Welcome
to the

Air Quality Module

Virendra Sethi
Professor

Environmental Science & Engineering Department
IIT Bombay

2023

In Service
of
YOU

In Honour
of
YOU
as
Future Leaders
and
Decision Makers

For this Module
Please Create a Game
where

YOU

are

Accountable for the Air Quality

in

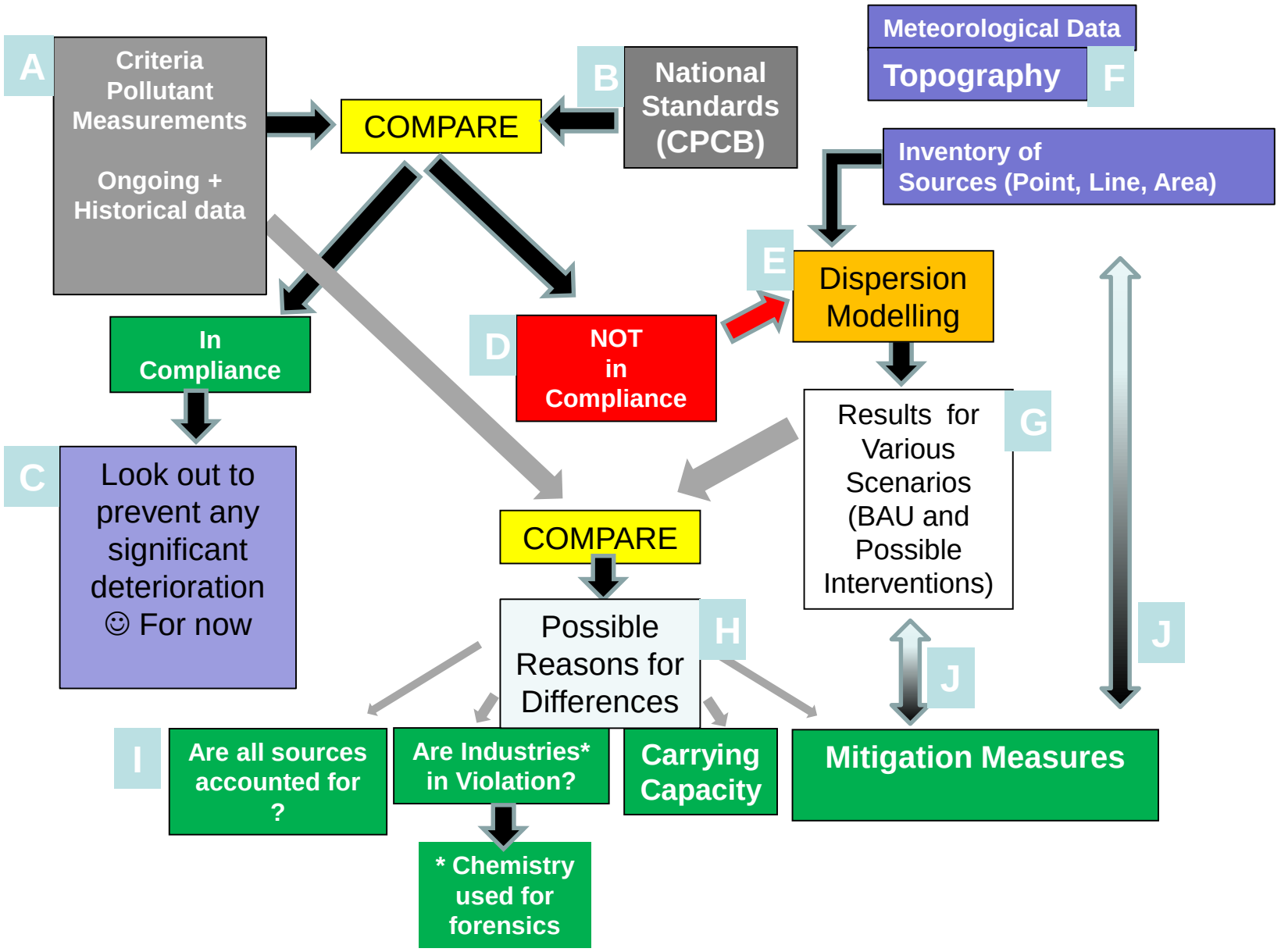
Your City

(The Appropriate Questions will Arise Naturally in that Game)

Module Objective

AQM

Air Quality Management


A
Criteria Pollutant Measurements
Ongoing + Historical data
COMPARE
B
National Standards (CPCB)
Meteorological Data
Topography
F
Inventory of Sources (Point, Line, Area)
E
Dispersion Modelling
In Compliance
D
NOT in Compliance
C
Look out to prevent any significant deterioration
☺ For now
COMPARE
Results for Various Scenarios (BAU and Possible Interventions)
G
Possible Reasons for Differences
H
J
J
I
Are all sources accounted for ?
Are Industries* in Violation?
Carrying Capacity
Mitigation Measures
* Chemistry used for forensics

Further Resources for the AQM Process

A. Air quality is routinely measured by :
   a. Hi-volume samplers in RSPM in the National Air Monitoring Program (NAMP) network of stations (twice a week) for
      i. RSPM (Respirable Suspended Particulate Matter ie size < 10 μm)
      ii. Oxides of Nitrogen
      iii. Oxides of Sulphur
      iv. eg Please see : http://www.cpcbenvis.nic.in/air_quality_data.html

   b. More recently also using CAAQMS(Continuous Ambient Air Quality Monitoring Stations)
      i. MPCB has one on campus near SAMEER Y-Point
      ii. eg Please see http://www.cpcb.gov.in/CAAQM/frmCurrentDataNew.aspx?StationName=MPCB%20Bandra&StateId=16&CityId=310

B. National Ambient Air Quality Standards

a. Please see : http://cpcbenvis.nic.in/air_pollution_main.html#

Standards are based on time of exposure. For example 8 hours standards or annual standard. You can be exposed to a higher concentration level for a short time.

C.These are the pollutants that are monitored for air pollution levels. If the levels are below these concentration levels, then the city is in compliance.

D.Else, it is in violation of the standards.

E. In case of non-compliance, efforts are made to understand the problem by using DISPERSION Modelling (For FUTURE reference you can see : https://www.sciencedirect.com/science/article/pii/S1352231006006339

F. Inputs required for DISPERSION Modelling are
   a. Meteorological conditions (wind speed, wind direction, vertical mixing) Please see wind rose : https://en.wikipedia.org/wiki/Wind_rose
   b. Topography
   c. Sources
      i. Point sources eg Industries (Chimneys)
      ii. Line sources eg Vehicles
      iii. Area sources eg coal mines

G. The model permits simulation of different scenarios such as
   a. Seasonal variations due to Meteorological conditions
   b. Turning on some sources and turning off other sources of pollution
   c. Adding new sources to study the impact of a new plant (eg coal power plant)
   d. Impact of introducing electric vehicles instead of petrol/diesel vehicles

H. Quite often, the results of the model do not compare with the measurements in A, and then further investigations are required.

I. Possible reasons could be
   a. Some sources are not included (eg road dust during dry seasons)
   b. Unexplained regional sources (dust storms, long distance agricultural burning)
   c. Industries may be violating the permitted levels of emissions
   d. Uncertainties in Met data and or the resolution of data (spatial and temporal)
   e. Diurnal variation of wind conditions and carrying capacity of the region

J. Results can be used to design mitigation measures and control strategies

Questions Arising in your Accountability

- Whether your home city is in compliance for NAAQS or not.
- What is the wind rose in your home city (or any city nearest to you)
- What are the key Point, Line and Area sources in your Home city ?
- What can be done to improve air quality in your home city ?

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Learnings

Three things learnt at Harvard **(Late Prof. Arcievala)**

1. Quantification
2. Library work
3. Apprenticeship

What is Air Pollution ?

- Perception
  - Visible
  - Odour

- What is clean air ?
  - 78% Nitrogen + 21% Oxygen + 1% Trace
  - 340 ppm CO_2 (0.034%)

- 340 ppm ?

Lifecycles/Statistics

- Capacity of the earth system as a sink
  - Feasibility (thermodynamics)
  - Proximity
- Characteristic times
  - Kinetics
  - Sulphur, Carbon, Nitrogen, Halogen Containing Compounds Cycles
- Statistics

Scales and Fate

- Local > Regional > Global
- Earth : Apple :: Atmosphere : Skin
- Ambient : Indoor
- Dispersion and Mixing

Module Objective

Air Quality Standards

&

Concentration Estimates

CPCB
National Ambient Air Quality Standards
(NAAQS)

1. Concentration

2. Exposure duration

Revised National Ambient Air Quality Standards (NAAQS)

[NAAQS Notification dated 18th November, 2009]

S. No.	Pollutants	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
			Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (notified by Central Government)	
1	Sulphur Dioxide (SO_2), µg/m^3	Annual*	50	20	1. Improved West and Gaeke 2. Ultraviolet Fluorescence
		24 Hours**	80	80	
2	Nitrogen Dioxide (NO_2), µg/m^3	Annual*	40	30	1. Modified Jacob & Hochheiser 2. Chemiluminescence
		24 Hours**	80	80	
3	Particulate Matter (Size <10µm) or PM_{10} µg/m^3	Annual*	60	60	1. Gravimetric 2. TEOM 3. Beta attenuation
		24 Hours**	100	100	
4	Particulate Matter (Size <2.5 µm) or $PM_{2.5}$ µg/m^3	Annual*	40	40	1. Gravimetric 2. TEOM 3. Beta attenuation
		24 Hours **	60	60	
5	Ozone (O_3), µg/m^3	8 hours**	100	100	1. UV photometric 2. Chemiluminescence 3. Chemical Method
		1 hours **	180	180	
6	Lead (Pb), µg/m^3	Annual *	0.50	0.50	1. AAS/ICP Method after sampling using EPM 2000 or equivalent filter paper 2. ED-XRF using Teflon filter
		24 Hour**	1.0	1.0	
7	Carbon Monoxide (CO),	8 Hours **	02	02	Non dispersive Infra Red (NDIR)

https://cpcb.nic.in/upload/NAAQS_2019.pdf

Exercise

- Given : Regulatory Limit for SO_2 in Ambient Air is
  - 80 $\mu g/m^3$ (0.03 ppm) for 24-hour average
  - 1300 $\mu g/m^3$ (0.5 ppm) for 3-hour average

- How many grams of Sulphur, if burnt in the room you are in, would exceed this 3-hour limit?

- $S + O_2 = SO_2$
- 32 gm S gives 64 gm of SO_2

- X gm will give 2X gm

- Mixed in how much volume ? Will lead to exposure concentration…

The REAL Question then is …

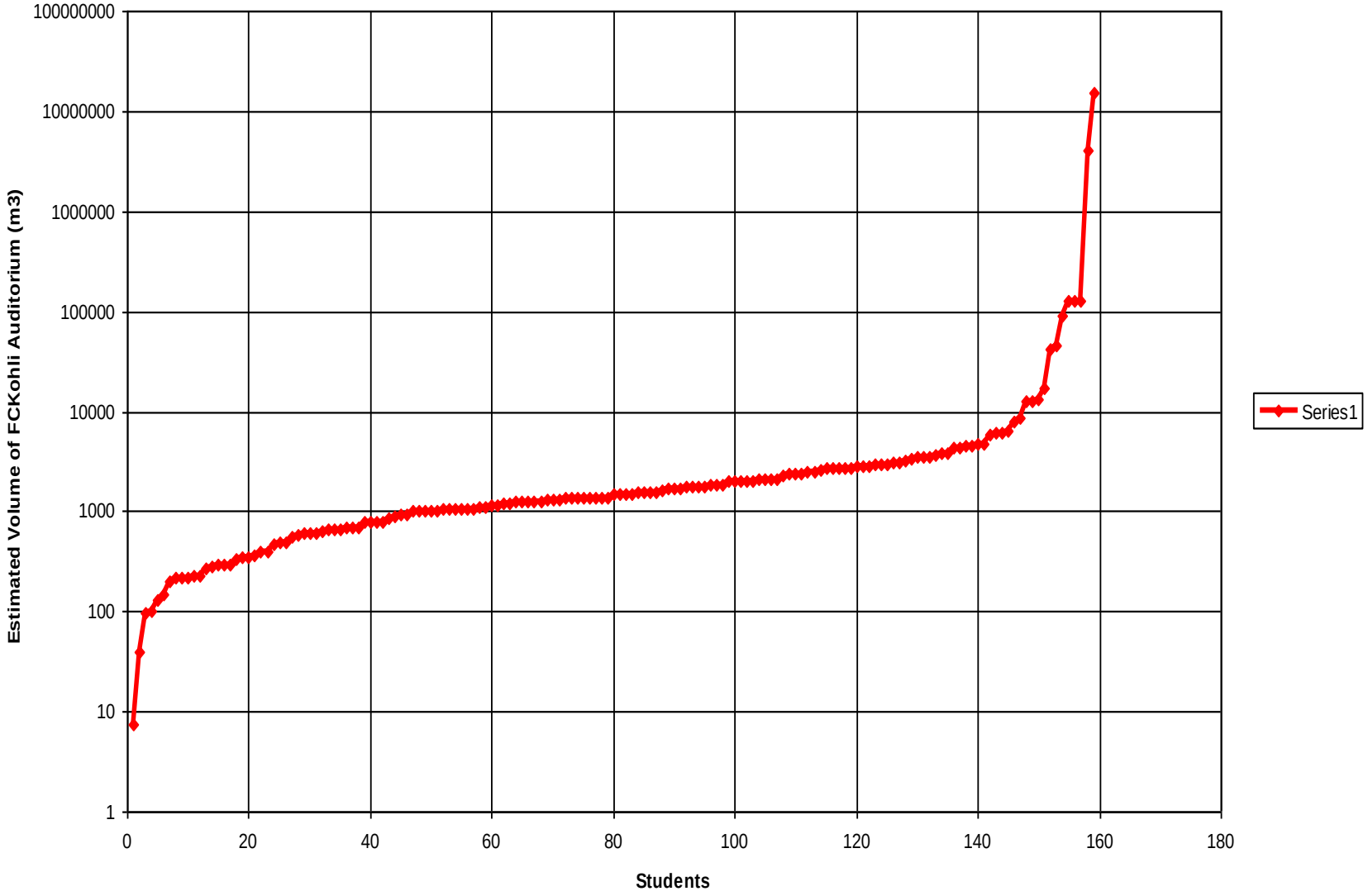
- What is the volume of air in your room (in m^3) ?

How Close were You ?

- Make an estimate of the length, breadth and height of your room.
- Now measure these with a measuring tape/scale
- How close was your estimate ?
- In a closed room, all dimensions are well defined. However, in the ambient, these are open. Uncertainty of measurements is HIGH.

Caution

Results from a Class Exercise



Consequences of a Bad Estimate

- RANGE
  - 20 mg to 8 kg of Sulphur
  - 20 mg : panic buttons for no reason
  - 8 kg : major error that can be fatal
- Actual measurements are IMPORTANT

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How do we Manage Air Quality ?

- At the source itself
  - Industry
  - Vehicles
  - Dust
  - Home cooking (Natural/Forced ventilation)
- After the source
  - Dispersion and Mixing

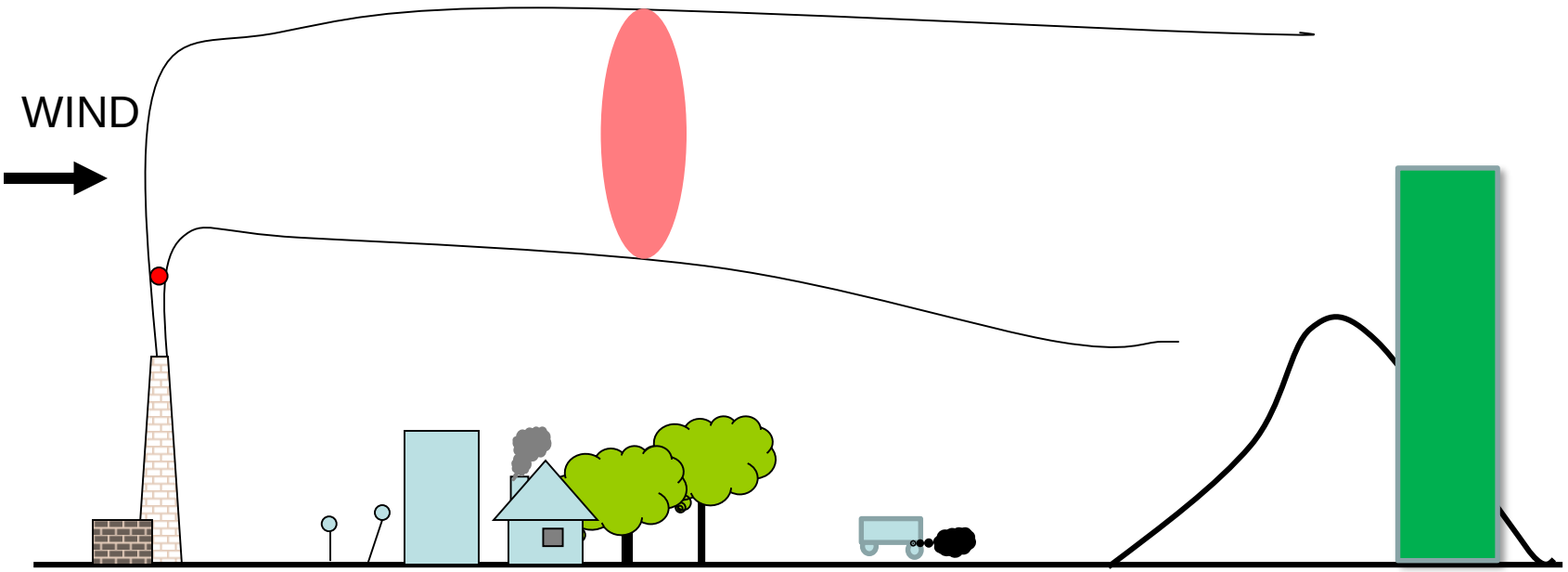
Three Kinds of Sources

- Point
- Line
- Area

https://pixabay.com/photos/environment-industry-4787978/

https://www.google.com/imgres?imgurl=https%3A%2F%2Fimg.rawpixel.com%2Fprivate%2Fstatic%2Fimages%2Fwebsite%2F2022-05%2Fpx757683-image-

Dispersion – Gaussian Plume



Mixing/Dispersion

- Meteorology
  - Horizontal
    - Wind
      - Speed
      - Direction
  - Vertical
    - Temperature
      - Lapse Rate

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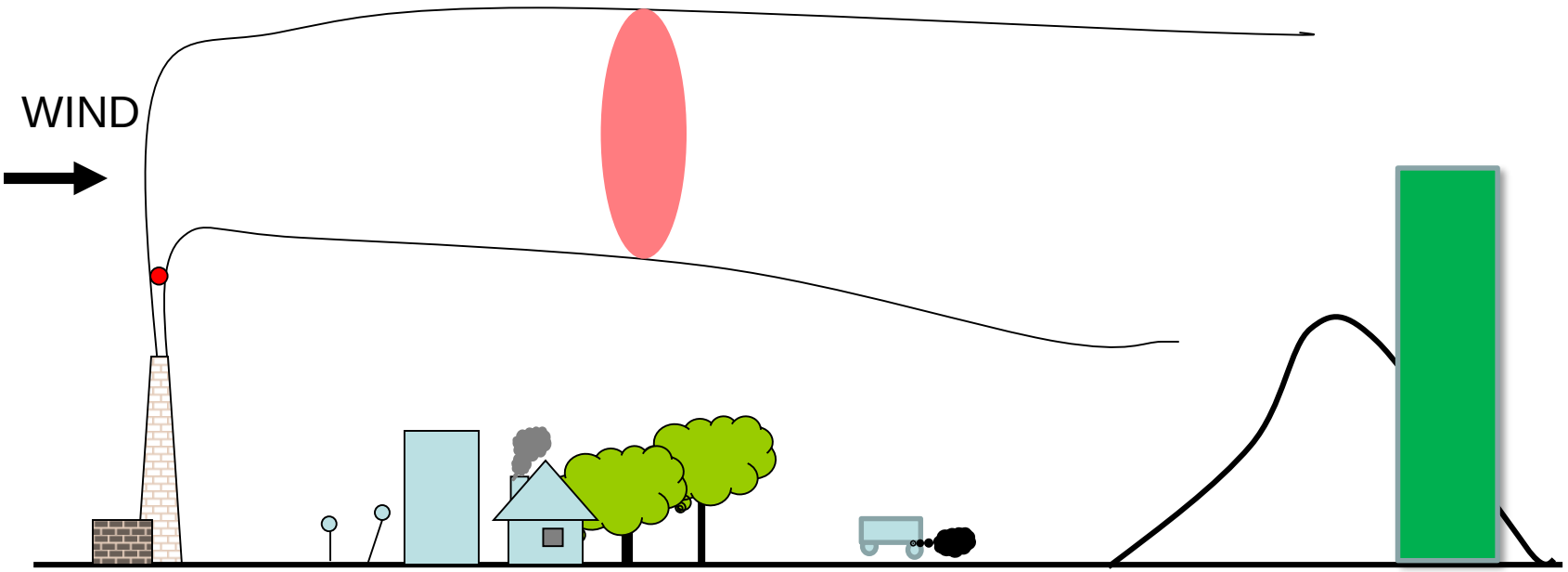

Mixing/Dispersion

- Meteorology
  - Horizontal
    - Wind
      - Speed
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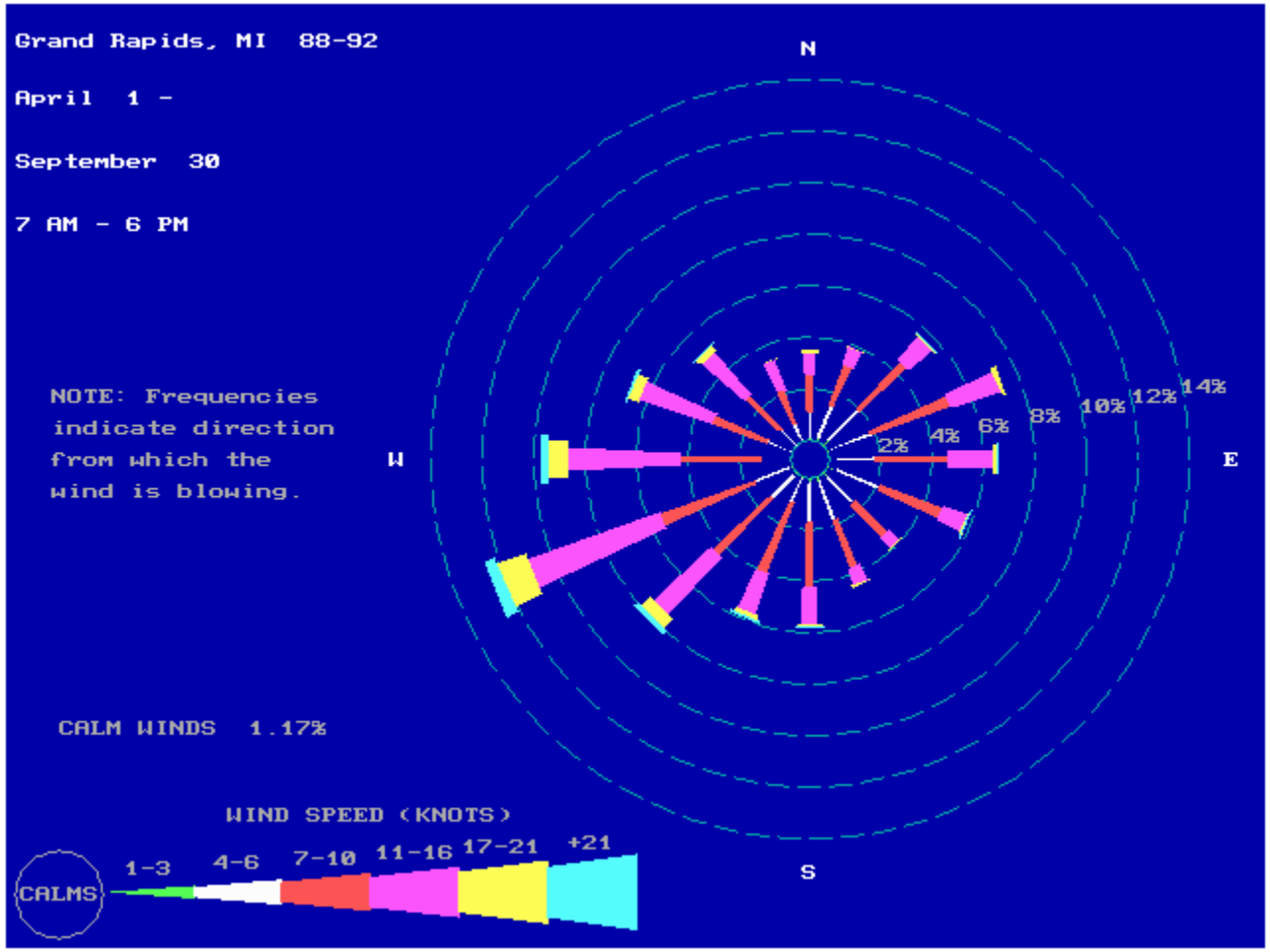
  - Vertical
    - Temperature
      - Lapse Rate

