ABC's of Air Quality

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02-2024

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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.

Send your questions and comments to simair@urbanemissions.info

Most of the illustrations are made using open-access “excalidraw” portal.

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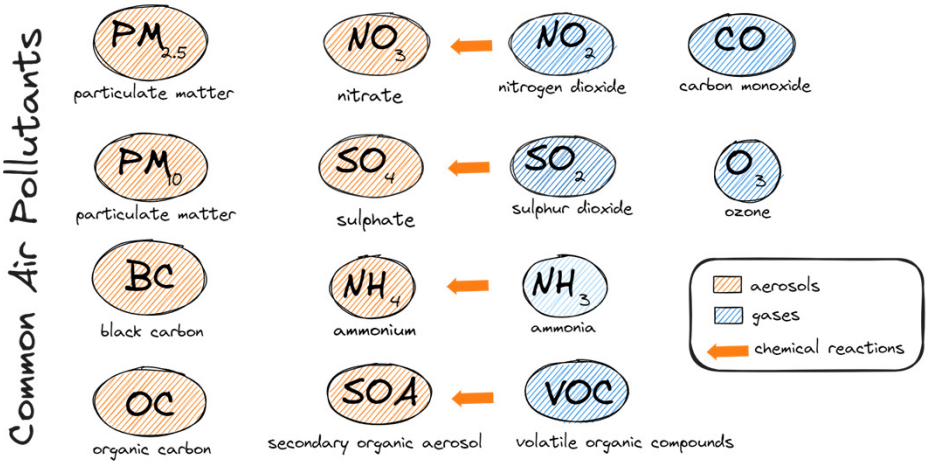
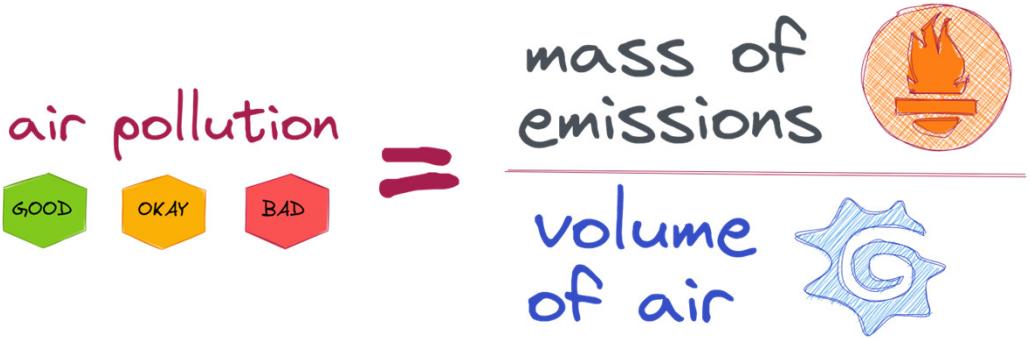
This booklet provides illustrated talking points on themes related to air quality and air pollution in alphabetical order.

Air Quality

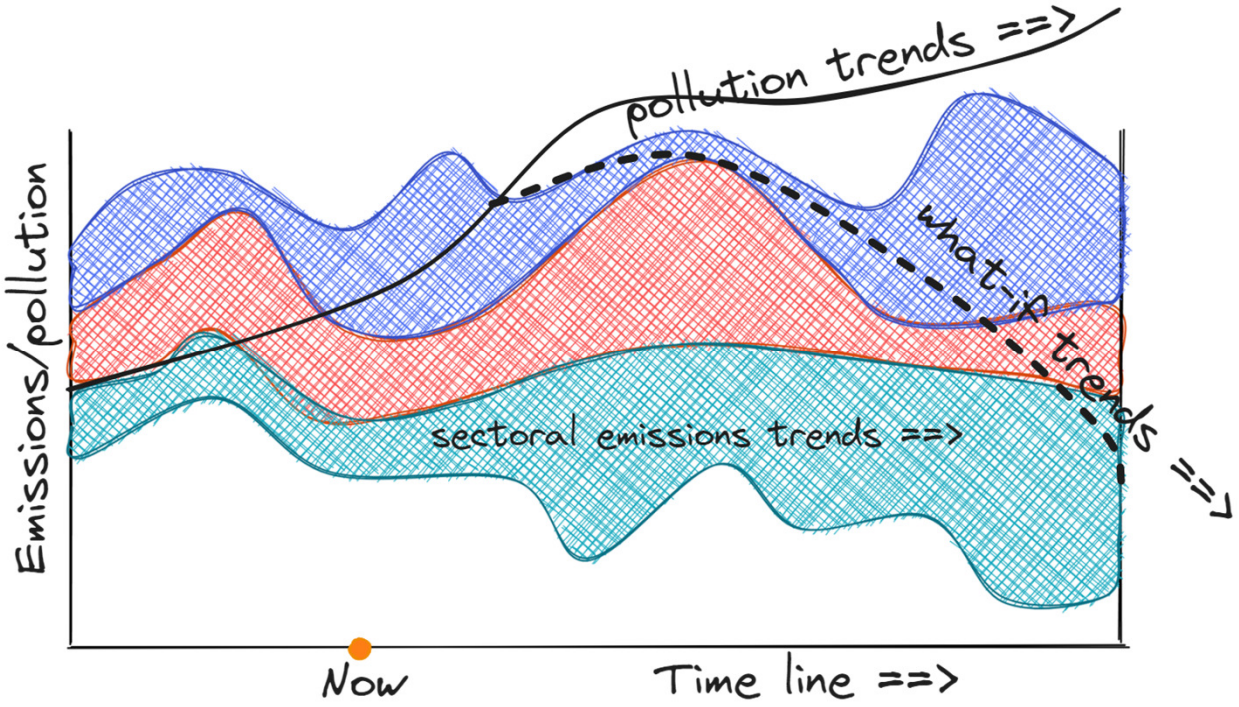




* All burning/combustion activities produce emissions
* Emissions is not the same as pollution/concentrations
* More emissions = more pollution = bad air quality
* All pollutants are critical for health, some are more harmful

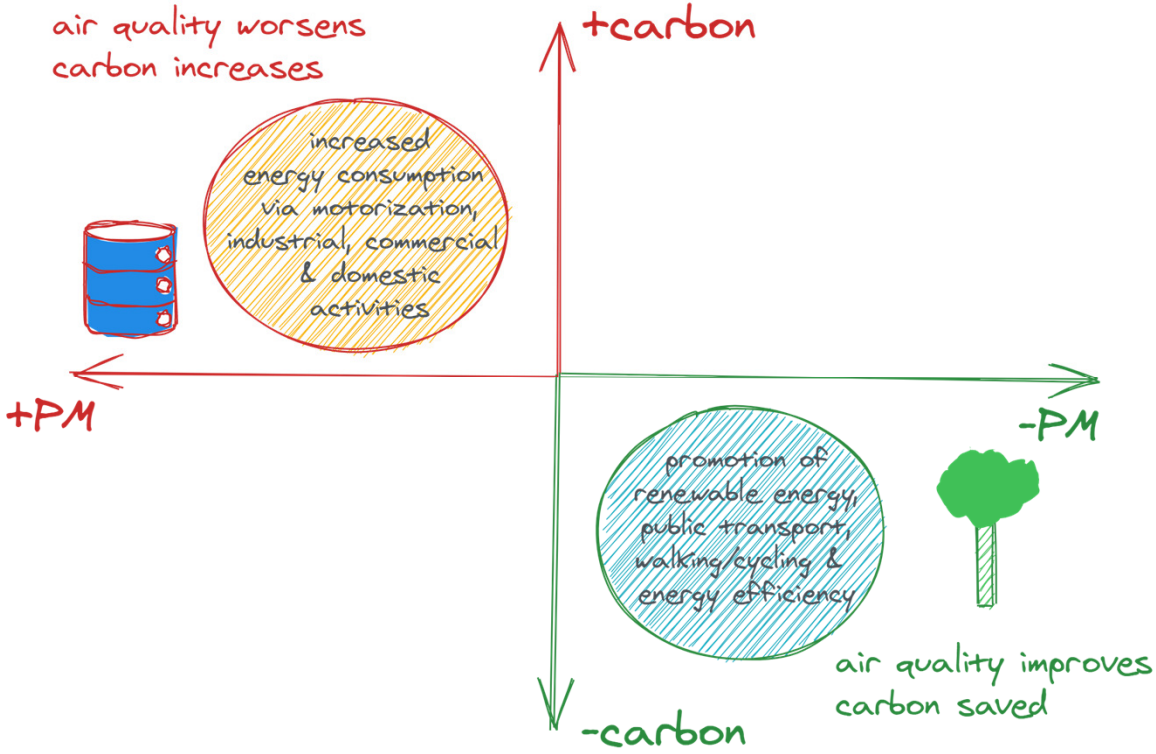
Baselines for emissions/pollution

B



* Any effective air quality management plan requires baselines
* Past trends can be used to project what-if scenarios
* Cost-benefit calculations can be used for policy dialogues
* Monitoring and modelling data can be used for baselines

