Xin Lan, Ph.D.

Research Scientist II,
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Education

University of Houston	Ph.D. in Atmospheric Science	2011-2014
University of New Hampshire	Ph.D. Study in Earth and Environmental Sciences	2010
Sun Yet-sen University	B.S. in Applied Meteorology	2006-2010

Employment

Research Scientist – CIRES, University of Colorado NOAA Global Monitoring Laboratory	2016-present
Post-Doctoral Fellow – National Research Council/ NOAA Global Monitoring Laboratory	2015-2016
Post-Doctoral Researcher – University of Houston	2015
Research Assistant – University of Houston	2011-2014
Research Assistant – University of New Hampshire	2010
Research Assistant – Sun Yat-sen University	2007-2010

Selected Paper Publications

Nisbet, E. G., Manning, M. R.,Dlugokencky, E. J., Michel, S. E., **Lan, X**., R.ckmann, T., et al. 2023. Atmospheric methane: Comparison between methane's record in 2006–2022 and during glacial terminations, *Global Biogeochemical Cycles*, https://doi.org/10.1029/2023GB007875

Nevison, C., **Lan, X**. and Ogle, S.M., 2023. Remote sensing soil freeze-thaw status and North American N2O emissions from a regional inversion. *Global Biogeochemical Cycles*, https://doi.org/10.1029/2023GB007759

Drinkwater, A., Palmer, P.I., Feng, L., Arnold, T., **Lan, X**., Michel, S.E., Parker, R. and Boesch, H., 2023. Atmospheric data support a multi-decadal shift in the global methane budget towards natural tropical emissions. *Atmospheric Chemistry and Physics*, *23*(14), pp.8429-845 https://doi.org/10.5194/acp-23-8429-2023.

Zhuang, Q., Guo, M., Melack, J. M., **Lan, X**., Tan, Z., Oh, Y., & Leung, L. R., 2023. Current and future global lake methane emissions: A process-based modeling analysis. *Journal of Geophysical Research: Biogeosciences*, 128, e2022JG007137. https://doi.org/10.1029/2022JG007137/acc1f7

Wittig, S., Berchet, A., Pison, I., Saunois, M., Thanwerdas, J., Martinez, A., Paris, J., Machida, T., Sasakawa, M., E. J. Worthy, D. E. J., **Lan, X.**, Thompson, R. L., Sollum, E., and Arshinov, M., 2022. Estimating Methane Emissions in the Arctic nations using surface observations from 2008 to 2019, Atmos. Chem. Phys, 2023, https://doi.org/10.5194/acp-23-6457-2023

Basu, S., **Lan, X**., Michel, S. E., Dlugokencky, E. J., Thoning, K. W., Bruhwiler, L. P., Miller, J. B., Schwietzke, S., and Tans, P. P., 2022. Estimating emissions of methane consistent with atmospheric measurements of methane and $\delta^{13}C$ of methane, *Atmos. Chem. Phys*., https://doi.org/10.5194/acp-22-15351-2022.

Peng, S., Lin, X., Thompson, R. L., Xi, Y., Liu, G., Hauglustaine, D., **Lan, X.**, Poulter, B., Ramonet, M., Saunois, M., Yin, Y., Zhang, Z., Zheng, B. and Ciais, P., 2022. Wetland emission and atmospheric sink changes explain methane growth in 2020, *Nature*, https://doi.org/10.1038/s41586-022-05447-w

Wang, F., Maksyutov, S., Janardanan, R., Tsuruta, A., Ito, A., Morino, I., Yoshida, Y., Tohjima, Y., Kaiser, J.W., **Lan, X**. and Zhang, Y., 2022. Atmospheric observations suggest methane emissions in north-eastern China growing with natural gas use. *Sci. Rep.*, *12*(1), 1-9.

Angot, H., Blomquist, B., Howard, D., Archer, S., Bariteau, L., Beck, I., Boyer, M., Crotwell, M., Helmig, D., Hueber, J., Jacobi, H.W., Jokinen, T., Kulmala, M., **Lan X**., et al. 2022. Year-round trace gas measurements in the central Arctic during the MOSAiC expedition. *Sci. Data*, *9*(1), 1-19.

