

PAUL O. WENNBERG

Division of Engineering and Applied Science
and
Division of Geological and Planetary Sciences
California Institute of Technology
Mail Stop 150-21
Pasadena, CA 91125
E-mail: wennberg@caltech.edu

DEGREES:

- June, 1994 Ph.D. in Physical Chemistry, Harvard University, Cambridge, MA
Thesis: "In Situ Measurements of Stratospheric Hydroxyl and Hydroperoxyl Radicals" Research Advisor: James G. Anderson
- June, 1985 B.A. in Chemistry, Oberlin College, Oberlin, OH.

PROFESSIONAL APPOINTMENTS:

- 2008 - Director, Linde Center for Global Environmental Science, California Institute of Technology.
- 2005 Visiting Prof., Depart. Of Chemistry, Univ. Otago, New Zealand
- 2005 – 2006 Secretary of the Atmospheric Sciences Section, American Geophysical Union.
- 2004 - R. Stanton Avery Professor of Atmospheric Chemistry and Environmental Science and Engineering, California Institute of Technology.
- 2001 -2004 Professor of Atmospheric Chemistry and Environmental Science and Engineering, California Institute of Technology.
- 1998 -2001 Associate Professor of Atmospheric Chemistry and Environmental Engineering Science, California Institute of Technology.
- 1994 -1997 Postdoctoral Research Fellow, Department of Chemistry, Harvard University.

HONORS AND AWARDS:

- 2002 MacArthur Fellow
- 1999- 2003 Presidential Early Career Award for Scientists and Engineers (PECASE)
- 1992 -1993 Hughes Corp., Graduate Fellowship.
- 1986 -1988 National Science Foundation Graduate Fellowship.

PUBLICATIONS:

1. Crounse JD, DeCarlo PF, Blake DE, Emmons LK, Campos TL, Apel EC, Clarke AD, A. J. Weinheimer AJ, McCabe DK, Yokelson RJ, Jimenez JL, and Wennberg PO, Biomass burning and urban air pollution over the Central Mexican Plateau, *Atmos. Chem. Phys.*, 9, 4929, 2009.
2. Chan, AWH, Galloway, MM, Kwan, AJ, Chhabra PS, Keutsch, FN, Wennberg PO, Flagan RC, Seinfeld, JH, Photooxidation of 2-Methyl-3-Buten-2-ol (MBO) as a Potential Source of Secondary Organic Aerosol, *Envir. Sci. Tech.*, 43, 4647, 2009.

