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Research Interests

In the past 15 years, Dejian has been serving in the international science-technology communities (atmospheric composition, instrumentation, algorithm, air quality, climate, molecular spectroscopy) and suborbital/orbital missions. Dejian's specialty is developing new remote sensing instruments and retrieval algorithms for profiling the atmospheric composition, with focus on the near surface layer (0–2 km) and the middle-upper troposphere. New global measurements in these two altitude regions are needed to address a suite of scientific objectives ranked as "MOST IMPORTANT" in the 2017 Earth Sciences Decadal Survey (ESDS), since the gaseous and aerosol pollutants in the near surface layer affect the health and economic prosperity of billions of people, and the middle-upper tropospheric constituents drive the regional-global climate changes.

Dejian has been leading the HiMAP instrument concept development since 2018. HiMAP will enable the new global measurement capability of quantifying the gaseous and aerosol pollutants in the near surface layer, via combining multiple angular, spectrally resolved, polarimetric measurements within a compact form factor (~6U). In 2019, he was funded by NASA ESTO to develop "A broadband metasurface for high spectral resolution, imaging spectropolarimetry" – HiMAP's key technology component. Dejian originated a full-physics atmospheric isoprene retrieval algorithm in 2014 when the laboratory isoprene cross sections in the thermal infrared (TIR) were first reported in an international molecular spectroscopy conference. Dejian and his team surveyed observations from the existing satellite TIR sensors (TES, CrIS, AIRS, IASI) and demonstrated that isoprene can be directly quantified from CrIS measurements to advance our understanding of the atmospheric chemistry and climate, since isoprene is a key species driving the atmospheric oxidizing capability. Dejian has also been serving in the remote sensing algorithm communities and satellite missions. His contributions include successful implementation and application of a retrieval algorithm, namely, MUSES, which enables the unique, joint NASA-NOAA-ESA multiple-spectra, multiple-species and multiple-satellite retrievals. MUSES is known as an algorithm tool that enhances near-surface sensitivity and extends the multiple-decade continuity of NASA atmospheric ozone and carbon monoxide profile data, thus supporting the new science of air quality and climate research.

Dejian gratefully received science-technology trainings from his graduate study (2003-2007) and post-doctoral research (2008-2010). These opportunities equipped him the skills for the developments of instrumentation, retrieval algorithms, and science applications. e.g., he led papers illustrating the system level of design-integration-test-characterization of instruments and algorithms for the PARIS-IR and CLARS-FTS.

Education

B.Eng., Physics (2000), East China Normal University, Shanghai, P.R. China

M.Sc., Geography (2003), East China Normal University, Shanghai, P.R. China

Ph.D., Atmospheric Chemistry (2007), University of Waterloo, Ontario, Canada

Professional Experience

Scientist (2010-present), Jet Propulsion Laboratory

- Research interests: [1] Developments of new retrieval algorithms, instrumentation, and measurement strategy for quantification of atmospheric composition using advanced remote sensing techniques, such as hyperspectral UV-Visible-NIR-TIR interferometry and polarimetry from multiple platforms (ground station, balloon, aircraft, and satellites); [2] Analysis of regional and global satellite data to access quantitative description on the changes of atmospheric composition, and their roles' in atmospheric chemistry and carbon cycles in the past and future climate states
- Serving in satellite missions: OCO3, Suomi-NPP CrIS-OMPS, Aura-OMI, Aqua-AIRS, Sentinel-5p TROPOMI
- Served in satellite mission: Aura-TES
- Served in NASA ROSES IIP Project CARBO: Carbon Balance Observatory
- Serving in megacities carbon project CLARS-FTS team

Graduate Research (2003-2007), University of Waterloo

- Served in Canadian SCISAT-1 mission and Middle Atmosphere Nitrogen TRend Assessment (MATRAN) project

Postdoctoral Scholar (2007-2008), University of Waterloo

Postdoctoral Scholar (2008-2010), JIFRESSE (UCLA and JPL)

