

Greenhouse Gas Emissions Information for Decision Making: A Framework Going Forward

Dissemination Meeting: U.S. Urban Greenhouse
Gas Emissions Information Needs

May 1st, 2023

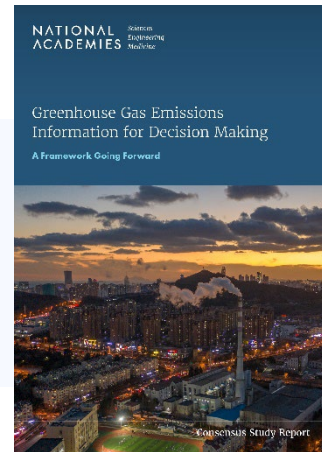
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Greenhouse Gas Emissions Information for Decision Making *A Framework Going Forward*

Dissemination Meeting:

US Urban Greenhouse Gas Emissions Information Needs



MAY 1, 2023 | All Times EDT

Purpose

- Disseminate recommendations from recent Academies' report, [*Greenhouse Gas Emissions Information for Decision Making: A Framework Going Forward \(2022\)*](#)
- Understand approaches for quantifying urban greenhouse gas (GHG) emissions
- Engage local stakeholders to better understand US urban GHG emissions information needs
- Discuss existing or potential assets and tools in the public, private, and research sectors at urban scales to aid local decision making in the US

11:00–11:05 Welcome and Meeting Goals

Don Wuebbles, University of Illinois, Committee Chair

11:05–11:30 Overview of Report: Greenhouse Gas Emissions Information for Decision Making

Kevin Gurney, Northern Arizona University, Committee Member

Brief overview of report with focus on recommendations relevant to urban scales

11:30–12:30 Approaches for quantifying and reporting urban GHG emissions

Moderator: Don Wuebbles, University of Illinois, Committee Chair

10 minute presentations + 30 min Q&A/discussion

- Ivonne Albarus, Laboratoire des Sciences du Climat et de l'Environnement
- Ron Cohen, UC Berkeley
- Kim Mueller, NIST

Prompting and discussion questions

- What approach and tools does your program or research use to quantify and report urban GHG emissions?
- How do approaches at the urban scale complement, interface with, and/or differentiate from global/national scale reporting requirements?
- How could the tools and methods used in your work be applied more broadly to other US cities?
- What are the challenges to applying these approaches to urban areas with less data, modeling, or quantification capacity?
- What types of GHG information have proven most useful to decision makers?

12:30–1:00 BREAK

1:00–1:45 US urban stakeholder information needs for decision making

Moderators: Annmarie Eldering, NIST, Committee Member

Brief intros + all moderated discussion

- Philip Fine, Bay Area Air Quality Management District
- Robert Stupka, Head of Climate Action Implementation for North America, C40
- Michael Burger, Columbia University
- Michael Ogletree, Air Pollution Control Division, State of Colorado

Discussion questions

- For decision making, you need more information than just an emissions estimate. What are your key information needs? At what spatial and temporal scales do you need this information?
- How well are you able to meet these needs with the current information available?
- What are the top one or two priorities for information, that could be assisted by the broader community?

1:45-2:30 Identifying tools to better inform urban decision makers in the US

Moderator: Kevin Gurney, Northern Arizona University, Committee Member

5-minute panelist presentations + 25 min Q&A/discussion

- Lesley Ott, NASA
- Emma Loewen, RMI
- Catherine Atkin, Stanford Law Climate Data Policy Initiative
- Ajay Nagpure, Princeton University

Prompting and discussion questions

- What tools do you use or develop in your work that can be used by urban decision makers?
- What are the most important attributes a GHG information tool must have to be useful to cities?
- What are the barriers to cities adopting new GHG information tools?
- How do your tools fill critical gaps in GHG information?

2:30–3:00 BREAK

3:00–4:00 Synthesis discussion: opportunities for urban GHG information moving forward

Moderators: Kevin Gurney, Northern Arizona University and Annmarie Eldering, NIST, Committee Members

Brief intros + all moderated discussion

Session 2&3 panelists

Discussion questions

- What are the primary challenges with the GHG information tools that cities currently use (even if simple)?
- Can a GHG information tool for cities and urban areas be universal (i.e., are there common algorithms) or must it be “tailored”?
- What are your thoughts on the financial model for a GHG information tool for cities? Who pays?
- What ways could information be better shared between the research community, information generators, government agencies, and the private sector?

4:00

MEETING ADJOURNS

Speaker Bios

Ivonne Albarus is a junior researcher affiliated with France's renowned Laboratory of Climate and Environmental Sciences (LSCE). Her Ph.D. research focuses on the intersection of urban climate politics and atmospheric monitoring. Ivonne has previously worked in the financial sector as a financial analyst at the Paris stock exchange, advising brokers on investment strategies. She earned a bachelor's degree in International Business from Germany and a Master's in Green Economy from the UK, giving her a unique trans-disciplinary experience to face the complex challenges of societies transitioning to a green economy.

