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Carbon Mapper
Pasadena, CA

SUMMARY

I am the Chief Executive Officer of the non-profit organization Carbon Mapper and am also a Research Scientist at the University of Arizona. I previously served as a Fellow and Chief Systems Engineer for JPL's Earth Science and Technology Directorate, with a broad portfolio of satellite and aircraft instruments and missions, research and analysis, and applied science, spanning NASA's earth science enterprise. I have worked for over 30 years at the intersection of science and engineering to deliver complex systems ranging from earth observing satellites to space telescopes.

My work applies earth science and systems engineering to the challenge of climate change decision support. In 2020 I co-founded Carbon Mapper with a public good mission to help drive the world toward direct, comprehensive, transparent global monitoring to facilitate science-based decision-making and mitigation of greenhouse gas emissions. Carbon Mapper leads a public-private partnership including philanthropies, NASA, an earth imaging company (Planet Labs PBC), the California Air Resources Board, the University of Arizona, Arizona State University and RMI to develop a constellation of satellites offering operational, high-resolution observations of methane and carbon dioxide emissions.

EXPERIENCE

CARBON MAPPER, Pasadena, California

- 2020-present, Chief Executive Officer

UNIVERSITY OF ARIZONA, Tucson, Arizona

- 2019-present, Research Scientist

JET PROPULSION LABORATORY, CALTECH, Pasadena, California

- 2017 – 2023, Engineering Fellow
 - 2008 – 2019, Chief Systems Engineer, Earth Science & Technology Directorate
 - 2002 – 2009, Chief Engineer & Project System Engineer, Kepler mission
 - 2000 – 2002, Instrument System Engineer, Starlight mission
 - 1996 – 2000, Metrology System Engineer, Shuttle Radar Topography Mission (SRTM)
- NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, Kennedy Space Center, Florida
- 1988 – 1995, Payload Integration, Test, Operations Engineer (5 space shuttle missions)

RESEARCH INTERESTS

My research extends the discipline of systems engineering to improving understanding of carbon emissions and working with diverse stakeholders to develop decision support systems to advance greenhouse gas mitigation efforts. I have been Principal Investigator on multiple research projects involving observational systems and analytic frameworks. My teams combine atmospheric measurements from satellites, aircraft and surface-based systems, tracer transport modeling, machine learning, and big data methods to detect, quantify and attribute emission sources.

EDUCATION

- Auburn University, Bachelor of Science, Electrical Engineering, 1991

HONORS

- NASA Group Achievement Awards (8 total, 1991-2023)
- NASA Exceptional Achievement Medals (2001 & 2010)
- NASA Systems Engineering Excellence Award (2010)
- JPL Mariner Award (2016)
- UN Climate Summit, Big Data Project to Watch: Megacities Carbon Project (2014)
- National Academy of Engineering Gilbreth Lecture (2013)
- Engineer's Council Distinguished Engineering Achievement Award (2012)

COMMITTEE SERVICE

- US National Academy of Sciences: Committee on Earth Science and Applications from Space (2022-present)
- US National Academy of Sciences: Committee on Developing a Research Agenda for Carbon Dioxide Removal and Sequestration (2017-2018)
- United States Carbon Cycle Science Program: 2nd State Of the Carbon Cycle Report – Writing Team, Decision Support and Urban Chapters (2016-2018)
- California Council on Science & Technology: Steering Committee for Long-term Viability of Natural Gas Storage Facilities (2017-2018)
- NASA Plankton, Aerosol, Cloud, and ocean Ecosystem (PACE): Standing Review Board (2017 – 2018)
- External Advisory Board, NYU Center for Urban Science & Policy (2016-2018)
- External Advisory Board, Greenhouse Gas Management Institute (2012-2018)
- Multiple NASA ROSES review panels

