Size-resolved Composition and Morphology of Particulate Matter During the Southwest Monsoon in Metro Manila, Philippines

Melliza Templonuevo Cruz[1,2], Paola Angela Bañaga[1,3], Grace Betito[3], Rachel A. Braun[4], Connor Stahl[4], Mojtaba Azadi Aghdam[4], Maria Obiminda Cambaliza[1,3], Hossein Dadashazar[4], Miguel Ricardo Hilario[3], Genevieve Rose Lorenzo[1], Lin Ma[4], Alexander B. MacDonald[4], Preciosa Corazon Pabroa[5], John Robin Yee[5], James Bernard Simpas[1,3], Armin Sorooshian[4,6]

[1]Manila Observatory
[2]Institute of Environmental Science and Meteorology, University of the Philippines
[3]Department of Physics, Ateneo de Manila University
[4]Department of Chemical and Environmental Engineering, University of Arizona
[5]Philippine Nuclear Research Institute
[6]Department of Hydrology and Atmospheric Sciences, University of Arizona

Outline

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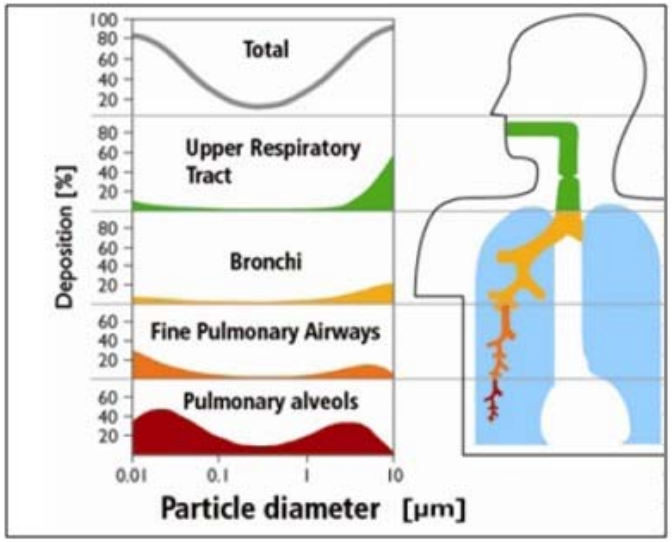
III. Results
   - Size distribution
     - Total PM mass
     - Water-soluble species
     - Black carbon
   - Morphology
   - Positive Matrix Factorization (PMF)
IV. Summary & Future Work

Motivation

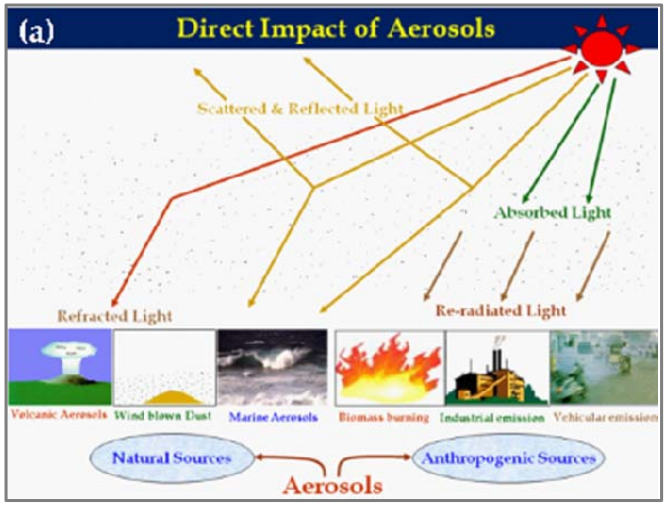
Size-dependent properties of particles govern their effects on:

