# Preliminary Insights from Ground-Based Particulate Matter Monitoring in the Primary Target Areas of the Multi-Angle Imager for Aerosols (MAIA) Investigation: A Focus on Developing Countries

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➤ NASA and the Italian Space Agency (Agenzia Spaziale Italiana, ASI) are jointly implementing the Multi-Angle Imager for Aerosols (MAIA) mission. The NASA-sponsored part of the science investigation will explore the association between PM types and adverse health outcomes.

➤ A set of 11 Primary Target Areas (PTAs) around the world has been selected for conducting the MAIA investigation.

➤ Fabrication of the MAIA instrument was completed in October 2022 and its launch is anticipated to occur in 2025 with a nominal 3-year mission duration.

➤ The MAIA satellite instrument will collect targeted measurements of aerosol microphysical properties.

➤ Satellite retrievals will be integrated with measurements from a network of ground-based PM monitors and outputs of a chemical transport model to generate daily maps of near-surface total PM_{10}, total $PM_{2.5}$, and speciated $PM_{2.5}$ (sulfate, nitrate, organic carbon, elemental carbon, and dust) mass concentrations at 1-km spatial resolution.

➤ The ground-based ambient PM data collection has begun in all PTAs. This poster summarizes the preliminary PM monitoring results collected in 2022-2023.

MAIA Target Areas

Target area dimensions: 360 km x 480 km
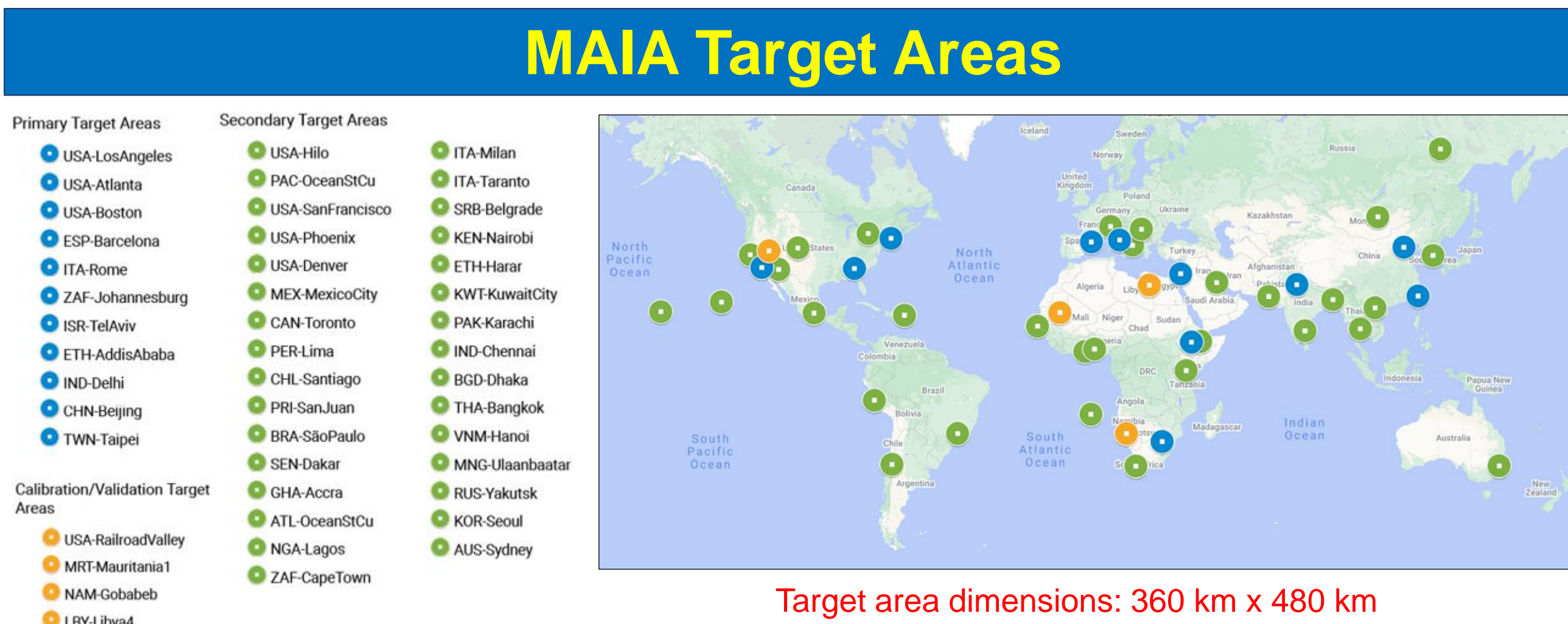
Primary Target Areas (PTAs) are chosen by the MAIA Science Team for conducting and supporting the MAIA health studies (3-4 satellite observations/week)