3. Paulot, F., Crouse JD, Kjaergaard HG, Kroll JH, Seinfeld JH, Wennberg PO, Isoprene photooxidation: new insights into the production of acids and organic nitrates, *Atmos. Chem. Phys.*, 9, 1479, 2009.
4. DeCarlo, PF, Dunlea, EJ, Kimmel, JR, Aiken, AC, Sueper, D, Crouse, J, Wennberg, PO, Emmons, L, Shinzuka, Y, Clarke, A, Zhou, J, Tomlinson, J, Collins, DR, Knapp, D, Weinheimer, AJ, Montzka, DD, Campos, T, Jimenez, JL, "Fast airborne aerosol size and chemistry measurements above Mexico City and Central Mexico during the MILAGRO campaign", *Atmos. Chem. Phys.*, 8, 4027, 2008.
5. Ng, N. L., Kwan, A. J., Surratt, J. D., Chan, A. W. H., Chhabra, P. S., Sorooshian, A., Pye, H. O. T., Crouse, J. D., Wennberg, P. O., Flagan, R. C., Seinfeld, J. H., "Secondary organic aerosol (SOA) formation from reaction of isoprene with nitrate radicals (NO₃)", *Atmos. Chem. Phys.*, 8, 4117, 2008.
6. Matthews, J., Fry, JL, Roehl, CM, Wennberg, PO, Sinha, A, "Vibrational overtone initiated unimolecular dissociation of HOCH₂OOH and HOCD₂OOH: Evidence for mode selective behavior", *J. Chem. Phys.*, 128, 12, 2008.
7. Heald, C. L., Goldstein, A. H., Allan, J. D., Aiken, A. C., Apel, E., Atlas, E. L., Baker, A. K., Bates, T. S., Beyersdorf, A. J., Blake, D. R., Campos, T., Coe, H., Crouse, J. D., DeCarlo, P. F., de Gouw, J. A., Dunlea, E. J., Flocke, F. M., Fried, A., Goldan, P., Griffin, R. J., Herndon, S. C., Holloway, J. S., Holzinger, R., Jimenez, J. L., Junkermann, W., Kuster, W. C., Lewis, A. C., Meinardi, S., Millet, D. B., Onasch, T., Polidori, A., Quinn, P. K., Riemer, D. D., Roberts, J. M., Salcedo, D., Sive, B., Swanson, A. L., Talbot, R., Warneke, C., Weber, R. J., Weibring, P., Wennberg, P. O., Worsnop, D. R., Wittig, A. E., Zhang, R., Zheng, J., Zheng, W., "Total observed organic carbon (TOOC) in the atmosphere: a synthesis of North American observations", *Atmos. Chem. Phys.*, 7, 2007, 2008.
8. Wennberg, PO, Dabdub, D, Atmospheric chemistry - Rethinking ozone production, *Science*, 319, 1624, 2008.
9. Peters, W., Jacobson, AR, Sweeney, C., Andrews, AE, Conway, TJ, Masarie, K, Miller, JB, Bruhwiler, LMP, Petron, G, Hirsch, AI, Worthy, DEJ, van der Werf, GR, Randerson, JT, Wennberg, PO, Krol, MC, Tans, PP, "An atmospheric perspective on North American carbon dioxide exchange: CarbonTracker", *Proc. Nat. Acad.*, 104, 18925, 2008.
10. Ng, NL, Chhabra, PS, Chan, AWH, Surratt, JD, Kroll, JH, Kwan, AJ, McCabe, DC, Wennberg, PO, Sorooshian, A, Murphy, SM, Dalleska, NF, Flagan, RC, Seinfeld, JH, "Effect of NO_x level on secondary organic aerosol (SOA) formation from the photooxidation of terpenes", *Atmos. Chem. Phys.*, 7, 5159, 2007.
11. Miller, CE, Crisp, D, DeCola, PL, Olsen, SC, Randerson, JT, Michalak, AM, Alkhaled, A, Rayner, P, Jacob, DJ, Suntharalingam, P, Jones, DBA, Denning, AS, Nicholls, ME, Doney, SC, Pawson, S, Boesch, H, Connor, BJ, Fung, IY, O'Brien, D, Salawitch, RJ, Sander, SP, Sen, B, Tans, P, Toon, GC, Wennberg, PO, Wofsy, SC, Yung, YL, Law, RM, "Precision requirements for space-based X-CO₂ data", *J. Geophys. Res.*, 112, AR D10314, 2007.
12. Ren, XR, Olson, JR, Crawford, JH, Brune, WH, Mao, JQ, Long, RB, Chen, Z, Chen, G, Avery, MA, Sachse, GW, Barrick, JD, Diskin, GS, Huey, LG, Fried, A, Cohen, RC, Heikes, B, Wennberg, PO, Singh, HB, Blake, DR, Shetter, RE, "HO_x chemistry during INTEX-A 2004: Observation, model calculation, and comparison with previous studies", 113, AR D05310, 2008.
13. R. Yokelson, S. Urbanski, E. Atlas, D. Toohey, E. Alvarado, J. Crouse, P. Wennberg, M. Fisher, C. Wold, T. Campos, K. Adachi, P. R. Buseck, and W. M. Hao, "Emissions from forest fires near Mexico City", *Atmos. Chem. Phys.*, 7, 6687, 2007.

