

STANLEY P. SANDER

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RELEVANT EXPERIENCE

Dr. Sander is a Senior Research Scientist at JPL with more than 40 years of experience in lab kinetics, photochemistry and spectroscopy, instrument development and flight missions with applications to Earth and planetary atmospheres. Current laboratory studies include kinetics of tropospheric reactions of organic peroxy radicals and Criegee biradicals, upper atmospheric radical kinetics of HO_x, NO_x and halogen oxide species, gas-surface reactions relevant to methane on Mars, and hydrocarbon reactions important in Titan's atmosphere. Dr. Sander is Chair of NASA's Panel for Data Evaluation which publishes periodic critical evaluations of laboratory data for atmospheric modeling. Another research focus is remote sensing spectroscopy for atmospheric trace gases and aerosols. He has developed and deployed several atmospheric Fourier transform and dispersive spectrometers at JPL's Table Mountain and CLARS facilities. He is PI and Co-I of NASA technology tasks to develop prototype geostationary imaging Fourier transform spectrometers. He has served on the science teams of several NASA atmospheric composition instruments including UVSI, TES, OCO, OMI and SAGE. Dr. Sander has 159 peer-reviewed publications in chemical kinetics, photochemistry, spectroscopy, instrument design and remote sensing. He also serves as the Chief Engineer of JPL's Science Division.

EDUCATION

Ph. D., Environmental Engineering Science, California Institute of Technology (1980)
minor in Physical Chemistry
M. S., Environmental Engineering Science, California Institute of Technology (1975)
B. A., Physics, Pomona College, *cum laude* (1974)

AREAS OF EXPERTISE

Laboratory Kinetics and Photochemistry, Chemistry and Composition of Earth and Planetary Atmospheres, Remote Sensing of Atmospheric Composition, Emissions of Trace Gases and Aerosols in Megacities, Satellite and Ground-Based Instrument Technologies (esp. Fourier Transform and Dispersive Spectrometers)

PROFESSIONAL EXPERIENCE

Jet Propulsion Laboratory

Chief Engineer, Science Division	2019-present
Senior Research Scientist	1996-present
Manager, Oceanic and Atmospheric Sciences Section	1992-1994
Lead Scientist, Atmospheric Chemistry Research Element	1994-1996
Supervisor, Laboratory Studies and Modeling Group	1998-2016
Research Scientist	1980-1995
Graduate Research Assistant and Part-Time Academic Employee	1971-1980

California Institute of Technology

Visiting Associate in Planetary Science	1998-present
Lecturer in Planetary Science and Env. Engineering Science	2002-2004, 2017
Visiting Associate in Chemical Engineering	1980-1981

University of California, Los Angeles
Visiting Professor, Department of Atmospheric Sciences 1996
Project Scientist, Joint Institute for Regional Earth System
Science and Engineering (JIFRESSE) 2008-present

CURRENT RESEARCH PROGRAMS

External

Laboratory Studies of Tropospheric Chemical Reactions, NASA SMD/ESD (P.I.)
Laboratory Studies of Reactions Important for Stratospheric Ozone, NASA SMD/ESD (P.I.)
Ground-Based Remote Sensing of Upper Atmospheric Trace Gases, NASA SMD/ESD (P.I.)
Mechanistic Studies of Benzene Formation in Titan's Atmosphere, NASA SMD/PSD (P.I.)
Validation of SAGE III/ISS Nighttime Measurements of NO₃ and NO₂, NASA SMD/ESD (P.I.)
Quantifying Trends in Methane Emissions in the Los Angeles Basin Using Remote Sensing
Spectroscopy at CLARS, California Air Resources Board (P.I.)
Radical Spectroscopy for Interpreting Observations of Triton, Pluto and other Kuiper Belt
Objects, NASA/SMD/PSD (Co-I)

Internal

Panchromatic Fourier Transform Spectrometer System Development – SR&TD (P.I.)