Catherine Atkin, Esq. is an attorney, climate entrepreneur and urban planner focused on building the policies and enabling environment needed to drive global decarbonization and sustainable development. She has deep expertise in local, national and global GHG accounting frameworks and methodologies, climate data policies and financing regimes with an emphasis on urban development, clean energy, and transportation. She is a Stanford Law School CodeX Fellow and Chair of the Climate Data Policy Initiative where she brings together climate experts, policy makers and technologists to inform the development of climate data policies that can catalyze climate tech innovation, unlock climate finance and accelerate scale. She is also working with the UNFCCC Global Innovation Hub on a demonstration project in Korea focused on city-level GHG accounting as well as private finance and city climate solution deployment. She received a BA from Stanford University, a law degree from UC Berkeley School of Law and a master's degree in Urban Planning from the University of California Los Angeles.

Michael Burger is the Executive Director at the Sabin Center for Climate Change Law and a Senior Research Scholar at Columbia Law School. As Executive Director of the Sabin Center for Climate Change Law, Michael leads a dynamic team that is at the forefront of domestic and international efforts to reduce greenhouse gas emissions and promote climate change adaptation through pollution control, resource management, land use planning and green finance. Past and present projects involve collaborations with a wide range of institutions in the public, private and academic sectors, including local and national environmental groups and government representatives, as well as international organizations. Michael is a widely published scholar, a frequent speaker at conferences and symposiums, and a regular source for media outlets. He is also a co-founder and member of the Environmental Law Collaborative. Michael is Of Counsel at Sher Edling LLP, a boutique plaintiffs firm that represents states, cities, public agencies, and businesses in high-impact, high-value environmental cases.

Ronald C. Cohen, Ph.D. is Professor of Atmospheric Chemistry at the University of California, Berkeley and the Chief Scientists at Secured Carbon, a company aiming to provide financing for projects coupled to verified greenhouse gas emission reductions. He was Director of the UC Berkeley Atmospheric Science Center from 2006-2016. Cohen is known for his work on the atmospheric nitrogen cycle, the temperature dependence of ozone and urban emissions of greenhouse gases and of air pollutants. He is a fellow of the American Association for the Advancement of Science and the American Geophysical Union. Cohen is co-author of over 310 peer-reviewed scientific publications. He has mentored over 50 PhD students and postdoctoral fellows and over 50 undergraduates in their research. His BEACO2N project is a hub for education and outreach to underrepresented K-12 students.

Philip Fine serves as the Executive Officer/Air Pollution Control Officer for the Air District, one of the preeminent air quality management agencies in the United States. As Executive Officer for the Air District, Dr. Fine is responsible for all agency functions and activities, including policy and rule development, enforcement, permitting, technology development, planning, grant allocation, administration and engagement with communities disproportionately impacted by air pollution to address environmental justice concerns. Dr. Fine joined the Air District from the U.S. Environmental Protection Agency, where he served as Principal Deputy

Associate Administrator for Policy, a presidentially appointed position. His EPA portfolio included a wide array of cross-agency policy and regulatory matters, including serving as EPA's Environmental Justice Officer. In this role, he led the Office of Environmental Justice through a period of unprecedented attention, action, and growth, including implementation of President Biden's Justice40 initiative. Prior to his term at the U.S. EPA, Dr. Fine served for 15 years at the South Coast Air Quality Management District in Southern California, the last five years in the position of Deputy Executive Officer for the Planning, Rule Development and Area Sources Division. Dr. Fine's previous responsibilities at South Coast Air Quality Management District included oversight of ambient air monitoring, laboratory services, quality assurance, and source testing. Before joining the South Coast Air Quality Management District, Dr. Fine was a Research Assistant Professor at the University of Southern California, Los Angeles. Here he taught courses and conducted extensive research on particulate pollution, air monitoring technologies, and exposure assessment. Dr. Fine received his Ph.D. from the California Institute of Technology in Environmental Science & Engineering, and his bachelor's degree in Mechanical Engineering and Materials Science & Engineering from the University of California, Berkeley.

Emma Loewen is a Senior Associate with RMI, an independent, non-partisan, nonprofit organization of experts across disciplines working to accelerate the clean energy transition. Her work at RMI focuses on developing tools to support cities in tackling the climate crisis. Her current projects include leading the City Climate Intelligence initiative to deliver open, near-real-time GHG emissions data in cities and supporting the development of a climate focused education platform to equip government officials with the tools and knowledge to deploy ambitious climate policy action at all levels of government. Prior to RMI, Emma worked in Toronto, Canada across a handful of government agencies working on urban sustainability issues, including delivering below-zero operational carbon and community-oriented development projects on Toronto's waterfront and providing research and government advisory support to scale clean technology solutions within the province of Ontario.

