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IGACnews

facilitating atmospheric chemistry research towards a sustainable world

issue 66
march 2020

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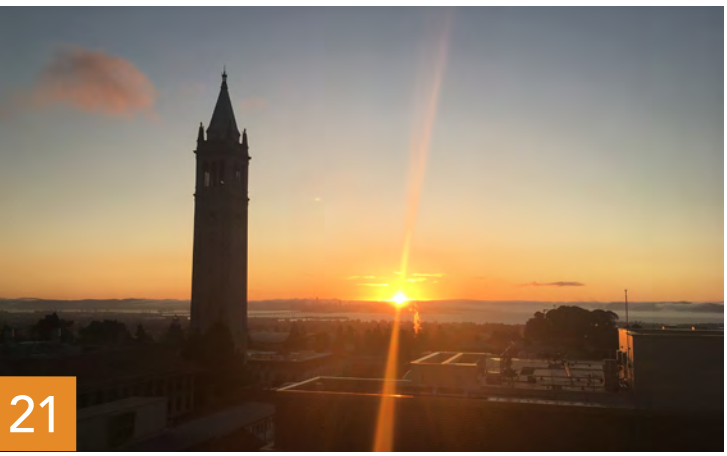

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On the Cover

Participants of the 2019 IGAC SSC meeting in front of the Central Library at the Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico. The mural is a Historical Representation of Culture created by the Mexican artist Juan O'Gorman. The Central Library as well as the UNAM campus are UNESCO World Heritage Sites. PHOTO CREDIT: EDIT NAGY-TANAKS, NIES, JAPAN.

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Design: Allison Gray

IGAC was formed in 1990 to address growing international concern over rapid changes observed in Earth's atmosphere. IGAC operates under the umbrella of Future Earth and is jointly sponsored by the international Commission on Atmospheric Chemistry and Global Pollution (iCACGP). The IGAC International Project Office is hosted by the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado and is sponsored by the US National Science Foundation (NSF), National Oceanic and Atmospheric Association (NOAA), and National Aeronautics and Space Administration (NASA). Any opinions, findings, and conclusions or recommendations expressed in this newsletter are those of the individual author(s) and do not necessarily reflect the views of the responsible funding agencies.

editor's note

Future Stewards Training

In this issue of IGACnews, you will find a summary of a Visioning Exercise the IGAC Scientific Steering Committee (SSC) did as part of the 2019 IGAC SSC Meeting. This was the second workshop I have attended that was facilitated by *Futures* practitioner **Bill Sharpe**. Bill uses the Three Horizons approach as a way to integrate multiple perspectives, priorities, and time horizons to guide participants to think about where they are now, where they want to be, and what is required to transition between the two. As you will read in the Visioning Exercise Summary, his approach led to a good outcome for IGAC.

I have found Bill's methodology so effective that I recently traveled to London to participate in a **Future Stewards Training**, which taught me the tools and skills necessary to lead and facilitate a workshop using the Three Horizons approach. The workshop covered three main areas: Pattern Facilitation, Three Horizons, and Dilemmas. What I took away from the workshop in these three areas is below.

Pattern Facilitation: The idea of pattern facilitation is to collect individual ideas from participants about an overarching topic related to what the workshop is about. In the case of the IGAC Visioning Exercise, the overarching topic was "the importance of atmospheric chemistry." Once individual ideas are collected, they are then clustered together by the participants in a process called silent clustering. The group eventually comes to a consensus on the clustering of the ideas. The facilitator then works with the participants to name the clusters, thus identifying patterns from the participants on the overarching topic. The result is that all participants conclude as a group on the insight and meaning of the overarching topic.

Three Horizons: The Three Horizons approach is a simple yet innovative way of looking at the future by looking at the short, medium, and long-term timelines, or futures, in the context of the present. Horizon 1 is the short-term view of what is currently happening, also referred to as business as usual. Horizon 3 is the long-term view, the vision for the future. Horizon 2 is the medium-term view, the transitional or innovative activities that bring Horizon 1 and 3 together. The process guides participants through understanding what each horizon is to them, the mindsets within each horizon, and that aspects of each horizon are always present. The approach allows participants to see the interplay between the three horizons in the present and begin to see steps forward to transition to the future.

Dilemmas: Dilemmas are often the result of two conflicting values, one that is based on an existing deeply rooted value and one that is based on a new, dynamic, and unpredictable value. For many scientists, a common dilemma might be fundamental scientific research versus applied or solution oriented scientific research. Dilemma resolution guides participants to view the two values not as opposing, but as an opportunity. There is a way in which both values can be honored and used in a collaborative, mutually beneficial, and generative process to get "the best of both worlds."

This process is not something as scientists we are used to doing. However, after participating in two workshops facilitated with the Three Horizons approach and participating in the Future Stewards Training, I am beginning to think our science might be able to have a bigger impact toward a sustainable world if we had a clearer narrative about its importance, its short to long-term timeline, and how it creates opportunities, not dilemmas, for the future.

Happy Reading!

MEGAN L. MELAMED
IGAC Executive Officer
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Megan Melamed received her PhD in 2006 in Environmental Engineering from the University of Colorado. She then received the National Science Foundation International Research Fellowship to work at the Universidad Nacional Autónoma de México (UNAM) in Mexico City for two years. Upon completion of the NSF Fellowship, Megan became an American Association for the Advancement of Science (AAAS) Science & Technology Policy Fellow at the U.S. Environmental Protection Agency. She has been the IGAC Director since January 2011.

IGAC Says Goodbye to Two SSC Members

At the end of 2019 two members of the IGAC Scientific Steering Committee completed their service. IGAC is very grateful for the years Judith Hoelzemann (UNFP, Brazil) and Kim Oanh (Asian Institute of Technology, Thailand) served on the SSC. Judith was instrumental in organizing the 2014 joint 13th iCACGP Quadrennial Symposium/13th IGAC Science Conference in Natal, Brazil as the chair of the Local Organizing Committee. Kim was a key player in helping IGAC connect to the scientific community in Asia, especially Southeast Asia, in her role as a SSC members and co-chair of the IGAC Monsoon Asia and Oceania Networking Group (MANGO). They will both be greatly missed.

IGAC Welcomes Three New SSC Members

At the start of 2020, IGAC welcomed three new members to its Scientific Steering Committee.

Laura Dawidowski

Laura Dawidowski is currently an Associate Professor in Atmospheric Pollution at the Environmental Research and Engineering Institute of the National San Martín University, Argentina, and Principal Researcher at the Environmental Chemistry Department of National Atomic Energy Commission (CNEA) where she developed, since 1994, most of her scientific career. Laura's research activities are aimed to characterize the role of the different sources on climate and air quality deterioration, with special interest in urban pollution and the link between technologies and emissions for air pollutants and greenhouse gases. She has been involved in several airborne field studies, and currently leads a Latin American team under an International Atomic Energy Agency project, focus on the identification of main local and regional aerosol sources in 14 main cities of the region. It comprises an extended aerosol field campaign and the application of receptor-oriented models using physical and chemical aerosol data from surface and satellite measurements. She also works on the estimation of actual, past and prospective emissions of greenhouse gases and air toxic pollutants and, in line with these activities, collaborates with the IPCC in the adoption of emission factors and in the development of guidelines to develop emission inventories.

Louisa Emmons

Louisa Emmons is a Senior Scientist in the Atmospheric Chemistry Observations and Modeling Laboratory of the National Center for Atmospheric Research (NCAR). Louisa received her Ph.D. Degree in Physics at the State University of New York at Stony Brook in 1994. Her graduate research focused on remote sensing measurements of stratospheric ozone depletion, using ground-based mm-wave spectroscopy to study the Antarctic ozone hole and the Arctic springtime stratosphere. Her research since then has encompassed both measurements and modeling of tropospheric chemistry, first as a post-doc at the University of Michigan and then as a research scientist at NCAR. Louisa's current research interests lie in the integration of measurements with models to investigate the impact of sources and their chemical evolution on tropospheric composition. Louisa has been co-chair of the CESM chemistry-climate working group since 2014 and leads the development of the chemistry-climate model CAM-chem, a component of CESM. Louisa has been an active participant in many field campaigns, providing forecasting and flight planning support, as well as post-mission analysis. She is part of the Leadership Team for

KORUS-AQ, a recent joint Korea-US air quality study in Korea.

