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Atmospheric chemistry research in Monsoon Asia and Oceania: Current status and future prospects

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ABSTRACT

We aimed to foster the community of atmospheric scientists in the Monsoon Asia and Oceania (MANGO) region to enhance communication among scientists in different countries and strengthen collaborations with the international community, with emphasis on air quality in Asia as it impacts human health and climate change. For this purpose, we have established a regional group, the International Global Atmospheric Chemistry–MANGO (IGAC–MANGO), under the IGAC project sponsored by Future Earth and the international Commission on Atmospheric Chemistry and Global Pollution. Through a series of committee meetings, scientific workshops, and training courses for students and early-career scientists, we analysed scientific activities in each country and identified research priorities in the MANGO region, significantly contributing to enhancing the capability and capacity of air quality research as well as fostering the next generation of scientists in the MANGO region.

HIGHLIGHTS

» A grassroots-level network was built for scientists in Monsoon Asia and Oceania.

» Priority themes in atmospheric chemistry in Monsoon Asia were identified.

» Air quality and human health research using low-cost sensors were established.

1. INTRODUCTION

The Monsoon Asia region is home to many countries undergoing rapid industrialization in response to the demand for economic growth. As a large portion of this region is located in a domain with copious amounts of water vapour and solar radiation, emissions associated with rapid urbanization lead to severe air pollution via complex atmospheric chemistry, causing critical environmental problems that are common among neighbouring nations. In addition, the region is characterized by complex meteorology, with regular pollution transport from seasonal and perennial anthropogenic sources (e.g., urban emissions).

In recognition of the common scientific challenges associated with critical environmental issues, and considering emerging atmospheric chemistry activities in South and Southeast Asia (A Sustainable Atmosphere for the Kathmandu Valley (SusKat); Atmospheric Composition and the Asian Monsoon (ACAM)), IGAC explored the feasibility of forming a Southeast Asia Working Group at its steering committee meeting in 2012 with a one-year scoping period. The idea was further discussed and evolved to become an overarching Asia Working Group, and the formal proposal was presented at the 2013 IGAC SSC meeting. Then, a core-preparatory committee was formed from Northeast, Southeast, and South Asia, and the possible structure was discussed and approved in the IGAC SSC meeting in 2014. To begin with, two workshops were held with the support from the NIES International Coordination Fund for two years (2014–2015) and the group officially started with the initial 17 members and three co-chairs from Northeast, Southeast, and South Asia. This group was named as the Monsoon Asia and Oceania Networking Group (MANGO) (Tanimoto, Kim Oanh, & Lawrence, 2015a; Tanimoto, Kim Oanh, & Lawrence, 2015b). Since 2017, the activities of MANGO have been boosted by the APN CAPaBLE fund "CBA2017-02MY-Tanimoto: Fostering of the next generation of scientists for better understanding of air quality in the Monsoon Asia and Oceania region".

As the group was inexperienced, there was a need to strengthen the working relationships among the members. Furthermore, although Monsoon Asia is a "frontier" for atmospheric chemistry research, the scientific studies by the scientists in the region as well as by the international community are limited. Hence, it was necessary to engage different countries from the Monsoon Asia region by holding meetings and capacity-building workshops to foster the community and enhance communication among scientists as well as between scientists and policymakers, and to establish close collaborations with the international community.

For this purpose, IGAC–MANGO aimed to form a cohesive network of atmospheric scientists in the Asian monsoon region, facilitate collaboration between Asian and international scientists, and foster the next generation of scientists in this region.

2. METHODOLOGY

To establish a robust structure using top-down and bottom-up approaches, the capacity development activities were organized by IGAC-MANGO and were three-fold: (1) committee meetings for country members; (2) scientific workshops for scientists including students and early- and mid-career scientists; and (3) training courses for students and early-career scientists that included hands-on sessions and science-policy panel discussions.

2.1 MANGO committee meetings

The IGAC–MANGO committee consists of members from South Asia, Southeast Asia, Northeast Asia, and Oceania. The committee meetings were held to discuss priority themes and scientific activities to be strongly pushed forward in the MANGO region. The committee also discussed how to enhance communication between scientists in Monsoon Asia, promote collaborations of the Asian community with the international community, and explore opportunities for funding and infrastructure that were needed to foster scientific research, capacity building, and regional collaborations.