Co-Benefits

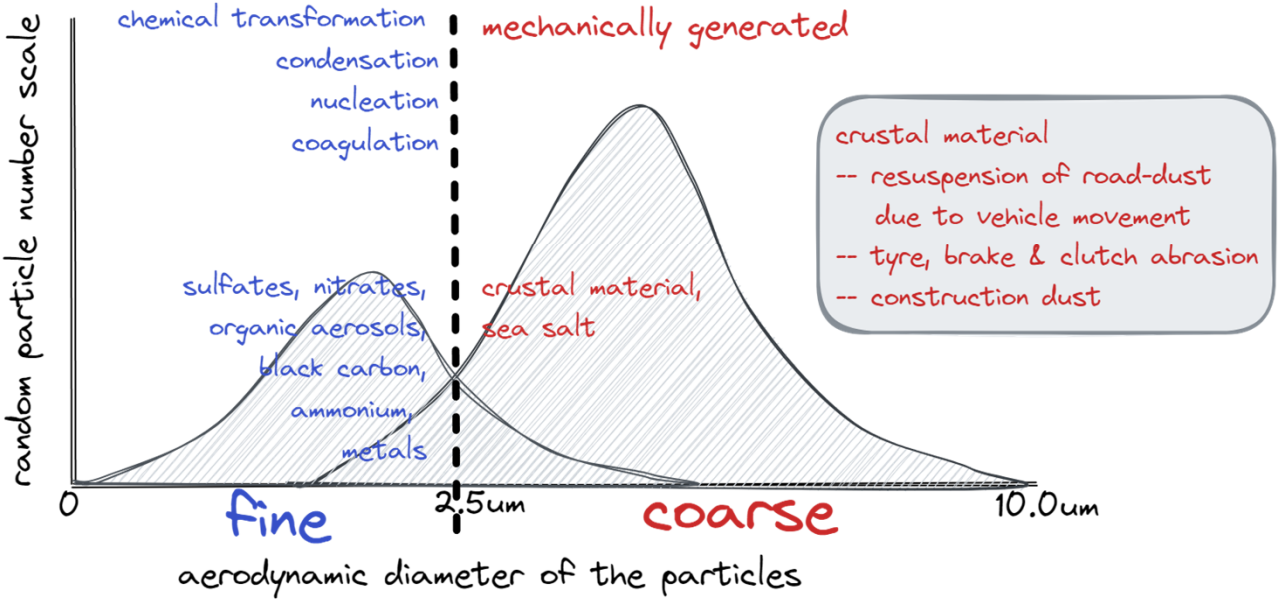


* Air pollutants & climate precursors (CP) have the same sources
* Air pollutants & CP have the same solutions too
* Managing air pollutants manages CP and vice versa
* Benefits of reducing air pollutants is observed in short-term

Dust (road/construction/desert)

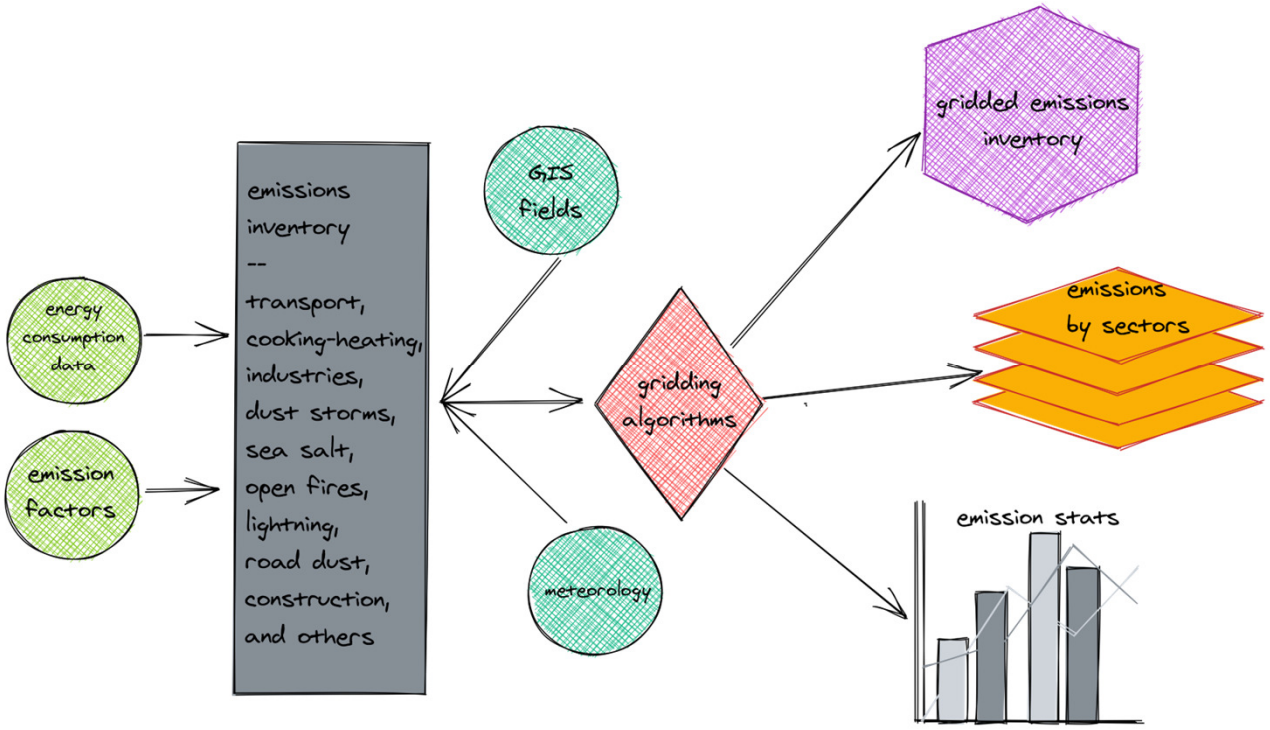
D

$PM_{2.5}$ = fine
PM_{10} = fine + coarse



* Dust is a large fraction of the coarse PM ($PM_{2.5}$ to PM_{10})
* Road conditions and driver behavior are key to dust control
* Wet sweeping temporarily reduces resuspension of road-dust
* Natural long-range desert dust is seasonal

