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# IGACnews

facilitating atmospheric chemistry research towards a sustainable world

issue 67
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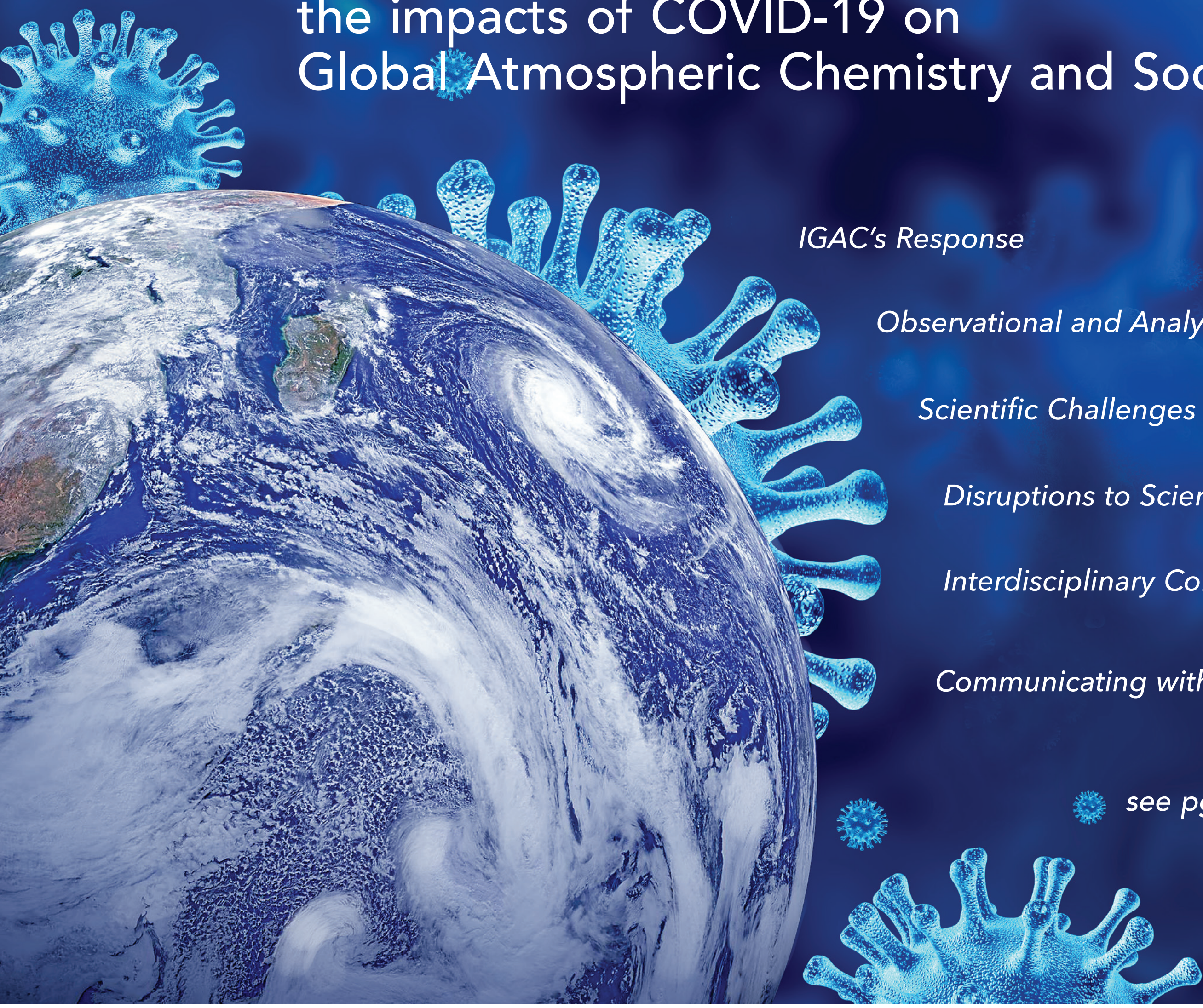
## Science Feature

## IGAC's Role in understanding the impacts of COVID-19 on Global Atmospheric Chemistry and Society



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*Scientific Challenges*

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futurearth
Research. Innovation. Sustainability.

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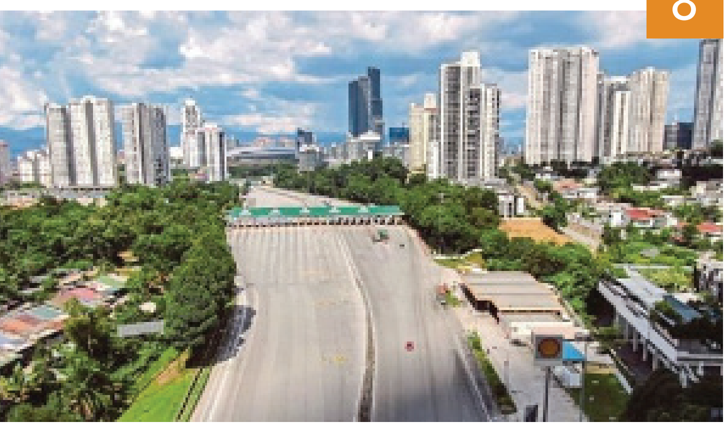

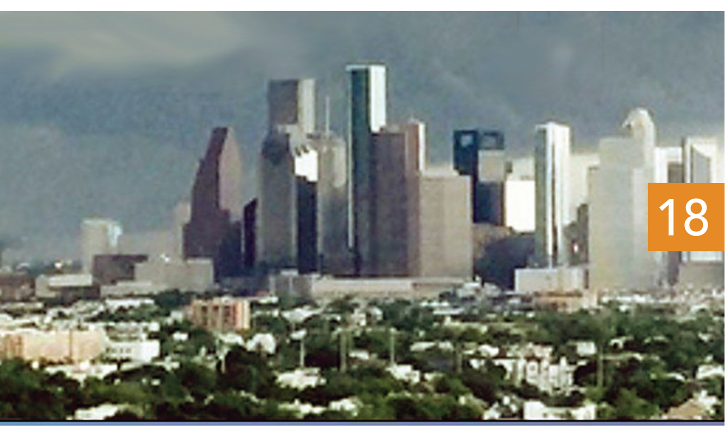


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### On the Cover

COVID-19 has had an unprecedented global impact. In relation to atmospheric chemistry, emissions to the atmosphere have changed due to travel restrictions and other consequences of city-wide lockdowns, scientists have observed a link between air quality and COVID-19 severity, and aerosols from exhalation play a role in the spread of COVID-19. The IGAC community has come together to distill lessons from COVID-19 and discuss the role of international atmospheric chemistry in this pandemic. PHOTO CREDITS: NASA, ISTOCKIMAGES

**Editor:** Megan L. Melamed
**Design:** Allison Gray

### 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 February 2021 issue of the IGACnews is 15 January 2021. Send all submissions to **info@igacproject.org**.

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

# Life Changes

**September/October 2020**

For the past decade, I have been extremely proud to be the IGAC Director. Serving the international atmospheric chemistry community has been an honor. But like all good things in life, my service to the international atmospheric chemistry community has come to an end.

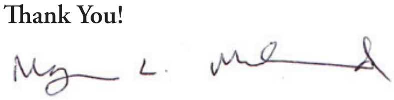
**Megan & Wren**

This past year, despite the COVID pandemic, I have been blessed with two life changes. The first is we welcomed our daughter Wren Julia Larson to the world on June 18th, 2020. The second is that I accepted a position in the Director's Office of the National Oceanic and Atmospheric Administration (NOAA) Chemical Sciences Laboratory (CSL). My new position at NOAA will allow me to travel less frequently, have "normal" work hours, and spend more time with my family.

One of the things that makes IGAC such a great organization is that the leadership and staff continuously rotate, making IGAC a true community organization. After a decade with IGAC, I feel it is time for me to hand over the duties of IGAC Director to someone new, someone who can bring new energy and ideas to the organization. Langley DeWitt, the new IGAC Director, will do just that. I hope you will welcome her with open arms as you welcomed me a decade ago.

I want to thank each and every one of you for being part of the IGAC community and for making my time with IGAC so rewarding. I look forward to staying in touch with you and continuing to see you at atmospheric chemistry related events, including the IGAC Science Conference, for years to come.

**Thank You!**



**MEGAN L. MELAMED**

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 served as the IGAC Director from 2011-2020.