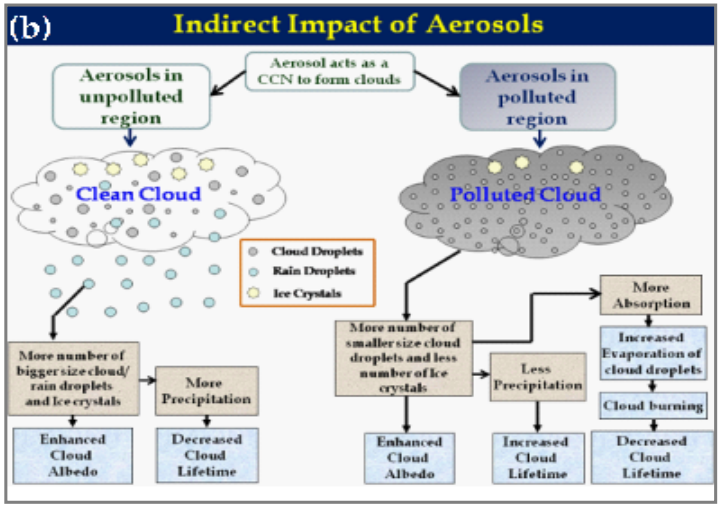
Health



Visibility

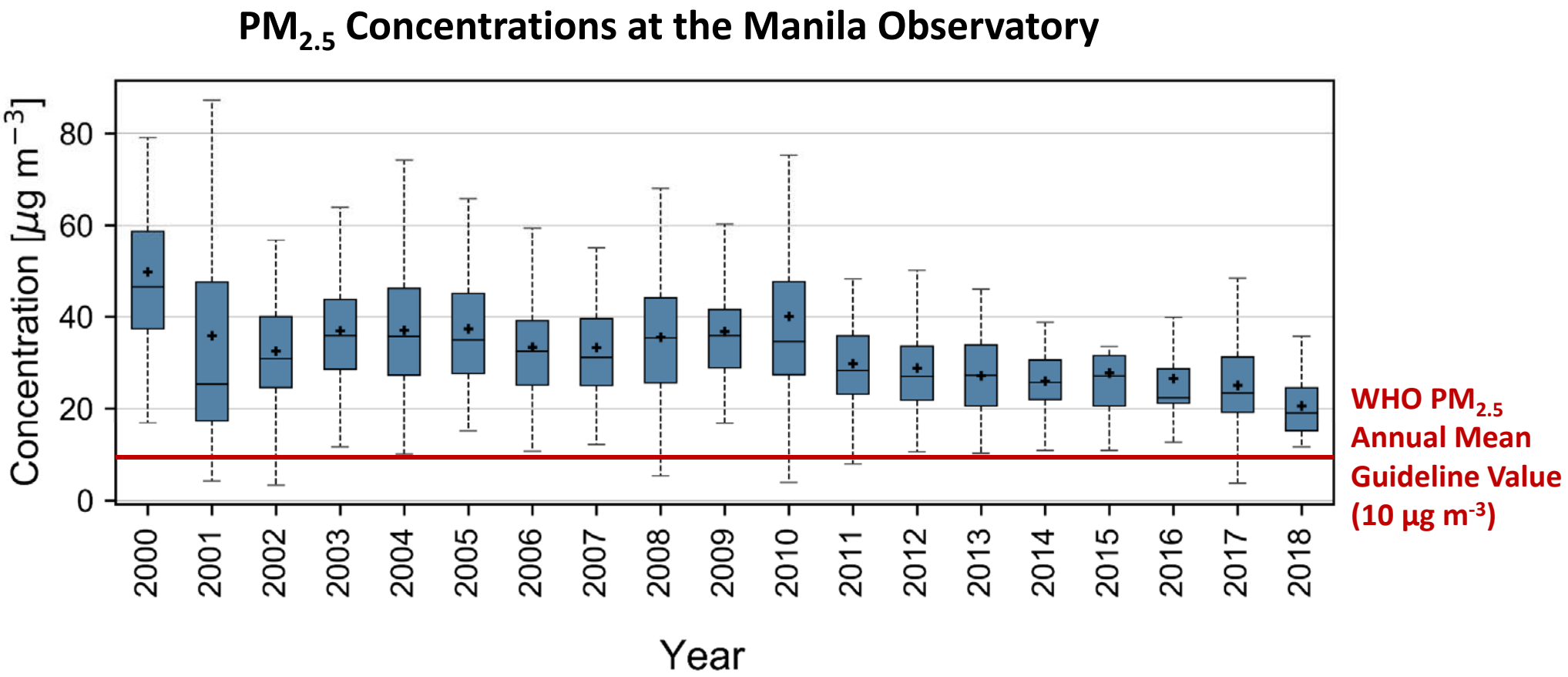
Climate



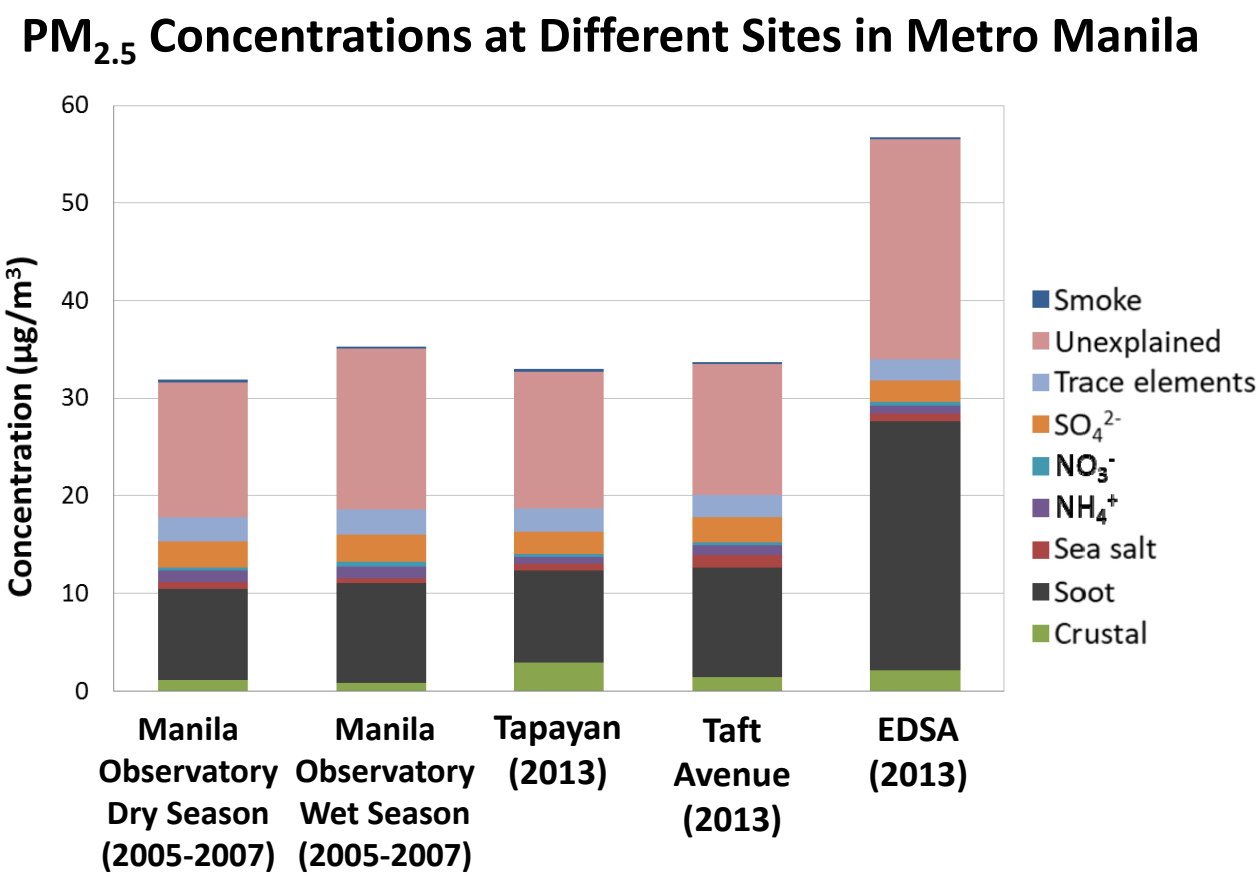


Sources: Srivastava et al., 2012; ICAO, Rappler

Motivation: Very High PM Levels in Metro Manila



Motivation: Poorly Understood Chemical Properties



Speciation has only been done for bulk $PM_{2.5}$

Objectives

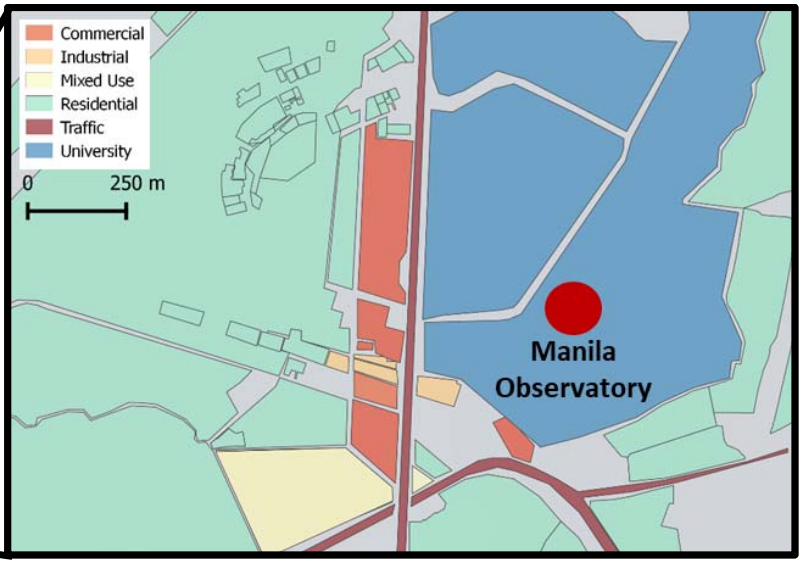
1. To report size-resolved PM mass, composition, and morphology during the Southwest Monsoon (SWM) season in Metro Manila.

2. To determine the possible sources and their contribution to the measured chemical components.

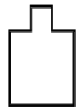
3. To provide baseline data of aerosol composition to be used to inform and assist research to be conducted during the CAMP^{2}Ex campaign.

Study Site


AH26
C-5
170
AH26
C-4
R-9
C-3
AH26
C-5
R-7
174
R-8
R-7
150
R-6
R-10
AH26
R-6
C-5
R-2
R-4
AH26