Secondary Target Areas (STAs) are areas of interest (e.g., cities with major pollution, aerosol source regions, climatically important cloud regimes), but where health studies are not mandated (1-4 satellite observations/week)

MAIA Ground-Based PM Monitoring Network

➤ Regression of retrieved aerosol properties against surface monitor data is used to calibrate the aerosol-to-PM transformations.

➤ Where available, MAIA collects data from existing ground-based monitoring networks.

➤ MAIA project has deployed additional surface PM monitors in selected PTAs to augment existing monitoring networks.

|	Existing monitoring networks	SS5i-$PM_{2.5}$ filter-based sampler	Aerosol Mass Outdoor Sampler (AMOS)	microAeth MA350	PA-II-SD
Vendor	Various vendors	AirPhoton (SPARTAN network)	Colorado State University	AethLabs	PurpleAir
Pollutants	Total $PM_{2.5}$/PM_{10}	$PM_{2.5}$ speciation	$PM_{2.5}$ speciation	$PM_{2.5}$ speciation	Black carbon	Total $PM_{2.5}$
Target areas	All target areas	USA-LosAngeles, USA-Atlanta, USA-Boston, IND-Delhi, ITA-Rome, ESP-Barcelona	CHN-Beijing (x1), ETH-AddisAbaba (x2), IND-Delhi (x2), ISR-TelAviv (x2), TWN-Taipei (x2), USA-Los Angeles (x1), ZAF-Johannesburg (x2)	CHN-Beijing (x1), ETH-AddisAbaba (x2), IND-Delhi (x2), TWN-Taipei (x1), USA-Atlanta (x1), USA-Los Angeles (x1), ZAF-Johannesburg (x1)	CHN-Beijing (x1), ETH-AddisAbaba (x2), IND-Delhi (x1), USA-Los Angeles (x1)	ETH-AddisAbaba (x10)

Example Photos of MAIA Ground-Based PM Monitoring Sites

SS5i-$PM_{2.5}$ sampler (SPARTAN Network): New Delhi, India IIT Delhi; Haifa, Israel Technion-Israel Institute of Technology; Tainan, Taiwan Cheng Kung University; Taipei, Taiwan NTU/IIS

Aerosol Mass Outdoor Sampler (AMOS): Gurugram, India Amity University; Centurion, S. Africa

microAeth MA350 aethalometer: New Delhi, India IIT Delhi; Addis Ababa, Ethiopia Addis Ababa University

PurpleAir PA-II-SD Sensors: Addis Ababa, Ethiopia US Embassy Commission; Addis Ababa, Ethiopia Black Lion Hospital

