

Viral Shah, Ph.D.

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RESEARCH INTERESTS

My work seeks to elucidate the factors that control the chemical composition of the atmosphere and the effects of human emissions that lead to air pollution, ecosystem damage, and climate change. This entails developing global atmospheric chemistry models and using them in synergy with observations from ground sites, aircraft, and satellites to investigate fundamental atmospheric processes. In addition, I use atmospheric chemistry models to assess the environmental impacts of engineered systems.

EDUCATION

- 2018** **Ph.D. in Atmospheric Sciences**, University of Washington, Seattle, WA
Faculty Advisor: Lyatt Jaeglé
Dissertation: Sources, chemistry, and transport of urban aerosols and oxidized mercury: An analysis combining aircraft and surface observations with a chemical transport model
- 2008** **M.S. in Civil & Environmental Engineering**
University of Pittsburgh, Pittsburgh, PA
- 2004** **B. Tech. in Civil Engineering**
Indian Institute of Technology, Bombay, India

RESEARCH EXPERIENCE

- 2018–** **Postdoctoral Fellow**, Harvard John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, MA
Faculty Mentor: Daniel J. Jacob

PUBLICATIONS

(7 first-author, 19 coauthored, Google Scholar h-index:10; i10-index:11)

Selected Publications

1. **Shah, V.**, and 7 others (2019), Effect of changing NO_x lifetime on the seasonality and long-term trends of satellite-observed tropospheric NO₂ columns over China, *Atmos Chem Phys Discuss.* doi: [10.5194/acp-2019-670](https://doi.org/10.5194/acp-2019-670) (in review)
2. **Shah, V.**, and 14 others (2019), Widespread pollution from secondary sources of organic aerosols during winter in the northeastern United States. *Geophys Res Lett*, 46(5), 2974–2983. doi:[10.1029/2018GL081530](https://doi.org/10.1029/2018GL081530)
3. **Shah, V.**, and 18 others (2018), Chemical feedbacks weaken the wintertime response of particulate sulfate and nitrate to emissions reductions over the eastern United States, *Proc Natl Acad Sci USA*, 115(32), 8110. doi:[10.1073/pnas.1803295115](https://doi.org/10.1073/pnas.1803295115)
4. **Shah, V.**, and 24 others (2016), Origin of oxidized mercury in the summertime free troposphere over the southeastern US, *Atmos Chem Phys*, 16(3), 1511–1530. doi:[10.5194/acp-16-1511-2016](https://doi.org/10.5194/acp-16-1511-2016)

