Lei Zhu, Ph.D.

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SCHOLARLY PROFILE

My research goal is to better understand the processes determining the distribution of reactive gases and aerosols, and their implications for air quality, public health, and climate. My research program combines **remote sensing**, **modeling**, and **data assimilation** techniques.

Research Interests
- Atmospheric chemistry and its implications
- Monitoring of trace gases from space
- Modeling of atmospheric composition

RESEARCH EXPERIENCE

2018 – Post-doctoral Fellow in Astrophysics, Harvard-Smithsonian Center for Astrophysics
Faculty Advisor: Gonzalo Gonzalez Abad, Physicist
Project: Developing operational formaldehyde products from the OMPS satellites

2017 – Post-doctoral Fellow in Atmospheric chemistry, Harvard University
Faculty Advisor: Daniel J. Jacob, Vasco McCoy Family Professor of Atmospheric Chemistry and Environmental Engineering
Project: A comprehensive coupled model for tropospheric halogen chemistry

EDUCATION

2016 Ph.D. in Environmental Science and Engineering, Harvard University
Thesis: Observing atmospheric formaldehyde from space: validation and implications
Advisor: Daniel J. Jacob

2011 MSci. in Environmental Science, Peking University
Thesis: Monitoring SO_2 emissions in China using satellites
Advisor: Yu Song

2008 B.S. in Environmental Science, Nankai University

PUBLICATIONS

First-author

Zhu, **L.**, D. J. Jacob, S. D. Eastham *et al.*: Effect of sea-salt aerosol on tropospheric bromine chemistry, *Atmos. Chem. Phys. Discuss.*, https://doi.org/10.5194/acp-2018-1239, in review, 2018.

Zhu, L., L. J. Mickley, D. J. Jacob *et al.*: Long-term (2005–2014) trends in formaldehyde (HCHO) columns across North America as seen by the OMI satellite instrument: Evidence of changing emissions of volatile organic compounds, *Geophys. Res. Lett.*, 44, 7079–7086, 2017.

Zhu, L., D. J. Jacob, F. N. Keutsch *et al.*: 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, 5650–5657, 2017.

Zhu, L., D. J. Jacob, P. S. Kim *et al.*: Observing atmospheric formaldehyde (HCHO) from space: validation

and intercomparison of six retrievals from four satellites (OMI, GOME2A, GOME2B, OMPS) with SEAC^{4}RS aircraft observations over the southeast US, *Atmos. Chem. Phys*., 16, 13477–13490, 2016.

Zhu, L., D. J. Jacob, L. J. Mickley *et al*.: Anthropogenic emissions of highly reactive volatile organic compounds in eastern Texas inferred from oversampling of satellite (OMI) measurements of HCHO columns, *Environ. Res. Lett*., 9, 114004, 2014.

Zhu, L., X. Huang, H. Shi *et al*.: Transport pathways and potential sources of PM_{10} in Beijing, *Atmos. Environ*., 45, 594–604, 2011.

Submitted

Shen, L., D. J. Jacob, **L. Zhu** *et al.*: 2005-2016 trends of formaldehyde columns over China observed by satellites: increasing anthropogenic emissions of volatile organic compounds and decreasing agricultural fire emissions, submitted, 2019.

Zhang, Y. *et al*. including **L. Zhu**: Estimating emissions from the offshore oil and gas production cluster in the Gulf of Mexico using satellite observations, submitted, 2018.

Co-authorship

Wang, X. *et al*. including **L. Zhu**: The role of chlorine in tropospheric chemistry, *Atmos. Chem. Phys. Discuss*., https://doi.org/10.5194/acp-2018-1088, in review, 2018.

Song, S. *et al*. including **L. Zhu**: Possible heterogeneous hydroxymethanesulfonate (HMS) chemistry in northern China winter haze and implications for rapid sulfate formation, *Atmos. Chem. Phys. Discuss*., https://doi.org/10.5194/acp-2018-1015, in review, 2018.

Sun, K., **Zhu, L**., K. Cady-Pereira *et al*.: A physics-based approach to oversample multi-satellite, multispecies observations to a common grid, *Atmos. Meas. Tech*., 11, 6679–6701, 2018.