R-1
C-4
C-5
Ninoy Aquino International Airport
R-2
Manila Bay


Commercial
Industrial
Mixed Use
Residential
Traffic
University
0
250 m
Manila Observatory

Sampling and Analyses



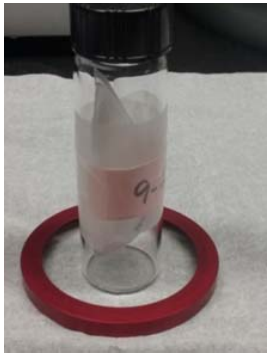
Inlet	
S1	> 18 µm
S2	10 - 18 µm
S3	5.6 - 10 µm
S4	3.2 - 5.6 µm
S5	1.8 - 3.2 µm
S6	1 - 1.8 µm
S7	0.56 - 1 µm
S8	0.32 - 0.56 µm
S9	0.18 - 0.32 µm
S10	0.1 - 0.18 µm
Spacer (S11)	0.056 - 0.1 µm
After filter (S12)	< 0.056 µm

Micro-Orifice Uniform Deposit Impactor (MOUDI)

Methodology

MOUDI 120, MSP Corp.

Teflon substrate



Extract by sonicating with Milli-Q water

Organic and inorganic ions
Ion Chromatography (IC),
Thermo Scientific Dionex ICS-2100

Elemental composition
Inductively Coupled
Plasma Mass Spectrometry
(ICP-QQQ), Agilent 8800 Series

Methodology

Aluminum Substrate

University of Arizona

Morphology and additional elemental composition
SEM-EDX, Hitachi S-4800 & Thermo Fisher Scientific

