Dr. Matthäus Kiel - Curriculum Vitae

Jet Propulsion Laboratory/California Institute of Technology
4800 Oak Grove Drive, Pasadena, CA 91109
✉ matthaeus.kiel@jpl.nasa.gov ☎ +1 (626) 590 2664

Reasearch Interests

Remote Sensing, Greenhouse Gases, Carbon Cycle, Air Quality, Retrieval Algorithms, Validation

Education

Ph.D. in Physics (Dr. rer. nat.) May 2013 – July 2016
Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Master of Science in Physics Oct. 2010 – Oct. 2012
Rheinische Friedrich-Wilhelms-Universität (RFWU), Bonn, Germany

Bachelor of Science in Physics Oct. 2006 – Oct. 2010
Rheinische Friedrich-Wilhelms-Universität (RFWU), Bonn, Germany

Research and Work Experience

Jet Propulsion Laboratory/Caltech, Pasadena, CA June 2019 – present
Research Scientist in Earth Science Division - Tropospheric Composition

Member of the Orbiting Carbon Observatory-2 (OCO-2), Orbiting Carbon Observatory-3 (OCO-3), and Multi-Angle Imager for Aerosols (MAIA) Science Teams.

- **Validation Lead (OCO-3):** Responsible for executing the mission's validation plan; Evaluate OCO-3 observations against independent data sets including ground/air/space-borne measurements and model simulations; Coordinate validation and field campaign activities with external research partners including the Total Carbon Column Observing Network (TCCON) and the Collaborative Carbon Column Observing Network (COCCON).
- **Local Sources Lead (OCO-3):** Lead and coordinate a group of scientists to address challenges in the anthropogenic footprint of carbon and its relationship to air quality; Contribute to the development of novel methods to identify and quantify small-scale greenhouse gas sources using OCO-3's Snapshot Area Map (SAM) observations.
- **OCO-2/3 Science Team:** Contribute to the development of the Atmospheric Carbon Observations from Space (ACOS) algorithm; Develop methods to mitigate local and global-scale biases in OCO-2/3 Level 2 data; Evaluate and validate OCO-2/3 against independent data sets; Provide science support for multiple project teams including calibration, algorithm, validation, and mission planning; Coordinate meetings for the working groups associated with validation and local sources.
- **MAIA Science Team:** Conceptualize and develop quality control measures for aerosols and particulate matter (PM) observations. Validation of Level 2/4 data against the Aerosol Robotic Network (AERONET) and PM surface monitors.

Caltech, Wennberg Research Group, Pasadena, CA Aug. 2016 – June 2019
Postdoctoral Scholar in Environmental Science and Engineering

- Studied the terrestrial carbon cycle and anthropogenic carbon dioxide emissions using satellite data, ground-based remote sensing observations, airborne in-situ measurements, and model data.
- Analyzed and calibrated data from the Total Carbon Column Observing Network (TCCON) against aircraft in-situ measurements.

KIT, Remote Sensing Research Group, Karlsruhe, Germany May 2013 – July 2016
Graduate Research Assistant

- Identified and quantified error sources in the retrieval of atmospheric trace gas abundances using ground-based solar FTIR measurements in the Network for the Detection of Atmospheric Composition Change (NDACC) and TCCON.
- Synthesized atmospheric retrievals of trace gas abundances from NDACC and TCCON measured in different spectral regions to improve the spatial and temporal coverage over each individual network.

Research Grants

- **NASA ROSES A.51 Science Team for the OCO Missions (2021)**
  Title: *Reducing OCO-2 regional biases through novel 3D-cloud and meteorology retrievals*

  JPL Lead CO-I: Dr. Matthäus Kiel
  Contribution: Implementation and evaluation of vertical water and vertical temperature retrievals in the OCO-2 retrieval system. Generating bias correction parameters for atmospheric retrievals.

Awards

- **JPL Voyager Award** for successfully coordinating and leading a group of scientists in the analysis of OCO-2/3 measurements over Los Angeles (2021).
- **JPL Team Bonus Award** for the successful delivery of high-quality results from the B10 Level 2 algorithm for the OCO missions (2020).
- **JPL Team Bonus Award** for the successful completion of OCO-3's In-Orbit-Checkout (2019).