PAST RESEARCH PROGRAMS (LAST 10 YEARS)

Panchromatic Fourier Transform Spectrometer for the GEO-CAPE Mission, NASA IIP (P.I.)
In-Pixel Digitization ROIC for the GEO-CAPE Mission, NASA ACT (Co-I)
Advanced Onboard Fault-Tolerant Interferogram Processing, NASA AIST (Co-I)
Planetary Major Equipment, NASA PSD (P.I.)
PanFTS Engineering Model for the GEO-CAPE Mission, NASA ESTO IIP (P.I.)
Megacity Carbon Project, NIST Greenhouse Gas Program, (Co-I)
Spatial Distributions of O₃ Precursors and Greenhouse Gases in the LA Basin, CARB, (Co-PI)
Validation of SAGE III/Meteosat Measurements of NO₃, NASA ESD (P.I.)
Mechanisms of CH₄ Oxidation on Mars, JPL R&TD (P.I.)
Retrievals of Aerosol Vertical Profiles Using O₂ Spectropolarimetry, PDRDF (Co-I)

HONORS AND AWARDS

NASA Exceptional Achievement Medal 2011, 2015
NASA Exceptional Service Medal 2007
AGU Editor's Citation for Excellence in Refereeing, IEEE Aerospace Conference Best Paper
Award (2012), JPL Lew Allen Award, Group Achievement Awards (8), Tech Brief Awards (3).

PROFESSIONAL ACTIVITIES

Chair, NASA Panel for Evaluation of Laboratory Data for Atmospheric Modeling
JPL Technical Equipment, Facilities and Infrastructure Management (TEFIM) Executive
Committee
NASA/WMO Ozone Assessment Report Panel
NASA Fluorocarbon Lifetime Assessment Panel
Co-Chair, 23rd Informal Photochemistry Conference, Pasadena, California
Chair, 2001 Gordon Conference on Atmospheric Chemistry, Newport, R.I.
Associate Editor, Journal of Geophysical Research – Atmospheres, 1998

Editorial Board, Internal Journal of Chemical Kinetics, 2000-2002
Proposal Panel Reviewer, NASA/NSF/EPA
Program Office Subject Matter Expert for the EV-M GeoCarb Mission

INSTRUMENT DEVELOPMENT

Fourier Transform Ultraviolet Spectrometer (FTUVS). This is a high-resolution UV-visible Fourier Transform Spectrometer (FTS) for measurements of atmospheric trace gases. Spectral resolution is 0.06 cm^{-1} (resolving power 500,000 at 300 nm) and spectral coverage is 250-1000 nm. The instrument is a plane-mirror design that is dynamically aligned. FTUVS is deployed at Table Mountain Facility and has been in continuous autonomous operation since 1997.

Ozone Spectropolarimeter. A medium resolution grating spectrograph for measurements of the polarization state of near-UV sky radiance. Deployed and operated at JPL for measurements of the vertical profile of ozone in the troposphere.

CLARS Fourier Transform Spectrometer. CLARS-FTS is a high-resolution FTS for remote sensing of greenhouse gases and pollutants located at JPL's California Laboratory for Atmospheric Remote Sensing (CLARS) on Mt. Wilson. This instrument is a corner-cube FTS with 0.02 cm^{-1} resolution (resolving power 750,000 at 600 nm) and operates autonomously in the 600-2500 nm spectral range with linear polarization capability.

Aerosol Polarization Spectrometer. This is a portable FTS based on a Bruker laboratory instrument for measurements of sky polarization in the $\text{O}_2\text{ A}$ band at 760 nm. The data products are measurements of the vertical concentration profiles of aerosols in the lower atmosphere.

Panchromatic Fourier Transform Spectrometer (Pan-FTS). PanFTS is a very wide-band, high-resolution imaging FTS with spectral coverage from near-UV to TIR. The design is meant to address the requirements for simultaneous remote sensing of multiple trace gases in multiple wavebands to obtain passive retrieval of trace gas vertical profiles. The instrument is specifically designed for deployment in a geostationary or Molniya orbit as a hosted payload on a comsat. A brassboard instrument was constructed under the Instrument Incubator Program and has been successfully tested in the field from Mt. Wilson. A version was proposed for EV-I ("TROMBONE") and was ranked "selectable".

MENTORING (since 1980):

Supervision of 34 postdocs, 12 Caltech graduate students, 8 undergraduates and 2 high school students.

Stanley P. Sander

REFEREED PUBLICATIONS

H number (Web of Science: 41, Google Scholar: 51)