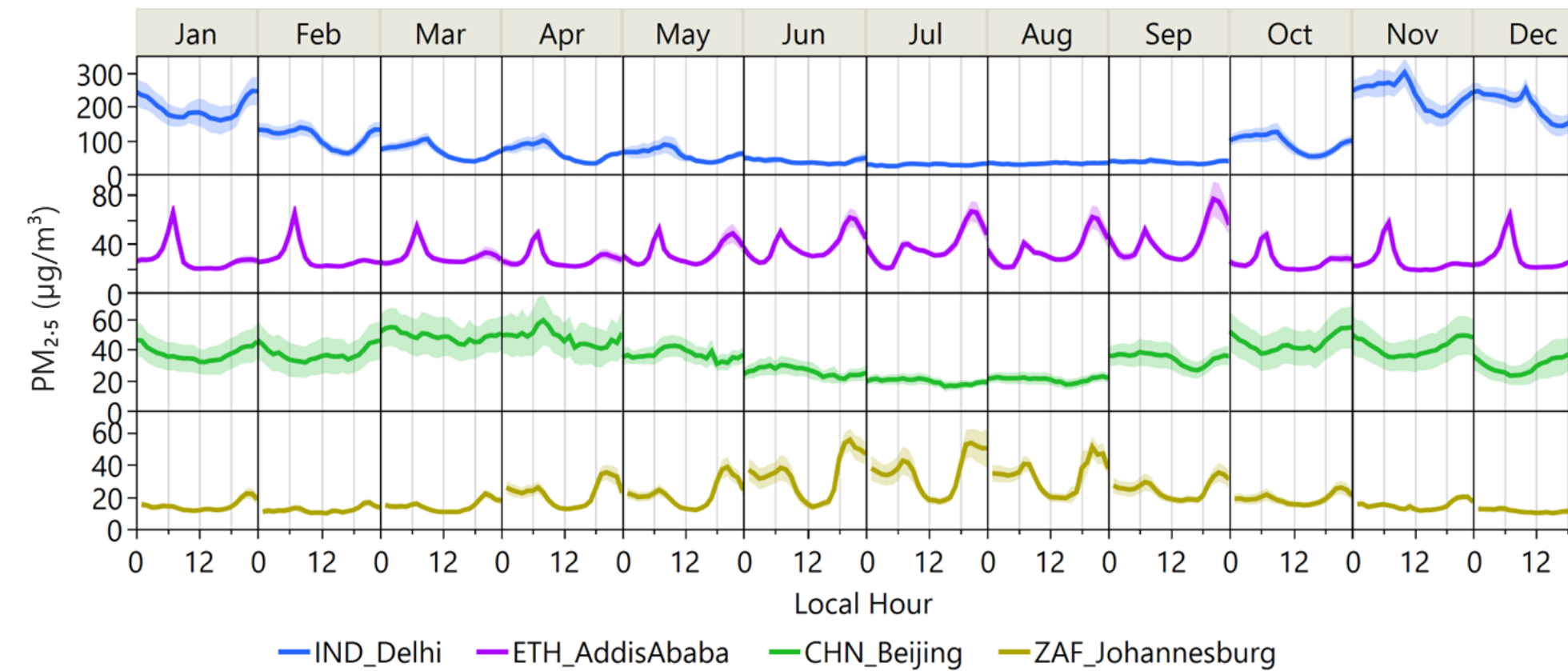## Preliminary Ground-Based PM Monitoring Results

Comparison of Total $PM_{2.5}$ Levels Across PTAs

➤ The World Bank categorizes countries by Gross National Income (GNI) per capita: low income (LI), lower-middle income (LMI), upper-middle income (UMI), and high income (HI).

➤ Average ambient $PM_{2.5}$ levels in 2022-2023 were highest in developing countries, while the lowest in high-income countries.