Service and Outreach

- Review manuscripts for scientific journals (e.g. Remote Sens. Environ, Atmos. Meas. Tech., Atmos. Chem. Phys., Remote Sens., Geophys. Res. Lett.)
- Review research grant proposals (e.g. NASA, FINESST21)
- Organize sessions at domestic and international conferences (e.g. IWGGMS17)
- Present science highlights at public events chosen by NASA's JPL Speakers Bureau (e.g. at the American Institute of Aeronautics and Astronautics (AIAA) - Los Angeles/Las Vegas Section)
- Collaborate with members of ESA and JAXA on the Tri-Agency Earth Observing Dashboard with the goal to inform the public about environmental, economic, and societal challenges impacting Earth's climate.

Teaching and Mentoring

- Co-mentoring NASA summer internship student, starting summer 2022, JPL, Pasadena, CA, USA

List of Publications

2022 Laughner, J., Andrews, A., Roche S., **Kiel, M.**, Toon, G. C., Wunch, D., Baier, B., Biraud, S., Chen, H., Kivi, R., Laemmel, T., Quéhé, P.-Y., Rousogenous, C., Stephens, B. B., and Wennberg, P. O.: *A new algorithm to generate a priori trace gas profiles for the GGG2020 retrieval algorithm*, to be submitted, 2022

Bell, E., Taylor, T. E., Merrelli A., O'Dell C., Nelson R. R., **Kiel, M.**, Eldering A., Rosenberg R., and Fisher, B.: *Exploring OCO-3 Snapshot Area Map swath bias via geometry, surface, and aerosol effects in simulations*, to be submittted, 2022

Rißmann, M., Chen J., Osterman, G., Dietrich, F., Zhao X., Makowski, M., and **Kiel, M.**: *Comparison of OCO-2 target observations to MUCCnet - Is it possible to capture urban XCO2 gradients from space?*, Atmos. Meas. Tech., submitted, 2022

Wu, D., Liu, J., Wennberg, P. O., Palmer, P. I., Nelson, R. R., **Kiel, M.**, and Eldering, A.: *Towards sector-based attribution using intra-city variations in satellite-based emission ratios between CO_2 and CO*, Atmos. Chem. and Phys. Discussions, 2022, 1–32, 2022

Taylor, T. E., O'Dell, C. W., Crisp, D., Kuze, A., Lindqvist, H., Wennberg, P. O., Chatterjee, A., Gunson, M., Eldering, A., Fisher, B., **Kiel, M.**, Nelson, R. R., Merrelli, A., Osterman, G., Chevallier, F., Palmer, P. I., Feng, L., Deutscher, N. M., Dubey, M. K., Feist, D. G., García, O. E., Griffith, D. W. T., Hase, F., Iraci, L. T., Kivi, R., Liu, C., De Mazière, M., Morino, I., Notholt, J., Oh, Y.-S., Ohyama, H., Pollard, D. F., Rettinger, M., Schneider, M., Roehl, C. M., Sha, M. K., Shiomi, K., Strong, K., Sussmann, R., Té, Y., Velazco, V. A., Vrekoussis, M., Warneke, T. and Wunch, D.: *An 11-year record of XCO_2 estimates derived from GOSAT measurements using the NASA ACOS version 9 retrieval algorithm*, Earth System Science Data, 14, 325–360, 2022

2021 Nassar, R., Mastrogiacomo, J.-P., Bateman-Hemphill W., McCracken C., MacDonald C. G., Hill T., O'Dell, C. W., **Kiel, M.**, and Crisp, D.: *Advances in quantifying power plant CO2 emissions with OCO-2*, Remote Sens. Environ., 264, 112579, 2021

Kiel, M., Eldering A., Roten, D. D., Lin, J. C., Feng, S., Lei, R., Lauvaux, T., Oda, T., Roehl, C. M., Blavier, J.-F., and Iraci, L.: *Urban-focused satellite CO_2 observations from the Orbiting Carbon Observatory-3: a first look at the Los Angeles Megacity*, Remote Sens. Environ., 258, 112314, 2021

2020 Taylor, T. E., Eldering, A., Merrelli, A., **Kiel, M.**, Somkuti, P., Cheng, C., Rosenberg, R., Fisher, B., Crisp, D., Basilio, R., Bennett, M., Cervantes, D., Chang, A., Dang, L., Frankenberg, C., Haemmerle, V. R. , Keller, G. R., Kurosu, T., Laughner, J. L., Lee, R., Marchetti, Y., Nelson, R. R., O'Dell, C. W., Osterman, G., Pavlick, R., Roehl, C., Schneider, R., Spiers, G., To, C., Wells, C., Wennberg, P. O., Yelamanchili, A., and Yu, S.: *OCO-3 early mission operations and initial (vEarly) XCO_2 and SIF retrievals*, Remote Sens. Environ., 251, 112032, 2020