Kim Mueller is a member of the Greenhouse Gas Measurement Program at the National Institute of Standards and Technology (NIST). Her research focuses on characterizing urban and regional CO₂ and CH₄ emissions. One key aspect of her work is to statistically assimilate trace gas measurements from various observational platforms (e.g., in-situ towers, aircraft, etc.) with emissions information. Ultimately, her research is aimed at promoting the program's goal of developing standardized GHG measurement methods that can be used by interested city, state, and federal actors. Prior to working at NIST, she worked in the US Congress and at the Science Technology and Policy Institute which supports the Office of Science and Technology Policy (OSTP) at the US White House.

Ajay Nagpure is an Urban System Scientist at the Department of Civil and Environmental Engineering at Princeton University. His research aims to identify infrastructural and environmental footprints at the microscale to increase awareness of environmental problems and implement mitigation strategies effectively. Ajay has previously worked as a Program Director, Air Quality at World Resources Institute India, where he developed Clean Air Action Plans for Indian cities and established guidelines for effective implementation. His past research work involves developing methods for estimating activities and environmental footprints of Municipal Solid Waste, Transportation, Household energy use, and Construction sectors. Ajay's research primarily focuses on performing a detailed analysis of urban infrastructure sectors and footprints to facilitate a better understanding of on-the-ground challenges, opportunities, and efficient policy formulation, as well as their effective implementation. He holds a Ph.D. from the Indian Institute of Technology Roorkee and has more than 12 years of post-Ph.D. experience in sustainable urban infrastructure systems research.

Michael Ogletree is the Division Director for the Air Pollution Control Division (APCD) of the Colorado Department of Public Health and Environment (CDPHE). Before becoming Division Director, Mr. Ogletree was the air quality program manager for the City and County of Denver, and as Secretary of the Air Quality Control Commission, where he promoted clean and healthy air for Colorado's citizens and visitors, protected

Colorado's scenic and natural resources. Michael Ogletree is an experienced leader with a passion for using technology to create positive change. With a strong background in leadership and a track record of driving successful initiatives, he has a natural ability to bring people together and drive meaningful change. Since being with Air Pollution Control Division, Mr. Ogletree has been instrumental in major initiatives that focus on reducing greenhouse gas emissions, creating strides towards public protections from toxic air contaminants, prioritizing Environmental Justice communities in engagement and permitting decisions, improving data transparency, and integrating the next-generation of air monitoring technology. Mr. Ogletree is dedicated to making a difference and creating a better future for us all.

Lesley Ott is a climate scientist with 20 years experience studying air pollution and greenhouse gases. She received her PhD in atmospheric science from the University of Maryland in 2006 and has been working at NASA's Goddard Space Flight Center ever since. She currently leads the carbon group within the Global Modeling and Assimilation Office, NASA's center for understanding contemporary weather and climate using a family of advanced Earth system modeling tools. Her work focuses on using a combination of satellite data and numerical models to better understand the sources and sinks of greenhouse gases and how the processes that control them may change over time. She also coordinates a group of university and government scientists that aims to inform how future satellite missions can improve understanding of carbon pollution and public policy.

Robert Stupka is the Head of Climate Action Implementation for North America at C40 Cities -- a global network of almost 100 mayors that are leading to confront the climate crisis. In his role, he works with C40's 17 cities in Canada and the United States and across C40's research and network teams to support city climate action. C40's leadership standards that cities need to meet include a requirement for GPC compliant inventories and climate action plans that are compliant with the Paris Agreement. Robert is a professional engineer based in Kelowna, British Columbia Canada where he has worked for over 15 years in sustainability consulting for cities, energy policy and conservation for utilities, and passive house design. Robert has a masters degree in Sustainable Infrastructure from the University of Toronto. In his spare time he enjoys skiing and mountain biking with his family as well as supporting community climate action within his city.