➤ IND-Delhi PTA showed the highest average $PM_{2.5}$, over two times higher than the second highest PTA, ETH-AddisAbaba.
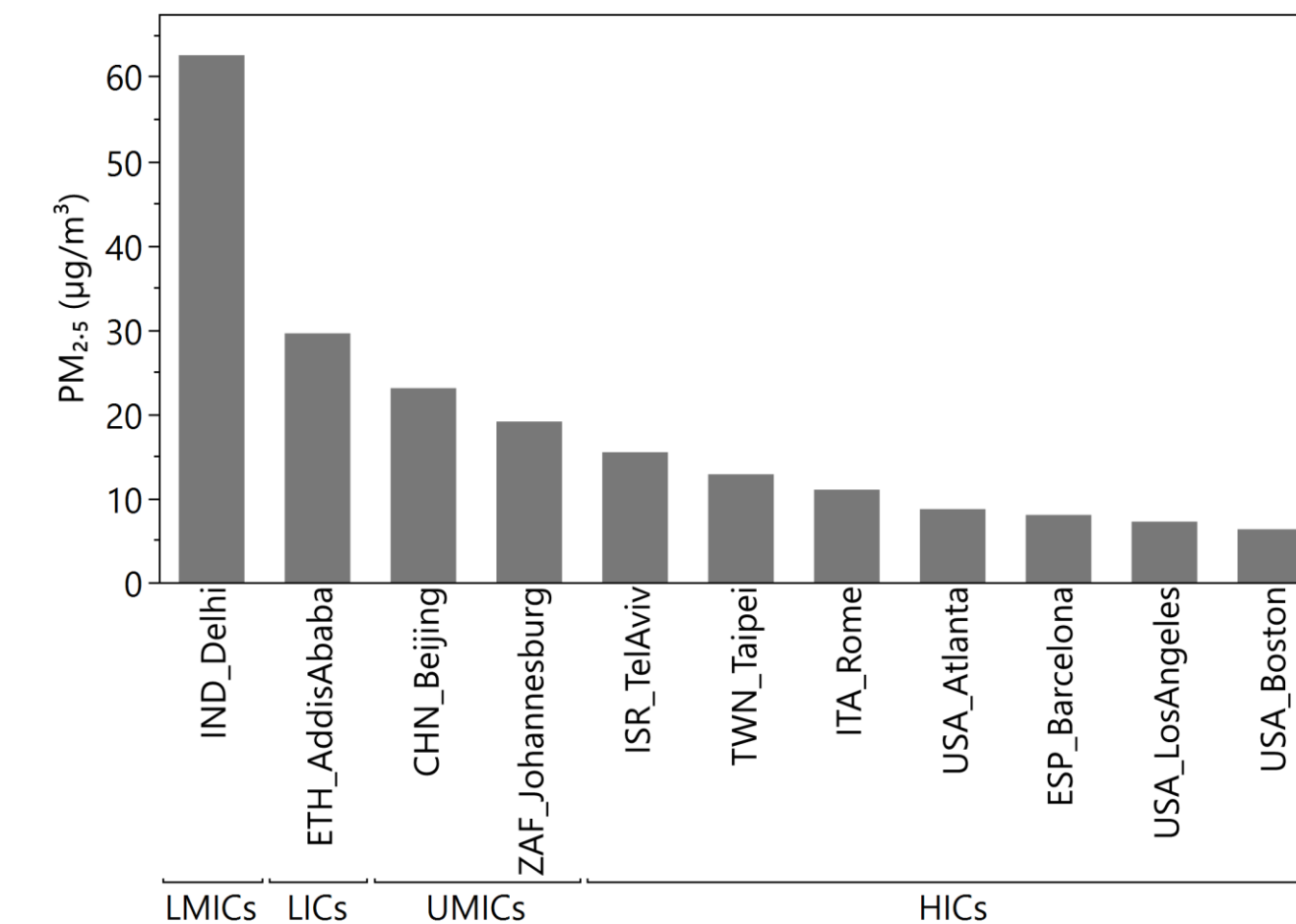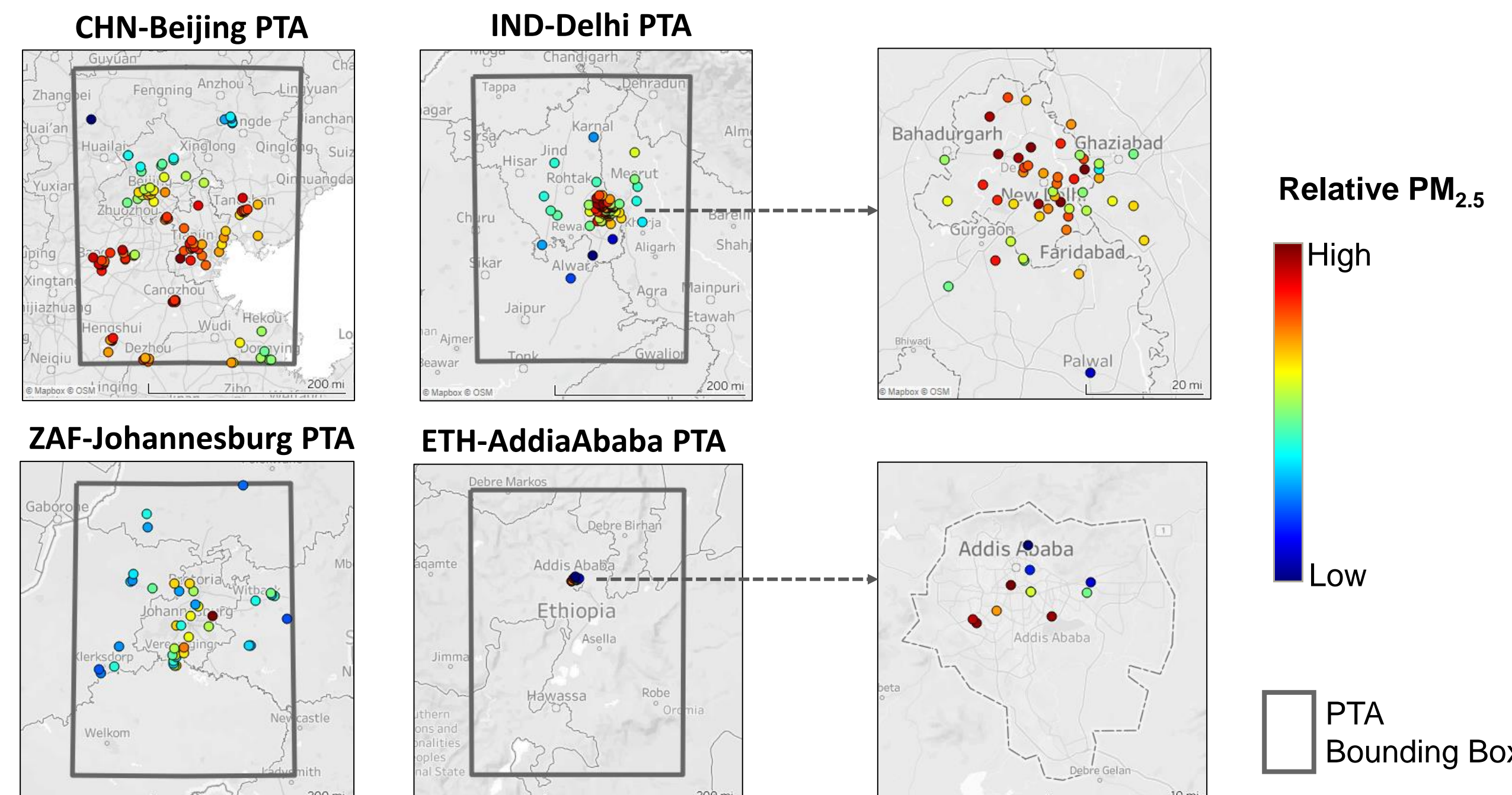