14. Z. Yang, Washenfelder R.A., Keppel-Aleks G., Wennberg P.O., Krakauer N.Y., Randerson J.T., Tans P., and Sweeney, C. "New constraints on Northern Hemisphere growing season net flux", *Geophys. Res. Lett.*, **34**, L12807, 2007.
15. G. Keppel-Aleks, Toon G.C., Wennberg P.O. and Deutscher N., "Reducing the impact of source brightness fluctuations on spectra obtained by FTS", *App. Optics*, **46**, 4774-4779, 2007, 2007.
16. Liang, Q, Jaegle, L, Hudman, RC, Turquety, S, Jacob, DJ, Avery, Browell, EV, Sachse, GW, Blake, DR, Brune, W, Ren, X, Cohen, RC, Dibb, JE, Fried, A, Fuelberg, H, Porter, M, Heikes, BG, Huey, G, Singh, HB, and Wennberg, PO, "Summertime influence of Asian pollution in the free troposphere over North America", *J. Geophys. Res.*, **112**, D12S11, 2007.
17. C.M. Roehl, Marka Z., Fry JL., Wennberg P.O. "Near-UV photolysis cross sections of CH₃OOH and HOCH₂OOH determined via action spectroscopy", *Atmos. Chem. Phys.*, **7**, 713-720, 2007.
18. T.H. Bertram, Perring A., Wooldridge, P.J., Crounse, J.D., Kwan, A.J., Wennberg, P.O., Scheuer, E., Dibb, J., Avery, M., Sachse, G., Vay, S.A., Crawford, J.H., McNaughton, C.S., Clarke, A., Pickering, K.A., Fuelberg, H., Huey, G., Blake, D.R., Singh, H.B., Hall, S.R., Shetter, R.E., Fried, A., Heikes, B.G., and Cohen, R.C., "Direct Measurements of the Convective Recycling of the Upper Troposphere", *Science*, DOI: 10.1126/science.1134548, 2007.
19. Miller, CE, Crisp, D, DeCola, PL, Olsen, SC, Randerson, JT, Michalak, AM, Alkhaled, A, Rayner, P, Jacob, DJ, Suntharalingam, P, Jones, DBA, Denning, AS, Nicholls, ME, Doney, SC, Pawson, S, Boesch, H, Connor, BJ, Fung, IY, O'Brien, D, Salawitch, RJ, Sander, SP, Sen, B, Tans, P, Toon, GC, Wennberg, PO, Wofsy, SC, Yung, YL, Law, RM, "Precision requirements for space-based X-CO₂ data", *J. Geophys. Res.*, **112**, D10314, 2007.
20. H. Boesch, Toon, G. C., Sen, B., Washenfelder, R. A., Wennberg, P. O., Buchwitz, M., de Beek, R., Burrows, J. P., Crisp, D., Christi, M., Connor, B. J., Natraj, V., Yung, Y. L., "Space-based near-infrared CO₂ measurements: Testing the Orbiting Carbon Observatory retrieval algorithm and validation concept using SCIAMACHY observations over Park Falls, Wisconsin", *J. Geophys. Res.*, **111**, D23302, 2006.
21. A.J. Kwan, J.D. Crounse, A.D. Clarke, Y. Shinozuka, B.E. Anderson, J.H. Crawford, M.A. Avery, C.S. McNaughton, W.H. Brune, H.B. Singh, and P.O. Wennberg, "On the flux of oxygenated volatile organic compounds from organic aerosol oxidation", *Geophys. Res. Lett.*, **33**, L15815, 2006.
22. J.D. Crounse, K.A. McKinney, A.J. Kwan, and P.O. Wennberg, "Measurement of gas-phase hydroperoxides by chemical ionization mass spectrometry (CIMS)", *Anal. Chem.*, **78** (19): 6726-6732, 2006.
23. R.A. Washenfelder, G. C. Toon, J-F. Blavier, Z. Yang, N. T. Allen, P. O Wennberg, S. A. Vay, D. M. Matross, "Carbon dioxide column abundances at the Wisconsin tall tower site", *J. Geophys. Res.*, **111**, D22305, 2006.
24. P.O. Wennberg, "Atmospheric chemistry - Radicals follow the sun", *Nature*, **442**, 145-146, 2006.
25. Kleinbohl A, Toon GC, Sen B, Blavier JFL, Weisenstein DK, Strekowski RS, Nicovich JM, Wine PH, Wennberg PO, "On the stratospheric chemistry of hydrogen cyanide", *Geophys. Res. Lett.*, **33**, L11806, 2006
26. J.L. Fry, Matthews J, Lane JR, Roehl CM, Sinha A, Kjaergaard HG, Wennberg PO, "OH-stretch vibrational spectroscopy of hydroxymethyl hydroperoxide", *J. Phys. Chem. A* **110**, 7072-7079, 2006
27. A. Kleinbohl, Toon GC, Sen B, Blavier J-F, Weisenstein, D., Wennberg P.O., "Infrared measurements of atmospheric CH₃CN", *Geophys. Res. Lett.*, **32**, Art. No. L23807, 2005
28. S.A. Nizkorodov, J.D. Crounse, J.L. Fry, C.M. Roehl, P.O. Wennberg, "Near-IR photodissociation of peroxy acetyl nitrate", *Atmos. Chem. Phys.*, **5**, 385-392, 2005