Liya Yu

Liya E. Yu is an Associate Professor in the Department of Civil & Environmental Engineering at the National University of Singapore (NUS). Her research group characterizes effects of semi-volatiles and photooxidation on physicochemical properties of ambient particulates, impacts of cross-border biomass burning smoke on urban air quality, behavior of secondary aerosols and transient new particle formation in warm humid tropical urban environment. She also works with her colleague at NUS to investigate personal exposure to airborne pollutants and mitigation of airborne pollutants by employing building envelope in large cities. She serves on advisory boards, editorial boards, working groups, and steering committees for international scientific journals and research communities. She received her PhD degree in Environmental Engineering from Stanford University.

Nominations Are NOW Being Accepted for the 2021 IGAC SSC

IGAC accepts both nominations and self-nominations.

More information **igacproject.org/IGAC_SSC_Nominations**

Nomination deadline is 17 April 2020.

Applications Are Now Being Accepted to the 2020 IGAC Early Career Short Course

For more information, visit **igacproject.org/igac-early-career-program/2020ECSC**

Application deadline is 27 March 2020.

16th International Global Atmospheric Chemistry
IGAC 2020
University of Manchester, UK

Abstract Submissions Are Now Being Accepted for IGAC 2020!!

14-18 September 2020
Manchester, UK

More information **igac2020.com**

Abstract submission deadline is 27 March 2020

Connect with others about IGAC2020!!
Facebook Group
Twitter #IGAC2020
Early Career Scientists Facebook Group
Twitter @IGAC_ECS

Now Soliciting Bids to Host the 2022 International Atmospheric Chemistry Conference

Jointly sponsored by the 15th iCACGP Quadrennial Symposium/17th IGAC Science Conference.

Bid submission deadline is 24 April 2020.

More information, **igacproject.org/conferences**

Recent IGAC Fostered Publications

CATCH
the Cryosphere and
ATmospheric CHemistry

Fostering multidisciplinary research on interactions between chemistry, biology, and physics within the coupled cryosphere-atmosphere system. Thomas, J.L., Stutz, J., Frey, M.M., Bartels-Rausch, T., Altieri, K., Baladima, F., Browse, J., Dall'Osto, M., Marelle, L., Mouginot, J., Murphy, J.G., Nomura, D., Pratt, K.A., Willis, M.D., Zieger, P., Abbatt, J., Douglas, T.A., Facchini, M.C., France, J., Jones, A.E., Kim, K., Matrai, P.A., McNeill, V.F., Saiz-Lopez, A., Shepson, P., Steiner, N., Law, K.S., Arnold, S.R., Delille, B., Schmale, J., Sonke, J.E., Dommergue, A., Voisin, D., Melamed, M.L. and Gier, J., 2019. *Elem Sci Anth.,* 7(1), p.58. DOI: 10.1525/elementa.396.

PACES
air Pollution in the Arctic:
Climate Environment and Societies

Local Arctic air pollution: A neglected but serious problem (2018), Schmale, J., S.R. Arnold, K.S. Law, T. Throp, S. Anenberg, W.R. Simpson, J. Mao, and K.A. Pratt. *Earth's Future*, 6, doi:10.1029/2018EF000952.

TOAR
tropospheric
ozone
assessment
report

The first TOAR assessment report is being published as a series of papers in the peer-reviewed journal, *Elementa – Science of the Anthropocene*. The papers are available through a **Special Feature** of Elementa. The final paper "TOAR-Ozone Budget" is currently available for **Open Comments**.

Tropospheric Ozone Assessment Report: Tropospheric ozone from 1877 to 2016, observed levels, trends and uncertainties. Tarasick, D., Galbally, I.E., Cooper, O.R., Schultz, M.G., Ancellet, G., Leblanc, T., Wallington, T.J., Ziemke, J., Liu, X., Steinbacher, M., Staehelin, J., Vigouroux, C., Hannigan, J.W., García, O., Foret, G., Zanis, P., Weatherhead, E., Petropavlovskikh, I., Worden, H., Osman, M., Liu, J., Chang, K.-L., Gaudel, A., Lin, M., Granados-Muñoz, M., Thompson, A.M., Oltmans, S.J., Cuesta, J., Dufour, G., Thouret, V., Hassler, B., Trickl, T. and Neu, J.L., 2019. Tropospheric Ozone Assessment Report: Tropospheric ozone from 1877 to 2016, observed levels, trends and uncertainties. *Elem Sci Anth*, 7(1), p.39. DOI : 10.1525/elementa.376.

Tropospheric Ozone Assessment Report: Present-day tropospheric ozone distribution and trends relevant to vegetation. Mills G, Pleijel H, Malley CS, Sinha B, Cooper OR, Schultz MG, Neufeld HS, Simpson D, Sharps K, Feng Z, Gerosa G, Harmens H, Kobayashi K, Saxena P, Paoletti E, Sinha V, Xu X,. *Elem Sci Anth*, 2018; 6(1):47. DOI: 10.1525/elementa.302.

Tropospheric Ozone Assessment Report: Present-day distribution and trends of tropospheric ozone relevant to climate and global atmospheric chemistry model evaluation. Gaudel, A., Cooper, O.R., Ancellet, G., Barret, B., Boynard, A., Burrows, J.P., Clerbaux, C., Coheur, P.-F., Cuesta, J., Cuevas, E., Doniki, S., Dufour, G., Ebojie, F., Foret, G., Garcia, O., Granados Muños, M.J., Hannigan, J.W., Hase, F., Huang, G., Hassler, B., Hurtmans, D., Jaffe, D., Jones, N., Kalabokas, P., Kerridge, B., Kulawik, S.S., Latter, B., Leblanc, T., Le Flochmoën, E., Lin, W., Liu, J., Liu, X., Mahieu, E., McClure-Begley, A., Neu, J.L., Osman, M., Palm, M., Petetin, H., Petropavlovskikh, I., Querel, R., Rahpoe, N., Rozanov, A., Schultz, M.G., Schwab, J., Siddans, R., Smale, D., Steinbacher, M., Tanimoto, H., Tarasick, D.W., Thouret, V., Thompson, A.M., Trickl, T., Weatherhead, E., Wespes, C., Worden, H.M., Vigouroux, C., Xu, X., Zeng, G. and Ziemke, J., 2018. *Elem Sci Anth*, 6(1), p.39. DOI: 10.1525/elementa.291.

Tropospheric ozone assessment report: Global ozone metrics for climate change, human health, and crop/ecosystem research. Lefohn, AS, Malley, CS, Smith, L, Wells, B, Hazucha, M, Simon, H, Naik, V, Mills, G, Schultz, MG, Paoletti, E, De Marco, A, Xu, X, Zhang, L, Wang, T, Neufeld, HS, Musselman, RC, Tarasick, D, Brauer, M, Feng, Z, Tang, H, Kobayashi, K, Sicard, P, Solberg, S and Gerosa, G 2018. *Elem Sci Anth*, 6: 28. DOI: 10.1525/elementa.279.

Tropospheric Ozone Assessment Report: Present-day ozone distribution and trends relevant to human health. Fleming, Z.L., Doherty, R.M., von Schneidemesser, E., Malley, C.S., Cooper, O.R., Pinto, J.P., Colette, A., Xu, X.,

Simpson, D., Schultz, M.G., Lefohn, A.S., Hamad, S., Moolla, R., Solberg, S. and Feng, Z., 2018. Elem Sci Anth, 6(1), p.12. DOI: 10.1525/elementa.73.

Tropospheric Ozone Assessment Report: Assessment of global-scale model performance for global and regional ozone distributions, variability, and trends. Young, P.J., Naik, V., Fiore, A.M., Gaudel, A., Guo, J., Lin, M.Y., Neu, J.L., Parrish, D.D., Rieder, H.E., Schnell, J.L., Tilmes, S., Wild, O., Zhang, L., Ziemke, J.R., Brandt, J., Delcloo, A., Doherty, R.M., Geels, C., Hegglin, M.I., Hu, L., Im, U., Kumar, R., Luhar, A., Murray, L., Plummer, D., Rodriguez, J., Saiz-Lopez, A., Schultz, M.G., Woodhouse, M.T. and Zeng, G., 2018. *Elem Sci Anth*, 6(1), p.10. DOI: 10.1525/elementa.265.

