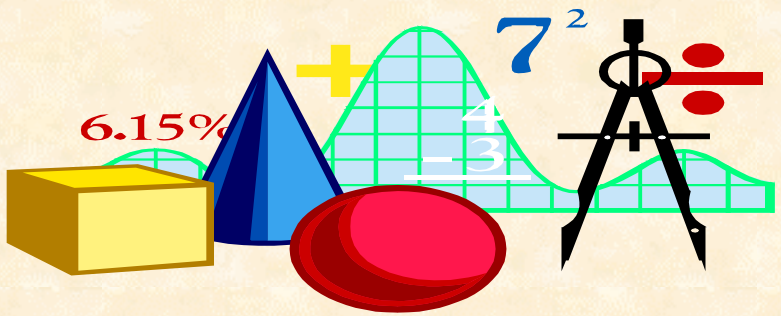
AIRPET - Regional Air Pollution Research Program Phase 1: 2001-2003 Sponsored by Sida/SAREC

http://www.serd.ait.ac.th/airpet/



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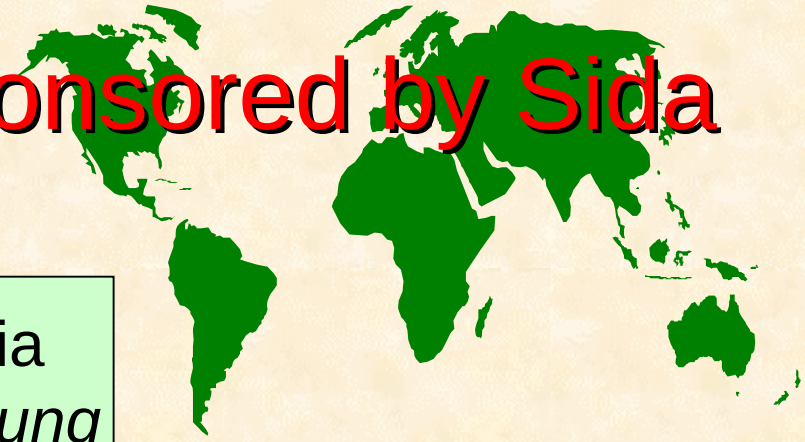
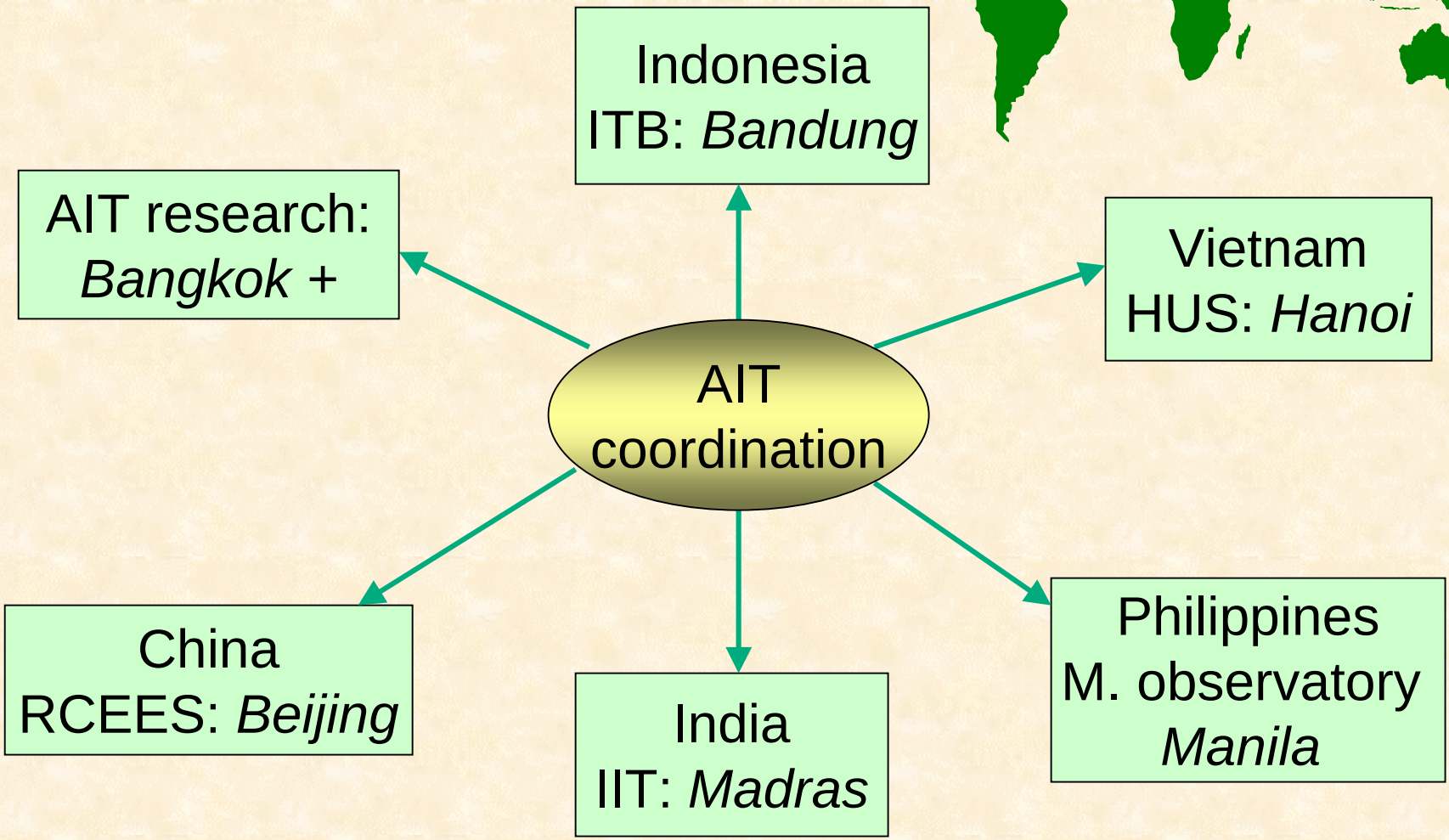
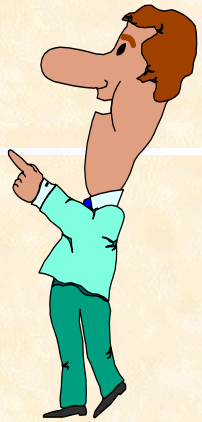




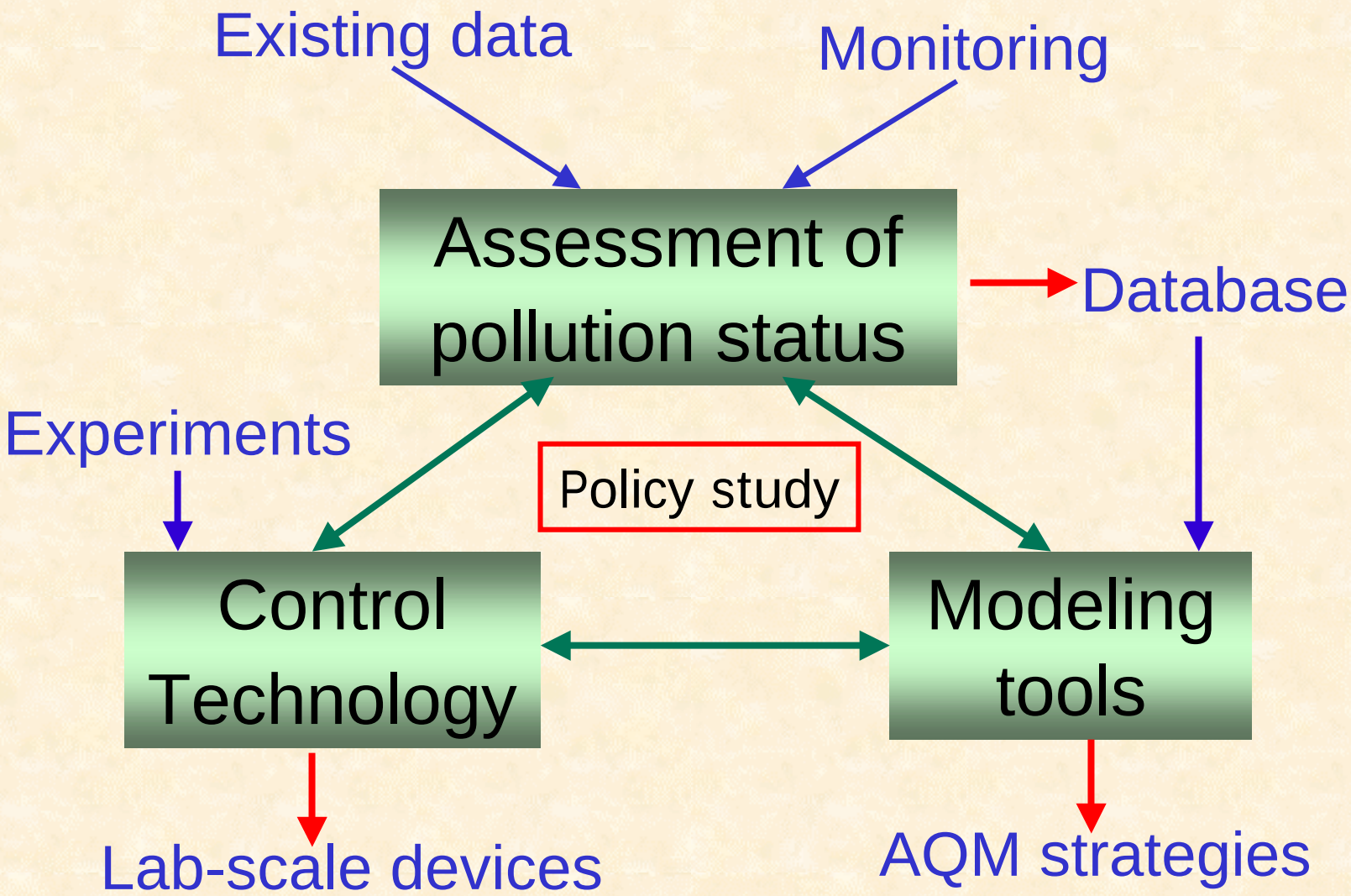
Improving Air Quality in Asian Developing Countries