164. Winiberg, F. A. F., Zuraski, K., Liu, Y., Sander, S. P. and Percival, C. J.; Pressure and temperature dependencies of rate coefficients for the reaction $\text{OH} + \text{NO}_2 + \text{M} \rightarrow$ products; *J. Phys. Chem. A*; **2020**, *124*, 10121-10131; <https://dx.doi.org/10.1021/acs.jpca.0c08920?ref=pdf>
163. Zuraski, K., Hui, A. O., Grieman, F. J., Darby, E., Møller, K. H., Winiberg, F. A. F., Percival, C. J., Smarte, M. D., Okumura, M., Kjaergaard, H. G. and Sander, S. P.; Acetonyl peroxy and hydro peroxy self- and cross-reactions: kinetics, mechanism, and chaperone enhancement from the perspective of the hydroxyl radical product; *J. Phys. Chem. A*; **2020**, *124*, 8128-8143, <https://doi.org/10.1021/acs.jpca.0c06220>
162. Wang, S., Li, K-F, Zhu, D., Sander, S. P., Yung, Y. L., Pazmino, A. and Querel, R.; Solar 11-Year cycle signal in stratospheric nitrogen dioxide—similarities and discrepancies between model and NDACC observations; *Solar Phys.*; **2020**, <https://doi.org/10.1007/s11207-020-01685-1>
161. Zeng, Z-C, Wang, Y., Pongetti, T. J., Gong, F-Y, Newman, S., Li, Y., Natraj, V., Shia, R-L, Yung, Y. L. and Sander, S. P.; Tracking the pulse of a North American megacity from a mountaintop remote sensing observatory; *Remote Sensing of Environment*; **2020**, <https://doi.org/10.1016/j.rse.2020.112000>
160. Cusworth, D. H., Duren, R. M., Yadav, V., Thorpe, A. K., Verhulst, K., Sander, S., Hopkins, F., Rafiq, T. and Miller, C. E.; Synthesis of methane observations across scales: strategies for deploying a multitiered observing network; *Geophys. Res. Lett.*; **2020**, <https://doi.org/10.1029/2020GL087869>
159. Zeng, Z-C, Xu, F., Natraj, V., Pongetti, T. J., Shia, R-L, Zhang, Q., Sander, S. P. and Yung, Y. L.; Remote sensing of angular scattering effect of aerosols in a North American megacity; *Remote Sensing of Environment*; **2020**, <https://doi.org/10.1016/j.rse.2020.111760>
158. Wang, J., Zhou, M., Xu, X., Roudini, S., Sander, S. P., Pongetti, T. J., Miller, S. D., Reid, J. S., Hyer, E. and Spurr, R.; Development of a nighttime shortwave radiative transfer model for remote sensing of nocturnal aerosols and fires from VIIRS; *Remote Sensing of Environment*; **2020**, <https://doi.org/10.1016/j.rse.2020.111727>
157. Zeng, Z. C., Chen, S., Natraj, V., Le, T., Xu, F., Merrelli, A., Crisp, D., Sander, S. P. and Yung, Y. L.; Constraining the vertical distribution of coastal dust aerosol using OCO-2 O₂ A-band measurements; *Remote Sensing of Environment*; **2020**, <https://doi.org/10.1016/j.rse.2020.111760>
156. J. B. Burkholder, S. P. Sander, J. Abbatt, J. R. Barker, C. Cappa, J. D. Crouse, T. S. Dibble, R. E. Huie, C. E. Kolb, M. J. Kurylo, V. L. Orkin, C. J. Percival, D. M. Wilmouth, and P. H. Wine "Chemical Kinetics and Photochemical Data for Use in Atmospheric