Wind Rose

1 knot = 1.82 km/hr



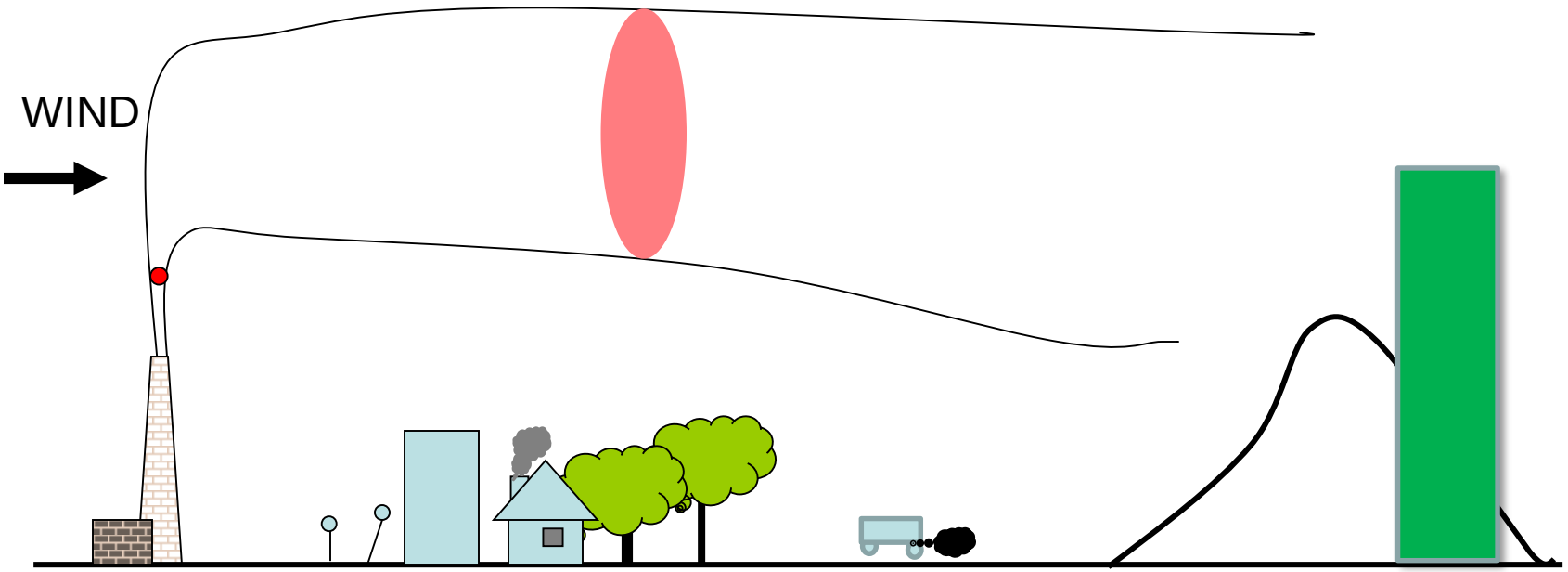
http://www.epa.gov/ttn/naaqs/ozone/areas/wind.htm#dlfi

- Wind roses are divided into 16 wind directions
- Each wind direction is divided into wind speeds
- As the percent of time the wind blows from a particular directions gets larger, the portion of the bar representing the wind speed gets larger both in length and width

Mixing/Dispersion

- Meteorology
  - Horizontal
    - Wind
      - Speed
      - Direction
  - Vertical
    - Temperature
      - Lapse Rate

Dispersion – Gaussian Plume

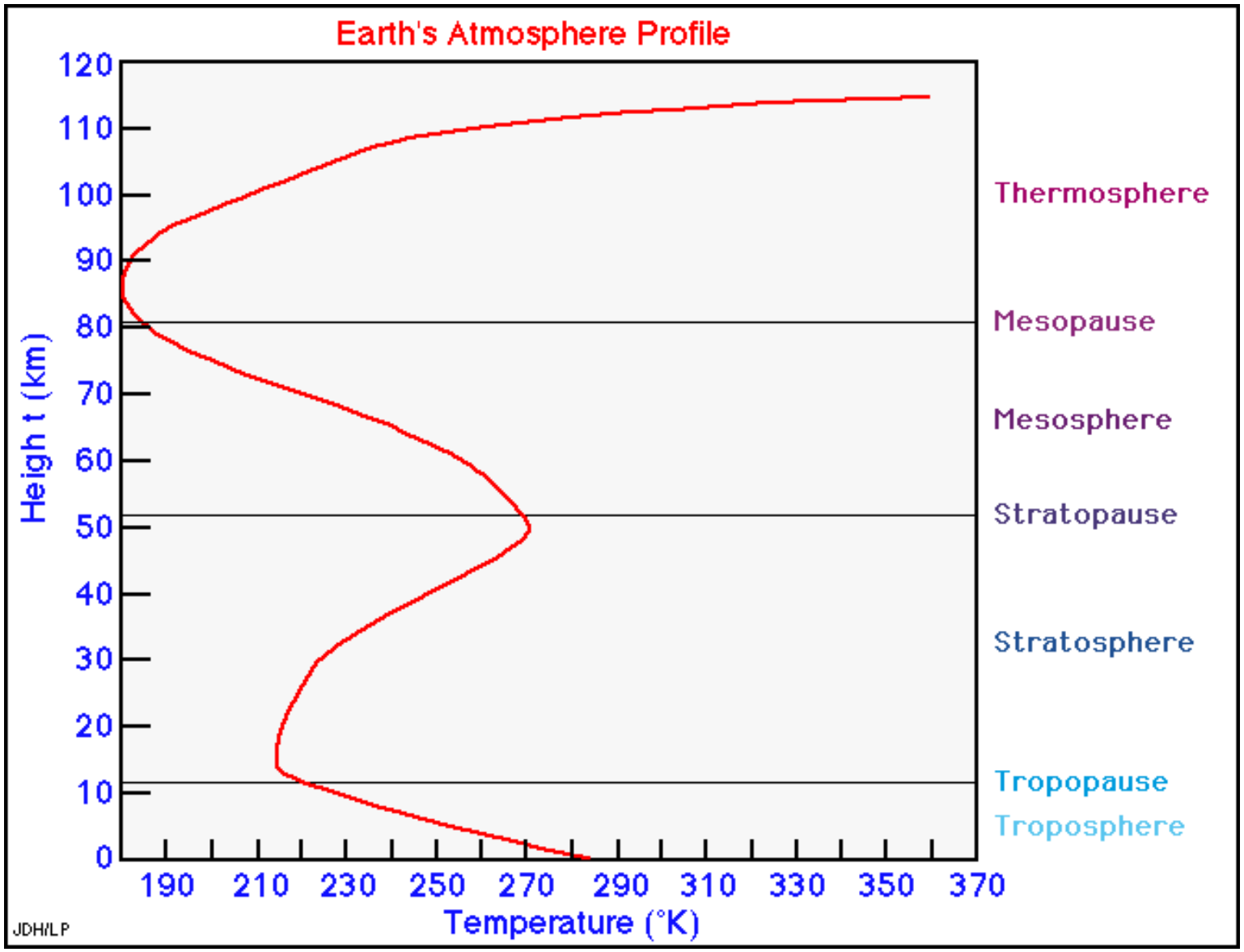


Volume of your Room

The mixing height is known

In the atmosphere **it changes**

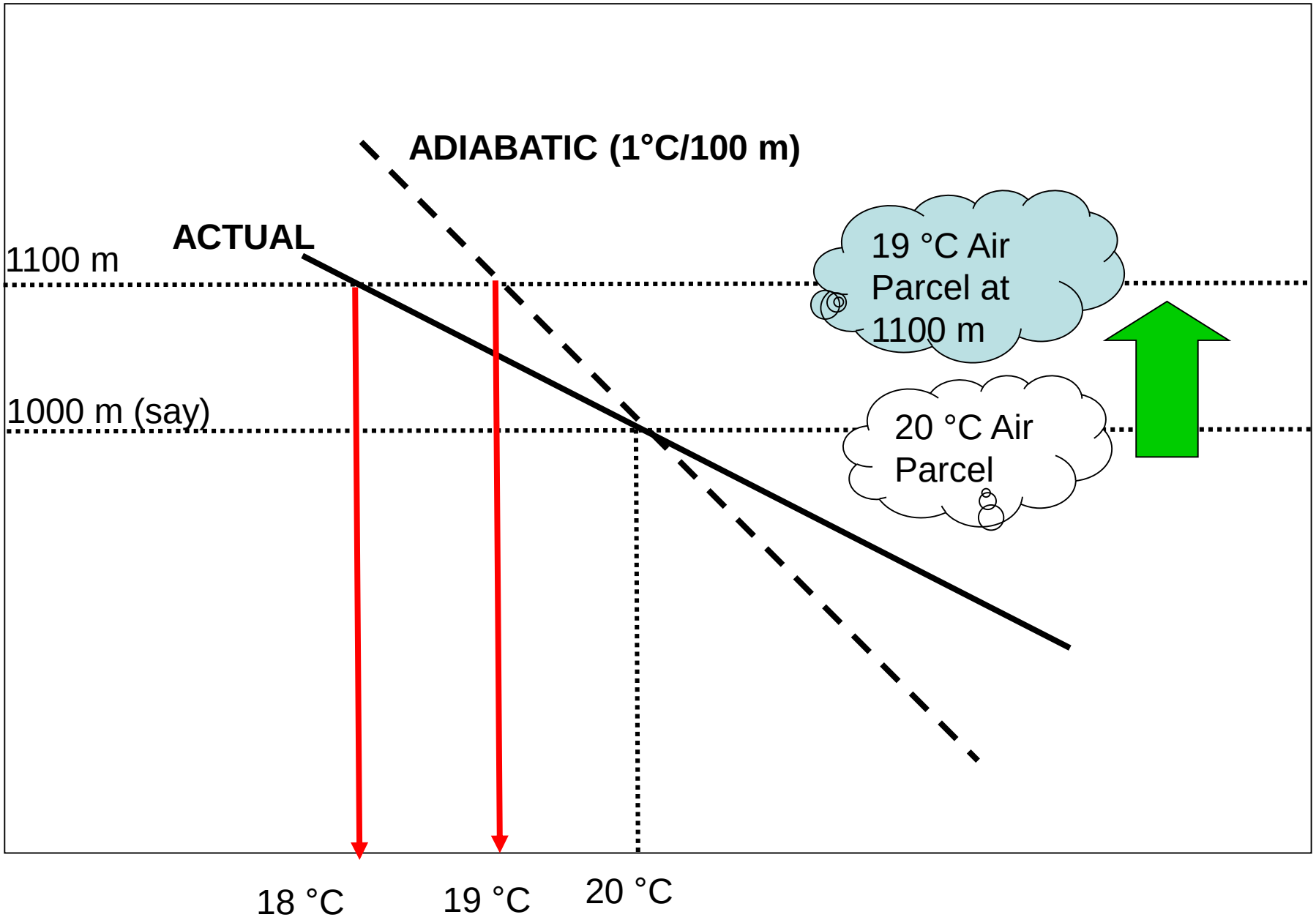
So the volume available for mixing (and dilution of the pollutants) also changes

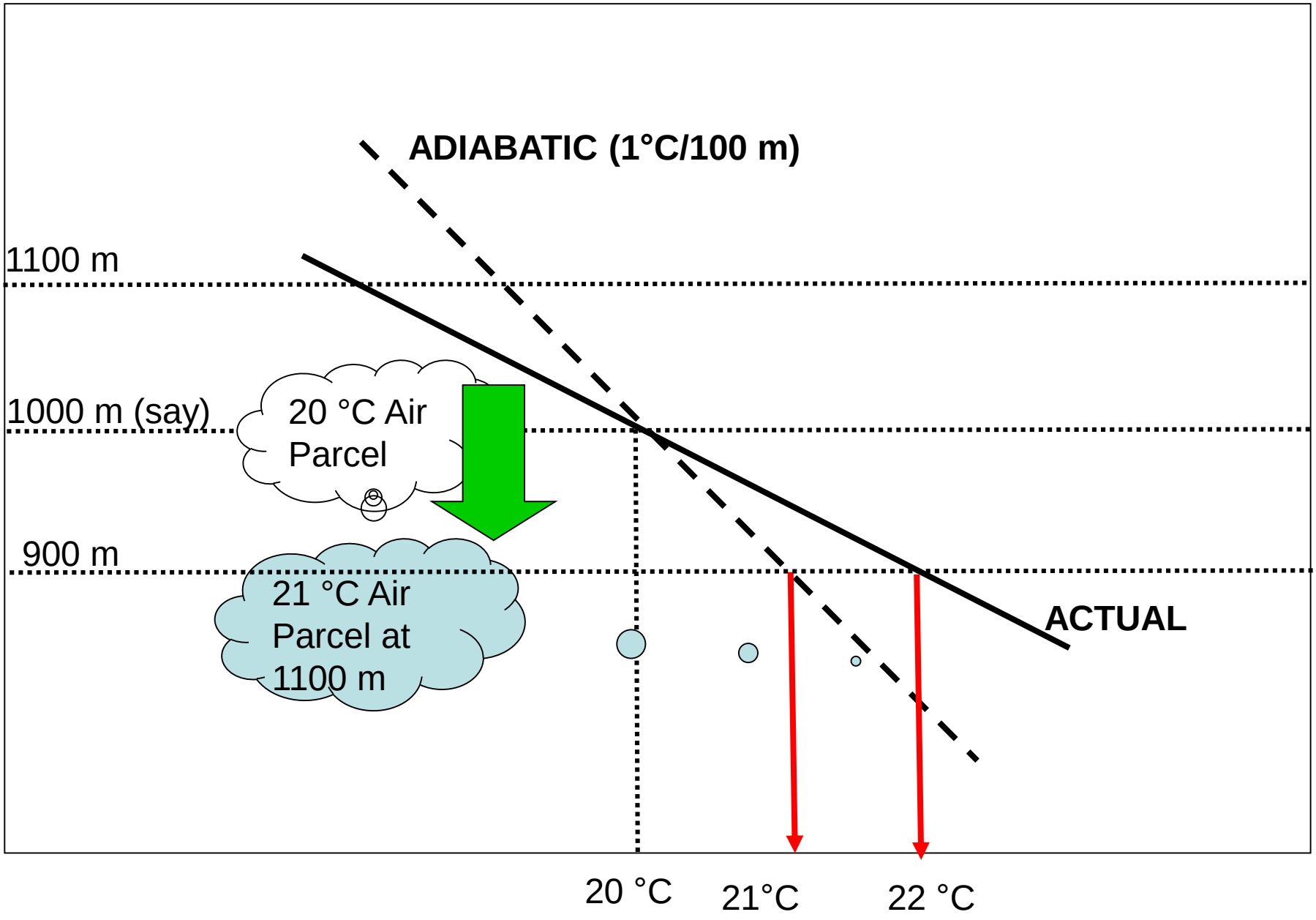


http://www.ldeo.columbia.edu/edu/dees/ees/climate/slides/atmprofile.gif

Lapse Rates

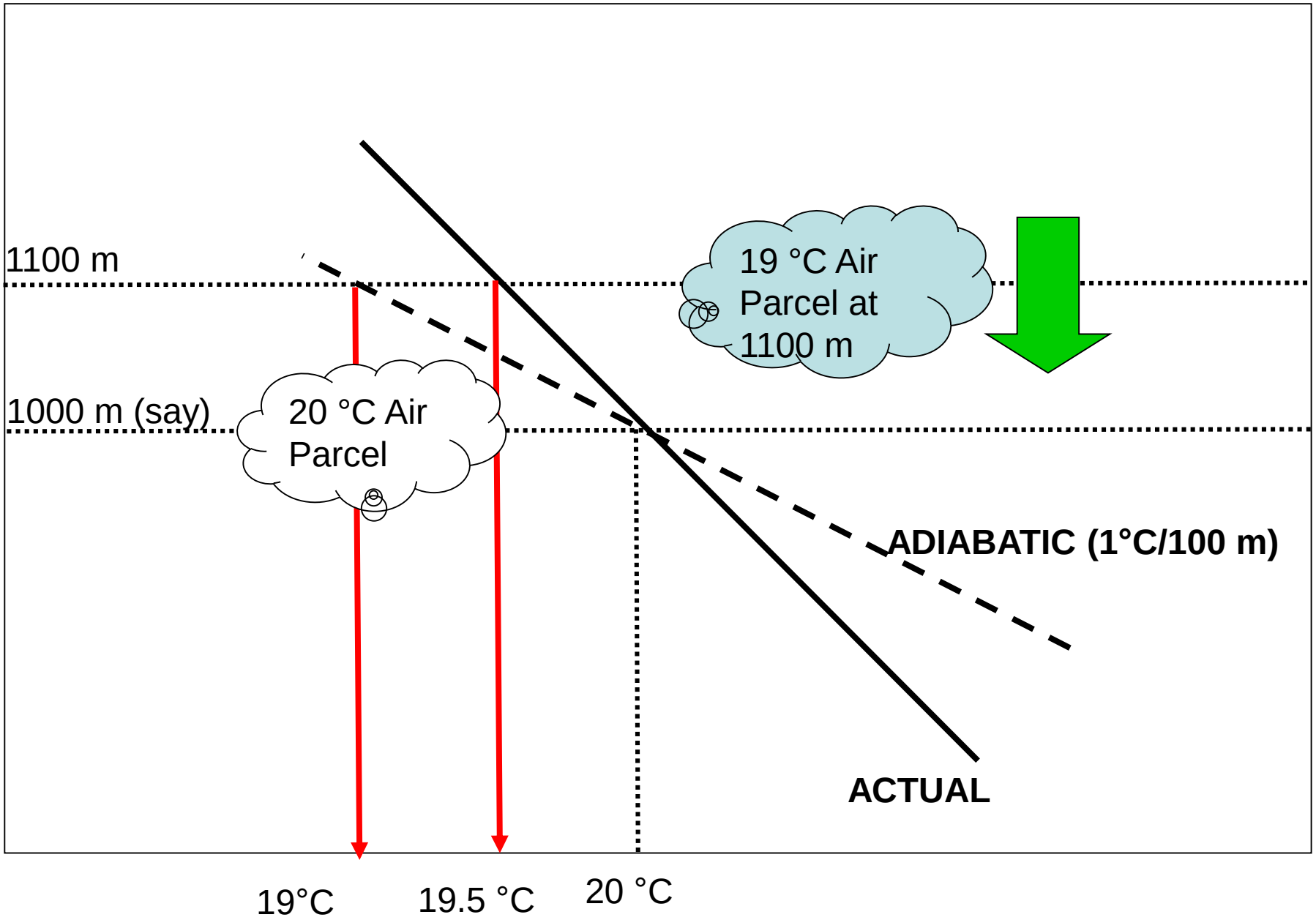
- Atmosphere cools with height
  - What rate ?
    - Dry (Adiabatic) 10°C/km
    - Wet (Adiabatic) 6°C/km
      - (Release of heat with condensation)

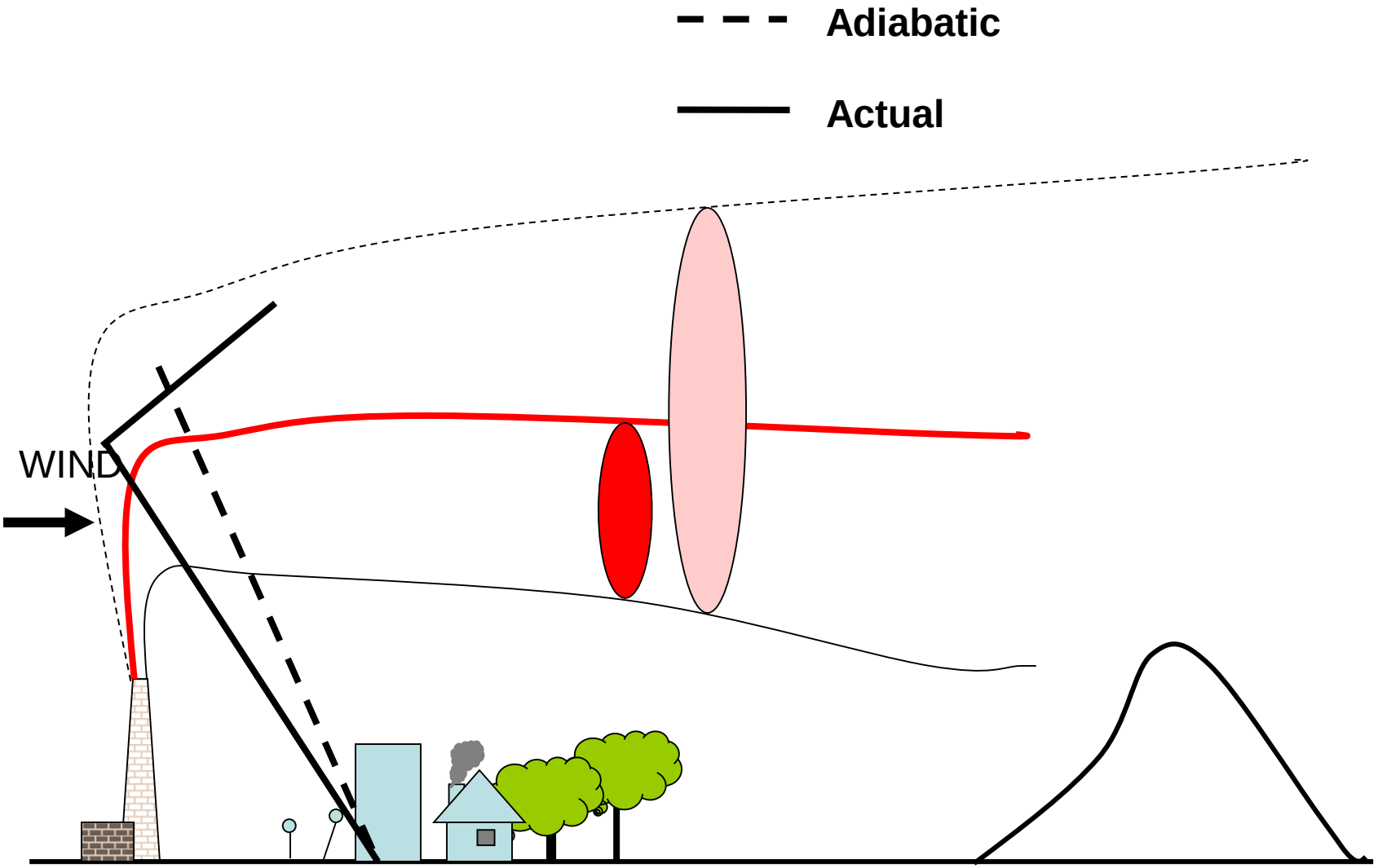

ADIABATIC (1°C/100 m)
ACTUAL
1100 m
1000 m (say)
19 °C Air Parcel at 1100 m
20 °C Air Parcel
18 °C
19 °C
20 °C


ADIABATIC (1°C/100 m)
1100 m
1000 m (say)
20 °C Air Parcel
900 m
21 °C Air Parcel at 1100 m
ACTUAL
20 °C
21°C
22 °C

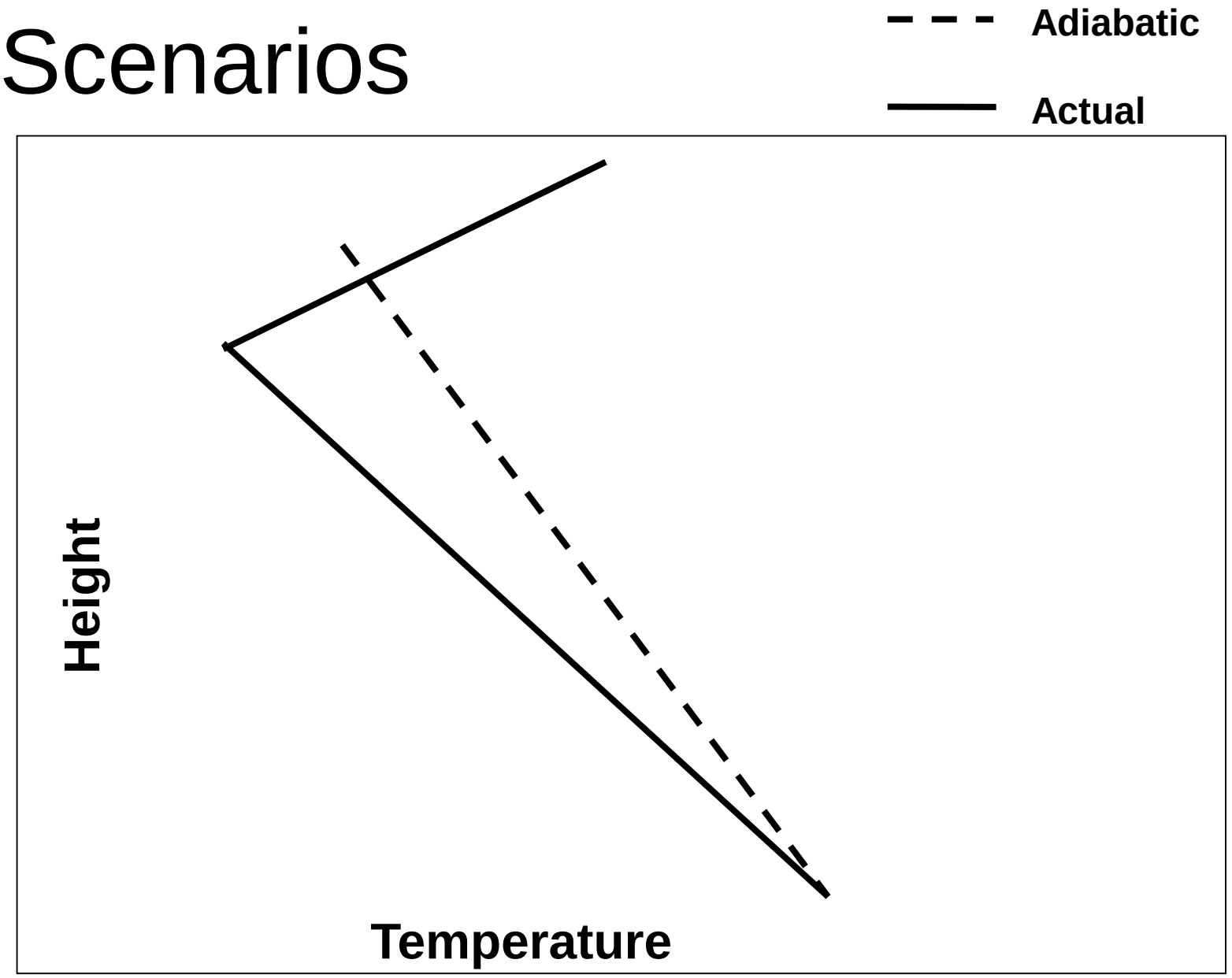
Change of (Relative Slope) Environmental Lapse Rate

(Adiabatic lapse rate slope does not change)