Study Committee Bios

Donald J. Wuebbles (*Chair*) is Emeritus Professor of Atmospheric Science at the University of Illinois. He is also Director of Climate Science for Earth Knowledge. From 2015 to 2017, Dr. Wuebbles was Assistant Director with the Office of Science and Technology Policy at the Executive Office of the President. After many years at Lawrence Livermore National Laboratory, Dr. Wuebbles came to the University of Illinois as Professor and Head of the Department of Atmospheric Sciences in 1994. He also led the development of the School of Earth, Society, and Environment at the University, and was its first director. Dr. Wuebbles is an expert in atmospheric physics and chemistry, with over 500 scientific publications related to the Earth's climate and atmospheric composition. He also provides analyses and development of metrics for translating science to policy and societal responses. He has been a leader in many international and national scientific assessments, including as a coordinating lead author on international climate assessments led by the Intergovernmental Panel on Climate Change (IPCC), thus contributing to IPCC being awarded the Nobel Peace Prize in 2007. He co-led Volume 1 of the 2017 4th U.S. National Climate Assessment. Amongst his major awards, Dr. Wuebbles has received the Cleveland Abbe Award from the American Meteorological Society, the Stratospheric Ozone Protection Award from the U.S. Environmental Protection Agency, and the Bert Bolin Global Environmental Change Award from the American Geophysical Union. He is a Fellow of three major professional science societies, the American Association for the Advancement of Science, the American Geophysical Union, and the American Meteorological Society. Dr. Wuebbles holds a B.S. and M.S. in electrical engineering from the University of Illinois and a Ph.D. in atmospheric sciences from University of California, Davis. He was a member of the joint U.S. National Academy of Science and UK Royal Society Committee on Climate Change that wrote *Climate Change: Evidence and Causes* in 2014 and updated in 2020.

Kamal Bawa (NAS) is Distinguished Professor Emeritus at the University of Massachusetts Boston, and Founder-President of the Ashoka Trust for Research in Ecology and the Environment (ATREE), Bengaluru, India. His main area of expertise is sustainability science. Among the many awards he has received are the Pew Award in Conservation and the Environment, Giorgio Ruffolo Fellowship at Harvard University, the Gunnerus Prize in Sustainability Science from the Royal Norwegian Society of Letters and Sciences, the international MIDORI Prize in Biodiversity from the Aeon Foundation in Japan, the Linnean Medal from the Linnean Society, and honorary doctorates from the University of Alberta and Concordia University in Montreal. He is an elected Fellow of the US National Academy of Sciences, the Royal Society, the American Philosophical Society, and the American Academy of Arts and Sciences. Dr. Bawa is the founding Editor-in-Chief of *Conservation and Society* and Editor of *Ecology, Economy and Society*. Dr. Bawa received his Ph.D. in botany from Punjab University, India. He recently served on the National Academies' Committee on Developing a Booklet on Biodiversity for the Public and Policy Makers.

Gabrielle Dreyfus is chief scientist at the Institute for Governance & Sustainable Development (IGSD), Washington, DC and Paris, and an adjunct faculty at Georgetown University. She joined IGSD in 2017 after nearly a decade of working at the science and policy interface with the US Department of Energy, rising to deputy director for the Office of International Climate and Clean Energy, and previously with the National Oceanic and Atmospheric Administration, and US Senate. In addition to dozens of scientific and technical publications, Dr. Dreyfus worked as the lead coordinating author on a synthesis report by the International Energy Agency and United Nations Environment Programme on the intersection of energy efficiency and the phasedown of hydrofluorocarbons in the cooling sector. Dr. Dreyfus is a member of the Montreal Protocol's Technology and Economic Assessment Panel Foams Technical Options Committee and Energy Efficiency Task Force, and was a member of the technical review committee of the Global Cooling Prize. She also contributed to the design and implementation of the \$50 million Kigali Cooling Efficiency Program (now Clean Cooling Collaborative), a philanthropic collaboration housed at the ClimateWorks Foundation. She was a 2021 Honoree of Environment+Energy Leader 100. Dr. Dreyfus holds a B.A. in Earth and Planetary Sciences from

Harvard University, and a masters and Ph.D. from Princeton University and Sorbonne Université in Geosciences.

Annmarie Eldering has over 30 years of experience in the fields of air pollution, greenhouse gases, and remote sensing. She retired from NASA's Jet Propulsion Laboratory (JPL) in 2022. Her early work at Caltech focused on measuring and modeling the aerosols that form in the Los Angeles Basin and drastically reduce visibility. Dr. Eldering developed advanced computer models to simulate these processes and evaluate possible strategies for emissions reductions and improvement in air quality. At the JPL, she was the Project Scientist on satellite projects to measure tropospheric air pollution (TES) and later carbon dioxide (the Orbiting Carbon Observatories (-2 and -3)). Through these satellite projects, she has worked closely with the modeling community that is combining ground-based measurements, emissions inventories, and satellite measurements in atmospheric models to create the most complete understanding of the carbon cycle and the state of Earth's atmospheric composition including greenhouse gases. She was also a deputy section manager and section manager in Earth Atmospheric Science at JPL for 5 years, guiding and organizing a cohort of near 100 scientists, technical staff, and postdocs. Dr. Eldering received her B.E. in chemical engineering from Cooper Union and her Ph.D. in Environmental Engineering Science from Caltech.