Project goal: mobilize and enhance capacity in the involved countries

- To establish comprehensive assessment of air pollution status
- To develop suitable control technologies
- To apply modeling tools for integrated air quality management

Activities – Outputs



Phase 1 Planned Activities
Jan. 2001- Dec. 2003

NRIs	Monitoring	Control	Modeling	
			Receptor	Disp.
AIT	X	X	X	X
China	X	X	X	
India	X	X	X	
Indonesia	X	X	X	
Philippines	X		X	X
Vietnam	X		X	X

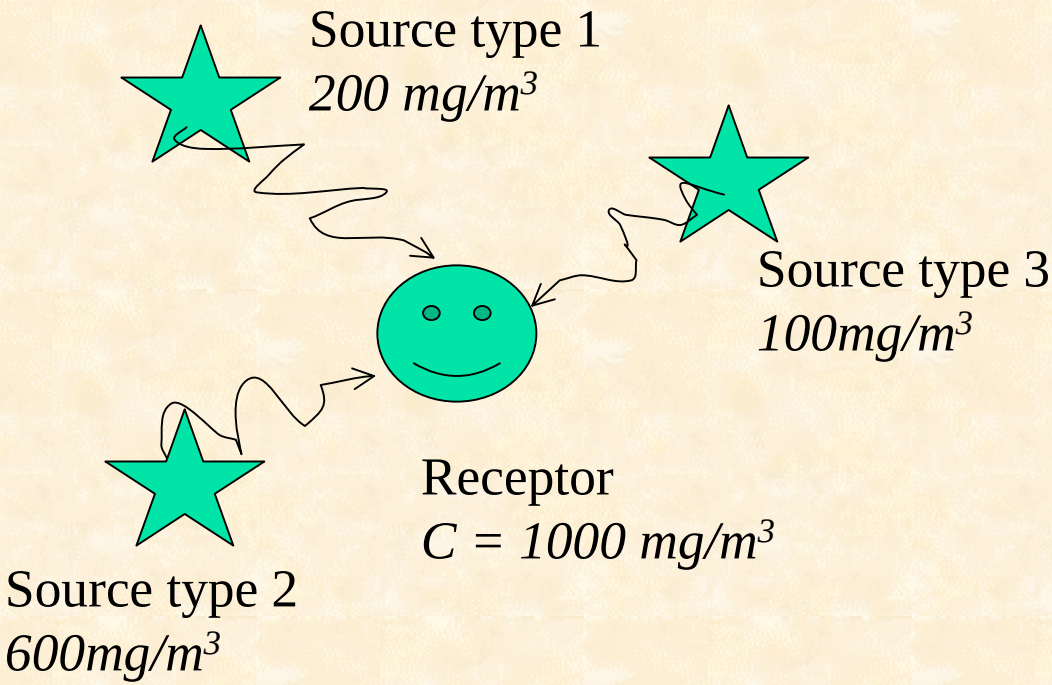
Monitoring: major issue
Designed Monitoring Program for Consistency and Uniformity

- Site selections:
  - 5 types: traffic, industrial, residential/mixed, commercial site and background
  - One site for each type
- Monitoring period/times: dry and wet seasons
- Sampling equipment for PM10 & PM2.5: dichot, available equipment to be evaluated against dichot
- Analytical methods: existing equipment and standard QA/QC: SRM, blanks & blind samples

Source apportionment of PM10, PM2.5 by receptor modeling

Objectives: to quantify source contributions by sector so that appropriate policies can be drafted

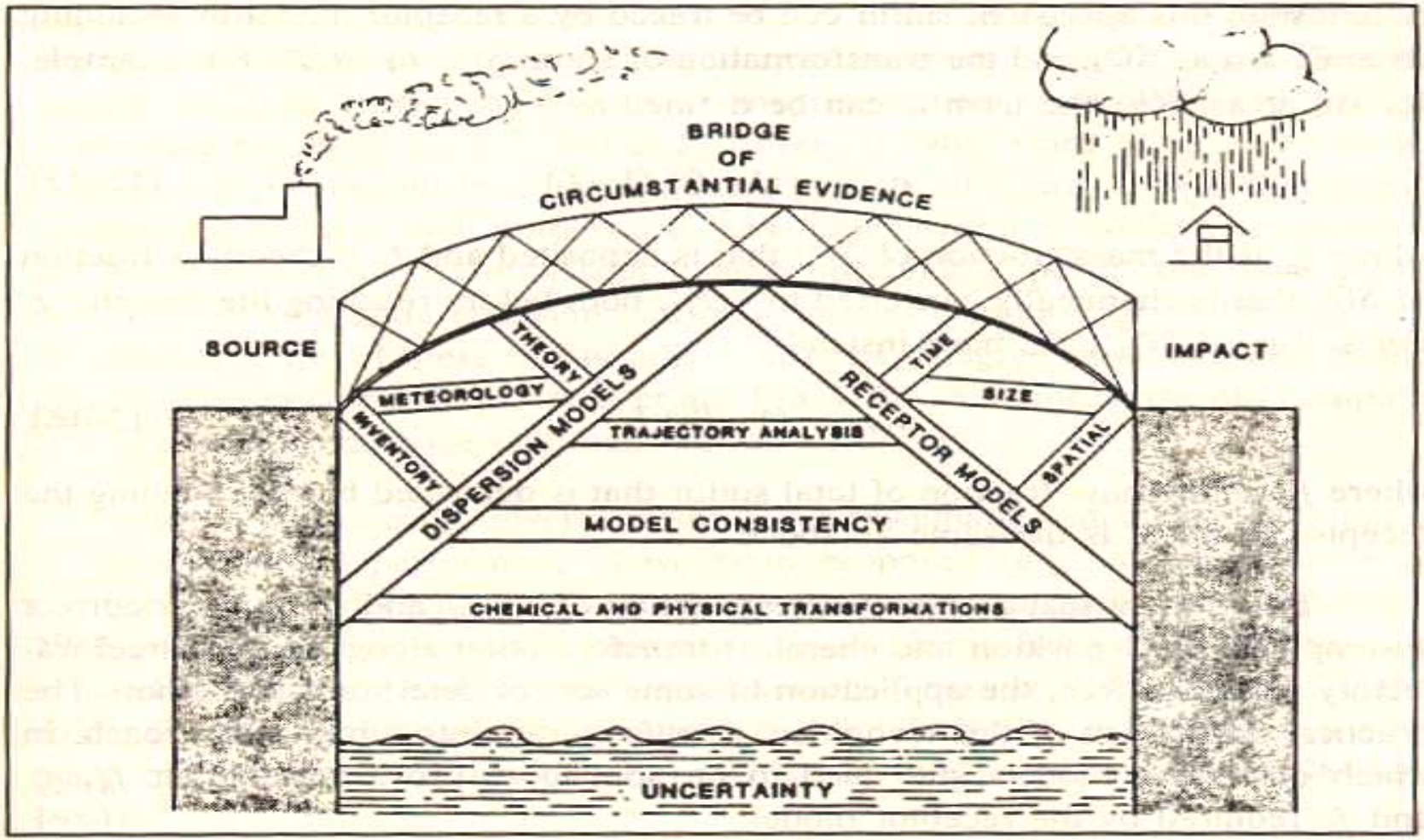
Receptor modeling



Measurement for PM, VOC at a receptor

Find main contributors to C: focus mitigation efforts

Receptor Model Complements Dispersion Model to Understand Source-Receptor Relationship



