The Application of Microscopic Chemical Imaging to Determine the Sources Contributing to $PM_{2.5}$ in Shanghai

Alan W. Gertler[1], Danny Moshe[2], Dongfang Wang[3], and Juntao Huo[3]

[1] Division of Atmospheric Sciences, Desert Research Institute, Reno, Nevada

[2] GreenVision Systems, Ltd., Tel Aviv, Israel

[3] Shanghai Environmental Monitoring Center, China

Background

- World Health Organization ranked Shanghai as the seventh most polluted megacity, having an average $PM_{2.5}$ level of 52 $\mu g/m^3$ during the period of 2011-2015 (WHO, 2016).
- Wu et al. (2017) applied a series of economic models to estimate the costs and impacts of $PM_{2.5}$ air pollution in Shanghai (in 2030):
  - 192,400 excess deaths
  - loss of 2.26% of GDP

What are the Sources of PM?: Examples of Previous Estimates of Source Contributions

- Lu et al. (2012): soot particles and fly ash were the major sources.
- Wang et al. (2013): traffic, industrial sources, and resuspended geological material dominated.
- Wang et al. (2016): based on the carbonaceous fraction - a greater contribution from mobile sources than coal combustion.

- Studies have been limited in scope and duration.

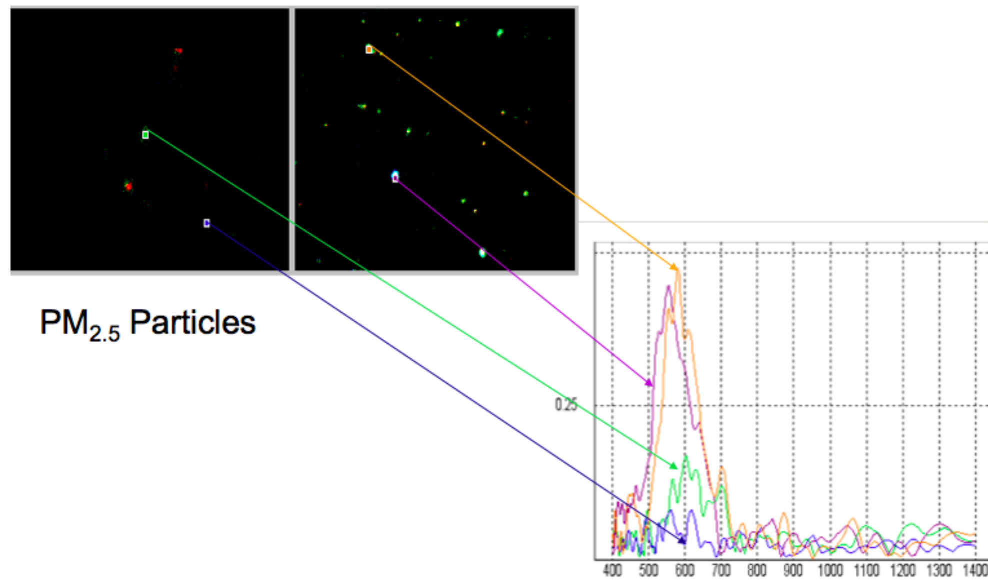
Objectives

- Overarching goal was to determine the sources contributing to ambient $PM_{2.5}$ in near-real time.

- Specific objectives included:
  - Proof of concept for the use of microscopic chemical imaging (MCI) for source apportionment in Shanghai.
  - Provide temporally resolved source contributions.
  - Demonstrate the ability to provide actionable results (i.e., within a timeframe that can allow for control strategies to be implemented).