Oh, Y., Zhuang, Q., Liu, L., Welp, L. R., **Lan, X**., Basu, S., Dlugokencky, E., Bruhwiler, L. P., Miller, J. B., Michel, S. E., Schwietzke, S., Tans, P. P., Ciais, P. and Chanton, J. P., 2022. Improved global wetland carbon isotopic signatures support post-2006 microbial methane emission increase, *Comm. Earth Environ.*, 3, 1-12.

Stell, A.C., Bertolacci, M., Zammit-Mangion, A., Rigby, M., Fraser, P.J., Harth, C.M., Krummel, P.B., **Lan, X**., Manizza, M., Mühle, J. and O'Doherty, S., 2022. Modelling the growth of atmospheric nitrous oxide using a global hierarchical inversion. *Atmos. Chem. Phys*., *22*(19), 12945-12960.

Bergamaschi, P., Segers,A., Brunner, D., Haussaire, J., Henne, S., Ramonet, M., Arnold, T., Biermann, T., Chen, H., Conil, S., Delmotte, M., Forster, G., Frumau, A., Kubistin, D., **Lan, X.**, Leuenberger, M., Lindauer, M., Lopez, M., Manca, G., Müller-Williams, J., O'Doherty, S., Scheeren, B., Steinbacher, M., Trisolino,P., Vítková, G., Kwok, C.Y, 2022. High-resolution inverse modelling of European CH_4 emissions using novel FLEXPART-COSMO TM5 4DVAR inverse modelling system, *Atmos. Chem. Phys*., 22, 13243–13268.

Tribby, A., Bois, J., Stephen, M., Atlas, E., Vimont, I., **Lan, X**., Tans, P., Elkins, J., Blake, D. and Wennberg, P., 2022. Hydrocarbon tracers suggest methane emissions from fossil sources occur predominately before gas processing and that petroleum plays are a significant source. *Environ. Sci. Techn.*, 56, 13, 9623-9631.

Sheng, J., Tunnicliffe, R., Ganesan, A.L., Maasakkers, J.D., Shen, L., Prinn, R.G., Song, S., Zhang, Y., Scarpelli, T., Bloom, A.A., Rigby, M., **Lan, X**. et al. 2021. Sustained methane emissions from China after 2012 despite declining coal production and rice-cultivated area. *Environ. Res. Lett.*, *16*(10), p.104018.

Lan, X., Nisbet, E.G., Dlugokencky, E.J. and Michel, S.E., 2021. What do we know about the global methane budget? Results from four decades of atmospheric CH_4 observations and the way forward. *Philos. Trans. Royal Soc. A*, *379*(2210), p.20200440.

Palmer, P.I., Feng, L., Lunt, M.F., Parker, R.J., Bösch, H., **Lan, X**., Lorente, A. and Borsdorff, T., 2021. The added value of satellite observations of methane for understanding the contemporary methane budget. *Philos. Trans. Royal Soc. A*, *379*(2210), p.20210106.

Chang, K.L., Schultz, M.G., **Lan, X**., McClure-Begley, A., Petropavlovskikh, I., Xu, X. and Ziemke, J.R., 2021. Trend detection of atmospheric time series: Incorporating appropriate uncertainty estimates and handling extreme events. *Elem Sci Anth*, *9*(1), p.00035.

Lan, X., Basu, S., Schwietzke, S., Bruhwiler, L., Dlugokencky, E.J., Michel, S.E., Sherwood, O., Tans, P. P., Thoning, K., Etiope, G., Zhuang, Q., Liu, L., Oh, Y., Miller, J., Petron, G., Vaughn, B. H., Andrews, A., Crippa, M., 2021. Improved constraints on global methane emissions and sinks using $\delta^{13}CH_4$. *Glob. Biogeochem*. Cycles, 35 (6), e2021GB007000.

Wang, F., Maksyutov, S., Janardanan, R., Tsuruta, A., Ito, A., Morino, I., Yoshida, Y., Tohjima, Y., Kaiser, J.W., Janssens-Maenhout, G. and **Lan, X**., 2021. Interannual variability on methane emissions in monsoon Asia derived from GOSAT and surface observations. *Environ. Res. Lett.*, *16*(2), p.024040.

Lan, X., Tans, P., Sweeney, C., Andrews, A., Dlugokencky, E., Schwietzke, S., Kofler, J., McKain, K., Thoning, K., Crotwell, M. and Montzka, S., 2019. Long-term measurements show little evidence for large increases in total US methane emissions over the past decade. *Geophys. Res. Lett.*, *46*(9), 4991-4999.

