

**Lei Zhu, Ph.D.**

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**SCHOLARLY PROFILE**

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My research goal is to better understand processes governing the distributions of atmospheric species, and their implications for air quality, public health, and climate. My research program combines **remote sensing, modeling, and data assimilation** techniques.

My **research interests** include: atmospheric chemistry and its implications, modeling of atmospheric chemistry, and observing trace gases from space.

**PROFESSIONAL EXPERIENCE**

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2018 – 2019 Post-doctoral Fellow and Visiting Scientist, Harvard-Smithsonian Center for Astrophysics  
Faculty Advisor: Gonzalo Gonzalez Abad, Physicist  
Project: Developing operational formaldehyde products from the OMPS satellites

2017 – 2019 Post-doctoral Fellow, 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**

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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<sub>2</sub> emissions in China using satellites  
Advisor: Yu Song

2008 B.S. in Environmental Science, Nankai University

**PUBLICATIONS**

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**First or corresponding author (\*)**

**Zhu, L.\***, Jacob, D. J., Eastham, S. D., *et al.*: Effect of sea salt aerosol on tropospheric bromine chemistry, *Atmos. Chem. Phys.*, 19, 6497–6507, 2019.

**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<sup>4</sup>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<sub>10</sub> in Beijing, *Atmos. Environ.*, 45, 594–604, 2011.

### Co-authorship

- Shen, L., D. J. Jacob, **L. Zhu** *et al.*: The 2005–2016 Trends of Formaldehyde Columns Over China Observed by Satellites: Increasing Anthropogenic Emissions of Volatile Organic Compounds and Decreasing Agricultural Fire Emissions, *Geophys. Res. Lett.*, 46, 2019.
- Zhang, Y. *et al.* including **L. Zhu**: Satellite-Observed Changes in Mexico's Offshore Gas Flaring Activity Linked to Oil/Gas Regulations, *Geophys. Res. Lett.*, 46, 1879–1888, 2019.
- Wang, X. *et al.* including **L. Zhu**: The role of chlorine in tropospheric chemistry, *Atmos. Chem. Phys.*, 19, 3981–4003, 2019.
- Song, S. *et al.* including **L. Zhu**: Possible heterogeneous chemistry of hydroxymethanesulfonate (HMS) in northern China winter haze, *Atmos. Chem. Phys.*, 19, 1357–1371, 2019.
- 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<sup>4</sup>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<sub>2</sub> 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<sub>10</sub> 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.

## AWARDS & GRANTS

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### Academic Recognition

Recognized reviewer for <i>Atmospheric Pollution Research</i>	2019
Outstanding reviewer for <i>Atmospheric Environment</i>	2017
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
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### Fellowships

Smithsonian Astrophysical Observatory Visiting Scientist Fellowship	2019
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

## PRESENTATIONS

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### Talks

- Satellite remote sensing for air quality applications, with a focus on formaldehyde (HCHO), University of Illinois at Urbana–Champaign, Champaign, IL, 2019 **(invited)**.
- Satellite remote sensing for air quality applications, with a focus on formaldehyde (HCHO), Institute of Atmospheric Physics Chinese Academy of Sciences, Beijing, China, 2019, **(invited)**.
- Satellite remote sensing for air quality applications, with a focus on formaldehyde (HCHO), Peking University, Beijing, China, 2019 **(invited)**.
- Satellite remote sensing for air quality applications, with a focus on formaldehyde (HCHO), Southern University of Science and Technology, Shenzhen, China, 2019 **(invited)**.
- Modeling of tropospheric halogen (Cl-Br-I) chemistry: cycling, debromination, and impact, *The 1<sup>st</sup> 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 9<sup>th</sup> 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<sup>4</sup>RS data, *SEAC<sup>4</sup>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 10<sup>th</sup> year anniversary celebration*, College Park, MD, 2014.
- Anthropogenic emissions of highly reactive VOCs (HRVOCs) inferred from oversampling of OMI formaldehyde columns, *The 6<sup>th</sup> 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 5<sup>th</sup> 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<sub>2</sub> 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 6<sup>th</sup> Seminar of Environment Modeling and Pollution Controlling*, Beijing, China, 2009.

### Posters

Validation of satellite formaldehyde (HCHO) retrievals using aircraft observations and implication for TEMPO, *TEMPO Science Meeting*, University of Wisconsin–Madison, WI, 2019.

Effect of sea-salt aerosol on tropospheric bromine chemistry, *The 9<sup>th</sup> International Conference of GEOS-Chem*, Harvard University, Cambridge, MA, 2019.

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 8<sup>th</sup> International GEOS-Chem Meeting*, Cambridge, MA, 2017.

Validation of satellite HCHO retrievals with aircraft (SEAC<sup>4</sup>RS) observations, *Atmospheric Radiation Workshop*, NCAR, Boulder, CO, 2016.

Indirect validation of new OMI, GOME-2B and OMPS formaldehyde retrievals using SEAC<sup>4</sup>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<sup>4</sup>RS data: Preliminary results, *The 7<sup>th</sup> 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<sup>4</sup>RS data: Preliminary results, *SEAC<sup>4</sup>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<sub>2</sub> emissions detected from space, *AGU Fall Meeting*, San Francisco, CA, 2010.

## TEACHING & ADVISING EXPERIENCE

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### 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

## PROFESSIONAL SERVICE

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### Committee Experience

GEMS Science Team Member	2019 –
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 <sup>4</sup> 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, Atmospheric Pollution Research, Environmental Science & Technology, Geophysical Research Letters, Journal of Geophysical Research, Nature Climate Change, Remote Sensing

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