The Global Environmental Measurement and Monitoring Initiative
GEMM Asia Summit: Meeting Report

5-6 December 2022

National University of Singapore Faculty of Law

Executive Summary

The GEMM Initiative, an international project of scientific societies Optica (formerly OSA) and the American Geophysical Union (AGU), held its first Asia Summit on 5-6 December 2022 at the National University of Singapore Faculty of Law.

This first-of-its-kind meeting brought together science, technology, and policy experts from several countries and regions across Asia to identify the capabilities of and gaps in measurement and monitoring in Asia; facilitate discussions and identify priorities of countries and regions; and identify challenges to improving capabilities. Panels representing a diversity of experts from Singapore, Japan, China, South Korea, India, the Philippines, Indonesia, Scotland, New Zealand, and the United States discussed opportunities and challenges in measuring and modeling air and water quality and greenhouse gases.

The Summit participants identified the following conclusions:

Strengthening Knowledge Networks: Summit participants emphasized the need to actively share technologies and knowledge through networks like GEMM. This collaborative effort aims to connect developed and developing regions in Asia.

Air Quality is an Urgent Issue: Summit participants underscored the urgency of tackling air pollution in Asia as an immediate entry point to combatting climate change.

Enhancing Policy Engagement: The Summit recommended decentralizing GEMM meetings and workshops while increasing the participation of policymakers. This step is essential for effective policy implementation.

Promoting Inclusivity: Prioritizing inclusivity across all Asian regions and countries emerged as a paramount goal. Subsequent meetings should focus on cities as entry points to address pressing environmental challenges.

The Role of Intermediaries: The role of Optica and AGU as critical intermediaries gained prominence. They are recognized as vital providers and translators of scientific insights to non-scientific communities and validators for scientific data and findings.

Ingredients for Expansion: Key elements crucial for GEMM expansion include nurturing in-country leadership and securing institutional support. Engagement with physical and social scientists, collaboration with city governments, and identifying funding opportunities through partnerships with GEMM are also imperative.

Celebrating Success: The Summit marked a highly successful initial step in introducing GEMM to experts in Asia, setting a promising trajectory for future endeavors.

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Opening Remarks

Satoshi Kawata, 2022 President of Optica

Satoshi Kawata, President of Optica, officially opened the GEMM Asia Summit and welcomed participants. He noted that several years ago GEMM launched as an international project of the American Geophysical Union (AGU) and Optica and became active in several regions around the world. Previously GEMM summits were held in North America and Europe; this was the first summit to be held in Asia with countries represented such as Singapore, Japan, China, India, South Korea, and the Philippines.

GEMM serves as a convergence point for experts hailing from the realms of science, technology, business, and policy. In a world bound by a shared responsibility to safeguard our environment, GEMM stands as a powerful catalyst for uniting global endeavors, ranging from the reduction of greenhouse gas emissions to the improvement of air and water quality.

The diversity of environmental challenges in Asia and across the globe is vast. Many Asian nations, such as Japan, are surrounded by waters, grappling with critical issues like microplastics and red tide pollution. Meanwhile, others wrestle with water pollution in their rivers and lakes. The adverse economic and health impacts of climate change are on the rise, presenting many complexities that defy one-size-fits-all solutions. However, the dialogue that unfolds within these walls will help guide us toward our goals.

In closing, Dr. Kawata anticipates that GEMM regional centers will be established in Asia following this Summit and thanked everyone for participating in the first GEMM Asia Summit.

Introduction

Tomohiro Oda, Chair

Tomohiro Oda, Chair of the GEMM Asia Summit, introduced the event, underscoring the diverse backgrounds of participants, including experts from physical and social sciences, policy, and law, in a format that accommodates both in-person and online attendance. This inaugural GEMM Summit in Asia marks the beginning of a promising journey.

He noted that GEMM serves as a unifying platform for science, technology, and policy stakeholders, with a mission to deliver practical, actionable environmental data. The GEMM Asia Summit's focus extends beyond greenhouse gases to encompass air and water quality. Throughout this two-day gathering, the objectives are clear:

1. Identify the existing capabilities and gaps in measurement and monitoring within Asia.
2. Facilitate dialogues to pinpoint the priorities of countries and regions.
3. Recognize the challenges that hinder capability enhancement and outline the subsequent steps.

Dr. Oda extended his gratitude to the dedicated members of the GEMM Asia Summit Organizing Committee, who are also moderating the country and regional panels (see Organizing Committee Member list below). He acknowledged Jolene Lin, Associate Professor at the National University of Singapore Faculty of Law, the host of the GEMM Asia Summit.

Jolene Lin, National University of Singapore Faculty of Law

Dr. Lin, who leads the Asia-Pacific Centre for Environmental Law, emphasized the significance of forging connections between science and law, bridging these two communities to discover solutions and translate research into practical action. The inaugural GEMM Summit in Asia holds profound importance, and she extended a warm welcome to all participants to Singapore.

Singapore Panel

Moderator: Jolene Lin

Jolene Lin, National University of Singapore, organized a panel of presentations and discussions featuring Matthias Roth, Erik Velasco, and Ben Cashore. The panel's remarks are summarized below.

Matthias Roth

Department of Geography, National University of Singapore

Matthias Roth explored how land use and land change impact the climates, especially in cities. When converting natural surfaces like grass into concrete it reduces water evaporation which impacts the water cycle. In addition, human activity in urban areas generates artificial heat which leads to the urban heat island effect. This causes cities to experience high temperatures compared to more rural areas, with a difference of up to 4 degrees Celsius.

Urbanization also disrupts the balance of energy exchange between Earth's surface and

atmosphere. This disruption affects the distribution of solar radiation, outgoing radiation, and energy transfer into the atmosphere. Urbanization and change of land surfaces also contribute to changes in rainfall patterns especially in urban areas, where there has been an increase in rainfall in cities, especially in rainfall intensity.

Understanding the connections between land use, land change, and climate dynamics is crucial for developing sustainable land use strategies and mitigating the adverse effects of urbanization. Addressing reduced water evaporation, the urban heat island effect, and the disruption of surface characteristics can promote more resilient and sustainable urban development in the face of climate change.

Erik Velasco

Molina Center for Energy and the Environment

Dr. Erik Velasco explained Singapore's commitment to sustainability and addressing climate change plans, such as the Singapore Green Plan, air quality management, and climate change monitoring. The Singapore Green Plan set ambitious targets, aiming to transform the country into a sustainable and net-zero emissions nation by 2050. This long-term vision guides Singapore's actions across sectors such as energy, waste management, and transportation to achieve sustainable economic growth while minimizing carbon emissions.

Singapore takes a target-driven approach when looking to limit different pollutants. The country sets specific targets for pollutants like particulate matter, sulfur dioxide, and nitrogen dioxide. With robust monitoring systems and effective regulatory measures, Singapore ensures that air quality remains within acceptable limits, prioritizing public health and environmental protection. This stance enables Singapore to respond swiftly to emerging air quality challenges and adapt to evolving needs.

Transparency and accountability are crucial aspects of Singapore's environmental initiatives. The progress made by Singapore in addressing environmental issues holds significant relevance for the Southeast Asia region. Many countries view Singapore as a role model, and its success inspires neighboring nations to adopt similar strategies and implement innovative technologies. By promoting knowledge exchange and sharing best practices, Singapore contributes to regional collaboration and efforts to achieve sustainable development goals.

Ben Cashore

National University of Singapore

Dr. Ben Cashore spoke about the complexities of global politics and measurement challenges in sustainable development, focusing on three major issues: the climate crisis, the mass extinction crisis, and equity concerns. To tackle the climate crisis, urgent actions are needed to limit global warming to the 1.5/2-degree goal, requiring peak emissions and net-zero targets. The mass extinction crisis demands innovative biodiversity conservation, including nature-based solutions, to protect ecosystems and species.

Equity concerns play a crucial role in the global decarbonization process, calling for a fair approach that considers the varying capacities and responsibilities of nations. However, with 92% of emissions originating from the global north, addressing class and wealth disparities

is essential to fostering an inclusive and just response to sustainability challenges. Understanding different perspectives on the climate crisis and aligning data to reinforce these views are vital for shaping well-informed and impactful policies.

By fostering international cooperation and equitable approaches, nations can collectively forge sustainable pathways, safeguarding the planet's future and ensuring a resilient and environmentally conscious global community. Addressing these intertwined challenges requires collaborative efforts and a comprehensive understanding of varying perspectives, paving the way for a more sustainable and inclusive world.

Japan Panel

Moderator: Yugo Kanaya

Yugo Kanaya, Japan Agency for Marine Earth Science and Technology, organized a panel of presentations and discussions featuring Mariko Harada, Eko Siswanto, and Eric Zusman. The panel's remarks are summarized below.

Yugo Kanaya

Japan Agency for Marine Earth Science and Technology (JAMSTEC)

Dr. Yugo Kanaya explained how air pollution research and development efforts have significantly contributed to our understanding of the state of air quality, with a particular focus on climate change and pollution levels. Particulate matter (PM2.5) and ozone have emerged as major air pollutants of concern. Although PM2.5 levels have shown substantial

reduction since 2013, further improvements are needed to meet optimal air quality standards. Notably, countries like Korea and Japan have relatively low PM2.5 levels compared to previous years; however, they still exceed the new standard of 5 micrograms per cubic meter (ug/m3), emphasizing the need for continued pollution control measures. Similarly, while high ozone episodes have been largely controlled, the levels remain at risk levels, necessitating ongoing efforts to mitigate ozone pollution.

Advancements in emission measurement technologies, particularly through satellite observations, have enabled significant progress in quantifying emissions and understanding their sources. Nitric oxide, nitrogen dioxide (NOx), and carbon dioxide (CO2) emissions can now be accurately measured at various scales, including continental, country, and point sources. This valuable data aids in developing effective policy interventions to mitigate emissions. To further improve air quality, it is crucial to target black carbon emissions from the residential sector. Hyperspectral observations have also emerged as essential tools, enabling precise measurements of greenhouse gasses, air pollutants, and ocean color. These observations provide detailed insights that inform policymakers, allowing them to make evidence-based decisions regarding pollution control measures, climate change mitigation, and ocean conservation efforts. By leveraging these advancements, policymakers can develop targeted strategies to address environmental challenges and ensure sustainable development.

Mariko Harada

Japan Aerospace Exploration Agency

Dr. Mariko Harada discussed how satellite technology is used to monitor greenhouse gas (GHG) emissions. Japan has been at the forefront of utilizing earth-observing satellites for over 30 years. Currently, Japan operates six satellites dedicated to various environmental observations, including ALOS-2, GPM Core, GCOM-W, GCOM-C, GOSAT, and GOSAT-2. These satellites play a crucial role in understanding the Earth's systems and monitoring GHG levels. The ability to observe from space provides wider coverage, enabling uniform and borderless monitoring capabilities that greatly enhance our understanding of global GHG emissions.

The policy relevance of satellite technology in GHG monitoring is significant. These satellites contribute to the global stocktake by improving transparency in GHG monitoring and supporting the evaluation and improvement of mitigation policies. The Ministry of the Environment in Japan is responsible for managing the missions related to GOSAT and GOSAT-2, overseeing budgeting and policies. Collaborations between the Japan Aerospace Exploration Agency (JAXA) and the National Institute for Environmental Studies further enhance the development and utilization of satellite missions. JAXA plays a crucial role in sensor development, satellite operation, data acquisition, calibration, and research products. Meanwhile, the National Institute for Environmental Studies focuses on algorithm development, utilizing satellite data for scientific research, and conducting validation to ensure the accuracy and reliability of the collected data.