Ganesan, A.L., Schwietzke, S., Poulter, B., Arnold, T., **Lan, X**., Rigby, M., Vogel, F.R., van der Werf, G.R., Janssens-Maenhout, G., Boesch, H. and Pandey, S., 2019. Advancing scientific understanding of the global methane budget in support of the Paris Agreement. *Glob. Biogeochem*. Cycles, *33*(12), 1475-1512.

Yang, S., **Lan, X**., Talbot, R. and Liu, L., 2019. Characterizing anthropogenic methane sources in the Houston and Barnett Shale areas of Texas using the isotopic signature δ13C in CH_4. *Sci. Tot. Environ.*, *696*, 133856.

Lan, X., Tans, P., Sweeney, C., Andrews, A., Jacobson, A., Crotwell, M., Dlugokencky, E., Kofler, J., Lang, P., Thoning, K. and Wolter, S., 2017. Gradients of column CO_2 across North America from the NOAA global greenhouse gas reference network. *Atmos. Chem. Phys*., *17*(24), 15151-15165.

Lan, X., Talbot, R., Laine, P. and Torres, A., 2015. Characterizing fugitive methane emissions in the Barnett Shale area using a mobile laboratory. *Environ. Sci. Techn., 49*(13), 8139-8146.

Zavala-Araiza, D., Lyon, D.R., Alvarez, R.A., Davis, K.J., Harriss, R., Herndon, S.C., Karion, A., Kort, E.A., Lamb, B.K., **Lan, X.** and Marchese, A.J., 2015. Reconciling divergent estimates of oil and gas methane emissions. *Proc. Natl Acad. Sci.*, *112*(51), 15597-15602.

Lyon, D.R., Zavala-Araiza, D., Alvarez, R.A., Harriss, R., Palacios, V., **Lan, X.**, Talbot, R., Lavoie, T., Shepson, P., Yacovitch, T.I. and Herndon, S.C., 2015. Constructing a spatially resolved methane emission inventory for the Barnett Shale region. *Environ. Sci. Techn.*, *49*(13), 8147-8157.

Zavala-Araiza, D., Lyon, D., Alvarez, R.A., Palacios, V., Harriss, R., **Lan, X.**, Talbot, R. and Hamburg, S.P., 2015. Toward a functional definition of methane super-emitters: Application to natural gas production sites. *Environ. Sci. Techn., 49*(13), 8167-8174.

Liu, L., Talbot, R. and **Lan, X.**, 2015. Influence of climate change and meteorological factors on Houston's air pollution: Ozone a case study. *Atmos.*, *6*(5), 623-640.

Lavoie, T., Shepson, P., Cambaliza1, M., Karion, A., Sweeney, C., Kort, C., Hirst, B., Yacovitch, T., **Lan, X.**, Lyon, D., Alvarez, R. and Harriss, R., 2015. Aircraft-based measurements of point source methane emissions in the Barnett Shale basin. *Environ. Sci. Techn., 49*(13), 7904-7913.

Lan, X., Talbot, R., Laine, P., Lefer, B., Flynn, J., and Torres, A., 2014. Seasonal and Diurnal Variations of Total Gaseous Mercury in Urban Houston, Texas (U.S.A.), *Atmos*., *5*, 399-419.

Lan, X., Talbot, R., Laine, P., Lefer, B., and Flynn, J., Atmospheric mercury in the Barnett Shale area, Texas: implications for emissions from oil and gas processing. *Environ. Sci. Techn., 49*(17), 10692-10700.

Lan, X., Talbot, R., Castro, M., Perry, K., and Luke, W., 2012. Seasonal and Diurnal Variations of Atmospheric Mercury across the US Determined from AMNET Monitoring Data, *Atmos. Chem. Phys*., *12*, 10569-10582.