Kaiser, J., D. J. Jacob, **L. Zhu** *et al*.: High-resolution inversion of OMI formaldehyde columns to quantify isoprene emission on ecosystem-relevant scales: application to the southeast US, *Atmos. Chem. Phys*., 18, 5483–5497, 2018.

Miller, C. C. *et al*. including **L. Zhu**: Glyoxal yield from isoprene oxidation and relation to formaldehyde: chemical mechanism, constraints from SENEX aircraft observations, and interpretation of OMI satellite data, *Atmos. Chem. Phys*., 17, 8725–8738, 2017.

Travis, K. R. *et al*. including **L. Zhu**: Why do models overestimate surface ozone in the Southeast United States?, *Atmos. Chem. Phys*., 16, 13561–13577, 2016.

Fisher, J. A. *et al*. including **L. Zhu**: Organic nitrate chemistry and its implications for nitrogen budgets in an isoprene- and monoterpene-rich atmosphere: constraints from aircraft (SEAC^{4}RS) and ground-based (SOAS) observations in the Southeast US, *Atmos. Chem. Phys*., 16, 5969–5991, 2016.

Yu, K. *et al*. including **L. Zhu**: Sensitivity to grid resolution in the ability of a chemical transport model to simulate observed oxidant chemistry under high-isoprene conditions, *Atmos. Chem. Phys*., 16, 4369–4378, 2016.

Marais, E. A. *et al*. including **L. Zhu**: Aqueous-phase mechanism for secondary organic aerosol formation from isoprene: application to the southeast United States and co-benefit of SO_2 emission controls, *Atmos. Chem. Phys*., 16, 1603–1618, 2016.

Kim, P. S. *et al*. including **L. Zhu**: Sources, seasonality, and trends of southeast US aerosol: an integrated analysis of surface, aircraft, and satellite observations with the GEOS-Chem chemical transport model, *Atmos. Chem. Phys*., 15, 10411–10433, 2015.

Li, M., X. Huang, **L. Zhu** *et al*.: Analysis of the transport pathways and potential sources of PM_{10} in Shanghai based on three methods, *Sci. Tot. Environ*., 414, 525–534, 2012.

Huang, X. et al. including **L. Zhu**: Mercury Emissions from Biomass Burning in China, *Environ. Sci. Technol*., 45, 5650–5657, 2011.

Song, Y. *et al*. including **L. Zhu**: A new emission inventory for nonagricultural open fires in Asia from 2000 to 2009, *Environ. Res. Lett*., 5, 014014, 2011.

Wang, B., **L. Zhu**, Z. Gong *et al*.: Introduction to the methods of parameter estimation for environmental monitoring data set with truncated data below a detection limit, *Acta Science Circumstantiae*., 29, 1345–1350, 2009.

PRESENTATIONS

Talks

Satellite remote sensing for air quality applications, with a focus on formaldehyde (HCHO), SUSTech, Shenzhen, China, 2019, **(invited)**.

Modeling of tropospheric halogen (Cl-Br-I) chemistry: cycling, debromination, and impact, *The 1st Regional GEOS-Chem Asia Meeting*, Nanjing, China, 2018.

Mapping surface air concentrations from OMI and inferring cancer risks: implications for TEMPO, *TEMPO Science Meeting*, Cambridge, MA, 2017, **(invited)**.

Observing atmospheric formaldehyde from space: validation, intercomparison, trend analysis and public health implications, *AGU Fall Meeting*, San Francisco, CA, 2016.

Observing atmospheric formaldehyde from space: Validation, intercomparison, trend analysis and public health implications, *Aura Science Meeting*, Rotterdam, The Netherlands, 2016.

Mapping of surface formaldehyde (HCHO) from space for air quality management, *The 9th NASA Air Quality Applied Sciences Team Meeting*, St. Louis University, St. Louis, MO, 2015.

Validation of satellite HCHO observations (OMI, GOME-2B, OMPS) using SEAC^{4}RS data, *SEAC^{4}RS Science Meeting*, Caltech, Pasadena, CA, 2015.

Anthropogenic emissions of highly reactive volatile organic compounds inferred from oversampling of OMI HCHO columns, *EOS Aura Science Team Meeting 10th year anniversary celebration*, College Park, MD, 2014.

