DANIEL J. VARON

Curriculum Vitae | 18 April 2024
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29 Oxford St | Cambridge, MA 02138

EDUCATION

Ph.D., Atmospheric Chemistry, Harvard University — 2015 – 2020
M.Sc., Applied Mathematics
Secondary field in Computational Science & Engineering
Faculty mentor: Daniel Jacob

B.A., English Literature, McGill University — 2010 – 2014
First Class Honours
Faculty mentor: David Hensley

B.Sc., Physics, McGill University — 2009 – 2014
First Class Honours
Faculty mentors: Shaun Lovejoy, Tracy Webb

PROFESSIONAL EXPERIENCE

Research Associate, Harvard University — 2023 –
School of Engineering and Applied Sciences

Visiting Postdoctoral Research Associate, Princeton University — 2021 – 2023
School of Public and International Affairs
Faculty host: Denise Mauzerall

Postdoctoral Research Fellow, Harvard University — 2020 – 2023
School of Engineering and Applied Sciences
Faculty mentor: Daniel Jacob

PUBLICATIONS (*submitted, †advisee)

h-index = 19, total citations = 1788 (as of 18 April 2024 on Google Scholar)

*38. Zhao, S., Zhang, Y., Zhao, S., Wang, X., and **Varon, D. J.**: Deep-transfer-learning-assisted detection of methane super-emitters in oil and gas fields using Sentinel-2 observations, submitted to *Rem. Sens. Env.*, 2023.

*37. Hakkarainen, J., Ialongo, I. **Varon, D. J.**, Kuhlmann, G. and Krol, M. C.: Linear Integrated Mass Enhancement: A method for estimating hotspot emission rates from space-based plume observations, submitted to *Rem. Sens. Env.*, 2023.

*36. Harris, S. and 67 co-authors including **D. J. Varon**: Methane emissions from the Nord Stream subsea pipeline leaks, submitted to *Nature*, in review, 2023.

*35. **Varon, D. J.**, Jervis, D., Pandey, S., Gallardo, S. L., Balasus, N., Yang, L. H., and Jacob, D. J.: Quantifying NO_x point sources with Landsat and Sentinel-2 satellite observations of NO_2 plumes, submitted to *Proc. Natl. Acad. Sci.*, in review, 2023. [PDF]

34. Nathan, B., Maasakkers, J. D., Naus, S., Gautam, R., Omara, M., **Varon, D. J.**, Sulprizio, M. P., Lorente, A., Borsdorff, T., Parker, R. J., and Aben, I.: Assessing methane emissions from collapsing Venezuelan oil production using TROPOMI, *EGUsphere* [preprint], https://doi.org/10.5194/egusphere-2023-2887, accepted, 2023.

33. Bruno, J., Jervis, D., **Varon, D. J.**, and Jacob, D. J.: U-Plume: Automated algorithm for plume detection and source quantification by satellite point-source imagers, *EGUsphere* [preprint], https://doi.org/10.5194/egusphere-2023-1343, accepted, 2023.

32. Dogniaux, M., Maasakkers, J. D., **Varon, D. J.**, and Aben, I.: Report on Landsat 8 and Sentinel-2B observations of the Nord Stream 2 pipeline methane leak, [preprint] https://eartharxiv.org/repository/view/5791, *Atmos. Meas. Tech.*, accepted, 2023.

31. He, T.-L., Boyd, R. J., **Varon, D. J.**, and Turner, A. J.: Increased methane emissions from oil and gas following the Soviet Union's collapse, https://doi.org/10.1073/pnas.2314600121, *Proc. Natl. Acad. Sci.*, 2023.

30. [†]Watine-Guiu, M., **Varon, D. J.**, Irakulis-Loitxate, I., Balasus, N., and Jacob, D. J.: Geostationary satellite observations of extreme and transient methane emissions from oil and gas infrastructure, https://www.pnas.org/doi/10.1073/pnas.2310797120, *Proc. Natl. Acad. Sci.*, 2023.
Extensive media coverage: https://pnas.altmetric.com/details/157610226.