## Note from IGAC Co-Chair Hiroshi Tanimoto

MY FIRST MEETING with Megan was at the IGAC workshop in 2011, when I was about to start the IGAC SSC membership and Megan just started her role at IGAC. Since then we have worked together on a number of projects for the IGAC missions. My memory goes back to several historic events – the 2015 MANGO launch, the 2016 Breckenridge conference, the 2018 Takamatsu conference, and the 2019 IGAC visioning exercise – among many, many regular meetings and telecons during the last 10 years. She recently became a mother of a cute baby, and this reminded me that Megan is also a mother of the current IGAC. I would like to thank her dedicated service for IGAC, congratulate her excellent graduation from IGAC, and wish another success in her new career in global atmospheric chemistry!

## Manchester Postponed Until 2021

Due to Covid-19, the Manchester IGAC 2020 conference is being postponed until 2021. Stay tuned for more information, including abstract submission/editing/withdrawal

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

**12-16 September 2021**
**Manchester, UK**

**Abstract announcements coming soon.**

**Connect with others about IGAC2021!!**

Facebook Group
Twitter #IGAC2021
Early Career Scientists Facebook Group
Twitter @IGAC_ECS

## IGAC 2020 Early Career Short Course Postponed

Stay tuned for more information.

# IGAC Welcomes New Director

LANGLEY DEWITT is an atmospheric chemist with a global perspective, whose research has spanned three continents, two oceans, two planets, and a couple eons of time. For her Ph.D. work in Analytical and Atmospheric Chemistry at the University of Colorado in Boulder, CO, USA she performed laboratory experiments to form and analyze aerosols relevant to the early Earth and Titan. She moved into present-day aerosol analysis as a National Research Council postdoctoral fellow at the National Oceanic and Atmospheric Administration (NOAA) Pacific Marine Environmental Laboratory (PMEL), USA. For NOAA, she measured the chemical composition of aerosols off the coast of California and the aerosol chemical and optical properties before, during, and after a Madden-Julian Oscillation event over the equatorial Indian Ocean. Following NOAA, she worked at the University of Aix-Marseille, France for two years as a researcher on several field campaigns and laboratory measurements. These included in-situ measurements of the chemistry of marine aerosols, cloud droplet chemistry experiments, and source apportionment of pollution near high-diesel roadways. Next, wanting to apply her skillset towards developing scientific knowledge and capacity in an understudied region, she took a position as the interim station chief scientist of the Rwanda-MIT Climate Observatory. There, she helped establish a climate change observatory measuring greenhouse-gases and air quality indicators on Mt. Mugogo and designed Rwanda's air quality monitoring network. After leadership of that work transitioned, as planned, to local scientists, Langley moved into air monitoring in industry to further expand her frame of reference for different applications of atmospheric chemistry. She consulted on a variety of air monitoring, pollution source apportionment, technology assessment, and other projects as a project manager and air quality consultant specialist in the greater Houston, TX, USA area. Langley is excited to bring her scientific expertise, international experience, and project management skills together to help foster international scientific community, collaboration, and outreach on issues related to atmospheric chemistry.

**Langley DeWitt**

# 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. *w* 2017;5:50. DOI: 10.1525/elementa.243.

If you have recently published an IGAC-relevant article and wish for it to be highlighted in IGACNews, please submit the citation to **info@igacproject.org**

## 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**.

# Dr. Andreas Hilboll | 14 November 1977 - 25 March 2020

WE DEDICATE THIS ISSUE of IGACnews to the memory of Andreas Hilboll, a valued member of the IGAC community who was lost to COVID-19 early in the pandemic. His highly-cited work on satellite trends in $NO_2$ around the globe has particular relevance to current efforts using satellite observations to document the impact of COVID-19 lockdowns and restrictions on polluting emissions and air quality. There is no doubt that he would have been keenly interested in interpreting and learning from the observed changes taking place. While we mourn his loss, we celebrate his contributions and positive impacts on the global atmospheric chemistry community.

Andreas Hilboll began his research career during his studies for his Diploma (B.Sc. and M.Sc.) in Mathematics at the University of Bonn, which he completed very successfully in 2007. His Diploma research focused on the modelling of the dynamics and interactions of Actin filaments. He then decided to move to the field of atmospheric physics and chemistry, and in 2008 joined the Institute of Environmental Physics (IUP) of the University of Bremen in Germany. His doctoral research was supervised by Professor John P. Burrows FRS and Dr. Andreas Richter. During this time, he developed new algorithms to retrieve tropospheric nitrogen dioxide ($NO_2$) columns from passive remote sensing of the solar radiation upwelling at the top of the atmosphere and measured by a then new type of spectrometer in space. This research was part of the EU FP7-ENVIRONMENT CITIZEN project, led by Dr. Michael Gauss (Norwegian Meteorological Institute). In a series of papers, Andreas used observations from several different instruments to investigate the spatial and temporal changes of $NO_2$ emitted from major population centres, e.g. urban agglomerations and megacities. After completing his doctorate with distinction (summa cum laude) in 2014, he extended his interest to the ground-based and satellite remote sensing of oxygenated volatile organic compounds. He also participated in key studies assessing the impact of economic crises on air pollution in the Mediterranean and contributed significantly to the identification of the changing emissions of both $NO_2$ and carbon dioxide ($CO_2$) in China.

In 2016, Andreas joined a new department at IUP, the Laboratory for Modelling and Observation of the Earth System, supervised by Professor Mihalis Vrekoussis, to forge a career in numerical modelling of the atmosphere. During the period 2016-2020, Andreas proved once more his ability to excel in science. He rapidly became an expert in modelling atmospheric chemistry and dynamics. In this context, Andreas has been a key member of the DFG EMeRGe (Effect of Megacities on the transport and transformation of pollutants on the Regional and Global scales) Project, which exploits the German Research Aircraft HALO for tropospheric research of the transport and transformation of pollution. He also was a key actor in creating an EU ERASMUS exchange-teaching programme. In 2020, Andreas became a tenured academic at the University of Bremen.

Andreas Hilboll

Andreas was motivated to achieve a better understanding of air pollution and climate change and educate the next generation of students. He was an excellent and dedicated scientist, a highly intelligent individual, an inspiring teacher, and a passionate advisor. Most importantly, at a personal level he was an extremely kind and generous person, who always cared for and helped others. He was there to discuss problems and find solutions. He was a much liked and well-respected member of IUP and the international atmospheric chemistry community.

Andreas died from contracting COVID-19 on the 25th of March 2020. In his career, Andreas made an impact and a difference. He was a wonderful human being who is and will be greatly missed by his friends and colleagues in Bremen and around the world.

commentary

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**PARTICIPATING NATIONS**

Argentina, Australia, Bangladesh, Canada, China, France, India, Japan, Mexico, The Netherlands, Singapore, South Africa, United Kingdom, United States

# IGAC's role in understanding the impacts of COVID-19 on Global Atmospheric Chemistry and Society

In the short time since its appearance, COVID-19 has left no part of the world untouched. The speed with which it has spread and the health risks that it poses have caused unprecedented disruptions to daily life as we seek to limit exposure and minimize the toll of the pandemic. The associated societal, economic, and environmental impacts resulting from restrictions on movement and physical distancing measures have manifested in myriad ways. Given the strong connections between human activity, emissions, and atmospheric chemistry, it is not surprising that several elements associated with the pandemic are relevant to our field of endeavor. These include the following:

- Evidence of reduced pollutant emissions linked to restrictions have been observed by satellites, ground-based measurements, and aircraft sampling.
- Air quality responses have been reported, such as improved visibility in areas of persistent haze.
- Epidemiological studies have suggested a link between long-term exposure to poor air quality and mortality from COVID-19.
- The role of fine aerosol in human exhalation has been highlighted as an important aspect of the airborne spread of the virus, and there is an obvious need to understand indoor air circulation and the efficacy of different types of masks in limiting the spread of the virus.

In the midst of this natural experiment playing out across the globe, we encourage the IGAC community to work together to distill lessons from the COVID-19 restrictions and their atmospheric impacts. While the abruptness and negative impacts of the restrictions are not a good model for change, the observed atmospheric responses could be used to inform more deliberate changes in our activity that would benefit air quality, human health, agriculture, ecosystems, and climate.


*Our need to maintain contact as a community and collaborate on the science of atmospheric chemistry spanning regional to global perspectives is IGAC's highest priority.*

In the following commentaries, we expand on this challenge by describing how **IGAC's Response** might look through actions by the Working Groups and Activities, the **Observational and Analytical Needs** for producing quantitative evidence for atmospheric impacts, the **Scientific Challenges** we face in relating these atmospheric responses to specific causes and outcomes, the ongoing **Disruptions to Science** that challenge our community, the **Interdisciplinary Connections** needed to fully understand impacts on health and ecosystems, and opportunities for **Communicating with Society** through our common experiences during this difficult time.