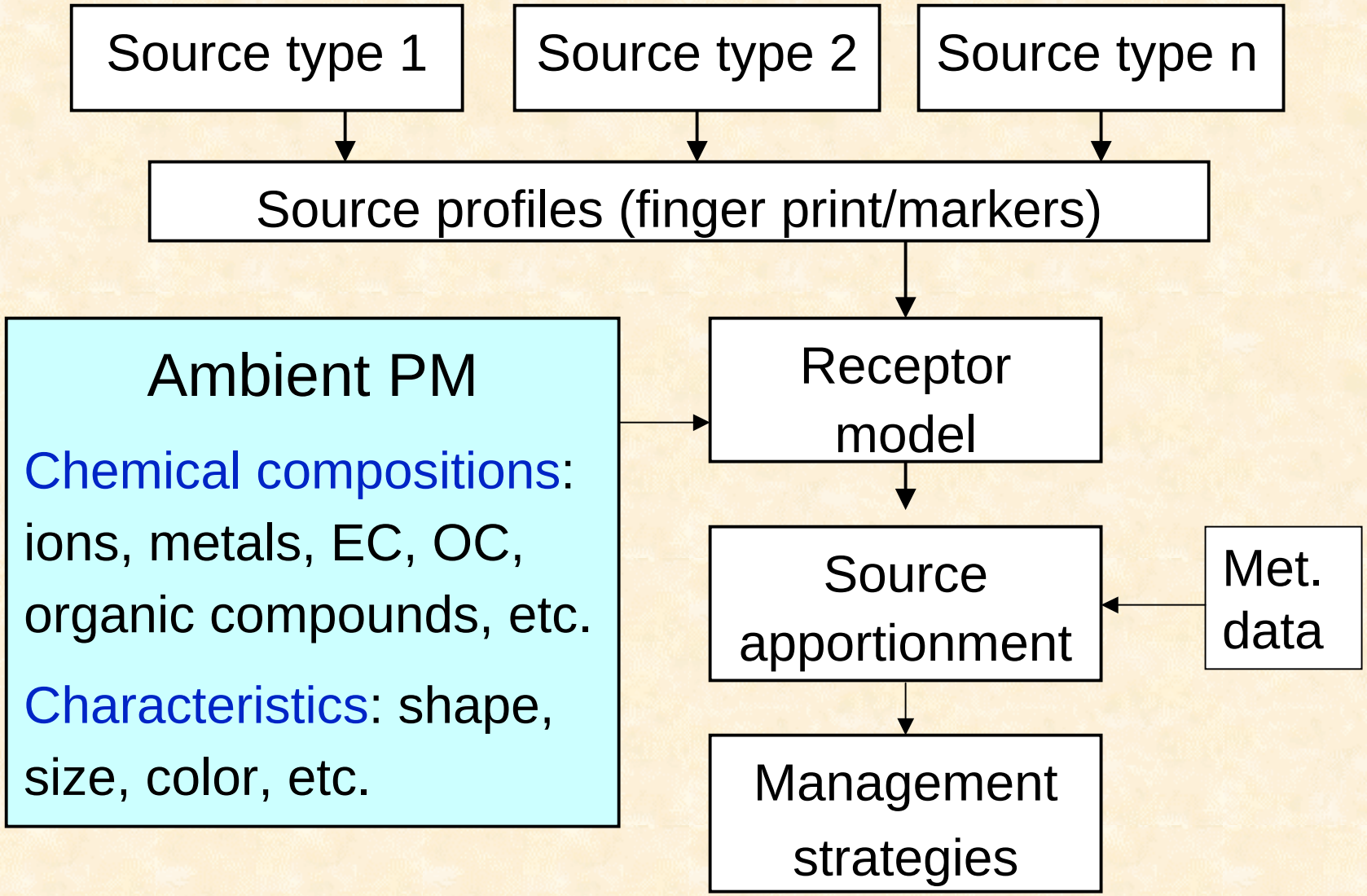
Receptor Modeling for Source Apportionment

- Quantify contributions to $PM_{2.5}$, PM_{10}, VOC, etc.
- Improve emissions inventories
- Verify source dispersion models
- Formulate conceptual models of source receptor relationships

Conceptual Receptor Model

- Describes the relevant physical and chemical processes
- Identifies potential sources of primary emissions
- Documents potential for secondary aerosol formation

Receptor models



Some Receptor Models

- Chemical Mass Balance
- Temporal and spatial correlation eigenvectors (e.g., PCA, FA)
- Multiple linear regression (MLR)
- Neural networks
- Time series (e.g., spectral analysis etc.)

Common Mathematical Formula for Receptor Modeling

The concentration of a pollutant at a receptor site is the sum of linear products of the source profile and the source strength

$$x_{ij} \approx \sum_{k} a_{ik} f_{kj}$$

Solve Equation for f_{kj}

x_{ij} = Concentration of species *i* in the sample *j*

a_{ik} = Source profiles (fraction of *i* in *k* source)

f_{kj} = Source strength or contribution of k^{th} source to j^{th} sample (unknown)

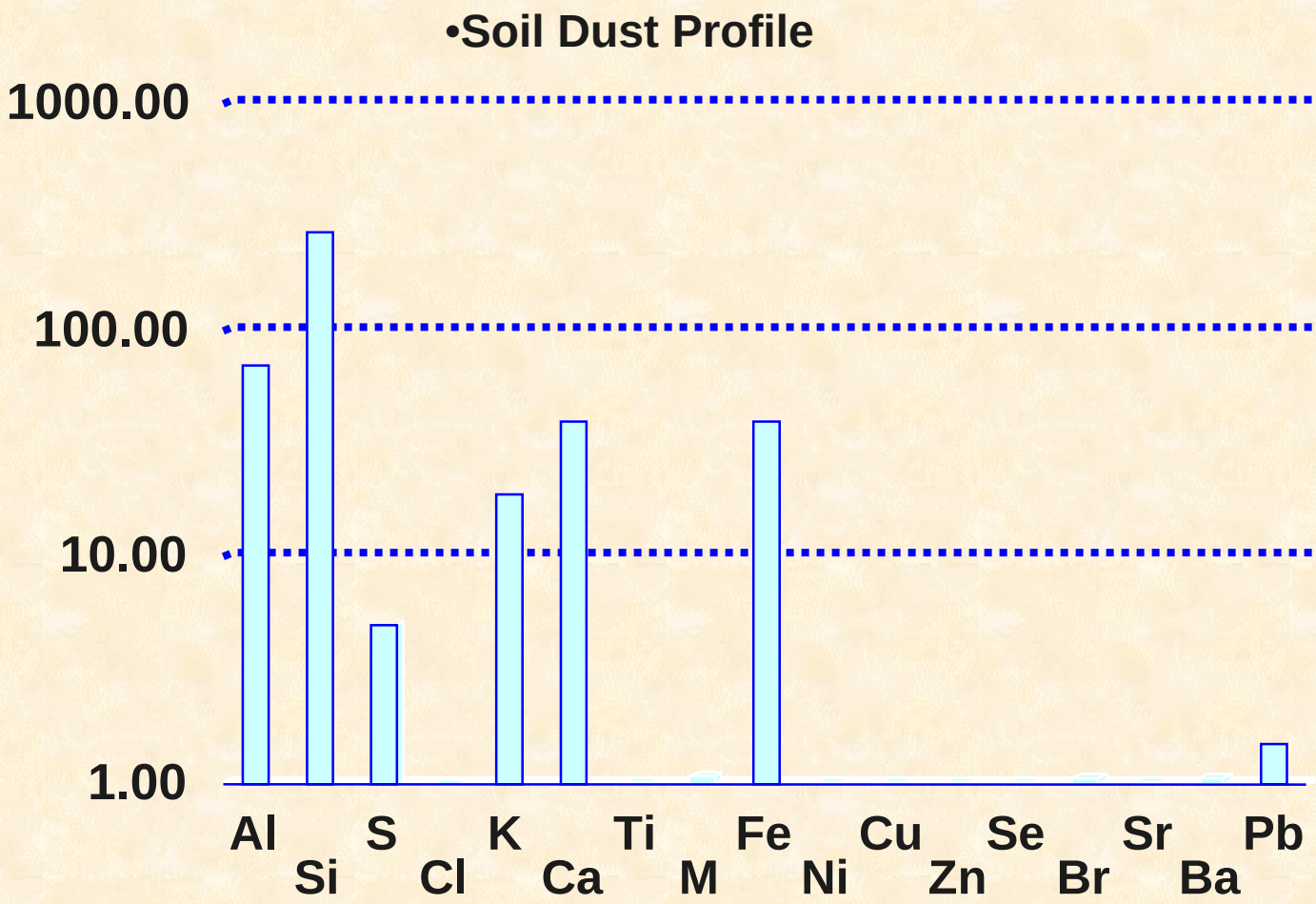
Example: CMB application

- Simple Example:
  - Pb in an ambient sample: X_{ij} = 1.0 ug/m^3
  - a_{ik} in Auto Exhaust = 20% = 0.2
- Contribution of Auto Exhaust is 5 ug/m^3
- Assumption: Autos are only source of Pb

Receptor Model Needs

- Source properties that identify and quantify source contributions at a receptor (source profiles)
- Measurements at receptor to better distinguish among sources
  - Sampling locations, periods and durations; particle sizes; precursor gases; and chemical and physical components