- Studies, Evaluation No. 19," JPL Publication 19-5, Jet Propulsion Laboratory, Pasadena, **2019** <http://jpldataeval.jpl.nasa.gov>
155. Nassar, R., McLinden, C., Sioris, C. E., McElroy, C. T., Mendonca, J., Tamminen, J., MacDonald, C. G., Adams, C., Boisvenue, C., Bourassa, A., Cooney, R., Degenstein, D., Drolet, G., Garand, L., Girard, R., Johnson, M., Jones, D. B. A., Kolonjari, F., Kuwahara, B., Martin, R. V., Miller, C. E., O'Neill, N., Rihela, A., Roche, S., Sander, S. P., Simpson, W. R., Singh, G., Strong, K., Trischenko, A. P., van Mierlo, H., Zanjani, Z. V., Walker, K. A., and Wunch, D.; The Atmospheric Imaging Mission for Northern Regions: AIM-North; *Can. J. Remote Sensing*; **2019**, <https://doi.org/10.1080/07038992.2019.1643707>
 154. He, L., Zeng, Z.-C., Pongetti, T. J., Wong, C., Liang, J., Gurney, K. R., Newman, S., Yadav, V., Verhulst, K., Miller, C. E., Duren, R., Frankenberg, C., Wennberg, P. O., Shia, R.-L., Yung, Y. L. and Sander, S. P.; Atmospheric methane emissions correlate with natural gas consumption from residential and commercial sectors in Los Angeles; *Geophys. Res. Lett.*; **2019**, <http://dx.doi.org/10.1029/2019GL083400>
 153. Hui, A. O., Okumura, M. and Sander, S. P.; Temperature dependence of the reaction of chlorine atoms with CH₃OH and CH₃CHO; *J. Phys. Chem. A*; **2019**, *123*, 4964-4972, <http://dx.doi.org/10.1021/acs.jpca.9b00038>
 152. Winiberg, F. A. F., Percival, C. J. and Sander, S. P.; Quantification of nitric acid using photolysis induced fluorescence for use in chemical kinetic studies; *Chem. Phys. Lett.*; **2019**, <https://doi.org/10.1016/j.cpletx.2019.100029>
 151. Hui, A. O., Fradet, M., Okumura, M. and Sander, S. P.; Temperature dependence study of the kinetics and product yields of the HO₂ + CH₃C(O)O₂ reaction by direct detection of OH and HO₂ radicals using 2f-IR wavelength modulation spectroscopy; *J. Phys. Chem. A*; **2019**, <http://dx.doi.org/10.1021/acs.jpca.9b00442>
 150. Yadav, V., Duren, R., Mueller, K., Verhulst, K., Nehr Korn, T., Kim, J., Weiss, R., Keeling, R., Sander, S., Fischer, M., Newman, S., Falk, M., Kuwayama, T., Hopkins, F., Rafiq, T., Whetstone, J. and Miller, C.; Spatio-temporally resolved methane fluxes from the Los Angeles Megacity; *J. Geophys. Res-Atm.*; **2019**, <https://doi.org/10.1029/2018JD030062>
 149. Kuwayama, T., Charrier-Klobas, J. G., Chen, Y., Vizenor, N. M., Blake, D. R., Pongetti, T., Conley, S. A., Sander, S. P., Croes, B., Herner, J. D.; Source apportionment of ambient methane enhancements in Los Angeles, California, to evaluate emission inventory estimates; *Environ. Sci. Technol.*; **2019**, <https://doi.org/10.1021/acs.est.8b02307>
 148. Zeng, Z-C, Natraj, V., Xu, F., Pongetti, R. J., Shia, R-L, Kort, E. A., Toon, G. C., Sander, S. P. and Yung, Y. L.; Constraining aerosol vertical profile in the boundary layer using hyperspectral measurements of oxygen absorption; *Geophys. Res. Lett.*; **2018**, <https://doi.org/10.1029/2018GL079286>
 147. Winiberg, F., Percival, C., Shannon, R., Khan, M., Anwar H., Liu, Y., Shallcross, D. and Sander, S.; Reaction kinetics of OH + HNO₃ under conditions relevant to the Upper Troposphere/Lower Stratosphere, *Phys. Chem. Chem. Phys.*; **2018**, *20*, 24652-24664. <https://doi.org/10.1039/c8cp04193h>