With the postponement of the 2020 IGAC Conference in Manchester, we do not know when our next opportunity for in-person meetings will come. Meanwhile, our need to maintain contact as a community and collaborate on the science of atmospheric chemistry spanning regional to global perspectives is IGAC's highest priority. Furthermore, we believe this crisis provides an unprecedented opportunity to demonstrate the importance of IGAC's mission to advance knowledge and convene scientific expertise, foster the international atmospheric chemistry community, build scientific capacity around the world, and engage society by making our science accessible to a broad audience.

## IGAC's Response to COVID-19

IGAC Working Groups and Activities are in a unique position to organize the global atmospheric chemistry community by fostering cooperation and fast exchange of knowledge in order to improve our understanding of the impact of COVID-19 on our atmosphere and the role air quality might play in the vulnerability to the disease. Researchers have already begun investigating the response of atmospheric chemistry to COVID-19 with both research papers and press releases documenting perturbations in observed pollutants. Both the timing and nature of restrictions affecting emissions and air quality have played out differently around the globe, and perturbations are expected to continue for some time. Can Working Groups help isolate these differences? How does the science of Activities relate?

Local understanding is needed to unravel the details driving the differences between business-as-usual and perturbed emissions. Regional Working Groups can provide perspectives that explain both the local policy decisions and societal responses to restrictions that are necessary to explain emissions changes. As an example, the African Group on Atmospheric Science (**ANGA**) has been active in research during the COVID-19 pandemic. This includes investigating the impact of COVID-19 measures on air quality in African cities, the application of AI in large data management, and developing air cleaning devices targeting small particles. In addition, members have been highlighting key issues for African air quality and environmental health during this time, such as the impact of indoor air quality and COVID-19 waste management in households (see **https://www.sei.org/perspectives/sei-works-with-kenyas-government-to-tackle-covid-19/** )

All of IGAC's activities offer a breadth of influence through their conferences, working groups, community networks, and inter-activity connections. Activities associated with emissions and air quality in particular stand out for their relevance to COVID-related outcomes for atmospheric chemistry. This includes facilitating research collaborations on COVID-related emissions impacts, rapid dissemination of this science, and linkages with other communities of practice, including health research, climate governance, and sustainability.

**GEIA** is steering the community in the development of emission inventories reflecting COVID-related perturbations for model implementation and testing. GEIA brings together experts on top-down emissions methods, which leverage satellite and in-situ observations to quantify emissions and their variability, and bottom-up inventory development, which quantifies the process-level understanding of emissions from a wide variety of sources.

**AMIGO** is positioned to lead in the use of multi-platform observations to infer emission changes and investigate their impacts. At this stage, the majority of papers and press coverage addressing COVID-19 and air quality have focused on changes detected by either satellite observations or ground monitoring. To stay abreast of this early information, AMIGO has established a website cataloging papers, press coverage, and other such information at **https://amigo.aeronomie.be/index.php/covid-19-publications**

**MAP-AQ**, through modelling efforts, has the potential to evaluate the sensitivity of air quality to emission changes and inform the benefit of more lasting changes that might be possible to implement.

**TOAR-II** has begun updating the ozone database, and early 2020 will be a period of intense study to understand ozone anomalies related to COVID-19. Responses in ozone can be particularly complicated given the nonlinear chemistry involved in its formation. This will be a long-term effort as the TOAR-II database will be finalized for research in 2023 with a review paper on COVID-19 as it relates to ozone expected shortly thereafter.

**DEBITS** will be looking for evidence of changes in deposition of biogeochemically important trace species, e.g. nitrogen and sulfur containing compounds. Such information promises to be insightful, since industrial operations (e.g. $SO_2$ from smelters) were halted in many regions and traffic (e.g. NOx emissions) was similarly affected.

COVID-19 will undoubtedly find its way into the discussions and analyses conducted by all of the IGAC Regional Working Groups and Activities as disruptions are still ongoing. The spread of the infection is not yet under control in many countries, and new spikes in coronavirus are expected while the world eagerly waits for the development of safe vaccination. Thus, there is still much to consider as the IGAC community works to further develop the information needed to support scientific analyses and understand how the related variations in human activity have affected atmospheric chemistry.

## Observational and Analytical Needs

Analysis of a wide variety of observations will be required to quantify the impacts of changed emissions due to the pandemic on air quality and atmospheric composition. In addition, observations are needed to derive accurate emissions inventories for this unique atmospheric experiment, including activity data for updating bottom-up emissions inventories and atmospheric observations for top-down derivation of emissions through inverse modeling. Model simulations will be needed to help quantify the causes of changes in air quality and must be evaluated with a broad range of observations of criteria pollutants (ozone, NOx, and $PM_{2.5}$) and their precursors (VOCs, CO, $SO_2$, BC). Secondary pollutants (ozone, aerosols) are particularly difficult to predict due to non-linear pollution regimes and significant uncertainty in precursor (NOx, VOC) emissions.

Observations with a long time record are particularly valuable to quantify the changes in atmospheric composition due to the changes in human activity during the pandemic as opposed to changes due to interannual variability in meteorological conditions. These include observations from satellites, ground-based in situ and remote sensing networks, and commercial aircraft.

Satellite observations of atmospheric composition provide global, long-term records of a number of critical parameters, which are critical for understanding the differences between 2020 and previous years. For example, TROPOMI provides high horizontal resolution for recent years of $NO_2$, HCHO, CO, $SO_2$, and $CH_4$, whereas OMI provides a longer time record for the same compounds but with coarser horizontal resolution. While different satellite instruments have different data availabilities and sensitivities to surface concentrations, many provide key information for analyzing the changes currently taking place. For example, MOPITT provides 20 years of CO retrievals sensitive to surface amounts. MODIS on Terra and Aqua also provides 20 years of aerosol optical depth (AOD). Satellite observations of $SO_2$ (e.g., from OMPS, OMI, and TROPOMI) and $NH_3$ (e.g., from IASI, CrIS) can also provide key insights during this period. **A website for visualizing satellite observations has been established by NASA, ESA and JAXA (https://eodashboard.org/).**

Long-term ground-based measurements are also key data sets for providing year-to-year variability as context for this year's observations. Networks such as the Network for the Detection of Atmospheric Composition Change (NDACC), the Total Carbon Column Observing Network (TCCON), Aeronet, and Pandora provide many years of remote sensing observations of trace gases, greenhouse gases, and aerosol optical depth. These networks also provide the necessary validation to link the satellite-based measurements to in-situ measurements at ground level. Ozonesondes launched routinely around the globe provide in-situ ozone profiles that can be used to track dynamic and chemical changes in the troposphere. Observations from commercial aircraft (IAGOS) also provide unique data sets in areas of the world lacking other data sets, particularly from the ascent and descent profiles, although this data set has been impacted due to the strong reduction in regular flights. The measurements close to airports will provide helpful information on the impact of reduced air traffic. Surface in-situ data from long-term networks are also key to understanding current composition changes, such as the NOAA Global Monitoring Laboratory (GML) network that provides gas phase and aerosol observations at generally remote locations around the world. Surface air quality monitoring networks in each country, as well as international collections of data such as the Global Atmosphere Watch (GAW) and OpenAQ provide key information on pollutant ($O_3$, $NO_2$, $PM_{2.5}$, $SO_2$, CO, visibility) levels at the source of changing emissions. The availability of coincident meteorology is key to sorting out year-to-year variability in these observations. Additional observations of speciated VOCs and aerosol composition can help greatly in attributing the changes in source emissions for different sectors (traffic, industry, residential). In a few places, there were opportunities for in-situ and aircraft sampling to measure ambient composition changes during reduced emissions periods, including, for example, by NOAA and a number of U.S. academic institutions. Conversely, many field campaigns were cancelled as a result of COVID-19 and the severe under-sampling of some regions of the globe in comparison to others remains a common challenge.

Atmospheric chemistry modeling, alongside analysis of observations, will help quantify the impacts of the changed emissions during 2020. Numerous efforts are underway to develop bottom-up emissions inventories based on actual activity data for traffic (e.g., from Google and Apple mobility data), power plants, industry, and home energy use. In addition, satellite observations are being used in inverse modeling to derive top-down emissions inventories.