OTHER AFFILIATIONS

- Member, American Geophysical Union

PEER-REVIEWED PUBLICATIONS

1. Sherwin, E.D., J. S. Rutherford, Z. Zhang, Y. Chen, E. B. Wetherley, P. V. Yakovlev, E. S.F. Berman, B. B. Jones, D. H. Cusworth, A. K. Thorpe, A. K. Ayasse, **R. M. Duren**, A. R. Brandt (2023). Quantifying oil and natural gas system emissions from six regions using over one million aerial site measurements, in press, *Nature*.
2. Ravikumar, A., E. Tullos, D.T. Allen, B. Cahill, S.P. Hamburg, D. Zimmerle, T. Fox, M. Caltagirone, L. Owens, R. Stout, A. J. Grimes, T. M. Fernandez, C. Jenks, **R. Duren**, A. Half, M. D. Bazilian, S. Rucker (2023). Measurement-Based Differentiation of Low Emission Global Natural Gas Supply Chains, in press, *Nature Energy*.
3. Cusworth, D.H., **R. M. Duren**, et al (2023), Quantifying Methane Emissions from United States Landfills, in review, *Science*.
4. Ayasse, A., D.Cusworth, K. O'Neill, J. Fisk, A. K Thorpe, **R. Duren** (2023). Performance and sensitivity of column-wise and pixel-wise methane retrievals for imaging spectrometers (2023). In review, *Atm Meas Tech*.

5. Cusworth, D.H., A.K. Thorpe, C. E. Miller, A. K. Ayasse, R. Jiorle, **R. M. Duren**, R. Nassar, Jon-Paul Mastrogioacomo, R. R. Nelson (2023). Two years of satellite-based carbon dioxide emission quantification at the world's largest coal-fired power plants, in review, *Atm Chem Phys*.
6. Thorpe, A.T., R.O. Green, D. R. Thompson, P. G. Brodrick, J. W. Chapman, C.D. Elder, I. Irakulis-Loitxate, D.H. Cusworth, A. K. Ayasse, **R. M. Duren**, C. Frankenber⁶, L. Guanter, J. R. Worden, P. E. Dennison, D. A. Roberts, K.D. Chadwick, M. L. Eastwood, J.E. Fahlen, C. E. Miller (2023), Attribution of individual methane and carbon dioxide emission sources using EMIT observations from space, in review, *Science Advances*.
7. Worden, J.R., S. Pandey, Y. Zhang, D. H. Cusworth, Z. Qu, A. A. Bloom, S. Ma, J. D. Maasackers, T. Scarpelli, B. Byrne, **R. Duren**, D. Crisp, D. Gordon, and D. J. Jacob (2023), A Bayesian Framework for Evaluating Methane Inventories and Trends With Atmospheric Methane Data, in review.
8. Yadav, V., K. Verhulst, **R.Duren**, A. Thorpe, J. Kim, R. Keeling, R.Weiss, D. Cusworth, M. Mountain, C. Miller, and J. Whetstone (2023). A declining trend of methane emissions in the Los Angeles Basin from 2015 to 2020. *Environ. Res. Lett.* 18 034004