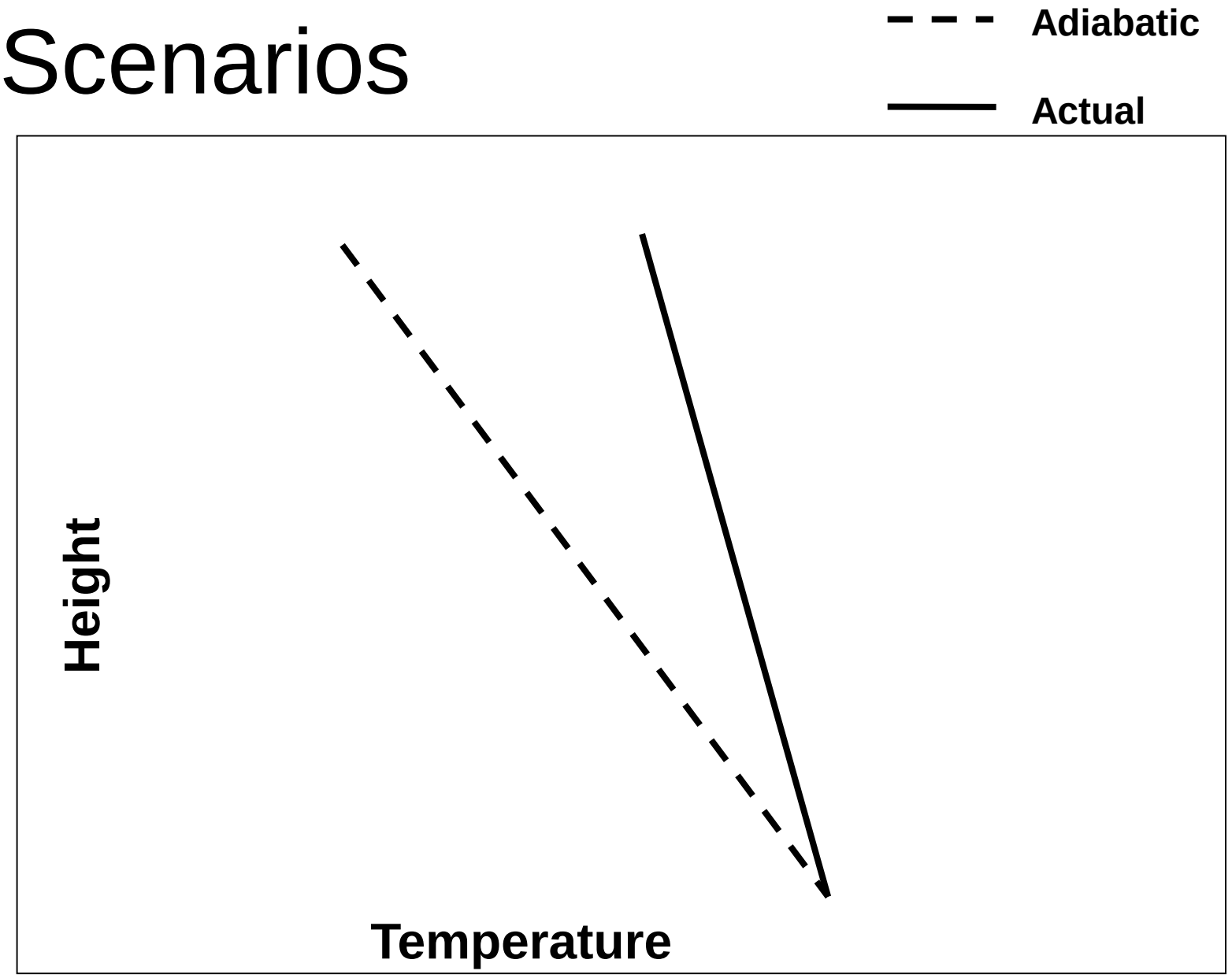

1100 m
1000 m (say)
19 °C Air Parcel at 1100 m
20 °C Air Parcel
ADIABATIC (1°C/100 m)
ACTUAL
19°C
19.5 °C
20 °C


Adiabatic
Actual
WIND

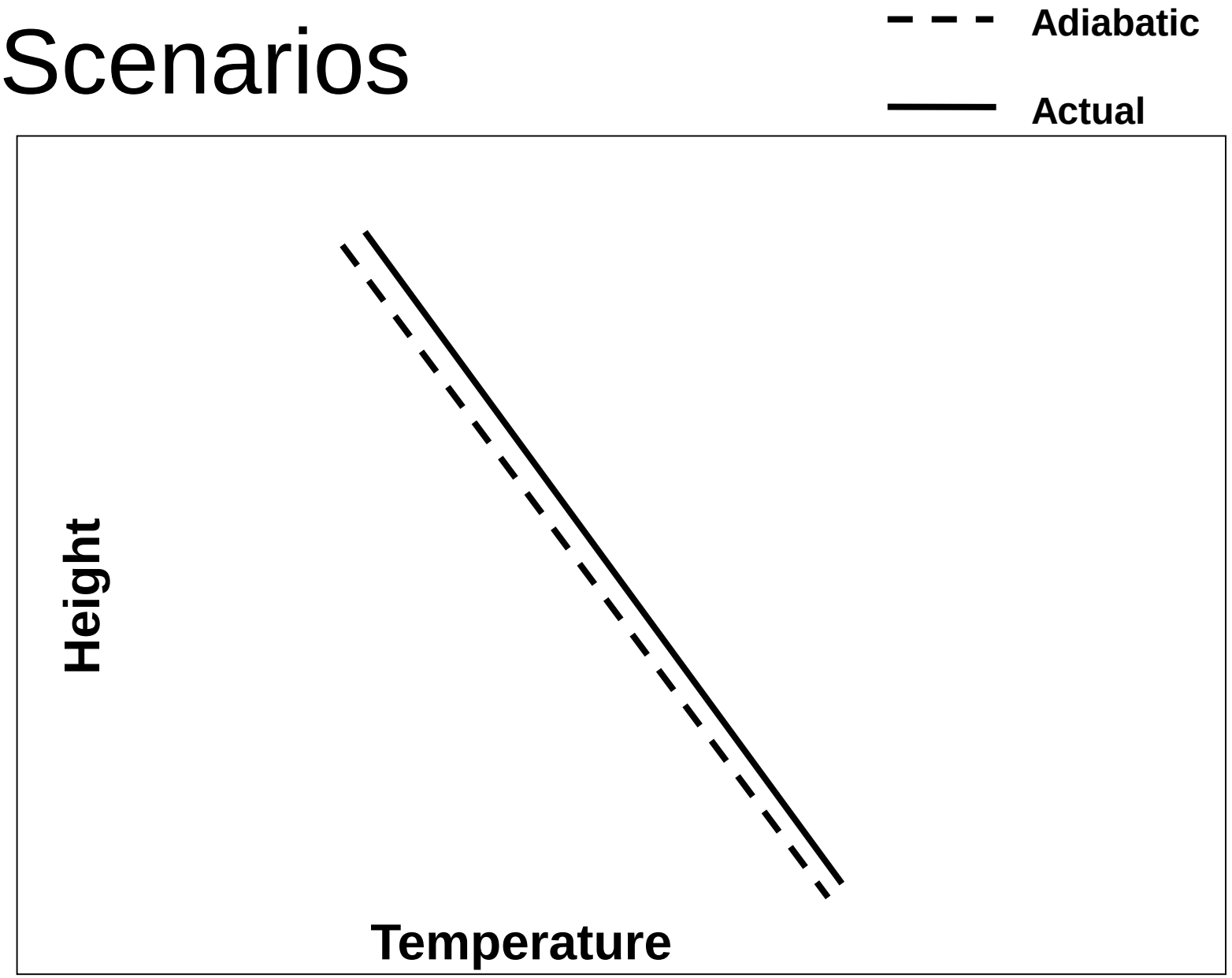
Scenarios



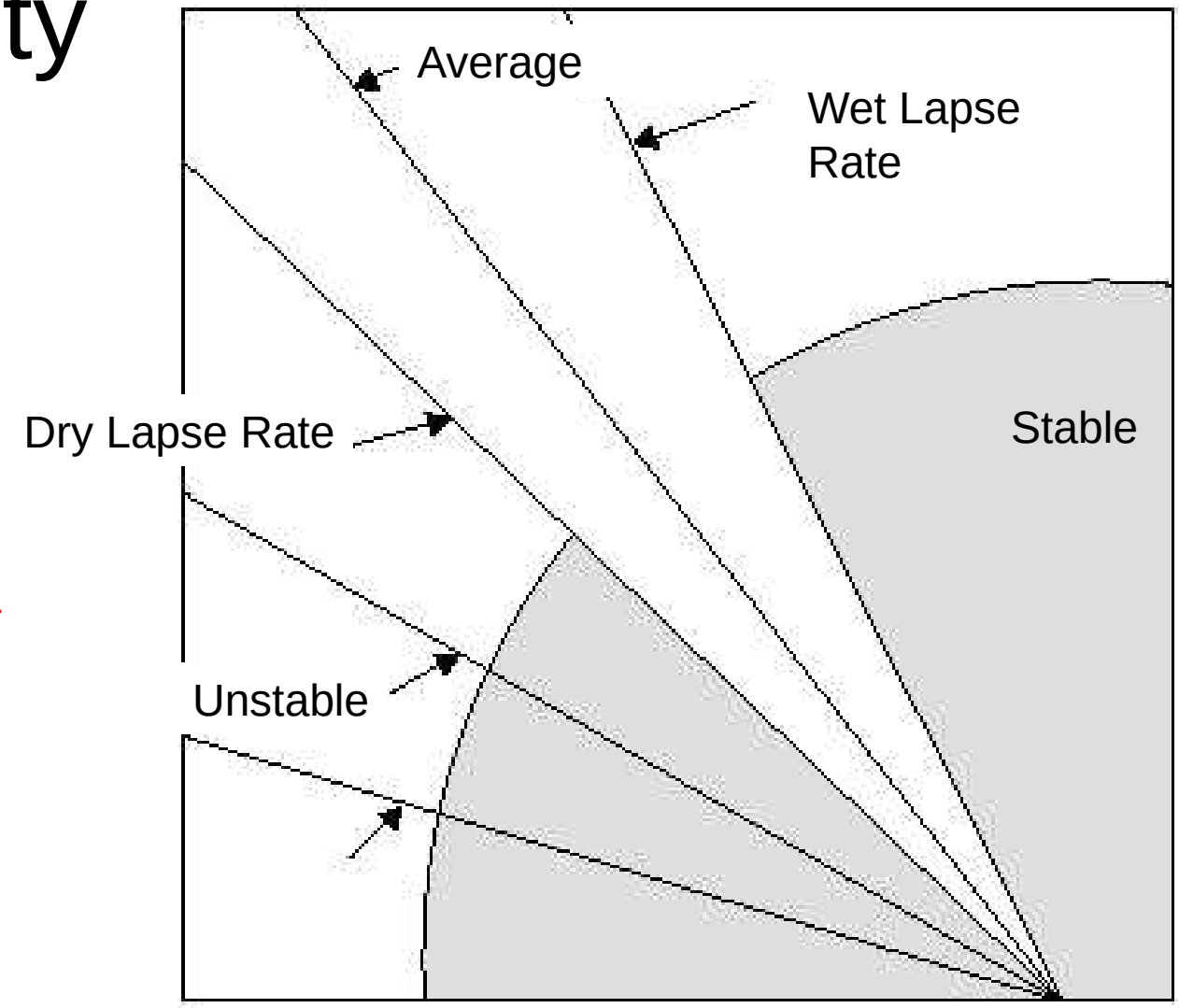
Scenarios



Scenarios

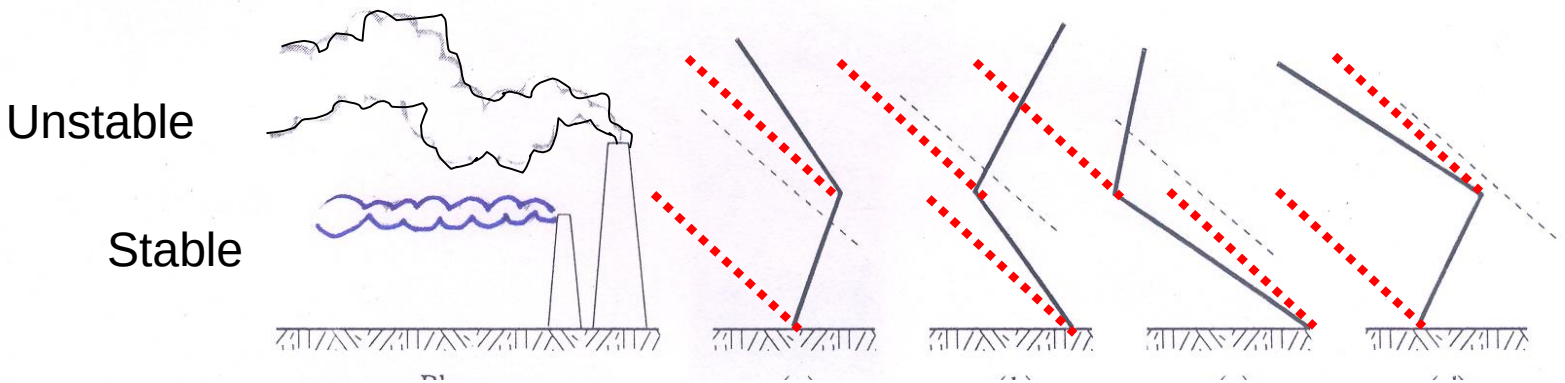


Stability



http://www.tpub.com/content/aerographer/14312/css/14312_47.htm

Exercise : Match the Likely Temperature Profile



(Adapted from Masters, 1997)

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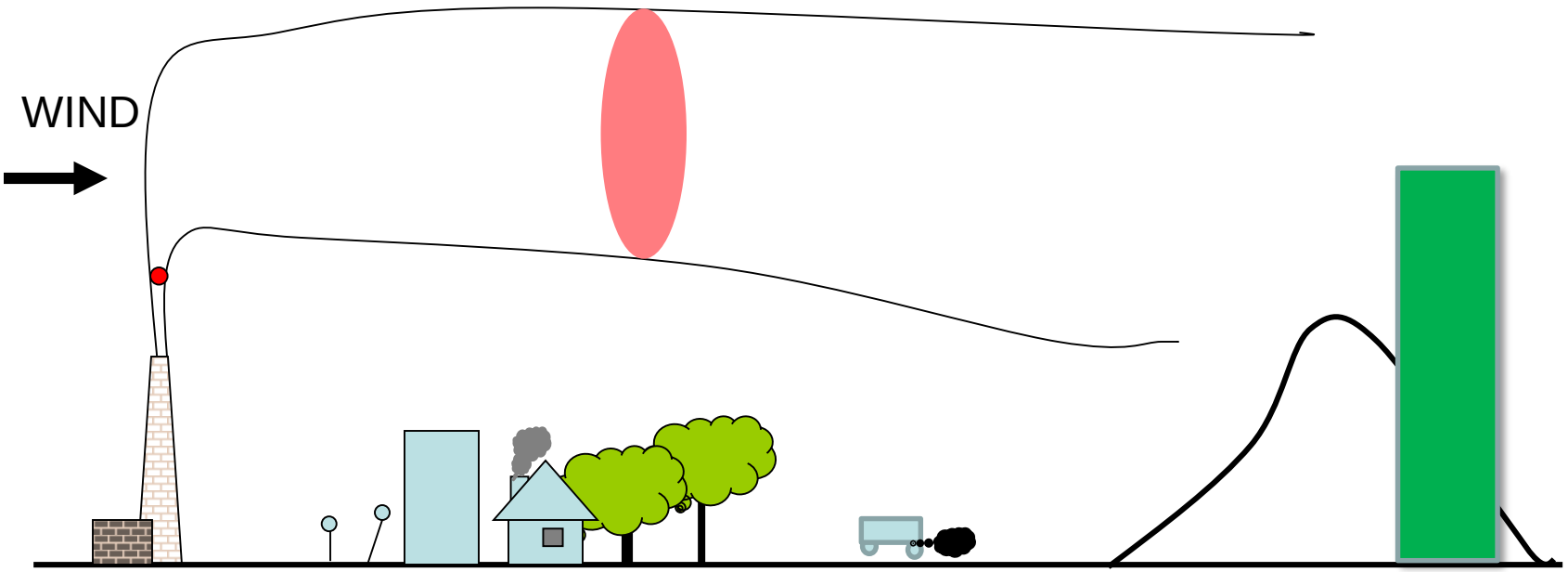
Dispersion – Gaussian Plume



Review

Dispersion and Mixing Influenced by :

- Wind
  - Speed
  - Direction
  - Wind Rose
- Temperature Lapse Rates
  - Dry adiabatic
  - Wet Adiabatic
  - Stability

Why are we doing all of this ?

- **If you want to set up a new industry, it implies adding a new source of pollutant(s)**
- **This source is PERMITTED to emit after it has applied the Best Available Control Technology (BACT) on their processes**
- **AFTER leaving the chimney, the concentrations on ground is determined by the meteorology**

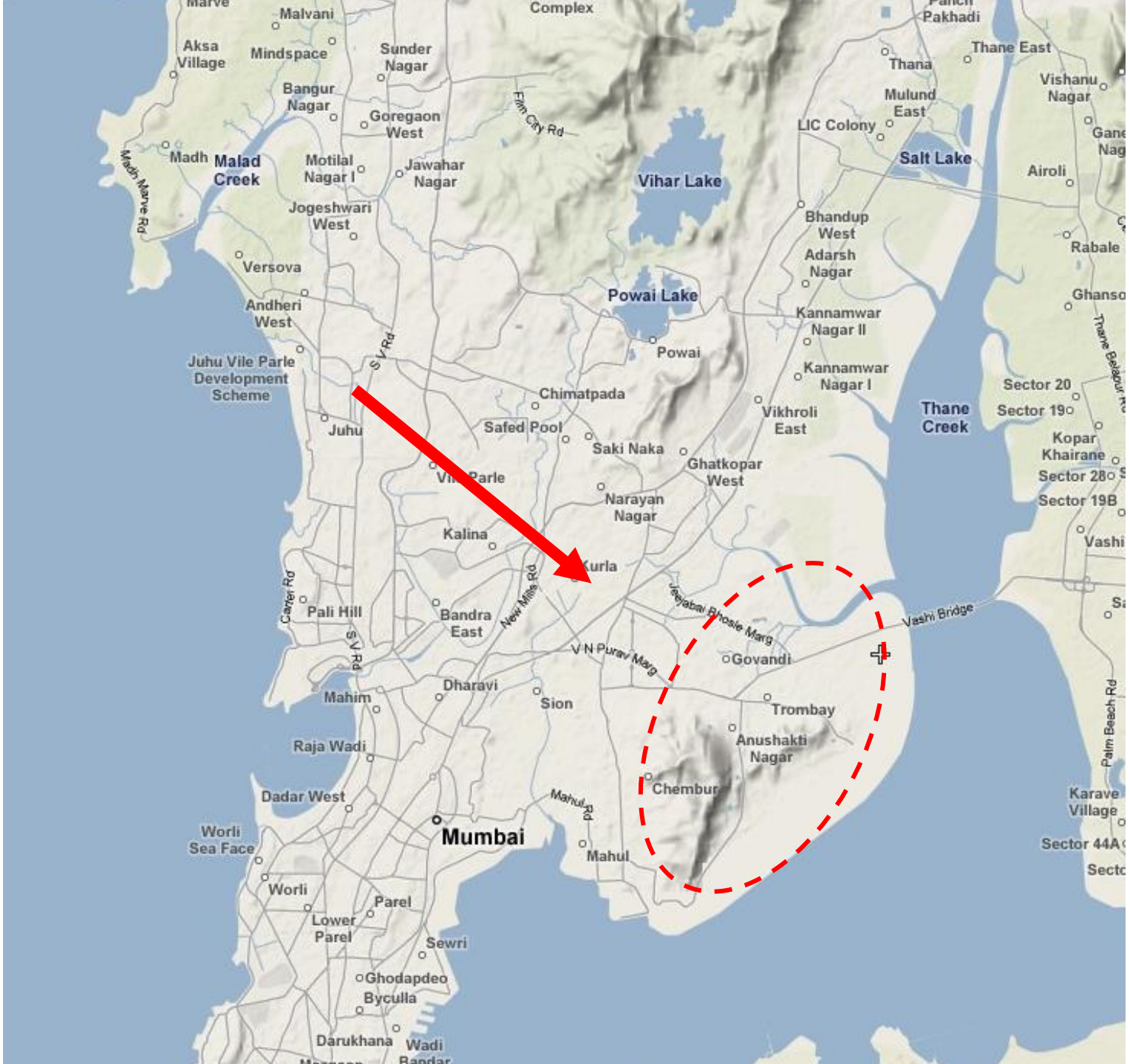
Why are we doing all of this ?

- **So,**
  - **If you want to know WHERE to put the new industry**
  - **If you want to know the pollution levels under the worst case scenario of STABLE conditions and low wind speeds**
  - **If you want to know what height does the chimney need to be**
  - **QUANTIFICATION of horizontal movement and vertical mixing becomes essential**

Why are we doing all of this ?

- **Gaussian Plume (Dispersion) Model (GPM) is used to estimate the Ground Level Concentrations for pollutants coming from a Chimney**

- **INPUTS to GPM**
  - **Height of chimney and Source Strength**
  - **Wind Rose Data**
  - **Atmospheric Stability of the region**

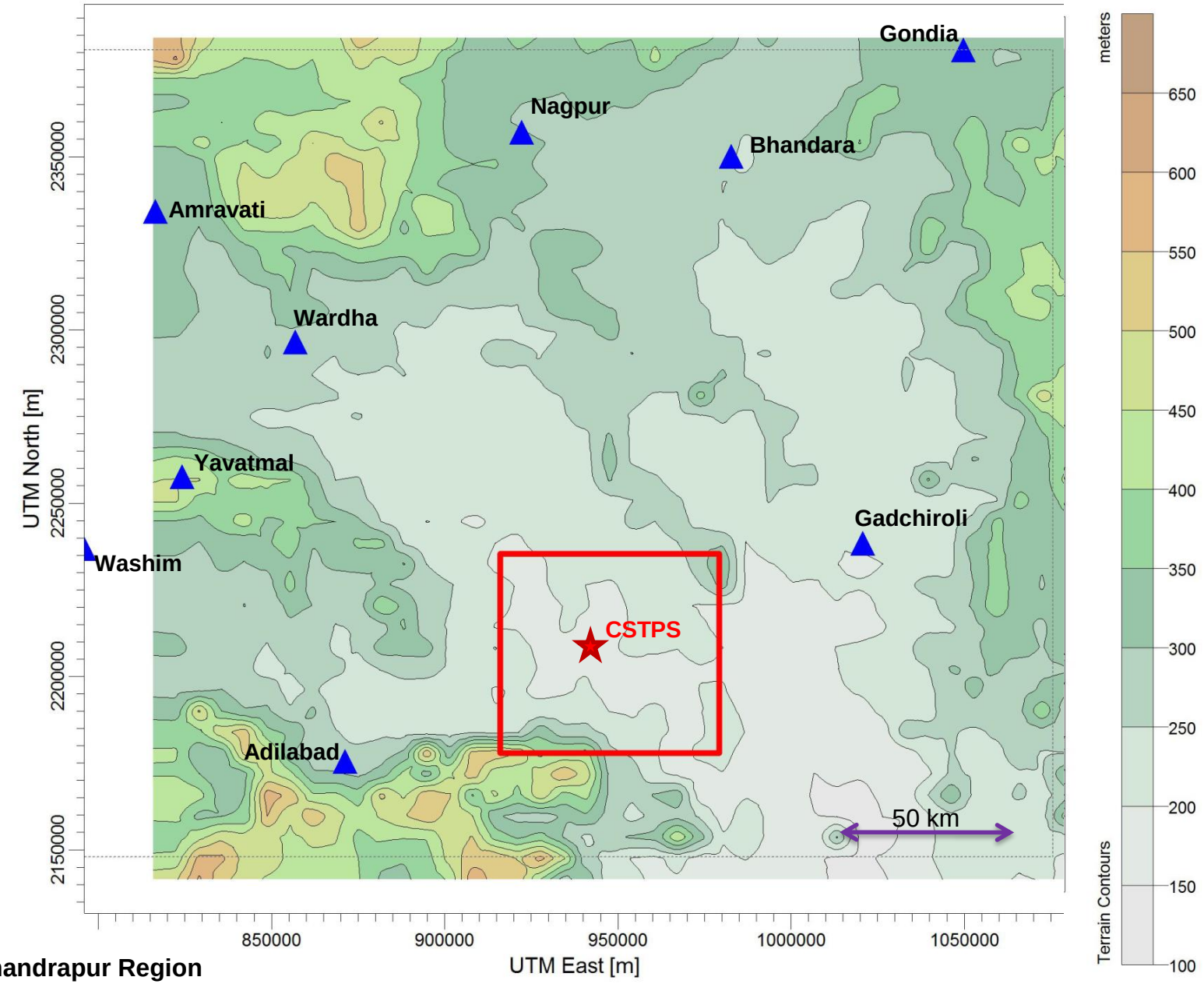

Malvani
Aksa Village
Mindspace
Sunder Nagar
Bangur Nagar
Goregaon West
Fifth City Rd
Madh
Malad Creek
Madh Marve Rd
Motilal Nagar I
Jawahar Nagar
Jogeshwari West
Versova
Andheri West
Juhu Vile Parle Development Scheme
S V Rd
Juhu
Complex
Vihar Lake
Powai Lake
Powai
Chimatpada
Safed Pool
Saki Naka
Kalina
Kurla
Narayan Nagar
Ghatkopar West
Vikhroli East
Thane Creek
Thana
Thane East
Mulund East
LIC Colony
Salt Lake
Vishanu Nagar
Airoli
Bhandup West
Adarsh Nagar
Kannamwar Nagar II
Kannamwar Nagar I
Rabale
Ghanso
Sector 20
Sector 19
Kopar Khairane
Sector 28
Sector 19B
Vashi
Vashi Bridge
Palm Beach Rd
Karave Village
Sector 44A
Pali Hill
Bandra East
New Mills Rd
Carter Rd
Jeejabai Bhosle Marg
V N Purav Marg
Govandi
Dharavi
Sion
Mahim
Trombay
Anushakti Nagar
Chembur
Raja Wadi
Dadar West
Mahul Rd
Mumbai
Mahul
Worli Sea Face
Worli
Parel
Lower Parel
Sewri
Ghodapdeo
Byculla
Darukhana
Wadi Bandar