Temporal Trends of Total $PM_{2.5}$ in Developing PTAs

➤ IND-Delhi experiences peak $PM_{2.5}$ levels during winter (Oct-Feb) and lower levels during the monsoon season (Jun-Sep), with diurnal trends peaking during the morning rush hours and at night.

➤ ETH-AddisAbaba observes a significant morning peak in $PM_{2.5}$ during rush hours, with a secondary peak in the evening, especially pronounced from May to Sep.

➤ ZAF-Johannesburg exhibits marked diurnal variation in $PM_{2.5}$, particularly in winter (JJA), with levels fluctuating up to threefold within a day.

➤ CHN-Beijing displays relatively modest diurnal and seasonal $PM_{2.5}$ trends compared to other developing countries.

Spatial Trends of Total $PM_{2.5}$ in Developing PTAs

CHN-Beijing PTA   IND-Delhi PTA

ZAF-Johannesburg PTA   ETH-AddiaAbaba PTA

Relative $PM_{2.5}$: High / Low

PTA Bounding Box

➤ In CHN-Beijing, $PM_{2.5}$ levels are higher in Tianjin, Baoding, and Tangshan than in Beijing.

➤ In IND-Delhi, the highest $PM_{2.5}$ levels are observed in and around New Delhi, decreasing with distance from the city.

➤ In ZAF-Johannesburg, $PM_{2.5}$ is generally highest in the densely populated Gauteng Province and lowest in smaller cities in other provinces (e.g., North West).

➤ In ETH-AddisAbaba, $PM_{2.5}$ levels are higher in western and southern part of the city.

Preliminary Ground-Based PM Monitoring Results
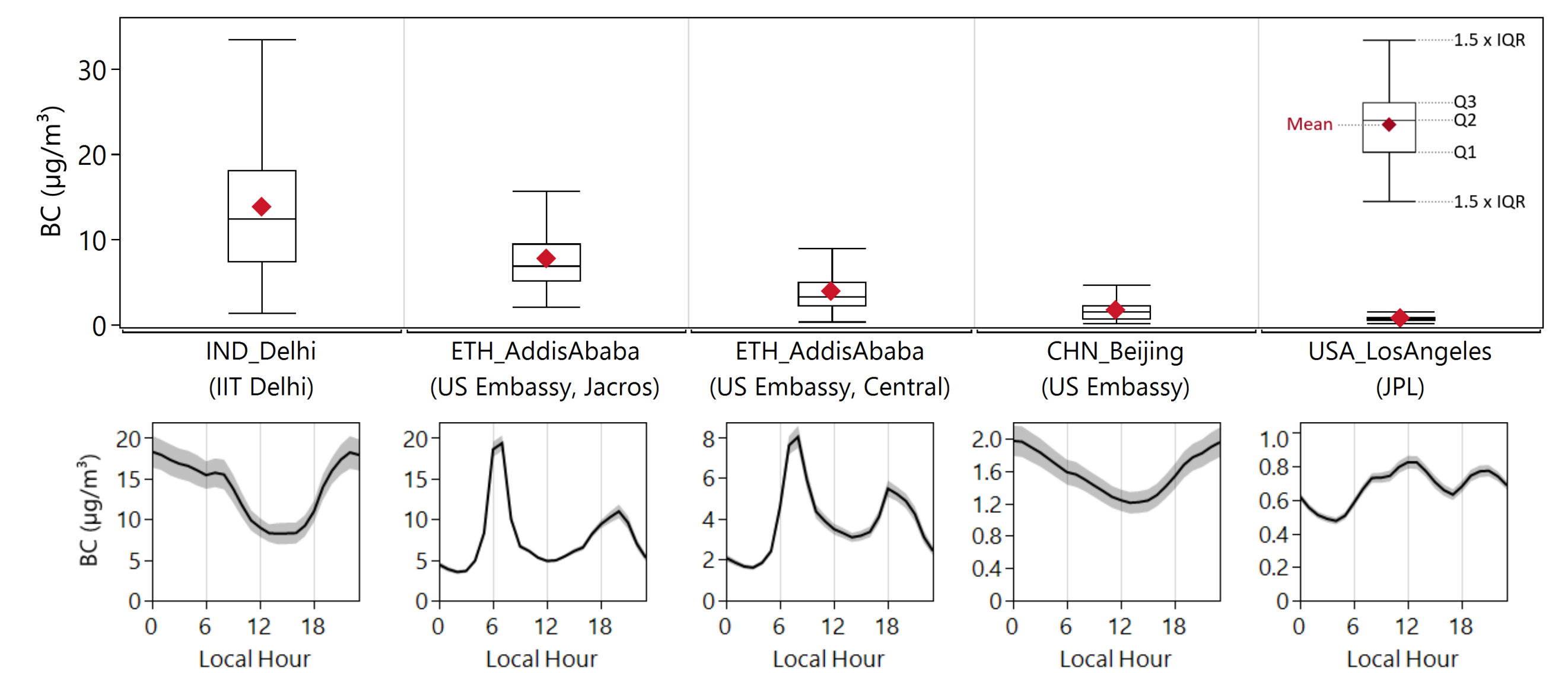
Comparison of Speciated $PM_{2.5}$ Levels Across PTAs