Fiji George has more than 27 years of experience covering corporate climate and sustainability strategy, fundamental science, regulatory and policy experience along natural gas value chain exploration/production, gas processing, transmission & storage, and liquefied natural gas (LNG). His expertise focuses on researching and implementing sustainable solutions for prudent development and use of natural gas and LNG in a low-carbon economy, and integrating corporate environmental, social & governance (ESG) programs to support the energy transition. Mr. George was a member of the National Academies of Sciences, Engineering and Medicine Committee on Anthropogenic Methane Emissions in the United States: Improving Measurement, Monitoring, Reporting, and Development of Inventories. He is a co-author on multiple peer-reviewed scientific papers, and the architect of the ONE Future Coalition voluntary methane inventory and mitigation program design. He has participated at Intergovernmental Panel on Climate Change (IPCC) Expert Meetings for Technical Assessment of IPCC Inventory Guidelines and provided feedback to the US Environmental Protection Agency on annual US national greenhouse gas inventories. At Cheniere, he leads the development of corporate policies and positions on climate and sustainability issues, including integration of climate considerations into corporate strategies and novel energy transition business plans such as the Cargo Emissions (CE) Tag, Quantification Monitoring Reporting & Verification (QMRV), and Lifecycle Analysis (LCA).

Heather Graven is a Reader in the Department of Physics and the Grantham Institute at Imperial College London, UK. She earned her Ph.D. in earth sciences from Scripps Institution of Oceanography at the University of California, San Diego and she worked previously at ETH Zurich, Switzerland. Her research focuses on the use of atmospheric measurements to understand the global carbon cycle and its response to human activities and climate change. She uses radiocarbon and stable carbon isotopes to distinguish fossil fuel and biogenic influences on carbon dioxide and methane, and to investigate carbon cycling in the ocean and land biosphere.

Kevin Gurney is an Atmospheric Scientist, Ecologist and Policy scientist currently working in the areas of carbon cycle science, climate science, and climate science policy at Northern Arizona University where he is a Professor in the School of Informatics, Computing, and Cyber Systems. Dr. Gurney is a co-founder of a for-profit business, Crosswalk Labs, which licenses a product that generates estimates of CO₂ emissions at fine scales across the United States to provide high-resolution CO₂ emissions to businesses, media, states, and local jurisdictions. Gurney's current University research involves understanding elements of the global carbon cycle using a variety of data/model fusion approaches. Over the last two decades Dr. Gurney has focused on quantification of fossil fuel CO₂ emissions at the global ("FFDAS"), national ("Vulcan") and urban ("Hestia") scales. Using data mining and assimilation algorithms, these very high-resolution greenhouse gas

quantification products are being used by analysts, scientists, and governments for emissions mitigation planning, tracking and assessment. The US work, in particular, is anchoring efforts at National Oceanic and Atmospheric Administration and the National Institute of Standards and Technology to develop prototypes of a multiscale greenhouse gas information system. He has degrees from UC Berkeley, MIT, and Colorado State University. He previously held faculty positions at Purdue University and Arizona State University. Gurney is an IPCC lead author, an NSF CAREER award recipient, Sigma Xi Young Scientist recipient, a Fulbright scholar, NAU Research and Creativity awardee, and has published over 150 peer-reviewed scientific articles with multiple papers in journals such as Nature and Science and a book from MIT Press, Mending the Ozone Hole.

Angel Hsu is an Assistant Professor of Public Policy and the Environment at UNC Chapel Hill and Founder/Director of the Data-Driven EnviroPolicy Lab, an interdisciplinary research group that innovates and applies quantitative approaches to pressing environmental issues. Her research explores the intersection of science and policy and the use of data-driven approaches to understand environmental sustainability, particularly in the areas of climate change and energy, urbanization and air quality. Dr. Hsu has provided expert testimony to the U.S. Senate Committee on Energy and Natural Resources, USChina Economic Security and Review Commission and is a member of the National Committee on USChina Relations and a Public Intellectual Program Fellow. She is a lead and contributing author to global climate science assessments, including the IPCC Sixth Assessment Report and the United Nations Environment Programme (UNEP) Emissions Gap Report. She previously held a joint appointment as Assistant Professor of Environmental Studies at Yale-NUS College in Singapore and the Yale School of Forestry and Environmental Studies as an adjunct. She holds a Ph.D. in environmental policy from Yale University, an M.Phil. in environmental policy from the University of Cambridge, and a B.S. in biology and B.A. in political science from Wake Forest University in Winston-Salem, NC.