29. Schuit, B. J., Maasakkers, J. D., Bijl, P., Mahapatra, G., van den Berg, A.-W., Pandey, S., Lorente, A., Borsdorff, T., Houweling, S., **Varon, D. J.**, McKeever, J., Jervis, D., Girard, M., Irakulis-Loitxate, I., Gorroño, J., Guanter, L., Cusworth, D. H., and Aben, I.: Automated detection and monitoring of methane super-emitters using satellite data, *Atmos. Chem. Phys.*, 23, 9071–9098, https://doi.org/10.5194/acp-23-9071-2023, 2023.

28. Pendergrass, D. C., Jacob, D. J., Nesser, H., **Varon, D. J.**, Sulprizio, M., Miyazaki, K., and Bowman, K. W.: CHEEREIO 1.0: a versatile and user-friendly ensemble-based chemical data assimilation and emissions inversion platform for the GEOS-Chem chemical transport model, *Geosci. Model Dev.*, 16, 4793–4810, https://doi.org/10.5194/gmd-16-4793-2023, 2023.

27. Balasus, N., Jacob, D. J., Lorente, A., Maasakkers, J. D., Parker, R. J., Boesch, H., Chen, Z., Kelp, M. M., Nesser, H., and **Varon, D. J.**: A blended TROPOMI+GOSAT satellite data product for atmospheric methane using machine learning to correct retrieval biases, *Atmos. Meas. Tech.*, 16, 3787–3807, https://doi.org/10.5194/amt-16-3787-2023, 2023.

26. Pandey, S., van Nistelrooij, M., Maasakkers, J. D., Sutar, P., Houweling, S., **Varon, D. J.**, Tol, P., Gains, D., Worden, J., and Aben, I.: Daily detection and quantification of methane leaks using Sentinel-3: a tiered satellite observation approach with Sentinel-2 and Sentinel-5p, *Rem. Sens. Env.*, https://doi.org/10.1016/j.rse.2023.113716, 2023.

25. Radman, A., Mahdianpari, M., **Varon, D. J.**, and Mohammadimanesh, F.: S2MetNet: A novel dataset and deep learning benchmark for methane point source quantification using Sentinel-2 satellite imagery, *Rem. Sens. Env.*, https://doi.org/10.1016/j.rse.2023.113708, 2023. [PDF]

24. **Varon, D. J.**, Jacob, D. J., Hmiel, B., Gautam, R., Lyon, D. R., Omara, M., Sulprizio, M., Shen, L., Pendergrass, D., Nesser, H., Qu, Z., Barkley, Z. R., Miles, N. L., Richardson, S. J., Davis, K. J., Pandey, S., Lu, X., Lorente, A., Borsdorff, T., Maasakkers, J. D., and Aben, I.: Continuous weekly monitoring of methane emissions from the Permian Basin by inversion of TROPOMI satellite observations, *Atmos. Chem. Phys.*, https://doi.org/10.5194/acp-23-7503-2023, 2023.
Selected as Highlight Paper

23. Chen, Z., Jacob, D. J., Gautam, R., Omara, M., Stavins, R. N., Stowe, R. C., Nesser, H., Sulprizio, M. P., Lorente, A., Varon, D. J., Lu, X., Shen, L., Qu, Z., Pendergrass, D. C., and Hancock, S.: Satellite quantification of methane emissions and oil–gas methane intensities from individual countries in the Middle East and North Africa: implications for climate action, *Atmos. Chem. Phys.*, 23, 5945–5967, https://doi.org/10.5194/acp-23-5945-2023, 2023.