Tropospheric Ozone Assessment Report: Database and Metrics Data of Global Surface Ozone Observations. Schultz, M.G., Schröder, S., Lyapina, O., Cooper, O., Galbally, I., Petropavlovskikh, I., von Schneidemesser, E., Tanimoto, H., Elshorbany, Y., Naja, M., Seguel, R., Dauert, U., Eckhardt, P., Feigenspahn, S., Fiebig, M., Hjellbrekke, A.-G., Hong, Y.-D., Christian Kjeld, P., Koide, H., Lear, G., Tarasick, D., Ueno, M., Wallasch, M., Baumgardner, D., Chuang, M.-T., Gillett, R., Lee, M., Molloy, S., Moolla, R., Wang, T., Sharps, K., Adame, J.A., Ancellet, G., Apadula, F., Artaxo, P., Barlasina, M., Bogucka, M., Bonasoni, P., Chang, L., Colomb, A., Cuevas, E., Cupeiro, M., Degorska, A., Ding, A., Fröhlich, M., Frolova, M., Gadhavi, H., Gheusi, F., Gilge, S., Gonzalez, M.Y., Gros, V., Hamad, S.H., Helmig, D., Henriques, D., Hermansen, O., Holla, R., Huber, J., Im, U., Jaffe, D.A., Komala, N., Kubistin, D., Lam, K.-S., Laurila, T., Lee, H., Levy, I., Mazzoleni, C., Mazzoleni, L., McClure-Begley, A., Mohamad, M., Murovic, M., Navarro-Comas, M., Nicodim, F., Parrish, D., Read, K.A., Reid, N., Ries, L., Saxena, P., Schwab, J.J., Scorgie, Y., Senik, I., Simmonds, P., Sinha, V., Skorokhod, A., Spain, G., Spangl, W., Spoor, R., Springston, S.R., Steer, K., Steinbacher, M., Suharguniyawan, E., Torre, P., Trickl, T., Weili, L., Weller, R., Xu, X., Xue, L. and Zhiqiang, M., 2017. *Elem Sci Anth*, 5, p.58. DOI: 10.1525/elementa.244.

Regional trend analysis of surface ozone observations from monitoring networks in eastern North America, Europe and East Asia. Chang K-L, Petropavlovskikh I, Cooper OR, Schultz MG, Wang T. *Elem Sci Anth*, 2017; 5:50. DOI: 10.1525/elementa.243. IGAC

IGAC ON SOCIAL MEDIA

IGAC is on LinkedIn, Twitter and Facebook in an effort to further advance international scientific cooperation and serve as a resource to the public, especially you. Please join us to stay apprised of the most current news on conferences, workshops and publications. Let us hear from you on how to improve the international conversation, **@IGACProject**.

Submit articles to the next IGACnews

IGAC is now accepting article submissions for the next IGACnews.

- Workshop Summaries, Science Features, Activity News, and Editorials are all acceptable and desired.
- Science Features should have an approximate length of 1500 words with 1-2 images.
- All other submissions should be approximately 500 words and have 1-2 images.
- Please provide high-resolution image files.

The deadline for submissions for the July 2020 issue of the IGACnew is 15 June 2020. Send all submissions to **info@igacproject.org**.

4-6 AUGUST 2019
THE CHINESE UNIVERSITY OF HONG KONG, HONG KONG

IGAC Sponsored

The IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) Summer School 'Earth System Modelling and Observations to Study Earth in a Changing Climate'

AUTHORS
Michaela Hegglin, University of Reading, UK
Tatsuya Nagashima, NIES, Japan
David Plummer, Environment and Climate Change, Canada
Seok-Woo Son, Seoul National University, South Korea
Amos P. K. Tai, CUHK, Hong Kong, China

HOST INSTITUTIONS

香港中文大學
The Chinese University of Hong Kong

香港中文大學環境、能源及可持續發展研究所
Institute of Environment, Energy and Sustainability, CUHK

Earth System Science Programme

FUNDING

SPARC Stratosphere-troposphere Processes And their Role in Climate

WCRP World Climate Research Programme

香港中文大學環境、能源及可持續發展研究所
Institute of Environment, Energy and Sustainability, CUHK

PARTICIPANTS
Argentina, Bangladesh, Canada, China, Hong Kong, India, Japan, Korea, Pakistan, South Africa, Switzerland, U.K.

BACKGROUND

ccmi chemistry-climate model initiative

This is the first summer school organized by the IGAC/ SPARC CCMI activity aiming at developing a critical understanding of the strengths and weaknesses of Earth-system observations and chemistry-climate models. The summer school places a strong emphasis on capacity building for early career scientists from developing countries with proud financial support from IGAC, SPARC and IEES of CUHK.

Participants of the 2019 CCMI Summer School

From the 4th to the 6th of August 2019, just before the CCMI Science Workshop, 16 early career scientists from eight different countries (across four continents) gathered on the Chinese University of Hong Kong (CUHK) campus to improve their understanding of the representation of atmospheric chemistry and atmosphere-biosphere interactions in Earth System Models. The course was a mixture of lectures, covering a broad range of topics relevant to the field of chemistry-climate interactions, and practical exercises. Lectures focused on the representation of physical and chemical processes in numerical models (David Plummer), an introduction to the chemistry and circulation of the stratosphere (Michaela Hegglin), the chemistry and

associated processes controlling tropospheric composition (Tatsuya Nagashima), as well as chemistry-climate and stratosphere-troposphere dynamical coupling (Seok-Woo Son) and approaches to modelling the role of the biosphere in the Earth System (Amos Tai). Practical exercises had the participants playing with simple one-dimensional advection codes to explore the limitations of solving differential equations discretized in space and time and investigating the complexities of comparing model output from the CCMI phase 1 data archive with station data from the Tropospheric Ozone Assessment Report (TOAR) ozone database. A highlight of the practical exercises was the chance to work with the Terrestrial Ecosystem Model in R (TEMIR) developed by Prof. Tai's group at CUHK to simulate the response of a forest canopy to increasing concentrations of CO_2 and to investigate how this modifies the relationship between evapotranspiration and photosynthesis. While the turbulent political situation in Hong Kong made for an interesting backdrop to the summer school, and a general strike on the second day meant a very late start for everyone, participants were enthusiastic about the opportunity to be exposed to a broad variety of topics in chemistry-climate interactions and the chance to meet colleagues from around the world.

The organisers would like to express their deep gratitude to Future Earth's IGAC and WCRP/SPARC for sponsoring the summer school, as well as to the Institute of Environment, Energy and Sustainability at CUHK for providing additional generous funding. The event was followed by the 2019 IGAC/SPARC CCMI Science Workshop, which provided the early career scientists with a great opportunity to get a taste of the most recent development in the field of chemistry-climate interactions and to discuss their own work with researchers around the world. IGAC

7-9 AUGUST 2019
THE CHINESE UNIVERSITY OF HONG KONG, HONG KONG

IGAC Sponsored

IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) 2019 Science Workshop

AUTHORS

Thomas Birner, University Munich, Germany

Andrew Gettelman, NCAR, U.S.A.

Michaela Hegglin, University of Reading, UK

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Jean-Francois Lamarque, NCAR, U.S.A.

Olaf Morgenstern, NIWA, New Zealand

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David Plummer, Environment and Climate Change, Canada

Seok-Woo Son, Seoul National University, South Korea

Amos Tai, CUHK, Hong Kong, China

Paul Young, Lancaster University, UK

HOST INSTITUTIONS

香港中文大學
The Chinese University of Hong Kong

香港中文大學環境、能源及可持續發展研究所
Institute of Environment, Energy and Sustainability, CUHK

Earth System Science Programme

FUNDING

SPARC Stratosphere-troposphere Processes And their Role in Climate

WCRP World Climate Research Programme

IGAC

香港中文大學環境、能源及可持續發展研究所
Institute of Environment, Energy and Sustainability, CUHK

PARTICIPANTS

Argentina, Australia, Bangladesh, Canada, China, France, Germany, Hong Kong, India, Japan, Korea, New Zealand, Nigeria, Pakistan, South Africa, Switzerland, United Kingdom, United States

CCMI 2019 Science Workshop Participants

The IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) 2019 Science Workshop was held August 7-9, 2019 in Hong Kong, hosted by Amos Tai and his research group at the Chinese University of Hong Kong (CUHK). More than 70 scientists and students from 18 different countries participated in the workshop, which consisted of keynote, invited and contributed presentations, two very lively poster

BACKGROUND

ccmi chemistry-climate model initiative

IGAC financially supported this workshop of the jointly sponsored IGAC / SPARC Chemistry-Climate Model Initiative (CCMI) activity. This activity was established to coordinate activities addressing chemistry-climate interactions in and between the troposphere and stratosphere. Science foci include the role of atmospheric chemistry and dynamics in controlling the impact of reactive greenhouse gases on the climate system; stratospheric ozone recovery and interactions with climate; connections among anthropogenic emissions, climate, and air pollution.

sessions, and break-out group discussions to advance the planning for Phase Two of CCMI.