29. R.J. Salawitch, D.K. Weisenstein, L.J. Kovalenko, C.E. Sioris, P.O. Wennberg, K. Chance, M.K.W. Ko, C.A. McLinden, "Sensitivity of ozone to bromine in the lower stratosphere", *Geophys. Res. Lett.*, **32**, L05811, 2005
30. Z. Yang, P.O. Wennberg, R.P. Cageao, T.J. Pongetti, G.C. Toon and S.P. Sander, "Ground-based photon path measurements from solar absorption spectra of the O₂ A-band", *J. Quant. Spect. Rad. Trans.*, **90**, 309, 2005.
31. S. Dhaniyala, P.O. Wennberg, R.C. Flagan, D.W. Fahey, M.J. Northway, R.S. Gao, T.P. Bui, "Stratospheric aerosol sampling: Effect of a blunt-body housing on inlet sampling characteristics", *Aerosol Sci. Tech.*, **38**, 1080, 2004.
32. D. Crisp, Atlas RM, Breon FM, Brown LR, Burrows JP, Ciais P, Connor BJ, Doney SC, Fung IY, Jacob DJ, Miller CE, O'Brien D, Pawson S, Randerson JT, Rayner P, Salawitch RJ, Sander SP, Sen B, Stephens GL, Tans PP, Toon GC, Wennberg PO, Wofsy SC, Yung YL, Kuang Z, Chudasama B, Sprague G, Weiss B, Pollock R, Kenyon D, Schroll S, "The orbiting carbon observatory (OCO) mission", *Adv. Space Res.*, **34**, 700, Sp.Iss. 2004.
33. P.O. Wennberg, S. Peacock, J.T. Randerson, R. Bleck, "Recent changes in the air-sea gas exchange of methyl chloroform", *Geophys. Res. Lett.*, **31**, L16112, 2004.
34. J.L. Fry, S.A. Nizkorodov, M. Okumura, C.M. Roehl, J.S. Francisco, P.O. Wennberg, "Cis-cis and trans-perp HOONO: Action spectroscopy and isomerization kinetics", *J. Chem. Phys.*, **121**, 1432-1448, 2004.
35. K.A. McKinney, P.O. Wennberg, S. Dhaniyala, D.W. Fahey, M.J. Northway, K.F. Kunzi, A. Kleinbohl, M. Sinnhuber, H. Kullmann, H. Bremer, M.J. Mahoney, T.P. Bui, "Trajectory studies of large HNO₃-containing PSC particles in the Arctic: Evidence for the role of NAT", *Geophys. Res. Lett.*, **31**, L05110, 2004.
36. S.A. Nizkorodov, J. Crouse, J. Fry, C.A. Roehl, and P.O. Wennberg, "Near-IR photodissociation of peroxy acetyl nitrate", *Atm. Chem. Phys. Dis.*, **4**, 1269-1289, 2004.
37. T. Rahn, J.M. Eiler, K.A. Boering, P.O. Wennberg, M.C. McCarthy, S. Tyler, S. Schauffler, S. Donnelly, and E. Atlas, "Extreme deuterium enrichment in stratospheric hydrogen and its significance for the global atmospheric budget of H₂" *Nature*, **424**, 918-921, 2003..
38. R.A. Washenfelder, G.C. Toon, and P.O. Wennberg, "Tropospheric methane retrieved from ground-based near-IR solar spectra", *Geophys. Res. Lett.*, **30**, 2226, 2003.
39. R.A. Washenfelder, C.M. Roehl, K.A. McKinney, R.R. Julian, and P.O. Wennberg, "A compact, lightweight gas standards generator for permeation tubes, *Rev. Sci. Instru.*, **74**, 3151, 2003.
40. Z.M. Kuang, G.C. Toon, P.O. Wennberg, and Y.L. Yung, "Measured HDO/H₂O ratios across the tropical tropopause", *Geophys. Res. Lett.*, **30**, 1372, 2003.
41. S. Dhaniyala, R.C. Flagan, K.A. McKinney, P.O. Wennberg, "Novel aerosol/gas inlet for aircraft based measurements", *Aerosol Sci. Tech.*, **37**, 828-840, 2003.
42. M. Rex et al., Chemical depletion of Arctic ozone in winter 1999/200, *J. Geophys. Res.*, 107, Art. No. 8276, 2002.
43. M.Y. Danilin, M.K.W. Ko, R.M. Bevilacqua, L.V. Lyjak, L. Froedevaux, M.L. Santee, J.M. Zawodny, K.W. Hoppel, E.C. Richard, J.R. Spackman, E.M. Weinstock, R.L. Herman, K.A. McKinney, P.O. Wennberg, F.L. Eisele, R.M. Stimpfle, C.J. Scott, J.W. Elkins, T.V. Bui, "Comparison of ER-2 aircraft and POAM III, MLS, and SAGE II satellite measurements during SOLVE using traditional correlative analysis and trajectory hunting technique, *J. Geophys. Res.*, **108**, 8315, 2002.
44. M.J. Northway, R.S. Gao, P.J. Popp, J.C. Holecek, D.W. Fahey, K.S. Carslaw, M.A. Tolbert, L.R. Lait, S. Dhaniyala, R.C. Flagan, P.O. Wennberg, M.J. Mahoney, R.L. Herman, G.C. Toon, and T.P.