Funded proposals

<u>Retrieval algorithm Development</u>

- PI: NASA Headquarter Directed R&TD (2017-2018) "*MUSES algorithm development, characterization, and science application*"
- PI: JPL R&TD Spontaneous Concept Task (2015-2016) "*First direct measurements of global atmospheric isoprene from satellite observations*"
- PI: ROSES/AC-AST (2013-2017) "*Tropospheric ozone profiles using multispectral measurements from OMI, MLS, and AIRS*"
- JPL-led PI (2018-2021): ROSES/TASNPP "*Multi-decadal record of satellite carbon monoxide observations from Terra/MOPITT to SNPP/CrIS*",
- JPL-led PI: ROSES/AST-ACMAP (2017-2020) "*Isoprene Measurements from Space: New Global Constraints on Emissions and Photochemistry from Synthesis of CrIS and OMI Data*"

<u>Instrumentation/Technology</u>

- PI: NASA Headquarter Directed R&TD (2019-2020) "*A broadband metasurface for high spectral resolution, imaging spectropolarimetry*"
- PI: JPL Strategic Initiative R&TD (2018-2021) "*Maturing HiMAP (High-resolution Imaging Multiple-species Atmospheric Profiler) System to TRL 6*"
- PI: JPL Topical R&TD (2017-2018) "*High-resolution Imaging Multiple-species Atmospheric Profiler*"

Honors and Awards

- William T. Pecora Award, the OMI Science Team, 2019
- JPL Group Achievement Award, OCO-3 mission, 2019
- NASA Group Achievement Award, the OCO-2 Science Algorithm Team, 2016
- JPL Voyager Award, 2016
- JPL Group Achievement Award, OCO-2 Algorithm Development 2015
- JPL Group Achievement Award, OCO-2 Algorithm Development 2014
- NASA Group Achievement Award, the Aura Project, 2014
- JPL Mariner Award, 2011
- Bruker BioSpin Graduate Scholarship, University of Waterloo, 2007
- Graduate Scholarship, University of Waterloo, September 2003–2007
- International Doctoral Student Award, University of Waterloo, 2003–2006

Postdoctoral Scholar mentored

- Dr. Myungje Choi 2018-present

Postdoctoral Scholar co-mentored:

Dr. Dan Chen (former member of Prof. Qinbin Li group); 2010-2012
Dr. Chang-Hyoung Park (former member of Prof. Qinbin Li group); 2010-2012
Dr. Olga Pikelnaya (former member of Prof. Jochen Stutz group); 2010-2013
Dr. Min Huang (former member of Tropospheric composition group) 2012-2015
Dr. Yingdi Liu (former member of Dr. Stanley Sander's group); 2012-2014
Dr. Kam Weng Wong (member of Dr. Stanley Sander's group); 2012-2015
Dr. Kuai Le (JIFRESSE) 2016 – 2018

Graduate students co-mentored

Qiong Zhang (Caltech); 2012 to 2017
Ross Cheung (UCLA); 2010 to 2012
Catalina Tsai (UCLA); 2010 to 2012
Xiaoyi Zhao (University of Toronto); 2011 to 2013

Undergraduate students co-mentored

Alexandra Crawford: 2017
Zhaocheng Zeng; January 2016 to present
Yanbing Zhu: 2015
Cheuk Hei Lau: 2011

Peer-reviewed Publications

1. **Fu D.**, Millet D.B., Wells K.C., Payne V.H., Yu S., Guenther A., and Eldering A.: Direct retrieval of isoprene from satellite-based infrared measurements, *Nature Communication*, 10.3811, doi:10.1038/s41467-019-11835-0. (2019).

2. Shannon Kian Zareh, Miller C., Wong A., Sullivan P., Rud M., Beregovski Y., Wilson D., Wallace J.K., Sellar G., Keymeule D., Brooks C.B., Eldering A., **Fu D.**, Mainzer A.: The Carbon Balance Observatory (CARBO) instrument for remote sensing of greenhouse gases from space, Proceedings Volume 11152, Remote Sensing of Clouds and the Atmosphere XXIV; *SPIE Remote Sensing*, https://doi.org/ 10.1117/12.2539078, (2019).

3. Herman R.L., Worden J., Noone D., Henze D., Bowman K., Cady-Pereira K., Payne V.H., Kulawik S., and **Fu D.**: Comparison of Optimal Estimation HDO/H_2O Retrievals from AIRS with ORACLES measurements, *Atmos. Meas. Tech. Disc*, in review, (2019).

4. Worden J.R., Kulawik S.S., **Fu D.**, Payne V.H., Lipton A.E., Polonsky I., He Y., Cady-Pereira K., Moncet J.-L., Herman R.L., Irion F.W., and Bowman K.W.: Characterization and Evaluation of AIRS-Based Estimates of the Deuterium Content of Water Vapor, *Atmos. Meas. Tech.*, 12, 2331–2339, (2019).