The categories of observations listed here can be used to help understand the impacts on atmospheric composition brought about by the large changes to societal activities during COVID-19 restrictions. The wide variation in composition changes around the globe was a result of different changes in emissions as well as different starting points in emissions and coincident weather conditions. All of these factors need to be considered when estimating atmospheric responses to emissions reductions.

## Scientific Challenges

Reduction in the amounts of many air pollutants has been quite obvious in highly polluted city centers during the lockdown period. However, it is a challenging task to distinguish the contribution of interannual variability and changes in the meteorological conditions. The impact of emissions reductions is more difficult to quantify at remote sites, including in mountainous and marine regions as well as aloft in the free troposphere during the COVID-19 lockdown period. For this analysis, databases that have long records from several of the ground-based networks and space-based systems are important.

The observed changes in atmospheric composition have to be attributed to specific causes. Thus, it is important to identify which emission sectors changed in relation to the observed variations and resulting quantified impacts. It is expected that shutting down different emissions sources (e.g. road/air transportation, energy industries, construction, petrochemical) could have different patterns around the globe. It is also important to study the changes in atmospheric chemistry in environments with different precursor abundances. If emissions changes can be determined in sufficient detail, this offers an excellent sensitivity test of our models and their ability to capture the observed variability in atmospheric composition. In this regard, some of the scientific challenges and questions are:

- How is the non-linear ozone chemistry responding as NOx and VOCs emissions change in different parts of the world? How is the oxidizing capacity of the atmosphere changing?
- How have precursor changes affected the formation of secondary organic/inorganic aerosols?
- What about haze conditions? Was the level and frequency of haze consistently reduced globally? Is it possible that changed transport patterns and/or changed local emissions could have led to enhanced formation of secondary aerosols? For instance, Chang et al. (2020) have already reported a case of enhanced formation of secondary inorganic (mostly nitrate) aerosols.
- Are observed reductions in various trace species (e.g. CO, NOx, $CH_4$, VOCs, $SO_2$, $CO_2$, $PM_{2.5}$, $PM_{10}$, AOD) consistent with decreased anthropogenic activities?
- Did deposition change in response to reduced emissions? This is particularly important in regions where industries do not yet have strongly regulated SOx and NOx emissions.
- Has there been any change in incoming solar radiation due to the reduction in pollutants? Are there measurable changes in weather (e.g. clear weather, cloudiness, wet, dry, etc.) conditions during the lockdown period that can be associated with emissions changes? Previous studies have shown aerosol impacts on precipitation. Have there been any changes in outgoing radiation? Is there evidence of changes in photochemistry and/or nighttime chemistry?
- There have been various theories on the role of aerosols in the monsoon. The lockdowns in the South Asian region have been just at the beginning of the summer. Is there any impact of reduction in the levels of aerosols on the Asian summer-monsoon?
- How have remote oceanic regions responded? What changes have occurred in the outflow of emissions from land-masses to oceanic regions? Have there been any significant changes in ship movements and hence emissions?
- As a result of changes at the Earth's surface, are there any marked changes in composition in the free troposphere? What about changes in the upper troposphere and lower stratosphere ($O_3$, NOy, $SO_2$) from reduced air traffic?
- It should be noted that power plants and heavy industries (e.g., petrochemical refineries) were not fully shut down in many countries. Events of agricultural residue burning also did not stop. Therefore, in this new scenario, how have emission patterns been altered, and how does this influence atmospheric chemistry?
- It is also important to assess changes in indoor air quality as population exposure will be increasingly driven by exposure inside during major lockdown periods due to shutdown of markets/restaurants and very limited travel.
- Are current air quality and atmospheric chemistry models adequate to reproduce observed changes and quantify emissions changes through inverse modeling?

#### Reference

Chang, Y., et al. (2020). Puzzling haze events in China during the coronavirus (COVID-19) shutdown. *Geophysical Research Letters, 47,* https://doi.org/10.1029/2020GL088533.

## Disruptions to Science

Perhaps the hardest part of the lifestyle changes we have faced during the COVID-19 pandemic has been the loss of direct social contact. The importance of this cannot be underestimated and was one of the primary reasons for postponing the 2020 IGAC Conference in Manchester for a full year. While our opportunities to gather are already limited by the distances we must cross, the time we spend together at the biennial IGAC meetings plays a critical role in the elements of our mission related to fostering community and building capacity. In the meantime, we have learned to get by with virtual meetings, and many would say that we have become more proficient in such interactions during this time. Screenshots of online meetings with mosaics of faces on webcams have replaced group photos from conferences. In some ways, formal interactions have increased through virtual avenues, but the intangible benefits of informal communication have suffered.

Beyond the social disruptions, shifts to telework, travel restrictions, and economic impacts have disrupted our community's participation in scientific activities in a number of ways. Access to facilities like laboratories, offices, and field sites was restricted for weeks or months, and in many countries this situation is ongoing. Several field campaigns, which often involved years of planning, have had to be cancelled or postponed. From this we can expect a domino effect on future campaigns for several years into the future. While many of us have shifted to working from home, this new reality has significantly disrupted in-person training of students and postdoctoral fellows. The pandemic has also severely restricted mobility of researchers, especially across borders.

While many of these challenges have been experienced across the world, they are also distributed unevenly. Disruptions to research progress are felt most acutely by early career researchers, or those at transitional stages in their careers. People with additional caregiving responsibilities may have significantly less time to devote to their professional commitments and experience more significant losses in research productivity. Given the major demands that the pandemic places on our economies, the extent to which countries can or will continue to prioritize funding for scientific research, and atmospheric chemistry specifically, will partly depend on their development status. IGAC recognizes the inequitable distribution of obstacles that has and will result from the pandemic and remains committed to building collaborations and fostering a community that is as diverse and inclusive as possible.

Our community has also responded by adapting to our new circumstances in a variety of ways. Many researchers have taken the opportunity to unearth neglected datasets, sometimes in combination with learning some new data analysis skills. This interruption provides the opportunity to reflect on just how much we could still learn by exploiting existing observations rather than making new measurements. When ambient measurements have been possible, unique data are being collected during lockdown periods, laying the foundation for novel understanding of emissions and chemistry. The importance of autonomous measurements has been emphasized, and many researchers are now adapting instruments to operate without our intervention. The explosion of online seminars and conference sessions has highlighted the possibility for reducing travel and its associated carbon footprint. Virtual conference participation (often at reduced costs) also allows for partial participation in meetings of adjacent fields, possibly opening the door to future interdisciplinary collaborations. As we move beyond COVID-19, it will be important to take lessons from these virtual interactions to develop a better balance with in-person events rather than a complete return to our traditional ways of interacting.

For a great example of making the most of the pandemic's disruption to regularly scheduled research, you may enjoy reading about the experience of researchers on the 3rd leg of **MOSAiC** (Multidisciplinary drifting Observatory for the Study of Arctic Climate), from Markus Frey, who got to spend an extra two months in the field. The story is highlighted in the July 2020 CATCH newsletter at **https://us14.campaign-archive.com/?u=12fd9195ec126c3cec6bd1f10&id=bc27f9064d**

## Interdisciplinary Connections

The IGAC community has over the years advanced the science of atmospheric chemistry to enable the monitoring and modelling of gas and particle-phase composition over a wide range of scales, accounting for emissions, transport, chemical and physical transformations, and loss processes over space and time. This allows the IGAC community to assess sectoral emissions and their changing impacts from local to global scales. Our progress as a community continues to rely on improving process-level understanding and the numerical simulation of these processes at various scales with increasing precision enhanced by assimilation of available data.

With global attention focused on the pandemic, how do these efforts connect to the current health crisis?

With our understanding of sectoral emissions and how


**A CNRS-IRCELYON team testing patients to develop an on-line testing of COVID-19** (Photo: Matthieu Riva)

they relate to socio-economic activity, our community could have a lead contribution in promoting possible low-emission development pathways to build back better. May this happen! Immediate attention can also be given to the impact of the global lockdown on emissions changes (see above for specific IGAC activities) with possible consequences for human health, crop productivity and climate.

In addition to these more obvious pursuits, atmospheric chemists have applied their skills to understanding the spread of the virus, especially when it comes to the role of aerosols. Face masks were initially missing in many locations, and local industries focused on increased production of masks. Efficacy of different mask material and designs were tested using instrumentation and know-how developed within our community. This effort turned out to be important in both recommending best practices for mask use and explaining their benefit.