- Bui, "An analysis of large HNO₃-containing particles sampled in the Arctic stratosphere during the winter of 1999/2000", *J. Geophys. Res.*, **108**, 8298, 2002.
45. R.J. Salawitch, P.O. Wennberg, G.C. Toon, B. Sen, and J.F. Blavier, "Near-IR Photolysis of HO₂NO₂: Implications for HO_x", *Geophys. Res. Lett.*, **29**, 1762, 2002.
 46. Y. Zhonghua, G.C. Toon, J.S. Margolis, and P.O. Wennberg, "Atmospheric CO₂ retrieved from ground-based near IR solar spectra", *Geophys. Res. Lett.*, **29**, 1339, 2002.
 47. S. A. Nizkorodov and P.O. Wennberg, "First spectroscopic observation of gas-phase HOONO", *J. Phys. Chem. A*, **106**, 855, 2002.
 48. S. Dhaniyala, K.A. McKinney, and P.O. Wennberg, "Lee-wave clouds and denitrification of the polar stratosphere", *Geophys. Res. Lett.*, **29**, 1332, 2002.
 49. C.M. Roehl, S.A. Nizkorodov, H. Zhang, G.A. Blake, and P.O. Wennberg, "Photodissociation of peroxyntic acid in the near IR", *J. Phys. Chem. A*, **106**, 3766, 2002.
 50. D.W. Fahey, R.S. Gao, K.S. Carslaw, J. Kettleborough, P.J. Popp, M.J. Northway, J.C. Holecek, S.C. Ciciora, R.J. McLaughlin, T.L. Thompson, R.H. Winkler, D.G. Baumgardner, B. Gandrud, P.O. Wennberg, S. Dhaniyala, K. McKinney, T. Peter, R.J. Salawitch, T.P. Bui, J.W. Elkins, C.R. Webster, E.L. Atlas, H. Jost, J.C. Wilson, R.L. Herman, A. Kleinbohl, M. von Konig, "The detection of large HNO₃-containing particles in the winter arctic stratosphere", *Science*, **291**, 1026-1031, 2001.
 51. L. Jaegle, D.J. Jacob, W.H. Brune, and P.O. Wennberg, "Chemistry of HO_x radicals in the upper troposphere", *Atmos. Environ.*, **35**, 469, 2001.
 52. E.J. Lanzendorf, T.F. Hanisco, R.M. Stimpfle, J.G. Anderson, P.O. Wennberg, R.C. Cohen, R.S. Gao, J.J. Margitan, and T.P. Bui, "Establishing the dependence of [HO₂]/[OH] on temperature, halogen, loading, O₃, and NO_x based on in situ measurements from the NASA ER-2", *J. Phys. Chem.*, **105**, 1535, 2001.
 53. E.J. Lanzendorf, T.F. Hanisco, R.M. Stimpfle, J.G. Anderson, P.O. Wennberg, and R.C. Cohen, "Comparing Atmospheric [HO₂]/[OH] to modeled [HO₂]/[OH]: identifying discrepancies in reaction rate constants", *Geophys. Res. Lett.*, **28**, 967, 2001.
 54. T.F. Hanisco, E.J. Lanzendorf, P.O. Wennberg, K.K. Perkins, R.M. Stimpfle, P.B. Voss, J.G. Anderson, R.C. Cohen, D.W. Fahey, R.S. Gao, E.J. Hints, R.J. Salawitch, J.J. Margitan, C.T. McElroy, and C. Midwinter, "Sources, Sinks and the distribution of OH in the lower stratosphere", *J. Phys. Chem.*, **105**, 1543, 2001.
 55. K.K. Perkins, T.F. Hanisco, R.C. Cohen, L.C. Koch, R.M. Stimpfle, P.B. Voss, G.P. Bonne, E.J. Lanzendorf, J.G. Anderson, P.O. Wennberg, R.S. Gao, L.A. Del Negro, R.J. Salawitch, C.T. McElroy, E.J. Hints, M. Lowenstein, and T.P. Bui, "The NO_x-HNO₃ system in the lower stratosphere: Insights from *in situ* measurements and implications of the JHNO₃ - OH relationship", *J. Phys. Chem* **105**, 1521-1534, 2001.
 56. D.W. Fahey, R.S. Gao, K.S. Carslaw, J. Kettleborough, P.J. Popp, M.J. Northway, J.C. Holecek, S.C. Ciciora, R.J. McLaughlin, T.L. Thompson, R.H. Winkler, D.G. Baumgardner, B. Gandrud, P.O. Wennberg, S. Dhaniyala, K. McKinney, T. Peter, R.J. Salawitch, T.P. Bui, J.W. Elkins, C.R. Webster, E.L. Atlas, H. Jost, J.C. Wilson, R.L. Herman, A. Kleinbohl, M. von Konig, "The detection of large HNO₃-containing particles in the winter arctic stratosphere", *Science*, **291**, 1026-1031, 2001
 57. P.B. Voss, R.M. Stimpfle, R.C. Cohen, T.F. Hanisco, G.P. Bonne, K.K. Perkins, E.J. Lanzendorf, J.G. Anderson, R.J. Salawitch, C.R. Webster, D.C. Scott, R.D. May, P.O. Wennberg, P.A. Newman, L.R. Lait, J.W. Elkins, T.P. Bui, "Inorganic chlorine partitioning in the summer lower stratosphere: Modeled and measured [ClONO₂]/[HCl] during POLARIS", *J. Geophys. Res.*, **106**, 1713-1732, 2001,