5. **Fu D.**, Kulawik S.S., Miyazaki K., Bowman K.W., Worden J.R., Eldering A., Livesey N.J., Teixeira J., Irion F.W., Herman R.L., Osterman G.B., Liu X., Levelt P.F., Thompson A.M., and Luo M.: Retrievals of Tropospheric Ozone Profiles from the Synergic Observation of AIRS and OMI: Methodology and Validation, *Atmos., Meas. Tech.*, 11, 5,587–5,605, (2018).

6. Miyazaki K., Sekiya T., **Fu D.**, Bowman K.W., Kulawik S.S., Sudo K., Walker T., Kanaya Y., Takigawa M., Ogochi K., Eskes H., Boersam F., Gaubert B., Barre J., and Emmons L.: Balance of emission and dynamical controls on ozone during KORUS-AQ from multi-constituent satellite data assimilation, *Journal of Geophysical Research: Atmospheres*, 124, 387–413, (2018).

7. Levelt P., Joiner J., Tamminen J., Veefkind P., Duncan B., Eskes H., Torres O., DeLand M., Marchenko S., Kleipool Q., Pickering K., Apituley A., Zweers D.S., Carn S., van der A R., Ialongo I., Arola A., Hassinen S., Hakkarainen J., McPeters R., Ziemke J., Boersma F., Krotkov N., **Fu D.**, Liu X., Abad G.G., Chance K., Suileman R., Li C., and Bhartia P.: The Ozone Monitoring Instrument: Overview of 14 years in space, *Atmos., Chem. Phys.*, 18, 5,699–5,745 (2018).

8. Irion F., Kahn B., Schreier M., Fetzer E., Fishbein E., **Fu D.**, Kalmus P., Wilson R.C., Wong S., and Yue Q.: Single-footprint retrievals of temperature, water vapor and cloud properties from AIRS, *Atmos., Meas. Tech.*, 11, 971–995, (2018).

9. Wallace J.K., Miller C., Shannon Kian Zareh, Mainzer A., Pagano T.S., Brooks C.B., Jaffe D.T., Wilson D., Eldering A., **Fu D.**, Bartos R., Beregovski Y., Rud M., McGuire J.P., Wong A., Keymeulen D., Sullivan P., Liggett E., Bernas M.: CARBO - The Carbon Observatory Instrument Suite – the next generation of Earth observing instruments for global monitoring of carbon gases, Proceedings

Volume 10785, Sensors, Systems, and Next-Generation Satellites XXII; 107850U, *SPIE Remote Sensing*, https://doi.org/10.1117/12.2513286, (2018).

10. Richter J., Chipman R., Daugherty B., Diner D.J., Eldering A., Hyon J., Kupisnki M., Neu J.L., **Fu D.**: Specifying Polarimetric Tolerances of a High-resolution Imaging Multiple-species Atmospheric Profiler (HiMAP), *Proc. SPIE. 10925, Photonic Instrumentation Engineering VI*, 2019.

11. Herman R.L., Ray E.A., Rosenlof K.H., Bedka K.M., Schwartz M.J., Read W.G., Troy R.F., Chin K., Christensen L.E., **Fu D.**, Stachnik R.A., Bui T.P., and Dean-Day J. M.: Enhanced stratospheric water vapor over the summertime continental United States and the role of overshooting convection, *Atmos. Chem. Phys.*, 17, 6113–6124, (2017).

12. Crisp D., Pollock H.R., Rosenberg R., Chapsky L., Lee R.A.M., Oyafuso F.A., Frankenberg C., O'Dell C.W., Bruegge C.J., Doran G.B., Eldering A., Fisher B.M., **Fu D.**, Gunson M.R., Mandrake L., Osterman G.B., Schwandner F.M., Sun K., Taylor T.E., Wennberg P.O., and Wunch D.: The On-Orbit Performance of the Orbiting Carbon Observatory-2 (OCO-2) Instrument and its Radiometrically Calibrated Products, *Atmos. Meas. Tech.*, 10, 59–81, (2017).