The workshop covered a wide variety of research themes. These reflected the on-going analysis of multi-model results from the first phase of CCMI (**Eyring et al., 2013**), in-depth process-based analyses of single models, as well as regionally-important topics - particularly by groups in south and east Asia who were well represented at the workshop. Analysis of the CCMI-1 simulations covered the stratosphere, investigating model simulated trends of ozone in the lower stratosphere and the dynamical influence of stratospheric ozone changes on the troposphere, for example; it also covered the troposphere via, among others, investigations into the diversity of hydroxyl radical concentrations across the CCMI models. Analysis of single model studies included the effects of land use and land cover changes on surface ozone, the ability of models to reproduce observed long-term changes in surface ozone, as well as the possible effects of continued emissions of CFC-11 on the future evolution of stratospheric ozone. Reflecting the importance of aerosols in heavily populated areas, a number of modelling studies were presented estimating the effects of aerosols on regional climates in South America and southern Africa, and the Asian monsoon. A number of studies were also presented to better characterize the distribution, seasonal cycle and sources of particulate matter, reflecting the growth of in-situ measurements sampling different regions of the world.

In addition to contributed presentations, the workshop featured two keynote presentations. The first was given by Dr. Becky Alexander from the University of Washington, who presented isotopic constraints on the ratio of O_3:HO_x from ice cores and how global chemistry models are unable to reproduce the derived changes in the ratio during the Last Glacial Maximum. The modelled response of the ratio, driven by the expected decreases in temperature-dependent emissions, was opposite to that derived from the ice core proxies, suggesting other factors not currently accounted for in the models are important. Dr. Jason West from the University of North Carolina presented the second keynote presentation, giving an overview of developing efforts to improve estimates of the impact of air pollution on human mortality, including within the Global Burden of Disease project. Dr. West highlighted recent work to revise hazard ratio functions and new work to fuse global observations of pollutant concentrations and models to improve estimates of health impacts. A number of invited speakers also presented the activities and future plans of research initiatives related to areas explored by CCMI, including the Tropospheric

Hong Kong, China *(Courtesy CUHK)*

Ozone Assessment Report (TOAR; Dr. Martin Schultz), Atmospheric Composition and the Asian Monsoon (ACAM; Dr. Mian Chin) and Solar Influences on Climate (SOLARIS-HEPPA, Dr. Eugene Rozanov).

Time during the workshop was also devoted to break-out group discussions to better define the scientific goals of a second phase of CCMI. An online discussion of the scientific questions that should motivate a CCMI-2, and the model experiments and outputs required to address them, had been on-going in the lead up to the workshop and can be found **here**. While discussions of the scientific focus of CCMI-2 continues, we are moving ahead defining experiments to provide input for the 2022 WMO/UNEP Ozone Assessment and more information on this activity can be found **here**. If you wish to be involved with either of these efforts please do not hesitate to contact one of the CCMI co-chairs, **Tatsuya Nagashima** or **David Plummer**.

The organisers would like to express their deep gratitude to **Institute of Environment, Energy and Sustainability** at CUHK for their generous financial support of the workshop, as well as Future Earth's IGAC and WCRP/SPARC for additional support.

18-20 SEPTEMBER 2019
OSLO, NORWAY

IGAC Sponsored

AUTHORS
Steve Arnold, University of Leeds, Leeds, UK
Kathy Law, CNRS, Paris, France

HOST INSTITUTION

CICERO

FUNDING

IASC

The Research Council of Norway

PARTICIPANTS
Argentina, Canada, China, Denmark, Estonia, Finland, France, Germany, Iceland, Italy, Japan, Netherlands, Norway, Russia, Sweden, United Kingdom, United States

BACKGROUND

PACES
air Pollution in the Arctic:
Climate Environment and Societies

IGAC sponsored this workshop to support the IGAC Activity air Pollution in the Arctic: Climate, Environment and Societies (PACES). This activity aims to coordinate international research on Arctic air pollution and its impacts.

3rd Pollution in the Arctic: Climate, Environment and Societies (PACES) Open Science Meeting

Participants of the 3rd PACES Open Science Meeting in Oslo, Norway.

The "air Pollution in the Arctic: Climate, Environment and Societies" (PACES, **https://pacesproject.org/**) initiative aims to review existing knowledge and foster new research on the sources and fate of Arctic air pollution, its impacts on climate, health, and ecosystems, on the feedbacks between pollution and natural sources, on climate responses, and on societal perspectives, including sustainability, adaptation and economic feedbacks. Arctic air pollution contributes to Arctic climate change, and is harmful to ecosystems and human health, but significant uncertainties surround quantification of these effects. Models show particularly diverse and poor model skill in simulating Arctic distributions of air pollutants. Improving our process understanding and model performance is hampered by a severe paucity of observational constraint in specific geographical regions (e.g. Russian Arctic), very limited long-term observations, as well as very limited information over the vertical profile. Moreover, the special physical environment of the Arctic means that unique processes and

CICERO, Oslo Science Park, Norway

photo by icero.oslo.no

interactions with natural cycles affect the environmental behaviour and societal impacts of pollutants and contaminants. This environment also makes it challenging to undertake new observational efforts, meaning that effective international collaboration is essential in terms of maximizing benefits from shared resources and expertise. PACES coordinates international research efforts on these topics in collaboration with existing and planned initiatives and motivates trans-disciplinary research related to Arctic air pollution and its impacts.

Around fifty scientists from 17 countries, with interests in Arctic air pollution gathered in Oslo, Norway, for the 3rd PACES Open Science Meeting in September 2019. Recent research highlights and ongoing and planned activities within PACES and more broadly were discussed in-depth. Scientific session themes included long-range pollution transport to the Arctic and global-scale linkages, Arctic aerosol-cloud interactions, local Arctic air pollution sources and high latitude polluted boundary layers, and sustainable Arctic development. More than 25 scientific presentations were given and 11 posters were presented across these topics, with additional group discussion around plans for new Arctic field activities and modeling exercises focused on addressing knowledge gaps in Arctic air pollution, sources and impacts. Funding from both IASC and IGAC allowed supported attendance of around 10 early career scientists.

Some specific highlights from the meeting included:

- Strong engagement from the aerosol-cloud interactions community, with a highly active session on exploring links between our understanding of Arctic polluted and natural aerosol sources and implications for Arctic clouds and climate.
- Development of a plan for a new set of model experiments under PACES Working Group 1, focused on comparing model performance and addressing model uncertainties during specific long-range pollution transport events from Asia to the Arctic.
- Continued discussion and planning for a range of field activities centred on improving understanding of chemical processing and impacts of air pollution in high latitude towns and cities under PACES Working Group 2. These include the planned Alaskan Layered air Pollution and Chemical Analysis (ALPACA) project **https://alpaca.community.uaf.edu/**, and the "Twin Cities" concept for assessment of risks associated with weather and air pollution in Arctic urban environments, and comparison across different settlements (in collaboration with the WMO GURME initiative, **http://mce2.org/wmogurme/**).
- A comprehensive Keynote Lecture from Len Barrie, setting out community achievements and remaining questions after 40 years of Arctic air chemistry research.

IGAC Visioning Exercise

28 OCTOBER 2019
UNAM, MEXICO CITY, MEXICO

IGAC Sponsored

AUTHORS

Hiroshi Tanimoto, National Institute for Environmental Studies, Japan

Jim Crawford, National Aeronautics and Space Administration, USA

Edit Nagy-Tanaka, National Institute for Environmental Studies, Japan

HOST INSTITUTION

FUNDING

National Institute for Environmental Studies

PARTICIPANTS

Australia, Bangladesh, Canada, China, France, Germany, India, Japan, Mexico, The Netherlands, South Africa, United Kingdom, and United States.

BACKGROUND

The scientific landscape around the atmospheric chemistry community has been changing over the last decade, with cutting-edge fundamental science evolving and a linkage to global sustainability emerging. The SSC started a discussion in 2017 on how we could best serve the community, and it was determined to be the right time for a Visioning Exercise to help develop the future direction of IGAC.

Participants of the IGAC Visioning Exercise

As a prelude to the annual IGAC SSC meeting, a one-day Visioning Exercise led by facilitator Bill Sharpe was held with the objective of discussing IGAC's present role and identifying its direction for the future. Thirteen current SSC members, along with one future and one past SSC member, participated in the exercise held on the campus of the National Autonomous University of Mexico (UNAM), in Mexico City, Mexico. UNAM, with over 300,000 students, is a highly-ranked public research university, and its campus is a UNESCO World Heritage site that was designed by some of Mexico's best-known architects of the 20th century. This creative environment provided an ideal setting for the Visioning Exercise.