Tomohiro Oda is a senior scientist at the Universities Space Research Association and an adjunct professor at the Department of Atmospheric and Oceanic Science, University of Maryland, College Park. Prior to the current positions, Dr. Oda held positions at NASA Goddard Space Flight Center, Colorado State University, NOAA Earth System Research Laboratory, and Japan's National Institute for Environmental Studies. Dr. Oda is a pioneer of the use of Earth Observations in development of high-resolution carbon spatial emission estimates. During his career, he has advanced spatial carbon emission modeling and the associated error and uncertainty quantification. Dr. Oda has also advanced and matured the carbon emission quantification using new space-based carbon observation. Dr. Oda is the Principal Investigator and developer of the Open-source Data Inventory for Anthropogenic CO₂ (ODIAC) emission inventory data product. He is a science team member of NASA's Orbiting Carbon Observatory mission as well as a key contributor to Japan's Greenhouse gas Observing Satellite (GOSAT) mission. Dr. Oda holds a Ph.D and a master's degree in engineering from Osaka University, Japan and an undergraduate degree in physics from Kwansei Gakuin University, Japan.

Irène Xueref-Remy is Physicist of the National Council of Astronomers and Physicists (CNAP), France, and Principal Investigator of the atmospheric activities at the Center for Scientific Research (CNRS) Observatoire de Haute Provence. She is a Professor at the University of Aix-Marseille (AMU) and she directs research programs at the Mediterranean Institute of Biodiversity and marine and continental Ecology (IMBE) at Aix-en-Provence. Her research focuses on assessing the variability of atmospheric greenhouse gases at different spatiotemporal scales; improving knowledge of emission inventories and natural greenhouse gas fluxes through atmospheric measurements and modeling techniques; and, bridging the gap between science and society by communicating her knowledge through conferences and collaborating with local air quality agencies and stakeholders within her research projects. Her current research focuses on the construction of scenarios for reaching carbon neutrality by 2050 in the Aix-Marseille metropolis in collaboration with local stakeholders. Among others, she is a member of the Scientific Council of the Regional Air Quality Agency and a member of the WMO IG3IS international program (Integrated Global Greenhouse Gas Information System) dedicated to help guiding stakeholders for taking valuable GHG emission-reduction actions in response to climate change.

Dr. Xueref-Remy has a diploma of Engineer from the Ecole Centrale de Lyon, obtained her Ph.D. at the University of Grenoble and performed three postdoctoral positions at the Juelich Research Center in Germany, at Harvard University, and at Laboratoire des Sciences du Climat et de l'Environnement in France.

Greenhouse Gas Emissions Information for Decision Making

A Framework Going Forward

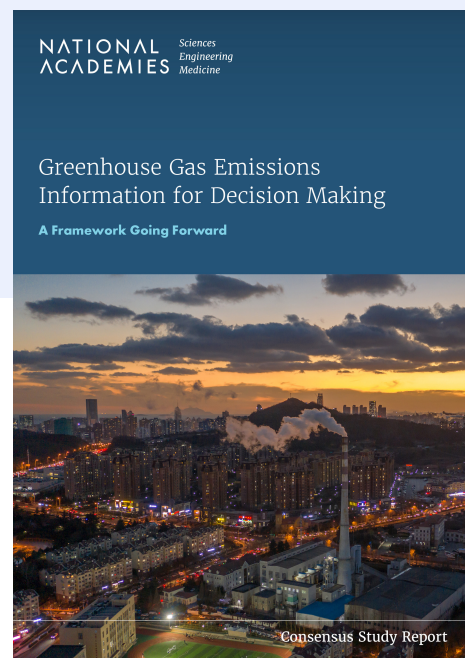
Climate change, driven by increases in human-produced greenhouse gases and particles such as soot (collectively referred to as GHGs), is the most serious environmental issue facing society. The need to reduce GHGs has become urgent as heat waves, heavy rain events, hurricanes, and other impacts of climate change have become more frequent and severe. Since the Paris Agreement was adopted in 2015, more than 136 countries, accounting for about 80 percent of total global GHG emissions, have committed to achieving net-zero emissions by 2050. Providing decision makers with useful, accurate, and trusted GHG emissions information is a crucial piece of this effort.

Three converging trends motivated this report: (1) the rapidly increasing demand from a range of users for GHG emissions information across multiple sectors and geographic scales; (2) the development of many new approaches that aim to address this increasing demand; and (3) a growing and rapidly evolving institutional landscape, including public, private, and academic entities seeking to provide better GHG emissions information. These trends point to the need for criteria or principles that users and decision makers could use when evaluating different types of GHG emissions information.

This report examines existing and emerging approaches used to generate and evaluate anthropogenic GHG emissions information at global to local scales and identifies their limitations. The report identifies six “pillars” that form a common framework to evaluate individual emissions datasets and approaches as well as to guide improvements in GHG emissions information products.