2.2 MANGO science workshops

By bringing together scientists on atmospheric chemistry and environmental changes from East, South and Southeast Asia, science workshops were held to enhance knowledge exchange and foster new knowledge for scientists, policymakers and other relevant stakeholders in Asia. These workshops were also planned to help characterize regional similarities and differences in Asia and to identify and assess air pollution and global change issues at local, national, and regional levels. Recently, a virtual knowledge-sharing workshop was conducted to assess the regional and local impacts of COVID-19 on air quality (Tanimoto et al., 2020). These information exchanges provided a crucial opportunity to build on existing and establish new networks and relationships among scientists and policymakers throughout the region. Furthermore, these workshops enabled us to identify priority areas for collaborative research among atmospheric scientists in the MANGO region.

2.3 MANGO training courses

Training courses were held for students and early career scientists (ECS) from developing countries in Asia to provide hands-on practises with emission inventory, satellite data, and air quality modelling as well as basic air pollution instruments. The course also included science-policy engagement to help bridge science and policy for the ECS. In addition, experts were engaged to participate in the workshop through a panel discussion to learn the relationship-building process.

3. RESULTS AND DISCUSSION

First, we recognized that the Monsoon Asia region is facing severe environmental issues, including air pollution and climate change, and that the role of atmospheric scientists in understanding scientific principles and providing scientific support to policymakers is of utmost importance. Therefore, we identified three critical factors exemplified as a three-legged stool for the development and growth of atmospheric chemistry research in the MANGO region (Figure 1). This approach entails science themes, human resources, and infrastructure that must each be firmly rooted and balanced in the community, and connected to the IGAC's focal areas.

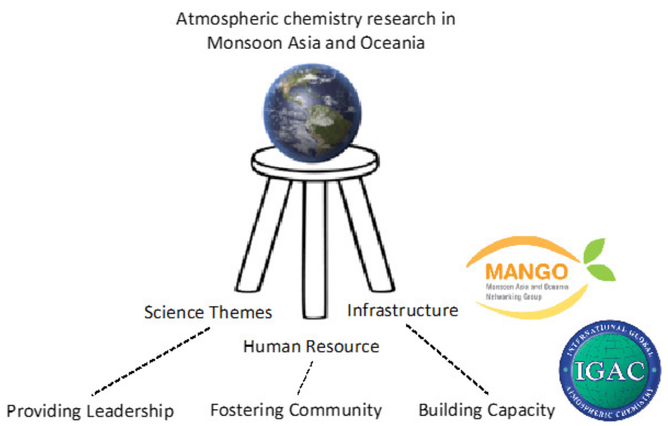

FIGURE 1. Three-legged stool approach to atmospheric chemistry research in MANGO requires science themes, human resource, and infrastructure that must each be strongly rooted and balanced in the community, and connected to the IGAC's focal areas.

3.1 Priority and emerging scientific themes

In recent years, Monsoon Asia has become a "frontier" for atmospheric chemistry research at the international level. One of the earlier projects, Atmospheric Brown Clouds (ABC) in the 2000s (Ramanathan & Crutzen, 2003), alerted the world that South Asia is a global air pollution hotspot, based on extensive observations carried out during Indian Ocean Experiments (INDOEX). Afterwards, the SusKat project was initiated jointly by the Institute for Advanced Sustainability Studies (IASS) and the International Centre for Integrated Mountain Development (ICIMOD) in 2012). The study focussed on the Kathmandu Valley in Nepal and addressed the relative roles of various pollution sources. In 2013, the ACAM project was initiated by the joint efforts of the IGAC and SPARC (Stratosphere–troposphere Processes And their Role in Climate) projects with a particular focus on four scientific themes relevant to air pollution and climate change in Asia: emissions and air quality in the Asian monsoon region; aerosols, clouds, and their interactions with the Asian monsoon; the impact of monsoon convection on chemistry; and the UTLS (the upper troposphere and the lower stratosphere) response to the Asian monsoon (Pan et al., 2014; Schlager, Chin, Latif, & Ahamad, 2019). Other studies include StratoClim (Stratospheric and upper tropospheric processes for better climate predictions) flight campaigns made over Nepal, India, and Bangladesh ("Balloon campaigns taking place simultaneously with the aircraft campaign," 2017), the AERONET (AErosol RObotic NETwork) project (AERONET), and SPARTAN (Surface Particulate Matter Network) project (SPARTAN: A Global Particulate Matter Network).