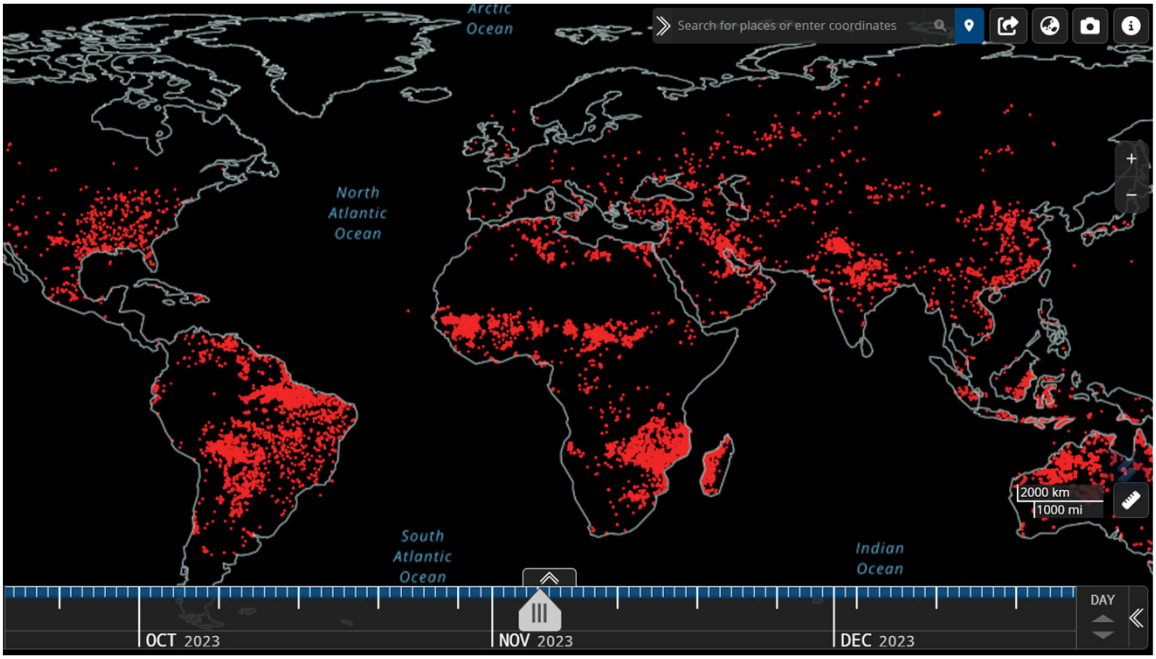
Emission inventories



* Inventory process accounts for sources in the airshed only
* Sources outside the airshed (boundary) are also important
* An inventory establishes a baseline for cost-benefit analysis
* Emissions inventory is a work-in-progress

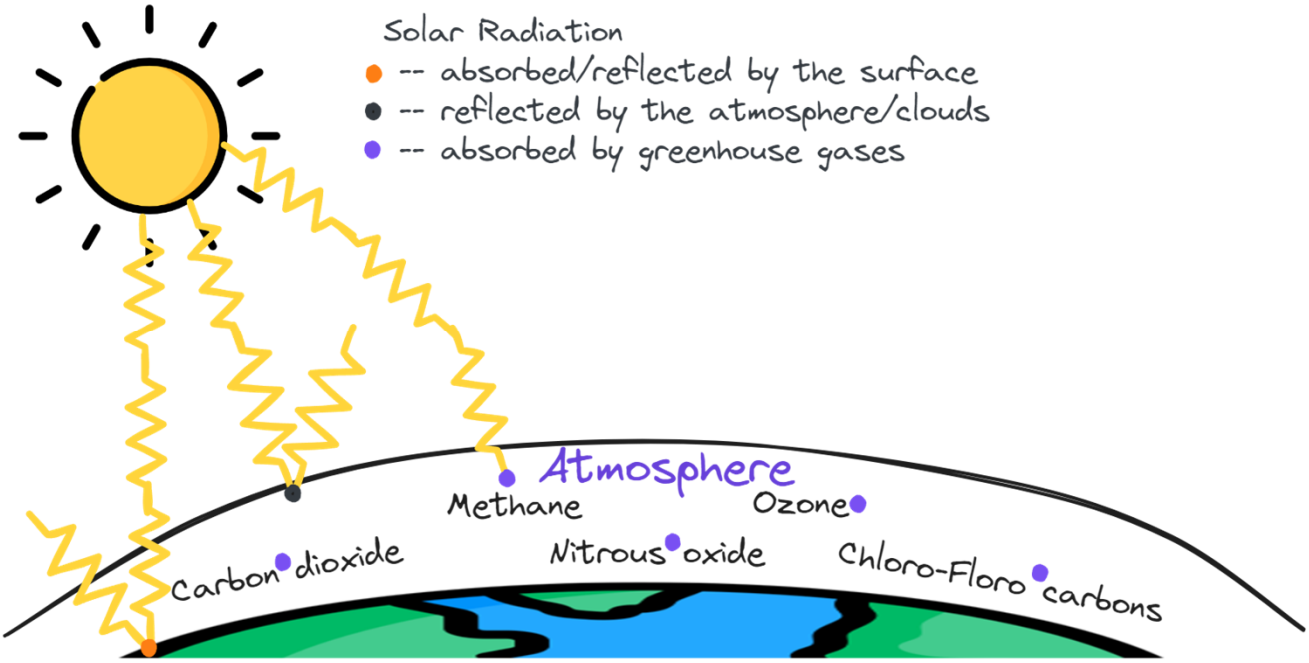
Fires

VIIRS satellite snapshot – each red 375m pixel is an instance of fire recorded during the satellite pass (source: NASA WorldView)



* Includes forest fires, agricultural land burnings, and flares
* Intersection with landuse-landcover provides segregation
* Geostationary satellites required for continuous monitoring
* Forecasts with meteorology can be used for pollution alerts

Greenhouse gases (climate change)



* All burning/combustion activities produce Greenhouse gases
* Carbon dioxide (CO_2) is the dominant greenhouse gas
* Short-lived climate pollutants (e.g. BC) are key for co-benefits
* Mitigating climate change is a long-term strategy

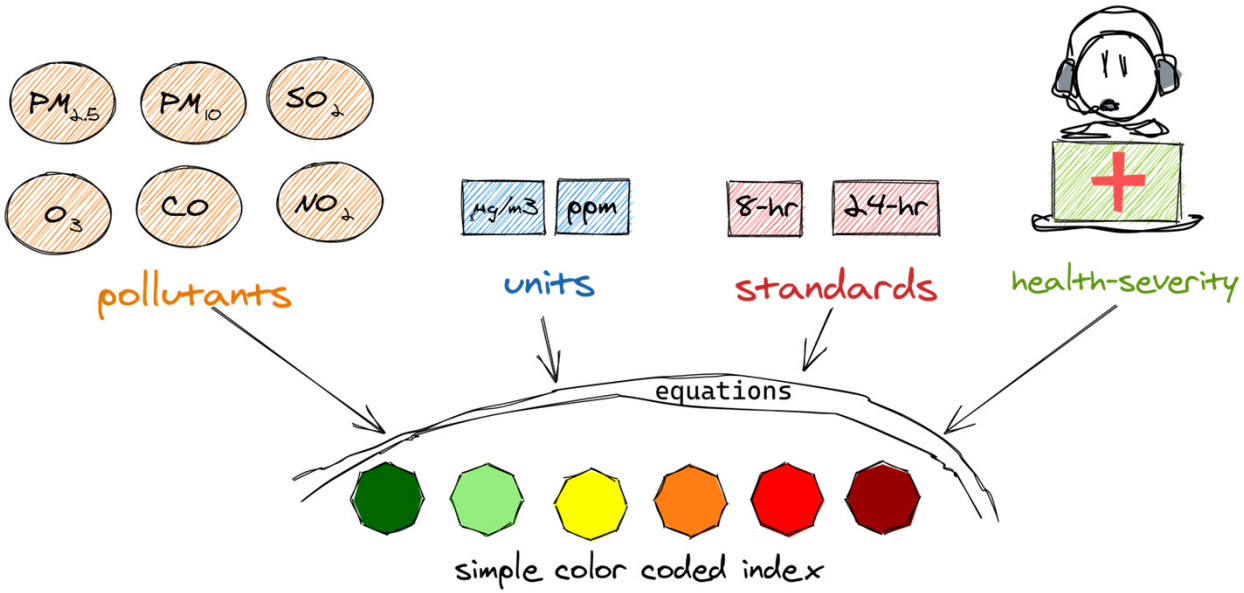
Health impacts

Particulate Matter (PM) & Ozone are epidemiologically linked to many health endpoints

-- Alzheimer (dementia)
-- Anxiety
-- Asthma cases & attacks
-- Blood pressure
-- Chronic lung diseases (COPD)
-- Developmental damage
-- Diabetes (sugar)
-- Heart attacks
-- Inflammation
-- Low infant birthweight
-- Lung cancer
-- Pneumonia
-- Reproduction disorders
-- Shortness of breath
-- Strokes
-- Wheezing & coughing