13. Eldering A., O'Dell C. W., Wennberg P. O., Crisp D., Gunson M. R., Viatte C., Avis C., Braverman A., Castano R., Chang A., Chapsky L., Cheng C., Connor B., Dang L., Doran G., Fisher B., Frankenberg C., **Fu D.**, Granat R., Hobbs J., Lee R.A.M., Mandrake L., McDuffie J., Miller C.E., Myers V., Natraj V., O'Brien D., Osterman G. B., Oyafuso F., Payne V.H., Pollock H.R., Polonsky I., Roehl C.M., Rosenberg R., Schwandner F., Smyth M., Tang V., Taylor T.E., To C., Wunch D., and Yoshimizu J.: The Orbiting Carbon Observatory-2: First 18 months of Science Data Products, *Atmos. Meas. Tech.*, 10, 549–563, (2017).

14. Griffin D., Walker K.A., Conway S., Kolonjari F., Strong K., Batchelor R., Boone C.D., Dan L., Drummond J.R., **Fu D.**, Lindenmaier R., Manney G.L., Sung K., and Weaver D.: Multi-year comparisons of ground-based and space-borne Fourier Transform Spectrometers in the high Arctic between 2006 and 2013, *Atmos. Meas. Tech.*, 10, 3273–3294, (2017).

15. **Fu D.**, Bowman K.W., Worden H., Natraj V., Worden J.R., Yu S., Veefkind P., Aben I., Landgraf J., Strow L., Han Y.: High resolution tropospheric carbon monoxide profiles retrieved from CrIS and TROPOMI, *Atmos. Meas. Tech.*, 9, 2567–2579, (2016).

16. Zeng Z.-C., Zhang Q., Margolis J., Shia R.-L., Newman S., **Fu D.**, et al.: Aerosol scattering effects on water vapor retrievals over the Los Angeles Basin, *Atmos. Chem. Phys.*, 17, 2495–2508, (2017).

17. Connor B., Bösch H., McDuffie J., Taylor T., **Fu D.**, et al.: Quantification of Uncertainties in OCO-2 Measurements of XCO2: Simulations and Linear Error Analysis, *Atmos. Meas. Tech.*, 9, 5227–5238, (2016).

18. Zhang Q., Natraj V., Li K-F, Shia R-L, **Fu D.**, Pongetti T.J., et al.: Accounting for aerosol scattering in the CLARS retrieval of column averaged CO_2 mixing ratios, *J. Geophys. Rev.*, 120(14), 7205–7218, (2015).

19. Wong K.W., **Fu D.**, Pongetti T. J., Newman S., Kort E.A., Duren R., Y.-K. Hsu, Miller C. E., Yung Y.L., and Sander S.P.: Mapping CH_4: CO_2 ratios in Los Angeles with CLARS-FTS from Mount Wilson, California, *Atmos. Chem. Phys.*, 15, 241–252, (2015).

20. Bella D., Culpepper J., Khaimova J., Ahmed N., Belkalai A., Arroyo I., Andrews J., Gentle S., Emmanuel S., Lahmouh M., Ealy J., King Z., Jenkins O., **Fu D.**, Choi Y., Osterman G., Gruszczynski J., Skeete D., and Blaszczak-Boxe C.S.: Characterization of pollution transport into Texas using OMI and TES satellite, GIS and in situ data, and HYSPLIT back trajectory analyses: implications for TCEQ State Implementation Plans, *Air Quality, Atmosphere & Health*, 1–20, (2015).

21. **Fu D.**, Pongetti T.J., Blavier J-F L., Crawford T.J., Manatt K.S., Toon G.C., Wong C., and Sander S.P.: Near-infrared remote sensing of Los Angeles trace gas distributions from a mountaintop site, *Atmos. Meas. Tech.*, 7713–7729, (2014).

22. **Fu D.**, Worden J.R., Liu X., Kulawik S.S., Bowman K.W., and Natraj V.: Characterization of ozone profiles derived from Aura TES and OMI radiances, *Atmos. Chem. Phys.*, 13, 3445–3462, (2013).

23. Worden H.M., Edwards D.P., Deeter M.N., **Fu D.**, Kulawik S.S., Worden J.R., Arellano A., Averaging kernel prediction from atmospheric and surface state parameters based on multiple regression for nadir-viewing satellite measurements of carbon monoxide and ozone, *Atmos. Meas. Tech.*, 6, 1633–1646, (2013).