In fact, atmospheric scientists have played a direct and important role during this health crisis by triggering a paradigm change on how airborne transmission of COVID-19 may take place. Initially, airborne transmission beyond a distance of one meter was assumed by the World Health Organization (WHO) to be of low significance. For those who understand how particles actually do travel in the air, this assumption seems naive and ill-informed. As a result, the community of atmospheric scientists has appealed to the medical community and relevant national and international bodies to recognize the potential for airborne spread of COVID-19 (e.g., *Morawska et al.*, 2020). It has been demonstrated beyond any reasonable doubt that viruses are released during exhalation, talking, and coughing in microdroplets small enough to remain aloft in air and pose a risk of exposure at distances beyond 1 to 2 m from an infected individual. For example, at typical indoor air velocities, a 5-µm droplet will travel tens of meters, much greater than the scale of a typical room, while settling from a height of 1.5 m to the floor. This poses the risk that people sharing such environments can potentially inhale these viruses, resulting in infection and disease. This group of scientists successfully advocated for the use of preventive measures to mitigate this route of airborne transmission.

These efforts have provided the confirmation needed to emphasize and expand the use of face masks. WHO changed its statement, indeed encouraging face masking globally, and highlighting the risk of airborne transmission such that indoor and now even outdoor regulations have been set in many countries. This highlights the necessity that sound science is essential in decision-making for the current pandemic and for future public health crises.

The analytical skills developed within the IGAC community have also been applied to the development of new COVID-19 testing methods. Indeed, beside needed protective measures, a key aspect for controlling the pandemic is the rapid deployment of reliable tests wherever needed. Several groups applied their VOC measurement capabilities to understand whether tracers of the virus can be detected in exhaled air from infected patients. Unlike the standard but uncomfortable PCR (polymerase chain reaction) tests, breath analysis is not invasive and can provide an immediate result. Thus, mapping the chemical tracers of COVID-19 in exhaled air can be used to detect the sickness. With quick tests like this one, patients could be rapidly identified and moved to the right area of the hospital. This research is still ongoing and the chemical tracers are expected to be identified in coming weeks or months.

Epidemiological studies are also providing evidence for a link between air quality and the severity of COVID-19 impacts on health and morbidity. These studies rely on the quality of long-term air quality exposure data to enable better elucidation of pre-dispositions associated with not only pollution exposure, but also with links to socio-economic status (i.e. poverty), gender, and other factors.

The IGAC community must continue to contribute its expertise to understanding the impacts and identifying positive responses to the current and future pandemics. Stronger ties to the health science community will result from our efforts to highlight the importance of airborne transmission of COVID-19 over longer distances. This work has had the positive impact of reinforcing protective measures and has initiated research into new online diagnostic approaches that may be useful during eventual new pandemics. This latter point highlights how going beyond traditional classification of sciences can lead to real progress for the benefit of our society. Bridging different fields of science could be one of the new targets of IGAC.

**Reference**

Morawska, L., D. K. Milton and 239 signatories (2020). It is Time to Address Airborne Transmission of COVID-19, *Clinical Infectious Diseases*, **https://doi.org/10.1093/cid/ciaa939**

## Communicating with Society

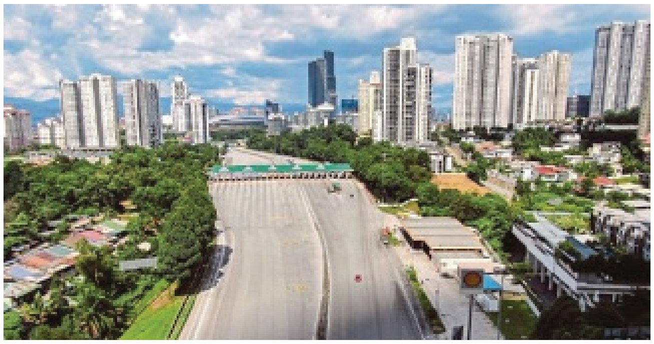
Along with the lockdowns and activity changes associated with COVID-19, responses in air quality have become newsworthy. While evidence from satellites and ground monitoring have been cited, perhaps the most compelling stories have been those addressing what people have experienced themselves as they have perceived changes in the environment around them. For instance, the beautiful Himalayan mountains revealed their vivid beauty again after being hidden behind the veil of heavy smog for decades (*Picheta*, CNN). While changes are being detected and studied around the globe, the more polluted locations have experienced more drastic and visible changes in air quality resulting from reduced anthropogenic emissions.

The MANGO working group (Monsoon Asian and Oceania Networking group) represents several countries combatting serious issues of air pollution that have witnessed astonishing changes in air quality during the pandemic. During their recent online meeting, MANGO members shared data and images related to these changes. Metro Manila in the Philippines, usually filled with concentrated soot, offers again for the first time in many years the skyline of mountains east of the city (Photo 1). Kalang Valley, Malaysia, proudly presents herself as one of the beautiful modern cities of the world, with blue sky and abundant clouds as the backdrop (Photo 2). The reduction of pollutants during the pandemic allows snapshots that appear like professionally made postcards. These examples can be used to highlight the importance and challenges of balancing anthropogenic activities with sustaining a healthy atmospheric environment. Knowing that both are important to quality of life, these temporary changes can help foster a dialogue on how we can achieve a better balance.

Improved air quality is complex and is not always simply explained by decreasing anthropogenic emissions. This is demonstrated by observations from other countries such as Indonesia and Vietnam. The rainy season during the period of COVID-19 in Jakarta, Indonesia, for example, washed away airborne pollutants, masking the potential observable effects of reduced anthropogenic emissions. Such conditions serve as a reminder that meteorological impacts have to be considered to provide objective understanding of varied air quality outcomes. The important influence of meteorological effects is also apparent in the observations of air quality on the east coast of China.

Vietnam's case offers one of the most interesting examples reflecting human behavior and enforcement of regulation. The initial period of the COVID-19 control measures indeed rendered an abrupt decrease in $PM_{2.5}$ concentrations concurrent with empty streets and few people outdoors due to fear of the coronavirus transmission. However, after a short time (about a week), traffic was back to normal levels, despite the requirement of staying-at-home stipulated by the government, yielding limited improvement in overall air quality.

In northern China, severe haze was actually reported in association with decreased NOx emissions, owing to both increased ozone and oxidation rates as well as high humidity and stagnant meteorology leading to faster heterogeneous production of secondary aerosol (*Le et al.*, 2020, Science). This example highlights the difficulty of explaining complex outcomes to the public, such as the nonlinear kinetics of ozone-NOx-VOC chemistry and the need for coordinated control of VOCs and NOx to



**Cleared sky in Manila, Philippines**
(Photo courtesy of Lau Jamero & Maria Obiminda Cambaliza)

effectively reduce ground-level ozone and oxidants.

Impacts of pandemic lockdowns and activity restrictions on the ambient environment continue to raise the interest of journalists, who have a keen sensitivity of what the public would like to be informed about. Some of IGAC's members have been on the front lines of engagement, being interviewed for various questions related to air quality and broadcasted through TV, newspapers, etc. (Photo 3). Others have received inquiries through phone calls, emails, etc. to gather technical advice. This shows that IGAC as a scientific community is close to the public in many countries, giving back to individual local communities.

## Beyond atmospheric sciences & technology

In the midst of the refreshed appreciation of clear skies and unveiled beauty such as the amazing silhouette of the Himalayas, COVID-19 will be more often and appropriately associated with negative impacts. Continuing to acknowledge the toll on health and mortality upfront will be essential if we hope to draw attention to the silver lining of air quality improvements and the lessons we can extract from the emissions changes that have occurred and will continue for some time into the future. For instance, the word "Hotspots" now carries an additional meaning, not only referring to burning sources emitting airborne pollutants, but also the locations containing highly infectious COVID-19 cases. In addition to caring for infected individuals and families, sustaining health-care systems to cope with escalated infection cases arises as one of the top priorities of various governments. Deaccelerating the spread of COVID-19 imposes a forceful brake on economic globalization with propagated influences. Closing border gates halts international trade, limited movement of goods magnifies the needs of being domestically self-sustaining, and paused factory manufacturing increases jobless rates. There have also been shortages of what seem to be necessities, such as clothes in some countries, due to manufacturing being done internationally instead of locally. A suddenly enlarged empty space in airports echoes great disruptions to air travel. Along with the costs of shutting down industries are the budget demands of turning production back on, which can be an unexpected toll to many companies.