Satellite technology, led by Japan's earth-observing satellites, has revolutionized GHG monitoring and holds great policy relevance. The capability to observe from space provides broader coverage, enabling uniform monitoring and a borderless perspective. These satellites contribute to global efforts by improving transparency in GHG monitoring and aiding in the evaluation and enhancement of mitigation policies. The collaboration between JAXA and the

National Institute for Environmental Studies ensures the effective development, operation, and accuracy of satellite missions. As satellite technology continues to advance, it will play an increasingly vital role in monitoring and addressing climate change challenges at a global scale.

Eko Siswanto

Japan Agency for Marine Earth Science and Technology (JAMSTEC)

Dr. Eko Siswanto discussed how ocean color remote sensing has emerged as a valuable tool for the research on harmful algal blooms (HABs) detection and monitoring. HABs can have severe economic impacts on businesses due to eutrophication caused by excessive fertilizer usage. Recognizing the need for effective monitoring systems, ongoing efforts are focused on the development of a near real-time (NRT) ocean color monitoring system with high spatial resolution.

To combat the economic and environmental impacts of HABs, countermeasures have been put into place, including estimating actual damages, investigating and researching the marine environment through monitoring, restoring the fishing environment, promoting production recovery and stabilization, and providing support for business continuity. Timely and accurate detection of HABs plays a vital role in implementing these countermeasures. Consequently, the development of specific algorithms tailored to different locations and HAB species becomes paramount for the successful utilization of the NRT ocean color monitoring system. The inherent optical properties (IOPs)-based approach has gained popularity for HAB detection, allowing for improved accuracy and reliability in identifying HABs.

Moreover, advancements in technology offer promising ways to enhance monitoring capabilities. Combining high-resolution ocean color measurements, employing hyperspectral observation techniques, and utilizing geostationary satellites can significantly improve the spatiotemporal and spectral monitoring of HABs. By harnessing these capabilities, policymakers and researchers can obtain a better understanding of the dynamics of HABs, their impacts on marine ecosystems and public health, and develop targeted interventions to mitigate their adverse effects. The development of a robust and efficient NRT ocean color monitoring system, alongside algorithm advancements, will help pave the way for effective HAB management and contribute to the preservation of coastal environments and local economies.

Eric Zusman

Research Director, Integrated Sustainability Center

Dr. Eric Zusman spoke about the integration of air pollution governance into assessment modeling, emphasizing the importance of aligning good science, policy, and politics. Focusing on Thailand, one of his research projects aims to estimate how economic, technical, social, and institutional barriers impact the feasibility and diffusion rate of air pollution solutions.

Specific measures to reduce PM2.5 pollution, such as clean cooking, emission standard transport, vehicle inspection, and addressing agricultural residue burning were identified. However, the implementation faces challenges due to barriers categorized into institutional, social, economic, and technological factors.

Surprisingly, the findings revealed that social and institutional barriers could lead to a substantial delay of 6-7 years over a ten-year period, surpassing the impact of technical or economic barriers. This underscores the need to include social and institutional considerations in assessment models, which are often overlooked. By adopting a holistic approach, policymakers can design more inclusive and effective strategies to combat air pollution and foster a cleaner and healthier environment for citizens in Thailand and elsewhere.

China Panel

Moderators: Ling Li and Wei Wan

Ling Li, Westlake University, and Wei Wan, Clean Air Asia, organized a panel of presentations and discussions featuring Thomas Wanger, Qingyan Fu, Bo Yao, Keding Lue, and Tao Xue. The panel's remarks are summarized below.

Wei Wan

Clean Air Asia, China

Wei Wan spoke about China's significant efforts in air quality monitoring and commitment to addressing climate change. The country has a vast network of over 1,700 monitoring systems nationwide and numerous city-level stations that actively track air quality for informed decision-making. Notably, 300 new stations were added in the past year, with further expansions anticipated, showcasing China's determination to comprehensively monitor air pollution.

China's dedication to combating climate change is evident through its ambitious goal for carbon neutrality, which was announced in 2020. The nation recognizes that reducing greenhouse gas emissions will not only benefit China but also positively impact the

surrounding region. Demonstrating its proactive approach, China revised its ambient air quality standards and introduced national action plans for cleaner air in 2013.

These transformative measures highlight China's commitment to creating a healthier and more sustainable environment. By investing in air quality monitoring and setting ambitious climate goals, China emerges as a leader in environmental stewardship, with its actions rippling positively beyond its borders, contributing to a greener future for the region and the global community.

Thomas Wanger

Westlake University

Dr. Thomas Wanger described how embedded systems monitoring in agricultural landscapes, from a global network perspective, plays a crucial role in addressing the challenges faced by the agricultural sector. The need to increase healthy food production by 50%, reduce arable land use by 32%, mitigate greenhouse gas emissions by 26%, and address the threat of extinction to one million species underscores the urgency of finding sustainable solutions. Agricultural diversification across scales and collaborative platforms, such as the Global Agroforestry Network (GAN) and China Rice Network (CRN), are key strategies employed to tackle these challenges.

Technological advancements play a vital role in facilitating and quantifying agricultural diversification. With the help of embedded systems and monitoring technologies, researchers can measure the impact of agricultural diversification on biodiversity, ecosystem services, and yields. Automated biodiversity monitoring systems, supported by AI-based embedded cameras, provide valuable data on cocoa flowers, biocontrol, and visitation patterns of pollinators. These tools improve our understanding of diversified agricultural systems and help us make informed decisions in promoting sustainable practices.

Collaborative platforms, such as GAN and CRN, foster knowledge sharing and promote research on specific crops like cocoa, coffee, rubber, and rice. These platforms facilitate the exchange of information, allowing researchers and policymakers to develop a deeper understanding of the socio-economic and environmental benefits of agricultural diversification. They also help identify the variability between countries and regions, highlighting the positive or neutral effects of diversification on crop production. This collaborative approach fosters sustainable development and promotes best practices in reclaimed areas, such as Hangzhou Bay in China, which is experiencing rapid economic growth in its coastal region. By quantifying the impacts of agricultural diversification and integrating technology and collaborative efforts, we can work towards mitigating plastic pollution, enhancing carbon sequestration, and promoting biodiversity in agricultural areas.

Qingyan Fu

Shanghai Environmental Monitoring Center

Dr. Qingyan Fu presented an overview of Shanghai's air quality monitoring efforts, highlighting its commitment to sophisticated, science-based city management. The city has established an extensive monitoring network covering 10 key industrial parks with 74 monitoring sites, equipped with 40 sets of automatic VOC-monitoring equipment. The monitoring sites are thoughtfully categorized into industrial, boundary, and peripheral types, while mobile vehicle

monitoring further enhances data collection capabilities. In 2021, Shanghai expanded its online dust monitoring sites to an impressive 4,500, utilizing a light scattering technique for accurate measurements.

Beyond industrial parks, Shanghai's commitment to air quality monitoring extends to various locations, encompassing 2,771 construction yard monitoring points, 450 storage yard monitoring points, 269 dock monitoring points, and 141 concrete batching plant points. This holistic approach ensures that air quality is closely monitored throughout the city, providing comprehensive data to identify potential sources of pollution. To optimize its monitoring capabilities, Shanghai employs advanced screening methods, using high-resolution remote sensing images to detect high emission points of Nitrogen Dioxide (NO2) and biomass burning ignition points. This proactive approach allows authorities to swiftly pinpoint potential pollution sources and take prompt action to mitigate their impact.

Moreover, Shanghai adopted targeted control measures to address air quality concerns effectively. The city focuses on strengthening ground position and navigation monitoring, especially concerning abnormal emissions from industrial product transportation and heavy vehicles within specific areas. This proactive strategy enables Shanghai to respond promptly to pollution events and improve overall air quality levels. The city's data-driven decision-making and implementation of responsive control measures exemplify its dedication to maintaining a healthier and more sustainable urban environment for its residents. Shanghai's pioneering efforts set a commendable standard for air quality management, serving as a model for other cities worldwide seeking to enhance their environmental stewardship.

Bo Yao

Fudan University

Dr. Bo Yao discussed how fluorinated gases (F-GHGs) are several groups of GHGs regulated by the Kyoto Protocol and the Montreal Protocol. These gases are key to ozone depletion and climate change. IPCC AR6 showed us that these gases are responsible for a large share of effective radiative forcing and so they have a very significant impact.

Unexpected emissions of F-GHGs have been reported in various journals in recent years, which can do further damage to the ozone hole and increase climate change. A possible explanation is that potential source regions are not sampled. There are only about 20 sampling stations worldwide because the observations require high precision (~105) due to low concentrations (0.1-500 ppt). No commercially available instrument was available for such observations before 2021.

After these unexpected emissions were discovered in 2018-19 the Chinese government planned to build an ODF and F-gas monitoring and early warning system. This system, ODS5-Pro, can observe almost all of the gases regulated by the Kyoto and Montreal protocols. The system is deployed in a handful of locations around China currently.

With these new observations, researchers found that NF_3 emissions in China were twice that of six years prior, and SF_6, HFC-32, and HFC-125 emissions grew at a rate consistent with inverse modeling results. Overall, ODS5-Pro provided precise data helpful to the estimation of national and regional F-GHG emissions utilizing a top-down method recommended by IPCC

2019 Refinement National GHG Inventory Guidelines.

This work can help expand F-GHG work in Asia and around the world, both for scientists and policymakers.

Keding Lue

Peking University, College of Environmental Sciences and Engineering

Dr. Keding Lue presented the essential concept of urban air pollution formation, wherein there are contributions from reductive gases and oxidizing gases and particulates. Oxidant chemistry can be very complicated for OH, NO_3, O_3, and SCI. Some of the formation mechanisms still are not yet fully understood.

Among atmospheric oxidants, those that are low on the temporal and spatial scales, like OH, HO_2, and NO_3, are highly variable and reactive, making them the most difficult species to measure. Measuring these species requires high-sensitivity spectroscopy. With this measurement system, one can achieve closure studies of atmospheric oxidants. Peking University's work in this area has focused on urban observations.

This research uncovered an underestimate in OH radicals, indicating a missing OH source resulting in the discovery of a new chemistry: an RO_2 H-shift under low NO_x conditions. The work also uncovered an unknown source of peroxy radicals.

In the future, it will be important to establish the direct measurement of speciated RO_2 concentrations to improve understanding of atmospheric oxidation chemistry in urban and rural areas. In particular, the speaker proposed a global science initiative to study the oxidation chemistry in the troposphere.

Tao Xue

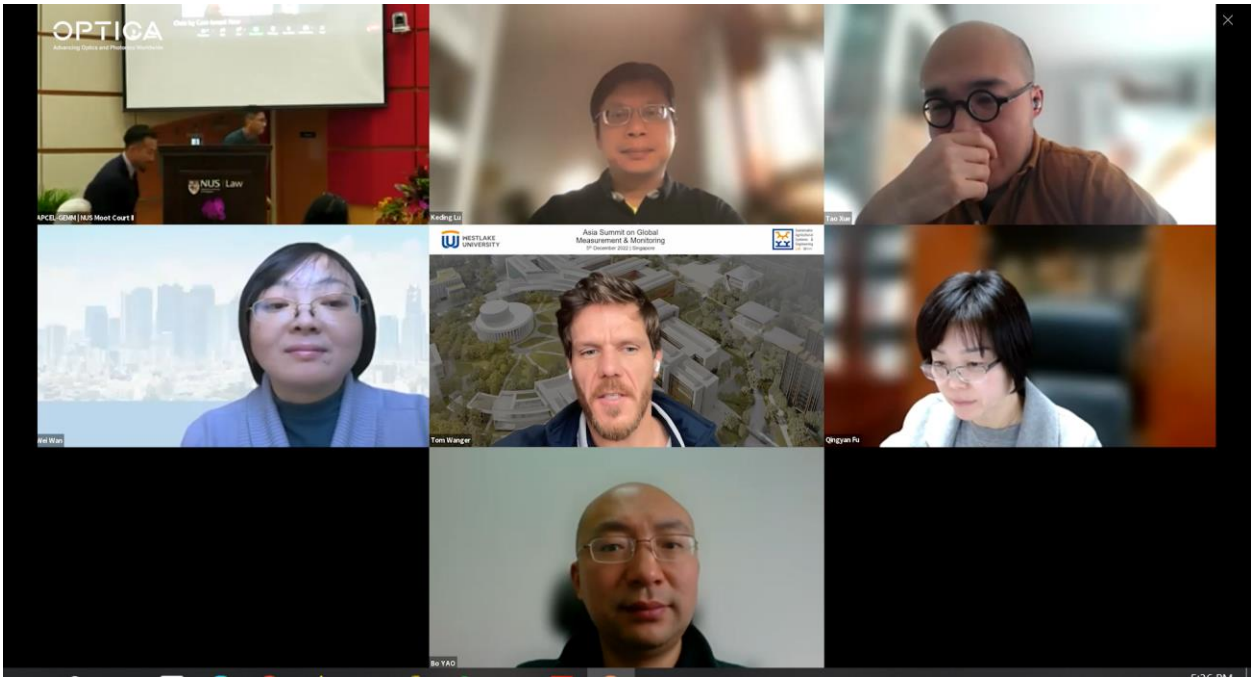
Peking University, School of Public Health

Dr. Tao Xue spoke about the crucial task of monitoring the health impacts of air pollution and climate change, with a particular focus on China. To help achieve this, he and colleagues conducted a data fusion study to monitor the levels of PM2.5 and O3 in the region. The study highlighted the significant health effects caused by air pollution trends in China, emphasizing the urgent need for effective monitoring systems. Moreover, the report introduced a data fusion method to assess the health impacts resulting from landscape fires, aiming to provide a comprehensive understanding of the issue.