9. Thorpe, A.T., et al (2023). Methane emissions decline from reduced oil, natural gas, and refinery production during COVID-19 *Environ. Res. Commun.* 5 021006
10. Cusworth, D.H., A.K. Thorpe, A.K. Ayasse, D. Stepp, J. Heckler, G. P. Asner, C. E. Miller, J.W. Chapman, M. L. Eastwood, R.O. Green, B. Hmiel, D. Lyon, and **R M. Duren** (2022). Strong methane point sources contribute a disproportionate fraction of total emissions across multiple basins in the U.S., *Proc. Natl Acad. Sci.* 119 (38)
<https://doi.org/10.1073/pnas.2202338119>
11. **Duren, R.**, D. Gordon (2022). Tackling unlit and inefficient gas flaring. *Science*,
<https://www.science.org/doi/10.1126/science.ade2315>
12. Jacob, D. J., Varon, D. J., Cusworth, D. H., Dennison, P. E., Frankenberg, C., Gautam, R., Guanter, L., Kelley, J., McKeever, J., Ott, L. E., Poulter, B., Qu, Z., Thorpe, A. K., Worden, J. R., and **Duren, R. M.** (2022). Quantifying methane emissions from the global scale down to point sources using satellite observations of atmospheric methane. *Atmos. Chem. Phys.* <https://doi.org/10.5194/acp-2022-246>.
13. Hmiel, Benjamin, David Lyon, Jack Warren, Jevan Yu, Daniel Cusworth, **R. Duren**, Steven Hamburg, Empirical Quantification of Methane Emission Intensity from Oil and Gas Producers in the Permian Basin (2022). *Environ. Res. Lett.* 18 024029,
<https://iopscience.iop.org/article/10.1088/1748-9326/acb27e>
14. A. K. Ayasse, A.K. Thorpe, D. H. Cusworth, E. A. Kort, A. G. Negron, J. Heckler, G.P. Asner, **R. M. Duren**, (2022). Methane remote sensing and emission quantification of offshore shallow water oil and gas platforms in the Gulf of Mexico, *Environ. Res. Lett.* 17 084039
<https://iopscience.iop.org/article/10.1088/1748-9326/ac8566/meta>
15. Yu, J., B. Hmiel, D. R. Lyon, J. Warren, D.H. Cusworth, **R. M. Duren**, Y. Chen, E. C. Murphy, and A. R. Brandt (2022). Methane Emissions from Natural Gas Gathering Pipelines in the Permian Basin, *Environ Sci Tech*, <https://doi.org/10.1021/acs.estlett.2c00380>
16. Lauvaux, T., C. Giron, M. Mazzolini, A. d'Aspremont, **R. Duren**, D. Cusworth, D. Shindell, P. Ciais (2022). Global assessment of oil and gas methane ultra-emitters, *Science*, 2 375, 6580 557-561 <https://www.science.org/doi/10.1126/science.abj4351>
17. Ehret, T., A. De Truchis, M. Mazzolini, J. Morel, A. d'Aspremont, T. Lauvaux, **R. Duren**; D. Cusworth, G. Facciolo (2022). Global Tracking and Quantification of Oil and Gas

