DR. MATTHÄUS KIEL - CURRICULUM VITAE

Jet Propulsion Laboratory, California Institute of Technology

PROFESSIONAL SUMMARY

Research scientist in the JPL Tropospheric Composition Group and a member of the Orbiting Carbon Observatory (OCO-2, OCO-3) and Multi-Angle Imager for Aerosols (MAIA) Science Teams. My research advances the understanding of the terrestrial carbon cycle and its influence on climate change and climate feedback mechanisms. I develop methods to quantify urban carbon fluxes, providing actionable data for scientific applications and decision-making. I contribute to atmospheric retrieval algorithm development and data validation, ensuring the accuracy and reliability of space-based atmospheric measurements. Experienced in collaborating with the Science Data Operations System (SDOS), Mission Operations System (MOS), and Instrument Calibration teams.

RESEARCH AND WORK EXPERIENCE

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

- **Validation Lead (OCO-3):** Oversee the mission's validation plan, evaluating OCO-3 data against independent datasets (ground, air, spaceborne, and models). Coordinate validation and field campaign activities with international research partners.
- **Local Sources Lead (OCO-3):** Lead a team of scientists to address the anthropogenic footprint of carbon on the terrestrial carbon cycle. Develop methods to identify and quantify small-scale greenhouse gas sources using satellite observations.
- **OCO-2/3 Science Team:** Contribute to the development of the ACOS algorithm and develop methods to reduce biases and errors in OCO-2/3 data. Provide science support for calibration, algorithm, validation, and mission operation teams.
- **MAIA Science Team:** Develop quality control measures for aerosol and particulate matter observations. Validate Level 2/4 data using AERONET and PM surface monitors.

EDUCATION

Postdoctoral Researcher (Wennberg Group) — Aug. 2016 – Jun. 2019
California Institute of Technology (Caltech), Pasadena, California, USA

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 Grants

- **NASA ROSES A.31 (2024)**, Co-I, “Validating OCO-2/3 retrieved profiles with TCCON partial columns”
- **NASA ROSES A.31 (2024)**, Collaborator: “Joint Space and Ground-based Observations for Across-Scale Fossil Fuel Emission Monitoring”
- **NASA ROSES A.51 (2020)**, JPL Lead Co-I: ”Reducing OCO-2 regional biases through novel 3D cloud, albedo, and meteorology estimation”
- **NASA ROSES A.51 (2020)**, Collaborator: “Reducing geometry-dependent OCO XCO2 biases to better inform SAM-based fossil fuel flux inversions”
- **NASA SURP (2021)**, Co-I: “Decision-Theoretic Uncertainty Quantification for Remote Sensing Inverse Problems”

Awards

- **JPL Voyager Award** for improving the scientific impact of OCO-3 data through validation and visualization efforts (2022).
- **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).

List of Publications

2025 Abu-Hani, A., Chen, J., Balmarugan, V., Osterman, G., and **Kiel, M.**: *From Gaps To Generalization: Predicting XCO2 over European Urban Areas from Targeted Satellite Observations Using Machine Learning*, in preparation for J. Geophys. Res.-Atmos., 2025

Mauceri, S., Keely, W., Laughner, J., O’Dell, C., **Kiel, M.**, et al.: *Uncertainty-aware Machine Learning Bias Correction and Filter for OCO-2: Part 1*, submitted to Earth and Space Science, 2025

Keely, W., Mauceri, S., Nelson, R., Laughner, J., O’Dell, C., **Kiel, M.**, et al.: *Uncertainty-aware Machine Learning Bias Correction and Filter for OCO-2: Part 2*, submitted to Earth and Space Science, 2025

Ahn, D., Goldberg D., Anenberg, S., Coombes, T., Loughner, C., **Kiel, M.**, and Chatterjee, A.: *Regional and Socioeconomic Characteristics in C40 cities’ CO2 Emissions Revealed from Space*, submitted to AGU Advances, 2025

2024 Das, S., **Kiel, M.**, Laughner, J., Osterman, G., O’Dell, C., Taylor, T. et al.: *Comparisons of the v11.1 Orbiting Carbon Observatory-2 (OCO-2) XCO2 Measurements with GGG2020 TCCON*, accepted for publication in Earth and Space Science, 2024

Laughner, J., Toon, G.C., Mendonca, J., Petri, C., Roche, S., Wunch, D., Blavier, J.F., Griffith, D., Heikkinen, P., Keeling, R., **Kiel, M.** et al.: *The Total Carbon Column Observing Network’s GGG2020 data version*, Earth Syst. Sci. Data, 16, 2197–2260, 2024

Sha, M., Das, S., Frey, M. M., **Kiel, M.** et al.: *Fiducial Reference Measurements for Greenhouse Gases (FRM4GHG): Validation of Satellite (Sentinel-5 Precursor, OCO-2 and GOSAT) Missions using COCCON*, Remote Sens., 17(5), 734, 2024

2023 Jacobs, N., O'Dell, C. W., Taylor, T. E., Logan, T. L., Byrne, B., **Kiel, M.**, Kivi, R., Heikkinen, P., Merrelli, A., Payne, V. H., and Chatterjee, A.: *The importance of digital elevation model accuracy in XCO2 retrievals: improving the Orbiting Carbon Observatory 2 Atmospheric Carbon Observations from Space version 11 retrieval product*, Atmos. Meas. Tech., 17, 1375–1401, 2023,

Taylor, T. E., O'Dell, C. W., Baker, D., Bruegge, C., Chang, A., Chapsky, L., Chatterjee, A., Cheng, C., Chevallier, F., Crisp, D., Dang, L., Drouin, B., Eldering, A., Feng, L., Fisher, B., Fu, D., Gunson, M., Haemmerle, V., Keller, G. R., **Kiel, M.**, et al..: *Evaluating the consistency between OCO-2 and OCO-3 XCO2 estimates derived from the NASA ACOS version 10 retrieval algorithm*, Atmos. Meas. Tech., 16, 3173–32092023, 2023

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*, Atmos. Meas. Tech., 16, 1121–1146, 2023

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*, Atmos. Meas. Tech., 16, 109–133, 2023

2022 Nassar, R., Moeini, O., Mastrogiacomo, J.-P., O'Dell, C. W., Nelson, R. R., **Kiel, M.**, Chatterjee, A., Eldering, A., and Crisp, D.: *Tracking CO2 emission reductions from space: A case study at Europe's largest fossil fuel power plant*, Front. Remote Sens. 3:1028240, 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., 15, 6605–6623, 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. Phys., 22, 14547–14570, 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 en-*

semble 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