Fun Exercise

- **Find the Wind Rose for**
  - **Mumbai**
  - **Your home city**
  - **Does IMD have a Met Station near your City ?**

Case Study
for
Wind Roses

Terrain Map of Chandrapur with 9 neighboring IMD stations

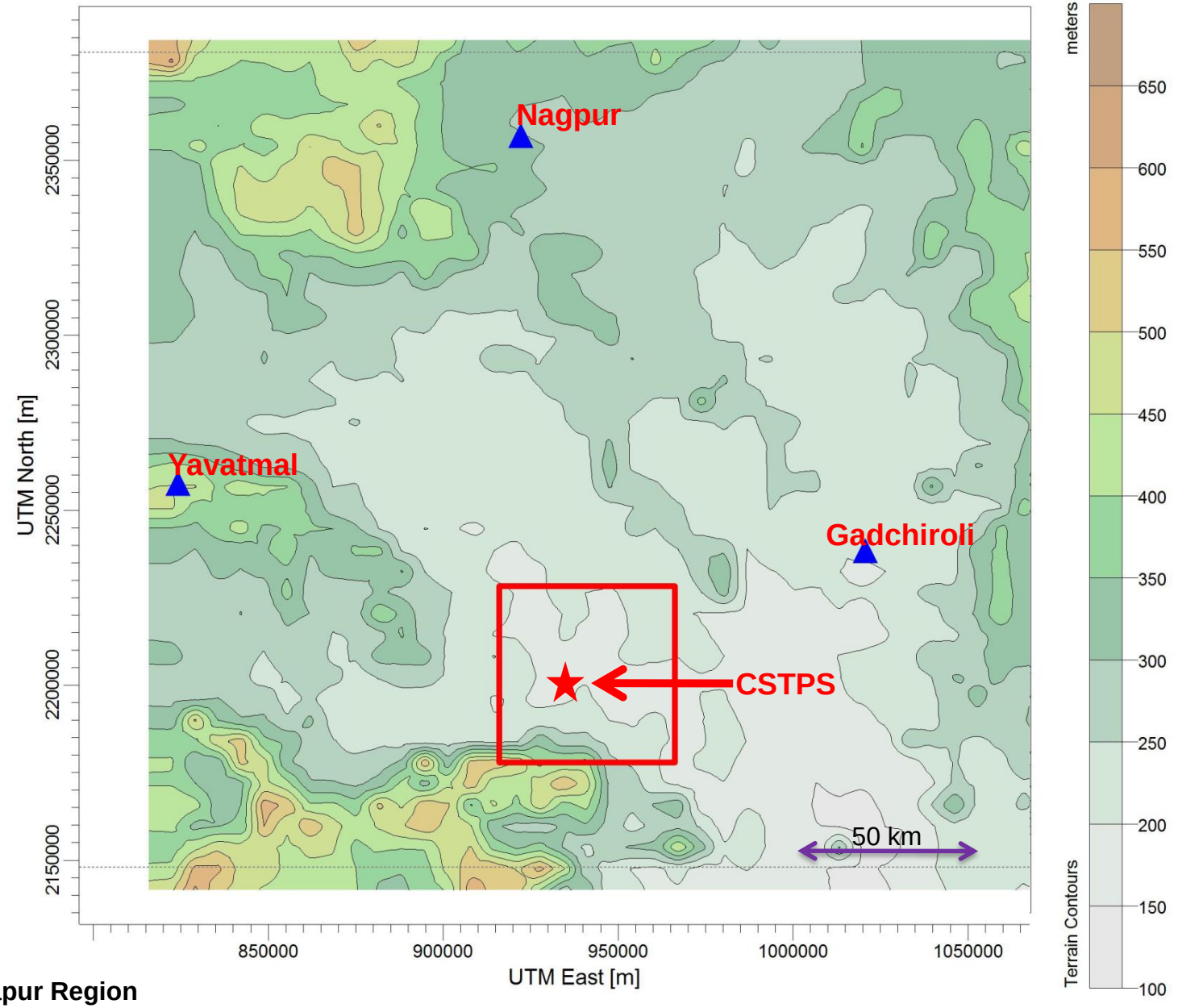


Chandrapur Region

- Three IMD stations were selected to eliminate possible influence of terrain on local scale wind patterns :

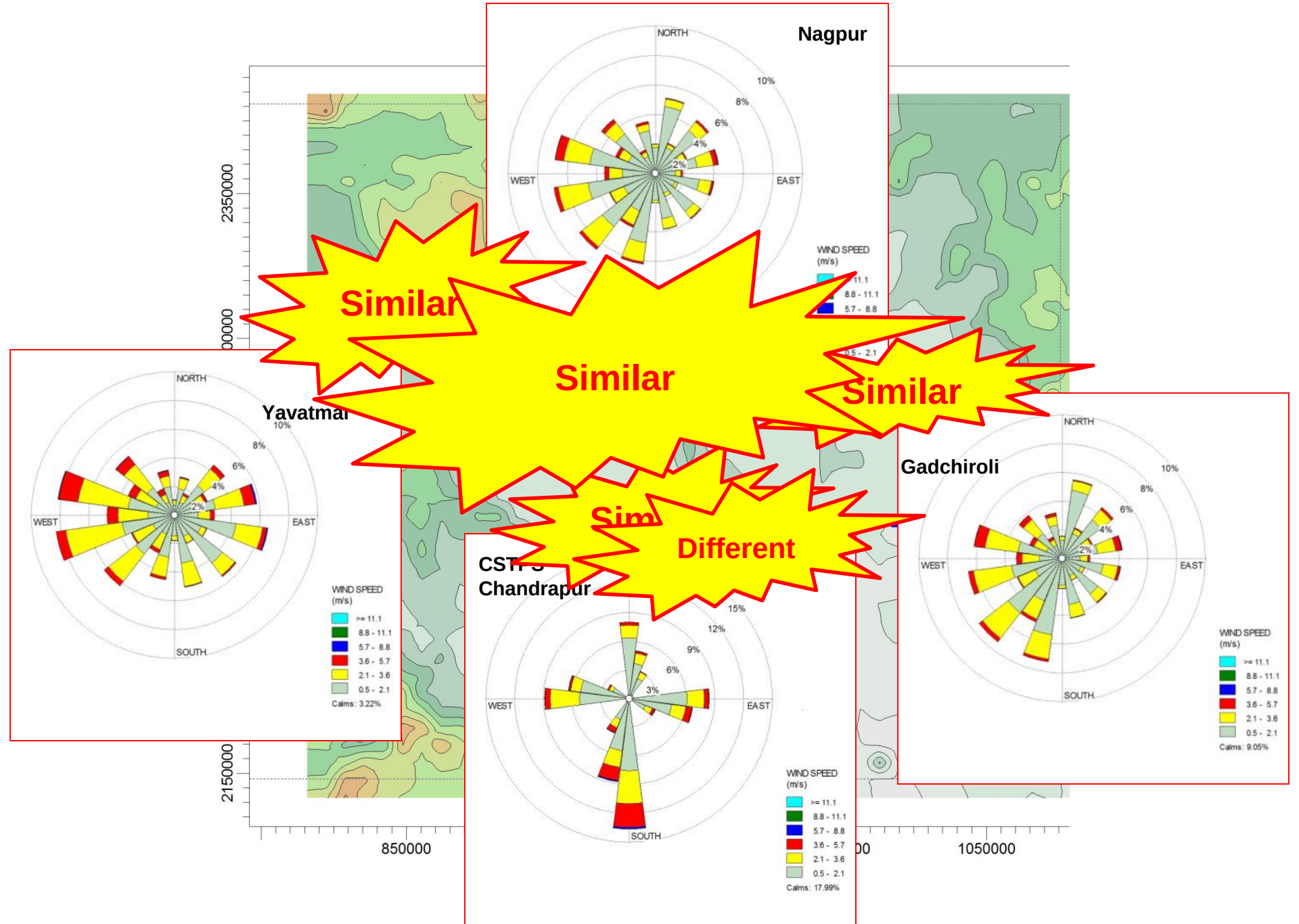
1. Nagpur
2. Gadchiroli
3. Yavatmal

Location of CSTPS met station with the 3 selected IMD stations



Chandrapur Region

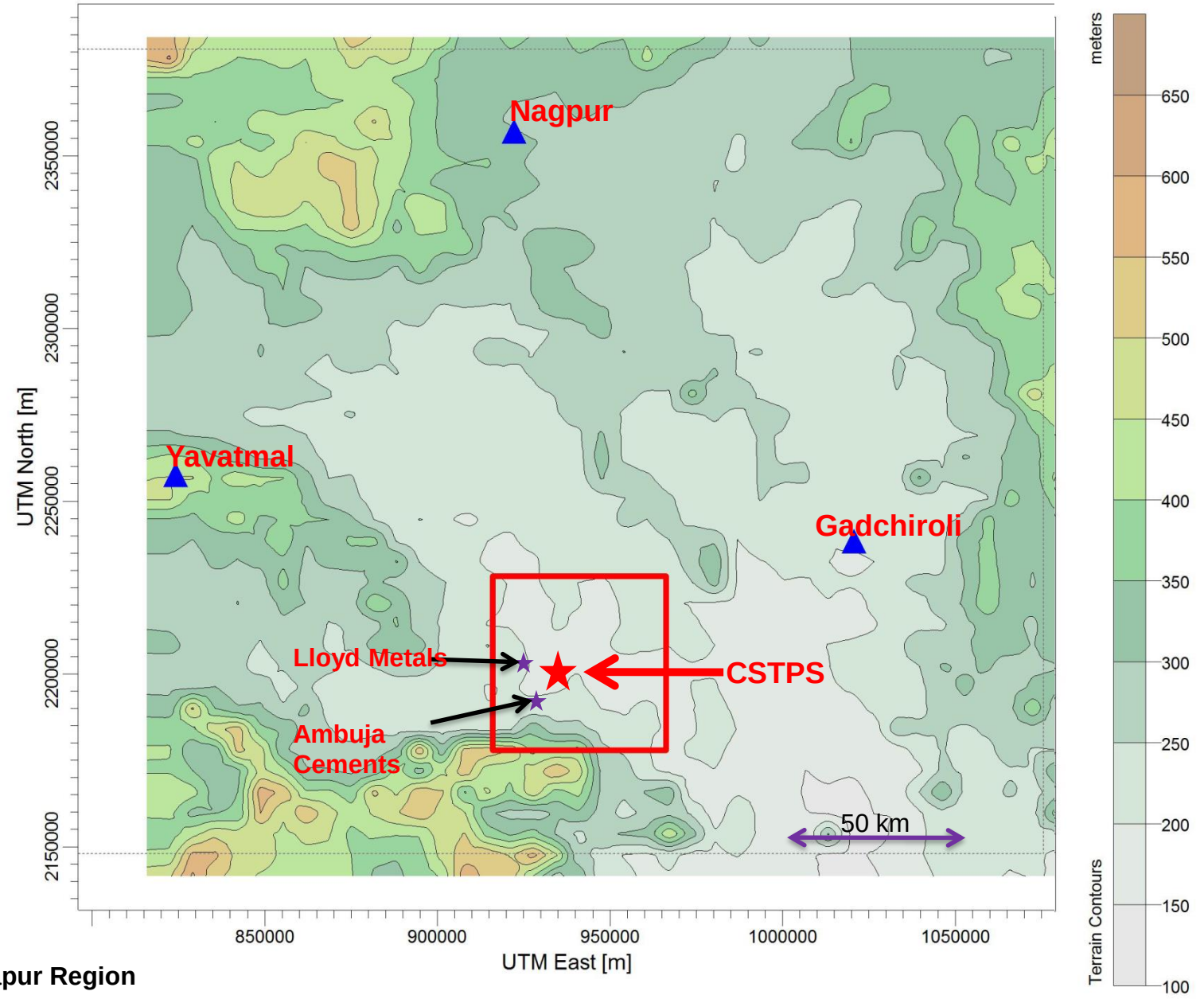
Wind conditions at 3 IMD Stations and CSTPS in Chandrapur



Conclusions

- Wind conditions are similar at the three IMD locations.
- CSTPS station by comparison is NOT similar.
- Therefore, CSTPS Met data needs to be verified with other Local Met Station Data
  - Ambuja Cement
  - Lloyd Metals

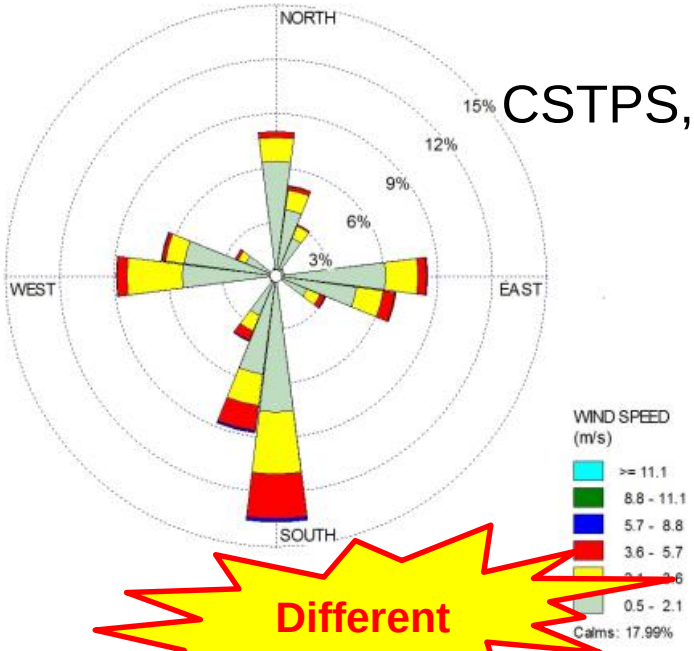
Location of CSTPS met station with other two local met stations from Lloyd Metals and Ambuja Cements



Chandrapur Region

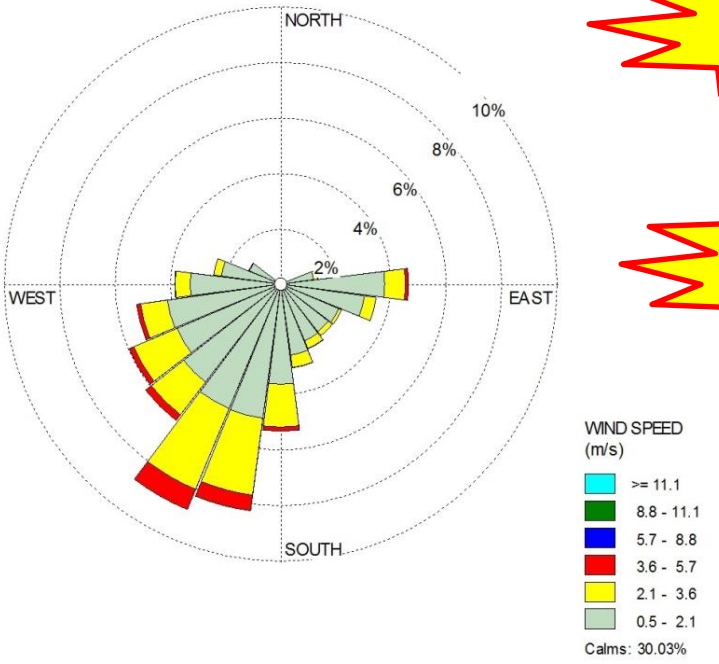
Wind condition at CSTPS for 2011, and M/s Lloyd Metals Ltd., M/s Ambuja Cements in Chandrapur for 2013

CSTPS,2011



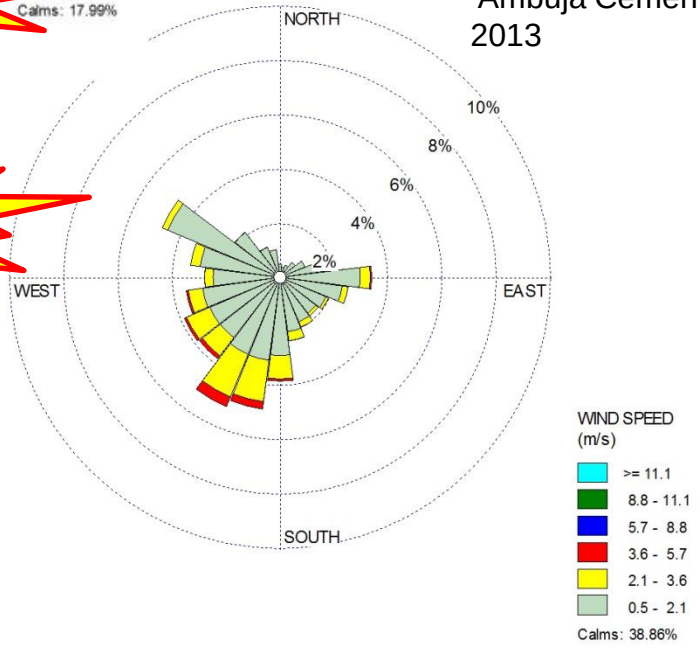
Different

Lloyd Metals, 2013



Similar

Ambuja Cements 2013



Models are only as Good as the Input Data

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NAAQS

National Ambient Air Quality Standards

- CPCB Website :

cpcb.nic.in/air-quality-standard/

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5	Ozone (O_3), µg/m^3	8 hours**	100	100	1. UV photometric 2. Chemiluminescence 3. Chemical Method
		1 hours **	180	180	
6	Lead (Pb), µg/m^3	Annual *	0.50	0.50	1. AAS/ICP Method after sampling using EPM 2000 or equivalent filter paper 2. ED-XRF using Teflon filter
		24 Hour**	1.0	1.0	
7	Carbon Monoxide (CO), mg/m^3	8 Hours **	02	02	Non dispersive Infra Red (NDIR) Spectroscopy
		1 Hour**	04	04	
8	Ammonia (NH_3), µg/m^3	Annual*	100	100	1. Chemiluminescence 2. Indophernol blue method
		24 Hour**	400	400	

8	Ammonia (NH_3), $\mu g/m^3$	Annual*	100	100	1. Chemiluminescence 2. Indophernol blue method
		24 Hour**	400	400	
9	Benzene (C_6H_6) , $\mu g/m^3$	Annual *	05	05	1. Gas chromatography based continuous analyzer 2. Adsorption and Desorption followed by GC analysis
10	Benzo(a)Pyrene (BaP)-particulate phase only, ng/m^3	Annual*	01	01	Solvent extraction followed by HPLC/GC analysis
11	Arsenic (As), ng/m^3	Annual*	06	06	AAS/ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni), ng/m^3	Annual*	20	20	AAS/ICP method after sampling on EPM 2000 or equivalent filter paper

** Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform interval.** 24 hourly 08 hourly or 01 hourly monitored values, as applicable shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.*

NOTE: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

Nature of Air Pollutants

1. Gaseous (SOx, NOx, CO…)

2. Particulate Matter (PM)

Gaseous Pollutants

- Similar sized molecules
- Behaviour
  - Physics : Same
  - Chemistry : Different
    - EXAMPLES
      - Solubility
      - Toxicity
      - Ozone Depletion Potential

Particulate Pollutants

- Behaviour
  - Physics : NOT the same
    - Size
    - Morphology
  - Chemistry :
    - Inert (Dust, Sand, No more reactive)
    - Smoke (Toxic, intoxicating)

Air Pollution

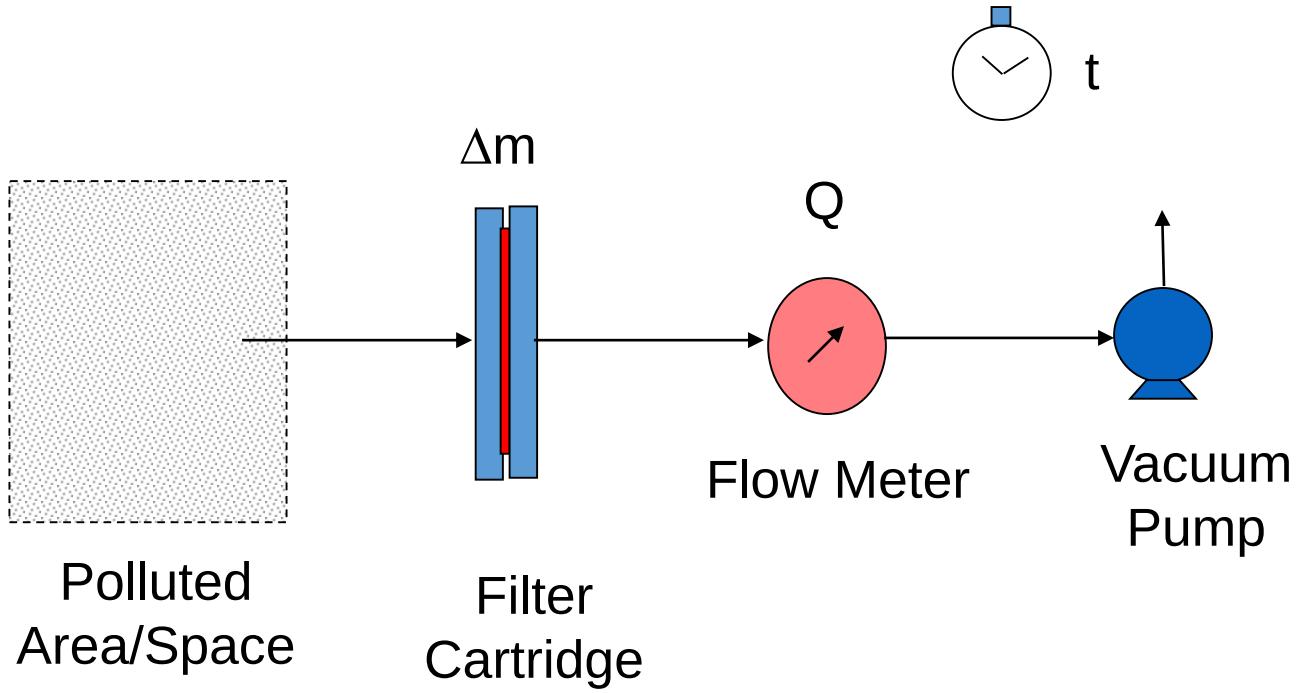
- Concentration
  - mass of pollutant / volume of air
  - number of particles / volume of air
  - opacity

- Duration – hours to days to years

- Criteria Pollutants
  - Primary
    - SOx
    - NOx
    - CO
    - PM-10, PM-2.5
    - …
  - Secondary
    - Ozone

- How do you measure the mass concentration of PM ?