22. Lu, X., Jacob, D. J., Zhang, Y., Shen, L., Sulprizio, M. P., Maasakkers, J. D., **Varon, D. J.**, Qu, Z., Chen, Z., Hmiel, B., Parker, R. J., Boesch, H., Wang, H., He, C., and Fan, S.: Observation-derived 2010-2019 trends in methane emissions and intensities from US oil and gas fields tied to

activity metrics, *Proc. Natl. Acad. Sci.*, https://doi.org/10.1073/pnas.2217900120 2023.

21. Gorroño, J., **Varon, D. J.**, Irakulis-Loitxate, I., and Guanter, L.: Understanding the potential of Sentinel-2 for monitoring methane point emissions, *Atmos. Meas. Tech.*, 16, 89–107, https://doi.org/10.5194/amt-16-89-2023, 2023.

20. Zhang, Z., Sherwin, E. D., **Varon, D. J.**, and Brandt, A. R.: Detecting and quantifying methane emissions from oil and gas production: algorithm development with ground-truth calibration based on Sentinel-2 satellite imagery, *Atmos. Meas. Tech.*, 15, 7155–7169, https://doi.org/10.5194/amt-15-7155-2022, 2022.

19. Shen, L., Gautam, R., Omara, M., Zavala-Araiza, D., Maasakkers, J. D., Scarpelli, T. R., Lorente, A., Lyon, D., Sheng, J., **Varon, D. J.**, Nesser, H., Qu, Z., Lu, X., Sulprizio, M. P., Hamburg, S. P., and Jacob, D. J.: Satellite quantification of oil and natural gas methane emissions in the US and Canada including contributions from individual basins, *Atmos. Chem. Phys.*, 22, 11203–11215, https://doi.org/10.5194/acp-22-11203-2022, 2022.

18. Chen, Z., Jacob, D. J., Nesser, H., Sulprizio, M. P., Lorente, A., **Varon, D. J.**, Lu, X., Shen, L., Qu, Z., Penn, E., and Yu, X.: Methane emissions from China: a high-resolution inversion of TROPOMI satellite observations, *Atmos. Chem. Phys.*, 22, 10809–10826, https://doi.org/10.5194/acp-22-10809-2022, 2022.

17. Qu, Z., Jacob, D. J., Zhang, Y., Shen, L., **Varon, D. J.**, Lu, X., Scarpelli, T., Bloom, A., Worden, J., and Parker, R. J.: Attribution of the 2020 surge in atmospheric methane by inverse analysis of GOSAT observations, *Environ. Res. Lett.*, 17, 9, https://doi.org/10.1088/1748-9326/ac8754, 2022.

16. Maasakkers, J. D., **Varon, D. J.**, Elfarsdóttir, A., McKeever, J., Jervis, D., Mahapatra, G., Pandey, S., Lorente, A., Borsdorff, T., Foorthuis, L. R., Schuit, B. J., Tol, P., van Kempen, T. A., van Hees, R., and Aben, I.: Using satellites to uncover large methane emissions from landfills, *Sci. Adv.*, 8, 32, https://doi.org/10.1126/sciadv.abn9683, 2022.

15. 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.: Quantifying methane emissions from the global scale down to point sources using satellite observations of atmospheric methane, *Atmos. Chem. Phys.*, 22, 9617–9646, https://doi.org/10.5194/acp-22-9617-2022, 2022.

14. **Varon, D.J.**, Jacob, D. J., Sulprizio, M., Estrada, L. A., Downs, W. B., Shen, L., Hancock, S. E., Nesser, H., Qu, Z., Penn, E., Chen, Z., Lu, X., Lorente, A., Tewari, A., and Randles, C. A.: Integrated Methane Inversion (IMI 1.0): A user-friendly, cloud-based facility for inferring high-resolution methane emissions from TROPOMI satellite observations, *Geosci. Mod. Dev.*, 15, 5787–5805, https://doi.org/10.5194/gmd-15-5787-2022, 2022.