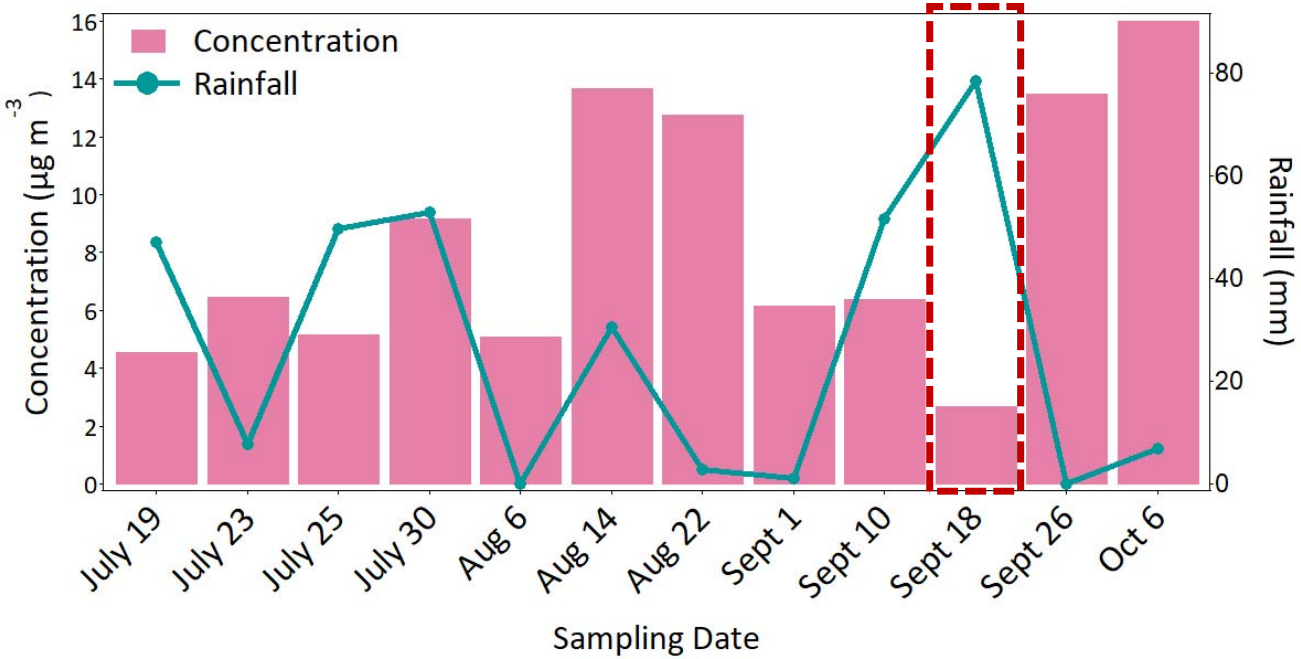
Teflon substrate

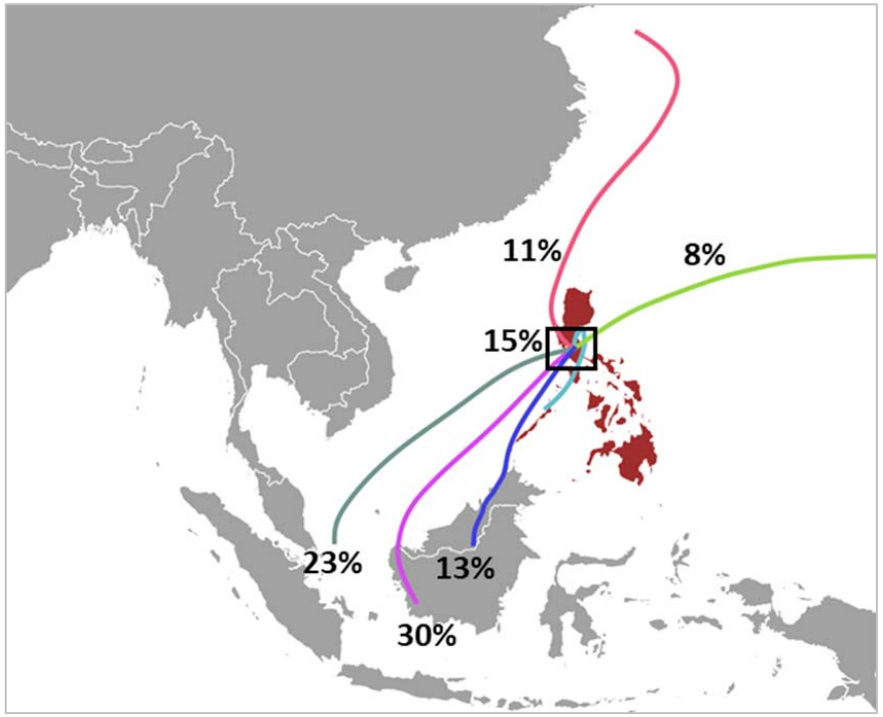
Mass
Sartorius ME5-F microbalance

Black Carbon
Multi-wavelength Absorption Black Carbon Instrument (MABI), ANSTO

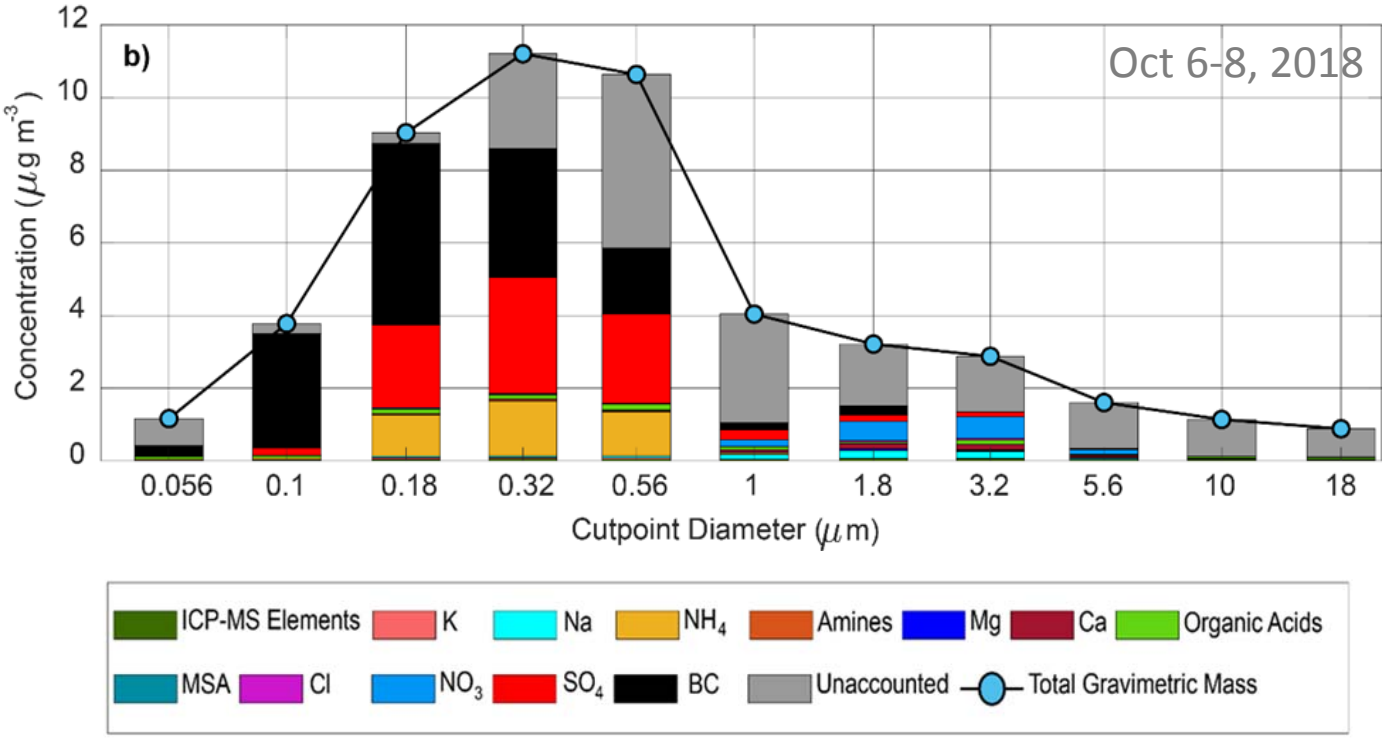
Sampling Parameters & Conditions