Source Profiles



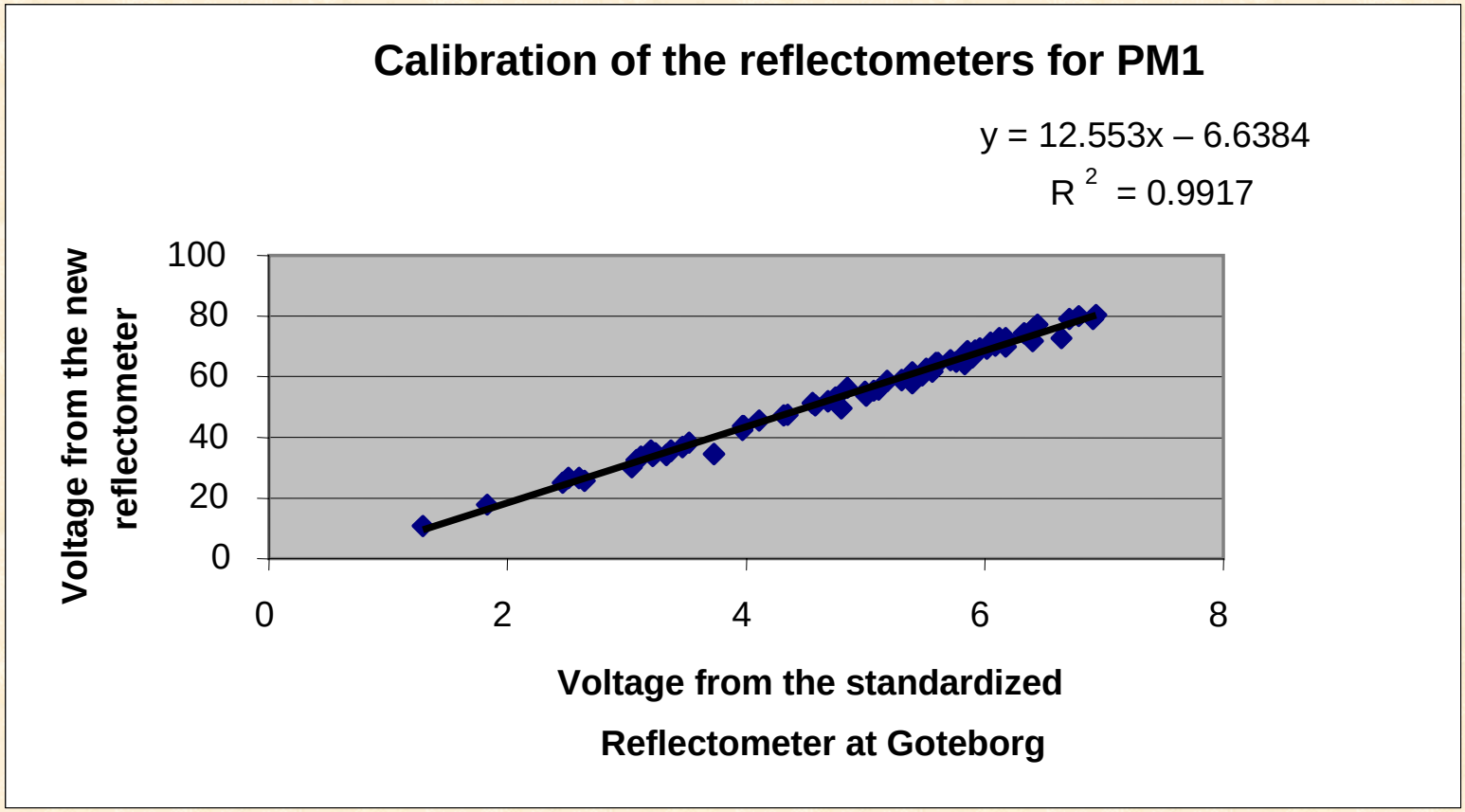
Chemical analysis of PM

- Speciation
  - Carbon – EC/OC/BC
  - Trace Elements
  - Ionic Species
    - Sulfate
    - Nitrate
    - Ammonium
  - Hydrocarbons

Analysis for PM chemical composition

Elements	Analytical equipment	Notes
Metals	AAS, ICP/MS, ICP/AES, INAA (upto 40 elements)	Sample destruction
	XRF & PIXE: ~ 25 elements with atomic No. 11-92	No destruction
OC, EC	Thermal combustion, Optical absorption, TMO, etc.	Operational definitions
BC (light abs.C)	Reflectormeter	No destruction
Carbonate Carbon	Acidification of filter at room temperature	Destruction
Ions	AAS: single ions (Na, Mg, K, Ca) IC: polyatomic ions (SO^-_4, NO^-_3, ...)	destruction

Black carbon measurements (AIT)



The standardized reflectormeter gives measurements which are converted to mass of BC using a formula

Number of samples required for receptor modeling

- CMB: in principle can run with 1 sample
- Statistical models (PMF) need more samples

  $N > 30 + (V + 3)/2$

  V: variables - No. of species measured (or source emission tracers), normally V= 20 => N_{min} = 42
- AIRPET focus:
  - Mixed site and background site: to have enough samples to run both models
  - Other sites: min 10-15 samples to run CMB8

Multicollinearity in source apportionment

- Nature of problem: 2 or more sources have very similar signatures. More generally, problem exists when one source signature is nearly a linear combination of any subset of the other signatures ➔ can not identify these sources
- Symptoms of CMB results:
  - Large negative aerosol contributions from these source types
  - Estimated uncertainties are larger than the calculated source contributions themselves

Dealing with Multicollinearity

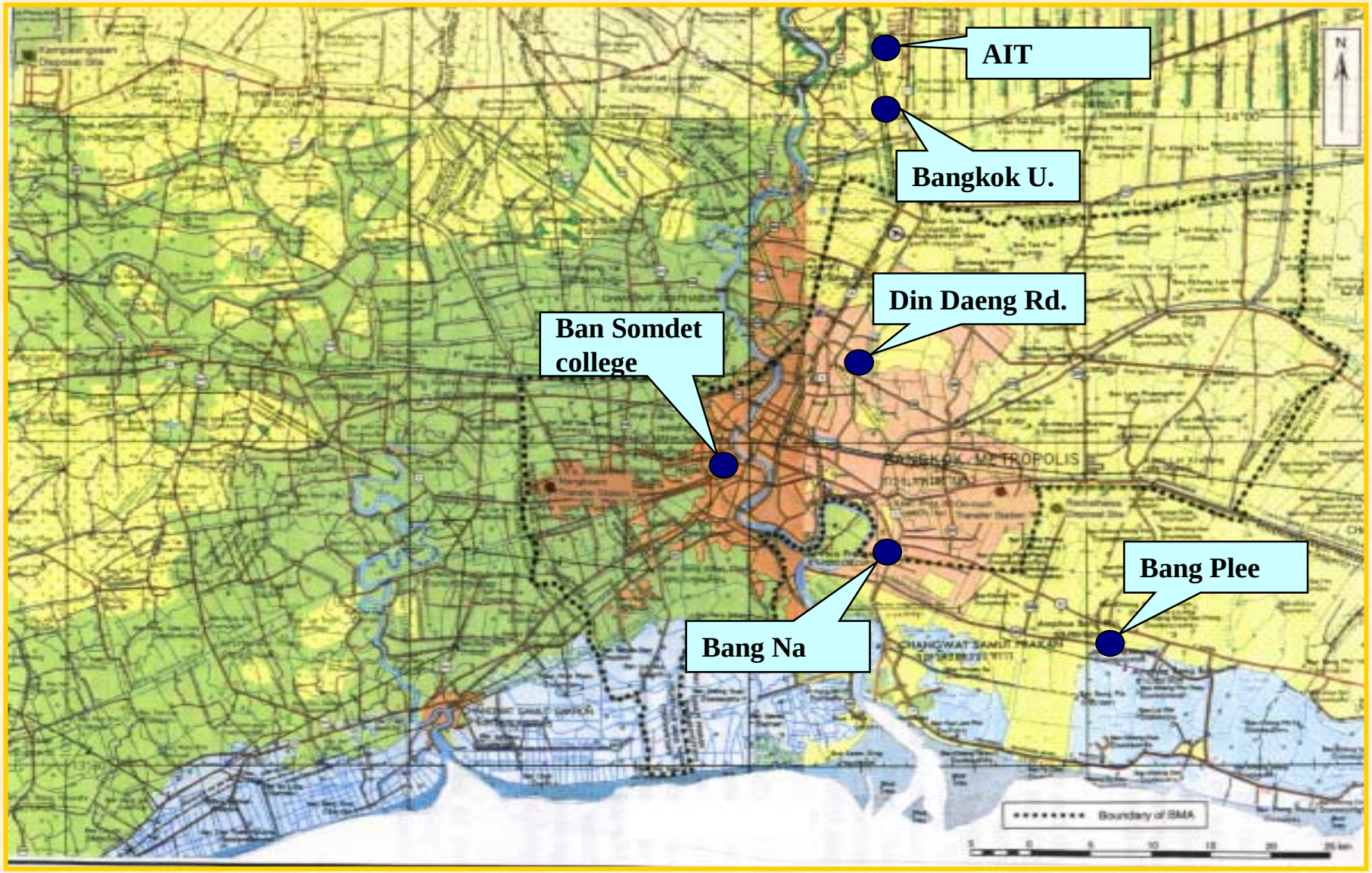
- Identify multicol. by physical & chemical judgement
  - Eliminate a source if strong physical evidence exists such as downwind sources during strong wind
  - Source selection: manual examination of source signatures and group sources with similar signatures (soil, road dust) => reduces resolution of apportionment
- Statistical measures to identify multicol. involving several sources:
  - VIF (variance inflation factor) is measure of multicol. VIF is the increase in error variance of the estimated aerosol contribution of a specific source due to multicol. alone
  - Use special statistical technique (ridge regression, regression on PCA)

Uncertainties of data

- Uncertainty of average source profiles: 2 approaches (Henry, 1982)
- Uncertainty of ambient data (for CMB8): standard deviation of the analytical methods, both gravimetric and chemical analysis ➔ for determination repeat analysis for the same sample and determine SD ➔ uncertainty of sampling?

