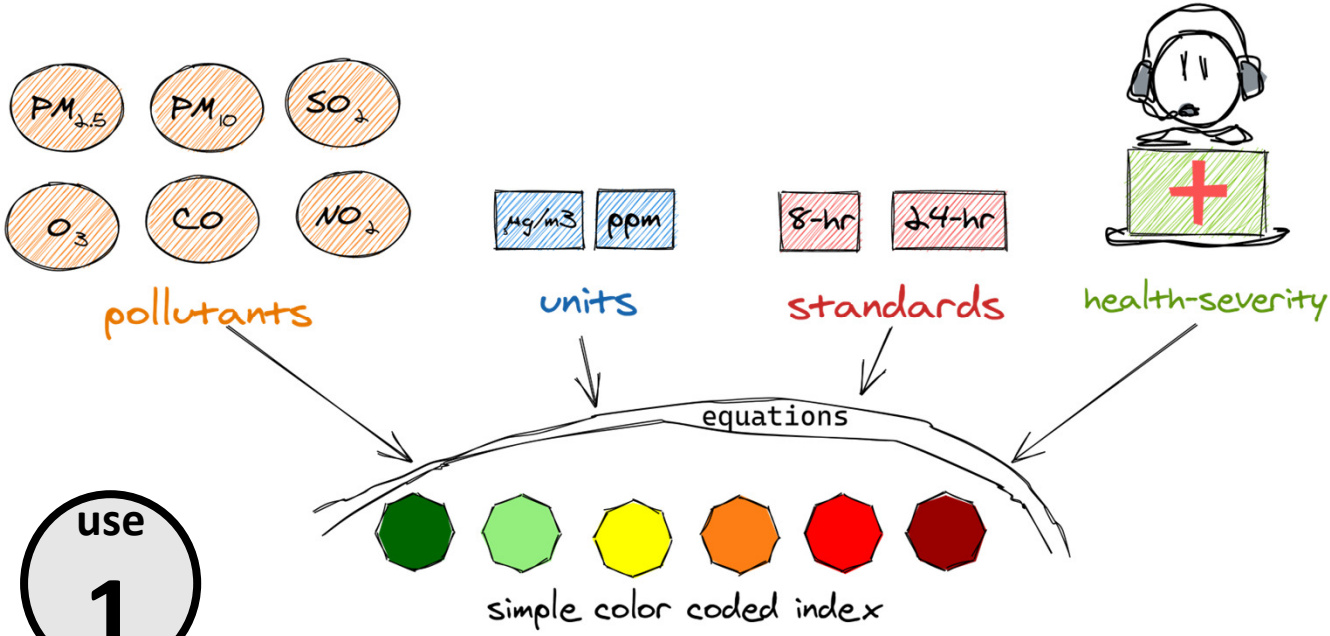
What are some of the uses of air quality data?

Saying goes, "We cannot manage what we cannot measure".

Having access to reliable data is very crucial for air quality management. This data helps in preparing action plans, supporting public awareness, and keeping track of progress (or lack thereof).

Here are some useful applications of air quality data.

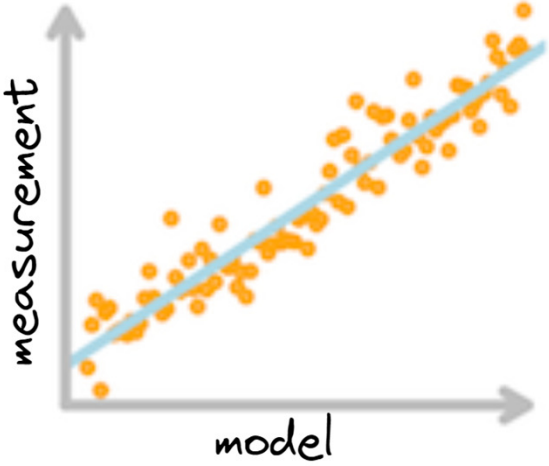
Very first is its use in calculating air quality index (AQI) - a unit less number which unifies all the complicated (a) science of pollution composition (b) health severity (c) ambient standards and (d) measurement and standard protocols, into simple color-coded alerts of good or bad or severe air pollution categories.



use 1

A large pool of monitoring data means a better understanding of the spatial and temporal trends in pollution.