13. Sànchez-García, E., Gorroño, J., Irakulis-Loitxate, I., **Varon, D. J.**, and Guanter, L.: Mapping methane plumes at very high spatial resolution with the WorldView-3 satellite, *Atmos. Meas. Tech.*, 15, 1657–1674, https://doi.org/10.5194/amt-15-1657-2022, 2022.

12. Guanter, L., Irakulis-Loitxate, I., Gorroño, J., Sánchez-García, E., Cusworth, D. H., **Varon, D. J.**, Cogliati, S., and Colombo, R.: Mapping methane point emissions with the PRISMA spaceborne imaging spectrometer, *Rem. Sens. Env.*, https://doi.org/10.1016/j.rse.2021.112671, 2021.

11. Irakulis, I., Guanter, L., Liu, Y., **Varon, D. J.**, Maasakkers, J. D., Zhang, Y., Thorpe, A. K.. Duren, R. M., Frankenberg, C., Lyon, D., Cusworth, D. H., Zhang, Y., Seg, K., Gorroño, J., Sánchez-Garcia, E., Sulprizio, M. P., Cao, K., Zhu, H., Liang, J., Li, X., Aben, I., and Jacob, D. J.: Satellite-based Survey of Extreme Methane Emissions in the Permian Basin, *Sci. Adv.*, 7, 27, https://advances.sciencemag.org/content/7/27/eabf4507, 2021.

10. Lyon, D. R., Hmiel, B., Gautam, R., Omara, M., Roberts, K. A., Barkley, Z. R., Davis, K. J., Miles, N. L., Monteiro, V. C., Richardson, S. J., Conley, S., Smith, M. L., Jacob, D. J., Shen, L., **Varon, D. J.**, Deng, A., Rudelis, X., Sharma, N., Story, K. T., Brandt, A. R., Kang, M., Kort, E. A., Marchese, A. J., and Hamburg, S. P.: Concurrent variation in oil and gas methane emissions and oil price during the COVID-19 pandemic. *Atmos. Chem. Phys.*, 21, 6605–6626, https://doi.org/10.5194/acp-21-6605-2021, 2021.

9. **Varon, D. J.**, Jervis, D., McKeever, J., Spence, I., Gains, D., and Jacob, D. J.: High-frequency monitoring of anomalous methane point sources with multispectral Sentinel-2 satellite observations. *Atmos. Meas. Tech.*, 14, 2771–2785, https://doi.org/10.5194/amt-14-2771-2021, 2021.
Among *AMT*'s most downloaded: https://amt.copernicus.org/most_downloaded.html.
Selected as Highlight Paper

8. Jervis, D., McKeever, J., Durak, B. O. A., Sloan, J. J., Gains, D., **Varon, D. J.**, Ramier, A., Strupler, M., and Tarrant, E.: The GHGSat-D Imaging Spectrometer. *Atmos. Meas. Tech. Discuss.*, 14, 2127–2140, https://doi.org/10.5194/amt-14-2127-2021, 2021.

7. Cusworth, D. H., Duren, R. M., Thorpe, A. K., Pandey, S., Maasakkers, J. D., Aben, I., Jervis, D., **Varon, D. J.**, Jacob, D., J., Randles, C. A., Smith, M., Gautam, R., Omara, M., Schade, G., Dennison, P. E., Frankenberg, C., Gordon, D., Lopinto, E., and Miller, C. E.: Multi-satellite imaging of a gas well blowout enables quantification of total methane emissions. *Geophys. Res. Lett.*, 48, 2, https://doi.org/10.1029/2020GL090864, 2020.

6. **Varon, D. J.**, Jacob, D. J., McKeever, J., and Jervis, D.: Quantifying time-averaged methane emissions from individual coal mine vents with GHGSat-D satellite observations. *Environ. Sci. Tech.*, 54, 16, 10246–10253, https://doi.org/10.1021/acs.est.0c01213, 2020.