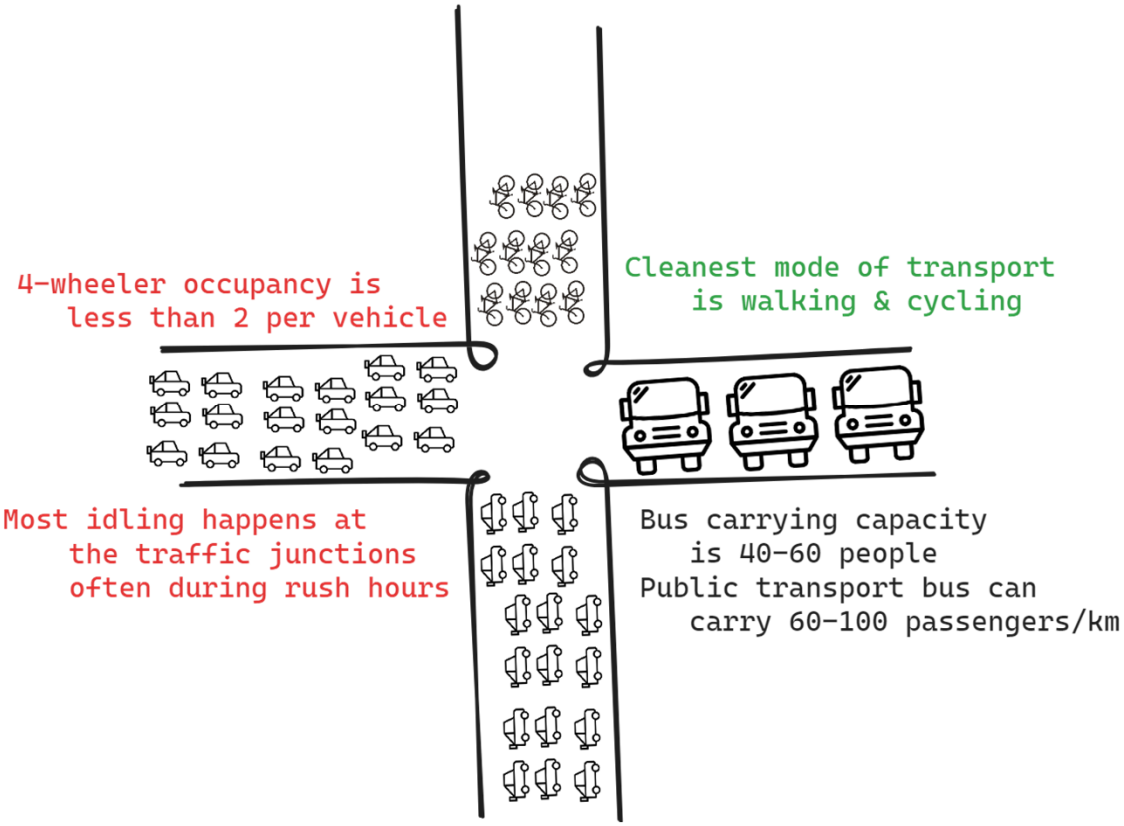
* All pollutants are critical to health, some are more harmful
* PM & Ozone also represent contributions from other gases
* Premature deaths due to poor AQ are highest in Asia-Africa
* Life-loss & morbidity costs are significant

air quality Index (AQI)



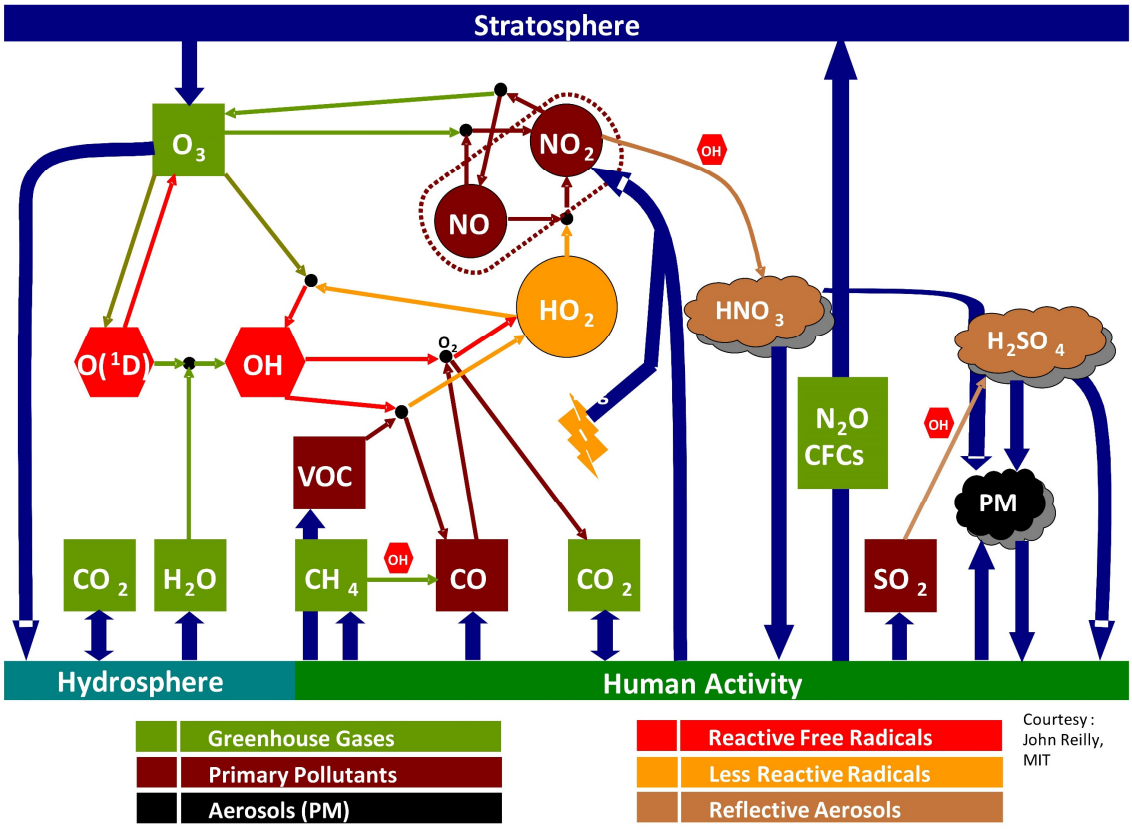
* AQI is not an absolute representation of air quality
* AQI represents combined pollution-health alert as a number
* In easy symbols - green = good/healthy; red = bad/unhealthy
* National methodologies vary based on their AQ standards

traffic Jams (congestion/idling)



* On average 10-20% of urban fuel is spent idling in jams
* Recommended to turn-off engines if idling for >30 seconds
* Higher public transport (PT) share can reduce idling times
* Congestion pricing will work if adequate PT is operational