Soft quarantine, i.e., staying at home, is required of the general public in many countries. Some places enforce such measures with fines. Masks are on, outdoor activities are down, and few people are seen in our cities. Having a haircut becomes a challenging task to be arranged and achieved. In contrast to empty shopping malls are the long queues in grocery stores. Worries of lacking daily necessities trigger panicked reactions that empty



**City street of Kalang Valley, Malaysia** (Photo courtesy of Mohd Talib Latif)


**Prof. Abdus Salam talks to the media about COVID-19 and air quality.**

store shelves. The soaring e-commerce business educates shoppers with a new expectation, a note indicating “delayed shipment”. This is a time to learn patience and to creatively work around these “delays”.

A lifestyle focusing on basic needs can become simpler than before. However, non-material-based issues can form greater challenges for some. Counsellors are busier than ever, advising how to adapt to daily activities in new forms: how to work from home while maintaining proper boundaries from family-related interferences; how to home-school children; how to develop new daily or weekly routines; how to relax, exercise and work in the same environment; how to prepare for proper e-communication; how to maintain one’s mental health and wellbeing, etc. Cooking and baking more at home have also boosted requests to nutritionists on healthy diets. Almost all components of life have inspired keen searches for new practices, “genius” ideas and creative tips, and answers often spring from internet searches. This also suggests that continual learning and adjustment are key principles to embracing all the inevitable changes arising from this crisis. Often new processes and new norms can bring satisfaction. In fact, sociologists tell us that despite all the challenges associated with the pandemic, a brighter side of humanity is showing itself, through more generous and transparent sharing, more compassion and understanding, etc. There is comfort and encouragement in the midst of the difficulties.

IGAC is mindful that atmospheric chemistry and air quality hold a few pieces of the entire puzzle that are intertwined with other impacts of COVID-19. Many IGAC researchers have been confronted with new challenges, such as conversion of in-person lecturing to online teaching and the possibility to obtain unique data during the lockdown periods with less anthropogenic emissions. IGAC believes that our community can learn beyond the atmospheric sciences and emerge from the pandemic and move forward with renewed perspectives.

Effectively communicating with society about COVID-19 and air quality will require us to share our common personal experiences as well as to translate our professional understanding. Share your experiences of how the pandemic has inspired you with non-technical insights that practically contribute to your scientific work with our entire community. Let us know by sending your stories to **info@igacproject.org** IGAC

**References**

Rob Picheta, April 09, 2020, CNN travel, People in India can see the Himalayas for the first time in ‘decades,’ as the lockdown eases air pollution, **https://edition.cnn.com/travel/article/himalayas-visible-lockdown-india-scli-intl/index.html**

Tianhao Le, Yuan Wang, Lang Liu, Jiani Yang, Yuk L. Yung, Guohui Li, John H. Seinfeld (2020). “Unexpected air pollution with marked emission reductions during the COVID-19 outbreak in China” *Science*, **https://doi.org/10.1126/science.abb7431**

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**BACKGROUND**

The Aerosols-Clouds-Precipitation-and-Climate (ACPC) initiative, which aims to better a scientific understanding of the interactions between aerosols, clouds, precipitation, and climate, is an IGAC Endorsed Activity. IGAC was proud to help host the 2020 ACPC Workshop virtually.

# Aerosols-Clouds-Precipitation and Climate (ACPC) Workshop

The sixth ACPC annual meeting was held as a virtual meeting on 23 – 24 April 2020, to discuss progress towards understanding the role of aerosol perturbations on clouds and precipitation. The meeting was originally planned to be held in Houston, Texas, USA, but due to the COVID-19 pandemic, it was held online instead. In recent years, ACPC has focused on two cloud regimes, shallow marine clouds and deep convective clouds. This year's meeting focused on research advancements on aerosol's influences on both cloud types, and updated roadmaps for research within the shallow and deep clouds working groups.

For shallow clouds, the focus has now shifted primarily to the analysis and modeling of cloud response to distinct aerosol perturbations that occur naturally, such as volcanic eruption, or are inadvertently caused by human activities, such as ship emissions, emission reduction from the COVID-19 pandemic or long-term emission control measures. Lagrangian approaches were shown to be valuable for examining cloud response to aerosol perturbation from ship and volcanic emissions in both satellite observation and models (Christensen et al. 2020). Shipping corridors were found to be useful for identifying regional scale impact of aerosol perturbation on clouds (Diamond et al., 2020), and the effects of aerosol perturbation can be dependent on background droplet number concentration. The long-term declining trend in aerosol loading over major industrial regions together with the synergetic observations of cloud and radiative properties was shown to be another way to study cloud and radiative response to aerosol perturbation and to further evaluate and constrain climate models (Bai et al., 2020). Spatial and temporal scales involved in these natural laboratories can be an important consideration in studying different aspects of cloud response to aerosol perturbation (Toll et al., 2019). The potential large-scale impact of the reduction in shipping emissions due to recent shipping fuel regulations on cloud and radiative fluxes were examined based on climate model results. A special session was dedicated to preliminary results of the potential impact of the emission reduction from the COVID-19 pandemic. It was recognized that, while pollution emission reduction was evident in many parts of the world, the effects on clouds and radiative forcing requires additional research, and isolating the meteorological impact could be critical to examine the effects on clouds and radiation for this relative short-term perturbation due to the COVID-19 pandemic. The shallow cloud group planned to synthesize and review work on natural laboratories for aerosol-cloud interactions, including comparison

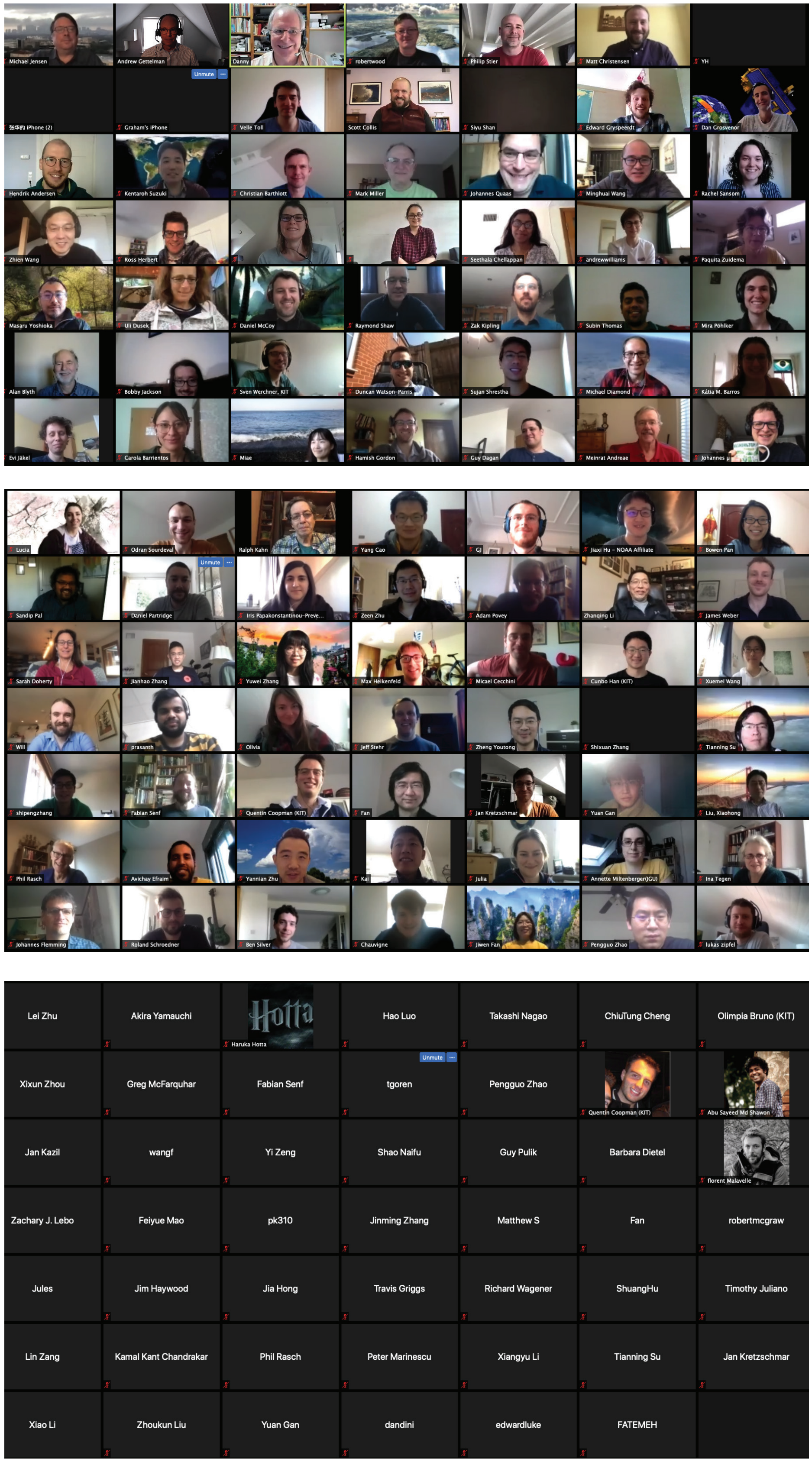

**Fig. 1. The planned TRACER campaign in the Houston area during summer 2021. A deployment of ASR Mobile Facility, radars and research aircraft, for research of aerosol and urban effects on deep tropical convective clouds in the background of the marine Gulf air mass.**

of different natural laboratories, different cloud regimes, and on different types of cloud perturbation and radiative fluxes, etc.