Concentration of Water-soluble Species During the Sampling Period





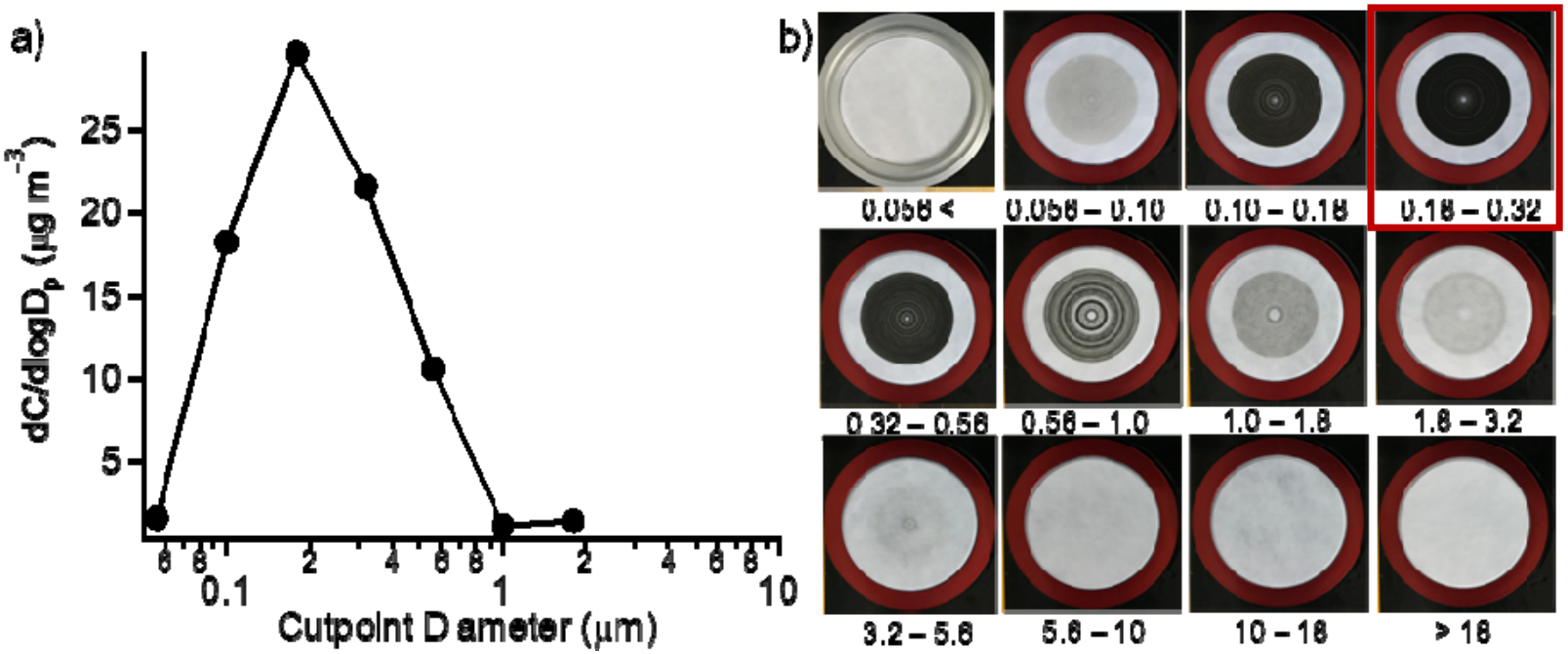
Mass Size Distribution of PM and its Components



Total Mass Concentration: 53.0 µg m^{-3}

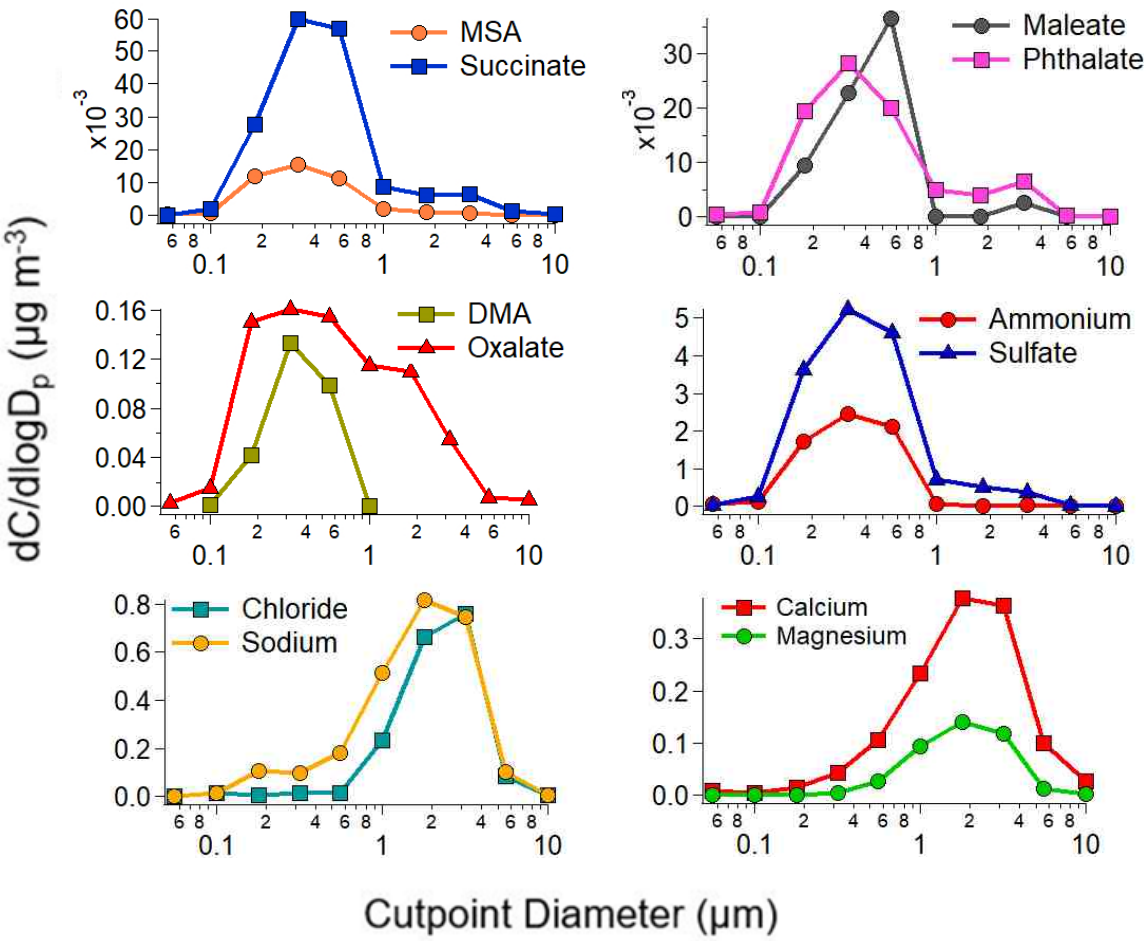
31.3% water-soluble species, 26.9% BC, 41.8% Unaccounted