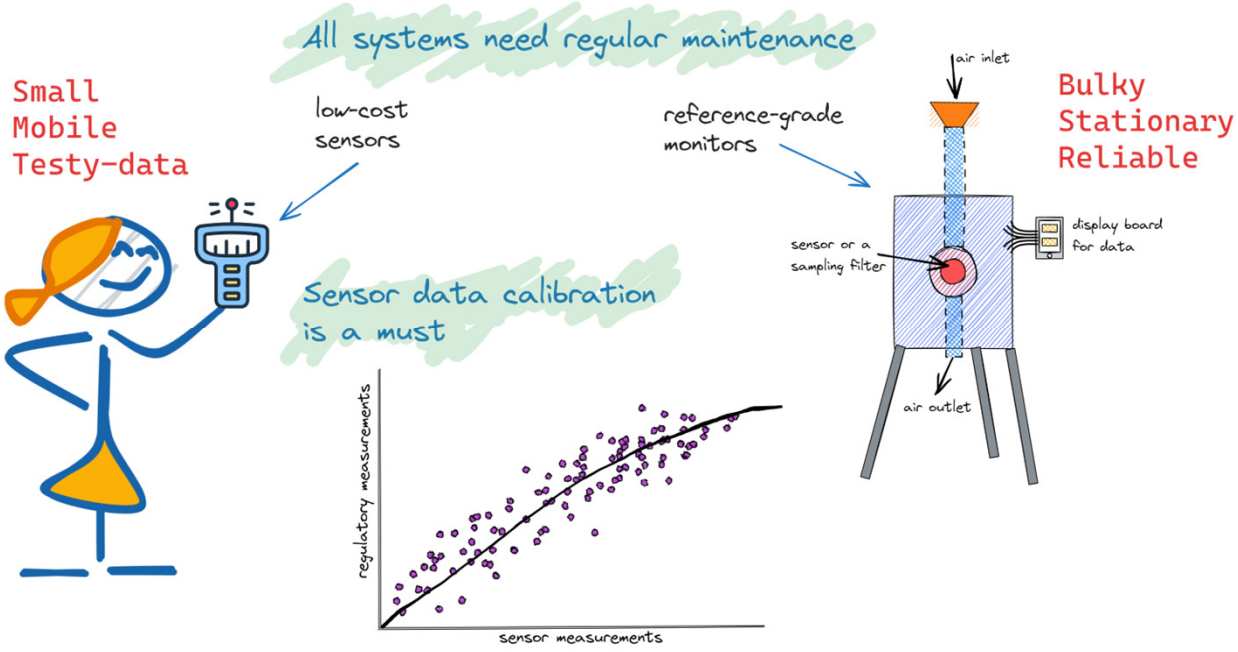
Kinetic (chemical) reactions



Courtesy : John Reilly, MIT

* Atmosphere is a dynamic and complex environment
* Production/destruction of pollutants is not a linear process
* Known chemical mechanisms run into 300-700 reactions
* Most models simulate chemistry in the troposphere (<12km)

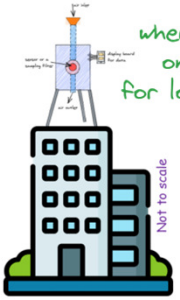
Low-cost sensors



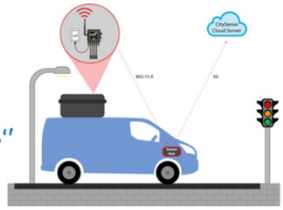
* Cheap, mobile, and easy to install
* Quick operations, with known uncertainties
* Best option to increase spatial representation with calibration
* Not considered for regulatory purposes (as of 2023)

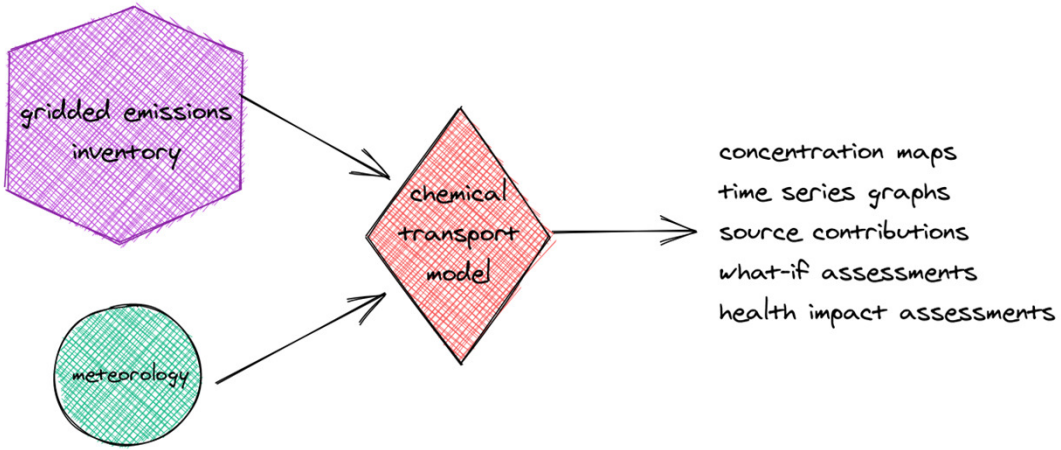
Monitoring/Modelling

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



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





* More monitoring = more understanding of the local trends
* Emission inventory can be validated using monitoring data
* Weather influences emission intensity & pollution dispersion
* Modelling is a work-in-progress

Natural sources of air pollution

N

Seasalt emissions

Mostly part of particulate matter

Lightning emissions

High bursts of nitrogen oxide (NOx) compounds vertically spread from cloud to ground

Biogenic emissions

Mostly volatile organic compounds (VOCs)
- plays a key role in ozone chemistry and formation of secondary organic aerosols (SOA)

Wind erosion emissions

Mostly part of particulate matter
- part of seasonal long-range transport dust

Open fire emissions

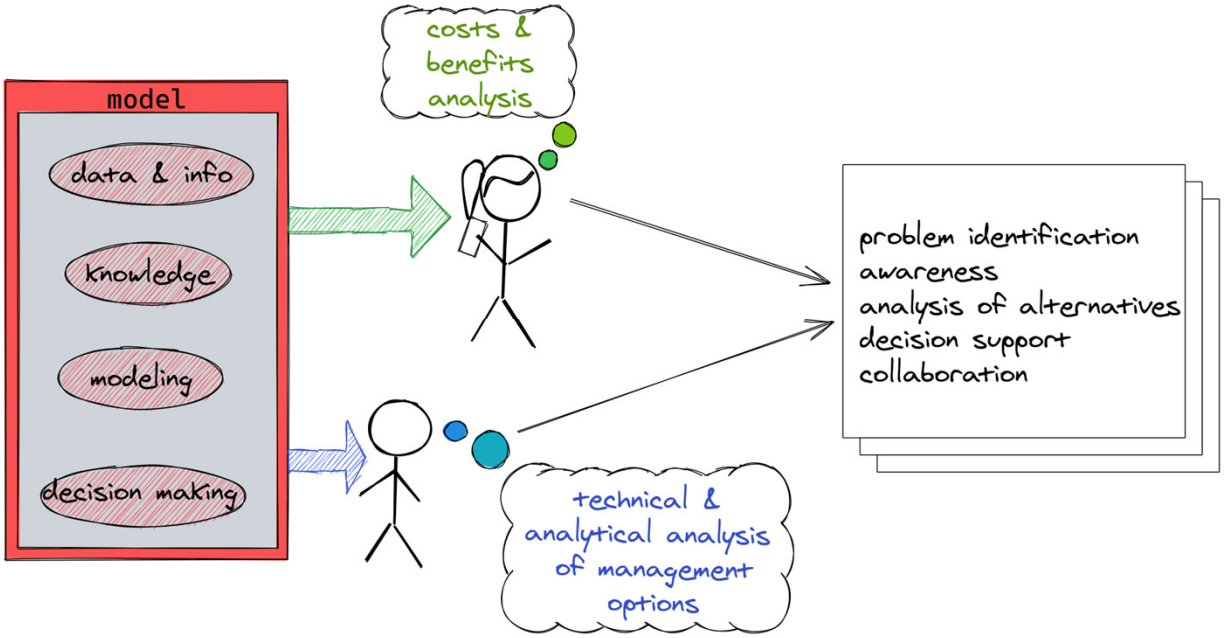
Mostly a result of high temperatures & lightning strikes, producing a mix of pollutant emissions

Volcanic emissions

Mostly sulphur dioxide (SO2) and particulate matter (ash)
- part of long-range transport