Results of PM Apportionment for Bangkok Metropolitan Region

- Sampling equipment: Dichot
  - PM2.5 and PM10-2.5
- Source profiles: from literature some available for BMR
- Sample analysis: Mass, BC, 29 elements, and 8 ions
- Totally: over 40 parameters



Bangna: urban mixed site (industrial)
Ban Somdet: urban residential site
Bangplee: industrial site

Din Daeng: traffic site
Bangkok Unv: Sub-urban site
AIT: Upwind background

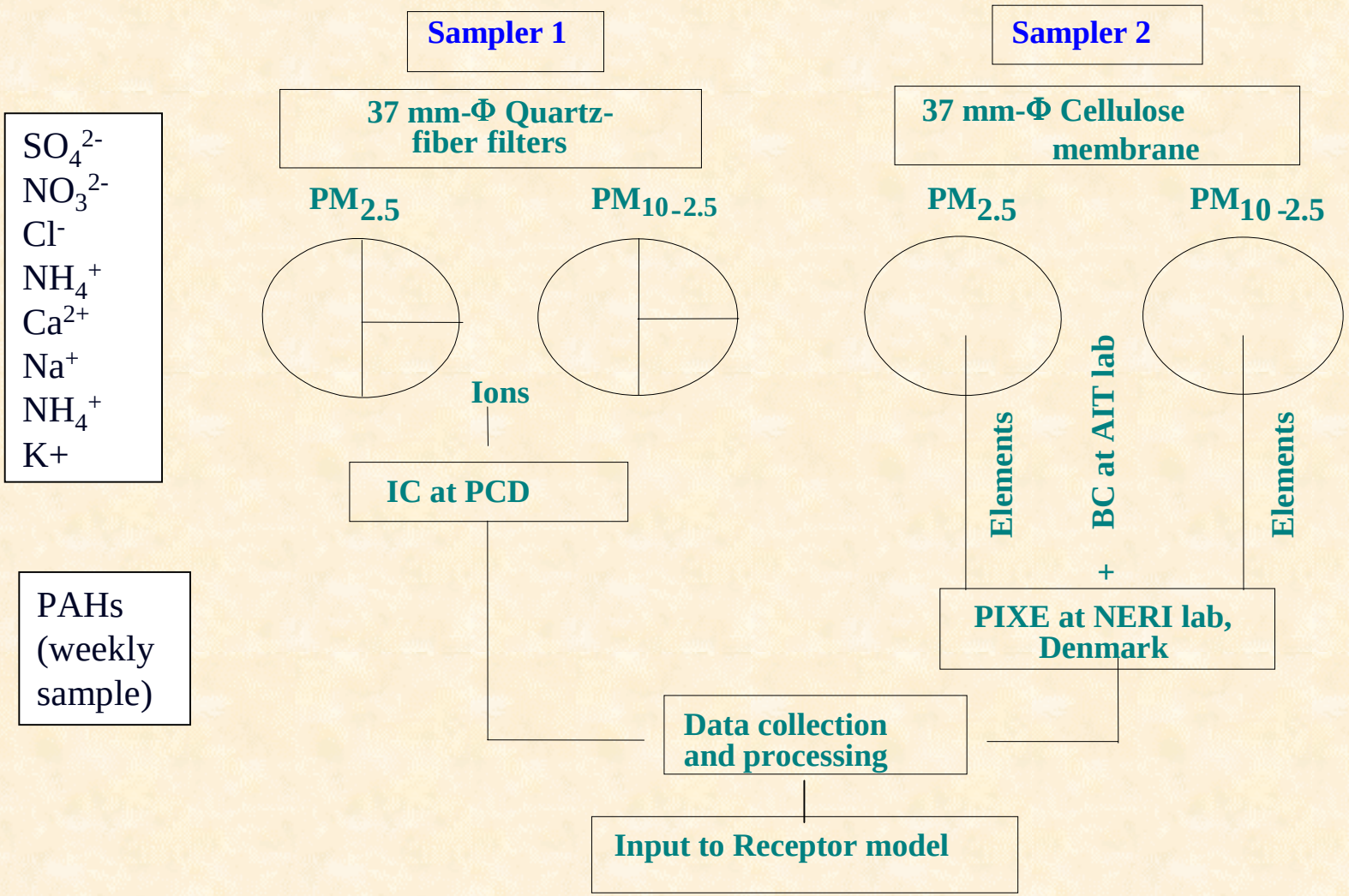
Dichotomous sampler

Flow control unit

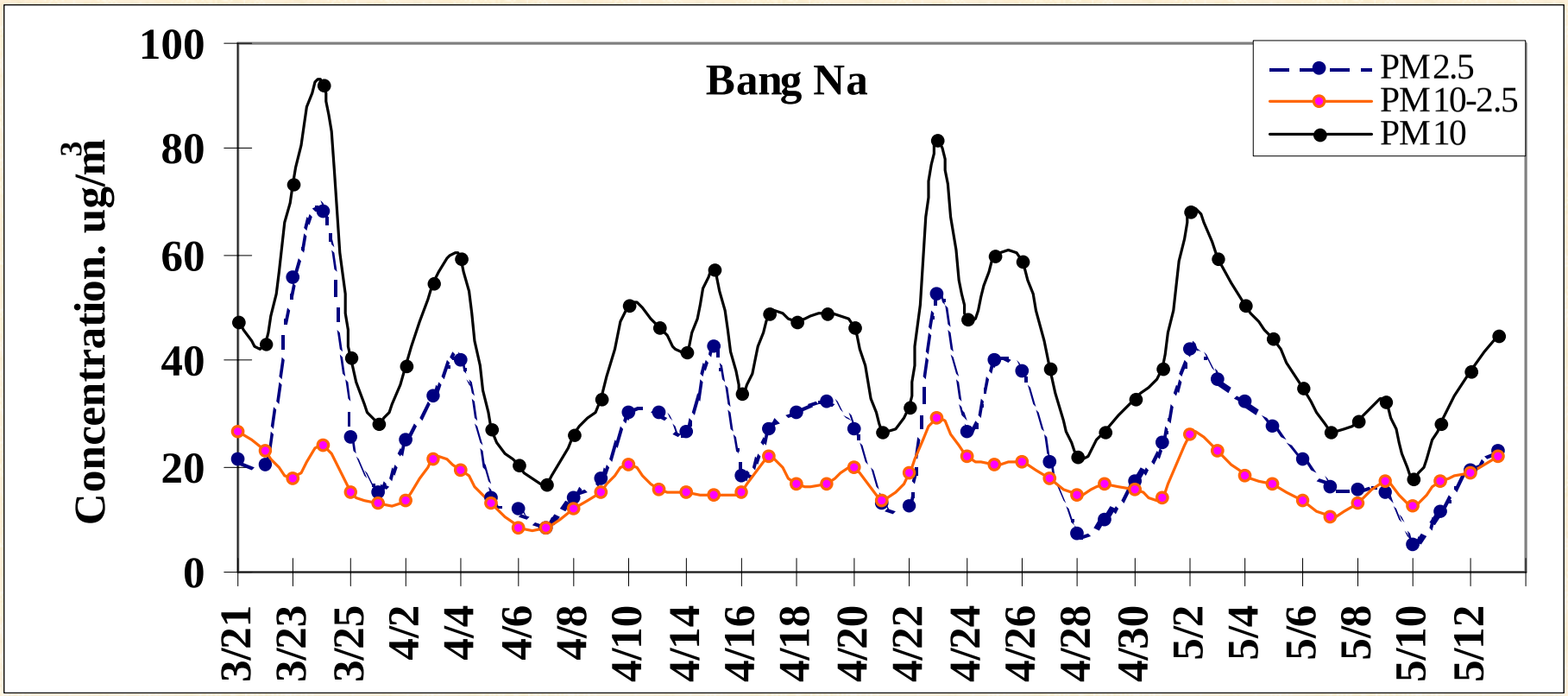
Co-location of dichot and other available samplers

- 2 dichotomous samplers at a site
- PM mass concentration comparability (not always the same)
- Different filter papers used simultaneously for different analyses