Another theme of the shallow cloud group is to examine aerosol-cloud interactions using satellite retrieved cloud condensation nuclei (CCN) (Rosenfeld et al., 2019). This is further used for a process-level understanding of aerosol-cloud interactions in climate models. For two cloud microphysics schemes examined in a regional climate model WRF-Chem, it was found that the conversion rate of cloud water to rain is overestimated at lower cloud droplet effective radius and this conversion is found to be less sensitive to cloud droplet number concentration in models than in satellite and aircraft observations.

For deep clouds, ACPC efforts are divided between simulations and observations of aerosols and clouds near the Houston area. The workshop reported the recent progress in both aspects and discussed the roadmap for deep cloud group activities. The deep cloud group focused on an extensive model intercomparison of convective clouds over Houston with different models and microphysical schemes. It showed similarities in the sign of the aerosol effects on rainfall accumulation, cloud water mass, low-level vertical velocity, and anvil characteristics. However, despite large aerosol effects indicated in most of the models, the differences among models were much larger than the differences between runs with "clean" and "polluted" aerosol conditions within a given scheme (Heever et al., 2020; Marinescu et al., 2020). A more constrained comparison between a two-moment bulk and a bin scheme using the same model WRF-Chem showed the saturation adjustment approach used for parameterizing droplet diffusional growth in the bulk scheme is mainly responsible for the much smaller aerosol effects compared with the bin scheme (Zhang et al. 2020). Those model studies suggest that much additional work is needed to improve the underlying physics representation before a satisfactory model for quantification of aerosol-convection interactions is available. This situation underlines the importance of observational studies that would constrain the simulations. Analysis of radar cell tracking over the Houston region indicates an increase in observed radar echo top height and lightning flash count with increasing cloud condensation nuclei. Such studies need to be done in ways that would isolate more clearly the aerosol from meteorological and urban effects on the clouds. This will be hopefully achieved by the upcoming Tracking Aerosol Convection Interaction Experiment (TRACER) supported by the Department of Energy Atmospheric Radiation Measurements (**https://www.arm.gov/research/campaigns/amf2021tracer**), which was conceived based on the ACPC activities. The field campaign will provide ample data to understand convective cell properties and their interactions with associated environmental conditions including aerosols and evaluate model performances. A deployment of the ARM Mobile Facility is planned in Houston for 15 April 2021 to 15 April 2022, with an intensive observational period during June-September 2021 (Fig. 1). TRACER will include multiple radars and aerosol measurements in the polluted urban and clean background air masses. Participation of research aircraft and mobile surface measuring platforms is also planned.

Attendants of the ACPC workshop



In addition, the workshop included talks with a focus on the planetary boundary layer (PBL) properties and how aerosols and urban land from Houston can influence these PBL conditions and then impact convective cloud activities (e.g., Fan et al., 2020). We had a dedicated session for the proposals considered or being considered to support or complement TRACER from various aspects such as aerosols, the planetary boundary layer, clouds, and precipitation.

While it is unfortunate that this year's ACPC meeting was held virtually due to the COVID19 pandemic, the virtual meeting provided great opportunities for ACPC to reach a broader audience. More than 200 participants registered for the virtual meeting from around the world, compared with around 60 participants for a physical attendance meeting. While opportunities for informal and external meetings typical of in person meetings were not possible during the virtual meeting, the chat feature allows participants to post comments and questions anytime they want, which helped to facilitate the discussion and interactions among participants. Given that the virtual meeting was a great success and allowed more people to participate, ACPC has decided to include a virtual component for future meetings. ACPC has also decided to draft a set of bylaws to govern the rotation of its leadership, including co-chairs and members of its scientific steering committee (SSC). ACPC will release a call for nominations and self-nominations of new SSC members this fall. The next ACPC meeting is planned for April 2021.

**References**

Bai, H., Wang, M., Zhang, Z., & Liu, Y. (2020). Synergetic Satellite Trend Analysis of Aerosol and Warm Cloud Properties ver Ocean and Its Implication for Aerosol-Cloud Interactions. *Journal of Geophysical Research: Atmospheres, 125(6)*. doi:10.1029/2019jd031598.

Christensen, M W., W. K. Jones and P. Stier (2020), Aerosols enhance cloud lifetime and brightness along the stratus-to-cumulus transition, *PNAS, 117* (30) 17591-17598; DOI:10.1073/pnas.1921231117.

Diamond, M. S., Director, H. M., Eastman, R., Possner, A., & Wood, R. (2020). Substantial Cloud Brightening from Shipping in Subtropical Low Clouds. *AGU Advances, 1*, e2019AV000111. **https://doi.org/10.1029/2019AV000111.**

Fan, J., Zhang, Y., Li, Z., Hu, J., and Rosenfeld, D.: Urbanization-induced land and aerosol impacts on sea breeze circulation and convective precipitation, *Atmos. Chem. Phys. Discuss.*, **https://doi.org/10.5194/acp-2020-411**, in review, 2020.

Marinescu, P. J., Susan C. van den Heever, Max Heikenfeld, Andrew I. Barrett, Christian Barthlott, Corinna Hoose, Jiwen Fan, Ann M. Fridlind, Toshihisa Matsui, Annette K. Miltenberger, Philip Stier, Benoit Vie, Bethan A. White, Yuwei Zhang, 2020, Impacts of Varying Concentrations of Cloud Condensation Nuclei On Deep Convective Cloud Updrafts – A Multimodel Assessment, *Journal of Atmospheric Sciences*, in review.

Rosenfeld, D., Y. Zhu, M. Wang, Y. Zheng, T. Goren, and S. Yu (2019), Aerosol-driven droplet concentrations dominate coverage and water of oceanic low-level clouds, *Science, 363*, doi:10.1126/science.aav0566.

van den Heever, S.C., P.J. Marinescu, M. Heikenfeld, B. White, P. Stier, M. Andreae, A. Barrett, C. Barthlott, J. Fan, A. Fridlind, C. Hoose, T. Matsui, A. Miltenberger, J. Quaas, D. Rosenfeld, J. Shpund, B. Vie, and Y. Zhang, 2020: A multimodel assessment of aerosol impacts on deep convective clouds systems. In preparation.

Toll, V., Christensen, M., Quaas, J. & Bellouin, N (2019), Weak average liquid-cloud-water response to anthropogenic aerosols, *Nature, 572*, 51–55.

Zhang, Y., Fan, J., Li, Z., and Rosenfeld, D.: Impacts of Cloud Microphysics Parameterizations on Simulated Aerosol–Cloud-Interactions for Deep Convective Clouds over Houston, *Atmos. Chem. Phys. Discuss.*, **https://doi.org/10.5194/acp-2020-372**, in review, 2020.

**JUNE 2020**

**VIRTUAL CONFERENCE, HOSTED BY THE UNIVERSITY OF CHILE**

*IGAC Sponsored*

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## 19th GEIA Conference

# The Global Emissions Initiative and Accelerating Social Transformations

IGAC's Global Emissions InitiAtive (GEIA) organizes an international conference, generally every two years, where members of the large GEIA network share their work, experience, and new ideas with their colleagues from all over the world. These discussions are organized around the main goals of GEIA: (1) promoting broad and consistent access to global and regional emissions data; (2) improving the scientific basis of emissions information by enhancing analysis of emissions processes; and (3) strengthening the global community of emissions stakeholders.