Additional Publications

5. Li, K., and 8 others including **Shah, V.** (2019), A two-pollutant strategy for improving ozone and particulate air quality in China. *Nat Geosci.* doi:[10.1038/s41561-019-0464-x](https://doi.org/10.1038/s41561-019-0464-x)
6. Green, J. R., and 16 others including **Shah, V.** (2019), Rates of wintertime atmospheric SO₂ oxidation based on aircraft observations during clear sky conditions over the eastern U.S. *J Geophys Res Atmos.* 124, 6630–6649. doi:[10.1029/2018JD030086](https://doi.org/10.1029/2018JD030086)
7. Holmes, C. D., and 5 others including **Shah, V.** (2019), The role of clouds in the tropospheric NO_x cycle: A new modeling approach for cloud chemistry and its global implications. *Geophys Res Lett.* 46, 4980– 4990. doi:[10.1029/2019GL081990](https://doi.org/10.1029/2019GL081990)
8. Sullivan, A. P., and 13 others including **Shah, V.** (2019), Biomass burning markers and residential burning in the WINTER aircraft campaign. *J Geophys Res: Atmos.* 124(3), 1846–1861. doi:[10.1029/2017JD028153](https://doi.org/10.1029/2017JD028153)
9. Shao, J., and 13 others including **Shah, V.** (2019), Heterogeneous sulfate aerosol formation mechanisms during wintertime Chinese haze events: air quality model assessment using observations of sulfate oxygen isotopes in Beijing. *Atmos Chem Phys*, 19(9), 6107–6123. doi:[10.5194/acp-19-6107-2019](https://doi.org/10.5194/acp-19-6107-2019)
10. Marais, E. A., and 10 others including **Shah, V.** (2018), Nitrogen oxides in the global upper troposphere: interpreting cloud-sliced NO₂ observations from the OMI satellite instrument. *Atmos Chem Phys*, 18(23), 17017–17027. doi:[10.5194/acp-18-17017-2018](https://doi.org/10.5194/acp-18-17017-2018)
11. Huang, J., Jaeglé, L., and **Shah, V.** (2018), Using CALIOP to constrain blowing snow emissions of sea salt aerosols over Arctic and Antarctic sea ice. *Atmos Chem Phys*, 18(22), 16253–16269. doi:[10.5194/acp-18-16253-2018](https://doi.org/10.5194/acp-18-16253-2018)
12. Jaeglé, L., **Shah, V.**, and 23 others (2018), Nitrogen oxides emissions, chemistry, deposition, and export over the northeast United States during the WINTER aircraft campaign. *J Geophys Res: Atmos.* 123(21), 12368–12393. doi:[10.1029/2018JD029133](https://doi.org/10.1029/2018JD029133)
13. Haskins, J. D., Jaeglé, L., **Shah, V.**, and 13 others (2018), Wintertime gas-particle partitioning and speciation of inorganic chlorine in the lower troposphere over the northeast United States and coastal ocean. *J Geophys Res: Atmos.* 123(22), 12897–12916. doi:[10.1029/2018JD028786](https://doi.org/10.1029/2018JD028786)
14. Schroder, J. C., and 22 others including **Shah, V.** (2018), Sources and secondary production of organic aerosols in the northeastern United States during WINTER, *J Geophys Res: Atmos.* 123(14), 7771–7796. doi:[10.1029/2018JD028475](https://doi.org/10.1029/2018JD028475)
15. Lee, B. H., and 18 others including **Shah, V.** (2018), Airborne observations of reactive inorganic chlorine and bromine species in the exhaust of coal-fired power plants, *J Geophys Res: Atmos.* 123(19), 11225–11237. doi:[10.1029/2018JD029284](https://doi.org/10.1029/2018JD029284)
16. Kenagy, H. S., and 20 others including **Shah, V.** (2018), NO_x lifetime and NO_y partitioning during WINTER, *J Geophys Res: Atmos.* 123(17), 9813–9827. doi:[10.1029/2018JD028736](https://doi.org/10.1029/2018JD028736)
17. McDuffie, E. E., and 26 others including **Shah, V.** (2018), Heterogeneous N₂O₅ uptake during winter: Aircraft measurements during the 2015 WINTER campaign and critical evaluation of current parameterizations, *J Geophys Res: Atmos.* 123(8), 4345–4372. doi:[10.1002/2018JD028336](https://doi.org/10.1002/2018JD028336)
18. Carlton, A. G., and 35 others including **Shah, V.** (2018), Synthesis of the Southeast Atmosphere Studies: Investigating fundamental atmospheric chemistry questions, *Bull Amer Meteor Soc.* 99(3), 545–567. doi:[10.1175/BAMS-D-16-0048.1](https://doi.org/10.1175/BAMS-D-16-0048.1)
19. **Shah, V.**, and Jaeglé, L. (2017), Surface deposition of oxidized mercury dominated by production in the upper and middle troposphere, *Atmos Chem Phys*, 17(14), 8999–9017. doi:[10.5194/acp-17-8999-2017](https://doi.org/10.5194/acp-17-8999-2017)
20. Zhu, L., and 13 others including **Shah, V.** (2017), Formaldehyde (HCHO) As a hazardous air pollutant: Mapping surface air concentrations from satellite and inferring cancer risks in the United States, *Environ Sci Technol.* 51(10), 5650–5657. doi:[10.1021/acs.est.7b01356](https://doi.org/10.1021/acs.est.7b01356)
21. Chen, Q., Schmidt, J. A., **Shah, V.**, and 3 others (2017), Sulfate production by reactive bromine: Implications for the global sulfur and reactive bromine budgets, *Geophys Res Lett.* 44(13), 7069–7078. doi:[10.1002/2017GL073812](https://doi.org/10.1002/2017GL073812)

22. Song, S., and 20 others including **Shah, V.** (2016), Constraints from observations and modeling on atmosphere–surface exchange of mercury in eastern North America, *Elementa: Science of the Anthropocene*, 4. doi:[10.12952/journal.elementa.000100](https://doi.org/10.12952/journal.elementa.000100)
23. Gratz, L. E., and 23 others including **Shah, V.** (2015), Oxidation of mercury by bromine in the subtropical Pacific free troposphere, *Geophys Res Lett*, 42(23), 10494–10502. doi:[10.1002/2015GL066645](https://doi.org/10.1002/2015GL066645)
24. Jaffe, D. A., and 30 others including **Shah, V.** (2014), Progress on understanding atmospheric mercury hampered by uncertain measurements, *Environ Sci Technol*, 48 (13), 7204–7206. doi:[10.1021/es5026432](https://doi.org/10.1021/es5026432)
25. **Shah, V.**, and Ries, R.J. (2009), A characterization model with spatial and temporal resolution for life cycle impact assessment of photochemical precursors in the United States, *Int J Life Cycle Assess*, 14 (4), 313–327. doi:[10.1007/s11367-009-0084-6](https://doi.org/10.1007/s11367-009-0084-6)
26. **Shah, V.**, Col Debella, D., and Ries, R.J. (2008), Life cycle assessment of residential heating and cooling systems in four regions of the United States, *Energy & Buildings*, 40 (4), 503–513. doi:[10.1016/j.enbuild.2007.04.004](https://doi.org/10.1016/j.enbuild.2007.04.004)