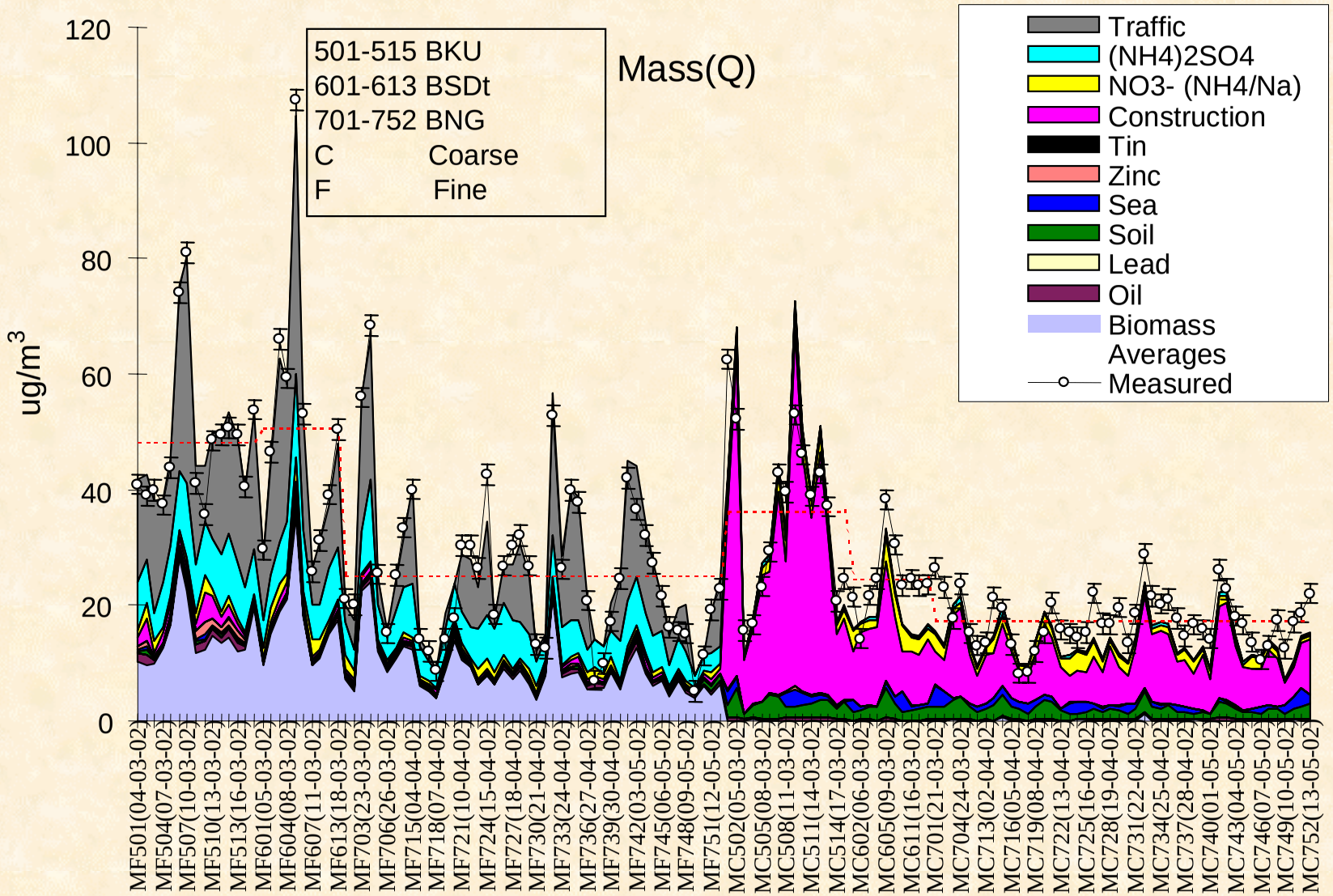
Analytical Plan for Receptor Modeling



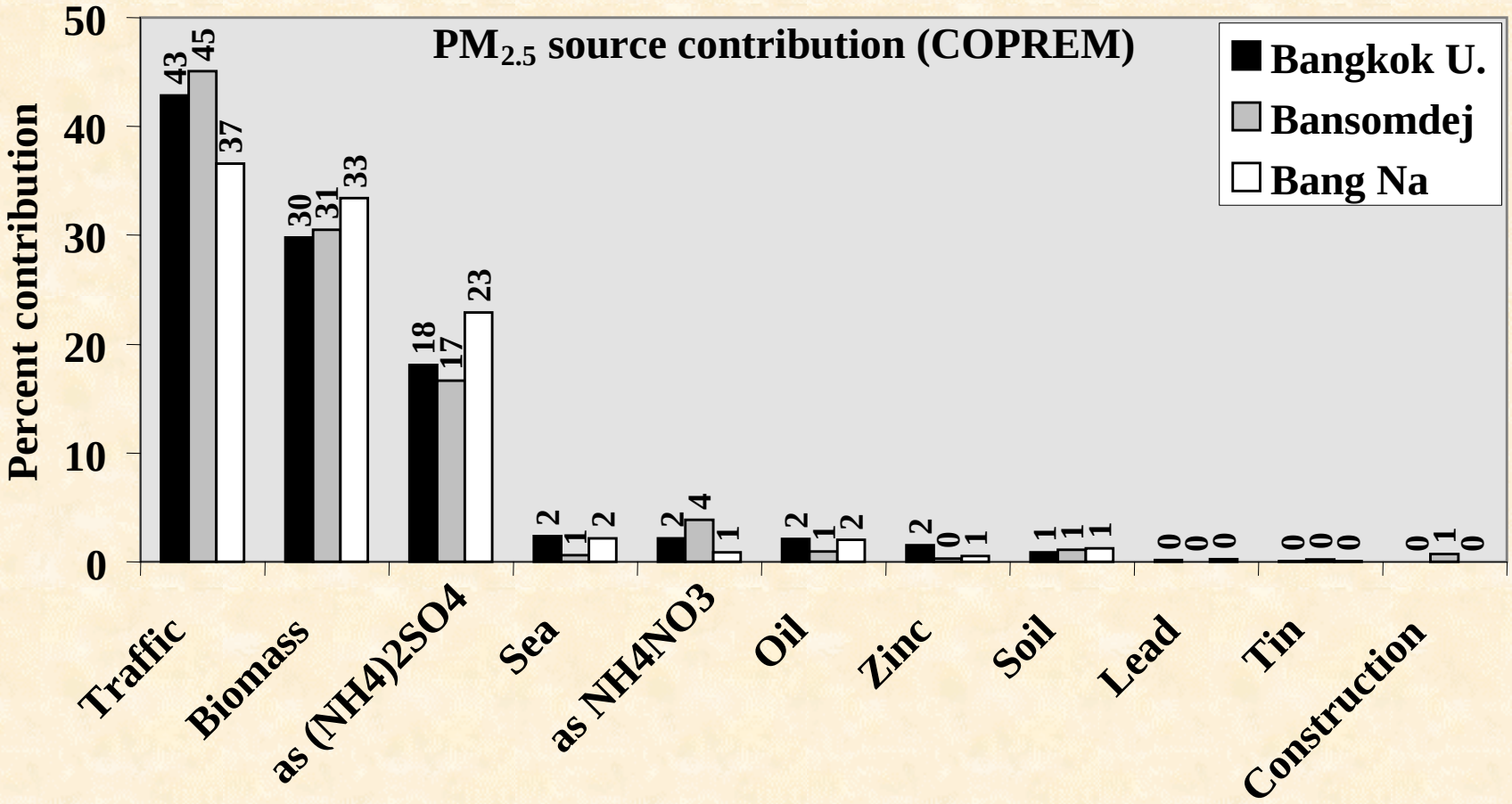
Variation of $PM_{2.5}$ and $PM_{10-2.5}$



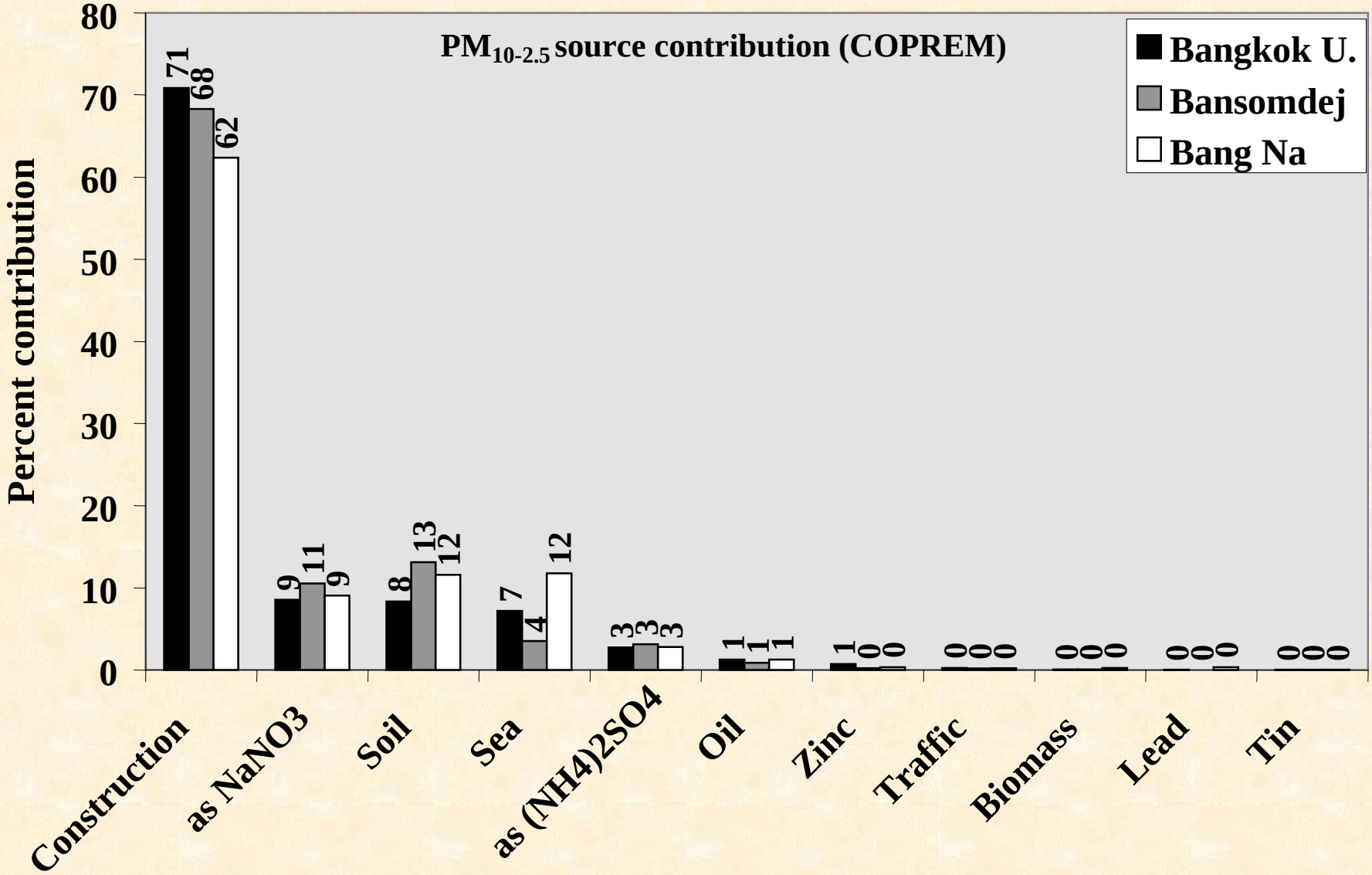
Source Apportionment by CORPREM for All Samples