Ohyama, H., Morino, I., Velazco, V. A., Klausner T., Bagtasa G., **Kiel, M.**, Frey M., Hori A., Uchino O., Matsunaga T., Deutscher, N. M., DiGangi, J. P., Choi, Y., Diskin, G. S., Pusede, S. E., Fiehn, A., Roiger, A., Lichtenstern, M., Schlager, H., Wang, P. K., Chou C., Andrés-Hernández M. D., and Burrows, J. P.: *Validation of XCO_2 and XCH_4 retrieved from a portable Fourier transform spectrometer with those from in situ profiles from aircraft-borne instruments*, Atmos. Meas. Tech., 13, 5149–5163, 2020

Byrne, B., Liu, J., Lee, M., Baker, I., Bowman, K., Deutscher, N., Feist, D., Griffith, D., Iraci, L., **Kiel, M.**, Kimball, J., Miller, C., Morino, I., Parazoo, N., Petri, C., Roehl, C., Sha, M., Strong, K., Velazco, V., Wennberg, P., and Wunch, D.: *Improved constraints on northern extratropical CO_2 fluxes obtained by combining surface-based and space-based atmospheric CO_2 measurements*, J. Geophys. Res.-Atmos., 125, e2019JD032029, 2020

2019 Kulawik, S. S., O'Dell, C. W., Osterman, G. B., Wennberg, P. O., Wunch, D., Roehl, C. M., Deutscher, N. M., **Kiel, M.**, Griffith, D. W. T., Velazco, V. A., Notholt, J., Warneke, T., Petri, C., De Maziere, M., Sha, M. K., Sussman, R., Rettinger, M., Pollard, D., Morino, I., Uchino, O., Hase, F., Feist, D. G., Strong, K., Kivi, R., Iraci, L., Shuji, K., Dubey, M. K., Sepulveda, E., Garcia, O. E., Te, Y., Jeseck, P., Heikkinen, P., Schneider, M., Wofsy, S. C., McKain, K., Sweeney, C., Baker, D. F., and Liu, J.: *Characterization of OCO-2 biases and errors for flux estimates*, Atmos. Meas. Tech. Discuss., 2019

Hedelius, J. K., He, T.-L., Jones, D. B. A., Baier, B. C., Buchholz, R. R., De Mazière, M., Deutscher, N. M., Dubey, M. K., Feist, D. G., Griffith, D. W. T., Hase, F., Iraci, L. T., Jeseck, P., **Kiel, M.**, Kivi, R., Liu, C., Morino, I., Notholt, J., Oh, Y.-S., Ohyama, H., Pollard, D. F., Rettinger, M., Roche, S., Roehl, C. M., Schneider, M., Shiomi, K., Strong, K., Sussmann, R., Sweeney, C., Té, Y., Uchino, O., Velazco, V. A., Wang, W., Warneke, T., Wennberg, P. O., Worden, H. M., and Wunch, D.: *Evaluation of MOPITT Version 7 joint TIR–NIR XCO retrievals with TCCON*, Atmos. Meas. Tech., 12, 5547–5572, 2019

Kiel, M., O'Dell, C. W., Fisher, B., Eldering, A., Nassar, R., MacDonald, C. G., and Wennberg, P. O.: *How bias correction goes wrong: Measurement of XCO_2 affected by erroneous surface pressure estimates*, Atmos. Meas. Tech., 12, 2241–2259, 2019

Frey, M., Sha, M. K., Hase, F., **Kiel, M.**, Blumenstock, T., Harig, R., Surawicz, G., Deutscher, N. M., Shiomi, K., Franklin, J., Bösch, H., Chen, J., Grutter, M., Ohyama, H., Sun, Y., Butz, A., Mengistu Tsidu, G., Ene, D., Wunch, D., Cao, Z., Garcia, O., Ramonet, M., Vogel, F., Orphal, J.: *Building the COllaborative Carbon Column Observing Network (COCCON): Long term stability and ensemble performance of the EM27/SUN Fourier transform spectrometer*, Atmos. Meas. Tech., 12, 1513–1530, 2019