According to the Global Burden of Disease assessment, the toll from air pollution is alarming, with a staggering 6.67 million deaths attributed to both indoor and outdoor sources. While satellite data offers accuracy, it may contain missing values, while the chemical transport model provides complete coverage but with some inaccuracies. The fusion of these data sources results in a more accurate and complete product, enabling a more nuanced understanding of the health impacts of air pollution and climate change.

Furthermore, his research underlines the limitations of relying solely on ground surface networks to monitor health impacts, particularly in low and middle-income countries. To

comprehensively assess PM2.5 produced by landscape fires, the combination of multi-source data is indispensable. This approach not only enhances the precision of monitoring but also provides critical insights for effective decision-making and interventions to protect public health, especially in regions with limited monitoring infrastructure. In conclusion, the fusion of multi-source data represents a vital step towards understanding and combating the health implications of air pollution and climate change, offering a robust foundation for safeguarding human well-being in the face of these environmental challenges.



Korea Panel

Moderator: Sujong Jeong

Sujong Jeong, Seoul National University, organized a panel of presentations and discussions featuring Chaerin Park, Jaepil Park, Seungmin Lee, and Youngsook Lyu. The panel's remarks are summarized below.

Chaerin Park

Seoul National University

Dr. Chaerin Park presented the importance of urban carbon monitoring, given that cities are responsible for over 70% of global fossil fuel-induced carbon emissions. Her study centers on Seoul, the fifth-largest carbon-emitting city worldwide, and Korea, ranking ninth among carbon-emitting countries. The urgent need to address carbon-related challenges in urban environments becomes apparent as these cities face significant carbon burdens.

The Seoul CO_2 project is an initiative to tackle carbon emissions within the city comprehensively. It has three components: Carbon Observations, Carbon Emissions, and Uptake Inventory, all reinforced by a sophisticated Modeling System. Under the Carbon Observations aspect, three distinct approaches are employed: satellite, ground, and mobile observations.

Satellite observations analyze overall CO_2 concentration patterns across the urban area using data obtained from greenhouse gas satellites. Ground observations leverage real-time CO_2

concentration data from Seoul's ground observation network to provide valuable insights into concentration characteristics, analyzed by region and time. Meanwhile, mobile carbon observation, facilitated by the climate laboratory, scrutinizes CO_2 concentration at a localized road-scale level. This synergy of observation methods equips the Seoul CO_2 project with a comprehensive understanding of urban carbon dynamics, empowering informed decision-making and targeted interventions to reduce carbon emissions and foster sustainability citywide.

The study also highlights the significance of the Carbon Emission and Uptake Inventory, incorporating the Inventory System for Accounting Anthropogenic CO_2 (ISAAC). This inventory system estimates CO_2 emissions by multiplying activity data and the CO_2 emissions coefficient while the Carbon Simulator from Space (CASS) employs data-based carbon flux models to estimate carbon flux, revealing diverse CO_2 flux amounts across Seoul concerning region and time. The Modeling System, supported by an inverse model, effectively verifies carbon emissions, reducing uncertainty about carbon emissions by an impressive 116.7%. The ultimate goal is to expand the Seoul CO_2 project to a country-wide scale, thereby facilitating comprehensive monitoring of the carbon cycle throughout South Korea. Establishing an integrated carbon monitoring system, combining observations, inventory, and modeling, is a pivotal step in gaining an in-depth understanding of the carbon cycle and fostering effective carbon management strategies.

Jaepil Park
Nara Space Technology

Dr, Park discussed Nara Space's small satellites used for environmental monitoring in Asian regions. These platforms can provide valuable insights into emission sources through precise location mapping. By utilizing advanced technologies like MethaneSAT, GHGSat, and Carbon Mapper, Nara Space's satellites can efficiently target area mapping and point source identification, enhancing our understanding of emission patterns and their impact.

One of the key advantages is the satellites' rapid revisit times, allowing them to visit an average of three Asian cities in just 30 minutes. By deploying additional satellites, the revisit time can be further reduced, expanding the scope of environmental monitoring and enabling a more comprehensive assessment of emission sources across the region.

Using small satellite technology for environmental monitoring promises significant advancements for Asian regions. Its versatility, cost-effectiveness, and swift revisit capabilities equip researchers with powerful tools to address pressing environmental challenges and pave the way for sustainable solutions in managing emission sources and their environmental impact. As small satellites' usage continues to grow it is poised to revolutionize environmental research and contribute to a greener and more sustainable future for the region and beyond.

Seungmin Lee
Korea Environment Institute

Dr. Seungmin Lee presented an overview of the air quality control policy in Korea, with a focus on changes in air quality over the past 20 years (2000-2019) and the current air management policies and status (2020-2021). During this period, notable progress has been made, as

evidenced by the steady decrease in PM10 and PM2.5 levels in Korea, indicating successful air quality management efforts.

A significant milestone in Korea's air quality control strategy is the implementation of the Fine Dust Management Master Plan for 2020-2024. This plan incorporates approximately 100 reduction measures aimed at achieving the 2024 concentration target. The primary goal is to achieve a 35% reduction in the annual concentration of PM2.5 by 2024, representing a big step forward in enhancing air quality throughout the country.

Notably, the year 2021 witnessed remarkable improvements in air quality, with a notable 59% increase in the number of good days for PM2.5 and a remarkable 51% improvement in bad days. These positive changes can be attributed to a combination of factors. First and foremost, they are a direct result of the proactive implementation of the Fine Dust Management Master Plan, signifying the effectiveness of policy measures. Secondly, neighboring countries' dedicated efforts, particularly China, to improve air quality have contributed to the reduction in air pollutants outside of Korea. Additionally, favorable weather conditions, particularly the east winds, have facilitated the inflow of cleaner air. Furthermore, the unforeseen impact of the COVID-19 pandemic, which led to reduced industrial activities and fewer vehicles on the roadways, has also played a role in the improved air quality scenario.

Looking ahead, Korea's commitment to achieving carbon neutrality by 2050 will necessitate transitioning various sectors to low-carbon emission energy sources. With the announcement of a list of 120 national projects in May 2022, the government has reaffirmed its dedication to reducing PM2.5 concentration by 2027 through the implementation of stronger air pollution reduction policies. These forward-looking measures underscore Korea's proactive stance towards further enhancing air quality and fostering sustainable environmental practices. The continuous effort towards cleaner air reflects the nation's determination to protect public health and preserve the environment for future generations.

Youngsook Lyu

National Institute of Environmental Research Ministry of Environment Korea

Dr. Youngsook Lyu highlighted Korea's ambitious efforts towards achieving carbon neutrality by 2050, focusing on its 2030 Nationally Determined Contribution (NDC). The NDC outlines intermediate goals aimed at reducing greenhouse gas (GHG) emissions by 40% by 2030 compared to 2018 levels, signifying the nation's commitment to combat climate change.

To achieve these goals, Korea is developing strategies and policies for emission reduction. One of the key initiatives involves the development of an index to select GHG monitoring sites across the country. This index will play a crucial role in identifying strategic locations for monitoring GHG emissions, facilitating accurate data collection, and informed decision-making.

With the 2030 NDC, Korea sets a clear path towards significant GHG emission reduction, aligning with global efforts to combat climate change and work towards a sustainable future. These proactive measures and long-term commitments to carbon neutrality demonstrate Korea's determination to contribute to global climate action and create a greener and more environmentally conscious nation for generations to come.

India Panel

Moderator: Keerthi Katam

Keerthi Katam, Mahindra University, organized a panel of presentations and discussions featuring ML Kansal, Sagnik Dey, and Bharti. Dr. Bharti moderated the panel during the event. The panel's remarks are summarized below.

ML Kansal

Indian Institute of Technology Roorkee

Dr. ML Kansal's presentation addressed sustainability challenges regarding water and the environment in India's Himalayan region. Water scarcity and reliable supply of clean, fresh water are significant concerns for residents there. Managing floods and their impact also presents challenges, necessitating effective actions.

To combat water scarcity, proposed measures include constructing new dams and canals, rainwater harvesting, and improved groundwater management. Enhancing water-saving practices and productivity are also crucial components of the plan. However, water pollution poses a significant threat, with untreated sewage, industrial waste, and mismanaged solid waste polluting water bodies. Addressing emerging pollutants like microplastics, pesticides, pharmaceuticals, and radioactive waste is essential to safeguard water quality.

The region's vulnerability to natural disasters, such as cloudbursts, flash floods, landslides, and earthquakes, adds to the complexity of the issue. However, remote and challenging monitoring in this area requires careful consideration, including transportation logistics and

gauging facility resilience during extreme events. Proposed solutions involve developing a water resources information system and strengthening legislative frameworks for environmental protection. Coordinated efforts among institutes and management boards are vital, with a key challenge being the identification of appropriate investment sources to address these sustainability issues effectively. By taking decisive actions, India can preserve its precious water resources and protect the environment in the Himalayan region.

Sagnik Dey

Indian Institute of Technology Delhi

Dr. Sagnik Dey spoke about air quality management for sustainable development in India, noting the link between air pollution and sustainable development goals. The research findings reveal alarming consequences of air pollution, with a 1.4% GDP loss and a substantial 4.8% decline in wheat yield. Moreover, the human toll is devastating, with over 1.6 million deaths attributed to air pollution, including cognitive impairment.

Notably, the impact of air pollution is not gender-neutral, as women are found to be more exposed to household air pollution. This underscores the need for gender-sensitive approaches in air quality management strategies. The economic impacts are also significant, with energy losses exceeding 20 terawatts, equivalent to around 325-845 million USD. Recognizing the importance of green infrastructure, addressing social vulnerability, and tackling urban pollution, India strives to achieve economic growth while ensuring a clean environment.

Furthermore, the report sheds light on how air pollution can influence precipitation and weather, emphasizing the urgency of effective air quality management for sustainable development. While India has ground monitoring systems, their concentration in urban areas and limited spread pose challenges. With an average distance of approximately 80 kilometers to the nearest monitor, expanding and strengthening the monitoring network becomes imperative for comprehensive air quality management nationwide. By addressing these issues and implementing targeted strategies, India can pave the way towards a sustainable future, enhancing public health, environmental quality, and overall socio-economic development.