This will also support the modeling efforts trying to understand these trends. Data is used for validating the models and increasing their confidence levels.



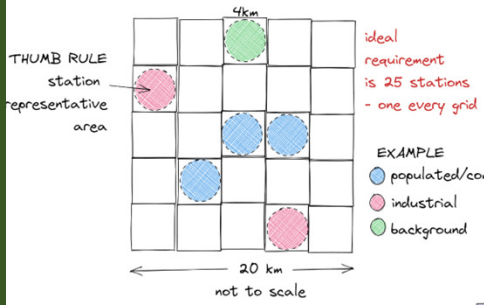
use

2

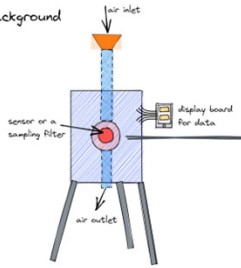
use

3

Filters collected at the manual stations can be used for chemical analysis-based assessment of source contributions.

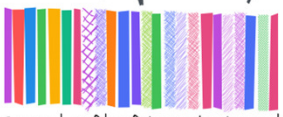


Step 1: Location selection



Step 2: Sample collection

Step 3:
Chemical Analysis
in Laboratory

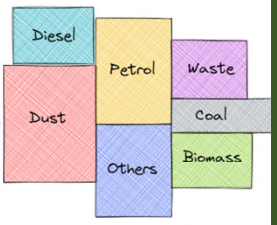


Chemical profile of the ambient sample
as ions, metals, and carbon species

Ambient Sample

Steo 5:
Receptor
Model

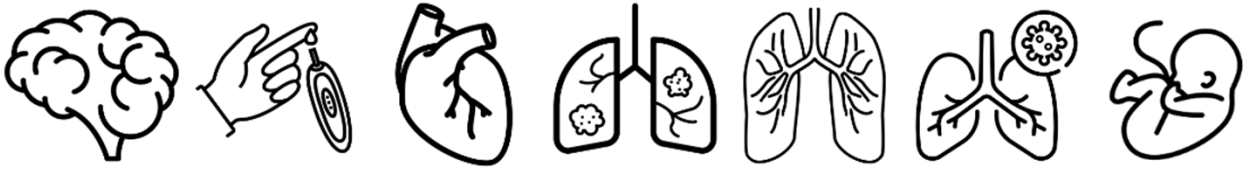
Results:
Modeled source contributions

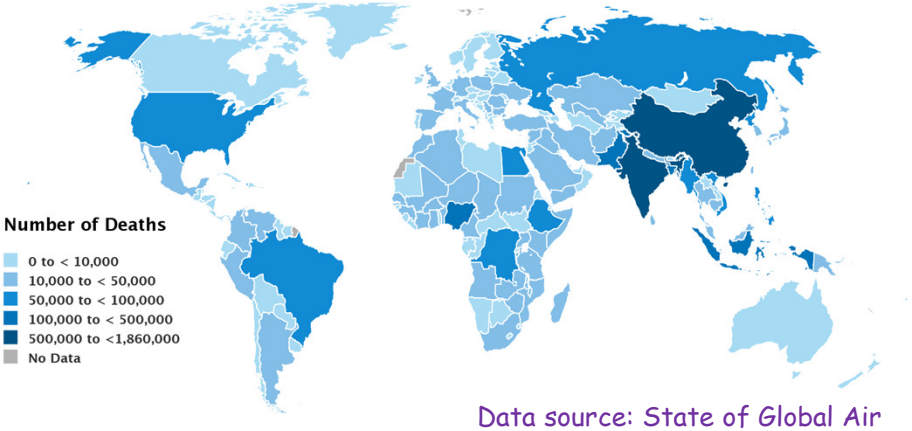


Step 4: Collect chemical profiles
of all known sources

One of the biggest uses of ambient air monitoring data is to establish a nexus with health impacts, which range from

* cases of ischemic heart disease (heart attacks)
* cerebrovascular disease (strokes)
* chronic obstructive pulmonary diseases
* lower respiratory infections
* cancers (in trachea, lungs, and bronchitis)
* obesity
* diabetes and
* Alzheimer's disease.





Data source: State of Global Air

use 4

We must increase the number of monitoring stations.

Combined with models, we can increase our understanding of pollution trends and sources.