2018 O'Dell, C. W., Eldering, A., Wennberg, P. O., Crisp, D., Gunson, M. R., Fisher, B., Frankenberg, C., **Kiel, M.**, Lindqvist, H., Mandrake, L., Merrelli, A., Natraj, V., Nelson, R. R., Osterman, G. B., Payne, V. H., Taylor, T. R., Wunch, D., Drouin, B. J., Oyafuso, F., Chang, A., McDuffie, J., Smyth, M., Baker, D. F., Basu, S., Chevallier, F., Crowell, S. M. R., Feng, L., Palmer, P. I., et al.: *Improved Retrievals of Carbon Dioxide from the Orbiting Carbon Observatory-2 with the version 8 ACOS algorithm*, Atmos. Meas. Tech., 6539-6576, 2018

Borsdorff, T., aan de Brugh, J., Hu, H., Hasekamp, O., Sussmann, R., Rettinger, M., Hase, F., Gross, J., Schneider, M., Garcia, O., Stremme, W., Grutter, M., Feist, D. G., Arnold, S. G., De Mazière, M., Kumar Sha, M., Pollard, D. F., **Kiel, M.**, Roehl, C., Wennberg, P. O., Toon, G. C., and Landgraf, J.: *Mapping carbon monoxide pollution from space down to city scales with daily global coverage*, Atmos. Meas. Tech. Discuss., 5507-5518, 2018

Oh, Y.-S., Kenea, S. T., Goo, T.-Y., Kim, G., Chung, K.-S., Rhee, J.-S., Ou, M.-L., Byun, Y.-H., Wennberg, P. O., **Kiel, M.**, Velazco, V. A., Oh, M.-L., and Griffith, D. W. T: *Characteristics of the Greenhouse Gas Concentration Derived from the Ground-based FTS Spectra at Anmyeondo, Korea*, Atmos. Meas. Tech., 11, 2361-2374, 2018

2017 Velazco V. A., Morino, I., Uchino O., Hori A., **Kiel, M**., Bukosa, B., Deutscher, N. M., Sakai, T., Nagai, T., Bagtasa, G., Izumim, T., Yoshida, Y., and Griffith, D. W. T.: *TCCON*

Philippines: First Measurement Results, Satellite Data and Model Comparisons in Southeast Asia, Remote Sens., 9, 1228, 2017

Wunch, D., Wennberg, P. O., Osterman G., Fisher, B., Naylor, B., Roehl, C. M., O'Dell C., Mandrake, L., Viatte, C., **Kiel, M.**, et al.: *Comparisons of the Orbiting Carbon Observatory-2 (OCO-2) XCO_2 measurements with TCCON*, Atmos. Meas. Tech., 10, 2209-2238, 2017

2016 Barthlott, S., Schneider, M., Hase, F., Blumenstock, T., **Kiel, M.**, Dubravica, D., Garcia O. E., Sepulveda, E., Mengistu Tsidu, G., Takele Kenea, S., Grutter, M., Stremme, W., Strong, K., Weaver, D., Palm, M., Warneke, T., Notholt, J., Mahieu, E., Jones, N., Griffith, D. W. T., Smale, D., and Robinson, J.: *Tropospheric water vapour isotopologue data ($H_2{}^{16}O$, $H_2{}^{18}O$ and $HD^{16}O$) as obtained from NDACC/FTIR solar absorption spectra*, Earth Syst. Sci. Data, 9, 15-29, 2016

Kiel, M., Hase, F., Blumenstock, T., and Kirner, O.: *Comparison of XCO abundances from the Total Carbon Column Observing Network and the Network for the Detection of Atmospheric Composition Change measured in Karlsruhe*, Atmos. Meas. Tech., 9, 2223-2239, 2016

Hase, F., Frey, M., **Kiel, M.**, Blumenstock, T., Harig, R., Keens, A., and Orphal, J.: *Addition of a channel for XCO observations to a portable FTIR spectrometer for greenhouse gas measurements*, Atmos. Meas. Tech., 9, 2303-2313, 2016

Kiel, M., Wunch, D., Wennberg, P. O., Toon, G. C., Hase, F., and Blumenstock, T.: *Improved retrieval of gas abundances from near-infrared solar FTIR spectra measured at the Karlsruhe TCCON station*, Atmos. Meas. Tech., 9, 669-682, 2016