Dr. Bharti

National Law University of Delhi

Dr. Bharti’s presentation examines India's significant role in global carbon emissions, accounting for approximately 7.09% of the total. As a key participant in the collective climate goal of limiting temperature rise to 1.5-2 degrees Celsius, India has made a committed declaration to achieve net-zero carbon emissions by 2070.

To support environmental protection efforts, India has established a robust legal framework, highlighted by the Environment Protection Act of 1986. Notably, Section 3 of this act empowers the central government to take necessary measures for safeguarding the environment. Additionally, the country has implemented various climate change frameworks, such as the 2001 Energy Conservation Act, 2003 Electricity Act, 2005 Disaster Management Act, and Right to Information Act, further bolstering its commitment to addressing climate challenges.

India's proactive approach is evident in the development of comprehensive action plans on climate change. The National Action Plan on Climate Change, introduced in 2008 with eight plans and expanded with three additional plans in 2022, demonstrates the country's dedication to addressing climate-related issues. The 2030 Nationally Determined Contribution outlines a goal of reducing the emission intensity of GDP by 33-35% below 2005 levels by 2030, with the ultimate aspiration of achieving net-zero carbon by 2070.

However, air pollution poses a critical challenge for India, with nine of the world's ten most polluted cities within its borders. The country presently has 804 air quality monitors in operation, yet an additional 1600-4000 monitors are required to effectively combat and monitor air pollution. Effectively addressing air quality issues remains pivotal to safeguarding public health and promoting sustainable development across the nation. By continuing its proactive approach and implementing comprehensive measures, India can further progress in its commitment to environmental protection and climate action.

Southeast Asia Nations Panel

Moderator: Luisa Molina

Dr. Luisa Molina, Massachusetts Institute of Technology, organized a panel of presentations and discussions featuring Linda Yanti Sulistiawati, Melliza Cruz, and Dang Espita Casanova. The panel’s remarks are summarized below.

Linda Yanti Sulistiawati

National University of Singapore

Dr. Linda Yanti Sulistiawati discussed Indonesia's proactive policy on climate change, focusing on its efforts to embrace oil and gas renewables and transition towards net-zero energy systems. Indonesia's commitment to combating climate change is evident through its multifaceted approach to environmental challenges.

Central to Indonesia's policy is its promotion of renewable energy sources, with a deliberate phasing down of fossil fuels. Embracing options like solar, wind, and hydroelectric power, the country aims to reduce greenhouse gas emissions and foster greener energy production. Additionally, it is exploring the potential of implementing a carbon tax and carbon trading mechanisms to incentivize emission reduction and encourage eco-friendly practices across industries.

To further its sustainable energy transition, Indonesia is actively exploring co-firing coal plants with renewable energy sources, gradually moving away from fossil fuels. It also is prioritizing the retirement of coal plants, recognizing the importance of shifting towards cleaner energy alternatives. These ambitious policies and initiatives position Indonesia as a trailblazer in the global fight against climate change, showcasing the country's commitment to securing a sustainable and greener future for generations to come. As Indonesia leads the way in adopting renewable energy and advancing towards net-zero energy systems, its actions serve as a motivating example for other nations seeking effective climate change solutions.

Melliza Cruz

Manila Observatory

Dr. Melliza Cruz dove into the state of air quality in Metro Manila, Philippines, with a particular focus on PM2.5 monitoring, a crucial indicator of fine particulate matter that can significantly impact public health. The Philippines initiated PM2.5 tracking in the late 1990s, providing valuable data on air pollution levels in the region. The findings indicate that PM2.5 concentrations have consistently surpassed the World Health Organization's (WHO) standard, highlighting the gravity of air pollution challenges in Metro Manila. However, there is a glimmer of hope as recent data shows a decreasing trend in PM2.5 levels over the past few years, hinting at potential improvements in air quality.

Despite this progress, the report identified several challenges and opportunities for further enhancements to air quality in Metro Manila. To sustain the momentum, the establishment of sustained long-term continuous aerosol monitoring and speciation is imperative, providing critical insights into the composition and sources of particulate matter. Expanding the measurement scope to encompass other pollutants and greenhouse gasses (GHG) will enable a more comprehensive understanding of air pollution dynamics. In addition, ensuring wider spatial coverage of monitoring stations is essential to gain a comprehensive picture of air pollution distribution and identify specific hotspots within the metropolitan area. Leveraging satellite measurements offers an additional opportunity to complement ground-based monitoring, enhancing the overall monitoring network's efficiency and efficacy.

By addressing these challenges and capitalizing on available opportunities, Metro Manila can make significant strides towards achieving cleaner and healthier air quality, safeguarding

public health, and fostering sustainable development for its residents. As policymakers and stakeholders work collectively to implement targeted interventions, the vision of a greener, more environmentally conscious city can be realized, benefitting both the current and future generations.

Dang Espita Casanova
Clean Air Asia

Dr. Dang Espita Casanova discussed transforming evidence into practical clean air solutions across Southeast Asia. Clean Air Asia focuses on clean air action planning to foster sustainable air quality improvements in prominent countries, including Mongolia, India, Vietnam, China, Philippines, Indonesia, and others. Frameworks are designed to enhance air quality in Asian cities by comprehending pollution levels, identifying sources of pollution, and assessing their far-reaching impacts.

To tackle air pollution effectively, solutions must be implemented at both the national and local levels. At the national level, transformative policies and frameworks play a pivotal role in reducing emissions and enhancing air quality standards. On the local level, clean air action plans (CAAPs) are instrumental, encompassing a range of measures and actions to enhance air quality, empowering individuals and communities to participate in the movement.

CAAPs implementation comprises cost-effective emission reduction strategies, planning, resource allocation, and ongoing monitoring and evaluation. Key implementation stakeholders involve government-led initiatives with strong engagement from various stakeholders and active public participation. Additionally, the speaker showcased successful cases of clean air endeavors in Southeast Asian cities, such as Quezon City's commitment to meeting air quality guidelines and Bogor City's accomplishment in completing its clean air action plan. Leadership and data-driven decision-making were critical to realizing clean air objectives. By adhering to the proposed guidance framework and drawing inspiration from these successful cases, Southeast Asian cities can embark on a transformative journey, fostering cleaner air, sustainable development, and improved quality of life for their residents.

Keynote Address

Susan Aitken
Glasgow City Council Leader

Glasgow City Council Leader Susan Aitken opened Day 2 of the GEMM Asia Summit with a keynote address. Council Leader Aitken emphasized the critical issue of air quality and climate impacts on Glasgow citizens. The City of Glasgow hosted COP26 in 2021, the first COP (Conference of the Parties of the United Nations Framework Convention of Climate Change) to give a voice and a platform to city leaders who are often leading the way on implementing climate solutions. Collaboration and sharing knowledge offer hope for addressing the climate emergency.

Glasgow is the largest city in Scotland and was associated in the past with building ships and manufacturing. It suffered economic decline in the later part of the 20th century and the

problems of post-industrial cities like Glasgow are also the problems faced by other urban areas.

Air quality remains a clear social justice issue. One-half of Glasgow's households do not have a car yet are impacted by transport emissions. Air pollution impacts health and affects all citizens, especially the most vulnerable.

Glasgow put in place the first zero emission zone to phase out all but the cleanest vehicles in the City Center. The City has a carbon net zero goal by 2030. As part of this, data and evidence will be critical to informing policy and measuring the effectiveness of decisions.

Before COP26, Glasgow was already working with GEMM to develop a network of sensors to get a detailed picture of carbon emissions at their source. The network is in place and helps to monitor progress and effectiveness in Glasgow's low-emission zone. For the first time, Glasgow can move away from time-lagged data on CO2 levels and see the real-time impact on carbon and air quality to meet air emission goals.

GEMM is a great example of a shared approach to address climate, combining technology innovation with international collaboration. Solutions to climate challenges cannot be achieved by local government or by any government alone. Innovative approaches to partnerships are needed to respond to the climate emergency and a willingness to work across boundaries.

GEMM can help policymakers to assess the effectiveness of plans and actions. Technology innovations and new approaches can be used everywhere. Already, Glasgow is expanding on the work with GEMM and linking measurements between indoor and outdoor air quality for a better understanding of personal exposure to emissions.

For Glasgow, climate action must be about more than targets. It must be about life and the well-being of its people.

The GEMM Initiative

Luisa Molina

Massachusetts Institute of Technology & AGU Global Engagement Committee

Dr. Luisa Molina presented the strategic plan of the American Geophysical Union (AGU), which aims to drive discovery and solution science for the betterment of humanity and the environment. While discovery science remains at the core of AGU's missions, the pressing need for science-based solutions to combat environmental pollution and climate change, especially for vulnerable communities, is undeniable.

To achieve its goals, the AGU emphasizes the importance of leveraging its traditional strengths in convening, vetting, and sharing scientific knowledge. By fostering collaboration and dialogue among researchers and experts, the AGU seeks to stimulate groundbreaking discoveries and develop effective solutions to tackle the critical environmental challenges of our time.

The strategic plan underscores the paramount role of science in safeguarding communities and preserving the planet. As the AGU aligns its efforts with this purpose, it is poised to make significant contributions to humanity's well-being and the protection of our environment. By prioritizing both discovery and solution science, the AGU can forge a path forward in addressing global issues and actively contribute to creating a sustainable and resilient future for all.

Scott Carney
Optica

Dr. P. Scott Carney spoke about the global nature of environmental challenges and the necessity for long-term commitments to address them. Across Asia, societies share close ties, promoting collaboration and knowledge exchange to tackle these complex issues collectively. Such collaboration allows for the pooling of resources and expertise, enabling effective solutions and sustainable development practices.

The upcoming meeting of the Global Society of Advancing Photonics in Busan holds significant promise for advancing environmental research and solutions. Photonics advancements offer cutting-edge tools for environmental monitoring and research, facilitating precise data collection and analysis. This meeting will serve as a vital platform for experts, researchers, and policymakers to engage in discussions and explore innovative approaches to tackle global environmental challenges.

To effectively address environmental issues on a global scale, fostering international partnerships and embracing technological advancements from photonics are crucial. By leveraging collective efforts and the latest innovations, all people can work towards building a greener and more resilient future for our planet and future generations.

Tom Baer

Stanford University

Dr. Tom Baer gave an overview of the GEMM Initiative, a collaboration between Optica and AGU to advance environmental measurement capabilities, and underscored its evolution over the past five years.

The discussion delved into the pivotal role of optics and photonics technologies play in environmental measurement technologies, citing examples such as satellite imaging, lasers, spectrometers, LiDAR, and oceanographic sensors. The speaker elucidated how these technologies contribute to precise measurements, temporal and spatial models, and the iterative refinement of climate predictions. Beyond scientific realms, he emphasized the integration of economic and social analyses into government policies, forming a comprehensive loop in addressing climate change impacts on society.

Dr. Baer continued by discussing the practical example of collaboration between GEMM Centers in Northern California and Scotland, showcased through a COP26 video. This collaboration described the deployment of state-of-the-art sensors around Glasgow, monitoring real-time greenhouse gas emissions and pollutants to produce accurate city maps. The GEMM Initiative's global network and its potential for localized sensor deployment were underscored, inviting participation and engagement, particularly from institutions in Asia. The speaker concluded by encouraging further discussions throughout the workshop,

fostering a dialogue on building a truly global network for comprehensive environmental solutions.

Ronald Cohen

University of California, Berkeley

Dr. Ron Cohen highlighted the Berkeley Environmental Air Quality and CO_2 Observation Network ($BEACO_2N$), which introduces a novel approach to understanding urban emissions. Leveraging advanced instruments, $BEACO_2N$ measures six crucial parameters at each location, encompassing CO_2 and particles using optical devices, and NO_2, NO, O_3, and CO through electrochemical measurements.

$BEACO_2N$'s innovative methodology delivers a comprehensive and detailed assessment of urban carbon emissions, providing researchers and policymakers with valuable insights into the intricacies of air quality within urban areas. By employing cutting-edge technology, $BEACO_2N$ sets a new standard for urban emission mapping, offering critical data to guide environmental policies and mitigate the impact of carbon emissions on urban populations.