58. R.C. Cohen, K.K. Perkins, L.C. Koch, R.M. Stimpfle, P.O. Wennberg, T.F. Hanisco, E.J. Lanzendorf, G.P. Bonne, P.B. Voss, R.J. Salawitch, L.A. Del Negro, J.C. Wilson, C.T. McElroy, T.P. Bui, "Quantitative constraints on the atmospheric chemistry of nitrogen oxides: An analysis along chemical coordinates", *J. Geophys. Res.*, **105**, 24283-24304, 2000.
59. H. Zhang, C.A. Roehl, S.P. Sander, P.O. Wennberg, "Intensity of the second and third OH overtones of H₂O₂, HNO₃, and HNO₄", *J. Geophys. Res.*, **105**, 14593-14, 2000.
60. H. Zhang, P.O. Wennberg, V. Wu, G.A. Blake, "Fractionation of ¹⁴N¹⁵N¹⁶O and ¹⁵N¹⁴N¹⁶O during photolysis at 213 nm", *Geophys. Res. Lett.*, **27**, 2481-2484, 2000.
61. D.W. Fahey, R.S. Gao, L.A. Del Negro, E.R. Keim, S.R. Kawa, R.J. Salawitch, P.O. Wennberg, T.F. Hanisco, E.J. Lanzendorf, K.K. Perkins, S.A. Lloyd, W.H. Swartz, M.H. Proffitt, J.J. Margitan, J.C. Wilson, R.M. Stimpfle, R.C. Cohen, C.T. McElroy, C.R. Webster, M. Loewenstein, J.W. Elkins, T.P. Bui, "Ozone destruction and production rates between spring and autumn in the Arctic stratosphere", *Geophys. Res. Lett.*, **27**, 2605-2608, 2000.
62. Del Negro LA, Fahey DW, Gao RS, Donnelly SG, Keim ER, Neuman JA, Cohen RC, Perkins KK, Koch LC, Salawitch RJ, Lloyd SA, Proffitt MH, Margitan JJ, Stimpfle RM, Bonne GP, Voss PB, Wennberg PO, McElroy CT, Swartz WH, Kusterer TL, Anderson DE, Lait LR, Bui TP "Comparison of modeled and observed values of NO₂ and J(NO₂) during the Photochemistry of Ozone Loss in the Arctic Region in Summer, (POLARIS) mission", *J. Geophys. Res.*, **104**, 26687-26703, 1999.
63. R.L. Herman, C.R. Webster, R.D. May, D.C. Scott, H. Hu, E.J. Moyer, P.O. Wennberg, T.F. Hanisco, E.J. Lanzendorf, R.J. Salawitch, Y.L. Yung, J.J. Margitan, and T.P. Bui, "Measurements of CO in the upper troposphere and lower stratosphere", *Chemosphere*, **1**, 173, 1999.
64. P.O. Wennberg, R.J. Salawitch, D.J. Donaldson, T.F. Hanisco, E.J. Lanzendorf, K.K. Perkins, S.A. Lloyd, V. Vaida, R.S. Gao, E.J. Hints, R.C. Cohen, W.H. Swartz, T.L. Kusterer, and D.E. Anderson, "Twilight observations suggest unknown sources of HO_x", *Geophys. Res. Lett.*, **26**, 1373-1376, 1999.
65. R.S. Gao, D.W. Fahey, L.A. Del Negro, S.G. Donnelly, E.R. Keim, J.A. Neuman, E. Teverovskaia, P.O. Wennberg, T.F. Hanisco, E.J. Lanzendorf, M.H. Proffitt, J.J. Margitan, J.C. Wilson, J.W. Elkins, R.M. Stimpfle, R.C. Cohen, C.T. McElroy, T.P. Bui, R.J. Salawitch, S.S. Brown, A.R. Ravishankara, R.W. Portmann, M.K.W. Ko, D.K. Weisenstein, P.A. Newman, "A comparison of observations and model simulations of NO_x/NO_y in the lower stratosphere", *Geophys. Res. Lett.*, **26**, 1153-1156, 1999.
66. P.O. Wennberg, T.F. Hanisco, L. Jaeglé, D.J. Jacob, E.J. Hints, E.J. Lanzendorf, J.G. Anderson, R.S. Gao, E.R. Keim, S.G. Donnelly, L.A. Del Negro, D.W. Fahey, S.A. McKeen, R.J. Salawitch, C.R. Webster, R.D. May, R.L. Herman, M.H. Proffitt, J.J. Margitan, E.L. Atlas, S.M. Schauffler, F. Flocke, C.T. McElroy, T.P. Bui., "Hydrogen Radicals, Nitrogen Radicals, and the production of ozone in the upper troposphere", *Science*, **279**, 49-53, 1998.
67. I. Folkins, P.O. Wennberg, T.F. Hanisco, J.G. Anderson, R.J. Salawitch, "OH, HO₂, and NO in two biomass burning plumes: Sources of HO_x and implications for ozone production", *Geophys. Res. Lett.*, **24**, 3185-3188, 1997.
68. L. Jaeglé, D.J. Jacob, P.O. Wennberg, C.M. Spivakovsky, T.F. Hanisco, E.L. Lanzendorf, E.J. Hints, D.W. Fahey, E.R. Keim, M.H. Proffitt, E. Atlas, F. Flocke, S. Schauffler, C.T. McElroy, C. Midwinter, L. Pfister, J.C. Wilson, "Observed OH and HO₂ in the upper troposphere suggest a major source from convective injection of peroxides", *Geophys. Res. Lett.*, **24**, 3181-3184, 1997.
69. S.A. McKeen, T. Gierczak, J.B. Burkholder, P.O. Wennberg, T.F. Hanisco, E.R. Keim, R.-S. Gao, S.C. Liu, A.R. Ravishankara, and D.W. Fahey, "The photochemistry of acetone in the upper troposphere: A source of odd-hydrogen radicals", *Geophys. Res. Lett.*, **24**, 3177-3180, 1997.