2015 Hase, F., Frey, M., Blumenstock, T., Groß, J., **Kiel, M.**, Kohlhepp, R., Mengistu Tsidu, G., Schäfer, K., Sha, M. K., and Orphal, J.: *Application of portable FTIR spectrometers for detecting greenhouse gas emissions of the major city Berlin*, Atmos. Meas. Tech., 8, 3059-3068, 2015

Frey, M., Hase, F., Blumenstock, T., Groß, J., **Kiel, M.**, Mengistu Tsidu, G., Schäfer, K., Sha, M. K., and Orphal, J.: *Calibration and instrumental line shape characterization of a set of portable FTIR spectrometers for detecting greenhouse gas emissions*, Atmos. Meas. Tech., 8, 3047-3057, 2015

2014 Porz, S., **Kiel, M.**, and Lehnertz, K.: *Can spurious indications for phase synchronization due to superimposed signals be avoided?*, Chaos, 24, 033112, 2014

SELECTED PRESENTATIONS

2021 **European Geosciences Union Gen. Assembly (Virtual), Vienna, Austria**
Kiel, M., Eldering A., Roten, D. D., Lin, J. C., Feng, S., Lei, R., Lauvaux, T., Oda, T., Roehl, C. M., Blavier, J.-F., and Iraci, L.: *Urban-focused satellite CO_2 observations from the Orbiting Carbon Observatory-3: a first look at the Los Angeles Megacity*, 4/2021, Oral

2020 **Annual NDACC-IRWG and TCCON Meeting (Virtual), St. Petersburg, Russia**
Kiel, M., Laughner, J., Eldering, A., Fisher, B. M., Kurosu, T. P., Pavlick, R. P., Osterman, G. B., Nelson, R. R., O'Dell, C. W., Somkuti, P., Taylor, T. E., Roehl, C. M., and the

TCCON team.: *An Overview of the First Year of the OCO-3 Mission*, 6/2020, Oral, **Invited**

American Geophysical Union Fall Meeting (Virtual), San Francisco, CA, USA

Kiel, M., Eldering, A., Roten, D. D., Lei, R., Feng, S., Lin, J. C., Lauvaux, T., Roehl, C., Oda, T.: *OCO-3 SAM mode: Spatiotemporal Variability of XCO_2 over the Los Angeles Megacity*, 12/2020, Oral

2019 **American Geophysical Union Fall Meeting, San Francisco, CA, USA**

Kiel, M., Laughner, J., Eldering, A., Fisher, B., Kurosu, T., Pavlick, R., Osterman, G., Nelson, R., O'Dell, C., Somkuti, P., Taylor, T., Roehl, C., and the TCCON team: *First Comparison of OCO-3 XCO2 Measurements with TCCON*, 12/2019, Oral

2018 **Annual NDACC-IRWG and TCCON Meeting, Mexico City, Mexico**

Kiel, M., Liu, J., Wennberg O. P.: *Variations of XCO_2 anomalies over the European continent observed from OCO-2 and TCCON*, 6/2018, Oral

14th International Workshop on GHG Measurements from Space, Toronto, Canada

Kiel, M., Fisher, B., Wennberg O. P.: *Correction of topography related biases in XCO_2 measurements from OCO-2*, 5/2018, Oral

2017 **NASA's OCO-2 Science Team Meeting, Boulder, CO, USA**

Kiel, M., and the OCO-2 Validation team.: *Analysis of V8 OCO-2 target mode measurements*, 10/2017, Oral

Annual NDACC-IRWG and TCCON Meeting, Paris, France

Kiel, M., Toon, G. C., Wunch, D., Mendonca, J., and Wennberg, P. O.: *Airmass dependent correction factors and Xair dependence*, 6/2017, Oral

2016 **European Geosciences Union Gen. Assembly, Vienna, Austria**

Kiel, M., Hase, F., Blumenstock, and T., Kirner, O.: textitComparison of XCO abundances measured in the MIR (NDACC) and NIR (TCCON) using Karlsruhe Fourier Transform Infrared (FTIR) measurements, 4/2016, Poster

2015 **American Geophysical Union Fall Meeting, San Francisco, CA, USA**

Kiel, M., Hase, F., and Blumenstock, T.: *Comparison of MIR (NDACC) and NIR (TCCON) column-averaged CO from ground-based solar Fourier Transform Infrared (FTIR) measurements*, 12/2015, Poster