Amid the global efforts to combat air pollution and address climate change, $BEACO_2N$'s accurate and continuous monitoring of key pollutants can be very impactful. By mapping urban carbon emissions, this initiative contributes significantly to the development of sustainable and environmentally conscious urban planning and policies, paving the way for cleaner and healthier cities for generations to come.

Grant Allan

University of Strathclyde

Dr. Grant Allan explored the vital role of economic and policy analysis in Scotland's pursuit of environmental targets. The country is aware of the economic opportunities and challenges inherent in various areas of work, recognizing their spatial implications. Striking a unique balance, Scotland aligns its environmental targets with its economic ambitions, all while considering the distributional consequences across different areas, groups, and sectors. This approach ensures that environmental initiatives are pursued in harmony with economic growth, fostering a sustainable and equitable future.

To support informed decision-making, policymakers must be equipped with robust frameworks, necessitating an expansion of existing knowledge and embracing innovative data production methods. Timely and relevant data is pivotal in effectively addressing emerging challenges and implementing timely interventions. By integrating economic and policy analysis into environmental planning, Scotland navigates the complexities of sustainable development adeptly. This dynamic and adaptive approach to balancing economic growth with environmental protection ensures the well-being of its citizens and the preservation of the environment for future generations. With its commitment to comprehensive analysis and informed decision-making, Scotland is on a path to achieving its environmental targets while fostering sustainable economic growth.

John Harvey

Southern Photonics & University of Otago

Dr. John Harvey highlighted the progress made by the GEMM regional center in New Zealand in environmental monitoring, particularly its work on water quality. By bringing together diverse agencies that do not normally interact, the center collaborates to identify and address major environmental challenges facing the country. One distinctive advantage of the region is the circulation of winds known as the "Roaring Forties," which remains untouched by large land masses, resulting in minimal pollution issues in the area. This natural condition provides a conducive environment for conducting pollution-free monitoring activities.

In its research on monitoring the quality of freshwater, the center employs a range of methods, including lab-based sampling and innovative technologies like UV absorption for detecting nitrates and Raman scattering for identifying phosphates. These advanced approaches enhance the accuracy and efficiency of water quality assessments. Notably, New Zealand's economy heavily relies on the agricultural sector, with dairy contributing significantly, accounting for 30% of the country's exports. Considering this economic significance, the efforts of the GEMM regional center hold even greater importance in ensuring sustainable water management practices while preserving the environment. Through the collective and multidisciplinary efforts of the GEMM regional center, New Zealand is poised to effectively address environmental monitoring challenges and promote responsible water management, thus contributing to the overall well-being of its ecosystems and society. The center's proactive approach serves as a model for other regions seeking to balance economic prosperity with environmental conservation.

Duncan Booker

City of Glasgow

Duncan Booker discussed the progress of town and gown cities as they lead the way toward sustainable futures through innovation and collaboration. The foundation of this progress is built upon three innovation districts centered around two research-intensive institutions. These districts serve as hubs for cutting-edge research and foster key collaborations, facilitated by the Glasgow City of Science and Innovation.

An essential aspect of this sustainable vision is the presence of a thriving entrepreneurial and innovative business base, driving advancements in various sectors. The inclusion of Catapult's innovation centers and PSREs (Public Sector Research Establishments) further amplifies these efforts, leading to significant strides in high-value manufacturing, offshore renewable energy, satellite applications, and connected places.

Among the noteworthy contributions are initiatives like CENIS (Circular Economy Network for Industrial Symbiosis), Construction Scotland Innovation Center, Digital Health and Care, and Industrial Biotechnology and Precision Medicine Scotland. These initiatives exemplify the cities' unwavering commitment to sustainable practices and their dedication to forging urban partnerships, as evident in their active involvement in the Global Resilient Cities Network.

Through these pioneering endeavors, cities emerge as frontrunners in the journey towards a greener and more resilient future, showcasing their leadership in sustainable development and creating positive impacts on communities and the environment.

Conclusions

Following the conclusion of the sessions' presentations, a roundtable discussion was held by all in attendance about priorities, common interests, differences, and shared conclusions. This conversation is summarized below:

- The Summit was a successful first meeting of its kind with interest from the parties to expand GEMM in Asia;
- Share technologies and knowledge through networks like GEMM to help address the disparity between developed and developing areas in Asia;
- Prioritize inclusivity across Asia regions and countries for subsequent meetings and focus on cities as entry points for tackling environmental challenges;
- Decentralize GEMM meetings and workshops and increase the participation of policymakers;
- Emphasize Optica and AGU's role as critical intermediaries and the providers and translators of science to non-scientific communities, and validators for the science and data;
- Air pollution is an urgent issue in Asia and an entry point to addressing climate change; and
- Key ingredients essential for GEMM expansion include in-country leadership and support, identifying an institution to play a leadership role and engaging physical and social scientists, involving city governments, and partnering with GEMM to identify funding opportunities.

Acknowledgments

We own much appreciation and many thanks to the GEMM Asia Organizing Committee:

Tomohiro Oda, Universities Space Research Association (Chair)
Jolene Lin, National University of Singapore (Host)
Tom Baer, Stanford Photonics Research Center
Yugo Kanaya, Japan Agency for Marine-Earth Science and Technology
Keerthi Katam, Mahindra University
Sujong Jeong, Seoul National University
Jeongsoon Lee, Korea Institute of Standards and Science
Ling Li, Westlake University
Luisa Molina, Massachusetts Institute of Technology
Julian Taylor, University of Strathclyde
Wei Wan, Clean Air Asia

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Finally, thank you to Natchapol Israngkura for compiling a majority of the contents for this report.

Appendixes

GEMM Asia Summit Program

Monday, 5 December

09:00 – GEMM Asia Opening

- Introduction, Tomohiro Oda, *Summit Chair*
- Opening Remarks, Satoshi Kawata, *Optica President*

09:30 - Welcome from National University of Singapore Faculty of Law

- Jolene Lin, *Host & NUS Asia-Pacific Centre for Environmental Law*

09:45 - Singapore

Presentations and Q&A Moderated by Jolene Lin, *Host & NUS Asia-Pacific Centre for Environmental Law*

- Effects of Land Use and Land Cover Changes on Local Climates in Urban Settings and Implications for Monitoring Air Temperature
    - Matthias Roth, *National University of Singapore*
- Air Quality Management and Climate Change Monitoring in Singapore
    - Erik Velasco, *Molina Center for Energy and the Environment*
- Singapore's Policy Approach to Tackling Its Key Environmental and Climate Change Challenges
    - Benjamin Cashore, *National University of Singapore*

10:45 – Tea & Coffee Break

11:00 - Japan

Presentations and Q&A Moderated by Yugo Kanaya, *Japan Agency for Marine-Earth Science and Technology*

- Satellite technology for GHG monitoring and policy relevance
    - Mariko Harada, *Japan Aerospace Exploration Agency*
- Ocean Color Research and Development
    - Eko Siswanto, *Japan Agency for Marine-Earth Science and Technology* (Virtual)
- Integrating Air Pollution and Climate Policy and Governance
    - Eric Zusman, *Institute for Global Environmental Strategies* (Virtual)

12:00 to 13:30 – Lunch

13:30 - China (Virtual)

Presentations and Q&A Moderated by Wei Wan, *Clean Air Asia* & Ling Li, *Westlake University*

- Embedded Ecosystem Monitoring in Agricultural Landscapes
    - Thomas Wanger, *Westlake University*
- Air Quality Monitoring to Support the Science-based and Sophisticated Management in Cities
    - Qingyan Fu, *Shanghai Environmental Monitoring Center*
- Fluorinate greenhouse gas monitoring in China: Progress, Challenges and Needs
    - Yao Bo, *Fudan University*

- The Precise Measurement and the Closure Study of the Atmospheric Oxidants
    - Keding Lu, *Peking University*
- Fusing multi-source data to monitor health impacts of air pollution and climate change
    - Tao Xue, *Peking University*

14:30 – South Korea

Presentations and Q&A Moderated by Sujong Jeong, *Seoul National University*

- GHG Monitoring "Megacity Seoul CO2 Project"
    - Chaerin Park, *Seoul National University*
- A Cubesat for Environmental Monitoring Over the Asian Regions
    - Jae-Pil Park, *CEO of NARA Space Technology*
- Policy of Air Quality Control in Korea
    - Seungmin Lee, *Korean Environment Institute*
- Policy of GHG Monitoring for Carbon Neutral in Korea
    - Youngsook Lyu, *National Institute of Environmental Research*

15:30 – Tea & Coffee Break

15:45 – India

Session organized by Keerthi Katam, *Mahindra University National*

Presentations and Q&A Moderated by Dr. Bharti, *Law University Delhi*

- Water & Environment - Sustainability Issues in the Indian Himalayan Regions
    - ML Kansal, *Indian Institute of Technology Roorkee*
- Air Quality Management for Sustainable Development: Perspectives for India
    - Sagnik Dey, *Indian Institute of Technology Delhi*
- India's Legal and Policy Framework on Climate Change and Key Environmental Parameters – Challenges and the Path Ahead
    - Dr. Bharti, *National Law University Delhi*

16:45 – Southeast Asia Nations

Presentations and Q&A Moderated by Luisa Tan Molina, *AGU Global Engagement Committee, Vice Chair*

- Environmental Cases from Southeast Asia and Indonesia Policy on Climate Change
    - Linda Yanti Sulistiawati, *National University of Singapore*
- Transforming Evidence into Clean Air Solutions in Southeast Asia
    - Dang Espita-Casanova, *Clean Air Asia*
- Air Quality Studies in Metro Manila, Philippines
    - Melliza Cruz, *Manila Observatory*

17:45 – Day One Closing Remarks

- Councilor Susan Aitken, *Glasgow City Council (Virtual*)

18:00 – Day One Conclusion

18:45 – Cocktail Reception

19:15 – Dinner

Tuesday, 6 December 2022

09:00 Day Two Objectives and Opening

- Tomohiro Oda, *Summit Chair*

09:10 Accelerating Actionable Science with GEMM

- Scott Carney, *Optica Chief Science and Technology Officer*
- Luisa Tan Molina, *AGU Global Engagement Committee, Vice Chair*

09:25 GEMM Regional Centers and Regional Measurement Solutions
Moderated by Tom Baer, *GEMM Initiative*

- Ron Cohen, *Northern California GEMM Center* (Virtual)
- Grant Allan, *Glasgow GEMM Center*
- John Harvey, *Dodd Walls GEMM Center*

10:00 Central to Actionable Science: The Town / Gown Relationship

- Duncan Booker, *City of Glasgow (Virtual)*

10:15 Tea & Coffee Break

10:45 Environmental Challenges & Opportunities with GEMM
Moderated by:

- Jolene Lin, *Host & NUS Asia-Pacific Centre for Environmental Law*
- Tom Baer, *GEMM Initiative*

11:50 Concluding Remarks

- Tomohiro Oda, *Summit Chair*

12:00 Summit Conclusion

Biographies

(In order of Appearance in the Program)

Tomohiro Oda

Dr. Tomohiro Oda is a senior scientist at the Universities Space Research Association (USRA) in Washington, D.C. and an adjunct professor at the Department of Atmospheric and Oceanic Science, University of Maryland, College Park. Prior to the current positions, Dr. Oda held positions at NASA Goddard Space Flight Center, Colorado State University, NOAA Earth System Research Laboratory, and Japan's National Institute for Environmental Studies. Dr. Oda is a pioneer of the use of Earth Observations in development of high-resolution greenhouse gas (GHG) spatial emission estimates. He is the founder and the Principal Investigator of the Open-source Data Inventory for Anthropogenic CO2 (ODIAC) emission inventory data product (www.odiac.org), which is known as the most beautiful map of CO2 emissions. Dr. Oda has also advanced and matured the carbon emission quantification using new space-based GHG observations. He has been a science team member of NASA's Orbiting Carbon Observatory mission as well as a key contributor to Japan's Greenhouse gas Observing Satellite (GOSAT) mission. Dr. Oda holds a Ph.D and a master's degree in engineering from Osaka University, Japan and an undergraduate degree in physics from Kwansei Gakuin University, Japan. Recently, Dr. Oda served as a committee member for the U.S. National Academies' fast-track consensus study and contributed to the development of GHG information evaluation framework.