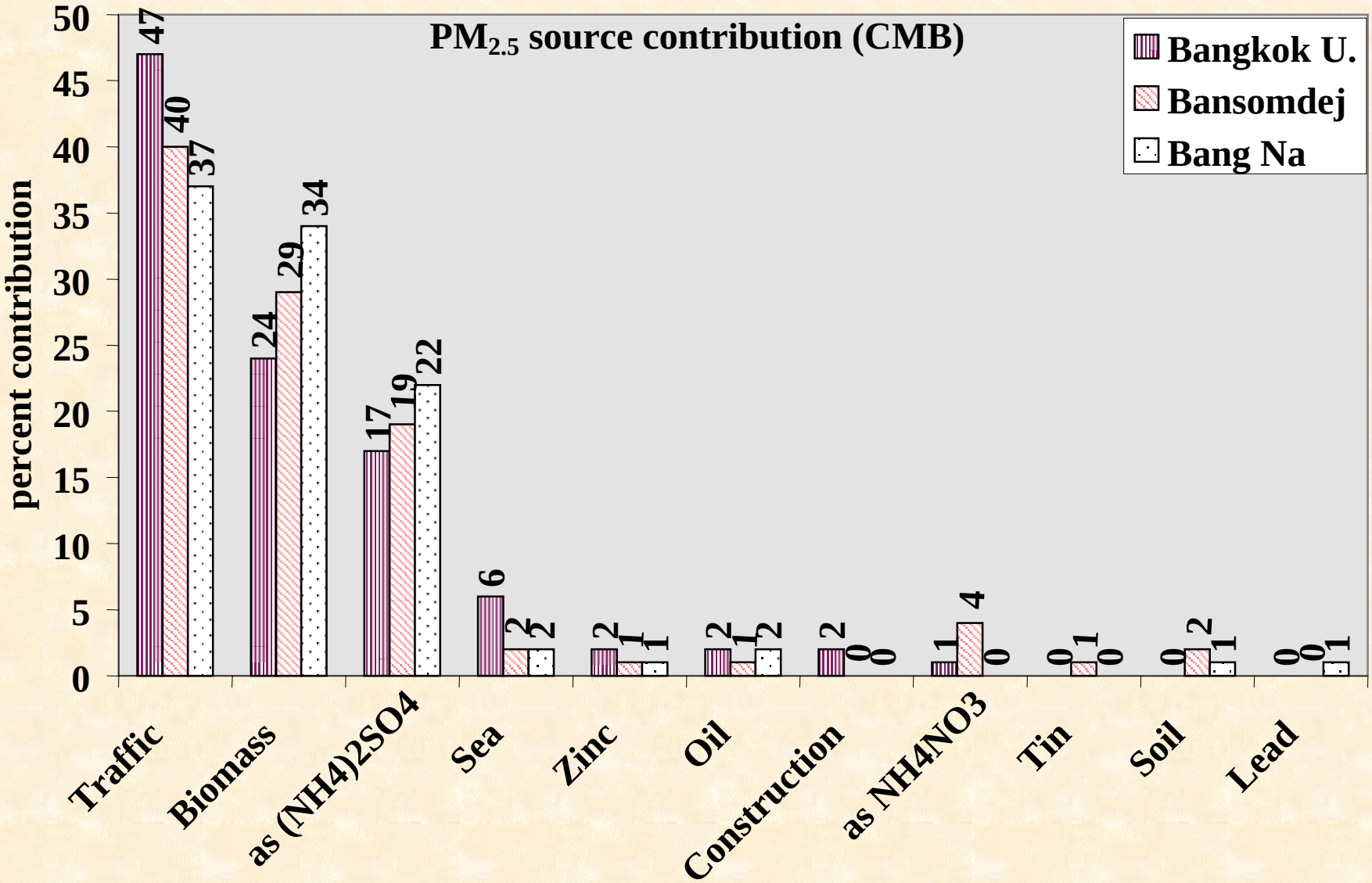
COPREM Source Apportionment



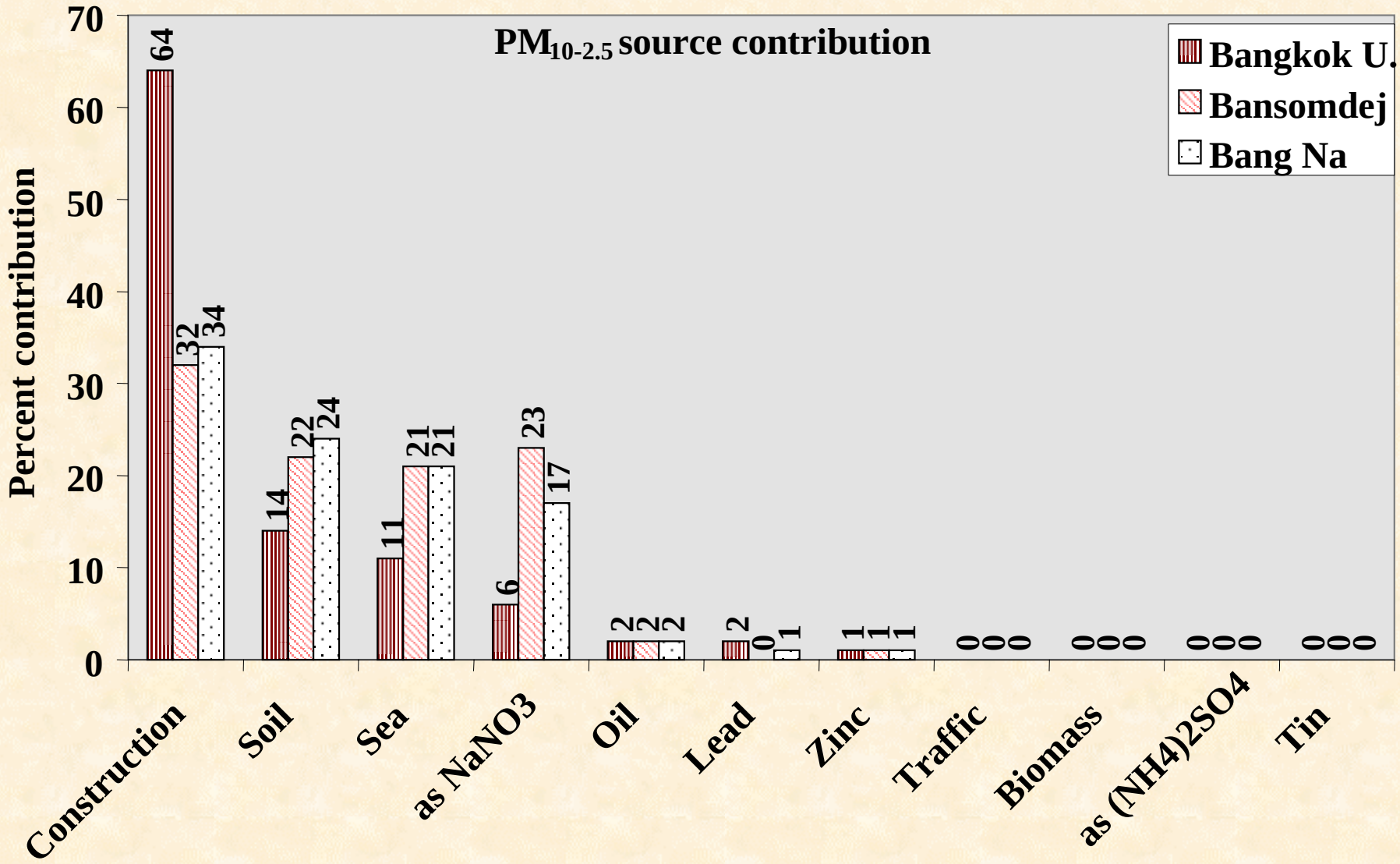
COPREM Results: Source Apportionment



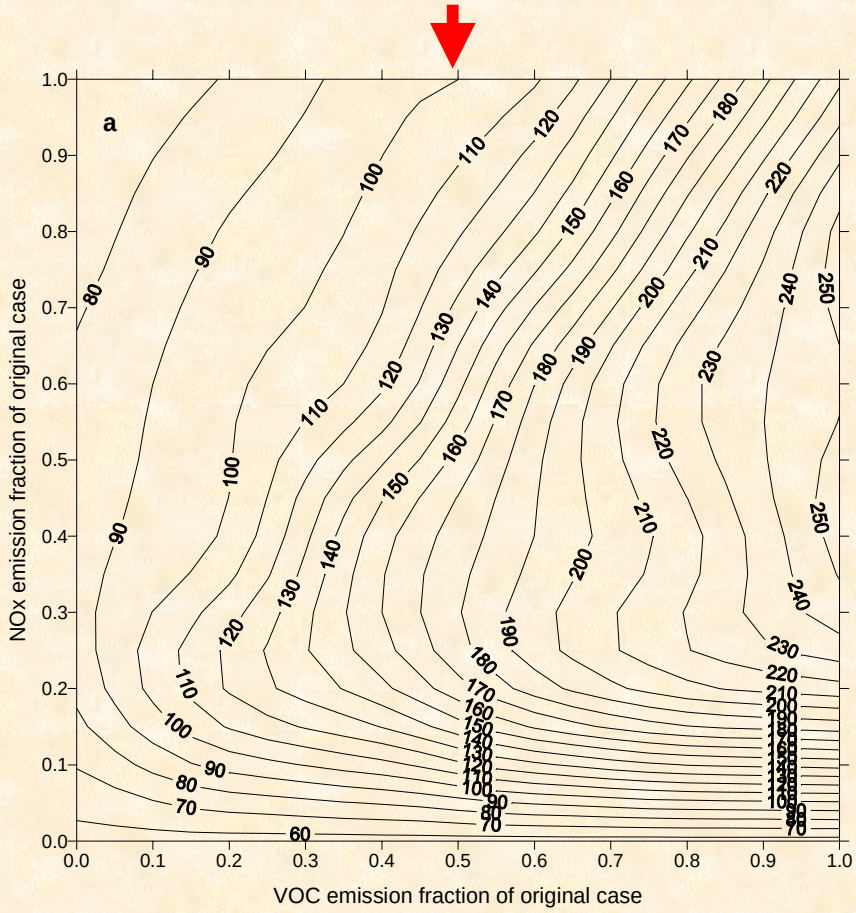
CMB Results: Source Apportionment



CMB Results: Source Contribution



Sensitivity of O_3 formation to precursor changes



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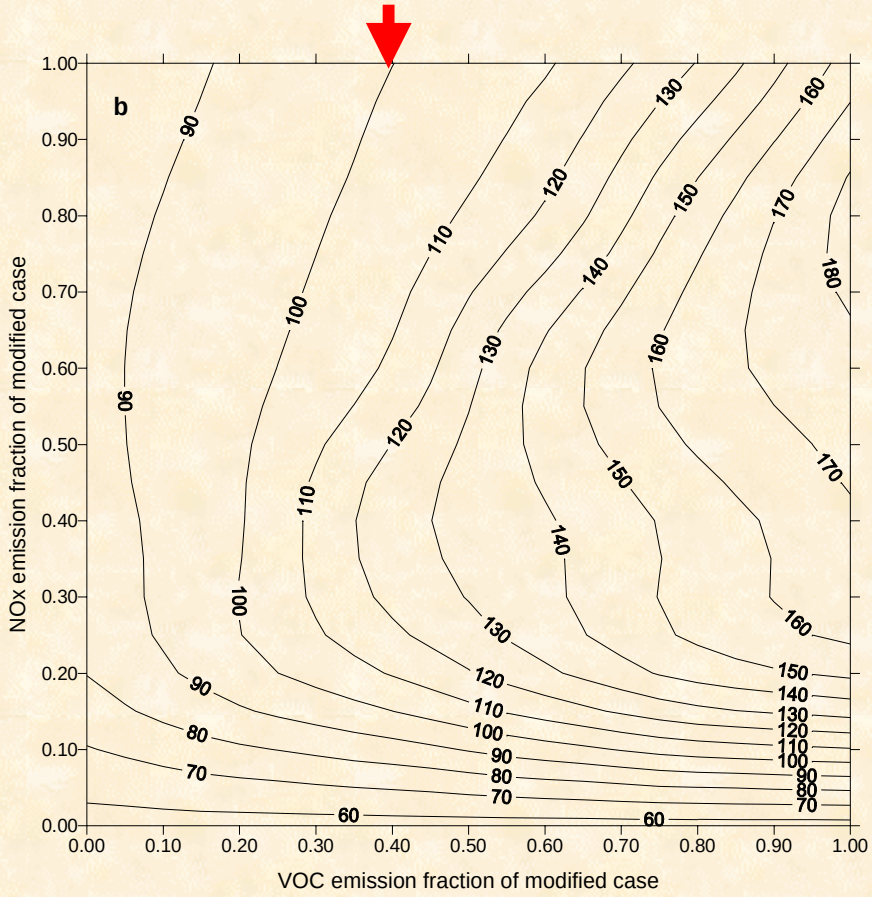