- Methane Emissions from Recurrent Sentinel-2 Imagery", *Environ. Sci. Technol.* 2022, 56, 14, 10517–10529, <https://doi.org/10.1021/acs.est.1c08575>
18. J. R. Worden, D. Cusworth, Z. Qu, Y. Yin, Y. Zhang, A. Bloom, S. Ma, B. Byrne, T. Scarpelli, J. D. Maasakkers, D. Crisp, **R. Duren**, and D. J. Jacob (2021). The 2019 Methane Budget And Uncertainties At 1 Degree Resolution And Each Country, Through Bayesian Integration Of GOSAT Total Column Methane Data And A Priori Inventory Estimates, *Atmos. Chem. Phys.*, 22, 6811–6841, 2022, <https://doi.org/10.5194/acp-22-6811-2022>
 19. Logan E. Mitchell, John C. Lin, Lucy R. Hutyra, David R. Bowling, Ronald C. Cohen, Kenneth J. Davis, Elizabeth DiGangi, **R.M. Duren**, James R. Ehleringer, Clayton Fain, Matthias Falk, Abhinav Guha, Anna Karion, Ralph F. Keeling, Jooil Kim, Natasha L. Miles, Charles. E. Miller, Sally Newman, Diane E. Pataki, Steve Prinzivalli, Xinrong Ren, Andrew Rice, Scott J. Richardson, Maryann Sargent, Britton B. Stephens, Jocelyn C. Turnbull, Kristal R. Verhulst, Felix Vogel, Ray F. Weiss, James Whetstone, Steven C. Wofsy (2022). A Multi-City Urban Atmospheric Greenhouse Gas Measurement Data Synthesis, *Nature Sci. Data*, <https://www.nature.com/articles/s41597-022-01467-3>
 20. D H. Cusworth, **R.M. Duren**, A. K. Thorpe, W. Olson-Duvall, J. Heckler, J.W. Chapman, M. L. Eastwood, M. C. Helmlinger, R. O. Green, G. P. Asner, P. E. Dennison, and C. E. Miller (2021). Intermittent methane emissions in the Permian basin. *Environ. Sci. Technol. Lett.* 8, 7, 567–573. <https://doi.org/10.1021/acs.estlett.1c00173>
 21. Cusworth, D. H., **R. M. Duren**, A.K. Thorpe, S. Pandey, J.D. Maasakkers, I. Aben, *et al.*, (2020). Multi-satellite imaging of a gas well blowout enables quantification of total methane emissions. *Geophysical Research Letters*, 47. e2020GL090864. <https://doi.org/10.1029/2020GL090864>
 22. Thorpe, A.K., O'Handley, C., Emmitt, G.D., DeCola, P.L., Hopkins, F.M., Yadav, V., Guha, A., Newman, S., Herner, J.D., Falk, M., **R.M. Duren** (2021). Improved methane emission estimates using AVIRIS-NG and an Airborne Doppler Wind Lidar, *Remote Sensing of Environment*.
 23. Cusworth, D.H., **R.M. Duren**, A. Thorpe, P.E. Dennison, C. Frankenberg, C.E. Miller (2021). Carbon dioxide emissions from power plants can be quantified globally using remote sensing, *AGU Advances*.
 24. Markus D. Foote, Philip E. Dennison, Patrick R. Sullivan, Kelly B. O'Neill, Andrew K. Thorpe, David R. Thompson, Daniel H. Cusworth, **R. Duren**, Sarang C. Joshi (2021). Impact of scene-specific enhancement spectra on matched filter greenhouse gas retrievals from imaging spectroscopy, *Remote Sensing of Environment*, Volume 264, <https://doi.org/10.1016/j.rse.2021.112574>
 25. V. Yadav, S. Ghosh, K. Mueller, A. Karion, G. Roest, S.M. Gourdji, I. Lopez-Coto, K. R. Gurney, N. Parazoo, K. R. Verhulst, J. Kim, S. Prinzivalli, C. Fain, T. Nehrkorn, M. Mountain, R. F. Keeling, R. F. Weiss, **R. Duren**, C. E. Miller, J. Whetstone (2021). The impact of COVID-19 on CO2 emissions in the Los Angeles and Washington DC/Baltimore metropolitan areas. *Geophysical Research Letters* 48, <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2021GL092744>
 26. Irakulis, I., L. Guanter, Yin-Nian Liu, D.J. Varon, J. D. Maasakkers, Y. Zhang, A. K. Thorpe, **R. M. Duren**, C. Frankenberg, D. Lyon, D. H. Cusworth, Yongguang Zhang, K. Segl, J. Gorrone, E. Sanchez-Garcia, M. P. Sulprizio, K. Cao, H. Zhu, J. Liang, X. Li, I. Aben, D. J. Jacob (2021). Satellite-based Survey of Extreme Methane Emissions in the Permian Basin, *Science Advances*, <https://www.science.org/doi/10.1126/sciadv.abf4507>