5. Zhang, Y., Gautam, R., Pandey, S., Omara, M., Maasakkers, J. D., Sadavarte, P., Lyon, D., Nesser, H., Sulprizio, M. P., **Varon, D. J.**, Zhang, R., Houweling, S., Zavala-Araiza, D., Alvarez, R. A., Lorente, A., Hamburg, S. P., Aben, I., and Jacob, D. J.: Quantifying methane emissions from the largest oil producing basin in the U.S. from space. *Science Advances*, 6, 17, https://www.science.org/doi/10.1126/sciadv.aaz5120, 2020.

4. Cusworth, D. H., Jacob, **D. J., Varon**, D. J., Chan Miller, C., Liu, X., Chance, K., Thorpe, A. K., Duren, R. M., Miller, C. E., Thompson, D. R., Frankenberg, C., Guanter, L., and Randles, C. A.: Potential of next-generation imaging spectrometers to detect and quantify methane point sources from space, *Atmos. Meas. Tech.*, 12, 5655–5668, https://doi.org/10.5194/amt-12-5655-2019, 2019.

3. **Varon, D. J.**, McKeever, J., Jervis, D., Maasakkers, J. D., Pandey, S., Houweling, S., Aben, I., Scarpelli, T., and Jacob, D. J.: Satellite discovery of anomalously large methane point sources from oil/gas production. *Geophys. Res. Lett.*, 46, 22, https://doi.org/10.1029/2019GL083798, 2019.
Extensive media coverage: https://wiley.altmetric.com/details/69396084.

2. **Varon, D. J.**, Jacob, D. J., McKeever, J., Jervis, D., Durak, B. O. A., Xia, Y., and Huang, Y.: Quantifying methane point sources from fine-scale satellite observations of atmospheric methane plumes. *Atmos. Meas. Tech.*, 11, 5673–5686, https://doi.org/10.5194/amt-11-5673-2018, 2018.
Among *AMT*'s most downloaded: https://amt.copernicus.org/most_downloaded.html

1. Lovejoy, S., Schertzer, S., and **Varon, D. J.**: Do GCMs predict the climate... or macro-weather? *Earth System Dynamics* 4, 439–454. http://www.earth-syst-dynam.net/4/439/2013/esd-4-439-2013.html, 2013.

RESEARCH SUPPORT

2023 *Continuous weekly monitoring of methane emissions from the Permian Basin*, GHGSat Inc., $35,000, PI

PRESENTATIONS

Invited talks

2024 MIT, Department of Civil and Environmental Engineering (CEE) seminar
2024 Methane Emissions Technology Alliance (META) seminar, Stanford University
2024 Harvard University, Atmospheric & Environmental Chemistry (AEC) seminar
2023 NASA GES DISC seminar
2023 SRON Netherlands Institute for Space Research, Leiden
2023 NOAA National Environmental Satellite, Data, and Information Service (NESDIS) meeting
2023 NASA Goddard Space Flight Center, Atmospheric Chemistry and Dynamics Lab seminar
2022 University of Wisconsin-Madison, Satellite Data for Energy Analysis and Policy conference
2022 MIT, Department of Earth, Atmospheric and Planetary Sciences (EAPS) seminar
2021 NASA Jet Propulsion Laboratory, Carbon Club seminar
2021 University of Washington, Department of Atmospheric Sciences seminar
2021 Stanford University, Energy Resources Engineering seminar
2019 American Geophysical Union Fall Meeting (U14C-10)
2019 SRON Netherlands Institute for Space Research, Utrecht