Megan Melamed opened the meeting with comments on IGAC's need to review its role in terms of what it did and why, and what direction it should take in the future. Hiroshi Tanimoto added that the scientific landscape around the atmospheric chemistry community has been changing over the last decade, with cutting-edge fundamental science evolving and a linkage to global sustainability emerging. He reminded the group of the discussion started by the SSC in 2017 on how it could best serve the community, and that now was the right time for a Visioning Exercise to help define IGAC's future direction. He encouraged the participants to imagine atmospheric chemistry in 2050, have an open mind, and listen to each other in this Visioning Exercise. Next, Bill Sharpe provided a brief introduction to the structure of the Visioning Exercise. He explained that his role in this exercise was to help identify participants' visions and collect ideas for the future direction of IGAC.

In order to discuss IGAC's present role and its future direction, we asked ourselves questions like "How does IGAC picture its future?", "How can it redefine its mission in the future to better meet the needs of science

Participants of the IGAC Visioning Exercise

and society?" Mr. Sharpe employed the "Three Horizons Model", which offers a simple but innovative way of looking at the future by helping groups to articulate a shared understanding of the current situation and their challenges (Horizon 1), visions for the future (Horizon 3) and the innovations and actions that can help to achieve the future vision (Horizon 2).

The Visioning Exercise was carried out in the form of team-work and group discussions that were presented to the whole group of participants. To start the Visioning Exercise, the participants discussed their visions for the future in general. Issues such as the following were mentioned: Particular visions in professional life (such as improving society in a certain country), efforts towards improving science, bringing knowledge into action, living up to children's expectations for the future, ensuring a good environment for our children.

This exercise was followed by having the participants write personal statements on the importance of atmospheric chemistry. These statements were pasted on the wall for the group to view and group into themes. The following three main topics emerged: "Sustainable world and mankind", "Curiosity, challenge, and collaboration", and "Interconnections between science and people".

Next, group members were paired and asked to review high-impact research papers to help identify parallels with IGAC's current situation and challenges (Horizon 1). The conclusion of this exercise was that although IGAC already was a multidisciplinary organization, it was important to reach out to other disciplines and to emphasize international and multidisciplinary collaborations.

In the afternoon, visions for IGAC's future activities were explored (Horizon 3) by considering the UN Sustainable Development Goals (SDGs) to determine their relevance to atmospheric chemistry and how IGAC could expand its mission to better meet the needs of science and society. In this exercise, individual visions and aspirations were also incorporated. After an animated discussion, the participants agreed that there was need for more exchange and dialogue with other scientific communities and a clear messaging to policy-makers and society.

Based on the team work and discussions, the last task for the Visioning Exercise was to review and rephrase the current three focal activities of IGAC to achieve its mission to facilitate atmospheric chemistry research toward a sustainable world. The current three focal activities are "Fostering community", "Building capacity", and "Providing leadership." All participants agreed that these three areas in general were good, but should be redefined by the SSC. "Providing Leadership" was specifically targeted as needing to be better defined given that SSC members had a diversity of opinion on its meaning. It was also noted that a new focus area was needed in order for IGAC to achieve its mission. This new focus area was described as "Engaging society". The IGAC SSC will be working throughout the coming year to develop these four focus areas that resulted from the Visioning Exercise, and the outcome will be shared with the entire IGAC community at the 2020 IGAC Science Conference in Manchester, UK 14-18 September, 2020. With this, the Visioning Exercise was successfully completed. We hope this exercise will be a historic event with a lasting impact for IGAC and the international atmospheric chemistry community toward the future.

If you'd like more information on the Visioning Exercise, please contact **megan@igacproject.org**.

29-31 OCTOBER 2019
UNAM, MEXICO CITY, MEXICO

IGAC Sponsored

AUTHORS
Hiroshi Tanimoto, National Institute for Environmental Studies, Japan

Jim Crawford, National Aeronautics and Space Administration, USA

HOST INSTITUTION

FUNDING

National Institute for Environmental Studies

futureearth
Research. Innovation. Sustainability.

PARTICIPANTS
Australia, Bangladesh, Brazil, Canada, China, France, India, Japan, Mexico, The Netherlands, South Africa, United Kingdom, and United States.

BACKGROUND
IGAC's priorities and activities are guided and, in many cases, implemented by an international Scientific Steering Committee (SSC). Currently the IGAC SSC consists of 16 members from around the world (current membership list at **igacproject.org/people**).

34th Annual IGAC SSC Meeting

Participants of the 2019 IGAC SSC Meeting in front of the iconic UNAM library.

Thirteen current SSC members, along with liaisons from several partner organizations, and one future SSC member, gathered at a campus of the National Autonomous University of Mexico (UNAM), known as the UNESCO World Heritage site, in Mexico City, Mexico, to discuss the ongoing activities, recent successes, and future plans of the highly-active international IGAC community. The SSC meeting immediately followed a one-day Visioning Exercise that was held with the objective of discussing IGAC's present role and identifying its direction for the future.

The SSC meeting opened with welcome remarks by co-chairs and a brief wrap-up of the Visioning Exercise, which suggested a new challenge for IGAC to have its activities and communication reach outside as well as within the community and to redefine its focal activities. Then, Megan Melamed presented an update from the International Project Office (IPO), including the exciting news that IGAC received additional funding from NIES to support the SSC meeting as well as the Visioning Exercise through 2021. This funding supplements the core funding received from US agency sponsors NSF, NOAA and NASA. The SSC is very grateful for all of these funders.

Activities are a core aspect of IGAC (see **igacproject.org/Activities**), as are several national/regional working groups (see **igacproject.org/Working-Groups**). The SSC conducts in-depth reviews of selected activities and working groups each year, with generally a 3-year rotation cycle among the activities and working groups. This year, TOAR, IBBI, PACES, and ACPC were reviewed. The SSC also conducts in-depth reviews of emerging activities after a few years since their initial proposal. This year, the development and status of CATCH, AMIGO, and MAP-AQ were reviewed and evaluated for full sponsorship. The progress within all of the reviewed activities was generally seen as commendable. Feedback on each activity was gathered through World Café sessions. During these sessions, SSC members rotated between stations where each activity could be discussed independently. The SSC members most closely affiliated with the activity being discussed stayed at their respective station to collect the observations. Results were then reported in plenary to drive a productive discussion during which consensus feedback to activities was developed.

The SSC meeting was followed by a session to discuss collaborations with several partner organizations, including our sponsors – Future Earth and iCACGP – as well as four of our main partners: WMO/GAW (World Meteorological Organization / Global Atmosphere Watch program), SOLAS (Surface Ocean - Lower Atmosphere Study), iLEAPS (Integrated Land Ecosystem-Atmosphere Process Study), and SPARC (Stratosphere-troposphere Processes And their Role in Climate). The session started by presentations provided by the liaisons, followed by a valuable discussion about the roles of IGAC and its partner organizations in the current and future landscape of these programs and projects, which are focusing on various related aspects of the Earth system science and global sustainability issues. In particular, the complementary roles of IGAC and iCACGP in the community were discussed.

Turning the attention of the SSC to the upcoming 16th IGAC Science Conference, Hugh Coe presented plans for the meeting which will be held in Manchester, England, September 14th-18th, 2020. This included updates from the Local Organizing Committee, the Local Organizing Early Career Committee, and the Scientific Program Committee. It was apparent to the SSC that the planning group had developed an exciting program, highlighting key aspects of atmospheric chemistry, providing a venue conducive to scientific discussions, and designing a very active program for early career scientists. In addition, SSC members that oversee the development of the 2020 IGAC Early Career Short Course, which will take September 11th-13th, 2020, presented an update on the selection of the organizing committee and next steps.

In the afternoon, the SSC looked back to the visioning exercises which suggested that IGAC reevaluate its stated mission moving forward. IGAC's mission, "Facilitating atmospheric chemistry research toward a sustainable world," has been realized by emphasizing three main foci – "Fostering Community", "Building Capacity", and "Providing Leadership". This framing has served very well, but discussions revealed a lack of clarity in the phrase "Providing Leadership" as various SSC members had different views of the meaning. Discussions led the group to recast this focus from "Providing Leadership" to "Advancing Knowledge". It was also agreed that IGAC and the science of atmospheric chemistry was mature enough to warrant a new focus on "Engaging Society". During the meeting, more complete statements defining each of the four roles were drafted. It was agreed that additional language would need to be developed in the coming months to provide specific details on how IGAC would promote these foci with the goal of presenting this updated framework at the Science Conference in Manchester.

The SSC meeting ended with a session to discuss future developments in the SSC composition. This discussion took several factors into consideration including the size of the group, maintaining adequate geographical representation, ensuring a breadth of expertise, and diversity in membership. At the end of 2019, two current IGAC SSC members will be completing their service on the IGAC SSC; Judith Hoelzemann (Federal University of Rio Grande do Norte, Brazil) and Kim Oanh (Asian Institute of Technology, Thailand). The SSC is grateful for the excellent service provided by Judith and Kim, in particular, for hosting the iCACGP-IGAC 2014 event and establishing the MANGO working group, respectively.