➤ Ambient $PM_{2.5}$ exhibits diverse chemical compositions across PTAs.

➤ The highest levels of elemental carbon are found in developing regions, particularly in African PTAs, where it constitutes 20-45% of the total $PM_{2.5}$ mass.

➤ In ESP-Barcelona, ISR-TelAviv, and ETH-AddisAbaba, dust comprises a major fraction of $PM_{2.5}$, accounting for 25-40%.

➤ Organic carbon makes up 20-50% of the $PM_{2.5}$ mass across PTAs, with the largest fraction observed in USA-Atlanta.
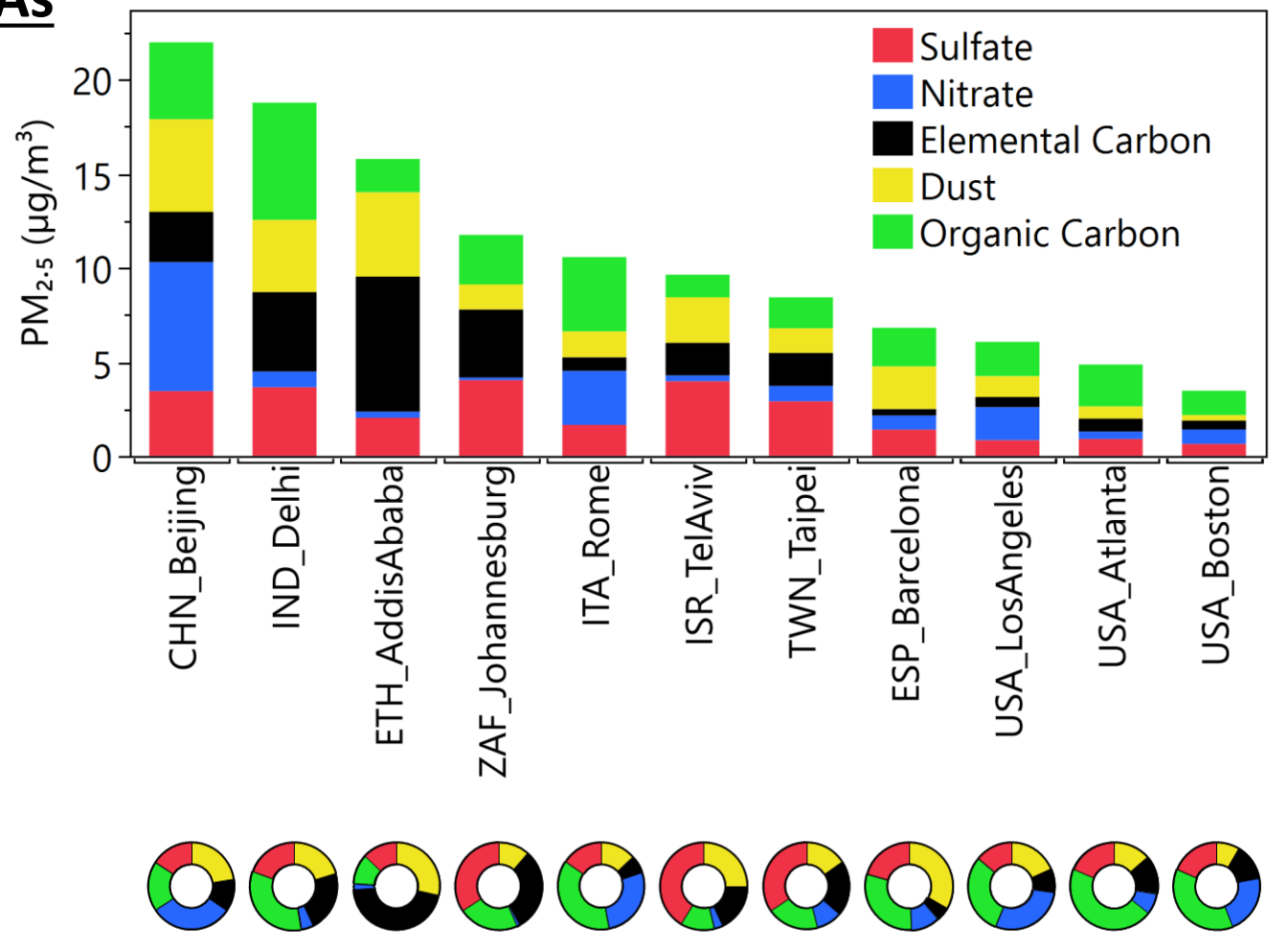
➤ $PM_{2.5}$ Nitrate contributions are highest in CHN-Beijing and USA-LosAngeles, whereas sulfate contributions are highest in ISR-TelAviv and ZAF-Johannesburg.