The 19th GEIA conference was first planned to take place in November 2019 in Santiago, Chile, with the title "The Global Emissions Initiative and Accelerating Social Transformations". Due to civil protests in Chile during the fall of 2020, the conference was rescheduled to April 2020 in Santiago. The COVID-19 pandemic forced the GEIA community to replace the in-person conference with a virtual conference. The virtual conference turned out to be a success. It was attended by more than 230 scientists representing 39 countries. The conference was adapted to an on-line format in the following way:

– During the first two weeks of June 2020, participants were invited to submit their presentations in the form of slides, posters and, if desired, videos of the scientists presenting their work. A detailed tutorial to record these videos was provided. All the online material (more than 120 presentations) was made available to the registered participants on the conference website at: **http://www.geia2019.cl**. Registered participants could also submit questions to presenters via an online chat system developed as part of the conference web site. This allowed participants to get acquainted with the materials before the actual on-line summary event.

– An on-line conference summary event was held on June 23rd, 2020. This event was designed to share reflections of the scientific materials that had been compiled in preparation for the conference. During this two-hour webinar, summaries with highlights of each conference theme were presented by the GEIA Scientific Steering Committee (SSC) members.

During the summaries, the webinar participants were able to post questions and messages via the online chat system. At the end of each theme summary, and after having addressed the main questions obtained in the different chat systems, an audience poll was broadcast in order to gather the views of the participants on new directions for the future.

– The on-line event was organized using the GoToWebinar platform, with excellent support from the Computing & Networking Resources group of the NOAA Chemical Sciences Laboratory in Boulder, Colorado, USA.

The conference was organized around four scientific themes:

## THEME 1: Natural Sources, Fires, Dust and Agriculture

There were 32 presentations in this theme and they provided a wide overview of natural sources, focusing on dust, land-use changes, soils, vegetation, oceans and volcanoes. More than 19 new emission inventories were presented.

- Measurements of emission factors of several types of chemical compounds including atmospheric pollutants, greenhouse gases and harmful compounds (e.g. furans) from crop residue and waste burning were presented.
- The uncertainties in biomass burning inventory emissions and their long-term changes due to changes in relative humidity and drought severity were shown. Wood combustion was also discussed, and the importance of condensable organics in wood combustion was mentioned.
- Several presentations highlighted the complexity of nitrogen from natural and agricultural soils, and showed the importance of soil properties, details of land spreading of manure and fertilizer applications, and information on crop and cattle distributions for accurate quantification of emissions.
- Natural and anthropogenic dust emissions were studied, and new measurements of emission factors and emission datasets were presented.
- Studies of the emissions of biogenic volatile organic compounds (BVOCs) showed the impact of using different land cover datasets and meteorological fields on the magnitude and spatial distribution of the emissions. Estimates of the impact of urban greening on BVOCs emissions and on pollutants were discussed.
- Several presentations given in this theme highlighted the use of remote sensing for the development of emission datasets.
- The discussions in the session were followed by a poll, which showed that a majority of participants are interested in further studies on the breakdown of emissions into greater detail by source. Many participants also indicated their interest in developing and using emission datasets at higher resolution, with more studies on the different land cover datasets, and using new techniques for inventory development.

## THEME 2: Top-down Emissions & Satellite Analyses

The 28 presentations in this theme focused on the improvement of methodologies to derive emissions, the use of remote sensing data for the quantification of emissions from fires, oil and gas extraction, and point sources, and emissions gridding.

- The presentations included studies at the global and regional scales using satellite observations from TROPOMI, OMI, CrIS, MOPITT, MODIS, and VIIRS, among other instruments. Improvements of NOx and BC emissions using TROPOMI and VIIRS observations, both in the magnitude of the emissions and their location, including for point sources, were discussed.
- Using TROPOMI, the impacts of the COVID-19 pandemic and the associated lockdowns on surface emissions were evaluated.
- As also discussed in Theme 1, ammonia emissions are difficult to quantify accurately. It was shown that the use of ammonia observations by IASI and CrIS allow a better quantification of these emissions, particularly in regions where no other data are available.
- The MOPITT instrument, which has been operating for two decades, was used to better quantify the trends in the CO emissions from anthropogenic, biomass burning, and natural sources.
- Progress has also been made on inverse techniques in which the emissions of multiple species can be optimized at the same time. An example was shown for CO2 and $CH_4$, using satellite, ground-based, and aircraft observations.
- New global inventories based on updated determinations of the emission factors and with better spatial and temporal resolutions were also presented in this session.

- The poll following the summary and the questions/answers from the chat indicated that a large number of the participants are interested in the use of satellite observations to constrain emissions in regions where bottom-up inventories are non-existent or not very reliable. The audience was also interested in seeing best practices defined to explore the full potential of satellite information to improve the spatial and temporal distribution of emissions.

## THEME 3: Development of Integrated Inventories & Evaluation of Air Quality Models

There were 32 presentations in this theme related to four emergent topics: the new information now available from Latin America, South Asia and Africa; the characterization of uncertainties; the challenges in improving inventories; and the use of information across scales.

- National inventories covering multiple sectors are now available for countries such as Argentina, Brazil, Colombia, Chile, Cuba, India and Mexico. Local inventories were also discussed for cities in Brazil, Ivory Coast and South Africa. Such new data will be very helpful for air quality studies and for defining mitigation policies.
- Regional and global inventories were assessed for different regions, with detailed sector-specific disaggregation. The evaluation of inventory uncertainties is always challenging since spatially and temporally resolved emissions require more data, and the spatial/temporal allocation methods themselves introduce uncertainties. The comparisons of inventory to atmospheric observations require the use of chemical-transport models that have their own uncertainties.
- The presentations highlighted several issues discussed in many past GEIA conferences, such as measurements of emission factors from road transportation, resuspension of particles from unpaved roads, the speciation of anthropogenic VOCs, and the downscaling of emissions both in time and space. Discussions demonstrated two main approaches: a bottom-up method with very detailed measurements of emission factors and activity levels, and a down-scaling approach starting with emission estimates at coarse scales combined with a disaggregation to finer scales using local information.
- The results of the poll after the theme summary and questions showed great interest in the questions “how do we facilitate information flow between the global and local scales” and “how do we facilitate and guide the use of uncertainty information between models and inventories”.

## THEME 4: Climate Change & Air Quality Assessments

With 32 presentations, this theme discussed the current understanding of local emissions and air quality, the assessments of regional and global emissions, the links between air quality and climate, and the use of remote sensing to evaluate inventories.

- Studies of the emissions in megacities and the role of different sources were shown, focusing on species such as PM, PAHs, and VOCs, including VOC emissions from product use.
- The impact of wood burning on residential emissions and air quality in cities and regions was also studied.
- A new dataset providing the emissions of engineered nanomaterials was proposed.
- Health impacts from air pollution at the urban/local and regional scales were discussed.
- Global inventories, assessments and tools were shown to be useful for policy and validation, and it was noted that further improvements are needed for sharing the results and inputs.
- The participants voted in the post-theme poll for more studies on emerging sources in local and urban pollution, from transportation and residential activities, as well as from small-scale industries, fugitive dust, waste and agriculture. More studies on emission inventories and scenarios, as well as the communication of these studies to policy communities, were also suggested.

Moving forward, GEIA is committed to enhancing understanding of what we are learning from the dramatic change in emissions during the global pandemic and how we as the GEIA community can better communicate our understanding to decision makers.

The conference ended with recognition of Leonor Tarrason (NILU, Kjeller, Norway), who has stepped down as GEIA co-chair after serving for more than 8 years. The conference also introduced the new GEIA Co-chair, Cathy Liousse (Laboratoire d’Aerologie, Toulouse, France), along with five new members of the GEIA Scientific Steering Committee: Monica Crippa (Joint Research Center, Ispra, Italy), Marc Guevara (Barcelona Supercomputing Center, Barcelona, Spain), Sekou Keita (University Peleforo Gon Coulibaly, Korhogo, Ivory Coast), Brian McDonald (NOAA Chemical Sciences Laboratory, Boulder, USA), and Katerina Sindelarova (Charles University, Prague, Czech Republic).

The entire online summary event was recorded and is available publicly at: **https://youtu.be/dCa7PrMaO8k**

This 19th Conference demonstrated that GEIA has been able to gather a vibrant community despite the current challenges to organize a virtual conference with participants from all over the world. GEIA is particularly grateful to our Santiago team (University of Chile and **www.4iD.science**) for their stellar organization. The next in-person meeting is scheduled in September 2022 at the Belgian Royal Academy of Sciences, Letters and Fine Arts of Belgium where the GEIA community has been invited by the Royal Belgian Institute for Space Aeronomy.

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