

# DANIEL J. VARON

Curriculum Vitae | 8 July 2023

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## EDUCATION

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|---|-------------|
| <b>Ph.D., Atmospheric Chemistry</b> , Harvard University<br>M.Sc., Applied Mathematics<br>Secondary field in Computational Science & Engineering<br><i>Faculty mentor: Daniel Jacob</i> | 2015 – 2020 |
| <b>B.A., English Literature</b> , McGill University<br>First Class Honours<br><i>Faculty mentor: David Hensley</i>  | 2010 – 2014 |
| <b>B.Sc., Physics</b> , McGill University<br>First Class Honours<br><i>Faculty mentors: Shaun Lovejoy, Tracy Webb</i>   | 2009 – 2014 |

## PROFESSIONAL EXPERIENCE

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|---|-------------|
| <b>Research Associate</b> , Harvard University<br>School of Engineering and Applied Sciences  | 2023 –      |
| <b>Visiting Postdoctoral Research Associate</b> , Princeton University<br>School of Public and International Affairs<br><i>Faculty host: Denise Mauzerall</i> | 2021 – 2023 |
| <b>Postdoctoral Research Fellow</b> , Harvard University<br>School of Engineering and Applied Sciences<br><i>Faculty mentor: Daniel Jacob</i>                 | 2020 – 2023 |

## PUBLICATIONS (\*SUBMITTED)

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h-index = 17, total citations = 1138 (as of 8 July 2023 on [Google Scholar](https://scholar.google.com/))

Students I supervise identified by †

- \*31. †Watine-Guiu, M., **Varon, D. J.**, Irakulis-Loitxate, I., Balasus, N., and Jacob, D. J.: Geostationary satellite observations of extreme methane emissions from a natural gas pipeline, EarthArXiv [preprint] <https://doi.org/10.31223/X5K661>, 2023.
- \*30. Bruno, J. H., Jervis, D., **Varon, D. J.**, and Jacob, D. J.: U-Plume: Automated algorithm for plume detection and source quantification by satellite point-source imagers, submitted to Atmos. Meas. Tech., 2023.
- \*29. 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, EGUsphere [preprint], <https://doi.org/10.5194/egusphere-2023-616>, 2023.
- \*28. 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. Discuss.* [preprint], <https://doi.org/10.5194/amt-2023-47>, in review, 2023.

27. 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.*, [preprint] <https://arxiv.org/abs/2212.11318>, accepted, 2023.
26. Radman, A., Mahdianpari, M., **Varon, D. J.**, and Mohammadimanesh, F.: Methane point source quantification using Sentinel-2 satellite observations and deep learning models, *Rem. Sens. Env.*, in press, 2023.
25. 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. Discuss.* [preprint], <https://doi.org/10.5194/acp-2022-862>, accepted, 2023.
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. Discuss.* [preprint], <https://doi.org/10.5194/acp-2022-749>, in press, 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. Sánchez-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-García, 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](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](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.

## PRESENTATIONS

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### Invited talks

- 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 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

### Conference presentations

- 2022 American Geophysical Fall Meeting ([A13E-06](#))
- 2022 American Meteorological Society 102nd Annual Meeting (AMS)
- 2020 16th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-16)
- 2020 MIT A+B Applied Energy Symposium (MITAB)
- 2019 American Geophysical Fall Meeting ([A53F-03](#))
- 2019 15th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-15)
- 2019 Industrial Methane Measurements Conference (IMM)
- 2018 14th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-14)
- 2017 American Geophysical Union Fall Meeting ([A32D-07](#))

### Selected poster presentations

- 2021 American Geophysical Union Fall Meeting ([B25G-1538](#))
- 2018 American Geophysical Union Fall Meeting ([A43R-3443](#))

## TEACHING EXPERIENCE

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### 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

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### 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

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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

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<b>Convener</b>	International Measurements of Methane Emissions from the Fossil Fuel Industries, ( <a href="#">A015</a> ) AGU Fall Meeting 2020.
<b>Reviewer</b>	<i>Atmospheric Chemistry &amp; Physics, Atmospheric Measurement Techniques, Environmental Research Letters, Environmental Science &amp; Technology, Geophysical Research Letters, Nature Scientific Reports, One Earth, Remote Sensing of Environment, Science Advances, Science of the Total Environment</i>  NASA ACCDAM review panel (2021), NOAA AC4 reviewer (2023).
<b>Leader</b>	Co-chair, <i>Methane Subgroup</i> , Harvard Atmospheric Chemistry Modeling Group (ACMG) Co-chair, <i>Machine Learning &amp; Data Science Subgroup</i> , Harvard ACMG Chair, <i>Point-source subgroup</i> , Harvard ACMG
<b>Participant</b>	IPCC Expert Meeting on Use of Atmospheric Observation Data in Emission Inventories, Geneva, September 2022
<b>Member</b>	American Geophysical Union
<b>Organizer</b>	<i>Building an inclusive community in EPS/ESE: Addressing gender-based discrimination and harassment.</i> Department-wide event, February 2018.  <i>2020 #ShutdownSTEM meeting</i> , Harvard ACMG

**Volunteer**    AstroMcGill astronomy outreach program, 2014