Since the IGAC SSC exists to serve the IGAC community, we are always happy to hear from you. We look forward to another exciting year in 2020 for the entire IGAC community, and hope to see many of you soon in Manchester!

28 NOVEMBER – 01 DECEMBER 2019
NAINITAL, INDIA

IGAC Sponsored

IGAC-MANGO Meeting, Science Workshop, and Training Courses 2019

AUTHORS

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HOST INSTITUTIONS

FUNDING

PARTICIPANTS

Japan, India, Bangladesh, Singapore, Myanmar, Malaysia, Indonesia, Vietnam, Philippines, Taiwan, Nepal, Sri Lanka, Cambodia, Brunei, Thailand, France, United Kingdom

BACKGROUND

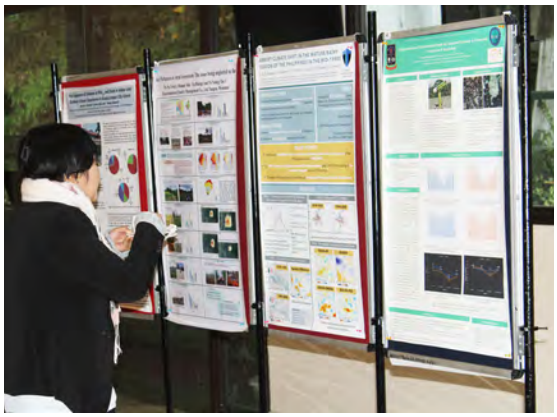
IGAC sponsored this workshop to foster the development of an atmospheric science community in Asia as part of its effort to create National/Regional Working Groups. IGAC-MANGO was established with the ultimate goal to form a cohesive network of atmospheric scientists in the Asian monsoon region, facilitate collaboration between Asian and international scientists, and foster the next generation of scientists in this region.

IGAC-MANGO 2019 Participants

Eleven current MANGO committee members, along with twenty-two early career scientists, and four invited lectures, gathered in Nainital, India, a town with a beautiful lake in the foothills of Himalayas, for the IGAC-MANGO Meeting, Science Workshop, and Training Course 2019. The main objective of IGAC-MANGO is 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. Recent updates and future directions of MANGO, including membership, new activities, and funding opportunities were discussed during the one day committee meeting. This was followed by a two-day science workshop and training course that included sessions dedicated to science-policy and science communication, as well as a joint MANGO-India scientific session, including 1 minute flash poster talks, and a course on satellite data analysis and low-cost sensors. Unique this year was a video-clip competition by MANGO early career scientists called "MANGO Junior" or "green-MANGO".

The sessions devoted to science-policy and science communication comprised four main components: an invited talk, a panel discussion, a video presentation, and a sharing talk on a case-study related to science

Nainital, India



◀ Training course, posters and launch of ozonesonde-radiosonde. ▶

communication. The invited talk entitled "Recurrent Haze in Southern ASEAN: What more can we do to prevent it?" given by Prof. David Koh covered multifaceted elements; it overviewed the recurrent smoke emissions from burning peat forest in Southeast Asia, the relevant policies built, the progression and challenges of policy implementation, and evolvement of understandings, as well as technologies of protecting the public by minimizing exposure to airborne smoke pollutants.

Following the invited talk, a panel discussion was convened where the invited members (Drs. David Koh, Shyam Lal, Candice Lung, MM Sarin, and Hiroshi Tanimoto) shared their individual experiences and insights on the gaps and dos-and-don'ts (for scientists) in effective communication linking science and policies. To provide a balanced view, the panel members encouraged to the early career scientists to concentrate on building solid scientific knowledge and research capabilities. Such endeavor is required to form a solid foundation to contribute to effective science-policy communication during later stages of ones' career development as a scientist.

A 20-min video focusing on "What is Science Policy? Why do we want to engage in Science-Policy" made by Dr. Erika von Schneidemesser was presented. The session in Science-Policy concluded with a successful story of how scientific findings led to meaningful policy of protecting the public from being overly exposed to emission of burning incense during religious activities in Taiwan. Dr. Candice Lung detailed local-culture-specific understandings in the mindset of public and policy makers, obstacles encountered, and the perseverance required to convince policy makers to address this issue. This was followed with a lively Q&A, encouraging all MANGO countries to endeavor a dynamic practice.

The MANGO 2019 workshop launched a new initiative on "MANGO Flavored Research-Educational Video Competition". The competition aims to enhance effective scientific learning and sharing through video literature that demonstrates (a) novel scientific research findings in the MANGO region, and/or (b) better explanation and understanding of existing yet challenging scientific concepts related to the scope within IGAC. A total of 10 submissions were received and all the MANGO members and invited delegates participated in the viewing and scoring of all the submitted videos.

Parallel sessions for a training course on satellite data handling/visualization and on low-cost sensors were also organized. Dr. Silvia Bucci gave lectures and hands-on training on satellite data retrievals with demonstrations of processing GOME-2, Sentinel 5P, and CAMS data.

Awards presentation

Lectures and hands-on training on low-cost sensors were provided on the next day by Drs. Tomoki Nakayama and Iq Mead. "Green-MANGOs" were grouped to perform and present measurements using low-cost sensors at different locations. These sensors were also provided to interested students/scientists for observations in their own countries. One of the unique events of the workshop was the live onsite launch of ozonesonde and radiosonde by Dr. Manish Naja, a rare experience and a highlight of the workshop.

A MANGO-India session on the second day hosted a total of 14 presentations, including two remote presentations, to provide an overview of the scientific research carried out in the individual member countries. The session helped to share information on status of air pollution and will contribute to focusing on future research themes in Asia. It was noted that so far, there has been only two major international observational field campaigns (INDOEX and Suskat) in South Asia. Considering the complexity and intensity of emission sources it is very important to have extensive observations, with open data policy, over this region with the Himalayas on the North and pristine oceanic regions to the South and a huge human population in between.

Dr. Hiroshi Tanimoto summarized the activities for 2020 and beyond. The event concluded with the distribution of top three posters and top two video clips awards with nicely made mementoes and certificates. Certificates of commendation were also emailed to individual awardees for their video clips.

Thank you for coming to Nainital for the first ever IGAC, NIES and APN sponsored meeting in India. The 3-day event highlighted the successes of the MANGO initiatives, while also outlining the work still needed. Further details of the event can be found at **http://cger.nies.go.jp/gac/igac-mango/**.

2019 CATCH Open Science Workshop

7-8 DECEMBER 2019
UC BERKELEY, CALIFORNIA, USA

IGAC Sponsored

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HOST INSTITUTION

Berkeley
UNIVERSITY OF CALIFORNIA

FUNDING

IASC

solas 2019

PARTICIPANTS

Argentina, Australia, Belgium, Canada, France, Italy, Japan, Pakistan, Spain, Sweden, Switzerland, USA, UK

BACKGROUND

CATCH
the Cryosphere and ATmospheric CHemistry

IGAC financially co-sponsored this workshop to support the jointly sponsored IGAC/SOLAS Cryosphere and Atmospheric Chemistry (CATCH) activity. This activity was established to facilitate atmospheric chemistry research within the international community, with a focus on natural processes specific to cold regions of the Earth.

CATCH Open Science Workshop Participants

Forty-four scientists attended the workshop coming from 14 countries and representing a wide range of science disciplines, with about one third being early career researchers. A workshop video link was provided and very well received. The workshop programme balanced science presentations (1 keynote lecture, 20 talks, 23 posters) with discussion in the plenary and in smaller breakout groups to achieve as much interaction and engagement as possible over the course of one and a half days. Five sessions were organised with invited talk(s) followed by 5-minute flash presentations on current research results highlighting scientific challenges for the wider community. Sessions concluded with a moderated speaker panel discussion.

Polar aerosol and clouds. To characterize polar aerosol and potential impact on cloud formation basic information is lacking, including chemical composition, properties of cloud condensation nuclei (CCN) and ice nucleating particles (INP), and size distributions; e.g. nanoparticles play a major role as cloud seeds in the Arctic and are partially linked to ice processes, but few measurements are available. It is agreed that more inter-disciplinarity, for example by including ice specialists and atmospheric dynamicists, would benefit the coordination of campaign-based and continuous long-term observations, the design of process-focused cloud-aerosol interaction studies and data interpretation.