As such, research activities on atmospheric chemistry and air pollution need a significant boost in many Asian countries. Airborne pollutants are a major environmental health risk across the MANGO region, where they are responsible for the premature deaths of a few million people annually. Also, many Asian countries need to improve their understanding of changes in regional climate, which is vital for decision-making processes regarding adaptation, mitigation and sustainable development.

We identified the following priority themes associated with emerging scientific and environmental issues that are common across MANGO countries:

» Air quality and health, including indoor air quality issues;
» Biomass burning and anthropogenic emissions, and trans-boundary haze pollution;
» Changes in atmospheric composition and interplay with Asian monsoons; and
» Air pollution and climate change.

3.2 Human resource capacity

Despite the importance of tackling the above-mentioned scientific themes relevant to air quality, the capacity of human resources and infrastructure have yet to be improved. In the MANGO region, the number of atmospheric scientists was insufficient, and the scientists were not well connected to the international scientific community. There was large asymmetry among the countries in the capacity to conduct scientific research. Hence, coordination across Asian nations was developed, especially with a focus on countries that are not big enough to have a national community, resulting in a cohesive network of atmospheric scientists in the Asian monsoon region.

Currently, the committee is represented by 17 different countries/regions: Australia, Bangladesh, China, Hong Kong, India, Indonesia, Japan, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan ROC, Thailand, and Vietnam (Naja, Yu, Salam, & Tanimoto, 2020). The committee continued its efforts to engage new members from currently under-represented countries, such as Bhutan, Maldives, Cambodia, Brunei, and South Korea.

In addition to enhancing the diversity of the current MANGO membership by including under-represented countries, we strived to promote the growth of the next generation of scientists in this region. One good measure was the participation of ECS in the 2018 joint 14th iCACGP Quadrennial Symposium and 15th IGAC Science Conference (iCACGP-IGAC 2018) (Tanimoto et al., 2018) held in Takamatsu, Japan. In this conference, which was held in Asia for the first time since 2012, 196 ECS from 17 APN member countries/regions participated. These countries/regions included Australia, Bangladesh, China, Hong Kong, India, Japan, Korea, Malaysia, Myanmar, Pakistan, Philippines, Russia, Singapore, Taiwan ROC, Thailand, the USA, and Vietnam. Notably, there were a total of 321 participants, inclusive of non-ECS, from 19 APN countries with Indonesia and Sri Lanka added to the above-listed countries. A large proportion of ECS came from Japan (31%) as Japan was the host country, followed by China (22%), USA (17%), South Korea (8%), India (5%), Australia (3%), Hong Kong (3%), and Bangladesh (3%). Smaller numbers of participants came from other countries (Figure 2). All the ECS participated in the face-to-face sessions and breakout discussions of atmospheric chemistry as they pertain to human activities, ecosystems, climate/weather, fundamental understanding, and future challenges (Ishino et al., 2018; Willis et al., 2018).

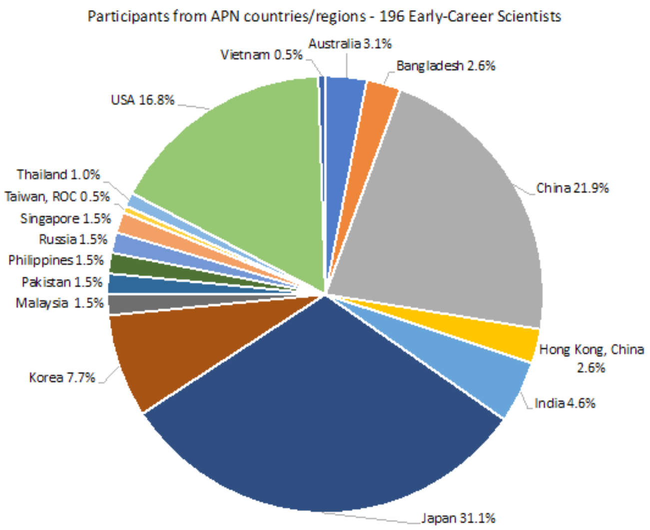

FIGURE 2. iCACGP-IGAC 2018 participants of early-career scientists from APN countries/regions. The definition of ECS is a current postgraduate student and a junior-level scientist within three working years of completing their PhD.