70. E.J. Lanzendorf, T.F. Hanisco, N.M. Donahue and P.O. Wennberg, "Comment on: The measurement of tropospheric OH radicals by laser-induced fluorescence spectroscopy during the POPCORN field campaign, by Hofzumahaus *et al.*", *Geophys. Res. Lett.*, **24**, 3037-3038, 1997.
71. L. Jaeglé, C.R. Webster, R.D. May, D.C. Scott, R.M. Stimpfle, D.W. Kohn, P.O. Wennberg, T.F. Hanisco, Cohen, M.H. Proffitt, K.K. Kelly, J. Elkins, D. Baumgardner, J.E. Dye, J.C. Wilson, R.F. Pueschel, K.R. Chan, R.J. Salawitch, A.F. Tuck, S.J. Hovde, Y.L. Yung, , "Evolution and stoichiometry of heterogeneous processing in the Antarctic stratosphere", *J. Geophys. Res.*, **102**, 13235-13253, 1997.
72. P.O. Wennberg, J.W. Brault, T.F. Hanisco, R.S. Salawitch, and G.H. Mount, "The atmospheric column abundance of IO: Implications for stratospheric ozone", *J. Geophys. Res.*, **102**, 8887-8898 1997 .
73. T.F. Hanisco, P.O. Wennberg, R.C. Cohen, J.G. Anderson, D.W. Fahey, E.R. Keim, R.S. Gao, R.C. Wamsley, S.G. Donnelly, L.A. Del Negro, R.J. Salawitch, K.K. Kelly, and M.H. Proffitt, "The role of HO_x in super- and subsonic aircraft exhaust plumes", *Geophys. Res. Lett.*, **24**, 65-68, 1997.
74. E.R. Keim, D.W. Fahey, L.A. Del Negro, E.L. Woodbridge, R.S. Gao, P.O. Wennberg, R.C. Cohen, R.M. Stimpfle, K.K. Kelly, E.J. Hints, J.C. Wilson, H.H. Jonsson, J.E. Dye, D. Baumgardner, R.S. Kawa, R.J. Salawitch, M.H. Proffitt, M. Lowenstein, J.R. Podolske, and K.R. Chan, "Observations of large reductions in the NO/NO_y ratio near the midlatitude tropopause and the role of heterogeneous chemistry", *Geophys. Res. Lett.*, **23**, 3223-3226, 1996.
75. M.K. Dubey, T.F. Hanisco, P.O. Wennberg, and J.G. Anderson, "Monitoring potential photochemical interference in the laser-induced fluorescence measurements of atmospheric OH", *Geophys. Res. Lett.*, **23**, 3215-3218, 1996.
76. D.W. Fahey, E.R. Keim, K.A. Boering, C.A. Brock, J.C. Wilson, S. Anthony, T.F. Hanisco, P.O. Wennberg, R.C. Miake-Lye, R.J. Salawitch, N. Lousinard, E.L. Woodbridge, R.S. Gao, S.G. Donnelly, R.C. Wamsley, L.A. Del Negro, B.C. Daube, S.C. Wofsy, C.R. Webster, R.D. May, K.K. Kelly, M. Loewenstein, J.R. Podolske, and K.R. Chan, "Emission measurements of the concorde supersonic aircraft In the lower stratosphere", *Science*, **270**, 70, 1995.
77. P.O. Wennberg, T.F. Hanisco, R.C. Cohen, R.M. Stimpfle, L.B. Lapson, and J.G. Anderson, "In Situ measurements of OH and HO₂ in the upper troposphere and stratosphere", *J. Atmos. Sci.*, **52**, 3413-20, 1995.
78. R.C. Cohen, P.O. Wennberg, R.M. Stimpfle, J. Koplow, J.G. Anderson, D.W. Fahey, E.L. Woodbridge, E.R. Keim, R. Gao, M.H. Proffitt, M. Loewenstein, and K.R. Chan, "Are models of catalytic removal of O₃ by HO_x accurate? Constraints from In Situ measurements of the OH to HO₂ ratio", *Geophys. Res. Lett.*, **21**, 2539-2542, 1994.
79. R.J. Salawitch, S.C. Wofsy, P.O. Wennberg, *et al.*, "The distribution of hydrogen, nitrogen, and chlorine Radicals in the lower stratosphere: Implications for changes in O₃ due to emission of NO_y from supersonic aircraft", *Geophys. Res. Lett.*, **21**, 2547-2550, 1994.
80. R.J. Salawitch, S.C. Wofsy, P.O. Wennberg, *et al.*, "The diurnal variation of hydrogen, nitrogen, and chlorine radicals: Implications for the heterogeneous production of HNO₂", *Geophys. Res. Lett.*, **21**, 2551-2554, 1994.
81. R.M. Stimpfle, J.P. Koplow, R.C. Cohen, D.W. Kohn, P.O. Wennberg, D.M. Judah, D.W. Toohey, L.M. Avallone, J.G. Anderson, R.J. Salawitch, E.L. Woodbridge, C.R. Webster, R.D. May, M.H. Proffitt, K. Aiken, J. Margitan, M. Loewenstein, J.R. Podolske, L. Pfister, and K.R. Chan, "The response of ClO radical concentrations to variations in NO₂ radical concentrations in the lower stratosphere", *Geophys. Res. Lett.*, **21**, 2543-2546, 1994.