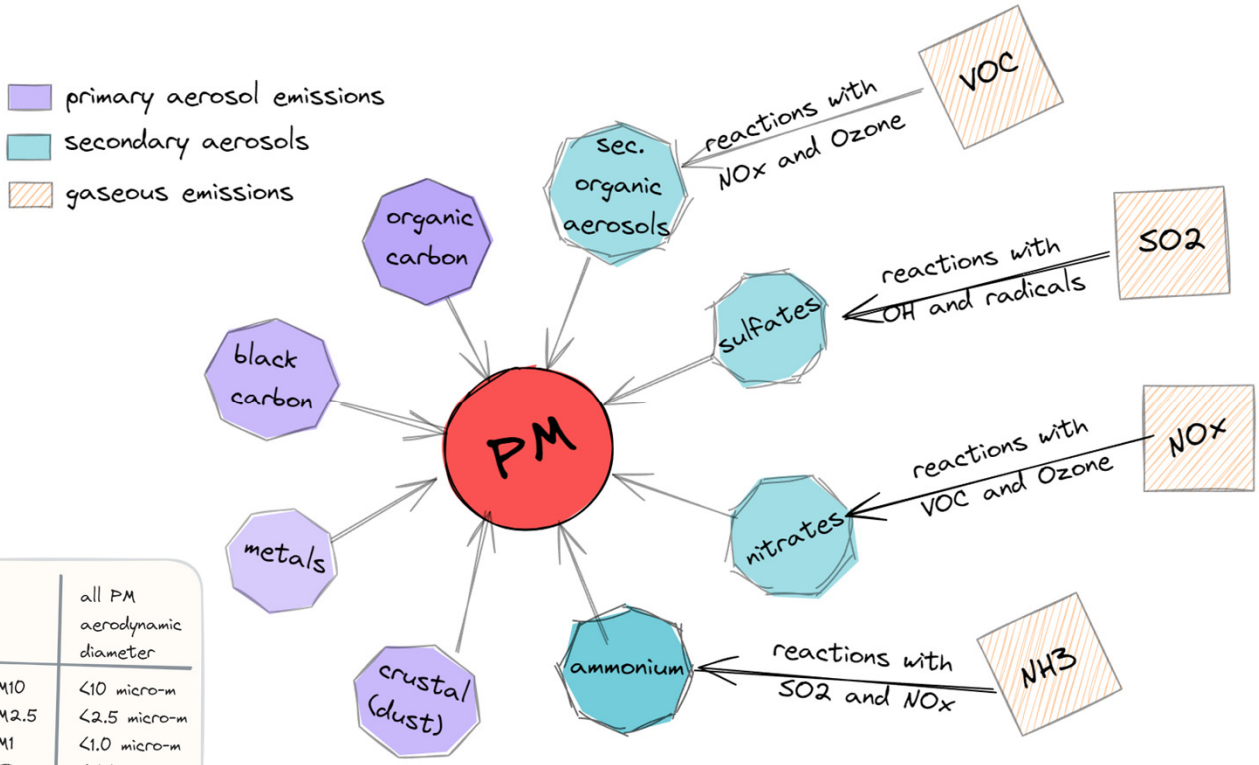
* All natural sources (NS) produce seasonal/sporadic emissions
* Weather forecasts can be used to anticipate NS alerts
* While NS emissions are big, human activities amplify bad AQ
* Established models are needed to account for NS emissions

Options – cost/benefit analysis



* Options are ranked based on their costs & health benefits
* Cost-benefit analysis needs baseline monitoring and modelling
* Financial feasibility will decide implementable options
* Options negotiation involves multi-stakeholder dialogues

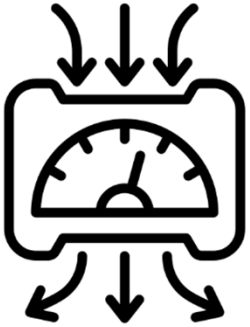
Particulate Matter (PM)

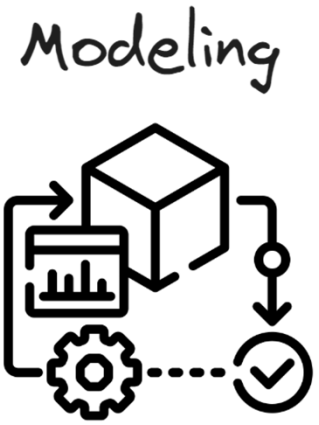


	all PM aerodynamic diameter
PM10	<10 micro-m
PM2.5	<2.5 micro-m
PM1	<1.0 micro-m
UFP	<100 nano-m

* PM includes contributions from gases via chemical reactions
* PM is the pollutant most linked to health impacts
* PM is the pollutant most measured for regulatory purposes
* $PM_{2.5}$ and PM_{10} are most measured by the governments

QA/QC of air quality data





* Quality assurance (QA) enhances reliability of data
* Quality control (QC) ensures compliance to standards
* QA/QC supports integrity, transparency, & accountability
* Open access to good data promotes widespread usage

Residential emissions

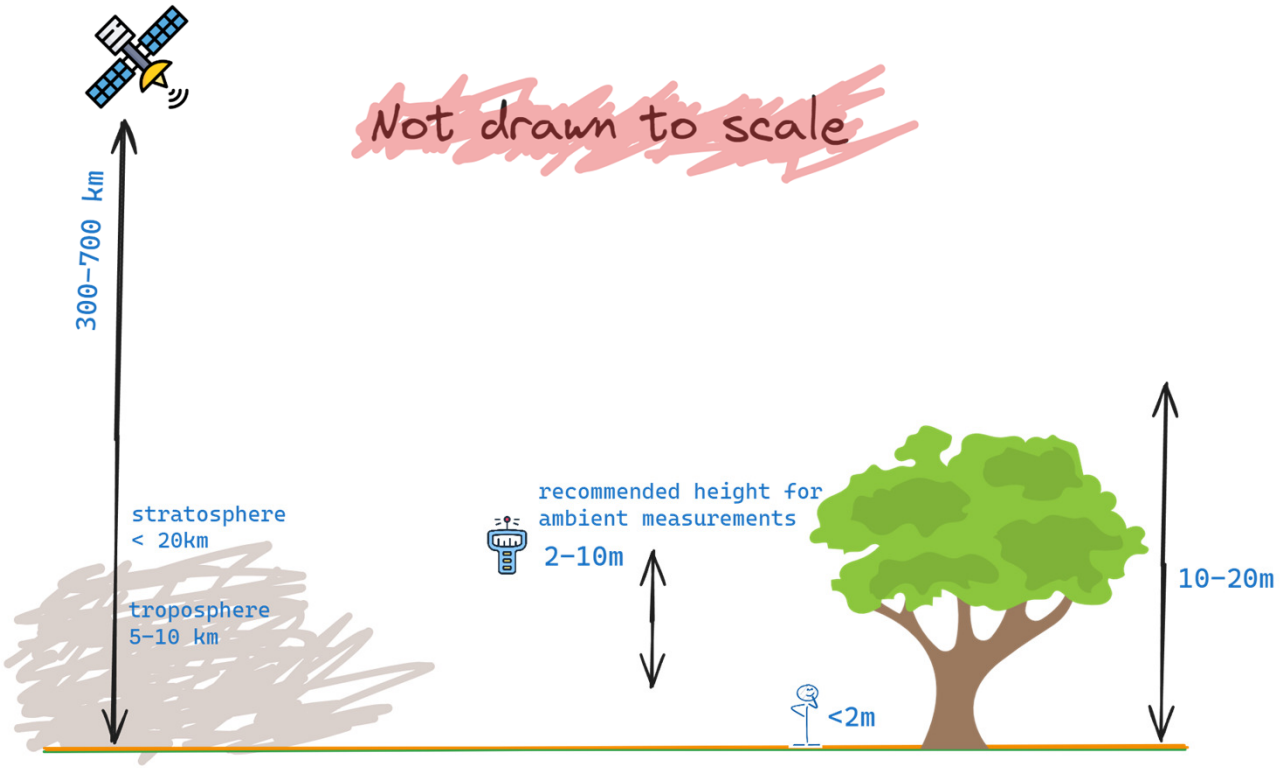
Residential cooking
Commercial cooking
Water heating

lighting

Space heating
(seasonal)

* Conventional fuels: wood, coal, cow-dung, crop residue, fuel-oil
* Heating fuels: mostly conventional, and waste
* Clean fuels: liquified petroleum gas (LPG), electricity
* Indoor air quality impacts are worse in conventional houses

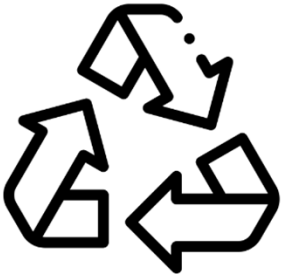
Satellite data



* Ground monitoring is preferred to study ambient trends
* Geostationary satellites are required for in-depth studies
* Satellite data needs vertical interpretation for ambient values
* Interpretations depend on local inventories and modelling