Black Carbon



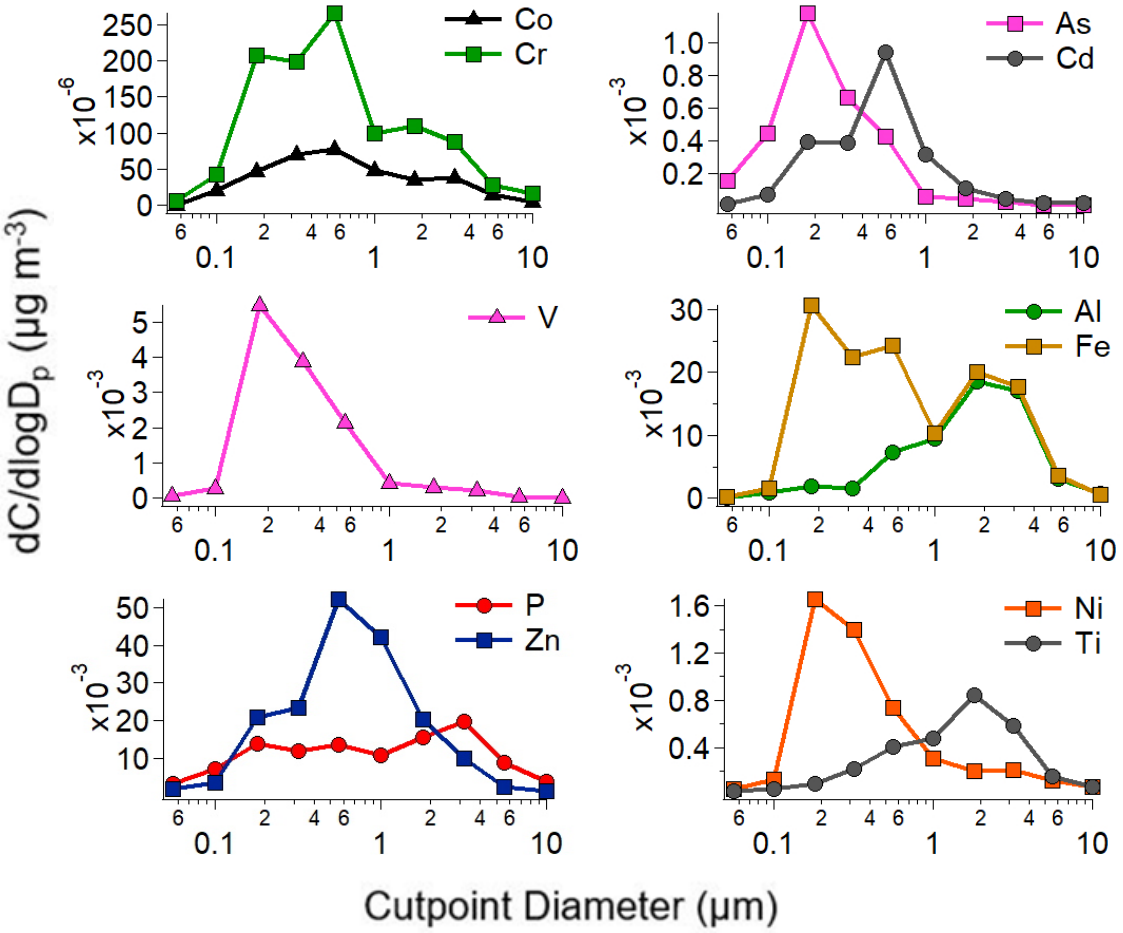
- Pronounced peak between 0.18–0.32 µm: 5.0 µg m^{-3}
- Total BC mass concentration integrated across all stages: 14.3 µg m^{-3}

Water-soluble Components (Ions)



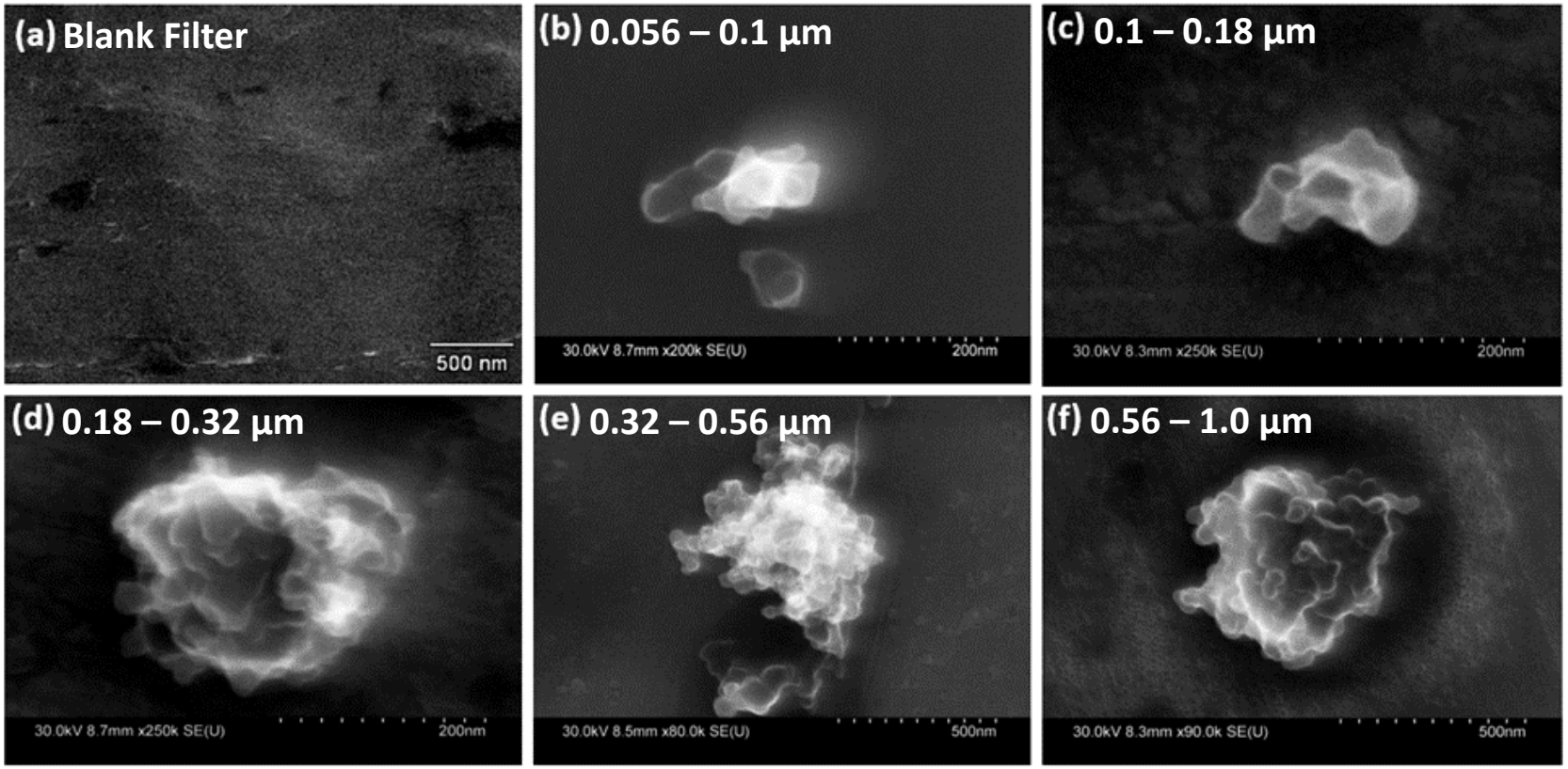
- Mass concentration mode between 0.32–0.56 µm: Secondarily produced species
- Mass concentration mode between 1.8–5.6 µm: Species related to sea salt and crustal materials