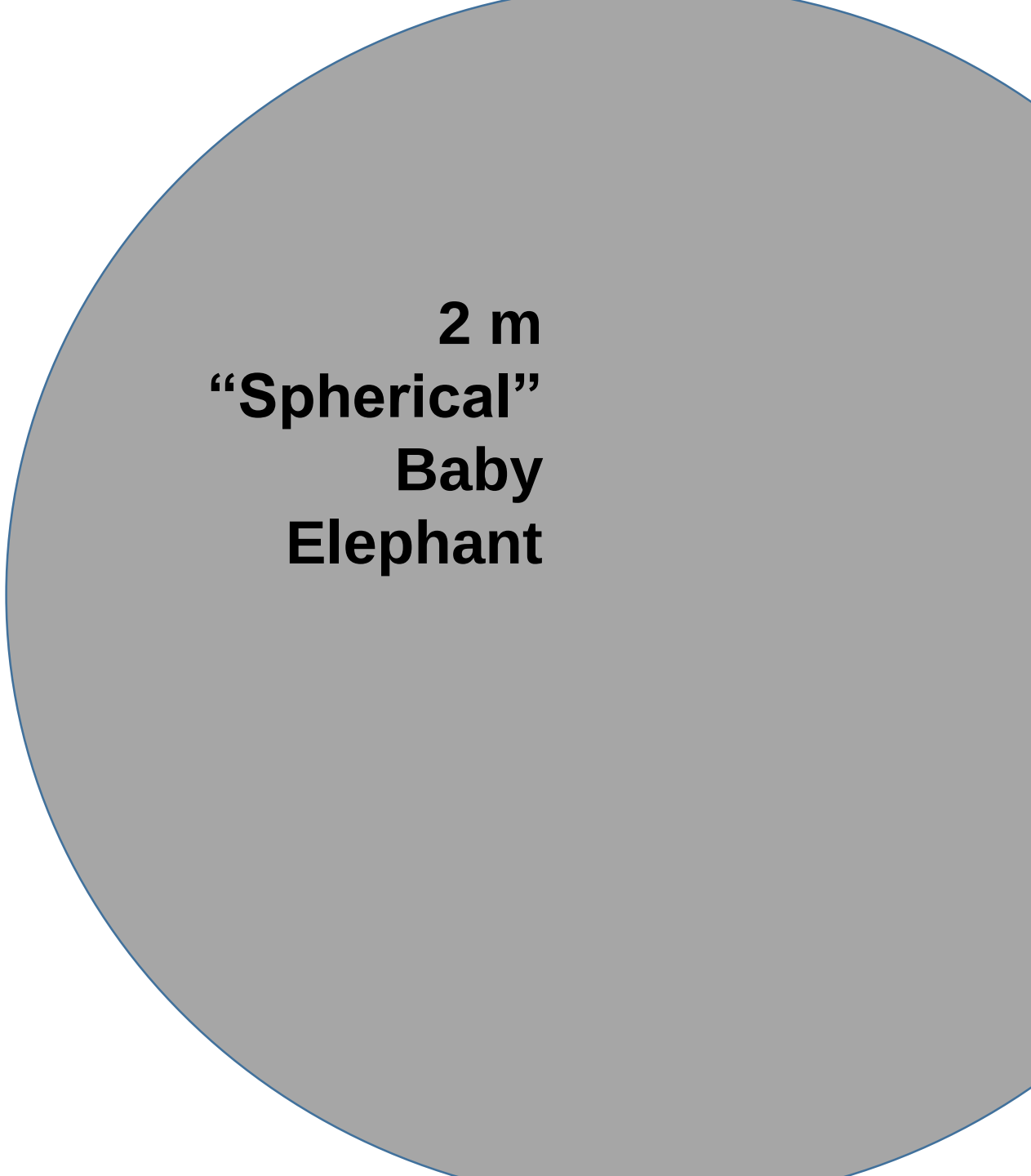
$$C_{TSP} = \Delta m/Qt$$



Perception

(Scales)

2 mm
Ant



3 Orders of Magnitude

Ants and Elephants

- Ant ~2mm
- “Spherical” Baby Elephant ~2 m
    - Order of magnitude 3
- Nitrogen Molecule ~0.3 nm
- Respirable particle ~300 nm
    - Order of magnitude 3

Particles in Air

are like

Elephants

suspended

in an

Ocean

of

Ants

(Gas Molecules)

Ants and Elephants

- All the well established physics of “ants” (IDEAL GAS) is not applicable to the “elephants”
- All the MAGIC of “nano” is in this “new” world of “elephants”
- Ability to understand this range of sizes has become possible due to development of instrumentation
- Last 4-5 decades have been exciting times for Aerosol Science and Engineering
    - Powder Production – Material science
    - Nano-products
    - Atmospheric Pollutants
    - Medical Sciences

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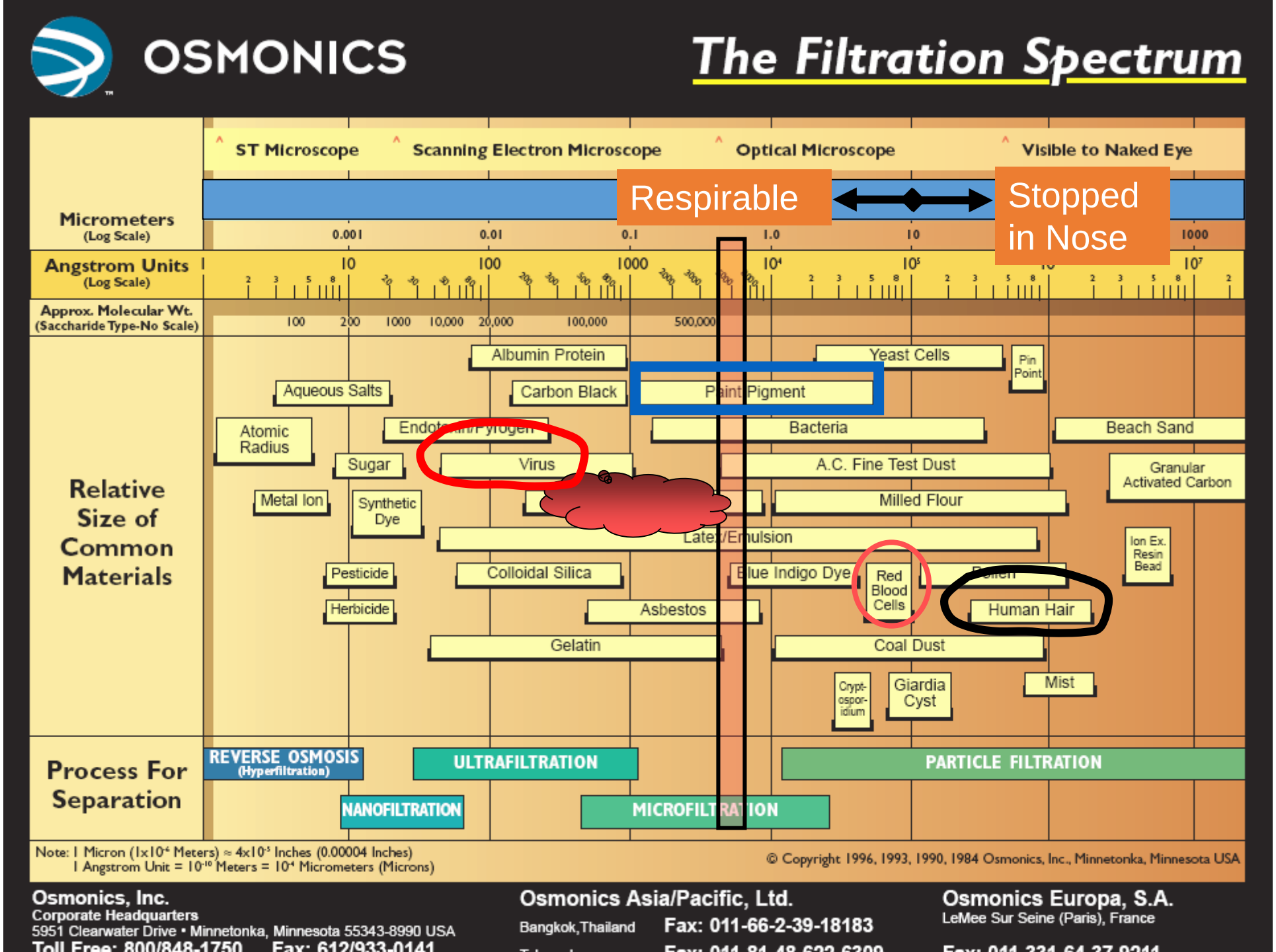
Even within the “Elephants”
There is a range of Sizes

which decide
WHERE
they would deposit in the lungs


OSMONICS
The Filtration Spectrum
ST Microscope
Scanning Electron Microscope
Optical Microscope
Visible to Naked Eye
Respirable
Stopped in Nose
Micrometers (Log Scale)
Angstrom Units (Log Scale)
Approx. Molecular Wt. (Saccharide Type-No Scale)
Relative Size of Common Materials
Albumin Protein
Yeast Cells
Pin Point
Aqueous Salts
Carbon Black
Paint Pigment
Atomic Radius
Bacteria
Beach Sand
Sugar
Virus
A.C. Fine Test Dust
Granular Activated Carbon
Metal Ion
Synthetic Dye
Milled Flour
Ion Ex. Resin Bead
Pesticide
Colloidal Silica
Blue Indigo Dye
Red Blood Cells
Herbicide
Asbestos
Human Hair
Gelatin
Coal Dust
Crypt-ospor-idium
Giardia Cyst
Mist
Process For Separation
REVERSE OSMOSIS (Hyperfiltration)
ULTRAFILTRATION
PARTICLE FILTRATION
NANOFILTRATION
MICROFILTRATION
Note: 1 Micron (1x10⁻⁴ Meters) ≈ 4x10⁻⁵ Inches (0.00004 Inches)
1 Angstrom Unit = 10⁻¹⁰ Meters = 10⁻⁴ Micrometers (Microns)
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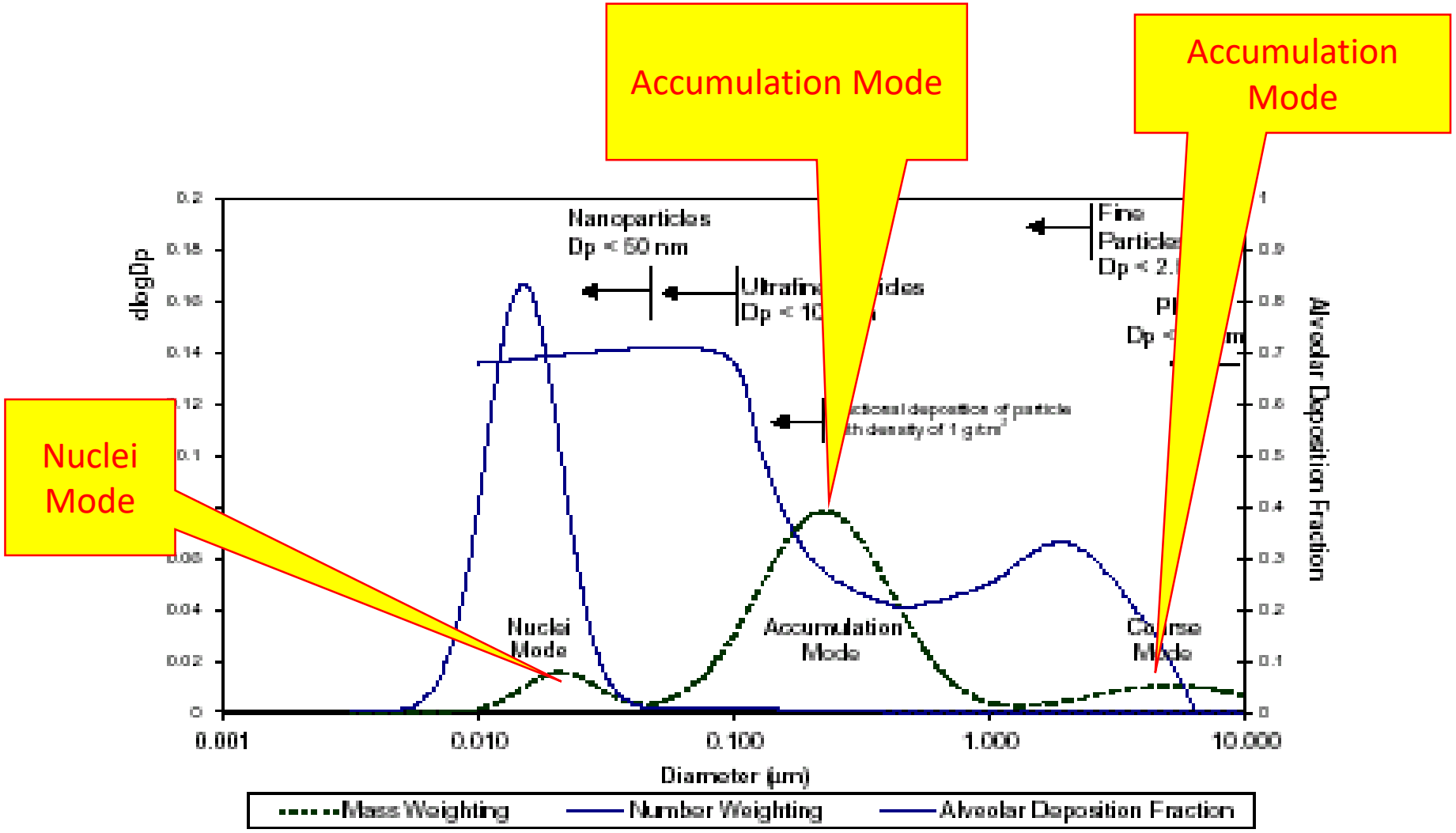
Corporate Headquarters
5951 Clearwater Drive • Minnetonka, Minnesota 55343-8990 USA
Toll Free: 800/848-1750 Fax: 612/933-0141
Osmonics Asia/Pacific, Ltd.
Bangkok,Thailand Fax: 011-66-2-39-18183
Osmonics Europa, S.A.
LeMee Sur Seine (Paris), France



Tri-modal Particle Size Distribution

(Source: Kittelson *et al*. 1999)

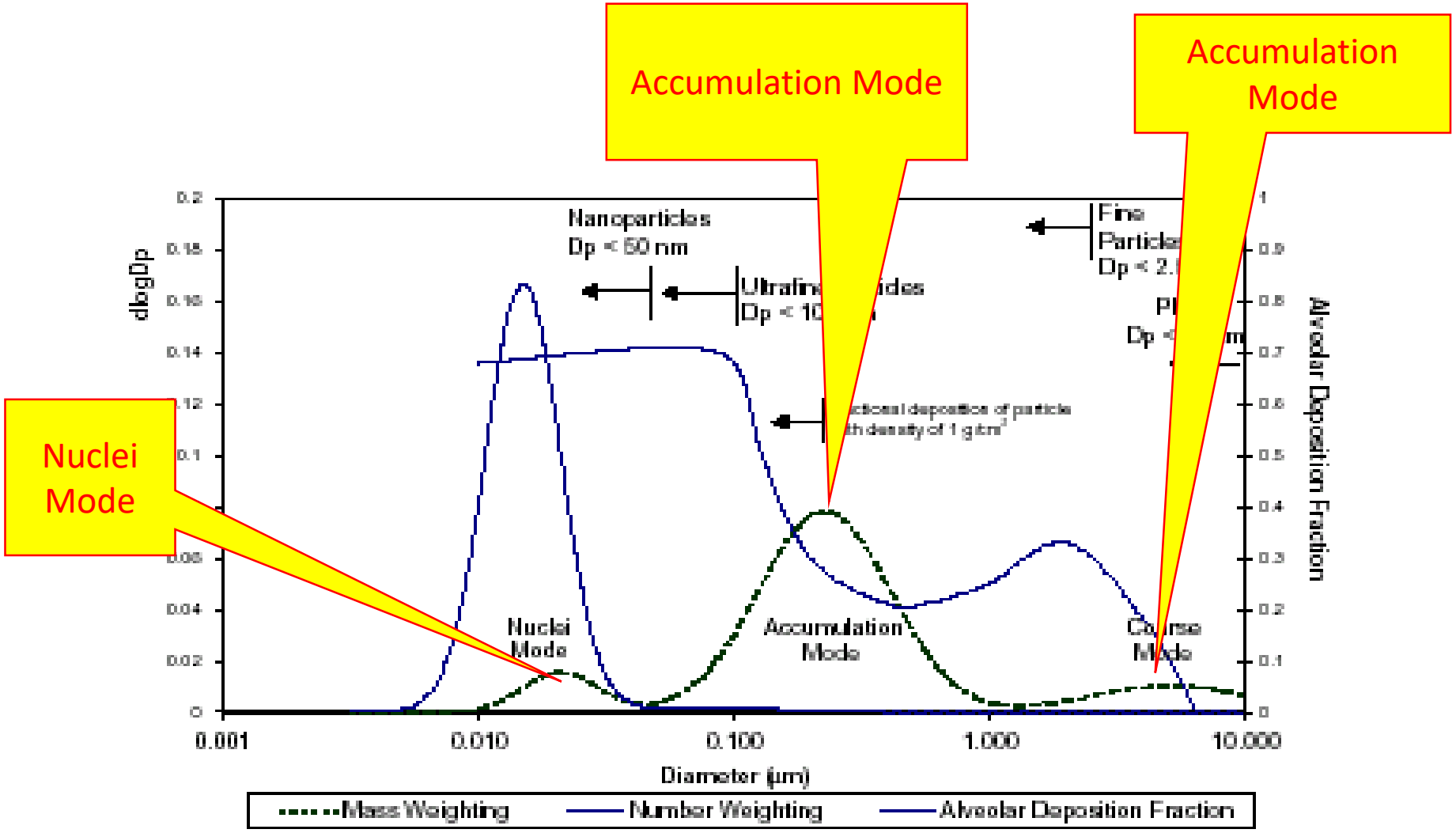
18

Mass - Size

Mass of ONE 1 μm particle

EQUALS

Mass of X 0.1μm particles

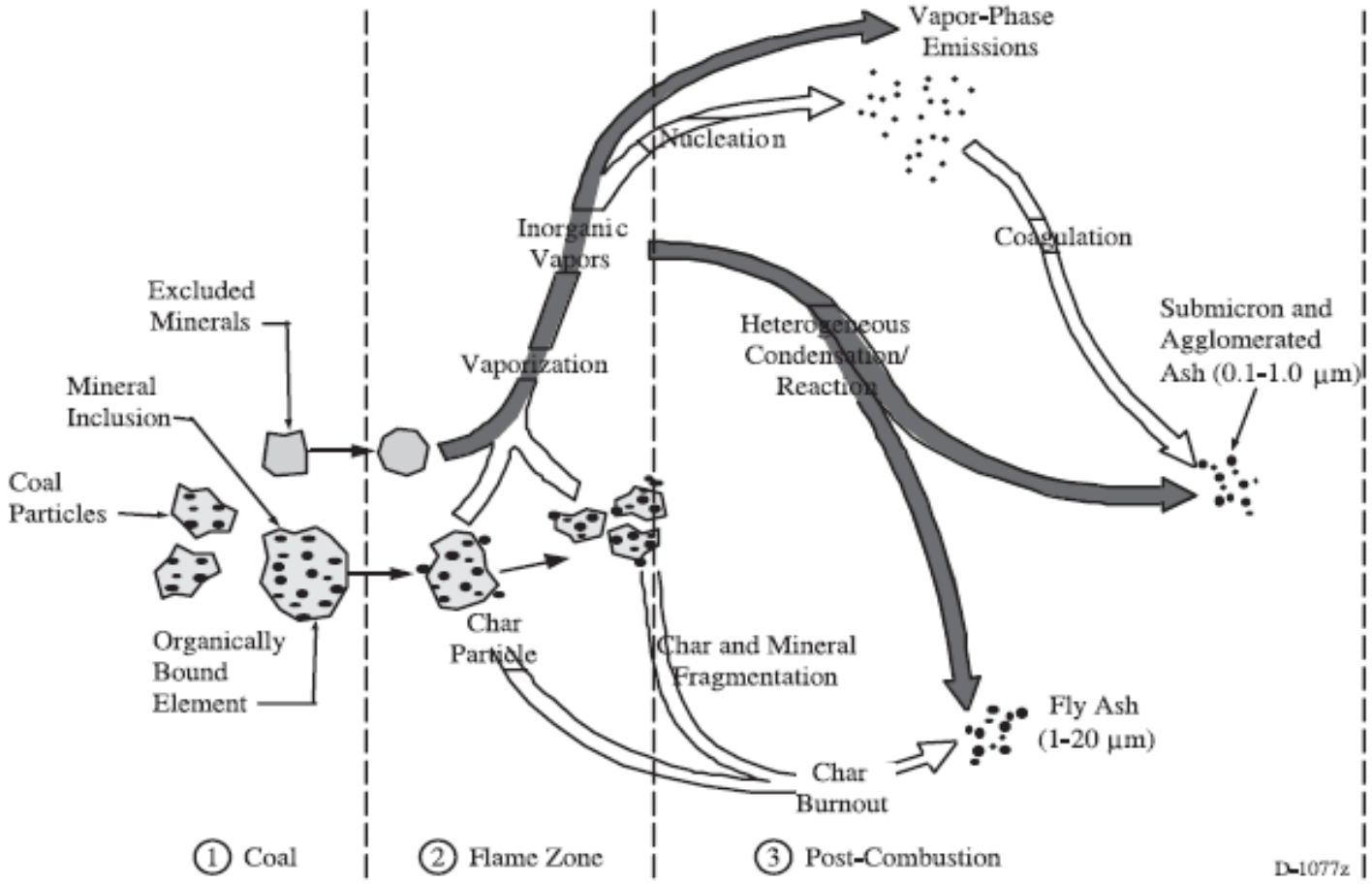


Tri-modal Particle Size Distribution

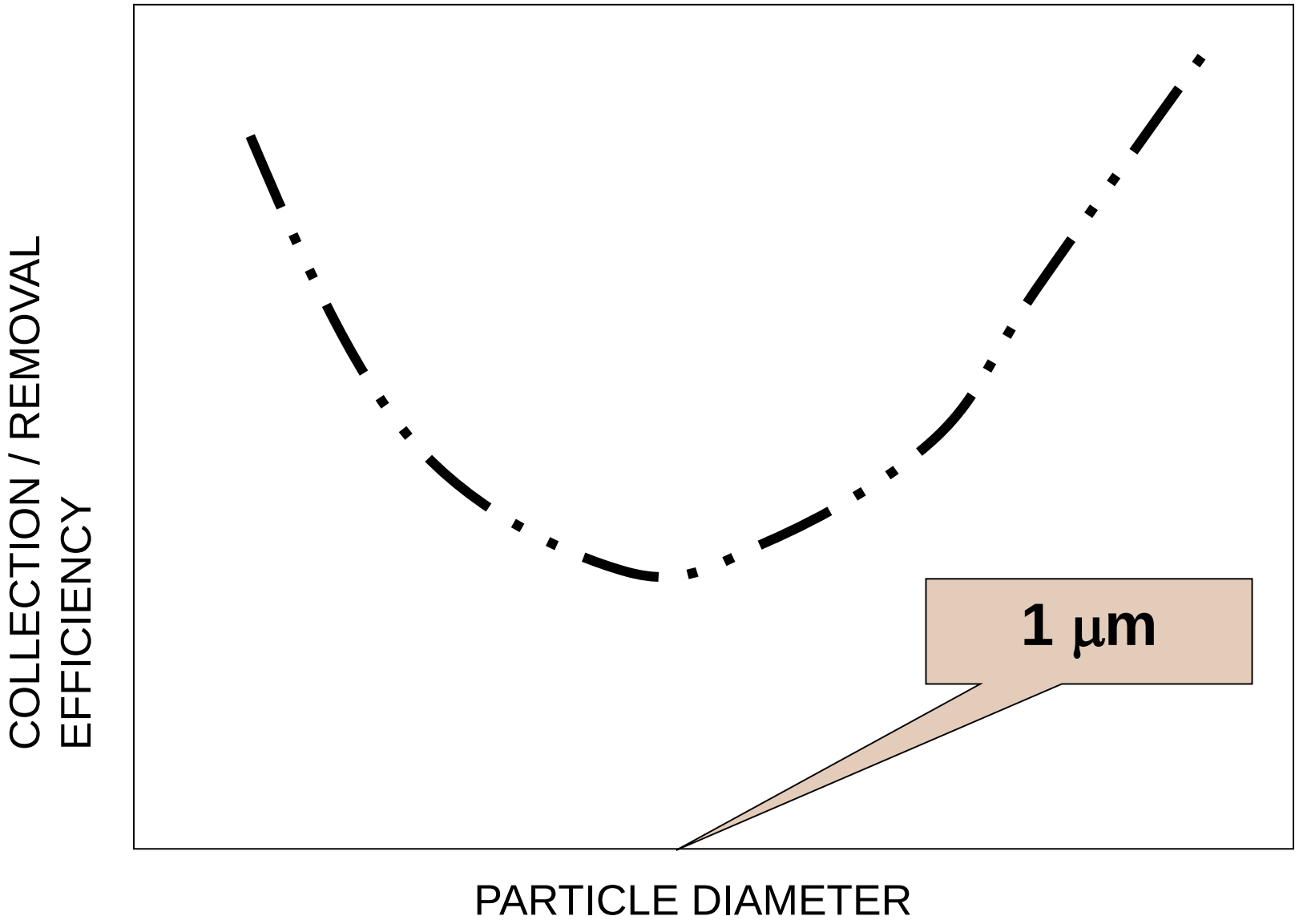
(Source: Kittelson *et al*. 1999)