24. Bekker D.L., Blavier J.L., **Fu D.**, Key R.W., Manatt K.S., McKinney C., Rider D.M., Sander S.P., Werne T.A., Wu A.C., Wu Y.H., Command and data handling system for the panchromatic Fourier transform spectrometer, *Aerospace Conference IEEE*, 1–10, (2012).

25. **Fu D.**, Bernath P.F., Sung K., Walker K.A., Strong K., Mittermeier R. and Fast H., Simultaneous atmospheric remote sensing using Fourier transform infrared spectrometers at Polar Environment Atmospheric Research Laboratory (PEARL) during Spring 2006, *Atmos. Chem. Phys.* 11, 5,383–5,405, (2011).

26. **Fu D.**, Boone C.D., Bernath P.F., Weisenstein D.K., Rinsland C.P., Manney G.L. and Walker K.A., First global observations of atmospheric COClF from the Atmospheric Chemistry Experiment mission, *J. Quant. Spectrosc. Rad. Trans.* 110, 974–985, (2009).

27. Allen N.D.C., Bernath P.F., Boone C.D., Chipperfield M.P., **Fu D.**, Manney G.L., Oram D.E., Toon G.C., Weisenstein D.K., Global carbon tetrachloride distributions obtained from the Atmospheric Chemistry Experiment (ACE), *Atmos. Chem. Phys.*, 9(19), 7,449–7,459, (2009).

28. **Fu D.**, Sung K., Boone C.D., Walker K.A., and Bernath P.F., Ground-based solar absorption studies for the Carbon Cycle science by Fourier Transform Spectroscopy (CC-FTS), J. Quant. Spectrosc. Rad. Trans., 109, 2,219–2,243, (2008).

29. **Fu D.**, Boone C.D., Bernath P.F., Walker K.A., Nassar R., Manney G.L. and McLeod S.D., Global phosgene observations from the Atmospheric Chemistry Experiment (ACE) mission, *Geophys. Res. Lett*. 34, (2007).

30. **Fu D.**, Walker K.A., Sung K., Boone C.D., Soucy M.-A. and Bernath P.F.: The Portable Atmospheric Research Interferometric Spectrometer for the Infrared, PARIS-IR, *J. Quant. Spectrosc. Rad. Trans.* 103, 362–370, (2007).

31. Fraser A., Bernath P.F., Blatherwick R.D., Drummond J.R., Fogal P.F., **Fu D.**: et al., Intercomparison of ground-based ozone and NO_2 measurements during the MANTRA 2004 campaign, *Atmos. Chem. Phys.* 7, 5,489–5,499, (2007).

32. Sung K., Skelton R., Walker K.A, Boone C.D., **Fu D.**, Bernath P.F.: N_2O and O_3 Arctic Column Amounts from PARIS-IR Observations: Retrievals, Characterization and Error Analysis, *J. Quant. Spectrosc. Rad. Trans.*, 107, 385–406, (2007).

33. Wunch D., Taylor J., **Fu D.**, Bernath P.F., Drummond J.R., et al.: Simultaneous ground-based observations of O_3, HCl, N_2O and CH_4 over Toronto using three Fourier transform spectrometers with different resolutions, *Atmos. Chem. Phys.* 7, 1,275–1,292, (2006).

34. Yu S., **Fu D.**, Shayesteh A., Gordon I.E., Appadoo D.R.T. and Bernath P.F.: Infrared and near infrared emission spectra of SbH and SbD, *J. Mol. Spectrosc.* 229(2), 257–265, (2005).

35. Yu S., Shayesteh A., **Fu D.**, and Bernath P.F.: The vibration-rotation emission spectrum of gaseous HZnCl, J. Phys. Chem. A, 109(18), 4,092–4,094, (2005).

36. Yu S., Shayesteh A., **Fu D.**, and Bernath P.F.: Infrared and near infrared emission spectra of TeH and TeD, *J. Mol. Spectrosc.* 230(2), 105–116, (2005).

37. **Fu D.**, Zhu J., and Shen H.: The effects from the shapes of river mouth on the formation of the turbidity maximum zone, *J. East China Normal University*, 4, 72–78, (2004).

38. Zhu J., **Fu D.**, Wu H. and Qi D.: Dynamical model and numerical experiments on the formation cause of the turbidity maximum zone, *Ocean Engineering*, 22, 83–90, (2004).

39. Zhu J. and **Fu D.**: Open boundary condition considered residual current and tidal current simultaneously in ocean model, *Journal of East China Normal University*, 1, 81–85, (2003).