82. P.O. Wennberg, R.C. Cohen, R.M. Stimpfle, J.P. Koplow, J.G. Anderson, R.J. Salawitch, D.W. Fahey, E.L. Woodbridge, E.R. Keim, R.S. Gao, C.R. Webster, R.D. May, D.W. Toohey, L.M. Avallone, M.H. Proffitt, M. Loewenstein, J.R. Podolske, K.R. Chan, and S.C. Wofsy, "Removal of stratospheric O₃ by radicals: In situ measurements of OH, HO₂, NO, NO₂, ClO, and BrO", *Science*, **266**, 398-404, 1994.
83. H.A. Michelsen, R.J. Salawitch, P.O. Wennberg, and J.G. Anderson, "Production of O(¹D) from photolysis of O₃", *Geophys. Res. Lett.*, **21**, 2227-2230, 1994.
84. P.O. Wennberg, J.G. Anderson, and D. Weisenstein, "Kinetics of the reactions of ground-state nitrogen atoms (⁴S_{3/2}) with NO and NO₂", *J. Geophys. Res.*, **99**, 18839-18846, 1994.
85. P.O. Wennberg, R.C. Cohen, N.L. Hazen, L.B. Lapson, N.T. Allen, T.F. Hanisco, J.F. Oliver, N.W. Lanham, J.N. Demusz, and J.G. Anderson, "An aircraft-borne, laser-induced fluorescence instrument for the in situ detection of hydroxyl and hydroperoxyl radicals", *Rev. Sci. Instrum.*, **65**, 1858-1876, 1994.
86. P.O. Wennberg, R.M. Stimpfle, E.M. Weinstock, A.E. Dessler, S.A. Lloyd, L.B. Lapson, J.J. Schwab, and J.G. Anderson, "Simultaneous, in situ measurements of OH, HO₂, O₃, and H₂O: A test of modeled stratospheric HO_x chemistry", *Geophys. Res. Lett.*, **17**, 1909, 1990.
87. R.M. Stimpfle, P.O. Wennberg, L.B. Lapson, and J.G. Anderson, "Simultaneous, in situ measurements of OH and HO₂ in the stratosphere", *Geophys. Res. Lett.*, **17**, 1905, 1990.
88. R.M. Stimpfle, L.B. Lapson, P.O. Wennberg, and J.G. Anderson, "Balloon borne in-situ detection of OH in the stratosphere from 37 to 23 km", *Geophys. Res. Lett.*, **16**, 1433, 1989.