27. Cusworth, D. H., **Duren, R. M.**, Yadav, V., Thorpe, A. K., Verhulst, K., Sander, S., et al, (2020). Synthesis of methane observations across scales: Strategies for deploying a multitiered observing network. *Geophys. Res. Lett.*, 47, e2020GL087869. <https://doi.org/10.1029/2020GL087869>
28. Miller, J.B., S.J. Lehman, K. Verhulst, C.E. Miller, **R.Duren**, V.Yadav, S. Newman, C. Sloop (2020). Large and seasonally varying biospheric CO₂ fluxes in the Los Angeles megacity revealed by atmospheric radiocarbon, *Proc. Natl Acad. Sci.*
29. Borchardt, J., Gerilowski, K., Krautwurst, S., Bovensmann, H., Thorpe, A. K., Thompson, D. R., Frankenberg, C., Miller, C. E., **Duren, R. M.**, and Burrows, J. P. (2020). Detection and Quantification of CH₄ Plumes using the WFM-DOAS retrieval on AVIRIS-NG hyperspectral data, *Atmos. Meas. Tech. Discuss.*, <https://doi.org/10.5194/amt-2020-275>, 2020.
30. Thorpe, A.K., **Duren, R.**, Conley, S., Prasad, K., Bue, B., Yadav, V., Foster, K., Rafiq, T., Hopkins, F., Smith, M. and Fischer, M.L., 2020. Methane emissions from natural gas storage in California, *Env. Res. Lett.*
31. Borucki, W., J. Jenkins, **R. Duren**, Science Merit Function for the KEPLER Mission, *Journal of Astronomical Telescopes Instruments and Systems* 6(04)
DOI:[10.1117/1.JATIS.6.4.044003](https://doi.org/10.1117/1.JATIS.6.4.044003)
32. Rafiq, T., **R. Duren**, A. Thorpe, K. Foster, R.Patarsuk, C.E. Miller, and F.M. Hopkins (2020). Source Attribution of Methane Point Source Emissions using Airborne Imaging Spectroscopy and the Vista-California Methane Infrastructure Dataset, *Environ. Res. Lett.* **15** 124001 DOI 10.1088/1748-9326/ab9af8
33. Guha, A., S. Newman, D. Fairley, T. M. Dinh, L. Duca, S.C. Conley, M. L. Smith, A. K. Thorpe, **R. M. Duren**, D.H. Cusworth, K. T. Foster, M.L. Fischer, S. Jeong, N. Yesiller, J.L. Hanson, and P. T. Martien (2020). Assessment of Regional Methane Emission Inventories through Airborne Quantification in the San Francisco Bay Area, *Environ. Sci. & Tech.* **54** (15), 9254-9264 , DOI: 10.1021/acs.est.0c01212
34. Cusworth, D.H., **Duren, R.M.**, Thorpe, A.K., Tseng, E., Thompson, D.R., Guha, A., Newman, S., Foster, K., Miller, C.E. (2020). Using remote sensing to detect, validate, and quantify methane emissions from California solid waste operations. *Environ. Res. Lett.* **15** 054012 DOI 10.1088/1748-9326/ab7b99
35. **Duren, R.**, A. Thorpe, K.T. Foster, T. Rafiq, F. M. Hopkins, V. Yadav, B.Bue, D.R. Thompson, S. Conley, N. Colombi, C. Frankenberg, I.McCubbin, M.Eastwood, M.Falk, J. Herner, B. E. Croes, R. Green, C. Miller (2019). California's Methane Super-emitters, *Nature* **575**, 180–184, doi:10.1038/s41586-019-1720-3.
36. Ware, J., E.A. Kort, **R. Duren**, K. Verhulst, V. Yadav (2019). Detecting Urban Emissions Changes and Events with a Near Real Time Capable Inversion System, *J. Geophys Res – A*, <https://doi.org/10.1029/2018JD029224>
37. Yadav, V., **R. Duren**, K.Mueller, K.R. Verhulst , T. Nehr Korn, J. Kim, R.F. Weiss, R. Keeling, S.Sander, M. L. Fischer, S.Newman, M. Falk, T. Kuwayama, F. Hopkins, T.Rafiq, J. Whetstone, C. Miller (2019). Spatio-temporally resolved methane fluxes from the Los Angeles Megacity, *J. Geophys. Res. – A*, <https://doi.org/10.1029/2018JD030062>
38. Gurney, K. R., Patarsuk, R., Liang, J., Song, Y., O'Keeffe, D., Rao, P., Whetstone, J. R., **Duren, R. M.**, Eldering, A., and Miller, C.: The Hestia Fossil Fuel CO₂ Emissions Data Product for the Los Angeles Megacity (Hestia-LA), *Earth Syst. Sci. Data Discuss.*, <https://doi.org/10.5194/essd-2018-162> (2019).