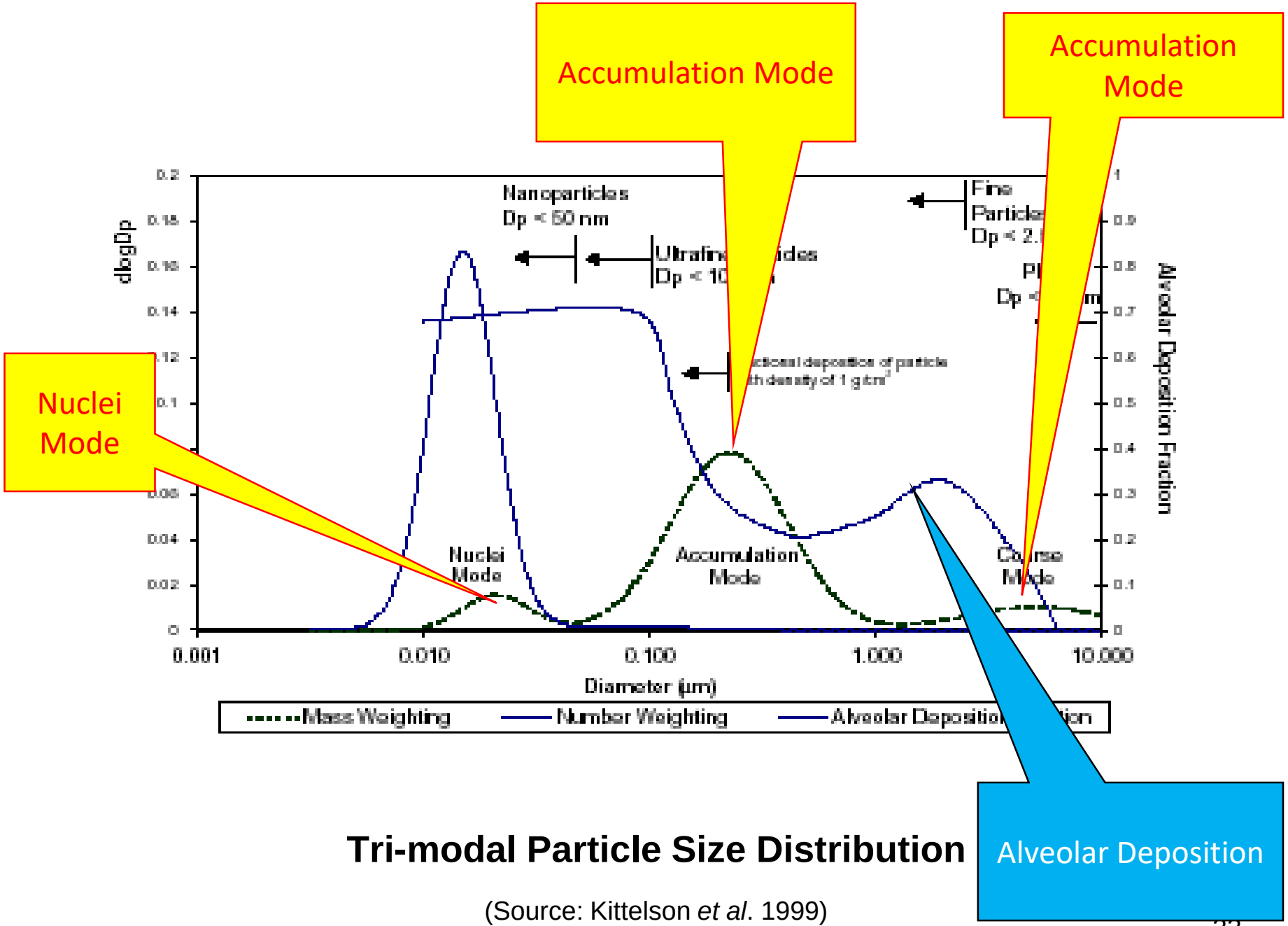
20

Particle Formation in Coal Combustion



Source: Flagan and Seinfeld, 1988

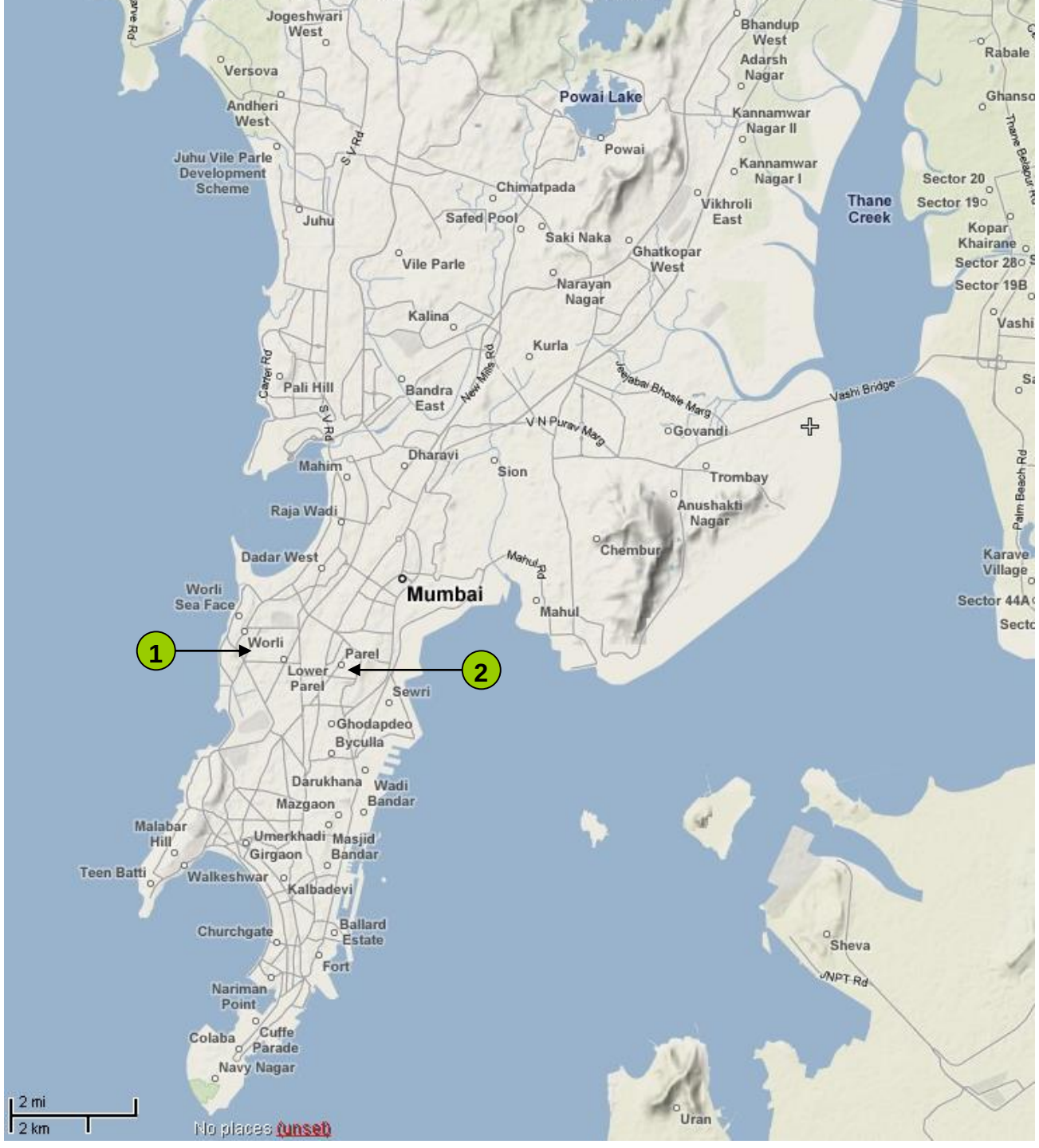

COLLECTION / REMOVAL EFFICIENCY
1 μm
PARTICLE DIAMETER



Tri-modal Particle Size Distribution

(Source: Kittelson *et al*. 1999)

23



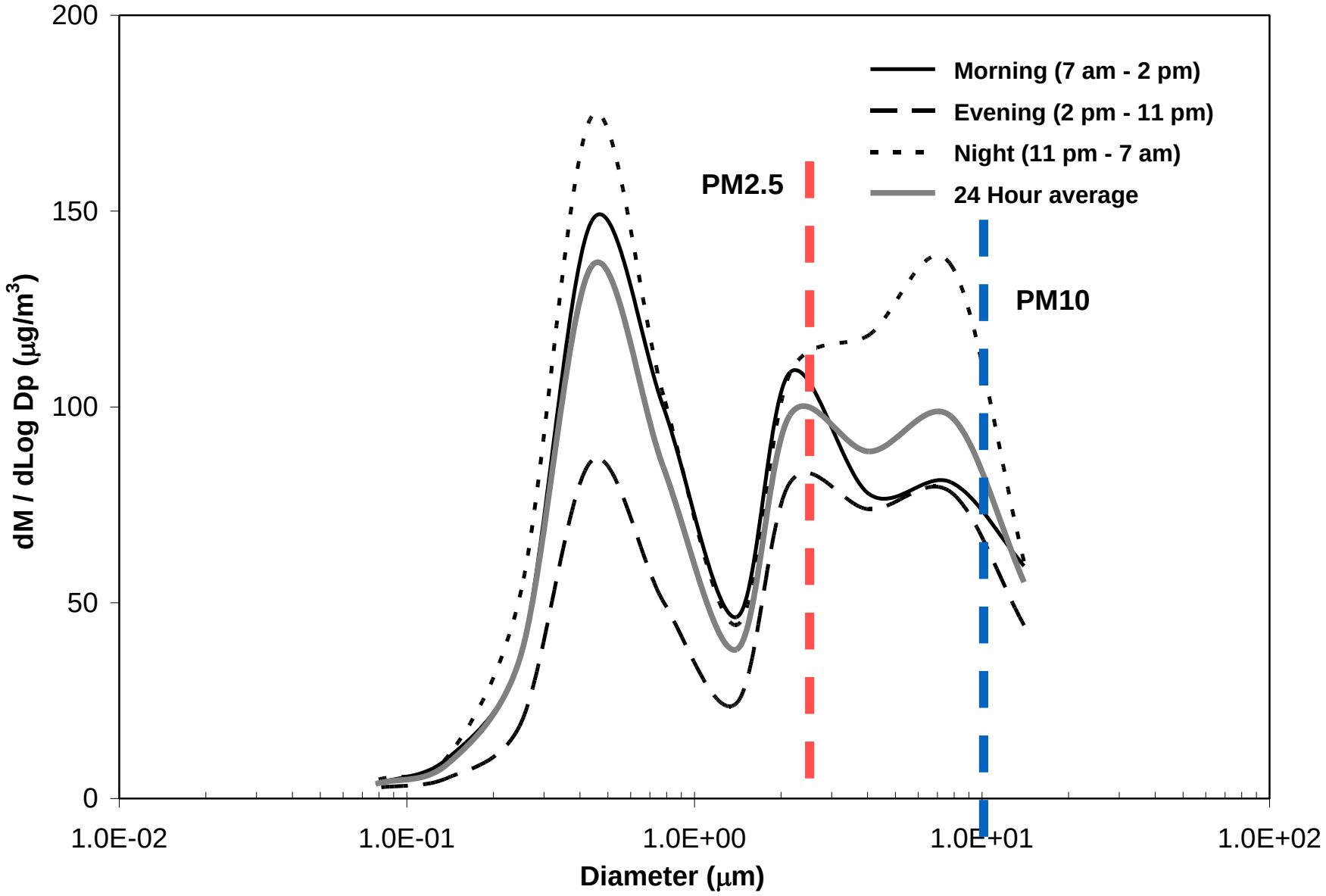
Study Area Mumbai

1. WRL (residential)

2. PAL (industrial)

Map Source:
http://wikimapia.org

Mass Size Distributions Measured for 5 Days in Mumbai (Goyal, 2008)



PM_{10} and $PM_{2.5}$

- PM_{10} is the mass concentration of particulate matter less than **10 μm** expressed as $\mu g/m^3$

- $PM_{2.5}$ is the mass concentration of particulate matter less than **2.5 μm** expressed as $\mu g/m^3$

$PM_{2.5}$ is a subset of PM_{10}

- Plot mass distribution function

- Mode in the <2.5 μm size is sourced by combustion and other anthropogenic activities. More toxic.

- Area under the curve
  - 0 to 10 μm PM_{10}
  - 0 to 2.5 μm $PM_{2.5}$

Ratio of $PM_{2.5}$ to PM_{10}

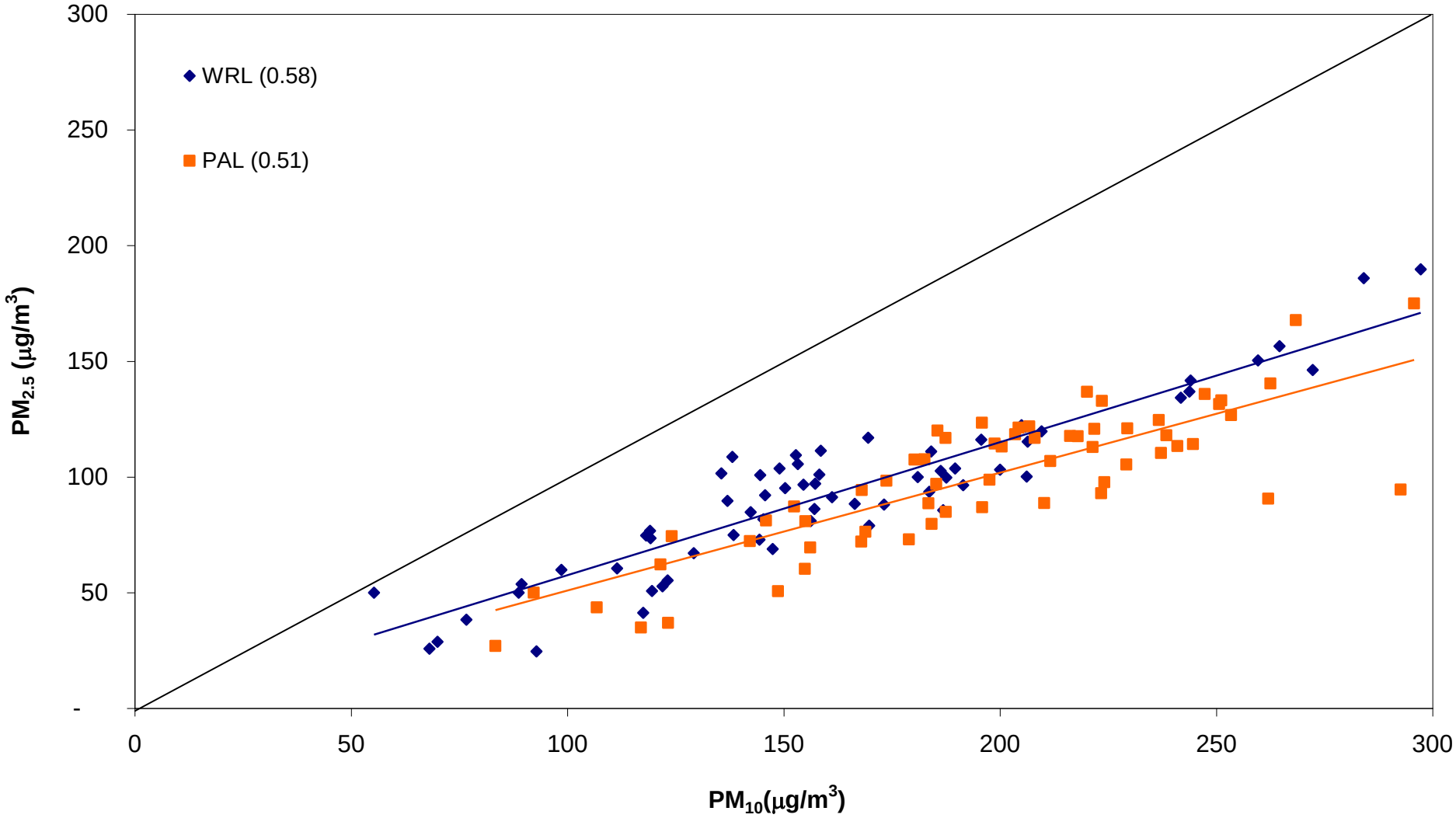
INDICATOR OF

ANTHROPOGENIC / COMBUSTION ACTIVITIES

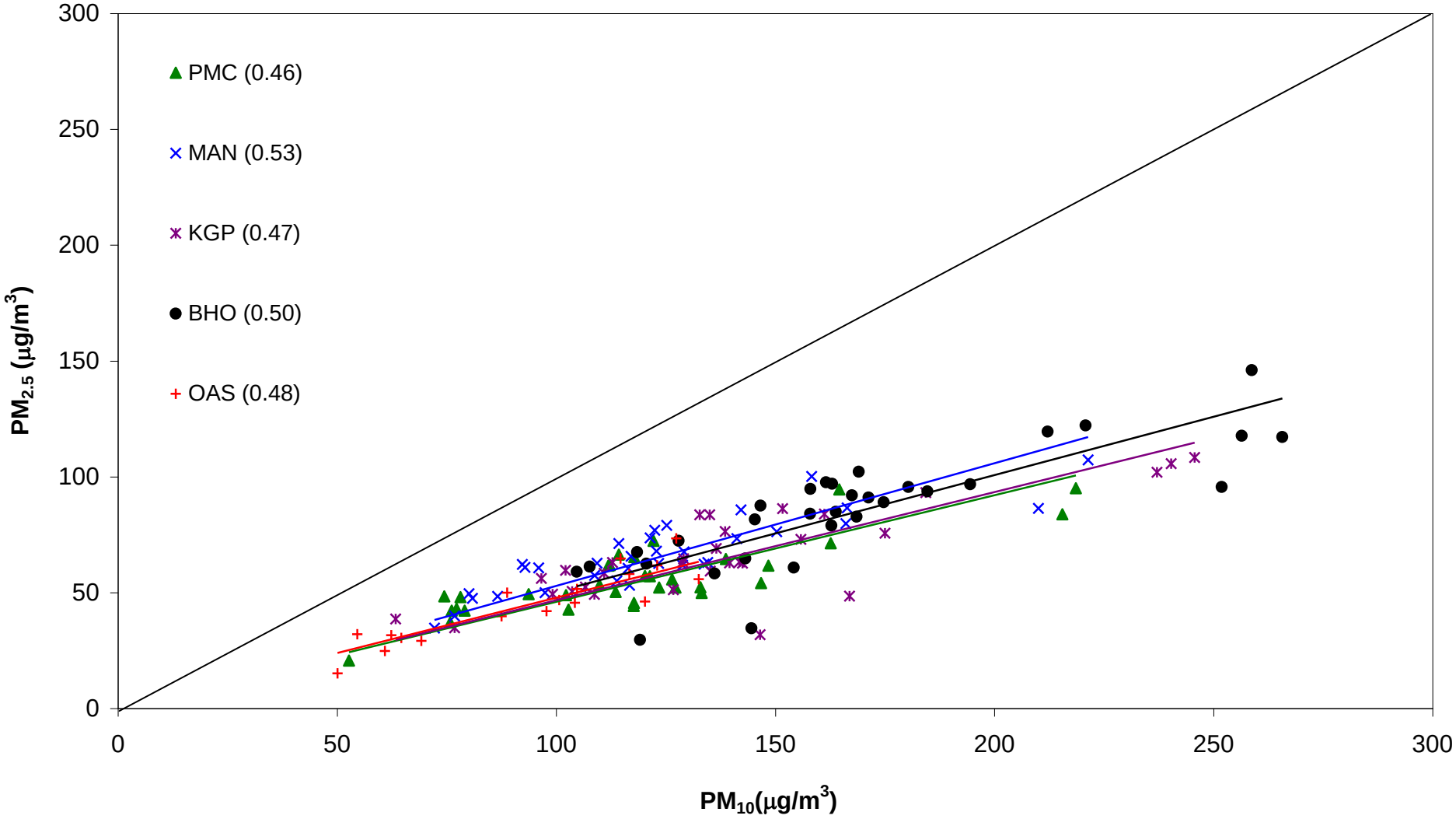
Ratio Small = Benign Particulate

Ratio Large = Most particles will reach lungs and possibly more toxic

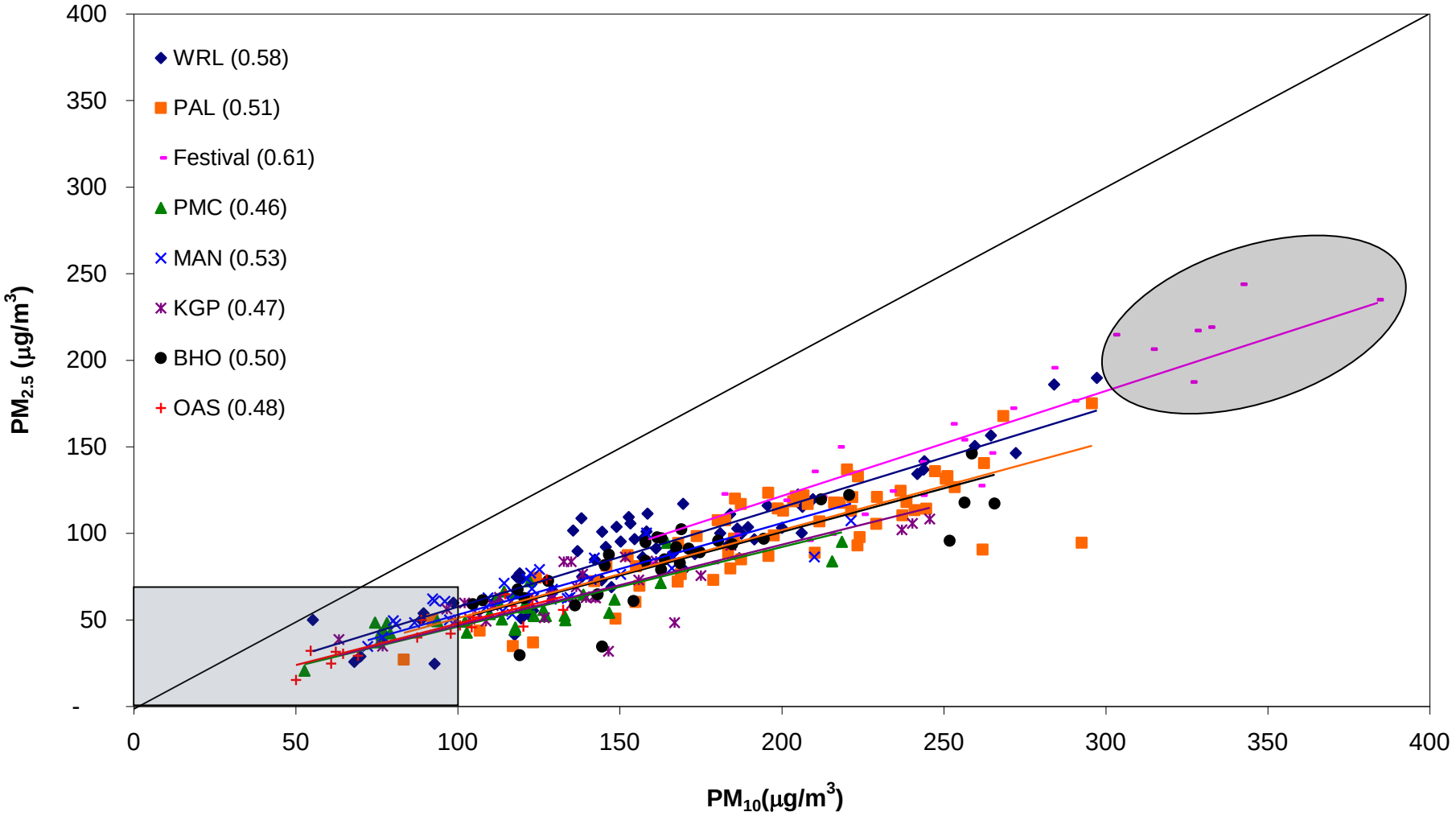
$PM_{2.5}$ and PM_{10} Measurements at Mumbai



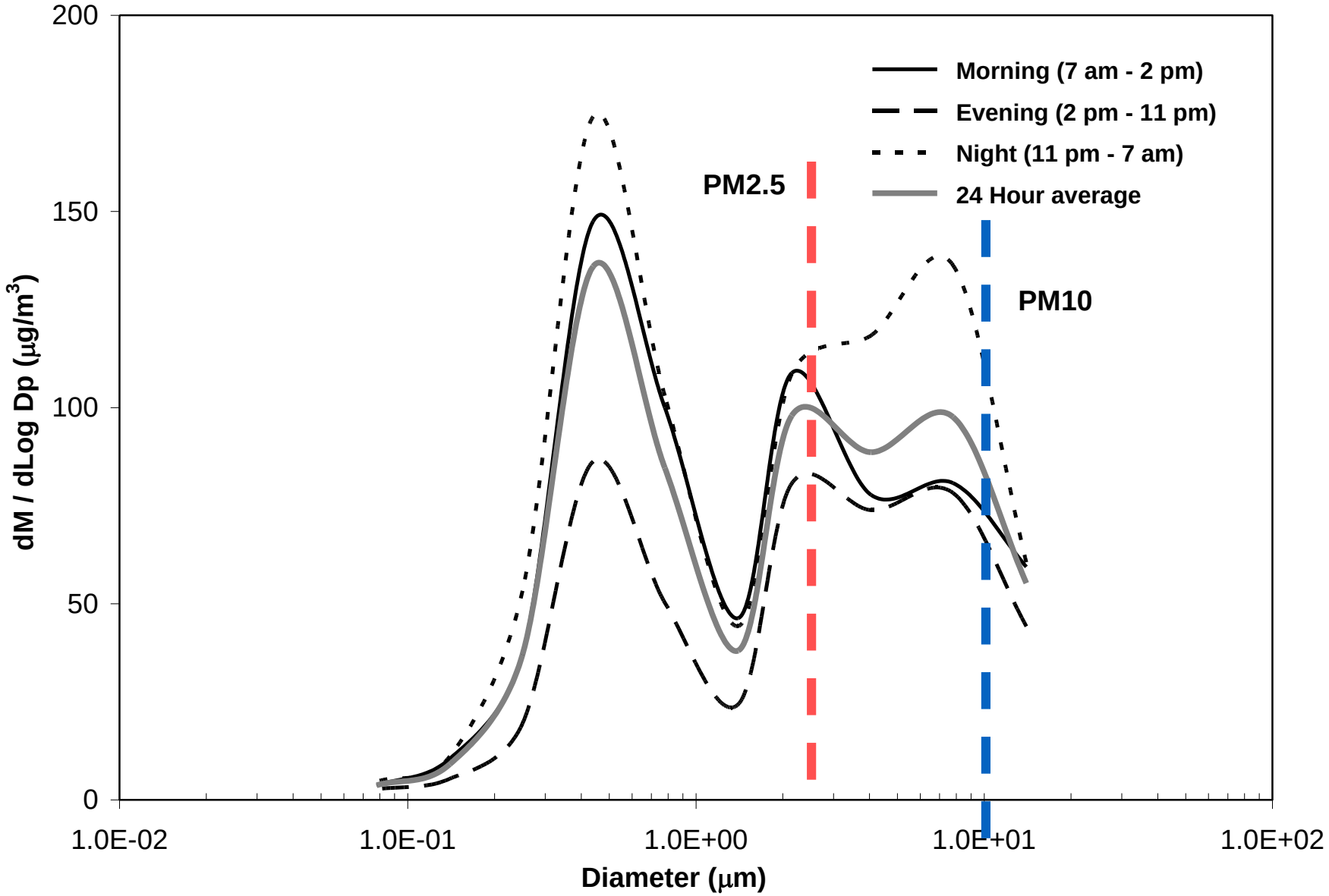
$PM_{2.5}$ and PM_{10} Measurements at Pune



$PM_{2.5}$ and PM_{10} Measurements at Mumbai and Pune



Mass Size Distributions Measured for 5 Days in Mumbai



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Sizing of Particles

Thought Exercise

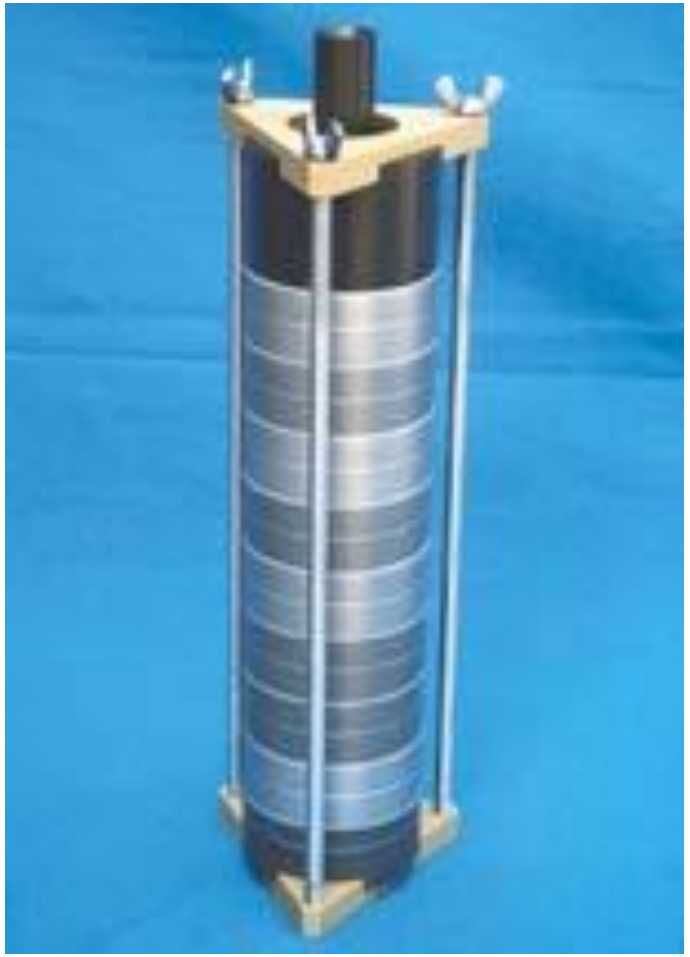
How would you
size and count
particles in air
in the
nanometer size range ?