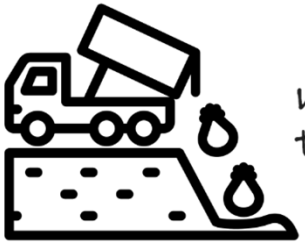
Trash (waste) burning emissions

Reduce waste generation



Recycle as much as possible

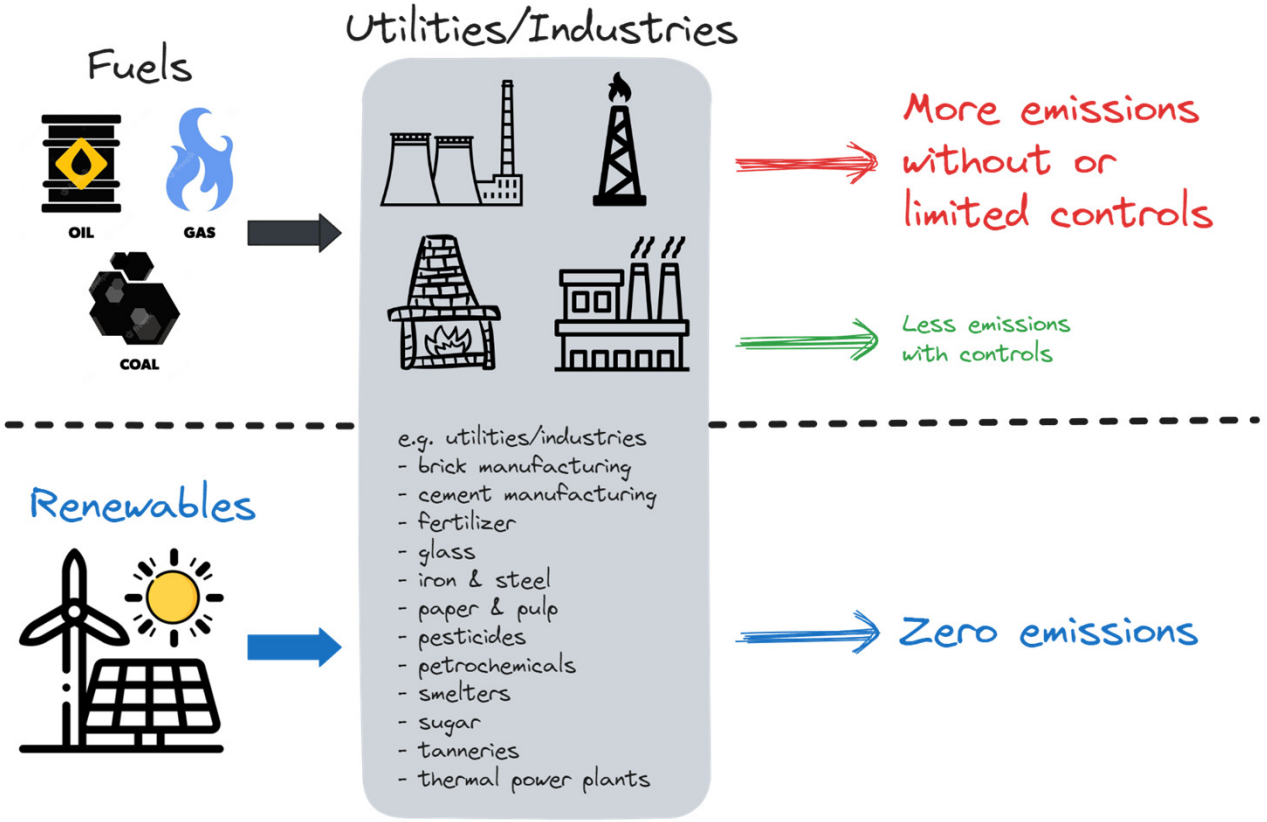
Remediation and repurpose of waste



Waste to the landfills

* Waste not collected/managed is eventually burnt
* Open waste burning (OWB) produces many carcinogens
* OWB produces black carbon – a short-lived climate pollutant
* OWB emissions is the most underrepresented in inventories

Utility (industry) emissions

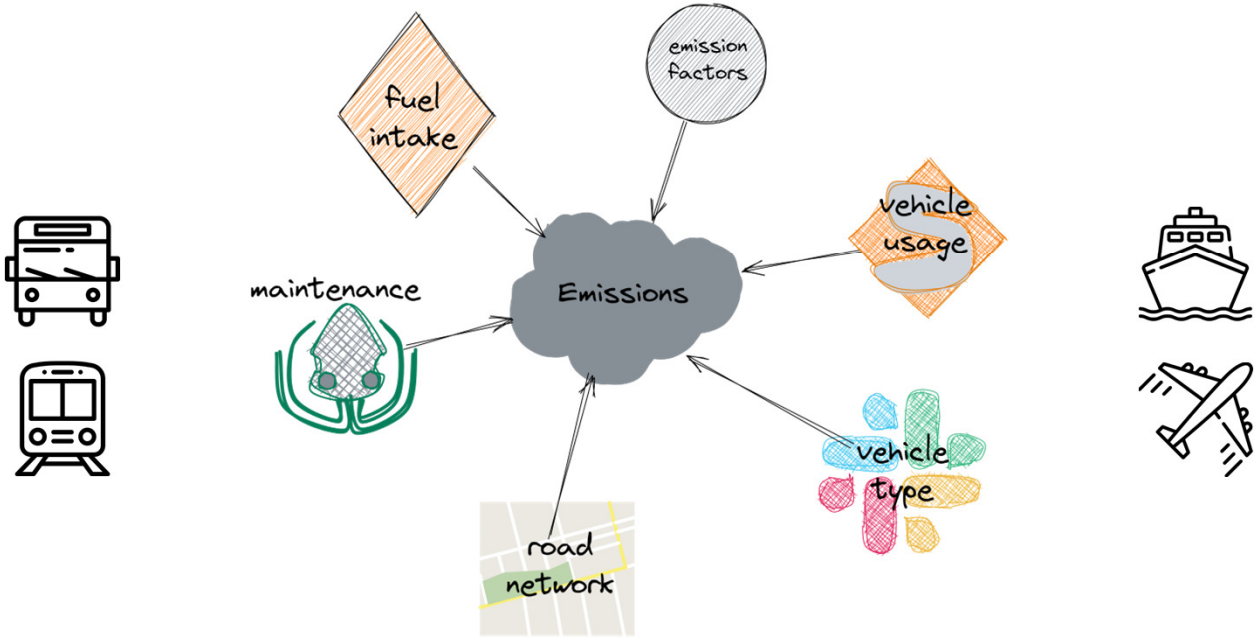


* Coal is the primary fuel for power & other industrial utilities
* Utilities share of CO_2 emissions burden is the highest
* Open emissions data is needed for accountability & compliance
* Emission standard enforcement is key for cleaner utilities

Vehicle (transport) emissions

Fundamental Equation:

Emissions = #vehicles * Vehicle usage (km) * emission factor (gm/km)



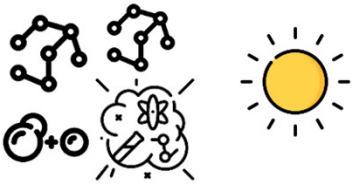
* Transport is just one of the key contributors to air pollution
* Freight transport links most known sources in an airshed
* Reducing vehicle usage and congestion are key control options
* Finer resolution analysis requires a lot of GIS/activity inputs

Weather (meteorology)

Emissions

. wet conditions = lesser dust resuspension
. cold temperatures = more heating demand
. windy conditions = more dust resuspension and dust storms

Formation



. Temperature, pressure, and humidity dependent chemical reactions
. cloudy conditions = lesser photochemistry