Jolene Lin

Jolene Lin is an Associate Professor at the National University of Singapore's Faculty of Law (NUS). She is also Director of the Asia-Pacific Centre for Environmental Law. Jolene has published extensively in peer-reviewed journals including Journal of Environmental Law, the European Journal of International Law, and the American Journal of International Law. She regularly conducts seminars and provides consultancy services to government agencies, judicial bodies, companies and non-governmental organizations. At NUS, Jolene teaches tort law and climate change law. She received the faculty's teaching award in 2020 in recognition of her passionate commitment to teaching.

Before joining the National University of Singapore, Jolene spent ten years at the University of Hong Kong where she was Associate Professor and Vice-Dean (International Affairs). During her time in Hong Kong, Jolene served on the Appeal Tribunal Panel (Buildings Ordinance) and the Appeal Board Panel (Town Planning). She is a founder of Urban Spring – a non-profit company dedicated to reducing plastic bottle waste – and continues to serve as a director.

Jolene grew up in Singapore and was always eager to explore the world. After completing her A levels, she pursued an LLB at the London School of Economics and Political Science where she discovered her love for international law and environmental law. She then crossed the Atlantic to read her LLM at New York University School of Law, where she also worked as a student research assistant to Professor Richard Stewart and Professor Katrina Wyman. Jolene's time at NYU was a formative experience that encouraged her to pursue an academic career. After obtaining her LLM, Jolene returned to Singapore to pursue her professional qualifications and be called to the Singapore Bar. After pupillage and a brief stint at one of Singapore's leading law firms, Jolene joined academia. As it frequently happens in common law jurisdictions, Jolene obtained her PhD in law (Erasmus University Rotterdam) after many years of employment as a law teacher and researcher. Jolene's PhD thesis examined the role of global cities in making and implementing climate change laws, and was supervised by Prof. Dr. Ellen Hey.

Satoshi Kawata

Satoshi Kawata received his B.S. and Ph.D. in Applied Physics from Osaka University in 1974 and 1979, respectively. After the experience of a postdoctoral fellow in Japan, he spent two years at the University of California, Irvine, as a postdoctoral scientist. Kawata joined the Department of Applied Physics of Osaka University as an Assistant Professor in 1981, and was promoted to a full Professor in 1993 and a Distinguished Professor in 2013. He has also been a Professor of the Department of Frontier Biosciences and School of Information Sciences at Osaka University. Kawata founded the Photonics Advanced Research Center (PARC) at Osaka University in 2007, where he was the Executive Director until 2016. In PARC, he initiated collaborations between 23 professors of 8 departments and more than 10 partners from various industries to peruse a variety of research collaborations, which resulted not only in high-level product-oriented research, but also in the birth of at least 5 startups at the university. Kawata also led a research group on nanophotonics as a Chief Scientist in RIKEN from 2002 to 2015. He is now a Professor Emeritus of Osaka University and Honorary Scientist in RIKEN. He founded two companies, one of which is a laser-scanning Raman microscope company, Nanophoton, established in 2002, where he has been the Chairman.

Satoshi Kawata has been an OSA member since 1980, and served as the Chair of the International Council (2009-2010), member of the OSA Executive Committee (2009-2010) and on the OSA Board of Directors (2009-2010). He has served on a number of OSA committees and councils, and organized topical meetings for OSA. He has been the advisor for the OSA Student Chapter of Osaka University, the first OSA student chapter in Japan, which now has nine chapters. He has given lectures at many student chapters including Stanford University, University of Sao Paulo and Utsunomiya University.

Satoshi Kawata was the President of Japan Society of Applied Physics (2014-2015), President of Spectroscopical Society of Japan (2007-2008), General Chair of Nano Science and Engineering of SPIE (2012-13), Editor of Optics Communications (2000-2009) and the Regional Representative of Journal of Microscopy (1988-2014). He chaired and organized a number of international conferences, including Near Field Optics (1998), Focus on Microscopy (2000, 2008) and UV Nanophotonics (2013).

Satoshi Kawata is one of the pioneers of near field optics (the inventor of tip-enhanced near-field microscopy), 3D microscopy, 3D optical data storage, plasmonics (SPR sensors, plasmonic nano-microscopy, plasmon holography, etc.), two-photon engineering (two-photon polymerization, two-photon isomerization, two-photon reduction, etc.), bio-molecular imaging, molecular spectroscopy and signal recovery. He has authored/edited more than 30 books and published more than 520 papers with h-index 72 (Web of Science). The "8-micron bull" fabricated with his invented two-photon technology has been awarded in Guinness Book of World Records 2004 Edition. He was awarded the Medal with Purple Ribbon from the Emperor of Japan, Leo Esaki Prize, LVMH da Vinci Excellence, Shimadzu Award and many others. He is a Fellow of Optica, SPIE, IOP and JSAP.

Matthias Roth

Matthias Roth is an Associate Professor in the Department of Geography at the National University of Singapore. He holds a PhD degree from the University of British Columbia, Vancouver (Canada). His research examines how land-use changes affect local climates with a particular focus on the climate of cities. He has held past academic appointments in Canada and Japan and was a Visiting Professor/Researcher at ETH and EPFL (Switzerland), ASU (USA) and Monash University (Australia). He is Past President of the International Association for Urban Climate (IAUC) and Associate Editor of the International Journal of Climatology. He is currently Deputy Head of the Department of Geography and Deputy Director of the NUS Bachelor of Environmental Studies programme.

Matthias' research examines how land-use changes affect local climates with a particular focus on the climate of cities and the role they play in climate change. As an experimental researcher he has conducted observations of urban heat islands, energy balance, carbon dioxide fluxes and fundamental turbulence properties in cities located in North America, Europe and Asia. Besides fundamental aspects of the surface-atmosphere exchanges, he is interested in the application of such knowledge to the climate-sensitive design of cities. He is a lead author of the recently completed WMO "Guidance to Measuring, Modelling and Monitoring the Canopy Layer Urban Heat Island (CL-UHI)".

Erik Velasco

Dr Erik Velasco investigates the impact of urbanization and climate change on the atmospheric environment and biogeochemical cycles. He is interested in the interactions between the urban surface and overlying atmosphere in terms of mass and energy exchange, in the chemical and physical processes driving air pollution and the accumulation of greenhouse gases, in the exposure to pollutants and heat in public spaces, and the impact of urbanization on the carbon cycle. The primary purpose of his research work is to provide reliable scientific information for devising effective solutions to improve the atmospheric environment while enhancing sustainability and livability. Dr. Velasco has over 20 years of experience on the matter. He received his PhD from Washington State University and has worked for institutes and universities in Mexico, USA and Singapore.

Benjamin Cashore

Ben Cashore specialises in global and multi-level environmental governance, comparative public policy and administration, and transnational business regulation/corporate social responsibility. His substantive research interests include climate policy, biodiversity conservation/land use change, and sustainable environmental management of forests and related agricultural sectors. His geographic focus includes Southeast Asia, North America, Latin America and Europe.

Ben's theoretical interests include the legitimacy and authority requirements of non-state market driven (NSMD) global governance, the influence of economic globalisation on domestic environmental policies, and the potential of anticipatory policy design for identifying path dependent policy mixes capable of ameliorating "super wicked" environmental problems. He integrates his theoretical and empirical research around two key themes: 1) developing and managing problem oriented multi-stakeholder policy learning processes 2) strategies for nurturing multiple step policy pathways.

Ben joined Lee Kuan Yew School of Public Policy after spending 18 years at Yale University as a professor of environmental governance and political science, where he also directed the Governance, Environment and Markets (GEM) initiative and, from 2014-2019, directed the Yale International Fox Fellows exchange program which awards promising graduate students in 18 partner universities. Ben was born and raised in British Columbia, Canada. His PhD is from the University of Toronto and he undertook postdoctoral research at Harvard University and the University of British Columbia. He worked for three years in Ottawa, Canada as a policy advisor to the leader of the Canadian New Democratic Party.

Yugo Kanaya

Yugo Kanaya is a Principal Researcher/Director of Earth Surface System Research Center (ESS) of Japan Agency for Marine-Earth Science and Technology (JAMSTEC). He received his Ph.D. in Chemistry at the University of Tokyo and joined JAMSTEC in 2000. He started his career with developing a laser-induced fluorescence instrument measuring OH/HO2 radicals, which was then applied to field observations, testing tropospheric photochemistry theory to reveal importance of halogen chemistry and heterogeneous loss of HO2 on aerosol surfaces. Upon his strong interest on optical measurements, he extended his studies on

ground and ship-based MAX-DOAS observations in support of satellite observations. His recent works are also on diagnosis of ozone production rates and regimes and on emission/removal rates of black carbon, both of which are important short-live climate forcers (SLCFs). His group is engaged in shipborne observations of ozone, halogens, and fluorescent aerosols to explore atmosphere/ocean interactions. He actively participates in many international studies: HOxCOMP, Mount Tai Experiment (MTX2006), CINDI, EMeRGe-Asia, TROPOMI validation, GEMS and PGN. He served as a Review Editor of IPCC AR6 WG1 Chapter 6 (SLCFs), and is a current IGAC SSC member. His research center studies Earth Surface altogether, i.e., air pollutants, GHGs, ocean ecosystems and biogeochemistry and land surface.

Mariko Harada

Mariko Harada is Associate Senior Administrator at Japan Aerospace Exploration Agency (JAXA) and Technical Advisor of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan.

Since joining JAXA, she has been working on satellite applications with domestic and international partners aiming at addressing global challenges. She has extensive experience in international affairs and space policy in the field of space and contributed to the intergovernmental Group on Earth Observations (GEO) for many years as a member of the Japanese delegation as well as JAXA.

She received the JAXA President Award in 2019 for her contribution to improving the role of Earth Observation satellites in the "Refinement to the 2006 UPCC Guidelines on National Greenhouse Gas Inventories".

Eko Siswanto

Dr Eko Siswanto earned his Doctorate degree in 2006 from Nagasaki University, Japan. He was then appointed as a postdoctoral researcher from 2006 to 2007 at the Sekai National Fisheries Research Institute – Japan Fisheries Research Agency, as a researcher from 2007 to 2011 at the Hydrospheric Atmospheric Research Center (HyARC), Nagoya University, and as a senior lecturer from 2011 to 2013 at Universiti Teknologi Malaysia. Currently, he is a research scientist at Japan Agency for Marine-Earth Science and Technology (JAMSTEC) since 2013 and concurrently as a temporary lecturer at Yamaguchi University since 2016. For more than ten years, Dr Siswanto has been utilizing satellite remote sensing observations to assess the impacts of climate changes and human activities on the marine ecosystems over the region encompassing the Asia-Pacific and the Arctic/subarctic marine environments.

Eric Zusman

Eric Zusman is a senior policy researcher/area leader at the Institute for Global Environmental Strategies in Hayama, Japan. Dr. Zusman holds a bachelor's degree in Mandarin Chinese from Rutgers University, a dual Master's Degree in public policy and Asian studies from the University of Texas at Austin and a Ph.D. in political science from the University of California, Los Angeles. For much of the past two decades he has conducted research on environmental issues in Asia. This has included working with China's Yellow River Conservancy Commission, the Chinese Research Academy on Environmental Science, Woodrow Wilson Center's China Environment Forum as well as Taiwan's Academia Sinica. He has published books and articles on water scarcity, air pollution regulation, environmental law, multilevel governance, sustainability transitions, low carbon development and the Sustainable Development Goals. He is currently serving as a lead author for the sixth assessment report of the Intergovernmental Panel on Climate Change (Chapter 17).