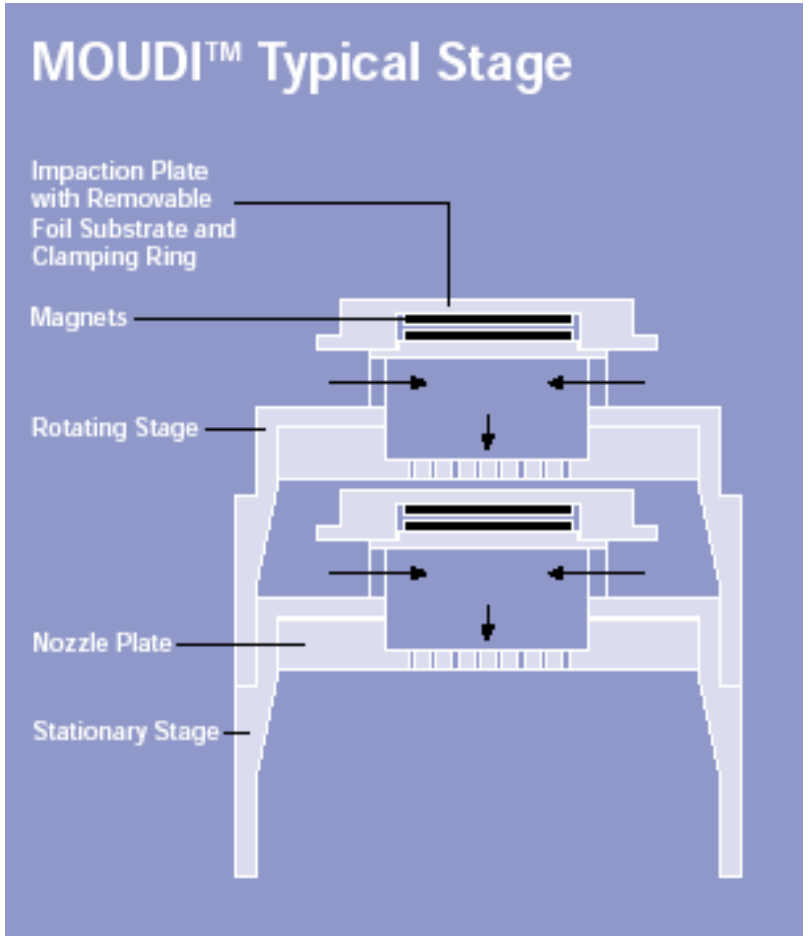
Instrumentation

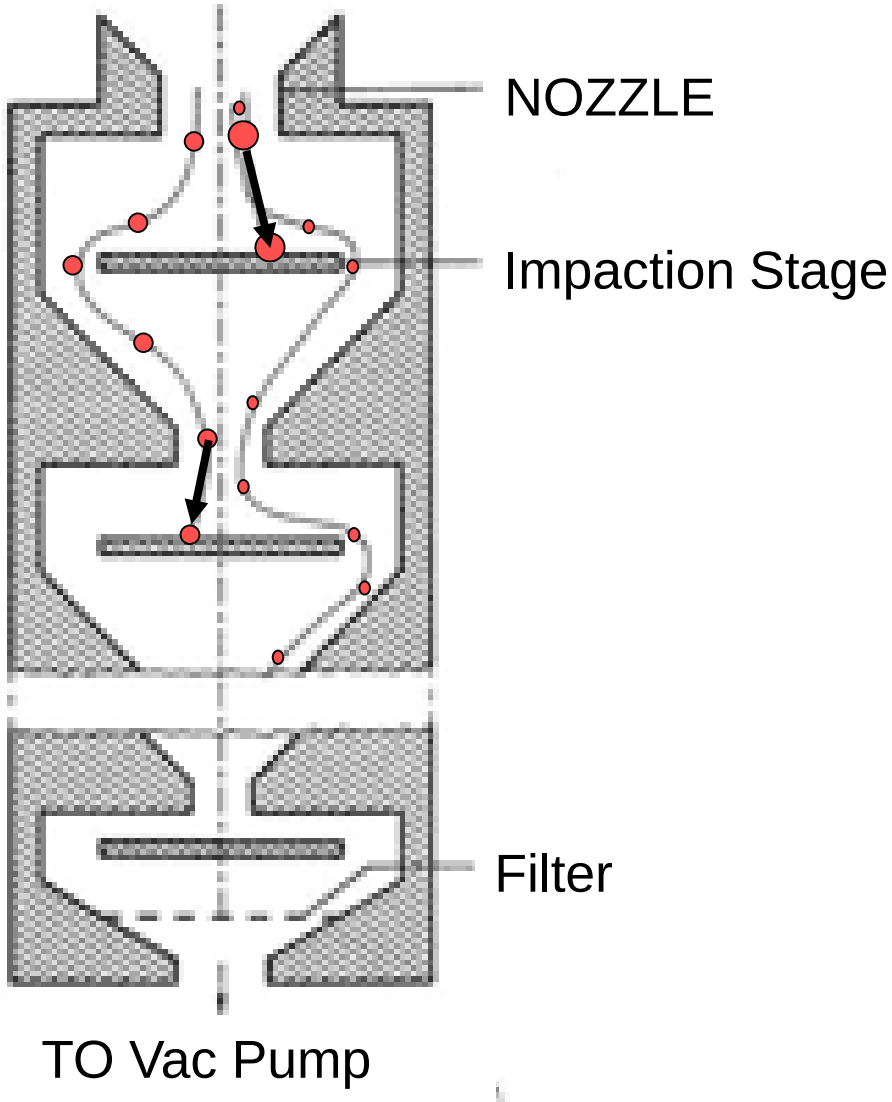
- Inertial Impactors
  - Mass based (> 56 nm)
- Optical Particle Counters
  - Number based (> 100 nm)
- Electrical Mobility
  - Sizing (> 6 nm)
  - Counting (Condensation Nuclei Counters)

MOUDI

Micro-Orifice Uniform Deposit Impactor






NOZZLE
Impaction Stage
Filter
TO Vac Pump

Instrumentation

- Inertial Impactors
  - Mass based (> 56 nm)
- Optical Particle Counters (OPC's)
  - Number based (> 100 nm)
- Electrical Mobility
  - Sizing (> 6 nm)
  - Counting (Condensation Nuclei Counters)

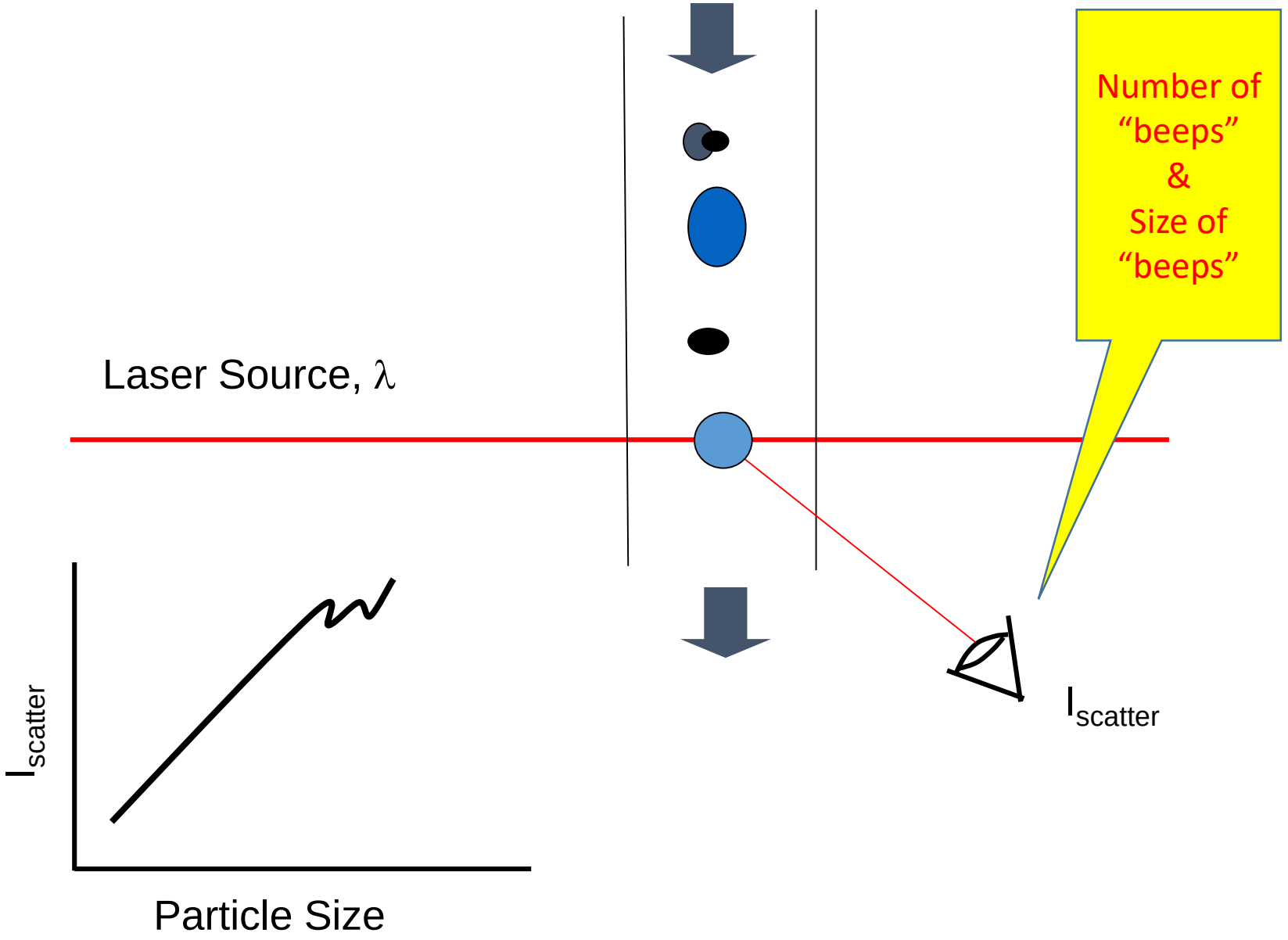
OPC's

- Light Scattering
- Light Extinction

  Limited to 0.09 μm

  $0.4 > \lambda_{opt} > 0.7$ μm

- Single Particle /Cloud of Particles


Number of
“beeps”
&
Size of
“beeps”
Laser Source, λ
$I_{scatter}$
$I_{scatter}$
Particle Size

x

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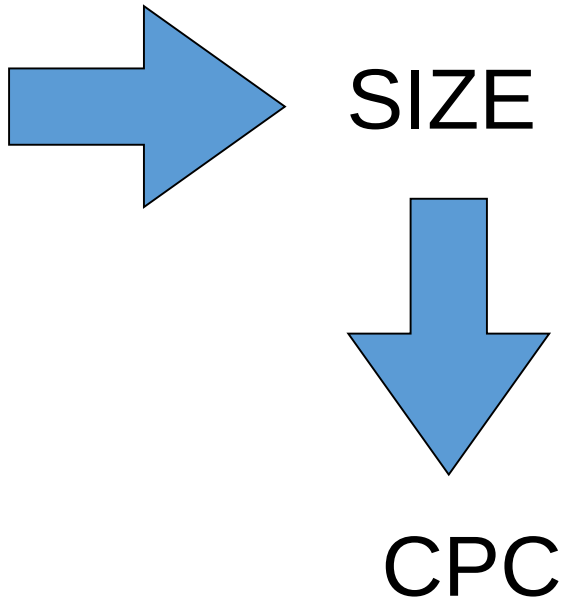
Sizing of Particles

Instrumentation

- Inertial Impactors
  - Mass based (> 56 nm)
- Optical Particle Counters
  - Number based (> 100 nm)
- Electrical Mobility
  - Sizing (> 3 nm)
  - Counting (Condensation Nuclei Counters)

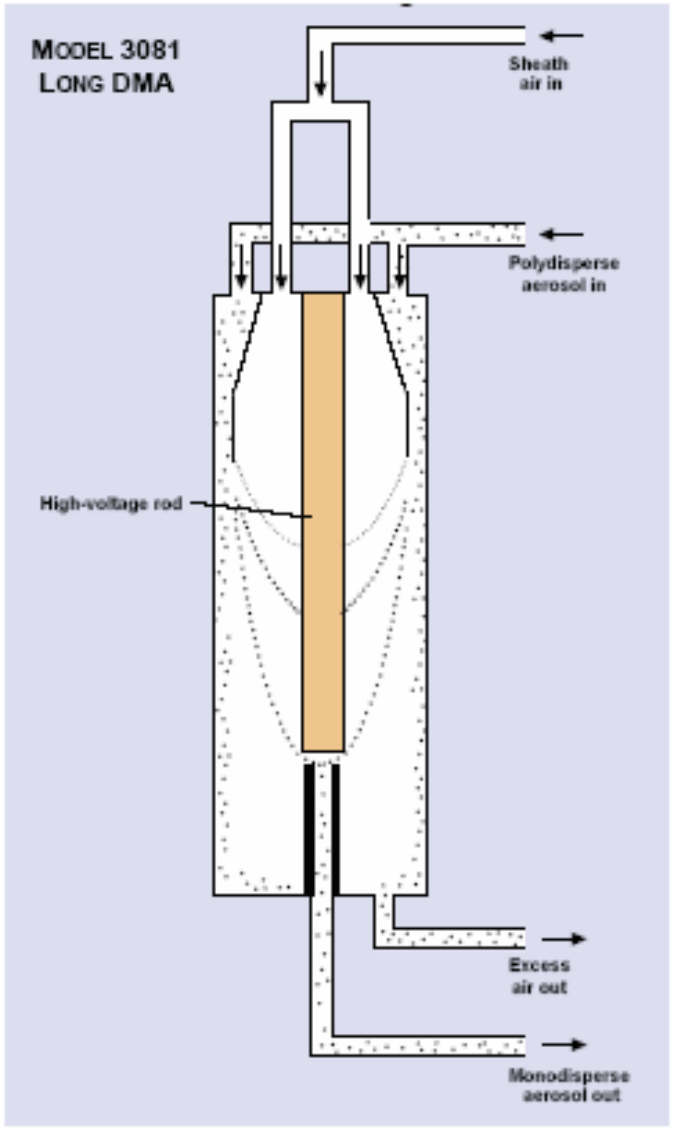
Electrical Mobility Analysers

- Charge particles
- Electrical Field



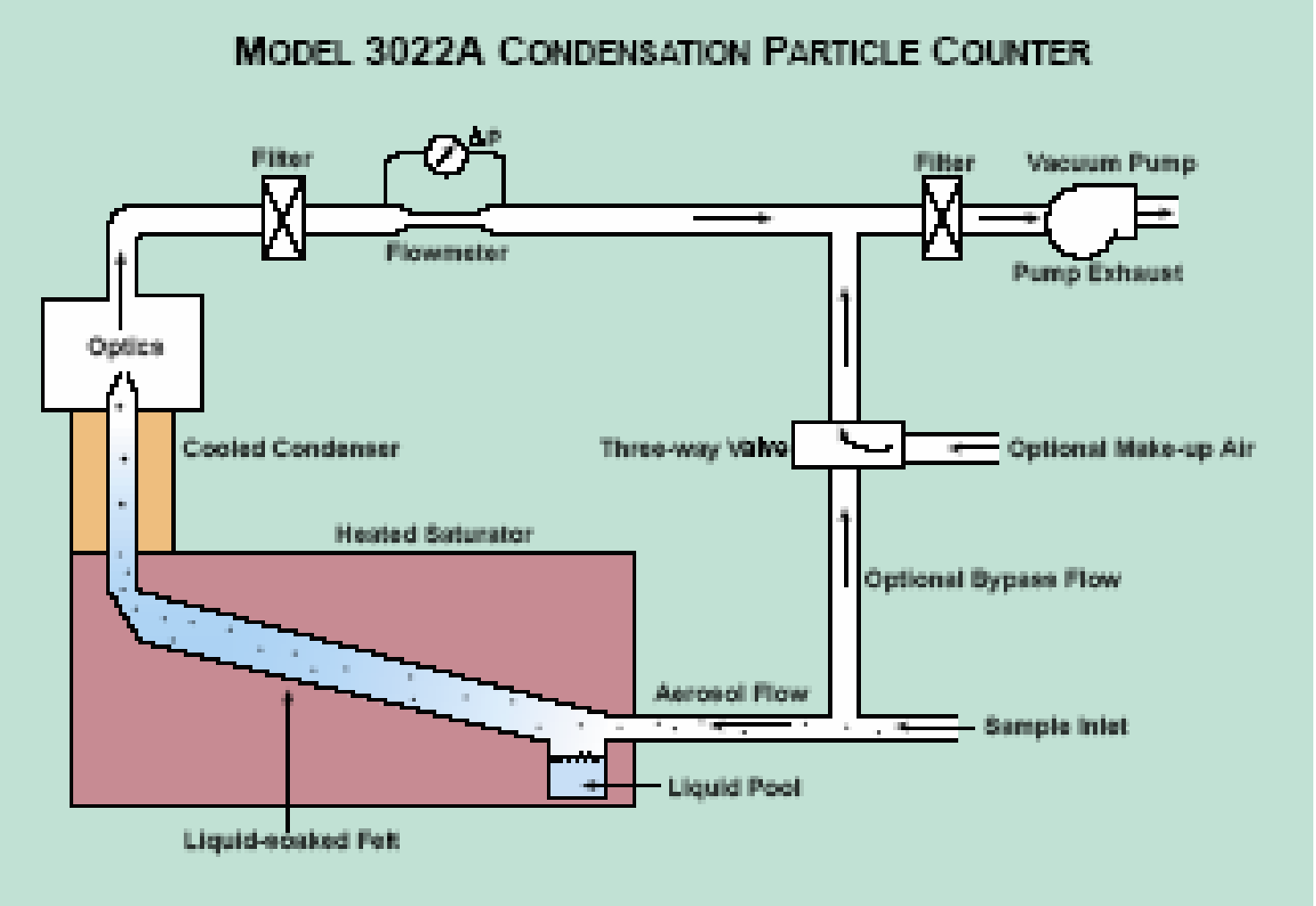
OPC in Principle – Alcohol used to grow size

Differential Mobility Analyser (For size separation using electrical mobility)



Source : TSI Inc.

Condensation Particle Counter (For growing the size separated particles and detecting them using light scattering)



Source : TSI Inc.

Scanning Mobility Particle Sizer

Field Instruments

- High Volume Samplers (~2 Lakhs)
  - Regulatory (RSPM, SOx, NOx)
- Mini-vol Samplers (~5 Lakhs)
  - Regulatory (PM10, PM2.5)
- Dust Trak (~7 Lakhs)
  - Real time (1 minute resolution)
  - PM_x (x = 1, 2.5, 4, 10)

Measuring Gaseous Pollutants

- Wet Chemistry (8 hour averages)
- Electrochemical sensors (Real time)
- Spectroscopy (Real time)
- Standard Methods (SPCB’s Analytical Labs)

x

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Controlling Air Pollutants

at the SOURCE

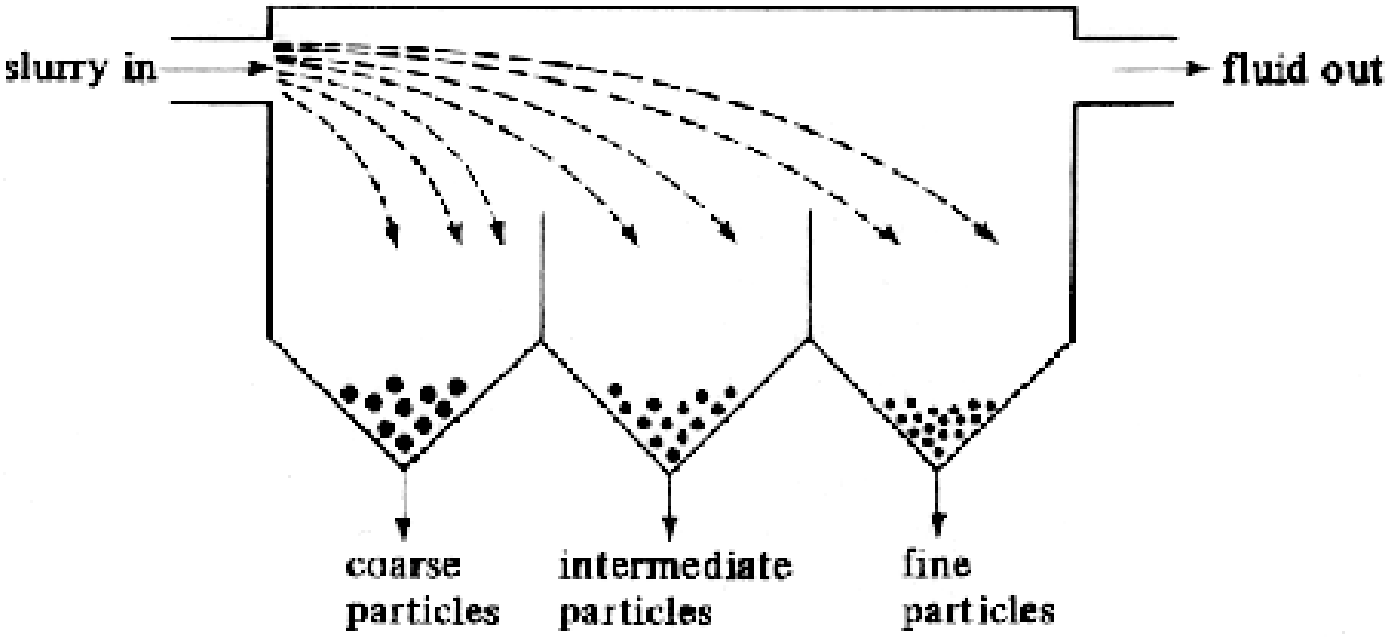
Particulate Matter

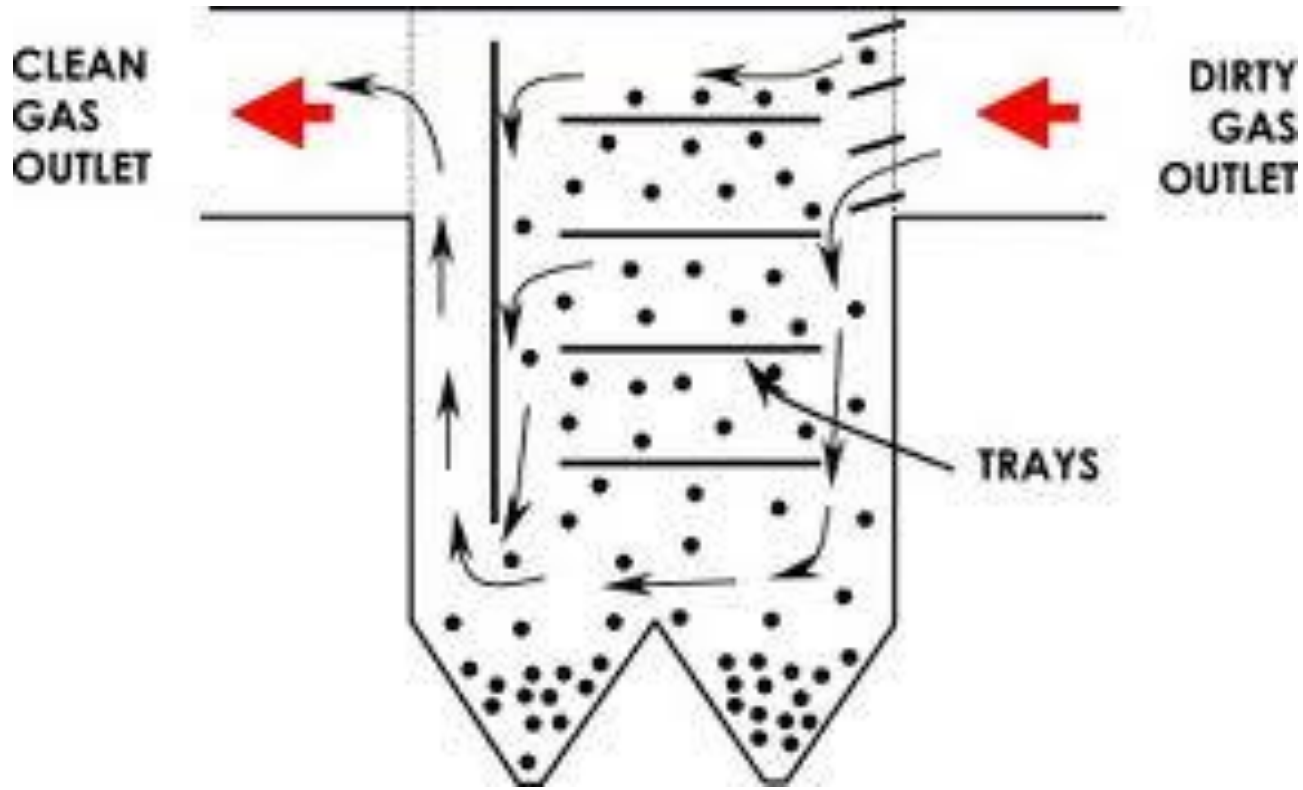
Air Pollution Control - PM

- MECHANICAL
  - Gravity – Settling Chambers 20 -100 μm
  - Inertia - Cyclones > 25 μm
  - Diffusion – Filters > 0.1 μm
- ELECTRICAL
  - Electrostatic Precipitators > 0.1 μm