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145. Zhang, X and Sander, S. P.; Infrared absorption spectrum of phenanthrene in an argon matrix; *Chem. Phys. Lett.*; **2017**, *688*, 47-50. <http://dx.doi.org/10.1016/j.cplett.2017.09.023>
144. Li, K-F; Zhang, Q.; Wang, S.; Sander, S. P.; Yung, Y. L.; Resolving model-observation discrepancy in the mesospheric and stratospheric HO_x chemistry; *Earth and Space Science*, **2017**, *4*, 607-624. <https://doi.org/10.1002/2017EA000283>
143. Zeng, Z-C; Zhang, Q.; Natraj, V.; Margolis, J. S.; Shia, R-L; Newman, S.; Fu, D.; Pongetti, T. J.; Wong, K. W.; Sander, S. P.; Wennberg, P.O. and Yung, Y. L.; Aerosol scattering effects on water vapor retrievals over the Los Angeles basin; *Atmos. Chem. Phys.*, **2017**, *17*, 2495-2508. <https://doi.org/10.5194/acp-17-2495-2017>
142. Orphal, J. and 48 other authors; Absorption cross-sections of ozone in the ultraviolet and visible spectral regions: Status report 2015; *J. Mol. Spec.*; **2016** *327*, 105-121. <http://dx.doi.org/10.1016/j.jms.2016.07.007>
141. Bloom, A. A.; Lauvaux, T.; Yadav, V.; Duren, R.; Sander, S.; Worden, J.; Schimel, D.; Resolving biogeochemical controls on greenhouse fluxes from space: a case study on Amazon wetland emissions; *Atmos. Chem. Phys.*; <http://dx.doi.org/10.5194/acp-16-15199-2016>.
140. Zhang, X.; Sander, S. P.; Cheng, L.; Venkatesan, T. S.; Stanton, J. F.; Matrix-isolated spectrum of CH₂BrOO radical; *Chem. Phys. Lett.*; **2016** *657*, 131-134. <http://dx.doi.org/10.1016/j.cplett.2016.05.060>
138. Feng, S.; Lauvaux, T.; Newman, S.; Rao, P.; Ahmadov, R.; Deng, A.; Diaz-Isaac, L. I.; Duren, R. M.; Fischer, M. L.; Gerbig, G.; Gurney, K. R.; Huang, J.; Jeong, S.; Li, Z.; Miller, C. E.; O'Keefe, D. O.; Patarasuk, R.; Sander, S. P.; Song, Y.; Wong, K. W.; Yung, Y. L.; L.A. Megacity: A high resolution land-atmosphere modeling system for urban CO₂ emissions; *Atmos. Chem. Phys.*; **2016**, *16*, 13121-13130, <http://dx.doi.org/10.5194/acp-16-9019-2016>
137. Wong, K. W.; Pongetti, T. J.; Oda, T.; Gurney, K. R.; Newman, S.; Duren, R.; Miller, C. E.; Yung, Y. L.; Sander, S. P.; Monthly trends of top-down methane emissions in the South Coast Air Basin from 2011-2015; *Atmos. Chem. Phys.*; **2016**, *16*, 9019-9045, <http://dx.doi.org/10.5194/acp-16-13121-2016>
136. Hosoda, T.; Fradet, M.; Frez, C.; Shterengas, L.; Sander, S.; Forouhar, S.; Belenky, G.; Laterally coupled distributed feedback cascade diode lasers emitting near 2.9 μm; *Electr. Lett.*; **2016**, *52*, 857-859, <http://dx.doi.org/10.1049/el.2016.0115>
135. Zhang, Q.; Shia, R-L.; Sander, S. P.; Yung, Y. L.; X_{CO2} retrieval over deserts near critical surface albedo, *Earth and Space Science.*; **2016**, *3*, <dx.doi.org/10.1002/2015EA000143>.
134. Zhang, X.; Sander, S. P.; Cheng, L.; Venkatesan, T. S.; Stanton, J. F.; Matrix-isolated spectrum of CH₂I₂OO radical, *J. Phys. Chem. A*; **2016**, *120*, 260-285, <dx.doi.org/10.1021/acs.jpca.5b12143>.

133. Burkholder, J. B., Sander, S. P. *et al.* *Chemical Kinetics and Photochemical Data for Use in Atmospheric Studies, Evaluation Number 18*, JPL Publication 15-10, Jet Propulsion Laboratory, Pasadena (2015).
132. Colosimo, S. F.; Natraj, V.; Sander, S. P.; Stutz, J.; A sensitivity study on the retrieval of aerosol vertical profiles using the oxygen A-band, *Atmos. Meas. Tech.*; **2015**, *8*, 11853-11924, <http://dx.doi.org/10.5194/amt-9-1889-2016>.
131. Wang, S.; Zhang, Q.; Millan, L.; Li, K.-F.; Yung, Y. L.; Sander, S. P.; Livesey, N. J.; Santee, M. L.; First evidence of middle atmospheric HO₂ response to 27-day solar cycles from satellite observations, *Geophys. Res. Lett.*, **2015**, *42*, 10,004-10,009, dx.doi.org/10.1002/2015GL065237.
130. Zhang, Q.; Natraj, V.; Li, K.-F.; Shia, R.-L.; Fu, D.; Pongetti, T. J.; Sander, S. P.; Roehl, C. M.; Yung, Y. L.; Accounting for aerosol scattering in the CLARS retrieval of column averaged CO₂ mixing ratios, *J. Geophys. Res. Atmos.*; **2015**, *120*, 7205-7218, dx.doi.org/10.1002/2015JD023499.
129. Xi, X.; Natraj, V.; Shia, R. L.; Luo, M.; Zhang, Q.; Newman, S.; Sander, S. P.; Yung, Y. L.; Simulated retrievals for the remote sensing of CO₂, CH₄, CO, and H₂O from geostationary orbit, *Atmos. Meas. Tech.*; **2015**, *8*, 4817-4830, dx.doi.org/10.5194/amt-8-4817-2015.
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- 11-year solar cycle, *Proc. Natl. Acad. Sci.*, **2013**, *110*, 2023-2028.
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