Atmosphere-cryosphere chemical interactions. There is an urgent need of advancing science in this area as the cryosphere, particularly in the Arctic, is changing at a faster rate than scientists can understand the underlying processes that are changing as well. Known uncertainties,

UC Berkeley, California, USA

which need to be addressed include improved measurements of fundamental properties of icy surfaces at the micro-scale such as the pH and the location of impurities and oxidants, as well as an improved process understanding. To understand the spatial impact of processes upscaling to regional and larger scales is needed possibly supported by relevant satellite measurements.

The cryosphere and climate change. The overarching questions are how cryosphere-atmospheric chemistry processes, interactions, and feedbacks impact climate change and how their understanding may reduce uncertainties in model predictions of climate in the 21st century. It was recognized that involving ice core sciences in CATCH has mutual benefits: a better understanding of the coupling between macro- and microscale processes at present will be very useful to better interpret ice core records of past climate change.

From micro-scale chemical, biological, and physical processes to regional cryosphere-atmosphere interactions. Fundamental process studies continue to be needed for the microscale as well smog-chamber equivalent studies. The key question remains to identify and characterise dominating reaction pathways that drive the large scale chemical fluxes observed.

Field campaigns and long-term observations. Recommended actions included i) the planning and delivery of a research cruise by the CATCH and BEPSII community and ii) development of a list of essential and desirable baseline observations, which is shared among existing observatories world-wide.

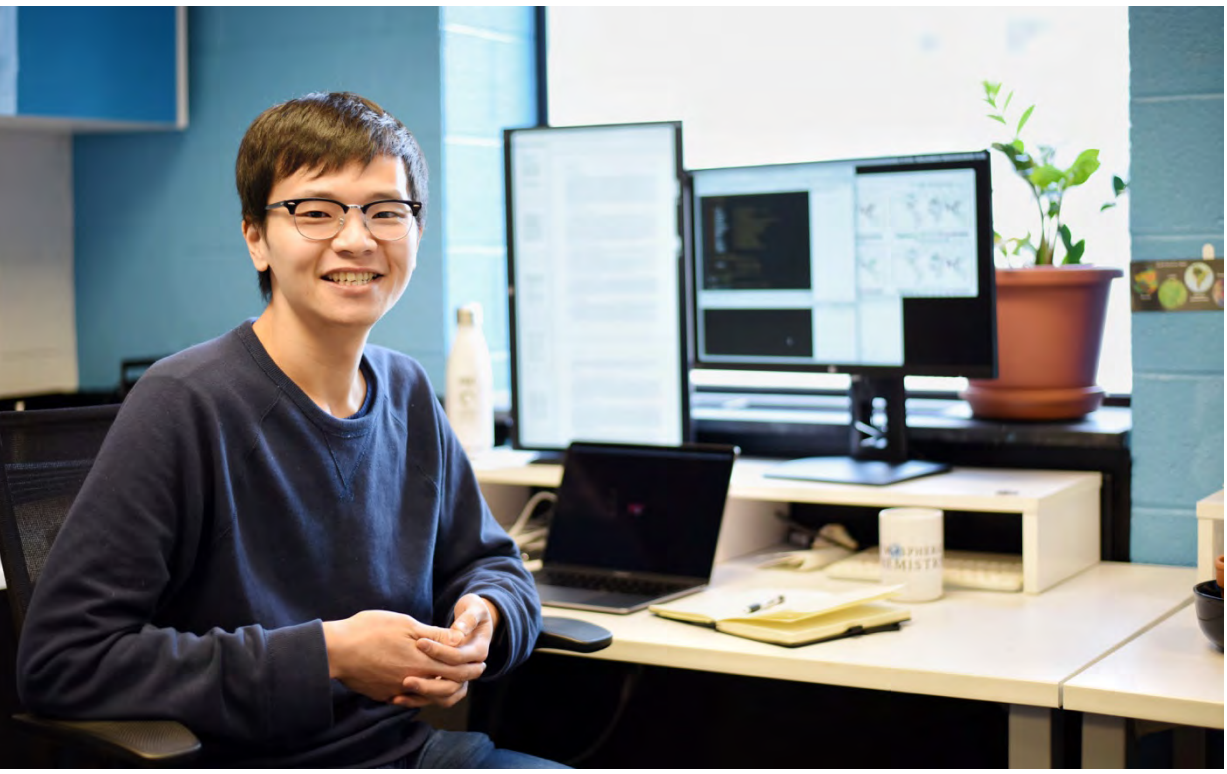
Models. The need for modelling improvement by going through a hierarchy of models, including box/1-D, regional, and global models was clearly recognized. The main activities suggested were i) development of a CATCH Community 1D-model that includes atmosphere/snow chemical interactions and ii) coupling existing snowpack models with atmospheric models. It became clear that CATCH science is an Earth System science, whereas the CATCH community consists primarily of atmospheric chemists with participation from biogeochemists. Thus, physical cryosphere sciences and hydrology will need to be involved in order to achieve progress in modelling.

Data. Public data repositories as well as synthesis papers highlighting available parameterizations are hugely important for modelers. The CATCH network is ideally placed to make significant contributions to both resources. In order to make use of existing measurements it is recommended to develop a CATCH meta-repository that lists relevant data from existing national and international data archives.

Outreach. Important stakeholders that were highlighted include the wider scientific community, the general public, and national or international funding agencies. It was recognised that it is of utmost importance to explain aims and relevance of CATCH to these stakeholders and a dedicated activity is required, which coordinates e.g. social media campaigns, specific workshops or townhall meetings.

Ka Ming Fung

Ka Ming Fung attended the 2019 CCMI Summer School and 2019 CCMI Science Workshop 4-9 August 2019 in Hong Kong.



Photograph by Dr. Chloe Gao

Ka Ming Fung was born and raised in Hong Kong. He received his undergraduate degree in Mechanical Engineering from the Hong Kong University of Science and Technology in 2009 and a Master of Science in Mathematics from The Chinese University of Hong Kong (CUHK) in 2012. In 2019 Ka Ming earned his Doctor of Philosophy in Earth and Atmospheric Sciences from CUHK. Working with Prof. Amos Tai, Ka Ming studied the interrelationship between sustainable agriculture and ammonia emission, and their impacts on food security, environmental health, and climate. Ka Ming is now a Postdoctoral Associate at the Massachusetts Institute of Technology in the USA, working with Prof. Colette Heald at the Atmospheric Chemistry and Composition Modeling Group, Department of Civil and Environmental Engineering. His postdoc project aims to accurately determine the climate impact of aerosol by improving the modeling of aerosol formation from the oxidation of dimethyl sulfide (DMS). With the help of laboratory experiments and observations, he is working towards updating the DMS chemistry in the Community Atmospheric Model with Chemistry (CAM-chem), which is developed by the National Center for Atmospheric Research (NCAR), to better capture atmospheric sulfate production. Such implementation allows users of CAM-chem to simulate aerosol composition in the pre-industrial and present-day atmosphere, estimate the corresponding aerosol radiative forcing due to natural and anthropogenic emissions, and assess the climate impact of the aerosol associated with human activities.

What was the highlight(s) of the 2019 CCMI Summer School and Science Workshop for you?

I think one of the highlights was the breakout sessions, which successfully created a supportive network among the attendees. In those sessions, participants could join different task forces to exchange ideas on specific CCMI-related topics and decide the near-term and long-term development focuses. Each group then took turns to present a summary of their discussion. This exercise enabled the task forces to efficiently determine necessary actions to further the model evaluation plans and associated modeling activities within CCMI while keeping everyone in the loop. I also think that it allowed early career scientists like me to learn to collaborate with other scientists. These breakout sessions made the event more than just a series of seminars.

This event was also an invaluable outreaching experience for me. Since CUHK was the local host, I volunteered as a coordinator of the organizing team. Throughout the event, I could socialize with virtually every single participant, giving me a strong sense of belonging to the CCMI community.

What do you think are the benefits of participating in IGAC training courses and workshops such as the 2019 CCMI Summer School and Science Workshop as an early career scientist? Would you encourage other early career scientists to participate in IGAC training courses and workshops?

I would definitely recommend my early career colleagues to join IGAC courses and workshops. Most of the training sections are tailored for scientists by senior scientists in the same field who had a similar learning experience. For example, instructors of the CCMI Summer School taught us programming languages like Python and R using standard datasets and models. The course exercises were also closely related to the frontier research questions in the field. I learned a lot of readily applicable skills and caught a glimpse of how other research groups conduct their work.

I also found IGAC workshops a great platform for early career scientists to network with peers as well as established scientists, fostering future collaboration. It can also be an excellent occasion to seek potential career opportunities.

What aspect of your research are you most excited about?