Wei Wan

Dr. Wei WAN is currently working as the China Program Director of Clean Air Asia, which is an international non-profit organization that leads the regional mission for better air quality and healthier, more livable cities in Asia. Since 2017, she has been working closely with the Peking University (PKU) and was appointed to lead the International Project Office of Monsoon Asia Integrated Study for Sustainability, which is a global research project of Future Earth hosted by PKU. She is also deeply engaged in the establishment of the AiR-Climate-Health (ARCH) Integrated Study and Exchange Platform initiated by PKU in collaboration with several leading research institutions in China. Dr. Wei WAN has served as project consultant for several international organizations, including UN Environment, World Bank, Asian Development Bank and World Resource Institute etc. Dr. Wei WAN He holds a Ph.D in Environmental Science from Peking University and has over 15 years of professional experience on air quality management and policy studies. She has taken lead in many research and capacity building projects in China and Asian region, implemented more than 40 technical trainings for Asian air quality management policy makers.

Ling Li

Prof Li graduated from Tsinghua University with a Bachelor of Engineering (Environmental) degree and received his PhD from University of Western Australia. He held various academic positions at Deakin University, University of Edinburgh and University of Queensland before joining Westlake University as Chair Professor of Environmental Hydrology in 2018. Prof Li's principal research interests lie in mathematical modelling of complex environmental systems across different scales. His research address fundamental aspects of ocean-land interactions and has contributed to understanding of eco-hydrological processes that underpin the functionality of coastal wetlands. Prof Li has led more than 20 large scientific research projects and published over 250 research papers in international journals. He is currently a co-editor of Water Science and Engineering and a member of the editorial board of Advances in Water Resources.

Thomas Wanger

Dr. Thomas Wanger is an Associate Professor at Westlake University and Principal Investigator of the 'Sustainable Agricultural Systems & Engineering' laboratory (https://www.tomcwanger.com), where he works with his team on agricultural diversification and coordinates multiple large scale research platforms. He is also an Adjunct Full Professor at the Universidade Estadual de Santa Cruz, Brazil and an Adjunct Senior Scientist at the University of Göttingen in Germany. He received his PhD degree in Environmental Sciences and Statistics from the University of Adelaide, Australia in 2011 and since then has worked as a Postdoc at Stanford University, US, the Swedish Agricultural University, Sweden and the University of Göttingen in Germany. He is an invited member to the IUCN commission of Ecosystem Management. Dr. Wanger is a regular speaker at high level conferences and is consulted for his expertise in sustainable agriculture, AI, and carbon sequestration of plantation crops. He has received multiple awards for scientific excellence including the 2020 Zhejiang High-level Talents Program Award. His work has been published in more than 50 papers, is cited over 8,400 times and published in leading journals such as Science, Nature, and Trends in Ecology and Evolution. His work has been featured in the international media including BBC, CGTN, and Mongabay amongst others.

Qingyan Fu

Fu Qingyan, Ph.D., has served successively as chief engineer and deputy director of Shanghai Environmental Monitoring Center, deputy director of Dianshan Lake Scientific Observation Station in Yangtze Delta Region of National Environmental Protection, and part-time doctoral supervisor of Fudan University. She has long been engaged in atmospheric environment monitoring, daily forecast of Shanghai ambient air quality, information construction of environmental monitoring, emission inventory and simulation of air pollutants,

emission verification of industrial areas, emission monitoring of pollution sources and research on composite air pollution. She has many years of working experience in the field of super station observation and tethered balloon vertical observation. She led Shanghai's air quality monitoring, AQI release and forecast, PM2.5 source analysis and air pollutant emission inventory, and participated in Shanghai's air pollution early warning and prevention and control work. She won the special allowance of the State Council, was selected as the leading talent of Shanghai in 2012 and the leading technical talent of national environmental protection in 2016, and successively won the second prize of National Science and Technology Award, the first prize of Shanghai Decision-making Consultation and Decision-making Award, the second and third prizes of Science and Technology of the Ministry of Environmental Protection, and the second and third prizes of Shanghai Scientific and Technological Progress Award. In recent years, she has led the development of a number of regional prediction products and directly served the air quality prediction business in the Yangtze River Delta region. It has successively provided monitoring, evaluation and prediction technical services in national large-scale activities and event guarantee activities such as the G20 in 2016, the BRICs meeting in 2017, the Qingdao Shanghai Cooperation summit in 2018 and the China Import Expo.

Bo Yao

Prof. Bo Yao comes from Department of Atmospheric and Oceanic Sciences, Fudan University. His work experience has covered a range of topics, including GHG measurement technology, long-term high precision GHG measurement, GHG and ODS emission estimation, GHG inventory and mitigation policies. He is one of the top scientists on GHG measurement in China and used to leads the GHG and ODS observation network of China Meteorological Administration. Prof. Yao is the project leader of the first HFC emission project by Chinese Natural Science Foundation and task leader of the first megacity carbon emission project funded by Chinese Ministry of Science and Technology, has groundbreakingly set a comprehensive CO2 observation network in China. Besides, he conducted the first in-situ measurement of HFC/PFC/NF3 and the first multidimensional CO2 intensive campaign in China. Prof. Yao has published more than 80 refereed journal papers, a series of research reports, and books on GHG measurement and emission, HFC inventories and mitigation projections, with kinds of partners. He is also the chapter author or review editor of WMO/UNEP Scientific Assessment of Ozone Depletion.

Tao XUE

Dr. Tao XUE is an Assistant Professor from School of the Public Health, Peking University Health Science Center. He holds a Bachelor degree in Environmental Science from Peking University, and a PhD degree in Public Health from University of Pittsburgh. His works are focused on the environmental risk factors including air pollution and climate change, and their exposure and health impact assessments. The relevant works have published in highly impactful journals such as Nature Communications, National Science Review, Lancet Planetary Health, Lancet Regional Health, Lancet Healthy Longevity, PLOS Medicine, and eLife.

Keding LU

Dr. Keding Lu is Associate Professor, Deputy Executive Director of College of Environmental Sciences and Engineering, State Environmental Protection Key Laboratory of Atmospheric Ozone Pollution Control; State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University. His main research concerns High Sensitivity Optical Instrumentation, Atmospheric Free-radical Chemistry, Urban Ozone Photochemistry and Control Strategy. He has been leading several key studies on regional air pollution, atmospheric chemistry, air pollutants observation and modelling to support the science-based air pollution control in China. He won the Gold medal of Young

Scientist Award of Chinese Academy of Environmental Sciences, Natural Science Fund for Distinguished Young Scientist in Beijing, and Changjiang Youth Scholar given by Ministry of Education of China, 2017.

Sujong Jeong

Sujong Jeong is currently associate professor at Seoul National University. His research mainly focuses on climate change and carbon cycle. His research group covers modeling, measuring, and analyzing global carbon cycle, carbon-climate feedback, greenhouse gases monitoring/modeling, atmosphere-biosphere interaction, terrestrial carbon flux, vegetation phenology, atmospheric microplastics, and forest air quality.

Chaerin Park

Chaerin Park has been a Ph.D. candidate in atmospheric science at Seoul National University since 2019. She is mainly engaged in research on the urban CO2 cycle based on ground observations and model simulation. She published papers about quantifying the urban CO2 enhancement in Seoul using satellite data and identifying the nature of CO2 variation in Seoul by establishing a CO2 ground observation network in Seoul. Currently, her main task is to manage the urban CO2 observation network in Seoul and identify the effect of urban CO2 emission on the global carbon cycle by using model simulations.

Jae-Pil Park

Jae-Pil Park is a co-founder and CEO of NARA Space Technology, a startup servicing CubeSat total solutions since 2015. NARA Space Technology is mainly servicing two major areas, small satellite manufacturing for under 50 kg and satellite bigdata related value-added service. He served as the project manager and system engineer for the CANYVAL-X(CubeSat Astronomy NASA and Yonsei using Virtual Telescope ALignment-eXperiment) mission which launched in 2018. The objective of the mission was to demonstrate its virtual telescope technology using two CubeSats in orbit.

Seungmin Lee

I received my Ph.D. from Seoul National University in 2013 on the subject of transboundary transport of air pollutants related to meteorological conditions. I have been researching air quality management policies in Korea since I joined the Korea Environment Institute (KEI) in 2014. I am mainly interested in improving domestic air quality management policies and evaluating their implementation, and international cooperation on air quality in Northeast Asia.

Youngsook Lyu

Youngsook Lyu has completed her Ph.D. course work at Seoul National University and works with the Ministry of Environment / National Institute of Environmental Research. She also works with the IPCC as a Corresponding Author for the 2019 Refinement to the 2006 IPCC Guidelines for the National Greenhouse Gas Inventories. Previously she received her bachelor's degree in environmental engineering from Konkuk University and she was a visiting researcher in 2006-07 in Civil and Environmental Engineering at the National University of Singapore.

Keerthi Katam

Dr. Keerthi Katam is presently working as an Assistant Professor in the Department of Civil Engineering, Mahindra University École Centrale School of Engineering (India). She finished her PhD in Civil Engineering from Indian Institute of Technology Hyderabad, India. She worked on "Developing a Cost-effective Biological Decentralized Domestic Wastewater Treatment System Using Bacteria and Microalgae for Residential Communities". During her PhD she also worked in Graduate school of Life science, Ritsumeikan University, Otsu, Shiga, Japan on projects "Aerobic Biodegradation of Surfactants and Fluorescent

Whitening Agents in Detergents of a Few Selected Asian Countries (India, Indonesia, Japan, and Thailand) and Developing trickling photobioreactor for removing Linear alkylbenzene sulphonate and Caffeine from wastewater" under the funding of JICA. Her research interests are bio-concrete, photobioreactors, biofuel production, biological wastewater treatment (algae-activated sludge), air quality and recycling constructing and demolition waste. She is also a reviewer of leading journals such Journal of Biotechnology, Journal of Water Process Engineering, and Arabian Journal of Chemistry etc.

Mitthan Lal (M.L) Kansal

Dr. Mitthan Lal Kansal, currently working as a Professor (HAG) in the Department of Water Resources Development & Management (WRD&M) at IIT Roorkee. He has served as Head of the Department, NEEPCO & JPSS Chair Professor & ADOSW at IIT Roorkee India). He is a Civil Engineering graduate with post-graduation in Water Resources Engineering. He obtained his PhD from Delhi University (India) and holds the Post Graduate Diploma in Operations Management. Previously, he served at Delhi Technical University, Delhi, NIT Kurukshetra, IIT Delhi and NIH, Roorkee (India) at various levels. He has published more than 200 research papers; two books and edited 6 books. He is the recipient of Visiting International Fellowship (VIF) of EWRI of ASCE, the USA in 2011. He acted as a reviewer for several International Journals and research agencies. Dr. Kansal acted as an international expert for RCUWM of UNESCO and IUCN, etc.