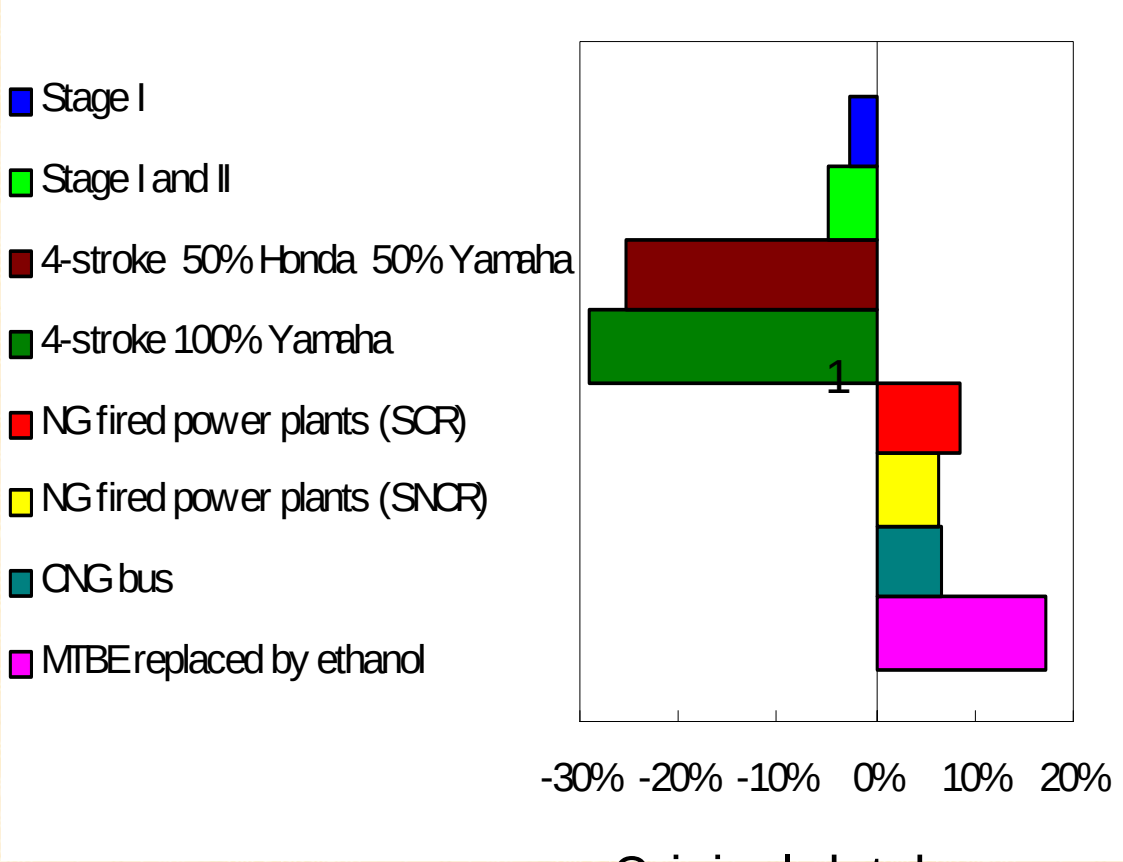


Modified database

Impact of Management Strategies on Peak 1-h O_3 in Bangkok



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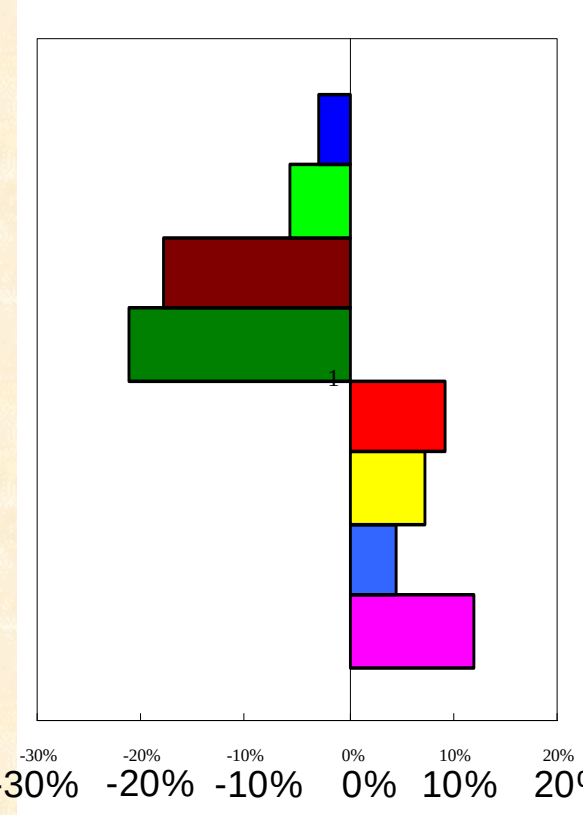

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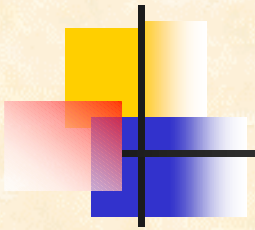

Thank you !