39. Cusworth, D., Jacob, D., Varon, D., Miller, C.C., Lu, X., Chance, K., Thorpe, A., **Duren, R.**, Miller, C., Thompson, D., Frankenberg, C., Guanter, L., Randles, C. (2019). Potential of next-generation imaging spectrometers to detect and quantify methane point sources from space, *Atmos. Meas. Tech.*, <https://doi.org/10.5194/amt-12-5655-2019>
40. Kuai, L., O.V. Kalashnikova, F. Hopkins, G. Hulley, H. Lee, M. J. Garay, **R. Duren**, J. Worden, S.Hook (2019). Quantification of ammonia emissions with high spatial resolution thermal infrared observations from the Hyperspectral Thermal Emission Spectrometer (HyTES) airborne instrument, *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 12, no. 12, pp. 4798-4812, Dec. 2019, doi: 10.1109/JSTARS.2019.2918093
41. Cui, Y.Y, A. Vijayan, M. Falk, Y. Hsu, D. Yin, Z. Zhao, J. Avise, K. Verhulst, L. T. Iraci, M.S. Johnson, Y. Chen, K. Stroud, J.Herner, B. Croes, **R.Duren** (2019). A multi-platform inversion estimation of statewide and regional methane emissions in California during 2014-2016, *Env. Sci. Tech.*, <https://doi.org/10.1021/acs.est.9b01769>
42. He, L., Zhao-Cheng Zeng, T. Pongetti, C. Wong, J.Liang, K. Gurney, S Newman, V.Yadav, K. Verhulst, C.Miller, **R. Duren**, C. Frankenberg, P. Wennberg, R. Shia, Y. Yung and S. Sander (2019). Leakage from natural gas usage correlates with seasonal methane emissions in Los Angeles, *Geophys. Res. Let.*
43. Jongaramrungruang, S., Frankenberg, C., Matheou, G., Thorpe, A., Thompson, D. R., Kuai, L., and **Duren, R.** (2019). Towards accurate methane point-source quantification from high-resolution 2D plume imagery, *Atmos. Meas. Tech.*, doi: 10.5194/amt-2019-173, <https://www.atmos-meas-tech-discuss.net/amt-2019-173/>
44. Ayasse, A.K., Dennison, P.E., Foote, M., Thorpe, A.K., Joshi, S., Green, R.O., **Duren, R.M.**, Thompson, D.R. and Roberts, D.A. (2019). Methane Mapping with Future Satellite Imaging Spectrometers. *Remote Sensing*, 11(24), p.3054.
45. Carranza, V., Rafiq, T., Frausto-Vicencio, I., Hopkins, F. M., Verhulst, K. R., Rao, P., **Duren, R. M.**, Miller, C. E. (2018). Vista-LA: Mapping methane-emitting infrastructure in the Los Angeles megacity. *Earth System Science Data*. 10(1), 653-676. DOI: [10.5194/essd-10-653-2018](https://doi.org/10.5194/essd-10-653-2018)
46. USGCRP, 2018: *Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report* [Cavallaro, N., G. Shrestha, R. Birdsey, M. A. Mayes, R. G. Najjar, S. C. Reed, P. Romero-Lankao, and Z. Zhu (eds.)]. **R. Duren** contributing author to Chapter 4: Understanding Urban Carbon Fluxes and Chapter 18: Carbon cycle science in support of decision making, U.S. Global Change Research Program, Washington, DC, USA, 878 pp., <https://doi.org/10.7930/SOCCR2.2018>
47. CCST, 2018: Long-Term Viability of Underground Natural Gas Storage in California [Long, Jane C.S.; Birkholzer, Jens T.; Mace, Amber J.; Brady, Sarah E., eds]; Lead authors: Fischer, M., **Duren, R.**: Section 1.5: Quantification of greenhouse gas emissions from underground gas storage in California, California Council on Science and Technology, <https://ccst.us/reports/long-term-viability-of-underground-natural-gas-storage-in-california-an-independent-review-of-scientific-and-technical-information/>
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51. Thompson, D.R., A. K. Thorpe, C. Frankenberg, R. O. Green, **R. Duren**, L. Guanter, A. Hollstein, E. Middleton, L. Ong, S. Ungar (2016). Space-based Remote Imaging Spectroscopy of the Aliso Canyon CH₄ Super-emitter, *Geophys. Res. Let.*, doi: 10.1002/2016GL069079
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57. Kuai, L., G. Hulley, J. Worden, F. M. Hopkins, King-Fai Li, C. E. Miller, S. Hook, **R. Duren**, A. Aubrey (2016). Characterization of anthropogenic methane plumes with the Hyperspectral Thermal Emission Spectrometer (HyTES): a retrieval method and error analysis, *Atmos. Meas. Tech.*, doi:10.5194/amt-2015-40
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59. Viatte, C., Lauvaux T., Hedelius J. K., Parker H., Chen J., Jones T., Franklin J. E., Deng A.J., Gaudet B., **Duren R.**, Verhulst K., Wunch D., Roehl C., Dubey M. K., Wofsy S., Wennberg P. O.(2016). Estimating methane emissions from dairies in the Los Angeles Basin, *Atmos. Chem. Phys.*
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SELECTED INVITED TALKS & PANELS