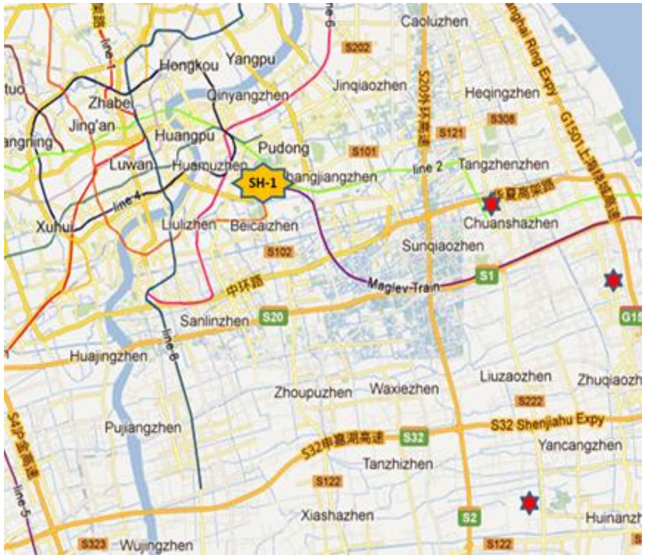
Microscopic Chemical Imaging

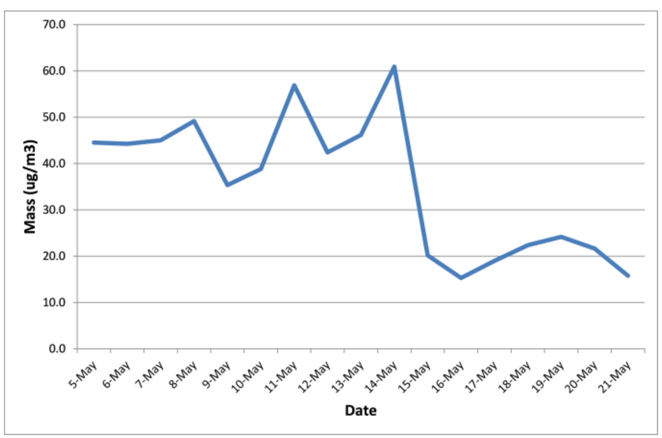
- Spectroscopic technique
- Builds upon “enhanced” CMB where PAHs are used as additional markers
- No sample prep
- Near-real time analysis and apportionment
- Correlates with CBM approach
- Also provides morphological Information (particle size, shape and density)