3.3 Infrastructural capacity

It was strongly recognized that more scientific infrastructure was needed to improve the scientific research and associated activities in the MANGO region, and also to help foster the capacity development of the ECS and regional collaboration of MANGO scientists. As mentioned above, common issues across the MANGO region have been raised. However, its severity differs from country to country. In some countries, atmospheric chemistry was not perceived as an important concern compared to water quality, which was seen as a more "visible" environmental issues associated with "direct" health risks. This was linked to the small number of atmospheric scientists and poor networking of local scientists in the country and affected the level of overall scientific activities and contributions to society. In some countries, national funding was minimal, affecting the level and amount of instruments/equipment for atmospheric chemistry research. "Which is lacking between observational or experimental instruments and modelling or theoretical tools?" was an interesting question. Some countries needed observational or experimental instruments, but some modelling or theoretical tools. However, the most important message was the importance of strengthening fundamental science in "both" ways.

With respect to observational infrastructures, many scientific instruments are costly and complex to operate. We highlighted the great potential of easy-to-operate instruments, with affordable cost for the Asian region, in a variety of research including domestic pollution hot spots, biomass burning, and trans-boundary long-range transport.

The importance of investigating air pollution and health issues in Asia was emphasized earlier. Air pollution, especially aerosols, considerably contribute to human health risks. Millions of deaths worldwide are attributable to PM2.5 (fine aerosols), which is potentially a human carcinogen and a major environmental health concern. Especially in Asia, rapid economic growth has taken its toll on human health. It was estimated that 2.2 million of the world's 7 million premature deaths each year from household (indoor) and ambient (outdoor) air pollution occur in Asia or the Pacific, which roughly coincides with the MANGO region ("Air pollution", 2018). Among the 2.2 million air pollution-related deaths in this region in 2016, 29% were due to heart disease, 27% by stroke, 22% by chronic obstructive pulmonary disease (COPD), 14% by lung cancer, and 8% by pneumonia. The health impacts of PM2.5 could be classified into acute and chronic effects. Chronic health impacts, such as COPD and lung cancer, are associated with long-term exposure. In contrast, acute health impacts such as asthmatic attacks and irregular heart conditions are directly associated with peak exposures, which are difficult to measure up to now. As the Asian population is exposed to considerable levels of PM2.5 compared to the rest of the world, research on the impacts of air pollution on health is necessary for Asia.

Emerging new technologies such as low-cost sensors (LCS) may assist Asian scientists to tackle the challenges and provide scientific evidence to set short-term standards to reduce health risks of acute effects. By taking advantage of these technologies, we have started a joint research project entitled "Health Investigation and Air Sensing for Asian Pollution (HI-ASAP)" led by Shih-Chun Candice Lung (Taiwan ROC), in collaboration with scientists from 13 countries.

3.4 Current issues and future challenges

We analysed the current issues, causes, and gaps in science, communication and collaboration, and early career capacity building based on what was actually working well in promoting early career capacity building. We also discussed potential ideas for short-term as well as future improvements.

The commonly identified issues are listed below:

1. Geopolitical issues;
2. Cultural differences in the workplace;
3. Lack of connection between ECS and established scientists;
4. Lack of connection among established scientists;
5. Lack of understanding of regional atmospheric chemistry issues (e.g., air quality, waste and agriculture, biomass burning);
6. Difficulty or challenge in connecting modelling, field measurements and laboratory studies;
7. Lack of funding;
8. Lack of awareness of available opportunities;
9. Lack of academic courses at both graduate and undergraduate levels; and
10. Lack of regional cooperation or policy discussion to control transboundary air pollution (e.g., winter haze in the IGP region).

Given these issues, we identified some important points to be implemented to promote fruitful scientific collaboration:

1. Equal opportunities for all partner institutes;
2. Gender balance;
3. Participation of ECS in collaborative activities;
4. Promotion of science and awareness beyond geopolitical differences;
5. Data and knowledge sharing through joint publications and collaborative projects;
6. Joint publications and white papers for policymakers;
7. Regularly sharing information, limitations, and experiences; and
8. Follow-up meetings to review the science questions, identified issues, and other aspects.