Sagnik Dey

Prof. Sagnik Dey is Institute Chair Professor at the Centre for Atmospheric Sciences, IIT Delhi. He received his M. Sc. in Applied Geoscience from Jadavpur University, Kolkata, and M. Tech. and PhD from Indian Institute of Technology Kanpur, India. He worked as Postdoctoral Scientist at Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign, USA from Aug 2007 to Jul 2010. His research interests are to understand 'air quality, climate change and health nexus' and 'remote sensing of the Earth's climate system'. He has published more than 125 peer-reviewed research articles. He received INSA Young Scientist Medal in 2008, NASI-SCOPUS Young Scientist Award in 2012, Dr. Sudhansu Kumar Banerji MoES outstanding young faculty fellowship for the period 2011-2013, and Teaching Excellence Award from IIT Delhi in 2016. He is an international collaborator and science team member of NASA's MAIA satellite mission and served as an expert member of WHO "Global Platform on Air Quality and Health". He is a collaborator of the Global Burden of Disease Study and served as an expert in the India arm of the GBD Study. Prof. Dey has been awarded the Fulbright-Nehru Academic and Professional Excellence Fellowship for 2017-18. Prof. Dey is the coordinator of Centre of Excellence for Research on Clean Air (CERCA), IIT Delhi and is an Associate Faculty of School of Public Policy and Transportation Research and Injury prevention Centre (TRIPC), IIT Delhi. He is a member of WHO Southeast Asia non-communicable diseases Regional Technical Advisory group. He is serving as Associate Editor of Atmospheric Environment (Elsevier journal) and is also Editorial board member of Scientific Reports (Nature) and Earth System Dynamics (EGU).

Dr. Bharti

Dr. Bharti is a Professor of Law at NLU, Delhi. Her experience in teaching law extends from 1998 at Faculty of Law, Law Center I and Law Center II, Delhi University and thereafter from 2009 at National Law University, Delhi. She has been Visiting Faculty at Delhi Judicial Academy, Indian Law Institute, Institute of Constitutional and Parliamentary Studies, Bureau of Parliamentary Studies and Training etc. Her areas of interest are Constitutional Law, Environmental Law, Family Law etc. She has coordinated several Workshops and Seminars at D.U. and NLUD. Besides being Resource person at several in-person and online Seminars/Conferences on the environmental theme, she has recently been Resource person to SOAS-NLUD Summer course on Climate Justice.

She has published several Articles and has made Paper Presentations on many legal themes at various places, including SAARCLAW, Bhutan and GAJE, Turkey. She is Director, Centre for Environmental Law, Policy and Research, NLUD. She is Convener, Online Distance Learning; University District Nodal Officer, Disaster Risk Reduction; Faculty Advisor, Alternate Dispute Resolution Committee; Presiding officer, Internal Complaints Committee (ICC); Faculty Advisor, Legal Aid at NLUD etc. She is Member, Academic Council, NLUJ, Board of Studies, Rajiv Gandhi University, Arunachal Pradesh etc. and has been Panel expert in various Selection Committees.

Luisa Molina

Dr. Luisa Tan Molina is affiliated with the Molina Center for Energy and the Environment and the Massachusetts Institute of Technology. Her research interests include atmospheric chemistry, urban air pollution, and stratospheric ozone chemistry. More recently she is involved in integrated assessment of air pollution in megacities and the emissions and impacts of Short-lived Climate Pollutants on urban and regional climate and air quality.

Linda Yanti Sulistiawati

Linda is a Senior Research Fellow at APCEL and also an Associate Professor of Law in Universitas Gadjah Mada. She is an internationally recognised scholar in Indonesian international environmental law and her research has established her as a leading expert who is frequently consulted by the Indonesian government and international organizations. Her research focuses on international environmental issues, such as climate change, REDD+, land issues and customary (adat) issues. Linda was a member of the delegation leading Indonesia's negotiations of the Paris Agreement on Climate Change. From 2018 to 2021, Linda is a lead author of the Intergovernmental Panel on Climate Change's Sixth Assessment Report. Linda was a Visiting Fellow at APCEL from 5 August 2019 to 3 September 2019 under the APCEL Visiting Fellow Programme.

Dang Espita-Casanova

Espita-Casanova oversees program development and strategic planning for Clean Air Asia's impact initiatives on transport, energy, and urban air quality. She worked for government, private, and non-profit organizations in the early years of her professional career, with training and experience on environmental pollution chemistry and management for more than 10 years. Her career with Clean Air Asia on air quality management started in 2014 when she led a team of about 15 international and regional experts in the development of the Guidance Framework for Better Air Quality in Asian Cities (Guidance Framework). The Guidance Framework is the core knowledge product of the Integrated Programme for Better Air Quality in Asia (IBAQ Programme), one of Clean Air Asia's key projects. She has led projects focusing on capacity building of governments for air quality management through policy guidance and direct technical assistance on air quality monitoring, emissions inventory and modeling, health impact assessment, air quality communication, and development of clean air action plans. Dang leads a team of specialists and researchers in the development of Clean Air Asia's key knowledge products, tools, and capacity building activities. Dang is a licensed chemist, holding a Master in Development Management from the Asian Institute of Management and a Bachelor's degree and Masters units in Chemistry from the University of the Philippines.

Liz Cruz

Liz is the Officer-in-Charge of the Air Quality Dynamics Laboratory of the Manila Observatory. Her research has been focused on aerosol monitoring and chemical speciation, source apportionment via emissions inventory and receptor modeling, and dispersion modeling. She has also investigated the aerosol-meteorology interactions in Metro Manila, particularly the effects of PBL height and synoptic and

mesoscale wind circulations. She is currently involved in research initiatives that use low cost sensors to evaluate the exposure to and health effects of PM2.5.

Susan Aitken

Susan Aitken became Leader of Glasgow City Council when the SNP became the largest party on the Council and formed a minority administration in May 2017. She was elected as a councillor for the Langside ward, where she lives, in 2012 and has been leader of the SNP group since 2014, having previously served as the group spokesperson on health and social care.

Before being elected, Susan worked in a variety of policy and research roles in the Scottish Parliament and the third sector, and as a freelance writer and editor specialising in health and social care policy. She grew up in Biggar in South Lanarkshire, moved to Glasgow aged 17 and is a graduate of both Glasgow and Strathclyde Universities.

P. Scott Carney

P. Scott Carney is the Chief Science and Technology Officer at Optica. He previously served as Director of The Institute of Optics (2017-2021) and faculty at the University of Illinois Urbana-Champaign (2001-2017). He has served as Editor-in-chief of JOSA A and General and Program chair of Frontiers in Optics. He is author of more than 100 peer-reviewed publications with a Google H-index of 43. He is a Fulbright fellow, Fellow of the American Medical and Biomedical Engineering society, a Fellow of Optica, winner of the W. F. Meggers award from the Society for Applied Spectroscopy, and has been recognized repeatedly for his contributions to teaching and educational innovation. His main contributions to research have come in computed imaging, spectroscopy, and coherence theory. His major career accomplishments include modeling of tip-sample interactions in near-field microscopy and the solution of related inverse problems, solution of the inverse problem for optical coherence tomography (OCT) and the subsequent invention of interferometric synthetic aperture microscopy (ISAM) and the recent development of synthetic optical holography (SOH). He has made contributions to spectroscopy and the correction of spectroscopic data to account for the effects of scattering and propagation. His major leadership accomplishments include the establishment of a BS degree program in Innovation Leadership and Engineering Entrepreneurship in the College of Engineering at UIUC and the Hybrid Optics Masters Education, a mostly online degree program at The Institute of Optics. He has a demonstrated record of inclusivity and has consistently ensured that new initiatives start out with a diverse team and established programs implement inclusive practices.

Thomas Baer

Dr. Thomas Baer is the chair of the AGU and Optica co-run Global Environmental Measurement and Monitoring (GEMM) Initiative. He is also an adjunct professor in the Applied Physics Department and faculty co-director of the Stanford Photonics Research Center at Stanford University. His current scientific research is focused on developing imaging and biochemical analysis technology for exploring the molecular basis of human developmental biology and regenerative medicine, optogenetics, developing new high-throughput technologies for protein engineering, and environmental measurement and monitoring technology and modeling. Before joining Stanford, Dr. Baer founded several companies in Silicon Valley including Arcturus Bioscience, Inc., which he established in 1996, serving as the company's Chairman and CEO until January 2005. He is a fellow of Optica and served as President in 2009.

Ron Cohen

Ronald C. Cohen attended Wesleyan University where he received his BA with high honors in 1985. He attended graduate school at the University of California, Berkeley, where he received his Ph.D. under the supervision of Richard Saykally in 1991. From 1991-1996 he was Postdoctoral Fellow and then a Research

Associate at Harvard University with James G. Anderson. In 1995 he joined the faculty at the University of California at Berkeley as an Assistant Professor of Chemistry and of Earth and Planetary Science. He was promoted to Associate Professor in 2002. He is a Faculty Scientist, in the Energy and Environment Technologies Division, LBNL (1996-present). In 2006-2007 he was a Visiting Professor, Max Planck Institute for Chemistry, Division of Biogeochemistry, Mainz, Germany. Cohen has shared the NASA Group Achievement Award, in 2005 and in 1998. He has received awards from the Hellman Family Faculty Fund, (1999); and a Regents Junior Faculty Fellowship, (1998). He is an Editor of the open access journal Atmospheric Chemistry and Physics.

Grant Allan

I am currently a Reader in the Department of Economics at the University of Strathclyde. His research interests lie in understanding the links between economic activity, natural resources and the environment, while I'm also interested in economic questions of tourism, and economic accounts. He is an applied economist, with a particular interest at questions below the national level (i.e. at regional or city scale). Grant has experience of leading research projects funded by organisations including ESRC, UK Energy Research Centre, Scottish Government and other public, private and third sector organisations.

John Harvey

John has been CEO of Southern Photonics since its inception in 2001. He left the University of Auckland in 2013 to enable full time involvement with Southern Photonics, although he still teaches some specialist courses within the Physics Department. He is also the commercialisation director of the newly formed Dodd Walls Centre for Photonic and Quantum Technologies (www.doddwalls.ac.nz).

Duncan Booker

Dr Duncan Booker is has worked on policy development in local government for more than twenty years in a range of areas, including sustainability, public health, equalities and social policy. He drafted the Council's report and recommendations on the climate emergency in 2019, which led to the city committing to achieve carbon neutrality by the year 2030. Duncan is currently working on arrangements for Glasgow to welcome the world to COP26 in November 2021. The city is keen to promote two key messages in its role as COP host city: that sustainability and social justice must go together, locally and globally, and that it is cities which will lead the way in delivering national ambitions on the climate agenda. In a former role Duncan was the lead officer for Glasgow's membership of the World Health Organization European Healthy Cities Network, so has a strong track record in supporting multinational city partnerships. He is a graduate of the universities of Oxford and Glasgow.

Julian Taylor

Julian Taylor has a leadership role at the University of Strathclyde to identify and engage with international partners. Recently, he jointly led a project to capitalise on the University's global strengths, creating synergy across all areas of the University's work in India, the Middle East and SE Asia. As part of this, Julian is now based in Singapore, setting up and running a regional hub for the University. His objectives are to identify and work with new business, university and government partners to develop collaborative relationships to achieve mutual benefit. Julian joined the University in 2020 after a 30-year career in economic development, most of it in senior leadership roles with Scotland's national economic development agency. For six years he led the trade and investment activity of the Scottish Government for the Asia Pacific region, based in Shanghai, with responsibility for teams based in China, India, Singapore, Korea, Japan, Australia and other counties throughout Asia. Julian is a Globalscot – the Scottish Government's world-wide network of senior business leaders and professionals that supports the development of the economy

David Lang

David Lang is the Senior Director of Global Policy & Affairs at Optica (formerly OSA) in Washington, D.C. where since 2018 he has directed the organization's advocacy and public affairs programs. Prior to joining Optica, David was with the National Academies of Sciences for 14 years where he worked on more than 20 projects spanning space and Earth sciences, physics, and telecommunications. He received his Master of Engineering and Public Policy in energy policy and technology from the University of Maryland, College Park and his Bachelor of Science in Astronomy and Astrophysics from the University of Michigan, Ann Arbor.

Daniel Klingenberg

Daniel is the Director of Global Affairs at Optica and part of the GEMM Organizing Team. He earned his J.D. from Arizona State University in 2017 focusing on Transnational Legal Issues, after having earned a BS in Business, Finance, and International Studies from Indiana University. Prior to working at Optica, Daniel worked as an International Affairs Consultant and a Fulbright (Research) Fellow to Albania.