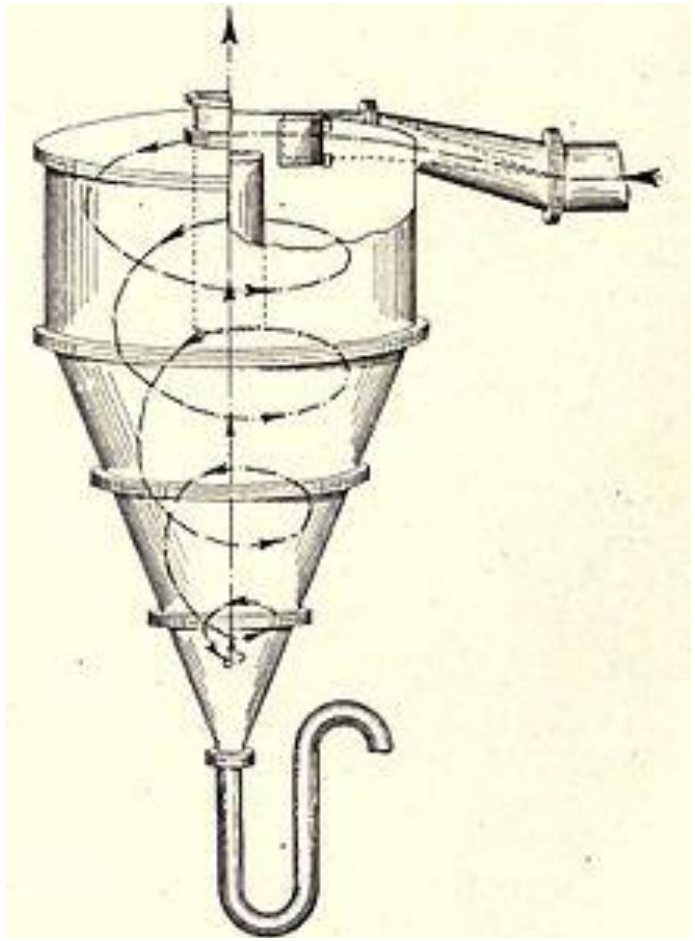
Mechanical

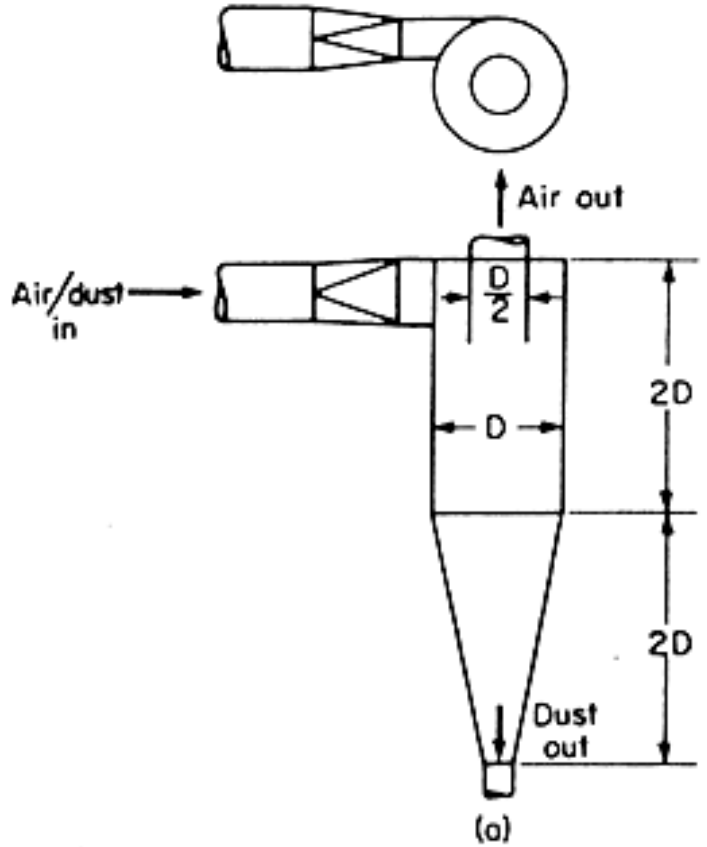
- Gravitational Settlers

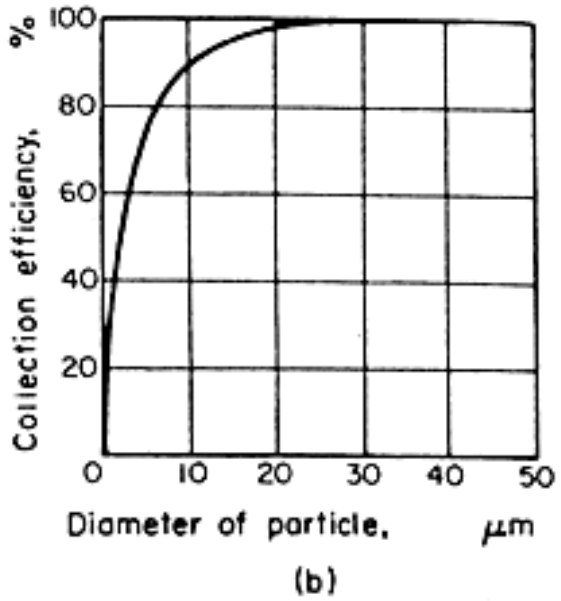



CLEAN
GAS
OUTLET
DIRTY
GAS
OUTLET
TRAYS

Mechanical - Inertia







XI

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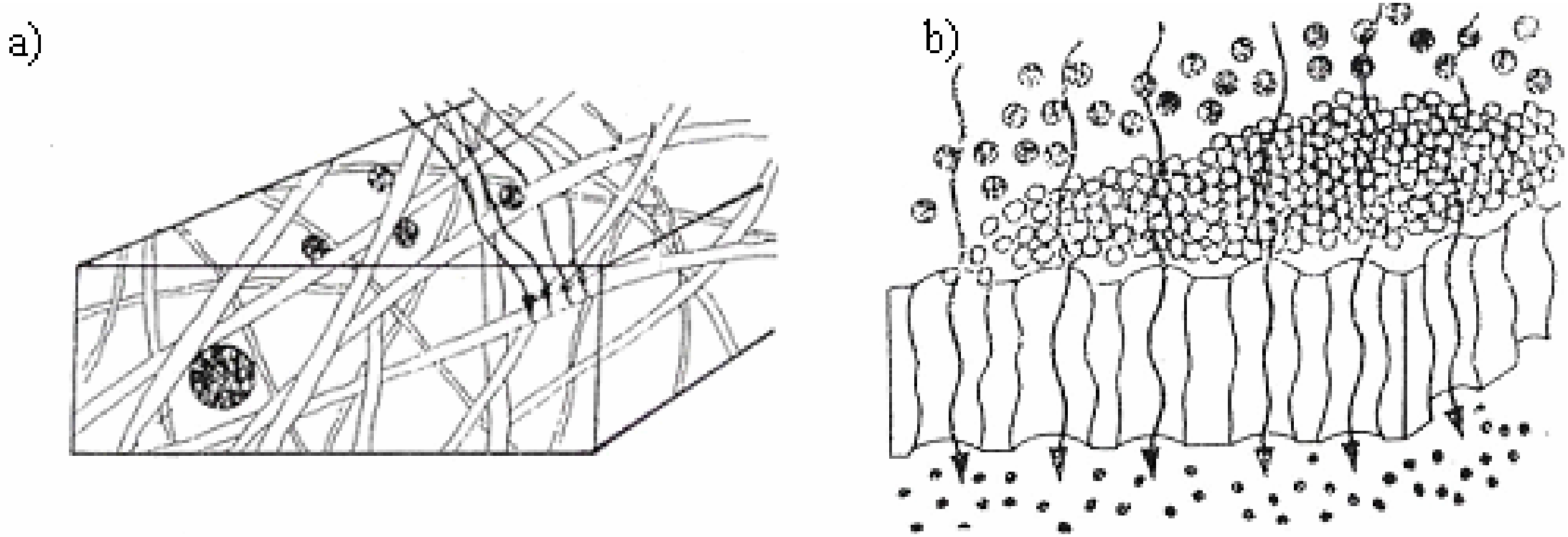
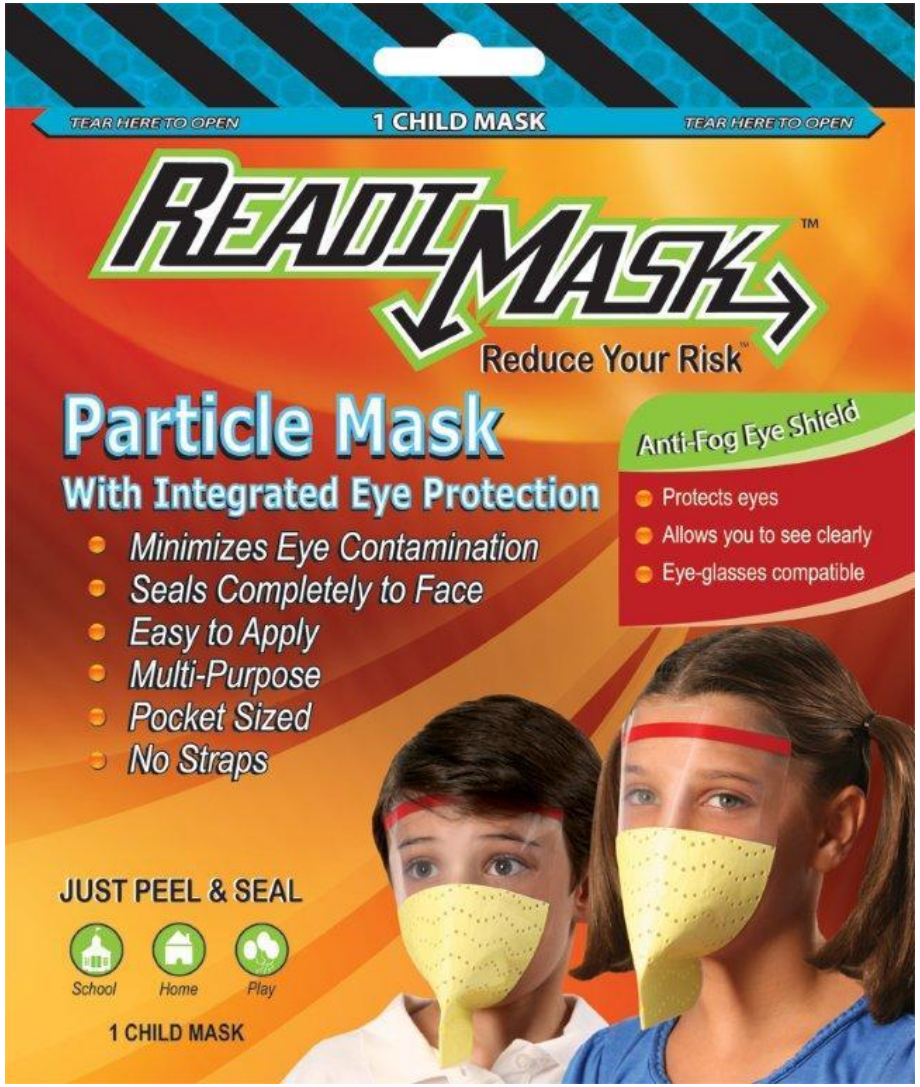
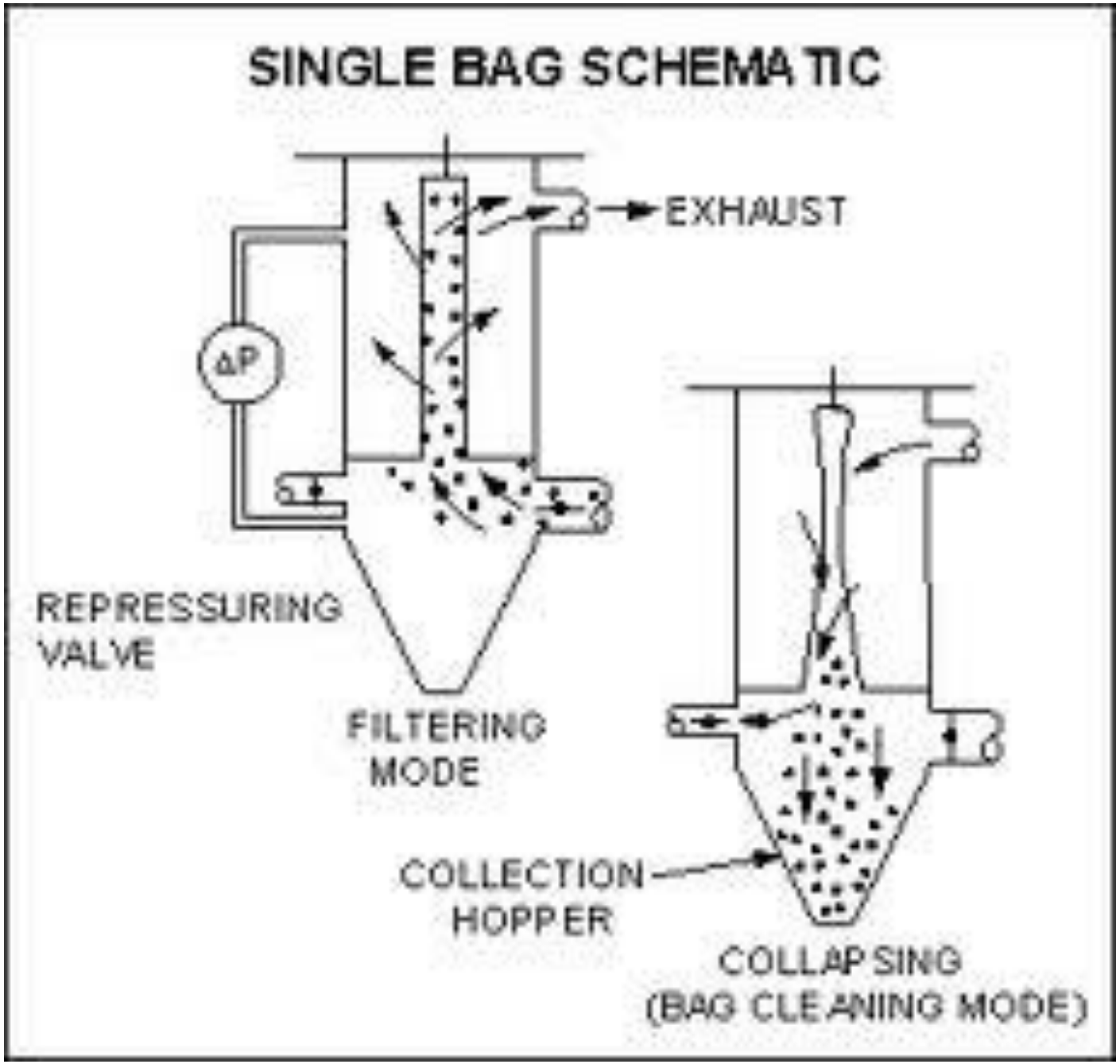
Mechanical - Filtration

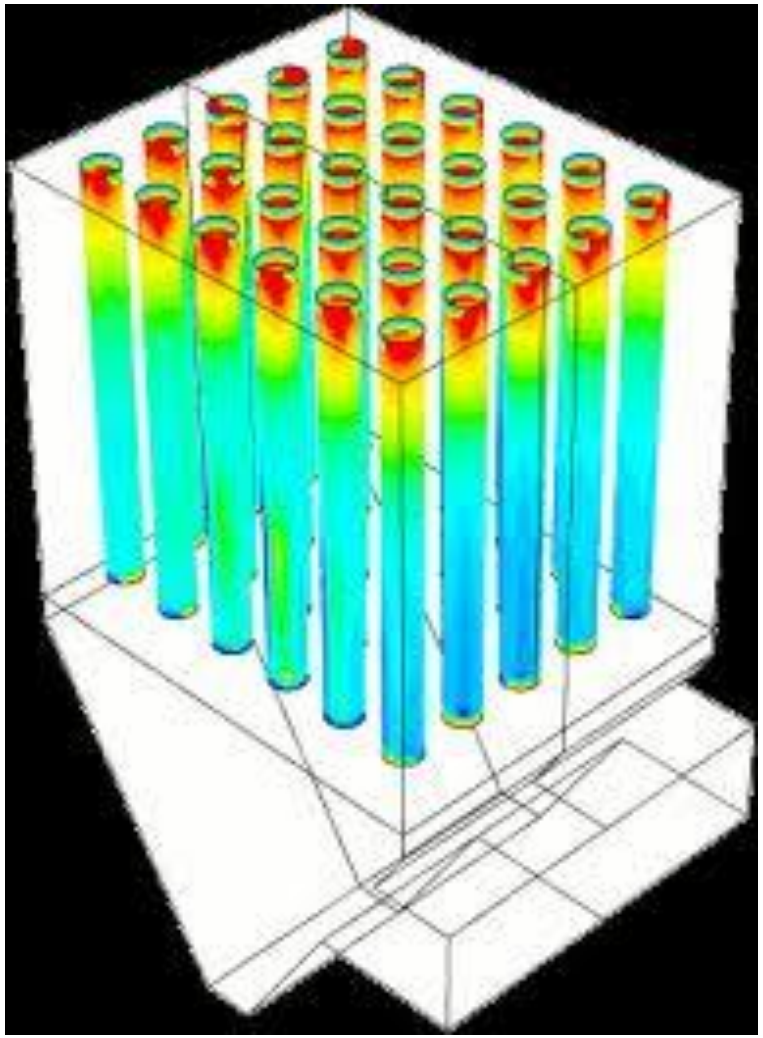



N95
PARTICULATE RESPIRATOR
MASQUE
RESPIRATOIRE
ANTIPOUSSIÈRES
3


TEAR HERE TO OPEN
1 CHILD MASK
TEAR HERE TO OPEN
READI MASK™
Reduce Your Risk™
Particle Mask
With Integrated Eye Protection
Minimizes Eye Contamination
Seals Completely to Face
Easy to Apply
Multi-Purpose
Pocket Sized
No Straps
Anti-Fog Eye Shield
Protects eyes
Allows you to see clearly
Eye-glasses compatible
JUST PEEL & SEAL
School
Home
Play
1 CHILD MASK


EFFICIENT PAPER
SILICON ANTI-DRAINBACK VALVE

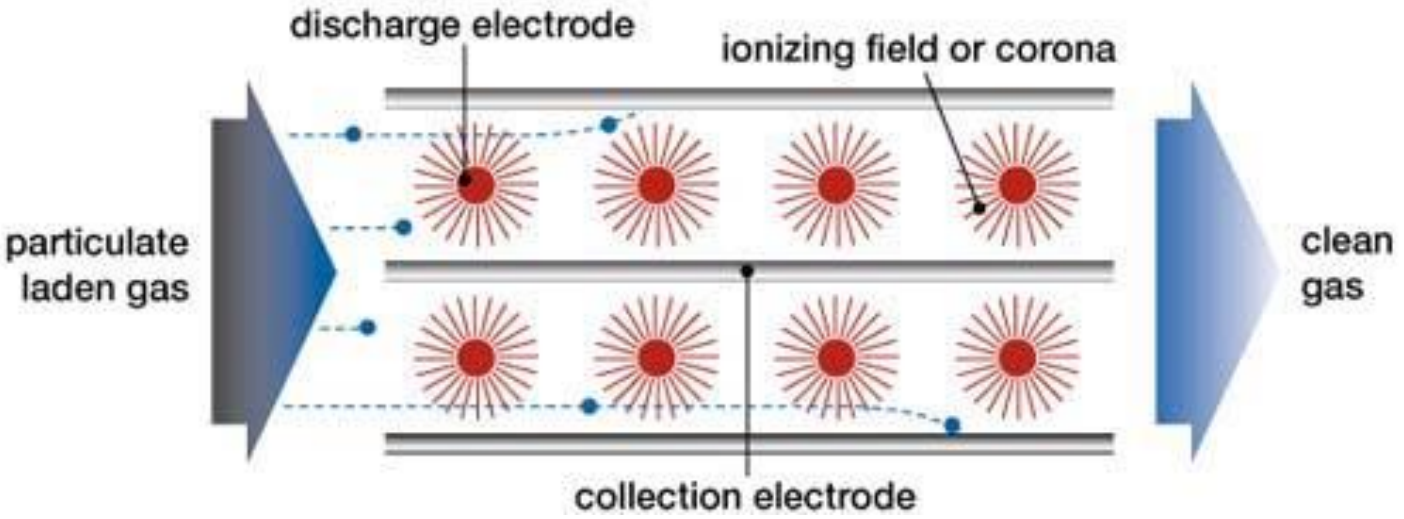

SINGLE BAG SCHEMATIC
EXHAUST
ΔP
REPRESSURING VALVE
FILTERING MODE
COLLECTION HOPPER
COLLAPSING (BAG CLEANING MODE)



- Through Fibrous Material :
  - FILTERED by
    - Diffusion
    - Impaction
    - Interception

    - (NOT SIEVING)

Electrostatic Precipitators



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Controlling Air Pollutants

at the SOURCE

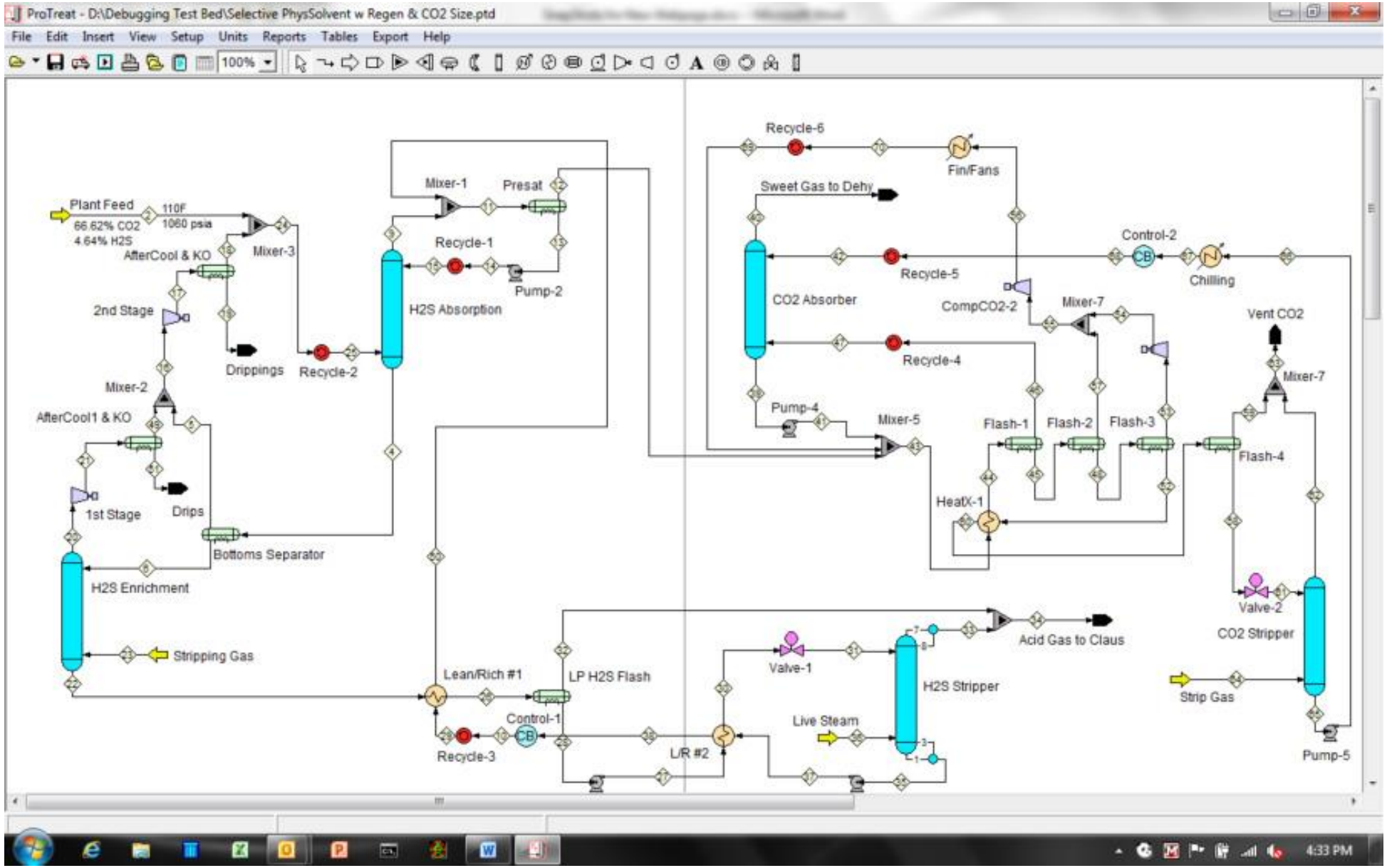
Gases

Air Pollution Control - Gases

- Absorption
- Adsorption
- Incineration
- Chemical Reactions
  - Catalysts
  - Flue gas Desulphurisation


Pingxiang Dier Chemical Packing Co., Ltd


SCANIA


ProTreat - D:\Debugging Test Bed\Selective PhysSolvent w Regen & CO2 Size.ptd
File Edit Insert View Setup Units Reports Tables Export Help
100%
Plant Feed
66.62% CO2
4.64% H2S
110F
1060 psia
AfterCool & KO
Mixer-3
Mixer-1
Presat
Recycle-1
Pump-2
H2S Absorption
2nd Stage
Drippings
Recycle-2
Mixer-2
AfterCool1 & KO
1st Stage
Drips
Bottoms Separator
H2S Enrichment
Stripping Gas
Lean/Rich #1
LP H2S Flash
Control-1
Recycle-3
L/R #2
Valve-1
Live Steam
H2S Stripper
Acid Gas to Claus
Recycle-6
Fin/Fans
Sweet Gas to Dehy
Control-2
Chilling
Recycle-5
CO2 Absorber
CompCO2-2
Mixer-7
Vent CO2
Recycle-4
Pump-4
Mixer-5
Flash-1
Flash-2
Flash-3
Flash-4
HeatX-1
Valve-2
CO2 Stripper
Strip Gas
Pump-5
4:33 PM

Adsorption


10" GAC FILTER
REPLACEMENT
PURE100
GRANULAR
ACTIVATED
CARBON FILTER

Incinerators - Flares

Thank you for your Time and Attention

Best Wishes

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