- *National Petroleum Council, Greenhouse Gases study workshop, Ft Collins 2023*
- *European Geophysical Union, Vienna, 2023*
- *United Nations Framework Convention on Climate Change, Conference of Parties, Sharm El Sheikh, 2022*
- *Global Methane, Climate and Clean Air Forum, Washington, 2022*
- *Summit of the Americas, Methane Mitigation Leadership in the Americas, Los Angeles, 2022*
- *United States House of Representatives Committee on Science, Space and Technology, testimony on Detecting and Quantifying Methane Emissions from the Oil and Gas Sector, Washington, 2022*
- *California Department of Food and Agriculture Board Meeting, Sacramento, 2022*
- *NAS BASC study: Greenhouse Gas Emissions Monitoring, Inventories, and Data Integration, 2022.*
- *United Nations Framework Convention on Climate Change, Conference of Parties, Glasgow, 2021*
- *Methane Detection Technology Workshop, US EPA, 2021*
- *United States House of Representatives Space & Aeronautics Subcommittee, testimony on NASA's Earth Science and Climate Change Activities: Current Roles and Future Opportunities, Washington, 2021*
- *CH₄ Connections, Understanding Methane Emissions from NG Systems, Ft Collins, 2021*
- *American Geophysical Union, San Francisco, 2020*
- *AAAS annual meeting, California Methane Monitoring, Austin, 2018*
- *Gas Technology Institute, Methane monitoring, Ft Collins, 2018*
- *Gordon Conference on Climate Engineering, Engineering Aspects & Outdoor Experimentation, 2017*
- *National Academy of Science - Polar Research Board, Arctic Climate Interventions, Washington, 2016*
- *DOE Workshop on Research Strategies on Oil and Gas Sector Methane Emissions, Washington, 2016*
- *AIAA Space Forum, Earth Observations: Space and the Paris Agreement, Long Beach, 2016*
- *American Geophysical Union, Climate Intervention Research, San Francisco, 2015*
- *AAAS annual meeting, Geoengineering risks/challenges, San Jose, 2015*
- *California Climate Symposium, Megacities Carbon Project and CA methane, Sacramento, 2015*
- *Bureau International des Poids et Mesures meeting on Greenhouse Gas monitoring, Megacities Carbon Project, Paris, 2015*
- *United Nations Framework Convention on Climate Change, Conference of Parties, Lima, 2014*
- *California Air Resources Board, directors meeting, Megacities Carbon Project, Sacramento, 2014*
- *Council on Foreign Relations, Geoengineering risks, Washington, 2014*
- *Bipartisan Policy Center, Solar Radiation Management field research, Washington, 2014*
- *American Geophysical Union, San Francisco, 2014*
- *National Academy of Engineering, Geoengineering, Irvine, 2013*
- *Von Karman Lecture Series, Geoengineering and Climate Intervention, Pasadena, 2013*
- *Defense Science Board Task Force on Climate Change, Arlington, 2011*
- *AAAS, Carbon Monitoring Systems, Washington, 2010 and 2009*
- *Intergovernmental Panel on Climate Change (IPCC) Task Force on Inventories, Expert Meeting on Greenhouse Gas Inventory Validation and Uncertainties, Utrecht, 2010*
- *US Senate Science and Technology Caucus, Washington, 2010*
- *National Academy of Engineering Frontiers of Engineering, Kepler mission, Irvine, 2009*

- *International Council On Systems Engineering (INCOSE)*, Keynote Speaker, Syracuse, 2005.

PUBLIC OUTREACH

- Print, television, and radio interviews with the *Associated Press*, *Reuters*, *Marketplace*, *Washington Post*, *New York Times*, *NPR*, *BBC*, *PBS News Hour*, *Los Angeles Times*, *KCRW*, *KQED*, *KCET*, *Nature news*, *New Yorker*, *NBC Nightly News*, *Bloomberg*, *Agence France-Press*, *Climate Wire*, *Earth magazine*, *Science Now*, *Scientific American*, *Space News*, *Voice of America*, *The Weather Channel*, *Barron's*, *Blue Dot Report*, *Vox*, *Reveal*, others.
- Numerous public lectures 2000-present