Anthropogenic emissions of highly reactive VOCs (HRVOCs) inferred from oversampling of OMI formaldehyde columns, *The 6th NASA Air Quality Applied Sciences Team Meeting*, Rice University, Houston, TX, 2014.

Math in Nature: finding order in chaos, at Harvard Medical School, *Science in News*, Boston, MA, 2013, **(invited)**.

Variability of HCHO over the United States: Implications for VOCs Emissions, *The 5th NASA Air Quality Applied Sciences Team Meeting*, University of Maryland, College Park, MD, 2013.

A spike in electricity demand due to severe summer heatwaves: Increase of SO_2 emissions detected from space, *The 18th Seminar of JSPS-MOE Core University Program*, Beijing, China, 2010.

Estimating of fire emissions in Boreal Siberia by satellite data sets, *The 6th Seminar of Environment Modeling and Pollution Controlling*, Beijing, China, 2009.

Posters and Abstracts

Effect of sea-salt aerosol on tropospheric bromine chemistry, *AGU Fall Meeting*, Washington, D.C., 2018.

Observing atmospheric formaldehyde from space: trend analysis and public health implications, *The 8th International GEOS-Chem Meeting*, Cambridge, MA, 2017.

Validation of satellite HCHO retrievals with aircraft (SEAC^{4}RS) observations, *Atmospheric Radiation Workshop*, NCAR, Boulder, CO, 2016.

Indirect validation of new OMI, GOME-2B and OMPS formaldehyde retrievals using SEAC^{4}RS data, *The 7th International Conference of GEOS-Chem*, Harvard University, Cambridge, MA, 2015.

Anthropogenic emissions of highly reactive volatile organic compounds inferred from oversampling of OMI HCHO columns, *AGU Fall Meeting*, San Francisco, CA, 2014.

Indirect validation of GOME-2/MetOp-A and B formaldehyde retrievals using SEAC^{4}RS data: Preliminary results, *The 7th NASA Air Quality Applied Sciences Team Meeting*, Harvard University, Cambridge, MA, 2014.

Indirect Validation of GOME-2/MetOp-A and B and New OMI formaldehyde (HCHO) retrievals using SEAC^{4}RS data: Preliminary results, *SEAC^{4}RS Science Meeting*, NIST, Boulder, CO, 2014.

Variability of HCHO over the Southeastern United States observed from space: Implications for VOC emissions, *AGU Fall Meeting*, San Francisco, CA, 2012.

Spikes in electricity demand during severe summer heat waves: Increased SO_2 emissions detected from space, *AGU Fall Meeting*, San Francisco, CA, 2010.

TEACHING & ADVISING EXPERIENCE

Teaching Assistant

Lab demonstrations/tutoring, grading, exam grading, offering weekly sections

- *Atmospheric Chemistry and Physics*, Graduate course, Harvard University, 12 students, 2017.
- *The Fluid Earth: Oceans, Atmosphere, and Climate*, Undergraduate course, Harvard University, 50 students, 2013.

Advising Experience

- 3 Undergraduate students
- 2 Graduate students

AWARDS & GRANTS

Fellowships

Harvard Graduate Consortium on Energy and Environment Fellowship	2014 – 2016
Graduate Scholarship, Peking University	2008 – 2010
China National Educational Opportunity Grant	2007
Undergraduate scholarship, Nankai University	2005 – 2006

Academic Recognition

NASA Group Achievement Award	2015
Graduate with honors, Nankai University	2008
Excellent All-round Student, Nankai University	2005 – 2007

Teaching

Harvard University Certificate of Distinction in Teaching	2013

PROFESSIONAL SERVICE

Committee Experience

OMPS Science Team Member	2018 –
TEMPO Science Team Member	2017 –
NASA Aura Science Team Member	2016 –
Chair of weekly Harvard Atmospheric Sciences seminar series	2016 – 2017
NASA SEAC^{4}RS Flight Campaign Team Member	2012 – 2015
NASA Air Quality Applied Sciences Team Science Team Member	2011 – 2015

Peer Review Journals

Atmosphere, Atmospheric Environment, Atmospheric Chemistry and Physics, Atmospheric Measurement Techniques, Environmental Science & Technology, Geophysical Research Letters, Journal of Geophysical Research, Remote Sensing

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