APPROACHES FOR QUANTIFYING ANTHROPOGENIC GREENHOUSE GAS EMISSIONS

Quantifying emissions of GHGs is challenging because there are many types of emissions sources and countless individual emitters. Some emissions can be measured directly at their source, such as power plants or industrial facilities, whereas other sources are more distributed in space, requiring that emissions be estimated or inferred from other data. GHG inventories are tools that quantify GHG emissions (or removals) often divided into economic and industrial sectors for a specific place and time. GHG inventories allow policy makers to identify key GHG-emitting sectors and make informed decisions by setting emission baselines, tracking emission changes over time,



and assessing emission mitigation efforts. GHG inventories are constructed using a wide range of approaches:



Activity-based approaches (often referred to as “bottom-up” approaches) generally utilize activity data such as fuel consumption statistics, traffic counts, population, or land area. These activity measures are transformed using a conversion factor such as the emission or removal of a GHG per unit of activity.



Atmospheric-based approaches (often referred to as “top-down” approaches) use atmospheric measurements of GHGs and an understanding of atmospheric transport and chemical processes to infer information on GHG fluxes (emissions and sinks). Surface-, aircraft-, and space-based observations are combined with analysis approaches and models to transform measurements of atmospheric concentrations into estimates of emissions.



Hybrid approaches generate GHG emissions information through the combination and more complete integration of activity- and atmospheric-based approaches, and/or other data sources, data assimilation, or emerging digital technologies. Hybrid approaches are nascent and hold the possibility of combining multiple measurement streams, atmospheric-, and activity-based approaches to produce more complete and accurate estimates of GHG emissions and sinks.

FRAMEWORK FOR EVALUATING

GREENHOUSE GAS EMISSIONS INFORMATION

As more GHG emissions information becomes available and as more decision makers use this information, a common evaluation framework can help users determine what information products best meet their needs and understand the limitations of that information. A common framework can also provide guidance to researchers for designing more useful and trusted data and information. The report identifies six criteria or

“pillars” that form a framework to evaluate current and future GHG emissions information:



1. **Usability and Timeliness:** information is comparable and responsive to decision maker needs and available on timescales relevant to decision-making;
2. **Information Transparency:** information is both publicly available and traceable by anyone;
3. **Evaluation and Validation:** review, assessment, and comparison to independent datasets;
4. **Completeness:** coverage of all sources and GHGs for the relevant geographic boundary;
5. **Inclusivity:** who is involved in GHG emissions information creation and who is covered by the information; and
6. **Communication:** methodologies and assumptions are described in understandable forms, well documented, and openly accessible.

Greenhouse gas emissions information development and evaluation should strive to align with the six pillars: usability and timeliness, information transparency, evaluation and validation, completeness, inclusivity, and communication.

The application of the six pillars of the framework to both individual datasets and approaches would advance the current complex GHG emissions information landscape toward one that could more comprehensively meet the needs of users and decision makers. Figure 1 summarizes how the current capabilities of the three

approaches, described above, generally perform relative to the pillars.

ADVANCING GREENHOUSE GAS EMISSIONS INFORMATION CAPABILITIES, TRUST, AND ACCESSIBILITY

Greenhouse gas emissions information should be better coordinated (e.g., through the creation of a coordinated repository or federation of repositories) across the global community, enabling adherence to a set of minimum common pillar attributes.

The pillars above embody the desired attributes for the institutions that develop GHG emissions information. A coordinated repository or federation of repositories where GHG emissions information can be hosted, documented, and clearly characterized would be a critical step forward in maximizing use and understanding of GHG emissions data products. It could establish standards and practices to help users grasp individual characteristics and quality of the wide range of GHG emissions information. Characteristics and functions of a coordinated repository or clearinghouse would operationalize the six pillars, for example, by providing timely, transparent, traceable information; standardized data formats; and governance mechanisms that are coordinated, trusted, and inclusive of the global community.

Greenhouse gas emissions information providers should clearly communicate underlying data, methods, and associated uncertainties.

In the shorter term, data providers can follow many of the guidelines outlined for a clearinghouse to facilitate comparability and verification of their data to foster trust between information providers and users. Resource allocation aimed at bringing data into the public domain with transparency standards could have a substantial impact on the utility of GHG emissions information.

ADDRESSING KEY DATA AND INFORMATION GAPS AND UNCERTAINTIES

Greenhouse gas emissions information (e.g., observations, data analysis, activity data, emission factors) development at more granular temporal and spatial scales with source-level detail should be accelerated to meet the rapidly increasing needs of cities, states, and provinces for managing their emissions.

The accuracy and representativeness of all underlying data used to estimate greenhouse gas emissions (e.g., emission factors, activity data) should be further improved.