We emphasize that MANGO can be a trusted platform that facilitates collaboration, as certain countries sometimes do not allow international collaboration. In contrast, international institutions/organizations are neutral platforms in which researchers from conflicting countries can also interact and establish international collaboration. We also find that MANGO can provide a platform for ECS to share their ideas, find potential supervisors to pursue higher degrees, and find good mentors and spokespersons representing each country.

To further improve capacity building of ECS, we realized that greater awareness of opportunities for ECS is facilitated through multiple media such as webinars, online courses, multidisciplinary workshops and internships, as well as a widely distributed news bulletins and newsletters.

4. CONCLUSIONS

We have established the IGAC–MANGO platform with the principal objective to enhance the capability and capacity of air quality research, with emphasis on its links to human health and climate change, including the components of trans-disciplinary collaboration. In total, 17 countries are involved in MANGO, namely Australia, Bangladesh, China, Hong Kong, India, Indonesia, Japan, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan ROC, Thailand, and Vietnam. By overseeing the scientific activities in the region and holding scientific workshops and capacity-building activities, including training courses for ECS, we have facilitated the collaboration between Asian and international scientists and accelerated the development of the next generation of scientists in this region. The project is expected to yield several fruits, including new leaders from Asia in international committees, enhanced interactions between Asian scientists resulting in joint research proposals, and increased opportunities for ECS to pursue their research with international scientists.

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REFERENCES

Ishino, S., Sakata, K., Mbandi, A., Kumar, M., Desservettaz, M., Willis, M., & Tzompa-Sosa (2018). 2018 iCACGP/IGAC early career short course. *IGAC news, 63*, 14–15.

Naja, M., Yu, L., Salam, A., & Tanimoto, H. (2020). IGAC-MANGO meeting, science workshop, and training course 2019. *IGAC news, 66*, 18–20.

Pan, L., Crawford, J., Tanimoto, H., Lawrence, M., Pandy, A., Babu, S. S., ... Bian, J. (2014). Report on the atmospheric composition and the summer Asian Monsoon (ACAM) workshop, 9-12 June 2013, Kathmandu, Nepal. *SPARC newsletter,* 42, 40–45.

Ramanathan, V., & Crutzen, P. J. (2003). New directions: Atmospheric brown clouds. *Atmospheric Environment, 37*, 4033–4035. doi:10.1016/S1352-2310(03)00536-3

Schlager, H., Chin, M., Latif, M. T., & Ahamad, F. (2019). Fourth workshop on atmospheric composition and the Asian Monsoon (ACAM). *IGAC news, 65*, 13–14.

Tanimoto, H., Kim Oanh, N. T., & Lawrence, M. G. (2015a). Planning workshop for developing a framework for cooperation between IGAC activities in Asia. *IGAC news, 54*, 16–17.

Tanimoto, H., Kim Oanh, N. T., & Lawrence, M. G. (2015b). Workshop for developing priority themes and activities for IGAC Monsoon Asia and Oceania Networking Group (IGAC-MANGO). *IGAC news, 55*, 12–13.

Tanimoto, H., Nagashima, T., Inomata, S., Heald, C., Keywood, M., Sakata, K., & Ishino, S. (2018). 2018 joint 14th iCACGP Quadrennial Symposium and 15th IGAC Science Conference. *IGAC news, 63*, 16–18.

Tanimoto, H., Crawford, J., Beukes, P., Dawidowski, L., Emberson, L., Emmons, L., ... Zheng, L (2020). IGAC's role in understanding the impacts of COVID-19 on global atmospheric chemistry and society. *IGACnews,* 8–17.

Willis, M., Ishino, S., Desservettaz, M., Mbandi, A., Tzompa-Sosa, Z., Kumar, M., & Sakata, K. (2018). An early career perspective on fostering the next generation of atmospheric scientists in an international community. *IGAC news, 63*, 21-24.

Balloon campaigns taking place simultaneously with the aircraft campaign. (2017, August 1). StratoClim. Retrieved from https://www.stratoclim.org

Air pollution. (2018, August 29). Retrieved from https://www.who.int/westernpacific/health-topics/air-pollution