Dataset Publications:

1. **Lan, X**., Dlugokencky, E.J., Mund, J.W., Crotwell, A.M., Crotwell, M.J., Moglia, E., Madronich, M., Neff D., and Thoning K.W.: Atmospheric Carbon Dioxide Dry Air Mole Fractions from the NOAA GML Carbon Cycle Cooperative Global Air Sampling Network, 1968-2021, Version: 2022-11-21, https://doi.org/10.15138/wkgj-f215
2. **Lan, X**., Dlugokencky, E.J., Mund, J.W., Crotwell, A.M., Crotwell, M.J., Moglia, E., Madronich, M., Neff D., and Thoning K.W.: Atmospheric Methane Dry Air Mole Fractions from the NOAA GML Carbon Cycle Cooperative Global Air Sampling Network, 1983-2021, Version: 2022-11-21, https://doi.org/10.15138/VNCZ-M766
3. **Lan, X**., Dlugokencky, E.J., Mund, J.W., Crotwell, A.M., Crotwell, M.J., Moglia, E., Madronich, M., Neff D., and Thoning K.W.: Atmospheric Nitrous Oxide Dry Air Mole Fractions from the NOAA GML Carbon Cycle Cooperative Global Air Sampling Network,1997-2021, Version: 2022-11-21, https://doi.org/10.15138/53g1-x417
4. **Lan, X**., Dlugokencky, E.J., Mund, J.W., Crotwell, A.M., Crotwell, M.J., Moglia, E., Madronich, M., Neff D., and Thoning K.W.: Atmospheric Sulfur Hexafluoride Dry Air Mole Fractions from the NOAA GML Carbon Cycle Cooperative Global Air Sampling Network, 1997-2021, Version: 2022-11-21, https://doi.org/10.15138/p646-pa37
5. **Lan, X**., Dlugokencky, E.J., A.M. Crotwell, K.W. Thoning, and J.W. Mund: Atmospheric methane from quasi-continuous measurements at Barrow, Alaska and Mauna Loa, Hawaii, 1986-2021, Version: 2022-03, https://doi.org/10.15138/ve0c-be70
6. Andrews, A., Crotwell, A., Crotwell, M., Handley, P., Higgs, J., Kofler, J., **Lan, X.,** Legard, T., Madronich, M., McKain, K., Miller, J., Moglia, E., Mund, J., Neff, D., Newberger, T., Petron, G., Turnbull, J., Vimont, I., Wolter, S., and NOAA Global Monitoring Laboratory: NOAA Global Greenhouse Gas Reference Network Flask-Air PFP Sample Measurements of CO_2 at Tall Tower and other Continental Sites, 2005-Present. https://doi.org/10.15138/gr3w-qm07, Version: 2022-11-01
7. Andrews, A., Crotwell, A., Crotwell, M., Handley, P., Higgs, J., Kofler, J., **Lan, X**., Legard, T., Madronich, M., McKain, K., Miller, J., Moglia, E., Mund, J., Neff, D., Newberger, T., Petron, G., Turnbull, J., Vimont, I., Wolter, S., and NOAA Global Monitoring Laboratory: NOAA Global Greenhouse Gas Reference Network Flask-Air PFP Sample Measurements of CH_4 at Tall Tower and other Continental Sites, 2005-Present. https://doi.org/10.15138/35JE-6D55, Version: 2022-11-01.
8. Andrews, A., Crotwell, A., Crotwell, M., Handley, P., Higgs, J., Kofler, J., **Lan, X**., Legard, T., Madronich, M., McKain, K., Miller, J., Moglia, E., Mund, J., Neff, D., Newberger, T., Petron, G., Turnbull, J., Vimont, I., Wolter, S., and NOAA Global Monitoring Laboratory: NOAA Global Greenhouse Gas Reference Network Flask-Air PFP Sample Measurements of N_2O at Tall Tower and other Continental Sites, 2005-Present. https://doi.org/10.15138/C11N-KD82, Version: 2022-11-01.
9. Andrews, A., Crotwell, A., Crotwell, M., Handley, P., Higgs, J., Kofler, J., **Lan, X**., Legard, T., Madronich, M., McKain, K., Miller, J., Moglia, E., Mund, J., Neff, D., Newberger, T., Petron, G., Turnbull, J., Vimont, I., Wolter, S. and NOAA Global Monitoring Laboratory: NOAA Global Greenhouse Gas Reference Network Flask-Air PFP Sample Measurements of SF_6 at Tall Tower and other Continental Sites, 2005-Present. https://doi.org/10.15138/5R14-K382, Version: 2022-11-01.
10. Sherwood O., Schwietzke S., **Lan X**.: Global Inventory of Fossil and Non-fossil $\delta^{13}C$-CH_4 Source Signature Measurements for Improved Atmospheric Modeling, 2021, https://doi.org/10.15138/qn55-e011