Cities, states, provinces, landowners, and the business community, among others, need consistent, standardized, trusted GHG emissions information to enact and evaluate mitigation policies. Currently, data available on granular space and time scales for local and regional decision-making is insufficient. There is a need to expand the necessary data resources to include activity data, emission factors, and atmospheric observations. Further, there is a need to improve the representativeness and resolution across the globe of key underlying data drivers to strengthen the completeness and accuracy of GHG emissions information.

		Pillars					
		Usability and Timeliness	Information Transparency	Evaluation and Validation	Completeness	Inclusivity	Communication
Activity-based	Methods	Medium	High	Medium	Medium	Low	Medium
	Data	Medium	Medium	Low	Medium	Low	Medium
Atmospheric-based	Methods	Low	High	Medium	Medium	Low	Low
	Data	Medium	Medium	High	Medium	Low	Medium
Hybrid	Methods & Data	Low	Low	Medium	Medium	Low	Low

FIGURE 1 A qualitative assessment of the current capabilities of three approaches for quantifying GHG emissions information were ranked from low (light green) to high (dark green) against the six evaluation pillars. These rankings are useful to compare the approaches to each other and identify strengths and opportunities for improvement.

OPERATIONALIZING CURRENT CAPABILITIES

Greenhouse gas emissions estimation research efforts should transition with urgency to operational capabilities with institutions to maintain and ensure longevity.

The need to reduce emissions is urgent, but the current timeline and processes to operationalize new data, technologies, or approaches to enable decision-useful strategies is misaligned to meet emissions reduction goals in a timely manner. Accelerating the transition of research to operations will require scientists, research funders, and data users to identify ways to lower existing barriers to that transition and ways to make new data products more immediately usable. The clearinghouse and other coordination mechanisms recommended above, along with alignment with the pillars, should help make new GHG emissions information usable more quickly.

STRIVING FOR HYBRID APPROACHES

Greenhouse gas emissions data collection, modeling, and information development should be designed and implemented to enable a fuller integration and “hybridization” of information and approaches.

Most of the current GHG inventory and information development to date has tended to use single methods or approaches with single-technique observations or data sources. Going forward, a “cross-technique” or hybridization of (traditional) approaches and datasets

would provide more accurate and comprehensive GHG emissions information. Some of this work has begun and includes data assimilation and data fusion as well as new machine learning and other techniques. Greater synergy between air quality, meteorology, and GHG data collection and analysis efforts would facilitate the development of these hybrid approaches. To strive for hybridization is to holistically improve GHG monitoring across scales, approaches, and capacity.

ENSURING USABILITY, TIMELINESS AND EFFECTIVE COMMUNICATION OF GHG EMISSIONS INFORMATION

Greenhouse gas emissions information generators, decision makers, and global stakeholders should engage in an iterative process in a timely manner to ensure the information provided is relevant and useful.

Incorporating decision maker input is critical for information developed to respond to the policy needs of stakeholders and decision makers. The time lag to integrate new research findings into GHG emissions information limits the development and execution of sound mitigation policy and can delay necessary investments and technology development. Usability and timeliness of GHG emissions information can be enhanced if data producers and users engage in an iterative process, which the clearinghouse or federated repository could support, to facilitate investments in systems that are focused on providing decision support and responsive to an evolving policy-making landscape.

COMMITTEE ON DEVELOPMENT OF A FRAMEWORK FOR EVALUATING GLOBAL GREENHOUSE GAS EMISSIONS INFORMATION FOR DECISION MAKING

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Any violation of this policy should be reported. If you experience or witness discrimination, harassment, or bullying, you are encouraged to make your unease or disapproval known to the individual at the time the incident occurs, if you are comfortable doing so. You are also urged to report any incident by:

- Filing a complaint with the Office of Human Resources at 202-334-3400 or hrservicecenter@nas.edu, or
- Reporting the incident to an employee involved in the activity in which the member or volunteer is participating, who will then file a complaint with the Office of Human Resources.

Complaints should be filed as soon as possible after an incident. To ensure the prompt and thorough investigation of the complaint, the complainant should provide as much information as is possible, such as names, dates, locations, and steps taken. The Office of Human Resources will investigate the alleged violation in consultation with the Office of the General Counsel.

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Information contained in a complaint is kept confidential, and information is revealed only on a need-to-know basis. NASEM will not retaliate or tolerate retaliation against anyone who makes a good faith report of discrimination, harassment, or bullying.

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A GUIDE TO THE Harassment Complaint Process for Participants AT THE NATIONAL ACADEMIES

Review the Policy [here](#).



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- Description of the incident(s), including the dates, locations and the presence of any witnesses;
- Steps taken to try to stop the harassment; and
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- Making a Commitment to Diversity, Equity, and Inclusion
- Preventing Discrimination, Harassment, and Bullying