$PM_{2.5}$ Particles

Monitoring Location and Dates

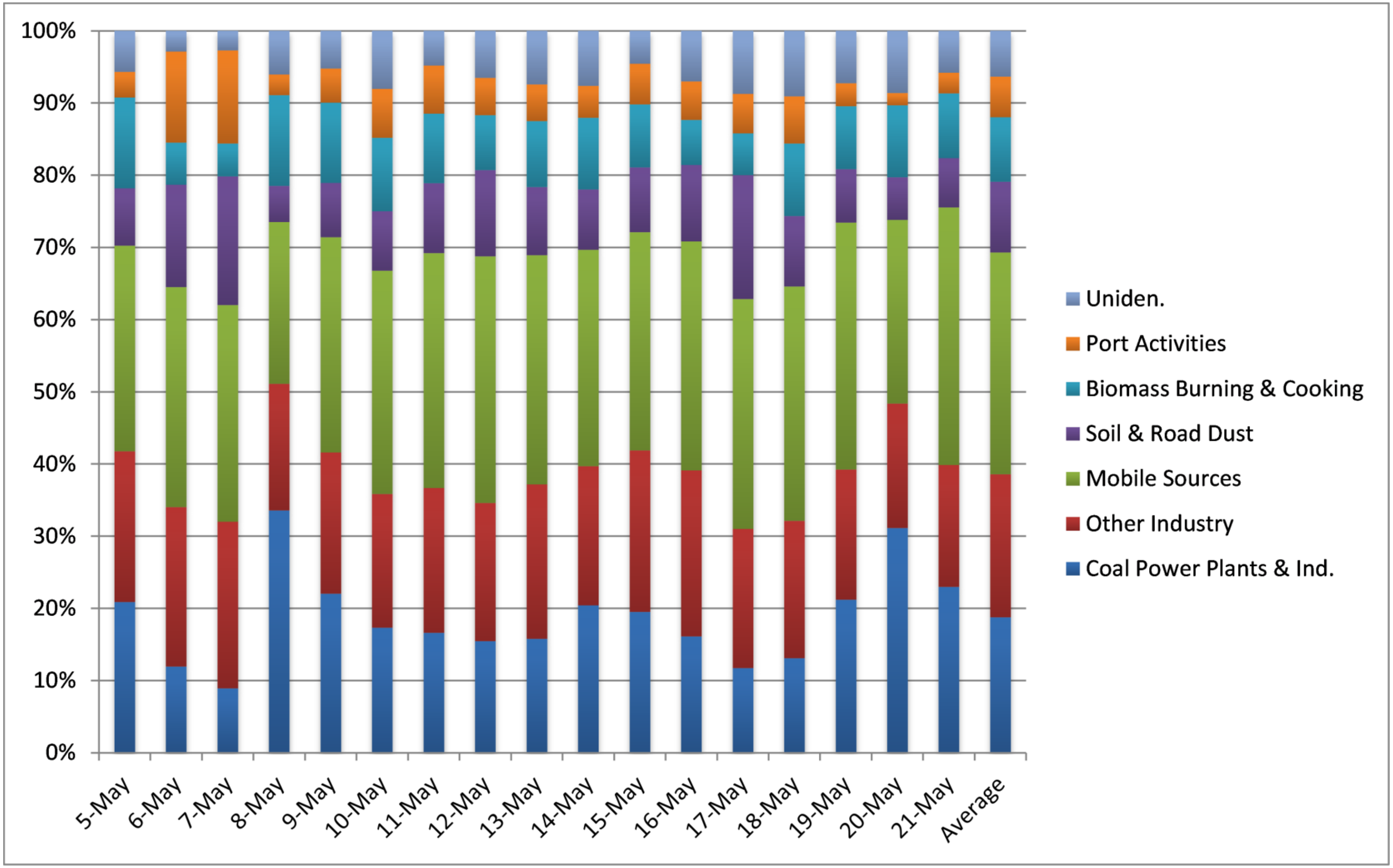




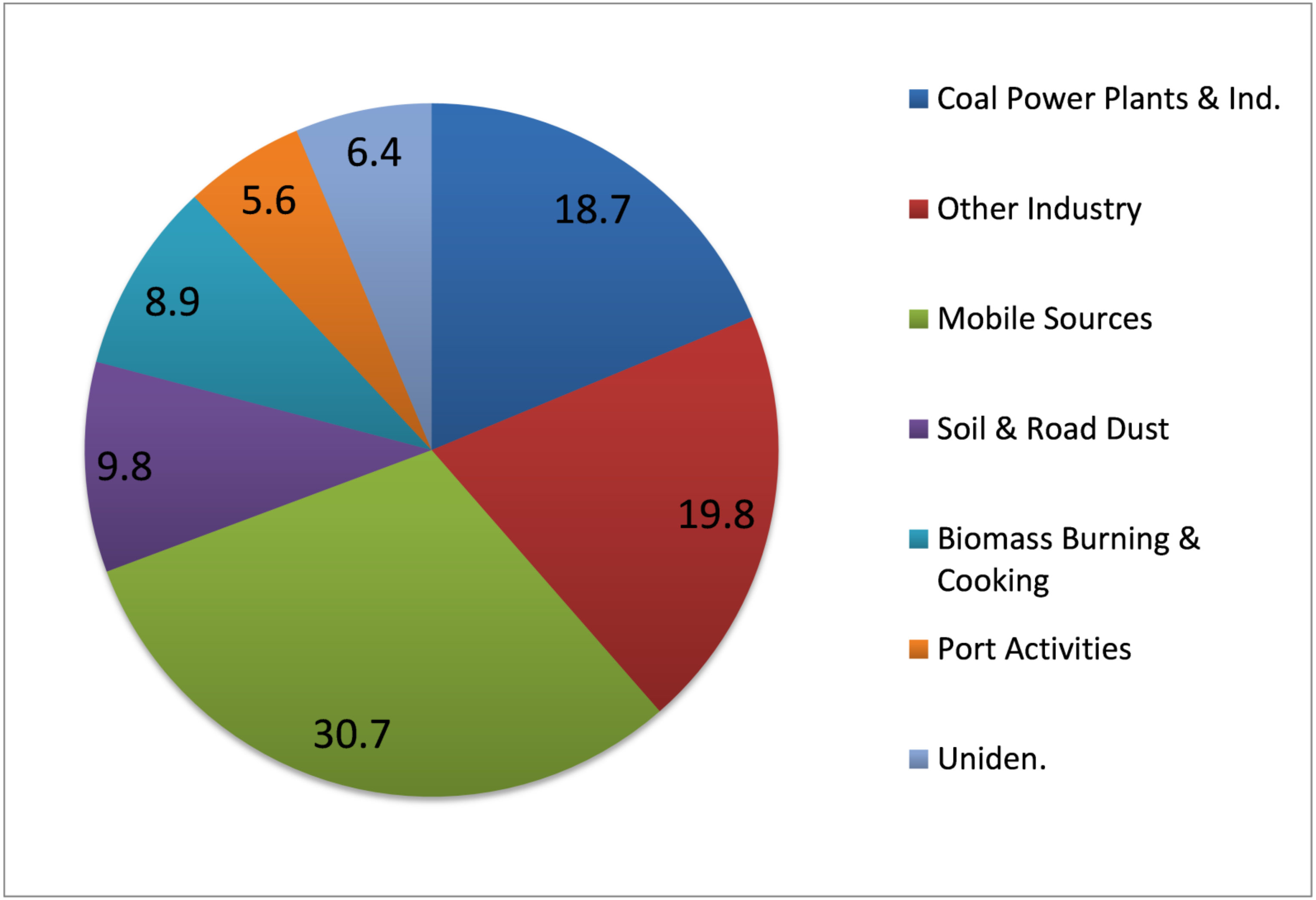
PM2.5 levels during the study

- Sampling conducted May 5-21, 2017.
- Sampling periods ranged from 4 to 12 hours.
- SEMC Pudong monitoring site - characterized as a residential/business area.

24-hr Source Contributions (%)



Average Source Contribution (%)



Summary and Conclusions

- Source apportionment results were provided in near-real time at one location during the period May 5-21, 2017.
- The MCI approach was shown to be an effective tool for assessing the sources contributing to $PM_{2.5}$ levels in Shanghai.
- Largest source was from the mobile source sector
  - mobile sources > industrial activity > coal-fired industrial sources > geological material > biomass burning and cooking > port activities
- Recommendations:
  - additional source apportionment monitoring be implemented over an extended period and at additional locations to better assess the spatial and temporal variability in source contributions
  - investigate control strategies for biomass burning/cooking and port activities, in addition to existing strategies for mobile sources, coal and industrial sources, and geological

Thank You

We would like to acknowledge:

- Financial and logistical support received from SEMC.
- In-kind, technical, and staff support from GVS.
- Sabbatical funding (AG) received from DRI and the Lady Davis Fellowship Foundation at the Hebrew University.