Water-soluble Components (Elements)



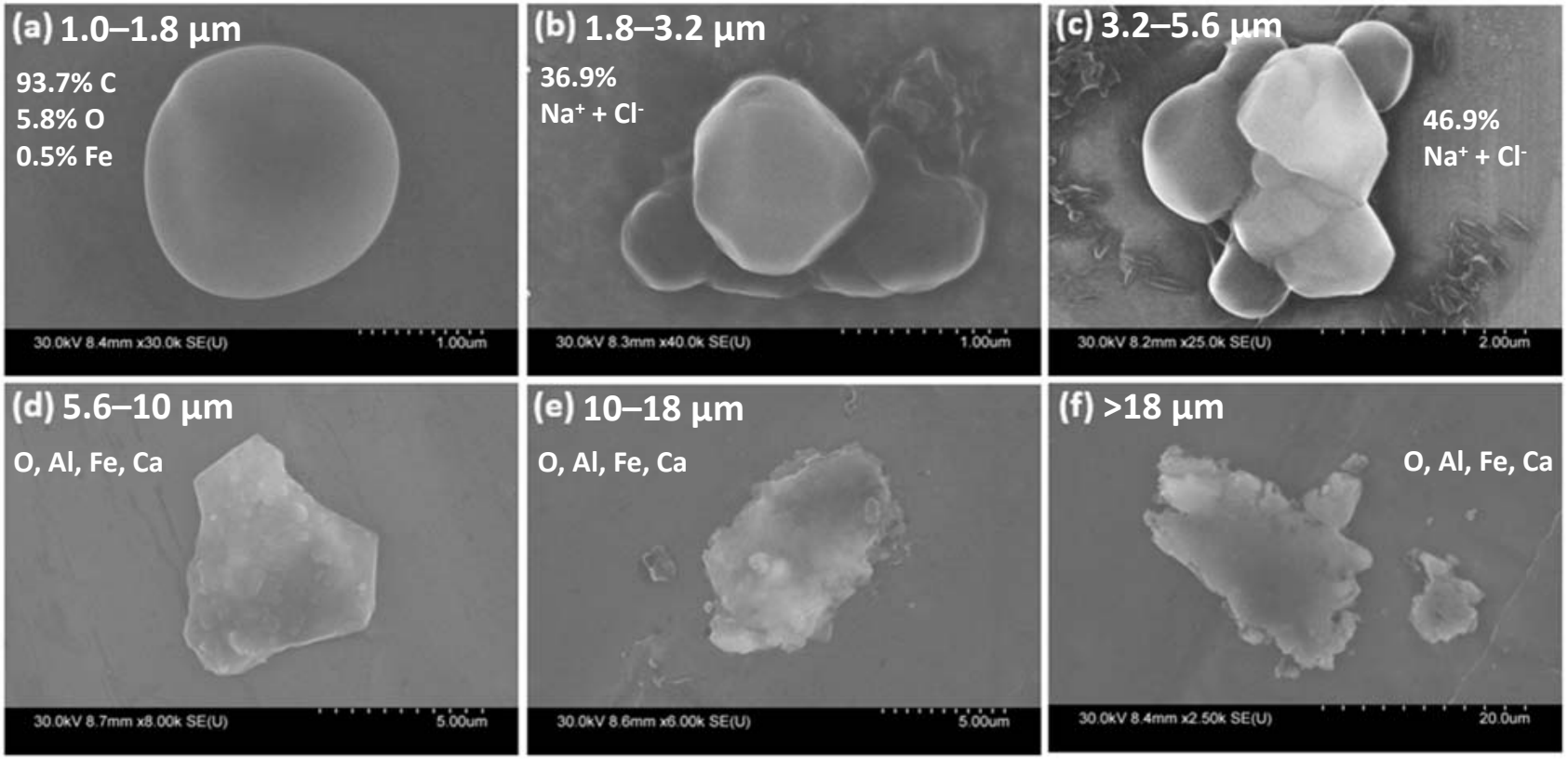
- Mass concentration mode between 0.18 – 0.56 µm: Species related to combustion sources
- Mass concentration mode > 1.0 µm: Species related to crustal materials
- Mass concentration mode in both sub- and supermicrometer stages: Fe which could be from combustion and crustal materials

Microscopy Analysis (Submicrometer Fraction)