Comparison of Black Carbon (BC) Levels Measured by microAeth MA350 in Different PTAs

IND_Delhi (IIT Delhi); ETH_AddisAbaba (US Embassy, Jacros); ETH_AddisAbaba (US Embassy, Central); CHN_Beijing (US Embassy); USA_LosAngeles (JPL)

➤ BC levels show substantial variation across PTAs.

➤ Average BC levels in IND-Delhi and ETH-AddisAbaba (US Embassy, Jacros) are 14 and 8 times higher than those measured in USA-LosAngeles, respectively.

➤ Diurnal trends are influenced by the strength of emission sources and meteorological conditions

Acknowledgments

➤ The MAIA project utilizes in-situ PM monitoring data provided by various organizations, including the China National Environmental Monitoring Centre (CNEMC), the Central Pollution Control Board's Continuous Ambient Air Quality Monitoring Stations (CAAQM) in India, Israel's Ministry of Environmental Protection, Arpa Lazio and Arpae Emilia Romagna in Italy, the Catalan Institute for Water Research (ICRA) through ISEO/Gencat, the European Environment Agency (EEA), the Environmental Protection Administration of Taiwan (MOENV), South Africa's South African Air Quality Information System (SAAQIS), PurpleAir, the U.S. EPA's Air Quality System (AQS), AirNow, the Institute for Environmental Assessment and Water Research (IDAEA) in Spain, the SPARTAN network managed by Washington University, Colorado State University, and AethLabs.

➤ The MAIA project is grateful to the field team members involved in the installation, operation, and maintenance of the air monitoring equipment, as well as those involved in laboratory analysis and data processing.

➤ The US Agency for International Development (USAID) has provided funding to supplement MAIA's activities in Africa.

➤ The US Department of State (DOS) facilitates shipments of equipment and consumables. DOS also hosts some of the air monitoring equipment at embassy sites.

➤ This research was carried out, in part, at the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA.

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