Conference presentations

2024 American Meteorological Society 104th Annual Meeting (AMS)
2023 American Geophysical Union Fall Meeting (A11A-03)
2023 Committee on Earth Observation Satellites (CEOS) Joint AC/VC-19 Meeting, Brussels
2023 19th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-19)
2023 International Coordination Workshop on Detection of Anthropogenic Methane Emissions from High-Resolution Satellites, Harvard University
2022 American Geophysical Union Fall Meeting (A13E-06)
2022 American Meteorological Society 102nd Annual Meeting (AMS)
2021 17th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-17)
2020 MIT A+B Applied Energy Symposium (MITAB)
2019 American Geophysical Union Fall Meeting (A53F-03)
2019 15th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-15)
2019 Industrial Methane Measurements Conference, Rotterdam NL (IMM)
2018 14th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-14)
2017 American Geophysical Union Fall Meeting (A32D-07)

Selected poster presentations

2023 American Geophysical Union Fall Meeting (INV33A-0886)
2023 Carbon Monitoring System Meeting, Pasadena, CA
2021 American Geophysical Union Fall Meeting (B25G-1538)
2018 American Geophysical Union Fall Meeting (A43R-3443)

TEACHING EXPERIENCE

Teaching assistant

Atmospheric Chemistry, Harvard University 2017

- Overall teaching score of 4.7/5.0 based on student reviews
- Awarded Harvard Certificate of Distinction in Teaching
- Responsibilities included developing new class materials, leading class discussions, writing and grading all assignments, and meeting with students individually.

MENTORING

Undergraduate students

- Chevaugn Campbell (Kenyon College), 2022. Landsat methane retrievals.
- Daniel Shen (Harvard University), 2021. Sentinel-2 methane retrievals.

Graduate students

- François Martin-Monier (MSc, ETH Zürich), 2023. ML-based Sentinel-2 methane detection.
- Marc Watine (MSc, ETH Zürich), 2023. Geostationary satellite methane retrievals.

AWARDS AND FELLOWSHIPS

Sigma Xi Honor Society	2019
AGU Outstanding Student Presentation Award	2018
Harvard University Certificate of Distinction in Teaching	2017
Stonington Graduate Fellowship of Environmental Science and Engineering	2015
McGill University Dean's Honour List	2014
Numerous B.Sc. research fellowships	2011 – 2013

SERVICE

Editor *Atmospheric Measurement Techniques*, Associate Editor

Board Member Methane Emissions Detection Using Satellites Assessment (MEDUSA) Advisory Board
ESA project led by SRON Netherlands Institute for Space Research

Reviewer *Atmospheric Chemistry & Physics*, *Atmospheric Measurement Techniques*, *Environmental Research Letters*, *Environmental Science & Technology*, *Geophysical Research Letters*, *Geoscientific Model Development*, *Journal of Geophysical Research: Atmospheres*, *Nature Climate Change*, *Nature Communications*, *Nature Scientific Reports*, *One Earth*, *Remote Sensing of Environment*, *Science Advances*, *Science of the Total Environment*

NASA review panel (2021; 2023), NOAA proposal reviewer (2023)

Convener Local to Regional Sources, 20th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-20), 2024

Data-Driven Methods for Quantifying Atmospheric Composition: Advances in Computation and Statistical Learning, (A11C and A12D) AGU Fall Meeting 2023

International Measurements of Methane Emissions from the Fossil Fuel Industries, (A015) AGU Fall Meeting 2020.

Leader Co-chair, *Methane Subgroup*, Harvard Atmospheric Chemistry Modeling Group (ACMG)

Chair, *Point Source Subgroup*, Harvard ACMG

Co-chair, *Statistical Learning for Atmospheric Chemistry* seminar series (2022–present)

Co-chair, Machine Learning & Data Science Subgroup, Harvard ACMG (2021–2022)

Participant IPCC Expert Meeting on Use of Atmospheric Observation Data in Emission Inventories, Geneva, September 2022

Organizer *Building an inclusive community in EPS/ESE: Addressing gender-based discrimination and harassment.* Department-wide event, February 2018.

2020 #ShutdownSTEM meeting, Harvard ACMG

Member American Geophysical Union, European Geosciences Union

Volunteer AstroMcGill astronomy outreach program, 2014