Dispersion

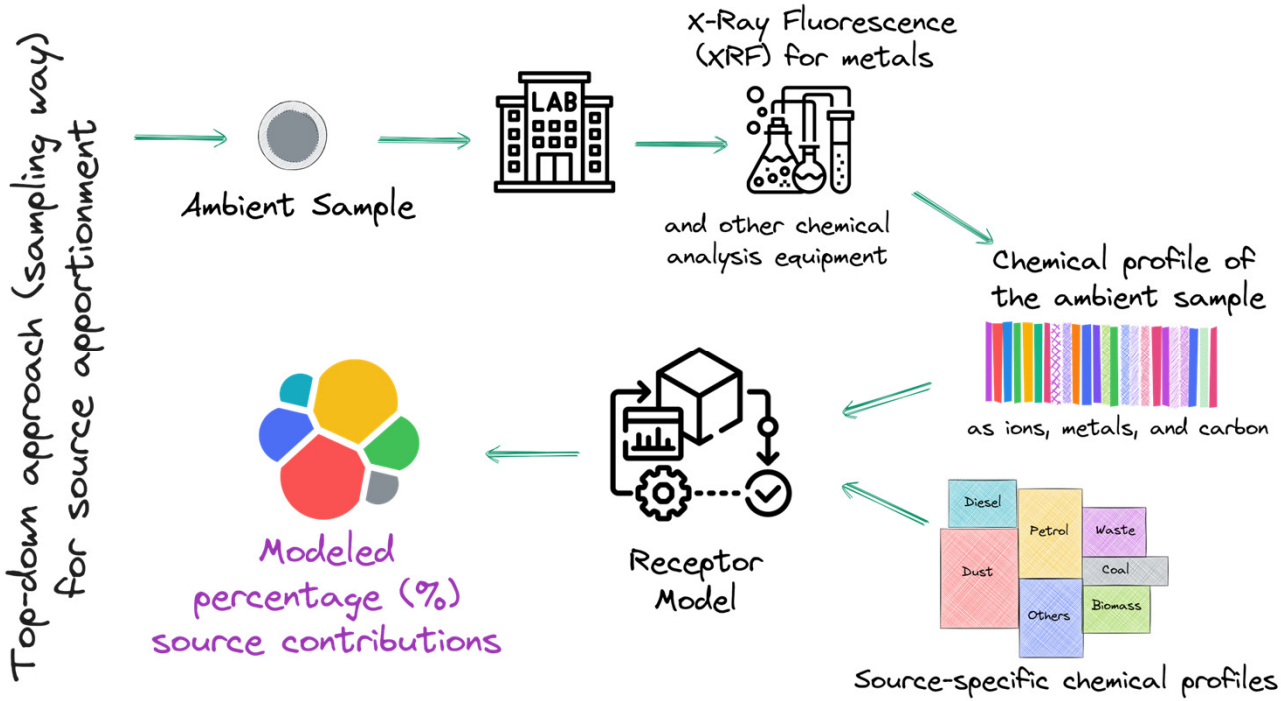
. rain = wet deposition of pollutants
. windy conditions = more dispersion

Pollution

. lower mixing height = more pollution
. windy conditions = lesser pollution
. wet conditions = lesser pollution
. foggy conditions = more pollution

* Weather influences emission intensity & pollution dispersion
* Windrose information is enough for general inferences
* 3-dimensional information is must for modelling studies
* Forecasts can be used to avert poor to severe pollution alerts

XRF (source apportionment)



* % source information is a must for an effective clean air plan
* This sampling approach is the most used method
* Other approach uses gridded emissions and meteorology
* More samples across airshed = more representative data

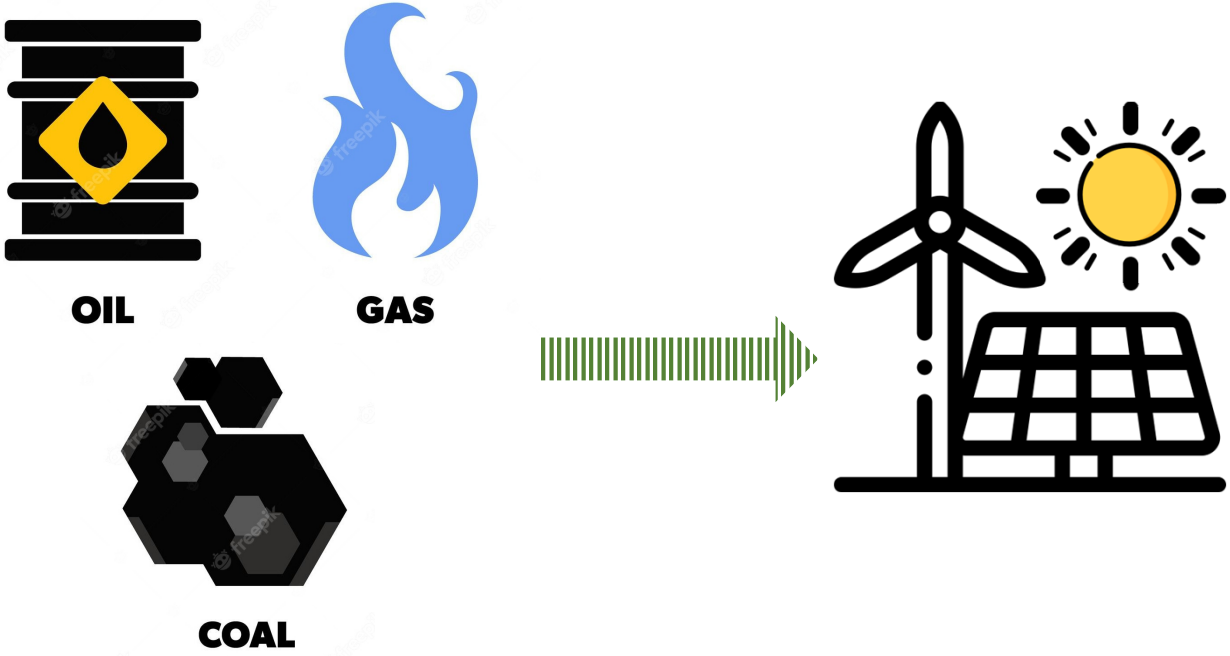
Your role

As an individual what can one do to reduce emissions footprint

-- Reduce personal vehicle use via public transportation
-- Promote walking or cycling for short trips
-- Regularly maintain vehicles for better fuel efficiency
-- Turn-off vehicles when idling for more than 30 seconds
-- Turn-off lights and appliances in the house when not in use
-- Use energy-efficient appliances in the house
-- Promote installation renewable energy sources
-- Plant trees and maintain green spaces
-- Avoid burning trash and/or garden waste
-- Use clean fuels for cooking and heating
-- Advocate for stricter air quality regulations and policies
-- Encourage community action via public awareness

Full article published in thewire.in (June 2019)
Scan QR code for the article (last accessed Feb 2024)

Zero emissions



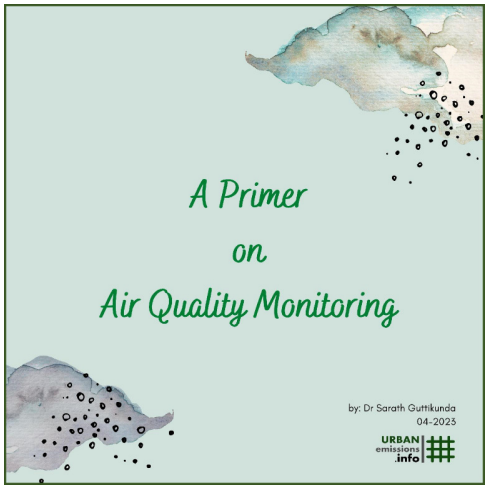
* All burning/combustion activities produce emissions
* Zero emissions is mentioned in the context of climate change
* All climate interventions also have benefits for air quality
* Zero/Lesser emissions = Zero/Lesser air pollution

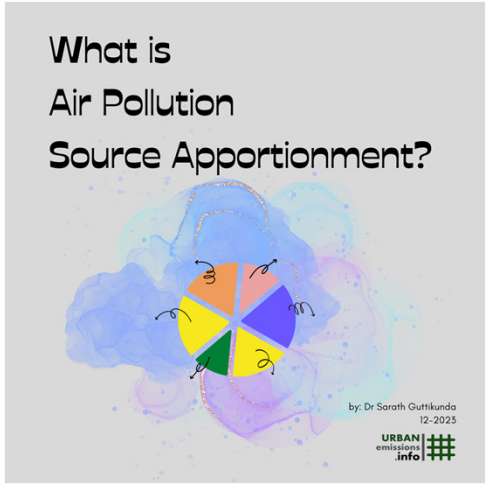
World Health Organization (WHO) Guidelines for Air Quality

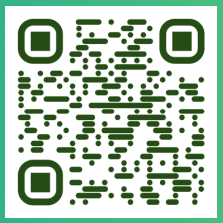
	1-year	24-hr	8-hr	1-hr
$PM_{2.5}$	5	15	-	-
PM_{10}	15	45	-	-
SO_2	-	40	-	-
NO_2	10	25	-	200
CO	-	4000	10000	35000
O_3	-	-	100	60

Units: $\mu g/m^3$

Other primers @ urbanemissions.info







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