I love my research because of its interdisciplinary nature. I have had broad interests in all STEM subjects since childhood. My Ph.D. thesis examined the impact of sustainable farming practices on food security and air quality, and as a postdoc, I am now investigating the climate impacts of atmospheric aerosols. Both projects rely heavily on computational models that integrate biogeochemistry, atmospheric chemistry, and other Earth system sciences. I also consider the implications of my results from multiple angles, such as environmental health and economics, to make my work more relatable to policymakers and stakeholders. I enjoy very much that I can learn and incorporate new knowledge to tackle the research challenges facing me every day.

What motivated you to pursue a career in science? Does this source continue to be your source of motivation today? If not what has changed?

I always wanted to convey my keen interest in STEM subjects into making a difference that benefits society. After receiving my bachelor's degree, I became a mechanical engineer. I participated in a project to modernize a public crematory in Hong Kong by installing an innovative flue gas treatment system, which could dramatically reduce air pollutant emissions from the facility. Working closely with the R&D engineers of the new system made me realize how vital scientific research is in advancing technology that addresses real-world challenges. I thus decided to study further in sciences that can help shape a better world.

In recent years, I strongly believe that most of the urgent environmental crisis can only be resolved by the synergy of all parties, including governments, industries, and individuals. As a trained researcher, I feel that I am responsible to chip in my science knowledge to assist stakeholders in formulating appropriate policies and action plans. This is my primary driving force today.

Outside of science, what are some of your other interests/hobbies?

I consider myself a "foodie." I enjoy trying new foods when traveling, discovering the stories behind the dishes, and getting to know foreign cultures. I also find that introducing food to others is a great conversation opener. Here is a fun fact – during the 2019 CCMI Summer School and Science Workshop, our organizing team deliberately served some local style refreshments, including dim sum, fish ball, and milk tea, as a way to introduce our hometown, Hong Kong, to the community.

For a healthier lifestyle, I practice yoga. It not only helps me relieve muscle tension after working all day but also promotes my mindfulness to alleviate mental stress.

High-resolution (400 m) operational air quality early warning system for Delhi, India.

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Managing air quality levels in the National Capital Region (NCR), especially Delhi, India has emerged as a complex task and is now a matter of top priority for the regulatory authorities as well as scientific and academic institutions. In recent years, the Government of India has been seeking credible scientific studies to develop meaningful policy options to mitigate the risk that acute air pollution episodes pose to public. Short-term (1-3 days) air quality forecasts can provide timely information about forthcoming air pollution episodes that the decision-makers can use to reduce public exposure to extreme air pollution events. In this perspective, first of its kind, a very high-resolution (400 m) operational air quality prediction system was developed to predict extreme air pollution events in Delhi and issue timely warnings to take necessary steps as per the newly designed Graded Response Action Plan (GRAP) of the Government of India. This system was developed jointly by scientists of Ministry of Earth Sciences (MoES), Government of India and the National Centre for Atmospheric Research (NCAR), USA.

The modeling framework consists of a high-resolution fully coupled state-of-the-science Weather Research and Forecasting model coupled with Chemistry (WRF-Chem) and three-dimensional Variational (3DVAR) framework of the community Gridpoint Statistical Interpolation (GSI) system. The system assimilates satellite aerosol optical depth (AOD) retrievals at 3 km resolution, and surface data from 43 air quality monitoring stations in NCR and high-resolution emissions from various anthropogenic and natural sources including dust and stubble burning. The chemical data assimilation is further integrated with dynamical downscaling to obtain improved chemical conditions for the 400 m resolution domain.

Short-term (1-3 days) air quality forecasts can provide timely information about forthcoming air pollution episodes that the decision-makers can use to reduce public exposure to extreme air pollution events.

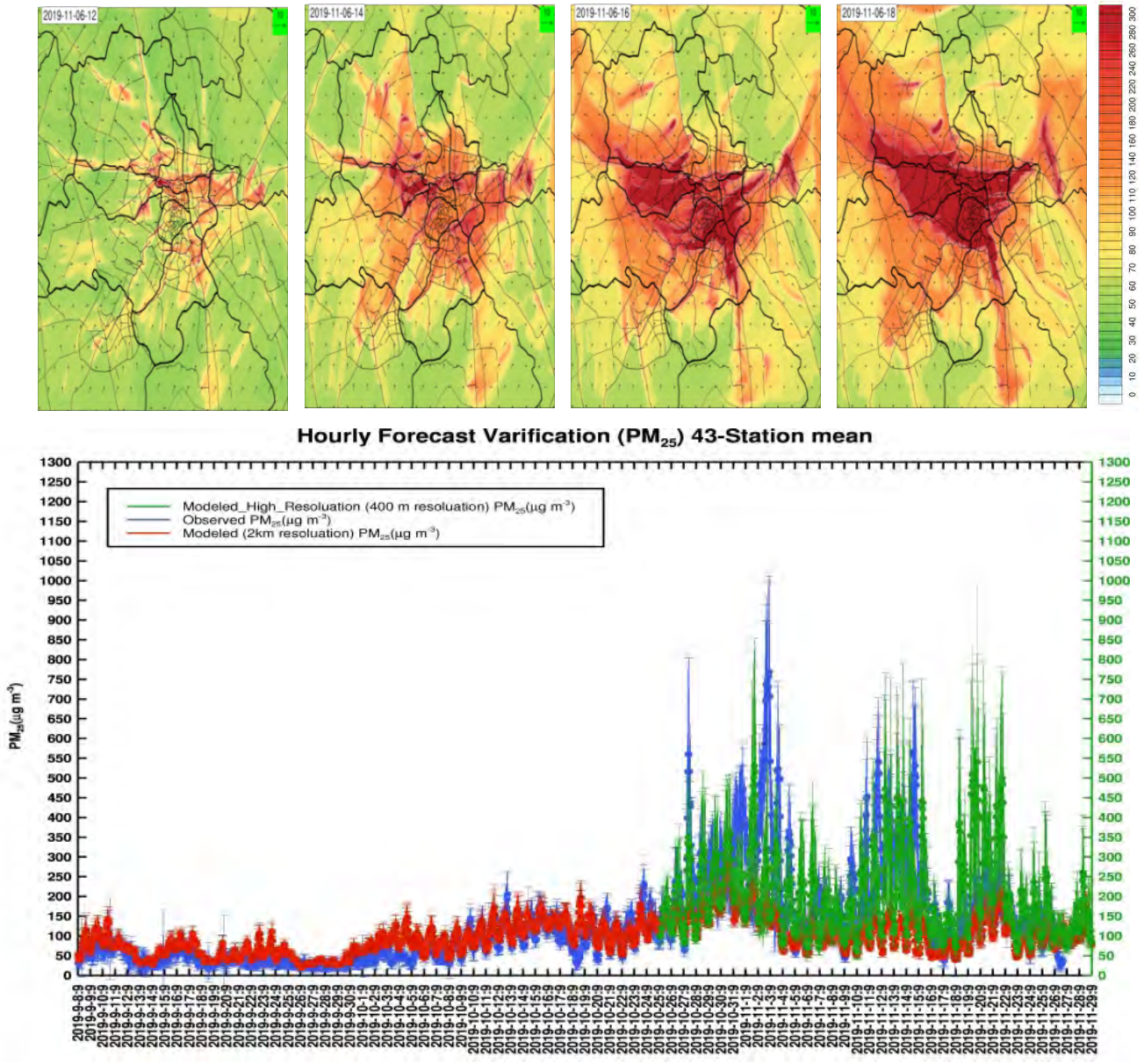

FIGURE. (Top) Spatial spread distribution of fine particulate matter ($PM_{2.5}$) in Delhi at 400 m resolution for different times of the day on November 06, 2019. **(Bottom)** Hourly forecast verification (Blue: mean $PM_{2.5}$ from 43 air quality monitoring stations, Red: forecast at 2km resolution with AOD and surface data assimilation, Green: 400 m resolution forecast with dynamical downscaling).

To efficiently disseminate air quality forecasts to the public and decision-makers in Delhi, MoES launched an Early Warning system (EWS, **https://ews.tropmet.res.in**). The EWS provides (1) near real-time observations of air quality and visibility over Delhi region and details about natural aerosols like dust (from dust storms), fire information, satellite AOD, and PBL height, (2) Predictions of air pollutants based on state-of-the-art atmospheric chemistry transport models, (3) Warning Messages, Alerts, and Bulletins and (4) forecast of the contribution of non-local fire emissions to the air quality in Delhi. The warning system also provides an air quality forecast for a few more cities in the northern region of India at 10 km resolution. The website also shows forecast verification for Delhi on a daily and hourly basis.

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