NEWS COVERAGE

- Origins of wintertime pollution. *Science*. Mar. 2019. <https://science.sciencemag.org/content/363/6434/1412.7>
- A new look at winter air quality in the eastern U.S. *Eos*, May 2019 <https://eos.org/research-spotlights/a-new-look-at-winter-air-quality-in-the-northeastern-united-states>
- Why are U.S. winter air pollution reductions less than summer? *Bull Am Met Soc*. Jan. 2019 http://www.viralshah.info/assets/files/BAMS_article.pdf
- Reducing one pollutant increases another. *Physics Today*. July 2018 <https://physicstoday.scitation.org/doi/10.1063/PT.6.1.20180727a/full/>
- Summers less smoggy now, but winter air hasn't improved. *US News & World Report*, July 2018 <https://health.usnews.com/health-care/articles/2018-07-27/summers-less-smoggy-now-but-winter-air-hasnt-improved>
- Why is winter air responding to pollution cuts so slowly? *Physics World*, July 2018 <https://physicsworld.com/a/why-is-winter-air-responding-to-pollution-cuts-so-slowly/>
- Study shows why eastern U.S. air pollution levels are more stagnant in winter. *UW News*, July 2018 <https://www.washington.edu/news/2018/07/23/study-shows-why-eastern-u-s-air-pollution-levels-are-more-stagnant-in-winter/>

SELECTED PRESENTATIONS

Talks

- Wintertime aerosols over the northeastern U.S.: Results from the 2015 WINTER campaign, NCAR Earth Observing Laboratory Seminar Series, Boulder, CO, Aug. 6, 2019 (invited)
- Using OMI NO₂ observations to evaluate NO_x emissions trends over China: influence of chemistry, NASA AURA Science Team Meeting, Pasadena, CA, Aug. 27–29, 2019.
- Using OMI NO₂ observations to evaluate seasonal trends in NO_x emissions over eastern China: influence of NO_x chemistry, International GEOS-Chem Meeting, Cambridge, MA, May 6–9, 2018
- Aircraft-based observations and modeling of wintertime submicron aerosol composition over the northeastern U.S. AGU Fall Meeting, San Francisco, CA, Dec. 11–15, 2017
- Distribution and sources of submicron aerosols during the WINTER 2015 aircraft campaign, International GEOS-Chem Meeting, Cambridge, MA, May 1–4, 2017
- Aircraft-based measurements and modeling of submicron aerosols over the northeastern U.S. during the WINTER 2015 campaign, AMS Annual Meeting, Seattle, WA, Jan. 22–26, 2017

Fast oxidation of elemental mercury in the subtropical troposphere, International Conference on Mercury as a Global Pollutant, Jeju, Korea, June 14–19, 2015
Constraining mercury oxidation using NOMADSS aircraft observations, International GEOS-Chem meeting, Cambridge, MA, May 4–7, 2015

Selected Posters

Tagging the origin of oxidized mercury in surface deposition, AGU Fall Meeting, San Francisco, CA, Dec. 12–16, 2016
NOMADSS observations suggest rapid oxidation of elemental mercury in the subtropical free troposphere, AGU Fall Meeting, San Francisco, CA, Dec. 15–19, 2014

TEACHING & ADVISING EXPERIENCE

Instructor of record

Responsible for the overall design and conduct of the course and issuing final grades.

- Climate and Climate Change (Summer 2017), University of Washington, Seattle, WA. 15 students.

Teaching Assistant/Associate

Gave guest lectures; led discussions; wrote and graded exams and assignments; and advised students.

- Climate and Climate Change (2014). University of Washington, Seattle, WA. 120 students, 4 sections.
- Air Pollution: From Urban Smog to Ozone Hole (2016). University of Washington, Seattle, WA. 10 students.
- Construction Management (2007). University of Pittsburgh, PA. 35 students.
- Engineering Mechanics (2006). University of Pittsburgh, PA. 40 students.

ADDITIONAL PROFESSIONAL EXPERIENCE

Construction Engineer, Turner Construction Company, New York, 2008–12
Structural Engineer, Sterling Engineering Consultancy Services, Mumbai, 2004–06

PROFESSIONAL SERVICE

Reviewer

Atmosphere, Atmospheric Chemistry and Physics, Atmospheric Environment, Geophysical Research Letters, Journal of Air and Waste Management Association, Journal of Advances in Modeling Earth Systems

Committee Work

Co-chair, Session on air pollution in urban airsheds, 2017 AGU Fall Meeting

Professional Affiliation

Member, American Geophysical Union, 2013–
Member, American Meteorological Society, 2016–17