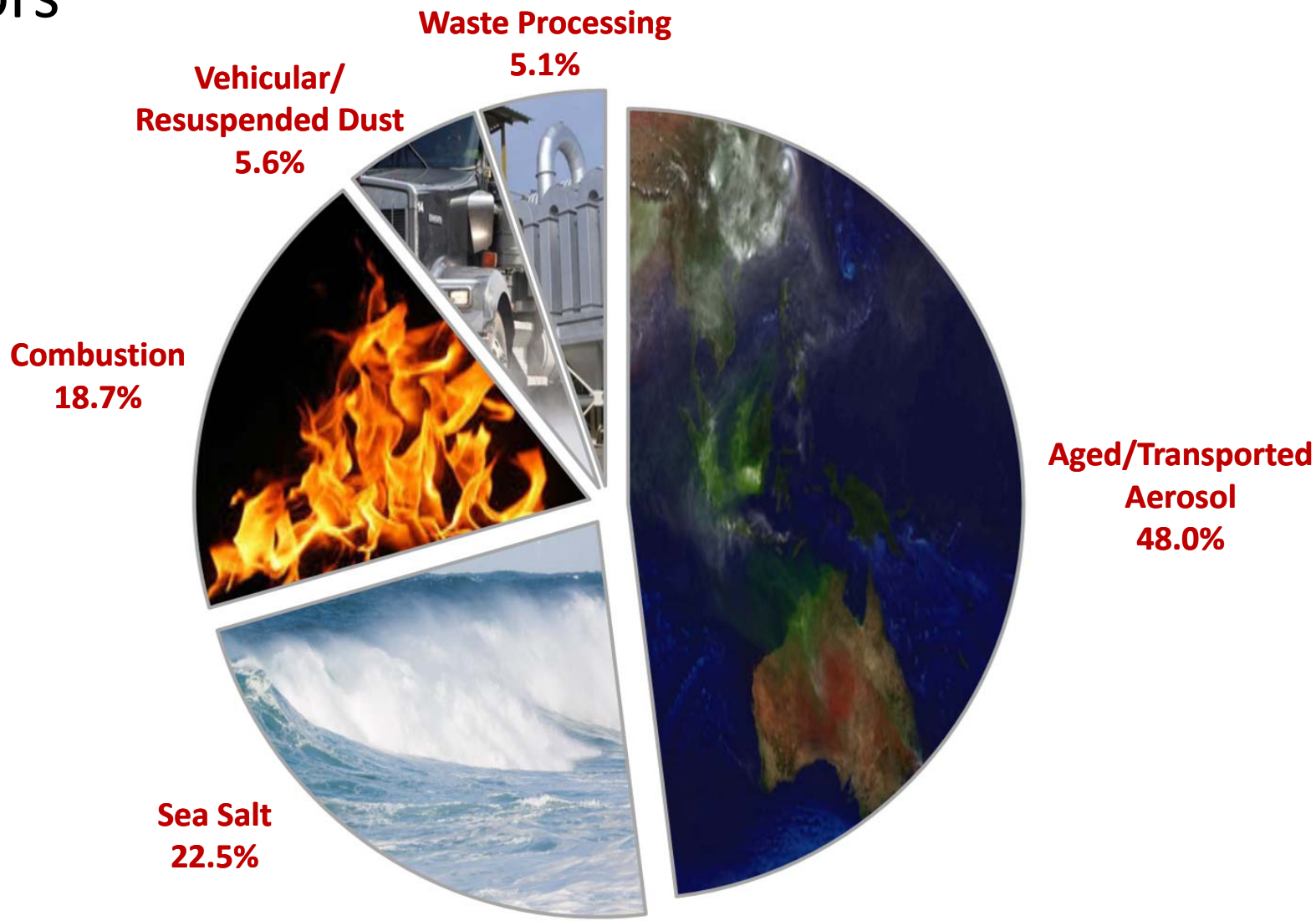
- Contrary to assumptions of sphericity in models, non-spherical particles were observed in all stages below 1.0 µm.
- Agglomeration of spherical particles formed through gas-to-particle conversion processes could potentially explain the appearance of observed particles.

Microscopy Analysis (Supermicrometer Fraction)

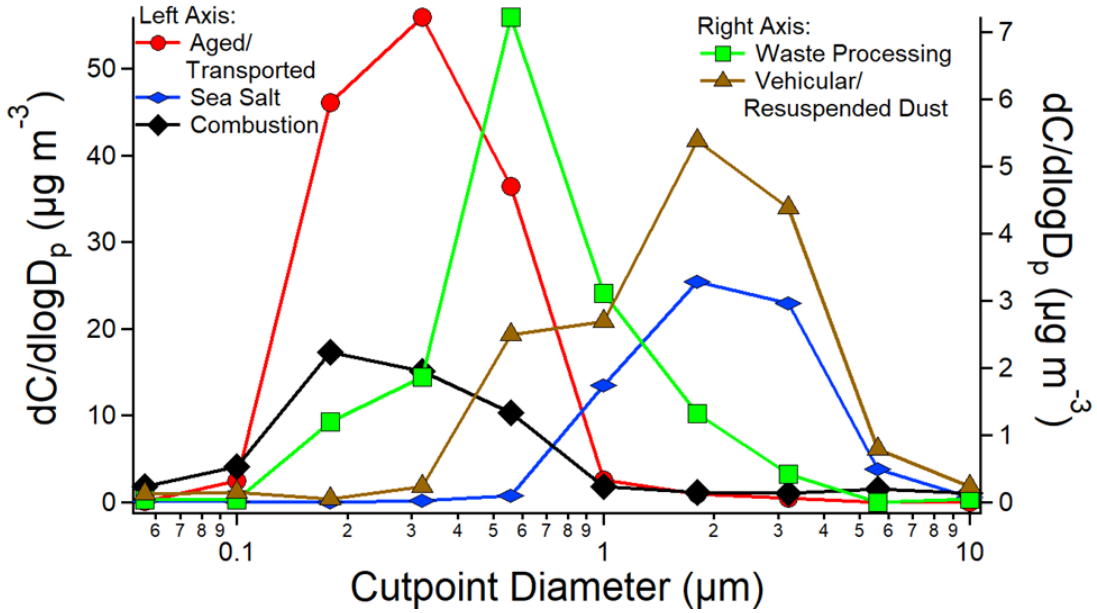


- As expected of sea salt and crustal material, most of the observed particles were not spherical.
- Only the particle in the 1.0 – 1.8 µm stage was close to being spherical.

PMF Factors


Waste Processing
5.1%
Vehicular/
Resuspended Dust
5.6%
Combustion
18.7%
Aged/Transported
Aerosol
48.0%
Sea Salt
22.5%

PMF Reconstructed Mass Size Distribution



Diameter Range (µm)	Aged/Transported	Sea Salt	Combustion	Vehicular/Resuspended Dust	Waste Processing
> 0.056	48.0%	22.5%	18.7%	5.6%	5.1%
0.056 – 1.0	68.9%	0.6%	23.9%	1.5%	5.1%
> 1.0	18.6%	53.5%	11.3%	11.3%	5.3%

Summary

1. Most of the total PM mass as well as 95% of the BC mass was in $D_p < 1.0$ µm.
2. BC and the water-soluble species accounted for 58% of the total PM mass with most of the unresolved mass in $D_p > 0.32$ µm.
3. Potential sources of the water-soluble fraction are Aged/Transported Aerosol, Sea Salt, Combustion, Vehicular/Resuspended Dust, and Waste Processing.
4. Future work will focus on Cl- depletion as well as seasonal variations of PM and its composition.

Acknowledgments

Manila Observatory Scientists and Staff
University of Arizona Scientists
Phil. Nuclear Research Institute

PMF Factor Profiles