11. Michel S. E., Vaughn B. H., Tans P., Thoning K., **Lan X**.: Atmospheric $\delta^{13}CH_4$ data from the Institute of Arctic and Alpine Research (INSTAAR) at the University of Colorado, Boulder in cooperation with NOAA Global Monitoring Laboratory, 2021, https://doi.org/10.15138/79jq-qc24
12. **Lan X**., Dlugokencky E., Michel S. E., Basu S., Schuldt. K., Mund J., and another 44 data providers: Database of methane (CH_4) abundance and its stable carbon isotope ($\delta^{13}CH_4$) composition from atmospheric measurements, 2022, https://doi.org/10.15138/64w0-0g71
13. Oh Y., Zhuang Q., **Lan X**., Global wetland $\delta^{13}CH_4$ by isoTEM model, 2022, https://doi.org/10.25925/9s6n-g811.
14. Dlugokencky, E., **Lan, X**., Michel, S., Pétron, G., Vimont, I., Crotwell, M., Madronich, M., Crotwell, A., Neff, D., Wolter, S., Moglia, E., Mund, J.: NOAA GML & INSTAAR SIL measurements of Greenhouse Gases and Related Tracers from the MOSAiC project (Version 2022.05.23), 2022, https://doi.org/10.25925/AYBV-YZ43

Scientific Reports

- Contributing author for IPCC AR6 Chapter 5 "CH_4, Trends, Variability and Budget", 2021
- Lead author for the "Long-lived Greenhouse Gases" section in the State of the Climate annual report (*Bull. Amer. Meteor.*), 2020, 2021, 2022.

Grants

- (2017-2023) Principal Investigator for "*Process-level investigation of revised global methane budget based on in situ and remote sensing of atmospheric composition and the land surface"*, funded by NASA ROSE IDS
- (2023-2026) Principal Investigator for "*Explaining recent increases in global methane and their sectoral attribution using isotopic and remotely sensed measurements of atmospheric methane*", solicited by NOAA-OAR-CPO-AC4

Selected Presentations:

- AGU presentation: "Constraining the global CH_4 budget with high-quality measurements of CH_4 and its stable carbon isotopes", Dec. 2022.
- Presentation at NOAA Global Monitoring Annual Conference "Atmospheric CH_4: A Record Annual Increase in 2021", May 2022
- Poster presentation at CIRES Rendezvous "Improved Constraints on Global Methane Emissions and Sinks Using Stable Carbon Isotopes of Methane", Mar. 2022
- Seminar at the Institute of Arctic and Alpine Research of University of Colorado (invited): "*Improved Constraints on Global Methane Emissions and Sinks Using Stable Carbon Isotopes of Methane"*, Feb. 2022
- Presentation at the UK Royal Society Conference-Rising methane: is warming feeding warming? (invited): "*Observational constraints on the global methane budget"*, Oct. 2021
- AGU presentation: "*What do we know about the global methane budget? Results from four decades of atmospheric methane observations and the way forward*", Dec. 2021
- Seminar at NASA Changes in the Arctic Boreal System group (invited): "*Recent growth in atmospheric methane and some clues from $^{13}CH_4$ isotope*", May 2021
- Seminar at the Department of Atmospheric Science of University of Wyoming (invited): "*Recent growth in atmospheric CH_4"*, Mar. 2021

- Presentation at NASA Terrestrial Ecology program science team meeting (invited): "Investigation of the global methane budget based on improved measurement datasets and prior emission information", Sep. 2019.

Scientific Journal Article Reviews for

Atmosphere (Serve as Reviewer Board Member)
Environmental Science & Technology
Environmental Research
Environmental Research Communication
Nature Climate Change
Science of the Total Environment
Journal of Geophysical Research-Atmospheres
Atmospheric Chemistry and Physics
Atmospheric Measurement Techniques
Journal of Environmental Quality
Remote Sensing

Proposal Reviews for

Natural Sciences and Engineering Research Council of Canada
National Research and Development Agency of Chile

Media Interviews by

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Reuters
Science (AAAS)
The Washington Post
WAMC Northeast Public Radio